Luton Rising
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Our planet.

December 2023

London Luton Airport Expansion

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Volume 5 Environmental Statement and Related Documents

5.02 Appendix 17.6 Outline Foundation Works Risk Assessment (Tracked Change Version)

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The Planning Act 2008

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

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5.02 ENVIRONMENTAL STATEMENT APPENDIX 17.6 OUTLINE FOUNDATION WORKS RISK ASSESSMENT (TRACKED CHANGE VERSION)

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1 INTRODUCTION

1.1.1 This Outline Foundation Works Risk Assessment (FWRA) has been developed by Luton Rising (a trading name of London Luton Airport Limited) ('the ~~a~~Applicant') to support the application for development consent (DCO) for the expansion of the airport ('the Proposed Development').

1.1.2 This is an outline document which has been developed following consultation with the Environment Agency and Local Planning Authorities (Luton Borough Council, Central Bedfordshire Council and North Hertfordshire District Council). As an outline document, this will inform the development of the final foundation works risk assessment which will allow further consideration of risk from foundation works during detailed design of individual large structures and development areas. This may be undertaken in the form of several documents that address specific areas or part of the development over the landfill depending on the design stage of that area.

~~1.1.1~~

~~1.1.2~~1.1.3 The Application Site is split into four distinct geographical components:

a. Main Application Site;
b. Off-site Car Parks;
c. Off-site Highway Interventions; and
d. Off-site Planting.

~~1.1.3~~1.1.4 For reporting purposes these areas have been further subdivided into smaller areas, as detailed below and identified on **Figure 1**:

a. Main Application Site: Existing Airport Land, LLAOL Contractor's Compound, the proposed Airport Access Road (previously known as Century Park Access Road (CPAR)) and Area A – Former Landfill, Area B – Land West of Winch Hill Lane and Area C – Land East of Winch Hill Lane.
b. Off-site Car Parks into Areas D – Off-site Car Park North and E – Off-site Car Park South.

~~1.1.4~~1.1.5 This FWRA is limited to the principal area of land affected by contamination identified from previous ground investigations (GI) and assessments (see **Section 1.2** below), which is Area A - Former Landfill, (part of the Main Application Site), herein referred to as the site.

~~1.1.5~~1.1.6 The geotechnical assessment work undertaken to date indicated that all buildings on the site are likely to require piled foundations mainly due to allowable settlement tolerances. However, it should be noted that there may be the possibility for shallow foundations to be used for small and lightly loaded structures, the details of which will be considered at detailed design phase. For the purpose of this report, it has been assumed that piled foundations will be adopted, as it is considered a worst-case scenario. The site has also been subject to detailed contamination assessment (see **Section 1.2**) and a potential risk to the underlying principal aquifer from proposed piling activities through the

landfill has been identified. Further details on the development and the assessment work undertaken are provided in **Sections 2.2** and **3.2** respectively. Details on the preferred piling method are discussed in **Section 4**.

~~1.1.6~~1.1.7 Retaining walls are planned across the site but are shallow in depth and will not penetrate the base of the landfill. Therefore, there is no interaction with the underlying aquifer, so are not considered further in this assessment. However, the necessary precautions regarding worker interaction with the landfill material are covered in Scenario 3 (see **Section 5** for details of pollution scenarios) and in detail within the Outline Remediation Strategy (ORS) (Ref. 1) (**Appendix 17.5**) of the Environmental Statement (ES) **[TR020001/APP/5.02]** and Code of Construction Practise (COCP) (Ref. 2) (**Appendix 4.2**) of the ES **[TR020001/APP/5.02]**.

~~1.1.7~~1.1.8 The objectives of the FWRA are to identify:

a. the environmental risks associated with the proposed piling methods and other in-ground construction required at the site; and

b. the range of appropriate risk management approaches and monitoring requirements which should be adopted to limit and control these risks in a practicable manner.

~~1.1.8~~1.1.9 This report presents the ground and groundwater conditions encountered beneath the site and considers the potential impact of the proposed use of piled foundations through a historical landfill and land affected by contamination. This report has been prepared in accordance with the Environment Agency guidance 'Piling and penetrative ground improvement methods on land affected by contamination: Guidance on pollution prevention' (Ref. 3). Reference is also made to Environment Agency guidance on drilling into waste on landfill sites from 'Landfill operators: environmental permits – design and build your landfill site' (Ref. 4).

1.2 Work undertaken to date

1.2.1 The site has been subject to a number of GI and assessments, which are relevant to this report. These include:

a. Aecom (2019) Luton Airport Landfill, Main Ground Investigation – Factual Report (Ref. 5);

b. Structural Soils Limited (2017) Luton Borough Council, Century Park Access Road, Factual Report on Ground Investigation (Ref. 6);

c. Structural Soils Limited (2017) London Luton Airport Limited, Century Park, Factual Report on Ground Investigation (Ref. 7);

d. Structural Soils Limited (2017) London Luton Airport Limited, Landfill, Factual Report on Ground Investigation (Ref. 8);

e. Arup (2017) London Luton Airport Limited. Century Park Development, Airport Way. Contamination Preliminary Risk Assessment – Former Eaton Green Landfill (Ref. 9);

f. Luton Rising (2023). Environmental Statement (ES). Chapter 17: Soils and Geology (Ref. 10);

g. Luton Rising (2023). Preliminary Risk Assessment of Land Contamination. (Ref. 11);

h. Luton Rising (2023). Hydrogeological Characterisation Report. (Ref. 12);

i. Luton Rising (2023). Land Contamination. Generic Quantitative Risk Assessment (GQRA) Report. (Ref. 13);

j. Luton Rising (2023). Detailed Quantitative Risk Assessment (DQRA) Report: Human Health and Ground Gases. (Ref. 14);

k. Luton Rising (2023). Detailed Quantitative Risk Assessment (DQRA) Report: Controlled Waters. (Ref. 15); and

l. Luton Rising (2023) Outline Remediation Strategy (ORS) for former Eaton Green Landfill. (Ref. 1).

1.2.2 The site setting (**Section 1**) has been summarised from the PRA (Ref. 11) (**Appendix 17.1**) and GQRA (Ref. 13) (**Appendix 17.2**) reports of the ES **[TR020001/APP/5.02]**. The key findings of the DQRAs (Ref. 14 and Ref. 15) are summarised in **Section** Error! Reference source not found., see **Appendix 17.3** and **Appendix 17.4** of the ES **[TR020001/APP/5.02]**.

2 SITE SETTING

2.1 Site description

2.1.1 For the purposes of the PRA (Ref. 11) the Proposed Development was subdivided into smaller areas, as described in **Section 1**. The PRA identified that only Area A – Former Landfill required further assessment in terms of the contamination conditions at this stage. Other areas of the development will be subject to GI post DCO. Area A is an historical landfill and is referred to as 'the site' within this report. The extent of the site is shown in **Figure 1** of this document.

2.1.2 The site is approximately 40 hectares and lies to the east of the London Luton Airport (the airport). It is located approximately 3.5 km east of Luton town centre, centred at National Grid Reference 512461 221724.

2.1.3 The site comprises public open space, known as Wigmore Valley Park (WVP). Sports pitches are present in the northeast and the long-stay car park for the airport is present in the west of the site. In the northwest is another car park (operated by TUI). The central and southern part of the site are a designated County Wildlife Site (CWS).

2.2 Proposed Development

2.2.1 The Proposed Development builds on the current operational airport with the construction of a new passenger terminal and additional aircraft stands to the north east of the runway. In addition to the above and to support the initial increase in demand, the existing infrastructure and supporting facilities will be improved in line with the phased incremental growth in capacity of the airport. In addition there would be an extension to the and new station, car parking and development of Green Horizons Park. The works will be phased to match airport capacity demand.

2.2.2 A detailed description of the Proposed Development is provided at **Chapter 4** of the Environmental Statement (ES) **[TR020001/APP/5.01]**.

2.3 Site history

2.3.1 The earliest available historical mapping (1879) shows the site was predominantly agricultural land. Ordnance Survey maps do not show the site in use as a landfill until 1960 however aerial photography dated from 1941 suggests that waste deposition and filling had begun earlier in the southwest of the site (Ref. 11).

2.3.2 Historical mapping and aerial imagery show the majority of the site was landfilled by 1975.The site appears to have been covered and landscaped between 2000 and 2002 to resemble its current condition, with WVP to the east and the airport car parks to the west.

2.3.3 The Long-stay car park was initially constructed in 2002 and has been extended over the landfill area to the south in 2009 and across the western area in 2013.

2.3.4 The landfill is an old 'dilute and disperse' landfill with no engineered capping or basal liner.

2.3.5 The potential sources of contamination based on the historical land uses is summarised in **Figure 2**.

2.4 Topography

2.4.1 The former landfill fills part of the head of a dry valley. The former landfill has an undulating surface of elevation between 150m above ordnance datum (AOD) and 155m AOD with the southern part being particularly uneven and the ground level to the south and east dropping off steeply. The elevation at the bottom of the dry valley adjacent to the landfill is approximately 130m AOD.

2.5 Ground model

2.5.1 A 3-Dimensional ground model was developed as part of the previous assessment based on the GIs undertaken to date. Full details of this ground model are provided in the GQRA (Ref. 15) (**Appendix 17.2**) of the ES **[TR020001/APP/5.02]**.

2.5.2 As previously stated, the former landfill fills the head of the dry chalk valley and the waste thickness reflects this. The stratigraphy of the site is summarised in **Table 2.1** below landfill material descriptions are summarised in

2.5.3 **Table 2.2**. Cross sections showing the landfill depth are shown in **Figure 3** and **Figure 4** of this document.

Table 2.1 General stratigraphy

Material Name	Typical Description	Typical Thickness
Landfill Material	Approximately 4.5 million m^3 mixed domestic, commercial and construction/demolition waste deposited between the 1930s and 1980s, directly on underlying chalk. Surface soils on the landfill were noted to be slightly clayey in places, which may represent capping material placed on the landfill, but it does not appear to be an engineered cap consistent with current standards. See **Table 2.2** below for additional detail on landfill materials descriptions	Between 4m at the edges and up to 20m (thickest above the base of the valley)
Dry Valley Deposits	Typically described as firm to stiff (occasionally soft) light brown, dark brown, orangish brown, reddish brown or greyish brown slightly sandy, slightly gravelly clay.	2m within the valley bottom
Head Deposits	Clay associated with the weathering of material in the valley sides and floor.	2m (but up to 5m in places) in the valley
Clay-with-Flints	Residual soil formed by the solution weathering of the chalk. Comprises stiff	Present on the plateau typically 3 – 5m in

Material Name	Typical Description	Typical Thickness
	reddish brown slightly sandy gravelly clay with a medium cobble content.	thickness (but up to 15 m thick in places). Absent in the valley area
Upper Chalk	Weathered near the surface, recovered as structureless sandy very silty gravel or sandy gravelly silt (Grade Dm). Different grades of chalk present up to grade A at depth – described as a very weak low or medium density white chalk.	Full thickness not proven, but typically up to 70m (Ref. 16)

2.5.4 Solution features are formed by the dissolution of the Chalk as a result of chemical weathering and are present at the interface between the Clay-with Flints Formation and the Chalk. The GI found evidence of solution pipes and infilled fissures beneath the former landfill. Characterised as the presence of greater thicknesses of cohesive deposits or an alternating sequence of weathered chalk and cohesive deposits.

Table 2.2 Landfill material descriptions

Type of material	Category	Description
Daily cover	Non-chalky cover fill	Material has been classified as non-chalky cover fill, if it has limited waste content, i.e., fragments of brick and concrete, and has minimal chalk content. It has been found across the site.
	Chalky cover fill	Material has been classified as chalky cover fill, if it has limited waste content, i.e., fragments of brick and concrete, and has significant chalk content. It has been found across the site at variable depths.
Waste	Construction and demolition waste	Significant brick, concrete cobble content, in rare cases it has been noted to contain rebar.
	Industrial waste	Waste material with significant clinker or slag, or high percentage composition of wood, metal and fabric infers an industrial nature.
	Old domestic waste	Waste material which is predominately ashy in nature with limited or no plastic component.
	Recent domestic waste	Waste material that contains household waste but has significant plastic content and limited ashy waste. It has been encountered widely across the site between 152.25m AOD and 137.39 m AOD. In places interspaced between non-chalk cover fill.

2.6 Hydrogeology

2.6.1 A comprehensive description of the hydrogeological characteristics beneath the airport has been undertaken, see **Appendix 20.3** of the ES **[TR020001/APP/5.02]** (Ref. 12), these characteristics have been taken into consideration through the design and assessment process. A summary of the key points is provided below:

2.6.2 The site is underlain by Chalk which is classified by the Environment Agency as a principal aquifer.

2.6.3 There are two main water body catchments which cover the Luton area; the Lee and the Mimram catchments. The former landfill (Area A) lies in the Mimram catchment and there is a groundwater divide to the west, where the current extent of the airport lies in the Lee catchment. Groundwater flow direction in the Lee catchment is influenced by local abstraction and flows in a westerly direction. The groundwater flow in the Mimram catchment is affected by the potable abstraction near Kings Walden (2.8km north east of the landfill) (Ref. 12) and a second potable water abstraction (Nine Wells) at Whitwell, 5.3km east of the former landfill. Both may create a more easterly flow direction than the south easterly regional flow.

2.6.4 The majority of the Main Application Site lies within a Source Protection Zone III – Total Catchment, relating to the Kings Walden abstraction and there are also a number of groundwater abstractions in Luton (to the west of the Proposed Development).

2.6.5 Groundwater levels in the chalk were measured in the boreholes installed during the most recent ground investigations in 2018. The groundwater levels beneath the site are typically 112m AOD (40m bgl) and range between 17.5m to 36m below the base of the landfill. The groundwater flow direction identified across the site is generally to the east.

2.6.6 The groundwater level in the Chalk Aquifer has significant annual and seasonal variation and is closely linked to rainfall. The Environment Agency's Hertfordshire Chalk regional groundwater model (Ref. 17), reports seasonal range in groundwater levels between 5m to 10m in the vicinity of the landfill, and up to a maximum 5m variation within the dry valleys. Observations from onsite groundwater monitoring data from 2018 is generally consistent with these ranges.

2.6.7 The design groundwater levels (Ref. 12) beneath the Proposed Development range from 134m AOD in the centre of the groundwater divide to 112m AOD in the dry valley at the eastern extent of the Proposed Development. The contours from this assessment are up to 10m higher than the published maximum contours from the Environment Agency Hertfordshire model (Ref. 17). Due to the large difference between the two, the groundwater levels from this assessment are considered conservative and therefore are considered appropriate for use in the design of the below ground elements of the Proposed Development.

2.6.8 The Chalk is a dual-porosity, dual permeability aquifer, such that the matrix allows for the storage of groundwater and the fractures facilitate permeable pathways (Ref. 18). Most of the flow in the chalk in the area is likely to occur via dilated fractures, typically occurring at or within the top 30m of the Chalk through dissolution enhanced features in the chalk. Flow within the Chalk is influenced by the presence of these solution features which can lead to hydraulic continuity between groundwater catchments (Ref.19).

2.6.9 Solution features are present at the interface between the Clay with Flints formation and the Chalk but less frequent in the base of the valley (below the base of the landfill).

~~2.6.7~~2.6.10 It is further complicated by the weathered top of the chalk, which is often referred to as 'putty chalk', where the chalk is structureless and forms a clayey silt. This material can have significantly lower hydraulic conductivity reducing the transmissivity of the aquifer. The travel time within the putty chalk horizon is estimated to be between 2-15 times slower than in the main Chalk (Ref. 19). The GI recorded the upper levels of the chalk beneath the landfill as heavily weathered i.e. 'putty chalk', generally recovered as structureless sandy very silty gravel or sandy gravelly silt.

Background groundwater quality

~~2.6.8~~2.6.11 Groundwater quality data for the Kings Walden potable water supply abstraction was obtained from the Environment Agency which covered the period from November 1992 to September 2018. A limited number of determinands are routinely monitored at the abstraction (pH, conductivity, ammoniacal nitrogen, nitrate and nitrite). Concentrations of nitrate are elevated (average of 11 mg/l) when compared to the background groundwater quality data obtained from the on-site monitoring wells and are likely to be reflective of agricultural land use in the area surrounding the abstraction. Ammoniacal nitrogen a common indicator of landfill leachate, has not been detected in the Kings Walden abstraction.

~~2.6.9~~2.6.12 Limited samples of groundwater from the abstraction have been analysed for other contaminants including metals, hydrocarbons and solvents. The concentrations of these contaminants indicated that they are either absent or within the normal background groundwater quality range expected in the Chalk (Ref. 20).

3 CONCEPTUAL SITE MODEL AND RISK ASSESSMENT

3.1.1 The risk assessment process aims to establish whether unacceptable risks exist and if so, what further actions need to be taken in relation to the site. It is an iterative, tiered approach which consists of three progressively detailed stages of risk assessment; PRA, GQRA and DQRA Depending on the nature of the site and contamination present, not all stages of risk assessment may be required. As detailed in the preceding sections a PRA (Ref. 11), GQRA (Ref. 13) and DQRA (Ref. 14) have been undertaken for the site and are provided at **Appendix 17.1**, **Appendix 17.2**, **Appendix 17.3** and **Appendix 17.4** of the ES **[TR020001/APP/5.02]**, respectively.

3.1.2 A brief summary of the key findings of the risk assessments and remediation requirements are detailed in the following sections. Further details can be found in the DQRAs (Ref. 14 and Ref. 15) and ORS (Ref. 1) (**Appendix 17.5**) of the ES **[TR020001/APP/5.02]**. The conceptual site model (CSM) is provided in **Appendix A** of this document.

3.2 Summary of DQRA findings

Waste characterisation

3.2.1 The waste is reasonably well degraded with no discernible biowastes. Only the slower degradable fractions of material remain, such as newspaper.

3.2.2 The waste contains a high proportion of cover material (27 vol.%) (both non-chalky and chalky) particularly in the more recent wastes (1970s onwards), a large proportion is also construction waste (36 vol. %).

3.2.3 Asbestos was detected most frequently and at the highest quantities in the industrial waste, no significant caches of asbestos containing materials (ACMs) were recorded.

3.2.4 Overall, there was no distinct spatial variation in the waste types or chemistry, the risk assessment was undertaken using a precautionary approach assuming that worst case conditions encountered are representative of the landfill as a whole.

3.2.5 The waste was noted to be relatively dry during the GI with limited volumes of leachate collected in the leachate wells.

3.2.6 Chemical analysis of the landfill leachate indicated the levels of contaminants are broadly consistent with leachate from aged waste, with the concentrations of many contaminants lower than those typical of an aged waste e.g., ammoniacal nitrogen, magnesium, manganese, zinc and lead.

Human health risk assessment

3.2.7 The human health risk assessment assessed the risks associated with the landfill materials, groundwater vapours and soil vapours. The risk assessment indicated the following:

a. Overall, the concentrations of contaminants in the landfill were not considered significantly elevated. The majority of contaminants with exceedances pose a risk through direct contact. The Proposed Development is largely hardstanding and therefore future users are unlikely to come into direct contact with the underlying material;

b. The vapour assessment indicated the soil vapours are unlikely to pose a risk to future occupants of the site; and

c. Volatile contaminants in groundwater have the potential to cause risk to human health via volatilisation and migration of vapours into overlying buildings or outdoor air space followed by inhalation.

Asbestos

3.2.8 No gross asbestos contamination was identified during the ground investigation, with only sporadic occurrences of visual asbestos identified in the soil.

3.2.9 Construction work has the highest potential to physically disturb any ACMs and Asbestos Containing Soils (ACS), therefore leading to an increased risk of fibre release. Using CARSOIL™ guidance (Ref. 21) and Joint Industry Work Group Decision Support Tool (JIWG DST) (Ref. 22) a hazard and exposure ranking for the earthworks involving the soil and landfill material has been assessed to determine the anticipated preliminary licensing status for the works. The JIWG assessment indicated the overall hazard and exposure ranking was medium. Therefore, the preliminary licensing status for groundworks, including ground excavation is anticipated as non-licensable works (NLW).

3.2.10 The GI provided sufficient information to characterise the condition of asbestos present within the landfill and inform this assessment, but it is recognised that the landfill is heterogenous in nature and as such localised areas of increased frequency of ACMs may exist. Therefore, a strategy for managing ACMs is included in the ORS, **Appendix 17.5** of the ES **[TR020001/APP/5.02]**. This includes measures to control risk during the piling works which will require a risk assessment to be completed in accordance with CAR 2012 (Ref. 23) to identify appropriate control measures and plan of works. The piling contractor should be supported in this by a specialist asbestos consultant.

3.2.11 Potential risks to future users and maintenance workers are considered low as the development will be mainly hardstanding. The potential risk can be further controlled by ensuring that soils for use as backfill to service trenches and in areas of soft landscaping/tree pits is free of asbestos.

Ground gas

3.2.12 The assessment of the gas monitoring data and GasSim modelling (Ref. 12) has identified that the landfill is past the stage of peak gas generation. Whilst there are high concentrations of bulk landfill gases (carbon dioxide and methane) within the waste, there are low or negligible standpipe emission flow rates, indicating low/very low rates of continuing biodegradation of residual organic matter.

3.2.13 A methane/carbon dioxide Characteristic Situation of CS4[1] is considered protective for the landfill area. While CS4 was only encountered on rare occasions within the landfill, it is considered this will allow for any changes to the gas regime within the landfill as a result of the proposed earthworks and construction to be mitigated. The development areas outside of the landfill can be considered as CS2 due to the low concentrations of ground gases recorded in this part of the site, which is considered low risk. Based on the gas regime across the development site, gas protection measures will be required within all new buildings proposed for the site. A combination of measures is required to achieve the gas protection score for buildings associated with the proposed development.

3.2.14 Gas protection measures would also be required for the Luton Direct Air to Rail Transit (Luton DART) extension[2] where it intersects the landfill, the aviation apron and the external paved and soft landscaped areas.

3.2.15 Perimeter gas control measures would also be installed prior to commencement of construction to prevent off-site lateral migration of gas to the existing airport and residential properties in the surrounding area.

3.2.16 Further detail of the proposed gas protection measures is presented in the ORS (Ref. 1).

Controlled waters

3.2.17 A detailed assessment of the risk that the landfill presents to controlled waters was undertaken. ConSim[3] modelling undertaken to inform the DQRA (Ref. 15) (**Appendix 17.4**) of the ES **[TR020001/APP/5.02]** indicated that there are contaminants within the landfill material which have the potential to break through the base of the unsaturated zone and migrate to identified receptor/compliance points. Concentrations of ammoniacal nitrogen, and benzene were predicted to reach the potable abstraction within 100 years.

3.2.18 While there is evidence of a weak leachate plume in groundwater down-gradient of the site, on-site groundwater monitoring provides little evidence that the landfill is causing significant contamination of the groundwater.

3.2.19 Leaching of contaminants from the landfill through the unsaturated zone is likely to be inhibited by localised layers of Clay-with-Flints, and other lower permeability layers such as weathered putty chalk and Head deposits. The presence of these features may contribute to contaminants being attenuated more in the unsaturated zone than predicted by ConSim.

3.2.20 The proposed airport development will result in the landfill being covered within buildings and hardstanding which will significantly reduce the volume of

[1] Gas monitoring results were assessed using the classification system presented within CIRIA C665 (Ref. 26). The classification system uses gas concentrations and recorded flow rates for methane and carbon dioxide to determine a gas screening value (GSV). The GSV is used to determine the Characteristic Situation (CS) for the site, which is a qualitative method of defining risk to a proposed development constructed on gassing ground. Characteristic Situation (CS) 3 is considered to moderate risk and a typical of a gas source being generated from old landfill, inert waste, or flooded mineworkings.

[2] The Luton DART is a new cable-hauled fast passenger transit connecting Luton Airport Parkway station to the airport (the announcement of an official opening date will be made in early 2023).

[3] ConSim is a computer software which allows the fate and transport of contaminants in soil, leachate and groundwater to be modelled to assess the impact on groundwater.

infiltration into the landfill waste material and generation of landfill leachate. ConSim modelling has predicted that in this scenario none of the potential contaminants of concern would break through the base of the unsaturated zone within a 1,000-year time period.

3.2.21 The main risk identified to controlled waters from the proposed development was considered to be from the driving of contaminants into the aquifer during piling.

Requirement for remediation

3.2.22 The DQRAs indicated that in its current state, the site generally represents a low risk to all receptors and remedial action is not required to protect current site users, neighbours or groundwater. However, the development will change the potential risk to future users and other receptors. Where a potential risk has been identified and mitigation measures inherent in the construction or operation of the Proposed Development might not be sufficient to break the pollutant linkage, there is assessed to be a relevant contaminant linkage (RCL) that would require specific measures to be implemented. The strategy to address these RCLs is detailed in the ORS (Ref. 1) (**Appendix 17.5**) of the ES **[TR020001/APP/5.02]**. The conceptual site model and a summary of the RCLs identified are provided in **Appendix A** of this document.

3.2.23 One of the key RCLs identified was the potential risk to the principal aquifer in the Chalk through driving of contaminants downwards during any future piling activities, this FWRA is an initial step to addressing that risk.

3.2.24 In addition to the RCLs, a number of potential contaminant linkages (PCLs) were identified within the DQRAs associated with the enabling/construction phase of the development. No specific remediation activities are required to address these PCLs however, these linkages need to be considered in the selection of an appropriate remediation technique and the works must address and manage these PCLs to protect site users and site neighbours. Recommended mitigation measures to address these PCLs are identified in the ORS (Ref. 1) (**Appendix 17.5**) of the ES **[TR020001/APP/5.02]** and are summarised in the conceptual site model in **Appendix A** of this document.

3.2.25 The earthworks and remediation undertaken on the landfill will be completed under a deposit for recovery DfR permit which would include the treatment and reuse of any pile arisings.

4 FOUNDATION DESIGN FOR THE PROPOSED DEVELOPMENT

4.1.1 All buildings for the proposed development made on the landfill 'platform' have been assumed to~~will~~ require piled foundations, Figure 5 shows the general arrangement of buildings to be piled. This includes the new terminal building, offices, hotel and multi-storey car park. It should be noted that there may be the possibility for shallow foundations to be used for small and lightly loaded structures, the details of which will be considered at detailed design phase.

4.1.2 Piles for the majority of buildings are expected to be constructed using continual flight auger (CFA). As CFA piles are limited to approximately 30m in length, in some areas where the landfill is significantly thick, such as the multi-storey car park, rotary bored (cast in situ) piles may be required to achieve suitable founding depths. The final design levels and loading requirements are not finalised at this stage of design and the use of different piling techniques should be confirmed following further design clarification.

4.1.3 The Environment Agency classifies both CFA and rotary bored (cast in situ) piling as replacement/non-displacement techniques (Ref. 3).

4.1.4 The CFA piles ~~-~~are formed by 'screwing in' ~~the excavation of soil using~~ a hollow stemmed continuous flight auger to the desired level and then injecting ~~form a void which on completion is filled with~~ concrete or cementitious grout ~~introduced~~ under pressure via the hollow stem into the base of the borehole. The auger is then withdrawn at a controlled rate whilst maintaining the concrete or grout at a positive pressure. Thus no void within the ground is formed using this method. Spoil is withdrawn from the hole on the auger flights and the concrete fills the hole under the auger head, the positive pressure forcing it into contact with the surrounding soil.

~~4.1.3~~4.1.5 Rotary bored (cast in situ) piling uses an auger or other tools to create the pile bore which is supported by temporary casing to ensure stability. Concrete is then tremied into the hole as the temporary casings are withdrawn to form the pile.

5 FOUNDATION WORKS RISK ASSESSMENT

Methodology

5.1.1 This FWRA has been completed in accordance with the following guidance:

a. Environment Agency National Groundwater & Contaminated Land Centre (2001). Piling and penetrative ground improvement methods on land affected by contamination: Guidance on pollution prevention (report NC/99/73) (Ref. 3).

5.1.2 The Environment Agency identify six possible pollution scenarios where piling or penetrative ground improvement operations have a potential to cause pollution. These scenarios are summarised in **Table 5.1** below and are addressed in the following risk assessment.

Table 5.1 Summary of pollution scenario descriptions

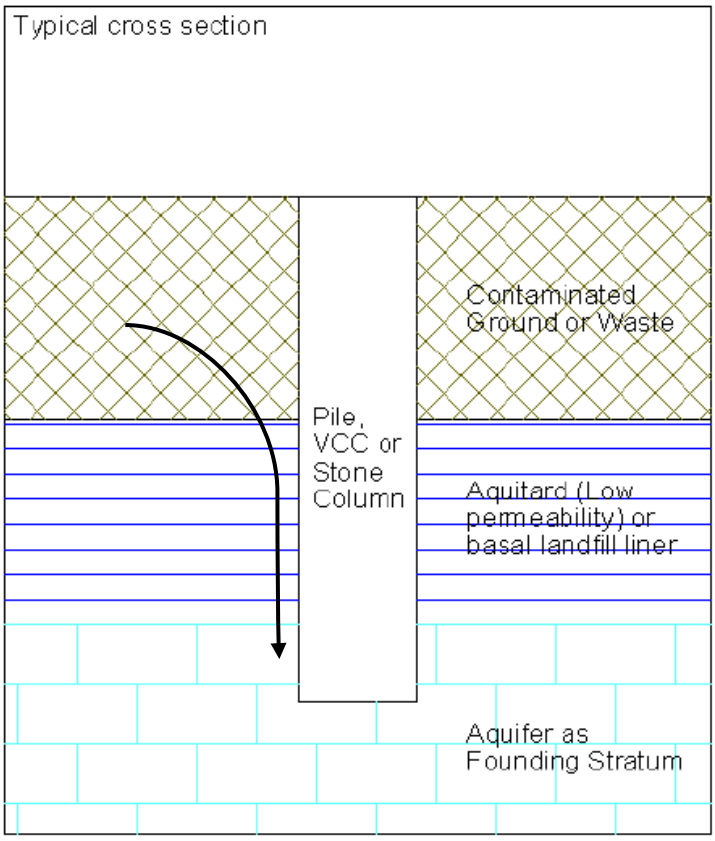
Pollution scenario	Description
1	Creation of preferential pathways through a low permeability layer, to allow potential contamination of an underlying aquifer.
2	Creation of preferential pathways through a low permeability surface layer, to allow upward migration of landfill gas, soil gas or contaminant vapours to the surface.
3	Direct contact of site workers and others with contaminated soil arisings that have been brought to surface.
4	Direct contact of the piles with contaminated soil or leachate causing degradation of pile material.
5	Driving solid contaminants into aquifer during piling.
6	Contamination of groundwater and, subsequently, surface waters by wet concrete, cement paste or grout.

5.2 Pollution scenario 1

Creation of preferential pathways through a low permeability layer, to allow potential contamination of an underlying aquifer.

5.2.1 **Drawing 1** below depicts an example of pollution scenario 1.

Drawing 1 Schematic of pollution scenario 1 taken from Environment Agency guidance (Ref. 3).



Note: VCC= Vibro Concrete Columns

5.2.2 The former landfill has no engineered containment as it predates modern waste regulations, therefore the proposed piling will not breach a basal liner. As discussed in **Section 2.5** above and shown in **Figure 3** of this document, the landfill is underlain by discontinuous units of:

a. Dry Valley Deposits (silty clay and gravel);

b. Head Deposits (clay); and

c. Clay-with-Flints (clay containing flint gravel) (these deposits only present beneath the southwest and edges of the landfill).

5.2.3 Where the superficial deposits are absent, the landfill sits directly onto the Chalk Bedrock. The upper, weathered layer of the Chalk (Grade Dm) (Ref. 24) beneath the landfill, has a permeability similar to predominately a silty clay. These lower permeability layers currently limit the downward migration of contaminants to the underlying Chalk aquifer and penetrating this layer has the potential to create a pathway to the underlying aquifer.

5.2.4 Replacement/non-displacement piling methods minimise the creation of preferential pathways along the sides of the pile, compared to displacement techniques as movement of the material surrounding the pile is reduced and there is little radial or vertical movement or densification. Any contaminated

materials that are brought to the surface during concreting will be subject to site controls and managed appropriately.

5.2.5 CFA techniques provide a tight seal to the surrounding soil and reduce permeability at the soil-pile interface due to the placement method of the concrete under ~~high~~ pressure. The ~~short time between~~ boring and placement of concrete is a continuous process and so means that there are no voids created~~a temporary pathway may be created however it is quickly closed~~. Concrete~~ To ensure support of the soil during CFA piling, the~~ is~~concrete should be~~ placed at a rate consistent with the withdrawal of the auger. CFA rigs are fully instrumented, meaning that any voids, obstructions and resistance caused by the bore interacting with certain waste types (e.g. fabrics) can be identified. 'Flighting' of the auger (i.e. rotation without progress),~~ which may give rise to loss of ground creating potential voids will be addressed within the piling specification with requirements to limit this. It should be noted that fabrics were not identified as present during the characterisation of the landfill.

~~5.2.5~~5.2.6 Rotary bored piling techniques can use temporary casings to provide stability to the landfill material, as well as acting as a seal pending placement of concrete. This further reduces the risk of creating a preferential pathway to the underlying aquifer. If leachate is identified during drilling of rotary bored holes, this can be removed and disposed of prior to advancing the bore further, reducing the risk of downhole contaminant transport. The bores can be advanced incrementally, to allow a visual check of arisings.

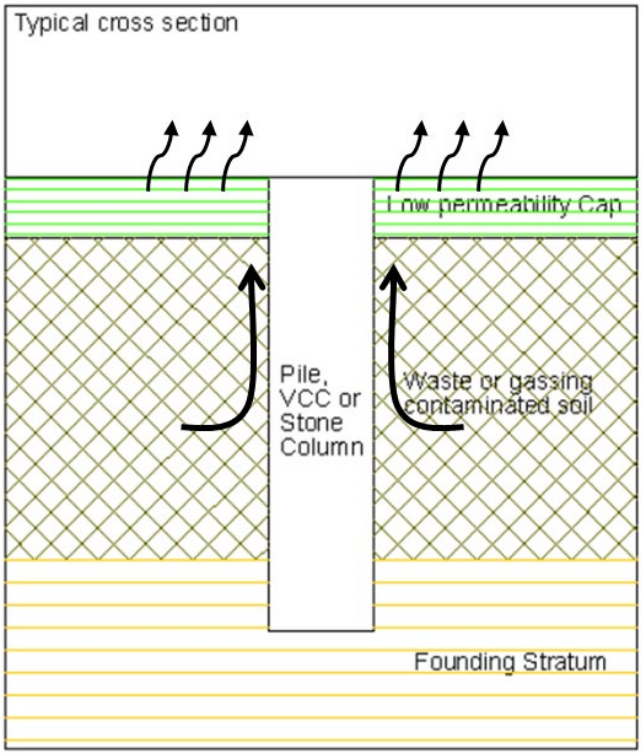
5.2.7 There are discontinuous low permeability deposits present beneath the landfill and penetrating these layers has the potential to create a pathway to the underlying aquifer. However, the proposed piling methods of rotary bored and CFA piles will minimise the creation of pathways to the underlying aquifer by maintaining a low permeability interface between the soil and pile shaft. Therefore, the risk of pollution of groundwater with regards to the creation of preferential pathways through low permeability layers is low.

~~5.2.6~~5.2.8 Trial pile construction is proposed to be carried out to verify the piling construction methodology. Measures such as pre-boring where obstructions are encountered would be part of the detailed specification requirements. National piling standards such as the 'Specification requirements for piling and embedded retaining walls' (ICE, 2016) include for such measures which will be developed further at the detailed design stage.

5.3 Pollution scenario 2

Creation of preferential pathways through a low permeability surface layer, to allow upward migration of landfill gas, soil gas or contaminant vapours to the surface.

5.3.1 Drawing 2 Schematic of pollution scenario 2 taken from Environment Agency guidance (Ref. 3).



5.3.2 As detailed in paragraph **5.2.2** above, the former landfill has no engineered containment as it predates modern waste regulations, therefore the proposed piling is not breaching any engineered capping layer. If a pile is being driven into a gas source that is not confined and gas is freely venting to the atmosphere (as are the current baseline conditions) then its final construction should not form a preferential pathway to the end development (Ref. 25).

5.3.3 However, during construction work within the landfill there is a risk of site workers being exposed to landfill gases which can migrate to the surface as the pile is being constructed and an open bore is created~~.~~ for a limited period of time. As on all contaminated sites, extra precautions should be taken to comply with the requirements of the CDM regulations and other relevant HSE guidance. The lead contractor and / or specialist piling contractor's risk assessment and method statement will need to address all issues in relation to potential exposure to ground gases during construction. A COCP (**Appendix 4.2**) of the ES **[TR020001/APP/5.02]** has been prepared which identifies the likely control measures.

5.3.4 The gas risk assessment undertaken in the DQRA (Ref. 14) (**Appendix 17.3**) of the ES **[TR020001/APP/5.02]** suggested that a precautionary assumption for the gassing regime classification at the site is CS4 (assessed in accordance with CIRIA report C665 (Ref. 26)). This characteristic situation requires gas protection measures to be incorporated into the new buildings.

5.3.5 The use of bored piles will minimise the creation of preferential migration pathways for gas along the sides of the pile with temporary casings providing stability to the landfill material and acting as a seal pending placement of concrete. Upon placement of concrete and as the casing is withdrawn a minimal

bleed into the soil pores is expected to reduce the permeability and limiting gas migration (Ref. 25).

5.3.6 CFA piling techniques is less likely to provide a~~may temporarily provide a~~ pathway to gas in the short term as no ~~between soil excavation and concrete placement as an~~ open bore is created. ~~However, these voids created are quickly closed and the permeability of the ground around the pile is reduced as concrete forms into the soil pores around the shaft.~~ Therefore, the potential risk is considered minimal.

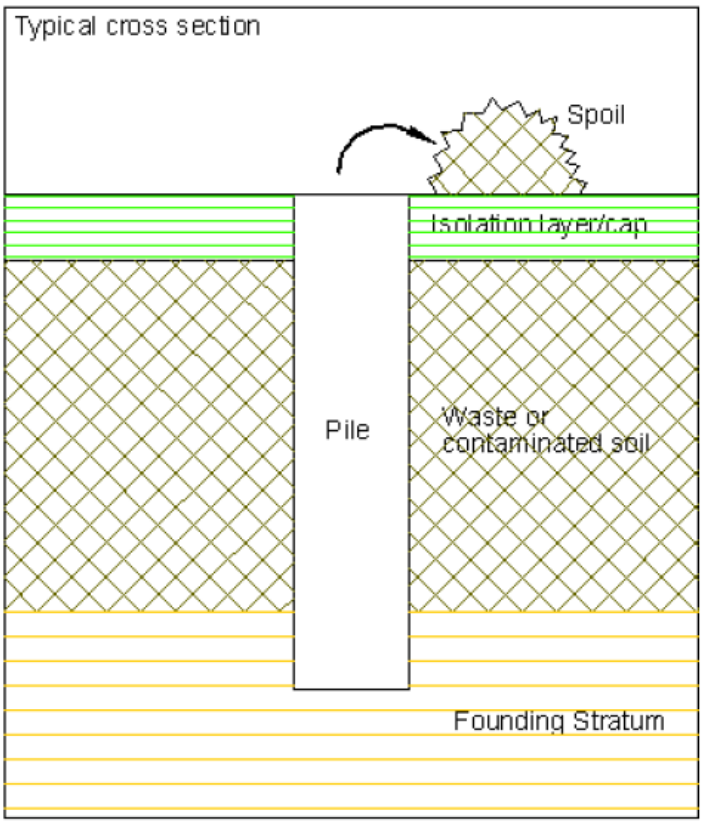
5.3.7 The risk of upwards migration of landfill gases with regards to the creation of preferential pathways is considered low for both the rotary bored and CFA techniques. ~~The provision of gas protection measures within the building to CS4 will fully mitigate pollution scenario 2.~~

5.4 Pollution scenario 3

Direct contact of site workers and others with contaminated soil arisings that have been brought to surface.

5.4.1 **Drawing 3** below depicts an example of pollution scenario 3.

Drawing 3 Schematic of pollution scenario 3 taken from Environment Agency guidance (Ref. 3).



5.4.2 Both rotary bored piling and CFA piling techniques will generate soil arisings at the surface, which will include material from the landfill.

5.4.3 A ORS (Ref. 1) (**Appendix 17.5**) of the ES **[TR200001/APP/5.02]** and COCP (Ref. 2) (**Appendix 4.2**) of the ES **[TR200001/APP/5.02]** have been developed for the site, which take into account the protection of site workers and adjacent site users whilst working with landfill arisings, including dealing with ACMs present within the landfill during works. The controls required would depend on the lead contractor/piling contractors risk assessments, but would likely include:

a. Use of PPE/RPE as identified by task specific risk assessments;

b. Use of dampening down measures during the piling works so materials are dampened as they arrive at the surface;

c. Airborne fibre monitoring at piling locations with control measures adapted should trigger levels be exceeded;

d. Watching brief by specialist consultant to identify if visible ACMs are brought to the surface, with hand picking as required; and

e. Relocation of landfill arisings (if ACMs identified) to waste treatment compound, where they will be processed~~treated~~.

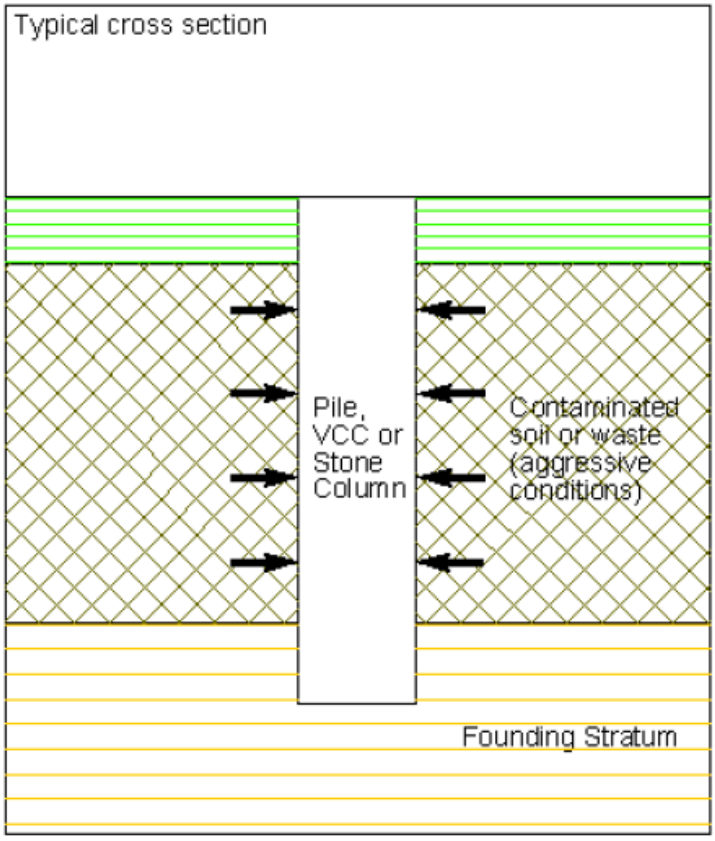
5.4.4 Providing the appropriate measures are in place the risk of site workers coming into direct contact with contaminated soil arisings/landfill material is low.

5.5 Pollution scenario 4

Direct contact of the piles with contaminated soil or leachate causing degradation of pile material.

5.5.1 **Drawing 4** below depicts an example of pollution scenario 4.

Drawing 4 Schematic of pollution scenario 4 taken from Environment Agency guidance (Ref. 3).



5.5.2 Concrete in contact with contaminated soils, leachate or groundwater may be subject to chemical attack and degradation. The degradation of concrete could reduce the effectiveness of the seal between the pile and surrounding ground ~~to~~ resulting in pathways to open along the soil/pile interface, increasing the risk of pollution scenarios 1 and 2. In particularly aggressive scenarios, degradation of concrete can cause structural weakness leading to long term settlement or eventual collapse of structures.

5.5.3 A preliminary assessment of the concrete class has been undertaken in accordance with BRE SD1 (Ref. 27) within the Geotechnical Investigation Report (GIR) (Ref. 28). This indicated that concrete to be constructed within the landfill would have a Design Sulphate (DS) Class of DS-2 and an Aggressive Chemical Environment for Concrete Class (ACEC) of AC-2. However, due to the landfill material being reworked the assessment indicated that the concrete class would increase to DS-4 and AC-4, due to the total potential sulphate (TPS). During detailed design, further consideration should be given to designing concrete to be used within the landfill with respect to DS class and ACEC in order to select a suitable concrete class for design, taking into account the design element associated with the concrete and its location within the landfill.

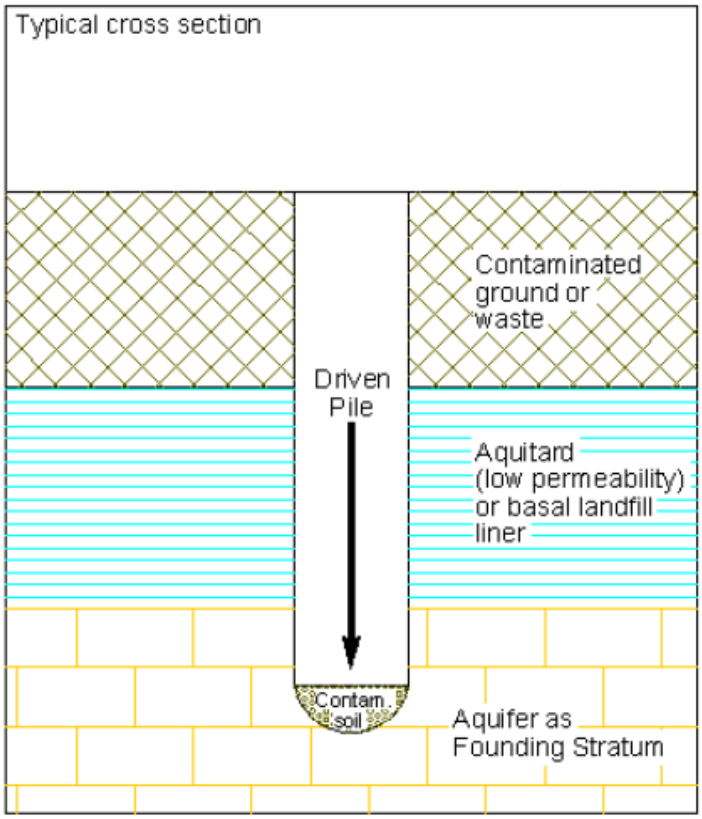
5.5.4 This will~~should~~ ensure that the risk of pile degradation will be negligible.

5.6 Pollution scenario 5

Driving solid contaminants into aquifer during piling.

5.6.1 **Drawing 5** below depicts an example of pollution scenario 5.

Drawing 5 Schematic of pollution scenario 5 taken from Environment Agency guidance (Ref. 3).



5.6.2 CFA and bored piles are replacement/non-displacement grout or concrete intruded piles (Ref. 3) and direct push of contaminants is not anticipated using these methods. The ground is supported throughout the CFA piling process,

initially by the auger bore and subsequently by the injected concrete through the hollow stem. As it is extracted, and concrete is injected there is no need for casings or drilling fluids to support the excavation. There is no or little disturbance and the piles are formed in intimate contact with surrounding soil. Conventional bored piles are similar in terms of being replacement/non-displacement, but temporary casings are used to support the Made Ground during construction and these are incrementally removed as concrete is placed.

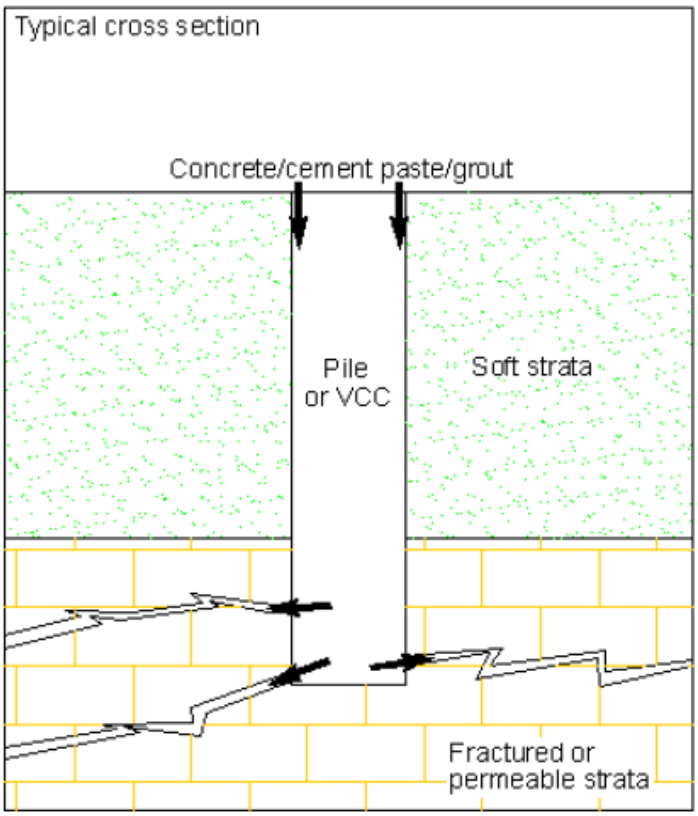
5.6.3 As the proposed pile types are not driven there is very little possibility of solid contaminants being pushed into the underlying aquifer. The use of CFA and bored piles will bring arisings to surface rather than driving them downwards, therefore piling risks associated with this scenario are considered to be very low.

5.7 Pollution scenario 6

Contamination of groundwater and, subsequently, surface waters by wet concrete, cement paste or grout.

5.7.1 **Drawing 6** below depicts an example of pollution scenario 6.

Drawing 6 Schematic of pollution scenario 6 taken from Environment Agency guidance (Ref. 3).



5.7.2 Piling below the water table may occur, with groundwater levels within the Chalk varying seasonally. Pile toe levels will be developed during detailed design,

taking into consideration more recent monitoring data. These will be presented in the detailed FWRA documents.

5.7.3 CFA and bored (cast in situ) piles will introduce concrete into the ground as part of the construction of the pile. The granular nature of the concrete , its low bleed potential and setting times which are generally no more than about 2 hours means that there is little risk of significant loss into the surrounding ground into fractured or more permeable strata.~~Mitigations including designing the concrete mix to limit bleeding into pore spaces/voids in the landfill or solution features shall be adopted.~~ Localised grout migration may occur until the concrete is set; however, this would be anticipated to be in the order of minutes or hours rather than days and any impact is likely to be very localised. The specification and composition of the grout to be used below the water table would be carefully considered and assessed at detailed design stage when pile lengths and capacities were further understood. Waste concrete at the surface of the pile will be collected and disposed of appropriately.

5.7.4 GI indicates that the top of the chalk material is weathered and described as structureless. Therefore, the hydraulic conductivity is significantly reduced, which will preclude the potential for migration of concrete before it has set.

~~5.7.2~~5.7.5 As the concrete design will not permit significant seepage of wet concrete the risks associated with this scenario are considered to be very low. Additives in the piling concrete are not anticipated to contain hazardous substances. Concrete mix would be agreed with the EA prior to construction.

5.8 Summary

Rotary bored and CFA piling

5.8.1 The assessment indicates there is an overall low to very low risk of pollution from both rotary bored and CFA piling techniques as shown in **Table 5.2**

Table 5.2 Summary of pollution risk – piling

Pollution scenario	Rotary bored piles			CFA piles		
	Probability	Consequence	Risk	Probability	Consequence	Risk
1	Low	Medium	**Low**	Low	Medium	**Low**
2	Low	Low	**Low**	Low	Low	**Low**
3	Very low	Low	**Very low**	Very low	Low	**Very low**
4	Very low	Medium	**Very low**	Very low	Medium	**Very low**
5	Very low	Medium	**Very low**	Very low	Medium	**Very low**
6	Medium	Low	**Low**	Medium	Low	**Low**

6 MITIGATION MEASURES

This section summarises the quality assurance and control measures recommended in **Section 5** to reduce the risks of the various pollution scenarios.

6.1 Legislation

6.1.1 All works will be undertaken in accordance with the relevant legislation at the time of construction. The primary environmental legislation which currently apply to the works are The Landfill Directive (Ref. 29), The Environmental Permitting Regulations (Ref. 30) and The Groundwater Directive (Ref. 31). The appointed specialist contractor will ensure that the required permits are obtained to comply with these legislations.

~~6.1.1~~6.1.2 Further detail is outlined within the **Code of Construction Practice (CoCP) (Appendix 4.2 of the ES)[TR020001/APP/5.02].**

6.2 General

6.2.1 The site wide mitigation measures are as follows:

a. Assurance of a high standard of work by selecting a competent contractor to carry out the piling, ideally with prior experience in similar conditions;

b. Compliance with the requirements of the CDM regulations, Control of Asbestos Regulations and other relevant HSE guidance, to protect site workers from exposure to landfill gases, contaminated material or asbestos;

c. Appropriate personal protection and dust control measures during site works, to minimise exposure to site workers;

d. Lead contractor/piling contractor's risk assessment and method statement to address all issues in relation to potential exposure to ground gases, contaminants and asbestos during construction

~~d.~~e. Cleaning down equipment if any obvious smearing or contaminated materials was observed to be adhering to the piling machinery, with any contaminated water resulting from this contained and disposed of appropriately as per the piling method statement;

~~e.~~f. Collection and appropriate disposal of waste concrete at the surface;

~~f.~~g. Monitoring of groundwater quality before, during and after the completion of piling, to include turbidity analysis. Agreement to be reached in the Environment Agency for collection and submission of this data;

~~g.~~h. Establishment of trigger levels based on monitoring data;

~~h.~~i. Implementation of additional mitigation if trigger levels are exceeded, such as cessation of piling, reduction in piling rate, localised additional remediation or change in piling method.

~~i.~~j. Treatment and reuse of pile arisings completed in accordance with the DfR permit.

6.3 Continuous flight auger piles

6.3.1 In addition to the above, the mitigation measures specifically relating to CFA piles are as follows:

a. Design of piles to try to minimise penetration into the chalk e.g. by considering larger pile groups with shorter piles;

~~a.~~b. Placement of concrete at a rate consistent with the withdrawal of the auger to ensure support of the soil during CFA piling;

~~b.~~c. A risk assessment in accordance with BRE Special Digest 1:2005 conducted at detailed design state in order to verify the concrete class (Ref. 27). This will ensure that the risks of pile degradation will be negligible; and

~~c.~~d. Design of the concrete mix for the piles to limit bleeding into pore spaces.

6.4 Rotary bored piles

6.4.1 The mitigation measures specifically relating to rotary bored piles are as follows:

a. Design of piles to try to minimise penetration into the chalk e.g. by considering larger pile groups with shorter piles;

~~a.~~b. Temporary casings to provide stability to the landfill material;

~~b.~~c. A risk assessment in accordance with BRE Special Digest 1:2005, conducted at detailed design state in order to verify the concrete class. This will ensure that the risks of pile degradation will be negligible; and

~~c.~~d. Design of the concrete mix for the piles to limit bleeding into pore spaces.

7 FURTHER WORK

7.1.1 Post DCO, at detailed design stage, a detailed Foundation Works Risk Assessment will be produced relating to the area associated with the phase of development works over the landfill.

7.1.2 A hydrogeological risk assessment (HRA) would be produced and agreed with the Environment Agency prior to works commencing. This will provide additional evidence there will be no adverse impacts from the proposed piling works and would identify 'investigation' and 'action levels' which would trigger additional control measures/mitigation to be undertaken if levels are exceeded.

~~7.1.1~~7.1.3 Prior to works commencing, a DfR permit will be obtained by a specialist remediation contractor. It is noted that there will be further permits which will be required in order to undertake works within the landfill, for example a groundwater ~~authorisation~~activity permit for penetrating the base of the landfill either through GI or piling activities and a waste treatment permit for treating waste.

~~7.1.2~~7.1.4 Engagement and consultation with Affinity Water to be continued, as any impacts to groundwater quality of the Chalk aquifer could impact the potable water abstraction at King's Walden.

~~7.1.3~~7.1.5 A piling specification would be produced in accordance with the Environment Agency guidance, in addition monitoring of the following parameters during construction would be undertaken to protect the Chalk aquifer

a. Monitoring concrete bleed; and
b. Localised monitoring of groundwater and ground gas (within 250m of the construction site) to confirm any short term fluctuations or impacts on the baseline regime.

~~7.1.4~~7.1.6 ~~Allied to the above, prior to works commencin~~Theg a DfR permit will ~~be obtained by the specialist remediation contractor. This will also~~ require the production of a Construction Quality Assurance (CQA) plan which would be drafted and submitted to the Environment Agency for agreement prior to commencement. The CQA plan would cover the construction aspects associated with the landfill and include the proposed detailed pile design and control measures and method statement.

~~7.1.5~~7.1.7 Following the completion of construction works a CQA Verification Report would be submitted to the Environment Agency. The report would provide details of the works completed to confirm that all agreed methods and standards had been complied with.

8 CONCLUSION

8.1.1 This FWRA has followed the approach recommended in Environment Agency guidance (Ref. 3).

8.1.2 The proposed piled foundations were initially considered to have the potential for groundwater pollution. However, by appropriate selection of piling techniques and associated control measure this ~~this~~ risk assessment indicates there is a low risk of pollution to controlled waters from both rotary bored cased piling and CFA piling (refer to **Table 5.1** above for a summary of the risks of each pollution scenario).

~~8.1.2~~8.1.3 ~~-~~If the mitigation measures outlined above in **Section 6** are implemented, both types of piling are ~~should be~~ considered to be suitable for use at the site. The decision on which of these two piling methods is used can be made at a later date following further design, taking into consideration, the detailed quantitative HRA and geotechnical and financial considerations.

GLOSSARY/ABBREVIATIONS

Term	Definition
Abbreviations	
ACM	asbestos containing material
ACS	asbestos containing soils
AOD	above ordnance datum
BGS	British Geological Survey
CFA	continual flight auger
CoCP	Code of Construction Practice
CIRIA	Construction Industry Research and Information Association
CQA	construction quality assurance
CS	characteristic situation
CSM	conceptual site model
CWS	County Wildlife Site
Luton DART	Luton Direct Air-Rail Transport
DCO	Development Consent Order
DfR	deposit for recovery permit
DQRA	Detailed Quantitative Risk Assessment
DST	decision support tool
ES	Environmental Statement
GSV	gas screening value
GQRA	Generic Quantitative Risk Assessment
GI	ground investigation
HRA	Hydrogeological Risk Assessment
LLAOL	London Luton Airport Operator Limited
NLW	non-licensable work
ORS	outline remediation strategy
PCL	potential contaminant linkage
PPE	personal protective equipment
PRA	Preliminary Risk Assessment
RCL	relevant contaminant linkage
TPH	total petroleum hydrocarbons
TPS	total potential sulphate
TVD	Thames Valley Drain
UXO	unexploded ordnance
WVP	Wigmore Valley Park
Glossary	
Above ordnance datum (AOD)	Above ordnance datum (AOD) is a vertical measurement used by ordnance survey as the basis for deriving altitudes on maps, usually by comparison with the mean sea level.
Adverse (environmental) effect	A detrimental or negative effect to an environmental resource or receptor.

Glossary	
Aquifer	An aquifer is an underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials (gravel, sand, or silt).
Application Site	~~The area covered by the proposed planning application boundary~~Development consent order boundary.
Baseline	A description of the current state of the environment without implementation of the project.
Code of Construction Practice (CoCP)	This document outlines the environmental management and mitigation requirements to be implemented throughout the construction period for the delivery of the Proposed Development.
Conceptual Site Model (CSM)	A representation of the characterisation of a site in diagrammatic and/or written form that shows the possible relationships between the contaminants, pathway and receptors. This helps to evaluate the potential risks that the site poses given the intended operations and future use of the site.
Continuous flight auger piles	Piles formed by drilling to the required depth using a hollow stem continuous flight auger to form a void which on completion is filled with concrete or cementitious grout introduced under pressure via the hollow stem into the base of the borehole.
Controlled waters	These are fully defined in section 104 of the Water Resources Act 1991. Controlled waters include, in summary: a. Relevant territorial waters which extend seaward for three miles from the low-tide limit from which the territorial sea adjacent to England and Wales is measured b. Coastal waters from the low-tide limit to the high-tide limit or fresh-water limit of a river or watercourse c. Inland freshwaters: natural and artificial lakes, ponds, reservoirs, rivers or watercourses above the fresh-water limit d. Natural and artificial underground rivers and watercourses e. Surface water sewers, ditches and soakaways that discharge to surface or groundwater it also includes those that may be currently dry f. Groundwaters – any waters contained in underground strata.
Detailed assessment	Method applied to gain an in-depth appreciation of the beneficial and adverse consequences of the project and to inform project decisions. Detailed Assessments are likely to require detailed field surveys and/or quantified modelling techniques.

Glossary	
Development Consent Order (DCO)	A Development Consent Order (DCO) is the means of obtaining permission for developments categorised as Nationally Significant Infrastructure Projects. This includes energy, transport, water and waste projects.
Effect	Term used to express the result/consequence of an impact (expressed as the 'significance of effect').
Emission	A material that is expelled or released to the environment. Usually applied to gaseous or odorous discharges to the atmosphere.
Environment Agency	The Environment Agency is responsible for environmental protection and regulation in England and plays a central role in implementing the government's environmental strategy. The Environment Agency is the main body responsible for managing the regulation of major industry and waste, treatment of contaminated land, water quality and resources, fisheries, inland river, estuary and harbour navigations, and conservation and ecology. They are also responsible for managing the risk of flooding from main rivers, reservoirs, estuaries and the sea.
Environmental Statement (ES)	A statutory report (this document) produced by the developer including: a. A description of the project b. A description of the likely significant effects of the project on the environment c. A description of the features of the project and/or measures envisaged in order to avoid, prevent or reduce and, if possible, offset likely significant adverse effects on the environment d. A description of the reasonable alternatives e. A non-technical summary f. Any additional information relevant to the characteristics of a project
Gas Screening Values (GSV)	The product of the groundwater flow rate and gas concentration within a borehole.
Groundwater	Groundwater is the water present beneath Earth's surface in rock and soil pore spaces and in the fractures of rock formations.
Groundwater divide	The boundary between groundwater basins; defined by a line connecting the high points on the water table or other potentiometric surface. Groundwater flows away from a groundwater divide.
Hardstanding	Ground improvement by the use of compacted stone or other materials which facilitates increased surface loading from vehicles or other plant.
Impact	The change or action. Either beneficial or adverse.

Glossary	
Inert materials	Inert material is material which is neither chemically or biologically reactive and will not decompose. Examples of this are sand, drywall, and concrete. This has particular relevance to landfills as inert materials typically require lower disposal fees than biodegradable waste or hazardous waste.
Leachate	A liquid that forms within waste accumulations such as landfills that contain increased concentrations of contaminants, specifically heavy metals, ammoniacal nitrogen and organic compounds. It is therefore hazardous and either must be indefinitely contained within the landfill or collected and suitably disposed of.
Made Ground	Made Ground is an area where the pre-existing (natural or artificial) land surface is raised or filled by artificial deposits consisting of materials such as refuse, demolition rubble etc.
Main Application Site	The airport site excluding off-site works
Mitigation measure	Measure aiming at preventing/reducing an adverse environmental effect.
Piled foundation	A series of columns constructed or inserted into the ground to transmit structural loads to a lower level of the subsoil
Potable water	Water that is safe to drink/consume.
Potential contaminant linkage	The potential contaminant linkage determines how contaminant travels from the contaminant source to a receptor.
Proposed Development	The proposed expansion of Luton Airport with new terminal and stands and associated developments (as described in **Chapter** 4 of the ES **[TR020001/APP/5.01]**).
Receptor (sensitive)	A component of the natural, created, or built environment such as human
Relevant contaminant linkage	Where a PCL has been identified and mitigation measures inherent in the construction or operation of the Proposed Development might not be sufficient to break the pollutant linkage, these are assessed to be a RCL and would require specific remediation measures to be implemented.
Residual effects	Those effects of the Proposed Development that cannot be mitigated following implementation of mitigation proposals.
Rotary-bored pile (cast in situ)	Piling uses an auger or other tools to create the pile bore which is supported by temporary casing to ensure stability. Concrete is then tremied into the hole as the temporary casings are withdrawn to form the pile.
Surface water	Water that collects on the surface of the ground.

Glossary	
Topography	The natural and man-made features of an area collectively.
Tremie	A watertight pipe, usually of about 250 mm inside diameter (150 to 300 mm), with a conical hopper at its upper end above the water level. Used to pour concrete over an underwater site to avoid washout of cement and produce a more reliable strength concrete.
Unexploded ordnance (UXO)	Unexploded ordnance (UXO), unexploded bombs, or explosive remnants of war are explosive weapons that did not explode when they were employed and still pose a risk of detonation, sometimes many decades after they were used or discarded.
Waste	Waste is defined in Article 3(1) of the European Waste Framework Directive 2008/98/EC (OJL 312/3) as any substance or object which the holder discards or intends or is required to discard. The term 'holder' is defined under article 3(6) as 'the waste producer or the natural or legal person who is in possession of the waste'. The waste 'producer' is defined under article 3(5) as 'anyone whose activities produce waste (original waste producer) or anyone who carries out pre-processing, mixing or other operations resulting in a change in the nature or composition of the waste'. Waste can be further classified as hazardous, non-hazardous or inert.
Water quality	Water quality refers to the chemical, physical, and biological characteristics of water based on the standards of its usage.
Worst-case (scenario)	The definition of a 'worst-case' varies by the field to which it is being applied, however ultimately it is the most unfavourable foreseen scenario. Often assessments use a worst-case scenario.

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FIGURES

All structure positions are indicative. The proposed works will be subject to detailed design development. The changes will be within limits of deviation specified in the Development Consent Order.

Legend

- Order Limits
- Off-site Planting
- Airport Access Road
- Site Subdivisions

Main Application Site

- Existing Airport Land
- LLAOL Contractor's Compound
- Area A Former Landfill
- Area B Land West of Winch Hill Lane
- Area C Land East of Winch Hill Lane

Other Areas

- Area D Offsite Car Park North
- Area E Offsite Car Park South
- Off-site Highway Interventions

First Issue	AB	RB TB	26/09/22	P02
Revision History	Drawn	Checked Approved	Date	Rev.

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Drawing Title

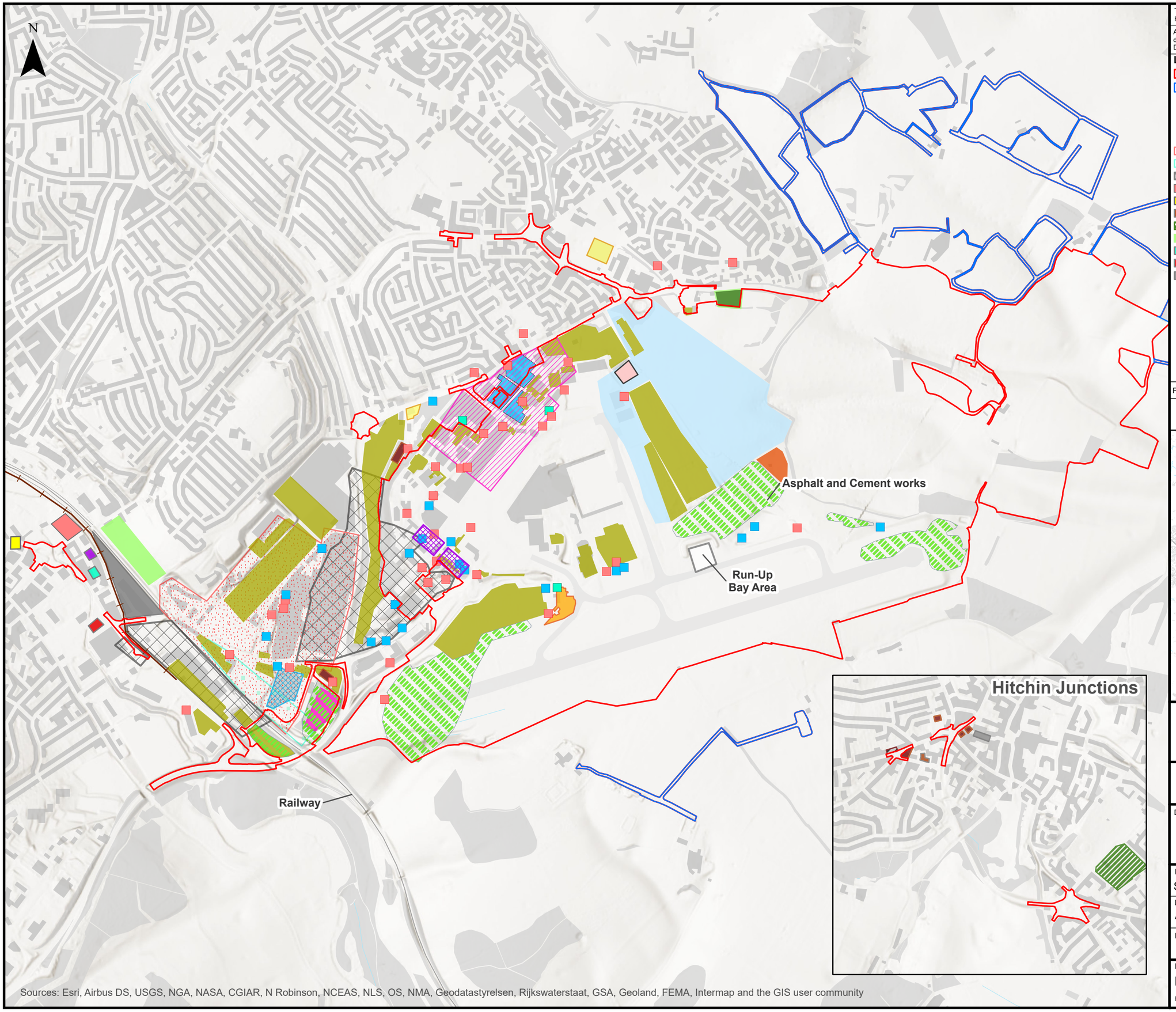
Figure 1
Location of Landfill

Purpose of issue				Suitability	
SUITABLE FOR INFORMATION				S2	
Drawn	Checked	Approved	Date	Scale	Size
AB	RB	TB	26/09/22	1:22,500	A3

DCO Application Ref.	APFP Regulation	DCO Document Ref.
TR020001	APFP 5(2)(a)	TR020001/APP/5.03

Drawing Number	Revision
LLADCO-3C-ARP-00-00-DR-YE-0276	P02

Project - Phase - Originator - Asset/Zone - Sub Asset - Type- Discp. - Number

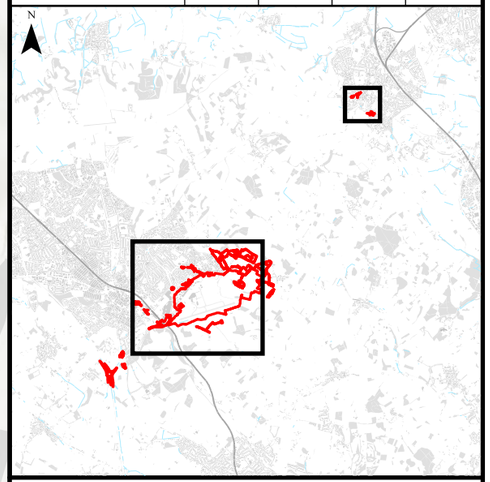


All structure positions are indicative. The proposed works will be subject to detailed design development. The changes will be within limits of deviation specified in the Development Consent Order.

Legend

- Order Limits
- Off-site Planting
- Former Railway
- De-icing Tanks
- Electrical Substation
- Fuel Tanks
- Historical Motor Works
- Historical Rifle Range
- Historical Sewage Farm/Tanks
- Historical Boiler Works
- Electricity Generating Station
- Burial Ground
- Potential Infilled Ground
- Cemetery
- Historical Dyeing and Bleaching Works
- Historical Abbatoir
- Historical Iron Foundry
- Historical Laundry
- Historical Timber Yard
- Allotments
- Car Park
- Fire Station
- Fire Training Ground
- Former Landfill
- Fuel Depots
- Garage
- Made Ground / Earthwork Fill
- Miscellaneous Works
- Percival Works
- Petrol Station
- Print Works
- Run-Up Bay Area
- Tidy Tip
- Trailer Park

First Issue	AB	RB TB	26/09/22	P02
Revision History	Drawn	Checked Approved	Date	Rev.



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Drawing Title

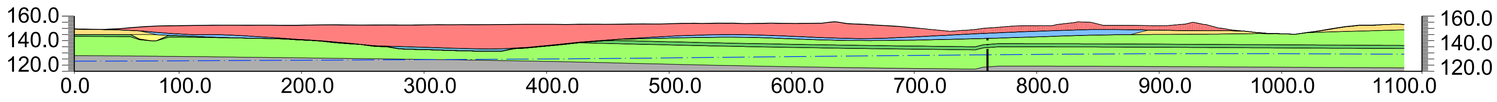
Figure 2 Potential Sources of Contamination

Purpose of issue				Suitability	
SUITABLE FOR INFORMATION				S2	
Drawn	Checked	Approved	Date	Scale	Size
AB	HP	TB	26/09/22	1:15,000	A3

DCO Application Ref.	APFP Regulation	DCO Document Ref.
TR020001	APFP 5(2)(a)	TR020001/APP/5.03

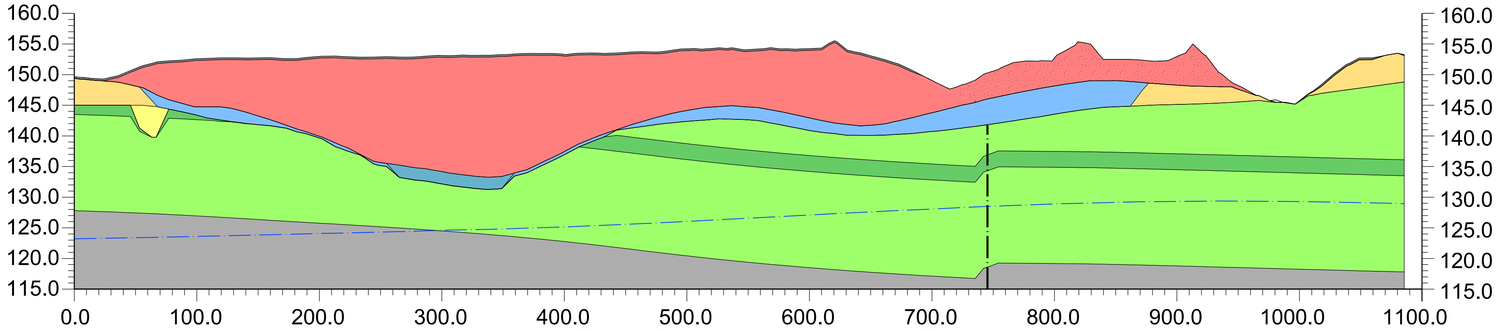
Drawing Number	Revision
LLADCO-3C-ARP-00-00-DR-YE-0277	P02

Project - Phase - Originator - Asset/Zone - Sub Asset - Type- Discp. - Number



Existing Conditions - Natural Scale

Scale H=1:2500 V=1:2500



Existing Conditions - Exaggerated Scale

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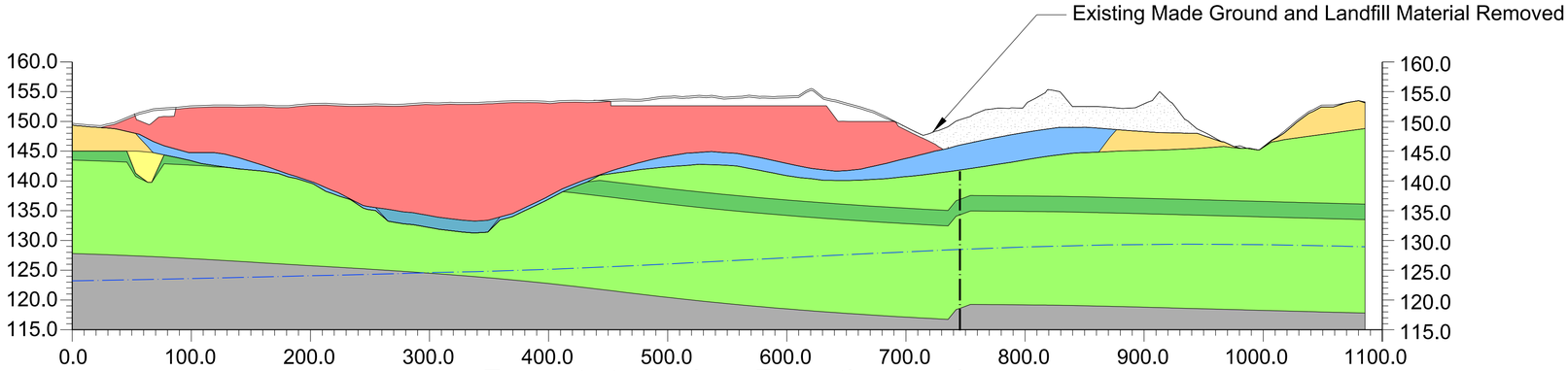
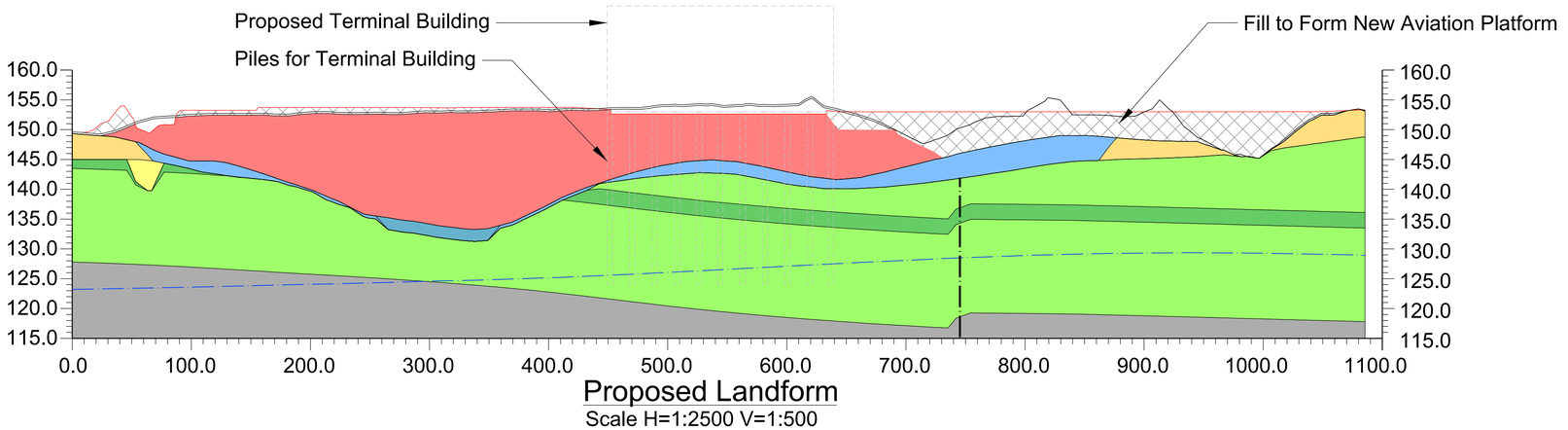


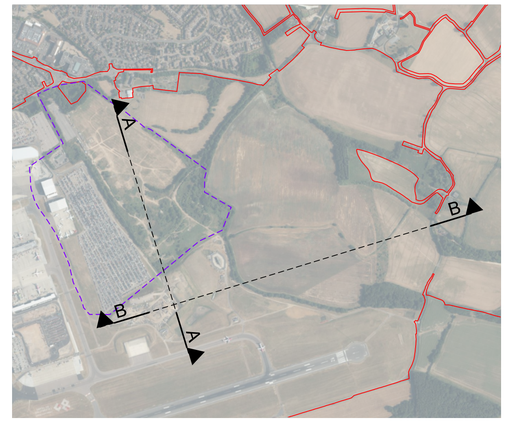
Excavate to Achieve Formation Level

Scale H=1:2500 V=1:500



Proposed Landform

Scale H=1:2500 V=1:500



Key Plan

All structure positions are indicative. The proposed works will be subject to detailed design development. The changes will be within limits of deviation specified in the Development Consent Order.

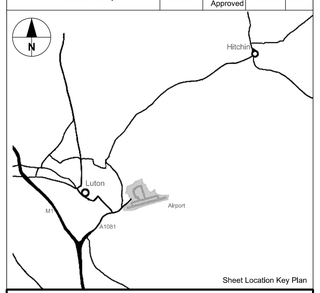
Legend

- The Order Limits
- Indicative Landfill Extents
- Landfill
- Made Ground
- Dry Valley Deposits
- Head
- Clay with Flints
- Solution Feature
- Lewes Nodular Chalk Formation
- Chalk Rock Member
- New Pit Chalk Formation
- Proposed Platform
- Landscape Fill Area
- Interpreted Fault
- 'Worst Case' Groundwater Level for design
- Proposed Finished Surface

Notes

1. Do not scale from this drawing.
2. All levels are in metres above ordnance datum unless noted otherwise.
3. These drawings are primarily intended to be viewed electronically. Some details may not be clear or visible on a printed version.
4. Strata and other levels have been drawn from interpolated 3D models of various boundaries logged in trial pits and boreholes, topographical data and data from geological maps etc.
   It is intended to provide a guide as to likely ground conditions and as such should be regarded as indicative. It is recommended that design decisions made on the basis of this information are confirmed by investigation.
5. Bing Maps Aerial - © 2021 Microsoft Corporation © 2021 Maxar ©CNES (2021) Distribution Airbus DS

Issue	IJ	RB TB	16/12/21	P01
Revision History	Drawn	Checked Approved	Date	Rev.



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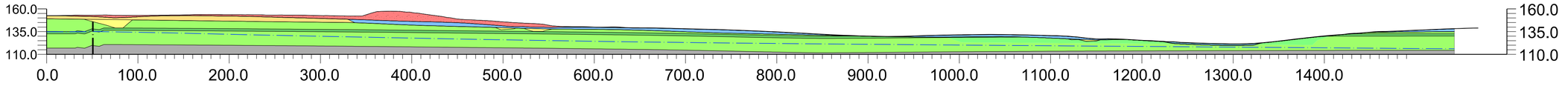
Drawing Title

Figure 03
Earthworks Stage 2 Design
Section A-A

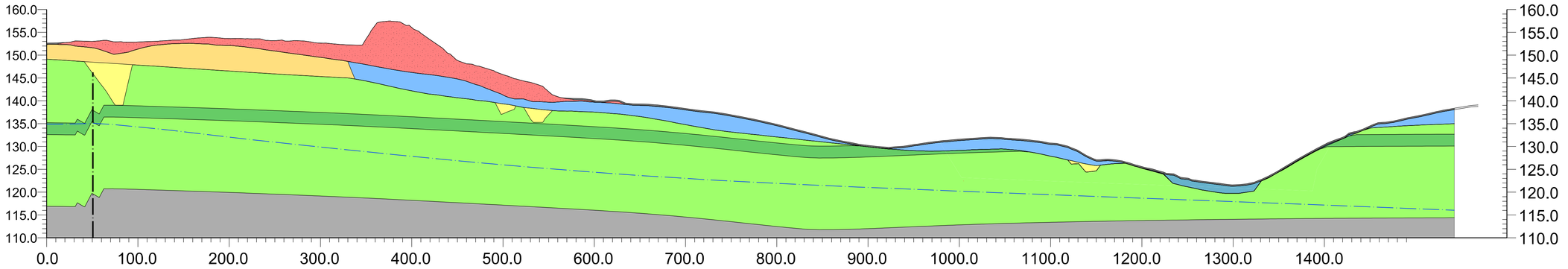
Purpose of issue				Suitability
SUITABLE FOR COORDINATION				S2
Drawn	Checked	Approved	Date	Scale / Size
IJ	RB	TB	30/09/22	AS / A1
DCO Application Ref.	APFP Regulation		DCO Document Ref.	
TR020001	(APFP 5(2)(a))		TR020001/APP/5.03	
Drawing Number				Revision
LLADCO-3C-ARP-00-00-DR-YE-0273				P01

Project – Phase – Originator – Asset/Zone – Sub Asset – Type – Discp. – Number



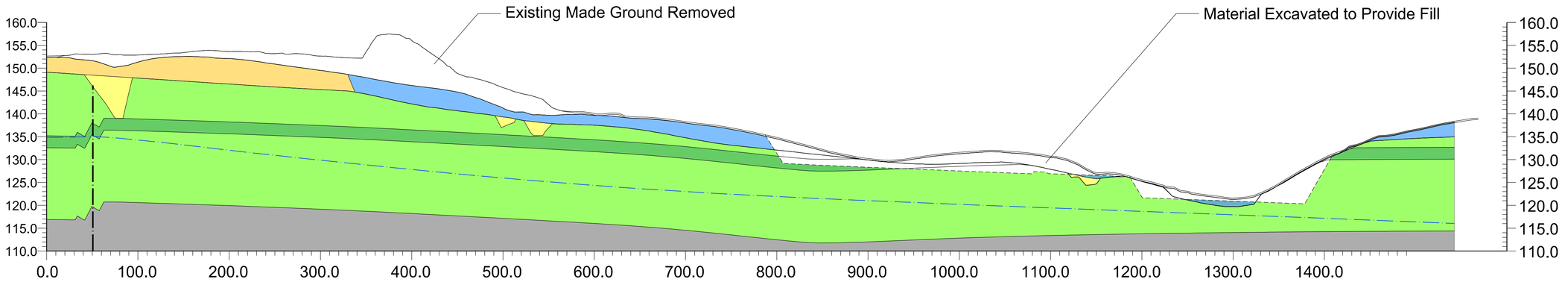
Existing Conditions - Natural Scale

Scale H=1:2500 V=1:2500



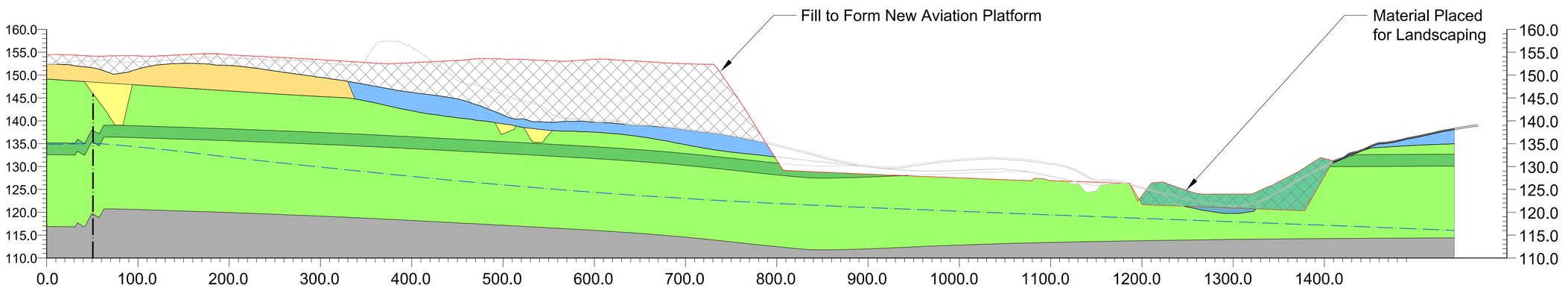
Existing Conditions

Scale H=1:2500 V=1:500



Excavate to Achieve Formation Level

Scale H=1:2500 V=1:500



Proposed Landform

Scale H=1:2500 V=1:500

All structure positions are indicative. The proposed works will be subject to detailed design development. The changes will be within limits of deviation specified in the Development Consent Order.

Legend

- Made Ground
- Dry Valley Deposits
- Head
- Clay with Flints
- Solution Feature
- Lewes Nodular Chalk Formation
- Chalk Rock Member
- New Pit Chalk Formation
- Proposed Platform
- Landscape Fill Area
- Interpreted Fault
- 'Worst Case' Groundwater Level for design
- Proposed Finished Surface

Notes

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   It is intended to provide a guide as to likely ground conditions and as such should be regarded as indicative. It is recommended that design decisions made on the basis of this information are confirmed by investigation.
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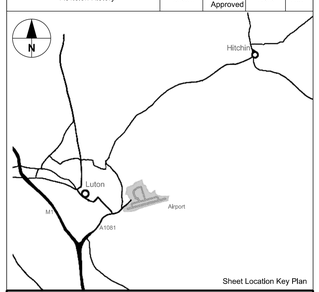
Revision History	Drawn	Checked / Approved	Date	Rev.
Issue	IJ	RB / TB	30/09/22	P01



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Drawing Title

Figure 04
Earthworks Stage 2 Design
Section B-B

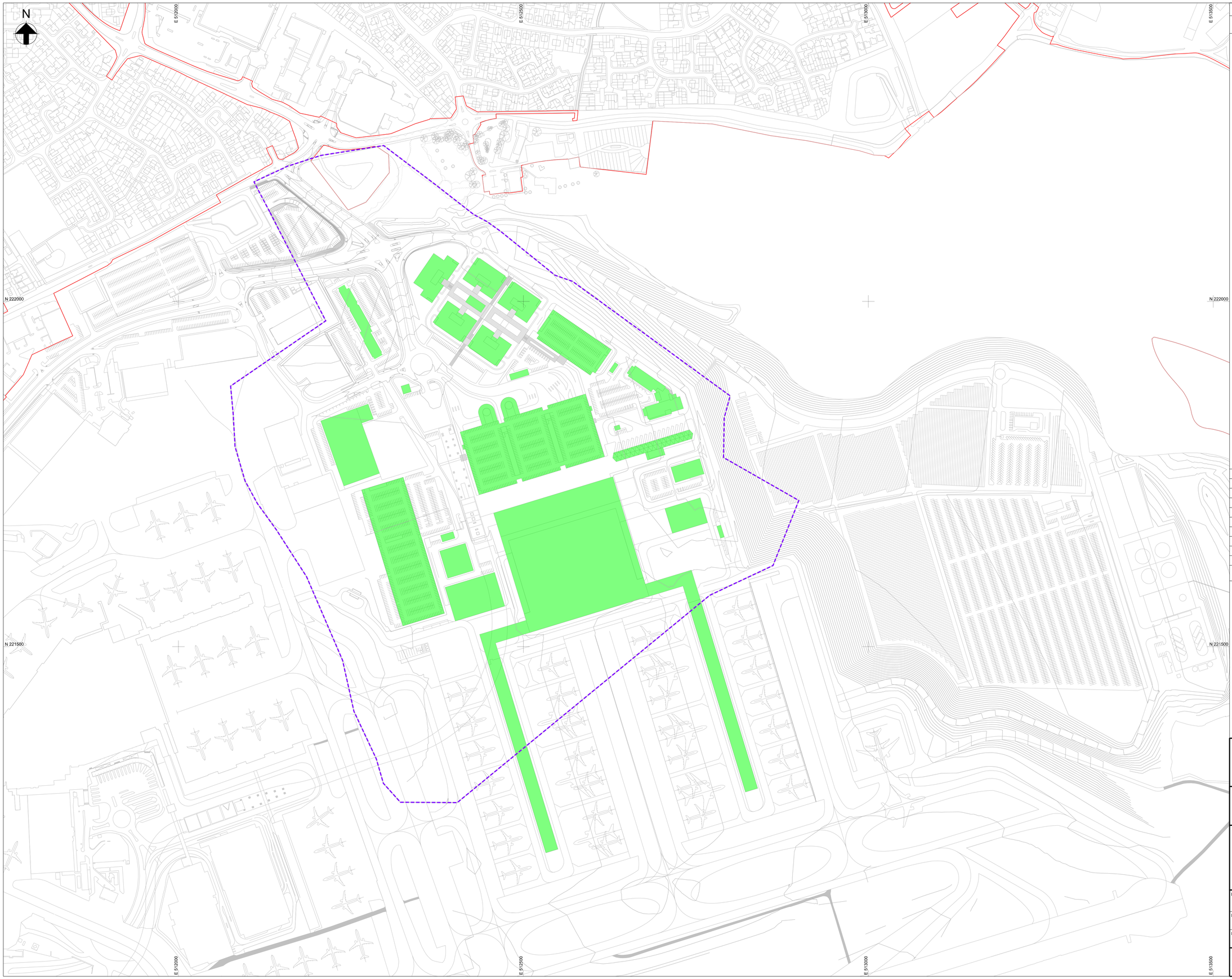
Purpose of issue	Suitability
SUITABLE FOR COORDINATION	S2

Drawn	Checked	Approved	Date	Scale	Size
IJ	RB	TB	30/09/22	AS	A1

DCO Application Ref.	APFP Regulation	DCO Document Ref.
TR020001	(APFP 5(2)(a))	TR020001/APP/5.03

Drawing Number	Revision
LLADCO-3C-ARP-00-00-DR-YE-0274	P01

Project – Phase – Originator – AssetZone – Sub Asset – Type – Discp. – Number



All structure positions are indicative. The proposed works will be subject to detailed design development. The changes will be within limits of deviation specified in the Development Consent Order.

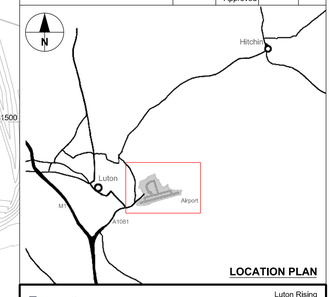
Legend

- The Order Limits
- Landfill Boundary
- 32MPPA Earthwork Contours
- Proposed Buildings with Piled Foundations

Notes

1. Do not scale from this drawing.
2. All levels are in metres above ordnance datum unless noted otherwise.
3. These drawings are primarily intended to be viewed electronically. Some details may not be clear or visible on a printed version.

Issue	IJ	RB SJ	06/01/23	P01
Revision History	Drawn	Checked Approved	Date	Rev.



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Drawing Title

Figure 05
Proposed Buildings with Piled Foundations

Purpose of issue				Suitability
SUITABLE FOR COORDINATION				S2
Drawn	**Checked**	**Approved**	**Date**	**Scale** / **Size**
IJ	RB	SJ	06/01/23	1:2500 / A1
DCO Application Ref.	**APFP Regulation**		**DCO Document Ref.**	
TR020001	(APFP 5(2)(a))		TR020001/APP/5.02	
Drawing Number				**Revision**
LLADCO-3C-ARP-00-00-DR-YE-0278				P01

Project – Phase – Originator – AssetZone – Sub Asset – Type – Disp. – Number

Appendix A- Conceptual Site Model

A1 Potential contaminant linkages (PCLs) and identified relevant contaminant linkages (RCLs)

A1.1.1 The DQRAs **Appendices 17.3** and **17.4** of the ES **[TR020001/APP/5.02]** indicated that the site generally represents a low risk to all receptors and remedial action is not required to protect current site users, neighbours or groundwater. However, the development will change the potential risk to future users and other receptors. Where a PCL has been identified and mitigation measures inherent in the construction or operation of the Proposed Development might not be sufficient to break the pollutant linkage, there is assessed to be a RCL that would require specific measures to be implemented. For ease of identification within the ORS these PCLs have also been assigned an identifying RCL number and are detailed in **Table A1 1** below.

A1.1.2 In addition to the RCLs, a number of PCLs were identified within the DQRA associated with the enabling/construction phase of the development. No specific remediation activities are required to address these PCLs. However, these linkages need to be considered in the selection of an appropriate remediation technique and the works must address and manage these PCLs to protect site users and site neighbours. Recommended mitigation measures for theses PCLs are also included in the ORS and presented in **Table A1 2** below.

A1 1 Revised conceptual site model (CSM) RCLs

PCL No.	RCL no.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk and identification of required remediation
Gas							
1	RCL1	DEV	Ground gases from former landfill e.g., methane	Migration into future buildings and aviation apron resulting in build-up of gases	Users of future development – public/airport operatives/ Green Horizons Park users	Moderate	High concentrations of bulk landfill gases (carbon dioxide and methane) were recorded within the waste but there are low or negligible standpipe emission flow rates, indicating low/very low rates of continuing biodegradation of residual organic matter. A methane/carbon dioxide characteristic situation (gas regime) of CS4 (maximum) is considered protective – many parts of the site might be only CS2 or CS3. Gas protection measures are required in proposed buildings consistent with those detailed in DQRA: Controlled Waters (Ref.15) and BS8485.
2	RCL2	DEV CON		Migration off-site	Adjacent site users (e.g., residential housing and other buildings on the airport, WVP Community Centre/ pavilion)	Low/ Moderate	Results do not suggest a current potential risk from gas migration but the proposed development may increase the potential risk of migration therefore boundary mitigation measures would be required. To be installed prior to disturbance of the former landfill. Measures will be required to treat existing preferential pathways e.g., Thames Valley Drain.
Human Health							
6	RCL3	DEV	Waste in former landfill	Direct contact e.g., dermal contact, soil ingestion	Future maintenance workers	Low/ Moderate	The GQRA indicated there was very few exceedances and the risk to future maintenance workers at the new airport development is low. Maintenance workers may be exposed to areas of landfill waste during future excavation. This can be

PCL No.	RCL no.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk and identification of required remediation
							reduced by placing of services in a clean cover system.
7	RCL4	DEV			Users of future development – public/airport operatives/ Green Horizons Park users	Low	The GQRA indicated there was very few exceedances and the risk to future users of the new airport development is low. The future development will comprise buildings & hardstanding, therefore there is unlikely to be any contact with landfilled wastes. However, given the heterogeneous nature of landfills and the lack of engineered cover system, it should be assumed that measures will be required, particularly in landscape areas to prevent direct contact with the waste.
9	RCL5	DEV		Direct or indirect contact with radionuclides – incurring radiation dose by indirect dose received from ingestion of radium (or other alpha emitting contaminated material) or direct risk from contact with beta emitters such as Carbon-14	Future maintenance workers	Low	The recent GI included testing for radionuclides, which indicated levels observed were consistent with background levels. However, given the heterogeneous nature of landfills and the lack of engineered cover system, it should be assumed that measures will be required. Maintenance workers may be exposed to areas of landfill waste during future excavation. This can be reduced by placing of services in a clean cover system.
10	RCL6	DEV			Users of future development – public/airport operatives/ Green Horizons Park users	Low	The recent GI included testing for radionuclides, which indicated levels observed were consistent with background levels. However, given the heterogeneous nature of landfills and the lack of engineered cover system, it should be assumed that measures will be required, particularly in landscape areas to prevent direct contact with the waste.

PCL No.	RCL no.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk and identification of required remediation
				or Caesium-137			
14	RCL7	DEV		Inhalation of airborne contaminants/ dust/ asbestos fibres and microorganisms	Users of future development – public/airport operatives/ Green Horizons Park users	Low	The future development will comprise buildings & hardstanding, therefore there is unlikely to be any contact with landfilled wastes. However, given the heterogeneous nature of landfills and the lack of engineered cover system, it should be assumed that measures will be required, particularly in landscape areas to prevent generation of dusts which may contain asbestos fibres.
21	RCL8	DEV	Leachate in former landfill[4]	Direct contact e.g., dermal contact	Future maintenance workers	Moderate/ Low	The GI undertaken indicates there is likely to be limited leachate present. Maintenance workers may be exposed to areas of landfill waste during future excavation. This can be reduced by placing of services in a clean cover system.
22	RCL9	DEV			Users of future development – public/airport operatives/ Green Horizons Park users	Low	The GI undertaken indicates there is likely to be limited leachate present. The future development will be buildings and hardstanding and is likely to include an engineered cover layer and leachate control system, therefore there is limited potential for contact with any leachate in the landfill.
29	RCL10	DEV	Contaminants in Made Ground (car park, capping material)	Direct contact e.g., dermal contact, soil ingestion	Future maintenance workers	Moderate/ Low	The GQRA indicated there was very few exceedances and the risk to maintenance workers of the new airport development is low. Maintenance workers may be exposed to areas of Made Ground during future excavation. This can be reduced by placing services in a clean cover system and adoption of appropriate site management protocols and personal protective equipment (PPE).

[4] The source of the leachate in assumed to be the landfill waste material

PCL No.	RCL no.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk and identification of required remediation
30	RCL11	DEV			Users of future development – public/ airport workers/users of Green Horizons Park	Low	The GQRA indicated there was very few exceedances and the risk to future users of the new airport development is low. The future development will comprise buildings & hardstanding, therefore there is unlikely to be any contact Made Ground. However, given the heterogeneous nature of landfills and the lack of engineered cover system, it should be assumed that measures will be required, particularly in landscape areas to prevent direct contact with the Made Ground.
32	RCL12	DEV		Inhalation of soil derived dusts/asbestos fibres	Future maintenance workers	Low	The future development will comprise buildings & hardstanding, therefore there is unlikely to be the potential for generation of soil derived dusts. Maintenance workers may be exposed to areas of Made Ground during future excavation. This can be reduced by placing of services in a clean cover system and adoption of appropriate site management protocols and PPE.
33	RCL13	DEV			Users of future development – public/ airport workers/users of Green Horizons Park	Low	The future development will comprise buildings & hardstanding, therefore there is unlikely to be the potential for generation of soil derived dusts. However, given the heterogeneous nature of landfills and the lack of engineered cover system, it should be assumed that measures will be required, particularly in landscape areas to prevent generation of dusts which may contain asbestos fibres.
Controlled Waters							

PCL No.	RCL no.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk and identification of required remediation
17	RCL14	CON	Waste in former landfill	Driving of contaminants downward during any future piling	Principal aquifer in Chalk	Moderate	The GQRA has indicated that there are isolated hot spots of contaminants present and a localised area of free product was encountered at location WS224. Care will be required during construction not to create a pathway. This may involve localised removal of hotspots in locations where works may create a pathway, recommendation is included in the ORS. Risks from piling and construction will be mitigated by completion of a detailed foundation works risk assessment at detailed design stage and a hydrogeological risk assessment-piling which will be produced to support the environmental permit application for works on the landfill. The documents will identify the most appropriate piling method and controls required to mitigate risks to the aquifer. The environmental permit will include a groundwater activity permit which will allow penetrations through the base of the landfill and continued groundwater monitoring.~~Risk from piling and construction can be mitigated by completion of a foundation works risk assessment report to determine appropriate piling technique.~~
23	RCL15	DEV	Leachate in former landfill[5]	Downward migration of leachate	Principal aquifer in Chalk	Moderate/ Low	DQRA has identified the potential for downward migration of leachate from the landfill. A weak leachate plume appears to be present immediately down gradient of the landfill, however groundwater monitoring completed to date does not suggest there is a significant contaminant plume affecting the aquifer. The sensitivity analysis

[5] The source of the leachate in assumed to be the landfill waste material

PCL No.	RCL no.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk and identification of required remediation
							indicated that minimising the rate of infiltration will prevent contaminants breaking through the base of the unsaturated zone and reaching receptors. Installation of a cover system with a drainage system to collect all infiltration in the area of the landfill will minimise any future risks to the groundwater from contaminants within the landfill.
26	RCL16	CON	Contaminants in perched water	Driving of contaminants downward during any future piling	Principal aquifer in Chalk	Low	GQRA indicated that perched water was present in some locations within the landfill. The GQRA indicated that there are isolated hot spots of contaminants present and a localised area of free product. Care will be required during construction not to create a pathway. This may involve localised removal of hotspots in locations where works may create a pathway. Risk from piling and construction can be mitigated by completion of foundation works risk assessment report to determine appropriate piling technique.
27	RCL17	CON		Migration of contaminants via preferential pathways e.g., drainage	Principal aquifer in Chalk	Moderate	Survey and assessment of purpose of TVD to be undertaken prior to diversion. Measure to be incorporated in design to prevent creation of preferential pathways.
40	RCL18	DEV	Contaminants in groundwater (dissolved phase)	Lateral migration of contaminants in groundwater	Controlled waters (including potable water groundwater abstraction)	Moderate	Overall, there were relatively few exceedances of potential contaminants of concern recorded in groundwater beneath the site. The DQRA indicated that whilst there is evidence of a weak leachate plume in groundwater down-gradient of the site, on-site groundwater monitoring provides little

PCL No.	RCL no.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk and identification of required remediation
							evidence that the landfill is causing significant contamination of the groundwater. The sensitivity analysis indicated that minimising the rate of infiltration will prevent contaminants breaking through the base of the unsaturated zone and reaching receptors. Installation of a cover system with a drainage system to collect all infiltration in the area of the landfill will minimise any future risks to the groundwater from contaminants within the landfill.
Others							
25	RCL19	DEV		Leachate breakout through the surface cover layer and off-site through horizontal movement of leachate and plant uptake off-site~~Leachate breakout and plant uptake~~	Areas of Landscaping in the airport and Green Horizons Park developments/WVP allotments~~Areas of Landscaping in the airport and Green Horizon Park/WVP allotments~~	Low~~Low~~	The GI undertaken indicates currently there is likely to be limited leachate present in the landfill. No evidence of leachate breakout currently occurring through sampling of shallow groundwater off-site and no observation of stress in vegetation on and off the landfill. A leachate control system will be installed prior to works on the landfill and installation of a clean cover system with suitable depth of growth medium will further reduce this risk.~~No evidence of leachate breakout currently occurring. The GI undertaken indicates there is likely to be limited leachate present. A clean cover system with suitable depth of growth medium will further reduce this risk.~~
KEY: CON- RCL during excavation, remediation and construction phase DEV- RCL associated with future use of proposed development							

A1 2 Revised conceptual site model (CSM) possible impacts

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
Gas						
Human Health						
3	DEV	Volatile radionuclides occupying buildings overlying radioactive land contamination	Migration into future buildings and build-up of gases	Users of future development – public/airport operatives/ Green Horizons Park users	Low	The recent GI included testing for radionuclides, which indicated levels observed were consistent with background levels. No further risk assessment of the radionuclide risks is required. However, a watching brief will be required during excavation works and procedures in place to ensure any suspected radionuclide containing material encountered is appropriately managed.
4	DEV		Migration off-site through preferential pathways	Adjacent site users (e.g., residential housing and other buildings on the airport, WVP Community Centre/ pavilion)	Low	
5	CON	Waste in former landfill	Direct contact e.g., dermal contact, soil ingestion	Construction worker	Low	Based on the results of the GQRA no special precautions, above and beyond best practice, are considered necessary during construction works to control potential acute risks. Appropriate measures should be undertaken during construction to ensure the site is secure and dusts are controlled. Any risks to construction worker can be reduced by adoption of appropriate site management protocols and PPE.
8	CON		Direct or indirect contact with radionuclides – incurring radiation dose by indirect dose received from ingestion of radium (or other alpha emitting contaminated material) or direct	Construction workers	Low/ Moderate	Potential for radioactive materials to be present within the earlier waste which was deposited prior to the introduction of the Radioactive Substances Act in 1963. Potential for arisings from piling and foundation activities to encounter such materials. The recent GI included testing for radionuclides, which indicated levels observed were consistent with background levels. Procedures during construction should be in place to detect any radionuclides which may be encountered.

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
			risk from contact with beta emitters such as Carbon-14 or Caesium-137			
11	CON	Waste in former landfill	Inhalation of vapours	Construction worker	Low	The GI provided sufficient information to characterise the potential risks from soils vapours. No elevated soil vapours were identified. However, due to the variable nature of landfill and potential for variability in vapour generation over time, vapour monitoring should be continued; prior to, during and post earthworks to confirm this assessment. A detailed monitoring strategy is included in the ORS. In addition, due to the heterogenous nature of the landfill, the ORS includes measures to detect and appropriately deal with material encountered which is different from those assessed and may have high vapour generation potential. The odour assessment indicates odour suppression techniques are likely to be required during the excavation works. Any future works should have an odour management plan in place to control any odours generated during works.
12	DEV			Future maintenance workers	Low	The GI provided sufficient information to characterise the potential risks from soils vapours. No elevated soil vapours identified during DQRA assessment which could be considered to pose a risk to the future development. Post earthworks monitoring will be undertaken to confirm assessment. A monitoring strategy is included in the ORS. If elevated concentrations are detected post earthworks the need for specific mitigation measures to prevent vapour intrusion into buildings should be reassessed.
13	DEV			Users of future development – public/airport operatives/ Green Horizons Park users	Low	
15	CON		Inhalation of airborne contaminants/ dust/	Adjacent site users (e.g., residential housing, the airport visitors and	Low	The GI provided sufficient information to characterise the condition of asbestos present within the landfill and inform this assessment. Overall, the risk is considered to be low based on; the ACM types

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
		Waste in former landfill	asbestos fibres and microorganisms	operatives, users of WVP)		encountered, their degradation state and fibre content. However, it is recognised that the landfill is heterogenous in nature and as such localised areas of increased frequency of ACMs may exist. Future works will require significant movement of waste i.e., for waste processing/re-engineering, therefore there is the potential for generation of airborne contaminants, which could affect adjacent site users. Careful consideration of techniques for waste processing/re-engineering will be required to minimise dust production, as well as good site management practices, monitoring and mitigation measures to reduce the potential risk. Any future works should have appropriate Dust Management Plans in place to include perimeter monitoring, with adoption of additional control measures as necessary.
16	CON			Construction workers	Moderate	The GI provided sufficient information to characterise the condition of asbestos present within the landfill/Made Ground and inform this assessment, but it is recognised that the landfill/Made Ground is heterogenous in nature and as such localised areas of increased frequency of ACMs may exist. Therefore, a strategy for managing ACMs has been developed as part of the ORS for the works. Construction workers are likely to be exposed to areas of landfill waste during future excavation. Any excavation work would adopt appropriate site management protocols and PPE to include personal monitoring and protection against airborne asbestos fibres as necessary based on outcome of risk assessments.
20	CON	Leachate in former landfill[6]	Direct contact e.g., dermal contact	Construction workers	Moderate/ Low	Construction workers may be exposed to landfill leachate during future excavation works. The GI undertaken indicates there is likely to be limited leachate present.

[6] The source of the leachate in assumed to be the landfill waste material

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
						Any excavation work would adopt appropriate site management protocols and PPE.
28	CON	Contaminants in Made Ground (car park, capping material)	Direct contact e.g., dermal contact, soil ingestion	Construction workers	Moderate/ Low	Based on the results of the GQRA no special precautions, above and beyond best practice, are considered necessary during construction works to control potential acute risks. Appropriate measures should be undertaken during construction to ensure the site is secure and dusts are controlled. Any risks to construction worker can be reduced by adoption of appropriate site management protocols and PPE.
31	CON		Inhalation of soil derived dusts/asbestos fibres	Construction workers	Moderate	The GI provided sufficient information to characterise the condition of asbestos present within the landfill/Made Ground and inform this assessment, but it is recognised that the landfill/Made Ground is heterogenous in nature and as such localised areas of increased frequency of ACMs may exist. Therefore, a strategy for managing ACMs forms part of the ORS for the works. Construction workers are likely to be exposed to areas of landfill waste during future excavation. Any excavation work would adopt appropriate site management protocols and PPE to include personal monitoring and protection against airborne asbestos fibres as necessary based on outcome of risk assessments.
34	CON	Contaminants in Made Ground (car park, capping material)	Inhalation of soil derived dusts/asbestos fibres	Adjacent site users (e.g., residential housing, the airport, WVP)	Low	The GI provided sufficient information to characterise the condition of asbestos present within the Made Ground and inform this assessment. Overall, the risk is considered to be low based on; the ACM types encountered, their degradation state and fibre content. However, it is recognised that Made Ground is heterogenous in nature and as such localised areas of increased frequency of ACMs may exist. Future works will require significant movement of material, therefore there is the potential for generation of airborne contaminants, which could affect adjacent site users. Careful consideration of techniques will be required to minimise dust production, as well as good site

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
						management practices, monitoring and mitigation measures to reduce the potential risk. Any future works should have appropriate Dust Management Plans in place to include perimeter monitoring, with adoption of additional control measures as necessary.
35	CON	Contaminants in Made Ground (car park, capping material)	Inhalation of vapours	Construction worker	Low	The GI provided sufficient information to characterise the potential risks from soils vapours. No elevated soil vapours were identified. However, due to the variable nature of Made Ground and potential for variability in vapour generation over time, vapour monitoring should be continued; prior to, during and post earthworks to confirm this assessment. An outline monitoring strategy is included in the ORS. The ORS also includes measures to detect and appropriately deal with material encountered which is different from those assessed and may have high vapour generation potential.
36	DEV			Future maintenance workers	Low	The GI provided sufficient information to characterise the potential risks from soils vapours. No elevated soil vapours identified during DQRA assessment which could be considered to pose a risk to the future development. Post earthworks monitoring will be undertaken to confirm assessment. A monitoring strategy is included in the ORS. If elevated concentrations are detected post earthworks the need for specific mitigation measures to prevent vapour intrusion into buildings should be reassessed.
37	DEV			Users of future development – public/ airport workers/users of Green Horizons Park	Moderate/ Low	
38	DEV			Adjacent site users (e.g., residential housing, the airport, WVP Buildings)	Low	DQRA indicated that risks from soil vapours is low. During construction works an appropriate Dust Management Plan should be in place to include perimeter monitoring, with adoption of additional control measures as necessary. Post earthworks monitoring will be undertaken to confirm assessment.
Controlled Waters						
39	CON	Contaminants in Made	Balancing pond	Principal aquifer in Chalk	Very Low	Thames Water balancing pond present in the north of the former landfill area, it will remain in place during

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
		Ground (car park, capping material)				the Proposed Development. Appropriate site management and construction techniques will be required during the development construction process in the vicinity of the current pond to reduce the risk.
Others						
18	DEV	Waste in former landfill	Direct contact of foundations of future development	Foundations of future buildings	Moderate	Presence of landfill waste in contact with building foundations may cause damage to foundations through aggressive ground conditions. Site investigation data will be considered in the design of the foundation. Risk can be mitigated by appropriate geotechnical design to select suitable foundation materials/concrete classification.
19	CON	Japanese Knotweed (JKW)	Direct contact with rhizomes on floor slabs, external pavement and drainage	Floor slabs/drainage/pavement	Moderate/ Low	Japanese Knotweed has been identified in the WVP, this can cause damage to buried infrastructure/buildings and pavement through growth of rhizome. Risk can be mitigated through application of treatment with herbicide/removal/on-site burial/containment.
24	DEV	Leachate in former landfill	Direct contact with foundations of future development	Foundations of future buildings	Moderate/ Low	Presence of leachate in contact with building foundations may cause damage to foundations through aggressive ground conditions. The GI undertaken indicates there is likely to be limited leachate present. Consider in the geotechnical design.
41	CON	Unexploded Ordnance	Driving of piles impact UXO	Construction workers/public/ terminal buildings	High/ Moderate	Based on Detailed UXO Risk Assessment there is a 'Very High' probability of UXO on-site, but low risk where works are to be undertaken within post war fill material. Correct detection and monitoring procedures would be required during site works to mitigate risks.

KEY:
CON- PCL during excavation, remediation and construction phase
DEV- PCL associated with future use of proposed development