M3 Junction 9 Improvement

Scheme Number: TR010055

7.11 Ground Investigation Report

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7.11 GROUND INVESTIGATION REPORT

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Executive Summary

The M3 Junction 9 Improvement Scheme ('the Scheme') comprises the development and delivery of works for increasing capacity, enhancing journey time reliability and supporting development in line with Local Plans. The Scheme includes widening of the M3 local to the junction to create four lanes each way, reconfiguring the existing main Junction 9 roundabout to make it more efficient, making provision for walkers, cyclists and horse-riders and improving the motorway slip roads.

This Ground Investigation Report (GIR) has been prepared in general accordance with BS EN 1997-1:2004+A1:2013, BS EN 1997-2:2007 and CD622 Managing Geotechnical Risk. It has been prepared following a ground investigation carried out to provide information on the ground and groundwater conditions. The report presents an assessment of the ground conditions, together with recommended characteristic values of geotechnical parameters for use in the design of the geotechnical elements of the proposed Project Control Framework (PCF) Stage 3B Scheme. In addition, this report presents an assessment of the risks associated with existing contamination in the ground to human health, the environment and proposed development.

Sections 1 and **2** provide a background and high-level description to the Scheme and presents the scope and objectives of this GIR. This section summarises the key existing information on the site previously reviewed in the Preliminary Sources Study Report (PSSR). It is anticipated that the scheme may be classified as a Geotechnical Category 2 project, as defined in BS EN 1997-1 (2004+A1:2013).

Section 3 summarises the GI fieldwork and laboratory studies conducted during Stage 3A to assess the ground conditions. This section provides details of the GI fieldwork and laboratory testing undertaken, including and a review of the 2019 Ground Investigation Factual Report. Since the completion of the ground investigation in 2019, the design of the Scheme has changed and therefore, the ground investigation carried out at Stage 3A does not provide adequate spatial or depth of investigation coverage for the design of all the geotechnical elements of the Stage 3B Scheme.

Section 4 is a summary of the ground conditions encountered across the Scheme. The ground conditions in the area of the Scheme indicate that the Stage 3B scheme typically lies on areas of Made Ground/Engineered Fill overlying Seaford Chalk Formation. However, locally around the River Itchen the Scheme lies on Alluvium and Head Deposits are present also over the Seaford Chalk Formation near the river. These ground conditions generally agree with the published geological information for the area.

Section 5 provides a commentary highlighting where differences or inconsistencies to previous fieldwork descriptions have been identified. The geotechnical parameters recommended in this section have been based on the available ground investigation testing information (measured or derived) and where there is insufficient or questionable information, published data has been used and a cautious approach to the selection of geotechnical parameters has been adopted. A further ground investigation will be required to confirm the assumed geotechnical parameters as well as to provide appropriate information on the ground conditions for the proposed structures.

Groundwater - Characteristic groundwater levels in the vicinity of the River Itchen should be taken to be at ground level and at 39.5m AOD for the new gyratory bridges and M3 and A34 underpasses.

Sections 6 and **7** summarise the evaluations of site-specific contamination data using published Generic Assessment Criteria (GAC) and assesses the risks from soil, groundwater and ground gas. The GI geoenvironmental risk assessment follows the government's 3-tier risk management guideline, entitled Land Contamination: Risk Management (LC:RM). Based on the information available, it is concluded that the ground conditions encountered during the investigation and the results of the geoenvironmental testing indicate that the potential for significant contamination is considered to be Low to Very Low.

Section 8 summarises the risk register which is appended to the GIR. The risk register gives a description of the construction activity, the potential geotechnical hazard, the consequence of the hazard, the likeliness of occurrence and the mitigation measures implemented to limit the impact of the hazard. The Stage 3B Scheme only includes conventional types of earthworks structures and foundations and therefore is classified as a Geotechnical Category 2 Project.

Section 9 presents comments on the ground conditions in relation to design and construction of the geotechnical elements of the proposed structures. For the Stage 3B Scheme, the principal geotechnical consideration will be the strength and compressibility of the founding soils and hence, the foundations for the bridges, retaining walls and proposed embankments and cuttings along the length of the scheme. This section also provides a range of options and recommendations for different elements of the Scheme, including the bridges, underpasses, subways retaining walls and pavement design. In order to confirm the design assumptions made in this report, and to meet the requirements of the BS EN 1997-2, additional exploratory holes are required to be undertaken prior to the construction stage. These are summarised in Section 11 and the subsequent provisional table.

1 Introduction

1.1 Background

1.1.1 Stantec UK Limited (Stantec) is working as the design consultants to VolkerFitzpatrick Ltd who has been awarded the proposed M3 Junction 9 Improvement Scheme (the Scheme) as part of the National Highways Regional Delivery Partnership. Highways England (the Applicant) previously commissioned a ground investigation for the Scheme. Stantec has been instructed by National Highways to produce a Ground Investigation Report (GIR) to be used in support of the Development Consent Order (DCO) application for the Scheme based on the ground investigation information provided to Stantec.

1.1.2 This report presents a summary and initial interpretation of the available information gathered in relation to the ground and groundwater conditions along the Scheme. The report has been prepared in accordance with BS EN 1997-1:2004+A1:2013, BS EN 1997-2:2007 and CD622 Managing Geotechnical Risk.

1.1.3 It should be noted that the ground investigation was specified based on a previous iteration of the Scheme (Stage 3A). Stantec is currently revising the Stage 3 preliminary design of the Scheme (Stage 3B) and this is the design being submitted as part of the DCO application.

1.2 Scope and Objective of the Report

1.2.1 This report has been prepared following a ground investigation carried out to provide information on the ground conditions. The fieldwork and laboratory testing were undertaken by Principal Contractor Geoffrey Osborne Limited (GOL) employing ground investigation contractors Soils Limited and SM Associates under the instruction of Jacobs. A factual ground investigation report was produced by Soils Ltd (Soils, 2020) and is presented in **Appendix A**.

1.2.2 This Ground Investigation Report has been prepared in general accordance with BS EN 1997-1:2004+A1:2013, BS EN 1997-2:2007 and CD622 Managing Geotechnical Risk. The report presents an assessment of the ground conditions, together with recommended characteristic values of geotechnical parameters for use in the design of the geotechnical elements of the Stage 3B Scheme. In addition, this report presents an assessment of the risks associated with existing contamination in the ground to human health, the environment and proposed development.

1.2.3 The comments and opinions in this report are based on engineering and scientific appraisal of information on the ground conditions encountered within the exploratory holes and the results of field and laboratory testing carried out for this investigation. There may be conditions pertaining to the site which were not disclosed by the investigation, and which therefore could not be taken into account.

1.3 Overview of the Scheme

Scheme Description

1.3.1 The improvements proposed as part of the Scheme both maintain existing connectivity on the road network, whilst providing enhanced capacity, simplified routing and improved facilities for walking, cycling and horse-riding routes and landscaping enhancements. The Scheme would provide new free flow links between the M3 and A34, as well as a dedicated new A33 alignment. The Scheme elements are as follows:

- Widening of the M3 from a dual two-lane motorway (two-lane motorway with hard shoulders) to a four-lane motorway (with hard shoulders) between the proposed M3 Junction 9 gyratory north and south slip roads.
- A new smaller grade separated gyratory roundabout arrangement within the footprint of the existing roundabout, incorporating new connections over the M3 with improved walking, cycling and horse-riding routes.
- Connector roads from and to the new gyratory roundabout.
- Improved slip roads to/from the M3.
- New structures (in the form of gyratory bridges, underpasses, retaining walls, subway and a new cycle and footbridge over the River Itchen).
- A new surface water runoff system with associated drainage and infiltration features.
- New signage and gantries.
- Utility diversions.
- New lighting (subways, underpasses and gantries).
- Modifications to topography through cuttings and false cuttings as well as re-profiling of existing landform.
- New walking, cycling and horse-riding provision.
- Creation of new areas of chalk grassland, woodland, scrub planting and species rich grassland.

1.3.2 The Application Boundary covers an area of approximately 109 hectares (ha). This includes the proposed land required for gantries, signage, temporary construction compound areas, areas for environmental mitigation, areas for drainage requirements (some of which would be temporary) and traffic management.

1.3.3 The Scheme includes a package of environmental mitigation and enhancement measures to reduce the impacts from the Scheme to the environment where possible. Consideration has also been given to the enhancement of the South Downs National Park where reasonably practicable.

1.3.4 Bridleways, footpaths and cycleways have been designed to allow all gradients to be less than 1:20 to comply with Department for Transport's (DfT) inclusive mobility impaired users. The walking, cycling and horse-riding routes are designed for cyclists, and therefore as all horizontal radii are suited for cyclists, they are also considered acceptable for mobility impaired users. The range of opportunities and barriers to all forms of users have been given due consideration in the design of the Scheme.

1.3.5 A number of new structures are required to be both constructed and demolished to facilitate the Scheme. Some of the main structures are as follows:

- The existing bridges at the M3 Junction 9 gyratory roundabout are proposed to be demolished and replaced by the two new bridge structures carrying the new gyratory
- A new underpass is proposed to carry the A34 southbound under the new A33 link road and the existing M3. The A34 northbound underpass would carry the new A34 northbound over the new A33 link
- The existing subways (Winnall Subway East and Winnall Subway West) located under the existing gyratory are proposed to be demolished to facilitate the construction of the reconfigured roundabout. New subways are proposed along the proposed walking, cycling and horse-riding route
- A new footbridge over the River Itchen is proposed between the existing Itchen Bridge, (which carries the A34 northbound carriageway), and the existing Kings Worthy Bridge which will carry the A33 north and southbound carriageways and the A34 southbound carriageway, respectively.

1.3.6 The walking, cycling and horse-riding facilities around and within the Scheme are to be upgraded. This includes an improvement to the National Cycle Network (NCN) Route 23. An additional footpath, cyclepath and bridleway is proposed on the eastern side of the Scheme to link Easton Lane with Long Walk. Such a route would provide a circular leisure path for those using the South Downs National Park with a link to the other paths around Long Walk with their links to local villages. A new combined footpath and cyclepath for the western side of the Scheme is proposed to link the A33 / B3047 Junction to Winnall Industrial Estate situated on Easton Lane.

1.3.7 A detailed description of the Scheme is provided in **Chapter 1 (Introduction)** and **Chapter 2 (The Scheme and its Surroundings)** of the **Environmental Statement (ES) (Document Reference 6.1)**.

Definition under the Planning Act 2008

1.3.8 The Scheme is a Nationally Significant Infrastructure Project (NSIP) under Section 14(1)(h) and Section 22(1)(b) of the Planning Act 2008.

1.3.9 Section 14(1)(h) of the Planning Act 2008 defines an NSIP as highway-related development falling within the criteria set out in Section 22 of the Planning Act 2008. Under Section 22(1) of the Planning Act 2008 an NSIP for highway-related development must fall within one of three specified categories, namely construction, improvement or alteration of a highway.

1.3.10 The Scheme constitutes an 'alteration' to a highway within the meaning of Section 22(1)(b) and meets the requirements of this definition under Section 22(3) and 22(4) as follows:

- The highway is wholly in England (Section 22(3)(a)).
- The Applicant, (as the strategic highways company), is the highway authority for the highway (Section 22(3)(b)).
- The area of development within the Application Boundary is greater than 15 hectares (Sections 22(3)(c) and 22(4)(a)).

1.3.11 As the Scheme is an NSIP, development consent must be obtained from the Secretary of State (SoS) for Transport to authorise it, and an application for a DCO must be made to the Planning Inspectorate who administer the DCO process on behalf of the SoS under Section 37 of the Planning Act 2008. If granted by the SoS, the DCO would provide the necessary authorisation to allow the Scheme to be constructed and operated.

1.4 Geotechnical Category

1.4.1 The project was previously categorised in the Preliminary Sources Study Report (PSSR) (WSP, 2017) as a Geotechnical Category 2. This categorisation was based on a previous design for the Scheme at Stage 3A.

1.4.2 Stantec has undertaken a review of the revised Scheme (Stage 3B) and associated project risks to assess the expected geotechnical classification of the project and thus the requirement for geotechnical certification. On this basis of this review, it is anticipated that the Scheme may be classified as a Geotechnical Category 2 project with potential structures and earthwork solutions of low/medium complexity.

1.4.3 Geotechnical Category 2 is defined in BS EN 1997-1 (2004+A1:2013) as a project including conventional types of earthworks, structures and foundations with no exceptional risk or difficult ground or loading conditions.

1.5 Other Relevant Information

1.5.1 The 2019 ground investigation was undertaken in accordance with a ground investigation specification that was produced to aid in the design of the Stage 3A Scheme design which is no longer being taken forward to detailed design. Therefore, the information obtained during the 2019 ground investigation does not satisfy the needs for the design of all the geotechnical elements of the current Stage 3B Scheme because some structures have been moved and additional major structures incorporated such that adequate ground investigation data is not available at all locations. Therefore, further ground investigation data will need to be obtained in line with the current Stage 3B Scheme design (i.e. that for the DCO application).

1.6 Limitations

1.6.1 The opinions and recommendations in this report are based on the information obtained from the PSSR and the ground investigation specified and carried out by others. Stantec can, therefore, only base any recommendations included in this report from the information provided within the Factual Ground Investigation Report (Soils, 2019).

1.7 Guidance of the Context of the Report

1.7.1 This report has been prepared within an agreed timeframe and to an agreed budget that will necessarily apply some constraints on its content and usage. The remarks below are presented to assist the reader in understanding the context of this report and any general limitations or constraints. If there are any specific limitations and constraints, they are described in the report text or relevant design appendix.

i. The recommendations presented in this report are based on statute, guidance, and best practice current at the time of its preparation. Stantec UK does not accept any liability whatsoever for the consequences of any future legislative changes or the release of subsequent guidance documentation, etc. Such changes may render some of the opinions and advice in this report inappropriate or incorrect and we will be pleased to advise if any report requires revision due to changing circumstances, especially those over one year old. Following delivery of any report PBA has no obligation to advise the Client or any other party of such changes or their repercussions.

ii. Some of the ground models and geotechnical parameters presented in this report are based on third party data or third-party interpretation. No guarantee can be given for the accuracy or completeness of any of the third-party data or interpretation used. Some of the data used in this report may be historical or for other reasons not fully compliant with the requirements of current standards and good practice guidance.

iii. The recommendations presented in this report are based on the information reviewed and/or the ground conditions encountered in exploratory holes and the results of any field or laboratory testing undertaken. There may be ground conditions at the site that have not been disclosed by the information reviewed or by the investigative work undertaken. Such undiscovered conditions cannot be taken into account in any analysis and design.

iv. It should be noted that groundwater levels and surface water levels can vary due to seasonal, climatic, tidal and man-made effects and that where necessary cautious estimates of the water level parameters have been used in design.

2 Existing Information

2.1 Introduction

2.1.1 A review of existing information on the site area is contained in the Preliminary Sources Study Report (WSP, 2017). Stantec is not aware of any significant changes to the site area since the issue of the PSSR, that may affect the ground conditions for the Scheme. A summary of salient points from the PSSR, relevant to the ground conditions at the Site, are briefly described below.

2.2 Topography

2.2.1 The Site is partly situated on the west facing side of the River Itchen valley. The ground generally slopes towards the river to the west. The River Itchen flows from north to south through Winchester to the west of the Scheme. Part of the Scheme crosses the River Itchen towards the northern extent of the A34 within the Scheme order limits.

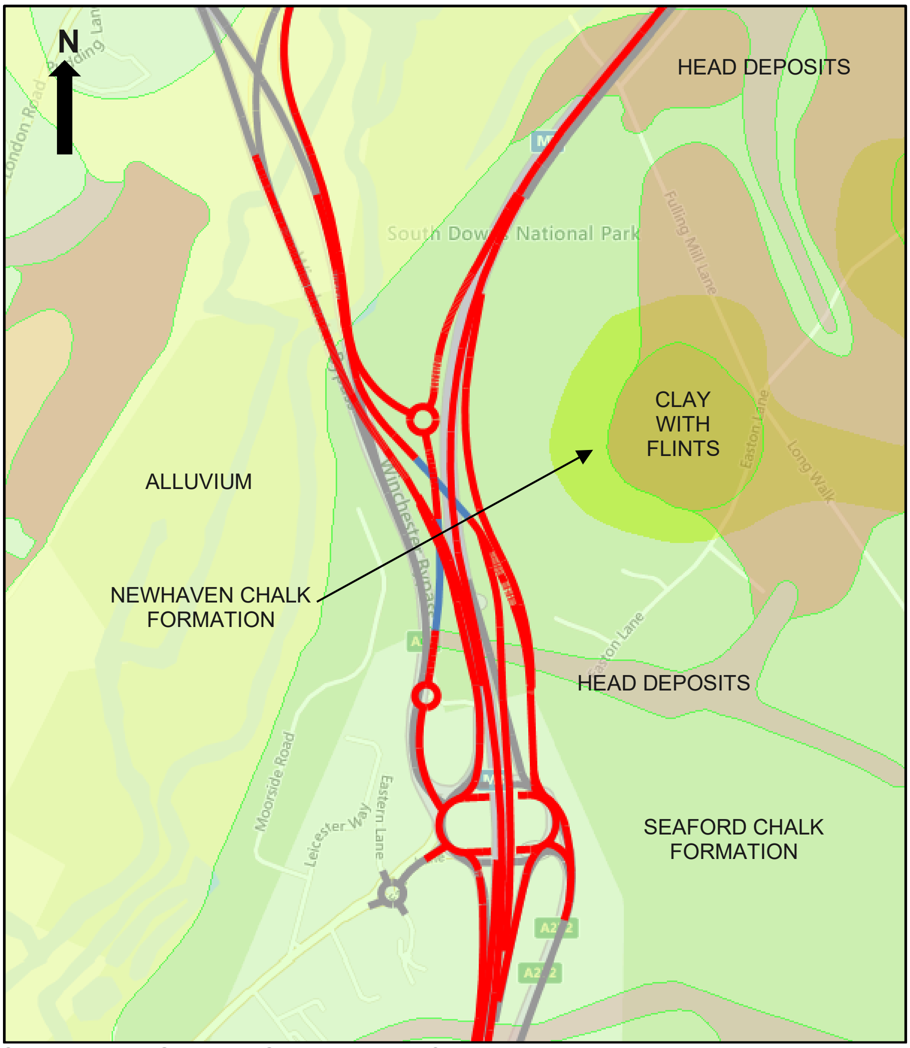
2.2.2 The topography across the Scheme varies significantly. The centre of the M3 Junction 9 roundabout varies between approximately 59.0m Above Ordnance Datum (AOD) at M3 carriageway level and up to 66.0m AOD at roundabout level. The elevation of Easton Lane on the east side of the Scheme is approximately 65.0m. The elevation of the A272 at the M3 junction is approximately 67m AOD and descends to a low point at approximately 60m AOD, 300m south-west of the junction. Elevation of the A34 falls from 67m AOD at the junction with the M3 to approximately 40m AOD at marker post MP1/5 by the Kings Worthy Flyover.

2.3 Geological Maps and Memoirs

2.3.1 The 1:50,000 Series Geological Map Sheet 299 Winchester (BGS, 1975) and memoir (BGS, 2003) indicate that solid geology of the Site is the Seaford Chalk Formation. The geological maps indicate that the site is underlain partly by superficial deposits at the northern end of A34, where the River Itchen crosses the carriageway and in the vicinity the roundabout of Junction 9. The superficial deposits recorded around the A34 comprises Alluvium associated with the River Itchen. The superficial deposits within the vicinity of Junction 9 are recorded as Head Deposits approximately 300m north and 450m south of the junction.

2.3.2 An extract of the BGS geological online mapping is presented below on Extract 1.

Extract 1: Extract of BGS Geological Map with Scheme Overlay



Contains British Geological Survey materials © UKRI [2021]

Made Ground

2.3.3 Made Ground is anticipated to be present within the Scheme extents comprising both Made Ground and Engineered Fill. The Made Ground is anticipated to be present locally across the Scheme comprising a combination of reworked Alluvium, Head Deposits, Clay-with-Flints and Chalk.

Engineered Fill

2.3.4 The Engineered Fill is anticipated to be encountered within the current road alignments and adjacent verges. The Engineered Fill along the Scheme is likely to comprise mainly of chalk fill associated with the construction of the M3 and A34.

Superficial Deposits

2.3.5 The geological maps indicate that there are no recorded areas of superficial deposits within the immediate vicinity of the existing M3 Junction 9 roundabout.

However, where the A34 carriageway crosses the River Itchen, a layer of Alluvium has been recorded, overlying Head Deposits. Two small areas of Head Deposits are recorded approximately 500m north and south of the Junction 9 roundabout within two linear dry valley features. Clay-with-Flints are also recorded within the northern eastern part of the Stage 3B Scheme.

2.3.6 The Alluvium in the area typically comprises clays, silts and sands with various proportions of gravel and pockets of organic material. The materials are overlapping sheets but frequently merging into one another (BGS, 2008).

2.3.7 The Head Deposits comprise sands and gravels. Locally with lenses of silt, clay or peat and organic material. The British Geological Survey (BGS 2008) describe these soils as being formed from material accumulated by down slope movements including landslide, debris flow, solifluction, soil creep and hill wash. They typically composed of very gravelly silty, sandy clay or diamiction, ranging to clayey sandy gravel, all with variable proportions of coarser material. The Head is typically derived by erosion of the Chalk and Palaeogene strata but may well include material reworked from older Quaternary Deposits.

2.3.8 The Clay-with-Flints typically comprises orange brown or reddish-brown clays and sandy clays with abundant nodules and pebbles of flint. BGS 2008 notes the formation is a residual deposit formed from the dissolution, decalcification and cryoturbation of bed rock strata of the Seaford Chalk Formation. Within the area of the Stage 3B Scheme, the formation lies upon the Seaford Chalk Formation with the interface being flat or uneven where it may result in dissolution features upon the Chalk. If the material is soliflucted and comes to rest on an inclined surface on a hillside, the material is classified as Head Deposits rather than Clay-with-Flints (BGS, 2008).

Bedrock Deposits

2.3.9 The Seaford Chalk Formation is a sedimentary bedrock formed approximately 84 to 89 million years ago in the Cretaceous Period. The stratum comprises a firm white chalk with conspicuous semi-continuous nodular and tabular flint seams. Hardground and thin marls are known to be present in the lowest beds of the formation. The Seaford Chalk Formation is typically between 40 to 65m thick in the area of the Scheme, with a generalised dip of between 5 and 10 degrees to the north (BGS, 2002).

Geological Faults

2.3.10 No geological faults have been identified on the geological map of the area.

2.4 Site History

2.4.1 The earliest available OS mapping published in the 1870s shows the Site to comprise agricultural land, woods and coppices present in a rural setting east of Winchester. The first development that occurred within the order limits of the Stage 3B Scheme was the Didcot, Newbury and Southampton GWR railway line in the northern extent of the A34, just to the south of Kings Worthy. A number of roman roads had existed through the early 20th Century within the boundaries of the Scheme, specifically in the area now occupied by the M3 carriageway. It is unknown how these old transport links were decommissioned; therefore, the remnants may still be present beneath the current ground surface. The Winchester Bypass was constructed in the early 1960s followed by the construction of the M3 motorway in the 1980s. Since the construction of the two major roads, no significant development has occurred with the order limits of the Scheme.

2.5 Aerial Photography

2.5.1 Publicly available aerial photography has been reviewed as part of this report, using Google Earth imagery from as early as 1999. The aerial photography typically aligns with the information from the historical maps obtained as part of the PSSR carried out by WSP (WSP, 2017). The aerial photographs show that the area of the Scheme has undergone very little change with the exception of the R&W Traffic Management Yard between the J9 M3 southbound on slip and the A272 between 2008 and 2017.

2.6 Natural and Mining Cavities

2.6.1 The Natural and Mining Cavities Databases, as maintained and updated by Stantec, have been searched for relevant natural and mining cavity records. A search was carried out at a 500m buffer around the proposed route alignment along with a review of the information presented in the PSSR. A technical note highlighting the potential for any mining cavity locations within the Scheme boundary is presented in **Appendix A**.

2.6.2 A review of the PSSR highlighted one natural cavity location 500m west of the Scheme. From a search of a database held by Stantec, this record pertained to a polygon of ten solution pipes up to 500m west of the site. The technical note presented in **Appendix A** summarises the details of the recorded natural cavities within the vicinity of the Scheme.

2.6.3 The PSSR highlighted the present of five chalk quarries located within 500m of the Site, two of which are within 250m of the site and one which is located within 100m of the site. All five records have been recorded as Chalk pits on the historical maps.

2.7 Land Use and Soil Survey Information

2.7.1 The land use on site is dominated by carriageways and associated verges of the A33 and A34. The land immediately surrounding site comprises mostly agricultural land to north and east within the South Downs National Park. Winnall Industrial Estate is immediate to the west of the A34 whilst the city of Winchester is approximately 18.8km to the south-west of the existing M3 Junction 9.

2.8 Archaeological and Historical Investigations

2.8.1 A geophysical survey was carried out by SUMO in 2018 as part of Stage 2 for the M3 Junction 9 improvement. This was followed by a targeted trial trench evaluation carried out by Wessex Archaeology in 2019. The findings of these investigations are presented in the Geophysical Survey Report (WSP, 2018) and the Archaeological Evaluation Report prepared by Wessex Archaeology Ltd (2019).

2.8.2 The investigations identified the remains of a Neolithic or Bronze Age ring ditch which had been partially excavated prior to the construction of the M3. The ring ditch which is centred on SU 495313 is of regional importance as a well-preserved example of its type, which was recorded by Wessex Archaeology to be of particular note due to the indications of comparatively early activity associated with it. It was noted that there were few other archaeological features encountered during the investigation other than several discrete pit-like features, former field boundaries and a parish boundary but these were noted to be of lesser significance.

2.8.3 The trial trench evaluation identified some areas of disturbance from agricultural activity, previous archaeological investigations and construction work associated with the building of the M3, but it was noted by Wessex Archaeology that this has not diminished the potential for significant archaeological remains to survive.

2.9 Previous Ground Investigations

2.9.1 The ground conditions along the current M3 alignment were previously investigated in 1973 by an intrusive ground investigation to provide specific information for the construction of the M3, referenced as M3 Popham to Compton Investigation (GDMS Reference 3212). The scope of the investigation comprised 5 boreholes using rotary coring techniques, 26 boreholes using cable percussion techniques and 10 trial pits.

2.9.2 The ground conditions in the vicinity of the Kings Worthy junction with the A34 were previously investigated in 2020 (GDMS Reference 25799) by an intrusive ground investigation to provide specific information for the proposed upgrade to the road restraint system on the A33 offside verge to protect the piers supporting the A34 over bridge. The scope of the investigation comprised 2 window sample borehole and 2 machine excavated trial pits.

2.10 Soils and Agricultural Land Use

2.10.1 An Agricultural Land Classification (ALC) survey was undertaken in 2017 to identify the ALC baseline of the Site. The survey identified that the site was a mix of Grade 3a (one of the categories of best and most versatile agricultural land (BMV)) and Grade 3b as well as land not classed as agricultural.

2.10.2 In accordance with DMRB guidance LA 109 Geology and Soils (National Highways, 2019), as the Scheme is likely to affect land classified as BMV, further consideration is given within **Chapter 9 (Geology and Soils)** of the **Environmental Statement (Document Reference 6.1)**.

2.11 Designated Sites

2.11.1 The River Itchen is designated a Site of Special Scientific Interest (SSSI) and a Special Area of Conservation (SAC) due to its ecological status. The Scheme only intersects these boundaries where the River Itchen flows underneath the A34. The north eastern part of the Stage 3B Scheme lies within the South Downs National Park (SDNP) and the eastern and south parts of the Stage 3B Scheme border the SDNP.

2.12 Hydrology and Flooding

2.12.1 The PSSR (WSP, 2017) indicates that the River Itchen Flood Plain is located on both sides of the A34 carriageway at the northern end of the study area. The Flood Risk Maps highlight that the areas on either side of the A34 is in a Flood Zone 2 (Extreme Flooding from rivers without flood defences). The Flood Risk Maps presented in the PSSR show that the River Itchen typically floods to the north on a much wider floodplain away from the M3/A34 junction interchange.

2.12.2 There are no known flood defences within the Scheme extents.

2.13 Hydrogeology

2.13.1 The Seaford Chalk Formation is classified as a Principal Bedrock Aquifer, which is defined as an aquifer where layers of rock or drift deposits have a high intergranular and/or fracture permeability, meaning they usually provide a high level of water storage. They may support water supply and or river base flow on a strategic scale. The Head Deposits and the Alluvium are designated as Secondary Aquifer with the Alluvium classified as a Secondary A Aquifer and the Head Deposits a Secondary (undifferentiated) Aquifer. A Secondary A aquifer is defined as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. A Secondary (undifferentiated) Aquifer is defined where it has been assigned cases where it has not been possible to attribute either category A or B to the strata. In most cases, this means that the layer in question has been previously designated as both minor and non-aquifer in different locations due to the variable characteristics of the strata.

2.13.2 The M3 and A34 corridors both pass through Source Protection Zones (SPZ) One and Two towards the northern extent of the Stage 3B Scheme north of the River Itchen. The SPZs are related to groundwater abstraction boreholes operated by Southern Water Services Limited located approximately 75m and 170m to the east of the M3.

2.14 Landfill Sites and Contaminated Land

2.14.1 From review of the PSSR (WSP, 2017), there are four historical landfill sites recorded in the vicinity of the Scheme. One of the historical landfills is recorded on site, on the east side of the current roundabout at Junction 9. This record is named the Spitfire Link landfill; however, there are no details in the PSSR as to when the landfill was operational or the waste that was received. The western part of the Spitfire Link landfill, which is located within the Scheme, was investigated by Soils Limited (Soils, 2020) with six exploratory holes undertaken within or immediately adjacent to the mapped extents of the landfill. No evidence of waste was indicated on those exploratory hole records.

2.14.2 The closest off-site record pertains to a landfill recorded adjacent to the Winchester Bypass located immediate to the east of the bypass. This historical landfill was recorded operation between July 1967 and July 1968 and received inert waste. Another smaller historical landfill is recorded just to the west of the A34, just north of the Winnall Industrial Estate, however, has no records when it was operational, or the waste received.

2.15 Unexploded Ordnance (UXO) Risk

2.15.1 A detailed UXO Assessment for the Scheme was undertaken by Zetica UXO in June 2018 prior to the ground investigation (Zetica, 2018) and is included in Appendix D of the Factual Report. The study concluded that the residual risk posed by UXO was low and that no further risk mitigation was required. The report states no military activity was identified on or affecting the Site area Pre-WWI nor during WWI. The WWI strategic targets identified within 5km of the Site comprised the following:

- Winnal Down Camp established in close proximity of the site. This was one of several camps in the vicinity of the Site, including those at Magdalen Hill and Avington
- The former GWR line, running across the western part of the Site, was used for transporting troops from regional military camps to the southern coast embarkation ports during WWI.

2.15.2 Within Scheme extents neither Pre-WWII nor WWII military activity on or affecting the Site was identified. There were a number of air raid incidents detailed in the vicinity of the site as detailed in maps within the detailed UXO Assessment.

3 Field and Laboratory Studies

3.1 Walkover Survey

3.1.1 A walkover survey was carried out before commencement of the 2019 ground investigation to confirm the access arrangement for the ground investigation. The walkover was attended by a representative of the Jacobs, the ground investigation contractor and a representative of the National Highways. At the time of writing this report, Stantec are unaware of any additional walkover surveys and have not conducted any walkover surveys themselves.

3.2 Geomorphological / Geological Mapping

3.2.1 No geomorphological or geological mapping has been undertaken as part of this Scheme.

3.3 Ground Investigation

3.3.1 Further details on the scope of the ground investigation are presented in the Ground Investigation Specification (Jacobs, 2018). The objective of the ground investigation was to investigate the locations of the principal geotechnical elements of the Stage 3A Scheme in order to provide information on the ground conditions required to develop and inform the design.

3.3.2 Since the completion of the ground investigation in 2019, the design of the Scheme has changed and therefore, the ground investigation carried out does not provide adequate spatial or depth of investigation coverage for the design of all the geotechnical elements of the Stage 3B Scheme.

3.3.3 The factual results of the investigation are presented in a report prepared by Soils Ltd (GDMS Ref, 32506) which should be read in conjunction with this report.

3.3.4 The aims of the ground investigation as set out in the Jacobs Ground Investigation Specification were to establish the ground conditions, suitability of the natural geological strata as a founding stratum and confirm the presence of and quantify the natural and likely extent of potential contaminants identified in a desk study.

3.3.5 The works carried out as part of the ground investigation comprised the following:

- Utility service clearance at all exploratory hole locations using a cable Avoidance tool (CAT) at inspection pit locations and at the base of the inspection pits.
- Provide unexploded ordnance awareness briefing to site staff at commencement of the works, prior to undertaking excavations:

- Thirty-two boreholes using a combination of dynamic sampling and rotary coring techniques to a maximum depth of 30m below existing ground level with standard penetration testing and the recovery of soil samples
- Seven windowless sampling boreholes to a maximum depth of 7m below existing ground level with standard penetration testing and the recovery of soil samples
- Eleven machine excavated trial pits with the recovery of soil samples.
- Variable head permeability testing in six selected boreholes at selected depths.
- Installation of standpipes and standpipe piezometers in selected boreholes and return site visits to monitor groundwater levels.
- A suite of geoenvironmental and geotechnical testing on selected soil samples.

3.3.6 Exploratory hole plans including locations from previous ground investigations have been produced as Drawings HE551511-VFK-HGT-X_XXXX_XX-DR-GE-0001 to 0004.

Description of Fieldwork

3.3.7 The ground investigation was carried out on the Site between 11March 2019 and the 5June 2019 by Principal Contractor Geoffrey Osborne Limited employing ground investigation contractors Soils Limited and SM Associates under the technical instruction of Jacobs

3.3.8 The boreholes were sunk using a tracked multi-purpose rig to a maximum depth of 30m below existing ground level using varying combinations of dynamic sampling and rotary coring techniques. The ground conditions were investigated by the recovery of open drive UT100 samples, disturbed small and bulk samples and standard penetration tests carried out using either a split spoon sampler or solid cone. On completion, standpipes were installed in twenty-four boreholes with response zones varying in depth between 3.0m and 30.0m below ground level. Other boreholes were backfilled with bentonite pellets and the surface reinstated.

3.3.9 Dynamic sampling boreholes were sunk using a small tracked rig to maximum depth of 7.0m below ground level (bgl). The ground conditions were investigated by recovery of disturbed small and bulk samples and standard penetration tests carried out using either a split spoon sampler or solid cone. On completion, all exploratory holes were backfilled with bentonite pellets and the surface reinstated.

3.3.10 The trial pits were excavated using a hydraulic excavator to depth of 4.0m below existing ground level to obtain detailed information on the near-surface ground conditions. On completion, the trial pits were backfilled with the arisings and compacted by the excavator every 300mm.

3.3.11 Five post fieldwork groundwater level and gas monitoring visits were carried out on twenty-one of the twenty-four boreholes with monitoring installations by Soils Limited between 13 June 2019 and 12 July 2019. Installations have been recorded in boreholes DS101, DS111 and DS209, however, have not been monitored as part of the post fieldwork monitoring. At the time of writing this report, it is unclear as to why the remaining three boreholes were not monitored during the post fieldwork monitoring. A summary of the groundwater levels monitored over this period are summarised in **Section 4** and presented in the **Table 4.1**.

3.3.12 Data loggers for groundwater monitoring were installed in 5 boreholes (DS301, DS302, DS114, DS104 and DS109A) on completion of the boreholes. In addition, baro loggers were also installed in boreholes DS301 and DS109A to measure the changes in atmospheric pressure in the boreholes during the monitoring period. Data was collected on the loggers between 15th June 2019 to 24 August 2020 at hourly intervals. The data is summarised in the **Table 4.1** below and presented on plots on **Figure 1a** and **Figure 1b**.

Ground Investigation Factual Report

3.3.13 All details of the ground investigation can be found in the Factual Report produced by Soils Limited (GDMS Ref. 32506).

In-situ Testing

3.3.14 Standard Penetration Tests (SPTs) were carried out in all boreholes at scheduled 1.5m intervals to determine the penetration resistance to correlated with geotechnical parameters. The SPTs were carried out in accordance with BS, EN ISO 22476-3: 2005 *'Geotechnical investigation and testing – Field testing Part 3: Standard penetration test'*. SPT results have been discussed in Section 5, Ground Conditions. Four SPT hammers were used in the ground investigation with energy ratios ranging between 68 and 82 per cent.

3.4 Drainage Studies

3.4.1 A total of 5 falling head tests were undertaken in boreholes DS104, DS107, DS109, DS210 and DS301. The falling head tests were undertaken in accordance with BS EN 22282-1:2012 '*Geotechnical investigation and Testing-geohydraulic testing. General Rules*'. The results of the tests are discussed in **Section 9.8** of this report and presented in the Factual Report prepared by Soil Ltd.

3.5 Geophysical Surveys

3.5.1 No geophysical surveys were undertaken a part of the ground investigation

3.6 Pile Tests

3.6.1 No pile tests were undertaken as part of the ground investigation

3.7 Other Fieldwork

3.7.1 No other fieldwork undertaken.

3.8 Laboratory Investigations

Geotechnical Laboratory Testing

3.8.1 Geotechnical laboratory soils testing was carried out to verify the visual identification and classification, and to determine the physical properties of selected samples of the materials encountered. The testing was scheduled by Investigation Supervisor (Jacobs) and carried by Geo Site & Testing Services Limited out in accordance with BS 1377 (1990) or, where superseded, by BS EN ISO 17892. Geo Site and Testing Services Limited hold UKAS accreditation for the geotechnical soil testing carried out (certificate reviewed online). The results of the geotechnical testing are presented in the factual report. The geotechnical tests have been summarised in **Table 3.1**.

Table 3.1 Summary of geotechnical testing

Property	Test Method	Number of Tests
Moisture Content	BS 1377:1990 Part 2	220
Liquid and Plastic Limit	BS 1377:1990 Part 2	51
Intact Dry Density	ASTM	43
Particle Size Distribution (PSD)	BS 1377:1990 Part 2	10
Dry Density / Optimum Moisture Content Relationship	BS 1377:1990 Part 4	34
Moisture Condition Value / Moisture Content Relationship	BS 1377:1990 Part 4	28
One Dimensional Consolidation	BS 1377:1990 Part 5	6
Consolidated Undrained Triaxial Compression	BS 1377:1990 Part 8	15
Uniaxial Compressive Strength	ISRM	5
Chalk Crushing Value	ISRM	1
Sulphate and pH	BRE Suite C	57
	Within Geoenvironmental testing suite	126

Geoenvironmental Laboratory Testing

3.8.2 Geoenvironmental testing was also carried out to determine the concentrations of contaminants of selected samples of soil and samples of groundwater. The testing suite comprised a range of heavy metals, inorganic and organic compounds, and for soils an asbestos screen. The testing was scheduled by the Investigation Supervisor (Jacobs) and carried out by DETS who hold UKAS and MCERTS accreditation for the geoenvironmental testing carried out. The results of the geoenvironmental testing are presented in the factual report. A summary of the testing carried out is in **Table 3.2** below:

Table 3.2 Summary of Geoenvironmental Testing

Samples	Testing	Number
Soil	Soil Suite	126
	WAC Testing	73
Groundwater	Water Suite	9

3.8.3 It should be noted that a second round of groundwater sampling is referred to in the Factual Report, however the results of the testing were not included. Stantec requested the missing data, however National Highways and Osbornes have confirmed that the testing results of the second round of groundwater sampling are not available. Therefore, the information on the groundwater testing in this report pertains to the first round of groundwater laboratory results only.

3.9 Review of the 2019 Ground Investigation Factual Report

3.9.1 Current good practice for the investigation and assessment of chalk, and for geotechnical design in chalk for foundations, retaining structures and earthworks is predicated on the recommendations given in CIRIA Report C574 *Engineering in Chalk* (CIRIA 2002). The report draws on and brings together previous research and guidance including that from the then named Transport Research Laboratory and Department of Transport.

3.9.2 Chalk as an engineering material in nature in the ground exhibits a wide range of mechanical and physical properties varying from a putty like clay and silt size matrix (that has properties akin to a soil and is called structureless chalk) to a relatively intact calcareous rock (structured chalk) such as that forming much of our coastal scenery. There are a whole range of gradations between these two types. Good practice in the selection of appropriate geotechnical parameters for engineering design in Chalk depends on the “recommended engineering classification of chalk” as set out in Section 3.3.6 of CIRIA 2002. The classification is based on a structured scheme of engineering geological description of the chalk and for structured chalk its intact dry density (see below for **Figure 9.1** (**Extract 2**) and **Table 9.2** (**Extract 3**) from CIRIA C574).

Extract 2: Engineering classification of chalk (CIRIA C574)

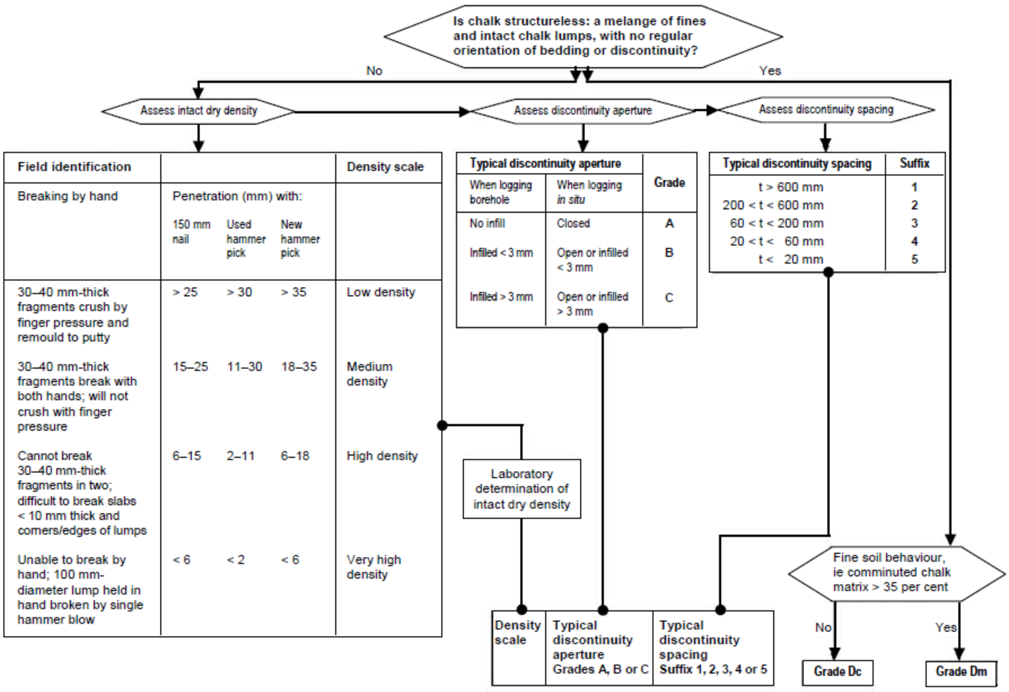


Figure 9.1 *Engineering classification of chalk (also Figure 3.1)*

Extract 3: Methods of identifying chalk density in the field to be backed up by laboratory measurements of intact dry density (CIRIA C574)

Table 9.2 *Methods of identifying chalk density in the field, to be backed up by laboratory measurements of intact dry density (based on Bowden* et al, *2002 and Matthews* et al, *1993, also Table 3.7)*

	CIRIA density class			
Identification method	**Low-density**	**Medium-density**	**High-density**	**Very-high-density**
Intact dry density(2)	< 1.55 Mg/m³	1.55 – 1.70 Mg/m³	1.70–1.95 Mg/m³	> 1.95 Mg/m³
Porosity(12)	> 0.43	0.43–0.37	0.37–0.28	< 0.28
Saturation moisture content(12)	> 27.5 per cent	27.5–21.8 per cent	21.8–14.3 per cent	< 14.3 per cent
Approximate UCS(3)	< 3 MN/m²	3–5 MN/m²	5–12.5 MN/m²	> 12.5 MN/m²
BS5930 strength term	Very weak and lower end of weak	Upper end of weak	Moderately weak	Moderately strong
Ease of breaking fragments (9)	30–40 mm-thick fragments can be crushed between finger and thumb, and remould to putty(4)	30–40 mm-thick fragments can be broken in two using both hands, but cannot be crushed between finger and thumb(4)	30–40 mm thick fragments cannot be broken in two(4). Only thin slabs < 10 mm thick, and corners and edges of lumps can be broken with difficulty using both hands	Cannot be broken by hand. 100 mm-diameter lump can be broken by a single hammer blow when held in the palm of the hand(5)
150 mm nail penetration (6) (7) (10)	> 25 mm putty, formed around nail	15–25 mm	6–15 mm	< 6 mm
Used hammer pick penetration(7) (8) (11)	> 30 mm, chalk splashes	11–30 mm	2–11 mm	< 2 mm
New hammer pick penetration(7) (8) (11)	> 35 mm, chalk splashes	18–35 mm	6–18 mm	< 6 mm

3.9.3 It is important to note however, that many methods of ground investigation involve relatively small diameter borehole drilling methods to recover samples of the ground. Chalk being often a very weak broken and fractured rock is very susceptible to disturbance caused by the drilling and sampling process such that the samples recovered do not reliably reflect the actual characteristics and properties of the chalk as it is present in the ground in its undisturbed state. Structured chalk of a high classification grade can be broken up by the investigation process to provide a lower grade or a structured chalk could be recovered as a structureless chalk by some drilling processes. Some methods of investigation may not recover the weaker grades of chalk at all, leaving just a few of the stronger intact lumps in the sample.

3.9.4 Consequently, investigative methods such as trial pitting or large diameter bored shafts are preferred for reliable visual description of the Chalk in-situ or if such techniques are impractical or not available then large diameter high quality rotary core drilling with an appropriate core barrel and suitable flushing medium should be used to recover a sample that is as little disturbed as possible. The Factual Report does not provide any information on the rotary coring method or the core diameters adopted.

3.9.5 We have reviewed the ground investigation methods adopted in the 2019 investigation and assessed the descriptions of chalk and its classification given on the exploratory hole records under the CIRIA scheme.

3.9.6 The descriptions of the chalk grades across the Scheme are inconsistent, often providing a range of grades or the grade classification is missing altogether from the description. For example, from review of the total core recovery (TCR) with the description, some of the descriptions do not match up with the TCR. In areas where Grade A chalk has been recorded you would expect to see TCR between 80-100 per cent, in some areas TCR is down between 0 and 25 per cent. Therefore, it is difficult to contemplate that a Grade A chalk in the ground would have such a low core recovery. Without commentary in the report text it is often unclear whether the description on the exploratory hole record reflects the characteristics of the chalk material as recovered at the surface, or whether that is an interpretation of the in-situ chalk and its grade. There are examples where the chalk descriptions on the exploratory hole records do not comply with the descriptive and classification scheme set out in CIRIA C574. There are no trial pit photographs in the Factual Report to aid interpretation.

3.9.7 It was noted that there is a fundamental inconsistency in the description of the chalk matrix, the material sampled from boreholes has been described as being recovered as a clay, whereas the material described from the trial pits has been described as recovered as a silt. Based on CIRIA C574 chalk matrix is described as silt.

3.9.8 In addition, there are concerns with the reported results of the intact dry density testing where the measured natural moisture contents in some of the samples have been reported as being greater than their saturation moisture content. This would indicate that the moisture content of the chalk in the ground is greater than its theoretical moisture content if all the voids were filled with water.

3.9.9 Therefore, for the purposes of this report, the engineering assessment of Seaford Chalk Formation has been simplified, with Chalk classified as either structureless or structured.

3.9.10 Six exploratory holes (DS103, DS104, DS105, DS112, TP02 and DS204) were completed to the south-east of the River Itchen, all with very similar descriptions for the superficial deposits. However, some of the descriptions on the borehole records have identified the material encountered (essentially similar throughout) as Alluvium and others as Head Deposits. The descriptions of the materials encountered are more typical of a Head Deposit rather than Alluvium.

3.9.11 From review of the descriptions of the Alluvium in exploratory holes to the north of the River Itchen (WS02 and WS03), the material differs greatly compared to the soils interpreted as Alluvium to the south east of the river.

3.9.12 Therefore, for the purposes of this Ground Investigation Report based on the review of the descriptions in conjunction with the topographical setting, Stantec has reassessed the geological strata names for the superficial deposits south east of the river, as Head Deposits with the exception of the materials encountered in DS103 and DS112 which could plausibly be Alluvium due to their proximity to the River Itchen and ground elevation.

3.9.13 Stantec has also identified a discrepancy in the description of the Made Ground across the Scheme. Stantec has identified that typically the Made Ground located along the M3 and A34 which is greater than 1.0m in thickness is likely to be Engineered Fill. For the purposes of this report anthropogenic Made Ground is defined as soils containing anthropogenic material, whereas Engineered Fill is defined as soils from existing earthworks comprising primarily of chalk. Engineered Fill has been identified in two boreholes along the M3 (DS217 and DS218) typically comprising structureless Chalk recovered as Gravel with lenses of sand and clays. Engineered Fill has been located along the A34 in five boreholes (DS101, DS111, WS02, WS03, WS08) and typically comprises structureless chalk again with lenses of sand and clay and occasional Peat.

3.9.14 An exploratory hole (WS03) located along the A34 did not fully penetrate the encountered Peat. In addition, laboratory testing was not carried out on the Peat for classification.

3.9.15 Within the laboratory testing, consolidated undrained triaxial compression tests were carried out on 7 samples of remoulded structureless chalk and 5 samples of undisturbed structured chalk to provide an angle shearing resistance and the effective cohesion. However, the tests that were carried out were single stage triaxial tests rather than multistage tests, meaning a value for angle of shearing resistance or effective cohesion could not be provided directly from the testing. Additional analysis is required to derive the angle of shearing resistance and cohesion from these test results.

3.9.16 Consolidated undrained triaxial tests on the undisturbed structured chalk were only undertaken on samples obtained from thin walled push or UT100 samples. The sampling techniques adopted are biased towards obtaining sample from the weaker chalk and will have been disturbed during the sampling process. In addition, no core subsamples were tested. Therefore, it is unlikely that the test results are characteristic of the mass properties of the structured chalk.

3.9.17 Stantec has identified that a number of groundwater records provided in the Factual Report are incorrect. The record for DS212 on the 13/06/19 is recorded at 21.51m below ground level, however, the groundwater monitoring standpipe was only installed to 10.50mbgl. This record may pertain to DS213 (which had an installation to 30m bgl) rather than DS212. The result on the 19/06/19 for DS212 is recorded at 11.38m also is below the installation depth and again may be a mistaking in the reporting.

4 Ground Summary

4.1 Geology

4.1.1 The ground conditions in the area of the Scheme as revealed by the ground investigations indicate that the Scheme typically lies on areas of Made Ground/Engineered Fill overlying Seaford Chalk Formation. However, locally around the River Itchen the Scheme lies on Alluvium and Head Deposits are present also over the Seaford Chalk Formation near the river. These ground conditions generally agree with the published geological information for the area.

4.1.2 In the text below descriptions of the strata encountered are based on the soil descriptions provided on the exploratory hole records in the Factual Report, and it is noted that some of the descriptions do not always comply with the descriptive schemes set out in BS EN ISO 14688-1, BS EN ISO 14688-2 and CIRIA C574.

4.1.3 Drawings indicating the geological strata encountered in each borehole, as well as cross-sections and long-sections are presented in the **Drawings** section of this report.

- HE551511-VFK-HGT-X_XXXX-XX-DR-GI-0001 – Geological Plan.
- HE551511-VFK-HGT-X_XXXX-XX-DR-GI-0021 to 023 – Geological Cross-sections
- HE551511-VFK-HGT-X_XXXX-XX-DR-GI-0031 to 034 – Geological Long-sections.

Topsoil

4.1.4 Topsoil was encountered in 16 of the 53 boreholes completed during the 2019 ground investigation (DS103, DS107, DS114, DS203, DS206, DS208, DS209, DS210, DS211, DS212, DS213, DS216, DS301, TP03, TP04 and WS04). Topsoil was encountered between ground level and 0.45m below ground level, typically comprising a dark brown slightly clayey gravelly SAND or a dark brown sandy gravelly CLAY. The average thickness of Topsoil encountered in the exploratory holes is approximately 0.3m.

Made Ground

4.1.5 Made Ground was encountered in 31 of the 53 boreholes completed during the 2019 ground investigation (DS101, DS104, DS108, DS109, DS109A, DS110, DS111, DS115, DS204, DS214, DS214A, DS215, DS217, DS218, DS219, DS220, TP02, TP05, TP06, TP07, TP08, TP09, TP10, TP11, TP12, WS01, WS02, WS03, WS06, WS07, WS08). The Made Ground was encountered between ground level and 4.20m below ground level. The Made Ground varies greatly along the Scheme, with varying amounts of fine and granular material along with horizons of organic material and structureless chalk.

Engineered Fill

4.1.6 Made Ground, which has been identified as Engineered Fill, was encountered in 7 of the 31 boreholes (DS111, DS217, DS218 along the M3 and WS01, WS02, WS03 and WS04 along the A34). The Engineered Fill was encountered between ground level and 11.35m below ground level. The material typically comprised structureless chalk recovered as clayey GRAVEL with occasional fine to coarse angular flint. However, along the A34 lenses of organic soil described as Peat were recorded within the fill material.

Alluvium

4.1.7 Alluvium was encountered in 7 of the 53 boreholes completed during the 2019 investigation (DS101, DS103, DS111, DS112, DS218, WS02 and WS03). Alluvium was encountered within the vicinity of the River Itchen described as containing horizons of both granular and cohesive material as well as organic material. The material was typically interbedded and encountered between ground level and 9.15m bgl. The cohesive material typically described as comprising variably soft and firm slightly sandy gravelly silty CLAY with occasional silty organic material. Gravel is fine to coarse angular to rounded of flint and chalk. The granular material was described as comprising slightly clayey sandy GRAVEL with a low cobble content. Gravel is fine to coarse angular to rounded of flint and chalk.

4.1.8 The Peat was typically encountered to the north of the River Itchen (WS02, WS03, DS111 and DS218). The thickness of the Peat was proved to range from 0.25m to 1.55m and was encountered at depths between 2.9m and 5.95m below existing ground level. The base of the Peat was not proven in WS03. The organic material was typically found beneath a layer of Engineered Fill that likely forms part of the road embankment. The material generally comprises either a spongy plastic brown pseudo fibrous PEAT or a firm slightly sandy slightly gravelly fibrous PEAT.

Head Deposits

4.1.9 Head Deposits were encountered in 14 of the 53 exploratory holes completed as part of the 2019 investigation (DS104, DS105, DS204, DS205, DS206, DS207, DS211, DS216, DS302, TP02, TP08, TP10, WS05 and WS08). The Head Deposits were encountered locally across the Scheme but typically encountered to the south and east of the River Itchen. The Head Deposits have been described as comprising both cohesive horizons and granular horizons, all typically interbedded. The Head Deposits were encountered between ground level and 10.00m bgl. Where encountered, the Head Deposits were generally less than 1m in thickness except in the exploratory holes (DS104, DS105, DS204, TP02 and WS08) which are located near to the A34 on the western extent of the Scheme. In this area the Head Deposits were proved to be between 6m (DS105) and 10m (DS104) thick. The full extent of the Head Deposits was not fully penetrated in all of these boreholes near to the A34.

4.1.10 The cohesive strata were typically described as a soft to firm brown sandy gravelly CLAY Sand and gravelly portions vary from slightly to very sandy/gravelly and typically comprises fine to coarse, angular to subrounded flint and chalk. The granular strata were typically described as a brown clayey gravelly SAND. Gravel is fine to coarse, angular to subrounded of flint and chalk.

Seaford Chalk Formation

4.1.11 As discussed in **Section 3.9** of this report, there are inconsistencies in the fieldwork descriptions and the assigned CIRIA grades of chalk, along with the reservations about the laboratory testing information provided. For the purposes of this report, chalk has been categorised as either Structureless Chalk or Structured Chalk. Structureless Chalk is that which has been described by the ground investigation contractor as Grade Dc or Dm. Structured Chalk is that where the ground investigation contractor has assigned grades, Grades A-C. Where no grading is assigned then the soil descriptions have been used to determine whether the Chalk is likely to be structured or structureless.

4.1.12 The Seaford Chalk Formation was encountered in all boreholes below the Topsoil or Made Ground or where the superficial deposits were fully penetrated. The chalk was investigated to between 0.25m and 30.45m depth below ground level.

4.1.13 The ground investigation contractor described Grade Dc chalk as recovered as an off white sandy silty fine to coarse subangular to subrounded chalk clast GRAVEL. Clasts are very weak to weak medium to high density with rare angular fine to coarse flints.

4.1.14 The ground investigation contractor described the Grade Dm chalk as recovered as off white or light brown sandy gravelly SILT/CLAY. Gravels are fine to coarse angular to subrounded very weak to weak low to high density chalk clast with rare angular flint.

4.1.15 The Structured Chalk typically comprises very weak to weak low to medium density white very lightly speckled black CHALK (assigned as Grades A2-C3) in the Factual Report. It should be noted that some of the descriptions are likely to have been based on heavily disturbed samples caused by the drilling techniques adopted during the ground investigation.

4.2 Hydrogeology

4.2.1 **Groundwater Entries:** During the ground investigation, groundwater was only encountered in three of the boreholes during drilling (WS02, WS03, WS08). Groundwater was encountered between 3.1m and 7.0m below ground level, recorded as seepage in all three boreholes. All three window sample boreholes are located along the A34 within the flood plain of the River Itchen.

4.2.2 **Groundwater Levels:** Throughout the fieldwork groundwater monitoring was carried out on completion of the boreholes daily between the 18 March 2019 and 15 April 2019. The groundwater from during the fieldwork are presented in

Appendix A.2 of the Factual Report (Soils, 2020). On completion of the fieldwork, groundwater monitoring was undertaken between 12 June 2019 and 12 July 2019 on five occasions. Groundwater was recorded in 4 of the 5 boreholes installed with data loggers, DS109A was recorded as dry. Groundwater measured between 2.60m and 28.80m bgl across the Scheme. A summary of the groundwater monitoring is presented in **Table 4.1** below.

Table 4.1 Summary of Post Fieldwork Groundwater Level Monitoring

Borehole	Ground Level, m OD	Base of Installation Level, m OD	Water level, m OD (m bgl)	
			Min	Max
DS104*	42.67	27.67	37.20 (5.43)	38.84 (3.83)
DS108	54.42	39.42	DRY	DRY
DS109A	65.18	44.68	Dry	44.55 (20.63) #
DS110	65.87	35.87	37.07 (28.80)	37.35 (28.52)
DS112	40.36	20.86	37.52 (2.84)	37.71 (2.65)
DS114*	48.66	29.16	37.17 (11.49)	38.99 (9.67)
DS115	62.23	42.73	DRY	DRY
DS203	57.43	51.43	DRY	51.39 (6.04) #
DS204	42.95	36.75	36.77 (6.18) #	37.54 (5.41)
DS205	69.19	49.89	DRY	DRY
DS206	56.88	50.88	DRY	DRY
DS207	64.65	58.65	DRY	58.76 (5.89) #
DS208	57.91	51.91	DRY	52.04 (5.87) #
DS210	61.41	55.41	DRY	55.41 (6.00) #
DS211	63.53	57.53	DRY	DRY
DS212	61.78	51.28	DRY	51.28 (10.50) #
DS213	58.82	28.82	37.03 (21.79)	37.34 (21.48)
DS215	61.10	55.10	DRY	DRY
DS216	49.01	34.01	37.28 (11.73)	37.45 (11.56)
DS301*	55.62	25.62	37.42 (18.19)	39.21 (16.41)
DS302*	55.70	25.70	37.32 (18.38)	39.38 (16.32)

Borehole	Ground Level, m OD	Base of Installation Level, m OD	Water level, m OD (m bgl)	
			Min	Max
Note: * denotes monitoring point installed with data loggers. # indicate groundwater in base of borehole and unlikely to be true reflection of groundwater levels				

4.2.3 The data in the above plots is summarised on **Figure 1a** and **Figure 1b**.

4.2.4 Groundwater was encountered within both the superficial deposits and the chalk at varying depths across the Scheme. The groundwater was recorded closest to existing ground level around the River Itchen within the superficial deposits. The groundwater was also recorded at varying depths within the Seaford Chalk Formation between 5.90m bgl and 28.80m bgl. The groundwater in the chalk was recorded at its highest elevation in DS203 along the M3 at northern end of the Scheme.

4.3 Visual and Olfactory Evidence of Contamination

4.3.1 Made Ground was encountered across the Scheme in a number of exploratory hole locations down to a maximum depth of 4.50m below ground level. This was generally found to be related to the existing road construction and any embankments constructed for the current infrastructure. It was recorded in the logs that no other visual or olfactory evidence of contamination was found.

4.4 Site Specific Ground Models

4.4.1 Based on the information from the recent and historical ground investigations, the ground conditions along the Scheme have been split between three areas of the Scheme in accordance with the differing geology, see Drawing HE551511-VFK-HGT-X_XXXX-XX-DR-GI-0020 (Areas A, B and C). Geological cross-sections and long-sections are presented on Drawings HE551511-VFK-HGT-X_XXXX-XX-DR-GI-0021 to 23 and HE551511-VFK-HGT-X_XXXX-XX-DR-GI-0031 to 34, respectively.

North and West of the River Itchen (Area A)

4.4.2 Based on the information obtained from the ground investigation the area to the north and west of the River Itchen is likely to comprise a layer of Engineered Fill over Alluvium over the Seaford Chalk Formation. The details of the geological strata are summarised in **Table 4.2** below:

Table 4.2 Summary of the Ground Conditions to the North and West of the River Itchen (Area A).

Strata	Depth to Top (m bgl)	Depth to Base (m bgl)	Thickness (m)	Typical GI Contractor Description
Engineered Fill	0.00	1.20 – >7.00	1.20 – >7.00	Off white mottled grey and brown structureless CHALK recovered as slightly clayey silty sandy GRAVEL. Gravel is fine to coarse subangular to subrounded chalk and flint. Locally recovered as a gravelly sandy silty CLAY.
Alluvium	0.30 - 4.65	5.00 – 9.00	2.70 - 7.80	Interbedded layers of: Soft to firm light brown and greyish brown slightly sandy gravelly silt CLAY. Gravel is fine to coarse angular to rounded of flint. Multicoloured slightly silty clayey sandy GRAVEL. Gravel is fine to coarse angular to subrounded of flint with low cobble content Plastic dark brown pseudo fibrous PEAT with fine gravel of chalk and flint.
Structureless Seaford Chalk Formation	5.34 - 7.10	6.23 – >15.00	0.89 – >7.00	Off white to yellowish brown structureless CHALK recovered as slightly gravelly silty clay. Gravel is fine to coarse subrounded to rounded Off white to orangish brown structureless CHALK recovered as slightly sandy silty GRAVEL and COBBLES. Clasts are very weak to weak medium to high density subrounded chalk.
Structured Seaford Chalk Formation	6.23 – 8.55	>19.95	>13.72	Very weak and weak low and medium density white unstained CHALK

4.4.3 However, boreholes completed in this area did not reach sufficient depth to be able to provide appropriate information for the foundation design of the proposed footbridge across the River Itchen. The deeper boreholes are located too far north of the proposed footbridge and therefore, the quality of the Chalk has not been assessed in the vicinity of the proposed footbridge. In addition, the boreholes along the A34 also do not fully penetrate the Peat, therefore, the extent of the Peat around the River Itchen is also unknown.

Area between A34 and M3 (Area B)

4.4.4 Based on the information from the ground investigation, the area to the south of the River Itchen between A34 and M3 and directly north of the National Highways Depot, is likely to be underlain by Alluvium, close to the river, over Head Deposits over the Seaford Chalk Formation. The details of the geological strata are summarised in **Table 4.3** below:

Table 4.3 Summary of the Ground Conditions between A34 and M3 (Area B)

Strata	Depth to Top (m bgl)	Depth to Base (m bgl)	Thickness (m)	Typical Gi Contractor Description
Topsoil / Made Ground	0.00	0.30 - 0.35	0.30 -0.35	Grass over dark brown soft to firm slightly gravelly clayey SAND. Gravel is fine to coarse subangular to sub round of flint and brick
Alluvium	0.30	6.00	5.70	Light brown clayey gravelly SAND. Gravel is fine to coarse and angular of flint and chalk Soft light brown slightly sandy to very sandy gravelly to very gravelly silty CLAY. Gravel is angular to subrounded fine to coarse flint and chalk.
Head Deposits	0.00 – 0.30	4.00 – 10.00	3.70 – 9.70	Interbedded: Soft to firm light brown slightly sandy slightly gravelly to very gravelly silty CLAY. Gravel is fine to coarse angular to subrounded of chalk and flint. Light brown clayey SANDS and GRAVELS. Gravel is fine to coarse angular to subrounded of chalk and flint

Strata	Depth to Top (m bgl)	Depth to Base (m bgl)	Thickness (m)	Typical Gi Contractor Description
Structureless Seaford Chalk Formation	0.35 - 6.00	1.20 - 8.00	0.95 -2.00	Structureless CHALK recovered as silty subangular and subrounded fine to coarse GRAVEL. Gravel is very weak low-density white chalk. Matrix is greyish brown
Structured Seaford Chalk Formation	1.20 – 10.00	>15.45	>9.55	Very weak and weak low and medium density white locally stained orangish brown and lightly speckled CHALK.

Remainder of the site (Area C)

4.4.5 Based on the information within the ground investigation, the geology across the majority of the Site typically comprised a layer of Made Ground or Topsoil over the Seaford Chalk Formation. The only exception is to the north of Junction 9 where the exploratory hole has been positioned within the road embankment. Across the Scheme where within the road embankments, the ground conditions will typically comprise a thickness of Engineered Fill over the Seaford Chalk Formation. The details of the geological strata are summarised in **Table 4.4** below:

Table 4.4 Summary of the Ground Conditions across the remainder of the site (Area C)

Strata	Depth to Top (m bgl)	Depth to Base (m bgl)	Thickness (m)	Typical GI Contractor Description
Made Ground (Hard Standing)	0.00	0.45 – 0.50	0.45 – 0.50	Tarmac over Concrete over subbase comprising of light orangish greyish brown sandy GRAVEL.
Made Ground (Grassed)	0.00	0.25 – 0.50	0.25 – 0.50	Grass over dark brown slightly gravelly organic clayey SAND. Gravel fine to coarse angular to subrounded of flint and brick.
Engineered Fill (DS217)	0.45	11.35	10.90	Weak low density white lightly speckled black CHALK recovered as silty angular to

Strata	Depth to Top (m bgl)	Depth to Base (m bgl)	Thickness (m)	Typical GI Contractor Description
				subrounded fine to coarse gravel.
Head Deposits	0.00 – 0.5	0.3 – 0.8	0.10 – 0.50	Soft to firm light brown gravely sandy CLAY or clayey SAND. Gravel is fine to coarse angular to subrounded of flint and chalk.
Structureless Seaford Chalk Formation	0.25 – 11.35	0.50 – 13.24	0.20 – 5.45	Interbedded: Structureless CHALK recovered as off white to white of slightly sandy silty GRAVELS and COBBLES. Clasts are very weak to weak low to high density. Rare to occasional fine o coarse subangular to subrounded flint. Structureless CHALK recovered as off white to light brown sandy gravelly SILT / CLAY. Gravel is fine to coarse angular to subrounded chalk and flint. Chalk is very weak to weak medium density subangular fine to coarse with rare cobbles.
Structured Seaford Chalk Formation	0.35 – 4.00	>30.45	>29.25	Extremely weak to weak low to medium density white speckled black CHALK.

4.4.6 The boreholes in the vicinity of the proposed M3 underpass in the revised Stage 3B Scheme terminated at 6.5m below ground level and therefore did not penetrate the underlying ground sufficiently deep enough to provide information for the design of the underpass and associated retaining walls. Therefore, additional boreholes will be required to understand the quality of the founding materials and to assign parameters for detailed design.

5 Ground Conditions and Material Properties

5.1 General

5.1.1 Comments on the nature and extent of each stratum are presented in the following sections of this report. Where characteristic values of parameters for geotechnical design are suggested in the discussion on ground conditions below, reference should be made to the terminology and definitions given in BS EN 1997-1 (2004) and BS EN 1997-2 (2007) as appropriate. Characteristic values of geotechnical parameters for use in design should be reviewed and selected by the Geotechnical Designers taking in consideration the limit states and design methods being used, and the process should be documented in the Geotechnical Design Report that will be produced during detailed design.

5.1.2 The geotechnical parameters recommended in this section have been based on the available ground investigation testing information (measured or derived) and where there is insufficient or questionable information, published data has been used and a cautious approach to the selection of geotechnical parameters has been adopted. A further ground investigation will be required to confirm the assumed geotechnical parameters as well as to provide appropriate information on the ground conditions for the proposed structures.

5.1.3 Where available and considered representative, the results from the 1973 ground investigation have been included in the figures and drawings generated. It should be noted that a hammer efficiency of 60% has been assumed for the 1973 data used on the SPT N_{60} versus depth plots.

5.2 Derivation methods

5.2.1 Derivation methods of assessing geotechnical parameters of the underlying geology of the Scheme have only been used where no direct testing has been undertaken on the strata.

Unit weight

5.2.2 Where there is no suitable testing to determine the unit weight of a material, the material characteristics have been cross referenced against Figures 1 and 2 in BS 8004.

Undrained shear strength

5.2.3 Derived values of undrained shear strength (c_u) for the cohesive strata have been determined using the empirical correlation with SPT N values (Stroud, 1989) corrected for hammer efficiency (N_{60}). The resulting c_u values have been calculated using the equation $c_u=f_1/N_{60}$ presented in Stroud, where f_1 is determined using the plasticity index of the material.

Angle of Shearing Resistance (Granular Horizons)

5.2.4 Angle of shearing resistance has been calculated using the equations presented in BS 8004.

5.2.5 For the granular material, the critical angle of shearing resistance has been derived using the equation 4, $\varphi'_{cv,k} = 30° + \varphi'_{ang} + \varphi'_{PSD}$, and Table 1 from BS 8004 which takes into the account the angularity of the granular material in the sample and the uniformity coefficient of the sample.

5.2.6 Where the material has a <15% fines content, the peak angle of shearing resistance can be calculated using the critical angle of shearing resistance and adding the density index provided from SPT N values as presented in equation 5, $\varphi'_{pk,k} = \varphi'_{cv,k} + \varphi'_{dil}$.

5.2.7 An extract of Table 1 from BS 8004 is presented below:

Extract 4: Table 1 from BS 8004

Table 1 **Values of φ'_{ang}, φ'_{PSD} and φ'_{dil} to obtain values of $\varphi'_{pk,k}$ and $\varphi'_{cv,k}$ for siliceous sands and gravels with fines content not exceeding 15%**

Soil property	Determined from	Classification	Parameter D)
Angularity of particles A)	Visual description of soil	Rounded to well-rounded	$\varphi'_{ang} = 0°$
		Sub-angular to sub-rounded	$\varphi'_{ang} = 2°$
		Very angular to angular	$\varphi'_{ang} = 4°$
Uniformity coefficient, C_U B)	Soil grading	$C_U < 2$ (evenly graded)	$\varphi'_{PSD} = 0°$
		$2 \leq C_U < 6$ (evenly graded)	$\varphi'_{PSD} = 2°$
		$C_U \geq 6$ (medium to multi graded)	$\varphi'_{PSD} = 4°$
		High C_U (gap graded), with C_U of fines < 2 E)	$\varphi'_{PSD} = 0°$
		High C_U (gap graded), with $2 \leq C_U$ of fines < 6 E)	$\varphi'_{PSD} = 2°$
Density index, I_D C)	Standard penetration test blow count, corrected for energy rating and overburden pressure $(N_1)_{60}$	$I_D = 0\%$	$\varphi'_{dil} = 0°$
		$I_D = 25\%$	$\varphi'_{dil} = 0°$
		$I_D = 50\%$	$\varphi'_{dil} = 3°$
		$I_D = 75\%$	$\varphi'_{dil} = 6°$
		$I_D = 100\%$	$\varphi'_{dil} = 9°$

A) Terms for defining particle shape can be found in BS EN ISO 14688-1.
B) The uniformity coefficient C_U is defined in BS EN ISO 14688-2.
C) The density index I_D is defined in BS EN ISO 14688-2. Density terms may be estimated from the results of field tests (e.g. Standard Penetration Test, Cone Penetration Test) using correlations given in BS EN 1997-2.
D) Values of φ'_{dil} are appropriate for siliceous sands and gravels reaching failure at a mean effective stress up to 400 kPa. For non-siliceous sands, see *The strength and dilatancy of sands* [21].
E) "Fines" refers to that fraction of the soil whose particle size is less than 0.063 mm.

Angle of shearing resistance (cohesive horizons)

5.2.8 For the cohesive horizons in the Alluvium and Head Deposits, the critical state effective angle of shearing resistance has been derived using equation 8, $\varphi'_{cv,k} = (42° - 12.5\log_{10}I_P)$ for $5\% \leq I_P \leq 100\%$ in BS8004 which takes into account the plasticity index (I_P) of the material.

Angle of shearing resistance and effective cohesion (chalk)

5.2.9 The angle of shearing resistance and effective cohesion have been derived using the data from the consolidated undrained triaxial compression test. From the results, the mean effective stress (s') and shear stress (t') have been plotted against one another and a line of best fit through the origin constructed to adopted a cautious approach for the effective cohesion (i.e. the origin is equivalent to a c' = 0). The angle (α') between the line of best fit and the x-axis is used to calculate the effective angle of shearing resistance (ϕ') using the equation $\phi' = \sin^{-1}(\tan \alpha')$

Youngs Modulus (Superficial Deposits)

5.2.10 Values of both horizontal and vertical Young's Modulus (in the undrained and drained condition) have been assumed to be the same for the superficial deposits as these deposits are unlikely to be over consolidated. Values of drained Young's Modulus can be determined using the equation of $E' = 1/m_v$ which is derived from the relationship between coefficient of volume compressibility and drained Young's Modulus (Stroud, 1989).

5.2.11 The undrained Young's Modulus (Eu), can be determined using the equation $E' = 0.73\ E_u$ based on a Poisson's Ratio of 0.1 as presented in CIRIA 143 (1995).

5.3 Made Ground

5.3.1 **Characteristic values**: Characteristic values of geotechnical parameters have not been provided for the Made Ground due to the limited thickness of the material across the Scheme and that it is likely that this material will be removed where encountered during construction and therefore it is not relevant for design purposes.

5.4 Engineered Fill

5.4.1 **Classification:** Eleven Atterberg tests were carried out on samples recovered within the Engineered Fill. From the samples tested nine of the samples were on Engineered Fill comprising predominantly of chalk and two tests on cohesive material from WS08. The results of the tests are presented in a Plasticity Chart on **Figure 2**. For the Engineered Fill comprising chalk, measured values of liquid and plastic limit were recorded between 29 and 49, and 16 and 24, respectively. In general, Atterberg tests have only limited use on the Chalk, however high liquid limits (30 to 34 per cent) are indicative of highly porous chalk and may cause problems in earthworks.

5.4.2 **Material Properties:** Three Particle Size Distribution tests were carried out on recovered samples of Engineered Fill from WS08, two of which have been carried out on cohesive material and one on Chalk, the results are presented on **Figures 3a and 3b**. The Engineered Chalk Fill sample comprised up to 55 per cent gravel size fraction, 10 per cent sand fraction and 35 per cent fines fraction. However, undertaking a PSD on a sample of chalk is likely to abrade the chalk clasts into finer material, therefore, providing a result not representative of that sample.

5.4.3 Moisture contents of the Engineered Fill were recorded between 16 and 29 per cent reflecting a variable nature of the Engineered Fill and the process in which it may have been placed.

5.4.4 **Penetration Resistance** Standard Penetration Test N values normalised for hammer efficiency (N_{60} values) are presented on **Figure 4a**. The SPT N_{60} for the Engineered Chalk Fill are between 1 and 70.

5.4.5 **Characteristic Values:** Where the Engineered Fill comprises chalk, it is recommended that the characteristic values for Structureless Chalk should be adopted. Where the Engineered Fill comprised a cohesive soil (i.e. as recorded in the WS08), then the characteristic values for Alluvium should be adopted.

5.5 Alluvium (Peat)

5.5.1 No classification testing was carried out on the Peat material recorded in the exploratory holes in the vicinity of the River Itchen.

5.5.2 **Penetration Resistance** A total of 3 Standard Penetration Tests were carried out in the Peat. The results normalised for hammer efficiency varied between 0 and 5 with no correlation with depth.

5.5.3 **Characteristic Values** No laboratory testing and very little in situ testing was carried out on the Peat encountered. The nature of Peat is highly variable and can be highly compressible, therefore, recommending characteristic values for the Peat would not be appropriate without further investigation and testing.

5.6 Alluvium

5.6.1 **Classification:** Eight Atterberg tests were carried out on samples recovered from the Alluvium around the River Itchen. The results of the tests are presented in a Plasticity Chart on **Figure 2**. Measured values of liquid and plastic limit were recorded between 31 and 39 per cent, and 16 and 27 per cent, respectively, with corresponding values of plasticity index between 4 and 20 per cent. This indicates that the Alluvium is of typically intermediate plasticity. Moisture contents in the Alluvium were recorded between 13 per cent and 46 per cent reflecting the variable nature of the material.

5.6.2 **Material Properties:** One particle size distribution was carried out on a recovered sample of cohesive Alluvium, the result is shown on **Figure 3b**. The result shows the Alluvium sample comprises around 40 per cent gravel sized material, 15 per cent sand and 45 per cent fines (i.e. silt and clay sized material).

5.6.3 **Penetration Resistance:** Standard Penetration Test N values normalised for hammer efficiency (N_{60} values) are presented on **Figure 4b**. The SPT N_{60} values for the cohesive strata are between 4 and 28, whereas the SPT N_{60}

values for the granular material are between 15 and 40. Typically for both the cohesive and granular material within the Alluvium the SPT N_{60} is around 15.

5.6.4 **Undrained Shear Strength:** Visual examination of the cohesive material indicates the material is typically soft to firm in consistency. It is expected that the variation in the noted consistency reflects the variable nature and degree of saturation of the material. Values of undrained shear strength that can be derived using the correlation with SPT N_{60} values are typically in the range of 60 to 80kPa for the cohesive strata.

5.6.5 **Consolidation**: The result of a single one-dimensional consolidation test undertaken on the Alluvium indicates that for a pressure of about 50kPa the value of coefficient of volume compressibility (m_v) is about 0.27m^2/MN and for 200kPa the m_v is 0.15m^2/MN. The result corresponds to a moderate to highly compressible material. Published data suggests that alluvial clays typically have a coefficient of volume compressibility of between 0.30m^2/MN and 1.5m^2/MN (Tomlinson, 2001).

5.6.6 **Characteristic Values:** From consideration of the properties and derived values, a uniform value for undrained shear strength of 60 kPa for the cohesive strata within the Alluvium is considered appropriate. From consideration of the average plasticity index of 18 per cent, an effective angle of friction of 26 degrees is considered appropriate for the cohesive strata within the Alluvium. For the granular strata within the Alluvium, using angularity of 2 degrees and a uniformity coefficient of 2 degrees, the effective angle of shearing resistance can be considered to be 34 degrees. For this material effective cohesion may be taken to be zero in the design analysis.

5.6.7 For the purposes of the preliminary design Alluvium should be considered as a cohesive strata due to the interbedding of the granular and cohesive horizons and therefore represents a cautious approach.

5.6.8 Based on the laboratory testing and published values of coefficient of volume compressibility, it is recommended that a value of 0.30m^2/MN should be adopted for design.

5.6.9 Values of drained Young's Modules (E') for the Alluvium can be determined to be 3 MPa. Value for undrained Young's Modulus (E_u) for the Alluvium can be determined to be 4 MPa.

5.6.10 A value of bulk unit weight of 18kN/m^3 may be taken for this material.

5.7 Head Deposits

5.7.1 **Classification** Fifteen Atterberg Tests were carried out in samples recovered within the Head Deposits. The results of the tests are presented in a Plasticity Chart on **Figure 2**. Measured values of liquid and plastic limit were recorded between 23 and 46 per cent, and 16 and 27 per cent, respectively, with corresponding values of plasticity index between 7 and 24 per cent. This indicates that the Head Deposits is of low to intermediate plasticity. Moisture contents in the Head Deposits were recorded between 13 per cent and 24 per cent reflecting the variable nature of the granular and cohesive material within the stratum.

5.7.2 **Material Properties:** Six Particle Size Distribution test were carried out on recovered samples of Head Deposits, the results are presented on **Figures 3a** and **3b**. The Head Deposits comprised around 15 to 35 per cent gravel sized material, around 10 per cent sand and 50 to 75 per cent fines (i.e. silt and clay sized material).

5.7.3 **Penetration Resistance:** Standard Penetration Test N values normalised for hammer efficiency (N_{60} values) are presented on **Figure 4c** and are typically between 30 at 1.2m bgl decreasing with depth to around 15 at 7.5m bgl**,** with the majority of the result falling between 10 and 20.

5.7.4 **Undrained Shear Strength:** Visual examination of the material indicates that the material is typically firm in consistency although locally the material was described as soft. It is expected that the variation in noted consistency reflects the variable nature and degree of saturation of the material. Values of undrained shear correlated with SPT N_{60} values and are typically in the range of 60 to 100kPa.

5.7.5 **Earthworks:** Two maximum dry density (MDD) vs optimum moisture contents (OMC) relationship tests were carried out samples of Head Deposits. The MDD for the Head Deposits was 1.77 and 1.87 Mg/m³ with corresponding OMC values of 17 and 15 per cent using a 2.5kg rammer. A maximum dry density vs optimum moisture content graph is present in **Figure 5a**.

5.7.6 **Consolidation**: The results of a five one-dimensional consolidation tests undertaken on the samples of Head Deposits indicate that for a pressure of about 50 kPa the value of coefficient of volume compressibility (m_v) is between 0.11 and 0.50 m^2/MN and for a pressure of 200 kPa, m_v ranges between 0.09 and 0.24 m^2/MN. The variation in the values for m_v are likely due to varying proportions of sands and gravels within the Head Deposits, highlighting the variable nature of the material.

5.7.7 **Characteristic Values:** From consideration of the properties and determined values, a value for undrained shear strength of 80 kPa is considered appropriate to use in design. From consideration of the average plasticity index of 15 per cent, an effective angle of shear resistance of 27 degrees is considered appropriate. The granular horizons are likely to provide a higher effective angle of shear resistance, however as the cohesive and granular materials are typically interbedded, the lower value of 27 degrees has been adopted as a cautious approach. For this material effective cohesion may be taken to be zero in the design analysis.

5.7.8 Based on the laboratory testing of coefficient of volume compressibility, it is recommended that a value of 0.2m^2/MN should be adopted for design.

5.7.9 The value of drained Young's Modulus E' for the Head Deposits has been determined to be 5 MPa and the undrained Young's Modulus E_u as 7 MPa

5.7.10 A value of bulk unit weight of 19kN/m^3 may be taken for this material.

5.8 Structureless chalk

5.8.1 **Material Properties:** The natural moisture contents for the Structureless Chalk range from 2.4 to 32 percent. Intact dry densities were tested on 6 samples presumably taken from clasts of intact chalk from within the matrix, with results ranging from 1.42 to 1.57 Mg/m³, this corresponds to a very low to low density chalk as presented on **Figure 6**. Bulk densities ranged from 1.83Mg/m³ to 2.02Mg/m³.

5.8.2 Three Atterberg Limit tests were undertaken giving measured values for liquid limit and plastic limit of between 29 and 47 per cent and 21 and 30 per cent respectively, with a corresponding plasticity index of between 7 and 11 per cent, see **Figure 2**. As stated earlier, Atterberg tests have only limited use on the Chalk, however high liquid limits (30 to 34 per cent) are indicative of highly porous chalk and may cause problems in earthworks.

5.8.3 **Penetration Resistance:** Standard Penetration Test N values normalised for hammer efficiency (N_{60} values) are presented on **Figure 4d** and are typically between 5 and 20 with no discernible correlation with depth.

5.8.4 **Earthworks:** Thirty-three maximum dry density (MDD) vs optimum moisture contents (OMC) relationship tests were carried out on samples recovered as Structureless Chalk and the results are plotted on **Figure 5b**. The MDD for the Structureless Chalk generally ranges from 1.50 and 1.65 Mg/m³ with corresponding OMC values between 18 and 24 per cent using a 2.5kg rammer. The natural moisture contents of the samples tested range between 22 and 32 per cent. CIRIA C574 states that It is difficult to obtain repeatable compaction test results on chalks. Most chalk is sufficiently weak to undergo significant breakdown during compaction. As the particle sizes of the specimen reduce, the density to which it can be compacted will change, for the given moisture content and compactive effort. Laboratory compaction tests are rarely useful in daily construction practice, because of their lack of repeatability.

5.8.5 **Consolidation:** The result of a single one-dimensional consolidation test undertaken on a sample of remoulded Grade Dm structureless chalk at 7.5m bgl indicate for a pressure of 100kPa the value of coefficient of volume compressibility (m_v) is 0.1 m^2/MN.

5.8.6 **Effective Strength:** Seven remoulded consolidated undrained triaxial tests were carried out on samples of the structureless chalk. The results of s' and t' have been plotted on **Figure 7** and the effective angle of shearing resistance of the remoulded structureless chalk may be derived from these test results as 44 degrees for an effective cohesion of zero.

5.8.7 CIRIA 574 recommends an effective angle of shearing resistance of 33 degrees and an effective cohesion of zero should be used in design for matrix dominated structureless chalk (Grade Dm). No published literature is available for clast dominated structureless chalk (Grade Dc), however, CIRIA C574 indicates that for clast dominated structureless chalk, the effective angle of friction may be greater, due the effect of particle interlocking.

5.8.8 The Young's Modulus for chalk is based off the relationship with dry density, using Figure 4.20 in CIRA 574. Therefore, based on a low-density chalk, the Young's Modulus for a Structureless Chalk would be around 3000MPa. This is considered appropriate for preliminary design until further testing is undertaken

5.8.9 **Characteristic Values:** From the review of the testing data and published information, for preliminary design, an effective angle of shearing resistance of 33 degrees and an effective cohesion of zero is considered appropriate for the preliminary design. Further testing will need to be undertaken to confirm whether this value is appropriate for detailed design.

5.8.10 A value of 19kN/m^3 should be adopted for the bulk unit weight.

5.9 Structured Chalk

5.9.1 **Material Properties:** The natural moisture content of 142 samples of chalk were recorded between 2.4 and 42 per cent. The intact dry densities of the 45 samples were recorded between 1.28 and 1.85 Mg/m^3 with corresponding bulk densities ranging from 1.72 and 2.17 Mg/m^3. These values correspond to the variable nature of the chalk across the Scheme with the chalk ranging between a very low to medium density chalk in accordance with CIRIA C574 (2002). A plot presenting the intact dry densities versus moisture contents is present on **Figure 6.**

5.9.2 Nine Atterberg tests were undertaken on samples of Structured Chalk. Measured values for liquid limit and plastic limit were recorded between 25 and 45 per cent and 19 and 34 per cent respectively, with a corresponding plasticity index of between 9 and 25 per cent. Though the results are presented on **Figure 2**, these tests have little value in determining chalk properties and it is unclear how these tests were undertaken without destroying the fabric of the intact chalk.

5.9.3 **Penetration Resistance:** Standard Penetration Test N values normalised for hammer efficiency (N_{60} values) are presented on **Figure 4e** and range between 5 and greater than 50. The N_{60} values show a wide variation in strength with depth, however for preliminary design purposes a cautious trend line has been shown. It should be noted that structure specific strength profiles will need to be developed when additional ground investigation information is available.

5.9.4 **Earthworks:** Two maximum dry density (MDD) vs optimum moisture contents (OMC) relationship tests were carried out samples of Structured Chalk. The results of the relationship are present on **Figure 5c**. The MDD for the Structured Chalk were 1.63 and 1.65Mg/m^3 with corresponding OMC values between 17 and 13 per cent using a 2.5kg rammer. The natural moisture contents of the samples tested were 23 and 24 per cent. The comments given in 5.8.4(above) also apply to this testing.

5.9.5 **Chalk Crushing Value:** One chalk crushing value of 3.7 was determined on a sample of Structured Chalk at 2.10m bgl.

5.9.6 **Effective Strength:** Five undisturbed consolidated undrained triaxial tests were carried out on samples of Structured Chalk. From the field descriptions, these were carried out on varying grades of Structured Chalk. The results of s’ and t’ have been plotted on **Figure 7** and the effective angle of shearing resistance of the undisturbed Structured Chalk from these results is suggested to be 31 degrees for an effective cohesion of zero. However, the limited dataset and sampling methodology means that the derived effective angle of shearing resistance may not be characteristic of the mass properties of the Structured Chalk and further testing is recommended.

5.9.7 CIRIA 574 indicates that moderately conservative strength parameters for structured chalk have been assessed at effective cohesion (c’) = 20 kN/m² and effective angle of shearing resistance (ϕ’) = 39°, with worst credible parameters of c’ = 0 and ϕ’ = 34°.

5.9.8 The Young’s Modulus for the chalk may be assessed from its relationship with dry density, using Figure 4.20 in CIRA 574. The dry density obtained from laboratory testing on the Structureless Chalk typically ranges from 1.35 to 1.65 Mg/m³ which corresponds to an approximate Young’s Modulus of between 1 and 10 GPa for the Structured Chalk.

5.9.9 A total of five uniaxial Compressive Strength Tests were carried out on the structured chalk ranging in depths from 9.60 to 28.15m below ground level. The results of the tests show UCS values of between 1.22 and 1.8MPa failing either by axial splitting or multiple fractures. There are insufficient test results to assess whether there is a correlation with depth.

5.9.10 **Characteristic Values:** It is likely that the samples tested were disturbed due to the drilling techniques adopted and therefore, an effective angle of shearing resistance of 34 degrees and an effective cohesion of zero should be appropriate for preliminary design Structured Chalk.

5.9.11 For preliminary pile design, founding within the Structured Chalk, the base resistance should be based on a SPT N_{60} value of 15 from 2.0m bgl to 15.0m bgl and 25 at 15.0m bgl and below. For shaft resistance, the recommendations in CIRIA 574 should be adopted.

5.9.12 Poisson’s Ratio for the Structured Chalk typically falls between 0.18 and 0.27 with an average of 0.24. Therefore, for design a Poisson’s Ratio of 0.24 is considered appropriate for design (CIRIA, 2002)

5.9.13 Due to high variability in the measured density of the Structured Chalk it is suggested that a value for the Young's Modulus of 5000 MPa is considered appropriate for preliminary design.

5.9.14 A value of 19kN/m^3 should be adopted for the bulk unit weight.

5.10 Groundwater

5.10.1 Continuous groundwater level monitoring was carried out between June 2019 and July 2020 in 4 boreholes using data loggers and in 21 boreholes during the post fieldwork monitoring period between the months of June and August 2019. The depth to groundwater is likely to vary across the Scheme with the closest to ground level being recorded in close vicinity of the River Itchen.

5.10.2 For the proposed footbridge over the River Itchen, groundwater is expected to be close to ground level. Groundwater monitoring recorded a groundwater high of 2.60m below ground level, corresponding to an elevation circa 37.5m AOD. However, this was recorded in the summer months and therefore, does not represent the worst case likely or highest groundwater level. Therefore, for the purposes of design it is recommended that the characteristic value of groundwater level is taken to be at ground level in this area.

5.10.3 Boreholes around Junction 9 recorded groundwater between 21.48m and 28.52m below ground level which corresponds to a reduced level of about 37.3m AOD. No data loggers were installed in the vicinity of the junction, the closest data logger is located approximately 450m to the north. However, the monitoring was undertaken in the summer months and correspond to the summer groundwater levels recorded elsewhere on the Scheme. Therefore, it is likely that the winter groundwater levels will also correspond to those recorded in the data loggers. Therefore, a characteristic groundwater level of 39.5mAOD should be considered for the new gyratory bridges.

5.10.4 Groundwater levels for the proposed underpass under the M3 to accommodate the new route of the A34 were recorded to be between 9.66m and 18.27m below ground level, corresponding to a reduced level of 37.00m and 39.20m. Therefore, a characteristic groundwater level should be considered to be at 39.50m AOD in the vicinity of the proposed A34 underpass.

Table 5.1 Summary of Characteristic Groundwater Levels (for preliminary design only)

Structure	Groundwater (m AOD)
Junction 9 Gyratory	39.50
A34 underpasses	39.50
Footbridge over the River Itchen	Ground Level

5.11 Geotechnical Parameters Summary Table

5.11.1 Recommended characteristic values of parameters for geotechnical design as determined from consideration of the results of geotechnical testing carried out on samples of the soils recovered during the ground investigation, consideration of published data and correlations with index properties are discussed in Section 4 of this report and are summarised in **Table 5.2** below:

Table 5.2 Summary of Geotechnical Parameters

Formation	Depth to Base (m bgl)	Bulk Unit Weight, kN/m^3	Undrained Shear Strength, kPa	Effective Cohesion, kPa	Effective Angle of Shearing Resistance, degrees	Poisson's Ratio	Drained Youngs Modulus (MPa)	Undrained Youngs Modulus (MPa)
Engineered Fill	1.2 - 11.35	20	-	0	34	0.24	3000	3000
Alluvium	5.0 – 9.0	18	60	0	26	0.1	3	4
Head Deposits	0.8 – 10.0	19	80	0	27	0.1	5	7
Structureless Seaford Chalk Formation	0.5 - >15.0	19	-	0	33	0.24	3000	3000
Structured Seaford Chalk Formation	>30.0	19	-	0	34	0.24	5000	5000

Note:
Values to be updated following further ground investigation.

6 Geoenvironmental Assessment

6.1 Introduction

6.1.1 Online guidance accessed from the government web portal, GOV.UK entitled Land Contamination: Risk Management (LC:RM), states that to manage existing (historical) contamination it is necessary to identify and assess the level of risk, decide if that risk is unacceptable to identified receptor(s) and decide how to manage any unacceptable risks. Further information on the assessment of land contamination is given in the Stantec guide presented in **Appendix C** of this report.

6.1.2 LC:RM presents three stages of risk management (1) Stage 1: Risk assessment (2) Stage 2: Options appraisal and (3) Stage 3: Remediation and each stage has three tiers.

6.1.3 The progressive tiers of a Stage 1 Risk Assessment are:

- Tier 1 Preliminary (qualitative) Risk Assessment (PRA): containing generic factual information with the assessed risks informed by professional judgement.
- Tier 2 Generic Quantitative Risk Assessment (GQRA): which uses site specific factual data from intrusive investigations with the assessed risks stated with reasonable certainty, through to.
- Tier 3 Detailed Quantitative Risk Assessment (DQRA): providing numerical analysis of modelling of the aquifer properties and groundwater quality.

6.1.4 **Section 7** of this report presents the Tier 2 of a Stage 1 Risk Assessment GQRA and the evaluation of site-specific contamination data using published Generic Assessment Criteria (GAC). Where the recorded concentration of a determinant is below the GAC for the specified end use the determinant is not deemed to be a hazard. Exceedance of the criterion indicates that the parameter is a potential hazard, and the identified pollutant linkage may represent an unacceptable risk that needs further evaluation.

6.1.5 Geochemical testing was carried out on 126 samples of soils for a range of general industrial contaminants, together with polynuclear aromatic hydrocarbons (PAH) and carbon banding of total petroleum hydrocarbons (TPH). The results of the analysis for general industrial contaminants, PAHs and TPHs of soil samples carried out are summarised in **Appendix D**. Full results of the chemical analysis are presented in the factual report of the ground investigation (Soils, 2020). Stantec's methodology for the assessment of potentially contaminated land and the GACs adopted are presented in **Appendix C**.

6.1.6 Geochemical testing was carried out on 9 samples of groundwater for a range of general industrial contaminants, together with polynuclear aromatic hydrocarbons (PAH) and carbon banding of total petroleum hydrocarbons

(TPH). The result of the analysis for the general industrial contaminants, PAHs and TPHs of the groundwater samples carried out are summarised in **Appendix E**. Full results of the chemical analysis are presented in the factual report of the ground investigation (Soils, 2020).

6.2 Generic Assessment Criteria

Soils

6.2.1 The results of the geochemical testing on the soil samples have been compared to the Category 4 Screening Levels (C4SL) for Public Open Space land uses prepared under the auspices of Defra (CLAIRE, 2014). Where C4SL is not available the concentrations were compared against Land Quality Management Ltd (LQM) Suitable 4 Use Levels (S4UL) for a commercial/industrial land uses (CIEH, 2015).

6.2.2 The additive effect of any hydrocarbon fractions is considered by calculating a hazard quotient for each carbon banding which the concentration dived by the fraction S4UL criterion for the selected land use. The hazard quotients are added together to give a Hazard Index for each sample assessed. A Hazard Index that exceeds unity can be indicative of a potentially significant human health hazard

6.2.3 The measured concentrations of potential contaminants are summarised in **Appendix D** of this report.

Controlled Waters

6.2.4 The results of the analysis have been compared against the Environmental Quality Standards (EQS) for Freshwater, in accordance with the Water Framework Directive (WFD) (DEFRA, 2010) for the protection of surface waters and ecological systems, and also compared with the Drinking Water Standard (DWS) (DETR, 2000) assessment criteria, on the basis that the groundwater is abstracted for potable supply.

6.2.5 Summary tables of the results are summarised in Appendix CWRA 3 of the Controlled Water Risk Assessment presented in **Appendix E** of this report.

Ground Gas

6.2.6 For each monitoring well the maximum gas concentration and steady flow rate for each round of monitoring was used to calculate the Gas Screening Value and determine the Characteristic Situation in accordance with BS8485 (2019) and CIRIA 665 (2007) in the chalk.

6.3 Waste Assessment

6.3.1 In addition, waste acceptance criteria (WAC) testing of 10 samples of near surface material was undertaken to allow a preliminary determination of the waste classification of any material to be disposed of off-site as part of the Stage 3B Scheme. The results of the WAC tests analysis classify the near surface material tested as Inert Waste. Full results for the WAC testing are presented in the factual report of the ground investigation (Soils, 2020).

6.3.2 However, classification of material for disposal off site will depend on the acceptability of the elevated concentrations to the EA regional office that regulates the landfill where material can be disposed. The soils on the site do not contain significant concentrations of contaminants and in accordance with the criteria set in Part 3 Landfill (England and Wales) Amendment Regulation 2004 and are likely to be accepted at an inert facility.

6.3.3 Particular care will be required in excavating material to identify and wherever practicable to segregate any potentially contaminated materials to ensure they do not adversely affect the classification of other excavated materials.

6.3.4 It is possible that additional testing may be required by the landfill operator prior to disposal to the soils to an off-site licensed facility.

6.4 Assessment of Soil Results

Potential Risks to Human Health

6.4.1 Summary tables of the soil results from both the Soils Limited ground investigation highlighting the exceedance of the selected GAC are presented in **Appendix D**.

6.4.2 The vast majority of the soil results are below the selected assessment criteria. The exception to this is one sample out of the 126 samples tested which indicates a marginal exceedances of the Public Open Space assessment criteria for Beryllium (2.3mg/kg compared to an assessment criteria of 2.2mg/kg). This is not considered significant.

6.5 Assessment of Groundwater Results

6.5.1 A full assessment of the groundwater monitoring results is presented in **Appendix E** of this report.

6.5.2 In summary, the vast majority of the groundwater samples are below the selected assessment criteria for the protection of controlled waters as an ecological receptor and as a drinking water resource. The exceptions to this are elevated concentrations of Nickel and Mercury when compared to the EQS and DWS at two specific locations and elevated concentrations of Nitrate as NO_3 when compared to the DWS in one location.

6.5.3 The laboratory limits of detection (LOD) were above the assessment criteria for the protection of ecological receptors for cadmium, hexavalent chromium and cyanide.

6.6 Assessment of Ground Gas Results

6.6.1 A full assessment of the ground gas monitoring results is presented in **Appendix F** of this report.

6.6.2 In all of the monitoring rounds in all locations monitored, the measured concentrations of carbon dioxide were below 3% v/v and methane were not detected in any location.

6.6.3 Very low gas flow rates were detected in all wells and typically <0.2l/hr. The exception to this was in DS207 on one occasion which recorded a gas flow of -0.5l/hr.

7 Tier 2 Geoenvironmental Summary and Risk Estimation

7.1 Hazard Identification

7.1.1 This Tier 2 risk assessment builds on the findings of the Preliminary Tier 1 assessments undertaken at the Site by Stantec (2020) and WSP (2017).

7.1.2 **Table 7.1** summarises the potential contaminative land uses and sources based on the current and historical land uses along with the contaminants of potential concern.

Table 7.1 Potential Sources of Contamination

Description	Contaminants of Potential Concern
Motorway/'A' Road	Metals and metalloids, chloride, polycyclic aromatic hydrocarbons (PAHs), oil/fuel hydrocarbons, sulphates, asbestos.
Inert Landfill - Infilled ground	Composition assumed to be naturally occurring arisings from road construction; but possible localised slightly elevated general industrial contaminants should be considered including metals, hydrocarbons, PAHs, asbestos and ground gases
Agricultural Usage	Hydrocarbons and lubricating oils associated with machinery and nitrates from fertilisers. Potential pesticides and herbicides. Asbestos (e.g. on farm tracks due to possible use of demolition rubble for surfacing).
Historical Land Use (Railway line, gas works, iron works, mixed industrial)	Metals and metalloids, PAHs, Polychlorinated Biphenyls (PCBs), oil/fuel hydrocarbons, lubricating oils, coal tars, creosotes, sulphates, inorganic compounds, asbestos PFAS
Peat and Organic Matter within Alluvial Deposits	Methane and Carbon Dioxide
Seaford Chalk – dissolution of calcium carbonate by acidic water	Carbon Dioxide

Soils

7.1.3 The ground investigation undertaken by Soils Limited investigated the agricultural land usages and roads source identified in **Table 7.1**. The ground investigation revealed that concentrations of potential contaminants are, for the vast majority of samples, below the relevant assessment criteria. The exception to this is 1No. sample which identified a marginal exceedance of the Public Open Space assessment criteria for Beryllium, however this is not considered significant.

Controlled Waters as an Ecological Receptor

7.1.4 The data reviewed indicates that at the majority of locations, concentrations of the potential contaminants tested, are below the relevant assessment criteria. However, some laboratory limits of detection (LOD) were above the assessment criteria that Stantec use for cadmium, hexavalent chromium and cyanide. It is not considered that this represents a significant risk to controlled waters, and this preliminary assessment should be further supported through additional sampling and analysis – using LODs below the assessment criteria where commercially available, and the use of the UK-TAG Metal Bioavailability Assessment tool.

7.1.5 Nickel and Mercury were also identified above the assessment criteria in two specific locations which are located close to two of the historical landfills; and whilst this is also not considered to represent a significant risk to controlled waters, further sampling and analysis is recommended to confirm this preliminary assessment and rule out possible previous sampling/testing errors. Further details on the assessment and conclusions can be found within **Appendix E**.

7.1.6 Based on the information available, there is no evidence to suggest that the groundwater at the site has been significantly impacted by anthropogenic contamination arising from within the Scheme boundary and therefore the potential for the works to impact groundwater below the site and to give rise to a hazard to ecological receptors is considered to be **Low**.

Controlled Waters as a Drinking Water Resource

7.1.7 The majority of the groundwater samples did not record any exceedances of the Drinking Water Standards (DWS), however exceedances were recorded within DS110, DS203 and DS216 for Mercury, Nickel and Nitrate as NO_3. The source of the Nitrate is likely to be off site agriculture and therefore unrelated to the Site. As described above (**Section 5.1.3**), whilst the Mercury and Nickel concentrations at these limited locations are not considered to represent a significant risk to controlled waters, further sampling and analysis is recommended.

7.1.8 Based on the information available, there is no evidence to suggest that the groundwater at the site has been significantly impacted by anthropogenic contamination arising from within the Scheme boundary and therefore the potential for the works to impact groundwater below the site and to give rise to a hazard to public water supply sources is considered to be **Low.**

Ground Gas

7.1.9 In accordance with Figure 6 within BS 8576:2013 the Gas Generation Potential of the Made Ground/Engineered fill, Alluvium and Peat is considered to be Low to Very Low given the limited degradable content indicated within the exploratory hole records. Further degradable organic content (DOC) testing should be undertaken on the natural strata to confirm this assessment.

7.1.10 It has been assessed from the ground gas monitoring data that the gas regime within the Seaford Chalk Formation is a Characteristic Situation 1 whereby no gas protection measures are required and therefore the potential for a significant ground gas risk to arise from the works is considered to be **Very Low** in accordance with BS8485+A1 (2019). Although this classification is designed for new buildings, it does give a reasonable indication of the ground gas risk.

7.1.11 It is also recognised that any construction activities and follow on maintenance work will be managed under an appropriate Environmental Management Plan, CDM regulations and compliance-based risk assessments which will further protect Construction and Maintenance workers.

7.2 Receptor Identification

7.2.1 Details of the potential receptors considered, and their sensitivity is presented in **Table 7.2** below:

Table 7.2 Summary of the Potential Receptors and their Sensitivity

Receptor Type	Comment	Sensitivity Score
Human Health – Current	Road Users, Ad-hoc access by agricultural workers and potential access by public (dog walkers etc).	4
Human Health – Future	Road, Users, Ad-hoc access by agricultural workers and potential access by public (dog walkers etc).	4
Human Health - Neighbours	Residential and Commercial	5
Human Health – Construction / Maintenance Workers	The Stage 3B scheme is considered likely to include extensive earthworks that could expose construction workers to any potential contamination in the soil material.	4

Receptor Type	Comment	Sensitivity Score
Groundwater	The site is underlain by a Principal chalk aquifer, which is abstracted for potable supply.	5
Surface Water	The River Itchen flows across the north and along the west of the Scheme area with several associated water courses. The River Itchen is designated a SSSI and a Special Area of Conservation (SAC). Nun's Walk Stream flows in a channel approximately parallel to the River Itchen and is classified by the EA as a Main River.	5
Property - Buildings	Mixed use surrounding the M3 J9 Improvement works, including residential, commercial properties and agricultural land.	2
Property - Animal or Crop Effect	Some areas will be restored to agricultural land.	1
Ecological Systems	The nearest environmentally sensitive area is the River Itchen SSSI and SAC and flows through the study area. The Scheme area also lies partly within the South Downs National Park.	5

7.3 Risk Estimation

7.3.1 Following the recent ground investigation, the Conceptual Model has been updated to reflect the knowledge and understanding of the ground conditions. However, these investigations were not undertaken within some areas of potential landfill because they were outside the Stage 3a order limits, therefore this potential source of contamination was not adequately investigated at the time of writing this report.

7.3.2 The ground conditions encountered during the investigation and the results of the geoenvironmental testing, indicate that the potential for significant contamination to present is considered to be **Low to Very Low**.

7.3.3 Risk estimation involves predicting the likely consequence (what degree of harm might result) and the probability that the consequences will arise (how likely the outcome is).

7.3.4 Based on the information available, there are a number of plausible pollutant linkages, assuming a worst-case scenario, the estimated risks have been classed as follows:

- Human Health (Current) – Very Low
- Human Health (Future Users) – Very Low
- Human Health (Construction/Maintenance Workers) – Very Low
- Human Health (Neighbouring residents) – Very Low
- Groundwater – Low
- Surface Water - Low
- Property (Buildings) – Very Low
- Property (animal or Crop Effect) – Very Low
- Ecological Systems - Low

7.4 Risk Evaluation

7.4.1 Possible pollutant linkages are determined using professional judgement. If a linkage is considered possible, it is considered that this represents a potentially 'unacceptable risk' and therefore requires further consideration. This may be through remediation or mitigation or through further tiers of assessment.

7.5 Recommendations

7.5.1 On the basis of this Tier 2 Risk Assessment, it is not currently considered that a Tier 3 Detailed Risk Assessment is required, although further supplementary Tier 2 Risk Assessment is recommended following additional ground investigation and soils, groundwater and surface water sampling and laboratory analysis.

7.5.2 It is recommended boreholes are undertaken and that monitoring wells are installed, and soils and groundwater sampling is undertaken within the areas of suspected landfill, deeper Made Ground and within areas that have not been previously investigated, together with additional groundwater sampling of existing monitoring wells.

7.5.3 It is also recommended that surface water samples are taken from the River Itchen to determine the baseline conditions in the River, and this should include upstream and downstream samples.

7.5.4 Whilst the current ground gas assessment would advise that no special protection measures are required, it is recognised that this assessment of a CS1 situation is based on a limited data set, as such it is recommended that further boreholes are drilled, and gas monitoring undertaken within the areas of suspected landfill, made ground/fill if it is found to contain considerable degradable material and within areas that have not been previously investigated.

8 Geotechnical Risk Register

8.1.1 Based on review of available information and results of the ground investigation, the geotechnical risk register has been updated to identify and rate the potential risk to the project for each of the principal geotechnical hazards identified for the Stage 3B Scheme. The main aim of the risk register is to allow for planning to prevent the risks occurring or to mitigate their consequences. The risk register is included as **Appendix G** of this report.

8.1.2 The risk register gives a description of the activity and potential geotechnical hazard, the consequence should the hazard occur and mitigation measures and actions to be taken to limit the impact of the hazard on the Stage 3B Scheme. The risk register also includes an assessment of the likelihood of occurrence and the impact on the project should the hazard occur.

8.1.3 Rating of the risk has been carried out so that greater effort can be spent planning the prevention and mitigation of those risks considered more serious in terms of the likelihood of their occurrence and their impact on the project if they do occur.

8.1.4 In relation to each risk there should be set out a simple action plan for the prevention/mitigation of relevant risk. Any action plan should be drawn up applying the principles of “SMART” that is actions should be Specific, Measurable, Agreed, Realistic and Time-bounded. A statement of the objective of the relevant action should be given as this will enable subsequent reviews of the risk register to consider whether any further action is necessary to achieve the objective.

8.1.5 Responsibility for the management of each risk should be allocated to a particular party or organisation as indicated on the risk register.

8.1.6 A review of the Scheme and project risks, as given in the geotechnical risk register, has been carried out to determine the geotechnical classification of the project and thus the requirement for geotechnical certification. On the basis of this review, the Stage 3B Scheme has been classified as a Geotechnical Category 2 Project. A Category 2 project is one that only includes conventional types of earthworks structures and foundations with no abnormal risk or unusual or exceptionally difficult ground conditions. It should be noted that both the geotechnical risk register and the geotechnical category of the Scheme are considered as love and can be changed and updated as more information becomes available.

9 Engineering Assessment

9.1 Introduction

9.1.1 For the Stage 3B Scheme, the principal geotechnical consideration will be the strength and compressibility of the founding soils and hence, the foundations for the bridges, retaining walls and proposed embankments and cuttings along the length of the Scheme. This section of the report presents comments on the ground conditions in relation to design and construction of the geotechnical elements of the proposed structures. The proposed structures are shown on Drawing HE551511-VFK-SGN-X_XXXX-XX-DR-CB-0100.

9.1.2 Recommended characteristic values of parameters for geotechnical design as determined from consideration of the available geotechnical testing carried out on samples recovered during the previous ground investigation, consideration of published data and correlations with index properties are discussed in **Section 5** of the report and are summarised in **Table 5.2**.

9.2 Natural and Mining Cavities

9.2.1 A technical note on the risks of natural and mining cavities along the Scheme is presented in **Appendix A** for this report. The technical note identifies areas of the Scheme where issues may arise from the presence of natural and mining cavities. The risk associated with the potential for cavities to be present has been assessed based on a review of geology, hydrogeology, geomorphology and historical records.

Natural Cavities

9.2.2 Where chalk is exposed and forms either the topographic hill top, or a slope face where Palaeogene/Quaternary deposits are absent at higher elevations, and therefore surface water is not anticipated to be directed towards, or accumulate in, areas of the chalk, the hazard rating for solution features to be present is considered Very Low.

9.2.3 Where Alluvium overlies the Chalk, and groundwater is anticipated to be at or above the chalk interface due to the influence of the floodplain, the hazard rating for solution features to be present is considered Low.

9.2.4 Where chalk is exposed and forms a slope face where Palaeogene/Quaternary deposits are present at higher elevations, and therefore surface water is anticipated to have originated upon the cover deposits and be directed onto the Chalk, the hazard rating for solution features to be present is considered Moderately Low.

9.2.5 Where either Head (1) or Head (2) deposits are present, the irregular contact between the deposit and the chalk presents favourable conditions for solution piping, creating conduits for surface water to underdrain into the chalk below, resulting in a hazard rating of Moderate.

9.2.6 The Clay-with-Flints forms a younger, successive cover deposit over the chalk surface and commonly infills any hollows and dissolution pipes in the weathered chalk surface. This produces potential for underdrainage into the chalk below, creating favourable circumstances for solution feature development. Previous experience of studying sites underlain by Clay-with-Flints has shown that natural cavities are frequent and pose a risk of differential settlement and possible ground collapse. This subsequently results in a hazard rating of Moderately High.

9.2.7 Therefore, with reference to the Natural Cavities risk assessment outlined in **Appendix A**, the risk to the Scheme from the presence of natural cavities is considered to range from Very Low to Medium.

Mining Cavities

9.2.8 From a review of the history of the Scheme area, the GDMS hazard rating, the geological, hydrogeological and geomorphological setting of the Scheme, the likelihood for mining cavities to be present is considered to range from Low to Moderately Low across the majority of the Scheme. However, where historical mining has been recorded, it should be considered to be Very High

9.3 Earthworks

Cuttings and Embankments

9.3.1 The majority of the material excavated within the cuttings will be the Seaford Chalk Formation. A small volume of Head Deposits will likely be excavated in cuttings to the east and south of the River Itchen. The materials are likely to be re-used as engineered fill in areas of embankments along the Scheme. The major cuttings are for the M3 southbound diverge, the M3 Underpass, the A34 southbound link to the M3 and the NMU route.

9.3.2 Engineered fill will be required for the embankments for the M3 slip road southbound from the A34, the approach road to Junction 9 from the M3 southbound off slip, the A34 northbound from the M3 and the A33 Link road roundabout.

9.3.3 From a review of the geotechnical parameters of the insitu materials, it is anticipated that the proposed side slopes for cuttings of 1 (v) in 2 (h) and for embankments at 1 (v) in 3 (h) or shallower are likely to be stable in the long-term subject to detailed stability analysis during geotechnical design. Cutting side slopes may be able to stand at a steeper angle, however consultations with South Downs National Park have indicated their preference for shallower slopes to reduce the visual impact of the Scheme on the landscape.

9.3.4 The areas of the cuttings and embankments are presented on drawings the overall Scheme plan on Drawing HE551511-VFK-HGT-X_XXXX-XX-DR-GI-0001. The depths and height of each of the cuttings and embankments are presented on the Proposed Contours Drawings HE551511-VFK-HGN-

X_XXXX_XX_DR-CH-0051 to 0055. These drawings are presented in the Drawings section of this report.

Materials

9.3.5 The materials that will arise from the cuttings within the Scheme will comprise Engineered Fill, Alluvium, Head Deposits, Structureless Chalk and Structured Chalk.

9.3.6 Based on the available particle size distribution testing, it is likely that the excavated Alluvium and Head Deposits will meet the requirements of a Class 2C material and the less granular horizons as a Class 2A/2B. There is insufficient testing on these materials to confirm how they will behave as an embankment fill. The material arising from the cuttings within the chalk, if suitable for re-use will be classed as a Class 3 material in accordance within the Specification for Highways Works, Series 600 (SHW, 2016).

9.3.7 A total of twenty-four Moisture Condition Value tests were undertaken on samples of Structureless Chalk. The Moisture Condition Values ranged from 8.5 to 13 for corresponding optimum moisture contents ranging between 19 and 24 per cent. One Moisture Condition Value test was undertaken on the Head Deposits with the value of 12 for a corresponding optimum moisture content of 17 percent.

9.3.8 Notwithstanding the shortcomings of the MDD vs OMC relationship data and the Intact Dry Density data described in **Section 5,** we have undertaken an initial preliminary assessment of site won material for reuse as an engineered fill. **Table 9.1** summarises the guidance presented in the CIRIA C574 and should be read in conjunction with **Figures 5a to 5c** and **Figure 6**. **Figure 6** also includes the available intact dry density information from the 1973 ground investigation.

Table 9.1 Summary of Initial Material Properties for Reuse in Earthworks

Properties	Guidance
Alluvium/Head Deposits	
OMC – Insufficient data 95% MDD – Insufficient data	Insufficient testing data to determine a moisture content range to achieve 95% compaction with less than 10% air voids
Structureless Chalk	
OMC – 22 per cent 95% MDD– 1.49 Mg/m³	Moisture Content Range –21 to 27 per cent Natural Moisture Content – 22 and 32 per cent, therefore, the material will likely require moisture conditioning e.g. by drying or the addition of lime/cement.

Properties	Guidance
Structured Chalk	
IDD - 1.25 to 1.45 Mg/m³ MC- >32 per cent	Unlikely to be economical for drying by lime/cement
IDD - 1.25 to 1.58 Mg/m³ MC – 28 to 32 per cent	Moisture conditioning required by lime/cement
IDD - 1.25 to 1.45 Mg/m³ MC – 16 to 28 per cent	Compaction trial needed to confirm the 10% air voids
IDD – 1.45 to 1.90 Mg/m³ MC – 16 to 28 per cent	Min 10% air voids should be achievable
IDD - 1.45 to 1.70 Mg/m³ MC - <25 per cent	Water may need to be added to achieve 10% air voids
IDD - >1.70 Mg/m³ MC - >15 per cent	Material may require wetting and/or crushing to achieve min 10% air voids
IDD - <1.55 Mg/m³ MC - < 16 per cent	Material unlikely to be suitable for reuse

9.3.9 Some of the results for intact dry density and moisture content provided in the Factual Report plot above the 100% saturation line in **Figure 6**, which indicates that the measured natural moisture of the chalk is above the saturation moisture content determined from the dry density and specific gravity of the chalk. These spurious results indicate possible errors in the reporting or testing procedures. Further laboratory testing is required to be able to assess the suitability of the chalk for reuse.

9.4 Site Preparation

Excavation Works

9.4.1 The materials excavated from cuttings across the Scheme will vary depending on the location of the cutting and the local geology. Cuttings located in the vicinity of the River Itchen are likely to encounter a thickness of superficial deposits comprising of Alluvium and/or Head Deposits over Chalk. Elsewhere chalk should be encountered near surface. Excavation of these materials should be possible using conventional plant and equipment.

9.4.2 Excavation of the surface pavements and any existing foundations and below ground structures may require pre-treatment by use of hydraulic breakers to fracture the material. Once fractured, it should be possible to excavate these materials using conventional tracked excavators. Any remains of walls, foundation et cetera within 1.0m of foundation formation level should be removed to prevent any development of concentrations of stress in foundation or pavements.

9.4.3 Particular care will be required in excavating material to identify and wherever practicable to segregate any potentially contaminated materials to ensure they do not adversely affect the classification of other excavated materials. In addition, materials of similar earthworks classification and properties will need to be segregated e.g. anything too wet will need to be separated for pre-treatment, prior to reuse.

9.4.4 It is essential that contractors carefully inspect and check the exposed formation for evidence of localised weak areas and possible voids, such as solutions features, and take appropriate measures to ensure the adequacy of the exposed formation.

9.4.5 Chalk can be a difficult material to use as an engineering fill as it is properties change with moisture content and it is susceptible to crushing and degradation from handling and transportation. Strict materials control will be required on site in accordance with Clause 605 of the Specification for Highways Works Series 600 Earthworks (SHW, 2016). Stockpiles, excavations and placed material will require protection from the weather to avoid deterioration of the chalk. Double handling of excavated chalk should be avoided to reduce the breakdown of the material into fines. There is a significant surplus of fill material to be generated from site, therefore the better-quality structured chalk could be segregated and used as engineering fill. The use of binders e.g. lime or cement may be required to allow the wetter chalk to be reused.

9.4.6 Where the formation on exposed chalk surfaces will be used for haulage routes, appropriate protection measures will be required in order not to degrade the surface of the chalk.

Stability of Temporary Excavations

9.4.7 Although the sides of open cut may stand with near vertical side slopes in the short term, these may need to be battered back to an appropriate slope angle or restrained by full face support to ensure stability in the short to medium term. The temporary slope angles will depend on the nature and strength of the material around excavation. It is anticipated that a temporary slope angles for cuttings within the Head Deposits and the Structureless Chalk will typically be between a 1 (v) in 1.5 (h) to 1 (v) in 2 (h). For temporary slopes within the Structured Chalk, a safe slope angle of 1 (v) :1 (h) is considered appropriate.

Groundwater Control

9.4.8 The groundwater levels encountered during the fieldwork and monitoring are summarised in **Table 5.1** of this report.

9.4.9 Based on this data, groundwater is unlikely to be encountered in any of the cuttings or excavations within the Scheme with the exception of any excavations associated with the footbridge across the River Itchen. The footbridge is sited within the River Itchen flood plain and therefore consideration should be given to the time of year excavations in this area are undertaken.

9.4.10 Further assessment of groundwater levels and their likely range of fluctuation will be required during the supplementary ground investigation. However, in the meantime allowance should be made for controlling groundwater and surface water that may enter into cuttings in order the reduce the degradation of the cutting faces within the chalk.

9.4.11 In addition, surface water needs to be controlled at the base of the proposed embankments to reduce the risk of inundation collapse settlement.

9.5 Highways Structures

M3 Junction 9 Gyratory Bridges (North and South)

9.5.1 The proposed bridges at Junction 9 are to span a distance of 45m over the M3, the north bridge is proposed to be 11.8m wide and the south bridge is proposed to be 15.5m wide. Three options were considered for the M3 Junction 9 Gyratory Bridges as presented in Structure Options Report (Stantec, 2021a). The options presented in the report are the following:

- Option 1 – Single span steel-concrete composite deck with reinforced concrete abutments and wing walls
- Option 2 – Three span steel-concrete composite deck
- Option 3 – Four-span beam and slab deck or solid infill deck

9.5.2 The Structures Options Report recommends Option 1.

9.5.3 The ground conditions encountered in the vicinity of the gyratory roundabout comprise a limited thickness of Made Ground over the Seaford Chalk Formation. The available information on the ground conditions indicates that either shallow spread foundations (based on foundations adopted for the current gyratory bridges) or piled foundations could be adopted.

9.5.4 From review of the ground investigation data, it is considered that there is sufficient information to develop a preliminary ground model for the north and south gyratory bridges.

River Itchen Footbridge

9.5.5 The proposed bridge over the River Itchen will span 35m and have a width of up to 4m. Three options were considered for the footbridge as presented in Structure Options Report (Stantec 2021b). The options presented in the report are as follows:

- Option 1 – Single-span timber truss
- Option 2 – Single span steel truss
- Option 3 – Two-span fibre reinforced polymer (FRP) footbridge

9.5.6 Option1 is recommended in the Structure Options Report.

9.5.7 The ground conditions in the vicinity of the footbridge were not fully investigated. In particular the base of the peat and the top of the chalk was not determined at the location of the proposed bridge. Based on the information available the ground conditions are likely to comprise a layer of Made Ground/ Topsoil over a layer of Alluvium possibly containing layers of Peat over Head Deposits over the Seaford Chalk. Given the presence of Alluvium and Peat it is anticipated that piles founding in chalk will be required for the abutment foundations.

9.5.8 In order to design the foundations for the proposed bridge additional boreholes will be required within the footprint of the abutments to determine the full lateral and vertical extent of the Alluvium and any layers of Peat, and to investigate the founding properties of the underlying chalk to a depth of 5m below the likely base depth of the toes of the piles.

M3 Underpass

9.5.9 The underpass to accommodate the new A34 southbound route under the M3 is proposed to be 125m long, 15m width and 6.2m high with a 200m long entry cutting on its north side and a 140m long exit cutting to the south. The underpass is proposed to be constructed using a reinforced concrete box culvert. The entry and exit cuttings will be in open cut slopes and partly fully retained within vertical sides. The box culvert will be founded on the Seaford Chalk Formation.

9.5.10 Three methods of construction are presented in the Structure Options Report (Stantec 2021c) for the M3 Underpass as presented below:

- Option 1 – Bottom-up construction (open excavation)
- Option 2 – Bottom-up construction (multi-propped embedded retaining wall)
- Option 3 – Top-down construction

9.5.11 Option 1 and 2 are considered appropriate for the construction of the underpass with the reinforced buried box constructed within an open or temporarily supported excavation. Option 3 is not recommended for reasons related to whole-life cost, appearance and maintenance.

9.5.12 During the 2019 ground investigation one borehole was located to the north of the northern portal and one to the south of the southern portal to a depth of only 6.0m. In order to design the underpass, its approaches and any temporary works required, additional deeper boreholes will be required at either end of the underpass.

9.5.13 The nature of the material currently comprising the M3 embankment is currently unknown. However, it is anticipated that the materials will comprise Engineered Chalk Fill. Additional exploratory holes will be required to understand the composition of the material beneath the M3.

A34 Northbound Underpass

9.5.14 The proposed A34 Northbound Underpass will be 100m long, 12m wide and 5.8m high with the approaches comprising partial cuttings and retaining walls up to 12m in height. The underpass is proposed to be constructed using a reinforced concrete box culvert. The box culvert will be founded on the Seaford Chalk Formation.

9.5.15 Two methods of construction have been presented in the Structure Options Report (Stantec, 2021d) for the A34 Northbound Underpass. The options are presented below:

- Option 1 - Top-down construction at existing ground level using contiguous bored pile abutments, wingwalls and adjoining retaining walls. The underpass ‘roof’ being formed by precast beams or in situ reinforced concrete deck slab.
- Option 2 - Bottom-up construction built using a proposed sheet pile temporarily for the underpass and permanent tied cantilever sheet piles for the wingwalls and adjoining retaining walls.

9.5.16 Option 1 has been recommended to construct the A34 Northbound Underpass.

9.5.17 The borehole information within the vicinity of the proposed underpass is not considered sufficient to develop a ground model, with two boreholes to between 15.0m and 20.0m below ground level and one trial pit to 4.0m bgl. Additional exploratory holes will be required in order for detailed design to be undertaken.

M3 Junction 9 Gyratory Subways

9.5.18 Three subways are proposed to be constructed for the NMU around the proposed gyratory. The subways vary in length from 24m to 28m, 4m wide and 3m in height with the approaches in cutting. The options for the subways within the M3 J9 Gyratory are included within the Structure Options Report for the NMU Route (Stantec 2021b). The options are presented below:

- Option 1 – In-situ reinforced concrete box structure
- Option 2 – precast concrete box structure.

9.5.19 Option 1 has been recommended for the M3 Junction 9 Gyratory Subways.

9.5.20 All three subways are to be founded on the Seaford Chalk Formation. The ground investigation information in this area of the Scheme is considered sufficient in order to develop a ground model and undertake geotechnical design for the subways.

A34 Northbound Subway

9.5.21 The A34 Northbound Subway is proposed to be 24m long, 4m wide and 3m high and will be founded on the Seaford Chalk Formation. The approaches to the subway will be in cutting.

9.5.22 The ground investigation information in the vicinity of the subway is considered sufficient in order to develop a ground model and undertake geotechnical design for the subway.

9.5.23 The options for the A34 subway are included within the Structure Option Report for the NMU Route (Stantec 2021b) and comprise an in-situ reinforced concrete box structure and precast concrete box structure. Both options are considered viable for this subway.

Retaining Walls

9.5.24 The Scheme will require the construction of 4 retaining walls (excluding wing walls to underpass portals and bridges) to support the proposed earthworks. The proposed retaining walls will range from 90m to 120m long and vary from 2.0m to 12m in height.

9.5.25 Two retaining walls are located along the east side of the A33 Link Road to the north and the south of the proposed underpass of the A34 Northbound with a maximum retained height of around 12m.

9.5.26 Five options have been considered in the Structure Option Report (Stantec 2021d) for the A33 Link Retaining Walls. The options are presented below:

- Option A – Steel sheet pile wall
- Option B – Contiguous bored pile wall
- Option C – Diaphragm walls
- Option D – Reinforced soil
- Option E – Reinforced concrete cantilever wall

9.5.27 Option B with Option D are considered to be the preferred options. A contiguous bored pile portal bridge structure with adjoining contiguous bored piles retaining walls that transition into reinforced soil vegetated. Additional ground investigation will be required in order to undertake the detailed design for these structures.

9.5.28 Another retaining wall is proposed to support the A34 Northbound carriageway. The retaining wall has a maximum height of 2.0m. Four options (Stantec 2021b) were considered for this retaining:

- Option 1 – Modular concrete block retaining wall system

- Option 2 – Vegetated wall system
- Option 3 – Precast (Option 3a) or in-situ (Option 3b) reinforced concrete cantilever wall
- Option 4 – Gabion retaining wall

9.5.29 Option 2 is considered to be the preferred option. No further ground investigation information is considered to be required as this wall will be constructed above existing ground level.

9.5.30 The fourth retaining wall is located adjacent to the A272 and is required to provide suitable visibility for the A272 northbound approach to the M3 gyratory roundabout. This wall will continue, where required, along the southbound on slip to the M3 to facilitate the widening of the lane merge. The maximum retained height will be 1.2m. There is no ground investigation information in this area and therefore all wall options should be considered.

9.6 Pavement Design

9.6.1 No in situ or laboratory California Bearing Ratio (CBR) or subgrade stiffness modulus testing was undertaken as part of the 2019 ground investigation, therefore, recommended CBR values for preliminary pavement design have been obtained from the review of published literature. CIRIA 574 recommends that for highways schemes cut into chalk, typically a design CBR of greater than 15 per cent is adopted for structured insitu chalk and for structureless in situ chalk a design CBR of 2 per cent is recommended. It should be noted that chalk is highly susceptible to frost action and therefore pavements need to be thick enough to prevent frost action on the sub-formation. Typically, minimum pavement thicknesses of 450mm are adopted.

9.6.2 CIRIA recommends for embankments comprising Engineered Chalk Fill using structured chalk, the guidance suggests that a CBR of 8 per cent is achievable. However, a higher CBR of 15 per cent or more is achievable if the reworked chalk is compacted to achieve air voids of not more than 10 per cent. For reworked structureless chalk forming embankment fill, a CBR of less than 2% is expected, dependent on the air voids and the degree of recementing within the matrix. Therefore, stabilisation with the use of lime or cement will be required for the structureless chalk if a higher the CBR value is to be achieved or if structured chalk comprises too much fines.

9.6.3 Without any available testing the CBR values presented in **Table 9.2** are considered a conservative estimate preliminary design purposes only. Further in-situ and laboratory testing should be undertaken to provide more appropriate CBR values/subgrade surface moduli for detailed design.

Table 9.2 Preliminary Design CBR Values

Material	Preliminary CBR Value	Subgrade Surface Modulus (MPa)
Insitu Structureless Chalk	2%	25
Insitu Structured Chalk	5%	50
Engineered Fill (Structureless Chalk)	2.5%	30
Engineered Fill (Structured Chalk)	5%	50

9.6.4 Testing of the subgrade will be required in during construction to confirm the design CBR values have been achieved.

9.7 Mix Design of Buried Concrete

9.7.1 The measured pH values and concentrations of water-soluble sulphate on soil samples recovered during the ground investigation are presented in the factual report and are summarised in **Table 9.3** below:

Table 9.3 Summary of pH and Sulphate Results

Stratum	Number of Tests	pH Value	Water Soluble Sulphate (mg/l)	Total Sulphur (%)
Made Ground	35	6.5 – 11.0	10 - 40	0.02
Alluvium	12	6.4 – 8.6	10	0.02
Head Deposits	15	6.4 – 8.5	10 - 40	0.02
Seaford Chalk Formation	136	7.2 – 8.5	10 - 93	0.02

9.7.2 For mobile groundwater conditions pH and sulphate concentrations in the samples from the Alluvium, Head Deposits and Seaford Chalk Formation generally correspond to Design Sulphate Class DS-1 and Aggressive Chemical Environment for Concrete (ACEC) class AC-1 as defined in BRE Special Digest 1 (BRE (2017).

9.7.3 The recommendations of BRE (2017) should be followed for the mix design of buried concrete for the classification given.

9.8 Drainage

9.8.1 As part of the ground investigation, 5 variable head permeability tests were undertaken in boreholes across the Scheme. The reported results of the variable head permeability tests are summarised in **Table 9.4** below.

Table 9.4 Summary of the Variable Head Permeability Tests

Location	Test Depth Range (m bgl)	Geology as per borehole records (m bgl)	Water Level Fall (m)	Test Duration (sec)	Result
DS104	0 - 4	0.3-3.0 sandy gravelly clay (Alluvium) 3.0-4.0 No description (Alluvium)	0.96	3600 (1 hr)	Insufficient fall in water to calculate permeability.
DS107	0 - 4	0.4-1.2 Structureless chalk 1.7-4.0 Chalk (Grade B2)	2.78	3600	1.48×10^{-6} m/s
DS109	0 - 3	0.5-1.2 Structureless chalk 1.2-3.0 Chalk (Grade B2)	1.31	3600	Insufficient fall in water to calculate permeability.
DS210	0 - 4	0-1.7 Structureless chalk (Grade Dc) 1.7 -4.0 Chalk (Grade B2)	1.52	9000 (2.5 hr)	Insufficient fall in water to calculate permeability.
DS301	5.7 – 10.15	5.7-7.0 Chalk Grade A3-A4 7.0-10.15 Chalk (Grade A3)	4.42	1800	7.6×10^{-6} m/s (Note the result in factual report is 8.2×10^{-6} m/s because start and end test water levels have been entered incorrectly)

9.8.2 It has been identified that the permeability calculated from the variable head permeability tests has been determined using the wrong method. The Factual Report states the tests were undertaken in accordance with BS EN ISO 22282-2:2012 and calculated using the Hvorslev method. However, Section B.4.2 of the British Standard states 'The Hvorslev method can only be applied below the water table', yet the factual report notes the boreholes were dry prior to the commencement of the tests. Therefore, the permeability results provided are considered not to reflect the in-situ permeability of the chalk.

9.8.3 Soil infiltration rates have, therefore, been derived by Stantec using the soil infiltration calculation as stated within BRE DG 365 and the raw data recorded from the variable head permeability tests undertaken as part of the ground investigation to give an indication of likely values for preliminary design purposes. A summary of the results is presented in **Table 9.5** below.

Table 9.5 Summary of calculated Soil Infiltration Rates

Location	Test Depth Range (m bgl)	Geology as per borehole records logs (m bgl)	Soil Infiltration - Calculated (m/s)	Soil Infiltration (m/hr)
DS104	0 - 4	0.3-3.0 sandy gravelly clay (Alluvium) 3.0-4.0 No description (Alluvium)	9.5×10^{-6}	3.4×10^{-2}
DS107	0 - 4	0.4-1.2 Structureless chalk 1.7-4.0 Chalk Grade B2	1.4×10^{-5}	5.2×10^{-2}
DS109	0 - 3	0.5-1.2 Structureless chalk 1.2-3.0 Chalk Grade B2	2.8×10^{-5}	1.0×10^{-1}
DS210	0 - 4	0-1.7 Structureless chalk (Grade Dc) 1.7 -4.0 Chalk Grade B2	4.2×10^{-6}	1.5×10^{-2}
DS301	5.7 – 10.15	5.7-7.0 Chalk Grade A3-A4 7.0-10.15 Chalk Grade A3	1.1×10^{-4}	4.1×10^{-1}

9.8.4 It should be noted the soil infiltration rates provided in **Table 9.5** were derived from the variable head permeability tests which were not undertaken in accordance with BRE DG 365 and therefore may not provide a true representation of the Site’s infiltration rates.

9.8.5 Structureless Chalk is unlikely to be suitable for infiltration drainage because of the predominance of silt like matrix and infiltration into the Structured Chalk will be affected by the presence of fractures and fissures and whether these have been infilled. CIRIA C574 only provides permeabilities for chalk, which is not the same parameter as infiltration rate,

9.8.6 Therefore, in the interim, until appropriate soil infiltration testing in accordance with BRE DG 365 can be undertaken, the infiltration rates have been reduced by an order of magnitude to ensure the Scheme is not over reliant upon the derived infiltration rates. The infiltration rates for preliminary Stage 3B surface water drainage design are summarised in **Table 9.6** below.

9.8.7 It should be noted that given that the infiltration rates are based upon variable head permeability tests, their localised proximity in relation to the extent of the Scheme is not representative. The infiltration rates have, therefore, been categorised based upon the underlying geology rather than location.

Table 9.6 Adopted Infiltration Rates

Underlying Geology	Soil Infiltration (m/s)	Soil Infiltration (m/hr)
Alluvium / Head Deposits	1×10^{-6}	2×10^{-3}
Structured Chalk (where encountered within the top 2m)	1×10^{-6}	2×10^{-3}
Structured Chalk (where encountered 2m below ground level or deeper	1×10^{-5}	2×10^{-2}

9.8.8 Soil infiltration testing will need to be undertaken to be targeted at the locations and depths where surface water infiltration drainage is proposed.

10 Additional Ground Investigation

10.1.1 In order to confirm the design assumptions made in this report and to meet the requirements of the BS EN 1997-2, additional exploratory holes are required to be undertaken prior to the construction stage. These are provisionally summarised in **Table 10.1** below:

Table 10.1 Summary of Provisional Additional Exploratory Holes

Location	No. of Exploratory Holes	Anticipated Depth (m bgl)	Purpose
M3 Underpass	3 - 5 (e.g. boreholes)	Up to 35	To obtain ground and groundwater conditions around the underpass in order to design the underpass foundations, assess settlement and assess the material for reuse.
A34 Northbound Underpass	3 - 5 (e.g. boreholes)	Up to 20	To obtain ground and groundwater conditions around the underpass in order to design the underpass foundations, assess settlement and assess the material for reuse.
M3 South bound Diverge	4 - 6 (e.g. boreholes and trial pits)	Up to 12	To obtain ground conditions and assess the material for reuse
River Itchen Footbridge	2 - 4 (e.g. boreholes)	Up to 20	To obtain ground and groundwater conditions to inform pile design.
A33 Link Retaining Wall (North)	2 - 3 (e.g. boreholes)	Up to 30	To obtain ground and groundwater conditions to inform the design of the retaining structure
A33 Link Retaining Wall (South)	2 - 3 (e.g. boreholes)	Up to 30	To obtain ground and groundwater conditions to inform the design of the retaining structure

Location	No. of Exploratory Holes	Anticipated Depth (m bgl)	Purpose
Motorway Signals, Signs and Gantries	12 (e.g. boreholes)	Up to 20	To obtain the ground and groundwater conditions at each gantry location to inform the design of the foundations
Infiltration Testing	12 - 15 (e.g. trial pits)	Up to 3	To obtain the infiltration rates across the scheme to inform the drainage design.
Earthworks Information	10 - 15	Up to 4	To obtain bulk samples for earthworks testing
Compound Areas	6 – 10 (e.g. boreholes and trial pits)	Up to 35	To obtain ground and groundwater conditions within proposed compound areas

10.1.2 In situ testing is to be undertaken and appropriate samples are to be obtained and tested to confirm the characteristic values of the geotechnical parameters adopted in the design. Further details of the proposed ground investigation will be provided in the Ground Investigation Scope Report as required. It should be noted that scope of the ground investigation presented above may be modified to meet the requirements for the detailed design of the Scheme.

10.1.3 The results of the additional ground investigation will be reported in a factual report provided by the ground investigation contractor accompanied with a separate AGS File. An Addendum Ground Investigation Report will be produced following the receipt of the factual information.

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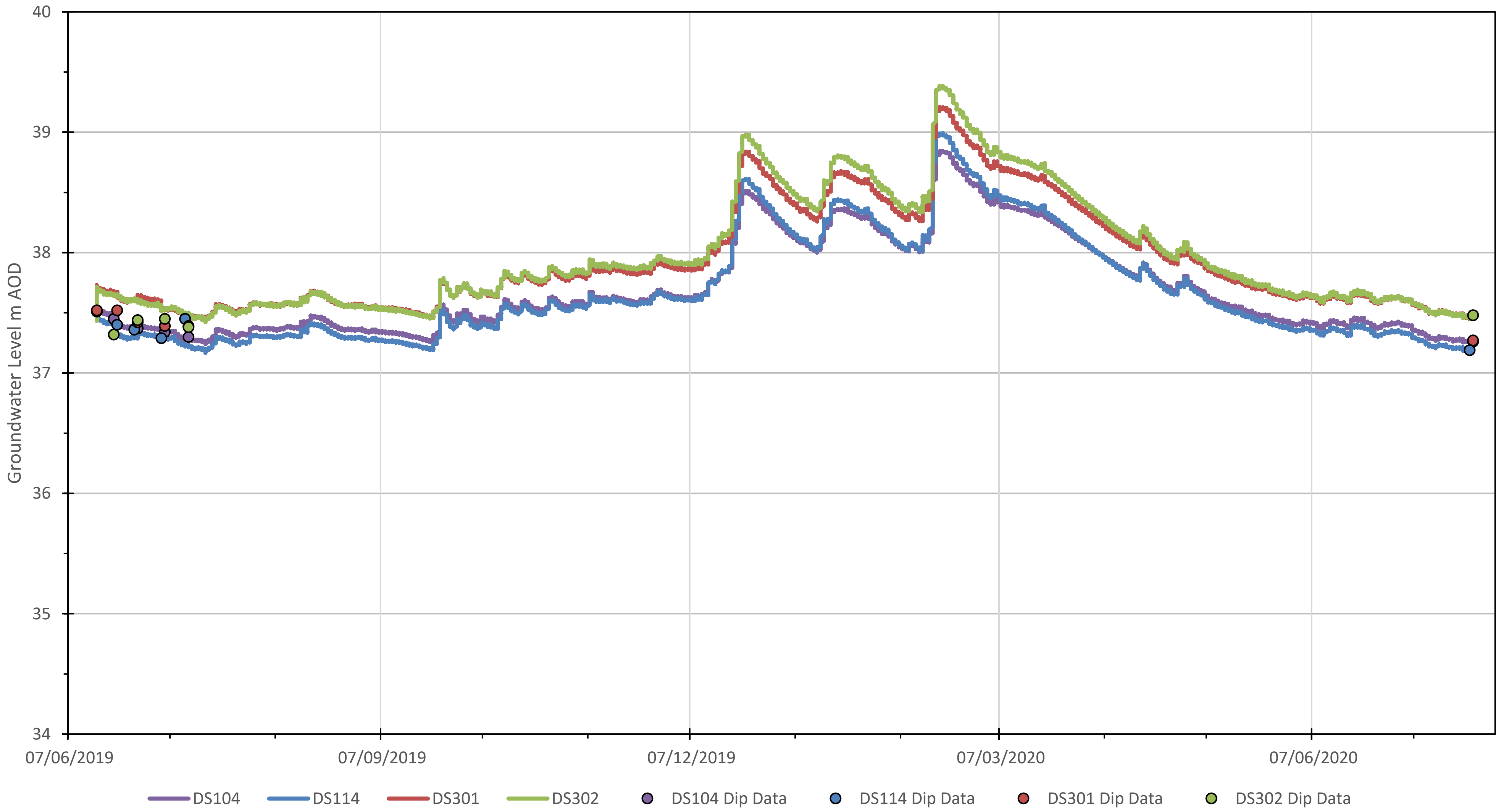
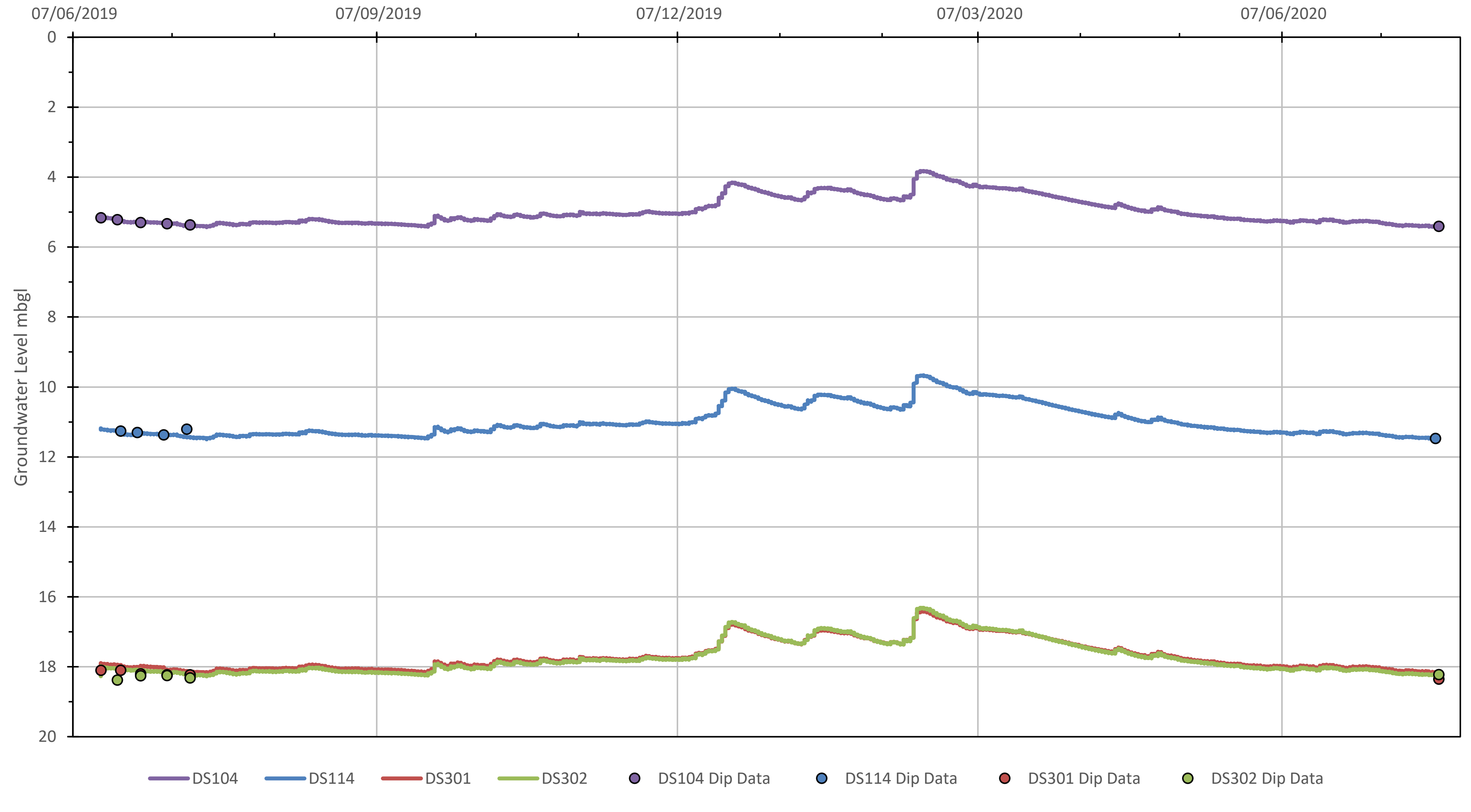
Figures



Stantec stantec.com/uk © Stantec UK Limited	Client **National Highways & Volkerfitzpatrick**	**M3 Junction 9 Improvements** **Barometrically Compensated Groundwater Level (m Above Ordnance Datum)**	Date May 2022 A4 Scale NTS Drawn TT Checked AD **Figure** **1a**

J:\48176 M3 Junction 9\3500 - Geotechnical\04 Data\Geo lab\[Data Logger GW Levels Fig.xlsx]M AOD



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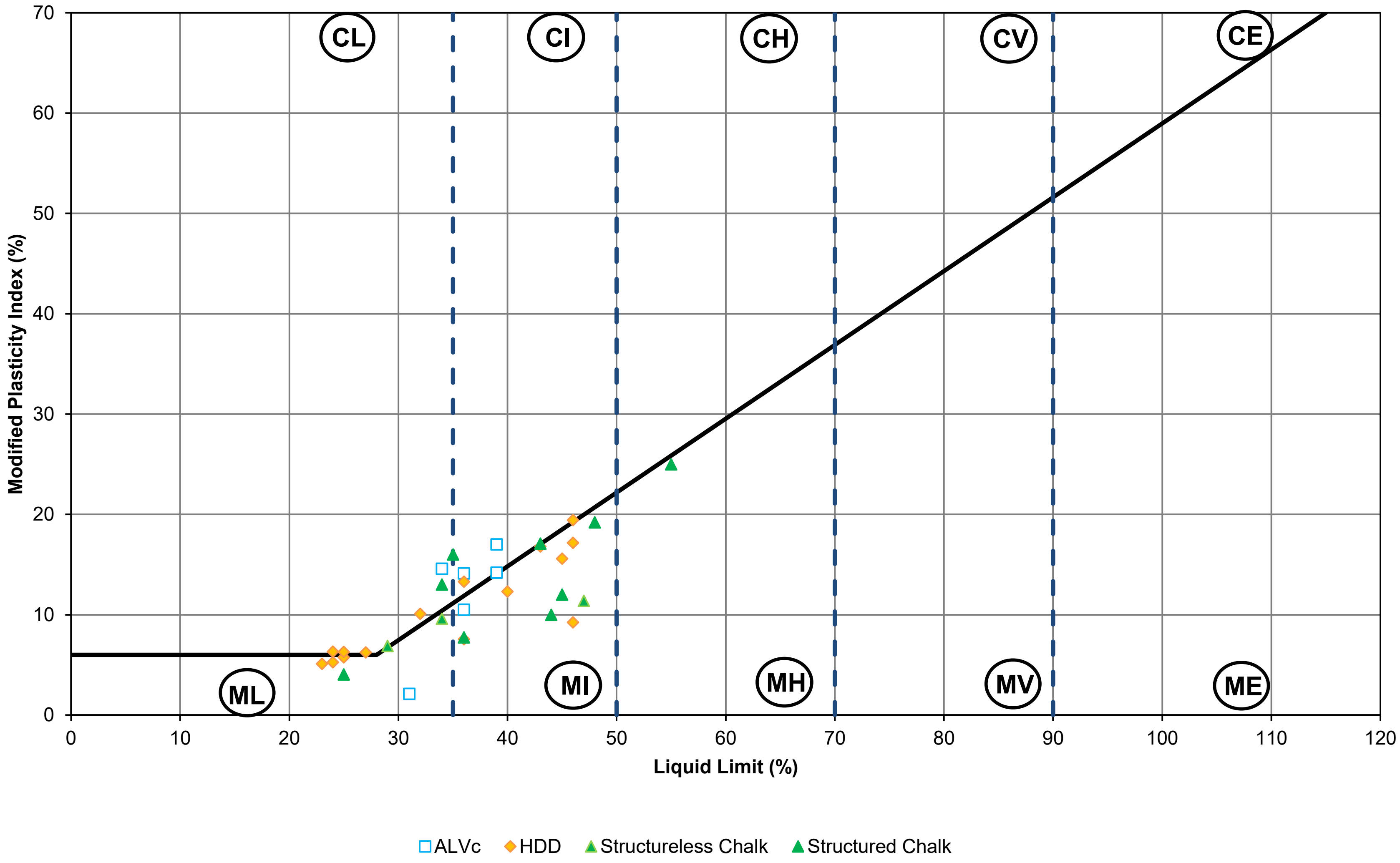
M3 Junction 9 Improvements

Barometrically Compensated Groundwater Level (m below ground level)

Date	May 2022
A4 Scale	NTS
Drawn	TT
Checked	AD

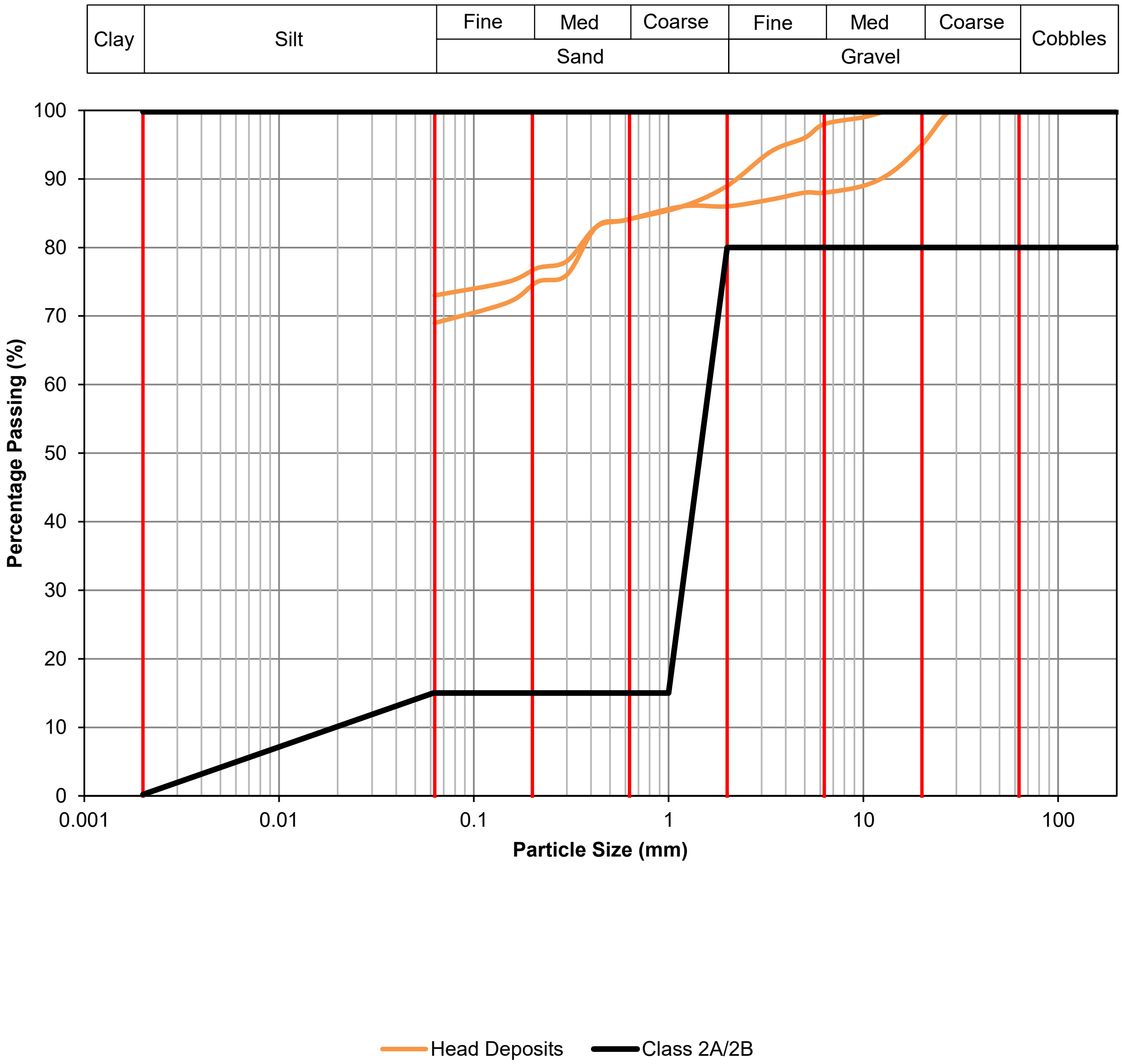
Figure 1b

J:\48176 M3 Junction 9\3500 - Geotechnical\04 Data\Geo lab\[Data Logger GW Levels Fig.xlsx] M BGL



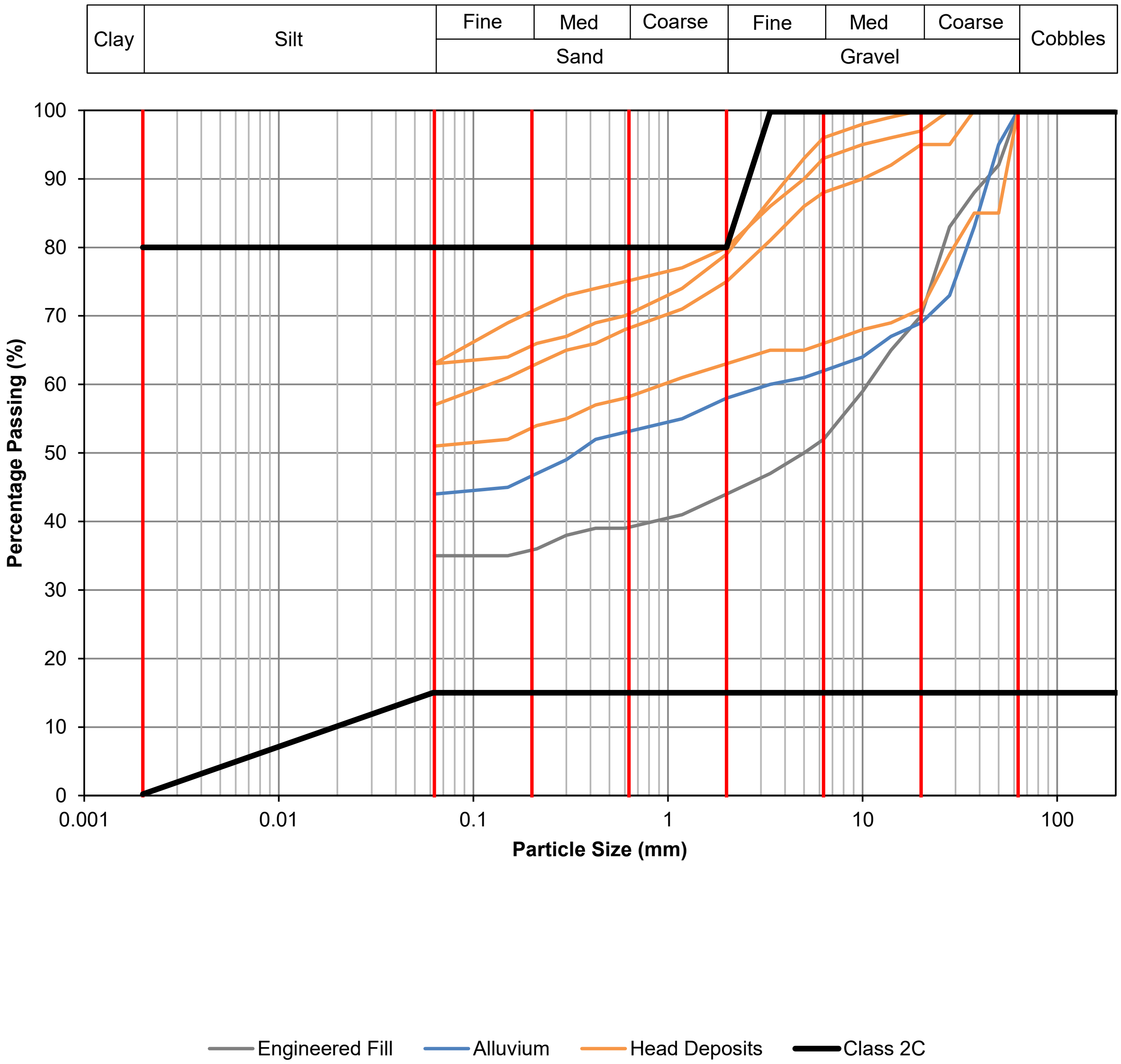
Stantec stantec.com/uk © Stantec UK Limited	Client **National Highways & Volkerfitzpatrick**	**M3 Junction 9 Improvements** **Atterberg Limits**	Date May 2022 A4 Scale nts Drawn TT Checked AD **Figure** **2**

J:\48176 M3 Junction 9\3500 - Geotechnical\04 Data\Geo lab\Figure 2 Atterbergs.xlsm



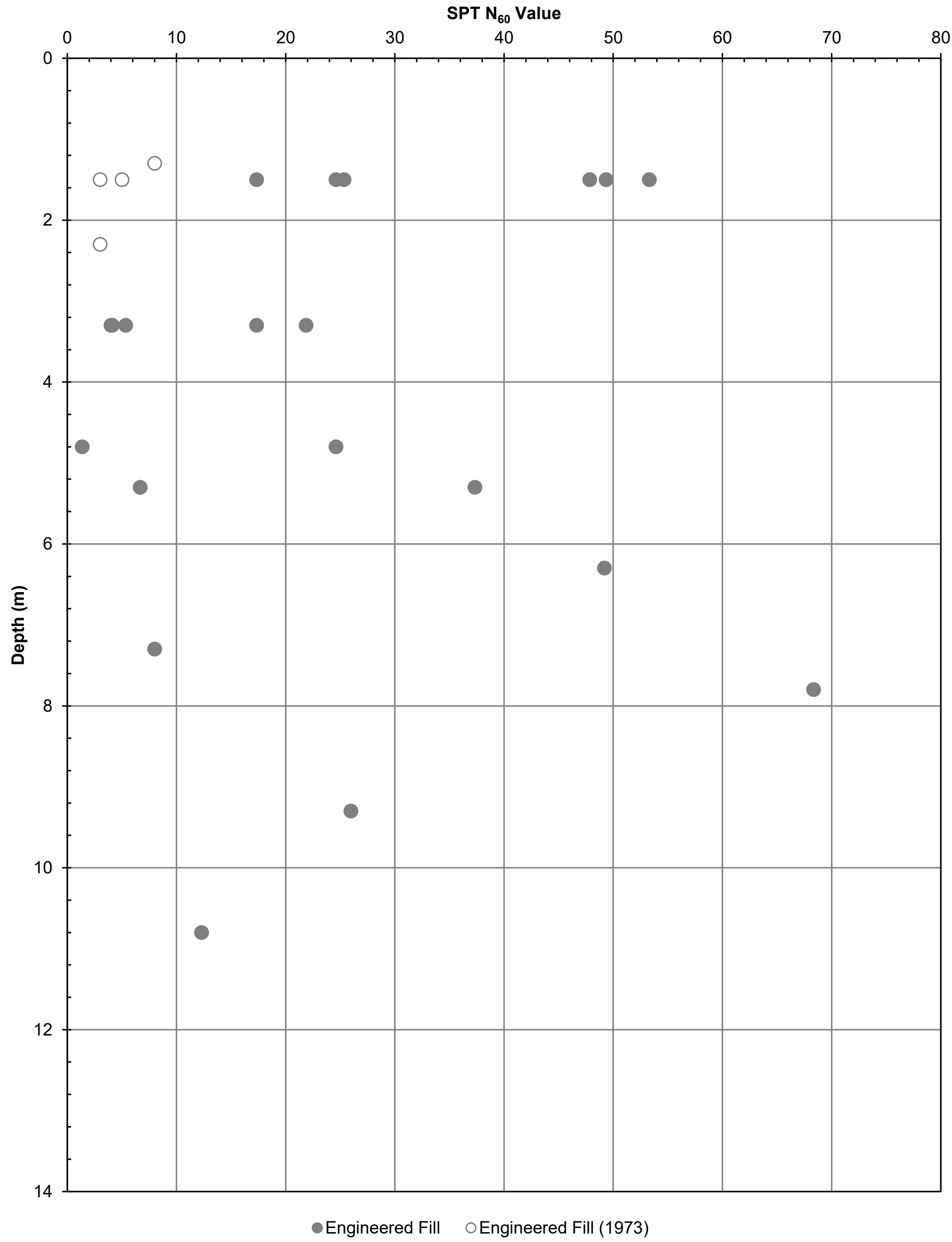
HA Specification for Highway Works Table 6/2 Grading Envelope for Class 2A/2B

Stantec stantec.com © Stantec UK Limited	Client **National Highways & Volkerfitzpatrick**	**M3 Junction 9 Improvements** **Particle Size Distribution - Class 2A/2B**	Date May 2022 A4 Scale NTS Drawn TT Checked AD Figure **3a**

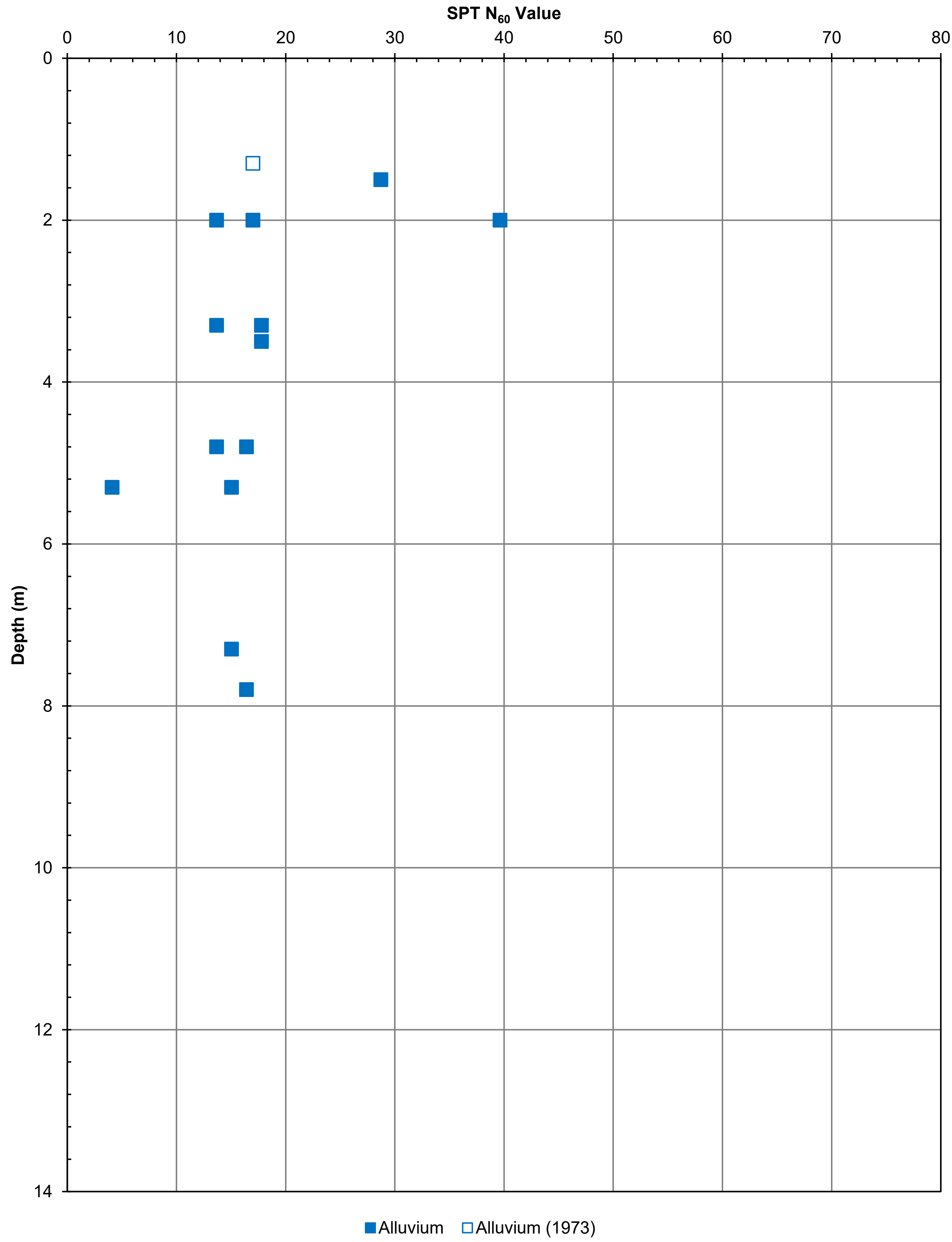


HA Specification for Highway Works Table 6/2 Grading Envelope for Class 2C

Stantec stantec.com © Stantec UK Limited	Client **National Highways & Volkerfitzpatrick**	**M3 Junction 9 Improvements** **Particle Size Distribution - Class 2C**	Date May 2022 A4 Scale NTS Drawn TT Checked AD Figure **3b**



Stantec stantec.com 	Client **National Highways & VolkerFitzpatrick**	**M3 Junction 9 Improvements** **SPT N_{60} vs Depth Engineered Fill**	Date May 2022 A4 Scale NTS Drawn AD Checked TT Figure **4a**



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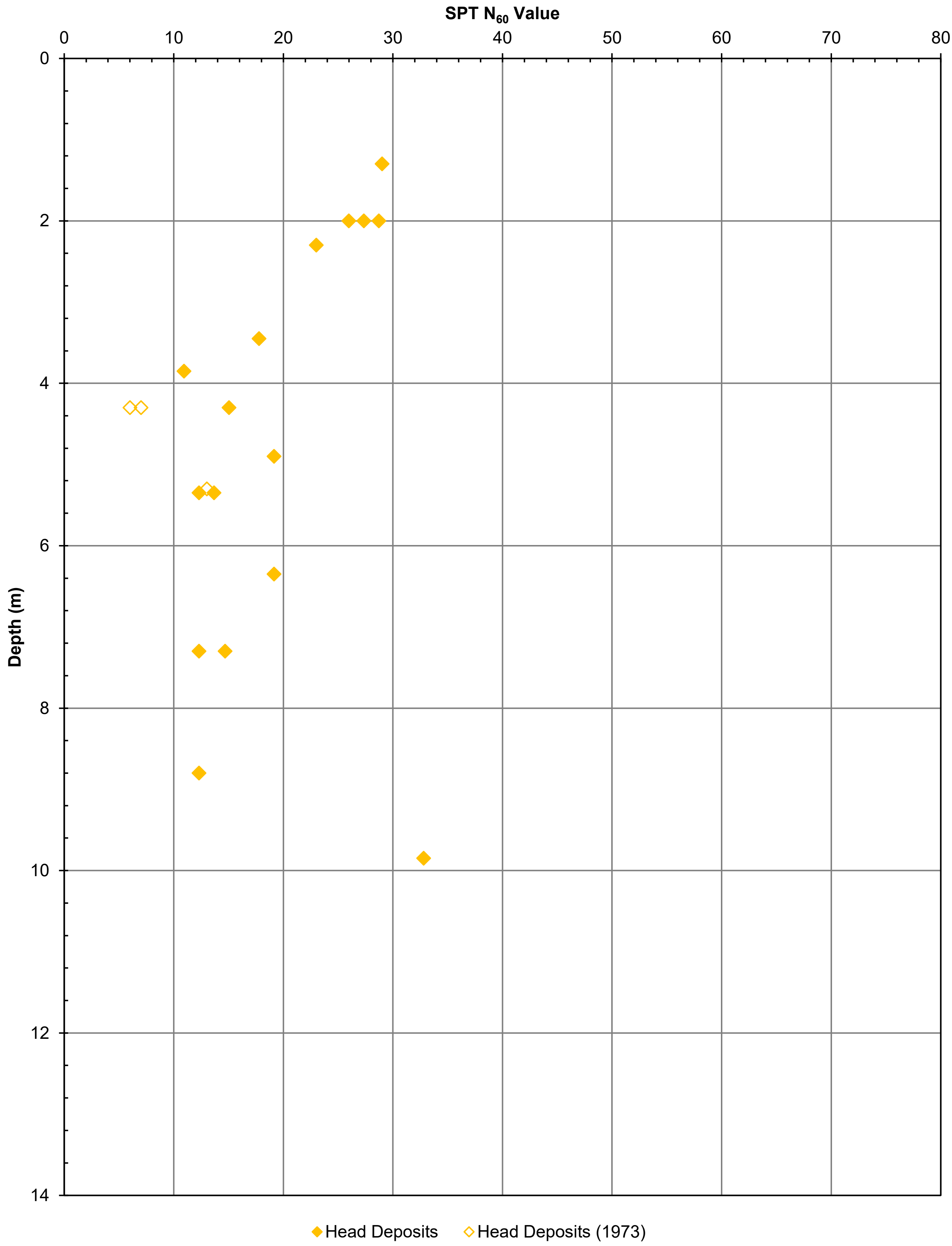
M3 Junction 9 Improvements

SPT N_{60} vs Depth Alluvium

Date	May 2022
A4 Scale	NTS
Drawn	TT
Checked	AD
Figure	**4b**

J:\48176 M3 Junction 9\3500 - Geotechnical\04 Data\Geo lab\SPT N60\PBA SPT N60 v Depth all data.xlsm



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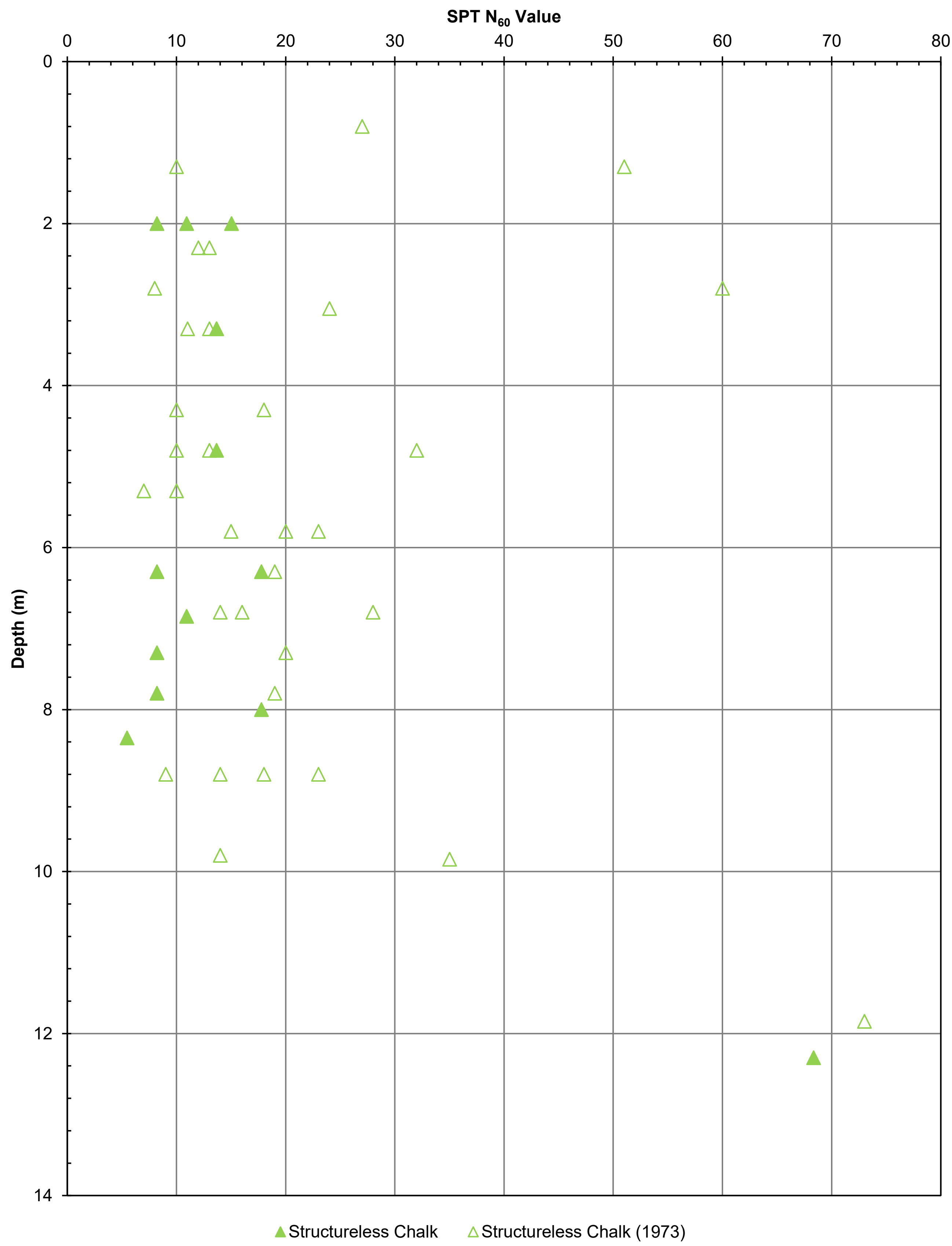
M3 Junction 9 Improvements

SPT N_{60} vs Depth
Head Deposits

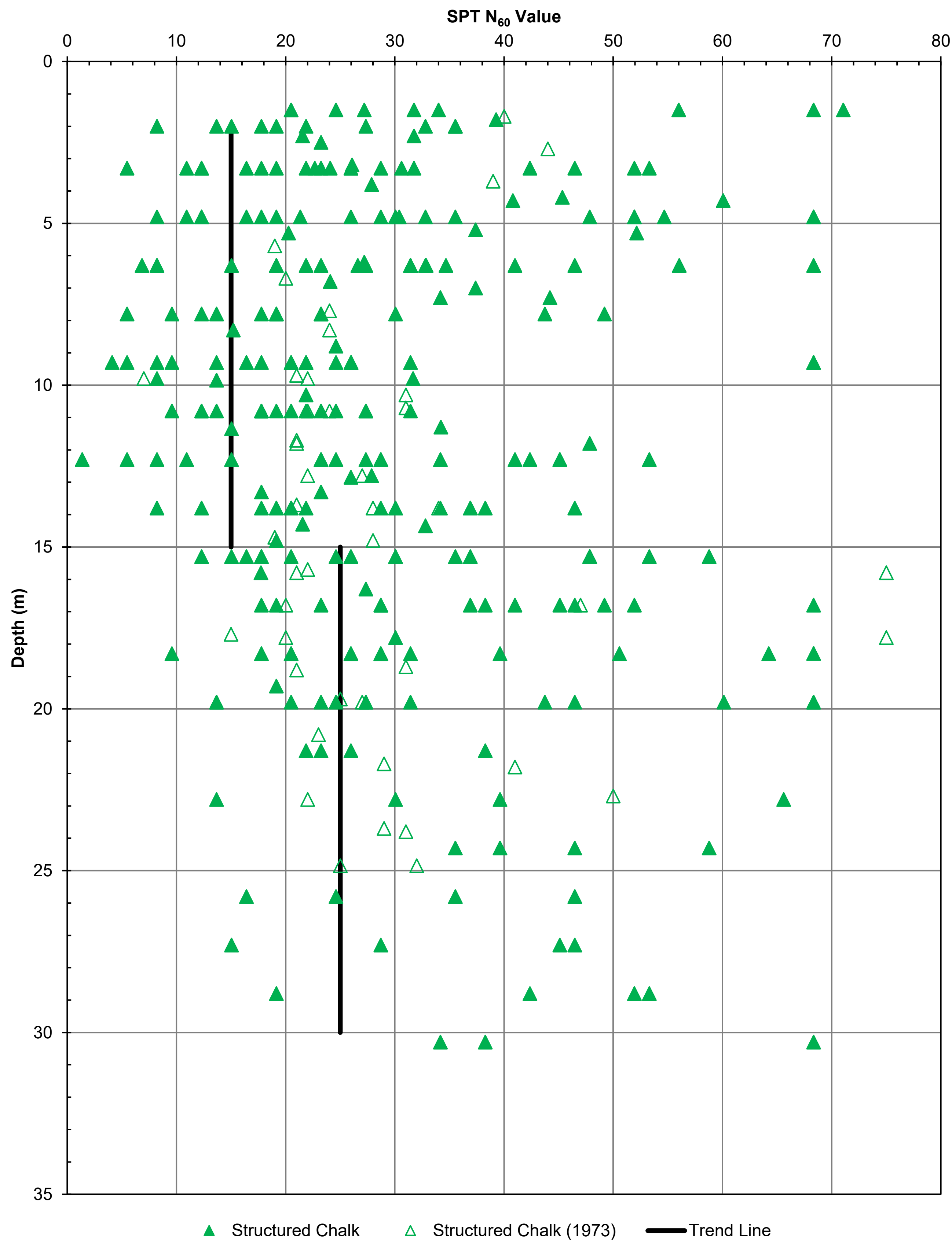
Date	May 2022
A4 Scale	NTS
Drawn	TT
Checked	AD
Figure	**4c**

J:\48176 M3 Junction 9\3500 - Geotechnical\04 Data\Geo lab\SPT N60\PBA SPT N60 v Depth all data.xlsm



Stantec stantec.com © Stantec UK Limited	Client **National Highways & VolkerFitzpatrick**	**M3 Junction 9 Improvements** **SPT N_{60} vs Depth Structureless Chalk**	Date: May 2022 A4 Scale: NTS Drawn: TT Checked: AD Figure: **4d**

J:\48176 M3 Junction 9\3500 - Geotechnical\04 Data\Geo lab\SPT N60\PBA SPT N60 v Depth all data.xlsm



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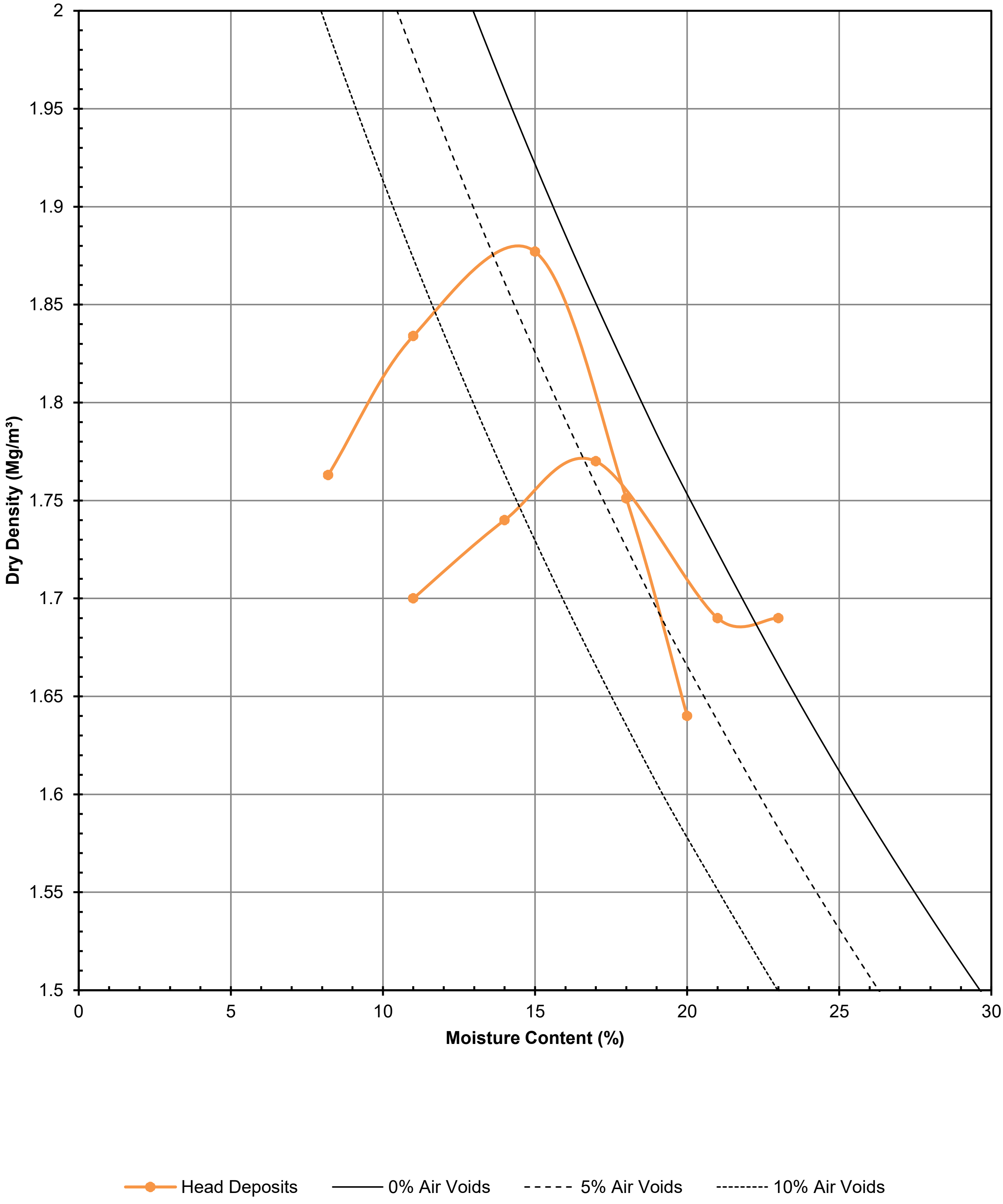
Client

National Highways & VolkerFitzpatrick

M3 Junction 9 Improvements

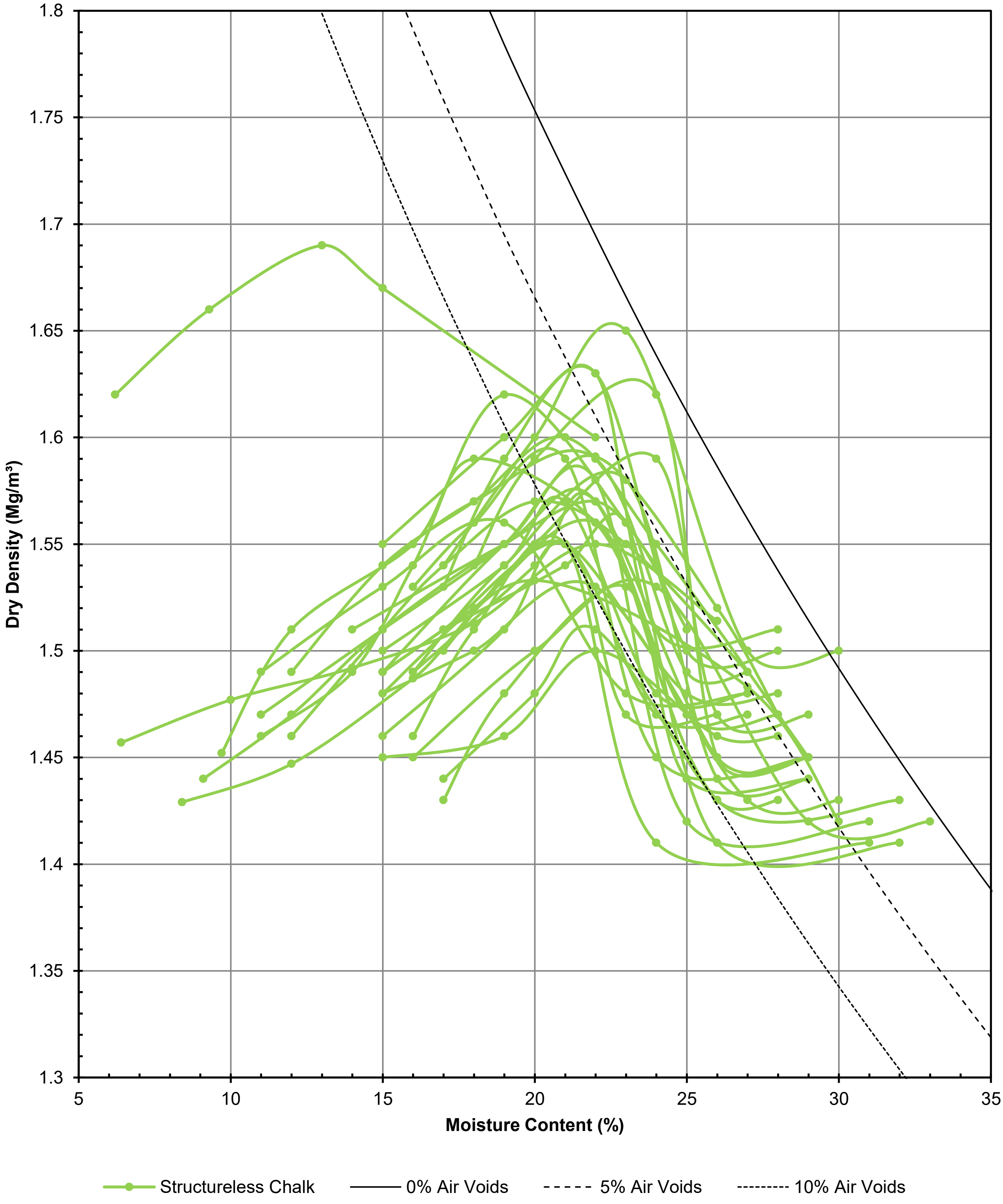
SPT N_{60} vs Depth Structured Chalk

Date	May 2022
A4 Scale	NTS
Drawn	TT
Checked	AD
Figure	**4e**



Assumed Specific Gravity = 2.7 Mg/m³

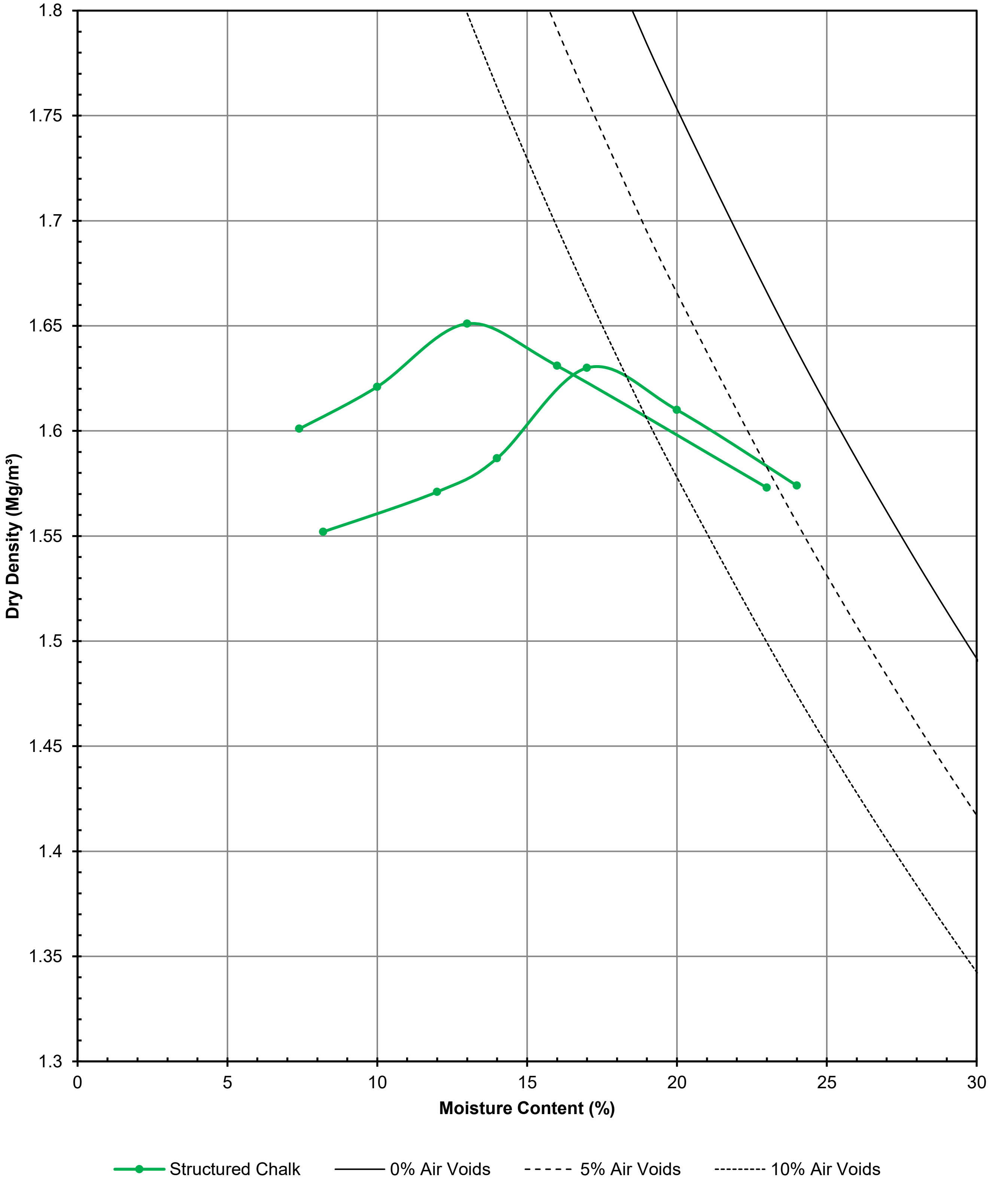
Stantec stantec.com © Stantec UK Limited	Client National Highways & VolkerFitzpatrick	M3 Junction 9 Improvements MDD vs OMC Relationship - Head Deposits	Date May 2022 A4 Scale NTS Drawn TT Checked AD Figure 5a



Assumed Specific Gravity = 2.7 Mg/m³

Stantec stantec.com © Stantec UK Limited	Client **National Highways & VolkerFitzpatrick**	**M3 Junction 9 Improvements** **MDD vs OMC Relationship - Structureless Chalk**	Date: May 2022 A4 Scale: NTS Drawn: TT Checked: AD Figure: **5b**

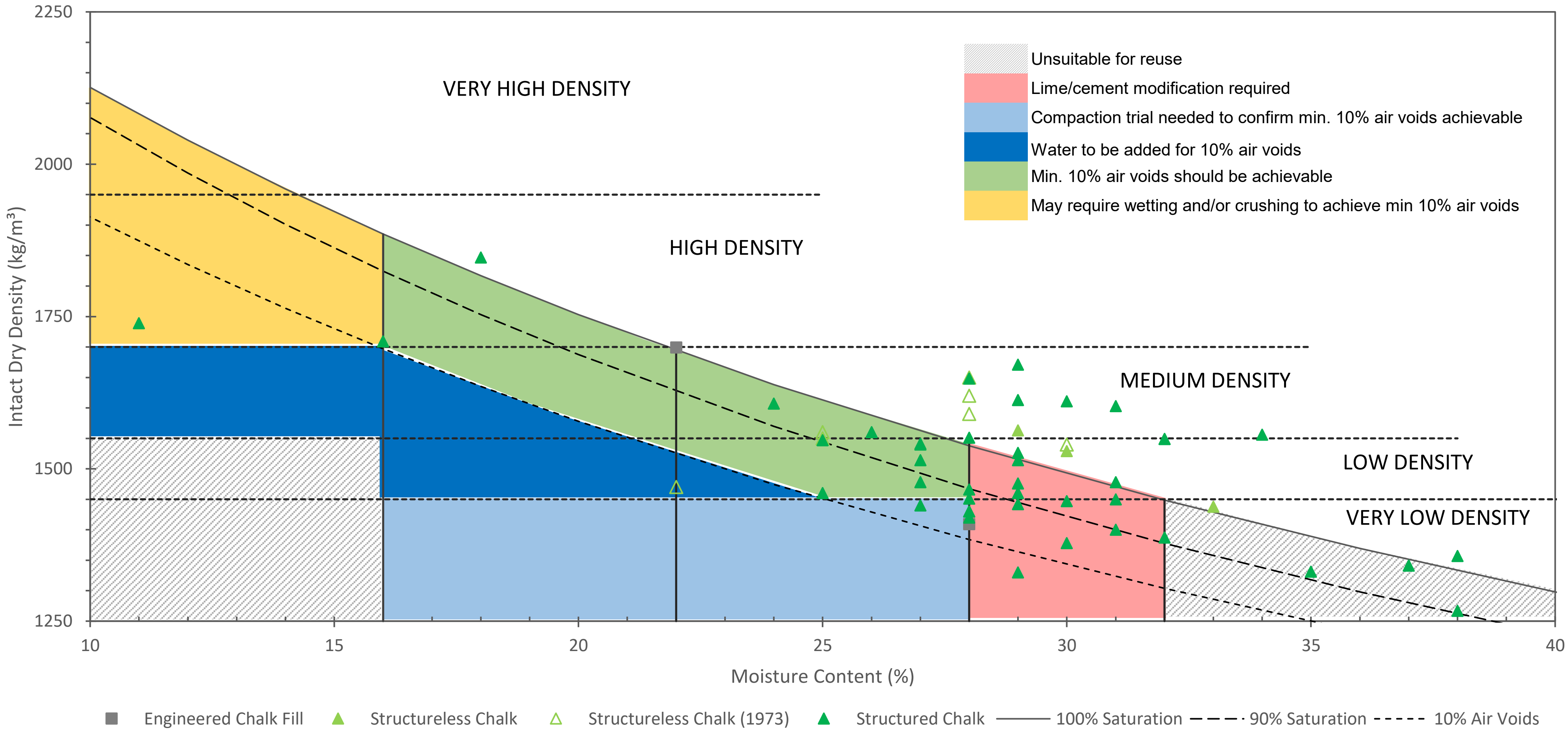
J:\48176 M3 Junction 9\3500 - Geotechnical\04 Data\Geo lab\PBA Compaction by Geology edit.xlsm



Assumed Specific Gravity = 2.7 Mg/m³

Stantec stantec.com © Stantec UK Limited	Client National Highways & VolkerFitzpatrick	M3 Junction 9 Improvements MDD vs OMC Relationship - Structured Chalk	Date May 2022 A4 Scale NTS Drawn TT Checked AD Figure 5c

J:\48176 M3 Junction 9\3500 - Geotechnical\04 Data\Geo lab\PBA Compaction by Geology edit.xlsm



Chalk Classification for Earthworks based on CIRIA C574

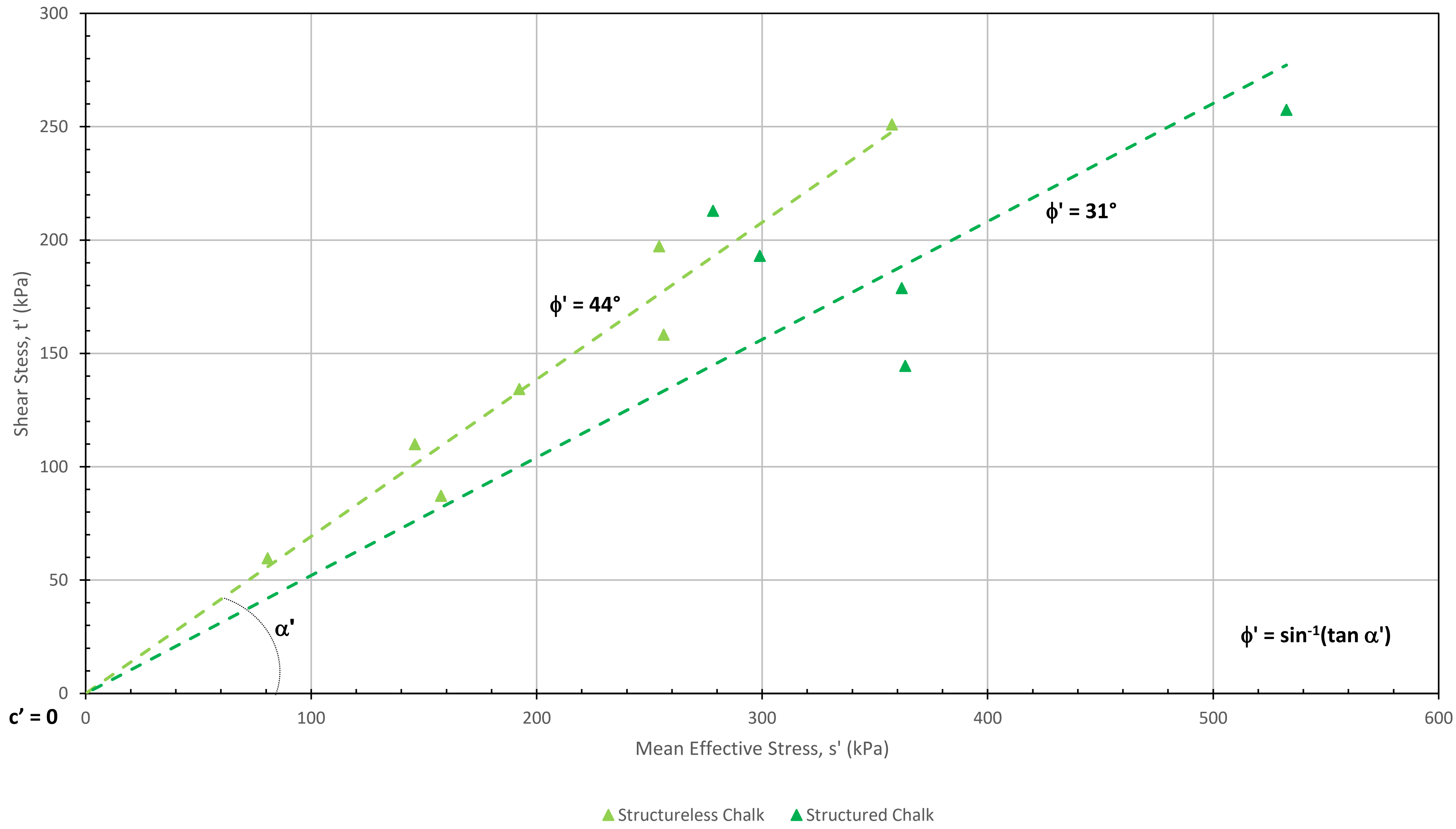
Intact Dry Density plotted against the Moisture Contents provided in the Factual Report.

Saturation and Air Voids lines are based on specific gravity value of 2.70

Points plotted above the 100% saturation line indicate reporting or testing procedure error

Stantec stantec.com/uk © Stantec UK Limited	Client **National Highways & Volkerfitzpatrick**	**M3 Junction 9 Improvements** **Preliminary Earthworks Chalk Classification**	Date May 2022 A4 Scale NTS Drawn AD Checked RHT **Figure** **6**

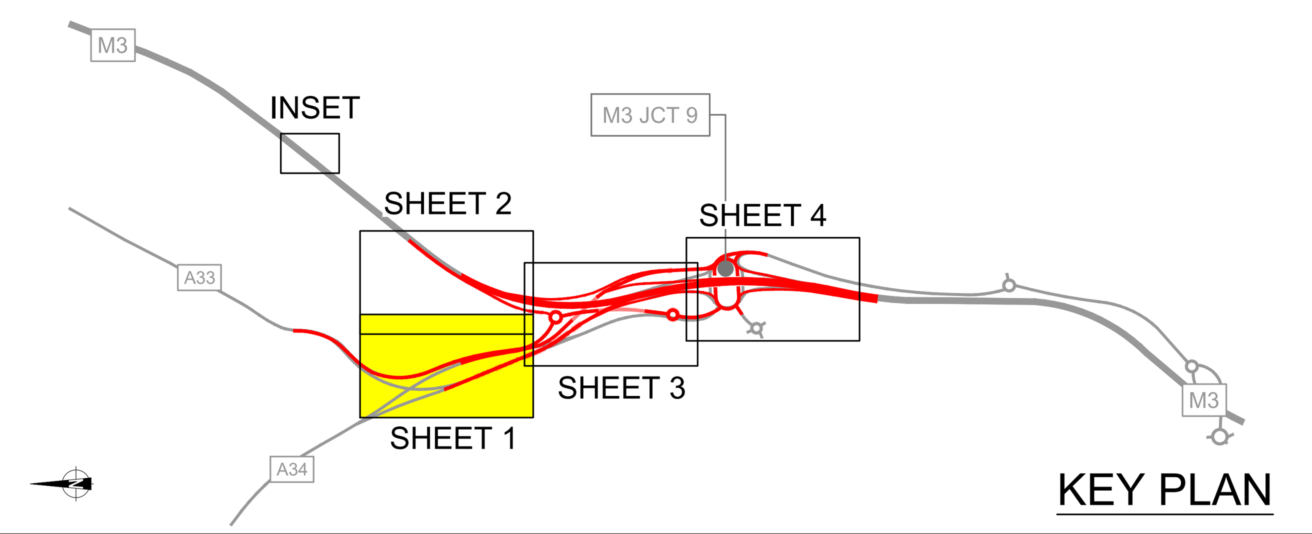
J:\48176 M3 Junction 9\3500 - Geotechnical\04 Data\Geo lab\[Rock Density Tests edit.xlsx]A4 LS TT



Stantec stantec.com/uk © Stantec UK Limited	Client **National Highways & Volkerfitzpatrick**	**M3 Junction 9 Improvements** **Effective Stress Plot from Consolidated Undrained Triaxial Tests**	Date: May 2022 A4 Scale: NTS Drawn: TT Checked: AD **Figure** 7

J:\48176 M3 Junction 9\3500 - Geotechnical\04 Data\Geo lab\[Effect Paramteres for Chalk T vs S.xlsx]s vs t

Drawings



KEY PLAN

GDMS HISTORICAL EXPLORATORY HOLES

- TRIAL PIT
- CABLE PERCUSSION BOREHOLE
- WINDOWLESS SAMPLING BOREHOLE

SOILS LIMITED 2019 EXPLORATORY HOLES

- TRIAL PIT
- DYNAMIC SAMPLING WITH ROTARY CORE FOLLOW ON
- WINDOWLESS SAMPLING BOREHOLE

Rev.	Date	Description	Drawn	Chk'd	App'd
P02	20.05.22	OMISSION OF MANAGED MOTORWAY SCHEME	davco	AD	RHT
P01	06.05.21	FIRST ISSUE	davco	AD	RHT

Drawing Status: FOR SGAR 3B

VolkerFitzpatrick

Client: national highways

Project Title: M3 JUNCTION 9 IMPROVEMENTS

Drawing Title: EXPLORATORY HOLE LOCATION PLAN

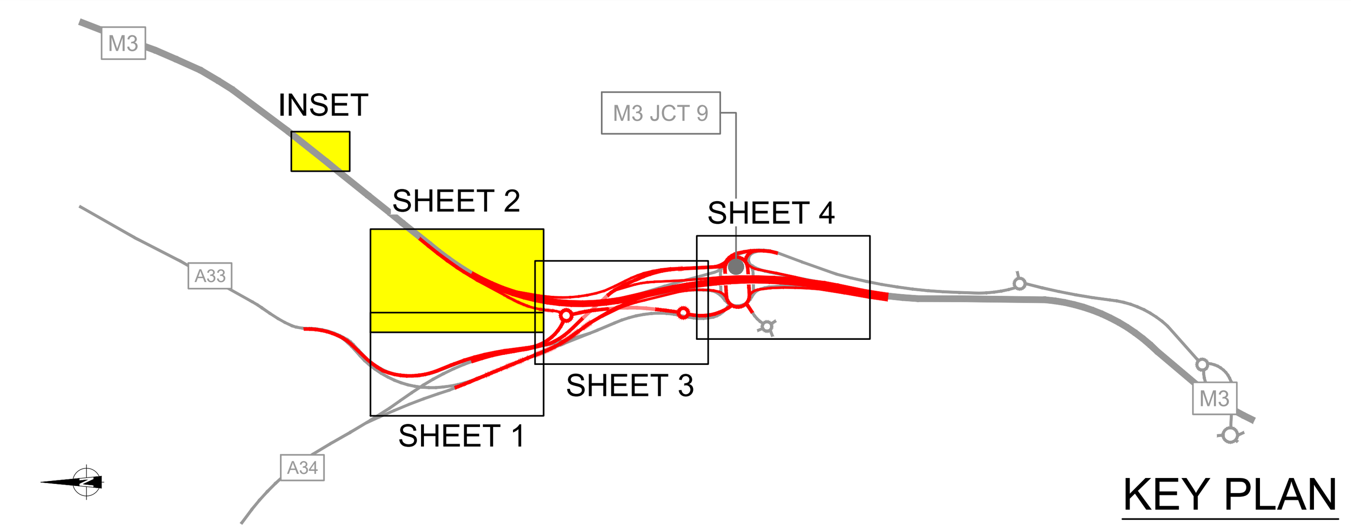
SHEET 1 OF 4

Scale	Designed	Drawn	Checked	Approved
1:1000	AD	davco	AD	RHT
Original Size: A1	Date: 05.05.21	Date: 05.05.21	Date: 05.05.21	Date: 06.05.21

Drawing Number: HE PIN | Originator | Volume — HE551511 - VFK - HGT - X_XXXX_XX - DR - GE - 0001 (Location | Type | Role | Number)

Project Ref. No.: 48176

Revision: P02



KEY PLAN

GDMS HISTORICAL EXPLORATORY HOLES

- TRIAL PIT
- CABLE PERCUSSION BOREHOLE
- WINDOWLESS SAMPLING BOREHOLE

SOILS LIMITED 2019 EXPLORATORY HOLES

- TRIAL PIT
- DYNAMIC SAMPLING WITH ROTARY CORE FOLLOW ON
- WINDOWLESS SAMPLING BOREHOLE

Rev.	Date	Description	Drawn	Chk'd	App'd
P02	20.05.22	OMISSION OF MANAGED MOTORWAY SCHEME	davco	AD	RHT
P01	06.05.21	FIRST ISSUE	davco	AD	RHT

Drawing Status: FOR SGAR 3B

VolkerFitzpatrick

Client: national highways

Project Title: M3 JUNCTION 9 IMPROVEMENTS

Drawing Title: EXPLORATORY HOLE LOCATION PLAN

SHEET 2 OF 4

Scale	Designed	Drawn	Checked	Approved
1:1000	AD	davco	AD	D
Original Size: A1	Date: 05.05.21	Date: 05.05.21	Date: 05.05.21	Date: RHT

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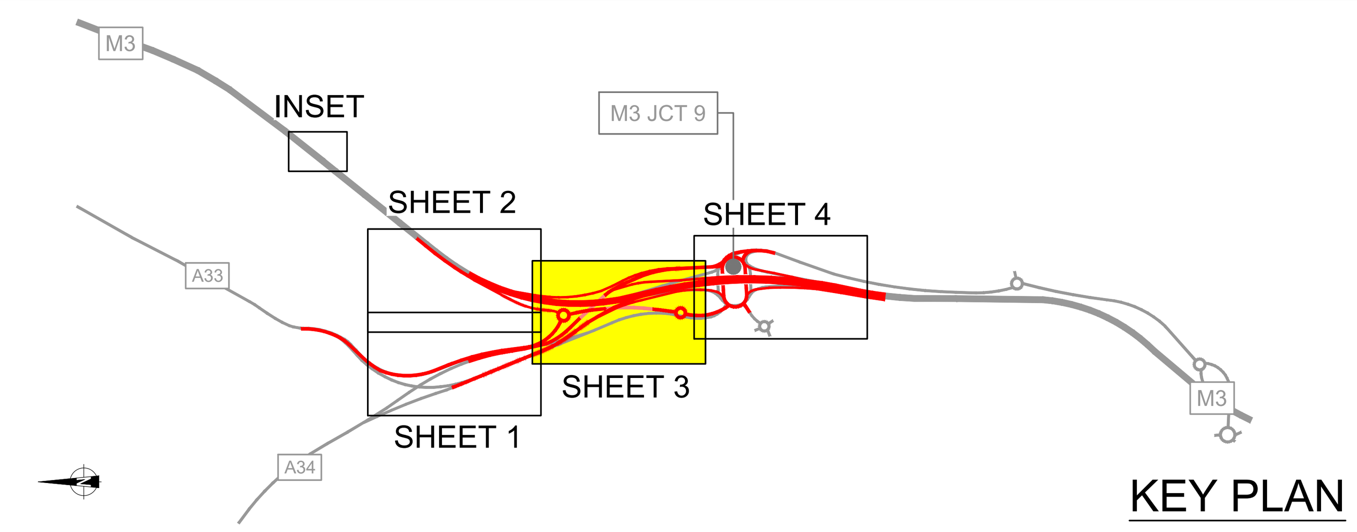
Project Ref. No.: 48176

Revision: P02



KEY PLAN

GDMS HISTORICAL EXPLORATORY HOLES

- TRIAL PIT
- CABLE PERCUSSION BOREHOLE
- WINDOWLESS SAMPLING BOREHOLE

SOILS LIMITED 2019 EXPLORATORY HOLES

- TRIAL PIT
- DYNAMIC SAMPLING WITH ROTARY CORE FOLLOW ON
- WINDOWLESS SAMPLING BOREHOLE

Rev.	Date	Description	Drawn	Chk'd	App'd
P02	20.05.22	OMISSION OF MANAGED MOTORWAY SCHEME	davco	AD	RHT
P01	06.05.21	FIRST ISSUE	davco	AD	RHT

Drawing Status: FOR SGAR 3B

VolkerFitzpatrick

Client: national highways

Project Title: M3 JUNCTION 9 IMPROVEMENTS

Drawing Title: EXPLORATORY HOLE LOCATION PLAN

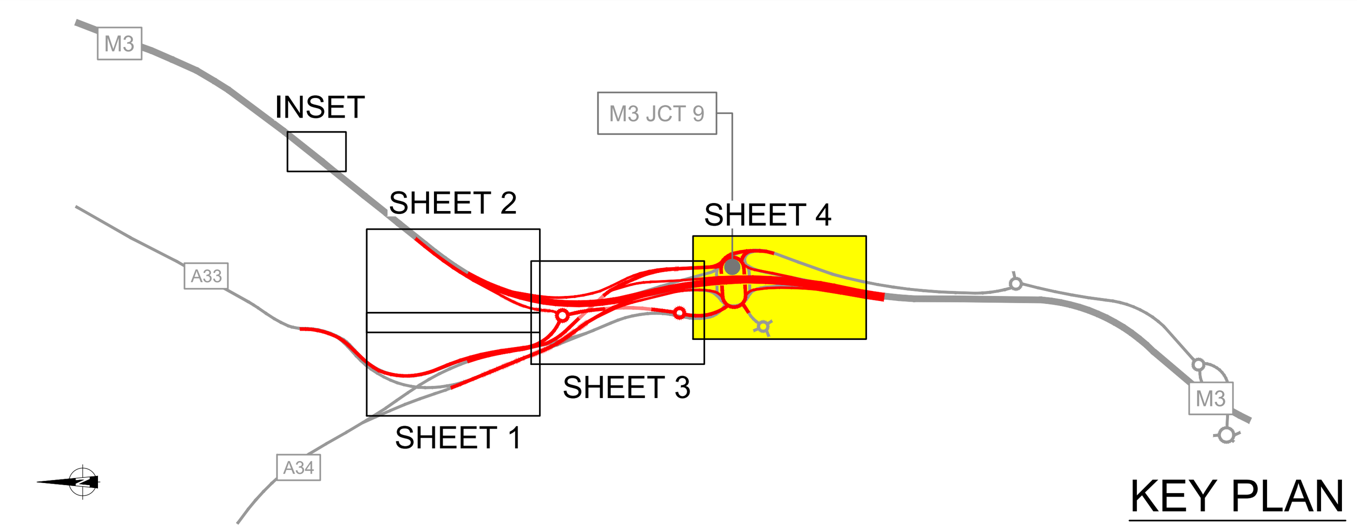
SHEET 3 OF 4

Scale	Designed	Drawn	Checked	Approved
1:1000	AD	davco	AD	RHT
Original Size A1	Date 05.05.21	Date 05.05.21	Date 05.05.21	Date 06.05.21

Drawing Number: HE PIN HE551511 - Originator VFK - Volume HGT - X_XXXX_XX - DR - GE - 0003 (Location, Type, Role, Number)

Project Ref. No. 48176

Revision P02



KEY PLAN

GDMS HISTORICAL EXPLORATORY HOLES

- TRIAL PIT
- CABLE PERCUSSION BOREHOLE
- WINDOWLESS SAMPLING BOREHOLE

SOILS LIMITED 2019 EXPLORATORY HOLES

- TRIAL PIT
- DYNAMIC SAMPLING WITH ROTARY CORE FOLLOW ON
- WINDOWLESS SAMPLING BOREHOLE

Rev.	Date	Description	Drawn	Chk'd	App'd
P02	20.05.22	OMISSION OF MANAGED MOTORWAY SCHEME	davco	AD	RHT
P01	06.05.21	FIRST ISSUE	davco	AD	RHT

Drawing Status: FOR SGAR 3B

VolkerFitzpatrick

Client: national highways

Project Title: M3 JUNCTION 9 IMPROVEMENTS

Drawing Title: EXPLORATORY HOLE LOCATION PLAN

SHEET 4 OF 4

Scale	Designed	Drawn	Checked	Approved
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Original Size: A1	Date: 05.05.21	Date: 05.05.21	Date: 05.05.21	Date: 06.05.21

Drawing Number: HE PIN HE551511 - Originator VFK - Volume HGT - X_XXXX_XX - Location - Type DR - Role GE - Number 0004

Project Ref. No. 48176

Revision P02

Key

- Made Ground
- Peat
- Alluvium
- Head
- Structureless Chalk (Grade Dm and Dc)
- Structured Chalk (Grade A to C)

Rev.	Date	Description	Drawn	Chk'd	App'd
P03	20.05.22	OMISSION OF MANAGED MOTORWAY SCHEME	davco	AD	RHT
P02	05.05.21	INCORPORATING HE COMMENTS	davco	AD	RHT

Drawing Status: FOR SGAR 3B

VolkerFitzpatrick

Client: national highways

Project Title: M3 JUNCTION 9 IMPROVEMENTS

Drawing Title: GEOLOGICAL PLAN

Scale	Designed	Drawn	Checked	Approved
1:2500	AD	davco	AD	RHT
Original Size: A1	Date: 01.12.20	Date: 01.12.20	Date: 04.12.20	Date: 08.12.20

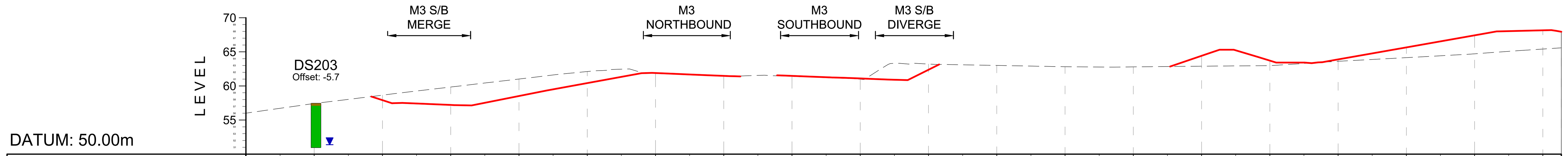
Drawing Number: HE PIN | Originator | Volume | Location | Type | Role | Number

HE551511 - VFK - HGT - X_XXXX_XX - DR - GE - 0020

Project Ref. No.: 48176

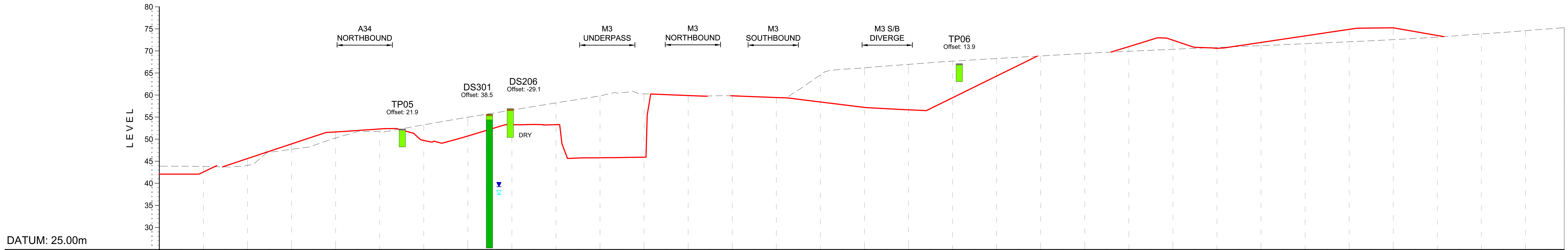
Revision: P03

SECTION A
SCALE: Hz 1:500, Vt 1:500



CHAINAGE	EXISTING LEVEL	PROPOSED LEVEL
0.000	56.000	
5.000	56.720	
10.000	57.420	
15.000	58.028	
20.000	58.649	57.918
25.000	59.258	57.423
30.000	59.838	57.211
35.000	60.428	57.525
40.000	61.011	58.519
45.000	61.609	59.499
50.000	62.108	60.416
55.000	62.456	61.333
60.000	61.862	61.889
65.000	61.663	61.682
70.000	61.475	61.474
75.000	61.545	
80.000	61.391	61.472
85.000	61.197	61.274
90.000	60.985	61.100
95.000	63.304	60.903
100.000	63.211	62.374
105.000	63.099	
110.000	63.006	
115.000	62.913	
120.000	62.822	
125.000	62.776	
130.000	62.793	
135.000	62.848	
140.000	62.892	64.417
145.000	62.936	65.225
150.000	62.980	63.714
155.000	63.295	63.423
160.000	63.617	63.888
165.000	63.885	64.771
170.000	64.153	65.654
175.000	64.421	66.539
180.000	64.711	67.423
185.000	65.073	68.037
190.000	65.409	68.161
192.707	65.582	67.947

SECTION B
SCALE: Hz 1:500, Vt 1:500



CHAINAGE	EXISTING LEVEL	PROPOSED LEVEL
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5.000	43.863	42.075
10.000	43.802	42.557
15.000	43.707	43.940
20.000	44.052	45.604
25.000	47.040	47.263
30.000	47.711	48.923
35.000	48.574	50.578
40.000	50.275	51.628
45.000	51.708	51.966
50.000	51.643	52.315
55.000	52.357	52.067
60.000	53.251	49.710
65.000	54.127	49.314
70.000	54.986	50.711
75.000	55.771	52.228
80.000	56.586	53.274
85.000	57.413	53.330
90.000	58.226	53.281
95.000	59.002	45.729
100.000	59.819	45.783
105.000	60.540	45.840
110.000	60.261	45.909
115.000	60.086	60.093
120.000	59.892	59.890
125.000	59.803	
130.000	59.820	59.821
135.000	59.626	59.626
140.000	59.433	59.431
145.000	61.151	59.045
150.000	64.566	58.429
155.000	65.855	57.813
160.000	66.183	57.198
165.000	66.576	56.907
170.000	66.955	56.650
175.000	67.333	56.932
180.000	67.682	59.388
185.000	67.987	61.844
190.000	68.282	64.299
195.000	68.573	66.751
200.000	68.861	
205.000	69.147	
210.000	69.432	
215.000	69.689	
220.000	69.923	70.980
225.000	70.146	72.519
230.000	70.368	72.432
235.000	70.576	70.818
240.000	70.777	70.579
245.000	70.992	71.181
250.000	71.202	71.921
255.000	71.413	72.661
260.000	71.631	73.405
265.000	71.853	74.148
270.000	72.074	74.891
275.000	72.301	75.188
280.000	72.554	75.241
285.000	72.831	74.370
290.000	73.126	73.499
295.000	73.485	
300.000	73.844	
305.000	74.202	
310.000	74.594	
315.000	74.979	
318.806	75.271	

Key
- Made Ground
- Topsoil
- Peat
- Alluvium
- Head
- Structureless Chalk (Grade Dm and Dc)
- Structured Chalk (Grade A to C)
- Maximum Recorded Groundwater Level
- Minimum Recorded Groundwater Level
- Existing Ground Level
- Proposed Ground Level

Note: Exploratory holes with negative offset values are located NORTH of the section line. Positive offsets are SOUTH of the section. Values are in linear metres

Rev.	Date	Description	Drawn	Chk'd	App'd
P03	20.05.22	OMISSION OF MANAGED MOTORWAY SCHEME	davco	AD	RHT
P02	05.05.21	INCORPORATING HE COMMENTS	davco	AD	RHT

Drawing Status: FOR SGAR 3B

Client

Project Title: M3 JUNCTION 9 IMPROVEMENTS

Drawing Title: GEOLOGICAL CROSS SECTIONS

SHEET 1 OF 3

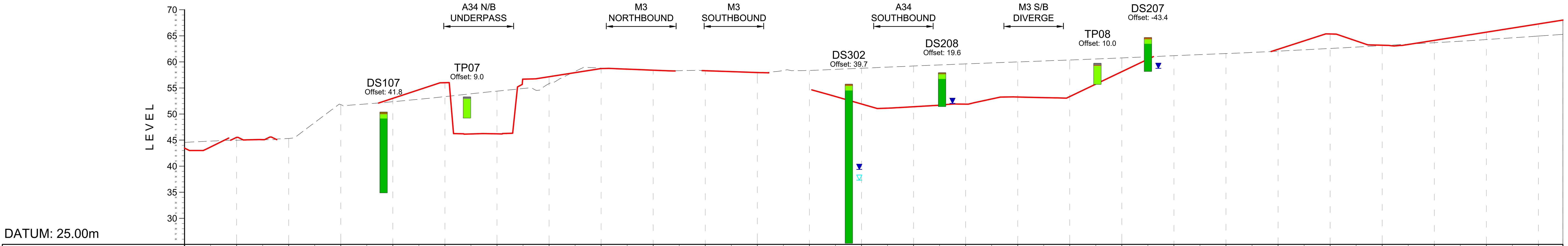
Scale	Designed	Drawn	Checked	Approved
1:2500	AD	davco	AD	RHT
Original Size A1	Date 01.12.20	Date 01.12.20	Date 01.12.20	Date 02.12.20

Drawing Number: HE PIN | Originator | Volume | Location | Type | Role | Number
HE551511 - VFK - HGT - X_XXXX_XX - DR - GE - 0021

Project Ref. No. 48176

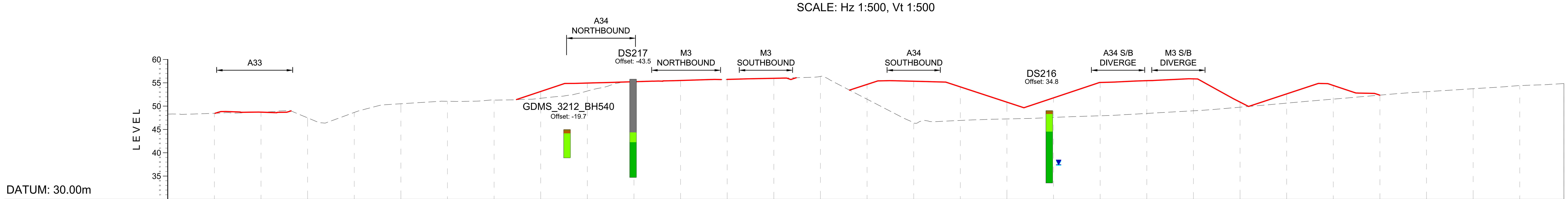
Revision P03

SECTION C
SCALE: Hz 1:500, Vt 1:500



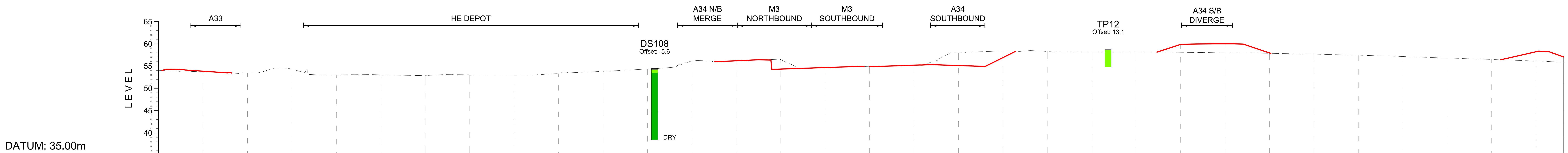
CHAINAGE	EXISTING LEVEL	PROPOSED LEVEL
0.000	44.566	43.457
5.000	44.802	43.680
10.000	44.976	45.528
15.000	45.072	45.095
20.000	45.310	
25.000	48.381	
30.000	51.804	
35.000	51.945	
40.000	52.364	53.015
45.000	52.837	54.656
50.000	53.340	56.013
55.000	53.883	46.183
60.000	54.391	46.204
65.000	54.890	56.694
70.000	55.834	57.156
75.000	58.172	57.944
80.000	58.826	58.723
85.000	58.606	58.612
90.000	58.412	58.410
95.000	58.313	
100.000	58.329	58.310
105.000	58.135	58.136
110.000	57.943	57.965
115.000	58.341	
120.000	58.351	
125.000	58.566	53.363
130.000	58.782	51.931
135.000	58.998	51.128
140.000	59.214	51.401
145.000	59.418	51.704
150.000	59.613	51.901
155.000	59.805	52.893
160.000	59.992	53.268
165.000	60.178	53.152
170.000	60.363	53.357
175.000	60.556	55.743
180.000	60.765	58.130
185.000	60.975	60.517
190.000	61.187	
195.000	61.395	
200.000	61.599	
205.000	61.813	
210.000	62.059	62.424
215.000	62.318	64.037
220.000	62.577	65.358
225.000	62.840	64.030
230.000	63.124	63.197
235.000	63.399	63.342
240.000	63.679	64.128
245.000	63.962	64.914
250.000	64.284	65.704
255.000	64.619	66.493
260.000	64.954	67.283
264.708	65.283	68.026

SECTION D
SCALE: Hz 1:500, Vt 1:500



CHAINAGE	EXISTING LEVEL	PROPOSED LEVEL
0.000	48.278	
5.000	48.296	
10.000	48.459	
15.000	48.520	48.761
20.000	48.716	48.704
25.000	49.003	48.685
30.000	47.485	
35.000	46.809	
40.000	48.643	
45.000	50.038	
50.000	50.510	
55.000	50.820	
60.000	51.037	
65.000	51.043	
70.000	51.299	
75.000	51.386	51.481
80.000	51.683	53.146
85.000	52.172	54.811
90.000	53.241	54.950
95.000	54.501	55.085
100.000	55.182	55.236
105.000	55.342	55.369
110.000	55.488	55.500
115.000	55.654	55.660
120.000	55.692	55.732
125.000	55.820	55.866
130.000	55.954	55.963
135.000	56.091	
140.000	56.368	
145.000	54.070	
150.000	51.485	54.655
155.000	48.900	55.463
160.000	46.347	55.334
165.000	46.686	55.204
170.000	46.928	54.128
175.000	47.125	52.488
180.000	47.253	50.848
185.000	47.362	50.111
190.000	47.579	51.778
195.000	47.778	53.445
200.000	47.934	55.074
205.000	48.152	55.258
210.000	48.436	55.457
215.000	48.719	55.676
220.000	49.003	55.842
225.000	49.343	53.566
230.000	49.771	50.861
235.000	50.199	50.974
240.000	50.640	52.623
245.000	51.087	54.272
250.000	51.503	54.430
255.000	51.928	52.810
260.000	52.358	
265.000	52.781	
270.000	53.099	
275.000	53.414	
280.000	53.729	
285.000	54.044	
290.000	54.408	
295.000	54.584	
299.465	54.840	

SECTION E
SCALE: Hz 1:500, Vt 1:500



CHAINAGE	EXISTING LEVEL	PROPOSED LEVEL
0.000	54.043	
5.000	53.830	54.225
10.000	53.703	53.845
15.000	53.503	53.507
20.000	53.479	
25.000	54.268	
30.000	54.301	
35.000	53.065	
40.000	53.037	
45.000	53.078	
50.000	53.041	
55.000	52.921	
60.000	52.841	
65.000	53.090	
70.000	52.988	
75.000	52.983	
80.000	52.955	
85.000	53.023	
90.000	53.253	
95.000	53.600	
100.000	53.813	
105.000	54.072	
110.000	54.336	
115.000	54.665	
120.000	56.170	
125.000	56.040	
130.000	56.242	56.189
135.000	56.405	56.424
140.000	56.446	54.330
145.000	54.461	54.498
150.000	54.652	54.666
155.000	54.826	54.833
160.000	54.863	54.858
165.000	55.039	55.029
170.000	55.218	55.204
175.000	56.187	55.286
180.000	57.989	55.118
185.000	58.227	54.965
190.000	58.388	56.898
195.000	58.392	
200.000	58.282	
205.000	58.185	
210.000	58.150	
215.000	58.147	
220.000	58.145	
225.000	58.136	58.240
230.000	58.090	59.863
235.000	58.040	59.972
240.000	57.991	60.001
245.000	57.942	59.633
250.000	57.859	57.951
255.000	57.774	
260.000	57.671	
265.000	57.563	
270.000	57.432	
275.000	57.302	
280.000	57.141	
285.000	56.971	
290.000	56.808	
295.000	56.646	
300.000	56.483	
305.000	56.309	57.085
310.000	56.136	58.220
316.202	55.875	57.045

Key

- Made Ground
- Topsoil
- Peat
- Alluvium
- Head
- Structureless Chalk (Grade Dm and Dc)
- Structured Chalk (Grade A to C)
- Maximum Recorded Groundwater Level
- Minimum Recorded Groundwater Level
- Existing Ground Level
- Proposed Ground Level

Note: Exploratory holes with negative offset values are located NORTH of the section line. Positive offsets are SOUTH of the section. Values are in linear metres

Rev.	Date	Description	Drawn	Chk'd	App'd
P03	20.05.22	OMISSION OF MANAGED MOTORWAY SCHEME	davco	AD	RHT
P02	05.05.21	INCORPORATING HE COMMENTS	davco	AD	RHT

Drawing Status: FOR SGAR 3B

Client

Project Title: M3 JUNCTION 9 IMPROVEMENTS

Drawing Title: GEOLOGICAL CROSS SECTIONS

SHEET 2 OF 3

Scale	Designed	Drawn	Checked	Approved
1:2500	AD	davco	AD	RHT

Original Size	Date	Date	Date	Date
A1	01.12.20	01.12.20	01.12.20	02.12.20

Drawing Number: HE PIN | Originator | Volume

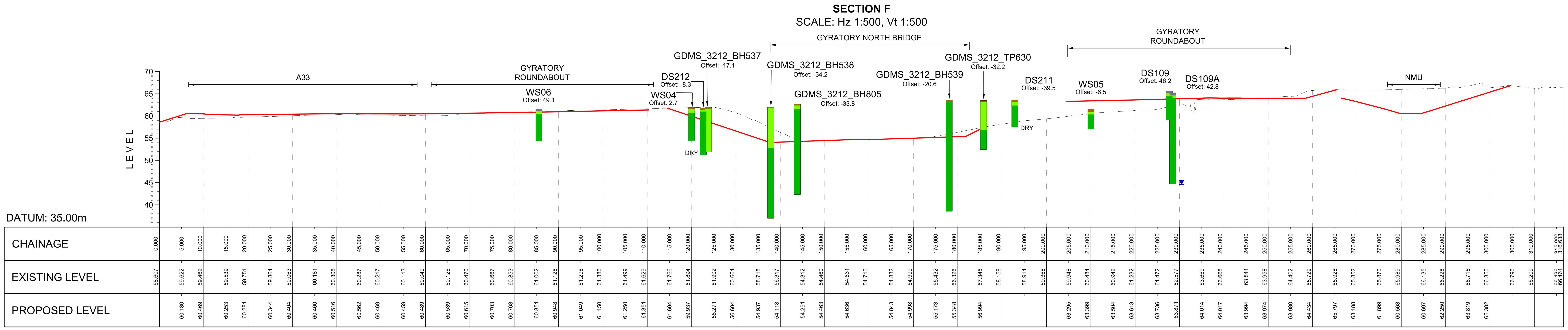
HE551511 - VFK - HGT - X_XXXX_XX - DR - GE - 0022

Location | Type | Role | Number

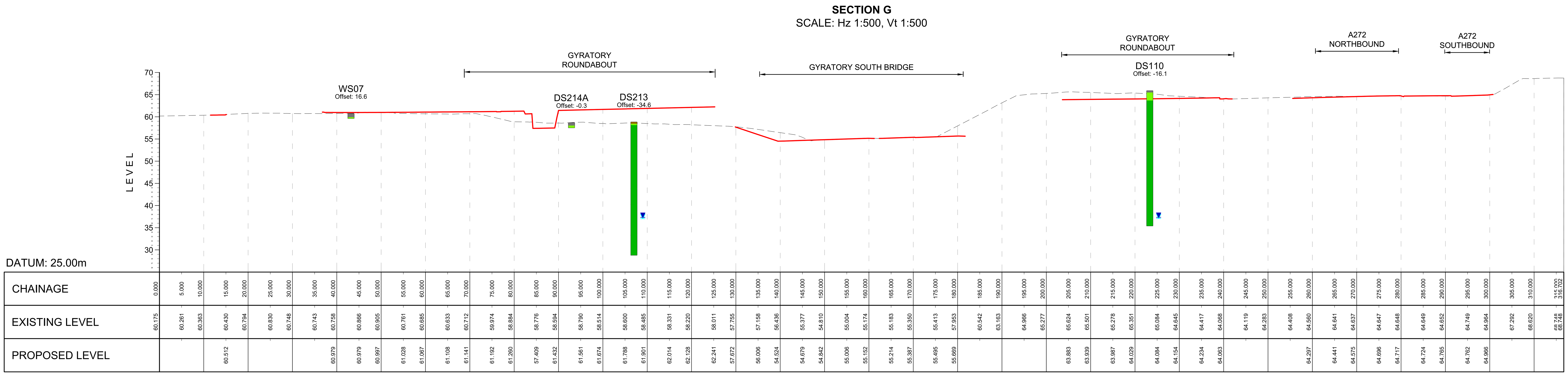
Project Ref. No. 48176

Revision P03

SECTION F
SCALE: Hz 1:500, Vt 1:500



SECTION G
SCALE: Hz 1:500, Vt 1:500



Key

- Made Ground
- Topsoil
- Peat
- Alluvium
- Head
- Structureless Chalk (Grade Dm and Dc)
- Structured Chalk (Grade A to C)
- Maximum Recorded Groundwater Level
- Minimum Recorded Groundwater Level
- Existing Ground Level
- Proposed Ground Level

Note: Exploratory holes with negative offset values are located NORTH of the section line. Positive offsets are SOUTH of the section. Values are in linear metres

Rev.	Date	Description	Drawn	Chk'd	App'd
P03	20.05.22	OMISSION OF MANAGED MOTORWAY SCHEME	davco	AD	RHT
P02	05.05.21	INCORPORATING HE COMMENTS	davco	AD	RHT

Drawing Status: FOR SGAR 3B

VolkerFitzpatrick

Client: national highways

Project Title: M3 JUNCTION 9 IMPROVEMENTS

Drawing Title: GEOLOGICAL CROSS SECTIONS

SHEET 3 OF 3

Scale	Designed	Drawn	Checked	Approved
1:2500	AD	davco	AD	RHT
Original Size A1	Date 01.12.20	Date 01.12.20	Date 01.12.20	Date 02.12.20

Drawing Number: HE PIN HE551511 - Originator VFK - Volume HGT - Location X_XXXX_XX - Type DR - Role GE - Number 0023

Project Ref. No. 48176

Revision P03

CHAINAGE	EXISTING LEVEL	PROPOSED LEVEL
0.000	40.492	
5.000	40.522	
10.000	40.549	
15.000	40.583	
20.000	40.629	
25.000	40.678	
30.000	40.726	
35.000	40.765	
40.000	40.808	
45.000	40.840	40.846
50.000	40.880	40.899
55.000	40.929	40.948
60.000	40.986	40.994
65.000	41.037	41.036
70.000	41.099	41.075
75.000	40.444	41.110
80.000	38.537	41.141
85.000	40.811	41.169
90.000	41.231	41.193
95.000	41.266	41.214
100.000	41.008	41.231
105.000	39.888	41.236
110.000	41.370	41.243
115.000	41.416	41.265
120.000	41.448	41.308
125.000	41.488	41.369
130.000	41.522	41.451
135.000	41.562	41.550
140.000	41.602	41.669
145.000	41.652	41.808
150.000	41.690	41.973
155.000	41.751	42.155
160.000	41.796	42.353
165.000	41.841	42.567
170.000	41.879	42.803
175.000	41.919	43.061
180.000	41.957	43.330
185.000	41.967	43.584
190.000	41.975	43.824
195.000	41.978	44.048
200.000	41.978	44.261
205.000	41.993	44.466
210.000	41.992	44.657
215.000	41.984	44.828
220.000	41.967	44.979
225.000	41.957	45.112
230.000	41.945	45.234
235.000	41.927	45.347
240.000	42.021	45.452
245.000	42.059	45.546
250.000	42.067	45.626
255.000	41.977	45.685
260.000	41.861	45.724
265.000	41.640	45.742
270.000	41.776	45.741
275.000	41.825	45.726
280.000	41.926	45.710
285.000	42.054	45.684
290.000	42.163	45.648
295.000	42.299	45.598
300.000	42.490	45.529
305.000	42.703	45.439
310.000	42.940	45.329
315.000	43.245	45.204
320.000	43.555	45.067
325.000	43.915	44.918
330.000	44.286	44.774
335.000	44.647	44.645
340.000	45.005	44.529
345.000	45.364	44.426
350.000	45.781	44.336
355.000	46.216	44.259
360.000	46.649	44.187

A34 SOUTHBOUND
SCALE: Hz 1:500, Vt 1:500

CHAINAGE	EXISTING LEVEL	PROPOSED LEVEL
355.000	46.216	44.259
360.000	46.649	44.187
365.000	47.040	44.124
370.000	47.428	44.073
375.000	47.820	44.034
380.000	48.265	44.009
385.000	48.707	43.995
390.000	49.105	43.994
395.000	49.521	44.005
400.000	50.657	44.029
405.000	51.777	44.065
410.000	53.029	44.114
415.000	54.258	44.176
420.000	55.479	44.250
425.000	56.268	44.336
430.000	56.568	44.435
435.000	56.896	44.546
440.000	57.225	44.671
445.000	57.581	44.808
450.000	58.012	44.957
455.000	58.444	45.118
460.000	58.869	45.292
465.000	59.309	45.478
470.000	59.739	45.675
475.000	60.307	45.902
480.000	60.387	46.142
485.000	60.128	46.391
490.000	60.052	46.640
495.000	59.857	46.887
500.000	59.678	47.131
505.000	59.512	47.373
510.000	59.427	47.614
515.000	59.413	47.851
520.000	59.297	48.084
525.000	59.128	48.313
530.000	58.957	48.541
535.000	58.808	48.768
540.000	58.648	48.985
545.000	60.010	49.180
550.000	61.571	49.372
555.000	61.632	49.564
560.000	61.414	49.756
565.000	61.246	49.944
570.000	61.066	50.125
575.000	60.888	50.301
580.000	60.678	50.478
585.000	60.470	50.655
590.000	60.262	50.832
595.000	60.014	51.004
600.000	59.719	51.168
605.000	59.413	51.325
610.000	59.099	51.477
615.000	58.781	51.629
620.000	58.475	51.781
625.000	58.171	51.934
630.000	57.849	52.088
635.000	57.545	52.241
640.000	57.240	52.386
645.000	56.977	52.524
650.000	56.689	52.659
655.000	56.344	52.795
660.000	55.943	52.931
665.000	55.618	53.067
670.000	55.253	53.199
675.000	54.852	53.322
680.000	54.459	53.440
685.000	54.063	53.555
690.000	53.722	53.670
695.000	53.393	53.782
700.000	53.062	53.886
705.000	52.758	53.984
710.000	52.453	54.080
715.000	52.171	54.178
720.000	51.904	54.274
725.000	51.632	54.363
730.000	51.356	54.450
735.000	51.060	54.537
740.000	50.753	54.611
745.000	50.438	54.673
750.000	50.117	54.731
755.000	49.823	54.788

CHAINAGE	EXISTING LEVEL	PROPOSED LEVEL
750.000	50.117	54.731
755.000	49.823	54.788
760.000	49.556	54.844
765.000	49.337	54.898
770.000	49.119	54.949
775.000	48.778	54.996
780.000	48.411	55.038
785.000	48.046	55.076
790.000	47.682	55.111
795.000	47.302	55.143
800.000	47.068	55.172
805.000	46.833	55.199
810.000	46.763	55.241
815.000	46.430	55.282
820.000	46.304	55.319
825.000	46.792	55.354
830.000	47.459	55.385
835.000	48.176	55.414
840.000	49.042	55.440
845.000	49.643	55.462
850.000	50.210	55.482
855.000	50.885	55.499
860.000	51.668	55.512
865.000	52.344	55.523
870.000	53.020	55.531
875.000	53.430	55.536
880.000	54.197	55.538
885.000	54.907	55.539
890.000	55.515	55.537
895.000	56.287	55.532
900.000	56.822	55.524
905.000	56.875	55.512
910.000	56.973	55.496
915.000	57.040	55.476
920.000	57.111	55.454
925.000	57.197	55.429
930.000	57.286	55.396
935.000	57.384	55.359
940.000	57.503	55.320
945.000	57.584	55.283
950.000	57.686	55.246
955.000	57.791	55.211
960.000	57.995	55.177
965.000	57.730	55.146
970.000	57.430	55.118
975.000	57.131	55.092
980.000	56.833	55.071
985.000	56.648	55.051
990.000	56.417	55.032
995.000	56.206	55.015
1000.000	56.017	54.998
1005.000	55.850	54.978
1010.000	55.998	54.961
1015.000	55.855	54.945
1020.000	55.765	54.931
1025.000	55.821	54.917
1030.000	55.578	54.906
1035.000	55.313	54.898
1040.000	55.551	54.913
1045.000	55.448	54.929
1050.000	55.413	54.945
1055.000	55.344	54.966
1060.000	55.309	54.987
1065.000	55.279	55.009
1070.000	55.197	55.031
1075.000	55.132	55.054
1080.000	55.042	55.078
1085.000	55.014	55.078
1090.000	54.990	55.074
1095.000	55.000	55.067
1100.000	55.014	55.059
1105.000	55.142	55.052
1110.000	55.038	55.047
1115.000	55.036	55.042
1120.000	55.026	55.039
1125.000	55.028	55.037
1130.000	55.029	55.037
1135.000	55.035	55.038
1140.000	55.036	55.040
1145.000	55.065	55.044
1148.919	55.047	55.048

Key
- Made Ground
- Topsoil
- Peat
- Alluvium
- Head
- Structureless Chalk (Grade Dm and Dc)
- Structured Chalk (Grade A to C)
- Maximum Recorded Groundwater Level
- Minimum Recorded Groundwater Level
- Existing Ground Level
- Proposed Ground Level

Note: Exploratory holes with negative offset values are located EAST of the section line. Positive offsets are WEST of the section. Values are in linear metres.

Rev.	Date	Description	Drawn	Chk'd	App'd
P03	20.05.22	OMISSION OF MANAGED MOTORWAY SCHEME	davco	AD	RHT
P02	05.05.21	INCORPORATING HE COMMENTS	davco	AD	RHT

Drawing Status: FOR SGAR 3B

VolkerFitzpatrick

Client: national highways

Project Title: M3 JUNCTION 9 IMPROVEMENTS

Drawing Title: GEOLOGICAL LONG-SECTIONS A34 SOUTHBOUND

SHEET 1 OF 4

Scale	Designed	Drawn	Checked	Approved
1:2500	AD	davco	AD	RHT
Original Size	Date 01.12.20	Date 01.12.20	Date 01.12.20	Date 02.12.20

Drawing Number: HE PIN HE551511 - Originator VFK - Volume HGT - Location X_XXXX_XX - Type DR - Role GE - Number 0031

Project Ref. No. 48176

Revision P03

A34 NORTHBOUND
SCALE: Hz 1:500, Vt 1:500

Key

- Made Ground
- Topsoil
- Peat
- Alluvium
- Head
- Structureless Chalk (Grade Dm and Dc)
- Structured Chalk (Grade A to C)
- Maximum Recorded Groundwater Level
- Minimum Recorded Groundwater Level
- Existing Ground Level
- Proposed Ground Level

Note: Exploratory holes with negative offset values are located EAST of the section line. Positive offsets are WEST of the section. Values are in linear metres.

Rev.	Date	Description	Drawn	Chk'd	App'd
P03	20.05.22	OMISSION OF MANAGED MOTORWAY SCHEME	davco	AD	RHT
P02	05.05.21	INCORPORATING HE COMMENTS	davco	AD	RHT

Drawing Status: FOR SGAR 3B

VolkerFitzpatrick

Client: national highways

Project Title: M3 JUNCTION 9 IMPROVEMENTS

Drawing Title: GEOLOGICAL LONG-SECTIONS A34 NORTHBOUND

SHEET 2 OF 4

Scale	Designed	Drawn	Checked	Approved
1:2500	AD	davco	AD	RHT
Original Size A1	Date 01.12.20	Date 01.12.20	Date 01.12.20	Date 02.12.20

Drawing Number: HE PIN | Originator | Volume
HE551511 - VFK - HGT - X_XXXX_XX - DR - GE - 0032
Location | Type | Role | Number

Project Ref. No. 48176

Revision P03

CHAINAGE	EXISTING LEVEL	PROPOSED LEVEL
0.000	40.599	40.606
5.000	40.623	40.631
10.000	40.647	40.657
15.000	40.683	40.686
20.000	40.716	40.717
25.000	40.754	40.750
30.000	40.777	40.785
35.000	40.809	40.823
40.000	40.844	40.863
45.000	40.889	40.904
50.000	40.928	40.948
55.000	41.455	40.995
60.000	41.035	41.043
65.000	40.203	41.092
70.000	38.245	41.136
75.000	41.164	41.176
80.000	41.188	41.210
85.000	41.215	41.239
90.000	41.234	41.264
95.000	41.252	41.284
100.000	41.264	41.298
105.000	41.281	41.308
110.000	41.428	41.313
115.000	41.313	41.322
120.000	41.327	41.349
125.000	41.349	41.397
130.000	41.375	41.464
135.000	41.400	41.549
140.000	41.420	41.653
145.000	41.502	41.774
150.000	41.561	41.913
155.000	41.622	42.068
160.000	41.644	42.244
165.000	41.619	42.449
170.000	41.661	42.682
175.000	41.683	42.926
180.000	41.732	43.172
185.000	41.373	43.420
190.000	41.119	43.665
195.000	41.117	43.981
200.000	41.202	44.307
205.000	41.276	44.661
210.000	41.396	45.046
215.000	41.526	45.458
220.000	41.673	45.883
225.000	41.908	46.295
230.000	42.158	46.690
235.000	42.407	47.090
240.000	42.655	47.499
245.000	42.917	47.918
250.000	43.170	48.333
255.000	43.447	48.735
260.000	43.767	49.125
265.000	44.087	49.520
270.000	44.415	49.913
275.000	44.758	50.286
280.000	45.131	50.637
285.000	45.494	50.962
290.000	45.892	51.258
295.000	46.318	51.526
300.000	46.779	51.761
305.000	47.271	51.964
310.000	47.821	52.155
315.000	48.370	52.337
320.000	48.934	52.561
325.000	49.498	52.696
330.000	50.093	52.827
335.000	50.682	
340.000	51.200	52.614
345.000	51.692	52.841
350.000	52.902	52.986
355.000	53.478	53.140
360.000	54.320	53.211
365.000	55.120	53.381

A33
SCALE: Hz 1:500, Vt 1:500

CHAINAGE	EXISTING LEVEL	PROPOSED LEVEL
360.000	54.320	53.211
365.000	55.120	53.381
370.000	55.940	53.479
375.000	56.711	53.548
380.000	57.144	53.632
385.000	57.613	53.714
390.000	58.001	53.794
395.000	58.508	53.871
400.000	58.810	53.943
405.000	58.833	54.012
410.000	58.992	54.068
415.000	58.857	54.109
420.000	58.749	54.137
425.000	58.713	54.150
430.000	58.685	54.148
435.000	58.657	54.131
440.000	58.609	54.105
445.000	58.592	54.064
450.000	58.574	54.008
455.000	58.561	46.478
460.000	58.535	44.814
465.000	58.520	45.015
470.000	58.465	45.223
475.000	58.400	45.437
480.000	58.346	52.092
485.000	58.310	53.189
490.000	58.216	53.012
495.000	58.072	52.820
500.000	57.942	52.615
505.000	57.867	52.395
510.000	57.790	52.161
515.000	57.700	51.911
520.000	57.593	51.646
525.000	57.480	51.367
530.000	57.330	51.074
535.000	57.204	50.764
540.000	57.060	50.439
545.000	56.900	50.098
550.000	56.682	49.742
555.000	56.472	49.371
560.000	56.277	48.985
565.000	56.086	48.586
570.000	55.874	48.195
575.000	55.641	47.821
580.000	55.397	47.466
585.000	55.116	47.130
590.000	54.790	46.812
595.000	54.478	46.513
600.000	54.154	46.232
605.000	53.820	45.971
610.000	53.483	45.728
615.000	53.147	45.503
620.000	52.794	45.298
625.000	52.452	45.117
630.000	52.116	44.955
635.000	51.770	44.812
640.000	51.409	44.687
645.000	51.060	44.581
650.000	50.741	44.494
655.000	50.418	44.425
660.000	50.105	44.376
665.000	49.769	44.346
670.000	49.412	44.337
675.000	49.058	44.346
680.000	48.729	44.373
685.000	48.388	44.418
690.000	48.043	44.484
695.000	47.659	44.569
700.000	47.270	44.675
705.000	46.820	44.798
710.000	46.384	44.939
715.000	45.979	45.099
720.000	45.552	45.277
725.000	45.145	45.475
730.000	44.755	45.696
735.000	44.378	45.919
740.000	44.312	46.134
745.000	44.887	46.339
750.000	45.848	46.536
755.000	46.689	46.725
760.000	47.108	46.904

CHAINAGE	EXISTING LEVEL	PROPOSED LEVEL
760.000	47.108	46.904
765.000	47.250	47.074
770.000	47.351	47.236
775.000	47.544	47.391
780.000	47.682	47.537
785.000	47.802	47.674
790.000	47.835	47.803
795.000	47.930	47.922
800.000	48.046	48.034
805.000	48.155	48.138
810.000	48.269	48.248
815.000	48.402	48.365
820.000	48.523	48.491
825.000	48.647	48.631
830.000	48.785	48.779
835.000	48.949	48.934
840.000	49.109	49.098
845.000	49.264	49.269
850.000	49.442	49.449
855.000	49.632	49.636
860.000	49.831	49.826
865.000	50.018	50.024
870.000	50.203	50.240
875.000	50.387	50.475
880.000	50.576	50.719
885.000	50.757	51.025
890.000	50.939	51.222
895.000	51.118	51.193
900.000	51.292	51.175
905.000	51.460	51.455
910.000	51.633	51.740
915.000	51.796	52.125
920.000	51.981	52.109
925.000	52.162	52.228
930.000	52.334	52.490
935.000	52.510	52.585
940.000	52.686	52.750
945.000	52.864	52.917
950.000	53.052	53.093
955.000	53.230	53.278
960.000	53.420	53.473
965.000	53.624	53.689
970.000	53.832	53.915
975.000	54.052	54.145
980.000	54.257	54.374
985.000	54.467	54.572
990.000	54.676	54.774
995.000	54.896	54.980
1000.000	55.104	55.191
1005.000	55.308	55.408
1010.000	55.526	55.628
1015.000	55.739	55.842
1020.000	55.941	56.038
1025.000	56.141	56.238
1030.000	56.358	56.444
1035.000	56.565	56.656
1040.000	56.772	56.871
1045.000	56.977	57.091
1050.000	57.191	57.316
1055.000	57.407	57.538
1060.000	57.604	57.711
1065.000	57.792	57.886
1070.000	57.981	58.074
1075.000	58.189	58.286
1080.000	58.429	58.527
1085.000	58.662	58.777
1090.000	58.846	58.990
1095.000	59.039	59.162
1100.000	59.219	59.341
1105.000	59.408	59.527
1110.000	59.603	59.716
1115.000	59.789	59.900
1120.000	59.904	60.028
1125.000	60.038	60.136
1130.000	60.188	60.248
1135.000	60.262	60.346
1140.000	60.252	60.401
1145.000	60.126	60.446
1150.000	60.029	60.499
1155.000	60.332	60.573
1160.000	60.616	60.592
1165.736	60.853	60.608

Key
- Made Ground
- Topsoil
- Peat
- Alluvium
- Head
- Structureless Chalk (Grade Dm and Dc)
- Structured Chalk (Grade A to C)
- Maximum Recorded Groundwater Level
- Minimum Recorded Groundwater Level
- Existing Ground Level
- Proposed Ground Level

Note: Exploratory holes with negative offset values are located EAST of the section line. Positive offsets are WEST of the section. Values are in linear metres.

Rev.	Date	Description	Drawn	Chk'd	App'd
P03	20.05.22	OMISSION OF MANAGED MOTORWAY SCHEME	davco	AD	RHT
P02	05.05.21	INCORPORATING HE COMMENTS	davco	AD	RHT

Drawing Status: FOR SGAR 3B

VolkerFitzpatrick

Client: national highways

Project Title: M3 JUNCTION 9 IMPROVEMENTS

Drawing Title: GEOLOGICAL LONG-SECTIONS
A33

SHEET 3 OF 4

Scale	Designed	Drawn	Checked	Approved
1:2500	AD	davco	AD	RHT

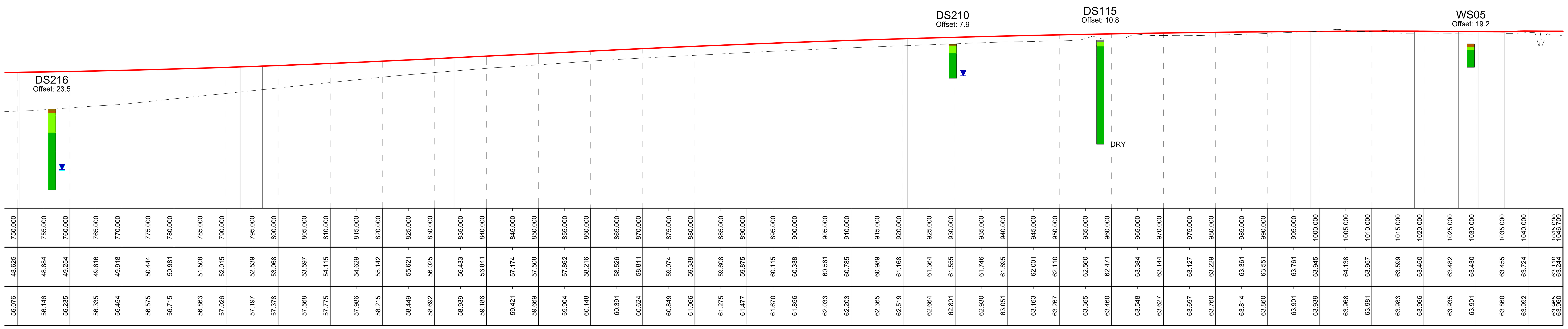
Original Size	Date	Date	Date	Date
A1	01.12.20	01.12.20	01.12.20	02.12.20

Drawing Number: HE PIN I Originator I Volume
HE551511 - VFK - HGT - X_XXXX_XX - DR - GE - 0033
Location I Type I Role I Number

Project Ref. No. 48176

Revision P03

M3 SB DIVERGE
SCALE: Hz 1:500, Vt 1:500



Key

- Made Ground
- Topsoil
- Peat
- Alluvium
- Head
- Structureless Chalk (Grade Dm and Dc)
- Structured Chalk (Grade A to C)
- Maximum Recorded Groundwater Level
- Minimum Recorded Groundwater Level
- Existing Ground Level
- Proposed Ground Level

Note: Exploratory holes with negative offset values are located EAST of the section line. Positive offsets are WEST of the section. Values are in linear metres.

Rev.	Date	Description	Drawn	Chk'd	App'd
P03	20.05.22	OMISSION OF MANAGED MOTORWAY SCHEME	davco	AD	RHT
P02	05.05.21	INCORPORATING HE COMMENTS	davco	AD	RHT

Drawing Status: FOR SGAR 3B

VolkerFitzpatrick

Client: national highways

Project Title: M3 JUNCTION 9 IMPROVEMENTS

Drawing Title: GEOLOGICAL LONG-SECTIONS M3 SOUTHBOUND DIVERGE

SHEET 4 OF 4

Scale	Designed	Drawn	Checked	Approved
1:2500	AD	davco	AD	RHT
Original Size: A1	Date: 01.12.20	Date: 01.12.20	Date: 01.12.20	Date: 02.12.20

Drawing Number: HE PIN | Originator | Volume
HE551511 - VFK - HGT - X_XXXX_XX - DR - GE - 0034
Location | Type | Role | Number

Project Ref. No.: 48176

Revision: P03

KEY

45	PROPOSED MAJOR CONTOURS (1m INTERVALS)
	PROPOSED MINOR CONTOURS (0.25m INTERVALS)
	EXISTING MAJOR CONTOURS (5m INTERVALS)
	EXISTING MINOR CONTOURS (1m INTERVALS)
1:3.0	SLOPE GRADIENT

NOTES

1. THIS DRAWING SHOULD BE PRINTED IN COLOUR
2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER DRAWINGS AND DOCUMENTS
3. ALL WORKS TO BE IN ACCORDANCE WITH THE HIGHWAYS ENGLAND SPECIFICATION FOR HIGHWAY WORKS VOLUME 1 AND CONTRACT SPECIFIC APPENDICES
4. THE CONTRACTOR SHALL VALIDATE THE ACCURACY OF THE TOPOGRAPHIC SURVEY PRIOR TO WORKS COMMENCING

0 20 40 60 80 100m
SCALE 1:1000

Rev.	Date	Description	Drawn	Chk'd	App'd
P01					

Drawing Status: S2 - FOR INFORMATION

VolkerFitzpatrick

Client: highways england

Project Title: M3 JUNCTION 9 IMPROVEMENTS

Drawing Title: PROPOSED CONTOURS AT 0.25 AND 1m INTERVALS

SHEET 1 OF 5

Scale	Designed	Drawn	Checked	Approved
1:1000	GP	GP	AC	TRA
Original Size A1	Date 21.04.21	Date 21.04.21	Date 21.04.21	Date 21.04.21

Drawing Number: HE PIN HE551511 - Originator VFK - Volume HGN - Location X_XXXX_XX - Type DR - Role CH - Number 0051

Project Ref. No. 48176

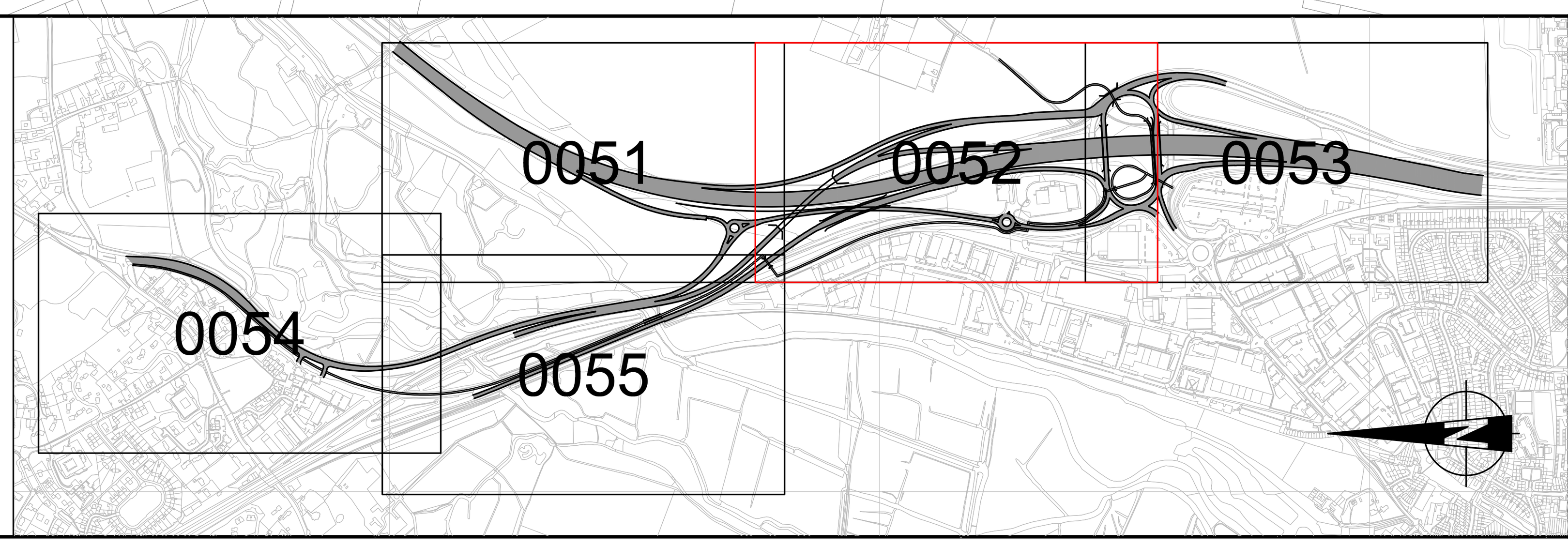
Revision P01

KEY

- 45 — PROPOSED MAJOR CONTOURS (1m INTERVALS)
- PROPOSED MINOR CONTOURS (0.25m INTERVALS)
- EXISTING MAJOR CONTOURS (5m INTERVALS)
- EXISTING MINOR CONTOURS (1m INTERVALS)
- 1:3.0 → SLOPE GRADIENT

NOTES

1. THIS DRAWING SHOULD BE PRINTED IN COLOUR
2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER DRAWINGS AND DOCUMENTS
3. ALL WORKS TO BE IN ACCORDANCE WITH THE HIGHWAYS ENGLAND SPECIFICATION FOR HIGHWAY WORKS VOLUME 1 AND CONTRACT SPECIFIC APPENDICES
4. THE CONTRACTOR SHALL VALIDATE THE ACCURACY OF THE TOPOGRAPHIC SURVEY PRIOR TO WORKS COMMENCING



SCALE 1:1000 (0 20 40 60 80 100m)

Rev.	Date	Description	Drawn	Chk'd	App'd
P01					

Drawing Status: S2 - FOR INFORMATION

VolkerFitzpatrick

Client: highways england

Project Title: M3 JUNCTION 9 IMPROVEMENTS

Drawing Title: PROPOSED CONTOURS AT 0.25 AND 1m INTERVALS

SHEET 2 OF 5

Scale	Designed	Drawn	Checked	Approved
1:1000	GP	GP	AC	TRA
Original Size A1	Date 21.04.21	Date 21.04.21	Date 21.04.21	Date 21.04.21

Drawing Number: HE PIN HE551511 | Originator VFK | Volume HGN | Location X_XXXX_XX | Type DR | Role CH | Number 0052

Project Ref. No. 48176

Revision P01

KEY

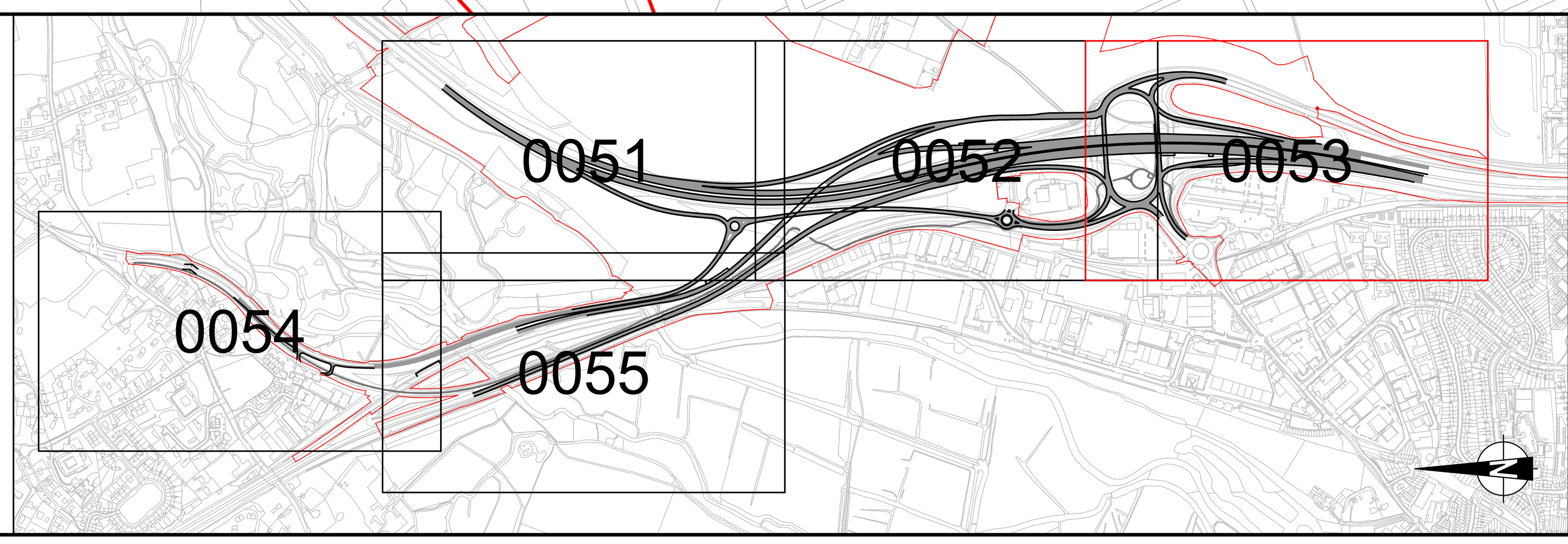
- DEVELOPMENT CONSENT ORDER BOUNDARY
- PROPOSED STRUCTURE/RETAINING WALL
- PROPOSED MAJOR CONTOURS (1m INTERVALS)
- PROPOSED MINOR CONTOURS (0.25m INTERVALS)
- EXISTING MAJOR CONTOURS (5m INTERVALS)
- EXISTING MINOR CONTOURS (1m INTERVALS)
- 1:3.0 PROPOSED SLOPE GRADIENT

NOTES

1. THIS DRAWING SHOULD BE PRINTED IN COLOUR.
2. DO NOT SCALE FROM THIS DRAWING.
3. THE LAYOUT SHOWN IS PRELIMINARY AND SUBJECT TO DETAILED DESIGN.
4. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH ALL OTHER SGAR 3 SUBMISSION DRAWINGS AND DOCUMENTS.
5. ALL WORKS TO BE IN ACCORDANCE WITH THE HIGHWAYS ENGLAND SPECIFICATION FOR HIGHWAY WORKS VOLUME 1 AND CONTRACT SPECIFIC APPENDICES.
6. THE CONTRACTOR SHALL VALIDATE THE ACCURACY OF THE TOPOGRAPHIC SURVEY PRIOR TO WORKS COMMENCING.

CONFIDENTIAL
THIS DRAWING IS FOR INFORMATION ONLY AND REPRESENTS CURRENT DESIGN DEVELOPMENT. THIS DRAWING SHALL BE USED FOR THE PURPOSE SUPPLIED AND SHALL BE CONSIDERED CONFIDENTIAL AND NOT DISCLOSED TO THIRD PARTIES OR PERSONS NOT INVOLVED WITH THIS PROJECT.

0 20 40 60 80 100m
SCALE 1:1000



Rev.	Date	Description	Drawn	Chk'd	App'd
P02	20.05.22	UPDATED TO SUIT OMISSION OF MANAGED MOTORWAY SCHEME	GP	LC	TRA
P01	10.11.21	ISSUED FOR S3 SUBMISSION	ljj	LC	TRA

Drawing Status: S3 - FOR REVIEW & COMMENT

VolkerFitzpatrick

Client: national highways

Project Title: M3 JUNCTION 9 IMPROVEMENT

Drawing Title: SGAR 3 PRELIMINARY DESIGN PROPOSED CONTOURS AT 0.25 AND 1m INTERVALS SHEET 3 OF 5

Scale	Designed	Drawn	Checked	Approved
1:1000	GP	GP	AC	TRA
Original Size: Size	Date: 21.04.21	Date: 21.04.21	Date: 21.04.21	Date: 21.04.21

Drawing Number: HE PIN HE551511 | Originator VFK | Volume HGN | Location X_XXXX_XX | Type DR | Role CH | Number 0053

Project Ref. No. 48176

Revision P02

FOR CONTINUATION SEE HE551511-VFK-HGN-X_XXXX_XX-DR-CH-0055

KEY

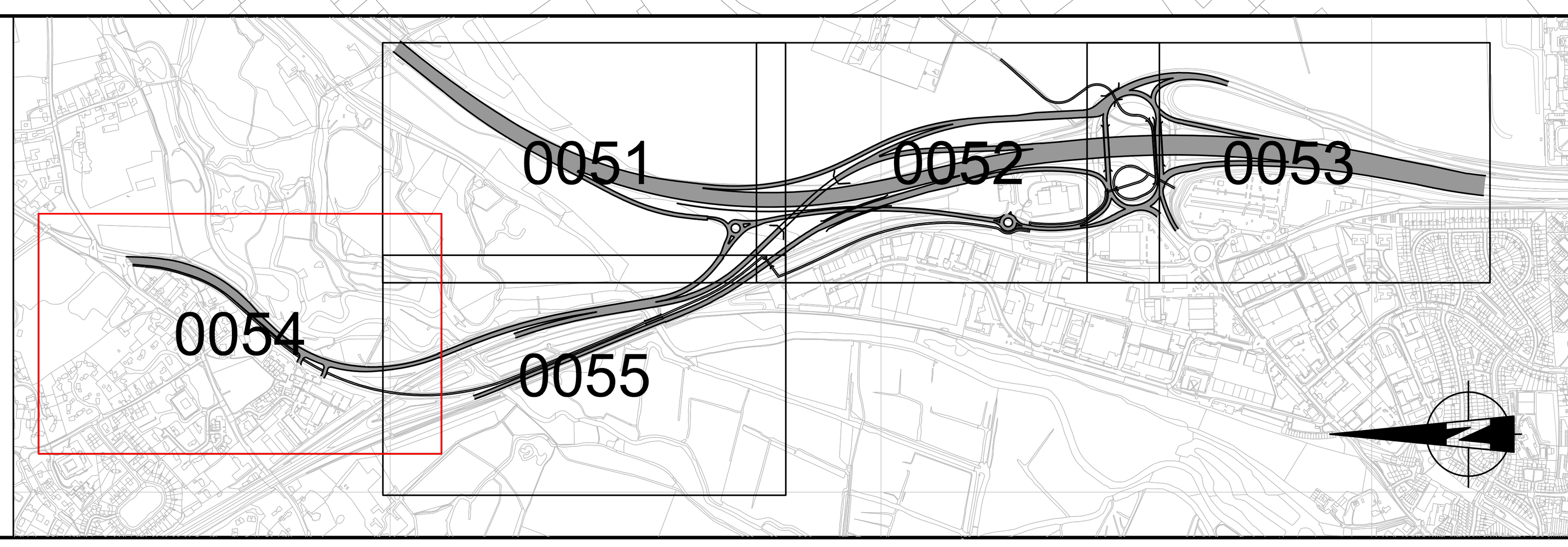
- 45 PROPOSED MAJOR CONTOURS (1m INTERVALS)
- PROPOSED MINOR CONTOURS (0.25m INTERVALS)
- EXISTING MAJOR CONTOURS (5m INTERVALS)
- EXISTING MINOR CONTOURS (1m INTERVALS)
- 1:3.0 SLOPE GRADIENT

NOTES

1. THIS DRAWING SHOULD BE PRINTED IN COLOUR
2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER DRAWINGS AND DOCUMENTS
3. ALL WORKS TO BE IN ACCORDANCE WITH THE HIGHWAYS ENGLAND SPECIFICATION FOR HIGHWAY WORKS VOLUME 1 AND CONTRACT SPECIFIC APPENDICES
4. THE CONTRACTOR SHALL VALIDATE THE ACCURACY OF THE TOPOGRAPHIC SURVEY PRIOR TO WORKS COMMENCING

0 20 40 60 80 100m

SCALE 1:1000



Rev.	Date	Description	Drawn	Chk'd	App'd
P01					

Drawing Status: S2 - FOR INFORMATION

VolkerFitzpatrick

Client: highways england

Project Title: M3 JUNCTION 9 IMPROVEMENTS

Drawing Title: PROPOSED CONTOURS AT 0.25 AND 1m INTERVALS

SHEET 4 OF 5

Scale	Designed	Drawn	Checked	Approved
1:1000	GP	GP	AC	TRA
Original Size: A1	Date: 21.04.21	Date: 21.04.21	Date: 21.04.21	Date: 21.04.21

Drawing Number: HE PIN HE551511 | Originator VFK | Volume HGN | Location X_XXXX_XX | Type DR | Role CH | Number 0054

Project Ref. No. 48176

Revision P01

FOR CONTINUATION SEE HE551511-VFK-HGN-X_XXXX_XX-DR-CH-0051

FOR CONTINUATION SEE HE551511-VFK-HGN-X_XXXX_XX-DR-CH-0054

KEY

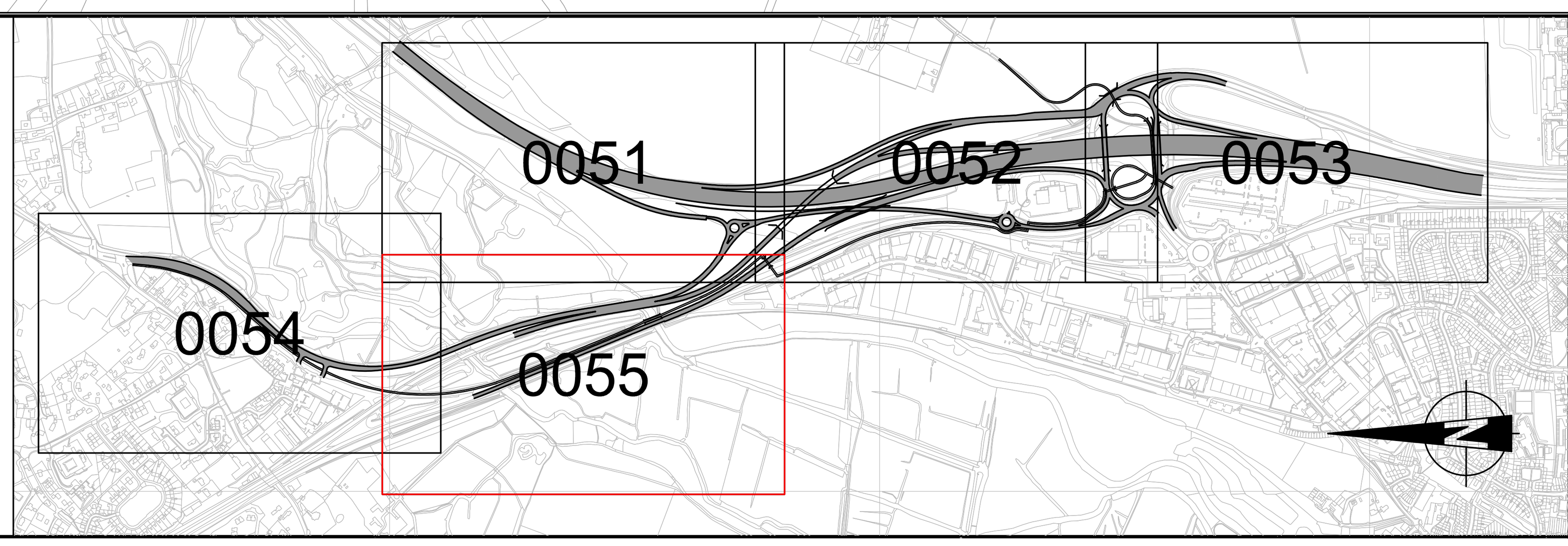
- 45 PROPOSED MAJOR CONTOURS (1m INTERVALS)
- PROPOSED MINOR CONTOURS (0.25m INTERVALS)
- EXISTING MAJOR CONTOURS (5m INTERVALS)
- EXISTING MINOR CONTOURS (1m INTERVALS)
- 1:3.0 SLOPE GRADIENT

NOTES

1. THIS DRAWING SHOULD BE PRINTED IN COLOUR
2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER DRAWINGS AND DOCUMENTS
3. ALL WORKS TO BE IN ACCORDANCE WITH THE HIGHWAYS ENGLAND SPECIFICATION FOR HIGHWAY WORKS VOLUME 1 AND CONTRACT SPECIFIC APPENDICES
4. THE CONTRACTOR SHALL VALIDATE THE ACCURACY OF THE TOPOGRAPHIC SURVEY PRIOR TO WORKS COMMENCING

0 20 40 60 80 100m

SCALE 1:1000



Rev.	Date	Description	Drawn	Chk'd	App'd
P01					

Drawing Status: S2 - FOR INFORMATION

VolkerFitzpatrick

Client: highways england

Project Title: M3 JUNCTION 9 IMPROVEMENTS

Drawing Title: PROPOSED CONTOURS AT 0.25 AND 1m INTERVALS

SHEET 5 OF 5

Scale	Designed	Drawn	Checked	Approved
1:1000	GP	GP	AC	TRA
Original Size A1	Date 21.04.21	Date 21.04.21	Date 21.04.21	Date 21.04.21

Drawing Number: HE PIN HE551511 | Originator VFK | Volume HGN | Location X_XXXX_XX | Type DR | Role CH | Number 0055

Project Ref. No. 48176

Revision P01

KEY:

- PROPOSED UNDERPASS/SUBWAY
- PROPOSED BRIDGE
- INDICATIVE APPLICATION BOUNDARY

0 50 100 150 200 250m

SCALE 1:2500

NOTES:

1. THIS DRAWING SHOULD BE PRINTED IN COLOUR.
2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER CONTRACT DRAWINGS AND DOCUMENTS.
3. ALL WORKS TO BE IN ACCORDANCE WITH THE HIGHWAYS ENGLAND SPECIFICATION FOR HIGHWAY WORKS VOLUME 1 AND CONTRACT SPECIFIC APPENDICES.

CONFIDENTIAL

THIS DRAWING IS FOR INFORMATION ONLY AND REPRESENTS CURRENT DESIGN DEVELOPMENT. THIS DRAWING SHALL BE USED FOR THE PURPOSE SUPPLIED AND SHALL BE CONSIDERED CONFIDENTIAL AND NOT DISCLOSED TO THIRD PARTIES OR PERSONS NOT INVOLVED WITH THIS PROJECT.

Rev.	Date	Description	Drawn	Chk'd	App'd
P04	25.05.22	AMENDED TO SUIT OMISSION OF MANAGED MOTORWAY SCHEME	MP	LC	TRA
P03	28.05.21	LAYOUT AND LABELS UPDATED	RR	AC	TRA
P02	06.05.21	LAYOUT & LABELS UPDATED	RR	AC	TRA
P01	13.11.20	FIRST ISSUE	ME	AC	TRA

Drawing Status: S2 - FOR INFORMATION

VolkerFitzpatrick

Client: national highways

Project Title: M3 JUNCTION 9 IMPROVEMENT

Drawing Title: GENERAL OVERVIEW LAYOUT

Scale	Designed	Drawn	Checked	Approved
1:2500	N/A	ME	AC	TRA

Original Size	Date	Date	Date	Date
A1	-	13.11.20	13.11.20	13.11.20

Drawing Number: HE PIN HE551511 - Originator VFK - Volume HML - X_XXXX_XX - Location DR - Type CH - Role 0101 Number

Project Ref. No. 48176

Revision P04

KEY

- EXISTING STRUCTURE RETAINED
- EXISTING STRUCTURE TO BE REMOVED
- PROPOSED STRUCTURE

Rev.	Date	Description	Drawn	Chk'd	App'd
P07	10.06.22	FOR INFORMATION	GCP	JWS	JWS
P05	04.10.21	FOR INFORMATION	GCP	JWS	JWS
P04	16.02.21	FOR INFORMATION	GCP	JAS	JWS
P03	01.12.20	PRELIMINARY DESIGN INFORMATION UPDATED	GCP	JAS	JWS
P02	13.11.20	PRELIMINARY DESIGN INFORMATION ADDED	AJA	JAS	JWS
P01	15.10.20	FOR DISCUSSION	GCP	JAS	JWS

Drawing Status: FOR INFORMATION

VolkerFitzpatrick

Client: national highways

Project Title: M3 JUNCTION 9 IMPROVEMENTS

Drawing Title: STAGE 3B STRUCTURES GENERAL ARRANGEMENT

Scale	Designed	Drawn	Checked	Approved
1:2500	GCP	GCP	JAS	JWS
Original Size: A1	Date: 14.10.20	Date: 14.10.20	Date: 15.10.20	Date: 15.10.20

Drawing Number: HE PIN HE551511 - Originator VFK - Volume SGN - Location X_XXXX_XX - Type DR - Role CB - Number 0100

Project Ref. No. 48176

Revision P07

Appendix A Cavity Occurrence Assessment

TECHNICAL NOTE

Job Name: M3 Junction 9 Improvements

Job No: 48176

Note No: HE551511-VFK-EGT-X_XXXX_XX-TN-GE-0001 P02

Date: May 2021

Prepared By: Harry Gordon & Angelo Indelicato

Reviewed By: James Weddle

Subject: **Stantec Cavities Occurrence Assessment & Preliminary Risk Assessment**

Item	Subject
1.	**Introduction** Stantec have undertaken the following Cavities Occurrence Assessment for the site at M3 Junction 9, Winchester. This preliminary desk top assessment evaluates the potential for natural and non-coal mining cavities to be present within the latest Order Limits Boundary (OLB) provided by Volker Fitzpatrick (Figure 001 Date 15/09/2020), against the vulnerability of the proposed scheme to these specific hazards. This has enabled a preliminary risk assessment to be undertaken to define the risk of natural and mining hazards spatially within the scheme
2.	**Sources of Information** A number of desktop sources were used to assess the potential of natural and non-coal mining cavities within the Order Limit Boundary, these were limited to; • British Geological Survey GeoIndex • British Geological Survey (2011) 1:50,000 scale series, Winchester (Sheet 299, 2002), Solid and Drift Edition. • British Geological Survey Online Interactive Viewer (http://mapapps.bgs.ac.uk/geolgyofbritain/home.html accessed October 2020). • Edmonds, C.N., 2001. Predicting Natural Cavities in Chalk. Land Surface Evaluation for Engineering Practice. The Geological Society, London. Engineering Geology Special Publications. • Environmental Data Search commissioned from Groundsure • Environmental Data Search commissioned from Landmark

DOCUMENT ISSUE RECORD

Technical Note No	Rev	Date	Prepared	Checked	Reviewed (Discipline Lead)	Approved (Project Director)
HE551511-VFK-EGT-X_XXXX_XX-TN-GE-0001	P01	30.10.20	HG	-AI	JW	RP
HE551511-VFK-EGT-X_XXXX_XX-TN-GE-0001	P02	14.05.21	HG	-AI	JW	RP

Peter Brett Associates LLP Caversham Bridge House Waterman Place, Reading Berkshire RG1 8DN

T: +44 (0)118 950 0761 E: reading@peterbrett.com

Item	Subject
	• Highways England Geotechnical Data Management Systems (HA GDMS) - Accessed October 2020 • Historical Mapping and Photograph (1873-2016, 1:10,560/1:10,000 scale) commissioned from Landmark • National Library of Scotland [redacted] - accessed October 2020) • Stantec Cavities Database
3.	**Stantec Natural Cavities Database Search**

A search of the Stantec Natural Cavities Database indicated that there are 1 natural cavity record within a 500m radius buffer of the OLB, as shown in Table 1 below.

Table 1: Stantec Natural Cavities Database records

Approximate NGR	Approximate distance from site centre (m)	Recorded Location	Geology	Natural Cavity Details	Source
SU 491 315 SU 488 310 SU 484 305	190 (W)	Course of River Itchen, Winchester, Hampshire	**Superficial:** Alluvium River Terrace Deposits **Bedrock:** Chalk Group	10 x Solution Pipes	Winchester City Council

It should be noted that the absence of, or the presence of, existing natural cavities within the OLB should not be considered conclusive.

4. **Stantec Non-Coal Mining Cavities Database Search**

A search of the Stantec Mining Cavities Database indicated that there are no man-made mining cavity records within 1km of the OLB boundary. The closest recorded mining cavity is located approximately 1.5km east north east of the OLB site centre and the cavity was described as possible voids encountered during piling operations.

It should be noted that the absence of, or the presence of, existing natural cavities within the OLB should not be considered conclusive.

5. **British Geological Survey – Non-Coal Mine Plans**

A review of the Non-Coal Mining Plans was undertaken through the British Geological Survey GeoIndex, which indicated no recorded mine plans located within the site boundaries or within 1km of the OLB boundary.

6. **Review of HA Geotechnical Data Management System (HA GDMS)**

Stantec have conducted a search of HA GDMS to evaluate the presence of non-coal mining related hazards within the area of the proposed scheme boundaries, Table 2 below summarises the available records and evaluated hazard ratings undertaken by others.

Table 2: Summary of Datasets relating to Non-Coal Mining Hazards HA GDMS

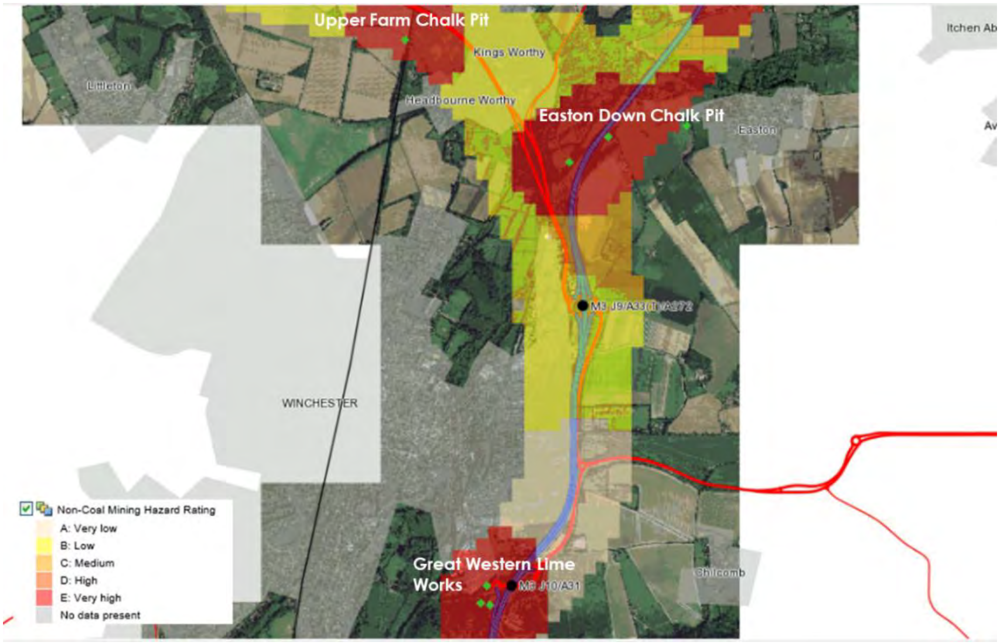
Dataset	Provider	Rating/ Records
BGS Mining Hazard (not including coal)	British Geological Survey	Very Low to Very High
BGS Recorded Mineral Sites	British Geological Survey	Opencast (Easton Down Chalk Pit (E 449900, N430462 and E 449583, N 13169), Upper Farm Chalk Pit (E 448208, N132717) &

Item	Subject

		Great Western Lime Works E 448892, N 128143)
Inventory of Closed Mining Waste	Environment Agency	No records
Mining Instability	Ove Arup & Partners	No records
Man Made Mining Cavities	Stantec UK Ltd	No records
Potential Mining Areas	Wardell Armstrong LLP	No records
Subterranean features	Landmark	No records

An extract of the HAGDMS Non-Coal Mining Hazard Rating, as evaluated by the British Geological Survey (BGS), is presented in Plate 1:

Plate 1: Extract of HA GDMS Non-Coal Mining Hazard Rating



7. **Geology**

With reference to online resources [redacted] the 1:50,000 scale BGS Solid and Drift Geological Map of the Area of Winchester (Sheet 299, 2002), and the the published geology within the Order Limits Boundary indicates the presence of the Winchester-East Meon Anticline towards the southern boundary, which assumes the form of an ellipsoidal dome with the principal axis trending east-west through Winchester. Towards Chilcomb and Bar End (south of the boundary), the core of the anticline has been eroded to expose the older Zig Zag Chalk Formation. This inlier is surrounded by progressively younger rings of chalk formations including the Holywell Nodular Chalk Formation, New Pit Chalk Formation and Seaford Chalk Formation, which presents the youngest and predominantly exposed chalk formation with the exception of a patchy outcrop of the Newhaven Chalk Formation within the designated Landscaping Area.

Superficial deposits within the site boundary vary depending on the topographic distribution and are discussed below;

Quaternary age Alluvium is present, tracing the River Itchen and forming flood-plain belts, occupied by marshes and meadow land. Deposits consist of loam, gravel, peat and tufaceous marl, arranged as overlapping sheets, but frequently merging into one another. The flood loam is silty, and usually contains some calcareous matter in the form of tufa and finely divided chalk. Isolated mounds or

Item	Subject
	"malm-knolls" of Calcareous Tufa are recorded within the Alluvium deposits of the Itchen valley. Their extent is considered greater than is recognised by the published geological maps, which indicates those only that outcrop at the surface. Clay-with-Flints deposits mantle much of the higher topographic levels in the area. These periglacial deposits occur as a residual deposit upon the Chalk outcrop, comprising weathered remnants of the former Palaeogene deposits, along with insoluble residue from the dissolution of the chalk surface. Two varieties of Head deposits are recorded within the site boundary. Such periglacial deposits are typically formed by nivation, which is a suite of weathering and slope processes that includes intensive freeze-thaw activity, enhanced chemical weathering, slopewash and accelerated solifluction of the parent Palaeogene/Quaternary lithology and Chalk under periglacial conditions. The older unit of Head (1) is associated with slope deposits and is generally recorded on the north facing slopes downslope from Clay-with-Flints deposits. This results in the composition of Head (1) comprising a gravelly content that includes Clay-with-Flint debris. The younger Head (2) deposits comprises sandy, silty clay with gravels including chalk and flint and are generally recorded within dry chalk valleys that incise the exposed chalk.
8.	**Hydrogeology** According to online resources [redacted] the published hydrogeological map Sheet 9: Hydrogeological Map of Hampshire and the Isle of Wight (1:100,000 scale – 1979) presents the condition at the site showing that the water table level within the chalk aquifer lies between 30 and 40 m AOD. Based on Ordnance Survey Terrain 50 DTM Data, viewed via the British Geological Survey GeoIndex, the topographic setting within the Order Limit Boundary is predominantly defined by the River Itchin Basin. The basin has a north-south orientation which has eroded through the chalk bedrock of the Winchester-East Meon Anticline. The anticline produces an east-west orientated ridgeline running through Winchester, from which land levels decline from and towards the River Itchen Basin. Dry chalk valleys incise the slope faces as they decline towards the basin, producing subtle, undulating surfaces. The area directly surrounding and within the River Itchen Basis forms a flood-plain which is occupied by marshes and meadow land. Geological deposits in these areas consist of approximately 6-10m of Alluvium and flood loams, directly overly the Chalk. In these areas, ground levels are generally at approximately 40m AOD and therefore, the groundwater would be expected to be at, or above the chalk interface. As ground levels rise away from the River Itchen Basin, the alluvial deposits become absent, exposing the chalk or being replaced by Head deposits or Clay-with-Flints at higher elevations. In these areas, the chalk interface is expected to rise above the groundwater level. As can be appreciated from the topographic variations within the Order Limit Boundary, the depth to the groundwater produces varying implications for both natural and mining cavities to have formed in the area.
9.	**Geomorphology** With reference to the Ordnance Survey Terrain 50 DTM data, viewed via the BGS GeoIndex, elevation levels across the OLB generally decline from the Chilcomb Down (453500E, 128830N) at c.130m AOD, towards the valley of the River Itchen at c.40m AOD. This produces a general north-west facing slope with aspects ranging between c.280-330°, with topographic variations observed due to the presence of east-west orientated dry valleys. Elevation levels along the M3 motorway within the OLB remain relatively consistent at c.59m AOD, with minor variations. The elevation of Easton Lane on the east side of the scheme is approximately 65.0m. The elevation of the A272 at the M3 junction is approximately 67m AOD and descends to a low point at

Item	Subject
	approximately 60m AOD, 300m south-west of the junction. Elevation of the A34 falls from 67m AOD at the junction with the M3 to approximately 40m AOD at marker post MP1/5 by the Kingsworthy Flyover. The chalk outcrop in this area has undergone a variety of erosional and depositional episodes, followed by tectonic uplift, and initial sub-aerial erosion of the chalk surface. During the late Cretaceous/early Palaeogene, the region experienced a series of marine and fluvio-lacustrine inundations and transgressions that resulted in the deposition of Palaeogene deposits such as the Lambeth Group and London Clay. Subsequent glaciofluvial and periglacial weathering initiated the erosion of the Palaeogene deposits. This largely resulted in the complete removal of the Palaeogene deposits in the area, with the exception of the higher topographic levels, where deposits of Clay-with-Flints were formed following the erosional degradation of the Lambeth Group. While much of the Clay-with-Flints is only approximately 1m thick, there are places where the deposit extends up to 3-4m in depth, infilling solution pipes that extend into the chalk below. These solution pipes result from the dissolution of the chalk by the downward percolating surface water and thawing ice rich permafrost, usually abound under patches of Clay-with-Flints; their own development stimulated by the slow but constant supply of acidulated soil-water seeping from the retentive loamy material within and above them. The Quaternary depositional environment was characterised by colder climatic conditions which occurred with glacial and periglacial episodes where ice cover would increase in thickness when water/sea levels fell. There were relatively short periods at the onset and finish of such conditions when groundwater table levels fell widely below the chalk surface level. During such times, downward percolation of groundwater occurred which likely initiated karstic weathering of the chalk surface, where favourable circumstances allowed. Such conditions might also have allowed more intense dissolution to occur more widely along bedding planes and fissures, steep sloping topography at times when cold groundwater was able to circulate through the chalk sequence. Colder groundwater has the capacity to hold more dissolved carbon dioxide making it more acidic along with humic and fulvic acids generated by the periglacial tundra. This karstic activity was only possible during times when the ground (and groundwater) was not frozen, such as spring thaws, summer periods, or where taliks (year-round unfrozen ground, often saturated with mineral salts) are present, typically underlying surface water bodies such as the River Itchen. Each time as the climate warmed after glacial and periglacial episodes, land drainage patterns were established. When permafrost had thawed or partially thawed and water table conditions were favourable, this allowed the infiltration of surface water, collecting upon cover deposits and discontinuous permafrost, to percolate downwards to initiate dissolution of the chalk below. As can be appreciated from the above events, there have been times when there were favourable conditions for solution feature development and other times when conditions were probably not favourable, together with times when solution features were actively destroyed by erosion.
10.	**Natural Cavities - Hazard Ratings** In areas underlain by Chalk, the interface with cover deposits often forms a karstic horizon where solution features (swallow holes, sinkholes and solution pipes) are found. The most prominent karstic horizon is the Palaeogene/Chalk interface, however at the site location, this horizon has been eroded away completely by periglacial and glaciofluvial erosion. An assessment of the site has been undertaken utilising the *Dr Edmonds Natural Cavity Prediction Model*. This approach considers the wider spatial area factors that pertain solution feature development in order to determine a Subsidence Hazard Rating value (SHRn) which represents the likelihood for cavities to be present. Given the geological, hydrogeological and geomorphological variation within the Order Limit Boundary, this has resulted in varying hazard ratings being implemented across the site. The hazard ratings are discussed below and are

Item	Subject
	illustrated on the Natural Cavities Hazard Map (Figure 1a). The following hazard rating criterion was applied as part of this assessment.

(1) Where chalk is exposed and forms either the topographic hill top, or a slope face where Palaeogene/Quaternary deposits are absent at higher elevations, and therefore surface water is not anticipated to be directed towards, or accumulate in, areas of the chalk, the hazard rating for solution features to be present is considered **VERY LOW**.

(2) Where Alluvium overlies the Chalk, and groundwater is anticipated to be at or above the chalk interface due to the influence of the floodplain, the hazard rating for solution features to be present is considered **LOW**.

(3) Where chalk is exposed and forms a slope face where Palaeogene/Quaternary deposits are present at higher elevations, and therefore surface water is anticipated to have originated upon the cover deposits and be directed onto the Chalk, the hazard rating for solution features to be present is considered **MODERATELY LOW.**

(4) Where either Head (1) or Head (2) deposits are present, the irregular contact between the deposit and the chalk presents favourable conditions for solution piping, creating conduits for surface water to underdrain into the chalk below, resulting in a hazard rating of **MODERATE.**

(5) The Clay-with-Flints forms a younger, successive cover deposit over the chalk surface and commonly infills any hollows and dissolution pipes in the weathered chalk surface. This produces potential for underdrainage into the chalk below, creating favourable circumstances for solution feature development. Previous experience of studying sites underlain by Clay-with-Flints has shown that natural cavities are frequent and pose a risk of differential settlement and possible ground collapse. This subsequently results in a hazard rating of **MODERATELY HIGH.**

The likelihood of the occurrence (SHRn Hazard Rating) of natural cavities within the OLB has been determined in accordance with the criteria given in the following tables:

Table 3: Natural Cavities SHRn Hazard Rating Classification

	Criteria	Description
SHRn Hazard Rating	5: High	Near certain to occur, probably in numerous locations
	4: Moderately High	Likely to occur, possibly in numerous locations
	3: Moderate	May occur, probably on a single location
	2: Moderately Low	May occur, but unlikely
	1: Low	Not expected to occur

Item	Subject
11.	**Natural Cavities - Preliminary Risk Rating**

Stantec have assessed the spatial distribution of the likelihood for unrecorded natural cavities to be present within the Order Limit Boundary and have considered these against the vulnerability (magnitude of impact) of such features to the proposed land usage presented on scheme drawings. This has been undertaken to produce the Natural Cavities Risk Map (Figure 1b). The aim of this risk assessment is to identify elements of the scheme that are particularly vulnerable to natural cavity hazards. The risk assessment has been undertaken in accordance with the risk assessment methodology outlined in the GIR Appendix F (GIR GRR01 Rev 2). It is envisaged that this risk assessment will be continuously developed and updated throughout the project as the investigations and works progress.

Table 4: Natural Cavities Vulnerability (Magnitude of Impact)Classification

	Criteria	Description
Vulnerability (Magnitude of Impact)	5: Severe	Severe loss or damage to life or infrastructure
	4: High	Major loss or damage to life or infrastructure
	3: Medium	Substantial loss or damage to infrastructure
	2: Low	Moderate loss or damage to infrastructure
	1: Negligible	Minor loss or damage to infrastructure and landscaping

The rating of the risk has been assessed using the following Risk Assessment Matrix, and is defined in line with criteria given in the following tables:

Table 5: Natural Cavities Vulnerability Mapping: Risk Assessment Matrix

		SHRn Hazard Rating				
		Low (1)	Moderately Low (2)	Moderate (3)	Moderately High (4)	High (5)
Vulnerability (Magnitude of Impact)	Severe (5)	**5**	**10**	**15**	**20**	**25**
	High (4)	**4**	**8**	**12**	**16**	**20**
	Medium (3)	**3**	**6**	**9**	**12**	**15**
	Low (2)	**2**	**4**	**6**	**8**	**10**
	Negligible (1)	**1**	**2**	**3**	**4**	**5**

Table 6: Natural Cavities Risk Rating Classification

	Criteria	Description
Risk Rating	Critical (20-25)	Severe loss or loss to life - High probability of occurrence with a High impact on the proposed scheme
	High (13-19)	Major loss or serious injury - Moderate to High probability of occurrence and a Medium to High impact on the proposed scheme
	Medium (6-12)	Substantial loss or damage to infrastructure - Moderate to High probability of occurrence and a or a Medium to High impact on the proposed scheme.
	Low (2-5)	Moderate loss or damage to infrastructure - Low to Moderate probability of occurrence or a Low to Medium impact on the proposed scheme
	Very Low (1-2)	Minor loss or damage to infrastructure - Low probability of occurrence and a Negligible to Low impact on the proposed scheme

The varying risk ratings implemented across the site have been illustrated on the Natural Cavities Risk Map (Figure 1b). A breakdown of the spatial distribution of Risk Ratings, in accordance with the existing or proposed development is listed in Table 7 below;

Item	Subject

Table 7: Overview of Natural Cavities Risk Calculation Methodology

Designated Area	SHRn Value (Probability)	Magnitude of Impact (Severity)	Risk
Depositional Areas			
• Northern	Moderate (3)	Negligible (1)	Low (3)
• Central	Low (1)	Negligible (1)	Very Low (1)
• Central	Moderately High (4)	Negligible (1)	Low (4)
• Southern	Low (1)	Negligible (1)	Very Low (1)
Construction Compounds			
• Northern	Moderately Low (2)	Negligible (1)	Very Low (2)
• A33/A34	Moderately Low (2)	Negligible (1)	Very Low (2)
• Central	Moderately Low (2)	Negligible (1)	Very Low (2)
Landscaping Areas	Moderately High (4)	Negligible (1)	Low
	Moderate (3)	Negligible (1)	Low
	Moderately Low (2)	Negligible (1)	Very Low (2)
Piling/Crane Mats	Moderately Low (2)	Negligible (1)	Very Low
Road Development	Moderate (3)	High (4)	Medium
	Moderately Low (2)	High (4)	Medium
	Low (1)	High (4)	Low

12. **Non-Coal Mining Cavities - Hazard Ratings**

The most common uses of mined chalk were agricultural purposes to obtain lime to spread on clay-rich soils to improve their drainage, lighten the soil texture for ploughing and improve crop yields. Another common use was to obtain mined chalk to powder and mix with milled clay to make bricks and tiles.

In addition, whenever chalk mining took place in the past, it was always carried out in dry chalk above the water table. No instances are known where dewatering was employed to create dry chalk for mining.

While the Stantec Mining Cavities Database search did not indicate any recorded mining cavities within a 1km radius of the Order Limit Boundary (OLB), a review of the historical mapping of the area, along with the HA GDNS non-coal mining hazard data has identified 2no. locations where Old Chalk Pits have been recorded. From the available OS County Series (dated 1869-1870, 1:2,500 scale), two Chalk Pits are recorded within the OLB, towards the north/north-east, within a field annotated as 'Easton Down'. The eastern most of these chalk pits has been annotated as 'Easton Down Chalk Pit' by HA GDMS, as illustrated in *Plate 1* above. The two pits have been annotated as Feature 1 and Feature 2 on the Mining Cavities Hazard Map (Figure 2a).

With reference to the HA GDMS extract provided in *Plate 1* above, varying hazard ratings have been assigned along this section of the M3. A Very High hazard rating has been assigned to each locality of a recorded chalk pit or mining feature. In addition, it appears that a 500m radius buffer zone has been applied, also assigned as a Very High hazard. Stantec agree that at the locality of a recorded mining feature, the hazard rating should be Very High due to the known presence of mining activity and extraction, the buffer zone is considered to be conservative and does not reflect the surrounding ground conditions. Stantec consider a 50m radius buffer zone to be more suitable.

Stantec have undertaken a hazard assessment of the site, which has considered the variable geological, hydrogeological and geomorphological factors that pertain to the potential for historical chalk mining to have occurred. This has resulted in a variable hazard rating across the site. The hazard ratings are discussed in depth below and are illustrated on the Mining Cavities Hazard Map (Figure 2a) in accordance with the following numeric values.

(1) Feature 1 represents a chalk pit located within an area of exposed chalk, at approximately 45m AOD. At this location, it is expected that there would be at least 5m of dry chalk, allowing for viable mining; resulting in a **VERY HIGH** hazard rating. To the south and east of this pit, land levels increase, subsequently increasing the thickness of dry chalk that could be extracted. Therefore, a 50m radius buffer zone applies in this direction with a

Item	Subject
	hazard rating of **HIGH**. However, to the north of this recorded chalk pit, the topography declines sharply towards the basin of the River Itchen, where a significant thickness of Alluvium is present overlying the chalk, and the groundwater table is expected to be at, or above, the chalk level. This subsequently lowers the potential for chalk mining to have occurred, resulting in a **LOW** hazard rating. (2) Feature 2 represents Easton Down Chalk Pit which is located within an area of exposed chalk, at approximately 58m AOD. At this location, it is expected that there would be at least 18m of dry chalk, allowing for viable mining; resulting in a **VERY HIGH** hazard rating. Due to the potential for unrecorded adits extending from the chalk pit, a 50m radius buffer zone applies with a hazard rating of **HIGH**. (3) Where chalk is exposed, and a thickness of at least 5m of dry chalk is present above the groundwater level, there are potentially favourable conditions for chalk mining to have occurred, resulting in a hazard rating of **MODERATELY LOW**. (4) Where the chalk is overlain by superficial deposits, but a thickness of at least 5m of dry chalk is present above the groundwater level, there are potentially favourable conditions for chalk mining to have occurred, resulting in a hazard rating of **MODERATELY LOW**. (5) Where the chalk is overlain by Alluvium, OR where the groundwater level is less than 5m below the chalk interface, at the chalk interface, or above the chalk interface, ground conditions are unfavourable for chalk mining to have occurred, resulting in a hazard rating of **LOW.** Furthermore, historical mapping and HA GDMS identify five further mining features, as shown in *Plate 1* above, however these are positioned outside of the Order Limit Boundary. Each of these features have been discussed briefly below (Features 3 to 7), however due to their proximity outside of the Order Limit Boundary, these have not been included in Figure 2. Feature 3 is located outside of the Order Limit Boundary; approximately 75m east of the assigned Northern Deposition Area. This recorded chalk pit is not considered to influence the site or the proposed works. Feature 4, or Upper Farm Chalk Pit, has been identified by the HA GDMS dataset, however it is located approximately 950m north-west of the Order Limit Boundary, and 2.1km south-east of the assigned Northern Construction Compound. This recorded chalk pit is not considered to influence the site or the proposed works. Feature 5, 6, and 7 is associated with the Great Western Lime Works, comprising the Lime Works and two chalk pits. This locality is situated approximately 1.4km south-west, outside of the Order Limit Boundary. As the chalk is at, or near outcrop at this locality, it is considered unlikely that any underground mining, associated with the Lime Works, has occurred. Furthermore, given the distance of the works from the Order Limit Boundary, regardless of any unrecorded underground mining, the works are not considered to influence the site or the proposed works.

Item	Subject
13.	**Non-Coal Mining Cavities - Risk Ratings**

Stantec have assessed the spatial distribution of the likelihood for unrecorded non-coal mining cavities to be present within the Order Limit Boundary and have considered these against the vulnerability (magnitude of impact) of such features to the proposed land usage presented on scheme drawings. This has been undertaken to produce the Non-Coal Mining Risk Map (Figure 2b). The aim of this risk assessment is to identify elements of the scheme that are particularly vulnerable to mining cavity hazards. The risk assessment has been undertaken in accordance with the risk assessment methodology outlined in the GIR Appendix F (GIR GRR01 Rev 2). It is envisaged that this risk assessment will be continuously developed and updated throughout the project as the investigations and works progress.

The likelihood of the occurrence and impact of non-coal mining cavities upon the site has been determined in accordance with the criteria given in the following tables:

Table 8: Non-Coal Mining Cavities Probability of Occurrence Classification

	Criteria	Description
Probability of Occurrence	6: Very High	Recorded occurrence
	5: High	Near certain to occur, probably in numerous locations
	4: Moderately High	Likely to occur, possibly in numerous locations
	3: Moderate	May occur, probably on a single location
	2: Moderately Low	May occur, but unlikely
	1: Low	Not expected to occur

Table 9: Non-Coal Mining Cavities Magnitude of Impact Classification

	Criteria	Description
Vulnerability (Magnitude of Impact)	5: Severe	Severe loss or damage to life or infrastructure
	4: High	Major loss or damage to life or infrastructure
	3: Medium	Substantial loss or damage to infrastructure
	2: Low	Moderate loss or damage to infrastructure
	1: Negligible	Minor loss or damage to infrastructure

The rating of the risks has been assessed using the following Risk Assessment Matrix, and is defined in line with criteria given in the following tables:

Table 10: Non-Coal Mining Cavities Vulnerability Mapping: Risk Assessment Matrix

		Probability of Occurrence					
		Low (1)	Moderately Low (2)	Moderate (3)	Moderately High (4)	High (5)	Very High (6)
Vulnerability (Magnitude of Impact)	Severe (5)	5	10	15	20	25	30
	High (4)	4	8	12	16	20	24
	Medium (3)	3	6	9	12	15	18
	Low (2)	2	4	6	8	10	12
	Negligible (1)	1	2	3	4	5	6

Item	Subject

Table 11: Non-Coal Mining Cavities Risk Rating Classification

	Criteria	Description
Risk Rating	Critical (20-30)	High probability of occurrence with a High impact on the proposed scheme
	High (13-19)	Moderate to High probability of occurrence and a Medium to High impact on the proposed scheme
	Medium (6-12)	Moderate to High probability of occurrence and a or a Medium to High impact on the proposed scheme.
	Low (2-5)	Low to Moderate probability of occurrence or a Low to Medium impact on the proposed scheme
	Very Low (1-2)	Low probability of occurrence and a Negligible to Low impact on the proposed scheme

The varying risk ratings implemented across the site have been illustrated on the *Mining Cavities Risk Map* (Figure 2b):

Table 12: Overview of Non-Coal Mining Cavities Risk Calculation Methodology

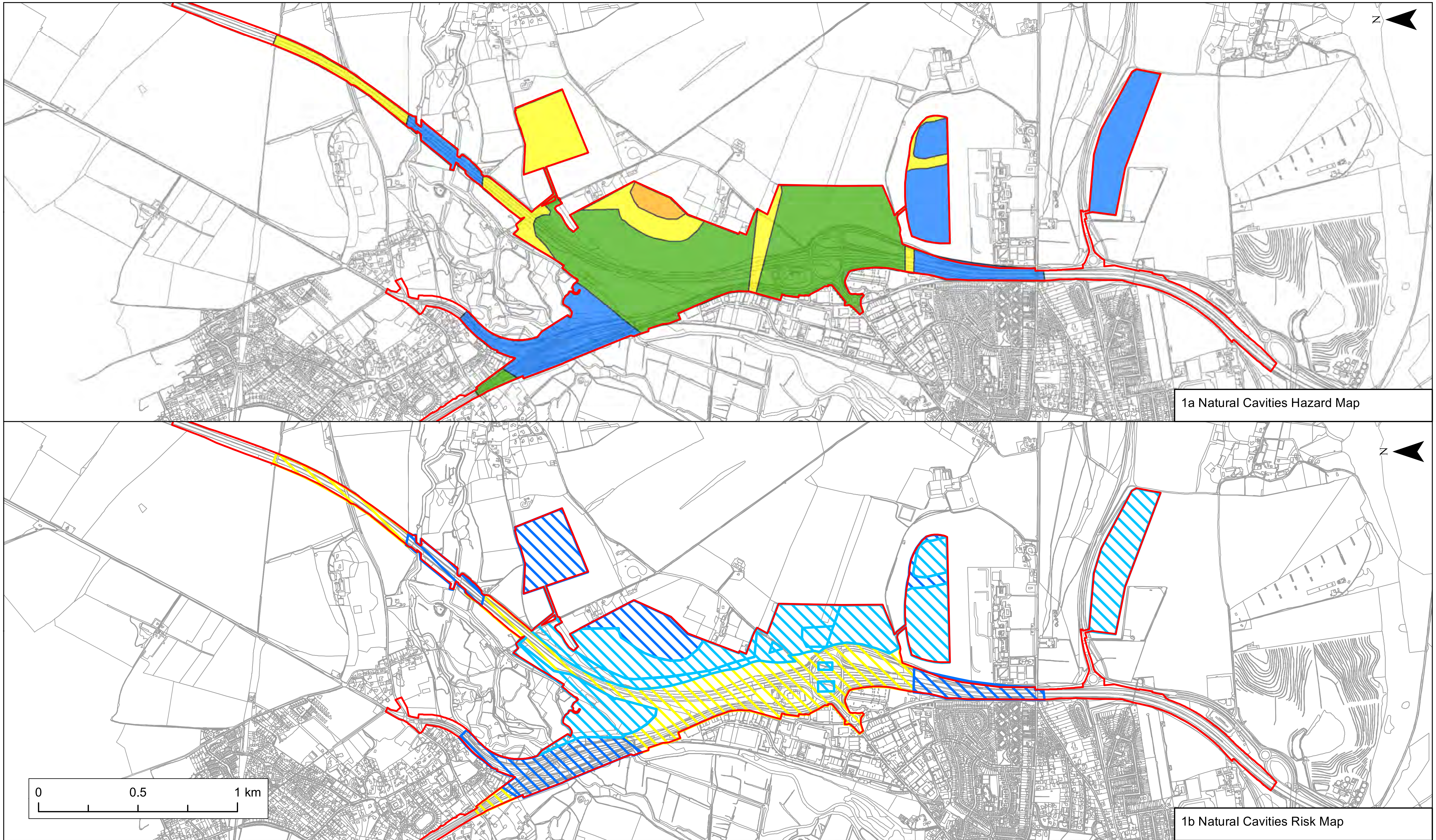
Designated Area	Probability of Occurrence	Vulnerability (Magnitude of Impact)	Risk
Depositional Areas			
• Northern	Moderately Low (2)	Negligible (1)	Very Low
• Central	Moderately Low (2)	Negligible (1)	Very Low
• Southern	Moderately Low (2)	Negligible (1)	Very Low
Construction Compounds			
• Northern	Moderately Low (2)	Negligible (1)	Very Low
• A33/A34	Moderately Low (2)	Negligible (1)	Very Low
• Central	Moderately Low (2)	Negligible (1)	Very Low
Landscaping Areas	Moderately Low (2)	Negligible (1)	Very Low
Piling/Crane Mats	Moderately Low (2)	Negligible (1)	Very Low
Road Development	Low (1)	High (4)	Low
	Moderately Low (2)	High (4)	Medium
	Very High (6)	Negligible (1)	Medium
	Very High (6)	Moderate (3)	High

14. **Recommendations**

As the project progresses, and more ground truthing data becomes available, the Hazard and Risk Maps appended to this report, should be revised and maintained to reflect the increased understanding of the ground conditions.

If during site investigation or construction, abnormal ground conditions are encountered, such as loose or very loose material or voiding, an experienced engineering geologist or geotechnical engineer with a background in geohazards should be consulted prior to continuing.

It would be prudent for foundation and drainage designers to make reference to CIRIA C574 (2002) “Engineering in chalk”.



KEY

- Indicative Application Boundary
- OS Mastermap

Natural Cavities Hazard Rating

- Low
- Moderate - Low
- Moderate
- Moderate - High

Natural Cavities Risk Rating

- Very Low
- Low
- Moderate

Figure Status: FOR INFORMATION

VolkerFitzpatrick

Client: highways england

Project Title: M3 JUNCTION 9 IMPROVEMENT

Figure Title: NATURAL CAVITY HAZARD AND RISK MAP

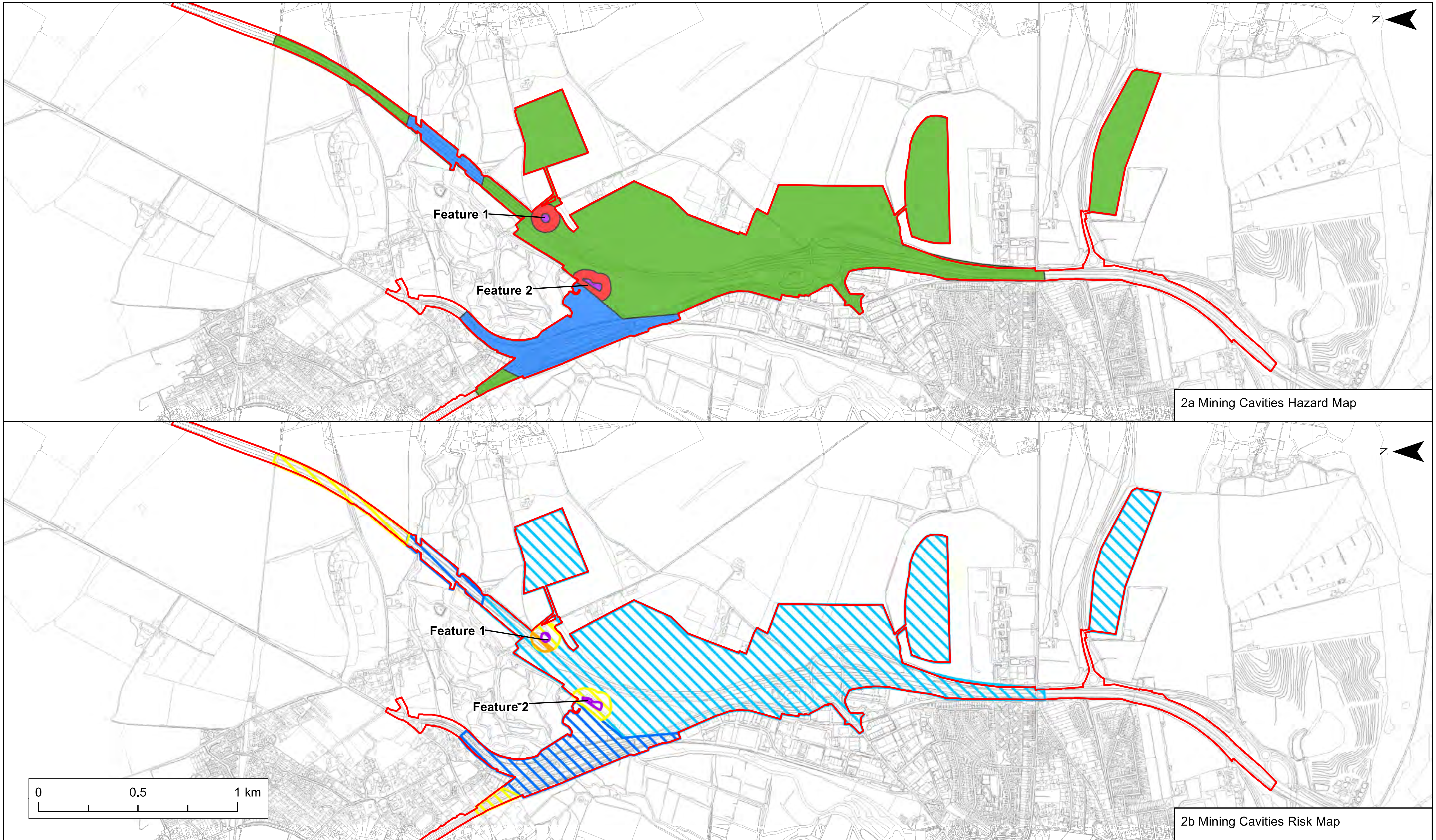
Scale: 1:18,000	Designed: TL	Drawn: TL	Checked: HG	Approved: HG
Original Size: A3	Date: 14/05/2021	Date: 14/05/2021	Date: 14/05/2021	Date: 14/05/2021

FIGURE 1

Project Ref No. 48176

Revision: A

Document Path: Z:\Projects\48176\02_mxd\Geophys\48176_Geo_Cavities_HazardVulnerabilityMap.mxd



KEY

Indicative Application Boundary

OS Mastermap

Mining Cavities Hazard Rating

- Low
- Moderate - Low
- Old Chalk Pit Moderate
- High

Mining Cavities Risk Rating

- Very Low
- Low
- Moderate
- High
- Old Chalk Pit - Very High

Figure Status: FOR INFORMATION	Project Title: M3 JUNCTION 9 IMPROVEMENT
VolkerFitzpatrick	Figure Title: MINING CAVITY HAZARD AND RISK MAP
Client: highways england	FIGURE 2

Scale: 1:18,000	Designed: TL	Drawn: TL	Checked: HG	Approved: HG
Original Size: A3	Date: 14/05/2021	Date: 14/05/2021	Date: 14/05/2021	Date: 14/05/2021

Project Ref No. 48176

Revision: A

Appendix B Stantec Methodology for the Assessment of Contaminated Land

1 INTRODUCTION

This document defines the approach adopted by Stantec in relation to the assessment of land contamination in England. The aim is for the approach to (i) be systematic and objective, (ii) provide for the assessment of uncertainty and (iii) provide a rational, consistent, transparent framework.

When preparing our methodology, we have made reference to various technical guidance documents and legislation referenced in Section 7 of which the principal documents are (I) Contaminated Land Statutory Guidance (Defra 2012), (ii) online guidance Land Contamination: Risk Management (LC:RM) accessed from GOV.UK which is expected to replace Contaminated Land Research (CLR) Report 11: Model Procedures for the Management of Contamination (EA 2004). It should be noted that LCRM is currently due to be revised following consultation and CLR 11 is archived, (iii) Contaminated land risk assessment: A guide to good practice (C552) (CIRIA 2001) (iv) National Planning Policy Framework (NPPF, 2019) (v) BS 10175 Investigation of potentially contaminated sites - Code of Practice (BSI 2017) and (vi) The series of British Standards on Soil Quality BS 18400.

2 DEALING WITH LAND CONTAMINATION

Government policy on land contamination aims to prevent new contaminated land from being created and promotes a risk-based approach to addressing historical contamination. For historical contamination, regulatory intervention is held in reserve for land that meets the legal definition and cannot be dealt with through any other means, including through planning. Land is only considered to be "*contaminated land*" in the legal sense if it poses an unacceptable risk.

UK legislation on contaminated land is principally contained in Part 2A of the Environmental Protection Act, 1990 (which was inserted into the 1990 Act by section 57 of the Environment Act 1995). Part 2A was introduced in England on 1 April 2000 and provides a risk-based approach to the identification and remediation of land where contamination poses an unacceptable risk to human health or the environment.

The Model Procedures for the Management of Land Contamination (CLR 11), were developed to provide the technical framework for applying a risk management process when dealing with land affected by contamination. The process involves identifying, making decisions on, and taking appropriate action to deal with land contamination in a way that is consistent with government policies and legislation within the UK. The approach, concepts and principles for land contamination management promoted by LC:RM (and its predecessor CLR 11) are applied to the determination of planning applications. The guidance given in LC:RM follows the same principles.

Other legislative regimes may also provide a means of dealing with land contamination issues, such as the regimes for waste, water, environmental permitting, and environmental damage. Further, the law of statutory nuisance may result in contaminants being unacceptable to third parties whilst not attracting action under Part 2A or other environmental legislation.

2.1 Part 2A

The Regulations and Statutory Guidance that accompanied the Act, including the Contaminated Land (England) Regulations 2006, has been revised with the issue of The Contaminated Land (England) (Amendment) Regulations 2012 (SI 2012/263) and the Contaminated Land Statutory Guidance for England 2012.

Part 2A defines contaminated land as "*land which appears to the Local Authority in whose area it is situated to be in such a condition that, by reason of substances in, on or under the land that significant harm is being caused, or there is a significant possibility that such significant harm (SPOSH) could be caused, or significant pollution of controlled waters is being caused, or there is a significant possibility of such pollution (SPOSP) being caused*".

Harm is defined as "*harm to the health of living organisms or other interference with the ecological systems of which they form part, and in the case of man, includes harm to his property*".

Part 2A provides a means of dealing with unacceptable risks posed by land contamination to human health and the environment, and under the guidance enforcing authorities should seek to find and deal with such land. It states that "*under Part 2A the starting point should be that land is not contaminated land unless there is reason to consider otherwise. Only land where unacceptable risks are clearly identified, after a risk assessment has been undertaken in accordance with the Guidance, should be considered as meeting the Part 2A definition of contaminated land*". Further, the guidance makes it clear that *"regulatory decisions should be based on what is reasonably likely, not what is hypothetically possible".*

The overarching objectives of the Government's policy on contaminated land and the Part 2A regime are:

"(a) To identify and remove unacceptable risks to human health and the environment.

(a) To seek to ensure that contaminated land is made suitable for its current use.

(b) To ensure that the burdens faced by individuals, companies and society as a whole are proportionate, manageable and compatible with the principles of

sustainable development".

The enforcing authority may need to decide whether and how to act in situations where decisions are not straight forward, and where there is uncertainty. "*In so doing, the authority should use its judgement to strike a reasonable balance between: (a) dealing with risks raised by contaminants in land and the benefits of remediating land to remove or reduce those risks; and (b) the potential impacts of regulatory intervention including financial costs to whoever will pay for remediation, health and environmental impacts of taking action, property blight, and burdens on affected people".*

The authority is required to "*take a precautionary approach to the risks raised by contamination, whilst avoiding a disproportionate approach given the circumstances of each case".* The aim is "*that the regime produces net benefits, taking account of local circumstances*".

The guidance recognises that *"normal levels of contaminants in soils should not be considered to cause land to qualify as contaminated land, unless there is a particular reason to consider otherwise".* Normal levels are quoted as:

"a) *natural presence of contaminants'* such as from underlying geology *'that have not been shown to pose an unacceptable risk to health and the environment*

b) *…low level diffuse pollution, and common human activity…"*

Similarly the guidance states that significant pollution or significant possibility of significant pollution of controlled waters is required for land to be considered contaminated and the "*fact that substances are merely entering water"* or "*where discharge from land is not discernible at a location immediately downstream"* does not constitute contaminated land.

To help achieve a more targeted approach to identifying and managing contaminated land in relation to the risk (or possibility) of harm to human health, the revised Statutory Guidance presented a new four category system for considering land under Part 2A, ranging from Category 4, where there is no risk that land poses a significant possibility of significant harm (SPOSH), or the level of risk is low, to Category 1, where the risk that land poses a significant possibility of significant harm (SPOSH) is unacceptably high.

For land that cannot be readily placed into Categories 1 or 4 further assessment is required. If there is sufficient concern that the risks could cause significant harm or have the significant possibility of significant harm the land is to be placed into Category 2. If the concern is not met land is considered Category 3.

The technical guidance clearly states that the currently published Soil Guidance Values (SGV's) and Generic Assessment Criteria (GAC's) represent *"cautious estimates of level of contaminants in soils"* which should be considered *"no risk to health or, at most, a minimal risk"*. These values do not represent the boundary between categories 3 and 4 and "*should be considered to be comfortably within Category 4".*

At the end of 2013 technical guidance in support of Defra's revised Statutory Guidance (SG) was published and then revised in 2014 (CL: AIRE 2014) which provided:

- A methodology for deriving C4SLs for four generic land-uses comprising residential, commercial, allotments and public open space; and

- A demonstration of the methodology, via the derivation of C4SLs for six substances – arsenic, benzene, benzo(a)pyrene, cadmium, chromium (VI) and lead.

For controlled waters, the revised Statutory Guidance states that the following types of pollution should be considered to constitute significant pollution of controlled waters:

"(a) *Pollution equivalent to "environmental damage" to surface water or groundwater as defined by The Environmental Damage (Prevention and Remediation) Regulations 2009, but which cannot be dealt with under those Regulations.*

(b) *Inputs resulting in deterioration of the quality of water abstracted, or intended to be used in the future, for human consumption such that additional treatment would be required to enable that use.*

(c) *A breach of a statutory surface water Environment Quality Standard, either directly or via a groundwater pathway.*

(d) *Input of a substance into groundwater resulting in a significant and sustained upward trend in concentration of contaminants (as defined in Article 2(3) of the Groundwater Daughter Directive (2006/118/EC)".*

The guidance also states that, in some circumstances, significant concentrations at a compliance point (in groundwater or surface water) may constitute pollution of controlled waters.

As with SPOSH for human health, the revised Statutory Guidance presents a four-category system for Significant Pollution of controlled waters. Category 1 covers land where there is a strong and compelling case for SPOSP, for example where significant pollution would almost certainly occur if no action was taken to avoid it. Category 4 covers land where there is no risk or the risk is low, for example, where the land contamination is having no discernible impact on groundwater or surface water quality. Category 2 is for land where the risks posed to controlled waters are not high enough to consider the land as Category 1 but nonetheless are of sufficient concern to constitute SPOSP, Category 3 is for land where the risks posed to controlled waters are higher than low but not of sufficient concern to constitute SPOSP.

2.2 Planning

The Local Planning Authority (LPA) is responsible for the control of development, and in doing so it has a duty to take account of all material considerations, including contamination.

The principal planning objective is to ensure that any unacceptable risks to human health, buildings and other property and the natural and historical environment from the contaminated condition of the land are identified so that appropriate action can be considered and taken to address those risks.

The National Planning Policy Framework (NPPF, 2021), includes the following.

Paragraph 120 states that planning policies and decisions should "*(c) give substantial weight to the value of using suitable brownfield land within settlements for homes and other identified needs, and support appropriate opportunities to remediate despoiled, degraded, derelict, contaminated or unstable land*."

Paragraph 184 states "*Where a site is affected by contamination or land stability issues, responsibility for securing a safe development rests with the developer and/or landowner*".

Paragraph 174 states "*planning policies and decisions should contribute to and enhance the natural and local environment by:*

(e) preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability. Development should, wherever possible, help to improve local environmental conditions such as air and water quality, taking into account relevant information such as river basin management plans; and

(f) remediating and mitigating despoiled, degraded, derelict, contaminated and unstable land, where appropriate."

Paragraph 183 describes the policy considerations the Government expects LPA's to have in regard to land affected by contamination when preparing policies for development plans and in taking decisions on applications.

Paragraph 183 states "*planning policies and decisions should ensure that:*

(a) a site is suitable for its proposed use taking account of ground conditions and any risks arising from land instability and contamination. This includes risks arising from natural hazards or former activities such as mining, and any proposals for mitigation including land remediation (as well as potential impacts on the natural environment arising from that remediation);

(b) after remediation, as a minimum, land should not be capable of being determined as contaminated land under Part IIA of the Environmental Protection Act 1990; and

c) adequate site investigation information, prepared by a competent person, is available to inform these assessments."

Paragraph 187 states "*The focus of planning policies and decisions should be on whether proposed development is an acceptable use of land, rather than the control of processes or emissions (where these are subject to separate pollution control regimes). Planning decisions should assume that these regimes will operate effectively. Equally, where a planning decision has been made on a development, the planning issues should not be revisited through the permitting regimes operated by pollution control authorities.*"

The Glossary in Annex 2 provides the following:

***Brownfield land registers**: Registers of previously developed land that local planning authorities consider to be appropriate for residential development, having regard to criteria in the Town and Country Planning (Brownfield Land Registers) Regulations 2017. Local planning authorities will be able to trigger a grant of permission in principle for residential development on suitable sites in their registers where they follow the required procedures.*

***Competent person (to prepare site investigation information)**: A person with a recognised relevant qualification, sufficient experience in dealing with the type(s) of pollution or land instability, and membership of a relevant professional organisation.*

***Previously developed land**: Land which is or was occupied by a permanent structure, including the curtilage of the developed land (although it should not be assumed that the whole of the curtilage should be developed) and any associated fixed surface infrastructure. This excludes: land that is or was last occupied by agricultural or forestry buildings; land that has been developed for minerals extraction or waste disposal by landfill, where provision for restoration has been made through development management procedures; land in built-up areas such as residential gardens, parks, recreation grounds and allotments; and land that was previously developed but where the* *remains of the permanent structure or fixed surface structure have blended into the landscape.*

Site investigation information*: Includes a risk assessment of land potentially affected by contamination, or ground stability and slope stability reports, as appropriate. All investigations of land potentially affected by contamination should be carried out in accordance with established procedures (such as BS10175 Investigation of Potentially Contaminated Sites – Code of Practice).*

Stantec adopt the principle that a Preliminary Investigation (Desk Study and Site Reconnaissance) and Preliminary Risk Assessment (see below) is the minimum assessment requirement to support a planning application.

The level at which contamination is deemed to be unacceptable, or, gives rise to adverse effects under a planning context has not been identified but is envisaged to be more precautionary than the level required to determine land as contaminated under Part 2A.

2.3 Building Control

The building control department of the local authority or private sector approved inspectors are responsible for the operation and enforcement of the Building Regulations (DCLG 2010) to protect the health, safety and welfare of people in and around buildings. Approved Document C requires the protection of buildings and associated land from the effects of contamination, to be applied (non-exclusively) in all changes of use from commercial or industrial premises, to residential property.

3 APPROACH

As with CLR11 the guidance given in LC:RM presents three stages of land contamination management: -

(a) Stage 1 - Risk Assessment;

(b) Stage 2 - Options Appraisal; and

(c) Stage 3 - Remediation.

Each stage has three tiers. The three tiers of Stage 1 Risk Assessment are: -

- Tier 1 - Preliminary Risk Assessment (PRA) - first tier of RA that develops the outline conceptual model (CM) and establishes whether there are any potentially unacceptable risks.
- Tier 2 - Generic Quantitative Risk Assessment (GQRA) - carried out using generic assessment criteria and assumptions to estimate risk.
- Tier 3 - Detailed Quantitative Risk Assessment (DQRA) - carried out using detailed site-specific information to generate Site Specific Assessment Criteria (SSAC) as risk evaluation criteria.

For each tier of a Stage 1 - Risk Assessment you must:

1. Identify the hazard - establish contaminant sources.

2. Assess the hazard - use a source-pathway-receptor (S-P-R) pollutant linkage approach to find out if there is the potential for unacceptable risk.

3. Estimate the risk - predict what degree of harm or pollution might result and how likely it is to occur.

4. Evaluate the risk - decide whether a risk is unacceptable.

A Stantec Preliminary Investigation report normally comprises a desk study, walkover site reconnaissance and preliminary risk assessment (PRA). The project specific proposal defines the actual scope of work which might include review of ground investigation data in which case the report includes a GQRA.

Risk estimation involves identifying the magnitude of the potential consequence (taking into account both the potential severity of the hazard and the sensitivity of the receptor) and the magnitude of the likelihood i.e. the probability (taking into account the presence of the hazard and the receptor and the integrity of the pathway). This approach is promoted in current guidance such as R&D 66 (NHBC 2008).

For a PRA, Stantec's approach is that if a pollution linkage is identified then it represents a potentially unacceptable risk which either (1) remediation / direct risk management or (2) progression to further tiers of risk assessment (GQRA and GQRA) requiring additional data collection and enabling refinement of the CM using the site specific data.

4 IDENTIFICATION OF POLLUTANT LINKAGES AND DEVELOPMENT OF A CONCEPTUAL MODEL (CM)

For all Tiers of a Stage 1 Risk Assessment, the underlying principle to ground condition assessment is the identification of *pollutant linkages* in order to evaluate whether the presence of a source of contamination could potentially lead to harmful consequences. A pollutant linkage consists of the following three elements: -

- A source/hazard – a substance or situation which has the potential to cause harm or pollution;
- A pathway – a means by which the hazard moves along / generates exposure; and
- A receptor/target – an entity which is vulnerable to the potential adverse effects of the hazard.

The *Conceptual Model* identifies the types and locations of potential contaminant sources/hazards and potential receptors and potential migration/transportation pathway(s). The CM is refined through progression to further tiers of risk assessment (GQRA and GQRA) requiring additional data collection.

4.1 Hazard Identification

A hazard is a substance or situation that has the potential to cause harm. Hazards may be chemical, biological or physical.

In a PRA the potential for hazards to be present is determined from consideration of the previous or ongoing activities on or near to the site in accordance with the criteria presented in the **Table 1**.

Based on the land use information Contaminants of Potential Concern (COPC) are identified. The COPC direct the scope of the collection of site-specific data and the analytical testing selected for subsequent Tiers.

At Tier 2 the site-specific data is evaluated using appropriate published assessment criteria (refer to Stantec document entitled Rationale for the Selection of Evaluation Criteria for a Generic Quantitative Risk Assessment (GQRA)). In general, published criteria have been developed using highly conservative assumptions and therefore if the screening criterion is not exceeded (and if enough samples from appropriate locations have been analysed) then the COPC is eliminated as a potential Hazard. It should be noted that exceedance does not necessarily indicate that a site is contaminated and/or unsuitable for use only that the COPC is retained as a potential Hazard. Published criteria are generated using models based on numerous and complex assumptions. Whether or not these assumptions are appropriate or sufficiently protective requires confirmation on a project by project basis. Manipulation of the default assumptions would normally form part of a Tier 3 Detailed Quantitative Risk Assessment (DQRA).

When reviewing or assessing site specific data Stantec utilise published guidance on comparing contamination data with a critical concentration (CL:AIRE/CIEH 2008) which presents a structured process for employing statistical techniques for data assessment purposes.

4.2 Receptor and Pathway Identification

For all Tiers the potential receptors (for both on site and adjoining land) that will be considered are:

- Human Health – including current and future occupiers, construction and future maintenance workers, and neighbouring properties/third parties;
- Ecological Systems; [1]
- Controlled Waters [2] – Under section 78A(9) of Part 2A the term "pollution of controlled waters" means the entry into controlled waters of any poisonous, noxious or polluting matter or any solid waste matter. The term "controlled waters" in relation to England has the same meaning as in Part 3 of the Water Resources Act 1991, except that "ground waters" does not include waters contained in underground strata but above the saturation zone.
- Property - Animal or Crop (including timber; produce grown domestically, or on allotments, for consumption; livestock; other owned or domesticated animals; wild animals which are the subject of shooting or fishing rights); and
- Property - Buildings (any structure or erection, and any part of a building including any part below ground level, but does not include plant or machinery comprised in a building, or buried services such as sewers, water pipes or electricity cables including archaeological sites and ancient monuments).

If a receptor is taken forward for further assessment it will be classified in terms of its sensitivity, the criteria for which are presented in **Table 2**. Table 2 has been generated using descriptions of environmental receptor importance/value given in various guidance documents including R&D 66 (NHBC 2008), EA 2017 and Transport Analysis Guidance (based on DETR 2000). Human health and buildings classifications have been generated by Stantec using the attribute description for each class. Surface water sensitivity is classified using the Water Framework Directive (WFD) status for the River Basin obtained from: [redacted]

[1] International or nationally designated sites (as defined in the statutory guidance (Defra Circular 04/12)) "*in the local area*" will be identified as potential ecological receptors. A search radius of 1, 2 or 5km will be utilised depending on the site-specific circumstances (see also pathway identification). The Environment Agency has published an ecological risk assessment framework (EA 2008) which promotes (as opposed to statutorily enforces) consideration of additional receptors to include locally protected sites and protected or notable species. These additional potential receptors will only be considered if a Phase 1 habitat survey, undertaken in accordance with guidance (JNCC 1993), is commissioned and the data provided to Stantec. It should be noted that without such a survey a Land Contamination risk assessment may conclude that the identification of potential ecological receptors is inconclusive (refer to Stantec Specification for a Preliminary Investigation (Desk Study and Site Reconnaissance).

[2] The definition of "pollution of controlled water" was amended by the introduction of Section 86 of the Water Act 2003. For the purposes of Part 2A groundwater does not include waters above the saturated zone and our assessment does not therefore address perched water other than where development causes a pathway to develop.

The exposure pathway and modes of transport that will be considered are presented in **Table 3**.

4.3 Note regarding Ecological Systems

The Environment Agency (EA) has developed an ecological risk assessment framework which aims to provide a structured approach for assessing the risks to ecology from chemical contaminants in soils (EA 2008). In circumstances where contaminants in water represent a potential risk to aquatic ecosystems then risk assessors will need to consider this separately.

The framework consists of a three-tiered process: -

- Tier 1 is a screening step where the site soils chemical data is compared to a soil screening value (SSV)
- Tier 2 uses various tools (including surveys and biological testing) to gather evidence for any harm to the ecological receptors
- Tier 3 seeks to attribute the harm to the chemical contamination

Tier 1 is preceded by a desk study to collate information about the site and the nature of the contamination to assess whether pollutant linkages are feasible. The framework presents ten steps for ecological desk studies and development of a conceptual model as follows.

1. Establish Regulatory Context
2. Collate and Assess Documentary Information
3. Summarise Documentary Information
4. Identify Contaminants of Potential Concern
5. Identify Likely Fate Transport of Contaminants
6. Identify Potential Receptors of Concern
7. Identify Potential Pathways of Concern
8. Create a Conceptual Model
9. Identify Assessment and Measurement Endpoints
10. Identify Gaps and Uncertainties

The information in a standard PRA report covers Steps 1 to 4 inclusive. Step 5 considers fate and transport of contaminants and it should be noted that our standard report adopts a simplified approach considering only transport mechanisms. A simplified approach has also been adopted in respect of Steps 6 and 7 receptors (a detailed review of the ecological attributes has not been undertaken) and pathways (a food chain assessment has not been undertaken). Step 9 is outside the scope of our standard PRA report.

It should be noted that the PRA report will present an assessment for ecological systems (where identified as a receptor for a land contamination assessment) considering the viability of the mode of transport given the site-specific circumstances and not specific pathways. The PRA may conclude that the risk to potential ecological receptors is inconclusive.

4.4 Note regarding controlled waters

Controlled waters are rivers, estuaries, coastal waters, lakes and groundwaters, but not perched waters.

The EU Water Framework Directive (WFD) 2000/60/EC provides for the protection of sub-surface, surface, coastal and territorial waters through a framework of river basin management. The EU Updated Water Framework Standards Directive 2014/101/EU amended the EU WFD to update the international standards therein; it entered into force on 20 November 2014 with the requirements for its provisions to be transposed in Member State law by 20 May 2016. Other EU Directives in the European water management framework include:

- the EU Priority Substances Directive 2013/39/EU;
- EU Groundwater Pollutants Threshold Values Directive 2014/80/EU amending the EU Groundwater Directive 2006/118/EC; and
- EU Biological Monitoring Directive 2014/101/EU.

The Ground Water Daughter Directive (GWDD) was enacted by the Groundwater Regulations (2009), which were subsumed by the Environmental Permitting Regulations (2010) which provide essential clarification including on the four objectives specifically for groundwater quality in the WFD: -

Achieve ‘Good’ groundwater chemical status by 2015, commonly referred to as ‘status objective’;
Achieve Drinking Water Protected Area Objectives;
Implement measures to reverse any significant and sustained upward trend in groundwater quality, referred to as ‘trend objective’; and

Prevent or limit the inputs of pollutants into groundwater, commonly referred to as ‘prevent or limit’ objectives

The Water Act 2003 (Commencement No.11) Order 2012 amends the test for 'contaminated land' which relates to water pollution so that pollution of controlled waters must now be "significant" to meet the definition of contaminated land.

The Water Framework Directive (WFD) requires the preparation, implementation and review of River Basin Management Plans (RBMP) on a six-year cycle. River basins are made up of lakes, rivers, groundwaters, estuaries and coastal waters, together with the land they drain. River Basin Districts (RBD) and the WFD Waterbodies that they comprise are important spatial management units, regularly used in catchment management studies. River Basin Management Plans (RBMP) have been developed for the 11 River Basin Districts in England and Wales.

These were released by Defra in 2009 (Defra 2009) and updated in 2015.

These RBMP's establish the current status of waters within the catchments of the respective Districts and the current status of adjoining waters identified. As part of a Tier 2 risk assessment water quality data is screened against the WFD assessment criteria. Comparison with the RBMP's current status of waters for the catchment under consideration would form part of a Tier 3 assessment.

5 RISK ESTIMATION

Risk estimation classifies what degree of harm might result to a receptor (defined as consequence) and how likely it is that such harm might arise (probability).
At Tier 1 the consequence classification is generated by multiplying the hazard classification score and the receptor sensitivity score. This approach follows that presented in the republished R&D 66 (NHBC 2008).

The criteria for classifying probability are set out in **Table 4** and have been taken directly from Table 6.4 CIRIA C552 (CIRIA 2001). Probability considers the integrity of the exposure pathway.

The consequence classifications detailed in **Table 5** have been adapted from Table 6.3 presented in C552 and R&D 66 (Annex 4 Table A4.3).

The Tier 1 risk classification is estimated for each pollutant linkage using the matrix given in **Table 6** which is taken directly from C552 (Table 6.5).

Subsequent Tiers refine the CM through retention or elimination of potential hazards and pollutant linkages.

6 RISK EVALUATION

Evaluation criteria are the parameters used to judge whether harm or pollution needs further assessment or is unacceptable. The evaluation criteria used will depend on:

- the reasons for doing the RA and the regulatory context such as Part 2A or planning;
- the CM and pollutant linkages present;
- any criteria set by regulators;
- any advisory requirements such as from Public Health England;
- the degree of confidence and precaution required;
- the level of confidence required to judge whether a risk is unacceptable;
- how you've used or developed more detailed assessment criteria in the later tiers of RA;
- the availability of robust scientific data;
- how much is known - for example, about the pathway mechanism and how the contaminants affect receptors; and
- any practical reasons such as being able to measure or predict against the criteria.

In order to put the Tier 1 risk classification into context the likely actions are described in **Table 7** which is taken directly from Table 6.6 of C552 (CIRIA 2001).

REFERENCES

BSI 2017 BS 10175:2011+A2:2017 Investigation of potentially contaminated sites - Code of Practice

BSI 2019 BS 8485:2015+A1:2019 Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings

CIRIA 2001: Contaminated land risk assessment – a guide to good practice C552.

CIRIA 2008: Assessing risks posed by hazardous ground gases to buildings C655

CL: AIRE/CIEH 2008 Guidance on Comparing Soil Contamination Data with a Critical Concentration. Published by Contaminated Land: Applications in Real Environments (CL: AIRE) and the Chartered Institute of Environmental Health (CIEH)

CL: AIRE 2013 SP1010 – Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination. Final Project Report published by Contaminated Land: Applications in Real Environments (CL: AIRE) 20th December 2013

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DETR 2000 Methodology for Multi Modal Studies. Volume 2 Section 4. The Environmental Objective.

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DEFRA, 2006 The Contaminated Land (England) Regulations 2006.

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DEFRA, 2013 Environmental Damage (Prevention and Remediation) Regulations 2009: Guidance for England and Wales

Defra '2009 Water for Life and Livelihoods. River Basin Management Plan. (11 Districts: Anglia, Dee, Humber, Northumbria, Northwest, Severn, Solway and Tweed, Southeast, Thames, Western Wales) December 2009

EA 2004: Contaminated Land Research (CLR) Report 11: The Model Procedures for the Management of Land Contamination CRL 11 by the Environment Agency (EA).

EA 2008 Ecological Risk Assessment Science Report Series SC070009 published by the Environment Agency (EA).

EA 2017 New groundwater vulnerability mapping methodology in England and Wales Report – SC040016/R Environment Agency (EA) September 2017

JNCC 1993 Handbook for Phase 1 Habitat Survey – A Technical for Environmental Audit prepared by the Joint Nature Conservancy Council (JNCC)

NHBC/EA/CIEH 2008: R&D Publication 66 Guidance for the safe development of housing on land affected by contamination.

National Planning Policy Framework (February 2019 revised), published by the Ministry of Housing, Communities and Local Government (MHCLG) at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1005759/NPPF_July_2021.pdf

Stantec Methodology for Assessment of Land Contamination (England)

Table 1: Criteria for Classifying Hazards / Potential for Generating Contamination

Classification/Score	Potential for generating contamination/gas based on land use
Very Low 1	Land Use: Residential, retail or office use, agriculture Contamination: Limited. Gas generation potential: Soils with low organic content
Low 2	Land Use: Recent small scale industrial and light industry Contamination: locally slightly elevated concentrations. Gas generation potential: Soils with high organic content (limited thickness)
Moderate 3	Land Use: Railway yards, collieries, scrap yards, engineering works. Contamination: Possible widespread slightly elevated concentrations and locally elevated concentrations. Gas generation potential: Dock silt and substantial thickness of organic alluvium/peat
High 4	Land Use: Heavy industry, non-hazardous landfills. Contamination: Possible widespread elevated concentrations. Gas generation potential: Shallow mine workings Pre 1960s landfill
Very High 5	Land Use: Hazardous waste landfills, gas works, chemical works, Contamination: Likely widespread elevated concentrations. Gas generation potential: Landfill post 1960

"Greenfield" is land which has not been developed and there has been no use of agrochemicals

Table 2: Criteria for Classifying Receptor Sensitivity/Value

Classification	Definition
Very Low 1	Receptor of limited importance • Groundwater: Unproductive strata (Strata with negligible significance for water supply or river baseflow) (previously Non-aquifer), Secondary B (water-bearing parts of non-aquifers), Secondary undifferentiated (previously minor or non-aquifer, but information insufficient to classify as secondary A or B) • Surface water: WFD Surface Water status Bad • Ecology: No local designation • Buildings: Replaceable • Human health: Unoccupied/limited access
Low 2	Receptor of local or county importance with potential for replacement • Groundwater: Secondary A aquifer • Surface water: WFD Surface Water status Poor • Ecology: local habitat resources • Buildings: Local value • Human health: Minimum score 4 where human health identified as potential receptor
Moderate 3	Receptor of local or county importance with potential for replacement • Groundwater: Principal aquifer • Surface water: WFD Surface Water status Moderate • Ecology: County wildlife sites, Areas of Outstanding Natural Beauty (AONB) • Buildings: Area of Historic Character • Human health: Minimum score 4 where human health identified as potential receptor
High 4	Receptor of county or regional importance with limited potential for replacement • Groundwater: Source Protection Zone 2 or 3 • Surface water: WFD Surface Water status Good • Ecology: SSSI, National or Marine Nature Reserve (NNR or MNR) • Buildings: Conservation Area • Human health: Minimum score 4 where human health identified as potential receptor
Very High 5	Receptor of national or international importance • Groundwater: Source Protection Zone (SPZ) 1 • Surface water: WFD Surface Water status High • Ecology: Special Areas of Conservation (SAC and candidates), Special Protection Areas (SPA and potentials) or wetlands of international importance (RAMSAR) • Buildings: World Heritage site • Human health: Residential, open spaces and uses where children are present

Table 3: Exposure Pathway and Modes of Transport

Receptor	Pathway	Mode of transport
Human health	Ingestion	Fruit or vegetable leaf or roots
		Contaminated water
		Soil/dust indoors
		Soil/dust outdoors
	Inhalation	Particles (dust / soil) – outdoor
		Particles (dust / soil) - indoor
		Vapours – outdoor - migration via natural or anthropogenic pathways
		Vapours - indoor - migration via natural or anthropogenic pathways
	Dermal absorption	Direct contact with soil
		Direct contact with waters (swimming / showering)
		Irradiation
Groundwater	Leaching	Gravity / permeation
	Migration	Natural – groundwater as pathway Anthropogenic (e.g. boreholes, culverts, pipelines etc.)
Surface Water	Direct	Runoff or discharges from pipes
	Indirect	Recharge from groundwater
	Indirect	Deposition of windblown dust
Buildings	Direct contact	Sulphate attack on concrete, hydrocarbon corrosion of plastics
	Gas ingress	Migration via natural or anthropogenic paths
Ecological systems	See Notes	Runoff/discharge to surface water body
	See Notes	Windblown dust
	See Notes	Groundwater migration
	See Notes	At point of contaminant source
Animal and crop	Direct	Windblown or flood deposited particles / dust / sediments
	Indirect	Plants via root up take or irrigation. Animals through watering
	Inhalation	By livestock / fish - gas / vapour / particulates / dust
	Ingestion	Consumption of vegetation / water / soil by animals

Table 4: Classification of Probability

Classification	Definition
High likelihood	There is a pollution linkage and an event either appears very likely in the short-term and almost inevitable over the long-term, or there is already evidence at the receptor of harm / pollution.
Likely	There is a pollution linkage and all the elements are present and in the right place, which means that it is probable that an event will occur. Circumstances are such that an event is not inevitable, but possible in the short-term and likely over the long-term.
Low likelihood	There is a pollution linkage and circumstances are possible under which an event could occur. However, it is by no means certain that even over a longer period such event would take place, and is less likely in the shorter-term.
Unlikely	There is a pollution linkage, but circumstances are such that it is improbable that an event would occur even in the very long-term.

Table 5: Classification of Consequence (score = magnitude of hazard and sensitivity of receptor)

Classification / Score	Examples
Severe **17-25** **(3 out of 25 outcomes)**	Human health effect - exposure likely to result in "significant harm" as defined in the Defra (2012) Part 2A Statutory Guidance [1]. Controlled water effect - short-term risk of pollution (note: Water Resources Act contains no scope for considering significance of pollution) of sensitive water resource. Equivalent to EA Category 1 incident (persistent and/or extensive effects on water quality leading to closure of potable abstraction point or loss of amenity, agriculture or commercial value. Major fish kill. Ecological effect - short-term exposure likely to result in a substantial adverse effect. Catastrophic damage to crops, buildings or property
Medium **10-16** **(7 out of 25 outcomes)**	Human health effect - exposure could result in "significant harm" [1]. Controlled water effect - equivalent to EA Category 2 incident requiring notification of abstractor Ecological effect - short-term exposure may result in a substantial adverse effect. Damage to crops, buildings or property
Mild **5-9** **(7 out of 25 outcomes)**	Human health effect - exposure may result in "significant harm" [1]. Controlled water effect - equivalent to EA Category 3 incident (short lived and/or minimal effects on water quality). Ecological effect - unlikely to result in a substantial adverse effect. Minor damage to crops, buildings or property. Damage to building rendering it unsafe to occupy (for example foundation damage resulting in instability).
Minor **1-4** **(8 out of 25 outcomes)**	No measurable effect on humans. Protective equipment is not required during site works. Equivalent to insubstantial pollution incident with no observed effect on water quality or ecosystems. Repairable effects to crops, buildings or property. The loss of plants in a landscaping scheme. Discolouration of concrete.

[1] Significant harm includes death, disease, serious injury, genetic mutation, birth defects or impairment of reproductive function. The local authority may also consider other health effects to constitute significant harm such as physical injury; gastrointestinal disturbances; respiratory tract effects; cardio-vascular effects; central nervous system effects; skin ailments; effects on organs such as the liver or kidneys; or a wide range of other health impacts. Whether or not these would constitute significant harm would depend on the seriousness of harm including impact on health, quality of life and scale of impact.

Table 6: Classification of Risk (Combination of Consequence Table 5 and Probability Table 4)

	Consequence			
Probability	***Severe***	***Medium***	***Mild***	***Minor***
High likelihood	Very high	High	Moderate	Low
Likely	High	Moderate	Moderate/	Low
Low likelihood	Moderate	Moderate	Low	Very low
Unlikely	Low	Low	Very low	Very low

Table 7: Description of Risks and Likely Action Required

Risk Classification	Description
Very high risk	There is a high probability that severe harm could arise to a designated receptor from an identified hazard, OR, there is evidence that severe harm to a designated receptor is currently happening. This risk, if realised, is likely to result in a substantial liability. Urgent investigation (if not undertaken already) and remediation is likely to be required in the short term.
High risk	Harm is likely to arise to a designated receptor from an identified hazard. Realisation of the risk is likely to present a substantial liability. Urgent investigation (if not undertaken already) is required and remedial works may be necessary in the short-term and are likely over the longer-term.
Moderate risk	It is possible that harm could arise to a designated receptor from an identified hazard. However, it is either relatively unlikely that any such harm would be severe, or if any harm were to occur it is more likely that the harm would be relatively mild. Investigation (if not already undertaken) is normally required to clarify the risk and to determine the potential liability. Some remedial works may be required in the longer-term.
Low risk	It is possible that harm could arise to a designated receptor from an identified hazard, but it is likely that this harm, if realised, would at worst normally be mild.
Very low risk	There is a low possibility that harm could arise to a receptor. In the event of such harm being realised it is not likely to be severe.

1 INTRODUCTION

The aim of this document is to present an explanation for the selection of the evaluation criteria routinely used by Stantec UK Ltd when undertaking a land contamination Tier 2 Generic Quantitative Risk Assessment (GQRA).

A GQRA uses published criteria to screen the site-specific contamination testing data and identify potential hazards to specific receptors. Generic criteria are typically conservative in derivation and exceedance does not indicate that a site is statutorily contaminated and/or unsuitable for use in the planning context. These criteria are used to identify situations where further assessment and/or action may be required. This document is divided into general introductory text and sections on soils, waters and gases.

2 GENERAL NOTES

This document should be read in conjunction with another entitled "Stantec Methodology for Assessment of Land Contamination" which summarises the legislative regime and our approach to ground contamination and risk assessment.

Any Stantec interpretation of contamination test results is based on a scientific and engineering appraisal. The perceptions of, for example, banks, insurers, lay people etc are not taken into account.

Any tables included in this document are produced for ease of reference to the criteria, they do not in any way replace the documents of origin (which are fully referenced) and which should be read to ensure appropriate use and interpretation of the data.

Generic criteria provide an aid to decision-making, but they do not replace the need for sound professional judgement in risk assessment (EA, 2006). The criteria are based on numerous and complex assumptions. The appropriateness of these assumptions in a site-specific context requires confirmation on a project by project basis. Our interpretative report will comment on the appropriateness of the routine criteria for project objectives or ground conditions. In some cases the published criteria whilst typically conservative may in some circumstances not be suitable for the site being assessed, either because they do not address the identified pollutant linkages or because they may not be sufficiently precautionary in the context of the site. Under these circumstances it may be necessary to recommend deriving site-specific assessment criteria. Any deviation from the routine criteria and/or selection of criteria for parameters not covered in this document will be described in the report text.

3 CRITERIA FOR EVALUATING SOIL RESULTS

3.1 Potential Harm to Human Health

The criteria used by Stantec UK Ltd to assess the potential for harm to human health are:-

- Category 4 Screening Levels (C4SLs) (Phase 1 substances DEFRA, 2014 and Phase 2 substances CLAIRE, 2021).
- Suitable 4 Use Levels (S4ULs) (Nathanail *et al*, 2015).
- CL:AIRE/EIC/AGS Generic Assessment Criteria (GAC) (CL:AIRE, 2010).
- Soil Guideline Values (SGVs) (EA, 2009a).

These criteria have been generated using the Contaminated Land Exposure Assessment model (CLEA) and supporting technical guidance (EA, 2009b, 2009c, 2009d, 2009e). The CLEA model uses generic assumptions about the fate and transport of chemicals in the environment and a generic conceptual model for site conditions and human behaviour to estimate child and adult exposures to soil contaminants for those potentially living, working, and/or playing on contaminated sites over long time periods (EA, 2009c).

The S4ULs, SGVs and GACs are all based on use of minimal/tolerable risk Health Criteria Values (HCVs) as the toxicological benchmark whereas the C4SL are based on use of a "low level of toxicological concern" (LLTC) as the toxicological benchmark. The LLTC represents a slightly higher level of risk than the HCV.

An update to the software (1.071) was published on 04/09/2015 (the handbook (EA 2009f) referring to version 1.05 is still valid). The update includes the library data sets from the DEFRA research project SP1010 (Development of Category 4 Screening Levels for assessment of land affected by contamination).

The CLEA model uses ten exposure pathways (Ingestion (outdoor soil, indoor dust, homegrown vegetables and soil attached to homegrown vegetables), Dermal Contact (outdoor soil and indoor dust) and Inhalation (outdoor dust, indoor dust, outdoor vapours and indoor vapours)). There are exposure pathways not included in the CLEA model such as the permeation of organics into plastic water supply pipes.

The presence and/or significance of each of the potential exposure pathways is dependent on the land use being considered. The model uses standard land use scenarios as follows:-

Residential – habitation of a dwelling up to two storeys high with various default material and design parameters, access to either private or nearby community open space with soil track back to form indoor dust. Assumes ingestion of homegrown produce.

Allotments – the model has default parameters for use and consumption of vegetables but not animals or their products (eggs).

Industrial/Commercial – assumes office or light physical work in a permanent three storey structure with breaks taken outside and that the site is NOT covered in hardstanding.

Public Open Space – two public open space (POS) scenarios are considered: POS_{resi} is shared communal space within a residential development where tracking back of soil into the home is assumed to occur. POS_{park} is intended for a public park sufficiently distant from housing (i.e. not adjacent to housing) such that tracking back of soil into the home is negligible. Note that the POS assessment criteria may not be appropriate for assessing sports fields.

The assessment criteria generated using CLEA can be used as a conservative starting point for evaluating long-term risks to human health from chemicals in soil.

It is important to note that the model does not assess all the potential exposure scenarios, for example risk to workers in excavations (short term exposure) or diffusion of contaminants through drinking water pipes.

Recent guidance (DEFRA 2012) introduces a four stage classification system where Category 1 sites are clearly contaminated land and Category 4 sites are definitely not contaminated land as defined by EPA 1990. Outside of these categories further specific risk assessment is required to determine if the site should fall into Category 2 (contaminated land) or Category 3 (not contaminated land). Category 4 screening values are considered to be more pragmatic than the current published SGV/GAC criteria but still strongly precautionary with the aim of allowing rapid identification of sites where the risk is above minimal but still low/acceptable.

Category 4 Screening Levels (C4SLs)

At the end of 2013, technical guidance in support of DEFRA's revised Statutory Guidance (SG) was published and then revised in 2014 (CL:AIRE 2014) which provided:

- A methodology for deriving C4SLs for the standard land-uses and two new public open space scenarios using the updated assumptions relating to the modelling of human exposure to soil contaminants; and
- A demonstration of the methodology, via the derivation of C4SLs for six substances – arsenic, benzene, benzo(a)pyrene, cadmium, chromium (VI) and lead.

Following issue of an Erratum in December 2014, a Policy Companion Document was published (DEFRA 2014).

A letter from Lord de Mauley dated 3rd September 2014 provides more explicit direction to local authorities on the use of the C4SL in a planning context. The letter identifies four key points:

1) that the screening values were developed expressly with the planning regime in mind

2) their use is recommended in DCLG's planning guidance

3) soil concentrations below a C4SL limit are considered to be 'definitely not contaminated' under Part IIA of the 1990 Environmental Protection Act and pose at most a 'low level of toxicological concern' and,

4) exceedance of a C4SL screening value does not mean that land is definitely contaminated land, just that further investigation may be warranted.

Stantec use the C4SLs as the Tier 2 soil screening criteria protective of human health for substances with C4SL available. Table 1 summarises the C4SL for each of the published substances.

Note that, with the exception of benzene, the DEFRA published C4SL are not dependent on soil organic matter content (SOM) ("*Given that BaP is non volatile and that empirical soil to plant concentration factors have been used, soil organic matter content has a negligible influence on the C4SLs for this chemical"*). The DEFRA published C4SL for benzene is based on an SOM of 6%. Stantec has used the CLEA model (v1.071) to derive C4SL for benzene for 1% and 2.5% SOM which are also shown in Table 1.

Note that an industry led project to derive C4SL for a further 20 substances has commenced (CL:AIRE, 2018). The project is being project managed by CL:AIRE and is funded by the Soil and Groundwater Technology Association (SAGTA), the Society of Brownfield Briefing (SoBRA) and others. A dedicated steering group, made up of representatives from SAGTA, DEFRA, Welsh Government, Public Health England, Environment Agency, Natural Resources Wales, Food Standards Agency, Homes England and further Land Forum representatives, has been set up to oversee the project. The new C4SL will be added to this document as they are published.

Suitable 4 Use Levels (S4ULs)

In July 2009, Generic Assessment Criteria (GACs) for 82 substances were published (LQM and CIEH, 2009) using the then current version of the CLEA software v1.04 and replaced those generated in 2006 using the original version of the model CLEA UK *beta*. In 2015 S4ULs were published by LQM/CIEH (Nathanail *et al*, 2015) to replace the second edition GACs. Table 2 summarises the S4ULs which are reproduced with permission; Publication Number S4UL3202.

Soil Guideline Values (SGVs) and Generic Assessment Criteria (GAC)

In 2009, Soil Guideline Values (SGVs) were published by the Environment Agency for arsenic, cadmium, mercury, nickel, selenium, benzene, toluene, ethyl benzene, xylenes, phenol and dioxins, furans and dioxin-like PCBs. These were derived using the CLEA model for residential, allotments and commercial land-uses.

These SGVs have now largely been superseded by the C4SLs and the S4ULs, with the exception of the SGVs for dioxins, furans and dioxin-like PCBs which are shown in Table 3.

In January 2010, Generic Assessment Criteria (GAC) derived using CLEA were published by CL:AIRE for 35 substances. These GAC are listed in Table 4.

Note that the SGVs for dioxins, furans and dioxin like PCBs and CL:AIRE GAC were derived using an older version of CLEA (v1.06) than used to derive the S4UL and C4SL (v1.07). This older version used slightly more conservative values for some exposure parameters and therefore the derived SGVs/GAC are still considered suitably precautionary for use as screening criteria.

Note on Mercury, Chromium and Arsenic

The analytical testing routinely undertaken by Stantec determines total concentration, however, the toxicity depends on the form of the contaminant.

If a source of Mercury, Chromium or Arsenic is identified or the total concentration exceeds the relevant worst case speciated criteria it will be desirable/necessary to undertake additional speciated testing and further assessment.

Note on Polycyclic Aromatic Hydrocarbons

Polycyclic Aromatic Hydrocarbons (PAHs) are a family of hundreds of different congeners whose chemical structures contain two or more fused aromatic rings. Whilst it is recognised that there is an ongoing debate on the most appropriate method to assess health effects of PAH mixtures, in 2010 the Health Protection Agency recommended the use of benzo[a]pyrene (BaP) as a surrogate marker approach in the assessment of carcinogenic risks posed by PAHs in soils (HPA, 2010).

In most cases, BaP is chosen as the surrogate marker (SM) due to its ubiquitous nature and the vast amount of data available and has been used by various authoritative bodies to assess the carcinogenic risk of PAHs in food. The SM approach estimates the carcinogenic toxicity of a mixture of PAHs in an environmental matrix by using toxicity data for a PAH mixture for which the composition is known.

Exposure to the SM is assumed to represent exposure to all PAHs in that matrix therefore the toxicity of the SM represents the toxicity of the mixture. The SM approach relies on a number of assumptions (HPA, 2010).

- The SM (BaP) must be present in all the samples.
- The profile of the different PAH relative to BaP should be similar in all samples.
- The PAH profile in the soil samples should be sufficiently similar to that used in the pivotal toxicity study on which HBGV was based i.e. the Culp study (Culp et al. (1998)).

In order to justify the use of a surrogate marker assessment criterion (C4SL for benzo(a)pyrene and S4UL coal tar) the LQM PAH Profiling Tool is used by Stantec to assess the similarity of the PAH profile in a soil sample to that of the toxicity study. The spreadsheet calculates the relative proportions of the genotoxic PAHs and plots them relative to the composition of the two coal mixtures used by Culp et al. Provided that the relative proportions are within an order of magnitude of those from the Culp Study (as suggested by HPA) Stantec will use the C4SL for benzo(a)pyrene as a surrogate marker for the carcinogenic PAHs, i.e. benzo(a)pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(ah)anthracene, indeno(123-cd)pyrene and benzo(ghi)perylene. For projects where this approach is appropriate the results will be assessed using the Coal Tar criterion (BAP C4SL) and the criteria for non-carcinogenic PAHs (S4ULs), i.e. naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene and pyrene.

Note on Total Petroleum Hydrocarbons

The S4UL for Total Petroleum Hydrocarbon (TPH) fractions are based on ‘threshold’ health effects. In accordance with Environment Agency guidance (EA, 2005) and the S4UL report (Nathanail *et al*, 2015) the potential for additivity of toxicological effects between fractions should be considered. Practically, to address this issue the hazard quotient (HQ) for each fraction should be calculated by dividing the measured concentration of the fraction by the GAC. The HQs are then added to form a hazard index (HI) for that sample. An HI greater than 1 indicates an exceedance.

Note on Dioxins, Furans and Dioxin-like PCBs

The SGVs for dioxins, furans and dioxin-like PCBs are based on an assumed congener profile for urban soils. The total measured concentration of dioxin, furan and dioxin-like PCB congeners listed in the SGV report (EA, 2009a) should be compared with the SGVs to make an initial assessment of risk. A more accurate assessment can be made using the Environment Agency's site specific worksheet for dioxins, furans and dioxin like PCBs available from [redacted].

Note on Asbestos

Asbestos in soil and made ground is currently under review by a number of bodies. There are no current published guidance values for asbestos in soil other than the waste classification values given in the EA's Technical Guidance WM3, Hazardous Waste – Interpretation of the definition and classification of hazard waste (EA, 2015). This guidance is only appropriate for soils that are being discarded as waste.

Testing for asbestos will be carried out on selected samples of made ground encountered during investigation, initially samples will be subjected to an asbestos screen and, if asbestos is found to be present, subjected to quantification depending on the project specific requirements. The reader is directed to the report text for guidance on the approach adopted in respect to any asbestos found to be present.

Further guidance is also available in publication C733, Asbestos in soil and made ground: a guide to understanding and managing risks (CIRIA 2014).

Note on Soil Saturation Concentration

The soil saturation concentration is the concentration of an organic constituent in soil at which either the pore water or soil vapour has theoretically become saturated with the substance, i.e. the substance concentration has reached its maximum aqueous solubility or vapour pressure. The soil saturation concentration is related to the properties of the substance as well as the properties of the soil (including soil organic matter content).

The soil saturation concentrations are shown in Table 2 in brackets where exceeded by the assessment criteria and in Table 4 for all substances. Measured concentrations in excess of the soil saturation concentration have various potential implications as discussed below.

Firstly, where measured concentrations exceed the soil saturation concentration, the risk from vapour inhalation and/or consumption of produce may be limited. The CLEA model calculates the soil saturation concentration but it does not limit exposure where this concentration is exceeded. This adds an additional level of conservatism for CLEA derived assessment criteria where these exceed the calculated soil saturation concentration. Secondly, the soil saturation concentration is sometimes used to flag the potential presence of non-aqueous phase liquid (NAPL, a.k.a. free phase) in soil. The presence of NAPL is an important consideration in the Tier 2 assessment because, where present, the risks from NAPL may need to be considered separately. Theoretically, where a measured concentration exceeds the soil saturation concentration NAPL could be present. However, using theoretical saturation values is not always reliable for the following reasons: The soil saturation concentration is based on the aqueous solubility and vapour pressure of a pure substance and not a mixture, of which NAPLs are often comprised; and

The soil saturation concentration does not account for the sorption capacity of the soil. As a result, exceedance of the soil saturation concentration does not necessarily imply that NAPL is present. This is particularly the case for longer chain hydrocarbons such as PAHs which have low solubility and vapour pressure and hence a low soil saturation concentration but that are strongly sorbed to soil.

The measured concentrations will be compared to the soil saturation concentrations shown in Tables 2 and 4. Where exceeded Stantec will use additional lines of evidence (such as visual evidence and concentration of total TPH) to determine whether or not NAPL is likely to be present. If the presence of NAPL is deemed plausible the implications will be considered in the risk assessment.

3.2 Potential Harm to the Built Environment

Land contamination can pose risks to buildings, building materials and services (BBM&S) in a number of ways. Volatile contaminants and gases can accumulate and cause explosion or fire. Foundations and buried services can be damaged by corrosive substances and contaminants such as steel slags can create unstable ground conditions through expansion causing structural damage.

Stantec use the following primary guidance to assess the significance of soil chemistry with respect to its potential to harm the built environment.

i) Approved Document C - Site Preparation and Resistance to Contaminants and Moisture. (DCLG, 2013);
ii) Concrete in aggressive ground SD1 (BRE 2005);
iii) Guidance for the selection of water supply pipes to be used in brownfield sites (UK WIR 2011);

iv) Protocols published by agreement between Water UK and the Home Builders Federation providing supplementary guidance which includes the Risk Assessment for Water Pipes (the 'RA') (Water UK 2014).
v) Performance of Building Materials in Contaminated Land report BR255 (BRE 1994).
vi) Risks of Contaminated Land to Buildings, Building Materials and Services. A Literature Review - Technical Report P331 (EA, 2000).
vii) Guidance on assessing and managing risks to buildings from land contamination - Technical Report P5 035/TR/01 (EA, 2001).

3.3 Potential to Harm Ecosystems, Animals, Crops etc

The criteria routinely used by Stantec as Tier 2 screening values to assess the potential of soil chemistry to harm ecosystems are taken from the following guidance and are summarised in Table 5.

i) Derivation and Use of Soil Screening Values for assessing ecological risks (EA, 2017a);
ii) The Restoration and Aftercare of Metalliferous Mining Sites for Pasture and Grazing (ICRCL 70/90, 1990);
iii) Sewage sludge on farmland: code of practice for England, Wales and Northern Ireland (DEFRA, 2018); and
iv) BS 3882:2015 Specification for topsoil and requirements for use (BSI, 2015).

Unless stated in the report the assessment is solely for phytotoxic parameters and additional assessment is required to determine suitability as a growing medium.

4 CRITERIA FOR EVALUATING LIQUID RESULTS

4.1 Potential Harm to Human Health via Ingestion

The Tier 2 water screening values routinely adopted by Stantec for assessing the potential for harm to human health via ingestion (presented as Table 6) are taken from The Water Supply (Water Quality) Regulations (S.I. 2018/647) unless otherwise indicated.

It should be noted that some of the prescribed concentrations listed in the Water Supply Regulations have been set for reasons other than their potential to cause harm to human health. The concentrations of iron and manganese are controlled because they may taint potable water with an undesirable taste, odour or colour or may potentially deposit precipitates in water supply pipes.

4.2 Potential Harm to Human Health via Inhalation of Vapours

The Tier 2 water screening values adopted by Stantec for assessing the potential for chronic human health risk from the inhalation of vapours from volatile contaminants in groundwater are presented in Table 7. These generic assessment criteria have been taken from a report published by the Society of Brownfield Risk Assessment (SoBRA) (SoBRA, 2017). The methodology adopted in their generation is considered compatible with the UK approach to deriving GAC and adopts a precautionary approach. As with all published GAC the suitability for use on the site being assessed has to be decided by the assessor based on a thorough understanding of the methodology and assumptions used in their derivation. Note, that the SoBRA groundwater vapour GAC are not intended for assessing risks to ground workers from short-term exposure.

Note that Table 7 shows the theoretical maximum aqueous solubility for each contaminant and indicates the GAC that exceed solubility. Measured concentrations in excess of solubility may be an indication that NAPL is present. As for the assessment of soils, if the presence of NAPL is deemed plausible the implications will be considered in the risk assessment.

4.3 Potential to Harm Controlled Waters

When assessing ground condition data and the potential to harm Controlled Waters Stantec uses the approach presented in the groundwater protection position statements published 14.03.17 (EA, 2017b) which describe the Environment Agency's approach to managing and protecting groundwater. They update and replace Groundwater Protection: principles and practice (GP3). Controlled Waters are rivers, estuaries, coastal waters, lakes and groundwaters. Water in the unsaturated zone is not groundwater but does come within the scope of the term "ground waters" as used and defined in the Water Resources Act 1991. It will continue to be a technical decision for the Environment Agency to determine what is groundwater in certain circumstances for the purposes of the Regulations. As discussed in our Methodology for Assessment of Land Contamination perched water is not considered a receptor in Stantec assessments.

The EU Water Framework Directive (WFD) 2000/60/EC provides for the protection of sub-surface, surface, coastal and territorial waters through a framework of river basin management.

The EU Updated Water Framework Standards Directive 2014/101/EU amended the EU WFD to update the international standards therein; it entered into force on 20 November 2014 with the requirement for its provisions to be transposed in Member State law by 20 May 2016.

Member States are required under the EU WFD to update their river basin management plans every six years. The first river basin management plans for England and Wales, Scotland and Northern Ireland were published in December 2009, and these were updated in 2015.

Other EU Directives in the European water management framework include:

- the EU Priority Substances Directive 2013/39/EU;
- EU Groundwater Pollutants Threshold Values Directive 2014/80/EU amending the EU Groundwater Daughter Directive (GWDD) 2006/118/EC; and
- the EU Biological Monitoring Directive 2014/101/EU.

The Priority Substances Directive set environmental quality standards (EQS) for the substances in surface waters (river, lake, transitional and coastal) and confirmed their designation as priority or priority hazardous substances (PS), the latter being a subset of particular concern. Environmental Quality Standards for PS are determined at the European level and apply to all Member States. Member States identify and develop standards for 'Specific Pollutants'. Specific Pollutants (SP) are defined as substances that can have a harmful effect on biological quality.

The Water Framework Directive (Standards and Classification) Directions (England and Wales) (DEFRA, 2015) were issued to the Environment Agency as an associated document of the Water Environment (WFD) (England and Wales) Regulations 2015 (S.I. 2015/1623) and provide directions for the classification of surface water and groundwater bodies. Schedule 3 parts 2 and 3 relate to surface water standards for specific pollutants in fresh or salt water bodies and priority substances in inland (rivers, lakes and related modified/artificial bodies) or other surface waters respectively. Although Schedule 5 presents threshold values for groundwater the Direction specifically excludes their use as part of site-specific investigations.

Table 6 presents the criteria routinely used by Stantec as Tier 2 screening values. This table only presents a selection of the more commonly analysed parameters and the source documents should be consulted for other chemicals. For screening groundwater the criteria selected are the standards for surface water and/or human consumption as appropriate together with the following:-

For a **hazardous substance** Stantec adopts the approach that, if the concentration in a discharge to groundwater is less than the Minimum Reporting Value (MRV), the input is regarded as automatically meeting the Article 2 (b) 'de-minimus' requirement of exemption 6 (3) (b) of the GWDD. Stantec has selected hazardous substances from the latest list published by the Joint Agencies Groundwater Directive Advisory Group (JAGDAG, 2018). MRV is the lowest concentration of a substance that can be routinely determined with a known degree of confidence, and may not be equivalent to limit of detection. MRVs have been identified from DEFRA's guidance on Hazardous Substances to Groundwater: Minimum Reporting Values (DEFRA, 2017), and are shown in Table 6.

Note that for land contamination assessments, where hazardous substances have already entered groundwater, remediation targets would typically be based on achieving appropriate water quality standards (e.g. drinking water standard or EQS) at a compliance point rather than an MRV. For this reason, when assessing measured groundwater or soil leachate concentrations, the values for human consumption, fresh water and salt water shown in Table 6 (whichever is appropriate for the context of the site) will be used as the Tier 2 assessment criteria rather than MRV. For hazardous substances with no water quality standard the laboratory method detection limit will be used as the assessment criteria.

For **non-hazardous substances** the GWDD requires that inputs be limited to avoid deterioration. UKTAG guidance equates deterioration with pollution. Non-hazardous substances are all substances not classified as hazardous. For Stantec assessments the values for human consumption, fresh water and salt water shown in Table 6 (whichever is appropriate for the context of the site) are used as the assessment criteria for non-hazardous substances.

Note on Copper, Lead, Manganese, Nickel and Zinc

$EQS_{bioavailable}$ have been developed for UK Specific Pollutants copper, zinc and manganese and the EU priority substances lead and nickel. An EQS is the concentration of a chemical in the environment below which there is not expected to be an adverse effect on the specific endpoint being considered, e.g. the protection of aquatic life.

It is very difficult to measure the bioavailable concentration of a metal directly. The UK has developed simplified Metal Bioavailability Assessment Tool (M-BAT) for copper, zinc, nickel and manganese which uses local water chemistry data, specifically pH, dissolved organic carbon (DOC) (mg/L) and Calcium (Ca) (mg/L).

Where the recorded total dissolved concentration exceeds the screening criteria for these parameters ($EQS_{bioavailable}$) further assessment will be undertaken using the tools downloaded from [redacted]

The models calculate a risk characterisation ratio

(RCR) and where this is greater than 1 this indicates the bioavailable concentration is above the EQS and the parameter is then identified as a potential hazard. The report will discuss this identified hazard noting that the pH, calcium and, in particular, the dissolved organic carbon (DOC) in groundwater may be quite different to the receiving water (e.g. due to the presence to leaf litter or organic sediments dissolving in the water).

5 CRITERIA FOR EVALUATING GAS RESULTS

Stantec use the following primary guidance on gas monitoring methods and investigation, the assessment of risk posed by soil gases (including Volatile Organic Compounds (VOCs)) and mitigation measures/risk reduction during site development.

i) BS 8576:2013 – Guidance on Ground Gas Investigations: Permanent gases and Volatile Organic Compounds (VOCs) (BSI, 2013);
ii) TB18 Continuous Ground-Gas Monitoring and the Lines of Evidence Approach to Risk Assessment CL:AIRE Technical Bulletin TB18 (CL:AIRE 2019)
iii) RB17 A pragmatic approach to Ground Gas Risk Assessment. CL:AIRE Research Bulletin RB17 (Card et al, 2012);
iv) The VOCs Handbook. C682 (CIRIA, 2009).
v) Assessing risks posed by hazardous gases to buildings C665 (CIRIA, 2007);
vi) Guidance on evaluation of development proposals on sites where methane and carbon dioxide are present. (NHBC, 2007); and
vii) BS 8485:2015+A1:2019- Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings (BSI, 2019).

Gas and borehole flow data are used to obtain the gas screening value (GSV) for methane and carbon dioxide. The GSV is used to establish the characteristic situation and to make recommendations for gas protection measures for buildings if required.

Radon

Stantec use the following primary guidance to assess the significance of the radon content of soil gas.

i) Radon: guidance on protective measures for new dwellings. Report BR211 (BRE, 2015); and
ii) Indicative Atlas of Radon in England and Wales (HPA & BGS, 2007).

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Table 1: Category 4 Screening Levels (C4SL)

	Allotments	Residential (with home-grown produce)	Residential (without home-grown produce)	Commercial	Public Open Space 1	Public Open Space 2
Arsenic	49	37	40	640	79	170
Benzene - 1% SOM* - 2.5% SOM* - 6% SOM	 0.039 0.081 0.18	 0.20 0.41 0.87	 0.89 1.6 3.3	 27 50 98	 140 140 140	 190 210 230
Benzo(a)pyrene (as a surrogate marker for carcinogenic PAHs)	5.7	5.0	5.3	77	10	21
Cadmium	3.9	22	150	410	220	880
Chromium VI	170	21	21	49	21	250
Lead	80	200	310	2300	630	1300
Vinyl Chloride/ Chloroethene/ Chloroethylene, (CAS No. 75-01-4)	 0.0017 0.0031 0.0058	 0.0064 0.010 0.017	 0.015 0.019 0.029	 1.1 1.4 2.2	 7.8 7.8 7.8	 18 19 19
Trichloroethene / Trichloroethylene/ TCE or 'Trike' (CAS No. 79-01-06)	 0.032 0.072 0.16	 0.0093 0.020 0.043	 0.0097 0.020 0.045	 0.73 1.5 3.4	 76 78 79	 41 54 69
Tetrachloroethene/ Tetrachloroethylene/ Perchloroethylene, PCE or 'perc', (CAS No. 127-18-4)	 2.0 4.8 11.0	 0.31 0.70 1.60	 0.32 0.71 1.60	 24 55 130	 3,200 3,300 3,400	 1,400 1,900 2,500

Units mg/kg dry weight

Values taken from SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination – Policy Companion Document (Department for Environment, Food and Rural Affairs December 2014), unless stated otherwise
Public Open Space 1 – for grassed area adjacent to residential housing
Public Open Space 2 - Park Type Public Open Space Scenario
Based on a sandy loam as defined in SR3 (Environment Agency, 2009b)
Note that, with the exception of benzene, these C4SL are not SOM dependent
* - Stantec derived C4SL using CLEA v1.071

Table 2: Suitable 4 Use Levels (S4UL)

Determinand	Allotment	$R_{\underline{W}}$HP	$R_{\underline{WO}}$HP	Commercial/ Industrial	POSresi	POSpark
Metals						
Arsenic (**Inorganic**)[a, b, c]	43	37	40	640	79	170
Beryllium [a, b, d, e]	35	1.7	1.7	12	2.2	63
Boron [a, b, d]	45	290	11000	240000	21000	46000
Cadmium (**pH6-8**) [a, b, d, f]	1.9	11	85	190	120	560
Chromium (trivalent) [a, b, d, g]	18000	910	910	8600	1500	33000
Chromium (hexavalent) [a, b, c]	1.8[h]	6[i]	6[i]	33[i]	7.7[i]	220[i]
Copper [a, b, c]	520	2400	7100	68000	12000	44000
Mercury (elemental) [a, b, c, j]	21	1.2	1.2	58[vap] (25.8)	16	30[vap] (25.8)
Mercury (inorganic) [a, b, c]	19	40	56	1100	120	240
Methylmercury [a, b, c]	6	11	15	320	40	68
Nickel [a, b, c]	53[k]	130[e]	180[e]	980[e]	230[e]	800[k]
Selenium [a, b, c]	88	250	430	12000	1100	1800
Vanadium [a, b, c, i, j]	91	410	1200	9000	2000	5000
Zinc [a, b, c]	620	3700	40000	730000	81000	170000
BTEX Compounds (SOM 1%/ 2.5%/ 6%)						
Benzene [a, b, l, m]	0.017/0.034/ 0.075	0.087/0.17/ 0.37	0.38/0.7/1.4	27 / 47 / 90	72 / 72 / 73	90 / 100 / 110
Toluene [a, b, l, m]	22 / 51 / 120	130 / 290 / 660	880[vap] (869) /1900/3900	56000[vap] (869) / 110000[vap] (1920)/ 180000[vap] (4360)	56000 / 56000 / 56000	87000[vap](869)/ 95000[vap](1920)/ 100000[vap](4360)
Ethylbenzene [a, b, l, m]	16 / 39 / 91	47 / 110 / 260	83 / 190 / 440	5700[vap] (518) / 13000[vap] (1220) / 27000[vap] (2840)	24000 / 24000 / 25000	17000[vap] (518) / 22000[vap](1220) / 27000[vap] (2840)
O – Xylene [a, b, l, m, n]	28 / 67 / 160	60 / 140 / 330	88 / 210 / 480	6600[sol] (478) / 15000[sol] (1120) / 33000[sol] (2620)	41000 / 42000 / 43000	17000[sol] (478) / 24000[sol] (1120) / 33000[sol] (2620)
M – Xylene [a, b, l, m, n]	31 / 74 / 170	59 / 140 / 320	82 / 190 / 450	6200[vap] (625) / 14000[vap] (1470) / 31000[vap] (3460)	41000 / 42000 / 43000	17000[vap] (625) / 24000[vap](1470) / 32000[vap] (3460)
P – Xylene [a, b, l, m, n]	29 / 69 / 160	56 / 130 / 310	79 / 180 / 430	5900[sol] (576) / 14000[sol] (1350) / 30000[sol] (3170)	41000 / 42000 / 43000	17000[sol] (576) / 23000[sol] (1350) / 31000[sol] (3170)

Determinand	Allotment	R_WHP	R_{WO}HP	Commercial/ Industrial	POSresi	POSpark
Total xylenes [t]	28 / 67 / 160	56 / 130 / 310	79 / 180 / 430	5900^{sol} (576) / 14000^{sol} (1350) / 30000^{sol} (3170)	41000 / 42000 / 43000	17000^{sol} (576) / 23000^{sol} (1350) / 31000^{sol} (3170)
Polycyclic Aromatic Hydrocarbons (SOM 1%/ 2.5%/ 6%) [a, b, l, p]						
Acenaphthene	34 / 85 / 200	210 / 510 / 1100	3000^{sol}(57.0)/ 4700^{sol} (141)/ 6000^{sol} (336)	84000^{sol} (57.0)/ 97000^{sol} (141)/ 100000	15000 / 15000 / 15000	29000/ 30000/ 30000
Acenaphthylene	28 / 69 / 160	170 / 420 / 920	2900^{sol}(86.1)/ 4600^{sol} (212)/ 6000^{sol} (506)	83000^{sol} (86.1)/ 97000^{sol} (212)/ 100000	15000 / 15000 / 15000	29000 / 30000 / 30000
Anthracene	380 / 950 / 2200	2400 / 5400 / 11000	31000^{sol}(1.17) /35000/ 37000	520000/ 540000/ 540000	74000 / 74000 / 74000	150000 / 150000 / 150000
Benzo(a)anthracene	2.9 / 6.5 / 13	7.2 / 11 / 13	11 / 14 / 15	170 / 170 / 180	29 / 29 / 29	49 / 56 / 62
Benzo(a)pyrene (Bap) [u]	0.97 / 2.0 / 3.5	2.2 / 2.7 / 3.0	3.2 / 3.2 / 3.2	35 / 35 / 36	5.7 / 5.7 / 5.7	11 / 12 / 13
Benzo(b)fluoranthene	0.99 / 2.1 / 3.9	2.6 / 3.3 / 3.7	3.9 / 4.0 / 4.0	44 / 44 / 45	7.1 / 7.2 / 7.2	13 / 15 / 16
Benzo(g,h,i)perylene	290 / 470 / 640	320 / 340 / 350	360 / 360 / 360	3900 / 4000 / 4000	640 / 640 / 640	1400 / 1500 / 1600
Benzo(k)fluoranthene	37 / 75 / 130	77 / 93 / 100	110 / 110 / 110	1200 / 1200 /1200	190 / 190 / 190	370 / 410 / 440
Chrysene	4.1 / 9.4 / 19	15 / 22 / 27	30 / 31 / 32	350 / 350 / 350	57 / 57 / 57	93 / 110 / 120
Dibenzo(ah)anthracene	0.14 / 0.27 / 0.43	0.24 / 0.28 / 0.3	0.31 / 0.32 / 0.32	3.5 / 3.6 / 3.6	0.57 / 0.57 / 0.58	1.1 / 1.3 / 1.4
Fluoranthene	52 / 130 / 290	280 / 560 / 890	1500 / 1600 / 1600	23000 / 23000 / 23000	3100 / 3100 / 3100	6300 / 6300 / 6400
Fluorene	27 / 67 / 160	170 / 400 / 860	2800^{sol} (30.9) /3800^{sol} (76.5) /4500^{sol} (183)	63000^{sol} (30.9) / 68000 / 71000	9900 / 9900 / 9900	20000 / 20000 / 20000
Indeno(1,2,3-cd)pyrene	9.5 / 21 / 39	27 / 36 / 41	45 / 46 / 46	500 / 510 / 510	82 / 82 / 82	150 / 170 / 180
Naphthalene [q]	4.1 / 10 / 24	2.3 / 5.6 / 13	2.3 / 5.6 / 13	190^{sol} (76.4) / 460^{sol} (183) / 1100^{sol} (432)	4900/ 4900/ 4900	1200^{sol} (76.4) / 1900^{sol} (183) / 3000
Phenanthrene	15 / 38 / 90	95 / 220 / 440	1300^{sol}(36.0) / 1500 / 1500	22000 / 22000 / 23000	3100 / 3100 / 3100	6200 / 6200 / 6300
Pyrene	110 / 270 / 620	620 / 1200 / 2000	3700 / 3800 / 3800	54000 / 54000 / 54000	7400 / 7400 / 7400	15000 / 15000 / 15000
Coal Tar (Bap as surrogate marker) [u]	0.32 / 0.67 / 1.2	0.79 / 0.98 / 1.1	1.2 / 1.2 / 1.2	15 / 15 / 15	2.2 / 2.2 / 2.2	4.4 / 4.7 / 4.8
Explosives [a, b, l, p]						
2, 4, 6 Trinitrotoluene	0.24 / 0.58 / 1.40	1.6 / 3.7 / 8.0	65 / 66 / 66	1000 / 1000 / 1000	130 / 130 / 130	260 / 270 / 270
RDX (Royal Demolition Explosive $C_3H_6N_6O_6$)	17 / 38 / 85	120 / 250 / 540	13000 / 13000 / 13000	210000 / 210000 / 210000	26000 / 26000 / 27000	49000^{sol} (18.7) / 51000 / 53000
HMX (High Melting Explosive $C_4H_8N_8O_8$)	0.86 / 1.9 / 3.9	5.7 / 13 / 26	6700 / 6700 / 6700	110000 / 110000 / 110000	13000 / 13000 / 13000	23000^{vap} (0.35) /23000^{vap} (0.39) /24000^{vap} (0.48)
Petroleum Hydrocarbons (SOM 1%/ 2.5%/ 6%) [a, b, l, m]						
Aliphatic EC 5-6	730 / 1700 / 3900	42 / 78 / 160	42 / 78 / 160	3200^{sol} (304) / 5900^{sol} (558) / 12000^{sol} (1150)	570000^{sol}(304) 590000 / 600000	95000^{sol} (304) / 130000^{sol} (558)/ 180000^{sol}(1150)
Aliphatic EC >6-8	2300 / 5600 / 13000	100 / 230 / 530	100 / 230 / 530	7800^{sol} (144) / 17000^{sol} (322) / 40000^{sol} (736)	600000 / 610000 / 620000	150000^{sol} (144) / 220000^{sol} (322)/ 320000^{sol} (736)
Aliphatic EC >8-10	320 / 770 / 1700	27 / 65 / 150	27 / 65 / 150	2000^{sol} (78) / 4800^{vap} (190) / 11000^{vap} (451)	13000 / 13000 / 13000	14000^{sol} (78) / 18000^{vap} (190) / 21000^{vap} (451)
Aliphatic EC >10-12	2200 / 4400 / 7300	130v^{ap} (48) / 330^{vap} (118) / 760^{vap} (283)	130v^{ap} (48) / 330^{vap} (118) / 770^{vap} (283)	9700^{sol} (48) / 23000^{vap} (118) / 47000^{vap} (283)	13000 / 13000 / 13000	21000^{sol} (48) / 23000^{vap} (118) / 24000^{vap} (283)
Aliphatic EC >12-16	11000 / 13000 / 13000	1100^{sol} (24) / 2400^{sol} (59) / 4300^{sol} (142)	1100^{sol} (24) / 2400^{sol} (59) / 4400^{sol} (142)	59000^{sol} (24) / 82000^{sol} (59) / 90000^{sol} (142)	13000 / 13000 / 13000	25000^{sol} (24) / 25000^{sol} (59) / 26000^{sol} (142)
Aliphatic EC >16-35 [o]	260000 / 270000 / 270000	65000^{sol}(8.48 92000^{sol} (21) 110000	65000^{sol} (8.48 92000^{sol} (21) 110000	1600000 / 1700000 / 1800000	250000 / 250000 / 250000	450000 / 480000 / 490000
Aliphatic EC >35-44 [o]	260000 / 270000 / 270000	65000^{sol}(8.48 92000^{sol} (21) / 110000	65000^{sol}(8.48 92000^{sol} (21) 110000	1600000 / 1700000 / 1800000	250000 / 250000 / 250000	450000 / 480000 / 490000
Aromatic EC 5-7 (benzene)	13 / 27 / 57	70 / 140 / 300	370 / 690 / 1400	26000^{sol} (1220) / 46000^{sol} (2260) / 86000^{sol} (4710)	56000 / 56000 / 56000	76000^{sol} (1220) /84000^{sol}(2260)/ 92000^{sol} (4710)
Aromatic EC >7-8 (toluene)	22 / 51 / 120	130 / 290 / 660	860 / 1800 / 3900	56000^{vap} (869)/ 110000^{sol} (1920)/ 180000^{vap} (4360)	56000 / 56000 / 56000	87000^{vap}(869) / 95000^{sol} (1920)/ 100000^{vap}(4360)
Aromatic EC >8-10	8.6 / 21 / 51	34 / 83 / 190	47 / 110 / 270	3500^{vap} (613) / 8100^{vap} (1500) / 17000^{vap} (3580)	5000 / 5000 / 5000	7200^{vap}(613) / 8500^{vap} (1500) / 9300^{vap} (3580)

Determinand	Allotment	R_{W}HP	R_{WO}HP	Commercial/ Industrial	POSresi	POSpark
Aromatic EC >10-12	13 / 31 / 74	74 / 180 / 380	250 / 590 / 1200	16000[sol] (364) / 28000[sol] (899) / 34000[sol] (2150)	5000 / 5000 / 5000	9200[sol] (364) / 9700[sol] (899) / 10000
Aromatic EC >12-16	23 / 57 / 130	140 / 330 / 660	1800 / 2300[sol] (419) / 2500	36000[sol] (169) / 37000 / 38000	5100 / 5100 / 5000	10000 / 10000 / 10000
Aromatic EC >16-21 [o]	46 / 110 / 260	260 / 540 / 930	1900 / 1900 / 1900	28000 / 28000 / 28000	3800 / 3800 / 3800	7600 / 7700 / 7800
Aromatic EC >21-35 [o]	370 / 820 / 1600	1100 / 1500 / 1700	1900 / 1900 / 1900	28000 / 28000 / 28000	3800 / 3800 / 3800	7800 / 7800 / 7900
Aromatic EC >35-44 [o]	370 / 820 / 1600	1100 / 1500 / 1700	1900 / 1900 / 1900	28000 / 28000 / 28000	3800 / 3800 / 3800	7800 / 7800 / 7900
Aliphatic + Aromatic EC >44-70 [o]	1200 / 2100 / 3000	1600 / 1800 / 1900	1900 / 1900 / 1900	28000 / 28000 / 28000	3800 / 3800 / 3800	7800 / 7800 / 7900
Chloroalkanes & Chloroalkenes (SOM 1%/ 2.5%/ 6%) [a, b, l, p]						
1,2-Dichloroethane	0.0046 / 0.0083 / 0.016	0.0071 / 0.011 / 0.019	0.0092 / 0.013 / 0.023	0.67 / 0.97 / 1.7	29 / 29 / 29	21 / 24 / 28
1,1,1 Trichloroethane (TCA)	48 / 110 / 240	8.8 / 18 / 39	9.0 / 18 / 40	660 / 1300 / 3000	140000 / 140000 / 140000	57000[vap](1425) 76000[vap](2915)/ 100000[vap](6392)
1,1,1,2 Tetrachloroethane	0.79 / 1.9 / 4.4	1.2 / 2.8 / 6.4	1.5 / 3.5 / 8.2	110 / 250 / 560	1400 / 1400 / 1400	1500 / 1800 / 2100
1,1,2,2 Tetrachloroethane	0.41 / 0.89 / 2.0	1.6 / 3.4 / 7.5	3.9 / 8.0 / 17	270 / 550 / 1100	1400 / 1400 / 1400	1800 / 2100 / 2300
Tetrachloromethane (Carbon Tetrachloride)	0.45 / 1.0 / 2.4	0.026 / 0.056 / 0.13	0.026 / 0.056 / 0.13	2.9 / 6.3 / 14	890 / 920 / 950	190 / 270 / 400
Trichloromethane (Chloroform)	0.42 / 0.83 / 1.7	0.91 / 1.7 / 3.4	1.2 / 2.1 / 4.2	99 / 170 / 350	2500 / 2500 / 2500	2600 / 2800 / 3100
Phenol & Chlorophenols [a, b, l, p]						
Phenol	23 / 42 / 83	120 / 200 / 380	440 / 690 / 1200	440[dir] (26000) / 690[dir] (30000) / 1300[dir] (34000)	440[dir] (10000)/ 690[dir](10000) 1300[dir](10000)	440[dir] (7600) / 690[dir] (8300) / 1300[dir] (93000)
Chlorophenols (excluding PCP) [r]	0.13[s] / 0.3 / 0.7	0.87[s] / 2.0 / 4.5	94 / 150 / 210	3500 / 4000 / 4300	620 / 620 / 620	1100 / 1100 / 1100
Pentachlorophenol (PCP)	0.03 / 0.08 / 0.19	0.22/ 0.52 / 1.2	27[vap] (16.4) / 29 / 31	400 / 400 / 400	60 / 60 / 60	110 / 120 / 120
Other [a, b, l, p]						
Carbon Disulphide	4.8 / 10 / 23	0.14 / 0.29 / 0.62	0.14 / 0.29 / 0.62	11 / 22 / 47	11000 / 11000 / 12000	1300 / 1900 / 2700
Hexachlorobutadiene (HCBD)	0.25 / 0.61 / 1.4	0.29 / 0.7 / 1.6	0.32 / 0.78 / 1.8	31 / 66 / 120	25 / 25 / 25	48 / 50 / 51
Pesticides (SOM 1%/ 2.5%/ 6%) [a, b, l, p]						
Aldrin	3.2 / 6.1 / 9.6	5.7/ 6.6 /7.1	7.3 / 7.4 / 7.5	170 / 170 / 170	18 / 18 / 18	30 / 31 / 31
Atrazine	0.5 / 1.2 / 2.7	3.3 / 7.6 / 17.4	610 / 620 / 620	9300 / 9400 / 9400	1200 / 1200 / 1200	2300 / 2400 / 2400
Dichlorvos	0.0049 / 0.010 / 0.022	0.032 / 0.066 / 0.14	6.4 / 6.5 / 6.6	140 / 140 / 140	16 / 16 / 16	26 / 26 / 27
Dieldrin	0.17/0.41/0.96	0.97/ 2 / 3.5	7.0 / 7.3 / 7.4	170 / 170 / 170	18 / 18 / 18	30 / 30 / 31
Alpha - Endosulfan	1.2 / 2.9 / 6.8	7.4 / 18 / 41	160[vap] (0.003)/ 280[vap] (0.007)/ 410[vap] (0.016)	5600[vap] (0.003) / 7400[vap] (0.007) / 8400[vap] (0.016)	1200 / 1200 / 1200	2400 / 2400 / 2500
Beta - Endosulfan	1.1 / 2.7 / 6.4	7.0 / 17 / 39	190[vap](0.00007) /320[vap](0.0002) /440[vap](0.0004)	6300[vap](0.00007) /7800[vap](0.0002) / 8700	1200 / 1200 / 1200	2400 / 2400 / 2500
Alpha-Hexachlorocyclohexane	0.035/0.087/ 0.21	0.23/0.55 / 1.2	6.9 / 9.2 / 11	170 / 180 / 180	24 / 24 / 24	47 / 48 / 48
Beta - Hexachlorocyclohexane	0.013 / 0.032 / 0.077	0.085 / 0.2 / 0.46	3.7 / 3.8 / 3.8	65 / 65 / 65	8.1 / 8.1 / 8.1	15 / 15 / 16
Gamma – Hexachlorocyclohexane	0.0092 / 0.023 / 0.054	0.06 / 0.14 / 0.33	2.9 / 3.3 / 3.5	67 / 69 / 70	8.2 / 8.2 / 8.2	14 / 15 / 15
Chlorobenzenes [a, b, l, p]						
Chlorobenzene	5.9 / 14 / 32	0.46 / 1.0 / 2.4	0.46 / 1.0 / 2.4	56 / 130 / 290	11000 / 13000 / 14000	1300[sol](675)/ 2000[sol](1520)/ 2900
1,2-dichlorobenzene (1,2-DCB)	94 / 230 / 540	23 / 55 / 130	24 / 57 / 130	2000[sol] (571) / 4800[sol] (1370) / 11000[sol] (3240)	90000 / 95000 / 98000	24000[sol] (571) / 36000[sol] (1370) /51000[sol] (3240)
1,3-dichlorobenzene (1,3-DCB)	0.25 / 0.6 / 1.5	0.4 / 1.0 / 2.3	0.44 /1.1 / 2.5	30 / 73 / 170	300 / 300 / 300	390 / 440 / 470
1-4-dichlorobenzene (1,4-DCB)	15[i] / 37[i] / 88 [i]	61[q] / 150[q] /350 [q]	61[q] / 150[q] / 350[q]	4400[vap,q] (224) / 10000[vap,q] (540) / 25000[vap,q] (1280)	17000[i] / 17000[i] / 17000[i]	36000[vap,i] (224) 36000[vap, i](540)/ 36000[vap,i](1280)
1,2,3-Trichlorobenzene	4.7 / 12 / 28	1.5 / 3.6 / 8.6	1.5 / 3.7 / 8.8	102 / 250 / 590	1800 / 1800 / 1800	770[vap] (134) / 1100[vap] (330) / 1600[vap] (789)
1,2,4- Trichlorobenzene	55 / 140 / 320	2.6 / 6.4 / 15	2.6 / 6.4 / 15	220 / 530 / 1300	15000 / 17000 / 19000	1700[vap] (318) / 2600[vap] (786) / 4000[vap] (1880)

Determinand	Allotment	R_W HP	R_WO HP	Commercial/ Industrial	POSresi	POSpark
1,3,5- Trichlorobenzene	4.7 / 12 / 28	0.33 / 0.81 / 1.9	0.33 / 0.81 / 1.9	23 / 55 / 130	1700 / 1700 / 1800	380[vap] (36.7) / 580[vap] (90.8) / 860[vap] (217)
1,2,3,4-Tetrachlorobenzene	4.4 / 11 / 26	15 / 36 / 78	24 / 56 / 120	1700[vap] (122) / 3080[vap] (304) / 4400[vap] (728)	830 / 830 / 830	1500[vap] (122) / 1600 / 1600
1,2,3,5- Tetrachlorobenzene	0.38 / 0.90 / 2.2	0.66 / 1.6 / 3.7	0.75 / 1.9 / 4.3	49[vap] (39.4) / 120[vap] (98.1) / 240[vap] (235)	78 / 79 / 79	110[vap] (39.4) / 120 / 130
1,2,4,5- Tetrachlorobenzene	0.06 / 0.16 / 0.37	0.33 / 0.77 / 1.6	0.73 / 1.7 / 3.5	42[sol] (19.7) / 72[sol] (49.1) / 96	13 / 13 / 13	25 / 26 / 26
Pentachlorobenzene (P_ECB)	1.2 / 3.1 / 7.0	5.8 / 12 / 22	19 / 30 / 38	640[sol] (43.0) / 770[sol] (107) / 830	100 / 100 / 100	190 / 190 / 190
Hexachlorobenzene (HCB)	0.47 / 1.1 / 2.5	1.8[vap] (0.20) / 3.3[vap] (0.5) / 4.9	4.1[vap] (0.20) / 5.7[vap] (0.5) / 6.7[vap] (1.2)	110[vap] (0.20) / 120 / 120	16 / 16 / 16	30 / 30 / 30

Units are mg/kg Dry Weight

R_W HP Residential with homegrown produce
R_WO HP Residential without homegrown produce
POSresi public open spaces near residential housing
POSpark public open space for recreational use but not dedicated sports pitches
SOM Soil Organic Matter – ***the S4UL for all organic compounds will vary according to SOM***

a Based on a sandy loam soil as defined in SR3 (Environment Agency, 2009b) and 6% soil organic matter (SOM)
b Figures rounded to two significant figures
c Based only on a comparison of oral and dermal soil exposure with oral Index Dose
d The background ADE is limited to being no larger than the contribution from the relevant soil ADE
e Based on comparison of inhalation exposure with inhalation TDI only
f Based on a lifetime exposure via the oral, dermal and inhalation pathways
g Based on localised effects comparing inhalation exposure with inhalation ID only
h Based on comparison of inhalation exposure with inhalation ID
i Based on comparison of oral and dermal exposure with oral TDI
j Based on comparison of oral, dermal and inhalation exposure with inhalation TDI
k Based on comparison of all exposure pathways with oral TDI
l S4ULs assume that free phase contamination is not present
m S4ULs based on a sub-surface soil to indoor air correction factor of 10
n The HCV applied is based on the intake of total Xylene and therefore exposure should not consider an isomer in isolation
o Oral, dermal and inhalation exposure compared with oral HCV
p S4ULs based on a sub-surface soil to indoor air correction factor of 1
q Based on a comparison of inhalation exposure with the inhalation TDI for localised effects
r Based on 2,4-dichlorophenol unless otherwise stated
s Based on 2,3,4,6-tetrachlorophenol
t Based on lowest GAC for all three xylene isomers
u Measured concentrations of benzo(a)pyrene should be compared to the S4UL for benzo(a)pyrene as a single compound and to the S4UL for benzo(a)pyrene as a surrogate marker of genotoxic PAHs.
vap S4UL presented exceeded the vapour saturation limit, which is presented in brackets
sol S4UL presented exceeds the solubility saturation limit, which is presented in brackets
dir S4ULs based on a threshold protective of direct skin contact, guideline in brackets based on the health effects following long term exposure provided for illustration only

Table 3: Soil Guideline Values (SGVs) for dioxins, furans and dioxin like PCBs

Determinand	Allotments	Residential with consumption of homegrown produce	Residential without consumption of homegrown produce	Commercial
Sum of PCDDs, PCDFs and dioxin-like PCBs	0.008	0.008	0.008	0.24

Units are mg/kg Dry Weight

Table 4: EIC/AGS/CL:AIRE Generic Assessment Criteria (GAC)

	Allotments	Residential with consumption of homegrown produce	Residential without consumption of homegrown produce	Commercial	Soil Saturation Concentration
Metals					
Antimony	ND	ND	550	7500	NA
Barium	ND	ND	1300	22000	NA
Molybdenum	ND	ND	670	17000	NA
Organics (SOM 1%/ 2.5%/ 6%)					
1,1,2 Trichloroethane	0.28 / 0.61 / 1.4	0.6 / 1.2 / 2.7	0.88 / 1.8 / 3.9	94 / 190 / 400	4030 / 8210 / 18000
1,1-Dichloroethane	9.2 / 17 / 35	2.4 / 3.9 / 7.4	2.5 / 4.1 / 7.7	280 / 450 / 850	1830 / 2960 / 5600
1,1-Dichloroethene	2.8 / 5.6 / 12	0.23 / 0.4 / 0.82	0.23 / 0.41 / 0.82	26 / 46 / 92	2230 / 3940 / 7940
1,2,4-Trimethylbenzene	0.38 / 0.93 / 2.2	0.35 / 0.85 / 2	0.41 / 0.99 / 2.3	42 / 99 / 220	557 / 1360 / 3250
1,2-Dichloropropane	0.62 / 1.2 / 2.6	0.024 / 0.042 / 0.084	0.024 / 0.042 / 0.085	3.3 / 5.9 / 12	1190 / 2110 / 4240
2,4-Dimethylphenol	3.1 / 7.2 / 17	19 / 43 / 97	210 / 410 / 730	16000 / 24000 / 30000	1380 / 3140 / 7240
2,4-Dinitrotoluene	0.22 / 0.49 / 1.1	1.5 / 3.2 / 7.2	170 / 170 / 170	3700 / 3700 / 3800	141 / 299 / 669
2,6-Dinitrotoluene	0.12 / 0.27 / 0.61	0.78 / 1.7 / 3.9	78 / 84 / 87	1900 / 1900 / 1900	287 / 622 / 1400
2-Chloronaphthalene	40 / 98 / 230	3.7 / 9.2 / 22	3.8 / 9.3 / 22	390 / 960 / 2200	114 / 280 / 669
Biphenyl	14 / 35 / 83	66 / 160 / 360	220 / 500 / 980	18000 / 33000 / 48000	34.4 / 84.3 / 201
Bis (2-ethylhexyl) phthalate	47 / 120 / 280	280 / 610 / 1100	2700 / 2800 / 2800	85000 / 86000 / 86000	8.68 / 21.6 / 51.7
Bromobenzene	3.2 / 7.6 / 18	0.87 / 2 / 4.7	0.91 / 2.1 / 4.9	97 / 220 / 520	853 / 1970 / 4580
Bromodichloromethane	0.016 / 0.032 / 0.068	0.016 / 0.03 / 0.061	0.019 / 0.034 / 0.07	2.1 / 3.7 / 7.6	1790 / 3220 / 6570
Bromoform	0.95 / 2.1 / 4.6	2.8 / 5.9 / 13	5.2 / 11 / 23	760 / 1500 / 3100	2690 / 5480 / 12000
Butyl benzyl phthalate	220 / 550 / 1300	1400 / 3300 / 7200	42000 / 44000 / 44000	940000 / 940000 / 950000	26.3 / 64.7 / 154
Chloroethane	110 / 200 / 380	8.3 / 11 / 18	8.4 / 11 / 18	960 / 1300 / 2100	2610 / 3540 / 5710
Chloromethane	0.066 / 0.13 / 0.23	0.0083 / 0.0098 / 0.013	0.0085 / 0.0099 / 0.013	1 / 1.2 / 1.6	1910 / 2240 / 2990
Cis 1,2 Dichloroethene	0.26 / 0.5 / 1	0.11 / 0.19 / 0.37	0.12 / 0.2 / 0.39	14 / 24 / 47	3940 / 6610 / 12900
Dichloromethane	0.1 / 0.19 / 0.34	0.58 / 0.98 / 1.7	2.1 / 2.8 / 4.5	270 / 360 / 560	7270 / 9680 / 15300
Diethyl Phthalate	19 / 41 / 94	120 / 260 / 570	1800 / 3500 / 6300	150000 / 220000 / 290000	13.7 / 29.1 / 65
Di-n-butyl phthalate	2 / 5 / 12	13 / 31 / 67	450 / 450 / 450	15000 / 15000 / 15000	4.65 / 11.4 / 27.3
Di-n-octyl phthalate	940 / 2100 / 3900	2300 / 2800 / 3100	3400 / 3400 / 3400	89000 / 89000 / 89000	32.6 / 81.5 / 196
Hexachloroethane	0.27 / 0.67 / 1.6	0.2 / 0.48 / 1.1	0.22 / 0.54 / 1.3	22 / 53 / 120	8.17 / 20.1 / 48.1
Isopropylbenzene	32 / 79 / 190	11 / 27 / 64	12 / 28 / 67	1400 / 3300 / 7700	390 / 950 / 2250
Methyl tert-butyl ether (MTBE)	23 / 44 / 90	49 / 84 / 160	73 / 120 / 220	7900 / 13000 / 24000	20400 / 33100 / 62700
Propylbenzene	34 / 83 / 200	34 / 82 / 190	40 / 97 / 230	4100 / 9700 / 21000	402 / 981 / 2330
Styrene	1.6 / 3.7 / 8.7	8.1 / 19 / 43	35 / 78 / 170	3300 / 6500 / 11000	626 / 1440 / 3350
Total Cresols (2-, 3- and 4-methylphenol)	12 / 27 / 63	80 / 180 / 400	3700 / 5400 / 6900	160000 / 180000 / 180000	15000 / 32500 / 73300
Trans 1,2 Dichloroethene	0.93 / 1.9 / 4	0.19 / 0.34 / 0.7	0.19 / 0.35 / 0.71	22 / 40 / 81	3420 / 6170 / 12600
Tributyl tin oxide	0.042 / 0.1 / 0.24	0.25 / 0.59 / 1.3	1.4 / 3.1 / 5.7	130 / 180 / 200	41.3 / 101 / 241

Units are mg/kg Dry Weight

Table 5: Tier 2 Criteria for the Assessment of Soils – Protection of Flora and Fauna

Parameter	ICRCL 70/90 [a]		SSVs [b]	Code of Practice for Agricultural Use of Sewage Sludge [c]	BS 3882:2015 Specification for topsoil and requirements for use
	Maximum				Phytotoxic contaminants
	Livestock	Crop Growth			
	mg/kgDW	mg/kgDW	mg/kgDW	mg/kgDW	mg/kgDW
Antimony			37		
Arsenic	500	1000		50	
Cadmium	30	50	0.6	3	
Chromium				400	
Cobalt			4.2		
Copper	500	250	35.1	80/ 100/ 135/ 200 [d]	<100/<135/<200 [e]
Fluoride	1000			500	
Lead	1000			300	
Mercury				1	
Molybdenum			5.1	4	
Nickel			28.2	50/ 60/ 75/ 110 [d]	<60/<75/<110 [e]
Selenium				3	
Silver			0.3		
Vanadium			2.0		

Parameter	ICRCL 70/90 [a]		SSVs [b]	Code of Practice for Agricultural Use of Sewage Sludge [c]	BS 3882:2015 Specification for topsoil and requirements for use
	Maximum				Phytotoxic contaminants
	Livestock	Crop Growth			
	mg/kgDW	mg/kgDW	mg/kgDW	mg/kgDW	mg/kgDW
Zinc	3000	1000	35.6	200/200/200/300 [d]	<200/<200/<300 [e]
Benzo(a)pyrene			0.15		
Bis(2-ethylhexyl) phthalate			13		
Hexachlorobenzene			0.002		
Pentachlorobenzene					
Pentachlorophenol			0.6		
Perfluorooctanoic acid			0.022		
Perfluorooctane sulfonate			0.014		
Polychlorinated alkanes medium chain			11.9		
Tetrachloroethene					
Toluene					
Triclosan			0.13		
Tris(2-chloroethyl)phosphate			1.1		
Tris(2-chloro-1-methylethyl) phosphate			1.8		

a. Interdepartmental Committee on the Redevelopment of Contaminated Land (ICRCL) 70/90 Restoration and Aftercare of Metalliferous Mining Sites for Pasture and Grazing 1st edition 1990.
b. Soil screening values for assessing ecological risks, EA 2017a Report – ShARE id26
c. Maximum permissible concentration of potentially toxic elements for Arable land from the Sewage sludge in agriculture: code of practice.. There are also criteria for Grassland which are higher than for Arable.
d. Where four values are presented, concentrations are for soils with pH values 5.0-5.5/ 5.5-6.0/ 6.0-7.0/ >7.0 (and the soils contain more than 5% calcium carbonate)
e. Where three values are presented, concentrations are for soils with pH values <6.0/ 6.0-7.0/ >7.0

Table 6: Tier 2 Criteria for Screening Liquids

	Screening Concentration (mg/l)			
	Minimum Reporting Value	Human Consumption	Fresh Water/Inland	Salt Water/Other
Arsenic SP	-	0.01	0.05 (2)	0.025 (2)
Boron	-	1	-	-
Cadmium PS	0.0001	0.005	≤0.00008, 0.00008, 0.00009, 0.00015, 0.00025 (14)	0.0002
Chromium (total)	-	0.05	-	-
Chromium (III) SP	-	-	0.0047	-
Chromium (VI) SP	-	-	0.0034	0.0006
Copper SP	-	2	0.001 bioavailable	0.00376 bioavailable
Iron SP	-	0.2	1	1
Lead PS	-	0.01	0.0012 bioavailable	0.0013 bioavailable
Mercury compounds PS	0.00001	0.001	0.00007 max	0.00007 max
Manganese SP	-	0.05	0.123 bioavailable	-
Nickel PS	-	0.02	0.004 bioavailable	0.0086 bioavailable
Selenium	-	0.01	-	-
Zinc SP	-	5(3)	0.0109bioavailable(13)	0.0068bioavailable (13)
Chlorinated Compounds				
C10-13 chloroalkanes PS short chain chlorinated paraffins	-	-	0.0004	0.0004
Dichloromethane PS	-	-	0.02	0.02
1,2-Dichloroethane PS	0.001	0.003	0.01	0.01

	Screening Concentration (mg/l)			
	Minimum Reporting Value	Human Consumption	Fresh Water/Inland	Salt Water/Other
Trichloroethene PS	0.0001	0.01[5]	0.01	0.01
1,1,1-Trichloroethane	0.0001	-	-	-
1,1,2-Trichloroethane	0.0001	-	-	-
Trichloromethanes PS	-	0.1[1]	0.0025	0.0025
1, 2, 4-Trichlorobenzene	0.00001			
Tetrachloroethene PS	0.0001	0.01[5]	0.01	0.01
Tetrachloromethane/ Carbon tetrachloride PS	0.0001	0.003	0.012	0.012
Tetrachloroethane SP	-		0.140	
Vinyl chloride	-	0.0005	-	-
Trichlorobenzene (TCB) PS	-	-	0.0004	0.0004
Chloroform	0.0001			
Chloronitrotoluenes(CNT)[11]	0.001	-	-	-
Hexachlorobutadiene PS	0.000005	-	0.0006 max	0.0006 max
Hexachlorocyclohexanes (HCH) PS	0.000001	-	0.00002	0.000002
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	-	-	-	-
Acenaphthylene	-	-	-	-
Anthracene PS	-	-	0.0001	0.0001
Benzo(a)anthracene	-	-	-	-
Benzo(b)fluoranthene PS	-	0.0001 [10]	0.000017 max [12]	0.000017 max [12]
Benzo(a)pyrene PS	-	0.00001	0.00000017	0.00000017
Benzo(k)fluoranthene PS	-	0.0001 [10]	0.000017 max [12]	0.000017 max [12]
Benzo(g,h,i)perylene PS	-	0.0001 [10]	0.0000082 max [12]	0.00000082 max [12]
Indeno(1,2,3-cd)pyrene PS	-	0.0001 [10]	- [12]	- [12]
Chrysene		-	-	-
Dibenzo(a,h)anthracene		-	-	-
Fluoranthene PS	-	-	0.0000063	0.0000063
Fluorene	-	-	-	-
Phenanthrene	-	-	-	-
Pyrene	-	-	-	-
Naphthalene PS	-	-	0.002	0.002
Polycyclic Aromatic Hydrocarbons		0.0001[10]		
Petroleum hydrocarbons				
Petroleum hydrocarbons/Mineral oil	-	0.01[3]	-	-
Benzene PS	0.001	0.001	0.01	0.008
Toluene SP	0.004	0.7[9]	0.074	0.074
Ethylbenzene	-	0.3[9]	-	-
Xylenes	0.003[4]	0.5[9]		
Methyl tert-butyl ether (MTBE)	-	0.015[7]	-	-
Pesticides and Herbicides				
Alachlor PS	-	-	0.0003	0.0003
Aldrin PS	0.000003	0.00003	0.00001[8]	0.000005[8]
Dieldrin PS	0.000003	0.00003		
Endrin PS	0.000003	0.0006[9]		
Isodrin	0.000003	-	-	-
2,4 dichlorophenol SP	0.0001	-	0.0042	0.00042
2,4 D ester SP	0.0001	-	0.0003	0.0003
op and pp DDT (each) PS	0.000002	0.001[6]	0.000025 [6]	0.000025 [6]
op and pp DDE (each)	0.000002			
op and pp TDE (each)	0.000002			
Dimethoate SP	0.00001	-	0.00048	0.00048
Endosulfan PS	0.000005	-	0.000005	0.0000005
Hexachlorobenzene PS	0.000001		0.00005 max	0.00005 max
Permethrin SP	0.000001	-	0.000001	0.0000002
Atrazine PS	0.00003	-	0.0006	0.0006
Simazine PS	0.00003	-	0.001	0.001
Linuron SP	-	-	0.0005	0.0005
Mecoprop SP		-	0.018	0.018
Trifluralin PS	0.00001	-	0.00003	0.00003
Total pesticides	-	0.0005		

	Screening Concentration (mg/l)			
	Minimum Reporting Value	Human Consumption	Fresh Water/Inland	Salt Water/Other
Miscellaneous				
Ammoniacal nitrogen (as NH4+)	-	0.5	0.26 [16] 0.39 [17]	-
Ammoniacal nitrogen (as N)	-	0.39	0.2 [16] 0.3 [17]	-
Unionised Ammonia (NH3) SP	-	-	-	0.021
Chloride	-	250		
Chlorine SP			0.002	0.01 max
Cyanide SP (hydrogen cyanide)	-	0.05	0.001	0.001
Nitrate (as NO_3)	-	50	-	-
Nitrite (as NO_2)	-	0.1	-	-
Phenol SP	-	0.005 (3)	0.0077	0.0077
Pentachlorophenol PS	0.0001	-	0.0004	0.0004
PCBs (individual congeners)	0.000001	-	-	-
Sodium	-	200	-	-
Sulphate	-	250		-
Tributyl and triphenyl tin compounds (each) PS	0.000001	-	0.0000002	0.0000002
Di(2-ethylhexyl)-phthalate PS	-	-	0.0013	0.0013

Substances highlighted in yellow are hazardous substances, PS = Priority Substances, SP = Specific Pollutants, '-' screening concentration is not available, 'max' – maximum allowable concentration used where no annual average provided

Notes:

1. Concentration for trihalomethanes is the sum of chloroform, bromoform, dibromochloromethane and bromodichloromethane.
2. Concentration is the dissolved fraction of a water sample obtained by filtration through a 0.45um filter.
3. Concentration is taken from Statutory Instrument 1989 No. 1147. The Water Supply (Water Quality) Regulations 1989, as amended.
4. Concentration for xylenes is 0.003mg/l each for o-xylene and m/p xylene.
5. Concentration is the Sum of TCE and PCE.
6. Concentration is for Total DDT. Para DDT on its own has a target concentration of 0.00001mg/l.
7. Concentration for MTBE is taken from Environment Agency guidance, dated 2006.
8. Concentration is the sum of aldrin, dieldrin, endrin.
9. Concentration is taken from WHO (2004) guidelines for drinking-water quality.
10. Sum of benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene, indeno(1,2,3-cd)pyrene
11. Concentration is for 2,6-CNT, 4,2-CNT, 4,3-CNT, 2,4-CNT, 2,5-CNT
12. BAP can be considered as a marker of the other PAHs for comparison with the annual average
13. Concentration plus ambient background concentration (dissolved)
14. For cadmium and its compounds the EQS depends on the hardness of the water (Class 1: < 40 mg CaCO3/l, Class 2: 40 to < 50 mg CaCO3/l, Class 3: 50 to < 100 mg CaCO3/l, Class 4: 100 to < 200 mg CaCO3/l and Class 5: ≥ 200 mg CaCO3/l).
15. Manufactured and used in industrial applications, such as flame retardants and plasticisers, as additives in metal working fluids, in sealants, paints, adhesives, textiles, leather fat and coatings. Persistent, bioaccumulate and toxic to aquatic life (carcinogen in rat studies). Candidate Persistent Organic Pollutant (POP).
16. Acceptable 90th percentile concentration for a freshwater lake/river with "High" chemical quality standard and alkalinity (as mg/l CaCO3) < 50 mg/L or alkalinity < 200 mg/L where river elevation > 80 m above Ordnance Datum (mAOD). See the Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 for further details.
17. Acceptable 90th percentile concentration for a freshwater lake/river with "High" chemical quality standard and alkalinity (as mg/l CaCO3) ≥ 50 mg/L where river elevation < 80 m mAOD or > 200 mg/l where river elevation > 80 mAOD. See the Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 for further details.

Table 7: Tier 2 Criteria for Screening Groundwater Vapour Generation Hazard

Chemical	CAS	GAC_{gwvap}(µg/l)[1,2]		Aqueous Solubility (µg/l)
		Residential	Commercial	
Petroleum Hydrocarbons				
1,2,4-Trimethylbenzene	95-63-6	24	2,200	559,000
Benzene [3]	71-43-2	210	20,000	1,780,000
Ethylbenzene [3]	100-41-4	10,000	*960,000 (sol)*	180,000
Isopropylbenzene	98-82-8	850	*86,000 (sol)*	56,000
Propylbenzene	103-65-1	2,700	*240,000 (sol)*	54,100
Styrene	100-42-5	8,800	*810,000 (sol)*	290,000
Toluene [3]	108-88-3	230,000	*21,000,000 (sol)*	590,000
TPH Aliphatic EC5-EC6 [3]		1,900	*190,000 (sol)*	35,900
TPH Aliphatic >EC6-EC8 [3]		1,500	*150,000 (sol)*	5,370
TPH Aliphatic >EC8-EC10 [3]		57	*5,700 (sol)*	427
TPH Aliphatic >EC10-EC12 [3]		37	*3,600 (sol)*	34
TPH Aromatic >EC5-EC7 [2,3]		210,000	*20,000,000 (sol)*	1,780,000
TPH Aromatic >EC7-EC8 [3]		220,000	*21,000,000 (sol)*	590,000
TPH Aromatic >EC8-EC10 [3]		1,900	*190,000 (sol)*	64,600
TPH Aromatic >EC10-EC12 [3]		6,800	*660,000 (sol)*	24,500
TPH Aromatic >EC12-EC16 [3]		39,000	*3,700,000 (sol)*	5,750
meta-Xylene [3,5]	108-38-3	9,500	*940,000 (sol)*	200,000
ortho-Xylene [3,5]	95-47-6	12,000	*1,100,000 (sol)*	173,000
para-Xylene [3,5]	106-42-3	9,900	*980,000 (sol)*	200,000
Polycyclic Aromatic Hydrocarbons (PAH)				
Acenaphthene	83-32-9	*170,000 (sol)*	*15,000,000 (sol)*	4,110
Acenaphthylene	208-96-8	*220,000 (sol)*	*20,000,000 (sol)*	7,950
Fluorene	86-73-7	*210,000 (sol)*	*18,000,000 (sol)*	1,860
Naphthalene	91-20-3	220	*23,000 (sol)*	19,000
Pesticides				
Aldrin	309-00-2	*47 (sol)*	*3,700 (sol)*	20
alpha-Endosulfan	959-98-8	*7,400 (sol)*	*590,000 (sol)*	530
beta-Endosulfan	33213-65-9	*7,500 (sol)*	*600,000 (sol)*	280
Halogenated Organics				
1,1,1,2-Tetrachloroethane	79-34-5	240	22,000	1,110,000
1,1,1-Trichloroethane	71-55-6	3,000	290,000	1,300,000
1,1,2,2-Tetrachloroethane	79-35-4	1,600	150,000	2,930,000
1,1,2-Trichloroethane	79-00-5	520	49,000	4,491,000
1,1-Dichloroethane	75-34-3	2,700	260,000	3,666,000
1,1-Dichloroethene	75-35-4	160	1,6000	3,100,000
1,2,3,4-Tetrachlorobenzene	634-66-2	240	*31,000 (sol)*	7,800
1,2,3,5-Tetrachlorobenzene	634-90-2	7.0	*600*	3,500
1,2,3-Trichlorobenzene	87-61-7	35	3,100	21,000
1,2,4,5-Tetrachlorobenzene	95-94-3	8.1	*700 (sol)*	600
1,2,4-Trichlorobenzene	120-82-1	68	7,200	41,400
1,2-Dichlorobenzene	95-50-1	2,000	*220,000 (sol)*	133,000
1,2-Dichloroethane	107-06-2	8.9	850	8,680,000
1,2-Dichloropropane	78-87-5	22	2,600	2,050,000
1,3,5-Trichlorobenzene	108-70-3	7.4	660	6,000
1,3-Dichlorobenzene	541-73-1	31	2,800	103,000
1,4-Dichlorobenzene	106-46-7	5,000	*460,000 (sol)*	51,200
Bromobenzene	108-86-1	220	20,000	388,040
Bromodichloromethane	75-27-4	17	1,600	3,000,000
Bromoform (Tribromomethane)	75-25-2	3,100	400,000	3,000,000
Chlorobenzene	108-90-7	98	15,000	387,000
Chloroethane	75-00-3	10,000	1,000,000	5,742,000
Chloroethene (Vinyl Chloride)	75-01-4	0.62	63	2,760,000
Chloromethane	74-87-3	14	1,400	5,350,000
cis-1,2-Dichloroethene	156-59-2	130	13,000	7,550,000
Dichloromethane	75-09-2	3,300	370,000	20,080,000
Hexachlorobenzene	118-74-1	*16 (sol)*	*1,400 (sol)*	10
Hexachlorobutadiene	87-68-3	1.7	230	4,800
Hexachloroethane	67-72-1	8.5	740	49,900

Chemical	CAS	GAC_{gwvap}(µg/l)[1,2]		Aqueous Solubility (µg/l)
		Residential	Commercial	
Pentachlorobenzene	608-93-5	140	*12,000 (sol)*	500
Tetrachloroethene	127-18-4	34	4,600	225,000
Tetrachloromethane (Carbon Tetrachloride)	56-23-5	5.3	770	846,000
trans-1,2-Dichloroethene	156-60-5	160	16,000	5,250,000
Trichloroethene	79-01-6	5.7	530	1,370,000
Trichloromethane (Chloroform)	67-66-3	790	85,000	8,950,000
Others (organic and inorganic)				
2-Chloronaphthalene	91-58-7	160	*14,000 (sol)*	11,700
Biphenyl (Lemonene)	92-52-4	*15,000 (sol)*	*1,300,000 (sol)*	4,060
Carbon Disulphide	75-15-0	56	5,600	2,100,000
Mercury, elemental	7439-97-6	1.1	*95 (sol)*	56
Methyl tertiary butyl ether (MTBE)	1634-04-4	83,000	7,800,000	48,000,000

Notes

1. GAC in *italics* with (sol) exceed aqueous solubility.
2. GAC rounded to two significant figures.
3. The GAC for these petroleum hydrocarbon contaminants have been calculated using a sub-surface soil to indoor air correction factor of 10 in line with the physical-chemical data sources.
4. The GAC for TPH fractions do not account for genotoxic mutagenic effects. Concentrations of TPH Aromatic >EC5-EC7 should therefore also be compared with the GAC for benzene to ensure that such effects are also assessed.
5. The Health Criteria Value used for each xylene isomer was for total xylene. If site specific additivity assessments are not completed, as a conservative measure the sum of isomer concentrations should be compared to the lowest xylene GAC (as is the case for soil GAC).

Appendix C Geoenvironmental Soils Assessment

TABLE SUMMARISING SOIL RESULTS AND HIGHLIGHTING EXCEEDANCES ABOVE SOIL ASSESSMENT CRITERIA
M3 JUNCTION 9 IMPROVEMENTS

SOM 6%			Assessment Criteria		Strata				No. of Exceedances			MG	ALVc	ALVc	TS	ALVc	SECK	MG	HDD	HDD	HDD	SECK	TS	SECK	SECK	SECK	SECK	MG	MG	SECK
												DS101	DS101	DS101	DS103	DS103	DS103	DS104	DS104	DS105	DS105	DS105	DS107	DS107	DS107	DS108	DS108	DS109	DS109A	DS109A
Analyte	Units	LOD	POSresi	POSpark	Commercial	No. of Tests	Min	Max	POSresi	POSpark	Commercial	0.5	2.8	7.8	0.25	2.6	6.9	0.25	1.5	0.25	1	7	0.25	5.2	6.85	0.25	6	0.25	0.25	3.4
Stones Content	%		-	-	-																									
Arsenic*	mg/kg	2	79	170	640	126	2	37				2	5	2	7	2	2	8	3	7	5	2	6	37	2	10	2	6	6	2
Cadmium*	mg/kg	0.2	220	880	410	126	0.2	1.3				0.2	0.3	0.3	0.9	0.3	0.2	0.9	0.4	1.2	0.4	0.2	0.8	0.9	0.2	0.5	0.2	0.8	0.8	0.4
Chromium Trivalent	mg/kg		1500	33000	8600																									
Chromium Hexavalent*	mg/kg	2	21	250	49	126	2	2				2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Copper	mg/kg	4	12000	44000	68000	126	4	93				8	10	7	14	9	8	16	10	16	9	9	17	93	9	42	8	20	20	9
Lead*	mg/kg	3	630	1300	2300	126	3	470				9	9	3	23	3	3	37	5	49	9	3	37	470	3	30	3	51	55	3
Mercury	mg/kg	1	120	240	1100	126	1	3.1				1	1	1	1	1	1	1	1	1	1	1	1	3.1	1	1	1	1	1	1
Nickel	mg/kg	3	230	800	980	126	3	47				3	13	5	14	5	3	15	7	11	8	3	6	47	3	18	3	10	12	3
Selenium	mg/kg	3	1100	1800	12000	126	3	13.6				3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Zinc	mg/kg	3	81000	170000	730000	126	3	190				18	37	12	63	16	9	64	18	68	24	8	46	9	9	81	10	65	73	8
Beryllium	mg/kg	0.5	2.2	63	12	126	0.5	2.3	1			0.5	0.6	0.5	0.8	0.5	0.5	0.8	0.5	0.7	0.5	0.5	0.5	2.3	0.5	0.9	0.5	0.6	0.6	0.5
Boron	mg/kg	1	21000	46000	240000	126	1	4				1	1	1	1	1	1	1	1	1	1	1	1	3.1	1	1	1	1	1	1
Vanadium	mg/kg	2	2000	5000	9000	126	2	52				4	22	6	30	8	2	32	11	24	14	2	15	52	2	26	2	20	23	2
Cyanide (Total)	mg/kg	2	-	-	-	126	2	2				2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Organic matter	mg/kg		-	-	-																									
Phenol, Total	mg/kg		1300	1300	1300																									
Sulphate (Total) as SO4	mg/l	0.02	-	-	-	126	0.02	0.46				0.04	0.05	0.04	0.1	0.05	0.04	0.1	0.04	0.23	0.06	0.04	0.1	0.17	0.04	0.09	0.05	0.1	0.11	0.04
pH	pH Units		-	-	-	126	6.5	11				8.1	8.6	8.2	7.7	8.1	8.1	6.8	7.1	8.5	8.1	8.2	6.7	8.2	7.3	7.7	7.7	7.1	6.5	6.9
>C5 to C6 Aliphatic	mg/kg	0.01	600000	180000	12000	126	0.01	0.01				0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
>C6 to C8 Aliphatic	mg/kg	0.05	620000	320000	40000	126	0.05	0.05				0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
>C8 to C10 Aliphatic	mg/kg	2	13000	21000	11000	126	2	2				2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C10 to C12 Aliphatic	mg/kg	2	13000	24000	47000	126	2	2				2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C12 to C16 Aliphatic	mg/kg	3	13000	26000	90000	126	3	62				3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
>C16 to C21 Aliphatic	mg/kg	3	-	-	-	126	3	282				3	3	3	3	3	3	3	3	3	3	3	3	3	3	5	3	3	3	3
>C21 to C35 Aliphatic	mg/kg	10	-	-	-	126	10	202				10	10	10	10	10	10	10	10	10	10	10	10	10	10	202	10	10	10	10
>C16 to C35 Aliphatic	mg/kg	13	250000	490000	1800000	126		292				13	13	13	13	13	13	13	13	13	13	13	13	13	13	207	13	13	13	13
>C35 to C44 Aliphatic	mg/kg		250000	490000	1800000																									
Total Aliphatic C5-C35	mg/kg	21	-	-	-	126	21	343				21	21	21	21	21	21	21	21	21	21	21	21	21	21	207	21	21	21	21
>C5 to C7 Aromatic	mg/kg		56000	92000	86000																									
>C7 to C8 Aromatic	mg/kg	0.05	56000	100000	180000	126	0.05	0.05				0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
>C8 to C10 Aromatic	mg/kg	2	5000	9300	17000	126	2	2				2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C10 to C12 Aromatic	mg/kg	2	5000	10000	34000	126	2	5				2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C12 to C16 Aromatic	mg/kg	2	5000	10000	38000	126	2	13				2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C16 to C21 Aromatic	mg/kg	3	3800	7800	28000	126	3	16				3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
>C21 to C35 Aromatic	mg/kg	10	3800	7900	28000	126	10	246				10	10	10	10	10	10	10	10	10	10	10	10	10	10	246	10	10	10	10
>C35 to C44 Aromatic	mg/kg		3800	7900	28000																									
Total Aromatic C5-C35	mg/kg	21	-	-	-	126	21	249				21	21	21	21	21	21	21	21	21	21	21	21	21	21	249	21	21	21	21
TPH Ali/Aro	mg/kg	42	-	-	-	126	42	457				42	42	42	42	42	42	42	42	42	42	42	42	42	42	457	42	42	42	42
EPH (C10-C40)	mg/kg		-	-	-																									
Hazard Index - POSresi	-	-	-	-	-	126	0.005	0.068				0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0681	0.0052	0.0052	0.0052	0.0052
Hazard Index - POSpark	-	-	-	-	-	126	0.003	0.033				0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0329	0.0026	0.0026	0.0026	0.0026
Hazard Index - Commercial	-	-	-	-	-	126	0.001	0.009				0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0095	0.0010	0.0010	0.0010	0.0010
Benzene*	mg/kg	0.002	140	230	98	126	0.002	0.002				0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Ethylbenzene	mg/kg	0.002	25000	27000	27000	126	0.002	0.002				0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Toluene	mg/kg	0.005	56000	100000	180000	126	0.005	0.01				0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Xylene	mg/kg		43000	33000	33000																									
M- & P- Xylene	mg/kg	0.002	-	-	-	126	0.002	0.002				0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
O-Xylene	mg/kg	0.002	-	-	-	126	0.002	0.002				0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Total Xylene (M, P & O)	mg/kg	0.004	43000	33000	33000	126		0.004				0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
MTBE	mg/kg		-	-	-																									
naphthalene	mg/kg	0.1	4900	3000	1100	126	0.1	0.1				0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
acenaphthylene	mg/kg	0.1	15000	30000	100000	126	0.1	0.1				0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
acenaphthene	mg/kg	0.1	15000	30000	100000	126	0.1	0.1				0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
fluorene	mg/kg	0.1	9900	20000	71000	126	0.1	0.1				0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
phenanthrene	mg/kg	0.1	3100	6300	23000	126	0.1	1.08				0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.15	0.1	0.1	0.15	0.1
anthracene	mg/kg	0.1	74000	150000	540000	126	0.1	0.29				0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
fluoranthene	mg/kg	0.1	3100	6400	23000	126	0.1	1.75				0.1	0.1	0.1	0.1	0.1	0.1	0.18	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.21	0.1	0.3	0.35	0.1
pyrene	mg/kg	0.1	7400	15000	54000	126	0.1	1.44				0.1	0.1	0.1	0.1	0.1	0.1	0.14	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.22	0.1	0.23	0.28	0.1
benzo(a)anthracene	mg/kg	0.1	29	62	180	126	0.1	0.58				0.1	0.1	0.1	0.1	0.1	0.1	0.36	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.13	0.1	0.44	0.47	0.1
chrysene	mg/kg	0.1	57	120	350	126	0.1	0.55				0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.16	0.1	0.1	0.13	0.1
benzo(b)fluoranthene	mg/kg	0.1	7.2	16	45	126	0.1	0.62				0.1	0.1	0.1	0.1	0.1	0.1	0.16	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.16	0.1	0.21	0.54	0.1
benzo(k)fluoranthene	mg/kg	0.1	190	440	1200	126	0.1	0.19				0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.13	0.1	0.1
benzo(a)pyrene	mg/kg	0.1	5.7	13	36	126	0.1	0.48				0.1	0.1	0.1	0.1	0.1	0.1	0.16	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.11	0.1	0.21	0.21	0.1
indeno(1,2,3-c,d)pyrene	mg/kg	0.1	82	180	510	126	0.1	0.46				0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
dibenzo(ah)anthracene	mg/kg	0.1	0.58	1.4	3.6	126	0.1	0.1				0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
benzo(g,h,i)perylene	mg/kg	0.1	640	1600	4000	126	0.1	0.41				0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total PAH	mg/kg		-	-	-																									
Coal Tar (Bap as surrogate)*	mg/kg	0.1	10	21	77	126	0.1	0.48				0.1	0.1	0.1	0.1	0.1	0.1	0.16	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.11	0.1	0.21	0.21	0.1
PCB (as Aroclors)	mg/kg	0.1	-	-	-	65	0.1	0.1				0.1	0.1		0.1		0.1	0.1	0.1	0.1		0.1				0.1	0.1	0.1		
1,2 Dichloroethane	mg/kg		1400	2300	1100																									
1,1,1 Trichloroethane (TCA)	mg/kg		140000	100000	3000																									
1,1,1,2 Tetrachloroethane	mg/kg		1400	2100	560																									
1,1,2,2 Tetrachloroethane	mg/kg		1400	2300	1100																									
Tetrachloroethene (PCE)	mg/kg		1400	1500	95																									
Carbon Tetrachloride	mg/kg		950	400	14																									
Trichloroethene (TCE)	mg/kg		120	120	5.7																									
Trichloromethane (Chloroform)	mg/kg		2500	3100	350																									
Vinyl Chloride (Chloroethene)	mg/kg		3.5	5.4	0.12																									
Asbestos (Presence of)	TEXT		-	-	-	126						Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
Asbestos Analysts Comments	TEXT		-	-	-																									
Asbestos Fibre Count	%																													

* Category 4 Screening Value @ 6% SOM

TABLE SUMMARISING SOIL RESULTS AND HIGHLIGHTING EXCEEDANCES ABOVE SOIL ASSESSMENT CRITERIA
M3 JUNCTION 9 IMPROVEMENTS

SOM 6%			Assessment Criteria		Strata	SECK	MG	SECK	SECK	MG	PEAT	SECK	ALVg	SECK	SECK	SECK	SECK	SECK	SECK	SECK	SECK	TS	SECK	ALVc	HDD	HDD	SECK	SECK
						DS109A	DS110	DS110	DS110	DS111	DS111	DS111	DS112	DS112	DS114	DS114	DS115	DS115	DS115	DS115	DS115	DS203	DS203	DS204	DS204	DS205	DS205	DS205
Analyte	Units	LOD	POSresi	POSpark	Commercial	9.1	0.25	1.7	8.3	1	4.5	10.3	0.5	6.6	0.5	4	0.25	0.5	3.8	5.1	8.8	0.25	2.2	0.5	5.75	0.25	0.5	4.95
Stones Content	%		-	-	-																							
Arsenic*	mg/kg	2	79	170	640	2	5	2	2	2	5	2	7	2	2	2	3	2	2	2	2	4	2	5	2	4	2	2
Cadmium*	mg/kg	0.2	220	880	410	0.4	0.8	0.4	0.4	0.2	0.9	0.2	0.7	0.2	0.2	0.2	0.6	0.4	0.4	0.3	0.3	0.9	0.3	0.4	0.2	0.8	0.4	0.4
Chromium Trivalent	mg/kg		1500	33000	8600																							
Chromium Hexavalent*	mg/kg	2	21	250	49	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Copper	mg/kg	4	12000	44000	68000	8	18	9	10	14	29	7	11	9	7	8	15	11	8	8	8	12	8	9	4	12	9	9
Lead*	mg/kg	3	630	1300	2300	3	41	3	3	18	22	3	15	3	3	3	16	3	3	3	3	15	3	6	3	11	3	3
Mercury	mg/kg	1	120	240	1100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Nickel	mg/kg	3	230	800	980	3	8	3	3	4	25	3	17	3	3	3	5	3	3	3	3	5	3	11	3	7	3	3
Selenium	mg/kg	3	1100	1800	12000	3	3	3	3	3	6.3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Zinc	mg/kg	3	81000	170000	730000	9	54	9	11	34	108	9	54	7	8	10	29	11	10	9	11	38	9	26	7	36	8	9
Beryllium	mg/kg	0.5	2.2	63	12	0.5	0.5	0.5	0.5	0.5	0.7	0.5	0.9	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Boron	mg/kg	1	21000	46000	240000	1	1	1	1	1	1.1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Vanadium	mg/kg	2	2000	5000	9000	2	16	3	2	5	19	2	32	2	2	2	9	2	2	2	2	14	2	18	3	13	2	2
Cyanide (Total)	mg/kg	2	-	-	-	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Organic matter	mg/kg		-	-	-																							
Phenol, Total	mg/kg		1300	1300	1300																							
Sulphate (Total) as SO4	mg/l	0.02	-	-	-	0.04	0.1	0.04	0.04	0.05	0.15	0.03	0.09	0.05	0.05	0.04	0.07	0.05	0.04	0.04	0.05	0.11	0.04	0.04	0.02	0.09	0.05	0.04
pH	pH Units		-	-	-	6.9	6.9	7	7.1	7.7	7.3	7.3	7	7	7.6	7.6	7.4	7.6	7.2	7.4	8	7.6	8.1	7.4	7.4	7.2	7.3	7.5
>C5 to C6 Aliphatic	mg/kg	0.01	600000	180000	12000	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
>C6 to C8 Aliphatic	mg/kg	0.05	620000	320000	40000	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
>C8 to C10 Aliphatic	mg/kg	2	13000	21000	11000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C10 to C12 Aliphatic	mg/kg	2	13000	24000	47000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C12 to C16 Aliphatic	mg/kg	3	13000	26000	90000	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
>C16 to C21 Aliphatic	mg/kg	3	-	-	-	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
>C21 to C35 Aliphatic	mg/kg	10	-	-	-	10	10	10	35	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
>C16 to C35 Aliphatic	mg/kg	13	250000	490000	1800000	13	13	13	38	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
>C35 to C44 Aliphatic	mg/kg		250000	490000	1800000																							
Total Aliphatic C5-C35	mg/kg	21	-	-	-	21	21	21	35	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
>C5 to C7 Aromatic	mg/kg		56000	92000	86000																							
>C7 to C8 Aromatic	mg/kg	0.05	56000	100000	180000	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
>C8 to C10 Aromatic	mg/kg	2	5000	9300	17000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C10 to C12 Aromatic	mg/kg	2	5000	10000	34000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C12 to C16 Aromatic	mg/kg	2	5000	10000	38000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C16 to C21 Aromatic	mg/kg	3	3800	7800	28000	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
>C21 to C35 Aromatic	mg/kg	10	3800	7900	28000	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
>C35 to C44 Aromatic	mg/kg		3800	7900	28000																							
Total Aromatic C5-C35	mg/kg	21	-	-	-	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
TPH Ali/Aro	mg/kg	42	-	-	-	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42
EPH (C10-C40)	mg/kg		-	-	-																							
Hazard Index - POSresi	-	-	-	-	-	0.0052	0.0052	0.0052	0.0053	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052
Hazard Index - POSpark	-	-	-	-	-	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026
Hazard Index - Commercial	-	-	-	-	-	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010
Benzene*	mg/kg	0.002	140	230	98	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Ethylbenzene	mg/kg	0.002	25000	27000	27000	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Toluene	mg/kg	0.005	56000	100000	180000	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.01	0.005	0.005	0.005
Xylene	mg/kg		43000	33000	33000																							
M- & P- Xylene	mg/kg	0.002	-	-	-	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
O-Xylene	mg/kg	0.002	-	-	-	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Total Xylene (M, P & O)	mg/kg	0.004	43000	33000	33000	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
MTBE	mg/kg		-	-	-																							
naphthalene	mg/kg	0.1	4900	3000	1100	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
acenaphthylene	mg/kg	0.1	15000	30000	100000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
acenaphthene	mg/kg	0.1	15000	30000	100000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
fluorene	mg/kg	0.1	9900	20000	71000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
phenanthrene	mg/kg	0.1	3100	6300	23000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
anthracene	mg/kg	0.1	74000	150000	540000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
fluoranthene	mg/kg	0.1	3100	6400	23000	0.1	0.23	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
pyrene	mg/kg	0.1	7400	15000	54000	0.1	0.21	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
benzo(a)anthracene	mg/kg	0.1	29	62	180	0.1	0.16	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
chrysene	mg/kg	0.1	57	120	350	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
benzo(b)fluoranthene	mg/kg	0.1	7.2	16	45	0.1	0.22	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
benzo(k)fluoranthene	mg/kg	0.1	190	440	1200	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
benzo(a)pyrene	mg/kg	0.1	5.7	13	36	0.1	0.13	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
indeno(1,2,3-c,d)pyrene	mg/kg	0.1	82	180	510	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
dibenzo(ah)anthracene	mg/kg	0.1	0.58	1.4	3.6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
benzo(g,h,i)perylene	mg/kg	0.1	640	1600	4000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total PAH	mg/kg		-	-	-																							
Coal Tar (Bap as surrogate)*	mg/kg	0.1	10	21	77	0.1	0.13	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
PCB (as Aroclors)	mg/kg	0.1	-	-	-	0.1	0.1		0.1	0.1	0.1							0.1				0.1	0.1					
1,2 Dichloroethane	mg/kg		1400	2300	1100																							
1,1,1 Trichloroethane (TCA)	mg/kg		140000	100000	3000																							
1,1,1,2 Tetrachloroethane	mg/kg		1400	2100	560																							
1,1,2,2 Tetrachloroethane	mg/kg		1400	2300	1100																							
Tetrachloroethene (PCE)	mg/kg		1400	1500	95																							
Carbon Tetrachloride	mg/kg		950	400	14																							
Trichloroethene (TCE)	mg/kg		120	120	5.7																							
Trichloromethane (Chloroform)	mg/kg		2500	3100	350																							
Vinyl Chloride (Chloroethene)	mg/kg		3.5	5.4	0.12																							
Asbestos (Presence of)	TEXT		-	-	-	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
Asbestos Analysts Comments	TEXT		-	-	-																							
Asbestos Fibre Count	%																											

* Category 4 Screening Value @ 6% SOM

TABLE SUMMARISING SOIL RESULTS AND HIGHLIGHTING EXCEEDANCES ABOVE SOIL ASSESSMENT CRITERIA
M3 JUNCTION 9 IMPROVEMENTS

					Strata	SECK	SECK	SECK	HDD	SECK	SECK	SECK	TS	SECK	SECK	SECK	SECK	TS	SECK	SECK	SECK	SECK	TS	SECK	TS	SECK	SECK	MG
SOM 6%			Assessment Criteria			DS206	DS206	DS206	DS207	DS207	DS207	DS207	DS208	DS208	DS208	DS209	DS209	DS210	DS210	DS210	DS211	DS211	DS212	DS212	DS213	DS213	DS213	DS214A
Analyte	Units	LOD	POSresi	POSpark	Commercial	0.5	1	4	0.25	0.5	2.4	3.6	0.25	0.5	5.5	0.5	3.8	0.25	0.5	5.1	0.5	4.4	0.25	4	0.25	0.5	5	0.25
Stones Content	%		-	-	-																							
Arsenic*	mg/kg	2	79	170	640	2	2	2	4	2	2	2	2	4	2	2	2	7	2	2	2	2	6	2	5	2	2	5
Cadmium*	mg/kg	0.2	220	880	410	0.6	0.4	0.3	0.9	0.5	0.5	0.4	0.4	0.8	0.3	0.4	0.3	0.8	0.5	0.3	0.3	0.3	0.8	0.4	0.9	0.4	0.3	0.9
Chromium Trivalent	mg/kg		1500	33000	8600																							
Chromium Hexavalent*	mg/kg	2	21	250	49	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Copper	mg/kg	4	12000	44000	68000	9	13	12	16	10	9	9	9	14	9	6	7	20	10	8	10	7	18	8	15	8	10	20
Lead*	mg/kg	3	630	1300	2300	4	3	3	15	3	3	3	4	25	3	3	3	50	16	3	9	5	45	3	26	3	3	48
Mercury	mg/kg	1	120	240	1100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Nickel	mg/kg	3	230	800	980	3	3	3	7	3	3	3	3	5	3	3	3	10	3	3	3	10	9	3	8	3	3	10
Selenium	mg/kg	3	1100	1800	12000	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Zinc	mg/kg	3	81000	170000	730000	14	12	9	48	14	13	9	11	37	9	11	10	56	15	11	20	24	70	9	50	11	12	64
Beryllium	mg/kg	0.5	2.2	63	12	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6
Boron	mg/kg	1	21000	46000	240000	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Vanadium	mg/kg	2	2000	5000	9000	3	2	2	14	3	2	2	2	11	2	2	2	19	3	2	5	15	18	2	17	2	2	20
Cyanide (Total)	mg/kg	2	-	-	-	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Organic matter	mg/kg		-	-	-																							
Phenol, Total	mg/kg		1300	1300	1300																							
Sulphate (Total) as SO4	mg/l	0.02	-	-	-	0.06	0.05	0.05	0.09	0.05	0.05	0.04	0.05	0.09	0.05	0.03	0.03	0.11	0.05	0.05	0.04	0.04	0.09	0.04	0.09	0.04	0.04	0.08
pH	pH Units		-	-	-	7	7.1	7.2	7.3	7.4	7.4	7.4	7.4	7.3	7.7	8.5	8.5	7.3	7.5	8	8.4	8.3	7.3	7.1	6.8	7.2	8	6.7
>C5 to C6 Aliphatic	mg/kg	0.01	600000	180000	12000	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
>C6 to C8 Aliphatic	mg/kg	0.05	620000	320000	40000	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
>C8 to C10 Aliphatic	mg/kg	2	13000	21000	11000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C10 to C12 Aliphatic	mg/kg	2	13000	24000	47000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C12 to C16 Aliphatic	mg/kg	3	13000	26000	90000	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	11
>C16 to C21 Aliphatic	mg/kg	3	-	-	-	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
>C21 to C35 Aliphatic	mg/kg	10	-	-	-	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
>C16 to C35 Aliphatic	mg/kg	13	250000	490000	1800000	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
>C35 to C44 Aliphatic	mg/kg		250000	490000	1800000																							
Total Aliphatic C5-C35	mg/kg	21	-	-	-	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
>C5 to C7 Aromatic	mg/kg		56000	92000	86000																							
>C7 to C8 Aromatic	mg/kg	0.05	56000	100000	180000	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
>C8 to C10 Aromatic	mg/kg	2	5000	9300	17000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C10 to C12 Aromatic	mg/kg	2	5000	10000	34000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C12 to C16 Aromatic	mg/kg	2	5000	10000	38000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	13
>C16 to C21 Aromatic	mg/kg	3	3800	7800	28000	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	5
>C21 to C35 Aromatic	mg/kg	10	3800	7900	28000	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
>C35 to C44 Aromatic	mg/kg		3800	7900	28000																							
Total Aromatic C5-C35	mg/kg	21	-	-	-	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
TPH Ali/Aro	mg/kg	42	-	-	-	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42
EPH (C10-C40)	mg/kg		-	-	-																							
Hazard Index - POSresi	-	-	-	-	-	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0086
Hazard Index - POSpark	-	-	-	-	-	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0043
Hazard Index - Commercial	-	-	-	-	-	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0014
Benzene*	mg/kg	0.002	140	230	98	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Ethylbenzene	mg/kg	0.002	25000	27000	27000	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Toluene	mg/kg	0.005	56000	100000	180000	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Xylene	mg/kg		43000	33000	33000																							
M- & P- Xylene	mg/kg	0.002	-	-	-	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
O-Xylene	mg/kg	0.002	-	-	-	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Total Xylene (M, P & O)	mg/kg	0.004	43000	33000	33000	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
MTBE	mg/kg		-	-	-																							
naphthalene	mg/kg	0.1	4900	3000	1100	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
acenaphthylene	mg/kg	0.1	15000	30000	100000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
acenaphthene	mg/kg	0.1	15000	30000	100000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
fluorene	mg/kg	0.1	9900	20000	71000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
phenanthrene	mg/kg	0.1	3100	6300	23000	0.1	0.1	0.1	0.14	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1.08	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
anthracene	mg/kg	0.1	74000	150000	540000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.29	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
fluoranthene	mg/kg	0.1	3100	6400	23000	0.1	0.1	0.1	0.32	0.1	0.1	0.1	0.55	0.1	0.1	0.1	0.1	1.75	0.1	0.1	0.1	0.1	0.1	0.1	0.15	0.1	0.1	0.15
pyrene	mg/kg	0.1	7400	15000	54000	0.1	0.1	0.1	0.26	0.1	0.1	0.1	0.44	0.1	0.1	0.1	0.1	1.44	0.1	0.1	0.1	0.1	0.1	0.1	0.15	0.1	0.1	0.15
benzo(a)anthracene	mg/kg	0.1	29	62	180	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.13	0.1	0.1	0.1	0.1	0.58	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
chrysene	mg/kg	0.1	57	120	350	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
benzo(b)fluoranthene	mg/kg	0.1	7.2	16	45	0.1	0.1	0.1	0.23	0.1	0.1	0.1	0.28	0.1	0.1	0.1	0.1	0.58	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
benzo(k)fluoranthene	mg/kg	0.1	190	440	1200	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.15	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
benzo(a)pyrene	mg/kg	0.1	5.7	13	36	0.1	0.1	0.1	0.15	0.1	0.1	0.1	0.18	0.1	0.1	0.1	0.1	0.44	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
indeno(1,2,3-c,d)pyrene	mg/kg	0.1	82	180	510	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.34	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
dibenzo(ah)anthracene	mg/kg	0.1	0.58	1.4	3.6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
benzo(g,h,i)perylene	mg/kg	0.1	640	1600	4000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.14	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total PAH	mg/kg		-	-	-																							
Coal Tar (Bap as surrogate)*	mg/kg	0.1	10	21	77	0.1	0.1	0.1	0.15	0.1	0.1	0.1	0.18	0.1	0.1	0.1	0.1	0.44	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
PCB (as Aroclors)	mg/kg	0.1	-	-	-	0.1		0.1		0.1				0.1		0.1	0.1		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1,2 Dichloroethane	mg/kg		1400	2300	1100																							
1,1,1 Trichloroethane (TCA)	mg/kg		140000	100000	3000																							
1,1,1,2 Tetrachloroethane	mg/kg		1400	2100	560																							
1,1,2,2 Tetrachloroethane	mg/kg		1400	2300	1100																							
Tetrachloroethene (PCE)	mg/kg		1400	1500	95																							
Carbon Tetrachloride	mg/kg		950	400	14																							
Trichloroethene (TCE)	mg/kg		120	120	5.7																							
Trichloromethane (Chloroform)	mg/kg		2500	3100	350																							
Vinyl Chloride (Chloroethene)	mg/kg		3.5	5.4	0.12																							
Asbestos (Presence of)	TEXT		-	-	-	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
Asbestos Analysts Comments	TEXT		-	-	-																							
Asbestos Fibre Count	%																											

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* Category 4 Screening Value @ 6% SOM

TABLE SUMMARISING SOIL RESULTS AND HIGHLIGHTING EXCEEDANCES ABOVE SOIL ASSESSMENT CRITERIA
M3 JUNCTION 9 IMPROVEMENTS

SOM 6%			Assessment Criteria		Strata	SECK	MG	SECK	SECK	SECK	MG	MG	MG	MG	MG	SECK	SECK	SECK	SECK	SECK	SECK	SECK	SECK	SECK	SECK	SECK	SECK	TS
						DS214A	DS215	DS215	DS216	DS216	DS217	DS217	DS218	DS218	DS218	DS219	DS219	DS220	DS220	DS301	DS301	DS301	DS302	DS302	DS302	TP03	TP03	TP04
Analyte	Units	LOD	POSresi	POSpark	Commercial	1	0.25	2.5	2.9	7	0.5	4.1	0.65	2	5.7	1	8.7	0.5	5.5	0.5	5.3	8.9	0.5	4.95	10.05	1	3	0.25
Stones Content	%		-	-	-																							
Arsenic*	mg/kg	2	79	170	640	2	7	2	2	2	4	2	2	2	2	2	2	4	2	2	2	2	2	2	2	2	2	4
Cadmium*	mg/kg	0.2	220	880	410	0.5	0.3	0.4	0.2	0.2	0.4	0.3	0.2	0.3	0.3	0.4	0.3	0.8	0.3	0.4	0.2	0.2	0.4	0.2	0.2	0.4	0.4	0.8
Chromium Trivalent	mg/kg		1500	33000	8600																							
Chromium Hexavalent*	mg/kg	2	21	250	49	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Copper	mg/kg	4	12000	44000	68000	8	10	9	9	8	35	7	4	6	7	7	8	10	7	9	9	7	10	9	10	9	8	13
Lead*	mg/kg	3	630	1300	2300	3	21	3	3	3	13	3	3	3	3	3	3	42	3	6	3	3	5	3	3	3	3	13
Mercury	mg/kg	1	120	240	1100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Nickel	mg/kg	3	230	800	980	3	10	3	3	3	6	3	3	3	3	3	3	4	3	3	3	3	4	3	3	3	3	6
Selenium	mg/kg	3	1100	1800	12000	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Zinc	mg/kg	3	81000	170000	730000	12	33	10	11	8	76	8	6	8	9	13	9	190	10	13	9	8	18	8	9	8	7	39
Beryllium	mg/kg	0.5	2.2	63	12	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Boron	mg/kg	1	21000	46000	240000	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Vanadium	mg/kg	2	2000	5000	9000	2	19	2	2	2	6	2	2	2	3	2	2	6	2	3	2	2	6	3	2	3	2	12
Cyanide (Total)	mg/kg	2	-	-	-	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Organic matter	mg/kg		-	-	-																							
Phenol, Total	mg/kg		1300	1300	1300																							
Sulphate (Total) as SO4	mg/l	0.02	-	-	-	0.05	0.46	0.04	0.05	0.05	0.06	0.03	0.02	0.04	0.04	0.04	0.04	0.06	0.04	0.06	0.06	0.04	0.06	0.05	0.05	0.05	0.04	0.08
pH	pH Units		-	-	-	7.2	11	8.3	7.6	7.6	9.6	7.3	8	8.5	8.5	8.6	8.5	7.9	7.5	7.2	7.4	7.4	7.9	7.9	7.9	8	8	7.8
>C5 to C6 Aliphatic	mg/kg	0.01	600000	180000	12000	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
>C6 to C8 Aliphatic	mg/kg	0.05	620000	320000	40000	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
>C8 to C10 Aliphatic	mg/kg	2	13000	21000	11000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C10 to C12 Aliphatic	mg/kg	2	13000	24000	47000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C12 to C16 Aliphatic	mg/kg	3	13000	26000	90000	3	3	3	3	3	3	3	3	3	3	62	3	3	3	3	3	3	3	3	3	3	3	3
>C16 to C21 Aliphatic	mg/kg	3	-	-	-	3	3	3	3	3	3	3	3	3	3	282	3	3	3	3	3	3	3	3	3	3	3	3
>C21 to C35 Aliphatic	mg/kg	10	-	-	-	10	48	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
>C16 to C35 Aliphatic	mg/kg	13	250000	490000	1800000	13	51	13	13	13	13	13	13	13	13	292	13	13	13	13	13	13	13	13	13	13	13	13
>C35 to C44 Aliphatic	mg/kg		250000	490000	1800000																							
Total Aliphatic C5-C35	mg/kg	21	-	-	-	21	48	21	21	21	21	21	21	21	21	343	21	21	21	21	21	21	21	21	21	21	21	21
>C5 to C7 Aromatic	mg/kg		56000	92000	86000																							
>C7 to C8 Aromatic	mg/kg	0.05	56000	100000	180000	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
>C8 to C10 Aromatic	mg/kg	2	5000	9300	17000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C10 to C12 Aromatic	mg/kg	2	5000	10000	34000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C12 to C16 Aromatic	mg/kg	2	5000	10000	38000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C16 to C21 Aromatic	mg/kg	3	3800	7800	28000	3	3	3	3	3	3	3	3	3	3	6	3	3	3	3	3	3	3	3	3	3	3	3
>C21 to C35 Aromatic	mg/kg	10	3800	7900	28000	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
>C35 to C44 Aromatic	mg/kg		3800	7900	28000																							
Total Aromatic C5-C35	mg/kg	21	-	-	-	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
TPH Ali/Aro	mg/kg	42	-	-	-	42	48	42	42	42	42	42	42	42	42	349	42	42	42	42	42	42	42	42	42	42	42	42
EPH (C10-C40)	mg/kg		-	-	-																							
Hazard Index - POSresi	-	-	-	-	-	0.0052	0.0054	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0117	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052
Hazard Index - POSpark	-	-	-	-	-	0.0026	0.0027	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0058	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026
Hazard Index - Commercial	-	-	-	-	-	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0019	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010
Benzene*	mg/kg	0.002	140	230	98	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Ethylbenzene	mg/kg	0.002	25000	27000	27000	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Toluene	mg/kg	0.005	56000	100000	180000	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Xylene	mg/kg		43000	33000	33000																							
M- & P- Xylene	mg/kg	0.002	-	-	-	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
O-Xylene	mg/kg	0.002	-	-	-	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Total Xylene (M, P & O)	mg/kg	0.004	43000	33000	33000	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
MTBE	mg/kg		-	-	-																							
naphthalene	mg/kg	0.1	4900	3000	1100	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
acenaphthylene	mg/kg	0.1	15000	30000	100000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
acenaphthene	mg/kg	0.1	15000	30000	100000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
fluorene	mg/kg	0.1	9900	20000	71000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
phenanthrene	mg/kg	0.1	3100	6300	23000	0.1	0.46	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
anthracene	mg/kg	0.1	74000	150000	540000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
fluoranthene	mg/kg	0.1	3100	6400	23000	0.1	0.62	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.22	0.1	0.1	0.1	0.1	0.1
pyrene	mg/kg	0.1	7400	15000	54000	0.1	0.46	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.17	0.1	0.1	0.1	0.1	0.1
benzo(a)anthracene	mg/kg	0.1	29	62	180	0.1	0.45	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
chrysene	mg/kg	0.1	57	120	350	0.1	0.16	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
benzo(b)fluoranthene	mg/kg	0.1	7.2	16	45	0.1	0.46	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.21	0.1	0.1	0.1	0.1	0.1
benzo(k)fluoranthene	mg/kg	0.1	190	440	1200	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
benzo(a)pyrene	mg/kg	0.1	5.7	13	36	0.1	0.18	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.13	0.1	0.1	0.1	0.1	0.1
indeno(1,2,3-c,d)pyrene	mg/kg	0.1	82	180	510	0.1	0.25	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
dibenzo(ah)anthracene	mg/kg	0.1	0.58	1.4	3.6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
benzo(g,h,i)perylene	mg/kg	0.1	640	1600	4000	0.1	0.15	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total PAH	mg/kg		-	-	-																							
Coal Tar (Bap as surrogate)*	mg/kg	0.1	10	21	77	0.1	0.18	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.13	0.1	0.1	0.1	0.1	0.1
PCB (as Aroclors)	mg/kg	0.1	-	-	-	0.1	0.1	0.1	0.1		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1									
1,2 Dichloroethane	mg/kg		1400	2300	1100																							
1,1,1 Trichloroethane (TCA)	mg/kg		140000	100000	3000																							
1,1,1,2 Tetrachloroethane	mg/kg		1400	2100	560																							
1,1,2,2 Tetrachloroethane	mg/kg		1400	2300	1100																							
Tetrachloroethene (PCE)	mg/kg		1400	1500	95																							
Carbon Tetrachloride	mg/kg		950	400	14																							
Trichloroethene (TCE)	mg/kg		120	120	5.7																							
Trichloromethane (Chloroform)	mg/kg		2500	3100	350																							
Vinyl Chloride (Chloroethene)	mg/kg		3.5	5.4	0.12																							
Asbestos (Presence of)	TEXT		-	-	-	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
Asbestos Analysts Comments	TEXT		-	-	-																							
Asbestos Fibre Count	%																											

* Category 4 Screening Value @ 6% SOM

TABLE SUMMARISING SOIL RESULTS AND HIGHLIGHTING EXCEEDANCES ABOVE SOIL ASSESSMENT CRITERIA
M3 JUNCTION 9 IMPROVEMENTS

SOM 6%			Assessment Criteria		Strata	SECK	SECK	SECK	MG	SECK	MG	SECK	HDD	SECK	SECK	SECK	HDD	SECK	SECK	SECK	SECK	SECK	MG	MG	MG	MG	ALVg	ALVg
						TP04	TP05	TP05	TP06	TP06	TP07	TP07	TP08	TP08	TP08	TP09	TP10	TP10	TP11	TP11	TP12	TP12	WS01	WS01	WS01	WS02	WS02	WS02
Analyte	Units	LOD	POSresi	POSpark	Commercial	1	0.5	2	0.25	3	0.25	1	0.3	1	3	3	0.5	3	0.3	3	1	4	0.25	0.5	4.7	0.5	2.55	4.8
Stones Content	%		-	-	-																							
Arsenic*	mg/kg	2	79	170	640	2	2	2	4	2	2	2	4	2	2	2	4	2	3	2	2	2	6	2	2	3	7	3
Cadmium*	mg/kg	0.2	220	880	410	0.4	0.4	0.3	0.8	0.3	0.2	0.3	0.9	0.4	0.2	0.2	0.5	0.2	0.5	0.2	0.2	0.3	0.5	0.2	0.2	0.2	0.2	1.3
Chromium Trivalent	mg/kg		1500	33000	8600																							
Chromium Hexavalent*	mg/kg	2	21	250	49	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Copper	mg/kg	4	12000	44000	68000	10	7	6	12	8	4	8	13	9	4	10	11	8	9	8	11	8	17	9	9	10	4	4
Lead*	mg/kg	3	630	1300	2300	3	3	3	19	3	3	3	15	3	3	3	13	3	5	3	3	3	53	8	11	4	8	3
Mercury	mg/kg	1	120	240	1100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Nickel	mg/kg	3	230	800	980	3	3	3	5	3	3	3	8	3	3	3	7	3	5	3	3	3	6	3	3	4	3	9
Selenium	mg/kg	3	1100	1800	12000	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Zinc	mg/kg	3	81000	170000	730000	11	11	10	34	8	3	9	48	12	7	10	29	8	19	9	11	10	52	15	15	16	8	11
Beryllium	mg/kg	0.5	2.2	63	12	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Boron	mg/kg	1	21000	46000	240000	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Vanadium	mg/kg	2	2000	5000	9000	3	2	3	12	2	2	2	15	3	2	3	12	2	8	2	2	2	10	3	2	6	9	6
Cyanide (Total)	mg/kg	2	-	-	-	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Organic matter	mg/kg		-	-	-																							
Phenol, Total	mg/kg		1300	1300	1300																							
Sulphate (Total) as SO4	mg/l	0.02	-	-	-	0.05	0.04	0.05	0.1	0.04	0.12	0.04	0.16	0.05	0.02	0.05	0.07	0.05	0.06	0.05	0.06	0.04	0.06	0.04	0.06	0.04	0.02	0.03
pH	pH Units		-	-	-	8	8.3	8.2	6.8	7.4	7.3	7.5	7.4	7.3	7.3	7.3	7.3	7.4	7.3	7.4	7.3	7.3	8.1	8.5	8.6	7.1	7.2	8
>C5 to C6 Aliphatic	mg/kg	0.01	600000	180000	12000	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
>C6 to C8 Aliphatic	mg/kg	0.05	620000	320000	40000	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
>C8 to C10 Aliphatic	mg/kg	2	13000	21000	11000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C10 to C12 Aliphatic	mg/kg	2	13000	24000	47000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C12 to C16 Aliphatic	mg/kg	3	13000	26000	90000	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	7	3	3	3	3	3
>C16 to C21 Aliphatic	mg/kg	3	-	-	-	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
>C21 to C35 Aliphatic	mg/kg	10	-	-	-	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	57	10	10	10	10	10
>C16 to C35 Aliphatic	mg/kg	13	250000	490000	1800000	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	60	13	13	13	13	13
>C35 to C44 Aliphatic	mg/kg		250000	490000	1800000																							
Total Aliphatic C5-C35	mg/kg	21	-	-	-	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	63	21	21	21	21	21
>C5 to C7 Aromatic	mg/kg		56000	92000	86000																							
>C7 to C8 Aromatic	mg/kg	0.05	56000	100000	180000	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
>C8 to C10 Aromatic	mg/kg	2	5000	9300	17000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C10 to C12 Aromatic	mg/kg	2	5000	10000	34000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C12 to C16 Aromatic	mg/kg	2	5000	10000	38000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	8	2	2	2	2	2
>C16 to C21 Aromatic	mg/kg	3	3800	7800	28000	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	14	3	3	3	3	3
>C21 to C35 Aromatic	mg/kg	10	3800	7900	28000	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	141	10	10	10	10	10
>C35 to C44 Aromatic	mg/kg		3800	7900	28000																							
Total Aromatic C5-C35	mg/kg	21	-	-	-	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	163	21	21	21	21	21
TPH Ali/Aro	mg/kg	42	-	-	-	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	226	42	42	42	42	42
EPH (C10-C40)	mg/kg		-	-	-																							
Hazard Index - POSresi	-	-	-	-	-	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0443	0.0052	0.0052	0.0052	0.0052	0.0052
Hazard Index - POSpark	-	-	-	-	-	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0214	0.0026	0.0026	0.0026	0.0026	0.0026
Hazard Index - Commercial	-	-	-	-	-	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0063	0.0010	0.0010	0.0010	0.0010	0.0010
Benzene*	mg/kg	0.002	140	230	98	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Ethylbenzene	mg/kg	0.002	25000	27000	27000	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Toluene	mg/kg	0.005	56000	100000	180000	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Xylene	mg/kg		43000	33000	33000																							
M- & P- Xylene	mg/kg	0.002	-	-	-	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
O-Xylene	mg/kg	0.002	-	-	-	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Total Xylene (M, P & O)	mg/kg	0.004	43000	33000	33000	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
MTBE	mg/kg		-	-	-																							
naphthalene	mg/kg	0.1	4900	3000	1100	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
acenaphthylene	mg/kg	0.1	15000	30000	100000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
acenaphthene	mg/kg	0.1	15000	30000	100000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
fluorene	mg/kg	0.1	9900	20000	71000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
phenanthrene	mg/kg	0.1	3100	6300	23000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.27	0.1	0.1	0.1	0.1	0.1
anthracene	mg/kg	0.1	74000	150000	540000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
fluoranthene	mg/kg	0.1	3100	6400	23000	0.1	0.1	0.1	0.1	0.1	0.12	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.85	0.1	0.1	0.1	0.1	0.1
pyrene	mg/kg	0.1	7400	15000	54000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.84	0.1	0.1	0.1	0.1	0.1
benzo(a)anthracene	mg/kg	0.1	29	62	180	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.58	0.1	0.1	0.1	0.1	0.1
chrysene	mg/kg	0.1	57	120	350	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.55	0.1	0.1	0.1	0.1	0.1
benzo(b)fluoranthene	mg/kg	0.1	7.2	16	45	0.1	0.1	0.1	0.1	0.1	0.21	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.62	0.1	0.1	0.1	0.1	0.1
benzo(k)fluoranthene	mg/kg	0.1	190	440	1200	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.19	0.1	0.1	0.1	0.1	0.1
benzo(a)pyrene	mg/kg	0.1	5.7	13	36	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.48	0.1	0.1	0.1	0.1	0.1
indeno(1,2,3-c,d)pyrene	mg/kg	0.1	82	180	510	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.29	0.1	0.1	0.1	0.1	0.1
dibenzo(ah)anthracene	mg/kg	0.1	0.58	1.4	3.6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
benzo(g,h,i)perylene	mg/kg	0.1	640	1600	4000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.41	0.1	0.1	0.1	0.1	0.1
Total PAH	mg/kg		-	-	-																							
Coal Tar (Bap as surrogate)*	mg/kg	0.1	10	21	77	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.48	0.1	0.1	0.1	0.1	0.1
PCB (as Aroclors)	mg/kg	0.1	-	-	-	0.1	0.1				0.1	0.1				0.1							0.1	0.1		0.1		
1,2 Dichloroethane	mg/kg		1400	2300	1100																							
1,1,1 Trichloroethane (TCA)	mg/kg		140000	100000	3000																							
1,1,1,2 Tetrachloroethane	mg/kg		1400	2100	560																							
1,1,2,2 Tetrachloroethane	mg/kg		1400	2300	1100																							
Tetrachloroethene (PCE)	mg/kg		1400	1500	95																							
Carbon Tetrachloride	mg/kg		950	400	14																							
Trichloroethene (TCE)	mg/kg		120	120	5.7																							
Trichloromethane (Chloroform)	mg/kg		2500	3100	350																							
Vinyl Chloride (Chloroethene)	mg/kg		3.5	5.4	0.12																							
Asbestos (Presence of)	TEXT		-	-	-	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
Asbestos Analysts Comments	TEXT		-	-	-																							
Asbestos Fibre Count	%																											

* Category 4 Screening Value @ 6% SOM

TABLE SUMMARISING SOIL RESULTS AND HIGHLIGHTING EXCEEDANCES ABOVE SOIL ASSESSMENT CRITERIA
M3 JUNCTION 9 IMPROVEMENTS

SOM 6%			Assessment Criteria		Strata	MG	PEAT	TS	SECK	SECK	HDD	SECK	MG	SECK	SECK	MG	SECK	MG	MG	HDD
						WS03	WS03	WS04	WS04	WS04	WS05	WS05	WS06	WS06	WS06	WS07	WS07	WS08	WS08	WS08
Analyte	Units	LOD	POSresi	POSpark	Commercial	3.92	4.76	0.25	1.8	6.7	0.25	3	0.25	2	6	0.25	1	0.5	1.7	5.9
Stones Content	%		-	-	-															
Arsenic*	mg/kg	2	79	170	640	5	5	6	2	2	6	2	5	2	2	3	2	7	2	4
Cadmium*	mg/kg	0.2	220	880	410	0.4	0.4	0.9	0.4	0.3	0.8	0.4	0.8	0.4	0.3	0.6	0.5	0.5	0.2	0.4
Chromium Trivalent	mg/kg		1500	33000	8600															
Chromium Hexavalent*	mg/kg	2	21	250	49	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Copper	mg/kg	4	12000	44000	68000	11	24	17	8	8	20	8	14	9	8	15	8	20	10	8
Lead*	mg/kg	3	630	1300	2300	21	3	47	3	3	49	3	29	3	3	26	6	61	3	4
Mercury	mg/kg	1	120	240	1100	1.2	2.9	1	1	1	1	1	1	1	1	1	1	1	1	1
Nickel	mg/kg	3	230	800	980	7	34	9	3	3	8	3	7	3	3	4	3	8	3	6
Selenium	mg/kg	3	1100	1800	12000	3	13.6	3	3	3	3	3	3	3	3	3	3	3	3	3
Zinc	mg/kg	3	81000	170000	730000	31	29	59	10	9	57	10	48	10	9	52	17	60	12	15
Beryllium	mg/kg	0.5	2.2	63	12	0.5	0.5	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Boron	mg/kg	1	21000	46000	240000	4	1.5	1	1	1	1	1	1	1	1	1	1	1	1	1
Vanadium	mg/kg	2	2000	5000	9000	8	17	20	2	2	18	2	16	2	2	8	2	3	4	10
Cyanide (Total)	mg/kg	2	-	-	-	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Organic matter	mg/kg		-	-	-															
Phenol, Total	mg/kg		1300	1300	1300															
Sulphate (Total) as SO4	mg/l	0.02	-	-	-	0.18	0.22	0.09	0.05	0.04	0.1	0.05	0.09	0.04	0.04	0.06	0.05	0.06	0.05	0.05
pH	pH Units		-	-	-	7.4	7.1	7.4	7.8	7.8	7.8	7.9	7.5	7.7	7.7	8	8.2	8	7.8	8
>C5 to C6 Aliphatic	mg/kg	0.01	600000	180000	12000	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
>C6 to C8 Aliphatic	mg/kg	0.05	620000	320000	40000	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
>C8 to C10 Aliphatic	mg/kg	2	13000	21000	11000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C10 to C12 Aliphatic	mg/kg	2	13000	24000	47000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C12 to C16 Aliphatic	mg/kg	3	13000	26000	90000	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
>C16 to C21 Aliphatic	mg/kg	3	-	-	-	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
>C21 to C35 Aliphatic	mg/kg	10	-	-	-	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
>C16 to C35 Aliphatic	mg/kg	13	250000	490000	1800000	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
>C35 to C44 Aliphatic	mg/kg		250000	490000	1800000															
Total Aliphatic C5-C35	mg/kg	21	-	-	-	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
>C5 to C7 Aromatic	mg/kg		56000	92000	86000															
>C7 to C8 Aromatic	mg/kg	0.05	56000	100000	180000	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
>C8 to C10 Aromatic	mg/kg	2	5000	9300	17000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
>C10 to C12 Aromatic	mg/kg	2	5000	10000	34000	2	2	2	2	2	2	2	2	2	5	2	2	2	2	2
>C12 to C16 Aromatic	mg/kg	2	5000	10000	38000	2	2	2	2	2	2	2	2	2	9	2	2	2	2	2
>C16 to C21 Aromatic	mg/kg	3	3800	7800	28000	16	3	3	3	3	3	3	3	3	3	3	3	3	3	3
>C21 to C35 Aromatic	mg/kg	10	3800	7900	28000	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
>C35 to C44 Aromatic	mg/kg		3800	7900	28000															
Total Aromatic C5-C35	mg/kg	21	-	-	-	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
TPH Ali/Aro	mg/kg	42	-	-	-	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42
EPH (C10-C40)	mg/kg		-	-	-															
Hazard Index - POSresi	-	-	-	-	-	0.0086	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0072	0.0052	0.0052	0.0052	0.0052	0.0052
Hazard Index - POSpark	-	-	-	-	-	0.0043	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0036	0.0026	0.0026	0.0026	0.0026	0.0026
Hazard Index - Commercial	-	-	-	-	-	0.0014	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0012	0.0010	0.0010	0.0010	0.0010	0.0010
Benzene*	mg/kg	0.002	140	230	98	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Ethylbenzene	mg/kg	0.002	25000	27000	27000	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Toluene	mg/kg	0.005	56000	100000	180000	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Xylene	mg/kg		43000	33000	33000															
M- & P- Xylene	mg/kg	0.002	-	-	-	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
O-Xylene	mg/kg	0.002	-	-	-	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Total Xylene (M, P & O)	mg/kg	0.004	43000	33000	33000	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
MTBE	mg/kg		-	-	-															
naphthalene	mg/kg	0.1	4900	3000	1100	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
acenaphthylene	mg/kg	0.1	15000	30000	100000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
acenaphthene	mg/kg	0.1	15000	30000	100000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
fluorene	mg/kg	0.1	9900	20000	71000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
phenanthrene	mg/kg	0.1	3100	6300	23000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1
anthracene	mg/kg	0.1	74000	150000	540000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
fluoranthene	mg/kg	0.1	3100	6400	23000	0.33	0.1	0.36	0.1	0.1	0.28	0.1	0.16	0.1	0.1	0.1	0.1	0.58	0.1	0.1
pyrene	mg/kg	0.1	7400	15000	54000	0.29	0.1	0.31	0.1	0.1	0.24	0.1	0.14	0.1	0.1	0.1	0.1	0.5	0.1	0.1
benzo(a)anthracene	mg/kg	0.1	29	62	180	0.4	0.1	0.42	0.1	0.1	0.44	0.1	0.1	0.1	0.1	0.1	0.1	0.48	0.1	0.1
chrysene	mg/kg	0.1	57	120	350	0.1	0.1	0.12	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.28	0.1	0.1
benzo(b)fluoranthene	mg/kg	0.1	7.2	16	45	0.32	0.1	0.49	0.1	0.1	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.52	0.1	0.1
benzo(k)fluoranthene	mg/kg	0.1	190	440	1200	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.18	0.1	0.1
benzo(a)pyrene	mg/kg	0.1	5.7	13	36	0.1	0.1	0.19	0.1	0.1	0.24	0.1	0.1	0.1	0.1	0.1	0.1	0.38	0.1	0.1
indeno(1,2,3-c,d)pyrene	mg/kg	0.1	82	180	510	0.1	0.1	0.1	0.1	0.1	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.46	0.1	0.1
dibenzo(ah)anthracene	mg/kg	0.1	0.58	1.4	3.6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
benzo(g,h,i)perylene	mg/kg	0.1	640	1600	4000	0.1	0.1	0.1	0.1	0.1	0.17	0.1	0.1	0.1	0.1	0.1	0.1	0.33	0.1	0.1
Total PAH	mg/kg		-	-	-															
Coal Tar (Bap as surrogate)*	mg/kg	0.1	10	21	77	0.1	0.1	0.19	0.1	0.1	0.24	0.1	0.1	0.1	0.1	0.1	0.1	0.38	0.1	0.1
PCB (as Aroclors)	mg/kg	0.1	-	-	-	0.1			0.1	0.1	0.1	0.1	0.1	0.1	0.1			0.1		
1,2 Dichloroethane	mg/kg		1400	2300	1100															
1,1,1 Trichloroethane (TCA)	mg/kg		140000	100000	3000															
1,1,1,2 Tetrachloroethane	mg/kg		1400	2100	560															
1,1,2,2 Tetrachloroethane	mg/kg		1400	2300	1100															
Tetrachloroethene (PCE)	mg/kg		1400	1500	95															
Carbon Tetrachloride	mg/kg		950	400	14															
Trichloroethene (TCE)	mg/kg		120	120	5.7															
Trichloromethane (Chloroform)	mg/kg		2500	3100	350															
Vinyl Chloride (Chloroethene)	mg/kg		3.5	5.4	0.12															
Asbestos (Presence of)	TEXT		-	-	-	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
Asbestos Analysts Comments	TEXT		-	-	-															
Asbestos Fibre Count	%																			

* Category 4 Screening Value @ 6% SOM

Appendix D Controlled Water Risk Assessment

TECHNICAL NOTE

Job Name: M3 Junction 9 Improvements

Job No: 48176/3501

Doc Ref: HE551511-VFK-EGT-X_XXXX_XX-TN-GE-003

Date: December 2020

Prepared By: Natasha Caton

Reviewed By: Kate Riley

Subject: **Controlled Waters Risk Assessment**

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1 Introduction

1.1 Preamble

1.1.1 Stantec UK Limited (Stantec) has been commissioned by VolkerFitzpatrick Limited and Highways England (the Client) to undertake a Controlled Waters Risk Assessment for the M3 Junction 9 Improvement Site, Winchester, based on the factual findings of the Factual Ground Investigation Report (HE551511-HEX-EGT-ZZ-RP-CE-0001) (Soils Limited, August 2019, amended July 2020)

1.1.2 This Technical Note has been written to accompany the Phase 2 Ground Investigation Report undertaken by Stantec (December 2020b) which contains information on the ground conditions. The Ground Investigation specification was prepared by Jacobs and the field data and laboratory analysis was undertaken by the Principal Contractor, Geoffrey Osborne Limited, who employed the ground investigation contractor Soils Limited.

1.1.3 This Technical Note presents a Stage 1, Tier 2 Generic Qualitative Risk Assessment (GQRA) in respect to Controlled Waters receptors and has also been prepared to support the Development Consent Order (DCO) application. An explanation of the staged risk management approach is presented in Section 4 of this Technical Note.

1.2 Sources of Information

1.2.1 The following sources of information were used in the preparation of this technical note and should be read in conjunction with this technical note:

- Factual Ground Investigation Report (HE551511-HEX-EGT-ZZ-RP-CE-0001) (Soils Limited, August 2019, amended July 2020)
- PCF Stage 2 – Preliminary Sources Study Report (HE551511-WSP-HGT-ZZ-RP-CE-0001) (WSP, September 2017)
- Preliminary Environmental Information Report (PEIR) (GFD19_0101_M3 Junction 9) (Jacobs, June 2019)
- Project Control Framework (PCF) Stage 2 – Preliminary Sources Study Report (HE551511-WSP-HGT-ZZ-RP-CE-0001) (WSP, September 2017)
- PCF Stage 3B: Phase 1 Ground Condition Assessment (Contamination and Stability for Proposed Deposition and Compound Areas (HE551511-VFK-EGT-X_XXXX_XX-RP-GE-0001) (Stantec, December 2020a)
- PCF Stage 3B: Ground Investigation Report (HE552988-VFK-HGT-X_XXXX_XX-RP-CE-0001) (Stantec, December 2020b)

2 Site Setting

2.1 Geology & Ground Conditions

2.1.1 The anticipated ground conditions within the M3 J9 Improvement Site have been determined through review of the published geological mapping and intrusive information contained within both the Factual Ground Investigation Report (Soils Limited, 2020) and the Ground Investigation Report (Stantec, 2020b).

Published Geology

2.1.2 The published BGS geological mapping indicates that the majority of the M3 J9 Improvement Site is underlain by solid geology comprising the Seaford Chalk formation, with the overlying Newhaven Chalk only present in the area to the east of the M3, in the northern part of the study area. The Seaford Chalk formation is underlain by the Lewes Nodular Chalk formation, and in the southern extent of the Site, the Lewes Nodular Chalk is indicated to outcrop at the ground surface.

2.1.3 Along the route of the River Itchen, which traverses the northern part of the M3 J9 Improvement Site, the solid geology is overlain by superficial deposits comprising Alluvium. There are also smaller transects of superficial deposits, comprising Head, overlying the solid geology, located to the north and to the south of the existing junction, and in the northern parts of the Site.

2.1.4 In the area to the east of the M3 and to the south of the River Itchen, the geological mapping also indicates there may be an area of Clay with Flints and Head deposits overlying the Newhaven Chalk Formation (which overlies the Seaford Chalk Formation where present).

Encountered Ground Conditions

2.1.5 A Phase 2 geotechnical and geo-environmental ground investigation was undertaken across parts of the M3 J9 Improvement Site between March 2019 and June 2019. The information from the investigation generally confirms the anticipated/published ground conditions. Further details can be found within the Ground Investigation Report (Stantec, 2020b).

2.1.6 In addition to the published geology described above, made ground and engineered fill is also present within the Site, associated with the construction of the M3, A34, A33 and other infrastructure. The made ground and engineering fill material predominantly comprises reworked natural strata with lenses of organic soil and extends to a maximum of 11.35m below ground level.

2.1.7 The Ground Investigation Report did not identify any evidence of contamination or exceedances of the relevant assessment criteria within the soil results.

2.2 Historical Land Use

2.2.1 The historical land use (relevant to the potential for contamination) has previously been determined and presented in the Preliminary Sources Study Report (PSSR) (WSP, 2017), and Phase 1 Desk Study (Stantec, 2020a) respectively. These are based on historical Ordnance Survey maps obtained as part of an Envirocheck Report. In summary, the area of the current M3 J9 roundabout and its immediate surroundings remained undeveloped until the construction of the A33 in the late 1930’s and later, in the early 1980’s, when J9 of the M3 is shown to have been constructed. The Didcot, Newbury and Southampton railway line is indicated to have been constructed in the late 1890’s 200m to the west of the Site, along the eastern bank of the River Itchen, crossing the northern section of the Site. The railway line remained until the 1960’s when it was dismantled. In the wider area there have been various industrial uses such as iron and gas works, although these sites have since been redeveloped and are outside of the proposed works.

2.2.2 A review of available other published information has identified records for three historical landfills or close to the Site. These are located beneath the existing M3 J9 roundabout (Spitfire Link), on the western side of the A34 at the northern tip of Wykeham Industrial Estate (land between Old Newbury Railway and A33) and between the A34/A33 and M3 carriageways, south of the River Itchen (land adjacent to Winchester Bypass). Further commentary is given below:

- The 'Spitfire Link, Easton Lane' landfill was investigated in part by Soils Limited (2020) with six exploratory holes undertaken within or immediately adjacent to the mapped extents of the landfill. No evidence of waste or Made Ground was indicated on those exploratory hole records. It is considered unlikely that the landfill therefore represents a source of significant contamination.

- The 'Land Adjacent to Winchester Bypass, Abbots Worth, Hampshire' landfill is recorded as accepting inert waste from 1967 through to 1968. The licence holder is listed as D Hewestson-Brown. The recorded operational period broadly corresponds with the widening of the Winchester Bypass and construction of a gantry crossing the River Itchen. It is considered that the landfill may therefore have been used to accept earthworks arisings from that scheme and is therefore unlikely to represent a source of significant contamination.

- The third landfill 'Land Between Old Newbury Railway and A33' is located to the west of Winchester bypass and is very small therefore unlikely to have operated commercially and therefore unlikely to represent a significant risk.

2.2.3 Based on the information above the risk from the historical landfills to the M3 J9 Improvement Site is considered to be Low.

2.2.4 Contrary to the 'published information' outlined above, a review of the available historical OS mapping and investigations to date have not specifically identified the presence of infilled workings/landfills.

2.3 Current Land Use

2.3.1 The majority of the M3 J9 Improvement Site comprises the carriageways of the M3, A33 and A34. In the area to the east of the M3, the land use is predominantly agricultural.

2.3.2 In the areas to the west of the A34, the land use is predominantly highway land or undeveloped land adjacent to the highway. However, in the wider Site, the land use is varied including flood plain, residential and mixed use industrial.

2.3.3 In the northern part of the M3 J9 Improvement Site, the predominant current land use is mixed, comprising residential, agricultural and flood plain.

3 Hydrological and Hydrogeological Conceptual Site Model

3.1 Introduction

3.1.1 The conceptual site model (CSM) describes the types and locations of potential contamination sources, the identification of potential receptors and the identification of potential transport/migration pathways.

3.1.2 For a pollutant linkage to be identified a connection between all three elements (source-pathway-receptor) is required. An assessment of the hydrogeological conceptual site model (CSM) has been undertaken and draws on the information from a ground investigation by Soils Limited which took place between March and June 2019.

3.1.3 It should be noted that this CSM only addresses risks to controlled waters; assessment of risks to human health and other receptors is presented within the Phase 2 Ground Investigation Report (Stantec, 2020b). A full description of the environmental setting of the M3 J9 Improvement Site, including the geology, hydrology and hydrogeology is contained within the Phase 1 Ground Condition Assessment (Stantec, 2020a) and Ground Investigation Report (Stantec, 2020b), together with supporting documents.

3.2 Sources

3.2.1 The potentially contaminative land uses and contaminants of concern based on the current and historical land uses are presented in **Table 3.1**.

Table 3-1 Potentially Contaminative Land Uses and Contaminants of Concern

Land Use	Potential Contaminants of Concern
Motorway/'A' Road	Metals and metalloids, chloride, polycyclic aromatic hydrocarbons (PAHs), oil/fuel hydrocarbons, sulphates, asbestos.
Historical Landfill	Metals and metalloids, PAHs), oil/fuel hydrocarbons, sulphates, asbestos, landfill gas, leachate, acids, ammonia.
Historical Railway Line	Metals and metalloids, PAHs, oil/fuel hydrocarbons, lubricating oils, creosotes, sulphates.
Agricultural Land	Hydrocarbons and lubricating oils associated with machinery and nitrates from fertilisers. Potential pesticides and herbicides.
Gas Works	Metals and metalloids, inorganic compounds, coal tars, PAHs, oil/fuel hydrocarbons, acids, alkalis.
Iron Works	Metals and metalloids, inorganic compounds, Polychlorinated Biphenyls (PCBs)
Mixed Industrial Use	Metals and organo-metals, PAHs, oil/fuel hydrocarbons, sulphates, asbestos, PFAS.

3.3 Receptors

3.3.1 The nearest surface water receptor is the River Itchen, which is present across the north and along the west of the M3 J9 Improvement Site. The River Itchen flows to the south towards Southampton and is designated a Site of Special Scientific Interest (SSSI) and a Special Area of Conservation (SAC). A further surface water feature and receptor, 'Nun's Walk Stream' flows in a channel approximately parallel to the River Itchen and is classified by the EA as a Main River.

3.3.2 The Seaford Chalk Formation which is beneath the entire M3 J9 Improvement Site is designated as a Principal Aquifer, and the overlying superficial deposits are designated as Secondary Aquifers, the Alluvium as a Secondary A Aquifer, and the Head as a Secondary (undifferentiated) Aquifer which are beneath only parts of the Site. It is also considered that the aquifers are in hydraulic continuity. These designations reflect the importance of the aquifers in terms of groundwater as a resource (drinking water supply) but also their role in supporting surface water flows and wetland ecosystems.

3.3.3 Parts of the study area in the north are covered by both Zones 1 and 2 groundwater Source Protection Zones (SPZs) which are associated with two abstraction points for potable drinking supply located in the north of the Site. These drinking water supplies are both abstracted from the Chalk. The Secondary A aquifer is also believed to be in continuity with the Principal aquifer.

3.3.4 The sensitivity of the receptors is detailed in **Table 3.2** below:

Table 3-3 Controlled Water Receptor Sensitivity

Receptor	Sensitivity
Groundwater	Very High
Surface Waters	Very High

3.4 Pathways

3.4.1 The leaching and vertical and lateral migration of dissolved phase contaminants to the surrounding and underlying Principal aquifer and River Itchen is considered a viable pathway. Infill material and superficial deposits across the M3 J9 Improvement Site may dependant on their precise nature and form also act as a preferential pathway to the Principal Aquifer and hence groundwater.

3.4.2 There is also the potential for runoff from roads and agricultural land to affect the River Itchen and groundwater, via either permeation into the underlying soils, and runoff, or as a result of surface water drainage discharges to water bodies.

3.5 Potential Pollutant Linkages

3.5.1 The preliminary Conceptual Model, as discussed above and also presented within the Ground Investigation Report (Stantec, 2020b) identified potential impacts to controlled waters receptors, including the underlying Secondary A aquifer within superficial deposits and Principal aquifer within the Seaford Chalk Formation and nearby surface water courses.

4 Generic Qualitative Risk Assessment (GQRA)

4.1 Introduction

4.1.1 Online guidance entitled Land Contamination: Risk Management (LC:RM) from GOV.UK states that to manage existing (historical) contamination it is necessary to identify and assess the level of risk, decide if that risk is unacceptable to identified receptor(s) and decide how to manage any unacceptable risks. Further information on the assessment of land contamination is given in the Stantec guide presented in **Appendix CWRA 1.**

4.1.2 LC:RM presents three stages of risk management (1) Stage 1: Risk assessment (2) Stage 2: Options appraisal and (3) Stage 3: Remediation and each stage has three tiers.

4.1.3 The progressive tiers of a Stage 1 Risk Assessment are:

- Tier 1 Preliminary (qualitative) Risk Assessment (PRA): containing generic factual information with the assessed risks informed by professional judgement.
- Tier 2 Generic Quantitative Risk Assessment (GQRA): which uses site specific factual data from intrusive investigations with the assessed risks stated with reasonable certainty, through to.
- Tier 3 Detailed Quantitative Risk Assessment (DQRA). providing numerical analysis of modelling of the aquifer properties and groundwater quality.

4.1.4 This technical note presents a Stage 1 Risk Assessment - Tier 2 GQRA and the evaluation of site-specific contamination data compared to published Generic Assessment Criteria (GAC).

4.1.5 Where the recorded concentration of a contaminant is below the GAC for the specified end use it is not deemed to be a hazard. Exceedance of the criterion indicates that the parameter is a potential hazard and the identified pollutant linkage may represent an unacceptable risk. The GQRA also determines whether further detailed assessment is required. In doing so, it confirms whether the potential contaminant linkages identified in the preliminary risk assessment are of concern or not.

4.2 Generic Assessment Criteria

4.2.1 The GAC that have been selected as appropriate to this Tier 2 controlled waters risk assessment are the UK Drinking Water Standards (DWS) (DETR,2000) on the basis that the groundwater is abstracted for potable supply, and also the Environmental Quality Standards (EQS) in accordance with the Water Framework Directive (WFD) (DEFRA,2010) for the protection of surface waters and ecological systems that could be affected by baseflow from potentially contaminated groundwater.

4.2.2 Full details of the assessment criteria are given in the guidance note included in **Appendix CWRA 2.**

4.3 Assessment of Groundwater Results

4.3.1 Groundwater samples were recovered from eight boreholes DS110, DS112, DS114, DS203, DS213, DS216, DS301 and DS302 on two occasions as part of the ground investigation undertaken in 2019. A total of nine samples were submitted for each round for geoenvironmental laboratory testing, including two samples obtained within DS110 at 12m and 29.5m below ground level (bgl). At the current time, the results from only one of the monitoring rounds has been made available to Stantec. All of the monitoring installations were installed within the Seaford Chalk Formation.

4.3.2 Two of the sampling locations (DS110 and DS213) are located within the Junction 9 roundabout, a further four locations (DS216, DS302, DS114 and DS203) are located within the vicinity of the north bound on-slip and south bound off-slip roads of the M3 J9 with the final two locations (DS112 and DS301) positioned approximately 950m north of Junction 9. All of the locations are on the southern side of the River Itchen which flows towards the south.

4.3.3 Surface water samples were not taken during the ground investigation or in the subsequent sampling/monitoring.

4.3.4 The results of the analysis have been compared against the Environmental Quality Standards (EQS) for Freshwater to assess the potential to affect controlled waters as an ecological receptor and also compared with the Drinking Water Standard (DWS) assessment criteria. Summary tables of the results are presented in **Appendix CWRA 3**.

Potential to Affect Controlled Waters as an Ecological Receptor

4.3.5 Comparison of the geoenvironmental laboratory testing groundwater results with the EQS indicates the following exceedances:

- One exceedance of Copper in DS103 (9ug/l compared to an assessment criterion of 1ug/l)
- Two exceedances of Mercury within DS110 and DS203 respectively (0.24ug/l and 18.3ug/l compared to an assessment criterion of 0.07ug/l)

- One exceedance of Nickel within DS203 (68ug/l compared to an assessment criterion of 4ug/l)

- One exceedance of Zinc within DS203 (27ug/l compared to an assessment criterion of 10.9ug/l)

4.3.6 The laboratory limit of detection (LOD) for some metals is higher than the assessment criteria, and the following results were all recorded below the LOD.

- All of the groundwater samples tested for Cadmium, were below the LOD of 0.4ug/l, however this exceeds the GAC of 0.08ug/l.

- All the groundwater samples tested for Hexavalent Chromium were below the LOD of 20ug/l, however this exceeds the GAC of 3.4ug/l,

- Eight out of the nine samples tested for Copper were below the LOD of 5ug/l, however this exceeds the GAC of 1ug/l.

- All of the groundwater samples tested for Lead were below the LOD of 5ug/l, however this exceeds the GAC of 1.2ug/l.

- All of the groundwater samples tested for Cyanide were below the LOD of 5ug/l however this exceeds the GAC of 1ug/l.

4.3.7 The recorded exceedances of the EQS for Copper, Mercury, Nickel, Zinc, and the LOD exceedances of the EQS for Cadmium, Hexavalent Chromium, Lead and Cyanide are taken forward as potential hazards to controlled waters and discussed further in **Section 4.4**.

4.3.8 All recorded concentrations of TPHs and PAHs were below the laboratory LOD. The laboratory LOD was higher than the GAC for several of the PAHs (fluoranthene, benzo(a)pyrene and benzo(g,h,i)perylene) and therefore these are taken forward as a potential hazard to controlled waters and discussed further in **Section 4.4**.

4.3.9 It should be noted that taking forward the parameters where the concentrations were below the LOD but the LOD is above the GAC is a conservative approach.

Potential to Affect Controlled Waters as a Drinking Water Resource

4.3.10 Comparison of the geoenvironmental laboratory testing groundwater results with the Drinking Water Standards (DWS) indicates the following exceedances:

- One exceedance of Mercury within DS203 (18.3ug/l compared to a GAC of 1ug/l)

- One exceedance of Nickel within DS203 (68ug/l compared to a GAC of 20ug/l)

- Two exceedances of Nitrate as NO_3 within DS110 and DS216 respectively (56,000ug/l and 54,600ug/l compared to a GAC of 50,000ug/l)

4.3.11 Mercury, Nickel and Nitrate as NO_3 are taken forward as potential Controlled Waters hazards in the context of the groundwater as a drinking water resource and discussed further in **Section 4.4**.

4.4 Interpretation of Controlled Waters GQRA

Potential to Affect Controlled Waters as an Ecological Receptor

4.4.1 Where the laboratory limit of detection (LOD) for some parameters was above the assessment criteria in the previous monitoring, further sampling and testing could be undertaken in laboratories able to achieve LODs below the specific assessment criteria. In this instance this would include testing for cadmium, hexavalent chromium, copper, lead and cyanide.

4.4.2 In some cases, the EQS is extremely low and the LOD of these compounds cannot be routinely achieved by commercial laboratories, therefore it is not pragmatic to recommend further testing for these compounds. These include fluoranthene, benzo(a)pyrene and benzo(g,h,i)perylene. Without a positive detection of any Polyaromatic Hydrocarbons or Total Petroleum Hydrocarbons within the groundwater results and evidence of only marginal exceedances of the LOD for these chemicals within soil results, (which are contained within the Ground Investigation Report (Stantec, 2020b)), it is considered that the ground conditions at the Site are not significantly adversely affecting the groundwater quality and PAHs as a potential controlled water hazard are not therefore considered further.

4.4.3 The EQS used as the GAC in the above assessment are not site-specific and consider a conservative scenario of high bioavailability, which is not applicable to all sites and depends on the local water quality. In order to consider the effect of site-specific conditions on metal bioavailability, the UK-TAG Metal Bioavailability Assessment tool (M-BAT) has been used.

4.4.4 The M-BAT tool uses water quality parameters to predict the potential risk posed by metals in the aquatic environment. It does this by calculating a ‘predicted no effect concentration’ (PNEC) which is considered to be a site-specific EQS, and the bioavailable fraction. Where measured concentrations of metals are used, the bioavailable concentration, (which is a comparison between the dissolved metal concentration and the bioavailable factor of the metal) and the Risk Characterisation ratio, (which indicates if the bioavailable concentration is above the EQS), are calculated.

4.4.5 The toxicity of metals is dependent on a range of water quality parameters such as pH, Calcium and Dissolved Organic Carbon (DOC). Where possible, these should be taken from the receiving water, in this case the River Itchen, but in the absence of surface water sampling data - the groundwater data has been used. The tool has been used to determine a PNEC for Copper, Zinc, Nickel and Lead.

4.4.6 The PNEC can be considered as a location specific EQS, to which the measured metal concentration can be compared. The calculated PNEC for each sample exceeding the EQS were:

- Copper in DS203 (9ug/l) the calculated PNEC for this location is 42.87ug/l with a bioavailable fraction of 2% and a bioavailable concentration of 0.12ug/l.
- Zinc in DS203 (27ug/l) the calculated PNEC for this location is 59.79ug/l with a bioavailable fraction of 18% and a bioavailable concentration of 4.94ug/l.
- Nickel in DS203 (68ug/l) the calculated PNEC for this location is 27.72ug/l with a bioavailable fraction of 14% and a bioavailable concentration of 9.81ug/l.

4.4.7 This indicates that the Zinc and Copper results that exceed the EQS do not exceed the location specific PNEC and therefore theses metals are not considered to be a risk to controlled waters as an ecological receptor in these circumstances. However, the single Nickel concentration in DS203 exceeds the location specific PNEC and therefore remains a potential risk to controlled waters.

4.4.8 The locations where Zinc, Copper, Nickel and Lead are below the LOD but exceed the EQS assessment criteria are not considered to pose a significant risk as the LODs, which were used in the calculation, are below the location specific PNECs calculated. The tables detailing the location specific PNECs are detailed within **Appendix CWRA 4**.

4.4.9 Exceedances of Mercury have also been detected within DS110 and DS203 along with the exceedance of the PNEC for Nickel within DS203 discussed above. These locations are within or close to two of the historical landfills identified on or close to the Site. Whilst the historical landfills are not considered to represent a significant potential source of contamination, and the limited exceedances of the GACs are also not considered to represent a significant risk to controlled waters, further sampling and analysis is recommended to confirm this preliminary assessment.

Potential to Affect Controlled Waters as a Drinking Water Resource

4.4.10 The samples of groundwater were all obtained from within the Seaford Chalk Formation and therefore the samples are considered to be representative of the groundwater aquifer receptor which is abstracted as a potable source. Within the samples obtained, a number of exceedances of the Drinking Water Standards (DWS) were recorded within DS110, DS203 and DS216 for Mercury, Nickel and Nitrate as NO3 and therefore were taken forward as a potential hazard to controlled waters as a drinking water resource.

4.4.11 The locations of the boreholes where elevated Nitrate concentrations were recorded are on the east side of the Site within or adjacent to areas of agricultural land use and therefore the nitrate source is considered to be the agricultural use within the area.

4.4.12 The elevated concentrations of Mercury and Nickel were encountered in boreholes within or close to historical landfills and as described above (see 4.4.9), although a significant potential source of contamination or risk to controlled waters has not been identified. Furthermore, the results of the Mercury and Nickel within DS203 are vastly different from the results of the surrounding groundwater monitoring locations and it is considered that this could also be due to a sampling or laboratory error. which could be determined through additional sampling and testing. Further sampling and analysis is recommended to confirm this preliminary assessment.

5 Conclusions

5.1 Assessed Geoenvironmental Risk

5.1.1 This Tier 2 risk assessment builds on the information available from the Preliminary Tier 1 assessments. The methodology and criteria adopted by Stantec for the geoenvironmental risk assessment is presented in **Appendix CWRA 1.**

Controlled Waters as an Ecological Receptor

5.1.2 The data reviewed indicates that at the majority of locations, concentrations of the potential contaminants tested, are below the relevant assessment criteria. However, some laboratory limits of detection (LOD) were above the assessment criteria for cadmium, hexavalent chromium and cyanide. It is not considered that this represents a significant risk to controlled waters, and this preliminary assessment could be further supported through additional sampling and analysis – using LODs below the assessment criteria where commercially available, and the use of the UK-TAG Metal Bioavailability Assessment tool.

5.1.3 Nickel and Mercury were also identified above the assessment criteria in two specific locations; and whilst this is also not considered to represent a significant risk to controlled waters, further sampling and analysis is recommended to confirm this preliminary assessment and rule out previous sampling/testing errors. .

5.1.4 Based on the information available, the potential for significant contamination to be present is considered to be **Low.** The estimated risks to the sensitive receptors are summarised below:

Table 5-1 Estimated Risk to Sensitive Ecological Receptors

Receptor	Assessed Sensitivity	Estimated Risk
Groundwater	Very High	Low
Surface Water	Very High	Low

Controlled Waters as a Drinking Water Resource

5.1.5 The majority of the groundwater samples did not record any exceedances of the Drinking Water Standards (DWS), however exceedances were recorded within DS110, DS203 and DS216 for Mercury, Nickel and Nitrate as NO_3. The source of the Nitrate is likely to be off site agriculture and therefore unrelated to the Site. As described above (Section 5.1.3), whilst the Mercury and Nickel concentrations at these limited locations are not considered to represent a significant risk to controlled waters, further sampling and analysis is recommended.

5.1.6 Based on the information available, the potential for significant contamination to be present is considered to be **Low.** The estimated risks to the sensitive receptors are summarised below:

Table 5-2 Estimated Risk to Sensitive Receptors as a Drinking Water Resource

Receptor	Assessed Sensitivity	Estimated Risk
Groundwater	Very High	Low

5.2 Protection of Controlled Waters

5.2.1 Whilst it is acknowledged that the groundwater below the Site shows limited marginal exceedances of the relevant assessment criteria, a specific / significant source for these concentrations has not been recorded. The concentrations recorded represent background/baseline concentrations at the Site and therefore specific remediation/mitigation measures are not necessary.

5.2.2 It is not considered that the Site represents a significant risk to controlled waters however further sampling and analysis is recommended to augment the baseline.

5.3 Recommendations

5.3.1 On the basis of this Tier 2 Risk Assessment, it is not currently considered that a Tier 3 Detailed Risk Assessment is required, although further supplementary Tier 2 Risk Assessment is recommended following additional ground investigation and both groundwater and surface water sampling and laboratory analysis.

5.3.2 It is recommended that further monitoring wells are installed, and groundwater sampling is undertaken within the areas of suspected landfill, deeper Made Ground and within areas that have not been previously investigated, together with additional sampling of existing monitoring wells.

5.3.3 It is also recommended that surface water samples are taken from the River Itchen to determine the baseline conditions in the River, and this should include upstream and downstream samples.

5.4 Limitations

5.4.1 The groundwater monitoring wells, and groundwater samples were only targeted into the Seaford Chalk Formation and therefore no assessment has been undertaken on any perched water within the Made Ground or groundwater within the superficial deposits.

5.4.2 Only the first round of groundwater monitoring results were issued to Stantec for review and therefore our assessment if only based on a singular monitoring event.

5.4.3 The opinions and recommendations in this report are based on the information obtained from the PSSR and the ground investigation specified and carried out by others. Stantec can, therefore, only base any recommendations included in this report from the information provided within the Factual Ground Investigation Report (Soils, 2019).

5.4.4 The ground investigation undertaken was carried out within the Highways boundary and adjacent farmland, therefore there were some constraints locating the boreholes for the ground investigations due to extensive buried services and badger setts. The boundary has also changed since the original investigation and, therefore, certain areas of the extended boundary have not been investigated.

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Appendix CWRA 1 – Stantec Methodology

Stantec Guide: Methodology for Assessment of Land Contamination (England)

1 INTRODUCTION

This document defines the approach adopted by Stantec in relation to the assessment of land contamination in England. The aim is for the approach to (i) be systematic and objective, (ii) provide for the assessment of uncertainty and (iii) provide a rational, consistent, transparent framework.

When preparing our methodology, we have made reference to various technical guidance documents and legislation referenced in Section 7 of which the principal documents are (i) Contaminated Land Statutory Guidance (Defra 2012), (ii) online guidance Land Contamination: Risk Management (LC:RM) accessed from GOV.UK which is expected to replace Contaminated Land Research (CLR) Report 11: Model Procedures for the Management of Contamination (EA 2004). It should be noted that LCRM is currently due to be revised following consultation and CLR 11 is archived, (iii) Contaminated land risk assessment: A guide to good practice (C552) (CIRIA 2001) (iv) National Planning Policy Framework (NPPF, 2019) (v) BS 10175 Investigation of potentially contaminated sites - Code of Practice (BSI 2017) and (vi) The series of British Standards on Soil Quality BS 18400.

2 DEALING WITH LAND CONTAMINATION

Government policy on land contamination aims to prevent new contaminated land from being created and promotes a risk-based approach to addressing historical contamination. For historical contamination, regulatory intervention is held in reserve for land that meets the legal definition and cannot be dealt with through any other means, including through planning. Land is only considered to be "*contaminated land*" in the legal sense if it poses an unacceptable risk.

UK legislation on contaminated land is principally contained in Part 2A of the Environmental Protection Act, 1990 (which was inserted into the 1990 Act by section 57 of the Environment Act 1995). Part 2A was introduced in England on 1 April 2000 and provides a risk-based approach to the identification and remediation of land where contamination poses an unacceptable risk to human health or the environment.

The Model Procedures for the Management of Land Contamination (CLR 11), were developed to provide the technical framework for applying a risk management process when dealing with land affected by contamination. The process involves identifying, making decisions on, and taking appropriate action to deal with land contamination in a way that is consistent with government policies and legislation within the UK. The approach, concepts and principles for land contamination management promoted by LC:RM (and its predecessor CLR 11) are applied to the determination of planning applications. The guidance given in LC:RM follows the same principles.

Other legislative regimes may also provide a means of dealing with land contamination issues, such as the regimes for waste, water, environmental permitting, and environmental damage. Further, the law of statutory nuisance may result in contaminants being unacceptable to third parties whilst not attracting action under Part 2A or other environmental legislation.

2.1 Part 2A

The Regulations and Statutory Guidance that accompanied the Act, including the Contaminated Land (England) Regulations 2006, has been revised with the issue of The Contaminated Land (England) (Amendment) Regulations 2012 (SI 2012/263) and the Contaminated Land Statutory Guidance for England 2012.

Part 2A defines contaminated land as "*land which appears to the Local Authority in whose area it is situated to be in such a condition that, by reason of substances in, on or under the land that significant harm is being caused, or there is a significant possibility that such significant harm (SPOSH) could be caused, or significant pollution of controlled waters is being caused, or there is a significant possibility of such pollution (SPOSP) being caused*".

Harm is defined as "*harm to the health of living organisms or other interference with the ecological systems of which they form part, and in the case of man, includes harm to his property*".

Part 2A provides a means of dealing with unacceptable risks posed by land contamination to human health and the environment, and under the guidance enforcing authorities should seek to find and deal with such land. It states that "*under Part 2A the starting point should be that land is not contaminated land unless there is reason to consider otherwise. Only land where unacceptable risks are clearly identified, after a risk assessment has been undertaken in accordance with the Guidance, should be considered as meeting the Part 2A definition of contaminated land*". Further, the guidance makes it clear that *"regulatory decisions should be based on what is reasonably likely, not what is hypothetically possible".*

The overarching objectives of the Government's policy on contaminated land and the Part 2A regime are:

"(a) To identify and remove unacceptable risks to human health and the environment.

(a) To seek to ensure that contaminated land is made suitable for its current use.

(b) To ensure that the burdens faced by individuals, companies and society as a whole are proportionate, manageable and compatible with the principles of

sustainable development".

The enforcing authority may need to decide whether and how to act in situations where decisions are not straight forward, and where there is uncertainty. "*In so doing, the authority should use its judgement to strike a reasonable balance between: (a) dealing with risks raised by contaminants in land and the benefits of remediating land to remove or reduce those risks; and (b) the potential impacts of regulatory intervention including financial costs to whoever will pay for remediation, health and environmental impacts of taking action, property blight, and burdens on affected people".*

The authority is required to "*take a precautionary approach to the risks raised by contamination, whilst avoiding a disproportionate approach given the circumstances of each case".* The aim is "*that the regime produces net benefits, taking account of local circumstances*".

The guidance recognises that *"normal levels of contaminants in soils should not be considered to cause land to qualify as contaminated land, unless there is a particular reason to consider otherwise".* Normal levels are quoted as:

"a) *natural presence of contaminants'* such as from underlying geology *'that have not been shown to pose an unacceptable risk to health and the environment*

b) *…low level diffuse pollution, and common human activity…"*

Similarly the guidance states that significant pollution or significant possibility of significant pollution of controlled waters is required for land to be considered contaminated and the "*fact that substances are merely entering water"* or "*where discharge from land is not discernible at a location immediately downstream"* does not constitute contaminated land.

To help achieve a more targeted approach to identifying and managing contaminated land in relation to the risk (or possibility) of harm to human health, the revised Statutory Guidance presented a new four category system for considering land under Part 2A, ranging from Category 4, where there is no risk that land poses a significant possibility of significant harm (SPOSH), or the level of risk is low, to Category 1, where the risk that land poses a significant possibility of significant harm (SPOSH) is unacceptably high.

For land that cannot be readily placed into Categories 1 or 4 further assessment is required. If there is sufficient concern that the risks could cause significant harm or have the significant possibility of significant harm the land is to be placed into Category 2. If the concern is not met land is considered Category 3.

The technical guidance clearly states that the currently published Soil Guidance Values (SGV's) and Generic Assessment Criteria (GAC's) represent *"cautious estimates of level of contaminants in soils"* which should be considered *"no risk to health or, at most, a minimal risk"*. These values do not represent the boundary between categories 3 and 4 and "*should be considered to be comfortably within Category 4".*

At the end of 2013 technical guidance in support of Defra's revised Statutory Guidance (SG) was published and then revised in 2014 (CL: AIRE 2014) which provided:

- A methodology for deriving C4SLs for four generic land-uses comprising residential, commercial, allotments and public open space; and

- A demonstration of the methodology, via the derivation of C4SLs for six substances – arsenic, benzene, benzo(a)pyrene, cadmium, chromium (VI) and lead.

For controlled waters, the revised Statutory Guidance states that the following types of pollution should be considered to constitute significant pollution of controlled waters:

"(a) *Pollution equivalent to "environmental damage" to surface water or groundwater as defined by The Environmental Damage (Prevention and Remediation) Regulations 2009, but which cannot be dealt with under those Regulations.*

(b) *Inputs resulting in deterioration of the quality of water abstracted, or intended to be used in the future, for human consumption such that additional treatment would be required to enable that use.*

(c) *A breach of a statutory surface water Environment Quality Standard, either directly or via a groundwater pathway.*

(d) *Input of a substance into groundwater resulting in a significant and sustained upward trend in concentration of contaminants (as defined in Article 2(3) of the Groundwater Daughter Directive (2006/118/EC)".*

The guidance also states that, in some circumstances, significant concentrations at a compliance point (in groundwater or surface water) may constitute pollution of controlled waters.

As with SPOSH for human health, the revised Statutory Guidance presents a four-category system for Significant Pollution of controlled waters. Category 1 covers land where there is a strong and compelling case for SPOSP, for example where significant pollution would almost certainly occur if no action was taken to avoid it. Category 4 covers land where there is no risk or the risk is low, for example, where the land contamination is having no discernible impact on groundwater or surface water quality. Category 2 is for land where the risks posed to controlled waters are not high enough to consider the land as Category 1 but nonetheless are of sufficient concern to constitute SPOSP, Category 3 is for land where the risks posed to controlled waters are higher than low but not of sufficient concern to constitute SPOSP.

2.2 Planning

The Local Planning Authority (LPA) is responsible for the control of development, and in doing so it has a duty to take account of all material considerations, including contamination.

The principal planning objective is to ensure that any unacceptable risks to human health, buildings and other property and the natural and historical environment from the contaminated condition of the land are identified so that appropriate action can be considered and taken to address those risks.

The National Planning Policy Framework (NPPF, 2019), includes the following.

Paragraph 118 states that planning policies and decisions should "*(c) give substantial weight to the value of using suitable brownfield land within settlements for homes and other identified needs, and support appropriate opportunities to remediate despoiled, degraded, derelict, contaminated or unstable land*."

Paragraph 179 states "*Where a site is affected by contamination or land stability issues, responsibility for securing a safe development rests with the developer and/or landowner*".

Paragraph 170 states "*planning policies and decisions should contribute to and enhance the natural and local environment by:*

(e) preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability. Development should, wherever possible, help to improve local environmental conditions such as air and water quality, taking into account relevant information such as river basin management plans; *and*

(f) remediating and mitigating despoiled, degraded, derelict, contaminated and unstable land, where appropriate."

Paragraph 178 describes the policy considerations the Government expects LPA's to have in regard to land affected by contamination when preparing policies for development plans and in taking decisions on applications.

Paragraph 178 states "*planning policies and decisions should ensure that:*

(a) a site is suitable for its proposed use taking account of ground conditions and any risks arising from land instability and contamination. This includes risks arising from natural hazards or former activities such as mining, and any proposals for mitigation including land remediation (as well as potential impacts on the natural environment arising from that remediation);

(b) after remediation, as a minimum, land should not be capable of being determined as contaminated land under Part IIA of the Environmental Protection Act 1990; and

c) adequate site investigation information, prepared by a competent person, is available to inform these assessments."

Paragraph 183 states "*The focus of planning policies and decisions should be on whether proposed development is an acceptable use of land, rather than the control of processes or emissions (where these are subject to separate pollution control regimes). Planning decisions should assume that these regimes will operate effectively. Equally, where a planning decision has been made on a development, the planning issues should not be revisited through the permitting regimes operated by pollution control authorities.*"

The Glossary in Annex 2 provides the following:

Brownfield land registers*: Registers of previously developed land that local planning authorities consider to be appropriate for residential development, having regard to criteria in the Town and Country Planning (Brownfield Land Registers) Regulations 2017. Local planning authorities will be able to trigger a grant of permission in principle for residential development on suitable sites in their registers where they follow the required procedures.*

Competent person (to prepare site investigation information)*: A person with a recognised relevant qualification, sufficient experience in dealing with the type(s) of pollution or land instability, and membership of a relevant professional organisation.*

Previously developed land*: Land which is or was occupied by a permanent structure, including the curtilage of the developed land (although it should not be assumed that the whole of the curtilage should be developed) and any associated fixed surface infrastructure. This excludes: land that is or was last occupied by agricultural or forestry buildings; land that has been developed for minerals extraction or waste disposal by landfill, where provision for restoration has been made through development management procedures; land in built-up areas such as residential gardens, parks, recreation grounds and allotments; and land that was previously developed but where the* *remains of the permanent structure or fixed surface structure have blended into the landscape.*

***Site investigation information**: Includes a risk assessment of land potentially affected by contamination, or ground stability and slope stability reports, as appropriate. All investigations of land potentially affected by contamination should be carried out in accordance with established procedures (such as BS10175 Investigation of Potentially Contaminated Sites – Code of Practice).*

Stantec adopt the principle that a Preliminary Investigation (Desk Study and Site Reconnaissance) and Preliminary Risk Assessment (see below) is the minimum assessment requirement to support a planning application.

The level at which contamination is deemed to be unacceptable, or, gives rise to adverse effects under a planning context has not been identified but is envisaged to be more precautionary than the level required to determine land as contaminated under Part 2A.

2.3 Building Control

The building control department of the local authority or private sector approved inspectors are responsible for the operation and enforcement of the Building Regulations (DCLG 2010) to protect the health, safety and welfare of people in and around buildings. Approved Document C requires the protection of buildings and associated land from the effects of contamination, to be applied (non-exclusively) in all changes of use from commercial or industrial premises, to residential property.

3 APPROACH

As with CLR11 the guidance given in LC:RM presents three stages of risk management: -

(a) Stage 1 - Risk Assessment;

(b) Stage 2 - Options Appraisal; and

(c) Stage 3 - Remediation.

Each stage has three tiers. The three tiers of Stage 1 Risk Assessment are: -

- Tier 1 - Preliminary Risk Assessment (PRA) - first tier of RA that develops the outline conceptual model (CM) and establishes whether there are any potentially unacceptable risks.

- Tier 2 - Generic Quantitative Risk Assessment (GQRA) - carried out using generic assessment criteria and assumptions to estimate risk.

- Tier 3 - Detailed Quantitative Risk Assessment (DQRA) - carried out using detailed site-specific information to generate Site Specific Assessment Criteria (SSAC) as risk evaluation criteria.

For each tier of a Stage 1 - Risk Assessment you must:

1. Identify the hazard - establish contaminant sources.

2. Assess the hazard - use a source-pathway-receptor (S-P-R) pollutant linkage approach to find out if there is the potential for unacceptable risk.

3. Estimate the risk - predict what degree of harm or pollution might result and how likely it is to occur.

4. Evaluate the risk - decide whether a risk is unacceptable.

A Stantec Preliminary Investigation report normally comprises a desk study, walkover site reconnaissance and preliminary risk assessment (PRA). The project specific proposal defines the actual scope of work which might include review of ground investigation data in which case the report includes a GQRA.

Risk estimation involves identifying the magnitude of the potential consequence (taking into account both the potential severity of the hazard and the sensitivity of the receptor) and the magnitude of the likelihood i.e. the probability (taking into account the presence of the hazard and the receptor and the integrity of the pathway). This approach is promoted in current guidance such as R&D 66 (NHBC 2008).

For a PRA, Stantec's approach is that if a pollution linkage is identified then it represents a potentially unacceptable risk which either (1) remediation / direct risk management or (2) progression to further tiers of risk assessment (GQRA and GQRA) requiring additional data collection and enabling refinement of the CM using the site specific data.

4 IDENTIFICATION OF POLLUTANT LINKAGES AND DEVELOPMENT OF A CONCEPTUAL MODEL (CM)

For all Tiers of a Stage 1 Risk Assessment, the underlying principle to ground condition assessment is the identification of *pollutant linkages* in order to evaluate whether the presence of a source of contamination could potentially lead to harmful consequences. A pollutant linkage consists of the following three elements: -

- A source/hazard – a substance or situation which has the potential to cause harm or pollution;
- A pathway – a means by which the hazard moves along / generates exposure; and
- A receptor/target – an entity which is vulnerable to the potential adverse effects of the hazard.

The *Conceptual Model* identifies the types and locations of potential contaminant sources/hazards and potential receptors and potential migration/transportation pathway(s). The CM is refined through progression to further tiers of risk assessment (GQRA and GQRA) requiring additional data collection.

4.1 Hazard Identification

A hazard is a substance or situation that has the potential to cause harm. Hazards may be chemical, biological or physical.

In a PRA the potential for hazards to be present is determined from consideration of the previous or ongoing activities on or near to the site in accordance with the criteria presented in the **Table 1**.

Based on the land use information Contaminants of Potential Concern (COPC) are identified. The COPC direct the scope of the collection of site-specific data and the analytical testing selected for subsequent Tiers.

At Tier 2 the site-specific data is evaluated using appropriate published assessment criteria (refer to Stantec document entitled Rationale for the Selection of Evaluation Criteria for a Generic Quantitative Risk Assessment (GQRA)). In general, published criteria have been developed using highly conservative assumptions and therefore if the screening criterion is not exceeded (and if enough samples from appropriate locations have been analysed) then the COPC is eliminated as a potential Hazard. It should be noted that exceedance does not necessarily indicate that a site is contaminated and/or unsuitable for use only that the COPC is retained as a potential Hazard. Published criteria are generated using models based on numerous and complex assumptions. Whether or not these assumptions are appropriate or sufficiently protective requires confirmation on a project by project basis. Manipulation of the default assumptions would normally form part of a Tier 3 Detailed Quantitative Risk Assessment (DQRA).

When reviewing or assessing site specific data Stantec utilise published guidance on comparing contamination data with a critical concentration (CL:AIRE/CIEH 2008) which presents a structured process for employing statistical techniques for data assessment purposes.

4.2 Receptor and Pathway Identification

For all Tiers the potential receptors (for both on site and adjoining land) that will be considered are:

- Human Health – including current and future occupiers, construction and future maintenance workers, and neighbouring properties/third parties;
- Ecological Systems; [1]
- Controlled Waters [2] – Under section 78A(9) of Part 2A the term "pollution of controlled waters" means the entry into controlled waters of any poisonous, noxious or polluting matter or any solid waste matter. The term "controlled waters" in relation to England has the same meaning as in Part 3 of the Water Resources Act 1991, except that "ground waters" does not include waters contained in underground strata but above the saturation zone.
- Property - Animal or Crop (including timber; produce grown domestically, or on allotments, for consumption; livestock; other owned or domesticated animals; wild animals which are the subject of shooting or fishing rights); and
- Property - Buildings (any structure or erection, and any part of a building including any part below ground level, but does not include plant or machinery comprised in a building, or buried services such as sewers, water pipes or electricity cables including archaeological sites and ancient monuments).

If a receptor is taken forward for further assessment it will be classified in terms of its sensitivity, the criteria for which are presented in **Table 2**. Table 2 has been generated using descriptions of environmental receptor importance/value given in various guidance documents including R&D 66 (NHBC 2008), EA 2017 and Transport Analysis Guidance (based on DETR 2000). Human health and buildings classifications have been generated by Stantec using the attribute description for each class. Surface water sensitivity is classified using the Water Framework Directive (WFD) status for the River Basin obtained from: [redacted]

[1] International or nationally designated sites (as defined in the statutory guidance (Defra Circular 04/12)) "*in the local area*" will be identified as potential ecological receptors. A search radius of 1, 2 or 5km will be utilised depending on the site-specific circumstances (see also pathway identification). The Environment Agency has published an ecological risk assessment framework (EA 2008) which promotes (as opposed to statutorily enforces) consideration of additional receptors to include locally protected sites and protected or notable species. These additional potential receptors will only be considered if a Phase 1 habitat survey, undertaken in accordance with guidance (JNCC 1993), is commissioned and the data provided to Stantec. It should be noted that without such a survey a Land Contamination risk assessment may conclude that the identification of potential ecological receptors is inconclusive (refer to Stantec Specification for a Preliminary Investigation (Desk Study and Site Reconnaissance).

[2] The definition of "pollution of controlled water" was amended by the introduction of Section 86 of the Water Act 2003. For the purposes of Part 2A groundwater does not include waters above the saturated zone and our assessment does not therefore address perched water other than where development causes a pathway to develop.

The exposure pathway and modes of transport that will be considered are presented in **Table 3**.

4.3 Note regarding Ecological Systems

The Environment Agency (EA) has developed an ecological risk assessment framework which aims to provide a structured approach for assessing the risks to ecology from chemical contaminants in soils (EA 2008). In circumstances where contaminants in water represent a potential risk to aquatic ecosystems then risk assessors will need to consider this separately.

The framework consists of a three-tiered process: -

- Tier 1 is a screening step where the site soils chemical data is compared to a soil screening value (SSV)
- Tier 2 uses various tools (including surveys and biological testing) to gather evidence for any harm to the ecological receptors
- Tier 3 seeks to attribute the harm to the chemical contamination

Tier 1 is preceded by a desk study to collate information about the site and the nature of the contamination to assess whether pollutant linkages are feasible. The framework presents ten steps for ecological desk studies and development of a conceptual model as follows.

1. Establish Regulatory Context
2. Collate and Assess Documentary Information
3. Summarise Documentary Information
4. Identify Contaminants of Potential Concern
5. Identify Likely Fate Transport of Contaminants
6. Identify Potential Receptors of Concern
7. Identify Potential Pathways of Concern
8. Create a Conceptual Model
9. Identify Assessment and Measurement Endpoints
10. Identify Gaps and Uncertainties

The information in a standard PRA report covers Steps 1 to 4 inclusive. Step 5 considers fate and transport of contaminants and it should be noted that our standard report adopts a simplified approach considering only transport mechanisms. A simplified approach has also been adopted in respect of Steps 6 and 7 receptors (a detailed review of the ecological attributes has not been undertaken) and pathways (a food chain assessment has not been undertaken). Step 9 is outside the scope of our standard PRA report.

It should be noted that the PRA report will present an assessment for ecological systems (where identified as a receptor for a land contamination assessment) considering the viability of the mode of transport given the site-specific circumstances and not specific pathways. The PRA may conclude that the risk to potential ecological receptors is inconclusive.

4.4 Note regarding controlled waters

Controlled waters are rivers, estuaries, coastal waters, lakes and groundwaters, but not perched waters.

The EU Water Framework Directive (WFD) 2000/60/EC provides for the protection of sub-surface, surface, coastal and territorial waters through a framework of river basin management. The EU Updated Water Framework Standards Directive 2014/101/EU amended the EU WFD to update the international standards therein; it entered into force on 20 November 2014 with the requirements for its provisions to be transposed in Member State law by 20 May 2016. Other EU Directives in the European water management framework include:

- the EU Priority Substances Directive 2013/39/EU;
- EU Groundwater Pollutants Threshold Values Directive 2014/80/EU amending the EU Groundwater Directive 2006/118/EC; and
- EU Biological Monitoring Directive 2014/101/EU.

The Ground Water Daughter Directive (GWDD) was enacted by the Groundwater Regulations (2009), which were subsumed by the Environmental Permitting Regulations (2010) which provide essential clarification including on the four objectives specifically for groundwater quality in the WFD: -

Achieve ‘Good’ groundwater chemical status by 2015, commonly referred to as ‘status objective’;
Achieve Drinking Water Protected Area Objectives;
Implement measures to reverse any significant and sustained upward trend in groundwater quality, referred to as ‘trend objective’; and

Prevent or limit the inputs of pollutants into groundwater, commonly referred to as ‘prevent or limit’ objectives

The Water Act 2003 (Commencement No.11) Order 2012 amends the test for 'contaminated land' which relates to water pollution so that pollution of controlled waters must now be "significant" to meet the definition of contaminated land.

The Water Framework Directive (WFD) requires the preparation, implementation and review of River Basin Management Plans (RBMP) on a six-year cycle. River basins are made up of lakes, rivers, groundwaters, estuaries and coastal waters, together with the land they drain. River Basin Districts (RBD) and the WFD Waterbodies that they comprise are important spatial management units, regularly used in catchment management studies. River Basin Management Plans (RBMP) have been developed for the 11 River Basin Districts in England and Wales.

These were released by Defra in 2009 (Defra 2009) and updated in 2015.

These RBMP's establish the current status of waters within the catchments of the respective Districts and the current status of adjoining waters identified. As part of a Tier 2 risk assessment water quality data is screened against the WFD assessment criteria. Comparison with the RBMP's current status of waters for the catchment under consideration would form part of a Tier 3 assessment.

5 RISK ESTIMATION

Risk estimation classifies what degree of harm might result to a receptor (defined as consequence) and how likely it is that such harm might arise (probability).
At Tier 1 the consequence classification is generated by multiplying the hazard classification score and the receptor sensitivity score. This approach follows that presented in the republished R&D 66 (NHBC 2008).

The criteria for classifying probability are set out in **Table 4** and have been taken directly from Table 6.4 CIRIA C552 (CIRIA 2001). Probability considers the integrity of the exposure pathway.

The consequence classifications detailed in **Table 5** have been adapted from Table 6.3 presented in C552 and R&D 66 (Annex 4 Table A4.3).

The Tier 1 risk classification is estimated for each pollutant linkage using the matrix given in **Table 6** which is taken directly from C552 (Table 6.5).

Subsequent Tiers refine the CM through retention or elimination of potential hazards and pollutant linkages.

6 RISK EVALUATION

Evaluation criteria are the parameters used to judge whether harm or pollution needs further assessment or is unacceptable. The evaluation criteria used will depend on:

- the reasons for doing the RA and the regulatory context such as Part 2A or planning;
- the CM and pollutant linkages present;
- any criteria set by regulators;
- any advisory requirements such as from Public Health England;
- the degree of confidence and precaution required;
- the level of confidence required to judge whether a risk is unacceptable;
- how you've used or developed more detailed assessment criteria in the later tiers of RA;
- the availability of robust scientific data;
- how much is known - for example, about the pathway mechanism and how the contaminants affect receptors; and
- any practical reasons such as being able to measure or predict against the criteria.

In order to put the Tier 1 risk classification into context the likely actions are described in **Table 7** which is taken directly from Table 6.6 of C552 (CIRIA 2001).

REFERENCES

BSI 2017 BS 10175:2011+A2:2017 Investigation of potentially contaminated sites - Code of Practice

BSI 2019 BS 8485:2015+A1:2019 Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings

CIRIA 2001: Contaminated land risk assessment – a guide to good practice C552.

CIRIA 2008: Assessing risks posed by hazardous ground gases to buildings C655

CL: AIRE/CIEH 2008 Guidance on Comparing Soil Contamination Data with a Critical Concentration. Published by Contaminated Land: Applications in Real Environments (CL: AIRE) and the Chartered Institute of Environmental Health (CIEH)

CL: AIRE 2013 SP1010 – Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination. Final Project Report published by Contaminated Land: Applications in Real Environments (CL: AIRE) 20th December 2013

DCLG 2010 Building Regulations 2010 Approved Document C Site preparation and resistance to contaminants and moisture.

DETR 2000 Methodology for Multi Modal Studies. Volume 2 Section 4. The Environmental Objective.

DEFRA 2012 Environmental Protection Act 1990: Part 2A. Contaminated Land Statutory Guidance. Department for Environment, Food and Rural Affairs

DEFRA, 2006 The Contaminated Land (England) Regulations 2006.

DEFRA, 2012 The Contaminated Land (England) (Amendment) Regulations 2012 (SI2012/263).

DEFRA, 2012 Environmental Protection Act 1990: Part 2A. Contaminated Land Statuary Guidance. April 2012.

DEFRA, 2013 Environmental Damage (Prevention and Remediation) Regulations 2009: Guidance for England and Wales

Defra '2009 Water for Life and Livelihoods. River Basin Management Plan. (11 Districts: Anglia, Dee, Humber, Northumbria, Northwest, Severn, Solway and Tweed, Southeast, Thames, Western Wales) December 2009

EA 2004: Contaminated Land Research (CLR) Report 11: The Model Procedures for the Management of Land Contamination CRL 11 by the Environment Agency (EA).

EA 2008 Ecological Risk Assessment Science Report Series SC070009 published by the Environment Agency (EA).

EA 2017 New groundwater vulnerability mapping methodology in England and Wales Report – SC040016/R Environment Agency (EA) September 2017

JNCC 1993 Handbook for Phase 1 Habitat Survey – A Technical for Environmental Audit prepared by the Joint Nature Conservancy Council (JNCC)

NHBC/EA/CIEH 2008: R&D Publication 66 Guidance for the safe development of housing on land affected by contamination.

National Planning Policy Framework (February 2019 revised), published by the Ministry of Housing, Communities and Local Government (MHCLG) at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/810197/NPPF_Feb_2019_revised.pdf

Stantec Methodology for Assessment of Land Contamination (England)

Table 1: Criteria for Classifying Hazards / Potential for Generating Contamination

Classification/Score	Potential for generating contamination/gas based on land use
Very Low 1	Land Use: Residential, retail or office use, agriculture Contamination: Limited. Gas generation potential: Soils with low organic content
Low 2	Land Use: Recent small scale industrial and light industry Contamination: locally slightly elevated concentrations. Gas generation potential: Soils with high organic content (limited thickness)
Moderate 3	Land Use: Railway yards, collieries, scrap yards, engineering works. Contamination: Possible widespread slightly elevated concentrations and locally elevated concentrations. Gas generation potential: Dock silt and substantial thickness of organic alluvium/peat
High 4	Land Use: Heavy industry, non-hazardous landfills. Contamination: Possible widespread elevated concentrations. Gas generation potential: Shallow mine workings Pre 1960s landfill
Very High 5	Land Use: Hazardous waste landfills, gas works, chemical works, Contamination: Likely widespread elevated concentrations. Gas generation potential: Landfill post 1960

"Greenfield" is land which has not been developed and there has been no use of agrochemicals

Table 2: Criteria for Classifying Receptor Sensitivity/Value

Classification	Definition
Very Low 1	Receptor of limited importance • Groundwater: Unproductive strata (Strata with negligible significance for water supply or river baseflow) (previously Non-aquifer), Secondary B (water-bearing parts of non-aquifers), Secondary undifferentiated (previously minor or non-aquifer, but information insufficient to classify as secondary A or B) • Surface water: WFD Surface Water status Bad • Ecology: No local designation • Buildings: Replaceable • Human health: Unoccupied/limited access
Low 2	Receptor of local or county importance with potential for replacement • Groundwater: Secondary A aquifer • Surface water: WFD Surface Water status Poor • Ecology: local habitat resources • Buildings: Local value • Human health: Minimum score 4 where human health identified as potential receptor
Moderate 3	Receptor of local or county importance with potential for replacement • Groundwater: Principal aquifer • Surface water: WFD Surface Water status Moderate • Ecology: County wildlife sites, Areas of Outstanding Natural Beauty (AONB) • Buildings: Area of Historic Character • Human health: Minimum score 4 where human health identified as potential receptor
High 4	Receptor of county or regional importance with limited potential for replacement • Groundwater: Source Protection Zone 2 or 3 • Surface water: WFD Surface Water status Good • Ecology: SSSI, National or Marine Nature Reserve (NNR or MNR) • Buildings: Conservation Area • Human health: Minimum score 4 where human health identified as potential receptor
Very High 5	Receptor of national or international importance • Groundwater: Source Protection Zone (SPZ) 1 • Surface water: WFD Surface Water status High • Ecology: Special Areas of Conservation (SAC and candidates), Special Protection Areas (SPA and potentials) or wetlands of international importance (RAMSAR) • Buildings: World Heritage site • Human health: Residential, open spaces and uses where children are present

Table 3: Exposure Pathway and Modes of Transport

Receptor	Pathway	Mode of transport
Human health	Ingestion	Fruit or vegetable leaf or roots
		Contaminated water
		Soil/dust indoors
		Soil/dust outdoors
	Inhalation	Particles (dust / soil) – outdoor
		Particles (dust / soil) - indoor
		Vapours – outdoor - migration via natural or anthropogenic pathways
		Vapours - indoor - migration via natural or anthropogenic pathways
	Dermal absorption	Direct contact with soil
		Direct contact with waters (swimming / showering)
		Irradiation
Groundwater	Leaching	Gravity / permeation
	Migration	Natural – groundwater as pathway Anthropogenic (e.g. boreholes, culverts, pipelines etc.)
Surface Water	Direct	Runoff or discharges from pipes
	Indirect	Recharge from groundwater
	Indirect	Deposition of windblown dust
Buildings	Direct contact	Sulphate attack on concrete, hydrocarbon corrosion of plastics
	Gas ingress	Migration via natural or anthropogenic paths
Ecological systems	See Notes	Runoff/discharge to surface water body
	See Notes	Windblown dust
	See Notes	Groundwater migration
	See Notes	At point of contaminant source
Animal and crop	Direct	Windblown or flood deposited particles / dust / sediments
	Indirect	Plants via root up take or irrigation. Animals through watering
	Inhalation	By livestock / fish - gas / vapour / particulates / dust
	Ingestion	Consumption of vegetation / water / soil by animals

Table 4: Classification of Probability

Classification	Definition
High likelihood	There is a pollution linkage and an event either appears very likely in the short-term and almost inevitable over the long-term, or there is already evidence at the receptor of harm / pollution.
Likely	There is a pollution linkage and all the elements are present and in the right place, which means that it is probable that an event will occur. Circumstances are such that an event is not inevitable, but possible in the short-term and likely over the long-term.
Low likelihood	There is a pollution linkage and circumstances are possible under which an event could occur. However, it is by no means certain that even over a longer period such event would take place, and is less likely in the shorter-term.
Unlikely	There is a pollution linkage, but circumstances are such that it is improbable that an event would occur even in the very long-term.

Table 5: Classification of Consequence (score = magnitude of hazard and sensitivity of receptor)

Classification / Score	Examples
Severe **17-25** **(3 out of 25 outcomes)**	Human health effect - exposure likely to result in "significant harm" as defined in the Defra (2012) Part 2A Statutory Guidance [1]. Controlled water effect - short-term risk of pollution (note: Water Resources Act contains no scope for considering significance of pollution) of sensitive water resource. Equivalent to EA Category 1 incident (persistent and/or extensive effects on water quality leading to closure of potable abstraction point or loss of amenity, agriculture or commercial value. Major fish kill. Ecological effect - short-term exposure likely to result in a substantial adverse effect. Catastrophic damage to crops, buildings or property
Medium **10-16** **(7 out of 25 outcomes)**	Human health effect - exposure could result in "significant harm" [1]. Controlled water effect - equivalent to EA Category 2 incident requiring notification of abstractor Ecological effect - short-term exposure may result in a substantial adverse effect. Damage to crops, buildings or property
Mild **5-9** **(7 out of 25 outcomes)**	Human health effect - exposure may result in "significant harm" [1]. Controlled water effect - equivalent to EA Category 3 incident (short lived and/or minimal effects on water quality). Ecological effect - unlikely to result in a substantial adverse effect. Minor damage to crops, buildings or property. Damage to building rendering it unsafe to occupy (for example foundation damage resulting in instability).
Minor **1-4** **(8 out of 25 outcomes)**	No measurable effect on humans. Protective equipment is not required during site works. Equivalent to insubstantial pollution incident with no observed effect on water quality or ecosystems. Repairable effects to crops, buildings or property. The loss of plants in a landscaping scheme. Discolouration of concrete.

[1] Significant harm includes death, disease, serious injury, genetic mutation, birth defects or impairment of reproductive function. The local authority may also consider other health effects to constitute significant harm such as physical injury; gastrointestinal disturbances; respiratory tract effects; cardio-vascular effects; central nervous system effects; skin ailments; effects on organs such as the liver or kidneys; or a wide range of other health impacts. Whether or not these would constitute significant harm would depend on the seriousness of harm including impact on health, quality of life and scale of impact.

Table 6: Classification of Risk (Combination of Consequence Table 5 and Probability Table 4)

	Consequence			
Probability	***Severe***	***Medium***	***Mild***	***Minor***
High likelihood	Very high	High	Moderate	Low
Likely	High	Moderate	Moderate/	Low
Low likelihood	Moderate	Moderate	Low	Very low
Unlikely	Low	Low	Very low	Very low

Table 7: Description of Risks and Likely Action Required

Risk Classification	Description
Very high risk	There is a high probability that severe harm could arise to a designated receptor from an identified hazard, OR, there is evidence that severe harm to a designated receptor is currently happening. This risk, if realised, is likely to result in a substantial liability. Urgent investigation (if not undertaken already) and remediation is likely to be required in the short term.
High risk	Harm is likely to arise to a designated receptor from an identified hazard. Realisation of the risk is likely to present a substantial liability. Urgent investigation (if not undertaken already) is required and remedial works may be necessary in the short-term and are likely over the longer-term.
Moderate risk	It is possible that harm could arise to a designated receptor from an identified hazard. However, it is either relatively unlikely that any such harm would be severe, or if any harm were to occur it is more likely that the harm would be relatively mild. Investigation (if not already undertaken) is normally required to clarify the risk and to determine the potential liability. Some remedial works may be required in the longer-term.
Low risk	It is possible that harm could arise to a designated receptor from an identified hazard, but it is likely that this harm, if realised, would at worst normally be mild.
Very low risk	There is a low possibility that harm could arise to a receptor. In the event of such harm being realised it is not likely to be severe.

Appendix CWRA 2 – Stantec Assessment Criteria Rationale

1 INTRODUCTION

The aim of this document is to present an explanation for the selection of the evaluation criteria routinely used by Stantec UK Ltd when undertaking a land contamination Tier 2 Generic Quantitative Risk Assessment (GQRA).

A GQRA uses published criteria to screen the site-specific contamination testing data and identify potential hazards to specific receptors. Generic criteria are typically conservative in derivation and exceedance does not indicate that a site is statutorily contaminated and/or unsuitable for use in the planning context. These criteria are used to identify situations where further assessment and/or action may be required. This document is divided into general introductory text and sections on soils, waters and gases.

2 GENERAL NOTES

This document should be read in conjunction with another entitled "Stantec Methodology for Assessment of Land Contamination" which summarises the legislative regime and our approach to ground contamination and risk assessment.

Any Stantec interpretation of contamination test results is based on a scientific and engineering appraisal. The perceptions of, for example, banks, insurers, lay people etc are not taken into account.

Any tables included in this document are produced for ease of reference to the criteria, they do not in any way replace the documents of origin (which are fully referenced) and which should be read to ensure appropriate use and interpretation of the data.

Generic criteria provide an aid to decision-making, but they do not replace the need for sound professional judgement in risk assessment (EA, 2006). The criteria are based on numerous and complex assumptions. The appropriateness of these assumptions in a site-specific context requires confirmation on a project by project basis. Our interpretative report will comment on the appropriateness of the routine criteria for project objectives or ground conditions. In some cases the published criteria whilst typically conservative may in some circumstances not be suitable for the site being assessed, either because they do not address the identified pollutant linkages or because they may not be sufficiently precautionary in the context of the site. Under these circumstances it may be necessary to recommend deriving site-specific assessment criteria. Any deviation from the routine criteria and/or selection of criteria for parameters not covered in this document will be described in the report text.

3 CRITERIA FOR EVALUATING SOIL RESULTS

3.1 Potential Harm to Human Health

The criteria used by Stantec UK Ltd to assess the potential for harm to human health are:-

- Category 4 Screening Levels (C4SLs) (DEFRA, 2014).
- Suitable 4 Use Levels (S4ULs) (Nathanail *et al*, 2015).
- CL:AIRE/EIC/AGS Generic Assessment Criteria (GAC) (CL:AIRE, 2010).
- Soil Guideline Values (SGVs) (EA, 2009a).

These criteria have been generated using the Contaminated Land Exposure Assessment model (CLEA) and supporting technical guidance (EA, 2009b, 2009c, 2009d, 2009e). The CLEA model uses generic assumptions about the fate and transport of chemicals in the environment and a generic conceptual model for site conditions and human behaviour to estimate child and adult exposures to soil contaminants for those potentially living, working, and/or playing on contaminated sites over long time periods (EA, 2009c).

The S4ULs, SGVs and GACs are all based on use of minimal/tolerable risk Health Criteria Values (HCVs) as the toxicological benchmark whereas the C4SL are based on use of a "low level of toxicological concern" (LLTC) as the toxicological benchmark. The LLTC represents a slightly higher level of risk than the HCV.

An update to the software (1.071) was published on 04/09/2015 (the handbook (EA 2009f) referring to version 1.05 is still valid). The update includes the library data sets from the DEFRA research project SP1010 (Development of Category 4 Screening Levels for assessment of land affected by contamination).

The CLEA model uses ten exposure pathways (Ingestion (outdoor soil, indoor dust, homegrown vegetables and soil attached to homegrown vegetables), Dermal Contact (outdoor soil and indoor dust) and Inhalation (outdoor dust, indoor dust, outdoor vapours and indoor vapours)). There are exposure pathways not included in the CLEA model such as the permeation of organics into plastic water supply pipes.

The presence and/or significance of each of the potential exposure pathways is dependent on the land use being considered. The model uses standard land use scenarios as follows:-

Residential – habitation of a dwelling up to two storeys high with various default material and design parameters, access to either private or nearby community open space with soil track back to form indoor dust. Assumes ingestion of homegrown produce.

Allotments – the model has default parameters for use and consumption of vegetables but not animals or their products (eggs).

Industrial/Commercial – assumes office or light physical work in a permanent three storey structure with breaks taken outside and that the site is NOT covered in hardstanding.

Public Open Space – two public open space (POS) scenarios are considered: POS_{resi} is shared communal space within a residential development where tracking back of soil into the home is assumed to occur. POS_{park} is intended for a public park sufficiently distant from housing (i.e. not adjacent to housing) such that tracking back of soil into the home is negligible. Note that the POS assessment criteria may not be appropriate for assessing sports fields.

The assessment criteria generated using CLEA can be used as a conservative starting point for evaluating long-term risks to human health from chemicals in soil.

It is important to note that the model does not assess all the potential exposure scenarios, for example risk to workers in excavations (short term exposure) or diffusion of contaminants through drinking water pipes.

Recent guidance (DEFRA 2012) introduces a four stage classification system where Category 1 sites are clearly contaminated land and Category 4 sites are definitely not contaminated land as defined by EPA 1990. Outside of these categories further specific risk assessment is required to determine if the site should fall into Category 2 (contaminated land) or Category 3 (not contaminated land). Category 4 screening values are considered to be more pragmatic than the current published SGV/GAC criteria but still strongly precautionary with the aim of allowing rapid identification of sites where the risk is above minimal but still low/acceptable.

Category 4 Screening Levels (C4SLs)

At the end of 2013, technical guidance in support of DEFRA's revised Statutory Guidance (SG) was published and then revised in 2014 (CL:AIRE 2014) which provided:

- A methodology for deriving C4SLs for the standard land-uses and two new public open space scenarios using the updated assumptions relating to the modelling of human exposure to soil contaminants; and
- A demonstration of the methodology, via the derivation of C4SLs for six substances – arsenic, benzene, benzo(a)pyrene, cadmium, chromium (VI) and lead.

Following issue of an Erratum in December 2014, a Policy Companion Document was published (DEFRA 2014).

A letter from Lord de Mauley dated 3rd September 2014 provides more explicit direction to local authorities on the use of the C4SL in a planning context. The letter identifies four key points:

1) that the screening values were developed expressly with the planning regime in mind

2) their use is recommended in DCLG's planning guidance

3) soil concentrations below a C4SL limit are considered to be 'definitely not contaminated' under Part IIA of the 1990 Environmental Protection Act and pose at most a 'low level of toxicological concern' and,

4) exceedance of a C4SL screening value does not mean that land is definitely contaminated land, just that further investigation may be warranted.

Stantec use the C4SLs as the Tier 2 soil screening criteria protective of human health for substances with C4SL available. Table 1 summarises the C4SL (DEFRA 2014) for each of the six substances.

Note that, with the exception of benzene, the DEFRA published C4SL are not dependent on soil organic matter content (SOM) ("*Given that BaP is non volatile and that empirical soil to plant concentration factors have been used, soil organic matter content has a negligible influence on the C4SLs for this chemical*"). The DEFRA published C4SL for benzene is based on an SOM of 6%. Stantec have used the CLEA model (v1.071) to derive C4SL for benzene for 1% and 2.5% SOM which are also shown in Table 1.

Note that an industry led project to derive C4SL for a further 20 substances has commenced (CL:AIRE, 2018). The project is being project managed by CL:AIRE and is funded by the Soil and Groundwater Technology Association (SAGTA), the Society of Brownfield Briefing (SoBRA) and others. A dedicated steering group, made up of representatives from SAGTA, DEFRA, Welsh Government, Public Health England, Environment Agency, Natural Resources Wales, Food Standards Agency, Homes England and further Land Forum representatives, has been set up to oversee the project. The new C4SL will be added to this document as they are published.

Suitable 4 Use Levels (S4ULs)

In July 2009, Generic Assessment Criteria (GACs) for 82 substances were published (LQM and CIEH, 2009) using the then current version of the CLEA software v1.04 and replaced those generated in

2006 using the original version of the model CLEA UK *beta*. In 2015 S4ULs were published by LQM/CIEH (Nathanail *et al*, 2015) to replace the second edition GACs. Table 2 summarises the S4ULs which are reproduced with permission; Publication Number S4UL3202.

Soil Guideline Values (SGVs) and Generic Assessment Criteria (GAC)

In 2009, Soil Guideline Values (SGVs) were published by the Environment Agency for arsenic, cadmium, mercury, nickel, selenium, benzene, toluene, ethyl benzene, xylenes, phenol and dioxins, furans and dioxin-like PCBs. These were derived using the CLEA model for residential, allotments and commercial land-uses.

These SGVs have now largely been superseded by the C4SLs and the S4ULs, with the exception of the SGVs for dioxins, furans and dioxin-like PCBs which are shown in Table 3.

In January 2010, Generic Assessment Criteria (GAC) derived using CLEA were published by CL:AIRE for 35 substances. These GAC are listed in Table 4.

Note that the SGVs for dioxins, furans and dioxin like PCBs and CL:AIRE GAC were derived using an older version of CLEA (v1.06) than used to derive the S4UL and C4SL (v1.07). This older version used slightly more conservative values for some exposure parameters and therefore the derived SGVs/GAC are still considered suitably precautionary for use as screening criteria.

Note on Mercury, Chromium and Arsenic

The analytical testing routinely undertaken by Stantec determines total concentration, however, the toxicity depends on the form of the contaminant.

If a source of Mercury, Chromium or Arsenic is identified or the total concentration exceeds the relevant worst case speciated criteria it will be desirable/necessary to undertake additional speciated testing and further assessment.

Note on Polycyclic Aromatic Hydrocarbons

Polycyclic Aromatic Hydrocarbons (PAHs) are a family of hundreds of different congeners whose chemical structures contain two or more fused aromatic rings. Whilst it is recognised that there is an ongoing debate on the most appropriate method to assess health effects of PAH mixtures, in 2010 the Health Protection Agency recommended the use of benzo[a]pyrene (BaP) as a surrogate marker approach in the assessment of carcinogenic risks posed by PAHs in soils (HPA, 2010).

In most cases, BaP is chosen as the surrogate marker (SM) due to its ubiquitous nature and the vast amount of data available and has been used by various authoritative bodies to assess the carcinogenic risk of PAHs in food. The SM approach estimates the carcinogenic toxicity of a mixture of PAHs in an environmental matrix by using toxicity data for a PAH mixture for which the composition is known.

Exposure to the SM is assumed to represent exposure to all PAHs in that matrix therefore the toxicity of the SM represents the toxicity of the mixture. The SM approach relies on a number of assumptions (HPA, 2010).

- The SM (BaP) must be present in all the samples.
- The profile of the different PAH relative to BaP should be similar in all samples.
- The PAH profile in the soil samples should be sufficiently similar to that used in the pivotal toxicity study on which HBGV was based i.e. the Culp study (Culp et al. (1998)).

In order to justify the use of a surrogate marker assessment criterion (C4SL for benzo(a)pyrene and S4UL coal tar) the LQM PAH Profiling Tool is used by Stantec to assess the similarity of the PAH profile in a soil sample to that of the toxicity study. The spreadsheet calculates the relative proportions of the genotoxic PAHs and plots them relative to the composition of the two coal mixtures used by Culp et al. Provided that the relative proportions are within an order of magnitude of those from the Culp Study (as suggested by HPA) Stantec will use the C4SL for benzo(a)pyrene as a surrogate marker for the carcinogenic PAHs, i.e. benzo(a)pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(ah)anthracene, indeno(123-cd)pyrene and benzo(ghi)perylene. For projects where this approach is appropriate the results will be assessed using the Coal Tar criterion (BAP C4SL) and the criteria for non-carcinogenic PAHs (S4ULs), i.e. naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene and pyrene.

Note on Total Petroleum Hydrocarbons

The S4UL for Total Petroleum Hydrocarbon (TPH) fractions are based on 'threshold' health effects. In accordance with Environment Agency guidance (EA, 2005) and the S4UL report (Nathanail *et al*, 2015) the potential for additivity of toxicological effects between fractions should be considered. Practically, to address this issue the hazard quotient (HQ) for each fraction should be calculated by dividing the measured concentration of the fraction by the GAC. The HQs are then added to form a hazard index (HI) for that sample. An HI greater than 1 indicates an exceedance.

Note on Dioxins, Furans and Dioxin-like PCBs

The SGVs for dioxins, furans and dioxin-like PCBs are based on an assumed congener profile for urban soils. The total measured concentration of dioxin, furan and dioxin-like PCB congeners listed in the SGV report (EA, 2009a) should be compared with the SGVs to make an initial assessment of risk. A more accurate assessment can be made using the Environment Agency's site specific worksheet for dioxins, furans and dioxin like PCBs available from [redacted]

Note on Asbestos

Asbestos in soil and made ground is currently under review by a number of bodies. There are no current published guidance values for asbestos in soil other than the waste classification values given in the EA's Technical Guidance WM3, Hazardous Waste – Interpretation of the definition and classification of hazard waste (EA, 2015). This guidance is only appropriate for soils that are being discarded as waste.

Testing for asbestos will be carried out on selected samples of made ground encountered during investigation, initially samples will be subjected to an asbestos screen and, if asbestos is found to be present, subjected to quantification depending on the project specific requirements. The reader is directed to the report text for guidance on the approach adopted in respect to any asbestos found to be present.

Further guidance is also available in publication C733, Asbestos in soil and made ground: a guide to understanding and managing risks (CIRIA 2014).

Note on Soil Saturation Concentration

The soil saturation concentration is the concentration of an organic constituent in soil at which either the pore water or soil vapour has theoretically become saturated with the substance, i.e. the substance concentration has reached its maximum aqueous solubility or vapour pressure. The soil saturation concentration is related to the properties of the substance as well as the properties of the soil (including soil organic matter content).

The soil saturation concentrations are shown in Table 2 in brackets where exceeded by the assessment criteria and in Table 4 for all substances. Measured concentrations in excess of the soil saturation concentration have various potential implications as discussed below.

Firstly, where measured concentrations exceed the soil saturation concentration, the risk from vapour inhalation and/or consumption of produce may be limited. The CLEA model calculates the soil saturation concentration but it does not limit exposure where this concentration is exceeded. This adds an additional level of conservatism for CLEA derived assessment criteria where these exceed the calculated soil saturation concentration. Secondly, the soil saturation concentration is sometimes used to flag the potential presence of non-aqueous phase liquid (NAPL, a.k.a. free phase) in soil. The presence of NAPL is an important consideration in the Tier 2 assessment because, where present, the risks from NAPL may need to be considered separately. Theoretically, where a measured concentration exceeds the soil saturation concentration NAPL could be present. However, using theoretical saturation values is not always reliable for the following reasons: The soil saturation concentration is based on the aqueous solubility and vapour pressure of a pure substance and not a mixture, of which NAPLs are often comprised; and

The soil saturation concentration does not account for the sorption capacity of the soil. As a result, exceedance of the soil saturation concentration does not necessarily imply that NAPL is present. This is particularly the case for longer chain hydrocarbons such as PAHs which have low solubility and vapour pressure and hence a low soil saturation concentration but that are strongly sorbed to soil.

The measured concentrations will be compared to the soil saturation concentrations shown in Tables 2 and 4. Where exceeded Stantec will use additional lines of evidence (such as visual evidence and concentration of total TPH) to determine whether or not NAPL is likely to be present. If the presence of NAPL is deemed plausible the implications will be considered in the risk assessment.

3.2 Potential Harm to the Built Environment

Land contamination can pose risks to buildings, building materials and services (BBM&S) in a number of ways. Volatile contaminants and gases can accumulate and cause explosion or fire. Foundations and buried services can be damaged by corrosive substances and contaminants such as steel slags can create unstable ground conditions through expansion causing structural damage.

Stantec use the following primary guidance to assess the significance of soil chemistry with respect to its potential to harm the built environment.

i) Approved Document C - Site Preparation and Resistance to Contaminants and Moisture. (DCLG, 2013);
ii) Concrete in aggressive ground SD1 (BRE 2005);
iii) Guidance for the selection of water supply pipes to be used in brownfield sites (UK WIR 2011);
iv) Protocols published by agreement between Water UK and the Home Builders Federation providing supplementary guidance which

includes the Risk Assessment for Water Pipes (the 'RA') (Water UK 2014).

v) Performance of Building Materials in Contaminated Land report BR255 (BRE 1994).

vi) Risks of Contaminated Land to Buildings, Building Materials and Services. A Literature Review - Technical Report P331 (EA, 2000).

vii) Guidance on assessing and managing risks to buildings from land contamination - Technical Report P5 035/TR/01 (EA, 2001).

3.3 Potential to Harm Ecosystems, Animals, Crops etc

The criteria routinely used by Stantec as Tier 2 screening values to assess the potential of soil chemistry to harm ecosystems are taken from the following guidance and are summarised in Table 5.

i) Derivation and Use of Soil Screening Values for assessing ecological risks (EA, 2017a);

ii) The Restoration and Aftercare of Metalliferous Mining Sites for Pasture and Grazing (ICRCL 70/90, 1990);

iii) Sewage sludge on farmland: code of practice for England, Wales and Northern Ireland (DEFRA, 2018); and

iv) BS 3882:2015 Specification for topsoil and requirements for use (BSI, 2015).

Unless stated in the report the assessment is solely for phytotoxic parameters and additional assessment is required to determine suitability as a growing medium.

4 CRITERIA FOR EVALUATING LIQUID RESULTS

4.1 Potential Harm to Human Health via Ingestion

The Tier 2 water screening values routinely adopted by Stantec for assessing the potential for harm to human health via ingestion (presented as Table 6) are taken from The Water Supply (Water Quality) Regulations (S.I. 2018/647) unless otherwise indicated.

It should be noted that some of the prescribed concentrations listed in the Water Supply Regulations have been set for reasons other than their potential to cause harm to human health. The concentrations of iron and manganese are controlled because they may taint potable water with an undesirable taste, odour or colour or may potentially deposit precipitates in water supply pipes.

4.2 Potential Harm to Human Health via Inhalation of Vapours

The Tier 2 water screening values adopted by Stantec for assessing the potential for chronic human health risk from the inhalation of vapours from volatile contaminants in groundwater are presented in Table 7. These generic assessment criteria have been taken from a report published by the Society of Brownfield Risk Assessment (SoBRA) (SoBRA, 2017). The methodology adopted in their generation is considered compatible with the UK approach to deriving GAC and adopts a precautionary approach. As with all published GAC the suitability for use on the site being assessed has to be decided by the assessor based on a thorough understanding of the methodology and assumptions used in their derivation. Note, that the SoBRA groundwater vapour GAC are not intended for assessing risks to ground workers from short-term exposure.

Note that Table 7 shows the theoretical maximum aqueous solubility for each contaminant and indicates the GAC that exceed solubility. Measured concentrations in excess of solubility may be an indication that NAPL is present. As for the assessment of soils, if the presence of NAPL is deemed plausible the implications will be considered in the risk assessment.

4.3 Potential to Harm Controlled Waters

When assessing ground condition data and the potential to harm Controlled Waters Stantec uses the approach presented in the groundwater protection position statements published 14.03.17 (EA, 2017b) which describe the Environment Agency's approach to managing and protecting groundwater. They update and replace Groundwater Protection: principles and practice (GP3). Controlled Waters are rivers, estuaries, coastal waters, lakes and groundwaters. Water in the unsaturated zone is not groundwater but does come within the scope of the term "ground waters" as used and defined in the Water Resources Act 1991. It will continue to be a technical decision for the Environment Agency to determine what is groundwater in certain circumstances for the purposes of the Regulations. As discussed in our Methodology for Assessment of Land Contamination perched water is not considered a receptor in Stantec assessments.

The EU Water Framework Directive (WFD) 2000/60/EC provides for the protection of sub-surface, surface, coastal and territorial waters through a framework of river basin management.

The EU Updated Water Framework Standards Directive 2014/101/EU amended the EU WFD to update the international standards therein; it entered into force on 20 November 2014 with the requirement for its provisions to be transposed in Member State law by 20 May 2016.
Member States are required under the EU WFD to update their river basin management plans every six years. The first river basin management plans for England and Wales, Scotland and Northern

Ireland were published in December 2009, and these were updated in 2015.

Other EU Directives in the European water management framework include:

- the EU Priority Substances Directive 2013/39/EU;
- EU Groundwater Pollutants Threshold Values Directive 2014/80/EU amending the EU Groundwater Daughter Directive (GWDD) 2006/118/EC; and
- the EU Biological Monitoring Directive 2014/101/EU.

The Priority Substances Directive set environmental quality standards (EQS) for the substances in surface waters (river, lake, transitional and coastal) and confirmed their designation as priority or priority hazardous substances (PS), the latter being a subset of particular concern. Environmental Quality Standards for PS are determined at the European level and apply to all Member States. Member States identify and develop standards for 'Specific Pollutants'. Specific Pollutants (SP) are defined as substances that can have a harmful effect on biological quality.

The Water Framework Directive (Standards and Classification) Directions (England and Wales) (DEFRA, 2015) were issued to the Environment Agency as an associated document of the Water Environment (WFD) (England and Wales) Regulations 2015 (S.I. 2015/1623) and provide directions for the classification of surface water and groundwater bodies. Schedule 3 parts 2 and 3 relate to surface water standards for specific pollutants in fresh or salt water bodies and priority substances in inland (rivers, lakes and related modified/artificial bodies) or other surface waters respectively. Although Schedule 5 presents threshold values for groundwater the Direction specifically excludes their use as part of site-specific investigations.

Table 6 presents the criteria routinely used by Stantec as Tier 2 screening values. This table only presents a selection of the more commonly analysed parameters and the source documents should be consulted for other chemicals. For screening groundwater the criteria selected are the standards for surface water and/or human consumption as appropriate together with the following:-

For a **hazardous substance** Stantec adopts the approach that, if the concentration in a discharge to groundwater is less than the Minimum Reporting Value (MRV), the input is regarded as automatically meeting the Article 2 (b) 'de-minimus' requirement of exemption 6 (3) (b) of the GWDD. Stantec has selected hazardous substances from the latest list published by the Joint Agencies Groundwater Directive Advisory Group (JAGDAG, 2018). MRV is the lowest concentration of a substance that can be routinely determined with a known degree of confidence, and may not be equivalent to limit of detection. MRVs have been identified from DEFRA's guidance on Hazardous Substances to Groundwater: Minimum Reporting Values (DEFRA, 2017), and are shown in Table 6.

Note that for land contamination assessments, where hazardous substances have already entered groundwater, remediation targets would typically be based on achieving appropriate water quality standards (e.g. drinking water standard or EQS) at a compliance point rather than an MRV. For this reason, when assessing measured groundwater or soil leachate concentrations, the values for human consumption, fresh water and salt water shown in Table 6 (whichever is appropriate for the context of the site) will be used as the Tier 2 assessment criteria rather than MRV. For hazardous substances with no water quality standard the laboratory method detection limit will be used as the assessment criteria.

For **non-hazardous substances** the GWDD requires that inputs be limited to avoid deterioration. UKTAG guidance equates deterioration with pollution. Non-hazardous substances are all substances not classified as hazardous. For Stantec assessments the values for human consumption, fresh water and salt water shown in Table 6 (whichever is appropriate for the context of the site) are used as the assessment criteria for non-hazardous substances.

Note on Copper, Lead, Manganese, Nickel and Zinc

$EQS_{bioavailable}$ have been developed for UK Specific Pollutants copper, zinc and manganese and the EU priority substances lead and nickel. An EQS is the concentration of a chemical in the environment below which there is not expected to be an adverse effect on the specific endpoint being considered, e.g. the protection of aquatic life.

It is very difficult to measure the bioavailable concentration of a metal directly. The UK has developed simplified Metal Bioavailability Assessment Tool (M-BAT) for copper, zinc, nickel and manganese which uses local water chemistry data, specifically pH, dissolved organic carbon (DOC) (mg/L) and Calcium (Ca) (mg/L).

Where the recorded total dissolved concentration exceeds the screening criteria for these parameters ($EQS_{bioavailable}$) further assessment will be undertaken using the tools downloaded from [redacted]

The models calculate a risk characterisation ratio (RCR) and where this is greater than 1 this indicates the bioavailable concentration is above the EQS and the parameter is then identified as a potential hazard. The report will discuss this identified hazard noting that the pH, calcium and, in particular, the dissolved organic carbon (DOC) in groundwater may be quite different to the receiving water (e.g. due to the presence to leaf litter or organic sediments dissolving in the water).

5 CRITERIA FOR EVALUATING GAS RESULTS

Stantec use the following primary guidance on gas monitoring methods and investigation, the assessment of risk posed by soil gases (including Volatile Organic Compounds (VOCs)) and mitigation measures/risk reduction during site development.

i) BS 8576:2013 – Guidance on Ground Gas Investigations: Permanent gases and Volatile Organic Compounds (VOCs) (BSI, 2013);
ii) TB18 Continuous Ground-Gas Monitoring and the Lines of Evidence Approach to Risk Assessment CL:AIRE Technical Bulletin TB18 (CL:AIRE 2019)
iii) RB17 A pragmatic approach to Ground Gas Risk Assessment. CL:AIRE Research Bulletin RB17 (Card et al, 2012);
iv) The VOCs Handbook. C682 (CIRIA, 2009).
v) Assessing risks posed by hazardous gases to buildings C665 (CIRIA, 2007);
vi) Guidance on evaluation of development proposals on sites where methane and carbon dioxide are present. (NHBC, 2007); and
vii) BS 8485:2015+A1:2019- Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings (BSI, 2019).

Gas and borehole flow data are used to obtain the gas screening value (GSV) for methane and carbon dioxide. The GSV is used to establish the characteristic situation and to make recommendations for gas protection measures for buildings if required.

Radon

Stantec use the following primary guidance to assess the significance of the radon content of soil gas.

i) Radon: guidance on protective measures for new dwellings. Report BR211 (BRE, 2015); and
ii) Indicative Atlas of Radon in England and Wales (HPA & BGS, 2007).

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Table 1: Category 4 Screening Levels (C4SL)

	Allotments	Residential (with home-grown produce)	Residential (without home-grown produce)	Commercial	Public Open Space 1	Public Open Space 2
Arsenic	49	37	40	640	79	170
Benzene - 1% SOM* - 2.5% SOM* - 6% SOM	 0.039 0.081 0.18	 0.20 0.41 0.87	 0.89 1.6 3.3	 27 50 98	 140 140 140	 190 210 230
Benzo(a)pyrene (as a surrogate marker for carcinogenic PAHs)	5.7	5.0	5.3	77	10	21
Cadmium	3.9	22	150	410	220	880
Chromium VI	170	21	21	49	21	250
Lead	80	200	310	2300	630	1300

Units mg/kg dry weight

Values taken from SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination – Policy Companion Document (Department for Environment, Food and Rural Affairs December 2014), unless stated otherwise
Public Open Space 1 – for grassed area adjacent to residential housing
Public Open Space 2 - Park Type Public Open Space Scenario
Based on a sandy loam as defined in SR3 (Environment Agency, 2009b)
Note that, with the exception of benzene, these C4SL are not SOM dependent
* - Stantec derived C4SL using CLEA v1.071

Table 2: Suitable 4 Use Levels (S4UL)

Determinand	Allotment	R<u>W</u>HP	R<u>WO</u>HP	Commercial/ Industrial	POSresi	POSpark
Metals						
Arsenic (**Inorganic**)[a, b, c]	43	37	40	640	79	170
Beryllium [a, b, d, e]	35	1.7	1.7	12	2.2	63
Boron [a, b, d]	45	290	11000	240000	21000	46000
Cadmium (**pH6-8**) [a, b, d, f]	1.9	11	85	190	120	560
Chromium (trivalent) [a, b, d, g]	18000	910	910	8600	1500	33000
Chromium (hexavalent) [a, b, c]	1.8[h]	6[i]	6[i]	33[i]	7.7[i]	220[i]
Copper [a, b, c]	520	2400	7100	68000	12000	44000
Mercury (elemental) [a, b, c, j]	21	1.2	1.2	58[vap] (25.8)	16	30[vap] (25.8)
Mercury (inorganic) [a, b, c]	19	40	56	1100	120	240
Methylmercury [a, b, c]	6	11	15	320	40	68
Nickel [a, b, c]	53[k]	130[e]	180[e]	980[e]	230[e]	800[k]
Selenium [a, b, c]	88	250	430	12000	1100	1800
Vanadium [a, b, c, i, j]	91	410	1200	9000	2000	5000
Zinc [a, b, c]	620	3700	40000	730000	81000	170000
BTEX Compounds (SOM 1%/ 2.5%/ 6%)						
Benzene [a, b, l, m]	0.017/0.034/ 0.075	0.087/0.17/ 0.37	0.38/0.7/1.4	27 / 47 / 90	72 / 72 / 73	90 / 100 / 110
Toluene [a, b, l, m]	22 / 51 / 120	130 / 290 / 660	880[vap] (869) /1900/3900	56000[vap] (869) / 110000[vap] (1920)/ 180000[vap] (4360)	56000 / 56000 / 56000	87000[vap](869)/ 95000[vap](1920)/ 100000[vap](4360)
Ethylbenzene [a, b, l, m]	16 / 39 / 91	47 / 110 / 260	83 / 190 / 440	5700[vap] (518) / 13000[vap] (1220) / 27000[vap] (2840)	24000 / 24000 / 25000	17000[vap] (518) / 22000[vap](1220) / 27000[vap] (2840)
O – Xylene [a, b, l, m, n]	28 / 67 / 160	60 / 140 / 330	88 / 210 / 480	6600[sol] (478) / 15000[sol] (1120) / 33000[sol] (2620)	41000 / 42000 / 43000	17000[sol] (478) / 24000[sol] (1120) / 33000[sol] (2620)
M – Xylene [a, b, l, m, n]	31 / 74 / 170	59 / 140 / 320	82 / 190 / 450	6200[vap] (625) / 14000[vap] (1470) / 31000[vap] (3460)	41000 / 42000 / 43000	17000[vap] (625) / 24000[vap](1470) / 32000[vap] (3460)
P – Xylene [a, b, l, m, n]	29 / 69 / 160	56 / 130 / 310	79 / 180 / 430	5900[sol] (576) / 14000[sol] (1350) / 30000[sol] (3170)	41000 / 42000 / 43000	17000[sol] (576) / 23000[sol] (1350) / 31000[sol] (3170)
Total xylenes [t]	28 / 67 / 160	56 / 130 / 310	79 / 180 / 430	5900[sol] (576) / 14000[sol] (1350) / 30000[sol] (3170)	41000 / 42000 / 43000	17000[sol] (576) / 23000[sol] (1350) / 31000[sol] (3170)
Polycyclic Aromatic Hydrocarbons (SOM 1%/ 2.5%/ 6%) [a, b, l, p]						
Acenaphthene	34 / 85 / 200	210 / 510 / 1100	3000[sol](57.0)/ 4700[sol] (141)/ 6000[sol] (336)	84000[sol] (57.0)/ 97000[sol] (141)/ 100000	15000 / 15000 / 15000	29000/ 30000/ 30000
Acenaphthylene	28 / 69 / 160	170 / 420 / 920	2900[sol](86.1)/ 4600[sol] (212)/ 6000[sol] (506)	83000[sol] (86.1)/ 97000[sol] (212)/ 100000	15000 / 15000 / 15000	29000 / 30000 / 30000
Anthracene	380 / 950 / 2200	2400 / 5400 / 11000	31000[sol](1.17) /35000/ 37000	520000/ 540000/ 540000	74000 / 74000 / 74000	150000 / 150000 / 150000
Benzo(a)anthracene	2.9 / 6.5 / 13	7.2 / 11 / 13	11 / 14 / 15	170 / 170 / 180	29 / 29 / 29	49 / 56 / 62
Benzo(a)pyrene (Bap) [u]	0.97 / 2.0 / 3.5	2.2 / 2.7 / 3.0	3.2 / 3.2 / 3.2	35 / 35 / 36	5.7 / 5.7 / 5.7	11 / 12 / 13
Benzo(b)fluoranthene	0.99 / 2.1 / 3.9	2.6 / 3.3 / 3.7	3.9 / 4.0 / 4.0	44 / 44 / 45	7.1 / 7.2 / 7.2	13 / 15 / 16

Determinand	Allotment	R$_{W}$HP	R$_{WO}$HP	Commercial/ Industrial	POSresi	POSpark
Benzo(g,h,i)perylene	290 / 470 / 640	320 / 340 / 350	360 / 360 / 360	3900 / 4000 / 4000	640 / 640 / 640	1400 / 1500 / 1600
Benzo(k)fluoranthene	37 / 75 / 130	77 / 93 / 100	110 / 110 / 110	1200 / 1200 /1200	190 / 190 / 190	370 / 410 / 440
Chrysene	4.1 / 9.4 / 19	15 / 22 / 27	30 / 31 / 32	350 / 350 / 350	57 / 57 / 57	93 / 110 / 120
Dibenzo(ah)anthracene	0.14 / 0.27 / 0.43	0.24 / 0.28 / 0.3	0.31 / 0.32 / 0.32	3.5 / 3.6 / 3.6	0.57 / 0.57 / 0.58	1.1 / 1.3 / 1.4
Fluoranthene	52 / 130 / 290	280 / 560 / 890	1500 / 1600 / 1600	23000 / 23000 / 23000	3100 / 3100 / 3100	6300 / 6300 / 6400
Fluorene	27 / 67 / 160	170 / 400 / 860	2800^{sol} (30.9) /3800^{sol} (76.5) /4500^{sol} (183)	63000^{sol} (30.9) / 68000 / 71000	9900 / 9900 / 9900	20000 / 20000 / 20000
Indeno(1,2,3-cd)pyrene	9.5 / 21 / 39	27 / 36 / 41	45 / 46 / 46	500 / 510 / 510	82 / 82 / 82	150 / 170 / 180
Naphthalene [q]	4.1 / 10 / 24	2.3 / 5.6 / 13	2.3 / 5.6 / 13	190^{sol} (76.4) / 460^{sol} (183) / 1100^{sol} (432)	4900/ 4900/ 4900	1200^{sol} (76.4) / 1900^{sol} (183) / 3000
Phenanthrene	15 / 38 / 90	95 / 220 / 440	1300^{sol}(36.0) / 1500 / 1500	22000 / 22000 / 23000	3100 / 3100 / 3100	6200 / 6200 / 6300
Pyrene	110 / 270 / 620	620 / 1200 / 2000	3700 / 3800 / 3800	54000 / 54000 / 54000	7400 / 7400 / 7400	15000 / 15000 / 15000
Coal Tar (Bap as surrogate marker) [u]	0.32 / 0.67 / 1.2	0.79 / 0.98 / 1.1	1.2 / 1.2 / 1.2	15 / 15 / 15	2.2 / 2.2 / 2.2	4.4 / 4.7 / 4.8
Explosives [a, b, l, p]						
2, 4, 6 Trinitrotoluene	0.24 / 0.58 / 1.40	1.6 / 3.7 / 8.0	65 / 66 / 66	1000 / 1000 / 1000	130 / 130 / 130	260 / 270 / 270
RDX (Royal Demolition Explosive $C_3H_6N_6O_6$)	17 / 38 / 85	120 / 250 / 540	13000 / 13000 / 13000	210000 / 210000 / 210000	26000 / 26000 / 27000	49000^{sol} (18.7) / 51000 / 53000
HMX (High Melting Explosive $C_4H_8N_8O_8$)	0.86 / 1.9 / 3.9	5.7 / 13 / 26	6700 / 6700 / 6700	110000 / 110000 / 110000	13000 / 13000 / 13000	23000^{vap} (0.35) /23000^{vap} (0.39) /24000^{vap} (0.48)
Petroleum Hydrocarbons (SOM 1%/ 2.5%/ 6%) [a, b, l, m]						
Aliphatic EC 5-6	730 / 1700 / 3900	42 / 78 / 160	42 / 78 / 160	3200^{sol} (304) / 5900^{sol} (558) / 12000^{sol} (1150)	570000^{sol}(304) 590000 / 600000	95000^{sol} (304) / 130000^{sol} (558)/ 180000^{sol}(1150)
Aliphatic EC >6-8	2300 / 5600 / 13000	100 / 230 / 530	100 / 230 / 530	7800^{sol} (144) / 17000^{sol} (322) / 40000^{sol} (736)	600000 / 610000 / 620000	150000^{sol} (144) 220000^{sol} (322)/ 320000^{sol} (736)
Aliphatic EC >8-10	320 / 770 / 1700	27 / 65 / 150	27 / 65 / 150	2000^{sol} (78) / 4800^{vap} (190) / 11000^{vap} (451)	13000 / 13000 / 13000	14000^{sol} (78) / 18000^{vap} (190) / 21000^{vap} (451)
Aliphatic EC >10-12	2200 / 4400 / 7300	130v^{ap} (48) / 330^{vap} (118) / 760^{vap} (283)	130v^{ap} (48) / 330^{vap} (118) / 770^{vap} (283)	9700^{sol} (48) / 23000^{vap} (118) / 47000^{vap} (283)	13000 / 13000 / 13000	21000^{sol} (48) / 23000^{vap} (118) / 24000^{vap} (283)
Aliphatic EC >12-16	11000 / 13000 / 13000	1100^{sol} (24) / 2400^{sol} (59) / 4300^{sol} (142)	1100^{sol} (24) / 2400^{sol} (59) / 4400^{sol} (142)	59000^{sol} (24) / 82000^{sol} (59) / 90000^{sol} (142)	13000 / 13000 / 13000	25000^{sol} (24) / 25000^{sol} (59) / 26000^{sol} (142)
Aliphatic EC >16-35 [o]	260000 / 270000 / 270000	65000^{sol}(8.48 92000^{sol} (21) 110000	65000^{sol} (8.48 92000^{sol} (21) 110000	1600000 / 1700000 / 1800000	250000 / 250000 / 250000	450000 / 480000 / 490000
Aliphatic EC >35-44 [o]	260000 / 270000 / 270000	65000^{sol}(8.48 92000^{sol} (21) / 110000	65000^{sol}(8.48 92000^{sol} (21) 110000	1600000 / 1700000 / 1800000	250000 / 250000 / 250000	450000 / 480000 / 490000
Aromatic EC 5-7 (benzene)	13 / 27 / 57	70 / 140 / 300	370 / 690 / 1400	26000^{sol} (1220) / 46000^{sol} (2260) / 86000^{sol} (4710)	56000 / 56000 / 56000	76000^{sol} (1220) /84000^{sol}(2260)/ 92000^{sol} (4710)
Aromatic EC >7-8 (toluene)	22 / 51 / 120	130 / 290 / 660	860 / 1800 / 3900	56000^{vap} (869)/ 110000^{sol} (1920)/ 180000^{vap} (4360)	56000 / 56000 / 56000	87000^{vap}(869) / 95000^{sol} (1920)/ 100000^{vap}(4360)
Aromatic EC >8-10	8.6 / 21 / 51	34 / 83 / 190	47 / 110 / 270	3500^{vap} (613) / 8100^{vap} (1500) / 17000^{vap} (3580)	5000 / 5000 / 5000	7200^{vap}(613) / 8500^{vap} (1500) / 9300^{vap} (3580)
Aromatic EC >10-12	13 / 31 / 74	74 / 180 / 380	250 / 590 / 1200	16000^{sol} (364) / 28000^{sol} (899) / 34000^{sol} (2150)	5000 / 5000 / 5000	9200^{sol} (364) / 9700^{sol} (899) / 10000
Aromatic EC >12-16	23 / 57 / 130	140 / 330 / 660	1800 / 2300^{sol} (419) / 2500	36000^{sol} (169) / 37000 / 38000	5100 / 5100 / 5000	10000 / 10000 / 10000
Aromatic EC >16-21 [o]	46 / 110 / 260	260 / 540 / 930	1900 / 1900 / 1900	28000 / 28000 / 28000	3800 / 3800 / 3800	7600 / 7700 / 7800
Aromatic EC >21-35 [o]	370 / 820 / 1600	1100 / 1500 / 1700	1900 / 1900 / 1900	28000 / 28000 / 28000	3800 / 3800 / 3800	7800 / 7800 / 7900
Aromatic EC >35-44 [o]	370 / 820 / 1600	1100 / 1500 / 1700	1900 / 1900 / 1900	28000 / 28000 / 28000	3800 / 3800 / 3800	7800 / 7800 / 7900
Aliphatic+Aromatic EC >44-70 [o]	1200 / 2100 / 3000	1600 / 1800 / 1900	1900 / 1900 / 1900	28000 / 28000 / 28000	3800 / 3800 / 3800	7800 / 7800 / 7900
Chloroalkanes & Chloroalkenes (SOM 1%/ 2.5%/ 6%) [a, b, l, p]						
1,2-Dichloroethane	0.0046 / 0.0083 / 0.016	0.0071 / 0.011 / 0.019	0.0092 / 0.013 / 0.023	0.67 / 0.97 / 1.7	29 / 29 / 29	21 / 24 / 28

Determinand	Allotment	RwHP	RwoHP	Commercial/ Industrial	POSresi	POSpark
1,1,1 Trichloroethane (TCA)	48 / 110 / 240	8.8 / 18 / 39	9.0 / 18 / 40	660 / 1300 / 3000	140000 / 140000 / 140000	57000[vap](1425) 76000[vap](2915)/ 100000[vap](6392)
1,1,1,2 Tetrachloroethane	0.79 / 1.9 / 4.4	1.2 / 2.8 / 6.4	1.5 / 3.5 / 8.2	110 / 250 / 560	1400 / 1400 / 1400	1500 / 1800 / 2100
1,1,2,2 Tetrachloroethane	0.41 / 0.89 / 2.0	1.6 / 3.4 / 7.5	3.9 / 8.0 / 17	270 / 550 / 1100	1400 / 1400 / 1400	1800 / 2100 / 2300
Tetrachloroethene (PCE)	0.65 / 1.5 / 3.6	0.18 / 0.39 / 0.90	0.18 / 0.4 / 0.92	19 / 42 / 95	1400 / 1400 / 1400	810[sol](424)/1100[sol] (951)/1500
Tetrachloromethane (Carbon Tetrachloride)	0.45 / 1.0 / 2.4	0.026 / 0.056 / 0.13	0.026 / 0.056 / 0.13	2.9 / 6.3 / 14	890 / 920 / 950	190 / 270 / 400
Trichloroethene (TCE)	0.041 / 0.091 / 0.21	0.016 / 0.034 / 0.075	0.017 / 0.036 / 0.080	1.2 / 2.6 / 5.7	120 / 120 / 120	70 / 91 / 120
Trichloromethane (Chloroform)	0.42 / 0.83 / 1.7	0.91 / 1.7 / 3.4	1.2 / 2.1 / 4.2	99 / 170 / 350	2500 / 2500 / 2500	2600 / 2800 / 3100
Chloroethene (Vinyl Chloride)	0.00055/ 0.001/ 0.0018	0.00064 / 0.00087/ 0.0014	0.00077 / 0.001 / 0.0015	0.059 / 0.077 / 0.12	3.5 / 3.5 / 3.5	4.8 / 5.0 / 5.4
Phenol & Chlorophenols [a, b, l, p]						
Phenol	23 / 42 / 83	120 / 200 / 380	440 / 690 / 1200	440[dir] (26000) / 690[dir] (30000) / 1300[dir] (34000)	440[dir] (10000)/ 690[dir](10000) 1300[dir](10000)	440[dir] (7600) / 690[dir] (8300) / 1300[dir] (93000)
Chlorophenols (excluding PCP) [r]	0.13[s] / 0.3 / 0.7	0.87[s] / 2.0 / 4.5	94 / 150 / 210	3500 / 4000 / 4300	620 / 620 / 620	1100 / 1100 / 1100
Pentachlorophenol (PCP)	0.03 / 0.08 / 0.19	0.22/ 0.52 / 1.2	27[vap] (16.4) / 29 / 31	400 / 400 / 400	60 / 60 / 60	110 / 120 / 120
Other [a, b, l, p]						
Carbon Disulphide	4.8 / 10 / 23	0.14 / 0.29 / 0.62	0.14 / 0.29 / 0.62	11 / 22 / 47	11000 / 11000 / 12000	1300 / 1900 / 2700
Hexachlorobutadiene (HCBD)	0.25 / 0.61 / 1.4	0.29 / 0.7 / 1.6	0.32 / 0.78 / 1.8	31 / 66 / 120	25 / 25 / 25	48 / 50 / 51
Pesticides (SOM 1%/ 2.5%/ 6%) [a, b, l, p]						
Aldrin	3.2 / 6.1 / 9.6	5.7/ 6.6 /7.1	7.3 / 7.4 / 7.5	170 / 170 / 170	18 / 18 / 18	30 / 31 / 31
Atrazine	0.5 / 1.2 / 2.7	3.3 / 7.6 / 17.4	610 / 620 / 620	9300 / 9400 / 9400	1200 / 1200 / 1200	2300 / 2400 / 2400
Dichlorvos	0.0049 / 0.010 / 0.022	0.032 / 0.066 / 0.14	6.4 / 6.5 / 6.6	140 / 140 / 140	16 / 16 / 16	26 / 26 / 27
Dieldrin	0.17/0.41/0.96	0.97/ 2 / 3.5	7.0 / 7.3 / 7.4	170 / 170 / 170	18 / 18 / 18	30 / 30 / 31
Alpha - Endosulfan	1.2 / 2.9 / 6.8	7.4 / 18 / 41	160[vap] (0.003)/ 280[vap] (0.007)/ 410[vap] (0.016)	5600[vap] (0.003) / 7400[vap] (0.007) / 8400[vap] (0.016)	1200 / 1200 / 1200	2400 / 2400 / 2500
Beta - Endosulfan	1.1 / 2.7 / 6.4	7.0 / 17 / 39	190[vap](0.00007) /320[vap](0.0002) /440[vap](0.0004)	6300[vap](0.00007) /7800[vap](0.0002) / 8700	1200 / 1200 / 1200	2400 / 2400 / 2500
Alpha-Hexachlorocyclohexane	0.035/0.087/ 0.21	0.23/0.55 / 1.2	6.9 / 9.2 / 11	170 / 180 / 180	24 / 24 / 24	47 / 48 / 48
Beta - Hexachlorocyclohexane	0.013 / 0.032 / 0.077	0.085 / 0.2 / 0.46	3.7 / 3.8 / 3.8	65 / 65 / 65	8.1 / 8.1 / 8.1	15 / 15 / 16
Gamma – Hexachlorocyclohexane	0.0092 / 0.023 / 0.054	0.06 / 0.14 / 0.33	2.9 / 3.3 / 3.5	67 / 69 / 70	8.2 / 8.2 / 8.2	14 / 15 / 15
Chlorobenzenes [a, b, l, p]						
Chlorobenzene	5.9 / 14 / 32	0.46 / 1.0 / 2.4	0.46 / 1.0 / 2.4	56 / 130 / 290	11000 / 13000 / 14000	1300[sol](675)/ 2000[sol](1520)/ 2900
1,2-dichlorobenzene (1,2-DCB)	94 / 230 / 540	23 / 55 / 130	24 / 57 / 130	2000[sol] (571) / 4800[sol] (1370) / 11000[sol] (3240)	90000 / 95000 / 98000	24000[sol] (571) / 36000[sol] (1370) /51000[sol] (3240)
1,3-dichlorobenzene (1,3-DCB)	0.25 / 0.6 / 1.5	0.4 / 1.0 / 2.3	0.44 /1.1 / 2.5	30 / 73 / 170	300 / 300 / 300	390 / 440 / 470
1-4-dichlorobenzene (1,4-DCB)	15[i] / 37[i] / 88 [i]	61[q] / 150[q] /350 [q]	61[q] / 150[q] / 350[q]	4400[vap,q] (224) / 10000[vap,q] (540) / 25000[vap,q] (1280)	17000[i] / 17000[i] / 17000[i]	36000[vap,i] (224) 36000[vap, i](540)/ 36000[vap,i](1280)
1,2,3-Trichlorobenzene	4.7 / 12 / 28	1.5 / 3.6 / 8.6	1.5 / 3.7 / 8.8	102 / 250 / 590	1800 / 1800 / 1800	770[vap] (134) / 1100[vap] (330) / 1600[vap] (789)
1,2,4- Trichlorobenzene	55 / 140 / 320	2.6 / 6.4 / 15	2.6 / 6.4 / 15	220 / 530 / 1300	15000 / 17000 / 19000	1700[vap] (318) / 2600[vap] (786) / 4000[vap] (1880)
1,3,5- Trichlorobenzene	4.7 / 12 / 28	0.33 / 0.81 / 1.9	0.33 / 0.81 / 1.9	23 / 55 / 130	1700 / 1700 / 1800	380[vap] (36.7) / 580[vap] (90.8) / 860[vap] (217)
1,2,3,4-Tetrachlorobenzene	4.4 / 11 / 26	15 / 36 / 78	24 / 56 / 120	1700[vap] (122) / 3080[vap] (304) / 4400[vap] (728)	830 / 830 / 830	1500[vap] (122) / 1600 / 1600
1,2,3,5- Tetrachlorobenzene	0.38 / 0.90 / 2.2	0.66 / 1.6 / 3.7	0.75 / 1.9 / 4.3	49[vap] (39.4) / 120[vap] (98.1) / 240[vap] (235)	78 / 79 / 79	110[vap] (39.4) / 120 / 130
1,2,4,5- Tetrachlorobenzene	0.06 / 0.16 / 0.37	0.33 / 0.77 / 1.6	0.73 / 1.7 / 3.5	42[sol] (19.7) / 72[sol] (49.1) / 96	13 / 13 / 13	25 / 26 / 26

Determinand	Allotment	$R_{\underline{W}}HP$	$R_{\underline{WO}}HP$	Commercial/ Industrial	POSresi	POSpark
Pentachlorobenzene (P_ECB)	1.2 / 3.1 / 7.0	5.8 / 12 / 22	19 / 30 / 38	640^{sol} (43.0) / 770^{sol} (107) / 830	100 / 100 / 100	190 / 190 / 190
Hexachlorobenzene (HCB)	0.47 / 1.1 / 2.5	1.8^{vap} (0.20) / 3.3^{vap} (0.5) / 4.9	4.1^{vap} (0.20) / 5.7^{vap} (0.5) / 6.7^{vap} (1.2)	110^{vap} (0.20) / 120 / 120	16 / 16 / 16	30 / 30 / 30

Units are mg/kg Dry Weight

$R_{\underline{W}}HP$ Residential with homegrown produce
$R_{\underline{WO}}HP$ Residential without homegrown produce
POSresi public open spaces near residential housing
POSpark public open space for recreational use but not dedicated sports pitches
SOM Soil Organic Matter – ***the S4UL for all organic compounds will vary according to SOM***

a Based on a sandy loam soil as defined in SR3 (Environment Agency, 2009b) and 6% soil organic matter (SOM)
b Figures rounded to two significant figures
c Based only on a comparison of oral and dermal soil exposure with oral Index Dose
d The background ADE is limited to being no larger than the contribution from the relevant soil ADE
e Based on comparison of inhalation exposure with inhalation TDI only
f Based on a lifetime exposure via the oral, dermal and inhalation pathways
g Based on localised effects comparing inhalation exposure with inhalation ID only
h Based on comparison of inhalation exposure with inhalation ID
i Based on comparison of oral and dermal exposure with oral TDI
j Based on comparison of oral, dermal and inhalation exposure with inhalation TDI
k Based on comparison of all exposure pathways with oral TDI
l S4ULs assume that free phase contamination is not present
m S4ULs based on a sub-surface soil to indoor air correction factor of 10
n The HCV applied is based on the intake of total Xylene and therefore exposure should not consider an isomer in isolation
o Oral, dermal and inhalation exposure compared with oral HCV
p S4ULs based on a sub-surface soil to indoor air correction factor of 1
q Based on a comparison of inhalation exposure with the inhalation TDI for localised effects
r Based on 2,4-dichlorophenol unless otherwise stated
s Based on 2,3,4,6-tetrachlorophenol
t Based on lowest GAC for all three xylene isomers
u Measured concentrations of benzo(a)pyrene should be compared to the S4UL for benzo(a)pyrene as a single compound and to the S4UL for benzo(a)pyrene as a surrogate marker of genotoxic PAHs.
vap S4UL presented exceeded the vapour saturation limit, which is presented in brackets
sol S4UL presented exceeds the solubility saturation limit, which is presented in brackets
dir S4ULs based on a threshold protective of direct skin contact, guideline in brackets based on the health effects following long term exposure provided for illustration only

Table 3: Soil Guideline Values (SGVs) for dioxins, furans and dioxin like PCBs

Determinand	Allotments	Residential with consumption of homegrown produce	Residential without consumption of homegrown produce	Commercial
Sum of PCDDs, PCDFs and dioxin-like PCBs	0.008	0.008	0.008	0.24

Units are mg/kg Dry Weight

Table 4: EIC/AGS/CL:AIRE Generic Assessment Criteria (GAC)

	Allotments	Residential with consumption of homegrown produce	Residential without consumption of homegrown produce	Commercial	Soil Saturation Concentration
Metals					
Antimony	ND	ND	550	7500	NA
Barium	ND	ND	1300	22000	NA
Molybdenum	ND	ND	670	17000	NA
Organics (SOM 1%/ 2.5%/ 6%)					
1,1,2 Trichloroethane	0.28 / 0.61 / 1.4	0.6 / 1.2 / 2.7	0.88 / 1.8 / 3.9	94 / 190 / 400	4030 / 8210 / 18000
1,1-Dichloroethane	9.2 / 17 / 35	2.4 / 3.9 / 7.4	2.5 / 4.1 / 7.7	280 / 450 / 850	1830 / 2960 / 5600
1,1-Dichloroethene	2.8 / 5.6 / 12	0.23 / 0.4 / 0.82	0.23 / 0.41 / 0.82	26 / 46 / 92	2230 / 3940 / 7940
1,2,4-Trimethylbenzene	0.38 / 0.93 / 2.2	0.35 / 0.85 / 2	0.41 / 0.99 / 2.3	42 / 99 / 220	557 / 1360 / 3250
1,2-Dichloropropane	0.62 / 1.2 / 2.6	0.024 / 0.042 / 0.084	0.024 / 0.042 / 0.085	3.3 / 5.9 / 12	1190 / 2110 / 4240
2,4-Dimethylphenol	3.1 / 7.2 / 17	19 / 43 / 97	210 / 410 / 730	16000 / 24000 / 30000	1380 / 3140 / 7240
2,4-Dinitrotoluene	0.22 / 0.49 / 1.1	1.5 / 3.2 / 7.2	170 / 170 / 170	3700 / 3700 / 3800	141 / 299 / 669
2,6-Dinitrotoluene	0.12 / 0.27 / 0.61	0.78 / 1.7 / 3.9	78 / 84 / 87	1900 / 1900 / 1900	287 / 622 / 1400
2-Chloronaphthalene	40 / 98 / 230	3.7 / 9.2 / 22	3.8 / 9.3 / 22	390 / 960 / 2200	114 / 280 / 669
Biphenyl	14 / 35 / 83	66 / 160 / 360	220 / 500 / 980	18000 / 33000 / 48000	34.4 / 84.3 / 201
Bis (2-ethylhexyl) phthalate	47 / 120 / 280	280 / 610 / 1100	2700 / 2800 / 2800	85000 / 86000 / 86000	8.68 / 21.6 / 51.7

	Allotments	Residential with consumption of homegrown produce	Residential without consumption of homegrown produce	Commercial	Soil Saturation Concentration
Bromobenzene	3.2 / 7.6 / 18	0.87 / 2 / 4.7	0.91 / 2.1 / 4.9	97 / 220 / 520	853 / 1970 / 4580
Bromodichloromethane	0.016 / 0.032 / 0.068	0.016 / 0.03 / 0.061	0.019 / 0.034 / 0.07	2.1 / 3.7 / 7.6	1790 / 3220 / 6570
Bromoform	0.95 / 2.1 / 4.6	2.8 / 5.9 / 13	5.2 / 11 / 23	760 / 1500 / 3100	2690 / 5480 / 12000
Butyl benzyl phthalate	220 / 550 / 1300	1400 / 3300 / 7200	42000 / 44000 / 44000	940000 / 940000 / 950000	26.3 / 64.7 / 154
Chloroethane	110 / 200 / 380	8.3 / 11 / 18	8.4 / 11 / 18	960 / 1300 / 2100	2610 / 3540 / 5710
Chloromethane	0.066 / 0.13 / 0.23	0.0083 / 0.0098 / 0.013	0.0085 / 0.0099 / 0.013	1 / 1.2 / 1.6	1910 / 2240 / 2990
Cis 1,2 Dichloroethene	0.26 / 0.5 / 1	0.11 / 0.19 / 0.37	0.12 / 0.2 / 0.39	14 / 24 / 47	3940 / 6610 / 12900
Dichloromethane	0.1 / 0.19 / 0.34	0.58 / 0.98 / 1.7	2.1 / 2.8 / 4.5	270 / 360 / 560	7270 / 9680 / 15300
Diethyl Phthalate	19 / 41 / 94	120 / 260 / 570	1800 / 3500 / 6300	150000 / 220000 / 290000	13.7 / 29.1 / 65
Di-n-butyl phthalate	2 / 5 / 12	13 / 31 / 67	450 / 450 / 450	15000 / 15000 / 15000	4.65 / 11.4 / 27.3
Di-n-octyl phthalate	940 / 2100 / 3900	2300 / 2800 / 3100	3400 / 3400 / 3400	89000 / 89000 / 89000	32.6 / 81.5 / 196
Hexachloroethane	0.27 / 0.67 / 1.6	0.2 / 0.48 / 1.1	0.22 / 0.54 / 1.3	22 / 53 / 120	8.17 / 20.1 / 48.1
Isopropylbenzene	32 / 79 / 190	11 / 27 / 64	12 / 28 / 67	1400 / 3300 / 7700	390 / 950 / 2250
Methyl tert-butyl ether (MTBE)	23 / 44 / 90	49 / 84 / 160	73 / 120 / 220	7900 / 13000 / 24000	20400 / 33100 / 62700
Propylbenzene	34 / 83 / 200	34 / 82 / 190	40 / 97 / 230	4100 / 9700 / 21000	402 / 981 / 2330
Styrene	1.6 / 3.7 / 8.7	8.1 / 19 / 43	35 / 78 / 170	3300 / 6500 / 11000	626 / 1440 / 3350
Total Cresols (2-, 3- and 4-methylphenol)	12 / 27 / 63	80 / 180 / 400	3700 / 5400 / 6900	160000 / 180000 / 180000	15000 / 32500 / 73300
Trans 1,2 Dichloroethene	0.93 / 1.9 / 4	0.19 / 0.34 / 0.7	0.19 / 0.35 / 0.71	22 / 40 / 81	3420 / 6170 / 12600
Tributyl tin oxide	0.042 / 0.1 / 0.24	0.25 / 0.59 / 1.3	1.4 / 3.1 / 5.7	130 / 180 / 200	41.3 / 101 / 241

Units are mg/kg Dry Weight

Table 5: Tier 2 Criteria for the Assessment of Soils – Protection of Flora and Fauna

Parameter	ICRCL 70/90 [a]		SSVs [b]	Code of Practice for Agricultural Use of Sewage Sludge [c]	BS 3882:2015 Specification for topsoil and requirements for use
	Maximum				Phytotoxic contaminants
	Livestock	Crop Growth			
	mg/kgDW	mg/kgDW	mg/kgDW	mg/kgDW	mg/kgDW
Antimony			37		
Arsenic	500	1000		50	
Cadmium	30	50	0.6	3	
Chromium				400	
Cobalt			4.2		
Copper	500	250	35.1	80/ 100/ 135/ 200 [d]	<100/<135/<200 [e]
Fluoride	1000			500	
Lead	1000			300	
Mercury				1	
Molybdenum			5.1	4	
Nickel			28.2	50/ 60/ 75/ 110 [d]	<60/<75/<110 [e]
Selenium				3	
Silver			0.3		
Vanadium			2.0		
Zinc	3000	1000	35.6	200/200/200/300 [d]	<200/<200/<300 [e]
Benzo(a)pyrene			0.15		
Bis(2-ethylhexyl) phthalate			13		
Hexachlorobenzene			0.002		
Pentachlorobenzene					
Pentachlorophenol			0.6		
Perfluorooctanoic acid			0.022		
Perfluorooctane sulfonate			0.014		
Polychlorinated alkanes medium chain			11.9		
Tetrachloroethene					
Toluene					
Triclosan			0.13		

Parameter	ICRCL 70/90 [a]		SSVs [b]	Code of Practice for Agricultural Use of Sewage Sludge [c]	BS 3882:2015 Specification for topsoil and requirements for use
	Maximum				Phytotoxic contaminants
	Livestock	Crop Growth			
	mg/kgDW	mg/kgDW	mg/kgDW	mg/kgDW	mg/kgDW
Tris(2-chloroethyl)phosphate			1.1		
Tris(2-chloro-1-methylethyl) phosphate			1.8		

a. Interdepartmental Committee on the Redevelopment of Contaminated Land (ICRCL) 70/90 Restoration and Aftercare of Metalliferous Mining Sites for Pasture and Grazing 1st edition 1990.
b. Soil screening values for assessing ecological risks, EA 2017a Report – ShARE id26
c. Maximum permissible concentration of potentially toxic elements for Arable land from the Sewage sludge in agriculture: code of practice.. There are also criteria for Grassland which are higher than for Arable.
d. Where four values are presented, concentrations are for soils with pH values 5.0-5.5/ 5.5-6.0/ 6.0-7.0/ >7.0 (and the soils contain more than 5% calcium carbonate)
e. Where three values are presented, concentrations are for soils with pH values <6.0/ 6.0-7.0/ >7.0

Table 6: Tier 2 Criteria for Screening Liquids

	Screening Concentration (mg/l)			
	Minimum Reporting Value	Human Consumption	Fresh Water/Inland	Salt Water/Other
Arsenic SP	-	0.01	0.05 (2)	0.025 (2)
Boron	-	1	-	-
Cadmium PS	0.0001	0.005	≤0.00008, 0.00008, 0.00009, 0.00015, 0.00025 (14)	0.0002
Chromium (total)	-	0.05	-	-
Chromium (III) SP	-	-	0.0047	-
Chromium (VI) SP	-	-	0.0034	0.0006
Copper SP	-	2	0.001 bioavailable	0.00376 bioavailable
Iron SP	-	0.2	1	1
Lead PS	-	0.01	0.0012 bioavailable	0.0013 bioavailable
Mercury compounds PS	0.00001	0.001	0.00007 max	0.00007 max
Manganese SP	-	0.05	0.123 bioavailable	-
Nickel PS	-	0.02	0.004 bioavailable	0.0086 bioavailable
Selenium	-	0.01	-	-
Zinc SP	-	5(3)	0.0109bioavailable(13)	0.0068bioavailable (13)
Chlorinated Compounds				
C10-13 chloroalkanes PS short chain chlorinated paraffins	-	-	0.0004	0.0004
Dichloromethane PS	-	-	0.02	0.02
1,2-Dichloroethane PS	0.001	0.003	0.01	0.01
Trichloroethene PS	0.0001	0.01(5)	0.01	0.01
1,1,1-Trichloroethane	0.0001	-	-	-
1,1,2-Trichloroethane	0.0001	-	-	-
Trichloromethanes PS	-	0.1(1)	0.0025	0.0025
1, 2, 4-Trichlorobenzene	0.00001			
Tetrachloroethene PS	0.0001	0.01(5)	0.01	0.01
Tetrachloromethane PS	0.0001	0.003	0.012	0.012
Tetrachloroethane SP	-		0.140	
Vinyl chloride	-	0.0005	-	-
Trichlorobenzene (TCB) PS	-	-	0.0004	0.0004
Chloroform	0.0001			
Chloronitrotoluenes(CNT)(11)	0.001	-	-	-
Hexachlorobutadiene PS	0.000005	-	0.0006 max	0.0006 max
Hexachlorocyclohexanes (HCH) PS	0.000001	-	0.00002	0.000002
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	-	-	-	-

	Screening Concentration (mg/l)			
	Minimum Reporting Value	Human Consumption	Fresh Water/Inland	Salt Water/Other
Acenaphthylene	-	-	-	-
Anthracene PS	-	-	0.0001	0.0001
Benzo(a)anthracene	-	-	-	-
Benzo(b)fluoranthene PS	-	0.0001 (10)	0.000017 max (12)	0.000017 max (12)
Benzo(a)pyrene PS	-	0.00001	0.00000017	0.00000017
Benzo(k)fluoranthene PS	-	0.0001 (10)	0.000017 max (12)	0.000017 max (12)
Benzo(g,h,i)perylene PS	-	0.0001 (10)	0.0000082 max (12)	0.00000082 max (12)
Indeno(1,2,3-cd)pyrene PS	-	0.0001 (10)	- (12)	- (12)
Chrysene		-	-	-
Dibenzo(a,h)anthracene		-	-	-
Fluoranthene PS	-	-	0.0000063	0.0000063
Fluorene	-	-	-	-
Phenanthrene	-	-	-	-
Pyrene	-	-	-	-
Naphthalene PS	-	-	0.002	0.002
Polycyclic Aromatic Hydrocarbons		0.0001 (10)		
Petroleum hydrocarbons				
Total petroleum hydrocarbons	-	0.01 (3)	-	-
Benzene PS	0.001	0.001	0.01	0.008
Toluene SP	0.004	0.7 (9)	0.074	0.074
Ethylbenzene	-	0.3 (9)	-	-
Xylenes	0.003 (4)	0.5 (9)		
Methyl tert-butyl ether (MTBE)	-	0.015 (7)	-	-
Pesticides and Herbicides				
Alachlor PS	-	-	0.0003	0.0003
Aldrin PS	0.000003	0.00003	0.00001 (8)	0.000005 (8)
Dieldrin PS	0.000003	0.00003		
Endrin PS	0.000003	0.0006 (9)		
Isodrin	0.000003	-	-	-
2,4 dichlorophenol SP	0.0001	-	0.0042	0.00042
2,4 D ester SP	0.0001	-	0.0003	0.0003
op and pp DDT (each) PS		0.001 (6)	0.000025 (6)	0.000025 (6)
op and pp DDE (each)				
op and pp TDE (each)				
Dimethoate SP	0.00001	-	0.00048	0.00048
Endosulfan PS	0.000005	-	0.000005	0.0000005
Hexachlorobenzene PS	0.000001		0.00005 max	0.00005 max
Permethrin SP		-	0.000001	0.0000002
Atrazine PS	0.00003	-	0.0006	0.0006
Simazine PS	0.00003	-	0.001	0.001
Linuron SP		-	0.0005	0.0005
Mecoprop SP		-	0.018	0.018
Trifluralin PS	0.00001	-	0.00003	0.00003
Total pesticides		0.0005		
Miscellaneous				
Ammoniacal nitrogen (as NH4+)	-	0.5	0.26 (16) 0.39 (17)	-
Ammoniacal nitrogen (as N)	-	0.39	0.2 (16) 0.3 (17)	-
Unionised Ammonia (NH3) SP	-	-	-	0.021
Chloride	-	250		
Chlorine SP			0.002	0.01 max
Cyanide SP (hydrogen cyanide)	-	0.05	0.001	0.001
Nitrate (as NO_3)	-	50	-	-
Nitrite (as NO_2)	-	0.1	-	-
Phenol SP	-	0.005 (3)	0.0077	0.0077
Pentachlorophenol PS	0.0001	-	0.0004	0.0004
PCBs (individual congeners)	0.000001	-	-	-
Sodium	-	200	-	-
Sulphate	-	250	-	-

	Screening Concentration (mg/l)			
	Minimum Reporting Value	Human Consumption	Fresh Water/Inland	Salt Water/Other
Tributyl and triphenyl tin compounds (each) PS	0.000001	-	0.0000002	0.0000002
Di(2-ethylhexyl)-phthalate PS	-	-	0.0013	0.0013

Substances highlighted in yellow are hazardous substances, PS = Priority Substances, SP = Specific Pollutants, '-' screening concentration is not available, 'max' – maximum allowable concentration used where no annual average provided

Notes:

1. Concentration for trihalomethanes is the sum of chloroform, bromoform, dibromochloromethane and bromodichloromethane.
2. Concentration is the dissolved fraction of a water sample obtained by filtration through a 0.45um filter.
3. Concentration is taken from Statutory Instrument 1989 No. 1147. The Water Supply (Water Quality) Regulations 1989, as amended.
4. Concentration for xylenes is 0.003mg/l each for o-xylene and m/p xylene.
5. Concentration is the Sum of TCE and PCE.
6. Concentration is for Total DDT. Para DDT on its own has a target concentration of 0.00001mg/l.
7. Concentration for MTBE is taken from Environment Agency guidance, dated 2006.
8. Concentration is the sum of aldrin, dieldrin, endrin.
9. Concentration is taken from WHO (2004) guidelines for drinking-water quality.
10. Sum of benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene, indeno(1,2,3-cd)pyrene
11. Concentration is for 2,6-CNT, 4,2-CNT, 4,3-CNT, 2,4-CNT, 2,5-CNT
12. BAP can be considered as a marker of the other PAHs for comparison with the annual average
13. Concentration plus ambient background concentration (dissolved)
14. For cadmium and its compounds the EQS depends on the hardness of the water (Class 1: < 40 mg CaCO3/l, Class 2: 40 to < 50 mg CaCO3/l, Class 3: 50 to < 100 mg CaCO3/l, Class 4: 100 to < 200 mg CaCO3/l and Class 5: ≥ 200 mg CaCO3/l).
15. Manufactured and used in industrial applications, such as flame retardants and plasticisers, as additives in metal working fluids, in sealants, paints, adhesives, textiles, leather fat and coatings. Persistent, bioaccumulate and toxic to aquatic life (carcinogen in rat studies). Candidate Persistent Organic Pollutant (POP).
16. Acceptable 90th percentile concentration for a freshwater lake/river with "High" chemical quality standard and alkalinity (as mg/l CaCO3) < 50 mg/L or alkalinity < 200 mg/L where river elevation > 80 m above Ordnance Datum (mAOD). See the Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 for further details.
17. Acceptable 90th percentile concentration for a freshwater lake/river with "High" chemical quality standard and alkalinity (as mg/l CaCO3) ≥ 50 mg/L where river elevation < 80 m mAOD or > 200 mg/l where river elevation > 80 mAOD. See the Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 for further details.

Table 7: Tier 2 Criteria for Screening Groundwater Vapour Generation Hazard

Chemical	CAS	GAC_{gwvap}(µg/l)[1,2]		Aqueous Solubility (µg/l)
		Residential	Commercial	
Petroleum Hydrocarbons				
1,2,4-Trimethylbenzene	95-63-6	24	2,200	559,000
Benzene [3]	71-43-2	210	20,000	1,780,000
Ethylbenzene [3]	100-41-4	10,000	*960,000 (sol)*	180,000
Isopropylbenzene	98-82-8	850	*86,000 (sol)*	56,000
Propylbenzene	103-65-1	2,700	*240,000 (sol)*	54,100
Styrene	100-42-5	8,800	*810,000 (sol)*	290,000
Toluene [3]	108-88-3	230,000	*21,000,000 (sol)*	590,000
TPH Aliphatic EC5-EC6 [3]		1,900	*190,000 (sol)*	35,900
TPH Aliphatic >EC6-EC8 [3]		1,500	*150,000 (sol)*	5,370
TPH Aliphatic >EC8-EC10 [3]		57	*5,700 (sol)*	427
TPH Aliphatic >EC10-EC12 [3]		37	*3,600 (sol)*	34
TPH Aromatic >EC5-EC7 [2,3]		210,000	*20,000,000 (sol)*	1,780,000
TPH Aromatic >EC7-EC8 [3]		220,000	*21,000,000 (sol)*	590,000
TPH Aromatic >EC8-EC10 [3]		1,900	*190,000 (sol)*	64,600
TPH Aromatic >EC10-EC12 [3]		6,800	*660,000 (sol)*	24,500
TPH Aromatic >EC12-EC16 [3]		39,000	*3,700,000 (sol)*	5,750
meta-Xylene [3,5]	108-38-3	9,500	*940,000 (sol)*	200,000
ortho-Xylene [3,5]	95-47-6	12,000	*1,100,000 (sol)*	173,000
para-Xylene [3,5]	106-42-3	9,900	*980,000 (sol)*	200,000
Polycyclic Aromatic Hydrocarbons (PAH)				
Acenaphthene	83-32-9	*170,000 (sol)*	*15,000,000 (sol)*	4,110

Chemical	CAS	GAC$_{gwvap}$(µg/l)[1,2]		Aqueous Solubility (µg/l)
		Residential	Commercial	
Acenaphthylene	208-96-8	*220,000 (sol)*	*20,000,000 (sol)*	7,950
Fluorene	86-73-7	*210,000 (sol)*	*18,000,000 (sol)*	1,860
Naphthalene	91-20-3	220	*23,000 (sol)*	19,000
Pesticides				
Aldrin	309-00-2	*47 (sol)*	*3,700 (sol)*	20
alpha-Endosulfan	959-98-8	*7,400 (sol)*	*590,000 (sol)*	530
beta-Endosulfan	33213-65-9	*7,500 (sol)*	*600,000 (sol)*	280
Halogenated Organics				
1,1,1,2-Tetrachloroethane	79-34-5	240	22,000	1,110,000
1,1,1-Trichloroethane	71-55-6	3,000	290,000	1,300,000
1,1,2,2-Tetrachloroethane	79-35-4	1,600	150,000	2,930,000
1,1,2-Trichloroethane	79-00-5	520	49,000	4,491,000
1,1-Dichloroethane	75-34-3	2,700	260,000	3,666,000
1,1-Dichloroethene	75-35-4	160	1,6000	3,100,000
1,2,3,4-Tetrachlorobenzene	634-66-2	240	*31,000 (sol)*	7,800
1,2,3,5-Tetrachlorobenzene	634-90-2	7.0	*600*	3,500
1,2,3-Trichlorobenzene	87-61-7	35	3,100	21,000
1,2,4,5-Tetrachlorobenzene	95-94-3	8.1	*700 (sol)*	600
1,2,4-Trichlorobenzene	120-82-1	68	7,200	41,400
1,2-Dichlorobenzene	95-50-1	2,000	*220,000 (sol)*	133,000
1,2-Dichloroethane	107-06-2	8.9	850	8,680,000
1,2-Dichloropropane	78-87-5	22	2,600	2,050,000
1,3,5-Trichlorobenzene	108-70-3	7.4	660	6,000
1,3-Dichlorobenzene	541-73-1	31	2,800	103,000
1,4-Dichlorobenzene	106-46-7	5,000	*460,000 (sol)*	51,200
Bromobenzene	108-86-1	220	20,000	388,040
Bromodichloromethane	75-27-4	17	1,600	3,000,000
Bromoform (Tribromomethane)	75-25-2	3,100	400,000	3,000,000
Chlorobenzene	108-90-7	98	15,000	387,000
Chloroethane	75-00-3	10,000	1,000,000	5,742,000
Chloroethene (Vinyl Chloride)	75-01-4	0.62	63	2,760,000
Chloromethane	74-87-3	14	1,400	5,350,000
cis-1,2-Dichloroethene	156-59-2	130	13,000	7,550,000
Dichloromethane	75-09-2	3,300	370,000	20,080,000
Hexachlorobenzene	118-74-1	*16 (sol)*	*1,400 (sol)*	10
Hexachlorobutadiene	87-68-3	1.7	230	4,800
Hexachloroethane	67-72-1	8.5	740	49,900
Pentachlorobenzene	608-93-5	140	*12,000 (sol)*	500
Tetrachloroethene	127-18-4	34	4,600	225,000
Tetrachloromethane (Carbon Tetrachloride)	56-23-5	5.3	770	846,000
trans-1,2-Dichloroethene	156-60-5	160	16,000	5,250,000
Trichloroethene	79-01-6	5.7	530	1,370,000
Trichloromethane (Chloroform)	67-66-3	790	85,000	8,950,000
Others (organic and inorganic)				
2-Chloronaphthalene	91-58-7	160	*14,000 (sol)*	11,700
Biphenyl (Lemonene)	92-52-4	*15,000 (sol)*	*1,300,000 (sol)*	4,060
Carbon Disulphide	75-15-0	56	5,600	2,100,000
Mercury, elemental	7439-97-6	1.1	*95 (sol)*	56
Methyl tertiary butyl ether (MTBE)	1634-04-4	83,000	7,800,000	48,000,000

Notes

1. GAC in *italics* with (sol) exceed aqueous solubility.
2. GAC rounded to two significant figures.
3. The GAC for these petroleum hydrocarbon contaminants have been calculated using a sub-surface soil to indoor air correction factor of 10 in line with the physical-chemical data sources.
4. The GAC for TPH fractions do not account for genotoxic mutagenic effects. Concentrations of TPH Aromatic >EC5-EC7 should therefore also be compared with the GAC for benzene to ensure that such effects are also assessed.
5. The Health Criteria Value used for each xylene isomer was for total xylene. If site specific additivity assessments are not completed, as a conservative measure the sum of isomer concentrations should be compared to the lowest xylene GAC (as is the case for soil GAC).

Appendix CWRA 3 – Data Assessment Tables

TABLE SUMMARISING WATER RESULTS AND HIGHLIGHTING EXCEEDANCES ABOVE WATER ASSESSMENT CRITERIA
M3 JUNCTION 9 IMPROVEMENTS

			Assessment Criteria	Summary				DS110	DS110	DS112	DS114	DS203	DS213	DS216	DS301	DS302
Analyte	Units	LOD	Fresh Water	No. of Tests	Min	Max	No. > Limit	12.0m	29.5m	17.0m	18.5m	5.2m	29.5m	14.0m	29.0m	29.0m
Alkalinity as $CaCO_3$	µg/l		-													
Arsenic	µg/l	5	50	9	5	5		5	5	5	5	5	5	5	5	5
Boron	µg/l	5	-	9	14	28		15	28	14	15	21	23	27	14	15
Cadmium	µg/l	0.4	0.08	9	0.4	0.4	9	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Chromuim (Total)	µg/l	5	-	9	5	10		8	5	8	8	5	10	8	10	5
Chromium Trivalent	µg/l		4.7													
Chromium Hexavalant	µg/l	20	3.4	9	20	20	9	20	20	20	20	20	20	20	20	20
Copper	µg/l	5	1	9	5	9	9	5	5	5	5	9	5	5	5	5
Iron	µg/l		1000													
Lead	µg/l	5	1.2	9	5	5	9	5	5	5	5	5	5	5	5	5
Mercury	µg/l	0.05	0.07	9	0.05	18.3	2	0.05	0.24	0.05	0.05	18.3	0.05	0.05	0.05	0.05
Manganese	µg/l		123													
Nickel	µg/l	5	4	9	5	68	9	5	5	5	5	68	5	5	5	5
Selenium	µg/l	5	-	9	5	5		5	5	5	5	5	5	5	5	5
Zinc	µg/l	2	10.9	9	2	27	1	2	2	2	2	27	2	2	2	2
Ammoniacal Nitrogen as NH_4	µg/l	50	260	9	50	107		54	50	50	107	107	50	50	96	50
Ammoniacal Nitrogen as NH_3	µg/l		-													
Chloride	µg/l		-													
Chlorine	µg/l		2													
Cyanide	µg/l	5	1	9	5	5	9	5	5	5	5	5	5	5	5	5
Nitrate as NO_3	µg/l	500	-	9	14300	56000		28800	56000	38800	37400	14300	49200	54600	38900	38000
Nitrite as NO_2	µg/l		-													
Phenol	µg/l		7.7													
Pentachlorophenol	µg/l		0.4													
PCBs	µg/l		-													
Sodium	µg/l		-													
Sulphate	µg/l	1000	-	9	6000	31000		8000	31000	9000	10000	6000	16000	14000	9000	9000
pH	pH Units	1	-	9	7.7	7.8		7.7	7.7	7.7	7.7	7.7	7.8	7.7	7.7	7.7
Dichloromethane	µg/l		-													
1,2 Dichloroethane	µg/l		10													
Trichloroethene (PCE)	µg/l		10													
1,1,1 Trichloroethane	µg/l		-													
1,1,2 Trichloroethane	µg/l		-													
Trichloromethane (Chloroform)	µg/l		2.5													
1,2,3 Trichlorobenzene	µg/l		-													
1,2,4 Trichlorobenzene	µg/l		-													
Trichlorobenzene (1,2,3 & 1,2,4)	µg/l		0.4													
Tetrachloroethene	µg/l		10													
Tetrachloromethane	µg/l		12													
1,1,1,2 Tetrachloroethane	µg/l		140													
Vinyl Chloride (Chloroethene)	µg/l		-													
>C5 to C6 Aliphatic	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
>C6 to C8 Aliphatic	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
>C8 to C10 Aliphatic	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
>C10 to C12 Aliphatic	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
>C12 to C16 Aliphatic	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
>C16 to C21 Aliphatic	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
>C21 to C35 Aliphatic	µg/l	10	-	9	10	18		10	10	10	10	18	10	10	10	10
>C35 to C44 Aliphatic	µg/l		-													
Total Aliphatic C5-35	µg/l	70	-	9	70	70		70	70	70	70	70	70	70	70	70
>C5 to C7 Aromatic	µg/l		-													
>C7 to C8 Aromatic	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
>C8 to C10 Aromatic	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
>C10 to C12 Aromatic	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
>C12 to C16 Aromatic	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
>C16 to C21 Aromatic	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
>C21 to C35 Aromatic	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
>C35 to C44 Aromatic	µg/l		-													
Total Aromatic C5-C35	µg/l		-													
TPH Ali/Aro	µg/l		-													
Benzene	µg/l	1	10	9	1	1		1	1	1	1	1	1	1	1	1
Ethylbenzene	µg/l	5	-	9	5	5		5	5	5	5	5	5	5	5	5
Toluene	µg/l	5	74	9	5	5		5	5	5	5	5	5	5	5	5
Xylene	µg/l		30													
M- & P-Xylene	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
O-Xylene	µg/l	5	-	9	5	5		5	5	5	5	5	5	5	5	5
Total Xylene (M, P & O)	µg/l	15	-	9	15	15		15	15	15	15	15	15	15	15	15
MTBE	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
naphthalene	µg/l	0.01	2	9	0.01	0.04		0.01	0.02	0.01	0.01	0.01	0.04	0.01	0.01	0.01
acenaphthylene	µg/l	0.01	-	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
acenaphthene	µg/l	0.01	-	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
fluorene	µg/l	0.01	-	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
phenanthrene	µg/l	0.01	-	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
anthracene	µg/l	0.01	0.1	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
fluoranthene	µg/l	0.01	0.0063	9	0.01	0.01	9	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
pyrene	µg/l	0.01	-	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
benzo(a)anthracene	µg/l	0.01	-	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
chrysene	µg/l	0.01	-	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
benzo(b)fluoranthene	µg/l	0.01	0.017	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
benzo(k)fluoranthene	µg/l	0.01	0.017	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
benzo(a)pyrene	µg/l	0.01	0.00017	9	0.01	0.01	9	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
benzo(g,h,i)perylene	µg/l	0.01	0.0082	9	0.01	0.01	9	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
dibenzo(ah)anthracene	µg/l	0.01	-	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
indeno(1,2,3-c,d)pyrene	µg/l	0.01	-	9	0.008	0.008		0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
Sum (benzo b, k, ghi & indeno123cd)	µg/l	0.04	-	9	0.038	0.038		0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038
Total PAH	µg/l		-													

Stantec

TABLE SUMMARISING WATER RESULTS AND HIGHLIGHTING EXCEEDANCES ABOVE WATER ASSESSMENT CRITERIA
M3 JUNCTION 9 IMPROVEMENTS

			Assessment Criteria	Summary				DS110	DS110	DS112	DS114	DS203	DS213	DS216	DS301	DS302
Analyte	Units	LOD	Human Consumption	No. of Tests	Min	Max	No. > Limit									
Alkalinity as $CaCO_3$	µg/l		-													
Arsenic	µg/l	5	10	9	5	5		5	5	5	5	5	5	5	5	5
Boron	µg/l	5	1000	9	14	28		15	28	14	15	21	23	27	14	15
Cadmium	µg/l	0.4	5	9	0.4	0.4		0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Chromuim (Total)	µg/l	5	50	9	5	10		8	5	8	8	5	10	8	10	5
Chromium Trivalent	µg/l		-													
Chromium Hexavalant	µg/l	20	-	9	20	20		20	20	20	20	20	20	20	20	20
Copper	µg/l	5	2000	9	5	9		5	5	5	5	9	5	5	5	5
Iron	µg/l		200													
Lead	µg/l	5	10	9	5	5		5	5	5	5	5	5	5	5	5
Mercury	µg/l	0.05	1	9	0.05	18.3	1	0.05	0.24	0.05	0.05	18.3	0.05	0.05	0.05	0.05
Manganese	µg/l		50													
Nickel	µg/l	5	20	9	5	68	1	5	5	5	5	68	5	5	5	5
Selenium	µg/l	5	10	9	5	5		5	5	5	5	5	5	5	5	5
Zinc	µg/l	2	5000	9	2	27		2	2	2	2	27	2	2	2	2
Ammoniacal Nitrogen as NH_4	µg/l	50	500	9	50	107		54	50	50	107	107	50	50	96	50
Ammoniacal Nitrogen as NH_3	µg/l		-													
Chloride	µg/l		250000													
Chlorine	µg/l		-													
Cyanide	µg/l	5	50	9	5	5		5	5	5	5	5	5	5	5	5
Nitrate as NO_3	µg/l	500	50000	9	14300	56000	2	28800	56000	38800	37400	14300	49200	54600	38900	38000
Nitrite as NO_2	µg/l		100													
Phenol	µg/l		0.5													
Pentachlorophenol	µg/l		-													
PCBs	µg/l		-													
Sodium	µg/l		200000													
Sulphate	µg/l	1000	250000	9	6000	31000		8000	31000	9000	10000	6000	16000	14000	9000	9000
pH	pH Units	1	-	9	7.7	7.8		7.7	7.7	7.7	7.7	7.7	7.8	7.7	7.7	7.7
Dichloromethane	µg/l		-													
1,2 Dichloroethane	µg/l		3													
Trichloroethene (PCE)	µg/l		10													
1,1,1 Trichloroethane	µg/l		-													
1,1,2 Trichloroethane	µg/l		-													
Trichloromethane (Chloroform)	µg/l		100													
1,2,3 Trichlorobenzene	µg/l		-													
1,2,4 Trichlorobenzene	µg/l		-													
Trichlorobenzene (1,2,3 & 1,2,4)	µg/l		-													
Tetrachloroethene	µg/l		10													
Tetrachloromethane	µg/l		3													
1,1,1,2 Tetrachloroethane	µg/l		-													
Vinyl Chloride (Chloroethene)	µg/l		0.05													
>C5 to C6 Aliphatic	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
>C6 to C8 Aliphatic	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
>C8 to C10 Aliphatic	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
>C10 to C12 Aliphatic	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
>C12 to C16 Aliphatic	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
>C16 to C21 Aliphatic	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
>C21 to C35 Aliphatic	µg/l	10	-	9	10	18		10	10	10	10	18	10	10	10	10
>C35 to C44 Aliphatic	µg/l		-													
Total Aliphatic C5-35	µg/l	70	-	9	70	70		70	70	70	70	70	70	70	70	70
>C5 to C7 Aromatic	µg/l		-													
>C7 to C8 Aromatic	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
>C8 to C10 Aromatic	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
>C10 to C12 Aromatic	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
>C12 to C16 Aromatic	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
>C16 to C21 Aromatic	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
>C21 to C35 Aromatic	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
>C35 to C44 Aromatic	µg/l		-													
Total Aromatic C5-C35	µg/l		-													
TPH Ali/Aro	µg/l		10													
Benzene	µg/l	1	1	9	1	1		1	1	1	1	1	1	1	1	1
Ethylbenzene	µg/l	5	300	9	5	5		5	5	5	5	5	5	5	5	5
Toluene	µg/l	5	700	9	5	5		5	5	5	5	5	5	5	5	5
Xylene	µg/l		500													
M- & P-Xylene	µg/l	10	-	9	10	10		10	10	10	10	10	10	10	10	10
O-Xylene	µg/l	5	-	9	5	5		5	5	5	5	5	5	5	5	5
Total Xylene (M, P & O)	µg/l	15	-	9	15	15		15	15	15	15	15	15	15	15	15
MTBE	µg/l	10	15	9	10	10		10	10	10	10	10	10	10	10	10
naphthalene	µg/l	0.01	-	9	0.01	0.04		0.01	0.02	0.01	0.01	0.01	0.04	0.01	0.01	0.01
acenaphthylene	µg/l	0.01	-	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
acenaphthene	µg/l	0.01	-	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
fluorene	µg/l	0.01	-	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
phenanthrene	µg/l	0.01	-	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
anthracene	µg/l	0.01	-	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
fluoranthene	µg/l	0.01	-	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
pyrene	µg/l	0.01	-	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
benzo(a)anthracene	µg/l	0.01	-	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
chrysene	µg/l	0.01	-	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
benzo(b)fluoranthene	µg/l	0.01	0.1	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
benzo(k)fluoranthene	µg/l	0.01	0.1	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
benzo(a)pyrene	µg/l	0.01	0.01	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
benzo(g,h,i)perylene	µg/l	0.01	0.1	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
dibenzo(ah)anthracene	µg/l	0.01	-	9	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
indeno(1,2,3-c,d)pyrene	µg/l	0.01	0.1	9	0.008	0.008		0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
Sum (benzo b, k, ghi & indeno123cd)	µg/l	0.04	0.1	9	0.038	0.038		0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038
Total PAH	µg/l		-													

Appendix CWRA 4 – PNEC Calculations

INPUT DATA						RESULTS (Pb)			
ID	Location	Waterbody	Date	Measured Pb Concentration (dissolved) (µg l^{-1})	DOC	Site Specific PNEC Dissolved Pb (µg l^{-1})	BioF	Available Pb (µg l^{-1})	Risk Characterisation Ratio
1	DS110			5.00	10.10	12.12	0.10	0.50	0.41
2	DS112			5.00	15.30	18.36	0.07	0.33	0.27
3	DS114			5.00	9.90	11.88	0.10	0.51	0.42
4	DS203			5.00	14.90	17.88	0.07	0.34	0.28
5	DS213			5.00	11.20	13.44	0.09	0.45	0.37
6	DS216			5.00	13.20	15.84	0.08	0.38	0.32
7	DS301			5.00	11.20	13.44	0.09	0.45	0.37
8	DS302			5.00	10.80	12.96	0.09	0.46	0.39

INPUT DATA											RESULTS (Copper)				RESULTS (Zinc)				RESULTS (Mn)				RESULTS (Ni)			
ID	Location	Waterbody	Date	Measured Cu Concentration (dissolved) (μg l^{-1})	Measured Zn Concentration (dissolved) (μg l^{-1})	Measured Mn Concentration (dissolved) (μg l^{-1})	Measured Ni Concentration (dissolved) (μg l^{-1})	pH	DOC	Ca	Site-specific PNEC Dissolved Copper (μg l^{-1})	BioF	Bioavailable Copper Concentration (μg l^{-1})	Risk Characterisation Ratio	Site-specific PNEC Dissolved Zinc (μg l^{-1})	BioF	Bioavailable Zinc Concentration (μg l^{-1})	Risk Characterisation Ratio	Site-specific PNEC Dissolved Manganese (μg l^{-1})	BioF	Bioavailable Manganese Concentration (μg l^{-1})	Risk Characterisation Ratio	Site-specific PNEC Dissolved Nickel (μg l^{-1})	BioF	Bioavailable Nickel Concentration (μg l^{-1})	Risk Characterisation Ratio
1	DS110			5	2		5	7.72	900	109	40.77	0.02	0.12	0.12	78.51	0.14	0.28	0.03	377.53	0.33			34.58	0.12	0.58	0.14
2	DS112			5	2		5	7.72	900	117	40.77	0.02	0.12	0.12	78.06	0.14	0.28	0.03	377.53	0.33			34.58	0.12	0.58	0.14
3	DS114			5	2		5	7.72	900	103	40.77	0.02	0.12	0.12	78.88	0.14	0.28	0.03	377.53	0.33			34.58	0.12	0.58	0.14
4	DS203			5	27		68	7.72	900	102	40.77	0.02	0.12	0.12	78.94	0.14	3.73	0.34	377.53	0.33			34.58	0.12	7.87	1.97
5	DS213			5	2		5	7.72	900	107	40.77	0.02	0.12	0.12	78.63	0.14	0.28	0.03	377.53	0.33			34.58	0.12	0.58	0.14
6	DS216			5	2		5	7.72	900	123	40.77	0.02	0.12	0.12	77.73	0.14	0.28	0.03	377.53	0.33			34.58	0.12	0.58	0.14
7	DS301			5	2		5	7.72	900	104	40.77	0.02	0.12	0.12	78.81	0.14	0.28	0.03	377.53	0.33			34.58	0.12	0.58	0.14
8	DS302			5	2		5	7.72	900	102	40.77	0.02	0.12	0.12	78.94	0.14	0.28	0.03	377.53	0.33			34.58	0.12	0.58	0.14

Appendix E Ground Gas Risk Assessment

TECHNICAL NOTE

Job Name: M3 Junction 9 Improvements

Job No: 48176/3502

Doc Ref: HE551511-VFK-EGT-X_XXXX_XX-TN-GE-004

Date: December 2020

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Subject: **Ground Gas Risk Assessment**

1 Introduction

1.1 Preamble

1.1.1 Stantec UK Limited (Stantec) has been commissioned by VolkerFitzpatrick Limited and Highways England (the Client) to undertake a Ground Gas Risk Assessment for the M3 Junction 9 improvement Site, Winchester, based on the factual findings of the Factual Ground Investigation Report (HE551511-HEX-EGT-ZZ-RP-CE-0001) (Soils Limited, August 2019, amended July 2020).

1.1.2 This Technical Note has been written to accompany the Phase 2 Ground Investigation Report undertaken by Stantec (December 2020b) which contains information on the ground conditions. The Ground Investigation specification was undertaken by Jacobs and the field data and laboratory analysis was undertaken by the Principal Contractor, Geoffrey Osborne Limited, who employed the ground investigation contractor Soils Limited and SM Associates.

1.1.3 This Technical Note presents a ground gas risk assessment in respect to receptors identified within the Ground Investigation Report (Stantec, 2020b) and also has been prepared to support the Development Consent Order (DCO) application.

1.2 Sources of Information

1.2.1 The following sources of information were used in the preparation of this technical note:

- Factual Ground Investigation Report (HE551511-HEX-EGT-ZZ-RP-CE-0001) (Soils Limited, August 2019, amended July 2020)
- PCF Stage 2 – Preliminary Sources Study Report (HE551511-WSP-HGT-ZZ-RP-CE-0001) (WSP, September 2017)
- Preliminary Environmental Information Report (PEIR) (GFD19_0101_M3 Junction 9) (Jacobs, June 2019)
- Project Control Framework (PCF) Stage 2 – Preliminary Sources Study Report (HE551511-WSP-HGT-ZZ-RP-CE-0001) (WSP, September 2017)
- PCF Stage 3B: Phase 1 Ground Condition Assessment (Contamination and Stability for Proposed Deposition and Compound Areas (HE551511-VFK-EGT-X_XXXX_XX-RP-GE-0001) (Stantec, December 2020a)
- PCF Stage 3B: Ground Investigation Report (HE552988-VFK-HGT-X_XXXX_XX-RP-CE-0001) (Stantec, December 2020b)

2 Site Setting

2.1 Geology & Ground Conditions

2.1.1 The anticipated ground conditions within the M3 J9 Improvement Site have been determined through review of the published geological mapping, and also site specific intrusive information contained within both the Factual Ground Investigation Report (Soils Limited, 2020) and the Ground Investigation Report (Stantec, 2020b).

Published Geology

2.1.2 The published BGS geological mapping indicates that the majority of the M3 J9 Improvement Site is underlain by solid geology comprising the Seaford Chalk formation, with the overlying Newhaven Chalk only present in the area to the east of the M3, in the northern part of the study area. The Seaford Chalk formation is underlain by the Lewes Nodular Chalk formation, and in the southern extent of the Site, the Lewes Nodular Chalk is indicated to outcrop at the ground surface.

2.1.3 Along the route of the River Itchen, which traverses the northern part of the M3 J9 Improvement Site, the solid geology is overlain by superficial deposits comprising Alluvium. There are also smaller transects of superficial deposits, comprising Head, overlying the solid geology, located to the north and to the south of the existing junction, and in the northern parts of the Site,

2.1.4 In the area to the east of the M3 and to the south of the River Itchen, the geological mapping also indicates there may be an area of Clay with Flints and Head deposits overlying the Newhaven Chalk Formation (which overlies the Seaford Chalk Formation where present).

Encountered Geology

2.1.5 A Phase 2 geotechnical and geo-environmental ground investigation was undertaken across parts of the M3 J9 Improvement Site between March 2019 and June 2019. The information from the investigation generally confirms the anticipated/published ground conditions. Further details can be found within the Ground Investigation Report (Stantec, 2020b).

2.1.6 In addition to the published geology described above, made ground and engineered fill is also present within the Site, associated with the construction of the M3, A34, A33 and other infrastructure. The made ground and engineering fill material predominantly comprises reworked natural strata with lenses of organic soil and extends to a maximum of 11.35m below ground level.

2.1.7 The Ground Investigation Report did not identify any evidence of contamination or exceedances of the relevant assessment criteria within the soil results.

2.2 Historical Land Use

2.2.1 The historical land use (relevant to the potential for contamination) has previously been determined and presented in the Preliminary Sources Study Report (PSSR) (WSP, 2017), and Phase 1 Desk Study (Stantec, 2020a) respectively. These are based on historical Ordnance Survey maps obtained as part of an Envirocheck Report. In summary, the area of the current M3 J9 roundabout and its immediate surroundings remained undeveloped until the construction of the A33 in the late 1930's and later, in the early 1980's, when J9 of the M3 is shown to have been constructed.

2.2.2 The Didcot, Newbury and Southampton railway line is indicated to have been constructed in the late 1890's 200m to the west of the Site, along the eastern bank of the River Itchen, crossing the northern section of the Site. The railway line remained until the 1960's when it was dismantled. In the wider area there have been various industrial uses such as iron and gas works, although these sites have since been redeveloped and are outside of the proposed works.

2.2.3 A review of available other published information has identified records for three historical landfills or close to the Site. These are located beneath the existing M3 J9 roundabout (Spitfire Link), on the western side of the A34 at the northern tip of Wykeham Industrial Estate (land between Old Newbury Railway and A33) and between the A34/A33 and M3 carriageways, south of the River Itchen (land adjacent to Winchester Bypass). Further commentary is given below:

- The 'Spitfire Link, Easton Lane' landfill was investigated in part by Soils Limited (2020) with six exploratory holes undertaken within or immediately adjacent to the mapped extents of the landfill. No evidence of waste or Made Ground was indicated on those exploratory hole records. It is considered unlikely that the landfill therefore represents a source of significant contamination.

- The 'Land Adjacent to Winchester Bypass, Abbots Worth, Hampshire' landfill is recorded as accepting inert waste from 1967 through to 1968. The licence holder is listed as D Hewestson-Brown. The recorded operational period broadly corresponds with the widening of the Winchester Bypass and construction of a gantry crossing the River Itchen. It is considered that the landfill may therefore have been used to accept earthworks arisings from that scheme and is therefore unlikely to represent a source of significant contamination.

- The third landfill 'Land Between Old Newbury Railway and A33' is located to the west of Winchester bypass and is very small therefore unlikely to have operated commercially and therefore unlikely to represent a significant risk.

2.2.4 Based on the information above the risk from the historical landfills to the M3 J9 Improvement Site is considered to be Low. The current development proposals do not include any works within or over the historical landfills and therefore these areas will not be disturbed by the M3 J9 Improvement Site.

2.2.5 Contrary to the 'published information' outlined above, a review of the available historical OS mapping has not specifically identified the presence of infilled workings/landfills.

Current Land Use

2.2.6 The majority of the M3 J9 Improvement Site comprises the carriageways of the M3, A33 and A34. In the area to the east of the M3, the land use is predominantly agricultural.

2.2.7 In the areas to the west of the A34, the land use is predominantly highway land or undeveloped land adjacent to the highway. However, in the wider Site, the land use is varied including flood plain, residential and mixed use industrial.

2.2.8 In the northern part of the M3 J9 Improvement Site, the predominant current land use is mixed, comprising residential, agricultural and flood plain.

3 Ground Gas Conceptual Site Model

3.1 Introduction

3.1.1 The conceptual site model (CSM) describes the types and locations of potential ground gas sources, the identification of potential receptors and the identification of potential transport/migration pathways.

3.1.2 For a pollutant linkage to be identified a connection between all three elements (source-pathway-receptor) is required. A ground gas conceptual site model (CSM) has been developed for the Site, based on the Stantec 2020 GIR which draws on a ground investigation by Soils Limited which took place between March and June 2019.

3.1.3 The CSM summarises the potential ground gas source(s), transport pathways and receptors in order to assess potential ground gas risk linkages.

3.1.4 It should be noted that this CSM only addresses potential risks from ground gases. A contaminant assessment and Geoenvironmental risk assessment are provided in the Stantec Phase 2 Ground Investigation Report (2020b).

3.2 Sources

3.2.1 The potential ground gas sources are presented in the table below:

Table 3-1 Potentially Contaminative Land Uses and Contaminants of Concern

Source	Potential Contaminants of Concern
Historical Landfill	Methane and Carbon Dioxide
Peat and Organic Matter within Alluvial Deposits	Methane and Carbon Dioxide
Seaford Chalk – dissolution of calcium carbonate by acidic water	Carbon Dioxide

3.3 Receptors

3.3.1 The following receptors have been identified that could be impacted by ground gases along with the sensitivity of the receptor, which is detailed in **Table 2.2** below:

Table 3-2 Receptor and Sensitivity

Receptor	Sensitivity
Construction and Maintenance workers	High
Off-site residents	Very High

3.4 Pathways

3.4.1 The following pathways are considered viable:

- Vertical and lateral migration of ground gas through permeable strata
- Ingress into confined spaces
- Inhalation
- Migration along services and underground structures
- Vertical and lateral migration through fractures in the Seaford Chalk Formation

4 Ground Gas Risk Assessment

4.1 Introduction

4.1.1 Ground gas monitoring was undertaken at twenty-one monitoring locations on five occasions. All of the monitoring wells were installed within the Seaford Chalk Formation.

4.1.2 The 'Spitfire Link, Easton Lane' landfill was investigated during the Soils Limited ground investigation (2019). No evidence of waste or Made Ground was indicated within the area investigated; however, two monitoring wells were installed within the boundary of the suspected landfill within the Seaford Chalk Formation.

4.1.3 The Alluvium has been identified as a potential source of ground gas, however, as the alluvial material does not appear to contain large quantities of organic material and this material only degrades very slowly by biological respiration producing very little ground gas the risk is considered to be Very Low in accordance with BS8578:2013 and therefore ground gas monitoring isn't required.

4.1.4 A copy of the ground gas monitoring data is presented within the Soils Limited Factual Report (2019).

4.2 Data Summary

4.2.1 The following table summarises the ground gas concentrations recorded in the gas monitoring wells installed as part of the ground investigation.

Table 4-1 Ground Gas Concentrations and Gas Flow

Gas	Concentrations
Methane, %v/v	0
Carbon Dioxide, %v/v	0 – 2.9
Oxygen, %v/v	10.3 - 24
Gas Flow, l/hr	-0.5 – 0.21

4.2.2 It is noted that the groundwater is above the slotted section of the standpipe in DS104, DS112, DS114, DS213, DS301, DS302, during all of the monitoring rounds, and as such the data may give a false impression of the gas risk due to a build-up in the pressure, caused by the rising water, which traps the gas within the solid section of the pipe. The data from these wells has therefore not been used in the assessment.

4.2.3 In all of the monitoring rounds in all locations monitored, the measured concentrations of carbon dioxide were below 3% v/v and methane was not detected in any location.

4.2.4 Very low gas flow rates were detected in all wells and typically <0.2l/hr. The exception to this was in DS207 on one occasion which recorded a gas flow of -0.5l/hr. BS8485+A1 (2019) advocates that if a negative flow is recorded then an assessment should be undertaken to determine if this flow could be equally positive (see section 4.3.3).

4.3 Characterisation

4.3.1 In each well the maximum gas concentration and steady state flow rate for each round have been used to calculate a Gas Screening Value (GSV). In this scenario the gas regime for both methane and carbon dioxide is identified as Characteristic Situation 1.

4.3.2 Using the highest maximum gas concentration and highest steady state flow rate for each well, the gas regime is also identified as Characteristic Situation 1 for both methane and carbon dioxide.

4.3.3 A further worst case check has also been undertaken using the highest gas flow of 0.0021l/hr and the highest gas concentration of 2.9%v/v for carbon dioxide, this also produced a GSV of 0.006 which equates to a gas regime of Characteristic Situation 1. Also, if the -0.5l/hr gas flow was assumed to be equally positive this would produce a GSV of 0.0145 also indicating a Characteristic Situation 1 gas regime.

4.3.4 In accordance with Table 6 within BS 8576:2013 the Gas Generation Potential of the Made Ground/Engineered fill, Alluvium and Peat is considered to be Low to Very Low given the limited degradable content indicated within the logs. The Chalk is also considered to have a Very Low Gas Generation Potential.

5 Conclusions

5.1 Assessed Ground Gas Risk

5.1.1 It has been assessed that the gas regime within the Seaford Chalk Formation is a Characteristic Situation 1 whereby no gas protection measures are required, and although this classification is designed for new buildings it does give a good indication of the ground gas risks.

5.1.2 Based on the information available, the potential for a significant ground gas risk to be present is considered to be **Very Low** in accordance with BS8485+A1 (2019). The estimated risks to the sensitive receptors are summarised below:

Table 5-1 Estimated Risk

Receptor	Assessed Sensitivity	Estimated Risk
Construction and Maintenance workers	High	Very Low
Off-site residents	Very High	Very Low

5.1.3 It is also recognised that any construction activities and follow on maintenance work will be managed under an appropriate Environmental Management Plan, CDM regulations and compliance-based risk assessments which will further protect Construction and Maintenance workers.

5.2 Recommendations

5.2.1 Whilst the current assessment would advise that no special protection measures are required, it is recognised that this assessment of a CS1 situation is based on a limited data set. as such it is recommended that further boreholes are drilled, and gas monitoring undertaken within the areas of suspected landfill, made ground/fill if it is found to contain considerable degradable material and within areas that have not been previously investigated.

5.3 Limitations

5.3.1 The ground gas monitoring wells were only targeted into the Seaford Chalk Formation and therefore no assessment has been undertaken on the Made Ground except from the descriptions within the logs. No installations were provided into the areas of potential landfill or within areas of made ground/engineered fill, albeit that two monitoring locations were located at the boundary of this area.

5.3.2 Current guidance indicates that ground gas monitoring should be carried out over a long enough period to allow prediction of worst-case conditions. At the current time none of the data appears to be taken during low or falling atmospheric pressure which is recommended to capture worst case conditions.

5.3.3 The opinions and recommendations in this report are based on the information obtained from the PSSR and the ground investigation specified and carried out by others. Stantec can, therefore, only base any recommendations included in this report from the information provided within the Factual Ground Investigation Report (Soils, 2019).

5.3.4 The ground investigation undertaken was carried out within the highway boundary and adjacent farmland, therefore there were some constraints locating the boreholes for the ground investigations due to extensive buried services and badger setts. The boundary has also changed since the original investigation as therefore certain areas of the extended boundary has not been investigated.

DOCUMENT ISSUE RECORD

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Appendix F Geotechnical Risk Register

GEOTECHNICAL RISK REGISTER

Project:	M3 Junction 9 Improvement		
Project No:	48176	**Date:**	May 2021
Register Number:	GIR – GRR01	**Revision**	P02

Ref No	Activity/Hazard	Consequence	Probability	Impact	HA Risk Rating	Mitigation/Action	Probability	Impact	HA Risk Rating	Comments
G1	**General**									
/a	Encountering unexpected contaminated ground	Risk of harm to site workers, general public and the environment. Delay and additional design and construction costs	2	2	4	Make provision for dealing with any unexpected sources of contamination	2	1	2	From known history of the site, being predominantly greenfield, and the results of chemical testing during the ground investigation the potential for contamination to be present is assessed to be very low.
/b	Inadequate existing geology / geotechnical information	Potential to have a significant impact on programme, costs and design.	5	5	25	Undertake an appropriate targeted supplementary GI and subsequent laboratory testing to inform the design process	2	3	6	There are significant data gaps in the current Ground investigation in key areas of the scheme.
/c	Encountering unexpected Shallow Groundwater Levels near or adjacent to River Itchen	Inadequate design of temporary works. Unplanned and potentially unsafe to construction sequence. Inundation of excavation. Cost and delay	3	3	9	Utilise information on ground conditions from supplementary GI in design and for consideration of temporary works. Provision of pumping equipment to control water ingress.	3	2	6	Groundwater unlikely to be encountered in excavations except for adjacent to the River Itchen
/d	Changes to groundwater regime and Chalk Aquifer	Changes in aquifer recharge and groundwater flow. Contamination of underlying aquifer from construction works. Delay and additional design and construction costs	3	4	12	Undertake piling risk assessment and hydrogeological risk assessment as required	3	3	9	
/e	Aggressive Ground Conditions	Long term chemical attack to foundations- Corrosion or weakening of supporting structural elements	2	3	6	Design process to account for aggressive ground when designing below ground structural components	1	2	2	

Notes:						
	a) Probability	1: Negligible	2: Unlikely	3: Probable	4: Likely	5: Very likely
	b) Impact	1: Very low	2: Low	3: Medium	4: High	5: Severe
	c) Rating	1-4: Negligible	5-9: Low	10-12: Medium	13-19: High	20-25: Severe

Ref No	Activity/Hazard	Consequence	Probability	Impact	HA Risk Rating	Mitigation/Action	Probability	Impact	HA Risk Rating	Comments
/f	Natural cavities; solution features	Local loss of ground support resulting in excess settlement or local failure of supported infrastructure or third-party property	3	3	9	Make the provision for inspection of exposed foundation and road formations for evidence of infilled natural cavities during construction works. Treat any features by backfilling / grouting. Consider inclusion of geogrids as part of road construction and design foundations accordingly.	2	3	6	No records of natural cavities within the scheme extents. Generally, the risk of solution features is very low, except where Head Deposits overlies the Chalk where the risk increases to moderate.
/g	Mining Cavities: Historical Chalk Mines or Chalk Pits.	Local loss of ground support resulting in excess settlement or local failure of supported infrastructure or third-party property	2	3	6	Treat any features by backfilling / grouting. Consider inclusion of geogrids as part of road construction and design foundations accordingly.	2	2	4	No records of mining cavities within the scheme extents, though chalk pits have been recorded in the vicinity. Generally, the risk of mining cavities is low except in the vicinity of where chalk pits have been recorded. Then the risk increases to medium to very high.
/h	Encountering unexpected in-ground obstructions associated with existing road and junctions and associated infrastructure	Potential variable foundation/subgrade strength which may cause differential settlement Delay and cost of breaking out and removal	2	2	4	Design to considers variable ground conditions and eliminates/mitigates any long-term settlement impacts	1	2	2	
/i	Encountering unexpected utilities	Damage during works posing risk to site workers and public; additional works to disconnect or realign services	2	3	6	Make provision for detailed survey to identify all live services before construction works.	1	3	4	
/j	Archaeology	Delay to programme due to heritage approval following archaeological finds	1	3	3	Keep watching brief during ground works	1	3	3	Unlikely as the areas of archaeological important have previously been highlighted.
G2	**Slopes and Earthworks**									
/a	Instability of existing slopes	Additional works to stabilise existing slopes and allow safe completion of works	1	3	3	Stability analysis as part of the GDR. Make provision for adequate control of earthworks.	1	3	3	No evidence of existing slope instability during ground investigation.

Notes:						
	a) Probability	1: Negligible	2: Possible	3: Probable	4: Likely	5: Very likely
	b) Impact	1: Negligible	2: Low	3: Medium	4: High	5: Severe
	c) Rating	1-4: Negligible	5-9: Low	10-12: Medium	13-19: High	20-25: Severe

Ref No	Activity/Hazard	Consequence	Probability	Impact	HA Risk Rating	Mitigation/Action	Probability	Impact	HA Risk Rating	Comments
/b	Instability of proposed side slopes - Embankments	Road closure, harm to road users and third parties, additional works to excavate failed material and reconstruct side slopes	3	3	9	Stability analysis as part of GDR Make provision for adequate engineering control of earthworks	2	3	6	
/c	Low strength or compressible foundation formation. Excess settlement of proposed embankments	Serviceability of road surface, potential road closure, additional materials as required to make up embankment and replace pavement – Cost and delay	3	4	12	Undertake assessment and settlement analysis as part of GDR. Make provision for adequate monitoring of earthworks and time for settlement	2	3	6	Peat highlighted in the Ground Investigation, full extent and nature is unknown at this stage, will require further Ground Investigation works.
/d	Chalk unsuitable for use as fill	Delay to programme and additional costs due to chalk treatment being required to use the material as fill.	3	4	12	Additional ground investigation and laboratory testing required to confirm the chalk quality. Develop appropriate earthworks strategy and specification to maximise reuse of site won chalk.	3	2	6	
/e	Earthwork volume surplus	Purchasing additional land to incorporating landscaping areas	4	3	12	Engineer slopes and alignment during design to minimise surplus soils Additional ground investigation required.	2	3	6	
/f	Double handling/stockpiling chalk for re-use	Deterioration of the chalk, may require treatment to be suitable for re-use. Collapse settlement	3	4	12	Additional ground investigation to provide information on the quality of the chalk in areas of Cut. Avoid double handling of the material and make sure material is protected from weather than may cause deterioration. Appropriate material control on site including placement and compaction.	2	4	8	
/g	Weather	Delay to programme and additional costs due to chalk treatment being required to use the material as fill. Potential slurry formed requiring off site disposal	4	5	20	Do not undertake excavation or placement of chalk during or when wet weather is expected	4	3	12	
G3	**Pavement Construction**									

Notes:						
	a) Probability	1: Negligible	2: Possible	3: Probable	4: Likely	5: Very likely
	b) Impact	1: Negligible	2: Low	3: Medium	4: High	5: Severe
	c) Rating	1-4: Negligible	5-9: Low	10-12: Medium	13-19: High	20-25: Severe

Ref No	Activity/Hazard	Consequence	Probability	Impact	HA Risk Rating	Mitigation/Action	Probability	Impact	HA Risk Rating	Comments
/a	Low strength or compressible formation to pavement construction	Additional works to excavate and replace unacceptable material	3	3	9	All proposed fill to be suitably engineered to achieve design CBR	2	2	4	The road in the area of Peat is to remain in place as it. No redevelopment of the road or pavements in the area of Peat.
G4	**Highway Structures**									
/a	Foundation design	Overdesign of foundations due to inadequate GI	5	5	25	Undertake additional GI to confirm ground conditions and design parameters	2	4	8	
/b	Stability of the proposed retaining walls	Road closure, harm to road users and third parties. Additional earthworks. Delay to programme	3	3	9	Undertake assessment and analysis as part of GDR.	2	2	4	Further ground investigation to determine design parameters due to insufficient data in the existing GI.
/c	Bearing capacity and stability of proposed Highway Structures	Road closures, harm to road users and third parties. Delay to programme.	3	3	9	Undertake assessment and analysis as part of the GDR.	2	2	4	Further ground investigation to determine design parameters due to insufficient data in the existing GI.

Notes:						
	a) Probability	1: Negligible	2: Possible	3: Probable	4: Likely	5: Very likely
	b) Impact	1: Negligible	2: Low	3: Medium	4: High	5: Severe
	c) Rating	1-4: Negligible	5-9: Low	10-12: Medium	13-19: High	20-25: Severe

The likelihood of the occurrence and impact of the hazard has been determined in line with the criteria given in the following tables.

	Criteria	Description
Probability of occurrence	5: Near Certain	Near certain to occur, probably on numerous occasions
	4: Likely	Likely to occur, possibly on numerous occasions.
	3: Probable	May occur, probably on a single occasion
	2: Possible	May occur, but unlikely
	1: Negligible	Not expected to occur

	Criteria	Description
Magnitude of Impact	5: Severe	Would result in a delay to completion of 10 weeks or more and/or additional costs of £1 million or more
	4: High	Would result in a delay to completion up to 10 weeks and/or additional costs up to £1 million
	3: Medium	Would result in a delay to completion up to 1 week and/or additional costs up to £200k
	2: Low	Would result in additional works up to 4 weeks and/or additional costs up to £50k but no delay to completion
	1: Negligible	Would result in additional works up to 1 weeks and/or additional costs up to £5k but no delay to completion

The rating of the risks has been assessed using the following matrix and is defined in line with the criteria given in the following table.

		Risk Rating				
Probability of occurrence	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
		Magnitude of Impact				

	Criteria	Description
Risk Rating	Severe (20-25)	High probability of occurrence and a high impact on the proposed scheme
	High (13-19)	Medium to high probability of occurrence and also a medium to high impact on the proposed scheme
	Medium (10-12)	Medium to high probability of occurrence or a medium to high impact on the proposed scheme
	Low (5-9)	Low to medium probability of occurrence or low to medium impact on the proposed scheme
	Negligible (1-4)	Negligible to low probability of occurrence and a negligible to low impact on the proposed scheme