File Note

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Project title	Cardiff Parkway Development Ltd	Job number	252199-00
cc		File reference	
Prepared by	Agnieszka Lopez-Parodi	Date	19 July 2018
Subject	Ground Gas Monitoring Strategy		

1 Introduction

Cardiff Parkway Development Ltd intends to develop land to the south of the existing St Mellons Business Park, to the east of Cardiff into a new mixed-use business and retail park. The site location is shown on Figure 1. The development is proposed to generally comprise two to three storey buildings and associated car parks, although there is a possibility that some higher rise structures may be considered up to 6/7 storeys.

The site is located approximately 7km east of Cardiff, in an area of agricultural fields. The Great Western Railway passes through the centre of the site, in a southwest-northeast orientation. A new train station is proposed as a key strategic aspect of the overall masterplan.

A desk-based review of available geotechnical and geo-environmental information pertaining to the site is presented in the Arup Geotechnical Desk Study [1]. The preliminary geo-environmental review identified the ground gas as one of the key risks to the proposed development due to the presence of organic natural deposits including peat bands. This note sets out an initial ground gas conceptual model and a monitoring regime for the proposed Cardiff Parkway development.

2 Initial Ground Gas Conceptual Site Model

The initial ground gas conceptual model is graphically presented on Figure 2 and described in detail below.

2.1 Potential Sources

The desk study review [1] indicated the site to be underlain by up to 7m of Tidal Flat Deposits (TFD) over up to 5m of Glacial Till (GT) overlying the bedrock, which comprises Mercia Mudstone or St Maughan's Formation. Locally TFD or GT may be absent. Localised and limited in extent areas of made ground may also be present. Layers of peat or organic clays are expected to be present within the TFD and these are considered to be the primary source of ground gas, particularly methane, within the site.

The site is located within the Wentlooge Levels, an area where groundwater levels are controlled by a network of drainage ditches (reens). Groundwater is expected to be very shallow, possibly 1-2m bgl. Therefore, it is expected that gases originating from the organic natural deposits are present in dissolved form. Gaseous form is only likely to be present within the unsaturated zone. [2]

Methane associated with peat bands/lenses is a result of microbial decay of organic material in anaerobic conditions. The rate of degradation is unlikely to be significant however over a long period of time it could lead to accumulation of methane in a confined space occupied by peat deposits. Bands/lenses of peat are generally surrounded by low permeability cohesive deposits - significantly limiting the potential for methane migration. Therefore, the potential for sustained high emissions of methane from peat deposits is very low. [6]

2.2 Potential Receptors

The proposed development is to comprise commercial buildings and a railway station with associated infrastructure, road access and landscaping. Construction workers are considered to be short term receptors at the site. Activities such as working in confined spaces, in particular in excavations, could potentially result in a risk of asphyxiation or explosion due to the accumulation of carbon dioxide or methane, albeit this is considered to be a low risk.

Long term receptors are site end users such as workers of the proposed railway station and commercial development.

Members of the general public, visitors and other short-term users of the site; including outdoor maintenance workers are unlikely to be affected by the effects of a potentially hazardous build up of ground gases due to very limited exposure times and atmospheric dilution of the gases.

2.3 Potential Pathways

The migration of gas is governed by different processes in saturated and unsaturated environments. As stated above, methane originating from peat or organic TFD, is expected to be in a dissolved form within the groundwater. The migration of this form of methane would be primarily driven by the groundwater movement and slow diffusion through the water body [2]. The TFD are likely to be of low permeability. Therefore, such migration is likely to be limited to migration within localised horizontal bands of more permeable materials, if present. Potential for vertical migration to surface is considered to be insignificant. This is supported by lack of evidence of vegetation destress at surface at the site, which is a typical indication of methane presence at shallow depth [2].

Exsolution (or degasification) of the dissolved gas from groundwater will occur at the boundary of the saturated and unsaturated zones. Migration within the unsaturated environment, which is the top 1-2m of the surface of the site including 0.5 -1 m of ground comprising a desiccated crust of TFD, and later post development, within the imported fill, including the drainage blanket, would be driven by hydrodynamic flows and gas pressure variations. A pressure gradient would be generated from natural fluctuations in atmospheric pressure or in the elevation of groundwater. No significant variations in groundwater level are expected considering the nature of the Levels and therefore the flows would be primarily driven by changes in atmospheric pressure. However, considering the low permeability of the TFD gas flux at surface from these deposits is likely to be insignificant. The presence of impermeable barriers like tarmac or concrete post development would inhibit upward migration of the gas, if any, and therefore lateral migration within the crust and overlying fill materials to a point or area of emergence would occur e.g. soft landscaped areas, service corridors, infrastructure [2].

Ground gas migration from peat deposits could however occur on disruption of the methane deposits. Reduction of pressure, and when the solubility limits of the gas are exceeded, would cause the gas to bubble out of solution and to form gaseous phase. A pressure decrease would occur e.g. when a borehole is drilled, which could result in a sudden release of gas. Similarly, piling or band drain installation can result in a sudden gas release. However, as mentioned in the 'Potential Sources' section, the potential for sustained high gas emissions from such peat deposits is very low.

Considering the proposed development, the following new pathways for ground gas migration may be created:

- Vertical migration along the piled foundations,
- Vertical migration through band drains and/or
- Horizontal migration through service corridors/trenches.

This could allow for ground gas migration from currently isolated areas within the TFD into enclosed/confined spaces, such as buildings, excavations and chambers/manholes.

Piled foundation

The buildings are likely to be founded on deep piled foundations. The piles are anticipated to be CFA/bored piles 450-600mm in diameter socketed into the bedrock. Pile installation works may result in release of methane currently contained within the peat bands. As discussed in the sections above it is unlikely for such a release to be sustained over a long period.

Upon formation of the piles, in cohesive ground, such as the TFD underlying the site, a number of factors would prevent creation of preferential flow paths for vertical migration. These include the lateral soil pressure that will close up any gaps around the pile due to concrete shrinkage, the hydrostatic pressure from wet concrete that will close the annulus or blinding concrete that will seal any annulus at the top of the pile. Therefore, the risk of pathway creation is low. In addition, where the thickness of the impermeable layer separating the strata containing gas from the surface is at least twice the pile diameter/width, the risk of creating a pathway is further significantly reduced. [3]

Although the ground conditions beneath the site have not been confirmed, based on the available information the risk of piled foundations creating preferential flow paths for methane contained within peat or gas generated in organic clay is considered to be very low or negligible. This will be reviewed on receipt of site specific data such as exploratory hole logs showing the thickness and nature of encountered strata, which will allow to assess the potential for creation of flow path.

Band drains

The site development will require upfilling to achieve the required flood protection level. Due to the nature of the underlying ground, surcharging may be required to consolidate the ground to avoid future differential settlement issues. In order to ensure that settlement periods are reasonable during the surcharging works (e.g. typically between 3-6 months), utilisation of vertical band drains may be necessary. If utilised, the band drains would be installed from the top of the working platform (which would also serve as a drainage layer, allowing the dissipation of the excess porewater pressures during the consolidation period). The band drains would be installed to the base of the TFD deposits, with typical spacings of between 1 and 1.5m on a triangular grid. The groundwater released as a result of consolidation will drain into the drainage layer. The band drains will remain in the ground on completion of the development. Refer to Drawing A5WTC-S1-DR-SD-0622 for an example cross section.

As the band drains penetrate the full thickness of the TFD, they will also penetrate any peat bands contained within these deposits. As with construction of the piles, it is anticipated that the insertion of the band drains will result in release of methane from the peat deposits. Once the equilibrium is reached the rate of methane emissions would be significantly slower than the initial release and would be a function of bacterial decomposition rate. It is anticipated that any methane produced within the intercepted peat deposits in the immediate vicinity of the band drains will migrate as bubbles to the groundwater surface via the band drains into the drainage layer from where it will escape through the nearest point or area of emergence. This has the potential to be an on-going pathway for methane migration to the surface.

Services corridors

Service corridors are likely to be constructed within the imported fill/drainage blanket for band drains, which comprise relatively permeable materials. Therefore, the creation of preferential lateral flow paths for gas migration as a result of service corridors introduction is not considered to be critical. However, it should not be discounted in any further risk assessments and this will be reviewed on receipt of site specific data.

3 Proposed ground gas monitoring

Groundwater conditions beneath the site are likely to present a challenge with respect to ground gas monitoring. Due to the high groundwater levels all installations with response zones in the peat or organic natural deposits are expected to be fully flooded and therefore the monitored gas concentrations are likely to represent methane that would come out of solution from the groundwater. As discussed earlier, any intrusion into that environment (e.g. construction of a borehole) may lead to a pressure release resulting in a release of methane into a gaseous form. The installation of a boreholes will significantly impact the migration mechanism and create a preferential flow path for gas migration. Therefore, the concentrations of methane and associated gas flows measured in flooded installations within the relatively impermeable matrix may provide over exaggerated concentrations of methane that will reach the surface of the site [4]. Consequently, the results of monitoring undertaken within the flooded installations would not be considered representative of the gas conditions expected within the proposed development.

The primary risk presented to the proposed development is the introduction of band drains that will create permanent preferential flow paths for methane migration from the intercepted peat deposits. Although the rate of methane emissions is unlikely to be significant at the steady state, quantification of that risk is required to ensure that the design of the proposed development incorporates adequate gas protection measures.

For the monitoring to provide data representative of the proposed development it is proposed to undertake ground gas monitoring in installations constructed to reflect band drain installation conditions. The response zone would extend from a min. 0.5m below the ground level to the base of the TFD and would capture both saturated and unsaturated zones. Due to the applied bentonite seal at the top of the installation (min. of 0.5m) the monitored conditions will be representative of the ground as there will not be a continuity with the atmospheric conditions [5]. The monitored atmosphere within the unsaturated zone would contain methane migrating from the peat and organic clay deposits and also any methane produced within the unsaturated zone and is expected to represent the atmosphere entering the drainage blanket, or when this becomes less permeable, the overlying fill.

In addition, where sufficient depth of unsaturated zone is present (at least 1m), a shallow installation would be placed to monitor near the ground surface conditions to confirm the baseline ground gas conditions on site. It is not proposed to target specific peat bands due to unreliability of the results obtained from flooded installations and that doing so would not provide representative monitoring of the post construction state.

The proposed locations for ground gas monitoring are shown on Figure 3, these are subject to encountered ground conditions during the investigations.

Initially it is proposed to undertake six rounds of gas monitoring at fortnightly intervals, which is in line with CIRIA C665 [7]. The results of the monitoring will form the basis of ground gas risk assessments completed also in accordance with CIRIA C665 [7]. Subject to the conclusions of these assessments, further monitoring may be considered. This may include continuous monitoring in selected installations.

References

[1] Cardiff Parkway Development Ltd, Cardiff Parkway, Geotechnical Desk Study, Arup, December 2017

[2] Methane: Its occurrences and hazards in construction, R130, CIRIA 1993

[3] Piled foundations and pathways for ground as migration in the UK, Steve Wilson and Sarah Mortimer, ICE 2017

[4] BS 8485:2015 Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings

[5] BS8576:2013 Guidance on investigations for ground gas. Permanent gases and Volatile Organic Compounds (VOCs)

[6] A pragmatic approach to ground gas risk assessment, CL:AIRE, RB 17, November 2012

[7] Assessing risks posed by hazardous ground gases to buildings, CIRIA C665, London 2007

DOCUMENT CHECKING (not mandatory for File Note)

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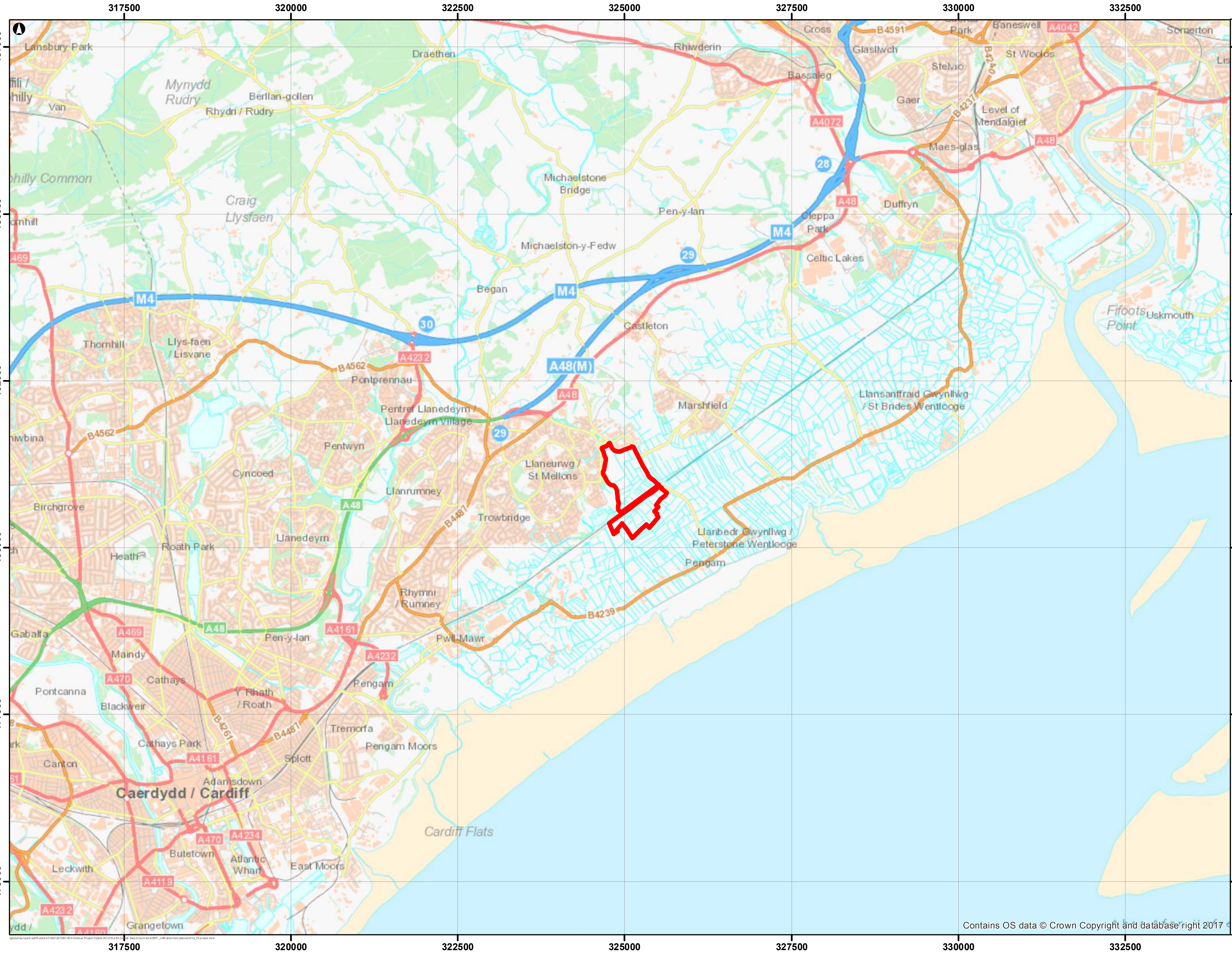
Signature			



S2	15/12/2017	EB	TW	DR
Issue	Date	By	Chkd	Appd

Metres

0 335 670 1,340

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Client

Cardiff Parkway Development Ltd

Job Title

Cardiff Parkway Business Park

Scale at A3

1:50,000

Job No 252199

Drawing Status Issue

Drawing No 1

Issue S2

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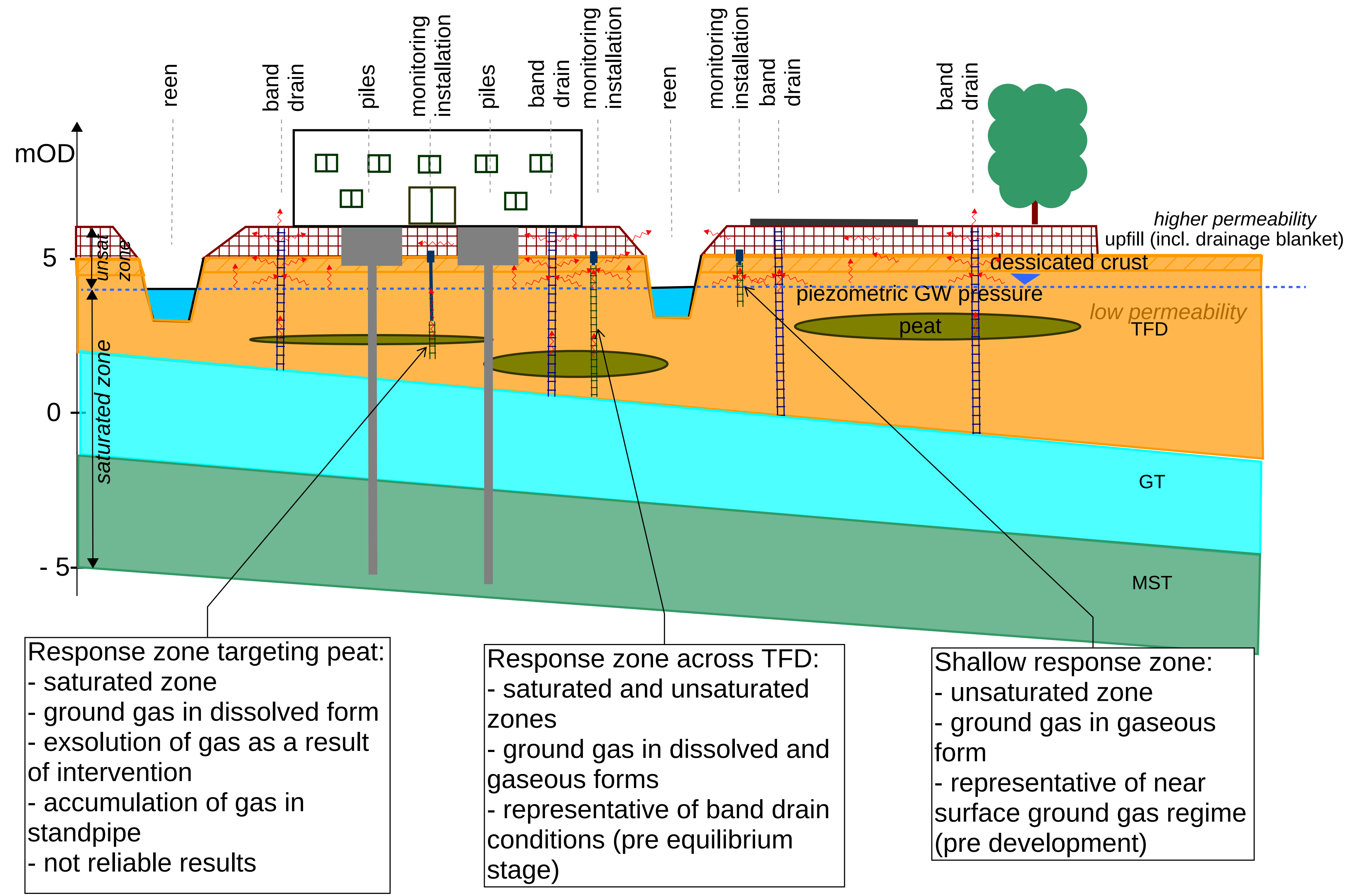
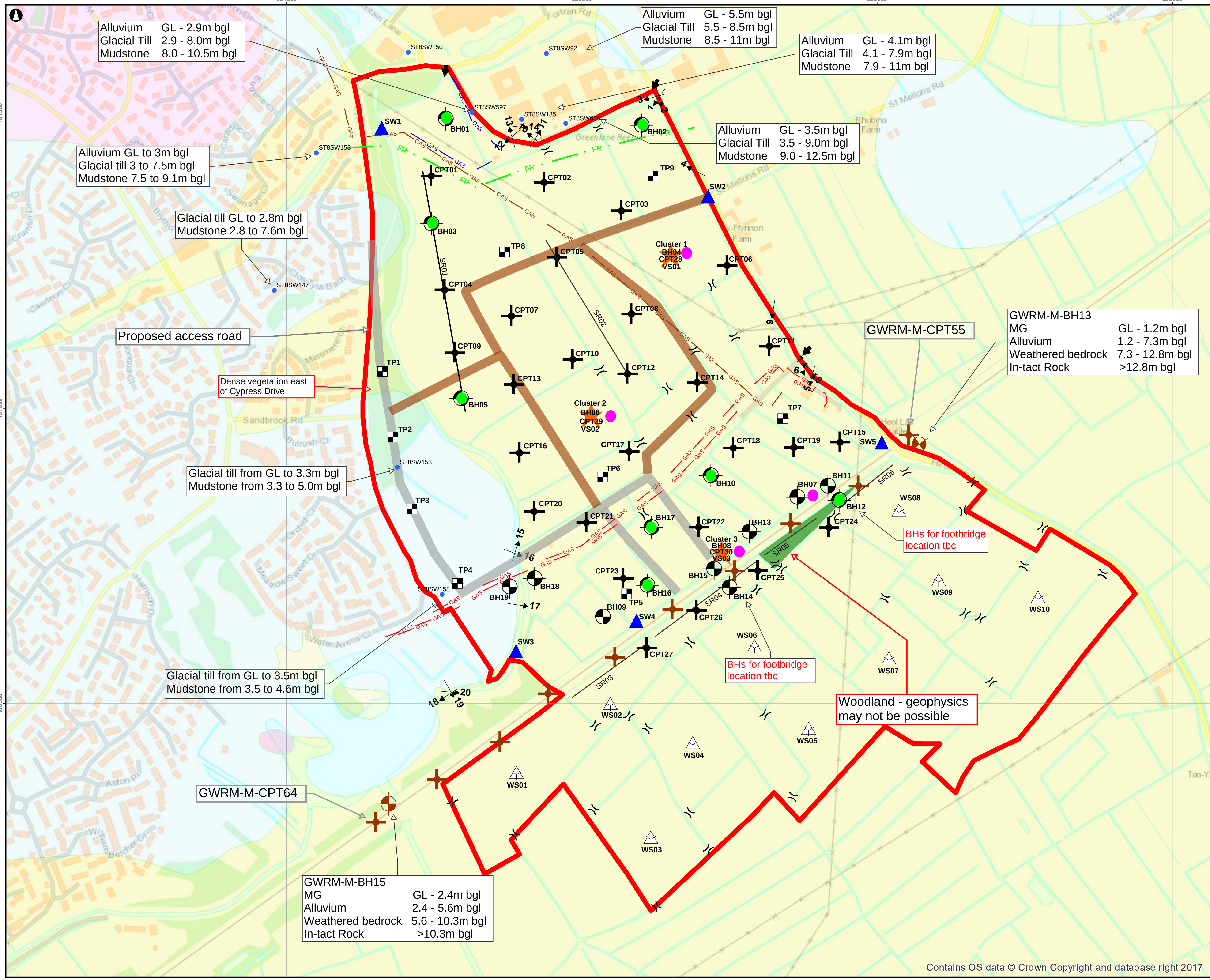


Figure 2

Ground gas conceptual site model



LEGEND

Proposed GI and monitoring

- Cable percussive borehole (*with rotary core follow on 15m into the bedrock either in GI for planning or Phase 1 GI for design)
- Trial pit
- CPT
- "Clusters" - CPT and shear vane tests close to location of BH4, BH6 and BH8
- Seismic refraction line
- Surface water monitoring
- Window sample

Other

- Access bridge (from aerial photography)
- Phase 1 access road
- Phase 2 spine road
- Access to fields
- Site visit photograph

Existing GI records

- ST8SW92 BGS borehole
- GWRM M CPT55 - CPT64
- GWRM M BH13 & BH15
- Long response zone
- Shallow response zone

Issue	Date	By	Chkd	Appd
S2	03/07/2018	EB	TW	DR

Metres 0 75 150 300

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Client: Cardiff Parkway Ltd

Job Title: Cardiff Parkway

Drawing Title: Ground investigation for Planning and Phase 1 design

Scale at A3: **1:6,000**

Job No: 252199

Drawing Status: Issue

Drawing No: Figure 3

Issue: S2

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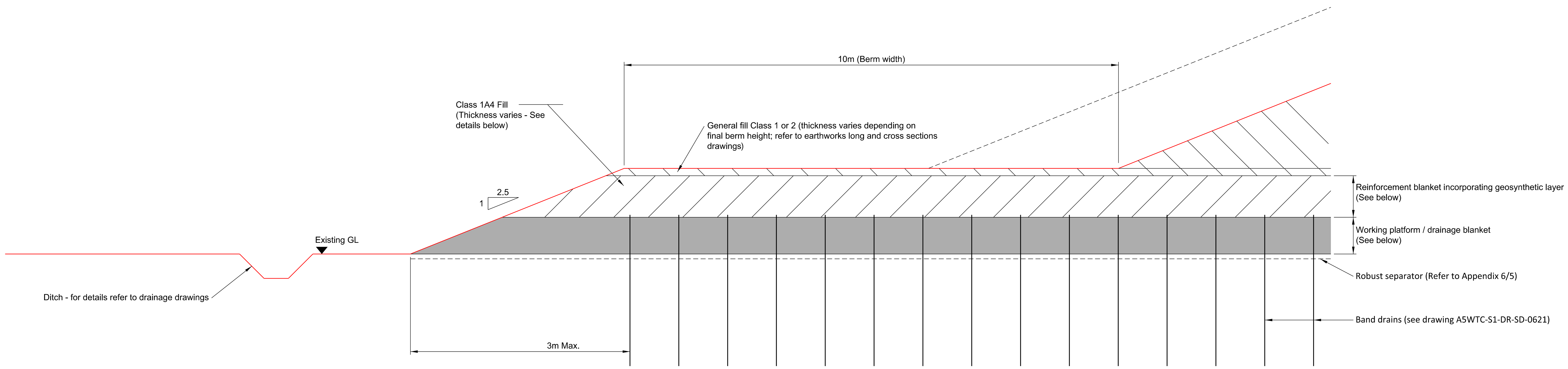
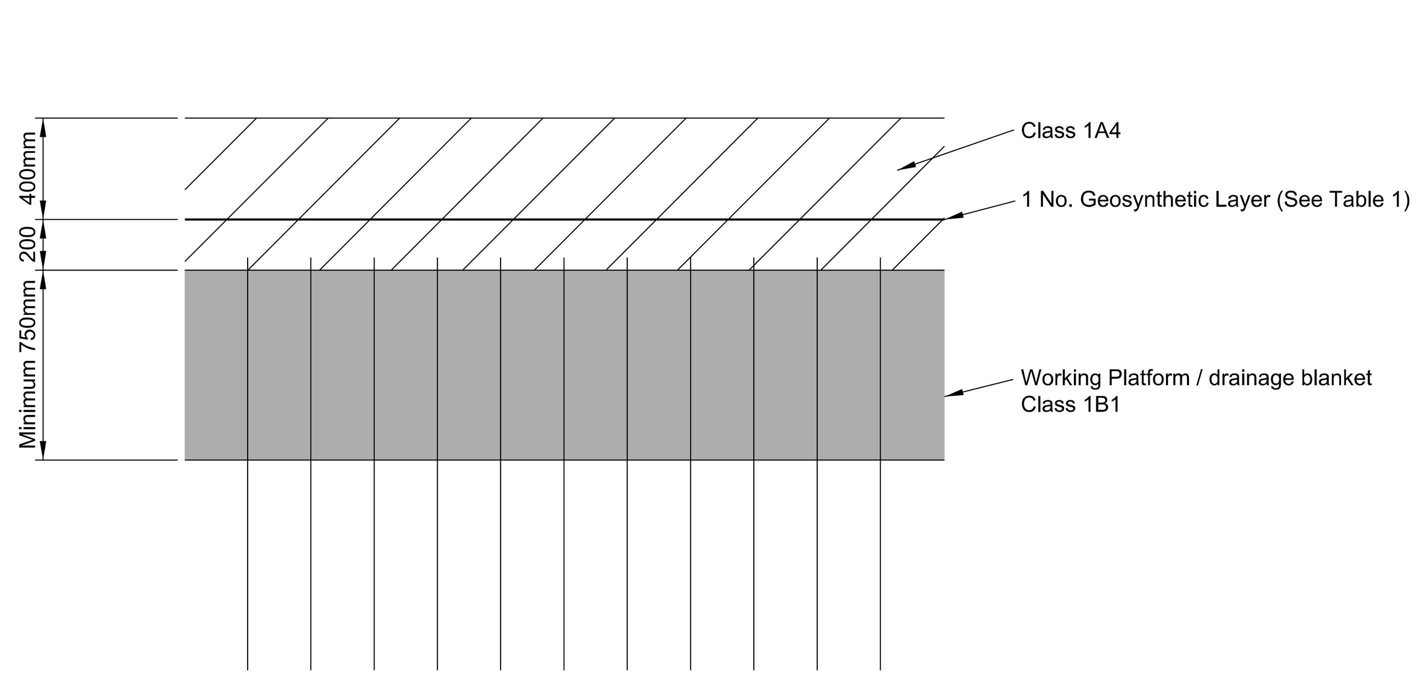
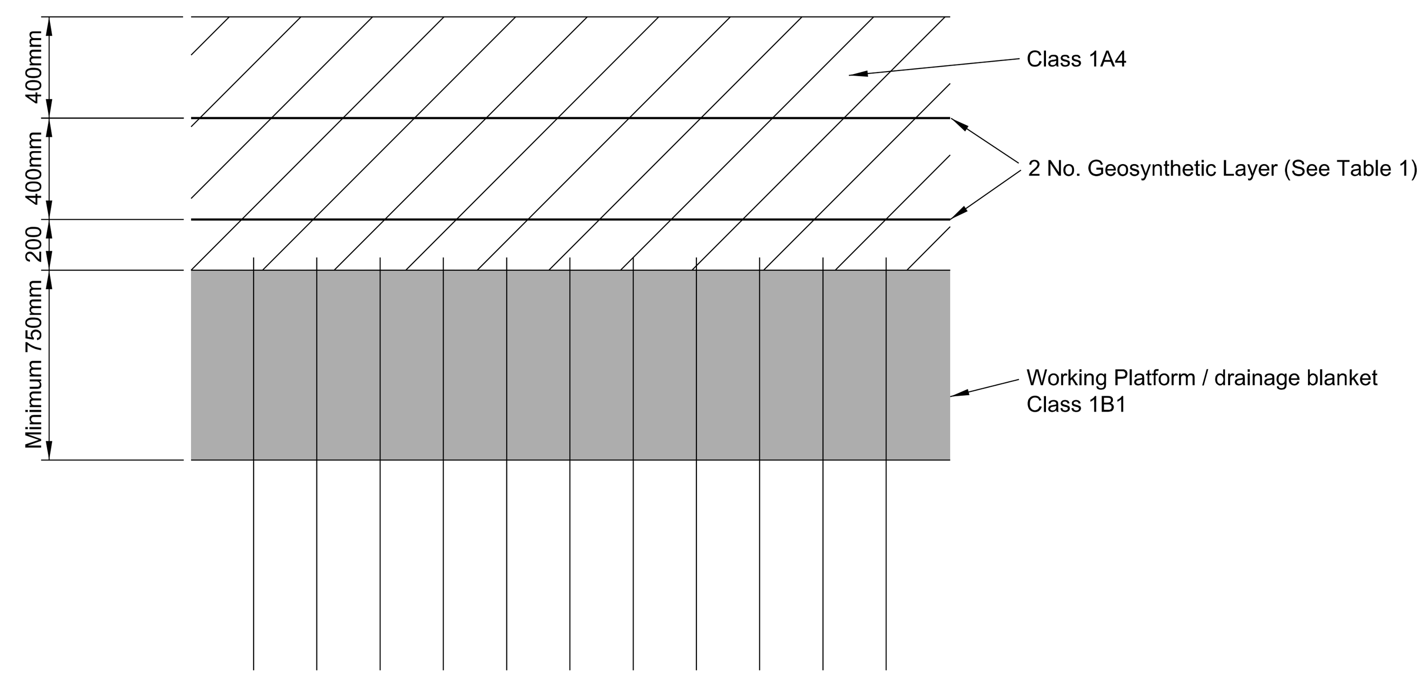




Typical Reinforcement Blanket and Working Platform / Drainage Blanket Section
(1 No. Geosynthetic Layer)



Typical Reinforcement Blanket and Working Platform / Drainage Blanket Section
(2 No. Geosynthetic Layers)

Table 1
Geosynthetic Requirements

Zone	Chainage	Basal Reinforcement	
		Short - Term $T_r * f_n$ (kN/m run)	Long - Term $T_r * f_n$ (kN/m run)
1	12340-12430	450	360
2	12430-12680	825	830
3	12770-13000	825	830
4	13000-13125	450	360
5	13870-14180	825	830
6	40m from piled embankment	1276	830

The basal reinforcement requirements are given in terms of (Tr*fn); where Tr is the maximum ULS tensile strength to be resisted by the reinforcement during short-term (i.e. construction stages) or long-term (i.e. design life), and fn is the factor for ramification of failure (taken as 1.1 based on a category 3 structure case in Table 9 of BS8006-1:2010). The basal reinforcement shall achieve an allowable ultimate limit state Design Strength TD equal to or higher than the specified (Tr * fn) and calculated in accordance with Annex A.3.a of BS8006-1:2010 considering the product-specific characteristic short term strength (at strain ε =10%) and short/long term specific reduction factors (i.e. reduction factor for creep RFCR and material safety factor fm). For zone 6 refer to drawing A5WTC-S1-DR-SD-0625

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION
IN ADDITION TO THE HAZARDS/RISKS NORMALLY ASSOCIATED WITH THE TYPES OF WORK DETAILED ON THIS DRAWING, NOTE THE FOLLOWING SIGNIFICANT RESIDUAL RISKS
CONSTRUCTION
CONSTRUCTION PLANT MAY SINK INTO SOFT GROUND IF WORKING PLATFORM NOT ADEQUATELY DESIGNED
MAINTENANCE/CLEANING
NONE
USE
NONE
DECOMMISSIONING/DEMOLITION
NONE

Notes :

1. The minimum thickness of the working platform/drainage blanket is 750mm, as shown on drawing No A5WTC-S1-DR-SD-0622. The platform shall be constructed without removing the topsoil, once any other vegetation has been cleared, to suit the existing topography. As the existing ground level is not flat, some areas of the platform will require greater thickness of material in order to keep the top of the platform at an acceptable gradient for construction plant to operate.
2. No excavation shall be undertaken in areas of soft soils.
3. At the interface between the soft ground and adjacent areas with higher ground levels it will be necessary to bench in the platform into the natural ground, as detailed in drawing No A5WTC-S1-DR-EW-104.

Stat	Rev	Purpose of Issue	Date	Auth	Rev	Description	By	Date	Chk'd	Auth
C	C1	FOR CONSTRUCTION	16/01/13	AP	C1	FOR CONSTRUCTION	LW	16/01/13	DR	AP
A	A2	FOR APPROVAL	11/10/12	AP	A2	FOR APPROVAL	HJ	11/10/12	DR	AP
A	A1	FOR APPROVAL	29/02/12	AP	A1	FOR APPROVAL	PLM	29/02/12	DR	AP

Client: ROADS Service

Project: A5 WTC Western Transport Corridor

Designer: Arup Atkins

Contractor: BbM

Title

SOFT GROUND AREAS
BASAL GRANULAR REINFORCED BLANKET
TYPICAL DETAILS

Sheet Size	Original Scale	Designed/Drawn	Checked	Authorised
A1	1:50	DS Date 18/01/13	FC Date 18/01/13	DR Date 18/01/13

Status	Drawing Number	Rev
C	A5WTC-S1-DR-SD-0622	C1

Rev C1
Drawing Number A5WTC-S1-DR-SD-0622
Status C
DO NOT SCALE
A1

File: A5WTC-S1-DR-SD-0622.dgn Plotted by: PLM
Date: 29/02/2012

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