Technical Note

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Project title	Machynys Hotel	Job number	278688
cc		File reference	
Prepared by	Nick Kontochristos	Date	17 December 2020
Subject	Geoenvironmental & Geotechnical Desk Study Note to support the Machynys Hotel Site Planning Application		

1 Introduction

This technical note has been prepared to support the outline planning application for the proposed hotel site in Machynys, which is located to the south of Llanelli and the B4304 (refer to Drawing 1).

Arup prepared a Geotechnical and Geo-environmental Desk Study for the Llanelli Wellness and Life Science Village (LWLV)[1] for Carmarthenshire County Council, issued in November 2016, in support of the pre-application consultation submission for the Llanelli Wellness and Life Science Village. The Machynys hotel site was included within this study (and is referred to within the Desk Study report as 'Site 6').

The proposed development comprises a hotel with 140 beds, up to 15 metres in height covering an area of up to 10,000sqm with associated car parking, access roads, landscape and infrastructure works, including the importation of material for infilling of land to raise level for the development.'

It is proposed to raise the site levels at least 1m for flood protection. Engineering measures are likely to be needed to mitigate for settlements resulting from this upfilling; including use of 'band drains' penetrating the underlying soft alluvial and peat deposits. The proposed hotel is likely to be founded on piles, transferring the load to competent strata expected to be at around 20m depth. The aim is to minimise the imported material required by only lifting the hotel itself, roads, car parks and hardstanding areas.

The existing bund on the northern part of the site (roadside boundary) will remain in place to be used for screening. An attenuation pond is also proposed on the north eastern part of the site connected to a new reen which will run along the eastern part of the site parallel to the site boundary before discharging to the existing reen which runs along the southern site boundary.

An illustrative site layout plan showing the proposed development is shown on Drawing 2.

[1] Arup Geotechnical and Geo-environmental Desk Study for the Llanelli Wellness and Life Science Village (LWLV), Nov 2016

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This technical note provides a summary of the available information on the history, environmental setting and previous ground investigations for the site and presents geotechnical and geoenvironmental constraints and considerations in relation to the proposed development.

2 Site Description & History

2.1 Current Conditions

The site is located south of the B4304 and adjacent to the Machynys Peninsula Golf and Country Club, which is to the immediate east and south off-site.

The site covers an area of 37,600sqm and it is currently grassland and overgrown with some areas of heavy vegetation. There is a hardstanding access track from the east of the site, which is now disused. A reen is running along the southern site boundary stopping at a copse of trees at the south eastern corner, potentially being culverted from that point onwards. The flow is towards the south west.

The topography is generally flat for the majority of the site area (circa 5m OD) with some local variations observed in the western part of the site where there are two existing bunds 1-2m high, and another existing bund around 1m high present along the roadside boundary in the north. The location of these are presented on Drawing 6.

Open grassland lies immediately to the west off-site and the Machynys Bay residential development is located at a distance to the south west. Commercial properties are located across the B4304 to the north off-site (Heavy Engineering Company Ltd, LBS Builders Merchants, Delta Lakes Enterprise Centre).

2.2 Site History

The site is shown on the 1889 map to be occupied by the Machynys Brick Works comprising a number of brick fields and a clay mill. Several buildings are shown within the site area with associated tramways. A reservoir is shown partially in the extreme north western part of the site, extending off-site, as shown on Drawing 6, which is expected to be associated with the nearby Burry Works (tin plate) to the west off-site.

Between 1901 and 1908 the brick works downsized, with several of the buildings removed and only the outline of the former clay mill present. Machynys Road is under construction, traversing the site from the north to the south west.

By 1921 almost all brick works infrastructure had been removed from the site area. The Burry Works had been expanded directly to the west off-site. The reservoir associated with these works remained in the north west. There was little change to the site from 1921 to 1952, when the last remaining brick works buildings had been removed and the Brick Works were annotated as disused.

During WWII, the Llanelli National Shell Factory was present next to the site (directly to the west off-site) where the Burry Extension Works were and was engaged in the manufacture of 6” shells. An adjacent factory was engaged in the rectification of 6” shells.

Substantial redevelopment of the site had occurred by 1965, with the site area being occupied by a succession of rectangular sheds, facilitated by rail and tram lines, at some point these have been associated with the Burry Works in the west off-site (becoming an engineering works in 1973). According to the 1973 historical map, the reservoir in the north west appeared to be in the process of being infilled.

By 1992 the rectangular buildings on site had been demolished. The outline of the reservoir remained apparent. The engineering works off-site in the west remained until 1999, when the site is shown to be clear of any infrastructure. By 1999 all of the buildings have been removed and the reservoir has been infilled.

Based on historic Google earth imagery, the housing to the south west off-site is shown to have developed since 1999 and the Machynys Golf and Country Club to the south and east of the site opened in 2005. The reen present along the southern site boundary seems to have been formed around that time. Since then, there has been little change on site until the present day.

3 Environmental Setting

3.1 Geology

The geology of the site has been interpreted from the published 1:10,560 scale BGS geological map Sheet SS 59 NW and the BGS memoir for the area (Sheet 247) has also been consulted. The geology of the site is shown on Drawings 4 and 5.

The geological map shows the site to be underlain by Estuarine Alluvium, with a cover of Artificial Ground over the full site extent. In the west off-site, Glaciofluvial deposits are shown.

The Estuarine Alluvium is likely to comprise very soft or soft clay and silt with organic deposits and peat or loose to medium dense granular deposits.

The solid geology comprises the Hughes Beds of the Upper Coal Measures. The geological plan indicates that the Hughes Beds are predominantly sandstone. The general dip of the beds is around 15° to the north.

The Swansea 2ft coal seam and other thin coal seams are shown to be within the Hughes Beds, and there are various coal mining features shown on the geological map. These are described in more detail in Section 3.3.

The geology plan describes details of the Machynys Borehole sunk to the south of the site in 1888. The log states that the drift cover was found to be 127 feet (38m) thick at this point. Another borehole approximately 600m to the east of the site describes 140 feet (42m) to rock.

3.2 Hydrology and Hydrogeology

3.2.1 Hydrology

The New Dafen River is located approximately 250m to the north of the site. This river is controlled by a sluice gate, which connects immediately to the River Lliedi (west) and beyond to the Loughor Estuary (Drawing 3).

The New Dafen River was subject to the previous "River Quality Objectives" RQO scheme. The scheme classification was used for planning water quality improvements until 2006 when the scheme ended. The RQO class of the New Dafen River is 3 (there are five classes ranging in order of decreasing quality from 1-5). From 1995 to 1998 (inclusive), the river water was recorded to "significantly fail" the Class 3 criteria (which includes unionised ammonia of 0.021mg/l and copper from 300ug/l to 2000ug/l subject to hardness class). From 1999 to 2006, the samples of river water were recorded to meet the Class 3 criteria.

Loughor Estuary is located around 500m south and west of the site (Drawing 3).

There is a reen running along the southern site boundary (flow south west) which is proposed to be connected to a new reen constructed as part of the attenuation system for the site development.

As part of the Machynys Golf and Country Club to the south of the site, there are various lakes and watercourses that form part of the golf course.

3.2.2 Hydrogeology

The Environment Agency aquifer maps (now Natural Resource Wales) shows the Estuarine Alluvium underlying the site to be designated as 'Secondary Undifferentiated' strata. This means that the Estuarine Alluvium has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the strata.

The Glaciofluvial Deposits are designated as a 'Secondary A' aquifer. Secondary A aquifers are defined as having 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. These are generally aquifers formerly classified as minor aquifers. The underlying Hughes Beds of the Upper Coal Measures bedrock is designated as a 'Secondary A' aquifer.

Based on available ground investigation information for the wider Llanelli area[2], groundwater is present within the more permeable layers in the alluvium (granular) subject to locally confining layers above and below. A groundwater body lies within the glaciofluvial deposits predominantly controlled by flow to the west and south west. This groundwater body is locally confined where overlain by cohesive alluvium. The groundwater in the glaciofluvial deposits is expected to be in some level of continuity with the Estuary.

The site does not lie within a source protection zone (SPZ) and no groundwater abstraction points are known to lie within the site area. Based on previous desk study information[3], the groundwater is likely to be brackish.

3.3 Mining

A detailed review of the mining risks to development has been undertaken as part of the 2016 Arup LWLV Desk Study including the proposed development site. A summary of this information is provided below.

[2] Arup 2020, Llanelli Wellness and Life Science Village Geotechnical and Geo-environmental Interpretative Report, Phase 1

[3] Arup 2020, Llanelli Wellness and Life Science Village Geotechnical and Geo-environmental Interpretative Report, Phase 1

The site is underlain by the Hughes Beds of the Upper Coal Measures. The town of Llanelli is known to have been mined for coal in the past, and the geological map shows several mining related features.

There is no evidence to suggest the site was mined for non-coal sources, for example metalliferous ironstones or rock quarries for construction aggregate.

The Coal Authority online interactive map viewer does not show any mine shafts or adits within the development site, and the site is not shown to be located within a 'Development High Risk Area.'

A Coal Authority report was also obtained for the site[4]. The report concludes that the site is not within a zone of likely physical influence on the surface from any past or present underground workings and there are no known coal mine entries within the site or within 20m of the site boundaries.

The preliminary assessment is that there is no significant potential for subsidence associated with any workings within coal seams beneath the site.

3.4 UXO

In accordance with CIRIA C681 'Unexploded ordnance (UXO), guide for the construction industry' (2009)[5], as part of the 2016 LWLV Desk Study, a preliminary unexploded ordnance (UXO) risk assessment has been carried out for the site by UXO specialist Zetica. A summary of the findings is provided below.

The following strategic targets were located in or in the vicinity of the site:

- Industry including tinplate works, a foundry and chemical works.
- Docks, including landing stages.
- Military training grounds.
- Transport infrastructure.

During WWII the borough of Llanelli recorded a low regional bombing density, however readily available records indicate that several bombs fell in close proximity to the site during a raid in July 1940.

The Llanelli National Shell Factory (NSF) was located directly to the west off-site and it was a part of the Burry extension works (Drawing 6), which engaged in the manufacture of 6" shells and an adjacent factory was engaged in the rectification of 6" shells.

The historical maps from 1889 show a rifle range on the southern end of the Machynys peninsula, approximately 700m from the site. This is shown as disused by 1973.

On account of the above, a detailed risk assessment was recommended to assess, and potentially zone, the Unexploded Ordnance (UXO) hazard level on the site.

[4] The Coal Authority Shaft Plan and Data Sheets LWLV, Llanelli, Carmarthenshire, Aug 2016
[5] CIRIA C681 Unexploded ordnance (UXO) A guide for the construction industry (2009)

A detailed UXO risk assessment for the site was undertaken by UXO specialist Dynasafe BACTEC[6]. The report concluded that Dynasafe BACTEC consider the site to be of low risk from UXO.

3.5 Radon Gas

Radon is a naturally occurring radioactive gas that can seep out of the ground and build up in buildings, the highest levels are usually found in underground spaces such as basements.

The site is shown on the UKRadon.org interactive map as being in the lowest band of radon potential, with less than 1% above the Action Level. Therefore, no radon protection measures are required for the proposed development.

4 Previous Ground Investigations

4.1 Previous Ground Investigations

There is previous ground investigation information available for the site, sourced from the British Geological Survey (BGS) Archives, Arup's LWLV Desk Study and a factual report of a ground investigation undertaken previously for Carmarthenshire County Council. The location of the exploratory holes on-site is shown on Drawing 6. A summary of the type of exploratory hole in each investigation is provided in the table below.

Table 1: Summary of Previous Ground Investigations

Previous Ground Investigation	Source	Location	Exploratory Holes	Testing and Monitoring
Machynys Redevelopment, Thyssen Geotechnical (1987)	BGS Archive	On-site	4no trial pits	N/A
Machynys Peninsula Study, Exploration Associates (1995)	BGS Archive	On-site	2no boreholes, 1no trial pit	N/A
Nicklaus Hotel, Machynys, Llanelli, Integral Geotechnique (2008)	Integral Geotechnique Factual Report[7]	On-site	5no boreholes, 13no trial pits	In-situ Static Cone Penetration testing (SCPT) in 8no locations including dissipation testing Laboratory chemical testing on soil, leachate and groundwater samples

[6] Explosive Ordnance Desktop Threat Assessment, Llanelli Wellness and Life Science Village, Ref 6844TA, Dynasafe BACTEC Ltd, Nov 2016

[7] Integral Geotechnique Site Investigation Factual Report, Nicklaus Hotel, Machynys, Llanelli, Sept 2008

Previous Ground Investigation	Source	Location	Exploratory Holes	Testing and Monitoring
				Laboratory analysis of a gas bomb sample and VOC sample taken 6no rounds of ground gas monitoring & 4no rounds of groundwater monitoring (installations within made ground and alluvium)
Machynys Mound, Soil Mechanics (2011)	Arup Geotechnical & Geoenvironmental Desk Study LWLV [8]	West Off-site	2no boreholes, 10no trial pits	In-situ Standard Penetration Tests (SPTs) at regular intervals throughout the depth of the cable percussive boreholes Sampling of soils and groundwater in both borehole and trial pit excavations for geotechnical and chemical laboratory testing 3no rounds of ground gas monitoring (installations within made ground)

4.2 Ground Conditions

Based on the available ground investigation information, a summary of the ground conditions is presented in the table below.

Table 2: Summary of Ground Conditions

Depth (m bgl)	Stratum
GL to 1.1 / 3.7	MADE GROUND: Medium dense locally dense gravelly silty clayey sand, locally cohesive, slightly ashy with occasional to rare gravel sized fragments of metal, slag, glass, wood and plastic Within the footprint of the backfilled reservoir, the thickness of made ground is anticipated to be around 2m comprising silty sandy fine to coarse gravel of sandstone with medium cobble content (lower layer comprising silty sandy gravel to sandy gravelly clay. Gravel comprises brick, concrete, metal, slag, clinker and industrial waste i.e. plastic, pipes etc.).
1.1 / 3.7 to 4.2 / 5.5	ALLUVIUM: Very soft to soft silty CLAY, with local sandy silt and peat bands and layers
4.2 / 5.5 to 5.3 / 6.7	PEAT: Soft to firm fibrous and amorphous

[8] Arup Geotechnical and Geo-environmental Desk Study for the Llanelli Wellness and Life Science Village (LWLV), Nov 2016

Depth (m bgl)	Stratum
5.3 / 6.7 to 9.4 / 12.7	ALLUVIUM: Soft silty sandy CLAY, locally peaty with peat bands
9.4 / 12.7 to 19.4 / 20.8	ALLUVIUM: Very loose to medium dense sandy clayey SILT to silty SAND
19.4 / 20.8 to >21.4	GLACIOFLUVIAL DEPOSITS: Dense / stiff clayey cobbly GRAVEL to sandy gravelly cobbly CLAY

4.2.1 Integral Geotechnique GI (2008)

Groundwater was struck within the made ground in the trial pits at depths varying from 1.5m to 2m bgl with slow to medium inflow rates. The groundwater was recorded as rising from the base of a number of trial pits. Groundwater levels in the boreholes ranged between 2.2 and 2.9m bgl.

The groundwater monitoring indicated that there is a discontinuous perched groundwater within the made ground sitting above the underlying cohesive alluvium.

No fall in head was interpreted across the site from the groundwater levels recorded. However given the hydrology of the surrounding areas, it is assumed that groundwater flow is to the south/south west towards the Loughor Estuary. The groundwater body may be affected by tidal movement.

Some minor visual or olfactory evidence of contamination of fill materials was observed during the excavation of the trial pits. This comprised groundwater with a slight to very slight hydrocarbon sheen encountered in 5no locations (TP1, TP2, TP9, TP10 and TP13) and a slight hydrocarbon odour encountered in one location (TP2). No potential asbestos containing materials were visually identified during the site investigation.

4.2.2 Soil Mechanics GI (2011)

Groundwater seepages were typically observed between depths of 1 and 3m below ground level. Groundwater was predominantly encountered within the made ground. Strikes were generally recorded as a seepage or slow ingress although one fast inflow was recorded in a trial pit. No groundwater strike was recorded in the borehole which was advanced to 7m below ground (0.2m AOD). Similarly there was no groundwater strikes in the borehole which was advanced to 8 m below ground.

Although no groundwater strikes were recorded in what were described as glacial deposits during fieldwork, groundwater was recorded in the standpipe piezometer from the borehole which was installed in the glacial deposits, which indicated the presence of an aquifer in these deposits.

For the first three visits the depth to water in the glaciofluvial standpipes was consistently measured at 0.6m below ground level. However two measurements in early March 2011 gave depths to water of around 5m below ground. Further monitoring was recommended to be carried out to confirm the results and to include monitoring over a tidal cycle to check whether the piezometer was influenced by the tidal fluctuations in the nearby Loughor Estuary; there is no record of this being undertaken.

During the investigation strong hydrocarbon odours were recorded at the base of the made ground encountered within one trial pit excavated near the site boundary to the west off-site. No other visual or olfactory evidence of contamination was observed during the ground investigation (with the exception of the made ground itself).

5 Contamination Potential

5.1 Conceptual Site Model

This section details the Conceptual Site Model for the site based on reviewed desk study and available ground investigation information. Constraints associated with geo-environmental issues identified are provided in Section 6.2 of this report. The CSM is presented in Figure 1.

5.1.1 Potential Sources

On account of the history of the site presented in Section 2.2, the primary sources of contamination on the site are considered to be associated with the site's industrial history, the made ground present under the site and the backfilling of the reservoir (north western part of the site). A summary of the potential sources of contamination is provided below.

Table 3: Potential Sources of Contamination

Potential Source	Potentially Contaminative Materials
On Site	
Made Ground within site area related to historic use as Machynys Brick Works (including contaminated perched groundwater within the made ground)	Likely to have been imported during industry construction. Asbestos, Metals (As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Zn), sulphate, phenol, petroleum and polycyclic aromatic hydrocarbons, volatile compounds and cyanide considered potential contaminants. Potential for leachable contaminants Source of ground gas (methane, carbon dioxide)
Historic Railway and tram lines (across site area)	Hydrocarbons (including petroleum hydrocarbons and polycyclic aromatic hydrocarbons) fuel oils, lubricating oils, greases, solvents, paints, heavy metals, asbestos, phenols and creosote considered likely contaminants. Possible historic herbicides used to control growth on tracks and sidings.
Existing bunds on the western and northern part of the site	Materials forming the bunds are of unknown nature and origin. Asbestos, Metals (As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Zn), sulphate, phenol, petroleum and polycyclic aromatic hydrocarbons, volatile compounds and cyanide considered potential contaminants. Potential for leachable contaminants.
Backfilled reservoir (partially under the site in the north western part)	Based on available ground investigation information the historic reservoir was infilled with materials comprising silty sandy gravel to sandy gravelly clay. Gravel is of brick, concrete, metal, slag, clinker and industrial waste i.e. plastic, pipes etc. (thickness of at least 2m). Source of ground gas (methane, carbon dioxide)

Potential Source	Potentially Contaminative Materials
Alluvium with peat bands	Natural soil strata with a high degradable organic content. Source of ground gas (methane, carbon dioxide)
Off Site	
Engineering works and other industrial units including shell factory (west off-site)	Specific activities undertaken within historic works units (iron, steel and tin plate works as part of "Burry Works' and Llanelli National Shell Factory). Potential contaminants therefore considered to be: Asbestos, metals, sulphate, pH, total petroleum hydrocarbons, polycyclic aromatic hydrocarbons, semi volatile and volatile organic compounds, PCBs, phenol and cyanide.

5.1.2 Potential Receptors

The receptors considered relevant to any existing contamination within the subsurface associated with the proposed development are identified as follows:

During Construction:

- Construction workers involved in the development works;
- Off-site residents and workers;
- Surface waters, including that within Loughor estuary and the existing reen south of the site and lakes and watercourses that form part of the golf course; and
- Groundwater beneath the site (groundwater within granular alluvium and glaciofluvial deposits - classed as secondary 'A' aquifer)

During Operation:

- Site end-users (hotel guests, visitors and employees);
- On-site maintenance workers;
- Groundwater beneath the site (groundwater within granular alluvium and glaciofluvial deposits - classed as secondary 'A' aquifer);
- Surface waters, including that within Loughor estuary and the existing reen south of the site and lakes and watercourses that form part of the golf course; and
- Building materials used in new development (including services).

Based on the available ground investigation information, the shallow perched groundwater within the made ground which is already impacted with contamination related to the previous land use (hydrocarbon sheen encountered in the groundwater during the previous GI and presence of total petroleum hydrocarbons recorded in the groundwater testing as detailed in section 5.2.3) and this is not considered to be a potential resource. Therefore, the perched groundwater with the made ground is not considered to be a potential receptor.

It is understood that the proposed attenuation pond and ditch formed as part of the development will be lined. Therefore these are not considered to be potential receptors to contamination.

5.1.3 Potential Pathways

For a risk to exist the (potential) sources and receptors must be connected by a viable pathway. Potential pathways by which human and environmental receptors may be impacted upon are as identified below:

- **Ingestion of contaminated soils and dust**: during construction of the proposed development, site workers who are dealing closely with excavated soils may come into contact with contaminants through ingestion of soils and dust.

  Site end users may also be impacted by the ingestion of soils and dust should existing site soils be present at or near surface level post completion of the development; particularly in any areas of landscaping (imported fill for raising of site levels for flood protection proposed only for the car park, hotel and hardstanding areas, to minimize the volume of imported fill required).

  Workers, or users of the neighbouring residential or commercial areas may be impacted by the ingestion of soils and dust should areas of open soils be present post development, or dust be created during development.

- **Dermal contact with soils and dust**: during site development, site workers who are engaged in ground works and handling of excavated soils may come into skin contact with impacted material and groundwater.

  Following development, site end users (primarily hotel guests, visitors and employees) and maintenance workers may also come into direct skin contact with shallow soils, should these remain at or near surface level post completion of the development in areas of soft landscaping (imported fill for raising of site levels for flood protection proposed only for the car park, hotel and hardstanding areas, to minimize the volume of imported fill required).

- **Inhalation of vapours, dust and gases**: volatilisation of hydrocarbon products and the emission of soil gases including carbon dioxide, methane, or other toxic and explosive gases may occur in the subsurface and be present in both indoor and outdoor air. Ground gas, potentially generated by made ground and the fill of the historic reservoir (NW), may migrate into confined spaces within the proposed building. Generation of dust through earthworks to facilitate the proposed development, may impact construction workers.

- **Gas Migration**: from backfill of reservoir, made ground and estuarine deposits directly beneath or adjacent to the site and into the proposed hotel building. Should piling be the preferred foundation option for the building these could act as a conduit for ground gas migration. Service trenches and the possible installation of band drains could also act as a pathway for ground gas migration.

- **Lateral and vertical migration of contaminants**: contaminants released to the ground through spillage or leaks may migrate vertically or laterally through the underlying strata. There is potential for lateral migration of contaminants through contaminated shallow perched groundwater within the made ground. However this is considered to be discontinuous perched water over cohesive alluvium which acts as an aquitard and therefore significant vertical migration is not anticipated.

Service trenches, proposed band drains as part of the engineering measures applied for ground settlements and piled foundations for the building could all act as a conduit for lateral and vertical migration of contamination.

- **Leachate generation and migration**: there is potential for the generation and migration of leachate from impacted soils which may enter and migrate within the underlying groundwater bodies.
- **Surface water run off** may occur onto nearby land and surface water receptors during construction. Post development the site will comprise some hardstanding at surface level and drainage to manage surface water run-off.
- **Direct contact with building materials – corrosion:** there is potential for chemical attack of concrete and pipe materials (of services) as a result of aggressive ground conditions (pH and sulphates) encountered.

5.2 Preliminary Risk Assessment

The purpose of this section is to identify the plausible pollution linkages (on the basis of their probability and consequence) and whether there is enough information to characterise them.

The following method of risk evaluation is a qualitative method of interpreting the source pathway receptor linkages identified and is based on that presented in CIRIA C552[9] and involves the classification of the magnitude of the potential consequence (severity) of a risk occurring and the magnitude of the probability of the risk occurring.

Once the consequence and probability have been classified these can then compared to produce a risk category which informs the scope of any further ground investigation required.

The identification and justification of the plausible pollution linkages and the associated risk classification are presented in Table 4 of this section.

The proposed development is to comprise a hotel (commercial end use) with associated access and car parking areas and areas of soft landscaping (public open space). The available ground investigation data (chemical test results and gas and groundwater monitoring information) has been reviewed in accordance with the proposed land use, the plausible pollution linkages and the current guidance and screening values to further confirm risks posed to human health and the environment and risks from ground gas.

With regards to the previous ground investigation and risk assessments carried out by Integral Geotechnique on-site (2008) and Soil Mechanics to the west off-site (2011), the screening criteria previously used have been updated. The chemical data from the previous ground investigations has been re-screened against the following criteria.

[9] Contaminated Land Risk Assessment, A guide to good practice, C552, CIRIA January 2001

Soil Analysis:

The Defra Category 4 Screening Levels (C4SLs)[10] and the Land Quality Management (LQM) / Chartered institute of environmental health (CIEH) 'Suitable 4 Use Levels' (S4ULs)[11] have been used for the following scenarios:

- Residential with no plant uptake end use criteria to assess risks posed to construction and maintenance workers (acute exposure);
- Commercial end use criteria to assess risks posed to site end users in proposed building and car parking areas; and
- Public open space (Park) criteria to assess risks posed to site end users in areas of soft landscaping.

Leachate & Groundwater Analysis:

Considering the potential controlled water receptors identified as part of the CSM (reen south of the site) the freshwater Environmental Quality Standards (EQS)[12] have been used or UK Drinking Water Standards in the absence of EQS.

5.2.1 Soil Analysis Results

2008 GI (on-site)

A total of 15no samples were tested as part of the 2008 GI and these were taken from the granular (12no) and cohesive made ground (2no). One sample was taken from the cohesive alluvium. The chemical analysis comprised metals (arsenic, cadmium, total chromium, copper, lead, selenium, mercury, boron, nickel, zinc), speciated PAHs, speciated TPHs (aliphatic-aromatic split), sulphate, pH, LOI, TOC, cyanide and phenols. There was no asbestos testing carried out as part of the GI.

Nine exceedances of arsenic and one exceedance of PAH (Dibenzo (a,h) anthracene) were recorded in the made ground samples for the residential with no plant uptake scenario. Seven exceedances of lead were also recorded for the residential with no plant uptake scenario. One exceedance of arsenic and Dibenzo (a,h) anthracene was recorded in made ground for both the commercial and public open space scenarios. TPHs were detected within several of the made ground samples tested, however these were all found to be below the assessment criteria.

Overall, the chemical analysis carried out as part of the GI indicated a lesser contamination status for the site than the one expected based on the site's history. However, it should be noted that the analysis carried out did not cover all the potential sources identified as part of the CSM. Further details on data gaps are provided in section 7 of this technical note.

[10] Defra, Development of Category 4 Screening levels for assessment of land affected by contamination, SP1010, Final Project report (Revision 2), September 2014

[11] The LQM /CIEH S4ULs for Human Health Risk Assessment, Version 1.0, Paul Nathaniel et al. February 2015

[12] The Water Framework Directive, (2015), (Standards and Classification) Directions (England and Wales), 2015.

2011 GI (west off-site)

Eighteen soil samples were obtained for laboratory chemical analyses. The majority of the soil samples were obtained from the made ground. The soil samples were submitted for a range of dry weight chemical tests.

Concentrations of arsenic, lead and vanadium were recorded in excess of the residential with no plant uptake criteria, however these were within the commercial and public open space criteria.

Asbestos fibres identified as chrysotile were found within six of the eighteen samples of made ground between 0.3m and 2m below ground level. No quantification testing was undertaken on the identified fibres.

Generally, concentrations of hydrocarbons were recorded to be low in samples of made ground and were below the commercial and public open space criteria. All concentrations were below the residential with no plant uptake criteria with the exception of benzo(a)pyrene in one location. Several TPH aliphatic and aromatic levels were recorded in excess of the residential with no plant uptake criteria in one location within the natural strata at 3m below ground level.

No PCBs were recorded above the laboratory limit of detection in the three samples of made ground analysed.

The results of the VOC and SVOC analyses undertaken on nine samples of made ground indicated generally less than detectable concentrations below all criteria. However several detected Polycyclic Aromatic Hydrocarbons were above the residential with no plant uptake (analysed for as part of the sVOC suite).

5.2.2 Leachate Analysis Results

2008 GI (on-site)

A total of 7no samples were tested as part of the 2008 GI and these were taken from the granular (6no) and cohesive made ground (1no). The chemical analysis comprised metals (arsenic, cadmium, total chromium, copper, lead, selenium, mercury, boron, nickel, zinc), speciated PAHs, sulphates, pH, LOI, TOC, phenols and cyanide.

Elevated cadmium, copper and zinc were recorded in a number of made ground samples above the screening criteria. One sample recorded elevated phenols (total) above the screening criteria. PAHs (naphthalene) were detected in a number of samples, however these were all below the assessment criteria.

2011 GI (west off-site)

Seven samples of made ground were submitted for laboratory leachate analysis for a suite of chemical determinants. The leachate results showed the made ground across the site to contain elevated concentrations of leachable copper, zinc, arsenic and molybdenum above the assessment criteria.

5.2.3 Groundwater Analysis Results

2008 GI (on-site)

Four rounds of groundwater monitoring were carried out as part of the 2008 GI. However, groundwater sampling and testing was only carried out in 3 of the 4no rounds. Monitoring standpipes were installed within the made ground (3no), granular alluvium (1no) and cohesive alluvium (1no). Groundwater samples were taken from all wells and were subject to chemical testing. Wells were purged until the pH, temperature and conductivity of the purged water had stabilised. Samples were taken immediately after purging. The chemical analysis comprised metals (arsenic, cadmium, total chromium, copper, lead, selenium, mercury, boron, nickel, zinc), speciated PAHs, phenols, sulphate and pH (2 of the 3no rounds) and TPH (banded) (all 3no rounds).

Elevated zinc was recorded above the assessment criteria in all boreholes. Elevated copper and lead were also recorded above the assessment criteria in the boreholes installed within the alluvium and selenium was recorded above the assessment criteria in two boreholes (installed within the alluvium and the made ground). During the first round, the presence of TPH >C24-C40 was identified in all wells, and the presence of TPH>C16-24 was identified in one borehole (installed with the alluvium). No hydrocarbons were detected in any of the boreholes over the next 2no rounds.

2011 GI (west off-site)

Three groundwater samples taken from the two boreholes were submitted for laboratory analysis for a suite of chemical determinants. The samples were obtained from the shallow standpipe installations, within the made ground strata.

Dissolved concentrations of nickel, zinc, chloride and ammoniacal nitrogen were recorded marginally above the EQS values. Other results were well below the screening values or below the laboratory detection limits.

Generally the concentrations of organic contaminants in samples of groundwater were recorded to be low and within the EQS values. This was with the exception of fluoranthene, which was recorded in excess of the applied criteria in both groundwater samples obtained from the two boreholes.

One detectable concentration of di-n-butylphthalate of 0.025mg/l was recorded in the groundwater obtained from one of the two boreholes. No other volatile or semi volatile organic compounds were detected in the samples of groundwater obtained.

5.2.4 Ground Gas

2008 GI (on-site)

Six rounds of ground gas monitoring were undertaken from the standpipes within the made ground. In accordance with the methodology provided in CIRIA C665[13], as a worst case scenario, a maximum methane concentration of 1.9% v/v and a maximum flow rate of 0.1 l/hr across all monitoring wells provides a GSV of 0.0019 l/hr for methane and a maximum carbon dioxide concentration of 5.8% v/v and flow rate of 0.1 l/hr provides a GSV of 0.0058 l/hr for carbon

[13] CIRIA C665 Construction Industry Research and Information Association (CIRIA 2007), Assessing risks posed by hazardous ground gases to buildings, Report C665.

dioxide. Considering the above, the site falls with the CS1 classification (GSV <0.07 l/h) which is equivalent to a very low hazard potential for gas from the made ground underlying the site[14] and therefore no gas protection measures would be required.

The underlying alluvium with peat bands (high degradable organic content) and backfilled reservoir are also potential sources of ground gas (methane, carbon dioxide) and these have not been investigated (installations within made ground only). Further ground investigation is required to confirm the ground gas regime under the site and to inform on the requirement for gas protection measures.

2011 GI (west off-site)

Three rounds of ground gas monitoring were undertaken from the standpipes within the made ground of the two boreholes.

A maximum methane concentration of 4.1 % vol and a maximum flow rate of 2 l/hr were recorded within the monitoring wells providing a GSV of 0.082 l/hr for made ground which falls within the CS2 classification (based on these results and the recommendations in C665 gas protection measures would be necessary in the construction of new developments).

[14] BS8485:2015 Code of Practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings

Table 4: Preliminary Risk Assessment

Source	Receptor	Pathway	Likelihood	Severity	Risk	Comment
Contaminated made ground within site area related to historic site use (Machynys Brick Works, Historic Railway and tram lines) including contaminated perched groundwater within the made ground Existing bunds of unknown origin and nature (western and northern parts of the site) Contamination related to Engineering Works	Site End Users (hotel guests, visitors and employees	Direct dermal	Likely	Medium	Moderate	Previous GI has indicated isolated elevated arsenic and PAH (Dibenzo (a,h) anthracene) within the made ground. Asbestos in the form of chrysotile fibres was identified within the made ground across the site to the west off-site. Taking into account that the wider area has a similar history, the presence of asbestos, is likely to be encountered on site and as such further ground investigation is required. Risks will be lowered with the importing of fill for the raising of the site levels for flood risk mitigation. However, the aim is to minimize the amount of material imported on site by raising only the hotel, car park and hardstanding areas. There is a moderate risk should areas of existing made ground remain at or close to surface following site development in areas of soft landscaping. Mitigation measures such as removal of hotspots/suitable capping may be required in these areas. It is unlikely that groundwater is encountered by end site users beneath site as part of the proposed development. Therefore the risk will be low. Further GI and assessment will be required to confirm risks posed to site end users particularly in relation to asbestos (no testing carried out as part of previous GI).
		Ingestion	Likely	Medium	Moderate	
		Inhalation of vapours	Unlikely	Medium	Low	
		Contact with contaminated water	Unlikely	Medium	Low	

Source	Receptor	Pathway	Likelihood	Severity	Risk	Comment
& Shell Factory (W off-site)	Construction & maintenance Workers	Direct dermal	Likely	Medium	Moderate Risk	Previous ground investigations indicated elevated arsenic, lead and isolated Dibenzo (a,h) anthracene within the made ground on-site and elevated arsenic, lead, vanadium, PAHS and TPH (aliphatic and aromatic) within the made ground to the west off-site. Asbestos in the form of chrysotile fibres was also identified within the made ground across the site to the west off-site. Taking into account that the wider area has a similar history, similar contamination and the presence of asbestos, is likely to be encountered on site. Constructions workers likely to be exposed as part of development works, during earthworks and enabling works. However, exposure duration will be short term only. Use of PPE and good hygiene practice throughout earthworks and construction phase is considered sufficient to mitigate risks presented. Further GI and assessment will be required to confirm risks posed to construction and maintenance workers particularly in relation to asbestos (no testing carried out as part of previous GI). Previous ground investigation indicated hydrocarbon sheen on the perched groundwater within the made ground and hydrocarbons were detected as part of the chemical testing of the groundwater samples taken from the wells installed within the made ground. The perched groundwater may be encountered as part of the works. Deep groundwater within glaciofluvial deposits may also be encountered depending on development proposals. Risk classification will likely lower on account of appropriate PPE and health and safety measures during works.
		Ingestion	Likely	Medium	Moderate Risk	
		Inhalation of vapours	Likely	Medium	Moderate Risk	
		Contact with contaminated groundwater	Likely	Medium	Moderate Risk	

Source	Receptor	Pathway	Likelihood	Severity	Risk	Comment
	Surface water receptors (Estuary, existing reen south of the site)	Surface water run-off Leachate migration of temporarily stockpiled and exposed excavated soils	Likely	Medium	Moderate Risk	The risk from surface water run-off during construction will be reduced by the preparation of a Construction Environmental Management Plan prior to any work undertaken on site to minimise or mitigate effects on the environment and the surrounding area. Post development the site will likely comprise both landscaping and buildings at surface level. Drainage will manage surface water run-off.
	Groundwater body (within granular alluvium and Glaciofluvial deposits)	Leaching into groundwater and subsequent flow beneath site	Unlikely	Medium	Low Risk	Previous GI indicated that shallow perched groundwater within made ground has been impacted by contamination (hydrocarbon sheen during GI and hydrocarbons detected within the groundwater as part of the chemical analysis). However this is considered to be discontinuous perched water over cohesive alluvium which act as an aquitard and therefore significant vertical migration is not anticipated. There has been no groundwater monitoring within the glaciofluvial deposits and only limited monitoring within the granular alluvium under the site. A review of the current groundwater regime – and contamination beneath the site including further groundwater monitoring and testing is required to confirm risks.
		Preferential pathway for migration created through service trenches, vertical	Likely	Medium	Moderate Risk	The proposed development will create preferential pathways for vertical migration through piling, service trenches and the possible installation of band drains. A Foundation Works Risk Assessment

Source	Receptor	Pathway	Likelihood	Severity	Risk	Comment
		band drains & piled foundations				is required to inform on selection of an appropriate piling method, the design of the band drains and any mitigation measures required.
	Building materials (including services)	Direct contact with building materials - corrosion	Likely	Medium	Moderate Risk	Possible chemical attack of concrete and pipe materials (of services) will require assessment to ensure appropriate, resistant materials are used during construction.
	Off-site residents and workers	Ingestion and inhalation of airborne dust	Low likelihood	Mild	Low Risk	Considered dust suppression measures will be adopted during earthworks which will mitigate risks.
	Off-site surface water receptor (Loughor estuary, reen south of the site and lakes and watercourses that form part of the golf course)	Surface water run-off	Unlikely	Mild	Very Low Risk	Post development the site will likely comprise both landscaping and buildings at surface level. Drainage will manage surface water run-off.

Source	Receptor	Pathway	Likelihood	Severity	Risk	Comment
Ground gas related to the made ground under the site backfilled reservoir	Site End Users (hotel guests, visitors and employees) using confined spaces	Ground gas migration into confined space and inhalation (including pathway created through piled foundations, band drains and service trenches)	Unlikely	Severe	Low Risk	Made ground present under the site is a potential source of ground gas. Review of ground gas monitoring results within the made ground from the previous GI on-site (2008) indicates a CS1 situation (very low hazard potential) with no gas protection measures required. Further gas monitoring is recommended from any existing monitoring wells (if these are still functioning) to confirm the ground gas regime and that no gas protection measures are required.
Ground gas related to the backfilled reservoir (partially under the site in the north western part)	Site End Users (hotel guests, visitors and employees) using confined spaces	Ground gas migration into confined space and inhalation (including pathway created through piled foundations, band drains and service trenches)	Likely	Severe	Moderate Risk	The backfilled reservoir partially present within the north western part of the site is a potential source of ground gas. Based on previous ground investigation information the nature of the backfill is expected to be different than the made ground encountered under the site. The backfilled reservoir has not been investigated as part of the ground gas monitoring carried out. Further gas monitoring required to target the backfilled reservoir to confirm level of risk and requirement of ground gas protection measures.

Source	Receptor	Pathway	Likelihood	Severity	Risk	Comment
Ground gas related to the alluvium with peat bands present under the site	Site End Users (hotel guests, visitors and employees) using confined spaces	Ground gas migration into confined space and inhalation (including pathway created through piled foundations, band drains and service trenches)	Likely	Severe	Moderate Risk	Alluvium with peat bands under the site is a potential source of ground gas. The alluvium has not been investigated as part of the ground gas monitoring carried out. Gas monitoring is required to target the alluvium/peat bands to confirm the level of risk and the requirement of ground gas protection measures.

6 Preliminary Considerations & Constraints for Site Development

6.1 Geotechnical Considerations

A review of available information pertaining to the development site has been undertaken, which has identified a number of geotechnical constraints and potential issues that should be considered as development progresses. These are summarised below.

6.1.1 Obstructions and Site Clearance

Buried obstructions are expected to be encountered from the historic use of the site. These include disused building foundations (possibly including piles as well as shallow foundations and substructure), disused railways and infrastructure. As part of the initial site preparation works, de-vegetation and topsoil clearance will be required - ahead of raising of site levels to meet flood requirements - where buildings and infrastructure are proposed. Historic shallow and deep foundations (piles) and obstructions should be taken into consideration as part of the site clearance works to avoid difficulties during later construction of buried services and foundations.

6.1.2 Excavations

Any excavations required for shallow foundations or services trenches are anticipated to be in Made Ground and Estuarine Alluvium. Excavation will be possible with conventional earthmoving equipment, however where obstructions are encountered in the Made Ground the use of a hydraulic breaker may be required. Potential obstructions include the various historic building foundations that may remain on site.

The majority of trial pits undertaken were slightly unstable within the granular made ground and temporary support measures or very shallow batters may be required for the sides of excavations.

Based on previous ground investigation, groundwater is expected at around 1.5m bgl - 3m bgl (3.5 - 2m OD approx.). If excavation below the groundwater level is required, then temporary drainage and dewatering measures may be required; perched water exists locally within the made ground, which may result in moderate water ingress.

With respect to permanent works excavations, the design of the proposed attenuation pond and ditches in the north eastern and eastern parts of the site should take into consideration the anticipated shallow groundwater.

Groundwater beneath the site may possibly be affected by tidal effects; a groundwater monitoring survey carried out to identify the extent of tidal effects may need to be considered once development proposals are better defined.

There is potential for buried unexploded ordnance (UXO) within the site, which may be encountered within excavations. The detailed risk assessment undertaken by UXO specialist Dynasafe BACTEC[15] concluded this risk to be low.

6.1.3 Ground Raising

As part of the development the ground levels in the hotel, car park and hardstanding areas will need to be raised due to the risk of flooding within the area surrounding the site. The total and differential settlements caused by loading of the underlying ground will need to be assessed when proposed raised ground levels have been determined.

Settlements will occur both in the made Ground and in the Estuarine Alluvium, with consolidation and creep of the Peat probably contributing to the greater part of the settlement magnitude. The likely settlement under loading from the proposed upfilling has been estimated at around 400mm in the report by Integral Geotechnique[16].

Settlements arising from compression of the Made Ground will contribute to the overall settlement, however this is likely to be relatively small in magnitude and largely will have taken place shortly after completion of filling.

The settlement of the soft Estuarine Alluvium and Peat will occur over time, probably over a number of years. Relatively uniform loading over large areas will cause more even settlement, whilst more localised variations in load are likely to result in greater differential settlements with greater consequence. Further investigation into the settlement characteristics of the Estuarine Alluvium and Peat is recommended once the development proposals are better defined.

It is likely that engineering measures to deal with otherwise excessive settlements of the ground will be needed, for example by causing most of the settlement magnitude to occur prior to construction of the site infrastructure. The measures may include:

- allowing for a waiting period between raising of the site and construction of site infrastructure;
- accelerating settlement rates by techniques such as ‘surcharging’ and /or use of ‘vertical band drains’.

The use of ‘surcharging’ will involve temporary placement of additional fill above proposed finished ground levels, which may require removal from site unless incorporated into the planned development. The function of ‘band drains’ is to speed up the consolidation of the soft cohesive ground deposits; the drains provide a preferential flow path for groundwater to be released from the ground - allowing the ground to consolidate more quickly - flowing into a drainage blanket built at existing ground level.

[15] Explosive Ordnance Desktop Threat Assessment, Llanelli Wellness and Life Science Village, Ref 6844TA, Dynasafe BACTEC Ltd, Nov 2016

[16] Integral Geotechnique Site Investigation Factual Report, Nicklaus Hotel, Machynys, Llanelli, Sept 2008

The re-use of excavated material within the proposed development is encouraged, however this would be subject to a geotechnical and geo-environmental assessment. The Estuarine Alluvium is likely to be unsuitable as engineered fill. The Made Ground is likely to be highly variable and may contain material that is suitable for re-use as engineered fill, subject to the geo-environmental assessment. The Made Ground or Estuarine Alluvium from a geotechnical perspective would be suitable as landscape fill, but again subject to geo-environmental assessment.

6.1.4 Foundations

The applied loads from the proposed hotel building are likely to be relatively high and the settlement criteria exceeded if founded directly on the Made Ground or Estuarine Alluvium that underlies the site. The depth of the Estuarine Alluvium is expected to be variable and up to 20m deep.

It is expected that the hotel building will need to be piled. A range of pile types would be suitable, depending on the loading conditions.

Displacement piles, such as pre-cast driven piles, driven cast in-situ and auger displacement piles have the advantage that no spoil is generated during installation, which can be expensive to manage and dispose off-site. The main disadvantages of these types of piles are the environmental impact of noise and vibration during installation. The buried historic structures potentially underlying the site may also cause an obstruction to displacement piling methods.

Bored piles are less noisy to install with less vibration. They do however generate spoil that would be disposed off-site or alternatively ways to re-use the material on site could be investigated. Conventional bored piles generally need temporary casing or bentonite fluid to support the bore.

Continuous Flight Auger (CFA) bored piles have the advantage that they generally do not require temporary casing, as the concrete is installed as the auger is removed, and they are generally much quicker to install. The depth of CFA piles are limited to the length of the augers available, which is commonly in the region of 25m.

There are no overhead lines present within the site, so there are no constraints to piling techniques available in terms working headroom.

There is potential for ground gases to be emitted from the Made Ground present on site and peat within the Estuarine Alluvium. This will need a detailed assessment during development of the foundation options and there is potential for protection measures to be required, i.e. under floor void venting and/or gas membranes.

6.2 Geoenvironmental Considerations

A review of available information and data pertaining to the development site has been undertaken, which has identified a number of geo-environmental constraints and potential issues associated with the proposed development. These are summarised below.

6.2.1 Human Health

The previous ground investigation undertaken on-site has indicated isolated areas of contamination (arsenic, lead, Dibenzo (a,h) anthracene) within the made ground. No potential asbestos containing materials were visually identified during the site investigation.

The previous ground investigation undertaken to the west off-site identified asbestos in the form of chrysotile fibres within the made ground across the site. Taking into account that the wider area has a similar history, similar contamination and the presence of asbestos is likely to be encountered on site. The off-site ground investigation has also indicated elevated arsenic, lead, vanadium, PAHS and TPH (aliphatic and aromatic) within the made ground.

Construction workers are likely to be exposed as part of the development works, during earthworks and enabling works. However, exposure duration will be short term only. Evidence of hydrocarbon contamination has been identified within the perched groundwater within the made ground. This may be encountered as part of the works. The use of PPE and good hygiene practice throughout earthworks and construction phase is considered sufficient to mitigate the risks presented.

Post development, there is a moderate risk to site end users, should areas of existing made ground remain at or close to surface in areas of soft landscaping, as the aim is to raise the site levels by using imported fill only in the hotel, car park and hardstanding areas in order to minimize the volume of imported material. The risk will be lowered with the adoption of remediation measures, e.g. suitable capping within areas of soft landscaping, removal of hotspots if required etc.

Further ground investigation and assessment will be required to confirm risks posed to construction and maintenance workers particularly in relation to asbestos (no asbestos testing has been carried out as part of the previous on-site ground investigation).

6.2.2 Controlled Waters

During construction, there is a risk from surface water run-off and leachate migration of temporarily stockpiled and exposed excavated soils towards the existing reen present along the southern site boundary. The risk will need to be addressed in the contractor's Construction Environmental Management Plan prior to any works undertaken on site to minimise or mitigate effects on the environment and the surrounding area.

Post development the site will comprise both landscaping, hardstanding areas and buildings at surface level. Drainage will manage the surface water run-off.

The groundwater present within the made ground is considered to be discontinuous perched water over cohesive alluvium which act as an aquitard and therefore significant vertical migration is not anticipated. The risk from contamination migration towards the deeper groundwater body within the granular alluvium and underlying glaciofluvial deposits is considered to be low. A review of the current groundwater regime and contamination beneath the site is required to confirm this.

The proposed development may create preferential pathways for vertical migration through piling and the possible installation of band drains. A Foundation Works Risk Assessment is required to

inform on the selection of an appropriate piling method, design of the band drains and any mitigation measures which may be required.

6.2.3 Ground Gas

There are potential sources of ground gas under the site including the made ground, backfilled reservoir (partially under the site in the north western part) and alluvium under the site with peat bands. There is a risk from ground gas migration into the proposed building including the potential pathway created through piled foundations, band drains and service trenches.

A review of ground gas monitoring results within the made ground from the previous GI indicates a CS1 situation; no protective measures would be required for the proposed building.

The alluvium with peat bands underlying the site and the backfilled reservoir partially under the site in the north west (of different nature than the made ground present under the site) have not been investigated as part of the ground gas monitoring carried out.

Further gas monitoring is required to confirm the ground gas regime under the site and the requirement of gas protection measures.

6.2.4 Building Materials

The nature of the made ground and fill material on the site is such that there is a potential risk of corrosion to building and service pipe materials. As such additional assessments will be required to confirm these risks and the appropriate selection of materials used, to ensure durability within the subsurface.

6.2.5 Imported Fill

It is anticipated that clean fill material will be imported to raise the site levels in the hotel, car park and hardstanding areas. This material will need to comply with an appropriate specification in order to be re used within the proposed development. There may also be a requirement to import some material to be used as capping in the areas of soft landscaping.

6.2.6 Existing Bunds /screening

It is understood that the existing bund at the northern boundary will be retained and the screen planting will be extended and enhanced where necessary. There is no ground investigation information available for the existing bunds on site. An assessment of the shallow subsurface in these areas, and the existing surface cover, will be required to assess the risks posed to human health. It cannot be ruled out at this stage that some form of remediation and/or mitigation measures will be required in these areas.

7 Recommendations for Further Work and Ground Investigation

A data gap analysis has been carried out as part of the review of the available ground investigation information for the site. The findings of the analysis are summarised below:

- There is no ground investigation information for the bunds present in the northern and western parts of the site;
- No geotechnical testing has been carried out as part of the previous ground investigation other than the in-situ Static Cone Penetration testing (SCPT);
- There has been no gas monitoring installation within the backfilled reservoir partially present under the north western part of the site;
- There have been no gas monitoring installations within the alluvium including the peat bands present under the site;
- There have been no groundwater monitoring installations with the glaciofluvial deposits and the granular alluvium;
- No asbestos testing has been carried out as part of the previous ground investigation;
- No PCB testing has been carried out as part of the previous ground investigation;
- No Waste Acceptance Criteria testing has been carried out as part of the previous ground investigation.

Based on the above, further information is required to ascertain the full thickness and consolidation characteristics of the estuarine alluvium across the site and to provide more robust data on soil, groundwater and gas contamination, for subsequent risk assessments to be undertaken.

It is recommended that a ground investigation including the following is specified and undertaken on the proposed development site in line with BS10175:2011 (Investigation of Potentially Contaminated Sites – Code of Practice):

- A number of machine excavated or hand dug pits in the existing bunds (northern and western parts of the site to provide samples for geo-environmental testing;
- A number of cable percussive boreholes taken into the underlying glacial deposits at around 15-20m depth, with undisturbed samples within the estuarine alluvium and peat, and combined groundwater and gas standpipes to provide appropriate samples for testing;
- Ground gas monitoring from any existing monitoring wells on-site (if these are still functioning) to confirm the ground gas regime and requirement of gas protection measures;

- Installation of boreholes within made ground comprising the backfilled reservoir in the north western part of the site, alluvium, glaciofluvial deposits for ground gas and groundwater monitoring;
- Geotechnical testing of samples taken from the boreholes including the consolidation characteristics of the estuarine alluvium and peat;
- Geo-environmental testing of soil, leachate and groundwater samples from the boreholes and trial pits including asbestos identification and quantification, heavy metals, PAH, TPH, VOCs and SVOCs, PCBs to inform human health and controlled waters risk assessments and WAC testing to inform off-site disposal options should excavated materials be not suitable for re-use.

Drawings

Drawing 1 – Site Location Plan

Drawing 2 – Illustrative Site Layout Plan

Drawing 3 – Site Setting Plan

Drawing 4 – Site Geology Plan (Superficial)

Drawing 5 – Site Geology Plan (Bedrock)

Drawing 6 – Features and Constraints Plan

Figures

Figure 1 – Conceptual Site Model (Cross Section)

Technical Note

278688 17 December 2020

DOCUMENT CHECKING

	Prepared by	Checked by	Approved by
Name	Nick Kontochristos	Charlie Martin	Aled Phillips
Signature			

A1

N

LLYNNOEDD DELTA / DELTA LAKES

MACHYNYS

BURRY ROAD

Works

Works

Builders Yard

Builders Yard

El Sub Sta

Pig Sty

Surgery

PENTRE NICKLAUS AVENUE

Golf Driving Range

Machynys

Pond

Pond

Reeds

Machynys Road (Path)

Legend

Application Boundary

Applicants Land Ownership

Location Plan

0 5 10 20 50 Metres

Scale 1:1250

Issue	Date	By	Chkd	Appd
P01	18/12/20	PB	AP	ME
Issued for Planning Purposes				

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Client: Carmarthenshire County Council

Job Title: Proposed Hotel at Machynys East, Llanelli

Drawing Title: Location Plan

Scale at A1: 1:1250

Discipline: Architectural

Job No: 278688

Drawing Status: Outline Planning

Drawing No: AL-0-01

Issue: P01

Do not scale

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Illustrative Site Layout

Notes:

1. Illustrative masterplan layout only to define development quantum.
2. All matters are reserved, final design/layout is subject to design development.
3. Highway access is subject to development and agreement with the Local Authority as a reserved matters application or to be developed by the adjacent housing development.

Issue	Date	By	Chkd	Appd
P01	18/12/20	PB	AP	ME
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Job Title: Proposed Hotel at Machynys East, Llanelli

Drawing Title: Illustrative Site Layout

Scale at A1: 1:500
Discipline: Architectural
Job No: 278688
Drawing Status: Outline Planning
Drawing No: AL-0-02
Issue: P01

Do not scale
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A3

LEGEND

Site Boundary

0 0.05 0.1 0.2 0.3 0.4 km

Rev.	Date.	Drawn.	Description.	Chkd.	Appd.	Date.
3	27/11/2020	NK		CM	AP	27-11-20

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Project Name.
Machynys Hotel

Drawing Title.
Site Setting Plan

Suitability.

Suitability Code.

Originator

Designer

Date.
27-11-20

Internal Project Number
278688

Scale
1:10,000

Rev.

Drawing Number.
3

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A3

N

LEGEND

- Site Boundary
- Artificial Ground
- Alluvium
- Glaciofluvial Deposits

0 25 50 100 150 200 m

Rev.	Date.	Drawn.	Description.	Chkd.	Appd.	Date.
	26/11/2020	NK		CM	AP	26-11-20

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Project Name.
Machynys Hotel

Drawing Title.
Site Geology Plan - Superficial Deposits

Suitability. | Suitability Code.

Originator	Designer	Date.
		26-11-20

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A3

LEGEND

Site Boundary

Hughes Member - Sandstone

0 25 50 100 150 200 m

Rev.	Date.	Drawn.	Description.	Chkd.	Appd.	Date.
	26/11/2020	NK		CM	AP	26-11-20

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Project Name.
Machynys Hotel

Drawing Title.
Site Geology Plan - Bedrock

Suitability.

Suitability Code.

Originator	Designer	Date.
		26-11-20

Internal Project Number	Scale	Rev.
278688	1:4,500	

Drawing Number.
5

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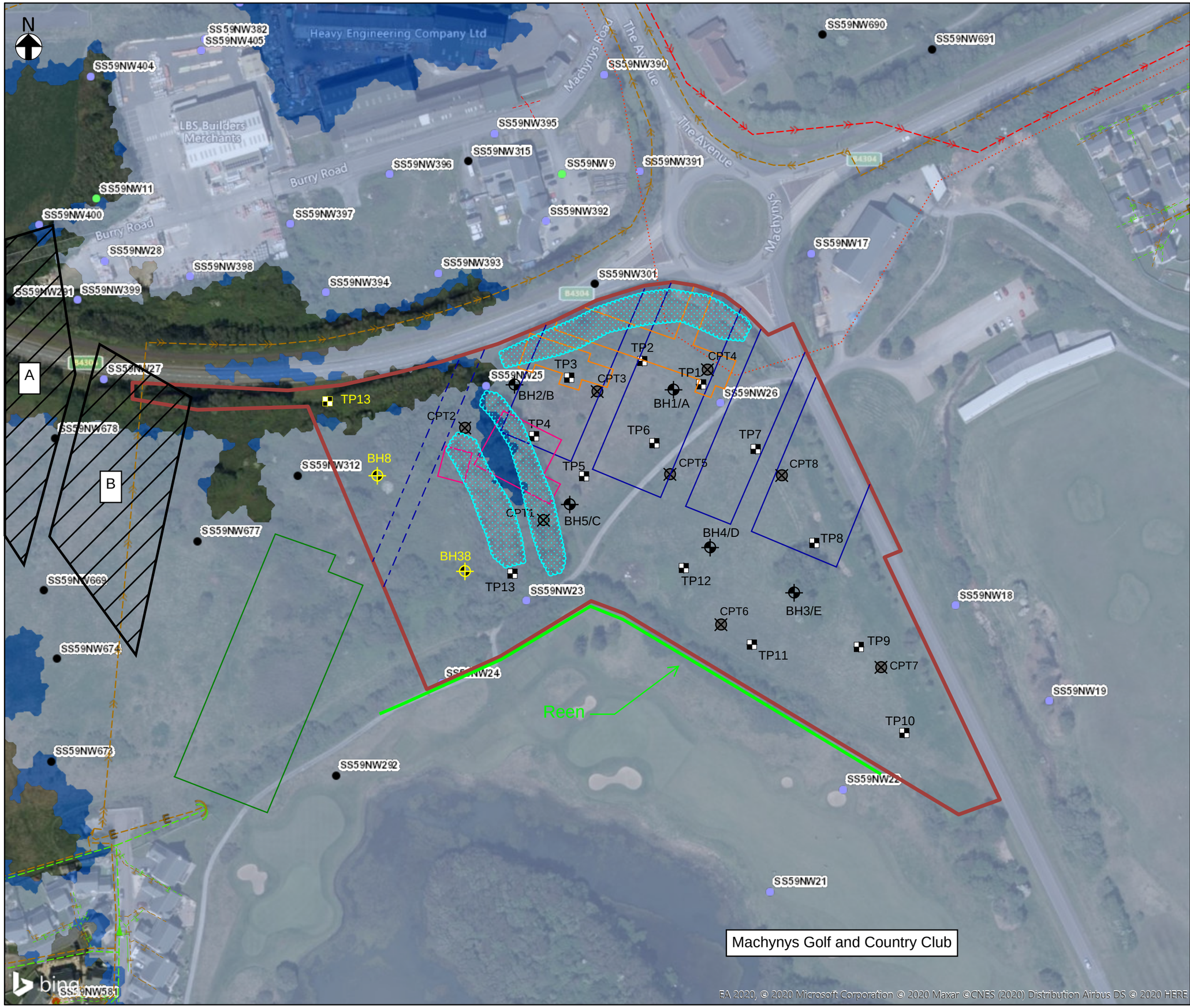

A3

LEGEND

- Site Boundary
- Existing bunds
- EA Historic Landfil lSites
- BGS Borehole - Unknown Length
- BGS Borehole - Confidential
- 0 - 10m Borehole - Machynys Redevelopment, Thyssen Geotechnical (1987)
- 10 - 30m Borehole - Machynys Redevelopment, Thyssen Geotechnical (1987)
- BH1/A — Borehole - Integral Geotechnique GI (2008)
- TP1 — Trial Pit - Integral Geotechnique GI (2008)
- CPT1 — Static Cone Penetrometer Position - Integral Geotechnique GI (2008)
- BH8 — Borehole - Machynys Peninsula Study, Exploration Associates (1995)
- TP13 — Trial Pit - Machynys Peninsula Study, Exploration Associates (1995)
- Flood Zone 3
- Flood Zone 2
- Abandoned Sewerage
- Combined Overflow Storage Casing Sewer
- Historic Clay Mill buildings (demolished between 1901 - 1908)
- Historic Mach-ynys Brick Work buildings (demolished between 1921 - 1948)
- Building Footprints associated with former "Works" (demolished between 1973 - 1992)
- Former Mach-ynys Road
- Former Reservoirs (A - backfilled between 1965 - 1973 and B - backfilled by 1999)
- Structure associated with "Burry Works" (Iron, Steel and Tin plate works) & Llanelli National Shell Factory

0 12.5 25 50 75 100 m

Rev.	Date.	Drawn.	Description.	Chkd.	Appd.	Date.
	26/11/2020	NK		CM	AP	26-11-20

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Project Name.
Machynys Hotel

Drawing Title.
Features & Constraints Plan

Suitability. | Suitability Code.

Originator	Designer	Date.
		26-11-20

Internal Project Number	Scale	Rev.
278688	1:2,566	

Drawing Number.
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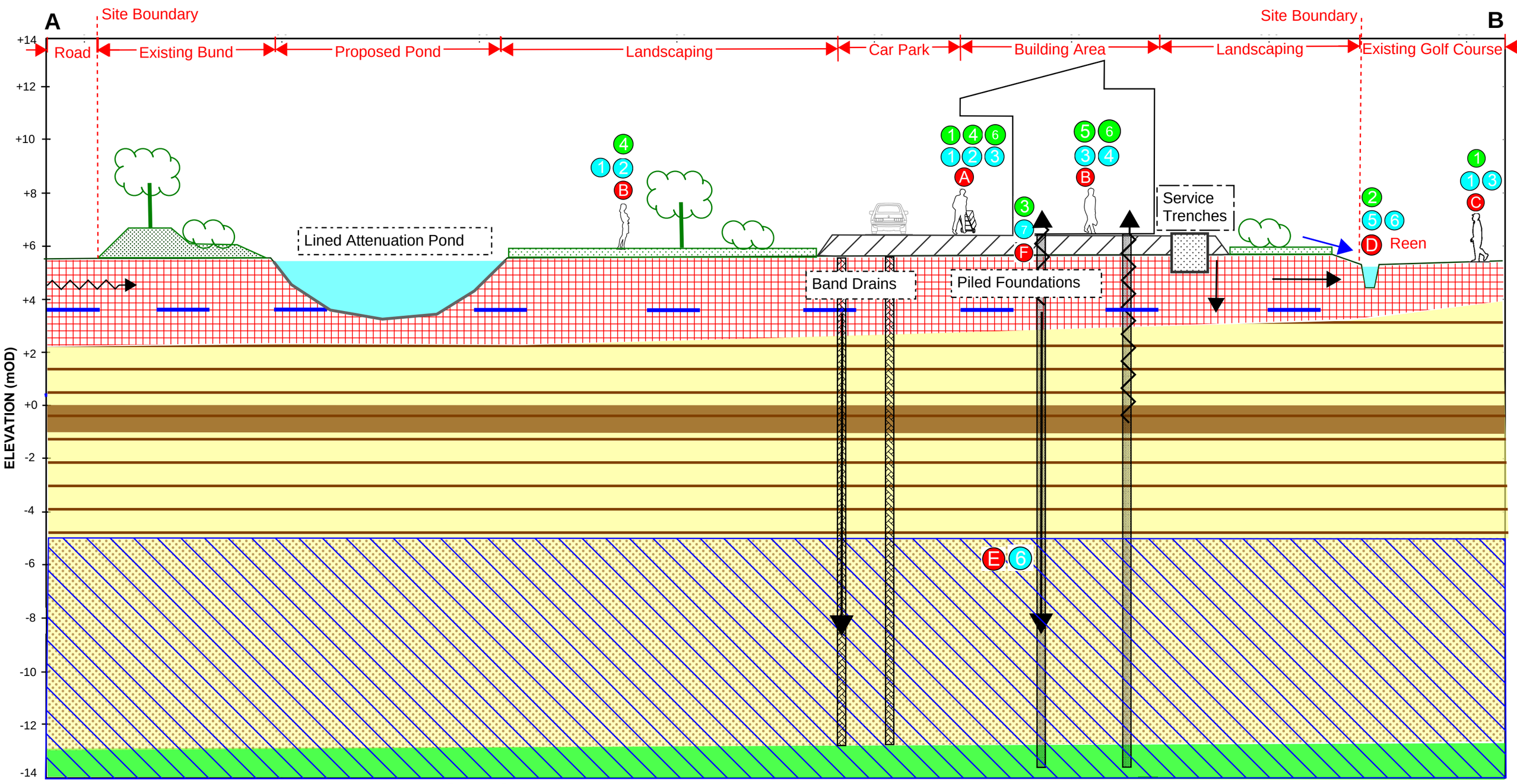


Potential Sources of Contamination:

- Made Ground related to historic use as Machynys Brick Works (including potentially contaminated perched groundwater within the made ground)
- Historic Railway and tram lines (on-site)
- Existing bunds comprised of material of unknown nature and origin (on-site)
- Engineering works & shell factory (W off-site)
- Ground gas from made ground and underlying alluvium/peat
- Ground gas from backfilled reservoirs (partially on site NW & off-site)

Potential Receptors:

- A Construction & maintenance workers
- B Site end-users (hotel guests, visitors and employees)
- C Site neighbours (off-site residents and workers)
- D Surface waters (Loughor estuary, ditch & existing reen south of the site)
- E Groundwater body within granular alluvium & Glaciofluvial deposits
- F Building materials (including services)

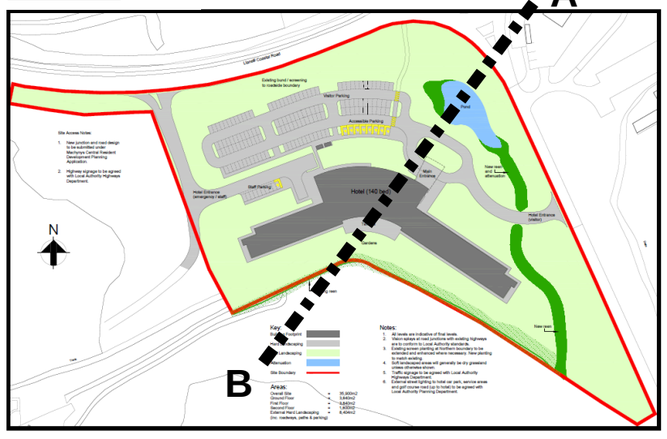
Potential Pathways:

1. Ingestion of contaminated soils and dust
2. Dermal contact with soils, groundwater and dust
3. Inhalation of vapours, dust and ground gas
4. Ground gas migration (& migration through piles)
5. Surface water run-off (construction)
6. Leachate generation and migration (& migration through piles, service trenches & band drains)
7. Direct contact with building materials - corrosion

Mitigation Measures:

1. Appropriate PPE to be worn and dust measures used
2. CEMP prior to works to mitigate effects on the environment and the surrounding area
3. Appropriate grade of concrete and water pipe material
4. If contaminated material placed in landscaped areas, 300mm topsoil / subsoil capping layer required
5. Installation of appropriate gas mitigation measures
6. Car park and building area covered in hardstanding

SITE PLAN



LEGEND

- Made Ground (Gravelly silty clayey ashy sand with fragments of metal, slag, glass, wood & plastic)
- Alluvium: Very soft to soft clay with peat bands; Very loose to medium dense sandy silt / silty sand
- Peat (soft to firm, fibrous & amorphous)
- Glaciofluvial Deposits (dense clayey gravel to stiff gravelly clay)
- Proposed Raised Ground (Imported Fill)
- Existing Bund (material of unknown nature and origin)
- Groundwater body
- Perched Groundwater

MACHYNYS HOTEL
CONCEPTUAL CROSS SECTION

278688

FIGURE 1