

# Earth Science Partnership

Consulting Engineers | Geologists | Environmental Scientists

**St Mary The Virgin School, Cardiff**

**Proposed New School & Nursery**

**Phase 1 Desk Study**

Report Reference: ESP.7048b.3095

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Consulting Engineers | Geologists | Environmental Scientists

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## St Mary The Virgin School, Cardiff Proposed School and Nursery Preliminary Geotechnical & Geo-environmental Investigation

Prepared for:  
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County Hall  
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Report Reference: **ESP.7048b.3095**

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<b>Notes:</b>	<ol style="list-style-type: none"><li>1. The status of this report is not final and is issued for comment only; as such, it is subject to change therefore it should not be relied up on. For a checked and authorised version please contact the Earth Science Partnership.</li><li>2. Once issued this document is Uncontrolled, for the latest version and/or to confirm you have authorisation to use it please contact the Earth Science Partnership at <a href="mailto:enquiries@earthsciencepartnership.com">enquiries@earthsciencepartnership.com</a> or by telephone at 029 2081 3385.</li><li>3. This document has been optimised for double sided printing and therefore may produce some blank pages when printed single sided.</li></ol>				

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### Figure 1 Proposed Site Layout Plan

Appendix A Risk Evaluation Methodology

Appendix B Historical Maps

Appendix C Environmental Data Report

Appendix D BGS Borehole Records (Representative Examples)

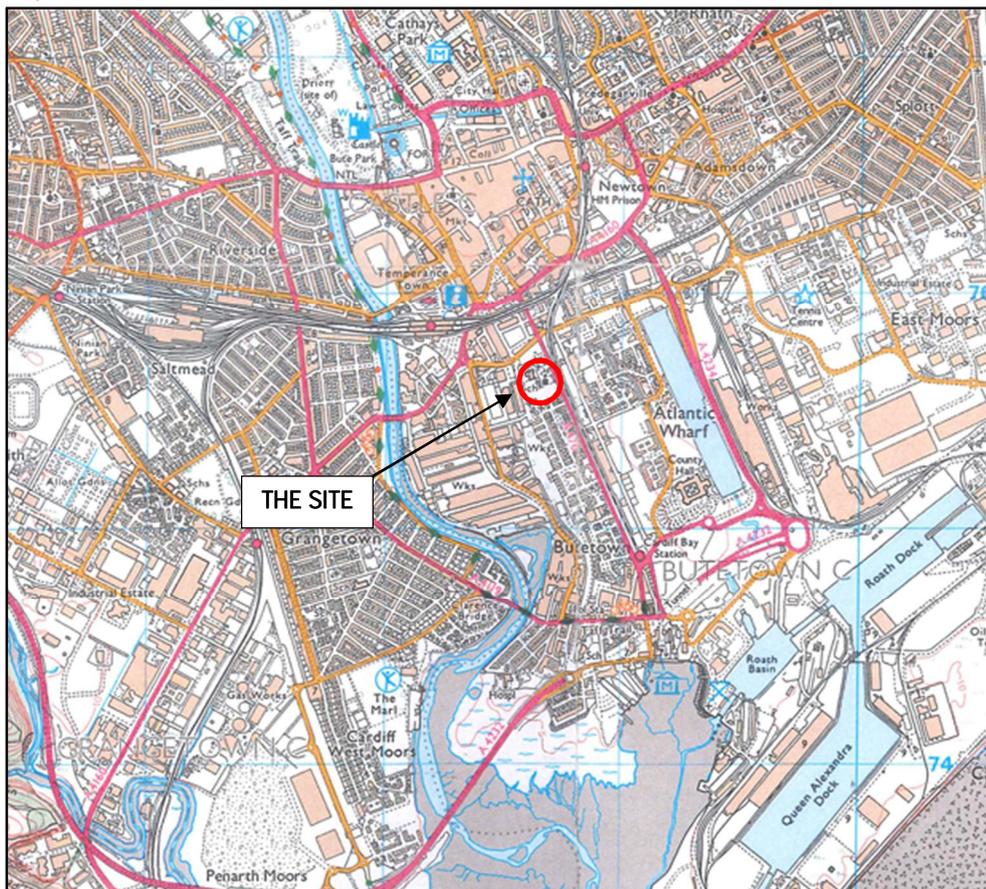
Appendix E Preliminary UXO Risk Assessment (Zetica, 2018 – *Awaited*)

General Notes

# 1 Introduction

## 1.1 Background

Cardiff County Council (hereafter known as the Client) are proposing to redevelop the subject site with a new school, nursery and associated external areas. The Earth Science Partnership Ltd (ESP), Consulting Engineers, Geologists and Environmental Scientists, were instructed by the Client, to undertake an integrated geotechnical and geo-environmental investigation and assessment to identify and evaluate potential ground hazards which could impact on the proposed development. The site location is shown below on Insert 1.



*Insert 1: Site Location Plan from Ordnance Survey 1:20,000 (OS License No.: AL100015788).*

The proposed development will comprise a three storey school, single storey nursery, possible community café, MUGA pitch and associated external areas of hardstanding, parking and landscaping. We understand that no significant changes to the current ground levels are proposed.

The proposed site layout is presented as Figure 1 in the enclosures. Based on the above, we understand that the proposed structures would be classified as Geotechnical Category 2 (BS5930:2015).

## 1.2 Objective and Scope of Works

The objective of the investigation was to obtain information on the geotechnical character and properties of the ground beneath the site, potential risks posed by contamination and ground gas, and to allow an assessment of these ground conditions with particular reference to the potential impact on the proposed development. In addition, the investigation was designed to identify potential geotechnical hazards at the site.

Developments of this kind will be subject to a range of standard and sometime site specific planning conditions regarding contamination and geotechnical stability and this report has been compiled taking into account our experience of these conditions, however, no associated planning conditions have yet been provided to us.

The scope of works for the investigation was mutually developed with the Client by ESP within an agreed budget and comprised a desk study review of available historical Ordnance Survey maps, environmental data, geological maps, memoirs and data, UXO report and further desk study information.

The contract was awarded on the basis of a competitive tender quotation. The terms of reference for the assessment are as laid down in the Earth Science Partnership email proposal of 18<sup>th</sup> October 2018.

## 1.3 Report Format

This report includes the Desk Study (Section 2), along with the Preliminary Risk Assessment stage (Section 3) of CLR11.

A preliminary risk register, identifying potential geotechnical hazards from the desk study review, is presented as Section 2.9 – this complies the relevant elements of the Geotechnical Design Report of BS EN 1997-2 (Eurocode 7) and BS5930:2015. The report concludes with a summary of any further surveys/ investigations/ assessments recommended (Section 4).

The assessment of the potential for hazardous substances (contamination) or conditions to exist on, at or near the site at levels or in a situation likely to warrant mitigation or consideration appropriate to the proposed end use has been undertaken using the guidance published by CIRIA (2001). This is discussed in more detail in Section 3.2.1 and in Appendix A.

## 1.4 Limitations of Report

This report represents the findings of the brief relating to the proposed end use and geotechnical category of structure(s) as detailed in Section 1.1. The brief did not require an assessment of the implications for any other end use or structures, nor is the report a comprehensive site characterisation and should not be construed as such. Should an alternative end use or structure be considered, the findings of the assessment should be re-examined relating to the new proposals.

Where preventative, ameliorative or remediation works are required, professional judgement will be used to make recommendations that satisfy the site specific requirements in accordance with good practice guidance. Consultation with regulatory authorities will be required with respect to proposed works as there may be overriding regional or policy requirements which demand additional work to be undertaken. It should be noted that both regulations and their interpretation by statutory authorities are continually changing.

This report represents the findings and opinions of experienced geo-environmental and geotechnical specialists. Earth Science Partnership does not provide legal advice and the advice of lawyers may also be required.

## 1.5 Digital Copy of Report

This report is issued as a digital version only.

## 2 Desk Study

The information presented in this section was obtained from desk-based research of sources detailed in the text, including historical maps (Appendix B) and an environmental data report (Appendix C). Further desk study reports/data/records are included as subsequent appendices as referenced in the text.

### 2.1 Site Location and Description

The site is located in the south east of Cardiff, near Atlantic Wharf. The National Grid Reference of the centre of the site is (ST) 318676E 175564N and the approximate postcode is CF10 5HG. A Site Location Plan is presented as Figure 1. The site comprises a roughly 'L' shaped parcel of land of around 100m length (West to east) at its longest point and 50m width (north to south) occupying an area of around 0.9Ha and is situated at an elevation of around 10mAOD, however, we have not been provided a formal topographic survey at this time. The site is situated in a densely urbanised area of Cardiff Bay, with a mix of residential/retail/commercial properties and infrastructure surrounding. It is presently undeveloped area and bounded by:

- To the north: immediately by St Mary The Virgin Church and an existing primary school, followed by commercial areas.
- To the east: immediately by the Bute Street, followed by residential areas and Atlantic Wharf approximately 700m to the east.
- To the south: immediately by commercial and industrial areas, with Cardiff Bay some 1.5km to the south.
- To the west: Immediately by commercial buildings, followed by residential areas.

The site is currently undeveloped and laid to grass with low level fencing on two sides of the site, with existing buildings forming the boundaries on the remaining two sites. The west portion of the site is segregated by a low level wooden fence.

A general view from Bute Street, showing the assumed access route and looking west across the site is presented as Insert 2 below.



*Insert 2: General View Across Site Looking West*

## 2.2 Site History

### 2.2.1 Published Historical Maps

The site history has been assessed from a review of available historical Ordnance Survey County Series and National Grid maps. Extracts from the historical maps are presented in Appendix B and the salient features since the First Edition of the County Series maps are summarised in Table 1 below.

**Table 1: Review of Historical Maps**

Date	On-Site	In Vicinity of Site
1879-1947	The site is indicated to be fully covered with residential buildings and associated access roads.	The site is located in the centre of a residential areas that is bordered by a highly industrialised zone. A church is present at the north boundary. The Glamorganshire Canal and associated wharves, are indicated approximately 20m to the west of the site followed by a timber yard and associated timber pond. A series of railways and foundry's are indicated further south. The River Taff and associated salt marshes are indicated approximately 500m to the west. A railway is indicated at the east boundary, followed by a series of works comprising wire rope manufacture, engineering services, flour mills, timber yards and warehousing. The Bute West Dock, is identified approximately 250m to the east. Significant rail infrastructure is indicated beyond the west dock leading to the Bute East Dock, some 500m to the east. The main Great Western Railway line with associated sidings, stations and good sheds is indicated approximately 250m to the north.
1953 – 1964	No significant changes are indicated.	The canal to the west is indicated to be disused and partially infilled. A series of engineering works and factories are indicated at the west boundary. An abattoir is indicated approximately 150m to the west.
1964 – 1969	The site is now indicated to vacant, with all buildings demolished, however, the previously existing roads are still indicated.	The canal to the west is now indicated to be fully infilled. No other significant changes are indicated.
1974 - 1995	No significant changes are indicated.	The timber pond to the west and the Bute West Dock are both indicated to have been infilled, with rough/marshy ground indicated. Engineering works and other structures are indicated to fully occupy the timber pond site and partially occupy the dock. St Mary The Virgin Primary School is indicated to the north. Realignment works along the River Taff (to the west) are noted during this period.
2002 - 2014	The site remains vacant and no other significant changes are indicated.	Significant development has occurred around the site, with the majority of the industry not identified but know to comprise, works, factories and warehousing. Significant residential development has occurred on the location of the former Bute West Dock alongside the construction of Lloyd George Avenue linking Cardiff City to Cardiff Bay. All rail infrastructure historically present to the west and east is no longer indicated but remains to the north.

### 2.2.2 Archaeological Setting

An archaeological assessment was not included within the brief, but we have not been advised of, or identified, any obvious evidence of any significant archaeological features on the site, however, historical information suggests the site has been previously developed.

### 2.2.3 Ecological Setting

An ecological assessment was not included within the brief, but we have not been advised of, or identified, any obvious evidence of any significant ecological features on the site.

## 2.3 Previous Investigations and Assessments

We have not been provided with any details of any previous geotechnical or geo-environmental investigations or assessments at the site, however, ESP have undertaken a number of projects in the local area. The general ground conditions comprise a (potentially) significant cover of Made Ground underlain by Tidal Flat Deposits and Mercia Mudstone bedrock. The wider area has historically been developed and redeveloped since the early 1800s with many potential contaminating uses including works, timber yards, commercial premises and residential properties.

## 2.4 Contact with Regulatory Bodies & Local Information Sources

The following departments of the Local Authority (Cardiff County Council) have been contacted as part of this assessment:

- Environmental Services/Health/Pollution Control
- Building Control
- Trading Standards (Petroleum Officer)

At the time of issue of this report, we have not yet received a response from the consultees. Once received, any response will be forwarded under separate cover. It should be appreciated that their responses may contain salient information on the site which could not be taken into account during the preparation of this report.

## 2.5 Hydrology

### 2.5.1 Surface Water Features

The nearest major surface water feature to the site is the Bute East Dock to the east of the site which is fed by the Dock Feeder Canal. The feeder canal branches off from the River Taff at Blackweir approximately 1.5km to the north and is culverted below Cardiff City Centre.

Other features located within the area include:

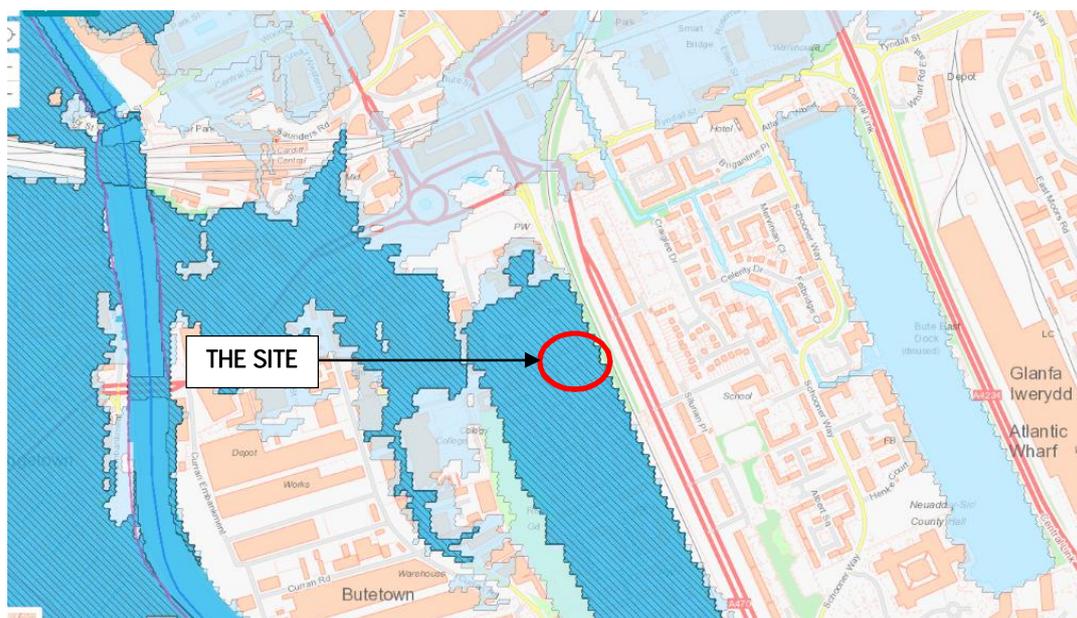
- The River Taff is located 500m, at its closest point, to the west of the site, which empties into Cardiff Bay/Bristol Channel.
- Roath Dock, Roath Basin and Queen Alexandra Dock are located approximately 1.5km, to the south east of the site;
- Cardiff Bay Barrage and the River Severn/Bristol Channel are located approximately 2.5km to the south..

### 2.5.2 Surface Water Abstractions

The environmental data report (Appendix C) indicates that there are no surface water abstractions within 250m of the site.

### 2.5.3 Flooding (Rivers and Seas)

From a review of topographical plans and flooding maps presented in the environmental data report and on the Environment Agency website (EA, 2018), the site is indicated to be at risk of flooding by rivers, seas and reservoirs, however, it is identified to be afforded protection of flood defences (see Insert 3). No further assessment of flood risk has been undertaken at this time, but ESP can offer further advice on this aspect when required.



Insert 3: Extract from Environment Agency Flooding Maps 1:10,000 (NRW, 2018).

### 2.5.4 Flooding (Groundwater)

Reference to the environmental report and NRW online mapping indicates that the site may be at risk from groundwater flooding and this should be considered in all land-use planning decisions.

## 2.6 Geology

### 2.6.1 Published Geology

The published geological map for the area of the site (1:10,000 scale, ST17SE) indicates the site to be underlain by Made Ground, followed by Tidal Flat Deposits overlying bedrock of the Mercia Mudstone Group.

Based on the information obtained, the historical map assessment and knowledge of the surrounding area, we anticipate the site will have a significant covering of Made Ground, especially where there has been demolition of buildings and subsequent re-development such as the construction of previously occupying buildings and the development and infilling of the Timber Pond, Glamorganshire Canal, and Docks.

The Tidal Flat superficial strata would be expected to be fine-grained in nature with some coarse bands and will also likely contain a high proportion of organic materials. The Mercia Mudstone Group bedrock comprises red, less commonly green-grey, mudstones and subordinate siltstones. Thin beds of gypsum/anhydrite can be widespread; sandstones are also present.

### 2.6.2 Available BGS Borehole Records/Previous Investigation

Reference to the website of the British Geological Survey (BGS, 2016) indicates a number of records within the site boundary and also adjacent to the site. A selection of these boreholes are presented in Appendix D for reference, however in summary they generally record a ground model comprising up to 2.5m of Made Ground over soft Alluvial (Tidal Flat) deposits and Marl (Mercia Mudstone) with the bedrock encountered at depths of between 10m and 12m.

## 2.7 Hydrogeology

### 2.7.1 Aquifer Classification

Based on the available desk study information, we consider that the main groundwater body beneath the site is likely to be within the superficial Tidal Flat Deposits and Mercia Mudstone Group bedrock.

Any coarse Tidal Flats and the Mudstone beneath the site are classed as a Secondary B Aquifer. Groundwater movement within the bedrock will be controlled by fracture flow, but is also likely to be heavily influenced by the presence of faults. The fine Tidal Flats Deposits are classified as Secondary (undifferentiated) aquifers.

The more sensitive Secondary B aquifers (generally correspond with previously classified "minor aquifers") and predominantly comprise lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers.

The superficial deposits indicated at the site include a significant covering of Made Ground followed by fine Tidal Flat deposits. It is likely that the covering of Made Ground may hold a perched water body.

### 2.7.2 Anticipated Groundwater Bodies

Based on the available information, we consider that the shallowest main groundwater body is likely to be located within the superficial strata. However, localised perched water bodies within the overlying Made Ground, if present, cannot be discounted.

### 2.7.3 Groundwater Abstractions

The environmental data report indicates that there are no groundwater abstractions or Source Protection Zones within 250m of the site.

### 2.7.4 Groundwater Movement

Groundwater movement within the superficial deposits will likely be controlled by intergranular flow whilst, in the bedrock, fracture flow is likely to be dominant and influenced by structural controls.

## 2.8 Environmental Setting

### 2.8.1 Summary of Environmental Data

The site exists in a historically urban/industrial setting and this setting continues to the modern day. An environmental data report has been obtained for the site and is presented in Appendix C, and the data therein is summarised in Table 2 below and, where salient, discussed in Section 2.8.2.

*Table 2: Summary of Environmental Data*

Item	On the Site	In the Immediate Vicinity
Environmentally Sensitive Sites	None identified.	None identified within 1km.
Potentially Contaminative Land Use	1no. recorded on site, corresponding to previous development and proximity to a wharf (associated with the former canal).	223no. recorded within 500m including but not limited to, wharfs, works, railway infrastructure, docks, warehousing, factories, timber yards and ponds, mills, abattoirs, tanks and substations.
Historical Tanks, PFS, Garages, Energy Facilities	None identified.	158no. identified within 500m and associated with former land uses identified above.
Potentially Infilled Land	1no. recorded on site and associated with former land use as residential housing.	53no. recorded within 500m of the site and corresponding to historical land uses including infilling of ponds, docks and other historical features.
IPPC Authorisations	None identified.	19no. identified within 500m.
Discharge Consents	None identified.	1 no. identified within 500m.
List 1 and 2 Dangerous Substances Sites	None identified.	None identified.
Radioactive Substance Sites	None identified.	None identified.
Enforcements	None identified.	None identified.
Pollution Incidents	None identified.	None identified within 250m, with 18no, identified between 250m and 500m.
Contaminated Land under Part 2A EPA 1990.	None identified.	None identified.
Waste Management Facilities	None identified.	30no. recorded 0m to 500m and include the infilling of the former canal, timber ponds, Bute West Dock. These features are recorded to have been backfilled with a range of materials from inert to household and commercial waste. Other more modern waste acceptance sites are also recorded.
Radon	The site is in an area where <1% of homes are above the Radon action level and no protection measures are required.	
<b>Notes</b>		
<ol style="list-style-type: none"> <li>1. Sensitive land uses include Sites of Special Scientific Interest, Nature Reserves, National Parks, Special Areas of Conservation, Special Protection Areas, Ramsar sites, World Heritage sites and Ancient Woodland.</li> <li>2. Nitrate vulnerable areas relate to the agricultural use of fertilizers and are not considered further in this assessment.</li> </ol>		

## 2.8.2 Further Discussion on Salient Environmental Features

The site is located in an area of Cardiff that has been subject to extensive development, which is recorded formally from at least the early 1800s. These land uses have included some significant contaminative uses including reclamation of land from previous waterways through infilling, such as the appropriation of former ponds, docks and canals.

The site is recorded have been occupied by housing from the early 1800s until early 1960s with residential housing and located in the centre of a number of the potentially contaminative land uses including factories, railways, canals, docks and wharves. Many of these were infilled in a time when regulations were less stringent and a wider range of wastes were accepted into sites.

### 2.8.3 On-Site Bulk Liquid Storage

The historical maps and field reconnaissance visit have provided no evidence of any past or recent above ground or underground bulk liquid (e.g. fuels/oils) storage on site. However, based on the previous historical uses, the historical (and unrecorded) presence of bulk liquid storage cannot be discounted.

### 2.8.4 On-Site Bulk Materials and Waste Storage

Review of aerial photos and available information indicated no evidence of recent materials or waste storage on the site. However, based on the previous historical uses, the historical (and unrecorded) presence of bulk material and waste storage cannot be discounted, particularly relating to munitions manufacture.

## 2.9 Preliminary Geotechnical Risk Register

### 2.9.1 Summary of Potential Geotechnical and Geomorphological Hazards

The potential for various geotechnical and geomorphological hazards at the site is provided in the environmental data report (Appendix C). The potential hazards, as reported in these reports are listed in Table 3 below, along with any salient further information on the potential hazard identified by ESP in the preparation of this report. Where a potential hazard has been identified, it is discussed further in subsequent sections.

Table 3: Preliminary Geotechnical Risk Register

Ground Stability Hazard	Potential <sup>1</sup>	ESP Comment
Coal Mining	Low	Site does not lie within historical coal mining area. No further information identified to contradict data report.
Mining (non-coal)	Low	Site does not lie within historical non coal mining area and no obvious quarry or other extraction features are noted on available historical information. No further information identified to contradict data report.
Shrinking or Swelling Clays	Very Low	See Section 2.9.2.
Landslides	Very Low	No further information identified to contradict data report.
Ground Dissolution (Soluble Rocks)	Negligible	No further information identified to contradict data report.
Compressible Ground	Moderate	See Section 2.9.3.
Collapsible Ground	Negligible	No further information identified to contradict data report.
Running Sand	Moderate	See Section 2.9.4.
Sulphate/Pyritic Ground	Not reported.	See Section 2.9.5.
Unexploded Ordnance	Not reported.	See Section 2.9.6.
Obstructions	Not reported.	See Section 2.9.7.
<b>Notes</b>		
1. Potential as reported in environmental data report (Appendix C)		
2. Salient hazards discussed in following sections.		

### 2.9.2 Shrinking or Swelling of Clays

The anticipated underlying Tidal Flat Deposits and upper (weathered) Mercia Mudstone may comprise soils of probable low strength and, hence, are potentially sensitive to volumetric change. Therefore, we consider that the potential for shrink/swell at the site should be advanced from that reported in the environmental data report (Table 3, Very Low) to **Moderate/High** until intrusive works are undertaken to confirm the risk.

### 2.9.3 Compressible Ground

The Made Ground and low strength Tidal Flat Deposits anticipated beneath the site are potentially compressible, particularly where containing organic materials are present, which could lead to significant settlement at the surface. Therefore, we consider that the potential for compressible ground at the site should be advanced from that reported in the environmental data report (Table 3, Moderate) to **Moderate/High** until intrusive works are undertaken to confirm the risk.

#### 2.9.4 Running Sand

The Tidal Flat Deposits anticipated below the site, can commonly contain bands/lenses with a high proportion of sand, which can contain water bodies. If intercepted within the excavations, we consider that the potential for running sands beneath as reported in the environmental data report (Table 3, Moderate) is appropriate.

#### 2.9.5 Pyritic Ground

The environmental data report does not consider the potential risk from sulphate rich or pyritic ground.

The Mudstone bedrock and anticipated Made Ground underlying the site are listed by the BRE (2005) as potentially containing elevated levels of pyrite, which may oxidise to sulphates and lead to aggressive attack on buried concrete. Given the above, we consider that the potential for sulphate/pyrite attack on buried concrete would be **Moderate**.

#### 2.9.6 Unexploded Ordnance

The environmental data report does not consider the potential risk from unexploded ordnance at the site.

A Preliminary UXO Desk Study assessment of risk is being completed in advance of site works by a specialist Ordnance consultant in accordance with CIRIA guidelines (Stone et al, 2009) and will be provided on completion, however, available mapping suggests the risk is likely to be **High** due to the proximity to the Cardiff docklands.

#### 2.9.7 Obstructions

The site has been previously developed and at one time, fully occupied by housing. There is a potential for obstructions in the form of historic foundations, basements and demolition materials. These may present a physical hazard to planned investigation works and subsequent redevelopment.

#### 2.10 Radon Hazard

Radon is a colourless, odourless, radioactive gas, which can pose a risk to human health. It originates in the bedrock beneath the site, where uranium and radium rich minerals are naturally present, and can move through fractures in the bedrock, and overlying superficial deposits, to collect in spaces within/beneath structures.

The environmental data report (Appendix C) indicates that the site does not lie in a radon affected area as defined by the Health Protection Agency, with less than 1% of properties above the Action Level, with no Radon protection measures required. Given the currently available information, the risk from radon is considered Low.

## 3 Preliminary Geo-Environmental Risk Assessment

### 3.1 Phase One Conceptual Site Model

#### 3.1.1 Background

The Phase One Conceptual Site Model lists the potential sources of geo-environmental risk, the receptors at risk and the pathways between the two. These are discussed in the following sections.

#### 3.1.2 Potential Contamination Sources

The site is located in an area of Cardiff that has been subject to extensive development, which is recorded formally from at least the early 1800s. These land uses have included some significant contaminative uses including reclamation of land from previous waterways through infilling, such as the appropriation of former ponds, docks and canals as well as the historically recorded housing on site

From the available information, we consider that the following features on site could prove sources of diffuse and point source contamination that could impact on the development, environment or site users:

- Potentially thick Made Ground – general diffuse contamination;
- Demolition materials from former housing – general diffuse contamination;
- Infilled canal and timber yard to the west and infilled dock to the east – potential for migrating contaminants;
- Mercia Mudstone and Made Ground - potentially contain pyrite, diffuse source.
- Asbestos – from previous historical development.

#### 3.1.3 Potential Contaminants Present

The potential contaminants associated with the above potential sources have been identified from various guidelines published by DEFRA, the Environment Agency and others. Based on this guidance and our experience, we consider that the following contaminants could be present on the site:

- heavy metals and semi-metals (arsenic, barium, boron, cadmium, chromium, copper, lead, mercury, nickel, vanadium, zinc);
- nitrates, cyanide, sulphate;
- polyaromatic hydrocarbon (PAH) compounds;
- petroleum hydrocarbons);
- phenols;
- asbestos.

No evidence has been identified from the desk study to suggest that radioactive substances may be present on the site (see Environmental Report – Appendix C).

### 3.1.4 Potential Sources of Hazardous Ground Gas and Radon

Based on the available information, the following potential sources of hazardous ground gas have been identified on, or in close vicinity of, the site:

- General Made Ground – organic and other materials could generate combustible and noxious gases;
- Infilled timber pond, canal and docks;
- Petroleum hydrocarbons within Made Ground – unweathered hydrocarbons can generate hazardous volatile organic vapours and as they degrade, the hydrocarbons can generate combustible and noxious gases;

Based on the guidelines presented by O’Riordan and Milloy (1995) and revised by Wilson et al (2009), the site would be classified as a low general potential however, the infilled features surrounding the site would be classified as of moderate to high gas generation potential.

As discussed in Section 2.10, the risk from radon is low and no radon protection measures are required for development.

### 3.1.5 Potential Receptors

As discussed in Section 1.1, the proposed site development will comprise a new school development with associated buildings and associated external areas. We consider that the most vulnerable receptors with regards to any contamination or hazardous ground gas present are likely to be as follows.

- Future site visitors.
- Construction and maintenance workers.
- Buried concrete (foundations, drainage etc.).
- The groundwater within the Tidal Flats and Mercia Mudstone beneath the site (classified as a Secondary B Aquifers).

The most vulnerable human receptors with regards to any soil contamination present will be staff and visitors including children. Attendance will be limited to break times during the school day and the most significant risks are considered to be associated with staff/maintenance workers who will have the longest potential exposure to contaminants.

### 3.1.6 Potential Migration Pathways

Based on the Conceptual Site Model discussed in the previous sections, the following are considered the most likely migration pathways with regard to any contamination or hazardous ground gas present beneath the site.

#### *Site Users:*

- Ingestion of soils and inhalation of dust in landscaping areas.
- Ingestion of edible plants and dust associated with such plants.
- Dermal contact with contaminated soils.
- Exposure to asbestos containing materials within the shallow soils.
- Potential explosive risk from flammable ground gas/vapours from on-site sources.
- Potential risk from toxic ground gas/vapours from on-site sources.
- Potential exposure to flammable or toxic ground gas/vapours originating from off-site.

*Construction and Maintenance Workers:*

- Exposure to asbestos containing materials within the shallow soils.
- Ingestion of soils and inhalation of dust across site.
- Dermal contact with contaminated soils.
- Potential explosive risk from flammable or toxic ground gas/vapours from on-site sources.
- Potential explosive risk from flammable or toxic ground gas/vapours from off-site sources.

*Buildings:*

- Sulphate attack on buried concrete (foundations, drainage etc.).
- Potential explosive risk from flammable ground gas/vapours from on-site sources.
- Potential explosive risk from flammable ground gas/vapours from off-site sources.

*Groundwater:*

- Leaching of mobile contaminants into the water-bearing strata within the Secondary B Aquifer.
- Any soakaways constructed for the development have the potential to leach contaminants from the infiltration strata, which could then impact on the groundwater beneath the site.

## 3.2 Preliminary Risk Evaluation & Plausible Pollutant Linkages

The land use history of the site and surrounding area, as established from the desk study and walkover, has identified a number of potential contamination linkages due to ground conditions or former operations either on, adjacent to, or in the vicinity of the site. Note that these potential linkages will need to be later assessed and re-established using actual site data obtained from an exploratory investigation.

### 3.2.1 Introduction to Risk Evaluation Methodology

The methodology set out in CIRIA C552 *Contaminated Land Risk Assessment – A Guide to Good Practice* (Rudland et al, 2001), has been used to assess whether or not risks are acceptable, and to determine the need for collating further information or remedial action.

Whilst at a later stage, this methodology may be informed by quantitative data (such as laboratory test results) the assessment is a qualitative method of interpreting findings to date and evaluating risk. The methodology requires the classification of:

- The magnitude of the potential consequence (severity) of risk occurring (Table A1 in Appendix A):
- The magnitude of the probability (likelihood) of risk occurring (Table A2 in Appendix A).

The classifications defined above are then compared to indicate the risk presented by each pollutant linkage, allowing evaluation of a risk category (Tables A3 and A4 in Appendix A). These tables have been revised slightly from those presented in CIRIA C552, to allow for the circumstances where no plausible linkage has been identified and, therefore, no risk would exist.

The methodology described above has been used to establish Plausible Pollutant Linkages (PPL) based on the Conceptual Site Model generated for the site and proposed development, and to evaluate the risks posed by those linkages, using information known about the site, at this desk study stage. This is presented as Table 4 in Section 3.2.2 below.

### 3.2.2 Tabulated Preliminary Risk Evaluation & Plausible Pollutant Linkages

Table 4: Preliminary Risk Evaluation & Plausible Pollutant Linkages (PPL)

Source	Pathway	Receptor	Classification of Consequence	Classification of Probability	Risk Category	Further Investigation or Remedial Action to be Taken
Potential contaminants in shallow soils from general Made Ground and previous on site land uses (former buildings etc) and encroachment of off site uses (railways, infilled timber pond, canal, dock etc.).	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Site Users	Medium – potential for chronic levels.	High likelihood <sup>2</sup>	Moderate/High Risk	Sampling of near-surface soils to confirm levels of total contamination present.
	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Construction/ Maintenance Workers	Minor – standard PPE likely to be sufficient	High likelihood <sup>2</sup>	Moderate Risk	Likely to be managed with PPE however, sampling of near-surface soils to confirm levels of total contamination present.
	Leaching of soil contaminants	Impact on Groundwater	Medium – site lies on Secondary Aquifer	Low likelihood <sup>2</sup>	Moderate/High Risk	Sampling of near-surface soils to confirm levels of leachable contamination present.
Asbestos in shallow soils.	Ingestion of fibres	Construction/ Maintenance Workers	Medium – potential for chronic levels	High Likelihood <sup>3</sup>	Moderate/High Risk	Sampling of shallow soils for asbestos.
Soil sulphate and pyrite	Aggressive groundwater	Buried Concrete	Mild – damage to structures	High likelihood <sup>4</sup>	Moderate Risk	Sampling of soils to confirm levels of sulphate, pH, and groundwater.
Hazardous ground gas/vapours from on and offsite sources including infilled timber pond, canal, docks etc. (see Section 3.1.4).	Asphyxiation/poisoning. Injury due to explosion.	Site Users/Visitors	Severe – acute risk.	High likelihood <sup>5</sup>	High Risk	Install and monitor gas wells.
	Damage through explosion.	Building/Property	Severe – acute risk.		High Risk	
	Asphyxiation/poisoning. Injury due to explosion.	Construction and Maintenance Workers.	Severe – acute risk.		High Risk	
Radon gas	Migration into Buildings	Site Users	Medium – potential for chronic levels	Unlikely <sup>6</sup>	Low Risk	No radon protection measures required.
<b>Notes:</b> <ol style="list-style-type: none"> <li>Methodology and details of risk consequence, probability and category based on CIRIA C552 (2001) and presented in Section 3.2.1.</li> <li>Although Made Ground is anticipated, the presence of contamination has yet to be confirmed on site.</li> <li>The presence of Asbestos Containing Materials or Asbestos within shallow soils has yet to be confirmed on site.</li> <li>The Mercia Mudstone strata can potentially contain sulphates/pyrite.</li> <li>Significant potential for on and off site ground gas sources.</li> <li>Radon risk identified in environmental data report (Section 2.10).</li> </ol>						

## 4 Recommendations

The Desk Study has identified the site has formerly been developed with historical uses comprising mainly residential housing, however, a number of potentially highly contaminative land uses have been identified to encroach on the site and they include infilled timber ponds, a canal at the west boundary and docks. The historical land uses present a significant risk from contamination as well as potential gassing sources.

We consider that the following further investigation and assessment would be required or prudent prior to development:

- Ground investigation comprising trial pits and/or windowless sampling and deeper boreholes;
- Sampling and analysis of soil samples to provide Tier 1 assessment;
- Recommendations for Level 2 and 3 assessments as necessary, however this is likely to be required;
- Sampling and analysis within shallow soils to determine presence of Asbestos and general contaminants;
- The installation and monitoring of ground gas and groundwater level wells.
- Undertaking of soakaway testing to satisfy requirement of planning conditions (see Section 1.0), however, it should be noted, the use of soakaways in thick Made Ground is generally unacceptable to regulators;
- Assessment of CBR values for access roads, parking and MUGA areas.

The Preliminary UXO Desk Study is yet to be returned and this will be communicated to the client upon completion.

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