RWE

Pembroke Power Station

Ground Investigation Report

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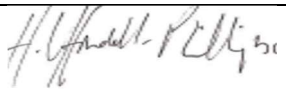
Reviewed by:	Hillary Uffindell-Phillips	Signed: 
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EXECUTIVE SUMMARY

Instruction	WYG were instructed by RWE to undertake an intrusive geoenvironmental and geotechnical assessment to provide information for proposed new backup start up generator installations and associated service infrastructure at the RWE Power Station in Pembroke.
The Site	The Pembroke B Combined Cycle Gas Turbine (CCGT) Power Station site covers an area of 4.5 Ha centred on LGR 193152, 202515 on the southwest side of the confluence between the Pembroke River and Milford Haven, and comprises open hardstanding and gravel areas and access roads surrounding the power station complex which is located centrally within the site.
Site History	Earliest OS maps from 1869 show the site to comprise open agricultural land until 1972 when the former Central Electricity Generating Board (CEGB) oil fuelled power plant was constructed to the east of the CCGT. The former power plant was demolished circa 2000, and construction of the CCGT was completed circa 2012. Remnant substructures of the CEGB encroach into the east of site (Plant Area 4), and based on archive drawings basements and voids from the CEGB may still exist and form part of the CCGT drainage infrastructure.
Hydrogeology	The site is underlain by a Primary and Secondary A aquifers of high vulnerability. The site is not located in an area classified as a source protection zone.
Environmental Database Search	An environmental database search has highlighted 2 no. integrated pollution prevention controls within 250m of the site, both related to discharge activities at the former CEGB Power Station (cooling water effluent). There are no recorded historic landfills, waste management facilities, pollution events, water abstractions or discharge consents within 250m of the site boundary.
Site Investigation	The site investigations, scoped to target the provisional proposed installation locations within the confines of the constraints plan developed by WYG in 2018, were undertaken in January 2019. Investigations were restricted by a dense engineered fill layer at the surface which prevented the progression of investigations to deeper levels in most areas. Completed investigations comprised non-intrusive service clearance, 12No. Plate Load Tests, 19No. Inspection Pits, 1No. Window Sample, 3No. groundwater and land gas monitoring installations, laboratory geotechnical and environmental assessment, and 2 return groundwater sampling and gas monitoring visits. Investigations were focused on the proposed footprints for the siting of the new installations.
Ground Conditions	Previous investigations undertaken by others prior to reducing levels for the construction of the CCGT, encountered less than 1m of Made Ground (which is likely to have been removed from most areas during level reduction), over variable thickness of superficial deposits (predominantly fine and coarse soils), overlying weathered bedrock (stiff grey clay over limestone). Most of the areas investigated during the WYG investigation were surfaced with shingle over a layer of coarse compacted fill (up to 400mm thick). A single exploratory hole progressed beyond the fill layer encountered Made Ground / disturbed superficial deposits comprising predominantly coarse soils. Groundwater (possibly perched water) was recorded at a depth of 0.52m bgl in WS3.

Geotechnical Assessment	Plate Load Testing undertaken within proposed installation footprints confirmed minimal settlements within the engineered fill layer (<10mm occurring below a pressure of 128kN/m^2) confirming that this layer should be suitable for the proposed lightly loaded units on raft foundations. Longer term settlements occurring within the underlying superficial deposits are likely to be minimal as soils below the fill layer comprise firm to stiff clays or coarse soils both of which have been subject to historical surcharge. Installations constructed to bridge service routes / sensitive structures would need to be supported by deeper conventional foundations bearing within the superficial deposits. The net allowable bearing capacity would need to be confirmed by deeper intrusive investigations undertaken local to the proposed installations. No obvious signs of structural instability was apparent from observation of remnant substructures at ground level and within core samples, and archive drawings suggest that associated voids and surge shafts are integrated with the substructure and are likely to be below the zone of influence (pressure bulb) introduced by the new installations. Furthermore, increased pore pressures will be rapidly diffused by the compacted coarse fill layers below the concrete slabs limiting the risk of longer-term settlements. However, it is recommended that a structural assessment is undertaken prior to adoption of remnant sub structures in Plant Area 4 to support new lightly loaded structures. There is potential for instability and groundwater in shallow excavations and deeper excavations may require extensive groundwater control. Previous site investigations recorded variable superficial deposits and karstification of limestone bedrock with associated zones of metastability which may present risks for permanent developments on a larger scale. A Design Sulphate Class for of DS-1 and ACEC Class of AC-1 should be adopted for concrete installations with the engineered fill.
Preliminary Contamination Assessment	On site sources of potential contamination include site won fill materials which includes demolition rubble with traces of Asbestos Containing Materials (ACMs), and current and historical industrial processes / fuel storage over the broader site. Pathways exist for potential impact to the site users, groundwater and nearby surface water receptors. The risk of the trace ACMs encountered should be managed under CDM and CAR 2016 regulations. No other evidence of significant contamination of shallow soils or groundwater was encountered during the investigations; however, it is noted that baseline conditions of deeper groundwater conditions could not be established due to the limited depth of the investigations. In general, the preliminary ground contamination assessment has found the site to be of **Low Risk** with respect to human health, and further investigations would be required to determine the risks to groundwater and surface water receptors. No evidence of land gas accumulation was recorded during the monitoring visits in the areas investigated.

1.0 INTRODUCTION

1.1 Instruction and Brief

WYG were initially commissioned by RWE to undertake a desk-based assessment and non-intrusive survey of the Combined Cycle Gas Turbine (CCGT) Power Station in Pembroke site to provide information to support the emerging designs for the proposed additional backup generator installations at the site.

These investigations were undertaken in September to November 2018 to help identify the likely constraints posed by existing services, sub structures and anticipated ground conditions at the provisionally proposed installation sites. The full brief of these initial surveys is detailed within the RWE document ref MPC1695 which includes the lateral extent of the proposed Plant and Service areas.

On completion of the above surveys, WYG produced the following documents pursuant to this brief.

- Drawing ref 1554_P_Pembroke, showing surveyed topographic features and features identified during the non-intrusive surveys (Appendix F).

The desk-based assessment and non-intrusive survey plan was used to develop a scope of intrusive investigations and in-situ testing, which was put forward in fee proposal reference rt 23.1.19 fplV3 and commissioned under Purchase Order 4200107006-R6-0174.

It is noted that some of the scoped locations were not accessible during the investigation and were consequently removed from the scope of work as summarised in Table 6.

The intrusive surveys detailed herein were completed during January 2019. The following report details the work undertaken and presents information from these investigations, which has then been used to consolidate the findings of the previous desk-based assessment, and further develop the conceptual site model to inform a detailed review of the geo-environmental and geotechnical risks to the proposed installations from shallow ground conditions.

In summary, the new installations and associated services will be positioned within the identified Plant and Service Areas, as summarised in Section 2.3. The proposed Plant and Service Areas are indicated on the Constraints Plan which is included with the development plants in Appendix F.

This report also provides a review of additional information provided by RWE post instruction, including previous ground investigation reports and schematic plans of existing buried infrastructure.

1.2 Information Provided

Information provided by RWE is summarised in Tables 1,2, 3 and 4.

Table 1 Reports provided by RWE

Reference	Report Reference	Date	Description
1	Gibb EPS/0264	August 1994	Geo-environmental study to provide information for the conversion of the former power station to use orimulsion fuels, inclusive of ground investigation data from trial pitting, boreholes and laboratory geotechnical and geo-environemtnal assessment.
2	Celtic Technologies R660/01/1722	December 2001	Desk study report providing a conceptual model and baseline condition assessment.
3	Soil Mechanics H6107	December 2006	Factual report providing information from two phases of ground investigation at the site of the new CCGT power station comprising trial pitting, rotary and cable percussive drilling, pressuremeter / dilatometer, falling head tests and downhole geophysics, and laboratory geotechnical / geo environmental assessment.
4	Halcrow 080104	Jan 2008	Contaminative Interpretative report including a review of previous investigations to summarise the anticipated risks to controlled waters during construction works for the CCGT power station. This report refers to various previous sources of information including ground investigation reports.
5	Alston PEB/00/W/07/DO/029	August 2009	Design Intent Memorandum defining civil aspects around main cooling water pipes will be considered for the design, corresponding to the New Combined Cycle Gas Turbine Power Plant (CCGT).

Table 2 Drawings Provided by RWE Showing the Layout of Services

Reference	Drawing Reference	Date	Description
6	UKP/PMB/0349/S1/AP2	2018	Proposed Black Start Facility (Gas Engines) Layout Option 4 – Location of Electrical Plant
7	PEB21EUZA82CHCS001	2010	Schematic plans of Underground Network Cable Ducts
8	PEB90EUZA82CHCS001	2010	Schematic plans of Schematic plans of Electrical System Network Area 1 -11
9	PEB90EUZA82CHCS002	2010	Schematic plans of Electrical System Network Area 2 -11
10	PEB90EUZA82CHCS002	2010	Schematic plans of Electrical System Network Area 6 -11
11	PEB90EUZA82CHCS003	2010	Schematic plans of Electrical System Network Area 3 -11
12	PEB90EUZA82CHCS004	2010	Schematic plans of Electrical System Network Area 4 -11
13	PEB90EUZA82CHCS005	2010	Schematic plans of Electrical System Network Area 5 -11
14	PEB90EUZA82CHCS006	2010	Schematic plans of Electrical System Network Area 7 -11
15	PEB90EUZA82CHCS007	2010	Schematic plans of Electrical System Network Area 8 -11
16	PEB90EUZA82CHCS008	2010	Schematic plans of Electrical System Network Area 6 -11
17	PEB90EUZA82--GA001_B	2009	Schematic plans of Cable Way Concept - General Arrangement
18	PEB90WPAB 10CE002_C2-D	2009	Schematic plans of COOLING WATER PIPING
19	PEB90WUGZ-20CE003_RFC-H	2009	Schematic plans of Surface Water Drainage System, Power Island and BOP Areas
20	PEB90WUGZ-DO002_U	2009	Schematic plans of Permanent Surface Water Drainage Layout
21	PEB90WUXH-CE001	2009	Schematic plans of Underground Earthing System - General Arrangement

Reference	Drawing Reference	Date	Description
22	PEB90WUZA81-20CE001_RFC	2009	Schematic plans of Drainage, Mechanical and Electrical Underground Services
23	PEB90WUGZ20CE010	2009	Schematic plans of Pumping Station Attenuation Pit
24	PPS/C/F/1	1965	Central Electricity Generating Board Power Station Main Foundations -Various drawings showing layouts and cross sections of the foundations of the Old Power Station
25	PPS/C/F/3-5	1965	
26	PPS/C/F/4-5	1965	
27	PPS/C/F/5	1965	
28	PPS/C/F/7	1965	
29	PPS/C/F/40	1965	
30	PPS/C/F/41	1965	
31	PPS/C/F/43	1965	
32	PPS/C/F/44	1965	

Table 3 Information Regarding the Proposed Installations

Reference	Drawing Reference	Date	Description
33	RWE UKP/PMB/0349/SK1/AP2	25/04/19	Plan showing the extents of the Plant Areas and Service Areas discussed in this report (included in Appendix F)
34	RWE UKP/PMB/0349/S1/AP3	31/10/19	Plan showing location of the Black Start Plant Layout (included in Appendix F)
35	Attachment 2 – BS and BGR equipment layout	22/01/19	Plan showing the layout of the BS and BGR layout (Appendix F)

Table 4 CCGT Power Station Design Reports and Drawings

Reference	Reference	Date	Description
36	Alstrom / Garassino R.2027.99.00	2007	General Geotechnical Report – Vol. 1 Soil Characterization
37	Alstrom / Garassino R.2027.184.02	2007	General Geotechnical Report – Vol. II.1 Deep Foundation Design
38	Alstrom / Garassino R.2027.297.00	2009	General Geotechnical Report – Vol. II.2 Shallow Foundation Design
39	Alstrom / Garassino R.2027.184.02	2009	General Geotechnical Report – Vol. 2.3 Shallow Foundation – Detailed Calculations
40	Alstrom / Garassino R.2027.326.00	2009	Rock Survey with Electrical Tomography
41	Alstrom PEB/00W/UZV-/CT/010	2009	Earthworks Plan
42	Alstrom PEB/00W/UZV-/CT/011	2009	Earthworks Sections 1-5
43	Alstrom PEB/00W/UZV-/CT/012	2009	Earthworks Sections 6-10

1.3 Limitations

The information contained in this report is intended for the use of RWE. WYG can take no responsibility for the use of this information by any third party or for uses other than that described in this report or detailed within the terms of our engagement.

The recommendations and opinions expressed in this report are based on information obtained as part of the desk study or provided by others. Information provided from other sources is taken in good faith and WYG cannot guarantee its accuracy.

This report is subject to the report conditions presented in Appendix A.

2.0 SITE INFORMATION

2.1 Location

The site of the RWE Pembroke B Combined Cycle Gas Turbine Power Station (CCGT) covers an area of approximately 10 Hectares centred on National Grid Reference SM 93000 02658. The site is located on the southwest bank of the confluence between the Pembroke River and Milford Haven Waterway, in Pembrokeshire, West Wales.

2.2 Area Context

The site is located within a predominantly rural area at an elevation ranging between 5 to 6m AOD. The elevation rises immediately to the north, south and west and falls to the east towards the site of the former Central Electricity Generating Board Power Station (CEGB) and the confluence between the River Pembroke and the tidal estuary of Milford Haven (Pennar Mouth), lying beyond approximately 500m west.

Surrounding land uses are summarised in Table 5.

Table 5 Surrounding Land Uses

	Description
North	The north of the site is bordered by a steep incline up to a level of approximately 45mAOD before a 350m wide stretch of open agricultural land and woodland forming the headland to the Milford Haven waterway.
East	To the east of the site the land largely consists of derelict industrial land formerly occupied by the Pembroke Oil Fired Power Station. Beyond this is the mouth of the Pembroke River, which joins the Milford Haven waterway immediately to the north.
South	The south of the site is bordered by a strip of woodland with open pastoral farmland lying beyond. Two reservoirs are located approximately 400 and 900m further to the south.
West	The west of the site is bordered by pastoral farm land and woodland, and the Hamlet of Pwyllchochran. The Pembroke Oil Refinery is located approximately 1.1km to the west.

2.3 Site Description

As part of the brief for the initial desk-based assessment and non-intrusive surveys, RWE divided the site into several areas based around the provisional siting plots of the proposed installations and associated service routes (as indicated on drawing reference A110093-1_CDF_N_ 2_R01 included in Appendix F) and summarised in Table 6.

Table 6 Area Reference Summary indicating Appendix F Drawing Tiles

Area Reference	Appendix F Drawing Tile	Inspection Pit and Test Locations	Plate Load Test Locations
Service Route 1	1	WS13*, WS14*, WS15*	
Service Route 2	3, 4, 5	WS19, WS20, WS21	
Service Route 3	5	WS01, WS02, WS03	PL1, PL2
Service Route 4	5, 6, 7		
Service Route 5	5, 6, 7	WS05, WS06, WS07, WS09, WS10, WS11	
Plant Area 3	2, 3	WS17, WS18	PL7, PL8, PL9
Plant Area 4	4, 5	WS22, WS23, WS24, WS25	PL10, PL11, PL12
Plant Area 5	5	WS04*	PL3
Plant Area 6	6		PL10
Plant Area 7	6,7		PL10
Plant Area 8	7	WS08	PL4, PL13
Plant Area 9	7		
10	7	WS12	PL5

* Location scoped but not undertaken due to site constraints

Surveys conducted in each of these areas included Ground Penetrating Radar and Electromagnetic Scanning and features surveyed were referenced to Ordinance Datum (OD).

The findings of these surveys have been compiled together with information from plans provided by RWE and statutory undertakers into a single constraints plan (Appendix F).

The following observations were made during a walkover survey undertaken by WYG on the 30th August 2018, and during WYG's supervision surveys undertaken during between the 17th September and the 3rd October 2018 and the 31st January and 13th February 2019. A photographic record of this survey is presented within Appendix B.

2.3.1 Service Route 1

It is understood that fuel gas pipework will be installed in Service Route 1 requiring shallow foundations for the above ground pipe supports.

This area comprises a 30x150m strip of land along the north-western border of the site. The area is bordered by the perimeter fence to the north and above ground pipework to the south. Ground cover in this area is predominantly limestone gravel. The area slopes gently to the west with a bank in the west of this area and localised depressions towards service trenches and manhole covers.

Several CCTV posts and lightning rods are present along the north border of this area, and a 450mm diameter gas pipeline marked to be entering the site in the far west of the area was traced to the east using GPR. CCTV and electrical cables detected using EM and GPR were traced across this area connecting to CCTV bases stationed across this area. Further EM traces were detected in the east of this area as indicated.

2.3.2 Service Route 2

The proposed installations within Service Route 2 are summarised in Table 7.

Table 7 Summary of Proposed Installations in Service Route 2

Item	Approximate Size	Approximate Weight	Notes
Fuel Gas Pipework			Road crossings for gas pipework in north section of service route.
In addition, the following equipment is expected to be located in the southern area of this service area			
Hardstanding	24 metres x 16 meters	See details of individual items listed below	Hardstanding area around the following equipment items.
Black Start Common Plant Switchroom (shown in Appendix B as E-House)	15m x 2.95 x 3.680m + 80mm (length x width x height)	34000kg	
6.75/3.5kV Black Start SSD Transformer (Shown in Appendix B as BST)	3.3m x 2.3m x 3.0m (length x width x height)	17000kg	Oil filled. Bund required.
Load Bank No.1	9.2m x 2.5m x 2.6m (length x width x height)	18000kg	
Load Bank No.2	9.2m x 2.5m x 2.6m (length x width x height)	18000kg	
Load Bank No.3	9.2m x 2.5m x 2.6m (length x width x height)	18000kg	
Harmonic Filter Package	9m x 3m x 3m (length x width x height) - Preliminary	10000kg - Preliminary	Optional work - requirement will be determined during detailed design phase post contract award.

Service Route 2 comprises a flat area covering approximately 1.5 hectares. The surfacing is mainly limestone gravel with a tarmac access road crossing in the north portion. Five parallel GRP water-cooling pipes run through this area, the vents of which can be seen towards the northern central portion of the area, run centrally through this area from the north before turning to the west before they connect to each turbine.

The location and route of the cooling pipes indicated on schematic drawings provided by RWE[6] was confirmed using GPR. These pipes are indicated on Section A of the drawing to be 2m wide, spaced 900mm apart and centred at -1.86m below the local datum (residing at +5.70mAOD), with a corresponding crown level at +4.84mAOD (indicated on the specification drawings at 300mm below the datum).

It is noted the GPR survey estimated that the pipes were deeper than indicated on Section A of the drawing[6] (which is located within Service Route 2), with GPR estimated depths ranging between 2.30 and 2.40m bgl in the north, and 1.10 to 1.50 in south (as indicated on the constraints plan Tile 4).

The nearest recorded ground level at WS02 is +0.44m above the drawing datum suggesting that finished levels are higher than the drawing[6] specification.

A specification note below Section B of the drawing indicates 'Heavy Equipment Load = 60kN/m2', however a note below Section A (which is within Service Route 2) suggests this area was not intended to be trafficked ('Shallow buried under non traffic areas').

Further construction details on the drawing[6] indicate the pipes are bedded within self-compacting gravel above a 100mm thick layer of 40 to 60mm dia. Crushed stone separated from the subgrade by a Geotextile ('Tencat Rock PEC 75/75 or similar') geotextile. The backfill above the pipes is indicated to be Class 3

Visual inspection of the cooling pipe vents in the north indicated the pipes to be constructed from galvanised sheet materials and in good condition. The area includes multiple visible above ground service runs. A slope of approximately 1m in height borders the area along the eastern boundary.

2.3.3 Service Route 3

Proposals include the installation of 6.6kV cables through Service Route 3 which are located in the south-eastern corner of the site and comprises an area of limestone gravel surfacing covering approximately 0.50hectares. A tarmac road runs east to west, and a concrete lined attenuation tank, measuring approximately 25x15m in plan, is located centrally to the south of this area (construction details are provided in drawing ref 23). The tank is connected by multiple pipes which continue below ground to the east. Visual inspection of the pipe indicated that they were in good condition.

2.3.4 Service Route 4

Service Route 4 comprises a strip of land running east to west located immediately to the north of 5 transformers. The area generally follows the route of a run of underground service trenches, which can be visually traced by concrete covers at regular intervals. Intermittently the route is blocked by industrial units located to the north of the transformer areas. The ground surface is mostly gravel and tarmac roads which cross the area from north-south providing access to the transformers from the access road to the north.

It is understood that there are no current plans for new installations in the Service Route 4 area.

2.3.5 Service Route 5

The proposed 6.6kV cable route continues through Service Route 5 which comprises a 0.30 Ha strip of land running east to west along the southern limit of the investigation area. The area is parallel to and of similar dimensions to Service Route 4. The area is predominantly gravel covered, with some concrete slabs and concrete service inspection chamber covers. Schematic plans of the site[6] and service markers indicate that this area is crossed at regular intervals by underground high voltage cables. EM Scanning confirmed the location of these cables which connect to each of the 5 transformer units located to the north. Service Route 5 includes six smaller areas of land crossing the tarmac road located to the north which connect this area to Plant Areas 6-10.

2.3.6 Plant Area 3

It is understood that fuel gas pipework will be installed in Plant Area 3 requiring shallow foundations for the above ground pipe supports.

This area comprises a 0.47Ha plot situated in the central northern portion of the site between Service Route 1 and 2. The area slopes gently towards the south and is bounded by a perimeter fence to the north and above ground 150 to 300mm diameter gas pipelines to the south. Visual inspection of the pipes indicated that they appeared to be in good condition. Several manholes and CCTV camera positions are located across the area and associated service where traced with EM and GPR.

2.3.7 Plant Area 4

The proposed installations within Plant Area 4 are summarised in Table 8.

Table 8 Summary of Proposed Installations in Plant Area 4

Item	Approximate Size	Approximate Weight	Notes
Fuel Gas System: Pressure Reduction Skid	8200 x 2200 x 3000 (L x W x H)	7,500kg	Located in northern area of Plant Area 4.
Fuel Gas System: Gas Heaters	No details	No details	Expected to be small package boilers. Located in northern area of Plant Area 4.
Genset containers / building	For individual genset containers assume plan foundation dimensions of 12.5-14.0m length x 2.5-4.0m width. For genset buildings assumed a width of 14m to 16m, and length of 30m+ (dependent upon the number of gensets required).	Up to 15kN/m2	Including self-weight of building / container, gensets, silencer, stack, and control panel. Excludes self-weight of foundation. Dynamic load of engine to be considered.
Genset auxiliaries	Minimum size of pad foundations is 1m x 1m.	Up to 30kN/m2.	Walkways and cooling fans supported on overhead gantries.
Electrical container / building, Control room container / building, Auxiliary transformer, Diesel gensets, Lube oil tanks	For these items it can be assumed that the loadings are no higher than values given above for the Genset auxiliaries.		
11/6.75kV Black Start Services Transformer	6m x 6m	50000kg - Estimate	Located at south of Plant Area 4, if required. Includes oil fill. Bund required.

Plant Area 4 comprises a flat area of concrete slab covering an area of approximately 0.4Ha surrounded by a wire mesh perimeter fence. Several additional wire mesh fences split the area

into smaller units. Several patches of rough vegetation growth and scaffold boards cover some peripheral sections of this area.

The CEGB Cooling Water (CW) Culverts run below this area as detailed in Section 4.2.2.

2.3.8 Plant Areas 5-10

Plant Areas 5-10 comprise a series of similar plots measuring approximately 30 by 10m in plan situated on the west side of five operational electrical transformers. The areas are flat and generally covered by limestone gravel. Temporary generators constructed on concrete foundation bases are located towards the north of each of these areas, whilst the remaining perimeter is bounded by tarmac pavements. Visual inspection of the ground surrounding the generators did not show signs of leakage or staining. Manholes and service access trenches and occasional above ground service gantries are located across these areas.

It is understood that 3.5kV BS Unit Switch rooms measuring 4.4 x 2.95m in plan, 0.80m in height, and weighing 7500kg are planned for installation to the west of the transformers in Plante Areas 8 and 10.

3.0 GEOLOGY, HYDROGEOLOGY, HYDROLOGY AND RADON

3.1 Geology

The site is covered by the British Geological Survey (BGS) 1:50,000 (solid and drift) geological map number 245 'Pembroke and 228 Haverfordwest'. Information regarding the geology and hydrogeology of the site has also been obtained from the online BGS GeoIndex Archive (2019).

3.1.1 Made Ground

BGS mapping does not show Made Ground to be present, however due to the sites development history some thickness of Made Ground is expected (as discussed in detail in Sections 4.2 and Section 8). Made Ground may occur as locally derived soils which have been disturbed during previous phases of construction and demolition, or as imported soils used as fill materials around substructures and for the construction of road surfaces and subbases.

It is understood from previous desk studies[2,4] that the former CEGB power Station was constructed on reclaimed land from mud flats located to the east of the existing CCGT. Reports state that the formation level for the CEGB was adjusted using material excavated from the west of the site (likely from below the CCGT).

There is also potential for demolition rubble, originating from the demolition of the CEGB, to be present, particularly where levels have been raised, or where previous sub-levels such as basements or service routes have been filled during demolition (discussed in further detail in Section 4.2.3).

Previous reports[2,4] state that ground levels in the CCGT area were reduced during the excavation of materials for reclamation and to raise levels to the east for the construction of the CEGB Power Station in the 1960s (discussed in further detail in Section 4.2.1).

3.1.2 Superficial Geology

BGS mapping shows superficial deposits in the south-east corner of the site which includes portions of Services Route 2,3,4 and 5, as well as Plant Area 4 and 5. The alluvium is described as deposits of clay, silt, sand and gravel.

Tidal Flat deposits associated with the Pembroke River are shown to be present beyond the site boundary further to the east of the site.

3.1.3 Solid Geology

BGS mapping show the northern portion of the site to be underlain by the Avon Group, which is described as interbedded grey mudstones and thin to medium bedded limestone with one to several thick units of mudstone interbedded with limestone. Thin units of calcite mudstone and mudstone are locally present.

The younger deposits of the Black Rock Subgroup and Gully Oolite Formation, which comprise undifferentiated limestones are shown across the southern areas of the site.

Smaller scale unrecorded structural features associated with local east west trending regional faults may be present, and although these are not thought to be associated with significantly unstable geology, they can coincide with localised deeper weathering profiles in karstic environments. The dislocation of stratigraphic sequences and rock units can also be associated with local and regional faulting, resulting in dramatic lateral and vertical changes in geology and geotechnical characteristics of the rock.

3.1.4 Historical Borehole Logs

The Soil Mechanics report[3] logs indicate a thickness of Made Ground generally less than 1m occurring within the CCGT power plant area. These soils were variable in composition although predominantly comprise coarse soils. It is noted that after this investigation was undertaken the levels were adjusted during the construction of the CCGT. This mainly involved a reduction in level through much of the area as discussed in detail in Section 4.2.3.

Variable thicknesses of superficial deposits were encountered beneath the Made Ground. These soils comprised both predominantly fine and coarse soils which were closely associated with the underlying weathered bedrock. The boundary between the superficial deposit soil horizons and underlying solid geology has not been fully interpreted on the investigation logs.

The weathered bedrock was generally described within the Halcrow report[3] as stiff grey laminated clay, silt and sand. Limestone beneath the site was found to be karstic, with clay filled voids of up to 1m in thickness also being interpreted from the logs.

Un-weathered bedrock (Avon Group) was encountered below the superficial deposits at depths ranging between 3 and 62m bgl. The depth generally increased towards the centre of the site where weathering may have exploited zones of structural weakness / jointing associated with regional structural trends. The Bedrock was variable in composition, comprising alternate 0.5 to 7m thick bands of limestone, mudstone and siltstone.

3.2 Hydrogeology

3.2.1 Aquifer Classification

The alluvium deposits shown to underlie the east extremity of the site (encroaching into Plant Area 4 and Service Routes 2 and 3) are classified by Natural Resources Wales (NRW) as a Secondary A Aquifer.

The Black Rock Subgroup and Gully Oolite Formation towards the south and south-east of the site are classified by NRW as Principal Aquifers (below Service Routes 4 and 5, Plant Areas 5 to 10 inclusive, and the southern portion of Service Route 2 and Plant Area 4) whilst the Avon Group outcrop located towards the north and west of the site is also classified as a Secondary A aquifer (below Plant Area 3, Service Route 1, and the northern portion of Plant Area 4 and Service Route 2).

Principal Aquifers are those which usually provide a high level of water storage and may support water supply and/or river base flow on a strategic rather than local scale. Secondary A Aquifers are 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.

The permeability of the Principal Aquifers below the site and their potential connectivity with to the River Pembroke located to the east via seepage pathways has not been quantified, although the karstic nature of the limestone render Gully Oolite Formation makes it susceptible to long term groundwater storage.

Groundwater monitoring undertaken during the site investigation for the CCGT site was used by Halcrow[4] to generate an estimated phreatic surface. This model generally shows groundwater in the CCGT area flowing east with recharge occurring from the western side of the site, potentially into a basement void (discussed in Section 4.2.1), suggesting that water is being drawn into the basement void via the sump pumping.

3.2.2 Groundwater Vulnerability

Groundwater vulnerability refers to the potential for impacts on groundwater quality beneath the site from a potential contamination source, and the ability of soils to transmit this contamination to the aquifer. The NRW classifies both the Principal and Secondary aquifers beneath the site to be of High Vulnerability. Aquifers of high vulnerability are those which are characterised by high-leaching soils and the absence of low-permeability overlying superficial deposits. It is noted that previous intrusive investigations[3] have encountered predominantly fine soils with low leaching potential below all areas of the site. Associated risks are discussed further in Section 9.3.

3.2.3 Flood Risk and Drainage

The 2018 Envirocheck report (Appendix C) indicates the eastern portion of the site to be at risk from flooding from rivers or sea with no defences and thinly bordered by a designation of risk from extreme flooding from rivers or sea.

Western and central areas of the site are indicated to be at no significant risk of flooding.

Areas of saturated or boggy ground were observed across the site during the site walkover, and standing water was observed to pool locally upon the concrete covered area of Plant Area 4.

It is further noted that the Halcrow report[4] mentions a series of french drains around the catchment of the CEGB power station that fell into disrepair post demolition, resulting in locally raised groundwater levels and ponding apparent in the CCGT area prior to its construction. These drains linked to an open concrete channel feeding into two oil separators, one of which was later removed, before discharging into the Pembroke River.

The CCGT Drainage layout is indicated on design drawing[20] which shows a network of stormwater drains below the access roads to the north and south of the main Power Station building which connect to an attenuation pit located in the southeast of the site before exiting off site to the south east.

3.2.4 Groundwater Abstractions

The 2018 Envirocheck report confirms that no groundwater abstractions are located within 1 kilometre of the site, however several tidal and surface water abstractions are recorded within 500m of the site boundary as discussed in Section 3.3.1.

3.2.5 Groundwater Source Protection Zones

The 2018 Envirocheck Report indicates that no Groundwater Source Protection Zones (SPZ) are located on the site, or within a 1km radius of the site boundary. The nearest is approximately 8 km to the east of the site.

3.3 Hydrology

The site is surrounded by several hydrological features, none of which cross into the site boundary.

The main hydrological receptors are considered to be Pembroke River and Pennar Mouth located 500m to the east of the site, and the tidal estuary of Milford Haven located 400m to the north of the site.

A small river or drainage channel is shown to run along the northern and western boundary of the site, and it is likely that there are smaller drainage ditches running along field boundaries close to the site.

Several local surface water features including streams and surface ponds are located near to the site, including two reservoirs located approximately 400 and 900m further to the south.

3.3.1 Surface Water Abstractions

The 2018 Envirocheck report indicates that there are several surface and tidal water abstractions within 500m of the site.

Three tidal abstractions are licenced at identical co-ordinates 378m to the east of the site (from Pembroke River). All three of these abstractions are licenced to RWE Power for non-evaporative cooling.

A further surface water abstraction from the River Pembroke licenced to National Power Plc again for non-evaporative cooling is located 467m to the east of the site.

3.3.2 Radon

BRE document 211 mapping coverage for the site area was consulted and indicates that the site is located within an area where full radon protection measures are required for new developments.

3.3.3 Unexploded Ordnance

The Landmark Preliminary Unexploded Ordnance (UXO) Threat Assessment (2018) is included in Appendix E. The report summarises the probability of a UXO encounter in accordance with current guidelines (CIRIA C681 Chapter 5) with a rating of 2, indicating a low probability of UXO encountered.

In accordance with CIRIA C681 the report recommends that no further action is required to address the UXO risk at the site.

4.0 SITE HISTORY

4.1 Introduction

The historical development of the site and surrounding area has been assessed using information available from historical Ordnance Survey (OS) maps within the Envirocheck Report (Appendix C) and using archive drawings provided by RWE (listed in Tables 1 to 4).

In the context of the summary of historical development of the surrounding area, the descriptions are limited to significant features identified within approximately 500m of the site boundary, unless specified.

4.2 Site History

4.2.1 Summary

Earliest mapping from 1869 shows the site to be largely undeveloped and used predominantly as farmland intersected by hedgerows and footpaths. Two lime kilns are the only signs of any industry within the local area on the early maps, and these features are no longer labelled from 1908.

Maps show that the site remained undeveloped until 1972 when the former oil fired CEGB Pembroke Power Station is shown partially extending into eastern areas of the site (Plant Area 4 and Service Area 2. The CEGB Power Station was a 2,000MW oil-fired power station, the footprint of which is indicated on OS maps from that period indicating several buildings and above ground storage tanks to the north. It is understood that the original power station was closed in 1996.

During the period 1972 to 2018 the maps show only minor developments including additional ancillary CEGB power plant buildings and minor alterations to the road layout.

Halcrow[4] mention that the CCGT site was subject to significant excavation in the 1960s to provide fill for reclamation of the Pembroke River Valley to the east for the construction of the CEGB Power Station. This excavation is said to have created a bowl-shaped cutting into the original valley profile, with cut slopes up to 15m depth formed along the north and south boundaries. This area was subsequently used as the contractor's area during the construction of the CEGB Power Station.

Further adjustments to the site levels occurring prior to the construction of the CCGT Power Station, are discussed in further detail in Section 8.

The most recent map from 2018 shows the current RWE Pembroke B Power Station in its present-day layout. The former CEGB Pembroke Power Plant is not shown and it is understood that its demolition began in 2000 and was completed in 2003.

Further details of the remediation of the CEGB site are included in the Celtic Technologies report[2] which mentions that the above ground buildings and structures were removed, whereas substructures, including service ducts and a basement void, where left in-situ.

The former CEGB power station site is dominated by the former station basement void the location of which is indicated on the insets of the schematic CCGT plans[7-9]. These plans show the basement extending below the Plant Area 4 footprint. Celtic Technologies[2] report that this basement provided the main drainage system of the site and that water was pumped from the basement below the former boiler house to interceptors before discharging into the River Pembroke. The report also mentions that site levels would potentially allow seawater to migrate into the drainage system.

Construction of the CCGT was completed in 2012, although there are no OS maps from these dates, there is publicly available aerial photography dated from 2006 which shows the partially demolished former power station. These photos show the footprint of the new power station to the east to be located in grassed areas.

Demolition of the CEGB saw the removal of most of the industrial buildings to the east of the site, as well as the removal of the above ground oil storage tanks and much of the internal road infrastructure in the area. A building indicated on OS plans to the southern end of the CEGB has remained and is still operational under the CCGT as a national grid substation.

Earthworks plans[40-42] for the CCGT substructure show the proposed elevation of the site preparation level to reside at 5.30m AOD around the perimeter of the power station. This upper level is shown to step down to a central lower level residing at 5.00mAOD which occupies the footprint of the main power station structure. The CCGT preparation level elevation profiles[42] show pre construction levels ranging between approximately 5.30 and 6.80mAOD in the west, sloping down to as low as 4.73m AOD in the eastern extremity of the site. Pre-construction levels indicated on the archive drawings are confirmed by the ground levels recorded during the previous CCGT preconstruction site investigations[3] and would have required excavation of much of the eastern area with fill occurring in the eastern extremity of the site, most likely using site won materials.

The current Pembroke B Power Station (CCGT) 2,000 MWe natural gas-powered combined cycle turbine was officially opened on 19 September 2012. At the time of compilation of this report (during April 2019) there were five 400 MW modules, each comprising a 288 MWe Alstom gas turbine, heat recovery steam generator and a steam turbine.

The CCGT is supplied from holders located approximately 4km north on the other side of the Haven and transported via a National Grid pipelines below Milford Haven.

4.2.2 Review of Historic OS Maps

Table 9 provides a summary of key features observed on available OS historical mapping coverage for the site and surrounding area dating back to 1869.

Table 9 Summary of OS Historical Mapping

Map Date & Scale	Site Description	Surrounding Area
County Series Pembrokeshire (1869) 1:10,560	The majority of the site is shown to comprise open agricultural land dissected by hedgerows/fences. The south-eastern portion of the site is indicated to comprise an area of mud flats stretching from the Pembroke river to the east. This area is thought to be the source of the superficial deposits shown to occupy the same area on BGS mapping.	The surrounding area is shown to comprise open agricultural farmland with an open mud flat extending towards Pennar Mouth to the east. Lime kilns are shown approximately 200m and 500m to the south and north-west of the site respectively. The small settlement of West Pennar is located 125m to the north-east of the site.
County Series Pembrokeshire (1875) 1:2,500	There are no significant changes from the previous map edition.	There are no significant changes from the previous map edition. A quarry is now indicated at the site of the Lime Kilns to south and northwest.
County Series Pembrokeshire (1908 – 1909) 1:10,560, 1:2500	There are no significant changes from the previous map edition.	There are no significant changes from the previous map edition. The lime kilns/quarry are indicated, but no longer labelled (possibly inferring they are no longer operational).
County Series Pembrokeshire (1937-1953) 1:10,560	There are no significant changes from the previous map edition.	There are no significant changes from the previous map edition.
County Series Pembrokeshire (1964) 1:10,000	There are no significant changes from the previous map edition.	There are no significant changes from the previous map edition.
County Series (1968) 1:10,000	There are no significant changes from the previous map edition.	There are no significant changes from the previous map edition.

Map Date & Scale	Site Description	Surrounding Area
Ordnance Survey Plan (1972) 1:1250	The site has been developed. The mud flat area within the site has been filled and the CEGB Pembroke Power Station has been constructed in the eastern portion of the current site boundary. A steep bank dipping towards the site follows the northern and western site boundaries.	Pembroke CEGB Power station extends from within the eastern portion of the site to the east beyond the site boundary. The development comprises several buildings including above ground tanks and pipelines connected by a new road system. Most of the power station buildings are within 250m of the east of the site. Multiple formed banks surround the CEGB Power plant area. Drainage channels intermittently intersect the banks.
County Series Pembroke (1976) 1:10,000	There are no significant changes from the previous map edition.	Most of the power station buildings are within 250m of the east of the site. A sewage works is shown 750m to the south-east of the site. The former mud flat area has been developed to include multiple jetties and a travelling crane for access to the Pembroke River and Pennar Mouth. An earthwork is marked 1000m to the north-east of the site. Sports grounds are located 200m to the south-west of the site. A reservoir has been constructed 800m to the south of the site.
Additional SIMS (1988 – 1990) 1:1,250	The road layout associated with the power plant has been modified slightly. An additional building has been constructed in the north-eastern corner of the site.	Additional tanks and buildings have been constructed in the CEGB area east of the site.
County Series Pembroke (1994) 1:10,000	There are no significant changes from the previous map edition.	Additional tanks are shown at the sewage works to the south-east of the site.
10k Raster Mapping (2000) 1:10,000	There are no significant changes from the previous map edition.	There are no significant changes from the previous map edition.
Street View Mapping (2018) 1:10,000	The CEGB Power Station has been removed from the eastern end of the site. RWE Pembroke CCGT Power Station has been constructed in central areas of the site. The new CCGT Power Station is shown to comprise multiple structures surrounded by a perimeter road and associated pipework.	The former Pembroke Power Station has been removed from the east of the site, although some road infrastructure remains. The building towards the south of the former works is still present. Tanks associated with the sewage works are removed.

4.2.3 Development History of Plant Areas and Service Routes

Plant Area 3

Historically, Plant Area 3 has been relatively undeveloped in comparison to much of the surrounding site. Throughout the operational life of the former CEGB Power Station the area remained generally unused.

Mapping from 1976 shows the area to be situated on an open plot of land at the base of a slope adjacent to the north of the site.

Mapping from 2000 shows a rectangular blue feature within the extents of Plant Area 3. Whist this feature is unidentified, it is interpreted as being a possible surface water tank / reservoir. Aerial photography dated 2006 shows this area as hardstanding. Another area of hard standing is shown in the east portion of this are of the site.

Aerial Photography dated to 2009 displays the site layout during decommissioning of the CEGB Power Station. The hardstanding areas described above are not visible on the photos and have either been removed or covered.

Layout plans from the CEGB Power Station indicate water supply points on the east side of this area along the access road around the perimeter of the power station.

Plant Area 4

Plant Area 4 is an area formerly occupied by the western extent of the CEGB Power Station. Following demolition of the former station the concrete floor slabs have remained, and aerial photography shows the area to have been used as a storage and lay down area of multiple containers and other unidentifiable features.

Archive drawings[25] shows the layout of the foundations of the CEGB Power Station and indicates Cooling Water (CW) Culverts running from the NNW to SSE through Plant Area 4. Two separate structures are shown running parallel on the west side of the CEGB site (as indicated on the constraints plan).

Based on conversions from the indicated imperial Ordnance Datum Newlyn measurements, the crown of the westernmost structure is positioned at a depth of approximately -5.7m AOD (approximately 10m below the existing ground level), and comprises a set of four culverts with internal dimensions of 2.74x 2.74m (width and height) housed in 1.20m thick concrete spanning an area of approximately 17m. The west extremity of this structure is indicated approximately 62m from Boiler House 1 of the CEGB and is therefore estimated to encroach approximately 15m into the Plant Area 4 from the West.

Further to the east, archive drawings[25] show that Plant Area 4 is adjacent to a structure which initiates as an open void before it is covered further to the south to form a basement void with a crown level at

approximately -2.74m AOD. The west extremity of this structure is centred '44ft' (approximately 13.4m) from the centre of the CW culverts, and could therefore encroach into the east of Plant Area 4.

Based solely on interpretation from the scale of the drawing, the east and west sidewalls of this structure are approximately 3.3m thick and the feature is rendered with hatching suggestive of concrete.

Schematic drawings[7] include an inset of the CEGB Power Station with an area indicated as 'Former Basement Void' which also extends into the southern portion of Plant Area 4. It is not clear how this basement void, which is reported to be 10m deep, interfaces with the CW shafts.

Previous reports[3] suggest that the substructures described above could for part of the existing site drainage system as summarised in Section 3.2.3.

In general, from a basic visual survey of the area, the concrete slabs in Plant Area 4 appeared to be in reasonably good condition with no obvious signs of significant cracking, settlement or structural distress. Although it is noted that the remnants of former dividing walls, also reduced to ground level, had some vegetation growth and deterioration of the original mortared brick work.

Plant Areas 5, 6, 7, 8 & 9 and Service Routes 4 & 5

Development history for these areas appears to have been generally minor and historic photos with the only notable feature being a road which was shown to cross Plant Area 5.

Service Route 1

Historical records do not show any significant development within the footprint of Service Route 1. Minor roads are shown in the western and central portions of the area prior to the construction of the CCGT, when the area became hardstanding.

Service Route 2

Historic aerial photography from 2006 shows the remnants of a floor slab in the north and occupying approximately one third of this area. The remainder of this area is indicated to be access roads and soft standing areas. The Cable Way inset drawings[17] show an oil interceptor immediately to the north of this area.

Service Route 3

Historical maps show the eastern portion of Service Route 3 occupied by structures related to the CEGB. Following the CEGBs demolition, aerial photos shows the area to have been largely cleared and used as a plant storage / laydown area for contractors during the construction of the CCGT. Concrete footings beneath the CEGB Power Station are shown to have been present following demolition, however it is not clear if these remain.

Preconstruction CCGT earthworks sections[41-43] indicate that much of this area would have been raised, most likely using site won materials from the west of the site where levels were reduced for the CCGT platform construction.

5.0 ENVIRONMENTAL DATABASE SEARCH

An environmental database report was commissioned from Envirocheck in September 2018 and is included as Appendix C of this report. The following summary is generally limited to locations within 250m of the site boundaries unless it is considered that specific activities or features beyond that range could potentially have an impact on the site or be affected by the redevelopment of the site.

Table 10 Summary of Environmental Database Search

Records	Comments
Discharge Consents	There are no licensed discharge consents recorded within the site boundary or 250m of the site. Halcrow[4] states that the basement void below the CEGB was drained into a sump at its western end before being pumped through oil interceptors and discharged into the Pembroke River under discharge consent BH0055002. Recovered oil products from the interceptor were temporarily stored on site prior to licensed disposal. BH005002 listed in the Envirocheck report as being located 617m E of the site was revoked and renewed in 1986, 2003 and 2015 under the Water Resources Act in 1991 (Amended by the Environment Act 1995) and remains active and operated by RWE Innogy PLc however the discharge type is listed as Storm Sewage Overflow. The report also states that the cooling water intake screen and pump chambers were screened and backfilled with demolition rubble. The following active discharge licences reference the location as 'Oil Interceptor' and are likely to relate to the discharge from the sump discussed in the Halcrow report. • 488m SE – Production & Distribution of Electricity – Trade Discharges – Process Effluent into freshwater stream/river. • 488 SE – Sub-station/Electricity/Gas/Air Conditioning Supply – Trade Discharges – Process Effluent into freshwater stream/river 488 SE – Sub-station/Electricity/Gas/Air Conditioning Supply – Trade Discharges – Process Effluent into freshwater stream/river. A further active treated effluent is listed in the Envirocheck report • 408m N – Production & Distribution of Electricity. Sewage discharges – Final/Treated Effluent into Saline Estuary. There are 5 No. revoked / replaced discharge consents within 500m of the site boundary details of which are listed below: • 431m N – Production & Distribution of Electricity – unspecified discharge into shore of Milford Haven (expired 1986) • 482m N – Production & Distribution of Electricity – Trade effluent into shore of Milford Haven (revoked and replaced 1993) • 482m N – Production & Distribution of Electricity – Trade effluent into shore of Milford Haven (revoked and replaced 1993) • 482m N – Production & Distribution of Electricity – Unspecified discharge into shore of Milford Haven (revoked 1986) • 482m N – Production & Distribution of Electricity – Unspecified discharge into shore of Milford Haven (revoked 1986)

Records	Comments
Integrated Pollution Prevention and Controls Local Authority Pollution Prevention and Controls	There are 2 no. Integrated Pollution Prevention and Controls recorded within 250m of the site, the details of which are as follows: • 113m South – RWE Npower PLC – Pembroke Power Station. Activity: Combustion; any fuel, greater or equal to 50 Mw. • 169m South – Pembroke Power Station – Activity not specified. There are no Local Authority Integrated Pollution Prevention and Controls within 250m of the site.
Pollution Incidents to Controlled Waters	There is one Pollution Incident to Controlled Waters recorded within 500m of the site, the details of which are as follows: Property Type: **Not Given** Date: **10th July 1997** Location: Near Milford, East of Texaco Refinery. 432m NE Incident Severity: **Category 3** – Minor incident Pollutant: Oils – Other Oils It is also noted that location of the 72,000 tonne crude oil spill from the Sea Empress in 1996 is approximately 15km west of the site.
Groundwater Abstractions	There are no groundwater or surface water abstractions recorded within 250m of the site.
Historical Landfill Sites and Registered Landfill Sites	There are no Historic or Registered Landfill sites within 250m of the site.
Licensed Waste Management Facilities or Registered Waste Treatment Site	No licensed waste management facilities or registered waste treatment sites are recorded within 250m of the site.
BGS Recorded Mineral Site	There are no BGS Recorded Mineral Sites within 250m of the site.
Fuel Stations	No fuel stations are identified to be present within 250m of the site.
Contemporary Trade Directory Entries	There is 1 no. record of Contemporary Trade Directory Entries within 250m of the site boundary. The details of which are as follows: • 17m E – Pembroke Power Station – Power Transmission Services – Inactive
Sensitive Land Uses	The site is located 288m from areas classified as ancient woodland. 338m to the North of the site is an area classified as a Site of Special Scientific Interest and Special Area of Conservation, for mixed biological and geological purposes. Pembrokeshire National Park is located within 10km to the east and west of the site.

6.0 WYG GROUND INVESTIGATION

6.1 Design and Scope

Table 6 lists the investigations undertaken between the 4th and 12th February 2019 in the separate Plant and Service Areas. The table also indicates the relevant constraints plan tile (Appendix F) covering each area. In summary, ground investigation works comprised the following;

- Ground Penetrating Radar (GPR) and Electromagnetic Scanning (EM) of exploratory hole / test locations.
- 12No. Plate Load tests undertaken at ground level and within shallow excavations to depths ranging between 0.10 and 0.50m bgl.
- 19No. Hand excavated inspection pits to depths ranging between 0.20 and 1.20m bgl.
- A single window sample to a depth of 3.45m bgl with standard penetration testing (SPTs).
- 3No. dual purpose gas and water monitoring standpipes were installed to depths of 0.80m bgl in WS03, 3.00mbgl (WS08) and 1.20m bgl (WS25).
- Samples were obtained from the exploratory holes for laboratory environmental and geotechnical analysis.
- 2No. return groundwater sampling and monitoring visits.

WS13 to WS16 inclusive and PL06 were located within an exclusion zone current at the time of the investigation and therefore could not be undertaken.

Factual information including engineering logs, in-situ testing and laboratory test reports are provided in Appendices H to K

6.2 Site Investigation Standards

Standards employed during the investigation were broadly in accordance with BS5930:2015 'Code of Practice for Site Investigation', which incorporates EN14688-1&2, Eurocode 7, Geotechnical Design (ref. BS-EN 1997-2:2007).

6.3 Ground Investigation Methods

Prior to the commencement of drilling works, all the exploratory hole locations were checked with reference to the Constraints plans (Appendix F) and cleared for buried services using a Cable Avoidance Tool (CAT) and GPR.

Hard standing areas were broken out using either a hydraulic breaker or 300mm diameter diamond coring. Inspection pits were progressed using insulated hand tools.

During the investigation, exploratory holes were supervised by an experienced WYG engineer, strata encountered were logged and samples were taken for laboratory testing purposes.

6.4 Groundwater Monitoring and Sampling

Gas and groundwater monitoring and sampling equipment were installed in three of the exploratory boreholes as summarised in Table 11.

Table 11 Summary of installations

Exploratory Hole	Installation Details	Response zone depths	
		From (m bgl)	To (m bgl)
WS03	Dual 50mm diameter HDPE standpipe with response zones comprising slotted pipe with 250µm filter wrap and a 10mm diameter washed pea-shingle surround. At least 0.20m thick bentonite seal above the response zone. Finished above ground level with a gas tap and upstanding concreted steel cover.	0.30	0.80
WS08		1.00	3.00
WS25		0.60	1.20

6.4.1 Well Development

Due to the shallow depth of the installations and limited water and recharge rate within each well, only limited well development was undertaken using cylindrical bailers.

6.4.2 Gas and Groundwater Monitoring & Sampling

Groundwater levels were monitored onsite using a dual phase dipmeter and gas readings were taken using a GA5000 portable gas analyser during two return visits. Ground water samples

were collected using cylindrical bailers. Monitoring results are provided in Appendix K and summarised in Table 13.

6.5 Ground Conditions Encountered

In summary, the shallow ground conditions encountered were broadly as anticipated and comprised coarse engineered fill below hardstanding and topsoil. In most areas the fill was well compacted, and this prevented the progression of exploratory holes to deeper levels during the excavation of inspection pits.

After a sustained attempt to reach deeper levels at WS08 an inspection pit was progressed to the scheduled depth of 1.20m and the hole was progressed using window sampling to a depth of 3.45m bgl. Soils encountered compared well with conditions anticipated from previous investigations and published information and comprised predominantly coarse soils consisting of interbedded layers of sand and limestone gravel.

The following sections summarise the conditions encountered within each of the scheduled Plant and Service Areas, and detailed logs are presented as Appendix H. Exploratory hole locations are indicated on the constraints plan (Appendix F).

6.5.1 Service Route 1

4No. window samples (WS13 to WS16 inclusive) and 1No. Plate Load Test (PL06) were scheduled within this area however they were within an exclusion zone and not accessible at the time of the investigation. As such, ground conditions could not be determined.

6.5.2 Service Route 2

WS19 and WS21 were undertaken within Service Route 1. Surfacing in this area comprised a 50mm thick layer of loose grey medium angular siltstone, sandstone and limestone gravel. Both locations refused within dense coarse soils at depths of 0.40m (WS19) and 0.80m bgl (WS21). Soils predominantly comprised dense (compacted) angular limestone gravel with some cobbles of limestone and subordinate sand, and siltstone and limestone gravel, with rare brick fragments encountered in WS19.

PL01 undertaken at the boundary between Service Route 2 and 3 within the footprint of the proposed BS and BGR Equipment, encountered similar ground conditions.

6.5.3 Service Route 3 (and proposed BS BGR Equipment Location)

WS1, WS2, PL1 and PL2 were undertaken within Service Route 3 and the proposed BS BGR Equipment Location. Ground conditions were similar to those encountered in Service Route 2 and comprised a 50mm thick layer of loose medium angular predominantly limestone gravel, over dense coarse soils (as described in Section 6.5.2). Locations were terminated within dense coarse soils at depths ranging between 0.20 and 0.40m bgl.

6.5.4 Service Route 4

No intrusive investigations were undertaken within this area.

6.5.5 Service Route 5

WS5, 6, 7, 9, 10 and 11 were undertaken in Service Route 5 area along the access road through areas surfaced with Tarmac. All exploratory holes encountered a 70mm thick Wearing Course comprising bitumen bound fine macadam over a 330mm to 360mm thick binder layer of coarse bitumen bound gravel. Exploratory holes in this area were terminated on refusal (likely a compacted engineered fill layer) at depths ranging between 0.40 and 0.45m bgl.

6.5.6 Plant Area 3

WS17 and WS18 were undertaken in Plant Area 3. Surfacing in this area comprised a 20mm thick layer of loose grey medium angular siltstone, sandstone and limestone gravel. Both locations refused within dense coarse soils at depths of 0.30m bgl. Soils were relatively uniform and comprised dense (compacted) angular limestone gravel Engineered Fill.

Three plate load tests (PL7, PL8 and PL9) were undertaken within this area.

6.5.7 Plant Area 4

RWE plan ref UKP/PMB/0349/S1/AP2 shows the proposed 'interface to RWE's breaker for Auxiliary power unit' to sited within Plant Area 4. This area is surfaced by remnant concrete slabs, foundations and sub structures of the former CEGB Power Station which are discussed in detail in Section 4.4.4.

WS22, WS23 and WS24, and PL10, PL11 and PL12 were initiated in this area via 300mm diameter coreholes through the concrete hard standing. The concrete thickness (where proven) was confirmed to be between 300mm (WS22) and 420mm, and in all areas the concrete appeared to be cast insitu. Multiple layers of concrete were encountered in WS23. Coarse Made Ground and compacted coarse Fill materials were encountered below the concrete.

Key details of the concrete and the underlying soils are summarised in Table 12.

Table 12 Summary Details of Concrete Encountered in Plant Area 4

Location	Thickness (mm)	Description	Underlying Soil Description
WS22	0.32	Concrete with coarse angular aggregate. No rebar visible.	Not encountered – exploratory hole refused on hard strata.
WS23	0.42	3No. layers measuring 100, 230 and 90mm thickness in deepening succession. A plastic membrane separates the upper and mid layer.	Variable coarse Made Ground comprising gravel, sand and cobbles of siltstone, sandstone and limestone with brick fragments, persisting to 0.82m bgl.
WS24	0.40	Concrete with demolition rubble derived aggregate (brick) at base.	Dark grey sandy gravel with fine to medium coarse subangular sandstone gravel, with brick and fused ash fragments.
PL10	>0.35	Concrete with coarse angular aggregate.	Not encountered.
PL11	0.30	Concrete with fine to medium gravel aggregate	Orangish brown mottled brown sandy slightly gravelly silt. Gravel is fine to coarse angular siltstone.
PL12	0.30	Concrete with fine to medium gravel aggregate. 20mm diameter rebar spaced at 100mm intervals.	Orangish brown mottled brown sandy slightly gravelly SILT. Gravel is fine to coarse angular siltstone.

6.5.8 Plant Areas 5-10

RWE plan ref UKP/PMB/0349/S1/AP2 shows the proposed locations of plant on the east side of each transformer and WS08 and WS12, and PL4, PL5 and PL10 were located within these areas.

WS12, positioned adjacent to Plant Area 10, encountered a 10mm thick layer of loose medium angular predominantly limestone gravel, over dense coarse soils (as described in Section 6.5.2). Locations were terminated on refusal in dense coarse soils at depth of 0.40m bgl.

WS08, positioned adjacent to Plant Area 8, encountered a 30mm thick layer of loose medium angular predominantly limestone gravel, over dense coarse soils (fine to coarse subangular to angular siltstone, sandstone and limestone with cobbles) to a depth of 0.40m bgl. The hole was

then progressed through coarse soils to a depth of 3.00m bgl. These soils comprised 5No 150 to 1100mm thick layers of gravelly cobbley sand and sandy gravel (gravel and cobbles comprising limestone and sandstone). 10 to 20mm diameter nodules of dark organic material were encountered between a depth of 1.65 to 2.10m bgl. No anthropogenic materials were encountered and it is possible that these soils are naturally deposited, however it is considered more likely that these soils are locally imported or disturbed soils, possibly originating from local natural successions.

Standard penetration testing (SPT) undertaken at 1m intervals within WS08 determined SPT N Values of between 14 and 15 with a gradual increase in depth.

PL4, PL5 encountered a 50 to 150mm layer of loose gravel over dense coarse soils.

PL10 undertaken in an area of concrete hardstanding and a 300mm concrete core sample confirmed a concrete thickness of greater than 350mm.

6.5.9 Groundwater

Groundwater was encountered in a single location during the investigation at a depth of 0.20m bgl in WS02.

Two return groundwater monitoring visits were undertaken on 19.3.19 and 3.4.19. Recorded groundwater levels are summarised in Table 13.

Table 13 Summary of Groundwater Levels During Return Monitoring Visits (m bgl)

Location	Round 1 19.3.19	03.4.19
WS03	0.27m bgl	0.39m bgl
WS08	Dry	0.52m bgl
WS25	Dry	Dry

6.5.10 Ground Gas Monitoring

Ground gases including methane, carbon dioxide, oxygen, carbon monoxide and hydrogen sulphide were measured during the two monitoring rounds using a GA2000 infra-red gas analyser.

A summary of ground gas results is presented in Table 14. The full results of ground gas monitoring recorded during each monitoring visit are provided in Appendix K.

Table 6 Summary of Ground Gas Monitoring Results

Location	Peak Flow (l/hr)		Methane (% CH4)		Carbon Dioxide (% CO2)		Oxygen (% O2)		CO (ppm)		H_2S (ppm)	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
WS3	-0.1	0.0	<0.1	<0.1	0.1	0.2	21.6	21.6	<1	<1	<1	<1
WS8	0.2	0.2	<0.1	<0.1	0.2	0.9	21.4	21.9	<1	<1	<1	<1
WS25	0.2	0.2	<0.1	<0.1	0.2	0.6	21.6	21.8	<1	<1	<1	<1

6.5.11 Plate Load Testing

12No. Plate Load Tests were undertaken within the proposed Plant installation areas as indicated in Table 15.

The objective of the plate loading test is the determination of the vertical deformation and strength properties of soil masses in-situ by recording the load and the corresponding settlement when a rigid plate modelling a foundation is loading the ground.

PLTs were undertaken pursuant to BS EN 1377: Part 9: 1990 Clause 4.1 and performed on a 0.29m^2 plate, using the front axle of a 9.5tonne wheeled excavator to provide a reaction load. PLT results are provided in Appendix H and summarised in Table 15.

Table 15 Summary of Plate Load Testing (Assumed Poissons Ratio – 0.25), GL – Ground Level

Plant Area Ref.	Test No	Depth (m bgl)	Maximum Applied Pressure (kN/m²)	Maximum Deformation (mm)	Modulous of Subgrade Reaction (k) (kN/m²/mm)	Test Strata Notes (See Section 6.5)
BGR	PL1	0.10	128.44	1.52	68.39	Coarse Fill
BGR	PL2	0.10	128.44	3.17	32.90	Coarse Fill
5	PL3	0.50	128.44	2.59	40.23	Coarse Fill
8	PL4	0.40	128.44	4.31	24.15	Coarse Fill
10	PL5	0.10	128.44	1.84	56.72	Coarse Fill
	PL6					Not accessible due to exclusion zone
3	PL7	0.20	128.44	0.69	150.27	Coarse Fill
3	PL8	0.30	128.44	0.94	111.23	Coarse Fill
3	PL9	0.50	128.44	0.90	115.76	Coarse Fill
4	PL10	GL	128.44	0.59	176.58	Concrete
4	PL11	0.50	128.44	5.20	20.048	Predominantly fine Made Ground
4	PL12	GL	128.44	0.72	144.03	Concrete
4	PL13	0.40	128.44	3.35	31.10	Coarse Fill

6.6 Laboratory Geotechnical Assessment

Laboratory geotechnical testing on samples recovered from the exploratory holes was scheduled by WYG. Testing has been undertaken by Professional Soils Laboratory Ltd, who are UKAS accredited for a wide range of geotechnical tests. All testing was carried out in accordance with BS1377:1990 Methods of Test for Soils for Civil Engineering Purposes as summarised in Table 16.

Table 7 Summary of Laboratory Geotechnical testing

Test	Standard	Scheduled	Completed
Particle size distribution (Wet sieving method)	BS1377: Part 2: 1990, Clause 9.2	9	9
BRE SD1 Concrete Aggressivity Chemical Testing Reduced Suite	BRESD1	9	9
Organic Matter Content – dichromate method	BS1377:1990 – Part 3:3	1	1

6.7 Laboratory Environmental Assessment

Environmental laboratory testing scheduled by WYG, was undertaken by ALS Laboratory who are UKAS and MCERTS accredited for a wide range of chemical tests.

Laboratory testing was carried out in accordance with BS10175:2011+A1:2013 Investigation of Potentially Contaminated Sites - Code of Practice.

The testing suites are listed in Table 17 and results are included in Appendix E.

Table 8 Summary of Laboratory Geotechnical testing

Testing Suite	Testing Included	No.
Soils – WYG Suite B	Arsenic, Boron Cadmium, Chromium (total & hexavalent), Copper, Lead, Mercury, Nickel, Selenium, Zinc, Cyanide (free & total), PAH by GCMS, Total Organic Carbon, pH and Asbestos (screen), Phenols by HPLC and BTEX, TPH CWG.	10
Water – WYG Suite B	Arsenic, Barium, Boron Cadmium, Chromium (total & hexavalent), Copper, Lead, Mercury, Nickel, Selenium, Zinc, Cyanide (free & total), PAH by GCMS, Total Organic Carbon, pH and Asbestos (screen), Phenols by HPLC, TPH CWG	4

7.0 GROUND MODEL

The recent WYG investigation was restricted by the dense fill present near surface which prevented the investigation reaching deeper levels with the mobilised equipment. A single exploratory location was progressed below the fill level and encountered soils that are likely to have been disturbed (or locally imported) prior to the construction of the CCGT power station.

Fill materials were excavated to depths ranging between 0.30 to 0.40m bgl, where investigations refused in dense coarse soils. This depth is equivalent to reduced levels ranging between approximately 5.0 and 5.4mAOD.

The ground level reduced to the east of the site (over Plant Area 4). It is noted that the ground level within this area has been retained at the level of the original CEGB Power station, and remnant substructures, including floor slabs form the ground surface in this area. Slightly deeper refusal depths occurred in this area at depth ranging between 4.74 and 4.03m AOD.

Ground levels surveyed during the recent WYG investigation are broadly higher than the levels of the 'preparation surface' indicated on the preconstruction Earthworks plans[41-41] . This suggests that the fill layer encountered during the recent WYG investigation is a layer of engineered fill imported directly onto the preparation level.

In most areas of the site the soils at the CCGT preconstruction preparation level are indicated by previous investigations to comprise Made Ground over Superficial Deposits. The thickness of the Made Ground is typically shown to be less than 1m and it is considered likely that this material was placed during the formation of the contractors lay-down area for the CEGB Construction. Much of this Made Ground would have been removed by excavations to attain the reduced CCGT preparation levels. Therefore, it is considered likely that the current engineered layer was constructed onto the excavated surface of the preparation level. Previous investigations[3] indicate that soils at the preparation level comprise superficial deposits in most areas.

It is also noted that the area of the CEGB was reclaimed using materials excavated from the CCGT area, therefore soils in the CCGT area, have been subject to historical surcharges prior to the further reduction of surcharge during the CCGT construction. This historic surcharge is likely to have increased from east to west across the site.

The superficial deposits described on the logs, are predominantly firm to stiff fine soils, although there are many exceptions, including coarse soil horizons and layers of soft fine soils, which are often associated

with the coarse horizons (fine soils may have been softened by mobile groundwater within the coarse soil horizons).

The sequence of shallow strata encountered below the preparation levels during the pre CCGT investigations are summarised in Table 18. Potentially problematic conditions within these soils are indicated by bold text.

Table 9 Summary of Strata Sequences below Plant Areas (estimated from Soil Mechanics 2006[3])

Area	Local Exploratory Holes	Strata
Plant Area 3	TPRB3, TPRB4, and TPRB5	Localised Made Ground to 5.40mAOD over predominantly coarse soils to around 5.25mAOD, overlying firm to stiff clay.
Plant Area 4	TPRB35, TPRB36, TPRB37 located to the west of this area.	**Predominantly coarse Made Ground to the full depth of the investigation in the north of this area (to 3.67mAOD). This is possibly related to backfill above the CW Culverts.** Firm grey CLAY (both natural and Made Ground) over coarse natural soils in the central and southern portion of this area.
BS and BGR Equipment	TPR39	**Soft consistency fine soils to 4.44mAOD above** firm to stiff predominantly fine soils to the full depth of the investigation (2.73m AOD)
Plant Area 5	TPR40	Coarse Made Ground to 3.98mAOD overlying firm predominantly fine soils 2.98m bgl. **Soft predominantly fine soils from 2.98mAOD to the full extent of the investigation (2.68m AOD).**
Plant Area 7	TPRB32	Coarse soils to 4.67m AOD overlying firm predominantly fine soils to the full depth of the investigation (3.17m AOD).
Plant Area 8	TPRB24	Coarse Made Ground to 5.25mAOD over firm to stiff predominantly fine soils to the full depth of the investigation (3.55mAOD).
Plant Area 10	TPR38	Firm fine soils to 2.56mAOD.

Borehole logs from the 2006[3] investigation also encountered low consistency fine soils, which often persist or occur at deeper levels, however the locations of these boreholes have not been confirmed from the information provided.

Based on the above information the shallow ground model is summarised as follows;

- concrete (where present up to 400mm thick) over,
- coarse engineered fill (approximately 400 to 1000mm thick) over,
- localised areas of Made Ground of variable composition and thickness which are derived from;
- superficial deposits comprising predominantly firm to stiff clay with some soft and very soft layers, all of which include subordinate silt, sand, gravel and cobbles, and also include layers of predominantly coarse soils.
- Based on information from recent monitoring undertaken by WYG and the previous investigations, the groundwater levels ranges from 5.52mAOD (near to or above the existing ground level) to -1.08mAOD.

7.1 Geotechnical Parameters

This section discusses the key geotechnical characteristics of each encountered stratum as determined from field observations and laboratory geotechnical testing.

In most cases, characteristic values or profiles will be assessed based on conservative best estimate of the available data set. Such values are referred to as moderately conservative. The selection process will take into account the variability of the data, but extreme or unrepresentative data values will be ignored. Additionally, comparisons with other published data, correlations with other parameters and engineering judgement are also used to arrive at a characteristic value. Moderately conservative values will be used, where appropriate, with appropriate safety factors.

It should be noted that it is intended that the designer must use his judgment and consider the appropriateness of individual design values to the level of strain and application of loading that applies to the specific design case and to the sensitivity of the structure to which they may be applied.

7.1.1 Engineered Fill

The Engineered Fill presents some degree of heterogeneity but was generally observed to be dense coarse soil. The material composition and properties reflect the origin from re-worked local natural deposits, and although predominately coarse (comprising sand and gravel), the soil can

also include some minor localised silt and clay, and anthropogenic materials such as demolition rubble.

Particle size distributions determined from samples of Made Ground collected from exploratory holes are presented in Appendix I of this report. These results confirm the engineer's description of predominantly coarse soils with cobble content ranging between 0 and 19%, gravel content ranging between 49 and 80%, sand content ranging between 8 and 23% and silt / clay content ranging between 4 and 32%.

As noted, excavation of these soils was difficult by hand and it is likely that these soils have been engineered via compaction and can be considered as Medium Dense to Dense. Conservative characteristic values for the Engineered Fill are presented in Table 19.

Table 10 Summary of Characteristic Geotechnical Parameters Engineered Layer

Parameter	Characteristic Value	Unit
Bulk Density	1900	Kg/m3
Φ	34	Degrees

The ground chemistry has been determined for the engineered fill layer encountered during the ground investigation. The Design Sulphate Class and ACEC Class have been obtained from the Building Research Establishment (BRE) Special Digest 1 "Concrete in Aggressive Ground."

The highest sulfate concentration measured in the laboratory tests on samples of the Engineered Fill is 0.04g/l and the pH ranged between 6.95 and 7.69. This corresponds to a Design Sulfate Class for of DS-1 and ACEC Class of AC-1 assuming mobile groundwater conditions.

7.1.2 Made Ground

Disturbed fine soils encountered during previous investigations (e.g within the vicinity of proposed BS and BGR equipment location) where most likely removed and replaced with compacted coarse fill during site preparation. However, since the recent investigation was unable to penetrate the fill materials, there is a residual risk that these soils remain below the engineered layer in some areas and a conservative assessment would include the parameters of these soils.

No direct assessment of the Made ground soil characteristics can be made as it is likely that the comprise both fine and coarse soils.

7.1.3 Superficial Deposits

Based on information from previous ground investigations [3], and the CCGT development excavation plans[41-43] which show the excavation / fill preparation level at 5.00 and 5.30m AOD, it is considered likely that the soils underlying the Engineered Fill layer in most areas (at the CCGT preconstruction preparation level) will comprise superficial deposits consisting of clay with subordinate variable quantities of sand and gravel.

Standard Penetration Testing (SPTs) recorded by others indicate SPT N values generally in the range of between 5 and 50 confirm the generally soft to stiff consistency of these soils, although very soft and soft horizons were encountered in many locations and often persisted to deeper levels.

A lower quartile SPT N value of 10 would be considered conservative and representative of the weaker soils and an undrained shear strength (Cu) of 55kPa is obtained using the relationship Cu = 5.5 x SPT N (Stroud and Butler 1975).

It should also be noted that partial drying of the clay soils from exposure and dewatering during the CCGT construction could have reduced poor pressures resulting in increased effective stress. This may explain the prevalence of higher consistency soils at shallow levels underlain by softer fine soils in some areas. These effects are ignored by the above characterisation.

Considering the above, the coefficient of volume compressibility is likely to be variable.

7.2 Geotechnical Risk Assessment

Table 20 presents a revised and geotechnical risk assessment which has been updated using the ground model discussed in Section 7 and developed in consideration of the proposed installation locations.

Table 20 Geotechnical Risk Assessment

Risk	Area / Hazard Potential	Comments
Settlement	Plant Area 4 Service Route 2 **Low risk**	The underlying soils are likely to comprise Made Ground or disturbed soils associated with backfill over the CW Culverts which may consist of variable materials. However, previous reports[3] encountered predominantly coarse soils to deeper levels in this area, and this was confirmed by the recent investigations which encountered coarse soils immediately below ground bearing concrete slabs. Therefore, there is limited potential for short term settlements below the proposed distributed loads, and this has been confirmed via in-situ testing (plate loads). Furthermore, this area has been subject to historic surcharges from previous buildings and haulage / layout across this site, and the risks of longer-term settlement occurring in any deeper horizons of fine soils are low. In consideration of the loads of the proposed structures (discussed in Section 2.3.7), any settlement is likely to be less than 10mm and will be short-term occurring during construction. Based on these assumptions the existing ground bearing floor slabs in Plant Area 4 are considered to be a suitable formation for lightly loaded structures. However, it is recommended that the slabs are checked by a suitably qualified structural engineer, and if required, that the underlying formation layer is inspected by a geotechnical engineer.

Risk	Area / Hazard Potential	Comments
Settlement	Service Route 1 **Low risk**	Although this area was not accessible during the investigation, it is assumed that there is a continuation of the engineered fill layer which should support light weight foundations for the gas pipework without risk of excessive or differential settlement. Furthermore, the levels were reduced prior to the CCGT construction and historic surcharge further reduces the risk of settlements occurring in the fine soils below the fill. Factoring in previous loading history, the settlements associated with these soils are likely to be minimal (<10mm) assuming that the proposed loads are well-distributed across the rafts, and a 400mm thick coarse compacted fill layer is retained below the foundation.
Settlement	Plant Area 3 Plant Area 8 Plant Are 10 **Low Risk**	The engineered fill layer encountered in this area should support light weight foundations for the gas pipework without risk of excessive or differential settlement. Furthermore, the levels were reduced prior to the CCGT construction and historic surcharge further reduces the risk of settlements occurring in the fine soils below the fill. Factoring in previous loading history, the settlements associated with these soils are likely to be minimal (<10mm) assuming that the proposed loads are well-distributed across the rafts, and a 400mm thick coarse compacted fill layer is retained below the foundation.
Settlement	Road Crossings for 6.6kV cables **Low risk**	The engineered fill layer and existing sub-base encountered across all areas should support road crossings over new buried service installations without risk of excessive settlement.

Risk	Area / Hazard Potential	Comments
Remnant Substructures	Plant Area 4 and Service Route 2 **Low risk**	Remnant substructures from the CEGB power station are likely to confined to the eastern portions of Plant Area 4 and Service Route 2 (discussed in detail in Section 4.2.3). Archive drawings suggest that these structures are buried at a depth of 10m below the existing ground level, and no evidence of near surface voiding was identified during the GPR surveys. It is also noted that archive drawings indicate that in some areas these structures are incorporated into the foundation of the CEGB and were therefore originally constructed to accommodate the structural loads of the CEGB which have been removed. Based on the depth of these structures, and the assumed structural specification and integrity, it is concluded that they pose low risk to the proposed installations. Loads well in excess of the proposed installations would have been historically accommodated by these structures and will be significantly dispersed through the overlying soils. However, it is recommended that the advice of a structural engineer is sought to confirm these assumptions.
Buried Services	All areas **Moderate risk**	Buried service routes and ducts indicated on the service plans and identified during the non-intrusive surveys were present in all sub areas of the site as detailed on the constraints plan (Appendix F). In some areas it may not be possible to locate the foundations of new installations and associated service trenches at suitable distances away from services, and in these areas deeper foundations may need to be considered to allow installations to transfer loads to deeper soils to bridge over sensitive areas. The susceptibility of soils to settlement in relation to the more concentrated loads of bridging foundations bearing at deeper levels vary in local areas, particularly if Made Ground is present. The presence of Made Ground below the engineered fill cannot be confirmed with the information currently available and further investigation would be required to provide localised assessments for specific structures. It is also noted that other unchartered services may exist which have not been up by standard non-intrusive surveys.

Risk	Area / Hazard Potential	Comments
Excavatability and Temporary Works	**Medium**	Soils were difficult to penetrate using standard hand tools in most areas of the site. Conditions below the engineered layer (at depths of >0.6 to 1.00m) are likely to be predominantly fine soils. Only minor groundwater was encountered to the depths investigated. Machine excavation for service trenches will likely require toothed buckets or breakers to penetrate the engineered layer. Shallow pits are likely to remain stable however man entry into pits should be restricted to adequately supported dewatered excavations or trenches battered to a safe angle of repose. Dewatering may be required for shallow excavations, as perched water may be present. Flows at shallow levels may not be excessive and could be dealt with by pumping from shallow temporary sumps. Groundwater flows into deeper excavations could be excessive leading to instability. A comprehensive groundwater control strategy in line with the guidance provided in CIRIA document C515: Ground Water Control – design and practice, 2000 would be required for deeper excavations and this would likely requiring pumping and filtering to licenced discharge points.
Groundwater / Drainage	**Moderate**	The site is predominantly covered with hardstanding and areas covered with imported gravel. The superficial deposits and unfractured bedrock may act as an aquitard causing perched groundwater and localised patches of standing water. Localised areas of saturated ground have been identified during site visits. Multiple surface water drainage features are already present on site. The ground investigation has confirmed that groundwater is present at relatively shallow levels, and potentially directed into basement voids below the former CEGB site. Extensive adjustments to ground levels and surface storm flows may increase volumes into the existing drainage network, and it is recommended that the capacity of the existing drainage system if reviewed by drainage consultant.
Karstic Rock Head	**Low**	Potentially karstic rock head conditions (typical of the limestone bedrock geology) have been confirmed by previous ground investigations.

8.0 GROUND CONTAMINATION TIER 1 SCREENING ASSESSMENT

8.1 Methodology

The objective of the Tier 1 Screening Assessment presented herein is to identify the chemical constituents which might potentially pose unacceptable levels of risk to sensitive on-site and off-site receptors. Measured concentrations in soil and groundwater have been compared with various sets of Tier 1 Screening Values (TSVs). Where measured concentrations in environmental media exceed these levels, this does not necessarily indicate a requirement for remediation; it can however, be the trigger for further assessment / consideration of mitigation options.

8.1.1 Human Health – Soil

In March 2014, DEFRA published the 'C4SLs' within the 'Policy Companion Document: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination' (SP1010). The purpose of the C4SLs is to identify a concentration in soil indicative of Category 4 status as defined by Part 2a Statutory Guidance 1 on the definition of contaminated land. In September 2014, further clarification was published in a letter from Lord DeMauley to Local Authorities instructing them to use C4SLs in planning.

Where available, C4SLs have been used as the preferred choice of screening criteria. For those constituents where no C4SL has been published by the EA / DEFRA, WYG have screened soil against Suitable for Use Levels (S4ULs)[1].

For the purposes of the risk assessment of human health screening values are based on industrial end usage.

A number of TSVs are dependent on the Soil Organic Matter (SOM) content, and as such TSVs are typically calculated for a SOM of 1%, 2.5% and 6%. The average recorded Fractional Organic Carbon (FOC) recorded within the soils was 0.0026. Using the equation of SOM(%)= FOC / 0.0058

[1] LQM/CIEH (3rd Edition) "Suitable for Use Levels (S4ULs) for Human Health Risk Assessment (2015)"

this equates to a site specific SOM of <1% and a site-specific SOM of 1% has been assumed for the purposes of screening all of the soil data.

8.1.2 Human Health – Groundwater

Groundwater data has not been screened to assess potential risks of harm to health.

8.1.3 Controlled Waters

Groundwater data has been screened against water quality targets by WYG. The adopted water quality targets are Transitional and Coastal Waters Environmental Quality Standards (EQS) originating from the Water Framework Directive (WFD, 2015) and subsequent Directions specific to England and Wales effective from December 2015. Annual average (AA) target criteria have been selected in preference to Maximum Admissible Concentrations (MAC). In the absence of EQS, Drinking Water Standards (DWS) have been used as alternative water quality criteria.

8.2 Assessment of Laboratory Data

8.2.1 Soil

In total ten soil samples were collected from site and scheduled for laboratory analysis. The results of the Tier 1 screening are provided in Appendix L and in all cases, concentrations of the analysed determinants were below the relevant screening criteria for an industrial end use.

Asbestos containing materials (ACMs) were encountered in a single sample from WS24 at 0.45m bgl. Gravimetric and PCOM quantification of the sample determined an asbestos content of 0.0026% and <0.001% respectively, with a corresponding Total Asbestos Quantification of 0.0031%.

8.2.2 Shallow Groundwater

Previous reports[3] suggest a marine influence within the groundwater below the site due to high chloride content (exceeding EQS thresholds), and it suggested that groundwater was being flushed with seawater leaking from the disused cooling tunnels. Other potential sources of chloride include maintenance cleaning solutions, water conditioning processes and the salt gritting of the access roads.

Levels of ammoniacal nitrogen, manganese, cobalt, nickel and phenol were also noted to be slightly above EQS thresholds in some groundwater samples recovered during the 2006 investigation.

WYG installed 3No. shallow groundwater monitoring wells at depths ranging between 0.80 and 3.00m bgl (see Section 6.4) and total of 3No. water samples were subject analysis. The results of this analysis have been compared with EQS (transitional and coastal waters) or (when EQS are unavailable) Drinking Water Standards 2016 (DWS 2016). The full groundwater tier 1 screening sheets are presented in Appendix L. Table 21 presents a summary of the exceedances above the adopted TSV.

Table 21 Summary of Groundwater Results exceeding the EQS

Chemical Constituent	Tier 1 Screening Criteria		Frequency of samples Exceeding Tier 1 Criteria	Concentration range (µg/L)	Location and sampling date of max concentration
	Conc. (µg/L)	Origin			
Cadmium	50	DWS 2016	1	86.6	WS3 18.03.2019
Selenium	10	DWS 2016	1	74.4	WS3 18.03.2019

Exceedences of tier 1 screening criteria are considered to be relatively minor, of a similar order of magnitude.

It is noted that due to the limited depth and lateral coverage of groundwater monitoring of the site, the information obtained can only be treated as indicative to inform initial risk assessments for the construction phase.

Further investigations would typically be required to establish baseline conditions of groundwater held in aquifers below the site.

8.2.3 Ground Gas Screening Assessment Results

This assessment is based on the gas readings obtained during the two monitoring visits outlined in Section 6.5.10.

Using the CIRIA C665 guidance on ground gas, a gas screening value (GSV) can be determined. In accordance with the guidance, the greatest flow rate and greatest concentrations of ground gasses are combined to reflect a worst-case scenario. The flow rates measured at the site ranged

between -0.1 to 0.1 l/hr. Therefore, in line with the guidance the maximum recorded value of 0.1 l/hr has been used.

No detectable concentrations of methane was recorded in any of the boreholes during the monitoring visit.

The highest concentration of carbon dioxide was 0.6% recorded in WS25. Therefore, the gas screening value is:

0.1 l/hr x 0.006 = 0.0006 litres of gas/hr

In accordance with the guidance, the gas screening value (0.0006 l/hr) has been adopted for the site and compared to the modified Wilson and Card Classification (Table 8.5 of CIRIA 665; Table 1, Section 6.3 of BS8485). The ground gas regime is comparable to a Characteristic Situation 1, and the site is deemed to be 'Very Low Risk'.

Guidance typically requires six visits to provide a robust assessment of the gas regime. However, due to time constraints only two monitoring visits were undertaken. The data therefore provides an initial indication of the gas regime at the site.

9.0 CONCEPTUAL SITE MODEL

9.1 Overview

Ground contamination can occur through a variety of causes and is often associated with historical operations and activities. Contamination can result from either on-site sources or from on-site migration from off-site sources, leading to long term liabilities under recent legislation for any site owner.

The Environmental Protection Act 1990 (Part 2A) makes provisions for a risk-based framework for the identification, assessment, management and redevelopment of contaminated land within the UK. The provisions of the Act came into effect in England in April 2000 and are aimed at ensuring that actions taken with respect to contaminated land are directed by a technically well-founded assessment of risk.

The process of risk assessment is an evaluation of the probability of harm, and comprises the identification of sources of contamination, receptors that may be affected by the contamination and pathways by which the receptors may be harmed.

It is noted that the following risk evaluation has been limited by the depth of investigation achievable. The following assessment can therefore only be treated as an indicative to inform the management and arrangements for the construction phase. Further investigations would be required for regulatory approvals.

9.2 Conceptual site model

RWE are proposing to construct multiple new structures across the site and the development will include the installation of all associated support infrastructure. Development plans for the proposal have not been finalised, therefore the following section will assess the site, whilst making reference to specific areas when relevant.

The following conceptual site model forms the basis for the qualitative assessment of ground contamination risks associated with the site. The key source, pathway, receptor model is outlined below within the context of potential development of the site.

9.2.1 Contamination Sources

The main potential sources of contamination on the site are associated with existing features as well as historical land uses on the site as summarised below.

- On Site Sources:

Current site use: The Site has been used as a combined-cycle gas turbine power station facility since 2012 and although associated processes likely include the use of fuels, oils, lubricants, paints, coolants, and heavy metals, which are considered to be potentially contaminative materials, the adherence to current regularity standards limits the risks these processes pose to identified receptors.

The site is frequented by heavy vehicles (such as HGVs, dumper trucks and bulldozers) which are considered to be potential sources of contamination via fuel/oil leaks and through airborne particulates.

Historical site use: The presence of Engineered Fill has been confirmed by the recent ground investigation and it is likely that this Fill was derived from site won processed materials. There is some limited evidence of demolition rubble from the former CEGB power station within these soils which include contaminated materials, including fused ash and asbestos fibres.

Based on the records of the sites development history it is considered likely that much of the Made Ground originally present on the site was removed to reduce the site levels after the demolition of the of the former CEGB Power Station[3]. Some areas of Made Ground could remain, although these are likely to be of limited extent and mainly confined to on the east side of the site where original site levels were lower.

Residual substructures from the former oil fuelled CEGB Power Station are also present in the west side of the site, and materials used in historic processes carried out in this area (including diesel generators, electrical transformers and fuel storage) could potentially include sources of contamination.

With the exception a minor quantity of ACM encountered in one of the soils samples, the screening of shallow soil samples against commercial setting C4SLs has not identified any sources of contamination within the soils or groundwaters. It is however noted that the investigation depths

achievable was limited by the dense fill and residual risks associated with deeper Made Ground and groundwater residing at deeper levels should still be taken into consideration.

Some limited exceedences of EQS TSVs have also been identified during the screening of shallow groundwater samples.

- Off Site Sources

Potential off-site sources of contamination are summarised as follows

- Potentially mobile ground contamination associated with the former oil fuelled power station, including former above ground storage tanks to the north-east of the site, and interceptors located at the discharge point of the site drainage system.
- Potentially mobile ground contamination associated with the former sewage works located towards the east of the site;
- Potentially mobile ground contamination associated with the Valero oil refinery to the west of the site.
- Potentially mobile ground contamination associated local agricultural activities (e.g slurry, pesticides, and fuel storage / transportation).

9.2.2 Pathways

The primary pathways by which sensitive receptors may come into contact with ground contamination are considered to be the following:

- Direct dermal contact or ingestion of soils, or inhalation of dust (i.e. human interaction with surface and sub-surface materials);
- Lateral and vertical migration of groundwater and surface water through permeable sub-surface materials and/or preferential pathways (such as service routes, drains, ducts and remnant substructures);
- The migration and accumulation of gases, vapours and liquids through permeable sub-surface materials and/or preferential pathways.

9.2.3 Potential receptors at risk

The following are considered to be sensitive receptors;

- Current site users;
- Future site users;
- Construction/ maintenance workers;
- Principal and Secondary A Aquifers;
- Surface waters (Pembroke River, Milford Haven);
- Adjacent site users.

9.3 Ground Contamination Risk Assessment

The source, pathway, receptor linkages identified in the previous section are outlined and a qualitative risk assessment shown in Table 22.

The risk assessment assesses potential risks to identified receptors in relation to the existing site setting and the proposed development. CIRIA C552 has been used to define the risk rating presented in the Qualitative Risk Assessment matrix, the methodology for which is presented in Appendix D.

Table 22 CIRIA C552 Qualitative Risk Assessment (definitions for risk ratings is presented in Appendix D).

Source	Pathway	Receptor	Consequence of risk being realised	Probability of risk being realised	Risk Classification	Potential risk management requirements
Historical site use: Made Ground / Engineered fill, residual structures and backfill- quantifiable asbestos fibres recorded in shallow soils.	Direct dermal contact or ingestion of soils, or inhalation of dust	Current Site Users	Severe	Unlikely	Low to Moderate Risk	The WYG ground investigation has confirmed limited contamination of the near surface soils, however quantifiable asbestos fibres have been recorded within shallow made ground. The pathway to current site users is largely broken by the extent of surface hardstanding. Risks to future site users can be mitigated by maintenance/ implementation of hardstanding.
		Future Site Users	Severe	Low Likelihood	Moderate Risk	
		Construction Workers	Severe	Unlikely	Low to Moderate Risk	Risks would be mitigated through standard CDM arrangements implemented in line with CAR 2002 inclusive of PPE and dust control.
		Adjacent site users	Severe	Unlikely	Low to Moderate Risk	Extent of hardstanding is considered to mitigate the risk of dust generation from shallow site soils.
	Lateral and vertical migration of groundwater through permeable sub-surface materials and/or preferential pathways	Principal and Secondary A Aquifers & Surface Water	Medium	Likely	Moderate to High Risk	The mobility of constituents from site soils has not been analysed. The generation of leachate is mitigated by the extent of hardstanding, however previous investigations have identified High mobility of groundwater through the site and former CEGB drainage system and remnant substructures indicates that mobility to surface waters is a plausible pathway.

Source	Pathway	Receptor	Consequence of risk being realised	Probability of risk being realised	Risk Classification	Potential risk management requirements
Potential off site ground contamination: associated with the former CEGB Power Station and sewage works	Direct dermal contact or ingestion of soils, or inhalation of dust	Current Site Users	Medium	Low Likelihood	Very Low Risk	There is potential for migration of contamination associated with the former CEGB Power Station towards the eastern portion of the site. Limited shallow Made Ground identified, however only shallow conditions assessed, further deeper impact may exist which has not yet been identified. Risk management would need to be based on deeper investigations of the Superficial Deposits in this area, and confirmation of the integrity of the drainage system and interceptors.
		Future Site Users	Medium	Low Likelihood	Very Low Risk	
		Construction Workers	Medium	Unlikely	Low Risk	
	Lateral and vertical migration of groundwater through permeable sub-surface materials and/or preferential pathways	Principal and Secondary A Aquifers & Surface Water	Medium	Likely	Moderate to High Risk	
Current site use: Potential ground contamination associated with the current site use, including existing above ground diesel generators, electrical transformers and general site activities and vehicle movements.	Direct dermal contact or ingestion of soils, or inhalation of dust	Current Site Users	Medium	Low Likelihood	Very Low Risk	It is assumed that current fuel storage regulations are adhered to this is supported by on-site observations of good housekeeping and no visible staining. Is is also assumed that vehicle drips/ leaks/spills on handstanding and that surface water drainage is through an oil/ water interceptor. Current and future use are similar and risks have been assessed as the same.
		Future Site Users	Medium	Low Likelihood	Very Low Risk	
		Site Construction Workers	Medium	Unlikely	Low Risk	Risks would be mitigated through standard CDM arrangements implemented in line with CAR 2012 inclusive of PPE and dust control.

Source	Pathway	Receptor	Consequence of risk being realised	Probability of risk being realised	Risk Classification	Potential risk management requirements
Current site use (Cont.)	Lateral and vertical migration of groundwater through permeable sub-surface materials and/or preferential pathways	Principal and Secondary A Aquifers & Surface Water	Medium	Likely	Moderate to High Risk	Risk management would need to be based on deeper investigations of the Superficial Deposits in this area, and confirmation of the integrity of the drainage system and of interceptors.
Potential ground gas associated with on-site made ground deposits	The migration and accumulation of gases, and vapours through permeable sub-surface materials and/or preferential pathways	Current Site Users	Medium	Low Likelihood	Very Low Risk	Limited initial evidence of ground gas generation was identified during the monitoring of standpipe installations. Further monitoring required for a robust assessment in line with current guidance.
		Future Site Users	Medium	Low Likelihood	Very Low Risk	
		Buildings	Medium	Low Likelihood	Very Low Risk	
		Adjacent site	Severe	Low Likelihood	Low Risk	

10.0 CONCLUSIONS AND RECOMMENDATIONS

10.1 Ground Contamination

Conclusions

Historical mapping shows that prior to the construction of the power plants, the subject site was largely undeveloped and used as agricultural land. There is unlikely to be any significant contamination associated with small scale historic agriculture on site. However, there are potential risks associated with recent larger scale agriculture (e.g slurry, pesticides, and localised pollution incidents (e.g spills of fuels and oils)) in the area surrounding the site.

The broader site (inclusive of the CEGB Power Station) has been associated with large scale fuel powered electricity generation since the 1970s and these activities are considered to be a primary source of potential contamination through onsite storage, transportation and incineration of large volumes of fuel oil and gas. Other potentially contaminative processes include cooling systems, lubrication, transformer oils, fluxes and the materials used in the construction of these types of installations during this period which may have included heavy metals and asbestos containing materials. Several potential off-site current sources of contamination have been identified, including tanks associated with the former oil fuelled power station stretching from the eastern portion of the site towards the Pembroke river, as well as former sewage works to the east of the site. Valero Oil Refinery to the west of the site is also considered to be a potential off-site source of mobile contamination. It is therefore considered possible for some level of ground contamination associated with the wider site industrial activities or construction materials to be present.

Site wide excavation of near surface soils is understood to have taken place prior to the current construction on site and have limited the extent of Made Ground on site.

Current site use sources are considered to be present limited impact to the site as current regulations and fuel storage good practice is assumed.

Current site users are considered to be at **Low to Moderate Risk** from potential sources given the asbestos fibres recorded within near surface soils and the hardstanding cover across the site and limited exposure to site users. Future site users are considered at **Moderate Risk** from potential sources as the development may potentially expose site soils, however the developments are unlikely to significantly change the land use at the site. The risk to future site workers can be mitigated if development areas remain covered with hardstanding, and exposure durations are likely to be very limited.

Site construction workers are considered to be at slightly greater risk of exposure to any potential contamination due to the nature of ground disturbance required by the works.

Earthworks associated with future construction work will introduce new pollutant linkages via disturbance to the Made Ground / Engineered Fill bringing ground workers into direct contact with impacted soils. It is considered that these risks, can be managed by via the implementation of CDM including appropriate working practices such as the use of personal protective equipment (PPE), provision of segregated welfare facilities and dust suppression measures (dampening down excavations) as and when required.

Trace ACMs were detected, however no further evidence of high concentrations of ACMs were identified and therefore during the planning of shallow excavation work (and removal of arisings) it can be assumed that the work will be exempt from licensing and notification to the HSE under CAR 2012 requirements. However, due to the heterogeneous nature of Made Ground / Engineered Fill it is possible that the potential for undiscovered buried asbestos and therefore the project risk register should list this a potential risk and mitigation measures should be in place should previously undiscovered asbestos be encountered during the works.

On encountering suspected ACMs within the soil during excavation, work would need to be suspended and operatives instructed to move away from the suspected ACM. It is recommended that operatives wear suitable PPE including P3 masks, disposable suits, gloves, and a water spray to dampen excavations during excavation works to limit the risks if ACMs are encountered.

If there is an uncontrolled release into the air of asbestos fibres, such as a excavations uncovering lagging or pockets of free fibres, there may be requirement for emergency action. This may be limited to decontamination of personnel & equipment, which in extreme cases may require removal of all clothing, bagging and disposal, and taking an emergency shower. A certified Asbestos Consultant should be contacted immediately for advice in such situations. Samples of suspected ACM's should be taken where safe to do so to confirm or disprove the presence of asbestos. A health record for any impacted personnel may also need to be made.

Assuming the above CDM / CAR 2012 requirements are implemented during constructions works the risk to construction workers is considered to be **Low to Moderate**.

There is potential for new pathways from contamination sources to receptors to be introduced via the installation of new service routes which could create preferential pathways for leachates and contaminated groundwater. Due to the high mobility of groundwater and the potential for contamination sources to reside at levels deeper than those investigated, below the water table / phreatic zone the risk to local controlled water receptors (aquifers and surface waters) is considered to be **Moderate**.

Ground gas monitoring did not identify evidence of land gas accumulation within shallow soils, and deeper soils have not been identified as having potential to generate significant quantities of land gas. Therefore the site is considered be at **Low Risk**. However, further monitoring is required to provide a robust assessment. It is noted that BRE 211 mapping indicates that the site is situated in an area at which full Radon gas protection measures are required for new residential developments.

Recommendations

- Further ground investigation to include deeper soil analysis, leachate testing and groundwater monitoring.

10.2 Geotechnical

It is understood that current development proposals comprise the relatively light weight installations (within the 'Plant' areas) and associated buried infrastructure (within the 'Service' areas).

Further information regarding the proposed installations provided by RWE on 4.10.18 (Appendix G) is summarised in Section 2.3.

A summary of geotechnical recommendations for the proposed installations is provided as follows.

- **Raft Foundations** – Intrusive investigations and PLTs of the near surface engineered fill layer has confirmed the presence of an Engineered Fill layer in all Plant Areas. The loads imposed during plate load testing (128kPa) in most Plant Areas recorded settlements of less than 5mm in the Engineered Fill and hardstanding. Slightly higher settlement (5.2mm) was recorded in the predominantly fine Made Ground in Plant Area 4. No obvious yield point has been identified in any of the tests.
- Based on this testing it is concluded that the fill should support the proposed loads imposed onto conventional raft foundations whilst limiting settlements to less than 10mm. Where the fill layer is not present (or removed during construction) it is recommended that the formation layer is checked, and any soft or loose pockets removed and replaced with a compacted coarse fill prior to the introduction of a subase of appropriate thickness.
- Longer term settlements associated with any fine soils present below the engineered fill layer are likely to be minimal due to the existing surcharge (from the fill layers, roads, pavements and associated dynamic loads).

If required consideration could also be given to the adoption of existing remnant substructures to support for the proposed installations. No obvious evidence of structural instability was encountered during the investigation, however there is potential for deeper voids / basements (e.g the CW shaft within Plant Area 4) to be present. Although historic / archive information suggests that these structures are of robust construction and are buried at a sufficient depth to disperse loads, it is recommended that the advice of a structural engineer is sought once installation locations are confirmed.

- **Services** – All areas (both Plant and Service) areas have existing buried service routes within the footprints indicated. New installations will need to be located and designed to avoid additional surcharges to these service routes and associated ducts (e.g via conventional shallow foundations).
- **Conventional Shallow Foundations** – Local constraints (e.g service routes or potentially unstable sub structures), which cannot accommodate additional surcharges imposed by raft foundations, may prevent the use of raft foundations in some areas. Where no alternative locations are available, deeper foundations may be required to support the concentrated loads and allow the installations to bridge over local constraints.
- Soils below the fill layer could include Made Ground or disturbed soils which could give rise to unacceptable total or differential settlements under the more concentrated loads imposed by conventional shallow foundations. It is therefore recommended that shallow foundations (or piles) pass through these soils into the natural superficial deposits. The depth to a suitable bearing stratum would need to be confirmed via intrusive investigations in local areas. Further investigations would also need to assess local parameters via in-situ and laboratory geotechnical assessment of soil to allow estimations net allowable bearing capacities.
- **Groundwater / excavation stability** – Machine excavation for service trenches will likely require toothed buckets or breakers in most areas to penetrate the engineered layer. Shallow pits are likely to remain stable however man entry into pits should be restricted to adequately supported dewatered excavations or trenches battered to a safe angle of repose. Perched water was encountered at shallow depth and dewatering may be required for shallow excavations. Flows at shallow levels are unlikely to be excessive and could be dealt with by pumping from shallow temporary sumps.
- Groundwater flows into deeper excavations could be excessive leading to instability. A comprehensive groundwater control strategy in line with the guidance provided in CIRIA document C515: Ground Water Control – design and practice, 2000 would be required for deeper excavations and this would likely requiring pumping and filtering to licenced discharge points.

- **Concrete classification**- chemical assessment of the shallow soils corresponds to a Design Sulphate Class for of DS-1 and ACEC Class of AC-1 assuming mobile groundwater conditions. It is noted that chemical conditions could change at deeper levels and therefore additional chemical assessment of soil samples obtained below the fill level would be required for deeper concrete sub structures.

Appendices

Appendix A – Report Conditions

APPENDIX A - REPORT CONDITIONS

GEO-ENVIRONMENTAL DESK TOP REVIEW

This report is produced solely for the benefit of RWE and no liability is accepted for any reliance placed on it by any other party unless specifically agreed in writing otherwise.

This report refers, within the limitations stated, to the condition of the site at the time of the inspections. No warranty is given as to the possibility of future changes in the condition of the site.

This report is based on a study of readily accessible referenced historical records. Some of the opinions are based on unconfirmed data and information and are presented in good faith without exhaustive clarification. Where ground conditions are discussed but no physical site test results are available to confirm this, the report must be regarded as initial advice only, and further assessment should be undertaken prior to detailed activities related to the site. Where test results undertaken by others have been made available these can only be regarded as a limited sample.

Whilst confident in the findings detailed within this report because there are no exact UK definitions of these matters, we are unable to give categorical assurances that they will be accepted by Authorities or Funds etc. without question, as such bodies may have unpublished, often more stringent objectives. This report is prepared for the proposed uses stated in the report and should not be used in a different context without reference to WYG. In time improved practices or amended guidance may necessitate a re-assessment. The opinions expressed cannot be absolute due to the limitations of time and resources within the context of the agreed brief and the possibility of unrecorded previous use and abuse of the site and adjacent sites. The report concentrates on the site as defined in the report and provides an opinion on surrounding sites.

Appendix B – Photographic Plates

Appendix C - Envirocheck Report

Appendix D - CIRIA C552 Risk Methodology

The following tables are derived from CIRIA C552 and have been used to define the risk rating presented in the Qualitative Risk Assessment matrix.

Classification of consequence

Classification	Definition
Severe	Short term (acute) risk to human health likely to result in 'significant harm' as defined by the Environment Protection Act 1990, Part IIA. Short term risk of pollution (note; Water Resources Act contains no scope for considering significant pollution) of sensitive water resource. Catastrophic damage to building/property. A short term risk to a particular ecosystem, or organism forming part of such ecosystem. (Note the definitions of ecological systems within the Draft Circular on Contaminated Land DETR, 2000).
Medium	Chronic damage to human health ('significant harm', as defined In DETR, 2000). Pollution of sensitive water resources (note; Water Resources Act contains no scope for considering significant pollution). A significant change in a particular ecosystem, or an organism forming part of such an ecosystem. (Note the definitions of ecological systems within the Draft Circular on Contaminated Land DETR, 2000).
Mild	Pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services ('significant harm', as defined In DETR, 2000). Damage to sensitive buildings/structures/services or the environment.
Minor	Harm, although not necessarily significant harm, which may result in a financial loss, or expenditure to resolve. Non-permanent health effects to human health (easily prevented by means such as personal protective clothing etc.). Easily repairable effects of damage to buildings, structures and services.

Classification of probability

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

Matrix of consequence against probability to gain a risk classification

		Consequence			
		Severe	**Medium**	**Mild**	**Minor**
Probability	**High Likelihood**	Very High Risk	High Risk	Moderate Risk	Moderate/Low Risk
	Likely	High Risk	Moderate Risk	Moderate/Low Risk	Low Risk
	Low likelihood	Moderate Risk	Moderate/Low Risk	Low Risk	Very Low Risk
	Unlikely	Moderate/Low Risk	Low Risk	Very Low Risk	Very Low Risk

Appendix E – Preliminary Unexploded Ordnance (UXO) Threat Assessment

Appendix F – Constraints Plan (also issued as CAD and KML Format) and Proposed Installation Footprints

Appendix E – Preliminary Unexploded Ordnance (UXO) Threat Assessment

Appendix F – Constraints Plan (also issued as digital CAD and KML format)

Appendix G – Information Provided by RWE on the Proposed Installations

Appendix H – WYG Investigation Engineering Logs and Plate Load Test Results

Appendix I – Laboratory Geotechnical Results

Appendix J – Laboratory Environmental Results

Appendix K – Return Monitoring Summary Sheets

Appendix L – Screened Laboratory Environmental Results