



Phase 1 Land Contamination and Ground Condition Report

**In support of Planning Application for Residential
Development at Pen-y-Bont, Pentre, Chirk, Wrexham
LL14 5AR**

Report Reference: CE-PY-1291-RP03-Final



Produced by Crestwood Environmental Ltd.

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DRAWINGS

Drawing No 17-020-02-Rev A

Master Plan

1:500 @ A0

1 INTRODUCTION

1.1 BACKGROUND

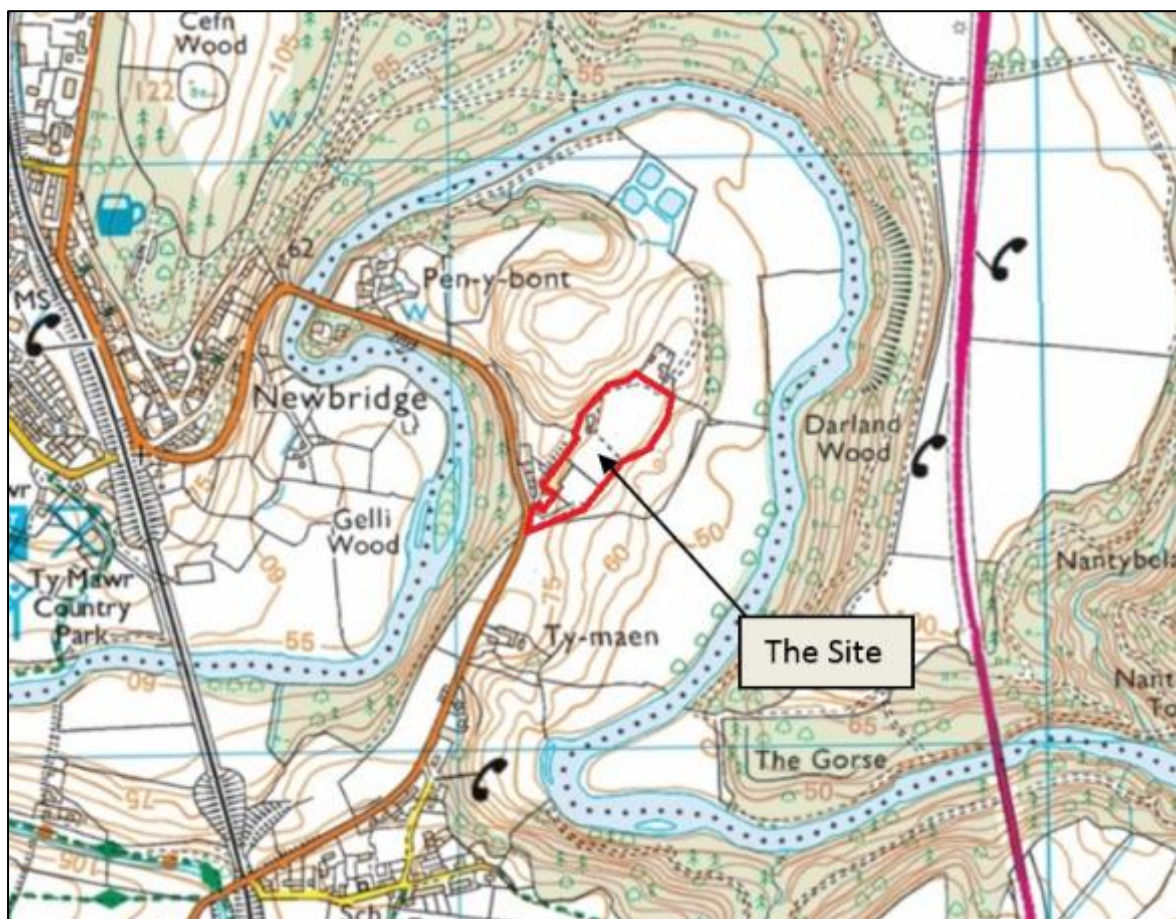
1.1.1 Crestwood Environmental Limited has been instructed by DBA Estates ('the Client'), to undertake a Phase 1 Land contamination report to assess potential land contamination and ground condition impacts on a proposed residential development at Pen-y-Bont, Pentre, Chirk, Wrexham, LL14 5AR. The National Grid Reference of the Site is SJ 29264 41519.

1.1.2 This Report accompanies submission of an application for outline permission to build up to 60 residential properties.

1.2 THE SITE

1.2.1 The red line boundary shown on Figure 1 below indicates the extent of the proposed development area ('the Site')

Diagram 1 Site Location



1.2.2 The Site is located on land adjacent to the former Pen-y-Bont Landfill and is currently accessible by road from the B5605 at the entrance to the former quarry and landfill lane. The town of Chirk is c.4km to the south and Wrexham is c.9km to the north east of the Site. At a distance of c.500m to the north-west and west of the Site on the other side of the River Dee are the interconnected villages of Newbridge, Rhosymedre and Pen-Y-Bont while the village of Pentre lies c.300m to the

south west.

- 1.2.3 The Site is roughly level ground constructed with a concrete covering and several buildings including a Grade II Listed Building utilised as the Site office located at the main entrance. The Site lies within a large loop of the River Dee (see Figure 1 above). The B5605 Newbridge Road lies to the west of the Site.
- 1.2.4 Agricultural land lies to the east and south of the Site while a narrow belt of woodland is established to the west adjacent to the B5605 road.
- 1.2.5 Secure fencing comprising 2m and 1.2m wire and barbed wire stock-proof material encompasses the perimeter of both the landfilled and non-landfilled areas. In addition, 2m steel gates are in place at the entrance to the Site.

1.3 THE PROPOSED DEVELOPMENT

- 1.3.1 **‘The Proposed Development’** consists of up to 60 residential units, complete with access roadways, landscaped areas, garages and gardens. Access to the developed site is to be from the B6505 at the entrance to the former quarry and landfill.
- 1.3.2 The Proposed Development details provided for use in the production of this report were as per Drawing No 17-020-02-Rev A.

1.4 THE STUDY AREA

- 1.4.1 The Study Area comprises the planning application boundary and surrounding environs to an extent and distance that might reasonably be judged to constitute source material with potential to impact on the Proposed Development.

1.5 REPORT PURPOSE

- 1.5.1 The purpose of a Phase 1 Land Contamination Report is to examine and establish the previous uses of the land at and near the Site and to identify potential sources of contamination, receptors and pathways. Information is then examined to indicate which likely source-pathway-receptor relationships can be identified and used to formulate a conceptual model. A Phase 1 report is a staged process involving data collection and interpretation. This is followed by reporting with recommendation of any further investigation which may be necessary.

1.6 LIMITATIONS

- 1.6.1 Crestwood Environmental Ltd have had access to third party data for landfill gas and water samples in consideration of this Phase 1 Report. The results of this monitoring have been accepted on face value and have not been verified by Crestwood Environmental. We can accept no liability for issues arising out of the accuracy of these results.
- 1.6.2 We have undertaken only a basic review of the potential for buried ordnance at the Site. There is no evidence that this site may have been a repository of unexploded ordnance on the risk map for Wrexham County Borough (traditionally in Denbighshire administrative area) (Zetica, n.d.).

2 METHODOLOGY AND APPROACH

2.1.1 The Phase 1 Report reviews information using a variety of sources of guidance as a basis, including the Environment Agency's Model Procedures for Management of Land Contamination CLR11 (Environment Agency, 2004), Section 2 of BS5930 (BSi, 2015) and Section 6 of BS10175 (BSi, 2013).

2.1.2 The Crestwood Environmental Ltd. methodology and approach aims to deliver a transparent and objective consideration toward assessment and evaluation of risk. The following process steps are followed to build up a preliminary model:

1. Assess the environmental setting;
2. Identify potential sources of contamination;
3. Identify receptors;
4. Formulate a conceptual model;
5. Assess information to inform likely source-pathway-receptor relationships; and
6. Evaluate risk.

Potential sources of contamination can be categorised according to the level of hazard (i.e. potential to lead to harm or pollution) as classified in Table 1.

Table 1 *Classification of sources of contamination*

Category	Examples of source potential for causing pollution/harm
Very Low	Greenfield land / Inert fill / made ground.
Low	Residential / office business / retail development on previously greenfield land.
Moderate	Light industry / engineering plant / pre-control landfill (pre mid-1970's).
High	Chemical works / heavy industrial works / non inert landfill (post 1970's).

2.1.3 Receptors can be classified as shown in the Table 2.

Table 2 *Categorisation of receptors*

Sensitivity	Examples of receptors by category
Very Low	Non-aquifer / low sensitivity watercourse / no WFD issues / no ecological designations / no business or properties.
Low	Minor aquifer / no WFD issues for surface water / industrial premises / low human exposure.
Moderate	Major aquifer / moderately sensitive water course / possible WFD compliance issues / human exposure (business / office).
High	Major aquifer-source protection zone / highly sensitive surface water / WFD compliance issues / SSSI or similar / extensive human access / residential land.

2.1.4 The methodology comprise a desktop study and a site walkover survey to examine the site setting, site history, site usage (historical and current), site geology, hydrogeology and surface water drainage. It is recognised that, depending on terrain and characteristics of both source and pathways (including geological atmospheric and hydrological factors), pollutants can potentially migrate away from a source distant to a site and have the potential to create impacts on receptors.

- 2.1.5 A conceptual model is then created which summarises the overall characteristics of the site under investigation relating the geology, drainage, sources of contamination, pathways and receptors. Assessment is then made of the effectiveness of pollutant linkages in providing a pathway for any identified sources of contamination (hazards) being potentially transferred to a receptor. Pollution linkage is categorised in terms of degrees of likelihood as shown in Table 3.

Table 3 Probability of pollutant linkage

Category	Definition (where pollutant linkage may be present)
High Likelihood	Long-term risk of occurrence almost certain or already evident.
Likely	Long-term risk of occurrence probable.
Low Likelihood	Long-term risk of occurrence possible, without certainty of any occurrence.
Unlikely	Circumstances for harm to occur are improbable.

- 2.1.6 Risk assessment is then carried out by use of a Risk Model which combines the relationship between the Source of contamination (the Hazard) and the Receptor which can be rated as potential severity of impact (or consequence of effect) categorised from severe to minor. This is shown in Table 4 with definitions of categories of severity.

Table 4 Potential severity of impact

Category	Definition
Severe	Acute risks to human health, catastrophic damage to property, major pollution of controlled waters.
Medium	Chronic risk to human health, pollution of controlled waters, significant damage to property.
Mild	Minor pollution of controlled waters, minor damage to property.
Minor	No measurable effect on humans or property, no observable effect on water quality or ecosystems.

- 2.1.7 The resulting risk is then evaluated for each receptor by considering the combined effects of potential severity of impact (Table 4) and the likelihood of effective pollutant linkage (Table 3). The overall Risk evaluation is shown in Table 5.

Table 5 Resultant risk

Probability ↓	Potential severity of impact			
	Severe	Medium	Mild	Minor
High Likelihood	Very high	High	Moderate	Moderate - Low
Likely	High	Moderate	Moderate - Low	Low
Low Likelihood	Moderate	Moderate - Low	Low	Negligible
Unlikely	Moderate - Low	Low	Negligible	Negligible

3 SITE HISTORY

- 3.1.1 Reference to historical maps and searches show records from 1873 and indicates the border of the Site similar in dimension as it is of today containing sparse amounts of trees. Pen-Y-Bont brick and tile works and clay pit are adjacent to the northern region with buildings along the eastern perimeter of the Site that extend northwards to the clay pit. The Site and proximal environs remain largely unchanged up until 1954 when the area of the contemporary landfill shows concentric

contours from excavation and quarrying operations extending south-west including the ridge towards the south-western perimeter. Unspecified works replace the brick and tile works and clay pit in 1962 with a pond occupying the central region of the disused works. Between 1986 and 1995 there is evidence of the former buildings associated with the brickworks gradually diminishing, presumably demolished with only a couple remaining on the Site in 1995.

- 3.1.2 Juxtaposing the north-western edge of the Site is the closed and restored landfill known as Pen-Y-Bont Landfill; which operated under planning permission granted by Wrexham County Borough Council in 1993. The landfill site was operational between November 16th 1997 and October 2016, accepting inert and non-hazardous domestic and commercial wastes with the benefit of a Waste Management Licence (WML), which was superseded by a Pollution Prevention Control (PPC) Permit from November 2005 (EPR/ GP3830BG).
- 3.1.3 Historically, the landfilled area accommodated a brick and tile works which excavated the native clays.
- 3.1.4 There is some evidence (Coal Authority, n.d.) of mining excavations for the purposes of prospecting for coal located in the region; refer to section 4.6 Coal Mining for more details.

4 SITE SETTING

4.1 LANDFORM

- 4.1.1 The Site currently forms a portion of the Pen-Y-Bont Landfill Site and comprises a raised area of between 70 and 75m AOD which lies within an oxbow meander of the River Dee at a distance of 100m at its closest extent. A further elevated topography to the north of the Proposed Development is due to anthropogenic activities. Depressions to the east and west fall to some 20m lower towards the River Dee at circa 50m AOD.
- 4.1.2 Aligned to the north to north-east of the landfilled area are 3 attenuation/settlement ponds which have been retained as part of the restoration scheme.
- 4.1.3 Landform to the east and west are surrounded by sloping land falling to the River Dee whilst to the north the topography is elevated to c.85m AOD as a consequence of landfill operations. To the south a raised ridge extends to the south at a height of c.80m AOD.

4.2 LOCAL ENVIRONS AND RECEPTORS

- 4.2.1 Located within a predominantly rural setting, the east and south of the Site is bounded by agricultural land while a belt of woodland lies to the west alongside the B5605. The former landfill located adjacent to the north and west perimeter of the Site comprises 3 cells situated in a west to east alignment.
- 4.2.2 Adjacent to the south-western boundary of the Site near to the main entrance is a collection of residential properties including Pen-Y-Bont cottage. Further to the north-west c.420m is Pen-Y-Bont Farm whilst another farm, Ty-maen Farm is located to the south at a distance of c.200m.

4.3 GEOLOGY

- 4.3.1 The British Geological Survey maps (BGS, 2016), for the area indicate that the Site is underlain by Carboniferous mudstones (Ruabon Marl) of the Etruria Formation which varies from a thickness of

2m to 50m. These strata consist of detrital sediments ranging from coarse to fine grained which were probably quarried and sorted to separate viable clay during the various phases of extraction. In turn, this formation overlies Carboniferous Middle Coal Measures comprising of sands and silts with localised organic horizons.

4.3.2 The superficial fluvial deposits that overlie the Etruria formation are typically between 2m and 10m thick and comprise of undifferentiated sands and gravels deposited by Quaternary rivers in the form of beds and lenses indicative of the channels, floodplains and levees of rivers or estuaries. As a consequence of historical industrial activities in the area, made ground deposits also cover the surface layers at a thickness range of 1 to 5m although within the floodplain to the east these have been found to reach depths of 15m.

4.3.3 During 1977 and 1988 colliery waste materials were tipped to the east and south of the Site which inevitably contributed to the quantities of made ground in the vicinity.

4.4 HYDROGEOLOGY

4.4.1 The strata in the area are designated (UK Government, 2017) Secondary A aquifers of variable permeability which relates to the whole of the Carboniferous Group from which water abstractions are viable from sandstone horizons. Yields however are temporally and spatially variable therefore at the Site itself (where marl is the dominant bedrock), intergranular and/or fracture flow would be low with the corresponding permeability modest hence the strata is classified as unproductive in terms of aquifer designation.

4.4.2 Secondary A aquifers are generally considered to be minor aquifers consisting of permeable strata capable of potentially supporting water supply at a local level rather than a strategic level. Part of the Site is also designated Secondary (undifferentiated) aquifer, indicative of strata exhibiting varying properties in different locations across one area. These differing lithological characteristics may be variously classified as minor and non-aquifer due to variable characteristics of rock type.

4.4.3 There are no Source Protection Zones (designated protection zones around public water supply abstractions) within the Site or the adjacent landfill.

4.4.4 Natural Resources Wales uses the Catchment Abstraction Management Strategy (CAMS) to determine the amount of water that is available for abstraction from a water source whether it be surface or groundwater in origin. The Site is positioned within the Upper and Middle Dee CAMS where licence applications will be considered on an individual case-by-case basis. Time restraints will apply to all new and varied licences issued (31st March 2027) unless a reduction in water volumes is requested.

4.4.5 In terms of groundwater, the principal resource is contained within the sandstone unit beneath the Middle and Lower reaches of the River Dee. The Site itself however falls within a non-sandstone area which is not exempt from licencing but contains negligible quantities of groundwater therefore unsuitable and unreliable for abstraction.

4.5 SURFACE WATER

4.5.1 The main surface water feature in the vicinity of the Site is the River Dee which flows 100m west at the closest point and is within proximal distance to the western, northern and eastern boundaries of the Site. A major tributary associated with the River Dee flows c.650m to the east while a number of minor tributaries are situated to the north of the Site beyond the northern river

banks within an area of woodland.

- 4.5.2 As an important resource for public water supply the River Dee and its tributaries have no new abstraction availability, so as to conserve the existing demand according to the Dee Catchment Abstraction Management Strategy.
- 4.5.3 There are no known licensed abstractions from surface water likely to be impacted by the Proposed Development. No checks have been made of private sources.
- 4.5.4 Surface water run-off emanating from the landfilled area discharges via perimeter surface drains which are directed towards the north east of the site where 3 settlement ponds serve as a water treatment area. Each of the ponds is unlined and bounded by a 0.5m high bund to ensure water retention and they are connected by a 1m wide channel.
- 4.5.5 Run-off is directed in turn to each of the settlement ponds to progressively remove suspended solids through a settling out process. The outlet system from the settlement ponds discharges to 3 infiltration basins located north of the ponds which contain reed beds. When discharged from the settlement ponds, the surface water infiltrates through the reed beds into soils and drift deposits to enter the local groundwater network under discharge consent CGG0385601.
- 4.5.6 If the surface water volume exceeds the capacity of the basins, the final basin is fitted with a 200mm overflow in order to control discharge to the River Dee in the event of an emergency, permitted by discharge consent CM0094101.

4.6 COAL MINING

- 4.6.1 The Coal Authority records numerous mine entry locations within a 2km zone of the Site that indicate entrances into a mine working. At closest extent to the Site there are 3 entry points situated 522m to the west, 560m to the south and 612m to the North West. Areas to the north and south of the Proposed Development are classified as Surface Coal Resource Areas at 385m south east and 420m north-west at the most proximal points. Probable shallow coal mine workings are interspersed within the region, predominantly in the north with the closest being 530m south and 630m west in relation to the Site. Historical mining areas are located 1.40km north west and 1.80km south east of the Site with no records of geological disturbances and no evidence in Coal Authority records of recent coal mining likely to affect the Proposed Development.

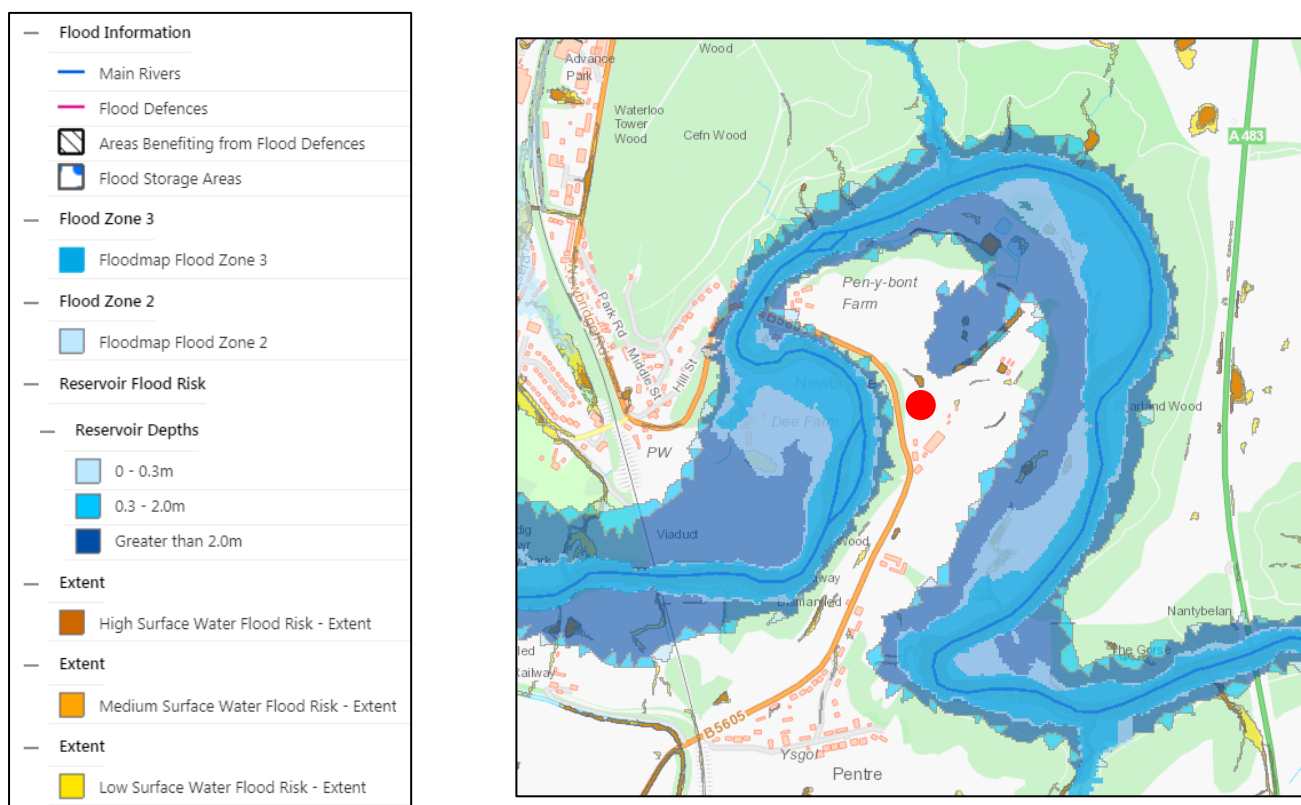
4.7 ENVIRONMENTALLY SENSITIVE SITES

- 4.7.1 Nationally recognised for its transition through a range of river types from mesotrophic to eutrophic, the River Dee is designated as a Site of Special Scientific Interest (SSSI) and is situated c.100m west of the site at the most proximal point. It supports diverse species such as otter, Atlantic salmon, club-tailed dragonfly and is also noted for its fluvial geomorphology. There is an area of special botanic interest located c.660m to the south east of the Site which is also a designated SSSI site. The Nat-Y-Belan and Prynella Woods represent a significant area of semi-natural woodland unaffected by large scale replanting of conifers and non-native hardwoods. A further statutory designation, a Special Area of Conservation (SAC) has been allocated to the River Dee and Bala Lakes. Implications for environmentally sensitive sites and species are dealt with fully in the separate Ecological report.

4.8 FLOOD RISK

The Long Term Flood Risk Map available from Natural Resources Wales at <http://naturalresourceswales.gov.uk/evidence-and-data/maps/?lang=en> places the Site within a Flood Zone where the risk of flooding is less than 0.1% which indicates properties in this location are likely to be at low probability of flooding (less than 1 in 1000 chance of surface water flooding in any given year). The River Dee which encompasses the Site is attributed to both medium and high risk of flooding whilst it is also indicated that there is a risk of flooding from reservoirs as shown in the map extract below (red circle denotes the location of the Site).

Diagram 2 Flood Risk Map



5 INTERPRETATION AND ASSESSMENT

5.1 POTENTIAL SOURCES OF CONTAMINATION

5.1.1 At this stage, any location or feature from which there may be the potential source of contamination, i.e. hazard which in certain circumstances could cause harm or pollution. These are identified in Table 6.

Table 6 Identification of potential sources and associated pollutants

	Source	Associated Contaminants
Historic Sources	Clay extraction and historical back filling with overburden and surplus mineral from quarry.	Fuels, oils, other hydrocarbons, natural overburden ground gas.
	Brickworks	Fuels, oils and other hydrocarbons
	Former Pen-Y-Bont landfill site (to the northwest).	Landfill gas (CH ₄ , CO ₂ , H ₂ S) and leachate

		(ammoniacal nitrogen, chloride, sulphate etc.)
Current Sources	Up until formal surrender of the permit Former Pen-Y-Bont landfill site (to the northwest). Gas Plant	Landfill gas (CH ₄ , CO ₂ , H ₂ S) and leachate (ammoniacal nitrogen, chloride, sulphate etc.) Gas (CH ₄ , CO ₂ , H ₂ S)

- 5.1.2 According to information retrieved from the UK Soil Observatory <http://www.ukso.org/mapviewer.html> and from the European Soil Bureau description the soils at the Site are glacial till with the parent material grain size classified as mixed argillic-rudaceous (i.e. pertains to clay containing fragments). The moisture content is recorded as 30-35% with impeded drainage potential due to the slow permeability, seasonally wet, acidic, loamy and clayey characteristics of the soil. With the potential to retain stagnating water as well as containing structural or moderate textural discontinuity, the soils are categorised as Stagnosols. There also appears to be previous indigenous quarrying materials (overburden, soils, excess mineral from historical extraction) arising naturally in the area.
- 5.1.3 From the historical mapping information the previous use of this land from the late 19th century has been successive phases of mineral (clay) extraction. Initially established in 1830 with 2 kilns, the brickworks subsequently expanded as of 1865 to 40 kilns with production ceasing in 1961. There is no evidence of importation of materials into the Site but we don't know the extent of stripping and stockpiling and replacement. There is no evidence to expect any additional risks to the land quality within the Site over and above any that might arise from naturally occurring land. There is no evidence or reason to expect any presence of industrial or agricultural contaminants. There is no record of pollution incidents at the Site from Natural Resources Wales records nor any records of incidents nearby likely to affect or which may have affected the Site.
- 5.1.4 A Closure Report for Pen-Y-Bont Landfill was prepared by Sirius Environmental, on behalf of FCC Waste Services Limited, in March 2018. The Closure Report states that the landfill was operational from 1997 and finished accepting waste in October 2016. The landfill is adjacent to the northwest boundary of the Site.
- 5.1.5 Waste deposits in the landfill are thought to have comprised predominantly non-hazardous wastes (up to 270,000 tonnes per annum) with lesser amounts of inert waste materials (up to 30,000 tonnes per annum).
- 5.1.6 Each of the three landfill cells was engineered with a 1m thick basal and side wall liner with maximum permeability of 1×10^{-9} m/sec (further details are provided in Section 5.4 below).
- 5.1.7 A fully engineered membrane cap was installed in November 2016 and since its initial development, the landfill was operated as a fully engineered containment site. Each cell is individually hydraulically contained to ensure that leachate levels are maintained below that of the local groundwater levels. Environmental Monitoring Data Reporting is undertaken to comply with the Permit Condition that states:

"A report or reports on the performance of the activities over the previous year shall be submitted to the agency by 31 January (or other date agreed in writing with the Agency) each year, the report(s) shall include as a minimum;

(a) A review of the results of the monitoring and assessments carried out in accordance with this permit against the relevant assumptions, parameters and results in the risk assessment

submitted in relation to the installation and any amendments thereto.

- 5.1.8 Compliance with the permit required monthly routine monitoring of landfill gas from perimeter monitoring boreholes stipulated in Table S4.5 of the site permit; sampling and levels taken of groundwater on a monthly basis in accordance with the requirements of Table S4.4. and S4.10 of the site permit; leachate monthly monitoring (as agreed with Natural Resources Wales in April 2013) and from November 2014 in accordance with Table S4.1. of the site permit variation V007 and surface water sampling at 3 points namely WP1,2 and 3 (upstream, downstream and adjacent to site) monitored on a monthly basis as specified in Table S4.9 of the site permit.

5.2 LANDFILL GAS ASSESSMENT

- 5.2.1 Methane, carbon dioxide, oxygen, relative pressure and atmospheric pressure readings are recorded on a monthly basis.
- 5.2.2 According to the Closure Report prepared by Sirius Environmental, borehole T11 was installed into colliery shale and *“has consistently showed high levels of methane which were proved to have been present prior to waste management tipping operations at the site. That is, when the gas from borehole T11 was sampled it indicated a chemical signature pointing to a source other than landfill in origin.”* Therefore landfill gas trigger levels are not applied to borehole T11.
- 5.2.3 The landfill gas control system is monitored in accordance with Table S4.7 of the landfill permit. In October 2016, before the installation of the final cap, an additional 12 gas wells were drilled at depths between 20 and 53m. The system is performing satisfactorily as indicated by a review of the gas well monitoring data.
- 5.2.4 Average methane concentrations for the gas extraction wells (from 1728 readings) was 46.5%(v/v) with a maximum reading of 82.9%(v/v) recorded in gas well 78 while average carbon dioxide concentrations were 34.7%(v/v) within the gas wells for the duration of the review period. Oxygen readings averaged 2.6%(v/v) over the 12 month period.
- 5.2.5 A landfill gas utilisation plant is located on landfill, which was installed and commissioned in 2003 and comprises 2 Caterpillar engines each capable of 1150kW and one 2500m³ high temperature flare capable of sufficient gas control in the event of the gas engines being unavailable. The landfill produces approximately 2000kW of exportable energy per month and the gas quality in 2016 was at an average quality of 48.8% CH₄, 0.9% O₂ and flow of 972m³/h. Following the completion of capping for the whole site by the end of November, the flow for December 2016 had increased to an average of 1063m³/h. In the landfill gas risk assessment (Ref WR4446/GRA), the modelled gas production for 2016 was 2050m³/h, however, this was based on annual waste inputs of between 100,000 and 200,000t/yr. The waste inputs during 2015 were just 47,642 tonnes which accounts for the current gas volumes being much less than originally modelled. The operation of the gas plant is in accordance with the conditions and requirements of the Environmental Permit regulated by Natural Resources Wales. The Permit will remain in place until formal surrender of the Permit is accepted by the Regulator.
- 5.2.6 Engine emissions for both engines and the flare were within the limits of the permit emissions standards for NO_x, Carbon Monoxide and total VOCs. Trace gases at the inlet to the gas compound were all below the UK national database average with the exception of arsenic, dimethyl disulphide and dimethyl sulphide which were all detected greater than the UK average although within an order of magnitude of.

- 5.2.7 The generation of methane and other landfill gases are considered to be at the highest rates during early years post deposit (Department of the Environment, 1995), (Environment Agency, 2014). In the case of Pen y Bont Landfill, after a twenty-year source term the rates of gas production are expected to have greatly reduced. The Landfill ceased importing waste in 2016 so is likely to continue generating gas at least until circa 2036. There are multiple monitoring boreholes around the site which have been previously monitored since the commencement of landfilling. These are still present with the benefit of additional monitoring boreholes installed as a requirement of an Improvement Condition.
- 5.2.8 An Environmental Monitoring Data Report: 1 Jan to 31 Jan 2016) has been prepared for the landfill (FCC Environment, April 2017). The report states there were no breaches of the 1% trigger level for methane in 2016. This is considered to be directly related to the continuing landfill gas utilisation plant and the use of an impermeable liner on the base and side walls of the landfill.
- 5.2.9 Although methane levels on the landfill boundary are low (as detected from monitoring boreholes) it is noted that the spacing between gas monitoring boreholes on part of the south eastern boundary of the landfill is circa 280m. Part of this boundary, i.e. circa 110m, is adjacent to the Site of the Proposed Development. Therefore there is no data in relation to gas concentrations on this part of the landfill boundary that is adjacent to the Proposed Development.

5.3 GROUNDWATER ASSESSMENT

- 5.3.1 Installed in 2007, 27 boreholes are measured on a monthly basis for groundwater levels and quality with the trigger levels agreed with the Environment Agency (now Natural Resources Wales) in accordance with Improvement Condition 1.4.1.2 submitted in June 2008.
- 5.3.2 The landfill site has operated under the principle of hydraulic containment. As such, a compliance limit of 43m AOD has been adopted based on the 2016 Hydrological Risk Assessment (HRA).
- 5.3.3 For the period throughout 2016, water levels ranged from 46.18mAOD in borehole BH05 located to the east of the site to 74.85mAOD in borehole BH02 towards the western perimeter and concur with levels reported in recent years. No breaches of the stipulated trigger levels were recorded in any of the boreholes monitored.
- 5.3.4 The groundwater flow regime across the local area is determined by the proximity of the river. The flow can vary depending on precise location northwards, eastwards and westwards in the direction of the River Dee, and in accordance with the loop of the river.
- 5.3.5 In terms of groundwater quality, there were no breaches of any substance with permit limits tested for during the course of 2016. Priority determinands outlined in the most recent HRA that are markers for leachate do not indicate detection of contamination. Ammoniacal Nitrogen concentrations for instance are significantly less than the value modelled in the HRA. At 66mg/l, the average Chloride level is higher than the concentration specified in the HRA however still remains substantially lower than the Drinking Water Standard of 250mg/l.
- 5.3.6 All other priority contaminants presented average and maximum levels either less or equal to the figure recommended in the HRA with the exception of Manganese which presented values only moderately above limits.
- 5.3.7 Provided that the head of leachate within the landfill is maintained at relatively low level (in accordance with the requirements of the Permit) by regular monitoring and pumped removal off

site a positive external head of groundwater is maintained. This will ensure that groundwater does not become contaminated around the landfill and beneath the Site.

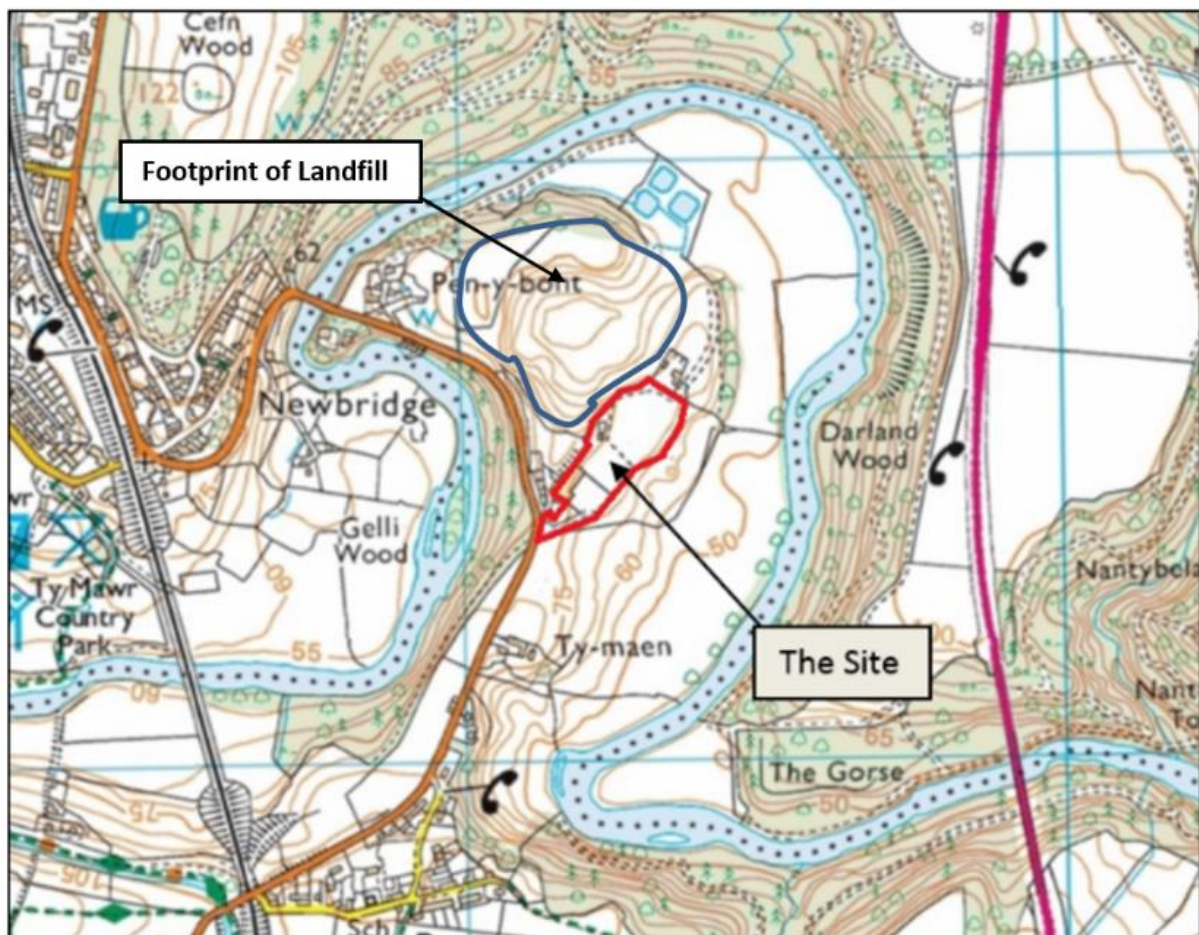
5.4 LEACHATE ASSESSMENT

- 5.4.1 Levels of leachate are monitored at a monthly frequency with trigger levels set at a 1m limit above the base of the cell while sampling of leachate is conducted at 8 leachate compliance points on a quarterly basis as agreed with Natural Resources Wales in April 2013.
- 5.4.2 Results throughout 2016 indicated that leachate compliance was maintained at 100% within the stipulated trigger limit.
- 5.4.3 Regarding the leachate quality, the mean concentration of Ammoniacal Nitrogen for the whole of the site was 3060mg/l with the maximum level detected at point LC4B (4480mg/l) thus classified as a relatively high strength leachate. Chloride concentrations in leachate presented an average of 1798mg/l across the site while the maximum was also recorded in LC4B at 2740mg/l. The mean COD value within leachate was 16,469mg/l with a maximum level of 48,825mg/l in LM4B.
- 5.4.4 Although the leachate is stronger than typical UK leachates of a landfill recovering biodegradable wastes, these determinands show a gradual reducing trend over the duration of the previous 6 years and the overall quality is comparable to that seen in similar sites across the UK.
- 5.4.5 Management of leachate is facilitated by the engineered capping of the site surface, lining system and active extraction from the in-waste leachate extraction wells.
- 5.4.6 All leachate collected at Pen-Y-Bont landfill site is removed from site and disposed of via third party tankering companies. The total amount of leachate removed from site during 2016 was 17,473m³. The leachate pumping system consists of interlinked pipework for leachate collection, with either cables to provide power to the electric pumps or compressed air provided to pneumatic pumps for discharge to the 2 tanks at the gas compound, prior to transfer to the tanks at the weighbridge in readiness for tankered export from site. The tanks have enough capacity to allow 24hour, 7 days per week pumping, although some downtime may occur on a Sunday if the tanks fill, as there are no disposal outlets available. The frequency of tankering reduced at the end of the year coinciding with the cessation of tipping operations and completion of final capping.
- 5.4.7 As previously mentioned, the landfilled area comprises 3 fully engineered cells which have all been constructed in accordance with the site permit and CQA plans. The basal sub-grade in each cell consists of unweathered Ruabon Marl and following the completion of waste infilling, capping and restoration, there have been no stability issues regarding the basal sub-grade layer.
- 5.4.8 The basal lining system for the cells comprise of 1m thick engineered clay liner with maximum permeability of $5.5 \times 10^{-10} \text{ ms}^{-1}$ succeeded by the following specifications:
- Cell 1: Herringbone piped leachate drainage blanket
 - Cell 2: 300mm thick granular leachate drainage blanket extending 2m vertically up the side slopes
 - Cell 3: 2mm HDPE geomembrane liner; Geotextile protection separator and a 300mm thick granular leachate drainage blanket extending 2m vertically up the side slopes.
- 5.4.9 In addition, the side slope lining system construction for each cell comprises :

- 1m thick engineered clay liner with maximum permeability of 1×10^{-9} ms;
- 2mm HDPE geomembrane liner and
- Geotextile protection separator

5.4.10 The level of leachate is maintained at a lower level than the surrounding groundwater. Provided that leachate continues to be removed and compliance with the level set by the Permit is maintained the landfill site will remain under hydraulic containment. This containment will effectively prevent the contamination of surrounding groundwater. With proper continued monitoring in accordance with the requirements of the Landfill Permit, there is no reason why leachate should impact upon groundwater beneath the Site.

Diagram 3 **Location and Extent of former Pen-Y-Bont Landfill**



5.5 RECEPTORS

5.5.1 The Receptors for consideration within the Site are:

- Construction-related operatives, during development of the Site;

- Future residents of the proposed residences;
- Ecological systems;
- Groundwater beneath Site;
- Surface water on Site; and
- Buildings at Site.

5.6 CONCEPTUAL MODEL

- 5.6.1 A conceptual model is a descriptive/diagrammatic representation of the subject site which examines both above and below ground aspects and which identifies and considers surrounding areas for potential impacts on the subject site. To do this potential sources of contamination (hazards) are identified, the pathways for possible transmission of contaminants are considered and the potential receptors are identified.
- 5.6.2 At the Phase 1 investigation stage, the conceptual model is based upon a preliminary site walkover and a desk based study examining the evidence compiled from historical surveys and available data searches described in previous sections.
- 5.6.3 A visual representation of the model is presented in Diagram 4 below (note that the cross section is vertically exaggerated). The extent and orientation of the section is represented by the red line on the accompanying map extract (Plate 1).

Diagram 4 Conceptual Model section across landfill showing location of the Site

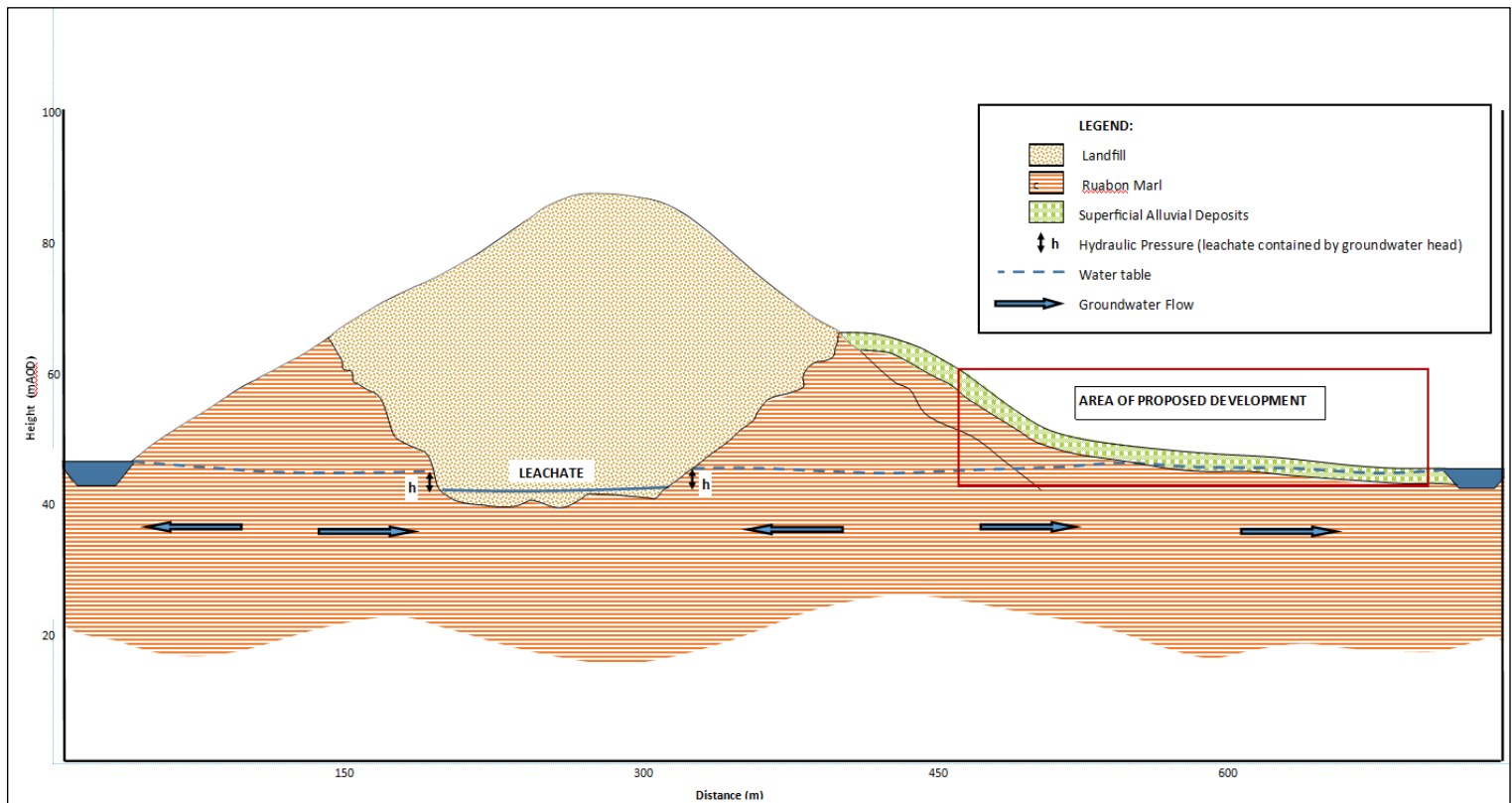
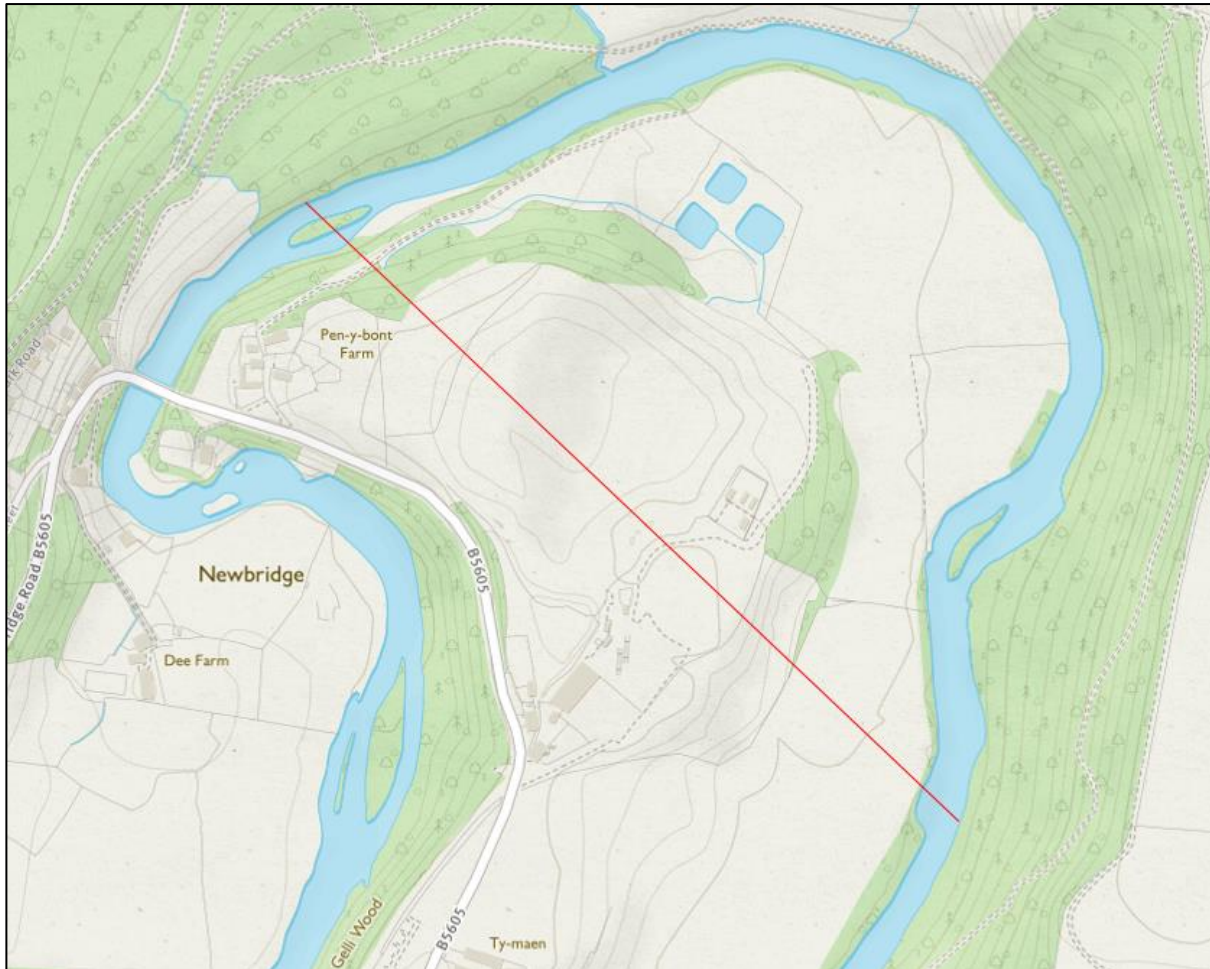


Plate 1 **Location of cross-section**



5.7 MIGRATION PATHWAYS

5.7.1 The pathways for consideration which might allow transfer (migration) of potentially harmful pollutants between source and receptors are:

- From made ground beneath the Site, i.e. underlying previously quarried material and
- Lateral migration through geological strata of gas and/or leachate from the closed Pen-Y-Bont landfill.

5.7.2 It is noted that the intervening area between the landfill and the Site forms a narrow depressed shallow basin making it unlikely that there is an effective connective pollutant linkage.

5.8 PRELIMINARY RISK ASSESSMENT

5.8.1 The assessment and preliminary evaluation of risk from the information gained through desk study and walkover survey potential pollutant (as outlined in Section 2) is presented in Table 7. This sets out the relationships between source and receptor and combines potential severity of impact and likelihood of the event occurring. This is then summated into an overall preliminary risk assessment, referencing the Resultant Risk matrix (Table 5, above).

Table 7 Preliminary Phase 1 Risk Evaluation

Source	Pathway	Receptor	Severity	Probability	Risk
Ground gas from made ground and natural strata	Migration in to excavations	Site workers	Severe	Unlikely	Low
	Migration in to properties	Residents	Severe	Unlikely	Low
Petroleum hydrocarbon compounds and associated organic and volatile organic compounds within shallow soil	Inhalation of vapour	Site workers / residents	Severe	Low	Mod / Low
	Ingestion and absorption		Severe	Low	Mod / Low
	Migration by liquid flow	Surface water	Minor	Unlikely	Negligible
		Groundwater	Mild	Low	Low
	Plant uptake	Ecosystems	Minor	Unlikely	Negligible
Leachate (possible aggressive substances)	Migration through ground	Site workers	Severe	Unlikely	Mod / Low
		Residents	Severe	Unlikely	Mod / Low
		Groundwater	Severe	Unlikely	Mod / Low
		Ecosystems	Mild	Unlikely	low
Landfill gas	Migration through ground	Site workers	Severe	Unlikely	Mod / Low
		Residents	Severe	Unlikely	Mod / Low
		Groundwater	Mild	Unlikely	Low
		Ecosystems	Minor	Unlikely	Negligible
Gas Plant	Emission/Leakage from gas plant	Site workers	Severe	Unlikely	Mod / Low
		Residents	Severe	Unlikely	Mod / Low
		Groundwater	Minor	Unlikely	Negligible
		Ecosystems	Minor	Unlikely	Negligible

6 CONCLUSION

- 6.1.1 There is no evidence to suggest that the potential for ground gas to be generated beneath the Site is anything greater than normal inert made ground and therefore there is consequently considered to be an overall low risk for on-site workers and future residents at the Site from this source.
- 6.1.2 In terms of petroleum hydrocarbons potentially migrating through the ground and affecting the Site, there is no record of any spillage. Similarly there is no evidence of spillage at the quarrying site. Hydrogeological assessment would indicate that if there had indeed been any spillage it is likely that with time drainage of contaminants would be into groundwater which in turn would be likely to then discharge into surface watercourses. There is no reported evidence of this happening; consequently this consideration is rated as low risk.
- 6.1.3 Potentially aggressive leachate related substances such as ammoniacal nitrogen, chlorides etc. have reduced substantially over recent years and are tankered off site so as to alleviate the risk of contamination. The base lining of the former landfilled area is constructed of specific engineered impermeable membrane and the indigenous soils are inherently low in permeability. In addition the site is operated on the basis of maintenance of low leachate levels and hydraulic containment by surrounding groundwater. These factors combined minimise the possibility of creating migration pathways for leachate to reach potential sensitive receptors. There is no evidence from Natural Resources Wales records of poor quality in receiving waters or groundwater that can be ascribed to this source.

- 6.1.4 Landfill gas is effectively monitored and managed at the landfill. Gas is removed to the Gas Plant and operationally these aspects will need to be continued under the conditions of the Environmental Permit, covering the landfill and the gas plant. Provided that the site continues to be managed and maintained in accordance with the Permit there should be no impact on the proposed Site. Attention is drawn however to the lack of perimeter gas monitoring on the southeast flank of the landfill.
- 6.1.5 The assessment undertaken is a preliminary Phase 1 study which is intended to give an indication of conditions within the Site. On this basis, the risk of the Proposed Development being adversely affected by the condition of the land has been considered qualitatively based upon walkover survey and desk study. It is considered unlikely that ground conditions or potential pollutant sources identified would have any significant impact on the condition of the land or the receptors identified, including people.

7 SUMMARY

- 7.1.1 A review of setting of the Site and available information has been undertaken in relation to proposed residential development at Pen-Y-Bont. The review has been further developed into an assessment of a source-pathway-receptor model.
- 7.1.2 The main sources of pollutants identified as having the potential to impact receptors at the Site were determined as the existing ground materials and the adjacent former Pen-Y-Bont Landfill site situated northwest of the Site.
- 7.1.3 There is no evidence that the existing ground is anything other than naturally arising materials from the previous quarrying extractive operations that took place at and adjacent to the Site. Review of historical maps indicates no evidence of other sources of contamination/pollution or any source material likely to cause significant risk to people or the environment. Similarly, there is no indication of intensive farming practice affecting the Site which might otherwise affect the ground condition present.
- 7.1.4 Pen-Y-Bont Landfill site ceased operations in October 2017. In accordance with the requirements of the Environmental Permit regular operational monitoring will be carried out until formal surrender of the permit and Certification of Completion is granted by Natural Resources Wales. The Permit requirement for continued monitoring includes conditions relating to the operation of and emissions from the gas plant.
- 7.1.5 There is no evidence of leachate problems and any escape of leachate is considered unlikely because of the low permeability cell engineering and hydraulic containment with surrounding groundwater.
- 7.1.6 Although landfill gas will continue to be generated for many years, the rate of production of gas from the landfill is likely to have reduced significantly and monitoring data made available supports this. The landfill gas utilisation system provides a preferential pathway for removal of gas from the landfill. It is considered unlikely, due to the reduction in the rate of production of gas at source, the preferential pathway provided by gas extraction plant and the shallow strip of depressed land lying in-between the Site and the former landfill, that there is an effective pathway to the receptors at the Site. It is noted that there are no perimeter gas monitoring wells on the southeast flank of the landfill adjacent to the Site and this should be addressed.
- 7.1.7 Natural Resources Wales flood risk maps indicates that the Site is within an area designated as low

risk of surface water flooding.

- 7.1.8 Overall, it is concluded to be unlikely that ground conditions or potential pollutant sources identified would have any significant impact on the condition of the land or the receptors identified, including people.

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