

**PILING RISK ASSESSMENT
REPORT:**




Proposed Residential Development at
Herbert Road, Newport

Prepared for:
Keepmoat

November 2016

Job No: 12032/PRA

Document Control

Report title	Foundation Works Risk Assessment Report, Proposed Proposed Residential Development at Herbert Road, Newport
Document status	Issue 1
Project ref	12032/PRA
Document date	November 2016
Originator	 Ruth Howells
Reviewed by	 Mathew Lake
Authorised by	 Dr G C Lake

Executive Summary

<p>Site Summary</p>	<p>An area of land off Herbert Road, Newport is to be residentially developed.</p> <p>Due to the presence of soft clay identified beneath the site a piled foundation was advised for the development.</p> <p>For the majority of the development precast concrete driven piles are to be used. A trunk sewer passes beneath the site and the use of precast concrete piles is prohibited along its route. Due to these restrictions all new dwellings to be built along the sewer route are to be founded upon bored piles. Piles will be founded within the underlying very weak red brown and grey mudstone.</p>
<p>Pollution scenario 1: Creation of preferential pathways through a low permeability layer (aquitard), to allow potential contamination of an aquifer</p>	<p>Groundwater present site is confined to isolated bands of sand and gravel. The level of any contamination is considered very low. The groundwater is not in hydraulic continuity with the River Usk. It is considered that the superficial clay deposits will mould around the piles sealing any potential pathways.</p>
<p>Pollution scenario 2: Creation of preferential pathways, through a low permeability surface layer to allow upward migration of landfill gas, soil gas or contaminant vapours to the surface</p>	<p>Gas protection measures comprising a gas membrane, passive under-floor venting and taping and sealing of joints will be installed in all new housing.</p> <p>Further gas assessment is to be performed after fill completion and during/following piling and gas prevention measures reviewed.</p>
<p>Pollution scenario 3: Direct contact of site workers and others with contaminated soil arisings which have been brought to the surface</p>	<p>Installation of precast concrete piles is a displacement method will not bring site workers into contact with soil arisings.</p> <p>Installation of bored piles will involve removal of materials from each pile location, bringing arisings to the surface.</p> <p>Site construction workers are deemed to be at very low risk from the identified contaminants given that any exposure time would be comparatively, to how the trigger levels are derived, exceedingly short. Furthermore, these very low risks may be mitigated through appropriate health and safety measures and procedures.</p>
<p>Pollution scenario 4: Direct contact of the piles or engineered structures with contaminated soil or leachate causing degradation of pile materials</p>	<p>ACEC Class AC-1 should be applied.</p> <p>Provided the concrete used for the piles is the correct class there is negligible risk of pile degradation.</p>
<p>Pollution Scenario 5: The driving of solid contaminants down into an aquifer during pile driving</p>	<p>All arisings from installation of bored piles are brought to the surface and removed. There is therefore no opportunity for contaminated soils to be driven downwards into the underlying aquifer. With regards to the precast concrete piles the use of a pointed or convex shoe is considered necessary during installation.</p>
<p>Pollution scenario 6: Contamination of groundwater and nearby surface waters by concrete, cement paste or grout</p>	<p>The risk of pollution via this scenario with bored piles is considered to be negligible. Driven piles are pre-fabricated off-site and thus do not pose a risk of wet concrete.</p>

TABLE OF CONTENTS

SECTION 1 Introduction

SECTION 2 Review of Geotechnical and Geo-environmental Site Investigation

- 2.1 General
- 2.2 Geology and Ground Conditions
- 2.3 Hydrology and Hydrogeology
- 2.4 Human Health and Environmental Risk Assessment

SECTION 3 Piling Risk Assessment

- 3.1 General
- 3.2 Pollution Linkages
 - 3.2.1 Pollution Scenario 1
 - 3.2.2 Pollution Scenario 2
 - 3.2.3 Pollution Scenario 3
 - 3.2.4 Pollution Scenario 4
 - 3.2.5 Pollution Scenario 5
 - 3.2.6 Pollution Scenario 6

Tables

- Table 2.1 Summary of Contaminants of Concern in Soil
- Table 2.2 Summary of Contaminants of Concern in Groundwater
- Table 3.1 Soil and Groundwater Sulphate and pH Results

SECTION 1 Introduction

An area of land off Herbert Road, Newport is to be residentially developed.

Terra Firma (Wales) Limited previously undertook geotechnical and geo-environmental investigation of the site for Greenhill Construction Limited, (Geo-environmental and Geo-technical Report No. 12032).

Based on the findings of the site investigation it was recommended that a piled foundation be used for the new development.

The Piling Risk Assessment Report has been prepared to achieve the following objectives:

1. Identify the source-pathway-receptor linkages associated with piling works
2. Undertake hazard assessment and risk estimation of the identified potential environmental consequences
3. Determine the requirement for mitigation measures and/or environmental monitoring

Keepmoat has requested that a Piling Risk Assessment is undertaken for the development. This report shall not be relied upon or transferred to any other parties without the express written authorisation of Terra Firma (Wales) Limited.

If an unauthorised third party comes into possession of this report they rely on it at their peril and the authors owe them no duty of care and skill. The report represents the findings and opinions of experienced geo-environmental and geotechnical consultants. Terra Firma (Wales) Limited does not provide legal advice and the advice of lawyers may be required. Any subsurface geological profiles, contamination and other plots are generalised by necessity and have been based on the information found at the locations of the exploratory holes and depths sampled and tested.

SECTION 2 Review of Geotechnical and Geo-environmental Site Investigation

2.1 General

Investigation of the site was previously undertaken by Terra Firma (Wales) Limited. The details of the investigation were reported on in March 2013 (Geo-environmental and Geo-technical Report No. 12032). A copy of this report is provided in **Annex A**.

The site investigation was carried out between the 31st of October and the 8th of November 2012 comprising 19 trial pits and six cable percussive boreholes and three mini percussive boreholes.

In March 2014 additional testing of groundwater was performed.

A summary of the site is provided in the following sections.

2.2 Geology and Ground Conditions

Compared to original levels (prior to initiation of fill works) the ground conditions encountered beneath the site can in general be summarised as made ground to between 0.2m and 3.3m depth, underlain by soft grey and brown clay superficial alluvium with bands of peat and intermittent sand and gravel deposits. Below 5.9m/10.3m depth red brown gravelly clay prevailed, grading in to red mudstone (St Maughan's Formation) at between 10m to 12.7m depth.

Due to the required raising of the site, upon completion of the development the ground level will up to 2.75m above the original level.

2.3 Hydrology and Hydrogeology

A drainage ree flows east to west through the site. This converges with the River Usk approximately 40m west of the site. The River Usk flows southwards and parallels the western site boundary.

The underlying mudstone bedrock is classified a Secondary A aquifer. These 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 superficial deposits are also classed as a Secondary A aquifer. In-situ monitoring on site has confirmed that groundwater within the superficial deposits is confined to intermittent and inconsistent bands of granular deposits and that it is not in hydraulic connectivity with the River Usk.

No perched groundwater was noted in the made ground on site, and is not expected in the recently imported fill due to heavy compaction and low porosity.

2.4 Human Health and Environmental Risk Assessment

During site investigation works both site soils (made ground) and groundwater were sampled and chemically analysed.

A number of substances tested for were found to be above their respective threshold levels in made ground. These exceedences are summarised in **Table 2.1** below.

Table 2.1 Summary of Contaminants of Concern in Soil			
Hole and depth (m bgl)	Chemical	Guideline (mg/kg)	Exceedance (mg/kg)
TP5 1.3m	Arsenic	32	40
TP2 0.90m	Cyanide	8	10
TP5 1.3	Lead	200	290
TP8 0.50m	Benzo(a)anthracene	7.2	13
	Benzo(a)pyrene	2.2	11
	Benzo(b)fluoranthene	2.6	9
	Dibenzo(a,h)anthracene	0.24	1.6
TP6 1.8 TP7 0.20m	Chrysotile – Loose Bundles	-	-
TP13 0.60m	PCB	0.08	0.16
	2,4,4'-Trichlorobiphenyl	0.08	0.12
	2,2',5,5'-Tetrachlorobiphenyl	0.08	0.05

Subsequent to the site investigation fill materials have been imported across the site. These materials have been chemically tested in accordance with the Terra Firma Remediation Strategy and have been deemed acceptable by both Newport City Council and NRW.

Any further fill to be will similarly be screened and approved prior to importation.

Substances found to be elevated in groundwater, (found in isolated bands of sand and gravel within the alluvium) and ree water are summarised in **Table 2.2** below.

Table 2.2 Summary of Contaminants of Concern in Groundwater			
Borehole	Chemical	Threshold (mg/l)	Exceedance (mg/l)
BH1 (08.01.2013)	Aliphatic C16-C21	0.01	0.11
	Aliphatic C21-C35	0.01	0.14
BH2 (08.01.2013)	Aliphatic C16-C21	0.01	0.037
	Aliphatic C21-C35	0.01	0.19
BH6 (08.01.2013)	Aliphatic C16-C21	0.001	0.03
	Aliphatic C21-C35	0.001	0.011
Reen (Upstream)	Aliphatic C16 - C21		0.021
	Aliphatic C21 - C35		0.17
	Aromatic C10 - C12	0.01	0.018
	Aromatic C21 - C35	0.0001	0.062
	Fluoranthene		0.00013
BH5 (06.03.2014)	Zinc	0.125	0.16

2.4 Human Health and Environmental Risk Assessment (Continued)

The petroleum hydrocarbons identified were attributed to contamination that occurred from the drilling process.

The hydrocarbons noted at the reën were identified up-stream but not down-stream and it was concluded that all of the determinants exiting the site and entering the River Usk from the reën were below threshold values.

Two rounds of groundwater testing in March 2014 identified only a single exceedence of zinc, in one location.

With regards to ground gas, the site has been classified as 'gas characteristic situation 3-4' in accordance with Table 8.5 of CIRIA Report C665. Ground gas beneath the site is attributed to the buried bands of peat.

Taking the underlying clay ground conditions into consideration, which will act to prevent upward gas migration, gas protection measures in line with 'gas characteristic 2' may prove adequate to prevent the risk from ground gas to future site residents. Table 8.6 of the CIRIA report confirms that for gas characteristic 2 sites, the following precautions are required:

- A 2000 gauge DPM/reinforced gas membrane
- Passive under-floor venting
- All joints taped and sealed

As a minimum these protection measures will be implemented, subject to further monitoring upon completion of fill works and piling.

Also, gas protection measures will be suitable for basic radon protection and the radon/gas barrier should also be effective as a barrier to PCB vapours.

SECTION 3 Piling Risk Assessment

3.1 General

Due to the presence of soft clay beneath the site traditional shallow foundations are likely to lead to high total and differential settlements.

A piled foundation was therefore advised for the proposed residential properties.

For the majority of the development precast concrete driven piles are to be used, founded within the underlying very weak red brown and grey mudstone.

A trunk sewer passes beneath the site and the use of precast concrete piles is prohibited along its route. Due to these restrictions all new dwellings to be built along the sewer route are to be founded upon bored piles. The sewer lies around 25m depth below ground level, within the underlying mudstone. These piles should be bored and installed as specified by the piling contractor.

Pile lengths are expected to vary between 14 and 17m below final ground level following completion of earthworks on site.

3.2 Potential Pollution Linkages

The Environment Agency publication 'Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention (2001)' was consulted.

The Environment Agency has identified six possible pollution linkages (scenarios):

- **Pollution scenario 1:** Creation of preferential pathways through a low permeability layer (aquitarde), to allow potential contamination of an aquifer
- **Pollution scenario 2:** Creation of preferential pathways, through a low permeability surface layer to allow upward migration of landfill gas, soil gas or contaminant vapours to the surface
- **Pollution scenario 3:** Direct contact of site workers and others with contaminated soil arisings which have been brought to the surface
- **Pollution scenario 4:** Direct contact of the piles or engineered structures with contaminated soil or leachate causing degradation of pile materials
- **Pollution Scenario 5:** The driving of solid contaminants down into an aquifer during pile driving
- **Pollution scenario 6:** Contamination of groundwater and nearby surface waters by concrete, cement paste or grout

3.2.1 Pollution Scenario 1

Creation of preferential pathways through a low permeability layer (aquitard), to allow potential contamination of an aquifer

Upon development the ground conditions beneath the site will comprise imported fill of approximately 2.5 – 2.75m thickness, underlain by made ground of up to 3.3m in thickness, further underlain by alluvial clays to an approximate depth of between 8.5m and 13m below finished ground level. Below this depth red brown gravelly clay prevails, grading into weathered red mudstone (St Maughan's Formation) between approximately 12.5m to 15.5m depth below finished level. Intermittent and laterally inconsistent bands/lenses of sand and gravel and/or peat feature within the alluvial clay, of varying depths and thicknesses.

This scenario considers the risk of migration of contaminated groundwater being transferred to the underlying St Maughan's Formation mudstone Secondary A Aquifer.

Investigative works found no perched groundwater within the made ground. Groundwater present site is confined to isolated bands of sand and gravel and the level of any contamination is considered very low. The groundwater is not in hydraulic continuity with the River Usk.

Precast piling is a displacement method, and due to significant stresses applied on soils during the process of driving these piles creation of preferential flow paths around the outside of the piles does not occur. In its publication 'Piling in Layered Ground: Risks to Groundwater and Archaeology' the Environment Agency state that square piles would 'be expected to seal when driven through a sufficient thickness of clay, that is, a thickness of two pile diameters. Although variable in thickness, and interrupted by bands of peat or granular deposits the alluvial clay is persistent across the site and it is considered that an adequate seal will be created between the piles and clay deposits.

Along the route of the trunk sewer bored piles are to be installed. This method involves boring a hole and its subsequent replacement by the pile. The pile is typically formed by casting concrete in situ. During drilling steel casing of the bored hole will be required to prevent collapse of the soft alluvial clays. This will be removed following pouring of the concrete pile.

The casing used during boring will act to minimise any downward flow of groundwater from the granular deposits. In addition, once the piles are concreted, as with the precast piles, it is considered that an adequate seal will be created between the piles and clay deposits.

3.2.2 Pollution Scenario 2

Creation of preferential pathways, through a low permeability surface layer to allow upward migration of landfill gas, soil gas or contaminant vapours to the surface

In-situ gas monitoring has identified a risk from ground gas on site in relation to the underlying peat and gas protection measures comprising a gas membrane, passive under-floor venting and taping and sealing of joints will be installed in all new housing.

The action of piling through the underlying peat deposits will potentially open up preferential gas pathways. However, it is considered that the alluvial deposits will seal around the piles closing these pathways.

As a precautionary measure further gas assessment is to be performed following completion of fill works to ensure the intended level of protection is adequate. This will entail monitoring of flux boxes placed across the site both immediately after fill completion and during/following piling. The frequency and sampling locations will be considered once the piling schedule has been determined.

Gas monitoring results will be assessed in accordance with CIRIA Report C665.

Should further monitoring identify concentrations of methane and/or carbon dioxide and flow rates beyond 'gas characteristic 2' criteria then more robust protection measures will be necessary.

In accordance with Table 8.6 of the CIRIA report, potential further protection measures could include:

- Proprietary gas resistant membrane
- Positively pressurised underfloor sub-space
- In-ground venting and venting wells

3.2.3 Pollution Scenario 3

Direct contact of site workers and others with contaminated soil arisings which have been brought to the surface

Installation of precast concrete piles is a displacement method will not bring site workers into contact with soil arisings.

Installation of bored piles will involve removal of materials from each pile location, bringing arisings to the surface.

The made ground and overlying imported fill are considered to be contaminated in terms of human health.

However, site construction workers are deemed to be at very low risk from the identified contaminants given that any exposure time would be comparatively, to how the trigger levels are derived, exceedingly short. Furthermore, these very low risks may be mitigated through good site management, COSHH, good standards of hygiene and appropriate health & safety on site, with personal protection equipment (PPE) and dust suppression where appropriate.

3.2.4 Pollution Scenario 4

Direct contact of the piles or engineered structures with contaminated soil or leachate causing degradation of pile materials

Soil and groundwater sulphate and pH results are summarised in **Table 3.1** below.

Table 3.1 Soil and Groundwater Sulphate and pH Results				
Soil Sulphate Concentrations (mg/kg)	Soil pH	Aqueous sulphate concentrations (mg/l)	Groundwater sulphate concentrations	Groundwater pH
Site Investigation				
200 - 2500	8.2 – 11.8	160		
			4.4 – 120	6.9 – 7.4
2014 Groundwater Monitoring				
			2.9 - 70	7.0 – 7.4
2015/2016 Groundwater Monitoring				
			9.8 - 120	6.7 – 7.8

With reference to Table C2 of BRE Special Digest 1:2005, Design Sulphate Class DS-1, ACEC Class AC-1 should be applied.

Provided the concrete used for the piles is the correct class there is negligible risk of pile degradation and consequential increase in pile permeability, void formation, creation of contaminant migration pathways and obviously structural performance/safety.

3.2.5 Pollution Scenario 5

The driving of solid contaminants down into an aquifer during pile driving

Contamination was identified within the made ground. Limited contamination was also identified in the imported fill.

Along the route of the trunk sewer bored piles are to be installed. All arisings from boring are brought to the surface and removed. There is therefore no opportunity for contaminated soils to be driven downwards into the underlying aquifer.

With regards to the precast concrete piles publication 'Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination' states that 'Driven displacement piles may drag down contaminated material as they penetrate underlying strata. This drag down may occur by a frictional mechanism along the shaft of the pile, or by pushing material ahead of the pile shoe. However, geotechnical research on driven piles has shown that the magnitude of these effects is normally low.'

The publication also noted 'Boutwell et al (2000) suggest that the use of a pointed or convex shoe should reduce the volume of material being pushed down ahead of the pile by between 1 and 3 orders of magnitude.'

The use of a pointed or convex shoe is therefore considered necessary during installation of the precast concrete piles.

3.2.6 Pollution Scenario 6

Contamination of groundwater and nearby surface waters by concrete, cement paste or grout

The bored pile method involves the casting of concrete directly against soil and there is the potential for leaching of wet concrete, cement paste or grout into fast flowing groundwater.

Limited groundwater is present beneath the site, and it is confined to laterally inconsistent bands/lenses of granular deposits. Groundwater flow beneath the site is therefore minimal.

The risk of pollution via this scenario is considered to be negligible.

Contractors should provide a method statement detailed measures to mitigate the risk of concrete spillage.

Driven piles are pre-fabricated off-site and thus do not pose a risk of wet concrete.