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CIVIL, STRUCTURAL, GEOTECHNICAL, TRANSPORT

Karl Baxter

Harwood St, Darwen

Phase 2 Geo-environmental Investigation & Assessment

G1320-R-01

2 September 2010

PSA Design Limited
The Old Bank House
6 Berry Lane
Longridge
Preston PR3 3JA

Tel. 01772 786066
Fax. 01772 786265

www.psadesign.co.uk
mail@psadesign.co.uk

Document Control Sheet

Harwood Street, Darwen

Phase 2 Geo-environmental Investigation & Assessment

Job	Date	Issue	Copy
G1320	*2 September 2010*	*G1320-R-01-o*	

Originator…….. Dr JS Birtwhistle BSc PhD FGS CGeol MBGA

Checker…….. DL Wallbank BEng CEng MICE

Approver…….. Dr JS Birtwhistle BSc PhD FGS CGeol MBGA

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1.0 PREFACE

The site is located off Harwood Street, Darwen, located within the western outskirts of Darwen Town Centre. (NGR 368560 422680). Site occupies an area of approximately 0.14 hectares.

PSA Design were commissioned by the *Karl Baxter* to provide a Phase 2 Geo-environmental Investigation & Assessment of the site, following the initial desk study carried out by Worms Eye (ref DL/BB31PD/08 (25th September 2008) and ground investigation by Mini-Bore Site Investigation (22nd October 2008). It is understood that consideration is being given to the redevelopment of the site for *residential* housing. A development layout plan has been provided, which is included in this report as Drawing No. G1320-G-03.

PSA Design's investigation included a review of the desk study and initial ground investigation. A summary of salient geo-environmental issues is provided in the table below.

Issue	**Remarks**
Former uses	Former uses of site have included residential building structures until a recent demolition and removal.
Hazardous Gas	The potential presence of fill in local areas surrounding the site represents a low/moderate risk of ground gas generation as well as peat deposits. Therefore, in accordance with CIRIA C665, and in view of the nature of the residential development, six gas monitoring visits were undertaken over a three month period. The results show that no gas protection measures are required for the development.
Mining & Quarrying	No evidence of coal seams or workings in the vicinity of the development. No quarrying in the vicinity of the development.
Flooding & Drainage	The site does not lie within an Environment Agency Flood Plain and is not likely to flood in extreme flood events. Site drainage is likely to enter the existing drainage network.
Ground Investigation	Intrusive investigation comprising window sampler boreholes across site, with gas/groundwater monitoring installations. Chemical and geotechnical soils analysis, with subsequent gas and groundwater monitoring.
Ground Conditions	Ground conditions varied across the site with varied thicknesses (and types) of made ground encountered. Underlying the made ground was a thin layer of soft-firm CLAY (alluvial deposits), overlying medium dense SAND (glacial deposits). The sand was underlain by a firm to stiff CLAY (glacial till). In one borehole (BH 1) MUDSTONE was encountered. Perched groundwater at 2.0-3.0mbgl.
Contamination	General upper surface fill materials show slightly raised levels of lead, arsenic and benzo-a-pyrene contamination, with potential impact upon construction workers, water supply pipes and residents.
Preparatory Works	Site clearance with vegetation removed prior to construction. Breaking up of remaining hardstand across the site. Excavation and screening of localised Made Ground across the site to remove relic structures and oversized materials, which may present obstruction to foundations of proposed buildings. Earthworks cut/fill exercise to create final landform.
Anticipated Foundation Solutions	Piled foundations or deep trench footings to competent bearing strata are anticipated to be the most economic foundation solutions across the site for the proposed residential buildings, subject to structural design assessment.
Recommendations for Remediation	Remediation Strategy required covering: Utility trenches for water pipes through raised As, Pb & PAH levels, sterile Garden areas in contaminated soils affected areas should use cover system/or remove contaminated materials.

At this stage, anticipated significant developer abnormal costs relating to geo-environmental issues at the site are:

- Grubbing up of remaining hardstand across the site
- Removal of relic structures, crushing of hard materials and possible re-engineering of fill materials for shallow foundations and highways,
- Capping of proposed gardens in southern area with uncontaminated subsoil/topsoil, possibly re-used from site won sources.
- Removal and treatment/disposal of localised contaminated soils.

2.0 INTRODUCTION

2.1 *Terms of Reference*

2.1.1 PSA Design were commissioned by *Karl Baxter* to carry out a Phase 2 Geo-environmental Investigation & Assessment of land off Harwood Street, Darwen.

2.1.2 The agreed scope of works included:

- Borehole investigation to sink two gas well installations following initial ground investigation works in 2008.
- Assessment of anticipated ground conditions, including potential contaminants
- Assessment of gas risk through monitoring over an agreed period
- Assessment of anticipated foundation and engineering issues associated with redevelopment for a *residential* end-use

2.2 *Proposed Development*

2.2.1 It is understood that consideration is being given to the redevelopment of the site as two semi-detached, split-level residential properties with front & rear garden areas.

2.2.2 A development layout plan has been provided, which is included in this report as Drawing No. G1320-G-03.

3.0 SITE DESCRIPTION

3.1 *General*

3.1.1 The site location is shown on Drawing Number G1320-G-01. Site details are summarised in the Table below. Current site layout plan shown in Drawing Number G1320-G-02. The site is situated at a high altitude on the upper areas of Darwen on a relatively steep hill, falling SW-NE.

Detail	Remarks
Location	Within western outskirts of Darwen, in Sunnyhurst area
Address	Harwood Street, Darwen, Lancashire. BB3 1PA.
NGR	368550 422670
Area	0.02 ha
Known services	To date, no services plans have been made available.

3.2 Site Features

3.2.1 A PSA Design Engineer completed a walkover survey of the site on *19th May 2010* and the salient features are presented below.

3.2.2 The site is currently vacant and has been partially cleared for the construction phase. Shed and caravan on site.

3.2.3 Patchy scrub grass vegetation within site, generally growing over granular hardstanding surface materials. Various hedges including conifer along borders.

3.2.4 Ground falling steeply to NE (4.5m drop over approximately 20m), partially terraced on site.

3.2.5 Existing salient features are summarised in the Table below and shown in Drawing Number G1320-G-02.

Feature	Remarks
Current Access	off Harwood Street.
Topography	Steeply falling to SE, with some terracing.
Approximate areas	228 m^2 – partially stripped land.
Nature of boundaries	N, W & S areas surrounded by hedges/ wooden fencing.
Surrounding land uses	North, South, West & East – Residential.

3.3 Site Operations

3.3.1 Current site operations are empty site, partially cleared for development and not therefore considered to represent a significant source of ground contamination.

4.0 HISTORICAL SITE INFORMATION

4.1 The desk study, completed by Worms Eye, states that the site was developed as terraced housing along Harwood Street, presumably No.89 between 1849 and 1894. At some point between 1911 and 1930 a garage/outbuilding was constructed within central area of site which by 1987 had been demolished. No. 89 terraced house demolished between 1987 and 1993. The history of the surrounding area can be summarised as residential and Mill construction (including reservoirs) at the turn of the twentieth century with a later garage area constructed (downhill) to the north of the site in the 1980's. Subsequently many houses and Mills have been demolished, with reservoirs infilled to the north of the site.

5.0 GROUND INVESTIGATION

5.1 Introduction

The proposed ground investigation was designed to assess the contamination and geotechnical risks for the proposed residential development at Harwood Street, Darwen and to take into account the findings of the previous ground investigation that was conducted in 2008.

5.2 Previous Ground Investigations

The following investigation has been undertaken by Mini-Bore Site Investigation in 2008.

- Harwood Street, Darwen (Mini-Bore Site Investigation, October 2008) Site investigation factual logs comprising 2x window sampler boreholes to varying depths (5.4-7.0m), installation of gas/groundwater standpipes in both wells (BH1 & BH2) with no chemical testing or gas monitoring.

5.3 Review of Findings of Investigations

5.3.1 Reviews of the site investigation undertaken within the site area suggests that there is a varying superficial made ground cover overlying sand & clay (approximately 1-2mbgl deepening to the NE).

5.3.2 Made ground materials varied from gravelly clays to lenses of granular materials, in particular ash & clinker, with sporadic inclusions of pottery, glass, wire, wood etc. The clay (encountered only in the SW) was described as sandy-gravelly clay with brick fragments (no shear value recorded). The granular fill material was described as a mixture of soil, clay and fragments of brick, cobbles and ash as well as rare glass. The underlying natural soils consisted of soft-firm clays, overlying loose, becoming medium dense sands overlying firm becoming stiff clays to the end of the bore, with mudstone encountered at 4.9mbgl in BH1 but not in BH2 (down to 7m), which terminated in stiff clay. Drilling refused within the mudstone. Groundwater was noted at 1.5mbgl (BH1) and 3.5mbgl (BH2).

5.3.3 No foundation recommendations were given following the ground investigation.

5.3.4 No chemical testing was carried out during the investigation.

5.3.5 Although gas wells were installed (BH1-4.7mbgl, BH2-6.0mbgl), no gas/groundwater monitoring was carried out on the site.

5.4 PSA Design Ground Investigation 2010

5.4.1 In addition to the above work previously undertaken on the site, PSA Design conducted the following additional work:

- Intrusive investigation of ground conditions beneath the site, to include excavation of targeted boreholes for additional sampling
- Chemical and geotechnical analysis of soils beneath the site

- Monitoring of groundwater and gas regimes across the site.

5.4.2 *Summary*

A ground investigation was undertaken to compliment and add to the original investigation in 2008 and assess the ground conditions at the site in preparation for the proposed return of the site to a *residential* end-use. The investigation consisted of a borehole drilling, followed by chemical testing of representative samples and gas monitoring over a three month period. Ground conditions varied across the site with varied thicknesses (and types) of made ground encountered. Underlying the made ground was a thin layer of soft-firm CLAY (alluvial deposits), overlying medium dense SAND (glacial deposits). The sand was underlain by a firm to stiff CLAY (glacial till). In one borehole (BH 1) MUDSTONE was encountered. Testing showed minor evidence of contamination isolated within the made ground materials within the site.

5.5 Fieldwork

5.5.1 Objectives

5.5.1.1 To determine the general nature of the soils underlying the site, including the thickness and type of any made ground.

5.5.1.2 To assess the nature of the fill materials, in particular any risk of contaminated materials.

5.5.1.3 To recover soil and groundwater samples for both chemical and geotechnical analysis.

5.5.1.4 To assess the density and strength of natural soils on the site.

5.5.1.5 Establish the potential for soil gas generation and migration through monitoring wells.

5.5.1.6 Identify and assess groundwater quality and flow regime through installation of monitoring wells.

5.5.2 Scope of Works

5.5.2.1 Fieldwork was carried out in one phase, drilling on the 19th May 2010. The fieldwork was supervised by PSA Design. The exploratory holes are listed in the following table.

Technique	Date	Exploratory Holes	Final Depth(s) & Location	Remarks
		Logs in Appendix A	*Ground Investigation Plan (Drg G1320-G-06)*	*Lab Testing in Appendix B.*
Window Sample Boreholes	19/05/10	2WS1	2.00mbgl [SW area]	General ground conditions, sampling for lab testing, in-situ testing & monitoring well installation.
		2WS2	3.50mbgl [NW area]	General ground conditions, sampling for lab testing, in-situ testing & monitoring well installation.
		2WS3	2.00mbgl [E area]	General ground conditions, sampling for lab testing, in-situ testing & monitoring well installation.

The exploratory holes are presented in Appendix A. The records provide descriptions, in accordance with BS 5930 (1999), of the materials encountered and details of the samples taken, together with observations made during drilling and pitting.

5.5.2.2 A total of 3No. boreholes were sunk across the site (2WS1-3) to depths of between 2.00-3.40mbgl using a window sampler rig. Detailed logs are presented in Appendix A.

5.5.3 Soil Descriptions, In-situ Testing and Sampling

5.5.3.1 The soils encountered during this investigation have been logged by a Chartered Geologist in accordance with BS5930:1999 “Code of Practice for Site Investigation”.

5.5.3.2 During excavation representative samples were taken at regular intervals, to assist in the identification of soils and allow chemical testing to be programmed.

5.5.3.3 Geotechnical in-situ testing of the materials encountered was undertaken using a Geonor H-60 Vane for measuring shear strength values.

5.5.4 Exploratory Hole Locations

5.5.4.1 Exploratory hole locations were selected to provide a representative view of strata beneath the site and are shown on Drawing No. G1320-G-06.

5.6 Ground Conditions

5.6.1 Geological Summary

The ground conditions encountered within the exploratory pits at the site have been compiled and reviewed. They can be described in terms of the given lithologies (based on published geological data) and are discussed in the subsequent paragraphs. The lithologies encountered during this investigation are summarised in the following table;

Table 5.1 Geological Summary

Lithology	Depth (m) to base below current ground levels	Thickness (m)
Made Ground (Mixed gravel/soils/clays - Construction Waste Fill)	0.0-1.6	0-0.85
Made Ground (Reworked Cohesive Fill)	0.0-0.9	0.0-0.4
Made Ground (Granular fill with ash and clinker)	0.0-0.85	0.0-0.70
Made Ground (Granular fill with ash and clinker- Demolition Fill)	0.0-0.1.6 (NW area only)	0.0-1.6
Topsoil	0.05-0.2	0.05-0.2
Soft-firm grey CLAY with organic inclusions (Alluvial Deposits)	0.0-1.9	0.0-0.7

Loose-medium dense clayey SAND (Glacial Deposits)	Undetermined, at least to 3.4	0.0-1.5
Firm becoming stiff sandy CLAY (Glacial Till)	Undetermined, at least to 7.00	1.2-3.6
MUDSTONE (Millstone Grit Series)	Undetermined, at least to 5.40	0.0-0.5
Groundwater Entries	Minor seepages in BH1&2 [water levels: 1.5-3.5mbgl], 2WS1-3 dry.	
Groundwater Levels (mbgl)	[(2.85-2.3 BH1), BH2 - 4.5 becoming dry over monitoring period]	

5.6.2 Made Ground

5.6.2.1 Made ground was encountered in all 5No. exploratory holes during the course of the two ground investigations.

5.6.2.2 The thickness of made ground was found to vary from 0.65m (borehole 2WS3) to a maximum of 2.45m in borehole 2WS2. The deeper areas of fill occur within the NW areas of the site where the ground surface is raised compared to the general slope (associated with historic house demolition).

5.6.2.3 Four distinct types of made ground material was observed within the fill materials:

- Construction waste – mixed cohesive and granular materials with fragments of glass/pottery/plastic
- Granular fill – brick/concrete gravel fragments with ash and clinker
- Cohesive Fill – reworked clay
- Mixed demolition waste- mixed cohesive and granular materials with ash & clinker

5.6.2.4 The construction waste fill was generally made up of a soil/clay/gravel mixture. In addition, various descriptions included, minor amounts of brick, ceramics, coal, wood, ash&clinker, metal and plastic. The fill was generally loose. Within all the exploratory holes recorded, no observations of visual or olfactory contamination were noted.

5.6.2.5 The granular fill was generally made up of loose brown ash & clinker with concrete, stone and brick fragments and found across the site.

5.6.2.6 Cohesive fill was present on site, generally sandy clay with brick fragments.

5.6.2.7 Within the NW raised area was a layer of demolition waste fill, generally made up of a soil/clay/gravel mixture. In addition, various descriptions included, minor amounts of brick, large cobbles, ash&clinker and glass.

5.6.3 *Natural Soils*

Topsoil

5.6.3.1 Topsoil was encountered in all five boreholes. The topsoil generally encountered was described as turf overlying soft black clayey TOPSOIL. The topsoil was between 0.05-0.2m thick, generally 0.1m thick.

Alluvial Clay (soft-firm)

5.6.3.2 The alluvial soft clay was encountered in 4No. of the exploratory holes, underlying the made ground. The material was described as soft to firm grey-light brown sandy CLAY with organic inclusions. The material was encountered from 0.70m to a maximum depth of 1.90mbgl. The thickness of this deposit, where encountered varied from 0.20-0.70m.

Glacial Sands

5.6.3.3 Sand was encountered in three out of five exploratory boreholes (BH1, BH2 & 2WS1) underlying the topsoil/made ground/alluvial deposits. The deposit was generally described as loose to medium dense, brown, slightly clayey, gravelly medium SAND. The full extent of the sand was not found due termination of drilling. The thickness of the deposit, where present varied from at least 0.40m to 1.50m.

Boulder Clay (firm-stiff)

5.6.3.4 The brown *firm* (becoming stiff with depth) gravelly clay was encountered in 4No. exploratory holes, underlying the glacial sands. The material was described as firm becoming stiff brown slightly gravelly (occasionally sandy) CLAY. The material was encountered from 0.90m to a maximum depth of 7.00mbgl. The thickness of this deposit, where present varied from 0.90-3.60m.

5.6.3.5 Mudstone

Hard brown MUDSTONE was encountered in only one (BH1) borehole at a depth of 4.9mbgl, with thickness of 0.50m.

5.6.4 Groundwater

5.6.4.1 During the 2008 ground investigation groundwater was encountered within both boreholes (BH1& BH2), noted as a slight seepage (depths 1.50-3.50mbgl). No groundwater was encountered during the 2010 ground investigation.

5.6.4.2 Water level results over the 3 month monitoring programme show that although initially both boreholes recorded water levels, further visits recorded BH2 being dry. BH1 water levels ranged from 2.30 to 2.85mbgl within the monitoring period.

5.6.4.3 It can be interpreted that the localised perched groundwater within the site is due to the water sitting within the glacial sands, contained by cohesive materials (boulder clay) beneath, which prevent the groundwater from percolating away through the sands.

5.6.5 Stability

5.6.5.1 Boreholes were generally recorded as unstable in the topsoil and made ground deposits during the ground investigation.

6.0 GEOTECHNICAL TESTING & ASSESSMENT

6.1 Introduction

Selective strata was investigated to gain geotechnical parameters of the ground conditions using the in-situ testing techniques of standard penetration tests (SPT's) and hand shear vanes, in accordance with BS 1377:1990. Furthermore, sulphate and chemical testing was carried out to aid concrete design.

6.2 In-situ Testing

6.2.1 9No. Standard Penetration Tests (SPT's) were carried out in the two original boreholes (BH1 & 2), within the made ground, glacial sands and boulder clay. These were carried out to provide data for estimating the maximum safe bearing capacities of the likely foundation stratum. Detailed results are tabulated in the borehole logs (Appendix A).

6.2.2 One CPT value for the made ground was recorded, N =12 blows for 300mm of penetration. SPT values (3No.) for the sands ranged from N =8-14 blows for 300mm of penetration. The results were generally about N=11 for the sand deposits. The SPT values (5No.) for the boulder clay ranged from N =7-33 blows for 300mm of penetration, increasing with depth. The final SPT in BH1 terminated within the mudstone, hence the high value of N=33.

6.2.3 12No. Hand Vane tests were carried out in the cohesive fill, alluvial clay and glacial till deposits. The tests were carried out on both disturbed and undisturbed samples. Detailed results are tabulated in the logs (Appendix A).

6.2.5 Shear strength results for the cohesive fill ranged 40-50kPa, alluvial clay ranged from 58-65kPa and the boulder clay values ranged from 45-80kPa.

6.3 Sulphate and PH

6.3.1 The concentration of water soluble sulphate (SO_4) was determined on samples of the natural soils. The results have been assessed in accordance with BRE Special Digest SD1; Concrete in Aggressive Ground, 2005.

6.3.2 Results of the 5No. samples are detailed in Appendix B. The sulphate values ranged from 310-2000 mg/kg. The upper limit for total sulphate in Design Sulphate Class 1 (DS - 1) is 0.24 %, which is equivalent to 2,400 mg/kg. The results would suggest that the materials tested lie within the Class DS-1 limit.

6.3.3 Soil pH values ranged from 7.8-8.3 indicating relatively neutral conditions. The site can be described as *brownfield location* with *mobile* groundwater conditions.

6.3.4 Therefore, the 'Aggressive Chemical Environment for Concrete' (ASEC) class for the site is considered to be *AC-1* and design/mix of buried concrete should be undertaken in accordance with these classifications.

6.4 *Foundation Construction*

6.4.1 The Made Ground material and alluvial deposits varied in thickness across the site and are not a suitable foundation stratum.

6.4.2 The upper parts of the glacial sands and boulder clay are not considered to be a competent founding stratum. The underlying medium dense sand and stiff boulder clay and mudstone are considered to be a competent founding stratum.

6.4.3 Due to the extent of fill materials and alluvial deposits encountered during the investigation of the site, and the steep slope it is recommended that the building foundations for the development be taken down on to the medium dense sands stratum or stiff clay or mudstone (of sufficient extent and thickness). The glacial till underlying the sand had shear strength values of approximately 80kPa, which would equate to an allowable bearing capacity of 130 kN/m^2. The medium dense sands with 'N' values of 10 would give an allowable bearing capacity of 110 kN/m^2, with the mudstone giving an allowable bearing capacity of >200kPa. Care should be taken to avoid differential settlement by founding within the same stratum.

6.4.4 A suitable foundation design requires the input of a structural engineer to assess the impact of the loads of the building on the ground conditions described in this report. Our basic recommendation (which needs verification from the structural engineer) would comprise trench fill with a lightly reinforced concrete strip footing or piled foundations founded within the denser sands or stiff clay/mudstone. The trench fill should be at least 600mm wide and comprise C20 mass concrete. A suitable piled foundation design requires the input of a specialist piling contractor to enable the most economic design solution to be constructed, combined with liaison with the structural engineer to assess the impact of the loads of the building on the ground conditions described in this report. The piling contractor should take account of the likely obstructions within the Made Ground when designing the piling scheme.

6.4.5 Floor slabs will need to be suspended.

6.5 Road Pavement Construction

6.5.1 The topsoil, made ground and alluvial deposits should not be used as sub formation material. Reference should be made to the relevant highways specification for the thickness and type of pavement and surfacing detail. The underlying brown sand and stiff clay is considered to be a competent founding stratum.

6.5.2 It is considered that excavation of a suitable thickness of the Made Ground and replacement with suitable aggregate in accordance with Series 600 (Earthworks) of the Department of Transport (DoT) "Specification for Highway Works" 1998 would be suitable for road construction. Approval should be sought from the local Highways Department prior to road construction (for adoption purposes).

6.5.3 For new road pavement construction design should be based upon CBR values of sub-grade strata. These strata are likely to be natural glacial soils, either sands or possibly a stiff clay within about 1.0m below current site levels. The preliminary design of new pavement at the site should be based on an indicative CBR Value of 2-5%. The design CBR value should be investigated further by appropriate, insitu testing at formation prior to construction

6.5.4 Notwithstanding, the formation should be proof-rolled prior to pavement construction and any weak or hard zones thus identified should be excavated out and replaced with engineered granular fill.

6.6 Earthworks

6.6.1 The topography of the site is a relatively steep slope, with re-grading potentially required to tie in with the exterior highway levels of the highway to the S and E of the site.

6.6.2 Should materials be exported from site, the materials should be disposed of according to current waste disposal legislation.

6.6.3 Arisings consisting of the brown sand or stiff clay from the construction of the building and pavement are suitable for re-use as fill materials or landscaping around the site.

6.6.4 The construction method statement should take account of compaction requirements of the appropriate highways specification for a granular material. The other in-situ materials (made ground and alluvial deposits) would appear not to be a suitable classification for use as an engineered fill.

6.7 Excavations & Groundwater

6.7.1 Excavations at the site should be feasible using an appropriate scale of hydraulic plant. However, as previously described, underground obstructions could be encountered and breaking techniques would be required for their removal to an appropriate depth, particularly in the footprint of the new structures, and beneath new external areas of hard-standing.

6.7.2 All excavations will require adequate lateral support to ensure their stability and a suitably designed dewatering system.

6.7.3 The majority of the site consists of Made Ground and alluvial material to depth. Recorded groundwater levels tended to be at 2.00-3.00mbgl, perched and localised. Allowance for temporary shoring should be made for excavations for drainage emplacement.

6.7.4 Consideration should be given to the in-situ strength of the soils within the upper levels of Made Ground when designing the drainage infrastructure for the site. If bearing capacities

of the Made Ground at placement level are found to be insufficient then trenches may need to be overdug and reinstated with compacted granular materials in order to achieve a suitable bearing surface.

6.7.5 Due to the risk of long term settlement within the deeper fill/alluvial deposits areas, allowance should be made for the design of flexibility within the services pipes/cables to avoid differential settlement causing failure/fracture.

6.7.6 It is recommended that the developer contact United Utilities Water Services to capacity in existing foul and surface water sewers in the vicinity of the proposed development area.

7.0 CONTAMINATION RESULTS & ANALYSIS

7.1 Introduction

The 2010 Ground Investigation by PSA Design was conducted to develop the understanding of the extent of the contamination. The PSA Design investigation encountered a mixture of results with some evidence of contamination within a localised area of the site. Chemical testing results are presented within Appendix B.

7.2 Chemical Analysis

7.2.1 In view of the site history, selected soil samples were taken during the ground investigation and were analysed for a screening suite. On the basis of the Conceptual Environmental Risk Model, it has been considered that a range of potential contaminants could exist in soils at the site, as follows:

- Elements which could pose a risk to human health and/or controlled water: arsenic, cadmium, chromium, lead, mercury, nickel , selenium;
- Potentially phyto-toxic elements: boron, copper & zinc;
- Inorganic chemicals which could pose a risk to human health, buildings and/or controlled water: cyanide, nitrate, sulphate & sulphide;
- Other inorganic contaminants: pH conditions;
- Organic contaminants: Polynuclear Aromatic Hydrocarbons (PAH's with split of 16 priority EPA PAH's);
- Total Petroleum Hydrocarbons.

7.2.2 Samples from the ground investigation were chemically tested at Envirolab Laboratories Ltd, a UKAS accredited laboratory.

7.2.3 Chemical testing was targeted at all the various surface strata identified within the ground investigation that would be deemed a threat to human health. This could be broken down into the following:

- Made Ground-Mixed fill
- Made Ground- Cohesive fill

7.2.4 Sample selection criteria for chemical testing included good coverage of the site area at various depths and lithologies. The samples to volume ratio reflected not only the spatial element of the various compositions of the ground but also represented the %composition of the particular lithological fill type in the total volume of the most recent fill, situated in the site. The sampling was in accordance with BS 10175:2001, Investigation of potentially contaminated sites- Code of Practice.

7.2.5 The PSA Design investigation took 5No. soil samples obtained from the site, were tested in total with 5 No. analysed for the following suite of chemical determinands:

- Arsenic, cadmium, chromium, lead, mercury, nickel, selenium
- Boron (water soluble), copper, zinc

- Cyanide (total)
- Sulphide (acid soluble)
- Nitrate (soluble)
- Phenol (total)
- Total PAH's (speciated)
- Sulphate (water soluble, 2:1 extract)
- pH conditions
- Total Petroleum Hydrocarbons

7.2.6 The analytical results of the chemical testing undertaken are presented in Appendix C.

7.3 Current Guidance on Interpretation of Analytical Data

7.3.1 The UK approach to contaminated land is based upon the principles of risk assessment. This in turn is founded upon the use of so called source→pathway→receptor/target principles in order to establish the presence, or potential presence, of a pollutant linkage.

7.3.2 PSA Design adopts a tiered approach to risk assessment that is consistent with UK guidance. The initial step (tier 1) is the comparison of site data with published guidance levels or remedial targets. In March 2002 DEFRA and the Environment Agency published a series of technical research papers (R&D Publications CLR7,8,9 &10) introducing a new approach to the assessment of risk to human health from land contamination. This research includes the development of the new CLEA model and the Soil Guidance Values (SGV's).

7.3.3 Currently, these guidelines only address seven contaminants and the development of both the CLEA model and additional SGV's is ongoing. Where published, SGV's have been utilised as intervention values for the purpose of a Tier 1 assessment.

7.3.4 For chemical determinants that have yet to have an SGV published alternative literature guidance sources have been used to create a generic assessment criteria (GAC). These sources are as follows:

- LQM Ltd (2009) *Generic Assessment Criteria for Human Health Risk Assessment (2nd Edition)*
- ICRCL (1987) *Guidance on the Assessment and Redevelopment of Contaminated Land Note 59/83* (Landscaped/buildings), DoE
- BRE (2005) *Concrete in Aggressive Ground* BRE Special Digest SD1

7.3.5 The potential risk to building material is considered through reference to relevant BRE Digests, with particular emphasis on BRE Special Digest SD1, 2005: "Concrete in Aggressive Ground".

7.3.6 Tier 1 groundwater risk assessments are undertaken by comparing leachate concentrations with the appropriate water quality standard. Depending upon the specific characteristics of the site, the appropriate standard may be one of the following:

- Water Supply (Water Quality) Regulations, 1989
- Environmental Quality Standards (for freshwater)
- The surface Waters (abstraction for drinking water) Regulations
- United Utilities (water supply pipes) Trigger and Action Levels for inorganic and organic contaminants.

7.3.7 Since the withdrawal of the ICRCL values in December 2002, there has seemingly been no direct reference for the assessment of potential phyto-toxic effects of contaminants. PSA Design continue to use the former ICRCL values for copper, nickel and zinc as the withdrawal was in relation to human health implications.

7.3.8 Should any Tier 1 criteria-in terms of human health, environment and groundwater be exceeded, then two courses of action are available. The first is to 'break' the pollutant linkage by recommending an appropriate level of remedial action – removal of contaminated material for example. The alternative approach is to carry out a detailed risk assessment in order to determine whether contamination risks actually exist.

7.4 Contamination Results

7.4.1 The analytical results certificates are presented in Appendix B. Statistical analysis has been carried out on each sample as presented in Appendix C.

7.4.2 The preliminary screening process has been compared with the relevant SGV's and GAC's for a *residential* end land use, as the most suitable equivalent for the proposed development.

7.4.3 The *residential* development will be predominantly covered with associated hard standing, but with some landscaping/garden zones at the rear and front of the properties.

7.4.4 For the proposed *residential* area within the site, four samples of Made Ground (borehole 2WS1-3) exceeded US_{95} concentrations for three of the CLEA deteminands by the statistical analysis. The three determinands were arsenic, lead and benzo-a-pyrene. The other sample was clear of contamination.

7.4.5 The chemical testing has confirmed that for the *residential* development there is some risk from contamination, however the relatively low values encountered, above threshold levels within the chemical testing analysis (and small shallow extent of the contaminated material) would suggest that a suitable simple remediation strategy could be adopted to alleviate the risks.

8.0 GAS TESTING & ASSESSMENT

8.1 Introduction

8.1.1 In order to characterise the ground gas regime and to obtain information on the groundwater conditions beneath the site, 2No. monitoring wells (BH1 & BH2) were monitored across the site during the ground investigation.

8.2 Scope of Works

8.2.1 The wells have been monitored on 6No. visits, undertaken between May and August 2010, following installation of the standpipes.

8.2.2 A standard procedure was followed in accordance with CIRIA guidance; this procedure involved measurement, in the following order of:

- Atmospheric temperature, pressure and ambient oxygen concentration on site immediately prior to and on completion of, monitoring
- Weather conditions
- Emission rate using a GA5.3 flowmeter
- Methane, oxygen and carbon dioxide concentrations using a Geotechnical Instruments GA94 infra-red gas analyser
- Measurements of peak and steady state concentrations of these gases were recorded via the standpipe gas valve over a time period of at least 180 seconds
- Standing water level using a dipmeter.

8.3 Current Guidance

8.3.1 Current guidance for the assessment of risk associated with the presence of methane and carbon dioxide within ground gas is provided by two recent publications; the NHBC *"Guidance on Evaluation of Development Proposals on sites where Methane and Carbon Dioxide are present"* and CIRIA Report C665 *"Assessing risks posed by hazardous ground gases to buildings".* These reports have developed from previous publications such as :

- BS8485:2007 "*Code of Practice for the characterization and remediation from ground gas in affected developments"*
- Waste Management Paper 27
- BRE Report 212 *"Construction of new buildings on gas-contaminated land"*
- CIRIA Report 149 "*Protecting Development from methane"*
- CIRIA Report 152 "*Risk assessment for methane and other gases from the ground"*
- CIRIA Report 150 "*Methane investigation strategies*"
- Wilson & Card, Ground Engineering "*Reliability and risk in gas protection design"*.

8.3.2 As indicated in these documents, the level of potential risk associated with a given ground gas regime not only depends upon ground gas composition, but also upon ground gas pressure, as this is a significant driving force for gas migration, either horizontally or

vertically through the sub-surface environment. Measurement of gas pressure within or gas flow from, a monitoring standpipe provides useful data which can be used, together with ground gas compositional analysis, to provide a more robust estimation of the level of risk posed to the building development, than consideration of gas composition data alone.

8.4 Monitoring Results

8.4.1 The results of the standpipe monitoring are presented in Appendix D and summarised in the table below.

Borehole	Response zone(mbgl)/strata	Evidence of contamination	No. of monitoring occasions & Dates	Methane (%)	Carbon dioxide (%)	Flow (l/hr)	Range of Atmospheric pressures during monitoring	Water Levels (mbgl)
BH1	*1.0-4.7 /M&S&C*	*Yes*	*6[28/05/10-31/08/10]*	*0.0*	*0.1-1.1*	*0.0*	*988-1027*	*2.30-2.85*
BH2	*1.0-6.0 /M&S&C*	*Yes*	*6[28/05/10-31/08/10]*	*0.0*	*0.0-0.1*	*0.0*	*988-1027*	*4.5-Dry*

M=Made Ground, C=Clay, S=Sand

8.4.2 The monitoring results show that none of the two borehole monitoring standpipes recorded methane during the entire monitoring period.

8.4.3 The results for carbon dioxide show raised concentrations (although still low) in one of the two wells (BH1), ranging from 0.0%v/v to 1.1%v/v. Oxygen concentrations were slightly depleted corresponding to the slightly elevated carbon dioxide levels.

8.4.4 No flow rates were recorded in the boreholes during the monitoring period.

8.5 Source of Gas

8.5.1 The presence of a historic infill within 250m of the site represents a low/medium risk of elevated concentrations of ground gas at the site.

8.5.2 The type of fill throughout the site is not considered a major source of gas, being relatively inert.

8.6 Frequency of Monitoring

8.6.1 The proposed end use for the development is classed as a residential development. The sensitivity of the development has been classed as *moderate* with the generation potential of the source as *low.*

8.6.2 The frequency of monitoring has been based on current guidance as set in the following table.

Typical minimum periods and frequency of monitoring (CIRIA 2007)

		Generation potential of source				
		Very Low	**Low**	**Moderate**	**High**	**Very High**
Sensitivity of development	**Low**	4/1	6/2	6/3	12/6	12/12
	Moderate	6/2	6/3	9/6	12/12	24/24
	High	6/3	9/6	12/6	24/12[3]	24/24[3]

1. First number is minimum number of readings and second number is minimum period, for example 4/1 – Four sets of readings over 1 month

2. At least two sets of readings must be at low and falling atmospheric pressure (<1000mb)

3. The acceptability of placing high sensitivity end use on a high gas hazard site is not normally acceptable unless source is removed or treated to reduce gassing potential

8.6.3 Potential temporal variable were accommodated within the monitoring regime with monitoring undertaken on *three* occasions at barometric pressures below 1000mb when the pressure was falling.

8.7 Gas Screening Values (GSVs)

8.7.1 Gas Screening Values (GSV's), which equate to the borehole gas volume flow rate, as defined by Wilson & Card (1999) as the borehole flow rate multiplied by the concentration in the air stream of the particular gas being considered have been calculated from a risk-based methodology for deriving threshold concentrations for gas flow rates. The Gas Screening Value (GSV) of a particular ground gas being considered equates to:

- GSV (l/hr) = borehole flow rate (l/hr) x gas concentration(%v/v).

8.7.2 Maximum methane concentration on site was 0.0% v/v. The maximum carbon dioxide concentration of 1.1%v/v with a worst case flow rate of 0.1 l/hr (for arithmetic purposes). The GSV can thus be calculated as:

- Methane 0.000 x 0.1 = ***0.0000 l/hr***
- Carbon Dioxide 0.011 x 0.1 = ***0.0011 l/hr***

8.8 Traffic Light System of Gas Assessment

8.8.1 The NHBC guidance has set out a series of 'Traffic Lights' that can be applied to gas risk assessments specific to low-rise housing developments (but have been assumed to be a worst case situation for this type of development). This is a risk-based approach that is designed to allow quick and easy design of gas protection for a low-rise development by comparing the measured gas emission rates to generic Traffic Lights. The Traffic Lights include 'Typical Maximum Concentrations' are provided for initial screening purposes and risk-based Gas Screening Values (GSVs) for consideration for situations where the Typical Maximum Concentrations are exceeded. The GSV's equate to the borehole gas volume flow rate, as defined by Wilson & Card (1999) as the borehole flow rate multiplied by the concentration in the air stream of the particular gas being considered. The calculations are carried out for both methane and carbon dioxide and the worst-case adopted in order to establish the appropriate protection measures. The table below sets out the gas risk assessment criteria:

GRA_Traffic Lights with Typical Max Concentrations and GSVs

Traffic Light Classification	Methane [1]		Carbon Dioxide [2]	
	Typical Maximum Concentration [3] (%v/v)	Gas Screening Value [2,4] (l/hr)	Typical Maximum Concentration [3] (%v/v)	Gas Screening Value [2,4] (l/hr)
Green	1	0.13	5	0.78
Amber 1	5	0.63	10	1.60
Amber 2	20	1.60	30	3.10
Red				

Notes:

1. The worst-case ground gas regime identified on the site, either methane or carbon dioxide, at the worst-case temporal conditions that the site may be expected to encounter will be the decider as to what Traffic Light is allocated;

2. Borehole Gas Volume Flow Rate, in litres per hour as defined in Wilson and Card (1999), is the borehole flow rate multiplied by the concentration in the air stream of the particular gas being considered;

3. The Typical Maximum Concentrations can be exceeded in certain circumstances should the Conceptual Site Model indicate it is safe to do so;

4. The Gas Screening Value thresholds should not generally be exceeded without the completion of a detailed ground gas risk assessment taking into account site-specific conditions.

8.8.2 The GSV for the site has been calculated as *0.0011* l/hr which puts the site in the Green Classification.

8.9 Gas Protection Measures

8.9.1 Based upon the Traffic Light classification the ground gas protection measures required can be defined as presented in the Table below:

Ground Gas Protection Measures

Traffic Light	Ground Gas Protection Measures Required
Green	Ground gas protection measures are not required.
Amber 1	Low-level ground gas protection measures are required, using a membrane and ventilated sub-floor void that creates a permeability contrast to limit the ingress of gas into buildings. Gas protection measures are to be installed as prescribed in BRE 414. Ventilation of the sub-floor void should be designed to provide a minimum of one complete volume change per 24 hours.
Amber 2	High-level ground gas protection measures are required, creating a permeability contrast to prevent ingress of gas into buildings. Gas protection measures are to be installed as prescribed in BRE 414. Membranes used should always be fitted by a specialist contractor and should be fully certified (see Appendix E). As with Amber 1, ventilation of the sub-floor void should be designed to provide a minimum of one complete volume change per 24 hours.
Red	Standard residential housing is not normally acceptable without further Ground Gas Risk Assessment and/or possible remedial mitigation measures to reduce/remove the source of the ground gases. In certain circumstances, active protection methods could be applied, but only when there is a legal agreement assuring the management and maintenance of the system for the life of the property.

8.9.2 On the basis of the Traffic Light Classification it is recommended that for the site development gas protection measures are ***not*** required.

9.0 HAZARD ASSESSMENT

9.1 Sources

9.1.1 The industrial processes and activities undertaken on or adjacent to the site that may act as potential historical or current sources of environmental hazard are shown in the Table below.

Type of Issue	SOURCE-Specific Issue	HAZARD-Remarks
Potential on-site contamination sources HISTORICAL	1. Made Ground beneath site and relic foundations from previous structures	1. Potential source of soil and groundwater contamination (metalloids, hydrocarbons, PAH)
Potential off-site contamination sources HISTORICAL	1. Infilled ground S & E of site 2. Potential isolated fuel/oil spill in garages.	1. Risk of ground gas production (CO2 & CH4) 2. Potential source of soil and groundwater contamination (metalloids, hydrocarbons, PAH)
Potential on-site contamination sources CURRENT	None	None
Potential off-site contamination sources CURRENT	None	None
Potential geotechnical hazards	1. Potential relict foundations and other buried structures post demolition. 2. Steep uneven site 3. Fill & Soft alluvial surface deposits	1. Obstructions for foundation construction. 2. Additional earthworks required cut/fill balance. 3. Deeper foundations due to made ground and alluvial deposits.

9.2 Pathways and Receptors

9.2.1 *Five* pollutant receptors have been identified for the site, and are listed in the table below, together with the pathways through which they may be linked to pollutant sources.

Receptor	Pathways
HUMAN HEALTH Re-development Workers End users-*residents*	Inhalation, ingestion, skin contact
FAUNA & FLORA Landscaping	Root uptake
WATER ENVIRONMENT Groundwater	Groundwater
BUILT ENVIRONMENT Buildings and services	Diffusion of petroleum vapours through ground Diffusion of landfill gas through ground and collection in confined spaces Direct contact with contaminated soil and vapours

9.3 *Conceptual Model and Qualitative Risk Assessment*

9.3.1 A preliminary conceptual model of pollutant linkages is given in the table below, together with a qualitative risk assessment for each linkage. The risk assessment uses the method of risk evaluation set out in CIRIA 552 'Contaminated Land Risk Assessment'. The scale of risk is determined from a matrix that combines the *consequence* of a hazard with the *likelihood* of the event happening. Details of the assessment method are included in Appendix E. A schematic summary of the revised conceptual model is given in Drawing Number G1320-G-05.

Source	Pathway	Receptor	Consequence	Probability	Risk Classification	Remediation
On-site historic sources of ground contamination arising from potential fill materials and relics of historic building foundations, fuel/oil spillage from off-site garages including metalloids, PAHs, hydrocarbons	Inhalation, ingestion, skin contact	Re-development workers	medium	low	Low/medium risk	*PPC required during groundworks.*
		End users-residents	medium	low	**Low/medium risk**	*Remediation required. Options include either containment (by hardstanding barrier) and/or removal of contaminated fill. In addition affected garden areas will require remediation measures, either 600mm cover system or removal of contaminated soils.*
	Root Uptake	Landscaping Vegetation	minor	likely	low risk	*Remediation unlikely to be required.*
	Groundwater	Controlled Waters	minor	unlikely	Very low risk	*Remediation unlikely to be required.*
	Diffusion of vapour	Buildings and Services	minor	likely	low risk	*Remediation unlikely to be required.*
	Direct Contact	Buildings and Services	medium	low	**Low/moderate risk**	*In areas where services run through contaminated soils strata with raised PAH levels, sterile trenches for utility pipes.*

Source	Pathway	Receptor	Consequence	Probability	Risk Classification	Remediation
Methane & Carbon Dioxide from on/off site fill sources.	Migration, ingress, accumulation and inhalation	Re-development workers	severe	unlikely	moderate/low risk	*No Gas Protection measures required following completion of gas monitoring.*
		End users-residents	severe	unlikely	moderate/low risk	
		Buildings and Services	medium	unlikely	low risk	

9.3.2 *On-site and off-site ground and groundwater contamination from historic fill, and relic building foundations and garage sources*

The risk classification for *six* pollutant linkages relating to potential sources of contamination in the Made Ground and natural materials from past infilling, possible historic spillages and relic foundations varied between *low* risk to *moderate/low* risk. Investigation, if not already undertaken, is normally required in cases where the risk is classified as *moderate* or higher, and some remedial works may be required. The *five* receptors include human health (construction workers and end users-residents), groundwater, landscaping vegetation and gardens, and buildings and services.

The risks to future residential users from on-site historical contamination from ground and groundwater migration from the made ground material would appear to be *low/moderate.* The made ground material, of mixed origin and randomly tipped only appears to have raised levels of PAH's, lead and arsenic. This will require some form of remediation measure to reduce the risk of affecting end user human health within the potential garden areas. Options of remediation measures should be developed in a remediation strategy.

The chemical characteristics of soil, as tested from the site poses some human health risk upon prolonged and repeated exposure to materials on site, specifically through ingestion or inhalation of soil particles during site work. The level of risk to construction staff can be adequately controlled by the implementation of good working practices during the site clearance/earthworks. During the ground works phase of the development, appropriate personal protective equipment, adequate hygiene and accommodation facilities, and the implementation of dust control when required should be implemented. The work force should undergo a site safety briefing to identify the site as 'brownfield' and potentially contaminated.

Raised levels of arsenic, lead and PAH's within the upper made ground of the site would provide a *moderate* risk to the water supply pipes if they were sat directly upon the material. It is recommended that remediation measures are undertaken for construction of the water supply trenches, such as surround with inert materials, or divert the pipes away from the affected zone.

For any proposed planting areas either excavation and replacement or clean cover should be provided to mitigate against potential phyto-toxic effects from elevated concentrations of various elements within the ground. Remediation options should be developed in a remediation strategy. Care should be taken to guarantee that imported topsoil for the garden areas is within clean soil guidance levels.

The risk to groundwater from the various contamination sources appears to be *low risk.* The groundwater observed was found to be perched, trapped within the interbedded glacial deposits. Care should be taken to minimise the risk of potentially contaminative incidents occurring during re-development of the site. Good working practices should be adopted during construction works in order to minimise the risk of contamination occurring

as a result of spillage or leakage of fuels, oils or chemicals stored or used at the site during re-development. All such materials should be sited on an impervious base within a bund and should be adequately secured.

9.3.3 *Gas Risk*

A gas risk assessment for the site is set out in Section 8.0.

9.3.4 *Uncertainties*

There remains the possibility that some historical occupation of the site has not been identified, which could lead to unforeseen ground contamination.

10.0 REMEDIATION

10.1 Introduction

10.1.1 Karl Baxter proposes to develop the site off Harwood Street, Darwen for *residential* usage.

10.1.2 The investigation has shown that the majority of the site is underlain by a variable, relatively shallow thickness of made ground, with a maximum made ground depth of 1.6m. This material overlies thin alluvial deposits (soft-firm clay) which are subsequently underlain by glacial sands and a stiff clay.

10.1.3 The proposed northerly residential property (No.79) contains the deepest fill material. The majority of the fill materials tested were slightly contaminated.

10.1.4 Made ground materials within the site, showed elevated levels of contaminants, including benz(a)pyrene, arsenic and lead. These deposits pose risks to human health through skin contact and ingestion within garden zones and service trenches.

10.2 Remediation Objectives

10.2.1 It is considered that the overall objectives of the remediation works should include the following:

- Provide a safe environment for the proposed end users (residents);
- Minimise risks to construction workers and adjacent residents;
- Reduce risks to the environment to acceptable levels;
- Adopt sustainable principles regarding the re-use of materials and reduction of off-site disposal to landfill sites.

10.3 Remediation Measures

10.3.1 Following the risk assessment, it is concluded that minor remediation measures are required for the site. These relate to the following:

- possible cover system in landscaped areas contaminated by lead, arsenic and benzo-a-pyrene within proposed residential area
- sterile trenches for water supply pipes should the pipe run through the effected area

10.4 Remediation Strategy and Validation

10.4.1 Due to the lack of significant remediation measures, it is considered that a detailed remediation statement is not required for the site, prior to commencement of any site works. It is recommended that due to the limited and small-scale nature of the remediation measures required that a remediation strategy is not necessary and that the remediation measures highlighted within this report are adopted.

10.4.2 All reclamation and remediation works should be undertaken to comply with the requirements of the Local Authority and Environment Agency.

10.4.3 A basic validation report should be prepared by a suitably qualified geo-environmental engineer and submitted to the Local authority prior to occupation of the properties.

10.4.4 Should any evidence of significant contamination be encountered during the site's re-development then further advice should be sought from PSA Design.

10.5 Remediation Method

10.5.1 Cover System

10.5.1 The majority of the site does not require any cover system as it is covered by the building footprint. This prescribed cover system is related to the proposed landscaped area which would be affected by raised lead, arsenic and PAH's. It would appear that the landscaping zone for the proposed buildings in the NW and SE areas of the site will be affected.

10.5.2 The cover should be sufficiently robust to allow the following:-

- prevent possible migration of contaminants;
- prevent residents coming into contact with contaminated soils;
- provide a 'clean' medium for the establishment of trees and shrubs.

10.5.3 It is estimated from "Cover systems for Land Regeneration" BRE, March 2004) that the thicknesses of clean cover to be provided at the site in these specific areas is 600mm.

10.5.4 The clean cover should contain contaminant concentrations less than the relevant SGV values. The clean cover thicknesses calculated above are based on the cover having a maximum concentration no greater than 75% of the CLEA soil guidance value for arsenic, lead and benzo-a-pyrene.

10.5.5 The thicknesses given above include for 150mm of topsoil.

10.5.6 Soils imported for use as cover material in areas of soft landscaping will meet the Acceptability Criteria in the table below together with any other relevant quality criteria (e.g. BS standard) specified for landscaping purposes. Prior to importation of soils, the source of the clean soils will be identified and if testing data is not available from the supplier to demonstrate that it meets the Acceptability Criteria, samples of the soil will be taken at source and tested for the determinands in the table.

10.5.7 Arisings from excavation works within lower natural soils would be suitable as a cover system material, in particular the glacial sands.

Imported Soils Acceptability Criteria

Determinand	Units	Acceptability criteria
pH	pH units	>5 - <11
Arsenic*	mg/kg	32
Boron	mg/kg	3
Cadmium	mg/kg	10
Chromium	mg/kg	130
Copper	mg/kg	2330
Cyanide	mg/kg	250
Lead	mg/kg	450
Mercury	mg/kg	170
Nickel	mg/kg	130
Selenium	mg/kg	350
Sulphate (total)	mg/kg	2000
Zinc	mg/kg	3750
Total Petroleum Hydrocarbons	mg/kg	100
Phenol	mg/kg	40
Asbestos	-	No Fibres Present
PAH	mg/kg	40

10.6 Waste Disposal

10.6.1 During the earthworks phase of construction, ground conditions may be encountered that are suspected to contain significant (localised) contamination sources that have not been identified to date. In this situation, work in the suspect area should cease and the situation reported to a suitable environmental specialist. Thereafter, the suspect materials should be left insitu, (or could be stockpiled, under cover, and on an impermeable base) sampled and analysed so that the most appropriate remedial action can then be decided upon and undertaken.

10.6.2 Excavated soils (if any) which require off-site disposal, are anticipated to be classified in accordance with the document Guidance on the Disposal of “Contaminated Soils” Version 3 (April 2001) produced by the Environment Agency. Furthermore, recent changes to waste disposal legislation has led to waste characterization to be in line with European Legislation EN 14473/02, specifying the criteria and procedures for acceptance of waste at landfills pursuant to Article 16 and Annex II of Directive 1999/31/EC (Landfill Directive).

10.6.3 On this basis, it is considered that the soils from foundation/trench arisings from the site may need to be removed to a suitably licensed engineered landfill. Uncontaminated material such as the brown glacial till may be acceptable for disposal at a suitably licensed inert landfill site. Materials and or soils that are significantly contaminated (with

hydrocarbons or similar) would probably require disposal at a suitable licensed engineered landfill, at rates appropriate to hazardous waste.

10.6.4 However, it should be appreciated that these comments have been given for guidance only. Definitive waste disposal classifications can only be provided by individual landfill operators, in accordance with their site licenses. Therefore, the test results and the exploratory hole records should be presented to, and discussions held with, appropriate licensed landfill operators for confirmation of disposal classification and potential costs. During construction, materials for off-site disposal should be stockpiled in such a way as to prevent run-off of leachate into the ground. Samples from the stockpile may be required by the landfill operator to be analysed for both total and leachable concentrations. These results should ultimately determine the correct destination of the arisings. It should be appreciated that off-site disposal of excavated soil arisings from the site re-development may be subject to landfill tax.

10.6.5 It should be noted that the recent implementation of the Hazardous Waste Directive, in conjunction with the Landfill Directive, will require 'treatment' of waste prior to disposal. This may possible apply to inert and non-hazardous waste which will need pre-treatment prior to disposal.

10.7 Health & Safety

10.7.1 The risk assessments and remediation strategy deal with assessing and addressing potential long-term chronic risks to human health and the environment from contamination identified at the site. There is however the potential for short-term risks to human health and the environment during remediation and construction work from contaminants of concern. These risks can be suitably mitigated by the implementation of appropriate good practice site management procedures. Procedures to be followed at the site in relation to contaminated materials and hazardous vapours are detailed below.

10.7.2 The risk presented by the presence of contamination in soils and groundwater at the site will be considered as part of the Health and Safety Plan prepared by the Contractor for the construction of the development.

10.7.3 Work will be undertaken in accordance with Health and Safety Guidance Note HS(G) 66 "The Protection of Workers and the General Public during the Development of Contaminated Land" 1991 and all appropriate legislation.

10.7.4 The following minimum precautions will be implemented to minimise the risk to site personnel from potentially hazardous materials, particularly through ingestion, inhalation and by contact with the skin

- All site staff will be provided with instruction on the nature of the known contaminants, the potential hazards, health risks and safety/first aid precautions.
- The telephone numbers and locations of emergency services on and off site including the nearest casualty department, together with the location of the

nearest clean water supply will be provided to all site staff.

- At a minimum personnel shall wear protective overalls with tight fitting ankles and wrists, safety shoes or boots, safety helmets and protective gloves, at all times when they are handling or in contact with potentially hazardous materials.
- No smoking or consumption of drink or food shall be permitted within contaminated areas. These activities shall be restricted to areas where hygiene facilities are provided.
- Hand washing and drying facilities will be provided on-site. These facilities shall be available for use by all personnel working on and visiting the site.
- The Contractor shall provide separate messing facilities and ensure that personnel shall not enter the messing facilities before removing soiled protective clothing or footwear and using the washing facilities provided.

10.8 Dust, Noise & Odour Control

10.8.1 The potential for the generation of dust will be dependent on the timing of earthworks and construction works. The following mitigation measures will significantly reduce the generation and entrainment of dust during the construction phase:

- careful management of any stockpiled material;
- all stockpiled material will be sited away from residential properties;
- all stockpiles of soil will be regularly dampened with water sprays during hot, dry weather conditions;
- all completed earthworks will be covered and/or re-vegetated as soon as possible;
- all site equipment will be carefully maintained and kept clean;
- removal and/or deliveries of soils to site will be covered;
- roads will be regularly cleaned to prevent dust being transported off site;
- drop heights will be minimised for all transfer activities;
- all mechanical cleaning or road sweeping will be undertaken as a wet process or another suitable system capable of suppressing dust;
- vehicles will be routed to avoid sensitive receptors.

10.8.2 If the above mitigation measures are implemented on site then significant adverse impacts during the construction phase are considered unlikely. During very dry, windy conditions if large quantities of dust are seen to be generated, the activity will be ceased until more appropriate conditions prevail.

10.8.3 All Best Practicable Means will be adopted for construction activities that have the potential to be noisy in order to minimise the potential impact of noise during the construction of the development. This may include the utilisation of low noise emission machinery; adoption of working practices to reduce noise emissions away from noise sensitive receptors; switching plant off during periods of inactivity; ensuring regular and effective maintenance procedures for all equipment on site; and ensuring sufficient communications occur with the local authority and neighbouring residential properties.

10.8.4 It is expected that a certain degree of noise associated with the construction of such a development will occur but that this will be minimised as far as reasonably possible.

10.8.5 On the basis of information available the potential for odours is not considered to be an issue. If conditions are encountered during remediation or construction works that could generate noxious odours such works will be stopped until a safe working practice that minimises such odours is agreed with the local authority.

10.9 Utilities

10.9.1 Details regarding the existing site services in the area should be reviewed, in order to assess their capacity to service the proposed building. In addition, existing services may need to be diverted to accommodate the development.

10.9.2 Following remediation of the site, the bulk of the existing made ground may still be present. This may contain occasional contaminants, and utility workers are likely to come into direct contact with these affected soils.

10.9.3 Although utility workers will only be exposed to the contaminated soils/fill for a relatively short period of time, the contaminants represent a small risk and simple health and safety precautions are required ie. appropriate personal protective equipment, good personal hygiene.

10.9.4 Utility trench excavations are likely to yield, in part contaminated arisings. Poor handling and control of such arisings could give rise to contamination of areas of the site previously devoid of any contamination. It is therefore recommended that any arisings from the made ground/contaminated soils are stockpiled in designated areas and sheeted to prevent fugitive dust emissions.

10.9.5 It is recommended that all statutory service bodies are consulted at an early stage with respect to the ground conditions within which they will lay services in order to enable them to assess, at an early stage, potential abnormal costs.

Water Pipe Trenches

10.9.6 United Utilities identify two contaminated land situations where special measures are required for water supply pipeline installations. These are; contamination from lead, arsenic and PAH's affecting the pipe, and contamination from lead, arsenic and PAH affecting workers installing or repairing the pipeline.

10.9.7 Testing evidence of lead, arsenic and PAH contamination was noted across the surface area from the ground investigation with trigger concentration exceedances recorded for lead, arsenic and PAH's only. Special installation measures are required within this moderate risk zone and it is recommended as a precautionary measure that clean selected granular fill should be used for pipe bedding and trench backfill in cases where the water supply pipes pass through the contaminated materials. Reference should be

made to pipe material properties within this level of contamination before specification. If at all possible it would be advisable for the pipe routes not to cross the localised contaminated zone.

11.0 CONCLUSIONS

11.1 A summary of the data collated in the ground investigation and assessment in terms of the various revisions to the original risk assessments in terms of contamination and geotechnical issues for the site and remediation recommendations are set out below in the summary table:

Issue	Remarks
Site Information	Location:- Harwood Street, Darwen. BB3 1PA GR 368550 423670 Current Situation:- Steep slope changes in level to NE, area 0.02Ha, overgrown area and scrubland with conifer trees and shed/caravan. Former uses of site have included building structures until a recent demolition and removal. The site is currently unoccupied.
Proposed Development	Re-development of the site as 2No. semi-detatched *residential* properties with associated gardens.
Ground Investigation	Intrusive investigation comprising window sampler boreholes across site, with gas/groundwater monitoring installations. Chemical and geotechnical soils analysis, with subsequent gas and groundwater monitoring.
Ground Conditions	Ground conditions varied across the site with varied thicknesses (and types) of made ground encountered. Underlying the made ground was a thin layer of soft-firm CLAY (alluvial deposits), overlying medium dense SAND (glacial deposits). The sand was underlain by a firm to stiff CLAY (glacial till). In one borehole (BH 1) MUDSTONE was encountered. Perched groundwater at 2.0-3.0mbgl.
Contamination	General upper surface fill materials show slightly raised levels of lead, arsenic and benzo-a-pyrene contamination, with potential impact upon construction workers, water supply pipes and residents.
Gas	Gas monitoring and testing showed *minimal* gas levels with *minimal* flow. Risk assessment recommended *no* gas protection measures required.
Anticipated Foundation Solutions	Piled foundations or deep trench footings to competent bearing strata are anticipated to be the most economic foundation solutions across the site for the proposed residential buildings, subject to structural design assessment.
Waste Disposal	Arisings made up of made ground should be removed to a suitably licensed landfill facility.
Working restrictions	Trenching may be difficult without shoring due to loose made ground and alluvial deposits.
Recommendations for Remediation	Remediation Strategy required covering: Utility trenches for water pipes through raised As, Pb & PAH levels, sterile Garden areas in contaminated soils affected areas should use cover system/or remove contaminated materials.
Geotechnical Issues	There is a slight risk of long term settlement occurring within the deeper fill areas and alluvial deposits (in particular the peat) that are not founded upon piles. Ground improvement of the made ground may be required to reduce the amount of long term settlement. A value-engineering exercise needs to be carried out during the pavement design to establish whether ground improvement/techniques will be cost effective rather than a “monitor and maintain approach” where long term maintenance issues may occur to remediate pavement distortion and ponding.

12.0 REPORT LIMITATIONS

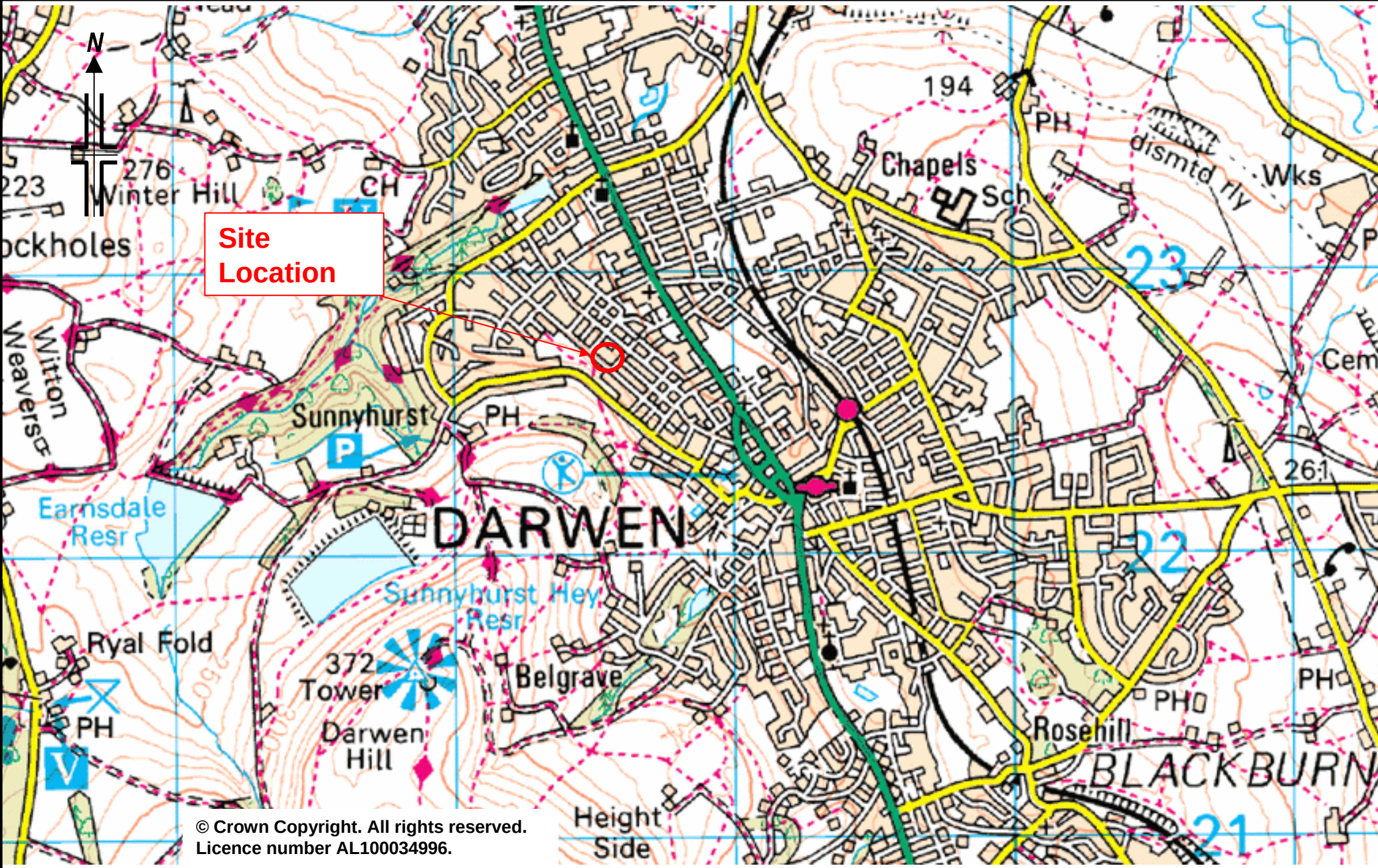
12.1 PSA Design believe that providing information with regard to limitations is essential to assist *the client* identify and therefore manage its risks. The ground is a product of continuing natural and artificial processes and, as a result, may exhibit a variety of characteristics which may vary from place to place, and with time. The risks associated with these variations may be mitigated by appropriate investigations, but cannot be eliminated.

12.2 This report contains interpretations of information which has been gathered from published sources and observations. Such information is only relevant to the ground at the published sources and observations. The information from these is interpreted here in good faith and is believed to be accurate. PSA Design cannot guarantee the authenticity of data obtained from external sources.

12.3 An interpretation or recommendation based on this information and given in this report is based on our judgment and experience of this information and not on any greater knowledge that might be implied.

12.4 The interpretations and recommendations contained herein represent our opinions which are provided for the sole use of our client in accordance with a specific brief. As such these do not necessarily address all aspects of ground behaviour at the site. Should these interpretations be used by any third party to assess ground conditions then verification should be made by reference to the appropriate factual information.

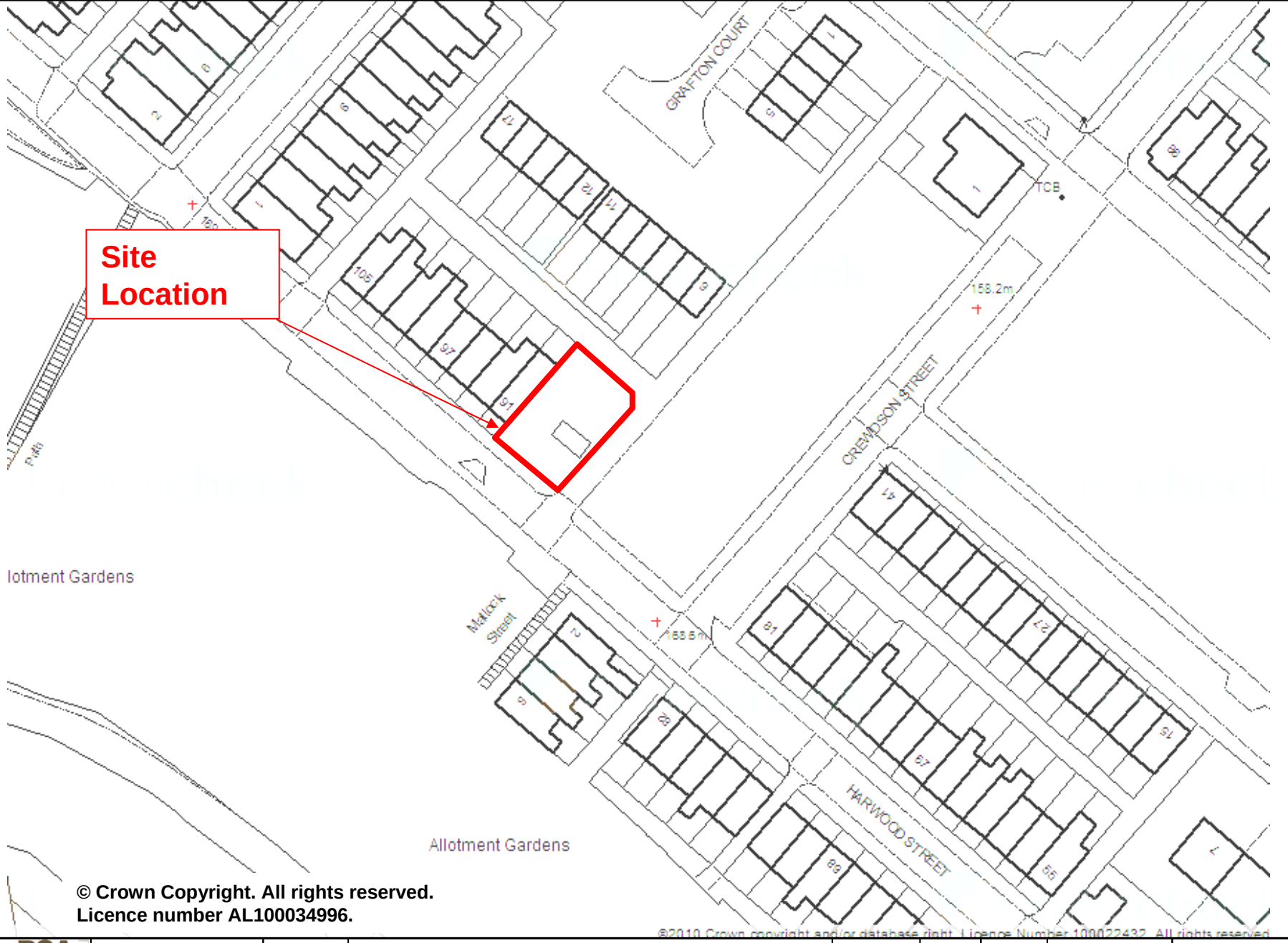
DRAWINGS



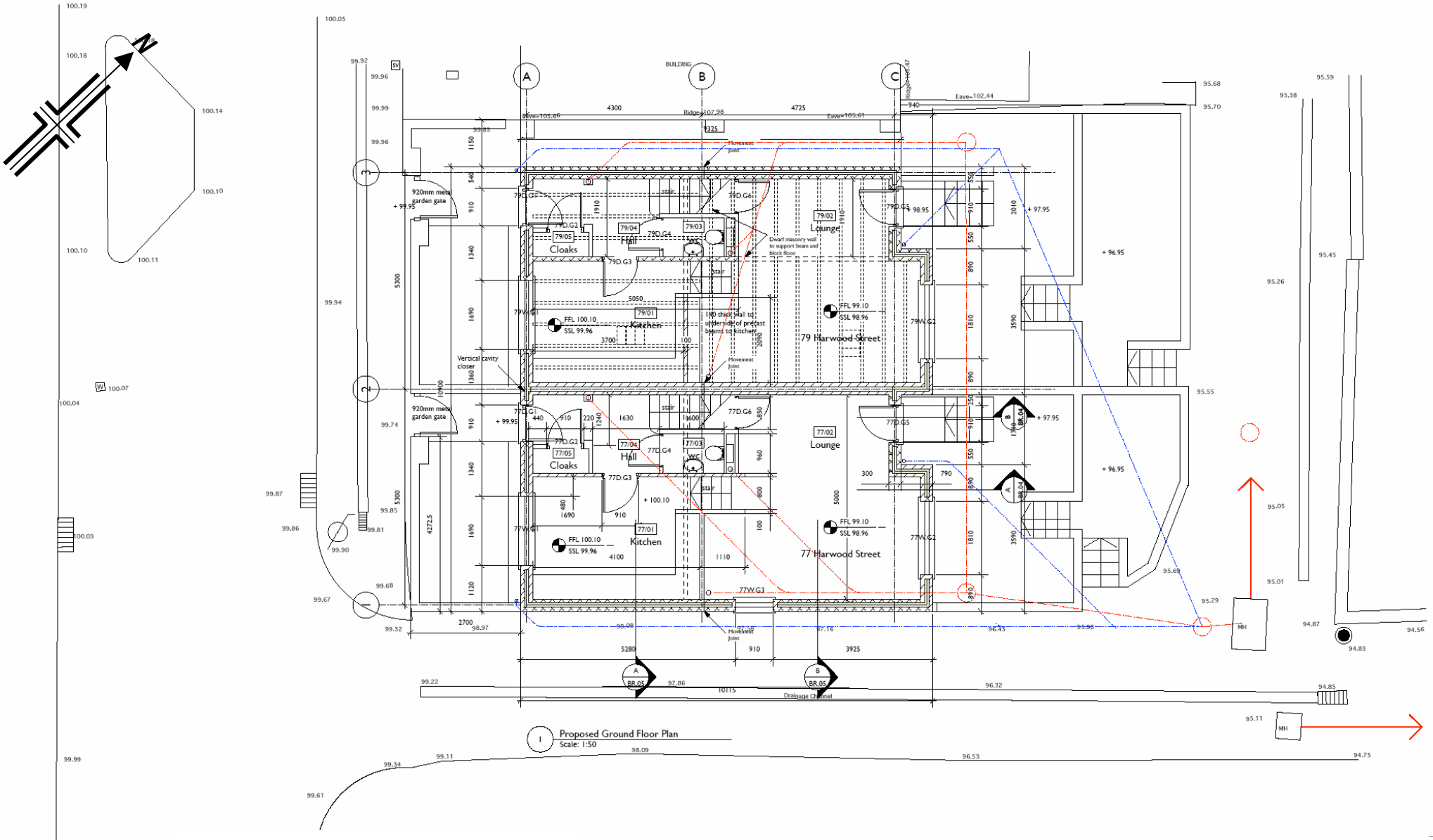
PSA DESIGN engineering your environment CIVIL, STRUCTURAL, GEOTECHNICAL, TRANSPORT	PSA Design The Old Bank House 6 Berry Lane, Longridge Preston, PR3 3JA Tel. 01772 786066	Client	**Karl Baxter**	Drawn	JB	Date	**12.05.2010**
		Job	**Harwood Street, Darwen**	Checked		Scale	**NTS**
		Title	**Regional Plan**	Approved			

Drawing No. **G1320-G-01**

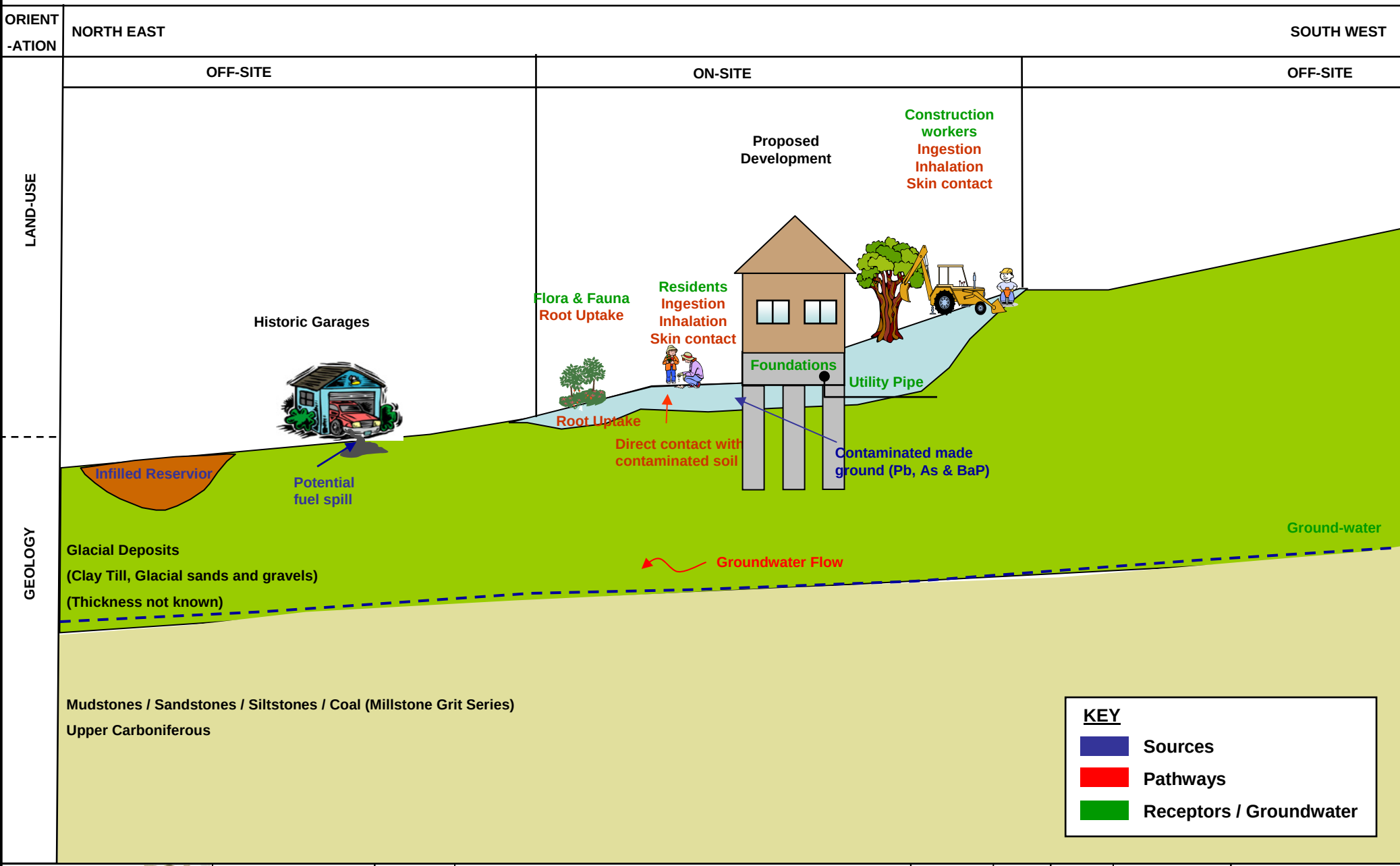
Rev



PSA DESIGN engineering your environment CIVIL, STRUCTURAL, GEOTECHNICAL, TRANSPORT	PSA Design The Old Bank House 6 Berry Lane, Longridge Preston, PR3 3JA Tel. 01772 786066	Client	**Karl Baxter**	Drawn	JB	Date	**12.05.2010**
		Job	**Harwood Street, Darwen**	Checked		Scale	**NTS**
		Title	**Current Layout Plan**	Approved		Drawing No.	**G1320-G-02**
						Rev	



PSA DESIGN engineering your environment CIVIL, STRUCTURAL, GEOTECHNICAL, TRANSPORT	PSA Design The Old Bank House 6 Berry Lane, Longridge Preston, PR3 3JA Tel. 01772 786066	Client	**Karl Baxter**	Drawn	JB	Date	**23.08.2010**	Drawing No. **G1320-G-03**
		Job	**Harwood Street, Darwen**	Checked		Scale	**NTS**	Rev
		Title	**Proposed Development Plan**	Approved				



PSA DESIGN
engineering your environment
CIVIL, STRUCTURAL, GEOTECHNICAL, TRANSPORT

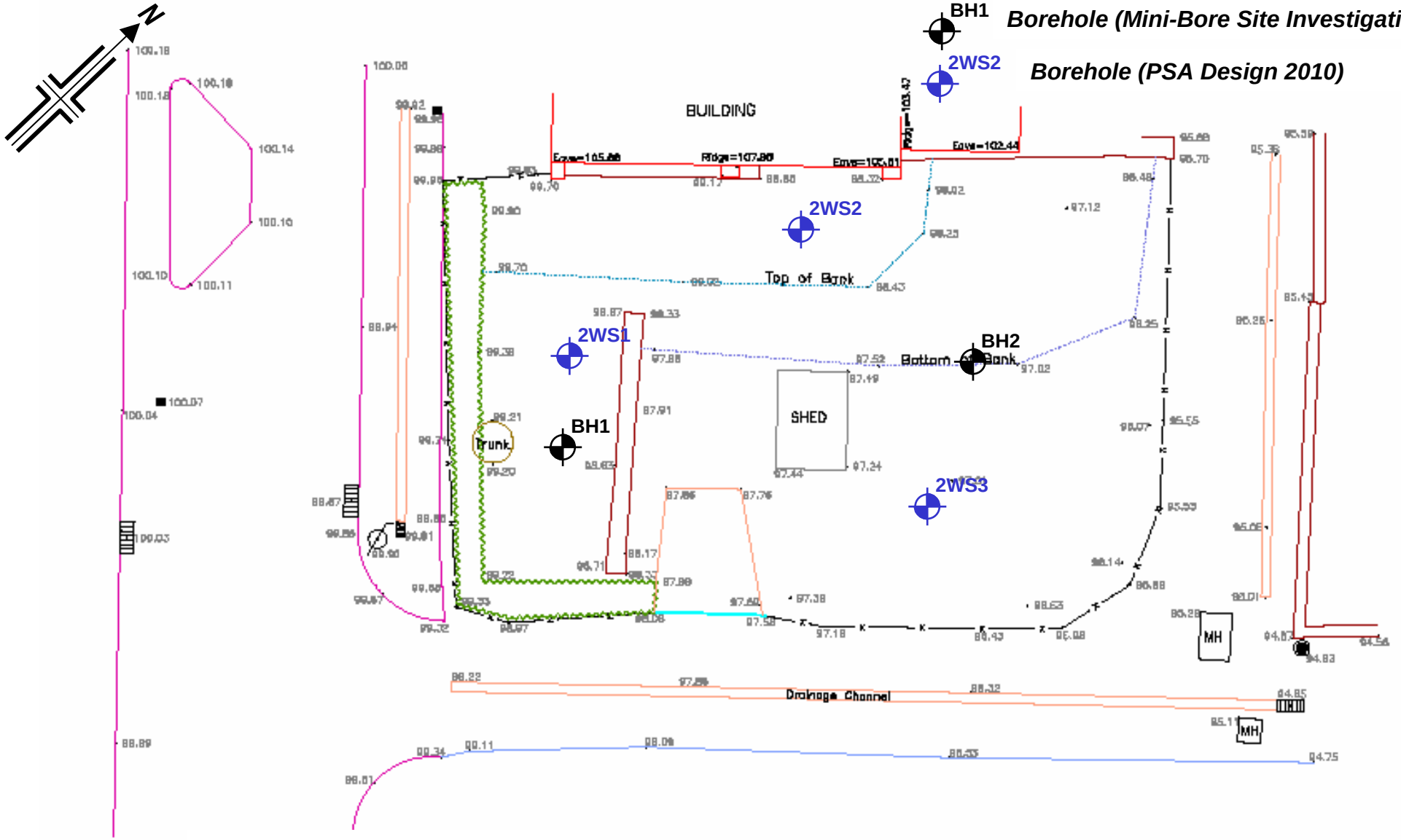
PSA Design
The Old Bank House
6 Berry Lane, Longridge
Preston, PR3 3JA
Tel. 01772 786066

Client	**Karl Baxter**	Drawn	JSB	Date	**25.08.10**	Drawing No. **G1320-G-05**
Job	**Harwood Street, Darwen**	Checked		Scale	**Not to Scale**	Rev
Title	**Conceptual Model**	Approved				

Legend

BH1 — *Borehole (Mini-Bore Site Investigation 2008)*

2WS2 — *Borehole (PSA Design 2010)*



PSA DESIGN engineering your environment CIVIL, STRUCTURAL, GEOTECHNICAL, TRANSPORT	PSA Design The Old Bank House 6 Berry Lane, Longridge Preston, PR3 3JA Tel. 01772 786066	Client	**Karl Baxter**	Drawn	JB	Date	**23.08.2010**
		Job	**Harwood Street, Darwen**	Checked			
		Title	**Ground Investigation Exploratory Holes Location Plan**	Approved		Scale	**NTS**

Drawing No. **G1320-G-06**

Rev

APPENDICES

APPENDIX A BOREHOLE LOGS

PSA DESIGN
engineering your environment
CIVIL, STRUCTURAL, GEOTECHNICAL, TRANSPORT

PSA Design
Tel: 01772 786066
Fax: 01772 786265
email: mail@psadesign.co.uk

Borehole No
2WS1
Sheet 1 of 1

Project Name	Project No.	Co-ords: -	Hole Type
Harwood St	G1320		WS
Location: Darwen		Level: 98.70 m AOD	Scale 1:50
Client: Karl Baxter		Dates: 19/05/2010	Logged By JSB

Well	Water Strikes	Samples & In Situ Testing			Depth (m)	Level (m AOD)	Legend	Stratum Description
		Depth (m)	Type	Results				
					0.07	98.63		Black clayey TOPSOIL with occasional brick gravel fragment. (MADE GROUND)
		0.30 0.20-0.40	IVN 1 ES	40	0.40	98.30		MADE GROUND Firm black brown gravelly clay. Material also contained f-m concrete & brick gravel fragments. (MADE GROUND)
		0.70 0.60-0.80	IVN 2 ES	45	0.90	97.80		MADE GROUND Firm grey/black brown gravelly clay. Material also contained concrete & brick fragments plus ash and clinker. (MADE GROUND)
		1.20 1.10-1.30	IVN 3 ES	65	1.60	97.10		Firm grey sl sandy gravelly CLAY with occasional organic inclusions. Gravel is predominantly fine to medium, subangular and of mixed lithologies. (ALLUVIUM)
					2.00	96.70		Medium dense (driller's description) red brown, m SAND. (SANDS & GRAVELS)
								End of Borehole at 2.00 m
			Type	Results				

Remarks: Premier Plant Hydraulic Compact Rubber Tracked Percussion Drilling Rig. In-situ shear strength (IVN) in kPa, based on avg of 3 tests using Geonor H-60 Vane

AGS

PSA Design
Tel: 01772 786066
Fax: 01772 786265
email: mail@psadesign.co.uk

Borehole No
2WS2
Sheet 1 of 1

Project Name	Project No.	Co-ords: -	Hole Type
Harwood St	G1320		WS
Location: Darwen		Level: 99.20 m AOD	Scale 1:50
Client: Karl Baxter		Dates: 19/05/2010	Logged By JSB

Well	Water Strikes	Samples & In Situ Testing			Depth (m)	Level (m AOD)	Legend	Stratum Description
		Depth (m)	Type	Results				
					0.05	99.15		Black clayey TOPSOIL with occasional brick gravel fragment. (MADE GROUND)
		0.40-0.60	ES					MADE GROUND Firm grey/black brown v gravelly clay. Material also contained grit-stone and much brick fragments (up to cobble size) plus rare glass (possible house demolition material). (MADE GROUND)
		0.60	IVN 1	45				
					0.90	98.30		
		1.10	IVN 2	40				MADE GROUND Firm grey/black brown gravelly clay. Material also contained concrete & brick fragments plus occasional concrete, coal, ash and clinker. (MADE GROUND)
		1.10-1.30	ES					
					2.50	96.70		Firm to stiff grey sl sandy gravelly CLAY. Gravel is predominantly fine to medium, subangular and of mixed lithologies. (BOULDER CLAY)
		2.60	IVN 3	55				
		2.50-2.70	ES					
		2.90	IVN 4	80				
					3.40	95.80		End of Borehole at 3.40 m
			Type	Results				

Remarks: Premier Plant Hydraulic Compact Rubber Tracked Percussion Drilling Rig. In-situ shear strength (IVN) in kPa, based on avg of 3 tests using Geonor H-60 Vane

PSA Design
Tel: 01772 786066
Fax: 01772 786265
email: mail@psadesign.co.uk

Borehole No
2WS3
Sheet 1 of 1

Project Name	Project No.	Co-ords: -	Hole Type
Harwood St	G1320		WS
Location: Darwen		Level: 97.00 m AOD	Scale 1:50
Client: Karl Baxter		Dates: 19/05/2010	Logged By JSB

Well	Water Strikes	Samples & In Situ Testing			Depth (m)	Level (m AOD)	Legend	Stratum Description
		Depth (m)	Type	Results				
					0.05	96.95		Black clayey TOPSOIL with occasional brick gravel fragment. (MADE GROUND)
		0.45-0.55	ES					
		0.65	IVN 1	50	0.60	96.40		MADE GROUND Firm grey/black brown gravelly clay. Material also contained topsoil, concrete & brick fragments plus occasional concrete, glass, pottery, coal, ash and clinker. (MADE GROUND)
		0.60-0.70	ES		0.70	96.30		
		0.70-0.80	ES		0.90	96.10		MADE GROUND Firm black brown sandy clay. Material also contained f-m concrete & brick gravel fragments. (MADE GROUND)
		0.80	IVN 2	45				
		1.30	IVN 3	60				Firm light brown sandy CLAY (ALLUVIUM)
		1.80	IVN 4	80				
					2.00	95.00		Firm to stiff grey sl sandy gravelly CLAY. Gravel is predominantly fine to medium, subangular and of mixed lithologies. (BOULDER CLAY)
								End of Borehole at 2.00 m
			Type	Results				

Remarks: Premier Plant Hydraulic Compact Rubber Tracked Percussion Drilling Rig. In-situ shear strength (IVN) in kPa, based on avg of 3 tests using Geonor H-60 Vane

Drilling Apparatus : Auto-Trip Standard Penetration Test Drop Hammer

Scheme : 89 Harwood Street, Darwen.

Date : 22/10/08

MINI BORE
Site Investigation
24 Pendle Fields, Fence, Burnley, BB12 9HN
Telephone/Fax : 01282 697491

Borehole Log No. 1

Depth (m)	Description	Shear Strength (kNm) $^{-2}$	Symbol
0.0	TOPSOIL		
	MADE GROUND- black ash & clinker		
0.5	MADE GROUND- sandy clay with gravel, brick fragments & some stone cobbles		
1.0	Soft to firm very sandy CLAY with occasional roots & very occasional brown peaty lenses/ vanes	58	
1.5	Medium dense grey very clayey SAND with many gravel inclusions & occasional stone cobbles Standard Penetration Tests From 1.7m to 2.15m 3 / 4 - 4, 4, 3, 3 N = 14		
2.0			
2.5	Stiff mid brown very sandy CLAY with many angular gravel inclusions & some stone cobbles From 2.7m to 3.15m 2 / 3 - 3, 4, 5, 4 N = 16		
3.0			
3.5	From 3.8m to 4.25m 3 / 4 - 4, 6, 6, 8 N = 24		
4.0			
4.5	From 4.7m to 5.15m 3 / 4 - 5, 8, 10, 10 N = 33		
5.0	Hard brown MUDSDTONE		

Continued Overleaf

Borehole Log No. 1

Depth (m)	Description	Shear Strength (kNm) $^{-2}$	Symbol
5.0	As before		
5.5	Refusal		
	GROUND WATER: Standing water at 1.5 metres deep		
	NOTE: gas monitoring well installed to 4.7m deep.		
6.0			
	Samples Recovered		
6.5	Glass Jars: 0.4, 0.8, 1.0, 1.6, 2.5 & 3.5m		
	Water Sample Recovered		
7.0			
7.5			
8.0			
8.5			
9.0			
9.5			
10.0			

Drilling Apparatus : Auto-Trip Standard Penetration Test Drop Hammer

Scheme : 89 Harwood Street, Darwen.

Date : 22/10/08

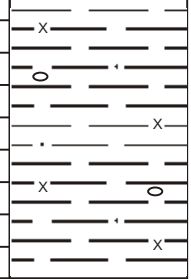
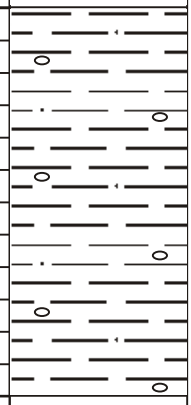
MINI BORE
Site Investigation
24 Pendle Fields, Fence, Burnley, BB12 9HN
Telephone/Fax : 01282 697491

Borehole Log No. 2

Depth (m)	Description	Shear Strength (kNm) $^{-2}$	Symbol
0.0	TOPSOIL		
	MADE GROUND- soil, black ash & clinker, a piece of rotting ply-wood & very occasional inclusions of clay		
0.5	Standard Penetration Tests		
	MADE GROUND- concrete rubble & stone cobbles		
	From 0.7m to 1.15m 2 / 2 - 2, 2, 5, 3 N = 12 (cone)		
1.0	MADE GROUND- soil & black ash with many gravel inclusions, occasional stone cobbles, occasional brick fragments & very occasional fragments of glass		
1.5	Firm light brown very sandy CLAY		
2.0	Loose brown very clayey SAND with many gravel inclusions		
	From 2.1m to 2.55m 2 / 2 - 2, 2, 2, 2 N = 8		
2.5			
	From 2.9m to 3.35m 2 / 2 - 3, 3, 4, 3 N = 13		
3.0	(Becoming medium dense at depth)		
3.5	Firm to stiff mid brown very sandy CLAY with many angular gravel inclusions		
4.0	Firm dark brown very silty, sandy CLAY with occasional gravel inclusions		
	From 4.2m to 4.65m 2 / 1 - 2, 1, 2, 2 N = 7		
4.5			
5.0			

Continued Overleaf

Borehole Log No. 2

Depth (m)	Description	Shear Strength (kNm)$^{-2}$	Symbol
5.0	As before		
5.5			
6.0	Stiff dark brown very sandy CLAY with many gravel & occasional cobble inclusions From 6.2m to 6.65m 4 / 4 - 3, 4, 5, 5 N = 17		
6.5			
7.0	End of Bore GROUND WATER: Standing water at 3.5 metres deep NOTE: gas monitoring well installed to 6.0m deep. Samples Recovered Glass Jars: 0.35, 0.6, 1.2, 1.7, 2.1m Sample Bag: 2.8m Water Sample Recovered		
7.5			
8.0			
8.5			
9.0			
9.5			
10.0			

APPENDIX B LABORATORY TESTING RESULTS

envirolab
Units 7 & 8 Sandpits Business Park
Mottram Road, Hyde, Cheshire, SK14 3AR

FINAL ANALYTICAL TEST REPORT

Envirolab Job Number: 10/01728
Issue Number: 2 **Date:** 10 June, 2010

Client:
PSA Design
The Old Bank House
6 Berry Lane
Longridge
Preston
Lancashire
UK
PR3 3JA

Project Manager: John Birtwhistle
Project Name: Harwood St, Darwen
Project Ref: G1320
Order No: G1320-01
Date Samples Received: 25/05/10
Date Instructions Received: 25/05/10
Date Analysis Completed: 10/06/10

Prepared by:
Melanie Marshall
Laboratory Coordinator

Approved by:
Iain Haslock
Analytical Consultant

Notes - Soil samples for chemical analysis
All results are reported as dry weight (<40°C).
Stones >10mm are removed from the sample prior to analysis and results corrected where appropriate.
Subscript A indicates analysis performed on the sample as received, D indicates analysis performed on dried & crushed sample.
Superscript M indicates method accredited to MCERTS.

Predominant Matrix Codes - 1 = SAND, 2 = LOAM, 3 = CLAY, 4 = LOAM/SAND, 5 = SAND/CLAY, 6 = CLAY/LOAM, 7 = OTHER.
Samples with Matrix Code 7 are not predominantly a SAND/LOAM/CLAY mix and are not covered by our MCERTS accreditation.
Secondary Matrix Codes - A = contains stones, B = contains construction rubble, C = contains visible hydrocarbons, D = contains glass/metal, E = contains roots/twigs.

Notes - General
Superscript # indicates method accredited to ISO 17025.
Analytical results reflect the quality of the sample at the time of analysis only.
Opinions and interpretations expressed are outside the scope of our accreditation.
IS indicates Insufficient sample for analysis.
NDP indicates No Determination Possible.

MCERTS THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME
UKAS TESTING 1247

envirolab

Envirolab Job Number: 10/01728

Client Project Name: Harwood St, Darwen

Client Project Ref: G1320

Lab Sample ID	10/01728/1	10/01728/2	10/01728/3	10/01728/4	10/01728/5				Units	Method ref
Client Sample No	1	1	2	1	2					
Client Sample ID	2WS1	2WS2	2WS2	2WS3	2WS3					
Depth to Top	0.30	0.50	1.20	0.50	0.65					
Depth To Bottom										
Date Sampled	19-May-10	19-May-10	19-May-10	19-May-10	19-May-10					
Sample Type	Soil	Soil	Soil	Soil	Soil					
Sample Matrix Code	4A	6A	6A	6A	5					
Asbestos Screen$_A$	No ACM	No ACM	No ACM	No ACM	-					Visual
pH$_D$ M#	7.9	8.3	8.2	8.1	7.8				pH	A-T-031s
Sulphate (acid soluble)$_D$ M#	1000	1500	1400	2000	310				mg/kg	A-T-028
Cyanide (total)$_A$ M#	<1	<1	<1	<1	<1				mg/kg	A-T-042sTCN
Phenols - Total by HPLC$_A$	<0.2	<0.2	<0.2	<0.2	<0.2				mg/kg	A-T-050s
Sulphide$_A$ #	<15	<15	<15	<15	<15				mg/kg	A-T-S2-s
Sulphur (elemental)$_D$ M#	47	58	37	76	48				mg/kg	A-T-029s
Arsenic$_D$ M#	45	15	15	32	4				mg/kg	A-T-024
Boron (water soluble)$_D$ M#	<1.0	<1.0	<1.0	<1.0	<1.0				mg/kg	A-T-027s
Cadmium$_D$ M#	0.9	0.9	1.4	1.9	<0.5				mg/kg	A-T-024
Copper$_D$ M#	212	62	47	209	8				mg/kg	A-T-024
Chromium$_D$ M#	38	58	37	117	34				mg/kg	A-T-024
Lead$_D$ M#	395	2390	872	5190	104				mg/kg	A-T-024
Mercury$_D$	0.36	0.52	0.36	1.40	0.26				mg/kg	A-T-024
Nickel$_D$ M#	62	28	25	41	10				mg/kg	A-T-024
Selenium$_D$ M#	2	<1	<1	<1	<1				mg/kg	A-T-024
Zinc$_D$ M#	263	584	1430	1390	65				mg/kg	A-T-024
TPH total (C6-C40)$_A$ #	<10	12	<10	195	<10				mg/kg	A-T-007s

Envirolab Job Number: 10/01728

Client Project Name: Harwood St, Darwen

Client Project Ref: G1320

Lab Sample ID	10/01728/1	10/01728/2	10/01728/3	10/01728/4	10/01728/5				Units	Method ref
Client Sample No	1	1	2	1	2					
Client Sample ID	2WS1	2WS2	2WS2	2WS3	2WS3					
Depth to Top	0.30	0.50	1.20	0.50	0.65					
Depth To Bottom										
Date Sampled	19-May-10	19-May-10	19-May-10	19-May-10	19-May-10					
Sample Type	Soil	Soil	Soil	Soil	Soil					
Sample Matrix Code	4A	6A	6A	6A	5					
PAH 16										
Acenapthene$_A^{M\#}$	0.03	0.03	0.01	0.08	<0.01				mg/kg	A-T-019s
Acenapthylene$_A^{\#}$	<0.01	<0.01	<0.01	0.18	<0.01				mg/kg	A-T-019s
Anthracene$_A^{M\#}$	0.13	0.23	0.29	1.71	<0.01				mg/kg	A-T-019s
Benzo(a)anthracene$_A^{\#}$	0.12	0.19	0.11	1.07	<0.01				mg/kg	A-T-019s
Benzo(a)pyrene$_A^{M\#}$	0.38	0.07	0.05	3.83	<0.01				mg/kg	A-T-019s
Benzo(b)fluoranthene$_A^{M\#}$	0.16	0.65	0.08	3.07	<0.01				mg/kg	A-T-019s
Benzo(ghi)perylene$_A^{M\#}$	0.14	0.05	0.03	2.31	<0.01				mg/kg	A-T-019s
Benzo(k)fluoranthene$_A^{M\#}$	0.24	0.61	0.10	2.67	<0.01				mg/kg	A-T-019s
Chrysene$_A^{M\#}$	0.36	0.75	0.25	5.74	<0.01				mg/kg	A-T-019s
Dibenzo(ah)anthracene$_A^{\#}$	0.02	0.08	<0.01	0.02	<0.01				mg/kg	A-T-019s
Fluoranthene$_A^{M\#}$	0.38	0.06	2.24	4.94	<0.01				mg/kg	A-T-019s
Fluorene$_A^{M\#}$	<0.01	<0.01	<0.01	<0.01	<0.01				mg/kg	A-T-019s
Indeno(123-cd)pyrene$_A^{\#}$	<0.01	0.33	<0.01	0.41	<0.01				mg/kg	A-T-019s
Napthalene$_A^{M\#}$	0.05	0.33	0.21	0.41	0.04				mg/kg	A-T-019s
Phenanthrene$_A^{M\#}$	0.60	0.40	0.64	3.18	<0.01				mg/kg	A-T-019s
Pyrene$_A^{M\#}$	<0.01	0.68	<0.01	0.29	0.05				mg/kg	A-T-019s
Total PAH$_A^{\#}$	2.62	4.43	4.02	29.9	0.10				mg/kg	A-T-019s

APPENDIX C STATISTICAL ANALYSIS OF CHEMICAL TEST DATA

Maximum Value Test
Harwood St, Darwen

T value for 10%, N = 5 is 1.67

			2010 test results					logarithm of results					statistical analysis				
Trial Pit/BH			2WS1	2WS2	2WS2	2WS3	2WS3										
Sample No			1	1	2	1	2										
Sample Depth (mbgl)			0.30	0.50	1.20	0.50	0.65										
Soil (S)/Water(W)			mixed MG	mixed MG	mixed MG	mixed MG	clay fill										
det name	LOD	units											average	standard dev	y max	no. samples	T
arsenic	3	mg/kg	45	15	15	32	4	1.65	1.18	1.18	1.51	0.60	1.22	0.40	1.65	5.00	1.06
boron	1	mg/kg	1	1	1	1	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	#DIV/0!
cadmium	0.5	mg/kg	0.9	0.9	1.4	1.9	0.5	-0.05	-0.05	0.15	0.28	-0.30	0.01	0.22	0.28	5.00	1.24
chromium	4.5	mg/kg	38	58	37	117	34	1.58	1.76	1.57	2.07	1.53	1.70	0.22	2.07	5.00	1.64
copper	6	mg/kg	212	62	47	209	8	2.33	1.79	1.67	2.32	0.90	1.80	0.58	2.33	5.00	0.90
lead	2	mg/kg	395	2390	872	5190	104	2.60	3.38	2.94	3.72	2.02	2.93	0.66	3.72	5.00	1.18
mercury	0.17	mg/kg	0.36	0.52	0.36	1.4	0.26	-0.44	-0.28	-0.44	0.15	-0.59	-0.32	0.28	0.15	5.00	1.66
nickel	0.9	mg/kg	62	28	25	41	10	1.79	1.45	1.40	1.61	1.00	1.45	0.30	1.79	5.00	1.16
selenium	1	mg/kg	2	1	1	1	1	0.30	0.00	0.00	0.00	0.00	0.06	0.13	0.30	5.00	1.79
zinc	2.5	mg/kg	263	584	1430	1390	65	2.42	2.77	3.16	3.14	1.81	2.66	0.56	3.16	5.00	0.88
cyanide (total)	1	mg/kg	1	1	1	1	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	#DIV/0!
phenols	0.2	mg/kg	0.2	0.2	0.2	0.2	0.2	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	0.00	-0.70	5.00	0.00
sulphate	200	mg/kg	1000	1500	1400	2000	310	3.00	3.18	3.15	3.30	2.49	3.02	0.32	3.30	5.00	0.88
sulphide	15	mg/kg	15	15	15	15	15	1.18	1.18	1.18	1.18	1.18	1.18	0.00	1.18	5.00	#DIV/0!
pH			7.9	8.3	8.2	8.1	7.8	0.90	0.92	0.91	0.91	0.89	0.91	0.01	0.92	5.00	1.15
sulphur	5	mg/kg	47	58	37	76	48	1.67	1.76	1.57	1.88	1.68	1.71	0.12	1.88	5.00	1.44
asbestos			0	0	0	0											
PAH (total)	0.01	mg/kg	2.62	4.43	4.02	29.9	0.1	0.42	0.65	0.60	1.48	-1.00	0.43	0.90	1.48	5.00	1.17
napthalene	0.01	mg/kg	0.05	0.33	0.21	0.41	0.04	-1.30	-0.48	-0.68	-0.39	-1.40	-0.85	-0.74	-0.83	5.00	-0.03
fluorene	0.01	mg/kg	0.01	0.01	0.01	0.01	0.01	-2.00	-2.00	-2.00	-2.00	-2.00	-2.00	-2.00	-2.00	5.00	0.00
benzo(a)pyrene	0.01	mg/kg	0.38	0.07	0.05	3.83	0.01	-0.42	-1.15	-1.30	0.58	-2.00	-0.86	-0.97	-0.89	5.00	0.04
dibenzo(a,h)anthracene	0.01	mg/kg	0.02	0.08	0.01	0.02	0.01	-1.70	-1.10	-2.00	-1.70	-2.00	-1.70	-1.70	-1.85	5.00	0.09
Total Petroleum Hydrocarbons	10	mg/kg	10	12	10	195	10	1.00	1.08	1.00	2.29	1.00	1.27	1.34	1.39	5.00	0.09

Harwood St, Darwen
Mean Value Test

number of samples = 5

		2010 test results					statistical analysis					generic reference values			
Trial Pit/BH		2WS1	2WS2	2WS2	2WS3	2WS3									
Sample No		1.0	1.0	2.0	1.0	2.0									
Sample Depth (mbgl)		0.30	0.50	1.20	0.50	0.65	average	std dev	t value	US 95		SGV	LCM 2009 (residntl)	BRE	ICRCL Threshold/ EA inert
Soil (S)/Water(W)		mixed MG	mixed MG	mixed MG	mixed MG	clay fill									
det name	units											(residntl)			(resid)
arsenic	mg/kg	45	15	15	32	4	22.2	16.2	2.132	37.65	arsenic	32			
boron	mg/kg	1	1	1	1	1	1.0	0.0	2.132	1.00	boron		291		
cadmium	mg/kg	0.9	0.9	1.4	1.9	0.5	1.1	0.5	2.132	1.64	cadmium	10			
chromium	mg/kg	38	58	37	117	34	56.8	35.0	2.132	90.14	chromium	130			
copper	mg/kg	212	62	47	209	8	107.6	96.0	2.132	199.12	copper		2330		
lead	mg/kg	395	2390	872	5190	104	1790.2	2094.7	2.132	3787.43	lead	450			
mercury	mg/kg	0.36	0.52	0.36	1.4	0.26	0.6	0.5	2.132	1.03	mercury	170			
nickel	mg/kg	62	28	25	41	10	33.2	19.5	2.132	51.80	nickel	130			
selenium	mg/kg	2	1	1	1	1	1.2	0.4	2.132	1.63	selenium	350			
zinc	mg/kg	263	584	1430	1390	65	746.4	633.6	2.132	1350.53	zinc		3750		
cyanide (complex)	mg/kg	1	1	1	1	1	1.0	0.0	2.132	1.00	cyanide (complex)				250
phenols	mg/kg	0.2	0.2	0.2	0.2	0.2	0.2	0.0	2.132	0.20	phenols	420			
sulphate	mg/kg	1000	1500	1400	2000	310	1242.0	631.1	2.132	1843.75	sulphate			2000	
sulphide	mg/kg	15	15	15	15	15	15.0	0.0	2.132	15.00	sulphide				
pH		7.9	8.3	8.2	8.1	7.8	8.1	0.2	2.132	8.26	pH				
sulphur	mg/kg	47	58	37	76	48	53.2	14.8	2.132	67.27	sulphur				
PAH (total)	mg/kg	2.62	4.43	4.02	29.9	0.1	8.2	12.2	2.132	19.88	PAH (total)				100
napthalene	mg/kg	0.05	0.33	0.21	0.41	0.04	0.2	0.2	2.132	0.37	napthalene		3.7		
fluorene	mg/kg	0.01	0.01	0.01	0.01	0.01	0.0	0.0	2.132	0.01	fluorene		380		
benzo(a)pyrene	mg/kg	0.38	0.07	0.05	3.83	0.01	0.9	1.7	2.132	2.45	benzo(a)pyrene		0.94		
dibenzo(a,h)anthracene	mg/kg	0.02	0.08	0.01	0.02	0.01	0.0	0.0	2.132	0.06	dibenzo(a,h)anthracene		0.86		

APPENDIX D GAS/GROUNDWATER MONITORING RESULTS

Gas Monitoring Results

PSA DESIGN
engineering your environment
CIVIL, STRUCTURAL, GEOTECHNICAL, TRANSPORT

JOB DETAILS				Sheet No:	*1*
Location:	*Harwood St, Darwen*			Engineer:	*Dr J Birtwhistle*
Date:	*28/05/2010*	Job No:	*G1320*	Time:	*11.30hrs*

Meteorological and site information

State of ground.	✓	*Dry*		Moist		Wet			
Wind.		*Calm*	✓	Light		Moderate		Strong	
Cloud cover.		*None*		Slight	✓	Cloudy		Overcast	
Precipitation.	✓	*None*		Slight		Moderate		Heavy	
Barometric pressure (mb)		*999*		Air Temp.		*14'C*			

Calibration (Start)	O.K.	Calibration (End)	O.K.	

B.H. Ref:	CH4 (% vol in air)	CO2 (% vol in air)	O2 (% vol in air)	LEL	Flow Range (l/hr)	Average Flow (l/hr)	Pressure difference (Mb)	Comments
BH1	*0.0*	*0.1*	*20.8*		*0.0*	*0.0*	*0.0*	*water level 2.85mbgl*
BH2	*0.0*	*0.1*	*20.8*		*0.0*	*0.0*	*0.0*	*water level 4.50mbgl*

Notes:
Water level was recorded in both well installations

Pressure lowering,low pressure system over British Isles

	CO2 (% vol in air)	O2 (% vol in air)
Background	0.1	20.8

Gas Monitoring Results

PSA DESIGN
engineering your environment
CIVIL, STRUCTURAL, GEOTECHNICAL, TRANSPORT

JOB DETAILS				Sheet No:	1
Location:	Harwood St, Darwen			Engineer:	Dr J Birtwhistle
Date:	10/06/2010	Job No:	G1320	Time:	8.30 am

Meteorological and site information

State of ground.		Dry	✓	Moist		Wet			
Wind.		Calm	✓	Light		Moderate		Strong	
Cloud cover.		None		Slight		Cloudy	✓	Overcast	
Precipitation.	✓	None		Slight		Moderate		Heavy	
Barometric pressure (mb)		999			Air Temp.	10'C			

Calibration (Start)	O.K.	Calibration (End)	O.K.	

B.H. Ref:	CH4 (% vol in air)	CO2 (% vol in air)	O2 (% vol in air)	LEL	Flow Range (l/hr)	Average Flow (l/hr)	Pressure difference (Mb)	Comments
BH1	0.0	1.1	20.1		0.0	0.0	0.0	water level 2.3mbgl
BH2	0.0	0.1	20.8		0.0	0.0	0.0	dry

Notes:
Water level was recorded in one well installation

Pressure lowering,low pressure system over British Isles

	CO2 (% vol in air)	O2 (% vol in air)
Background	0.1	20.8

Gas Monitoring Results

PSA DESIGN
engineering your environment
CIVIL, STRUCTURAL, GEOTECHNICAL, TRANSPORT

JOB DETAILS				Sheet No:	*1*
Location:	*Harwood St, Darwen*			Engineer:	*Dr J Birtwhistle*
Date:	*14/07/2010*	Job No:	*G1320*	Time:	*8.30 am*

Meteorological and site information

State of ground.		*Dry*		Moist	✓	Wet			
Wind.		*Calm*	✓	Light		Moderate		Strong	
Cloud cover.		*None*		Slight		Cloudy	✓	Overcast	
Precipitation.		*None*	✓	Slight		Moderate		Heavy	
Barometric pressure (mb)		*988*		Air Temp.		*18'C*			

Calibration (Start)	O.K.	Calibration (End)	O.K.	

B.H. Ref:	CH4 (% vol in air)	CO2 (% vol in air)	O2 (% vol in air)	LEL	Flow Range (l/hr)	Average Flow (l/hr)	Pressure difference (Mb)	Comments
BH1	*0.0*	*0.9*	*20.4*		*0.0*	*0.0*	*0.0*	*water level 2.3mbgl*
BH2	*0.0*	*0.1*	*20.8*		*0.0*	*0.0*	*0.0*	*dry*

Notes:
Water level was recorded in one well installation

Pressure lowering,low pressure system over British Isles

	CO2 (% vol in air)	O2 (% vol in air)
Background	0	20.9

Gas Monitoring Results

PSA DESIGN
engineering your environment
CIVIL, STRUCTURAL, GEOTECHNICAL, TRANSPORT

JOB DETAILS				Sheet No:	*1*
Location:	*Harwood St, Darwen*			Engineer:	*Dr J Birtwhistle*
Date:	*03/08/2010*	Job No:	*G1320*	Time:	*8.30 am*

Meteorological and site information

State of ground.		*Dry*		Moist	✓	Wet		
Wind.		*Calm*	✓	Light		Moderate		Strong
Cloud cover.		*None*		Slight		Cloudy	✓	Overcast
Precipitation.		*None*	✓	Slight		Moderate		Heavy
Barometric pressure (mb)		*1015*			Air Temp.	*16'C*		

Calibration (Start)	O.K.	Calibration (End)	O.K.	

B.H. Ref:	CH4 (% vol in air)	CO2 (% vol in air)	O2 (% vol in air)	LEL	Flow Range (l/hr)	Average Flow (l/hr)	Pressure difference (Mb)	Comments
BH1	*0.0*	*0.6*	*20.2*		*0.0*	*0.0*	*0.0*	*water level 2.3mbgl*
BH2	*0.0*	*0.0*	*20.8*		*0.0*	*0.0*	*0.0*	*dry*

Notes:
Water level was recorded in one well installation

Occluded front with high pressure system to W of British Isles

	CO2 (% vol in air)	O2 (% vol in air)
Background	0	20.8

Gas Monitoring Results

PSA DESIGN
engineering your environment
CIVIL, STRUCTURAL, GEOTECHNICAL, TRANSPORT

JOB DETAILS				Sheet No:	1
Location:	Harwood St, Darwen			Engineer:	Dr J Birtwhistle
Date:	13/08/2010	Job No:	G1320	Time:	8.30 am

Meteorological and site information

State of ground.		Dry		Moist	✓	Wet			
Wind.		Calm	✓	Light		Moderate		Strong	
Cloud cover.		None		Slight		Cloudy	✓	Overcast	
Precipitation.		None		Slight	✓	Moderate		Heavy	
Barometric pressure (mb)		1006			Air Temp.	15'C			

Calibration (Start)	O.K.	Calibration (End)	O.K.	

B.H. Ref:	CH4 (% vol in air)	CO2 (% vol in air)	O2 (% vol in air)	LEL	Flow Range (l/hr)	Average Flow (l/hr)	Pressure difference (Mb)	Comments
BH1	0.0	0.5	20.3		0.0	0.0	0.0	water level 2.3mbgl
BH2	0.0	0.0	20.7		0.0	0.0	0.0	dry

Notes:
Water level was recorded in one well installation

Occluded front with high pressure system over British Isles

	CO2 (% vol in air)	O2 (% vol in air)
Background	0	20.7

Gas Monitoring Results

PSA DESIGN
engineering your environment
CIVIL, STRUCTURAL, GEOTECHNICAL, TRANSPORT

JOB DETAILS				Sheet No:	1
Location:	Harwood St, Darwen			Engineer:	Dr J Birtwhistle
Date:	31/08/2010	Job No:	G1320	Time:	8.30 am

Meteorological and site information

State of ground.		Dry	✓	Moist		Wet			
Wind.	✓	Calm		Light		Moderate		Strong	
Cloud cover.		None	✓	Slight		Cloudy		Overcast	
Precipitation.	✓	None		Slight		Moderate		Heavy	
Barometric pressure (mb)		1027			Air Temp.	20'C			

Calibration (Start)	O.K.	Calibration (End)	O.K.	

B.H. Ref:	CH4 (% vol in air)	CO2 (% vol in air)	O2 (% vol in air)	LEL	Flow Range (l/hr)	Average Flow (l/hr)	Pressure difference (Mb)	Comments
BH1	0.0	0.4	20.4		0.0	0.0	0.0	water level 2.3mbgl
BH2	0.0	0.0	20.7		0.0	0.0	0.0	dry

Notes:
Water level was recorded in one well installation

Occluded front with high pressure system over British Isles

	CO2 (% vol in air)	O2 (% vol in air)
Background	0	20.7

APPENDIX E RISK ASSESSMENT METHOD

Table 6.3 Classification of Consequence

Classification	Definition	Examples
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 significance of pollution) of sensitive water resource. Catastrophic damage to buildings/property. A short-term risk to a particular ecosystem (note: the definitions of ecological systems within the Draft Circular on Contaminated Land, DETR, 2000).	High concentrations of cyanide on the surface of an informal recreation area. Major spillage of contaminants from site into controlled water. Explosion, causing building collapse (can also equate to a short-term human health risk if buildings are occupied)
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 significance of pollution). A significant change in 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).	Concentrations of a contaminant from site exceed the generic, or site -specific assessment criteria. Leaching of contaminants from a site to a major or minor aquifer. Death of a species within a designated nature reserve.
Mild	Pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services ("significant harm" as defined in the *Draft Circular on Contaminated Land*, DETR, 2000). Damage to sensitive buildings/structures or the environment.	Pollution of non-classified groundwater. Damage to building rendering it unsafe to occupy (e.g. foundation damage resulting in instability).
Minor	Harm, although not necessarily significant harm, which may result in a financial loss, or expenditure to resolve. Non-permanent health effects to health (easily prevented by means such as personal protective clothing etc). Easily repairable effects of damage to buildings, structures and services.	The presence of contaminants at such concentrations that protective equipment is required during site works. The loss of plants in a landscaping scheme. Discoloration of concrete.

Table 6.4 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 pollution 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 such an event would take place, and is 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.

Table 6.5 Comparison of consequence against probability

probability	consequence: severe	medium	mild	minor
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

Table 6.6 Description of the classified risks and likely action required

Very high risk	There is a high probability that severe harm could arise to a designated receptor from an identified hazard, OR, there is evidence that severe harm to a designated receptor is currently happening. This risk, if realised, is likely to result in a substantial liability. Urgent investigation (if not undertaken already) and remediation are likely to be required.
High risk	Harm is likely to arise to a designated receptor from an identified hazard. Realisation of the risk is likely to present a substantial liability. Urgent investigation (if not undertaken already) is required and remedial work may be necessary in the short term and are likely over the longer term.
Moderate risk	It is possible that harm could arise to a designated receptor from an identified hazard. However, if it is either relatively unlikely that any such harm would be severe, or if any harm were to occur it is more likely that the harm would be relatively mild. Investigation (if not already undertaken) is normally required to clarify the risk and to determine the potential liability. Some remedial works may be required in the longer term.
Low risk	It is possible that harm could arise to a designated receptor from an identified hazard, but it is likely that this harm, if realised, would at worst normally be mild.
Very low risk	There is a low possibility that harm could arise to a receptor. In the event of such harm being realised it is not likely to be severe.