

WREXHAM COUNTY BOROUGH COUNCIL

**NANT SILYN,
WREXHAM. LL13 8SQ**

GROUND INVESTIGATION REPORT

Contract: 42166

Date: February 2018

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GROUND INVESTIGATION REPORT

carried out at

**NANT SILYN,
WREXHAM. LL13 8SQ**

Prepared for

**WREXHAM COUNTY BOROUGH COUNCIL
Cefn Road
Wrexham
LL13 9NG**

Contract No: 42166

Date: February 2018

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EXECUTIVE SUMMARY

On the instructions of Wrexham County Borough Council (WCBC) a ground investigation was undertaken to determine ground conditions to inform design for new council housing.

The scope of the sitework and laboratory testing was determined by WCBC.

The site is situated at the former Nant Silyn Nursing Home, approximately 0.80km to the southeast of the town centre of Wrexham.

The geological map indicates the site to be underlain by superficial deposits predominantly comprising River Terrace Deposits. Alluvium is noted on the northern part of the site. A lens of Glaciolacustrine Deposits comprising clay and silt was located on the southwestern corner of the site. Bedrock beneath the site is recorded as Mudstone, Sandstone and Conglomerate of Salop Formation of Permian and Carboniferous age.

The site work was carried out between the 11th to 15th January 2018.

The sequence encountered generally comprises of made ground up to depth of 1.40m overlying natural strata of coarse soils of sand and gravel and localised fine soils of clay and silt.

The proposed building will be underlain by variable soil types including soft clay, silt and loose sand up to depth 5.00m. These variations in soil thickness and characteristics may result in variable bearing capacity and settlement characteristics across the development.

Ground improvement may be carried out to increase bearing characteristics at shallow depth and unify settlement characteristics. Alternatively, piled foundations may be utilised to limit differential settlements across the building footprint.

Design Sulphate Class may be taken as DS-1. An ACEC class for the site of AC-1 would be appropriate.

Analytical testing indicated all the contaminants concentrations to be below their respective Guidance Levels. No asbestos was detected. Therefore, no significant contamination risks to human health are considered to be associated with the proposed development of the site. This assessment is based on one soil sample as required by WCBC in the scope of works. Additional soil sampling and analysis may be required to determine variation across the site.

CONTENTS

EXECUTIVE SUMMARY

1.0	INTRODUCTION	3
2.0	SITE SETTING	4
2.1	Site Location	4
2.2	Geological Setting	5
3.0	SITE WORK	6
4.0	LABORATORY TESTS	7
4.1	Geotechnical Testing	7
4.2	Chemical Testing	8
5.0	GROUND CONDITIONS ENCOUNTERED	9
5.1	Sequence	9
5.2	Made Ground	9
5.3	Natural Strata	10
5.4	Groundwater	11
6.0	GEOTECHNICAL ASSESSMENT	12
6.1	Proposed Development	12
6.2	Foundations	12
6.3	Ground Floor Slabs	13
6.4	Excavations	13
6.5	Chemical Attack on Buried Concrete	13
7.0	ENVIRONMENTAL RISK ASSESSMENT IN RELATION TO PROPOSED DEVELOPMENT	14
7.1	Contaminated Land	14
7.2	Risk Assessment	14
7.3	Pollutant Linkage	14
7.4	Risk Assessment – Human Health	15
7.5	Protection Of Services	16
8.0	MANAGEMENT OF CONTAMINATION	16
8.1	Remediation and Verification	16
8.2	Management of Unidentified Sources of Contamination	16
8.3	Consultation	17
8.4	Risk Management During Site Works	17
9.0	REFERENCES	19
APPENDIX 1	- DRAWINGS	
Figure A1.1	- Site Location Plan	
Figure A1.2	- Site Plan	

Figure A1.3	-	Nominal Section	
Figure A1.4	-	SPT vs Depth Plot	
APPENDIX 2	-	SITE WORK	
		General Notes on Site Work	ii/i-ii/ii
BH01 to BH03	-	Borehole Records	
APPENDIX 3	-	LABORATORY TESTS	
		General Notes on	
		Laboratory Tests on Soils	iii/i-iii/iii
Test Report 42166	-	Moisture Content Summary	
	-	Plasticity Indices Summary	
	-	Particle Size Distribution Curves	
	-	Triaxial Compression Curves	
Test Report 18-01203	-	pH and Water-soluble Sulphate Summary – soil	
Test Reports 18-00257, 18-00299 & 18-00306	-	pH and Water-soluble Sulphate Summary – water	
APPENDIX 4	-	CHEMICAL TESTS	
Test Report 18-00258	-	Results of Chemical Tests – Soils	
APPENDIX 5	-	DESIGN CONSIDERATIONS	
		Guidelines for the Design of	
		Piles - First Approximation	
		of Working Loads	v/i-v/iv
APPENDIX 6	-	CONTAMINATION ASSESSMENT	
		General Notes on Chemical Contamination	

1.0 INTRODUCTION

- 1.1 It is understood that the proposed development comprises the construction of new council housing on the land of the former Nant Silyn nursing home.
- 1.2 On the instructions of Wrexham County Borough Council (WCBC) a ground investigation was undertaken to determine ground conditions to inform design for the project.
- 1.3 It is recommended that a copy of this report be submitted to the relevant authorities to enable them to carry out their own site assessments and provide any comments.
- 1.4 This report has been prepared for the sole use of the Client for the purpose described and no extended duty of care to any third party is implied or offered. Third parties using any information contained within this report do so at their own risk.
- 1.5 The comments given in this report and the opinions expressed herein are based on the information received, the conditions encountered during site works, and on the results of tests made in the field and laboratory. However, there may be conditions prevailing at the site which have not been disclosed by the investigation and which have not been taken into account in the report.
- 1.6 The comments on groundwater conditions are based on observations made at the time the site work was carried out. It should be noted that groundwater levels vary owing to seasonal or other effects.

2.0 SITE SETTING

2.1 Site Location

- 2.1.1 The site is situated at Nant Silyn, approximately 0.80km to the southeast of the town centre of Wrexham.
- 2.1.2 The may be located by Grid Reference SJ 343 498.
- 2.1.3 A site location plan and aerial photograph are included in Appendix 1, Figures A1.1 and A1.2.

2.2 Site Description

- 2.1.1 At the time of the investigation the site was the disused Nant Silyn Nursing Home.
- 2.1.2 The site is approximately 0.35 Ha and is rectangular.
- 2.1.3 The disused nursing home comprised a single storey block building with tarmacadam car parking to the east.
- 2.1.4 The site was reasonably level. Levels noted as 65mAOD.
- 2.1.5 Grassed areas were located northeast and southeast surrounded by a mixture of wooden and mesh fencing.
- 2.1.6 A grassed slope was located to the south of the site.
- 2.1.7 The site was accessed off Pont Wen to the east. The access to the site sloped towards the north.
- 2.1.8 Japanese Knotweed was observed along the northern edges of the site.
- 2.1.9 The site is bound to the northwest by the River Gwenfro, to the southwest by a dismantled railway on embankment and to the southeast and northeast by residential properties.

2.2 Geological Setting

- 2.2.1 Details of the geology underlying the site have been obtained from the British Geological Survey web based geological records database (contains British Geological Survey materials ©NERC 2017).
- 2.2.2 The geological map indicates the majority of the site to be underlain by superficial deposits comprising River Terrace Deposits. The northern part of the site was underlain by Alluvium comprising clay, silt, sand and gravel.
- 2.2.3 Lenses of Glaciolacustrine Deposits comprising clay and silt were located on the southwest corner of the site,
- 2.2.4 Bedrock beneath the site is recorded as Mudstone, Sandstone and Conglomerate of the Salop Formation of Permian and Carboniferous age.
- 2.2.5 The site is within an urban area and, although not indicated as present on the site from the geological maps, the possibility that Made Ground exists on site cannot be discounted.
- 2.2.6 Historical boreholes have been viewed through the BGS web based database (contains British Geological Survey materials ©NERC 2017). The following boreholes were viewed: SJ34NW249, SJ34NW253, SJ34NW254 and SJ34NW255. These were located between 30m to 65m south and west of the site and indicated made ground up to depths of 1.90m. Beneath the made ground superficial deposits predominately comprised sand and gravel with clay bands up depth of 3.65m. SJ34NW255 encountered clay between 1.90m and 2.05m.

3.0 SITE WORK

- 3.1 The site work was carried out between the 11th and 15th January 2018.
- 3.2 The scope of the works was determined by WCBC. The locations of exploratory holes were indicated on drawings provided by the WCBC.
- 3.3 The site works were carried out on the basis of the practices set out in CLR 4, (ref. 9.1), BS 5930:2015 (ref. 9.2), BS EN ISO 14688-1:2002+A1:2013 (ref. 9.3) and BS 10175:2011, (ref. 9.4).
- 3.4 Exploratory holes were undertaken as follows:
 - BH01 to BH03: Cable percussion boreholes
- 3.5 A site plan showing the positions of the boreholes is presented in Appendix 1 as Figure A1.2.
- 3.6 The depths of boreholes, descriptions of strata encountered and comments on groundwater conditions are given in the records presented in Appendix 2.
- 3.7 A Cable Avoidance Tool (CAT) survey was undertaken at each exploratory hole location prior to excavation. At the location of boreholes an inspection pit was excavated by hand to a depth of 1.20m below ground level to check for buried services.
- 3.8 Representative disturbed and undisturbed samples were taken at the depths shown on the records. Samples for environmental analysis were collected in appropriate containers and kept in cool boxes for daily despatch to the analytical laboratory.
- 3.9 Standard penetration tests (SPT), ref. 9.3 were carried out in boreholes in the various strata to assess the relative density or consistency. The values of penetration resistance are given in the borehole records. Energy ratio calibration certification for SPT hammers used on site are presented in Appendix 2.
- 3.10 The coordinates for the exploratory hole locations reported on the records, were estimated from online GIS mapping sources.
- 3.11 Levels has been estimated from topography plan provided by the client.

4.0 LABORATORY TESTS

4.1 Geotechnical Testing

- 4.1.1 The scope of testing was determined by WCBC.
- 4.1.2 Geotechnical testing schedules were prepared by Ian Farmer Associates (IFA).
- 4.1.3 Geotechnical testing was undertaken by IFA at their Washington Laboratory. Geotechnical chemical tests were undertaken by Derwentside Environmental Testing, in Consett and Envirolab in Hyde.
- 4.1.4 Soil samples for testing were prepared in accordance with BS1377: Part One: 1990 ref. 9.9 and representative sub-samples were taken for testing. The following tests were carried out:

Soil

- 3 No. Moisture contents
- 3 No. Plasticity indices
- 6 No. Particle size distribution by wet sieving
- 2 No. Particle size distribution by sedimentation
- 1 No Undrained shear strength
- 1 No. Water soluble sulphate
- 1 No pH value

Groundwater

- 3 No. Water soluble sulphate
 - 3 No pH value
- 4.1.5 The results of the soil tests are presented in Appendix 3, Test Report 42166/1.
 - 4.1.6 The results of the groundwater tests are presented in Appendix 3, Test Reports 18-00257, 18-00299 and 18-00306.

4.2 Chemical Testing

- 4.2.1 The scope of chemical testing was determined by WCBC.
- 4.2.2 Chemical testing schedules were prepared by IFA.
- 4.2.3 The chemical analyses were carried out on one sample of soil. The nature of the analyses is detailed below:
- 4.2.4 **Metal screen** - arsenic, cadmium, chromium, lead, mercury, selenium, boron (water soluble), copper, nickel and zinc
- 4.2.5 **Organic Screen** - total petroleum hydrocarbons (TPH) – C₁₀ to C₁₄ and C₁₅ to C₃₆ aliphatic hydrocarbons, polyaromatic hydrocarbons (PAH) – USEPA 16 suite, monohydric phenols
- 4.2.6 **Inorganics Screen** - cyanide (total), sulphate (water soluble)
- 4.2.7 **Others** - pH, soil moisture content, organic matter, asbestos identification
- 4.2.8 The results of chemical analysis on soil samples are presented in Appendix 4, Test Report 18-00258.

5.0 GROUND CONDITIONS ENCOUNTERED

5.1 Sequence

- 5.1.1 The sequence of the strata encountered during the investigation generally confirms the anticipated geology as interpreted from the geological map.
- 5.1.2 The sequence encountered generally comprised made ground overlying natural strata of coarse soils of sand and gravel and localised fine soils of clay and silt.
- 5.1.3 The general sequence of strata is shown on the nominal section; Figure A1.3.
- 5.1.4 SPT 'N' values are plotted against depth in Figure A1.4.

5.2 Made Ground

- 5.2.1 Made ground was encountered within all boreholes at depth between 0.50m to 1.40m.
- 5.2.2 Grass over topsoil was encountered within BH03 to a depth of 0.20m. The material comprised dark brown, slightly clayey, fine to coarse sand with rootlets.
- 5.2.3 A thin veneer of tarmacadam and associated limestone gravel (hardcore) was encountered within BH01 and BH02 up to depth of 0.40m.
- 5.2.4 Made ground encountered across the site varied in composition. Granular made ground was encountered within BH02 and BH03 at depths of 0.15m and 0.20m respectively.
- 5.2.5 Clay was encountered within BH01. The material comprised soft, dark bluish grey mottled black, gravelly, slightly sandy clay.
- 5.2.6 Made ground gravel was encountered within BH02. The material comprised brown mottled black, very clayey, sandy gravel up to 1.10m.
- 5.2.7 Made ground sand was encountered within BH03 up to depth 0.50m. The material comprised light yellowish brown, slightly clayey, fine to coarse sand.
- 5.2.8 Anthropogenic fragments included brick and tarmacadam.
- 5.2.9 One particle size distribution test (BH02 at 0.50m) indicated fine to coarse gravel with secondary sand content of 35%. Fine constituent (silt and clay) of 25% was recorded.
- 5.2.10 Laboratory analysis of made ground indicated pH values from 7.39 to 8.74 and soluble SO₄ contents from <10mg/l to 123mg/l.
- 5.2.11 The base of the made ground was proven within BH01, BH02 and BH03 at depths of 1.40m, 1.10m and 0.50m.

5.3 Natural Strata

5.3.1 Natural strata were encountered directly beneath made ground.

5.3.2 The natural strata variably comprised coarse and fine soils. Coarse soils dominate the natural strata, generally comprising sand with localised gravel.

Coarse Soils

5.3.3 The sand predominantly comprised of greyish, brown, fine to coarse sand with clay bands. The coarse soils may represent River Terrace Deposits.

5.3.4 Gravel was encountered between 1.40m and 2.80m within BH01. The material was described as dark yellow brown, slightly sandy gravel.

5.3.5 Laboratory analysis of groundwater within coarse soils indicated pH values from 7.04 to 7.67 and soluble SO₄ contents from 40mg/l to 94mg/l.

5.3.6 Three particle size distribution tests (BH01 at 3.50m; BH02 at 2.00m and BH03 at 2.00m) indicated fine and medium sand with secondary gravel contents of 2 and 27%. Fine constituents (silt and clay) of 11 to 28% were recorded.

5.3.7 One particle size distribution test (BH03 at 0.50m) indicated fine to coarse gravel with secondary sand of 8%. Fine constituents (silt/clay) of 4% were recorded.

5.3.8 Seventeen SPT 'N' values from 2 to 17 were obtained within coarse soils. These values indicate very loose through loose to medium dense.

5.3.9 BH01, BH02 and BH03 were terminated at depths of 6.00m, 10.50m and 5.45m respectively within sand.

Fine Soils

5.3.10 Fine soils were encountered within BH02 and BH03 at depths of 1.10m and 0.50m respectively. The fine soils may represent Alluvium.

5.3.11 Silt was encountered between 0.50m and 1.10m within BH03. The material was described as soft, bluish grey mottled yellow, sandy clayey silt.

5.3.12 Laboratory analysis of silt indicated a pH value of 8.4 and a soluble SO₄ content of 19.5mg/l.

5.3.13 Clay was encountered within BH02 (1.10m to 1.90m). The material was described as soft, brownish grey, slightly sandy silty clay.

5.3.14 Atterberg limits on three samples of clay recorded plastic limits of 20% to 27% and plastic index values of 13 to 19% with 31% to 98% passing 425µm sieve. Moisture contents in the range of 15.4 to 31.4%.

5.3.15 Based on these results the material may be classified as low plasticity clay (one samples) and intermediate plasticity clay (two samples).

5.3.16 One triaxial test on clay recorded an undrained shear strength (C_u) of 20kN/m^2 (BH02, 1.20m). This value indicates low strength material.

5.3.17 The base of the fine soils were proven in BH02 and BH03 at depths of 1.90m and 1.10m respectively.

5.4 Groundwater

5.4.1 Groundwater strikes within exploratory holes have been outlined below:

Exploratory Hole	Depth (m)	Strata
BH01	3.00m rose to 2.60m after 20mintues	Sand
BH02	3.00m rose to 2.20m after 20mintues	Sand
BH03	2.90m rose to 2.40m after 20mintues	Sand

6.0 GEOTECHNICAL ASSESSMENT

6.1 Proposed Development

- 6.1.1 It is understood that the proposed development is to consist of the construction of new council housing.
- 6.1.2 The comments and discussion below do not fall within the requirements of EC7 (ref. 9.3) and are offered for guidance. The comments and recommendations below should be reviewed as development details become available.

6.2 Foundations

- 6.2.1 The investigation has proved made ground to depths up to depth 1.40m.
- 6.2.2 The proposed building will be underlain by variable soil types including made ground, soft clay, silt and loose sand and gravel.
- 6.2.3 These variations in soil thickness and characteristics may result in variable bearing capacity and settlement characteristics across the development.
- 6.2.4 Ground improvement may be carried out to increase bearing characteristics at shallow depth and unify settlement characteristics.
- 6.2.5 Alternatively, piled foundations may be utilised to limit differential settlements across the building footprint.
- 6.2.6 Guidelines for the design of piles are given in Appendix 5.
- 6.2.7 The carrying capacity of piles depends not only on their size and the ground conditions but also on their method of installation. Pile design and installation are continuously evolving processes and state-of-the-art are often employed before they reach the public domain, perhaps several years down the line. Therefore, it is recommended that specialist Piling Contractors be contacted as to the suitability and carrying capacity of their piles in the ground conditions pertaining to the site.

6.3 Ground Floor Slabs

- 6.3.1 Ground floor slabs will depend on the chosen foundation solution.
- 6.3.2 Ground floor slabs may be constructed bearing on the pile caps by a network of beams are considered appropriate to minimise any differential settlement between the floor and the piled structure.
- 6.3.3 Alternatively, consideration may be given to ground floor slab placed material subjected to ground improvement or suitably engineered fill.

6.4 Excavations

- 6.4.1 On the basis of observations on site, together with the results of in-situ and laboratory tests, it is considered that excavations to less than 1.00m should stand unsupported in the short term. Side support for safety purposes should of course be provided to all excavations which appear unstable, and those in excess of 1.20m deep, in accordance with Health and Safety Regulations.
- 6.4.2 Groundwater should not be expected in shallow excavations for foundations or services. However, it is possible that perched groundwater could be present in the Made Ground overlying the natural deposits. It is considered that this could be dealt with by pumping.
- 6.4.3 Groundwater could be expected in excavations taken to depths in excess of 2.00m.

6.5 Chemical Attack on Buried Concrete

- 6.5.1 The site has been classified in accordance with BRE Special Digest 1, ref. 9.18, as natural ground without the presence of pyrite and laboratory testing undertaken accordingly. It is recommended that the guidelines given in BRE Special Digest 1, ref. 9.18, be adopted. Relevant details of this digest are included in Appendix 5, Figure A5.6.
- 6.5.2 The results of chemical tests in the non-pyritic soils indicate a sulphate concentration in the soil of <10mg/l to 123mg/l as a 2:1 water/soil extract, with pH values in the range of 7.39 to 8.4.
- 6.5.3 In the groundwater the sulphate concentrations were between 40mg/l and 94mg/l with pH in the range of 7.04 to 7.67.
- 6.5.4 It is recommended that for conventional shallow foundations the groundwater should be regarded as mobile.
- 6.5.5 On the basis of the laboratory test results it is considered that a Design Sulphate Class for this material may be taken as DS-1. The site conditions would suggest that an ACEC class for the site of AC-1 would be appropriate.

7.0 ENVIRONMENTAL RISK ASSESSMENT IN RELATION TO PROPOSED DEVELOPMENT

7.1 Contaminated Land

7.1.1 The statutory definition of contaminated land is defined in the Environmental Protection Act 1990, ref 9.20, which was introduced by the Environment Act 1995, ref 9.21, as;

- ‘Land which appears to the Local Authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land, that –
- significant harm is being caused or there is a significant possibility of such harm being caused; or
- significant pollution of controlled waters is being caused, or there is a significant possibility of such pollution being caused.’

7.2 Risk Assessment

7.2.1 The definition of contaminated land is based on the principles of risk assessment. Risk is defined as a combination of:

- The probability, or frequency of exposure to a substance with the potential to cause harm, and:
- The seriousness of the consequence.

7.3 Pollutant Linkage

7.3.1 The basis of an environmental risk assessment involves identifying a ‘source’ of contamination, a ‘pathway’ along which the contamination may migrate and a ‘receptor’ at risk from the contamination.

7.3.2 Current legislation defines the various elements of the pollution linkage as:

- A contaminant is a substance which is in or under the ground and which has the potential to cause harm or to cause pollution of controlled waters.
- A pathway is one or more routes through which a receptor is being exposed to, or affected by, a contaminant, or could be so affected.
- A receptor is either a living organism, an ecological system, a piece of land or property, or controlled water.

7.3.3 A pollutant linkage indicates that all three elements have been identified. The site can only be defined as ‘Contaminated Land’ if a pollutant linkage exists and the contamination meets the criteria in Section 7.1 above.

7.3.4 The guidance proposes a four-stage approach for the assessment of contamination and the associated risks. The four stages are listed below:

- Hazard Identification
- Hazard Assessment
- Risk Assessment
- Risk Evaluation

7.3.5 The risk assessment and evaluation stages are presented in this phase 2 interpretive report, after an intrusive ground investigation has taken place.

7.4 Risk Assessment – Human Health

7.4.1 The proposed development consists of the construction of new council housing. The risk assessment has therefore been based on guidelines for a residential with homegrown produce end use.

7.4.2 The results of the soil analyses from the current investigation have been compared to CLEA SGVs published in Environment Agency Science Reports SC050021/SR3, ref 9.24 and SC050021, ref 9.25, where available, Generic Assessment Criteria (GAC), determined by LQM and CIEH, ref 9.26, DEFRA C4SL, ref. 9.27 as well as Assessment Criteria (AC) derived in-house using the CLEA Software Version 1.06, ref 9.27. The CLEA AC have been derived by Ian Farmer Associates in accordance with current legislation and guidance.

7.4.3 The guidance values used within this contamination assessment have been tabulated and are detailed within Appendix 6.

7.4.4 Where the concentrations determined on site are at or below the respective Guidance Level, they are considered not to pose a risk and are removed from further consideration, unless otherwise stated.

7.4.5 All the contaminants concentrations are below the Guidance Level.

7.4.6 No asbestos was detected.

7.4.7 On this basis it is considered that significant contamination risks to human health would not be associated with the proposed development of the site.

7.4.8 This assessment is based on one soil sample as required by WCBC in the scope of works. Additional soil sampling and analysis may be required to determine variation across the site.

7.5 Protection of Services

- 7.5.1 Guidance from the UKWIR, ref 9.32, sets out the material requirements for newly laid water supply pipes within Brownfield sites. However, the exact requirements should be clarified with the relevant local water utility supplier for the site.

8.0 MANAGEMENT OF CONTAMINATION

8.1 Remediation and Verification

- 8.1.1 The risk management framework set out in the Model Procedures for the Management of Land Contamination, CLR 11, ref. 9.33, is applicable to the redevelopment of sites that may be affected by contamination.
- 8.1.2 The risk management process set out in the Model Procedures has three main components:
- Risk assessment
 - Options appraisal
 - Implementation
- 8.1.3 This initial risk assessment has not identified any sources of contamination at the site and therefore a revised conceptual model has not been presented.
- 8.1.4 In the absence of a contamination source and pollutant linkage a remediation strategy would not be appropriate for this site.
- 8.1.5 In the absence of a site remediation strategy no validation would be required.

8.2 Management of Unidentified Sources of Contamination

- 8.2.1 There is the possibility that other sources of contamination may be present on the site, which were not detected during the investigation. Should such contamination be identified or suspected during the site clearance or ground works, these should be dealt with accordingly. A number of options are available for handling this material, which include:
- The removal from site and disposal to a suitably licensed tip of all material suspected of being contaminated. The material would need to be classified prior to disposal.
 - Short-term storage of the suspected material while undertaking verification testing for potential contamination. The storage area should be a contained area to ensure that contamination does not migrate and affect other areas of the site. Depending upon the amounts of material under consideration, this could be either a skip or a lined area.

- Having a suitably experienced environmental engineer either on-call or with a watching brief for the visual and olfactory assessment of the material, and sampling for verification purposes.

8.3 Consultation

8.3.1 During the development of a contaminated site, consultation may be required for a number of reasons with a number of regulatory Authorities. The following provides an indication as to the most likely Authorities with which consultation may be required.

- **Local Authority.** There may be a planning condition regarding contamination and consultation will be required with a designated Contaminated Land Officer within the Environmental Health Department. The Local Authority is generally concerned with human health risks. Some Authorities now require 'Completion Certificates' to be signed off following remediation works.
- **Environment Agency.** Where a site is within a groundwater protection zone or has been designated as a special site, the Environment Agency is likely to be involved to ensure that controlled waters are protected.
- **National House Building Council, NHBC.** Section 4.1 of the NHBC Standards requires land management to be addressed. For a new housing development to be approved by the NHBC, any remediation will require a validation report.

8.3.2 Based on the results of any consultation, there may be specific remediation requirements imposed by one or more of the Authorities.

8.4 Risk Management During Site Works

8.4.1 During ground works, some simple measures may have to be put in place to mitigate the risk of contamination affecting the site workers and the environs. The majority of the proposed measures represent good practice for the construction industry and include:

- Informing the site workers of the contamination on site and the potential health effects from exposure.
- Where appropriate, the provision of suitable Personal Protective Equipment (PPE) for workers who may be potentially impacted by working in areas of the contamination.
- Ensuring good hygiene is enforced on site and washing facilities are maintained on the site. Workers are discouraged from smoking, eating or drinking without washing their hands first.

- Dust monitoring, and if necessary, suppression measures should be put into practice where contamination is becoming airborne.

8.4.2 Where contaminated materials are being removed from the site they should be disposed of at a suitably licensed landfill, with a 'duty of care' system in place and maintained throughout the disposal operations.

9.0 REFERENCES

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For and on behalf of Ian Farmer Associates (1998) Limited

H. Hadwin
BSc (Hons) MSc FGS
Engineering Geologist

T. Downes
BSc (Hons) MSc FGS
Principal Engineering Geologist

APPENDIX 1
DRAWINGS



500m

THE SITE



PROJECT: 42166 Nant Silyn

FIGURE No. A1.1.

SCALE: NTS

TITLE: Site Location Plan

IAN FARMER ASSOCIATES
Geotechnical & Environmental Specialists

Project Id:	42166	Title:	Site Plan
Project Title:	Nant Silyn, Wrexham	Scale:	1:1000
Location:		Engineer:	HH
Client:	Wrexham County Council	Contractor:	



Project Id: 42166

Project Title: Nant Silyn, Wrexham

Location:

Client: Wrexham County Council

Title: Section line 1

Vertical Scale: 1:92

Horizontal Scale: 1:413

Engineer: HH

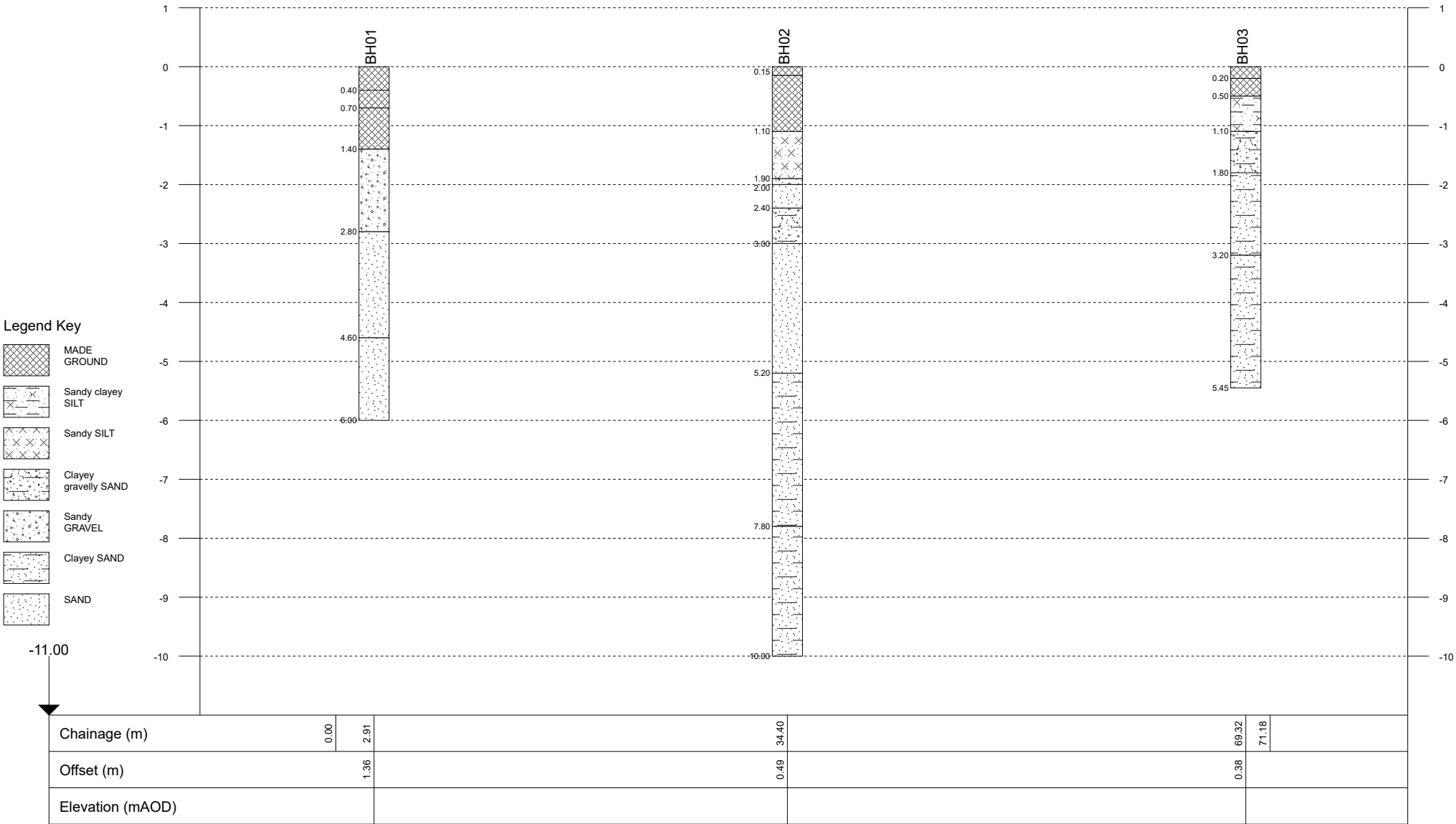
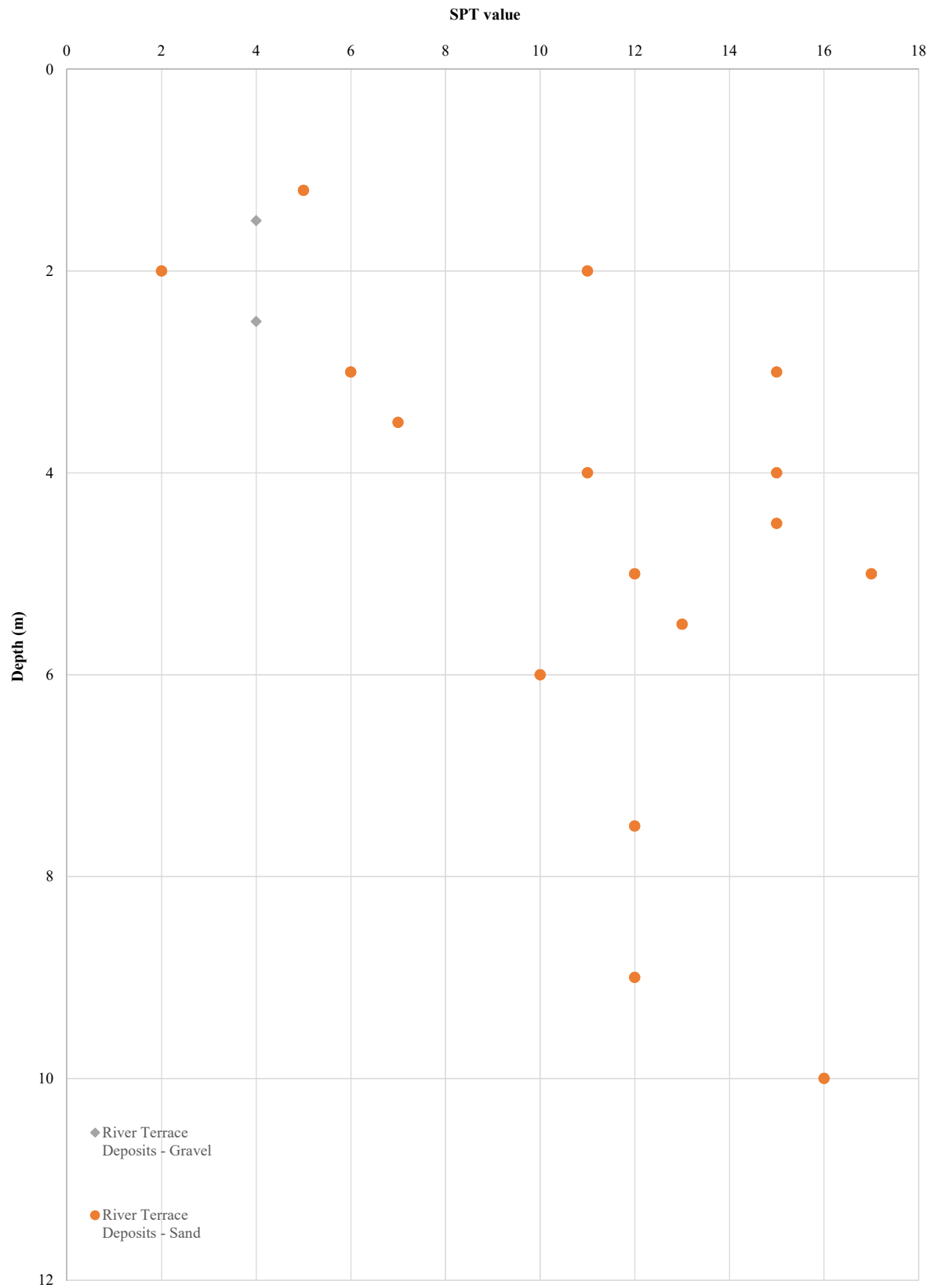


Figure A1.4 SPT vs Depth



APPENDIX 2

SITE WORK

APPENDIX 2

GENERAL NOTES ON SITE WORKS

A2.1 SITE WORK

A2.1.1 General

Site work is carried out in general accordance with the guidelines given in ISO 1997, 9.3 and BS 5930, ref 9.2.

A2.1.2 Light Cable Percussion Boring

For routine soil exploration to depths in excess of 3m, the light cable percussion rig is generally employed for boring through soils and weak rocks, refs 9.2, 9.3 and 9.7. It consists of a powered winch and tripod frame, with running wheels that are permanently attached so that the rig may be towed behind a suitable vehicle. The rig is towed into position and set up using its own winching system.

The locations of services are checked to make sure the borehole is not situated unacceptably near any services. Regardless of the proximity of services, a CAT scan is undertaken at the borehole location and a trial hole dug to 1.20m by hand.

Boreholes are advanced in soil by the percussive action of the cable tool. The force of the cylindrical tool as it is dropped a short distance cuts a plug of cohesive soil that is removed by the tool.

In non-cohesive soils, the borehole is advanced by a 'shell', otherwise known as a 'bailer' or 'sand pump', which incorporates a clack valve. Material is transferred into the shell and retained by the clack valve. The water level in a borehole is maintained above that in the surrounding granular soil to allow for temporary reductions in the head of water as the shell is withdrawn from the borehole. Water should flow from the borehole into the surrounding soil at all times to prevent 'piping' and loosening the soil at the base of the hole. The casing is always advanced with the borehole in granular soil so that material is drawn from the base rather than the borehole sides.

Obstructions to boring are overcome by fitting a serrated chiselling ring to the base of the percussion tool. For large obstructions, a heavy chisel with a hardened cutting edge may have to be used.

Disturbed samples are taken in polythene bags, jars or tubs that are sealed against air or water loss.

Undisturbed samples are generally taken in cohesive materials at changes in strata and at one metre intervals to 5 metres then at 1.5 metre intervals to the full depths of the borehole. The general purpose open-tube sampler is suitable for firm to stiff clays, but is often used to retrieve disturbed samples of weak rocks, soft or hard clay and also clayey sand or silts. This has been adopted for routine use, and usually consists of a 100mm internal diameter tube (U100), which is capable of taking soil samples up to 450mm in length. The undisturbed samples are sealed at each end using micro-crystalline wax to prevent drying.

Standard penetration tests are generally carried out in non-cohesive soils but also in stiff clays and soft rocks at frequencies similar to that of undisturbed sampling.

A2.2 IN-SITU TESTS

A2.2.1 Standard Penetration Test

The Standard Penetration Test is carried out in accordance with the proposals recommended by ISO 1997, ref 9.3, BS 1377, Part 9, 1990 ref 9.9 and ISO 22476 ref 9.7.

The standard penetration test, **SPT**, covers the determination of the resistance of soils to the penetration of a split barrel sampler. A 50mm diameter split barrel sampler is driven 450mm into the soil using a 63.5kg hammer with a 760mm drop. The penetration resistance is expressed as the number of blows required to obtain 300mm penetration below an initial seating drive of 150mm.

through any disturbed ground at the bottom of the borehole. The number of blows to achieve the standard penetration of 300mm is reported as the 'N' value.

The test is generally carried out in fine soils, however, it may also be carried out in coarse granular soils, weak rocks and glacial tills using the same procedure as for the SPT but with a 50mm diameter, 60° apex solid cone replacing the split spoon sampler, **CPT**.

When attempting the standard penetration test in very dense material or weathered rocks it may be necessary to terminate the test before completion to prevent damage to the equipment. In these circumstances it is important to distinguish how the blow count relates to the penetration of the sampler. This may be achieved in the following manner:

- Where the seating drive has been completed, the test drive is terminated if 50 blows are reached before the full penetration of 300mm is achieved. The penetration for 50 blows is recorded and an approximate N value obtained by linear extrapolation of the number of blows for the partial test drive.
- If the seating drive of 150mm is not achieved within the first 25 blows, the penetration after 25 blows is recorded and the test drive then commenced.
- For tests in soft rocks, the test drive should be terminated after 100 blows where the penetration of 300mm has not been achieved.

The N-value obtained from the Standard Penetration Test may be used to assess the relative density of sands and gravels as follows:

Term	SPT N-Value : Blows/300mm Penetration
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	Over 50

A2.3 SAMPLES

- U represents undisturbed 100mm diameter sample, the number of blows to obtain the sample also recorded.
- U fail indicates undisturbed sample not recovered
- B represents large bulk disturbed samples
- D represents small disturbed sample
- ES represents environmental sample
- EW represents water sample
- ▽ represents water strike
- ▼** represents level to which water rose

A2.4 DESCRIPTION OF SOILS

A2.4.1 General

The procedures and principles given in ISO 14688 Parts 1 and 2, ref 9.3, supplemented by section 6 of BS 5930, ref. 9.2 have been used in the soil descriptions contained within this report.

SPT Hammer Certificate

SPT Hammer Energy Test Report

in accordance with BSEN ISO 22476-3:2005

ARCHWAY ENGINEERING
AINLEYS INDUSTRIAL ESTATE
ELLAND
WEST YORKSHIRE
HX5 9JP

SPT Hammer Ref: AR1801
Test Date: 26/10/2017
Report Date: 26/10/2017
File Name: AR1801.spt
Test Operator: SH

Instrumented Rod Data

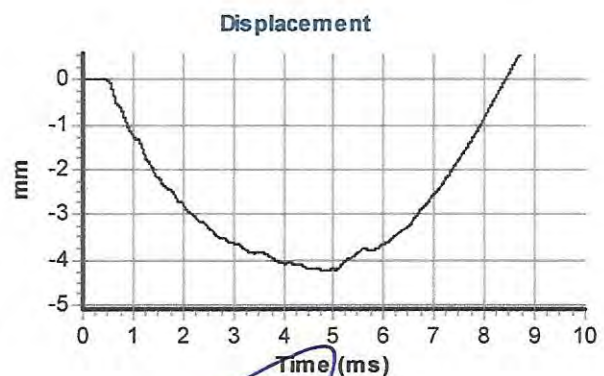
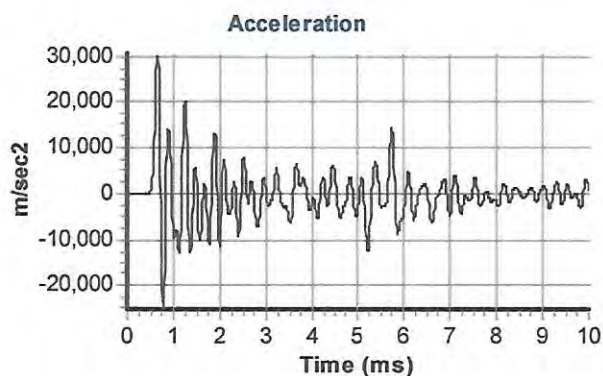
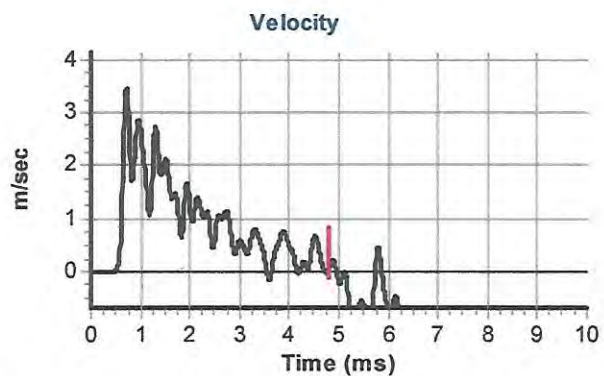
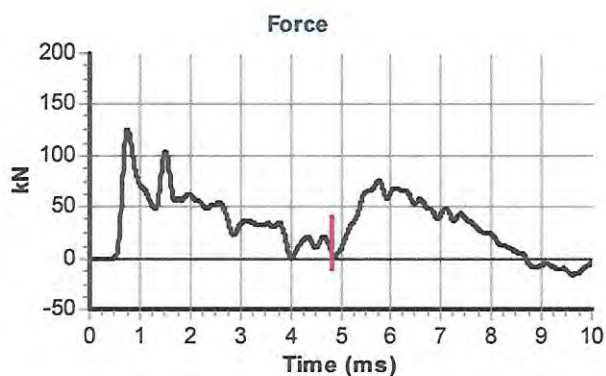
Diameter d_r (mm): 54
Wall Thickness t_r (mm): 6.0
Assumed Modulus E_a (GPa): 200
Accelerometer No.1: 7080
Accelerometer No.2: 11609

SPT Hammer Information

Hammer Mass m (kg): 63.5
Falling Height h (mm): 760
SPT String Length L (m): 10.0

Comments / Location

CALIBRATION



Calculations

Area of Rod A (mm^2): 905
Theoretical Energy E_{theor} (J): 473
Measured Energy E_{meas} (J): 292

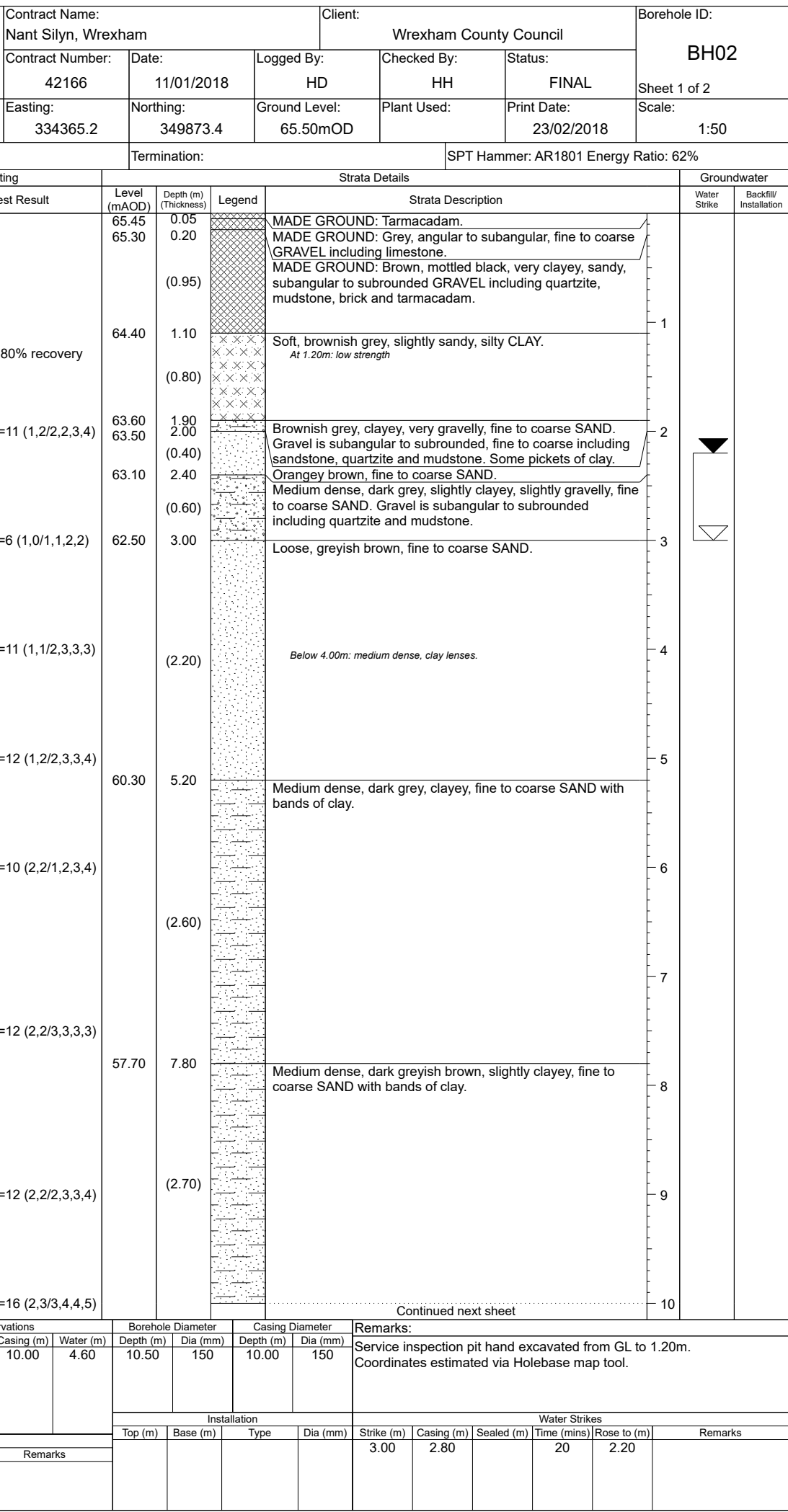
Energy Ratio E_r (%): **62**

Signed: S. HOWARTH
Title: FITTER

The recommended calibration interval is 12 months

Borehole Records

		Contract Name: Nant Silyn, Wrexham			Client: Wrexham County Council			Borehole ID: BH01						
		Contract Number: 42166	Date: 12/01/2018	Logged By: HD	Checked By: HH	Status: FINAL	Sheet 1 of 1							
Cable Percussion Borehole Log		Easting: 334342.5	Northing: 349851.6	Ground Level: 65.40mOD	Plant Used:	Print Date: 23/02/2018	Scale: 1:50							
Weather:			Termination:			SPT Hammer: AR1801 Energy Ratio: 62%								
Samples & In Situ Testing				Strata Details				Groundwater						
Depth	Sample ID	Test Result	Level (mAOD)	Depth (m) (Thickness)	Legend	Strata Description	Water Strike	Backfill/ Installation						
0.20	D2	SPT(S) N=4 (1,3/1,1,1,1)	65.35	0.05		MADE GROUND: Tarmacadam.	1							
0.20	ES1		65.00	0.35		MADE GROUND: Grey, angular to subangular, fine to coarse GRAVEL including limestone.								
0.50	D5					64.70			0.40		MADE GROUND: Soft, dark blueish grey mottled black, gravelly, slightly sandy CLAY. Gravel is angular to subrounded, fine to coarse including mudstone, quartzite and tarmacadam.			
0.50	ES3										64.00	0.70		MADE GROUND: Soft, dark blueish grey, very gravelly, slightly sandy CLAY with high cobble content. Gravel is angular to subrounded, fine to coarse including mudstone, quartzite and brick. Cobbles are subangular to subrounded including quartzite, mudstone and brick.
0.50 - 1.00	B4													62.60
1.00	D7					60.80			1.80		Loose, dark brown, fine to coarse SAND with some fragments of coal.			
1.00	ES6	60.80	4.60		Medium dense, brown, slightly clayey, fine to coarse SAND.									
1.50	B8				SPT(S) N=4 (1,1/1,1,1,1)	62.60	2.80		3					
1.50 - 1.95		B9	60.80	4.60								5		
2.50	EW16	SPT(S) N=7 (1,1/1,2,2,2)			60.80	1.80		4						
2.50 - 2.95			B10	60.80						4.60		5		
2.60	D11	60.80	4.60			5								
3.50	B12			SPT(S) N=15 (1,2/3,3,4,5)				60.80	4.60		5			
3.50 - 3.95		D13	60.80		4.60		5							
3.50 - 3.95	B15	SPT(S) N=13 (2,2/3,3,3,4)		60.80				4.60		5				
4.50			D14		60.80	4.60						5		
4.50 - 4.95	B15	SPT(S) N=13 (2,2/3,3,3,4)	60.80	4.60					5					
4.50 - 4.95					D15	60.80	4.60					5		
5.50	B15	SPT(S) N=13 (2,2/3,3,3,4)	60.80	4.60				5						
5.50 - 5.95						D16	60.80			4.60		5		
5.95	B15	SPT(S) N=13 (2,2/3,3,3,4)	60.80	4.60		5								
							D17		60.80	4.60		5		
	D18	60.80	4.60		5									
	D19						60.80	4.60		5				
	D20	60.80	4.60		5									
	D21						60.80	4.60		5				
	D22	60.80	4.60		5									
	D23						60.80	4.60		5				
	D24	60.80	4.60		5									
	D25						60.80	4.60		5				
	D26	60.80	4.60		5									
	D27						60.80	4.60		5				
	D28	60.80	4.60		5									
	D29						60.80	4.60		5				
	D30													



[illegible]

	Contract Name: Nant Silyn, Wrexham			Client: Wrexham County Council			Borehole ID: BH03									
	Contract Number: 42166		Date: 15/01/2018		Logged By: HD		Checked By: HH		Status: FINAL							
	Easting: 334390.6		Northing: 349897.4		Ground Level: 65.00mOD		Plant Used:		Print Date: 23/02/2018							
Cable Percussion Borehole Log			Weather:			Termination:			SPT Hammer: AR1801 Energy Ratio: 62%							
Samples & In Situ Testing			Strata Details						Groundwater							
Depth	Sample ID	Test Result	Level (mAOD)	Depth (m) (Thickness)	Legend	Strata Description				Water Strike	Backfill/ Installation					
0.20	D2	SPT(S) N=5 (3,2/1,1,1,2)	64.80	0.20		MADE GROUND: Grass over, dark brown, slightly clayey, fine to coarse SAND with rootlets.				1						
0.20	ES1		64.50	(0.30)		MADE GROUND: Light yellowish brown, slightly clayey, fine to coarse SAND with occasional rootlets.										
0.50	D5					Soft, blueish grey mottled yellow, sandy, clayey SILT.										
0.50	ES3						(0.60)									
0.50 - 1.00	B4															
1.00	D7															
1.00	ES6															
1.20	B8							63.90	(0.70)				Dark brownish grey, slightly clayey, gravelly SAND with clay bands. Gravel is subangular to rounded including mudstone, sandstone and limestone.			
1.20 - 1.65																
1.20 - 1.65																
2.00	B10	SPT(S) N=2 (1,0/1,0,1,0)			63.20			1.80	Very loose, greyish brown, fine to coarse SAND with clay bands.				2			
2.00																
2.00																
2.00 - 2.45																
2.00 - 2.45																
2.00 - 2.45	D11	(1.40)	61.80	3.20	Below 3.00m: medium dense.				3							
2.40	EW13															
3.00	B14				SPT(S) N=15 (1,1/2,3,4,6)	3.20	Medium dense, dark brownish grey, slightly clayey, fine to coarse SAND with occasional bands of clay.									
3.00 - 3.45																
3.00 - 3.45																
4.00	B16	SPT(S) N=15 (2,2/3,3,4,5)	(2.25)	Between 4.00m and 5.45m: medium sand sized flecks of coal/charcoal.				4								
4.00 - 4.45																
4.00 - 4.45																
5.00	D18	SPT(S) N=17 (2,2/3,4,5,5)	59.55	5.45	End of Borehole at 5.45m				5							
5.00 - 5.45																
Start & End of Shift Observations			Borehole Diameter		Casing Diameter		Remarks:									
Date	Time	Depth (m)	Casing (m)	Water (m)	Depth (m)	Dia (mm)	Depth (m)	Dia (mm)	Service inspection pit hand excavated from GL to 1.20m. Coordinates estimated via Holebase map tool.							
15-01-2018	16:30	5.50	4.70	3.10	5.50	150	5.50	150								
Chiselling					Installation			Water Strikes								
From (m)	To (m)	Duration	Remarks		Top (m)	Base (m)	Type	Dia (mm)	Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks		
									2.90	2.50		20	2.40			

APPENDIX 3
LABORATORY TESTS

APPENDIX 3

GENERAL NOTES ON LABORATORY TESTS ON SOILS

A3.1 GENERAL

- A3.1.1 Where applicable all tests are carried out in accordance with the relevant British Standard. The laboratory test procedures are as below:

Test Name	Procedures BS1377:1990 Part:Clause
Moisture Content	2:3
Liquid Limit	2:4
Plastic Limit and Plastic Index	2:5
Particle Size Distribution	9:2
Sedimentation	9:4
Mass Loss on Ignition	3:4
Sulphate content	3:5
pH Value	3:9
Compaction Test	4:3
California Bearing Ratio	4:7
Consolidation	5:3
Bulk Density	7:2*
Laboratory Vane Tests	7:3*
Triaxial Compression	
Total Stress Single-Stage	7:8
Total Stress Multi-Stage	7:9
Desiccation	Note 1*

Note 1 - BRE Information paper IP4 issued February 1993

* Tests are not included in UKAS accreditation

- A3.1.2 Where an external laboratory carried out testing, their report, including test methods is included in this Appendix.
- A3.1.3 A summary sheet of laboratory test results undertaken by Ian Farmer Laboratories is included, however where copies of the individual test results are required these will be provided on request.
- A3.1.4 Any discussion in this report is based on the values and results obtained from the appropriate tests. Due allowance should be made, when considering any result in isolation, of the possible inaccuracy of any such individual result. Details of the accuracy of results are included in this section, where applicable.

A3.2 MOISTURE CONTENT

- A3.2.1 Unless stated to the contrary, the moisture content of a soil sample was determined by the standard oven drying method, BS 1377, Part 1, Test 3. The result is reported to an accuracy of $\pm 0.5\%$

A3.3 ATTERBERG LIMITS

- A3.3.1 The Liquid Limit, **LL**, is the moisture content at which the soil passes from the liquid to plastic state. Unless stated to the contrary, the Liquid Limit was determined using the four point, cone penetrometer method, Test 4. The value is reported to the nearest whole number, to an accuracy of $\pm 0.5\%$.
- A3.3.2 The Plastic Limit, **PL**, is the moisture content at which soil passes from the plastic to solid state and becomes too dry to remain in a plastic condition. The Plastic Limit was determined using the method described in Test 5. The value is reported to the nearest whole number, to an accuracy of $\pm 0.5\%$.

- A3.3.3 The Plasticity Index, **PI**, is the numerical difference between the liquid and plastic limits, corresponding to the range of moisture contents over which a soil is in a plastic state. The determination of the Plasticity Index is covered by Test 5.

A3.4 SOIL CLASSIFICATION

- A3.4.1 Classification of soils is usually undertaken by means of the Plasticity Classification Chart, sometimes called the A-Line Chart. This is graphical plot of PI against LL with the A-Line defined as $PI = 0.73(LL - 20)$.
- A3.4.2 This line is defined from experimental evidence and does not represent a well defined boundary between soil types, but forms a useful reference datum. When the values of LL and PI for inorganic clays are plotted on the chart they generally lie just above the A-Line in a narrow band parallel to it, while silts and organic clays plot below this line.
- A3.4.3 Clays and silts are divided into five zones of plasticity:
- | | |
|-------------------------------|----------------------|
| Low Plasticity (L) | LL less than 35 |
| Intermediate Plasticity (I) | LL between 35 and 50 |
| High Plasticity (H) | LL between 50 and 70 |
| Very High Plasticity (V) | LL between 70 and 90 |
| Extremely High Plasticity (E) | LL greater than 90 |
- A3.4.4 In general, clays of high plasticity are likely to have a lower permeability, are more compressible and consolidate over a longer period of time under load than clays of low plasticity. Clays of high plasticity are more difficult to compact as fill material.

A3.5 SHEAR STRENGTH TESTS

- A3.5.1 The shear strength tests have been carried out in accordance with the procedures given in BS1377, Part 7.
- The type of test referred to is:
- A3.5.2 U1(100) - Undrained triaxial compression test on single specimen of 100mm diameter at a lateral pressure approximately equal to overburden pressure.
- A3.5.3 UM(100) - Multi-stage undrained triaxial compression test on a specimen of 100mm diameter. An initial low cell pressure is applied and the deviator stress increased until failure is imminent. The cell pressure is then increased and the procedure repeated until the failure stress at three different cell pressures have been determined.
- A3.5.4 U1(38) - Undrained triaxial compression test on a single specimen of 38mm diameter at a lateral pressure approximately equal to overburden pressure.
- A3.5.5 U(38) - Undrained triaxial compression test on set of three specimens of 38mm diameter at three differential lateral pressures.
- A3.5.6 Consolidated undrained triaxial – The Effective Stress Parameters were determined in accordance with the procedure detailed in BS1377: Part 8:1990 Clause 7 and the samples were prepared in accordance with clause 4.
- A3.5.7 Small shearbox – The peak, and in some cases residual, shear stress parameters were determined in accordance with the procedure detailed in BS1377: Part 7: 1990 Clause 4 and the samples were prepared in accordance with clause 4.

A3.6 CHEMICAL TESTS

- A3.6.1 The total sulphate content of soil was determined using the gravimetric method detailed in BS1377: Part 3:1990, Test 5. The results are recorded to an accuracy of $\pm 0.1\%$.
- A3.6.2 The water soluble sulphate content of soil was determined using the gravimetric method detailed in BS1377: Part 3: 1990, Test 5. The results are recorded to an accuracy of $\pm 0.1\text{g/l}$.
- A3.6.3 The sulphate content of groundwater was determined using the gravimetric method detailed in BS1377: Part 3: 1990, Test 5. The results are record to an accuracy of $\pm 0.1\text{g/l}$.
- A3.6.4 The pH value was determined electrometrically using the procedures given in BS 1377: Part 3: 1990, Test 9. The results are recorded to an accuracy of ± 0.1 pH units.
- A3.6.5 The total sulphur content of soil was determined using the ignition in oxygen method detailed in TRL Report 447, Test 4B.
- A3.6.6 The organic content of soil was determined in accordance with the chemical method detailed in BS1377: Part 3:1990 Clause 3. The sample was prepared in accordance with Clause 3.4.2.
- A3.6.7 The organic content of soil was determined in accordance with the loss on ignition method detailed in BS1377: Part 3:1990 Clause 4. The sample was prepared in accordance with Clause 4.3.2.

F.A.O.

Test Report - 42166 / 1

Site: Nant Silyn, Wrexham
Job Number: 42166
Originating Client: Wrexham County Council
Originating Reference: 42166
Date Sampled: Not Given
Date Scheduled: 16/01/2018
Date Testing Started: 24/01/2018
Date Testing Finished: 01/02/2018
Remarks:

Authorised By:



Tim Robinson
Quality Technician

Date: 01/02/2018

Page: 2

Borehole / Trial Pit	Depth (m)	Sample	Natural / Sieved	Natural Water Content %	Sample Passing 425 µm Sieve		Liquid Limit %	Plastic Limit %	Plasticity Index %	Liquidity Index	Class	Description / Remarks
					Percentage %	Water Content %						
BH01	0.50	D5	Natural	25.2	38	58.0	40	22	18	1.99	CI	Grey/Black gravelly CLAY
BH02	1.00	D7	Natural	31.4	98	32.0	46	27	19	0.26	CI	Brown CLAY
BH02	1.20	U8	Sieved	15.4	31	38.0	33	20	13	1.39	CL	Brown sandy CLAY



1464



Site: Nant Silyn, Wrexham

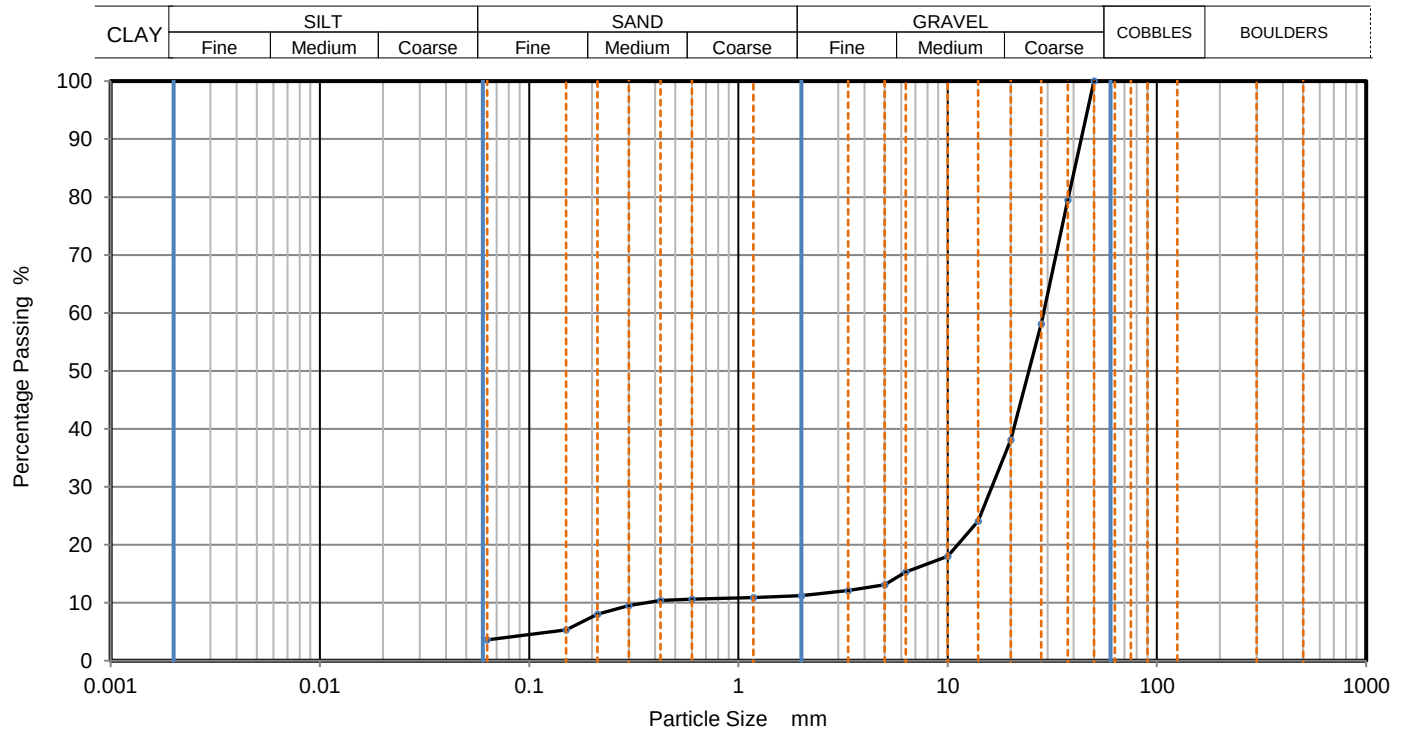
Job Number: 42166

Client: Wrexham County Council

Page: 3

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Borehole / Trial Pit	Depth (m)	Sample	Testing Type	Description
BH01	1.50	B8	Wet Sieve	Brown slightly clayey, slightly sandy GRAVEL



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
50	100		
37.5	80		
28	58		
20	38		
14	24		
10	18		
6.3	15		
5	13		
3.35	12		
2	11		
1.18	11		
0.6	11		
0.425	10		
0.3	10		
0.212	8		
0.15	5		
0.063	4		

Dry Mass of sample, g

4021

Sample Proportions	% dry mass
Very coarse	0
Gravel	89
Sand	8
Fines <0.063mm	4

Grading Analysis		
D100	mm	50
D60	mm	28.7
D30	mm	16.3
D10	mm	0.367
Uniformity Coefficient		78
Curvature Coefficient		25

Remarks

Preparation and testing in accordance with BS1377 unless noted below

Method of Preparation: BS 1377:Part 1:1990, clause 7.3 Initial preparation
BS 1377:Part 1:1990, clause 7.4.5 Preparation of particle size tests

Method of Test: BS1377:Part 2:1990, clause 9.2 Determination of particle size distribution by wet sieving method





Site: Nant Silyn, Wrexham

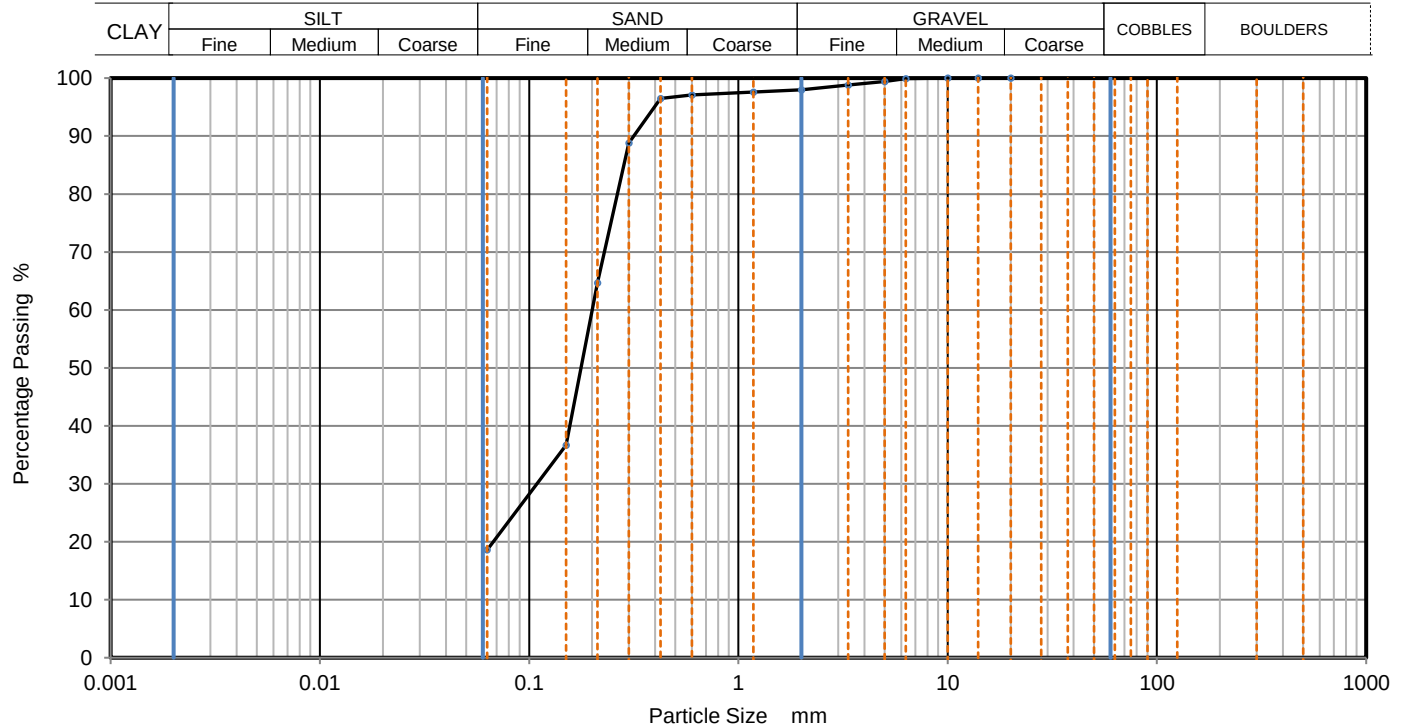
Job Number: 42166

Client: Wrexham County Council

Page: 4

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Borehole / Trial Pit	Depth (m)	Sample	Testing Type	Description
BH01	3.50	B10	Wet Sieve	Brown silty SAND



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
20	100		
14	100		
10	100		
6.3	100		
5	99		
3.35	99		
2	98		
1.18	98		
0.6	97		
0.425	97		
0.3	89		
0.212	65		
0.15	37		
0.063	19		

Dry Mass of sample, g

1142

Sample Proportions	% dry mass
Very coarse	0
Gravel	2
Sand	79
Fines <0.063mm	19

Grading Analysis		
D100	mm	10
D60	mm	0.2
D30	mm	0.109
D10	mm	
Uniformity Coefficient		
Curvature Coefficient		

Remarks

Preparation and testing in accordance with BS1377 unless noted below

Method of Preparation: BS 1377:Part 1:1990, clause 7.3 Initial preparation
BS 1377:Part 1:1990, clause 7.4.5 Preparation of particle size tests

Method of Test: BS1377:Part 2:1990, clause 9.2 Determination of particle size distribution by wet sieving method





Site: Nant Silyn, Wrexham

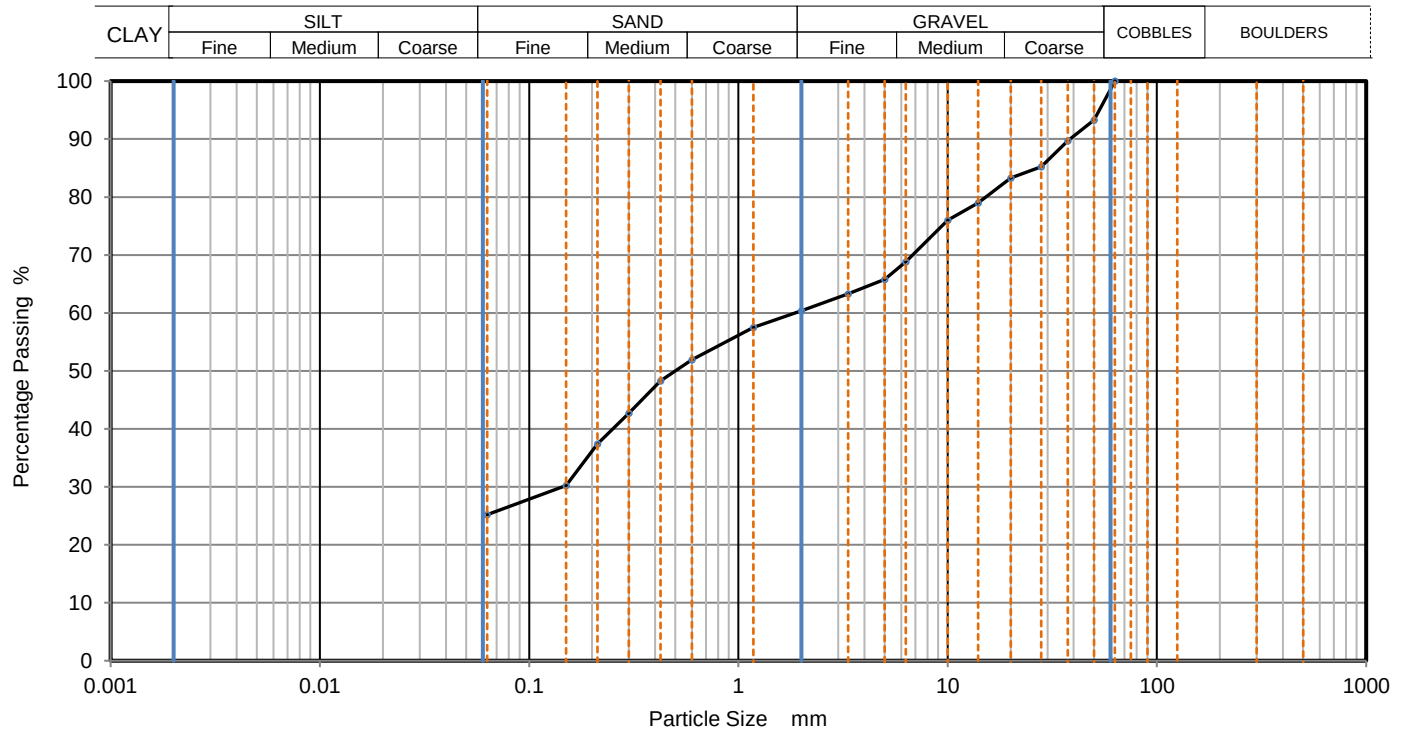
Job Number: 42166

Client: Wrexham County Council

Page: 5

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Borehole / Trial Pit	Depth (m)	Sample	Testing Type	Description
BH02	0.50	B4	Wet Sieve	Brown/Grey clayey, sandy GRAVEL



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
63	100		
50	93		
37.5	90		
28	85		
20	83		
14	79		
10	76		
6.3	69		
5	66		
3.35	63		
2	60		
1.18	58		
0.6	52		
0.425	48		
0.3	43		
0.212	37		
0.15	30		
0.063	25		

Dry Mass of sample, g

2857

Sample Proportions	% dry mass
Very coarse	0
Gravel	40
Sand	35
Fines <0.063mm	25

Grading Analysis		
D100	mm	63
D60	mm	1.86
D30	mm	0.146
D10	mm	
Uniformity Coefficient		
Curvature Coefficient		

Remarks

Preparation and testing in accordance with BS1377 unless noted below

Method of Preparation: BS 1377:Part 1:1990, clause 7.3 Initial preparation
BS 1377:Part 1:1990, clause 7.4.5 Preparation of particle size tests

Method of Test: BS1377:Part 2:1990, clause 9.2 Determination of particle size distribution by wet sieving method



Site: Nant Silyn, Wrexham

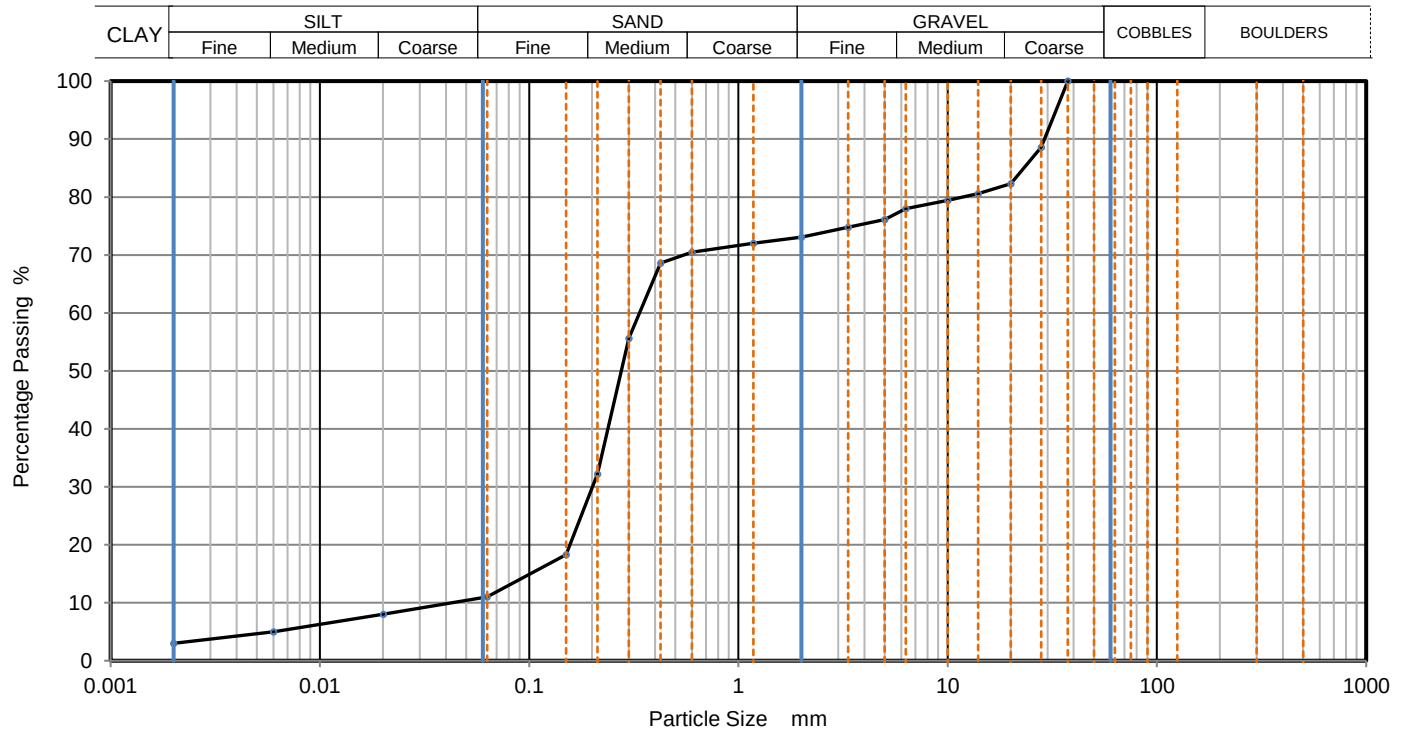
Job Number: 42166

Client: Wrexham County Council

Page: 6

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Borehole / Trial Pit	Depth (m)	Sample	Testing Type	Description
BH02	2.00	B11	Wet Sieve + Pipette	Brown slightly clayey, slightly silty, gravelly SAND



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
		0.0201	8
		0.0060	5
		0.0020	3
37.5	100		
28	89		
20	82		
14	81		
10	79		
6.3	78		
5	76		
3.35	75		
2	73		
1.18	72	Particle density (assumed) 2.65 Mg/m3	
0.6	71		
0.425	69		
0.3	56		
0.212	32		
0.15	18		
0.063	11		

Dry Mass of sample, g

1993

Sample Proportions	% dry mass
Very coarse	0
Gravel	27
Sand	62
Silt	8
Clay	3

Grading Analysis		
D100	mm	37.5
D60	mm	0.337
D30	mm	0.201
D10	mm	0.0427
Uniformity Coefficient		7.9
Curvature Coefficient		2.8

Remarks

Preparation and testing in accordance with BS1377 unless noted below

Method of Preparation: BS 1377:Part 1:1990, clause 7.3 Initial preparation
BS 1377:Part 1:1990, clause 7.4.5 Preparation of particle size tests

Method of Test: BS1377:Part 2:1990, clause 9.2 Determination of particle size distribution by wet sieving method
BS1377:Part 2:1990, clause 9.4 Determination of sedimentation by pipette method





Site: Nant Silyn, Wrexham

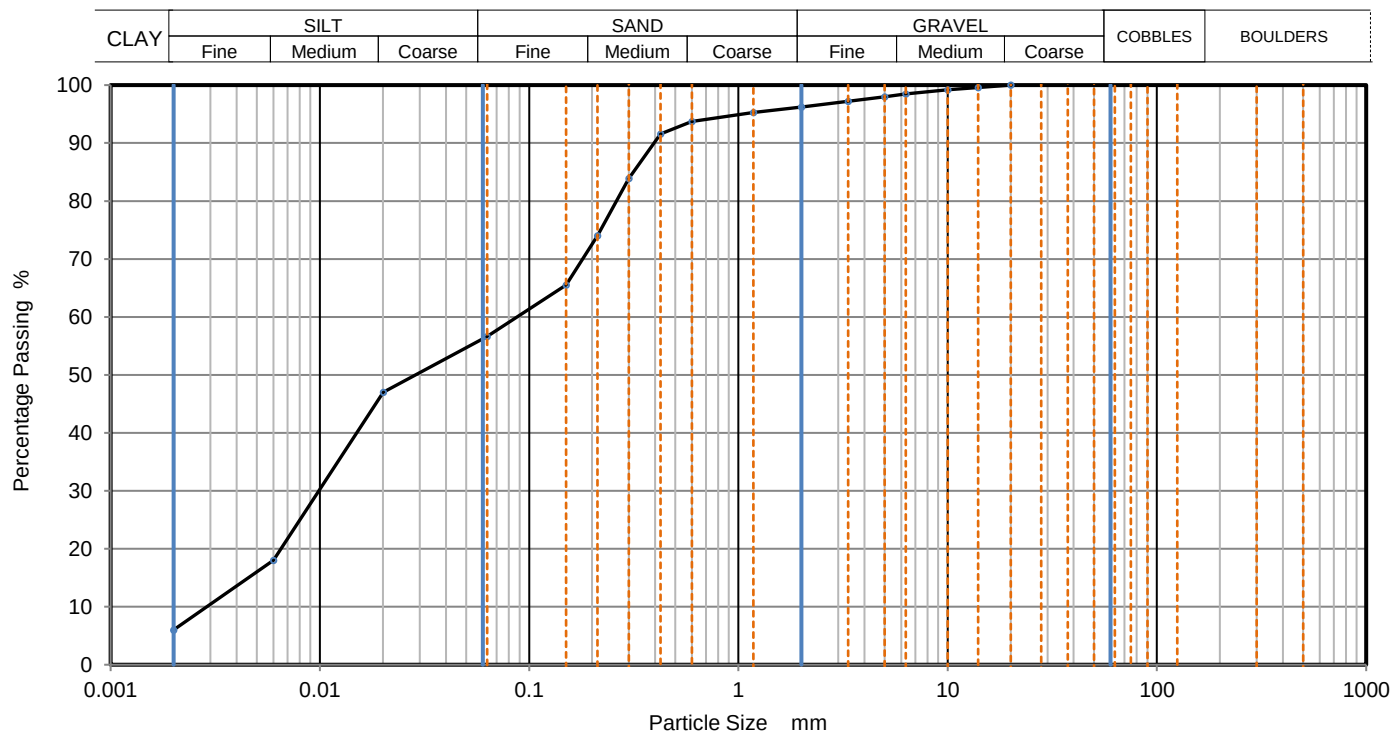
Job Number: 42166

Client: Wrexham County Council

Page: 7

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Borehole / Trial Pit	Depth (m)	Sample	Testing Type	Description
BH03	0.50	B4	Wet Sieve + Pipette	Brown slightly gravelly, slightly clayey, sandy SILT



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
		0.0201	47
		0.0060	18
		0.0020	6
20	100		
14	100		
10	99		
6.3	99		
5	98		
3.35	97		
2	96		
1.18	95	Particle density (assumed) 2.65 Mg/m3	
0.6	94		
0.425	92		
0.3	84		
0.212	74		
0.15	66		
0.063	57		

Dry Mass of sample, g

2004

Sample Proportions	% dry mass
Very coarse	0
Gravel	4
Sand	40
Silt	51
Clay	6

Grading Analysis		
D100	mm	20
D60	mm	0.0881
D30	mm	0.0101
D10	mm	0.00299
Uniformity Coefficient		29
Curvature Coefficient		0.38

Remarks

Preparation and testing in accordance with BS1377 unless noted below

Method of Preparation: BS 1377:Part 1:1990, clause 7.3 Initial preparation
BS 1377:Part 1:1990, clause 7.4.5 Preparation of particle size tests

Method of Test: BS1377:Part 2:1990, clause 9.2 Determination of particle size distribution by wet sieving method
BS1377:Part 2:1990, clause 9.4 Determination of sedimentation by pipette method





Site: Nant Silyn, Wrexham

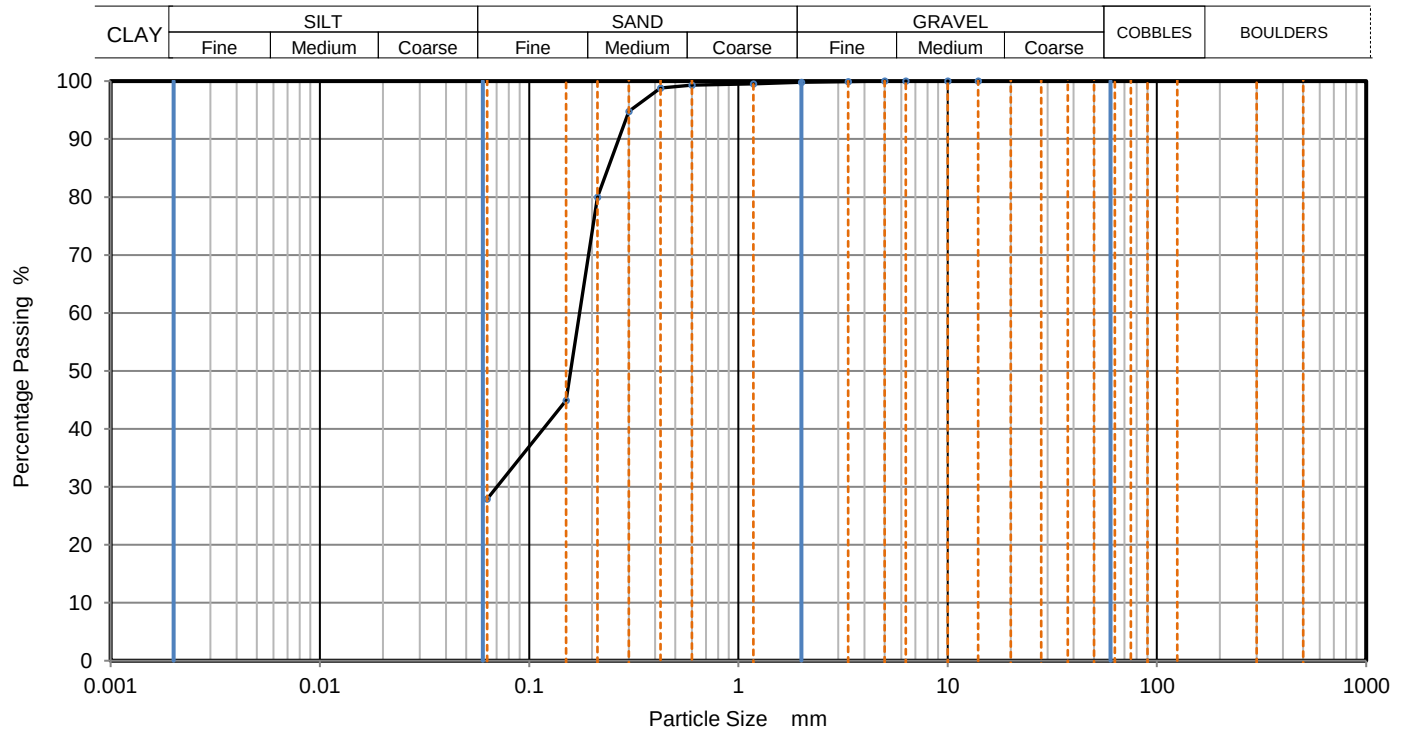
Job Number: 42166

Client: Wrexham County Council

Page: 8

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Borehole / Trial Pit	Depth (m)	Sample	Testing Type	Description
BH03	2.00	B10	Wet Sieve	Brown clayey SAND



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
14	100		
10	100		
6.3	100		
5	100		
3.35	100		
2	100		
1.18	100		
0.6	99		
0.425	99		
0.3	95		
0.212	80		
0.15	45		
0.063	28		

Dry Mass of sample, g

1462

Sample Proportions	% dry mass
Very coarse	0
Gravel	0
Sand	72
Fines <0.063mm	28

Grading Analysis		
D100	mm	5
D60	mm	0.174
D30	mm	0.07
D10	mm	
Uniformity Coefficient		
Curvature Coefficient		

Remarks

Preparation and testing in accordance with BS1377 unless noted below

Method of Preparation: BS 1377:Part 1:1990, clause 7.3 Initial preparation
BS 1377:Part 1:1990, clause 7.4.5 Preparation of particle size tests

Method of Test: BS1377:Part 2:1990, clause 9.2 Determination of particle size distribution by wet sieving method

Site: Nant Silyn, Wrexham

Job Number: 42166

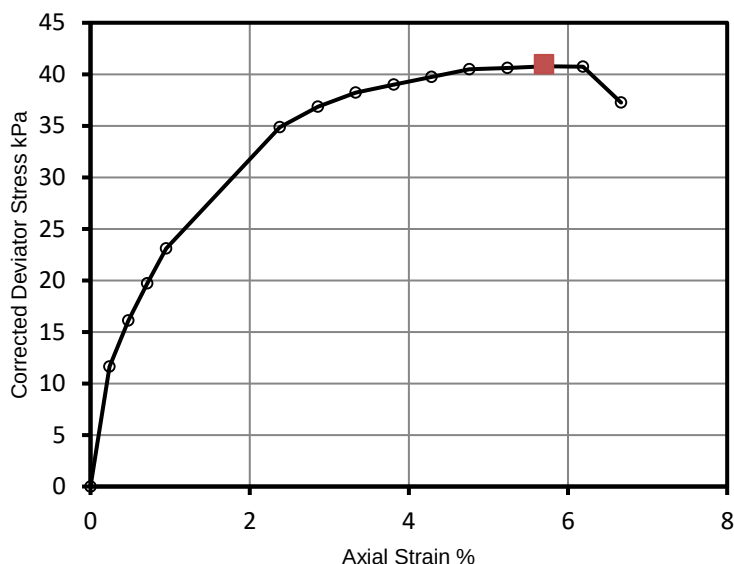
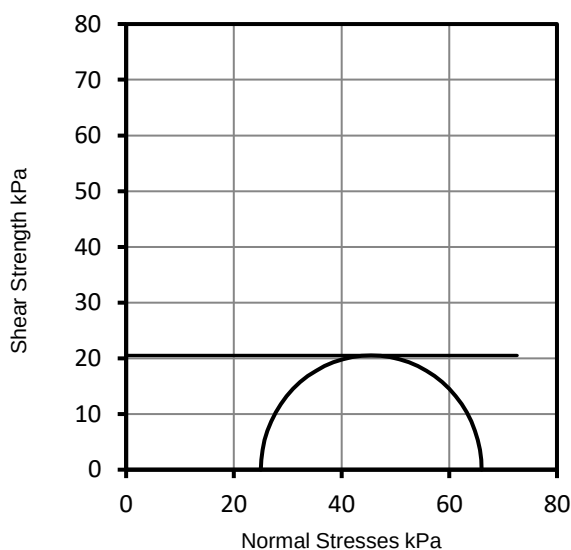
Client: Wrexham County Council

Page: 9

Unconsolidated Undrained Triaxial Compression Test without measurement of pore pressure - single specimen (Definitive Method)

Borehole / Trial Pit	Depth (m)	Sample	Description
BH02	1.20	U8	Brown CLAY

Initial Sample	Test Number	1
	Original Length (mm)	240.00
	Depth from Top (mm)	10.00
	Condition	Undisturbed
	Orientation	Vertical
Length (mm)		210.00
Diameter (mm)		105.00
Moisture Content (%)		18.40
Bulk Density (Mg/m ³)		2.00
Dry Density (Mg/m ³)		1.69
Membrane Thickness (mm)		0.29
Membrane Type		Latex
Rate of Strain (%/min)		1.9
Test Results	Cell Pressure (kPa)	25
	Axial Strain (%)	5.7
	Membrane Corr. (kPa)	0.42
	Deviator Stress, ($\sigma_1 - \sigma_3$)f (kPa)	41
	Undrained Shear Strength, $c_u = \frac{1}{2}(\sigma_1 - \sigma_3)$ f (kPa)	20
	Mode of Failure	Plastic

Deviator Stress v Axial Strain

Mohr Circles


Deviator stress corrected for area change and membrane effects

Mohr circles and their interpretation is not covered by BS1377.
This is provided for information only.

Method of Preparation:

BS 1377:PT1:1990:8.3 Preparation of undisturbed samples for testing or
BS 1377:PT1:1990:7.7.5.2 Preparation of disturbed samples for testing

Method of Test:

BS 1377:PT2:1990:7.2 Determination of density by linear measurement.
BS 1377:PT7:1990:8.4 Determination of undrained shear strength in triaxial compression without measurement of pore pressure (Definitive method)



Test Report - 42166 / 1

Site: Nant Silyn, Wrexham
Job Number: 42166
Originating Client: Wrexham County Council

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Date: 01/02/2018



Certificate of Analysis

Certificate Number 18-01203

22-Jan-18

Client Ian Farmer Associates
14-15 Rufford Court
Hardwick Grange
Woolston
Warrington
Cheshire
WA1 4RF

Our Reference 18-01203

Client Reference 42166

Order No 43902

Contract Title Nant Silyn, Wrexham

Description 3 Soil samples.

Date Received 17-Jan-18

Date Started 17-Jan-18

Date Completed 22-Jan-18

Test Procedures Identified by prefix DETSn (details on request).

Notes Opinions and interpretations are outside the laboratory's scope of ISO 17025 accreditation. This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service. The results reported herein relate only to the material supplied to the laboratory. This certificate shall not be reproduced except in full, without the prior written approval of the laboratory.

Approved By

Adam Fenwick
Contracts Manager



Summary of Chemical Analysis

Matrix Descriptions

Our Ref 18-01203

Client Ref 42166

Contract Title Nant Silyn, Wrexham

Sample ID	Other ID	Depth	Lab No	Completed	Matrix Description
BH01	7	1	1285283	22/01/2018	Dark brown slightly gravelly, sandy CLAY
BH02	5	0.5	1285284	22/01/2018	Brown slightly gravelly, sandy CLAY
BH03	7	1	1285285	22/01/2018	Brown gravelly, sandy CLAY

Summary of Chemical Analysis

Soil Samples

Our Ref 18-01203

Client Ref 42166

Contract Title Nant Silyn, Wrexham

Lab No	1285283	1285284	1285285
Sample ID	BH01	BH02	BH03
Depth	1.00	0.50	1.00
Other ID	7	5	7
Sample Type	D	D	D
Sampling Date	16/01/18	16/01/18	16/01/18
Sampling Time	n/s	n/s	n/s

Test	Method	LOD	Units			
Inorganics						
pH	DETSC 2008#			8.7	7.8	8.4
Sulphate Aqueous Extract as SO ₄	DETSC 2076#	10	mg/l	120	61	20

Information in Support of the Analytical Results

Our Ref 18-01203
 Client Ref 42166
 Contract Nant Silyn, Wrexham

Containers Received & Deviating Samples

Lab No	Sample ID	Date Sampled	Containers Received	Holding time exceeded for tests	Inappropriate container for tests
1285283	BH01 1.00 SOIL	16/01/18	PT 1L		
1285284	BH02 0.50 SOIL	16/01/18	PT 1L		
1285285	BH03 1.00 SOIL	16/01/18	PT 1L		

Key: P-Plastic T-Tub

DETS cannot be held responsible for the integrity of samples received whereby the laboratory did not undertake the sampling. In this instance samples received may be deviating. Deviating Sample criteria are based on British and International standards and laboratory trials in conjunction with the UKAS note 'Guidance on Deviating Samples'. All samples received are listed above. However, those samples that have additional comments in relation to hold time, inappropriate containers etc are deviating due to the reasons stated. This means that the analysis is accredited where applicable, but results may be compromised due to sample deviations. If no sampled date (soils) or date+time (waters) has been supplied then samples are deviating. However, if you are able to supply a sampled date (and time for waters) this will prevent samples being reported as deviating where specific hold times are not exceeded and where the container supplied is suitable.

Soil Analysis Notes

Inorganic soil analysis was carried out on a dried sample, crushed to pass a 425µm sieve, in accordance with BS1377.

Organic soil analysis was carried out on an 'as received' sample. Organics results are corrected for moisture and expressed on a dry weight basis.

The Loss on Drying, used to express organics analysis on an air dried basis, is carried out at a temperature of 28°C +/-2°C.

Disposal

From the issue date of this test certificate, samples will be held for the following times prior to disposal :-

Soils - 1 month, Liquids - 2 weeks, Asbestos (test portion) - 6 months

Appendix A - Details of Analysis

Method	Parameter	Units	Limit of Detection	Sample Preparation	Sub-Contracted	UKAS	MCERTS
DETSC 2002	Organic matter	%	0.1	Air Dried	No	Yes	Yes
DETSC 2003	Loss on ignition	%	0.01	Air Dried	No	Yes	Yes
DETSC 2008	pH	pH Units	1	Air Dried	No	Yes	Yes
DETSC 2024	Sulphide	mg/kg	10	Air Dried	No	Yes	Yes
DETSC 2076	Sulphate Aqueous Extract as SO ₄	mg/l	10	Air Dried	No	Yes	Yes
DETSC 2084	Total Carbon	%	0.5	Air Dried	No	Yes	Yes
DETSC 2084	Total Organic Carbon	%	0.5	Air Dried	No	Yes	Yes
DETSC 2119	Ammoniacal Nitrogen as N	mg/kg	0.5	Air Dried	No	Yes	Yes
DETSC 2130	Cyanide free	mg/kg	0.1	Air Dried	No	Yes	Yes
DETSC 2130	Cyanide total	mg/kg	0.1	Air Dried	No	Yes	Yes
DETSC 2130	Phenol - Monohydric	mg/kg	0.3	Air Dried	No	Yes	Yes
DETSC 2130	Thiocyanate	mg/kg	0.6	Air Dried	No	Yes	Yes
DETSC 2321	Total Sulphate as SO ₄	%	0.01	Air Dried	No	Yes	Yes
DETSC 2325	Mercury	mg/kg	0.05	Air Dried	No	Yes	Yes
DETSC 3049	Sulphur (free)	mg/kg	0.75	Air Dried	No	Yes	Yes
DETSC2123	Boron (water soluble)	mg/kg	0.2	Air Dried	No	Yes	Yes
DETSC2301	Arsenic	mg/kg	0.2	Air Dried	No	Yes	Yes
DETSC2301	Barium	mg/kg	1.5	Air Dried	No	Yes	Yes
DETSC2301	Beryllium	mg/kg	0.2	Air Dried	No	Yes	Yes
DETSC2301	Cadmium Available	mg/kg	0.1	Air Dried	No	Yes	Yes
DETSC2301	Cadmium	mg/kg	0.1	Air Dried	No	Yes	Yes
DETSC2301	Cobalt	mg/kg	0.7	Air Dried	No	Yes	Yes
DETSC2301	Chromium	mg/kg	0.15	Air Dried	No	Yes	Yes
DETSC2301	Copper	mg/kg	0.2	Air Dried	No	Yes	Yes
DETSC2301	Manganese	mg/kg	20	Air Dried	No	Yes	Yes
DETSC2301	Molybdenum	mg/kg	0.4	Air Dried	No	Yes	Yes
DETSC2301	Nickel	mg/kg	1	Air Dried	No	Yes	Yes
DETSC2301	Lead	mg/kg	0.3	Air Dried	No	Yes	Yes
DETSC2301	Selenium	mg/kg	0.5	Air Dried	No	Yes	Yes
DETSC2301	Zinc	mg/kg	1	Air Dried	No	Yes	Yes
DETSC 3072	Ali/Aro C10-C35	mg/kg	10	As Received	No	Yes	Yes
DETSC 3072	Aliphatic C10-C12	mg/kg	1.5	As Received	No	Yes	Yes
DETSC 3072	Aliphatic C10-C12	mg/kg	10	As Received	No	Yes	Yes
DETSC 3072	Aliphatic C10-C35	mg/kg	10	As Received	No	Yes	Yes
DETSC 3072	Aliphatic C12-C16	mg/kg	1.2	As Received	No	Yes	Yes
DETSC 3072	Aliphatic C12-C16	mg/kg	10	As Received	No	Yes	Yes
DETSC 3072	Aliphatic C16-C21	mg/kg	1.5	As Received	No	Yes	Yes
DETSC 3072	Aliphatic C16-C21	mg/kg	10	As Received	No	Yes	Yes
DETSC 3072	Aliphatic C21-C35	mg/kg	3.4	As Received	No	Yes	Yes
DETSC 3072	Aliphatic C21-C35	mg/kg	3.4	As Received	No	Yes	Yes
DETSC 3072	Aromatic C10-C12	mg/kg	0.9	As Received	No	Yes	Yes
DETSC 3072	Aromatic C10-C12	mg/kg	10	As Received	No	Yes	Yes
DETSC 3072	Aromatic C10-C35	mg/kg	10	As Received	No	Yes	Yes
DETSC 3072	Aromatic C12-C16	mg/kg	0.5	As Received	No	Yes	Yes
DETSC 3072	Aromatic C12-C16	mg/kg	10	As Received	No	Yes	Yes
DETSC 3072	Aromatic C16-C21	mg/kg	0.6	As Received	No	Yes	Yes
DETSC 3072	Aromatic C16-C21	mg/kg	10	As Received	No	Yes	Yes
DETSC 3072	Aromatic C21-C35	mg/kg	1.4	As Received	No	Yes	Yes
DETSC 3072	Aromatic C21-C35	mg/kg	1.4	As Received	No	Yes	Yes
DETS 062	Benzene	mg/kg	0.01	As Received	No	Yes	Yes
DETS 062	Ethylbenzene	mg/kg	0.01	As Received	No	Yes	Yes
DETS 062	Toluene	mg/kg	0.01	As Received	No	Yes	Yes
DETS 062	Xylene	mg/kg	0.01	As Received	No	Yes	Yes
DETS 062	m+p Xylene	mg/kg	0.01	As Received	No	Yes	Yes
DETS 062	o Xylene	mg/kg	0.01	As Received	No	Yes	Yes
DETSC 3311	C10-C24 Diesel Range Organics (DRO)	mg/kg	10	As Received	No	Yes	Yes
DETSC 3311	C24-C40 Lube Oil Range Organics (LORO)	mg/kg	10	As Received	No	Yes	Yes
DETSC 3311	EPH (C10-C40)	mg/kg	10	As Received	No	Yes	Yes

Appendix A - Details of Analysis

Method	Parameter	Units	Limit of Detection	Sample Preparation	Sub-Contracted	UKAS	MCERTS
DETSC 3303	Acenaphthene	mg/kg	0.03	As Received	No	Yes	Yes
DETSC 3303	Acenaphthylene	mg/kg	0.03	As Received	No	Yes	Yes
DETSC 3303	Benzo(a)pyrene	mg/kg	0.03	As Received	No	Yes	Yes
DETSC 3303	Benzo(a)anthracene	mg/kg	0.03	As Received	No	Yes	Yes
DETSC 3303	Benzo(b)fluoranthene	mg/kg	0.03	As Received	No	Yes	Yes
DETSC 3303	Benzo(k)fluoranthene	mg/kg	0.03	As Received	No	Yes	Yes
DETSC 3303	Benzo(g,h,i)perylene	mg/kg	0.03	As Received	No	Yes	Yes
DETSC 3303	Dibenzo(a,h)anthracene	mg/kg	0.03	As Received	No	Yes	Yes
DETSC 3303	Fluoranthene	mg/kg	0.03	As Received	No	Yes	Yes
DETSC 3303	Indeno(1,2,3-c,d)pyrene	mg/kg	0.03	As Received	No	Yes	Yes
DETSC 3303	Naphthalene	mg/kg	0.03	As Received	No	Yes	Yes
DETSC 3303	Phenanthrene	mg/kg	0.03	As Received	No	Yes	Yes
DETSC 3303	Pyrene	mg/kg	0.03	As Received	No	Yes	Yes
DETSC 3401	PCB 28 + PCB 31	mg/kg	0.01	As Received	No	Yes	Yes
DETSC 3401	PCB 52	mg/kg	0.01	As Received	No	Yes	Yes
DETSC 3401	PCB 101	mg/kg	0.01	As Received	No	Yes	Yes
DETSC 3401	PCB 118	mg/kg	0.01	As Received	No	Yes	Yes
DETSC 3401	PCB 153	mg/kg	0.01	As Received	No	Yes	Yes
DETSC 3401	PCB 138	mg/kg	0.01	As Received	No	Yes	Yes
DETSC 3401	PCB 180	mg/kg	0.01	As Received	No	Yes	Yes
DETSC 3401	PCB Total	mg/kg	0.01	As Received	No	Yes	Yes

Method details are shown only for those determinands listed in Annex A of the MCERTS standard. Anything not included on this list falls outside the scope of MCERTS. No Recovery Factors are used in the determination of results. Results reported assume 100% recovery. Full method statements are available on request.

APPENDIX 4
CHEMICAL TESTS

FINAL ANALYTICAL TEST REPORT

SUPPLEMENT TO TEST REPORT 18/00257/1

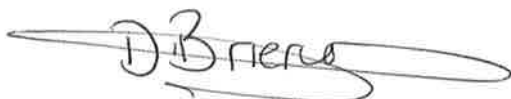
Envirolab Job Number: 18/00257
Issue Number: 2

Date: 19 January, 2018

Client: Ian Farmer Associates (Warrington)
14/15 Rufford Court
Hardwick Grange
Warrington
WA1 4RF

Project Manager: Hannah Hadwin
Project Name: Nant Silyn
Project Ref: 42166
Order No: 43889
Date Samples Received: 11/01/18
Date Instructions Received: 15/01/18
Date Analysis Completed: 17/01/18

Prepared by:

A handwritten signature in black ink, appearing to read "D Brierley", with a long horizontal flourish extending to the right.

Danielle Brierley
Client Manager

Approved by:

A handwritten signature in black ink, appearing to read "Richard Wong", with a large, stylized loop at the end.

Richard Wong
Client Manager

Envirolab Job Number: 18/00257

Client Project Name: Nant Silyn

Client Project Ref: 42166

Lab Sample ID	18/00257/1								Units	Method ref
Client Sample No	ES5									
Client Sample ID	BH2									
Depth to Top	2.20									
Depth To Bottom										
Date Sampled	11-Jan-18									
Sample Type	Water - EW									
Sample Matrix Code	N/A									
pH (w) _A	7.67								pH	A-T-031w
Sulphate (w) _A [#]	40								mg/l	A-T-026w

REPORT NOTES

General:

This report shall not be reproduced, except in full, without written approval from Envirolab.

All samples contained within this report, and any received with the same delivery, will be disposed of one month after the date of this report.

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.

If results are in italic font they are associated with an AQC failure and there is insufficient sample to repeat the analysis. These are not accredited and are unreliable.

A deviating samples report is appended and will indicate if samples or tests have been found to be deviating. Any test results affected may not be an accurate record of the concentration at the time of sampling and, as a result, may be invalid.

Soil chemical analysis:

All results are reported as dry weight (<40°C).

For samples with Matrix Codes 1 - 6 natural stones, brick and concrete fragments >10mm and any extraneous material (visible glass, metal or twigs) are removed and excluded from the sample prior to analysis and reported results corrected to a whole sample basis. This is reported as '% stones >10mm'.

For samples with Matrix Code 7 the whole sample is dried and crushed prior to analysis and this supersedes any "A" subscripts

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TPH analysis of water by method A-T-007:

Free and visible oils are excluded from the sample used for analysis so that the reported result represents the dissolved phase only.

Electrical Conductivity of water by Method A-T-037:

Results greater than 12900µS/cm @ 25°C / 11550µS/cm @ 20°C fall outside the calibration range and as such are unaccredited.

Asbestos:

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Predominant Matrix Codes:

1 = SAND, 2 = LOAM, 3 = CLAY, 4 = LOAM/SAND, 5 = SAND/CLAY, 6 = CLAY/LOAM, 7 = OTHER, 8 = Asbestos bulk ID sample.

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Key:

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US indicates Unsuitable Sample for analysis.

NDP indicates No Determination Possible.

NAD indicates No Asbestos Detected.

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Superscript "M" indicates method accredited to MCERTS.

Subscript "A" indicates analysis performed on the sample as received.

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Please contact us if you need any further information.

FINAL ANALYTICAL TEST REPORT

SUPPLEMENT TO TEST REPORT 18/00306/1

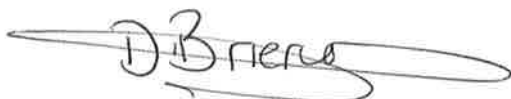
Envirolab Job Number: 18/00306
Issue Number: 2

Date: 22 January, 2018

Client: Ian Farmer Associates (Warrington)
14/15 Rufford Court
Hardwick Grange
Warrington
WA1 4RF

Project Manager: Hannah Hadwin
Project Name: Nant Silyn
Project Ref: 42166
Order No: 43901
Date Samples Received: 15/01/18
Date Instructions Received: 16/01/18
Date Analysis Completed: 18/01/18

Prepared by:

A handwritten signature in black ink, appearing to read "D Brierley", with a long horizontal flourish extending to the right.

Danielle Brierley
Client Manager

Approved by:

A handwritten signature in black ink, appearing to read "R Wong", with a large, looping flourish that extends under the signature.

Richard Wong
Client Manager

Envirolab Job Number: 18/00306

Client Project Name: Nant Silyn

Client Project Ref: 42166

Lab Sample ID	18/00306/1								Units	Method ref
Client Sample No	13									
Client Sample ID	BH03									
Depth to Top	2.40									
Depth To Bottom										
Date Sampled	15-Jan-18									
Sample Type	Water - EW									
Sample Matrix Code	N/A									
pH (w) _A [#]	7.38								pH	A-T-031w
Sulphate (w) _A [#]	94								mg/l	A-T-026w

REPORT NOTES

General:

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All samples contained within this report, and any received with the same delivery, will be disposed of one month after the date of this report.

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.

If results are in italic font they are associated with an AQC failure and there is insufficient sample to repeat the analysis. These are not accredited and are unreliable.

A deviating samples report is appended and will indicate if samples or tests have been found to be deviating. Any test results affected may not be an accurate record of the concentration at the time of sampling and, as a result, may be invalid.

Soil chemical analysis:

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FINAL ANALYTICAL TEST REPORT

SUPPLEMENT TO TEST REPORT 18/00299/1

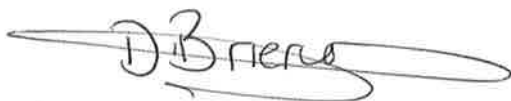
Envirolab Job Number: 18/00299
Issue Number: 2

Date: 22 January, 2018

Client: Ian Farmer Associates (Warrington)
14/15 Rufford Court
Hardwick Grange
Warrington
WA1 4RF

Project Manager: Hannah Hadwin
Project Name: Nant Silyn
Project Ref: 42166
Order No: 43901
Date Samples Received: 12/01/18
Date Instructions Received: 16/01/18
Date Analysis Completed: 18/01/18

Prepared by:

A handwritten signature in black ink, appearing to read "D Brierley", with a long horizontal flourish extending to the right.

Danielle Brierley
Client Manager

Approved by:

A handwritten signature in black ink, appearing to read "R Wong", with a large, looping flourish.

Richard Wong
Client Manager

Envirolab Job Number: 18/00299

Client Project Name: Nant Silyn

Client Project Ref: 42166

Lab Sample ID	18/00299/1								Units	Method ref
Client Sample No	ES10									
Client Sample ID	BH01									
Depth to Top	2.60									
Depth To Bottom										
Date Sampled	12-Jan-18									
Sample Type	Water - EW									
Sample Matrix Code	N/A									
pH (w) _A [#]	7.04								pH	A-T-031w
Sulphate (w) _A [#]	75								mg/l	A-T-026w

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APPENDIX 5
DESIGN CONSIDERATIONS

APPENDIX 5

GEOTECHNICAL DESIGN CONSIDERATIONS

A5.1 ASSESSMENT OF GRANULAR SOIL CONDITION

- A5.1.1 SPT 'N' values reported on the borehole logs are as measured in the field with no corrections applied.
- A5.1.2 However for general design in sands the 'N' values should be normalised to 60% by the following equation:-
- A5.1.3 $N_{60} = E_r/60.N$ where:-
- N is the blow count and
- E_r is the energy ratio of the specific test equipment
- A5.1.4 Further corrections for rod length and overburden pressure in sands may be applied in accordance with BS EN ISO 22476-3, ref 9.6.

A5.2 ASSESSMENT OF COHESIVE SOIL CONDITION

- A5.2.1 In accordance with BS EN ISO 22475-1, ref. 9.8, and BS5930, ref.9.2, the thick walled U100 sample is considered as a Class B sampling technique and will only produce Class 3 to 5 quality samples in accordance with EN 1997-2:2007, ref.9.3.
- A5.2.2 Laboratory strength and consolidation testing should only be carried out on Class 1 quality samples, which can be obtained from a Class A sampling technique, ref. 9.5. This is due to possible disturbance during sampling, giving a weaker strength in testing.
- A5.2.3 Therefore laboratory test values for c_u and m_v obtained from thick walled U100 samples should only be used as guidance and not used as absolute values for the shear strength and compressibility properties of the clay and only used to provide guidance to descriptive strength on the borehole records.
- A5.2.4 Work undertaken by Stroud, ref. 9.10 determined a relationship between SPT 'N' values, plasticity undrained shear strength and compressibility of many over-consolidated clays. Further work by Stroud and Butler, ref.9.11, in which data was analysed from sites covering a wide range of glacial deposits, confirmed there to be a correlation between the 'N' value plasticity undrained shear strength and compressibility.
- A5.2.5 The relationship was of the form:
- $$C_u = f_1 \times N$$
- and
- $$m_v = 1/(f_2 \times N)$$
- Where
- c_u = Un-drained shear strength
- m_v = Coefficient of compressibility
- f_1 and f_2 = Factors
- A5.2.6 It was determined by Stroud that f_1 varied between 4kPa for material of high plasticity and 6kPa for material of low plasticity. Similarly f_2 varied between 400kPa and 600kPa.

A5.3 GUIDELINES FOR THE DESIGN OF PILES FIRST APPROXIMATION OF WORKING LOAD

A5.3.1 PILING PARAMETERS – GENERAL

The ultimate carrying capacity, Q_u , of a particular pile is taken as the sum of the ultimate shaft friction resistance, Q_s , and the ultimate end bearing resistance, Q_b . This may be expressed as follows:-

$$\begin{aligned} Q_u &= Q_s + Q_b \\ &= f.A_s + q.A_b \end{aligned}$$

where

$$\begin{aligned} f &= \text{unit shaft resistance} \\ A_s &= \text{embedded surface area of pile} \\ q &= \text{unit end bearing resistance} \\ A_b &= \text{effective cross-sectional area of pile base} \end{aligned}$$

A5.3.2 COHESIVE SOILS

A5.3.2.1 Shaft Resistance

The ultimate shaft resistance, f , for piles in both compression or tension in cohesive soils is determined by applying a factor to the undrained shear strength, C_s , which exists in the soils along the embedded length of the pile, and is given by:-

$$f = \alpha.C_s$$

Where α is an adhesion factor, which for straight-shafted bored piles may be taken as 0.45 to 0.60.

Ultimate unit shaft friction should not exceed 100kN/m².

A5.3.2.2 End Bearing

For piles terminating in cohesive soils, the ultimate unit end bearing resistance q , is given by:-

$$q = N_c.C_b$$

where C_b is the undrained shear strength at the base of the pile

and N_c is a bearing capacity factor

The value of N_c for a cohesive material is variable, depending on the depth of the penetration of the pile into the bearing stratum. Generally, N_c could be taken to have a value of 9, except in the case of large diameter short piles where a lesser value should be used.

A5.3.3 COHESIONLESS SOILS

A5.3.3.1 Shaft Resistance

For piles driven in cohesionless soils the ultimate unit shaft resistance, f , may be calculated using the following method, which gives:-

$$f = 0.5 \gamma' (D+d) K_s \tan \delta$$

where γ' = average effective unit weight of soil surrounding the pile

D = depth to the pile toe or to the base of the granular stratum whichever is the lesser

d = depth to the top of the granular stratum

δ = angle of friction between pile and soil
(see below)

K_s = a coefficient (see below)

TABLE OF VALUES FOR K_s AND δ

Pile Type	δ	K_s		
		Relative Density		Tension Piles
		Low	High	
Steel	20°	0.5	1.5	0.5
Concrete	0.75ϕ	1.0	2.0	0.5

The value of ϕ may be interpreted from standard penetration tests.

For bored and cast-in-place piles, $\delta = 22^\circ$ and $K_s = 1$ should be used to allow for loosening of the soil during boring.

It has been found that the ultimate unit shaft resistance does not exceed 100kN/m² and therefore this value should not be exceeded in design.

A5.3.3.2 End Bearing

The unit ultimate end bearing resistance (q) of piles in cohesionless soils may be calculated as follows:-

$$q = \gamma' \cdot D \cdot N_q$$

where γ' = average effective unit weight of soil surrounding the pile

D = depth to pile toe

N_q = bearing capacity factor

Values for N_q , where piles penetrate the bearing stratum by more than five diameters, may be taken from work carried out by Berezantsev, ref.9.19. In addition, the ultimate unit base resistance should not exceed a value of 11,000kN/m². For bored and cast-in-place piles the value of N_q used should correspond to loose soil conditions.

A5.3.4 FACTORS OF SAFETY

A5.3.4.1 Cohesive and Non-cohesive Soils

For cohesive and non-cohesive soils a factor of safety of 3 may be used to obtain the allowable or safe carrying capacity of piles from the ultimate carrying capacity.

APPENDIX 6
CONTAMINATION ASSESSMENT

APPENDIX 6

GENERAL NOTES ON CONTAMINATION ASSESSMENT

A6.1 STATUTORY FRAMEWORK AND DEFINITIONS

A6.1.1 The statutory definition of contaminated land is defined in the Environmental Protection Act 1990, ref 9.20, which was introduced by the Environment Act 1995, ref 9.21;

‘Land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land, that –

(a) significant harm is being caused or there is a significant possibility of such harm being caused; or

(b) pollution of controlled waters is being, or is likely to be, caused.’

A6.1.2 The UK guidance on the assessment of contaminated has developed as a direct result of the introduction of these two Acts. The technical guidance supporting the legislation was originally summarised in a number of key documents collectively known as the Contaminated Land Reports (CLRs), a proposed series of twelve documents. Seven were originally published in March 1994, four more were published in April 2002, while the final guidance document, CLR 11, ref 9.33 was published in 2004. CLR7 to 10 were withdrawn in 2008, with CLR 9 and 10 effectively replaced by the Environment Agency in the form of Science Reports SR2, ref 9.30 and SR3, ref 9.24. CLR11 remains valid and sets out the framework of the investigation process.

A6.1.3 In establishing whether a site fulfils the statutory definition of ‘contaminated land’ it is necessary to identify, whether a pollutant linkage exists in respect of the land in question and whether the pollutant linkage:

- is resulting in significant harm being caused to the receptor in the pollutant linkage,
- presents a significant possibility of significant harm being caused to that receptor,
- is resulting in the pollution of the controlled waters which constitute the receptor, or
- is likely to result in such pollution.

A6.1.4 A ‘pollutant linkage’ may be defined as the link between a contaminant ‘source’ and a ‘receptor’ by means of a ‘pathway’.

A6.2 ASSESSMENT METHODOLOGY

A6.2.1 The guidance proposes a four-stage assessment process for identifying potential pollutant linkages on a site. These stages are set out in the table below:

No.	Process	Description
1	Hazard Identification	Establishing contaminant sources, pathways and receptors (the conceptual model).
2	Hazard Assessment	Analysing the potential for unacceptable risks (what linkages could be present, what could be the effects).
3	Risk Estimation	Trying to establish the magnitude and probability of the possible consequences (what degree of harm might result and to what receptors, and how likely is it).
4	Risk Evaluation	Deciding whether the risk is unacceptable.

- A6.2.2 Stages 1 and 2 develop a ‘*conceptual model*’ based upon information collated from desk based studies, and frequently a walkover of the site. The walkover survey should be conducted in general accordance with CLR 2, ref 9.35. The formation of a conceptual model is an iterative process and as such, it should be updated and refined throughout each stage of the project to reflect any additional information obtained.
- A6.2.3 The extent of the desk studies and enquiries to be conducted should be in general accordance with CLR 3, ref 9.22. The information from these enquiries is presented in a desk study report with recommendations, if necessary, for further work based upon the conceptual model. In the absence of specific information on contamination anticipated to be encountered, specific DoE ‘Industry Profiles’ provide guidance on the nature of contaminants relating to a variety of industrial processes and should be used as the basis for determining which contaminants are more likely to be present on a site.
- A6.2.4 If potential pollutant linkages are identified within the conceptual model, a Phase 2 site investigation and report will be recommended. The investigation should be planned in general accordance with CLR 4, ref 9.1. The number of exploratory holes and samples collected for analysis should be consistent with the size of the site and the level of risk envisaged. This will enable a generic quantitative risk assessment (GQRA) to be conducted, at which point the conceptual model can be updated and relevant pollutant linkages can be identified.
- A6.2.5 A two-stage investigation may be more appropriate where time constraints are less of an issue. The first stage investigation being conducted as an initial assessment for the presence of potential sources, a second being a more refined investigation to delineate wherever possible the extent of the identified contamination.
- A6.2.6 All site works should be in general accordance with the British Standards, BS 5930:2010, ref. 9.2, ISO 1997, ref 9.3 and BS 10175:2011, ref 9.4.
- A6.2.7 The GQRA screens the results of the chemical analysis against generic guidance values, appropriate to the end-use of the site. Soils will be compared to Soil Guideline Values (SGV) where published, Generic Assessment Criteria (GAC) developed by LQM/CIEH, ref 9.26, or internal screening values generated using the Contaminated Land Exposure Assessment (CLEA) Software, Version 1.06, ref 9.27. Toxicological and physico-chemical/fate and transport data used to generate the AC has been derived from a hierarchy of data sources as follows:
1. Environment Agency or Department of Environment Food and Rural Affairs (DEFRA) documents;
 2. Other documents produced by UK Government or state organisations;
 3. European institution documents;
 4. International organisation documents;
 5. Foreign government institutions.
- A6.2.8 For many of the contaminants considered, input data has been drawn from the relevant SGV where available, or existing toxicological reports published by the Environment Agency which have not

yet been withdrawn/replaced. Fate and transport data has been derived in the first instance from Environment Agency (2008), ref 9.23.

- A6.2.9 Recommendations for tolerable intakes of lead are based on evaluation of the relationship between exposure and blood lead levels. The existing toxicological report for lead considers a health criteria value based on an uptake dose, whereas the CLEA model estimates exposure in terms of an intake dose. At present, the CLEA model is not considered appropriate for determining a screening value for lead. In the absence of a current published assessment criterion, the SGV for lead reported in R&D Publication CLR 10 ref 9.31 have been used in this assessment. This will be updated in due course in light of any further published information.
- A6.2.10 Chemical laboratory test results are processed as follows. A statistical analysis of the results is conducted, as detailed in CIEH and CL:AIRE ‘Guidance on Comparing Soil Contamination Data with a Critical Concentration’, ref 9.28. Individual concentrations are compared to the selected guideline values to identify concentrations of contaminants that are above the selected screening criteria.
- A6.2.11 Initially the distribution of the data set is tested using the Shapiro-Wilk normality test, ref 9.29 to determine if the data set is, or is not, normally distributed. Where the distribution of the data is shown to be normal, the mean value test is applied to determine whether the mean characteristics of the selected soil unit present a significant possibility of significant harm to human health. Where the data is not normally distributed a method based on the Chebychev Theorem can be applied to test the same hypothesis. The significance of the data is further tested using the maximum value test. This determines whether the highest recorded contaminant concentrations are from the same statistical distribution or whether they may represent a ‘hot spot’.
- A6.2.12 Where the risk estimation identifies significant concentrations of one or more contaminants, a further risk evaluation needs to be undertaken.
- A6.2.13 The risk evaluation will address the potential pollutant linkages between an identified source of contamination and the likely receptors both on and off site.
- A6.2.14 The potential receptors include:
- 1) Humans – current site occupants, construction workers, future site users and neighbouring site users.
 - 2) Controlled Waters – surface water and groundwater resources
 - 3) Plants – current and future site vegetation
 - 4) Building materials
- A6.2.15 The potential hazards to be considered in relation to contamination are:
- a) Ingestion and inhalation.
 - b) Uptake of contaminants via cultivated vegetables.
 - c) Dermal contact
 - d) Phytotoxicity (the prevention or inhibition of plant growth)
 - e) Contamination of water resources
 - f) Chemical attack on building materials and services
 - g) Fire and explosion
- A6.2.16 Dependent on the outcome of the initial, generic contamination risk assessment, further detailed assessment of the identified risks may be required.

A6.3 Generic Guidance Values Used Within Contamination Risk Assessment

Residential End Use with Homegrown Produce

Residential with Homegrown Produce	Determinant	Guidance Value (mg/kg)	Guidance Value (mg/kg)	Guidance Value (mg/kg)	Primary Data Source
		1% SOM	2.5% SOM	6% SOM	
PAH	Acenaphthene	210	510	1100	LQM/CIEH S4UL
	Acenaphthylene	170	420	920	LQM/CIEH S4UL
	Anthracene	2400	5400	11000	LQM/CIEH S4UL
	Benzo(a)anthracene	7.2	11	13	LQM/CIEH S4UL
	Benzo(a)pyrene	2.2	2.7	3	LQM/CIEH S4UL
	Benzo(b)fluoranthene	2.6	3.3	3.7	LQM/CIEH S4UL
	Benzo(ghi)perylene	320	340	350	LQM/CIEH S4UL
	Benzo(k)fluoranthene	77	93	100	LQM/CIEH S4UL
	Chrysene	15	22	27	LQM/CIEH S4UL
	Dibenzo(ah)anthracene	0.24	0.28	0.30	LQM/CIEH S4UL
	Fluoranthene	280	560	890	LQM/CIEH S4UL
	Fluorene	170	400	860	LQM/CIEH S4UL
	Indeno(123-cd)pyrene	27	36	41	LQM/CIEH S4UL
	Naphthalene	2.3f	5.6f	13f	LQM/CIEH S4UL
	Phenanthrene	95	220	440	LQM/CIEH S4UL
	Pyrene	620	1200	2000	LQM/CIEH S4UL
Other Organics	Phenol	280	550	1100	LQM/CIEH S4UL
Metals	Arsenic	37	37	37	LQM/CIEH S4UL
	Beryllium	1.7	1.7	1.7	LQM/CIEH S4UL
	Boron	290	290	290	LQM/CIEH S4UL
	Cadmium	11	11	11	LQM/CIEH S4UL
	Chromium (III)	910	910	910	LQM/CIEH S4UL
	Chromium (VI)	6	6	6	LQM/CIEH S4UL
	Copper	2400	2400	2400	LQM/CIEH S4UL
	Lead	200	200	200	EA C4SL
	Mercury	40	40	40	LQM/CIEH S4UL
	Nickel	180f	180	180	LQM/CIEH S4UL
	Selenium	250	250	250	LQM/CIEH S4UL
	Vanadium	410e	410	410	LQM/CIEH S4UL
	Zinc	3700	3700	3700	LQM/CIEH S4UL

d = Based on inhalation exposure compared with inhalation ID

e = Based on oral and dermal exposure with oral TDI

f = Based on comparison of exposure from all pathways with TDI oral

Residential with Homegrown Produce	Guidance Value (mg/kg)	Guidance Value (mg/kg)	Guidance Value (mg/kg)	Primary Data Source
	1% SOM	2.5% SOM	6% SOM	
Aliphatic				
EC 5-6	42	78	160	LQM/CIEH S4UL
EC >6-8	100	230	530	LQM/CIEH S4UL
EC >8-10	27	65	150	LQM/CIEH S4UL
EC >10-12	130 (48)	330 (118)	770 (283)	LQM/CIEH S4UL
EC >12-16	1100 (24)	2400 (59)	4400 (142)	LQM/CIEH S4UL
EC >16-35	65000 (8.48)	92000 (21)	110000	LQM/CIEH S4UL
EC >35-44	65000 (8.48)	92000 (21)	110000	LQM/CIEH S4UL
Aromatic				
EC 5-7 (benzene)	70	140	300	LQM/CIEH S4UL
EC >7-8 (toluene)	130	290	660	LQM/CIEH S4UL
EC >8-10	34	83	190	LQM/CIEH S4UL
EC >10-12	74	180	380	LQM/CIEH S4UL
EC >12-16	140	330	660	LQM/CIEH S4UL
EC >16-21	260f	540f	930f	LQM/CIEH S4UL
EC >21-35	1100f	1500f	1700f	LQM/CIEH S4UL
EC >35-44	1100f	1500f	1700f	LQM/CIEH S4UL
Aliphatic and Aromatic				
EC >44-70	1600f	1800f	1900f	LQM/CIEH S4UL
BTEX				
Benzene	0.087	0.17	0.37	LQM/CIEH S4UL
Toluene	130	290	660	LQM/CIEH S4UL
Ethylbenzene	47	110	260	LQM/CIEH S4UL
p Xylenes	56	130	310	LQM/CIEH S4UL
m Xylenes	59	140	320	LQM/CIEH S4UL
o Xylene	60	140	330	LQM/CIEH S4UL

SOM = Soil Organic Matter

Values in brackets indicate the solubility or vapour saturation limit where this is exceeded by the GAC

