

Table 4-3 ICSM and Potential Contaminant Linkages

Contaminant Linkage	Source (S)	Pathway (P)	Receptor (R)	Probability	Consequence	Current Risk	Investigation
Human Health							
1	On Site S1: Potential for localised made ground from former backfilled ponds / vicinity of the site. S2: Potential for localised spills of fuels / oils from farm machinery using the land. S3: Agricultural soils. Off Site S5: ACMs falling onto site associated with disused building/s adjacent to the northeast boundary.	P1: Ingestion of contaminated particulates. P2: Dermal contact. P3: Inhalation of contaminated dust / particles.	R1: Site end users.	Low	Medium	Low / moderate	Site investigation recommended to establish current levels of contamination and risk.
2			R2: Construction workers / maintenance workers.	Low	Medium	Low / Moderate	

Contaminant Linkage	Source (S)	Pathway (P)	Receptor (R)	Probability	Consequence	Current Risk	Investigation
3	On Site S1 & S3: as above Off Site S5: as above.	P3: Inhalation of contaminated dust / particles.	R3: Members of the public and residential properties adjacent to the site during construction	Unlikely	Medium	Low	Site investigation recommended to establish current levels of contamination and risk. Dust suppression to be adopted during construction.
4	On Site & off-Site S1 & S6: Ground gas arising from potential areas of localised Made Ground. S2: VOCs arising from sources listed above.	P3: Inhalation of vapours in indoor and outdoor air. P4: Migration of asphyxiant and explosive/ harmful gasses into confined spaces	R1 & R2 as above	Unlikely	Medium	Low	Site investigation recommended to establish current levels of contamination and risk.
Controlled Waters							
5	On Site	P5: Leaching of contamination into groundwater.	R4: Secondary (A) / (B) / Undifferentiated Aquifer.	Unlikely	Mild	Very Low	Site investigation recommended to establish current

Contaminant Linkage	Source (S)	Pathway (P)	Receptor (R)	Probability	Consequence	Current Risk	Investigation
6	S1 & S3: as above.	P6: Surface water on & off site via migration of contaminated groundwater and overland flow into surface water (run-off).	R5: On-site drainage ditch.	Unlikely	Mild	Very Low	levels of contamination and risk.
Property and Infrastructure							
7	On Site S4: Natural subsoils with potentially high sulphate concentrations.	P5: Leaching of sulphates, corrosive contaminants and / or acidic or alkaline leachate. P7: Direct contact with aggressive ground.	R6: Buried concrete & structures on-site and buried services.	Low	Mild	Low	Site investigation recommended to establish current levels of contamination.
Ecology							
8	On Site S1 - S3: as above	P8: Uptake of available phytotoxic contaminants via direct contact with contaminants.	R7: Ecological receptors Flora & Fauna on and off-site.	Low	Mild	Low	Site investigation recommended to establish current levels of contamination and risk.

5. Site Investigation

5.1 Summary of Site Works

The intrusive ground investigation works were undertaken on the 15th - 16th December 2021 and the 13th January 2022 by PJSG to establish the ground conditions beneath the site.

The locations of the exploratory holes were positioned taking into consideration the proposed development. No intrusive investigation works were carried out in the vicinity of identified underground or overhead utilities in the north, central and southern central areas of the site. Only boreholes were positioned within areas of the site where ridge and furrow / species rich grassland is present in order to minimise any disruption.

The ground investigation works were designed in general accordance with BS10175:2011+A2:2017 'Investigation of Potentially Contaminated Sites'. Further details of the ground investigation work undertaken, including the rationale for the location of the exploratory holes are detailed below in Table 5-1.

An Exploratory Hole Location Plan (PJSG21-58-DR-003-A) is provided within the Drawings Section of this report.

Table 5-1 Summary of Site Investigation Works

Method / Activity	No.	Hole Reference	Depth Range (m)	Testing	Gas & Groundwater Ancillaries	Rationale
Investigation Method						
Window Sample Borehole (WS)	20	WS01 to WS20.	3.00 – 5.00	*SPT's	8	To determine ground conditions.
Machine Excavated Trial Pits (TP)	21	TP01 to TP21.	2.30 – 3.40	Hand Shear Vanes (HSVs)	-	To determine ground conditions.
Gas & Groundwater Monitoring						
Gas data meter, flow meter and groundwater dip meter	6 to date.	WS01, WS03, WS07, WS08, WS10, WS13, WS15 and WS16.	-	Ground gas & Groundwater monitoring	-	To further determine the ground gas regime in accordance with CIRIA C665.

*SPTs undertaken in accordance with the guidance set out within BS EN 22476-3 2005 +A1:2011;

The exploratory logs are presented within Appendix B and the results of the SPT / HSV tests are shown on the individual exploratory hole logs.

The SPT hammer calibration certificate for the WS drilling rigs is also included within Appendix B.

5.2 Laboratory Testing and Sampling

Representative soil samples of the various strata types present were collected during the site investigation works by a suitably qualified engineer. Samples were recovered using a stainless-steel trowel and disposable gloves.



Samples were stored in cooler boxes prior to being transported to an MCERTS accredited laboratory. A selection of these samples was tested for the presence of contaminants and for classification purposes. Chemical testing was undertaken by i2 Analytical Ltd and Chemtech Environmental, whilst geotechnical testing was undertaken by Exploration & Testing Associates Ltd.

A summary of the laboratory testing carried out is presented below.

Table 5-2 Summary of Laboratory Testing

Quantity	Analysis
Chemical Testing - Soils	
12	PJS Contamination Suite comprising: Moisture content, pH, Organic matter, Speciated USEPA 16 PAHs, Metals: As, Cd, Cr III & VI, Cu, Pb, Hg, Ni, Se, Zn, Water soluble sulphate (SO ₄).
9	Asbestos Identification (ID).
6	BRE Suite B (Greenfield but possibly pyritic)
Geotechnical Testing	
11	Moisture Content
11	Liquid and Plastic Limits
1	Particle Size Distribution (grading analysis)

Geotechnical laboratory testing was generally carried out in accordance with the relevant part of BS1377: 1990, *Methods of Test for Soils for Civil Engineering Purposes*, or, where superseded, by the relevant part of BS EN ISO 17892:2014+ *Geotechnical investigation and testing – Laboratory Testing of Soil*.

The laboratory results are included within Appendix C and D of this report.



6. Ground Conditions

6.1 Summary of Ground Conditions

The geology encountered during the intrusive investigation was generally consistent with geological records. A summary of the general strata encountered across the site is provided in the Table 6-1 below, with more detailed descriptions given on the exploratory hole logs presented within Appendix B.

6.2 Summary of Geological Descriptions

The geology encountered below the site is described below.

Table 6-1 Geological Descriptions

Topsoil	Topsoil	Encountered at all locations and generally recovered as a sandy clayey TOPSOIL. The depth of topsoil encountered across the site ranges between 0.25 to 0.40m, with an average thickness of 0.35m.
Superficial Geology	Glacial Cohesive Deposits	Encountered within all exploratory hole locations generally comprising an upper horizon of firm brown sandy gravelly CLAY overlying a lower horizon of firm to stiff grey gravelly CLAY. Gravels comprised fine to coarse, angular to sub-rounded quartzite, siltstone, mudstone and chalk. Stiff grey clayey SILT was encountered within WS14 at a depth of 3.00 to 5.00m, albeit a localised soft pocket was noted between 4.50 – 4.75m.
	Glacial Granular Deposits	Encountered at 11 No. exploratory hole locations (TP05, TP15, WS01, WS02, WS04 - WS06, WS15, WS16, WS18 and WS20) generally comprising wet clayey gravelly SAND. Yellowish brown very wet clayey very sandy GRAVEL was encountered within TP19 (southeast) at depth of 1.10m, the excavation was aborted at 2.40m due to instability within this stratum.
Bedrock Geology	Mercia Mudstone Group	Not encountered at any exploratory hole locations.

6.3 Summary of Field Observations

The following field observations were made during the intrusive investigation works.

Table 6-2 Field Observations

	Locations Encountered	Observation	Depth Range (m)
Groundwater	TP01	Slight groundwater ingress	1.60
	TP02	Slight groundwater ingress	1.20
	TP05	Wet strata	1.40
	TP15	Land drain struck	1.70
	TP19	Land drain struck	0.80
	TP20	Groundwater ingress	2.20 – 2.40
	WS01	Groundwater at base	4.00



	Locations Encountered	Observation	Depth Range (m)
	WS02	Groundwater	3.00
	WS05	Groundwater	3.00
	WS07	Groundwater	2.00
	WS10	Groundwater	2.00
	WS11	Groundwater at base	5.00
	WS14	Groundwater	2.00
	WS15	Groundwater	4.00
	WS16	Groundwater	1.00
	WS19	Groundwater	1.00
	WS20	Groundwater	2.00
Instability / Trench Collapse	TP05	Minor collapse	1.40 – 2.10
	TP15	Unstable	1.70 – 2.30
	TP19	Unstable	1.10
	TP20	Major collapse	1.20
	WS01	Borehole collapse	3.40 – 4.00
	WS16	Borehole collapse	3.00 – 5.00
Soft / Loose Strata	TP11	Pockets of soft clay	0.30 - 1.00
	TP18	Pockets of soft clay	0.70 – 1.00
	WS02	Soft clay	1.00 – 2.00
	WS04	Loose sand	1.00 – 1.50
	WS05	Soft clay / Loose sand	1.00 – 1.60
	WS06	Loose sand	1.10 – 1.80
	WS08	Soft clay	0.25 – 1.00
	WS11	Soft clay	0.40 – 0.70
	WS14	Soft silt	4.50 – 4.75
	WS17	Soft clay	
	WS18	Loose sand	1.00 – 2.00
	WS20	Soft clay	1.00 – 1.40
Running sands	TP20	Running sands	1.20
Contamination	Not encountered	-	-

6.4 Summary of SPT Testing within Boreholes

A summary of the uncorrected SPT N Values recorded in the boreholes advanced across the site is summarised below in Table 6-4.

Table 6-3 SPT Summary in relation to Ground Conditions

Borehole Ref:	SPT 'N' Value with Depth					
	1m	2m	3m	3.8m	4m	5m
WS01	19	25	24	-	23	-
WS02	6	14	24	50	-	-
WS03	15	16	50	-	-	-
WS04	7	16	25	-	27	-
WS05	4	19	13	-	31	35
WS06	8	14	21	-	27	-
WS07	11	14	19	-	11	19
WS08	9	13	16	-	30	31

Borehole Ref:	SPT 'N' Value with Depth					
	1m	2m	3m	3.8m	4m	5m
WS09	11	16	28	-	41	34
WS10	11	16	20	-	20	-
WS11	12	18	22	-	19	27
WS12	11	13	20	-	32	28
WS13	8	10	17	-	29	-
WS14	8	12	14	-	17	19
WS15	9	14	14	-	12	10
WS16	4	19	14	-	12	7
WS17	4	20	19	-	29	-
WS18	7	21	31	-	29	23
WS19	9	13	18	-	13	23
WS20	4	16	50	-	-	-

Natural cohesive deposits – Natural Granular Deposits

Several low N value results in both granular and cohesive stratum have been recorded during the PJS investigation. The implication of the low N Values encountered is discussed further in Section 7.0. The recorded SPT N values are detailed on the exploratory hole logs presented within Appendix B.

6.5 Gas & Groundwater Monitoring

To characterise the ground gas regime for the site, gas and groundwater monitoring has been carried out on 6 No. monitoring visits to date between 23rd December 2021 and 23rd March 2022 at atmospheric pressures ranging between 983mb to 1025mb

The concentration (initial and steady state) of methane (CH₄), carbon dioxide (CO₂), oxygen (O₂) by percentage volume and gas flow rates within each borehole were recorded. Weather conditions and atmospheric pressures before, during and after monitoring were also recorded. A summary of the ground gas monitoring results obtained to date are displayed in the table below.

Table 6-4 Ground Gas Monitoring Summary

Ground Gas Monitoring Summary	Minimum	Maximum
Methane (CH ₄) %	< 0.1	0.3
Carbon dioxide (CO ₂) %	< 0.1	2.6
Oxygen (O) ₂ %	14.6	21.2
Carbon monoxide (CO) PPM	0	16
Hydrogen sulphide (H ₂ S) PPM	0	0
Atmospheric Pressure (mb)	991	1025
Flow Rates (m/s)	*<0.1	2.5

**The limit of detection has been used for negative flows rates.*

A summary of the groundwater monitoring results obtained to date are displayed in the table below.

Table 6-5 Groundwater Monitoring Summary

Borehole Ref.	Minimum Depth bgl. (m)	Maximum Depth bgl. (m)	Response Zone Flooded on Arrival (Y/N)	Number of Occasions Flooded
WS01	1.33	2.00	Y	2 of 6
WS03	0.85	1.17	Y	3 of 6
WS07	0.60	0.63	Y	6 of 6
WS08	0.70	0.74	Y	6 of 6
WS10	0.80	0.83	Y	5 of 6
WS13	0.98	1.04	Y	2 of 6
WS15	1.37	1.53	N	-
WS16	0.46	0.49	Y	6 of 6

To facilitate ground gas monitoring, the initial groundwater depth was recorded in boreholes then each of these boreholes was bailed dry and was left to stabilise for a period. Gas monitoring was then undertaken.

The gas and groundwater monitoring results are contained within Appendix E of this report.



7. Geotechnical Assessment

7.1 Introduction

Redevelopment proposals for the site are understood to comprise the construction of residential buildings with areas of hardstand and soft landscaping.

At this stage, an illustrative masterplan has been provided and is presented in the Drawings section of this report.

7.2 Material Properties

To assist with foundation design, in-situ testing and geotechnical classification testing has been undertaken on a selection of the soil samples recovered from site. The geotechnical properties of the soil types encountered across the site as summarised in the sections below.

Geo-technical analysis of the samples was carried out by Exploration & Testing Associates Ltd. Results are contained within the Appendix D.

7.3 Particle Size Distribution (PSD) Analysis

1 No. PSD analyses were undertaken on samples recovered from site to aid in the classification of soils. Classification was undertaken in accordance with BS1377: 1990 Part 2: Clause 9.2 and the results of the tests are summarised below:

Table 7-1 Summary of PSD Analysis

Sample Location	Depth (m)	Lab Soil Description	Percentage Passing (%)			
			Very Coarse Soils (>63mm)	Gravel (63mm – 2mm)	Sand (2mm - 0.063mm)	Fines (<0.063mm)
TP19	1.40	Brown slightly sandy CLAY	0	2	20	78

The results of the PSD test confirms that the strata sampled comprises predominately cohesive material and therefore soils at this location should be treated as cohesive rather than granular.

7.4 Plasticity Index & Volume Change Potential

A total of 12 No. Plasticity Index (PI) tests were undertaken on soil samples in accordance with BS1377-2: 1990 Clause 3.2, to determine the Modified Volume Change Potential (VCP) in accordance with NHBC Standards (Chapter 4.2).

Results of the PI tests and the related VCP of the samples is summarised below.



Table 7-2 Summary of Plasticity Testing

Sample Location	Depth (m)	Strata	Moisture Content (%)	Plasticity Index (%)	Percentage Passing 425µm Sieve (%)	Modified Plasticity Index (%)	VCP
TP03 – D1	2.40	CLAY	24.00	24.00	98.00	23.52	Medium
TP05 – D1	1.00	CLAY	26.00	24.00	98.00	23.52	Medium
TP05 – B1	2.00	Very clayey SAND	18.00	19.00	97.00	18.43	Low
TP11 – D1	2.40	CLAY	17.00	20.00	93.00	18.60	Low
TP15 – D1	1.50	CLAY	22.00	9.00	98.00	8.82	Non-shrinkable
TP15 – B1	2.00	Clayey SAND	13.00	-			
TP19 – B1	1.40	CLAY	24.00	17.00	97.00	16.49	Low
WS01 – D1	2.00	CLAY	14.00	15.00	88.00	13.20	Low
WS13 – D1	1.00	CLAY	17.00	16.00	97.00	16.49	Low
WS14 – D1	1.80	CLAY	26.00	23.00	100.00	23.00	Medium
WS14 – D2	3.00	SILT	24.00	10.00	98.00	9.80	Non-shrinkable

Geotechnical testing has determined the cohesive deposits beneath the site to range from non-shrinkable to medium VCP as indicated in the above table.

Samples of granular material were obtained and tested for plasticity at a depth of 1.40m and 2.00m from TP05 and TP19 respectively, in order to confirm if the strata were non-shrinkable. The test result for these samples indicate modified VCP results of 18.43% and 16.49% and therefore the materials should be classified as low VCP.

Based on the results it is considered that a medium VCP should be assumed for foundation design purposes.

Where founding in medium VCP deposits detailed foundation design will be required to determine the required founding level in accordance with NHBC Guidelines Chapter 4.2 – Building Near Trees. Heave precautions will also be required on the inside face of foundation trenches.

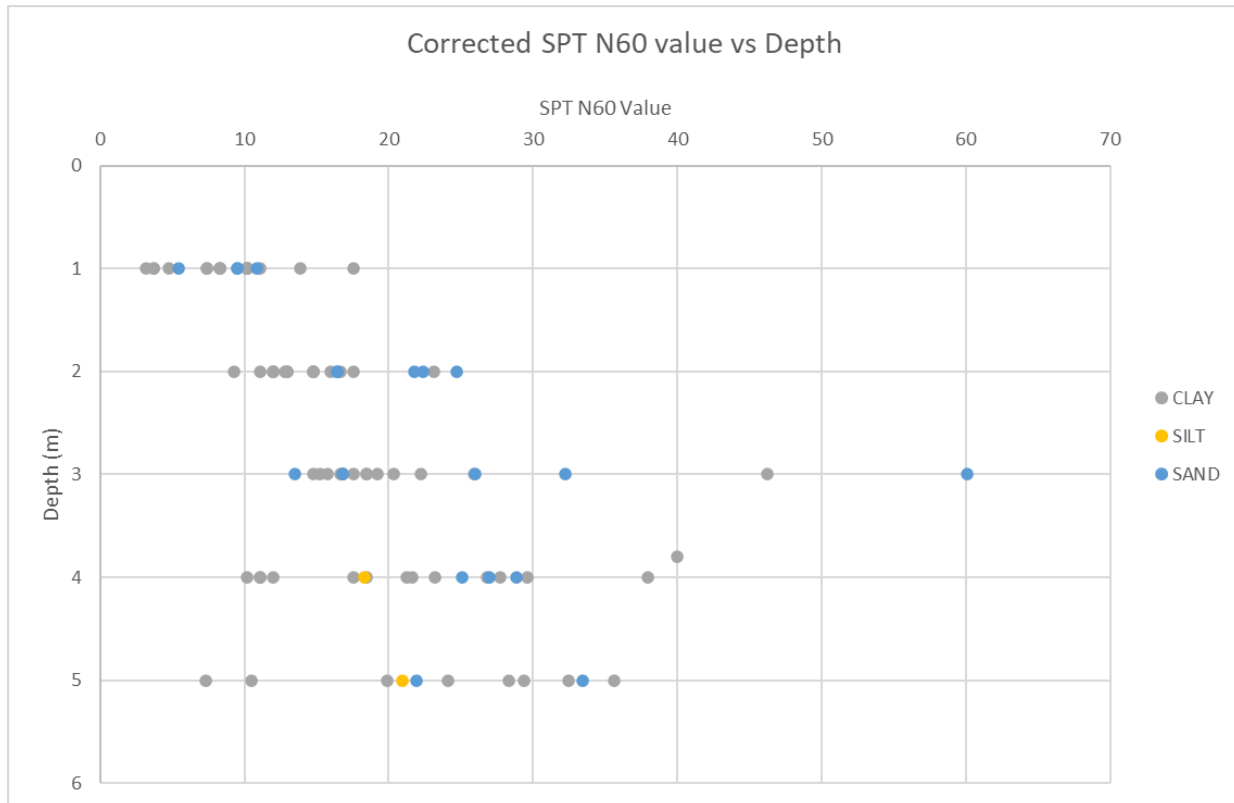
In accordance with NHBC standards, foundation depths should be a minimum of 0.90m below existing or reduced levels (where foundations are located outside the zone of influence of trees) within cohesive deposits.

7.5 In-situ Standard Penetration Testing

Standard Penetration Tests were undertaken at regular intervals during drilling of the window sample boreholes in accordance with the methodology outlined in British Standard BS EN 22476-3 2005.

A plot of corrected SPT N values recorded with depth below the site during the investigation is presented below in Figure 1. A copy of the SPT calibration certificate for the window sample drilling rig is presented within Appendix B.

Figure 1 - Corrected SPT N60 Value with depth



Results of the corrected SPT N60 testing would indicate that cohesive deposits generally comprise firm to stiff clays which increase in strength with depth. The N60 values for the granular strata indicate that materials generally comprise medium dense sands.

Loose granular deposits have been identified at a depth of 1m within WS04, WS05 and WS06 located in the north and within WS18 located in the west of the site.

Very soft to soft cohesive deposits have been identified at a depth of 1m in WS02 located in the northern field and within WS16, WS17 and WS20 all located in the south / southeast of the site. Soft cohesive deposits were also noted with WS16 at a depth of 5m, which coincided with poor sample recovery.

7.6 Undrained Shear Strength

The undrained shear strength of the materials has been estimated from the SPT N Values by empirical correlation as described in CIRIA Report C143 (after Stroud and Butler, 1975):

$$c_u = \tilde{N} f_1 \text{ (kN/m}^2\text{)} \quad [1]$$

Where c_u is the undrained shear strength, N is the SPT N value and f_1 is an empirical correlation factor based on the soil plasticity index. The soil plasticity data obtained from soil samples recovered below the site during the investigation has been used. The samples of granular strata are not considered to be representative of the cohesive

deposits beneath the site and therefore have been removed from the data set below in order to gain the F_1 value. Based on the plasticity index testing carried out, the values in Table 7-3 have been assumed for the purpose of calculation.

Table 7-3 Calculated F_1 Values

Strata	Average I_p	F_1 Value
Cohesive	20	5.4

Calculated using corrected N60 value range of 3 – 46 the estimated undrained shear strength of the cohesive strata is between 17 kN/m² and 250 kN/m².

Figure 2 – Calculated Shear Strength with depth

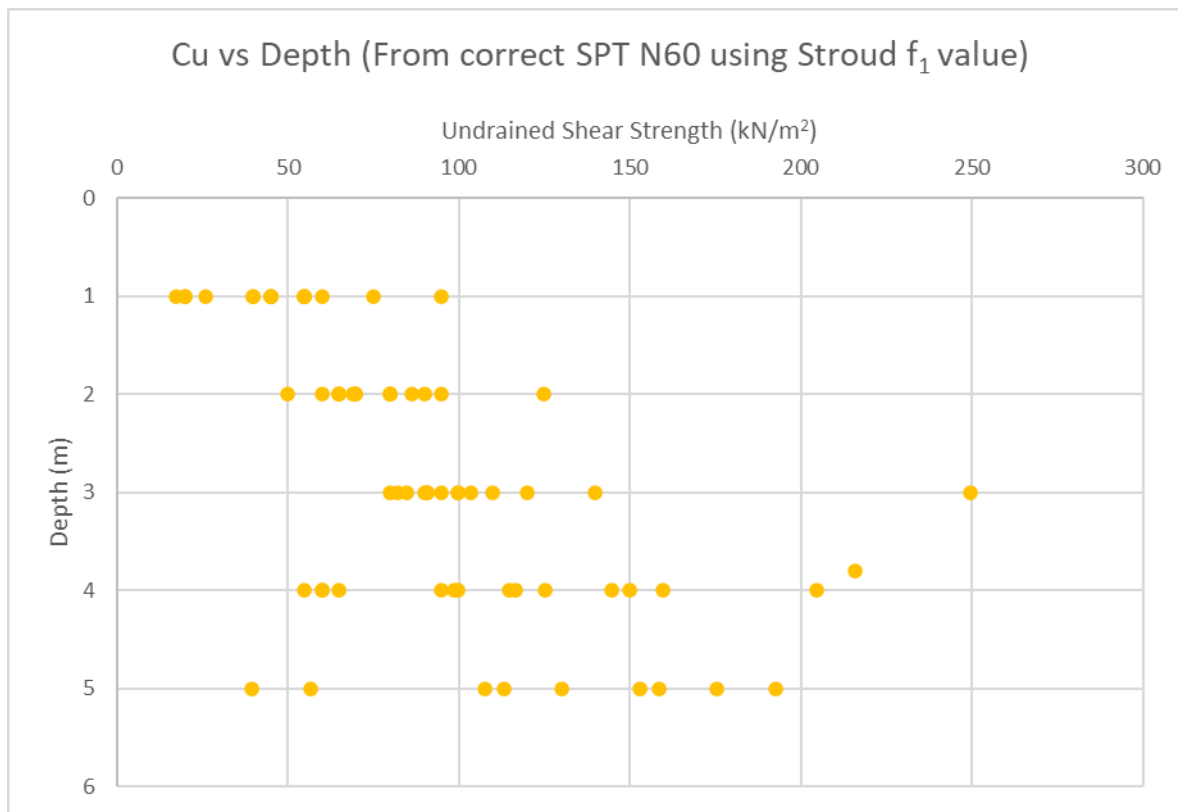


Figure 2 presents a plot of the estimated undrained shear strength with depth beneath the site based on the soil plasticity testing as described above. The results show a clear trend of increasing shear strength with depth.

