DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING

SURICATES (NWE462): SEDIMENT USES AS RESOURCES IN CIRCULAR AND TERRITORIAL ECONOMIES

DELIVERABLE T2.2.1 – BIOENGINEERING WITH SEDIMENT: FORMULATION AND LAB TESTS OF ECO-SOLUTIONS REPORT (SCOTTISH SEDIMENT CHARACTERISATION STUDY)

[redacted]

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1 INTRODUCTION

The aim of the SURICATES (Sediment Uses as Resources In Circular And Territorial EconomieS) project is to increase sediment reuse for erosion and flood protection through innovative pilot implementation. Within technical work package (WP) T2 (“demonstrate and evaluate innovative sediment reuse solutions for flood erosion and protection”) the University of Strathclyde have a specific role as leaders of activity 2 (“formulation and lab tests of 3 eco-solutions for UK/Bowling River pilot sites”). In this activity “from the pilot sites sediment characteristics, University of Strathclyde (UoS), with the support of ARMINES, Deltares, CIT and BRGM, will define and test at lab scale the processes and formulations able to set up 3 eco-solutions (bio-engineering with sediment, sediment as a pozzolanic material, concrete made with cement and sediment) for erosion and flood protection. For each eco-solution, several processes/formulations will be defined to be tested in real life conditions. Results will be inputs for UK investment WPs. The first deliverable for activity 2 is “bioengineering with sediment: Formulation and lab tests of eco-solutions report”. The purpose of this report is to describe the various activities by University of Strathclyde since the start of the project which contribute to meeting this deliverable, especially to determine the sediment characteristics for WPT2 described above.

Following discussion with the project partners at the initial meetings for the project and this work package (project kick-off meeting, Lille 17-19 Jan 2018, WPT2 meetings in Glasgow 23-25 April 2018 and Delft 8 June 2018) we identified a serious gap in existing data for Scottish sites. From a review of existing data on sediment characteristics, following up information from other project partners, we quickly realised that additional characterisation of Scottish canal sediments was needed before pilot-trials could be planned, especially for three key parameters needed for the two technical reuse options (concrete, pozzolanic material), specifically total organic carbon (TOC), particle size distribution (PSD) and calcimetry. These were almost totally absent from previous analytical data, which focussed on organic and inorganic contaminants likely to effect environmental toxicity or waste classification. The very limited data available included TOC and PSD on dewatered placed sediments at Applecross Street, which were sourced from locations at Cadder and Spiers Wharf, also on the Forth & Clyde Canal, together with two sets of sediment samples from the Inverness section of the Caledonian Canal, one of which was analysed for PSD and the other one for organic matter (OM) (Appendix 1).

Sediments tested from both canals were sand-dominant with organic matter up to c.18% but with more gravel and a generally lower OM in the Highland area. Likewise, nutrient analyses (critical for plant growth in the bioengineering trial) were partial and restricted to the placed sediments at Applecross Street and the second Caledonian Canal sediment set.

We therefore planned a programme of sediment sampling from the Forth & Clyde and Caledonian Canals near Glasgow and Fort William respectively with commercial laboratory analysis for a comprehensive range of determinants. Provisional results were reported first at the WPT2 meeting in Lille (15-11-18), dried samples were then prepared and passed to ARMINES during the Steering Committee meeting in Rotterdam, while prior to this the stored wet samples were also analysed by pXRF by BRGM during the baseline monitoring mission to Bowling (24 to 29-9-18).

2 AIMS AND OBJECTIVES

The aim of the current sampling and analytical work was to collect and fully characterise the properties of sediments from the Forth & Clyde Canal (at Bowling and at Applecross Street in Glasgow) and the Caledonian Canal (at Laggan, near Fort William) where the Investment Work Package (IWP) pilots are planned including the critical parameters for reuse which were missing in previous campaigns (i.e. TOC, PSD, calcimetry, total and available nutrients).

Specific objectives were:

1. To compare and select methods for sampling *in situ* sediment ahead of dredging activity
2. To identify appropriate methods offered by commercial laboratories contracting to Scottish Canals and to add these to analytical schedules
3. To determine the characteristics of canal sediments in Scotland, including analyses of TOC, PSD, calcimetry, total and available nutrients on the same samples.
4. To compare the sediment characteristics of Lowland Canals in Scotland (Forth & Clyde or Union) with Highland Canals (Caledonian or Crinan)
5. To consider these results in the context of the proposed bioengineering trials/pilots in WP I3 and then I2

3. METHODOLOGY

3.1 Sampling locations & methods

Details of the three sampling locations are given in Table 1. At Applecross Street the Scottish Canals maintenance vessel *Rockvilla* was used (Fig 1 a), which is fitted with a hydraulic clam-shell. The excavated sediments were initially semi-solid (Fig 1 b) but were transferred to 25 L buckets for homogenisation with a stainless steel border spade, prior to subsampling (Fig 2 c), whereupon liquefaction occurred (Fig 1 d). As sampling at Bowling took place on the same day, so as to meet sample preservation requirements for nutrient analysis, a trailered craft was used (Fig 2 a), thus avoiding the one-day delay navigating *Rockvilla* between the two locations by water through the five locks of the Maryhill Flight. Attempts to sample sediments at Bowling at the first location, immediately above Bowling Lock 38 using the hired 0.5L Van Veen sampler (Fig 2b) were hampered by the amount of weed and also the very liquid material recovered (Fig 2 c). This was partly because the area had recently been cleared using the Truxor weed cutter, so floating reed stems had accumulated above the lock gate. Samples were therefore collected mechanically using a sediment scoop or “spoon”, which allowed material with a sludge consistency[1] to be brought to the surface. For the Caledonian Canal sampling at Laggan Locks the service vessel is fitted with a boom-mounted larger capacity (1L?) version of the Van Veen sediment grab (Fig 3a), which successfully delivered suitably solid samples to the surface from the greater water depth found at this location (Fig 3b).

[1] The Environment Agency defines a waste that flows only slowly, rather than near instantaneously (as does a liquid), into a hollow to be a sludge or a fine-grained solid

Table 1. Details of sediment characterisation sampling programme.

SC Sample Number	**Sample ID**	**Sample date**	**Location description**	**Sampling location (national grid reference)**	**Sampling (coordi**
SC/069/002	B2	17/09/2018	250m east of Lock 38	NS 45475 73389	55.928661,
SC/069/004	B4	17/09/2018	Immediately west of Bridge 48	NS 45871 73068	55.925908,
SC/070/002	G2	17/09/2018	110m south of sidearm D2	NS 58261 67387	55.878721,
SC/072/001	L1	28/09/2018	500m from Laggan spout towards Laggan locks	NN 29055 97214	57.034506,
SC/072/003	L3	28/09/2018	At Laggan spout	NN 29426 97552	57.037504,
SC/072/005	L5	28/09/2018	500m from Laggan spout towards Loch Oich	NN 29773 97910	57.040729,

Fig 1 Photographs of sediment sampling at Applecross Street

(a) Scottish Canals service vessel *Rockvilla*.

(b) Hydraulic clam-shell used for sampling sediment (as semi-solid sludge).

(c) Sediment homogenisation and replicate subsampling.

(d) Sediments subsamples illustrating liquefaction.

Fig 2 Photographs of sediment sampling at Bowling.

(a) Trailer-towed portable vessel.

(b) Attempts using Van Veen 0.5 L sampler (hired from Van Walt).

(c) Liquid sediment recovered and weed issues using Van Veen grab.

(d) “Spoon” sampling illustrating recovered sediment as a sludge.

Fig 3 Photographs of sediment sampling at Laggan Locks, Caledonian Canal.
(a) Boom-mounted Van Veen sampler.

(b) Recovered sediment (sludge)

Fig. 4. Sediment sample sites – Bowling.

Table 2. Details of commercial laboratories used (see Appendix B).

Site/samples	Contaminant Suite laboratory	Nutrient Suite laboratory	PSD laboratory	Report/Job (see Appendices)
Bowling (B1 to B4)	Envirolab	NRM Laboratories	Structural Soils Ltd (subcontracted to Envirolab)	18/07627, 783401, 28054-18
Glasgow, Applecross St (G1 to G3)	Envirolab	NRM Laboratories	Structural Soils Ltd (subcontracted to Envirolab)	18/07627, 783402, 28054-18
Laggan Locks (L1 to L5, SB)	Envirolab	Envirolab	Structural Soils Ltd (subcontracted to Envirolab)	18/08116, 783437 R1

Fig. 5. Sediment sample sites – Glasgow, Applecross St

3.2 Analytical laboratories

Prior to sampling it was agreed that analysis would be carried out by commercial laboratories, with an agreed list of determinants, using the framework, approved supply list or tendered laboratories who were typically contracted by Scottish Canals and University of Strathclyde. For Scottish Canals this involved adding some new determinants to the usual suite, since this was typically just those required to check for contamination issues and or to determine suitability for landfill disposal. University of Strathclyde had previously used NRM Laboratories for a number of years for contaminated land and waste-to-land nutrient analyses. The final split of analysis between laboratories is shown in table 2.

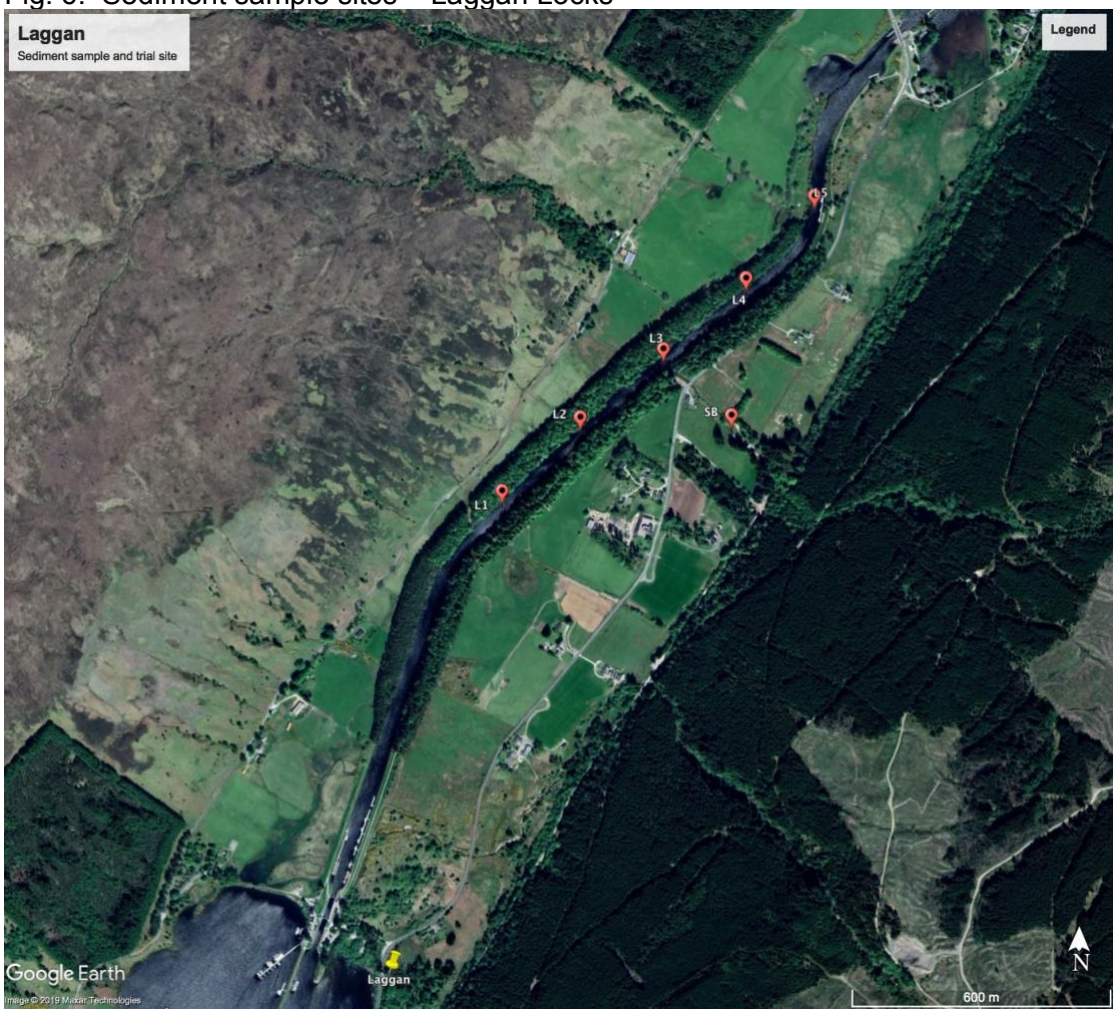
4. RESULTS

4.1 Critical parameters for sediment reuse

Those parameters deemed critical for assessing the potential for reuse of dredged sediments are summarised in Table 3 for the sets of samples from each of the three locations.

The very high water content of *in situ* sediments is clear, which is >60 % by weight for all but the very coarse gravels at Laggan Spout, where the Laggan Burn discharges

Fig. 6. Sediment sample sites – Laggan Locks



into the canal, and in the Stilling Basin which it passes through. The maximum recorded water contents were over 83 % for two spoon samples from Bowling, corresponding to dry matter contents of only < 17 %. It is possible that this in part may reflect the sampling method and collection at the surface of the sediment profile. However, water contents of 60 – 70 % total mass were still reported for samples collected at greater depth (c 0.5 m) with the hydraulic clam-shell used at Applecross Street, Glasgow.

Particle size distributions were dominantly sand in the two Forth and Clyde locations, and sand or silt at Laggan in the Caledonian Canal. These would mostly be classified as sandy or silty loam soils (Avery, 1990, 1973). This was unexpected as previous samples of placed dredgings from the Forth and Clyde were classed as clay loam soils, while sediments in the Inverness stretch of the Caledonian Canal were dominantly closely graded gravely medium and course SAND according to geotechnical classification schemes (British Standards Institution, 2015a).

Surprisingly, spoon samples from the sediment surface at Bowling gave some of the highest sand contents, while those from Laggan gave the highest silt contents. The working conclusion is that sand, silt and clay contents may vary widely and locally, irrespective of the Canal. However, a positive outcome from this is that the predominance of mixtures of the three endmembers gives loam soil classifications, indicating a potential suitability for cultivation purposes, such as is required bioengineering or phytoremediation.

TOC analyses range from <5% to over 18 % (averaging c.8.4 %) corresponding to organic matter contents of 8.2 to 32 %, assuming that the standard conversion factor

for soils (OM = 1.724 * TOC), which is now considered to be a minimum value (Pribyl, 2010), can also be applied to sediments.
Carbonate was detected in most samples, including sediments from each location. Equivalent concentrations of $CaCO_3$ range up to 8.8 % in one sample from Bowling but are typically c. 2 %.

4.2 Potentially toxic elements

Analyses for potentially toxic elements show contrasting results for the three sites, reflecting their geographical location and the extent of current and previous potentially contaminative industry. There are currently no UK guideline values for terrestrial sediments (Energy Institute, 2013). The Centre for Environment, Fisheries and Aquaculture Science’s (Cefas) original and proposed amended guideline action levels for marine sediments (Table 5) are not statutory limits but are provided for consideration of disposal to sea. Those below action level 1 are of no concern, whereas those above action level 2 are considered unsuitable for disposal to sea, with a tiered approach to risk assessment now expected (see URL 4). Instead these freshwater canal sediments have been compared to four sets of analogous guidance in order to assess their suitability for use as a growing medium in bioengineering applications: Firstly, the concentration limits for compost produced from urban green waste to specification PAS100 (2) which then allows use as a product in landscaping following the Quality Protocol. Secondly, the limits for metal loadings in agricultural soil used for receiving sewage sludge applications, which have a general applicability in assessing soil quality. Finally, two current sets of generic guideline values to assess the suitability for use of contaminated soils from brownfield sites. The Department of Environment, Food and Rural Affairs (DEFRA)’s Category 4 Screening Levels (C4SLs) are the upper limits below which there is no significant probability of significant harm following the UK’s current risk assessment methodology for standard exposure assumptions based on future land use (8). In this case the $C4SL_{POS}$ values have been selected which is for the scenario of use as Public Open Space without adjacent residential properties, as would be applied to an urban park. The more conservative LQM-CIEH Suitable 4 Use Levels (S4ULs) are shown for comparison, which give an idea of acceptable soil concentrations for planning purposes for the same land use scenarios, rather than the levels at which these become of regulatory concern (Nathanail et al., 2015a).
The sediment samples from Applecross Street show significant concentrations of metals and metalloids, including Zn, Cu, Cd, Cr, As, Pb and Hg, together with more minor PAH and hydrocarbon contamination. Historic maps for the adjacent land in this part of Glasgow show a history of previous heavy industry, including a chemical works, iron foundry, iron and brass works, glassworks, timber yards, boatbuilding yard, chrome tannery, coal pits, brickworks/claypits and historic landfill. Timber treatment using copper-chrome-arsenic solutions (CCA) is the likely source of these elements (5), with the brass works possibly adding to the Zn and Cu levels also typically found with Pb in areas of historic industry and coal use. All samples exceed the compost limits for all 7 of the metal/metalloid contaminants noted above as well as the sludge limits where applicable, suggesting that the material would not be considered a suitable growing medium unless the purpose was phytoremediation. Furthermore, the levels of As exceed those acceptable for Public Open Space so this would probably prevent reuse in soils as part of the canal infrastructure. The levels of Cr would also be unacceptable if assumed to be the more hazardous Cr^{IV} (chromate) as a worst case. However, recent analysis of nearby soils at Applecross Street indicate that these contain exclusively Cr^{III}, for which the S4ULs are much higher
Sediment samples from Bowling contain higher levels of Zn and occasionally Pb and Cd than are acceptable in compost or sludge-amended fields. These are consistent

Table 3. Summary table of critical parameters for sediments from Bowling, Applecross Street (Glasgow) and

	G1	G2	G3	B1	B2	B3	B4	L1	L2	L3-LS
Sediment sampling method	Clam-shell grab	Clam-shell grab	Clam-shell grab	Spoon	Spoon	Spoon	Spoon	VV Grab	VV Grab	VV G
% H_2O (dried @ < 40 °C)	70.2	59.7	60.2	70.7	74.3	83.1	83.6	75.9	69.8	15
Gravel % > 2 mm										43
Sand % 2 - 0.063 mm	64	68	46	69	79	72	77	46	35	57
Silt % 0.063-0.002 mm	26	19	41	21	14	16	15	50	59	0
Clay % <0.002 mm	10	13	13	10	7	12	8	4	6	0
Soil textural class (Avery, 1990, 1973) except for * (British Standards Institution, 2015a)	Sandy loam	Sandy loam	Sandy silt loam	Sandy loam	Loamy sand	Sandy loam	Sandy loam	Sandy silt loam	Sandy silt loam	Very grave SAN
Carbonate as $CaCO_3$ %	4.0	1.9	2.2	5.0	<0.8	8.8	<0.8	0.9	2.9	2.3
TOC %	11.2	18.3	11.4	7.48	8.13	12	12.3	7.65	7.66	0.19
Zn $mg.kg^{-1}$	***4030***	***2360***	***4060***	***538***	***579***	***1060***	***1140***	86	78	41
Cu $mg.kg^{-1}$	***495***	***451***	***795***	117	80	162	164	21	19	6
Cd $mg.kg^{-1}$	***9.6***	***6.1***	***8.1***	1.4	**1.5**	**2.9**	***3.2***	1.1	1.0	0.5
Cr $mg.kg^{-1}$ (if Cr^{VI})	**400**	**611**	**1120**	62	34	57	61	40	38	18
As $mg.kg^{-1}$	***238***	***431***	***474***	23	21	36	36	<1	<1	<1
Pb $mg.kg^{-1}$	***798***	***685***	***1160***	***319***	117	**230**	**298**	31	28	8
Hg $mg.kg^{-1}$	***4.51***	***6.89***	***13***	0.51	0.17	0.47	0.30	0.35	<0.17	<0.1
B(a)-P $mg.kg^{-1}$	0.2	1.46	5.20	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Benzene $mg.kg^{-1}$	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.0
TPH (C_6 -C_{40}) $mg.kg^{-1}$	2860	2950	5400	516	354	604	591	294	272	<5

Key: **Bold**: exceeds compost limits, *italic*: exceeds Sludge (Use in Agriculture) limits, underlined: exceeds $C4SL_{POS}$ and

Table 4. Comparison of laboratory methods and or standards (by laboratory).

Parameter(s)	Envirolab[2]	NRM	Structura
Water content, dry matter content	% moisture at < 40 ºC (A-T-044)	Oven Dry Matter	
Particle size distribution	-	Air-dried, <2 mm fraction, laser diffraction on suspended sample in flow cell, sand 2.00-0.063 mm, silt 0.063-0.002, clay <0.002	BS1377 (*purposes* sieve me 9.4)
Textural classification	-	Soil Survey of England & Wales (Avery, 1990, 1973)	
Carbonate as $CaCO_3$	(CO_3)	Lime equivalent as $CaCO_3$	
Total Organic Carbon (TOC)	(A-T-032s)	Dumas @ 1000 ºC after acid treatment	
Potentially toxic elements (PTEs), Zn, Cu, Cd, Cr As, Pb, Hg	(A-T-024s)	Hot aqua regia digestion, ICP-OES/ICP-MS. Sample dried @105 ºC (60ºC for Hg).	
Benzo-(a)-pyrene	(A-T-019s)	-	
Benzene	(A-T-022s)	-	
Total petroleum hydrocarbons	(A-T007s)	-	
pH	A-T-031s)	1:6, sample:water (fresh sample), potentiometrically on suspension	
Loss on ignition	(A-T-030s)		
Electrical conductivity (EC)	A-T-037s)	1:6, Fresh sample:water, potentiometrically on suspension	
Total N	Subcon Yara	Dumas 1000 ºC, <30 ºC air-dried sample ground/sieved <0.5 mm	
Total P	(A-T-024s)	As for PTEs and K	
Total K	(A-T-024s)	As for PTEs and P	
Available N as nitrate	(A-T-028s)		
Available N as ammonium	(A-T-033s)		
Available P		Olsen's reagent extraction (0.5M $NaHCO_3$@ pH 8.5), colourimetry	
Available K		1 M NH_4NO_3 extraction, AAS	
Bulk density			

[2] Awaiting detailed information on specific methods listed from the laboratory

Table 5. Current DEFRA Category 4 Screening Levels (C4SL) compared to relevant LQM/CIEH Suitable
mg.kg^{-1}, used to assess significance of soil contamination (8)(Nathanail et al., 2015b).

Substance	Residential – with home grown produce	Residential – without home grown produce	Allotments	Commercial	F S -
Arsenic	37, *37*	40, *40*	49, *43*	640, *640*	7
Benzene (1% SOM for minimum S4UL)	0.87, *0.087*	3.3, *0.38*	0.18, *0.017*	98, *27*	1
Benzo(a)pyrene (as a surrogate marker for genotoxic PAHs), (1% SOM for minimum S4UL)	5.0, *0.79*	5.3, *1.2*	5.7, *0.32*	76, *15*	1
Cadmium	26, *11*	149, *85*	4.9, *1.9*	410, *190*	2
Chromium (VI)	21, *6*	21, *6*	170, *1.8*	49, *33*	2
Chromium (III)	*910*	*910*	*18000*	*8600*	*1*
Copper	*2400*	*7100*	*520*	*68000*	*1*
Lead	200	310	80	2330	6
Zinc	*3700*	*40000*	*620*	*730000*	*8*

Table 6. Compilation of UK guideline values relevant to reuse of sediments for soil-forming purposes (in $mg.kg^{-1}$).

	PAS100 Compost limits (2)	Safe Sludge matrix (86/278/EEC) soil load limits for pH 5, pH >7 (3)	CEFAS action level 1 (1995/2003)	CEFAS action level 2 (1995/2003)	BS3882 topsoil & BS8601 subsoil limits for phytotoxicity pH <6/6-7/>7
Cu, $mg.kg^{-1}$	200	80, 200	40/30	400/300	< 100/135/200
Zn, $mg.kg^{-1}$	400	200, 450	130/130	800/600	< 200/200/300
Pb, $mg.kg^{-1}$	200	300	50/50	500/400	
Cd, $mg.kg^{-1}$	1.5	3	0.4/0.4	5/4	
Hg, $mg.kg^{-1}$	1.0	1.0	0.3/0.25	3/1.5	
Ni, $mg.kg^{-1}$	50	50, 110	20/30	200/150	< 60/75/110
Cr^{T}, $mg.kg^{-1}$	100	Test req.	40/50	400/370	

with the results of the baseline monitoring, where coincident concentrations of Zn and Pb were detected by pXRF[3], especially in areas of clinker-rich made ground and possible dredging deposition along the River Clyde (6).
Sediment samples from the Caledonian Canal at Laggan Locks are effectively “clean” compared to the limits we have applied. Total Petroleum Hydrocarbons (TPH) were reported above the method detection limits but below regulatory limits, possibly reflect fuel residues from powered craft.

4.3. British Standards for subsoil and topsoil

In Table 7 the sediment samples have each been compared to the British Standard specifications for subsoil (British Standards Institution, 2013) and topsoil (British Standards Institution, 2015b), if these are intended for sale offsite (i.e. as a “product”) from a construction site. In each case the specifications for multipurpose soils have been selected, as these are most common. Subsoils are expected to have a lower organic matter content than top soils, which is reflected by the limit of 2 % loss on ignition between 125-440 °C, a drying temperature designed to avoid contribution from bound water and an ashing temperature to avoid contributions from carbonates, fossil carbon and water in crystal structures. The sediment samples were ashed at 550 °C,

[3] Comment on draft version: It would be good to compare the pXRF data that BRGM have on the same wet sediments using their filter press, to link with WP1

Table 7. Comparison of sediments from Bowling, Applecross Street (Glasgow) and Laggan Locks to requirem (BS8601:2013) and topsoil (BS3882:2015).

	G1	G2	G3	B1	B2	B3	B4	L1	L2	L3-L
Soil texture <2 mm fraction BS8601:2013	Sandy loam	Sandy loam	Sandy silt loam	Sandy loam	Loamy sand	Sandy loam	Sandy loam	***Sandy silt loam***	Sandy silt loam	***Sand***
Med-fine gravel > 2 mm, < 20 mm %										***43***
Sand % 2 - 0.063 mm (% of <2 mm)	64	68	46	69	79	72	77	46	35	57 (***1***
Silt % 0.063-0.002 mm (% of < 2mm)	26	19	41	21	14	16	15	50	59	***0***
Clay % <0.002 mm	10	13	13	10	7	12	8	***4***	6	***0***
pH	7.53	7.18	7.12	6.94	7.10	7.45	7.56	6.61	6.78	7.14
Loss on ignition 550 °C	***29.9***	***28.8***	***35.2***	***47.2***	***50.0***	***30.6***	***60.2***	**17.7**	**15.9**	0.8
EC µs.cm^{-1}	1090	701	500	2250	1780	1760	1740	207	146	26
Zn mg.kg^{-1}	***4030***	***2360***	***4060***	***538***	***579***	***1060***	***1140***	86	78	41
Cu mg.kg^{-1}	***495***	***451***	***795***	117	80	162	164	21	19	6
Ni mg.kg^{-1}	59	61	70	29	26	44	46	26	26	17
N^T wt %	0.85	1.09	0.78	1.08	1.28	1.17	1.06	0.44	0.34	0.01
P mg.kg^{-1}*	*<0.01*	*<0.01*	*<0.01*	*<0.01*	*<0.01*	*<0.01*	*<0.01*	nd	nd	nd
K mg.kg^{-1}*	*80.0*	171	*48.2*	*105*	*81.1*	131	*76.8*	nd	nd	nd
Mg mg.kg^{-1}*	*19.8*	*26.0*	*30.6*	78.1	61	86.8	51.9	nd	nd	nd
C/N	13.2	16.8	14.6	6.9	6.3	10.3	11.6	17.4	*22.5*	19
Failures for BS8601:2013	**LOI, Zn, Cu**	**LOI, Zn, Cu**	**LOI, Zn, Cu**	**LOI, Zn**	**LOI, Zn**	**LOI, Zn**	**LOI, Zn**	***Texture,* LOI**	**LOI**	***Text coar frags***
Failures for BS3882:2015	*LOI, Zn, Cu, P, K, Mg*	*LOI, Zn, Cu P, Mg*	*LOI, Zn, Cu P, K, Mg*	*LOI, Zn P, K,*	*LOI, Zn, P, K*	*LOI, Zn, P*	*LOI, Zn, P, K*	*Texture*	*C/N*	*Coar frags textu*

Key: **Bold**: fails requirements for subsoil BS8601:2013, *Italic*: fails requirements for BS3882:2015
*Comparing our analyses in mg.kg^{-1} to BS3882 limits given in mg.L^{-1} for air dried soil assumes a dry sample density of

Table 8. Nutrient analysis of sediment samples.

Sample No.	% dry solid content	pH	Conductivity	Wet bulk density (approx.)	Dry matter (approx)	N_T	P_T	K_T	Mg_T	Ca_T	S_T	N_{N03}	N_{NH4}	SMN for 10,000m^3 AR/ha*	P_A	
	% w/w		*uS/cm*	*Kg/m^3*	*%*	%w/w	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	kgN/ha	mg/kg	mg
G1	29.8	7.3	193	1.13	25.4	0.85	2421	897	2585	14968	12940	<10	94.6	319	<0.01	8
G2	42.0	7.3	209	1.23	43.7	1.09	1946	820	2328	9919	8303	<10	78.8	407	<0.01	1
G3	32.6	7.1	196	1.22	32.1	0.78	4364	1429	5400	15484	9878	<10	125.0	497	<0.01	4
B1	13.8	7.5	199	1.00	14.4	1.08	1177	1488	5553	47023	14118	<10	73.9	102	<0.01	1
B2	19.1	7.4	247	1.04	12.7	1.28	1238	1713	5982	55071	16248	<10	<10	<20	<0.01	8
B3	13.2	7.4	214	0.94	13.1	1.17	1211	1724	5959	64043	15421	<10	<10	<12	<0.01	1
B4	12.6	7.6	179	0.98	11.9	1.06	1359	1669	6183	47476	16773	<10	<10	<12	<0.01	7
L1	24.1	6.6	207	1.00	21.9	0.445	652	2630	6360	2210	898	<1	92.3	222	nd	
L2	30.2	6.8	146	1.06	31.6	0.341	712	2370	5720	2360	826	<1	89.9	288	nd	
L3-LS	85.0	7.1	26	1.72	77.5	0.012	321	694	3880	1340	86	<1	1.5	22	nd	
L4	33.6	7.0	120	1.07	32.7	0.226	829	2310	5380	2210	679	<1	65.0	234	nd	
L5	35.1	6.3	98	1.04	28.9	0.169	751	2140	5270	2170	641	<1	36.7	134	nd	
SB	97.9	6.9	21	nd	nd	0.007	439	718	4520	1170	61	<1	1.4	nd	nd	

Table 9. Nutrient indices for sediment samples following Nutrient Management Guide RB209 (Anon, 2017). Abbrevi
(available or leachable P), K_A (available or leachable K), Mg_A (available or leachable Mg).

		SMN	P_A	K_A	Mg_A
G1		6	0	1	0
G2		6	0	2-	1
G3		6	0	0	1
B1		3	0	1	2
B2		0	0	1	2
B3		0	0	2-	2
B4		0	0	1	2
L1		5	nd	nd	nd
L2		6	nd	nd	nd
L3-LS		0	nd	nd	nd
L4		5	nd	nd	nd
L5		4	nd	nd	nd
SB		#N/A	nd	nd	nd
	Index (RB209)				
	0	<60	0-9	0-60	0-25
	1	61-80	10-15	61-120	26-50
	2	81-100	16-25	121-240*	51-100
	3	101-120	26-45	241-400	101-175
	4	121-160	46-70	401-600	176-250
	5	161-240	71-100	601-900	251-350
	6	>240	101-140	901-1500	351-600
	7		141-200	1501-2400	601-1000
	8		201-280	2401-3600	1001-1500
	9		>280	>3600	>1500
				*121-180 (2-)	
				*180-240(2+)	

Table 10. Calculated nutrient loadings and availability for wet and dried sediments. Nutrients are analysed on wet sam
on convention, so will be reduced in proportion to water content

Sample No.	N_T/per wet cube	N_T/per dry tonne	P_T/per wet cube	P_T/per dry tonne	K_T/per wet cube	K_T/per dry tonne	N_A/per wet cube	P_A/per wet cube	K_A/wet cube	N available fraction	K available fraction
0.0	kg/m^3 AR	kg/t dry	kg/m^3 AR	kg/t dry	kg/m^3 AR	kg/t dry	kg/m^3 AR	kg/m^3 AR	kg/m^3 AR	%	%
G1	2.86	8.50	0.82	2.42	0.30	0.90	0.032	<0.001	0.027	1.1	8.92
G2	5.63	10.90	1.01	1.95	0.42	0.82	0.041	<0.001	0.088	0.7	20.85
G3	3.10	7.80	1.74	4.36	0.57	1.43	0.050	<0.001	0.019	1.6	3.37
B1	1.49	10.80	0.16	1.18	0.21	1.49	0.010	<0.001	0.014	0.7	7.06
B2	2.54	12.80	0.25	1.24	0.34	1.71	<0.002	<0.001	0.016	<0.1	4.73
B3	1.45	11.70	0.15	1.21	0.21	1.72	<0.001	<0.001	0.016	<0.1	7.60
B4	1.31	10.60	0.17	1.36	0.21	1.67	<0.001	<0.001	0.009	<0.1	4.60
L1	1.07	4.45	0.16	0.65	0.63	2.63	0.022	nd	nd	nd	nd
L2	1.09	3.41	0.23	0.71	0.76	2.37	0.029	nd	nd	nd	nd
L3-LS	0.17	0.12	0.47	0.32	1.01	0.69	0.002	nd	nd	nd	nd
L4	0.81	2.26	0.30	0.83	0.83	2.31	0.023	nd	nd	nd	nd
L5	0.62	1.69	0.27	0.75	0.78	2.14	0.013	nd	nd	nd	nd
SB	nd	0.07	nd	0.44	nd	0.72	nd	nd	nd	nd	nd

presumably after drying at 105 °C, so could be slightly overestimated by including water loss, so exceedances shown should be viewed as conservative. However, all of the typical sediments have far higher LOI % values, other than the two gravels from Laggan Spout and the stilling basin. These also fail the textural criteria, as the <2 mm fraction is almost entirely sand and the proportion of coarser fragments between 2- 20 mm is too high. Two of the silty sediments from the Caledonian also have unsuitable textures due to lack of an adequate clay component. Textural limits are set due to the difficulty of preserving soil function when very silty or clay-rich soils are transported. Samples from Glasgow and Bowling also have unacceptable levels of potentially phytotoxic metals at the given pH values, for both Zn and Cu at Applecross Street, but also for Zn at Bowling. Here conductivity levels are slightly higher, which may reflect the influence of saline groundwaters, as were detected in monitoring wells during the baseline sampling. pH levels are acceptable in all cases.

If the sediments are compared to the topsoil specification, the issues of phytotoxic contaminants and textural issues described above remain an issue, while the loss on ignition for samples from Applecross Street and Bowling is too high still for the new range of 3-20 %. Interestingly, this is the reverse of the general situation for marine sediments, where low organic matter was found to be one of the general barriers to using marine sediments to manufacture BS topsoils (Sheehan et al., 2010a). The total nitrogen content of the soils is acceptably low but the available forms of other nutrients are mostly too low for phosphorous and potassium, together with magnesium at Applecross Street. The BS3882 limits for nutrients assume analyses are in $mg.L^{-1}$ for air dried soil, while our analyses in $mg.kg^{-1}$ dry matter, so this assumes a dry sample density of $1g.cm^{-3}$, as density was not reported by either laboratory. Typical dry soil densities below $1g.cm^{-3}$ would make the nutrient levels by volume slightly lower than the values assumed here and so their classification against the BS minimum limits possibly overly conservative. The fine-grained samples from Laggan have much lower total nitrogen but moderate TOC, resulting in further failures for excessive C/N ratios, which would tend to lock up any plant available forms of nitrogen. In conclusion, none of the sediment samples would pass all the specifications for either sub-soil or topsoil, so would not be suitable for export off site, although this would not preclude suitability for use on site locally.

4.4. Nutrients for plant growth

A complete set of total and available nutrients were analysed by NRM Laboratories on samples from Glasgow (Applecross Street) and Bowling, together with total major nutrients and available nitrogen species in those from Laggan (Table 8). The sediments at Glasgow and Bowling have a surprisingly high content of total N (c. 1 %), presumably reflecting their significant organic matter content (c. 20%). This is roughly the same dry matter N concentration as is found in greenwaste compost, although it should be remembered that the “as received” concentration will be reduced significantly in proportion to the water content in the sediments. However, only about 1-2% of this is available (Table 10), and it is present as ammonium rather than nitrate. Samples from Laggan have broadly similar ammonium N contents, although the total N is much lower. Total P is also lower here than in Glasgow or Bowling, with no leachable (available) P detected in either location. Total K is higher at Laggan than Bowling and then Applecross Street, with variable availability, but much higher than for N (at c 10 %). As a result, soil nutrient indices are generally low for available K and Mg (1-2), but very low for available P (Table 9). Soil mineral nitrogen (SMN) index depends on the depth of the soil, here calculated for 1 m^3 of wet sediments (as received) placed per m^2 over 1 hectare, which gives moderate to high values when available N (as ammonium) is present. Thus plant trials might require addition of some

available P to establish well (e.g. superphosphate, green waste compost etc.), and possibly N too, especially if thinly spread. Shrinkage during natural dewatering and drying has not yet been quantified but was observed to be nearly in proportion to mass reduction by water loss in the laboratory oven drying.
Unfortunately, bulk density was not specified for either commercial laboratory in error, so measurements from records of drying additional 1 L samples for export to ARMINES have been used to calculate approximate wet bulk density of samples (Table 8). These have been used to estimate total and available major nutrient loadings supplied by 1 cubic metre unit of wet sediment (AR), or by 1 tonne of dry matter (Table 10). These represent the two end-members for application to land, before and after dewatering, from which nutrient budgets can be calculated for different depths (more or less than 1 m) by simple proportion or extrapolated to figures per hectare (multiplied by 10,000). Taking sediment G3 as the worst case scenario indicates that 1 cubic metre applied as received per square metre would result in an available N application equivalent to 410 $kg.ha^{-1}$ which could be above the un-derogated limit of 170 $kg.ha^{-1}$ set by the Nitrates Directive (European Commission, 1991) if implemented at field or farm scale. Conversely, no available P would be applied with the sediment, which could be advantageous in P sensitive areas.

5. DISCUSSION

5.1. Context and background to bioengineering with sediments

During development of the SURICATES project a number of potential applications for applying nature-based solutions to reusing dredgings were discussed and identified, including those falling under the following headings:

- Phyto-remediation: The use of plants to remediate soils or sediments, typically where contaminated, including phyto-extraction or phyto-stabilisation[4] of metals/metalloids, and phyto-degradation of organics
- Phyto-dewatering: Use of plants to aid dewatering of placed sediments
- Phyto-conditioning: Use of plants to condition soils for reuse, such as for topsoil or landscaping
- Bioengineering: The use of plants (fungi or bacteria) to strengthen or otherwise improve the properties of sediments where used in engineering applications, potentially including applications in flood defences, or preventing erosion (hence also possibly physical “phyto-stabilisation” of placed sediments)

The specific focus of the SURICATES project is towards reusing the larger volumes of uncontaminated material which are potentially suitable for use, rather than addressing the widespread legacy of contaminated sediments that need treatment. Hence applications of phyto-dewatering, phyto-conditioning and bioengineering are the main focus, although phyto-remediation might be an additional benefit. Sludge phyto-conditioning (SPC), was initially developed in the UK’s wastewater industry for sewage sludge treatment, offering enhanced treatment of biosolids and creating saleable topsoil as a product (Kay, 2014; Taylor, 2004). It has also been trialled on inland waterways dredgings (British Waterways pers. com.) and compost-like output from treatment of municipal waste (Yorkshire Water pers. com.). It involves the placement of anaerobically digested sewage sludge conditioned by blending with green waste compost in windrows on hardstanding, which are seeded with annual ryegrass, grown for c.1 year, followed by blending with quarried sand to meet topsoil specifications.

[4] Phyto-stabilisation here refers to the chemical stabilisation of contaminants in soil by root exudates, induced pH or other chemical changes etc.

Figure 7. Hand broadcasting reed canarygrass on a Scottish landfill site using a fiddle drill.

Figure 8. Placed sediment from canalised section of tidal river, Tees Barrage, 2008.

Fig. 9 . View from R to L of same location as Fig 7 in 2010 with mature RCG

Figure 10. Dense network of fibrous roots and rhizomes established in shallow soil.

Figure 11. Midstream establishment in river gravel in an upland river, Scotland

Figure 12. Wild reed canarygrass on Clyde Estuary, opposite the Bowling pilot site

Figure 13. Wild reed canarygrass at the sediment dewatering site, Falkirk Wheel.

Figure 14. Tees Barrage site in June 2018, showing RCG has died out 10 years later.

Optimum results are achieved for depths < 1.0 m, a full season’s growth and ryegrass species (*Lolium multiflorium, Lolium perenne*) which outcompete weeds. Analogous sediment treatment examples in Mediterranean climates include the combined use of grasses, shrubs and earth worms (Bianchi et al., 2010) or agricultural scale phytoremediation (Iannelli et al., 2008) to treat polluted harbour dredged sediment. The economic and environmental feasibility of producing manufactured topsoil from mixed waste streams including dredged material has been evaluated at the Port of Waterford (Sheehan et al., 2010a, 2010b). As many dredged sediments are derived by erosion from land, returning them to landscaping applications stabilised by vegetation is an attempt to close this loop and design out “waste” to create a materials cycle following the “restorative and regenerative” principles of a circular economy (7).

5.2 Relevance to bioengineering trials and pilots in WP2, I2, I3

The objective of the present study is to extend this approach to freshwater sediments in wetter, colder climates of NW Europe, so this will require the identification of suitable low cost establishment, non-invasive plant species for phyto-conditioning, low energy methods of dewatering, aerobic bioremediation of organic contaminants and reduction of organic matter. Reed canarygrass (*Phalaris arundinacea*), a prolific perennial native species seeded grass and potential energy crop, has been shown to be cheap to plant,

establish readily on a variety of challenging soil types, to tolerate inundation, desiccation, and contaminated soils (Lord, 2015). The phytoremediation potential of RCG is an emerging area of research, with applications in phytoextraction, phyto-degradation, as a bio-indicator, passive wastewater treatment systems and considerable potential in the physical phyto-stabilisation of soils and sediments (Jensen et al., 2018). The following characteristics make RCG a suitable candidate for bioengineering applications with placed sediments:

- Rapid establishment from seed, allowing hand-sowing (Fig 7), manual broadcasting, hydroseeding etc., establishing rapidly on unamended placed sediment (Fig 8, Fig 9)
- Root system reaches 3m with vigorous rhizome and shallow root system (Fig 10) fortifying the surface of wet soils (Lewandowski et al., 2003)
- Tolerant of extensive flooding and poor soil aeration (Wrobel et al., 2009), even surviving inundation to water depths of 2.7 m by developing floating rafts
- Survives cyclic inundation helping to stabilize reservoir banks that are frequently flooded (Rice and Pinkerton, 1993)
- Limited bioaccumulation and above-ground translocation of heavy metals, with contaminant concentrations generally ranking roots>sediments>leaves>stems (Polechońska and Klink, 2014)
- Can achieve rapid sediment stabilisation (Fig 11) sufficient to resist 100-year flood events with flows of up to 227m^3s^{-1} (Bankhead et al., 2017), increasing channel roughness, sedimentation and delaying runoff (Martinez and Mcdowell, 2016)
- RCG is considered invasive in waterbodies in USA , even though it is a native species, due to the introduction of European genotypes (Jakubowski et al., 2011; Lavergne and Molofsky, 2004), which are already commonplace and non-invasive in NWE, especially W Scotland (Fig 12, 13)

In 2008 reed canarygrass was successfully grown on placed sediments at the Tees Barrage, Stockton-on-Tees (Fig 7, Fig 8). This was a follow-on to successful planting of RCG as part of the BioReGen Life Project on adjacent land owned by British Waterways (Lord et al., 2010, 2008; Lord, 2015). The sediment material was excavated from a coffer dam during construction of the central pier of the Infinity

Bridge. This part of the river Tees was originally below the tidal limit but was canalised and became freshwater following construction of the Tees Barrage in 1995. The seed was broadcast by hand onto the desiccated surface of the dredgings after natural drying allowed access. No amendment or fertilization was required, with a good strike and rapid growth, which persisted without management for c 10 years (Fig 14).

Information on the nutrient requirements of RCG are mainly from field trials as an energy crop on agricultural land, in particular Sweden (Lewandowski et al., 2003), so are mainly concerned with biomass yield optimisation using nitrogen, for which results are somewhat contradictory (Jensen et al., 2018). Table 11 compares these to the available nutrient levels provided by an application rate of 1 m^3 of wet sediment per m^2, either per m^2 or per hectare. From this all sediments from Bowling and Applecross would supply adequate available K, but no available P (the Lagan samples were not analysed for these). In comparison, adequate available N would be supplied by all sediments sampled at Applecross Street, none at Bowling, but just the three sandy silt loams at Laggan (L1, L2, L4), not the courser or sandy material.

6. *CONCLUSIONS*

The inherent physical and chemical properties of Scottish Canal sediments show promise for use as soils in bioengineering applications. Relevant aspects include the mixed grain size distribution, corresponding to sandy or silt loam soils, the significant organic matter content and some neutralisation potential and/or equivalent carbonate content. Negative aspects include concentrations of potentially toxic elements in urban areas with historic industrial activity (e.g. CCA from timber treatment in Glasgow) which are sufficiently high to mitigate against use as soils in public open space. This includes levels of potentially phytotoxic metals (e.g. zinc, lead, cadmium) which are below concentrations considered for human health risk assessment but might still be a consideration for plant growth. In addition, the very high levels of organic matter , and hence excessive loss on ignition, mean that the sediments would not meet British Standard specifications for export as either subsoil or topsoil, with limits for Zn (Bowling and Glasgow) and Cu (Glasgow) also exceeded. Comparison to nutrient requirements for reed canarygrass suggest that sufficient available K and probably N will be supplied by placing the equivalent of 1m^3 of wet material per m^2, whereas no available P was detected. Good long term availability of nutrients for plant growth is also expected from the total contents of N P and K, which are likely to be released as the organic matter content is broken down.

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Table 11. Nutrient requirements for Reed Canary Grass establishment and growth compared to that supplied by sediments.

	N	P	K	Comment
When planted	40 kg.ha^{-1}	15 kg.ha^{-1}	50 kg.ha^{-1}	For Swedish field trials (Lewandowski et al., 2003)
Following year	100 kg.ha^{-1}	15 kg.ha^{-1}	80 kg.ha^{-1}	
Subsequent years (after harvest)	50 kg.ha^{-1}	5 kg.ha^{-1}	20 kg.ha^{-1}	
At establishment	0.004 kg.m^{-2}	0.002 kg.m^{-2}	0.005 kg.m^{-2}	As above, recalculated to give requirements per m^2 of bioengineering trial
Following year	0.010 kg.m^{-2}	0.002 kg.m^{-2}	0.008 kg.m^{-2}	
Subsequent years	0.005 kg.m^{-2}	0.001 kg.m^{-2}	0.002 kg.m^{-2}	
Available content of 1m^3/m^2 wet sediments (min)	<10-20 kg.ha^{-1} <0.010-0.020 kg.m^{-2}	Not detected	90 kg.ha^{-1} 0.009 kg.m^{-2}	See table 10 for sediment samples.
Available content of 1m^3/m^2 wet sediments (max)	500 kg.ha^{-1} 0.050 kg.m^{-2}	Not detected	880 kg.ha^{-1} 0.088 kg.m^{-2}	See table 10 for sediment samples.

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APPENDICES

Appendix A. Report on existing PSD and TOC data (R Lord 25-5-18)

Appendix B. Analytical reports (Envirolab, NRM, Structural Soils)

Appendix A. Scottish Canals sediment PSD and TOC analysis examples from previous projects.

Sediments ex Forth & Clyde Canal nr. Glasgow 2014 (all gouge auger composite samples from placed material to 0.1 m depth). NRM Laboratories.

Sample	Source	Sand (2-0.063 mm) %	Silt (0.063-0.002) %	Clay (<0.002) %	Textural class (Avery, 1990, 1973)	Organic matter (Walkley and Black, 1934) % w/w
PWS Jun 14, Pinkston Water Sports, beached in N arm	ex Pinkston Basin,	50	26	24	Clay loam	16.3
ASC Jun 14 Applecross Street trial	ex F & C at Cadder	49	26	25	Clay loam	9.0
ASSW Jun 14 Applecross Street trial	ex F & C at Spier’s Wharf	45	27	28	Clay loam	12.4

Caledonian Canal nr. Inverness 2012 (in situ spot samples, Dochgarroch Lock to Muirtown Locks). Ruiridh Milne MEng dissertation (2012), University of Strathclyde.

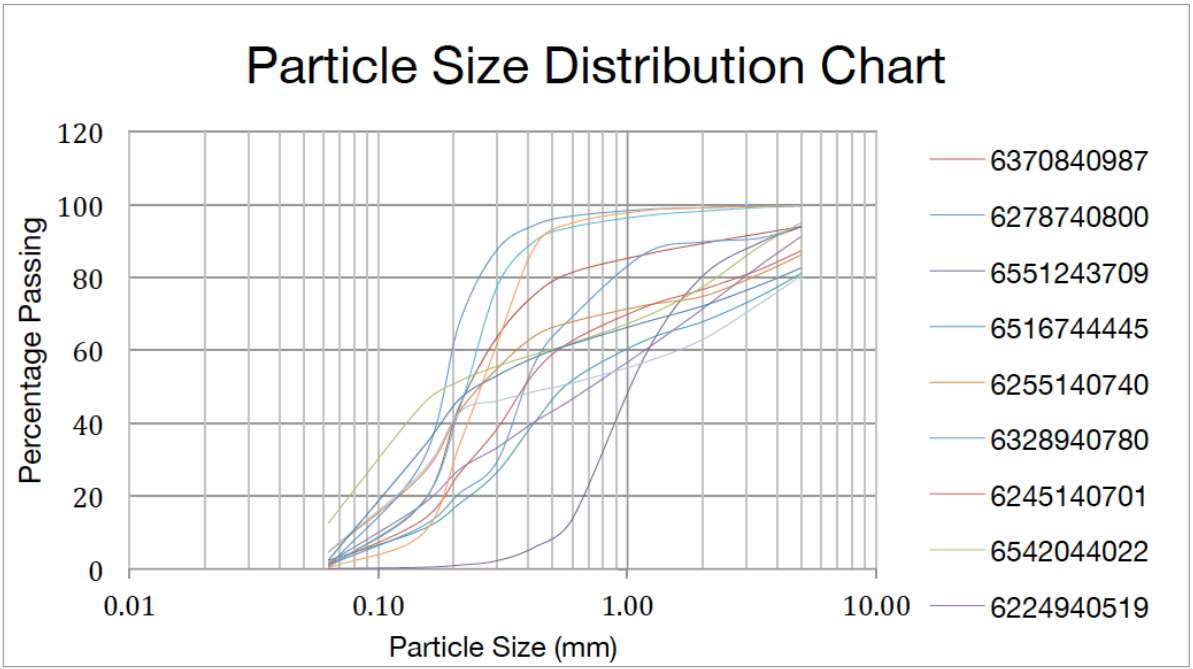


Figure 9-2 PSD graph for the sample sediments along the Northerly stretch of the Caledonian Canal, from the Muirtown Locks to the Dochgarroch Lock

Closely graded gravely medium and course SAND following British Soil Classification System for Engineering Purposes (BSCS), as described in BS 5930 (British Standards Institution, 2015a)

(0-13% < 0.063mm, 0-36% > 2.00 mm, otherwise mostly 75% sand 0.063-2.00 mm) OM up to 18%, but typically 0.5-3 %, TOC up to 1.8 %, but typically 0.1-0.9% (SAL report 335254-2 for samples CLD1 to CLD12 12 Jun 2013 for proposed application to land).

Richard Lord 25-5-18

Supporting additional data

(a) Caledonian Canal sample suite (SAL 335254-2)

Sample	CLD 1	CLD 2	CLD 3	CLD 4	CLD 5	CLD 6	CLD 7	CLD 8	CLD 9	CLD10	CLD11	CLD12
OM %	13.5	0.5	0.5	0.4	5.6	17.8	2.7	1.6	3.6	0.7	0.8	2.9
TOC %	0.9	0.2	0.1	0.1	0.9	2.6	0.7	0.5	0.8	0.2	0.4	1.8
NH_3 as NH_4^+ mg/kg	6.9	5.8	4.9	6.7	5.6	12	7.0	5.8	4.9	6.7	5.8	7.8
NO_3^- mg/kg	<1	<1	2	<1	<1	<1	<1	<1	8	<1	6	<1
N^T mg/kg	1400	<250	<250	<250	680	2900	430	470	490	<250	<250	1300
P^T mg/kg	390	330	310	410	460	620	500	470	350	260	310	520
K^T mg/kg	1400	1100	1100	1100	1300	2000	1600	1300	1300	860	790	1900

(b) Pinkston nutrients

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

FINAL ANALYTICAL TEST REPORT

Envirolab Job Number: 18/07627
Issue Number: 1 **Date:** 05 October, 2018

Client:
British Waterways Scotland
Canal House
1 Applecross Street
Glasgow
G4 9SP

Project Manager: Julia Johnstone
Project Name: Glasgow Dredgings
Project Ref: SC/070
Order No: PO00012188
Date Samples Received: 19/09/18
Date Instructions Received: 20/09/18
Date Analysis Completed: 05/10/18

Prepared by:

Melanie Marshall
Laboratory Coordinator

Approved by:

Richard Wong
Client Manager

Envirolab Job Number: 18/07627

Client Project Name: Glasgow Dredgings

Client Project Ref: SC/070

Lab Sample ID	18/07627/1	18/07627/2	18/07627/3						Units	Method ref
Client Sample No	SC/069/001	SC/069/002	SC/069/003							
Client Sample ID	150m North of Sidearm	110 South of Sidearm	200m North of Bridge 54							
Depth to Top										
Depth To Bottom										
Date Sampled	17-Sep-18	17-Sep-18	17-Sep-18							
Sample Type	Solid	Solid	Solid							
Sample Matrix Code	7	7	7							
% Moisture at <40C$_A$	70.2	59.7	60.2						% w/w	A-T-044
% Stones >10mm$_A$	<0.1	<0.1	<0.1						% w/w	A-T-044
pH$_D^{M\#}$	7.53	7.18	7.12						pH	A-T-031s
Carbonate as CaCO3$_D$	4.0	1.9	2.2						% w/w	CO3s
ANC to pH4$_D$	0.10	0.09	0.04						mol/kg	A-T-ANCs
ANC to pH6$_D$	0.04	0.03	0.04						mol/kg	A-T-ANCs
Electrical conductivity @ 20degC$_D$	1090	701	500						µs/cm	A-T-037s
Cyanide (total)$_A^{M\#}$	37	20	48						mg/kg	A-T-042sTCN
Phenols - Total by HPLC$_A$	<0.2	<0.2	<0.2						mg/kg	A-T-050s
Sulphide$_A$	860	62	830						mg/kg	A-T-S2-s
Loss on ignition (550degC)$_D$	29.9	28.8	35.2						% w/w	A-T-030s
Total Organic Carbon$_D^{M\#}$	11.2	18.3	11.4						% w/w	A-T-032s
Total Carbon$_D$	11.6	24.2	11.8						% w/w	A-T-032s
Total Inorganic Carbon$_D$	0.4	5.9	0.4						%	A-T-032s
Arsenic$_D^{M\#}$	238	431	474						mg/kg	A-T-024s
Barium$_D$	288	387	529						mg/kg	A-T-024s
Boron (water soluble)$_D^{M\#}$	2.9	2.5	2.4						mg/kg	A-T-027s
Cadmium$_D^{M\#}$	9.6	6.1	8.1						mg/kg	A-T-024s
Copper$_D^{M\#}$	495	451	795						mg/kg	A-T-024s
Chromium$_D^{M\#}$	400	611	1120						mg/kg	A-T-024s
Lead$_D^{M\#}$	798	685	1160						mg/kg	A-T-024s
Mercury$_D$	4.51	6.89	13						mg/kg	A-T-024s
Molybdenum$_D^{M\#}$	2	<1	<1						mg/kg	A-T-024s
Nickel$_D^{M\#}$	59	61	70						mg/kg	A-T-024s
Selenium$_D^{\#}$	8	8	11						mg/kg	A-T-024s
Tin$_D$	73	59	82						mg/kg	A-T-024s
Vanadium$_D^{M\#}$	54	59	59						mg/kg	A-T-024s
Zinc$_D^{M\#}$	4030	2360	4060						mg/kg	A-T-024s
Benzo(b)(j)(k)fluoranthene$_A$	0.27	2.16	7.51						mg/kg	A-T-019s
1.12a PSD (3.35mm-2um clay)(Sedimentation by Pipette/Hydrometer)BS1377 1990 pt2cl9.4/9.5$_A$	Appended	Appended	Appended							Subcon SS
BTEX										

Envirolab Job Number: 18/07627

Client Project Name: Glasgow Dredgings

Client Project Ref: SC/070

Lab Sample ID	18/07627/1	18/07627/2	18/07627/3						Units	Method ref
Client Sample No	SC/069/001	SC/069/002	SC/069/003							
Client Sample ID	150m North of Sidearm	110 South of Sidearm	200m North of Bridge 54							
Depth to Top										
Depth To Bottom										
Date Sampled	17-Sep-18	17-Sep-18	17-Sep-18							
Sample Type	Solid	Solid	Solid							
Sample Matrix Code	7	7	7							
BTEX - Benzene$_A^{\#}$	<0.01	<0.01	<0.01						mg/kg	A-T-022s
BTEX - Toluene$_A^{\#}$	<0.01	<0.01	<0.01						mg/kg	A-T-022s
BTEX - Ethyl Benzene$_A^{\#}$	<0.01	<0.01	<0.01						mg/kg	A-T-022s
BTEX - m & p Xylene$_A^{\#}$	<0.01	<0.01	<0.01						mg/kg	A-T-022s
BTEX - o Xylene$_A^{\#}$	<0.01	<0.01	<0.01						mg/kg	A-T-022s
PAH-8MS Carcinogenic										
Benzo(a)anthracene$_A^{M\#}$	0.20	1.12	3.52						mg/kg	A-T-019s
Benzo(a)pyrene$_A^{M\#}$	0.20	1.46	5.20						mg/kg	A-T-019s
Benzo(b)fluoranthene$_A^{M\#}$	0.27	1.66	5.68						mg/kg	A-T-019s
Benzo(k)fluoranthene$_A^{M\#}$	<0.07	0.52	1.83						mg/kg	A-T-019s
Chrysene$_A^{M\#}$	0.30	1.51	3.79						mg/kg	A-T-019s
Dibenzo(ah)anthracene$_A^{M\#}$	<0.04	0.17	0.70						mg/kg	A-T-019s
Indeno(123-cd)pyrene$_A^{M\#}$	0.13	0.84	3.64						mg/kg	A-T-019s

Envirolab Job Number: 18/07627

Client Project Name: Glasgow Dredgings

Client Project Ref: SC/070

Lab Sample ID	18/07627/1	18/07627/2	18/07627/3						Units	Method ref
Client Sample No	SC/069/001	SC/069/002	SC/069/003							
Client Sample ID	150m North of Sidearm	110 South of Sidearm	200m North of Bridge 54							
Depth to Top										
Depth To Bottom										
Date Sampled	17-Sep-18	17-Sep-18	17-Sep-18							
Sample Type	Solid	Solid	Solid							
Sample Matrix Code	7	7	7							
Speciated PCB-EC7										
PCB BZ $28_A^{M\#}$	<0.002	<0.002	<0.002						mg/kg	A-T-004s
PCB BZ $52_A^{M\#}$	<0.002	<0.002	0.005						mg/kg	A-T-004s
PCB BZ $101_A^{M\#}$	<0.004	<0.004	<0.004						mg/kg	A-T-004s
PCB BZ $118_A^{M\#}$	<0.007	<0.007	<0.007						mg/kg	A-T-004s
PCB BZ $138_A^{M\#}$	<0.006	<0.006	<0.006						mg/kg	A-T-004s
PCB BZ $153_A^{M\#}$	<0.004	<0.004	<0.004						mg/kg	A-T-004s
PCB BZ $180_A^{M\#}$	<0.004	<0.004	<0.004						mg/kg	A-T-004s
Total Speciated PCB-$EC7_A^{M\#}$	<0.007	<0.007	<0.007						mg/kg	A-T-004s
TPH Banded 2										
>C6-$C10_A^{M\#}$	<5	<5	<5						mg/kg	A-T-007s
>C10-$C25_A^{M\#}$	993	953	1800						mg/kg	A-T-007s
>C25-$C40_A^{\#}$	1870	2000	3600						mg/kg	A-T-007s
Total TPH Banded $2_A^{\#}$	2860	2950	5400						mg/kg	A-T-007s

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, 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
All analysis is performed on the sample as received for soil samples which are positive for asbestos or the client has informed asbestos may be present and/or if they are from outside the European Union and this supersedes any "D" subscripts.

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:
Asbestos in soil analysis is performed on a dried aliquot of the submitted sample and cannot guarantee to identify asbestos if only present in small numbers as discrete fibres/fragments in the original sample.
Stones etc. are not removed from the sample prior to analysis.
Quantification of asbestos is a 3 stage process including visual identification, hand picking and weighing and fibre counting by sedimentation/phase contrast optical microscopy if required. If asbestos is identified as being present but is not in a form that is suitable for analysis by hand picking and weighing (normally if the asbestos is present as free fibres) quantification by sedimentation is performed. Where ACMs are found a percentage asbestos is assigned to each with reference to 'HSG264, Asbestos: The survey guide' and the calculated asbestos content is expressed as a percentage of the dried soil sample aliquot used.

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.
Samples with Matrix Code 7 & 8 are not predominantly a SAND/LOAM/CLAY mix and are not covered by our BSEN 17025 or MCERTS accreditations, with the exception of bulk asbestos which are BSEN 17025 accredited.
Secondary Matrix Codes:
A = contains stones, B = contains construction rubble, C = contains visible hydrocarbons, D = contains glass/metal,
E = contains roots/twigs.

Key:
IS indicates Insufficient Sample for analysis.
US indicates Unsuitable Sample for analysis.
NDP indicates No Determination Possible.
NAD indicates No Asbestos Detected.
N/A indicates Not Applicable.
Superscript # indicates method accredited to ISO 17025.
Superscript "M" indicates method accredited to MCERTS.
Subscript "A" indicates analysis performed on the sample as received.
Subscript "D" indicates analysis performed on the dried sample, crushed to pass a 2mm sieve

Please contact us if you need any further information.

STRUCTURAL SOILS LTD

TEST REPORT

Report No. 783402

1774

Date 05-October-2018 Contract 18/07627

Client Envirolab Ltd
Address Units 7 & 8 Sandpits Business Park
Mottram Road
Hyde
SK14 3AR

For the Attention of Iain Haslock

Samples submitted by client	20/09/2018	Client Reference	18/07627
Testing Started	21/09/2018	Client Order No.	P0739097
Testing Completed	01/05/2019	Instruction Type	Written

UKAS Accredited Tests Undertaken

Particle Size Distribution sedimentation pipette method BS1377:Part 2:1990,clause 9.4

* This clause of BS1377 is no longer the most up to date method due to the publication of ISO17892

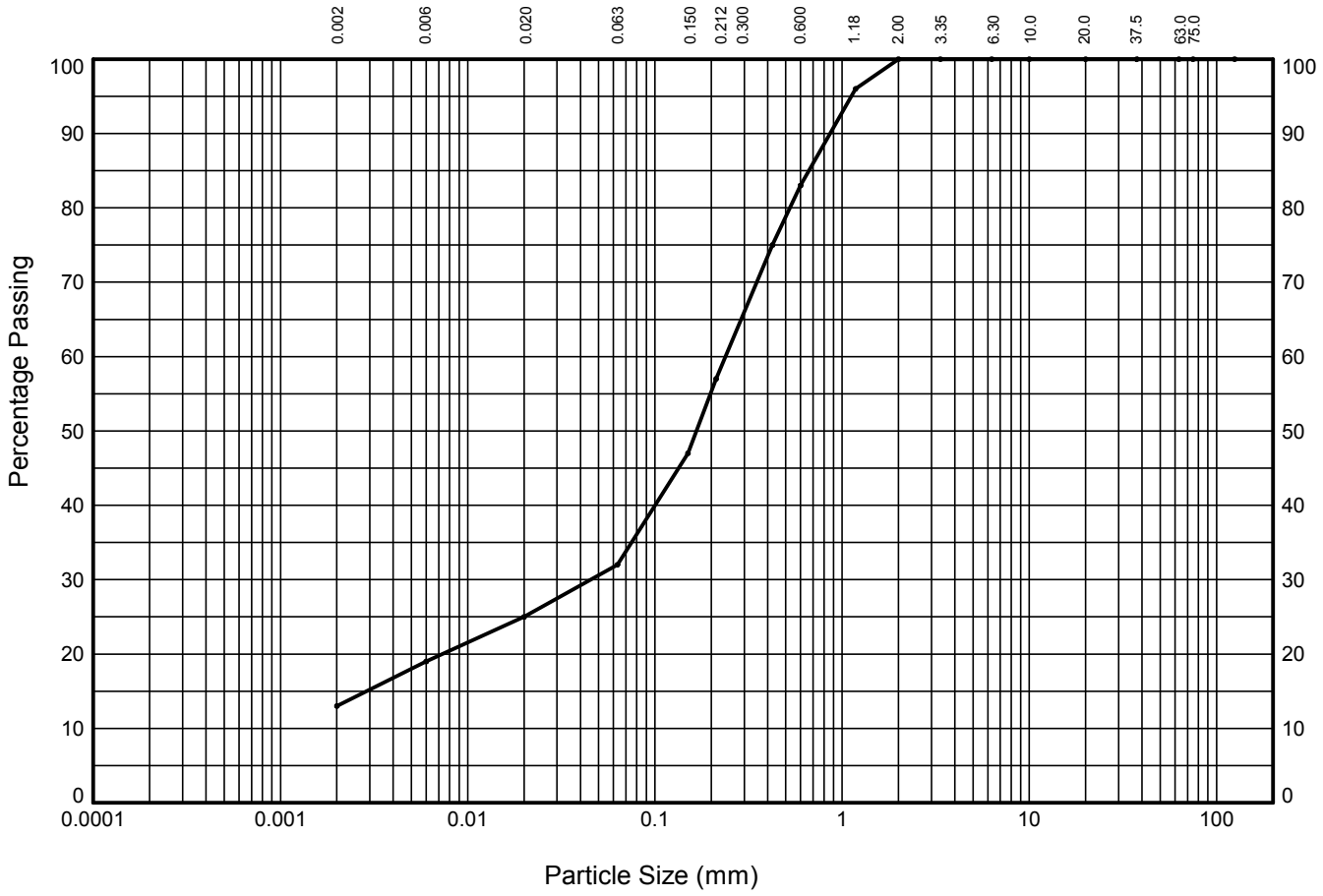
Please Note: Remaining samples will be retained for a period of one month from today and will then be disposed of.
Test were undertaken on samples 'as received' unless otherwise stated.
Opinions and interpretations expressed in this report are outside the scope of accreditation for this laboratory.

Structural Soils Ltd, The Potteries, Pottery Street, Castleford, WF10 1NJ Tel.01977 552255. E-mail mark.athorne@soils.co.uk

PARTICLE SIZE DISTRIBUTION TEST

In accordance with clauses 9.2, 9.4 of BS1377:Part 2:1990

Position ID: **110m South of Sidearm** Sample Ref: **18/07627/2** Sample Type: **B** Depth (m): **-**



CLAY	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	COBBLES
	SILT			SAND			GRAVEL			

Test Sieve (mm)	Percent Passing (%)
125.0	**100**
75.0	**100**
63.0	**100**
37.5	**100**
20.0	**100**
10.0	**100**
6.30	**100**
3.35	**100**
2.00	**100**
1.18	**96**
0.600	**83**
0.425	**75**
0.212	**57**
0.150	**47**
0.063	**32**

Particle Diameter (mm)	Percent Passing (%)
0.02	**25**
0.006	**19**
0.002	**13**

Sedimentation sample was not pre-treated

Soil Fraction	Sieve Percentage (%)
GRAVEL	**0**
SAND	**68**
SILT	**19**
CLAY	**13**

Soil Description:
Very clayey SAND

STRUCTURAL SOILS
The Potteries
Pottery Street
Castleford
W. Yorkshire WF10 1NJ

Compiled By		Date
C Cole	**CATHERINE COLE**	**05/10/18**

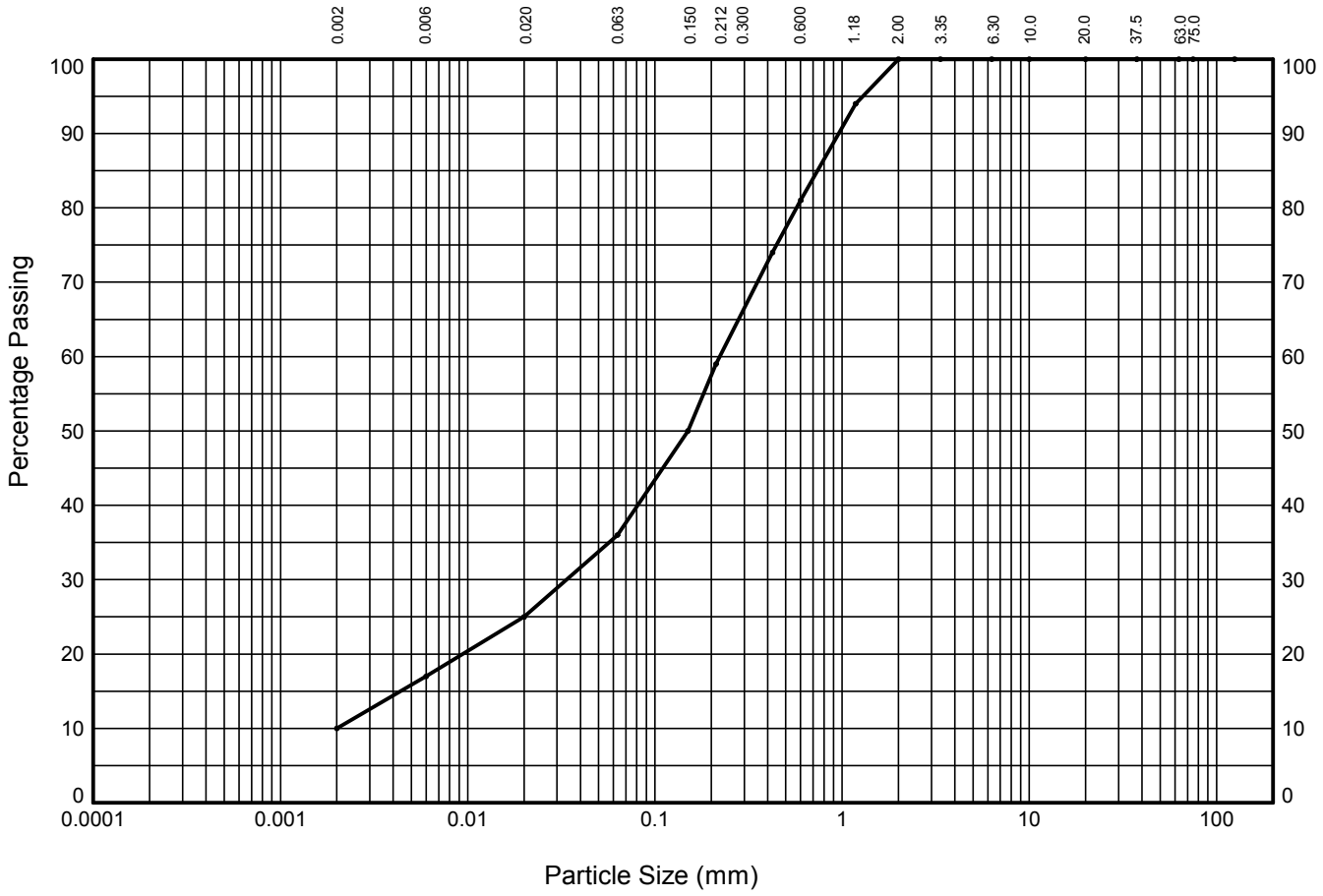
Contract	Contract Ref:
18/07627	**783402**

AGS

PARTICLE SIZE DISTRIBUTION TEST

In accordance with clauses 9.2, 9.4 of BS1377:Part 2:1990

Position ID: **150m North of Sidearm** Sample Ref: **18/07627/1** Sample Type: **B** Depth (m): **-**



CLAY	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	COBBLES
	SILT			SAND			GRAVEL			

Test Sieve (mm)	Percent Passing (%)
125.0	**100**
75.0	**100**
63.0	**100**
37.5	**100**
20.0	**100**
10.0	**100**
6.30	**100**
3.35	**100**
2.00	**100**
1.18	**94**
0.600	**81**
0.425	**74**
0.212	**59**
0.150	**50**
0.063	**36**

Particle Diameter (mm)	Percent Passing (%)
0.02	**25**
0.006	**17**
0.002	**10**

Sedimentation sample was not pre-treated

Soil Fraction	Sieve Percentage (%)
GRAVEL	**0**
SAND	**64**
SILT	**26**
CLAY	**10**

Soil Description:

Very clayey SAND

STRUCTURAL SOILS
The Potteries
Pottery Street
Castleford
W. Yorkshire WF10 1NJ

Compiled By		Date
C Cole	**CATHERINE COLE**	**05/10/18**

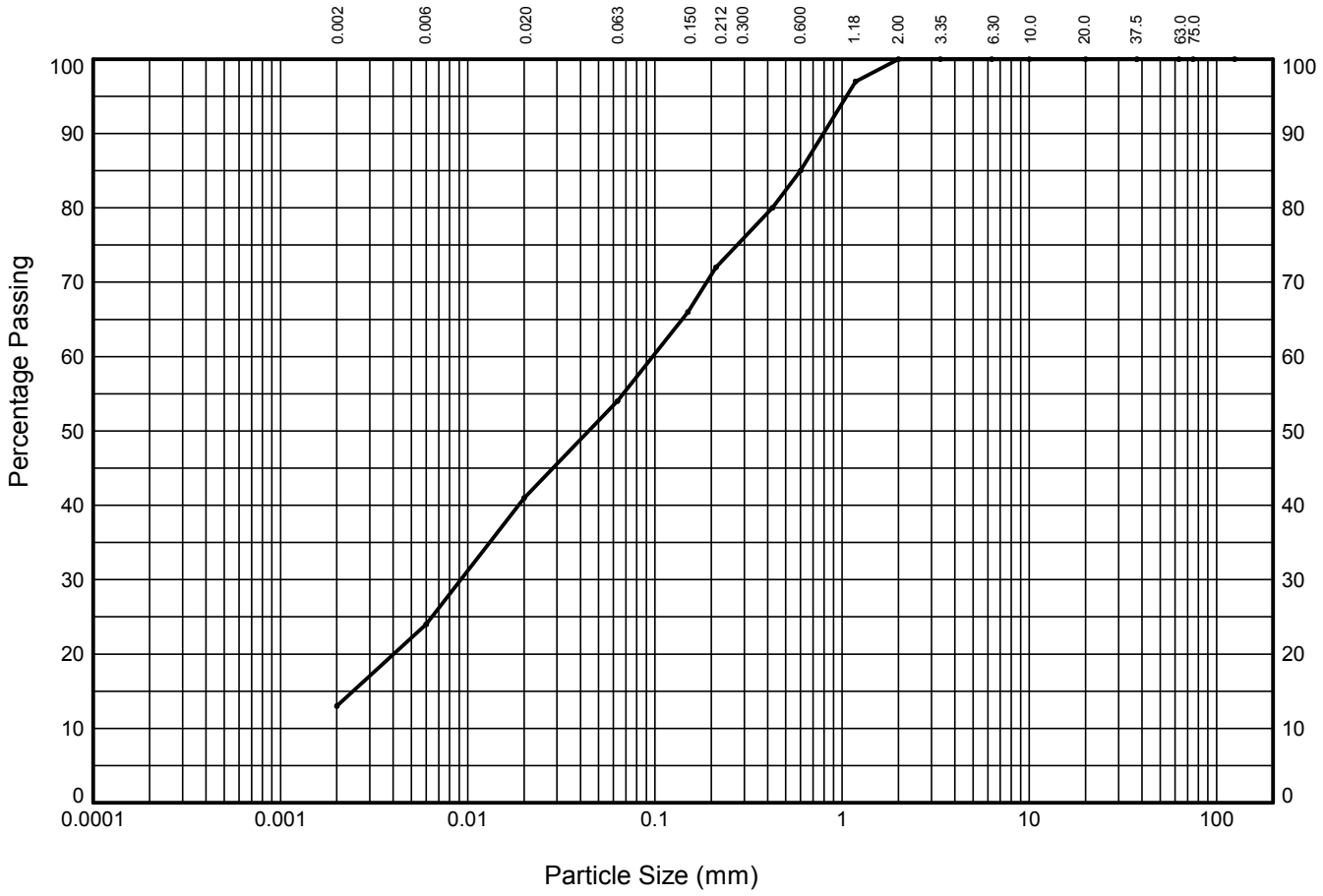
Contract	Contract Ref:
18/07627	**783402**

AGS

PARTICLE SIZE DISTRIBUTION TEST

In accordance with clauses 9.2, 9.4 of BS1377:Part 2:1990

Position ID: **200m North of Bridge 54** Sample Ref: **18/07627/3** Sample Type: **B** Depth (m): **-**



CLAY	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	COBBLES
	SILT			SAND			GRAVEL			

Test Sieve (mm)	Percent Passing (%)
125.0	**100**
75.0	**100**
63.0	**100**
37.5	**100**
20.0	**100**
10.0	**100**
6.30	**100**
3.35	**100**
2.00	**100**
1.18	**97**
0.600	**85**
0.425	**80**
0.212	**72**
0.150	**66**
0.063	**54**

Particle Diameter (mm)	Percent Passing (%)
0.02	**41**
0.006	**24**
0.002	**13**

Sedimentation sample was not pre-treated

Soil Fraction	Sieve Percentage (%)
GRAVEL	**0**
SAND	**46**
SILT	**41**
CLAY	**13**

Soil Description:

Sandy CLAY

STRUCTURAL SOILS
The Potteries
Pottery Street
Castleford
W. Yorkshire WF10 1NJ

Compiled By		Date
C Cole	**CATHERINE COLE**	**05/10/18**

Contract	Contract Ref:
18/07627	**783402**

AGS

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

FINAL ANALYTICAL TEST REPORT

Envirolab Job Number: 18/07626
Issue Number: 1 **Date:** 05 October, 2018

Client: British Waterways Scotland
Canal House
1 Applecross Street
Glasgow
G4 9SP

Project Manager: Julia Johnstone
Project Name: Bowling Dredgings
Project Ref: SC/069
Order No: PO00012163
Date Samples Received: 19/09/18
Date Instructions Received: 20/09/18
Date Analysis Completed: 05/10/18

Prepared by:

Melanie Marshall
Laboratory Coordinator

Approved by:

Richard Wong
Client Manager

Envirolab Job Number: 18/07626

Client Project Name: Bowling Dredgings

Client Project Ref: SC/069

Lab Sample ID	18/07626/1	18/07626/2	18/07626/3	18/07626/4					Units	Method ref
Client Sample No	SC/069/001	SC/069/002	SC/069/003	SC/069/004						
Client Sample ID	Immediatley East of Lock 38	250m East of Lock 38	500m East of Lock 38	Immediately West of Bridge 48						
Depth to Top										
Depth To Bottom										
Date Sampled	17-Sep-18	17-Sep-18	17-Sep-18	17-Sep-18						
Sample Type	Solid	Solid	Solid	Solid						
Sample Matrix Code	7	7	7	7						
% Moisture at <40C$_A$	70.7	74.3	83.1	83.6					% w/w	A-T-044
% Stones >10mm$_A$	<0.1	<0.1	<0.1	<0.1					% w/w	A-T-044
pH$_D^{M\#}$	6.94	7.10	7.45	7.56					pH	A-T-031s
Carbonate as CaCO3$_D$	5.0	<0.8	8.8	<0.8					% w/w	CO3s
ANC to pH4$_D$	0.16	0.19	0.17	0.22					mol/kg	A-T-ANCs
ANC to pH6$_D$	0.04	0.04	0.03	0.08					mol/kg	A-T-ANCs
Electrical conductivity @ 20degC$_D$	2250	1780	1760	1740					µs/cm	A-T-037s
Cyanide (total)$_A^{M\#}$	<1	<1	<1	<1					mg/kg	A-T-042sTCN
Phenols - Total by HPLC$_A$	<0.2	<0.2	<0.2	<0.2					mg/kg	A-T-050s
Sulphide$_A$	44	<5	47	49					mg/kg	A-T-S2-s
Loss on ignition (550degC)$_D$	47.2	50.0	30.6	60.2					% w/w	A-T-030s
Total Organic Carbon$_D^{M\#}$	7.48	8.13	12	12.3					% w/w	A-T-032s
Total Carbon$_D$	8.3	8.4	13.8	12.8					% w/w	A-T-032s
Total Inorganic Carbon$_D$	0.8	0.3	1.8	0.5					%	A-T-032s
Arsenic$_D^{M\#}$	23	21	36	36					mg/kg	A-T-024s
Barium$_D$	167	146	219	136					mg/kg	A-T-024s
Boron (water soluble)$_D^{M\#}$	3.6	5.9	10.0	<1.0					mg/kg	A-T-027s
Cadmium$_D^{M\#}$	1.4	1.5	2.9	3.2					mg/kg	A-T-024s
Copper$_D^{M\#}$	117	80	162	164					mg/kg	A-T-024s
Chromium$_D^{M\#}$	62	34	57	61					mg/kg	A-T-024s
Lead$_D^{M\#}$	319	117	230	298					mg/kg	A-T-024s
Mercury$_D$	0.51	0.17	0.47	0.30					mg/kg	A-T-024s
Molybdenum$_D^{M\#}$	<1	<1	<1	2					mg/kg	A-T-024s
Nickel$_D^{M\#}$	29	26	44	46					mg/kg	A-T-024s
Selenium$_D^{\#}$	3	3	5	5					mg/kg	A-T-024s
Tin$_D$	11	12	16	23					mg/kg	A-T-024s
Vanadium$_D^{M\#}$	35	31	49	56					mg/kg	A-T-024s
Zinc$_D^{M\#}$	538	579	1060	1140					mg/kg	A-T-024s
Benzo(b)(j)(k)fluoranthene$_A$	<0.07	<0.07	<0.07	<0.07					mg/kg	A-T-019s
1.12a PSD (3.35mm-2um clay)(Sedimentation by Pipette/Hydrometer)BS1377 1990 pt2cl9.4/9.5$_A$	Appended	Appended	Appended	Appended						Subcon SS

Envirolab Job Number: 18/07626

Client Project Name: Bowling Dredgings

Client Project Ref: SC/069

Lab Sample ID	18/07626/1	18/07626/2	18/07626/3	18/07626/4					Units	Method ref
Client Sample No	SC/069/001	SC/069/002	SC/069/003	SC/069/004						
Client Sample ID	Immediatley East of Lock 38	250m East of Lock 38	500m East of Lock 38	Immediately West of Bridge 48						
Depth to Top										
Depth To Bottom										
Date Sampled	17-Sep-18	17-Sep-18	17-Sep-18	17-Sep-18						
Sample Type	Solid	Solid	Solid	Solid						
Sample Matrix Code	7	7	7	7						
BTEX										
BTEX - Benzene$_A^{\#}$	<0.01	<0.01	<0.01	<0.01					mg/kg	A-T-022s
BTEX - Toluene$_A^{\#}$	<0.01	<0.01	<0.01	<0.01					mg/kg	A-T-022s
BTEX - Ethyl Benzene$_A^{\#}$	<0.01	<0.01	<0.01	<0.01					mg/kg	A-T-022s
BTEX - m & p Xylene$_A^{\#}$	<0.01	<0.01	<0.01	<0.01					mg/kg	A-T-022s
BTEX - o Xylene$_A^{\#}$	<0.01	<0.01	<0.01	<0.01					mg/kg	A-T-022s
PAH-8MS Carcinogenic										
Benzo(a)anthracene$_A^{M\#}$	<0.04	<0.04	<0.04	<0.04					mg/kg	A-T-019s
Benzo(a)pyrene$_A^{M\#}$	<0.04	<0.04	<0.04	<0.04					mg/kg	A-T-019s
Benzo(b)fluoranthene$_A^{M\#}$	<0.05	<0.05	<0.05	<0.05					mg/kg	A-T-019s
Benzo(k)fluoranthene$_A^{M\#}$	<0.07	<0.07	<0.07	<0.07					mg/kg	A-T-019s
Chrysene$_A^{M\#}$	<0.06	<0.06	<0.06	<0.06					mg/kg	A-T-019s
Dibenzo(ah)anthracene$_A^{M\#}$	<0.04	<0.04	<0.04	<0.04					mg/kg	A-T-019s
Indeno(123-cd)pyrene$_A^{M\#}$	<0.03	<0.03	<0.03	<0.03					mg/kg	A-T-019s

Envirolab Job Number: 18/07626

Client Project Name: Bowling Dredgings

Client Project Ref: SC/069

Lab Sample ID	18/07626/1	18/07626/2	18/07626/3	18/07626/4					Units	Method ref
Client Sample No	SC/069/001	SC/069/002	SC/069/003	SC/069/004						
Client Sample ID	Immediatley East of Lock 38	250m East of Lock 38	500m East of Lock 38	Immediately West of Bridge 48						
Depth to Top										
Depth To Bottom										
Date Sampled	17-Sep-18	17-Sep-18	17-Sep-18	17-Sep-18						
Sample Type	Solid	Solid	Solid	Solid						
Sample Matrix Code	7	7	7	7						
Speciated PCB-EC7										
PCB BZ $28_A^{M\#}$	<0.002	<0.002	<0.002	<0.002					mg/kg	A-T-004s
PCB BZ $52_A^{M\#}$	<0.002	<0.002	<0.002	<0.002					mg/kg	A-T-004s
PCB BZ $101_A^{M\#}$	<0.004	<0.004	<0.004	<0.004					mg/kg	A-T-004s
PCB BZ $118_A^{M\#}$	<0.007	<0.007	<0.007	<0.007					mg/kg	A-T-004s
PCB BZ $138_A^{M\#}$	<0.006	<0.006	<0.006	<0.006					mg/kg	A-T-004s
PCB BZ $153_A^{M\#}$	<0.004	<0.004	<0.004	<0.004					mg/kg	A-T-004s
PCB BZ $180_A^{M\#}$	<0.004	<0.004	<0.004	<0.004					mg/kg	A-T-004s
Total Speciated PCB-$EC7_A^{M\#}$	<0.007	<0.007	<0.007	<0.007					mg/kg	A-T-004s
TPH Banded 2										
>C6-$C10_A^{M\#}$	<5	<5	<5	<5					mg/kg	A-T-007s
>C10-$C25_A^{M\#}$	137	101	160	140					mg/kg	A-T-007s
>C25-$C40_A^{\#}$	379	253	444	451					mg/kg	A-T-007s
Total TPH Banded $2_A^{\#}$	516	354	604	591					mg/kg	A-T-007s

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, 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
All analysis is performed on the sample as received for soil samples which are positive for asbestos or the client has informed asbestos may be present and/or if they are from outside the European Union and this supersedes any "D" subscripts.

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:
Asbestos in soil analysis is performed on a dried aliquot of the submitted sample and cannot guarantee to identify asbestos if only present in small numbers as discrete fibres/fragments in the original sample.
Stones etc. are not removed from the sample prior to analysis.
Quantification of asbestos is a 3 stage process including visual identification, hand picking and weighing and fibre counting by sedimentation/phase contrast optical microscopy if required. If asbestos is identified as being present but is not in a form that is suitable for analysis by hand picking and weighing (normally if the asbestos is present as free fibres) quantification by sedimentation is performed. Where ACMs are found a percentage asbestos is assigned to each with reference to 'HSG264, Asbestos: The survey guide' and the calculated asbestos content is expressed as a percentage of the dried soil sample aliquot used.

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.
Samples with Matrix Code 7 & 8 are not predominantly a SAND/LOAM/CLAY mix and are not covered by our BSEN 17025 or MCERTS accreditations, with the exception of bulk asbestos which are BSEN 17025 accredited.
Secondary Matrix Codes:
A = contains stones, B = contains construction rubble, C = contains visible hydrocarbons, D = contains glass/metal,
E = contains roots/twigs.

Key:
IS indicates Insufficient Sample for analysis.
US indicates Unsuitable Sample for analysis.
NDP indicates No Determination Possible.
NAD indicates No Asbestos Detected.
N/A indicates Not Applicable.
Superscript # indicates method accredited to ISO 17025.
Superscript "M" indicates method accredited to MCERTS.
Subscript "A" indicates analysis performed on the sample as received.
Subscript "D" indicates analysis performed on the dried sample, crushed to pass a 2mm sieve

Please contact us if you need any further information.

STRUCTURAL SOILS LTD

TEST REPORT

Report No. 783401

1774

Date 05-October-2018 Contract 18/07626

Client Envirolab Ltd
Address Units 7 & 8 Sandpits Business Park
Mottram Road
Hyde
SK14 3AR

For the Attention of Iain Haslock

Samples submitted by client	20/09/2018	Client Reference	18/07626
Testing Started	21/09/2018	Client Order No.	P0739096
Testing Completed	01/05/2019	Instruction Type	Written

UKAS Accredited Tests Undertaken

Particle Size Distribution sedimentation pipette method BS1377:Part 2:1990,clause 9.4

* This clause of BS1377 is no longer the most up to date method due to the publication of ISO17892

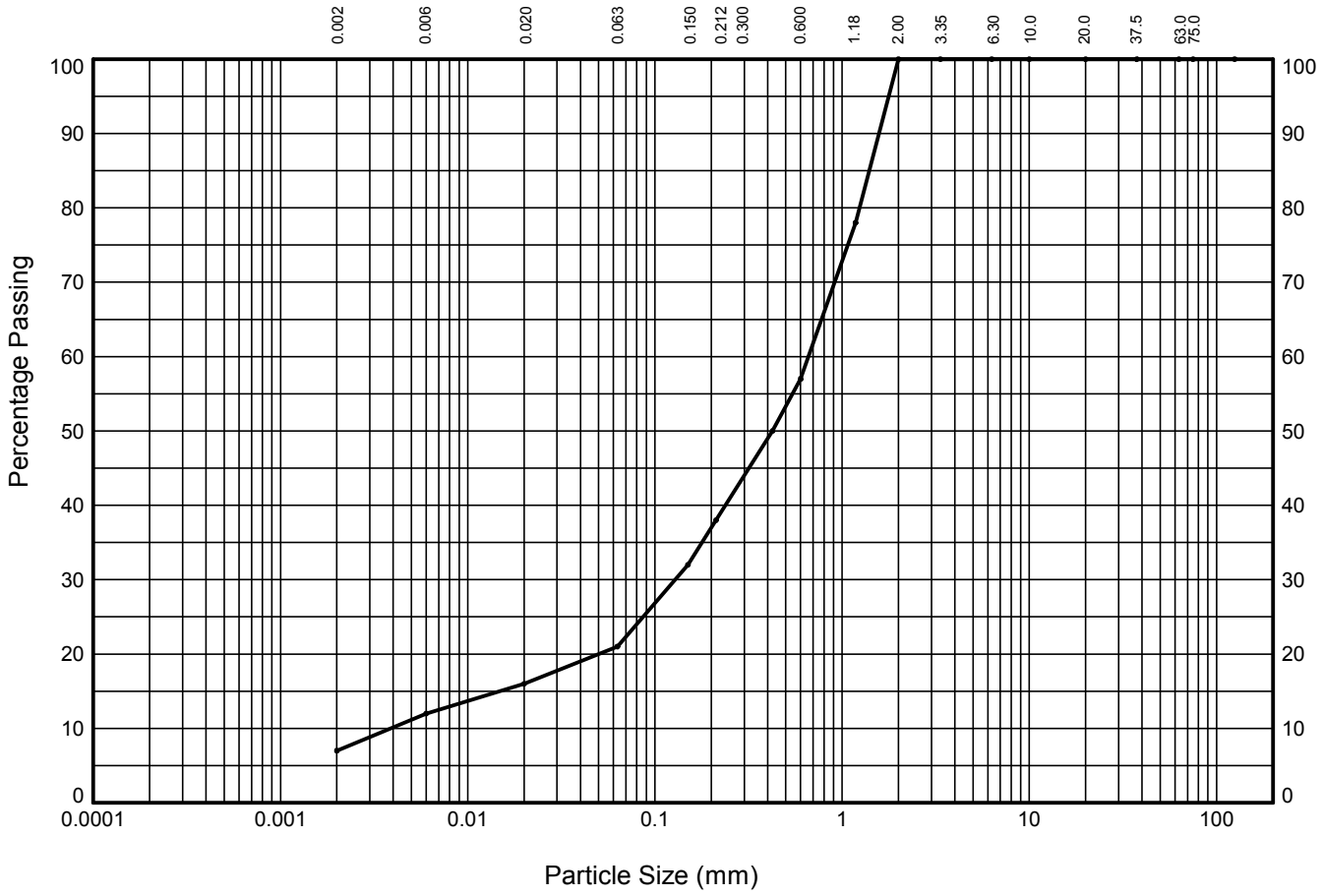
Please Note: Remaining samples will be retained for a period of one month from today and will then be disposed of.
Test were undertaken on samples 'as received' unless otherwise stated.
Opinions and interpretations expressed in this report are outside the scope of accreditation for this laboratory.

Structural Soils Ltd, The Potteries, Pottery Street, Castleford, WF10 1NJ Tel.01977 552255. E-mail mark.athorne@soils.co.uk

PARTICLE SIZE DISTRIBUTION TEST

In accordance with clauses 9.2, 9.4 of BS1377:Part 2:1990

Position ID: **250m East of Lock 38** Sample Ref: **18/07626/2** Sample Type: **B** Depth (m): **-**



CLAY	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	COBBLES
	SILT			SAND			GRAVEL			

Test Sieve (mm)	Percent Passing (%)
125.0	**100**
75.0	**100**
63.0	**100**
37.5	**100**
20.0	**100**
10.0	**100**
6.30	**100**
3.35	**100**
2.00	**100**
1.18	**78**
0.600	**57**
0.425	**50**
0.212	**38**
0.150	**32**
0.063	**21**

Particle Diameter (mm)	Percent Passing (%)
0.02	**16**
0.006	**12**
0.002	**7**

Sedimentation sample was not pre-treated

Soil Fraction	Sieve Percentage (%)
GRAVEL	**0**
SAND	**79**
SILT	**14**
CLAY	**7**

Soil Description:

Dark brown organic CLAY

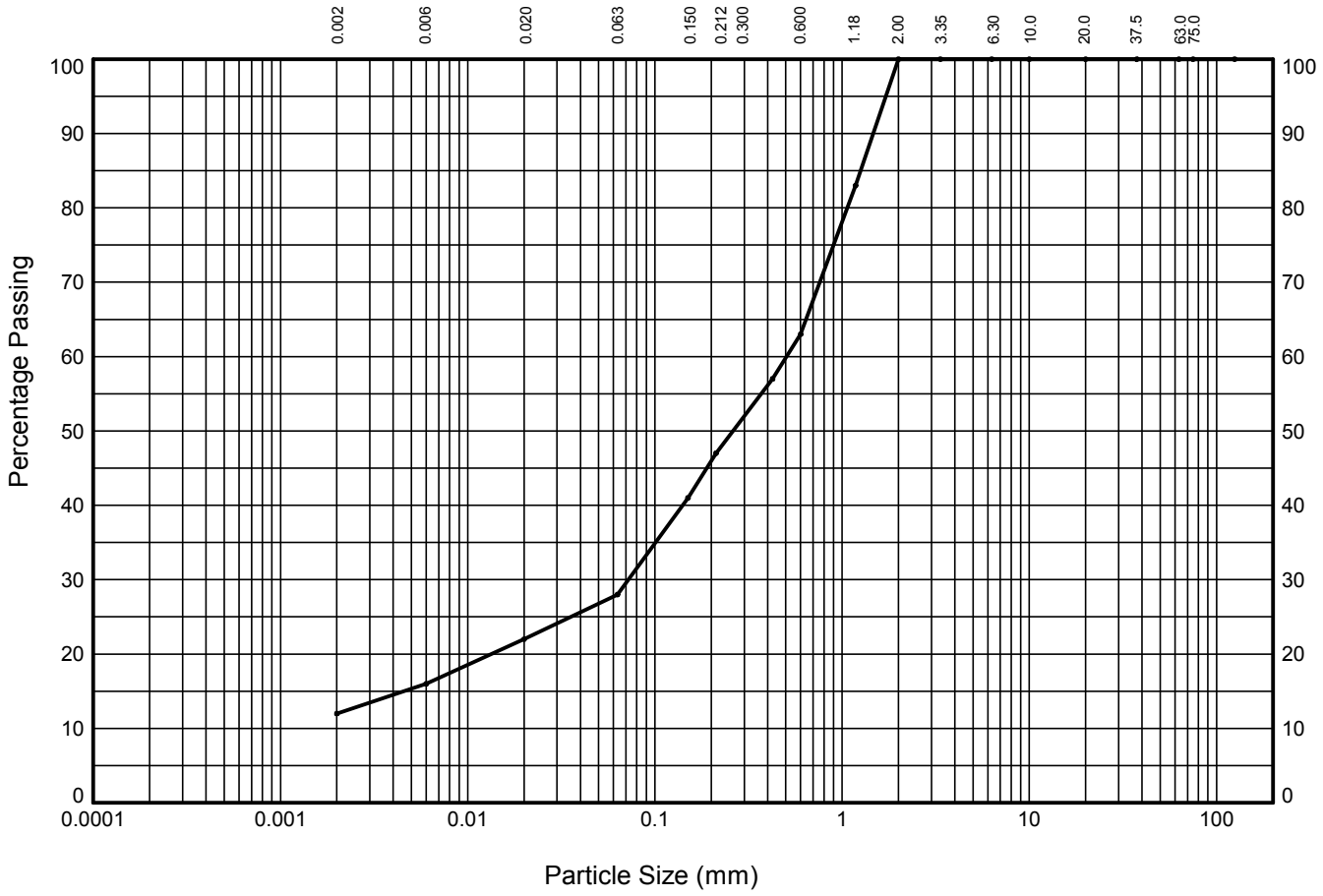
STRUCTURAL SOILS
The Potteries
Pottery Street
Castleford
W. Yorkshire WF10 1NJ

Compiled By		Date
C Cole	**CATHERINE COLE**	**05/10/18**
Contract: **18/07626**	Contract Ref: **783401**	

PARTICLE SIZE DISTRIBUTION TEST

In accordance with clauses 9.2, 9.4 of BS1377:Part 2:1990

Position ID: **500m East of Lock 38** Sample Ref: **18/07626/3** Sample Type: **B** Depth (m): **-**



CLAY	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	COBBLES
	SILT			SAND			GRAVEL			

Test Sieve (mm)	Percent Passing (%)
125.0	**100**
75.0	**100**
63.0	**100**
37.5	**100**
20.0	**100**
10.0	**100**
6.30	**100**
3.35	**100**
2.00	**100**
1.18	**83**
0.600	**63**
0.425	**57**
0.212	**47**
0.150	**41**
0.063	**28**

Particle Diameter (mm)	Percent Passing (%)
0.02	**22**
0.006	**16**
0.002	**12**

Sedimentation sample was not pre-treated

Soil Fraction	Sieve Percentage (%)
GRAVEL	**0**
SAND	**72**
SILT	**16**
CLAY	**12**

Soil Description:

Dark brown organic CLAY

STRUCTURAL SOILS
The Potteries
Pottery Street
Castleford
W. Yorkshire WF10 1NJ

Compiled By		Date
C Cole	**CATHERINE COLE**	**05/10/18**

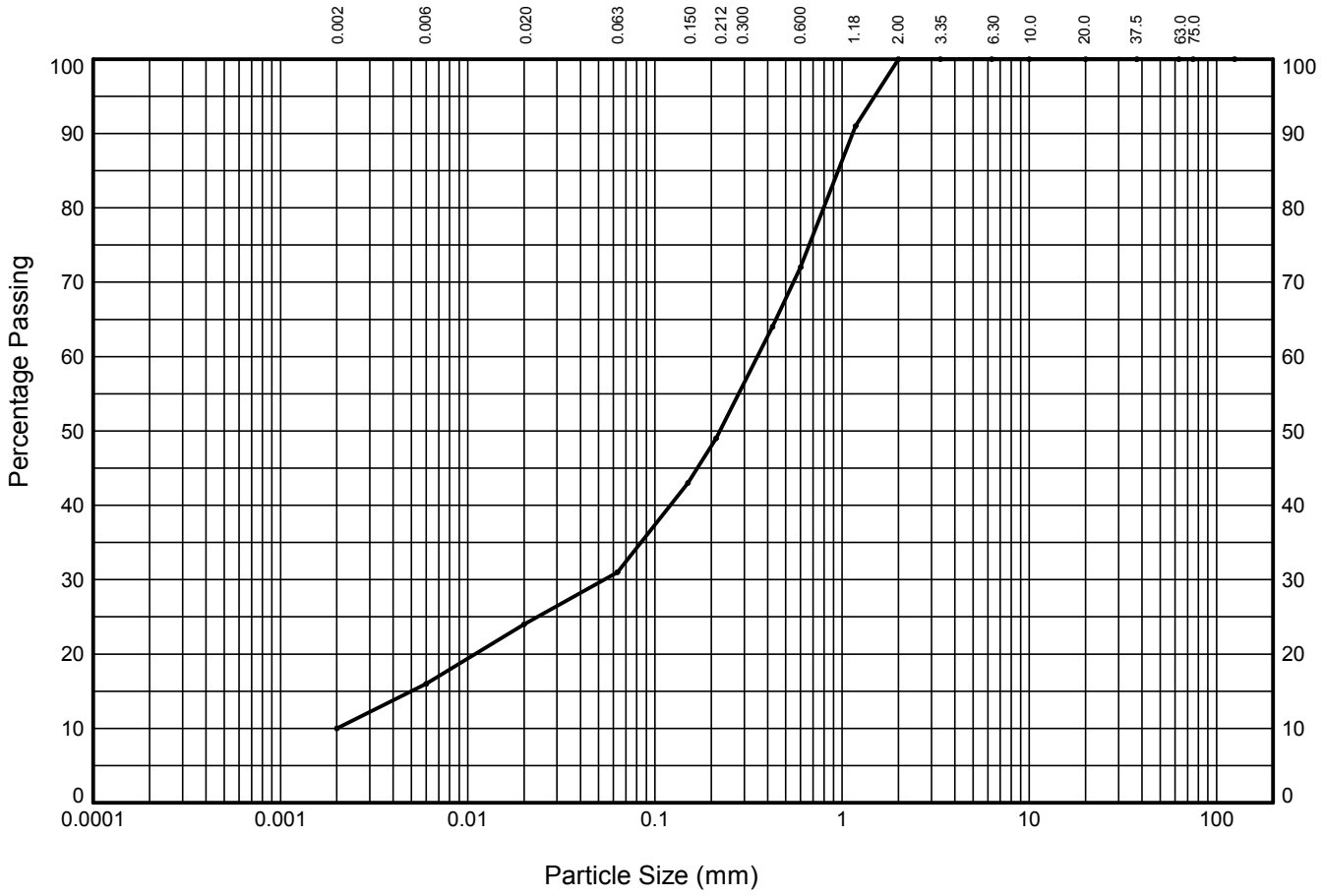
Contract	Contract Ref:
18/07626	**783401**

AGS

PARTICLE SIZE DISTRIBUTION TEST

In accordance with clauses 9.2, 9.4 of BS1377:Part 2:1990

Position ID: **Immediately East of Lock 38** Sample Ref: **18/07626/1** Sample Type: **B** Depth (m): **-**



CLAY	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	COBBLES
	SILT			SAND			GRAVEL			

Test Sieve (mm)	Percent Passing (%)
125.0	**100**
75.0	**100**
63.0	**100**
37.5	**100**
20.0	**100**
10.0	**100**
6.30	**100**
3.35	**100**
2.00	**100**
1.18	**91**
0.600	**72**
0.425	**64**
0.212	**49**
0.150	**43**
0.063	**31**

Particle Diameter (mm)	Percent Passing (%)
0.02	**24**
0.006	**16**
0.002	**10**

Sedimentation sample was not pre-treated

Soil Fraction	Sieve Percentage (%)
GRAVEL	**0**
SAND	**69**
SILT	**21**
CLAY	**10**

Soil Description:

Dark brown organic CLAY

STRUCTURAL SOILS
The Potteries
Pottery Street
Castleford
W. Yorkshire WF10 1NJ

Compiled By		Date
C Cole	**CATHERINE COLE**	**05/10/18**

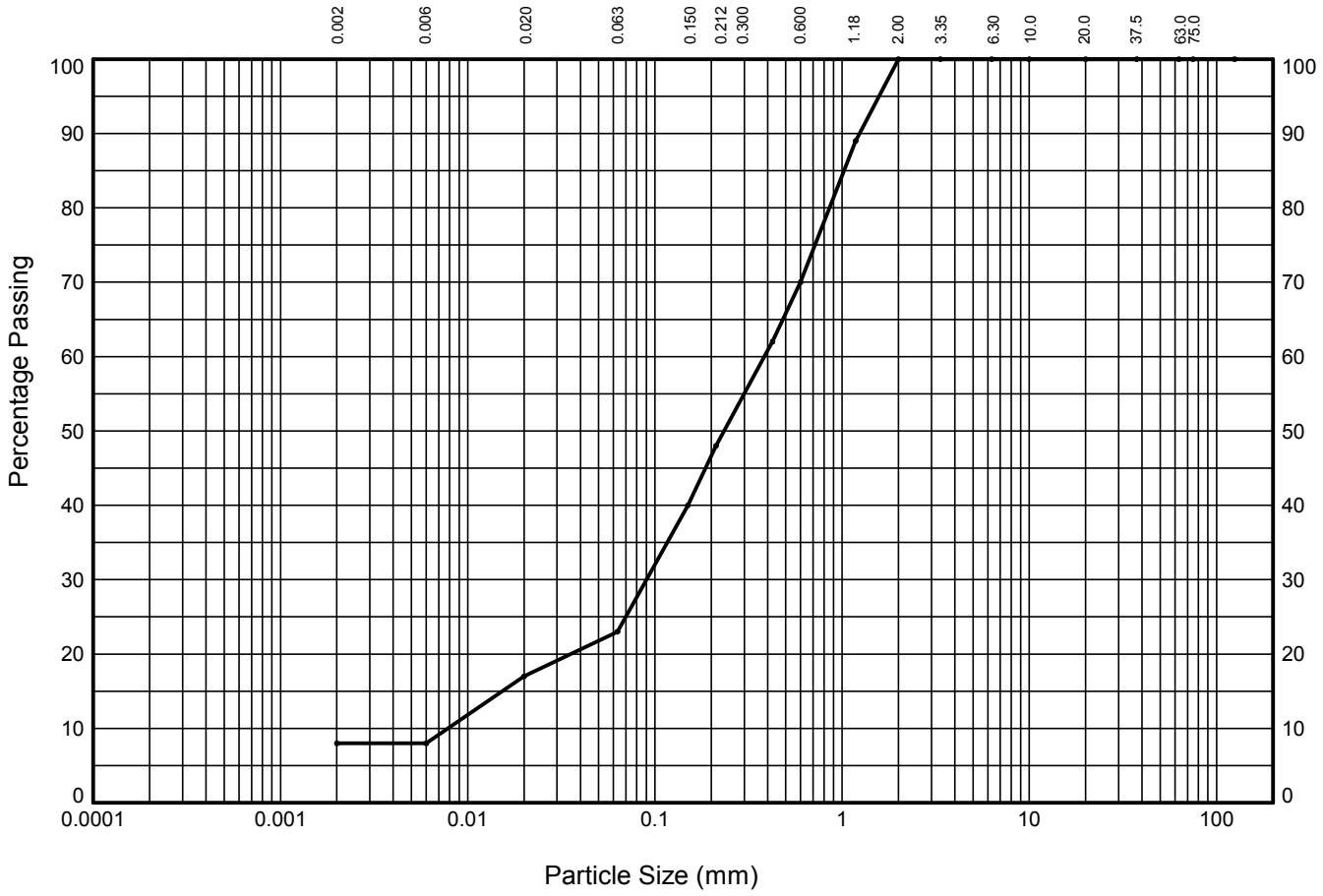
Contract	Contract Ref:
18/07626	**783401**

AGS

PARTICLE SIZE DISTRIBUTION TEST

In accordance with clauses 9.2, 9.4 of BS1377:Part 2:1990

Position ID: **Immediately West of Bridge 48** Sample Ref: **18/07626/4** Sample Type: **B** Depth (m): -



CLAY	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	COBBLES
	SILT			SAND			GRAVEL			

Test Sieve (mm)	Percent Passing (%)
125.0	**100**
75.0	**100**
63.0	**100**
37.5	**100**
20.0	**100**
10.0	**100**
6.30	**100**
3.35	**100**
2.00	**100**
1.18	**89**
0.600	**70**
0.425	**62**
0.212	**48**
0.150	**40**
0.063	**23**

Particle Diameter (mm)	Percent Passing (%)
0.02	**17**
0.006	**8**
0.002	**8**

Sedimentation sample was not pre-treated

Soil Fraction	Sieve Percentage (%)
GRAVEL	**0**
SAND	**77**
SILT	**15**
CLAY	**8**

Soil Description:

Dark brown organic CLAY

STRUCTURAL SOILS
The Potteries
Pottery Street
Castleford
W. Yorkshire WF10 1NJ

Compiled By		Date
C Cole	**CATHERINE COLE**	**05/10/18**

Contract	Contract Ref:
18/07626	**783401**

AGS

ANALYTICAL REPORT

Report Number	**28054-18**	**N823**	**UNIVERSITY OF STRATHCLYDE**	**Client RICHARD**
Date Received	**19-SEP-2018**		**DEPARTMENT OF CIVIL &**	
Date Reported	**25-SEP-2018**		**ENVIRONMENTAL ENGINEERING**	
Project	**FRESH WATER DREDGINGS**		**16 RICHMOND STREET**	
Reference	**RICHARD LORD**		**GLASGOW**	
Order Number	**5110332**		**G1 1XQ**	

Laboratory Reference		**MANU94998**	**MANU94999**	**MANU95000**	**MANU95001**	**MANU95002**	**MANU95003**	**M**
Sample Reference		**G1**	**G2**	**G3**	**B1**	**B2**	**B3**	
Determinand	**Unit**	FRESH WATER DREDG	FRESH WATER DREDG	FRESH WATER DREDG	FRESH WATER DREDG	FRESH WATER DREDG	FRESH WATER DREDG	FRESH
Oven Dry Matter	%	29.8	42.0	32.6	13.8	19.1	13.2	
Conductivity 1:6 [Fresh]	uS/cm	193	209	196	199	247	214	
Total Nitrogen	% w/w	0.85	1.09	0.78	1.08	1.28	1.17	
Nitrate Nitrogen	mg/kg	<10	<10	<10	<10	<10	<10	
Ammonium Nitrogen	mg/kg	94.6	78.8	125	73.9	<10	<10	
Total Phosphorus (P)	mg/kg	2421	1946	4364	1177	1238	1211	
Total Potassium (K)	mg/kg	897	820	1429	1488	1713	1724	
Total Magnesium (Mg)	mg/kg	2585	2328	5400	5553	5982	5959	
Total Sulphur (S)	mg/kg	12940	8303	9878	14118	16248	15421	
Total Calcium (Ca)	mg/kg	14968	9919	15484	47023	55071	64043	
pH 1:6 [Fresh]		7.30	7.30	7.10	7.50	7.40	7.40	
Lime Equivalent as CaCO3	% w/w	7.0	5.5	8.6	13.6	14.7	18.0	
Water Soluble Magnesium	mg/kg	19.8	26.0	30.6	78.1	61.0	86.8	
Water Soluble Phosphorus	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
Water Soluble Potassium	mg/kg	80.0	171	48.2	105	81.1	131	
Water Soluble Sulphur	mg/kg	78.8	70.6	59.4	188	204	165	
Water Soluble Calcium	mg/kg	143	109	170	490	426	582	
Neutralising Value as CaO [TNV]	% w/w	3.9	3.1	4.8	7.6	8.2	10.1	

Notes

Analysis Notes

The sample submitted was of adequate size to complete all analysis requested.
The results as reported relate only to the item(s) submitted for testing.
The results are presented on a dry matter basis unless otherwise stipulated.

Document Control

ANALYTICAL NOTES

Report Number	**28054-18**	**N823**	**UNIVERSITY OF STRATHCLYDE**	**Client RICHARD**
Date Received	**19-SEP-2018**		**DEPARTMENT OF CIVIL &**	
Date Reported	**25-SEP-2018**		**ENVIRONMENTAL ENGINEERING**	
Project	**FRESH WATER DREDGINGS**		**16 RICHMOND STREET**	
Reference	**RICHARD LORD**		**GLASGOW**	
Order Number	**5110332**		**G1 1XQ**	

Notes

Reported by

Darren Whitbread

Natural Resource Management, a trading division of Cawood Scientific Ltd.
Coopers Bridge, Braziers Lane, Bracknell, Berkshire, RG42 6NS
Tel: 01344 886338
Fax: 01344 890972
email: enquiries@nrm.uk.com

Purchase Order : 5110332

UNIVERSITY OF STRATHCLYDE
DEPARTMENT OF CIVIL &
ENVIRONMENTAL ENGINEERING
16 RICHMOND STREET
GLASGOW
G1 1XQ

N823

Please quote above code for all enquiries

RICHARD LORD

FRESH WATER DREDGINGS

FRESH WATER DREDGINGS (Metric Units)

Sample Reference : G1

Sample Matrix : FRESH WATER DREDGINGS

The sample submitted was of adequate size to complete all analysis requested.

The sample will be kept as the dry ground sample for at least 1 month.

Laboratory References	
Report Number	28054
Sample Number	94998

Date Received	19-SEP-2018
Date Reported	25-SEP-2018

ANALYTICAL RESULTS

Determinand on a DM basis unless otherwise indicated	Units	Result	Amount per fresh tonne	Amount applied at an equivalent total Nitrogen application of 250 kg N/ha	Units
pH 1:6 [Fresh]		7.30			
Oven Dry Matter	%	29.8	298.00	29412	kg DM
Total Nitrogen	% w/w	0.85	2.53	250	kg N
Ammonium Nitrogen	mg/kg	94.6	0.03	2.78	kg NH4-N
Nitrate Nitrogen	mg/kg	<10	< 0.01		kg NO3-N
Total Phosphorus (P)	% w/w	0.242	1.65	162.99	kg P2O5
Total Potassium (K)	% w/w	0.090	0.32	31.76	kg K2O
Total Magnesium (Mg)	% w/w	0.259	1.28	126.45	kg MgO
Total Sulphur (S)	% w/w	1.29	9.61	948.53	kg SO3
Total Calcium (Ca)	mg/kg	14968	4.46	440.24	kg Ca
Equivalent field application rate		—	1.00	98.70	tonnes/ha

The above equivalent field application rate for total nitrogen of 250 kg/ha has been provided purely for guidance purposes only. Organic manures should be used in accordance with the Defra Code of Good Agricultural Practice and where required within the specific regulatory guidance for the spreading of that material to land. To get the most benefit from your organic manures it is recommended that you follow the principles as set out in Defra's Fertiliser Manual (RB209) or as directed by a FACTS qualified adviser.

Released by Darren Whitbread Date 25/09/18

NRM Coopers Bridge, Braziers Lane, Bracknell, Berkshire RG42 6NS
Tel: +44 (0) 1344 886338 **Fax:** +44 (0) 1344 890972 **Email:** enquiries@nrm.uk.com **www**.nrm.uk.com

Purchase Order : 5110332

UNIVERSITY OF STRATHCLYDE
DEPARTMENT OF CIVIL &
ENVIRONMENTAL ENGINEERING
16 RICHMOND STREET
GLASGOW
G1 1XQ

N823

Please quote above code for all enquiries

RICHARD LORD

FRESH WATER DREDGINGS

FRESH WATER DREDGINGS (Metric Units)

Sample Reference : G1

Sample Matrix : FRESH WATER DREDGINGS

The sample submitted was of adequate size to complete all analysis requested.

The sample will be kept as the dry ground sample for at least 1 month.

Laboratory References	
Report Number	28054
Sample Number	94998

Date Received	19-SEP-2018
Date Reported	25-SEP-2018

ANALYTICAL RESULTS

Determinand on a DM basis unless otherwise indicated	Units	Result
Conductivity 1:6 [Fresh]	uS/cm	193
Lime Equivalent as CaCO3	% w/w	7.00
Water Soluble Magnesium	mg/kg	19.8
Water Soluble Phosphorus	mg/kg	<0.01
Water Soluble Potassium	mg/kg	80.0
Water Soluble Sulphur	mg/kg	78.8
Water Soluble Calcium	mg/kg	143
N. V. as CaO equivalents	% w/w	3.92

Released by Darren Whitbread Date 25/09/18

NRM Coopers Bridge, Braziers Lane, Bracknell, Berkshire RG42 6NS
Tel: +44 (0) 1344 886338 **Fax:** +44 (0) 1344 890972 **Email:** enquiries@nrm.uk.com **www**.nrm.uk.com

Purchase Order : 5110332

UNIVERSITY OF STRATHCLYDE
DEPARTMENT OF CIVIL &
ENVIRONMENTAL ENGINEERING
16 RICHMOND STREET
GLASGOW
G1 1XQ

N823

Please quote above code for all enquiries

RICHARD LORD

FRESH WATER DREDGINGS

FRESH WATER DREDGINGS (Metric Units)

Sample Reference : G2

Sample Matrix : FRESH WATER DREDGINGS

The sample submitted was of adequate size to complete all analysis requested.

The sample will be kept as the dry ground sample for at least 1 month.

Laboratory References	
Report Number	28054
Sample Number	94999

Date Received	19-SEP-2018
Date Reported	25-SEP-2018

ANALYTICAL RESULTS

Determinand on a DM basis unless otherwise indicated	Units	Result	Amount per fresh tonne	Amount applied at an equivalent total Nitrogen application of 250 kg N/ha	Units
pH 1:6 [Fresh]		7.30			
Oven Dry Matter	%	42.0	420.00	22936	kg DM
Total Nitrogen	% w/w	1.09	4.58	250	kg N
Ammonium Nitrogen	mg/kg	78.8	0.03	1.81	kg NH4-N
Nitrate Nitrogen	mg/kg	<10	< 0.01		kg NO3-N
Total Phosphorus (P)	% w/w	0.195	1.88	102.42	kg P2O5
Total Potassium (K)	% w/w	0.082	0.41	22.57	kg K2O
Total Magnesium (Mg)	% w/w	0.233	1.62	88.71	kg MgO
Total Sulphur (S)	% w/w	0.830	8.72	475.92	kg SO3
Total Calcium (Ca)	mg/kg	9919	4.17	227.50	kg Ca
Equivalent field application rate		—	1.00	54.61	tonnes/ha

The above equivalent field application rate for total nitrogen of 250 kg/ha has been provided purely for guidance purposes only. Organic manures should be used in accordance with the Defra Code of Good Agricultural Practice and where required within the specific regulatory guidance for the spreading of that material to land. To get the most benefit from your organic manures it is recommended that you follow the principles as set out in Defra's Fertiliser Manual (RB209) or as directed by a FACTS qualified adviser.

Released by Darren Whitbread Date 25/09/18

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Please quote above code for all enquiries

RICHARD LORD

FRESH WATER DREDGINGS

FRESH WATER DREDGINGS (Metric Units)

Sample Reference : G2

Sample Matrix : FRESH WATER DREDGINGS

The sample submitted was of adequate size to complete all analysis requested.

The sample will be kept as the dry ground sample for at least 1 month.

Laboratory References	
Report Number	28054
Sample Number	94999

Date Received	19-SEP-2018
Date Reported	25-SEP-2018

ANALYTICAL RESULTS

Determinand on a DM basis unless otherwise indicated	Units	Result
Conductivity 1:6 [Fresh]	uS/cm	209
Lime Equivalent as CaCO3	% w/w	5.54
Water Soluble Magnesium	mg/kg	26.0
Water Soluble Phosphorus	mg/kg	<0.01
Water Soluble Potassium	mg/kg	171
Water Soluble Sulphur	mg/kg	70.6
Water Soluble Calcium	mg/kg	109
N. V. as CaO equivalents	% w/w	3.11

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RICHARD LORD

FRESH WATER DREDGINGS

FRESH WATER DREDGINGS (Metric Units)

Sample Reference : G3

Sample Matrix : FRESH WATER DREDGINGS

The sample submitted was of adequate size to complete all analysis requested.

The sample will be kept as the dry ground sample for at least 1 month.

Laboratory References	
Report Number	28054
Sample Number	95000

Date Received	19-SEP-2018
Date Reported	25-SEP-2018

ANALYTICAL RESULTS

Determinand on a DM basis unless otherwise indicated	Units	Result	Amount per fresh tonne	Amount applied at an equivalent total Nitrogen application of 250 kg N/ha	Units
pH 1:6 [Fresh]		7.10			
Oven Dry Matter	%	32.6	326.00	32051	kg DM
Total Nitrogen	% w/w	0.78	2.54	250	kg N
Ammonium Nitrogen	mg/kg	125	0.04	4.01	kg NH4-N
Nitrate Nitrogen	mg/kg	<10	< 0.01		kg NO3-N
Total Phosphorus (P)	% w/w	0.436	3.25	320.01	kg P2O5
Total Potassium (K)	% w/w	0.143	0.56	55.00	kg K2O
Total Magnesium (Mg)	% w/w	0.540	2.92	287.31	kg MgO
Total Sulphur (S)	% w/w	0.988	8.05	791.67	kg SO3
Total Calcium (Ca)	mg/kg	15484	5.05	496.28	kg Ca
Equivalent field application rate		—	1.00	98.32	tonnes/ha

The above equivalent field application rate for total nitrogen of 250 kg/ha has been provided purely for guidance purposes only. Organic manures should be used in accordance with the Defra Code of Good Agricultural Practice and where required within the specific regulatory guidance for the spreading of that material to land. To get the most benefit from your organic manures it is recommended that you follow the principles as set out in Defra's Fertiliser Manual (RB209) or as directed by a FACTS qualified adviser.

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FRESH WATER DREDGINGS

FRESH WATER DREDGINGS (Metric Units)

Sample Reference : G3

Sample Matrix : FRESH WATER DREDGINGS

The sample submitted was of adequate size to complete all analysis requested.

The sample will be kept as the dry ground sample for at least 1 month.

Laboratory References	
Report Number	28054
Sample Number	95000

Date Received	19-SEP-2018
Date Reported	25-SEP-2018

ANALYTICAL RESULTS

Determinand on a DM basis unless otherwise indicated	Units	Result
Conductivity 1:6 [Fresh]	uS/cm	196
Lime Equivalent as CaCO3	% w/w	8.58
Water Soluble Magnesium	mg/kg	30.6
Water Soluble Phosphorus	mg/kg	<0.01
Water Soluble Potassium	mg/kg	48.2
Water Soluble Sulphur	mg/kg	59.4
Water Soluble Calcium	mg/kg	170
N. V. as CaO equivalents	% w/w	4.81

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RICHARD LORD

FRESH WATER DREDGINGS

FRESH WATER DREDGINGS (Metric Units)

Sample Reference : B1

Sample Matrix : FRESH WATER DREDGINGS

The sample submitted was of adequate size to complete all analysis requested.

The sample will be kept as the dry ground sample for at least 1 month.

Laboratory References	
Report Number	28054
Sample Number	95001

Date Received	19-SEP-2018
Date Reported	25-SEP-2018

ANALYTICAL RESULTS

Determinand on a DM basis unless otherwise indicated	Units	Result	Amount per fresh tonne	Amount applied at an equivalent total Nitrogen application of 250 kg N/ha	Units
pH 1:6 [Fresh]		7.50			
Oven Dry Matter	%	13.8	138.00	23148	kg DM
Total Nitrogen	% w/w	1.08	1.49	250	kg N
Ammonium Nitrogen	mg/kg	73.9	0.01	1.71	kg NH4-N
Nitrate Nitrogen	mg/kg	<10	< 0.01		kg NO3-N
Total Phosphorus (P)	% w/w	0.118	0.37	62.55	kg P2O5
Total Potassium (K)	% w/w	0.149	0.25	41.39	kg K2O
Total Magnesium (Mg)	% w/w	0.555	1.27	213.26	kg MgO
Total Sulphur (S)	% w/w	1.41	4.86	815.97	kg SO3
Total Calcium (Ca)	mg/kg	47023	6.49	1088.50	kg Ca
Equivalent field application rate		—	1.00	167.74	tonnes/ha

The above equivalent field application rate for total nitrogen of 250 kg/ha has been provided purely for guidance purposes only. Organic manures should be used in accordance with the Defra Code of Good Agricultural Practice and where required within the specific regulatory guidance for the spreading of that material to land. To get the most benefit from your organic manures it is recommended that you follow the principles as set out in Defra's Fertiliser Manual (RB209) or as directed by a FACTS qualified adviser.

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FRESH WATER DREDGINGS

FRESH WATER DREDGINGS (Metric Units)

Sample Reference : B1

Sample Matrix : FRESH WATER DREDGINGS

The sample submitted was of adequate size to complete all analysis requested.

The sample will be kept as the dry ground sample for at least 1 month.

Laboratory References	
Report Number	28054
Sample Number	95001

Date Received	19-SEP-2018
Date Reported	25-SEP-2018

ANALYTICAL RESULTS

Determinand on a DM basis unless otherwise indicated	Units	Result
Conductivity 1:6 [Fresh]	uS/cm	199
Lime Equivalent as CaCO3	% w/w	13.6
Water Soluble Magnesium	mg/kg	78.1
Water Soluble Phosphorus	mg/kg	<0.01
Water Soluble Potassium	mg/kg	105
Water Soluble Sulphur	mg/kg	188
Water Soluble Calcium	mg/kg	490
N. V. as CaO equivalents	% w/w	7.64

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RICHARD LORD

FRESH WATER DREDGINGS

FRESH WATER DREDGINGS (Metric Units)

Sample Reference : B2

Sample Matrix : FRESH WATER DREDGINGS

The sample submitted was of adequate size to complete all analysis requested.

The sample will be kept as the dry ground sample for at least 1 month.

Laboratory References	
Report Number	28054
Sample Number	95002

Date Received	19-SEP-2018
Date Reported	25-SEP-2018

ANALYTICAL RESULTS

Determinand on a DM basis unless otherwise indicated	Units	Result	Amount per fresh tonne	Amount applied at an equivalent total Nitrogen application of 250 kg N/ha	Units
pH 1:6 [Fresh]		7.40			
Oven Dry Matter	%	19.1	191.00	19531	kg DM
Total Nitrogen	% w/w	1.28	2.44	250	kg N
Ammonium Nitrogen	mg/kg	<10	< 0.01		kg NH4-N
Nitrate Nitrogen	mg/kg	<10	< 0.01		kg NO3-N
Total Phosphorus (P)	% w/w	0.124	0.54	55.46	kg P2O5
Total Potassium (K)	% w/w	0.171	0.39	40.08	kg K2O
Total Magnesium (Mg)	% w/w	0.598	1.90	193.88	kg MgO
Total Sulphur (S)	% w/w	1.62	7.74	791.02	kg SO3
Total Calcium (Ca)	mg/kg	55071	10.52	1075.61	kg Ca
Equivalent field application rate		——	1.00	102.26	tonnes/ha

The above equivalent field application rate for total nitrogen of 250 kg/ha has been provided purely for guidance purposes only. Organic manures should be used in accordance with the Defra Code of Good Agricultural Practice and where required within the specific regulatory guidance for the spreading of that material to land. To get the most benefit from your organic manures it is recommended that you follow the principles as set out in Defra's Fertiliser Manual (RB209) or as directed by a FACTS qualified adviser.

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FRESH WATER DREDGINGS

FRESH WATER DREDGINGS (Metric Units)

Sample Reference : B2

Sample Matrix : FRESH WATER DREDGINGS

The sample submitted was of adequate size to complete all analysis requested.

The sample will be kept as the dry ground sample for at least 1 month.

Laboratory References	
Report Number	28054
Sample Number	95002

Date Received	19-SEP-2018
Date Reported	25-SEP-2018

ANALYTICAL RESULTS

Determinand on a DM basis unless otherwise indicated	Units	Result
Conductivity 1:6 [Fresh]	uS/cm	247
Lime Equivalent as CaCO3	% w/w	14.7
Water Soluble Magnesium	mg/kg	61.0
Water Soluble Phosphorus	mg/kg	<0.01
Water Soluble Potassium	mg/kg	81.1
Water Soluble Sulphur	mg/kg	204
Water Soluble Calcium	mg/kg	426
N. V. as CaO equivalents	% w/w	8.22

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FRESH WATER DREDGINGS

FRESH WATER DREDGINGS (Metric Units)

Sample Reference : B3

Sample Matrix : FRESH WATER DREDGINGS

The sample submitted was of adequate size to complete all analysis requested.

The sample will be kept as the dry ground sample for at least 1 month.

Laboratory References	
Report Number	28054
Sample Number	95003

Date Received	19-SEP-2018
Date Reported	25-SEP-2018

ANALYTICAL RESULTS

Determinand on a DM basis unless otherwise indicated	Units	Result	Amount per fresh tonne	Amount applied at an equivalent total Nitrogen application of 250 kg N/ha	Units
pH 1:6 [Fresh]		7.40			
Oven Dry Matter	%	13.2	132.00	21368	kg DM
Total Nitrogen	% w/w	1.17	1.54	250	kg N
Ammonium Nitrogen	mg/kg	<10	< 0.01		kg NH4-N
Nitrate Nitrogen	mg/kg	<10	< 0.01		kg NO3-N
Total Phosphorus (P)	% w/w	0.121	0.37	59.21	kg P2O5
Total Potassium (K)	% w/w	0.172	0.27	44.10	kg K2O
Total Magnesium (Mg)	% w/w	0.596	1.31	211.40	kg MgO
Total Sulphur (S)	% w/w	1.54	5.08	822.65	kg SO3
Total Calcium (Ca)	mg/kg	64043	8.45	1368.44	kg Ca
Equivalent field application rate		—	1.00	161.88	tonnes/ha

The above equivalent field application rate for total nitrogen of 250 kg/ha has been provided purely for guidance purposes only. Organic manures should be used in accordance with the Defra Code of Good Agricultural Practice and where required within the specific regulatory guidance for the spreading of that material to land. To get the most benefit from your organic manures it is recommended that you follow the principles as set out in Defra's Fertiliser Manual (RB209) or as directed by a FACTS qualified adviser.

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RICHARD LORD

FRESH WATER DREDGINGS

FRESH WATER DREDGINGS (Metric Units)

Sample Reference : B3

Sample Matrix : FRESH WATER DREDGINGS

The sample submitted was of adequate size to complete all analysis requested.

The sample will be kept as the dry ground sample for at least 1 month.

Laboratory References	
Report Number	28054
Sample Number	95003

Date Received	19-SEP-2018
Date Reported	25-SEP-2018

ANALYTICAL RESULTS

Determinand on a DM basis unless otherwise indicated	Units	Result
Conductivity 1:6 [Fresh]	uS/cm	214
Lime Equivalent as CaCO3	% w/w	18.0
Water Soluble Magnesium	mg/kg	86.8
Water Soluble Phosphorus	mg/kg	<0.01
Water Soluble Potassium	mg/kg	131
Water Soluble Sulphur	mg/kg	165
Water Soluble Calcium	mg/kg	582
N. V. as CaO equivalents	% w/w	10.1

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RICHARD LORD

FRESH WATER DREDGINGS

FRESH WATER DREDGINGS (Metric Units)

Sample Reference : B4

Sample Matrix : FRESH WATER DREDGINGS

The sample submitted was of adequate size to complete all analysis requested.

The sample will be kept as the dry ground sample for at least 1 month.

Laboratory References	
Report Number	28054
Sample Number	95004

Date Received	19-SEP-2018
Date Reported	25-SEP-2018

ANALYTICAL RESULTS

Determinand on a DM basis unless otherwise indicated	Units	Result	Amount per fresh tonne	Amount applied at an equivalent total Nitrogen application of 250 kg N/ha	Units
pH 1:6 [Fresh]		7.60			
Oven Dry Matter	%	12.6	126.00	23585	kg DM
Total Nitrogen	% w/w	1.06	1.34	250	kg N
Ammonium Nitrogen	mg/kg	<10	< 0.01		kg NH4-N
Nitrate Nitrogen	mg/kg	<10	< 0.01		kg NO3-N
Total Phosphorus (P)	% w/w	0.136	0.39	73.45	kg P2O5
Total Potassium (K)	% w/w	0.167	0.25	47.26	kg K2O
Total Magnesium (Mg)	% w/w	0.618	1.29	241.95	kg MgO
Total Sulphur (S)	% w/w	1.68	5.29	990.57	kg SO3
Total Calcium (Ca)	mg/kg	47476	5.98	1119.72	kg Ca
Equivalent field application rate		—	1.00	187.18	tonnes/ha

The above equivalent field application rate for total nitrogen of 250 kg/ha has been provided purely for guidance purposes only. Organic manures should be used in accordance with the Defra Code of Good Agricultural Practice and where required within the specific regulatory guidance for the spreading of that material to land. To get the most benefit from your organic manures it is recommended that you follow the principles as set out in Defra's Fertiliser Manual (RB209) or as directed by a FACTS qualified adviser.

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FRESH WATER DREDGINGS

FRESH WATER DREDGINGS (Metric Units)

Sample Reference : B4

Sample Matrix : FRESH WATER DREDGINGS

The sample submitted was of adequate size to complete all analysis requested.

The sample will be kept as the dry ground sample for at least 1 month.

Laboratory References	
Report Number	28054
Sample Number	95004

Date Received	19-SEP-2018
Date Reported	25-SEP-2018

ANALYTICAL RESULTS

Determinand on a DM basis unless otherwise indicated	Units	Result
Conductivity 1:6 [Fresh]	uS/cm	179
Lime Equivalent as CaCO3	% w/w	14.1
Water Soluble Magnesium	mg/kg	51.9
Water Soluble Phosphorus	mg/kg	<0.01
Water Soluble Potassium	mg/kg	76.8
Water Soluble Sulphur	mg/kg	203
Water Soluble Calcium	mg/kg	273
N. V. as CaO equivalents	% w/w	7.92

Released by Darren Whitbread Date 25/09/18

How does your sample analysis compare with the 'standard' figures for organic manures?

Farmyard Manure	Dry Matter (% DM)	Total Nitrogen (Kg N/t)	Total Phosphate (Kg P2O5/t)	Total Potash (Kg K2O/t)	Total Sulphur (Kg SO3/t)	Total Magnesium (Kg MgO/t)
Cattle FYM	25	6.0	3.2	9.4	2.4	1.8
Pig FYM	25	7.0	6.0	8.0	3.4	1.8
Sheep FYM	25	7.0	3.2	8.0	4.0	2.8
Duck FYM	25	6.5	5.5	7.5	2.6	2.4
Horse FYM	25	5.0	5.0	6.0	1.6	1.5
Goat FYM	40	9.5	4.5	12.0	2.8	1.8

Notes: The 'standard' phosphate & potash availability figures to the next crop grown from Defra's Fertiliser Manual are 60% & 90% respectively.

Poultry Manure	Dry Matter (% DM)	Total Nitrogen (Kg N/t)	Total Phosphate (Kg P2O5/t)	Total Potash (Kg K2O/t)	Total Sulphur (Kg SO3/t)	Total Magnesium (Kg MgO/t)
	20	9.4	8.0	8.5	3.0	2.7
	40	19.0	12.0	15.0	5.6	4.3
	60	28.0	17.0	21.0	8.2	5.9
	80	37.0	21.0	27.0	11.0	7.5

Notes: The 'standard' phosphate & potash availability figures to the next crop grown from Defra's Fertiliser Manual are 60% & 90% respectively.

Cattle & Pig Slurries	Dry Matter (% DM)	Total Nitrogen (Kg N/m3)	Total Phosphate (Kg P2O5/m3)	Total Potash (Kg K2O/m3)	Total Sulphur (Kg SO3/m3)	Total Magnesium (Kg MgO/m3)
Cattle slurry	6.0	2.6	1.2	2.5	0.7	0.6
Dirty water (from cattle)	0.5	0.5	0.1	1.0	0.1	0.1
Separated cattle slurries						
- strainer box liquid	1.5	1.5	0.3	1.5	ND	ND
- weeping wall liquid	3.0	2.0	0.5	2.3	ND	ND
- mechanically separated liquid	4.0	3.0	1.2	2.8	ND	ND
- solid portion after separation	20.0	4.0	2.0	3.3	ND	ND
Pig slurry	4.0	3.6	1.5	2.2	0.7	0.7
Separated pig slurry - liquid	3.0	3.6	1.1	2.0	ND	ND
Separated pig slurry - solid	20.0	5.0	3.7	2.0	ND	ND

Notes: ND = no data.
The 'standard' phosphate & potash availability figures to the next crop grown from Defra's Fertiliser Manual are 50% & 90% respectively (50% & 100% for dirty water).

Biosolids	Dry Matter (% DM)	Total Nitrogen (Kg N/t)	Total Phosphate (Kg P2O5/t)	Total Potash (Kg K2O/t)	Total Sulphur (Kg SO3/t)	Total Magnesium (Kg MgO/t)
Digested cake	25	11.0	11.0	0.6	8.2	1.6
Thermally dried	95	40.0	55.0	2.0	23.0	6.0
Lime stablised	25	8.5	7.0	0.8	7.4	2.4
Composted	40	11.0	10.0	3.0	6.1	2.0

Notes: The 'standard' phosphate & potash availability figures to the next crop grown from Defra's Fertiliser Manual are 50% & 90% respectively.

Other Organic Manures	Dry Matter	Total Nitrogen	Total Phosphate	Total Potash	Total Sulphur	Total Magnesium
Composts	(% DM)	(Kg N/t)	(Kg P2O5/t)	(Kg K2O/t)	(Kg SO3/t)	(Kg MgO/t)
Green compost	60	7.5	3.0	6.8	3.4	3.4
Green/food compost	60	11.0	4.9	8.0	5.1	3.4
Mushroom compost	35	6.0	5.0	9.0	ND	ND
Digestates						
Food-based whole	4.1	4.8	1.1	2.4	0.7	0.2
Food-based separated liquor	3.8	4.5	1.0	2.8	1.0	0.2
Food-based separated fibre	27.0	8.9	10.2	3.0	4.0	2.2
Farm-sourced whole	5.5	3.6	1.7	4.0	0.8	0.6
Farm-sourced separated liquor	3.0	1.9	0.6	2.5	<0.1	0.4
Farm-sourced separated fibre	24.0	5.6	4.7	6.0	1.2	1.8
Paper Crumble						
Chemically / physically treated	40	2.0	0.4	0.2	0.6	1.4
Biologically treated	30	7.5	3.8	0.4	2.4	1.0
Water Treatment Cake						
Water treatment cake	25	2.4	3.4	0.4	5.5	0.8
Food industry 'wastes'	(% DM)	(Kg N/m3)	(Kg P2O5/m3)	(Kg K2O/m3)	(Kg SO3/m3)	(Kg MgO/m3)
Dairy waste	4	1.0	0.8	0.2	ND	ND
Soft drinks waste	4	0.3	0.2	Trace	ND	ND
Brewing waste	7	2.0	0.8	0.2	ND	ND
General food waste	5	1.6	0.7	0.2	ND	ND

Notes: ND = no data.

The 'standard' figures for the above organic manures have been taken from Defra's Fertiliser Manual 2017 (RB209) 9th edition and the corresponding PLANET version 3 software. Further information on fertiliser recommendations for organic manures can be obtained from the Fertiliser Manual or from a FACTS qualified adviser.

envirolab
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FINAL ANALYTICAL TEST REPORT

Envirolab Job Number: 18/08116
Issue Number: 1 **Date:** 19 October, 2018

Client:
British Waterways Scotland
Canal House
1 Applecross Street
Glasgow
G4 9SP

Project Manager: Julia Johnstone
Project Name: Laggan
Project Ref: SC/072
Order No: PO00012269
Date Samples Received: 02/10/18
Date Instructions Received: 04/10/18
Date Analysis Completed: 17/10/18

Prepared by:

Melanie Marshall
Laboratory Coordinator

Approved by:

Richard Wong
Client Manager

Envirolab Job Number: 18/08116

Client Project Name: Laggan

Client Project Ref: SC/072

Lab Sample ID	18/08116/1	18/08116/2	18/08116/3	18/08116/4	18/08116/5	18/08116/6			Units	Method ref
Client Sample No	SC/072/001	SC/072/002	SC/072/003	SC/072/004	SC/072/005	SC/072/006				
Client Sample ID	C1 500m from Laggan Spout Towards Laggan Locks	250m from Laggan Spout towards Laggan Locks	At Laggan Spout	250m from Laggan Spout towards Loch Oich	500m from Laggan Spout towards Loch Oich	Stilling Basin at Laggan Spout				
Depth to Top										
Depth To Bottom										
Date Sampled	28-Sep-18	28-Sep-18	28-Sep-18	28-Sep-18	28-Sep-18	28-Sep-18				
Sample Type	Soil	Soil	Soil	Soil	Soil	Solid				
Sample Matrix Code	4E	4E	4A	4E	4E	7				
% Moisture at <40C$_A$	75.9	69.8	15.0	66.4	64.9	12.1			% w/w	A-T-044
% Stones >10mm$_A$	<0.1	<0.1	13.2	<0.1	<0.1	<0.1			% w/w	A-T-044
pH$_D^{M\#}$	6.61	6.78	7.14	6.99	6.31	6.87			pH	A-T-031s
Carbonate as CaCO3$_D$	0.9	2.9	2.3	2.7	1.9	1.7			% w/w	CO3s
ANC to pH4$_D$	0.03	0.03	0.03	0.05	0.09	0.06			mol/kg	A-T-ANCs
ANC to pH6$_D$	0.01	0.01	<0.01	0.01	0.03	0.01			mol/kg	A-T-ANCs
Electrical conductivity @ 20degC$_D$	207	146	26	120	98	21			µs/cm	A-T-037s
Ammonium / Ammoniacal Nitrogen as NH4$_D$	92.3	89.9	1.51	65	36.7	1.35			mg/kg	A-T-033s
Nitrate (water sol 2:1)$_D$	<2	<1	<1	<1	<1	<1			mg/kg	A-T-026s
Nitrogen, Total$_A$	4447	3408	115	2260	1685	67			mg/kg	Subcon Yara
Sulphate (water sol 2:1)$_D^{M\#}$	0.03	0.02	<0.01	0.03	0.02	<0.01			g/l	A-T-026s
Sulphate (acid soluble)$_D^{M\#}$	860	710	<200	660	570	<200			mg/kg	A-T-028s
Sulphur (total)$_D$	898	826	86	679	641	61			mg/kg	A-T-024s
Cyanide (total)$_A^{M\#}$	<1	<1	<1	<1	<1	<1			mg/kg	A-T-042sTCN
Phenols - Total by HPLC$_A$	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2			mg/kg	A-T-050s
Sulphide$_A$	<5	<5	<5	<5	<5	<5			mg/kg	A-T-S2-s
Loss on ignition (550degC)$_D$	17.7	15.9	0.8	11.9	10.1	1.6			% w/w	A-T-030s
Total Organic Carbon$_D^{M\#}$	7.65	7.66	0.19	4.95	4.76	3.28			% w/w	A-T-032s
Total Carbon$_D$	7.5	8.7	0.2	6.0	6.0	4.0			% w/w	A-T-032s
Total Inorganic Carbon$_D$	<0.1	<0.1	<0.1	<0.1	<0.1	0.7			%	A-T-032s
Arsenic$_D^{M\#}$	<1	<1	<1	<1	<1	<1			mg/kg	A-T-024s
Barium$_D$	124	120	48	117	139	50			mg/kg	A-T-024s
Boron (water soluble)$_D^{M\#}$	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0			mg/kg	A-T-027s
Cadmium$_D^{M\#}$	1.1	1.0	0.5	0.9	0.7	0.5			mg/kg	A-T-024s
Calcium$_D$	2210	2360	1340	2210	2170	1170			mg/kg	A-T-024s
Copper$_D^{M\#}$	21	19	6	18	15	6			mg/kg	A-T-024s
Chromium$_D^{M\#}$	40	38	18	35	38	28			mg/kg	A-T-024s
Lead$_D^{M\#}$	31	28	8	27	143	9			mg/kg	A-T-024s
Magnesium$_D$	6360	5720	3880	5380	5270	4520			mg/kg	A-T-024s
Mercury$_D$	0.35	<0.17	<0.17	<0.17	<0.17	<0.17			mg/kg	A-T-024s
Molybdenum$_D^{M\#}$	<1	<1	<1	<1	<1	<1			mg/kg	A-T-024s

Envirolab Job Number: 18/08116

Client Project Name: Laggan

Client Project Ref: SC/072

Lab Sample ID	18/08116/1	18/08116/2	18/08116/3	18/08116/4	18/08116/5	18/08116/6			Units	Method ref
Client Sample No	SC/072/001	SC/072/002	SC/072/003	SC/072/004	SC/072/005	SC/072/006				
Client Sample ID	C1 500m from Laggan Spout Towards Laggan Locks	250m from Laggan Spout towards Laggan Locks	At Laggan Spout	250m from Laggan Spout towards Loch Oich	500m from Laggan Spout towards Loch Oich	Stilling Basin at Laggan Spout				
Depth to Top										
Depth To Bottom										
Date Sampled	28-Sep-18	28-Sep-18	28-Sep-18	28-Sep-18	28-Sep-18	28-Sep-18				
Sample Type	Soil	Soil	Soil	Soil	Soil	Solid				
Sample Matrix Code	4E	4E	4A	4E	4E	7				
Nickel$_D^{M\#}$	26	26	17	26	24	20			mg/kg	A-T-024s
Phosphorus$_D$	652	712	321	829	751	439			mg/kg	A-T-024s
Potassium$_D$	2630	2370	694	2310	2140	718			mg/kg	A-T-024s
Selenium$_D^{\#}$	2	2	<1	1	<1	<1			mg/kg	A-T-024s
Tin$_D$	<5	<5	<5	<5	11	<5			mg/kg	A-T-024s
Vanadium$_D^{M\#}$	36	36	16	31	32	15			mg/kg	A-T-024s
Zinc$_D^{M\#}$	86	78	41	72	65	42			mg/kg	A-T-024s
1.12a PSD (3.35mm-2um clay)(Sedimentation by Pipette/Hydrometer)BS1377 1990 pt2cl9.4/9.5$_A$	Appended	Appended	Insufficient Sample	Appended	Appended	Insufficient Sample				Subcon SS
1.10 PSD (Grading/63um/sand fraction/wet sieve) BS1377 pt 2 1990 cl 9.2$_A^{\#}$	-	-	Appended	-	-	Appended				Subcon SS
BTEX										
BTEX - Benzene$_A^{\#}$	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			mg/kg	A-T-022s
BTEX - Toluene$_A^{\#}$	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			mg/kg	A-T-022s
BTEX - Ethyl Benzene$_A^{\#}$	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			mg/kg	A-T-022s
BTEX - m & p Xylene$_A^{\#}$	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			mg/kg	A-T-022s
BTEX - o Xylene$_A^{\#}$	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			mg/kg	A-T-022s
PAH-8MS Carcinogenic										
Benzo(a)anthracene$_A^{M\#}$	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04			mg/kg	A-T-019s
Benzo(a)pyrene$_A^{M\#}$	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04			mg/kg	A-T-019s
Benzo(b)fluoranthene$_A^{M\#}$	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05			mg/kg	A-T-019s
Benzo(b)(j)(k)fluoranthene$_A$	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07			mg/kg	A-T-019s
Benzo(k)fluoranthene$_A^{M\#}$	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07			mg/kg	A-T-019s
Chrysene$_A^{M\#}$	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06			mg/kg	A-T-019s
Dibenzo(ah)anthracene$_A^{M\#}$	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04			mg/kg	A-T-019s
Indeno(123-cd)pyrene$_A^{M\#}$	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03			mg/kg	A-T-019s

Envirolab Job Number: 18/08116

Client Project Name: Laggan

Client Project Ref: SC/072

Lab Sample ID	18/08116/1	18/08116/2	18/08116/3	18/08116/4	18/08116/5	18/08116/6			Units	Method ref
Client Sample No	SC/072/001	SC/072/002	SC/072/003	SC/072/004	SC/072/005	SC/072/006				
Client Sample ID	C1 500m from Laggan Spout Towards Laggan Locks	250m from Laggan Spout towards Laggan Locks	At Laggan Spout	250m from Laggan Spout towards Loch Oich	500m from Laggan Spout towards Loch Oich	Stilling Basin at Laggan Spout				
Depth to Top										
Depth To Bottom										
Date Sampled	28-Sep-18	28-Sep-18	28-Sep-18	28-Sep-18	28-Sep-18	28-Sep-18				
Sample Type	Soil	Soil	Soil	Soil	Soil	Solid				
Sample Matrix Code	4E	4E	4A	4E	4E	7				
Speciated PCB-EC7 & WHO12										
PCB BZ $28_A^{M\#}$	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			mg/kg	A-T-004s
PCB BZ $52_A^{M\#}$	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002			mg/kg	A-T-004s
PCB BZ 81_A	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005			mg/kg	A-T-004s
PCB BZ $101_A^{M\#}$	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004			mg/kg	A-T-004s
PCB BZ 105_A	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005			mg/kg	A-T-004s
PCB BZ 114_A	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005			mg/kg	A-T-004s
PCB BZ $118_A^{M\#}$	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007			mg/kg	A-T-004s
PCB BZ 123_A	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005			mg/kg	A-T-004s
PCB BZ 126_A	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005			mg/kg	A-T-004s
PCB BZ $138_A^{M\#}$	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006			mg/kg	A-T-004s
PCB BZ $153_A^{M\#}$	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004			mg/kg	A-T-004s
PCB BZ 156_A	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005			mg/kg	A-T-004s
PCB BZ 157_A	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005			mg/kg	A-T-004s
PCB BZ 167_A	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005			mg/kg	A-T-004s
PCB BZ 169_A	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005			mg/kg	A-T-004s
PCB BZ $180_A^{M\#}$	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004			mg/kg	A-T-004s
PCB BZ 189_A	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005			mg/kg	A-T-004s
PCB BZ 77_A	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005			mg/kg	A-T-004s
Total Speciated PCB-EC7 & $WHO12_A$	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007			mg/kg	A-T-004s
TPH Banded 2										
$>C6\text{-}C10_A^{M\#}$	<5	<5	<5	<5	<5	<5			mg/kg	A-T-007s
$>C10\text{-}C25_A^{M\#}$	33	30	<5	21	20	<5			mg/kg	A-T-007s
$>C25\text{-}C40_A^{\#}$	261	242	<5	170	171	9			mg/kg	A-T-007s
Total TPH Banded $2_A^{\#}$	294	272	<5	191	191	9			mg/kg	A-T-007s

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, 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
All analysis is performed on the sample as received for soil samples which are positive for asbestos or the client has informed asbestos may be present and/or if they are from outside the European Union and this supersedes any "D" subscripts.

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:
Asbestos in soil analysis is performed on a dried aliquot of the submitted sample and cannot guarantee to identify asbestos if only present in small numbers as discrete fibres/fragments in the original sample.
Stones etc. are not removed from the sample prior to analysis.
Quantification of asbestos is a 3 stage process including visual identification, hand picking and weighing and fibre counting by sedimentation/phase contrast optical microscopy if required. If asbestos is identified as being present but is not in a form that is suitable for analysis by hand picking and weighing (normally if the asbestos is present as free fibres) quantification by sedimentation is performed. Where ACMs are found a percentage asbestos is assigned to each with reference to 'HSG264, Asbestos: The survey guide' and the calculated asbestos content is expressed as a percentage of the dried soil sample aliquot used.

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.
Samples with Matrix Code 7 & 8 are not predominantly a SAND/LOAM/CLAY mix and are not covered by our BSEN 17025 or MCERTS accreditations, with the exception of bulk asbestos which are BSEN 17025 accredited.
Secondary Matrix Codes:
A = contains stones, B = contains construction rubble, C = contains visible hydrocarbons, D = contains glass/metal,
E = contains roots/twigs.

Key:
IS indicates Insufficient Sample for analysis.
US indicates Unsuitable Sample for analysis.
NDP indicates No Determination Possible.
NAD indicates No Asbestos Detected.
N/A indicates Not Applicable.
Superscript # indicates method accredited to ISO 17025.
Superscript "M" indicates method accredited to MCERTS.
Subscript "A" indicates analysis performed on the sample as received.
Subscript "D" indicates analysis performed on the dried sample, crushed to pass a 2mm sieve

Please contact us if you need any further information.

STRUCTURAL SOILS LTD

TEST REPORT

1774

Report No. 783437 R1

Date 17-October-2018 Contract 18/08116

Client Envirolab Ltd
Address Units 7 & 8 Sandpits Business Park
Mottram Road
Hyde
SK14 3AR

For the Attention of Iain Haslock

Samples submitted by client	04/10/2018	Client Reference	18/08116
Testing Started	05/10/2018	Client Order No.	P0739233
Testing Completed	17/10/2018	Instruction Type	Written

UKAS Accredited Tests Undertaken

Particle Size Distribution wet sieve method BS1377:Part 2:1990,clause 9.2
Particle Size Distribution sedimentation pipette method BS1377:Part 2:1990,clause 9.4

* This clause of BS1377 is no longer the most up to date method due to the publication of ISO17892

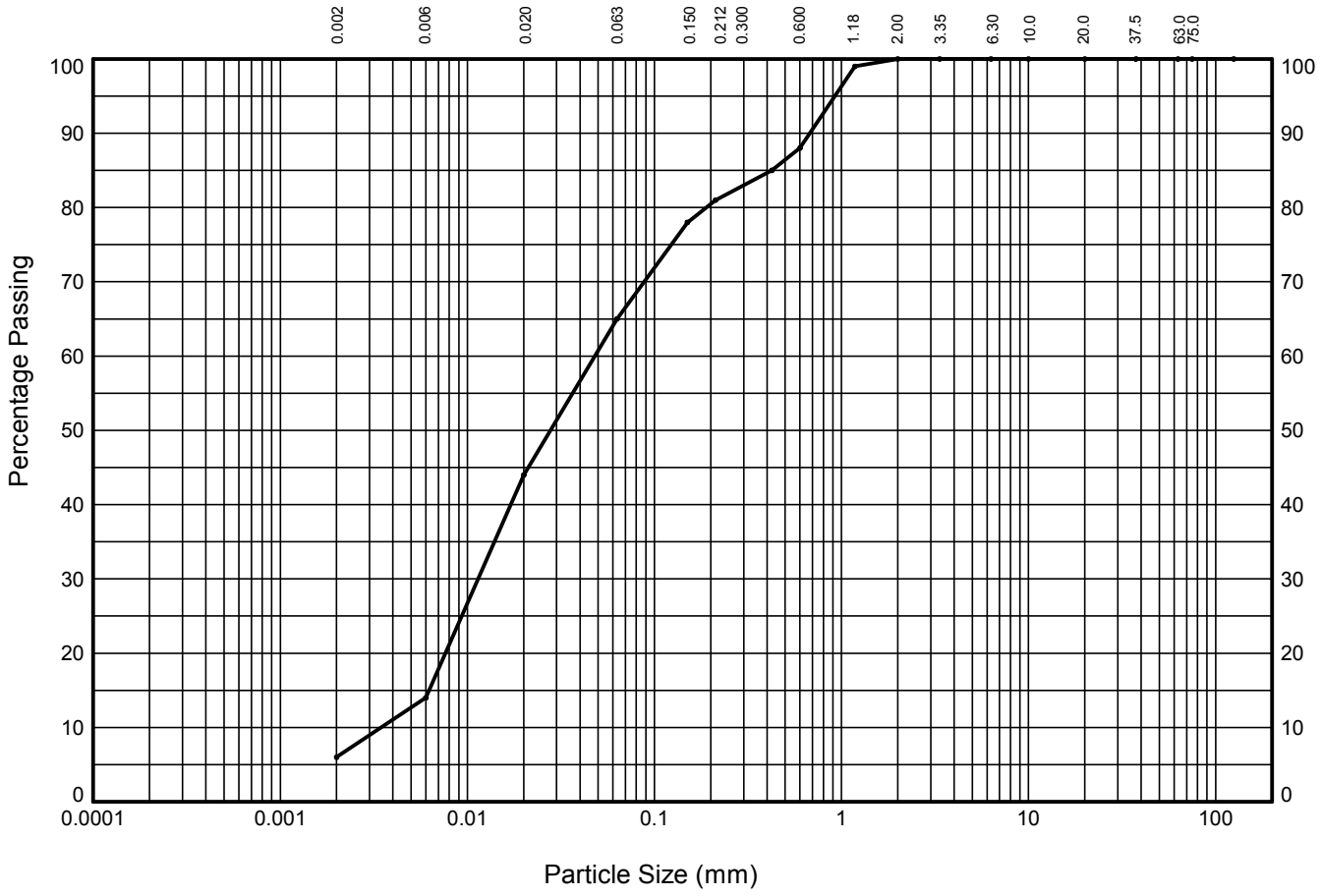
Please Note: Remaining samples will be retained for a period of one month from today and will then be disposed of.
Test were undertaken on samples 'as received' unless otherwise stated.
Opinions and interpretations expressed in this report are outside the scope of accreditation for this laboratory.

Structural Soils Ltd, The Potteries, Pottery Street, Castleford, WF10 1NJ Tel.01977 552255. E-mail mark.athorne@soils.co.uk

PARTICLE SIZE DISTRIBUTION TEST

In accordance with clauses 9.2, 9.4 of BS1377:Part 2:1990

Position ID: **250m from LS towards LL** Sample Ref: **18/08116/2** Sample Type: **B** Depth (m): **-**



CLAY	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	COBBLES
	SILT			SAND			GRAVEL			

Test Sieve (mm)	Percent Passing (%)
125.0	**100**
75.0	**100**
63.0	**100**
37.5	**100**
20.0	**100**
10.0	**100**
6.30	**100**
3.35	**100**
2.00	**100**
1.18	**99**
0.600	**88**
0.425	**85**
0.212	**81**
0.150	**78**
0.063	**65**

Particle Diameter (mm)	Percent Passing (%)
0.02	**44**
0.006	**14**
0.002	**6**

Sedimentation sample was not pre-treated

Soil Fraction	Sieve Percentage (%)
GRAVEL	**0**
SAND	**35**
SILT	**59**
CLAY	**6**

Soil Description:

Brown slightly clayey sandy SILT

STRUCTURAL SOILS
The Potteries
Pottery Street
Castleford
W. Yorkshire WF10 1NJ

Compiled By		Date
Sarah Mundy	**SARAH MUNDY**	**17/10/18**

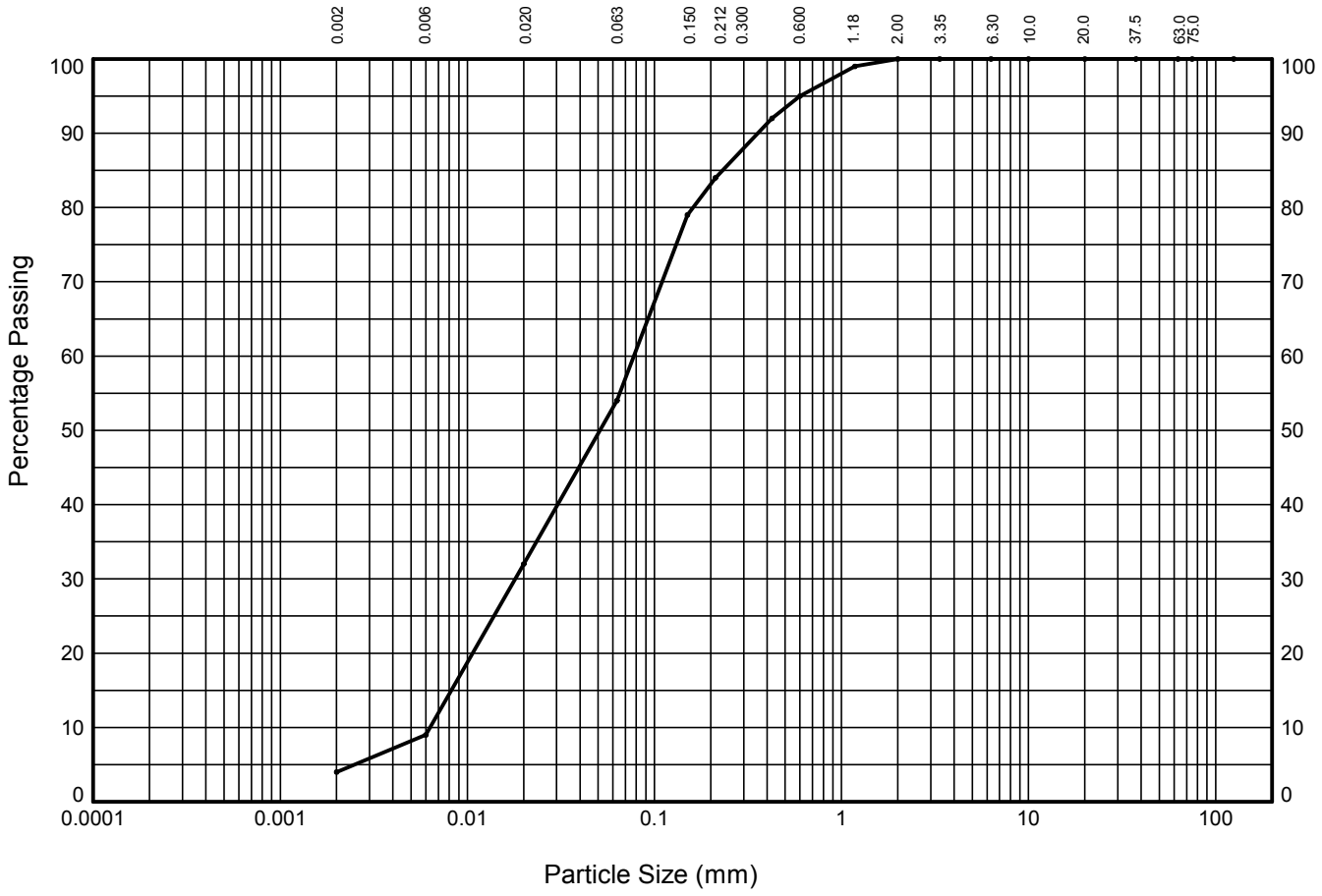
Contract	Contract Ref:
18/08116	**783437**

AGS

PARTICLE SIZE DISTRIBUTION TEST

In accordance with clauses 9.2, 9.4 of BS1377:Part 2:1990

Position ID: **250m from LS towards LO** Sample Ref: **18/072/004** Sample Type: **B** Depth (m): **-**



CLAY	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	COBBLES
	SILT			SAND			GRAVEL			

Test Sieve (mm)	Percent Passing (%)
125.0	**100**
75.0	**100**
63.0	**100**
37.5	**100**
20.0	**100**
10.0	**100**
6.30	**100**
3.35	**100**
2.00	**100**
1.18	**99**
0.600	**95**
0.425	**92**
0.212	**84**
0.150	**79**
0.063	**54**

Particle Diameter (mm)	Percent Passing (%)
0.02	**32**
0.006	**9**
0.002	**4**

Sedimentation sample was not pre-treated

Soil Fraction	Sieve Percentage (%)
GRAVEL	**0**
SAND	**46**
SILT	**50**
CLAY	**4**

Soil Description:

Brown slightly clayey sandy SILT

STRUCTURAL SOILS
The Potteries
Pottery Street
Castleford
W. Yorkshire WF10 1NJ

Compiled By		Date
Sarah Mundy	**SARAH MUNDY**	**17/10/18**

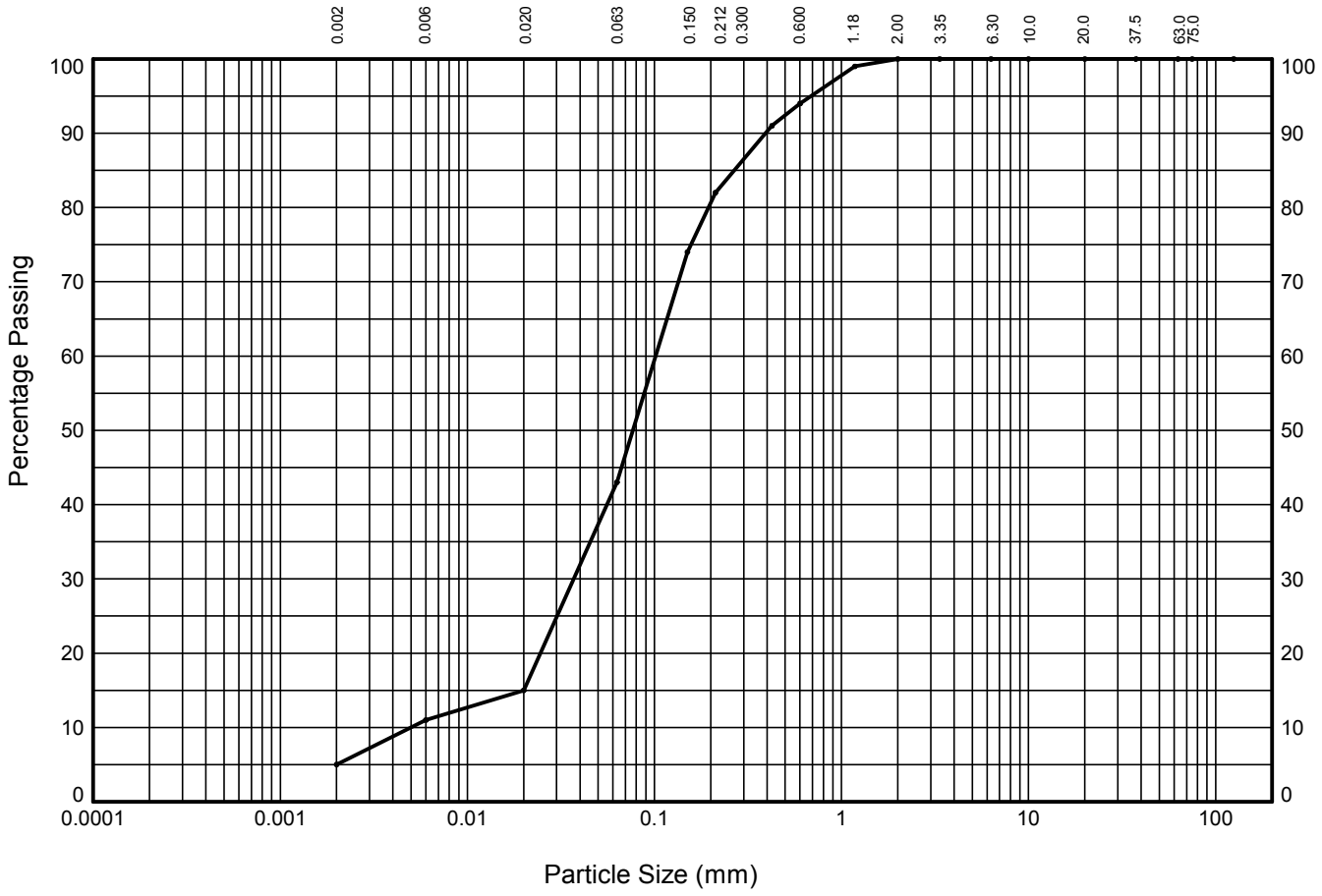
Contract	Contract Ref:
18/08116	**783437**

AGS

PARTICLE SIZE DISTRIBUTION TEST

In accordance with clauses 9.2, 9.4 of BS1377:Part 2:1990

Position ID: **500m from LS towards LO** Sample Ref: **18/072/005** Sample Type: **B** Depth (m): **-**



CLAY	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	COBBLES
	SILT			SAND			GRAVEL			

Test Sieve (mm)	Percent Passing (%)
125.0	**100**
75.0	**100**
63.0	**100**
37.5	**100**
20.0	**100**
10.0	**100**
6.30	**100**
3.35	**100**
2.00	**100**
1.18	**99**
0.600	**94**
0.425	**91**
0.212	**82**
0.150	**74**
0.063	**43**

Particle Diameter (mm)	Percent Passing (%)
0.02	**15**
0.006	**11**
0.002	**5**

Sedimentation sample was not pre-treated

Soil Fraction	Sieve Percentage (%)
GRAVEL	**0**
SAND	**57**
SILT	**38**
CLAY	**5**

Soil Description:

Brown slightly clayey silty SAND

STRUCTURAL SOILS
The Potteries
Pottery Street
Castleford
W. Yorkshire WF10 1NJ

Compiled By		Date
M. Athorne	**MARK ATHORNE**	**17/10/18**

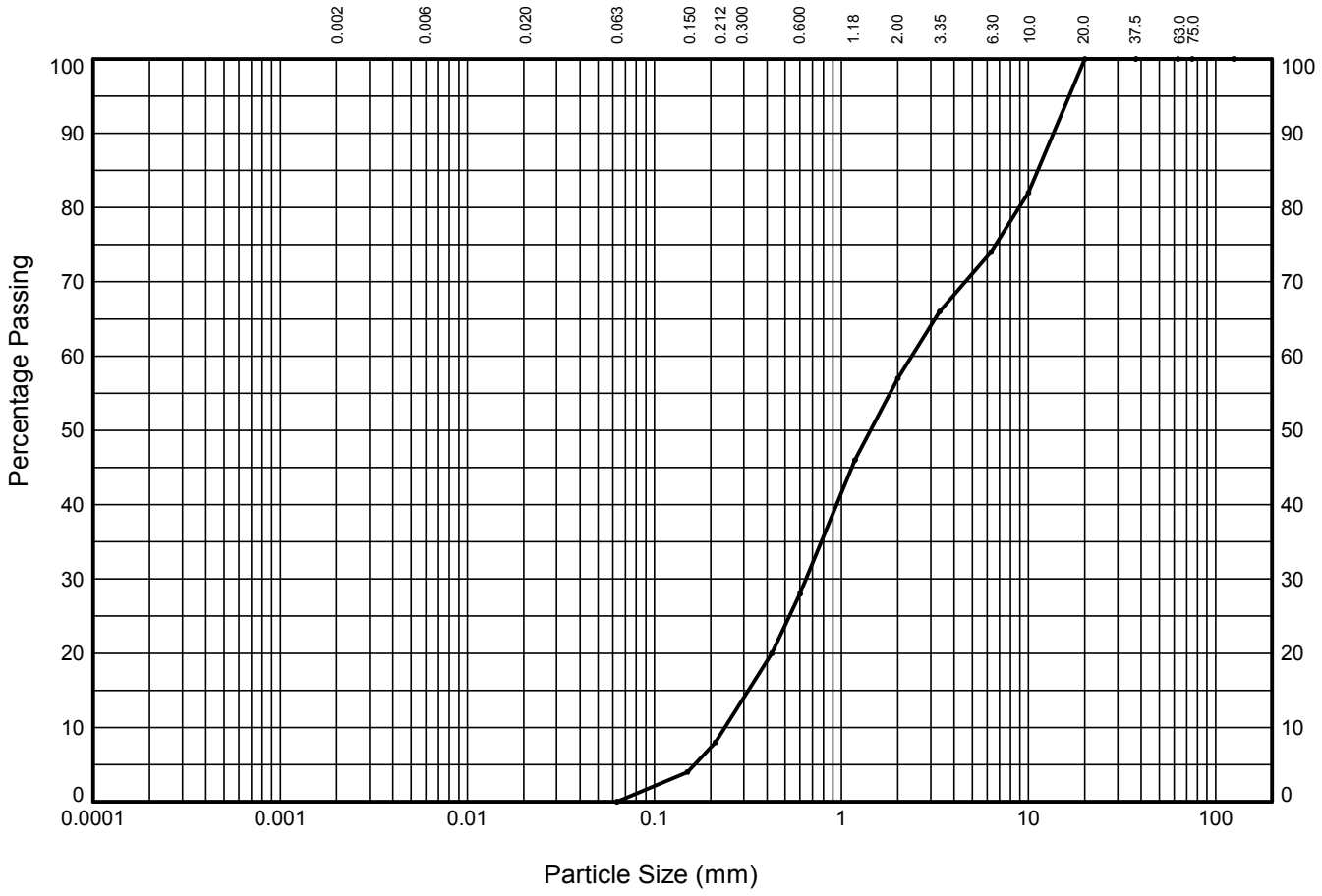
Contract	Contract Ref:
18/08116	**783437**

AGS

PARTICLE SIZE DISTRIBUTION TEST

In accordance with clauses 9.2 of BS1377:Part 2:1990

Position ID: **At Laggan Spout** Sample Ref: **18/08116/3** Sample Type: **B** Depth (m): **-**



CLAY	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	COBBLES
	SILT			SAND			GRAVEL			

Test Sieve (mm)	Percent Passing (%)
125.0	**100**
75.0	**100**
63.0	**100**
37.5	**100**
20.0	**100**
10.0	**82**
6.30	**74**
3.35	**66**
2.00	**57**
1.18	**46**
0.600	**28**
0.425	**20**
0.212	**8**
0.150	**4**
0.063	**0**

Particle Diameter (mm)	Percent Passing (%)

Sedimentation sample was not pre-treated

Soil Fraction	Sieve Percentage (%)
GRAVEL	**43**
SAND	**57**
SILT/CLAY	**0**

Soil Description:

Brown very gravelly SAND

STRUCTURAL SOILS
The Potteries
Pottery Street
Castleford
W. Yorkshire WF10 1NJ

Compiled By		Date
Sarah Mundy.	**SARAH MUNDY**	**17/10/18**

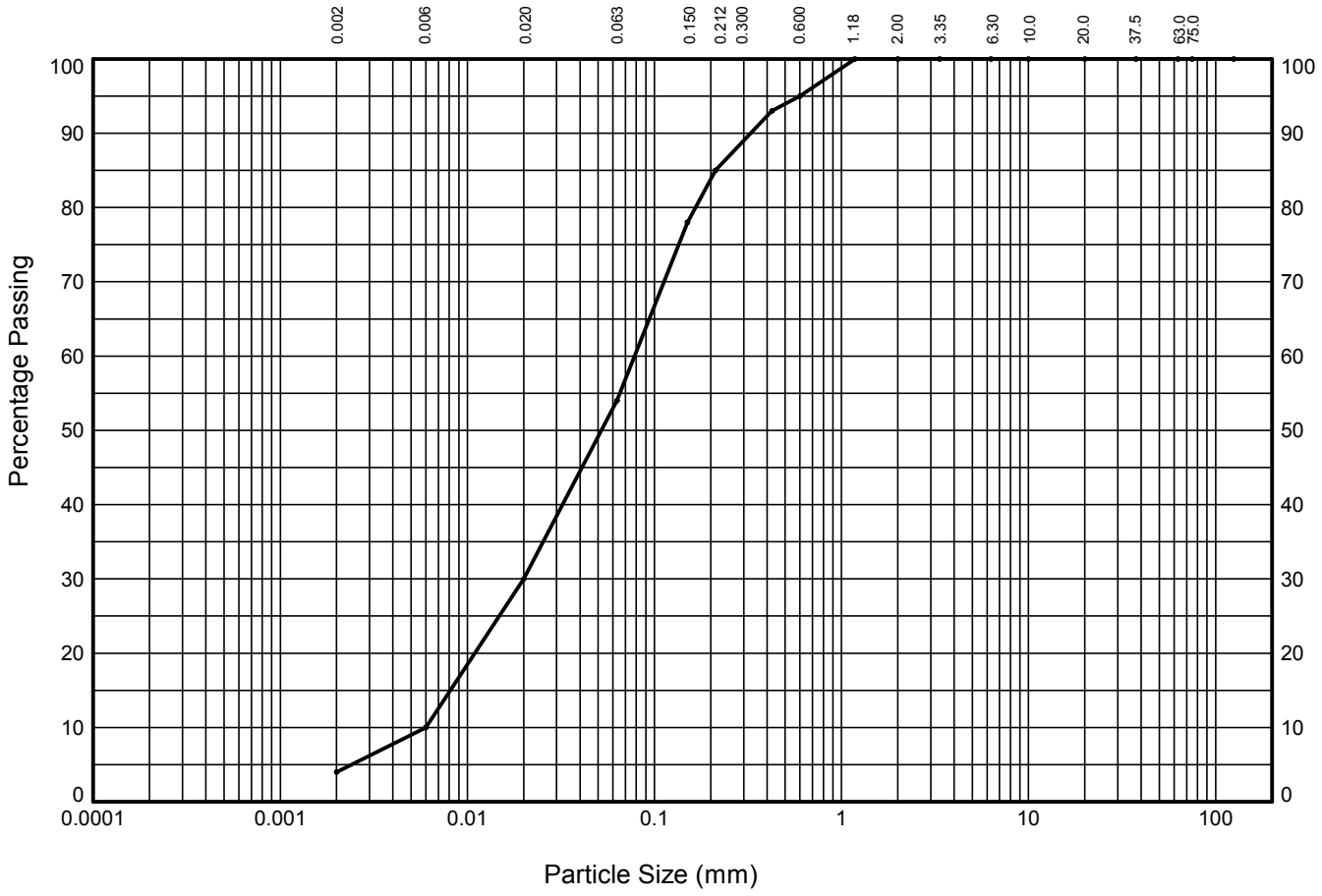
Contract	Contract Ref:
18/08116	**783437**

AGS

PARTICLE SIZE DISTRIBUTION TEST

In accordance with clauses 9.2, 9.4 of BS1377:Part 2:1990

Position ID: **C1 500m from LS towards LL** Sample Ref: **18/08116/1** Sample Type: **B** Depth (m): **-**



CLAY	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	COBBLES
	SILT			SAND			GRAVEL			

Test Sieve (mm)	Percent Passing (%)
125.0	**100**
75.0	**100**
63.0	**100**
37.5	**100**
20.0	**100**
10.0	**100**
6.30	**100**
3.35	**100**
2.00	**100**
1.18	**100**
0.600	**95**
0.425	**93**
0.212	**85**
0.150	**78**
0.063	**54**

Particle Diameter (mm)	Percent Passing (%)
0.02	**30**
0.006	**10**
0.002	**4**

Sedimentation sample was not pre-treated

Soil Fraction	Sieve Percentage (%)
GRAVEL	**0**
SAND	**46**
SILT	**50**
CLAY	**4**

Soil Description:

Brown slightly clayey sandy SILT

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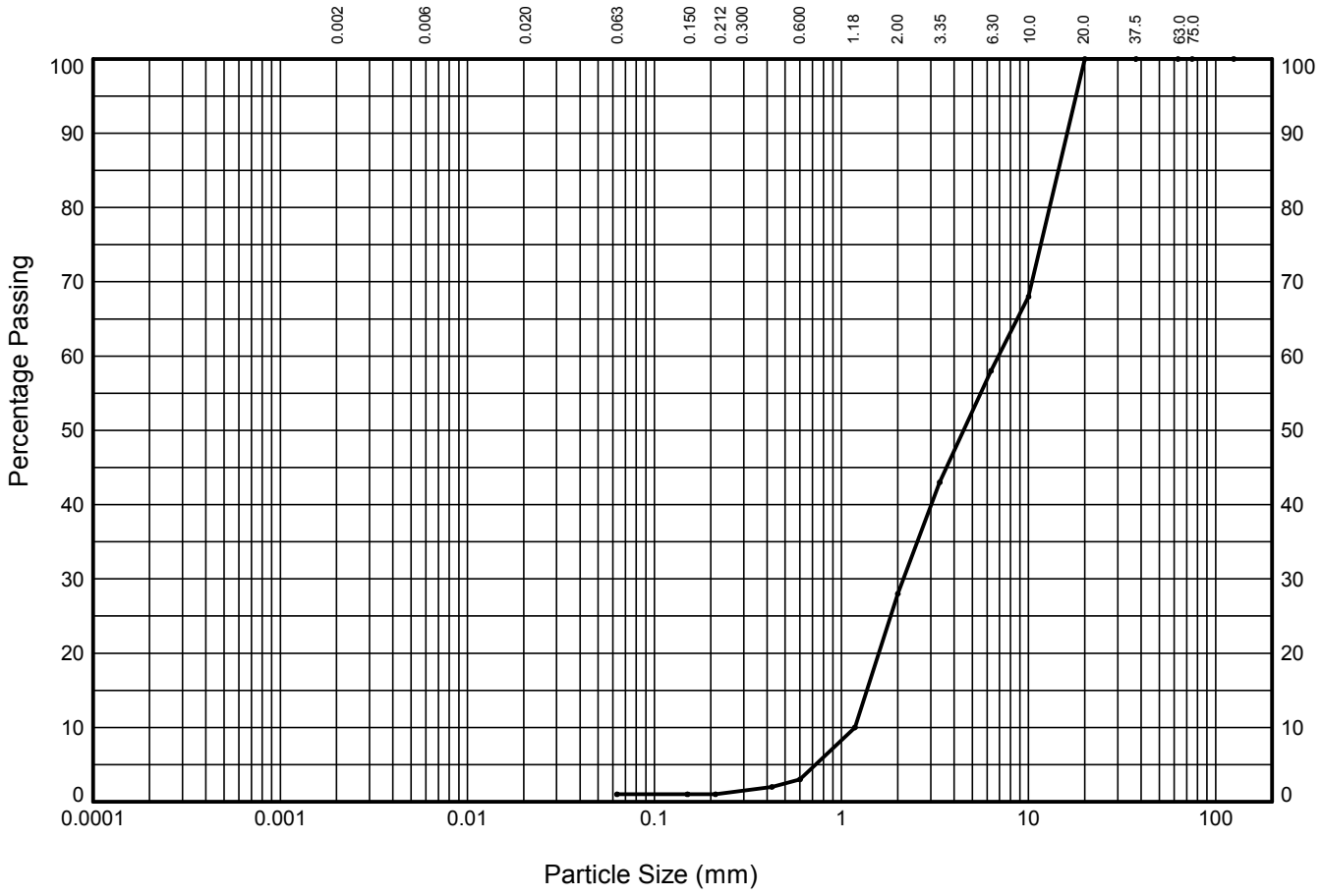
Contract	Contract Ref:
18/08116	**783437**

AGS

PARTICLE SIZE DISTRIBUTION TEST

In accordance with clauses 9.2 of BS1377:Part 2:1990

Position ID: **Stilling Basin at LS** Sample Ref: **18/072/006** Sample Type: **B** Depth (m): **-**



CLAY	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	COBBLES
	SILT			SAND			GRAVEL			

Test Sieve (mm)	Percent Passing (%)
125.0	**100**
75.0	**100**
63.0	**100**
37.5	**100**
20.0	**100**
10.0	**68**
6.30	**58**
3.35	**43**
2.00	**28**
1.18	**10**
0.600	**3**
0.425	**2**
0.212	**1**
0.150	**1**
0.063	**1**

Particle Diameter (mm)	Percent Passing (%)

Sedimentation sample was not pre-treated

Soil Fraction	Sieve Percentage (%)
GRAVEL	**72**
SAND	**27**
SILT/CLAY	**1**

Soil Description:

Brown slightly clayey very sandy GRAVEL

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Contract	Contract Ref:
18/08116	**783437**

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