Appendix 9.1.3

Geotechnical Report PM 2009

IGSL
Ltd.

Meath Waste Management Facility

Factual Ground Investigation Report
(Project No. 14039)

Indaver Ireland
PM Group

May 2009

Meath Waste Management Facility

Carranstown, Duleek, Co. Meath

Factual Geotechnical Investigation Report

(Report No. 14039)

Client: Indaver Ireland

Engineer: PM Group Ltd

May 2009

IGSL Ltd

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APPENDICES

FOREWORD

The following conditions and notes on site investigation procedures should be read in conjunction with this report.

General

The ground investigation works have been carried out in accordance with BS 5930 (1990) and the IEI Specification & Related Documents for Ground Investigation in Ireland (2006). No responsibility can be held for conditions which have not been revealed by exploratory work, or which occur between exploratory hole locations.

Whilst the report may suggest the likely configuration of strata, both between exploratory hole locations, or below the maximum depth of the investigation, this is only indicative, and liability cannot be accepted for its accuracy. Unless specifically stated, no account has been taken of possible subsidence due to mineral extraction below or close to the site.

Boring Procedures

Unless otherwise stated, the 'Shell and Auger' technique of soft ground boring has been employed. All boring operations sampling and/or logging of soils and in-situ testing complies with the recommendations of the British Standard Code of Practice BS 5930 (1981), 'Site Investigation' and BS 1377:1990, 'Methods of test for soils for civil engineering purposes'.

Whilst the technique allows the maximum data to be obtained in soft ground, some disturbance and variation of soft and layered soils is unavoidable. Attention is drawn to this condition, whenever it is suspected. Where cobbles and boulders are recorded, no conclusion should be drawn concerning the size, presence, lithological nature, or numbers per unit volume of ground.

Where peat has been encountered during siteworks, samples have been logged in accordance with the Von Post Classification (ref. Von Post, L. 1992. Sveriges Gologiska Undersoknings torvinventering och nogra av dess hittils vunna resultat (SGU peat inventory and some preliminary results) Svenska Mosskulturforeningens Tidskrift, Jonkoping, Swedden, 36, 1-37 & Hobbs N. B. Mire morphology and the properties of some British and foreign peats. QJEG, Vol. 19, 1986).

Routine Sampling

Undisturbed samples of soils, predominantly cohesive in nature are obtained unless otherwise stated by a 104mm diameter open-drive tube sampler. In granular soils, and where undisturbed sampling is inappropriate, disturbed samples are collected. Smaller disturbed samples are also recovered at intervals to allow a visual examination of the full strata section.

In-Situ Testing

Standard penetration tests, utilising either the standard split spoon sampler or solid cone and automatic trip-hammer are conducted unless otherwise where required by instruction. Subsequent to a seating drive of 150mm, a summation for the number of blows for 300mm penetration is recorded on the boring records together with the blow count for each 75mm penetration. In cases where incomplete penetration is obtained, the number of blows for the depth of penetration are recorded. In coarse granular soils, a cone end is fitted to the sampler and a similar procedure adopted.

Groundwater

The depth of entry of any influx of groundwater is recorded during the course of boring operations. However, the normal rate of boring does not usually permit the recording of an equilibrium level for any one water strike. Where possible drilling is suspended for a period of twenty minutes to monitor the subsequent rise in water level.

Groundwater conditions observed in the borings or pits are those appertaining to the period of investigation. It should be noted however, that groundwater levels are subject to diurnal, seasonal and climatic variations and can also be affected by drainage condition, tidal variation or other causes.

Retention of Samples

After satisfactory completion of all the scheduled laboratory tests on any sample, the remaining material will be discarded. Unless a period of retention of samples is agreed, it is our normal practice to discard all soil samples one month after submission of our final report.

Disclaimer

This report has been prepared for Project Management Group / Indaver Ireland and the information should not be used without prior approval or written permission of either party. IGSL Ltd accepts no responsibility or liability for this document being used other than for the purposes for which it was intended.

1. INTRODUCTION

At the request of Project Management (PM) and Indaver Ireland, IGSL has undertaken a programme of geotechnical investigation works for a waste to energy facility at Carranstown, Duleek, Co. Meath. The works were performed as directed by PM Group, consulting engineers for the project. The site is located at Carranstown, Duleek, Co. Meath and encompasses an area of approximately 25 acres. The site is bounded to the south by the R150 Duleek to Navan Road, to the east by the Platin Cement Works and farmland to the west and north.

It is understood that the proposed development will involve the construction of a waste management facility and include a waste handling area (bunker & furnace), emissions stack, ash bunker, workshop, office and administration buildings and general site infrastructure (i.e. roads, drainage, service utilities, culverts etc). The waste handling area will require a basement type structure (bunker) with a proposed dig depth of the order of 7m below existing ground level (i.e. formation of c23m OD). Site enabling works were completed prior to IGSL commencing the geotechnical investigations and produced a platform level of 30.5m OD. It is noted that a programme of geotechnical investigations were originally carried out in 2007 and details are presented in a report prepared by Byrne Looby Partners (B580 May 2007).

The geophysical and geotechnical fieldworks works for this phase were carried out in accordance with BS 5930, Code of Practice for Site Investigations (1999) and the IEI Specification & Related Documents for Ground Investigation in Ireland (2006). The fieldworks included geophysical surveying, rotary core drillholes and percolation tests. Core drillholes GC 1 to GC 5 were positioned at the footprint of the bunker (note the location of this structure was subsequently altered) while RP 1, 2 and 5 were located at a zone where karst weathering was identified in the original investigations. The geophysical surveying was performed by Apex Geoservices and included seismic refraction spreads and surface wave analysis (MASW) to determine small strain stiffness. Geotechnical soil and rock laboratory testing was performed on selected samples in accordance with BS 1377 and ISRM.

The primary objectives of the investigation were as follows:

- Evaluate rock quality, weathering profile, strength and fracture state of the bedrock at the proposed bunker & emissions stack
- Recover samples for geotechnical laboratory testing (soil & rock)
- Assess percolation characteristics of the upper soils at designated locations

This report presents the factual geotechnical data obtained from the exploratory locations and laboratory testing. A separate geotechnical interpretative report (GIR) has been prepared and includes a discussion of the ground conditions, engineering properties of the soils and bedrock and recommendations developed on the key geotechnical issues impacting on the proposed development. The locations of the exploratory holes are presented on a site plan in Appendix 7. It is noted that sampling of the glacial till from the waste bunker and stockpiles were scheduled by PM in March 2009 and this information is included in Appendix 8 (addendum to the final report issued on 30 March 2009).

2. FIELDWORK

2.1 General

The fieldworks were carried out during the period February 2009 and comprised the following:

- Rotary core drillholes (9 No.)
- Percolation tests (2 No.)
- Geophysical surveying

2.2 Rotary Drillholes

Rotary drilling was undertaken at nine locations using a top drive Knebel rig. Geobor core drilling methods were utilized at six locations (denoted GC 1 to GC 6) with conventional air mist drilling employed at three locations (RP 1, 2 & 5). The Geobor drilling system used polymer gel flush and recirculation tanks, with the emphasis on high quality recovery in the glacial soils and upper bedrock zone.

The Geobor coring produced 102mm diameter cores while the conventional coring produced 80mm diameter cores using air mist flush. Recovery in the Geobor holes was excellent with 100% recovery in the majority of the runs. The Geobor drillholes achieved depths of between 11.80 and 15.10m while each of the conventional holes terminated at depths of 10.50m. Each of the core drillholes were backfilled with cement/bentonite grout (tremmied) as directed by PM.

The rock cores were placed in 3m capacity timber boxes and logged by an IGSL engineering geologist. This included photography of the cores with a digital camera. The core log records are presented in Appendices 1 and 2 and include engineering geological descriptions of the rock cores, details of the bedding / discontinuities and mechanical indices (TCR, SCR and RQD's) for each core run.

Where rock core was recovered, a graphic fracture log is also presented alongside the mechanical indices. This illustrates the fracture state of the rock cores and allows easy identification of highly fractured / non-intact zones and discontinuity spacings. It should be noted that no correction for dip of the joints has been made and that the spacings shown are successive joint / core intersections within the core.

2.3 Percolation Tests

Percolation or soakaway tests were performed at two locations to evaluate the infiltration potential of the upper soils. The tests were conducted in accordance with BRE 365 guidelines and the data sheets are presented in Appendix 3. The infiltration rate values (F Values) were calculated using the field data and are shown on each of the logs.

2.4 Geophysical Surveying

Geophysical surveying was carried out by Apex Geoservices and included resistivity profiling, seismic refraction spreads and multi-channel analysis of surface waves to assess soil stiffness (GMax v depth). Details of the methodologies used, x-sections / profiles and maps are presented in a separate report by Apex Geoservices.

2.5 Trial Pits & Bulk Sampling for Stabilization Testing

Samples of the glacial till were taken from the footprint of the waste bunker and stockpiles to facilitate earthwork and stabilization testing. Two trial pits were excavated at the waste bunker footprint and both extended to a depth of 4m bgl. Large bulk disturbed samples were recovered (c 50 kg) and placed in heavy duty polyethene bags and returned to Naas for testing. The trial pit logs and associated laboratory test data are presented in Appendix 8.

3. LABORATORY TESTING

Geotechnical soil laboratory testing was performed on selected Geobor core samples in accordance with BS 1377 (1990). The soils testing included the following and results are presented in Appendices 4 and 8.

- Moisture content
- Particle size analysis
- Atterberg Limits (Liquid & Plastic Limits)
- Consolidated quick undrained triaxial
- Consolidation (oedometer)
- pH & sulphate
- California Bearing Ratio (CBR)
- Moisture Condition Value (MCV)
- CBR, MCV & sulphates following the addition of lime or cement binders

Rock testing was undertaken on representative core samples and focused on Point Load Strength Index (PLSI)) and unconfined compressive strength (UCS) tests in accordance with ISRM. The results of the rock testing are presented in Appendix 5.

References

1. BRE Digest 365 Soakaway Design

2. BS 5930 (1999) Code of Practice for Site Investigation, British Standards Institution (BSI).

3. BS 1377 (1990) Methods of Testing of Soils for Civil Engineering Purposes, BSI.

4. Indaver, Carranstown Geotechnical Assessment Report (B580), May 2007, Byrne Looby Partners

5. Site Investigation Practice: Assessing BS 5930 (1986), Geological Society Special Publication, No. 2.

KEY TO EXPLORATORY RECORDS

Cable Percussion Boreholes

D	Small Disturbed Sample
B	Large Disturbed Sample
T	Tub Sample (for moisture content profiling)
U100	Undisturbed Sample (driven tube sample)
W	Groundwater Sample
C	SPT N-Value (Solid Cone)
S	SPT N-Value (Split Spoon / Open Shoe)
FHT	Falling Head Permeability Test
RHT	Rising Head Permeability Test

Rotary Core Drillholes

TCR	Total Core Recovery (%)
SCR	Solid Core Recovery (%)
RQD	Rock Quality Designation Value (%)
FS	Fracture Spacing (mm) Presented as Graphic Fracture Log
NI	Non-Intact (where rock core is highly fractured)
ECL	Estimated Core Loss

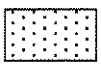
Trial Pits

B	Bulk Disturbed Sample
T	Tub Sample
VT	Vane Test (KPa) Using Genor H-70 Hand Vane
HP	Hand Penetrometer Test (KPa)
W	Groundwater Sample

Groundwater Installations

SP	Standpipe (uPVC 50mm diameter with 1mm slots)
Piez	Casagrande Piezometer (19mm diameter)

Strata Legends / Symbolic Logs



Strata legends / symbolic logs are in accordance with BS 5930 (1999). Legend codes are selected from Holebase / GINT to reflect stratum.

Appendix 1

Rotary Core Drillhole Records (Geobor Holes)

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 14039

CONTRACT	Indaver Waste Management Facility, Duleek	**DRILLHOLE NO**	**RC GC1**
		SHEET	Sheet 1 of 2
CO-ORDINATES	306,263.87 E 270,930.70 N	**GROUND LEVEL (m)**	30.10
		CORE DIAMETER (mm)	102
		DATE STARTED	17/02/2009
		DATE COMPLETED	17/02/2009
CLIENT	Indaver	**INCLINATION**	-90
ENGINEER	PM Group	**FLUSH**	Polymer Gel
		DRILLED BY	Petersen
		LOGGED BY	A. Mahony

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Non-intact zones	Strata description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
0								OPEN HOLE DRILLING: Observed by driller as returns of brown silty, very sandy gravelly clay	0.80		29.30		
1	0.80	86	0	0				Soft brown sandy gravelly CLAY. Gravel is sub-angular and medium grained.	1.50		28.60		
2	1.50	80	0	0				Brown clayey gravelly fine SAND. Gravel is rounded to sub-angular and fine to medium grained.	3.16				
3	3.00							Brown SILT	3.40		26.94		
4		100	0	0				Brown slightly silty gravelly fine SAND. Gravel is rounded to angular and fine to coarse grained.	4.25		26.70		
5	4.50	100	0	0				Firm to stiff brown sandy gravelly CLAY. Gravel is sub-angular to sub-rounded and fine to coarse grained.	4.95		25.85		
6	6.00	93	27	27				Brown silty very gravelly fine SAND with occasional cobbles (5.3m-5.8m. Gravel is sub-angular to sub-rounded and fine to coarse grained.	5.80 6.20 6.60		25.15 24.30 23.90		
7	7.50	100	61	61				Firm to stiff brown sandy very gravelly CLAY. Gravel is sub-angular to sub-rounded and fine to coarse grained.		Discontinuities are rough and undulose to irregular. Apertures are open with local clay sand smearing/infill (non intact zones). Dips are commonly sub-45° with variable fractures throughout.	23.50		
8								Firm brown clayey sandy gravelly SILT (sand layer at 6.4m). Gravel is sub-angular to sub-rounded and fine to coarse grained.	8.55		21.55		
9	9.00	100	99	94	900			Strong to very strong, locally moderately strong, medium to					

REMARKS

7 Core boxes, 10.7m Core liner used. No groundwater encountered. Grout 0.0m-12.0m. 50% flush loss from 7.5m, 100% flush loss from 11.8m.

WATER STRIKE DETAILS

Water Strike	Casing Depth	Sealed At	Rise To	Time (min)	Comments
					No water strike recorded

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

IGSL RC NEWLOG 10M PER PG 14039.GPJ IGSL.GDT 30/3/09

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 14039

CONTRACT	Indaver Waste Management Facility, Duleek	**DRILLHOLE NO**	**RC GC1**
		SHEET	Sheet 2 of 2
CO-ORDINATES	306,263.87 E 270,930.70 N	**GROUND LEVEL (m)**	30.10
		CORE DIAMETER (mm)	102
		DATE STARTED	17/02/2009
		DATE COMPLETED	17/02/2009
CLIENT	Indaver	**INCLINATION**	-90
ENGINEER	PM Group	**FLUSH**	Polymer Gel
		DRILLED BY	Petersen
		LOGGED BY	A. Mahony

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Non-intact zones	Strata description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
10								thickly bedded, blue grey, medium grained LIMESTONE (siliceous and fossiliferous). Fresh to slightly weathered.		Discontinuities are rough and undulose. Apertures are open with clay sand smearing surfaces. Dips are sub-10° with sub-vertical fractures (10.0-10.4m, 10.5-10.97m). *(continued)*			
	10.50												
11		100	79	79				Very strong, locally strong, thickly bedded, blue grey, fine to coarse grained LIMESTONE (siliceous and fossiliferous). Fresh to locally slightly weathered. *(continued)*	12.00			
12	12.00										18.10		
13								End of Corehole at 12 (m)					
14													
15													
16													
17													
18													
19													

REMARKS

7 Core boxes, 10.7m Core liner used. No groundwater encountered. Grout 0.0m-12.0m. 50% flush loss from 7.5m, 100% flush loss from 11.8m.

WATER STRIKE DETAILS

Water Strike	Casing Depth	Sealed At	Rise To	Time (min)	Comments
					No water strike recorded

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

IGSL RC NEWLOG 10M PER PG 14039.GPJ IGSL.GDT 30/3/09

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 14039

CONTRACT	Indaver Waste Management Facility, Duleek	DRILLHOLE NO	RC GC2
		SHEET	Sheet 1 of 2
CO-ORDINATES	306,286.09 E 270,892.72 N	GROUND LEVEL (m)	30.00
		CORE DIAMETER (mm)	102
		DATE STARTED	11/02/2009
		DATE COMPLETED	12/02/2009
CLIENT	Indaver	INCLINATION	-90
ENGINEER	PM Group	FLUSH	Polymer Gel
		DRILLED BY	Petersen
		LOGGED BY	A. Mahony

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Non-intact zones	Strata description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
0								OPEN HOLE DRILLING: Observed by driller as returns of brown silty, very sandy gravelly clay	1.50				
1	1.50	100	0	0				Brown very sandy, very gravelly CLAY with occasional cobbles (sandy gravel at 2.95m-3.05m).	3.40		28.50		
2	3.00	100	0	0									
3	3.50	100	0	0				Brown very clayey, very sandy GRAVEL with occasional cobbles. Gravel is angular to rounded, predominantly fine grained.	5.30		26.60		
4	4.50	100	0	0									
5	5.30	100	10	0				Strong to very strong, locally moderately strong, medium to thickly bedded, blue grey, fine to medium grained LIMESTONE (siliceous and fossiliferous). Fresh to locally slightly weathered.		Discontinuities are rough and undulose. Apertures are tight to open with local clay sand smearing/infill (5.3m-6.0m6.31-6.33m, 6.73-6.9m, 7.69-7.72m, 8.09-8.1m, 9.22-9.3m, 10.46-10.61m, 11.55-11.75m, 14.13-14.28m), and local slight iron oxide stained surfaces (9.22-9.3m, 14.69m). Dips are sub-0°-20° locally 45° and local sub-vertical fractures (5.3-6.0m, 7.35-7.64m, 9.3-9.67m).	24.70		
6	6.00	100	96	96									
7	6.90	100	58	58									
8	7.50	100	80	64									
9	8.40	100	100	100	600								
	9.00	100	61	53									

REMARKS

8 Core boxes, 13.6m Core liner used. No groundwater encountered. Grout 0.0m-15.0m. 50% flush loss from 6.0m, 100% flush loss from 7.5m. Move & Setup 1hr.

WATER STRIKE DETAILS

Water Strike	Casing Depth	Sealed At	Rise To	Time (min)	Comments
					No water strike recorded

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

IGSL RC NEWLOG 10M PER PG 14039.GPJ IGSL.GDT 30/3/09

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 14039

CONTRACT	Indaver Waste Management Facility, Duleek	**DRILLHOLE NO**	**RC GC2**
		SHEET	Sheet 2 of 2
CO-ORDINATES	306,286.09 E 270,892.72 N	**GROUND LEVEL (m)**	30.00
		CORE DIAMETER (mm)	102
		DATE STARTED	11/02/2009
		DATE COMPLETED	12/02/2009
CLIENT	Indaver	**INCLINATION**	-90
ENGINEER	PM Group	**FLUSH**	Polymer Gel
		DRILLED BY	Petersen
		LOGGED BY	A. Mahony

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Non-intact zones	Strata description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
10	10.30	100	80	80				Strong to very strong, locally moderately strong, medium to thickly bedded, blue grey, fine to medium grained LIMESTONE (siliceous and fossiliferous). Fresh to locally slightly weathered. *(continued)*		Discontinuities are rough and undulose. Apertures are tight to open with local clay sand smearing/infill (5.3m-6.0m6.31-6.33m, 6.73-6.9m, 7.69-7.72m, 8.09-8.1m, 9.22-9.3m, 10.46-10.61m, 11.55-11.75m, 14.13-14.28m), and local slight iron oxide stained surfaces (9.22-9.3m, 14.69m). Dips are sub-0°-20° locally 45° and local sub-vertical fractures (5.3-6.0m, 7.35-7.64m, 9.3-9.67m). *(continued)*			
11	10.50	100	82	82									
12	12.00	100	91	91									
13	13.50	100	100	100									
14													
15	15.10							End of Corehole at 15.1 (m)	15.10		14.90		
16													
17													
18													
19													

REMARKS

8 Core boxes, 13.6m Core liner used. No groundwater encountered. Grout 0.0m-15.0m. 50% flush loss from 6.0m, 100% flush loss from 7.5m. Move & Setup 1hr.

WATER STRIKE DETAILS

Water Strike	Casing Depth	Sealed At	Rise To	Time (min)	Comments
					No water strike recorded

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

IGSL RC NEWLOG 10M PER PG 14039.GPJ IGSL.GDT 30/3/09

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 14039

CONTRACT	Indaver Waste Management Facility, Duleek	DRILLHOLE NO	RC GC3
		SHEET	Sheet 1 of 2
CO-ORDINATES	306,299.12 E 270,902.06 N	GROUND LEVEL (m)	30.14
		CORE DIAMETER (mm)	102
		DATE STARTED	12/02/2009
		DATE COMPLETED	13/02/2009
CLIENT	Indaver	INCLINATION	-90
ENGINEER	PM Group	FLUSH	Polymer Gel
		DRILLED BY	Petersen
		LOGGED BY	A. Mahony

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Non-intact zones	Strata description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
0								OPEN HOLE DRILLING: Observed by driller as returns of brown silty, very sandy gravelly clay	0.70		29.44		
1	0.70	100	0	0				Firm brown (soft 0.7-0.85m) clayey very sandy (occasionally gravelly layers) SILT. Gravel is sub-angular to sub-rounded and fine to coarse grained.	2.00		28.14		
2	1.50	100	0	0									
3	2.40	100	0	0				Firm brown sandy/gravelly (fine gravel, mostly sand from 2.25m) SILT/CLAY with occasional cobbles	3.65				
	3.40	100	0	0				Brown silty fine SAND with occasional gravel	3.75		26.49		
4	4.10	100	0	0				Firm brown very sandy gravelly SILT with occasional cobbles	4.15		26.39 25.99		
	4.50	100	10	10				Firm brown very sandy gravelly SILT/CLAY (local sand layer at 4.28m & 5.02m	5.15				
5								Brown silty fine SAND	5.40		24.99		
								COBBLE	5.55		24.74 24.59		
6	6.00	100	0	0				Brown silty very sandy GRAVEL (predominantly fine to medium) with occasional cobbles.	6.25 6.45		23.89 23.69		
7								Dark brown, gravelly, silty, fine to medium SAND					
	7.50	100	31	31				Brown silty clayey sandy gravelly, COBBLES (possible highly weathered upper bedrock)	8.00		22.14		
8													
9	9.00	100	15	15									

REMARKS

7 Core boxes, 11.1m Core liner used. No groundwater encountered. Grout 0.0m-11.8m. 100% flush loss from 7.0m.

WATER STRIKE DETAILS

Water Strike	Casing Depth	Sealed At	Rise To	Time (min)	Comments
					No water strike recorded

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

IGSL RC NEWLOG 10M PER PG 14039.GPJ IGSL.GDT 30/3/09

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 14039

CONTRACT	Indaver Waste Management Facility, Duleek	**DRILLHOLE NO**	**RC GC3**
		SHEET	Sheet 2 of 2
CO-ORDINATES	306,299.12 E 270,902.06 N	**GROUND LEVEL (m)**	30.14
		CORE DIAMETER (mm)	102
		DATE STARTED	12/02/2009
		DATE COMPLETED	13/02/2009
CLIENT	Indaver	**INCLINATION**	-90
		DRILLED BY	Petersen
ENGINEER	PM Group	**FLUSH**	Polymer Gel
		LOGGED BY	A. Mahony

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Non-intact zones	Strata description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
10	10.30							Strong to moderately strong, medium bedded, blue grey medium grained LIMESTONE (fossiliferous and siliceous). Heavily infilled with clay/sand/gravel (esp. 9.4m-10.03m) (possible variably weathered upper bedrock *(continued)*					
11		100	15	11									
12	11.80								11.80		18.34		
								End of Corehole at 11.8 (m)					
13													
14													
15													
16													
17													
18													
19													

REMARKS

7 Core boxes, 11.1m Core liner used. No groundwater encountered. Grout 0.0m-11.8m. 100% flush loss from 7.0m.

WATER STRIKE DETAILS

Water Strike	Casing Depth	Sealed At	Rise To	Time (min)	Comments
					No water strike recorded

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

IGSL RC NEWLOG 10M PER PG 14039.GPJ IGSL.GDT 30/3/09

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 14039

CONTRACT	Indaver Waste Management Facility, Duleek	DRILLHOLE NO	RC GC4
		SHEET	Sheet 1 of 2
CO-ORDINATES	306,275.13 E 270,938.38 N	GROUND LEVEL (m)	30.02
		CORE DIAMETER (mm)	102
		DATE STARTED	16/02/2009
		DATE COMPLETED	17/02/2009
CLIENT	Indaver	INCLINATION	-90
ENGINEER	PM Group	FLUSH	Polymer Gel
		DRILLED BY	Petersen
		LOGGED BY	A. Mahony

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Non-intact zones	Strata description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
0								OPEN HOLE DRILLING: Observed by driller as returns of brown silty, very sandy gravelly clay	0.70		29.32		
1	0.70	63	0	0				Soft brown mottled cream/black/dark brown, very sandy, very gravelly CLAY with occasional cobbles. Gravel is sub-angular to sub-rounded and fine to coarse grained.	1.50		28.52		
2	1.50	97	0	0				Firm reddish brown, very sandy, very gravelly CLAY (locally slightly soft 1.5m-2.0m). Gravel is sub-angular and fine to coarse grained.	3.30		26.72		
3	3.00	87	0	0				Firm yellow brown, slightly gravelly(fine) /coarse sandy SILT	4.50		25.52		
4	4.50	100	0	0				COBBLE	4.60		25.42		
								Firm dark brown sandy gravelly SILT/CLAY	4.90		25.12		
5	5.10	100	17	17				Very gravelly (fine to medium), dark brown fine to coarse SAND	5.10		24.92		
								COBBLE	5.25		24.77		
6	6.00	100	0	0				Brown clayey/silty gravelly, medium SAND with occasional cobbles. Gravel is rounded to sub-angular and fine to medium grained.	6.00		24.02		
7	6.90	100	60	53				Firm brown sandy gravelly CLAY with occasional cobbles (becoming sandier towards 6.9m)	6.90		23.12		
	7.50	100	53	53				Dark brown, silty/clayey, gravelly, medium SAND	7.15	Discontinuities are rough and undulose to irregular. Apertures are open with local clay sand smearing/infill (non intact zones). Dips are commonly sub-45° with variable fractures throughout.	22.87		
8	8.50	100	56	40				Strong to very strong, locally moderately strong, medium to thickly bedded, blue grey, medium grained	10.00				
9	9.00	100	15	15									

REMARKS

7 Core boxes, 10.85m Core liner used. No groundwater encountered. Grout 0.0m-12.1m.

WATER STRIKE DETAILS

Water Strike	Casing Depth	Sealed At	Rise To	Time (min)	Comments
					No water strike recorded

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 14039

CONTRACT	Indaver Waste Management Facility, Duleek	**DRILLHOLE NO**	**RC GC4**
		SHEET	Sheet 2 of 2
CO-ORDINATES	306,275.13 E 270,938.38 N	**GROUND LEVEL (m)**	30.02
		CORE DIAMETER (mm)	102
		DATE STARTED	16/02/2009
		DATE COMPLETED	17/02/2009
CLIENT	Indaver	**INCLINATION**	-90
		DRILLED BY	Petersen
ENGINEER	PM Group	**FLUSH**	Polymer Gel
		LOGGED BY	A. Mahony

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Non-intact zones	Strata description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
10	10.00	100	100	100	520			LIMESTONE (siliceous and fossiliferous). Fresh to slightly weathered.		Discontinuities are rough and undulose. Apertures are open with clay sand smearing surfaces. Dips are sub-10° with sub-vertical fractures (11.6-12.07m).	20.02		
	10.50	100	98	98	710			Very strong, locally strong, thickly bedded, blue grey, fine to coarse grained LIMESTONE (siliceous and fossiliferous). Fresh to locally slightly weathered.					
11	11.50	100	28	15									
12	12.15							End of Corehole at 12.15 (m)	12.15		17.87		
13													
14													
15													
16													
17													
18													
19													

REMARKS

7 Core boxes, 10.85m Core liner used. No groundwater encountered. Grout 0.0m-12.1m.

WATER STRIKE DETAILS

Water Strike	Casing Depth	Sealed At	Rise To	Time (min)	Comments
					No water strike recorded

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

IGSL RC NEWLOG 10M PER PG 14039.GPJ IGSL.GDT 30/3/09

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 14039

CONTRACT	Indaver Waste Management Facility, Duleek	**DRILLHOLE NO**	**RC GC5**
		SHEET	Sheet 1 of 2
CO-ORDINATES	306,280.57 E 270,916.06 N	**GROUND LEVEL (m)**	30.08
		CORE DIAMETER (mm)	102
		DATE STARTED	13/02/2009
		DATE COMPLETED	16/02/2009
CLIENT	Indaver	**INCLINATION**	-90
ENGINEER	PM Group	**FLUSH**	Polymer Gel
		DRILLED BY	Petersen
		LOGGED BY	A. Mahony

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Non-intact zones	Strata description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
0								OPEN HOLE DRILLING: Observed by driller as returns of brown silty, very sandy gravelly clay	0.70		29.38		
1	0.70	88	0	0				Brown mottled black/dark brown, sandy gravelly CLAY with occasional cobbles	1.50		28.58		
2	1.50	100	0	0				Brown very sandy gravelly SILT/CLAY with occasional cobbles	2.20		27.88		
	2.50	100	0	0				Brown SILT/CLAY	3.20		26.88		
3	3.00	100	0	0				Brown mottled yellow/dark brown, slightly sandy gravelly (fine), CLAY with occasional cobbles	3.90		26.18		
4	4.00	100	0	0					4.05		26.03		
	4.50							Dark brown fine SAND with occasional gravel	4.30		25.78		
5		100	0	0					4.40		25.68		
	5.50							Dark brown gravelly, slightly silty fine SAND	4.60		25.48		
		100	58	58				Dark brown silty, gravelly SAND.					
6	6.00							Brown very sandy gravelly SILT/CLAY with occasional cobbles	5.80		24.28		
		100	20	20				Brown silty, very sandy GRAVEL (very silty/clayey 5.5m-5.8m)		Discontinuities are rough and undulose to irregular. Apertures are open with clay/sand/gravel smeared and infilled, slightly iron oxide stained. Dips are sub-0° with sub-vertical fractures common.			
7								Strong to moderately strong and locally very strong where intact, blue grey, medium to coarse grained LIMESTONE (siliceous and fossiliferous). Slightly to moderately weathered.					
	7.50												
8		100	53	53									
9	9.00												
		100	83	76									

REMARKS

7 Core boxes, 11.2m Core liner used. No groundwater encountered. Grout 0.0m-12.2m. 100% flush loss from 6.5m,

WATER STRIKE DETAILS

Water Strike	Casing Depth	Sealed At	Rise To	Time (min)	Comments
					No water strike recorded

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

IGSL RC NEWLOG 10M PER PG 14039.GPJ IGSL.GDT 30/3/09

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 14039

CONTRACT	Indaver Waste Management Facility, Duleek	DRILLHOLE NO	RC GC5
		SHEET	Sheet 2 of 2
CO-ORDINATES	306,280.57 E 270,916.06 N	GROUND LEVEL (m)	30.08
		CORE DIAMETER (mm)	102
		DATE STARTED	13/02/2009
		DATE COMPLETED	16/02/2009
CLIENT	Indaver	INCLINATION	-90
ENGINEER	PM Group	FLUSH	Polymer Gel
		DRILLED BY	Petersen
		LOGGED BY	A. Mahony

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Non-intact zones	Strata description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
10													
	10.60							Strong to moderately strong and locally very strong where intact, blue grey, medium to coarse grained LIMESTONE (siliceous and fossiliferous). Slightly to moderately weathered. *(continued)*		Discontinuities are rough and undulose to irregular. Apertures are open with clay/sand/gravel smeared and infilled, slightly iron oxide stained. Dips are sub-0° with sub-vertical fractures common. *(continued)*			
11		100	90	90	900								
12	12.20				628.9999999999999				12.20				
								End of Corehole at 12.2 (m)			17.88		
13													
14													
15													
16													
17													
18													
19													

REMARKS

7 Core boxes, 11.2m Core liner used. No groundwater encountered. Grout 0.0m-12.2m. 100% flush loss from 6.5m,

WATER STRIKE DETAILS

Water Strike	Casing Depth	Sealed At	Rise To	Time (min)	Comments
					No water strike recorded

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 14039

CONTRACT	Indaver Waste Management Facility, Duleek	DRILLHOLE NO	RC GC6
		SHEET	Sheet 1 of 2
CO-ORDINATES	306,325.72 E 270,960.26 N	GROUND LEVEL (m)	30.27
		CORE DIAMETER (mm)	102
		DATE STARTED	18/02/2009
		DATE COMPLETED	18/02/2009
CLIENT	Indaver	INCLINATION	-90
ENGINEER	PM Group	FLUSH	Polymer Gel
		DRILLED BY	Petersen
		LOGGED BY	A. Mahony

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Non-intact zones	Strata description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
0								OPEN HOLE DRILLING: Observed by driller as returns of brown silty, very sandy gravelly clay	0.80		29.47		
1	0.80	100	0	0				Brown very sandy, gravelly CLAY/SILT (Gravel is fine to coarse, sub-rounded to angular)	1.50		28.77		
	1.50	100	0	0				Brown silty fine SAND	2.00		28.27		
2								Brown very silty, gravelly fine to medium grained SAND. (Gravel is fine to coarse, sub-rounded to angular)	2.50		27.77		
	2.50	100	0	0									
3	3.00	100	0	0				Brown silty, sandy, gravelly CLAY. (Gravel is fine to coarse, sub-rounded to sub-angular)					
4	4.00	100	0	0									
	4.50	100	0	0									
5													
	5.50	100	0	0									
6	6.00	100	9	9									
7										Discontinuities are rough and undulose. Apertures are wide to very wide with sandy/clayey/gravelly smeared surfaces and infilling. Dips appear sub-40° with variably dipping fractues throughout.			
	7.40	100	0	0									
	7.50												
8		100	7	7					8.25		22.02		
9	9.00												
		100	18	18									

REMARKS

8 Core boxes, 12.2m Core liner used. No groundwater encountered. Grout 0.0m-13.5m. 50% flush loss from 9.0m. ½hr dayworks - laid 60m of Geogrid to improve access to location.

WATER STRIKE DETAILS

Water Strike	Casing Depth	Sealed At	Rise To	Time (min)	Comments
					No water strike recorded

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

IGSL RC NEWLOG 10M PER PG 14039.GPJ IGSL.GDT 30/3/09

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 14039

CONTRACT	Indaver Waste Management Facility, Duleek	DRILLHOLE NO	RC GC6
		SHEET	Sheet 2 of 2
CO-ORDINATES	306,325.72 E 270,960.26 N	GROUND LEVEL (m)	30.27
		CORE DIAMETER (mm)	102
		DATE STARTED	18/02/2009
		DATE COMPLETED	18/02/2009
CLIENT	Indaver	INCLINATION	-90
ENGINEER	PM Group	FLUSH	Polymer Gel
		DRILLED BY	Petersen
		LOGGED BY	A. Mahony

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Non-intact zones	Strata description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
10													
	10.50							Strong to moderately strong, medium bedded, grey, medium to coarse grained LIMESTONE (fossiliferous and siliceous). Heavily infilled with clay/sand/gravel. (10.5m-10.9m, 11.17m-11.76m, marly, sandy clayey highly weathered rock - structure locally preserved) *(continued)*		Discontinuities are rough and undulose. Apertures are wide to very wide with sandy/clayey/gravelly smeared surfaces and infilling. Dips appear sub-40° with variably dipping fractues throughout. *(continued)*			
11		90	13	13									
12													
	12.60												
13		100	42	42					13.50				
	13.50							End of Corehole at 13.5 (m)			16.77		
14													
15													
16													
17													
18													
19													

REMARKS

8 Core boxes, 12.2m Core liner used. No groundwater encountered. Grout 0.0m-13.5m. 50% flush loss from 9.0m. ½hr dayworks - laid 60m of Geogrid to improve access to location.

WATER STRIKE DETAILS

Water Strike	Casing Depth	Sealed At	Rise To	Time (min)	Comments
					No water strike recorded

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

IGSL RC NEWLOG 10M PER PG 14039.GPJ IGSL.GDT 30/3/09

Appendix 2

Rotary Core Drillhole Records (Conventional P Drillholes)

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 14039

CONTRACT	Indaver Waste Management Facility, Duleek	DRILLHOLE NO	RC RP1
		SHEET	Sheet 1 of 2
CO-ORDINATES(_)	306,246.51 E 270,914.34 N	GROUND LEVEL (m)	29.94
		CORE DIAMETER (mm)	80
		DATE STARTED	10/02/2009
		DATE COMPLETED	10/02/2009
CLIENT	Indaver	INCLINATION	-90
ENGINEER	PM Group	FLUSH	Air/Mist
		DRILLED BY	Petersen
		LOGGED BY	A. Mahony

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Non-intact zones	Strata description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
0								OPEN HOLE DRILLING: Observed by driller as returns of brown silty, very sandy gravelly clay					
1													
2													
3													
4													
5													
6									6.40		23.54		
								OPEN HOLE DRILLING: Observed by driller as angular gravel size returns of	6.90				

REMARKS

1 Core box. No groundwater encountered. 2hrs dayworks - laid 150m of Geogrid to improve access to location.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

IGSL RC NEWLOG 10M PER PG 14039.GPJ IGSL.GDT 9/3/09

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 14039

CONTRACT	Indaver Waste Management Facility, Duleek	DRILLHOLE NO	RC RP1
		SHEET	Sheet 2 of 2
CO-ORDINATES(_)	306,246.51 E 270,914.34 N	GROUND LEVEL (m)	29.94
		CORE DIAMETER (mm)	80
		DATE STARTED	10/02/2009
		DATE COMPLETED	10/02/2009
CLIENT	Indaver	INCLINATION	-90
ENGINEER	PM Group	FLUSH	Air/Mist
		DRILLED BY	Petersen
		LOGGED BY	A. Mahony

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Non-intact zones	Strata description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
7								limestone (probable variably weathered bedrock) OPEN HOLE DRILLING: Observed by driller as angular gravel size returns of limestone (probable bedrock) *(continued)*			23.04		
	7.50								7.50				
8		87	79	79				Strong to very strong, thickly bedded, blue grey, medium grained LIMESTONE (siliceous and fossiliferous). Fresh to locally slightly weathered. Cavity observed by driller at 8.7m-8.9m)		Discontinuities are rough and undulose. Apertures are open with local clay smearing (7.79m-7.88m, 8.84-9.57m, 9.72-9.91m), and local slight iron oxide stained surfaces (8.84m-9.57m). Dips are sub-0°-20° with local sub-vertical fractures (8.84m-9.57m, 9.72-9.91m).	22.44		
9	9.00												
		97	21	21									
10									10.50				
	10.50							End of Corehole at 10.5 (m)			19.44		
11													
12													
13													

REMARKS

1 Core box. No groundwater encountered. 2hrs dayworks - laid 150m of Geogrid to improve access to location.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

IGSL RC NEWLOG 10M PER PG 14039.GPJ IGSL.GDT 9/3/09

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 14039

CONTRACT	Indaver Waste Management Facility, Duleek	DRILLHOLE NO	RC RP2
		SHEET	Sheet 1 of 2
CO-ORDINATES(_)	306,241.74 E 270,906.39 N	GROUND LEVEL (m)	30.03
		CORE DIAMETER (mm)	80
		INCLINATION	-90
		FLUSH	Air/Mist
		DATE STARTED	10/02/2009
		DATE COMPLETED	10/02/2009
CLIENT	Indaver	DRILLED BY	Petersen
ENGINEER	PM Group	LOGGED BY	A. Mahony

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Non-intact zones	Strata description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
0								OPEN HOLE DRILLING: Observed by driller as returns of brown silty, very sandy gravelly clay					
1													
2													
3													
4													
5									5.70				
6								OPEN HOLE DRILLING: Observed by driller as angular gravel size returns of limestone (probable variably weathered bedrock)			24.33		
									7.00				

REMARKS

1 Core box. No groundwater encountered.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 14039

CONTRACT	Indaver Waste Management Facility, Duleek	DRILLHOLE NO	RC RP2
		SHEET	Sheet 2 of 2
CO-ORDINATES(_)	306,241.74 E 270,906.39 N	GROUND LEVEL (m)	30.03
		CORE DIAMETER (mm)	80
		INCLINATION	-90
		FLUSH	Air/Mist
		DATE STARTED	10/02/2009
		DATE COMPLETED	10/02/2009
CLIENT	Indaver	DRILLED BY	Petersen
ENGINEER	PM Group	LOGGED BY	A. Mahony

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Non-intact zones	Strata description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
7								OPEN HOLE DRILLING: Observed by driller as angular gravel size returns of limestone (probable bedrock)	7.50		23.03		
	7.50							Strong to very strong, locally moderately strong, medium to thickly bedded, grey, medium grained LIMESTONE (siliceous and fossiliferous). Fresh to slightly weathered.		Discontinuities are rough and undulose. Apertures are open with local clay smearing (7.84m-8.06m, 8.28m). Dips are sub-0°-10° with local sub-vertical and 45° fractures.	22.53		
8		100	78	72									
9	9.00												
		97	63	63									
10									10.50				
	10.50							End of Corehole at 10.5 (m)			19.53		
11													
12													
13													

REMARKS

1 Core box. No groundwater encountered.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

IGSL RC NEWLOG 10M PER PG 14039.GPJ IGSL.GDT 9/3/09

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 14039

CONTRACT	Indaver Waste Management Facility, Duleek	DRILLHOLE NO	RC RP5
		SHEET	Sheet 1 of 2
CO-ORDINATES(_)	306,255.43 E 270,916.96 N	GROUND LEVEL (m)	30.18
		CORE DIAMETER (mm)	80
		DATE STARTED	19/02/2009
		DATE COMPLETED	19/02/2009
CLIENT	Indaver	INCLINATION	-90
ENGINEER	PM Group	FLUSH	Air/Mist
		DRILLED BY	Petersen
		LOGGED BY	A. Mahony

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Non-intact zones	Strata description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
0								OPEN HOLE DRILLING: Observed by driller as returns of brown silty, very sandy gravelly clay					
1													
2													
3													
4													
5													
6									6.70		23.48		

REMARKS

1 Core box. No groundwater encountered. Grout 0.0m-10.5m.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

IGSL RC NEWLOG 10M PER PG 14039.GPJ IGSL.GDT 9/3/09

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 14039

CONTRACT	Indaver Waste Management Facility, Duleek	DRILLHOLE NO	RC RP5
		SHEET	Sheet 2 of 2
CO-ORDINATES(_)	306,255.43 E 270,916.96 N	GROUND LEVEL (m)	30.18
		CORE DIAMETER (mm)	80
		DATE STARTED	19/02/2009
		DATE COMPLETED	19/02/2009
CLIENT	Indaver	INCLINATION	-90
ENGINEER	PM Group	FLUSH	Air/Mist
		DRILLED BY	Petersen
		LOGGED BY	A. Mahony

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Non-intact zones	Strata description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
7								OPEN HOLE DRILLING: Observed by driller as clayey angular gravel size returns of limestone (probable variably weathered bedrock) *(continued)*	7.50		22.68		
	7.50	64	0	0				Moderately strong to moderately weak, grey, medium to coarse grained LIMESTONE (siliceous and fossiliferous). Moderately weathered. Non intact throughout with clayey (dry) sandy gravel and cobble size returns.	8.65	Discontinuities are rough and undulose. Apertures are wide with sandy surfaces. Variably dipping fractues and locally sub-vertical fractures (8.91m-8.98m, 9.22m-9.41m) and sub-45 planar break at 9.85m.	21.53		
8	8.60												
9		91	63	63									
	9.70	100	84	72				Strong to locally moderately strong, medium to thinly bedded, grey, medium to coarse grained LIMESTONE (siliceous and fossiliferous). Fresh to slightly and locally moderately weathered.	10.50		19.68		
10	10.50							End of Corehole at 10.5 (m)					
11													
12													
13													

REMARKS

1 Core box. No groundwater encountered. Grout 0.0m-10.5m.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

IGSL RC NEWLOG 10M PER PG 14039.GPJ IGSL.GDT 9/3/09

Appendix 3

Percolation Test Records

Soakaway Design f -value from field tests IGSL

Contract: Indaver Ireland Contract No. 14039
Test No. PP2
Engineer PM Group
Date:

Summary of ground conditions

from	to	Description	Ground water
0.00	0.20	Soft brown SILT/CLAY with some organic matter	None
0.20	1.20	Firm brown sandy gravelly CLAY with sub-angular and angular cobbles	
1.20		Stiff brown sandy gravelly CLAY with pockets of sandy SILT and many	
	2.00	sub-angular and angular cobbles	

Notes:

Field Data

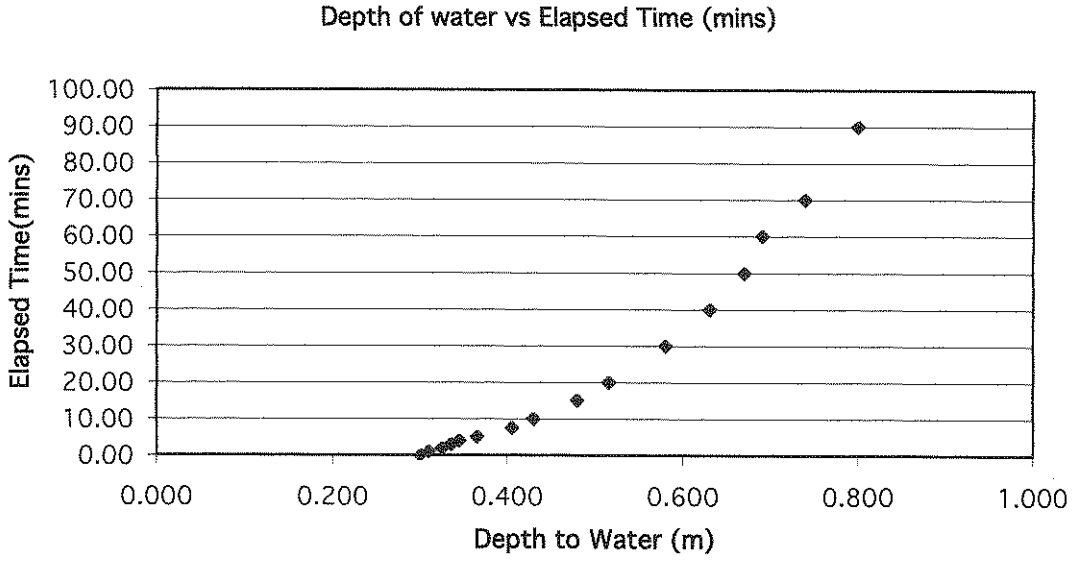
Depth to Water (m)	Elapsed Time (min)
0.300	0.00
0.310	1.00
0.325	2.00
0.335	3.00
0.345	4.00
0.365	5.00
0.405	7.50
0.430	10.00
0.480	15.00
0.515	20.00
0.580	30.00
0.630	40.00
0.670	50.00
0.690	60.00
0.740	70.00
0.800	90.00

Field Test

Depth of Pit (D)	2.00	m
Width of Pit (B)	0.40	m
Length of Pit (L)	1.20	m
Initial depth to Water =	0.30	m
Final depth to water =	0.80	m
Elapsed time (mins)=	90.00	
Top of permeable soil		m
Base of permeable soil		m
Base area=	0.48	m2
*Av. side area of permeable stratum over test period=	4.64	m2
Total Exposed area =	5.12	m2

Infiltration rate (f) = Volume of water used/unit exposed area / unit time

f= 0.00052 m/min or 8.6806E-06 m/sec



Soakaway Design f -value from field tests IGSL

Contract: Indaver Ireland Contract No. 14039
Test No. PP3
Engineer PM Group
Date:

Summary of ground conditions

from	to	Description	Ground water
0.00	0.30	Soft brown slightly sandy CLAY with some organic matter	None
0.30		Soft brown slightly gravelly, sandy CLAY with occasional rounded	
	1.10	cobbles	
1.10		Firm brown slightly gravelly, sandy CLAY with occasional sub-angular	
	1.85	and angular cobbles	

Notes:

Field Data

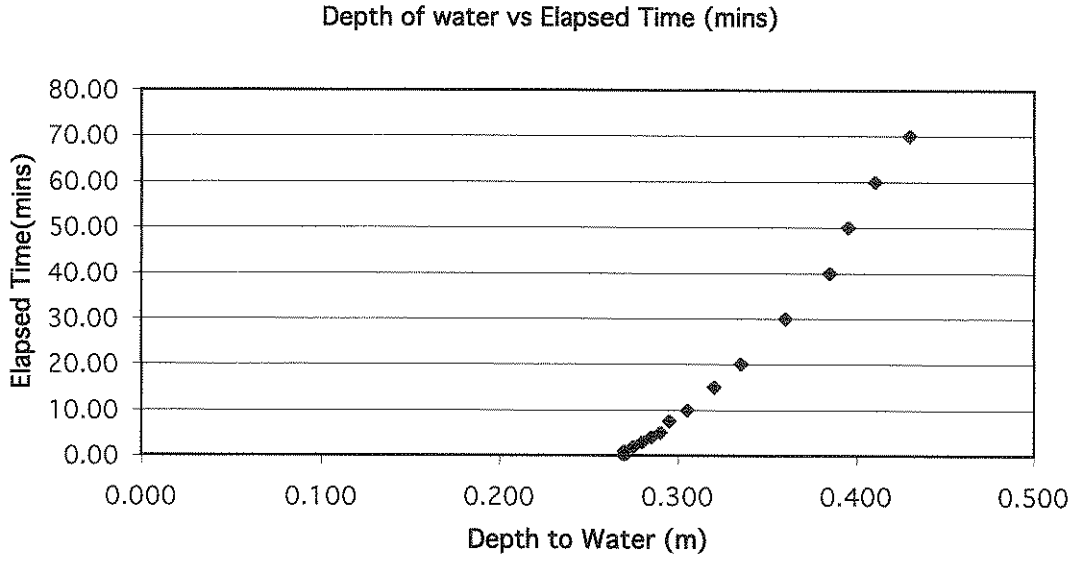
Depth to Water (m)	Elapsed Time (min)
0.270	0.00
0.270	1.00
0.275	2.00
0.280	3.00
0.285	4.00
0.290	5.00
0.295	7.50
0.305	10.00
0.320	15.00
0.335	20.00
0.360	30.00
0.385	40.00
0.395	50.00
0.410	60.00
0.430	70.00

Field Test

Depth of Pit (D)	1.80	m
Width of Pit (B)	0.45	m
Length of Pit (L)	1.10	m
Initial depth to Water =	0.27	m
Final depth to water =	0.43	m
Elapsed time (mins)=	70.00	
Top of permeable soil		m
Base of permeable soil		m
Base area=	0.495	m2
*Av. side area of permeable stratum over test period=	4.495	m2
Total Exposed area =	4.99	m2

Infiltration rate (f) = Volume of water used/unit exposed area / unit time

f= 0.00023 m/min or 3.779E-06 m/sec



Appendix 4

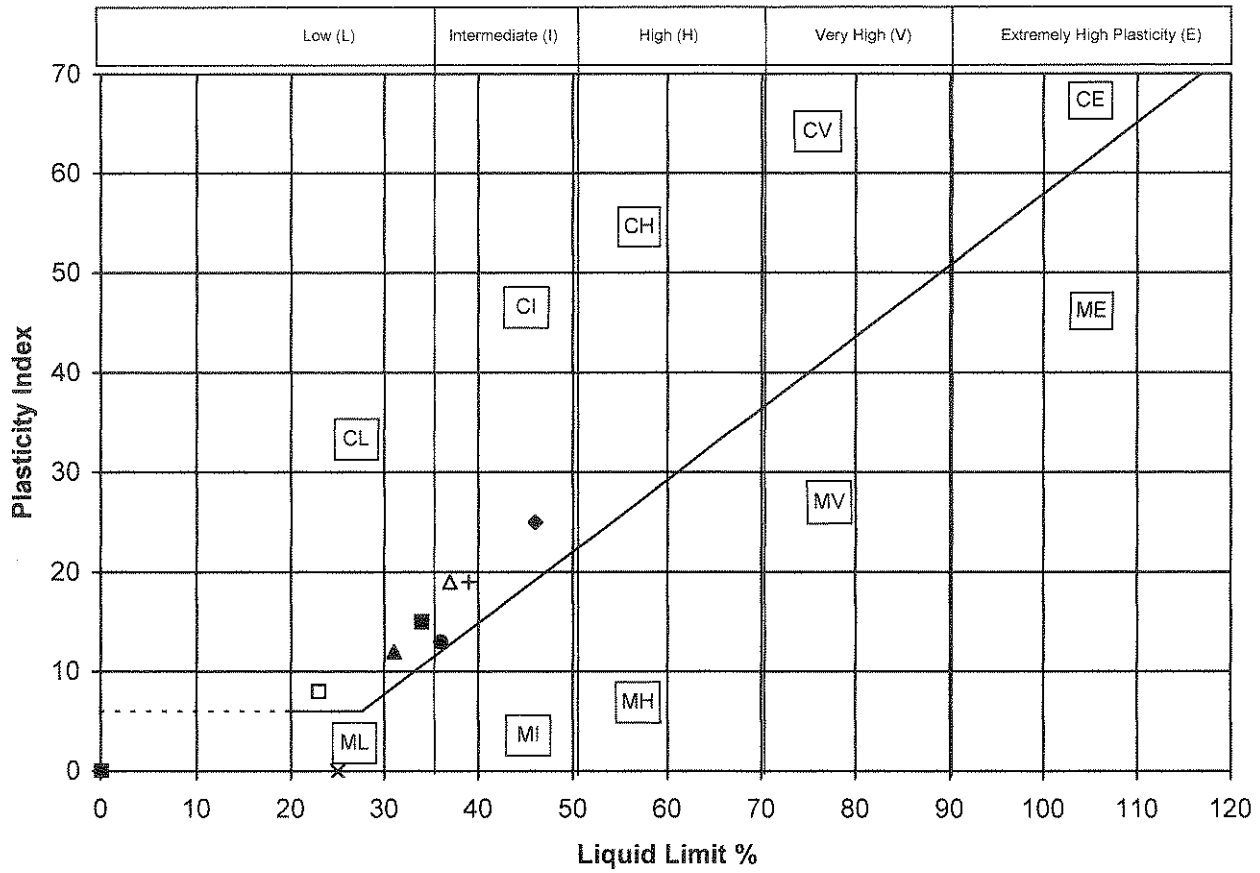
Geotechnical Soil Laboratory Test Records

Plasticity Chart - Summary of Liquid & Plastic Limit Tests

BS1377:Part 2:1990, clauses 3.2, 4 & 5

Chart in accordance with BS5930:1999, fig.18

Contract No. 14039 Contract: INDAVER WASTE MANAGEMENT FACILITY, DU



Code	BH/TP	Sample	Depth (m)	MC%	LL%	PL%	PI%	%<425µm	Description
▲	GC1	AH2527	2.60	23	31	19	12	88	Orangish brown slightly sandy slightly gravelly CLAY
■	GC2	AH2529	2.50	11.3	34	19	15	28	Grey brown silty very sandy GRAVEL
●	GC2	0	4.50	8.1	36	23	13	13	Grey brown silty sandy GRAVEL
◆	GC3	AH2525	2.00	20	46	21	25	95	Orangish brown slightly sandy slightly gravelly CLAY
×	GC3	0	4.50	13	25	NP	0	69	Light brown slightly sandy slightly gravelly SILT
+	GC4	AH2526	3.20	19.6	39	20	19	98	Light brown slightly sandy slightly gravelly CLAY
△	GC5	AH2528	3.00	18.7	37	18	19	79	Brown slightly sandy slightly gravelly CLAY
□	GC6+	AH2524	2.50	10.9	23	15	8	56	Orangish brown slightly sandy slightly gravelly CLAY
○									
◇									
▲									
■									
●									
◆									
×									
+									
△									

NP denotes specimen is non-plastic.

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IGSL		27/03/2009			

Summary of Classification Tests

BS1377:Part 2:1990, clauses 3.2, 4.3, 5.3 & 5.4

BH/TP No.	Sample No.	Depth (m)	Sample Type	Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index	<425µm %	Preparation	Description	Classification
GC1	AH2527	2.60	GCS	23	31	19	12	88	WS	Orangish brown slightly sandy slightly gravelly CLAY	C L
GC2	AH2529	2.50	GCS	11.3	34	19	15	28	WS	Grey brown silty very sandy GRAVEL	
GC2		4.50	GCS	8.1	36	23	13	13	WS	Grey brown silty sandy GRAVEL	C I
GC3	AH2525	2.00	GCS	20	46	21	25	95	WS	Orangish brown slightly sandy slightly gravelly CLAY	C I
GC3		4.50	GCS	13	25	NP		69	WS	Light brown slightly sandy slightly gravelly SILT	M L
GC4	AH2526	3.20	GCS	19.6	39	20	19	98	WS	Light brown slightly sandy slightly gravelly CLAY	C I
GC5	AH2528	3.00	GCS	18.7	37	18	19	79	WS	Brown slightly sandy slightly gravelly CLAY	C I
GC6+	AH2524	2.50	GCS	10.9	23	15	8	56	WS	Orangish brown slightly sandy slightly gravelly CLAY	C L

Notes: NAT - tested as received WS - Wet sieved (425µm) NP - Non Plastic

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Determination of Particle Size Distribution

BS1377:Part2:1990 , clauses 9.2

particle size	% passing	
75	100	COBBLES
63	100	
50	100	
37.5	100	
28	100	
20	100	GRAVEL
14	95	
10	93	
6.3	91	
5	91	
3.35	90	
2	90	
1.18	89	
0.6	88	SAND
0.425	88	
0.3	87	
0.15	85	
0.063	82	
0.037	72	
0.027	65	
0.017	50	SILT/CLAY
0.010	36	
0.007	28	
0.004	19	
0.002	13	

Contract No: 14039

Contract: INDAVER WASTE MANAGEMENT FACILITY, DULEEK

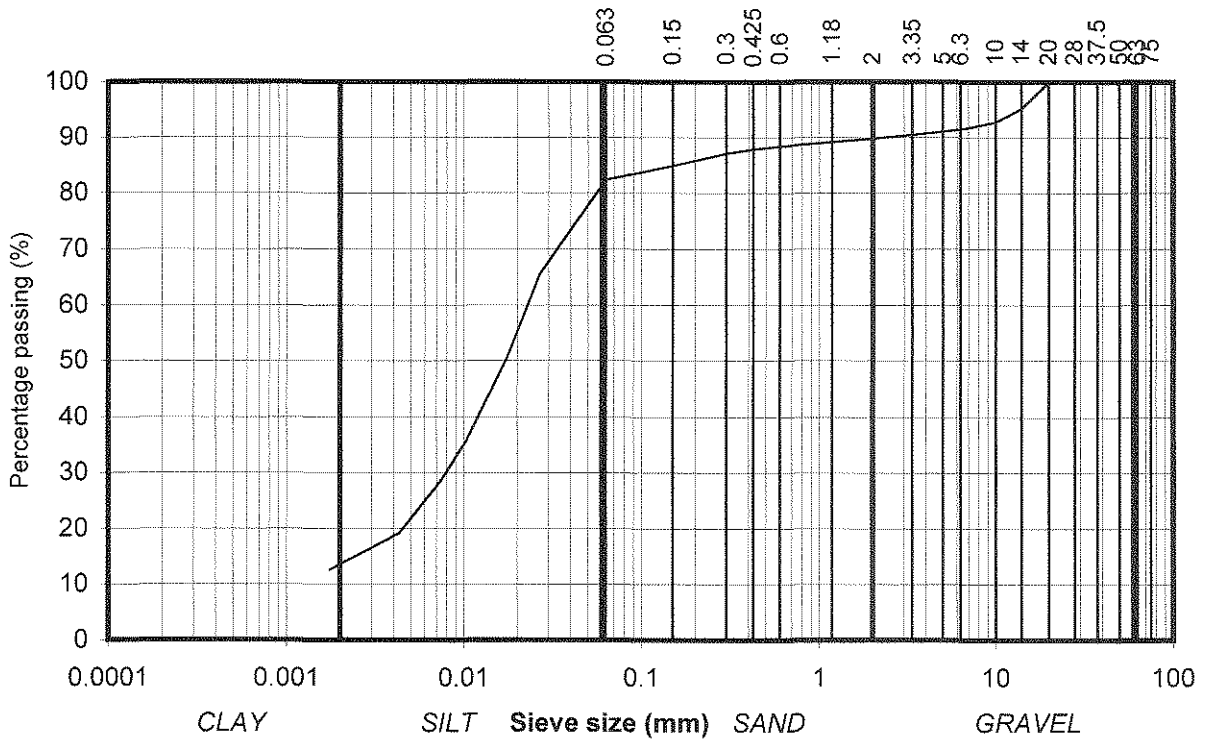
BH/TP No: GC1

SAMPLE No.: AH2527 SAMPLE TYPE: GCS

DEPTH (m): 2.60

TEST METHOD: Wet sieve and hydrometer

DESCRIPTION: Orangish brown slightly sandy, slightly gravelly, CLAY



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Determination of Particle Size Distribution

BS1377:Part2:1990 , clauses 9.2

particle size	% passing	
75	100	COBBLES
63	100	GRAVEL
50	89	
37.5	89	
28	89	
20	82	
14	74	
10	65	
6.3	57	
5	52	
3.35	47	
2	42	SAND
1.18	37	
0.6	31	
0.425	28	
0.3	26	
0.15	22	
0.063	17	SILT/CLAY
0.038	12	
0.028	10	
0.018	7	
0.011	4	
0.008	3	
0.004	2	
0.002	1	

Contract No: 14039

Contract: INDAVER WASTE MANAGEMENT FACILITY, DULEEK

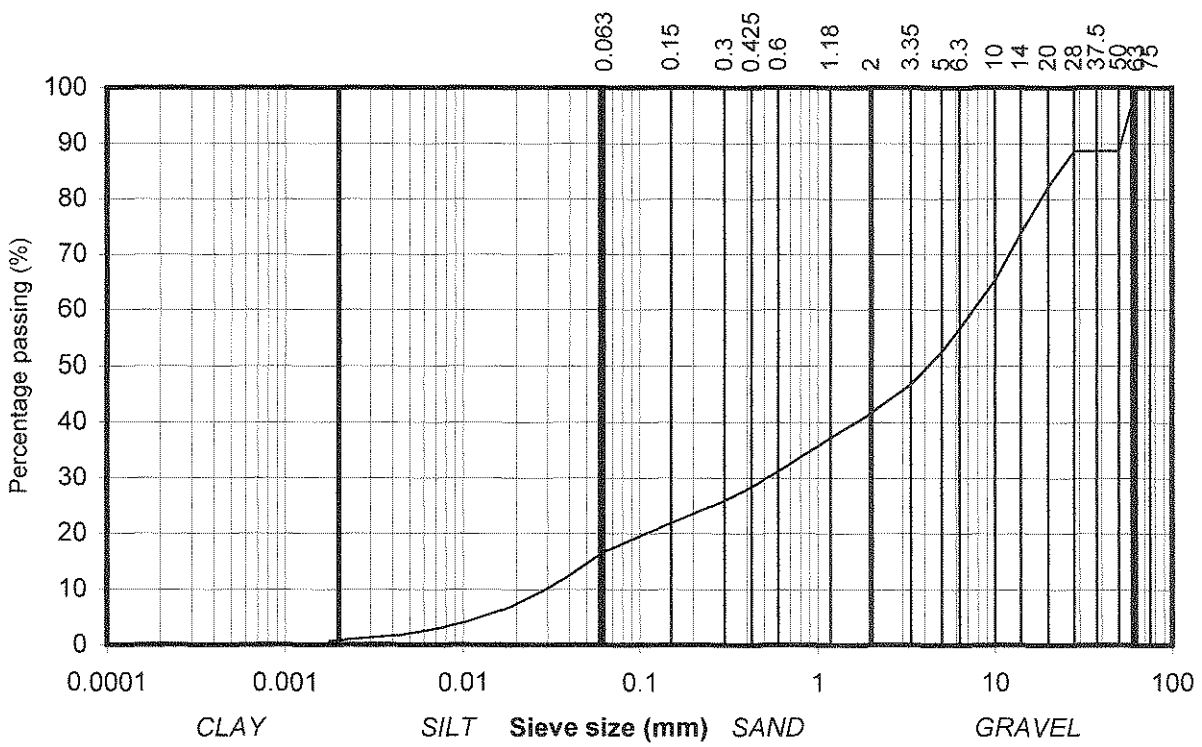
BH/TP No: GC2

SAMPLE No.: AH2529 SAMPLE TYPE: GCS

DEPTH (m): 2.50

TEST METHOD: Wet sieve and hydrometer

DESCRIPTION: Grey brown silty, very sandy, GRAVEL



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Determination of Particle Size Distribution

BS1377:Part2:1990 , clauses 9.2

particle size	% passing	
75	100	COBBLES
63	100	GRAVEL
50	100	
37.5	94	
28	81	
20	68	
14	56	
10	49	
6.3	40	
5	37	
3.35	31	
2	25	SAND
1.18	20	
0.6	15	
0.425	13	
0.3	11	
0.15	8	
0.063	5	SILT/CLAY
0.043	#N/A	
0.030	#N/A	
0.019	#N/A	
0.011	#N/A	
0.008	#N/A	
0.005	#N/A	
0.002	#N/A	

Contract No: 14039

Contract: INDAVER WASTE MANAGEMENT FACILITY, DULEEK

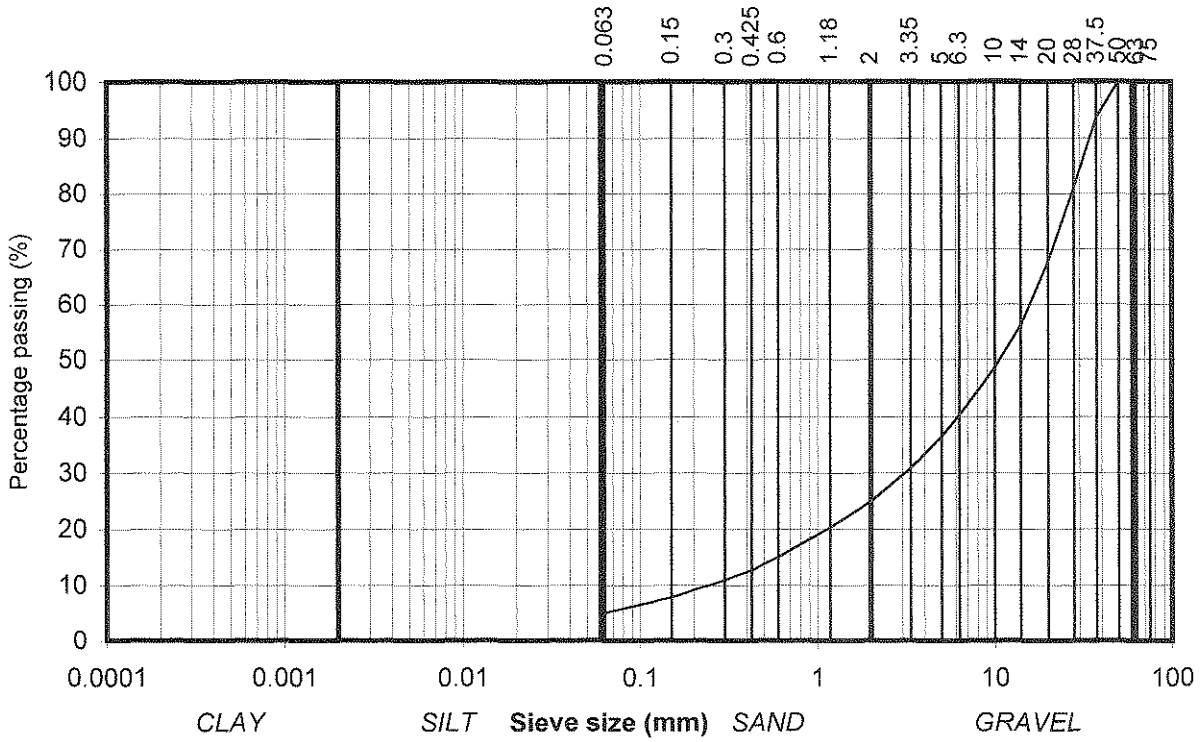
BH/TP No: GC2

SAMPLE No.: 0 SAMPLE TYPE: GCS

DEPTH (m): 4.50

TEST METHOD: Wet sieve

DESCRIPTION: Grey brown silty, sandy, GRAVEL



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Determination of Particle Size Distribution

BS1377:Part2:1990 , clauses 9.2

particle size	% passing	
75	100	COBBLES
63	100	GRAVEL
50	100	
37.5	100	
28	100	
20	100	
14	100	
10	100	
6.3	100	
5	99	
3.35	99	
2	99	SAND
1.18	98	
0.6	96	
0.425	95	
0.3	92	
0.15	83	
0.063	75	SILT/CLAY
0.037	66	
0.027	54	
0.017	42	
0.010	32	
0.007	27	
0.004	21	
0.002	16	

Contract No: 14039

Contract: INDAVER WASTE MANAGEMENT FACILITY, DULEEK

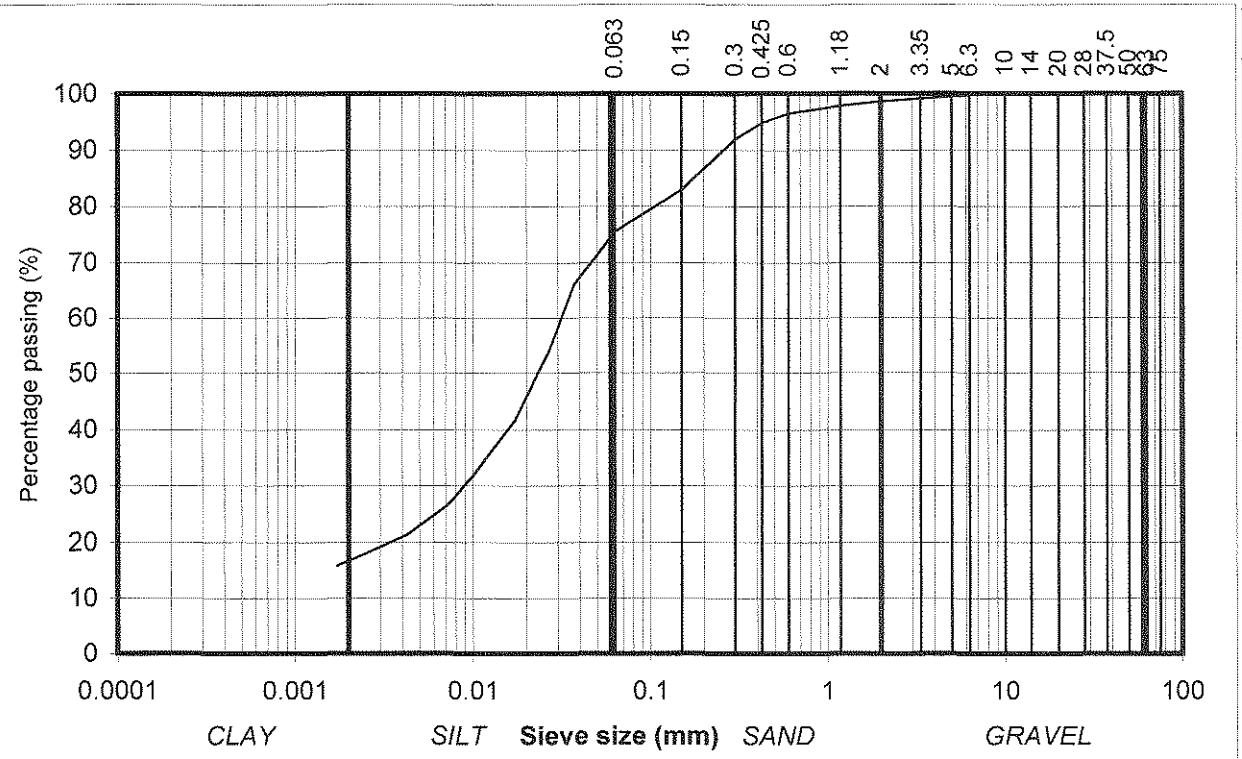
BH/TP No: GC3

SAMPLE No.: AH2525 SAMPLE TYPE: GCS

DEPTH (m): 2.00

TEST METHOD: Wet sieve and hydrometer

DESCRIPTION: Orangish brown slightly sandy, slightly gravelly, SILT



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Determination of Particle Size Distribution

BS1377:Part2:1990 , clauses 9.2

particle size	% passing	
75	100	COBBLES
63	100	GRAVEL
50	100	
37.5	100	
28	100	
20	97	
14	93	
10	89	
6.3	86	
5	84	
3.35	80	
2	77	SAND
1.18	74	
0.6	71	
0.425	69	
0.3	67	
0.15	57	
0.063	45	SILT/CLAY
0.043	#N/A	
0.030	#N/A	
0.019	#N/A	
0.011	#N/A	
0.008	#N/A	
0.005	#N/A	
0.002	#N/A	

Contract No: 14039

Contract: INDAVER WASTE MANAGEMENT FACILITY, DULEEK

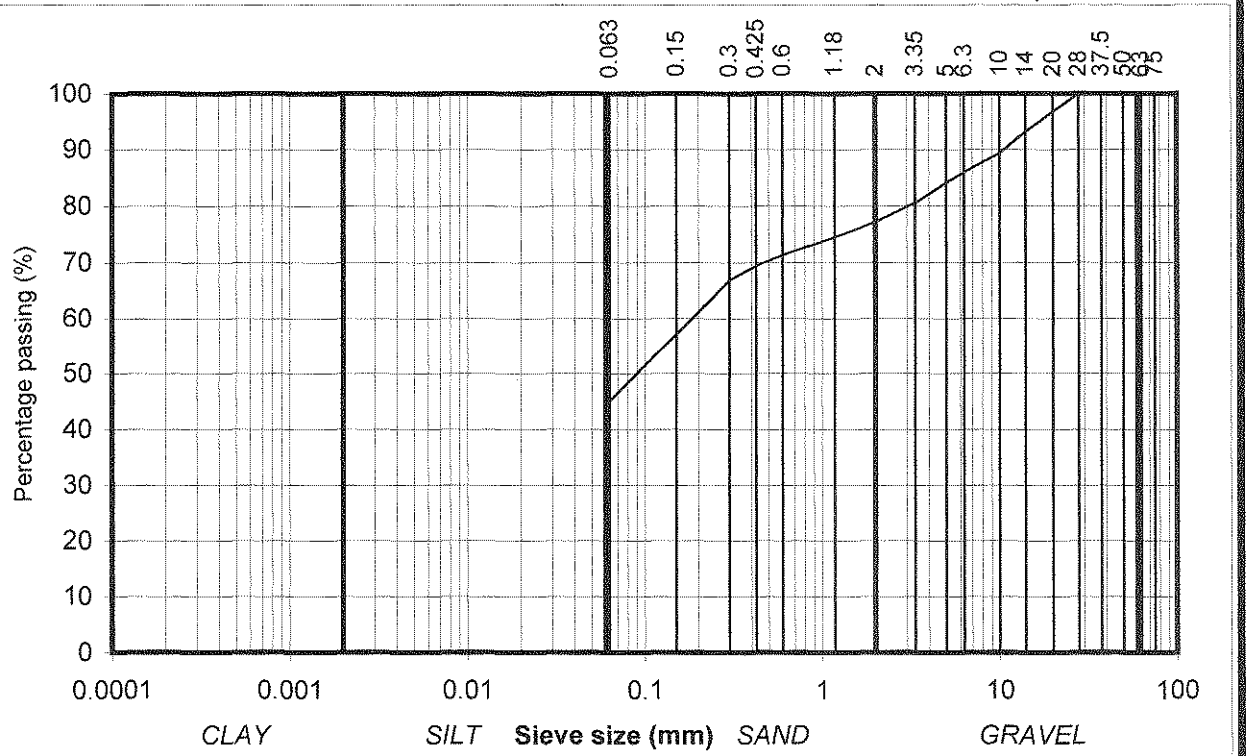
BH/TP No: GC3

SAMPLE No.: 0 SAMPLE TYPE: GCS

DEPTH (m): 4.50

TEST METHOD: Wet sieve

DESCRIPTION: Light brown slightly sandy, slightly gravelly, SILT



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Determination of Particle Size Distribution

BS1377:Part2:1990 , clauses 9.2

particle size	% passing	
75	100	COBBLES
63	100	
50	100	
37.5	100	
28	100	
20	100	GRAVEL
14	100	
10	100	
6.3	99	
5	99	
3.35	99	
2	99	
1.18	98	
0.6	98	SAND
0.425	98	
0.3	97	
0.15	91	
0.063	75	
0.038	60	
0.028	45	
0.018	29	SILT/CLAY
0.011	17	
0.007	14	
0.004	10	
0.002	7	

Contract No: 14039

Contract: INDAVER WASTE MANAGEMENT FACILITY, DULEEK

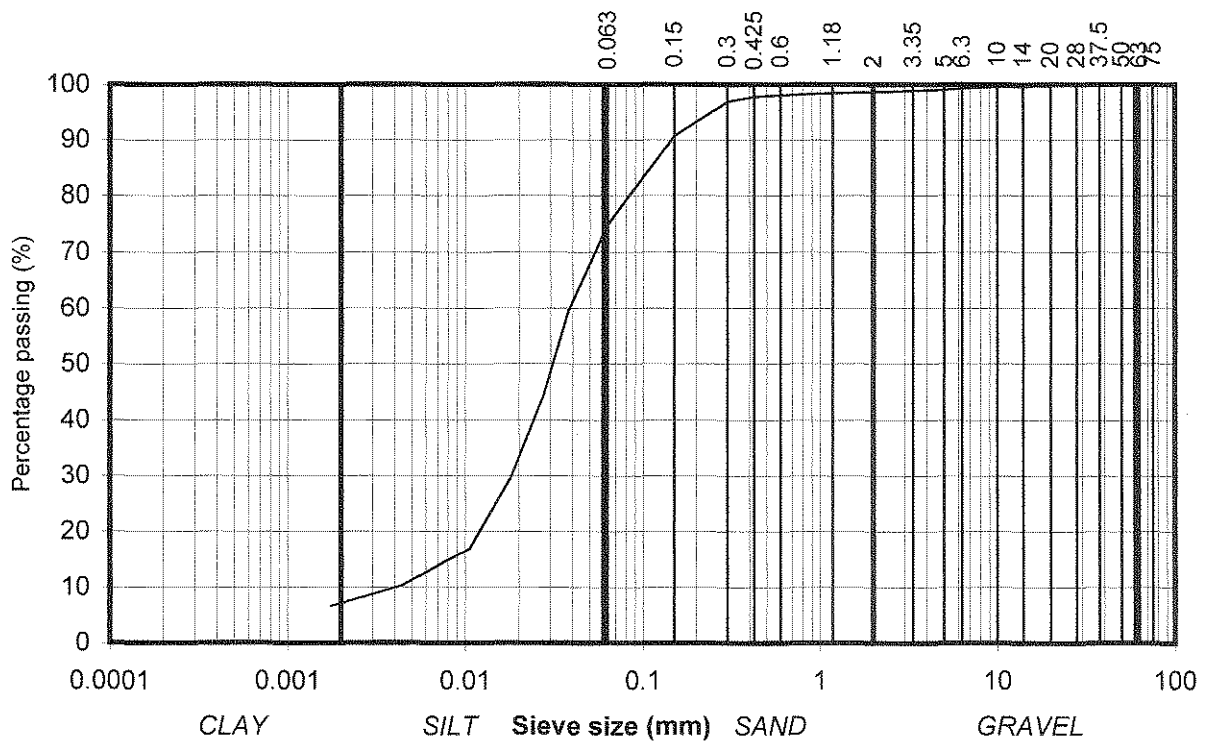
BH/TP No: GC4

SAMPLE No.: AH2526 SAMPLE TYPE: GCS

DEPTH (m): 3.20

TEST METHOD: Wet sieve and hydrometer

DESCRIPTION: Light brown slightly sandy, slightly gravelly, CLAY



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Determination of Particle Size Distribution

BS1377:Part2:1990 , clauses 9.2

particle size	% passing	
75	100	COBBLES
63	100	
50	100	
37.5	100	
28	100	
20	96	GRAVEL
14	94	
10	93	
6.3	91	
5	89	
3.35	88	
2	86	
1.18	84	
0.6	81	SAND
0.425	79	
0.3	77	
0.15	71	
0.063	65	
0.037	58	
0.027	51	
0.017	43	SILT/CLAY
0.010	33	
0.007	27	
0.004	21	
0.002	10	

Contract No: 14039

Contract: INDAVER WASTE MANAGEMENT FACILITY, DULEEK

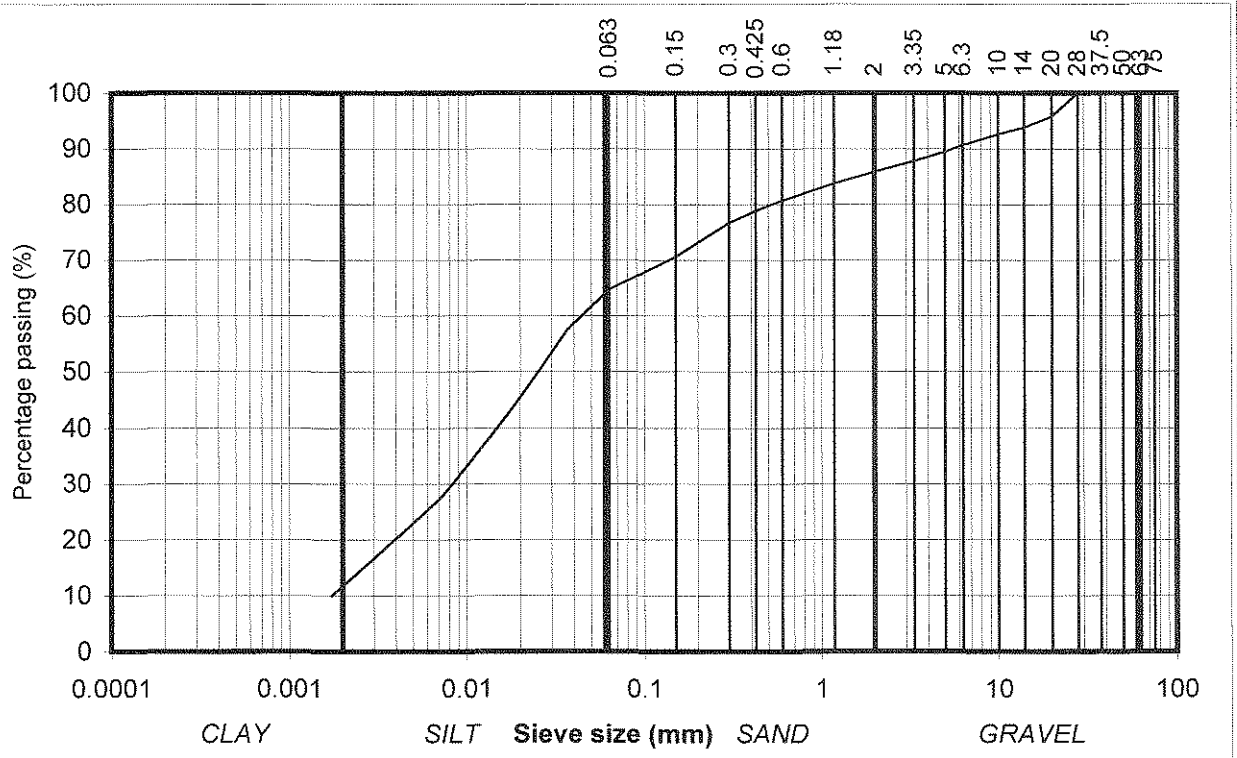
BH/TP No: GC5

SAMPLE No.: AH2528 SAMPLE TYPE: GCS

DEPTH (m): 3.00

TEST METHOD: Wet sieve and hydrometer

DESCRIPTION: Brown slightly sandy, slightly gravelly, CLAY



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Determination of Particle Size Distribution

BS1377:Part2:1990 , clauses 9.2

particle size	% passing	
75	100	COBBLES
63	100	
50	100	
37.5	100	
28	100	
20	92	GRAVEL
14	88	
10	84	
6.3	78	
5	76	
3.35	71	
2	66	
1.18	62	
0.6	58	SAND
0.425	56	
0.3	54	
0.15	47	
0.063	37	
0.038	29	
0.027	24	
0.018	18	SILT/CLAY
0.010	13	
0.007	11	
0.004	9	
0.002	5	

Contract No: 14039

Contract: INDAVER WASTE MANAGEMENT FACILITY, DULEEK

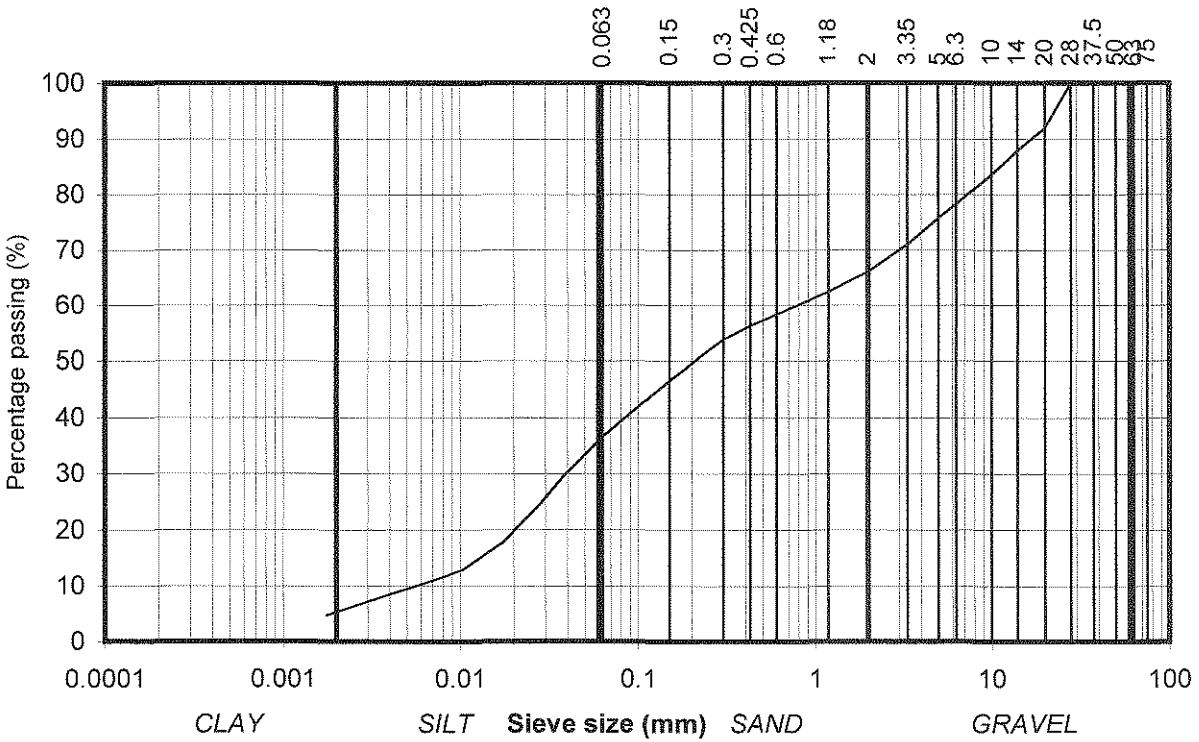
BH/TP No: GC6+

SAMPLE No.: AH2524 SAMPLE TYPE: GCS

DEPTH (m): 2.50

TEST METHOD: Wet sieve and hydrometer

DESCRIPTION: Orangish brown slightly sandy, slightly gravelly, CLAY



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Consolidated Quick-undrained (CQu) Triaxial Test

Manual of Soil Laboratory Testing Volume 3 KH Head Clause 19.3.3

BH	RC1	Sample	AH2527	Depth (m)	2.6

Condition: Undisturbed

Corrections 2 membranes and side drains

Description Orangish brown sandy gravelly CLAY

Initial Conditions

Height (mm)	200	Diameter (mm)	103
Area (mm^2)	8332.29	Volume (cm^3)	1666.46
% Moisture Content	23	Bulk Density (Mg/m^3)	2.06
		Dry Density (Mg/m^3)	1.68

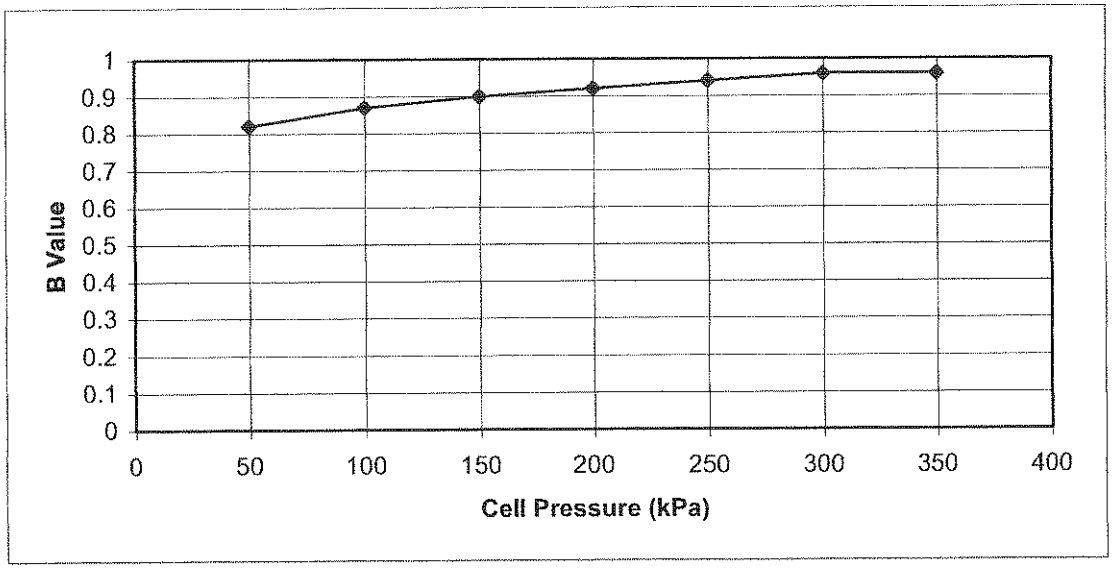
Final Conditions

% Moisture Content	20	Bulk Density (Mg/m^3)	2.02
		Dry Density (Mg/m^3)	1.69

Saturation stage

Effective stress (kPa) 50 Saturation by 50kPa Cell Pressure Increments

Initial B Value 0.82 Final B Value 0.96



IGSL Ltd.

Contract Duleek

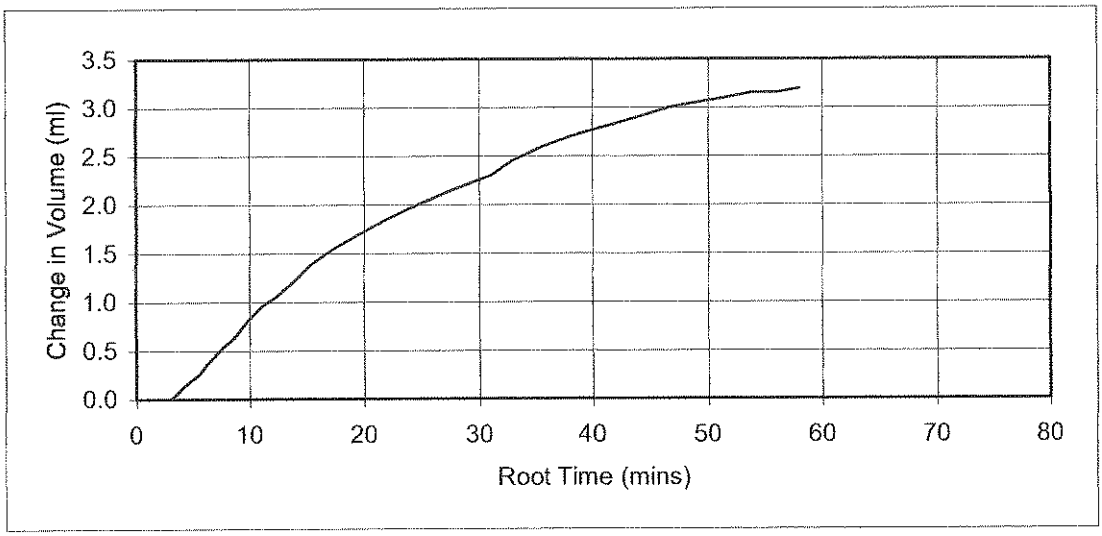
Contract No. 14039

Consolidated Quick-undrained (CQu) Triaxial Test

Manual of Soil Laboratory Testing Volume 3 KH Head Clause 19.3.3

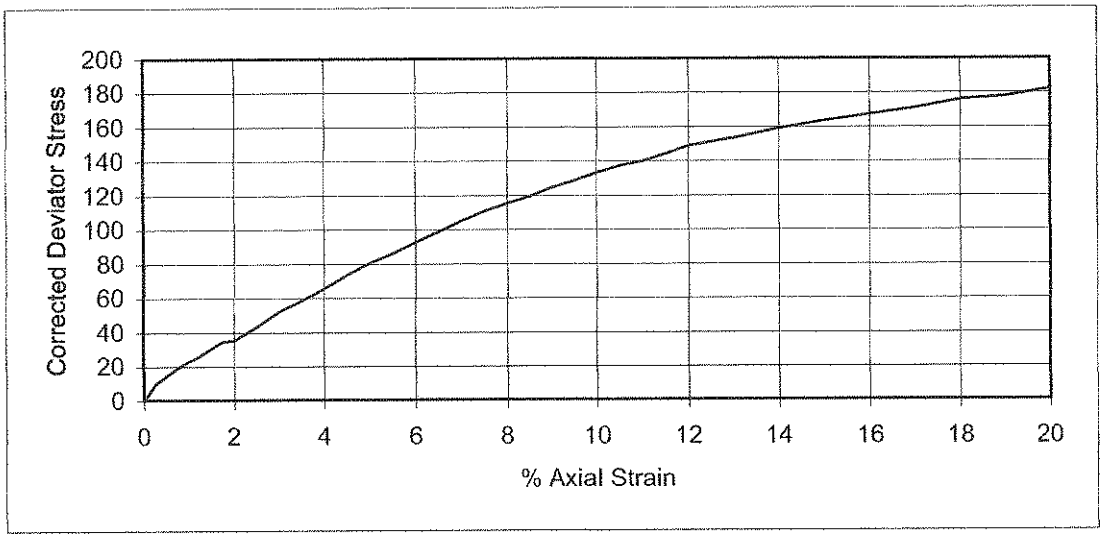
BH	RC1	Sample	AH2527	Depth (m)	2.6

Consolidation stage



Effective stress (kPa)	50	Change in Volume (ml)	3.20

Compression stage



Cell Pressure (kPa)	50	Cohesion	91
Axial strain at failure (%)	20	Failure Type	Compound

Consolidated Quick-undrained (CQu) Triaxial Test

Manual of Soil Laboratory Testing Volume 3 KH Head Clause 19.3.3

BH	RC3	Sample	AH2525	Depth (m)	2.0

Condition: Undisturbed

Corrections 2 membranes and side drains

Description Orangish brown sandy CLAY

Initial Conditions

Height (mm)	200	Diameter (mm)	101
Area (mm^2)	8011.85	Volume (cm^3)	1602.37
% Moisture Content	14	Bulk Density (Mg/m^3)	2.29
		Dry Density (Mg/m^3)	2.01

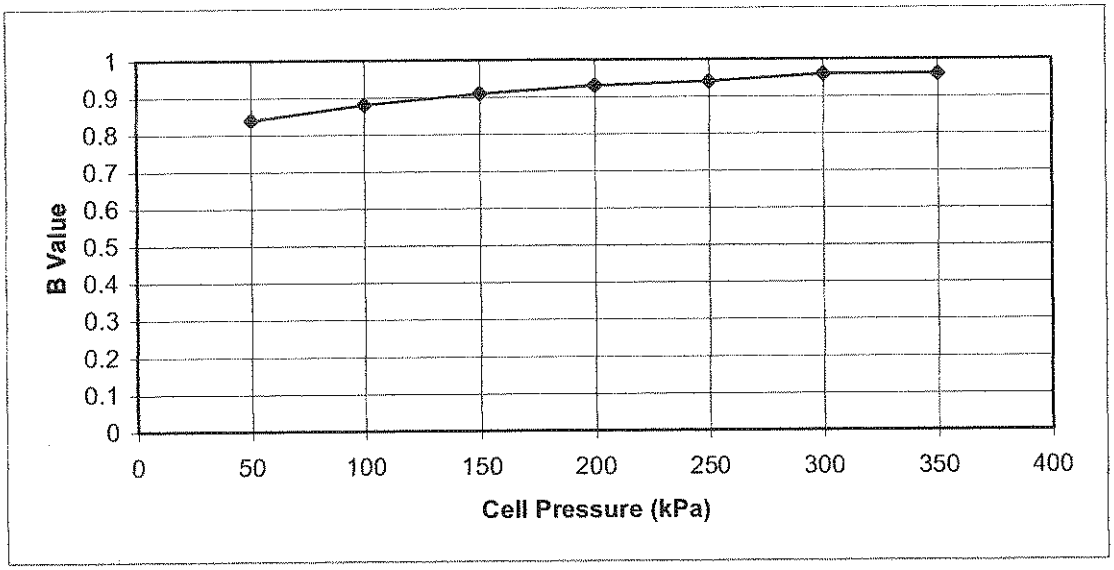
Final Conditions

% Moisture Content	14	Bulk Density (Mg/m^3)	2.29
		Dry Density (Mg/m^3)	2.01

Saturation stage

Effective stress (kPa) 50 Saturation by 50kPa Cell Pressure Increments

Initial B Value 0.84 Final B Value 0.96



IGSL Ltd.

Contract Duleek

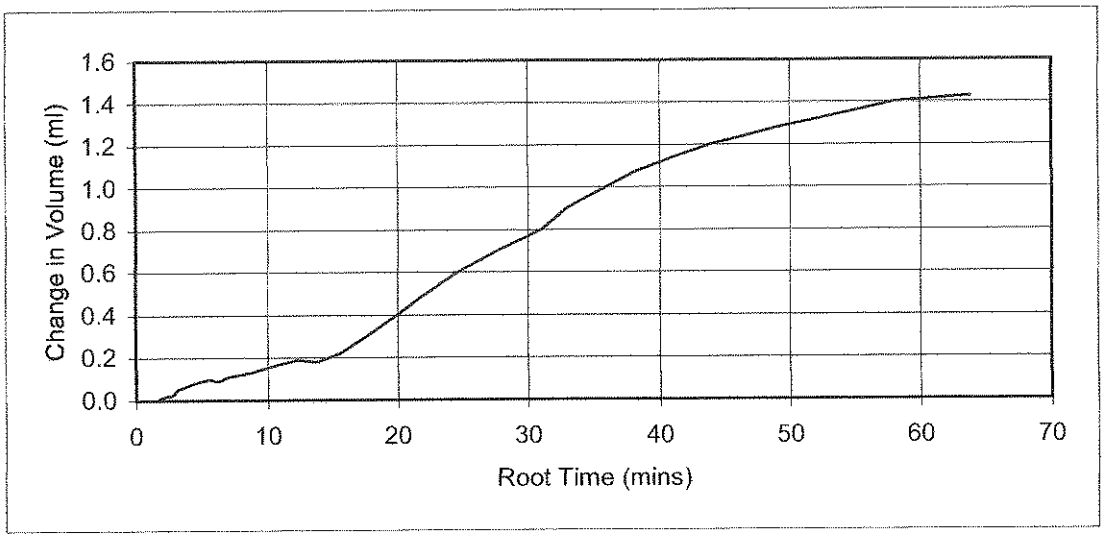
Contract No. 14039

Consolidated Quick-undrained (CQu) Triaxial Test

Manual of Soil Laboratory Testing Volume 3 KH Head Clause 19.3.3

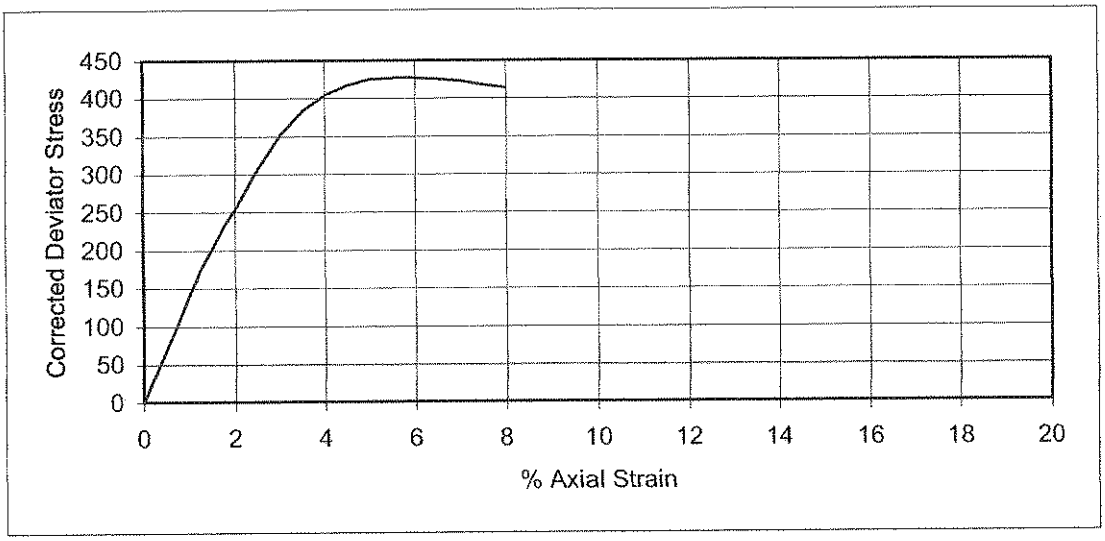
BH	RC3	Sample	AH2525	Depth (m)	2.0

Consolidation stage



Effective stress (kPa)	50	Change in Volume (ml)	1.43

Compression stage



Cell Pressure (kPa)	50	Cohesion	214
Axial strain at failure (%)	6	Failure Type	Compound

Consolidated Quick-undrained (CQu) Triaxial Test

Manual of Soil Laboratory Testing Volume 3 KH Head Clause 19.3.3

BH RC3 Sample Depth (m) 4.5

Condition: Undisturbed

Corrections 2 membranes

Description Yellowish brown sandy gravelly CLAY

Initial Conditions

Height (mm)	201	Diameter (mm)	100
Area (mm^2)	7853.98	Volume (cm^3)	1575.51
% Moisture Content	9.9	Bulk Density (Mg/m^3)	2.36
		Dry Density (Mg/m^3)	2.15

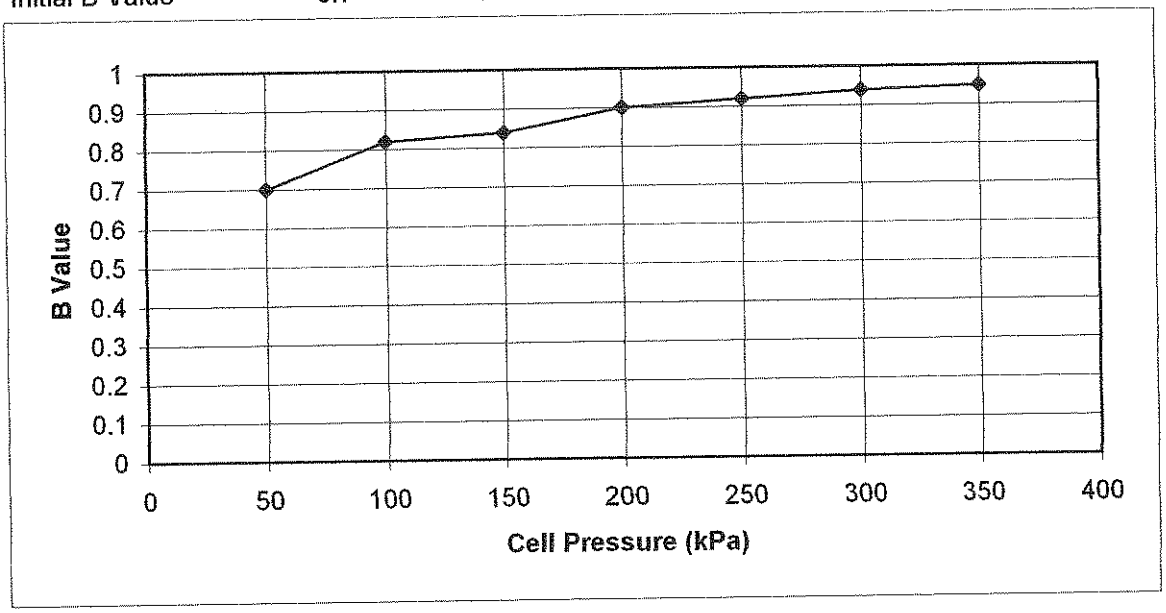
Final Conditions

% Moisture Content	9.7	Bulk Density (Mg/m^3)	2.37
		Dry Density (Mg/m^3)	2.16

Saturation stage

Effective stress (kPa) 50 Saturation by 50kPa Cell Pressure Increments

Initial B Value 0.7 Final B Value 0.95



IGSL Ltd.

Contract Duleek

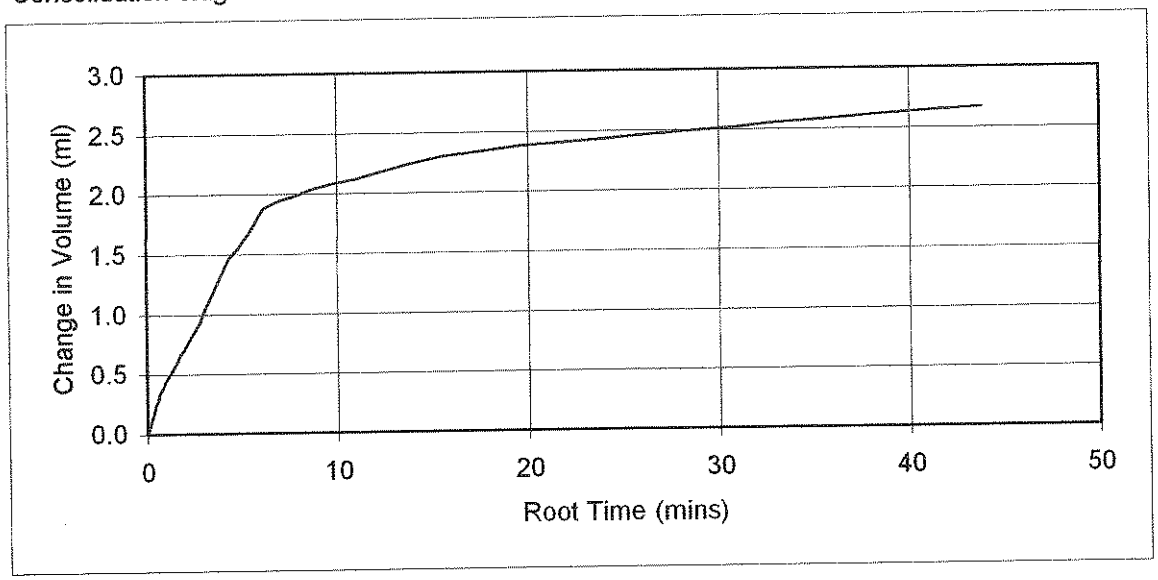
Contract No. 14039

Consolidated Quick-undrained (CQu) Triaxial Test

Manual of Soil Laboratory Testing Volume 3 KH Head Clause 19.3.3

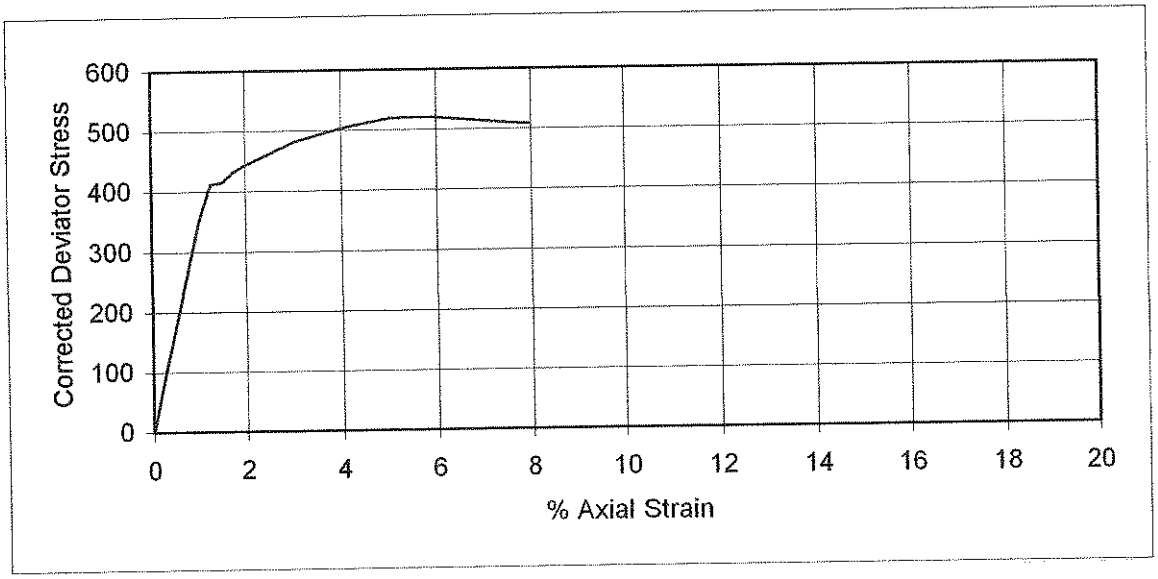
BH	RC3	Sample		Depth (m)	4.5

Consolidation stage



Effective stress (kPa)	50	Change in Volume (ml)	2.67

Compression stage



Cell Pressure (kPa)	50	Cohesion	260
Axial strain at failure (%)	5.5	Failure Type	Compound

Consolidated Quick-undrained (CQu) Triaxial Test

Manual of Soil Laboratory Testing Volume 3 KH Head Clause 19.3.3

BH	RC4	Sample	AH2526	Depth (m)	3.2

Condition: Undisturbed

Corrections 2 membranes and side drains

Description Orangish brown sandy gravelly CLAY

Initial Conditions

Height (mm)	200	Diameter (mm)	101
Area (mm^2)	8011.85	Volume (cm^3)	1602.37
% Moisture Content	23	Bulk Density (Mg/m^3)	2.16
		Dry Density (Mg/m^3)	1.76

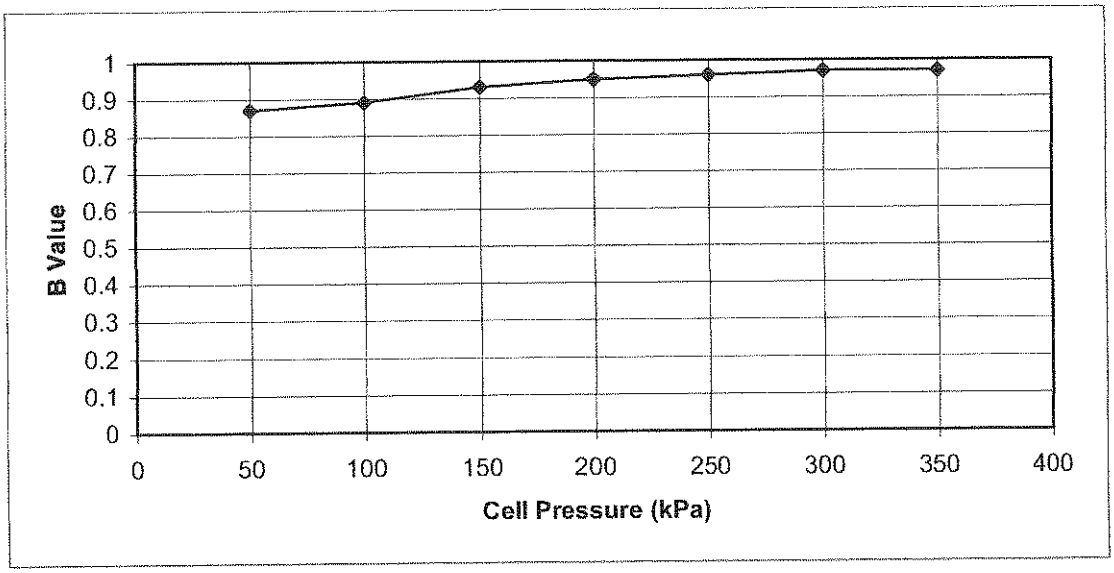
Final Conditions

% Moisture Content	22	Bulk Density (Mg/m^3)	2.15
		Dry Density (Mg/m^3)	1.76

Saturation stage

Effective stress (kPa) 50 Saturation by 50kPa Cell Pressure Increments

Initial B Value 0.87 Final B Value 0.97



IGSL Ltd.

Contract Duleek

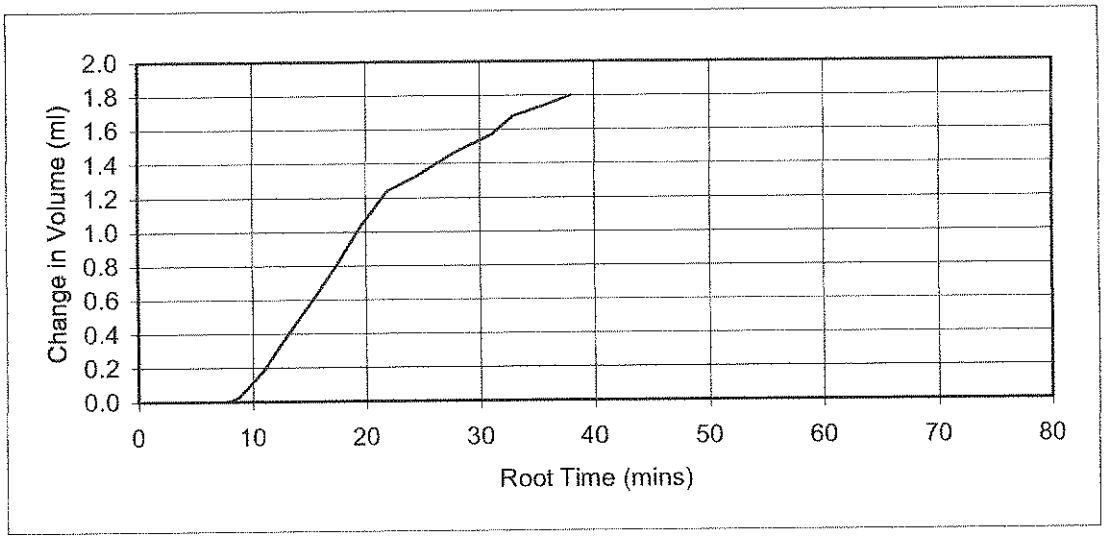
Contract No. 14039

Consolidated Quick-undrained (CQu) Triaxial Test

Manual of Soil Laboratory Testing Volume 3 KH Head Clause 19.3.3

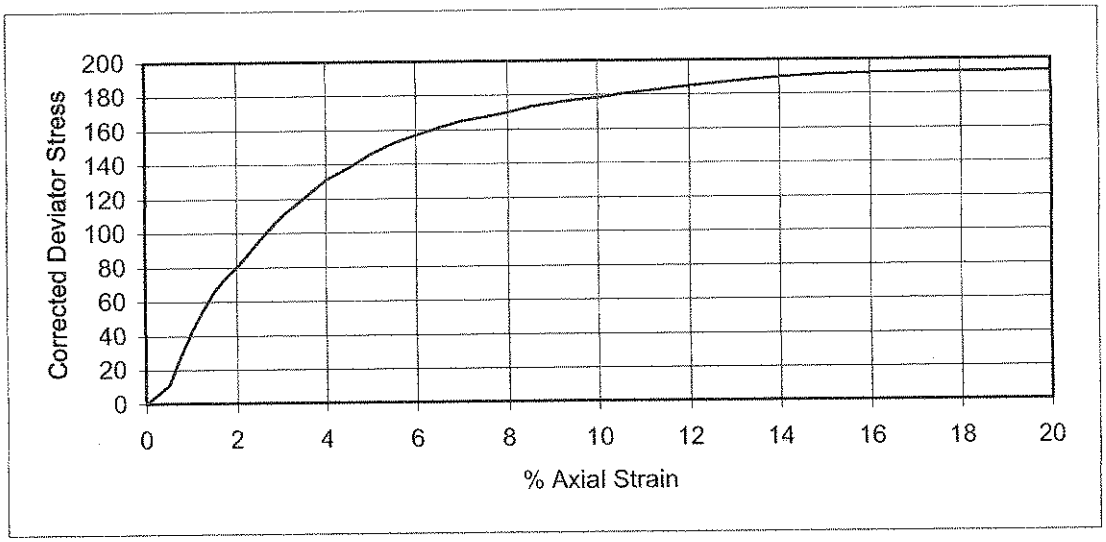
BH	RC4	Sample	AH2526	Depth (m)	3.2

Consolidation stage



Effective stress (kPa)	50	Change in Volume (ml)	1.80

Compression stage



Cell Pressure (kPa)	50	Cohesion	96
Axial strain at failure (%)	20	Failure Type	Plastic

Consolidated Quick-undrained (CQu) Triaxial Test

Manual of Soil Laboratory Testing Volume 3 KH Head Clause 19.3.3

BH	RC5	Sample	AH2528	Depth (m)	3.0

Condition: Undisturbed

Corrections 2 membranes

Description Orangish brown sandy gravelly CLAY

Initial Conditions

Height (mm)	200	Diameter (mm)	101.5
Area (mm^2)	8091.37	Volume (cm^3)	1618.27
% Moisture Content	11	Bulk Density (Mg/m^3)	2.32
		Dry Density (Mg/m^3)	2.10

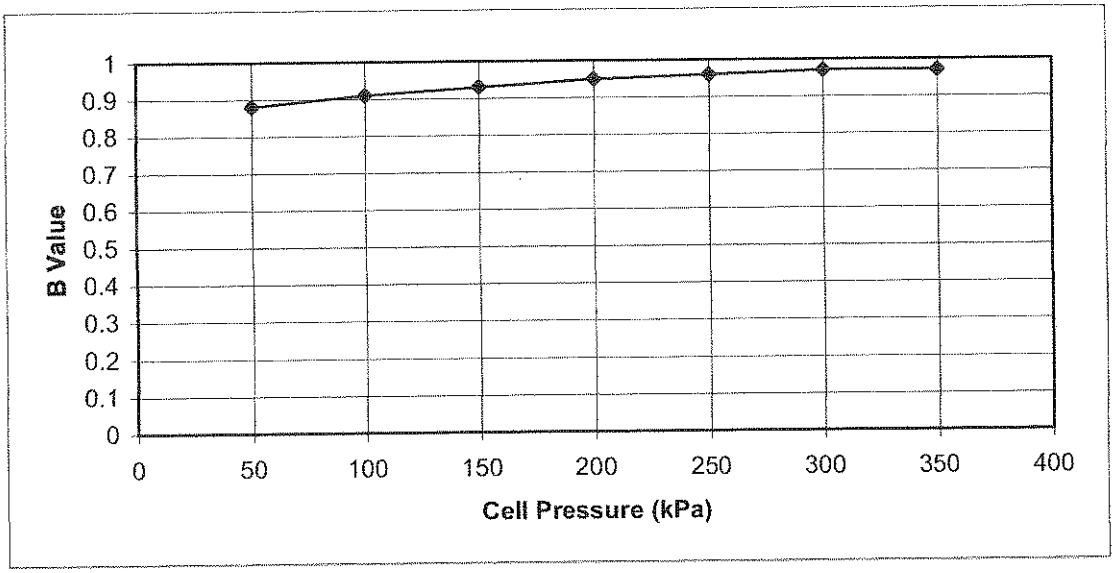
Final Conditions

% Moisture Content	11	Bulk Density (Mg/m^3)	2.35
		Dry Density (Mg/m^3)	2.11

Saturation stage

Effective stress (kPa) 50 Saturation by 50kPa Cell Pressure Increments

Initial B Value 0.88 Final B Value 0.97



IGSL Ltd.

Contract Duleek

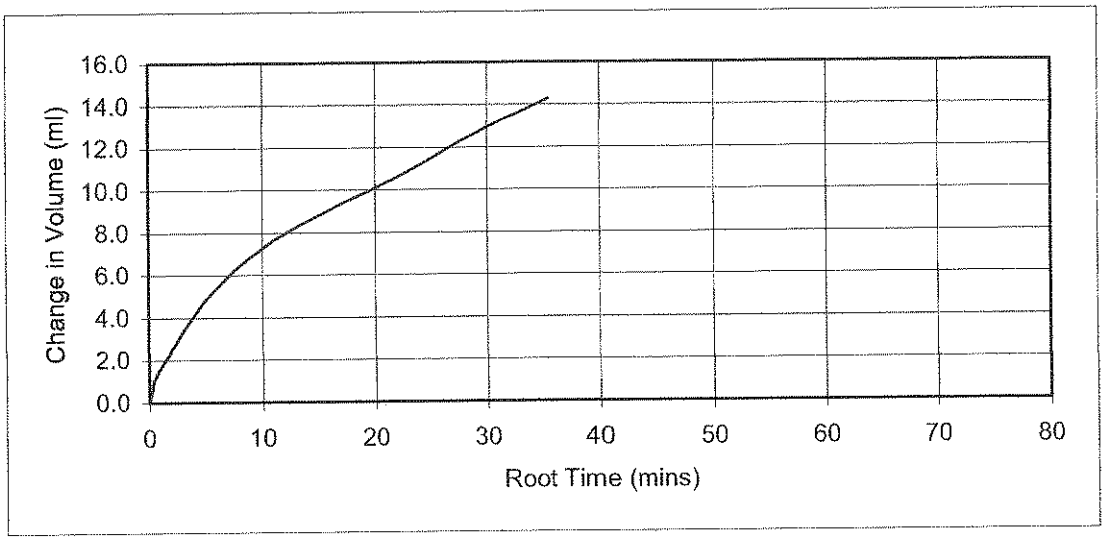
Contract No. 14039

Consolidated Quick-undrained (CQu) Triaxial Test

Manual of Soil Laboratory Testing Volume 3 KH Head Clause 19.3.3

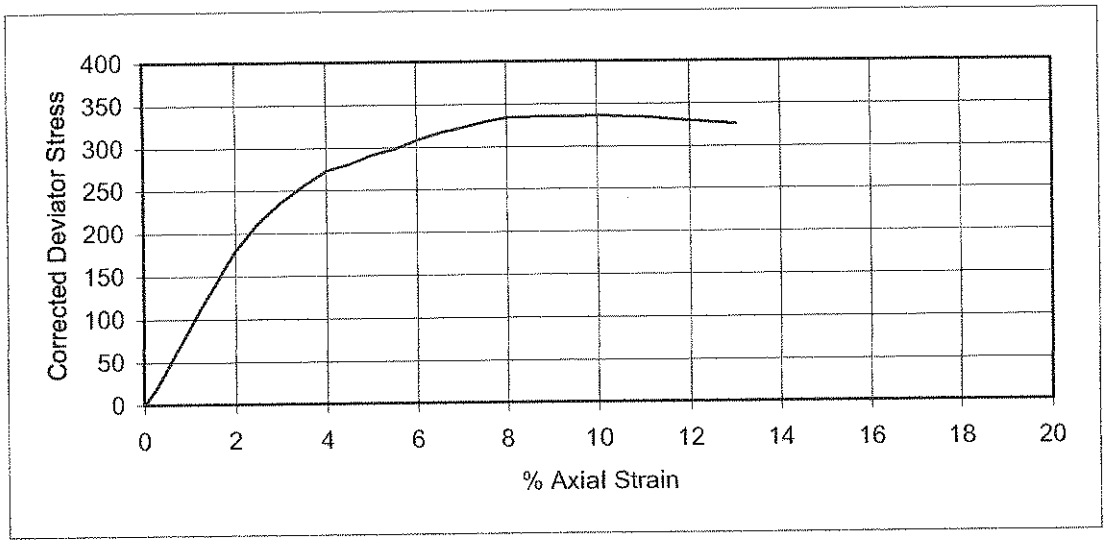
BH	RC5	Sample	AH2528	Depth (m)	3.0

Consolidation stage



Effective stress (kPa)	50	Change in Volume (ml)	14.28

Compression stage



Cell Pressure (kPa)	50	Cohesion	168
Axial strain at failure (%)	10	Failure Type	Compound

CONSOLIDATION TEST CALCULATIONS IGSL

initial height	18.85	
Wt. soil+ring	278.7	
final wet wt.	280.1	
final dry wt	258.7	
wt. of ring	89.3	
w/c initial	11.8%	
w/c final	12.6%	
S.G.	2.65	Assumed
e final	0.3347698	
change in e	0.0723296	*change in Ht.
Final Height	18.454	

Contract:	INDAVER WASTE MANAGEMENT FACILITY, DULEEK
Borehole No:	GC6
Sample No:	AH2524
Sample Type	GCS
Depth:	2.50

Pressure range		increment	change in Ht.	change in e	e at end of stage	average e	MV (m2/MN.)	HEIGHT H	AV. HEIGHT
from	to				0.363			18.85	
0	20	20	0.092	0.007	0.357	0.360	0.245	18.758	18.804
20	50	30	0.114	0.008	0.349	0.353	0.203	18.644	18.701
50	100	50	0.13	0.009	0.339	0.344	0.140	18.514	18.579
100	200	100	0.166	0.012	0.327	0.333	0.090	18.348	18.431
200	20	-180	-0.106	-0.008	0.335	0.331	0.032	18.454	18.401
					0.335				
					0.335				
					0.335				
					0.335				
					0.335				

I.G.S.L.

CV calculations

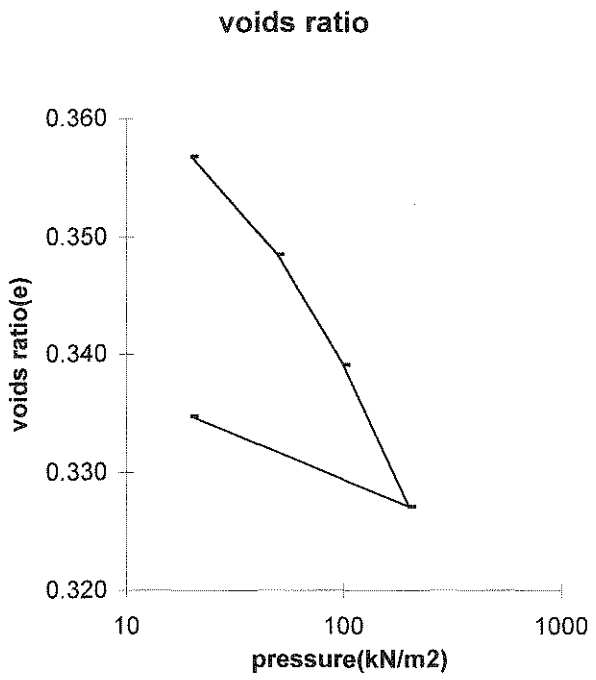
Pressure Range from	to	t 50 mins	t 90 mins	av. Height	Cv =0.026H2 / t50	Cv=0.111H2 / t90
0	20		1.21	18.804		32.44
20	50		0.81	18.701		47.93
50	100		1.69	18.579		22.67
100	200		1	18.431		37.71
200	20					

Contract	INDAVER WASTE MANAGEMENT FACILITY, DULEEK
Borehole No.	GC6
Sample No.	AH2524
Depth	2.5

CONSOLIDATION TEST RESULTS

IGSL

Sample Description: Orangish brown slightly sandy slightly gravelly CLAY



Pressure Range (kN/M2) from	to	Voids Ratio e	MV(m2/MN)	CV(m2/year)
0	20	0.357	0.24	32.44
20	50	0.349	0.20	47.93
50	100	0.339	0.14	22.67
100	200	0.327	0.09	37.71
200	20	0.335		

Contract: INDAVER WASTE MANAGEMENT FACILITY, DULEEK
Borehole No. GC6
Sample No. AH2524
Depth: 2.50

CONSOLIDATION TEST CALCULATIONS IGSL

initial height	18.85	
Wt. soil+ring	278.7	
final wet wt.	280.1	
final dry wt	258.7	
wt. of ring	89.3	
w/c initial	11.8%	
w/c final	12.6%	
S.G.	2.65	Assumed
e final	0.3347698	
change in e	0.0727078	*change in Ht.
Final Height	18.358	

Contract:	INDAVER WASTE MANAGEMENT FACILITY, DULEEK
Borehole No:	GC2
Sample No:	AH2529
Sample Type	GCS
Depth:	2.50

Pressure range		increment	change in Ht.	change in e	e at end of stage	average e	MV (m2/MN.)	HEIGHT H	AV. HEIGHT
from	to				0.371			18.85	
0	20	20	0.116	0.008	0.362	0.366	0.309	18.734	18.792
20	50	30	0.144	0.010	0.352	0.357	0.257	18.59	18.662
50	100	50	0.156	0.011	0.340	0.346	0.169	18.434	18.512
100	200	100	0.182	0.013	0.327	0.334	0.099	18.252	18.343
200	20	-180	-0.106	-0.008	0.335	0.331	0.032	18.358	18.305
					0.335				
					0.335				
					0.335				
					0.335				
					0.335				

I.G.S.L.

CV calculations

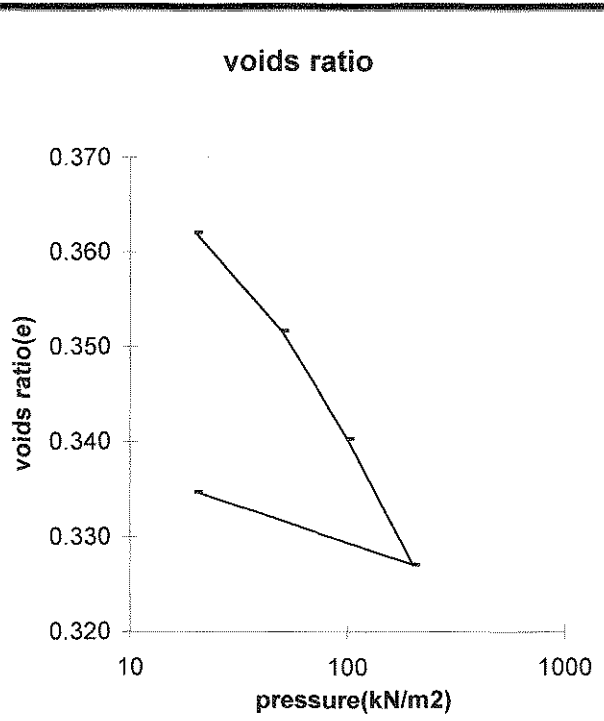
Pressure Range from	to	t 50 mins	t 90 mins	av. Height	Cv =0.026H2/t50	Cv=0.111H2/t90
0	20		4.84	18.792		8.10
20	50		1.44	18.662		26.85
50	100		1.21	18.512		31.44
100	200		1	18.343		37.35
200	20					

Contract	INDAVER WASTE MANAGEMENT FACILITY, DULEEK
Borehole No.	GC2
Sample No.	AH2529
Depth	2.5

CONSOLIDATION TEST RESULTS

IGSL

Sample Description: Grey brown silty very sandy GRAVEL



Pressure Range (kN/M2) from	to	Voids Ratio e	MV(m2/MN)	CV(m2/year)
0	20	0.362	0.31	8.10
20	50	0.352	0.26	26.85
50	100	0.340	0.17	31.44
100	200	0.327	0.10	37.35
200	20	0.335		

Contract: INDAVER WASTE MANAGEMENT FACILITY, DULEEK
Borehole No. GC2
Sample No. AH2529
Depth: 2.50

REPORT NO.

SULPHATE ANALYSIS

IGSL

CONTRACT: **INDAVER WASTE MANAGEMENT FACILITY, DULEEK** CONTRACT NO 14039

BH/TP NO.	DEPTH (M)	SAMPLE NO.	SAMPLE TYPE	TEST CODE	% Passing 2mm	SULPHUR TRIOXIDE		(so3 X 1.2)	pH
						2:1WATER SOIL EXTRACT So3 g/L	TOTAL SOIL so3 %	2:1WATER SOIL EXTRACT So4 g/L	VALUE
GC1	2.60	AH2527	GCS	A	67	0.01		0.012	7.2
GC2	2.50	AH2529	GCS	A	53	0.02		0.029	7.5
GC3	2.00	AH2525	GCS	A	96	0.01		0.007	7.0
GC4	3.20	AH2526	GCS	A	99	0.03		0.032	7.1
GC5	3.00	AH2528	GCS	A	84	0.01		0.012	7.2
GC6+	2.50	AH2524	GCS	A	71	0.02		0.024	7.7

TEST CODE W = WATER S = SOIL A = AQUEOUS SOIL EXTRACT(2:1)

Appendix 5

Geotechnical Rock Laboratory Test Records

POINT LOAD TEST RESULTS

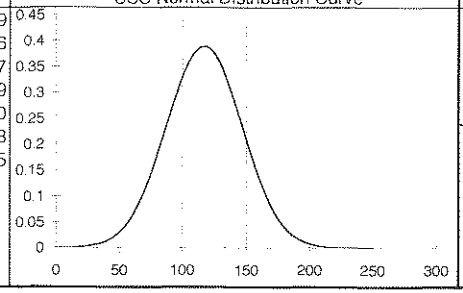
Contract: Indaver Duleek
Contract no. 14039
Date of test: 12/03/2009 Tested by: A. Mahony

Sample Type: LIMESTONE

Sample No.	Depth m	Width1 mm	Width2 mm	Diameter mm	*P kN	=	*Is Mpa	*Is(50) Mpa	*UCS MPa	Type
GC1	11.50			102	48.0	1.378	4.61	6.36	127	d
GC1	6.90			102	50.0	1.378	4.81	6.62	132	d
GC1	9.90			102	44.0	1.378	4.23	5.83	117	d
GC1	8.35			102	45.0	1.378	4.33	5.96	119	d
GC2	6.20			102	43.0	1.378	4.13	5.70	114	d
GC2	9.10			102	45.0	1.378	4.33	5.96	119	d
GC2	13.00			102	38.0	1.378	3.65	5.03	101	d
GC2	8.60			102	47.0	1.378	4.52	6.23	125	d
GC2	8.00			102	21.0	1.378	2.02	2.78	56	d
GC2	11.80			102	29.0	1.378	2.79	3.84	77	d
GC3	8.70			102	51.0	1.378	4.90	6.76	135	d
GC3	7.00			102	53.0	1.378	5.09	7.02	140	d
GC3	9.10			102	55.0	1.378	5.29	7.29	146	d
GC3	11.65			102	42.0	1.378	4.04	5.56	111	d
GC3	10.10	99.00	87.00	60	28.0	1.086	7.78	8.44	169	d
GC4	11.40			102	57.0	1.378	5.48	7.55	151	d
GC4	8.40			102	45.0	1.378	4.33	5.96	119	d
GC4	8.60			102	48.0	1.378	4.61	6.36	127	d
GC4	7.40			102	32.0	1.378	3.08	4.24	85	d
GC4	10.60			102	53.0	1.378	5.09	7.02	140	d
GC5	5.90			102	57.0	1.378	5.48	7.55	151	d
GC5	8.60			102	21.0	1.378	2.02	2.78	56	d
GC5	11.40			102	52.0	1.378	5.00	6.89	138	d
GC5	10.30			102	46.0	1.378	4.42	6.09	122	d
GC6	10.05			102	32.0	1.378	3.08	4.24	85	d
GC6	11.10			102	37.0	1.378	3.56	4.90	98	d
GC6	13.20			102	22.0	1.378	2.11	2.91	58	d
GC6	8.80			102	46.0	1.378	4.42	6.09	122	d
GC6	9.70			102	57.0	1.378	5.48	7.55	151	d

Statistical Summary Data	Is(50)	UCS*
Number of Samples Tested	29	29
Minimum	2.78	56
Average	5.85	117
Maximum	8.44	169
Standard Dev.	1.49	30
Upper 95% Confidence Limit	8.76	175.18
Lower 95% Confidence Limit	2.93	58.65

*UCS Normal Distribution Curve



Abbreviations	
i	irregular
a	axial
b	block
d	diametral

Comments:
*UCS (Uniaxial Compressive Strength) taken as k x Point Load Is(50): k= 20
*Is = Index Strength. *Is(50) = Corrected Index Strength
*P = Failure Load

POINT LOAD TEST RESULTS

Contract: Indaver Duleek
Contract no. 14039
Date of test: 12/03/2009 Tested by: A. Mahony

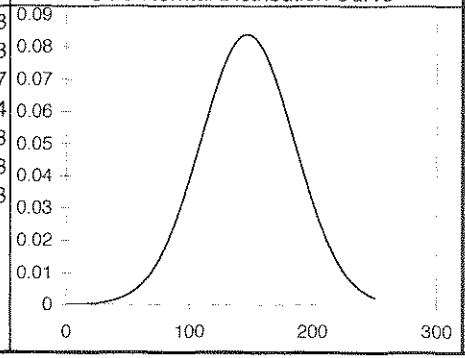
Sample Type: LIMESTONE

Sample No.	Depth m	Width1 mm	Width2 mm	Diameter mm	*P kN	F	*Is Mpa	*Is(50) Mpa	*UCS MPa	Type
RP1	8.95			80	31.0	1.236	4.84	5.98	120	d
RP1	10.1			80	35.0	1.236	5.47	6.76	135	d
RP1	7.7			80	58.0	1.236	9.06	11.20	224	d
RP2	9.30			80	24.0	1.236	3.75	4.63	93	d
RP2	8.10			80	36.0	1.236	5.63	6.95	139	d
RP5	10			80	39.0	1.236	6.09	7.53	151	d
RP5	9.6			80	40.0	1.236	6.25	7.72	154	d
RP5	8.80			80	42.0	1.236	6.56	8.11	162	d

Statistical Summary Data	Is(50)	UCS*
Number of Samples Tested	8	8
Minimum	4.63	93
Average	7.36	147
Maximum	11.20	224
Standard Dev.	1.90	38
Upper 95% Confidence Limit	11.09	221.73
Lower 95% Confidence Limit	3.63	72.68

Comments:
*UCS (Uniaxial Compressive Strength) taken as k x Point Load Is(50): k= 20
*Is = Index Strength. *Is(50) = Corrected Index Strength
*P = Failure Load

*UCS Normal Distribution Curve



Abbreviations	
i	irregular
a	axial
b	block
d	diametral

Uniaxial Compression Test Report Sheet

I.G.S.L.

Sample Identification

Contract Name:	Indaver Duleek
Job Number:	14039
Hole No:	RC GC1
Depth (m):	8.80

Sample Description

Colour:	Blue grey
Grain size:	Medium
Weathering Grade:	Fresh
Rock Type:	LIMESTONE

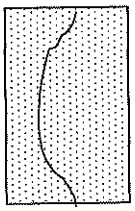
Weathering Grade Criteria

I. Fresh:	Unchanged from original state
II. Slightly weathered:	Slight discolouration, slight weakening
III. Moderately weathered:	Considerable weakening, penetrative discolouration
IV. Highly weathered:	Considerable weakening, penetrative discolouration, breaks in hand

Sample Measurements

Length	251.5	mm
Diameter (Ø)	102	

Sketch of Failure Surfaces



Testing

Load Rate	42	kN/min
Load at Failure (P)	217.9	kN

Strength Calculations

Uniaxial Compressive Strength $= \frac{217900}{8167.14}$

$= \frac{1000 \times P}{\prod \times (Ø/2)^2}$

$=$ 26.67 (Mpa)

Bulk Density $=$ 2.66 (Mg/m^3)

Notes:

Uniaxial Compression Test Report Sheet

I.G.S.L.

Sample Identification

Contract Name:	Indaver Duleek
Job Number:	14039
Hole No:	RC GC2
Depth (m):	6.50

Sample Description

Colour:	Blue grey
Grain size:	Medium
Weathering Grade:	Fresh
Rock Type:	LIMESTONE

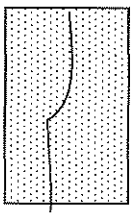
Weathering Grade Criteria

I. Fresh:	Unchanged from original state
II. Slightly weathered:	Slight discolouration, slight weakening
III. Moderately weathered:	Considerable weakening, penetrative discolouration
IV. Highly weathered:	Considerable weakening, penetrative discolouration, breaks in hand

Sample Measurements

Length	253	
Diameter (Ø)	102	mm

Sketch of Failure Surfaces



Testing

Load Rate	88	kN/min
Load at Failure (P)	589.8	kN

Strength Calculations

Uniaxial Compressive Strength $= \dfrac{589800}{8167.14}$

$= \dfrac{1000 \times P}{\Pi \times (Ø/2)^2}$

$=$ 72.18 (Mpa)

Bulk Density $=$ 2.68 (Mg/m^3)

Notes:

Uniaxial Compression Test Report Sheet

I.G.S.L.

Sample Identification

Contract Name:	Indaver Duleek
Job Number:	14039
Hole No:	RC GC4
Depth (m):	10.30

Sample Description

Colour:	Blue grey
Grain size:	Medium
Weathering Grade:	Fresh
Rock Type:	LIMESTONE

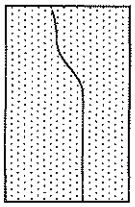
Weathering Grade Criteria

I. Fresh:	Unchanged from original state
II. Slightly weathered:	Slight discolouration, slight weakening
III. Moderately weathered:	Considerable weakening, penetrative discolouration
IV. Highly weathered:	Considerable weakening, penetrative discolouration, breaks in hand

Sample Measurements

Length	251.5	
Diameter (Ø)	102	mm

Sketch of Failure Surfaces



Testing

Load Rate	52.5	kN/min
Load at Failure (P)	293.6	kN

Strength Calculations

Uniaxial Compressive Strength $= \dfrac{293600}{8167.14}$

$= \dfrac{1000 \times P}{\prod \times (Ø/2)^2}$

$=$ 35.93 (Mpa)

Bulk Density $=$ 2.69 (Mg/m^3)

Notes:

Uniaxial Compression Test Report Sheet

I.G.S.L.

Sample Identification

Contract Name:	Indaver Duleek
Job Number:	14039
Hole No:	RC GC5
Depth (m):	7.90

Sample Description

Colour:	Blue grey
Grain size:	Medium
Weathering Grade:	Fresh
Rock Type:	LIMESTONE

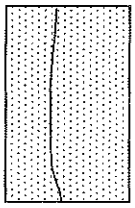
Weathering Grade Criteria

I. Fresh:	Unchanged from original state
II. Slightly weathered:	Slight discolouration, slight weakening
III. Moderately weathered:	Considerable weakening, penetrative discolouration
IV. Highly weathered:	Considerable weakening, penetrative discolouration, breaks in hand

Sample Measurements

Length	250	
Diameter (Ø)	102	mm

Sketch of Failure Surfaces



Testing

Load Rate	46.5	kN/min
Load at Failure (P)	310.8	kN

Strength Calculations

Uniaxial Compressive Strength $= \dfrac{310800}{8167.14}$

$= \dfrac{1000 \times P}{\prod \times (Ø/2)^2}$

$=$ 38.04 (Mpa)

Bulk Density $=$ 2.68 (Mg/m^3)

Notes:

Uniaxial Compression Test Report Sheet

I.G.S.L.

Sample Identification

Contract Name:	Indaver Duleek
Job Number:	14039
Hole No:	RC GC6
Depth (m):	9.20

Sample Description

Colour:	Blue grey
Grain size:	Medium
Weathering Grade:	Fresh
Rock Type:	LIMESTONE

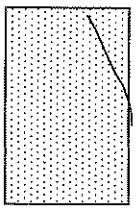
Weathering Grade Criteria

I. Fresh:	Unchanged from original state
II. Slightly weathered:	Slight discolouration, slight weakening
III. Moderately weathered:	Considerable weakening, penetrative discolouration
IV. Highly weathered:	Considerable weakening, penetrative discolouration, breaks in hand

Sample Measurements

Length	251	
Diameter (Ø)	102	mm

Sketch of Failure Surfaces



Testing

Load Rate	53	kN/min
Load at Failure (P)	321.7	kN

Strength Calculations

Uniaxial Compressive Strength $= \frac{321700}{8167.14}$

$= \frac{1000 \times P}{\prod \times (Ø/2)^2}$

$=$ 39.37 (Mpa)

Bulk Density $=$ 2.66 (Mg/m^3)

Notes:

Uniaxial Compression Test Report Sheet

I.G.S.L.

Sample Identification

Contract Name:	Indaver Duleek
Job Number:	14039
Hole No:	RP1
Depth (m):	8.10

Sample Description

Colour:	Blue grey
Grain size:	Medium
Weathering Grade:	Fresh
Rock Type:	LIMESTONE

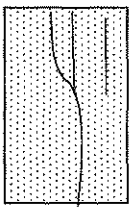
Weathering Grade Criteria

I. Fresh:	Unchanged from original state
II. Slightly weathered:	Slight discolouration, slight weakening
III. Moderately weathered:	Considerable weakening, penetrative discolouration
IV. Highly weathered:	Considerable weakening, penetrative discolouration, breaks in hand

Sample Measurements

Length	202	
Diameter (Ø)	80	mm

Sketch of Failure Surfaces



Testing

Load Rate	34.5	kN/min
Load at Failure (P)	185.2	kN

Strength Calculations

Uniaxial Compressive Strength $= \dfrac{185200}{5024}$

$= \dfrac{1000 \times P}{\Pi \times (Ø/2)^2}$

$=$ 36.84 (Mpa)

Bulk Density $=$ 2.68 (Mg/m^3)

Notes:

Uniaxial Compression Test Report Sheet

I.G.S.L.

Sample Identification

Contract Name:	Indaver Duleek
Job Number:	14039
Hole No:	RP2
Depth (m):	7.70

Sample Description

Colour:	Grey
Grain size:	Medium
Weathering Grade:	Fresh
Rock Type:	LIMESTONE

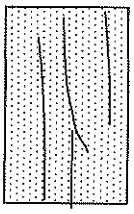
Weathering Grade Criteria

I. Fresh:	Unchanged from original state
II. Slightly weathered:	Slight discolouration, slight weakening
III. Moderately weathered:	Considerable weakening, penetrative discolouration
IV. Highly weathered:	Considerable weakening, penetrative discolouration, breaks in hand

Sample Measurements

Length	112	
Diameter (Ø)	80	mm

Sketch of Failure Surfaces



Testing

Load Rate	46.5	kN/min
Load at Failure (P)	274	kN

Strength Calculations

Uniaxial Compressive Strength $= \dfrac{274000}{5024}$

$= \dfrac{1000 \times P}{\prod \times (Ø/2)^2}$

$= 54.51$ (Mpa)

Bulk Density $= 2.68$ (Mg/m^3)

Notes:

Uniaxial Compression Test Report Sheet

I.G.S.L.

Sample Identification

Contract Name:	Indaver Duleek
Job Number:	14039
Hole No:	RP5
Depth (m):	10.20

Sample Description

Colour:	Grey
Grain size:	Medium
Weathering Grade:	Fresh
Rock Type:	LIMESTONE

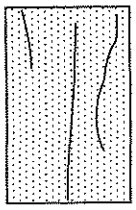
Weathering Grade Criteria

I. Fresh:	Unchanged from original state
II. Slightly weathered:	Slight discolouration, slight weakening
III. Moderately weathered:	Considerable weakening, penetrative discolouration
IV. Highly weathered:	Considerable weakening, penetrative discolouration, breaks in hand

Sample Measurements

Length	200	mm
Diameter (Ø)	80	

Sketch of Failure Surfaces



Testing

Load Rate	48.5	kN/min
Load at Failure (P)	299.7	kN

Strength Calculations

Uniaxial Compressive Strength $= \dfrac{299700}{5024}$

$= \dfrac{1000 \times P}{\Pi \times (Ø/2)^2}$

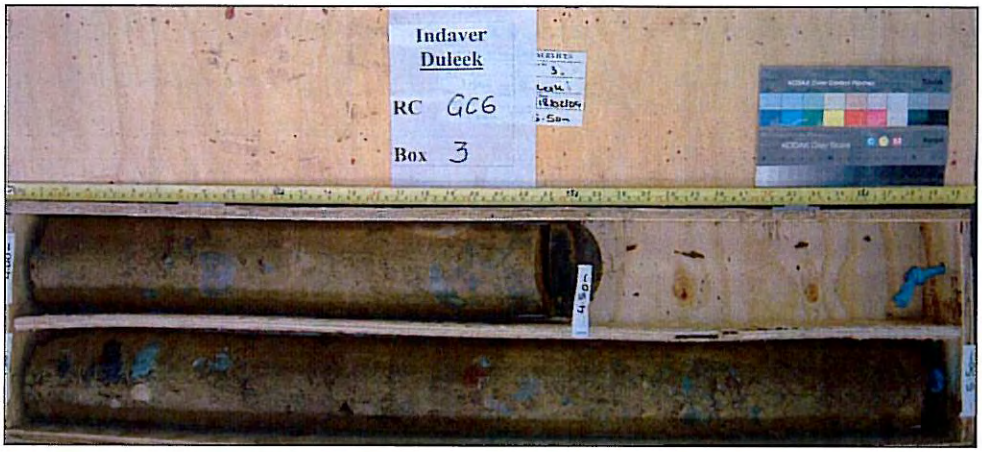
$=$ 59.62 (Mpa)

Bulk Density $=$ 2.68 (Mg/m^3)

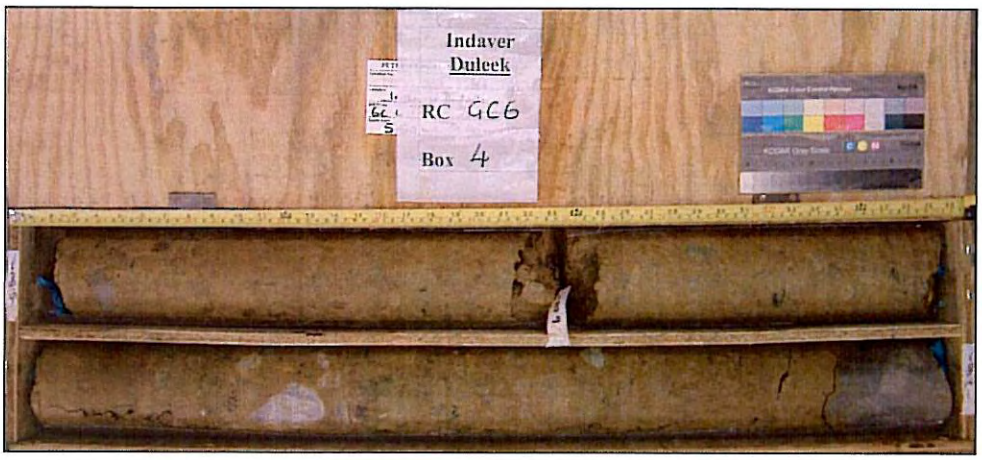
Notes:

Core Photography – Indaver Duleek (14039)

RC GC6 BOX 3 OF 8

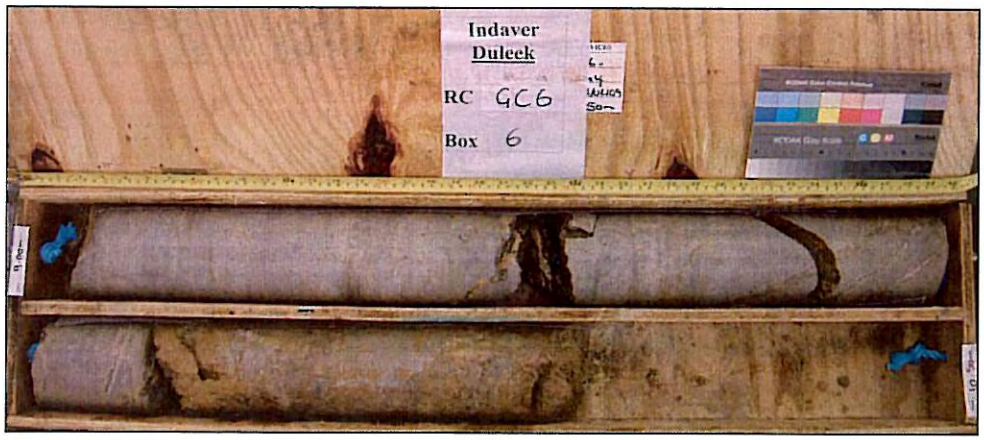


RC GC6 BOX 4 OF 8

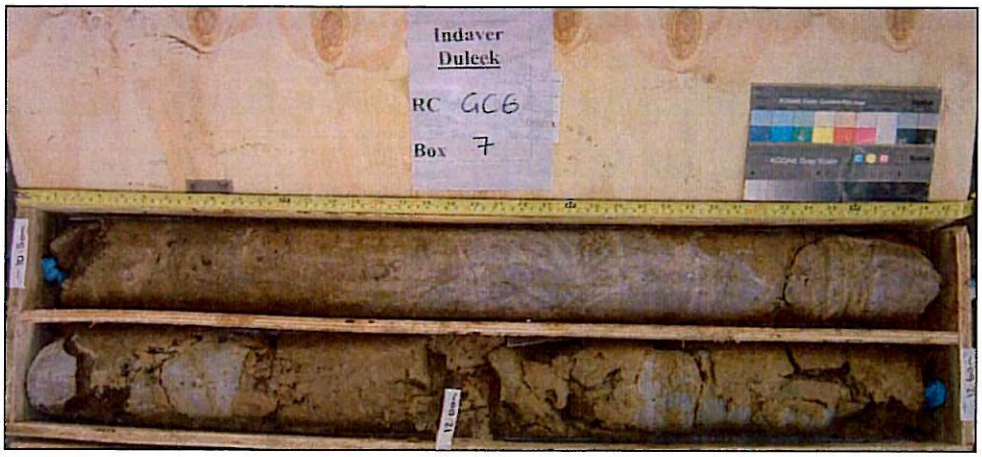


RC GC6 BOX 5 OF 8

RC GC6 BOX 6 OF 8



RC GC6 BOX 7 OF 8

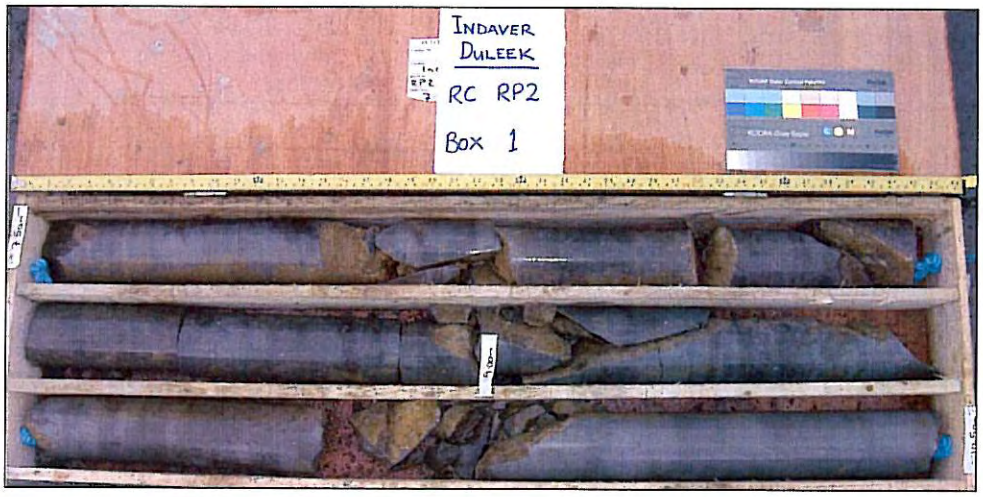


RC GC6 BOX 8 OF 8

Core Photography – Indaver Duleek (14039)

RC RP1 BOX 1 OF 1

RC RP2 BOX 1 OF 1



Core Photography – Indaver Duleek (14039)

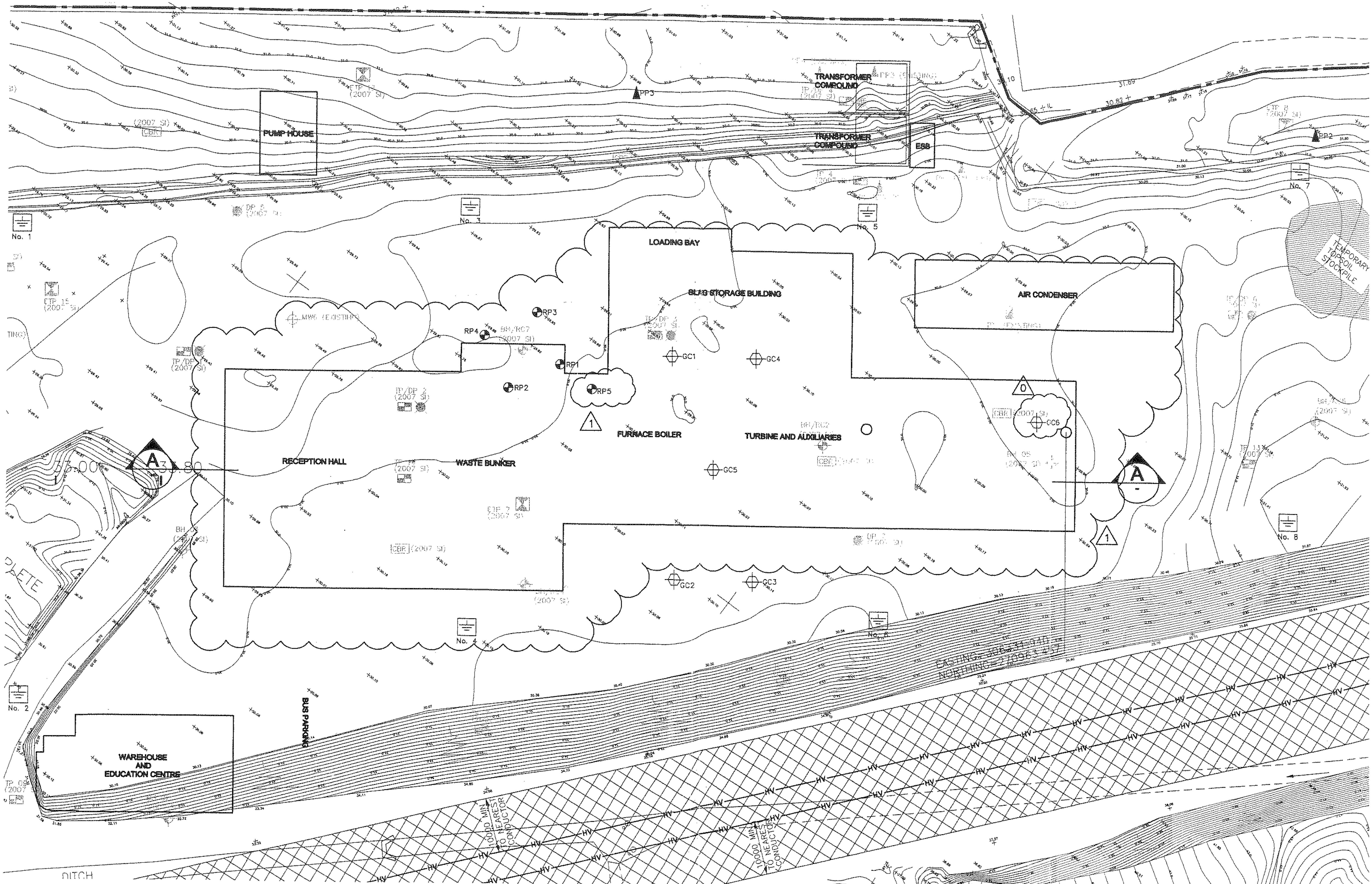
RC RP5 box 1 of 1

Appendix 7

Exploratory Site Plan

GPS SURVEY - INDAVER PROJECT

EXPLORATORY NO.	EASTING (m)	NORTHING (m)	HEIGHT (m)
GC1	306263.874	270930.70	30.096
GC2	306286.093	270892.715	30.003
GC3	306299.117	270902.057	30.144
GC4	306275.131	270938.384	30.019
GC5	306280.567	270916.062	30.081
GC6	306325.715	270960.256	30.269
PP2	306334.870	271034.982	30.788
PP3	306229.147	270963.299	29.350
RP1	306246.509	270914.342	29.943
RP2	306241.735	270906.390	30.026
RP5	306255.430	270916.960	30.175


PUMP HOUSE
TRANSFORMER COMPOUND
TRANSFORMER COMPOUND
ESB
PP3
PP2
No. 1
No. 2
No. 3
No. 4
No. 5
No. 6
No. 7
No. 8
LOADING BAY
SLAG STORAGE BUILDING
AIR CONDENSER
TEMPORARY TOPSOIL STOCKPILE
RP1
RP2
RP3
RP4
RP5
GC1
GC2
GC3
GC4
GC5
CC6
RECEPTION HALL
WASTE BUNKER
FURNACE BOILER
TURBINE AND AUXILIARIES
WAREHOUSE AND EDUCATION CENTRE
BUS PARKING
10000 MIN TO NEAREST CONDUCTOR
10000 MIN TO NEAREST CONDUCTOR
HV
DITCH

Appendix 8

Stabilization Test Data

TRIAL PIT RECORD

REPORT NUMBER 14039

CONTRACT	Indaver Waste Management Facility	TRIAL PIT NO.	TP1
		SHEET	Sheet 1 of 1
LOGGED BY	D Tallon	CO-ORDINATES(_)	
		DATE STARTED	30/03/200930/03/2009
		DATE COMPLETED	
CLIENT	Indaver	GROUND LEVEL (m)	
ENGINEER	PM Group	EXCAVATION METHOD	13T Tracked

Geotechnical Description	Legend	Depth (m)	Elevation	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
0.0 Very firm brown very sandy gravelly CLAY									
					AD1376	LB	1.50-1.50		
1.0					AD1377	LB	1.50-1.50		
Dense brown clayey gravelly fie to coarse SAND		1.90							
2.0									
3.0					AD1378	LB	3.00-3.00		
					AD1379	LB	3.00-3.00		
Dense brown clayey sandy GRAVEL with occasional cobbles		3.30							
4.0 End of Trial Pit at 4.00m		4.00			AD1380	LB	4.00-4.00		
					AD1381	LB	4.00-4.00		

Groundwater Conditions
Pit dry

Stability
Pit Stable

General Remarks

IGSL TP LOG 14039.GPJ IGSL.GDT 30/3/09

TRIAL PIT RECORD

REPORT NUMBER 14039

CONTRACT	Indaver Waste Management Facility	TRIAL PIT NO.	TP2
		SHEET	Sheet 1 of 1
LOGGED BY	D Tallon	CO-ORDINATES(_)	
		DATE STARTED	30/03/200930/03/2009
		DATE COMPLETED	
CLIENT	Indaver	GROUND LEVEL (m)	
ENGINEER	PM Group	EXCAVATION METHOD	13T Tracked

	Geotechnical Description	Legend	Depth (m)	Elevation	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
0.0	Loose grey slightly clayey very sandy GRAVEL					AD1382	LB	1.50-1.50		
1.0						AD1383	LB	1.50-1.50		
2.0										
3.0	Medium dense grey/brown very sandy clayey GRAVEL with occasional cobbles		3.00			AD1384	LB	2.90-3.00		
						AD1385	LB	2.90-3.00		
4.0	End of Trial Pit at 4.00m		4.00			AD1386	LB	3.90-4.00		
						AD1387	LB	3.90-4.00		

Groundwater Conditions
Pit dry

Stability
Pit Unstable from 1.0m

General Remarks

IGSL TP LOG 14039.GPJ IGSL.GDT 30/3/09

REPORT NO. **SULPHATE ANALYSIS** **IGSL**

CONTRACT: **Indaver Waste Management Facility** CONTRACT NO 14039

BH/TP NO.	DEPTH (M)	SAMPLE NO.	SAMPLE TYPE	TEST CODE	% Passing 2mm	SULPHUR TRIOXIDE		(so3 X 1.2)	pH
						2:1WATER SOIL EXTRACT So3 g/L	TOTAL SOIL so3 %	2:1WATER SOIL EXTRACT So4 g/L	VALUE
COMBINED SAMPLES FROM STOCKPILE 1,2 & 4	TREATED WITH 1%LIME TESTED AFTER 14	SP1A	S	A	N/A	0.41		0.492	11.9
	TREATED WITH 2%LIME TESTED AFTER 14	SP1B	S	A	N/A	0.007		0.008	12.8
	TREATED WITH 1%LIME & 1% CEMENT TESTED	SP1C	S	A	N/A	0.014		0.017	12.6
COMBINED SAMPLES FROM STOCKPILE 3	TREATED WITH2% LIME TESTED AFTER 14 DAYS	SP2A	S	A	N/A	0.017		0.020	12.4
COMBINED SAMPLES FROM TRIAL PIT 1	TREATED WITH 1%LIME TESTED AFTER 14 DAYS	TP1A	S	A	N/A	0.031		0.037	11.7
COMBINED SAMPLES FROM TRIAL PIT 2	TREATED WITH 1%CEMENT TESTED AFTER 14 DAYS	TP2A	S	A	N/A	0.141		0.169	11.0

TEST CODE W = WATER S = SOIL A = AQUEOUS SOIL EXTRACT(2:1)

Report No.

MCV SUMMARY

I.G.S.L.

Contract: **Indaver Waste Management Facility** CONTRACT No 14039

Location	Sample No.	Depth (m)	Sample Description	MCV	MC %	% Passing 20mm	REMARKS
COMBINED SAMPLES FROM TRIAL PIT 1	TP1A		NATURAL	10.5	12.1	93.9	
			NATURAL	9.8	11.7	93.9	
			TREATED WITH 1% LIME TESTED AFTER 3 HRS	13.6	11.5	93.9	
			TREATED WITH 1% LIME TESTED AFTER 3 HRS	12.9	11.6	93.9	

Test Code:

Report No.

MCV SUMMARY

I.G.S.L.

Contract: **Indaver Waste Management Facility** CONTRACT No 14039

Location	Sample No.	Depth (m)	Sample Description	MCV	MC %	% Passing 20mm	REMARKS
COMBINED SAMPLES FROM TRIAL PIT 2	TP2A		NATURAL	9.0	12.0	81.7	
			NATURAL	8.9	12.6	81.7	
			TREATED WITH 1%CEMENT TESTED AFTER 3 HRS	9.7	13.3	81.7	
			TREATED WITH 1%CEMENT TESTED AFTER 3 HRS	10.1	13.2	81.7	

Test Code:

Report No.

MCV SUMMARY

I.G.S.L.

Contract: **Indaver Waste Management Facility** CONTRACT No 14039

Location	Sample No.	Depth (m)	Sample Description	MCV	MC %	% Passing 20mm	REMARKS
COMBINED SAMPLES FROM STOCKPILE 3	SP2A		NATURAL	2.9	23.2	92.8	
			NATURAL	3.2	23.9	92.8	
			TREATED WITH 2% LIME TESTED AFTER 3 HRS	5.6	25.9	92.8	
			TREATED WITH 2% LIME TESTED AFTER 3 HRS	5.5	26.5	92.8	

Test Code:

Report No.

MCV SUMMARY

I.G.S.L.

Contract: **Indaver Waste Management Facility** CONTRACT No 14039

Location	Sample No.	Depth (m)	Sample Description	MCV	MC %	% Passing 20mm	REMARKS
COMBINED SAMPLES FROM STOCKPILE 1,2 & 4	SP1A		NATURAL	3.0	16.6	91.5	
			NATURAL	2.7	16.8	91.5	
			TREATED WITH 1% LIME TESTED AFTER 3 HRS	6.3	18.3	91.5	
			TREATED WITH 1% LIME TESTED AFTER 3 HRS	7.6	18.6	91.5	

Test Code:

Report No.

MCV SUMMARY

I.G.S.L.

Contract: **Indaver Waste Management Facility** CONTRACT No 14039

Location	Sample No.	Depth (m)	Sample Description	MCV	MC %	% Passing 20mm	REMARKS
COMBINED SAMPLES FROM STOCKPILE 1,2 & 4	SP1B		NATURAL	3.0	16.6	91.5	
			NATURAL	2.7	16.8	91.5	
			TREATED WITH 2% LIME TESTED AFTER 3 HRS	7.9	17.8	91.5	
			TREATED WITH 2% LIME TESTED AFTER 3 HRS	8.4	17.3	91.5	

Test Code:

Report No.

MCV SUMMARY

I.G.S.L.

Contract: **Indaver Waste Management Facility** CONTRACT No 14039

Location	Sample No.	Depth (m)	Sample Description	MCV	MC %	% Passing 20mm	REMARKS
COMBINED SAMPLES FROM STOCKPILE 1,2 & 4	SP1C		NATURAL	3.0	16.6	91.5	
			NATURAL	2.7	16.8	91.5	
			TREATED WITH 1%LIME & 1% CEMENT TESTED AFTER 3 HR	7.5	17.6	91.5	
			TREATED WITH 1%LIME & 1% CEMENT TESTED AFTER 3 HR	7.5	18.0	91.5	

Test Code:

Report No.

CALIFORNIA BEARING RATIO

I.G.S.L.

Contract: **Indaver Waste Management Facility** **DATE: 12/05/2009** CONTRACT No 14039

Location	Sample No.	Depth of Sample	Sample Description	Water Content %	Test Code	Test Code	Water Content Top %	Water Content Bottom %	Bulk Density Mg/M3	% Passing 20mm	C.B.R. Top %	C.B.R. Base %	C.B.R. Average %
	TP1A		NATURAL	11.9	NAT	L/St	12.0	11.8	2.25	93.9	16.5	18.2	17.4
			NATURAL	11.8	NAT	L/St	11.9	11.7	2.25	93.9	18.5	18.2	18.3
COMBINED SAMPLES FROM TRIAL PIT 1			TREATED WITH 1%LIME	11.4	1 DAY	L/St	11.3	11.4	2.20	93.9	38.9	36.4	37.6
			TREATED WITH 1%LIME	11.5	1 DAY	L/St	11.5	11.5	2.20	93.9	33.9	38.1	36.0
			TREATED WITH 1%LIME	11.4	3 DAY	L/St	11.5	11.3	2.20	93.9	33.5	30.5	32.0
			TREATED WITH 1%LIME	11.7	3 DAY	L/St	11.8	11.5	2.20	93.9	38.2	38.4	38.3
			TREATED WITH 1%LIME	11.2	14 DAY	L/St	11.3	11.1	2.20	93.9	44.4	54.7	49.6
			TREATED WITH 1%LIME	11.4	14 DAY	L/St	11.6	11.2	2.20	93.9	48.3	53.4	50.9

Test Code U.-Undisturbed Sample L.-2.5Kg. Rammer A/5.-5% Air Voids Ratio V.- Vibrating Hammer
D.-Dynamic Compaction H.-4.5Kg. Rammer A10.-10% Air Voids Ratio M.- Method Number
St.-Static compaction RN29.- Road Note 29 (St. 95% H.)

Report No.

CALIFORNIA BEARING RATIO

I.G.S.L.

Contract: **Indaver Waste Management Facility** **DATE: 12/05/2009** CONTRACT No 14039

Location	Sample No.	Depth of Sample	Sample Description	Water Content %	Test Code	Test Code	Water Content Top %	Water Content Bottom %	Bulk Density Mg/M3	% Passing 20mm	C.B.R. Top %	C.B.R. Base %	C.B.R. Average %
COMBINED SAMPLES FROM TRIAL PIT2	TP2A		NATURAL	13.2	NAT	L/St	13.2	13.1	2.24	81.7	23.3	17.6	20.5
			NATURAL	13.3	NAT	L/St	13.0	13.5	2.24	81.7	16.4	17.4	16.9
			TREATED WITH 1% CEMENT	13.4	1 DAY	L/St	13.3	13.5	2.23	81.7	55.5	55.6	55.6
			TREATED WITH 1% CEMENT	13.4	1 DAY	L/St	13.3	13.4	2.23	81.7	58.7	49.6	54.1
			TREATED WITH 1% CEMENT	13.5	3 DAY	L/St	13.3	13.6	2.23	81.7	58.1	43.3	50.7
			TREATED WITH 1% CEMENT	13.1	3 DAY	L/St	13.1	13.0	2.23	81.7	69.2	67.4	68.3
			TREATED WITH 1% CEMENT	12.4	14 DAY	L/St	12.4	12.4	2.23	81.7	69.0	78.4	73.7
			TREATED WITH 1% CEMENT	12.9	14 DAY	L/St	12.9	12.8	2.23	81.7	74.1	65.0	69.6

Test Code U.-Undisturbed Sample L.-2.5Kg. Rammer A/5.-5% Air Voids Ratio V.- Vibrating Hammer
D.-Dynamic Compaction H.-4.5Kg. Rammer A10.-10% Air Voids Ratio M.- Method Number
St.-Static compaction RN29.- Road Note 29 (St. 95% H.)

Report No.

CALIFORNIA BEARING RATIO

I.G.S.L.

Contract: **Indaver Waste Management Facility** **DATE: 12/05/2009** CONTRACT No 14039

Location	Sample No.	Depth of Sample	Sample Description	Water Content %	Test Code	Test Code	Water Content Top %	Water Content Bottom %	Bulk Density Mg/M3	% Passing 20mm	C.B.R. Top %	C.B.R. Base %	C.B.R. Average %
	SP1A		NATURAL	19.5	NAT	L/St	19.5	19.5	2.07	91.5	1.0	0.8	0.9
			NATURAL	19.7	NAT	L/St	19.2	20.1	2.07	91.5	1.1	0.6	0.9
COMBINED SAMPLES FROM STOCKPILE 1,2 & 4			TREATED WITH 1%LIME & 1% CEMENT	18.1	1 DAY	L/St	18.1	18.1	2.10	91.5	10.3	10.1	10.2
			TREATED WITH 1%LIME & 1% CEMENT	18.7	1 DAY	L/St	18.4	19.0	2.10	91.5	10.1	10.2	10.1
			TREATED WITH 1%LIME & 1% CEMENT	18.4	3 DAY	L/St	18.4	18.4	2.10	91.5	10.6	10.5	10.6
			TREATED WITH 1%LIME & 1% CEMENT	18.8	3 DAY	L/St	18.8	18.7	2.10	91.5	13.9	14.5	14.2
			TREATED WITH 1%LIME & 1% CEMENT	18.6	14 DAY	L/St	18.7	18.4	2.09	91.5	19.1	12.8	16.0
			TREATED WITH 1%LIME & 1% CEMENT	18.1	14 DAY	L/St	17.8	18.4	2.09	91.5	15.7	16.2	16.0

Test Code U.-Undisturbed Sample L.-2.5Kg. Rammer A/5.-5% Air Voids Ratio V.- Vibrating Hammer
D.-Dynamic Compaction H.-4.5Kg. Rammer A10.-10% Air Voids Ratio M.- Method Number
St.-Static compaction RN29.- Road Note 29 (St. 95% H.)

Report No.

CALIFORNIA BEARING RATIO

I.G.S.L.

Contract: **Indaver Waste Management Facility** **DATE: 12/05/2009** CONTRACT No 14039

Location	Sample No.	Depth of Sample	Sample Description	Water Content %	Test Code	Test Code	Water Content Top %	Water Content Bottom %	Bulk Density Mg/M3	% Passing 20mm	C.B.R. Top %	C.B.R. Base %	C.B.R. Average %
COMBINED SAMPLES FROM STOCKPILE 3	SP2A		NATURAL	27.8	NAT	L/St	27.0	28.6	1.89	92.8	0.3	0.2	0.3
			NATURAL	26.7	NAT	L/St	26.2	27.2	1.89	92.8	0.4	0.3	0.3
			TREATED WITH 2%LIME	26.2	1 DAY	L/St	26.3	26.1	1.95	92.8	4.2	4.2	4.2
			TREATED WITH 2%LIME	26.1	1 DAY	L/St	26.8	25.4	1.95	92.8	3.7	4.8	4.2
			TREATED WITH 2%LIME	26.4	3 DAY	L/St	26.3	26.4	1.95	92.8	2.8	2.7	2.7
			TREATED WITH 2%LIME	26.6	3 DAY	L/St	26.5	26.6	1.95	92.8	3.4	3.1	3.3
			TREATED WITH 2%LIME	25.3	14 DAY	L/St	25.0	25.6	1.95	92.8	5.6	5.6	5.6
			TREATED WITH 2%LIME	25.8	14 DAY	L/St	25.2	26.3	1.95	92.8	6.1	6.2	6.1

Test Code U.-Undisturbed Sample L.-2.5Kg. Rammer A/5.-5% Air Voids Ratio V.- Vibrating Hammer
D.-Dynamic Compaction H.-4.5Kg. Rammer A10.-10% Air Voids Ratio M.- Method Number
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Location	Sample No.	Depth of Sample	Sample Description	Water Content %	Test Code	Test Code	Water Content Top %	Water Content Bottom %	Bulk Density Mg/M3	% Passing 20mm	C.B.R. Top %	C.B.R. Base %	C.B.R. Average %
COMBINED SAMPLES FROM STOCKPILE 1,2 & 4	SP1A		NATURAL	19.5	NAT	L/St	19.5	19.5	2.07	91.5	1.0	0.8	0.9
			NATURAL	19.7	NAT	L/St	19.2	20.1	2.07	91.5	1.1	0.6	0.9
			TREATED WITH 2%LIME	18.9	1 DAY	L/St	18.7	19.0	2.11	91.5	11.1	5.9	8.5
			TREATED WITH 2%LIME	19.0	1 DAY	L/St	19.0	19.0	2.11	91.5	12.7	11.9	12.3
			TREATED WITH 2%LIME	18.1	3 DAY	L/St	18.3	17.8	2.11	91.5	15.1	11.2	13.1
			TREATED WITH 2%LIME	18.5	3 DAY	L/St	18.5	18.5	2.11	91.5	16.9	16.4	16.6
			TREATED WITH 2%LIME	18.0	14 DAY	L/St	18.0	18.0	2.11	91.5	17.3	19.2	18.2
			TREATED WITH 2%LIME	17.6	14 DAY	L/St	17.1	18.0	2.11	91.5	16.5	17.4	16.9

Test Code U.-Undisturbed Sample L.-2.5Kg. Rammer A/5.-5% Air Voids Ratio V.- Vibrating Hammer
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Location	Sample No.	Depth of Sample	Sample Description	Water Content %	Test Code	Test Code	Water Content Top %	Water Content Bottom %	Bulk Density Mg/M3	% Passing 20mm	C.B.R. Top %	C.B.R. Base %	C.B.R. Average %
COMBINED SAMPLES FROM STOCKPILE 1,2 & 4	SP1A		NATURAL	19.5	NAT	L/St	19.5	19.5	2.07	91.5	1.0	0.8	0.9
			NATURAL	19.7	NAT	L/St	19.2	20.1	2.07	91.5	1.1	0.6	0.9
			TREATED WITH 1%LIME	19.3	1 DAY	L/St	19.8	18.7	2.09	91.5	5.4	5.5	5.4
			TREATED WITH 1%LIME	19.4	1 DAY	L/St	19.0	19.7	2.09	91.5	4.6	6.3	5.4
			TREATED WITH 1%LIME	19.3	3 DAY	L/St	19.4	19.1	2.09	91.5	5.4	5.8	5.6
			TREATED WITH 1%LIME	18.8	3 DAY	L/St	18.8	18.7	2.09	91.5	3.4	5.9	4.7
			TREATED WITH 1%LIME	18.9	14 DAY	L/St	19.1	18.6	2.09	91.5	8.0	6.5	7.2
			TREATED WITH 1%LIME	17.9	14 DAY	L/St	18.1	17.6	2.09	91.5	8.6	9.7	9.2

Test Code U.-Undisturbed Sample L.-2.5Kg. Rammer A/5.-5% Air Voids Ratio V.- Vibrating Hammer
D.-Dynamic Compaction H.-4.5Kg. Rammer A10.-10% Air Voids Ratio M.- Method Number
St.-Static compaction RN29.- Road Note 29 (St. 95% H.)

Meath Waste Management Facility

Carranstown, Co. Meath

Geotechnical Interpretative Report

(Report No. 14039)

Client: Indaver Ireland

Engineer: PM Group Ltd

May 2009

IGSL Ltd

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FOREWORD

The following conditions and notes on site investigation procedures should be read in conjunction with this geotechnical report.

General

The ground investigation works for the Meath Waste Management Facility, Duleek have been carried out in accordance with BS 5930 (1990) and the IEI Specification & Related Documents for Ground Investigation in Ireland (2006).

Recommendations made and opinions expressed in this report are based on the strata observed in the exploratory holes, together with the results of in-situ and laboratory test data. No responsibility can be held for conditions which have not been revealed by exploratory work, or which occur between exploratory hole locations.

Whilst the report may suggest the likely configuration of strata, both between exploratory hole locations, or below the maximum depth of the investigation, this is only indicative, and liability cannot be accepted for its accuracy. Unless specifically stated, no account has been taken of possible subsidence due to mineral extraction below or close to the site.

Disclaimer

The geotechnical interpretative report has been prepared for Project Management Group / Indaver Ireland and the information should not be used without prior approval or written permission of either party. The recommendations developed in this report are based on the IGSL factual ground investigation data (IGSL Project No. 14039), Byrne Looby Geotechnical Assessment Report (B580) and Apex Geophysical Report. IGSL Ltd accepts no responsibility or liability for this document being used other than for the purposes for which it was intended.

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1. INTRODUCTION

At the request of Project Management (PM) and Indaver Ireland, IGSL has undertaken a programme of geotechnical investigation works for a waste to energy facility at Carranstown, Duleek, Co. Meath. The works were performed as directed by PM Group, consulting engineers for the project. The site is located at Carranstown, Duleek, Co. Meath and encompasses an area of approximately 25 acres. The site is bounded to the south by the R150 Duleek to Navan Road, to the east by the Platin Cement Works and farmland to the west and north.

It is understood that the proposed development will involve the construction of a waste management facility and include a waste handling area (bunker & furnace), emissions stack, ash bunker, workshop, office and administration buildings and general site infrastructure (i.e. roads, drainage, service utilities, culverts etc). The waste handling area will require a basement type structure (bunker) with a proposed dig depth of the order of 7m below existing ground level (i.e. formation of c23m OD). Site enabling works were completed prior to IGSL commencing the geotechnical investigations and produced a platform level of 30.5m OD. It is noted that a programme of geotechnical investigations were originally carried out in 2007 and details are presented in a report prepared by Byrne Looby Partners (B580 May 2007).

The geophysical and geotechnical fieldworks works for this phase were carried out in accordance with BS 5930, Code of Practice for Site Investigations (1999) and the IEI Specification & Related Documents for Ground Investigation in Ireland (2006). The fieldworks included geophysical surveying, rotary core drillholes and percolation tests. Core drillholes GC 1 to GC 5 were positioned at the footprint of the bunker (note the location of this structure was subsequently altered) while RP 1, 2 and 5 were located at a zone where karst weathering was identified in the original investigations. The geophysical surveying was performed by Apex Geoservices and included seismic refraction spreads and surface wave analysis (MASW) to determine small strain stiffness.

Geotechnical soil and rock laboratory testing was performed on selected samples in accordance with BS 1377 and ISRM. In addition, modification / stabilization trial testing was performed in the laboratory to evaluate the behaviour of the glacial till, following the addition of lime (calcium oxide) and ordinary portland cement. This element of the testing focused on MCV, CBR and sulphates.

The primary objectives of the investigation were as follows:

- Evaluate rock quality, weathering profile, strength and fracture state of the bedrock at the proposed bunker & emissions stack
- Recover samples for geotechnical laboratory testing (soil & rock)
- Assess percolation characteristics of the upper soils at designated locations

This report presents an interpretation of the ground conditions and engineering properties of the soils and bedrock. Recommendations are developed and provided on the key geotechnical issues impacting on the proposed development. A separate factual report has been prepared and this includes the rotary drillhole records, percolation test data and laboratory test results.

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2. FIELDWORK

2.1 General

The fieldworks were carried out during the period February 2009 and comprised the following:

- Rotary core drillholes (9 No.)
- Percolation tests (2 No.)
- Geophysical surveying

2.2 Rotary Drillholes

Rotary drilling was undertaken at nine locations using a top drive Knebel rig. Geobor core drilling methods were utilized at six locations (denoted GC 1 to GC 6) with conventional air mist drilling employed at three locations (RP 1, 2 & 5). The Geobor drilling system used polymer gel flush and recirculation tanks, with the emphasis on high quality recovery in the glacial soils and upper bedrock zone.

The Geobor coring produced 102mm diameter cores while the conventional coring produced 80mm diameter cores using air mist flush. Recovery in the Geobor holes was excellent with 100% recovery in the majority of the runs. The Geobor drillholes achieved depths of between 11.80 and 15.10m while each of the conventional holes terminated at depths of 10.50m. Each of the core drillholes were backfilled with cement/bentonite grout (tremmied) as directed by PM.

The rock cores were placed in 3m capacity timber boxes and logged by an IGSL engineering geologist. This included photography of the cores with a digital camera. The core log records are presented in Appendices 1 and 2 of the factual report and include engineering geological descriptions of the rock cores, details of the bedding / discontinuities and mechanical indices (TCR, SCR and RQD's) for each core run.

Where rock core was recovered, a graphic fracture log is also presented alongside the mechanical indices. This illustrates the fracture state of the rock cores and allows easy identification of highly fractured / non-intact zones and discontinuity spacings. It should be noted that no correction for dip of the joints has been made and that the spacings shown are successive joint / core intersections within the core.

2.3 Percolation Tests

Percolation or soakaway tests were performed at two locations to evaluate the infiltration potential of the upper soils. The tests were conducted in accordance with BRE 365 guidelines and the data sheets are presented in Appendix 3 of the factual report. The infiltration rate values (F Values) were calculated using the field data and are shown on each of the logs.

2.4 Geophysical Surveying

Geophysical surveying was carried out by Apex Geoservices and included resistivity profiling, seismic refraction spreads and multi-channel analysis of surface waves to assess soil stiffness (GMax v depth). Details of the methodologies used, x-sections / profiles and maps are presented in a separate report by Apex Geoservices.

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3. LABORATORY TESTING

Geotechnical soil laboratory testing was performed on selected Geobor core samples in accordance with BS 1377 (1990). The soils testing included the following and results are presented in Appendix 4 of the factual report.

- Moisture contents
- Particle size analysis
- Atterberg Limits (Liquid & Plastic Limits)
- Consolidated quick undrained triaxial tests
- Consolidation (oedometer) tests
- pH & sulphates

Soil modification / stabilization testing was carried out on samples of the glacial till recovered from stockpiles and at the bunker footprint. The results of these tests are presented in Appendix 6 of the factual report. Rock testing was undertaken on representative core samples and focused on Point Load Strength Index (PLSI)) and unconfined compressive strength (UCS) tests in accordance with ISRM. The results of the rock testing are presented in Appendix 5 of the factual report.

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4. GROUND CONDITIONS & ENGINEERING PROPERTIES

4.1 Ground Profile

The exploratory holes have revealed the ground conditions at this site to comprise:

- Glacial deposits
- Limestone Bedrock

4.2 Glacial Deposits

The Byrne Looby (BLP) investigatory works show the indigenous soils at this site comprise low plasticity, brown very sandy gravelly CLAY with cobbles (locally grading to SILT). Subordinate horizons or pockets of sandy GRAVEL and gravelly or clayey SAND were also uncovered during the aforementioned investigations (trial pits). The cohesive or fine grained material is referred to as 'glacial till', while the subordinate coarse or granular dominant materials are typical of fluvio-glacial deposits. Ground levels (mOD) were not reported on the BLP records, however it appears that the cable percussion boreholes refused on cobble / boulder obstructions.

The soils are thought to represent over-consolidated lodgement till and examination of the BLP borehole and trial pit descriptions show changes in colour and grading with depth. The gravel constituents or clasts range from fine to coarse, are subrounded to subangular and predominantly limestone in origin. Recovery of the glacial till in the Geobor drillholes was good to excellent and the cores show a complex and variable stratigraphy. An example of the core recovery in the glacial till is presented in Plate 1.

Plate 1 – Geobor Recovery in Glacial Till (GC 3)

No undisturbed samples (U100's) were recovered by BLP/GII for laboratory strength testing. However, the SPT test is widely used in establishing the strength or relative density of glacial till deposits and relationships exist between SPT N-Value (blows for 300mm penetration) and undrained shear strength (C_u). The most widely used correlation between N-Value and C_u for glacial till soils is that proposed by Stroud & Butler where $C_u \approx 4$ to 6N. An SPT data plot has been prepared using the relevant BLP/GII borehole data and this is presented in Figure 1. The N-Values show the upper glacial till to be principally firm in consistency, becoming firm / stiff with depth.

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Consolidated quick undrained (CQu) triaxial compression and odeometer consolidation tests were performed by IGSL on selected Geobor samples. The CQu tests produced cohesion values of between 91 and 241 kN/m^2 (mean value of 166 kN/m^2) and these indicate stiff and very stiff glacial soils. Bulk densities range from 2.06 to 2.36 Mg/m^3 and these are characteristic of over-consolidated gravel or cobble dominant glacial till.

Inspection of the oedometer test data shows Modulus of Volume compressibility (Mv) values typically around 0.3 m^2/MN in the 100 to 200 kN/m^2 pressure range. Coefficients of consolidation (Cv) were also calculated and appear to be quite consistent, with values typically of the order of 20 to 30 m^2/yr. It is highlighted that the oedometer test is performed on a 76mm diameter sample and in glacial till materials, this can produce higher Mv's as the gravel and cobble constituents are excluded in the laboratory test.

On a field scale, the gravel / cobble constituents tend to enhance the stiffness of a glacial till deposit. The oedometer consolidation tests produced higher Mv's than expected and the values suggest the till is of medium compressibility (Mv of 0.1 to 0.30 m^2/MN). For settlement calculations, a Modulus of Volume Compressibility value of 0.2 to 0.25 m^2/MN for the firm glacial till is deemed reasonable.

Table 1 - Summary Details of Consolidated Quick Undrained (CQu) Tests

Geobor Drillhole	Sample Depth (m bgl)	Dry Density (Mg/m^3)	Bulk Density (Mg/m^3)	NMC (%)	Cohesion (kN/m^2)
RC 1	2.60	1.68	2.06	20	91
RC 3	2.00	2.01	2.29	14	214
RC 3	4.50	2.10	2.36	9.7	260
RC 4	3.20	1.76	2.16	22	96
RC 5	3.00	2.10	2.32	11	168

Natural moisture contents were determined on representative Geobor core samples and produced values mostly in the range 11 to 19%. Liquid and Plastic Limit tests (consistency indices) were also performed on selected samples and these show the till to be predominantly of low plasticity (CL). With the exception of one sample (GC 3 at 4.50m) the remainder of the tests plot above the A-Line on the Casagrande Chart. The majority of the plasticity Indices are in the 12 to 19% range. Fines contents (i.e. silt & clay) vary considerably in the Geobor drillholes, with the till having between and 30 and 70% fines. Applying the Hazen or Sherard equations, the boulder clay is classed as being of low permeability, with coefficients of permeability (K) of the order of $10^{-8}$to 10^{-9}m/s.

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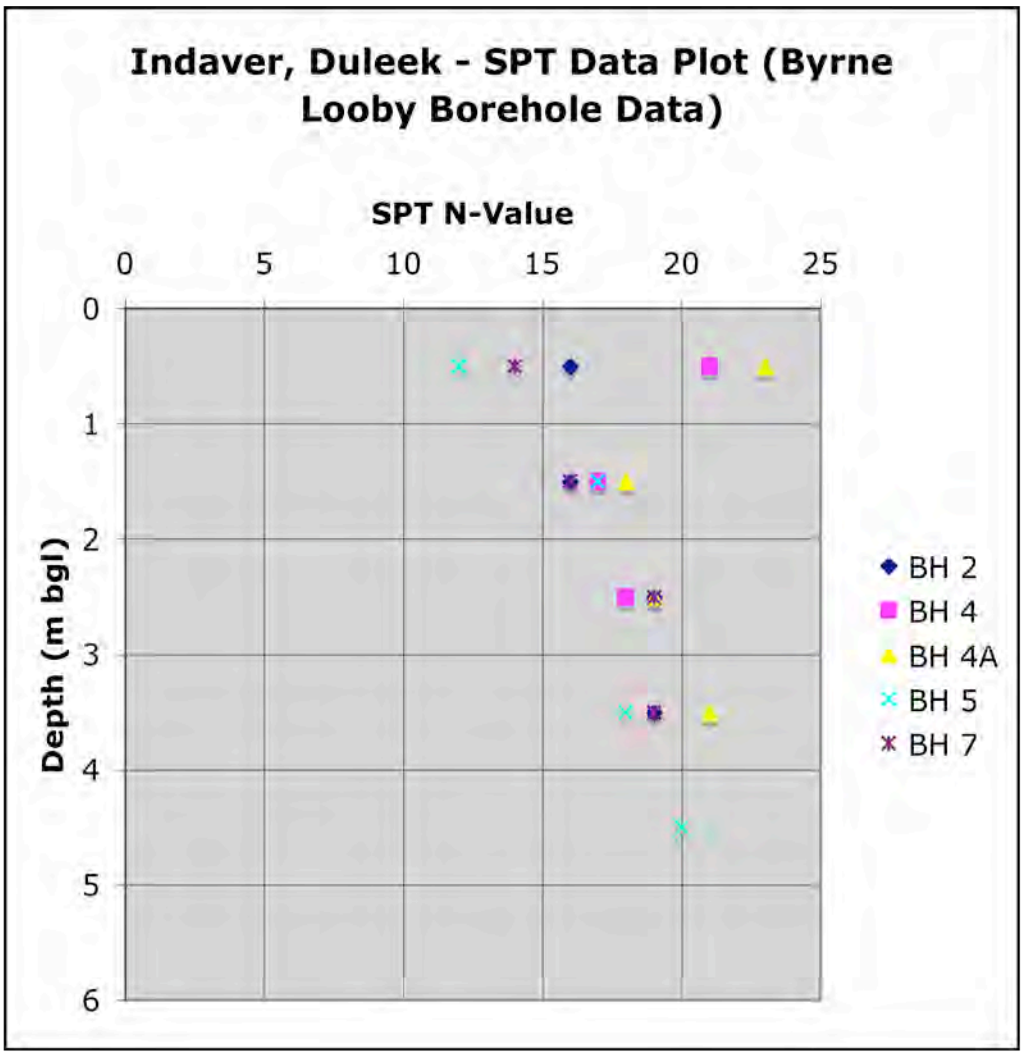
Figure 2 - SPT Data Plot



Surface wave velocities (Rayleigh waves) were measured by Apex Geoservices at five spread locations using an array of geophones at designated spacings. The shear wave velocity data (Vs) was used to derive small strain shear modulus or stiffness values (G_{max}) with depth. The shear wave velocity and small strain stiffness plots have been combined and are presented in Figures 2 and 3 respectively. The shear wave velocities increase with depth and this data can be used to derive Bulk Modulus, Youngs Modulus, Poisson's Ratio and G_{max}. Values of dynamic moduli (G_{max}) are typically an order of magnitude *greater* than static values, established by routine in-situ testing. Ground strains are generally accepted to be < 0.1% and therefore small strain stiffness values can be used to make reasonable predictions of deformations (Jardine et al. 1986). The Apex geophysical report presents values of Vs, Vp, Density, Poissons Ratio, Youngs Modulus (dynamic & static)) and Bulk Modulus.

The data shows of G_{Max} values in the upper glacial soils typically ranging from around 50 MPa to 150 MPa (firm / stiff boulder clay), increasing to 500 MPa in the very stiff till /upper variably weathered bedrock. The variations in the small strain stiffness values correlate well with the variations in soil composition as indicated by the Geobor core recovery. There is a noticeable 'kick' at a depth of approximately 5 to 6m, this correlates with the core drillhole data (GC 1 to 5) where rockhead was confirmed at depths of 5.30 to 8.00m.

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Figure 2 – Shear Wave Velocities v Depth

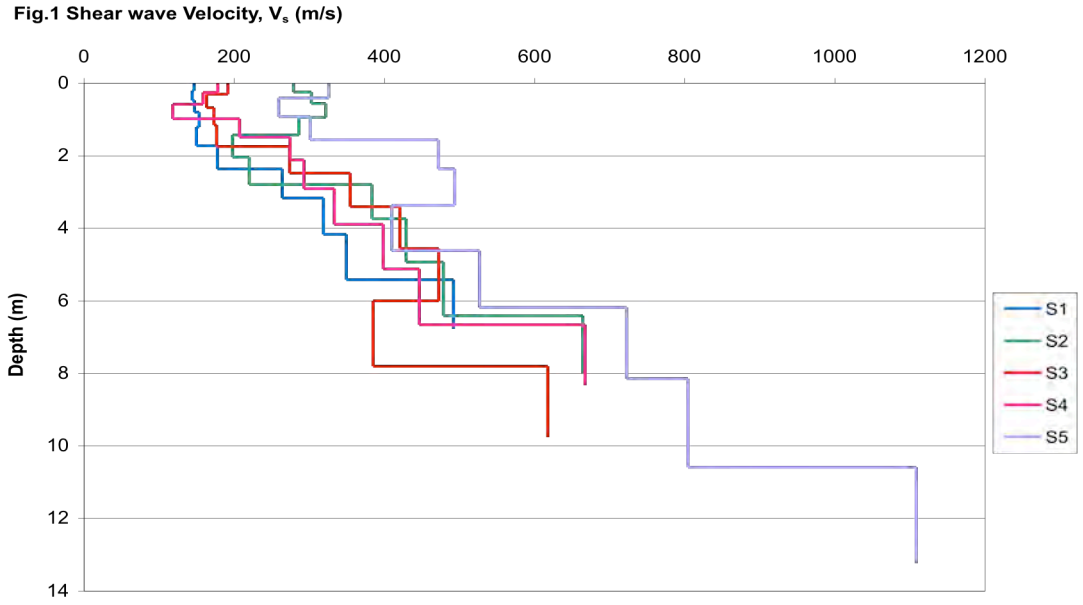
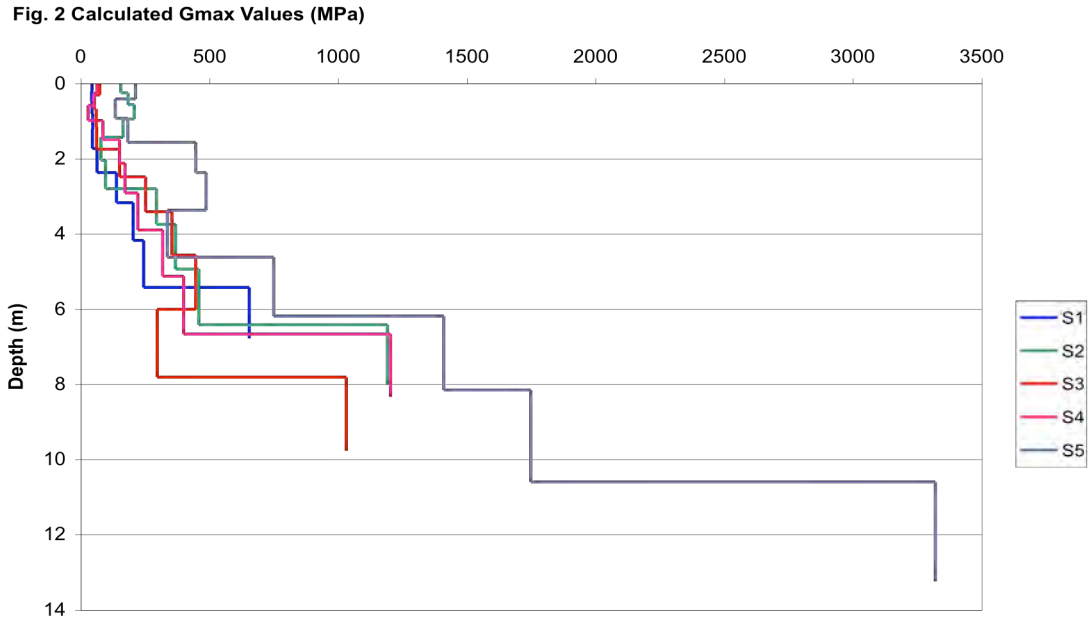


Figure 3 – Small Strain Stiffness (GMax) v Depth



4.3 Bedrock

The core drilholes show that bedrock consists of mid grey and grey blue, fine to medium grained silileous and fossiliferous LIMESTONE belonging to the Platin Formation (GSI Sheet 13, Geology of Meath). The limestone appears to be have been silicified, and is classed as being predominantly slightly weathered to fresh, though zones of moderately weathered and heavily fractured (non-intact) limestone were also uncovered. Table 1 presents summary details of the rotary drillholes, and includes rockhead depths and an overview of rock quality at each exploratory location. Not

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unexpectedly, rockhead elevation appears to be irregular at the site and appears to be deepest in GC 3 and GC 6 (east of the turbine and auxillaries).

Plate 2 – Example of Limestone Bedrock at Waste Bunker (RP 2)

The Geobor drillholes produced high quality core recovery in the variably weathered upper bedrock. Prominent clay, sand and gravel infill was noted in a number of the drillholes and there is clear evidence that the bedrock has been subjected to karst weathering / alteration. It should be noted that the siliceous limestone is more resistant to solution weathering (as opposed to the more calcareous fine grained limestone which is much more susceptible) and this may 'mask' the true rock mass quality. There is good reason to suspect that a paleokarst system could be present at the site and this will be discussed further in Section 5.

Discontinuities are generally rough and undulose while apertures appear to have widths of around 1 to 2mm. Dips mostly vary between sub-horizontal and 45º and surfaces show iron staining or discolouration. There is also evidence of clay smearing or infill along discontinuity surfaces. Discontinuity spacings are principally close (60 to 200mm) and medium (200 to 600mm) spaced though GC 3 shows very closely spaced (20 to 60mm) discontinuities, with much of the core more akin to a coarse angular gravel.

Point load strength index (PLSI) tests were carried out on a number of core samples and results are presented in Appendix 5 of the factual report. Inspection of the data sheets shows Is_{50} values of between 2.78 and 11.2 MPa with a mean value of 6.6 MPa. The compressive strength of the rock (q_c) can be established using a correlation suggested by Goodman where $q_c \approx 18$ to 24 x Is_{50}. Using a correlation value of 20, the point load test data shows the limestone to be predominantly strong (i.e. 50 to 100 MPa) to locally very strong (100 to 200 MPa).

Unconfined compressive strength (UCS) tests were also undertaken on selected rock cores and produced values of 27, 72, 35, 38, 39, 36, 54 and 59 MPa respectively. The UCS test data classes the limestone as moderately strong to locally strong and this is clearly at variance with the PLSI data. It is thought that the core samples failed prematurely during UCS testing (failure along

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incipient discontinuities as the principal stress was applied) and hence does not truly reflect the inherent strength of the limestone bedrock.

Table 2 - Summary Details of Rotary Drillholes

Rotary Hole	Total Depth (m bgl)	Rockhead (m bgl)	Rock Quality Characteristics
GC 1	12.00	6.60m (23.5m OD)	Strong to very strong (where intact) and locally moderately strong, fresh to slightly weathered LIMESTONE. Very closely fractured from 6.60 to c8.7m. Dry.
GC 2	15.10	5.30 (24.70m OD)	Strong to very strong (where intact) and locally moderately strong, fresh to locally slightly weathered LIMESTONE. Dry.
GC 3	11.80	8.00 (22.14m OD)	Strong to moderately strong, slightly to locally moderately weathered LIMESTONE. Dry. Prominent infill with sand, gravel & clay throughout, indicative of karst weathering / alteration.
GC 4	12.15	7.15 (23.12m OD)	Strong to very strong (where intact) and locally moderately strong, fresh to locally slightly weathered LIMESTONE. Locally highly fractured (8.60 to 9.80m). Dry.
GC 5	12.20	5.80 (24.28m OD)	Strong to moderately strong, fresh to slightly weathered LIMESTONE. Dry.
GC 6	13.50	8.25 (22.02m OD)	Strong to moderately strong, fresh to locally slightly weathered LIMESTONE. Highly fractured with very prominent clay, sand, gravel infill, indicative of karst weathering / alteration. Dry.
RP 1	10.50	6.40 (23.54m OD)	Strong to very strong (where intact), fresh to locally slightly weathered LIMESTONE. *Cavity* noted by driller from 8.70 to 8.90m, indicative of karst weathering / alteration. Dry.
RP 2	10.50	5.70 (24.33m OD)	Strong to very strong (where intact) and locally moderately strong, fresh to locally slightly weathered LIMESTONE. Dry.
RP 5	10.50	6.70 (23.48m OD)	Moderately strong (where intact) to moderately weak, moderately to locally highly weathered LIMESTONE. Becoming strong to moderately strong from c8.60m,

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			upper bedrock zone highly weathered / non-intact (6.70 to c8.60m). Dry.

4.4 Groundwater

Groundwater was not encountered in any of the nine IGSL rotary core drilholes. It is highlighted that loss of water flush was observed during drilling and this is characteristic of karst bedrock. It is noted that standpipes were not installed in the rotary drillholes to establish equilibrium groundwater levels.

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5. DISCUSSION & RECOMMENDATIONS

5.1 General

It is understood that a waste to energy facility will be constructed at this site. In light of this and the geotechnical / geophysical findings, the following ground engineering issues are developed and discussed:

- Bearing capacity
- Foundations & floor slabs
- Excavatability
- Earthworks & modification of glacial soils
- Groundwater
- Slopes & ground retention
- Karst weathering & geotechnical risk management

5.2 Bearing Capacity

The strength and relative density of the soils has been discussed previously in Section 4.2. The upper glacial till is principally firm and firm / stiff in consistency, while the lower till is typically stiff to locally very stiff. The weathering and strength of the limestone bedrock has been discussed in Section 4.3 and on foot of the strengths established by the laboratory testing, safe bearing and recommended allowable capacities (as defined in Section 2.2.8 of Tomlinson, 7th Ed) are presented in Table 2.

Table 2 - Summary Details of Safe Bearing Capacities

Stratum	Characteristic Strength or Relative Density Range	Assumed Safe Bearing Capacity (kN/m^2)	Recommended Allowable Bearing Capacity* (kN/m^2)
Upper till - firm and firm / stiff brown and grey brown sandy gravelly CLAY / SILT (N-Values of 15 to 20)	75 to 100 kN/m^2	175 to 225	200
Lower till – stiff and very stiff sandy very gravelly CLAY / SILT with cobbles (N-Values of 20 or greater)	125 to 150 kN/m^2	250 to 300	275
Variably weathered (slightly to moderately weathered) upper LIMESTONE	Moderately strong to strong	1250 to 1500	1250

** Recommended allowable bearing pressures presented are proposed to limit differential settlement*

The upper glacial till is typically firm / stiff and should provide an allowable bearing capacity of 200 kN/m^2. The Geobor cores and associated laboratory testing indicates the lower till to be stiff / very stiff and this should safely support loads of the order of 250 kN/m^2. It is highlighted that the low plasticity glacial till will be particularly susceptible or sensitive to small increases in moisture content and should be protected without delay to avoid degradation.

An allowable bearing capacity of 1250 kN/m^2 is suggested for pad or spread foundations located on the upper variably weathered limestone bedrock. Should foundations be located on the slightly weathered / fresh strong or very strong limestone, then an allowable bearing capacity of 1750 to 2000 kN/m^2 could be adopted.

5.3 Foundations

It is understood that the waste to energy facility building will be on two levels (34.00 & 30.50m OD) while the bunker will have a formation level of 22.60m OD. Building column loads are typically of the order of 500 KN, though equipment loads vary greatly, with the heavier structures having loads of 2000 kN and in some areas up to 3900 kN (furnace boiler). The reception hall building is expected to have column loads of approximately 350 kN while the ash (slag) storage building will have column loads of c500 kN.

In light of these loads and the geotechnical findings, foundation solutions for the principal structures are suggested in Table 3. This is to provide guidance to the designer and he must consider all of the relevant geotechnical data and impact of differential settlement with regard to the foundation design for the structure.

Table 3 - Suggested Foundation Solutions

Structure	Column Loads	Floor Slab Loads	Proposed Foundation Solution
Reception Hall	350 kN	Axle loads 13t Truck load 30t	Pads / strip footings founded on stabilized fill or imported granular fill with ground bearing floor slabs
Waste / Ash Bunker	1600 kN/m along retaining wall	100kN/m^2 on bunker slab	Raft founded on upper limestone bedrock (remove glacial till & replace with lean mix concrete)
Furnace Boiler	+ 500kN along building perimeter Equipment 1500 to 3900 kN	20 kN/m^2	Piles
Turbine Area	+ 500 kN along building perimeter Equipment loads 2000 to 3500 kN	20 kN/m^2	Piles

Slag Storage	+ 500 kN building loads	20 kN/m^2	Pads & strip footings*
Lab Area	+500 kN building loads Equipment 800 to 3500 kN	20 kN/m^2	Piles

** refer to text

Reception Hall / Building

It is understood that the reception hall / building will have a floor level of 34.00m and with ground levels at c30.0m, this will entail approximately 3.5 to 4m of engineering fill. Either modified glacial till (use of lime or cement to increase strength / stiffness) or imported granular fill (6F1 / 6F2 capping or 6N) could be used to achieve the platform level. If modified glacial till is selected, it should be placed in layers not exceeding 300mm and high quality compaction should be attained using either smooth drum or sheepsfoot rollers having a minimum mass per metre width of roll of not less than 5400kg. Modified / stabilized glacial till should be compacted to achieve a minimum of 95% of Proctor optimum (as determined by the 2.5kg rammer method) or air voids not exceeding 5%. Geotechnical testing should form an integral part of the modification works, with plate tests to derive CBR values and modulus of sub-grade reaction (Ks) values.

Waste Ash Bunker

Formation level for the waste ash bunker will be 22.60m OD and this will involve removing approximately 8m of glacial till and limestone. The rotary core drillholes (BLP/IGSL) have established rockhead at elevations of 23 to 24.3m OD at the northern section and 24.9m OD at the south / southeast corner. Based on this, it is expected that the waste bunker foundations will be located on the upper limestone bedrock. (Bedrock topography map will be produced by Apex Geoservices afer completion of the additional site works on 31/3/09). Given the variability in weathering and irregular rockhead profile, provision should be made for excavating pockets or zones of moderately to highly weathered limestone and replacing with lean mix concrete. It appears from the two phases of geotechnical investigations that cavities are present in the limestone at Carranstown (note adjacent Irish Cement Platin Works site is known to contain prominent karst features) and these should be a key consideration during the construction works at Indaver.

Both the BLP and IGSL geotechnical investigations encountered cavities within the upper limestone bedrock. RP 1 identified a cavity between 8.70 and 8.90m while RC 7 encountered a cavity between 8.50 and 9.90m. It is strongly advised that the bedrock formation material at the waste bunker be closely inspected by an experienced geotechnical engineer. In addition, provision shoud be made for geophysical surveying (ground probing radar & resistivity profiling methods) to be carried out when excavation works are complete. A reinforced concrete raft foundation is advised for the bunker, and should be designed to deal with a potential open void or cavity span of at least 1m.

Furnace Boiler

With equipment loads of 1500 to 3900 kN at the furnace boiler, it is advised that piles are utilized. The expectation is that bored piles would be used and formed by odex / symmetrix methods, extending through the superficial deposits and into the limestone bedrock. The rotary core drillholes undertaken at this area (GC 1, GC 5 & RP 5) encountered rockhead at elevations of 23.5 to 24.3m OD. The aforementioned drillholes showed significant variations in rock mass quality (i.e. weathering and strength) and this has to be considered in pile design. RP 5 showed a distinctive

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highly weathered profile from 23.5 to 21.5m OD. On the evidence of the rotary holes (particularly RP 5) pile lengths are expected to vary considerably, with load capacity dependant on variation in strengths and alteration due to karst weathering.

For preliminary foundation design purposes, it would be reasonable to assume that 600mm diameter piles, founded in the limestone bedrock, would provide a safe working load of the order of 1500kN. Therefore, pile groups of 3 or 4 could be designed to accommodate equipment loads of 4000 to 5000 kN. The piles should achieve adequate socket depths and rely largely on skin friction developed within the glacial till and limestone bedrock. If end bearing is to be relied upon, then core drilling should be carried out to validate rock quality below the pile toe. In view of the variably weathered nature of the karst altered limestone bedrock, the emphasis should be on reducing pile capacity and ensuring that the pile group can safely accommodate the column loads. It is expected that bored piles would have a minimum socket depth of 2.5 to 3m but this will be governed by the actual weathering profile and degree of intactness of the limestone bedrock at each pile group location.

Turbine Area

The ground conditions at the turbine area comprise stiff glacial till underlain by strong and very strong limestone bedrock (at an elevation of approximately 21.3m OD based on RC 2 BLP/GII Report). Again, equipment loads are considerable at the turbine area (up to 3500 kN), hence piles are recommended. It is expected that the piles for this structure will extend into the limestone bedrock (to provide an adequate socket). There was no evidence of cavities or voids in RC 2 and total core recovery (TCR) was fair to good. The limestone appears to be largely intact (though non-intact zone was present from 19 to 18.2m OD) and should provide a competent founding medium. Again, 600 or 900mm diameter bored piles are expected to be used and extend sufficiently into the intact or competent limestone.

Slag Storage Building

Building column loads at the slag storage building are estimated at +500 kN. GC 1 and GC 4 are most relevant to this area (note an absence of geotechnical information at the northern portion) and showed the glacial till materials to be generally stiff or upperbound medium dense. It is expected that pad and strip footing foundations will be utilized at this area and should be sized using an allowable bearing capacity of 200 kN/m^2. The real concern with utilizing pads at this building is the potential for differential settlement and the impact this would have on the structure.

In karst altered terrain, the strength / stiffness of glacial till soils can be highly variable (due to migration into voided zones) and this should be considered. Before foundations are finalized for the slag storage building, a programme of dynamic probing should be considered (grid of 5 x 5m) to evaluate the strength of the upper soils (i.e. within 3 to 4m of existing ground level). This data should be subsequently reviewed with the small strain stiffness geophysical data (Gmax profiles).

5.4 Floor Slabs

Anticipated floor slab loadings are presented in Table 2 and are generally of the order of 20 kN/m^2. Ground bearing floor slabs are expected to be suitable for the reception hall, slag storage, administration and laboratory buildings. Ground bearing floor slabs should not be located on made ground / fill material. This is due to its inherent variability and likely poor compaction (or no compaction), hence total and differential settlement would be a real concern. Made ground / fill materials should be removed and replaced with suitable approved engineering fill (i.e. imported granular fill or stabilized glacial till).

Given the silt dominant nature of the glacial till and proposed floor slabs loadings of 20 kN/m^2 a minimum granular layer thickness (6F1 / 6F2) of 500 mm is recommended. However, where floor slab loading are > 20 kN/m^2 an enhanced modulus granular layer should be considered. A granular

layer thickness of 600 to 800mm should be considered where modulus of sub-grade reaction values (Ks) are < 20 MPa/m or CBR < 1%.
If imported limestone / mudstone derived granular fill is used under floor slabs or structures, then it should have a minimum Ten Per Cent Fines Value of 130 kN and minimum CBR value of 15% (derived using plate bearing plate method). From a chemical and pyrite degradation aspect, granular fill material should have a maximum equivalent pyrite content of < 1% (i.e. low to medium swelling potential in accordance with CTQ-M200), maximum total sulphur content of 1.0% (or < 0.4% if pyrrhotite is suspected) and maximum acid soluble sulphate of 0.2% in accordance with IS EN 13242:2002.

If pyrite is present in granular fill, this may lead to problems with oxidation, weathering and adverse reaction with carbonate minerals. Potentially expansive fill materials should not be used under structures. Imported granular fill material (e.g. capping or sub-base) should be thoroughly checked for total sulphur and soluble sulphates (SO_4). Thin section petrographic analysis should also be carried out to determine mineralogical composition, particularly for the presence of pyrite in the rock matrix (especially more reactive fine grained or framboidal pyrite).

5.5 Excavatability
The key factors which govern or control excavation methods in glacial till / boulder clay and hence production rates are the strength of the matrix and frequency or predominance of boulders. On the basis of the SPT Values and strength descriptors on the logs, excavation of the glacial till is expected to be efficiently carried out using 20t tracked excavators.

The three key factors, which govern or control excavation methods and hence production rates in bedrock are:

- compressive strength of the rock
- discontinuity / bed spacings
- orientation and tightness of the discontinuities or bedding

A number of methods are available to assess the excavatability characteristics of the limestone bedrock, including the Pettifer & Fookes chart, Weaver rating chart etc. On the basis of the mechanical indices (SCR/RQD), discontinuity characteristics and strengths established by the point load tests, heavy digging and hydraulic breaking (6 or 8t breakers mounted on 50t excavators) is anticipated to efficiently loosen or fracture the upper bedrock. The strong / very strong siliceous or fossiliferous limestone bedrock will be more onerous to loosen and this should be considered by civil engineering contractors.

Trench excavations in the strong / very strong limestone bedrock will be very onerous (due to the lack of a free face) and the siliceous limestone will tend to reduce to a powder. It is highlighted that the Pettifer & Fookes excavatability chart (nomogram) tends to be very optimistic for indurated Irish bedrock deposits, particularly strong / very strong materials. It provides no information on production rates and serves only as a guide in assessing possible excavation methods digging/ripping/hydraulic breaking/blasting).

5.6 Earthworks & Modification of Glacial Soils
In view of the variability of the glacial till soils and concerns regarding their re-use potential, a programme of laboratory modification / stabilization testing was carried out by IGSL. Moisture Condition Value (MCV) and California Bearing Ratio (CBR) tests were undertaken on samples of the glacial till recovered from the bunker footprint and stockpiles constructed by Sisk. This focused on two modes of testing following the addition of calcium oxide (supplied by White Rhino, Clogrennane) or OPC to the glacial till. MCV's were carried out after a period of circa 3 hours and

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CBR tests following curing for periods of 1, 3 and 14 days respectively. The CBR and MCV tests were performed on unsoaked samples, where the material was allowed to cure at a laboratory temperature of 16 to 18°C.

Inspection of the laboratory test data in the factual report shows MCV's increased significantly after lime or cement binder was added. The MCV's were undertaken after mixing and curing for 3 hours. In the majority of cases, the MCV's increased to +7 with the material from the bunker footprint (TP 1A & 1B) performing best. The samples from the stockpiles were considerably wetter and the MCV's on these samples increased modestly after adding 1 or 2% calcium oxide. With regard to the CBR test data, the glacial till material showed a good exothermic reaction with calcium oxide, particularly the samples from the bunker (TP 1A & 1B), which produced high CBR values. The CBR values from the stockpile samples were considerably lower and more erratic, even with 2% binder.

It is concluded from the modification / stabilization laboratory trial testing that the glacial till has the capacity to produce a good quality engineering fill, following the addition of 1 to 2% calcium oxide or OPC. It is expected that a minimum CBR value of 5% will be required for bulk engineering fill (after curing for a period of 7 days) under structures and floor slabs. In view of the laboratory CBR values obtained from the stockpiles, provision should be made for at least 2% binder. Given the composition and variability of the glacial till, a combination of lime and cement (e.g. 2% lime with 1% cement) should be considered for the variable stockpiled material. Field trials are advised during the early stages of the modification / stabilization works to determine dosage or consumption quantities to achieve an MCV of 8 to 14 and minimum CBR value of 5% or modulus of sub-grade reaction (Ks) value of 40 MPa/m.

5.7 Pavement

Capping material (6F1 / 6F2) is used to protect the sub-grade and the sub-base material and increase the stiffness modulus and strength of the formation. In accordance with DMRB Design Guidance for Road Pavement (HD 25) the lower-end equilibrium CBR values should be used to determine appropriate capping layer thickness. Remoulded CBR values were carried out by BLP/GII on the soils at depths from 0.5 to 3.50m and values range from 1.0 to 18%. Taking a characteristic lower end CBR value of around 2%, a capping layer thickness of the order of 400 to 450mm is recommended.

Provision should be made for additional CBR tests to be carried out during the earthworks phase at the principal access roads and pavement formations (i.e. preferably plate bearing tests to derive CBR values). It is expected that this would be undertaken during the early earthworks phase to confirm design CBR value and validate appropriate capping layer thickness. A geotextile fabric (PB 120 or similar) should be used for separation at roads, car park and general pavement areas.

5.8 Groundwater

As set out in Section 4.4, groundwater was not encountered in any of the IGSL rotary drillholes. Groundwater was locally intercepted in the BLP/GII trial pits (i.e. 1.9 to 3.5m bgl). These levels are unlikely to reflect long term equilibrium water conditions but should be considered in terms of ingress during excavation works. Packer tests were not carried out to evaluate the permeability or water-tightnes of the bedrock. However, on the evidence of the discontinuity spacings and fracture state of the cores, the bedrock would be expected to be of medium permeability (i.e. Lugeon Values of 5 to 20).

In light of the BLP/GII borehole and trial pit findings, provision should be made for sump pumping in excavations. It is possible that some groundwater pumping may be required at the bunker and other deeper foundations areas (chambers or waste sump tanks etc). Perimeter drains and sumps should be carefully located and constructed, to ensure that groundwater is efficiently removed from excavations and trenches.

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5.9 Slopes

On the basis of the strength of the material from the SPT's,and Gebor cores and groundwater conditions, a slope batter of 33º (1V:1.5H) is suggested for temporary excacations in the firm / stiff glacial till. Temporary slope protection measures should be installed to prevent the risk of spalling. To mitigate against cobbles, boulders or loose blocks / clods spalling, either galvanised mesh or a geogrid (Tensar SS 30 or similar) should be fixed against the crest, mid-point and toe of the batter. This is normally carried out with upturned reinforcing bars or a bulb of concrete at the toe.

Temporary slopes should be regularly inspected during the course of any excavation works by an experienced geotechnical engineer. The purpose of this is to evaluate unfavourable or potentially unstable ground conditions, general slope behaviour and groundwater. The slope batters should be inspected daily by an experienced site engineer. If there are concerns with instability, then advice should be sought from a suitably experienced geotechnical engineer.

5.10 Ground Retention

With an excavation depth of the order of 7m required for the bunker, ground retention is expected to be used. Considering the prevailing ground and groundwater conditions at the bunker footprint, it is believed that either a contiguous bored piled wall or king post wall is most appropriate, Given the space constraints within the excavation (19m wide), a cantilever contiguous bored piled (600mm diameter) wall or unpropped king post wall would be preferred. With groundwater largely absent in the boreholes / drillholes, king posts could be constructed with universal columns at 5m centres and utilizing precast concrete panels.

To progress through the strong limestone bedrock and attain the required embedment depths for either solution, robust bored piling methods will be necessary. The use of CFA piling techniques is not recommended, as this system is not expected to penetrate through strong limestone bedrock. Odex / symmetrix or down the hole hammer methods are considered most suitable.

Geotechnical instrumentation should form a key part of the ground retention works. Inclinometers (minimum of 2 No.) should be installed to measure lateral wall deflections. The actual deflections should be compared with the predicted values and ensure that they do not exceed threshold limits agreed with the Engineer.

5.11 Karst Weathering

Karst subsidence is a function of groundwater movement and hydrogeological changes in surface water. Groundwater play a key role in the formation of subsidence sinkholes. A subsidence sinkhole was defined by Waltham (1989) as a 'failure of soil or weak rock into underlying cavernous limestone'. Newton & Waltham (1989) identified sinkholes into two types: firstly those resulting from water level decline and secondly, those resulting from diversion or impoundment of surface drainage.

Temporary lowering of the water table down to bedrock level is known to be a significant contributory factor in sinkhole development. It is also well established, that periods of dry weather followed by very heavy prolonged rainfall can trigger subsidence. Similarly, stripping of topsoil or vegetation increases the rate of infiltration of surface water and redirection of run-off can cause preferential flow and initiate subsidence. Subsidence sinkholes can develop very quickly following heavy rainfall and earthworks stripping.

As noted in Section 4.3, there is evidence of solution weathering or karstification in the limestone bedrock at this site. Karstification is known to occur in the Duleek / Carranstown area and the Platin Formation is known to be very susceptible to karst weathering. Considering all of this, the potential or likelihood for karst subsidence features to occur should be strongly considered in both foundation and drainage design. The site development earthworks (completed in January 2009)

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have produced a platform level of 30m OD. Surface water was present during the course of the rotary drilling works (early to mid February) but there was no evidence of sinkholes or depressions. It is noted that significant water flush loss during drilling was recorded by the driller and this suggests fissures or voids in the limestone bedrock.

A number of measures can be taken to minimise the risk associated with excavation works and foundations. Surface water should be carefully managed and controlled, so as to avoid indiscriminate run-off or dissipation into the formation soils. The civil engineering contractor should be aware of the risks associated with this particular site and provide tool box talks to engineering staff and site operatives. Bunds or swales should be constructed to control surface water run-off and discharge to attenuation ponds.

The groundwater levels in the BLP/GII standpipes should be monitored during the course of the excavation works for the bunker and should groundwater levels drop below equilibrium levels, this should be a cause for concern, as significant lowering of the groundwater table (as noted previously) can trigger or initiate subsidence sinkholes. Piling contractors should also be made aware of the potential issues with ground engineering works in karst altered limestone. Earthwork and piling contractors should evaluate the risk of ground hazards and address in method statements. As regards foundations located on the limestone bedrock (i.e. waste bunker), the recommendations outlined in Section 5.3 should be considered and implemented.

5.12 Geotechnical Risk Management

Reference should be made to the ICE / DETR 'Managing Geotechnical Risk' report which addresses the principles of managing geotechnical risk, steps in risk management, undertaking risk analysis and setting up a risk register with designers, contractors and of course the client. Given the scale of the main structures and the fact that karst limestone is present, a risk assessment is suggested. Geotechnical risk management provides a means of:

- Identifying potential geotechnical or ground related hazards
- Reducing the uncertainty of geotechnical or ground related hazards
- Evaluating the vulnerability of construction activities (particularly foundations & earthworks) to the geotechnical risks
- Producing robust geotechnical designs with back-up plans in the event that unforeseen conditions arise

A key part of geotechnical risk management is the setting up of a risk register or risk management log. The risk register provides a means of recording potential uncertainties or hazards before and during construction. The type of risk can be identified, consequences established and the risk classed accordingly (low, medium, high or very high). A risk management register is strongly recommended for this project and both the designer and contractor should identify particular geotechnical risks or hazards pertaining to the main structures.

Examples of a risk register are presented in Appendix A of the aforementioned ICE / DETR report and a sample version is presented in Table 5. This presents an outline of the key geotechnical risks for four key areas at the site. The design strategy or risk control measures (RCM) must be adequately robust to deal with uncertainties identified by the geotechnical investigations and requirements of the client.

The risk register should be reviewed and updated as design and construction progresses. This can be used to re-assess risk and re-rank the key risks accordingly. On-going assessment is

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particularly important in karst affected sites, where subsidence features can develop randomly and without warning.

Table 5 - Sample of Geotechnical Risk Register / Log for Indaver Carranstown Project

Structure	Key Risks	Probability (1,2,3)	Impact (1,2,3)	Risk Class (L,M,H.C)	Design Strategy
Reception Hall	Ability of modification / stabilization works to achieve target strength / stiffness. Differential settlement of pad or strip footing foundations. Elevated sulphates in modified glacial till.				
Waste Bunker	Rock excavatibility. Ability of contiguous bored piles or king posts to attain design embedment depth. Potential for subsidence (voids / cavities) to develop under foundations or void migration.				
Turbine & Auxillaries	Differential settlement between pads. Piles failing to achieve adequate embedment or socket depth in limestone bedrock. Possibility of void migration under turbine and auxillary structures.				
Slag Storage	Differential settlement between pads. Stiffness of formation soils to accommodate floor slab loads. Possibility of void migration under slag storage.				

Probability (1=Low, 2=Medium, 3= High)
Risk Class (Low, Medium, High, Critical)

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References

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2. BS 1377 (1990) Methods of Testing of Soils for Civil Engineering Purposes, BSI

3. BS 8004 (1986) Code of Practice for Foundations, BSI

4. Indaver, Carranstown Geotechnical Assessment Report (B580), May 207, Byrne Looby Partners

5. IS EN 13242:2002, Aggregates For Unbound and Hydraulically Bound Materials for use in Civil Engineering and Road Construction, January 2003

6. Managing Geotechnical Risk, DETR / ICE, Thomas Telford, 2001

7. NRA Specification for Road Works, March 2000

8. Site Investigation Practice: Assessing BS 5930 (1986), Geological Society Special Publication, No. 2

9. Tomlinson, M.J. Foundation Design & Construction, 7th Edition

10. Waltham, A.C. (1989). Sinkholes on Limestone. Ground Subsidence, Blackie, Glasgow, 17-40

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Appendix 9.2

Trial Pit Logs 2000

Trial Pit Records

Project No. : 2175 **Location :** Duleek, Co. Meath **Date :** 28/4/00

Drilling Method : JCB **Supervisor :** Amy Brennan

TRIAL PIT NO.1

Geology :

0 - 0.25	Dark brown organic-rich TOPSOIL
0.25 - 0.9	Medium brown silty CLAY with occasional subrounded pebbles.
0.9 - 3.0	Fine grained, homogeneous, brown SAND.
3.0 - 3.2	Brown BOULDER CLAY with occasional large limestone boulders
3.2 - 3.3	Stiff, black BOULDER CLAY

Depth to Rock : >3.3m

Rock Type :

Water Entry : None

Static Water :

Total Depth : 3.3m

Comments : Composite soil samples taken; Dry deposits. No unusual colours o odours noted.

Trial Pit Records

Project No. : 2175 **Location :** Duleek, Co. Meath **Date :** 28/4/00

Drilling Method : JCB **Supervisor :** Amy Brennan

TRIAL PIT NO.2

Geology :

0 - 0.2	Brown organic-rich TOPSOIL
0.2 - 1.1	Medium brown silty CLAY with occasional subangular pebbles.
1.1 - 1.6	Medium brown, silty BOULDER CLAY with large limestone boulders
1.6 - 3.4	Extremely coarse, clayey GRAVEL deposits (boulders up to 40 - 45cm), with water.

Depth to Rock : >3.4m

Rock Type :

Water Entry : 3.2m

Static Water : 3.2

Total Depth : 3.4m

Comments : Water seen to be flowing in through the gravels. Composite soil sample taken. No unusual colours or odours noted.

Trial Pit Records

Project No. : 2175 **Location :** Duleek, Co. Meath **Date :** 28/4/00

Drilling Method : JCB **Supervisor :** Amy Brennan

TRIAL PIT NO.3

Geology :

0 - 0.15	Dark brown organic-rich TOPSOIL
0.15 - 1.9	Dark brown, moderately well-sorted , dry, clayey, sandy GRAVEL.
1.9 - 3.4	Lighter brown, clayey SAND with occasional pebbles up to 3-4cm in size.

Depth to Rock : >3.4m

Rock Type :

Water Entry : Seepage into the excavation from approx. 1.9m

Static Water :

Total Depth : 3.4m

Comments : Water was seen to be seeping in through the clayey SAND layer. Composite soil sample was taken. No unusual colours or odours.

Trial Pit Records

Project No. : 2175 **Location :** Duleek, Co. Meath **Date :** 28/4/00

Drilling Method : JCB **Supervisor :** Amy Brennan

TRIAL PIT NO.4

Geology :

0 - 0.15	Brown organic-rich TOPSOIL
0.15 - 0.4	Medium brown subsoil.
0.4 - 1.25	Loose, light brown, silty, sandy, CLAY with occasional rounded pebbles.
1.25 - 3.45	Poorly sorted, subrounded, brown, clayey, sandy, GRAVEL with some black colouration due to presence od shaley fragments.

Depth to Rock : >3.45m

Rock Type :

Water Entry : Gravels moist- Very small amount of seepage.

Static Water :

Total Depth : 3.45m

Comments : Gravel layer collapsing into the hole. No unusual colours or odours noted. Composite soil samples taken.

Trial Pit Records

Project No. : 2175 **Location :** Duleek, Co. Meath **Date :** 28/4/00

Drilling Method : JCB **Supervisor :** Amy Brennan

TRIAL PIT NO.5

Geology :

0 - 0..12	Medium brown organic-rich TOPSOIL
0.12 - 1.3	Loose, light brown, sandy CLAY.
1.3 - 2.7	Loose, fine grained, homogeneous brown SAND.
2.7 - 3.4	Quite stiff, light brown BOULDER CLAY

Depth to Rock : >3.4m

Rock Type :

Water Entry : Water seeping into the hole at approx 2.7m through the bottom of the sands.

Static Water : Not available. Hole filled up with sand.

Total Depth : 3.4m

Comments : Walls of the excavation very unstable and sand collapsing into the hole. No unusual colours or odours noted. Composite soil samples taken.

Trial Pit Records

Project No. : 2175 **Location :** Duleek, Co. Meath **Date :** 28/4/00

Drilling Method : JCB **Supervisor :** Amy Brennan

TRIAL PIT NO.6

Geology :

0 - 0.15	Dark brown organic-rich TOPSOIL
0.15 - 0.6	Medium brown silty CLAY with only occasional subrounded pebbles.
0.6 - 1.85	Grey brown, loose, silty CLAY with boulders up to 25cm in size.
1.85 - 3.15	Moderately well sorted, clayey GRAVEL, with occasional large boulders (up to 30cm).

Depth to Rock : >3.15m

Rock Type :

Water Entry : Spring seen to be flowing into the excavation at approx 1.85m

Static Water : 3.0m and rising

Total Depth : 3.15m

Comments : Spring flowing in from the northern side of the excavation, quite quickly. No unusual colours or odours. Composite soil sample taken.

Trial Pit Records

Project No. : 2175 **Location :** Duleek, Co. Meath **Date :** 28/4/00

Drilling Method : JCB **Supervisor :** Amy Brennan

TRIAL PIT NO.7

Geology :

0 - 0.3	Dark brown organic-rich TOPSOIL & subsoil
0.3 - 0.95	Dark brown, clayey, sandy, SILT with occasional pebbles
0.95 - 3.1	Moderatley well-sorted, dark brown, sandy, clayey, GRAVEL
3.1 - 3.3	Tight, dark brown BOULDER CLAY .

Depth to Rock : >3.3m

Rock Type :

Water Entry : None

Static Water :

Total Depth : 3.3m

Comments : Composite soil samples taken; Dry deposits. No unusual colours or odours noted.

Appendix 9.3
Soil Sampling Results Tables

Table 9.1: Soil Analytical Results - Metals Phenols (28/4/00)

Sample Identity	Depth (m)	Arsenic mg/kg	Cadmium mg/kg	Chromium mg/kg	Copper mg/kg	Mercury mg/kg	Nickel mg/kg	Lead mg/kg	Selenium mg/kg	Zinc mg/kg	Total Phenols mg/kg
TP1	0 - 3.3	<1	2	16	37	2	33	10	<1	54	0.01
TP2	0 - 3.4	1	<1	44	48	<1	58	13	<1	72	<0.01
TP3	0 - 3.4	<1	<1	46	26	1	46	9	<1	54	<0.01
TP4	0 - 3.5	<1	<1	49	30	<1	54	12	<1	66	<0.01
TP5	0 - 3.4	19	<1	43	25	<1	43	11	<1	51	<0.01
TP6	0 - 3.1	<1	<1	36	29	3	47	11	<1	59	<0.01
TP7	0 - 3.3	23	<1	39	37	<1	55	13	<1	60	<0.01
TP-7 Duplicate	0 - 3.3	3	<1	42	38	<1	39	9	<1	46	n.a.
Dutch MAC S Values		29	0.8	100	36	0.3	35	85	-	140	-
Dutch MAC I Values		55	12	380	190	10	210	530	-	720	-

Legend

mg/kg: milligrams per kilogram

MAC: Dutch Standard Maximum Admissible Concentration

S Value: Dutch Guidline for normal uncontaminated soil

I Value: Dutch Guideline for Intervention

"-": MAC Guideline not available

n.a. = not analysed

"<" = below detection limit

Table 9.2: Soil Analytical Results - VOCs (28/4/00)

Trace Organics (VOCs)		TP1	TP2	TP3	TP4	TP5	TP6	TP7	Dutch MACs S-Value	Dutch MACs I-Value
Dichlorofluoromethane	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Chloromethane	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Vinylchloride	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	100
Bromomethane	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Chloroethane	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Trichlorofluoromethane	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
trans-1,2-Dichloroethene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Dichloromethane	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	20,000
1,1 Dichloroethene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
1,1 Dichloroethane	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
cis-1,2-Dichloroethene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Bromochloromethane	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Chloroform	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
2,2-Dichloropropane	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
1,2-Dichloroethane	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	4,000
1,1,1-Trichloroethane	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
1,1-Dichloropropene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Benzene	µg/kg	<1	<1	<1	<1	<1	<1	<1	50	1,000
Carbontetrachloride	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Dibromomethane	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
1,2-Dichloropropane	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Bromodichloromethane	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Trichloroethene	µg/kg	<1	<1	<1	<1	<1	<1	<1	1	60,000
cis-1,3-Dichloropropene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
trans-1,3-Dichloropropene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
1,1,2-Trichloroethane	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Toluene	µg/kg	<1	<1	<1	<1	<1	<1	<1	50	130,000
1,3-Dichloropropane	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Dibromochloromethane	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
1,2-Dibromoethane	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Tetrachloroethene	µg/kg	<1	<1	<1	<1	<1	<1	<1	10	4,000
1,1,1,2 -Tetrachloroethane	µg/kg	<1	<1	<1	<1	<1	<1	<1		
Chlorobenzene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Ethylbenzene	µg/kg	<1	<1	<1	<1	<1	<1	<1	50	50,000
p/m Xylenes	µg/kg	<1	<1	<1	<1	<1	<1	<1	50	25,000
Bromoform	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Styrene	µg/kg	<1	<1	<1	<1	<1	<1	<1	100	100,000
1,1,2,2-Tetrachloroethane	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
o - Xylene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
1,2,3-Trichloropropane	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Isopropylbenzene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Bromobenzene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
2-Chlorotoluene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Propylbenzene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
4-Chlorotoluene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
1,2,4-Trimethylbenzene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
4-Isopropyltoluene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
1,3,5-Trimethylbenzene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
1,2-Dichlorobenzene	µg/kg	<1	<1	<1	<1	<1	<1	<1	10	-
1,4-Dichlorobenzene	µg/kg	<1	<1	<1	<1	<1	<1	<1	10	-
sec-Butylbenzene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
tert-Butylbenzene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
1,3-Dichlorobenzene	µg/kg	<1	<1	<1	<1	<1	<1	<1	10	-
n-Butylbenzene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
1,2-Dibromo-3-Chloropropane	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
1,2,4-Trichlorobenzene	µg/kg	<1	<1	<1	<1	<1	<1	<1	10	-
Naphthalene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
1,2,3-trichlorobenzene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Hexachlorobutadiene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-

LEGEND
µg/kg: micrograms per kilogram
MAC: Maximum Admissible Concentration
Dutch S-Value: Target Value
Dutch I-Value: Intervention Value
'-': MAC Guideline Not Available
< = Below current laboratory detection limit

Table 9.3: Soil Analytical Results - Polynuclear Aromatic Hydrocarbons (28/4/00)

Parameters	Depth (m)	TP1 -	TP2 -	TP3 -	TP4 -	TP5 -	TP6 -	TP7 -	Dutch MAC Values	
	Units								S-Value	I-Value
Acenaphthene	µg/kg	<1	12	<1	<1	<1	<1	5	-	-
Acenaphthylene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Benzo(B)fluoranthene	µg/kg	38	25	5	9	5	11	9	-	-
Dibenz(AH)anthracene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Fluorene	µg/kg	5	25	3	12	4	3	3	-	-
Pyrene	µg/kg	12	25	6	7	9	16	4	-	-
PAHs included in 'PAH (Sum of 10)' Dutch S and I MAC values for PAHs in soil										
Anthracene	µg/kg	28	13	9	7	4	9	5	-	-
Benzo(a)anthracene	µg/kg	65	18	5	<1	6	4	10	-	-
Benzo(a)pyrene	µg/kg	21	21	<1	<1	<1	<1	<1	-	-
Benzo(ghi)perylene	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Benzo(k)flouranthene	µg/kg	22	15	4	4	2	6	4	-	-
Chrysene	µg/kg	51	28	7	<1	2	10	7	-	-
Fluoranthene	µg/kg	17	28	8	9	12	14	5	-	-
Indeno(123-cd)pyrene	µg/kg	4	10	<1	<1	<1	<1	3	-	-
Naphthalene	µg/kg	67	148	59	94	40	54	34	-	-
Phenanthrene	µg/kg	120	63	13	21	16	18	12	-	-
PAH (Sum of 10)	µg/kg	395	344	105	135	82	115	80	1000	40000
PAH (Total)	µg/kg	449	432	118	162	100	146	100	-	-

Legend

µg/kg: micrograms per kilogram

MAC: Maximum admissable concentration

S-level: Dutch guideline for normal uncontaminated soil

I-Level: Dutch guideline for Intervention

Results awaiting confirmation

"-": MAC not available

< = below laboratory detection limit

Table 9.4: Soil Analytical Results - Polychlorinated Biphenyls (28/4/00)

Parameters		TP1	TP2	TP3	TP4	TP5	TP6	TP7	Dutch MAC Values	
	Depth								S	I
	Units									
PCB Aroclor 1016	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
PCB Aroclor 1221	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
PCB Aroclor 1232	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
PCB Aroclor 1242	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
PCB Aroclor 1248	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
PCB Aroclor 1254	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
PCB Aroclor 1260	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
PCB total	µg/kg	<1	<1	<1	<1	<1	<1	<1	20	1000

Legend

µg/kg: micrograms per kilogram

MAC: Maximum admissable concentration

S-level: Dutch guideline for normal uncontaminated soil

I-Level: Dutch guideline for Intervention

-: MAC not available

< = below laboratory detection limit

Table 9.5: Soil Analytical Results - Pesticide Analysis (28/4/00)

Pesticide	Units	TP 1	TP 2	TP 3	TP 4	TP 5	TP 6	TP 7	Dutch Values	
									S- Value	I Value
Dichlorvos	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Mevinphos	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Phorate	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Alpha-BHC	µg/kg	<1	<1	<1	<1	<1	<1	<1	2.5	-
Beta-BHC	µg/kg	<1	<1	<1	<1	<1	<1	<1	1	-
Gamma-BHC	µg/kg	<1	<1	<1	<1	<1	<1	<1	0.05	-
Diazinon	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Disulfoton	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Delta-BHC	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Methyl Parathion	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Heptachlor	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Fenitrothion	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Aldrin	µg/kg	<1	<1	<1	<1	<1	<1	<1	2.5	-
Malathion	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Parathion	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Heptachlor Epoxide	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Endosulfan I	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Dieldrin	µg/kg	<1	<1	<1	<1	<1	<1	<1	0.5	-
4,4-DDE	µg/kg	<1	<1	<1	<1	<1	<1	<1	2.5	4000
Endrin Ketone	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Endosulfan II	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
4,4-DDD	µg/kg	<1	<1	<1	<1	<1	<1	<1	2.5	4000
Ethion	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Endrin	µg/kg	<1	<1	<1	<1	<1	<1	<1	1	-
Endosulfan Sulphate	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
4,4-DDT	µg/kg	<1	<1	<1	<1	<1	<1	<1	2.5	4000
Methoxychlor	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-
Azinphos Methyl	µg/kg	<1	<1	<1	<1	<1	<1	<1	-	-

Legend

µg/kg: micrograms per kilogram
MAC: Maximum Admissable Concentration
S-level: Dutch guideline for normal uncontaminated soil
I-Level: Dutch guideline for Intervention
-: MAC not available
< = below laboratory detection limit

Appendix 9.4
Puraflo Report

Report on the Suitability of a Site for the Installation of a Puraflo™ System at Carranstown, Co Louth.

December 2000

Prepared by:

K.T. Cullen & Co. Ltd.,
Hydrogeological & Environmental Consultants,
Bracken Business Park,
Bracken Road,
Sandyford Industrial Estate,
Dublin 18.

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Figures

Appendix

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eMail: info@ktcullen.ie

K.T.Cullen & Co. Ltd.

Report on the Suitability of a Site for the Installation of a Puraflo™ System at Carranstown, Co. Louth.

1. Introduction

K.T Cullen & Co. were requested by Project Management to carry out trial pitting and percolation tests at a site in Carranstown Co. Louth. The purpose of the work was to assess the suitability of the site for the installation of a Puraflo™ system with associated septic tank and percolation area. The system was designed to cater for a maximum of 100 people.

2. Field Work

2.1 On Site Assessment

The site is underlain by limestone bedrock. No outcrops, springs or karst features were seen at the site. Monitoring wells and trial wells drilled at the site in May 2000 indicate relatively deep overburden deposits varying from approximately 5 metres to 21 metres of clays and gravels. The water table in one of these boreholes (MW1) was measured as being approximately 10.5 metres below the ground level at the time of trial pitting (12/12/00).

The field in which the work was carried out has a shallow ditch to the south-east which had water in it at the time of trial pitting. Prior to fieldwork, the weather in general had been extremely wet and parts of the field near the ditch were experiencing ponding of surface water.

The site is presently under grass and apart from the localised ponding appears to be well-drained. The brown/red colour of the subsoil would also indicate a well-drained site.

2.2 Trial Pits

Two trial pits were dug at the site of the proposed percolation area. The trial pit logs are shown in Appendix A and their location is shown in Figure 1. The trial pits were excavated to a depth of 2.8 m and 3 m respectively. Both encountered similar overburden deposits-1.2-1.8 m of boulder clay and then

a clayey gravel which became more gravelly with depth. No seepages were encountered during the digging and after 48 hours, no water had entered the hole.

2.3 Percolation Pits

Four percolation pits were dug at the site of the proposed percolation area. The top 0.30 metres of soil was removed at the location of each of the four pits by the JCB. 0.30 metres was chosen as this is the depth at which effluent will be introduced to the soil according to Puraflo™ Agrément Certificate 97/00060. The pits were then dug in these depressions with in accordance to dimensions specified in the EPA's Wastewater Treatment Manuals. The percolation pits measured 0.3 m by 0.3 m and were completed at a depth of 0.4 m-approximately 0.7 m below the ground surface.

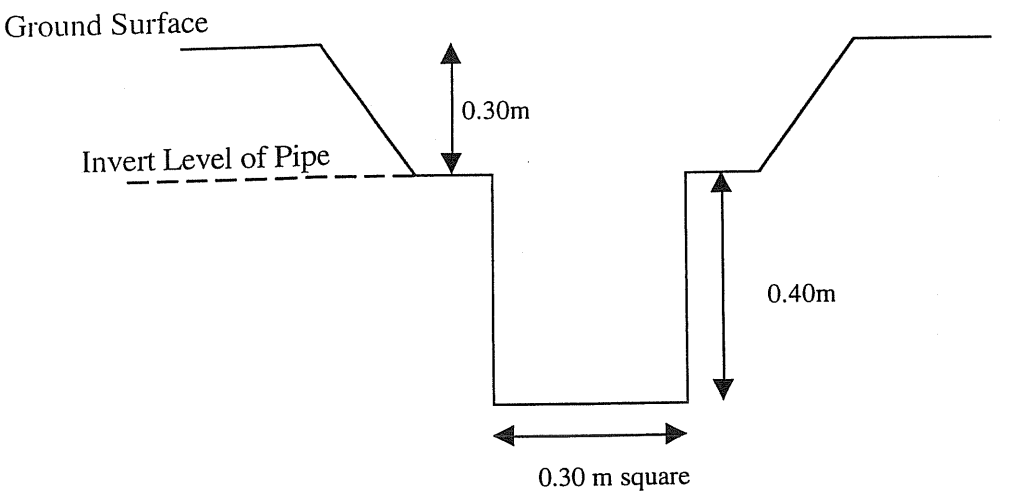


Figure 2: Design of the Percolation Pits as recommended by EPA Wastewater Treatment Manual.

The sides of the percolation pits were scored with a trowel and filled with water to simulate fully saturated soil conditions. The pits were then left overnight to soak.

On the following day the water had still not drained completely out of the holes even though it had dropped in each of them. The holes were refilled to a depth of 0.30 m with water, in order to assess the time taken for the water level to drop 0.1 m (100 mm). After 4 hours the water level had dropped 0.04 m in Percolation Pits 1 and 4, 0.01 m in Percolation Pit 2 and 0 m in Percolation Pit 3. This would give a minimum T value of 150.

3. Conclusions

The site has failed the percolation test as the T value obtained was greater than 50 (EPA Wastewater Manual). This is due to the presence of clays beneath the site which had become highly saturated during the recent bad weather.

The water table at the site is not high and no seepages were seen in the trial pits.

4. Recommendations

- We would recommend, in accordance with EPA Guidelines, that the site be engineered to meet the required specifications. This will involve the removal of the existing overburden material over an area of 300 m^2 and the importing of material with a suitable T value-preferably a fine sand or clayey sand with a T value of between 5 and 15. The imported soil can be placed in layers 0.3 m thick and each layer should be compacted lightly prior to the adding of the next layer. Percolation tests should be carried out on every 0.3 m thick layer. The depth of the fill should be approximately 2 metres to allow at least 1 m between the lowest level of a percolation trench (0.7 m below ground level) and the original soil level. This is a total volume of material of 600 m^3. Once the overburden material is in place a full percolation test should be carried out. A reserve percolation area should also be constructed in the event of the main area malfunctioning.

- Alternatively, a sand filter could be constructed with associated polishing filter. The loading rate on this constructed filter is recommended to be 50 l/m^2/day. The advantage of this type of sand filter is that it takes up considerably less area than the trenched percolation area. The disadvantages are that a polishing filter is necessary and pumping of wastewater might be needed to transfer effluent from the sand filter to the polishing filter. Sand filters are used in conjunction with septic tanks in soil which is unsuitable for conventional percolation areas. The filter system consists of 600-900 mm of graded sand underlain by 200 mm of gravel. The filter system is overlain by the natural topsoil but is separated from it by a geotextile membrane. The wastewater is treated by moving through the sand filter and can then be directed under gravity or pumping to a final polishing filter. (EPA Wastewater Treatment Manual).

Respectfully Submitted

Victoria Conlon

Victoria Conlon B.Sc.M.Sc.

8/01/01

Date

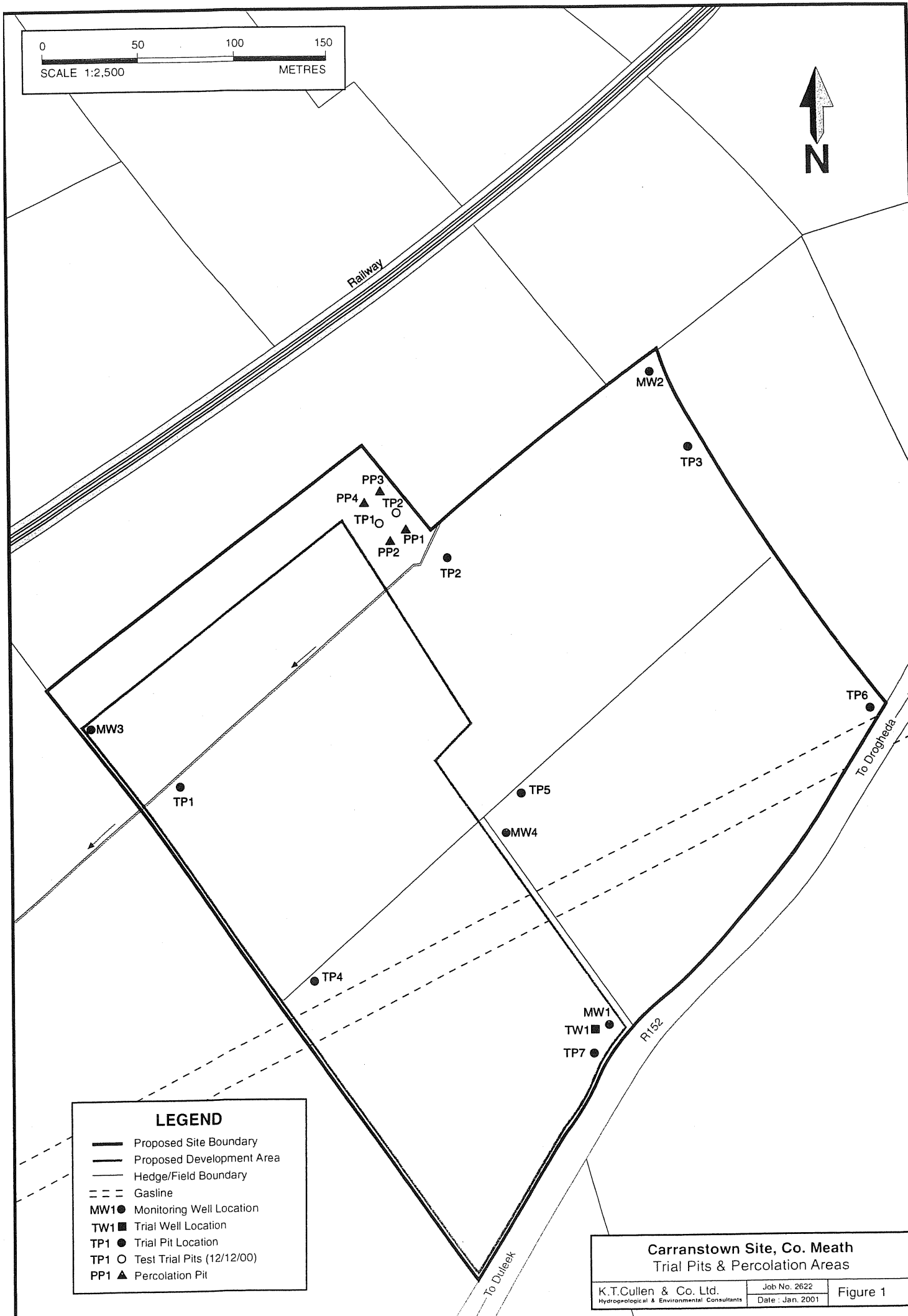
K O'Dwyer

Kieran O Dwyer BE MIEI

8/01/01

Date

FIGURE


0
50
100
150
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METRES
N
Railway
MW2
TP3
PP3
PP4
TP2
TP1
PP1
PP2
TP2
TP6
MW3
TP1
TP5
MW4
To Drogheda
TP4
MW1
TW1
TP7
R152
To Duleek
LEGEND
Proposed Site Boundary
Proposed Development Area
Hedge/Field Boundary
Gasline
MW1 Monitoring Well Location
TW1 Trial Well Location
TP1 Trial Pit Location
TP1 Test Trial Pits (12/12/00)
PP1 Percolation Pit
Carranstown Site, Co. Meath
Trial Pits & Percolation Areas
K.T.Cullen & Co. Ltd.
Hydrogeological & Environmental Consultants
Job No. 2622
Date : Jan. 2001
Figure 1

APPENDIX A

Trial Pit Records

Project No. : 2622 **Location :** Carranstown Duleek **Date :** 12/12/00

Drilling Method : JCB **Supervisor :** VC

TRIAL PIT NO. 1

Geology :

0 - 0.1	Grass and Topsoil
0.1 - 1.8	Light Brown Silty BOULDER CLAY with pebbles and cobbles
1.8-2.8	Light Grey Clayey Sandy GRAVEL with well rounded boulders, becoming more gravelly with depth.

Depth to Rock : >2.8

Rock Type : None Encountered

Water Entry : None Encountered

Static Water : None after 48 hours

Total Depth : 2.8 metres

Elevation

Comments : N/A

K.T.Cullen & Co. Ltd.
Hydrogeological & Environmental Consultants

Trial Pit Records

Project No. : 2622 **Location :** Carranstown Duleek **Date :** 12/12/00

Drilling Method : JCB **Supervisor :** VC

TRIAL PIT NO. 2

Geology :

0 - 0.1	Grass and Topsoil
0.1 - 1.2	Light Brown Silty BOULDER CLAY with pebbles and cobbles
1.2 - 3.0	Light Grey Clayey, Sandy GRAVEL with well rounded boulders, becoming more gravelly with depth. Mostly limestone boulders

Depth to Rock : >3 metres

Rock Type : None Encountered

Water Entry : None Encountered

Static Water : None after 48 hours

Total Depth : 3 metres

Elevation

Comments :

K.T.Cullen & Co. Ltd.
Hydrogeological & Environmental Consultants

Appendix 9.5

Puraflo Design and Certification

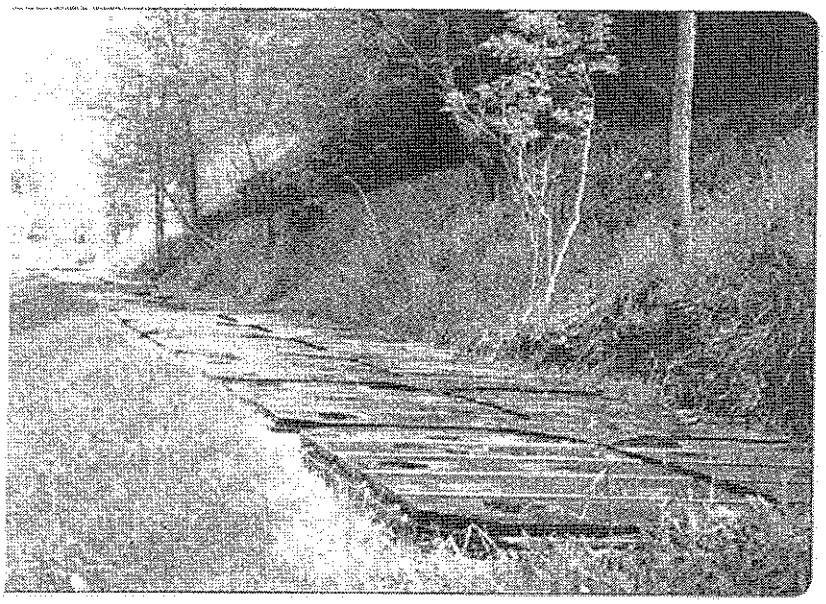
Appendix D4: Puraflo Brochure

BORD NA MÓNA

BORD NA MÓNA ENVIRONMENTAL LIMITED

Wastewater Solutions

Peat Bio-Filter



Bord na Móna's Peat Bio-Filter is designed to provide effective, cost efficient, low maintenance, secondary and/or tertiary wastewater treatment. The company's extensive experience with the Peat Bio-Filter and long-term research on the performance of the system shows extremely high treatment efficiency with significant reductions in the BOD and TSS content of wastewater and similarly, high reductions in faecal coliform and bacterial numbers.

The modular nature of the system provides maximum design flexibility for secondary and tertiary treatment, across a range of applications. The peat media can also be housed in site constructed retaining structures dependant on requirements.

The Peat Bio-Filter Process

The treatment process is based on simple bio filtration principles. The bio-fibrous peat media in the system is home to a complex and diverse ecological population, ranging from large numbers of aerobic and facultatively aerobic micro organisms to a wide variety of protozoans, rotifers and higher life forms.

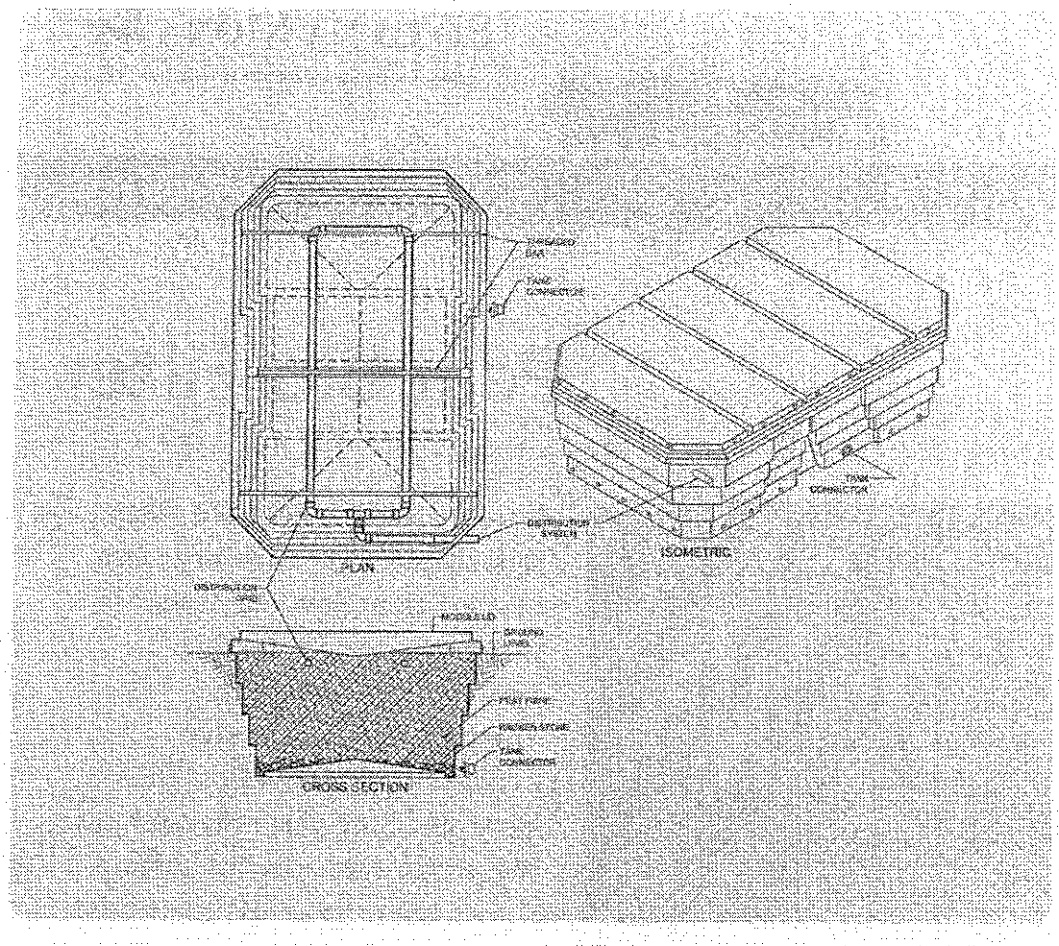
These organisms biologically degrade and assimilate the organic material in the wastewater.

Effluent is dispersed evenly onto the surface of the peat fibre and percolates through the media. Treatment of the wastewater within the system is achieved by a combination of unique physical, chemical and biological interactions between the wastewater and the fibrous media. Considerable BOD, SS and NH3-N reductions are achieved and the system is also very effective at eliminating enteric bacteria contained in the waste. The Peat Bio-Filter is a low maintenance system and requires no desludging or backwashing.

Performance

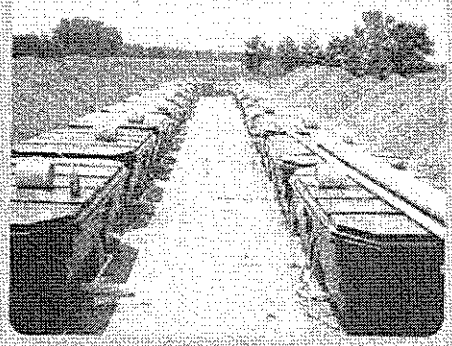
PARAMETER	INFLUENT	EFFLUENT	% REDUCTION
B.O.D. (mg/l)	296	Less than 10	96 +
T.S.S. (mg/l)	195	Less than 10	95 +
NH3-N (mg/l)	47	Less than 5	90 +
Tot. Coliforms*	2.8×10^6	3.3×10^4	99.9 +
E. coli*	11×10^5	1.8×10^4	99.9 +
Pathogenic Bacteria**	Present	Absent	

** CFU's per 100ml ** Including Salmonella, Staphylococcus and Shigella species, Pseudomonas aeruginosa and Sulphide reducing Clostridia*



Intermittent and Seasonal Use of the Peat Bio-Filter System

The Bord na Móna Peat Bio-Filter system is proven effective in situations of intermittent or seasonal loading. Due to the water binding properties of the peat, the media and consequently the microbial film does not dry out upon reduction or complete cessation of wastewater supply. This unique property combined with the physical and chemical processes which take place in the peat ensure that a high level of treatment is maintained under variable loading conditions.



Why Choose the Peat Bio-Filter System?

- Simplicity of design, installation and operation.
- Secondary and/or tertiary treatment.
- High effluent quality.
- Low capital and operating costs.
- No desludging or backwashing required.
- Flexible, modular design.
- Seasonal or intermittent use.
- Retrofits existing plants to improve effluent quality.

Puraflo Modules

Population Equivalent PE	Average Daily Flow m^3/d	Applied Organic Load kg/d BOD	No. of Modules No.	Associated Septic Tank m^3	Tertiary Treatment No. of Modules No.
20	3.6	1.2	8	5.4	12
50	9	3	18	13.5	30
100	18	6	36	27	60
150	27	9	54	40.5	90
200	36	12	72	54	120
250	45	15	90	67.5	150
300	54	18	108	81	180
350	63	21	126	94.5	210
400	72	24	144	108	240
450	81	27	162	121.5	270

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Cl/SfB
(52.3)

IRISH AGRÉMENT BOARD

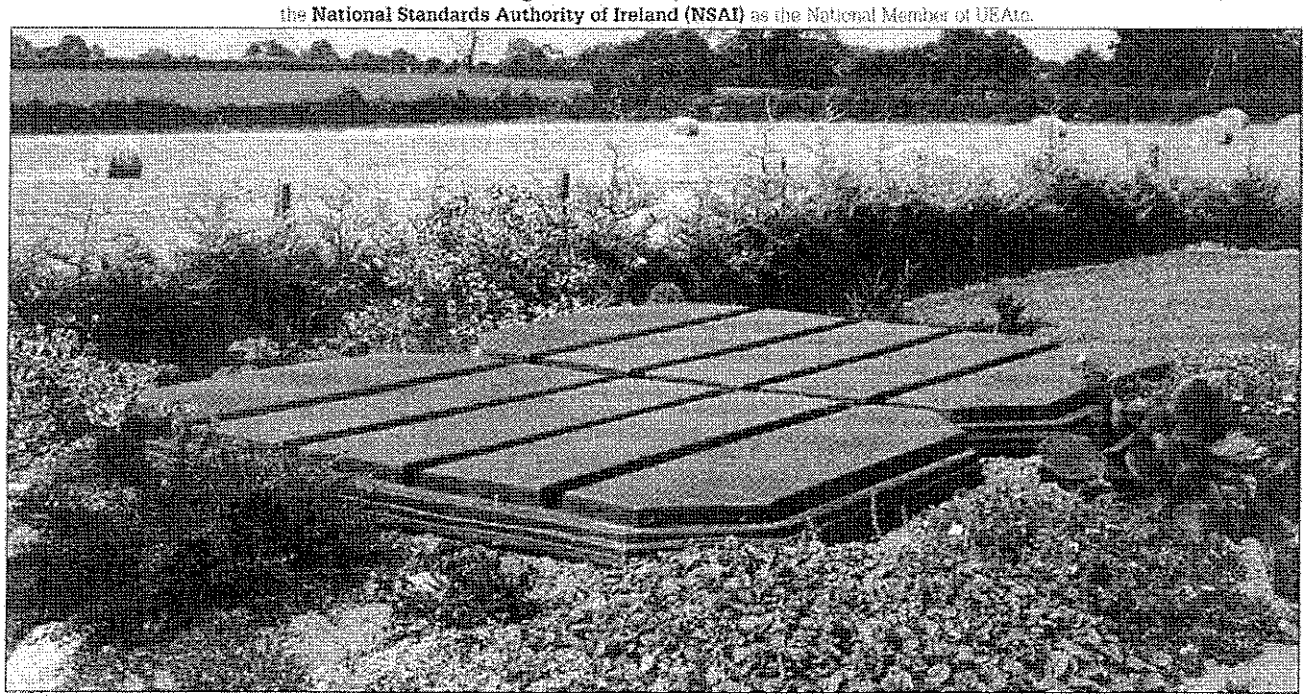
BUILDING PRODUCT CERTIFICATION

CERTIFICATE No. 99/0060

Bord na Móna Environmental Division
Newbridge Co Kildare Ireland
Tel: 045-431201 Fax 045-431647

PURAFLO LIQUID EFFLUENT TREATMENT SYSTEM

Systémes de traitement des eaux résiduaires
Abwasseraufbereitung



PRODUCT DESCRIPTION:
This Certificate relates to Puraflo™ Liquid Effluent Treatment System.

USE:
For the treatment of septic tank effluent from single dwellings.

MANUFACTURING AND MARKETING:
The system is manufactured and marketed by:
Bord na Móna Environmental Division
Newbridge Co Kildare Ireland

PART 1 CERTIFICATION

1.1 ASSESSMENT
In the opinion of the Irish Agrément Board (IAB) the Puraflo™ Liquid Effluent Treatment system is satisfactory for the purpose defined above, and meets the requirements of the Building Regulations 1997 as indicated in Section 1.2 of this Certificate.

1.2 BUILDING REGULATIONS 1997

Requirements:

Part D – Materials and Workmanship
The Puraflo™ Liquid Effluent Treatment System is made of acceptable materials as indicated in Part 4 of this Certificate.

Part H – Drainage and Waste Disposal

H1 – Drainage Systems:
The Puraflo™ Liquid Effluent Treatment System is easily integrated with new and existing septic tanks constructed to meet Building Regulations requirements.

H2 – Septic Tanks:
The Puraflo™ Liquid Effluent Treatment System is an aerobic system and is used in addition to a septic tank fitted with an outlet filter system. The Puraflo™ Liquid Effluent Treatment System can be used where septic tank systems and their percolation areas are not acceptable, or where sites do not comply with the recommendations of S.R.6 : 1991 *Septic Tank Systems Recommendations for Domestic Effluent Treatment and Disposal from a Single Dwelling House* and/or where septic tank percolation systems have failed.

2.1 DESCRIPTION

This Certificate relates to the Puraflo™ Liquid Effluent Treatment System. The system consists of a filter system fitted to the outlet of the connected septic tank, an effluent collecting chamber (sump), a pump and a number of biofibrous media containing modules. The Puraflo™ modules (Figs. 1a and 1b) are manufactured from polyethylene. Each module utilises approx. 2.5 cubic metres of biofibrous media which is compacted into 2 cubic metres. The effluent from the septic tank is evenly distributed over the surface of the biofibrous media and percolates through the media before emerging as a treated liquid at the base of the unit. The treatment of the waste within the system is achieved by a combination of physical, chemical and biological interactions between the pollutants and the biofibrous media. The system is designed to treat the waste water from single dwellings with a total population of up to 15 persons using 2, 4 or 6 modules as required.

Septic Tank Outlet Filter

A special baffle filter similar to that illustrated in Fig. 2 is fitted on the outlet pipe from the septic tank to retain solids.

Pump Sump & Pump Unit

The pump sump consists of a concrete or corrosion free polyethylene sump (Figs. 3, 4, 5) fitted with a submersible pump (0.30 kW rating, single phase) with thermal overload protection. Effluent from the septic tank flows by gravity to the sump from where it is pumped via a 40-50mm (1.5-2 in.) pump line to the modules containing the biofibrous media. The standard pump can cater for a head of up to 6 metres. An alarm float is installed in the sump and a visual/audible warning unit is located in the dwelling served by the system to alert the owner to pump malfunctions.

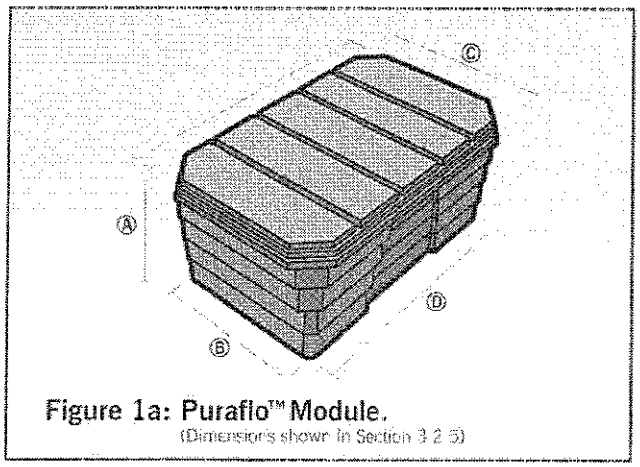


Figure 1a: Puraflo™ Module.
(Dimensions shown in Section 3.2.5)

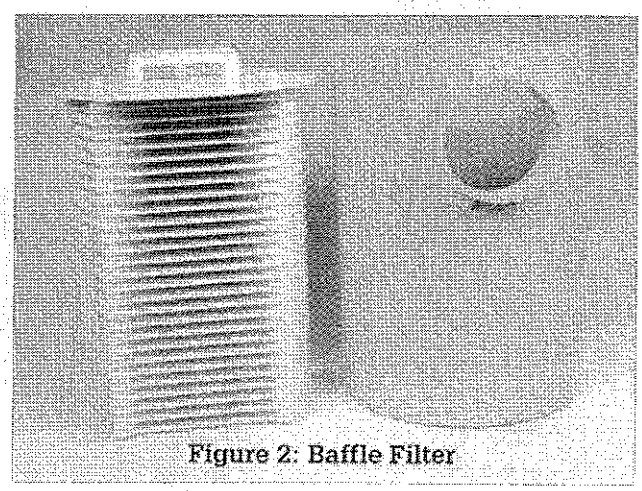


Figure 2: Baffle Filter

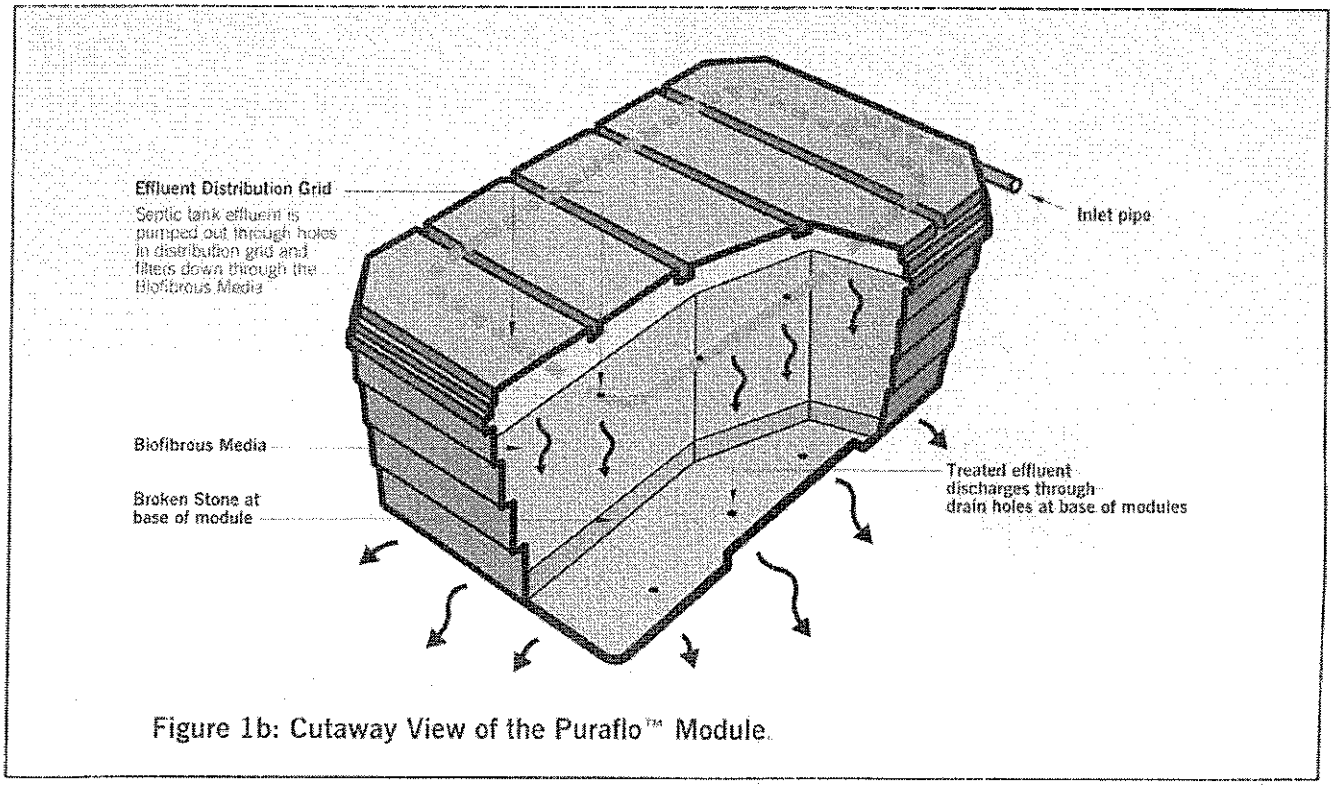


Figure 1b: Cutaway View of the Puraflo™ Module.

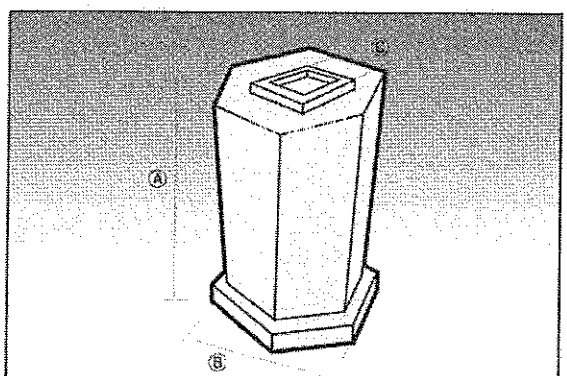


Figure 3: Standard Concrete Sump.
(Dimensions shown in Section 3.2.3)

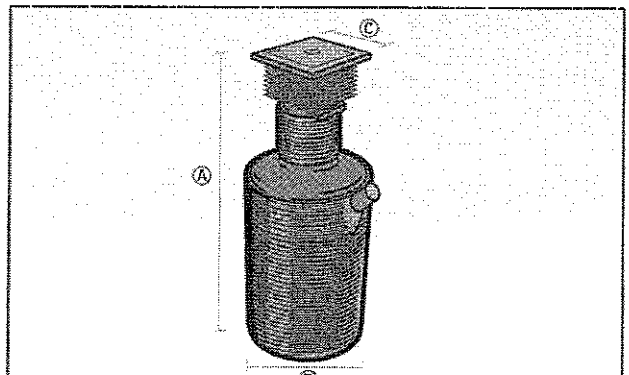


Figure 4: Polyethylene Sump.
(Dimensions shown in Section 3.2.3)

Puraflo™ Modules
Biofibrous media is filled in layers into Puraflo™ modules approx. 0.76m deep x 2.5m² with a contained volume of approximately 2m³ of compacted biofibrous media.

Product Range
The Puraflo™ Liquid Effluent Treatment System is supplied in combinations of Puraflo™ modules to suit the following applications:

- Single house unit using two modules of total area 5m² to serve a population of up to 6 persons
- Single house unit using 3 modules of total area 7.5m² to serve a population of up to 9 persons
- Single house unit using 4 modules of total area 10m² to serve a population of up to 11 persons
- Single house unit using 5 modules of total area 12.5m² to serve a population of up to 13 persons
- Single house unit using 6 modules of total area 15m² to serve a population of up to 15 persons

2.2 PIPEWORK/ASSEMBLY
Pipework used for the manifold and distribution system is in accordance with BS 3505: 1986 *Specification for unplasticised polyvinyl chloride (PVC-U) pressure pipes for cold potable water* and relevant parts of BS 4346: *Joints and fittings for use with unplasticised PVC pressure pipes*. A pump, a sampling chamber (Fig. 6) and a PVC distribution manifold complete the pipework assembly. All electrical connections are completed on site.

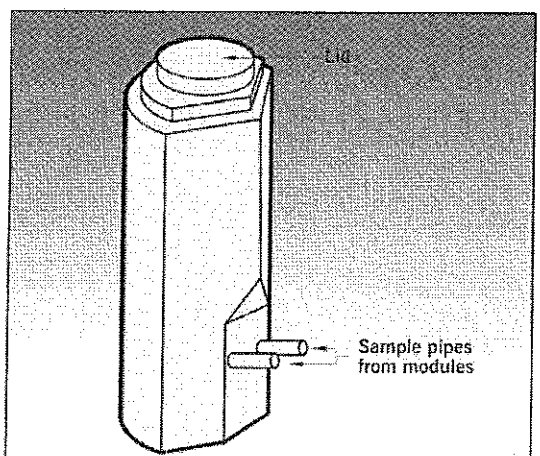


Figure 6: Sampling Chamber.

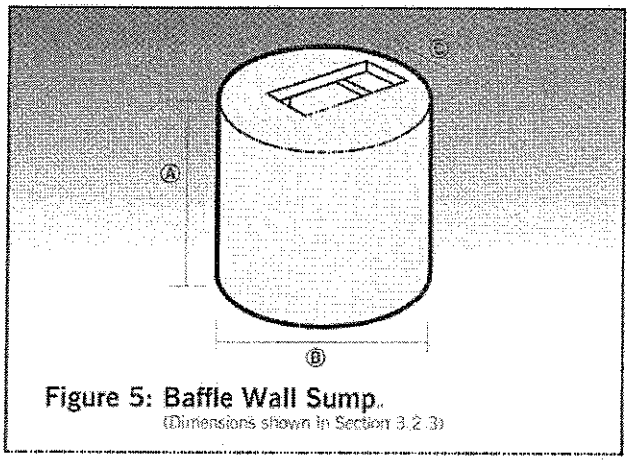


Figure 5: Baffle Wall Sump.
(Dimensions shown in Section 3.2.3)

2.3 DELIVERY, STORAGE AND MARKING
The Puraflo™ modules are completed ready for delivery at the manufacturer's works. Off-loading of each individual module must be carefully supervised using chains, steel cables or lifting bars with SWL of 800kg and should conform with the requirements of the Safety, Health and Welfare at work Act, 1989. The manufacturer's instructions must be followed to avoid damage to the modules during off-loading and placing in the excavation. Suitable lifting equipment must be employed.

The modules are labelled on the outside to indicate the IAB identification Mark incorporating the number of this Certificate.

2.4 INSTALLATION PROCEDURE

2.4.1 GENERAL
The Puraflo™ modules can be installed above or at ground level depending on the height of the local watertable or vertical separation requirements.

(i) For connection to a septic tank meeting the requirements of the Building Regulations 1997 and permitting the fitting of an outlet baffle filter, a concrete (or polyethylene) sump is installed adjacent to the septic tank as illustrated in Fig. 7.

(ii) For connection to septic tanks not permitting the fitting of an outlet baffle filter, a special concrete sump is installed as illustrated in Fig. 8. This sump is comprised of 2 chambers with the first chamber designed to accommodate the outlet filter and to provide for desludging.

Installation and the sequence of steps are detailed in the manufacturer's instruction manual must be followed exactly.

2.4.2 SITE PREPARATION

Site Preparation is as follows.

(i) *Septic Tank*
For installations where a new septic tank is required excavations to the necessary depth are made to receive a septic tank conforming to the requirements of the Building Regulations 1997 including all necessary blinding of the base to ensure a uniform bearing support.

(ii) *Pump Sump*
A suitable excavation is prepared downstream of the septic tank to receive the concrete or polyethylene pump sump.

(iii) *Puraflo™ Modules*
An area is prepared and levelled to create an even surface on which to place concrete blocks and lintels to support the modules.

Broken stone approx. 25–50mm is filled level with the top of the concrete blocks and lintels over this area to a depth of 200mm approx.

Depending on site conditions, various designed lengths of stone filled drain may be required extending from the stone base under the modules.

A pipe trench 450mm deep (minimum) x 150mm wide is excavated from the sump to the modules.

(iv) *Electrical Supply*
A trench 450mm deep (minimum) x 150mm wide is excavated from power source to the sump for an armoured cable electrical supply to the pump.

(v) *Disposal of Treated Effluent*
The disposal route for the treated effluent will depend on local conditions. Normally the treated effluent is disposed of by soil percolation. The materials in percolation areas are chosen and laid as described in Section 2.4.8 of this Certificate.

2.4.3 PLACING AND LEVELLING OF MODULES

(i) Using a lifting frame, the modules are positioned carefully on the lintels. Each module is checked for level when fitted.

(ii) Effluent inlet pipes are checked for proper orientation for connecting to the pump line.

2.4.4 INSTALLATION OF SUMP AND ASSOCIATED PIPEWORK

(i) The sump is fitted at least 0.5m from a new septic tank or at least 1m from an existing septic tank.

(ii) The septic tank outlet is connected to the sump using a 110mm dia. pipe at a gradient of 1 in 100.

(iii) Backfilling is compacted around the sump below the outlet pipe and the cable entry ensuring that the material used for backfilling is free of stones and material which could damage the sump.

(iv) A pump line 40–50mm dia. is laid from the sump to the modules.

(v) The pump line is connected to the outlet from the pump.

(vi) The pump line is connected to the manifold at the modules.

(vii) The manifold is placed in position and connected by 40mm dia. plastic flexible pipes to the effluent distribution grids in the modules.

2.4.5 CONNECTION OF ELECTRICAL SUPPLY

(i) The armoured cable from the power source to the sump is placed unstretched in the bottom of the cable trench. A 5 core 5mm PVC SWA cable is used.

(ii) The armoured cable is connected to the terminal box provided in the sump.

(iii) The control panel is installed. The power supply to the control panel is taken from an independent MCB to avoid nuisance tripping to existing circuits. The control panel has an ELCB fitted to protect the pump and control system.

(iv) The cable from the sump is connected to the control panel.

2.4.6 COMMISSIONING

(i) The alarm float is suspended approximately 150mm above the submersible pump.

(ii) The pump MCB is switched off at the Puraflo™ panel.

(iii) The sump is filled with clean water until the alarm float lifts; under these conditions the alarm should indicate a fault.

(iv) The pump MCB is switched on to restore the power supply to the pump. With the pump operating properly the alarm will switch off when the water level in the sump drops below the level specified in (i) above.

(v) All pipe connections in the sump and at the modules are checked for leaks.

2.4.7 LOCATION

The septic tank should not be closer than 7 m from the dwelling served and should not be nearer than 20 m from the nearest point of any other dwelling.

The Puraflo™ Liquid Effluent Treatment System and septic tank should not be located in any area where vehicles could traverse or damage them and provision should be made for access for a tank emptying vehicle and its equipment.

The separation distance from wells should be not less than 20 m except in the case of very sandy soils or gravels where a minimum distance of 40 m should be maintained. In all cases the percolation area should be located down gradient of any nearby well. Where it is not possible to locate the percolation area down gradient of any nearby well a separation distance of at least 100 m, depending on percolation conditions, must be maintained. If necessary a mound of top soil (of appropriate characteristics) may be constructed to

achieve the required 0.5 m minimum vertical separation between the base of the Puraflo™ unit and the seasonally high water table. Typical setback distances for the Puraflo™ system are shown in Table 1 below.

Feature	Minimum Setback Distances (m)	
	Treatment Modules	*Percolation Area*
Dwelling served	7	5
Adjacent dwelling	10	5
Site boundaries	3	1
Watercourse	3	3
Roads	3	1
Walls	3	1
Drinking Water Sources	20	20-100

Table 1: *Recommended setback distances for various elements of the Puraflo™ Liquid Effluent Treatment System*

2.4.8 TREATED WASTE WATER DISPOSAL

Treated waste water may be disposed of by either of the following means:

(a) *Sub-Surface Disposal*
The treated effluent from the base of the Puraflo™ Liquid Effluent Treatment System passes downwards into a prepared area filled with 25-50mm approx. broken stone to a depth of 250mm. The extent of the percolation area will be determined by the population served and the subsoil type at the site in accordance with the recommendations in Tables 2a, 2b and 2c. Percolation drains are constructed (see Fig. 9) adjacent to the Puraflo™ modules to make up the required percolation area. Percolation drains, 400mm wide x 400mm deep (approx.) depending on site conditions shall be filled to a depth of 250mm with 25-50mm (approx.) broken stone and covered with geotextile or other protective material before backfilling (to prevent the entry of silt). A typical subsurface disposal field is illustrated in Fig. 9.

(b) Alternatively the treated effluent can be collected and pumped to irrigation in which case a site specific engineered design will be prepared.

(c) *Surface Water Disposal*
Treated effluent from the base of the Puraflo™ Liquid Effluent Treatment System can be discharged directly or via a stone filled drain to receiving waters (ditch or drain). If this option is selected a licence to discharge to waters, (on a case by case basis) will be required from the local authority to comply with the Water Pollution Acts (1977-1990 incl. amendments).

2.4.8.1 GENERAL GUIDANCE FOR THE SIZING OF PERCOLATION AREA

The required percolation areas for treated effluent are derived from consideration of the effluent quality (e.g. 95% reduction in BOD and 99% reduction in faecal bacteria) and the soil percolation characteristics.

Table 2a refers only to percolation characteristics. Table 2a should be regarded as guidance only so that water logging of sites does not occur. For each site a test shall be carried out in accordance with approved percolation test procedures in order to confirm the suitability of the percolation system (see section 2.4.8.2).

Different configurations of percolation areas are acceptable. This also applies to sites where split percolation areas are needed to obtain the recommended total area.

Soil Group	Soil Classification Description	Percolation Rate
1	Sand, gravels, loam sand	Very good
2	Sandy loam, loam, sandy clay loam	Good
3	Silty loam, clay loam, silty clay loam	Moderate
4	Sandy clay, silty clay, clay	Poor

Table 2a: *Identification of soil groupings*

2.4.8.2 PERCOLATION TEST PROCEDURES

A standard "T" test (or other approved soil percolation test) is carried out by the developer/owner to identify the soil group and measured percolation rate. The size of the soil disposal area required is based on the results of this test used in conjunction with the physical properties of the soil and the level of effluent treatment achieved. The depth within the soil profile where this test should be conducted will reflect the invert level at which the effluent will be introduced to the soil. In the majority of instances this will be within 30cm of the surface.

2.4.8.3 SOIL PERCOLATION AREA

	Percolation area (m^2)			
	Soil Group			
Population served	Group 1	Group 2	Group 3	Group 4
up to 6	10	20	45	65
6-11	15	30	60	95
11-15	20	40	80	120

Table 2b: *Soil percolation area with Puraflo™ system in various soil classification groupings*

2.4.8.4

The relationship between the percolation area, reported in Table 2b and the linear pipe (m) length of percolation trench required is 1:1. In Table 2b the figures can be expressed as m^2 percolation area or linear m of percolation trench. An actual length of 10m is allowed within the prepared area beneath and surrounding the **Puraflo™** modules. Additional length of percolation trench is installed by inserting drains of up to 20m in length and a minimum of 2m apart.

2.4.8.5 MAXIMUM 'LONG TERM' HYDRAULIC LOADINGS

Maximum hydraulic loading $l/m^2/d$			
Soil Group			
Group 1	Group 2	Group 3	Group 4
135	68	34	23

Table 2c: *Maximum 'long term' hydraulic loadings applied to the soil percolation areas in each soil group.*

2.5 COMMISSIONING

Commissioning will be carried out by Bord na Móna Environmental Division personnel or their appointed agents after installation is completed and all services are connected.

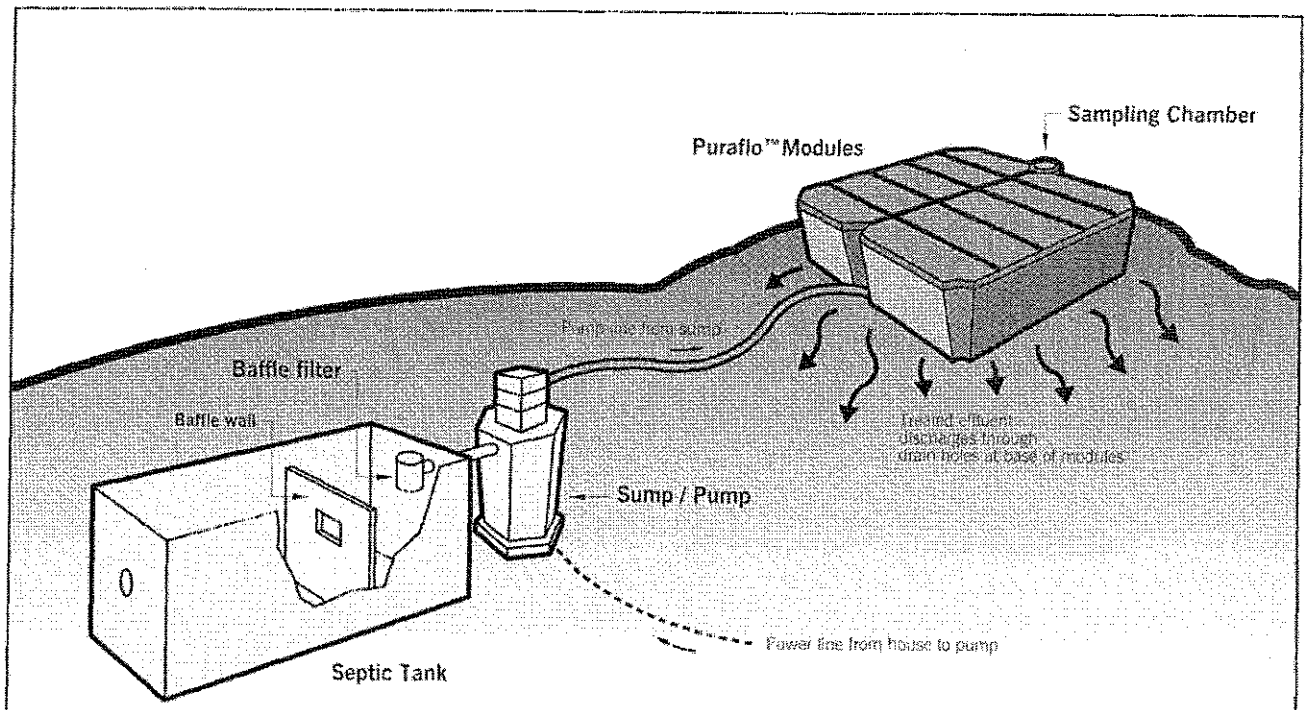


Figure 7: Single House Installation with Standard Concrete Sump.

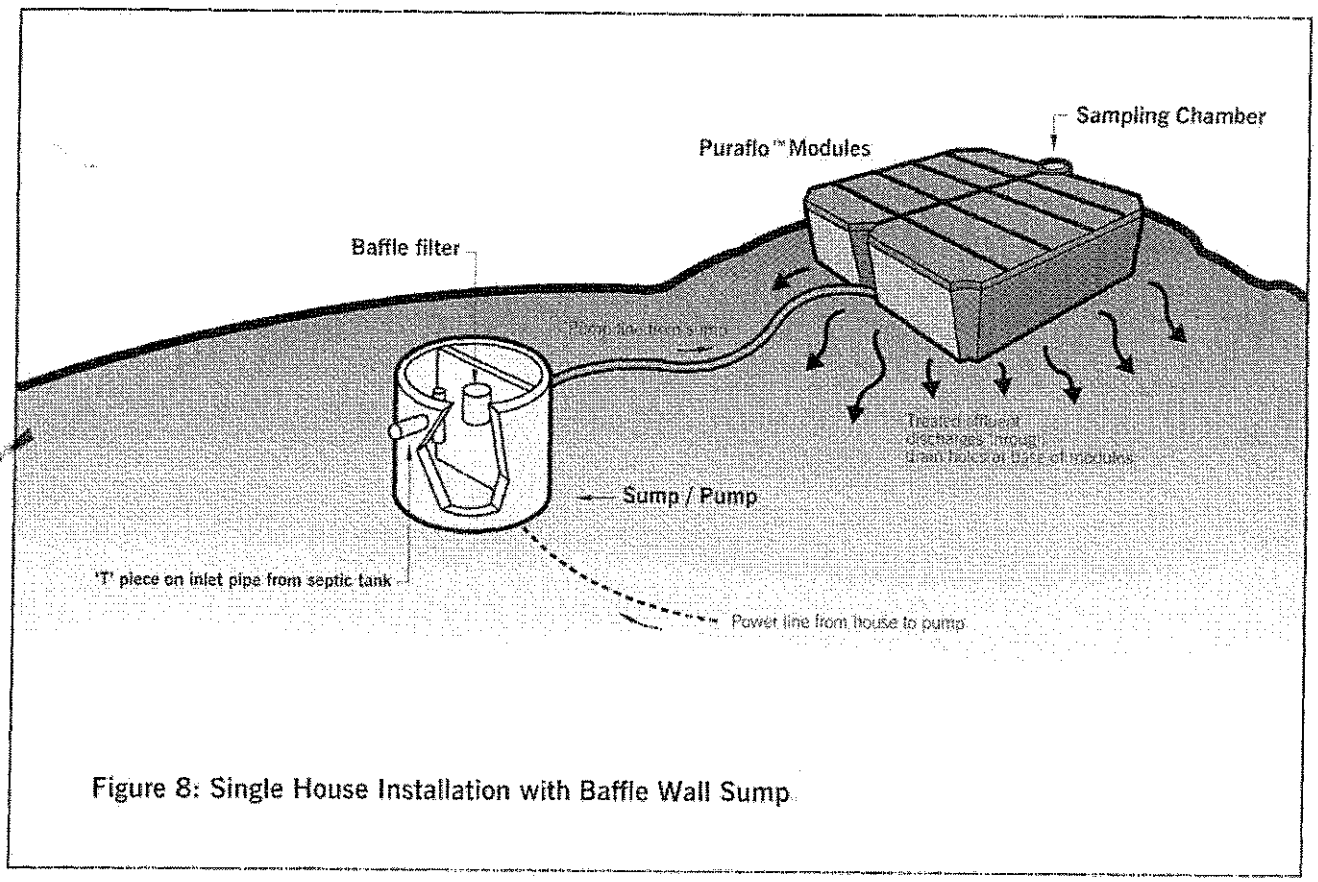


Figure 8: Single House Installation with Baffle Wall Sump

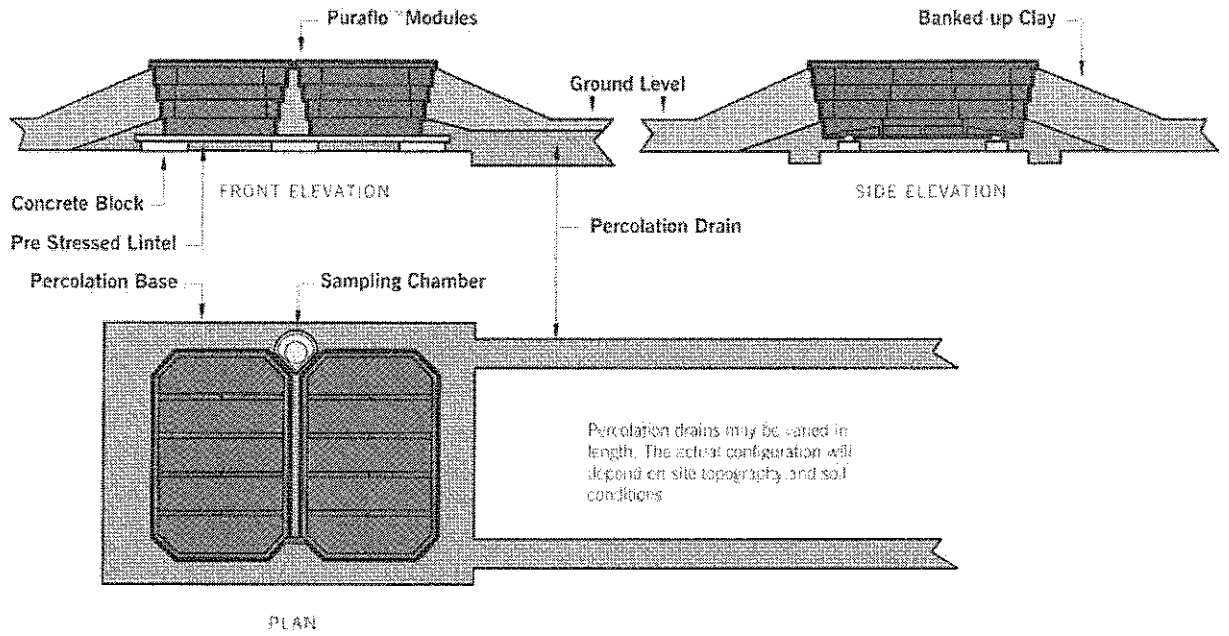


Figure 9: Typical Sub-Surface Disposal Field. (Drawing not to scale)

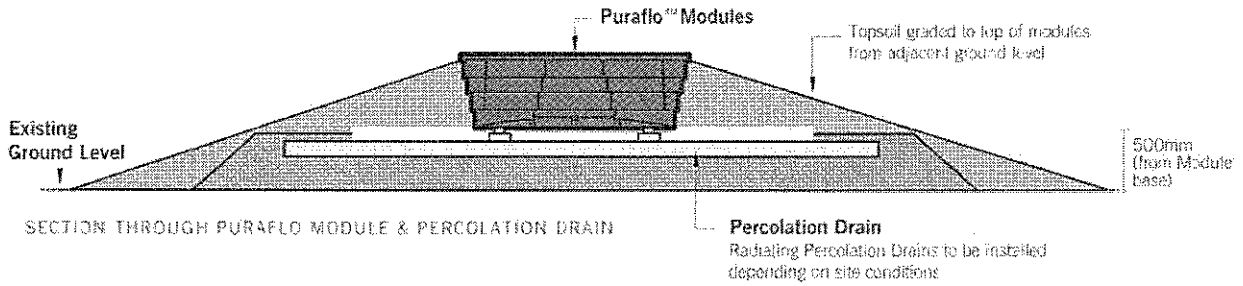


Figure 10: Disposal for Site with High Water Table. (Drawing not to scale)

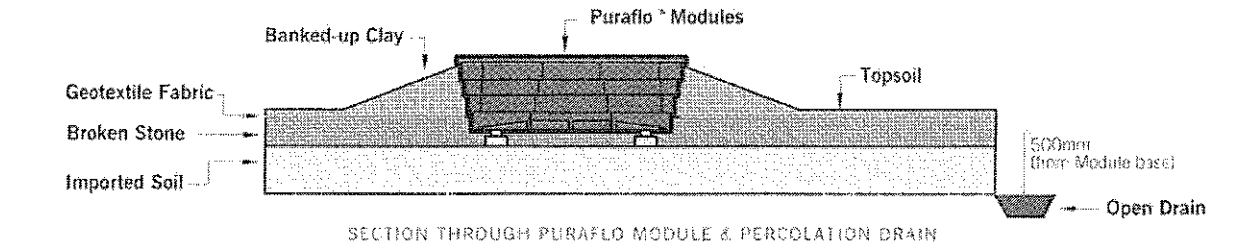


Figure 11: Disposal for Site with Poor Percolating Soil and Receiving Water. (Drawing not to scale)

PART 3 DESIGN DATA

3.1 GENERAL

The Puraflo™ Liquid Effluent Treatment System has been designed to treat domestic waste water from up to 15 persons. It is suitable for installation at sites where a septic tank and percolation system does not afford an environmentally safe and acceptable means of disposing of domestic waste water. Such sites include those where the water table is high and where soil types do not afford good percolation. To ensure optimum efficiency the drainage of the premises served must be checked to ensure that storm water from roofs and paved surfaces does not discharge into the system.

The system is designed and installed in accordance with the Puraflo™ Liquid Effluent Treatment System Specifications. Due to the high quality effluent treatment achieved (see Table 4, Section 3.2.10) the Puraflo™ Liquid Effluent Treatment System may be installed close to habitable buildings as indicated in Section 2.4.7 subject to any special requirements of the particular site.

The Puraflo™ Liquid Effluent Treatment System is supplied with an alarm which will alert the owner to a pump malfunction and this will enable corrective action to be taken before overflow occurs. Details of corrective actions are contained in the Puraflo™ maintenance manual supplied with the unit.

3.2 DESIGN BASIS

The Puraflo™ liquid effluent treatment system is supplied in a modularised configuration. Daily waste water loadings of up to 3.0m³/d (equivalent to a population of 15 persons) can be treated. Table 3 details the range of populations served, the associated hydraulic generation and the modular arrangement used in each case.

Max. Population Served	Daily Flow m^3d^{-1} (max)	Puraflo™ area required (m^2)	No of Modules
6	1.2	5	2
9	1.8	7.5	3
11	2.2	10	4
13	2.6	12.5	5
15	3.0	15	6

Table 3: *Modular configuration*

DESIGN CRITERIA

Assumptions:

Hydraulic loadings	200 l/p/d*
Organic Loadings	60g BOD /p/d
Solid Loadings	40g TSS/p/d

Max. Application rates *(to the biofilter after primary settlement)*

Hydraulic loadings	240 l/m^2/d
Organic loadings	average 72g BOD/m^2/d
Solid Loadings	average 24g TSS/m^2/d

3.2.1 SEPTIC TANK

The Septic tank should meet the requirements of the Building Regulations 1997. The septic tank should allow for the fitting of an outlet baffle filter; otherwise the baffle wall sump shown in Fig. 5 will be installed to provide for the fitting of the baffle filter in the first chamber of this sump, while the second chamber acts as the pump sump.

3.2.2 FILTER

An outlet baffle filter (see Fig. 2) is installed upstream of the pump sump to retain solids.

3.2.3 SUMP

The sump used may be single chamber concrete, single chamber polyethylene (Figs. 3 and 4) or a concrete sump with baffle wall and baffle filter (Fig. 5) as described in Section 2.4.1. Where the concrete sump with a baffle wall is employed access via a manhole is provided to facilitate desludging.

Pump sump dimensions are shown below with reference to Figs. 3, 4 and 5.

	DIMENSIONS (mm)		
Sump type	**A**	**B**	**C**
Polyethylene	1840	720	480
Concrete (standard)	1480	820	500
Baffle wall sump	1300	1440	380

3.2.4 Pump Unit and Electrical Installation

The irrigation pump used is of a standard submersible type which can vary in size depending on site conditions. It delivers a discharge volume of 0.2 to 2.0 l/s, against a discharge head of 1 to 6m. All models are single phase 220-240 volt 50 Hz motor with enclosures to IP 68. Effluent from the tank flows by gravity to the sump from where it is pumped via a 40-50mm diameter pumping main to the biofilter modules containing the biofibrous media. A visual/audible warning unit is installed to alert the owner to pump malfunctions.

The design and installation of the pump and electrics are in compliance with 'The National Rules For Electrical Installations' (ETCI), published by the 'Electro-Technical Council of Ireland' (Document no. ET101/1991: A1/1997).

3.2.5 MODULES and MEDIA

The Puraflo™ modules (see Fig. 1) are manufactured from high density polyethylene. A minimum of two Biofilter modules shall be installed with dimensions as shown below.

(i) *Biofilter Module Dimensions, mm, are shown below and illustrated in Fig. 1*

Biofilter Module	DIMENSIONS (mm)				
	A	B	C	D	E
	760	1185	1400	2150	1935

(ii) *Fibre*
The peat fibres consist of root residues of eriophorum (cottongrass) plants extracted from bog peats

Specifications of Fibres

Moisture content	50–70% by weight
Fines content (<5mm)	30% max

(iii) *Typical Physical Characteristics of Fibre Media*

Loose density (range @50% m/c)	110–140 kg/m³
Organic matter content	>95% w/w (anhydrous basis)

(iv) *Typical Botanical Composition of Fibre Media*

Fibre (eriophorum)	50% (v/v)
Humic materials	40% (v/v)
Sphagnum materials	10% (v/v)

(v) *Typical Design Specification for Puraflo® single house system*

PARAMETER	SPECIFICATION
Media Type	100% fibre (Biofibre)
Compaction	50%
Depth of compacted media	0.7m
Distribution of septic tank effluent over modules	Rectangular pipe grid
Minimum Number of modules per installation	2 modules
Total Hydraulic load (max.)	3.0m/day (6 modules)
Total Organic loading (max.)	0.900 kg/day (septic tank and Puraflo® System) 0.630 kg/day (Biofilter alone) (6 modules)
Sample Chamber	In all installations

3.2.6. BROKEN STONE
The stone filter under the Puraflo® modules and in the drainage trenches is composed of 25–50mm approx. broken stone

3.2.7 LIQUID EFFLUENT ANALYSIS
The pH, BOD and suspended solids (T.S.S.) concentrations demonstrated in Table 4 will be attained within a few weeks of commissioning. It is predicted that the stipulated nitrate (NO_3) and ammonia (NH_3) values will be consistently achieved over the lifetime of the biofibrous media currently estimated to be at least 10 years.

3.2.8 MONITORING SYSTEM ALARM
The installed electrical warning system will signal an alarm to indicate impending flooding or failure of the pump unit.

3.2.9 COMMISSIONING
Commissioning of the unit must include testing of the alarm system and the completion of all safety checks.

3.2.10 MAINTENANCE SYSTEM
During desludging of the septic tank the sump unit must also be de-sludged. Following removal of the sludge the pump should be hosed down and the resulting sludge removed from the sump.

The units should not be opened or the media disturbed. Any such disruption of the media may result in channelling of the effluent or over-compaction leading to flooding.

Table 4: *Treated Waste Water Quality*

PARAMETER	CONCENTRATION
pH (pH units)	5-8
B.O.D. (mg/l)	< 15
T.S.S. (mg/l)	< 15
NH_3-N (mg/l)	< 5
Nitrate N (mg/l)	20
Total Coliforms elimination	> 99.9%
Faecal Coliforms elimination	> 99.9%
*Pathogenic Bacteria	Absent

**Including Salmonella spp. Shigella spp. Sulphide reducing Clostridia Staphylococcus spp. and Pseudomonas aeruginosa*

4.1 ENVIRONMENTAL ASSESSMENT
The treated waste water from a number of working installations has been comprehensively monitored for 18 months. The test results show that values stated for the parameters listed in Table 4 are consistently achievable over a range of operating conditions.

4.2 STRENGTH
The design and testing of the plant has been assessed as satisfactory. The modules and sumps have adequate resistance to handling stresses, the loads applied by ground pressure and internal liquid loads.

4.3 WATER PENETRATION
The plant and modules with its pipe connections when correctly installed will not allow seepage either into or from the surrounding soil.

4.4 DURABILITY
The biofibrous media when installed, used and maintained in accordance with the requirements of this Certificate will have a life of at least 10 years. The mechanical components of the system excepting pumps will have a life in excess of 20 years.

Spent treatment media should be disposed of in accordance with National Waste Regulations.

4.5 CLEANING AND MAINTENANCE
All Puraflo™ units are inspected by Bord na Móna personnel for their performance after one year approx. of operation and the effluent analysed. As part of routine maintenance the owner must keep the inlet and outlet from the septic tank free from blockages and desludge the septic tank. The septic tank and the first chamber of the two chamber sump (where this option is used) should be desludged at least once per annum.

4.6 SAFETY
4.6.1 SAFETY OF PERSONNEL
The Puraflo™ Liquid Effluent Treatment System is generally installed above ground level. All pump sump covers are securely fixed to prevent unauthorised access.

The treatment system should be positioned, or marked, or protected to prevent superimposed loading or accidental impact by vehicles and underground electric cables should be marked with warning tape.

4.6.2 SAFETY OF SYSTEM
The Puraflo™ Liquid Effluent Treatment System has a visual/audible warning device connected to the pump/sump unit to alert the owner to malfunctions of the pump.

4.7 TESTS AND ASSESSMENTS WERE CARRIED OUT TO DETERMINE
- Watertightness
- Strength of covers, modules & sumps
- Resistance of units to hydrostatic pressure
- Quality of treated effluent

4.8 OTHER INVESTIGATIONS
(i) Existing data on the history of use of previous installations was assessed.

(ii) The manufacturing process was examined including the methods adopted for quality control, and details were obtained of the quality and composition of the materials used.

(iii) Site visits were conducted to assess the practicability of installation.

(iv) A user survey and visits to established sites were conducted to evaluate performance in use.

(v) No failures of the product in use have been reported to the IAB.

PART 5 CONDITIONS

5.1 CONDITIONS OF CERTIFICATION

The National Standards Authority of Ireland ("NSAI") following consultation with the Irish Agrément Board ("IAB") has assessed the performance and method of installation of the product/process and the quality of the materials used in its manufacture and certifies the product/process to be fit for the use for which it is certified provided that it is manufactured installed used and maintained in accordance with the descriptions and specifications set out in this certificate and in accordance with the manufacturer's instructions and usual trade practice. This certificate shall remain valid so long as:

(a) the specification of the product is unchanged;

(b) the Building Regulations 1997 and any other regulation or standard applicable to the product/process its use or installation remain unchanged;

(c) the product continues to be assessed for the quality of its manufacture and marking by NSAI;

(d) no new information becomes available which in the opinion of the NSAI would preclude the granting of the certificate;

(e) the product or process continues to be manufactured installed, used and maintained in accordance with the description specifications and safety recommendations set out in this certificate.

5.2 The IAB mark and certification number may only be used on or in relation to products/processes in respect of which a valid certificate exists. If the certificate becomes invalid the certificate holder must not use the IAB mark and certification number and must remove them from products already marked.

5.3 In granting this certificate, the NSAI makes no representation as to:

(a) the presence or absence of patent rights subsisting in the product/process; or

(b) the legal right of the certificate holder to market, install or maintain the product/process; or

(c) whether individual products have been manufactured or installed by the certificate holder in accordance with the descriptions and specifications set out in this certificate.

5.4 This certificate does not comprise all installation instructions and does not replace the manufacturer's directions or any professional or trade advice relating to use and installation which may be appropriate.

5.5 Any recommendations contained in this certificate relating to the safe use of the certified product or process are preconditions to the validity of the certificate. However, the NSAI does not certify that the manufacture or installation of the certified product or process in accordance with the descriptions and specifications set out in this certificate will satisfy the requirements of the Safety, Health and Welfare at Work Act, 1989 or of any other current or future statute or current or future common law duty of care owed by the manufacturer or by the certificate holder.

5.6 The NSAI is not responsible to any person or body for loss or damage, including personal injury, arising as a direct or indirect result of the use of this product or process.

5.7 Where reference is made in this certificate to any Act of the Oireachtas, regulation made thereunder, statutory instrument, code of practice, national standards, manufacturer's instructions or similar publication, it shall be construed as reference to such publication in the form in which it is in force at the date of this certification.

THE IRISH AGRÉMENT BOARD

This Certificate No. 99/0060 is accordingly granted to Bord na Móna on behalf of the Irish Agrément Board.

Date of Issue: 02 June 1995

Signed: _____

Director of Standards, NSAI

Readers may check that the status of this Certificate has not changed by contacting the

Irish Agrément Board,
NSAI, Glasnevin, Dublin 9, Ireland.

Telephone: (01) 807 3800
Telex: 32501
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