AECOM

Shannon Technology and Energy Park (STEP) Power Plant

Appendix A5.1: Onshore Site Investigation Report

Shannon LNG Limited

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IGSL Limited

Ground Investigation

Tarbert / Ballylongford Onshore SI

Project No. 12239–Volume 1

Introduction to Site Investigation Works

On Behalf

Of

Arup Consulting Engineers

TABLE OF CONTENTS

1. INTRODUCTION

The proposed site is located in the townlands of Knockfinglus and Ralappane between Ballylongford and Tarbert in north County Kerry, Ireland. It is proposed to construct a new industrial facility on this site and as part of the development works an investigation of the subsoil conditions was supervised by Arup Consulting Engineers (Arup) on behalf of their Client, Shannon LNG.

This report contains the factual information obtained from the ground investigation. No interpretation of this data was requested.

2. PROPOSED DEVELOPMENT

The proposed development is a Liquid Natural Gas (LNG) Import Terminal which comprises the construction of four storage tanks and associated processing, administration buildings and infrastructure. To the west of this development, an Embankment – Pond is proposed.

3. SCOPE OF WORK

The purpose of the ground investigation is to provide information on the sub-soil conditions, bedrock geology and groundwater regime at the site. Two site investigations were undertaken, the first investigation was carried out from October 2006 to January 2007 in the area of the proposed import terminal and is referred to as the Main Onshore Site Investigation Report. Additional works were undertaken in the proposed Embankment – Pond area to the west of the main development between February and April 2007.

The initial fieldwork programme for the Main Onshore Site Investigation included

- twenty six rotary coreholes, twenty of which were located under the storage tanks;
- thirty three trial pits, located approximately on a 100m grid;
- six geologging holes;
- scanlines along the coastal section;
- one pump test;

– 2-D Resistivity, Electromagnetic and Seismic Refraction Geophysical Survey;

– Soil, Rock and, Chemical Laboratory Testing.

Additional work was completed at the Embankment – Pond site which comprised:

– four rotary coreholes located along the footprint of the embankment;

– twenty one trial pits, located along the footprint of the embankment and and the pond;

– four geologging holes;

– 2-D Resistivity and Seismic Refraction Geophysical Survey;

– Soil and Chemical Laboratory Testing.

A programme of laboratory testing was scheduled by Arup to assist with soil and rock classification.

This is a factual report, which describes the various field and laboratory operations but does not include an interpretation of the findings in relation to the proposed works. The location and layout of the site are presented in Figure 1. Exploratory hole locations for both the Main and the Embankment – Pond Site Investigation are presented in Figure 2 and 3.

4. REPORT STRUCTURE

The report has been separated into four volumes which are the following:

- Volume 1: Introduction to Site Investigation Works;
- Volume 2: Main Onshore Site Investigation. Appendices comprising field records, photographs, geologging, scanline and laboratory data;
- Volume 3: Main Onshore Site Investigation. Appendices comprising the Pump Test and Geophysical Report;
- Volume 4: Embankment - Pond Site Investigation.

The layout and content of volumes 2 to 4 are presented in Appendix A.

5. FIELDWORK

5.1 Rotary Coring

Cable percussion drilling was not considered as a method for investigating the soil as ground conditions are unsuitable. As a result, rotary coring techniques were employed.

Where rotary coring encountered overburden material in-situ standard penetration testing (SPT) was performed to obtain an indication of the overburden consistency to rock level.

Rotary coring was carried out using an air/mist flush to ensure good recovery within the bedrock. Cores of 102mm (S size) and 84mm (P size) diameter were recovered and transported from site in wooden storage boxes.

The recovered core was inspected by a qualified engineering geologist from IGSL Ltd and logged broadly in accordance with BS 5930: 1999. In addition a detailed fracture log (spacing between successive core joints measured from the cores) was made of the core recovered and the strength of representative units determined using Point Load and Uniaxial Compression Strength (UCS) tests.

All cores were labelled and photographed for inclusion in the report. Core photographs are also presented in digital format.

5.2 Trial Pits

Trial pits were excavated in the stipulated locations to permit detailed examination of the upper soils and to permit recovery of large samples for analysis. Pits also provide information on soil stability and water ingress. Pits were excavated using a tracked mechanical excavator.

The majority of trial pits were excavated to depths of between 2.0 and 4.5 m BGL. At some locations, excavation was prematurely terminated. This was mainly due to hard ground conditions and the presence of bedrock.

Hand shear vanes were carried out in the pit sidewalls to depths of up to 1.2 metres BGL in order to estimate the in-situ undrained shear strengths of the soils.

Pits were backfilled with the excavated material placing and compacting in layers.

5.3 Pump Test

A pump test was undertaken on the site to determine if the required amount of water for the construction stage of the project was obtainable on site. The pump well (PW01) was constructed using symmetrix open hole drilling . Four step down tests were completed to calibrate the equipment followed by the pump test which was terminated after 28.60 hrs due to low flow rates. Two nearby coreholes were used as monitoring wells, to measure the effect of drawdown from the pumping. A description of the pumping test is presented in Volume 3, Appendix B of this report.

5.4 Standpipe Installations and Groundwater Monitoring

At selected locations, standpipes were installed to permit long-term monitoring of water levels. The standpipe installations were constructed in accordance with the BS5930. In general the construction comprised a response zone of 50mm and 27mm slotted HDPE pipe surrounded by a gravel pack. This response zone was sealed with bentonite grout. Un-slotted pipe was used through the sealed section to surface.

Steel lockable head-works or flush steel covers were constructed to protect the installation.

On completion of boring, all boreholes in which no installations were constructed were backfilled.

A set of water level readings were taken in the standpipes during the fieldwork period and these are tabulated in Volume 2 and 4 of the report.

5.5 Downhole Geologging

Down hole geologging was undertaken by Borehole Logging Solutions for the Main Onshore Site Investigation and by Robertsons Geologging for the Embankment – Pond Site Investigation. In both cases an optical televiewer was used to provide a continuous, detailed and orientated 360º image of the corehole walls. The data obtained was interpreted to obtain a complete feature analysis of the rock that includes dip, strike, frequency and fracture aperture. A visual 360º image of the insitu coreholes is also included in the reports which are presented in Volume 2 and 4 of the factual report. One corehole drilled during the main site investigation collapsed therefore the full depth of the hole could not be logged.

5.6 Scanline Survey

Scanline surveys were completed along the foreshore of the beach , where cross sections through the local stratigraphy were exposed. Data regarding bedrock discontinuity orientation and condition were recorded and results are presented in Volume 2 of the report.

5.7 Surface Geophysical Surveys

Two geophysical surveys were undertaken in the main development area and along the footpirint of the embankment. The objective of the survey was to profile variations in bedrock topography and to provide information on geotechnical properties of the overburden and bedrock. The surveys were undertaken by Apex Geoservices. Problems were encountered during the fieldwork period during the main site investigation due to the poor weather conditions. As a result some of the seismic refraction lines were completed in December 2006 and the remainder in March 2007.

Details of the survey are presented in Volume 3, Appendix A and Volume 4, Appendix E of the factual report.

5.8 Packer Tests

A wireline hydraulically inflated packer system was used to access the hydrogeological properties of various horizons within the bedrock under the footprint of the proposed embankment - pond. Double 'Injection' packers tests were undertaken at depths indicated by the engineer. The Inject (Lugeon) Test consists of isolating a borehole and injecting water under pressure in to the rock to determine the effective transmissivity (T) of the zone. The data recorded during the test simply consists of the flow rate and the corresponding pressure when 'steady state' conditions have been achieved. The data is recorded over a number of increasing and decreasing steps as is detailed in the Packer Test Data sheets presented in Volume 4, Appendix C.

5.9 Surveying

After completion of the exploratory works the 'as built' location of all exploratory points was determined to National Grid Co-ordinates and levelled to Malin Head datum.

As built survey work was performed by IGSL using Realtime Kinetic (RTK) GPS methods.

5.10 Photography

Rock cores recovered from the rotary coreholes were photographed at the time of geological logging in the laboratory. Open trial pit excavations and spoil material were also photographed .

Photographs have are presented in an Addendum to Volume 2 and 4 of the report.

5.11 Soil and Rock Descriptions

The soil descriptions were completed by IGSL Ltd and are in accordance with BS5930: 1999. In the description of the glacial till which, in some cases, has a low fines content, the delineation between fine and coarse soils has been relaxed by IGSL Ltd in accordance with the code.

In this code, well-graded soils, which exhibit cohesion and contain sufficient fine grains to fill the spaces between the coarse grains can be described as having silt or clay as the dominant component. The description is, therefore, based on the soil's engineering behaviour rather than on its composition. During this project, the transition from coarse grained to fine grained behaviour was implemented when the fines content was typically in the range 15-40%.

Where grading analysis of granular soils revealed a fines content of less than 2%, this was omitted from the description of the soil.

6. LABORATORY TESTING

Laboratory testing was performed on a selection of samples as specified by Arup via laboratory test schedules.

Most samples removed from site were labelled with sample labels. The sample labels included the location number, depth of sample, date of sampling and a reference number. The reference number is a four digit number ranging between 0001 and 9999 with a letter prefix e.g. R1234.

If duplication does occur, this does not present a problem to tracking samples through the field procurement and laboratory testing stages, as each label carries information on location reference, depth, and date of sampling which ensures that each sample label is unique.

It is important to appreciate that the measured moisture content values of some test specimens may differ from those measured shortly after sampling. This is due to the movement, and possibly loss, of moisture during transportation. This occurs particularly in sandy soils or in clays, which contain pockets or layers of granular material. With sandy silts, vibration can cause loss of water while, in clays containing granular material, water can migrate from the granular zones to the matrix material. Softening due to water migration can result in soil performance that may not reflect the true in-situ condition of the soil. Where obvious soil deterioration was noted, samples were recorded as unsuitable. Moisture content values related to these tests should be regarded as "as received" values.

It is accepted that, for practical reasons it is not possible to recover or test samples of very coarse deposits. In some instances, therefore, it may be considered valid to apply corrections to results obtained in the laboratory to reflect the actual performance of the total soil mass.

Soil laboratory tests were undertaken both by IGSL Ltd and Terratek Site Investigation and Laboratory Servives Ltd. There are discrepancies in soil descriptions between the results from both laboratories. This is primarily due to the subjectivity of the laboratory technicians describing the soil.

Tests were performed in approved laboratories. Unless otherwise stated the tests are in accordance with BS 1377:1990.

The following are certain aspects of the testing which are specific to this project.

6.1 Soil Laboratory Tests

6.1.1 Moisture Content

The moisture contents of disturbed samples (sealed bags, tubs) were determined on material passing the 20 mm sieve. This is to ensure that valid comparisons can be made between moisture content values obtained from various tests such as compaction, MCV and CBR, which are carried out on samples passing the 20 mm sieve.

Moisture content values for selected disturbed samples were determined as soon as possible after sampling.

6.1.2 Atterberg Limits

The liquid limits were determined using the cone method as described in BS 1377 Pt.2:1990. In the majority of cases, the specimens for liquid and plastic limit determination were obtained at their natural state by removal of particles greater than 425 μm. This is the definitive method, as stated in BS1377: Part 2: 1990, Clause 4. Where this was considered impractical, specimens were air-dried and sieved, as recommended in BS 1377.

While BS 1377 suggests that the results should include the percentage of material passing the 425 micron sieve, this information can be misleading in the case of coarse soils such as the glacial till encountered on this site. In the laboratory the percentage can only be related to the sample presented for testing while the actual soil stratum may contain coarse gravel and cobbles which would not necessarily be contained in the sample. Inclusion of coarse soil in a small sample would also distort the proportions.

6.1.3 Particle Size Distributions

Particle size distribution tests were carried out to BS1377: Part 2: 1990, method 9.2 (Wet sieving). Where specified by the Engineer hydrometer tests to BS1377: Part 2: 1990, Method 9.5 were conducted to establish the percentage of silt and clay present.

The necessity to exclude the coarse fraction such as coarse gravel and cobbles should be considered when reviewing and assessing the laboratory test results in relation to actual in-situ soil composition.

In addition, in the absence of an accompanying grading analysis, the percentage may only be estimated from visual examination.

To obtain particle size distributions, wet sieving methods were used, as specified. Cobble and boulder size material was excluded from all tests while, in some instances the maximum particle size was further limited to take into account the mass of the sample. BS 1377 suggests that, for specimens with less than 10% retained on the 20 mm sieve a sample mass of 2.5 kg should be used. This compares with a sample mass of 17 kg for specimens with less than 10% retained on the 37.5mm sieve. Reference should, therefore, be made to the trial pit records for a full description of the soil stratum.

6.1.4 Moisture Condition Value Tests

MCV tests were generally performed on specimens at their "as sampled" water content values obtained after removal of material retained on the 20 mm sieve. The procedures are in accordance with BS1377: Part4: 1990, Clause 5.4. For selected samples, tests were performed over a range of water content values, in conjunction with compaction tests or for calibration purposes

6.1.5 CBR Analysis

BS 1377: 1990: Part 4, Clause 7 ' Determination of California Bearing Ratio' describes six methods of preparing specimens. The methods are sub-divided into dry density specification and compactive effort specification. The soil can be placed in the test mould by a number of methods such as compression in layers, rammer compaction or vibrating hammer.

For tests on samples recovered from proposed grade level, specimens should be prepared to a density which is as close as possible to the in-situ density.

To permit a valid comparison between CBR tests carried out at grade and those carried out in conjunction with compaction tests, all tests were performed on specimens, compacted to a density equal to that obtained in the 2.5 kg compaction test.

To minimise disturbance, specimens were prepared in accordance with clause 7.2.3.3 Method 2. This entails compressing the soil into the test mould in three equal layers using a hydraulic ram.

6.1.6 Compaction/CBR/MCV

Compaction tests were carried out in accordance with BS1377: Part4: 1990, Method 3.3 (soil passing the 20 mm sieve). In this test the 2.5kg rammer is used. By limiting the maximum particle size to 20 mm a sample size of 10kg is adequate. By comparison, for test 3.4, compaction of soils containing coarse gravel, a minimum soil mass of 50kg is recommended

Where requested by Arup, CBR tests were performed at each moisture content on the compaction curve, placing the soil in the mould in three layers by compression, to the density achieved in the compaction test. MCV tests were also performed at each moisture content.

6.1.7 Pinhole Tests

The Pinhole Tests was undertaken in accordance with BS1377: Part 5. They were carried out by Terratek Site Investigation and Laboratory Services Ltd, on samples collected during the embankment-pond site investigation.

The purpose of the test was to attempt to access the dispersibility of the soil by measuring the size of a cavity after distilled water was pushed through it under a high hydraulic gradient.

6.1.8 Maximum and Minimum Density

This test was undertaken in accordance with BS1377: Part 4 to determine the maximum and minimum density to which a soil sample can be compacted.

6.1.9 Pyknometer Test

The small pyknometer test was undertaken in accordance with BS1377: Part 2 by Terratek Site Investigation and Laboratory Services Ltd. This test measures the particle density of clay, silt and sand sized particles.

6.1.10 Triaxial Permeability Test

The triaxial permeability tests were undertaken in accordance with BS1377: Part 6. This test was completed by Terratek Site Investigation and Laboratory Services Ltd in the United Kingdom, on samples collected during the embankment – pond site investigation.

The test uses a recompacted specimen set up for a triaxial compression test. The volume of water passing through the soil in a known time, and under a constant hydraulic head gradient is measured.

It should be noted that some of the resulting permeabilies of the tests appear very low and should be viewed with caution.

6.2 Rock Laboratory Tests

6.2.1 Uniaxial Compressive Strength Testing

The UCS tests were undertaken in accordance with ISRM 1981 standards. In some cases specified UCS tests could not be undertaken due to fractures intersecting the rock core or specimens breaking during preparation (sawing). Some of the depths may, therefore, differ from the specified depths. As an added extra, some rock samples were sent to Fugro Engineering Services Ltd to determine stress-strain curves, Young's modulus and Poissons Ratio in uniaxial compression. This test was carried out in accordance with the ISRM 1981 standards.

6.2.2 Point Load Strength Tests

Point load strength tests were undertaken in accordance with ISRM 1981. The point load tests were conducted under diametral and axial loading. Diametral and axial test results are presented separately. All point load (Is) values have been corrected for sample size to standard Is_{50} values.

6.2.3 Los Angeles Abrasion Test

The Los Angeles Abrasion Tests were undertaken in accordance with BS EN1097-2:1998. The samples were placed in the Los Angeles abrasion testing machine and rotated by a certain number of revolutions. The Los Angeles Coefficient is calculated as the loss in weight of the sample from the start to the end of the test. This weight loss is expressed as a percentage of the original weight and is reported as the percentage wear.

6.2.4 Slake Durability Test

The Slake Durability Tests were undertaken in accordance with ISRM 1981 by Fugro Engineering Services in the United Kingdom. The test is intended to access the resistance offered by a rock sample to weakening and disintegration when subjected to two standard cycles of drying and wetting. The slake durability index is calculated as the percentage ratio of final to initial dry sample masses.

6.2.5 Acoustic Velocities

Acoustic velocities were carried out on rock samples by the University of Redding, United Kingdom in accordance with ISRM 1981. Samples were measured to calculate laboratory compressional (P-wave) velocity, shear (S-wave) velocity on selected core samples. Vp and Vs ratios were also calculated to check on the consistency of the Vp and Vs measurements.

6.3 Chemical Laboratory Tests

6.3.1 Sulphate and pH Tests

Determination of pH values, sulphate content of soil and water are in accordance with BS 1377: Part3: 1990.

The sulphate content of soil samples was determined as the acid-soluble sulphate content (total sulphate content) which is obtained from an acid extract. Analysis was then carried out by the gravimetric method. Results are generally expressed as % SO3 except where otherwise stated.

The gravimetric method was used for groundwater analysis.

pH values were obtained in accordance with Clause 9 of BS 1377: Part 3: 1990

6.3.2 Nitrates and Phosphates

The nitrates and phosphates were carried out by ALcontrol Laboratories in Dublin, Ireland. The following standards and references were used to undertake the tests:

Nitrate by KONE (S3LS TM 102D)

References:

- Kone Operator's Manual.
- SLS TM 015 – KoneAnalyser –Operator's Guide
- Standard Methods for the Examination of Water and Waste Water 20th edition American Public Health Association, American Water Works Association and Water Environment Federation 4500- H 4-119

Phosphate by KONE (SLS TM 100)

References:

- Kone Operator's Manual;
- SLS TM 140 –Kone Lab 30 Analyser – Operator's Guide;
- SLS TM 015 – Kone Lab 20 Analyser – Operator's Guide;
- AWWA/APHA 19th Edition Method 4500-P E;
- Hazardous Substances Assessment No. 2.

6.3.3 Electrical Conductivity, Sodium and Chloride and Total Alkalinity

The tests were carried out by ALcontrol Laboratories in Dublin, Ireland. The following standards and references were used to undertake the tests:

Sodium and Potassium by Flame Photometer (SLS TM 083D)

This method is an in-house method.

Chloride by KONE (SLS TM 097D)

References:

- Konelab 20 Manual;
- SLS TM 015 – Kone Lab 20 Analyser Operator's Guide;
- EPA Methods 325.1 & 325.2;
- COSHH Sheet 23.

Electrical Conductivity (SLS TM 120D)

References:

- Review of Electrolytic Conductance standards, Wu, Koch, Hamer, and Kay, J. Soln. Chem. 1987, 16,985-997;
- Thermo Orion bench top pH/Conductivity meter model 550A manual;
- Thermo Orion AS3000 series Autosampler manual;
- 2510B – Standard Methods for the Examination of Water and Wastewaters, 20th Edition, 1998, APHA, AWWA, WEF.

Alkalinity (SLS TM 043)

References:

- BS2690 : Part109 : 1984 - Alkalinity in water;
- The Determination of Alkalinity and Acidity in water 1981, Blue Book-MEWAM.

7.0 Electronic Data

In accordance with the specification, the final report data is also issued in electronic format.

8.0 References and Standards

General Site Investigation

1. BS 5930; Code of Practice for Site Investigations; British Standards Institute; 1999.
2. Manual of Contract Documents for Highway Works, Volume 5, Section 3, Ground Investigation, Part 4: Specification

Soil and Rock Laboratory Testing

3. BS1377; British Standard Methods of Test for Soils for Civil Engineering Purposes; British Standards Institute;1990.
4. BS EN1097-2:1998: Los Angles Abrasion Test.
5. ISRM Suggested Methods – Rock Characterisation, Testing and Monitoring – Editor E.T. Brown, International Society of Rock Mechanics, 1981.

Chemical Laboratory Testing

6. AWWA/APHA 19th Edition Method 4500-P E.
7. BS2690 : Part109 : 1984 - Alkalinity in water.
8. COSHH Sheet 23.
9. EPA Methods 325.1 & 325.2.
10. Hazardous Substances Assessment No. 2.
11. Kone Lab 20 Analyser Operator's Manual.
12. Review of Electrolytic Conductance standards, Wu, Koch, Hamer, and Kay, J. Soln. Chem. 1987, 16,985-997.
13. SLS TM 015 – Kone Lab 20 Analyser –Operator's Guide.
14. SLS TM 140 –Kone Lab 30 Analyser – Operator's Guide.
15. Standard Methods for the Examination of Water and Waste Water 20th edition American Public Health Association, American Water Works Association and Water Environment Federation 4500- H 4-119.
16. Thermo Orion bench top pH/Conductivity meter model 550A manual.
17. Thermo Orion AS3000 series Autosampler manual.
18. The Determination of Alkalinity and Acidity in water 1981, Blue Book-MEWAM.
19. 2510B – Standard Methods for the Examination of Water and Wastewaters, 20th Edition, 1998, APHA, AWWA, WEF.

Packer Tests

20. Houlsbey, A.C. 1976. Routine Interpretation of the Lugeon Water Test. Quaterly Journal of Engineering Geology, Vol 9 pp. 303 – 313.

Figures

Site Boundary

Shannon LNG

Ordnance Survey Ireland
Licence No EN 0002807
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Note
This graphic is for diagrammatic purposes only. No measurements to be taken

ARUP

Shannon LNG Terminal EIS

Site Location

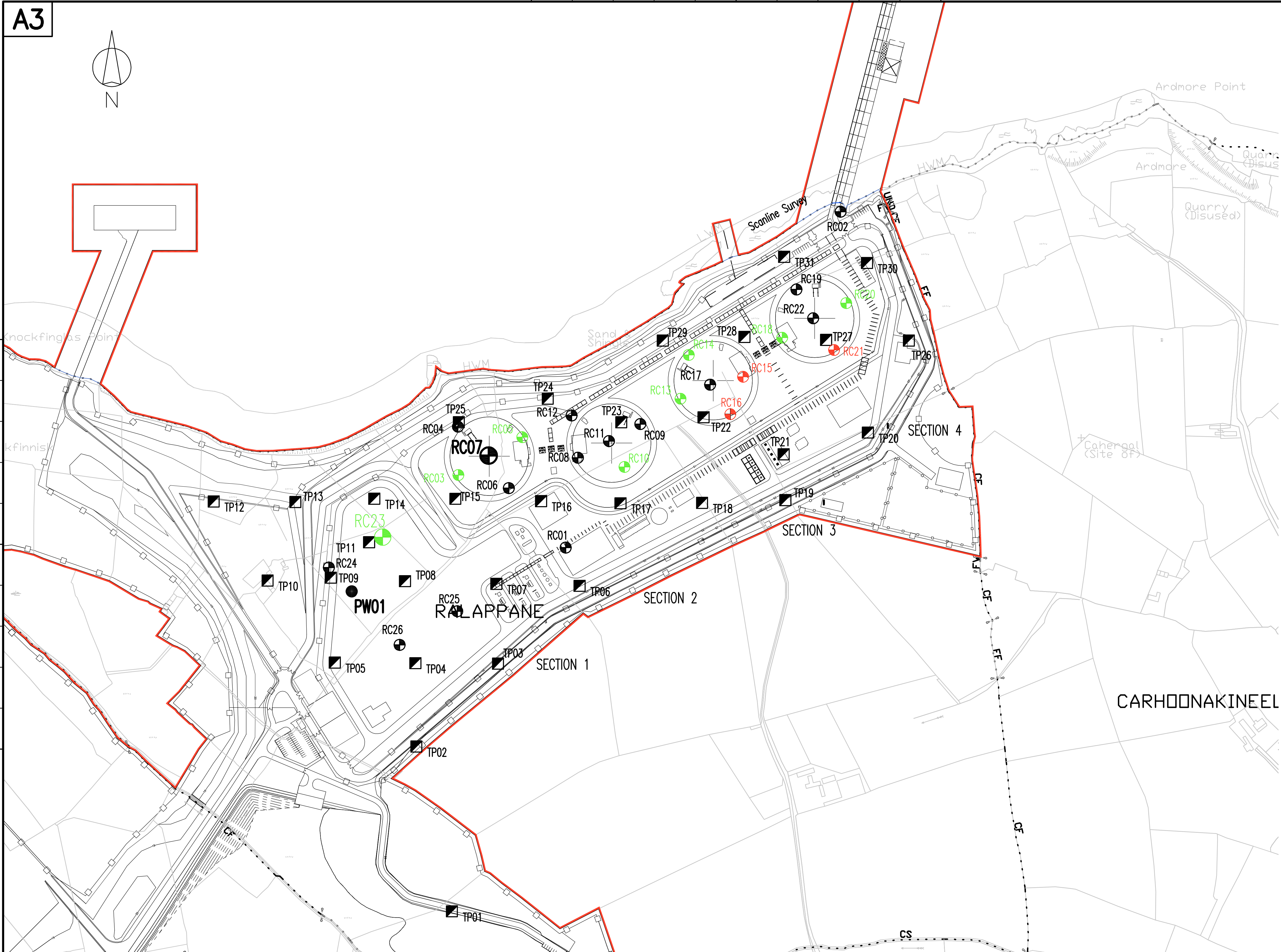
Job No.: C1676.10

Date: September 2007

Figure: 1

A3

10cm – SCALE WITH CAUTION AS DISTORTION CAN OCCUR



Location	Easting	Northing	Elevation
Coreholes			
PW01	102105.531	148474.28	13.16
RC1	102366.81	148527.735	23.32
RC2	102702.336	148937.664	5.544
RC3	102235.723	148616.252	17.01
RC4	102235.223	148675.356	14.179
RC5	102313.816	148662.468	17.912
RC6	102297.397	148600.339	21.717
RC7	102272.717	148640.021	19.091
RC8	102381.655	148637.417	17.342
RC9	102457.889	148678.488	15.614
RC10	102438.558	148626.089	19.588
RC11	102419.581	148657.717	16.492
RC12	102373.942	148688.953	13.059
RC13	102507.352	148709.383	17.084
RC14	102517.059	148762.875	13.464
RC15	102583.362	148736.224	22.28
RC16	102567.786	148690.586	21.678
RC17	102543.067	148726.548	18.552
RC18	102631.079	148783.914	19.002
RC19	102648.523	148842.776	12.965
RC20	102709.254	148826.109	18.096
RC21	102694.453	148768.896	21.501
RC22	102668.945	148807.619	17.836
RC23	102143.352	148540.507	13.107
RC24	102077.684	148503.385	10.571
RC25	102234.404	148450.017	19.023
RC26	102163.972	148408.974	16.613
Trial Pits			
TP1	102227.834	148083.794	18.967
TP2	102184.447	148284.92	18.972
TP3	102284.093	148386.066	23.135
TP4	102183.249	148386.634	18.262
TP5	102084.892	148387.388	13.169
TP6	102383.71	148481.047	25.687
TP7	102282.167	148483.421	21.396
TP8	102170.614	148486.777	15.956
TP9	102080.012	148490.98	11.214
TP10	102002.806	148487.529	8.439
TP11	102126.766	148534.317	12.379
TP12	101937.024	148584.019	6.815
TP13	102036.707	148583.319	7.214
TP14	102133.171	148587.347	10.939
TP15	102232.088	148587.272	17.607
TP16	102336.659	148584.49	20.238
TP17	102433.673	148581.819	22.483
TP18	102533.26	148582.374	26.926
TP19	102634.942	148585.631	31.035
TP20	102735.74	148668.155	29.318
TP21	102632.779	148641.615	28.127
TP22	102535.095	148686.732	20.12
TP23	102434.595	148680.682	14.984
TP24	102344.838	148709.512	11.561
TP25	102236.255	148680.674	13.653
TP26	102785.745	148780.436	23.428
TP27	102684.656	148781.265	20.431
TP28	102584.995	148784.831	16.9
TP29	102485.326	148780.418	8.962
TP30	102734.671	148875.129	15.883
TP31	102633.425	148882.664	8.917

Rev.	Date	By	Description	Chd By
PL2	14.01.08	EG	ISSUED FOR INFORMATION	
P2	15.06.07	EG	ISSUED FOR INFORMATION	
P1	12.02.07	EG	ISSUED FOR INFORMATION	

Legend

RCXX — Groundwater monitoring well locations.

PW01, RC07 & RC23 — Pump test and monitoring well locations.

RC07, RC10, RC15, RC16, RC20, RC21 — Downhole Geologging Locations.

Job Title

SHANNON LNG: TARBERT/BALLYLONGFORD TERMINAL

Shannon LNG

Drawing Title

LOCATION OF SECTION LINES FOR CROSS SECTION FIGURES

Drawing Status

PLANNING

ARUP
15 Oliver Plunkett Street Cork
Tel 021-4277670 Fax 021-4272345
EMail cork@arup.com
DUBLIN CORK LIMERICK

Scales 1:5000 @ A3 | Originator EG

Checked | Approved | Date 07.02.07

Job No. C1676.10 | Drawing No. SK–048 | Rev. PL2

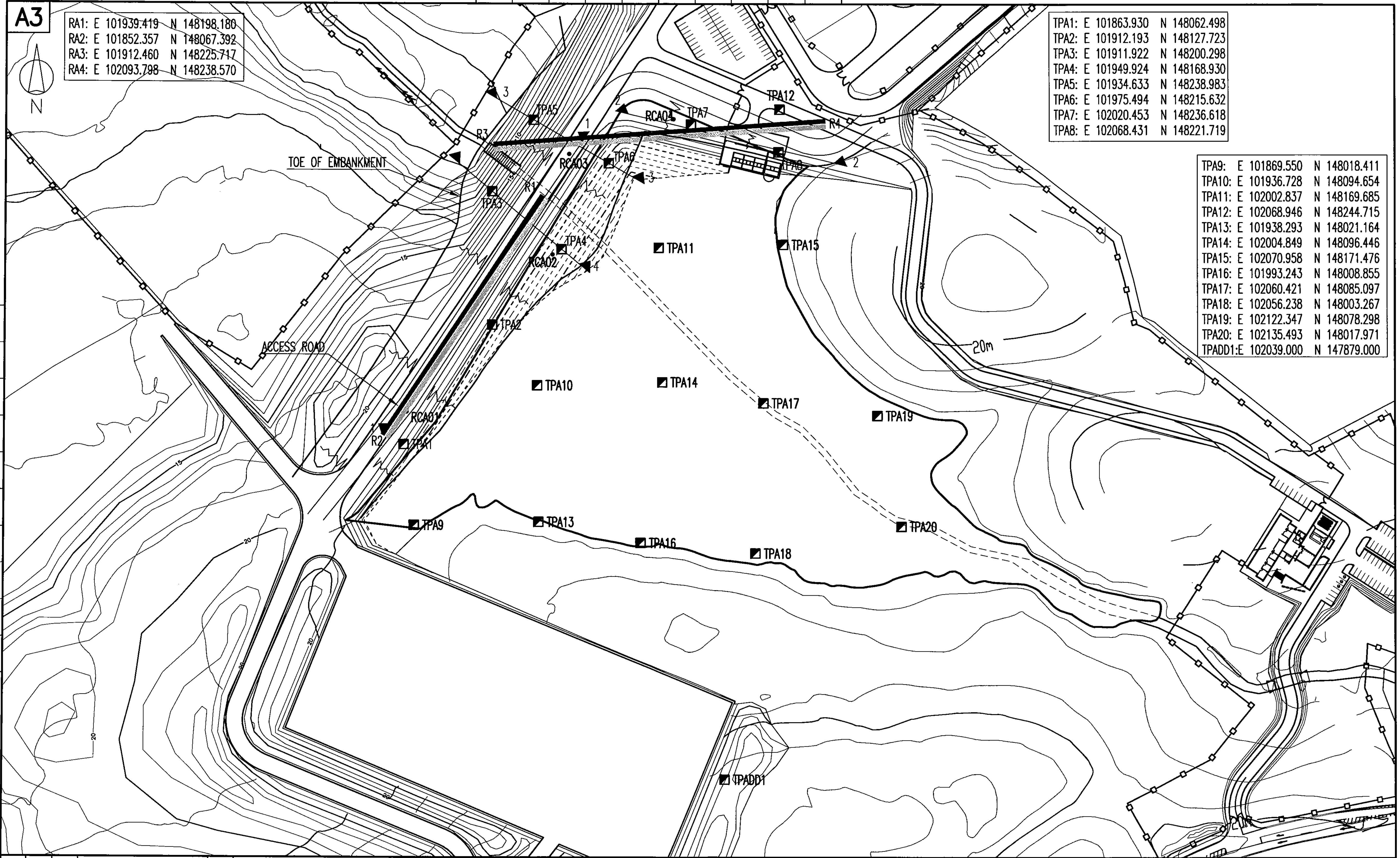
10cm - SCALE WITH CAUTION AS DISTORTION CAN OCCUR

A3

RA1:	E 101939.419	N 148198.180
RA2:	E 101852.357	N 148067.392
RA3:	E 101912.460	N 148225.717
RA4:	E 102093.798	N 148238.570

TPA1:	E 101863.930	N 148062.498
TPA2:	E 101912.193	N 148127.723
TPA3:	E 101911.922	N 148200.298
TPA4:	E 101949.924	N 148168.930
TPA5:	E 101934.633	N 148238.983
TPA6:	E 101975.494	N 148215.632
TPA7:	E 102020.453	N 148236.618
TPA8:	E 102068.431	N 148221.719

TPA9:	E 101869.550	N 148018.411
TPA10:	E 101936.728	N 148094.654
TPA11:	E 102002.837	N 148169.685
TPA12:	E 102068.946	N 148244.715
TPA13:	E 101938.293	N 148021.164
TPA14:	E 102004.849	N 148096.446
TPA15:	E 102070.958	N 148171.476
TPA16:	E 101993.243	N 148008.855
TPA17:	E 102060.421	N 148085.097
TPA18:	E 102056.238	N 148003.267
TPA19:	E 102122.347	N 148078.298
TPA20:	E 102135.493	N 148017.971
TPADD1:	E 102039.000	N 147879.000



Rev.	Date	By	Description	Chd By
P5	25.05.07	EG	ISSUED FOR INFORMATION	
P4	16.04.07	EG	ISSUED FOR INFORMATION	
P3	03.04.07	EG	ISSUED FOR INFORMATION	
P2	02.04.07	EG	ISSUED FOR INFORMATION	
P1	12.02.07	EG	ISSUED FOR INFORMATION	

1. COORDINATES SHOWN ARE TO IRISH NATIONAL GRID.
2. FOR DETAILS OF MARINE/LAND ELEVATION TABLE REFER TO DWG. NO. SK-019.

——— 2D RESISTIVITY

- - - - SEISMIC REFRACTION

Job Title
SHANNON LNG LTD.:
SHANNON LNG TERMINAL

Shannon LNG

Drawing Title
TRIAL PIT AND GEOPHYSICS SURVEY LOCATIONS FOR THE PROPOSED DAM

Drawing Status
PRELIMINARY

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Scales 1:2000 @ A3 | Originator EG

Checked | Approved | Date 11.02.07

Job No. C1676.10 | Drawing No. SK-049A | Rev. P5

Appendix A

Report Layout and Content

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IGSL Limited

Ground Investigation

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On Behalf

Of

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Appendix A - Embankment – Pond SI Trial Pit Data

Trial Pit Records	Figures: TPA 1 - 20, ADD1

TRIAL PIT RECORD

REPORT NUMBER	12239
CONTRACT	Tarbert/Ballylongford Embankment-Pond SI
TRIAL PIT NO.	TPA1
SHEET	Sheet 1 of 1
CO-ORDINATES(_)	101,863.90 E 148,062.00 N
GROUND LEVEL (m)	14.75
DATE STARTED	15/02/2007
DATE COMPLETED	15/02/2007
CLIENT	Shannon LNG
ENGINEER	Arup Consulting Engineers
EXCAVATION METHOD	12t track

Scale (m)	Geotechnical Description	Legend	Depth (m)	Elevation (m OD)	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
0.0	TOPSOIL		0.20	14.55						
	Firm grey brown sandy gravelly CLAY		1.00	13.75	1					
1.0	LAND DRAIN trial pit terminated		1.20	13.55						
	End of Trial Pit at 1.20m									
2.0										
3.0										
4.0										

Groundwater Conditions
Rapid flow at 1.0mbgl

Stability
No instablity noted

General Remarks
Land Drain encountered trial pit terminate and moved 5metres. Mailn Head Ordnance Datum used.

Figure TPA 1

TRIAL PIT RECORD

REPORT NUMBER	12239

CONTRACT	Tarbert/Ballylongford Embankment-Pond SI	TRIAL PIT NO.	TPA1A
		SHEET	Sheet 1 of 1
CO-ORDINATES(_)	101,863.90 E 148,062.00 N	DATE STARTED	15/02/2007
GROUND LEVEL (m)	14.75	DATE COMPLETED	15/02/2007
CLIENT	Shannon LNG	EXCAVATION METHOD	12t track
ENGINEER	Arup Consulting Engineers		

Scale	Geotechnical Description	Legend	Depth (m)	Elevation (m OD)	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
0.0	TOPSOIL									
	Firm brown sandy slightly gravelly CLAY with occasional subrounded to subangular cobbles and occasional subangular to angular boulders(300mm maximum diameter)		0.30	14.45		AA9255 AA9256	B D	0.50-0.50 0.50-0.50		
1.0	Stiff grey brown slightly sandy gravelly CLAY with some subrounded to angular cobbles and occasional subangular to angular boulders(500mm maximum diameter)		0.90	13.85	1	AA9257 AA9258	B D	1.50-1.50 1.50-1.50		
2.0						AA9259 AA9260	B D	2.50-2.50 2.50-2.50		
3.0	Stiff grey black slightly sandy gravelly CLAY with occasional subrounded to subangular cobbles and occasional subrounded to subangular boulders(400mm maximum diameter)		3.00	11.75		AA9261 AA9262	B D	3.50-3.50 3.50-3.50		
4.0	End of Trial Pit at 4.00m		4.00	10.75						

Groundwater Conditions
Seepage observed from 1.3mbgl, slight ingress noted

Stability
No instablity noted

General Remarks
Mailn Head Ordnance Datum used.

Figure TPA1A

TRIAL PIT RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Embankment-Pond SI	**TRIAL PIT NO.**	**TPA2**
		SHEET	Sheet 1 of 1
CO-ORDINATES(_)	101,912.19 E 148,127.72 N	**DATE STARTED**	15/02/2007
GROUND LEVEL (m)	12.71	**DATE COMPLETED**	15/02/2007
CLIENT	Shannon LNG	**EXCAVATION METHOD**	12t track
ENGINEER	Arup Consulting Engineers		

Scale (m)	Geotechnical Description	Legend	Depth (m)	Elevation (m OD)	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
0.0	TOPSOIL		0.20	12.51						
	Firm brown slightly gravelly SILT with some subrounded to angular cobbles and occasional subrounded to angular boulders(500mm maximum diameter)		0.90	11.81		AA9247 AA9248	B D	0.50-0.50 0.50-0.50		
1.0	Stiff mottled redish brown grey sandy gravelly CLAY with some subrounded to angular cobbles and occasional subangular to angular boulders(600mm maximum diameter)		2.20	10.51		AA9249 AA9250	B D	1.50-1.50 1.50-1.50		
2.0 / 3.0	Stiff grey slightly sandy gravelly CLAY with some subangular to angular cobbles and occasional subangular to angular boulders(600mm maximum diameter)		4.00	8.71		AA9251 AA9252 AA9253 AA9254	B D B D	2.50-2.50 2.50-2.50 3.50-3.50 3.50-3.50		
4.0	End of Trial Pit at 4.00m									

Groundwater Conditions
No Groundwater observed.

Stability
Minor collapse from 1.5-3.5mbgl

General Remarks
Mailn Head Ordnance Datum used.

Figure TPA 2

TRIAL PIT RECORD

REPORT NUMBER	12239
CONTRACT	Tarbert/Ballylongford Embankment-Pond SI
TRIAL PIT NO.	TPA3
SHEET	Sheet 1 of 1
CO-ORDINATES(_)	101,911.92 E 148,200.29 N
GROUND LEVEL (m)	5.36
DATE STARTED	15/02/2007
DATE COMPLETED	15/02/2007
CLIENT	Shannon LNG
ENGINEER	Arup Consulting Engineers
EXCAVATION METHOD	12t track

Geotechnical Description	Legend	Depth (m)	Elevation (m OD)	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
TOPSOIL		0.10	5.26						
Soft brown fibrous PEAT (Von Post H4)		0.30	5.06						
Stiff mottled grey blue slightly sandy slightly gravelly CLAY with organic fibres, occasional subrounded to angular cobbles and occasional subangular to angular boulders(600mm maximum diameter)					AA9239 AA9240	B D	0.50-0.50 0.50-0.50		
					AA9241 AA9242	B D	1.50-1.50 1.50-1.50		
		2.50	2.86						
Stiff grey sandy gravelly CLAY with some subangular to angular cobbles and occasional subangular to angular boulders(575mm maximum diameter)					AA9243 AA9244	B D	2.50-2.50 2.50-2.50		
				1					
		3.60	1.76		AA9245 AA9246	B D	3.50-3.50 3.50-3.50		
Obstruction possible boulder or bedrock End of Trial Pit at 3.60m									

Groundwater Conditions
Surface water ingressed into trial pit. Slow flow observed at 3.5mbgl.

Stability
Trial Pit unstable from 2.5-3.4mbgl

General Remarks
Mailn Head Ordnance Datum used.

Figure TPA 3

TRIAL PIT RECORD

REPORT NUMBER	12239
CONTRACT	Tarbert/Ballylongford Embankment-Pond SI
TRIAL PIT NO.	TPA4
SHEET	Sheet 1 of 1
CO-ORDINATES(_)	101,949.92 E 148,168.93 N
GROUND LEVEL (m)	7.03
DATE STARTED	15/02/2007
DATE COMPLETED	15/02/2007
CLIENT	Shannon LNG
ENGINEER	Arup Consulting Engineers
EXCAVATION METHOD	12t track

Scale (m)	Geotechnical Description	Legend	Depth (m)	Elevation (m OD)	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
0.0	TOPSOIL									
	Soft grey sandy SILT with organic fibres		0.20	6.83						
	Soft brown fibrous PEAT (Von Post H4)		0.40	6.63		AA9236	B	0.50-0.50		
1.0	Stiff grey sandy SILT with organic fibres, occasional subangular to angular cobbles and occasional subangular to angular boulders(400mm maximum diameter)		1.00	6.03	1					
	Obstruction possible boulder or bedrock End of Trial Pit at 1.30m		1.30	5.73		AA9237 AA9238	B D	1.30-1.30 1.30-1.30		
2.0										
3.0										
4.0										

Groundwater Conditions
Moderate flow at 1.2mbgl.

Stability
No instablity noted

General Remarks
Mailn Head Ordnance Datum used.

Figure TPA 4

TRIAL PIT RECORD

REPORT NUMBER	12239
CONTRACT	Tarbert/Ballylongford Embankment-Pond SI
TRIAL PIT NO.	TPA5
SHEET	Sheet 1 of 1
CO-ORDINATES(_)	101,934.63 E 148,238.98 N
GROUND LEVEL (m)	5.51
DATE STARTED	15/02/2007
DATE COMPLETED	15/02/2007
CLIENT	Shannon LNG
ENGINEER	Arup Consulting Engineers
EXCAVATION METHOD	12t track

Scale	Geotechnical Description	Legend	Depth (m)	Elevation (m OD)	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
0.0	TOPSOIL									
	Firm grey sandy CLAY with occasional subrounded to angular cobbles		0.20	5.31						
	Firm grey green slightly sandy gravelly CLAY with occasional subrounded to angular cobbles and occasional boulders(300mm maximum diameter)		0.40	5.11	1	AA9224 AA9225 AA9226	B D D	0.50-0.50 0.50-0.50 0.50-0.50		
1.0										
	Stiff grey blue slightly sandy gravelly CLAY with occasional subrounded to subangular cobbles and occasional subrounded to angalar boulders(525mm maximum diameter)		1.50	4.01		AA9227 AA9228 AA9229	B D D	1.50-1.50 1.50-1.50 1.50-1.50		
2.0										
						AA9230 AA9231 AA9232	B D D	2.50-2.50 2.50-2.50 2.50-2.50		
3.0										
						AA9233 AA9234 AA9235	B D D	3.50-3.50 3.50-3.50 3.50-3.50		
4.0	End of Trial Pit at 3.90m		3.90	1.61						

Groundwater Conditions
Moderate flow at 0.8mbgl.

Stability
No instablity noted

General Remarks
Pit terminated due to large boulders. Mailn Head Ordnance Datum used.

Figure TPA 5

TRIAL PIT RECORD

REPORT NUMBER
12239

CONTRACT	Tarbert/Ballylongford Embankment-Pond SI	**TRIAL PIT NO.**	**TPA6**
		SHEET	Sheet 1 of 1
CO-ORDINATES(_)	101,975.49 E 148,215.63 N	**GROUND LEVEL (m)**	6.92
		DATE STARTED	15/02/2007
		DATE COMPLETED	15/02/2007
CLIENT	Shannon LNG	**EXCAVATION METHOD**	12t track
ENGINEER	Arup Consulting Engineers		

Scale	Geotechnical Description	Legend	Depth (m)	Elevation (m OD)	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
0.0	TOPSOIL									
	Firm grey sandy CLAY with occasional subrounded to angular cobbles		0.30	6.62		AA9217 AA9218 AA9219	B D D	0.50-0.50 0.50-0.50 0.50-0.50		
1.0	Stiff mottled brown blue slightly sandy slightly gravelly CLAY with organic fibres, occasional subangular to angular cobbles and occasional subangular to angular boulders(800mm maximum diameter)		0.90	6.02	1	AA9220 AA9221 AA9222	B D D	1.50-1.50 1.50-1.50 1.50-1.50		
2.0	Medium dense grey sandy fine to coarse angular GRAVEL with occasional lenses of grey clay and some angular cobbles(Possible weathered rock)		2.00	4.92	2	AA9223	B	2.50-2.50		
3.0	Obstruction possible boulder or bedrock End of Trial Pit at 3.00m		3.00	3.92						
4.0										

Groundwater Conditions
Slow flow observed at 2.0mbgl and moderate flow observed at 2.7mbgl.

Stability
Minor side wall collapse from 2.5mbgl

General Remarks
Mailn Head Ordnance Datum used.

Figure TPA 6

TRIAL PIT RECORD

REPORT NUMBER	12239
CONTRACT	Tarbert/Ballylongford Embankment-Pond SI
TRIAL PIT NO.	TPA7
SHEET	Sheet 1 of 1
CO-ORDINATES(_)	102,020.45 E 148,236.61 N
GROUND LEVEL (m)	12.55
DATE STARTED	15/02/2007
DATE COMPLETED	15/02/2007
CLIENT	Shannon LNG
ENGINEER	Arup Consulting Engineers
EXCAVATION METHOD	12t track

Scale	Geotechnical Description	Legend	Depth (m)	Elevation (m OD)	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
0.0	TOPSOIL									
	Firm redish brown sandy CLAY with rootlets		0.20	12.35						
	Stiff mottled grey green brown sandy gravelly CLAY with some subangular to angular cobbles and occasional subangular to angular boulders(650mm maximum diameter)		0.45	12.10		AA9209 AA9210	B D	0.50-0.50 0.50-0.50		
1.0						AA9211 AA9212	B D	1.50-1.50 1.50-1.50		
2.0	Stiff grey green slightly sandy gravelly CLAY with some subangular to angular cobbles and occasional subangular to angular boulders(700mm maximum diameter)		1.90	10.65						
						AA9213 AA9214	B D	2.50-2.50 2.50-2.50		
3.0						AA9215 AA9216	B D	3.50-3.50 3.50-3.50		
4.0	End of Trial Pit at 4.00m		4.00	8.55						

Groundwater Conditions
No Groundwater observed.

Stability
Minor side wall collapse due to boulders from 1.1-2.6mbgl

General Remarks
Mailn Head Ordnance Datum used.

Figure TPA 7

TRIAL PIT RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Embankment-Pond SI	**TRIAL PIT NO.**	**TPA8**
		SHEET	Sheet 1 of 1
CO-ORDINATES(_)	102,068.43 E 148,221.71 N	**GROUND LEVEL (m)**	15.53
DATE STARTED	15/02/2007	**DATE COMPLETED**	15/02/2007
CLIENT	Shannon LNG	**EXCAVATION METHOD**	12t track
ENGINEER	Arup Consulting Engineers		

Depth scale	Geotechnical Description	Legend	Depth (m)	Elevation (m OD)	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
0.0	TOPSOIL									
	Firm redish brown sandy CLAY with rootlets		0.20	15.33						
	Stiff mottled grey green brown slightly sandy gravelly CLAY with some subangular to angular cobbles and occasional subangular to angular boulders(550mm maximum diameter)		0.40	15.13		AA9201 AA9202	B D	0.50-0.50 0.50-0.50		
1.0						AA9203 AA9204	B D	1.50-1.50 1.50-1.50		
2.0	Stiff grey green sandy gravelly CLAY with some subangular to angular cobbles and occasional subangular to angular boulders(600mm maximum diameter)		1.90	13.63		AA9205 AA9206	B D	2.50-2.50 2.50-2.50		
3.0						AA9207 AA9208	B D	3.50-3.50 3.50-3.50		
4.0	End of Trial Pit at 4.00m		4.00	11.53						

Groundwater Conditions
No Groundwater observed.

Stability
No instablity noted

General Remarks
Mailn Head Ordnance Datum used.

Figure TPA 8

TRIAL PIT RECORD

REPORT NUMBER: 12239

CONTRACT	Tarbert/Ballylongford Embankment-Pond SI
TRIAL PIT NO.	**TPA9**
SHEET	Sheet 1 of 1
CO-ORDINATES(_)	101,869.55 E 148,018.41 N
GROUND LEVEL (m)	16.63
DATE STARTED	19/04/2007
DATE COMPLETED	19/04/2007
CLIENT	Shannon LNG
ENGINEER	Arup Consulting Engineers
EXCAVATION METHOD	14t Track

Geotechnical Description	Depth (m)	Elevation (m OD)	Water Strike
Brown clay loam TOPSOIL	0.30	16.33	
Firm' friable orange brown with grey mottling sandy slightly gravelly CLAY with some (c. 10%) subangular sandstone cobbles. Gravel is fine to coarse subangular and subrounded of sandstone and siltstone.	0.60	16.03	
Assessed as very compact grey brown very clayey very sandy fine to coarse subangular and subrounded sandstone and siltstone GRAVEL locally grading to friable sandy very gravelly clay with some (c. 20%) angular and subangular sandstone cobbles and occasional subangular boulders (<0.60m).	1.30	15.33	
Stiff fissured and friable brown with grey mottling sandy slightly gravelly CLAY with some (c. 5%-10%) subangular sandstone cobbles. Gravel is fine to coarse subangular and subrounded of sandstone and siltstone.	1.80	14.83	
Stiff fissured brown sandy slightly gravelly CLAY with some (c. 5%-10%) subangular sandstone cobbles and occasional boulders (<0.50m). Gravel is fine to coarse subangular and subrounded of sandstone and siltstone.	2.70	13.93	1 (c. 2.40m)
Very stiff fissured bluish grey sandy slightly gravelly CLAY with some (c. 10%) subangular sandstone cobbles and occasional boulders (<0.40m). Gravel is fine to coarse subangular and subrounded of sandstone and siltstone.	4.00	12.63	
End of Trial Pit at 4.00m			

Samples

Sample Ref	Type	Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
AA8579	D	0.30-0.40		
AA8580	B	0.70-0.90		
AA8581	D	1.00-1.10		
AA8582	B	1.40-1.50		
AA8583	D	1.90-2.00		
AA8584	B	2.40-2.50		
AA8585	D	2.80-2.90		
AA8586	B	3.40-3.50		
AA8587	D	3.90-4.00		

Groundwater Conditions
Seepage below 2.40m bgl.

Stability
Relatively stable

General Remarks
Orientation East-West. Dimensions 1.70m x 4.30m x 4.00m. Mailn Head Ordnance Datum used.

Figure TPA 9

TRIAL PIT RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Embankment-Pond SI	**TRIAL PIT NO.**	**TPA10**
		SHEET	Sheet 1 of 1
CO-ORDINATES(_)	101,936.73 E 148,094.65 N	**DATE STARTED**	18/04/2007
GROUND LEVEL (m)	12.88	**DATE COMPLETED**	18/04/2007
CLIENT	Shannon LNG	**EXCAVATION METHOD**	14t Track
ENGINEER	Arup Consulting Engineers		

Scale (m)	Geotechnical Description	Legend	Depth (m)	Elevation (m OD)	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
0.0	Brown clay loam TOPSOIL					AA8558	D	0.30-0.40		
	Firm friable orange brown sandy CLAY with occasional gravel.		0.65	12.23		AA8559	B	0.85-0.95		
1.0	Stiff friable brown, grey and reddish brown mottled sandy to very sandy slightly gravelly CLAY locally grading to very clayey sand and gravel with some locally many (c. 20%) subangular sandstone cobbles and occasional angular boulders (<0.70m). Gravel is fine to coarse subangular and subrounded of sandstone and siltstone.		0.95	11.93		AA8560	B	1.20-1.40		
2.0						AA8561	D	1.90-2.00		
						AA8562	B	2.40-2.50		
3.0	Assessed as compact to very compact dark brown very clayey very sandy fine to coarse subangular and subrounded sandstone and siltstone GRAVEL with some locally many (c. 20%-30%) subangular and subrounded sandstone cobbles and occasional boulders (<0.60m).		2.80	10.08	1	AA8563	D	2.90-3.00		
						AA8564	B	3.30-3.40		
						AA8565	D	3.90-4.00		
4.0	End of Trial Pit at 4.00m		4.00	8.88						

Groundwater Conditions
Damp below 2.80m bgl.

Stability
Relatively stable

General Remarks
Orientation North-South. Dimensions 1.70m x 4.00m x 4.00m. Mailn Head Ordnance Datum used.

TRIAL PIT RECORD

REPORT NUMBER	12239
CONTRACT	Tarbert/Ballylongford Embankment-Pond SI
TRIAL PIT NO.	TPA11
SHEET	Sheet 1 of 1
CO-ORDINATES(_)	102,002.84 E 148,169.69 N
GROUND LEVEL (m)	8.13
DATE STARTED	17/04/2007
DATE COMPLETED	17/04/2007
CLIENT	Shannon LNG
ENGINEER	Arup Consulting Engineers
EXCAVATION METHOD	14t Track

Scale	Geotechnical Description	Legend	Depth (m)	Elevation (m OD)	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
0.0	Brown clay loam TOPSOIL		0.35	7.78						
	Firm friable orange brown sandy slightly gravelly CLAY with some (c. 10%) angular to subrounded sandstone cobbles and occasional boulders (<0.40m). Gravel is fine to coarse angular and subangular of sandstone and siltstone.		0.85	7.28		AA8527	B	0.40-0.65		
1.0	Highly weathered fractured thinly bedded moderately strong grey with red and dark grey staining SILTSTONE. Recovered medium and coarse angular GRAVEL and COBBLES. Possible SILTSTONE bedrock		1.15	6.98		AA8528	B	0.85-0.90		
	End of Trial Pit at 1.15m									
2.0										
3.0										
4.0										

Groundwater Conditions
No groundwater encountered during excavation.

Stability
Relatively stable

General Remarks
Orientation East-West. Dug perpendicular to slope. Dimensions 1.70m x 3.50m x 1.15m. Mailn Head Ordnance Datum used.

Figure TPA 11

TRIAL PIT RECORD

REPORT NUMBER	12239
CONTRACT	Tarbert/Ballylongford Embankment-Pond SI
TRIAL PIT NO.	TPA12
SHEET	Sheet 1 of 1
CO-ORDINATES(_)	102,068.94 E 148,244.72 N
GROUND LEVEL (m)	13.96
DATE STARTED	18/04/2007
DATE COMPLETED	18/04/2007
CLIENT	Shannon LNG
ENGINEER	Arup Consulting Engineers
EXCAVATION METHOD	14t Track

Scale (m)	Geotechnical Description	Legend	Depth (m)	Elevation (m OD)	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
0.0	Brown clay loam TOPSOIL									
	Firm friable orange brown sandy slightly gravelly to gravelly CLAY with some sandstone cobbles. Gravel is fine to coarse angular and subangular of sandstone and siltstone.		0.35	13.61		AA8534	D	0.35-0.55		
1.0 2.0	Stiff to very stiff fissured and slightly friable light grey brown and red brown mottled sandy slightly gravelly CLAY locally grading to very clayey sand and gravel with some (c. 10%) subangular and subrounded sandstone cobbles and occasional boulders (<0.50m). Gravel is fine to coarse angular to subrounded of sandstone and siltstone. Below c. 1.00m bgl grey brown. Below c. 1.50m bgl stiff fissured grey brown and reddish brown. Below c. 2.00m bgl brown, loss of mottling, less fissured.		0.55	13.41		AA8535 AA8536 AA8537 AA8538 AA8539	B D B D B	0.70-0.80 1.00-1.10 1.50-1.60 1.90-2.00 2.40-2.50		
3.0	Very stiff hard fissured grey brown sandy slightly gravelly CLAY with some (c. 10%) subangular sandstone cobbles. Gravel is fine to coarse subangular and subrounded of sandstone and siltstone.		2.70	11.26		AA8540 AA8541	D B	2.90-3.00 3.60-3.70		
4.0	Stiff friable brown sandy to very sandy slightly gravelly CLAY with occasional subangular sandstone. Gravel is fine to coarse subangular and subrounded of sandstone and siltstone.		3.90	10.06		AA8542	D	4.10-4.20		
	End of Trial Pit at 4.20m		4.20	9.76						

Groundwater Conditions
No groundwater encountered during excavation.

Stability
Relatively stable

General Remarks
Orientation North-South. Dimensions 1.70m x 4.20m x 4.20m. Mailn Head Ordnance Datum used.

Figure TPA 12

TRIAL PIT RECORD

REPORT NUMBER	12239
CONTRACT	Tarbert/Ballylongford Embankment-Pond SI
TRIAL PIT NO.	TPA13
SHEET	Sheet 1 of 1
CO-ORDINATES(_)	101,938.29 E 148,021.16 N
GROUND LEVEL (m)	16.67
DATE STARTED	18/04/2007
DATE COMPLETED	18/04/2007
CLIENT	Shannon LNG
ENGINEER	Arup Consulting Engineers
EXCAVATION METHOD	14t Track

Geotechnical Description	Legend	Depth (m)	Elevation (m OD)	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
Brown clay loam TOPSOIL		0.35	16.32						
Firm to stiff fissured and friable light grey, grey brown and red brown mottled sandy slightly gravelly CLAY with some/many (c. 20%) angular sandstone cobbles and occasional boulders (<0.40m). Gravel is fine to coarse subangular and subrounded of sandstone and siltstone. Below c. 1.00m bgl stiff to very stiff.		1.30	15.37		AA8550	B	0.50-0.70		
					AA8551	D	1.00-1.10		
Very stiff fissured brown sandy slightly gravelly CLAY some locally many (c. 10%-20%) subangular sandstone cobbles and occasional boulders (<0.40m). Gravel is fine to coarse subangular and subrounded of sandstone and siltstone. Below c. 2.00m stiff.		3.10	13.57		AA8552	B	1.40-1.50		
				1	AA8553	D	1.98-2.00		
					AA8554	B	2.40-2.50		
					AA8555	D	3.00-3.10		
Very stiff fissured bluish grey sandy slightly gravelly CLAY with some (c. 10%) subangular sandstone cobbles and occasional boulders (<0.40m). Gravel is fine to coarse subangular and subrounded of sandstone and siltstone.		4.00	12.67		AA8556	B	3.30-3.40		
					AA8557	D	3.90-4.00		
End of Trial Pit at 4.00m									

Depth scale: 0.0, 1.0, 2.0, 3.0, 4.0

Groundwater Conditions
Seepages from fissures below c. 2.00m bgl.

Stability
Relatively stable

General Remarks
Orientation North-South. Dimensions 1.70m x 4.70m x 4.00m. Mailn Head Ordnance Datum used.

Figure TPA 13

TRIAL PIT RECORD

REPORT NUMBER	12239
CONTRACT	Tarbert/Ballylongford Embankment-Pond SI
TRIAL PIT NO.	TPA14
SHEET	Sheet 1 of 1
CO-ORDINATES(_)	102,004.85 E 148,096.45 N
GROUND LEVEL (m)	14.78
DATE STARTED	18/04/2007
DATE COMPLETED	18/04/2007
CLIENT	Shannon LNG
ENGINEER	Arup Consulting Engineers
EXCAVATION METHOD	14t Track

Scale (m)	Geotechnical Description	Legend	Depth (m)	Elevation (m OD)	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
0.0	Brown clay loam TOPSOIL									
	Firm friable orange brown sandy slightly gravelly CLAY with some (c. 10%-20%) subangular sandstone cobbles. Gravel is fine to coarse subangular and subrounded of sandstone and siltstone.		0.30	14.48		AA8566	B	0.40-0.60		
	Stiff fissured and slightly friable brown sandy locally very sandy slightly gravelly CLAY locally grading to very clayey sand and gravel with some (c. 10%) subangular sandstone cobbles and occasional boulders (<0.50m). Gravel is fine to coarse subangular and subrounded of sandstone and siltstone. Between 0.60m and 1.50m bgl, Very stiff light grey and reddish brown mottled. becoming a GRAVEL from 3.90m.		0.60	14.18						
1.0						AA8567	B	1.00-1.10		
						AA8568	D	1.50-1.70		
2.0						AA8569	B	1.90-2.00		
						AA8570	D	2.40-2.50		
3.0					1	AA8571	B	2.80-2.90		
						AA8572	D	3.40-3.50		
4.0	End of Trial Pit at 4.00m		4.00	10.78		AA8573	B	3.90-4.00		

Groundwater Conditions
Damp below 3.00m bgl.

Stability
Relatively stable

General Remarks
Orientation North-South. Dug at top of slope. Dimensions 1.70m x 4.80m x 4.00m. Mailn Head Ordnance Datum used.

Figure TPA 14

TRIAL PIT RECORD

IGSL	REPORT NUMBER 12239
CONTRACT	Tarbert/Ballylongford Embankment-Pond SI
TRIAL PIT NO.	TPA15
SHEET	Sheet 1 of 1
CO-ORDINATES(_)	102,070.96 E 148,171.48 N
GROUND LEVEL (m)	16.76
DATE STARTED	17/04/2007
DATE COMPLETED	17/04/2007
CLIENT	Shannon LNG
ENGINEER	Arup Consulting Engineers
EXCAVATION METHOD	14t Track

Scale (m)	Geotechnical Description	Legend	Depth (m)	Elevation (m OD)	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
0.0	Brown clay loam TOPSOIL									
	Firm friable orange brown sandy slightly gravelly CLAY with occasional rootlets. Gravel is fine to coarse angular and subangular of sandstone and siltstone.		0.30	16.46		AA8518	D	0.30-0.50		
	Stiff fissured and friable brown sandy locally very sandy slightly gravelly CLAY wth some (c. 10%) subangular sandstone cobbles and occasional boulders (<1.0m). Locally intermixed with very clayey/very silty sand and gravel. Gravel is fine to coarse angular and subangular of sandstone and siltstone. Between 0.50m and 1.50m bgl light grey brown locally very stiff (desiccated).		0.50	16.26		AA8519	B	0.50-0.70		
1.0						AA8520	D	1.00-1.10		
						AA8521	B	1.40-1.50		
2.0						AA8522	D	2.00-2.10		
						AA8523	B	2.40-2.50		
3.0						AA8524	D	2.90-3.00		
						AA8525	B	3.40-3.50		
4.0						AA8526	D	4.00-4.20		
	End of Trial Pit at 4.20m		4.20	12.56						

Groundwater Conditions
No groundwater encountered during excavation.

Stability
Relatively stable

General Remarks
Orientation North-South. Dimensions 1.70m x 5.00m x 4.20m. Mailn Head Ordnance Datum used.

Figure TPA 15

TRIAL PIT RECORD

REPORT NUMBER	12239
CONTRACT	Tarbert/Ballylongford Embankment-Pond SI
TRIAL PIT NO.	TPA16
SHEET	Sheet 1 of 1
CO-ORDINATES(_)	101,993.24 E 148,008.86 N
GROUND LEVEL (m)	16.85
DATE STARTED	18/04/2007
DATE COMPLETED	18/04/2007
CLIENT	Shannon LNG
ENGINEER	Arup Consulting Engineers
EXCAVATION METHOD	14t Track

Scale (m)	Geotechnical Description	Legend	Depth (m)	Elevation (m OD)	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
0.0	Brown clay loam TOPSOIL					AA8545	B	0.25-1.50		
	Assessed as compact reddish brown very clayey SAND and GRAVEL with some (c. 10%-15%) locally some/many (c. 20%) subangular sandstone cobbles and with occasional boulders (<0.40m). Gravel is fine to coarse subangular and subrounded of sandstone and siltstone. Locally grading to very sandy gravelly clay and very silty very sandy gravel.		0.40	16.45		AA8543	B	0.50-0.60		
1.0	Stiff fissured light grey, grey brown and reddish brown mottled sandy slightly gravelly CLAY.		1.00	15.85		AA8544	D	1.00-1.10		
	Very stiff fissured and friable brown sandy slightly gravelly CLAY with some (c. 10%) subangular sandstone cobbles and occasional boulders (<0.40m). Gravel is fine to coarse subangular and subrounded of sandstone and siltstone. Below c. 2.00m bgl stiff to very stiff.		1.30	15.55						
2.0						AA8546	D	1.90-2.00		
						AA8547	B	2.30-2.40		
3.0						AA8548	D	3.00-3.10		
	Stiff friable sandy to very sandy gravelly CLAY/very clayey SAND and GRAVEL with some/many (c. 20%) subangular sandstone cobbles and occasional boulders (<0.80m). Gravel is fine to coarse subangular and subrounded of sandstone and siltstone.		3.10	13.75	▼	AA8549	B	3.40-3.60		
4.0	Obstruction. End of Trial Pit at 3.90m		3.90	12.95						

Groundwater Conditions
Seepage below 3.50m.

Stability
Relatively stable

General Remarks
Orientation North-South. Dimensions 1.70m x 5.50m x 3.90m. Pit terminated at 3.90m bgl, boulder. Mailn Head Ordnance Datum used.

Figure TPA 16

TRIAL PIT RECORD

REPORT NUMBER	12239
CONTRACT	Tarbert/Ballylongford Embankment-Pond SI
TRIAL PIT NO.	TPA17
SHEET	Sheet 1 of 1
CO-ORDINATES(_)	102,060.42 E 148,085.10 N
GROUND LEVEL (m)	10.07
DATE STARTED	19/04/2007
DATE COMPLETED	19/04/2007
CLIENT	Shannon LNG
ENGINEER	Arup Consulting Engineers
EXCAVATION METHOD	14t Track

Scale (m)	Geotechnical Description	Legend	Depth (m)	Elevation (m OD)	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
0.0	Brown clay loam TOPSOIL		0.35	9.72						
	Moderately weathered fractured thinly bedded moderately strong light grey with dark grey staining SILTSTONE.		0.50	9.57						
	End of Trial Pit at 0.50m									
1.0										
2.0										
3.0										
4.0										

Groundwater Conditions
No groundwater encountered during excavation.

Stability
Relatively stable

General Remarks
Orientation North-South. Dug at toe of slope. Dimensions 1.70m x 3.70m x 0.50m. No samples taken. Mailn Head Ordnance Datum used.

Figure TPA 17

TRIAL PIT RECORD

REPORT NUMBER	12239
CONTRACT	Tarbert/Ballylongford Embankment-Pond SI
TRIAL PIT NO.	TPA18
SHEET	Sheet 1 of 1
CO-ORDINATES(_)	102,056.24 E 148,003.27 N
GROUND LEVEL (m)	16.32
DATE STARTED	19/04/2007
DATE COMPLETED	19/04/2007
CLIENT	Shannon LNG
ENGINEER	Arup Consulting Engineers
EXCAVATION METHOD	14t Track

Scale (m)	Geotechnical Description	Legend	Depth (m)	Elevation (m OD)	Water Strike	Sample Ref	Type	Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
0.0	Brown clay loam TOPSOIL		0.45	15.87		AA8574	D	0.30-0.40		
	Firm fissured and friable light grey and reddish brown sandy slightly gravelly CLAY with some angular and subangular sandstone cobbles and occasional/some boulders (<1.0m). Gravel is fine to coarse subangular and subrounded of sandstone and siltstone. Push-in U100 - 80% recovery.		1.05	15.27		AA8575 AA8576	B U	0.60-0.70 0.70-1.15		
1.0	Stiff friable brown sandy gravelly CLAY grading to very clayey sandy and gravel intermixed with stiff fissured light grey and reddish brown mottled sandy slightly gravelly CLAY. Many angular and subangular siltstone cobbles and some siltstone boulders (<0.50m). Gravel is fine to coarse angular and subangular of siltstone.		1.70	14.62	1	AA8577 AA8578	D B	1.15-1.20 1.50-1.60		
	Moderately weathered fractured thinly bedded moderately strong light grey SILTSTONE. End of Trial Pit at 1.70m									
2.0										
3.0										
4.0										

Groundwater Conditions
Seepage at 1.50m bgl.

Stability
Relatively stable

General Remarks
Orientation East-West. Rockhead variable 1.40m - 1.70m bgl. Dimensions 1.70m x 4.60m x 1.70m. Mailn Head Ordnance Datum used.

Figure TPA 18

TRIAL PIT RECORD

REPORT NUMBER	12239

CONTRACT	Tarbert/Ballylongford Embankment-Pond SI	TRIAL PIT NO.	TPA19
		SHEET	Sheet 1 of 1
CO-ORDINATES(_)	102,122.35 E 148,078.30 N	GROUND LEVEL (m)	15.32
		DATE STARTED	17/04/2007
		DATE COMPLETED	17/04/2007
CLIENT	Shannon LNG	EXCAVATION METHOD	14t Track
ENGINEER	Arup Consulting Engineers		

Scale (m)	Geotechnical Description	Legend	Depth (m)	Elevation (m OD)	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
0.0	Brown clay loam TOPSOIL		0.30	15.02						
	Stiff fissured slightly friable orange brown and light grey brown mottled sandy slightly gravelly CLAY with occasional subangular sandstone cobbles. Gravel is fine to coarse angular and subangular of sandstone and siltstone. Push-in U100 - 100% recovery.		0.70	14.62		AA8529 AA8530	B U	0.40-0.50 0.50-0.95		
1.0	Stiff to very stiff fissured light bluish grey and orange brown mottled sandy slightly gravelly CLAY with occasional/some (5%-10%) subangular and subrounded sandstone cobbles and occasional boulders (<0.60m). Gravel is fine to coarse subangular and subrounded of sandstone and siltstone.		1.40	13.92	1	AA8531 AA8532	D B	0.95-1.00 1.30-1.40		
	Assessed as moderately compact dark brown very clayey/very silty SAND and GRAVEL locally grading to firm fissured and friable sandy to very sandy slightly gravelly CLAY with some/many (c. 20%) angular siltstone cobbles and some angular (tabular) siltstone boulders. Gravel is fine to coarse angular and subangular and sandstone and silstone.		2.00	13.32		AA8533	D	1.50-1.60		
2.0	Weathered fractured light grey SILTSTONE. Bedrock at 1.55m bgl in West Face. End of Trial Pit at 2.00m									
3.0										
4.0										

Groundwater Conditions
Damp below 1.40m bgl.

Stability
Relatively stable

General Remarks
Orientation North-South. Dug across slight slope. Dimensions 1.70m x 3.70m x 2.00m. Mailn Head Ordnance Datum used.

Figure TPA 19

TRIAL PIT RECORD

IGSL	TRIAL PIT RECORD	REPORT NUMBER 12239
CONTRACT	Tarbert/Ballylongford Embankment-Pond SI	TRIAL PIT NO. TPA20
		SHEET Sheet 1 of 1
CO-ORDINATES(_)	102,135.49 E 148,017.00 N	GROUND LEVEL (m) 14.36
		DATE STARTED 19/04/2007
		DATE COMPLETED 19/04/2007
CLIENT	Shannon LNG	EXCAVATION METHOD 14t Track
ENGINEER	Arup Consulting Engineers	

Scale	Geotechnical Description	Legend	Depth (m)	Elevation (m OD)	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
0.0	Brown clay loam TOPSOIL									
	Assessed as compact light grey and brown mottled very silty very sandy fine to coarse angular and subangular sandstone and siltstone GRAVEL with some (c. 10%) angular siltstone cobbles and some angular boulders of boulders (<1.0m). Below 0.85m bgl intermixed with very stiff grey sandy slightly gravelly clay with many angular silstone cobbles.		0.30	14.06	1					
1.0	Moderately weathered fractured thinly bedded moderately strong light grey with drak grey staining SILTSTONE with fracture infilling of grey sandy gravelly clay. End of Trial Pit at 1.00m		1.00	13.36						
2.0										
3.0										
4.0										

Groundwater Conditions
Seepage below 0.80m bgl.

Stability
Relatively stable

General Remarks
Orientation North-South. Dug on flat ground adjacent to stream. Dimensions 1.70m x 3.10m x 1.00m. No samples taken. Mailn Head Ordnance Datum used.

Figure TPA 20

TRIAL PIT RECORD

REPORT NUMBER	12239
CONTRACT	Tarbert/Ballylongford Embankment-Pond SI
TRIAL PIT NO.	TPADD1
SHEET	Sheet 1 of 1
CO-ORDINATES(_)	102,039.00 E 147,879.00 N
GROUND LEVEL (m)	21.20
DATE STARTED	19/04/2007
DATE COMPLETED	19/04/2007
CLIENT	Shannon LNG
ENGINEER	Arup Consulting Engineers
EXCAVATION METHOD	14t Track

Geotechnical Description	Legend	Depth (m)	Elevation (m OD)	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
Brown clay loam TOPSOIL		0.30	20.90						
Firm' friable orange brown sandy slightly gravelly CLAY with occasional subangular sandstone cobbles. Gravel is fine to coarse subangular and subrounded of sandstone and siltstone.		0.50	20.70						
Very stiff fissured and friable grey brown and reddish brown mottled sandy slightly gravelly CLAY with some (c. 10%) subangular sandstone cobbles and occasional boulders (<0.40m). Gravel is fine to coarse subangular and subrounded of sandstone and siltstone.		1.20	20.00						
Assessed as compact brown very clayey SAND and GRAVEL with occasional/some (c. 5%-10%) angular cobbles of sandstone. Gravel is fine to coarse angular and subangular of sandstone and siltstone.		2.30	18.90						
Moderately to hightly weathered fractured thinly bedded moderately strong light grey with dark grey staining SILTSTONE. Recovered as GRAVEL and COBBLES.		2.70	18.50						
End of Trial Pit at 2.70m									

Depth scale: 0.0, 1.0, 2.0, 3.0, 4.0

Groundwater Conditions
No groundwater encountered during excavation.

Stability
Relatively stable

General Remarks
Orientation East-West. Dimensions 1.70m x 4.20m x 2.70m. Pit dug at ther request of The Engineer. No samples taken. Mailn Head Ordnance Datum used.

Figure TPADD1

Appendix B - Embankment – Pond SI Rotary Coring Data

Rotary Corehole Records — Figures: RCA 1 - 4

GEOTECHNICAL CORE LOG RECORD

IGSL

REPORT NUMBER 12610

CONTRACT	Tarbert/Ballylongford Embankment-Pond SI	**DRILLHOLE NO**	**RC A1**
		SHEET	Sheet 1 of 2
CO-ORDINATES(_)	101,865.44 E 148,080.15 N	**DATE STARTED**	18/04/2007
GROUND LEVEL (m)	13.91	**DATE COMPLETED**	18/04/2007
CORE DIAMETER (mm)	78	**DRILLED BY**	Mill Drill
INCLINATION		**LOGGED BY**	IGSL
FLUSH	Air/mist		
CLIENT	Shannon LNG		
ENGINEER	Arup Consulting Engineers		

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation (mOD)	Standpipe Details	SPT (N Value)
0							SYMMETRIX OPEN HOLE DRILLING: Observed by driller as returns of clay.	1.40		12.51		
1.40							SYMMETRIX OPEN HOLE DRILLING: Observed by driller as returns of gravelly clay.	9.00		4.91		N = 19 (3, 4, 3, 5, 4, 7) N = 23 (2, 3, 6, 5, 8, 4) N = 32 (4, 9, 10, 7, 8, 7) N = 34 (5, 6, 8, 7, 10, 9) N = 34 (4, 5, 7, 7, 9, 11) N = 41 (5, 5, 8, 11, 12, 10)
9.00	9.80						SYMMETRIX OPEN HOLE DRILLING: Observed by driller as angular gravel size returns of siltstone (probable bedrock).	9.80		4.11		

REMARKS

3 Core boxes. Move and set up 1hr.100mm wavin pipe installed from GL to 9.8m. Malin Head Ordnance Datum used

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

Figure RCA1 (1 of 2)

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12610

CONTRACT	Tarbert/Ballylongford Embankment-Pond SI	**DRILLHOLE NO**	**RC A1**
		SHEET	Sheet 2 of 2
CO-ORDINATES(_)	101,865.44 E 148,080.15 N	**DATE STARTED**	18/04/2007
GROUND LEVEL (m)	13.91	**DATE COMPLETED**	18/04/2007
CORE DIAMETER (mm)	78		
CLIENT	Shannon LNG	**DRILLED BY**	Mill Drill
ENGINEER	Arup Consulting Engineers	**LOGGED BY**	IGSL
INCLINATION			
FLUSH	Air/mist		

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation (mOD)	Standpipe Details	SPT (N Value)
10		100	0	0			Moderately strong to locally strong and locally moderately weak, thinly bedded (laminations within), dark grey to black and locally grey, fine grained, SILTSTONE with interbedded shale. Fresh to slightly and locally moderately weathered. *(continued)*		Discontinuities are smooth and planar to locally undulose. Apertures are tight to moderately open with locally iron oxide stained. Locally clay gravel infilled (10.4m-10.56m). Dips are sub-20° with locally sub-vertical fractures (9.95m-9.99m, 10.12m-10.17m, 10.64m-10.79m, 11.5m-11.6m, 11.64m-11.79m, 12.13m-12.18, 13.01m-13.1m, 13.91m-14.02m, 15.53m-15.63m, 16.58m-16.7m). *(continued)*			
11	10.30	100	37	10								
12	11.60	100	77	7								
13	13.10	100	35	0								
14	14.60	100	42	0								
15	15.20	100	71	29								
16	16.70						End of Corehole at 16.7 (m)	16.70		-2.79		
17												
18												
19												

REMARKS

3 Core boxes. Move and set up 1hr.100mm wavin pipe installed from GL to 9.8m. Malin Head Ordnance Datum used

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

RC OLDLOG1 12239.GPJ IGSL.GDT 13/11/07

Figure RCA1 (2 of 2)

GEOTECHNICAL CORE LOG RECORD

IGSL

REPORT NUMBER 12610

CONTRACT	Tarbert/Ballylongford Embankment-Pond SI	**DRILLHOLE NO**	**RC A2**
		SHEET	Sheet 1 of 3
CO-ORDINATES(_)	101,945.00 E 148,166.00 N	**DATE STARTED**	16/04/2007
GROUND LEVEL (m)	7.08	**DATE COMPLETED**	18/04/2007
CORE DIAMETER (mm)	78	**DRILLED BY**	Mill Drill
INCLINATION		**LOGGED BY**	IGSL
CLIENT	Shannon LNG		
ENGINEER	Arup Consulting Engineers		
FLUSH	Air/mist		

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation (mOD)	Standpipe Details	SPT (N Value)
0 – 1.70							SYMMETRIX OPEN HOLE DRILLING: Observed by driller as returns of gravelly clay.	1.70		5.38		
1.70 – 2.10							SYMMETRIX OPEN HOLE DRILLING: Observed by driller as angular gravel size returns of siltstone (probable bedrock).	2.10		4.98		
2.10 – 4.90	2.10–2.30	100	40	0			Strong to moderately strong, thinly bedded, grey to locally dark grey, fine to medium grained, SILTSTONE. Fresh to slightly and locally moderately weathered.	4.90	Discontinuities are smooth to locally rough and planar to locally slightly undulose. Apertures are tight to locally open with commonly iron oxide stained surfaces. Dips are sub-10° with locally sub-vertical fractures (2.1m-2.2m, 3.09m-3.2m, 3.52m-3.62m).	2.18		
	2.30–2.80	100	68	0								
	2.80–3.10	100	53	0								
	3.10–3.30	100	0	0								
	3.30–3.70	100	33	0								
	3.70–4.80	100	45	32								
4.90 –	4.80–6.10	100	71	0			Strong to moderately strong, medium to thinly bedded (cross bedded laminations), dark grey to black, fine to locally medium (6.3m-6.9m) grained, SILTSTONE with interbedded grey sandstone. Fresh to locally slightly weathered (hairline fractures throughout 0.5cm-1cm apart).		Discontinuities are smooth to locally rough and planar to locally slightly undulose. Apertures are tight to locally open with commonly iron oxide stained surfaces. Dips are sub-10° with locally sub-vertical fractures (4.97m-5.04m, 6.27m-6.32m, 12.6m-12.68m, 14.45m-14.56m).			
	6.10–7.30	100	56	28								
	7.30–8.70	100	97	0								
	8.70–	100	94	0								

REMARKS

7 Core boxes. Move and set up 2hrs. Packer tests at 6.0m-7.10m (WL @ 1.13mbgl), 9.0m-10.0m (double; WL @ 0.50mbgl), 13.0m-14.0m (WL @ 0.34 mbgl) (Total 7½hrs). Water flowing over top of corehole during initial core runs. 100mm wavin pipe installed from GL - 2.10m bgl. Malin Head Ordnance Datum used

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

Figure RCA2
(1 of 3)

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER	12610
CONTRACT	Tarbert/Ballylongford Embankment-Pond SI
DRILLHOLE NO	RC A2
SHEET	Sheet 2 of 3
CO-ORDINATES(_)	101,945.00 E 148,166.00 N
GROUND LEVEL (m)	7.08
CORE DIAMETER (mm)	78
INCLINATION	
FLUSH	Air/mist
DATE STARTED	16/04/2007
DATE COMPLETED	18/04/2007
CLIENT	Shannon LNG
ENGINEER	Arup Consulting Engineers
DRILLED BY	Mill Drill
LOGGED BY	IGSL

Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%
10.30	100	90	43
11.90	100	96	51
13.40	100	68	43
14.20	100	70	59
15.30	100	82	75
16.70	100	79	65
17.80	100	85	67
18.60	100	98	92

Downhole Depth (m): 10 – 19

Description: Strong to moderately strong, medium to thinly bedded (cross bedded laminations), dark grey to black, fine to locally medium (6.3m-6.9m) grained, SILTSTONE with interbedded grey sandstone. Fresh to locally slightly weathered (hairline fractures throughout 0.5cm-1cm apart). *(continued)*

Depth (m): 19.90

Discontinuities: Discontinuities are smooth to locally rough and planar to locally slightly undulose. Apertures are tight to locally open with commonly iron oxide stained surfaces. Dips are sub-10° with locally sub-vertical fractures (4.97m-5.04m, 6.27m-6.32m, 12.6m-12.68m, 14.45m-14.56m). *(continued)*

End of Corehole at 19.90m

REMARKS

7 Core boxes. Move and set up 2hrs. Packer tests at 6.0m-7.10m (WL @ 1.13mbgl), 9.0m-10.0m (double; WL @ 0.50mbgl), 13.0m-14.0m (WL @ 0.34 mbgl) (Total 7½hrs). Water flowing over top of corehole during initial core runs. 100mm wavin pipe installed from GL - 2.10m bgl. Malin Head Ordnance Datum used

INSTALLATION REMARKS

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

Figure RCA2 (2 of 3)

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER	12610

CONTRACT	Tarbert/Ballylongford Embankment-Pond SI	DRILLHOLE NO	RC A2
		SHEET	Sheet 3 of 3
CO-ORDINATES(_)	101,945.00 E 148,166.00 N	DATE STARTED	16/04/2007
GROUND LEVEL (m)	7.08	DATE COMPLETED	18/04/2007
CORE DIAMETER (mm)	78	DRILLED BY	Mill Drill
INCLINATION		LOGGED BY	IGSL
CLIENT	Shannon LNG		
ENGINEER	Arup Consulting Engineers		
FLUSH	Air/mist		

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation (mOD)	Standpipe Details	SPT (N Value)
20	19.90									-12.82		
21												
22												
23												
24												
25												
26												
27												
28												
29												

REMARKS

7 Core boxes. Move and set up 2hrs. Packer tests at 6.0m-7.10m (WL @ 1.13mbgl), 9.0m-10.0m (double; WL @ 0.50mbgl), 13.0m-14.0m (WL @ 0.34 mbgl) (Total 7½hrs). Water flowing over top of corehole during initial core runs. 100mm wavin pipe installed from GL - 2.10m bgl. Malin Head Ordnance Datum used

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

Figure RCA2
(3 of 3)

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER
12610

CONTRACT	Tarbert/Ballylongford Embankment-Pond SI	**DRILLHOLE NO**	**RC A3**
		SHEET	Sheet 1 of 2
CO-ORDINATES(_)	101,953.98 E 148,220.51 N	**DATE STARTED**	19/04/2007
GROUND LEVEL (m)	6.38	**DATE COMPLETED**	20/04/2007
CORE DIAMETER (mm)	78		
CLIENT	Shannon LNG	**DRILLED BY**	Mill Drill
ENGINEER	Arup Consulting Engineers	**LOGGED BY**	IGSL
INCLINATION			
FLUSH	Air/mist		

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation (mOD)	Standpipe Details	SPT (N Value)
0							SYMMETRIX OPEN HOLE DRILLING: Observed by driller as returns of gravelly clay.	4.60		1.78		
5	5.00	100	99	65			SYMMETRIX OPEN HOLE DRILLING: Observed by driller as angular gravel size returns of siltstone (probable bedrock).	5.00		1.38		
	6.50	100	93	75			Very strong to strong, medium to thinly bedded, grey, fine to medium grained SILTSTONE. Freshly weathered.	8.70	Discontinuities are slightly rough and planar to locally undulose. Apertures are tight to moderately open. Dips are sub-20° with locally sub-vertical fractures (8.3m-8.38m, 9.33m-9.39m, 9.98m-10.17m, 10.32m-10.55m, 10.79m-10.83m, 11.44m-11.58m, 15.12m-15.24m).	-2.32		
	8.10	100	85	30								
	9.50											

REMARKS

5 Core boxes. Move and set up 2½hrs. Packer tests at 7.0m-8.0m (WL @ 1.89m bgl) and 9.80 - 10.80m (WL @ 0.59m bgl) (4½hrs). 100mm wavin pipe installed GL - 0.50m bgl.Malin Head Ordnance Datum used

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

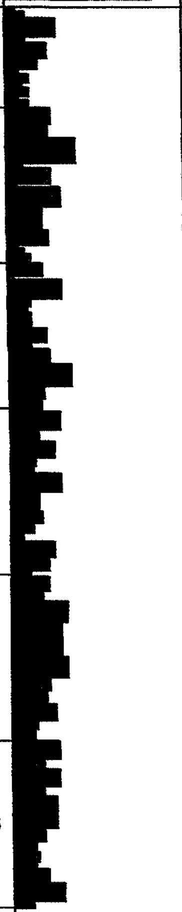
RC OLDLOG1 12239.GPJ IGSL.GDT 13/11/07

Figure RCA3 (1 of 2)

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER	12610

CONTRACT	Tarbert/Ballylongford Embankment-Pond SI	DRILLHOLE NO	RC A3
		SHEET	Sheet 2 of 2
CO-ORDINATES(_)	101,953.98 E 148,220.51 N	GROUND LEVEL (m)	6.38
		CORE DIAMETER (mm)	78
		INCLINATION	
		FLUSH	Air/mist
DATE STARTED	19/04/2007	DATE COMPLETED	20/04/2007
CLIENT	Shannon LNG	DRILLED BY	Mill Drill
ENGINEER	Arup Consulting Engineers	LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation (mOD)	Standpipe Details	SPT (N Value)
10		100	40	7		× ×	Strong to locally very strong (10.9m-11.4m) and locally moderately strong, medium to thinly (cross-laminated) bedded, grey, dark grey and black, fine to locally medium grained SILTSTONE with interbedded shale. Freshly weathered. *(continued)*		Discontinuities are smooth and planar to locally undulose. Apertures are tight to locally open. Dips are sub-20° with locally sub-vertical fractures (9.33m-9.39m, 9.98m-10.10m, 10.79m-10.83m, 11.44m-11.11.58m, 15.12m-15.24m). *(continued)*			
11	10.90	100	99	72								
12	12.30	100	90	45								
13–14	13.60	100	95	36								
15	15.10	100	97	65								
16–17	16.60	100	98	75				18.10				
18	18.10						End of Corehole at 18.1 (m)			-11.72		
19												

REMARKS

5 Core boxes. Move and set up 2½hrs. Packer tests at 7.0m-8.0m (WL @ 1.89m bgl) and 9.80 - 10.80m (WL @ 0.59m bgl) (4½hrs). 100mm wavin pipe installed GL - 0.50m bgl.Malin Head Ordnance Datum used

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

Figure RCA3
(2 of 2)

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER	12610
CONTRACT	Tarbert/Ballylongford Embankment-Pond SI
DRILLHOLE NO	RC A4
SHEET	Sheet 1 of 2
CO-ORDINATES(_)	102,010.83 E 148,239.45 N
GROUND LEVEL (m)	11.69
CORE DIAMETER (mm)	78
INCLINATION	
FLUSH	Air/mist
DATE STARTED	21/04/2007
DATE COMPLETED	21/04/2007
CLIENT	Shannon LNG
ENGINEER	Arup Consulting Engineers
DRILLED BY	Mill Drill
LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation (mOD)	Standpipe Details	SPT (N Value)
0							SYMMETRIX OPEN HOLE DRILLING: Observed by driller as returns of gravelly clay.					
1–2												N = 18 (3, 4, 3, 5, 4, 6)
2–3												N = 23 (4, 4, 7, 6, 5, 5)
4												N = 50/10 mm (14, 11, 50)
5–6												N = 34 (7, 5, 8, 10, 7, 9)
								6.70		4.99		
							SYMMETRIX OPEN HOLE DRILLING: Observed by driller as angular gravel size returns of siltstone (probable bedrock).	7.00		4.69		
7	7.00–7.50	100	96	70			Strong to moderately strong, thinly (cross-laminated) bedded, grey, dark grey and black, fine to coarse grained SILTSTONE with interbedded fine grained shale. Freshly to locally slightly/moderately weathered.		Discontinuities are smooth and planar to locally undulose. Apertures are tight to moderately open with local slight to moderate iron oxide staining and locally silt smeared surfaces. Dips are sub-10° with frequent short (>10cm) sub-vertical fractures.			
8	7.50–8.70	100	23	13								
9	8.70–	100	71	21								

REMARKS

4 Core boxes. Move and set up 1hr. 100mm wavin pipe installed from GL - 7.0m bgl. Malin Head Ordnance Datum used

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

RC OLDLOG1 12239.GPJ IGSL.GDT 13/11/07

Figure RCA4 (1 of 2)

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER
12610

CONTRACT	Tarbert/Ballylongford Embankment-Pond SI	**DRILLHOLE NO**	RC A4
		SHEET	Sheet 2 of 2
CO-ORDINATES(_)	102,010.83 E 148,239.45 N	**GROUND LEVEL (m)**	11.69
		CORE DIAMETER (mm)	78
		DATE STARTED	21/04/2007
		DATE COMPLETED	21/04/2007
CLIENT	Shannon LNG	**INCLINATION**	
ENGINEER	Arup Consulting Engineers	**FLUSH**	Air/mist
		DRILLED BY	Mill Drill
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation (mOD)	Standpipe Details	SPT (N Value)
10	10.30					x x	Strong to moderately strong, thinly (cross-laminated) bedded, grey, dark grey and black, fine to coarse grained SILTSTONE with interbedded fine grained shale. Freshly to locally slightly/moderately weathered. *(continued)*		Discontinuities are smooth and planar to locally undulose. Apertures are tight to moderately open with local slight to moderate iron oxide staining and locally silt smeared surfaces. Dips are sub-10° with frequent short (>10cm) sub-vertical fractures. *(continued)*			
11		100	63	27								
12	11.80	100	81	46								
13	12.90	100	36	0								
14	13.70	100	49	14								
15												
16	15.30	100	75	29				16.90				
17	16.90						End of Corehole at 16.9 (m)			-5.21		
18												
19												

REMARKS

4 Core boxes. Move and set up 1hr. 100mm wavin pipe installed from GL - 7.0m bgl. Malin Head Ordnance Datum used

INSTALLATION REMARKS

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

RC OLDLOG1 12239.GPJ IGSL.GDT 13/11/07

Figure RCA4
(2 of 2)

Appendix C - Embankment – Pond SI Packer Test Data

Packer Test Data Sheets	Figures PT 1 - 5

PACKER TEST RESULT SHEET — IGSL (F13)

JOB NO.	12239	GROUND LEVEL (mOD Malin Head)	7.08
CONTRACT	Tar/Ballylong	BOTTOM OF HOLE (m)	7.10
LOCATION	Co. Kerry	TOP OF TEST SECTION (m)	6.00
		BOTTOM OF TEST SECTION (m)	7.10
BOREHOLE NO.	RC-A02	CENTRE OF TEST SECTION (m)	6.55
TEST NO.	1	GUAGE HEIGHT ABOVE GROUND LEVEL (m)	0.40
		INITIAL GROUND WATER LEVEL (m)	1.13

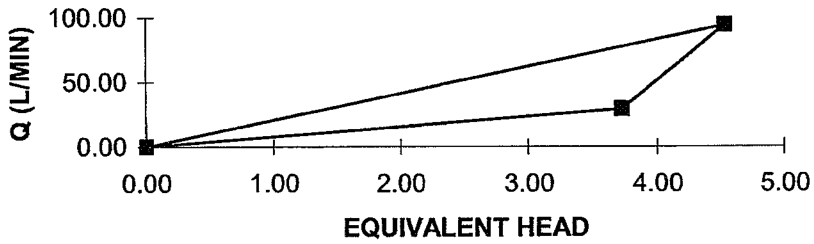
FLOW METER READINGS

RUN NUMBER	PRESSURE (BAR)	0 MIN (LITRES)	2 MIN (LITRES)	5 MIN (LITRES)	10 MIN (LITRES)	14 MIN (LITRES)	25 MIN (LITRES)
1	0.22	11220.0	11308.0	11419.5	11579.0	11671.5	n/a
		14 MIN (LITRES)	16 MIN (LITRES)	16 MIN (LITRES)	17 MIN (LITRES)		
2	0.3	11780.0	11890.0	11990.0	12090.0	n/a	n/a

WATER TAKEN

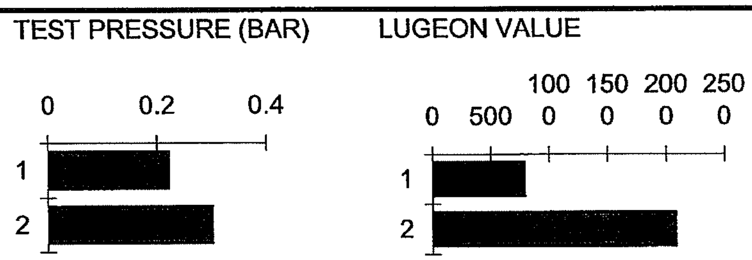
RUN NUMBER	0-2 MIN (LITRES)	2-5 MIN (LITRES)	5-10 MIN (LITRES)	10-14 MIN (LITRES)	20-25 MIN (LITRES)	Cumlative (LITRES)	Q (L/MIN)
1	88.00	111.50	159.50	92.50	n/a	451.50	32.25
	14-15 MIN (LITRES)	15-16 MIN (LITRES)	16-17 MIN (LITRES)	0-2 MIN (LITRES)			
2	110.00	100.00	100.00	n/a	n/a	310.00	103.33

EQUIVALENT HEAD (M)	Q (L/MIN/METRE)
0.00	0.00
3.73	29.32
4.53	93.94
0.00	0.00



AVERAGE LUGEON **1429.9**

Analysis by Houlsbey Method



Notes:
Packer Pressure: 90 PSI Start Time: 17:10 16/04/2007
Gooseneck: 0.95m bgl Stick-up 0.52m
Geology: Fractured SILTSTONE

PACKER TEST RESULT SHEET

IGSL (F13)

JOB NO.	12239	GROUND LEVEL (mOD Malin Head)	7.08
CONTRACT	Tar/Ballylong	BOTTOM OF HOLE (m)	14.50
LOCATION	Co. Kerry	TOP OF TEST SECTION (m)	13.00
		BOTTOM OF TEST SECTION (m)	14.50
BOREHOLE NO.	RC-A02	CENTRE OF TEST SECTION (m)	13.75
TEST NO.	2	GUAGE HEIGHT ABOVE GROUND LEVEL (m)	0.35
		INITIAL GROUND WATER LEVEL (m)	0.34

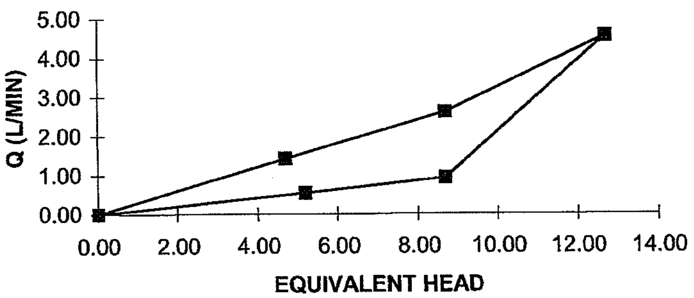
FLOW METER READINGS

RUN NUMBER	PRESSURE (BAR)	0 MIN (LITRES)	5 MIN (LITRES)	10 MIN (LITRES)	15 MIN (LITRES)	20 MIN (LITRES)	25 MIN (LITRES)
1	0.45	12169.0	12173.5	12177.4	12181.3	n/a	n/a
2	0.8	12181.3	12188.5	12195.5	12202.2	n/a	n/a
3	1.2	12202.2	12232.3	12271.0	12304.5	n/a	n/a
4	0.8	12304.5	12323.2	12343.3	12363.2	n/a	n/a
5	0.4	12363.2	12373.5	12385.1	12395.3	n/a	n/a

WATER TAKEN

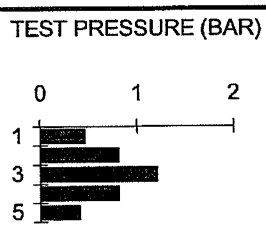
RUN NUMBER	0-5 MIN (LITRES)	5-10 MIN (LITRES)	10-15 MIN (LITRES)	15-20 MIN (LITRES)	20-25 MIN (LITRES)	Cumlative (LITRES)	Q (L/MIN)
1	4.50	3.90	3.90	n/a	n/a	12.30	0.82
2	7.20	7.00	6.70	n/a	n/a	20.90	1.39
3	30.10	38.70	33.50	n/a	n/a	102.30	6.82
4	18.70	20.10	19.90	n/a	n/a	58.70	3.91
5	10.30	11.60	10.20	n/a	n/a	32.10	2.14

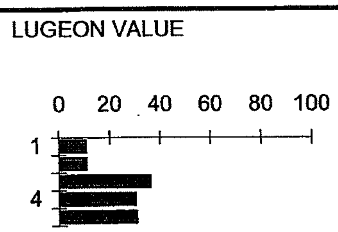
EQUIVALENT HEAD (M)	Q (L/MIN/METRE)
0.00	0.00
5.19	0.55
8.69	0.93
12.69	4.55
8.69	2.61
4.69	1.43
0.00	0.00



AVERAGE LUGEON **23.5**

Analysis by Houlsbey Method





Notes:

Packer Pressure: 90 PSI Start Time: 09:00 17/04/2007
Gooseneck: 1.25m bgl Stick-up 0.52m
Geology: Fracured SILTSTONE
Single Packer

PACKER TEST RESULT SHEET

IGSL (F13)

JOB NO.	12239	GROUND LEVEL (mOD Malin Head)	7.08
CONTRACT	Tar/Ballylong	BOTTOM OF HOLE (m)	18.30
LOCATION	Co. Kerry	TOP OF TEST SECTION (m)	9.00
		BOTTOM OF TEST SECTION (m)	10.00
BOREHOLE NO.	RC-A02	CENTRE OF TEST SECTION (m)	9.50
TEST NO.	3	GUAGE HEIGHT ABOVE GROUND LEVEL (m)	0.35
		INITIAL GROUND WATER LEVEL (m)	0.50

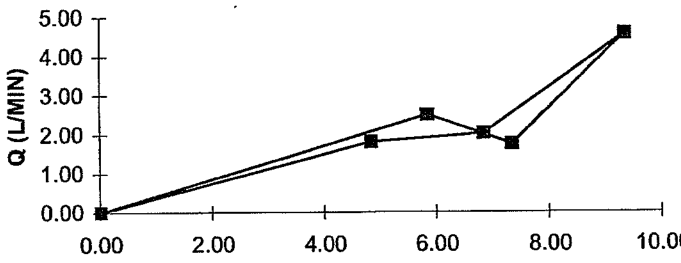
FLOW METER READINGS

RUN NUMBER	PRESSURE (BAR)	0 MIN (LITRES)	5 MIN (LITRES)	10 MIN (LITRES)	15 MIN (LITRES)	20 MIN (LITRES)	25 MIN (LITRES)
1	0.5	12438.2	12451.8	12463.9	12476.2	12488.2	n/a
2	0.65	12488.2	12496.0	12504.8	12514.5	n/a	n/a
3	0.85	12514.5	12534.0	12558.0	12582.9	n/a	n/a
4	0.6	12582.9	12596.9	12606.5	12613.3	n/a	n/a
5	0.4	12613.5	12621.8	12632.5	12640.6	n/a	n/a

WATER TAKEN

RUN NUMBER	0-5 MIN (LITRES)	5-10 MIN (LITRES)	10-15 MIN (LITRES)	15-20 MIN (LITRES)	20-25 MIN (LITRES)	Cumlative (LITRES)	Q (L/MIN)
1	13.60	12.10	12.30	12.00	n/a	50.00	2.50
2	7.80	8.80	9.70	n/a	n/a	26.30	1.75
3	19.50	24.00	24.90	n/a	n/a	68.40	4.56
4	14.00	9.60	6.80	n/a	n/a	30.40	2.03
5	8.30	10.70	8.10	n/a	n/a	27.10	1.81

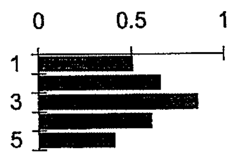
EQUIVALENT HEAD (M)	Q (L/MIN/METRE)
0.00	0.00
5.85	2.50
7.35	1.75
9.35	4.56
6.85	2.03
4.85	1.81
0.00	0.00



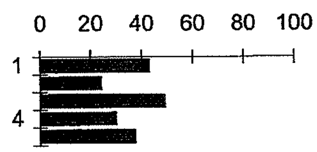
AVERAGE LUGEON **36.4**

Analysis by Houlsbey Method

TEST PRESSURE (BAR)



LUGEON VALUE



Notes:

Packer Pressure: 90 PSI Start Time: 09:00 18/04/2007
Gooseneck: 0.75m bgl Stick-up 0.52m
Geology: Fracured SILTSTONE
Double Packer

PACKER TEST RESULT SHEET

IGSL (F13)

JOB NO.	12239	GROUND LEVEL (mOD Malin Head)	6.83
CONTRACT	Tar/Ballylong	BOTTOM OF HOLE (m)	8.00
LOCATION	Co. Kerry	TOP OF TEST SECTION (m)	7.00
		BOTTOM OF TEST SECTION (m)	8.00
BOREHOLE NO.	RC-A03	CENTRE OF TEST SECTION (m)	7.50
TEST NO.	1	GUAGE HEIGHT ABOVE GROUND LEVEL (m)	0.20
		INITIAL GROUND WATER LEVEL (m)	1.89

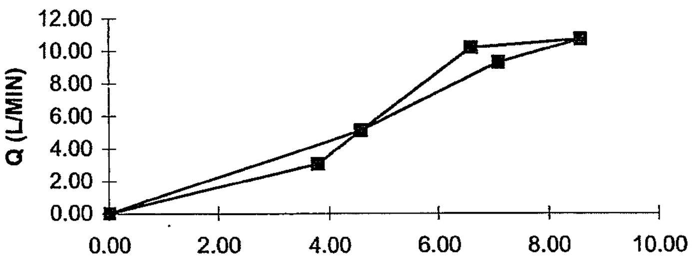
FLOW METER READINGS

RUN NUMBER	PRESSURE (BAR)	0 MIN (LITRES)	5 MIN (LITRES)	10 MIN (LITRES)	15 MIN (LITRES)	20 MIN (LITRES)	25 MIN (LITRES)
1	0.17	12685.0	12704.7	12719.1	12731.2	n/a	n/a
2	0.45	12731.2	12778.8	12832.0	12884.4	n/a	n/a
3	0.65	12884.4	12939.0	12992.7	13045.0	n/a	n/a
4	0.5	13045.0	13092.0	13138.5	13184.7	n/a	n/a
5	0.25	13184.7	13214.4	13242.4	13261.6	n/a	n/a

WATER TAKEN

RUN NUMBER	0-5 MIN (LITRES)	5-10 MIN (LITRES)	10-15 MIN (LITRES)	15-20 MIN (LITRES)	20-25 MIN (LITRES)	Cumlative (LITRES)	Q (L/MIN)
1	19.70	14.40	12.10	n/a	n/a	46.20	3.08
2	47.60	53.20	52.40	n/a	n/a	153.20	10.21
3	54.60	53.70	52.30	n/a	n/a	160.60	10.71
4	47.00	46.50	46.20	n/a	n/a	139.70	9.31
5	29.70	28.00	19.20	n/a	n/a	76.90	5.13

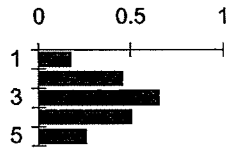
EQUIVALENT HEAD (M)	Q (L/MIN/METRE)
0.00	0.00
3.79	3.08
6.59	10.21
8.59	10.71
7.09	9.31
4.59	5.13
0.00	0.00



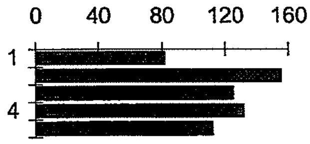
AVERAGE LUGEON **120.8**

Analysis by Houlsbey Method

TEST PRESSURE (BAR)



LUGEON VALUE



Notes:

Packer Pressure: 90 PSI Start Time: 16:45 19/04/2007

Gooseneck: 1.35m bgl Stick-up 0.50m

Geology: Fractured SILTSTONE

Single Packer

Figure PT 4

PACKER TEST RESULT SHEET

IGSL (F13)

JOB NO.	12239	GROUND LEVEL (mOD Malin Head)	6.38
CONTRACT	Tar/Ballylong	BOTTOM OF HOLE (m)	10.80
LOCATION	Co. Kerry	TOP OF TEST SECTION (m)	9.80
		BOTTOM OF TEST SECTION (m)	10.80
BOREHOLE NO.	RC-A03	CENTRE OF TEST SECTION (m)	10.30
TEST NO.	2	GUAGE HEIGHT ABOVE GROUND LEVEL (m)	0.20
		INITIAL GROUND WATER LEVEL (m)	0.59

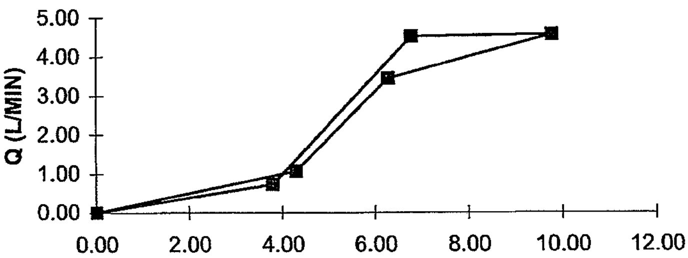
FLOW METER READINGS

RUN NUMBER	PRESSURE (BAR)	0 MIN (LITRES)	5 MIN (LITRES)	10 MIN (LITRES)	15 MIN (LITRES)	20 MIN (LITRES)	25 MIN (LITRES)
1	0.3	13309.5	13316.1	13316.8	Stopped	n/a	n/a
2	0.6	13316.8	13332.6	13355.8	13384.6	n/a	n/a
3	0.9	13384.6	13408.2	13430.6	13453.1	n/a	n/a
4	0.55	13453.1	13471.2	13487.8	13504.8	n/a	n/a
5	0.35	13504.8	13514.0	13515.5	Stopped	n/a	n/a

WATER TAKEN

RUN NUMBER	0-5 MIN (LITRES)	5-10 MIN (LITRES)	10-15 MIN (LITRES)	15-20 MIN (LITRES)	20-25 MIN (LITRES)	Cumlative (LITRES)	Q (L/MIN)
1	6.60	0.70	n/a	n/a	n/a	7.30	0.73
2	15.80	23.20	28.80	n/a	n/a	67.80	4.52
3	23.60	22.40	22.50	n/a	n/a	68.50	4.57
4	18.10	16.60	17.00	n/a	n/a	51.70	3.45
5	9.20	1.50	n/a	n/a	n/a	10.70	1.07

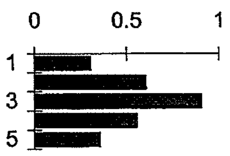
EQUIVALENT HEAD (M)	Q (L/MIN/METRE)
0.00	0.00
3.79	0.73
6.79	4.52
9.79	4.57
6.29	3.45
4.29	1.07
0.00	0.00



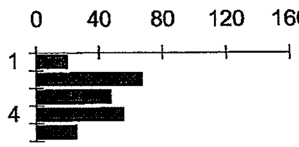
AVERAGE LUGEON **42.4**

Analysis by Houlsbey Method

TEST PRESSURE (BAR)



LUGEON VALUE



Notes:

Packer Pressure: 90 PSI Start Time: 11:00 20/04/2007
Gooseneck: 1.50m bgl Stick-up 0.50m
Geology: Fractured SILTSTONE
Single Packer

Appendix D - Embankment – Pond SI Downhole Geologging Data

Notes on Geologging	Pages RG 1 – 5
Geologging Records	Figures: OPTV 1 - 4

RG

ROBERTSON GEOLOGGING LIMITED

Tarbert/Ballylongford Embankment – Pond SI

Coreholes
RCA 1-2-3-4
26th April 2007

SUMMARY

Robertson Geologging Ltd carried out a programme of geophysical wireline logging works in boreholes for IGSL at Tarbert / Ballylongford 26th April 2007

This report includes wireline log data from four boreholes 1-2-3-4. Boreholes were core-drilled and were nominally vertical and all logged on above date.

The logging suite in all boreholes comprised of Optical televiewer only, Acoustic televiewer was not used due to clarity of borehole fluid.

Meterage Logged

Borehole Number	OPTV	Start Depth metre	Finnish Depth metre	Casing Depth metre	Water Level	Casing Size mm	Bit Size mm	Drill Depth metre
RCA01	OPTV	10	16.1	10	unknown	100	85	16.7
RCA02	OPTV	2.43	18.9	2.5	.86	100	85	19.1
RCA03	OPTV	5.3	17.6	5.3	GL	100	85	18.1
RCA04	OPTV	7.1	16.2	7.1	GL	100	85	16.9

DATA ACQUISITION

No operational difficulties were encountered in all of the boreholes and the data quality was high throughout. The optical televiewer, provided excellent fracture and bedding resolution and characterisation.

Field data were acquired in accordance with normal working practice.

PROCESSING AND INTERPRETATION

Log depths referenced to ground level, distortion are the effects of near-surface magnetic anomalies cased usually by casing. The logs are corrected to magnetic north and fracture and discontinuities were recognised as features.

GLOSSARY OF TERMS

Centraliser

A device designed to maintain a probe in the centre of a borehole.

Correlation

Determination of the position of straigraphically equivalent rock units in different wells, often done by matching the character of geophysical logs; also the matching of variables, such as log response and core analyses.

Curve

A trace or continuous record of a property measured in a borehole. May be used as a synonym for log, or several curves may constitute a log.

Decentralise

Forcing a logging probe against the side of the drill hole.

Deviation log

A log of the departure azimuth and distance in degrees or metres between the drill hole or probe axis and the vertical.

Dip

The angle of inclination, measured from the horizontal, of a geologically-significant lineation, e.g. bedding or fracture.

Formation

Geological materials through which the borehole is drilled

Open Hole

Uncased intervals of a drill hole

Optical Televiewer Log

An optical image derived from light reflected by the borehole wall; provides location and orientation of bedding, fractures and cavities.

Probe

Also called sonde or tool; downhole well-logging instrument package.

Tadpole Plot

An arrow plot of the results of calculation of the dip and strike of beds or fractures from televiewer and dipmeter logs. The lateral position of the tadpole or arrow indicates the angle of dip, and the direction of the line or arrow indicates the dip direction.

TOOL SPECIFICATIONS

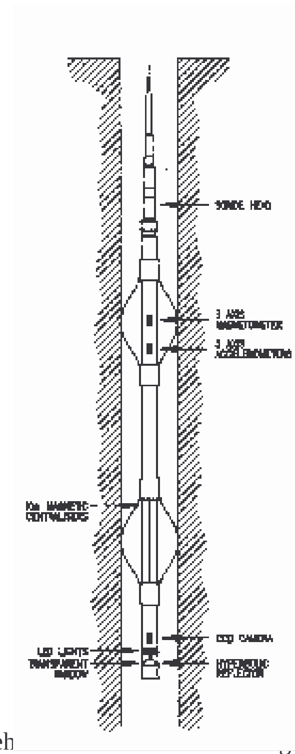
RG probes range in diameter from 38mm to 60mm and, as standard, are designed for pressures of 20MPa (3000psi) and temperatures up to 70ºC. Most probes are also available with extended ranges of 33MPa (5000psi) and 125ºC and certain probes may be upgraded to higher temperatures and pressures to special order.

Most RG probes include multiple sensors, and may acquire up to thirty two log measurements simultaneously. Data acquisition is depth-based, with a typical sample interval of 1cm (or 1/20th foot), controlled from the surface through a downhole microprocessor. The data transmission through the logging cable is in a standard serial format, removing any requirements for dedicated surface modules for individual probes.

RG slimhole logging systems digitise data right at the point of measurement, in the probe. All subsequent data transmission, processing and recording is in digital format. Some well known benefits of this include:

- Accurate stable measurements requiring minimal calibration
- No significant signal distortion during cable transmission
- Simple operation without critical adjustments
- No dedicated surface modules required for individual probes
- Compatibility with popular PC-compatible hardware

BOREHOLE OPTICAL TELEVIEWER



The OPTV probe provides a continuous, very high resolution image of the borehole walls using a unique optical imaging system. This can be rapidly interpreted, using data from the integral orientation module, to obtain a complete feature analysis including dip, strike, frequency and fracture aperture. A popular visual data display option is the projection of features onto an imaginary core which can be rotated and viewed from any orientation. An OPTV survey can often replace expensive coring with its associated problems of incomplete core recovery.

The RG OPTV has unique technical features which allow it to log at speeds of 2.5m/min while still achieving 1mm resolution, even on long cable lengths. Other probes on the market are limited typically to 0.8m/min under similar conditions. The probe can also operate as a normal video camera and external lightheads are available for up to 20inch boreholes

The OPTV is based on a downhole CCD camera which views a reflection of the borehole walls in a hyperbolic mirror. At successive depth increments (normally 0.5mm), rings of pixels corresponding to scans of the borehole walls are acquired from the probe and built up into an image. This is orientated to North, displayed in real time and recorded on disk for subsequent data analysis.

The OPTV offers a major advantage over a conventional CCTV survey in providing a continuous ‘unwrapped’ 360° image of the boreh netic North. It also replaces the acoustic televiewer (ATV or BHTV) where high image resolution is required or where the lack of borehole fluid prevents the use of acoustic probes.

Optional RG-dip interpretation software is available for detailed analysis of the displayed features including conventional dipmeter arrow plots, stereograms of feature orientations and synthetic core images. Refer to the software area of the site for further details.

MEASUREMENTS:

Real-time: VDU display of actual and unfolded images of borehole walls

Recorded data: Digital record of unfolded image to HDD, Probe orientation

APPLICATIONS:

Ground investigation for civil engineering
Slope stability studies
Tunnel hazard prediction including weak rock and water entry
Nuclear waste repository pre-studies
Blast design
Mining
Environmental

OPTV DATA PROCESSING
RGLDIP vsn 6.2
INTERPRETED OPTV DIPS LOG

15 Oct 2007

IGSL

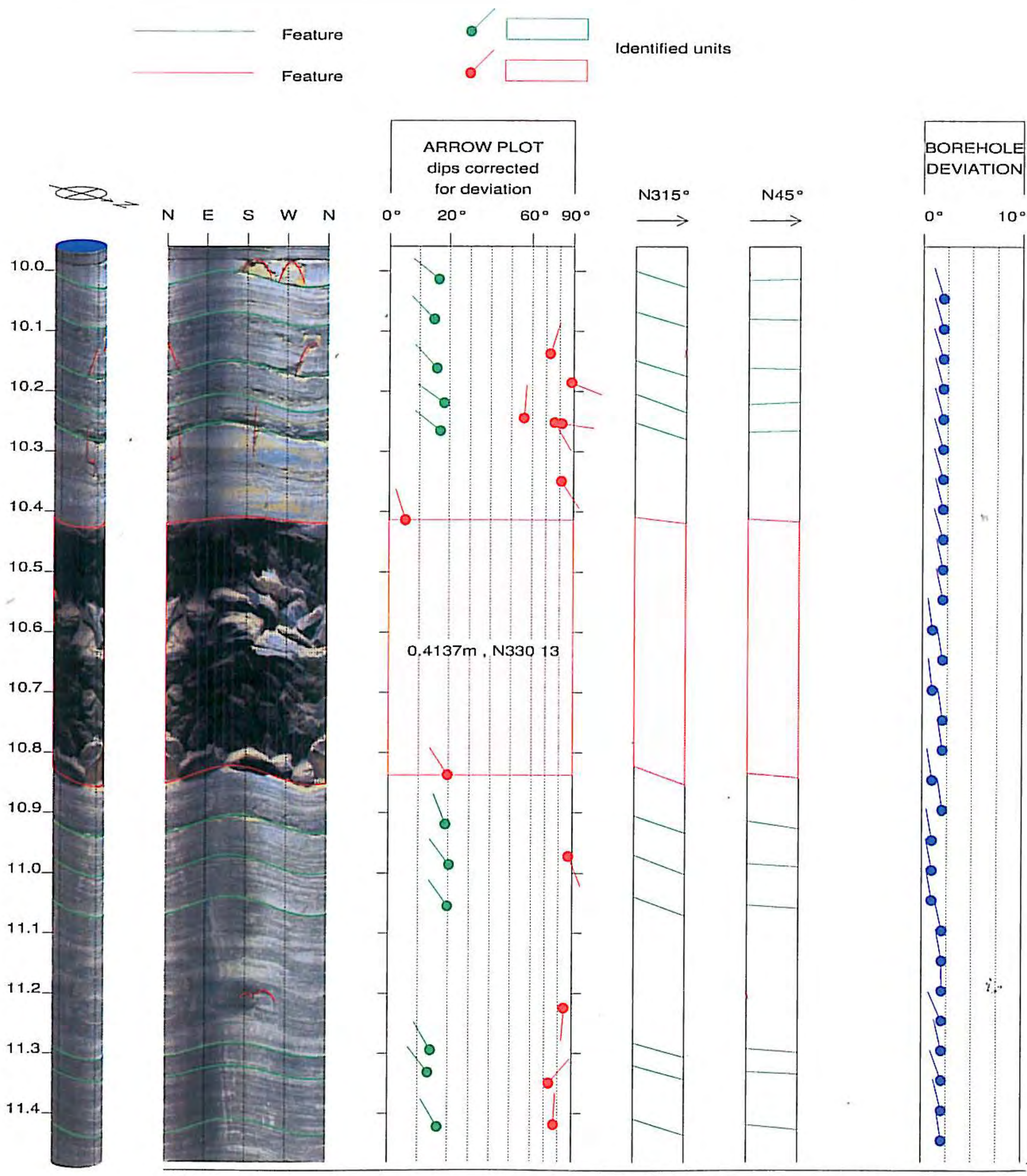
Borehole: RCA 01

Tarbert/Ballylongford Embankment - Pond Site Investigation

top of borehole.....		North ref. is magnetic	
East:	101865.44	Depth units are metres	
North:	148080.15	Vertical scale: 1/10	
Elev:	13.91	Horiz scale = vert scale	

Zone from 16.163 to 9.959m
Format: BHTV-NESWN

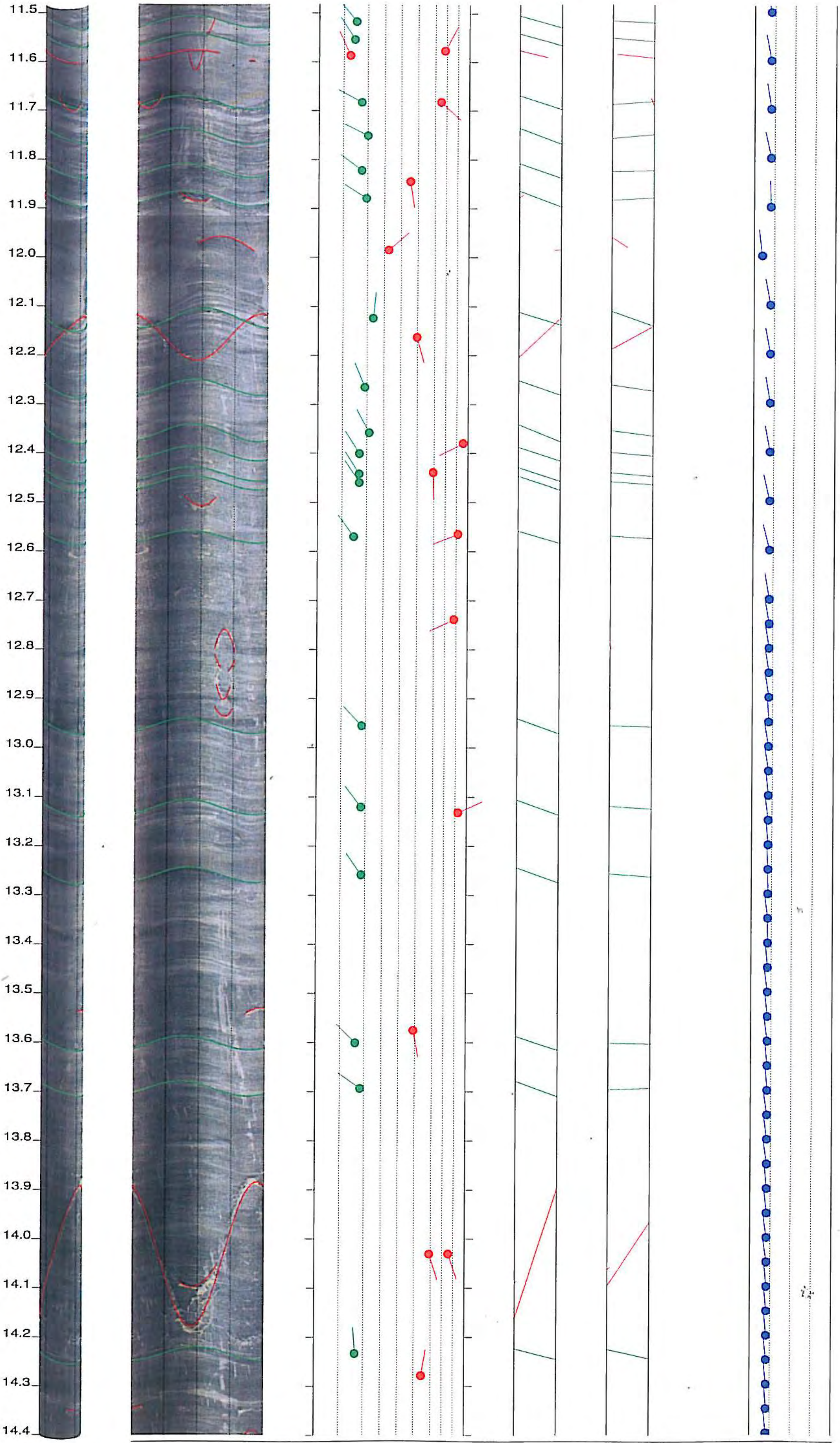
Borehole diam: 8.500cm
Vertical = borehole-axis



RCA 01

11.482 to 9.959m

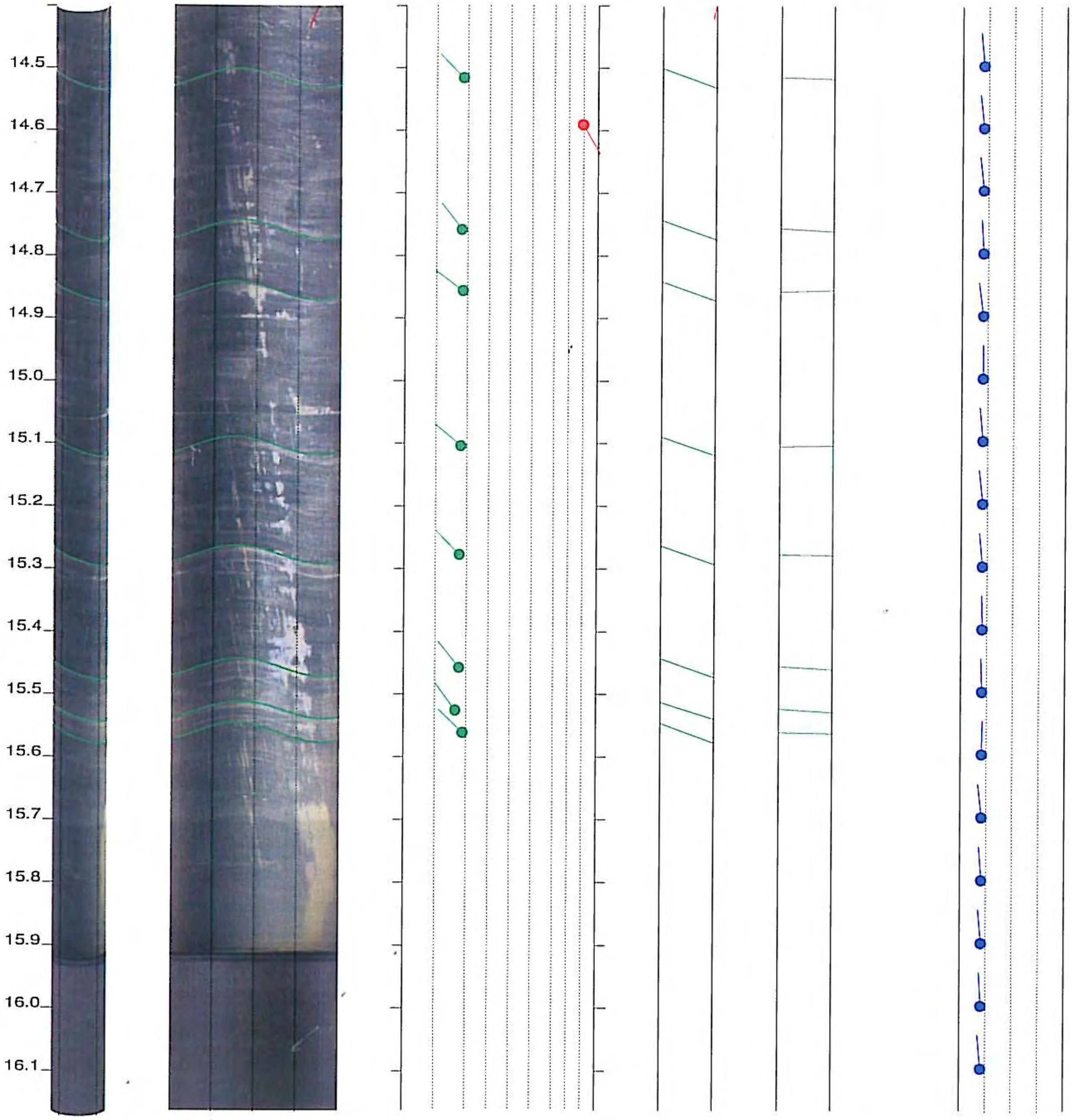
Figure OPTV1
(1 of 6)



RCA 01

14.400 to 11.482m

Figure OPTV1
(2 of 6)


14.5
14.6
14.7
14.8
14.9
15.0
15.1
15.2
15.3
15.4
15.5
15.6
15.7
15.8
15.9
16.0
16.1

optvdata RCA1[1].txt

RGLDIPv6.2 OPTV results

K = 0: BEDDING
K = 2: FRACTURE

borehole RCA 01
zone from 9.959 to 16.164 m
North ref is magnetic
Dip format: Dip-azimuth and Dip

deviation Dev	Depth Thickness	Azimuth	Dip	1-P0/100	n	Q	K	Upper Depth	Lower Depth	Well Diam	Well Azimuth
1 2.00	15.562 0.0000	N314	18.8	0.965	4	B	0	15.546	15.577	0.085	1.00
2 2.00	15.526 0.0000	N323	16.4	0.979	5	A	0	15.512	15.540	0.085	359.81
3 2.00	15.458 0.0000	N322	17.6	0.993	4	A	0	15.443	15.473	0.085	358.00
4 2.00	15.278 0.0000	N315	17.6	0.992	5	A	0	15.263	15.293	0.085	355.36
5 2.00	15.105 0.0000	N310	18.0	0.953	6	B	0	15.090	15.120	0.085	355.51
6 2.00	14.857 0.0000	N306	18.4	0.991	5	A	0	14.841	14.872	0.085	0.09
7 2.00	14.759 0.0000	N322	18.1	0.939	4	C	0	14.743	14.774	0.085	352.52
8 2.00	14.591 0.0000	N150	79.8	1.000	3	A	2	14.391	14.435	0.085	354.00
9 2.00	14.516 0.0000	N316	18.5	0.999	4	A	0	14.501	14.532	0.085	354.59
10 2.00	14.280 0.0000	N009	54.8	1.000	3	A	2	14.341	14.344	0.085	354.00
11 2.00	14.234 0.0000	N356	16.6	0.959	6	B	0	14.220	14.249	0.085	354.23
12 2.00	14.032 0.0000	N162	59.2	1.000	3	A	2	14.053	14.098	0.085	352.00
13 2.00	14.031 0.0000	N161	75.8	0.933	4	C	2	13.884	14.178	0.085	352.00
14 2.00	13.694 0.0000	N306	18.3	0.975	4	A	0	13.678	13.709	0.085	355.95
15 2.00	13.601 0.0000	N315	16.3	0.981	5	A	0	13.587	13.615	0.085	353.20
16 2.00	13.576 0.0000	N169	49.3	1.000	3	A	2	13.530	13.542	0.085	353.41
17 2.00	13.259 0.0000	N325	18.3	0.973	5	A	0	13.243	13.274	0.085	357.51
18 2.00	13.133 0.0000	N065	82.9	1.000	3	A	2	12.760	12.808	0.085	353.26
19 2.00	13.121 0.0000	N323	18.2	0.969	4	B	0	13.106	13.137	0.085	353.49
20 2.00	12.955 0.0000	N316	18.3	0.969	4	B	0	12.940	12.971	0.085	355.71
21 2.00	12.739 0.0000	N245	78.4	1.000	3	A	2	12.918	12.937	0.085	350.00
22 2.00	12.570 0.0000	N324	14.8	0.960	4	B	0	12.558	12.583	0.085	348.06
23 2.00	12.565 0.0000	N249	81.8	0.987	4	A	2	12.812	12.845	0.085	348.46
24	12.460	N327	16.9	0.975	5	A	0	12.446	12.475	0.085	348.42

2.00	0.0000										
25	12.443	N328	16.9	0.985	5	A	0	12.428	12.457	0.085	349.00
2.00	0.0000										
26	12.440	N179	59.7	1.000	3	A	2	12.488	12.507	0.085	349.00
2.00	0.0000										
27	12.401	N328	17.0	0.988	4	A	0	12.386	12.415	0.085	349.00
2.00	0.0000										
28	12.380	N243	85.9	1.000	3	A	2	12.873	12.902	0.085	348.68
2.00	0.0000										
29	12.358	N332	21.3	0.963	4	B	0	12.340	12.377	0.085	348.25
2.00	0.0000										
30	12.266	N337	19.0	0.957	4	B	0	12.249	12.282	0.085	349.39
2.00	0.0000										
31	12.163	N165	49.8	0.960	4	B	2	12.116	12.210	0.085	349.00
2.00	0.0000										
32	12.124	N006	23.4	0.979	4	A	0	12.104	12.145	0.085	349.00
2.00	0.0000										
33	11.985	N050	32.9	1.000	3	A	2	11.957	11.986	0.085	353.65
1.22	0.0000										
34	11.880	N303	19.5	0.961	5	B	0	11.864	11.896	0.085	356.09
2.00	0.0000										
35	11.845	N172	45.7	0.964	4	B	2	11.867	11.886	0.085	351.92
2.00	0.0000										
36	11.823	N307	17.6	0.984	4	A	0	11.808	11.837	0.085	350.13
2.00	0.0000										
37	11.752	N297	20.0	0.976	4	A	0	11.735	11.769	0.085	348.88
2.00	0.0000										
38	11.683	N298	17.4	0.975	4	A	0	11.669	11.698	0.085	351.50
2.00	0.0000										
39	11.683	N133	65.2	1.000	3	A	2	11.597	11.598	0.085	351.52
2.00	0.0000										
40	11.587	N335	12.9	0.995	4	A	2	11.576	11.597	0.085	349.55
2.00	0.0000										
41	11.577	N027	68.7	0.978	4	A	2	11.667	11.696	0.085	350.13
2.00	0.0000										
42	11.555	N327	14.5	0.976	4	A	0	11.542	11.567	0.085	351.48
2.00	0.0000										
43	11.518	N321	15.2	0.968	5	B	0	11.505	11.531	0.085	350.88
2.00	0.0000										
44	11.423	N330	16.4	0.993	5	A	0	11.408	11.437	0.085	348.65
2.00	0.0000										
45	11.419	N003	77.1	1.000	3	A	2	11.200	11.207	0.085	348.31
2.00	0.0000										
46	11.350	N040	73.6	1.000	3	A	2	11.196	11.215	0.085	340.53
2.00	0.0000										
47	11.332	N323	13.3	0.982	5	A	0	11.320	11.343	0.085	341.98
2.00	0.0000										
48	11.295	N330	14.1	0.999	4	A	0	11.282	11.307	0.085	346.72
2.00	0.0000										
49	11.225	N184	84.3	1.000	3	A	2	11.510	11.542	0.085	345.45
2.00	0.0000										
50	11.055	N325	19.7	0.961	4	B	0	11.039	11.072	0.085	349.44
1.19	0.0000										
51	10.986	N323	20.3	0.949	4	B	0	10.970	11.003	0.085	349.19
1.00	0.0000										
52	10.973	N158	87.2	1.000	3	A	2	11.575	11.616	0.085	349.46
1.00	0.0000										
53	10.919	N338	18.9	0.979	5	A	0	10.903	10.935	0.085	351.08
1.54	0.0000										
54	10.838	N327	19.7	0.948	5	B	2	10.822	10.854	0.085	351.00
1.16	0.4137										
55	10.414	N342	5.5	0.985	5	A	2	10.408	10.420	0.085	345.28
2.00	0.0000										
56	10.350	N147	81.4	1.000	3	A	2	10.121	10.174	0.085	344.16
2.00	0.0000										
57	10.266	N308	16.7	0.996	4	A	0	10.251	10.280	0.085	344.61
2.00	0.0000										
58	10.254	N098	81.8	1.000	3	A	2	9.986	10.020	0.085	344.84

2.00	0.0000										
59	10.252	N150	76.4	1.000	3	A	2	10.122	10.163	0.085	344.88
2.00	0.0000										
60	10.244	N004	56.1	1.000	3	A	2	10.307	10.312	0.085	345.00
2.00	0.0000										
61	10.220	N305	18.0	0.957	5	B	0	10.204	10.235	0.085	345.00
2.00	0.0000										
62	10.186	N112	88.6	1.000	4	A	2	10.226	10.307	0.085	344.60
2.00	0.0000										
63	10.162	N317	15.6	0.989	4	A	0	10.148	10.175	0.085	343.62
2.00	0.0000										
64	10.138	N018	73.1	1.000	3	A	2	9.982	10.009	0.085	343.17
2.00	0.0000										
65	10.080	N316	14.7	0.990	4	A	0	10.067	10.093	0.085	343.68
2.00	0.0000										
66	10.014	N308	16.2	0.960	5	B	0	10.000	10.027	0.085	343.00
2.00	0.0000										

OPTV DATA PROCESSING
RGLDIP vsn 6.2
INTERPRETED OPTV DIPS LOG

15 Oct 2007

IGSL

Borehole: RCA 02

Tarbert/Ballylongford Embankment-Pond Site Investigation

top of borehole.....	North ref. is magnetic
East: 101945	Depth units are metres
North: 148166	Vertical scale: 1/10
Elev: 7.08	Horiz scale = vert scale

Zone from 18.881 to 2.451m
Format: BHTV-NESWN

Borehole diam: 8.500cm
Vertical = borehole-axis

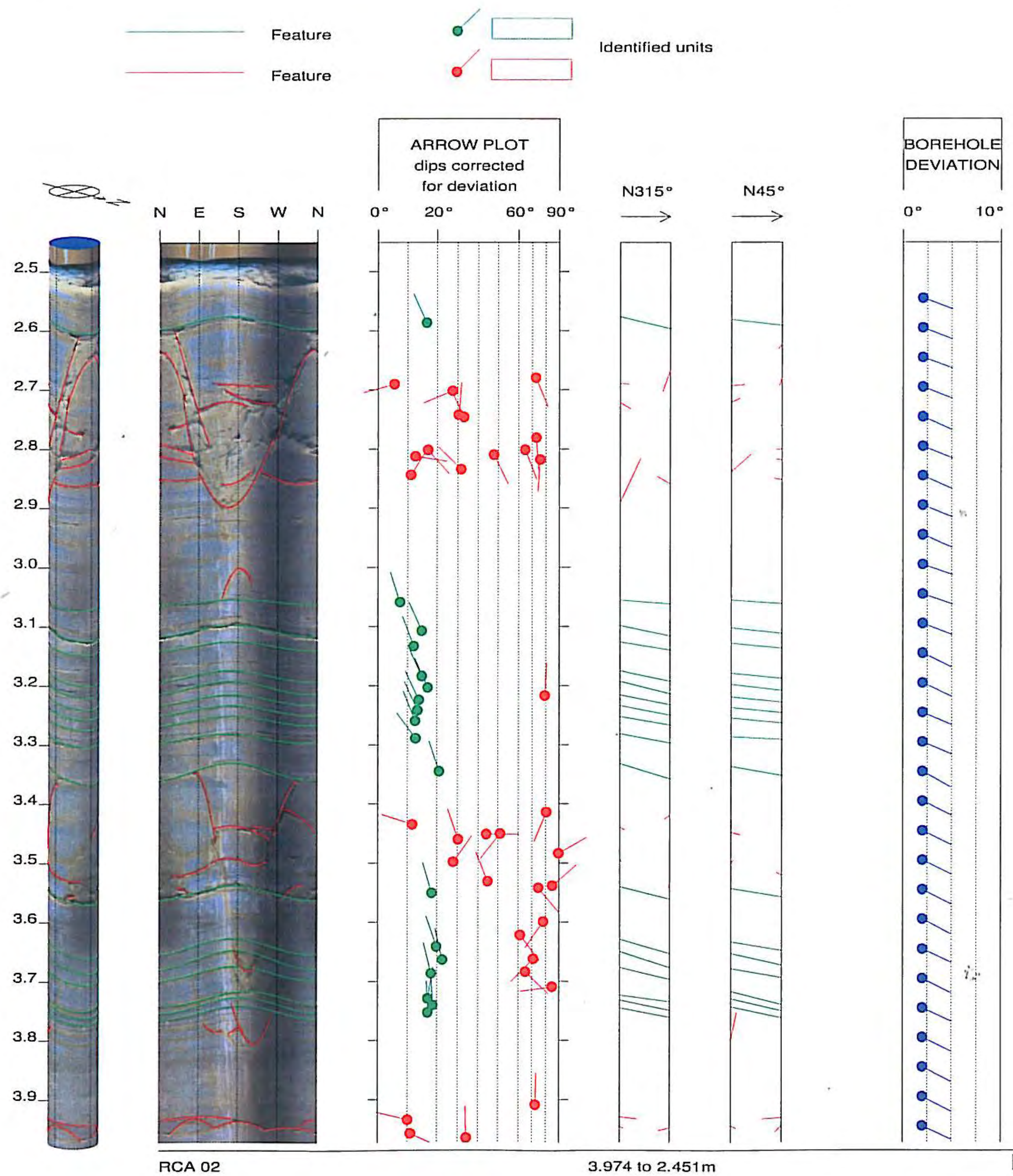
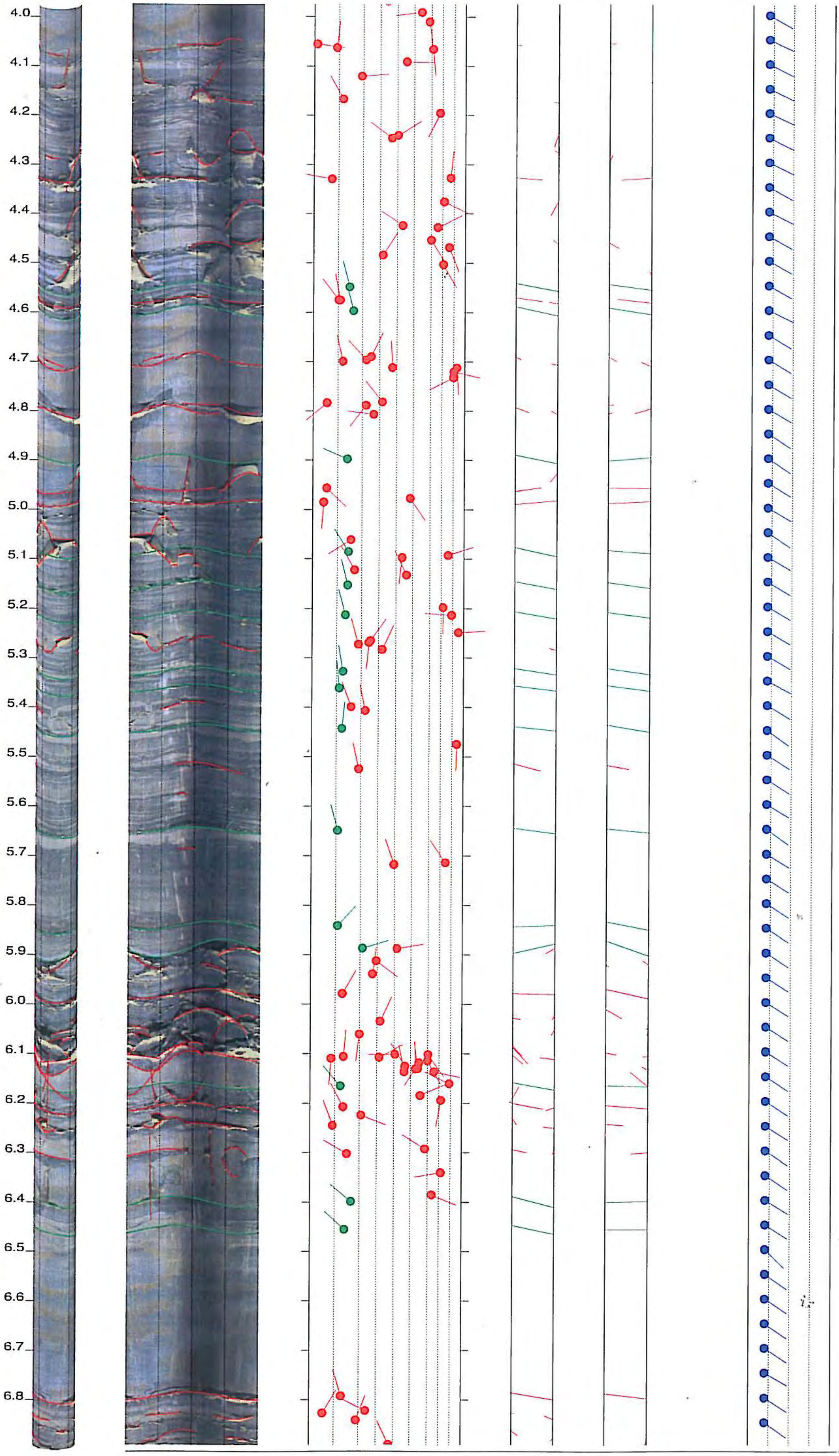


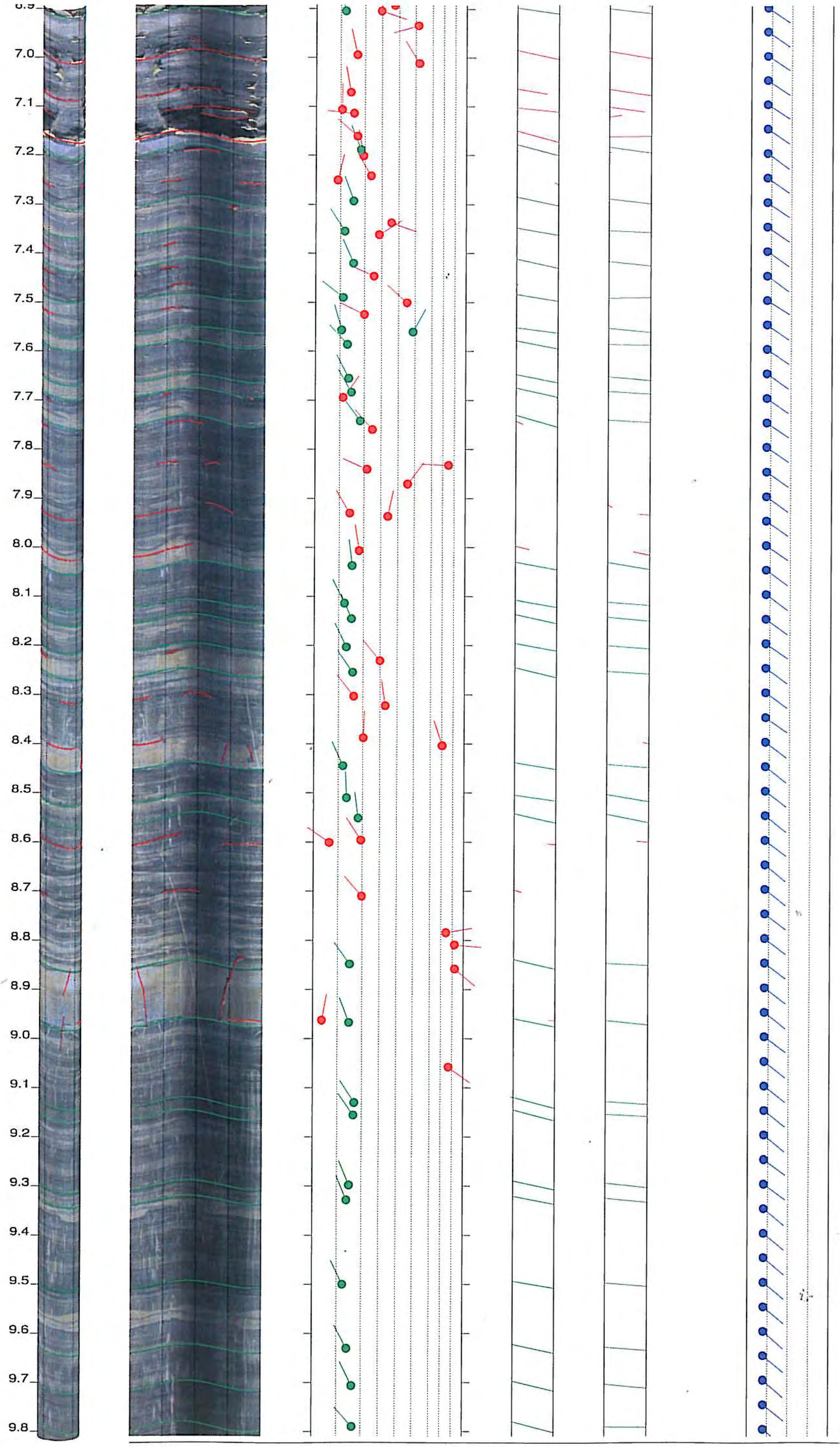
Figure OPTV2
(1 of 18)



RCA 02

6.892 to 3.974m

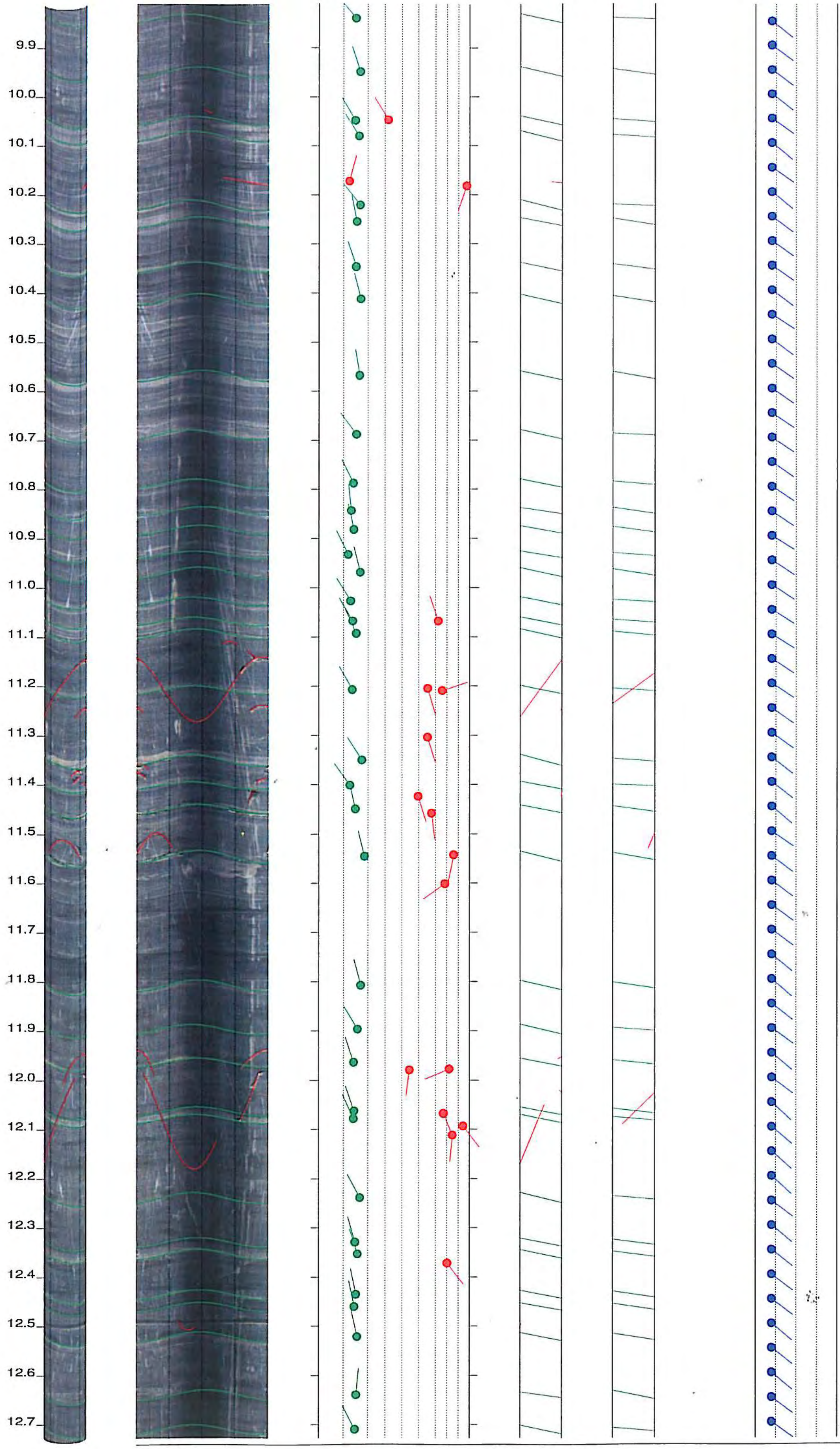
Figure OPTV2
(2 of 18)



RCA 02

9.810 to 6.892m

Figure OPTV2
(3 of 18)



RCA 02 | 12.728 to 9.810m | Figure OPTV2 (4 of 18)

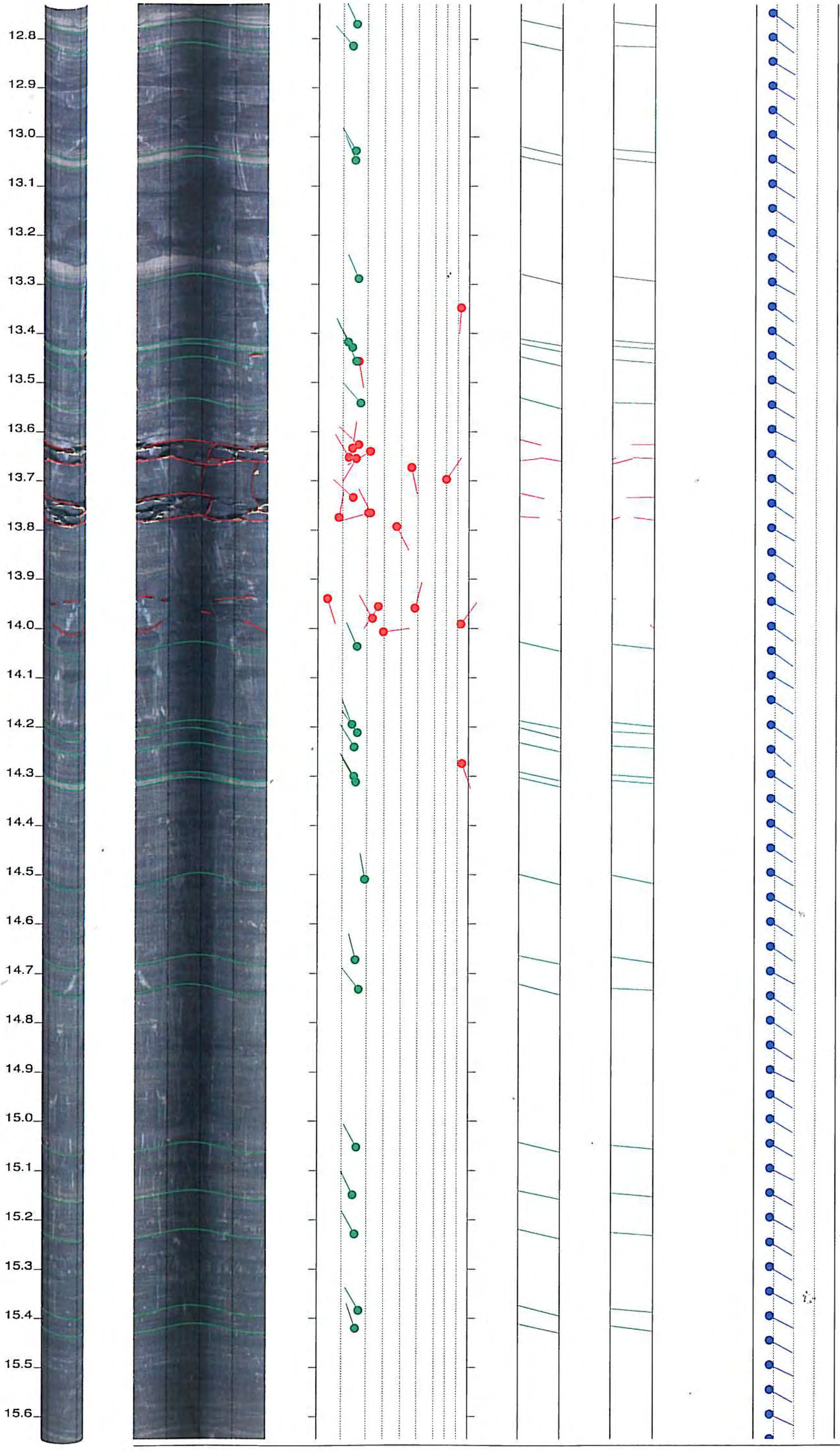
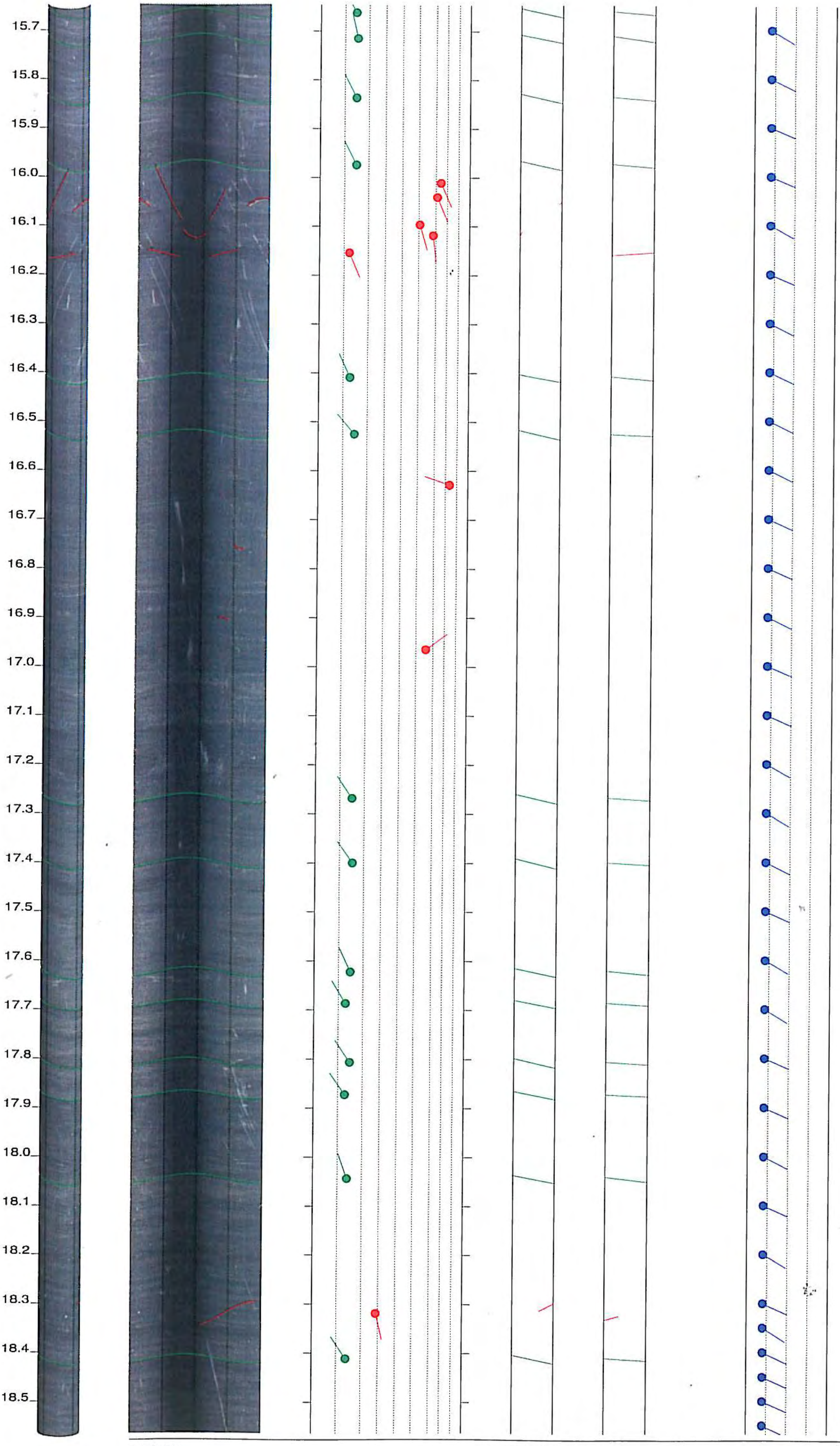


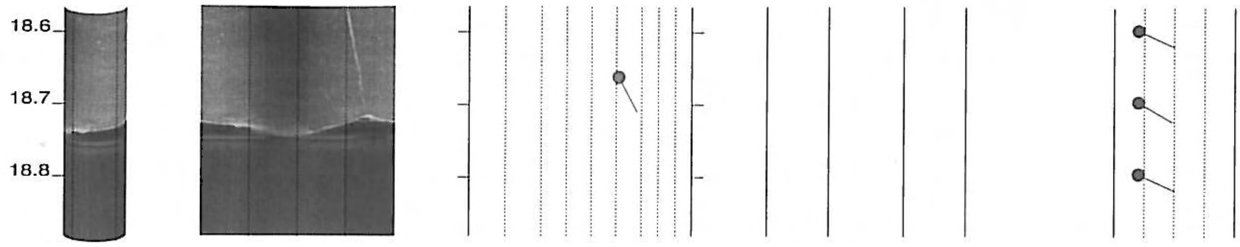
Figure OPTV2'
(5 of 18)



RCA 02

18.564 to 15.646m

Figure OPTV2
(6 of 18)


18.6
18.7
18.8

optvdata RCA02[1].txt

RGLDIPv6.2 OPTV results

K = 0: Feature
K = 2: Feature

borehole RCA 02
zone from 2.451 to 18.882 m
North ref is magnetic
Dip format: Dip-azimuth and Dip

deviation	Depth	Azimuth	Dip	1-P0/100	n	Q	K	Upper Depth	Lower Depth	Well Diam	Well Azimuth	Dev	Thickness
1	18.662	N153	51.1	1.000	3	A	2	18.606	18.608	0.085	121.37	2.00	0.0000
2	18.412	N326	13.9	0.987	5	A	0	18.403	18.421	0.085	114.69	2.00	0.0000
3	18.320	N167	28.9	0.981	4	A	2	18.295	18.342	0.085	117.80	2.00	0.0000
4	18.044	N341	13.9	0.997	4	A	0	18.034	18.053	0.085	114.12	2.00	0.0000
5	17.873	N325	12.8	0.986	5	A	0	17.864	17.881	0.085	115.86	2.00	0.0000
6	17.807	N326	14.8	0.996	6	A	0	17.797	17.817	0.085	114.09	2.00	0.0000
7	17.687	N329	12.9	0.993	5	A	0	17.679	17.695	0.085	120.82	2.00	0.0000
8	17.622	N335	14.7	0.971	4	B	0	17.613	17.632	0.085	120.00	2.00	0.0000
9	17.400	N325	15.3	0.993	4	A	0	17.390	17.411	0.085	115.91	2.00	0.0000
10	17.269	N326	14.9	0.979	4	A	0	17.259	17.278	0.085	119.45	2.00	0.0000
11	16.965	N054	55.9	1.000	3	A	2	16.900	16.904	0.085	114.23	2.00	0.0000
12	16.629	N289	74.0	1.000	3	A	2	16.752	16.760	0.085	117.32	2.00	0.0000
13	16.526	N320	14.7	0.980	5	A	0	16.516	16.536	0.085	113.61	2.00	0.0000
14	16.410	N335	12.7	0.975	5	A	0	16.401	16.418	0.085	115.27	2.00	0.0000
15	16.155	N157	12.3	0.956	5	B	2	16.148	16.163	0.085	117.94	2.00	0.0000
16	16.119	N174	58.7	1.000	3	A	2	16.046	16.060	0.085	119.00	2.00	0.0000
17	16.097	N164	50.7	1.000	3	A	2	16.042	16.058	0.085	119.00	2.00	0.0000
18	16.040	N158	61.5	1.000	3	A	2	16.107	16.124	0.085	119.23	2.00	0.0000
19	16.011	N157	64.6	0.986	4	A	2	15.977	16.088	0.085	115.16	2.00	0.0000
20	15.975	N333	14.8	0.977	6	A	0	15.965	15.985	0.085	113.42	2.00	0.0000
21	15.838	N333	14.8	0.990	5	A	0	15.828	15.848	0.085	113.49	2.00	0.0000
22	15.716	N347	15.2	0.968	6	B	0	15.705	15.726	0.085	119.04	2.00	0.0000
23	15.662	N330	14.6	0.986	5	A	0	15.653	15.672	0.085	118.31	2.00	0.0000
24	15.421	N341	15.7	0.944	5	C	0	15.410	15.432	0.085	117.50		

												2.00	0.0000
25	15.385	N330	17.1	0.993	4	A	0	15.373	15.396	0.085	117.23	2.00	0.0000
26	15.229	N331	15.3	0.988	5	A	0	15.219	15.240	0.085	120.34	2.00	0.0000
27	15.150	N334	14.5	0.987	5	A	0	15.140	15.159	0.085	119.00	2.00	0.0000
28	15.053	N331	16.0	0.972	6	B	0	15.042	15.064	0.085	119.57	2.00	0.0000
29	14.733	N322	16.8	0.988	5	A	0	14.721	14.744	0.085	122.40	2.00	0.0000
30	14.673	N345	15.4	0.989	5	A	0	14.662	14.683	0.085	120.34	2.00	0.0000
31	14.509	N350	19.2	0.960	5	B	0	14.496	14.523	0.085	120.00	2.00	0.0000
32	14.312	N330	15.5	0.971	5	B	0	14.302	14.323	0.085	123.67	2.00	0.0000
33	14.300	N329	14.6	0.988	7	A	0	14.290	14.310	0.085	123.92	2.00	0.0000
34	14.275	N161	84.5	1.000	3	A	2	13.654	13.712	0.085	126.51	2.00	0.0000
35	14.241	N328	14.9	0.980	5	A	0	14.231	14.251	0.085	129.40	2.00	0.0000
36	14.212	N325	16.1	0.990	4	A	0	14.201	14.223	0.085	125.92	2.00	0.0000
37	14.195	N338	13.9	0.983	5	A	0	14.186	14.204	0.085	123.95	2.00	0.0000
38	14.037	N336	16.0	0.963	5	B	0	14.026	14.048	0.085	125.82	2.00	0.0000
39	14.007	N082	29.8	1.000	3	A	2	13.985	14.007	0.085	125.22	2.00	0.0000
40	13.992	N036	83.3	0.997	4	A	2	13.625	13.728	0.085	124.57	2.00	0.0000
41	13.980	N330	23.4	1.000	3	A	2	13.965	13.970	0.085	123.40	2.00	0.0000
42	13.959	N015	48.3	1.000	3	A	2	13.982	14.006	0.085	121.31	2.00	0.0000
43	13.956	N213	26.7	1.000	3	A	2	13.934	13.942	0.085	120.97	2.00	0.0000
44	13.940	N163	4.0	1.000	3	A	2	13.936	13.943	0.085	120.47	2.00	0.0000
45	13.793	N152	37.4	1.000	3	A	2	13.759	13.763	0.085	120.21	2.00	0.0000
46	13.775	N010	8.6	0.983	4	A	2	13.769	13.781	0.085	121.68	2.00	0.0000
47	13.766	N254	20.8	1.000	3	A	2	13.771	13.781	0.085	122.44	2.00	0.0000
48	13.766	N333	22.1	1.000	3	A	2	13.778	13.781	0.085	122.43	2.00	0.0000
49	13.734	N312	14.3	0.969	4	B	2	13.725	13.740	0.085	124.24	2.00	0.0000
50	13.698	N034	70.2	1.000	3	A	2	13.718	13.756	0.085	124.96	2.00	0.0000
51	13.674	N168	46.5	1.000	3	A	2	13.626	13.635	0.085	125.45	2.00	0.0000
52	13.655	N211	15.6	0.917	6	C	2	13.650	13.667	0.085	125.82	2.00	0.0000
53	13.653	N330	12.5	1.000	3	A	2	13.648	13.661	0.085	125.86	2.00	0.0000
54	13.641	N240	22.0	1.000	3	A	2	13.652	13.657	0.085	125.14	2.00	0.0000
55	13.635	N008	14.0	1.000	3	A	2	13.627	13.639	0.085	124.16	2.00	0.0000
56	13.627	N313	16.5	0.981	4	A	2	13.616	13.631	0.085	122.99	2.00	0.0000
57	13.543	N319	17.2	0.993	5	A	0	13.531	13.554	0.085	120.93	2.00	0.0000
58	13.458	N171	16.6	1.000	3	A	2	13.444	13.448	0.085	123.05		

												2.00	0.0000
59	13.457	N333	15.4	0.979	5	A	0	13.447	13.468	0.085	123.10	2.00	0.0000
60	13.429	N330	13.8	0.981	5	A	0	13.420	13.438	0.085	124.00	2.00	0.0000
61	13.418	N334	12.0	0.978	5	A	0	13.411	13.426	0.085	124.00	2.00	0.0000
62	13.348	N184	83.2	1.000	3	A	2	13.732	13.769	0.085	125.90	2.00	0.0000
63	13.289	N336	16.3	0.969	5	B	0	13.278	13.301	0.085	119.79	2.00	0.0000
64	13.048	N338	14.9	0.992	5	A	0	13.038	13.058	0.085	122.00	2.00	0.0000
65	13.029	N330	15.1	0.990	5	A	0	13.019	13.039	0.085	122.67	2.00	0.0000
66	12.815	N320	13.8	0.995	5	A	0	12.806	12.824	0.085	124.68	2.00	0.0000
67	12.771	N335	15.4	0.992	5	A	0	12.760	12.781	0.085	127.00	2.00	0.0000
68	12.710	N333	14.6	0.991	4	A	0	12.701	12.720	0.085	126.29	2.00	0.0000
69	12.640	N005	15.2	0.970	5	B	0	12.629	12.650	0.085	127.25	2.00	0.0000
70	12.522	N348	15.6	0.983	5	A	0	12.511	12.532	0.085	128.97	2.00	0.0000
71	12.460	N348	14.4	0.992	5	A	0	12.450	12.470	0.085	127.86	2.00	0.0000
72	12.435	N349	15.1	0.984	4	A	0	12.425	12.446	0.085	127.00	2.00	0.0000
73	12.372	N142	70.4	1.000	3	A	2	12.488	12.506	0.085	127.47	2.00	0.0000
74	12.353	N342	15.7	0.986	5	A	0	12.343	12.364	0.085	127.85	2.00	0.0000
75	12.330	N344	14.7	0.988	6	A	0	12.320	12.339	0.085	128.66	2.00	0.0000
76	12.239	N332	16.7	0.997	5	A	0	12.227	12.250	0.085	127.73	2.00	0.0000
77	12.113	N185	75.1	1.000	3	A	2	11.939	11.991	0.085	130.34	2.00	0.0000
78	12.094	N142	84.5	1.000	3	A	2	11.410	11.437	0.085	130.12	2.00	0.0000
79	12.078	N336	14.1	0.989	6	A	0	12.069	12.088	0.085	131.05	2.00	0.0000
80	12.069	N157	67.2	0.985	4	A	2	11.985	12.179	0.085	131.65	2.00	0.0000
81	12.063	N341	14.4	0.990	6	A	0	12.053	12.072	0.085	132.00	2.00	0.0000
82	11.980	N188	44.7	1.000	3	A	2	11.937	11.974	0.085	127.95	2.00	0.0000
83	11.978	N248	72.4	1.000	3	A	2	11.982	12.080	0.085	128.07	2.00	0.0000
84	11.963	N341	14.2	0.990	5	A	0	11.954	11.973	0.085	128.95	2.00	0.0000
85	11.897	N329	15.8	0.987	5	A	0	11.886	11.907	0.085	126.07	2.00	0.0000
86	11.807	N345	17.0	0.966	4	B	0	11.796	11.819	0.085	130.31	2.00	0.0000
87	11.602	N235	68.5	1.000	3	A	2	11.498	11.536	0.085	126.88	2.00	0.0000
88	11.546	N346	18.5	0.948	5	B	0	11.533	11.559	0.085	127.00	2.00	0.0000
89	11.543	N191	76.2	1.000	3	A	2	11.358	11.367	0.085	126.90	2.00	0.0000
90	11.459	N173	57.7	1.000	3	A	2	11.388	11.395	0.085	128.70	2.00	0.0000
91	11.449	N347	14.9	0.988	5	A	0	11.439	11.460	0.085	129.65	2.00	0.0000
92	11.425	N163	49.8	1.000	3	A	2	11.374	11.384	0.085	129.15		

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 93     11.401   N324   12.6    0.987  5 A  0   11.393   11.409  0.085  128.21
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 94     11.350   N328   17.5    0.966  5 B  0   11.338   11.362  0.085  128.00
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 95     11.304   N163   55.3    0.995  4 A  2   11.239   11.251  0.085  126.34
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 96     11.210   N071   66.1    0.996  4 A  2   11.108   11.118  0.085  123.56
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 97     11.207   N331   13.5    0.980  5 A  0   11.198   11.216  0.085  123.45
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 98     11.205   N164   55.5    1.000  3 A  2   11.140   11.271  0.085  123.37
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 99     11.093   N335   15.1    0.987  4 A  0   11.083   11.103  0.085  122.00
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100     11.068   N341   62.5    1.000  3 A  2   11.128   11.142  0.085  122.00
2.00     0.0000
101     11.068   N330   13.7    0.999  5 A  0   11.059   11.077  0.085  122.00
2.00     0.0000
102     11.027   N329   12.9    0.981  5 A  0   11.019   11.036  0.085  122.37
2.00     0.0000
103     10.969   N346   16.7    0.967  5 B  0   10.957   10.981  0.085  123.00
2.00     0.0000
104     10.933   N334   11.8    0.986  5 A  0   10.925   10.941  0.085  122.74
2.00     0.0000
105     10.882   N348   14.2    0.979  5 A  0   10.872   10.892  0.085  122.56
2.00     0.0000
106     10.844   N354   13.1    0.996  4 A  0   10.835   10.853  0.085  123.95
2.00     0.0000
107     10.788   N334   14.0    0.985  5 A  0   10.779   10.797  0.085  123.32
2.00     0.0000
108     10.688   N323   15.3    0.962  4 B  0   10.678   10.699  0.085  124.00
2.00     0.0000
109     10.568   N351   16.5    0.982  6 A  0   10.557   10.580  0.085  125.00
2.00     0.0000
110     10.413   N345   17.0    0.975  5 A  0   10.401   10.425  0.085  125.66
2.00     0.0000
111     10.347   N342   15.1    0.985  5 A  0   10.337   10.357  0.085  125.04
2.00     0.0000
112     10.255   N349   15.4    0.968  6 B  0   10.245   10.266  0.085  126.82
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113     10.221   N322   16.8    0.985  5 A  0   10.210   10.232  0.085  127.99
2.00     0.0000
114     10.182   N199   87.5    1.000  3 A  2    8.908    8.976  0.085  127.91
2.00     0.0000
115     10.172   N015   12.5    1.000  3 A  2   10.165   10.181  0.085  127.09
2.00     0.0000
116     10.081   N327   16.4    0.978  4 A  0   10.070   10.092  0.085  128.09
2.00     0.0000
117     10.049   N330   14.8    0.991  5 A  0   10.039   10.059  0.085  126.19
2.00     0.0000
118     10.048   N329   32.2    0.995  4 A  2   10.027   10.033  0.085  126.11
2.00     0.0000
119      9.949   N342   16.9    0.997  5 A  0    9.938    9.961  0.085  127.07
2.00     0.0000
120      9.840   N320   15.0    0.960  5 B  0    9.831    9.850  0.085  129.11
2.00     0.0000
121      9.791   N319   16.5    0.971  4 B  0    9.780    9.802  0.085  129.79
2.00     0.0000
122      9.707   N334   16.3    0.945  4 C  0    9.696    9.718  0.085  130.35
2.00     0.0000
123      9.631   N332   14.2    0.993  5 A  0    9.622    9.641  0.085  129.59
2.00     0.0000
124      9.500   N334   12.4    1.000  4 A  0    9.492    9.508  0.085  129.00
2.00     0.0000
125      9.328   N337   13.9    0.990  4 A  0    9.319    9.338  0.085  127.94
2.00     0.0000
126      9.298   N338   14.9    0.977  5 A  0    9.288    9.308  0.085  126.12
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2.00	0.0000										
127	9.156	N325	16.6	0.975	5	A	0	9.145	9.167	0.085	128.20
2.00	0.0000										
128	9.130	N328	16.9	0.970	5	B	0	9.119	9.142	0.085	128.00
2.00	0.0000										
129	9.058	N126	77.3	1.000	3	A	2	8.833	8.974	0.085	128.00
2.00	0.0000										
130	8.967	N339	14.7	0.987	5	A	0	8.958	8.977	0.085	127.14
2.00	0.0000										
131	8.963	N011	3.8	0.990	4	A	2	8.962	8.966	0.085	127.31
2.00	0.0000										
132	8.859	N130	82.7	1.000	3	A	2	8.404	8.437	0.085	127.00
2.00	0.0000										
133	8.849	N324	14.9	0.991	5	A	0	8.839	8.858	0.085	127.00
2.00	0.0000										
134	8.809	N095	82.5	1.000	3	A	2	8.394	8.451	0.085	127.00
2.00	0.0000										
135	8.785	N081	74.7	1.000	3	A	2	8.854	8.907	0.085	127.00
2.00	0.0000										
136	8.711	N319	19.9	1.000	3	A	2	8.697	8.703	0.085	127.71
2.00	0.0000										
137	8.601	N305	6.6	0.991	4	A	2	8.603	8.605	0.085	127.21
2.00	0.0000										
138	8.597	N327	19.4	0.987	4	A	2	8.583	8.608	0.085	127.02
2.00	0.0000										
139	8.551	N352	18.1	0.974	4	A	0	8.539	8.564	0.085	127.89
2.00	0.0000										
140	8.510	N358	13.4	0.989	4	A	0	8.501	8.519	0.085	127.28
2.00	0.0000										
141	8.445	N336	11.9	0.973	5	A	0	8.437	8.453	0.085	127.98
2.00	0.0000										
142	8.404	N342	70.8	1.000	3	A	2	8.293	8.302	0.085	127.17
2.00	0.0000										
143	8.388	N002	20.5	1.000	3	A	2	8.390	8.403	0.085	126.68
2.00	0.0000										
144	8.323	N352	33.3	1.000	3	A	2	8.297	8.304	0.085	125.45
2.00	0.0000										
145	8.304	N322	16.4	1.000	3	A	2	8.304	8.312	0.085	125.85
2.00	0.0000										
146	8.255	N325	15.7	0.985	4	A	0	8.244	8.265	0.085	126.00
2.00	0.0000										
147	8.232	N321	30.1	1.000	3	A	2	8.209	8.217	0.085	125.42
2.00	0.0000										
148	8.203	N334	13.1	0.990	4	A	0	8.195	8.212	0.085	124.29
2.00	0.0000										
149	8.145	N337	15.1	0.971	4	B	0	8.135	8.156	0.085	126.00
2.00	0.0000										
150	8.114	N334	12.2	0.987	4	A	0	8.106	8.122	0.085	126.00
2.00	0.0000										
151	8.037	N353	15.2	1.000	3	A	0	8.027	8.048	0.085	125.66
2.00	0.0000										
152	8.007	N351	18.3	0.970	4	B	2	7.994	8.020	0.085	124.44
2.00	0.0000										
153	7.937	N012	34.4	1.000	3	A	2	7.909	7.933	0.085	125.17
2.00	0.0000										
154	7.930	N329	14.4	1.000	3	A	2	7.922	7.938	0.085	125.31
2.00	0.0000										
155	7.871	N037	46.2	1.000	3	A	2	7.827	7.831	0.085	125.51
2.00	0.0000										
156	7.841	N294	22.1	1.000	3	A	2	7.826	7.831	0.085	124.91
2.00	0.0000										
157	7.833	N272	75.4	1.000	3	A	2	7.688	7.691	0.085	124.74
2.00	0.0000										
158	7.760	N319	25.1	0.990	4	A	2	7.742	7.749	0.085	124.00
2.00	0.0000										
159	7.743	N324	18.3	0.980	5	A	0	7.730	7.755	0.085	124.07
2.00	0.0000										
160	7.695	N036	11.5	1.000	3	A	2	7.688	7.698	0.085	125.00

2.00	0.0000										
161	7.684	N330	14.6	0.996	5	A	0	7.674	7.694	0.085	125.00
2.00	0.0000										
162	7.656	N333	13.6	0.997	5	A	0	7.647	7.665	0.085	125.00
2.00	0.0000										
163	7.587	N318	12.9	0.979	4	A	0	7.578	7.595	0.085	124.19
2.00	0.0000										
164	7.561	N028	48.7	1.000	3	A	0	7.609	7.609	0.085	124.69
2.00	0.0000										
165	7.557	N344	10.6	0.969	6	B	0	7.550	7.564	0.085	124.78
2.00	0.0000										
166	7.525	N296	20.1	0.992	4	A	2	7.511	7.515	0.085	123.75
2.00	0.0000										
167	7.501	N312	45.5	1.000	3	A	2	7.461	7.468	0.085	122.30
2.00	0.0000										
168	7.491	N309	11.2	0.972	5	B	0	7.484	7.497	0.085	122.44
2.00	0.0000										
169	7.447	N294	25.8	1.000	3	A	2	7.428	7.433	0.085	125.94
2.00	0.0000										
170	7.421	N337	15.4	0.962	4	B	0	7.411	7.432	0.085	125.50
2.00	0.0000										
171	7.362	N058	28.8	1.000	3	A	2	7.376	7.385	0.085	124.33
2.00	0.0000										
172	7.356	N328	11.8	0.958	4	B	0	7.348	7.363	0.085	124.19
2.00	0.0000										
173	7.338	N109	36.0	1.000	3	A	2	7.305	7.308	0.085	124.00
2.00	0.0000										
174	7.294	N340	15.4	0.953	6	B	0	7.283	7.304	0.085	124.05
2.00	0.0000										
175	7.250	N013	9.1	1.000	3	A	2	7.247	7.253	0.085	124.91
2.00	0.0000										
176	7.242	N329	24.0	1.000	3	A	2	7.254	7.259	0.085	125.08
2.00	0.0000										
177	7.201	N350	19.6	0.993	4	A	2	7.187	7.195	0.085	125.90
2.00	0.0000										
178	7.189	N338	18.3	0.957	4	B	0	7.176	7.202	0.085	125.72
2.00	0.0000										
179	7.161	N311	17.1	0.946	5	C	2	7.150	7.173	0.085	124.61
2.00	0.0000										
180	7.114	N276	15.7	1.000	3	A	2	7.113	7.125	0.085	123.37
2.00	0.0000										
181	7.106	N000	10.8	1.000	4	A	2	7.099	7.113	0.085	123.21
2.00	0.0000										
182	7.071	N350	14.3	1.000	3	A	2	7.061	7.080	0.085	123.50
2.00	0.0000										
183	7.012	N328	52.5	1.000	3	A	2	6.960	6.975	0.085	123.31
2.00	0.0000										
184	6.994	N347	17.0	0.992	4	A	2	6.982	7.006	0.085	123.08
2.00	0.0000										
185	6.934	N254	51.8	1.000	3	A	2	6.882	6.899	0.085	125.00
2.00	0.0000										
186	6.905	N345	12.0	0.990	5	A	0	6.897	6.912	0.085	125.00
2.00	0.0000										
187	6.904	N108	29.9	1.000	3	A	2	6.877	6.885	0.085	125.00
2.00	0.0000										
188	6.892	N335	37.7	1.000	3	A	2	6.861	6.879	0.085	125.00
2.00	0.0000										
189	6.842	N021	19.1	1.000	3	A	2	6.856	6.856	0.085	124.75
2.00	0.0000										
190	6.828	N031	5.6	1.000	3	A	2	6.826	6.832	0.085	123.90
2.00	0.0000										
191	6.823	N298	24.1	1.000	3	A	2	6.831	6.840	0.085	123.61
2.00	0.0000										
192	6.793	N343	13.0	0.975	5	A	2	6.784	6.802	0.085	121.82
2.00	0.0000										
193	6.456	N313	14.0	0.983	4	A	0	6.447	6.465	0.085	124.38
2.00	0.0000										
194	6.399	N310	16.6	0.999	4	A	0	6.388	6.410	0.085	121.06

2.00	0.0000										
195	6.386	N112	64.1	1.000	3	A	2	6.290	6.306	0.085	121.41
2.00	0.0000										
196	6.341	N260	72.0	1.000	3	A	2	6.221	6.230	0.085	123.00
2.00	0.0000										
197	6.303	N300	15.0	0.997	4	A	2	6.293	6.308	0.085	123.00
2.00	0.0000										
198	6.293	N302	58.7	0.986	4	A	2	6.229	6.251	0.085	122.94
2.00	0.0000										
199	6.246	N340	9.2	1.000	3	A	2	6.240	6.251	0.085	122.01
2.00	0.0000										
200	6.225	N111	21.1	0.956	8	B	2	6.207	6.217	0.085	122.42
2.00	0.0000										
201	6.208	N332	13.5	0.968	6	B	2	6.199	6.216	0.085	122.76
2.00	0.0000										
202	6.195	N191	71.9	1.000	3	A	2	6.058	6.069	0.085	123.00
2.00	0.0000										
203	6.185	N066	55.8	1.000	3	A	2	6.245	6.250	0.085	123.00
2.00	0.0000										
204	6.165	N320	12.2	0.980	4	A	0	6.157	6.173	0.085	123.00
2.00	0.0000										
205	6.161	N296	79.2	1.000	3	A	2	6.313	6.349	0.085	123.00
2.00	0.0000										
206	6.137	N349	46.4	0.982	4	A	2	6.094	6.135	0.085	122.82
2.00	0.0000										
207	6.137	N102	65.8	1.000	3	A	2	6.034	6.074	0.085	122.83
2.00	0.0000										
208	6.131	N353	54.3	1.000	4	A	2	6.075	6.187	0.085	122.70
2.00	0.0000										
209	6.131	N360	53.0	1.000	3	A	2	6.077	6.083	0.085	122.70
2.00	0.0000										
210	6.126	N327	46.9	0.999	4	A	2	6.083	6.106	0.085	122.59
2.00	0.0000										
211	6.119	N212	55.1	1.000	3	A	2	6.058	6.066	0.085	122.45
2.00	0.0000										
212	6.115	N151	60.1	0.984	4	A	2	6.164	6.194	0.085	122.38
2.00	0.0000										
213	6.110	N184	8.5	1.000	3	A	2	6.103	6.109	0.085	122.28
2.00	0.0000										
214	6.108	N062	31.6	1.000	3	A	2	6.121	6.135	0.085	122.23
2.00	0.0000										
215	6.106	N005	13.6	1.000	3	A	2	6.097	6.115	0.085	122.20
2.00	0.0000										
216	6.102	N144	60.5	0.998	4	A	2	6.021	6.032	0.085	122.12
2.00	0.0000										
217	6.102	N270	41.0	1.000	3	A	2	6.091	6.102	0.085	122.11
2.00	0.0000										
218	6.061	N188	20.0	1.000	3	A	2	6.045	6.051	0.085	122.00
2.00	0.0000										
219	6.035	N025	32.1	1.000	3	A	2	6.009	6.030	0.085	122.00
2.00	0.0000										
220	5.979	N030	12.9	0.976	5	A	2	5.969	5.989	0.085	122.00
2.00	0.0000										
221	5.939	N007	27.6	1.000	3	A	2	5.918	5.935	0.085	122.13
2.00	0.0000										
222	5.913	N127	29.6	0.994	4	A	2	5.886	5.900	0.085	122.67
2.00	0.0000										
223	5.888	N081	41.9	0.996	4	A	2	5.903	5.928	0.085	123.00
2.00	0.0000										
224	5.887	N073	21.4	0.943	5	C	0	5.869	5.905	0.085	123.00
2.00	0.0000										
225	5.841	N043	10.7	0.994	7	A	0	5.833	5.850	0.085	123.00
2.00	0.0000										
226	5.718	N341	39.8	1.000	3	A	2	5.685	5.688	0.085	121.45
2.00	0.0000										
227	5.714	N326	75.1	1.000	3	A	2	5.573	5.577	0.085	121.37
2.00	0.0000										
228	5.649	N345	10.6	0.989	5	A	0	5.642	5.656	0.085	125.72

2.00	0.0000										
229	5.525	N348	19.2	1.000	3	A	2	5.511	5.535	0.085	122.00
2.00	0.0000										
230	5.475	N181	84.4	1.000	3	A	2	4.936	4.958	0.085	123.66
2.00	0.0000										
231	5.443	N006	12.1	0.982	4	A	0	5.434	5.451	0.085	125.61
2.00	0.0000										
232	5.407	N348	22.6	1.000	3	A	2	5.393	5.404	0.085	121.33
2.00	0.0000										
233	5.399	N340	16.0	1.000	3	A	2	5.388	5.392	0.085	120.42
2.00	0.0000										
234	5.361	N355	11.0	0.994	4	A	0	5.354	5.369	0.085	118.62
2.00	0.0000										
235	5.327	N350	12.5	0.980	4	A	0	5.319	5.336	0.085	118.75
2.00	0.0000										
236	5.284	N025	32.3	1.000	3	A	2	5.257	5.265	0.085	120.00
2.00	0.0000										
237	5.273	N345	18.9	1.000	3	A	2	5.271	5.286	0.085	120.00
2.00	0.0000										
238	5.269	N186	24.7	1.000	3	A	2	5.249	5.254	0.085	120.00
2.00	0.0000										
239	5.265	N036	25.5	1.000	3	A	2	5.257	5.272	0.085	120.00
2.00	0.0000										
240	5.249	N087	85.8	1.000	3	A	2	6.136	6.199	0.085	120.00
2.00	0.0000										
241	5.214	N274	79.7	1.000	3	A	2	5.015	5.053	0.085	120.00
2.00	0.0000										
242	5.213	N344	13.4	0.991	5	A	0	5.204	5.222	0.085	120.00
2.00	0.0000										
243	5.198	N181	72.2	1.000	3	A	2	5.058	5.096	0.085	120.00
2.00	0.0000										
244	5.153	N346	14.2	0.979	5	A	0	5.143	5.163	0.085	120.86
2.00	0.0000										
245	5.133	N334	46.6	1.000	3	A	2	5.091	5.095	0.085	120.74
2.00	0.0000										
246	5.122	N330	17.2	0.997	4	A	2	5.111	5.114	0.085	120.53
2.00	0.0000										
247	5.097	N187	44.0	1.000	3	A	2	5.065	5.108	0.085	120.03
2.00	0.0000										
248	5.093	N072	76.3	1.000	3	A	2	5.268	5.286	0.085	120.26
2.00	0.0000										
249	5.085	N328	14.5	0.988	4	A	0	5.076	5.095	0.085	120.86
2.00	0.0000										
250	5.061	N238	15.7	1.000	3	A	2	5.050	5.055	0.085	122.78
2.00	0.0000										
251	4.985	N184	4.5	0.966	5	B	2	4.981	4.989	0.085	120.22
2.00	0.0000										
252	4.977	N146	48.5	0.995	4	A	2	4.926	4.957	0.085	120.37
2.00	0.0000										
253	4.956	N133	5.7	1.000	3	A	2	4.954	4.962	0.085	120.79
2.00	0.0000										
254	4.898	N294	13.9	0.973	4	A	0	4.889	4.907	0.085	123.90
2.00	0.0000										
255	4.808	N278	26.8	1.000	3	A	2	4.788	4.810	0.085	120.70
2.00	0.0000										
256	4.789	N218	22.3	1.000	3	A	2	4.798	4.806	0.085	120.14
2.00	0.0000										
257	4.784	N230	5.7	0.990	4	A	2	4.784	4.788	0.085	120.24
2.00	0.0000										
258	4.782	N322	31.8	1.000	3	A	2	4.791	4.807	0.085	120.28
2.00	0.0000										
259	4.733	N243	80.6	1.000	3	A	2	4.905	4.962	0.085	121.00
2.00	0.0000										
260	4.721	N103	80.9	1.000	3	A	2	4.892	4.989	0.085	121.00
2.00	0.0000										
261	4.713	N357	37.7	1.000	3	A	2	4.681	4.702	0.085	121.00
2.00	0.0000										
262	4.713	N176	83.3	1.000	3	A	2	4.278	4.332	0.085	121.00

2.00	0.0000										
263	4.700	N347	12.1	1.000	3	A	2	4.701	4.708	0.085	121.00
2.00	0.0000										
264	4.697	N317	22.4	1.000	3	A	2	4.686	4.701	0.085	121.00
2.00	0.0000										
265	4.691	N026	25.2	1.000	3	A	2	4.690	4.711	0.085	121.00
2.00	0.0000										
266	4.598	N345	16.2	0.945	5	C	0	4.586	4.609	0.085	116.17
2.00	0.0000										
267	4.576	N350	10.9	0.984	4	A	2	4.568	4.583	0.085	117.23
2.00	0.0000										
268	4.575	N323	10.3	0.997	4	A	2	4.577	4.581	0.085	117.27
2.00	0.0000										
269	4.549	N345	14.6	0.975	4	A	0	4.539	4.559	0.085	118.83
2.00	0.0000										
270	4.504	N150	71.2	1.000	3	A	2	4.385	4.421	0.085	119.00
2.00	0.0000										
271	4.484	N033	32.0	0.990	4	A	2	4.458	4.471	0.085	119.00
2.00	0.0000										
272	4.469	N158	76.3	1.000	3	A	2	4.271	4.283	0.085	119.00
2.00	0.0000										
273	4.454	N149	60.5	1.000	3	A	2	4.373	4.428	0.085	119.00
2.00	0.0000										
274	4.428	N063	66.3	1.000	3	A	2	4.478	4.530	0.085	118.29
2.00	0.0000										
275	4.425	N304	43.6	1.000	3	A	2	4.448	4.462	0.085	118.14
2.00	0.0000										
276	4.376	N116	71.8	1.000	3	A	2	4.230	4.268	0.085	117.80
2.00	0.0000										
277	4.329	N280	7.4	0.980	4	A	2	4.325	4.331	0.085	118.01
2.00	0.0000										
278	4.328	N006	77.4	1.000	3	A	2	4.149	4.175	0.085	117.91
2.00	0.0000										
279	4.247	N307	37.2	1.000	3	A	2	4.270	4.277	0.085	116.98
2.00	0.0000										
280	4.241	N058	40.8	1.000	3	A	2	4.275	4.279	0.085	116.82
2.00	0.0000										
281	4.196	N206	68.0	1.000	3	A	2	4.281	4.301	0.085	115.01
2.00	0.0000										
282	4.167	N331	12.0	1.000	3	A	2	4.165	4.175	0.085	115.57
2.00	0.0000										
283	4.121	N085	19.5	1.000	3	A	2	4.131	4.136	0.085	116.51
2.00	0.0000										
284	4.091	N091	45.7	1.000	3	A	2	4.045	4.061	0.085	116.81
2.00	0.0000										
285	4.065	N175	61.6	1.000	3	A	2	4.093	4.141	0.085	115.78
2.00	0.0000										
286	4.063	N006	9.3	1.000	3	A	2	4.065	4.068	0.085	115.67
2.00	0.0000										
287	4.056	N097	1.3	1.000	3	A	2	4.054	4.058	0.085	115.38
2.00	0.0000										
288	4.010	N173	58.9	1.000	3	A	2	3.936	3.948	0.085	118.64
2.00	0.0000										
289	3.990	N264	54.4	1.000	3	A	2	3.934	3.960	0.085	119.38
2.00	0.0000										
290	3.966	N358	34.4	1.000	3	A	2	3.938	3.952	0.085	117.03
2.00	0.0000										
291	3.958	N115	11.1	1.000	3	A	2	3.949	3.954	0.085	116.25
2.00	0.0000										
292	3.935	N285	10.2	1.000	3	A	2	3.929	3.936	0.085	115.43
2.00	0.0000										
293	3.909	N001	72.7	1.000	3	A	2	3.780	3.788	0.085	116.47
2.00	0.0000										
294	3.753	N358	16.8	0.975	4	A	0	3.741	3.765	0.085	115.14
2.00	0.0000										
295	3.741	N357	18.4	0.996	4	A	0	3.727	3.754	0.085	115.22
2.00	0.0000										
296	3.729	N009	16.8	0.970	5	B	0	3.717	3.742	0.085	115.67

2.00	0.0000										
297	3.710	N262	85.0	1.000	3	A	2	3.346	3.464	0.085	116.43
2.00	0.0000										
298	3.687	N346	18.0	0.988	4	A	0	3.674	3.700	0.085	116.63
2.00	0.0000										
299	3.685	N133	65.3	1.000	3	A	2	3.773	3.786	0.085	116.54
2.00	0.0000										
300	3.664	N347	22.5	1.000	3	A	0	3.647	3.680	0.085	115.71
2.00	0.0000										
301	3.663	N225	71.2	1.000	3	A	2	3.542	3.549	0.085	115.67
2.00	0.0000										
302	3.641	N341	19.7	0.976	4	A	0	3.627	3.655	0.085	115.29
2.00	0.0000										
303	3.622	N142	61.5	1.000	3	A	2	3.538	3.555	0.085	116.41
2.00	0.0000										
304	3.600	N215	78.6	0.993	5	A	2	3.738	3.807	0.085	117.75
2.00	0.0000										
305	3.551	N343	18.1	0.991	4	A	0	3.538	3.564	0.085	117.10
2.00	0.0000										
306	3.543	N140	75.0	1.000	3	A	2	3.362	3.452	0.085	116.93
2.00	0.0000										
307	3.539	N049	85.3	1.000	3	A	2	4.078	4.133	0.085	116.86
2.00	0.0000										
308	3.531	N338	45.1	1.000	3	A	2	3.491	3.499	0.085	116.71
2.00	0.0000										
309	3.498	N035	28.0	1.000	3	A	2	3.503	3.521	0.085	116.05
2.00	0.0000										
310	3.484	N060	89.7	1.000	3	A	2	0.608	0.716	0.085	116.00
2.00	0.0000										
311	3.460	N341	30.3	0.977	4	A	2	3.437	3.460	0.085	116.00
2.00	0.0000										
312	3.451	N090	44.3	1.000	3	A	2	3.408	3.450	0.085	116.00
2.00	0.0000										
313	3.451	N219	51.2	1.000	3	A	2	3.491	3.503	0.085	116.00
2.00	0.0000										
314	3.435	N289	11.7	1.000	3	A	2	3.437	3.441	0.085	116.00
2.00	0.0000										
315	3.414	N202	80.9	0.995	4	A	2	3.646	3.682	0.085	116.00
2.00	0.0000										
316	3.345	N341	20.8	0.980	5	A	0	3.330	3.360	0.085	118.88
2.00	0.0000										
317	3.289	N324	12.7	0.962	6	B	0	3.281	3.297	0.085	113.00
2.00	0.0000										
318	3.260	N338	12.5	0.989	4	A	0	3.251	3.268	0.085	113.00
2.00	0.0000										
319	3.242	N336	13.2	0.982	4	A	0	3.233	3.251	0.085	113.17
2.00	0.0000										
320	3.224	N335	13.7	0.988	5	A	0	3.215	3.233	0.085	113.88
2.00	0.0000										
321	3.217	N004	79.5	1.000	3	A	2	3.002	3.050	0.085	114.14
2.00	0.0000										
322	3.203	N336	16.7	0.978	4	A	0	3.192	3.215	0.085	114.71
2.00	0.0000										
323	3.184	N335	14.6	0.994	4	A	0	3.174	3.194	0.085	115.24
2.00	0.0000										
324	3.133	N339	11.9	0.982	4	A	0	3.125	3.141	0.085	114.74
2.00	0.0000										
325	3.108	N336	14.7	0.996	4	A	0	3.098	3.118	0.085	112.18
2.00	0.0000										
326	3.059	N342	7.4	0.944	5	C	0	3.054	3.064	0.085	109.52
2.00	0.0000										
327	2.844	N031	11.2	1.000	3	A	2	2.848	2.853	0.085	113.93
2.00	0.0000										
328	2.835	N315	31.8	1.000	3	A	2	2.837	2.860	0.085	113.57
2.00	0.0000										
329	2.819	N184	76.2	1.000	3	A	2	2.637	2.716	0.085	112.91
2.00	0.0000										
330	2.813	N099	12.7	1.000	3	A	2	2.812	2.823	0.085	112.68

2.00	0.0000											
331	2.811	N154	48.0	1.000	3	A	2	2.840	2.860	0.085	112.58	
2.00	0.0000											
332	2.802	N159	64.9	1.000	3	A	2	2.786	2.899	0.085	112.23	
2.00	0.0000											
333	2.802	N139	16.9	1.000	3	A	2	2.791	2.809	0.085	112.24	
2.00	0.0000											
334	2.781	N177	73.2	0.984	4	A	2	2.632	2.787	0.085	112.58	
2.00	0.0000											
335	2.747	N334	33.1	1.000	3	A	2	2.720	2.736	0.085	113.98	
2.00	0.0000											
336	2.743	N005	30.6	1.000	3	A	2	2.756	2.766	0.085	113.81	
2.00	0.0000											
337	2.703	N248	27.7	1.000	3	A	2	2.700	2.724	0.085	111.39	
2.00	0.0000											
338	2.691	N255	5.6	1.000	3	A	2	2.689	2.694	0.085	110.90	
2.00	0.0000											
339	2.680	N157	72.8	0.989	4	A	2	2.598	2.791	0.085	110.69	
2.00	0.0000											
340	2.587	N336	16.3	0.986	5	A	0	2.575	2.598	0.085	110.81	
2.00	0.0000											
341	2.246	N092	83.9	1.000	3	A	2	2.717	2.812	0.085	110.00	
2.00	0.0000											
342	0.848	N090	87.7	0.981	4	A	2	6.285	6.436	0.085	110.00	
2.00	0.0000											

OPTV DATA PROCESSING
RGLDIP vsn 6.2
INTERPRETED OPTV DIPS LOG

15 Oct 2007

IGSL

Borehole: RCA 03

Tarbert/Ballylongford Embankment-Pond Site Investigation

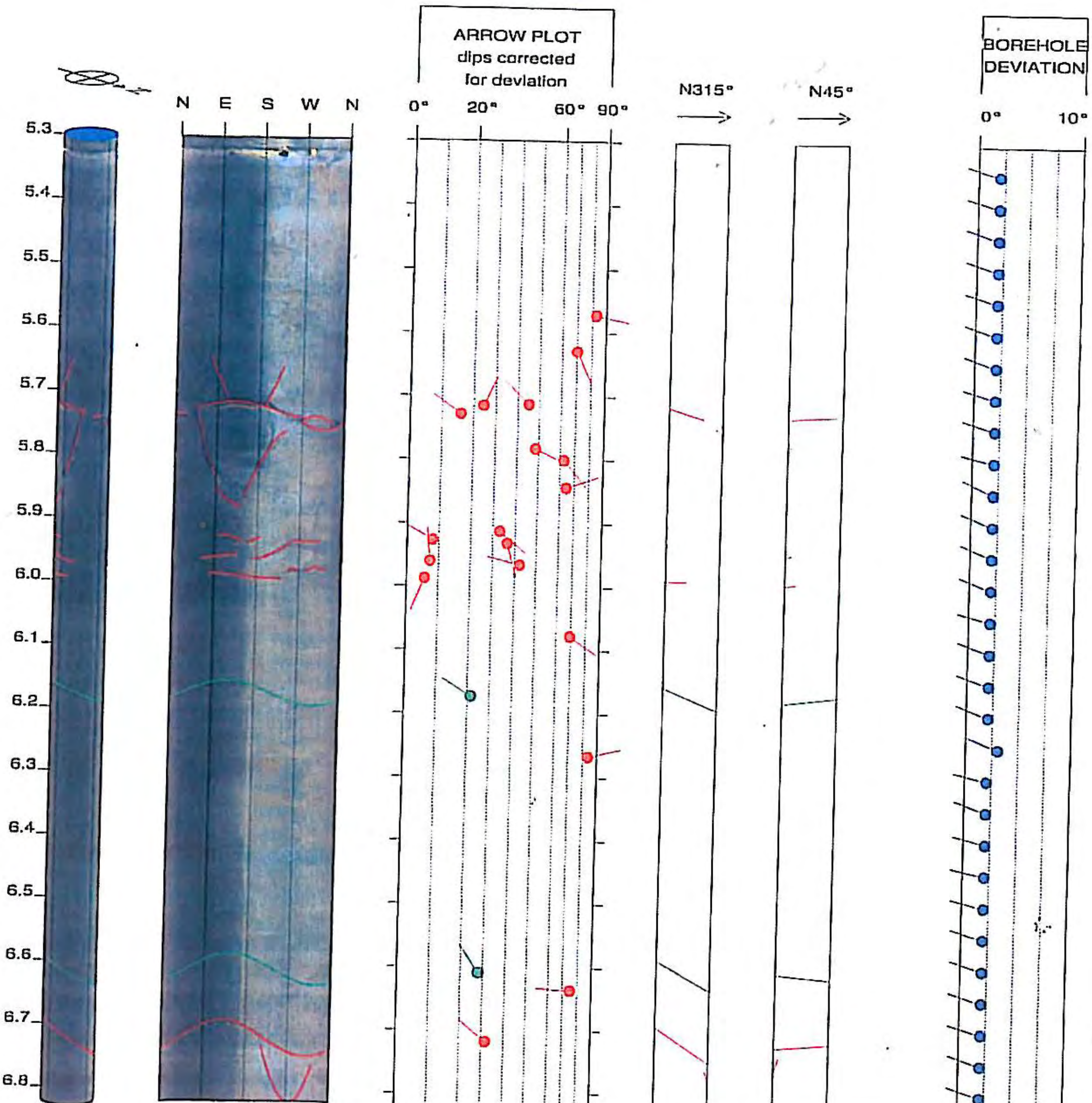
top of borehole.....
East: 101953.98
North: 148220.51
Elev: 6.38

North ref. is magnetic
Depth units are metres
Vertical scale: 1/10
Horiz scale = vert scale

Zone from 17.658 to 5.299m
Format: BHTV-NESWN

Borehole diam: 8.500cm
Vertical = borehole-axis

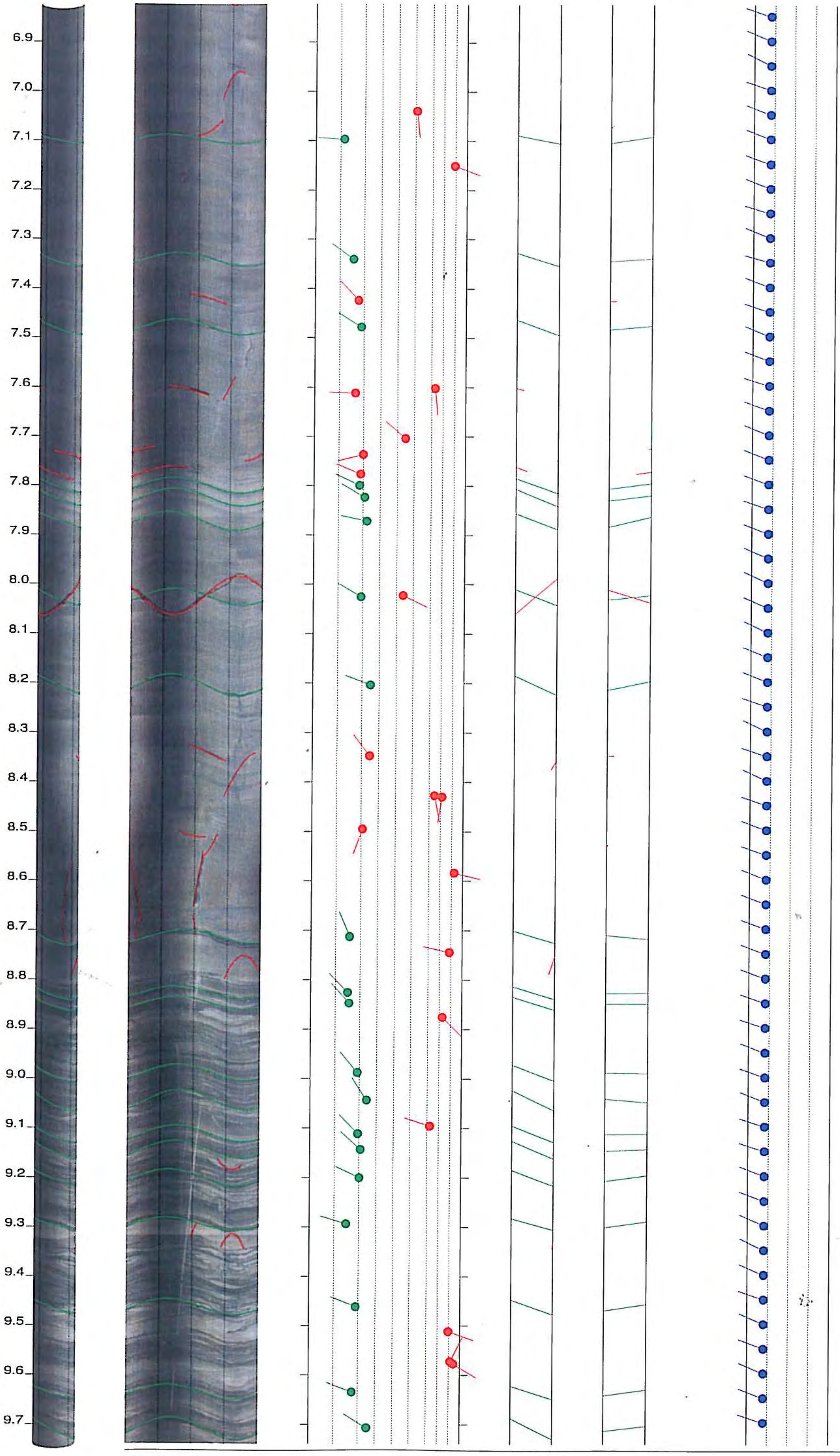
Feature — Feature — Identified units



RCA 03

6.822 to 5.299m

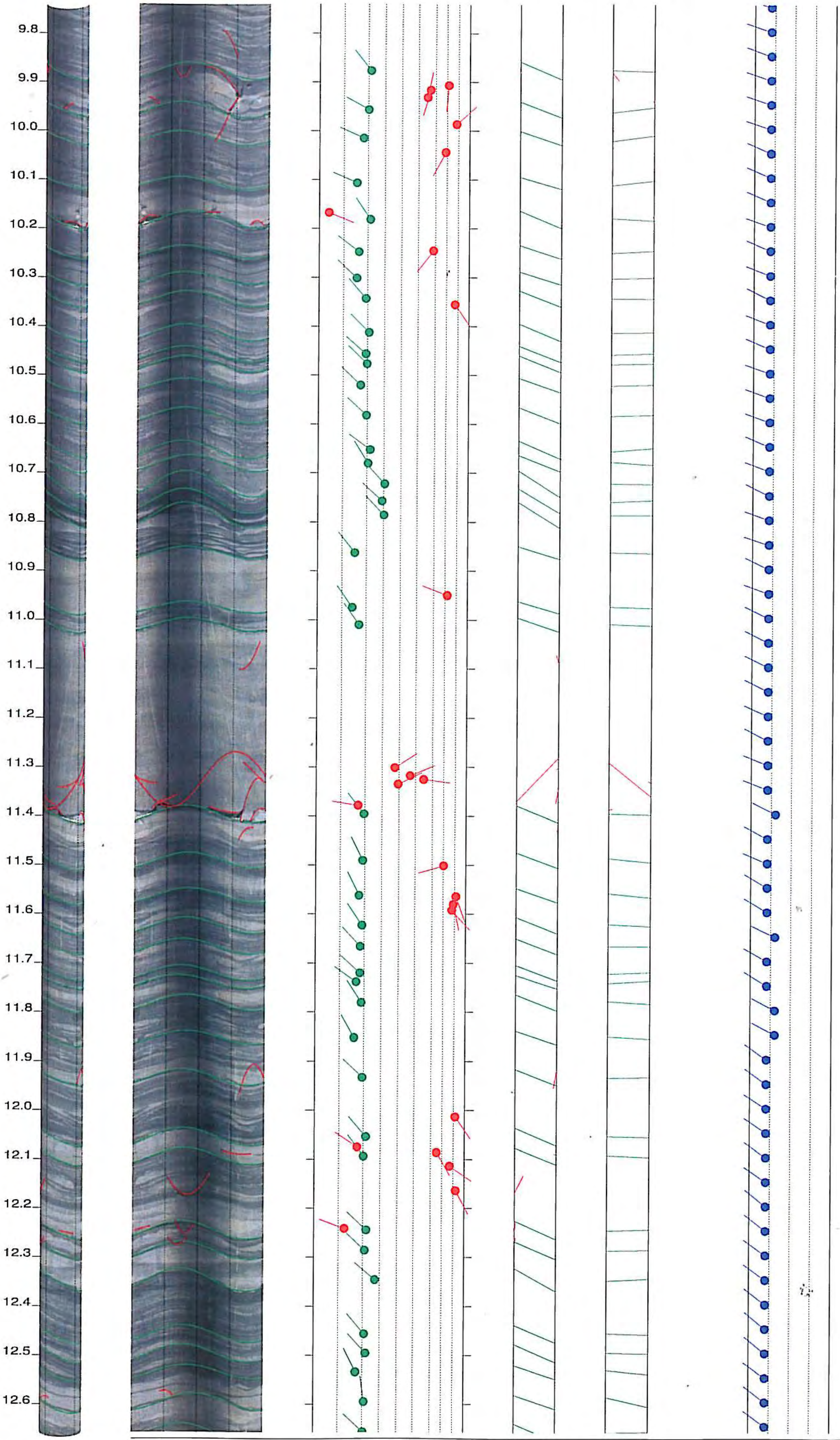
Figure OPTV 3
(1 of 12)



RCA 03

9.740 to 6.822m

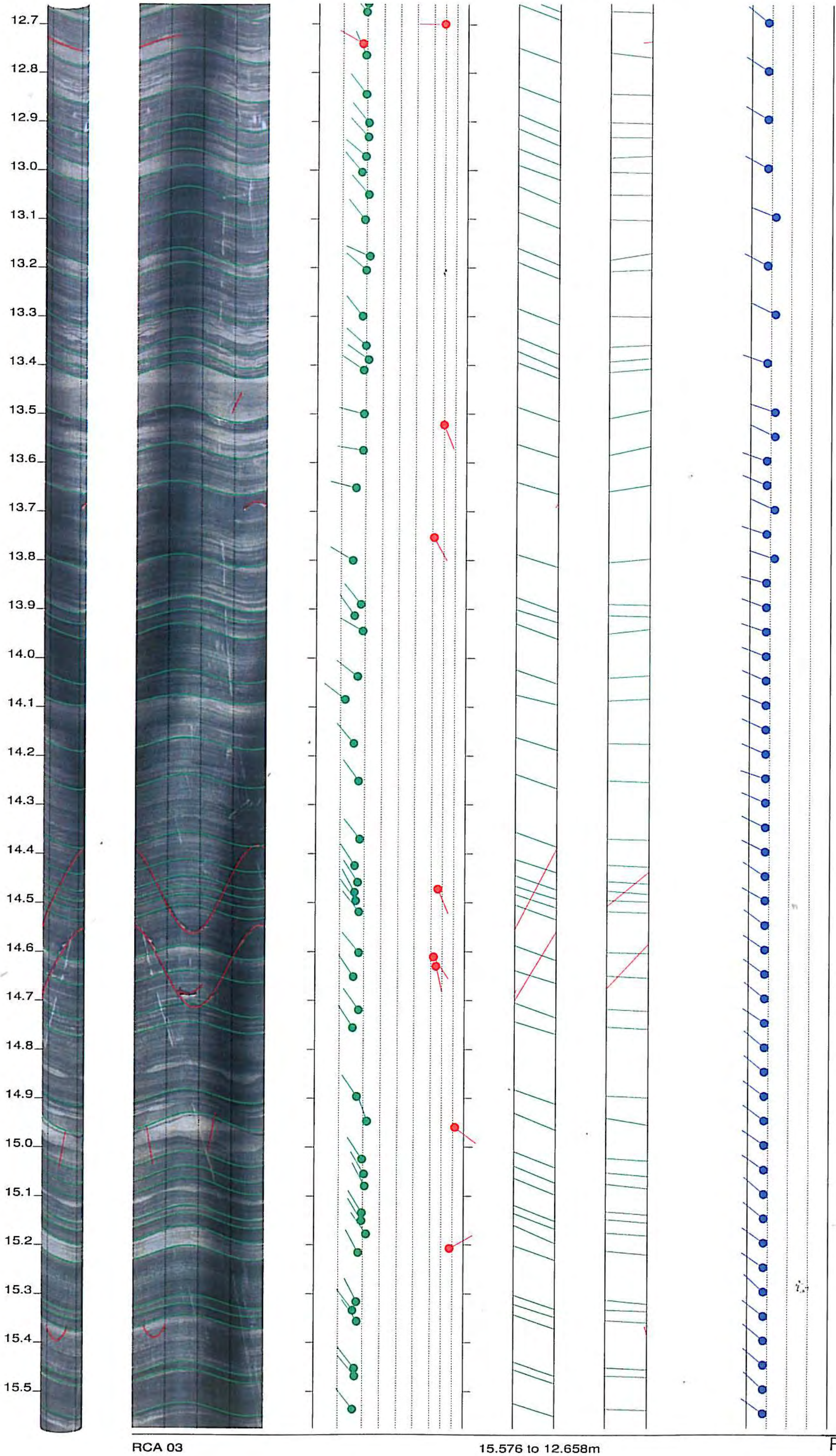
Figure OPTV3
(2 of 12)



RCA 03

12.658 to 9.740m

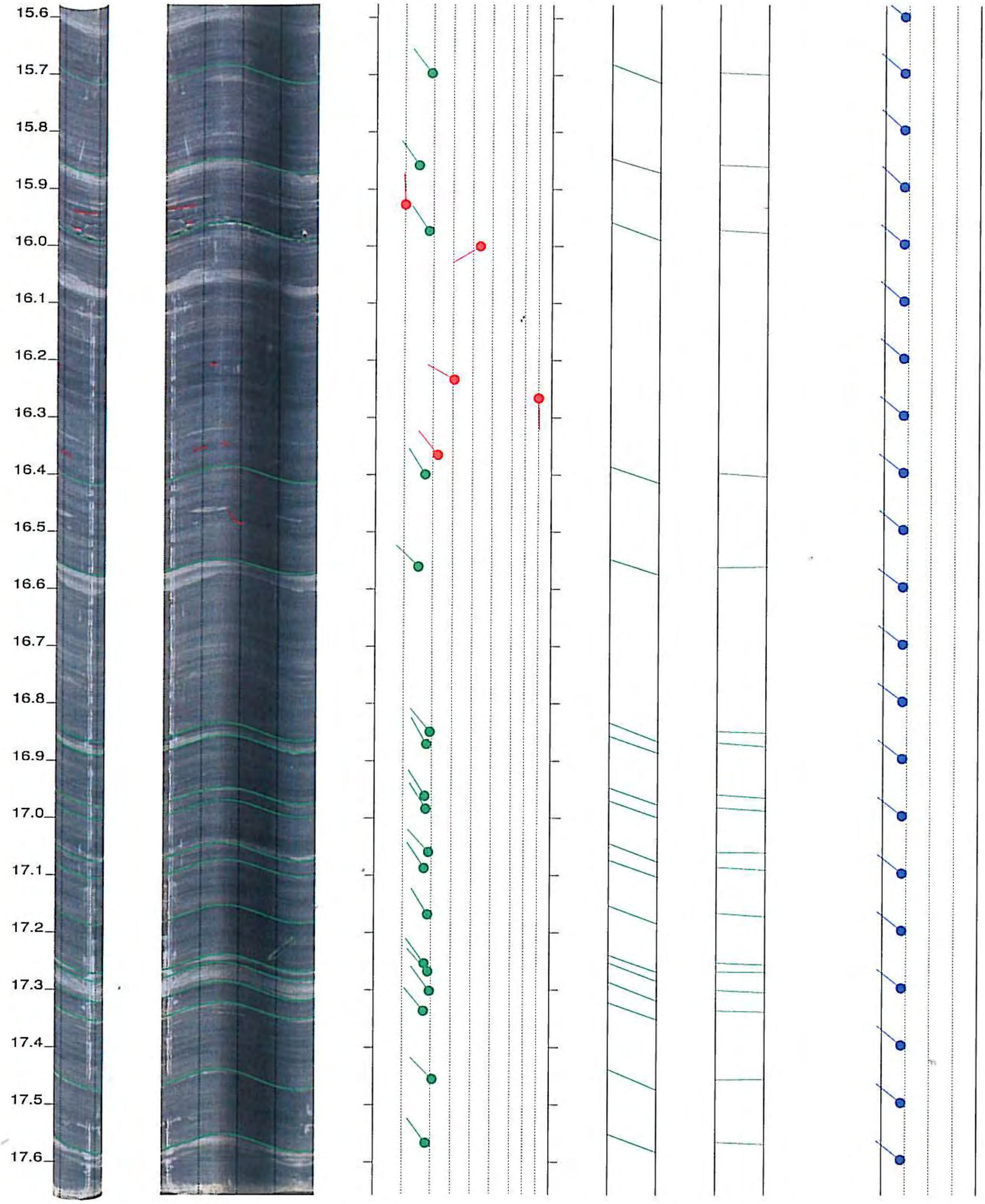
Figure OPTV3
(3 of 12)



RCA 03

15.576 to 12.658m

Figure OPTV3
(4 of 12)


15.6
15.7
15.8
15.9
16.0
16.1
16.2
16.3
16.4
16.5
16.6
16.7
16.8
16.9
17.0
17.1
17.2
17.3
17.4
17.5
17.6

RGLDIPv6.2 OPTV results

K = 0: FEATURE
K = 2: FEATURE

borehole RCA 3
zone from 5.299 to 17.658 m
North ref is magnetic
Dip format: Dip-azimuth and Dip

deviation								Upper	Lower	Well	Well		
	Depth	Azimuth	Dip	1-P0/100	n	Q	K	Depth	Depth	Diam	Azimuth	Dev	Thickness
1	17.567	N323	18.2	0.983	5	A	0	17.551	17.583	0.085	309.16	2.00	0.0000
2	17.456	N314	20.7	0.967	4	B	0	17.439	17.474	0.085	308.79	2.00	0.0000
3	17.337	N320	17.3	0.968	4	B	0	17.322	17.352	0.085	308.81	2.00	0.0000
4	17.302	N323	19.4	0.949	5	B	0	17.286	17.319	0.085	308.12	2.00	0.0000
5	17.268	N318	18.8	0.955	5	B	0	17.252	17.284	0.085	308.56	2.00	0.0000
6	17.254	N323	17.6	0.995	5	A	0	17.239	17.269	0.085	308.85	2.00	0.0000
7	17.169	N328	18.7	0.981	4	A	0	17.153	17.184	0.085	307.45	2.00	0.0000
8	17.088	N327	17.4	0.988	5	A	0	17.073	17.103	0.085	308.16	2.00	0.0000
9	17.060	N318	18.9	0.979	5	A	0	17.043	17.076	0.085	308.73	2.00	0.0000
10	16.984	N328	17.9	0.972	5	B	0	16.969	17.000	0.085	308.00	2.00	0.0000
11	16.962	N328	17.5	0.984	4	A	0	16.947	16.977	0.085	308.00	2.00	0.0000
12	16.872	N330	18.0	0.984	5	A	0	16.856	16.887	0.085	307.51	2.00	0.0000
13	16.850	N320	19.2	0.979	5	A	0	16.833	16.866	0.085	307.08	2.00	0.0000
14	16.562	N314	15.0	0.962	5	B	0	16.549	16.574	0.085	306.31	2.00	0.0000
15	16.400	N328	17.3	0.996	6	A	0	16.386	16.415	0.085	308.00	2.00	0.0000
16	16.366	N321	22.6	0.999	4	A	2	16.347	16.360	0.085	308.60	2.00	0.0000
17	16.267	N179	80.3	1.000	3	A	2	16.466	16.486	0.085	309.00	2.00	0.0000
18	16.234	N299	30.8	1.000	3	A	2	16.207	16.208	0.085	309.47	2.00	0.0000
19	16.001	N240	43.9	1.000	3	A	2	15.959	15.960	0.085	310.39	2.00	0.0000
20	15.974	N326	18.4	0.978	6	A	0	15.959	15.990	0.085	309.14	2.00	0.0000
21	15.928	N357	10.2	0.992	4	A	2	15.930	15.936	0.085	309.83	2.00	0.0000
22	15.860	N324	14.8	0.954	7	B	0	15.847	15.872	0.085	311.54	2.00	0.0000
23	15.698	N322	19.2	0.999	5	A	0	15.681	15.714	0.085	310.90	2.00	0.0000
24	15.537	N323	16.0	0.985	5	A	0	15.524	15.551	0.085	307.23		

												2.00	0.0000
25	15.469	N321	16.9	0.982	7	A	0	15.455	15.484	0.085	311.40	2.00	0.0000
26	15.454	N322	16.7	0.981	7	A	0	15.439	15.468	0.085	310.45	2.00	0.0000
27	15.357	N326	17.7	0.968	7	B	0	15.342	15.372	0.085	308.44	2.00	0.0000
28	15.334	N324	15.9	0.985	7	A	0	15.321	15.348	0.085	309.16	2.00	0.0000
29	15.317	N333	17.4	0.984	5	A	0	15.302	15.331	0.085	310.94	2.00	0.0000
30	15.217	N331	18.2	0.983	6	A	0	15.201	15.232	0.085	305.18	2.00	0.0000
31	15.208	N060	77.8	1.000	3	A	2	15.364	15.391	0.085	305.52	2.00	0.0000
32	15.178	N325	22.0	0.992	6	A	0	15.159	15.197	0.085	307.07	2.00	0.0000
33	15.151	N329	19.4	0.997	5	A	0	15.135	15.168	0.085	308.68	2.00	0.0000
34	15.135	N329	19.6	0.994	5	A	0	15.118	15.152	0.085	309.43	2.00	0.0000
35	15.080	N332	21.0	0.997	5	A	0	15.062	15.098	0.085	309.10	2.00	0.0000
36	15.056	N329	20.6	0.973	5	A	0	15.038	15.073	0.085	306.16	2.00	0.0000
37	15.025	N326	19.6	0.982	5	A	0	15.008	15.042	0.085	305.00	2.00	0.0000
38	14.960	N127	82.3	0.989	4	A	2	14.928	15.035	0.085	306.43	2.00	0.0000
39	14.948	N340	22.2	0.966	5	B	0	14.929	14.967	0.085	306.93	2.00	0.0000
40	14.897	N326	17.3	0.977	6	A	0	14.882	14.911	0.085	307.00	2.00	0.0000
41	14.756	N327	15.5	0.990	6	A	0	14.743	14.769	0.085	305.00	2.00	0.0000
42	14.720	N325	17.9	0.990	6	A	0	14.705	14.735	0.085	306.61	2.00	0.0000
43	14.652	N326	15.7	0.984	6	A	0	14.638	14.665	0.085	306.33	2.00	0.0000
44	14.630	N167	64.7	0.966	5	B	2	14.546	14.715	0.085	305.69	2.00	0.0000
45	14.611	N146	62.6	1.000	3	A	2	14.668	14.687	0.085	305.31	2.00	0.0000
46	14.603	N320	17.8	0.982	5	A	0	14.587	14.618	0.085	305.13	2.00	0.0000
47	14.519	N322	17.9	0.982	6	A	0	14.504	14.535	0.085	303.27	2.00	0.0000
48	14.497	N324	16.5	0.972	6	B	0	14.483	14.511	0.085	300.11	2.00	0.0000
49	14.479	N332	16.0	0.985	5	A	0	14.466	14.493	0.085	301.00	2.00	0.0000
50	14.473	N157	66.3	0.953	4	B	2	14.383	14.563	0.085	301.38	2.00	0.0000
51	14.459	N327	17.2	0.979	6	A	0	14.444	14.474	0.085	302.21	2.00	0.0000
52	14.424	N327	16.0	0.979	5	A	0	14.411	14.438	0.085	300.42	2.00	0.0000
53	14.370	N322	18.0	0.992	4	A	0	14.355	14.386	0.085	296.49	2.00	0.0000
54	14.252	N324	17.6	0.982	5	A	0	14.237	14.267	0.085	288.70	2.00	0.0000
55	14.175	N320	15.5	0.976	4	A	0	14.161	14.188	0.085	294.43	2.00	0.0000
56	14.085	N308	11.9	0.963	5	B	0	14.075	14.096	0.085	293.22	2.00	0.0000
57	14.038	N307	16.9	0.953	4	B	0	14.024	14.053	0.085	293.54	2.00	0.0000
58	13.945	N300	19.1	0.999	4	A	0	13.929	13.961	0.085	289.02		

												2.00	0.0000
59	13.914	N325	15.6	0.977	7	A	0	13.900	13.927	0.085	289.65	2.00	0.0000
60	13.890	N321	18.2	0.982	5	A	0	13.875	13.906	0.085	289.44	2.00	0.0000
61	13.800	N301	14.9	0.962	5	B	0	13.787	13.814	0.085	287.74	2.91	0.0000
62	13.754	N151	61.7	1.000	4	A	2	13.680	13.694	0.085	288.00	2.15	0.0000
63	13.652	N284	16.0	0.989	5	A	0	13.638	13.666	0.085	293.24	2.12	0.0000
64	13.575	N280	18.8	0.982	5	A	0	13.559	13.592	0.085	291.87	2.41	0.0000
65	13.523	N158	70.1	1.000	3	A	2	13.454	13.497	0.085	292.75	3.00	0.0000
66	13.500	N284	19.1	0.957	6	B	0	13.483	13.518	0.085	289.60	3.00	0.0000
67	13.411	N304	19.0	0.975	6	A	0	13.395	13.428	0.085	291.12	2.30	0.0000
68	13.389	N305	21.4	0.969	5	B	0	13.371	13.408	0.085	289.13	2.13	0.0000
69	13.361	N311	19.8	0.970	6	B	0	13.343	13.378	0.085	289.71	2.71	0.0000
70	13.300	N321	18.4	0.958	6	B	0	13.284	13.317	0.085	295.51	3.00	0.0000
71	13.206	N310	19.8	0.979	5	A	0	13.189	13.223	0.085	297.81	2.19	0.0000
72	13.177	N294	21.8	0.950	5	B	0	13.158	13.196	0.085	298.00	2.00	0.0000
73	13.102	N321	19.2	0.967	5	B	0	13.085	13.119	0.085	292.78	2.87	0.0000
74	13.051	N319	21.1	0.965	5	B	0	13.033	13.069	0.085	296.51	2.10	0.0000
75	13.005	N320	17.9	0.965	6	B	0	12.989	13.020	0.085	298.65	2.00	0.0000
76	12.973	N310	19.5	0.969	5	B	0	12.956	12.989	0.085	299.00	2.00	0.0000
77	12.933	N317	20.7	0.976	5	A	0	12.915	12.950	0.085	299.54	2.00	0.0000
78	12.904	N321	21.0	0.975	6	A	0	12.886	12.921	0.085	300.70	2.00	0.0000
79	12.844	N322	19.6	0.966	5	B	0	12.828	12.861	0.085	299.12	2.00	0.0000
80	12.764	N336	19.4	0.964	4	B	0	12.748	12.780	0.085	304.92	2.00	0.0000
81	12.740	N299	18.3	1.000	3	A	2	12.725	12.748	0.085	306.33	2.00	0.0000
82	12.699	N271	69.8	1.000	3	A	2	12.573	12.586	0.085	308.82	2.00	0.0000
83	12.675	N320	19.6	0.977	5	A	0	12.658	12.692	0.085	308.17	2.00	0.0000
84	12.657	N313	20.4	0.986	6	A	0	12.640	12.675	0.085	307.46	2.00	0.0000
85	12.596	N352	21.0	0.956	5	B	0	12.578	12.613	0.085	307.98	2.00	0.0000
86	12.535	N334	17.2	0.998	4	A	0	12.520	12.549	0.085	306.68	2.00	0.0000
87	12.496	N318	21.8	0.987	5	A	0	12.477	12.515	0.085	308.99	2.00	0.0000
88	12.457	N320	20.9	0.974	5	A	0	12.439	12.475	0.085	309.78	2.00	0.0000
89	12.346	N310	27.2	0.939	6	C	0	12.322	12.370	0.085	306.00	2.00	0.0000
90	12.286	N314	21.1	0.986	4	A	0	12.268	12.304	0.085	306.39	2.00	0.0000
91	12.245	N313	21.9	0.951	5	B	0	12.226	12.263	0.085	308.03	2.00	0.0000
92	12.242	N291	12.5	1.000	3	A	2	12.237	12.244	0.085	308.08		

2.00	0.0000										
93	12.164	N152	82.4	1.000	3	A	2	11.907	11.967	0.085	306.47
2.00	0.0000										
94	12.114	N124	77.2	1.000	3	A	2	12.259	12.275	0.085	305.63
2.00	0.0000										
95	12.094	N323	20.1	0.975	5	A	0	12.077	12.111	0.085	305.96
2.00	0.0000										
96	12.087	N150	65.3	1.000	3	A	2	12.127	12.172	0.085	305.82
2.00	0.0000										
97	12.076	N304	17.5	1.000	3	A	2	12.083	12.091	0.085	305.59
2.00	0.0000										
98	12.054	N319	21.4	0.939	5	C	0	12.036	12.073	0.085	305.17
2.00	0.0000										
99	12.014	N145	81.7	1.000	3	A	2	12.227	12.251	0.085	303.72
2.00	0.0000										
100	11.933	N314	19.4	0.978	5	A	0	11.916	11.950	0.085	306.00
2.00	0.0000										
101	11.852	N331	15.9	0.990	5	A	0	11.838	11.866	0.085	298.96
2.88	0.0000										
102	11.780	N327	18.8	0.975	5	A	0	11.764	11.797	0.085	299.24
2.69	0.0000										
103	11.738	N305	16.7	0.984	5	A	0	11.724	11.753	0.085	301.69
2.00	0.0000										
104	11.720	N312	18.3	0.968	5	B	0	11.704	11.736	0.085	300.96
2.00	0.0000										
105	11.666	N317	18.3	0.998	4	A	0	11.650	11.682	0.085	296.99
2.60	0.0000										
106	11.623	N326	19.0	0.969	5	B	0	11.607	11.640	0.085	297.73
2.54	0.0000										
107	11.593	N138	77.8	1.000	3	A	2	11.424	11.448	0.085	301.00
2.00	0.0000										
108	11.581	N168	79.1	1.000	3	A	2	11.385	11.411	0.085	301.00
2.00	0.0000										
109	11.565	N161	81.5	0.993	4	A	2	11.324	11.410	0.085	301.00
2.00	0.0000										
110	11.562	N334	17.7	0.971	4	B	0	11.547	11.577	0.085	301.00
2.00	0.0000										
111	11.502	N254	70.3	0.999	4	A	2	11.372	11.385	0.085	293.90
2.00	0.0000										
112	11.490	N333	19.2	0.994	5	A	0	11.474	11.507	0.085	293.67
2.00	0.0000										
113	11.396	N322	19.5	0.979	5	A	0	11.379	11.414	0.085	297.01
3.00	0.0000										
114	11.379	N279	17.2	1.000	3	A	2	11.383	11.394	0.085	295.28
2.66	0.0000										
115	11.336	N064	39.7	1.000	3	A	2	11.357	11.369	0.085	292.00
2.00	0.0000										
116	11.326	N097	54.8	0.991	4	A	2	11.270	11.382	0.085	292.00
2.00	0.0000										
117	11.318	N067	46.9	1.000	3	A	2	11.291	11.332	0.085	292.00
2.00	0.0000										
118	11.302	N057	37.6	1.000	3	A	2	11.320	11.333	0.085	292.00
2.00	0.0000										
119	11.010	N325	17.1	0.975	5	A	0	10.995	11.024	0.085	296.28
2.00	0.0000										
120	10.974	N325	14.2	0.993	4	A	0	10.962	10.987	0.085	293.42
2.00	0.0000										
121	10.951	N291	72.3	1.000	3	A	2	11.045	11.102	0.085	290.54
2.00	0.0000										
122	10.863	N321	15.2	0.975	5	A	0	10.850	10.876	0.085	290.77
2.00	0.0000										
123	10.786	N316	30.1	0.955	5	B	0	10.760	10.813	0.085	291.17
2.00	0.0000										
124	10.757	N312	29.1	0.980	4	A	0	10.732	10.783	0.085	294.63
2.00	0.0000										
125	10.723	N317	30.6	0.931	5	C	0	10.696	10.749	0.085	293.18
2.00	0.0000										
126	10.680	N328	20.6	0.987	4	A	0	10.663	10.698	0.085	290.93

2.00	0.0000										
127	10.653	N306	21.9	0.984	5	A	0	10.634	10.671	0.085	292.60
2.00	0.0000										
128	10.582	N313	19.6	0.972	6	B	0	10.566	10.599	0.085	290.00
2.00	0.0000										
129	10.521	N313	17.2	0.972	6	B	0	10.506	10.535	0.085	289.49
2.00	0.0000										
130	10.477	N314	19.9	0.983	5	A	0	10.460	10.494	0.085	290.49
2.00	0.0000										
131	10.457	N312	19.3	0.995	6	A	0	10.441	10.474	0.085	292.12
2.00	0.0000										
132	10.413	N315	20.8	0.985	6	A	0	10.395	10.431	0.085	291.68
2.00	0.0000										
133	10.356	N146	77.8	1.000	3	A	2	10.185	10.197	0.085	295.81
2.00	0.0000										
134	10.344	N319	19.2	0.973	5	B	0	10.327	10.360	0.085	296.75
2.00	0.0000										
135	10.302	N313	15.4	0.971	6	B	0	10.288	10.315	0.085	292.57
2.00	0.0000										
136	10.248	N307	16.3	0.951	6	B	0	10.234	10.262	0.085	293.91
2.00	0.0000										
137	10.246	N218	59.0	1.000	3	A	2	10.174	10.187	0.085	293.99
2.00	0.0000										
138	10.182	N326	21.3	0.975	5	A	0	10.164	10.200	0.085	290.40
2.00	0.0000										
139	10.167	N112	4.1	0.995	4	A	2	10.167	10.168	0.085	291.86
2.00	0.0000										
140	10.107	N294	15.4	0.990	6	A	0	10.094	10.120	0.085	294.00
2.00	0.0000										
141	10.044	N208	69.0	1.000	3	A	2	9.932	9.947	0.085	293.80
2.00	0.0000										
142	10.016	N294	18.0	0.975	5	A	0	10.000	10.031	0.085	290.35
2.00	0.0000										
143	9.987	N047	78.5	1.000	3	A	2	9.794	9.849	0.085	288.18
2.00	0.0000										
144	9.957	N299	20.1	0.975	6	A	0	9.940	9.974	0.085	288.78
2.00	0.0000										
145	9.932	N011	55.2	0.990	4	A	2	9.870	9.928	0.085	289.00
2.00	0.0000										
146	9.916	N197	57.0	1.000	3	A	2	9.932	9.958	0.085	289.00
2.00	0.0000										
147	9.907	N185	71.6	1.000	3	A	2	9.965	10.021	0.085	289.00
2.00	0.0000										
148	9.877	N321	21.5	0.935	6	C	0	9.859	9.895	0.085	289.38
2.00	0.0000										
149	9.708	N302	25.1	0.993	5	A	0	9.686	9.730	0.085	288.24
2.00	0.0000										
150	9.635	N291	17.5	0.954	5	B	0	9.620	9.650	0.085	291.45
2.00	0.0000										
151	9.578	N121	84.2	1.000	3	A	2	9.867	9.889	0.085	292.27
2.00	0.0000										
152	9.573	N026	81.7	1.000	3	A	2	9.291	9.319	0.085	292.09
2.00	0.0000										
153	9.512	N109	79.8	1.000	3	A	2	9.315	9.346	0.085	293.03
2.00	0.0000										
154	9.462	N292	18.9	0.989	5	A	0	9.445	9.478	0.085	290.56
2.00	0.0000										
155	9.294	N287	14.9	0.972	4	B	0	9.281	9.307	0.085	293.85
2.00	0.0000										
156	9.200	N295	20.1	0.961	4	B	0	9.183	9.218	0.085	290.91
2.00	0.0000										
157	9.144	N312	20.7	0.982	5	A	0	9.126	9.161	0.085	288.00
2.00	0.0000										
158	9.111	N315	19.4	0.981	5	A	0	9.095	9.128	0.085	288.00
2.00	0.0000										
159	9.096	N288	62.4	1.000	3	A	2	9.165	9.185	0.085	288.00
2.00	0.0000										
160	9.043	N326	24.2	0.991	4	A	0	9.023	9.064	0.085	291.85

2.00	0.0000										
161	8.988	N320	19.1	0.984	5	A	0	8.971	9.004	0.085	289.17
2.00	0.0000										
162	8.876	N135	72.9	1.000	3	A	2	8.752	8.798	0.085	288.40
2.00	0.0000										
163	8.847	N318	15.5	0.968	5	B	0	8.834	8.860	0.085	288.97
2.00	0.0000										
164	8.826	N316	14.9	0.949	4	B	0	8.813	8.839	0.085	289.40
2.00	0.0000										
165	8.745	N283	78.8	0.987	4	A	2	8.671	8.722	0.085	290.00
2.00	0.0000										
166	8.713	N337	15.6	0.960	4	B	0	8.700	8.726	0.085	290.00
2.00	0.0000										
167	8.584	N103	82.6	0.974	4	A	2	8.541	8.678	0.085	291.28
2.00	0.0000										
168	8.496	N201	21.0	1.000	3	A	2	8.503	8.512	0.085	289.99
2.00	0.0000										
169	8.430	N189	71.4	1.000	3	A	2	8.505	8.551	0.085	290.89
2.00	0.0000										
170	8.428	N169	64.7	1.000	3	A	2	8.342	8.428	0.085	291.19
2.00	0.0000										
171	8.347	N322	24.8	1.000	3	A	2	8.328	8.358	0.085	288.17
2.00	0.0000										
172	8.204	N291	24.9	0.994	4	A	0	8.182	8.225	0.085	291.53
2.00	0.0000										
173	8.026	N301	19.3	0.997	4	A	0	8.009	8.042	0.085	293.81
2.00	0.0000										
174	8.023	N115	44.1	0.946	5	C	2	7.985	8.061	0.085	293.92
2.00	0.0000										
175	7.872	N282	22.2	0.977	4	A	0	7.853	7.891	0.085	290.03
2.00	0.0000										
176	7.824	N300	20.8	0.975	5	A	0	7.806	7.842	0.085	289.44
2.00	0.0000										
177	7.800	N296	18.5	0.999	4	A	0	7.784	7.816	0.085	289.92
2.00	0.0000										
178	7.777	N293	19.0	1.000	3	A	2	7.761	7.783	0.085	290.75
2.00	0.0000										
179	7.737	N256	20.1	1.000	3	A	2	7.721	7.733	0.085	292.00
2.00	0.0000										
180	7.705	N311	45.0	1.000	3	A	2	7.736	7.750	0.085	292.00
2.00	0.0000										
181	7.612	N272	16.7	0.998	4	A	2	7.598	7.618	0.085	287.97
2.00	0.0000										
182	7.603	N175	63.3	1.000	3	A	2	7.579	7.625	0.085	287.40
2.00	0.0000										
183	7.479	N302	18.8	0.975	4	A	0	7.463	7.495	0.085	291.27
2.00	0.0000										
184	7.424	N317	17.9	1.000	3	A	2	7.410	7.432	0.085	289.30
2.00	0.0000										
185	7.341	N306	15.5	0.968	4	B	0	7.328	7.355	0.085	286.57
2.00	0.0000										
186	7.151	N110	79.5	1.000	3	A	2	6.959	7.015	0.085	290.21
2.00	0.0000										
187	7.097	N273	11.4	1.000	4	A	0	7.087	7.108	0.085	290.97
2.00	0.0000										
188	7.040	N174	50.7	1.000	3	A	2	7.058	7.090	0.085	290.76
2.00	0.0000										
189	6.719	N309	32.0	0.959	7	B	2	6.691	6.748	0.085	288.40
2.00	0.0000										
190	6.637	N274	75.3	1.000	3	A	2	6.733	6.824	0.085	288.19
2.00	0.0000										
191	6.609	N326	27.8	0.943	4	C	0	6.585	6.633	0.085	288.73
2.00	0.0000										
192	6.267	N076	83.8	1.000	3	A	2	5.977	5.982	0.085	288.61
2.58	0.0000										
193	6.173	N302	21.5	0.935	5	C	0	6.155	6.192	0.085	291.09
2.00	0.0000										
194	6.078	N124	69.5	1.000	3	A	2	5.975	5.982	0.085	289.18

2.00	0.0000										
195	5.989	N203	5.7	1.000	3	A	2	5.986	5.993	0.085	292.30
2.00	0.0000										
196	5.967	N285	42.6	1.000	3	A	2	5.925	5.935	0.085	293.18
2.00	0.0000										
197	5.961	N355	7.4	1.000	3	A	2	5.956	5.964	0.085	293.39
2.00	0.0000										
198	5.933	N165	36.8	1.000	3	A	2	5.935	5.963	0.085	293.73
2.00	0.0000										
199	5.928	N299	8.1	1.000	3	A	2	5.933	5.935	0.085	293.64
2.00	0.0000										
200	5.914	N129	33.2	1.000	3	A	2	5.928	5.937	0.085	293.36
2.00	0.0000										
201	5.844	N071	64.8	1.000	3	A	2	5.762	5.865	0.085	295.59
2.00	0.0000										
202	5.801	N139	63.0	1.000	3	A	2	5.854	5.879	0.085	285.25
2.00	0.0000										
203	5.784	N115	48.7	1.000	3	A	2	5.739	5.749	0.085	284.98
2.00	0.0000										
204	5.730	N306	16.1	0.982	5	A	2	5.716	5.740	0.085	287.67
2.00	0.0000										
205	5.716	N025	24.6	1.000	3	A	2	5.733	5.735	0.085	287.40
2.00	0.0000										
206	5.714	N315	45.3	1.000	3	A	2	5.745	5.759	0.085	287.36
2.00	0.0000										
207	5.630	N154	70.5	0.965	4	B	2	5.647	5.717	0.085	289.00
2.00	0.0000										
208	5.572	N101	83.0	1.000	3	A	2	5.722	5.833	0.085	288.53
2.00	0.0000										

OPTV DATA PROCESSING
RGLDIP vsn 6.2
INTERPRETED OPTV DIPS LOG

15 Oct 2007

IGSL

Borehole: RCA 04

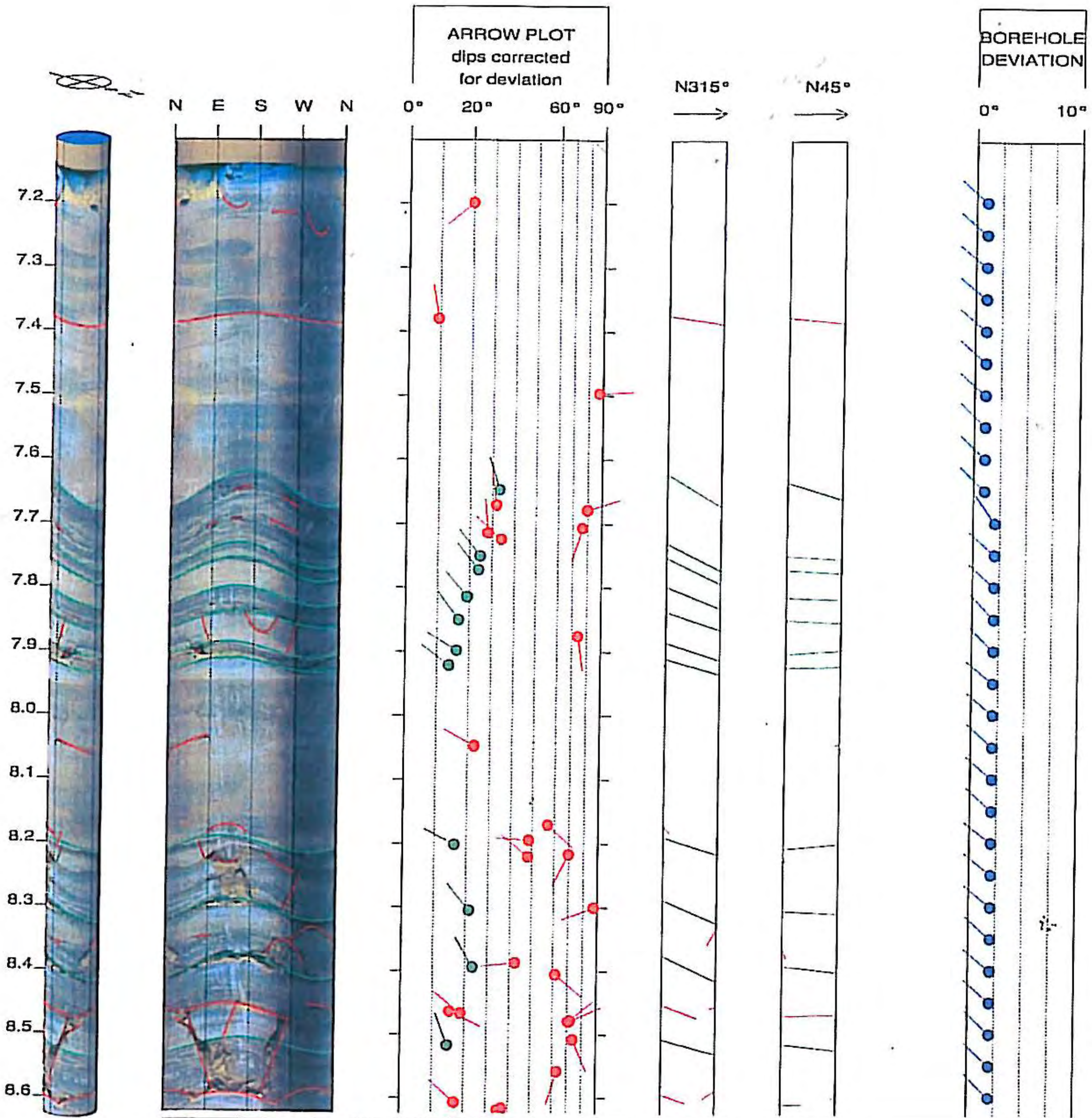
Tarbert/Ballylongford Embankment-Pond Site Investigation

top of borehole.....		North ref. is magnetic
East:	102010.83	Depth units are metres
North:	148239.45	Vertical scale: 1/10
Elev:	11.69	Horiz scale = vert scale

Zone from 16.197 to 7.101m
Format: BHTV-NESWN

Borehole diam: 8.500cm
Vertical = borehole-axis

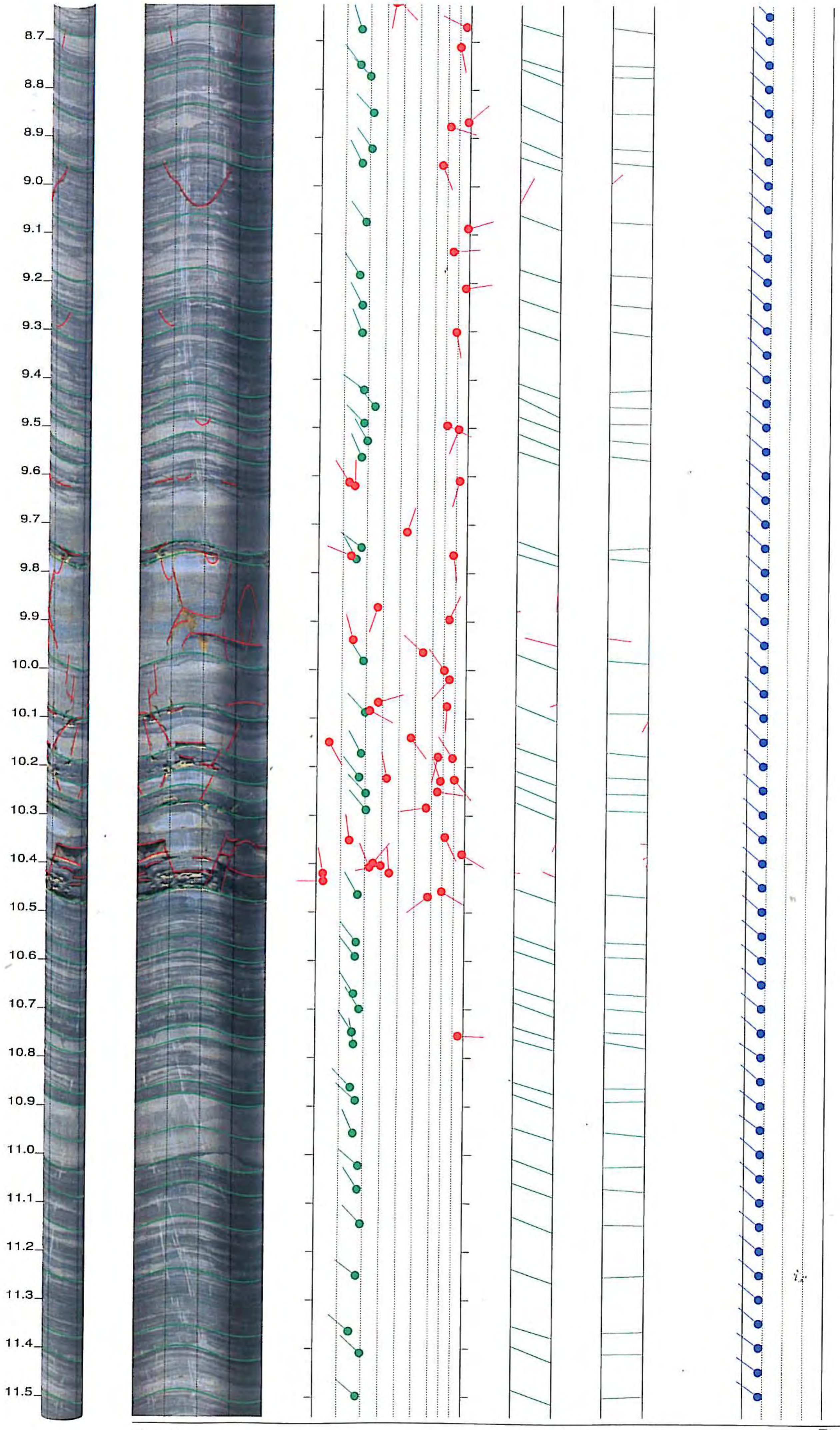
Feature
Feature
Identified units



RCA 04

8.624 to 7.101m

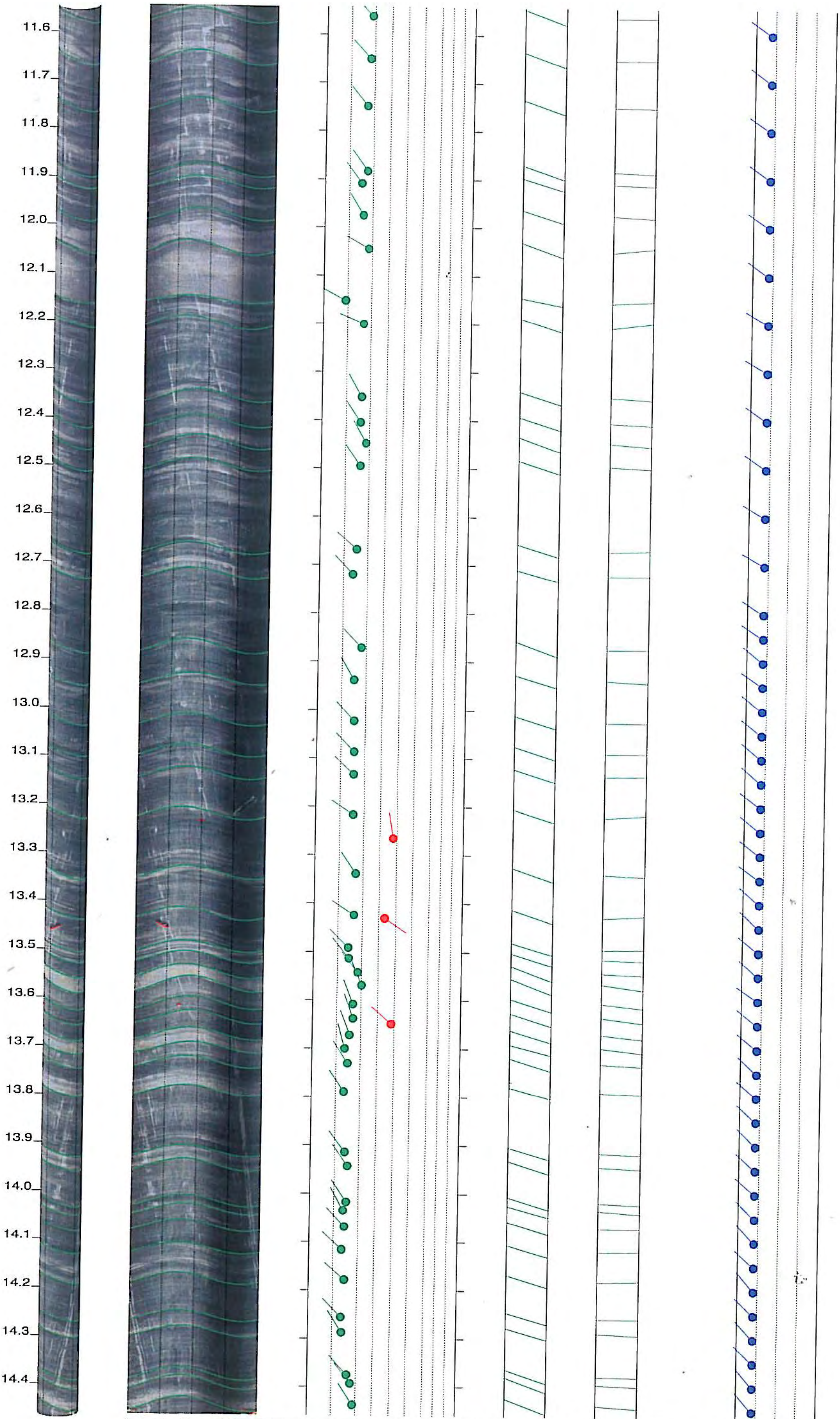
Figure OPTV 4
(1 of 11)



RCA 04

11.542 to 8.624m

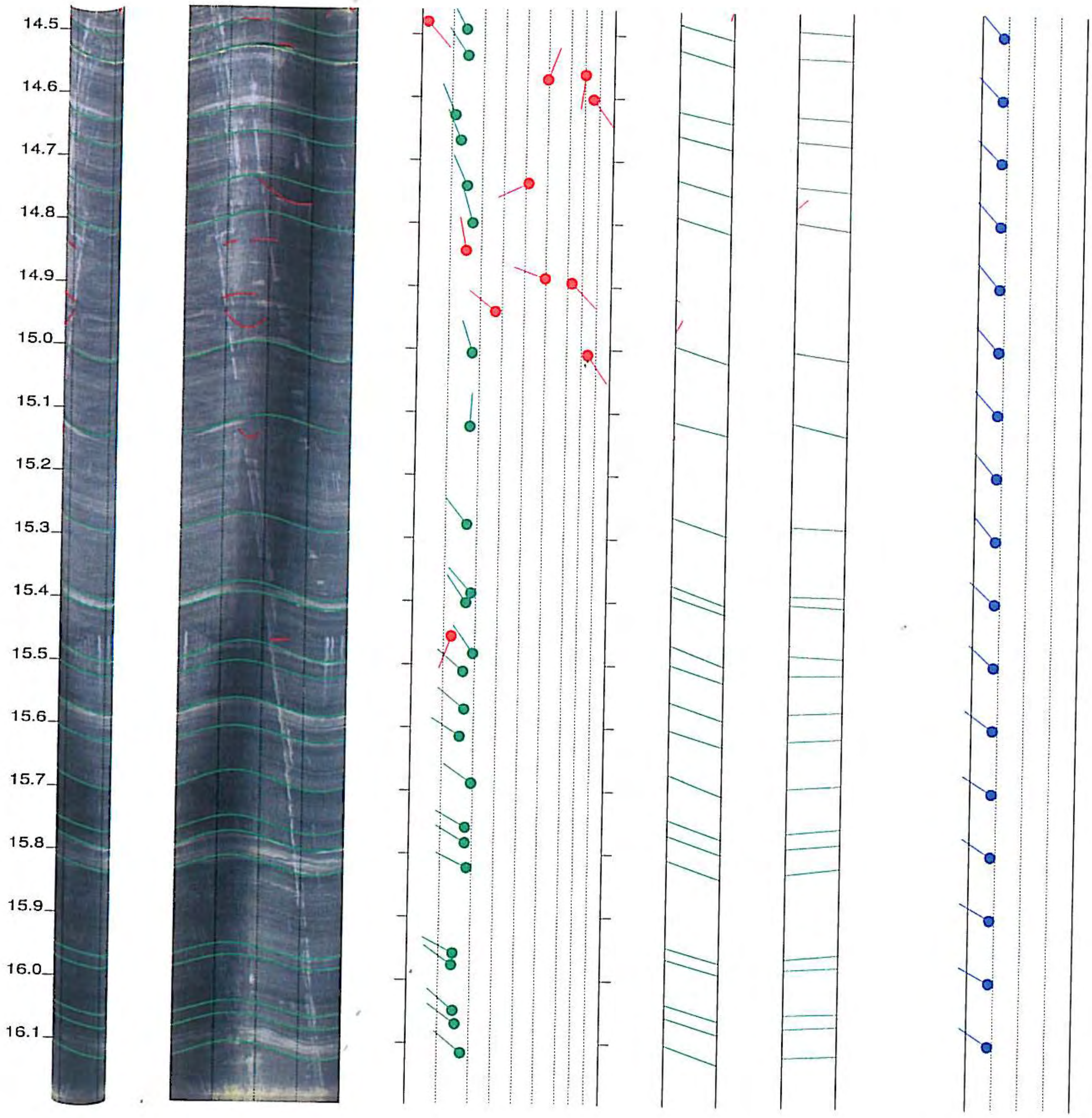
Figure OPTV4
(2 of 11)



RCA 04

14.460 to 11.542m

Figure OPTV4
(3 of 11)


14.5
14.6
14.7
14.8
14.9
15.0
15.1
15.2
15.3
15.4
15.5
15.6
15.7
15.8
15.9
16.0
16.1

RGLDIPv6.2 OPTV results

K = 0: FEATURE
K = 2: FEATURE

borehole RCA 4
zone from 7.101 to 16.197 m
North ref is magnetic
Dip format: Dip-azimuth and Dip

deviation

Dev	Depth / Thickness	Azimuth	Dip	1-P0/100	n	Q	K	Upper Depth	Lower Depth	Well Diam	Well Azimuth
1 / 2.00	16.116 / 0.0000	N310	17.4	0.983	6	A	0	16.101	16.131	0.085	303.60
2 / 2.00	16.070 / 0.0000	N306	15.5	0.989	5	A	0	16.057	16.084	0.085	303.48
3 / 2.00	16.049 / 0.0000	N311	14.8	0.979	5	A	0	16.036	16.062	0.085	303.06
4 / 2.00	15.976 / 0.0000	N306	14.1	0.984	5	A	0	15.964	15.989	0.085	298.61
5 / 2.00	15.958 / 0.0000	N298	14.4	0.976	5	A	0	15.945	15.970	0.085	298.23
6 / 2.00	15.823 / 0.0000	N296	18.4	0.997	5	A	0	15.807	15.838	0.085	301.94
7 / 2.00	15.783 / 0.0000	N301	17.7	0.975	6	A	0	15.768	15.798	0.085	301.98
8 / 2.00	15.759 / 0.0000	N300	17.7	0.997	5	A	0	15.744	15.774	0.085	300.02
9 / 2.00	15.689 / 0.0000	N305	19.4	0.970	5	B	0	15.672	15.706	0.085	302.69
10 / 2.00	15.615 / 0.0000	N304	15.5	0.996	5	A	0	15.601	15.628	0.085	306.38
11 / 2.00	15.572 / 0.0000	N309	16.8	0.982	6	A	0	15.557	15.586	0.085	305.51
12 / 2.00	15.512 / 0.0000	N311	16.2	0.984	5	A	0	15.498	15.526	0.085	310.45
13 / 2.00	15.483 / 0.0000	N324	19.3	0.984	5	A	0	15.467	15.500	0.085	311.74
14 / 2.00	15.456 / 0.0000	N200	12.6	1.000	3	A	2	15.463	15.465	0.085	309.01
15 / 2.00	15.403 / 0.0000	N325	16.9	0.982	5	A	0	15.389	15.418	0.085	312.29
16 / 2.00	15.388 / 0.0000	N318	18.4	0.971	6	B	0	15.372	15.404	0.085	313.17
17 / 2.00	15.279 / 0.0000	N321	16.7	0.995	5	A	0	15.264	15.293	0.085	319.65
18 / 2.00	15.123 / 0.0000	N003	17.2	0.974	5	A	0	15.109	15.138	0.085	319.64
19 / 2.00	15.008 / 0.0000	N146	74.8	1.000	3	A	2	15.133	15.146	0.085	319.25
20 / 2.00	15.006 / 0.0000	N342	17.5	0.996	5	A	0	14.991	15.021	0.085	319.21
21 / 2.00	14.940 / 0.0000	N308	27.0	1.000	3	A	2	14.917	14.924	0.085	318.23
22 / 2.00	14.894 / 0.0000	N136	63.1	1.000	3	A	2	14.944	14.971	0.085	319.92
23 / 2.00	14.887 / 0.0000	N290	49.8	1.000	3	A	2	14.834	14.840	0.085	319.66
24	14.844	N349	15.3	1.000	3	A	2	14.831	14.833	0.085	317.96

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2.00     0.0000
 25     14.800   N344   17.0    0.995  4 A  0   14.786   14.815  0.085  317.08
2.00     0.0000
 26     14.741   N335   15.1    0.985  5 A  0   14.728   14.754  0.085  313.19
2.00     0.0000
 27     14.736   N245   41.5    1.000  3 A  2   14.736   14.775  0.085  313.39
2.00     0.0000
 28     14.669   N337   12.9    0.985  5 A  0   14.658   14.680  0.085  315.00
2.00     0.0000
 29     14.629   N337   11.0    0.988  5 A  0   14.619   14.639  0.085  315.34
2.00     0.0000
 30     14.602   N144   76.2    1.000  3 A  2   14.452   14.476  0.085  315.87
2.00     0.0000
 31     14.571   N020   49.7    1.000  3 A  2   14.520   14.524  0.085  317.48
2.00     0.0000
 32     14.563   N187   70.5    1.000  3 A  2   14.451   14.459  0.085  317.97
2.00     0.0000
 33     14.534   N326   14.9    0.994  5 A  0   14.521   14.547  0.085  319.00
2.00     0.0000
 34     14.493   N333   14.3    0.969  5 B  0   14.480   14.505  0.085  319.00
2.00     0.0000
 35     14.480   N139    2.0    1.000  3 A  2   14.480   14.480  0.085  319.00
2.00     0.0000
 36     14.439   N327   18.8    0.957  6 B  0   14.423   14.455  0.085  319.15
2.00     0.0000
 37     14.394   N322   17.8    0.964  5 B  0   14.379   14.410  0.085  319.81
2.00     0.0000
 38     14.376   N318   16.2    0.979  5 A  0   14.362   14.390  0.085  317.65
2.00     0.0000
 39     14.288   N327   13.9    0.945  4 C  0   14.276   14.300  0.085  316.51
2.00     0.0000
 40     14.256   N316   13.6    0.979  4 A  0   14.244   14.268  0.085  314.60
2.00     0.0000
 41     14.179   N311   14.7    0.996  5 A  0   14.166   14.191  0.085  317.22
2.00     0.0000
 42     14.117   N313   13.5    0.976  5 A  0   14.105   14.128  0.085  314.93
2.00     0.0000
 43     14.069   N317   14.4    0.980  5 A  0   14.056   14.081  0.085  315.92
2.00     0.0000
 44     14.035   N331   13.8    0.991  6 A  0   14.023   14.047  0.085  314.12
2.00     0.0000
 45     14.018   N327   15.0    0.982  5 A  0   14.005   14.031  0.085  312.74
2.00     0.0000
 46     13.943   N325   15.3    0.971  6 B  0   13.930   13.957  0.085  312.11
2.00     0.0000
 47     13.914   N323   14.1    0.974  5 A  0   13.902   13.927  0.085  313.26
2.00     0.0000
 48     13.790   N326   13.4    0.980  5 A  0   13.778   13.801  0.085  311.26
2.00     0.0000
 49     13.731   N327   14.7    0.988  5 A  0   13.718   13.743  0.085  311.78
2.00     0.0000
 50     13.700   N344   13.5    0.984  5 A  0   13.689   13.712  0.085  309.35
2.00     0.0000
 51     13.672   N339   15.3    0.999  5 A  0   13.659   13.685  0.085  308.53
2.00     0.0000
 52     13.650   N311   38.5    1.000  3 A  2   13.614   13.614  0.085  308.08
2.00     0.0000
 53     13.638   N340   16.7    0.983  5 A  0   13.624   13.653  0.085  307.54
2.00     0.0000
 54     13.609   N338   16.6    0.978  5 A  0   13.595   13.623  0.085  305.76
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 55     13.570   N337   20.1    0.968  5 B  0   13.553   13.587  0.085  308.65
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 56     13.543   N322   18.4    0.984  5 A  0   13.528   13.559  0.085  311.84
2.00     0.0000
 57     13.514   N321   14.5    0.975  5 A  0   13.501   13.526  0.085  310.06
2.00     0.0000
 58     13.491   N315   14.4    0.982  6 A  0   13.479   13.504  0.085  309.37
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 59     13.432   N123   33.7    1.000  3 A  2   13.442   13.454  0.085  312.42
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 60     13.425   N303   16.4    0.987  5 A  0   13.411   13.439  0.085  312.15
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 61     13.339   N326   17.0    0.980  5 A  0   13.325   13.354  0.085  306.27
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 62     13.266   N351   38.1    1.000  3 A  2   13.231   13.232  0.085  308.60
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 63     13.217   N304   15.5    0.988  4 A  0   13.203   13.230  0.085  307.83
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 64     13.134   N313   15.4    0.990  5 A  0   13.120   13.147  0.085  310.75
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 65     13.087   N316   15.5    0.985  5 A  0   13.074   13.101  0.085  309.65
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 66     13.023   N317   15.2    0.968  5 B  0   13.010   13.036  0.085  308.00
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 67     12.939   N330   15.0    0.979  5 A  0   12.926   12.952  0.085  305.58
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 68     12.872   N316   17.9    0.983  5 A  0   12.857   12.887  0.085  306.10
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 69     12.720   N317   13.8    0.984  5 A  0   12.708   12.732  0.085  301.92
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 70     12.668   N311   15.2    0.987  6 A  0   12.655   12.681  0.085  301.12
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 71     12.496   N325   16.2    0.959  5 B  0   12.482   12.510  0.085  305.00
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 72     12.448   N330   18.5    0.988  5 A  0   12.433   12.464  0.085  305.00
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 73     12.405   N326   16.0    0.987  6 A  0   12.391   12.419  0.085  305.00
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 74     12.352   N330   16.3    0.990  5 A  0   12.338   12.366  0.085  301.50
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 75     12.201   N293   16.7    0.944  5 C  0   12.187   12.216  0.085  301.21
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 76     12.153   N298    9.1    0.998  4 A  0   12.145   12.161  0.085  302.72
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 77     12.046   N299   18.5    0.947  5 B  0   12.030   12.062  0.085  305.00
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 78     11.976   N329   16.0    0.986  5 A  0   11.962   11.990  0.085  304.20
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 79     11.909   N323   15.2    0.969  5 B  0   11.896   11.922  0.085  305.21
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 80     11.884   N324   17.5    0.987  5 A  0   11.869   11.899  0.085  305.52
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 81     11.750   N320   17.2    0.970  5 B  0   11.735   11.764  0.085  305.93
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 82     11.651   N316   18.3    0.973  5 B  0   11.635   11.666  0.085  304.28
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 83     11.563   N316   18.9    0.958  6 B  0   11.547   11.579  0.085  309.32
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 84     11.499   N311   17.9    0.961  6 B  0   11.484   11.515  0.085  306.33
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 85     11.410   N314   19.5    0.959  6 B  0   11.394   11.427  0.085  306.00
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 86     11.365   N310   14.8    0.974  5 A  0   11.352   11.378  0.085  308.48
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 87     11.249   N308   17.6    0.981  5 A  0   11.234   11.264  0.085  309.93
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 88     11.143   N317   19.2    0.993  5 A  0   11.127   11.160  0.085  309.17
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 89     11.072   N328   17.9    0.974  5 A  0   11.056   11.087  0.085  311.51
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 90     11.023   N311   18.1    0.967  5 B  0   11.007   11.038  0.085  311.00
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 91     10.956   N336   16.0    0.951  5 B  0   10.942   10.970  0.085  307.80
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 92     10.888   N312   16.8    0.968  5 B  0   10.874   10.903  0.085  308.48
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93	10.861	N317	14.7	0.972	5	B	0	10.848	10.874	0.085	310.10	2.00	0.0000
94	10.772	N350	15.8	0.996	5	A	0	10.758	10.785	0.085	307.91	2.00	0.0000
95	10.754	N092	85.2	1.000	3	A	2	10.380	10.461	0.085	309.99	2.00	0.0000
96	10.747	N328	15.2	0.970	5	B	0	10.734	10.760	0.085	310.88	2.00	0.0000
97	10.700	N328	18.0	0.977	6	A	0	10.684	10.715	0.085	309.15	2.00	0.0000
98	10.668	N328	15.7	0.970	5	B	0	10.655	10.682	0.085	310.12	2.00	0.0000
99	10.591	N322	16.2	0.997	5	A	0	10.577	10.605	0.085	309.10	2.00	0.0000
100	10.562	N322	16.6	0.970	5	B	0	10.548	10.576	0.085	309.68	2.00	0.0000
101	10.469	N234	58.2	1.000	3	A	2	10.399	10.408	0.085	311.00	2.00	0.0000
102	10.464	N330	17.1	0.969	5	B	0	10.449	10.479	0.085	311.00	2.00	0.0000
103	10.457	N121	69.6	1.000	3	A	2	10.354	10.375	0.085	311.00	2.00	0.0000
104	10.436	N270	3.0	1.000	3	A	2	10.434	10.436	0.085	311.00	2.00	0.0000
105	10.420	N350	2.9	1.000	3	A	2	10.417	10.419	0.085	311.00	2.00	0.0000
106	10.419	N355	34.8	1.000	3	A	2	10.388	10.393	0.085	311.00	2.00	0.0000
107	10.408	N338	22.9	1.000	3	A	2	10.409	10.427	0.085	311.00	2.00	0.0000
108	10.404	N259	29.7	1.000	3	A	2	10.379	10.398	0.085	311.00	2.00	0.0000
109	10.399	N039	25.0	1.000	3	A	2	10.380	10.383	0.085	311.00	2.00	0.0000
110	10.381	N121	87.6	1.000	3	A	2	9.827	9.883	0.085	311.00	2.00	0.0000
111	10.352	N352	13.6	1.000	3	A	2	10.353	10.363	0.085	311.00	2.00	0.0000
112	10.345	N155	72.3	0.960	4	B	2	10.338	10.444	0.085	311.00	2.00	0.0000
113	10.289	N320	20.5	0.979	6	A	0	10.272	10.307	0.085	311.00	2.00	0.0000
114	10.285	N263	56.7	1.000	3	A	2	10.350	10.353	0.085	311.00	2.00	0.0000
115	10.255	N316	20.2	0.949	5	B	0	10.238	10.272	0.085	311.00	2.00	0.0000
116	10.252	N098	65.1	0.991	4	A	2	10.222	10.271	0.085	311.00	2.00	0.0000
117	10.230	N341	68.0	1.000	3	A	2	10.213	10.244	0.085	311.33	2.00	0.0000
118	10.227	N141	80.5	1.000	3	A	2	10.104	10.167	0.085	311.38	2.00	0.0000
119	10.224	N349	32.9	1.000	3	A	2	10.195	10.206	0.085	311.44	2.00	0.0000
120	10.222	N323	17.4	0.992	4	A	0	10.207	10.237	0.085	311.49	2.00	0.0000
121	10.182	N327	78.6	1.000	3	A	2	9.927	9.953	0.085	312.55	2.00	0.0000
122	10.180	N194	65.5	1.000	3	A	2	10.091	10.163	0.085	312.65	2.00	0.0000
123	10.173	N332	18.2	0.995	5	A	0	10.157	10.188	0.085	312.93	2.00	0.0000
124	10.150	N151	5.0	1.000	3	A	2	10.151	10.152	0.085	313.85	2.00	0.0000
125	10.140	N144	47.4	1.000	3	A	2	10.178	10.184	0.085	313.67	2.00	0.0000
126	10.088	N316	19.8	0.934	5	C	0	10.071	10.105	0.085	311.33		

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127     10.084   N118   22.5    1.000  3 A  2   10.068   10.075  0.085  311.48
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128     10.075   N183   73.2    1.000  3 A  2   10.165   10.204  0.085  311.84
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129     10.067   N073   27.6    1.000  3 A  2   10.082   10.088  0.085  312.16
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130     10.020   N221   75.3    1.000  3 A  2   10.107   10.167  0.085  313.00
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131     10.001   N324   70.7    1.000  3 A  2    9.876    9.946  0.085  313.00
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132      9.982   N326   18.8    0.959  4 B  0    9.966    9.998  0.085  312.45
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133      9.964   N312   54.2    1.000  3 A  2    9.901    9.913  0.085  311.73
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134      9.939   N345   14.6    1.000  3 A  2    9.926    9.951  0.085  311.29
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135      9.896   N024   74.7    1.000  3 A  2   10.044   10.058  0.085  313.00
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136      9.871   N199   26.9    1.000  3 A  2    9.876    9.892  0.085  313.00
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137      9.772   N331   15.5    0.958  5 B  0    9.759    9.785  0.085  312.48
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138      9.765   N292   13.6    1.000  3 A  2    9.754    9.768  0.085  312.62
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139      9.764   N173   78.0    0.986  4 A  2    9.794    9.863  0.085  312.65
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140      9.748   N306   17.6    0.961  5 B  0    9.733    9.763  0.085  312.96
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141      9.716   N019   44.2    1.000  3 A  2    9.740    9.758  0.085  313.00
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142      9.620   N001   14.8    1.000  3 A  2    9.611    9.619  0.085  310.46
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143      9.613   N327   12.5    1.000  3 A  2    9.607    9.616  0.085  310.03
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144      9.610   N196   83.3    1.000  3 A  2    9.782    9.887  0.085  309.84
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145      9.562   N335   17.4    0.982  5 A  0    9.547    9.577  0.085  310.37
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146      9.528   N330   19.7    0.969  5 B  0    9.511    9.545  0.085  310.64
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147      9.503   N202   82.0    1.000  3 A  2    9.761    9.783  0.085  310.15
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148      9.495   N115   71.5    1.000  3 A  2    9.598    9.609  0.085  309.99
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149      9.491   N316   18.3    0.974  4 A  0    9.475    9.507  0.085  309.90
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150      9.457   N320   24.1    0.975  5 A  0    9.436    9.478  0.085  309.22
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151      9.422   N307   18.2    0.990  5 A  0    9.407    9.438  0.085  309.94
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152      9.304   N338   17.2    0.968  4 B  0    9.290    9.319  0.085  311.33
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153      9.302   N171   79.2    1.000  3 A  2    9.481    9.496  0.085  311.24
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154      9.247   N332   17.2    0.999  4 A  0    9.232    9.262  0.085  311.98
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155      9.212   N081   87.3    1.000  3 A  2    9.776    9.816  0.085  310.62
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156      9.185   N326   16.0    0.967  5 B  0    9.171    9.199  0.085  310.00
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157      9.136   N085   76.1    1.000  3 A  2    9.260    9.291  0.085  310.20
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158      9.088   N073   88.7    0.997  4 A  2    9.997   10.055  0.085  311.33
2.00     0.0000
159      9.075   N324   18.5    0.992  5 A  0    9.059    9.091  0.085  311.83
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160      8.957   N160   65.8    1.000  3 A  2    8.964    9.044  0.085  313.57
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161     8.953   N332   16.7   0.992  5 A  0   8.939   8.968  0.085  313.70
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162     8.924   N324   21.0   0.971  5 B  0   8.906   8.942  0.085  312.66
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163     8.877   N107   72.6   0.981  4 A  2   8.955   8.996  0.085  312.15
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164     8.868   N049   88.3   0.997  4 A  2  10.048  10.102  0.085  312.69
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165     8.849   N317   21.8   0.981  4 A  0   8.830   8.868  0.085  313.81
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166     8.773   N316   19.9   0.981  4 A  0   8.756   8.790  0.085  313.91
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167     8.750   N322   15.7   0.998  4 A  0   8.736   8.763  0.085  314.86
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168     8.711   N169   80.9   0.984  4 A  2   8.655   8.739  0.085  314.30
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169     8.676   N342   16.1   0.934  4 C  0   8.662   8.690  0.085  314.40
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170     8.670   N296   86.2   0.999  4 A  2   9.884   9.954  0.085  314.53
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171     8.620   N191   35.3   1.000  3 A  2   8.591   8.605  0.085  315.00
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172     8.617   N137   37.1   1.000  3 A  2   8.587   8.610  0.085  315.00
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173     8.608   N313   17.0   1.000  3 A  2   8.594   8.613  0.085  315.00
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174     8.559   N197   63.3   1.000  3 A  2   8.478   8.502  0.085  314.25
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175     8.518   N340   14.6   0.985  6 A  0   8.505   8.530  0.085  314.00
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176     8.508   N157   73.9   0.995  4 A  2   8.465   8.592  0.085  314.00
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177     8.480   N051   70.8   1.000  3 A  2   8.456   8.509  0.085  313.36
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178     8.479   N067   72.2   1.000  3 A  2   8.352   8.390  0.085  313.32
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179     8.468   N310   18.7   1.000  3 A  2   8.452   8.479  0.085  312.88
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180     8.465   N116   15.4   1.000  3 A  2   8.455   8.468  0.085  312.76
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181     8.406   N130   61.7   1.000  3 A  2   8.333   8.359  0.085  310.39
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182     8.395   N329   23.3   0.977  5 A  0   8.375   8.415  0.085  310.08
2.00    0.0000
183     8.388   N264   42.6   1.000  3 A  2   8.347   8.348  0.085  310.49
2.00    0.0000
184     8.306   N321   21.3   0.924  5 C  0   8.287   8.324  0.085  310.58
2.00    0.0000
185     8.301   N250   87.6   0.998  4 A  2   9.921   9.984  0.085  310.29
2.00    0.0000
186     8.222   N309   48.0   1.000  3 A  2   8.171   8.183  0.085  308.51
2.00    0.0000
187     8.218   N207   70.0   1.000  3 A  2   8.246   8.304  0.085  308.43
2.00    0.0000
188     8.203   N298   16.1   0.962  5 B  0   8.189   8.217  0.085  308.13
2.00    0.0000
189     8.196   N274   48.3   1.000  3 A  2   8.218   8.246  0.085  308.05
2.00    0.0000
190     8.171   N132   56.9   1.000  3 A  2   8.222   8.232  0.085  310.45
2.00    0.0000
191     8.048   N299   22.9   1.000  3 A  2   8.032   8.054  0.085  311.95
2.00    0.0000
192     7.922   N307   13.6   0.957  4 B  0   7.910   7.934  0.085  311.89
2.00    0.0000
193     7.898   N302   16.0   0.966  4 B  0   7.885   7.912  0.085  314.71
2.00    0.0000
194     7.876   N172   74.3   0.976  4 A  2   7.848   7.907  0.085  315.80
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195	7.850	N324	16.5	0.984	5	A	0	7.836	7.864	0.085	316.83
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196	7.814	N319	19.1	0.995	5	A	0	7.798	7.831	0.085	313.84
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197	7.772	N322	23.8	0.955	5	B	0	7.752	7.793	0.085	312.00
2.00	0.0000										
198	7.751	N322	24.5	0.990	5	A	0	7.730	7.772	0.085	312.00
2.00	0.0000										
199	7.725	N313	34.2	1.000	3	A	2	7.694	7.708	0.085	317.06
2.00	0.0000										
200	7.715	N355	28.1	1.000	3	A	2	7.695	7.716	0.085	319.47
2.00	0.0000										
201	7.707	N198	76.7	1.000	3	A	2	7.839	7.872	0.085	321.40
2.00	0.0000										
202	7.679	N072	80.0	1.000	3	A	2	7.896	7.907	0.085	320.99
1.67	0.0000										
203	7.672	N352	31.9	0.951	4	B	2	7.644	7.675	0.085	319.61
1.51	0.0000										
204	7.647	N343	33.0	0.963	5	B	0	7.619	7.676	0.085	315.23
1.03	0.0000										
205	7.497	N087	87.4	1.000	3	A	2	8.200	8.224	0.085	312.04
1.00	0.0000										
206	7.381	N351	9.4	1.000	3	A	2	7.373	7.388	0.085	310.69
1.00	0.0000										
207	7.200	N231	20.1	1.000	3	A	2	7.214	7.215	0.085	311.93
1.00	0.0000										
208	7.084	N132	72.3	1.000	3	A	2	7.193	7.210	0.085	312.00
1.00	0.0000										
209	7.029	N307	78.1	1.000	3	A	2	7.218	7.249	0.085	312.00
1.00	0.0000										

Appendix E - Embankment – Pond SI Geophysical Survey

APEX Geoservices Ltd.
Geophysical & Geological Consultants

REPORT

ON THE

GEOPHYSICAL SURVEY

FOR THE

TARBERT/BALLYLONGFORD EMBANKMENT-POND SI

FOR

IRISH GEOTECHNICAL SERVICES LTD.

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PRIVATE AND CONFIDENTIAL

THE FINDINGS OF THIS REPORT ARE THE RESULT OF A GEOPHYSICAL SURVEY USING NON-INVASIVE SURVEY TECHNIQUES CARRIED OUT AT THE GROUND SURFACE. INTERPRETATIONS CONTAINED IN THIS REPORT ARE DERIVED FROM A KNOWLEDGE OF THE GROUND CONDITIONS, THE GEOPHYSICAL RESPONSES OF GROUND MATERIALS AND THE EXPERIENCE OF THE AUTHOR. APEX GEOSERVICES LTD. HAS PREPARED THIS REPORT IN LINE WITH BEST CURRENT PRACTICE AND WITH ALL REASONABLE SKILL, CARE AND DILIGENCE IN CONSIDERATION OF THE LIMITS IMPOSED BY THE SURVEY TECHNIQUES USED AND THE RESOURCES DEVOTED TO IT BY AGREEMENT WITH THE CLIENT. THE INTERPRETATIVE BASIS OF THE CONCLUSIONS CONTAINED IN THIS REPORT SHOULD BE TAKEN INTO ACCOUNT IN ANY FUTURE USE OF THIS REPORT.

PROJECT NUMBER	AGL07118		
AUTHOR	CHECKED	REPORT STATUS	DATE
YVONNE O'CONNELL P.GEO., M.SC (GEOPHYSICS)		FINAL	11TH JANUARY 2008

TABLE OF CONTENTS

E1. INTRODUCTION

APEX Geoservices Ltd. was requested by Irish Geotechnical Services Ltd. (IGSL), on behalf of Arup Consulting Engineers, to carry out a geophysical survey as part of the site investigation at the site of the proposed embankment for the Shannon LNG: Tarbert/Ballylongford LNG Terminal.

E1.1 Survey Objectives

The objectives of the survey were:

- to profile variations in the bedrock topography
- to provide the following geotechnical properties of the overburden and bedrock
  - classification of the overburden and bedrock
  - determine the consistency and density of the individual units in the stratigraphic profile
  - Dynamic Shear Modulus (Gmax)
  - Dynamic Young's Modulus (Dynamic Emax)
  - Dynamic Bulk Modulus

E1.2 Survey Methodology

- 2D Resistivity profiling to provide information on lateral and vertical variations in overburden type and thickness, bedrock type and profile.
- P-wave and S-wave Seismic Refraction profiling to verify overburden type, thickness and stiffness and provide information on depth to bedrock, rock type and strength.

E1.3 Site Background

The site is located between Ballylongford and Tarbert on the south coast of the Shannon Estuary. The survey was carried out over a distance of 400m (approx. 200m either side of the river). The topography of the survey line ranges from 14mOD to the east and west of the river to 5mOD at the river.

The geological map for the area (Geology of the Shannon Estuary, Sheet 17, GSI) indicates that the site is underlain by Shannon Group mudstone, siltstone and sandstone.

As part of the site investigation a program of eight trial pits and four rotary cored boreholes was conducted by IGSL (their locations are indicated on Map E1). The core and pit logs were made available to assist with the interpretation of the geophysical data. The trial pits encountered topsoil over firm to stiff sandy gravelly clay to depths ranging from 1.3m to 4m. The rotary cores indicated 1.7m to 9m of gravelly clay overlying 0.3 to 0.8m angular gravel (probable siltstone) overlying fresh to locally slightly and moderately weathered siltstone.

E1.4 Report Outline

- The survey results are interpreted in Part E2.
- A summary is made in Part E3.
- The locations of the geophysical readings are shown on Map E1.
- The interpreted resistivity and seismic data are shown on Sections E1 & E2.
- The interpreted P-wave seismic data are contained in Appendix EII.
- The interpreted S-wave seismic data are contained in Appendix EIII.
- Dynamic Moduli calculations are contained in Appendix EIV.
- Excavatability ratings are shown in Appendix EV.

E2. INTERPRETED RESULTS

E2.1 2D Resistivity Profiling

Four 2D Resistivity profiles were recorded across the site (Map E1, Sections E1 & E2). The recorded resistivity values, in conjunction with the trial pit and borehole data, have been interpreted on the following basis:

Resistivity (Ohm-m)	Interpretation
50 - 250	Sandy gravelly Clay
250 - 525	Clayey Sand/Gravel
525-1000	Sand/Gravel
50 - 385	Weathered Siltstone
50 - 385	Siltstone

E2.2 Seismic Refraction Profiling

Six P-wave seismic spreads were recorded across the site (Map E1, Appendix EII). The seismic survey also included the measurement of the shear wave (S-wave) velocity depth profile using the Multichannel Analysis of Surface Waves (MASW) method.

The P-wave seismic data, in conjunction with the trial pit and borehole data, have been interpreted as indicating four velocity layers as follows:

Layer	P-wave Velocity (Vp) Range (m/s)	Average Velocity (m/s)	Interpretation
1	250-1000	462	Soft to Firm or Loose to Medium Dense Overburden
2	536-1333	872	Firm to Stiff Overburden
3	1300-2264	1771	Stiff to Very Stiff Overburden
			Moderately to Slightly Weathered Bedrock
4	3300-4050	3617	Slightly Weathered to Fresh Bedrock

Layer 1 P-wave velocities (Vp) would be typical of soft to firm or loose to medium dense overburden material. Layer 2 Vp would be typical of firm to stiff or medium dense to dense overburden material. Layer 3 Vp has been interpreted as indicating stiff to very stiff overburden material or moderately to slightly weathered rock. The recorded Layer 4 Vp would be typical of slightly weathered to fresh bedrock.

The MASW signal achieved a maximum penetration of up to 21.5 – 27.2 m bgl. The measured shear wave velocities (Vs) range from 229 to 1670 m/s and the derived G_{max} values range from 114 to 7526 MPa (Appendix EIII).

Layers 1 and 2 have a Vs which is generally between 230 and 550 m/s. Seismic spread S6 recorded a decrease in Vs from 1m to 2m b.g.l . In addition, seismic spreads S1 and S2 recorded a decrease in Vs from 19.7m and 20.9m b.g.l respectively.

The Vp data were combined with the Vs data to calculate Poissons ratio, dynamic Bulk modulus and dynamic Youngs Modulus for each of the layers outlined by the Vp data analysis using the formulae fron Elastic Theory as presented by Davies & Schulteiss, 1980 contained in Appendix EI. The calculated modulii are contained in Appendix EIV.

Note: A soil density of 2180 kg/m^3 (derived/calculated from lab data) and a rock density of 2700kg/m^3 (derived/calculated from lab data) has been used as directed by the Engineer, Arup.

E2.3 Integrated Interpretation

The integrated interpretation of the 2D resistivity data, seismic data, trial pit and borehole data has been drawn on Sections E1 & E2. The combined geophysical data have been interpreted indicating four subsurface layers as follows:

Layer	Vp Velocity (m/s)	Average Vp Velocity (m/s)	Resistivity (Ohm-m)	Interpretation	Stiffness/ Rock Quality	Estimated Excavatability
1	250-1000	462	50-250	Sandy gravelly Clay	Soft - Firm	Diggable
			250-525	Clayey Sand/Gravel	Loose-Medium Dense	
			525-2000	Sand/Gravel		
2	536-1333	872	50-250	Sandy gravelly Clay	Firm - Stiff	Diggable
			250-525	Clayey Sand/Gravel	Medium dense-dense	
			525-2000	Sand/Gravel		
3	1300-2264	1771	50 - 250	Sandy gravelly Clay	Stiff-Very Stiff	Diggable
			50 - 385	Moderately to Slightly weathered Siltstone	Fair - Good	Marginally Rippable – Break/Blast
4	3300-4050	3617	50 - 385	Slightly weathered to fresh Siltstone	Good	Break /Blast

Layer 1

The geophysical data indicates an upper layer of soft to firm sandy gravelly clay or loose to medium dense clayey sand/gravel with three small pockets of sand/gravel on Section E1. The interpreted thickness of Layer 1 ranges from 0.5-1.3m with an average thickness of 0.9m and should be diggable.

Layer 2

The geophysical data indicates an underlying layer of firm to stiff sandy gravelly clay or medium dense to dense clayey sand/gravel with two small pockets of sand/gravel on Section E1. The interpreted thickness of Layer 2 ranges from 0-3.3m with an average thickness of 1.7m and should be diggable.

Layer 3

Layer 3 Vp velocities would typically indicate stiff to very stiff sandy gravelly clay or moderately to slightly weathered mudstone/siltstone. In conjunction with the trial pit data, diggable stiff to very stiff sandy gravelly clay has been interpreted for this layer however, this layer may contain moderately to slightly weathered siltstone at its base. If weathered rock is present, the velocities would indicate that this layer will be marginally rippable where seismic velocities fall below 1800 m/s and will require breaking/blasting where velocities are >1800 m/s.

Layer 4

Velocities from 3300-4050m/s have been interpreted as indicating slightly weathered to fresh siltstone. The velocities recorded for this layer indicate that any excavation will require breaking/blasting.

E3. CONCLUSIONS & RECOMMENDATIONS

- The geophysical data was found to correlate well with the trial pit and borehole depths.
- Four subsurface layers have been interpreted from the combined data.
- Layer 1 has been interpreted as comprising diggable soft to firm sandy gravelly clay or loose to medium dense clayey sandy gravel ranging in thickness from 0.5 to 1.3m.
- Layer 2 has been interpreted as comprising diggable firm to stiff sandy gravelly clay or medium dense to dense clayey sandy gravel ranging in thickness from 0 to 3.3m.
- Layer 3 has been interpreted as diggable stiff to very stiff sandy gravelly clay however, this layer may contain moderately to slightly weathered siltstone at its base. If present the weathered rock should be marginally rippable where Vp velocities fall below 1800 m/s and will require breaking/blasting where Vp velocities are >1800 m/s.
- Layer 4 has been interpreted as slightly weathered to fresh siltstone. The Vp velocities recorded for this layer indicate that any excavation will require breaking/blasting.
- Where bedrock excavation is proposed a detailed assessment of excavatability should be carried out combining the results of the geophysical survey, rotary core drilling, strength testing, and trial excavation pits using a high powered excavator.
- A table presented in Appendix E: V illustrates the excavability of the bedrock, which considers the seismic compressional wave results.
-

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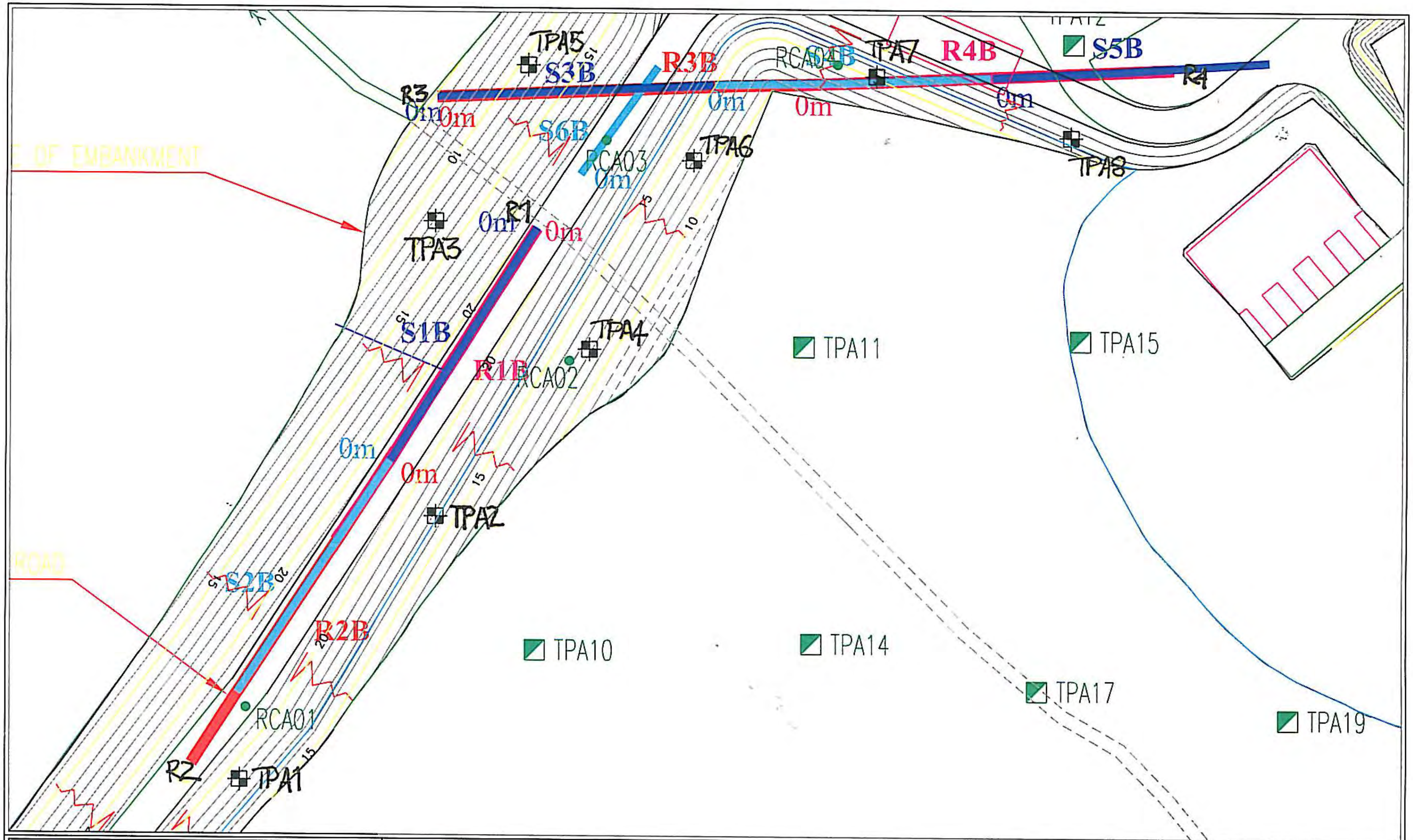
MAP



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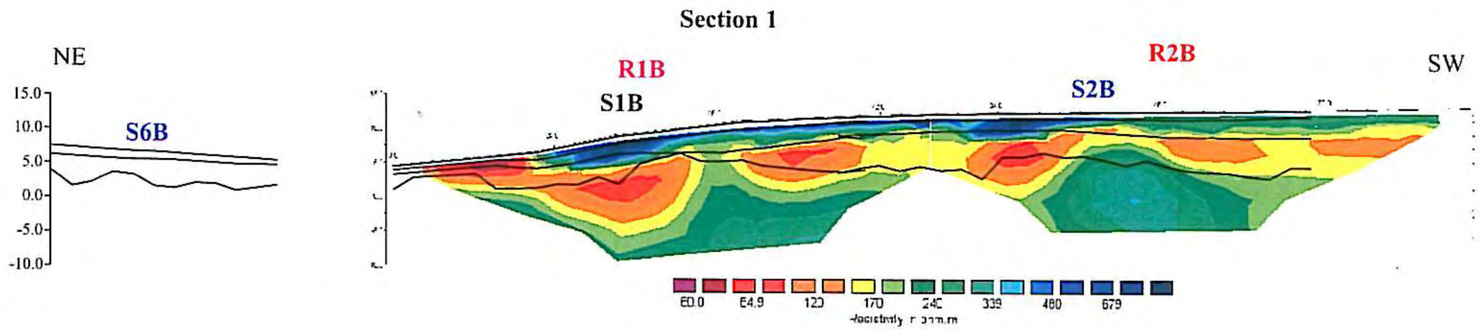
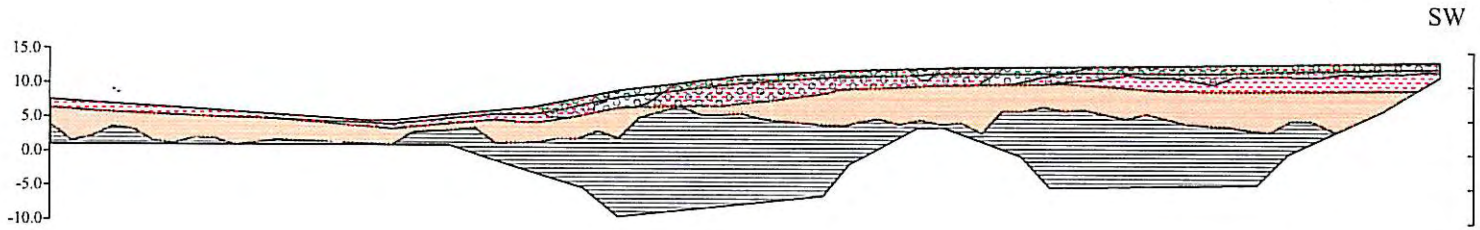
Resistivity Profile
Seismic Spread
Trial Pit

PROJECT:	Shannon LNG: Tarbert/Ballylongford LNG Embankment
DRAWING TITLE:	Map E1 Geophysical Survey Locations
DATE:	June 2007
CLIENT:	IGSL/Arup Consulting Engineers
SCALE:	1:1250

INTERPRETED SECTIONS

Interpreted 2D Resistivity & Seismic Profiles





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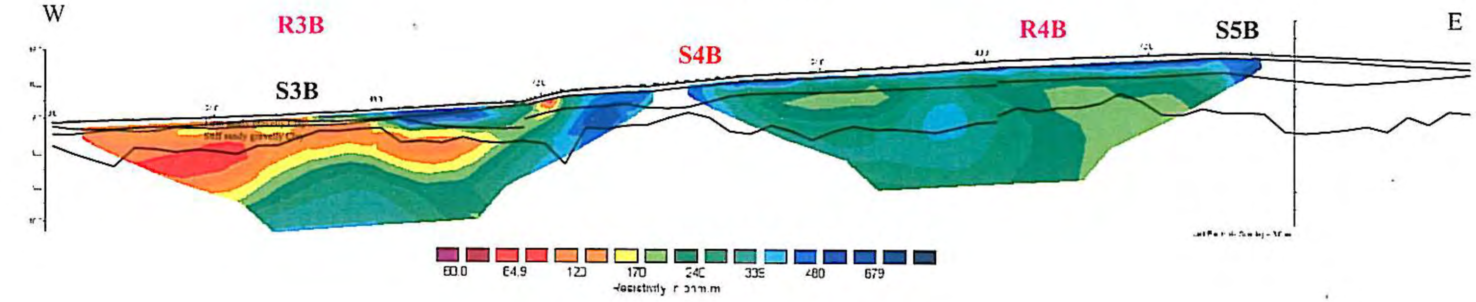
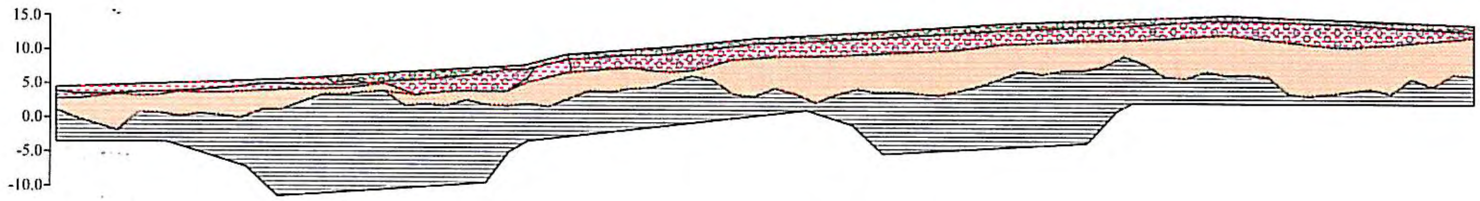
- Loose-Medium Dense Sand/Gravel
- Firm-Stiff Sandy Gravelly Clay
- Medium Dense-Dense Clayey Sand/Gravel
- Medium Dense-Dense Sand/Gravel
- Stiff -Very Stiff Sandy Gravelly Clay
- Slightly Weathered-Fresh Siltstone

PROJECT:	Shannon LNG: Tarbert/Ballylongford LNG Embankment
DRAWING TITLE:	Section E1
DATE:	October 2007
CLIENT:	Arup Consulting Engineers
SCALE:	1:1250@A3

Section 2





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- Medium Dense-Dense Sand/Gravel
- Stiff -Very Stiff Sandy Gravelly Clay
- Slightly Weathered-Fresh Siltstone

PROJECT:	Shannon LNG: Tarbert/Ballylongford LNG Embankment
DRAWING TITLE:	Section E2
DATE:	October 2007
CLIENT:	Arup Consulting Engineers
SCALE:	1:1250@A3

APPENDIX EI GEOPHYSICAL METHODOLOGY

APPENDIX EI GEOPHYSICAL METHODOLOGY

M1. Methods Used

1.1 2D-Resistivity Profiling

The resistivity surveying technique used for the survey makes use of the Wenner resistivity array whereby four electrodes are placed in a line in the ground and a current is passed through the two outer electrodes. The potential difference is measured across the two inner electrodes. The measured potential is divided by the current value to obtain the resistance. The resistivity is determined from the resistance using the following formula:

Resistivity = Resistance* 2 * Pi * Spacing.

The 2D-resistivity profiling method records a large number of resistivity readings in order to map lateral and vertical changes in material types. The 2D-resistivity profiling method involves the use of 32 to 64 electrodes connected to a resistivity meter, using computer software to control the process of data collection and storage.

1.2 Seismic Refraction Profiling

This method measures the velocity of refracted seismic waves through the overburden and rock material and allows an assessment of the thickness and quality of the materials present to be made. Stiffer and stronger materials usually have higher seismic velocities while soft, loose or fractured materials have lower velocities. Readings are taken using geophones connected via multi-core cable to a seismograph.

In the MASW method Surface waves (Rayleigh waves) are utilized to determine the elastic properties of the shallow subsurface (<15m). Surface waves carry up to two/thirds of the seismic energy but are usually considered as noise in conventional body wave reflection and refraction seismic surveys.

The penetration depth of surface waves changes with wavelength, i.e. longer wavelengths penetrate deeper. When the elastic properties of near surface materials vary with depth, surface waves then become dispersive, i.e. propagation velocity changes with frequency. The propagation (or phase) velocity, is determined by the average elastic property of the medium within the penetration depth. Therefore the dispersive nature of surface waves may be used to investigate changes in elastic properties of the shallow subsurface.

The Multi-channel Analysis of Surface Waves (MASW) was used for this survey (Park et al., 1998, 1999). This method employs the multi-channel recording and processing techniques (Sheriff and Geldart, 1982) that have similarities to those used in a seismic reflection survey and which allow better waveform analysis and noise elimination. To produce a stiffness profile of the subsurface using Surface waves the following basic procedure is followed:

(i) A point source (eg. a sledgehammer) is used to generate vertical ground motions,

(ii) the ground motions are measured using low frequency geophones, which are disposed along a straight line directed toward the source,

(iii) the ground motions are recorded using either a conventional seismograph, oscilloscope or spectrum analyzer,

(iv) a dispersion curve is produced from a spectral analysis of the data showing the variation of Surface wave velocity with wavelength,

(v) the dispersion curve in inverted using a modeling and least squares minimization process to produce a subsurface profile of the variation of Surface wave and shear wave velocity with depth.

M2. Equipment Used

2.1 2D-Resistivity Profiling

Four profiles were recorded from the 4th to the 5th April 2007 using a Tigre resistivity meter, imaging software, two 32 takeout multicore cables and 64 stainless steel electrodes. The recorded data was processed and viewed immediately after the survey.

2.2 Seismic Refraction Profiling

Six spreads were recorded from the 4th to the 5th April 2007 using a Ras-24 high resolution 24 channel digital seismograph with 24 no. 10HZ vertical geophones using 3m geophone spacings. The record length was 600 ms. The energy source of the seismic waves was a sledgehammer. The equipment was carried in 4WD vehicle with 2 person crew.

M3. Field Procedure

3.1 2D-Resistivity Profiling

Electrode spacings of 3m investigating to a maximum depth of 19m below ground level were used. Resistances were measured for expanding arrays. 2 cycles were recorded to 3% repeatability. Saline solution was added around electrodes in areas of high contact resistance. Local conditions and variations were recorded. QC inversion of each profile was carried out before removal of electrodes.

3.2 Seismic Refraction Profiling

The seismic spreads consisted of 12 or 24 collinear geophones at spacings of 3m. The depth of investigation was of the order of 23m below ground level. Records from up to seven different positions were taken on each spread (2 x off-end, 2 x end, 3 x middle) to ensure optimum coverage of all refractors. Ongoing estimation of refractor velocities was carried out to monitor refractor type and depth.

M4. Data Processing

4.1 2D-Resistivity Profiling

The field readings were stored in computer files and inverted using the RES2DINV package (Campus Geophysical Instruments, 1997) with up to 5 iterations of the measured data carried out for each profile to obtain a 2D-Depth model of the resistivities.

The inverted 2D-Resistivity models and corresponding interpreted geology are displayed on Sections E1 and E2. The chainage is indicated along the horizontal axis of the profile and the depth below ground level is indicated on the vertical axis. All profiles have been contoured using the same contour intervals and colour codes.

It is important to note that the data displayed on the 2D-Resistivity profiles is real physical data however interpretation of the geophysical results is required to transform the resistivities directly into geological layers.

4.2 Seismic Refraction Profiling

For the P-wave interpretation, first break picking in digital format was carried out using the FIRSTPIX software program to construct traveltime plots for each spread. Velocity phases were selected from these plots using the GREMIX software program and were used to calculate the thickness of individual velocity units. Topographic data were input. Material types were assigned and estimation made of material properties, cross-referenced to the 2D Resistivity and borehole data. The processed seismic data are displayed in Appendix EII and on Sections E1 and E2.

Approximate errors for velocities are estimated to be +/- 10%. Errors for the calculated layer thicknesses are of the order of +/-20%. Possible errors due to the "hidden layer" and "velocity inversion" effects may also occur (Soske, 1959).

For the S-wave interpretation, processing was carried out using the SURFSEIS processing package developed by Kansas Geological Survey (KGS, 2000). SURFSEIS is designed to generate a shear wave velocity profile. SURFSEIS data processing involves three steps:

(i) Preparation of the acquired multichannel record. This involves converting the data file into the processing format.

(ii) Production of a dispersion curve from a spectral analysis of the data showing the variation of Raleigh wave phase velocity with wavelength. Confidence in the dispersion curve can be estimated through a measure of signal to noise ratio (S/N) which is obtained from a coherency analysis. Noise includes both body waves and higher mode surface waves. To obtain an accurate dispersion curve the spectral content and phase velocity characteristics are examined through an overtone analysis of the data.

(iii) Inversion of the dispersion curve is then carried out to produce a subsurface profile of the variation of shear wave velocity with depth.

The shear wave velocities were then converted into shear modulus values using the formula:

(1) $$G = V_s^2 * \rho / 1000000$$

Where G = Shear Modulus (GPa)
V_s = Shear Wave Velocity (m/s)
ρ = Density (kg/m^3)

Processing parameters were optimized by test processing using varying options in the processing package and also by reference to optimal parameters referred to in the literature.

The first arrivals on each MASW record were also picked using the FIRSTPIX and GREMIX, 1993 packages in order to produce a conventional layered P-wave depth section and P-wave velocities. These velocities were combined with the shear wave velocity data to calculate Poissons ratio, dynamic Bulk modulus and Youngs Modulus for each of the layers outlined by the P-wave data analysis using the Theory of Elastcity formulae presented by Davies & Schulteiss, 1980 as follows:

(2) $$nu=(Vp/Vs)^2-2 / 2((Vp/Vs)^2-2)$$

(3) $$E = 2V_s^2 \rho(1 + nu)/1000$$

where E = Youngs Modulus (GPa)
V_s = Shear Wave Velocity (m/s)
ρ = Density (kg/m^3)

	nu	=	Poisson's ratio

and

(4) $$B = E/3(1-2\,nu)$$

where	B	=	Bulk Modulus (GPa)
	E	=	Youngs Modulus (GPa)
	nu	=	Poisson's ratio

For the purpose of the calculation in this report a soil density of 2180 kg/m^3 and a rock density of 2700kg/m^3 (derived from lab data) have been used as directed by Arup.

APPENDIX EII P-WAVE SEISMIC REFRACTION DATA

LINE	Station	V1	V2	V3	V4	T1	T2	T3	T1+T2	T1+T2+T3	SURFACE	BASE1	BASE2	BASE3
		m/s	m/s	m/s	m/s	m	m	m	m	m	mOD	mOD	mOD	mOD
1	0	780	1300	2090	3954	0.5	0.7	2.3	1.2	3.4	4.6	4.1	3.4	1.2
1	3	780	1308	2264	3954	0.5	0.7	0.8	1.2	1.9	4.9	4.4	3.7	3.0
1	6	781	1317	2264	3954	0.5	0.7	0.8	1.2	2.0	5.2	4.7	4.0	3.2
1	9	781	1325	2264	3954	0.5	0.8	1.0	1.2	2.2	5.5	5.0	4.3	3.3
1	12	782	1333	2264	3954	0.5	0.8	0.9	1.3	2.2	5.8	5.3	4.5	3.6
1	15	782	1333	2222	3954	0.5	0.8	3.4	1.3	4.7	6.1	5.6	4.8	1.4
1	18	685	1222	2121	4007	0.8	1.1	3.1	1.9	5.0	6.4	5.6	4.5	1.4
1	21	588	1111	2019	3840	1.1	1.2	2.9	2.3	5.2	6.7	5.6	4.4	1.5
1	24	491	1000	1917	3840	1.2	1.4	2.7	2.5	5.2	7.3	6.2	4.8	2.1
1	27	394	889	1816	3840	1.1	1.5	3.3	2.6	5.9	7.9	6.8	5.3	2.0
1	30	297	777	1714	4008	1.0	1.5	2.9	2.5	5.4	8.5	7.5	6.0	3.2
1	33	297	777	1714	4008	1.0	1.5	4.4	2.5	6.9	9.1	8.1	6.6	2.2
1	36	307	819	1771	4008	1.0	1.8	1.6	2.8	4.4	9.5	8.5	6.7	5.1
1	39	317	860	1829	4008	1.0	2.1	0.7	3.1	3.8	9.8	8.8	6.7	6.0
1	42	327	902	1886	4008	1.0	2.4	0.1	3.4	3.5	10.2	9.2	6.8	6.7
1	45	338	944	1943	3964	1.0	2.7	1.3	3.7	5.0	10.6	9.6	6.9	5.6
1	48	348	985	2000	3964	1.0	3.0	1.3	4.0	5.3	10.9	9.9	6.9	5.6
1	51	348	985	2000	3964	1.0	3.0	1.5	4.0	5.5	11.3	10.3	7.3	5.8
1	54	387	960	1943	3964	1.0	2.8	2.6	3.9	6.4	11.4	10.4	7.5	5.0
1	57	427	934	1886	4046	1.0	2.7	3.3	3.7	6.9	11.6	10.6	7.9	4.7
1	60	466	908	1829	4046	0.9	2.5	3.9	3.5	7.4	11.8	10.9	8.3	4.4
1	63	506	883	1771	4047	0.8	2.4	4.5	3.2	7.7	11.9	11.1	8.7	4.2
1	66	545	857	1714	4049	0.7	2.3	5.1	3.0	8.1	12.1	11.4	9.1	4.1
1	69	545	857	1481	4050	0.7	2.5	4.7	3.1	7.9	12.2	11.5	9.1	4.4
2	0	444	1000	1486	3509	0.9	1.6	5.4	2.6	8.0	12.7	11.8	10.1	4.7
2	3	439	958	1484	3509	0.9	1.7	5.0	2.6	7.5	12.8	11.9	10.2	5.3
2	6	433	915	1481	3509	0.9	1.7	4.5	2.6	7.1	12.8	11.9	10.2	5.7
2	9	428	873	1479	3509	0.9	1.7	5.4	2.6	8.0	12.8	11.9	10.3	4.8
2	12	422	831	1476	3509	0.9	1.7	5.0	2.5	7.5	12.9	12.0	10.4	5.4
2	15	422	831	1476	3509	0.9	1.7	5.7	2.5	8.3	12.9	12.0	10.4	4.6
2	18	407	811	1437	3509	0.9	1.6	5.5	2.5	8.0	12.9	12.0	10.4	4.9
2	21	393	792	1398	3443	0.9	1.6	7.1	2.5	9.6	13.0	12.1	10.5	3.4
2	24	378	772	1358	3486	0.9	1.6	3.9	2.5	6.3	13.0	12.1	10.5	6.7
2	27	363	753	1319	3486	0.9	1.6	3.9	2.5	6.4	13.0	12.1	10.5	6.6
2	30	348	733	1280	3486	0.9	1.6	3.4	2.4	5.9	13.1	12.2	10.7	7.2
2	33	348	733	1280	3405	0.9	1.6	4.0	2.4	6.4	13.1	12.2	10.7	6.7
2	36	366	733	1381	3405	0.9	1.8	3.6	2.7	6.3	13.1	12.2	10.4	6.9
2	39	383	733	1481	3405	1.0	1.9	4.1	2.9	7.0	13.2	12.2	10.3	6.2
2	42	401	733	1582	3597	1.0	2.1	4.5	3.2	7.7	13.2	12.2	10.0	5.5
2	45	418	733	1683	3597	1.1	2.3	3.6	3.4	7.1	13.3	12.2	9.9	6.2
2	48	435	733	1783	3563	1.2	2.5	4.2	3.7	7.9	13.3	12.2	9.6	5.4
2	51	435	733	1783	3563	1.2	2.5	4.9	3.7	8.6	13.3	12.2	9.6	4.8
2	54	482	747	1747	3584	1.2	2.6	5.1	3.7	8.9	13.4	12.2	9.7	4.5
2	57	528	760	1710	3584	1.2	2.6	5.2	3.8	9.0	13.4	12.2	9.6	4.4
2	60	574	773	1673	3584	1.1	2.7	5.7	3.8	9.5	13.4	12.3	9.6	3.9
2	63	620	787	1637	3584	1.0	2.8	6.1	3.9	9.9	13.5	12.5	9.6	3.6
2	66	667	800	1600	3584	0.9	3.0	4.4	3.9	8.3	13.5	12.6	9.6	5.2
2	69	667	800	1600	3584	0.9	3.0	4.4	3.9	8.3	13.5	12.6	9.6	5.2
3	0	1000	1333	2000	3450	0.6	1.1	1.7	1.7	3.4	4.4	3.8	2.7	1.1
3	3	856	1333	2000	3455	1.1	0.7	2.8	1.8	4.6	4.5	3.5	2.8	-0.1
3	6	711	1333	2000	3459	1.3	0.4	4.1	1.7	5.7	4.7	3.4	3.1	-1.0
3	9	567	1333	2000	3464	1.3	0.1	5.3	1.4	6.7	4.8	3.5	3.4	-1.9
3	12	422	1333	2000	3472	1.2	0.5	2.4	1.7	4.1	4.9	3.7	3.2	0.8
3	15	422	1333	2000	3472	1.2	0.5	2.6	1.7	4.3	5.0	3.8	3.3	0.7
3	18	471	1267	1958	3472	1.1	0.1	3.6	1.3	4.8	5.1	4.0	3.8	0.3
3	21	520	1200	1917	3472	1.1	0.4	3.1	1.5	4.6	5.2	4.1	3.7	0.6
3	24	569	1133	1875	3541	1.0	0.6	3.4	1.6	4.9	5.3	4.3	3.7	0.4
3	27	618	1067	1834	3506	0.9	0.8	3.9	1.6	5.5	5.5	4.7	3.9	0.0
3	30	667	1000	1792	3506	0.7	0.9	2.8	1.6	4.4	5.6	4.9	4.0	1.2
3	33	667	1000	1792	3506	0.7	0.9	2.8	1.6	4.4	5.7	5.0	4.1	1.3
3	36	589	1000	1834	3506	1.0	0.7	1.7	1.7	3.5	5.9	4.9	4.2	2.4
3	39	510	1000	1875	3506	1.3	0.5	0.8	1.8	2.6	6.1	4.9	4.3	3.5
3	42	432	1000	1917	3506	1.3	0.4	1.0	1.8	2.7	6.2	4.9	4.4	3.5
3	45	354	1000	1958	3526	1.3	0.4	0.9	1.7	2.6	6.4	5.1	4.7	3.8
3	48	276	1000	2000	3605	1.2	0.3	1.2	1.5	2.7	6.6	5.4	5.1	4.0
3	51	276	1000	2000	3605	1.2	0.3	3.4	1.5	4.9	6.8	5.6	5.3	1.9
3	54	335	945	2000	3605	1.2	1.1	2.6	2.3	4.9	7.0	5.8	4.7	2.1
3	57	394	891	2000	3591	1.2	1.7	2.4	2.9	5.3	7.2	6.0	4.3	1.9
3	60	453	836	2000	3591	1.1	2.3	1.4	3.3	4.7	7.4	6.4	4.1	2.7
3	63	512	782	2000	3624	0.8	2.8	2.0	3.6	5.6	7.6	6.8	4.0	2.1
3	66	571	727	2000	3624	0.5	3.2	2.1	3.7	5.8	7.7	7.2	4.0	1.9
3	69	571	727	2000	3624	0.5	3.3	1.9	3.8	5.7	7.9	7.4	4.1	2.2
4	0	250	620	1600	3450	0.6	1.9	3.2	2.5	5.7	8.0	7.5	5.5	2.3
4	3	271	620	1585	3455	0.6	1.9	4.4	2.5	6.9	8.3	7.7	5.8	1.4
4	6	292	620	1569	3460	0.7	1.9	8.0	2.5	10.6	8.6	7.9	6.1	-2.0
4	9	313	619	1554	3553	0.7	1.8	3.0	2.6	5.6	8.9	8.2	6.3	3.4
4	12	333	619	1538	3553	0.8	1.8	3.4	2.6	6.0	9.3	8.5	6.7	3.3
4	15	333	619	1538	3553	0.8	1.8	3.1	2.6	5.7	9.6	8.8	7.0	3.9
4	18	343	625	1341	3553	0.8	2.2	2.6	3.0	5.6	9.9	9.1	6.9	4.3
4	21	353	631	1143	3553	0.8	2.8	1.4	3.6	5.0	10.3	9.5	6.7	5.3
4	24	362	637	1143	3672	0.8	2.9	0.8	3.7	4.5	10.6	9.8	6.9	6.2
4	27	372	643	1143	3672	0.8	2.4	2.3	3.2	5.5	10.9	10.1	7.7	5.5
4	30	382	649	1553	3527	0.8	2.0	5.2	2.8	7.9	11.3	10.5	8.6	3.4

LINE	Station	V1	V2	V3	V4	T1	T2	T3	T1+T2	T1+T2+T3	SURFACE	BASE1	BASE2	BASE3
		m/s	m/s	m/s	m/s	m	m	m	m	m	mOD	mOD	mOD	mOD
4	33	382	649	1553	3527	0.8	2.0	5.8	2.8	8.6	11.6	10.8	8.9	3.1
4	36	382	688	1556	3527	0.8	2.1	4.6	2.9	7.5	11.8	11.0	8.9	4.3
4	39	382	727	1559	3670	0.8	2.1	5.5	3.0	8.5	12.0	11.2	9.0	3.5
4	42	382	766	1563	3670	0.9	2.2	6.8	3.1	9.9	12.1	11.2	9.0	2.2
4	45	382	805	1566	3670	0.9	2.2	5.8	3.2	8.9	12.3	11.4	9.2	3.4
4	48	382	844	1569	3670	1.0	2.3	5.1	3.2	8.3	12.5	11.5	9.3	4.2
4	51	382	844	1569	3608	1.0	2.3	5.7	3.2	8.9	12.7	11.7	9.5	3.8
4	54	378	836	1603	3625	1.0	2.3	5.8	3.3	9.1	12.9	11.9	9.6	3.8
4	57	375	827	1637	3625	1.0	2.4	6.2	3.3	9.5	13.1	12.1	9.8	3.6
4	60	371	818	1671	3625	1.0	2.4	6.6	3.4	10.0	13.3	12.3	9.9	3.3
4	63	367	809	1705	3625	1.0	2.5	6.0	3.4	9.5	13.5	12.5	10.1	4.0
4	66	364	800	1739	3625	1.0	2.5	5.5	3.5	9.0	13.7	12.7	10.2	4.8
4	69	364	800	1739	3625	1.0	2.5	5.5	3.5	9.0	13.9	12.9	10.4	5.0
5	0	400	889	1571	3418	1.0	2.1	5.0	3.1	8.1	14.0	13.1	10.9	5.9
5	3	377	867	1594	3418	1.0	2.1	4.0	3.1	7.1	14.1	13.1	11.1	7.1
5	6	355	844	1618	3418	1.0	2.0	4.6	3.0	7.7	14.2	13.2	11.2	6.6
5	9	332	822	1642	3418	1.0	2.0	4.2	3.0	7.3	14.4	13.3	11.3	7.1
5	12	310	800	1665	3418	1.0	2.0	4.3	3.0	7.3	14.5	13.5	11.5	7.1
5	15	310	800	1665	3414	1.0	2.0	3.8	3.0	6.8	14.6	13.6	11.6	7.8
5	18	334	747	1696	3525	1.0	2.1	2.4	3.1	5.5	14.7	13.7	11.6	9.3
5	21	358	694	1727	3525	0.9	2.2	3.6	3.1	6.7	14.8	13.9	11.7	8.1
5	24	383	641	1757	3525	0.9	2.2	5.6	3.1	8.7	15.0	14.1	11.9	6.2
5	27	407	589	1788	3525	0.8	2.2	6.0	3.0	9.0	15.1	14.3	12.1	6.1
5	30	432	536	1818	3525	0.7	2.2	5.2	2.9	8.1	15.2	14.5	12.3	7.1
5	33	432	536	1818	3553	0.7	2.2	5.9	2.9	8.8	15.3	14.6	12.5	6.5
5	36	479	599	1845	3710	0.7	2.4	5.5	3.1	8.6	15.2	14.5	12.1	6.6
5	39	526	662	1872	3710	0.7	2.7	5.4	3.3	8.7	15.1	14.4	11.8	6.4
5	42	573	725	1899	3545	0.7	2.9	7.7	3.6	11.2	15.0	14.3	11.4	3.8
5	45	620	788	1926	3545	0.6	3.1	7.6	3.8	11.3	14.9	14.2	11.1	3.5
5	48	667	851	1952	3545	0.6	3.3	7.0	3.9	11.0	14.7	14.1	10.8	3.8
5	51	667	851	1952	3545	0.6	3.3	6.6	3.9	10.5	14.6	14.0	10.7	4.1
5	54	618	851	1880	3545	0.7	2.9	6.3	3.6	10.0	14.5	13.8	10.9	4.6
5	57	568	851	1808	3545	0.8	2.5	7.3	3.3	10.6	14.4	13.6	11.1	3.8
5	60	519	851	1736	3707	0.8	2.1	5.3	2.9	8.3	14.3	13.5	11.4	6.1
5	63	470	850	1663	3707	0.9	1.7	6.7	2.6	9.3	14.2	13.3	11.6	4.9
5	66	421	850	1591	3707	0.9	1.3	5.2	2.1	7.3	14.1	13.2	11.9	6.8
5	69	421	850	1591	3707	1.0	0.8	5.7	1.8	7.5	14.0	13.0	12.2	6.5
6	0	800		2000	3300	0.7	0.0	3.0	0.7	3.7	5.4	4.8	4.8	1.7
6	3	713		2013	3422	0.8	0.0	3.5	0.8	4.3	5.6	4.8	4.8	1.3
6	6	625		2026	3543	1.0	0.0	3.9	1.0	4.9	5.8	4.9	4.9	1.0
6	9	538		2039	3543	1.0	0.0	3.1	1.0	4.1	6.0	5.0	5.0	1.9
6	12	450		2052	3543	1.0	0.0	3.2	1.0	4.2	6.2	5.2	5.2	2.0
6	15	450		2065	3543	1.0	0.0	4.2	1.0	5.2	6.4	5.4	5.4	1.2
6	18	417		2079	3543	1.1	0.0	4.0	1.1	5.1	6.6	5.5	5.5	1.5
6	21	384		2092	3543	1.2	0.0	2.3	1.2	3.5	6.7	5.5	5.5	3.2
6	24	351		2105	3543	1.3	0.0	2.0	1.3	3.3	6.9	5.6	5.6	3.6
6	27	319		2118	3346	1.3	0.0	3.6	1.3	5.0	7.1	5.8	5.8	2.2
6	30	286		2131	3346	1.3	0.0	4.4	1.3	5.8	7.3	6.0	6.0	1.6
6	33	286		2131	3346	1.3	0.0	2.4	1.3	3.7	7.5	6.2	6.2	3.8
	MIN	250	536	1143	3300	0.5	0.0	0.1	0.7	1.9	4.4	3.4	2.7	-2.0
	MAX	1000	1333	2264	4050	1.3	3.3	8.0	4.0	11.3	15.3	14.6	12.5	9.3
	AVERAGE	462	872	1771	3617	0.9	1.7	3.9	2.6	6.5	10.4	9.5	7.8	3.9

APPENDIX EIII S-WAVE SEISMIC REFRACTION DATA DETERMINED BY THE MASW METHOD

Shear Wave Velocities and calculated Gmax Values

S1			S2			S3		
Depth m	Vs m/s	Gmax* MPa	Depth m	Vs m/s	Gmax* MPa	Depth m	Vs m/s	Gmax* MPa
0.99	297	192	1.05	253	139	0.91	247	133
2.23	297	192	2.37	253	139	2.05	247	133
2.23	500	545	2.37	555	671	2.05	405	357
3.78	500	545	4.02	555	671	3.48	405	357
3.78	659	947	4.02	626	853	3.48	624	848
5.71	659	***1173***	6.08	626	853	5.27	624	***1050***
5.71	786	***1666***	6.08	858	1607	5.27	590	***940***
8.13	786	***1666***	8.66	858	***1990***	7.5	590	***940***
8.13	1058	***3021***	8.66	1013	***2768***	7.5	730	***1437***
11.15	1058	***3021***	11.88	1013	***2768***	10.13	730	***1437***
11.15	1233	***4102***	11.88	1172	***3707***	10.13	965	***2515***
14.93	1233	***4102***	15.91	1172	***3707***	13.56	965	***2515***
14.93	1362	***5006***	15.91	1259	***4279***	13.56	1161	***3639***
19.66	1362	***5006***	20.94	1259	***4279***	17.85	1161	***3639***
19.66	1178	***3746***	20.94	1148	***3557***	17.85	1366	***5039***
25.56	1178	***3746***	27.23	1148	***3557***	23.21	1366	***5039***

S4			S5			S6		
Depth m	Vs m/s	Gmax* MPa	Depth m	Vs m/s	Gmax* MPa	Depth m	Vs m/s	Gmax* MPa
0.77	263	151	0.98	361	284	0	327	233
1.73	263	151	2.21	361	284	1.01	327	233
1.73	407	361	2.21	483	509	1.01	229	114
2.93	407	361	3.74	483	509	2.27	229	114
2.93	679	1006	3.74	801	1400	2.27	505	556
4.82	679	1006	5.66	801	1400	3.84	505	556
4.82	823	1477	5.66	849	1570	3.84	572	713
6.86	823	1477	8.06	849	1570	5.81	572	***884***
6.86	967	2039	8.06	993	2147	5.81	633	***1083***
9.41	967	***2525***	11.05	993	***2660***	8.27	633	***1083***
9.41	1058	***3021***	11.05	1243	***4171***	8.27	944	***2408***
12.6	1058	***3021***	14.8	1243	***4171***	11.34	944	***2408***
12.6	1138	***3497***	14.8	1532	***6341***	11.34	1078	***3136***
16.59	1138	***3497***	19.48	1532	***6341***	15.18	1078	***3136***
16.59	1311	***4640***	19.48	1670	***7526***	15.18	1244	***4178***
21.57	1311	***4640***	25.33	1670	***7526***	19.98	1244	***4178***
						19.98	1415	***5404***
						25.99	1415	***5404***

*Assumes soil density of 2180kg/m3
Assumes rock density of 2700kg/m3
Gmax: Measures small strain stiffness of the ground

APPENDIX EIV CALCULATED MODULI

Calculation of static and dynamic moduli - S1							
Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
0.99	512	297	2180	0.247	0.19	0.479	0.315
2.23	1024	297	2180	0.454	0.19	0.559	2.030
2.23	1024	500	2180	0.344	0.54	1.464	1.560
3.78	1947	500	2180	0.465	0.54	1.596	7.538
3.78	1947	659	2180	0.435	0.95	2.718	7.002
5.71	3974	659	2700	0.486	1.17	3.485	41.077
5.71	3974	786	2700	0.480	1.67	4.930	40.419
8.13	3974	786	2700	0.480	1.67	4.930	40.419
8.13	3974	1058	2700	0.462	3.02	8.832	38.612
11.15	3974	1058	2700	0.462	3.02	8.832	38.612
11.15	3974	1233	2700	0.447	4.10	11.870	37.170
14.93	3974	1233	2700	0.447	4.10	11.870	37.170
14.93	3974	1362	2700	0.433	5.01	14.353	35.965
19.66	3974	1362	2700	0.433	5.01	14.353	35.965
19.66	3974	1178	2700	0.452	3.75	10.878	37.645
25.56	3974	1178	2700	0.452	3.75	10.878	37.645
* from Davies & Schulteiss,1980.							

Calculation of static and dynamic moduli - S2

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
1.05	450	253	2180	0.270	0.14	0.353	0.256
2.37	795	253	2180	0.444	0.14	0.402	1.192
2.37	795	555	2180	0.025	0.67	1.376	0.483
4.02	1526	555	2180	0.424	0.67	1.912	4.181
4.02	1526	626	2180	0.399	0.85	2.387	3.939
6.08	1526	626	2180	0.399	0.85	2.387	3.939
6.08	1526	858	2180	0.269	1.61	4.076	2.934
8.66	3521	858	2700	0.468	1.99	5.844	30.820
8.66	3521	1013	2700	0.455	2.77	8.055	29.782
11.88	3521	1013	2700	0.455	2.77	8.055	29.782
11.88	3521	1172	2700	0.438	3.71	10.659	28.531
15.91	3521	1172	2700	0.438	3.71	10.659	28.531
15.91	3521	1259	2700	0.427	4.28	12.210	27.768
20.94	3521	1259	2700	0.427	4.28	12.210	27.768
20.94	3521	1148	2700	0.441	3.56	10.248	28.731
27.23	3521	1148	2700	0.441	3.56	10.248	28.731

* from Davies & Schulteiss,1980.

Calculation of static and dynamic moduli - S3

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
0.91	532	247	2180	0.362	0.13	0.363	0.439
2.05	1066	247	2180	0.472	0.13	0.392	2.300
2.05	1066	405	2180	0.416	0.36	1.012	2.001
3.48	1948	405	2180	0.477	0.36	1.056	7.796
3.48	1948	624	2180	0.443	0.85	2.447	7.142
5.27	3529	624	2700	0.484	1.05	3.116	32.225
5.27	3529	590	2700	0.486	0.94	2.794	32.371
7.50	3529	590	2700	0.486	0.94	2.794	32.371
7.50	3529	730	2700	0.478	1.44	4.247	31.710
10.13	3529	730	2700	0.478	1.44	4.247	31.710
10.13	3529	965	2700	0.460	2.52	7.342	30.272
13.56	3529	965	2700	0.460	2.52	7.342	30.272
13.56	3529	1161	2700	0.439	3.64	10.475	28.773
17.85	3529	1161	2700	0.439	3.64	10.475	28.773
17.85	3529	1366	2700	0.412	5.04	14.229	26.907
23.21	3529	1366	2700	0.412	5.04	14.229	26.907

* from Davies & Schulteiss, 980.

Calculation of static and dynamic moduli - S4

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
1.73	713	263	2180	0.421	0.15	0.429	0.907
1.73	713	407	2180	0.259	0.36	0.908	0.627
2.93	713	407	2180	0.259	0.36	0.908	0.627
2.93	1531	679	2180	0.377	1.01	2.771	3.769
4.82	1531	679	2180	0.377	1.01	2.771	3.769
4.82	1531	823	2180	0.297	1.48	3.830	3.141
6.86	1531	823	2180	0.297	1.48	3.830	3.141
6.86	1531	967	2180	0.168	2.04	4.763	2.392
9.41	3587	967	2700	0.461	2.52	7.377	31.373
9.41	3587	1058	2700	0.452	3.02	8.776	30.711
12.60	3587	1058	2700	0.452	3.02	8.776	30.711
12.60	3587	1138	2700	0.444	3.50	10.099	30.077
16.59	3587	1138	2700	0.444	3.50	10.099	30.077
16.59	3587	1311	2700	0.423	4.64	13.205	28.553
21.57	3587	1311	2700	0.423	4.64	13.205	28.553

* from Davies & Schulteiss,1980.

Calculation of static and dynamic moduli - S5

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
2.21	764	361	2180	0.357	0.28	0.769	0.894
2.21	764	483	2180	0.167	0.51	1.187	0.594
3.74	1753	483	2180	0.459	0.51	1.484	6.021
3.74	1753	801	2180	0.368	1.40	3.831	4.832
5.66	1753	801	2180	0.368	1.40	3.831	4.832
5.66	1753	849	2180	0.347	1.57	4.230	4.606
8.06	1753	849	2180	0.347	1.57	4.230	4.606
8.06	1753	993	2180	0.264	2.15	5.429	3.836
11.05	3550	993	2700	0.458	2.66	7.754	30.480
11.05	3550	1243	2700	0.430	4.17	11.929	28.466
14.80	3550	1243	2700	0.430	4.17	11.929	28.466
14.80	3550	1532	2700	0.385	6.34	17.570	25.573
19.48	3550	1532	2700	0.385	6.34	17.570	25.573
19.48	3550	1670	2700	0.358	7.53	20.440	23.992
25.33	3550	1670	2700	0.358	7.53	20.440	23.992

* from Davies & Schulteiss,1980.

Calculation of static and dynamic moduli - S6

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
1.01	2071	229	2180	0.494	0.11	0.341	9.198
2.27	2071	229	2180	0.494	0.11	0.341	9.198
2.27	2071	505	2180	0.468	0.56	1.634	8.608
3.84	2071	505	2180	0.468	0.56	1.634	8.608
3.84	2071	572	2180	0.459	0.71	2.081	8.399
5.81	3373	572	2700	0.485	0.88	2.624	29.540
5.81	3373	633	2700	0.482	1.08	3.209	29.274
8.27	3373	633	2700	0.482	1.08	3.209	29.274
8.27	3373	944	2700	0.457	2.41	7.020	27.507
11.34	3373	944	2700	0.457	2.41	7.020	27.507
11.34	3373	1078	2700	0.443	3.14	9.052	26.537
15.18	3373	1078	2700	0.443	3.14	9.052	26.537
15.18	3373	1244	2700	0.421	4.18	11.876	25.148
19.98	3373	1244	2700	0.421	4.18	11.876	25.148
19.98	3373	1415	2700	0.393	5.40	15.058	23.513
25.99	3373	1415	2700	0.393	5.40	15.058	23.513

* from Davies & Schulteiss,1980.

APPENDIX EV EXCAVATABILITY

The seismic velocity of a rock formation is related to characteristics of the rock mass which include rock hardness and strength, degree of weathering and discontinuities. Usually the velocity is just one of several parameters used in the assessment of excavatability. The excavatability of a rock formation is favoured by the following factors:

- Open fractures, faults and other planes of weakness of any kind
- Weathering
- Brittleness and crystalline nature
- High degree of stratification or lamination
- Large grain size
- Low compressive strength

Weaver (1975) presented a comprehensive rippability rating chart (Fig.1) in which the p-wave velocity value and the relevant geological factors could be entered and assigned appropriate weightings. The total weighted index was found to correlate very well with actual rippability.

Fig.1 Rippability Rating Chart according to Weaver

Rock class	I	II	III	IV	V
Description	Very good rock	Good rock	Fair rock	Poor rock	Very poor rock
Seismic velocity (Vp) (m/s)	>2150	2150-1850	1850-1500	1500-1200	1200-450
Rating	26	24	20	12	5
Rock hardness	Extremely hard rock	Very hard rock	Hard rock	Soft rock	Very soft rock
Rating	10	5	2	1	0
Rock weathering	Unweathered	Slightly weathered	Weathered	Highly weathered	Completely weathered
Rating	9	7	5	3	1
Joint spacing (mm)	>3000	3000-1000	1000-300	300-50	<50
Rating	30	25	20	10	5
Joint continuity	Non continuous	Slightly continuous	Continuous- no gouge	Continuous- some gouge	Continuous- with gouge
Rating	5	5	3	0	0
Joint gouge	No separation	Slight separation	Separation <1mm	Gouge <5mm	Gouge >5mm
Rating	5	5	4	3	1
Strike and dip orientation	Very unfavourable	Unfavourable	Slightly unfavourable	Favourable	Very favourable
Rating	15	13	10	5	3
Total rating	100-90	90-70*	70-50	50-25	<25
Rippability assessment	Blasting	Extremely hard ripping and blasting	Very hard ripping	Hard ripping	Easy ripping
Tractor horsepower		770/385	385/270	270/180	180
Tractor kilowatts		575/290	290/200	200/135	135

Appendix F - Embankment – Pond SI Geotechnical Laboratory Test Data (Soils and Chemical)

IGSL Ltd Soils Laboratory

Contract Name: Talbert/Ballylongford Onshore SI

Contract No. 12239

Client: Arup Consulting Engineers

General Notes on Test Reports

1. Tests are carried out in general accordance with BS1377:1990.

2. The following abbreviations are used to denote sample types in the reports

   - D/W – Small disturbed sample
   - B – Bulk disturbed sample
   - U – Sample provided to the laboratory in sampling tube (normally 100mm in diameter), or intact rotary core sample
   - RC – Rotary Core
   - P – Piston sample

3. Notes on classification tests

   - WS – prepared by wet sieving through a 425□m test sieve
   - Nat – tested as received
   - NP – Non-plastic
   - MC – Moisture Content

4. Sample descriptions are in general accordance with BS5930:1999, as required by the test method.

IGSL Ltd
Materials Laboratory
Unit J5, M7 Business Park
Newhall, Naas
Co. Kildare
045 846176

Test Report

Determination of Moisture Content, Liquid & Plastic Limits

Tested in accordance with BS1377:Part 2:1990, clauses 3.2, 4.3, 4.4 & 5.3

Report No. R22690 Contract No. M677 Contract Name: Tarbert/Ballylongford Embankment/Pond SI

Client: Arup Consulting Engineers

Samples Received: 06/03/07 Date Tested: 06/03/07 Material Type: Soil Specification: NA

Sample No.	Client Ref:	Sample Type	Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index	% <425µm	Preparation	Liquid Limit Clause	Classification (BS5930)	Description
A07/0290	AA9257, TPA1A, 1.5m Depth	B	12	37	23	14	48	WS	4.4	C I	Brown Slightly Sandy Gravelly CLAY
A07/0291	AA9258, TPA1A, 1.5m Depth	B	10								Brown Slightly Sandy Gravelly CLAY
A07/0292	AA9262, TPA1A, 3.5m Depth	B	12	35	19	16	50	WS	4.4	C L	Grey Slightly Sandy Gravelly CLAY
A07/0293	AA9248, TPA2, 0.5m Depth	B	7.0	25	NP	NP	48	WS	4.4		Brown Slightly Sandy Gravelly SILT
A07/0294	AA9252, TPA2, 2.5m Depth	B	10								Brown Slightly Sandy Gravelly CLAY
A07/0295	AA9239, TPA3, 0.5m Depth	B	17	26	17	9	63	WS	4.4	C L	Grey Slightly Sandy Slightly Gravelly CLAY
A07/0296	AA9240, TPA3, 0.5m Depth	B	14								Grey Sandy Gravelly CLAY
A07/0299	AA9225, TPA5, 0.5m Depth	B	16	33	20	13	56	WS	4.4	C L	Grey Brown Slightly Sandy Gravelly CLAY
A07/0300	AA9230, TPA5, 2.5m Depth	B	10	28	17	11	54	WS	4.4	C L	Grey Slightly Sandy Gravelly CLAY
A07/0301	AA9222, TPA6, 1.5m Depth	B	19	31	20	11	72	WS	4.4	C L	Grey Brown Slightly Sandy Slightly Gravelly CLAY
A07/0303	AA9214, TPA7, 2.5m Depth	B	16	34	21	13	56	WS	4.4	C L	Brown Slightly Sandy Gravelly CLAY
A07/0305	AA9204, TPA8, 1.5m Depth	B	8.0	32	21	11	53	WS	4.4	C L	Brown Slightly Sandy Gravelly CLAY
A07/0306	AA9205, TPA8, 2.5m Depth	B	13	30	18	12	52	WS	4.4	C L	Brown Slightly Sandy Gravelly CLAY

Notes:
Preparation: WS - Wet sieved
AR - As received
NP - Non plastic
Liquid Limit Clause: 4.3 Cone Penetrometer definitive method
4.4 Cone Penetrometer one point method

Sample Type: B - bulk disturbed
U - Undisturbed

Remarks:

Opinions and interpretations are outside the scope of accreditation.
The results relate to the specimens tested. Any remaining material will be retained for one month.

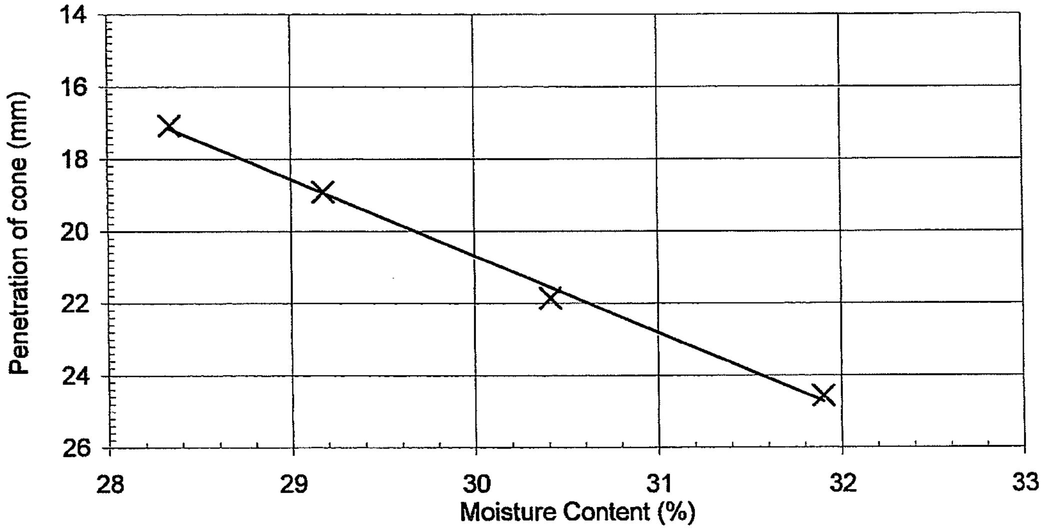
Approved signatories: ☐ J Barrett (Quality Manager) ☑ J Langley (Lab. Manager) ☐ H Byrne (Dep Lab. Manager)

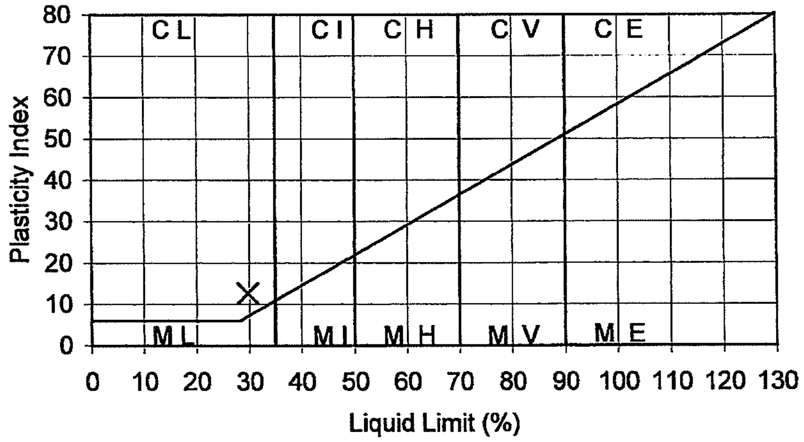
Compiled by	Date	Checked/Approved by	Date	Page
J Barrett	15/03/07		15/03/07	Figure S 1

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES	Site	TARBERT/BALLYLONGFORD EMBANKMENT - POND SI	Contract No.	C2525
			Hole ID	TPA10
	Client	Shannon LNG	Depth (m)	2.40-2.50
	Engineer	Arup Consulting Engineers		

Description : Dark yellowish brown slightly sandy gravelly CLAY. Gravel is fine to cobble sized.

Preparation : Sample washed and air dried





Results :

Natural Moisture Content :	10 %
Percentage retained on 425µm sieve :	56 %
Liquid Limit :	30 %
Plastic Limit :	17 %
Plasticity Index :	13
Equivalent moisture content of material passing 425µm sieve :	23 %
Liquidity Index :	0.44

Originator	Checked & Approved	**Liquid Limit (Four Point Cone Penetrometer Method)** **Plastic Limit and Plasticity Index** BS 1377:Part 2:Clause 4.3:1990 BS 1377:Part 2:Clause 5:1990	TTK	Figure S 2
CM	LA 31/10/07			

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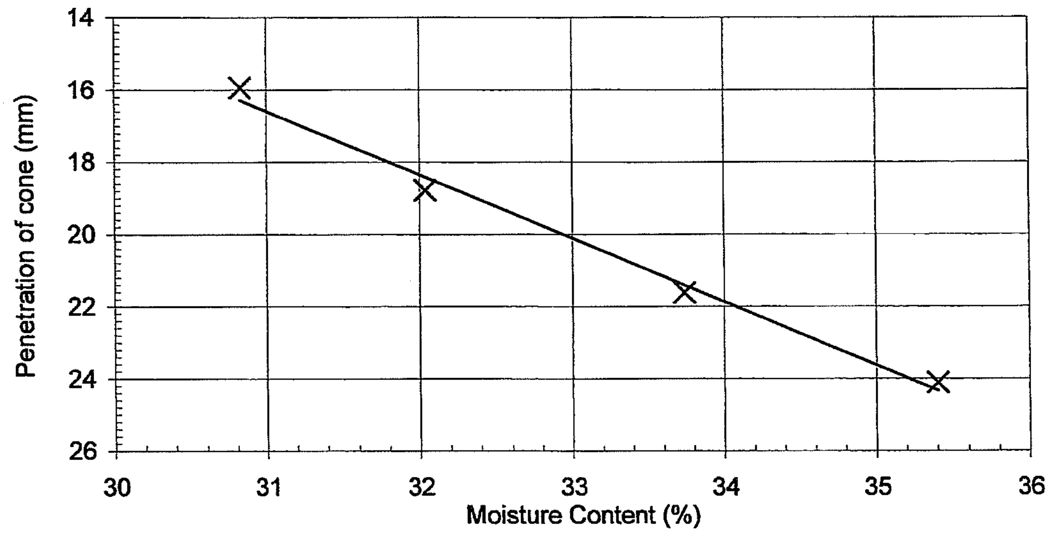
F123 Revision 1.2. .3/05/2007
H:\Lab\Lab Report Data\c2525\Liquid & Plastic\Liquid & Plastic TPA10 2.40 -CS20666.xls : Sample ID CS20666
Minera.. .re, Chesham, Bucks, HP5NL
Lab Project No C2525 : 30/10/2007 14:13:24

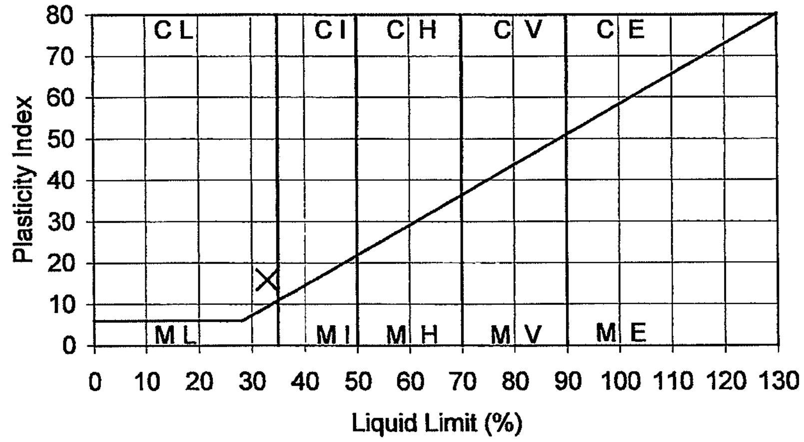
F123 Revision 1.2‿ ‿3/05/2007
H:\Lab\Lab Report Data\c2525\Liquid & Plastic\Liquid & Plastic TPA12 1.50 -CS20667.xls : Sample ID CS20667

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES	Site	TARBERT/BALLYLONGFORD EMBANKMENT - POND SI	Contract No.	C2525
			Hole ID	TPA12
	Client	Shannon LNG	Depth (m)	1.50-1.60
	Engineer	Arup Consulting Engineers		

Description : Dark yellowish brown slightly sandy slightly gravelly CLAY. Gravel is fine to cobble sized.

Preparation : Sample washed and air dried





Results :

Natural Moisture Content :	12	%
Percentage retained on 425µm sieve :	44	%
Liquid Limit :	33	%
Plastic Limit :	17	%
Plasticity Index :	16	
Equivalent moisture content of material passing 425µm sieve :	21	%
Liquidity Index :	0.28	

Originator	Checked & Approved	Liquid Limit (Four Point Cone Penetrometer Method) Plastic Limit and Plasticity Index BS 1377:Part 2:Clause 4.3:1990 BS 1377:Part 2:Clause 5:1990	TTk	Figure S 3
CM	ISA 31/10/07			

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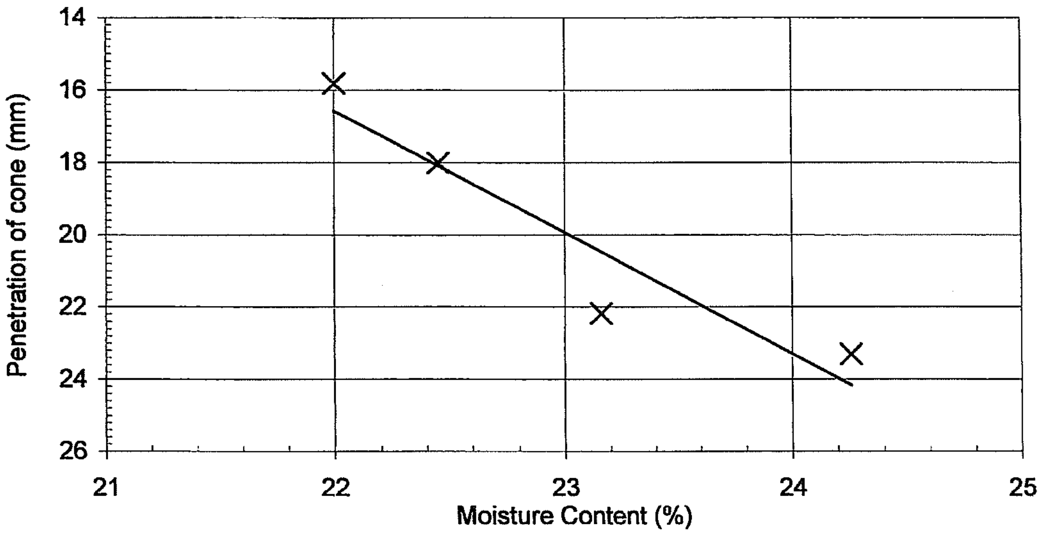
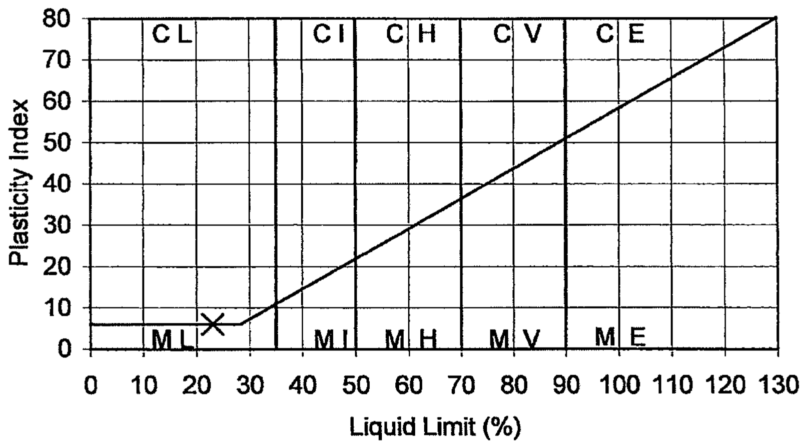
Minera‿ ‿ne, Chesham, Bucks, HP5NL
Lab Project No C2525 : 30/10/2007 14:24:02

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES	Site	TARBERT/BALLYLONGFORD EMBANKMENT - POND SI	Contract No.	C2525
			Hole ID	TPA14
	Client	Shannon LNG	Depth (m)	3.90-4.00
	Engineer	Arup Consulting Engineers		

Description : Dark yellowish brown slightly clayey very silty very sandy GRAVEL. Gravel is fine to coarse.

Preparation : Sample washed and air dried





Results :

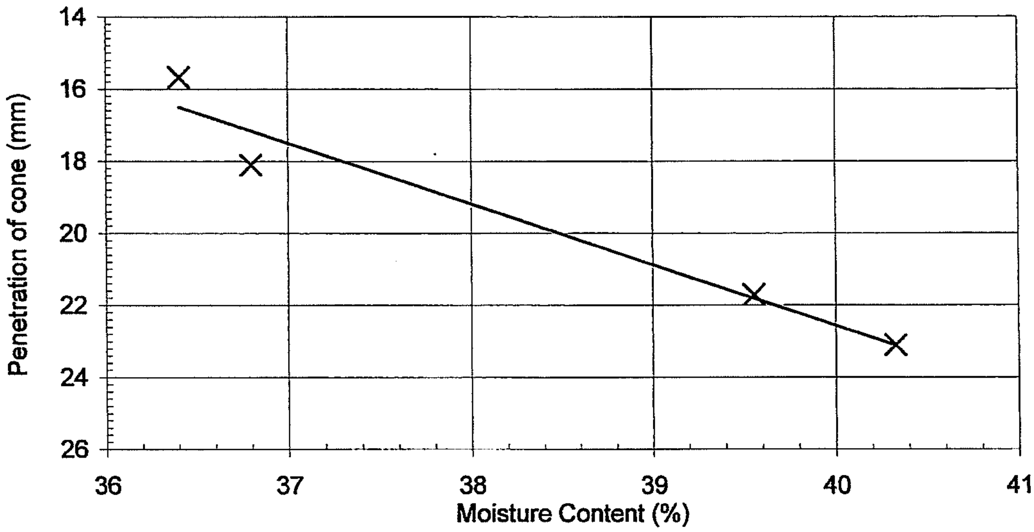
Natural Moisture Content :	10 %
Percentage retained on 425µm sieve :	62 %
Liquid Limit :	23 %
Plastic Limit :	17 %
Plasticity Index :	6.0
Equivalent moisture content of material passing 425µm sieve :	26 %
Liquidity Index :	1.55

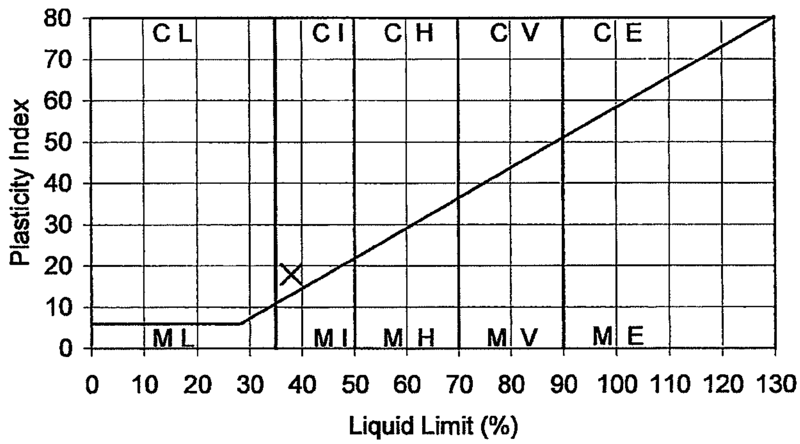
Originator	Checked & Approved	Liquid Limit (Four Point Cone Penetrometer Method) Plastic Limit and Plasticity Index BS 1377:Part 2:Clause 4.3:1990 BS 1377:Part 2:Clause 5:1990	TTK	Figure S 4
CM	LA 31/10/07			

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES	Site	TARBERT/BALLYLONGFORD EMBANKMENT - POND SI	Contract No.	C2525
			Hole ID	TPA18
	Client	Shannon LNG	Depth (m)	0.60-0.70
	Engineer	Arup Consulting Engineers		

Description : Yellowish brown slightly sandy gravelly CLAY. Gravel is fine to coarse.

Preparation : Sample washed and air dried





Results :

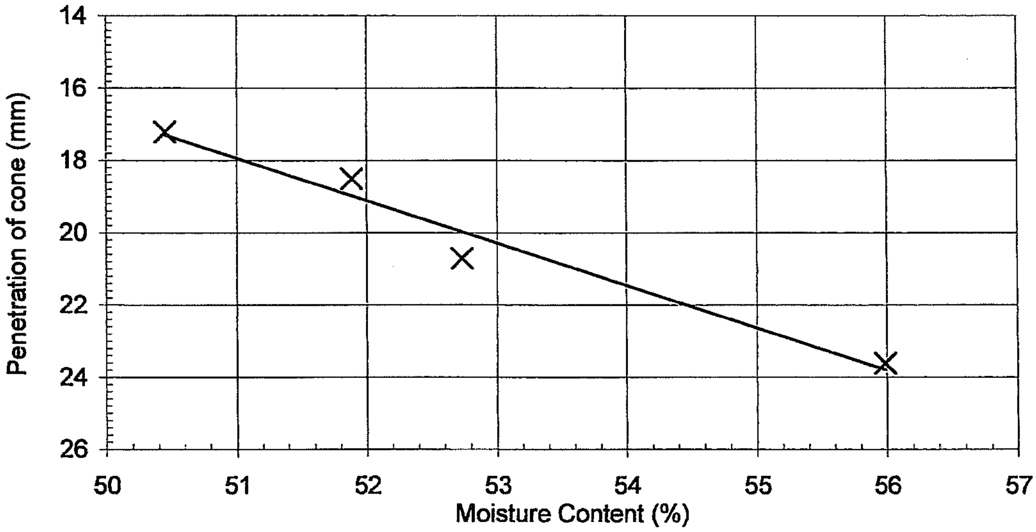
Natural Moisture Content :	18 %
Percentage retained on 425µm sieve :	44 %
Liquid Limit :	38 %
Plastic Limit :	20 %
Plasticity Index :	18
Equivalent moisture content of material passing 425µm sieve :	32 %
Liquidity Index :	0.68

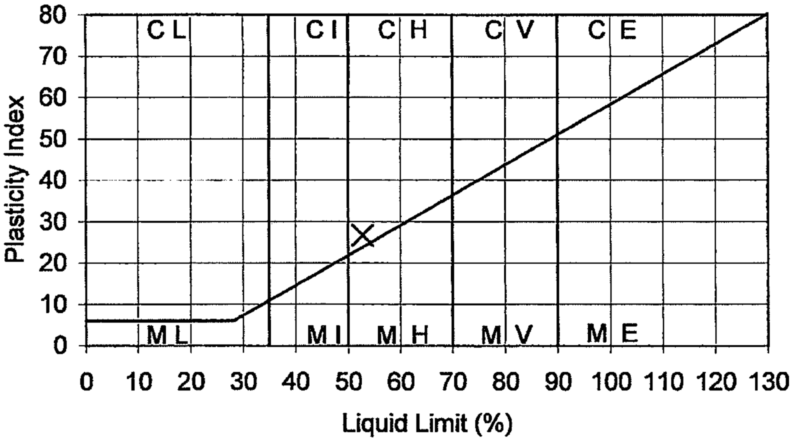
Originator	Checked & Approved	Liquid Limit (Four Point Cone Penetrometer Method) Plastic Limit and Plasticity Index BS 1377:Part 2:Clause 4.3:1990 BS 1377:Part 2:Clause 5:1990	TTK	Figure S 5
CM	[signature] 31/10/07			

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES	Site	TARBERT/BALLYLONGFORD EMBANKMENT - POND SI	**Contract No.**	**C2525**
	Client	Shannon LNG	Hole ID	TPA19
	Engineer	Arup Consulting Engineers	Depth (m)	0.40-0.50

Description : Dark yellowish brown slightly gravelly slightly sandy CLAY. Gravel is fine to coarse.

Preparation : Sample washed and air dried





Results :

Natural Moisture Content :	29 %
Percentage retained on 425μm sieve :	18 %
Liquid Limit :	53 %
Plastic Limit :	26 %
Plasticity Index :	27
Equivalent moisture content of material passing 425μm sieve :	35 %
Liquidity Index :	0.35

Originator	Checked & Approved	**Liquid Limit (Four Point Cone Penetrometer Method)** **Plastic Limit and Plasticity Index**	TTK
CM	[signature] 31/10/07	BS 1377:Part 2:Clause 4.3:1990 BS 1377:Part 2:Clause 5:1990	Figure S 6

TEST REPORT

Determination of Particle Size Distribution

Tested in accordance with: BS1377:Part2:1990 , clause 9.2 & 9.5

(note: Sedimentation stage not accredited)

DETAILED IN SCOPE REG NO.133T

particle size	% passing	
75	100	COBBLES
63	100	GRAVEL
50	95	
37.5	90	
28	79	
20	71	
14	63	
10	56	
6.3	49	
5	47	
3.35	43	
2	38	SAND
1.18	34	
0.6	30	
0.425	28	
0.3	27	
0.15	25	
0.063	22	SILT/CLAY
0.031	20.9	
0.023	19.3	
0.015	17.3	
0.009	14.0	
0.007	10.6	
0.004	8.3	
0.002	7.1	

Contract No: M677 Report No. R22691

Contract: Tarbert/Ballylongford Embankment/Pond SI

BH: TP A1A

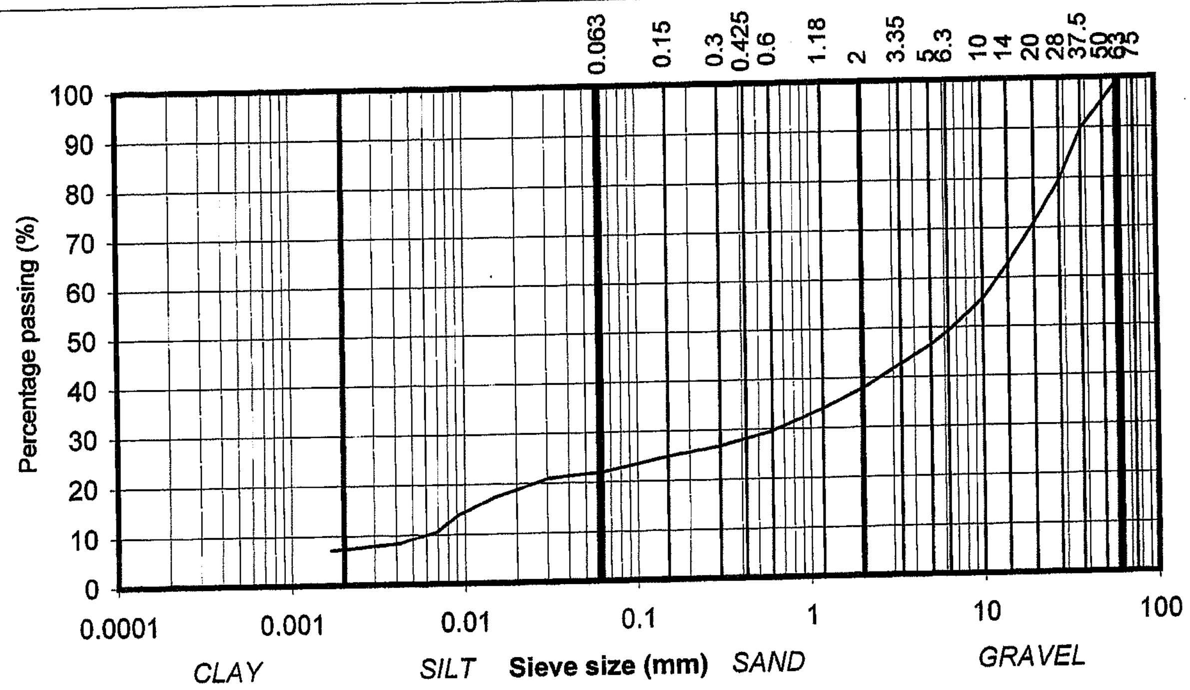
Sample No. AA9257 Lab. Sample No. A07/0290

Depth (m): 1.50 Client: Arup Consulting Engineers

Date Received 06/03/2007 Date Tested 06/03/2007

Description: Brown slightly sandy, gravelly, CLAY

Remarks



IGSL

Compiled by:	Date:	Checked by:	Date:	Page no:
J Barrett	15/03/2007		15/03/2007	Figure S 7

Approved Signatories: ☐ J Barrett (Technical Manager) ☑ J Langley (Laboratory Manager) ☐ H Byrne (Dep Lab Manager)

IGSL Ltd, M7 Business Park, Newhall, Naas, Co Kildare

TEST REPORT

Determination of Particle Size Distribution

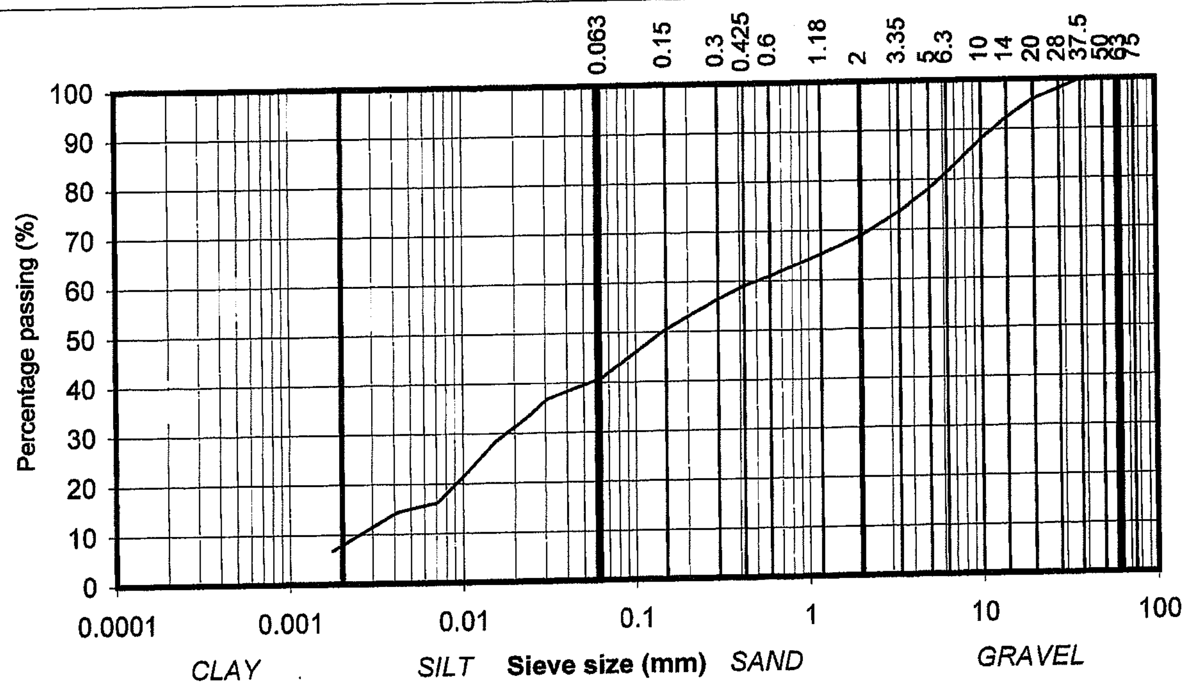
Tested in accordance with: BS1377:Part2:1990 , clause 9.2 & 9.5

(note: Sedimentation stage not accredited)

particle size	% passing	
75	100	COBBLES
63	100	GRAVEL
50	100	
37.5	100	
28	98	
20	96	
14	92	
10	88	
6.3	81	
5	78	
3.35	74	
2	69	SAND
1.18	65	
0.6	61	
0.425	59	
0.3	56	
0.15	51	
0.063	41	SILT/CLAY
0.031	36.9	
0.023	32.9	
0.015	28.3	
0.010	20.7	
0.007	16.2	
0.004	14.4	
0.002	6.8	

Contract No: M677 Report No. R22692
Contract: Tarbert/Ballylongford Embankment/Pond SI
BH: TP A3
Sample No. AA9239 Lab. Sample No. A07/0295
Depth (m): 0.50 Client: Arup Consulting Engineers
Date Received 06/03/2007 Date Tested 06/03/2007
Description: Grey slightly sandy, slightly gravelly, CLAY

Remarks



IGSL	Compiled by:	Date:	Checked by:	Date:	Page no:
	J Barrett	15/03/2007		15/03/2007	Figure S 8

Approved Signatories: ☐ J Barrett (Technical Manager) ☑ J Langley (Laboratory Manager) ☐ H Byrne (Dep Lab Manager)

IGSL Ltd, M7 Business Park, Newhall, Naas, Co Kildare

TEST REPORT

Determination of Particle Size Distribution

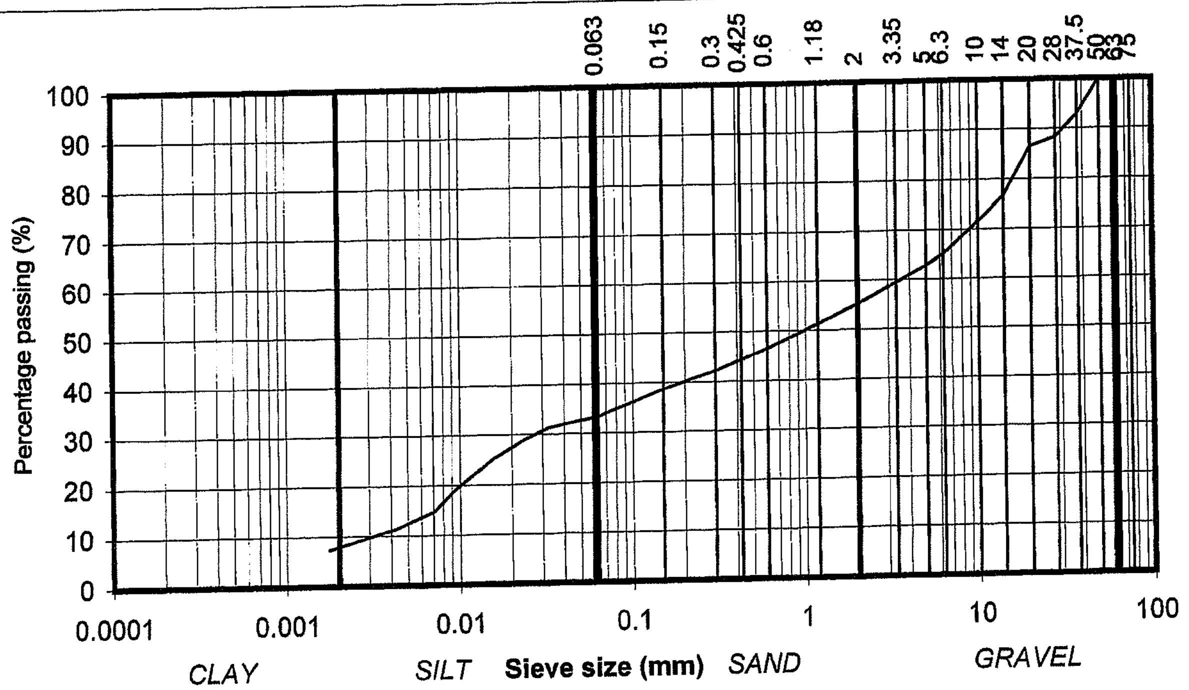
Tested in accordance with: BS1377:Part2:1990 , clause 9.2 & 9.5

(note: Sedimentation stage not accredited)

particle size	% passing	
75	100	COBBLES
63	100	GRAVEL
50	100	
37.5	93	
28	88	
20	87	
14	77	
10	72	
6.3	65	
5	63	
3.35	59	
2	55	SAND
1.18	51	
0.6	46	
0.425	44	
0.3	42	
0.15	39	
0.063	33	SILT/CLAY
0.033	31.3	
0.024	29.0	
0.016	25.3	
0.010	19.4	
0.007	14.8	
0.004	11.3	
0.002	7.3	

Contract No:	M677	Report No.	R22693
Contract:	Tarbert/Ballylongford Embankment/Pond SI		
BH:	TP A5		
Sample No.	AA9230	Lab. Sample No.	A07/0300
Depth (m):	2.50	Client:	Arup Consulting Engineers
Date Received	06/03/2007	Date Tested	06/03/2007
Description:	Grey slightly sandy, gravelly, CLAY		

Remarks



Compiled by:	Date:	Checked by:	Date:	Page no:
J Barrett	15/03/2007	[signature]	15/03/2007	Figure S 9

IGSL

Approved Signatories: ☐ J Barrett (Technical Manager) ☑ J Langley (Laboratory Manager) ☐ H Byrne (Dep Lab Manager)

IGSL Ltd, M7 Business Park, Newhall, Naas, Co Kildare

H:\Lab\Lab Report Data\c2525\PSD\PSD TPA10 2.40 -CS20666.xls : Sample ID CS20666

TERRA TEK Site Investigation & Laboratory Services	Site: TARBERT/BALLYLONGFORD EMBANKMENT - POND SI	Contract No: C2525
	Client: Shannon LNG	Hole ID: TPA10
	Engineer: Arup Consulting Engineers	Depth (m): 2.40-2.50

Particle Size	% Passing
90.0 mm	100
75.0 mm	100
63.0 mm	98
50.0 mm	92
37.5 mm	86
28.0 mm	82
20.0 mm	78
14.0 mm	74
10.0 mm	70
6.30 mm	65
5.00 mm	63
3.35 mm	58
2.00 mm	54
1.18 mm	50
600 µm	45
425 µm	44
300 µm	42
212 µm	40
150 µm	38
63 µm	34
20 µm	24
6 µm	15
2 µm	9

Non Engineering Description

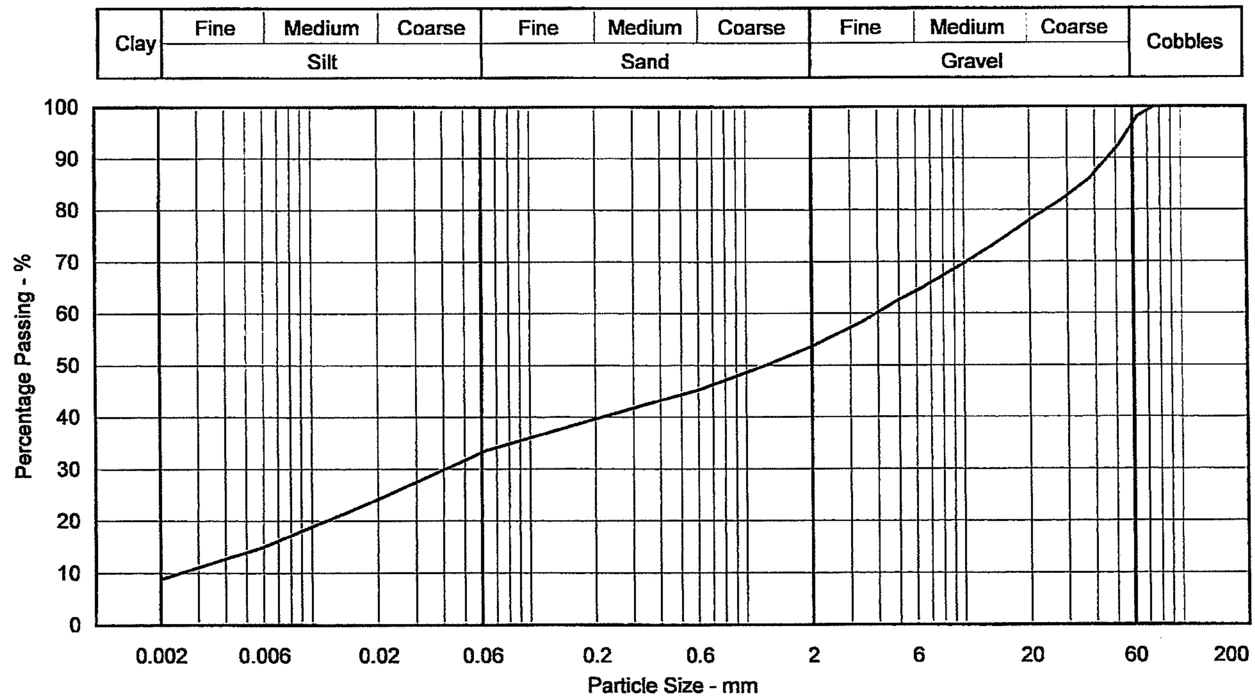
Dark yellowish brown slightly sandy gravelly CLAY. Gravel is fine to cobble sized.

Sample Proportions - %	
Cobbles	3.4
Gravel	42.9
Sand	20.7
Silt	24.1
Clay	8.9

Particle Diameter - mm	
D100	75.00
D60	3.90
D10	0.00
Uniformity Coefficient	1604.6

Notes

Disclaimer: Sample does not comply with BS1377 minimum mass requirments.



Originator	Checked & Approved	PARTICLE SIZE DISTRIBUTION BS1377:Part 2:1990 Clause 9.2 - Wet Sieving BS1377:Part 2:1990 Clause 9.4 - Sedimentation by Pipette	TTK Figure S 10
CM	LA 31/10/07		

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Lab Project No C2525 : 30/10/2007 14:28:32

H:\Lab\Lab Report Data\c2525\PSD\PSD TPA12 1.50 -CS20667.xls : Sample ID CS20667

TERRA TEK Site Investigation & Laboratory Services

Site	TARBERT/BALLYLONGFORD EMBANKMENT - POND SI	Contract No	C2525
		Hole ID	TPA12
Client	Shannon LNG	Depth (m)	1.50-1.60
Engineer	Arup Consulting Engineers		

Particle Size	% Passing
90.0 mm	100
75.0 mm	100
63.0 mm	98
50.0 mm	98
37.5 mm	94
28.0 mm	92
20.0 mm	89
14.0 mm	85
10.0 mm	81
6.30 mm	76
5.00 mm	73
3.35 mm	70
2.00 mm	65
1.18 mm	61
600 µm	57
425 µm	56
300 µm	54
212 µm	53
150 µm	51
63 µm	46
20 µm	35
6 µm	23
2 µm	15

Non Engineering Description

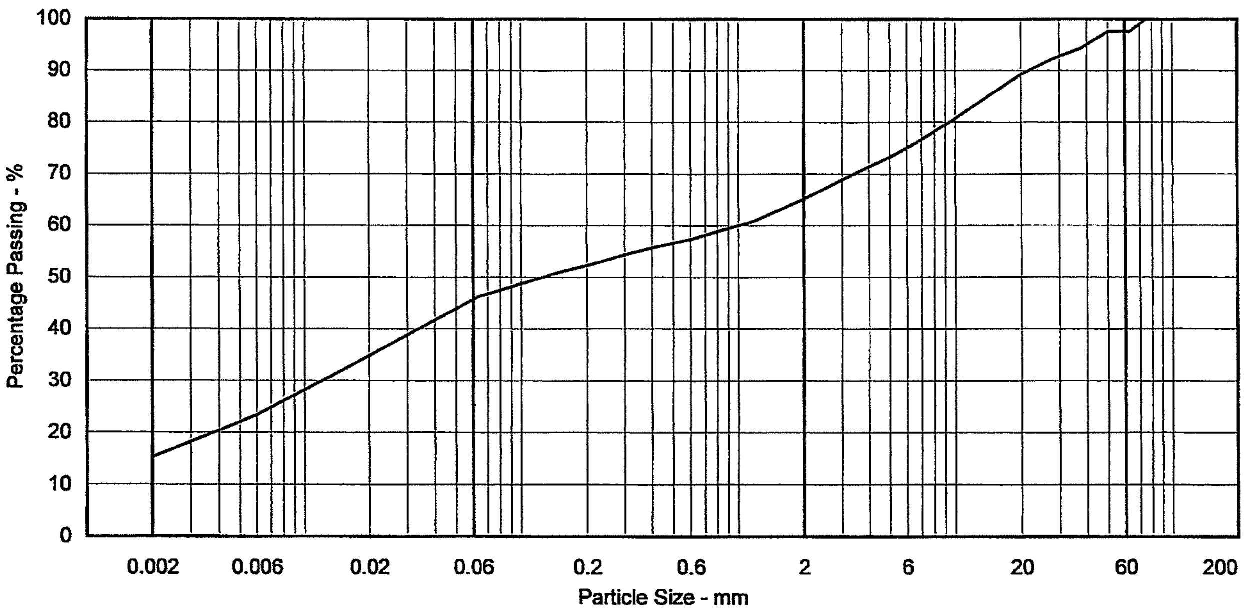
Dark yellowish brown slightly sandy slightly gravelly CLAY. Gravel is fine to cobble sized.

Sample Proportions - %	
Cobbles	2.4
Gravel	32.4
Sand	19.8
Silt	30.2
Clay	15.3

Particle Diameter - mm	
D100	75.00
D60	1.00
D10	
Uniformity Coefficient	N/A

Notes

Clay	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	Cobbles
	Silt			Sand			Gravel			



Mineral L: Chesham, Bucks, HP5 1NL

Lab Project No C2525 : 30/10/2007 14:29:18

Originator	Checked & Approved
JAH	LA 31/10/07

PARTICLE SIZE DISTRIBUTION

BS1377:Part 2:1990 Clause 9.2 - Wet Sieving

BS1377:Part 2:1990 Clause 9.4 - Sedimentation by Pipette

TTK

Figure S 11

TERRA TEK
Site Investigation & Laboratory Services

Site	TARBERT/BALLYLONGFORD EMBANKMENT - POND SI
Client	Shannon LNG
Engineer	Arup Consulting Engineers
Contract No	C2525
Hole ID	TPA14
Depth (m)	3.90-4.00

Particle Size	% Passing
90.0 mm	100
75.0 mm	100
63.0 mm	100
50.0 mm	94
37.5 mm	92
28.0 mm	88
20.0 mm	83
14.0 mm	77
10.0 mm	72
6.30 mm	66
5.00 mm	63
3.35 mm	58
2.00 mm	52
1.18 mm	46
600 µm	40
425 µm	38
300 µm	36
212 µm	34
150 µm	32
63 µm	26
20 µm	14
6 µm	7
2 µm	3

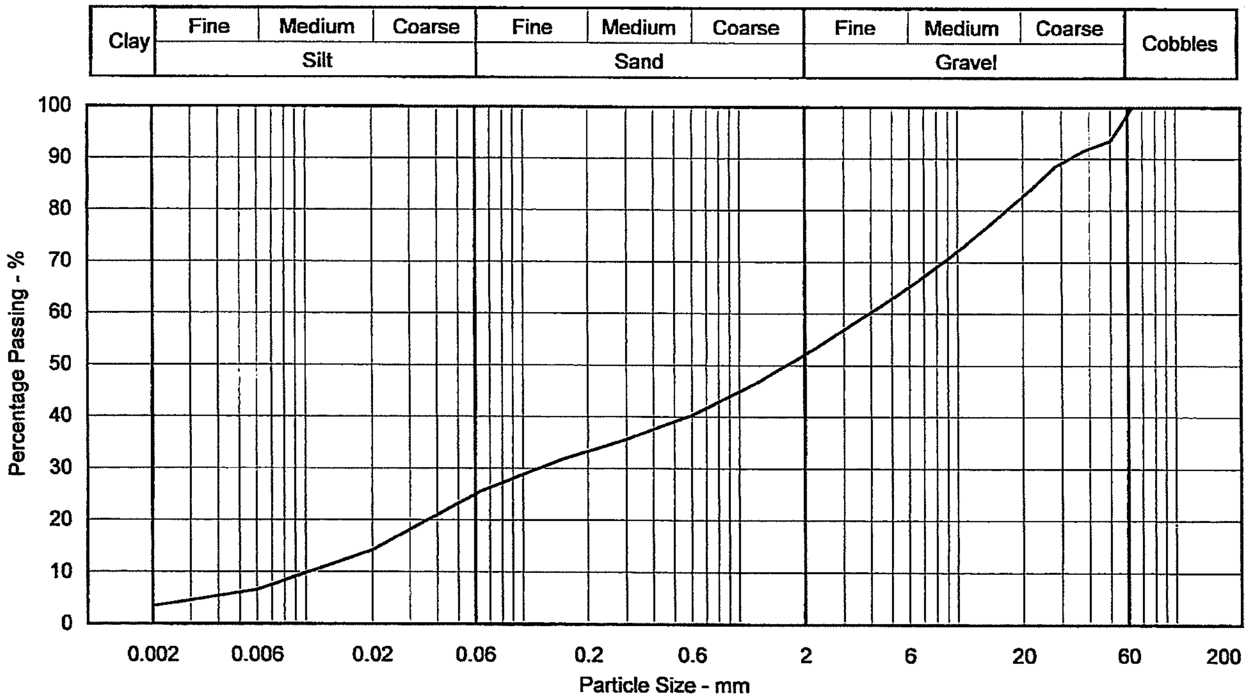
Non Engineering Description

Dark yellowish brown slightly clayey very silty very sandy GRAVEL. Gravel is fine to coarse.

Sample Proportions - %	
Cobbles	1.5
Gravel	46.4
Sand	27.4
Silt	21.3
Clay	3.4

Particle Diameter - mm	
D100	63.00
D60	3.89
D10	0.01
Uniformity Coefficient	378.6

Notes



Originator	Checked & Approved
CM	[signature] 31/10/07

PARTICLE SIZE DISTRIBUTION

BS1377:Part 2:1990 Clause 9.2 - Wet Sieving
BS1377:Part 2:1990 Clause 9.4 - Sedimentation by Pipette

TTk

Figure S 12

H:\Lab\Lab Report Data\c2525\PSD\PSD TPA18 0.60 -CS20669.xls : Sample ID CS20669

TERRA TEK
Site Investigation & Laboratory Services

Site	TARBERT/BALLYLONGFORD EMBANKMENT - POND SI	Contract No	C2525
Client	Shannon LNG	Hole ID	TPA18
Engineer	Arup Consulting Engineers	Depth (m)	0.60-0.70

Particle Size	% Passing
90.0 mm	100
75.0 mm	100
63.0 mm	100
50.0 mm	100
37.5 mm	95
28.0 mm	93
20.0 mm	87
14.0 mm	83
10.0 mm	78
6.30 mm	72
5.00 mm	70
3.35 mm	67
2.00 mm	64
1.18 mm	60
600 µm	57
425 µm	56
300 µm	55
212 µm	53
150 µm	52
63 µm	48
20 µm	38
6 µm	27
2 µm	16

Non Engineering Description

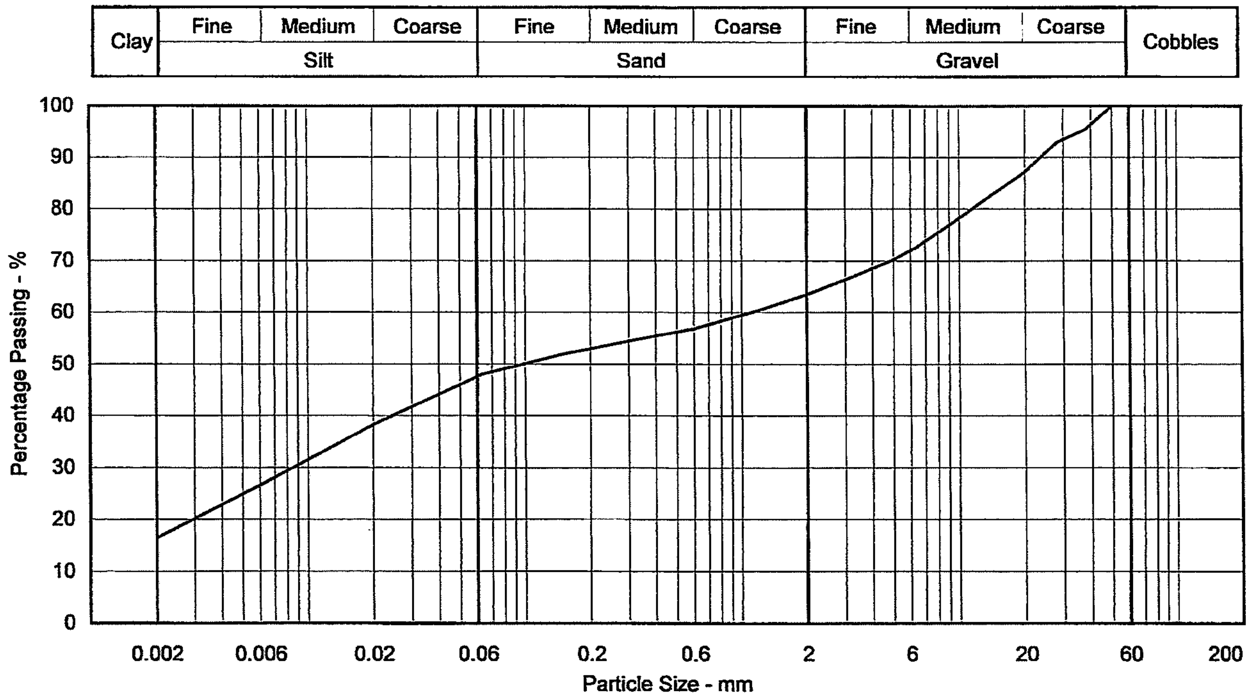
Yellowish brown slightly sandy gravelly CLAY. Gravel is fine to cobble size.

Sample Proportions - %	
Cobbles	0.0
Gravel	36.5
Sand	16.2
Silt	30.9
Clay	16.4

Particle Diameter - mm	
D100	50.00
D60	1.10
D10	
Uniformity Coefficient	N/A

Notes

Note: Cobble removed prior to test equivalant to 10.6% of mass of total sample.



Mineral L, Chesham, Bucks, HP5 1NL
Lab Project No C2525 : 30/10/2007 14:30:26

Originator	Checked & Approved		
CM	LA 31/10/07	**PARTICLE SIZE DISTRIBUTION** BS1377:Part 2:1990 Clause 9.2 - Wet Sieving BS1377:Part 2:1990 Clause 9.4 - Sedimentation by Pipette	TTK Figure S 13

TERRA TEK Site Investigation & Laboratory Services	Site TARBERT/BALLYLONGFORD EMBANKMENT - POND SI	Contract No C2525
	Client Shannon LNG	Hole ID TPA19
	Engineer Arup Consulting Engineers	Depth (m) 0.40-0.50

Particle Size	% Passing
90.0 mm	100
75.0 mm	100
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	97
20.0 mm	96
14.0 mm	96
10.0 mm	95
6.30 mm	92
5.00 mm	91
3.35 mm	89
2.00 mm	87
1.18 mm	85
600 µm	83
425 µm	82
300 µm	81
212 µm	79
150 µm	78
63 µm	71
20 µm	58
6 µm	40
2 µm	25

Non Engineering Description

Dark yellowish brown slightly gravelly slightly sandy CLAY. Gravel is fine to coarse with some cobbles.

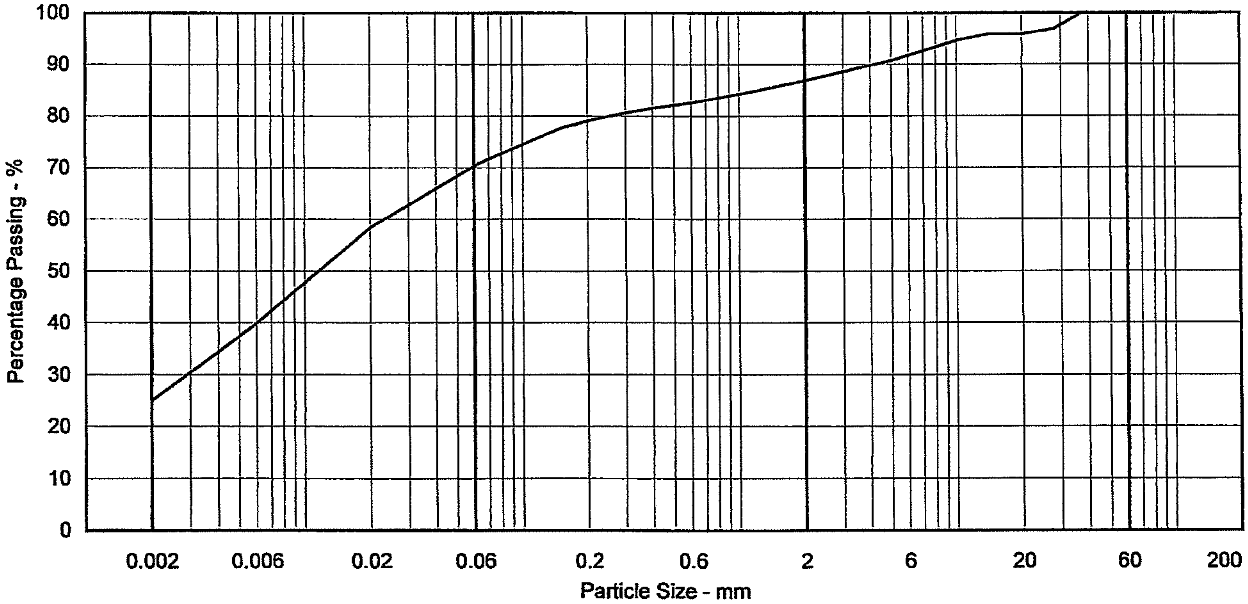
Sample Proportions - %	
Cobbles	0.0
Gravel	13.1
Sand	16.9
Silt	45.0
Clay	25.0

Particle Diameter - mm	
D100	37.50
D60	0.02
D10	
Uniformity Coefficient	N/A

Notes

Note: Cobbles removed prior to test eqvilalent to 24.6% of total mass of sample.

Clay	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	Cobbles
	Silt			Sand			Gravel			



Originator	Checked & Approved	PARTICLE SIZE DISTRIBUTION	
JAH	[signature] 31/10/07	BS1377:Part 2:1990 Clause 9.2 - Wet Sieving BS1377:Part 2:1990 Clause 9.4 - Sedimentation by Pipette	TTK Figure S 14

TERRA TEK Site Investigation & Laboratory Services	Site TARBERT/BALLYLONGFORD EMBANKMENT - POND SI	Contract No. C2525 Hole ID TPA10
	Client Shannon LNG Engineer Arup Consulting Engineers	Depth (m) 2.40-2.50

Description: Dark yellowish brown gravelly sandy CLAY. Gravel is fine to medium.

Sample Details:	Initial:	Final:
Diameter:	105.4 mm	105.0 mm
Height:	115.3 mm	114.9 mm
Moisture content:	11 %	12 %
Bulk density:	2.28 Mg/m³	2.32 Mg/m³
Dry density:	2.05 Mg/m³	2.08 Mg/m³
Sample condition:	Remoulded using 4.5kg compactive effort at the as-received moisture content	

Saturation Stage:

Initial pore pressure coefficient, B:	0.69
Final pore pressure coefficient, B:	0.99
Duration of stage:	5 days

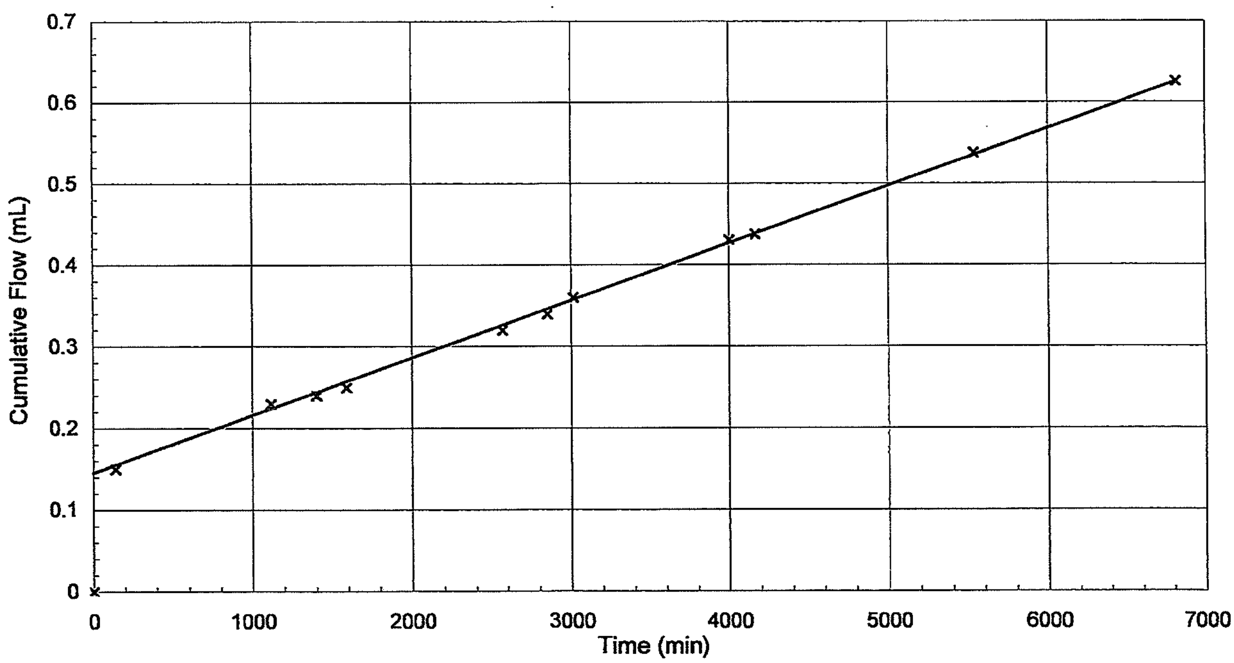
Consolidation stage:

Effective pressure:	85 kPa
Duration of stage:	1 day

Permeability stage:

Pressure difference across specimen:	20 kPa
Mean effective stress:	85 kPa
Duration of stage:	4 days

Coefficient of permeability at 20°C, Kv: 7.3×10^{-12} m/s



Originator	Checked & Approved	PERMEABILITY IN A TRIAXIAL CELL BS1377 : Part 6 : Clause 6 : 1990 Permeability under constant head conditions in a triaxial cell	TTK Figure S15
AB	Lsl 31/10/07		

Rev April 2004 H:\Lab\Lab Repo..\ata\c2525\Txl Perm\Txl Perm TPA12 1.50 -CS20667.xls : Sa..ple ID CS20667

TERRA TEK Site Investigation & Laboratory Services	Site TARBERT/BALLYLONGFORD EMBANKMENT - POND SI	Contract No. C2525
	Client Shannon LNG	Hole ID TPA12
	Engineer Arup Consulting Engineers	Depth (m) 1.50-1.60

Description:	Dark yellowish brown slightly sandy slightly gravelly CLAY. Gravel is fine to cobble sized.	
Sample Details:	Initial:	Final:
Diameter:	105.5 mm	105.1 mm
Height:	115.6 mm	115.1 mm
Moisture content:	13 %	13 %
Bulk density:	2.24 Mg/m³	2.27 Mg/m³
Dry density:	1.98 Mg/m³	2.01 Mg/m³
Sample condition:	Remoulded using 4.5kg compactive effort at the as-received moisture content	

Saturation Stage:

Initial pore pressure coefficient, B:	0.57
Final pore pressure coefficient, B:	0.99
Duration of stage:	5 days

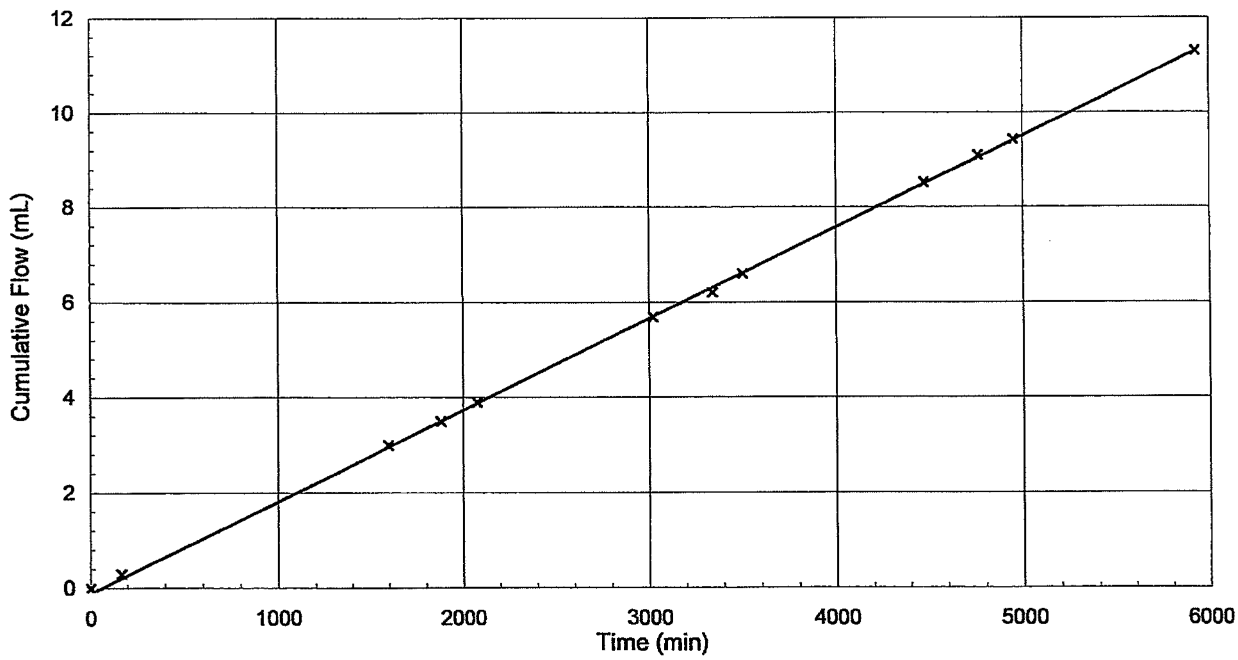
Consolidation stage:

Effective pressure:	60 kPa
Duration of stage:	1 day

Permeability stage:

Pressure difference across specimen:	20 kPa
Mean effective stress:	60 kPa
Duration of stage:	4 days

Coefficient of permeability at 20°C, Kv: 2.0×10^{-10} m/s



Originator	Checked & Approved	PERMEABILITY IN A TRIAXIAL CELL	TTK
AB	[signature] 31/10/07	BS1377 : Part 6 : Clause 6 : 1990 Permeability under constant head conditions in a triaxial cell	Figure S16

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TERRA TEK Site Investigation & Laboratory Services	Site: TARBERT/BALLYLONGFORD EMBANKMENT - POND SI	Contract No. C2525
	Client: Shannon LNG	Hole ID: TPA14
	Engineer: Arup Consulting Engineers	Depth (m): 3.90-4.00

Description: Dark yellowish brown slightly clayey very silty very sandy GRAVEL. Gravel is fine to coarse.

Sample Details:	Initial:	Final:
Diameter:	105.0 mm	104.8 mm
Height:	117.6 mm	117.4 mm
Moisture content:	11 %	11 %
Bulk density:	2.26 Mg/m^3	2.26 Mg/m^3
Dry density:	2.03 Mg/m^3	2.04 Mg/m^3
Sample condition:	Remoulded using 4.5kg compactive effort at the as-received moisture content	

Saturation Stage:

Initial pore pressure coefficient, B:	0.92
Final pore pressure coefficient, B:	0.92
Duration of stage:	3 days

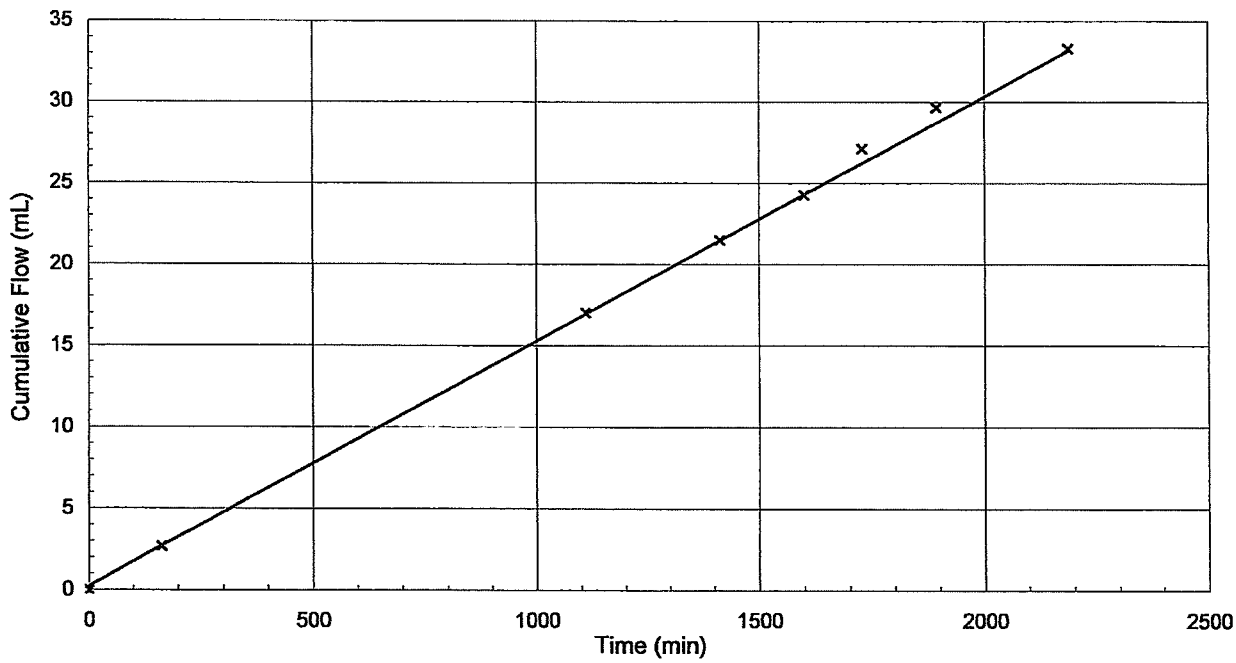
Consolidation stage:

Effective pressure:	100 kPa
Duration of stage:	1 day

Permeability stage:

Pressure difference across specimen:	20 kPa
Mean effective stress:	100 kPa
Duration of stage:	4 days

Coefficient of permeability at 20°C, Kv: 1.6×10^{-9} m/s



Originator	Checked & Approved	PERMEABILITY IN A TRIAXIAL CELL	
MB	31/10/07	BS1377 : Part 6 : Clause 6 : 1990 Permeability under constant head conditions in a triaxial cell	TTK Figure S17

TERRA TEK
Site Investigation & Laboratory Services

Site	TARBERT/BALLYLONGFORD EMBANKMENT - POND SI	**Contract No.**	**C2525**
		Hole ID	TPA18
Client	Shannon LNG	Depth (m)	0.60-0.70
Engineer	Arup Consulting Engineers		

Description: Yellowish brown slightly sandy gravelly CLAY. Gravel is fine to coarse.

Sample Details:	Initial:	Final:
Diameter:	105.0 mm	104.4 mm
Height:	115.2 mm	114.4 mm
Moisture content:	20 %	19 %
Bulk density:	2.10 Mg/m³	2.12 Mg/m³
Dry density:	1.75 Mg/m³	1.78 Mg/m³
Sample condition:	Remoulded using 2.5kg compactive effort at the as-received moisture content	

Saturation Stage:

Initial pore pressure coefficient, B:	0.85
Final pore pressure coefficient, B:	0.97
Duration of stage:	5 days

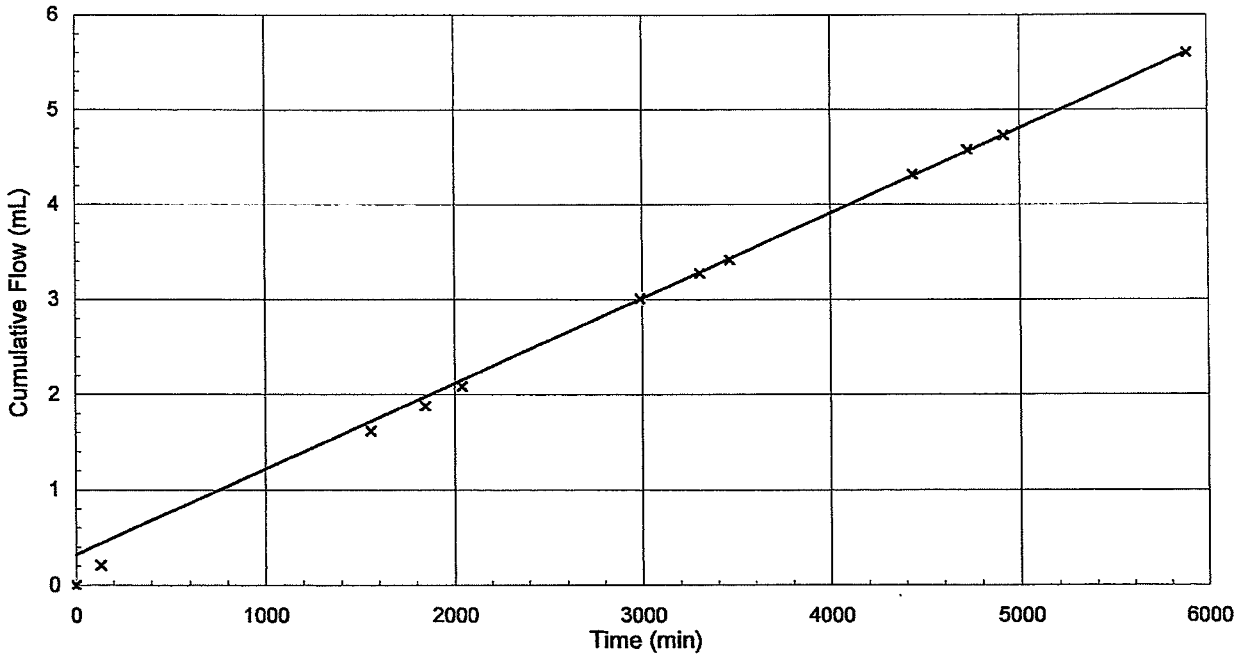
Consolidation stage:

Effective pressure:	60 kPa
Duration of stage:	3 days

Permeability stage:

Pressure difference across specimen:	20 kPa
Mean effective stress:	60 kPa
Duration of stage:	4 days

Coefficient of permeability at 20°C, Kv: 9.5×10^{-11} m/s



Originator	Checked & Approved	**PERMEABILITY IN A TRIAXIAL CELL** BS1377 : Part 6 : Clause 6 : 1990 Permeability under constant head conditions in a triaxial cell	TTK Figure S18
AB	LA 31/10/07		

TERRA TEK
Site Investigation & Laboratory Services

Site: TARBERT/BALLYLONGFORD EMBANKMENT - POND SI		**Contract No.** C2525
Client: Shannon LNG		Hole ID: TPA19
Engineer: Arup Consulting Engineers		Sample: 2
		Depth (m): 0.50-0.95

Description: Stiff intact light olive grey slightly sandy gravelly CLAY. Gravel is fine to coarse.

Sample Details:	Initial:	Final:
Diameter:	104.6 mm	104.2 mm
Height:	103.5 mm	103.1 mm
Moisture content:	26 %	27 %
Bulk density:	1.87 Mg/m³	1.91 Mg/m³
Dry density:	1.48 Mg/m³	1.50 Mg/m³
Sample condition:	Undisturbed	

Saturation Stage:

Initial pore pressure coefficient, B:	0.67
Final pore pressure coefficient, B:	0.99
Duration of stage:	7 days

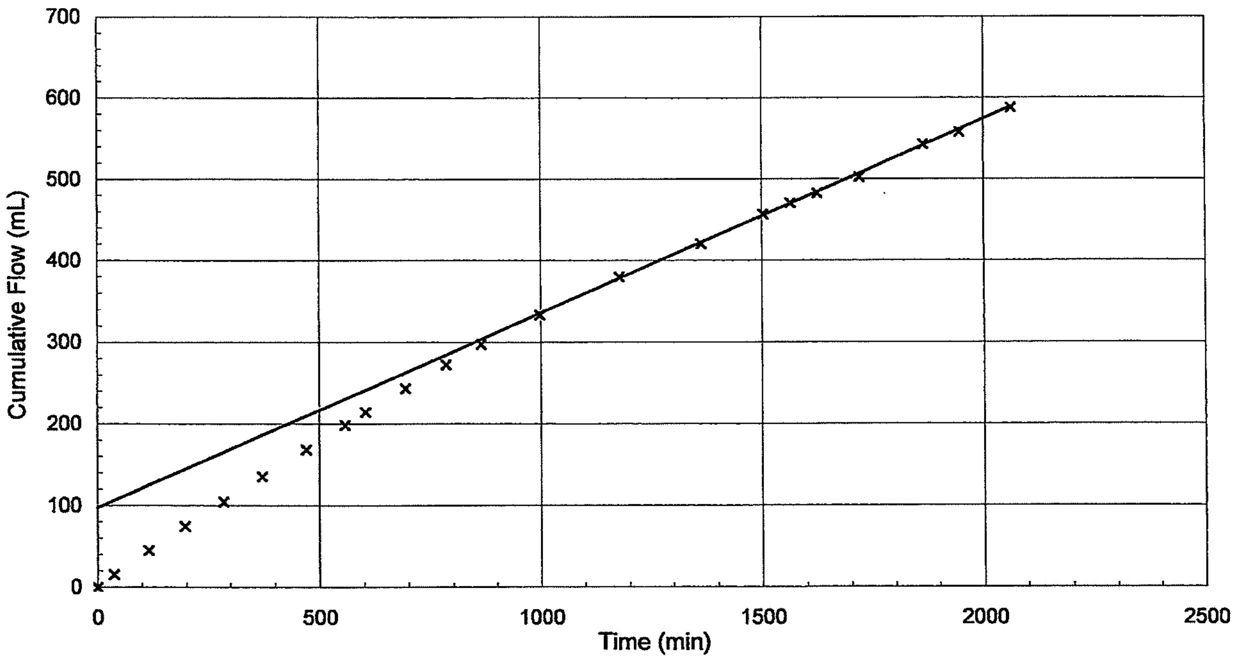
Consolidation stage:

Effective pressure:	20 kPa
Duration of stage:	1 day

Permeability stage:

Pressure difference across specimen:	60 kPa
Mean effective stress:	20 kPa
Duration of stage:	4 days

Coefficient of permeability at 20°C, Kv: 7.6×10^{-9} m/s



Originator	Checked & Approved		
AB	[signature] 31/10/07	**PERMEABILITY IN A TRIAXIAL CELL** BS1377 : Part 6 : Clause 6 : 1990 Permeability under constant head conditions in a triaxial cell	TTK Figure S19

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TERRA TEK Site Investigation & Laboratory Services	Site **TARBERT/BALLYLONGFORD EMBANKMENT - POND SI**	**Contract No. C2477**
		Hole ID TPA1A
	Client Shannon LNG	Sample A07/0291
		Depth (m) 1.50

Specimen Details

Description: Olive brown slightly sandy gravelly CLAY.. Gravel is fine to coarse.

Preparation: Passed through a 2mm sieve with 52% retained

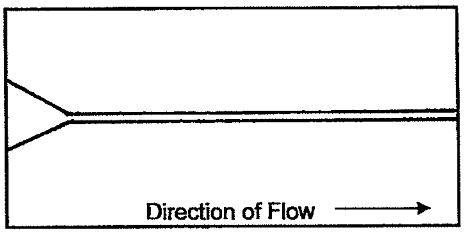
Plastic Limit	16.6	%
Initial Wet Density	2.28	Mg/m³
Initial Dry Density	1.95	Mg/m³

Test Stage

Hydraulic Head (mm)	Volume Collected (mL)	Duration of Flow (s)	Rate of Flow (mL/s)	Appearance of Water		Turbidity
				From Side	From Top	
50	10	190	0.05	Perfectly clear	Perfectly clear	None
180	25	27	0.93	Perfectly clear	Clear	None
380	25	9	2.78	Clear	Barely visible	No discernable particle

Dispersibilty

Sketch of Hole After Test



Diameter of Hole After Test: 1.5 mm

Dispersion Category: ND3

Originator	Checked & Approved	**Determination of Dispersibility by Pinhole Method** BS1377: Part 5: 1990 Clause 6	TTK Figure S20
OL	LA 31/10/07		

TERRA TEK Site Investigation & Laboratory Services	Site: TARBERT/BALLYLONGFORD EMBANKMENT - POND SI	Contract No. C2477
	Client: Shannon LNG	Hole ID TPA3
		Sample A07/0208
		Depth (m) 1.50

Specimen Details

Description: Dark grey slightly sandy slightly gravelly CLAY. Gravel is fine to medium.

Preparation: Passed through 2mm sieve with 19% retained

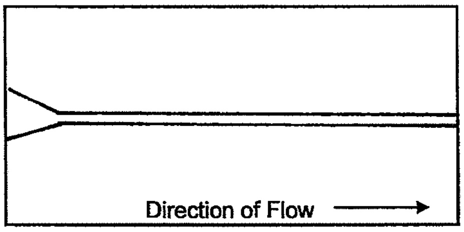
Plastic Limit	14	%
Initial Wet Density	2.48	Mg/m³
Initial Dry Density	2.18	Mg/m³

Test Stage

Hydraulic Head (mm)	Volume Collected (mL)	Duration of Flow (s)	Rate of Flow (mL/s)	Appearance of Water From Side	Appearance of Water From Top	Turbidity
50	10	27	0.37	Clear	Barely visible	No individual particles
180	25	17	1.47	Slightly dark	Moderately dark	No individual particles

Dispersibilty

Sketch of Hole After Test



Diameter of Hole After Test 2 mm

Dispersion Category ND3

Originator	Checked & Approved	Determination of Dispersibility by Pinhole Method	TTK
	Ld 31/10/07	BS1377: Part 5: 1990 Clause 6	Figure S21

TERRA TEK Site Investigation & Laboratory Services	Site TARBERT/BALLYLONGFORD EMBANKMENT - POND SI	Contract No. C2477 Hole ID TPA6
	Client Shannon LNG	Sample A07/0301 Depth (m) 1.50

Specimen Details

Description: Olive brown slightly sandy slightly gravelly CLAY. Gravel is fine to medium.

Preparation: Passed through a 2mm sieve with 18% retained

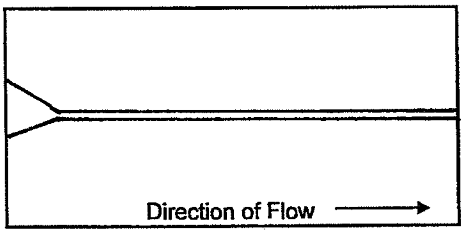
Plastic Limit	19.8	%
Initial Wet Density	2.23	Mg/m^3
Initial Dry Density	1.86	Mg/m^3

Test Stage

Hydraulic Head (mm)	Volume Collected (mL)	Duration of Flow (s)	Rate of Flow (mL/s)	Appearance of Water		Turbidity
				From Side	From Top	
50	10	14	0.71	Perfectly clear	Clear	No individual particles
180	10	8	1.25	Clear	Barely visible	No individual particles
380	25	10	2.50	Barely visible	Barely visible	No individual particles

Dispersibilty

Sketch of Hole After Test



Diameter of Hole After Test 1.5 mm

Dispersion Category ND3

Originator	Checked & Approved	Determination of Dispersibility by Pinhole Method BS1377: Part 5: 1990 Clause 6	TTk Figure S22
OL	[signature] 31/10/07		

www.terra-tek.co.uk Mineral Lane, Amersham Road, Chesham, Bucks, HP5 1NL

TERRA TEK Site Investigation & Laboratory Services	Site: TARBERT/BALLYLONGFORD EMBANKMENT - POND S1	Contract No. C2477
	Client: Shannon LNG	Hole ID TPA8
		Sample A07/0305
		Depth (m) 1.50

Specimen Details

Description: Olive brown slightly gravelly slightly sandy CLAY. Gravel is fine to medium.

Preparation: Passed through a 2mm sieve with 71% retained

Plastic Limit: 16 %

Initial Wet Density: 2.31 Mg/m^3

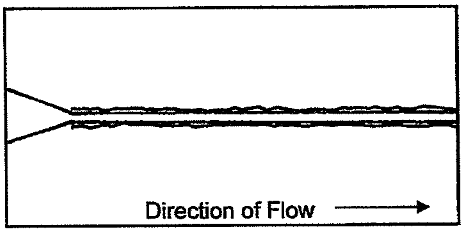
Initial Dry Density: 1.99 Mg/m^3

Test Stage

Hydraulic Head (mm)	Volume Collected (mL)	Duration of Flow (s)	Rate of Flow (mL/s)	Appearance of Water		Turbidity
				From Side	From Top	
50	10	328	0.03	Perfectly clear	Clear	None
180	10	11	0.91	Clear	Barely visible	No individual particles
380	25	10	2.50	Slightly dark	Moderately dark	Some discernable particles

Dispersibilty

Sketch of Hole After Test



Diameter of Hole After Test: 1.5 mm

Dispersion Category: ND3

Originator	Checked & Approved	Determination of Dispersibility by Pinhole Method	TTK
OL	LS 31/10/07	BS1377: Part 5: 1990 Clause 6	Figure S23

Derwentside Environmental Testing Services

UKAS TESTING

2139

Certificate of Analysis

Date: 21/03/2007

Certificate Number: 07-10345

Client:	IGSL Ltd Industrial Estate Newbridge Co. Kildare
Our Reference:	07-10345
Client Reference:	M677
Contract Title:	Tarbert / Ballyloncford Embankment - Pond S.I.
Description:	7 soil samples
Date Received:	12/03/2007
Date Started:	12/03/2007
Date Completed:	21/03/2007
Test Procedures:	Identified by prefix DETSn, details available upon request.
Notes:	Observations and interpretations are outside the scope of UKAS accreditation * denotes test not included in laboratory scope of accreditation $ denotes tests completed by approved subcontractors I/S denotes insufficient sample to carry out test N/S denotes that the sample is not suitable for testing Solid samples will be disposed 1 month and liquids 2 weeks after the date of issue of this test certificate
Approved By:	
Authorised Signatories:	Rob Brown Business Manager

Derwentside Environmental Testing Services Limited
Unit 2, Park Road Industrial Estate South, Consett, Co Durham. DH8 5PY
Tel: 01207 582333 • Fax: 01207 582444 • Email: info@dets.co.uk • www.dets.co.uk
Registered in England No. 370 5645 • VAT No. 708 978 678

Summary of Chemical Analysis
Soil Samples

Our Ref: 07-10345

Client Ref: M677

Contract Title: Tarbert / Ballyloncford Embankment - Pond S.I.

		Lab No.	69610	69611	69612	69613	69614
		Sample Ref	TPA1A	TPA3	TPA5	TPA5	TPA7
		Depth	1.50	0.50	0.50	2.50	2.50
		Other Ref	A07/0290	A07/0296	A07/0299	A07/0300	A07/0303
		Sample Type					
Test	**Units**	**DETSxx**					
Chloride	g/l	DETS 055	0.04	0.02	0.05	0.03	0.02
Sulphate Aqueous Extract as SO4	g/l	DETS 076	0.01	0.09	0.01	0.01	< 0.01
pH		DETS 008	8.1	8.2	8.7	8.9	8.1

Summary of Chemical Analysis
Soil Samples

Our Ref: 07-10345
Client Ref: M677
Contract Title: Tarbert / Ballyloncford Embankment - Pond S.I.

Test	Units			
		Lab No.	69615	69616
		Sample Ref	TPA8	TPA1A
		Depth	2.50	3.50
		Other Ref	A07/0306	A07/0292
		Sample Type		
Test	**Units**	**DETSxx**		
Chloride	g/l	DETS 055	0.02	0.01
Sulphate Aqueous Extract as SO4	g/l	DETS 076	< 0.01	< 0.01
pH		DETS 008	8.0	8.7

Appendix G - Embankment – Pond SI Site Location Maps

Exploratory Hole Location Plan
– provided by the Engineer Drawing SK – 049A

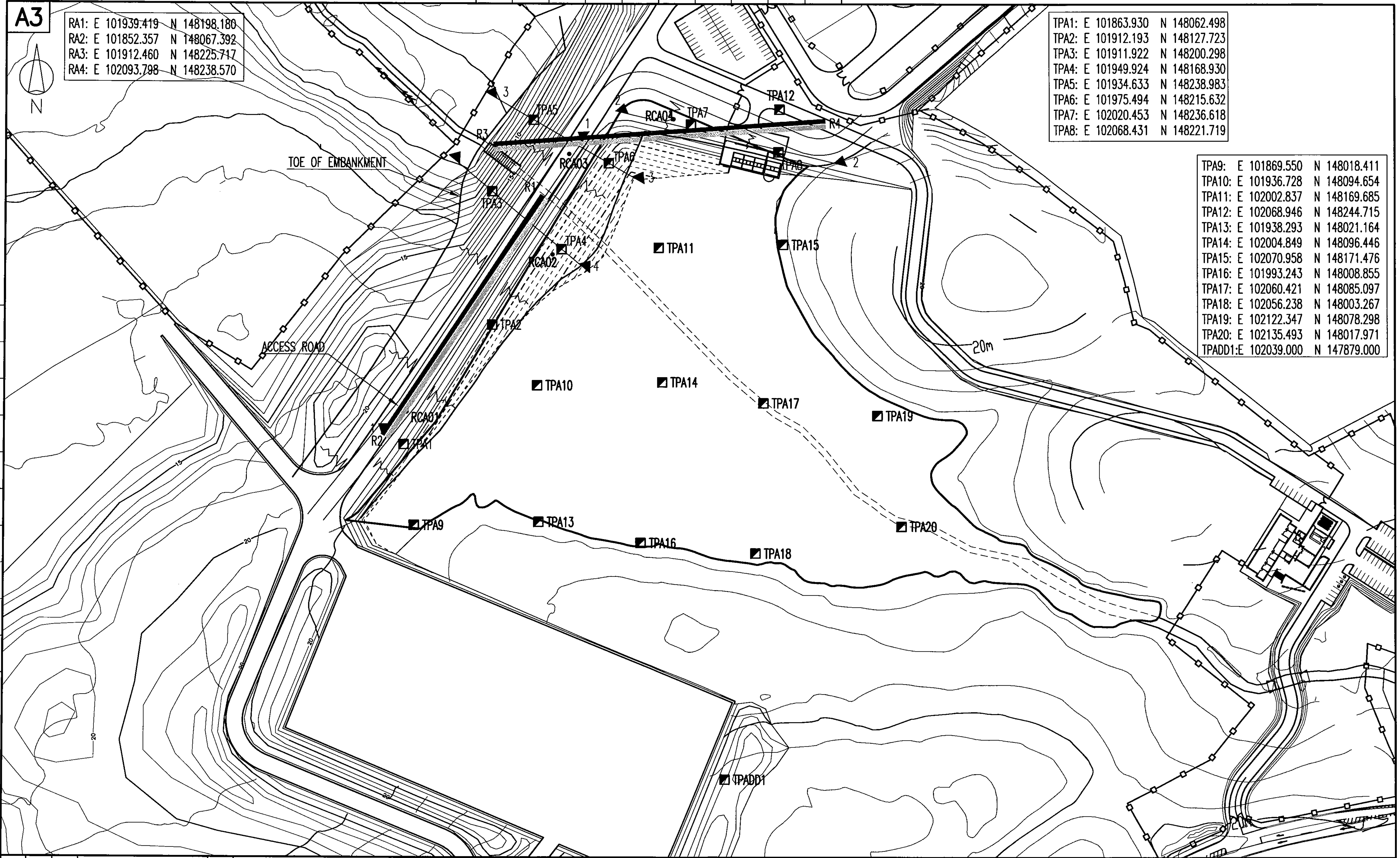
10cm - SCALE WITH CAUTION AS DISTORTION CAN OCCUR

A3

RA1:	E 101939.419	N 148198.180
RA2:	E 101852.357	N 148067.392
RA3:	E 101912.460	N 148225.717
RA4:	E 102093.798	N 148238.570

TPA1:	E 101863.930	N 148062.498
TPA2:	E 101912.193	N 148127.723
TPA3:	E 101911.922	N 148200.298
TPA4:	E 101949.924	N 148168.930
TPA5:	E 101934.633	N 148238.983
TPA6:	E 101975.494	N 148215.632
TPA7:	E 102020.453	N 148236.618
TPA8:	E 102068.431	N 148221.719

TPA9:	E 101869.550	N 148018.411
TPA10:	E 101936.728	N 148094.654
TPA11:	E 102002.837	N 148169.685
TPA12:	E 102068.946	N 148244.715
TPA13:	E 101938.293	N 148021.164
TPA14:	E 102004.849	N 148096.446
TPA15:	E 102070.958	N 148171.476
TPA16:	E 101993.243	N 148008.855
TPA17:	E 102060.421	N 148085.097
TPA18:	E 102056.238	N 148003.267
TPA19:	E 102122.347	N 148078.298
TPA20:	E 102135.493	N 148017.971
TPADD1:	E 102039.000	N 147879.000



1. COORDINATES SHOWN ARE TO IRISH NATIONAL GRID.
2. FOR DETAILS OF MARINE/LAND ELEVATION TABLE REFER TO DWG. NO. SK-019.

2D RESISTIVITY

SEISMIC REFRACTION

Rev.	Date	By	Description	Chd By
P5	25.05.07	EG	ISSUED FOR INFORMATION	
P4	16.04.07	EG	ISSUED FOR INFORMATION	
P3	03.04.07	EG	ISSUED FOR INFORMATION	
P2	02.04.07	EG	ISSUED FOR INFORMATION	
P1	12.02.07	EG	ISSUED FOR INFORMATION	

Job Title
SHANNON LNG LTD.:
SHANNON LNG TERMINAL

Shannon LNG

Drawing Title
TRIAL PIT AND GEOPHYSICS SURVEY LOCATIONS FOR THE PROPOSED DAM

Drawing Status
PRELIMINARY

ARUP
15 Oliver Plunkett Street Cork
Tel 021-4277670 Fax 021-4272345
EMail cork@arup.com
DUBLIN CORK LIMERICK

Scales 1:2000 @ A3
Originator EG
Checked
Approved
Date 11.02.07

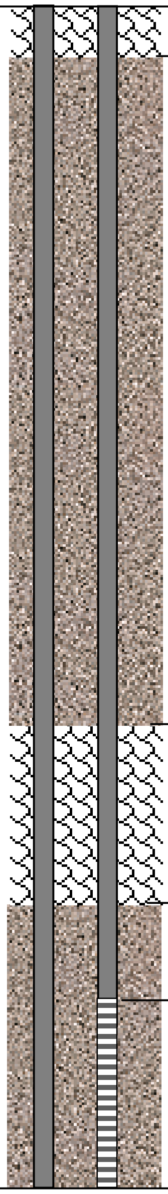
Job No. C1676.10
Drawing No. SK-049A
Rev. P5

Appendix H - Embankment – Pond SI Groundwater Monitoring Installation Details

National Irish Grid Co-Ordinates & Elevation		BH Type & No.	RC-A1
Location (x, y)	101865E 148080N	Page Number	Page 1 of 2
Ground Level (z)	13.91mOD Malin	Total Depth (m)	16.7m
Upstand(s)	P1 = 14.22mOD P2 = 14.18mOD	Date drilled: Logged by: Date drawn:	18/04/2007 IGSL 30/11/2007 (OM)
		Drilling by: Drilling Equipment:	Millenium Drilling Rotary Core
		Hole OD:	78mm (3")

Borehole Design & Completion
(Minerex (AC) 22/11/07)

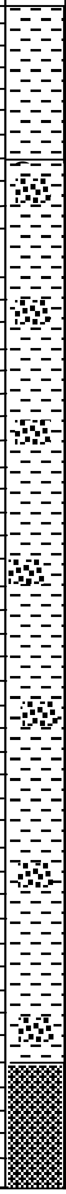
P1 P2



Soil/Water Sample No.	Depth Interval	Groundwater occurrence	Depth (m)
	7.69 (Open Hole)	▼	

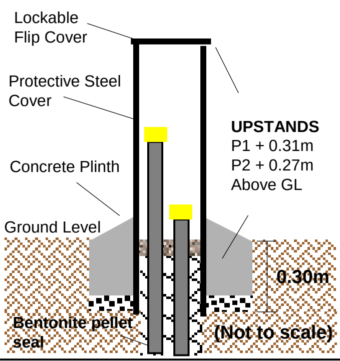
Depth (m): 1.0, 1.4, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0

Geology - graphical log



Description (IGSL 18/04/07)	Interpretation/ Comments
Observed by Driller as: **CLAY** *(Log supplied by IGSL)*	Topsoil Aquitard
Observed by Driller as: Gravelly **CLAY** *(Log supplied by IGSL)*	Aquitard

Well Head Completion



Legend

- Phreatic Water Table
- Water inflow
- 27mm OD/18mm ID (3/4") uPVC Slotted casing
- 27mm OD/18mm ID (3/4") uPVC casing
- Gravel pack, nominal 2-5mm in diameter (Siliciclastic – Neutral pH)
- Bentonite seal

Title	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry
Client	Arup Consulting Engineers
MEL Document No.	1946-024 (Figure H1, 1 of 2)

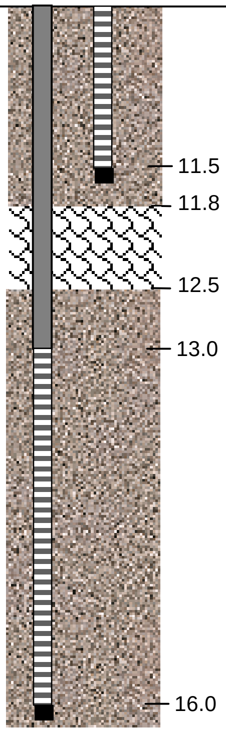
Minerex Environmental Limited

National Irish Grid Co-Ordinates & Elevation	
Location (x, y)	101865E 148080N
Ground Level (z)	13.91mOD Malin
Upstand(s) (z)	P1 = 14.22mOD P2 = 14.18mOD

BH Type & No.	RC-A1
Page Number	Page 2 of 2
Total Depth (m)	16.7m
Date drilled: Logged by: Date drawn:	18/04/2007 IGSL 30/11/2007 (OM)
Drilled by: Drilling Equipment:	Millenium Drilling Rotary Core
Hole OD:	78mm (3”)

Borehole Design & Completion
(Minerex (AC) 22/11/07)

P1 P2

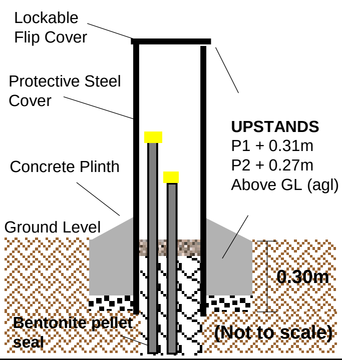


EOH = 16.16m

Soil/Water Sample No.	Depth Interval	Groundwater occurrence	Depth (m)	Geology - graphical log	Description (IGSL 18/04/07)	Interpretation/ Comments
			11.0 – 16.7		**SILTSTONE**, moderately strong to locally strong and locally moderately weak, thinly bedded (laminations within), dark grey to black and locally grey, fine grained, SILTSTONE with interbedded shale. Fresh to slightly and locally moderately weathered. *(Log supplied by IGSL)*	Aquitard
			16.7		EOH = 16.7m	

Depth scale (m): 11.0, 12.0, 13.0, 14.0, 15.0, 16.0, 16.7, 17.0, 18.0, 19.0, 20.0

Well Head Completion



Legend

- Phreatic Water Table
- Water inflow
- 27mm OD/18mm ID (3/4”) uPVC Slotted casing
- 27mm OD/18mm ID (3/4”) uPVC casing
- Gravel pack, nominal 2-5mm in diameter (Siliciclastic – Neutral pH)
- Bentonite seal

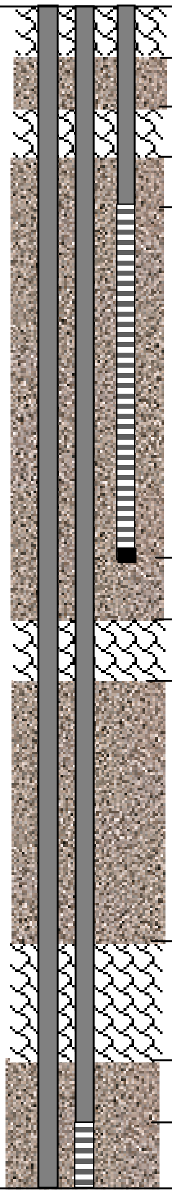
Title	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry
Client	Arup Consulting Engineers
MEL Document No.	1946-024 (Figure H1, 2 of 2)

Minerex Environmental Limited

National Irish Grid Co-Ordinates & Elevation		BH Type & No.	RC-A2
Location (x, y)	101945E 148166N	Page Number	Page 1 of 2
Ground Level (z)	7.08mOD Malin	Total Depth (m)	19.9m
Upstand(s)	P1 = 7.36mOD P2 = 7.32mOD P3 = 7.29mOD	Date drilled: Logged by: Date drawn:	16-18/04/2007 IGSL 03/12/2007 (OM)
		Drilled by: Drilling Equipment:	Millenium Drilling Rotary Core
		Hole ID:	78mm (3")

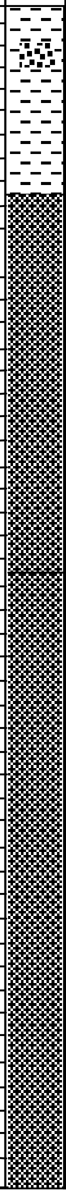
Borehole Design & Completion
(Minerex (AC) 22/11/07)

P1 P2 P3

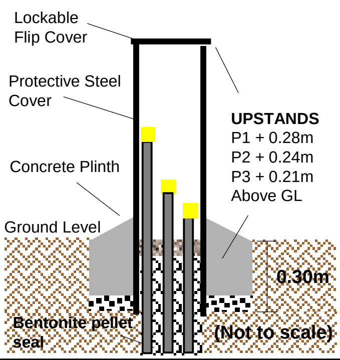


Soil/Water Sample No.	Depth Interval	Groundwater occurrence	Depth (m)	Geology - graphical log	Description (IGSL 16-18/04/07)	Interpretation/ Comments
			0.0 – 1.7		Observed by Driller as: Gravelly **CLAY** *(Log supplied by IGSL)*	Topsoil / Aquitard
			1.7 – 4.9		Strong to moderately strong, thinly bedded, grey to locally dark grey, fine to medium grained, **SILTSTONE**. Fresh to slightly and locally moderately weathered. *(Log supplied by IGSL)*	Aquitard
			4.9 – 10.0		Strong to moderately strong, medium to thinly bedded (cross bedded laminations), dark grey to black, fine to locally medium (6.3m – 6.9m) grained, **SILTSTONE** with interbedded grey sandstone. Fresh to locally slightly weathered (hairline fractures throughout 0.5cm – 1cm apart). *(Log supplied by IGSL)*	Aquitard

Depth scale (m): 1.0, 1.7, 2.0, 3.0, 4.0, 4.9, 6.0, 7.0, 8.0, 9.0, 10.0



Well Head Completion



Legend

- Phreatic Water Table
- Water inflow
- 27mm OD/18mm ID (3/4") uPVC Slotted casing
- 27mm OD/18mm ID (3/4") uPVC casing
- Gravel pack, nominal 2-5mm in diameter (Siliciclastic – Neutral pH)
- Bentonite seal

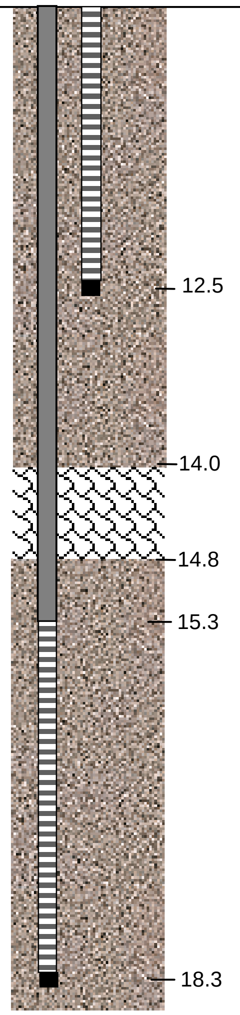
Title	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry
Client	Arup Consulting Engineers
MEL Document No.	1946-024 (Figure H2, 1 of 2)

Minerex Environmental Limited

National Irish Grid Co-Ordinates & Elevation	
Location (x, y)	101945E 148166N
Ground Level (z)	7.08mOD Malin
Upstand(s) (z)	P1 = 7.36mOD P2 = 7.32mOD P3 = 7.29mOD

BH Type & No.	RC-A2
Page Number	Page 2 of 2
Total Depth (m)	19.9m
Date drilled: Logged by: Date drawn:	16-18/04/2007 IGSL 03/12/2007 (OM)
Drilled by: Drilling Equipment:	Millenium Drilling Rotary Core
Hole ID:	78mm (3")

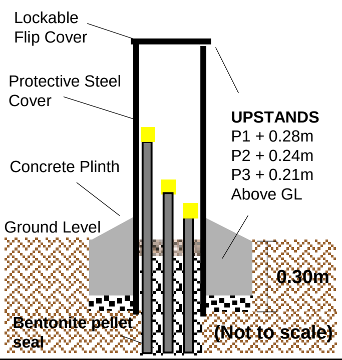
Borehole Design & Completion
(Minerex (AC) 22/11/07)



EOH = 18.6m

Soil/Water Sample No.	Soil/Water Sample Depth Interval	Groundwater occurrence	Depth (m)	Geology - graphical log	Description (IGSL 16-18/04/07)	Interpretation/ Comments
			11.0 – 20.0 (16.7)		Strong to moderately strong, medium to thinly bedded (cross bedded laminations), dark grey to black, fine to locally medium (6.3m – 6.9m) grained, **SILTSTONE** with interbedded grey sandstone. Fresh to locally slightly weathered (hairline fractures throughout 0.5cm – 1cm apart). *(continuted)* *(Log supplied by IGSL)* EOH = 19.9m	Aquitard

Well Head Completion



Legend

- Phreatic Water Table
- Water inflow
- 27mm OD/18mm ID (3/4") uPVC Slotted casing
- 27mm OD/18mm ID (3/4") uPVC casing
- Gravel pack, nominal 2-5mm in diameter (Siliciclastic – Neutral pH)
- Bentonite seal

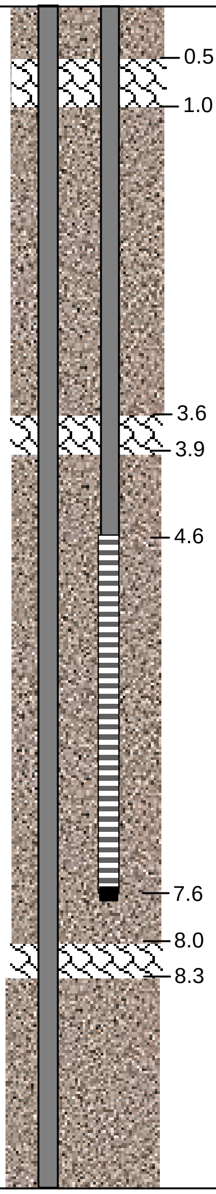
Title	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry
Client	Arup Consulting Engineers
MEL Document No.	1946-024 (Figure H2, 2 of 2)

Minerex Environmental Limited

National Irish Grid Co-Ordinates & Elevation	
Location (x, y)	101954E 148221N
Ground Level (z)	6.38mOD Malin
Upstand(s)	P1 = 6.65mOD P2 = 6.61mOD

BH Type & No.	RC-A3
Page Number	Page 1 of 2
Total Depth (m)	18.1m
Date drilled: Logged by: Date drawn:	19-20/04/2007 IGSL 03/12/2007 (OM)
Drilled by: Drilling Equipment:	Millenium Drilling Rotary Core
Hole OD:	78mm (3")

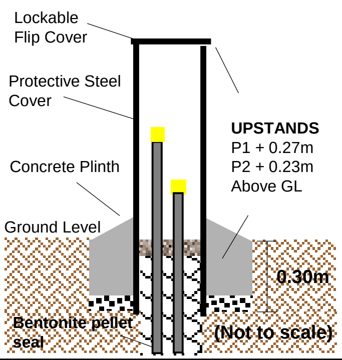
Borehole Design & Completion
(Minerex (AC) 21/11/07)



Soil/Water Sample No.	Soil/Water Sample Depth Interval	Groundwater occurrence	Depth (m)	Description (IGSL 19-20/04/07)	Interpretation/ Comments
	0.48 (Open Hole)	Phreatic water table at 0.48	0.0 – 4.6	Observed by Driller as: Gravelly **CLAY** *(Log supplied by IGSL)*	Aquitard
			4.6 – 8.7	Very strong to strong, medium to thinly bedded, grey, fine to medium grained **SILTSTONE**. Freshly weathered. *(Log supplied by IGSL)*	Aquitard
			8.7 – 10.0		

Depth (m) scale: 1.0, 2.0, 3.0, 4.0, 4.6, 4.9, 6.0, 7.0, 8.0, 8.7, 9.0, 10.0

Well Head Completion



Legend

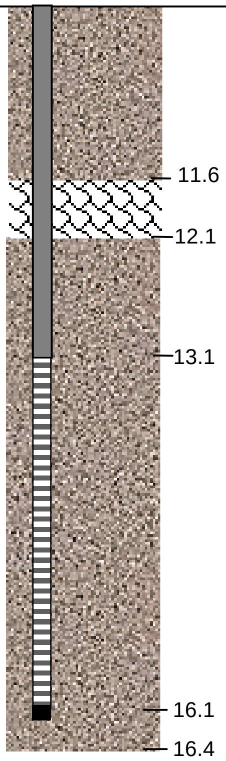
- Phreatic Water Table
- Water inflow
- 27mm OD/18mm ID (3/4") uPVC Slotted casing
- 27mm OD/18mm ID (3/4") uPVC casing
- Gravel pack, nominal 2-5mm in diameter (Siliciclastic – Neutral pH)
- Bentonite seal

Title	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry
Client	Arup Consulting Engineers
MEL Document No.	1946-024 (Figure H3, 1 of 2)

Minerex Environmental Limited

National Irish Grid Co-Ordinates & Elevation		Soil/Water Sample		Groundwater occurrence	Depth (m)	Geology - graphical log	BH Type & No.	RC-A3
Location (x, y)	101954E 148221N						Page Number	Page 2 of 2
Ground Level (z)	6.38mOD Malin						Total Depth (m)	18.1m
Upstand(s) (z)	P1 = 6.65mOD P2 = 6.61mOD						Date drilled: Logged by: Date drawn:	19-20/04/2007 IGSL 03/12/2007 (OM)
Borehole Design & Completion (Minerex (AC) 21/11/07)		No.	Depth Interval				Drilled by: Drilling Equipment:	Millenium Drilling Rotary Core
							Hole OD:	78mm (3”)

P1

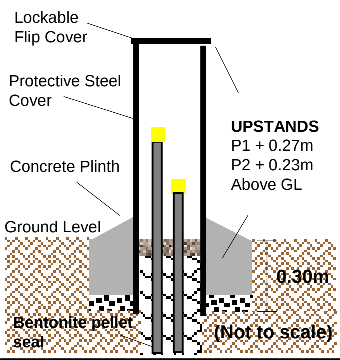


EOH = 16.4m

Depth (m): 11.0, 12.0, 13.0, 14.0, 15.0, 16.0, 17.0, 18.0, 19.0, 20.0

Description (IGSL 19-20/04/07)	Interpretation/ Comments
Strong to locally very strong (10.9m – 11.4m) and locally moderately strong, medium to thinly (cross laminated) bedded, grey, dark grey and black, fine to locally medium grained **SILTSTONE** with interbedded shale. Freshly weathered. *(continued)* *(Log supplied by IGSL)*	Aquitard
EOH = 18.1m	

Well Head Completion



Legend

- Phreatic Water Table
- Water inflow
- 27mm OD/18mm ID (3/4”) uPVC Slotted casing
- 27mm OD/18mm ID (3/4”) uPVC casing
- Gravel pack, nominal 2-5mm in diameter (Siliciclastic – Neutral pH)
- Bentonite seal

Title	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry
Client	Arup Consulting Engineers
MEL Document No.	1946-024 (Figure H3, 2 of 2)

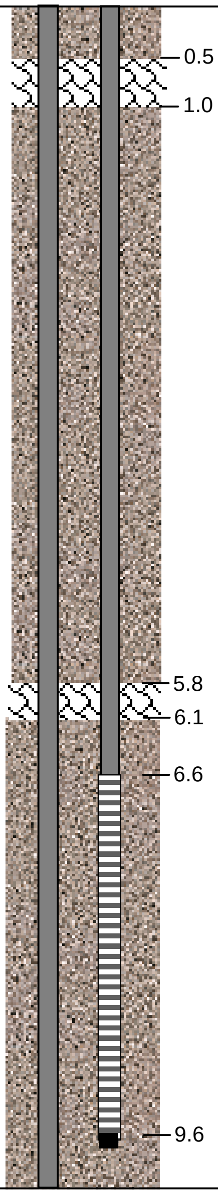
Minerex Environmental Limited

National Irish Grid Co-Ordinates & Elevation	
Location (x, y)	102011E 148239N
Ground Level (z)	11.69mOD Malin
Upstand(s)	P1 = 12.01mOD P2 = 11.96mOD

BH Type & No.	RC-A4
Page Number	Page 1 of 2
Total Depth (m)	16.9
Date drilled: Logged by: Date drawn:	21/04/2007 IGSL 03/12/2007 (OM)
Drilled by: Drilling Equipment:	Millenium Drilling Rotary Core
Hole OD:	78mm (3")

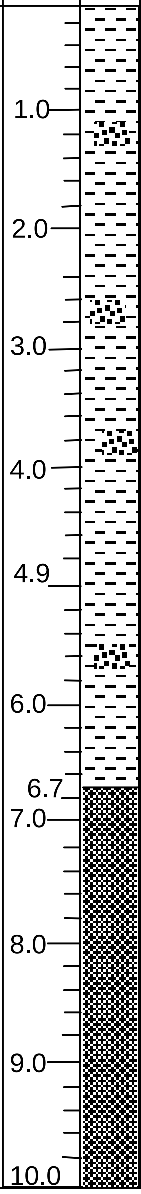
Borehole Design & Completion
(Minerex (AC) 21/11/07)

P1 P2

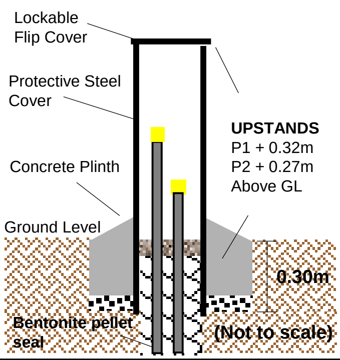


Soil/Water Sample No.	Soil/Water Sample Depth Interval	Groundwater occurrence	Depth (m)	Description (IGSL 21/04/07)	Interpretation/ Comments
			0 – 6.7	Observed by Driller as: Gravelly **CLAY** *(Log supplied by IGSL)*	Aquitard
	5.89 (Open Hole)	▼ (Phreatic Water Table)			
			6.7 –	Strong to moderately strong, thinly (cross laminated) bedded, grey, dark grey and black, fine to coarse grained **SILTSTONE** with interbedded fine grained shale. Freshly to locally slightly / moderately weathered. *(Log supplied by IGSL)*	Aquitard

Geology - graphical log



Well Head Completion



Legend

- Phreatic Water Table
- Water inflow
- 27mm OD/18mm ID (3/4") uPVC Slotted casing
- 27mm OD/18mm ID (3/4") uPVC casing
- Gravel pack, nominal 2-5mm in diameter (Siliciclastic – Neutral pH)
- Bentonite seal

Title	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry
Client	Arup Consulting Engineers
MEL Document No.	1946-024 (Figure H4, 1 of 2)

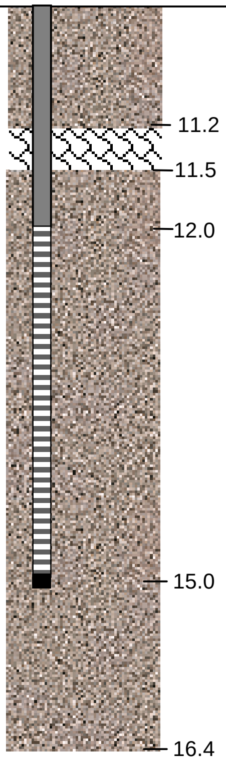
Minerex Environmental Limited

National Irish Grid Co-Ordinates & Elevation	
Location (x, y)	102011E 148239N
Ground Level (z)	11.69mOD Malin
Upstand(s) (z)	P1 = 12.01mOD P2 = 11.96mOD

BH Type & No.	RC-A4
Page Number	Page 2 of 2
Total Depth (m)	16.9m
Date drilled: Logged by: Date drawn:	21/04/2007 IGSL 03/12/2007 (OM)
Drilled by: Drilling Equipment:	Millenium Drilling Rotary Core
Hole OD:	78mm (3”)

Borehole Design & Completion
(Minerex (AC) 21/11/07)

P1

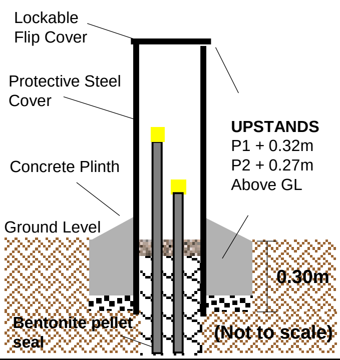


EOH = 16.4m

Soil/Water Sample No.	Depth Interval	Groundwater occurrence	Depth (m)	Geology - graphical log	Description (IGSL 21/04/07)	Interpretation/ Comments
			11.0 – 16.9		Strong to moderately strong, thinly (cross laminated) bedded, grey, dark grey and black, fine to coarse grained **SILTSTONE** with interbedded fine grained shale. Freshly to locally slightly / moderately weathered. *(continued)* *(Log supplied by IGSL)*	Aquitard
			17.0		EOH = 16.9m	

Depth scale (m): 11.0, 12.0, 13.0, 14.0, 15.0, 16.0, 17.0, 18.0, 19.0, 20.0

Well Head Completion



Legend

- Phreatic Water Table
- Water inflow
- 27mm OD/18mm ID (3/4”) uPVC Slotted casing
- 27mm OD/18mm ID (3/4”) uPVC casing
- Gravel pack, nominal 2-5mm in diameter (Siliciclastic – Neutral pH)
- Bentonite seal

Title	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry
Client	Arup Consulting Engineers
MEL Document No.	1946-024 (Figure H4, 2 of 2)

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GENERAL LEGEND, ABBREVIATIONS AND INSTALLATION DETAILS

BEDROCK

Metamorphic bedrock
Igneous bedrock
Sandstone bedrock
Siltstone bedrock
Mudstone bedrock
Limestone bedrock

COLOUR

Light Grey	Gy_l
Medium Grey	Gy_m
Dark Grey	Gy_d
Blue/grey	Bl-Gy
Orange/Brown	Or-Bn
Black	Bk

GRAIN SIZE (Soil)

Clay (% of)	C(20)
Silt (% of)	St(20)
Sand (% of)	Sd(20)
Gravel (% of)	G(20)
Sand (Fine to Medium)	Sd_{F-M}
Gravel (Fine to Coarse Subangular to angular)	$G_{F-C\ SA-A}$

MONITORING POINT COMPLETIONS

TS/C1/PH1	Terminal Site/Couple no./Phreatic no.
PR/C2/P2	Peat Repository/Couple no./Piezometer no.
H7	Von Post humification scale
	Push-on cap
	18mm ID / 27mm OD screen
	18mm ID / 27mm OD casing
	18mm ID / 27mm OD tip
	Drive cone
P2 PH1	Piezometer no. and Phreatic tube no.
	Bentonite pellets
	Gravel pack, nominal 2-5mm in diameter
	Wet and damp
	Static water table

PLAN SKETCHES

PWS1	Percussion Window Sampler (PWS) boreholes
TP1	Hand dug trial pits / Shallow pit excavations (JCB)
100 BG	FID in ppm Hydrocarbons with BG = background
99.791	Reduced levels - maOD Malin
	Oil pipeline
	Storage tanks (Overground and underground)

OVERBURDEN (Description uses BS 5930 and GSI guidelines)

BOULDER(S) (>200mm)

COBBLES (60 to 200mm)

GRAVEL (Homogeneous larger sized particles from 2 to 60 mm)

SAND (General, if without grain size description) Particle sizes: 2 to 0.06mm. Three sub-categories distinguishable to the eye)

Coarse **SAND** (2-0.6mm)

Medium **SAND** (0.6-0.2mm)

Fine **SAND** (0.2-0.06mm)

SILT (0.06 - 0.002mm)

CLAYS (<0.002mm)

CONCRETE

CRUSHED STONE or AGGREGATE or TARMACADAM

LANDFILL (eg plastic, glass, wood, domestic waste, concrete etc.)

FILL (unspecified)

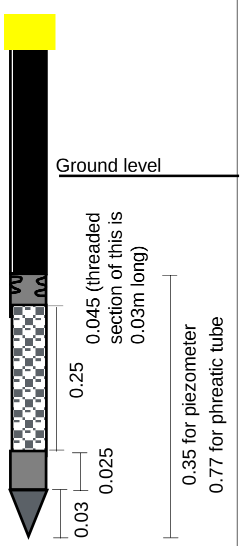
COLLAPSED FORMATION (with possible voids)

LOSS (Blank - white)

TOP SOIL

PEAT (General) (with descriptions such as colour, plant remains evident, distinct H_2S smell etc) (H (Von Post) value associated commonly)

MONITORING POINT DESIGN FOR PEAT SUBSOILS



Push-on, female cap

The cap is loosely fitted to allow easy removal. The piezometer is labelled using indellible ink inside and outside the cap. A small hole is drilled in the side to enable air movement in and out of the piezometer.

Casing up-stand

The upstand is the height of the casing above ground level in meters. The height depends on local groundwater and surface water circumstances. The piezometer number is scrapped onto the side of the casing near the cap as with time the writing on the cap wears off. Upstands vary from 0.3 to 1.0m in height. The convention is allow a higher upstand for those piezometers positioned at a higher level.

Casing

The casing is black or dark grey coloured, flush-threaded, uPVC. The OD is 26.80mm and the ID is 18.40. The casing is flush-threaded to the piezometer tip.

Tube or Piezometer tip

This section is installed opposite the required formation. There are two sections to the piezometer tip. The inner tube section is 18.40mm ID, white in colour and involves extruded microporous polyethylene. The outer comprises grey or black coloured uPVC with 10 x 0.013m diameter holes per 0.10m of piezometer tip. Therefore the surface area exposed to the formation (peat) is small. The piezometer tube tip is flush-threaded, either male or female, to the piezometer casing. Threaded part is 0.03m long. The phreatic tube tip is longer than the piezometer tube tip to allow for greater water level fluctuations.

Drive cone

This is grey coloured, solid, uPVC, pushed or screwed into the tube or piezometer tip. No glue has been used. If the ground is soft, a push-in button cap may be used instead of a drive cone.

NOTES:-

The phreatic tubes are pushed by hand into the peat. The piezometers are pushed or driven into the peat and mineral soil after a narrow diameter hole has been formed using overburden drilling (Cobra or Percussion Window Sampler) / coring equipment (Gouge corer). The tubes and piezometers have three main functions: water table measurements, water sampling, permeability measurements

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Appendix I - Embankment – Pond SI Groundwater Levels

Non-variable Monitoring Data								Variable Monitoring Results					
			Monitoring point type	HYDRO- / GEO UNIT Monitored	HABITATS & DESIGNATION			Date	Time	Water levels			Comments
Monitoring point ID	Easting Differential / Hand-held GPS (For Mapinfo Use)	Northing Differential / Hand-held GPS (For Mapinfo Use)			Habitat Monitored	Fossitt Habitat Code	Designation (SAC, NHA, SAC & NHA, None)			Ref mOD (top of Plastic Casing / top of SG)	WL mbRef	WL mOD (Malin)	
RC-A1-P1	101865.440	148080.150	Piezometer	BEDROCK	Spoil or Bare Ground - Area cleared by local farmer 2007	ED2	None	23/11/07		14.22	7.82	6.40	Installed 22/11/07
RC-A1-P1	101865.440	148080.150	Piezometer	BEDROCK	Spoil or Bare Ground - Area cleared by local farmer 2007	ED2	None	11/12/07	16:05	14.22	7.21	7.01	Purging not carried out - Water level too low.
RC-A1-P2	101865.440	148080.150	Piezometer	BEDROCK	Spoil or Bare Ground - Area cleared by local farmer 2007	ED2	None	23/11/07		14.18	7.80	6.38	Installed 22/11/07
RC-A1-P2	101865.440	148080.150	Piezometer	BEDROCK	Spoil or Bare Ground - Area cleared by local farmer 2007	ED2	None	11/12/07	16:05	14.18	7.18	7.00	Purging not carried out - Water level too low.
RC-A2-P1	101945.000	148166.000	Piezometer	BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	23/11/07		7.36	1.08	6.28	Installed 22/11/07
RC-A2-P1	101945.000	148166.000	Piezometer	BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	11/12/07	16:20	7.36	0.47	6.89	Purged 5 litres.
RC-A2-P2	101945.000	148166.000	Piezometer	BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	23/11/07		7.32	1.07	6.25	Installed 22/11/07
RC-A2-P2	101945.000	148166.000	Piezometer	BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	11/12/07	16:21	7.32	0.43	6.89	Purged 5 litres.
RC-A2-P3	101945.000	148166.000	Piezometer	BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	23/11/07		7.29	1.04	6.25	Installed 22/11/07
RC-A2-P3	101945.000	148166.000	Piezometer	BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	11/12/07	16:22	7.29	0.47	6.82	Purged 5 litres.
RC-A3-P1	101953.980	148220.510	Piezometer	BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	23/11/07		6.65	0.60	6.05	Installed 21/11/07
RC-A3-P1	101953.980	148220.510	Piezometer	BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	11/12/07	14:16	6.65	0.00	6.65	Artesian upwelling.
RC-A3-P2	101953.980	148220.510	Piezometer	BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	23/11/07		6.61	0.57	6.04	Installed 21/11/07
RC-A3-P2	101953.980	148220.510	Piezometer	BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	11/12/07	14:17	6.61	0.00	6.61	Artesian upwelling.
RC-A4-P1	102010.830	148239.450	Piezometer	BEDROCK	Improved Agricultural Grassland	GA1	None	23/11/07		12.01	6.15	5.86	Installed 21/11/07
RC-A4-P1	102010.830	148239.450	Piezometer	BEDROCK	Improved Agricultural Grassland	GA1	None	11/12/07	13:06	12.01	4.78	7.23	Purged 5 litres.
RC-A4-P2	102010.830	148239.450	Piezometer	BEDROCK	Improved Agricultural Grassland	GA1	None	23/11/07		11.96	5.96	6.00	Installed 21/11/07
RC-A4-P2	102010.830	148239.450	Piezometer	BEDROCK	Improved Agricultural Grassland	GA1	None	11/12/07	13:07	11.96	5.00	6.96	Purged 5 litres.

Addendum - Embankment – Pond SI Photographs

Trial Pits

Rotary Coreholes

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TP A1 Digging Face

TP A1 Digging face

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TP A4 Sidewall

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TP A5 Sidewall

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TP A5 Spoil

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TPA6 Digging Face

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TPA6 Digging Fce

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TPA6 Spoil

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TP A7 Sidewall

TPA7 Digging Face

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TPA7 Spoil

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TPA8 Spoil

TP A8 Sidewall

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TP A8 Digging Face

TP A9 Digging face 1

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TP A9 Digging face 2

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TP A9 Sidewall 1

TP A9 Sidewall 2

TP A10 Digging Face 1

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TP A10 Digging Face 2

TP A10 Side Wall

TP A10 Spoil

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TP A11 Digging Face 1

TP A11 Digging Face 2

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TP A11 Digging Face 3

TP A11 Spoil

TP A12 Digging Face 1

TP A12 Digging Face 2

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TP A12 Sidewall

TP A12 Spoil

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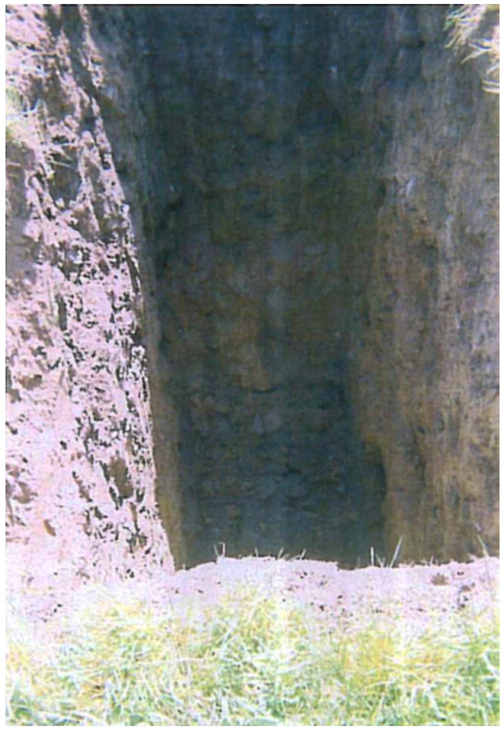

TP A13 Digging Face 1

TP A13 Digging Face 2

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TP A13 Side wall 1

TP A13 Spoil

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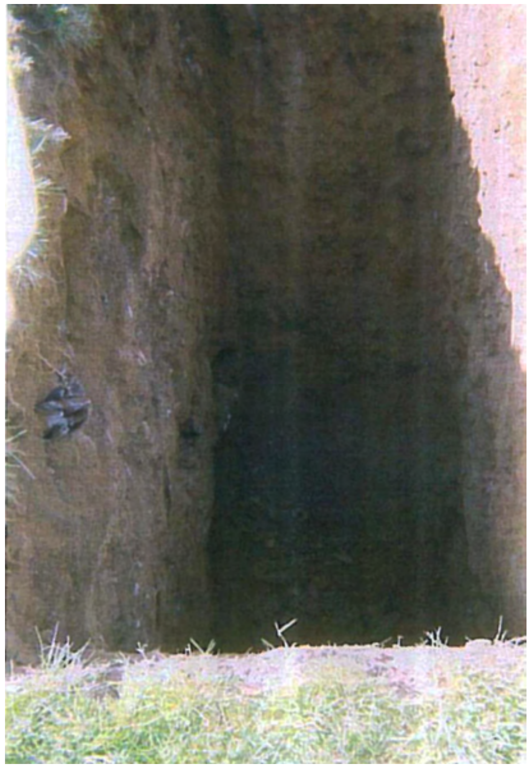

TP A14 Digging Face 1

TP A14 Digging Face 2

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TP A14 Sidewall

TP A14 Spoil

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TP A15 Digging Face 1

TP A15 Digging Face 2

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TP A15 Sidewall

TP A15 Spoil

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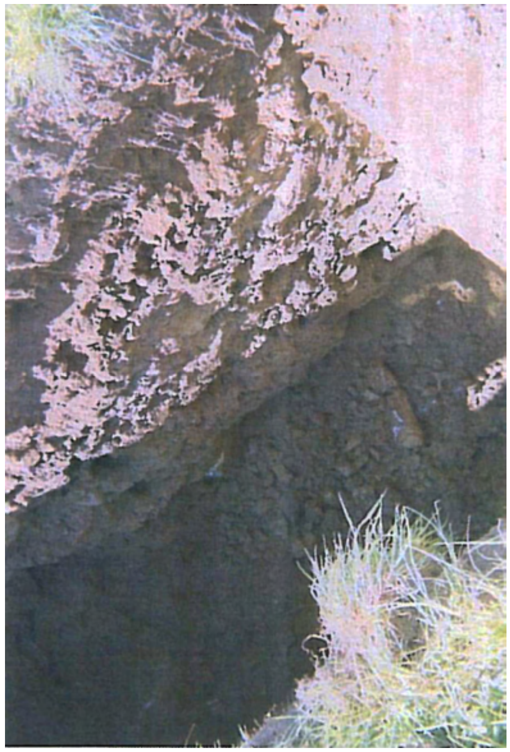
TP A16 Digging Face 1

TP A16 Digging Face 2



TP A16 Sidewall

TP A16 Spoil

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TP A17 Digging Face 1

TP A17 Digging Face 2

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TP A17 Spoil

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TP A18 Digging Face 1

TP A18 Digging Face 2

TP A18 Sidewall

TP A18 Spoil

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TP A19 Digging Face 1

TP A19 Digging Face 2

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TP A19 Digging Sidewall

TP A19 Spoil

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TP A20 Digging Face 1

TP A20 Digging Face 2

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TP A20 Sidewall

TP A20 Spoil

TP ADD1 Digging Face 1

TP ADD1 Digging Face 2

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TP ADD1 Sidewall

TP ADD1 Spoil

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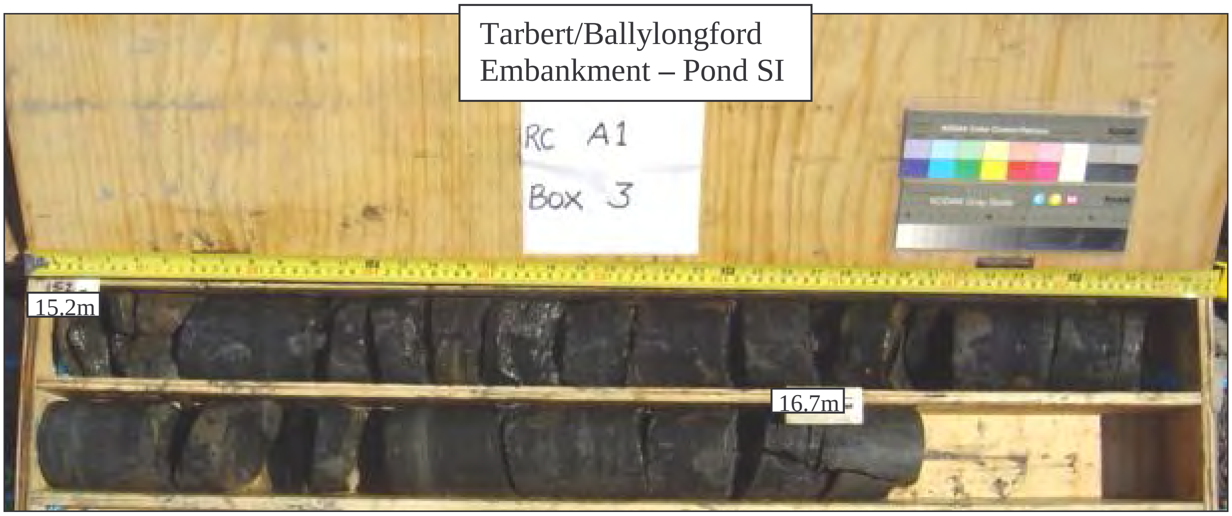
Embankment – Pond SI Rotary Corehole Photographs

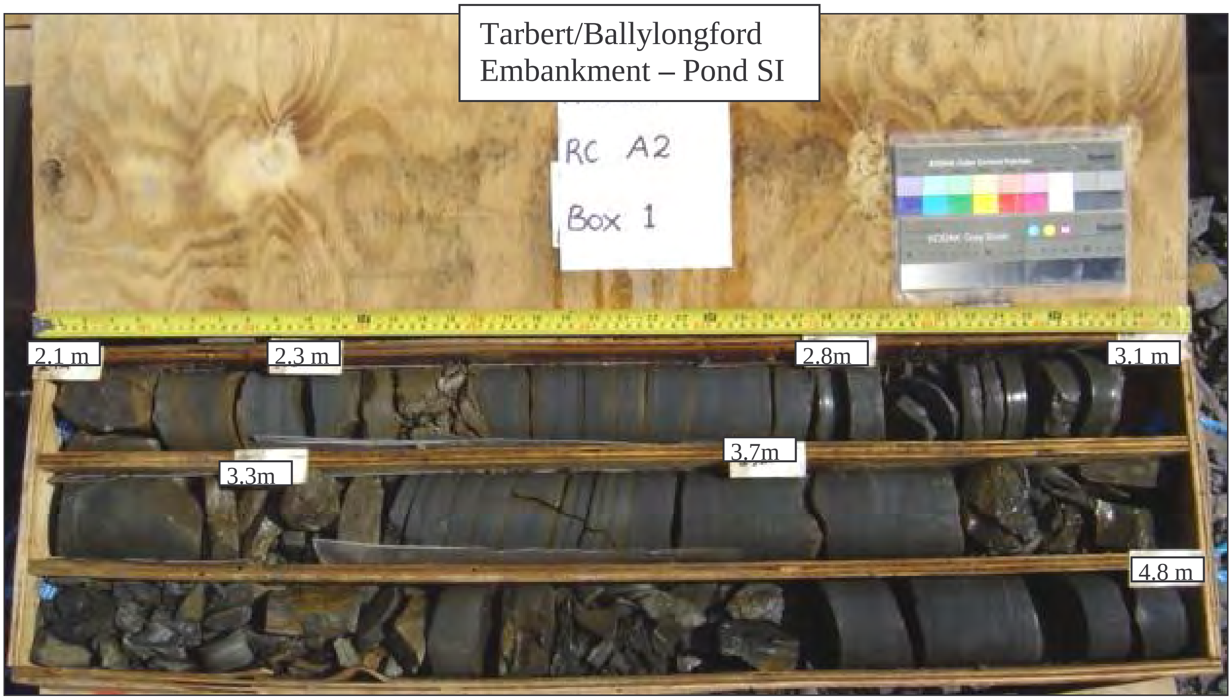
RC A1 box 1 of 3

RC A1 box 2 of 3

RC A1 box 3 of 3



RC A2 box 1 of 7



RC A2 box 2

RC A2 box 3 of 7

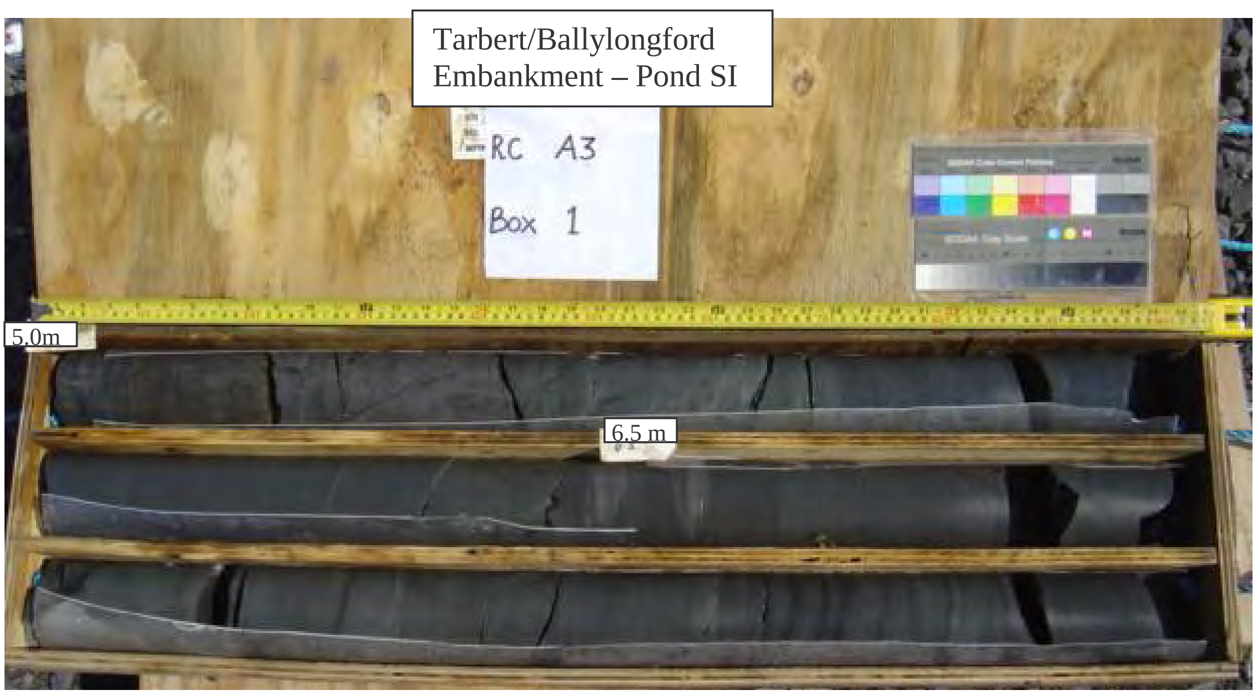
RC A2 box 4 of 7

RC A2 box 5 of 7

RC A2 box 6 of 7

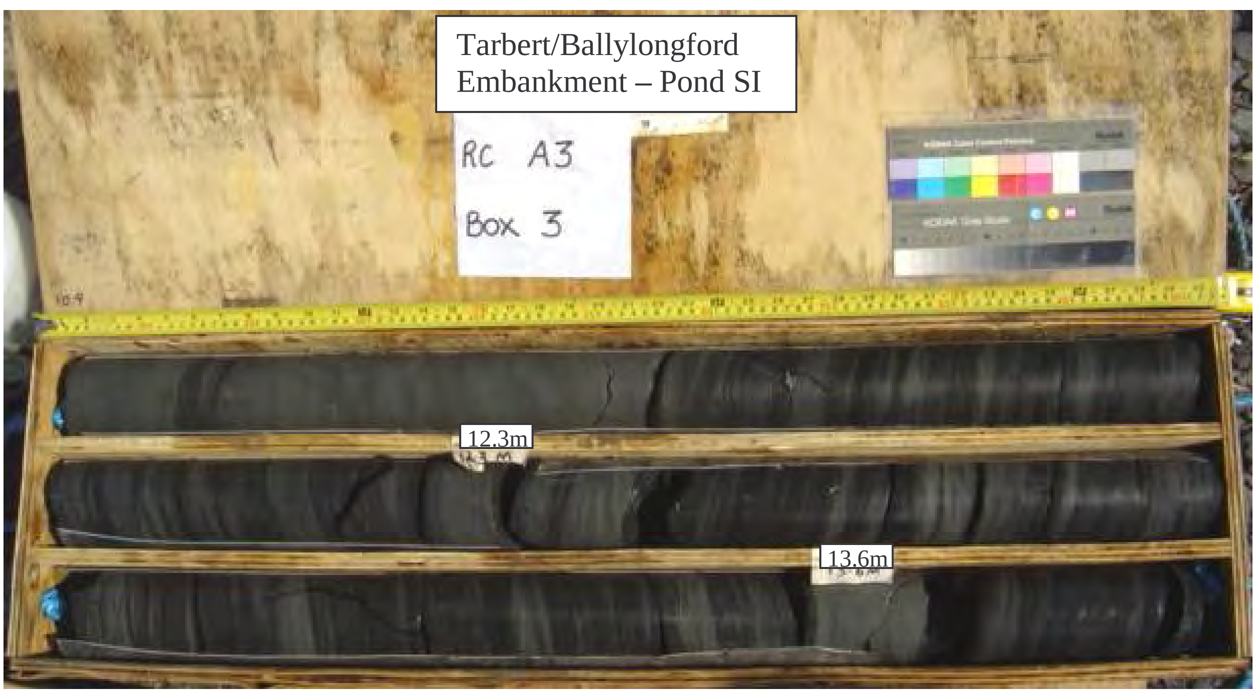
RC A2 box 7

RC A3 box 1 of 5



RC A3 box 2 of 5

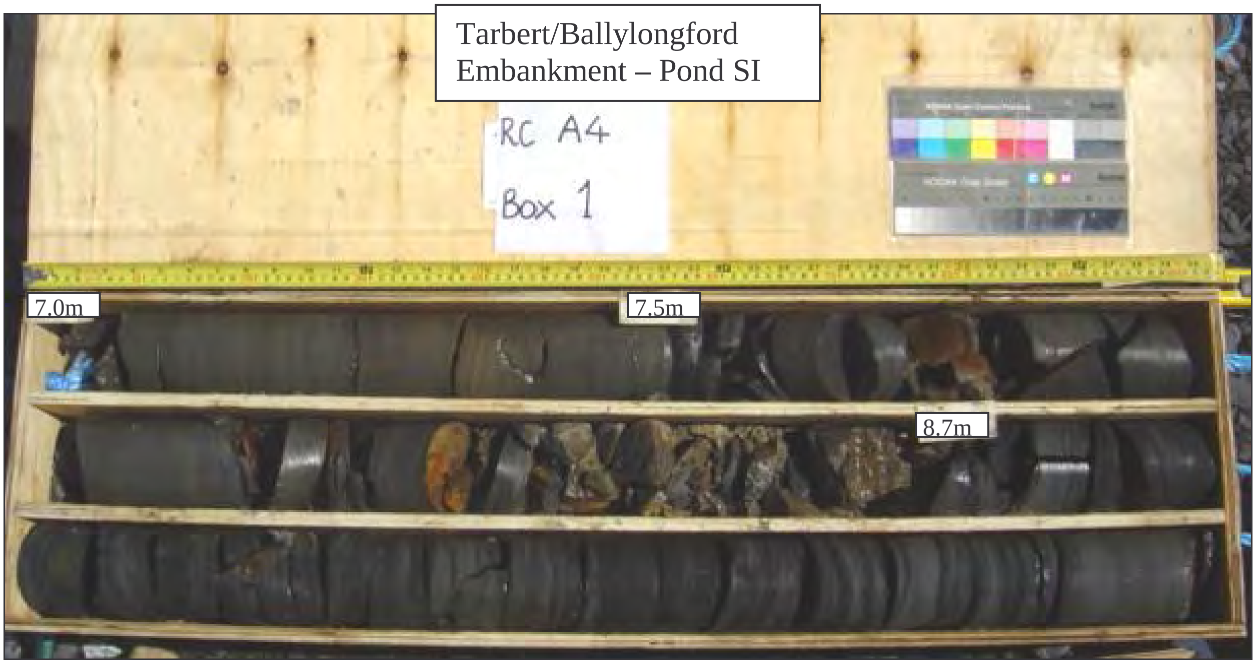
RC A3 box 3 of 5



RC A3 box 4 of 5

RC A3 box 5 of 5

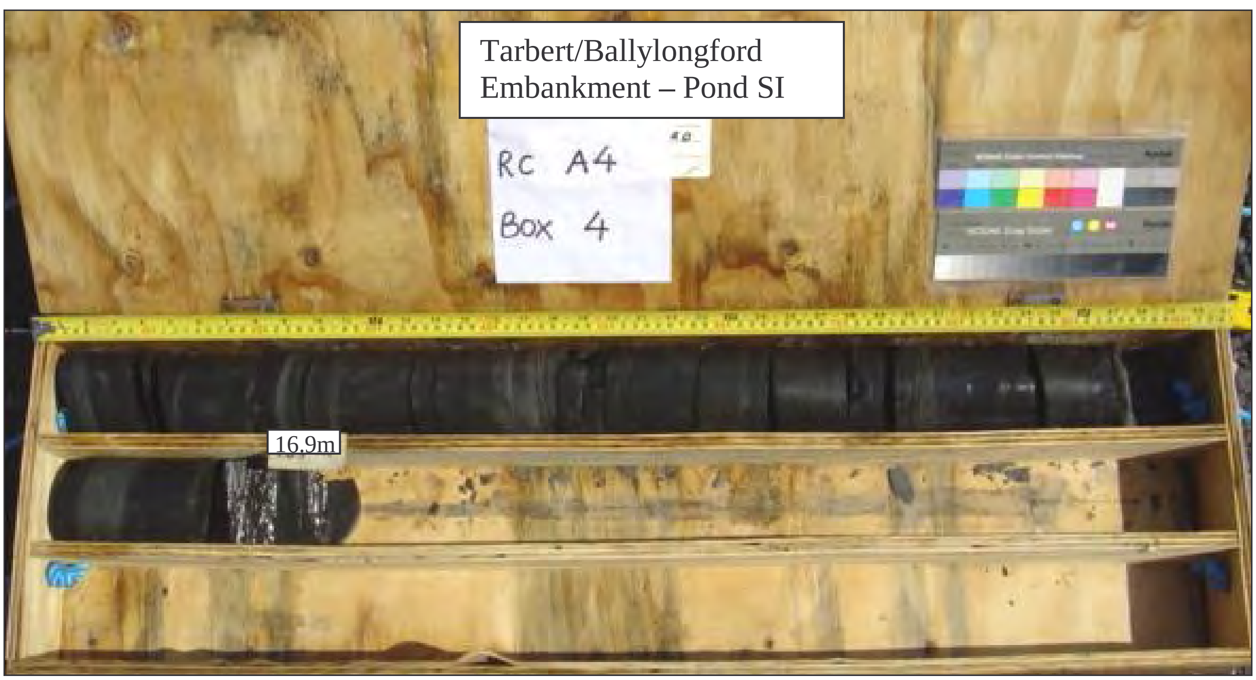
RC A4 box 1 of 4



RC A4 box 2 of 4

RC A4 box 3 of 4

RC A4 box 4 of 4



Appendix A - Main Onshore SI Geophysical Survey

APEX Geoservices Ltd.
Geophysical & Geological Consultants

REPORT

ON THE

GEOPHYSICAL SURVEY

FOR THE

TARBERT/BALLYLONGFORD MAIN ONSHORE SI

FOR

IRISH GEOTECHNICAL SERVICES LTD.

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PRIVATE AND CONFIDENTIAL

THE FINDINGS OF THIS REPORT ARE THE RESULT OF A GEOPHYSICAL SURVEY USING NON-INVASIVE SURVEY TECHNIQUES CARRIED OUT AT THE GROUND SURFACE. INTERPRETATIONS CONTAINED IN THIS REPORT ARE DERIVED FROM A KNOWLEDGE OF THE GROUND CONDITIONS, THE GEOPHYSICAL RESPONSES OF GROUND MATERIALS AND THE EXPERIENCE OF THE AUTHOR. APEX GEOSERVICES LTD. HAS PREPARED THIS REPORT IN LINE WITH BEST CURRENT PRACTICE AND WITH ALL REASONABLE SKILL, CARE AND DILIGENCE IN CONSIDERATION OF THE LIMITS IMPOSED BY THE SURVEY TECHNIQUES USED AND THE RESOURCES DEVOTED TO IT BY AGREEMENT WITH THE CLIENT. THE INTERPRETATIVE BASIS OF THE CONCLUSIONS CONTAINED IN THIS REPORT SHOULD BE TAKEN INTO ACCOUNT IN ANY FUTURE USE OF THIS REPORT.

PROJECT NUMBER	AGL06246		
AUTHOR	**CHECKED**	**REPORT STATUS**	**DATE**
EURGEOL YVONNE O'CONNELL P.GEO., M.SC (GEOPHYSICS)	EURGEOL PETER O'CONNOR P.GEO., M.SC (GEOPHYSICS), DIP. EIA MGT.	FINAL	11TH JANUARY 2008

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APPENDICES

A1. INTRODUCTION

APEX Geoservices Ltd. was requested by Irish Geotechnical Services Ltd. (IGSL), on behalf of Arup Consulting Engineers, to carry out a geophysical survey as part of the site investigation for the Shannon LNG: Tarbert/Ballylongford LNG Terminal.

A1.1 Survey Objectives

The objectives of the survey were:

- to profile variations in the bedrock topography
- to provide the following geotechnical properties of the overburden and bedrock
  - classification of the overburden and bedrock
  - determine the consistency and density of the individual units in the stratigraphic profile
  - Dynamic Shear Modulus (Gmax)
  - Dynamic Young's Modulus (Dynamic Emax)
  - Dynamic Bulk Modulus

A1.2 Survey Methodology

- Electromagnetic conductivity surveying to zone the site in terms of overburden thickness, lateral variations in overburden type, possible soft ground and backfilled areas.
- 2D Resistivity profiling to provide information on lateral and vertical variations in overburden type and thickness, bedrock type and profile.
- P-wave and S-wave Seismic Refraction profiling to verify overburden type, thickness and stiffness and provide information on depth to bedrock, rock type and strength.

A1.3 Site Background

The site is located between Ballylongford and Tarbert on the south coast of the Shannon Estuary. The site covers approx. 114 hectares and the survey was carried out across approx. 30.5 hectares (76.5 acres) in the northeast of the site. The topography of the survey area ranges from 2mOD along the coast to 33mOD in the southeast of the survey area.

The geological map for the area (Geology of the Shannon Estuary, Sheet 17, GSI) indicates that the site is underlain by Shannon Group mudstone, siltstone and sandstone.

As part of the site investigation a program of trial pits and boreholes was conducted by IGSL. Depths to rock from the boreholes and trial pits were made available to assist with the interpretation of the geophysical data. The locations of these trial pits and boreholes are indicated on Map A:1. Thirty three trial pits were opened (TP01 – TP31, TP8B & TP 11B). The trial pits encountered shallow rock to the northeast of the site with thicker overburden to the southwest. Twenty six boreholes were cored (RC01 - RC26). The boreholes encountered interbedded sandstone and siltstone bedrock from 0.5m to 9.8m across the site with depth to rock generally shallower to the northeast of the site with thicker overburden to the southwest.

A1.4 Report Outline

- The survey results are interpreted in Part A2.
- A summary is made in Part A3.
- The locations of the geophysical readings are shown on Map A:1.
- The Electromagnetic Conductivity values are plotted on Map A: 2.
- Interpreted thickness of seismic Layer 1 is plotted on Map A:3.
- Interpreted thickness of seismic Layers 1 and 2 is plotted on Map A:4.
- Interpreted overburden thickness is plotted on Map A:5.
- The survey results are summarized on Map A:6.
- The interpreted resistivity and seismic data are shown on Sections A(a) to A(h).
- The interpreted P-wave seismic data are contained in Appendix A:II.
- The interpreted S-wave seismic data are contained in Appendix A:III.
- Dynamic Moduli calculations are contained in Appendix A:IV.
- Excavatability ratings are shown in Appendix A:V.

A2. INTERPRETED RESULTS

A2.1 Electromagnetic Conductivity Surveying

The results of the EM31 Conductivity Survey have been contoured and plotted on Map A:2. The recorded conductivity values ranged from 1 to 13.3 mS/m. The data have generally been interpreted on the following basis:

Conductivity (mS/m)	Interpretation of 0 – 6m Below Ground Level
1 - 3	Thin overburden (<3m) or localized clayey gravel & sand/gravel deposits
3 – 13.3	Thick overburden (3-9m)

28% of the values were ≤3 mS/m and 72% of the values were >3 mS/m. In conjunction with the 2D resistivity, seismic, borehole and trial pit data, the low conductivity values (1-3 mS/m) have been interpreted as indicating thin overburden (<3m) in the centre and north of the Conductivity Survey area and localized clayey gravel & sand/gravel deposits in the south of the Conductivity Survey area.

A2.2 2D Resistivity Profiling

Eight 2D Resistivity profiles were recorded across the site (Map A:1, Sections A(a) to A(h)). The recorded resistivity values, in conjunction with the trial pit and borehole data, have been interpreted on the following basis:

Resistivity (Ohm-m)	Interpretation
50 - 250	Sandy gravelly Clay
250 - 525	Clayey Sand/Gravel
525-1000	Sand/Gravel
385 - 2000	Weathered Bedrock
50 - 385	Mudstone / Siltstone
385 - 2000	Sandstone

A2.3 Seismic Refraction Profiling

Twenty three P-wave seismic spreads were recorded across the site (Map A:1, Appendix A:II). The seismic survey also included the measurement of the shear wave (S-wave) velocity depth profile using the Multichannel Analysis of Surface Waves (MASW) method.

The P-wave seismic data, in conjunction with the trial pit and borehole data, have been interpreted as indicating three velocity layers as follows:

Layer	P-wave Velocity (Vp) Range (m/s)	Average Vp Velocity (m/s)	Interpretation
1	284-787	508	Soft to Firm or Loose to Medium Dense Overburden
2	815-2222	1467	**815-1400 m/s** Firm to Stiff Overburden or Highly to Moderately to Slightly Weathered Bedrock
			1400-2222 m/s Moderately to Slightly Weathered Bedrock
3	3050-4997	3905	Slightly Weathered to Fresh Bedrock

Layer 1 P-wave velocities (Vp) would be typical of soft to firm or loose to medium dense overburden material. The interpreted thickness of Layer 1 (from the seismic data) is contoured on Map A:3.

Layer 2 Vp velocities varied significantly across the site. In conjunction with the 2D resistivity, trial pit and borehole data, velocities from 1400-2222 m/s have been interpreted as indicating moderately to slightly weathered rock while velocities from 815-1400 m/s have been interpreted as indicating firm to stiff/medium dense to dense overburden material or highly to moderately weathered rock.

The combined thicknesses of Layers 1 and 2 (from the seismic data) are contoured on Map A:4.

The recorded Layer 3 Vp velocities would be typical of slightly weathered to fresh bedrock.

The MASW signal achieved a maximum penetration of 31.7 m bgl. The measured shear wave (Vs) velocities range from 145 to 2093 m/s and the derived G_{max} values range from 46 to11825 MPa (Appendix A:III).

The Vp data were combined with the Vs data to calculate Poissons ratio, dynamic Bulk modulus and Youngs Modulus for each of the layers outlined by the Vp data analysis using the formulae from Elastic Theory presented by Davies & Schulteiss, 1980 contained in Appendix A:I. The calculated modulii are contained in Appendix A:IV.

Note: A soil density of 2180 kg/m^3 (derived/calculated from lab data) and a rock density of 2700kg/m^3 (derived/calculated from lab data) has been used as directed by the Engineer.

A2.4 Integrated Interpretation

The integrated interpretation of the 2D resistivity data, seismic data, trial pit and borehole data has been drawn on Sections A(a) to A(h).

The combined geophysical data have been interpreted indicating three subsurface layers as follows:

Layer	Vp Velocity (m/s)	Resistivity (Ohm-m)	Interpretation	Stiffness/ Rock Quality	Estimated Excavatability
1	284-787	50-250	Sandy gravelly Clay	Soft - Firm	Diggable
		250-525	Clayey Sand/Gravel	Loose-Medium Dense	
		525-2000	Sand/Gravel		
2	815-1400	50-250	Sandy gravelly Clay	Firm - Stiff	Diggable
		250-525	Clayey Sand/Gravel	Medium dense-dense	
		525-2000	Sand/Gravel		
		50-525	Highly to moderately weathered rock	Poor - Fair	Rippable – Marginally Rippable
	1400-2222	385 - 2000	Moderately to Slightly weathered rock	Fair - Good	Marginally Rippable – Break/Blast
3	3050-4997	50 - 385	Slightly weathered to fresh Mudstone / Siltstone	Good	Break /Blast
		385 - 2000	Slightly weathered to fresh Sandstone		

Layer 1
The geophysical data indicates an upper layer of soft to firm sandy gravelly clay or loose to medium dense clayey sandy gravel. This layer has an approximate average thickness of 1.8m across the site and should be diggable.

Layer 2
Layer 2 Vp velocities varied significantly across the site; velocities from 815-1400 m/s were found to occur where the 2D Resistivity profiles recorded low resistivities (50-385 Ohm-m)) and have been interpreted as indicating firm to stiff sandy gravelly clay or medium dense to dense clayey sand/gravel which should be diggable. This interpretation is confirmed by the occurrence of rock at an average depth of 5.6m bgl in RC1, RC9-RC13 and RC23-RC26.

However, these velocities may also indicate rippable to marginally rippable highly to moderately weathered rock and the descriptive borehole logs would need to be reviewed to confirm the composition of this material.

Vp velocities from 1400-2222 m/s were found to occur where the 2D Resistivity profiles recorded high resistivities (385-2000 Ohm-m). These velocities have been interpreted as indicating moderately to slightly weathered rock. This interpretation is confirmed by the occurrence of rock at shallow depths in RC6, RC7 and RC14-RC22. These boreholes encountered rock at an average depth of 1.7m bgl. The descriptive borehole logs would need to be reviewed to confirm the composition of this material. The velocities for this layer indicate that this layer will be marginally rippable where seismic velocities fall below 1800 m/s and will require breaking/blasting where velocities are >1800 m/s.

The combined thicknesses of the soft to firm sandy gravelly clay or loose to medium dense clayey sandy gravel of Layer 1 and the firm to stiff sandy gravelly clay or medium dense to dense clayey sand/gravel of Layer 2 have been plotted on Map A:5. The 2D Resistivity and borehole data indicate that across Seismic Spreads 13 and 14 Layer 2 comprises both stiff sandy gravelly clay overlying probable moderately to slightly weathered rock. As the boundary between the overburden and the weathered rock cannot be distinguished due to both materials having similar velocities, the overburden thicknesses for these spreads have not been contoured on Map A:5

Layer 3
Vp velocities from 3050-4997m/s have been interpreted as indicating slightly weathered to fresh bedrock. This slightly weathered to fresh bedrock has been subdivided into two lithologies based on variations in resistivities. Low resistivities (50-385 Ohm-m) have been interpreted as indicating mudstone/siltstone bedrock and higher resistivities (385-2000 Ohm-m) have been interpreted as indicating sandstone bedrock. The velocities recorded for this layer indicate that any excavation will require breaking/blasting. In addition, excavatability will vary with marginally easier excavation expected over the mudstone/siltstone while the stronger sandstone is likely to require heavy breaking.

The interpreted overburden thickness, combining the 2D resistivity and seismic interpretations with depths to rock from the trial pit and borehole logs, is contoured on Map A:5.

The integrated interpretation is summarized on Map A:6. The combined geophysical data indicates two zones across the site:

Zone 1 indicates areas across the site where the geophysical and borehole data indicate <3m overburden underlain by moderately to slightly weathered bedrock (Vp = 1400-2222m/s) over slightly weathered to fresh bedrock.

Zone 2 indicates areas across the site where the geophysical and borehole data indicate 3-9m of overburden underlain by slightly weathered to fresh bedrock. The overburden thickness is a combination of Layer 1 material and Layer 2 material where Vp velocities range from 815-1400 m/s.

Some localised pockets of near-surface clayey gravel and/or sand/gravel have also been interpreted from the geophysical data in the southwest of the site (Map A:6).

A3. CONCLUSIONS & RECOMMENDATIONS

- The three subsurface layers have been interpreted from the combined data.

- Layer 1 has been interpreted as comprising diggable soft to firm sandy gravelly clay or loose to medium dense clayey sandy gravel with an average thickness of 1.7m across the site.

- Layer 2 has been subdivided based on variations in velocities:

  Low Vp velocities (<1400m/s) have been interpreted as indicating diggable firm to stiff sandy gravelly clay or medium dense to dense clayey sand/gravel. The velocities for this material may also indicate rippable to marginally rippable highly to moderately weathered rock and the descriptive borehole logs would need to be reviewed to confirm the composition of this material.

  Higher Vp velocities (>1400m/s) have been interpreted as indicating moderately to slightly weathered rock. The descriptive borehole logs would need to be reviewed to confirm the composition of this material. This layer should be marginally rippable where Vp seismic velocities fall below 1800 m/s and will require breaking/blasting where Vp velocities are >1800 m/s.

- Layer 3 has been interpreted as slightly weathered to fresh bedrock subdivided into low resistivity (50-385 Ohm-m) mudstone/siltstone and higher resistivities (385-2000 Ohm-m) sandstone bedrock. The Vp velocities recorded for this layer indicate that any excavation will require breaking/blasting. In addition, excavatability will vary with marginally easier excavation expected over the mudstone/siltstone while the stronger sandstone is likely to require heavy breaking.

- The site has been subdivided into two main zones:

  Zone 1 has been interpreted as having <3m overburden underlain by a layer of moderately to slightly weathered bedrock over slightly weathered to fresh bedrock.

  Zone 2 has been interpreted as having 3-9m_overburden over slightly weathered to fresh bedrock.

- Some localised pockets of near-surface clayey gravel and/or sand/gravel have also been interpreted from the geophysical data in the southwest of the site.

- Where bedrock excavation is proposed a detailed assessment of excavatability should be carried out combining the results of the geophysical survey, rotary core drilling, strength testing, and trial excavation pits using a high powered excavator.

- A table presented in Appendix A:V illustrates the excavability of the bedrock, which considers the seismic compressional wave results.

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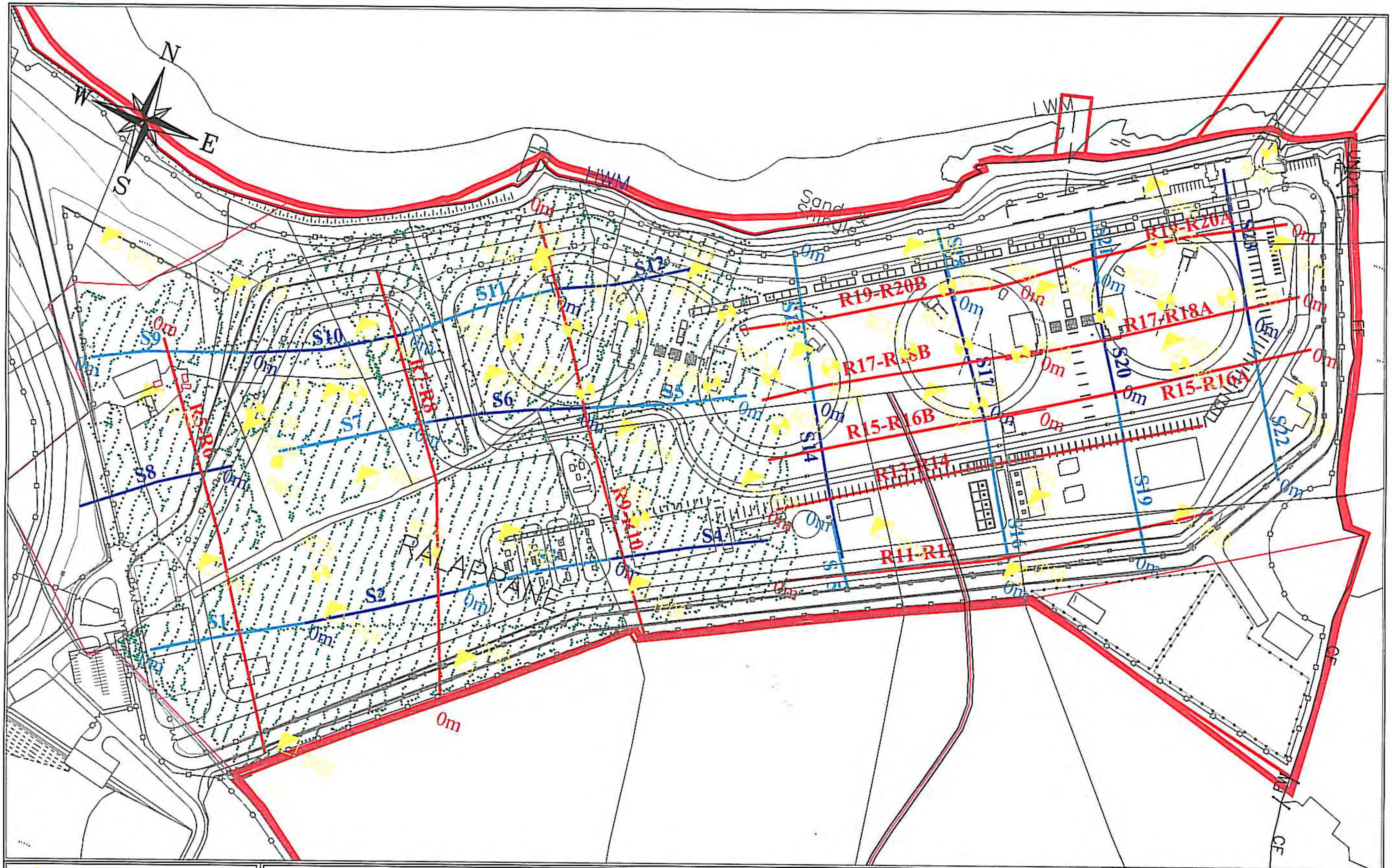
MAPS



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Legend	
(red line)	Resistivity Profile
(blue line)	Seismic Spread
+	Conductivity Station
⊕	Borehole
⊞	Trial Pit

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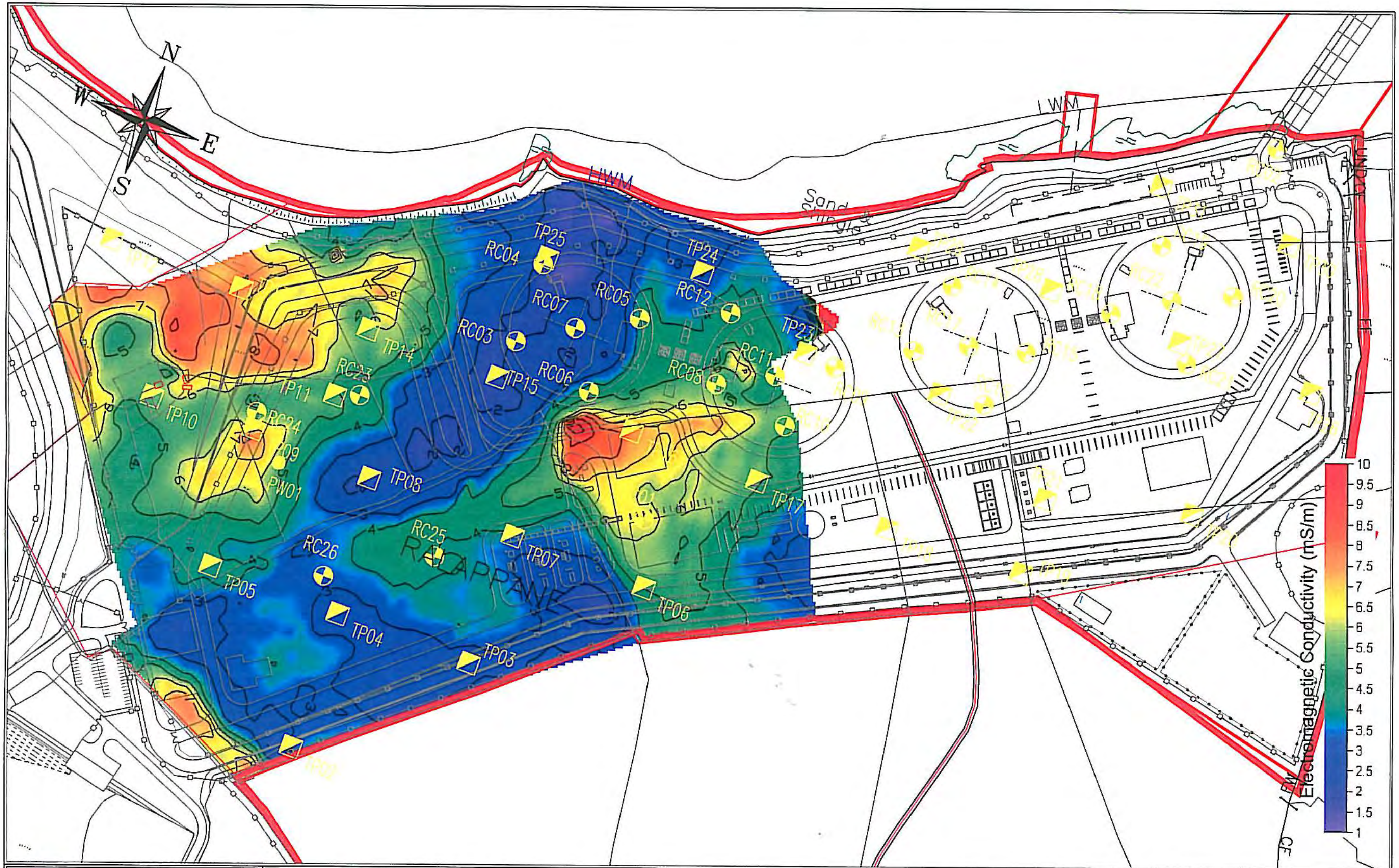

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Conductivity station

PROJECT:	Shannon LNG
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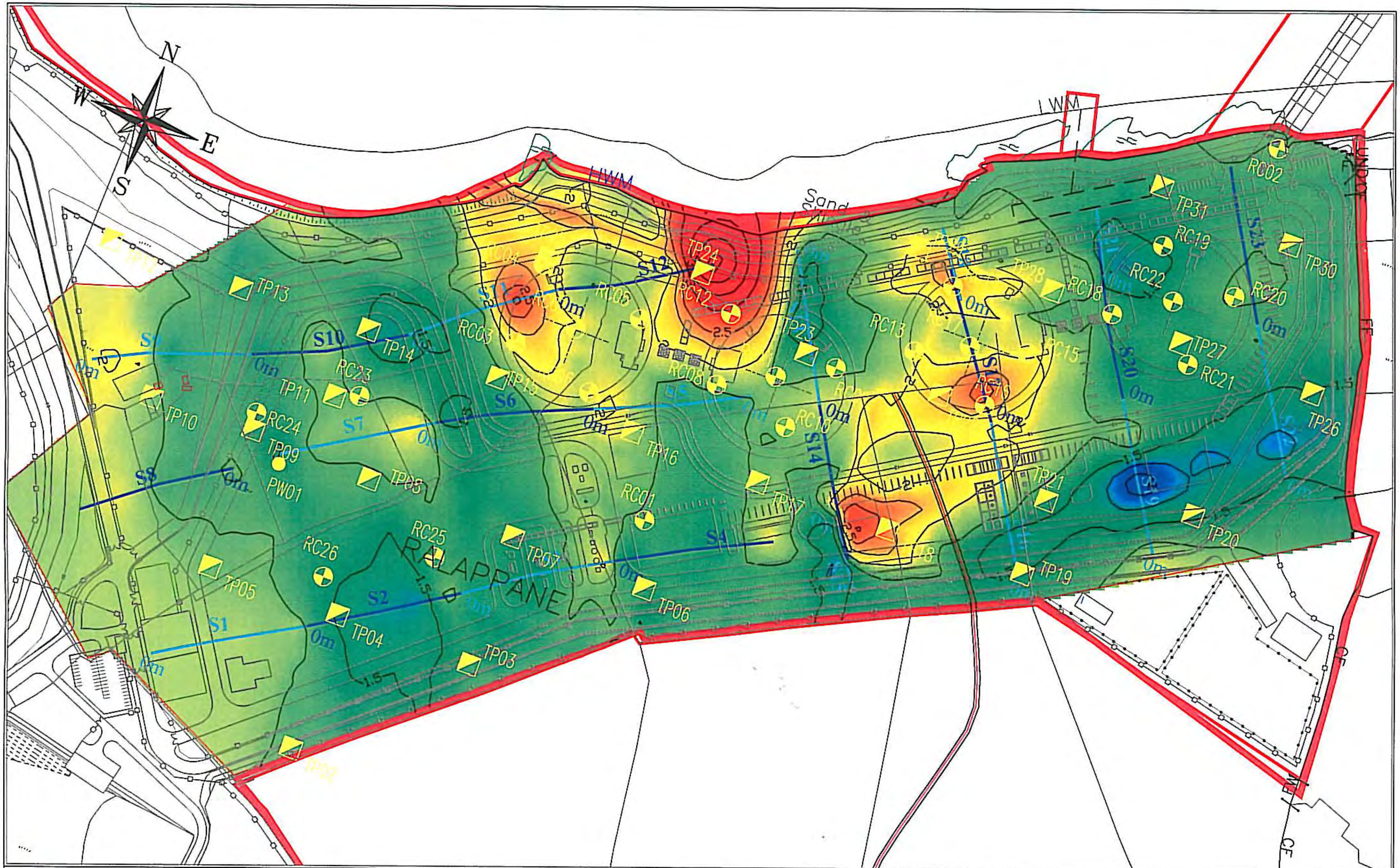

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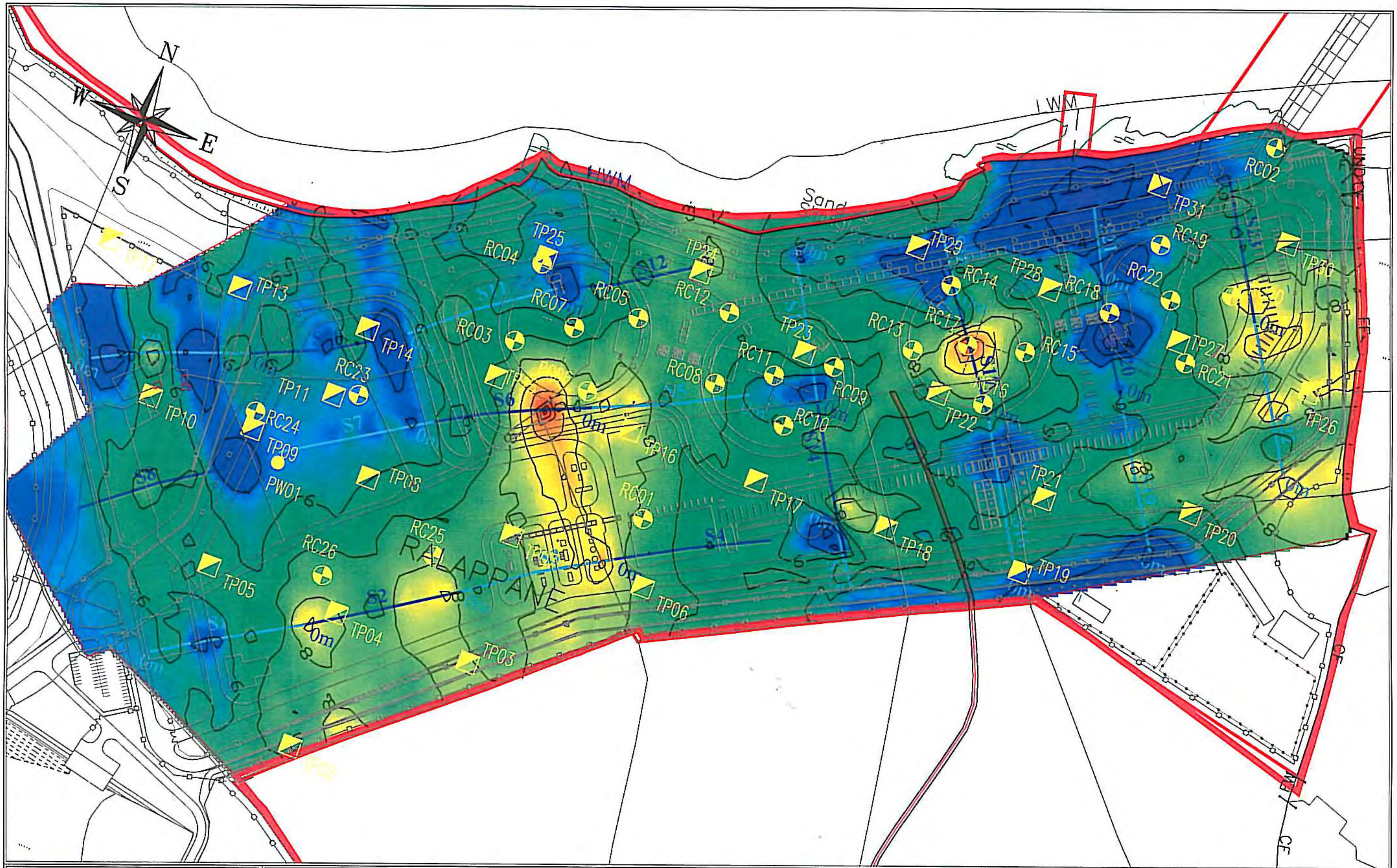

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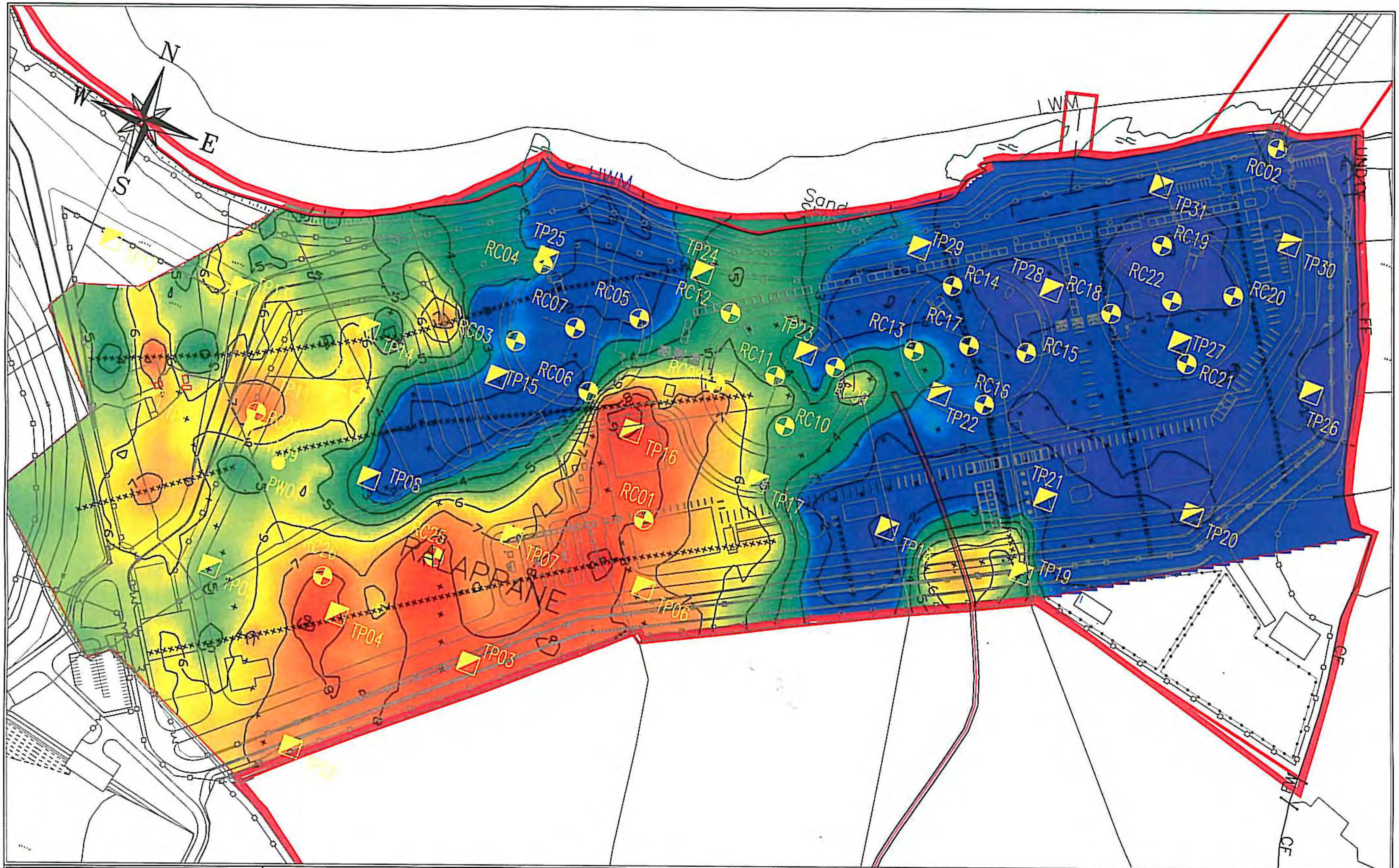

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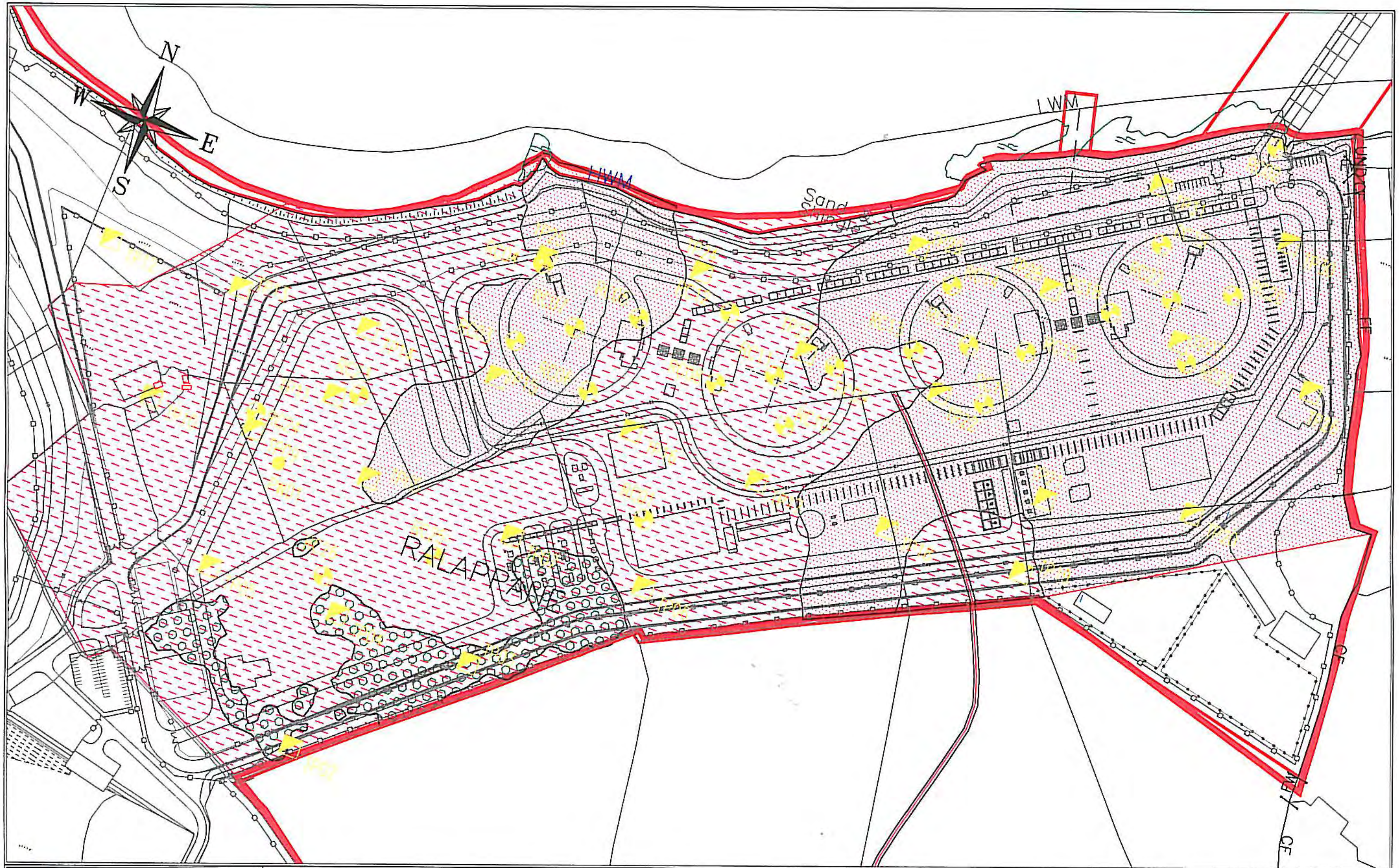

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Zone 1

Zone 2

Localised Clayey/Sand/Gravel Deposits

PROJECT:	Shannon LNG
DRAWING TITLE:	Map A:6 - Summary Map
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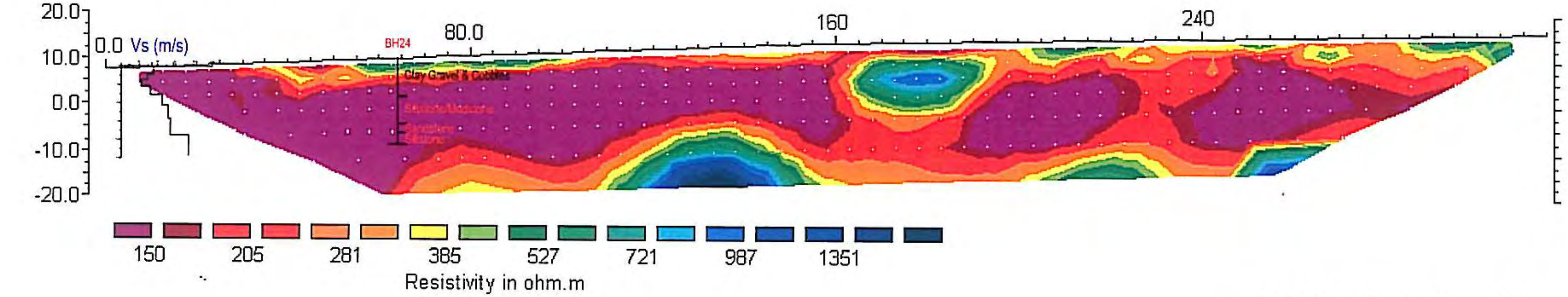
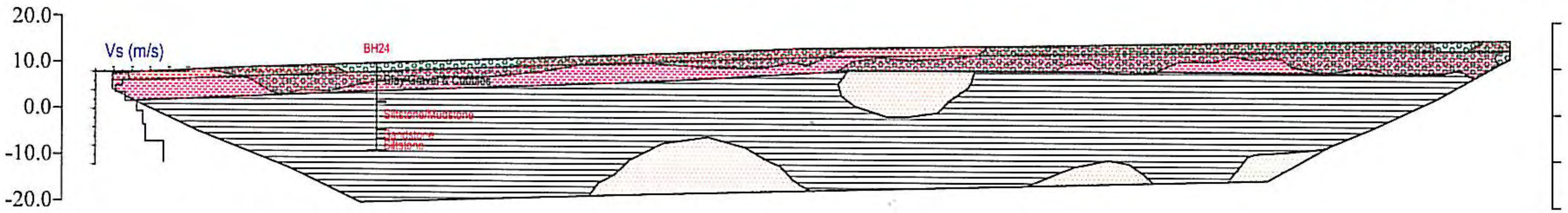
INTERPRETED SECTIONS

Interpreted 2D Resistivity & Seismic Profiles

2D Resistivity Profile 5-6





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- Firm-Stiff Sandy Gravelly Clay
- Medium Dense-Dense Clayey Sand/Gravel
- Medium Dense-Dense Sand/Gravel
- Moderately-Slightly Weathered Rock
- Slightly Weathered-Fresh Mudstone/Siltstone
- Slightly Weathered-Fresh Sandstone

PROJECT:	Shannon LNG: Tarbert/Ballylongford LNG Terminal
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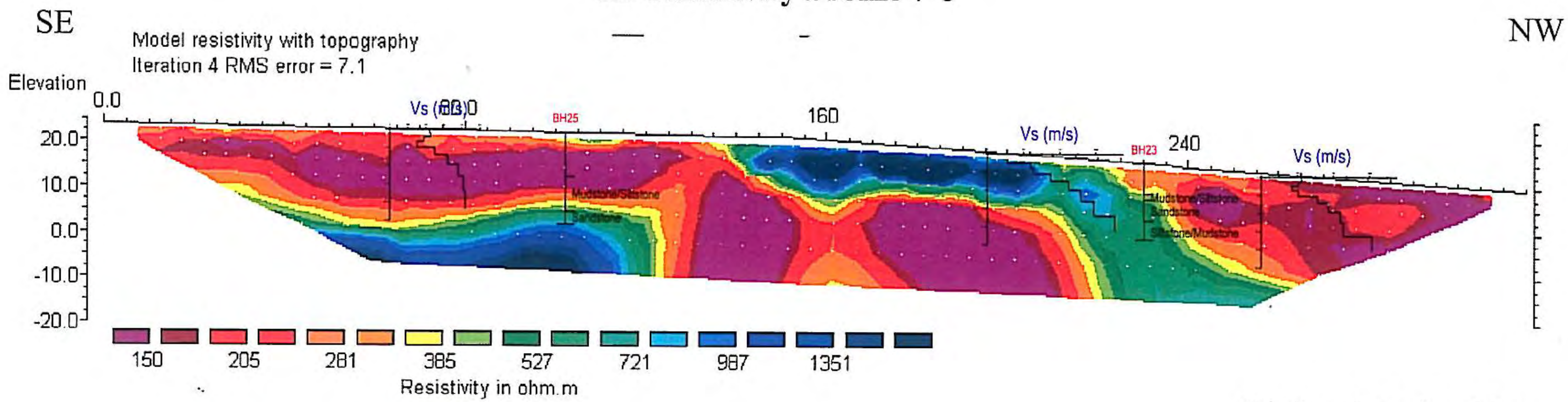
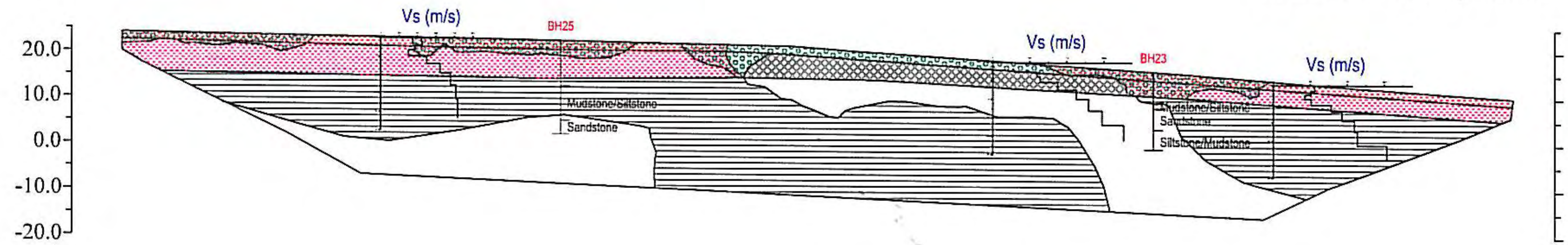
2D Resistivity Profile 7-8





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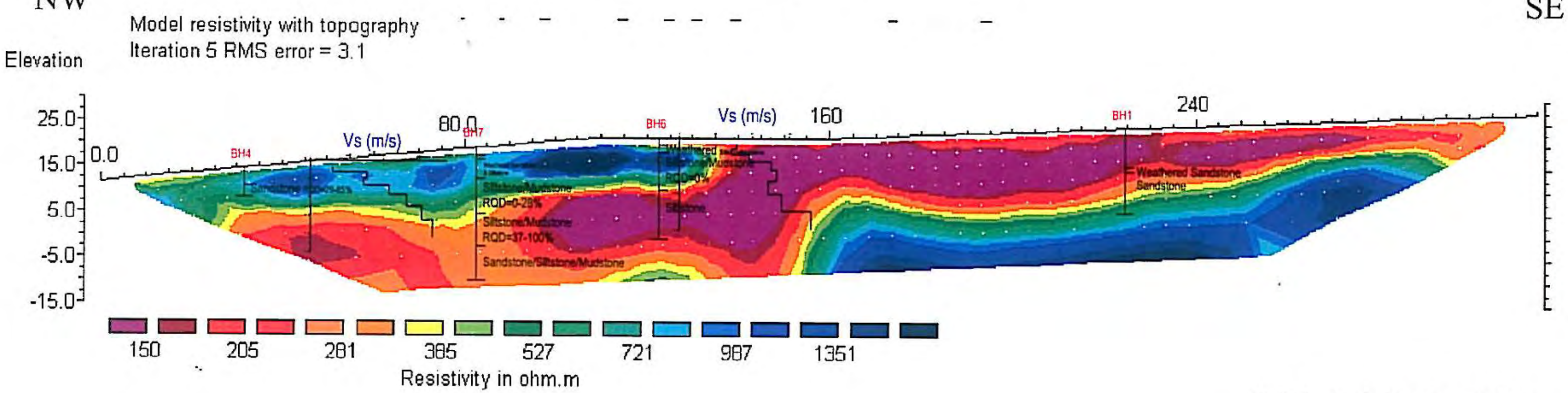
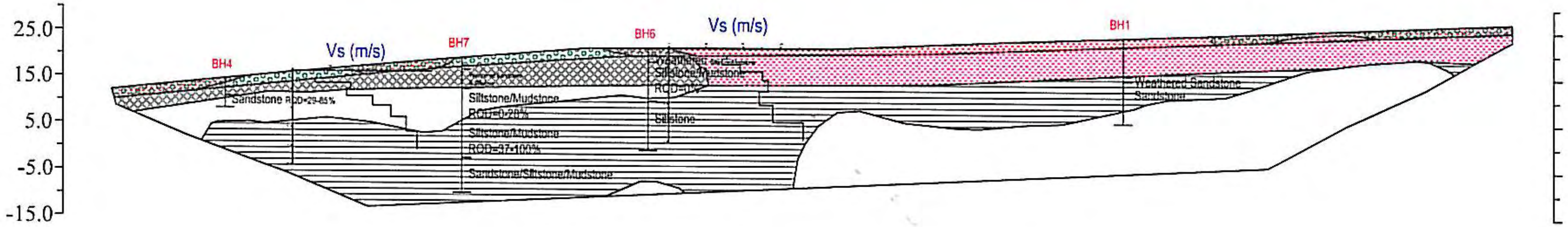
2D Resistivity Profile 9-10





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- Slightly Weathered-Fresh Mudstone/Siltstone
- Slightly Weathered-Fresh Sandstone

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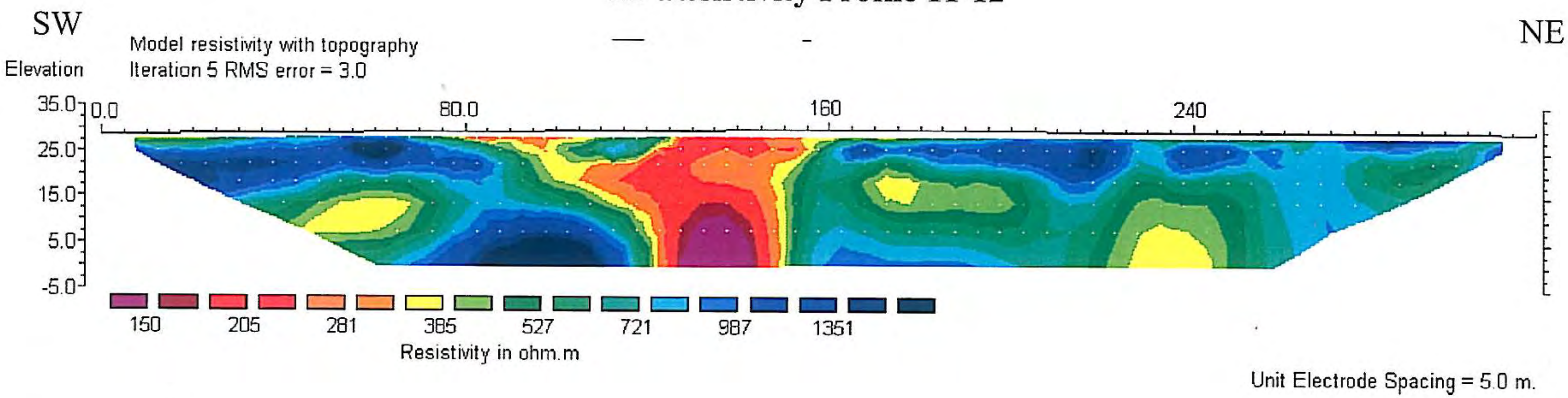
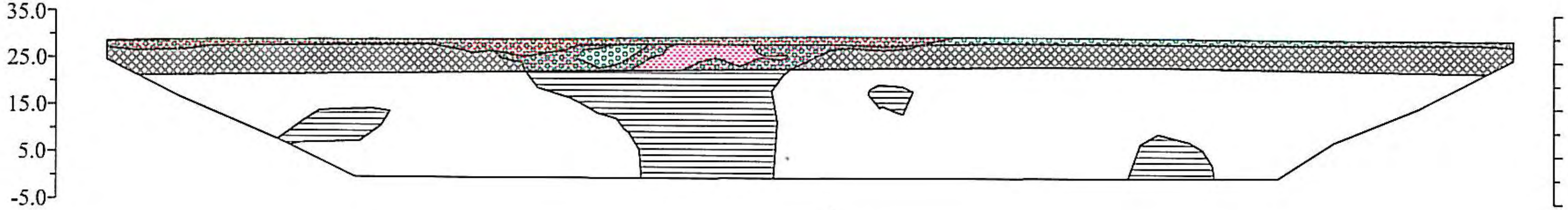
2D Resistivity Profile 11-12





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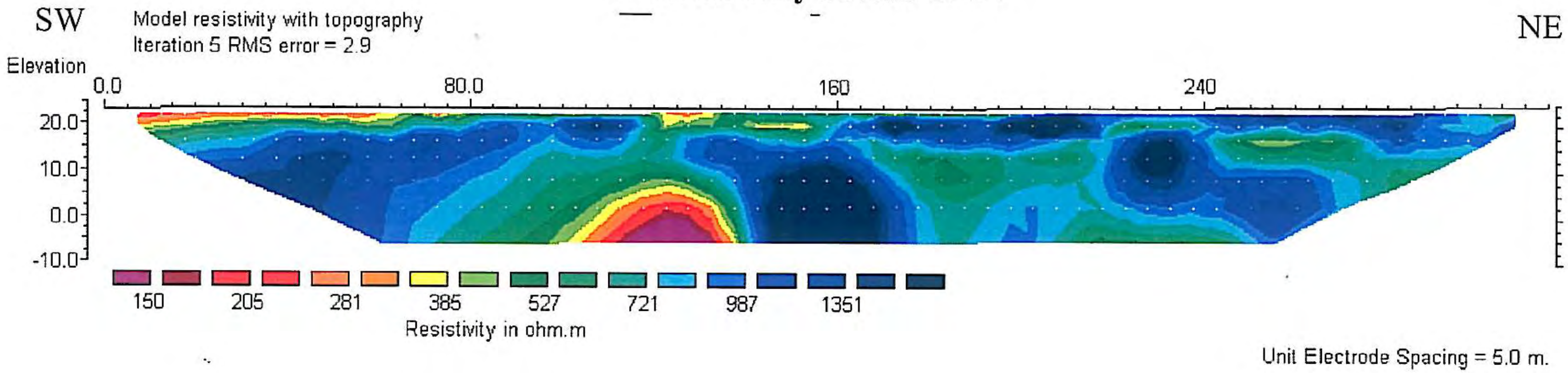
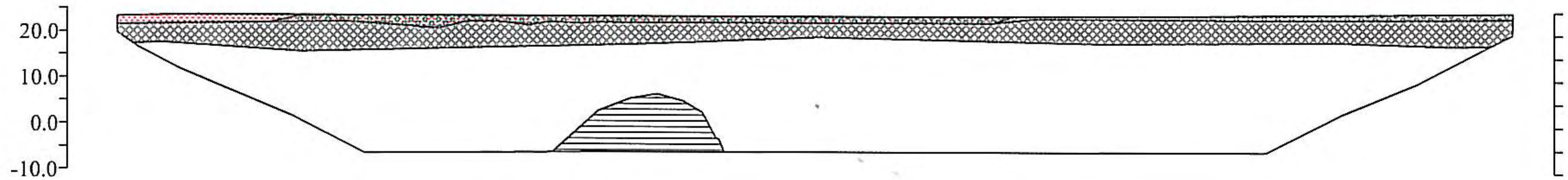
- Slightly Weathered-Fresh Sandstone

PROJECT:	Shannon LNG: Tarbert/Ballylongford LNG Terminal
DRAWING TITLE:	Section A(d)
DATE:	February 2007
CLIENT:	IGSL
SCALE:	1:1000

2D Resistivity Profile 13-14





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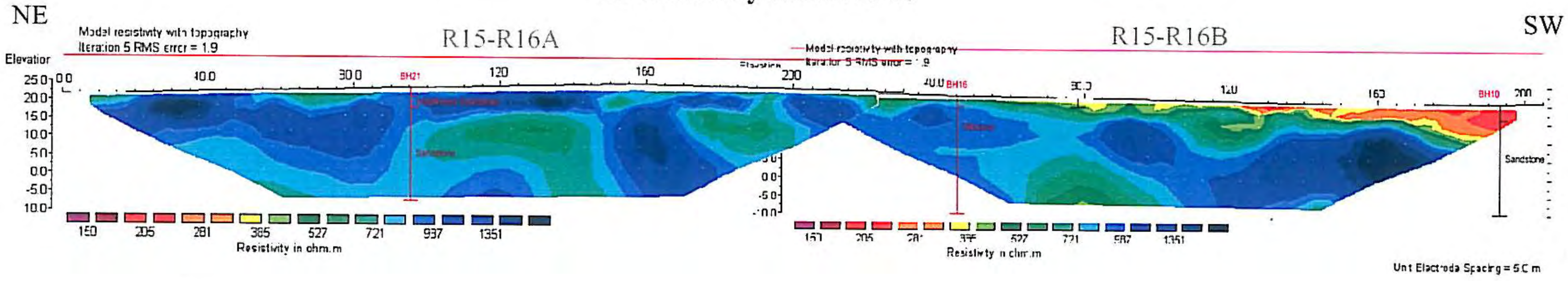
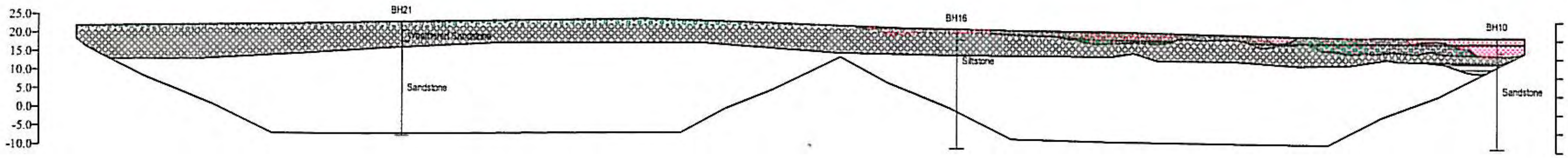
- Soft-Firm Sandy Gravelly Clay
- Loose-Medium Dense Clayey Sand/Gravel
- Loose-Medium Dense Sand/Gravel
- Firm-Stiff Sandy Gravelly Clay
- Medium Dense-Dense Clayey Sand/Gravel
- Medium Dense-Dense Sand/Gravel
- Moderately-Slightly Weathered Rock
- Slightly Weathered-Fresh Mudstone/Siltstone
- Slightly Weathered-Fresh Sandstone

PROJECT:	Shannon LNG: Tarbert/Ballylongford LNG Terminal
DRAWING TITLE:	Section A(e)
DATE:	February 2007
CLIENT:	IGSL
SCALE:	1:1000

2D Resistivity Profile 15-16





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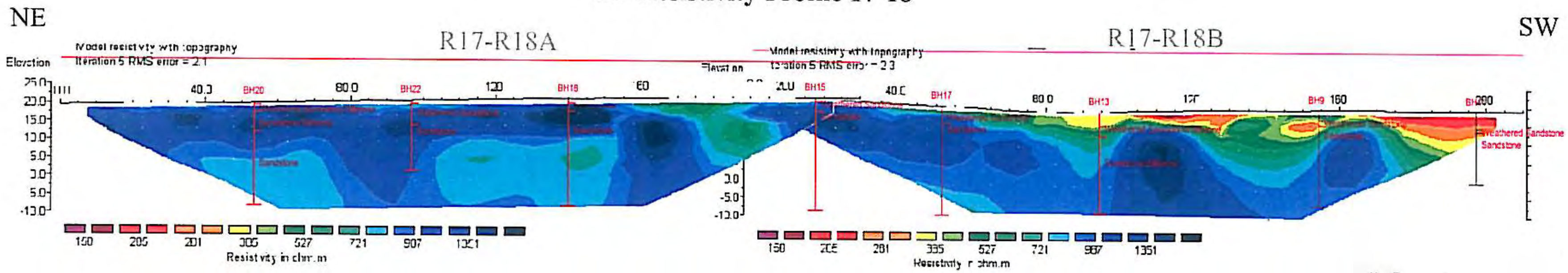
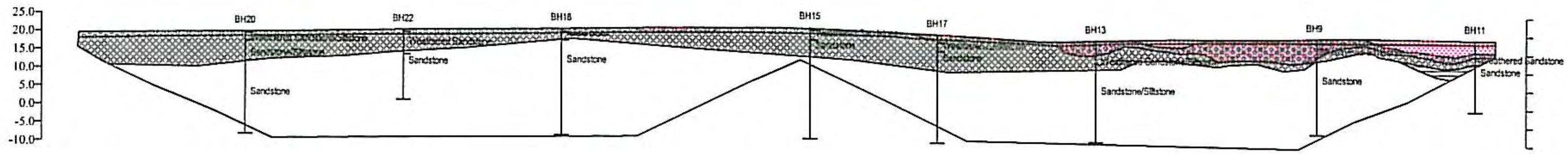
PROJECT:	Shannon LNG: Tarbert/Ballylongford LNG Terminal
DRAWING TITLE:	Section A(f)
DATE:	May 2007
CLIENT:	IGSL
SCALE:	1:1250

2D Resistivity Profile 17-18





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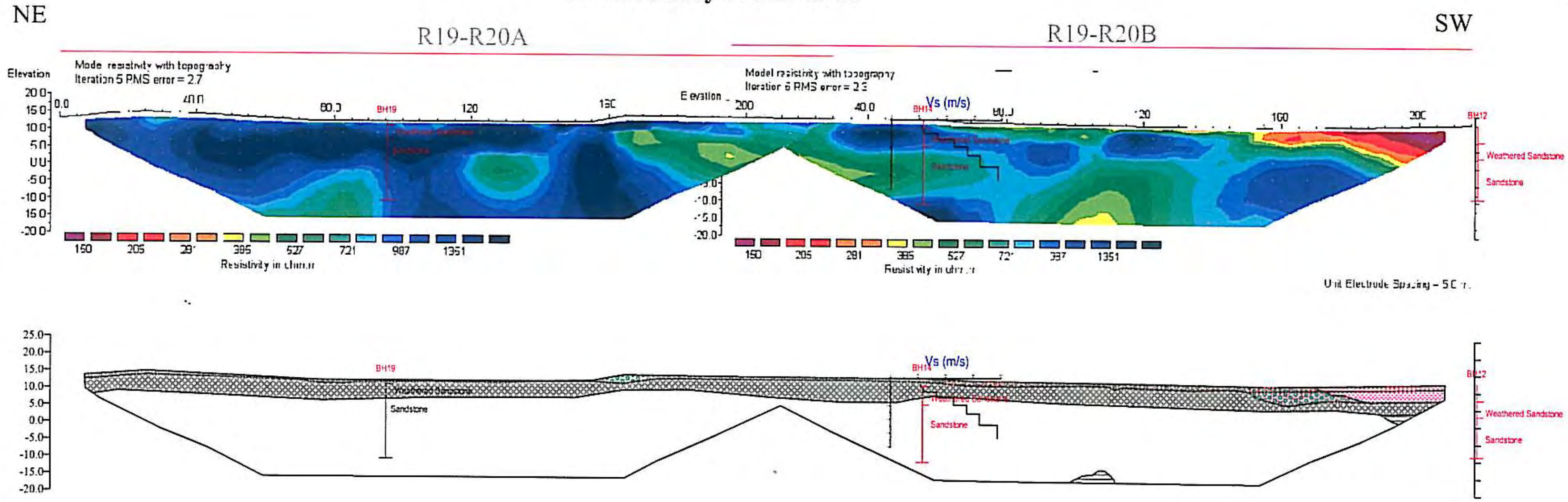
- Moderately-Slightly Weathered Rock
- Slightly Weathered-Fresh Mudstone/Siltstone
- Slightly Weathered-Fresh Sandstone

PROJECT:	Shannon LNG: Tarbert/Ballylongford LNG Terminal
DRAWING TITLE:	Section A(g)
DATE:	May 2007
CLIENT:	IGSL
SCALE:	1:1250

2D Resistivity Profile 19-20



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- Medium Dense-Dense Sand/Gravel
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- Slightly Weathered-Fresh Mudstone/Siltstone
- Slightly Weathered-Fresh Sandstone

PROJECT:	Shannon LNG: Tarbert/Ballylongford LNG Terminal
DRAWING TITLE:	Section A(h)
DATE:	May 2007
CLIENT:	IGSL
SCALE:	1:1250

APPENDIX A:I GEOPHYSICAL METHODOLOGY

APPENDIX A:I GEOPHYSICAL METHODLOGY

M1. **Methods Used**

1.1 EM31 Conductivity Mapping

1.2 2D-Resistivity Profiling

1.3 Seismic Refraction Profiling

M2. **Equipment Used**

2.1 EM31 Conductivity Mapping

2.2 2D-Resistivity Profiling

2.3 Seismic Refraction Profiling

M3. **Field Procedure**

3.1 EM31 Conductivity Mapping

3.2 2D-Resistivity Profiling

3.3 Seismic Refraction Profiling

M4. **Data Processing**

4.1 EM31 Conductivity Mapping

4.2 2D-Resistivity Profiling

4.3 Seismic Refraction Profiling

M1. Methods Used

1.1 EM31 Conductivity Mapping

This method operates on the principle of inducing currents in conductive substrata and measuring the resultant secondary electro-magnetic field. The strength of this secondary EM field is calibrated to give apparent ground conductivity in milliSiemens/metre (mS/m). As the effective penetration of this method is around 6m below ground level the measured conductivity is a function of the different overburden layers and/or rock from 0 to 6m below ground level.

1.2 2D-Resistivity Profiling

The resistivity surveying technique used for the survey makes use of the Wenner resistivity array whereby four electrodes are placed in a line in the ground and a current is passed through the two outer electrodes. The potential difference is measured across the two inner electrodes. The measured potential is divided by the current value to obtain the resistance. The resistivity is determined from the resistance using the following formula:

Resistivity = Resistance* 2 * Pi * Spacing.

The 2D-resistivity profiling method records a large number of resistivity readings in order to map lateral and vertical changes in material types. The 2D-resistivity profiling method involves the use of 32 to 64 electrodes connected to a resistivity meter, using computer software to control the process of data collection and storage.

1.3 Seismic Refraction Profiling

This method measures the velocity of refracted seismic waves through the overburden and rock material and allows an assessment of the thickness and quality of the materials present to be made. Stiffer and stronger materials usually have higher seismic velocities while soft, loose or fractured materials have lower velocities. Readings are taken using geophones connected via multi-core cable to a seismograph.

In the MASW method Surface waves (Rayleigh waves) are utilized to determine the elastic properties of the shallow subsurface (<15m). Surface waves carry up to two/thirds of the seismic energy but are usually considered as noise in conventional body wave reflection and refraction seismic surveys.

The penetration depth of surface waves changes with wavelength, i.e. longer wavelengths penetrate deeper. When the elastic properties of near surface materials vary with depth, surface waves then become dispersive, i.e. propagation velocity changes with frequency. The propagation (or phase) velocity, is determined by the average elastic property of the medium within the penetration depth. Therefore the dispersive nature of surface waves may be used to investigate changes in elastic properties of the shallow subsurface.

The Multi-channel Analysis of Surface Waves (MASW) was used for this survey (Park et al., 1998, 1999). This method employs the multi-channel recording and processing techniques (Sheriff and Geldart, 1982) that have similarities to those used in a seismic reflection survey and which allow better waveform analysis and noise elimination. To produce a stiffness profile of the subsurface using Surface waves the following basic procedure is followed:

(i) A point source (eg. a sledgehammer) is used to generate vertical ground motions,

(ii) the ground motions are measured using low frequency geophones, which are disposed along a straight line directed toward the source,

(iii) the ground motions are recorded using either a conventional seismograph, oscilloscope or spectrum analyzer,

(iv) a dispersion curve is produced from a spectral analysis of the data showing the variation of Surface wave velocity with wavelength,

(v) the dispersion curve in inverted using a modeling and least squares minimization process to produce a subsurface profile of the variation of Surface wave and shear wave velocity with depth.

M2. Equipment Used

2.1 EM31 Conductivity Mapping

The equipment used was an EM31 Conductivity meter equipped with data logger. This instrument features a real time graphic display of the previous 20 measurement points to monitor data quality and results. 6499 conductivity readings were recorded on the 14th and 15th December 2006.

2.2 2D-Resistivity Profiling

Eight profiles were recorded from the 8th to 15th December 2006 using a Tigre resistivity meter, imaging software, two 32 takeout multicore cables and 64 stainless steel electrodes. The recorded data was processed and viewed immediately after the survey.

2.3 Seismic Refraction Profiling

Twenty three spreads were recorded from the 19th to the 22nd December 2006 using a Ras-24 high resolution 24 channel digital seismograph with 24 no. 10HZ vertical geophones using 5m geophone spacings. The record length was 600 ms. The energy source of the seismic waves was a sledgehammer. The equipment was carried in 4WD vehicle with 2 person crew.

M3. Field Procedure

3.1 EM31 Conductivity Mapping

Conductivity and in-phase values were recorded on a 5m x 10m grid over an approximate area of 17 hectares. Local conditions and variations were recorded.

3.2 2D-Resistivity Profiling

Electrode spacings of 5m investigating to a maximum depth of 29m below ground level were used. Resistances were measured for expanding arrays. 2 cycles were recorded to 3% repeatability. Saline solution was added around electrodes in areas of high contact resistance. Local conditions and variations were recorded. QC inversion of each profile was carried out before removal of electrodes.

3.3 Seismic Refraction Profiling

The seismic spreads consisted of 12 or 24 collinear geophones at spacings of 5m. The depth of investigation was of the order of 30m below ground level. Records from up to seven different positions were taken on each spread (2 x off-end, 2 x end, 3 x middle) to ensure optimum coverage of all refractors. Ongoing estimation of refractor velocities was carried out to monitor refractor type and depth.

M4. Data Processing

4.1 EM31 Conductivity Mapping

The data were downloaded and plotted. Assignation of material types and possible anomaly sources was carried out, with cross-reference to other data. A contoured map of recorded conductivity values was prepared (Map A:2).

4.2 2D-Resistivity Profiling

The field readings were stored in computer files and inverted using the RES2DINV package (Campus Geophysical Instruments, 1997) with up to 5 iterations of the measured data carried out for each profile to obtain a 2D-Depth model of the resistivities.

The inverted 2D-Resistivity models and corresponding interpreted geology are displayed on Sections A to H. The chainage is indicated along the horizontal axis of the profile and the depth below ground level is indicated on the vertical axis. All profiles have been contoured using the same contour intervals and colour codes.

It is important to note that the data displayed on the 2D-Resistivity profiles is real physical data however interpretation of the geophysical results is required to transform the resistivities directly into geological layers.

4.3 Seismic Refraction Profiling

For the P-wave interpretation, first break picking in digital format was carried out using the FIRSTPIX software program to construct traveltime plots for each spread. Velocity phases were selected from these plots using the GREMIX software program and were used to calculate the thickness of individual velocity units. Topographic data were input. Material types were assigned and estimation made of material properties, cross-referenced to the 2D Resistivity and borehole data. The processed seismic data are displayed in Appendix A:II and the Layer 1 and Layer 1+2 thicknesses are plotted on Maps A:5 and A:6.

Approximate errors for velocities are estimated to be +/- 10%. Errors for the calculated layer thicknesses are of the order of +/-20%. Possible errors due to the "hidden layer" and "velocity inversion" effects may also occur (Soske, 1959).

For the S-wave interpretation, processing was carried out using the SURFSEIS processing package developed by Kansas Geological Survey (KGS, 2000). SURFSEIS is designed to generate a shear wave velocity profile. SURFSEIS data processing involves three steps:

(i) Preparation of the acquired multichannel record. This involves converting the data file into the processing format.

(ii) Production of a dispersion curve from a spectral analysis of the data showing the variation of Raleigh wave phase velocity with wavelength. Confidence in the dispersion curve can be estimated through a measure of signal to noise ratio (S/N) which is obtained from a coherency analysis. Noise includes both body waves and higher mode surface waves. To obtain an accurate dispersion curve the spectral content and phase velocity characteristics are examined through an overtone analysis of the data.

(iii) Inversion of the dispersion curve is then carried out to produce a subsurface profile of the variation of shear wave velocity with depth.

The shear wave velocities were then converted into shear modulus values using the formula:

(1) $$G = V_s^2 * \rho / 1000000$$

Where	G	=	Shear Modulus (GPa)
	V_s	=	Shear Wave Velocity (m/s)
	ρ	=	Density (kg/m^3)

Processing parameters were optimized by test processing using varying options in the processing package and also by reference to optimal parameters referred to in the literature.

The first arrivals on each MASW record were also picked using the FIRSTPIX and GREMIX, 1993 packages in order to produce a conventional layered P-wave depth section and P-wave velocities. These velocities were combined with the shear wave velocity data to calculate Poissons ratio, dynamic Bulk modulus and Youngs Modulus for each of the layers outlined by the P-wave data analysis using the theory of Elasticity formulae in Davies & Schulteiss, 1980 as follows:

(2) $$nu=(Vp/Vs)^2-2 / 2((Vp/Vs)^2-2)$$

(3) $$E = 2V_s^2 \rho(1 + nu)/1000$$

where	E	=	Youngs Modulus (GPa)
	V_s	=	Shear Wave Velocity (m/s)
	ρ	=	Density (kg/m^3)
	nu	=	Poisson's ratio

and

(4) $$B = E/3(1-2\,nu)$$

where	B	=	Bulk Modulus (GPa)
	E	=	Youngs Modulus (GPa)
	nu	=	Poisson's ratio

For the purpose of the calculation in this report a soil density of 2180 kg/m^3 and a rock density of 2700kg/m^3 (derived/calculated from lab data) have been used as directed by the Arup.

APPENDIX A:II P-WAVE SEISMIC REFRACTION DATA

line	easting	northing	station	v1	v2	v3	t1	t2	t1+t2	surface topo	base 1	base 2
				m/s	m/s	m/s	m	m	m	mOD	mOD	mOD
1	102066.5	148313.7	0	370	1333	3880	1.9	3.6	5.5	10.8	8.9	5.3
1	102070.8	148316.2	5	370	1333	3812	1.9	4.0	5.9	11.2	9.3	5.4
1	102075.1	148318.7	10	370	1333	3743	1.9	4.3	6.2	11.6	9.7	5.4
1	102079.5	148321.2	15	370	1333	3743	1.9	4.6	6.5	12.0	10.1	5.5
1	102083.8	148323.8	20	370	1333	3743	1.9	4.9	6.7	12.4	10.5	5.7
1	102088.1	148326.3	25	370	1333	3743	1.9	4.1	5.9	12.8	10.9	6.9
1	102092.4	148328.8	30	354	1283	3743	1.9	3.0	4.9	13.1	11.2	8.2
1	102096.7	148331.3	35	338	1233	3841	1.9	3.1	5.0	13.3	11.4	8.3
1	102101.1	148333.8	40	322	1183	3841	1.9	2.6	4.5	13.5	11.6	9.0
1	102105.4	148336.4	45	306	1133	3841	1.9	3.6	5.4	13.8	11.9	8.4
1	102109.7	148338.9	50	290	1083	3915	1.9	2.4	4.3	14.0	12.1	9.7
1	102114.0	148341.4	55	290	1083	3915	1.9	4.2	6.1	14.2	12.3	8.1
1	102118.3	148343.9	60	311	1111	3915	1.9	4.3	6.2	14.7	12.8	8.5
1	102122.7	148346.4	65	332	1139	3927	1.9	4.7	6.6	15.1	13.2	8.5
1	102127.0	148349.0	70	352	1167	3927	1.9	5.3	7.2	15.5	13.6	8.3
1	102131.3	148351.5	75	373	1194	3935	1.9	5.8	7.6	15.9	14.0	8.3
1	102135.6	148354.0	80	394	1222	3935	1.8	4.5	6.3	16.3	14.5	10.0
1	102139.9	148356.5	85	394	1222	3935	1.8	4.7	6.5	16.7	14.9	10.2
1	102144.3	148359.0	90	393	1244	3935	1.8	5.0	6.8	17.0	15.2	10.2
1	102148.6	148361.5	95	393	1267	3935	1.8	4.6	6.4	17.3	15.5	10.9
1	102152.9	148364.0	100	393	1289	3989	1.8	4.4	6.2	17.7	15.9	11.5
1	102157.2	148366.6	105	392	1311	3770	1.8	5.9	7.7	18.0	16.2	10.3
1	102161.5	148369.1	110	392	1333	3770	1.9	8.1	10.0	18.3	16.5	8.3
1	102165.9	148371.6	115	392	1333	3770	1.9	7.1	8.9	18.6	16.8	9.7
2	102165.0	148371.2	0	444	966	3395	1.6	7.3	8.9	18.6	17.0	9.7
2	102169.2	148373.9	5	429	940	3395	1.6	8.1	9.7	18.7	17.1	9.0
2	102173.5	148376.5	10	413	914	3395	1.6	7.1	8.6	18.7	17.2	10.1
2	102177.7	148379.2	15	397	887	3759	1.5	6.7	8.3	18.8	17.3	10.6
2	102181.9	148381.9	20	381	861	3847	1.5	6.9	8.4	18.9	17.4	10.5
2	102186.2	148384.5	25	381	861	3847	1.5	6.8	8.3	19.0	17.5	10.7
2	102190.4	148387.2	30	401	852	3847	1.5	6.2	7.6	19.1	17.6	11.5
2	102194.6	148389.9	35	420	843	3847	1.4	5.9	7.3	19.2	17.8	11.9
2	102198.8	148392.5	40	440	833	3883	1.4	6.1	7.5	19.3	17.9	11.8
2	102203.1	148395.2	45	459	824	4008	1.4	6.2	7.5	19.3	18.0	11.8
2	102207.3	148397.9	50	479	815	4008	1.3	4.8	6.1	19.4	18.1	13.3
2	102211.5	148400.5	55	479	815	4008	1.3	5.0	6.3	19.5	18.2	13.2
2	102215.8	148403.2	60	516	883	4008	1.3	5.8	7.1	19.6	18.3	12.5
2	102220.0	148405.8	65	554	951	3909	1.3	6.9	8.2	19.7	18.4	11.5
2	102224.2	148408.5	70	591	1020	3909	1.3	7.4	8.7	19.8	18.5	11.1
2	102228.5	148411.2	75	629	1088	3966	1.3	7.7	9.0	20.0	18.7	11.0
2	102232.7	148413.8	80	667	1156	3966	1.2	7.6	8.8	20.1	18.9	11.3
2	102236.9	148416.5	85	667	1156	3966	1.2	7.3	8.5	20.2	19.0	11.7
2	102241.1	148419.2	90	617	1221	3966	1.5	7.5	9.0	20.3	18.8	11.3
2	102245.4	148421.8	95	567	1286	3966	1.6	7.4	9.0	20.4	18.8	11.4

line	easting	northing	station	v1	v2	v3	t1	t2	t1+t2	surface topo	base 1	base 2
				m/s	m/s	m/s	m	m	m	mOD	mOD	mOD
2	102249.6	148424.5	100	517	1351	3966	1.8	7.1	8.9	20.5	18.7	11.6
2	102253.8	148427.2	105	467	1416	3842	1.8	7.5	9.4	20.6	18.8	11.2
2	102258.1	148429.8	110	417	1481	3842	1.9	7.1	9.0	20.7	18.9	11.7
2	102262.3	148432.5	115	417	1481	3842	1.9	6.5	8.4	20.8	19.0	12.5
3	102261.5	148431.9	0	476	952	4248	1.4	5.1	6.5	20.8	19.4	14.3
3	102265.7	148434.6	5	452	958	4248	1.5	5.3	6.8	21.1	19.6	14.3
3	102269.9	148437.3	10	429	964	4248	1.6	5.2	6.8	21.3	19.7	14.5
3	102274.2	148439.9	15	405	970	4419	1.6	5.3	6.9	21.5	19.9	14.6
3	102278.4	148442.6	20	381	976	4419	1.6	5.5	7.1	21.7	20.1	14.6
3	102282.6	148445.3	25	381	976	4419	1.6	5.7	7.3	22.0	20.4	14.7
3	102286.8	148448.0	30	386	959	4419	1.6	6.1	7.7	22.2	20.6	14.5
3	102291.1	148450.7	35	391	941	4343	1.6	6.0	7.6	22.4	20.8	14.8
3	102295.3	148453.3	40	395	924	4343	1.6	5.4	7.0	22.7	21.1	15.7
3	102299.5	148456.0	45	400	906	4415	1.5	6.3	7.8	22.9	21.4	15.1
3	102303.7	148458.7	50	404	889	4415	1.5	6.2	7.7	23.1	21.6	15.4
3	102307.9	148461.4	55	404	889	4415	1.5	6.8	8.3	23.3	21.8	15.0
3	102312.2	148464.0	60	402	933	4415	1.6	7.3	8.8	23.3	21.8	14.5
3	102316.4	148466.7	65	400	978	4327	1.6	7.0	8.6	23.3	21.7	14.7
3	102320.6	148469.4	70	397	1022	4327	1.7	6.4	8.0	23.3	21.7	15.3
3	102324.8	148472.1	75	395	1067	4362	1.7	7.0	8.7	23.3	21.6	14.6
3	102329.1	148474.7	80	392	1111	4362	1.8	6.9	8.6	23.4	21.6	14.8
3	102333.3	148477.4	85	392	1111	4362	1.8	7.5	9.2	23.4	21.6	14.2
3	102337.5	148480.1	90	403	1156	4362	1.8	7.0	8.9	23.4	21.6	14.6
3	102341.7	148482.8	95	413	1200	4362	1.9	6.7	8.6	23.4	21.5	14.8
3	102346.0	148485.5	100	424	1244	4269	2.0	7.3	9.2	23.4	21.4	14.2
3	102350.2	148488.1	105	434	1289	4269	2.1	8.8	10.9	23.4	21.4	12.5
3	102354.4	148490.8	110	444	1333	4335	2.1	7.4	9.6	23.4	21.3	13.8
3	102358.6	148493.5	115	444	1333	4400	2.1	7.0	9.1	23.4	21.3	14.3
4	102357.5	148492.8	0	444	1111	4997	1.3	6.7	8.0	23.4	22.1	15.4
4	102361.9	148495.1	5	453	1139	4558	1.4	6.7	8.0	23.5	22.1	15.5
4	102366.4	148497.4	10	462	1167	4389	1.5	5.9	7.4	23.6	22.1	16.2
4	102370.8	148499.7	15	470	1194	4389	1.6	6.4	8.0	23.7	22.1	15.7
4	102375.3	148501.9	20	479	1222	4389	1.7	5.7	7.3	23.8	22.1	16.5
4	102379.7	148504.2	25	479	1222	4389	1.7	5.4	7.0	23.8	22.1	16.8
4	102384.2	148506.5	30	466	1182	4389	1.7	5.1	6.7	23.9	22.2	17.2
4	102388.6	148508.8	35	454	1142	4389	1.7	5.7	7.3	24.0	22.4	16.7
4	102393.1	148511.1	40	441	1103	4472	1.6	5.3	7.0	24.1	22.5	17.2
4	102397.5	148513.4	45	429	1063	4697	1.6	5.3	7.0	24.2	22.6	17.2
4	102402.0	148515.7	50	417	1023	4697	1.6	5.3	6.9	24.3	22.7	17.4
4	102406.4	148518.0	55	417	1023	4697	1.6	5.4	7.0	24.4	22.8	17.4
4	102410.9	148520.2	60	417	1026	4697	1.6	5.2	6.8	24.5	22.9	17.7
4	102415.3	148522.5	65	417	1030	4744	1.6	4.8	6.3	24.6	23.0	18.3
4	102419.7	148524.8	70	417	1033	4911	1.6	4.1	5.7	24.7	23.1	19.1
4	102424.2	148527.1	75	417	1037	4911	1.5	4.6	6.1	24.7	23.2	18.6

line	easting	northing	station	v1	v2	v3	t1	t2	t1+t2	surface topo	base 1	base 2
				m/s	m/s	m/s	m	m	m	mOD	mOD	mOD
4	102428.6	148529.4	80	417	1037	4911	1.5	4.7	6.2	24.8	23.3	18.6
4	102433.1	148531.7	85	413	1111	4911	1.6	5.0	6.6	24.9	23.3	18.3
4	102437.5	148534.0	90	409	1185	4840	1.7	5.0	6.7	25.0	23.3	18.3
4	102442.0	148536.2	95	404	1259	4769	1.8	4.9	6.7	25.1	23.3	18.4
4	102446.4	148538.5	100	400	1333	4698	1.8	4.8	6.6	25.2	23.4	18.6
4	102450.9	148540.8	105	396	1407	4627	1.9	4.8	6.7	25.3	23.4	18.6
4	102455.3	148543.1	110	392	1481	4627	2.0	3.9	5.8	25.4	23.4	19.6
4	102459.8	148545.4	115	392	1481	4627	2.0	4.4	6.4	25.5	23.5	19.1
5	102407.7	148638.3	0	370	1111	3393	1.8	3.7	5.4	17.7	15.9	12.3
5	102403.2	148636.2	5	385	1119	3393	1.8	4.1	5.8	17.7	15.9	11.9
5	102398.6	148634.1	10	400	1127	3523	1.7	4.9	6.6	17.8	16.1	11.2
5	102394.1	148632.0	15	416	1135	3680	1.7	5.1	6.9	17.8	16.1	11.0
5	102389.6	148629.8	20	431	1143	3680	1.7	5.8	7.4	17.9	16.2	10.5
5	102385.0	148627.7	25	431	1143	3680	1.7	5.8	7.5	17.9	16.2	10.4
5	102380.5	148625.6	30	443	1159	3680	1.7	6.2	7.9	18.0	16.3	10.1
5	102376.0	148623.5	35	456	1175	3591	1.7	6.1	7.8	18.0	16.3	10.2
5	102371.5	148621.4	40	469	1190	3591	1.7	5.5	7.1	18.0	16.3	10.9
5	102366.9	148619.3	45	482	1206	3591	1.6	5.3	6.9	18.1	16.5	11.2
5	102362.4	148617.2	50	495	1222	3842	1.6	6.5	8.1	18.1	16.5	10.0
5	102357.9	148615.0	55	495	1222	3842	1.6	5.1	6.7	18.2	16.6	11.5
5	102353.3	148612.9	60	495	1335	3842	1.7	4.6	6.3	18.4	16.7	12.1
5	102348.8	148610.8	65	495	1448	3835	1.7	4.8	6.5	18.6	16.9	12.1
5	102344.3	148608.7	70	495	1560	3835	1.8	6.3	8.1	18.8	17.0	10.7
5	102339.7	148606.6	75	495	1673	3981	1.8	6.9	8.7	19.0	17.2	10.3
5	102335.2	148604.5	80	495	1786	3981	1.9	7.1	8.9	19.2	17.3	10.3
5	102330.7	148602.4	85	495	1786	3981	1.9	7.3	9.1	19.4	17.5	10.3
5	102326.1	148600.3	90	484	1873	3981	1.9	7.3	9.2	19.6	17.7	10.4
5	102321.6	148598.1	95	474	1960	3981	2.0	5.5	7.5	19.9	17.9	12.4
5	102317.1	148596.0	100	464	2048	3767	2.0	7.5	9.5	20.1	18.1	10.6
5	102312.5	148593.9	105	454	2135	3767	2.1	7.7	9.7	20.3	18.2	10.6
5	102308.0	148591.8	110	444	2222	3767	2.1	6.0	8.1	20.5	18.4	12.4
5	102303.5	148589.7	115	444	2222	3767	2.1	6.0	8.1	20.7	18.6	12.6
6	102304.5	148590.2	0	417	1995	3714	1.7	5.3	7.0	20.7	19.0	13.7
6	102300.0	148588.1	5	438	1995	3591	1.8	7.2	9.0	20.7	18.9	11.8
6	102295.5	148585.9	10	458	1995	3591	1.8	5.3	7.1	20.8	19.0	13.7
6	102291.0	148583.8	15	479	1994	3591	1.9	6.5	8.4	20.8	18.9	12.4
6	102286.4	148581.6	20	500	1994	3591	2.0	8.0	9.9	20.9	19.0	11.0
6	102281.9	148579.5	25	500	1994	3591	2.0	8.9	10.8	20.9	19.0	10.1
6	102277.4	148577.3	30	541	1951	3591	1.9	9.8	11.7	21.0	19.1	9.3
6	102272.9	148575.2	35	581	1908	3591	1.9	12.2	14.1	21.0	19.1	7.0
6	102268.4	148573.0	40	622	1866	3695	1.8	9.2	11.0	21.0	19.2	10.0
6	102263.9	148570.9	45	663	1823	3695	1.7	7.3	9.0	21.1	19.4	12.1
6	102259.4	148568.7	50	704	1780	3695	1.6	7.7	9.3	20.8	19.2	11.5
6	102254.8	148566.6	55	704	1780	3695	1.6	7.2	8.8	20.5	18.9	11.7

line	easting	northing	station	v1	v2	v3	t1	t2	t1+t2	surface topo	base 1	base 2
				m/s	m/s	m/s	m	m	m	mOD	mOD	mOD
6	102250.3	148564.4	60	679	1697	3695	1.6	5.9	7.5	20.1	18.5	12.6
6	102245.8	148562.3	65	655	1613	3695	1.6	5.6	7.2	19.8	18.2	12.6
6	102241.3	148560.1	70	630	1530	3702	1.6	4.9	6.5	19.4	17.8	12.9
6	102236.8	148558.0	75	605	1447	3702	1.5	4.3	5.8	19.1	17.6	13.3
6	102232.3	148555.8	80	581	1363	3797	1.5	5.8	7.3	18.7	17.2	11.4
6	102227.7	148553.7	85	581	1363	3797	1.5	4.7	6.2	18.3	16.8	12.1
6	102223.2	148551.5	90	598	1333	3797	1.5	4.2	5.7	17.8	16.3	12.1
6	102218.7	148549.4	95	615	1303	4019	1.5	3.6	5.1	17.4	15.9	12.3
6	102214.2	148547.2	100	632	1273	4019	1.5	4.9	6.4	17.0	15.5	10.6
6	102209.7	148545.1	105	649	1242	3926	1.4	4.3	5.7	16.5	15.1	10.8
6	102205.2	148543.0	110	667	1212	3833	1.4	5.4	6.8	16.1	14.7	9.3
6	102200.6	148540.8	115	667	1333	3740	1.4	4.8	6.2	15.7	14.4	9.5
7	102201.6	148541.2	0	500	1500	3792	1.9	3.8	5.6	15.6	13.7	10.0
7	102197.3	148538.6	5	468	1542	3792	1.9	3.8	5.8	15.5	13.6	9.7
7	102193.1	148536.0	10	435	1583	3816	2.0	2.9	4.9	15.3	13.3	10.4
7	102188.8	148533.4	15	403	1625	3816	2.0	2.9	4.9	15.1	13.1	10.2
7	102184.5	148530.8	20	370	1667	3883	2.0	2.5	4.5	15.0	13.0	10.6
7	102180.3	148528.1	25	370	1667	3883	2.0	3.6	5.6	14.8	12.8	9.2
7	102176.0	148525.5	30	375	1578	3883	2.0	3.9	5.9	14.7	12.8	8.9
7	102171.7	148522.9	35	379	1489	3783	1.9	4.4	6.3	14.5	12.6	8.2
7	102167.5	148520.3	40	383	1400	3783	1.9	3.1	4.9	14.4	12.5	9.5
7	102163.2	148517.7	45	388	1311	3783	1.8	3.1	4.9	14.2	12.4	9.3
7	102159.0	148515.1	50	392	1222	3791	1.8	3.2	5.0	14.0	12.2	9.0
7	102154.7	148512.5	55	392	1222	3770	1.8	3.7	5.5	13.9	12.1	8.4
7	102150.4	148509.9	60	390	1222	3770	1.8	4.4	6.2	13.8	12.0	7.6
7	102146.2	148507.3	65	388	1222	3687	1.8	3.7	5.5	13.6	11.8	8.1
7	102141.9	148504.6	70	386	1222	3687	1.8	3.2	5.0	13.5	11.7	8.5
7	102137.6	148502.0	75	383	1222	3687	1.8	3.5	5.3	13.3	11.5	8.0
7	102133.4	148499.4	80	381	1222	3782	1.8	3.6	5.4	13.2	11.4	7.8
7	102129.1	148496.8	85	381	1222	3782	1.8	3.5	5.3	13.1	11.3	7.8
7	102124.9	148494.2	90	416	1200	3775	1.8	3.7	5.5	12.9	11.1	7.4
7	102120.6	148491.6	95	451	1178	3738	1.8	3.9	5.6	12.8	11.0	7.2
7	102116.3	148489.0	100	486	1156	3738	1.7	3.4	5.1	12.7	11.0	7.6
7	102112.1	148486.4	105	521	1133	3738	1.6	3.9	5.5	12.5	10.9	7.0
7	102107.8	148483.8	110	556	1111	3769	1.4	3.7	5.2	12.4	11.0	7.2
7	102103.5	148481.2	115	556	1111	3769	1.4	4.2	5.6	12.2	10.8	6.6
8	102075.8	148459.8	0	444	1100	3500	1.8	2.2	4.1	12.4	10.6	8.3
8	102071.7	148456.9	5	452	1083	3494	1.8	3.0	4.7	12.3	10.5	7.6
8	102067.6	148454.0	10	459	1066	3487	1.7	3.6	5.3	12.2	10.5	6.9
8	102063.5	148451.1	15	467	1049	3481	1.7	2.5	4.1	12.1	10.4	8.0
8	102059.5	148448.3	20	474	1032	3481	1.6	4.6	6.2	12.0	10.4	5.8
8	102055.4	148445.4	25	474	1032	3481	1.6	5.8	7.4	12.0	10.4	4.6
8	102051.3	148442.5	30	449	1033	3481	1.7	5.8	7.5	11.9	10.2	4.4
8	102047.2	148439.6	35	425	1034	3353	1.7	5.1	6.8	11.8	10.1	5.0

line	easting	northing	station	v1	v2	v3	t1	t2	t1+t2	surface topo	base 1	base 2
				m/s	m/s	m/s	m	m	m	mOD	mOD	mOD
8	102043.1	148436.7	40	400	1035	3353	1.7	5.4	7.1	11.7	10.0	4.6
8	102039.0	148433.8	45	375	1036	3353	1.7	4.4	6.1	11.6	9.9	5.5
8	102034.9	148431.0	50	351	1037	3551	1.7	5.2	6.9	11.5	9.8	4.6
8	102030.9	148428.1	55	351	1037	3551	1.7	5.6	7.3	11.4	9.7	4.1
8	102026.8	148425.2	60	342	1074	3551	1.7	4.9	6.7	11.4	9.7	4.8
8	102022.7	148422.3	65	333	1111	3355	1.8	6.4	8.2	11.3	9.5	3.1
8	102018.6	148419.4	70	324	1148	3355	1.9	6.0	7.8	11.2	9.3	3.4
8	102014.5	148416.5	75	315	1185	3355	1.9	4.9	6.8	11.1	9.2	4.3
8	102010.4	148413.7	80	306	1222	3409	2.0	4.4	6.3	11.1	9.2	4.8
8	102006.4	148410.8	85	306	1222	3409	2.0	4.1	6.1	11.0	9.1	4.9
8	102002.3	148407.9	90	328	1274	3409	2.0	4.4	6.4	10.9	8.9	4.5
8	101998.2	148405.0	95	350	1326	3295	2.0	4.4	6.3	10.8	8.8	4.5
8	101994.1	148402.1	100	372	1378	3295	1.9	4.2	6.1	10.8	8.9	4.7
8	101990.0	148399.2	105	394	1430	3118	1.9	3.3	5.2	10.7	8.8	5.5
8	101985.9	148396.4	110	417	1481	3118	1.9	4.1	5.9	10.6	8.8	4.7
8	101981.8	148393.5	115	417	1481	3118	1.9	3.2	5.1	10.5	8.7	5.4
9	101953.1	148498.0	0	417	1667	3050	1.9	3.7	5.7	8.8	6.9	3.1
9	101957.7	148499.9	5	383	1587	3058	2.0	1.9	3.9	8.7	6.7	4.8
9	101962.4	148501.8	10	350	1507	3058	2.0	0.8	2.8	8.7	6.7	5.9
9	101967.0	148503.6	15	317	1427	3162	2.0	1.0	3.0	8.7	6.7	5.7
9	101971.6	148505.5	20	284	1347	3162	2.0	1.3	3.2	8.7	6.7	5.5
9	101976.3	148507.4	25	284	1347	3162	2.0	1.9	3.9	8.7	6.7	4.8
9	101980.9	148509.3	30	334	1348	3162	2.1	3.4	5.5	8.8	6.7	3.3
9	101985.5	148511.2	35	384	1349	3162	2.1	5.8	7.8	8.8	6.8	1.0
9	101990.2	148513.1	40	434	1351	3160	2.0	6.5	8.4	8.8	6.8	0.4
9	101994.8	148514.9	45	484	1352	3160	1.8	7.2	8.9	8.3	6.5	-0.6
9	101999.4	148516.8	50	534	1353	3340	1.5	6.9	8.4	7.7	6.2	-0.7
9	102004.1	148518.7	55	534	1353	3340	1.5	5.5	7.0	7.2	5.7	0.2
9	102008.7	148520.6	60	511	1327	3340	1.6	3.5	5.1	7.3	5.7	2.2
9	102013.3	148522.5	65	487	1300	3340	1.6	2.2	3.8	7.4	5.8	3.6
9	102018.0	148524.3	70	464	1273	3340	1.7	1.8	3.5	7.5	5.8	4.1
9	102022.6	148526.2	75	440	1246	3441	1.7	2.9	4.6	7.6	5.9	3.0
9	102027.2	148528.1	80	417	1220	3317	1.7	2.8	4.5	7.7	6.0	3.2
9	102031.9	148530.0	85	417	1220	3317	1.7	1.6	3.3	7.8	6.1	4.5
9	102036.5	148531.9	90	455	1272	3317	1.7	2.1	3.9	7.9	6.2	4.0
9	102041.1	148533.7	95	492	1324	3251	1.7	4.1	5.8	8.0	6.3	2.2
9	102045.7	148535.6	100	530	1377	3251	1.7	5.1	6.8	8.1	6.4	1.3
9	102050.4	148537.5	105	568	1429	3207	1.7	5.7	7.4	8.2	6.5	0.8
9	102055.0	148539.4	110	606	1481	3207	1.7	5.1	6.8	8.3	6.6	1.5
9	102059.6	148541.3	115	606	1481	3207	1.7	4.0	5.7	8.4	6.7	2.7
10	102060.0	148541.5	0	513	1111	3505	1.5	3.5	5.0	8.4	6.9	3.4
10	102064.4	148543.8	5	500	1200	3505	1.6	4.2	5.8	8.6	7.1	2.8
10	102068.9	148546.1	10	487	1289	3407	1.6	4.0	5.6	8.8	7.2	3.2
10	102073.3	148548.4	15	473	1378	3559	1.6	4.7	6.3	9.0	7.4	2.7

line	easting	northing	station	v1	v2	v3	t1	t2	t1+t2	surface topo	base 1	base 2
				m/s	m/s	m/s	m	m	m	mOD	mOD	mOD
10	102077.8	148550.7	20	460	1467	3582	1.7	5.0	6.6	9.2	7.6	2.6
10	102082.2	148552.9	25	460	1467	3582	1.7	5.1	6.7	9.4	7.8	2.7
10	102086.7	148555.2	30	480	1520	3582	1.7	4.9	6.6	9.6	7.9	3.1
10	102091.1	148557.5	35	500	1572	3760	1.7	3.6	5.3	9.8	8.1	4.5
10	102095.6	148559.8	40	520	1625	3760	1.8	3.8	5.6	10.0	8.2	4.4
10	102100.0	148562.1	45	540	1677	3754	1.8	3.0	4.8	10.2	8.4	5.4
10	102104.5	148564.4	50	559	1730	3754	1.9	4.0	5.8	10.4	8.5	4.6
10	102108.9	148566.7	55	559	1730	3754	1.9	2.7	4.6	10.6	8.7	6.0
10	102113.3	148569.0	60	598	1665	3754	1.8	2.4	4.2	10.7	8.9	6.5
10	102117.8	148571.2	65	636	1601	3754	1.8	4.4	6.1	10.8	9.0	4.7
10	102122.2	148573.5	70	674	1536	3745	1.7	5.0	6.7	11.0	9.3	4.4
10	102126.7	148575.8	75	712	1472	3806	1.6	6.1	7.7	11.1	9.5	3.4
10	102131.1	148578.1	80	750	1407	3806	1.5	5.4	6.9	11.2	9.7	4.3
10	102135.6	148580.4	85	750	1407	3806	1.5	4.3	5.8	11.4	9.9	5.6
10	102140.0	148582.7	90	742	1459	3806	1.4	3.1	4.5	11.5	10.1	7.0
10	102144.5	148585.0	95	733	1511	3631	1.4	2.7	4.1	11.6	10.2	7.5
10	102148.9	148587.3	100	725	1563	3631	1.3	1.6	2.9	11.8	10.5	8.9
10	102153.4	148589.6	105	717	1615	3631	1.3	2.1	3.4	11.9	10.7	8.5
10	102157.8	148591.8	110	708	1667	3691	1.2	3.4	4.6	12.0	10.8	7.4
10	102162.2	148594.1	115	700	1667	3691	1.2	4.4	5.6	12.2	11.0	6.6
11	102161.5	148593.7	0	556	1765	4005	1.8	4.1	5.9	12.2	10.4	6.3
11	102165.5	148596.7	5	572	1609	3984	1.7	4.4	6.0	12.4	10.8	6.4
11	102169.5	148599.7	10	589	1452	3963	1.5	4.5	6.0	12.6	11.1	6.6
11	102173.5	148602.7	15	606	1296	3963	1.4	4.3	5.7	12.8	11.4	7.1
11	102177.5	148605.8	20	606	1296	3963	1.4	5.1	6.5	13.0	11.6	6.5
11	102181.4	148608.8	25	579	1271	3963	1.5	6.4	7.9	13.2	11.7	5.3
11	102185.4	148611.8	30	552	1245	3852	1.5	6.4	7.9	13.4	11.9	5.5
11	102189.4	148614.8	35	525	1220	3852	1.6	5.2	6.8	13.6	12.0	6.8
11	102193.4	148617.8	40	498	1194	3852	1.6	6.4	8.0	13.8	12.2	5.8
11	102197.4	148620.8	45	471	1168	3852	1.6	5.9	7.5	14.0	12.4	6.5
11	102201.4	148623.9	50	444	1143	3960	1.6	5.3	6.9	14.2	12.6	7.3
11	102205.4	148626.9	55	444	1143	3960	1.6	5.0	6.6	14.4	12.8	7.8
11	102209.4	148629.9	60	466	1192	3960	1.9	4.7	6.5	14.7	12.8	8.2
11	102213.3	148632.9	65	487	1241	4010	2.1	3.2	5.3	14.9	12.8	9.6
11	102217.3	148635.9	70	508	1290	4010	2.4	3.4	5.8	15.2	12.8	9.5
11	102221.3	148638.9	75	529	1340	4010	2.6	3.7	6.3	15.4	12.8	9.1
11	102225.3	148642.0	80	550	1389	4009	2.9	2.9	5.8	15.6	12.7	9.8
11	102229.3	148645.0	85	528	1389	4009	2.8	2.9	5.7	15.9	13.1	10.2
11	102233.3	148648.0	90	506	1444	4009	2.6	3.1	5.7	16.1	13.5	10.4
11	102237.3	148651.0	95	483	1500	3934	2.4	3.3	5.7	16.4	14.0	10.7
11	102241.3	148654.0	100	461	1556	3934	2.3	3.5	5.7	16.6	14.4	10.9
11	102245.2	148657.0	105	439	1611	3934	2.1	3.8	5.9	16.9	14.8	11.0
11	102249.2	148660.1	110	417	1667	4018	1.9	3.2	5.1	17.1	15.2	12.0
11	102253.2	148663.1	115	417	1667	4018	1.9	2.7	4.6	17.3	15.4	12.7

line	easting	northing	station	v1	v2	v3	t1	t2	t1+t2	surface topo	base 1	base 2
				m/s	m/s	m/s	m	m	m	mOD	mOD	mOD
12	102252.1	148662.2	0	417	1500	3687	2.0	3.1	5.0	17.3	15.4	12.3
12	102256.5	148664.7	5	441	1500	3632	1.9	1.3	3.3	17.5	15.6	14.3
12	102260.8	148667.1	10	465	1500	3632	1.9	2.0	3.9	17.6	15.7	13.7
12	102265.1	148669.6	15	489	1500	3632	1.8	3.1	4.9	17.7	15.9	12.8
12	102269.5	148672.1	20	513	1500	3763	1.7	4.6	6.3	17.8	16.1	11.5
12	102273.8	148674.5	25	513	1500	3763	1.7	4.4	6.2	18.0	16.3	11.8
12	102278.2	148677.0	30	506	1522	3763	1.8	3.2	5.0	18.1	16.3	13.1
12	102282.5	148679.5	35	499	1543	3675	1.8	3.7	5.5	18.2	16.4	12.7
12	102286.9	148681.9	40	492	1565	3675	1.8	3.0	4.8	18.3	16.5	13.5
12	102291.2	148684.4	45	485	1587	3675	1.9	5.8	7.6	17.7	15.9	10.1
12	102295.6	148686.9	50	479	1609	3819	1.9	6.1	8.0	17.1	15.2	9.1
12	102299.9	148689.3	55	479	1609	3819	1.9	6.4	8.2	16.5	14.6	8.3
12	102304.3	148691.8	60	462	1565	3819	1.9	4.1	6.0	16.0	14.1	10.0
12	102308.6	148694.3	65	445	1521	3819	1.9	4.4	6.2	15.5	13.6	9.3
12	102313.0	148696.7	70	428	1477	3819	1.9	5.1	7.0	15.0	13.1	8.0
12	102317.3	148699.2	75	411	1433	3602	1.9	6.6	8.5	14.4	12.5	6.0
12	102321.7	148701.7	80	394	1389	3602	1.9	6.1	8.0	13.9	12.0	6.0
12	102326.0	148704.1	85	394	1389	3602	1.9	6.1	8.0	13.4	11.5	5.5
12	102330.4	148706.6	90	442	1444	3602	2.2	4.5	6.7	12.9	10.7	6.2
12	102334.7	148709.1	95	571	1500	3602	3.1	4.7	7.8	12.4	9.3	4.6
12	102339.1	148711.5	100	700	1400	3602	4.5	2.1	6.6	11.8	7.4	5.2
12	102343.4	148714.0	105	700	1400	3672	4.5	3.3	7.8	11.3	6.8	3.5
12	102347.8	148716.5	110	700	1400	3672	4.7	3.9	8.5	10.8	6.1	2.3
12	102352.1	148718.9	115	700	1400	3672	4.9	3.5	8.3	10.3	5.5	2.0
13	102403.0	148748.7	0	556	1667	3704	1.8	4.4	6.2	6.0	4.2	-0.2
13	102405.4	148744.3	5	546	1583	3704	1.7	3.0	4.7	6.5	4.8	1.8
13	102407.7	148739.9	10	536	1500	3721	1.6	2.9	4.5	7.0	5.4	2.5
13	102410.0	148735.5	15	526	1417	3721	1.5	4.3	5.8	7.5	6.0	1.7
13	102412.4	148731.0	20	516	1333	3721	1.5	4.5	6.0	8.1	6.6	2.1
13	102414.7	148726.6	25	516	1333	3771	1.5	5.5	7.0	8.6	7.1	1.6
13	102417.1	148722.2	30	513	1333	3771	1.5	4.3	5.8	9.1	7.6	3.3
13	102419.4	148717.8	35	510	1333	3759	1.5	4.9	6.3	9.6	8.2	3.3
13	102421.8	148713.4	40	506	1333	3759	1.4	5.3	6.8	10.1	8.7	3.4
13	102424.1	148709.0	45	503	1333	3759	1.4	5.1	6.5	10.6	9.2	4.1
13	102426.5	148704.6	50	500	1333	3759	1.4	5.3	6.7	11.2	9.8	4.5
13	102428.8	148700.2	55	500	1333	3896	1.4	6.4	7.8	11.7	10.3	3.9
13	102431.2	148695.7	60	535	1366	3896	1.5	6.4	7.8	12.2	10.7	4.4
13	102433.5	148691.3	65	569	1400	3835	1.5	5.3	6.8	12.6	11.1	5.8
13	102435.9	148686.9	70	604	1433	3835	1.5	5.4	6.9	13.1	11.6	6.2
13	102438.2	148682.5	75	639	1466	3835	1.5	6.3	7.8	13.6	12.1	5.8
13	102440.6	148678.1	80	673	1499	3954	1.6	7.4	9.0	14.1	12.6	5.1
13	102442.9	148673.7	85	673	1499	3954	1.6	5.6	7.1	14.6	13.1	7.5
13	102445.3	148669.3	90	628	1532	3954	1.7	4.4	6.1	15.1	13.4	9.0
13	102447.6	148664.8	95	582	1566	3954	1.8	3.9	5.7	15.5	13.7	9.8

line	easting	northing	station	v1	v2	v3	t1	t2	t1+t2	surface topo	base 1	base 2
				m/s	m/s	m/s	m	m	m	mOD	mOD	mOD
13	102450.0	148660.4	100	536	1600	3954	1.9	0.7	2.5	16.0	14.1	13.5
13	102452.3	148656.0	105	490	1633	3954	1.9	3.0	4.9	16.5	14.6	11.6
13	102454.7	148651.6	110	444	1667	4126	1.9	1.6	3.5	17.0	15.1	13.5
13	102457.0	148647.2	115	444	1667	4126	1.9	4.1	6.0	17.5	15.6	11.5
14	102456.0	148649.3	0	417	1666	3800	2.0	4.9	6.8	17.5	15.5	10.7
14	102458.6	148645.0	5	400	1583	3801	1.9	4.2	6.1	17.9	16.0	11.8
14	102461.1	148640.7	10	384	1500	3935	1.9	3.6	5.5	18.4	16.5	12.9
14	102463.7	148636.4	15	368	1417	4037	1.8	4.1	5.9	18.8	17.0	12.9
14	102466.2	148632.1	20	352	1333	4037	1.8	6.3	8.1	19.2	17.4	11.1
14	102468.8	148627.8	25	352	1333	4237	1.8	6.9	8.7	19.7	17.9	11.0
14	102471.3	148623.5	30	370	1311	4237	1.8	6.1	7.9	20.1	18.3	12.3
14	102473.9	148619.2	35	389	1289	4144	1.8	4.9	6.6	20.6	18.8	14.0
14	102476.4	148614.9	40	407	1267	4144	1.8	4.9	6.6	21.0	19.2	14.4
14	102479.0	148610.6	45	426	1244	4144	1.7	5.5	7.2	21.4	19.7	14.2
14	102481.5	148606.3	50	444	1222	4266	1.7	4.5	6.2	21.9	20.2	15.7
14	102484.1	148602.0	55	444	1222	4266	1.7	4.2	5.9	22.3	20.6	16.4
14	102486.6	148597.7	60	473	1377	4266	1.8	3.8	5.7	22.7	20.9	17.1
14	102489.2	148593.4	65	502	1533	4296	2.0	5.3	7.3	23.1	21.1	15.8
14	102491.7	148589.1	70	531	1688	4296	2.1	5.5	7.7	23.4	21.3	15.8
14	102494.3	148584.8	75	560	1843	4381	2.3	6.2	8.5	23.8	21.5	15.3
14	102496.8	148580.5	80	589	1999	4381	2.5	6.5	9.0	24.2	21.7	15.2
14	102499.4	148576.2	85	589	1999	4381	2.5	5.5	7.9	24.6	22.1	16.7
14	102501.9	148571.9	90	560	2043	4381	2.4	4.8	7.2	25.0	22.6	17.8
14	102504.5	148567.6	95	531	2088	4442	2.3	4.6	6.9	25.3	23.0	18.4
14	102507.0	148563.3	100	502	2133	4442	2.2	2.4	4.6	25.7	23.5	21.1
14	102509.6	148559.0	105	473	2177	4442	2.1	3.2	5.3	26.1	24.0	20.8
14	102512.1	148554.7	110	444	2222	4292	2.0	2.6	4.6	26.5	24.5	21.9
14	102514.7	148550.4	115	444	2222	4292	2.0	3.5	5.6	26.9	24.9	21.3
15	102498.1	148576.6	200	444	2000	4193	1.6	4.6	6.2	24.1	22.5	17.9
15	102500.7	148572.3	205	458	1967	4193	1.7	3.4	5.1	24.5	22.9	19.4
15	102503.3	148568.1	210	472	1933	4193	1.7	2.3	4.0	25.0	23.3	21.0
15	102506.0	148563.8	215	486	1900	4193	1.8	1.6	3.4	25.5	23.7	22.2
15	102508.6	148559.5	220	500	1867	4193	1.8	1.0	2.8	25.9	24.1	23.1
15	102511.2	148555.3	225	500	1833	4068	1.6	3.3	4.8	26.4	24.8	21.6
15	102513.8	148551.0	230	548	1800	4068	1.3	6.4	7.6	26.9	25.7	19.3
15	102516.4	148546.8	235	596	1767	3806	1.3	6.3	7.7	27.3	26.0	19.6
15	102519.0	148542.5	240	644	1733	3806	1.4	7.1	8.6	27.7	26.3	19.2
15	102521.7	148538.2	245	693	1700	3806	1.5	6.2	7.7	28.1	26.6	20.4
15	102524.3	148534.0	250	741	1667	3887	1.6	4.8	6.3	28.5	27.0	22.2
15	102526.9	148529.7	255	741	1667	3887	1.6	3.6	5.2	29.0	27.5	23.8
16	102633.4	148582.1	0	370	833	3628	1.6	3.5	5.1	30.6	29.1	25.5
16	102630.9	148586.4	5	411	878	3628	1.5	4.8	6.4	30.2	28.7	23.9
16	102628.4	148590.7	10	452	922	3727	1.5	5.1	6.6	29.9	28.4	23.3
16	102625.9	148595.1	15	493	966	3727	1.4	5.9	7.3	29.5	28.1	22.2

line	easting	northing	station	v1	v2	v3	t1	t2	t1+t2	surface topo	base 1	base 2
				m/s	m/s	m/s	m	m	m	mOD	mOD	mOD
16	102623.4	148599.4	20	534	1011	3994	1.2	5.5	6.7	29.2	28.0	22.5
16	102620.9	148603.7	25	534	1011	3994	1.2	5.5	6.7	28.8	27.6	22.1
16	102618.3	148608.0	30	517	1118	3994	1.4	4.8	6.2	28.5	27.1	22.3
16	102615.8	148612.4	35	499	1225	3903	1.5	4.4	5.9	28.1	26.6	22.2
16	102613.3	148616.7	40	482	1332	3903	1.6	4.5	6.2	27.7	26.1	21.6
16	102610.8	148621.0	45	464	1439	3903	1.8	5.1	6.9	27.4	25.7	20.5
16	102608.3	148625.3	50	446	1546	3978	1.9	3.4	5.2	27.0	25.2	21.8
16	102605.8	148629.7	55	446	1546	3978	1.9	3.6	5.4	26.7	24.9	21.3
16	102603.3	148634.0	60	446	1596	3978	1.9	4.2	6.1	26.2	24.3	20.1
16	102600.8	148638.3	65	446	1645	3905	2.0	4.0	6.0	25.8	23.9	19.8
16	102598.3	148642.6	70	446	1694	3905	2.0	2.5	4.5	25.4	23.4	20.9
16	102595.7	148647.0	75	446	1743	3905	2.1	2.3	4.4	24.9	22.9	20.6
16	102593.2	148651.3	80	446	1793	3905	2.1	2.6	4.7	24.5	22.4	19.8
16	102590.7	148655.6	85	446	1793	4023	2.1	3.0	5.1	24.0	21.9	19.0
16	102588.2	148659.9	90	440	1824	4023	2.1	2.6	4.7	23.6	21.5	18.9
16	102585.7	148664.2	95	435	1854	3980	2.0	3.3	5.4	23.2	21.2	17.8
16	102583.2	148668.6	100	429	1885	3980	2.0	1.4	3.4	22.7	20.7	19.3
16	102580.7	148672.9	105	423	1916	3999	2.0	4.3	6.3	22.3	20.3	16.0
16	102578.2	148677.2	110	417	1947	4004	1.9	3.4	5.4	21.8	19.9	16.4
16	102575.7	148681.5	115	417	1667	3854	2.0	2.4	4.4	21.4	19.4	17.0
17	102576.2	148680.7	0	417	1667	3950	1.9	3.9	5.9	21.4	19.5	15.5
17	102573.3	148684.8	5	445	1667	3948	2.1	5.6	7.7	21.1	19.0	13.4
17	102570.5	148688.9	10	473	1667	4015	2.3	5.6	7.9	20.9	18.6	13.0
17	102567.6	148693.0	15	501	1667	4015	2.5	5.0	7.5	20.6	18.1	13.1
17	102564.7	148697.1	20	529	1667	4100	2.7	5.7	8.4	20.3	17.6	11.9
17	102561.9	148701.2	25	529	1667	4100	2.7	5.3	8.1	20.0	17.3	12.0
17	102559.0	148705.3	30	530	1772	4100	2.5	5.9	8.4	19.8	17.3	11.4
17	102556.1	148709.4	35	531	1878	4040	2.4	6.6	9.0	19.5	17.2	10.5
17	102553.3	148713.5	40	532	1983	4128	2.2	7.3	9.4	19.2	17.0	9.8
17	102550.4	148717.6	45	533	2089	4128	2.0	7.1	9.1	18.9	16.9	9.8
17	102547.5	148721.7	50	534	2194	4128	1.8	10.1	11.9	18.7	16.9	6.8
17	102544.7	148725.8	55	534	2194	4128	1.8	10.7	12.5	18.4	16.6	5.9
17	102541.8	148729.9	60	511	2055	4128	1.8	10.2	12.0	17.9	16.1	5.9
17	102538.9	148734.0	65	488	1916	4128	1.9	5.6	7.4	17.4	15.5	10.0
17	102536.1	148738.1	70	465	1778	4128	1.9	5.9	7.7	16.9	15.0	9.2
17	102533.2	148742.2	75	441	1639	4128	1.9	3.6	5.5	16.4	14.5	11.0
17	102530.3	148746.2	80	453	1500	4066	2.1	3.7	5.8	15.9	13.9	10.2
17	102527.5	148750.3	85	465	1500	4005	2.1	3.8	5.9	15.3	13.2	9.4
17	102524.6	148754.4	90	477	1472	3921	2.2	4.6	6.8	14.8	12.6	8.0
17	102521.7	148758.5	95	488	1444	3837	2.3	3.3	5.5	14.1	11.9	8.6
17	102518.9	148762.6	100	500	1417	3753	2.3	4.4	6.8	13.4	11.1	6.6
17	102516.0	148766.7	105	472	1389	3668	2.2	4.4	6.6	12.6	10.4	6.0
17	102513.1	148770.8	110	444	1361	3584	2.1	4.2	6.3	11.9	9.8	5.6
17	102510.3	148774.9	115	444	1333	3500	2.1	2.9	5.0	11.2	9.1	6.3

line	easting	northing	station	v1	v2	v3	t1	t2	t1+t2	surface topo	base 1	base 2
				m/s	m/s	m/s	m	m	m	mOD	mOD	mOD
18	102524.3	148754.1	0	612	1333	3538	2.1	4.2	6.3	14.8	12.7	8.5
18	102521.5	148758.2	5	588	1375	3538	2.2	1.9	4.1	14.1	11.9	10.1
18	102518.7	148762.4	10	564	1417	3494	2.3	3.7	6.0	13.4	11.2	7.4
18	102515.9	148766.5	15	540	1458	3494	2.3	3.0	5.3	12.6	10.3	7.3
18	102513.1	148770.7	20	516	1500	3534	2.4	2.8	5.2	11.9	9.5	6.7
18	102510.3	148774.8	25	523	1500	3534	2.4	2.8	5.2	11.2	8.8	6.0
18	102507.5	148778.9	30	529	1533	3534	2.3	2.4	4.7	10.5	8.2	5.8
18	102504.7	148783.1	35	536	1567	3770	2.2	2.3	4.4	9.9	7.7	5.5
18	102501.9	148787.2	40	542	1600	3770	2.0	2.7	4.7	9.3	7.3	4.6
18	102499.0	148791.3	45	549	1633	3770	1.9	1.8	3.7	8.6	6.7	4.9
18	102496.2	148795.5	50	556	1667	3830	1.8	2.8	4.6	8.0	6.2	3.4
18	102493.4	148799.6	55	556	1667	3830	1.8	5.6	7.4	7.3	5.5	-0.1
19	102717.7	148631.7	0	600	1666	3808	1.9	1.9	3.8	31.2	29.3	27.4
19	102715.1	148636.0	5	603	1666	3808	1.8	2.0	3.8	31.0	29.2	27.2
19	102712.6	148640.3	10	606	1666	3808	1.7	1.4	3.1	30.7	29.0	27.6
19	102710.0	148644.6	15	608	1667	3808	1.6	5.0	6.6	30.5	28.9	24.0
19	102707.4	148648.9	20	611	1667	4035	1.5	7.6	9.0	30.2	28.7	21.2
19	102704.9	148653.2	25	611	1667	4035	1.5	6.7	8.2	30.0	28.5	21.8
19	102702.3	148657.5	30	635	1630	4253	1.4	4.8	6.1	29.7	28.3	23.6
19	102699.8	148661.7	35	660	1593	4253	1.2	5.9	7.2	29.4	28.2	22.2
19	102697.2	148666.0	40	684	1556	4253	1.1	5.9	7.0	29.2	28.1	22.2
19	102694.6	148670.3	45	708	1519	4176	0.9	8.0	9.0	28.9	28.0	20.0
19	102692.1	148674.6	50	733	1481	4176	0.7	5.9	6.6	28.7	28.0	22.1
19	102689.5	148678.9	55	733	1481	4176	0.7	8.2	8.9	28.4	27.7	19.5
19	102686.9	148683.2	60	711	1630	4145	1.0	8.8	9.8	28.6	27.6	18.8
19	102684.4	148687.5	65	690	1778	4145	1.3	6.7	8.0	28.8	27.6	20.8
19	102681.8	148691.8	70	668	1926	4145	1.5	5.8	7.3	29.0	27.5	21.7
19	102679.2	148696.1	75	647	2074	4327	1.7	4.4	6.1	28.4	26.7	22.3
19	102676.7	148700.4	80	625	2222	4327	1.9	3.2	5.1	27.9	26.0	22.8
19	102674.1	148704.7	85	625	2134	4327	1.9	3.9	5.8	27.3	25.4	21.5
19	102671.5	148709.0	90	633	2047	4327	1.8	2.2	4.1	26.8	25.0	22.8
19	102669.0	148713.3	95	642	1959	4327	1.8	3.6	5.4	26.2	24.4	20.8
19	102666.4	148717.5	100	650	1871	4342	1.7	4.9	6.6	25.7	24.0	19.1
19	102663.9	148721.8	105	658	1784	4066	1.7	4.5	6.2	25.1	23.4	18.9
19	102661.3	148726.1	110	667	1696	3967	1.7	5.2	6.8	24.5	22.9	17.7
19	102658.7	148730.4	115	667	1696	3967	1.7	3.8	5.4	24.0	22.4	18.6
20	102659.2	148729.6	0	556	1666	3609	1.5	2.6	4.1	24.0	22.5	19.9
20	102656.8	148734.0	5	613	1669	3718	1.5	3.1	4.6	23.8	22.3	19.2
20	102654.3	148738.3	10	671	1671	3718	1.5	5.0	6.5	23.6	22.1	17.1
20	102651.9	148742.7	15	729	1674	4201	1.5	4.2	5.7	23.4	21.9	17.7
20	102649.4	148747.0	20	787	1677	4201	1.5	4.4	5.9	23.2	21.7	17.3
20	102647.0	148751.4	25	787	1677	4201	1.5	4.7	6.2	23.0	21.5	16.8
20	102644.6	148755.8	30	736	1632	4201	1.6	2.3	3.9	22.8	21.2	18.9
20	102642.1	148760.1	35	686	1587	4201	1.6	0.7	2.3	22.6	21.0	20.3

line	easting	northing	station	v1	v2	v3	t1	t2	t1+t2	surface topo	base 1	base 2
				m/s	m/s	m/s	m	m	m	mOD	mOD	mOD
20	102639.7	148764.5	40	635	1542	4201	1.7	0.3	1.9	22.4	20.7	20.5
20	102637.2	148768.9	45	585	1497	4151	1.7	1.9	3.6	21.7	20.0	18.2
20	102634.8	148773.2	50	534	1452	4233	1.7	0.6	2.3	21.0	19.4	18.7
20	102632.4	148777.6	55	534	1452	4233	1.7	2.4	4.0	20.2	18.6	16.2
20	102629.9	148782.0	60	571	1488	4233	1.7	3.5	5.2	19.4	17.7	14.3
20	102627.5	148786.3	65	608	1524	4194	1.7	4.4	6.1	18.6	16.9	12.5
20	102625.0	148790.7	70	645	1560	4194	1.7	4.0	5.7	17.8	16.1	12.2
20	102622.6	148795.1	75	683	1595	4194	1.7	4.6	6.3	17.0	15.3	10.8
20	102620.2	148799.4	80	720	1631	4353	1.6	4.7	6.4	16.2	14.6	9.9
20	102617.7	148803.8	85	720	1631	4353	1.6	4.4	6.0	15.4	13.8	9.4
20	102615.3	148808.1	90	687	1637	4353	1.6	3.6	5.2	14.8	13.2	9.6
20	102612.8	148812.5	95	654	1643	4244	1.6	3.3	4.9	14.2	12.6	9.3
20	102610.4	148816.9	100	621	1649	4293	1.5	2.5	4.0	13.5	12.0	9.5
20	102608.0	148821.2	105	588	1654	4293	1.5	3.7	5.2	12.9	11.4	7.7
20	102605.5	148825.6	110	556	1660	4293	1.4	4.2	5.6	12.2	10.8	6.6
20	102603.1	148830.0	115	556	1666	4451	1.5	1.4	2.9	11.6	10.1	8.7
21	102618.3	148803.4	0	513	1667	4190	1.4	2.6	4.0	15.4	14.1	11.5
21	102616.1	148807.9	5	513	1667	3762	1.4	4.2	5.6	14.9	13.6	9.3
21	102613.9	148812.4	10	513	1667	3762	1.4	2.8	4.2	14.3	13.0	10.1
21	102611.6	148816.8	15	513	1666	3762	1.4	1.9	3.2	13.8	12.5	10.6
21	102609.4	148821.3	20	513	1666	3762	1.4	4.7	6.0	13.2	11.9	7.2
21	102607.2	148825.8	25	513	1666	3934	1.4	3.6	5.0	12.7	11.4	7.7
21	102605.0	148830.3	30	531	1666	4134	1.4	2.6	4.0	12.2	10.8	8.2
21	102602.7	148834.7	35	550	1666	4134	1.5	2.9	4.4	11.6	10.1	7.2
21	102600.5	148839.2	40	569	1666	4134	1.5	0.6	2.2	11.1	9.6	9.0
21	102598.3	148843.7	45	587	1666	4134	1.6	3.6	5.1	10.5	8.9	5.4
21	102596.1	148848.2	50	606	1666	4134	1.6	2.5	4.2	10.0	8.4	5.8
21	102593.8	148852.7	55	606	1666	4162	1.6	1.6	3.2	9.4	7.8	6.2
22	102790.1	148715.1	0	741	2222	3700	1.6	7.9	9.4	27.4	25.8	18.0
22	102787.5	148719.4	5	691	1944	3672	1.5	7.8	9.2	27.0	25.5	17.8
22	102785.0	148723.7	10	641	1667	3672	1.4	5.6	7.0	26.7	25.4	19.7
22	102782.4	148728.0	15	591	1389	3997	1.3	5.6	6.8	26.3	25.1	19.5
22	102779.8	148732.3	20	541	1111	3997	1.2	4.8	5.9	26.0	24.8	20.1
22	102777.3	148736.6	25	541	1111	3997	1.2	4.8	5.9	25.6	24.4	19.7
22	102774.7	148740.8	30	560	1269	3739	1.2	5.4	6.6	25.3	24.1	18.7
22	102772.2	148745.1	35	579	1427	3836	1.2	5.8	7.1	24.9	23.7	17.8
22	102769.6	148749.4	40	598	1585	3836	1.3	6.6	7.9	24.6	23.3	16.7
22	102767.0	148753.7	45	617	1743	3919	1.3	9.0	10.3	24.2	22.9	13.9
22	102764.5	148758.0	50	636	1901	3919	1.4	9.2	10.6	23.9	22.5	13.3
22	102761.9	148762.3	55	636	1901	3919	1.4	7.7	9.1	23.5	22.1	14.4
22	102759.3	148766.6	60	642	1888	3919	1.4	7.3	8.8	23.2	21.8	14.4
22	102756.8	148770.9	65	648	1874	3919	1.5	6.0	7.5	22.8	21.3	15.3
22	102754.2	148775.2	70	655	1861	4160	1.6	5.0	6.5	22.4	20.9	15.9
22	102751.6	148779.5	75	661	1847	3868	1.6	5.9	7.5	22.1	20.5	14.6

line	easting	northing	station	v1	v2	v3	t1	t2	t1+t2	surface topo	base 1	base 2
				m/s	m/s	m/s	m	m	m	mOD	mOD	mOD
22	102749.1	148783.8	80	667	1834	3868	1.7	6.5	8.1	21.7	20.0	13.6
22	102746.5	148788.1	85	667	1834	3868	1.7	7.3	8.9	21.3	19.6	12.4
22	102743.9	148792.4	90	681	1861	3868	1.7	7.4	9.1	21.0	19.3	11.9
22	102741.4	148796.7	95	696	1889	3868	1.7	8.0	9.7	20.6	18.9	10.9
22	102738.8	148800.9	100	711	1917	3868	1.7	9.0	10.8	20.2	18.5	9.4
22	102736.3	148805.2	105	726	1945	3965	1.8	7.6	9.4	19.8	18.0	10.4
22	102733.7	148809.5	110	741	1972	3938	1.8	6.0	7.8	19.5	17.7	11.7
22	102731.1	148813.8	115	741	2000	4091	1.8	6.0	7.8	19.1	17.3	11.3
23	102731.5	148813.2	0	606	1800	4200	1.6	6.0	7.6	19.1	17.5	11.5
23	102729.0	148817.5	5	597	1794	4188	1.6	6.9	8.6	18.8	17.2	10.3
23	102726.6	148821.9	10	589	1789	4177	1.7	7.8	9.5	18.4	16.7	8.9
23	102724.1	148826.2	15	580	1783	4165	1.8	8.7	10.4	18.1	16.3	7.7
23	102721.6	148830.6	20	571	1778	4165	1.8	7.6	9.4	17.8	16.0	8.4
23	102719.1	148834.9	25	571	1778	4165	1.8	7.8	9.6	17.5	15.7	7.9
23	102716.7	148839.3	30	560	1785	4189	1.8	6.0	7.8	17.1	15.3	9.3
23	102714.2	148843.6	35	548	1792	3984	1.8	5.8	7.5	16.8	15.0	9.3
23	102711.7	148848.0	40	536	1798	3984	1.8	5.7	7.5	16.5	14.7	9.0
23	102709.3	148852.3	45	525	1805	3984	1.8	4.9	6.6	16.1	14.4	9.5
23	102706.8	148856.7	50	513	1812	3984	1.7	3.9	5.7	15.8	14.1	10.2
23	102704.3	148861.0	55	513	1812	3984	1.7	4.0	5.8	15.5	13.8	9.7
23	102701.8	148865.4	60	544	1782	3888	1.7	5.3	7.0	15.1	13.4	8.1
23	102699.4	148869.7	65	574	1752	3888	1.7	3.6	5.3	14.8	13.1	9.5
23	102696.9	148874.1	70	605	1723	3888	1.7	4.1	5.8	14.5	12.8	8.7
23	102694.4	148878.4	75	636	1693	3888	1.7	5.1	6.8	14.1	12.4	7.3
23	102692.0	148882.7	80	667	1663	4154	1.6	5.8	7.4	13.4	11.8	6.0
23	102689.5	148887.1	85	667	1663	4154	1.6	6.5	8.2	12.7	11.1	4.5
23	102687.0	148891.4	90	644	1663	4154	1.7	6.2	7.9	12.0	10.3	4.1
23	102684.5	148895.8	95	622	1664	4022	1.7	5.0	6.7	11.2	9.5	4.6
23	102682.1	148900.1	100	600	1664	4022	1.7	2.7	4.4	10.3	8.6	5.9
23	102679.6	148904.5	105	578	1665	4022	1.7	2.5	4.2	9.3	7.6	5.1
23	102677.1	148908.8	110	556	1665	4022	1.7	3.3	5.0	8.4	6.7	3.4
23	102674.7	148913.2	115	556	1666	4190	1.8	3.8	5.6	7.4	5.6	1.8
			Minimum	284	815	3050	0.7	0.3	1.9	6.0	4.2	-0.7
			Maximum	787	2222	4997	4.9	12.2	14.1	31.2	29.3	27.6
			Average	508	1467	3905	1.8	4.8	6.6	17.8	16.0	11.2

APPENDIX A:III S-WAVE SEISMIC REFRACTION DATA WAS DETERMINED BY THE MASW METHOD.

S1			S2			S3			S4		
Depth m	**Vs m/s**	**Gmax MPa**	**Depth m**	**Vs m/s**	**Gmax MPa**	**Depth m**	**Vs m/s**	**Gmax MPa**	**Depth m**	**Vs m/s**	**Gmax MPa**
0.00	203	90	0.00	439	421	1.70	323	228	0.74	411	368
0.21	203	90	0.68	439	421	2.87	323	228	1.25	411	368
0.21	233	119	0.68	453	447	2.87	449	439	1.25	330	238
0.48	233	119	1.52	453	447	5.13	449	439	1.89	330	238
0.48	223	108	1.52	378	312	5.13	665	965	1.89	466	474
0.81	223	108	2.58	378	312	7.30	665	965	2.33	466	474
0.81	151	50	2.58	303	200	7.30	803	***1741***	2.33	510	567
1.22	151	50	3.90	303	200	10.02	803	***1741***	3.53	510	567
1.22	145	46	3.90	501	547	10.02	924	***2304***	3.53	680	1008
1.74	145	46	5.56	501	547	13.41	924	***2304***	5.02	680	1008
1.74	289	182	5.56	643	902	13.41	1091	***3212***	5.02	993	***2664***
2.38	289	182	7.62	643	***1117***	17.66	1091	***3212***	6.89	993	***2664***
2.38	324	229	7.62	756	***1543***	17.66	1224	***4046***	6.89	1117	***3371***
3.19	324	229	10.20	756	***1543***	22.96	1224	***4046***	9.23	1117	***3371***
3.19	456	453	10.20	816	***1799***		1342		9.23	1284	***4452***
4.62	456	453	13.43	816	***1799***		1417		12.14	1284	***4452***
4.62	555	670	13.43	837	***1890***				12.14	1483	***5934***
6.57	555	670	17.47	837	***1890***				15.79	1483	***5934***
6.57	768	***1593***									
9.01	768	***1593***									
9.01	856	***1979***									
12.07	856	***1979***									
12.07	1038	***2912***									
15.88	1038	***2912***									
15.88	1255	***4255***									
20.65	1255	***4255***									

indicates rock density of 2700kg/m³
Gmax: Measures small strain shear stiffness of the ground

S5			**S6**			**S7**		
Depth m	**Vs m/s**	**Gmax MPa**	**Depth m**	**Vs m/s**	**Gmax MPa**	**Depth m**	**Vs m/s**	**Gmax MPa**
0.00	377	310	1.38	626	783	1.18	222	98
0.34	377	310	2.34	626	***1057***	2.01	222	98
0.34	391	334	2.34	572	***884***	2.01	477	455
0.75	391	334	3.54	572	***884***	3.04	477	455
0.75	381	317	3.54	769	***1595***	3.04	513	527
1.28	381	317	5.04	769	***1595***	4.32	513	527
1.28	317	219	5.04	1008	***2745***	4.32	702	987
1.93	317	219	6.92	1008	***2745***	5.93	702	***1332***
1.93	288	181	6.92	1063	***3049***	5.93	899	***2182***
2.75	288	181	9.26	1063	***3049***	7.93	899	***2182***
2.75	422	388	9.26	973	***2557***	7.93	1032	***2876***
3.77	422	388	12.19	973	***2557***	10.44	1032	***2876***
3.77	552	664	12.19	1117	***3367***	10.44	1177	***3741***
5.04	552	664	15.86	1117	***3367***	13.58	1177	***3741***
5.04	600	785	15.86	1441	***5608***	13.58	1411	***5375***
6.64	600	785	19.82	1441	***5608***	16.98	1411	***5375***
6.64	712	1104						
8.63	712	***1367***						
8.63	1000	***2698***						
10.79	1000	***2698***						

indicates rock density of 2700kg/m³

Gmax: Measures small strain shear stiffness of the ground

S8			S9			S10			S11		
Depth m	**Vs m/s**	**Gmax MPa**	**Depth m**	**Vs m/s**	**Gmax MPa**	**Depth m**	**Vs m/s**	**Gmax MPa**	**Depth m**	**Vs m/s**	**Gmax MPa**
0.00	238	123	0.00	360	282	0.00	445	432	1.46	244	130
0.22	238	123	0.75	360	282	0.50	445	432	2.48	244	130
0.22	247	133	0.75	364	289	0.50	451	443	2.48	620	838
0.49	247	133	1.69	364	289	1.13	451	443	3.75	620	838
0.49	225	110	1.69	290	184	1.13	409	365	3.75	583	740
0.83	225	110	2.86	290	184	1.91	409	365	5.34	583	740
0.83	183	73	2.86	218	104	1.91	342	254	5.34	863	***2010***
1.26	183	73	4.33	218	104	2.89	342	254	7.32	863	***2010***
1.26	188	77	4.33	322	226	2.89	410	366	7.32	1056	***3013***
1.80	188	77	6.17	322	***280***	4.12	410	366	9.80	1056	***3013***
1.80	279	169	6.17	453	***554***	4.12	624	850	9.80	1220	***4019***
2.47	279	169	8.46	453	***554***	5.65	624	850	12.90	1220	***4019***
2.47	354	274	8.46	516	***720***	5.65	745	***1498***	12.90	1339	***4843***
3.30	354	274	11.32	516	***720***	7.56	745	***1498***	16.77	1339	***4843***
3.30	416	376	11.32	544	***798***	7.56	878	***2080***			
4.35	416	376	14.91	544	***798***	9.96	878	***2080***			
4.35	403	354	14.91	740	***1480***	9.96	910	***2234***			
5.65	403	354	19.39	740	***1480***	12.95	910	***2234***			
5.65	605	***989***				12.95	1226	***4057***			
8.90	605	***989***				16.19	1226	***4057***			
8.90	921	***2289***									
12.22	921	***2289***									
12.22	1057	***3017***									
16.36	1057	***3017***									
16.36	1238	***4139***									
21.53	1238	***4139***									
21.53	1355	***4954***									
28.00	1355	***4954***									

indicates rock density of 2700kg/m³
Gmax: Measures small strain shear stiffness of the ground

S12			**S13**			**S14**		
Depth m	**Vs m/s**	**Gmax MPa**	**Depth m**	**Vs m/s**	**Gmax MPa**	**Depth m**	**Vs m/s**	**Gmax MPa**
1.22	314	198	0.70	312	212	1.98	679	922
1.84	314	198	1.57	312	212	3.36	679	***922***
1.84	340	***311***	1.57	554	668	3.36	646	***836***
2.62	340	***311***	2.65	554	668	5.08	646	***836***
2.62	488	***643***	2.65	817	1456	5.08	1323	***3503***
3.59	488	***643***	4.01	817	1456	7.24	1323	***3503***
3.59	573	***887***	4.01	815	1448	7.24	1438	***4138***
4.69	573	***887***	5.71	815	1448	9.93	1438	***4138***
4.69	729	***1437***	5.71	1246	***4190***	9.93	1686	***5687***
7.09	729	***1437***	7.84	1246	***4190***	13.29	1686	***5687***
7.09	960	***2488***	7.84	1490	***5998***	13.29	2042	***8337***
10.10	960	***2488***	10.49	1490	***5998***	17.49	2042	***8337***
10.10	1208	***3939***	10.49	1700	***7798***			
13.85	1208	***3939***	13.81	1700	***7798***			
13.85	1385	***5178***	13.81	1725	***8031***			
18.54	1385	***5178***	17.96	1725	***8031***			
18.54	1660	***7441***						
24.41	1660	***7441***						
24.41	1908	***9832***						
31.74	1908	***9832***						

indicates rock density of 2700kg/m³
Gmax: Measures small strain shear stiffness of the ground

S15			S16			S17			S18		
Depth m	**Vs m/s**	**Gmax MPa**	**Depth m**	**Vs m/s**	**Gmax MPa**	**Depth m**	**Vs m/s**	**Gmax MPa**	**Depth m**	**Vs m/s**	**Gmax MPa**
2.33	955	***2461***	0.00	360	283	0.84	391	306	1.53	437	417
3.52	955	***2461***	0.14	360	283	1.27	391	306	***2.59***	***437***	***517***
3.52	903	***2203***	0.14	390	331	1.27	356	253	***2.59***	***473***	***605***
5.02	903	***2203***	0.33	390	331	1.81	356	253	***3.91***	***473***	***605***
5.02	1086	***3187***	0.33	392	335	1.81	465	***583***	***3.91***	***671***	***1214***
6.88	1086	***3187***	0.55	392	335	2.48	465	***583***	***5.57***	***671***	***1214***
6.88	1504	***6109***	0.55	343	257	2.48	742	***1485***	***5.57***	***913***	***2251***
9.21	1504	***6109***	0.83	343	257	3.32	742	***1485***	***7.64***	***913***	***2251***
9.21	1752	***8284***	0.83	294	189	3.32	928	***2326***	***7.64***	***1105***	***3294***
12.13	1752	***8284***	1.19	294	189	4.38	928	***2326***	***10.22***	***1105***	***3294***
12.13	2067	***11541***	1.19	302	199	4.38	1055	***3006***	***10.22***	***1288***	***4482***
15.77	2067	***11541***	1.63	302	199	5.69	1055	***3006***	***13.46***	***1288***	***4482***
			1.63	503	552	5.69	1298	***4547***	***13.46***	***1549***	***6475***
			2.18	503	***684***	8.75	1298	***4547***	***17.50***	***1549***	***6475***
			2.18	580	***909***	8.75	1583	***6767***			
			2.87	580	***909***	11.71	1583	***6767***			
			2.87	703	***1332***	11.71	1828	***9023***			
			3.74	703	***1332***	15.42	1828	***9023***			
			3.74	819	***1811***	15.42	1805	***8798***			
			5.56	819	***1811***	20.05	1805	***8798***			
			5.56	1260	***4285***						
			7.63	1260	***4285***						
			7.63	1459	***5744***						
			10.22	1459	***5744***						
			10.22	1713	***7918***						
			13.45	1713	***7918***						
			13.45	1859	***9327***						
			17.49	1859	***9327***						

indicates rock density of 2700kg/m³
Gmax: Measures small strain shear stiffness of the ground

S19			S20			S21		
Depth m	**Vs m/s**	**Gmax MPa**	**Depth m**	**Vs m/s**	**Gmax MPa**	**Depth m**	**Vs m/s**	**Gmax MPa**
1.75	898	1759	0.44	270	159	2.39	1028	***2851***
2.64	898	***2179***	0.74	270	159	3.62	1028	***2851***
2.64	850	***1951***	0.74	315	217	3.62	948	***2426***
3.76	850	***1951***	1.11	315	217	5.15	948	***2426***
3.76	922	***2293***	1.11	528	***754***	5.15	1032	***2874***
5.16	922	***2293***	1.59	528	***754***	7.07	1032	***2874***
5.16	1323	***4728***	1.59	611	***1007***	7.07	1506	***6128***
6.91	1323	***4728***	2.18	611	***1007***	9.47	1506	***6128***
6.91	1565	***6616***	2.18	521	***734***	9.47	1774	***8497***
9.09	1565	***6616***	2.91	521	***734***	12.46	1774	***8497***
9.09	1545	***6445***	2.91	642	***1112***	12.46	2093	***11825***
11.82	1545	***6445***	3.44	642	***1112***	16.20	2093	***11825***
			3.44	952	***2448***			
			5.20	952	***2448***			
			5.20	960	***2486***			
			7.41	960	***2486***			
			7.41	1386	***5185***			
			10.16	1386	***5185***			
			10.16	1676	***7583***			
			13.60	1676	***7583***			
			13.60	1868	***9424***			
			17.90	1868	***9424***			
			17.90	1837	***9108***			
			23.28	1837	***9108***			

indicates rock density of 2700kg/m^3
Gmax: Measures small strain shear stiffness of the ground

S22			S23		
Depth m	Vs m/s	Gmax MPa	Depth m	Vs m/s	Gmax MPa
1.43	606	801	1.48	586	688
2.43	606	***993***	2.51	586	688
2.43	636	***1092***	2.51	945	1786
3.67	636	***1092***	3.80	945	1786
3.67	1113	***3347***	3.80	1211	2931
5.22	1113	***3347***	5.41	1211	2931
5.22	1259	***4281***	5.41	1253	3140
7.16	1259	***4281***	7.42	1253	3140
7.16	1230	***4086***	7.42	1367	3740
9.59	1230	***4086***	9.94	1367	3740
9.59	1375	***5107***	9.94	1523	4641
12.62	1375	***5107***	13.08	1523	4641
12.62	1827	***9013***	13.08	1472	***5847***
16.41	1827	***9013***	17.01	1472	***5847***
			17.01	1990	***10696***
			21.26	1990	***10696***

indicates rock density of 2700kg/m³

Gmax: Measures small strain shear stiffness of the ground

APPENDIX A:IV CALCULATED MODULI

Calculation of dynamic moduli - S1

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
0.00	360	203	2180	0.265	.902	0.228	0.162
0.21	360	203	2180	0.265	.902	0.228	0.162
0.21	360	233	2180	0.138	.119	0.270	0.124
0.48	360	233	2180	0.138	.119	0.270	0.124
0.48	360	223	2180	0.190	.108	0.257	0.138
0.81	360	223	2180	0.190	.108	0.257	0.138
0.81	360	151	2180	0.393	.050	0.138	0.216
1.22	360	151	2180	0.393	.050	0.138	0.216
1.22	360	145	2180	0.403	.046	0.129	0.221
1.74	360	145	2180	0.403	.046	0.129	0.221
1.74	1243	289	2180	0.471	.181	0.535	3.126
2.38	1243	289	2180	0.471	.181	0.535	3.126
2.38	1243	324	2180	0.463	.229	0.671	3.063
3.19	1243	324	2180	0.463	.229	0.671	3.063
3.19	1243	456	2180	0.422	.453	1.290	2.764
4.62	1243	456	2180	0.422	.453	1.290	2.764
4.62	1243	555	2180	0.376	.670	1.844	2.474
6.57	1243	555	2180	0.376	.670	1.844	2.474
6.57	3854	768	2700	0.479	1.59	4.714	37.980
9.01	3854	768	2700	0.479	1.59	4.714	37.980
9.01	3854	856	2700	0.474	1.979	5.833	37.466
12.07	3854	856	2700	0.474	1.979	5.833	37.466
12.07	3854	1038	2700	0.461	2.912	8.507	36.222
15.88	3854	1038	2700	0.461	2.912	8.507	36.222
15.88	3854	1255	2700	0.441	4.255	12.260	34.431
20.65	3854	1255	2700	0.441	4.255	12.260	34.431

* from Davies & Schulteiss, 1980.

Calculation of dynamic moduli - S2

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
1.52	1038	378	2180	0.424	.312	0.887	1.933
2.58	1038	378	2180	0.424	.312	0.887	1.933
2.58	1038	303	2180	0.454	.200	0.581	2.082
3.90	1038	303	2180	0.454	.200	0.581	2.082
3.90	1038	501	2180	0.348	.547	1.476	1.619
5.56	1038	501	2180	0.348	.547	1.476	1.619
5.56	1038	643	2180	0.188	.902	2.143	1.146
7.62	3849	643	2700	0.486	1.117	3.319	38.511
7.62	3849	756	2700	0.480	1.543	4.567	37.943
10.20	3849	756	2700	0.480	1.543	4.567	37.943
10.20	3849	816	2700	0.476	1.799	5.313	37.601
13.43	3849	816	2700	0.476	1.799	5.313	37.601
13.43	3849	837	2700	0.475	1.890	5.575	37.481
17.47	3849	837	2700	0.475	1.890	5.575	37.481

* from Davies & Schulteiss, 1980.

Calculation of dynamic moduli - S3

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
2.87	1045	323	2180	0.447	.228	0.660	2.077
2.87	1045	449	2180	0.387	.439	1.218	1.795
5.13	1045	449	2180	0.387	.439	1.218	1.795
5.13	1045	665	2180	0.159	.965	2.238	1.093
7.30	1045	665	2180	0.159	.965	2.238	1.093
7.30	4354	803	2700	0.482	1.741	5.163	48.863
10.02	4354	803	2700	0.482	1.741	5.163	48.863
10.02	4354	924	2700	0.476	2.304	6.803	48.113
13.41	4354	924	2700	0.476	2.304	6.803	48.113
13.41	4354	1091	2700	0.467	3.212	9.420	46.903
17.66	4354	1091	2700	0.467	3.212	9.420	46.903
17.66	4354	1224	2700	0.457	4.046	11.790	45.791
22.96	4354	1224	2700	0.457	4.046	11.790	45.791

* from Davies & Schulteiss, 1980.

Calculation of dynamic moduli - S4

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
1.89	1167	330	2180	0.456	.238	0.693	2.652
1.89	1167	466	2180	0.405	.474	1.331	2.337
2.33	1167	466	2180	0.405	.474	1.331	2.337
2.33	1167	510	2180	0.382	.567	1.566	2.214
3.53	1167	510	2180	0.382	.567	1.566	2.214
3.53	1167	680	2180	0.243	1.008	2.506	1.625
5.02	1167	680	2180	0.243	1.008	2.506	1.625
5.02	4655	993	2700	0.476	2.664	7.866	54.954
6.89	4655	993	2700	0.476	2.664	7.866	54.954
6.89	4655	1117	2700	0.469	3.371	9.908	54.011
9.23	4655	1117	2700	0.469	3.371	9.908	54.011
9.23	4655	1284	2700	0.459	4.452	12.990	52.570
12.14	4655	1284	2700	0.459	4.452	12.990	52.570
12.14	4655	1483	2700	0.444	5.934	17.133	50.594
15.79	4655	1483	2700	0.444	5.934	17.133	50.594

* from Davies & Schulteiss, 1980.

Calculation of dynamic moduli - S5

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
1.28	1500	317	2180	0.477	.219	0.646	4.614
1.93	1500	317	2180	0.477	.219	0.646	4.614
1.93	1500	288	2180	0.481	.181	0.535	4.664
2.75	1500	288	2180	0.481	.181	0.535	4.664
2.75	1500	422	2180	0.457	.388	1.131	4.387
3.77	1500	422	2180	0.457	.388	1.131	4.387
3.77	1500	552	2180	0.422	.665	1.889	4.019
5.04	1500	552	2180	0.422	.665	1.889	4.019
5.04	1500	600	2180	0.405	.785	2.207	3.858
6.64	1500	600	2180	0.405	.785	2.207	3.858
6.64	1500	712	2180	0.355	1.104	2.991	3.433
8.63	3749	712	2700	0.481	1.367	4.051	36.126
8.63	3749	1000	2700	0.462	2.698	7.889	34.351
10.79	3749	1000	2700	0.462	2.698	7.889	34.351

* from Davies & Schulteiss, 1980.

Calculation of dynamic moduli - S6

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
2.34	1657	626	2700	0.417	1.057	2.995	6.004
2.34	1657	572	2700	0.432	.884	2.532	6.235
3.54	1657	572	2700	0.432	.884	2.532	6.235
3.54	1657	769	2700	0.363	1.595	4.348	5.286
5.04	1657	769	2700	0.363	1.595	4.348	5.286
5.04	1657	1008	2700	0.206	2.745	6.621	3.754
6.92	1657	1008	2700	0.206	2.745	6.621	3.754
6.92	3723	1063	2700	0.456	3.049	8.878	33.358
9.26	3723	1063	2700	0.456	3.049	8.878	33.358
9.26	3723	973	2700	0.463	2.557	7.484	34.014
12.19	3723	973	2700	0.463	2.557	7.484	34.014
12.19	3723	1117	2700	0.451	3.367	9.768	32.935
15.86	3723	1117	2700	0.451	3.367	9.768	32.935
15.86	3723	1441	2700	0.412	5.608	15.836	29.946
19.82	3723	1441	2700	0.412	5.608	15.836	29.946

* from Davies & Schulteiss, 1980.

Calculation of dynamic moduli - S7

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
1.18	423	222	2180	0.311	.107	0.281	0.247
2.01	1334	222	2180	0.486	.107	0.318	3.737
2.01	1334	477	2180	0.427	.496	1.415	3.218
3.04	1334	477	2180	0.427	.496	1.415	3.218
3.04	1334	513	2180	0.413	.574	1.623	3.114
4.32	1334	513	2180	0.413	.574	1.623	3.114
4.32	1334	702	2180	0.308	1.075	2.814	2.446
5.93	3779	702	2700	0.482	1.332	3.948	36.783
5.93	3779	899	2700	0.470	2.182	6.416	35.649
7.93	3779	899	2700	0.470	2.182	6.416	35.649
7.93	3779	1032	2700	0.460	2.876	8.397	34.723
10.44	3779	1032	2700	0.460	2.876	8.397	34.723
10.44	3779	1177	2700	0.446	3.741	10.821	33.570
13.58	3779	1177	2700	0.446	3.741	10.821	33.570
13.58	3779	1411	2700	0.419	5.375	15.255	31.391
16.98	3779	1411	2700	0.419	5.375	15.255	31.391

* from Davies & Schulteiss, 1980.

Calculation of dynamic moduli - S8

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
0.00	388	238	2180	0.199	.123	0.296	0.164
0.22	388	238	2180	0.199	.123	0.296	0.164
0.22	388	247	2180	0.159	.133	0.309	0.151
0.49	388	247	2180	0.159	.133	0.309	0.151
0.49	388	225	2180	0.247	.110	0.275	0.181
0.83	388	225	2180	0.247	.110	0.275	0.181
0.83	388	183	2180	0.356	.073	0.199	0.231
1.26	388	183	2180	0.356	.073	0.199	0.231
1.26	388	188	2180	0.347	.077	0.207	0.226
1.80	388	188	2180	0.347	.077	0.207	0.226
1.80	1163	279	2180	0.470	.169	0.498	2.723
2.47	1163	279	2180	0.470	.169	0.498	2.723
2.47	1163	354	2180	0.449	.274	0.794	2.583
3.30	1163	354	2180	0.449	.274	0.794	2.583
3.30	1163	416	2180	0.427	.376	1.074	2.447
4.35	1163	416	2180	0.427	.376	1.074	2.447
4.35	1163	403	2180	0.432	.354	1.014	2.476
5.65	1163	403	2180	0.432	.354	1.014	2.476
5.65	3390	605	2700	0.484	.989	2.936	29.709
8.90	3390	605	2700	0.484	.989	2.936	29.709
8.90	3390	921	2700	0.460	2.289	6.685	27.977
12.22	3390	921	2700	0.460	2.289	6.685	27.977
12.22	3390	1057	2700	0.446	3.017	8.726	27.006
16.36	3390	1057	2700	0.446	3.017	8.726	27.006
16.36	3390	1238	2700	0.423	4.139	11.781	25.510
21.53	3390	1238	2700	0.423	4.139	11.781	25.510
21.53	3390	1355	2700	0.405	4.954	13.921	24.423
28.00	3390	1355	2700	0.405	4.954	13.921	24.423

* from Davies & Schulteiss, 1980.

Calculation of dynamic moduli - S9

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
1.69	1372	290	2180	0.477	.184	0.542	3.859
2.86	1372	290	2180	0.477	.184	0.542	3.859
2.86	1372	218	2180	0.487	.104	0.309	3.965
4.33	1372	218	2180	0.487	.104	0.309	3.965
4.33	1372	322	2180	0.471	.226	0.665	3.802
6.17	3230	322	2700	0.495	.280	0.837	27.796
6.17	3230	453	2700	0.490	.554	1.650	27.430
8.46	3230	453	2700	0.490	.554	1.650	27.430
8.46	3230	516	2700	0.487	.720	2.141	27.209
11.32	3230	516	2700	0.487	.720	2.141	27.209
11.32	3230	544	2700	0.485	.798	2.370	27.105
14.91	3230	544	2700	0.485	.798	2.370	27.105
14.91	3230	740	2700	0.472	1.480	4.357	26.196
19.39	3230	740	2700	0.472	1.480	4.357	26.196

* from Davies & Schulteiss, 1980.

Calculation of dynamic moduli - S10

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
1.13	604	409	2180	0.076	.365	0.785	0.308
1.91	1514	409	2180	0.461	.365	1.067	4.510
1.91	1514	342	2180	0.473	.254	0.750	4.658
2.89	1514	342	2180	0.473	.254	0.750	4.658
2.89	1514	410	2180	0.461	.366	1.068	4.509
4.12	1514	410	2180	0.461	.366	1.068	4.509
4.12	1514	624	2180	0.398	.850	2.376	3.864
5.65	1514	624	2180	0.398	.850	2.376	3.864
5.65	3667	745	2700	0.478	1.498	4.430	34.309
7.56	3667	745	2700	0.478	1.498	4.430	34.309
7.56	3667	878	2700	0.470	2.080	6.114	33.533
9.96	3667	878	2700	0.470	2.080	6.114	33.533
9.96	3667	910	2700	0.467	2.234	6.555	33.328
12.95	3667	910	2700	0.467	2.234	6.555	33.328
12.95	3667	1226	2700	0.437	4.057	11.659	30.898
16.19	3667	1226	2700	0.437	4.057	11.659	30.898

* from Davies & Schulteiss, 1980.

Calculation of dynamic moduli - S11

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
1.46	510	244	2180	0.352	.130	0.351	0.394
2.48	1379	244	2180	0.484	.130	0.385	3.973
2.48	1379	620	2180	0.373	.838	2.302	3.028
3.75	1379	620	2180	0.373	.838	2.302	3.028
3.75	1379	583	2180	0.391	.740	2.059	3.159
5.34	1379	583	2180	0.391	.740	2.059	3.159
5.34	3959	863	2700	0.475	2.010	5.929	39.640
7.32	3959	863	2700	0.475	2.010	5.929	39.640
7.32	3959	1056	2700	0.462	3.013	8.809	38.301
9.80	3959	1056	2700	0.462	3.013	8.809	38.301
9.80	3959	1220	2700	0.448	4.019	11.635	36.960
12.90	3959	1220	2700	0.448	4.019	11.635	36.960
12.90	3959	1339	2700	0.435	4.843	13.902	35.862
16.77	3959	1339	2700	0.435	4.843	13.902	35.862

* from Davies & Schulteiss, 1980.

Calculation of dynamic moduli - S12

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
1.22	505	314	2180	0.184	.215	0.510	0.269
1.84	505	314	2180	0.184	.215	0.510	0.269
1.84	1490	340	2700	0.473	.311	0.917	5.579
2.62	1490	340	2700	0.473	.311	0.917	5.579
2.62	1490	488	2700	0.440	.643	1.853	5.136
3.59	1490	488	2700	0.440	.643	1.853	5.136
3.59	1490	573	2700	0.413	.887	2.508	4.811
4.69	1490	573	2700	0.413	.887	2.508	4.811
4.69	1490	729	2700	0.342	1.437	3.857	4.079
7.09	3851	729	2700	0.481	1.437	4.257	38.126
7.09	3851	960	2700	0.467	2.488	7.300	36.724
10.10	3851	960	2700	0.467	2.488	7.300	36.724
10.10	3851	1208	2700	0.445	3.939	11.387	34.790
13.85	3851	1208	2700	0.445	3.939	11.387	34.790
13.85	3851	1385	2700	0.426	5.178	14.764	33.138
18.54	3851	1385	2700	0.426	5.178	14.764	33.138
18.54	3851	1660	2700	0.386	7.441	20.625	30.120
24.41	3851	1660	2700	0.386	7.44	20.625	30.120
24.41	3851	1908	2700	0.337	9.832	26.296	26.932
31.74	3851	1908	2700	0.337	9.832	26.296	26.932

* from Davies & Schulteiss, 1980.

Calculation of dynamic moduli - S13

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
0.70	544	312	2180	0.256	.212	0.532	0.363
1.57	544	312	2180	0.256	.212	0.532	0.363
1.57	1465	554	2180	0.417	.668	1.894	3.787
2.65	1465	554	2180	0.417	.668	1.894	3.787
2.65	1465	817	2180	0.274	1.456	3.710	2.737
4.01	1465	817	2180	0.274	1.456	3.710	2.737
4.01	1465	815	2180	0.276	1.448	3.695	2.748
5.71	1465	815	2180	0.276	1.448	3.695	2.748
5.71	3851	1246	2700	0.442	4.190	12.079	34.456
7.84	3851	1246	2700	0.442	4.190	12.079	34.456
7.84	3851	1490	2700	0.412	5.998	16.937	32.044
10.49	3851	1490	2700	0.412	5.998	16.937	32.044
10.49	3851	1700	2700	0.379	7.798	21.509	29.644
13.81	3851	1700	2700	0.379	7.798	21.509	29.644
13.81	3851	1725	2700	0.375	8.031	22.079	29.333
17.96	3851	1725	2700	0.375	8.031	22.079	29.333

* from Davies & Schulteiss, 1980.

Calculation of dynamic moduli - S14

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
3.36	1655	679	2700	0.399	1.244	3.481	5.736
3.36	1655	646	2700	0.410	1.128	3.181	5.891
5.08	1655	646	2700	0.410	1.128	3.181	5.891
5.08	4222	1323	2700	0.446	4.729	13.672	41.823
7.24	4222	1323	2700	0.446	4.729	13.672	41.823
7.24	4222	1438	2700	0.434	5.587	16.027	40.679
9.93	4222	1438	2700	0.434	5.587	16.027	40.679
9.93	4222	1686	2700	0.405	7.678	21.577	37.891
13.29	4222	1686	2700	0.405	7.678	21.577	37.891
13.29	4222	2042	2700	0.347	11.255	30.329	33.122
17.49	4222	2042	2700	0.347	11.255	30.329	33.122

* from Davies & Schulteiss, 1980.

Calculation of dynamic moduli - S15

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
2.33	1819	955	2700	0.310	2.461	6.447	5.653
3.52	1819	955	2700	0.310	2.461	6.447	5.653
3.52	1819	903	2700	0.336	2.203	5.888	5.996
5.02	1819	903	2700	0.336	2.203	5.888	5.996
5.02	4025	1086	2700	0.461	3.187	9.309	39.493
6.88	4025	1086	2700	0.461	3.187	9.309	39.493
6.88	4025	1504	2700	0.419	6.109	17.336	35.596
9.21	4025	1504	2700	0.419	6.109	17.336	35.596
9.21	4025	1752	2700	0.383	8.284	22.916	32.697
12.13	4025	1752	2700	0.383	8.284	22.916	32.697
12.13	4025	2067	2700	0.321	11.541	30.486	28.354
15.77	4025	2067	2700	0.321	11.541	30.486	28.354

* from Davies & Schulteiss, 1980.

Calculation of dynamic moduli - S16

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
0.83	454	294	2180	0.137	.189	0.430	0.197
1.19	454	294	2180	0.137	.189	0.430	0.197
1.19	454	302	2180	0.104	.199	0.439	0.184
1.63	454	302	2180	0.104	.199	0.439	0.184
1.63	1466	503	2700	0.433	.684	1.960	4.891
2.18	1466	503	2700	0.433	.684	1.960	4.891
2.18	1466	580	2700	0.407	.909	2.559	4.590
2.87	1466	580	2700	0.407	.909	2.559	4.590
2.87	1466	703	2700	0.351	1.332	3.600	4.026
3.74	1466	703	2700	0.351	1.332	3.600	4.026
3.74	1466	819	2700	0.273	1.811	4.612	3.388
5.56	1466	819	2700	0.273	1.811	4.612	3.388
5.56	3909	1260	2700	0.442	4.285	12.359	35.543
7.63	3909	1260	2700	0.442	4.285	12.359	35.543
7.63	3909	1459	2700	0.419	5.744	16.302	33.599
10.22	3909	1459	2700	0.419	5.744	16.302	33.599
10.22	3909	1713	2700	0.381	7.918	21.874	30.699
13.45	3909	1713	2700	0.381	7.918	21.874	30.699
13.45	3909	1859	2700	0.354	9.327	25.256	28.821
17.49	3909	1859	2700	0.354	9.327	25.256	28.821

* from Davies & Schulteiss, 1980.

Calculation of dynamic moduli - S17

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
1.81	1705	465	2700	0.460	.583	1.702	7.072
2.48	1705	465	2700	0.460	.583	1.702	7.072
2.48	1705	742	2700	0.383	1.485	4.108	5.869
3.32	1705	742	2700	0.383	1.485	4.108	5.869
3.32	1705	928	2700	0.289	2.326	5.999	4.747
4.38	1705	928	2700	0.289	2.326	5.999	4.747
4.38	1705	1055	2700	0.190	3.006	7.152	3.841
5.69	1705	1055	2700	0.190	3.006	7.152	3.841
5.69	3984	1298	2700	0.441	4.547	13.102	36.792
8.75	3984	1298	2700	0.441	4.547	13.102	36.792
8.75	3984	1583	2700	0.406	6.767	19.032	33.833
11.71	3984	1583	2700	0.406	6.767	19.032	33.833
11.71	3984	1828	2700	0.367	9.023	24.662	30.825
15.42	3984	1828	2700	0.367	9.023	24.662	30.825
15.42	3984	1805	2700	0.371	8.798	24.122	31.124
20.05	3984	1805	2700	0.371	8.798	24.122	31.124

* from Davies & Schulteiss, 1980.

Calculation of dynamic moduli - S18

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
2.59	1538	437	2700	0.456	.517	1.504	5.698
2.59	1538	473	2700	0.448	.605	1.752	5.580
3.91	1538	473	2700	0.448	.605	1.752	5.580
3.91	1538	671	2700	0.383	1.214	3.357	4.768
5.57	3645	671	2700	0.482	1.214	3.600	34.254
5.57	3645	913	2700	0.467	2.251	6.601	32.871
7.64	3645	913	2700	0.467	2.251	6.601	32.871
7.64	3645	1105	2700	0.449	3.294	9.550	31.480
10.22	3645	1105	2700	0.449	3.294	9.550	31.480
10.22	3645	1288	2700	0.429	4.482	12.805	29.897
13.46	3645	1288	2700	0.429	4.482	12.805	29.897
13.46	3645	1549	2700	0.390	6.475	17.999	27.239
17.50	3645	1549	2700	0.390	6.475	17.999	27.239

* from Davies & Schulteiss, 1980.

Calculation dynamic moduli - S19

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
2.64	1753	898	2700	0.322	2.179	5.761	5.392
2.64	1753	850	2700	0.346	1.951	5.253	5.696
3.76	1753	850	2700	0.346	1.951	5.253	5.696
3.76	1753	922	2700	0.309	2.293	6.004	5.239
5.16	1753	922	2700	0.309	2.293	6.004	5.239
5.16	4125	1323	2700	0.443	4.728	13.641	39.639
6.91	4125	1323	2700	0.443	4.728	13.641	39.639
6.91	4125	1565	2700	0.416	6.616	18.736	37.120
9.09	4125	1565	2700	0.416	6.616	18.736	37.120
9.09	4125	1545	2700	0.418	6.445	18.283	37.349
11.82	4125	1545	2700	0.418	6.445	18.283	37.349

* from Davies & Schulteiss, 1980.

Calculation of dynamic moduli - S20							
Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
0.44	644	270	2180	0.394	.159	0.442	0.693
0.74	644	270	2180	0.394	.159	0.442	0.693
0.74	644	315	2180	0.342	.217	0.582	0.615
1.11	644	315	2180	0.342	.217	0.582	0.615
1.11	1606	528	2700	0.439	.754	2.170	5.959
1.59	1606	528	2700	0.439	.754	2.170	5.959
1.59	1606	611	2700	0.415	1.007	2.850	5.621
2.18	1606	611	2700	0.415	1.007	2.850	5.621
2.18	1606	521	2700	0.441	.734	2.114	5.986
2.91	1606	521	2700	0.441	.734	2.114	5.986
2.91	1606	642	2700	0.405	1.112	3.124	5.482
3.44	1606	642	2700	0.405	1.112	3.124	5.482
3.44	4180	952	2700	0.473	2.448	7.210	43.911
5.20	4180	952	2700	0.473	2.448	7.210	43.911
5.20	4180	960	2700	0.472	2.486	7.321	43.860
7.41	4180	960	2700	0.472	2.486	7.321	43.860
7.41	4180	1386	2700	0.438	5.185	14.916	40.262
10.16	4180	1386	2700	0.438	5.185	14.916	40.262
10.16	4180	1676	2700	0.404	7.583	21.297	37.065
13.60	4180	1676	2700	0.404	7.583	21.297	37.065
13.60	4180	1868	2700	0.375	9.424	25.921	34.610
17.90	4180	1868	2700	0.375	9.424	25.921	34.610
17.90	4180	1837	2700	0.380	9.108	25.144	35.032
23.28	4180	1837	2700	0.380	9.108	25.144	35.032

* from Davies & Schulteiss, 1980.

Calculation of dynamic moduli - S21

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
2.39	1666	1028	2700	0.193	2.851	6.802	3.693
3.62	1666	1028	2700	0.193	2.851	6.802	3.693
3.62	1666	948	2700	0.261	2.426	6.117	4.259
5.15	4000	948	2700	0.470	2.426	7.135	39.965
5.15	4000	1032	2700	0.464	2.874	8.416	39.369
7.07	4000	1032	2700	0.464	2.874	8.416	39.369
7.07	4000	1506	2700	0.417	6.1287	17.370	35.030
9.47	4000	1506	2700	0.417	6.128	17.370	35.030
9.47	4000	1774	2700	0.378	8.497	23.410	31.871
12.46	4000	1774	2700	0.378	8.497	23.410	31.871
12.46	4000	2093	2700	0.312	11.825	31.017	27.434
16.20	4000	2093	2700	0.312	11.825	31.017	27.434

* from Davies & Schulteiss, 1980.

Calculation of dynamic moduli - S22

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
2.43	1750	606	2700	0.432	.993	2.843	6.945
2.43	1750	636	2700	0.424	1.092	3.110	6.812
3.67	1750	636	2700	0.424	1.092	3.110	6.812
3.67	1750	1113	2700	0.160	3.347	7.765	3.806
5.22	1750	1113	2700	0.160	3.347	7.765	3.806
5.22	3892	1259	2700	0.442	4.281	12.343	35.190
7.16	3892	1259	2700	0.442	4.281	12.343	35.190
7.16	3892	1230	2700	0.445	4.086	11.803	35.451
9.59	3892	1230	2700	0.445	4.086	11.803	35.451
9.59	3892	1375	2700	0.429	5.107	14.591	34.090
12.62	3892	1375	2700	0.429	5.107	14.591	34.090
12.62	3892	1827	2700	0.359	9.013	24.492	28.881
16.41	3892	1827	2700	0.359	9.013	24.492	28.881

* from Davies & Schulteiss, 1980.

Calculation of dynamic moduli - S23

Depth (m bgl)	Vp m/sec	Vs m/sec	density kg/m^3	Poissons ratio	Shear* Mod. GPa Dynamic Gmax	Youngs * Mod. GPa Dynamic Emax	Bulk* Mod. GPa Dynamic
2.51	1741	586	2700	0.436	.928	2.666	6.946
2.51	1741	945	2700	0.291	2.411	6.226	4.969
3.80	1741	945	2700	0.291	2.411	6.226	4.969
3.80	1741	1211	2700	0.032	3.957	8.167	2.908
5.41	1741	1211	2700	0.032	3.957	8.167	2.908
5.41	4061	1253	2700	0.447	4.239	12.271	38.875
7.42	4061	1253	2700	0.447	4.239	12.271	38.875
7.42	4061	1367	2700	0.436	5.049	14.501	37.796
9.94	4061	1367	2700	0.436	5.049	14.501	37.796
9.94	4061	1523	2700	0.418	6.265	17.768	36.175
13.08	4061	1523	2700	0.418	6.265	17.768	36.175
13.08	4061	1472	2700	0.424	5.847	16.658	36.731
17.01	4061	1472	2700	0.424	5.847	16.658	36.731
17.01	4061	1990	2700	0.342	10.696	28.706	30.267
21.26	4061	1990	2700	0.342	10.696	28.706	30.267

* from Davies & Schulteiss, 1980.

APPENDIX A:V EXCAVATABILITY

The seismic velocity of a rock formation is related to characteristics of the rock mass which include rock hardness and strength, degree of weathering and discontinuities. Usually the velocity is just one of several parameters used in the assessment of excavatability. The excavatability of a rock formation is favoured by the following factors:

- Open fractures, faults and other planes of weakness of any kind
- Weathering
- Brittleness and crystalline nature
- High degree of stratification or lamination
- Large grain size
- Low compressive strength

Weaver (1975) presented a comprehensive rippability rating chart (Fig. A1) in which the p-wave velocity value and the relevant geological factors could be entered and assigned appropriate weightings. The total weighted index was found to correlate very well with actual rippability.

Fig A:1 Rippability Rating Chart (according to Weaver 1975)

Rock class	I	II	III	IV	V
Description	Very good rock	Good rock	Fair rock	Poor rock	Very poor rock
Seismic velocity (Vp) (m/s)	>2150	2150-1850	1850-1500	1500-1200	1200-450
Rating	26	24	20	12	5
Rock hardness	Extremely hard rock	Very hard rock	Hard rock	Soft rock	Very soft rock
Rating	10	5	2	1	0
Rock weathering	Unweathered	Slightly weathered	Weathered	Highly weathered	Completely weathered
Rating	9	7	5	3	1
Joint spacing (mm)	>3000	3000-1000	1000-300	300-50	<50
Rating	30	25	20	10	5
Joint continuity	Non continuous	Slightly continuous	Continuous-no gouge	Continuous-some gouge	Continuous-with gouge
Rating	5	5	3	0	0
Joint gouge	No separation	Slight separation	Separation <1mm	Gouge <5mm	Gouge >5mm
Rating	5	5	4	3	1
Strike and dip orientation	Very unfavourable	Unfavourable	Slightly unfavourable	Favourable	Very favourable
Rating	15	13	10	5	3
Total rating	100-90	90-70*	70-50	50-25	<25
Rippability assessment	Blasting	Extremely hard ripping and blasting	Very hard ripping	Hard ripping	Easy ripping
Tractor horsepower		770/385	385/270	270/180	180
Tractor kilowatts		575/290	290/200	200/135	135

Appendix B - Main Onshore SI Pump Test Report

Tarbert / Ballylongford Main Onshore SI
Pump Test
Report

CONTENTS

Figures

Tables

Appendices

Appendix B:1 – Corehole Field Records
(Figures B9 – B11)

Appendix B:2 - Digital Pump Test Readings (on CD)

B1.0 Introduction

IGSL were employed to undertake a pump test as part of a ground investigation for a proposed Liquid Natural Gas Terminal near Ballylongford, Co. Kerry. Water will be required for the production of concrete and for hydrotesting the LNG tanks. The purpose of the pump test was to determine if an adequate amount of water could be supplied by the on-site ground water conditions. IGSL understands that approximately 6 litres/second was the required design flow. The pump test was undertaken in January 2007 and comprised of monitoring drawdown, discharge and recovery in the pump well and draw down and recovery in two number monitoring wells.

Yield from the well was poor and the required design flow rate was not achieved.

B2.0 Geological conditions

The pump test was carried out after the main ground investigation works had been completed. Observations on site, namely marshy waterlogged ground conditions and the presence of reeds indicated a pocket of springs the northern western area of the site. Coreholes drilled during the main site investigation phase indicated that artesian water conditions in this section. These springs were believed to be topographical in that the ground surface dipped to the north more sharply than the bedrock and the springs occurred in areas of shallow overburden. The drilling records indicated that the main water bearing zone was likely to be the fractured bedrock immediately below rock head.

The bedrock underlying the site forms part of the Namurian age Shannon Group (siltstones, sandstones and mudstones). The Shannon Group is identified as being a poor aquifer in the Geological Survey of Ireland groundwater records. The overburden is a glacial till, primarily a clay, of low permeability. Given the springs and the impermeability of the overburden, the aquifer is considered to be confined.

The location of the well was chosen by Arup and is located in the north west corner of the site in the an area of springs. See Figure B:1 for location of pump well and monitoring wells. Ground elevation at the pump well is 13.16m OD.

All levels given in this report are to Malin Head Datum.

B3.0 Weather Conditions

Weather conditions during the pump test were generally cool, with scattered showers allowing limited recharge of the aquifer. However in November and December 2006, the two months before the test, unseasonably high rainfall was recorded.

B4.0 Pump Well and Monitoring Well Construction

The pump well (PW01) was constructed using the symmetrix open hole drilling system with an air/mist flush. The diameter of the drill hole was 150 mm. Details of the overburden strata and rock strata encountered are presented in the log in Appendix B:2.

Rock was encountered at 4.6m below ground level (bgl) and the well was drilled into the bedrock to 10m bgl. A 140mm ID HDPE well screen was installed from 4.6m bgl to the base (9.4m plumbed) with a closed pipe in the overburden and finished some 0.5m above surrounding ground level. Some silting of the pump well occurred following construction.

A 50mm ID HDPE pipe had been installed in the nearby borehole RC-23 (MW1) for monitoring groundwater levels. The installation was screened at the rock head interface and was taken to 0.5m above surrounding ground level. RC-07(MW2) contained a 100mm diameter uPVC temporary casing.

It was decided to use these locations as monitoring wells during the pumping test. RC-23 and RC-07 were located some 72m and 232m respectively from the pump well. See Figure B:1 for their locations.

B4.1 Well Development

The well was developed by air lifting.

B5.0 Pump Test Specification

The pumping was carried out in accordance with the following:

- IGSL Ltd. Method Specification,
- BS5930:1999, and
- Project specification

Calculations of the aquifer properties were not required. The two monitoring wells were used to record the response of the aquifer during pumping.

B6.0 Water levels prior to Pump Test

Water levels in the pump well (PW1) and in monitoring well 1 (MW1) were slightly artesian before the commencement of any pumping. Following the drilling of the pump well and the installation of the well screen the well was left to equalise over night. Water levels on the following day were 0.5m above ground level and over flowing the well lining. Monitoring well 2 (MW2) was not artesian. Water levels before pumping were recorded at 0.27m bgl.

B7.0 Details of Test Set Up, Step Test and Pump Test

Set Up

Pressure transducers were installed in the pump well and in the two monitoring wells to automatically measure drawdown. A Barologger was installed at ground level adjacent to the coreholes to measure barometric pressure. Manual readings, using a dip meter, were also taken to check and verify the automated water level readings.

Flow rates were measured initially by the pump flow gauge with the quantity pumped being recorded at appropriate intervals to determine discharge rates. As the pump test progressed the flow rate decreased to a level below what the flow gauge could measure therefore it was necessary to manually measure the flow by a timed filling of a container of known volume.

Temperature and electrical conductivity were also recorded during the pump test.

The water from the step and pump tests was discharged some 100m down hill from the pump well. Given the artesian pressures and the low permeable nature of the overburden this discharge location was chosen to ensure there was no feed back to the aquifer.

B7.1 Step Test

A Grundfos SP30 submersible pump was used based on a maximum discharge of 10.5l/sec being required. The pump was installed in the pumping well on 5th January 2007 and calibrated. The calibration was effected using a step down test. Three step down tests of 2 hours duration were undertaken. Discharge rates of 1.98, 2.79 and 2.83 litres/second were used. A fourth step with discharge increased to 3.02 l/sec resulted in the water levels with the pump well falling to the level of the inlet of the pump (approximately 8.01m bgl) and was therefore terminated.

Based on the results of the step test the short term yield of the pump well was judged to be approximately 2 litres/second.

Water levels were allowed to recover overnight and the resting groundwater levels prior to the start of the pump test were less than 0.5m bgl in both pump well (PW1 – 0.46m bgl) and monitoring well 1 (MW1 – 0.27m bgl). Water levels in MW2 was recorded at 4.67m

B7.2 Pump Test

The pump test was undertaken for 28.6 hours on the 7th and 8th January 2007. The early discharge rate (for approximately the first five hours) was approximately 2litres/second (7.2m^3/hour). This was consistent with the results of the step test. The discharge rate dropped with time and had reduced to 0.90litres/second (3.2m^3/hour) after 28 hours.

The average discharge over the period of the test (as manually measured) was 1.4litres/second (5m^3/hour). The maximum recorded drawdown within the pump well (PW01) was 7.80m (8.25m bgl) after 24 hours.

The maximum drawdown in monitoring well 1 (MW1) was 2.94m (3.21m bgl). No appreciable drawdown was observed in monitoring well 2 (MW2) during the pump test and the level lifted slightly during the step test. This could possibly be due to rainfall.

Recovery of groundwater levels was monitored over a 20 hour period following cessation of pumping.

A summary of the pump test data is presented on the Summary Data Sheet. The full compiled data set from the pumping test is presented on the CD accompanying this volume, Volume 3, of the factual report.

The complete data sheets contain information date, time, water level and temperature readings which were taken every 30 seconds whilst discharge and electrical conductivity readings were taken at greater intervals. Information is provided for the pump well and monitoring wells during pumping and recovery for both the step test and the pump test.

Some of the data is also presented in graphical format in the figures detailed below.

Figure B:2 illustrates the recorded drawdown in the pump well over the duration of the pump test and also the decrease in discharge rates over this period.

Figure B:3 illustrates the recorded drawdown in the pump well over the duration of the pump test and the groundwater temperatures.

Figure B:4 illustrates the recorded drawdown in the pump well over the duration of the pump test and the response in the monitoring wells MW1 and MW2.

Figure B:5 illustrates the recorded drawdown in the pump well over the duration of the pump test and the response in the monitoring well MW1 during the test plotted on a log/log scale.

Figure B:6 illustrates the recovery data from both the step test and the pump test plotted on a log/log scale.

Figure B:7 illustrates the drawdown and discharge relationship in the pump well during the step test.

Figure B:8 illustrates the drawdown in the pump well during the step test and the response in monitoring well MW1.

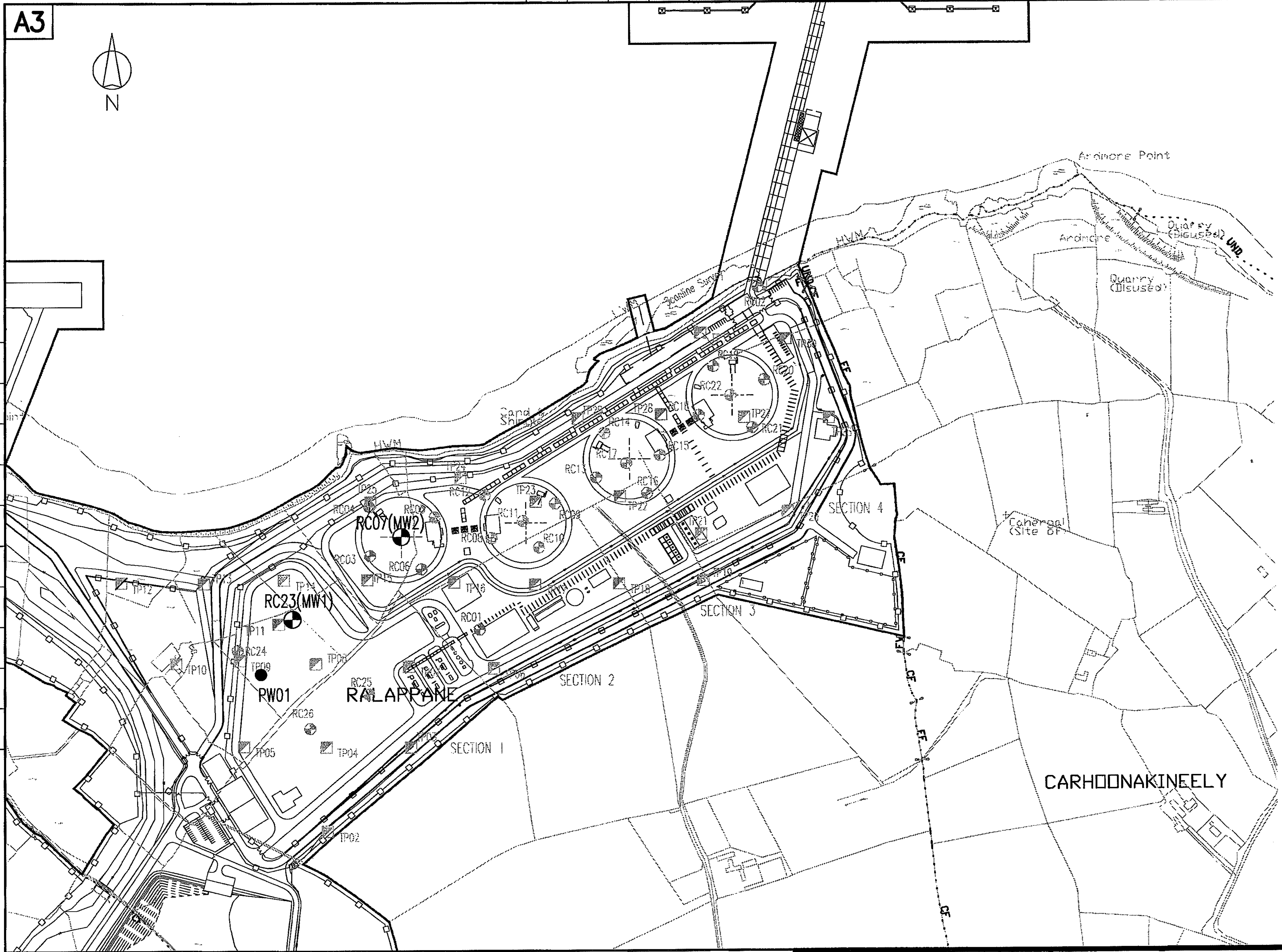
B8.0 Results of Pump Test

The pump well (PW01) and monitoring well 1 (MW1) were located in an area where springs were noted. Groundwater levels prior to the test were observed to be slightly artesian with the water level being approximately 0.5m above surrounding ground levels before any pumping commenced. Based on an examination of the exploratory hole logs from the main site investigation the main productive groundwater zone was observed to be within the upper section of the bedrock (approximately 2m in thickness). Observations during the drilling of the pump well indicated the bedrock at the location of the pump well was a MUDSTONE. In the pump well the groundwater productive zone was believed to be in the fractured MUDSTONE between 4.60 and 6.50m bgl. As the aquifer is overlain by a low permeability clay the aquifer has been assumed to be confined. In the analyses of the data two thicknesses of bedrock aquifer are considered. Ho_1 is the full penetrated distance of the well into the bedrock (9.4m-4.6m = 4.8m) and Ho_2 is the estimated thickness of the productive zone based on the exploratory hole logs.

Over a 28.6 hour pumping period, an average estimated discharge of 1.4litres/second or $5m^3$/hour was achieved. Maximum drawdown in the pumping well was 7.8m (8.25m bgl). The actual drawdown in the aquifer immediately adjacent to the well was difficult to assess, but was probably close to the base of the main productive zone, around 6.5m bgl. The marked response in monitoring well MW1 suggests that the main ground water pathways are probably structurally controlled with marked response along fracture zones only. Based on the high ground water table at the location of the pump well and monitoring well MW1 and the high connectivity between these wells, it is possible that the selected location of the pump well may represent one of the areas of higher yield within the aquifer.

The long-term yield of the well is however less than 1litre/second and therefore inappropriate for the construction phase needs.

A3



Location	Easting	Northing	Elevation
Coreholes			
PW01	102105.531	148474.28	13.16
RC1	102366.81	148527.735	23.32
RC2	102702.336	148937.664	5.544
RC3	102235.723	148616.252	17.01
RC4	102235.223	148675.356	14.179
RC5	102313.816	148662.468	17.912
RC6	102297.397	148600.339	21.717
RC7	102272.717	148640.021	19.091
RC8	102381.655	148637.417	17.342
RC9	102457.889	148678.488	15.614
RC10	102438.558	148626.089	19.588
RC11	102419.581	148657.717	16.492
RC12	102373.942	148688.953	13.059
RC13	102507.352	148709.383	17.084
RC14	102517.059	148762.875	13.464
RC15	102583.362	148736.224	22.28
RC16	102567.786	148690.586	21.678
RC17	102543.067	148726.548	18.552
RC18	102631.079	148783.914	19.002
RC19	102648.523	148842.776	12.965
RC20	102709.254	148826.109	18.096
RC21	102694.453	148768.896	21.501
RC22	102668.945	148807.619	17.836
RC23	102143.352	148540.507	13.107
RC24	102077.684	148503.385	10.571
RC25	102234.404	148450.017	19.023
RC26	102163.972	148408.974	16.613
Trial Pits			
TP1	102227.834	148083.794	18.967
TP2	102184.447	148284.92	18.972
TP3	102284.093	148386.066	23.135
TP4	102183.249	148386.634	18.262
TP5	102084.892	148387.388	13.169
TP6	102383.71	148481.047	25.687
TP7	102282.167	148483.421	21.396
TP8	102170.614	148486.777	15.956
TP9	102080.012	148490.98	11.214
TP10	102002.806	148487.529	8.439
TP11	102126.766	148534.317	12.379
TP12	101937.024	148584.019	6.815
TP13	102036.707	148583.319	7.214
TP14	102133.171	148587.347	10.939
TP15	102232.088	148587.272	17.607
TP16	102336.659	148584.49	20.238
TP17	102433.673	148581.819	22.483
TP18	102533.26	148582.374	26.926
TP19	102634.942	148585.631	31.035
TP20	102735.74	148668.155	29.318
TP21	102632.779	148641.615	28.127
TP22	102535.095	148686.732	20.12
TP23	102434.595	148680.682	14.984
TP24	102344.838	148709.512	11.561
TP25	102236.255	148680.674	13.653
TP26	102785.745	148780.436	23.428
TP27	102684.656	148781.265	20.431
TP28	102584.995	148784.831	16.9
TP29	102485.326	148780.418	8.962
TP30	102734.671	148875.129	15.883
TP31	102633.425	148882.664	8.917

Rev.	Date	By	Description	Chd By
P2	15.06.07	EG	ISSUED FOR INFORMATION	
P1	12.02.07	EG	ISSUED FOR INFORMATION	

Job Title
SHANNON LNG: TARBERT/BALLYLONGFORD TERMINAL

Shannon LNG

Drawing Title
LOCATION OF SECTION LINES FOR CROSS SECTION FIGURES

Drawing Status
PLANNING

ARUP
15 Oliver Plunkett Street Cork
Tel 021-4277670 Fax 021-4272345
EMail cork@arup.com
DUBLIN CORK LIMERICK

Scales 1:5000 @ A3 | Originator EG
Checked | Approved | Date 07.02.07

Job No. C1676.10 | Drawing No. Figure B:1 | Rev. PL1

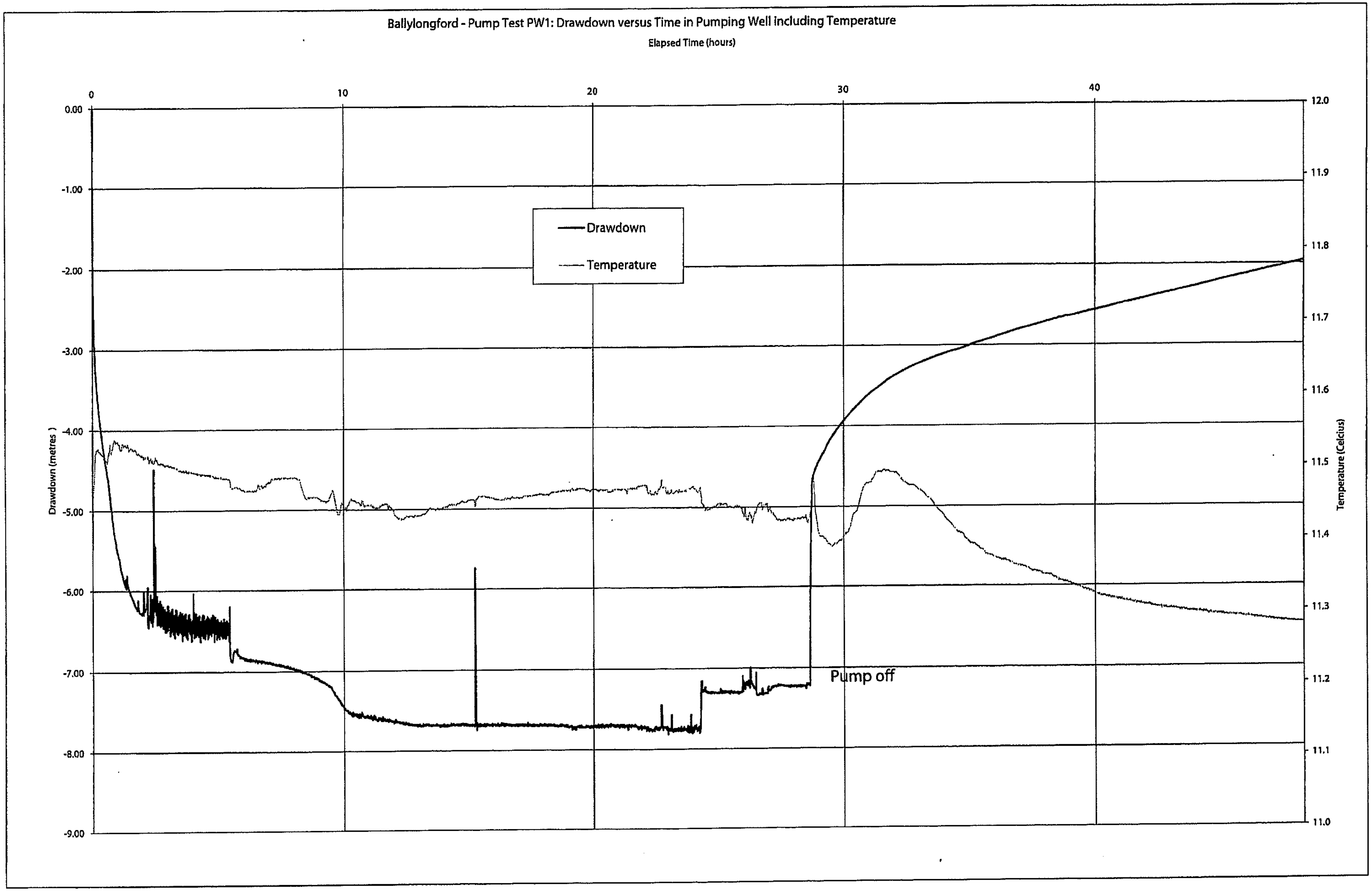

Ballylongford - Pump Test PW1: Drawdown versus Time in Pumping Well including Temperature
Elapsed Time (hours)
0
10
20
30
40
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
-7.00
-8.00
-9.00
Drawdown (metres)
12.0
11.9
11.8
11.7
11.6
11.5
11.4
11.3
11.2
11.1
11.0
Temperature (Celcius)
Drawdown
Temperature
Pump off

Figure B:2

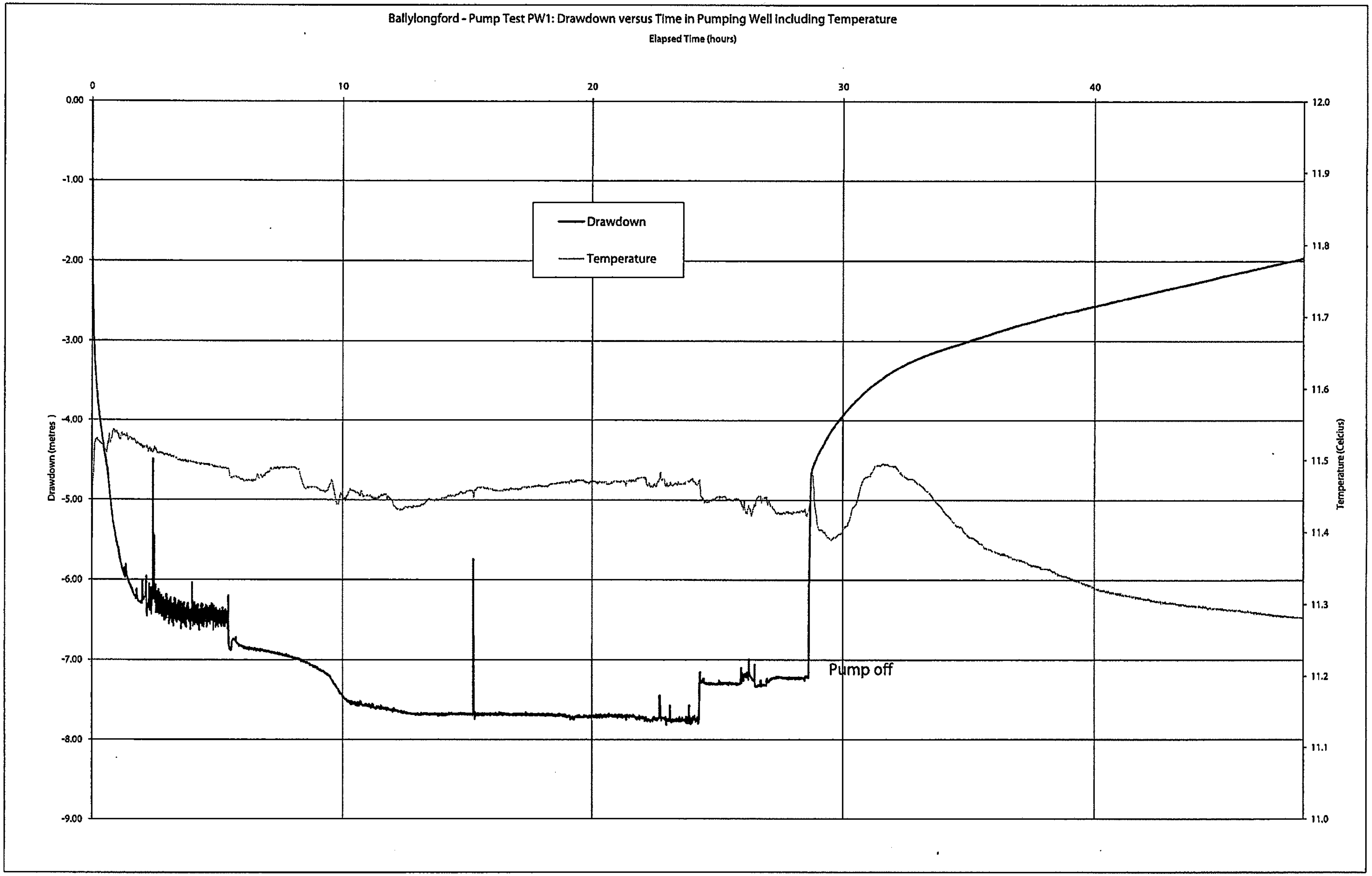

Ballylongford - Pump Test PW1: Drawdown versus Time in Pumping Well Including Temperature
Elapsed Time (hours)
0
10
20
30
40
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
-7.00
-8.00
-9.00
Drawdown (metres)
12.0
11.9
11.8
11.7
11.6
11.5
11.4
11.3
11.2
11.1
11.0
Temperature (Celcius)
Drawdown
Temperature
Pump off

Figure B:3

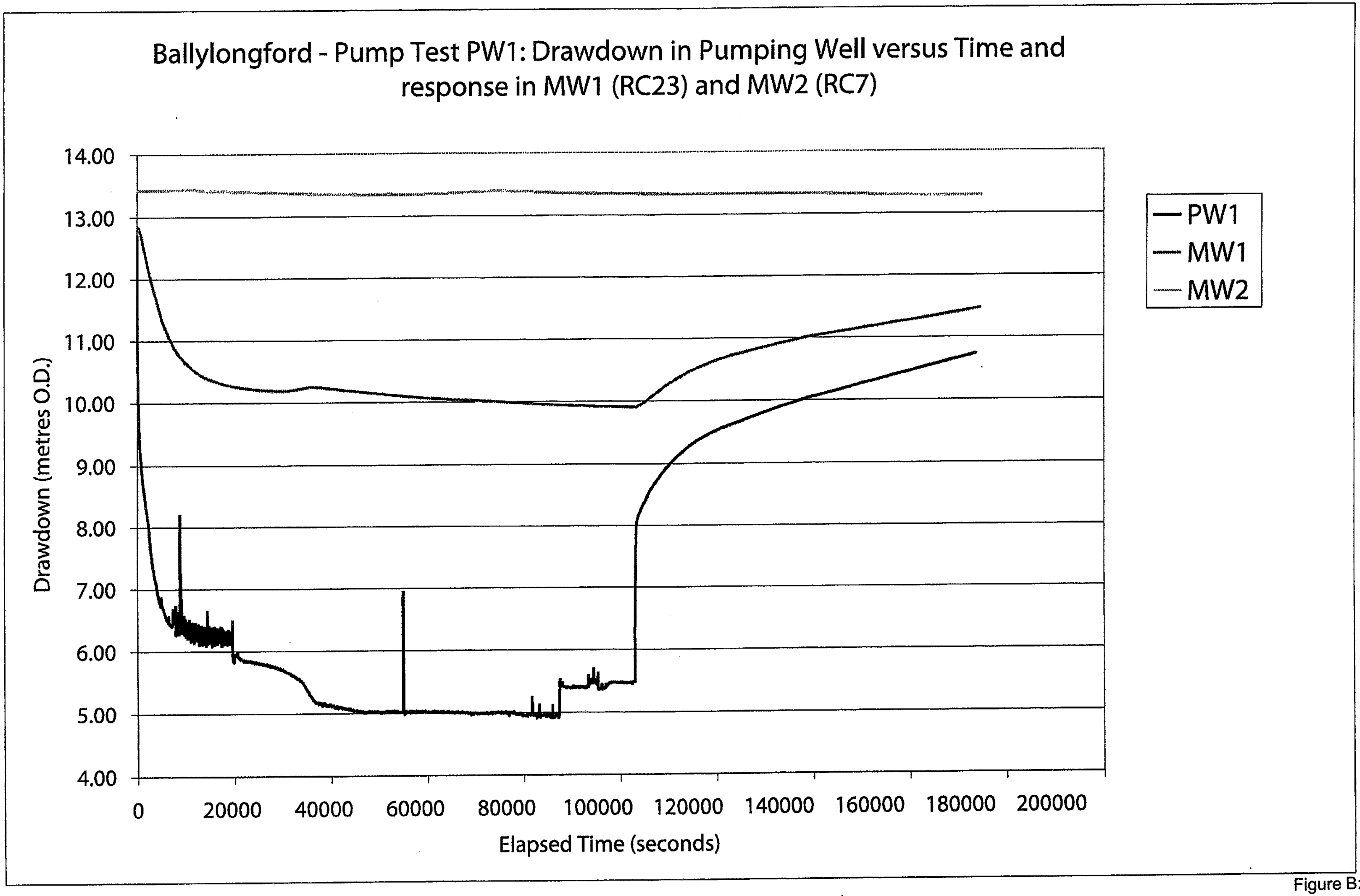
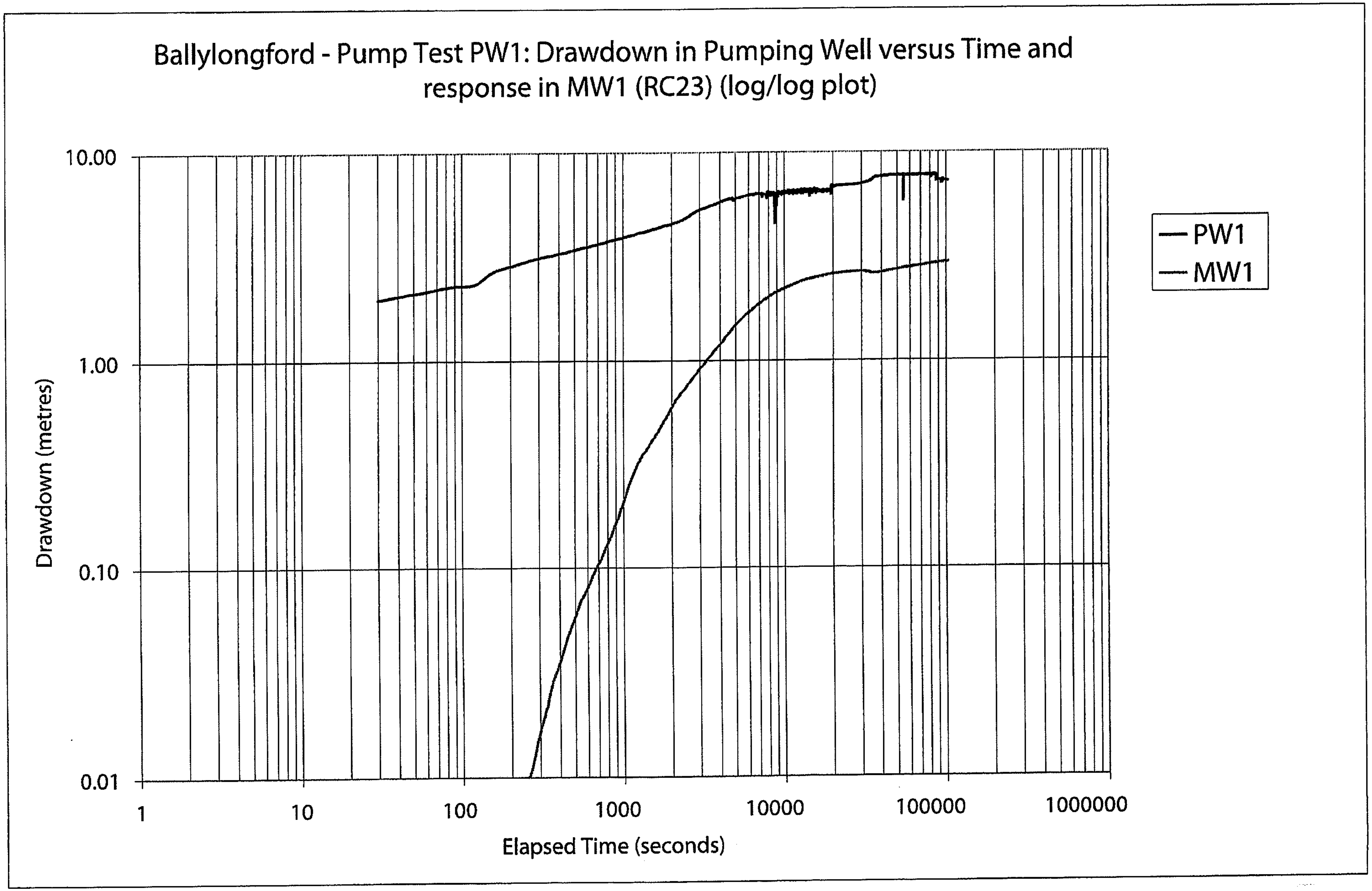

Ballylongford - Pump Test PW1: Drawdown in Pumping Well versus Time and response in MW1 (RC23) and MW2 (RC7)
14.00
13.00
12.00
11.00
10.00
9.00
8.00
7.00
6.00
5.00
4.00
Drawdown (metres O.D.)
0
20000
40000
60000
80000
100000
120000
140000
160000
180000
200000
Elapsed Time (seconds)
PW1
MW1
MW2

Figure B:4



Ballylongford - Pump Test PW1: Drawdown in Pumping Well versus Time and response in MW1 (RC23) (log/log plot)
Drawdown (metres)
10.00
1.00
0.10
0.01
1
10
100
1000
10000
100000
1000000
Elapsed Time (seconds)
PW1
MW1

Figure B:5

Ballylongford - Pump Test/Step Test PW1: Recovery in Pumping Well versus Time (Pump Test and Step Test) and Recovery in MW1 (RC23) (log/log plot)

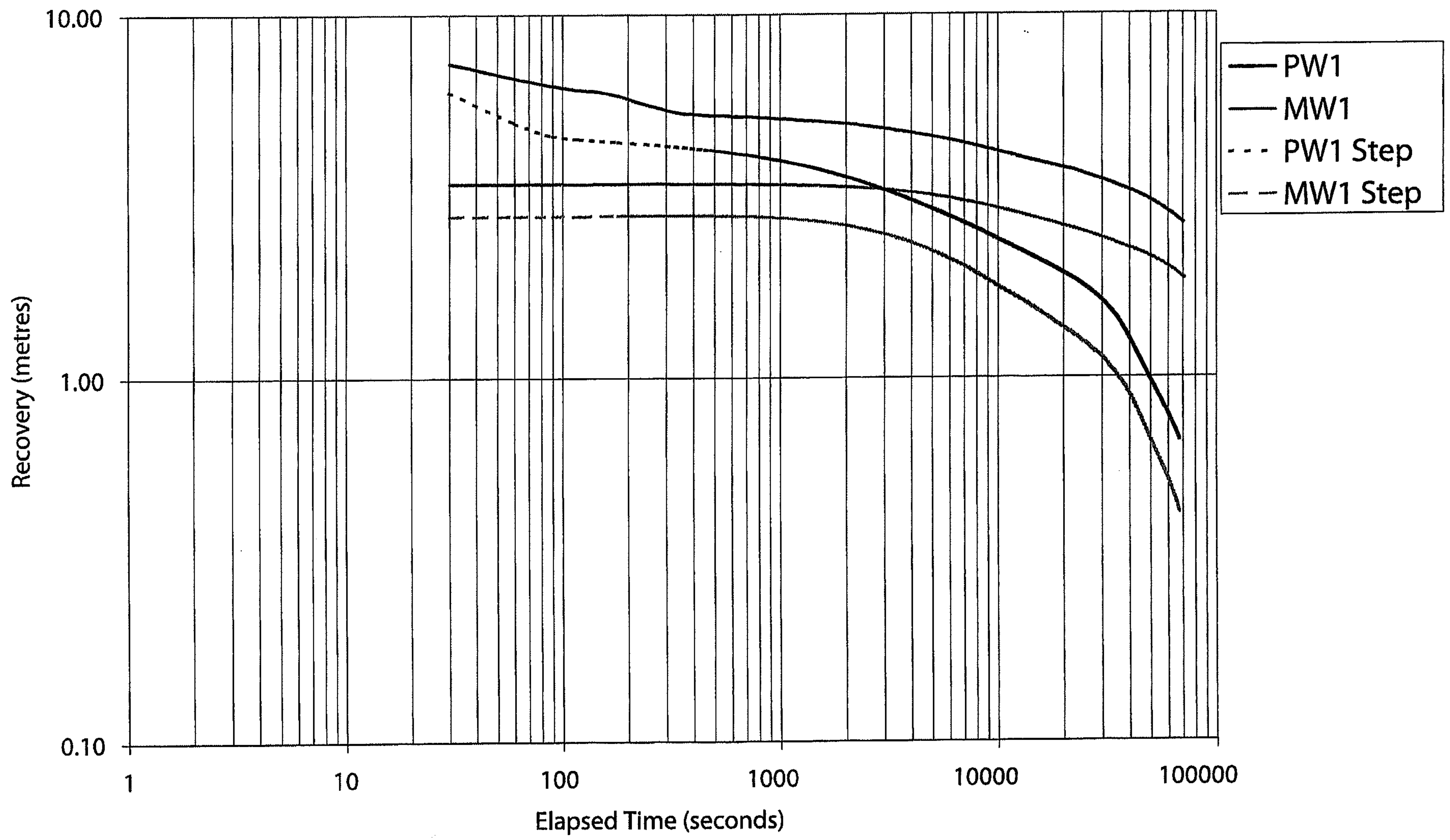


Figure B:6

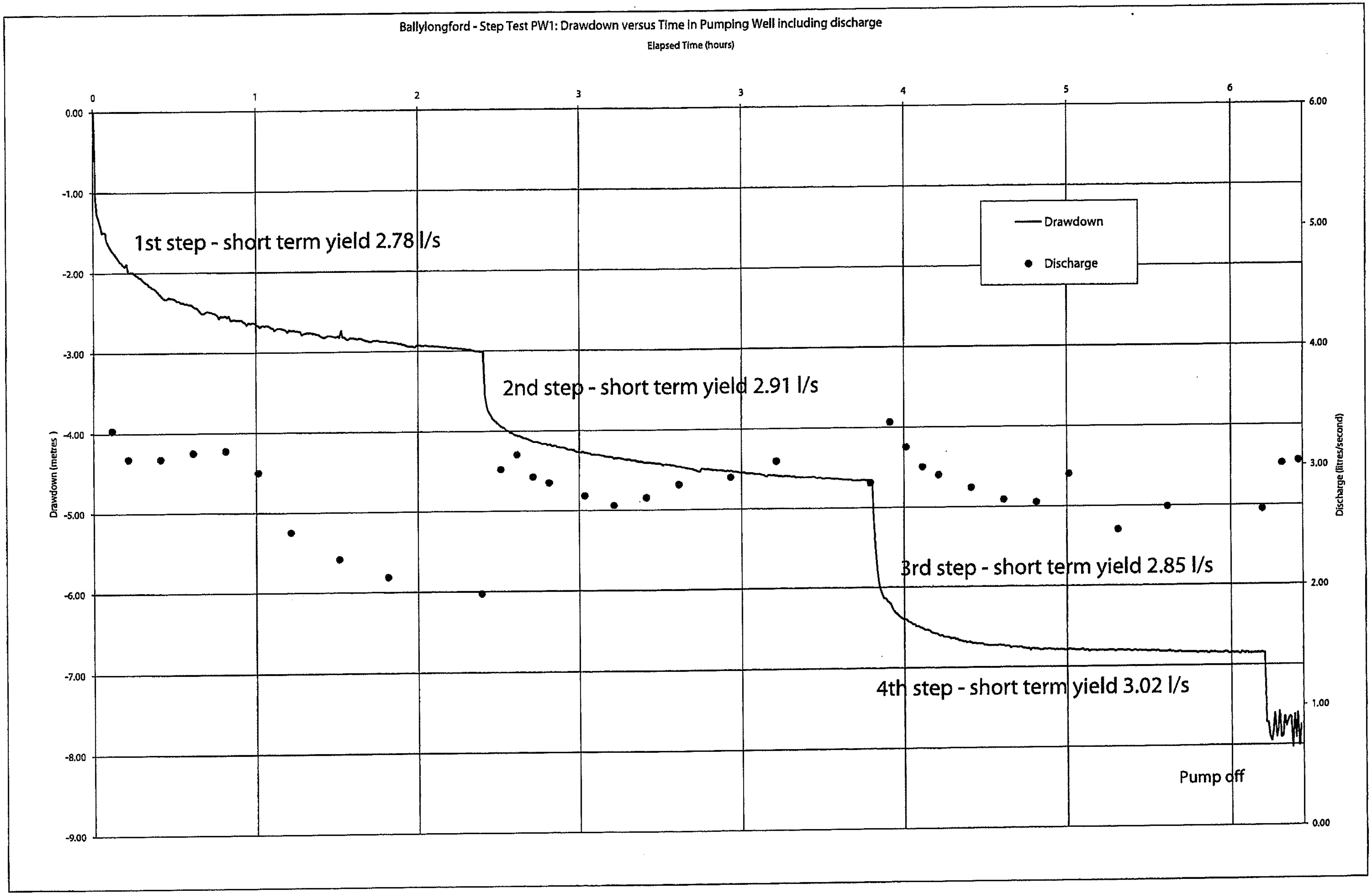

Ballylongford - Step Test PW1: Drawdown versus Time in Pumping Well including discharge
Elapsed Time (hours)
0
1
2
3
3
4
5
6
Drawdown (metres)
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
-7.00
-8.00
-9.00
Discharge (litres/second)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Drawdown
Discharge
1st step - short term yield 2.78 l/s
2nd step - short term yield 2.91 l/s
3rd step - short term yield 2.85 l/s
4th step - short term yield 3.02 l/s
Pump off

Figure B:7

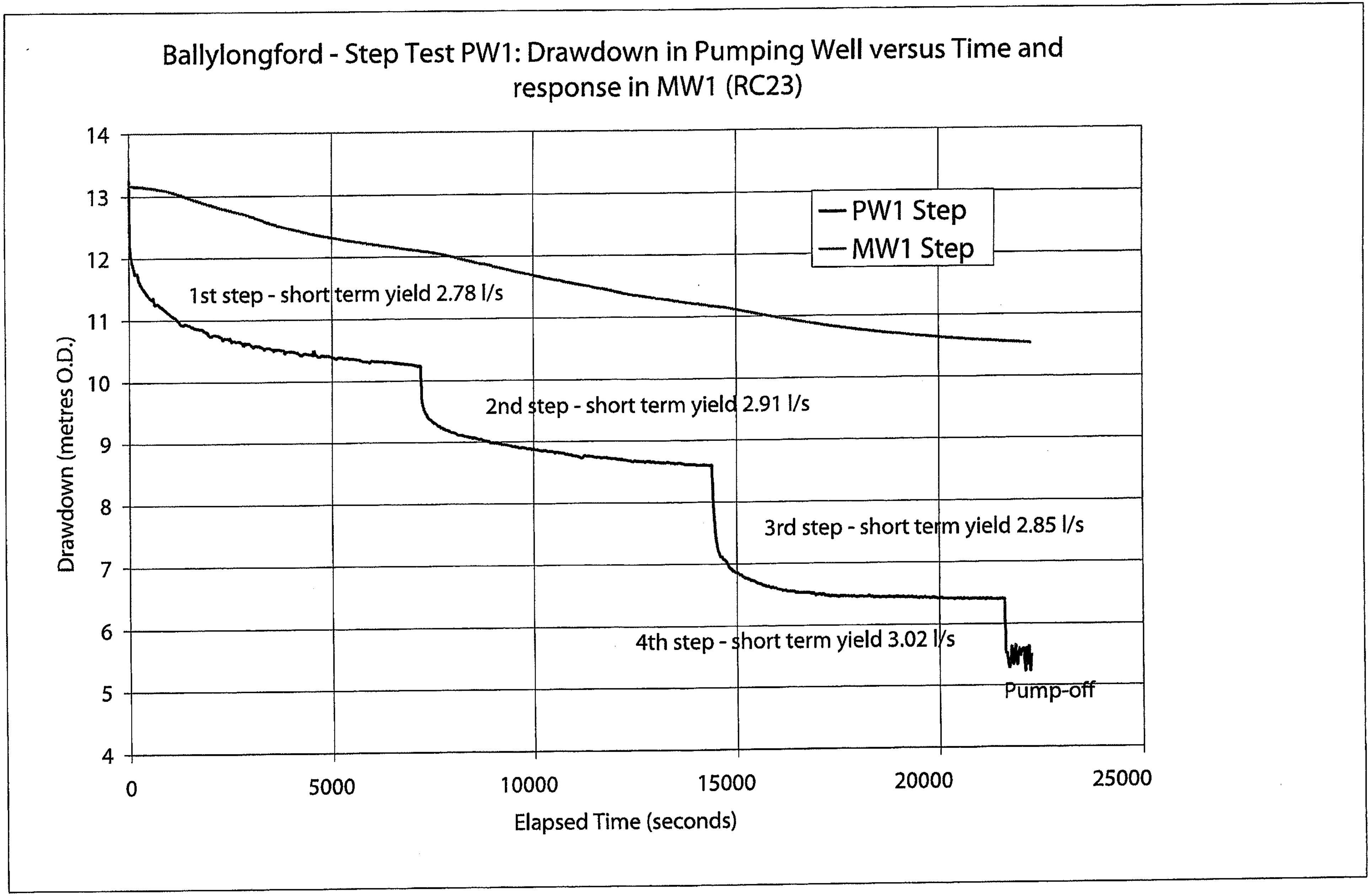

Ballylongford - Step Test PW1: Drawdown in Pumping Well versus Time and response in MW1 (RC23)
PW1 Step
MW1 Step
1st step - short term yield 2.78 l/s
2nd step - short term yield 2.91 l/s
3rd step - short term yield 2.85 l/s
4th step - short term yield 3.02 l/s
Pump-off
Drawdown (metres O.D.)
14
13
12
11
10
9
8
7
6
5
4
Elapsed Time (seconds)
0
5000
10000
15000
20000
25000

Figure B:8

LNG Ballylongford
Project No: 12239
Pump Test and Step Test Data Sheet
PW1

Test No: 1

Original Conditions			
Operative	CDL	Aquifer Type	Confined
Weather	Showers (both tests)	Geology	Fractured MUDSTONE
Pump	Grundfos SP30	Aquifer Note	Upper fractured MUDSTONE most productive (c.4.60m-c.6.50m)
Inlet	8.77m bgl	Development	Airlifting during drilling
Installation	05/01/2007	Recording	Logger/Manual Correction
Borehole Diameter	165mm	Monitoring Wells	2 No.
Screen	140mm ID(HDPE)	Recharge Bounderies	None Known locally
Test Zone	4.60m - 9.40m bgl	Other reading:	Temperature (Conductivity)
Note: Borehole located in area of topographical spring.			

Step Test

Start		End		Duration		
Date	Time	Date	Time	Hours	Minutes	Seconds
06/01/2007	10:33:30	06/01/2007	16:44	6.1833	371	22260

Drawdown/Response Details

		PW2 Step Test			
		Step 1	Step 2	Step 3	Step 4
	Rest	t120mns	t240mns	t360mns	t371mns
Water level mbgl	-0.09	2.92	4.57	6.76	7.92
Drawdown (m)	0.00	-3.01	-4.66	-6.85	-8.01
Ds (m)	n/a	3.01	1.65	2.19	1.16
Ds (residuals-graph)	n/a	2.59	1.5	2.09	1.06
Discharge (l/s)	0	1.98	2.79	2.83	3.02

	Monitoring Wells	
	MW1	MW2
WL rest (mbgl)	0.06	4.69
WL end (mbgl)	2.58	4.63
Drawdown	2.64	-0.05

Estimated maximum 90miniute well yield		c. 2 l/s
Estimated long-term yeid		<1 l/s

Figures 5-7 Discharge during each step difficult to assess

Pump Test

Start		End		Duration		
Date	Time	Date	Time	Hours	Minutes	Seconds
07/01/2007	11:33:30	08/01/2007	16:11:30	28.6333 17	17.998 103	079.9

Drawdown/Response Details

Borehole	Easting	Northing	m O.D.	Radial Distance	Rest WL (m bgl)	WL mO.D. Rest	WL (24hrs)	WL m O.D. (24 hrs)	s (24hrs)	Base of Aquifer 1	Base of Aquifer 2	top confin	Ho_1	Ho_2
PW1	102105.5	148479.3	13.16		0.46	12.70	8.20 4	.50 -7	74 9	40 6.5	0 4.6	0 4	80 1.90	
MW1	102143.4	148540.5	13.11	71.97	0.27	12.84	3.17 9	.67 -2	90 7.5	0 7.5	0 6.7	0 0	80 0.80	
MW2	102272.7	148640.0	19.09	231.92	4.67	14.42	4.73 9	.69 -0.	06 29	00 14.5	0 1.7	0 27	30 12.80	
										Average			10.97	5.17

Figures 1 - 4

Discharge Details

Intial Reading	Final Reading	Take (modelled)	Discharge (l/s)	Ave (l/s)	Ave (m^3/s)
n/a	n/a	145600	0.91	1.4124968	0.001412

Due to low level of discharge some results are based on manual readings;
Total discharge is therefore modelled not measured.

Table B:1

Appendix B:1
Corehole Field Records
(Figure B9 - B11)

GEOTECHNICAL CORE LOG RECORD

IGSL

REPORT NUMBER	12239		
CONTRACT	Tarbet/Ballylongford Onshore SI	DRILLHOLE NO	PW01
		SHEET	Sheet 1 of 1
CO-ORDINATES(_)	102,105.50 E 148,474.30 N	DATE STARTED	17/12/2006
GROUND LEVEL (m)	13.16	DATE COMPLETED	17/12/2006
CORE DIAMETER (mm)			
INCLINATION		DRILLED BY	Mill Drill
CLIENT	Shannon LNG		
ENGINEER	Arup Consulting Engineers	LOGGED BY	IGSL
FLUSH	AIR/MIST		

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation (mOD)	Standpipe Details	SPT (N Value)
0 – 4.60							SYMMETRIX OPEN HOLE DRILLING: Observed by driller as returns of clay and gravel.	4.60		8.56		
4.60 – 10.00							SYMMETRIX OPEN HOLE DRILLING: Observed by driller as gravel size returns of siltstone/mudstone. Probable bedrock.	10.00				

End of Corehole at 10.00m

REMARKS

150mm well hole drilled. 140mm standpipe installed from 10.0m bgl to + 0.50m above ground level. Malin Head Ordnance Datum used

INSTALLATION REMARKS

140mm Well Screen

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
17-12-07	10.00	4.60	10.00	

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments
17-12-06				Standing 0.50m above GL

RC OLDLOG1 12239RC.GPJ IGSL.GDT 13/11/07

Figure B 9

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbet/Ballylongford Onshore SI	**DRILLHOLE NO**	**RC07**
		SHEET	Sheet 1 of 3
CO-ORDINATES(_)	102,272.72 E 148,640.02 N	**GROUND LEVEL (m)**	19.09
		CORE DIAMETER (mm)	102
		DATE STARTED	22/11/2006
		DATE COMPLETED	24/11/2006
CLIENT	Shannon LNG	**INCLINATION**	
ENGINEER	Arup Consulting Engineers	**FLUSH**	AIR/MIST
		DRILLED BY	Mill Drill
		LOGGED BY	IGSL

Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%
2.50–3.50	100	83	24
3.50–4.70	100	42	11
4.70–6.30	100	41	9
6.30–6.70	100	20	0
6.70–8.20	100	91	22
8.20–9.80	100	52	28

Fracture Spacing (mm) 0 – 250 – 500

Description	Depth (m)	Discontinuities	Elevation (mOD)	SPT (N Value)
SYMMETRIX OPEN HOLE DRILLING: Observed by driller as returns of clay and gravel.	1.70		17.39	N = 50/130 mm (9, 13, 10, 19, 21)
SYMMETRIX OPEN HOLE DRILLING: Observed by driller as gravel size returns of sandstone/siltstone. Probable bedrock.	2.50		16.59	
Strong to locally moderately strong, thinly bedded, grey, fine grained SANDSTONE, interbedded with fine to medium grained siltstone. Fresh to locally slightly weathered.	3.60	Discontinuities are rough to smooth, planar and locally undulose. Apertures are tight to locally moderately open with iron oxide stained and locally clay/gravel infilled (3.18m-3.2m) surfaces. Dips are 30° and locally sub-vertical fractures (2.79m-2.95m, 3.55m-3.75m).	15.49	
Moderately strong to locally strong, thinly bedded, grey/dark grey, fine grained SILTSTONE/MUDSTONE, showing cross-stratification. Fresh to slightly weathered.	9.00	Discontinuities are smooth, planar and locally undulose. Apertures are tight to open with commonly iron oxide stained and commonly clay smeared (3.99m-4.08m, 4.8m-4.88m, 5.56m, 6.79m) surfaces. Dips are 30° and locally sub-vertical fractures (3.88m-3.99m, 4.22m-4.26m, 7.46m-7.62m, 7.98m-8.38m).	10.09	

REMARKS

Waterstrike at 3.8m. 14 Core boxes. 1 Wavin Pipe installed from 0.0m-2.5m. Malin Head Ordnance Datum used

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments
22-11-06			3.80	Waterstrike

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

RC OLDLOG1 12239RC.GPJ IGSL.GDT 13/11/07

Figure B10
(1 of 3)

GEOTECHNICAL CORE LOG RECORD

IGSL

REPORT NUMBER	12239
CONTRACT	Tarbet/Ballylongford Onshore SI
DRILLHOLE NO	RC07
SHEET	Sheet 2 of 3
CO-ORDINATES(_)	102,272.72 E 148,640.02 N
GROUND LEVEL (m)	19.09
CORE DIAMETER (mm)	102
INCLINATION	
FLUSH	AIR/MIST
DATE STARTED	22/11/2006
DATE COMPLETED	24/11/2006
CLIENT	Shannon LNG
ENGINEER	Arup Consulting Engineers
DRILLED BY	Mill Drill
LOGGED BY	IGSL

Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%
to 11.40	100	50	14
11.40–12.90	100	65	13
12.90–14.50	100	45	8
14.50–16.10	100	94	37
16.10–17.70	100	94	54
17.70–19.20	100	76	63
19.20–			

Downhole Depth (m): 10 – 19

Fracture Spacing (mm): 0 – 250 – 500

Description

Strong (axially) to moderately strong and locally moderately weak, thinly bedded, grey and dark grey, fine grained SILTSTONE/MUDSTONE (very locally, thinly bedded, medium siltstone/very fine sandstone), exibiting cross-stratification. Fresh to locally slightly weathered. *(continued)*

Discontinuities

Discontinuities are smooth, planar and locally undulose. Apertures are tight to moderately open and locally open. Dips are 30° and locally sub-vertical fractures (9.06m-9.09m, 9.17m-9.22m, 9.26m-9.48m, 9.71m-9.8m, 10.16m-10.21m, 10.56m-10.75m[clay smeared], 12.16m-12.58m, 13.25m-13.41m, 14.63m-14.7m, 16.04m-16.12m, 18.56m-18.85m). *(continued)*

Depth (m) | Elevation (mOD) | Standpipe Details | SPT (N Value)

REMARKS

Waterstrike at 3.8m. 14 Core boxes. 1 Wavin Pipe installed from 0.0m-2.5m. Malin Head Ordnance Datum used

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

RC OLDLOG1 12239RC.GPJ IGSL.GDT 13/11/07

Figure B10
(2 of 3)

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER	12239
CONTRACT	Tarbet/Ballylongford Onshore SI
DRILLHOLE NO	RC07
SHEET	Sheet 3 of 3
CO-ORDINATES(_)	102,272.72 E 148,640.02 N
GROUND LEVEL (m)	19.09
CORE DIAMETER (mm)	102
INCLINATION	
FLUSH	AIR/MIST
DATE STARTED	22/11/2006
DATE COMPLETED	24/11/2006
CLIENT	Shannon LNG
ENGINEER	Arup Consulting Engineers
DRILLED BY	Mill Drill
LOGGED BY	IGSL

Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%
20.00 – 20.80	100	100	59
20.80 – 22.40	100	58	53
22.40 – 24.00	100	94	59
24.00 – 25.50	100	97	63
25.50 – 27.10	100	96	77
27.10 – 27.50	100	100	100
27.50 – 29.00	100	100	97

Fracture Spacing (mm) 0 250 500

Description	Depth (m)	Discontinuities	Elevation (mOD)	Standpipe Details	SPT (N Value)
Strong (axially) to moderately strong and locally moderately weak, thinly bedded, grey and dark grey, fine grained SILTSTONE/MUDSTONE (very locally, thinly bedded, medium siltstone/very fine sandstone), exibiting cross-stratification. Fresh to locally slightly weathered. *(continued)*	21.50	Discontinuities are smooth, planar and locally undulose. Apertures are tight to moderately open and locally open. Dips are 30° and locally sub-vertical fractures (9.06m-9.09m, 9.17m-9.22m, 9.26m-9.48m, 9.71m-9.8m, 10.16m-10.21m, 10.56m-10.75m[clay smeared], 12.16m-12.58m, 13.25m-13.41m, 14.63m-14.7m, 16.04m-16.12m, 18.56m-18.85m). *(continued)*	-2.41		
Strong to locally moderately strong, thinly bedded, grey/dark grey, fine grained SST/SILT/MUDST, showing cross-stratification. Fresh to slightly weathered.	29.00	Discontinuities are smooth, planar and locally rough to smooth and undulose. Apertures are tight to open. Dips are 30° to 45° and locally sub-vertical fractures (21.51m-21.86m, 22.34m[60°], 22.5m[60°], 22.4m-22.73m).	-9.91		
End of Corehole at 29 (m)					

REMARKS

Waterstrike at 3.8m. 14 Core boxes. 1 Wavin Pipe installed from 0.0m-2.5m. Malin Head Ordnance Datum used

INSTALLATION REMARKS

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

Figure B10
(3 of 3)

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbet/Ballylongford Onshore SI	**DRILLHOLE NO**	RC23
		SHEET	Sheet 1 of 2
CO-ORDINATES(_)	102,143.35 E 148,540.51 N	**DATE STARTED**	16/11/2006
GROUND LEVEL (m)	13.11	**DATE COMPLETED**	17/11/2006
CORE DIAMETER (mm)	102	**DRILLED BY**	Mill Drill
INCLINATION		**LOGGED BY**	IGSL
FLUSH	AIR/MIST		
CLIENT	Shannon LNG		
ENGINEER	Arup Consulting Engineers		

Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Description	Depth (m)	Discontinuities	Elevation (mOD)	SPT (N Value)
				SYMMETRIX OPEN HOLE DRILLING: Observed by driller as returns of clay and gravel and cobbles.	6.70		6.41	N = 27 (2, 5, 4, 7, 6, 10) N = 15 (1, 2, 3, 1, 4, 7) N = 35 (3, 5, 8, 9, 8, 10) N = 41 (19, 6, 11, 7, 10, 13)
7.00	100	21	0	SYMMETRIX OPEN HOLE DRILLING: Observed by driller as gravel size returns of Probable bedrock.	7.00		6.11	
7.90	100	42	42	Moderately weak to moderately strong, thin to medium bedding, dark grey, very fine grained MUDSTONE/SILTSTONE. Moderately to locally slightly weathered.	8.00	Discontinuities are smooth and undulose. Apertures are open to locally moderately open with commonly clay smeared surfaces. Dips are 10° and irregular fractures.	5.11	
9.40				Strong to locally moderately strong, thin to medium bedding, grey, fine to medium grained SANDSTONE with lenses of siltstone. Fresh to locally slightly weathered.		Discontinuities are rough and undulose to planar and locally smooth. Apertures are open to moderately open. Dips are 10° and locally sub 90° and irregular fractures.		

Fracture Spacing (mm): 0 250 500

REMARKS

Waterstrike at 6.7m. 6 Core boxes. Malin Head Ordnance Datum used

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments
16-11-06			6.70	Waterstrike

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
17-11-06	7.50	5.00	7.50	50mm SP

Figure B11
(1 of 2)

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER	12239
CONTRACT	Tarbet/Ballylongford Onshore SI
DRILLHOLE NO	RC23
SHEET	Sheet 2 of 2
CO-ORDINATES(_)	102,143.35 E 148,540.51 N
GROUND LEVEL (m)	13.11
CORE DIAMETER (mm)	102
INCLINATION	
FLUSH	AIR/MIST
DATE STARTED	16/11/2006
DATE COMPLETED	17/11/2006
CLIENT	Shannon LNG
ENGINEER	Arup Consulting Engineers
DRILLED BY	Mill Drill
LOGGED BY	IGSL

Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%
10.00–10.90	100	79	73
10.90–12.40	100	93	77
12.40–13.90	100	77	34
13.90–15.50	100	96	34
15.50–16.10	100	85	63
16.10–16.80	100	57	20

Fracture Spacing (mm) 0 250 500

Description	Depth (m)	Discontinuities	Elevation (mOD)
Strong to locally moderately strong, thin to medium bedding, grey, fine to medium grained SANDSTONE with lenses of siltstone. Fresh to locally slightly weathered. *(continued)*	12.60	Discontinuities are rough and undulose to planar and locally smooth. Apertures are open to moderately open. Dips are 10° and locally sub 90° and irregular fractures. *(continued)*	0.51
Strong to moderately strong and very locally moderately weak, thinly bedded (cross stratified), grey/dark grey, fine to locally medium grained SILTSTONE/MUDSTONE with lenses of sandstone. Fresh to locally slightly weathered.	16.80	Discontinuities are smooth and planar to undulose. Apertures are open to locally tight with commonly clay smeared surfaces. Dips are 10° and locally 90° fractures.	-3.69
End of Corehole at 16.8 (m)			

Downhole Depth (m): 10, 11, 12, 13, 14, 15, 16, 17, 18, 19

Standpipe Details | SPT (N Value)

REMARKS

Waterstrike at 6.7m. 6 Core boxes. Malin Head Ordnance Datum used

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
17-11-06	7.50	5.00	7.50	50mm SP

Figure B11
(2 of 2)

Appendix B:2
Digital Pump Test Readings