Appendix V

APEX GEOSERVICES GEOPHYSICAL REPORT

AGL18164_01

REPORT

ON THE

GEOPHYSICAL SURVEY

AT

KILLYCARD, CASTLEBLAYNEY

CO. MONAGHAN

FOR

FEHILLY TIMONEY & CO.

APEX GEOSERVICES LIMITED
Unit 6 Knockmullen Business Pk.,
Gorey,
Co. Wexford, Ireland

T: 0402 21842
F: 0402 21843
E: info@apexgeoservices.ie
W: www.apexgeoservices.com

14TH NOVEMBER 2018

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	AGL18164		
AUTHOR	**CHECKED**	**REPORT STATUS**	**DATE**
EURGEOL PETER O'CONNOR M.SC. (GEOPHYSICS), P.GEO. DIP EIA MGT.	TONY LOMBARD M.SC. (GEOPHYSICS)	V1 DRAFT	14TH NOVEMBER 2018

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1. EXECUTIVE SUMMARY

APEX Geoservices Ltd. was requested by Fehilly Timoney & Co. to carry out a geophysical survey at a landfill site in Killycard, County Monaghan. The purpose of the investigation is to determine the extent, thickness, type and volume of imported material across the site. The site area covers approximately 2.2Ha of which approximately 0.9 Ha is covered in buildings and hardstands.

The site is underlain by cut away peat, with Lower Palaeozoic glacial till on the more elevated ground to the north and south.

The rock type locally is black pyritic, occasionally graptolitic, shale-schist of the Oghill Formation. Depth to rock is shallow and a number of old quarry workings occur in the vicinity.

Trial pit logs from a previous investigation show thin topsoil over mixed waste over soft peat and clay/silt. A number of the trial pit logs record 'black waste' on the logs.

The geophysical investigation consisted of EM ground conductivity mapping with follow-up Electrical Resistivity Tomography (ERT), Seismic Refraction profiling and MASW.

Both the elevated EM conductivity readings and the trial pit logs show waste to be present across the all of the survey area. Two zones with different types of waste have been outlined:

Zone A - TOPSOIL over MADE GROUND/WASTE (Predominantly organic) over very soft PEAT/CLAY with LEACHATE extending between 2 and 5m into the underlying peat, clay and silt layers. This area corresponds well with the location of those trial pits where 'black waste' was encountered.

Zone B - TOPSOIL over MADE GROUND/WASTE (mixed with CLAY/SILT) over very soft PEAT/CLAY.

As electrical contrasts between waste, leachate and soils are low the most reliable waste thickness information comes from the trial pit and MASW data. The average thickness of the Zone A waste is 2.1m and the average thickness of the Zone B waste is 2.4m.

The S-wave velocities for the survey area indicate soft to very soft waste and underlying soils and some **long term settlement** can be expected.

The volumes of waste calculated are as follows:

Zone	Extent (sq. m.)	Thickness (m.)	Volume (cu. m.)	Tonnes (@ 1.4 tonnes/cu.m.)
A	6743	2.1	14,160	19,824
B	6473	2.4	15,535	21,750
Totals	13,216		29,695	41,574

Bedrock elevation is around 85-90 mOD increasing to around 88-90 mOD to the south of the survey area. Combined waste and soil thicknesses range from around 5m to 10m.

Boreholes are recommended to confirm the findings of the geophysical report.

The geophysical report should be reviewed after the completion of any further direct investigation.

2. INTRODUCTION

APEX Geoservices Ltd. was requested by Fehilly Timoney & Co. to carry out a geophysical survey at a landfill site in Killycard, County Monaghan. A Tier 2 environmental risk assessment is being carried out at the site. As part of the risk assessment there is a requirement for a geophysical investigation. The purpose of the investigation is to determine the extent, thickness and type of imported material across the site.

2.1 Project Objectives

The objectives of the survey were to provide information on:

- The extent of the waste body
- The type of waste present
- The thickness of the waste and presence of any anomalous features
- A volume calculation
- Depth to bedrock (if within limits of the survey)
- Proposed location of direct investigation points.

2.2 Site Background

The historic landfill is located approximately 1.7km to the north-west of Castleblayney Town on the R-183 Castleblayney to Ballybay regional road. A Tier 1 environmental risk assessment (ERA) was conducted by Fehilly Timoney & Co. in June 2018 which included a detailed desk study and site walkover. The ERA concluded that a high-risk classification (Class A) can be assigned to the site and that further investigation was warranted. The area to be investigated covers approximately 2.2Ha of which approximately 0.9 Ha is covered in buildings and hardstands (Fig. 2.1).

Figure 2.1. Site location indicated by magenta boundary.

The site is bounded to the north by agricultural land, to the west by Corrinshigo Lough and to the east and south by farmland and farm buildings. The site is relatively flat lying at an elevation of c. 94 mOD.

2.3 Geology & Soils

The Teagasc soils map for the area (Fig. 2.2) indicates that the site is originally underlain by cut away peat, with Lower Palaeozoic glacial till on the more elevated ground to the north and south.

Figure 2.2: Brown = cut-away peat, red = glacial till.

The Geological Survey of Ireland (GSI) 1:100,000 Bedrock Geology map for the area (Figure 2.3) indicates that the site is underlain by the Oghill Formation, which consists of grey to grey-green massive sandstone (greywacke), microconglomerate and amalgamated beds with subordinate thin to thick-bedded greywacke and locally infaulted dark grey or black pyritic, occasionally graptolitic shale-mudstone.

Examination of the GSI 6'' geology sheet for the site shows the rock in the immediate vicinity of the site to be dark fissile, pyritic shale with occasional schists and white quartz veins. Depth to rock is shallow and a number of old quarry workings occur in the vicinity.

Figure 2.3. Bedrock geological map for the survey area.

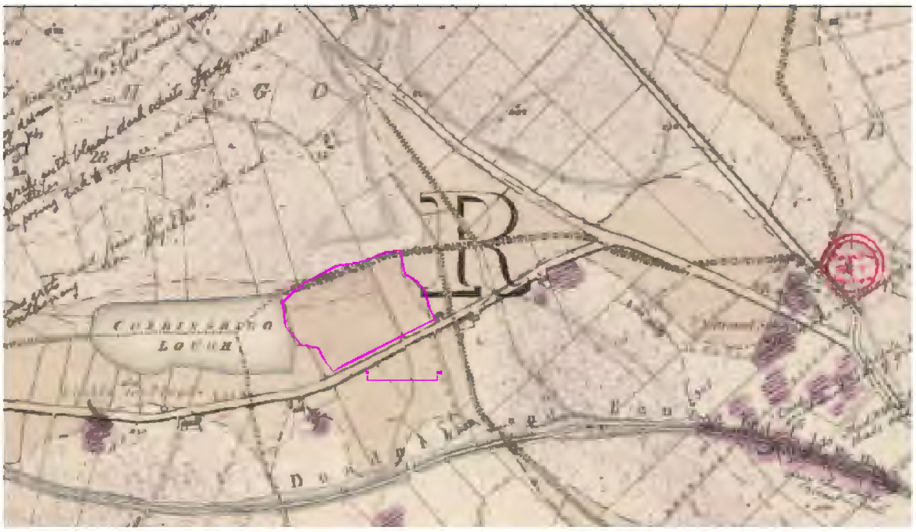

Figure 2.4. Geological Survey of Ireland 6'' sheet for the area.

2.4 Site Investigation

Thirteen trial pits and 3 monitoring wells were completed at the site in a previous investigation. The trial pit logs show the following general stratigraphy; thin topsoil (0.1m) over made ground consisting of mixed waste material to between 1.1 and 3.4m bgl. The waste is underlain by between between 0.8 and 1.6m of soft peat which in turn overlies soft to firm clay. The trial pit data have been incorporated into the geophysical interpretation presented in this report.

The location of the trial pits are shown on AGL18164_01. A number of trial pits record 'black waste' on the logs. These locations are designated with a 'K' after the Trial Pit number.

2.5 Survey Rationale

The investigation consisted of reconnaissance EM ground conductivity mapping with follow-up Electrical Resistivity Tomography (ERT), Seismic Refraction profiling and MASW:

EM ground conductivity mapping 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). This technique will provide information on the shallow (0-6m below ground level) variation of the superficial deposits and outline the extent of any shallow bedrock.

ERT soundings image the resistivity of the materials in the subsurface along a profile to produce a pseudo-section showing the variation in resistivity to depths dependent on the length of the profile. Each pseudo-section is interpreted to determine the material type along the profile based on the typical resistivities returned for Irish ground materials.

Seismic Refraction Profiling measures the P-wave 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. This method profiles the depth to the top of the stiff soils and bedrock, and provides information on the quality/strength of the bedrock.

The **MASW** method is used to estimate shear-wave velocities (Vs) in the ground material. Overburden material with a Vs <175 m/s is generally classified as soft/loose.

As with all geophysical methods the results are based on indirect readings of the subsurface properties. The effectiveness of the proposed approach will be affected by variations in the ground properties. By combining a number of techniques it is possible to provide a higher quality interpretation and reduce any ambiguities which may otherwise exist. Further information on the detailed methodology of each geophysical method employed in this investigation is given in **APPENDIX A: DETAILED METHODOLOGY**.

3 RESULTS & INTERPRETATION

The geophysical survey locations are indicated on Drawing AGL18164_01 (Appendix B). The survey area to the west of the yards and buildings extends to approximately 1.32 Ha.

3.1 EM Ground Conductivity Mapping

The EM31 conductivity survey locations are shown on Drawing AGL18164_01. The recorded EM31 conductivity values are contoured on Drawing AGL18164_02. The conductivity values range from 25-125 milliSiemens/metre (mS/m). The conductivity values have been interpreted as follows:

Conductivity (mS/m)	Interpretation
25 - 60	TOPSOIL over MADE GROUND/WASTE (mixed with CLAY/SILT) over very soft PEAT/CLAY
60 - 125	TOPSOIL over MADE GROUND/WASTE (Predominantly organic) over very soft PEAT/CLAY **with LEACHATE**

Note: EM31 measurements refer to the bulk electrical conductivity of the upper 6m of ground.

3.2 Electrical Resistivity Tomography

Five resistivity profiles were recorded across the site (Profiles R1 to R5). The locations are shown on Drawing AGL18164_01. Interpreted cross sections were compiled for the profiles and are presented on Drawings AGL18164_R1-R5.

In determining the various types of imported material present from the resistivity sections R1-R5 it should be noted that:

- typical resistivities of Irish soils range from 20 ohm-m (clays) to around 3000 Ohm-m (dry gravel),
- the resistivity generally increases as the sand/gravel content increases,
- silt/clay typically has values in the range 30-50 Ohm-m ,
- silty gravelly clay typically has resistivity values in the range 50-100 Ohm-m,
- deposits of predominantly organic waste such as those occurring in municipal landfills typically have resistivities in the range 5-30 Ohm-m.
- leachate saturated soils originating from predominantly organic waste have a similar resistivity range to organic waste, but will be influenced by the resistivities of the host material and the degree of dilution and dispersion of the leachate,
- inert C & D waste such as concrete, brick and mixed rock fill, stone and clay will usually have resistivities similar to gravelly material (50-500 Ohm-m).

The resistivity values recorded at this site ranged from 5-150 Ohm-m and have been interpreted as follows:

Resistivity (Ohm-m)	Interpretation
5-24	MADE GROUND/WASTE (Predominantly organic) over very soft PEAT/CLAY **with LEACHATE**
24-34	MADE GROUND/WASTE (mixed with CLAY/SILT) over very soft PEAT/CLAY
34-48	CLAY/SILT
48-150	PYRITIC SHALE/SCHIST BEDROCK

3.3 Seismic Refraction Profiling

Three seismic refraction profiles (S1-S3) were recorded across the site. The locations are shown on Drawing AGL18164_01 and the results are included on the interpreted cross sections in Drawings AGL18164_R1-R5 and in Appendix C.

The P-wave seismic velocities have been interpreted as follows:

Layer	Velocity (m/s)	Interpretation
1	300-350	Soft/loose MADE GROUND/WASTE/PEAT
2	700-800	Firm/medium dense or semi-saturated CLAY/SILT
3	2500-3200	Weak to occasionally moderately strong, cleaved SHALE/SCHIST

3.4 MASW

Shear wave (S-wave) velocity (Vs) and Gmax values were determined for the made ground/waste and underlying soil material. Vs velocities and corresponding soil cohesion ranges are summarised in Figure 3.1.

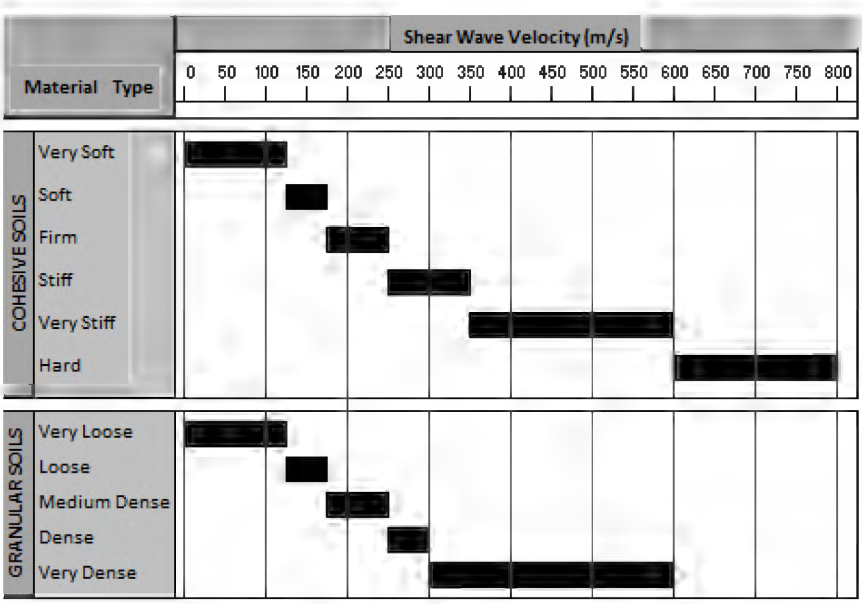

Fig 3.1: Vs velocities and corresponding soil cohesion ranges

The S-wave seismic velocities from this site have been interpreted as follows:

Layer	Velocity (m/s)	Interpretation
1	125 - 145	Soft/Loose MADE GROUND/WASTE (mixed with CLAY/SILT)
2	80 - 90	Very soft/Loose MADE GROUND/WASTE (Predominantly organic)
3	65 - 100	Very soft PEAT/CLAY

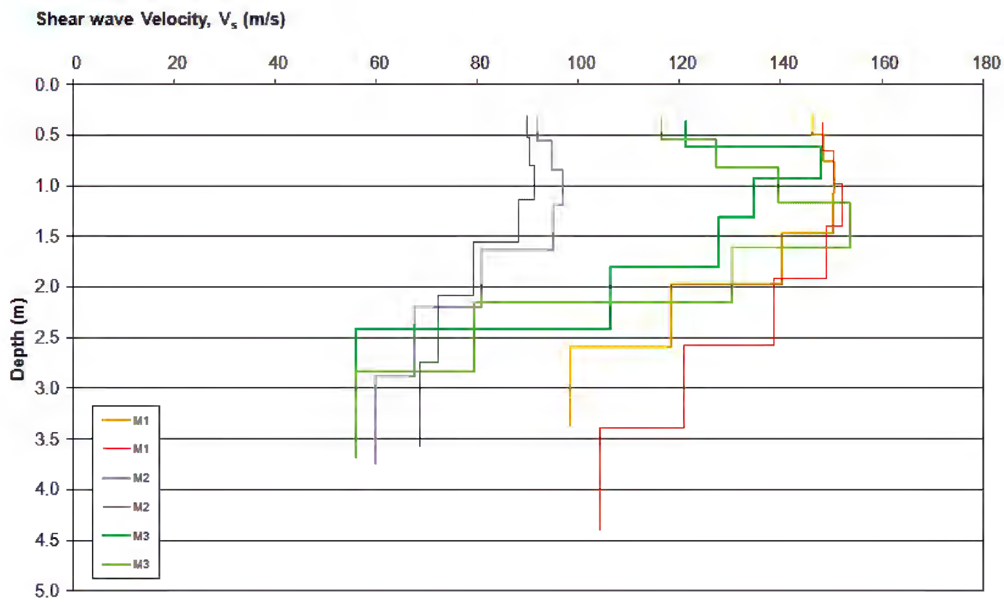

Fig 3.2: Vs velocities across site (M1-M3)

3.5 Discussion

The interpretation of the geophysical data is plotted on Drawings AGL18164_R1 to AGL18164_R5 and summarised on Drawings AGL18164_03.

3.5.1 Extent of the waste

Both the elevated EM conductivity readings and the trial pit logs show the waste to be present across the all of the survey area.

3.5.2 Type of waste

Both the EM Conductivity and the ERT profiles have outlined two types of waste present across the site:

The high EM conductivity and low ERT resistivity values have outlined an area of **0.67 Ha** which has been interpreted as TOPSOIL over MADE GROUND/WASTE (Predominantly organic) over very soft PEAT/CLAY with LEACHATE (**Zone A**). This area corresponds well with the location of trial pits where 'black waste' was encountered.

The lower EM conductivity and higher ERT resistivity values have outlined an area of **0.65 Ha** which has been interpreted as TOPSOIL over MADE GROUND/WASTE (mixed with CLAY/SILT) over very soft PEAT/CLAY **(Zone B)**. This area corresponds well with the location of trial pits where brown or grey-black waste mixed with clay or silt was encountered.

3.5.3 Thickness of waste and other information.

Electrical contrasts between both waste types and the underlying peat and clay are poor and the best thickness information comes from the trial pit and MASW data. The average thickness of the Zone A waste is 2.1m and the average thickness of the Zone B waste is 2.4m.

All of the ERT profiles in Zone A show the low resistivity zone to extend between 2 and 5m below the bottom of the waste as found on the trial pit logs. This has been interpreted as a zone of **leachate** beneath the waste body extending into the underlying peat, clay and silt layers.

The S-wave velocities for the waste layer indicate that it is slightly more compacted/stiffer/denser than the softer underlying peat/clay/silt material on which it sits. Some **long term settlement** can be expected on this basis.

3.5.4 Volume calculation

The volumes of waste calculated using the extents and thicknesses shown above are as follows:

Zone	Extent (sq. m.)	Thickness (m.)	Volume (cu. m.)	Tonnes (@ 1.4 tonnes/cu.m.)
A	6743	2.1	14,160	19,824
B	6473	2.4	15,535	21,750
Totals	13,216		29,695	41,574

3.5.5 Bedrock

The unusually low resistivity and the low seismic velocity for rock are both typical of what is expected from a fissile pyritic shale/schist of the type indicated on the GSI 6'' sheet for the area. Bedrock elevation is around 85-90 mOD increasing to around 88-90 mOD to the south. Combined waste and soil thicknesses range from around 5m to 10m. Due to the poor resistivity and seismic velocity contrasts between the pyritic shale/schist and overlying clays, silts, peat and waste, the exact bedrock profile is difficult to interpret with certainty.

4 RECOMMENDATIONS

To confirm the findings of the geophysical report the following boreholes are recommended:

No.	Easting	Northing	Comment
PBH1	680891.2	820416.5	to investigate predominantly organic waste and underlying leachate
PBH2	680948.3	820403.1	to investigate waste mixed with CLAY/SILT

The geophysical report should be reviewed after the completion of any direct investigation.

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APPENDIX A: DETAILED METHODOLOGY

A combination of a number of geophysical techniques was used to provide the high quality interpretation and reduce any ambiguities, which may otherwise exist.

A.1 EM Ground Conductivity Mapping

Principles

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). Readings over material such as organic waste and peat give high conductivity values while readings over dry materials with low clay mineral content such as gravels, limestone or quartzite give low readings. The EM31 survey technique determines the apparent conductivity of the ground material from 0-6m bgl depending on the dipole mode used. Depending on the dipole mode used, the measured conductivity is a function of the different overburden layers and/or rock from 0 to 6m below ground level.

Data collection

The EM31 equipment used was a GF CMD-4 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. Conductivity and in-phase values were recorded across the site. Local conditions and variations were recorded.

Data processing

The conductivity and in-phase field readings were downloaded, contoured and plotted using the SURFER 9 program (Golden Software, 2009). Data which was affected by metallic objects was removed. Assignation of material types and possible anomaly sources was carried out, with cross-reference to other data.

A.2 Electrical Resistivity Tomography

Principles

This surveying technique makes use of the Wenner resistivity array. 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 electrodes connected to a resistivity meter, using computer software to control the process of data collection and storage.

Data Collection

The data were recorded using a Tigre resistivity meter, imaging software, a 32 takeout multicore cables and 32 stainless steel electrodes. Saline solution was used at the electrode\ground interface in order to gain a good electrical contact required for the technique to work effectively. The recorded data were processed and viewed immediately after the survey.

Data Processing

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 the accompanying drawings. Distance is indicated along the horizontal axis of the profiles. Profiles have been contoured using the same contour intervals and colour codes.

A.3 Seismic Refraction Profiling

Principles
The seismic refraction profiling 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.

Data Collection
Seismic spreads were recorded using a Geode high-resolution 24 channel digital seismograph with geophone spacings of 2 m and 3 m. The source of the seismic waves was a sledgehammer. 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.

Data Processing
First break picking in digital format was carried out using the FIRSTPIX software program to construct traveltime plots for each spread. The recorded data was processed and interpreted using the intercept-time and plus-minus methods, to acquire depths to boundaries and the P-wave velocities of these layers, using the GREMIX programme from INTERPEX

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).

A.4 Multichannel Analysis of Surface Waves

Principles
The Multi-channel Analysis of Surface Waves (MASW) (Park et al., 1998, 1999) utilizes Surface waves (Rayleigh waves) 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 MASW 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. The following procedure is followed to produce a shear wave velocity (Vs) profile and a stiffness profile of the subsurface using surface waves:

(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 deposited along a straight line directed toward the source,
(iii) the ground motions are recorded using a seismograph,
(iv) a dispersion curve is produced from spectral analysis of the data showing the variation of surface wave velocity with wavelength,
(v) the dispersion curve in inverted using a modelling and least squares minimization process to produce a subsurface profile of the variation of shear wave velocity with depth.

Data Collection
The recording equipment consisted of a Geode 24 channel digital seismograph, 24 no. 4HZ vertical geophones, hammer energy source with mounted trigger and a 24 take-out cable, with geophone spacings of 2 m and 3 m.

Data Processing
MASW processing was carried out using the SURFSEIS processing package developed by Kansas Geological Survey (KGS, 2000). SURFSEIS data processing involves three steps:

(i) Preparation of the acquired multichannel record. This involves converting 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 bedrock P-wave velocities were converted to S-wave velocities using the following equation:

Vs=(((Vp^2)-2*v*(Vp^2))/((1-v)*2))^0.5

Where Vs = S-wave velocity in m/s, Vp = P-wave velocity in m/s and v = Poisson’s ratio.

A.5 Spatial Relocation

All the geophysical investigation locations were acquired using Trimble Geo 7X high-accuracy GNSS handheld GPS system using the settings listed below. This system allows collecting GPS data with c.20mm accuracy.

Projection:	Irish National Grid
Datum:	Ordnance
Coordinate units:	Meters
Altitude units:	Meters
Survey altitude reference:	MSL
Geoid model:	Republic of Ireland

APPENDIX B: DRAWINGS

The information derived from the geophysical investigation as well as correlation with the available direct investigation is presented in the following drawings:

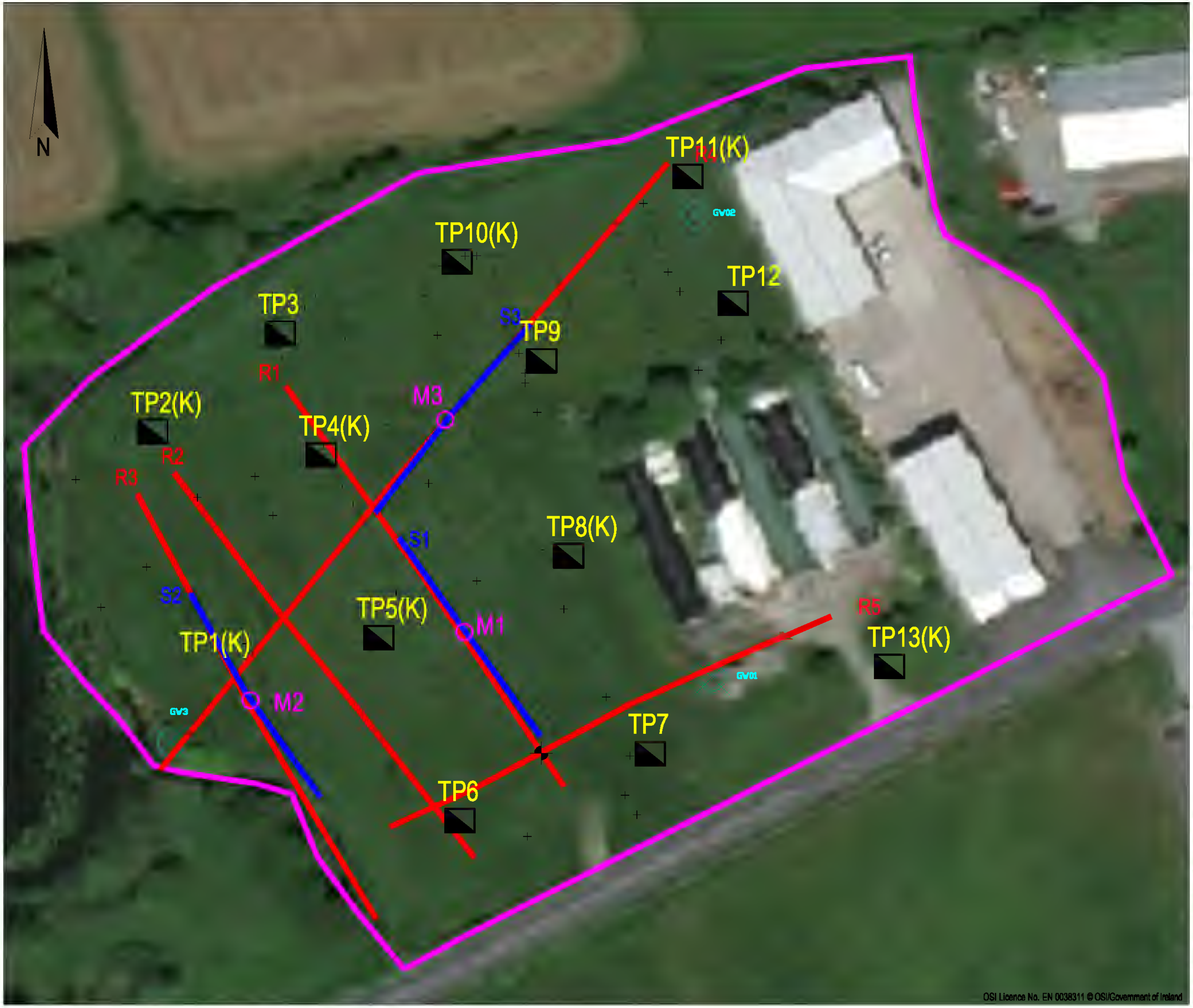
AGL18164_01	Geophysical Investigation Locations	Scale 1:1000 @ A4
AGL18164_02	EM Conductivity Contours (mS/m)	Scale 1:1000 @ A4
AGL18164_03	Summary Interpretation Map	Scale 1:1000 @ A4

The ERT and seismic refraction data with geological interpretations are presented in the following drawings:

Drawing AGL18164_R1	Results and Interpretation R1	Scale 1:750 @ A4
Drawing AGL18164_R2	Results and Interpretation R2	Scale 1:750 @ A4
Drawing AGL18164_R3	Results and Interpretation R3	Scale 1:750 @ A4
Drawing AGL18164_R4	Results and Interpretation R4	Scale 1:750 @ A4
Drawing AGL18164_R5	Results and Interpretation R5	Scale 1:750 @ A4

GEOPHYSICAL INVESTIGATION LOCATIONS

SCALE 1:1000



INDEX MAP:

LEGEND:

- Site
- EM conductivity/gravity reading
- R1 2D resistivity profile
- S1 Seismic refraction profile
- M1 MASW sounding
- TP1 Previous Trial Pit (K denotes black waste on log.)
- GV Monitoring Well

The information displayed here is to be used in conjunction with Report AGL18164_01 Report on the Geophysical Investigation at Killycard Landfill, Co. Monaghan, APEX Geoservices Ltd. 14-11-2018.

apex geoservices

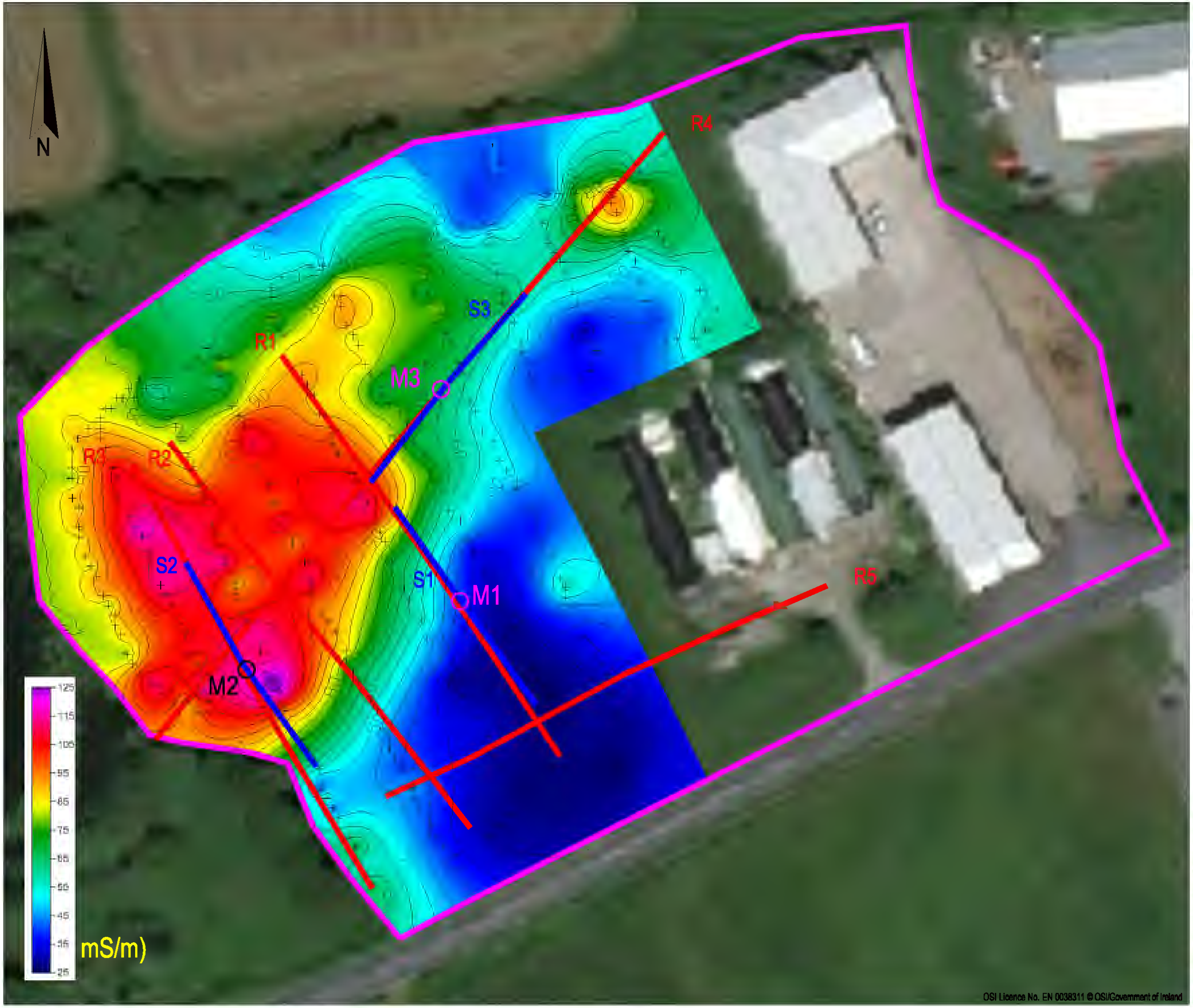
6 Knockmullen Business Park
Gorey
Co. Wexford
Ireland.
T +353 (0)402-21842
F +353 (0)402-21843
E info@apexgeoservices.ie
www.apexgeoservices.ie

PROJECT:	KILLYCARD LANDFILL GEOPHYSICAL INVESTIGATION
CLIENT:	FEHILY TIMONEY & CO.
DRAWING NO:	AGL18164_01
SCALE:	AS INDICATED @ A4
DATE:	14-11-2018

Version:	Date:	Drawn By:	Checked:
01	14-11-2018	POC	YOC

EM CONDUCTIVITY CONTOURS (mS/m)

SCALE 1:1000



INDEX MAP:

LEGEND:

- Site
- EM conductivity/gravity reading
- R1 2D resistivity profile
- S1 Seismic refraction profile
- M1 MASW sounding
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- GW Monitoring Well

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apex geoservices

6 Knockmullen Business Park
Gorey
Co. Wexford
Ireland.
T +353 (0)402-21842
F +353 (0)402-21843
E info@apexgeoservices.ie
www.apexgeoservices.ie

PROJECT:	KILLYCARD LANDFILL GEOPHYSICAL INVESTIGATION
CLIENT:	FEHILY TIMONEY & CO.
DRAWING NO:	AGL18164_02
SCALE:	AS INDICATED @ A4
DATE:	14-11-2018

Version:	Date:	Drawn By:	Checked:
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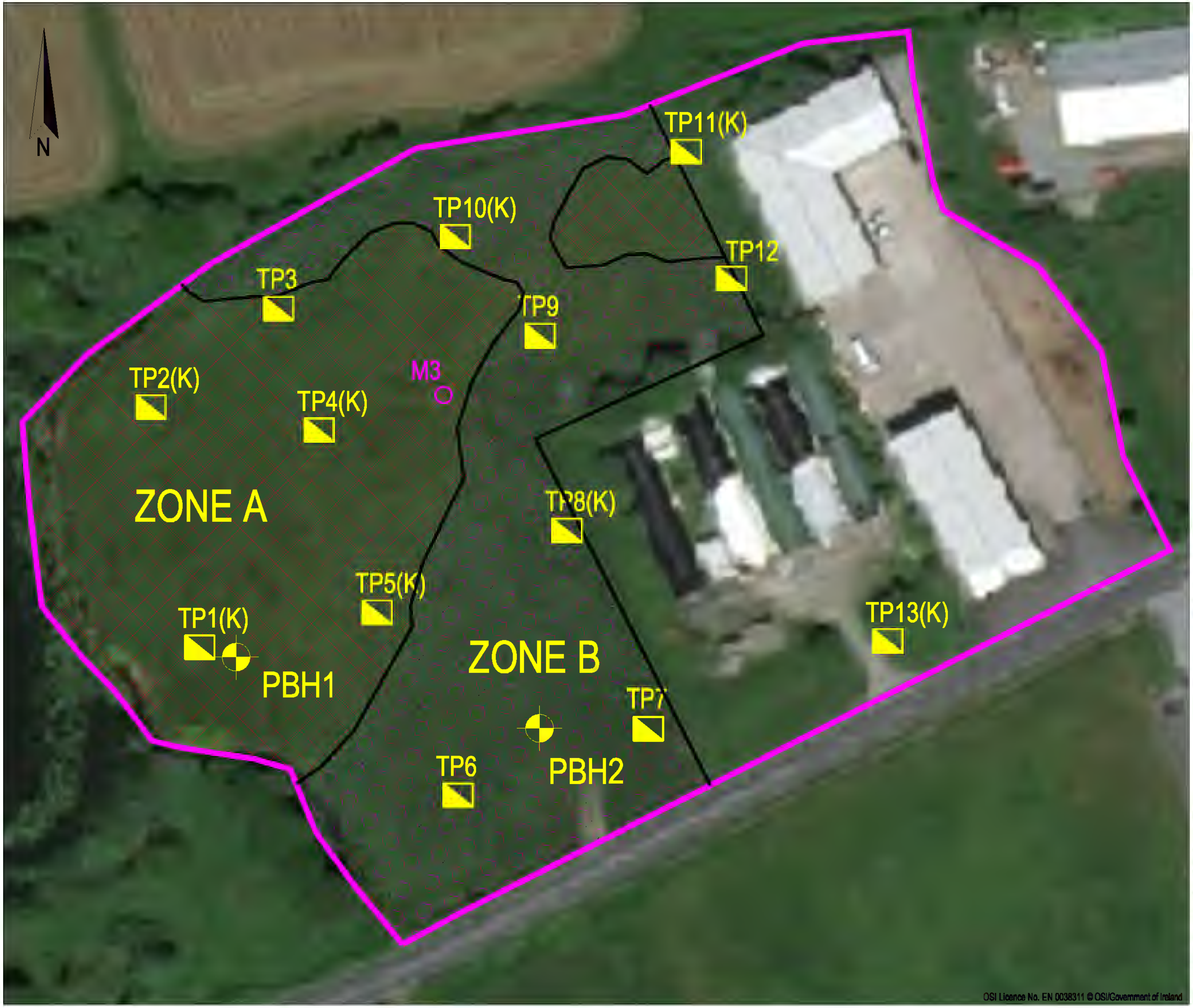
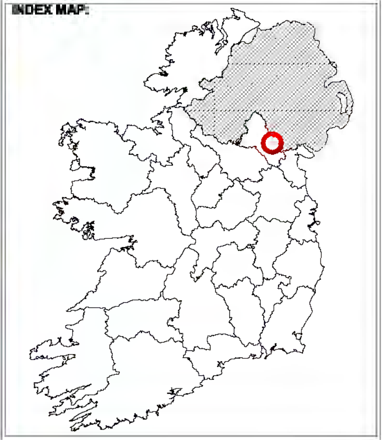
SUMMARY INTERPRETATION MAP

SCALE 1:1000



INDEX MAP:



LEGEND:

SITE

ZONE A - TOPSOIL OVER MADE GROUND/WASTE (PRED. ORGANIC) OVER VERY SOFT PEAT/CLAY WITH LEACHATE

ZONE B - TOPSOIL OVER MADE GROUND/WASTE (MIXED WITH CLAY/SILT) OVER VERY SOFT PEAT/CLAY

PBH1 PROPOSED BOREHOLE

The information displayed here is to be used in conjunction with Report AGL18164_01 Report on the Geophysical Investigation at Killycard Landfill, Co. Monaghan, APEX Geoservices Ltd. 14-11-2018.

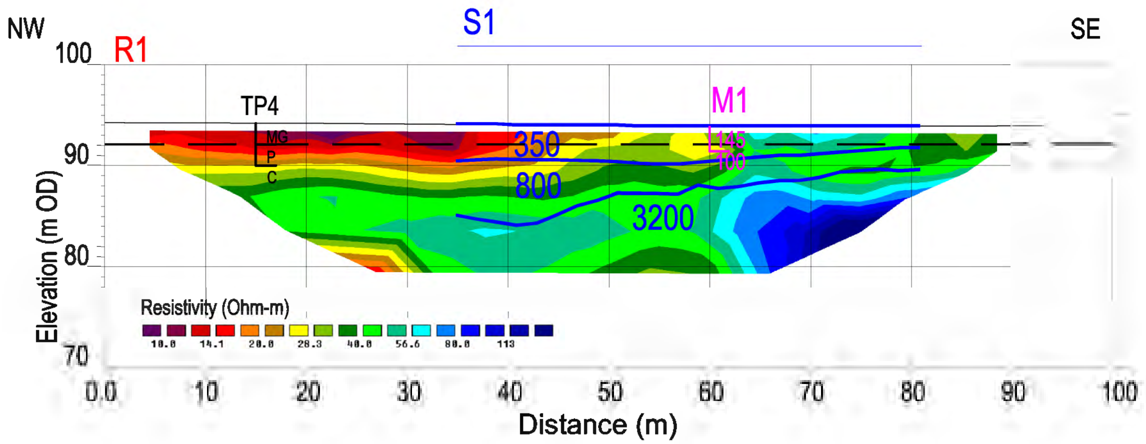
apex geoservices

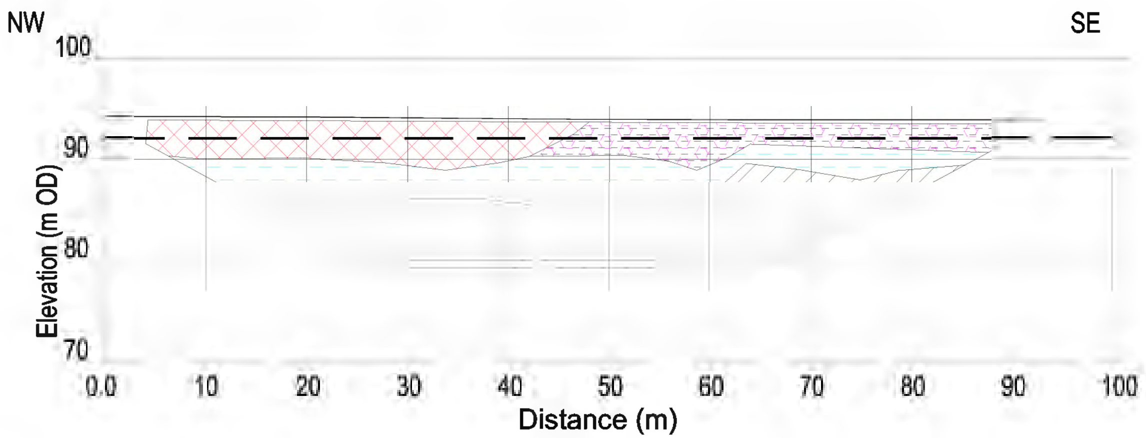
6 Knockmullen Business Park
Gorey
Co. Wexford
Ireland.
T +353 (0)402-21842
F +353 (0)402-21843
E info@apexgeoservices.ie
www.apexgeoservices.ie

PROJECT:	KILLYCARD LANDFILL GEOPHYSICAL INVESTIGATION
CLIENT:	FEHILY TIMONEY & CO.
DRAWING NO:	AGL18164_03
SCALE:	AS INDICATED @ A4
DATE:	14-11-2018

Version:	Date:	Drawn By:	Checked:
01	14-11-2018	POC	YOC

RESULTS AND INTERPRETATION - R1
SCALE 1:750





INDEX MAP:

LEGEND:

- MADE GROUND/WASTE (PRED. ORGANIC) OVER VERY SOFT PEAT/CLAY WITH LEACHATE
- MADE GROUND/WASTE (MIXED WITH CLAY/SILT) OVER VERY SOFT PEAT/CLAY
- SOFT-FIRM CLAY/SILT
- PYRITIC SHALE/SCHIST BEDROCK
- TP1 — Previous Trial Pit Summary **MG(Made Ground/Waste), P(Peat),C(Clay)**
- Base of waste (from Trial Pits)
- 1288 — Seismic refraction layer with interpreted P-wave velocity (m/s)
- 145 — MASW with S-wave velocity (m/s)
- PBH1 — Proposed borehole

The information displayed here is to be used in conjunction with Report AGL18164_01 Report on the Geophysical Investigation at Killycard Landfill, Co. Monaghan, APEX Geoservices Ltd. 14-11-2018.

apex geoservices

6 Knockmullen Business Park
Gorey
Co. Wexford
Ireland.
T +353 (0)402-21842
F +353 (0)402-21843
E info@apexgeoservices.ie
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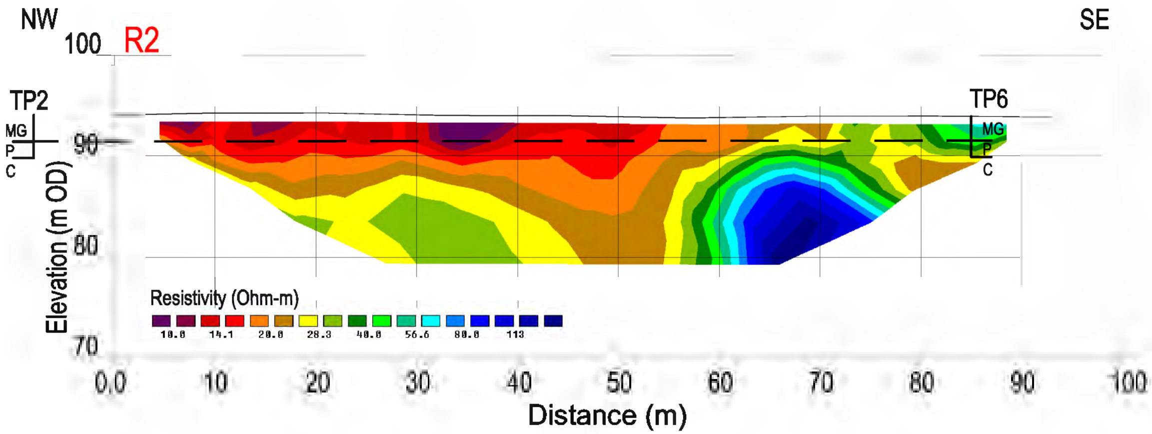
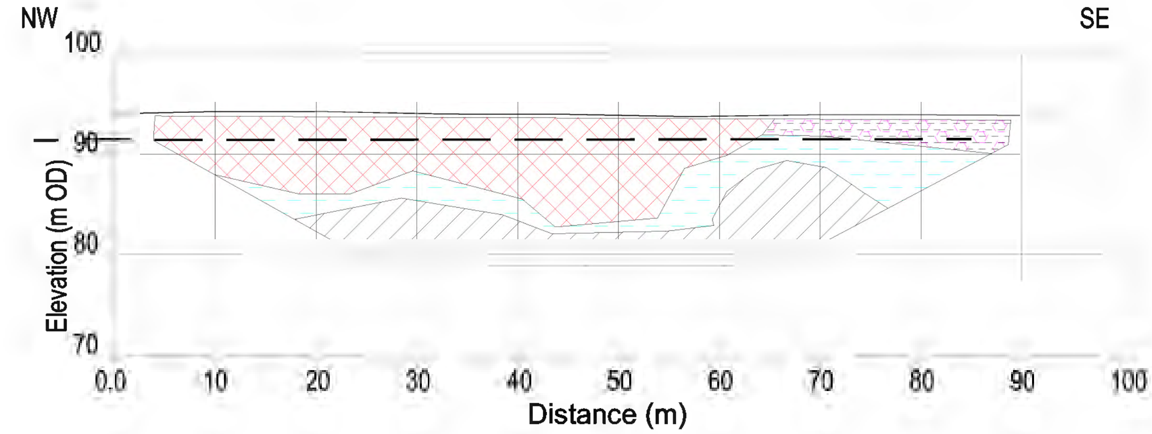
PROJECT:	KILLYCARD LANDFILL GEOPHYSICAL INVESTIGATION
CLIENT:	FEHILY TIMONEY & CO.
DRAWING NO:	AGL18164_R1
SCALE:	AS INDICATED @ A4
DATE:	14-11-2018

Version:	Date:	Drawn By:	Checked:
01	14-11-2018	ROC	YOC

RESULTS AND INTERPRETATION - R2

SCALE 1:750





LEGEND:

- MADE GROUND/WASTE (PRED. ORGANIC) OVER VERY SOFT PEAT/CLAY WITH LEACHATE
- MADE GROUND/WASTE (MIXED WITH CLAY/SILT) OVER VERY SOFT PEAT/CLAY
- SOFT-FIRM CLAY/SILT
- PYRITIC SHALE/SCHIST BEDROCK
- TP1 Previous Trial Pit Summary **MG(Made Ground/Waste), P(Peat),C(Clay)**
- Base of waste (from Trial Pits)
- 1288 Seismic refraction layer with interpreted P-wave velocity (m/s)
- 145 MASW with S-wave velocity (m/s)
- Proposed borehole

The information displayed here is to be used in conjunction with Report AGL18164_01 Report on the Geophysical Investigation at Killycard Landfill, Co. Monaghan, APEX Geoservices Ltd. 14-11-2018.

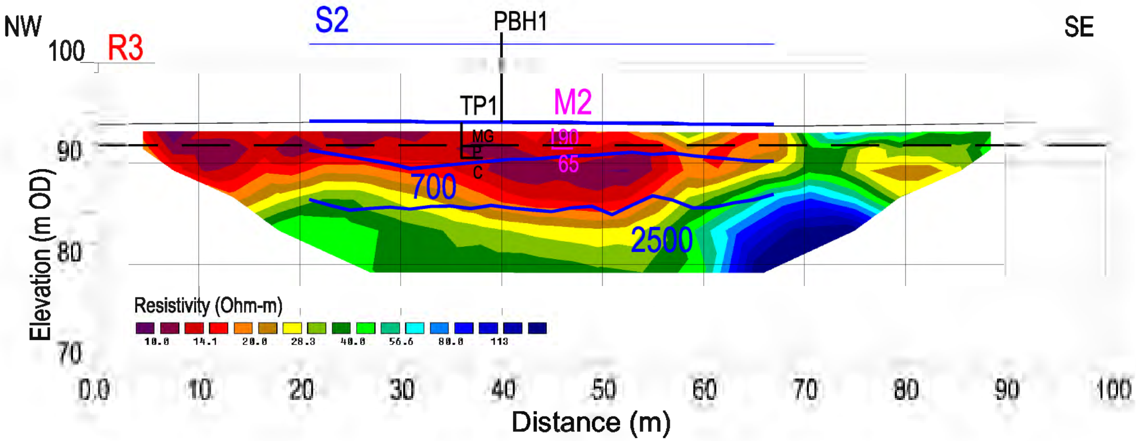
apex geoservices

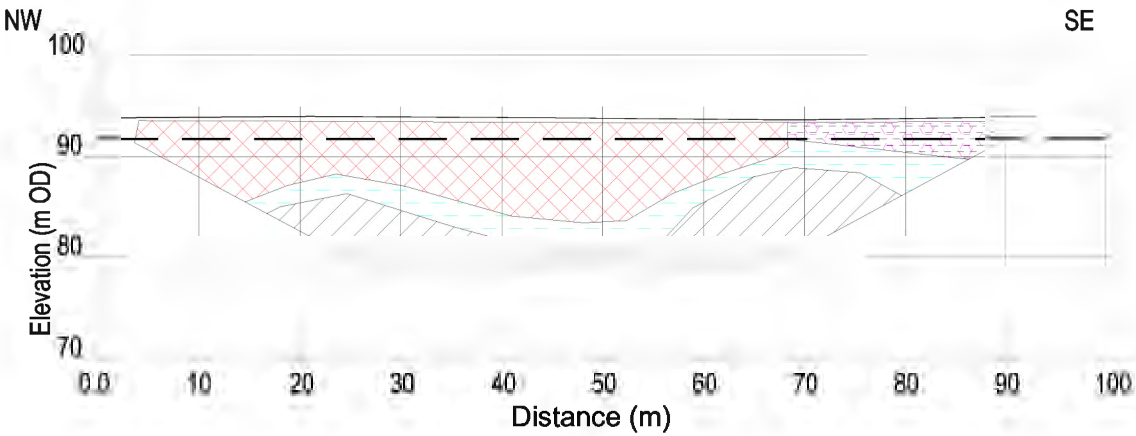
6 Knockmullen Business Park
Gorey
Co. Wexford
Ireland.
T +353 (0)402-21842
F +353 (0)402-21843
E info@apexgeoservices.ie
www.apexgeoservices.ie

PROJECT:	KILLYCARD LANDFILL GEOPHYSICAL INVESTIGATION
CLIENT:	FEHILY TIMONEY & CO.
DRAWING NO:	AGL18164_R2
SCALE:	AS INDICATED @ A4
DATE:	14-11-2018

Version:	Date:	Drawn By:	Checked:
01	14-11-2018	ROC	WOC

RESULTS AND INTERPRETATION - R3
SCALE 1:750





INDEX MAP:

LEGEND:

MADE GROUND/WASTE (PRED. ORGANIC) OVER VERY SOFT PEAT/CLAY WITH LEACHATE

MADE GROUND/WASTE (MIXED WITH CLAY/SILT) OVER VERY SOFT PEAT/CLAY

SOFT-FIRM CLAY/SILT

PYRITIC SHALE/SCHIST BEDROCK

TP1 Previous Trial Pit Summary **MG(Made Ground/Waste), P(Pest),C(Clay)**

Base of waste (from Trial Pits)

1288 Seismic refraction layer with interpreted P-wave velocity (m/s)

145 MASW with S-wave velocity (m/s)

PBH1 Proposed borehole

The information displayed here is to be used in conjunction with Report AGL18164_01 Report on the Geophysical Investigation at Killycard Landfill, Co. Monaghan, APEX Geoservices Ltd. 14-11-2018.

apex geoservices

6 Knockmullen Business Park
Gorey
Co. Wexford
Ireland.
T +353 (0)402-21842
F +353 (0)402-21843
E info@apexgeoservices.ie
www.apexgeoservices.ie

PROJECT: KILLYCARD LANDFILL GEOPHYSICAL INVESTIGATION

CLIENT: FEHILY TIMONEY & CO.

DRAWING NO: AGL18164_R3

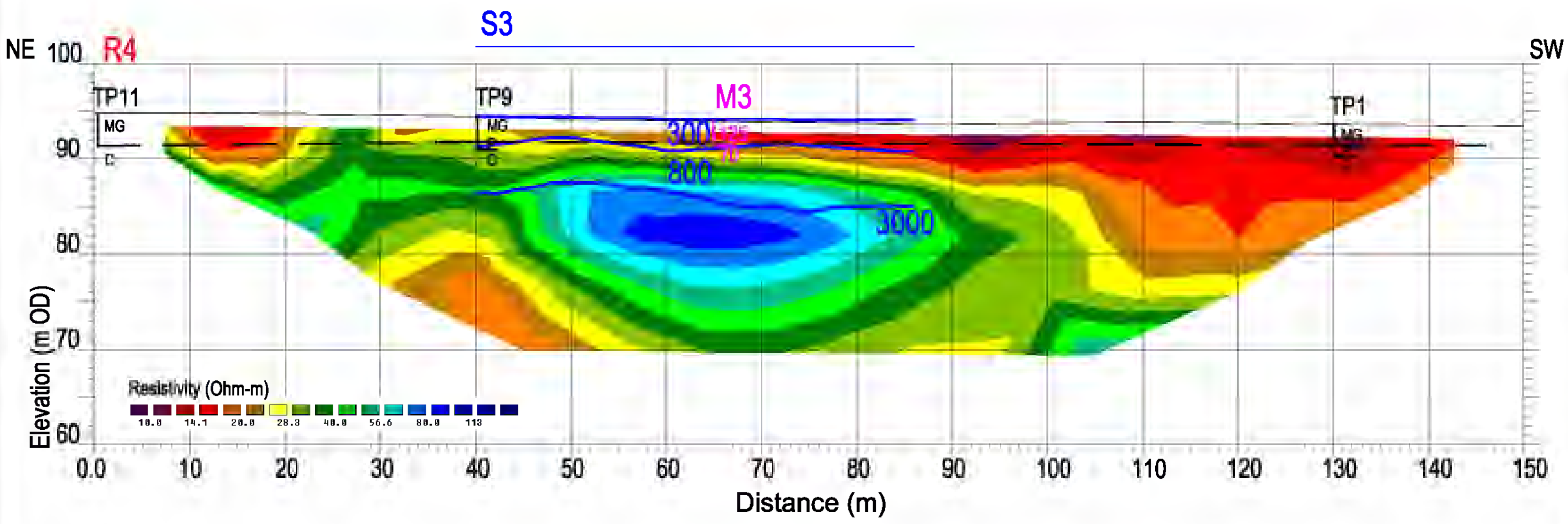
SCALE: AS INDICATED @ A4

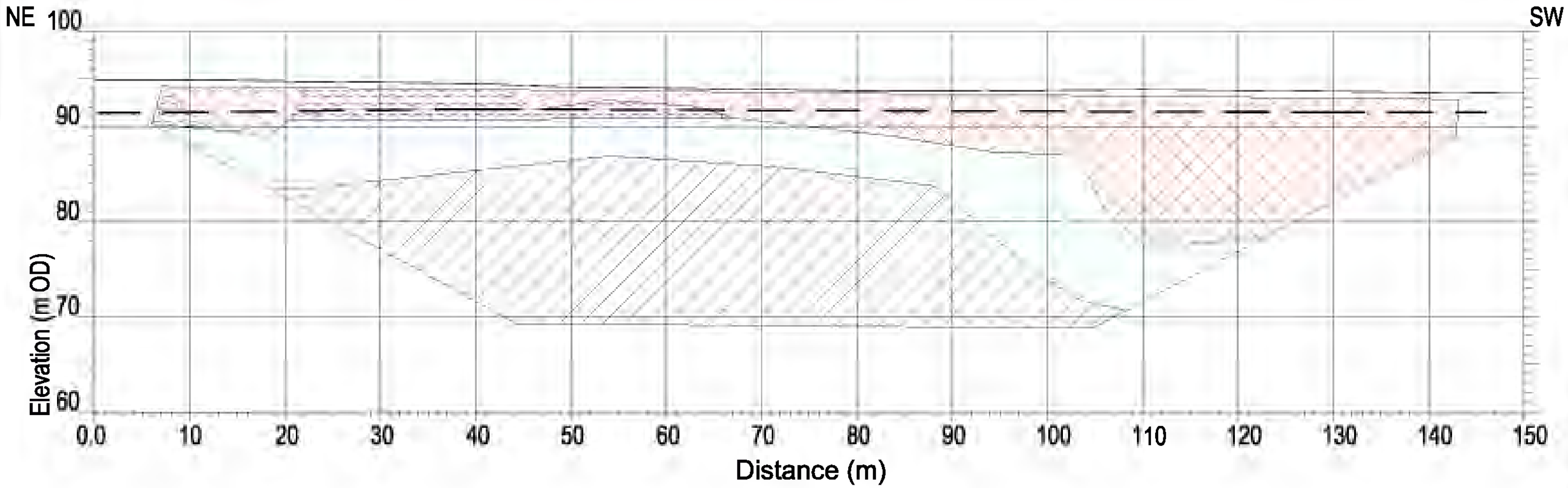
DATE: 14-11-2018

Version:	Date:	Drawn By:	Checked:
01	14-11-2018	ROC	WOC

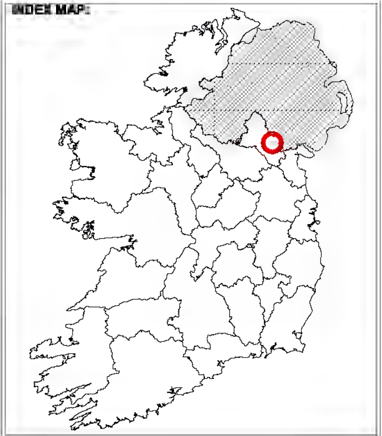
RESULTS AND INTERPRETATION - R4

SCALE 1:750





INDEX MAP:



LEGEND:

- MADE GROUND/WASTE (PRED. ORGANIC) OVER VERY SOFT PEAT/CLAY WITH LEACHATE
- MADE GROUND/WASTE (MIXED WITH CLAY/SILT) OVER VERY SOFT PEAT/CLAY
- SOFT-FIRM CLAY/SILT
- PYRITIC SHALE/SCHIST BEDROCK
- TP1 Previous Trial Pit Summary **MG(Made Ground/Waste), P(Peat),C(Clay)**
- Base of waste (from Trial Pits)
- 1288 Seismic refraction layer with interpreted P-wave velocity (m/s)
- 145 MASW with S-wave velocity (m/s)
- PBH1 Proposed borehole

The information displayed here is to be used in conjunction with Report AGL18164_01 Report on the Geophysical Investigation at Killycard Landfill, Co. Monaghan, APEX Geoservices Ltd. 14-11-2018.

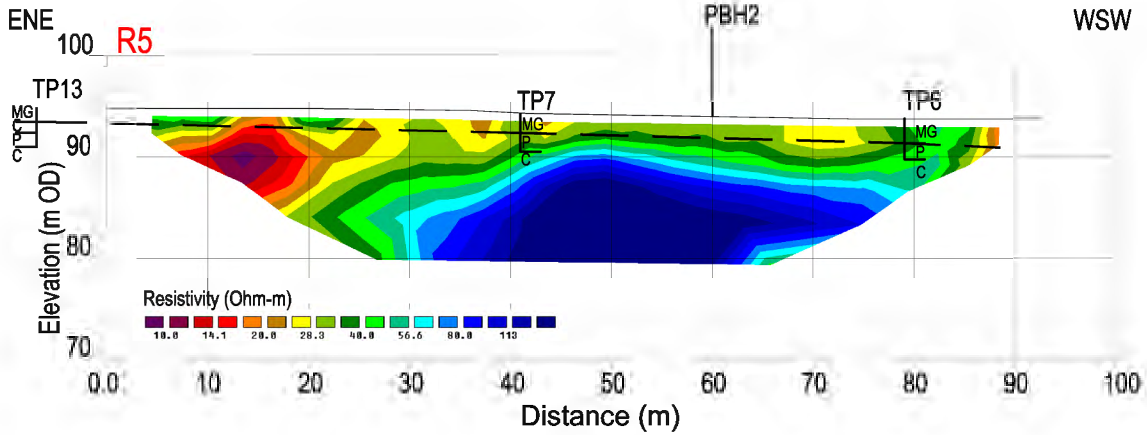
apex geoservices

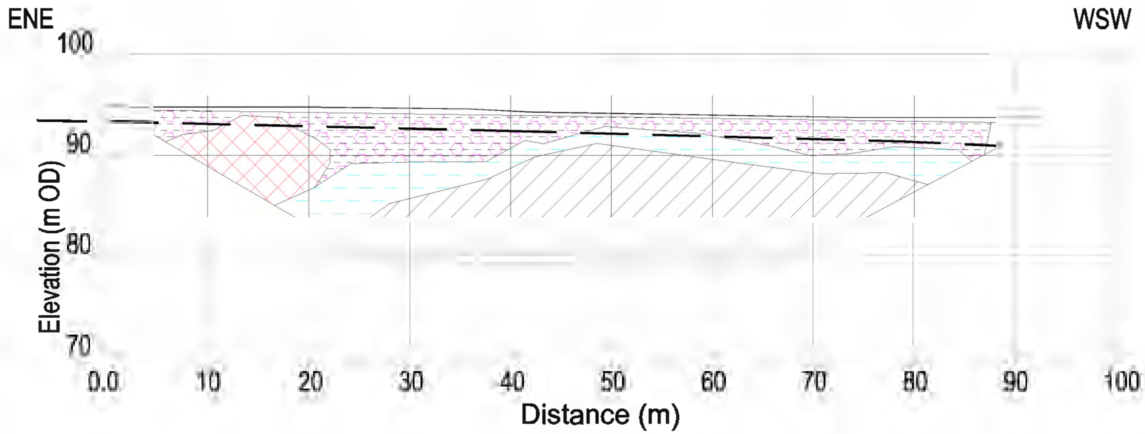
6 Knockmullen Business Park
Gorey
Co. Wexford
Ireland.
T +353 (0)402-21842
F +353 (0)402-21843
E info@apexgeoservices.ie
www.apexgeoservices.ie

PROJECT:	KILLYCARD LANDFILL GEOPHYSICAL INVESTIGATION
CLIENT:	FEHILY TIMONEY & CO.
DRAWING NO:	AGL18164_R5
SCALE:	AS INDICATED @ A4
DATE:	14-11-2018

Version:	Date:	Drawn By:	Checked:
01	14-11-2018	POC	YOC

RESULTS AND INTERPRETATION - R5
SCALE 1:750





INDEX MAP:

LEGEND:

MADE GROUND/WASTE (PRED. ORGANIC) OVER VERY SOFT PEAT/CLAY WITH LEACHATE

MADE GROUND/WASTE (MIXED WITH CLAY/SILT) OVER VERY SOFT PEAT/CLAY

SOFT-FIRM CLAY/SILT

PYRITIC SHALE/SCHIST BEDROCK

TP1 Previous Trial Pit Summary
MG(Made Ground/Waste), P(Peat),C(Clay)

Base of waste (from Trial Pits)

1288 Seismic refraction layer with interpreted P-wave velocity (m/s)

145 MASW with S-wave velocity (m/s)

Proposed borehole

The information displayed here is to be used in conjunction with Report AGL18164_01 Report on the Geophysical Investigation at Killycard Landfill, Co. Monaghan, APEX Geoservices Ltd. 14-11-2018.

apex geoservices

6 Knockmullen Business Park
Gorey
Co. Wexford
Ireland.
T +353 (0)402-21842
F +353 (0)402-21843
E info@apexgeoservices.ie
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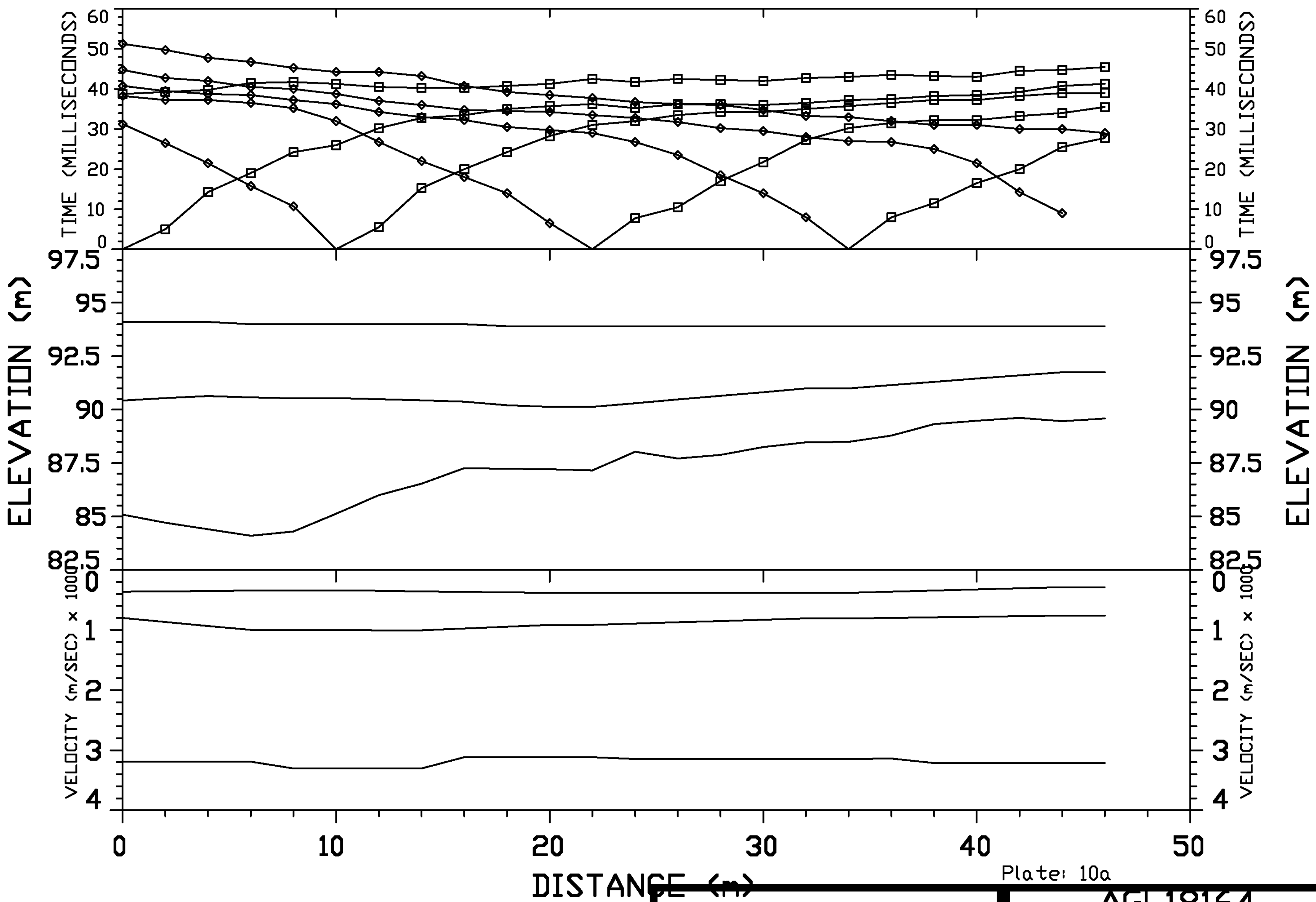
PROJECT:	KILLYCARD LANDFILL GEOPHYSICAL INVESTIGATION
CLIENT:	FEHILY TIMONEY & CO.
DRAWING NO:	AGL18164_R5
SCALE:	AS INDICATED @ A4
DATE:	14-11-2018

Version:	Date:	Drawn By:	Checked:
01	14-11-2018	ROC	WOC

APPENDIX C: SEISMIC PLATES



for: Fehilly Timoney & Co.

by: APEX Geoservices Ltd.

Data SetS1 | Date: 5-10-18

Equipment: Geode | Spread: 1

AGL18164

Killycard
Monaghan

Azimuth:

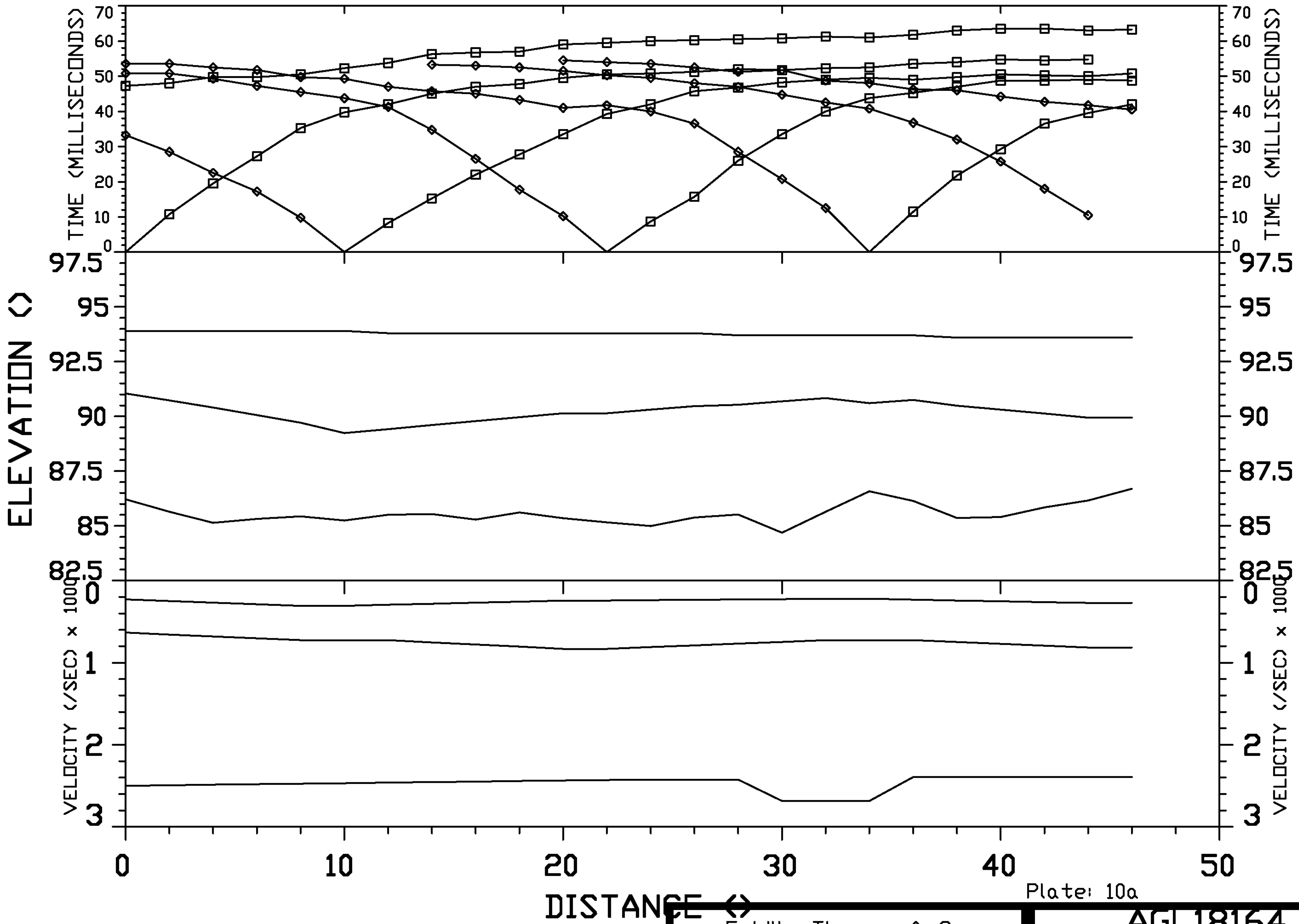


Plate: 10a

for: Fehilly Timoney & Co.	AGL18164
by: APEX Geoservices Ltd.	Killycard Monaghan
Data SetS2 / Date: 5-10-18	
Equipment: Geode / Spread: 2	Azimuth:

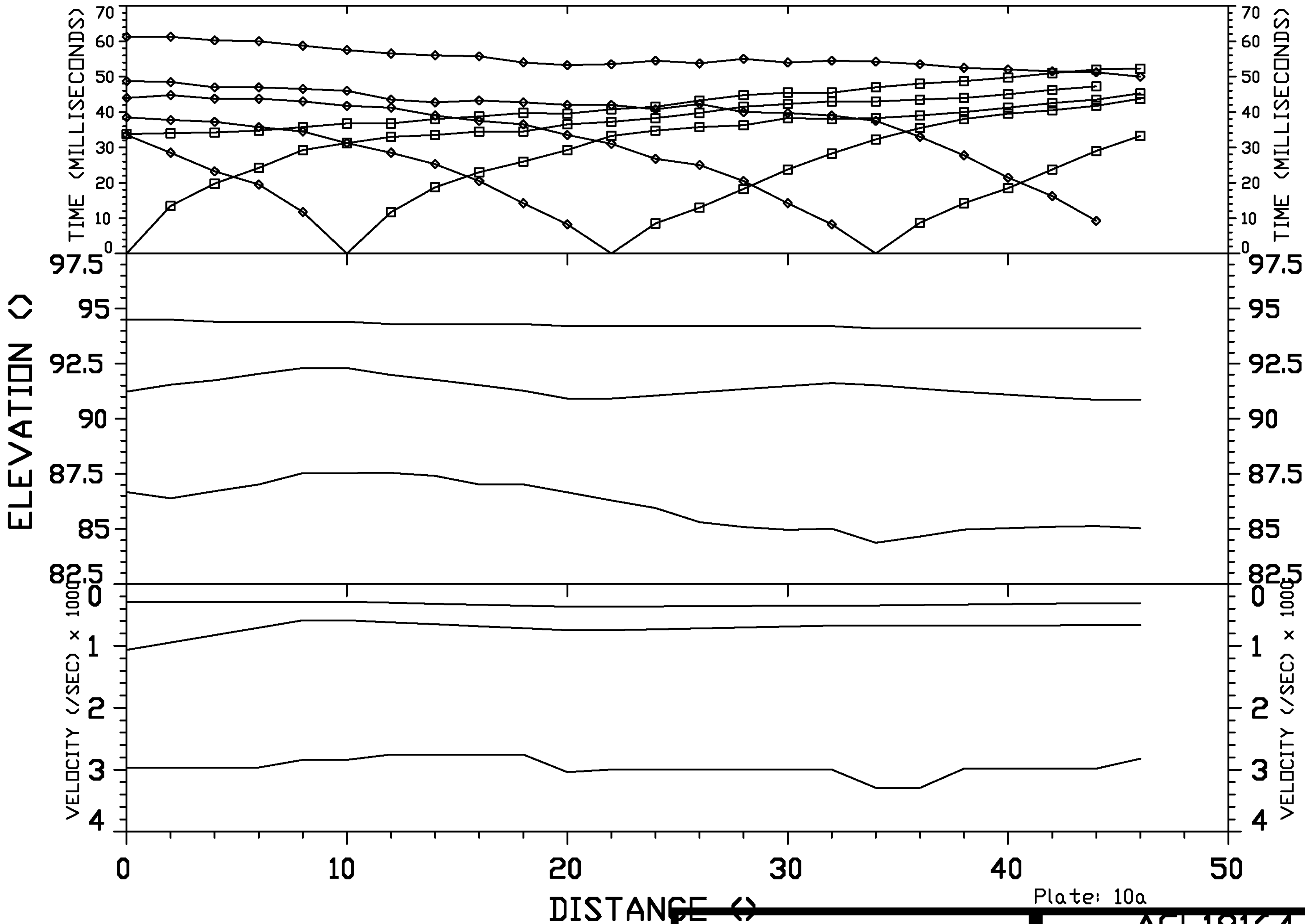
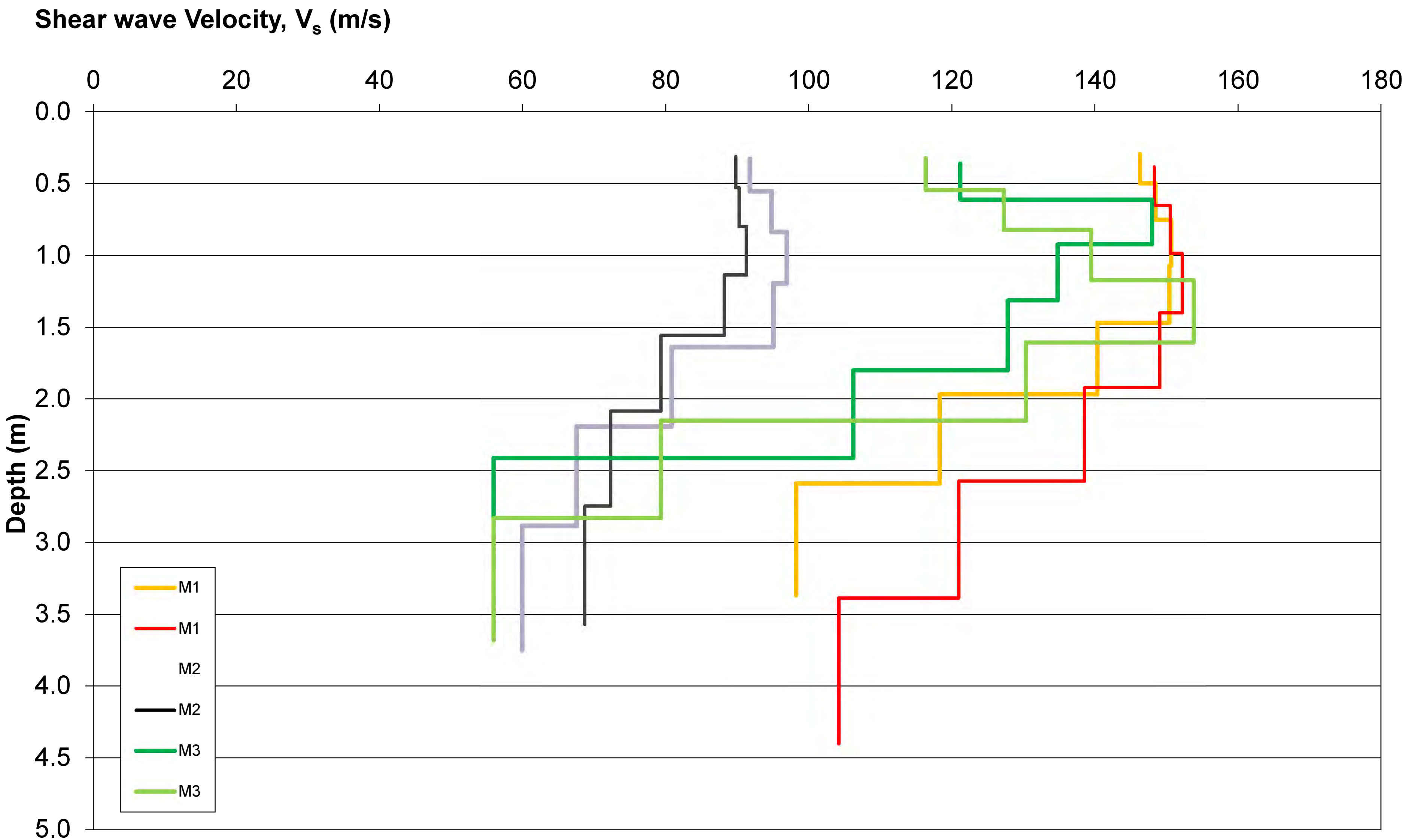


Plate: 10a

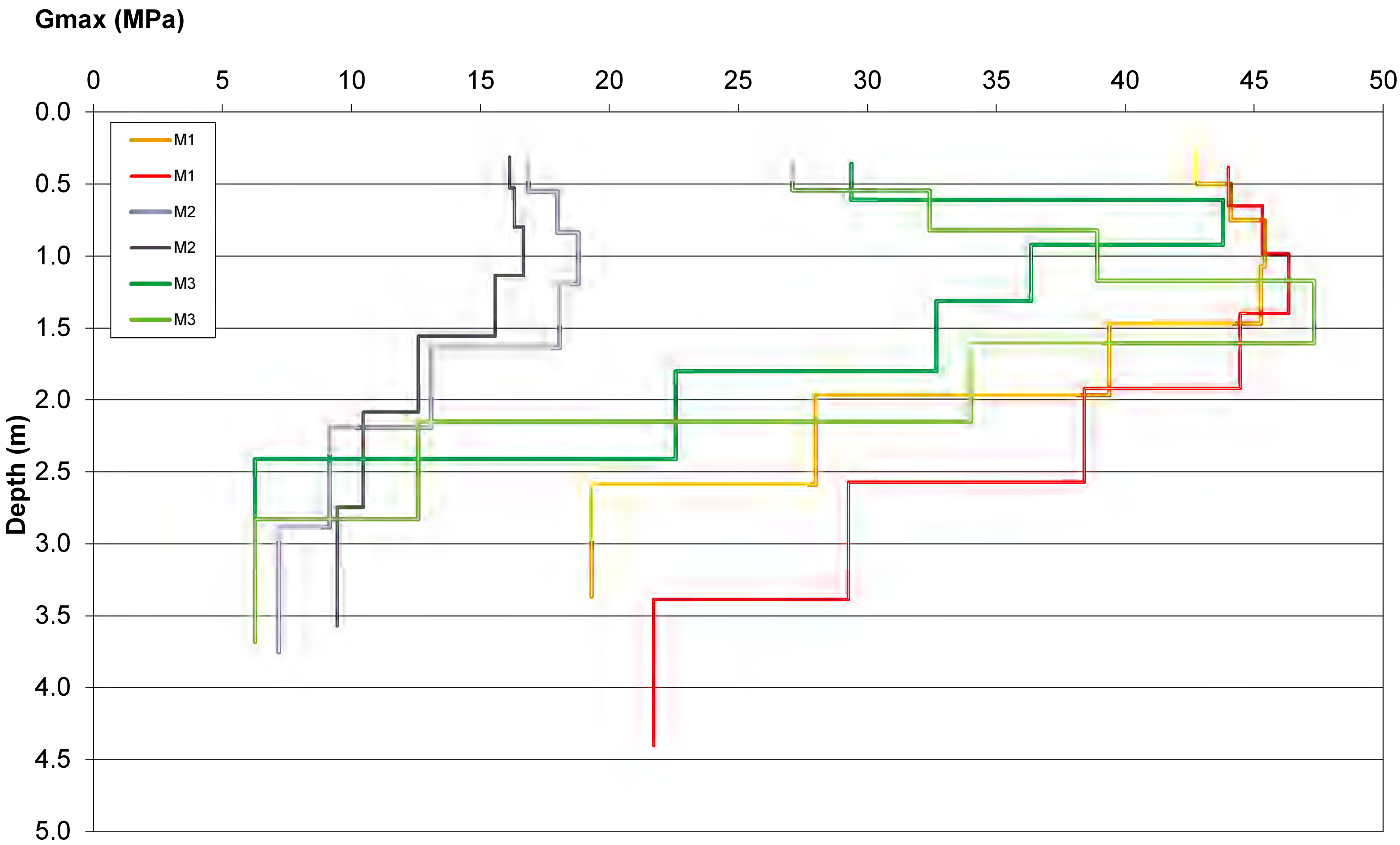
for: Fehilly Timoney & Co.		AGL18164
by: APEX Geoservices Ltd.		Killycard Monaghan
Data SetS3	Date: 5-10-18	
Equipment: Geode	Spread: 3	Azimuth:

APPENDIX D: MASW DATA

M1	1004		M1	1013		M2	1019		M2	1028		M3	1034		M3	1043	
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	DEPTH M	VS M/S	GMAX MPA	DEPTH M	VS M/S	GMAX MPA
0.3	146	43	0.4	148	44	0.3	92	17	0.3	90	16	0.4	121	29	0.3	116	27
0.5	146	43	0.7	148	44	0.6	92	17	0.5	90	16	0.6	121	29	0.5	116	27
0.5	148	44	0.7	151	45	0.6	95	18	0.5	90	16	0.6	148	44	0.5	127	32
0.8	148	44	1.0	151	45	0.8	95	18	0.8	90	16	0.9	148	44	0.8	127	32
0.8	151	45	1.0	152	46	0.8	97	19	0.8	91	17	0.9	135	36	0.8	139	39
1.1	151	45	1.4	152	46	1.2	97	19	1.1	91	17	1.3	135	36	1.2	139	39
1.1	150	45	1.4	149	44	1.2	95	18	1.1	88	16	1.3	128	33	1.2	154	47
1.5	150	45	1.9	149	44	1.6	95	18	1.6	88	16	1.8	128	33	1.6	154	47
1.5	140	39	1.9	139	38	1.6	81	13	1.6	79	13	1.8	106	23	1.6	130	34
2.0	140	39	2.6	139	38	2.2	81	13	2.1	79	13	2.4	106	23	2.2	130	34
2.0	118	28	2.6	121	29	2.2	68	9	2.1	72	10	2.4	56	6	2.2	79	13
2.6	118	28	3.4	121	29	2.9	68	9	2.7	72	10	3.2	56	6	2.8	79	13
2.6	98	19	3.4	104	22	2.9	60	7	2.7	69	9				2.8	56	6
3.4	98	19	4.4	104	22	3.8	60	7	3.6	69	9				3.7	56	6



Shear wave Velocity, V_s (m/s)
0
20
40
60
80
100
120
140
160
180
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Depth (m)
M1
M1
M2
M2
M3
M3



Gmax (MPa)
0
5
10
15
20
25
30
35
40
45
50
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Depth (m)
M1
M1
M2
M2
M3
M3

Appendix VI

CONTROL SURVEYS
TOPOGRAPHICAL MAPPING




NOTES:
1. All levels are relative to Ordnance Datum Malin Head
2. 50m sq grid relative to Irish Transverse Mercator Co-ordinate reference system
3. Contours are at .25m intervals

SYMBOL LEGEND

AV	Air Valve	SV	Sluice Valve
V	Valve	WV	Water Valve
FH	Fire Hydrant	WM	Water Meter
IC	Inspection Chamber	Post	Post
ICTE	Telecom Duct	ICE	ESB Duct
TE Box	Telcom Box	ESB Box	ESB Box
T	Tree	EP	ESB Pole
	Tree Spread	TP	Telecom Pole
	Bush/Shrub	LS	Lamp Standard
Sign	Sign	T Sign	Traffic Sign
AJ	Armstrong Junction	GY	Gully
ER	Earth Rod	Gas	Gas
TL	Traffic Light	B	Bollard
CATV	Cable TV Duct	Bin	Bin
G	Gate	Stay	Stay
MH 4.93	Manhole & Cover Level	Serv	Service
STN 1 10.00	Survey Station	Pipe	Pipe
Ridge 8.73	Ridge Height	Coping 8.73	Coping Height
F.F.L. 8.73	Finished Floor Level	Gutter 8.73	Gutter Height
Eaves 8.73	Eaves Height	Roof 8.73	Roof Height
6.78	Boundary Height	9.55	Spot Height

LINE TYPE LEGEND

	Wall		Concrete Edge
	Fence		Centerline of Trees
	Footpath		Hedge
	Drain/River		Step
	Flower Bed		Plinth
	ESB Line		Telecom Line
	Mound		Building
	Kerb		Road
11.00	Contour Major	10.75	Contour Minor
	Bottom of Bank		Top of Bank
	Yellow Line		White Line

REVISIONS

No.	Date	Description

Control Surveys
land and building surveyors
THE IRISH INSTITUTION OF SURVEYORS No. 562
6 Crestwood, Kilteragh, Dooradoyle, Limerick.
Tel: 087 2659112 email: cian@controlsurveys.ie
website: www.controlsurveys.ie

- Topographical Surveys
- Measured Building Surveys
- Legal Mapping
- As Built Surveys
- GPS Surveys
- Setting Out

Client:

Professional:
Fehilly Timoney & Company

Project Title:
Topographical Survey of Site Located at Killycard, Co. Monaghan.
(Preliminary Issue)

Drawn:	I.R	Dwg No:	18-293-01
Scale:	1:500	Date:	13-09-18