WILLIAMSON
WATER & LAND ADVISORY

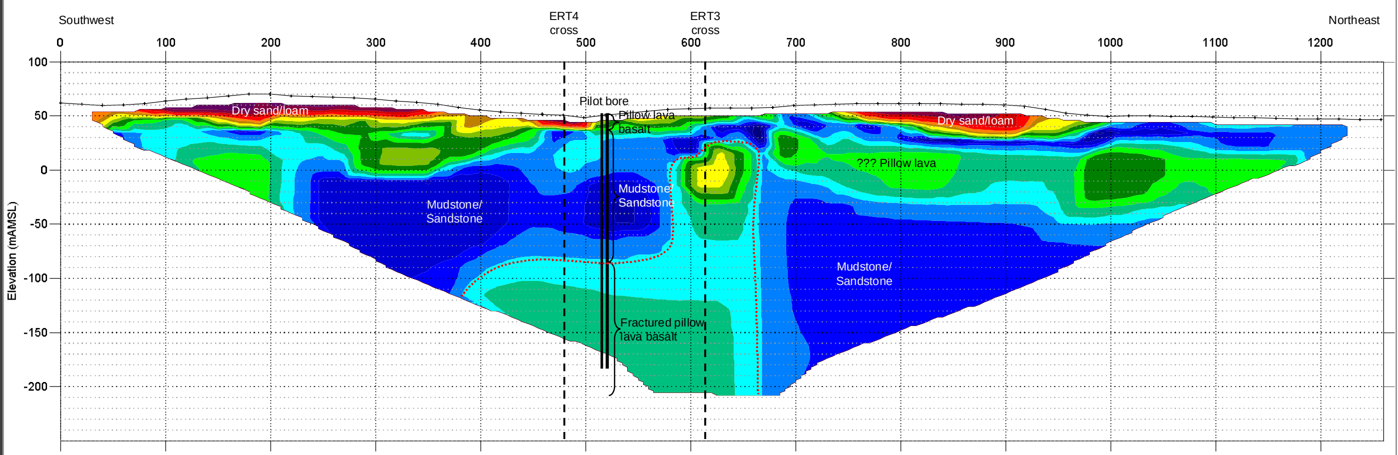
Muriwai Downs - Assessment of Basalt Extent

Appendix D - Electrical Resistivity Tomography Survey

BEARS HOME PROJECT MANAGEMENT LTD

WWLA0321 | Rev. 2

5 August 2021



Muriwai Downs - Electrical Resistivity Tomography Survey

Project no:	WWLA0321
Document title:	Basalt Extent Assessment - Electrical Resistivity Tomography
Revision:	2
Date:	5 August 2021
Client name:	Bears Home Project Management Ltd
Project manager:	Jon Williamson
Author(s):	Louise Soltau and Jon Williamson
File name:	G:\Shared drives\Projects\Bears Home Project Management Ltd\WWLA0321_Muriwai Downs Golf Project\Deliverables\Reports\ERT Survey Report\Report_Muriwai Downs Golf Project_ERT Survey_v2.docx

Williamson Water & Land Advisory

PO Box 314,
Kumeu 0841,
Auckland
T +64 21 654422

Document history and status

Rev	Date	Description	By	Review	Approved
1	22 July 2021	Internal draft	Louise Soltau	Jon Williamson	
2	5 August 2021	Final report	Louise Soltau	Jon Williamson	Jon Williamson

Distribution of copies

Rev	Date issued	Issued to	Comments
2	5 August 2021	The Bears Home Project Management Ltd	For client review and discussion

Contents

Executive Summary

Williamson Water & Land Advisory (WWLA) were commissioned by Bears Home Project Management Ltd to conduct a resistivity survey to delineate the subsurface extent of the basalt aquifer associated with the recently drilled pilot irrigation bore, with the aim of estimating the water storage volume within the basalt aquifer. The volume of groundwater that could be obtained for the irrigation supply for the proposed golf course will be pivotal in defining surface water storage required, hence a greater sustainable groundwater supply will require less reliance on surface water and hence a smaller reservoir.

Resistivity data were acquired along four profiles, which indicated pillow lava at shallow depth (15 m), underlain by sandstone of the Nihotupu Formation (15-120 m), underlain by highly fractured pillow lava basalt at depth (120-200 m). The bore information was used to correlate with the resistivity data to estimate the subsurface extent of the basalt, with generally close correlation, hence the interpretation is considered accurate.

The general resistivity distribution shows: 1) a high resistivity (65-300 Ohm.m) layer within the shallow subsurface (up to 25 mBGL) across the higher elevation areas, which is interpreted as dry sand or loam; 2) low resistivity (2-15 Ohm.m) zones associated with the sandstone of the Nihotupu Formation; 3) intermediate resistivity (15-65 Ohm.m) associated with the highly fractured pillow lava at depth; and 4) a layer of similarly intermediate resistivity at shallower depth varying in thickness between 45 and 60 m, that is interpreted as a shallow pillow lava.

The top surface of the basalt was delineated from the resistivity profiles with coordinates extracted for each data point along the ERT profiles. This surface was interpolated between the ERT profiles and the basalt volume was estimated using the volume function on the Surfer software and a lower cut-off level for the basalt of -150 mAMSL, which is the elevation of the bottom of the bore. The volume of basalt derived was 10.19 Mm^3, which is considered a conservative estimate of the basalt because the basalt extends beyond this depth. The drilling was stopped before the bore reached the basement rock and the ERT also indicates basalt extending beyond this depth.

The water storage potential of the basalt was estimated using the likely porosity of the basalt. Porosity of fractured basalt can vary between 5 and 50% (Freeze and Cherry, 1979). However, in this study low porosity values of between 5 and 10% were used for a conservative estimate of water storage volume. The likely storage volume varies from approximately 500,000 m^3 for 5% porosity to 1,000,000 m^3 for 10% porosity. The maximum annual irrigation requirements for the golf course is approximately 235,000 m^3, hence the water volume stored within the basalt will be sufficient for the golf course irrigation, subject to the production bore providing adequate access to the aquifer.

1. Introduction

Williamson Water and Land Advisory (WWLA) were commissioned by Bears Home Project Management Ltd in July 2021 to undertake an electrical resistivity tomography (ERT) survey at their Muriwai Downs Property (Property) to delineate the extent of underlying basalt.

The irrigation supply for the proposed golf course is likely to be obtained from a combination of groundwater and surface water. A pilot bore has been drilled in the basalt, and indicated highly fractured basalt from a depth of approximately 120 mBGL to at least 200 mBGL. Initial airlift yield testing indicated high transmissivity for the basalt, but there was uncertainty as to the lateral extent of the basalt, and it was conservatively indicated as a likely constraint to limit the sustainable groundwater supply volume on an annual basis (PDP, 2021). If this constraint eventuated, it would place a greater reliance on surface water for irrigation, and hence the need for a larger reservoir. Conversely, with higher groundwater supply volumes, storage volume, cost and space considerations associated with the surface water reservoir could be reduced.

1.1 Objective and Scope of work

The specific objective of the ERT survey was to delineate the subsurface extent of the basalt intrusion, which was thought to likely be an intrusive dyke or vent feature. The basalt extent would then be used to define the volume of water that was stored within the basalt. The resistivity method is used to define lateral and vertical changes in electrical properties along a subsurface profile that can be related to changes in earth material properties including clay content, rock density and porosity, and groundwater quality. The basalt was expected to have a high resistivity compared to the lower resistivity of the surrounding sandstone and mudstone. Identifying the change or contrast in electrical resistivity by correlating with the interfaces intersected in the bore, allows for the extent of the basalt to be defined.

The ERT survey involved the following components:

1. Initial survey to assess suitability of the technique to delineate the extent of the basalt.
2. The resistivity contrast between the basalt and the mudstone/sandstone correlated well with the groundtruth (bore) information and the survey was expanded to delineate the basalt extent.
3. The volume of basalt was determined using surfer interpolation of the basalt extent.
4. The volume of water stored within the basalt were calculated based on the likely porosity of the basalt.

1.2 Report Structure

The report comprises:

- **Section 2 –** Background Information: a summary of the existing information on the basalt intrusion.
- **Section 3 –** Resistivity survey, data analysis and interpretation, and discussion; and
- **Section 4 –** Analysis of the storage volume within the basalt.
- **Section 5** – Conclusions and the way forward.

2. Background Information

An outcrop of basalt pillow lava has been quarried previously to a limited extent at the Property. The surface outcrop is mapped as limited in lateral extent on the QMAP geology map, however the vertical extent is unknown (**Figure 1**). This was targeted for groundwater development by a geomagnetic survey conducted by Scantec in December 2020 (Scantec, 2021). The survey indicated a complex geomagnetic signature that could not be interpreted in terms of shape and size of the anomaly. The centre of a strong dipolar NE-SW trending anomaly coincided with the quarry site and was targeted for the drilling of an investigative bore.

The drilling indicated a thin outcrop of the shallow pillow lava at surface (only 15 m), with a deeper highly fractured pillow lava structure occurring at 120-200 mBGL (**Figure 2**). The subsequent airlift yield testing indicated a high yielding basalt aquifer within the sandstone of the Nihotupu Formation (**Section 2.1**) however, with likely limited extent of the basalt aquifer. The basalt is essentially considered an underground reservoir of finite size surrounded by the Nihotupu Formation sandstone, which forms a leaky roof to the reservoir. It is considered that the water “stored” within the basalt aquifer can be sustainably abstracted for use during summer and will be naturally recharged during the off season. The volume of water stored within the basalt aquifer will depend on its size and the porosity of the basalt.

2.1 Geology

A brief summary of the mapped geology (GNS Science, 2014) is provided as context for the ERT survey. The geology of the area is shown on the map in **Figure 1**.

The Property is underlain by Awhitu Group (^ad) sandstone, which comprises moderate to poorly consolidated sandstone, with paleosols, lignite and carbonaceous mudstone. This is locally covered by Tauranga Group alluvium (Q1a) comprising of sand, silt, mud and clay, and underlain by the volcaniclastic sandstone of the Nihotupu Formation (Mtn), comprising submarine volcaniclastic grit, sandstone and siltstone. The basalt flows, pillow lavas with minor basic andesite of the Waiatarua Formation (Mtw) outcrops in the area of interest and was intersected by the pilot bore at the surface and again at depth, as shown in **Figure 2**.

There are no faults mapped within the area of interest.

2.2 Hydrogeology

As mentioned previously, the fractured basalt/andesitic pillow lava at depth is considered the prospect for development of the groundwater source. The resistivity survey is targeted at delineating the three-dimensional extent of the basalt, which will enable estimation of the rock volume of the basalt aquifer. The water storage volume within the basalt can be estimated based on standard or textbook porosity estimates.

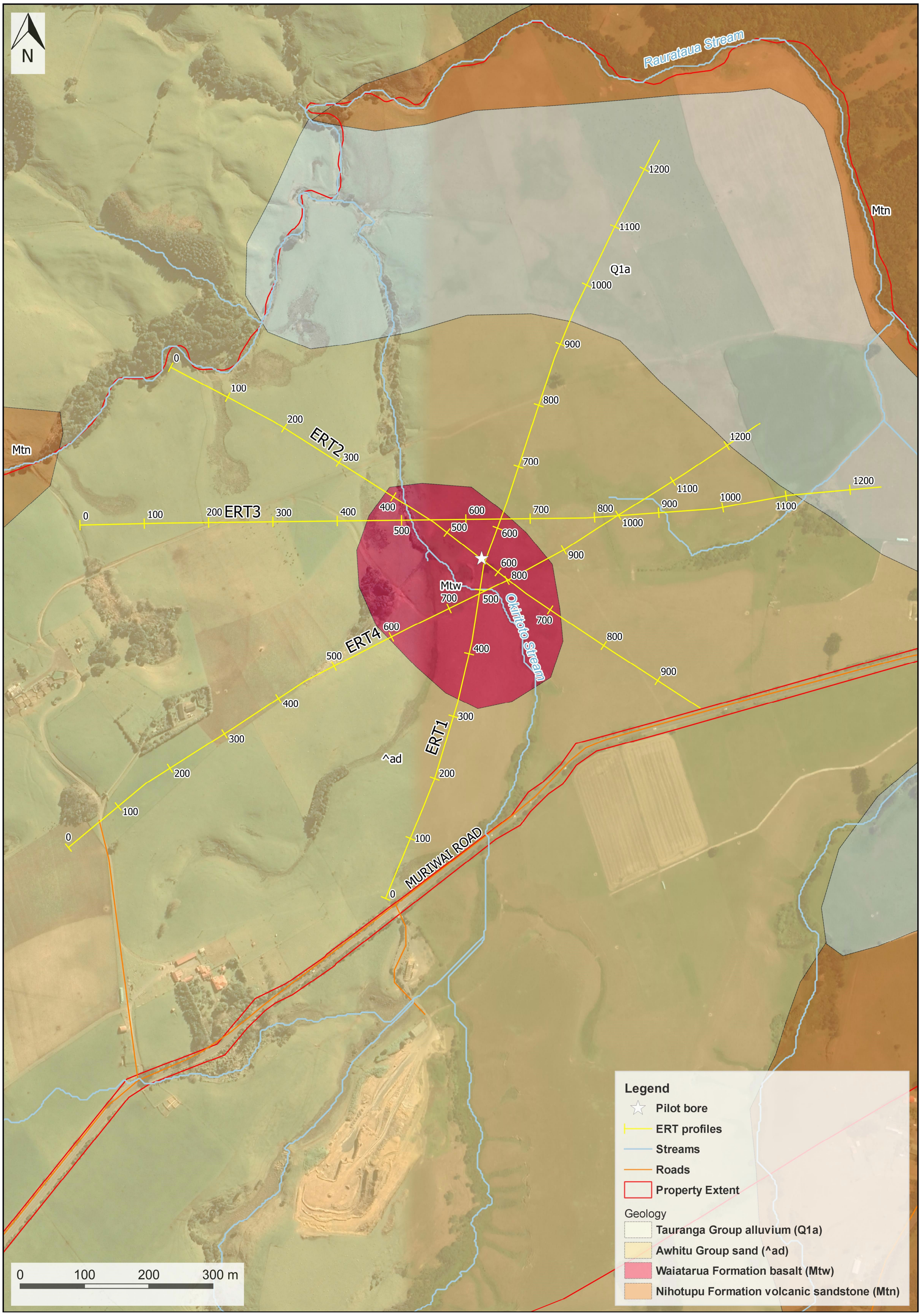


Figure 1. Geology within the area of pilot bore at Muriwai Downs.

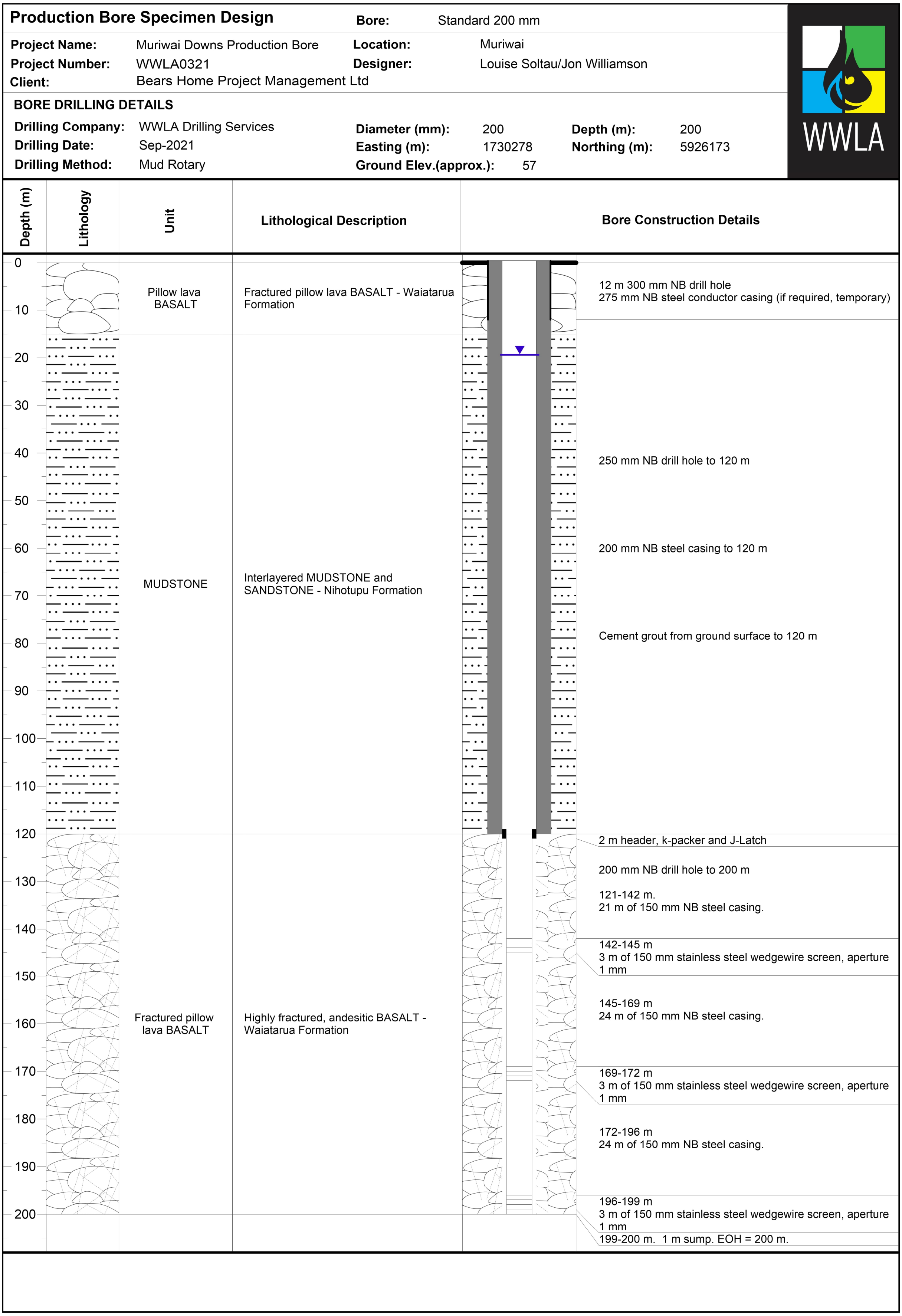


Figure 2. Lithological of the pilot hole.

3. Electrical Resistivity Tomography Survey

3.1 Technique

Electrical resistivity tomography[1] (ERT) is a geophysical technique for imaging sub-surface structures from electrical resistivity measurements made at the surface.

The ERT survey was undertaken using an ABEM Terrameter LS (Lund System), which is a high-tech, completely automated resistivity data acquisition system.

The ERT method provides a pseudo-section of change in electrical properties in the subsurface along a specified profile line. The resistivity method measures the resistivity of the subsurface using direct current coupling and is used to delineate lateral and vertical changes in electrical properties that are related to changes in earth formation physical properties, such as porosity, grain size and degree of induration or compaction.

Eight multi-core cables with eight electrode take-outs every 20 m for a total spread of 64 electrodes were used. The cables were laid out end to end in a straight line, as far as possible. This resulted in a resistivity profile length of approximately 1260 m.

An electrode (stainless steel stake) is inserted into the ground next to every electrode take-out on the cable, using a hammer. The electrode take-out is then connected to the electrode with a short cable jumper. The multi-core cables are connected to the Terrameter that controls the measurement sequence based on a predefined protocol loaded on the Terrameter and takes and stores the resistivity measurements. The data were collected using a standard protocol with the Schlumberger array[2]. All data were acquired for n = 1 to 20 where n is the ratio of the distances between the first current and potential electrode (A-M), and the potential electrodes (M-N).

3.2 Survey Undertaken

The resistivity data were acquired from 24 to 25 June and 30 June to 1 July 2021 along four profiles labelled ERT1 to ERT4, across the Property as indicated on **Figure 1**. ERT1 and ERT 2 were positioned to cross the pilot bore from southwest to northeast and from northwest to southeast, respectively. ERT3 and ERT4 were located from south to north along the central race across the Property. ERT2, ERT3 and ERT4 were located based on the results of the previous profiles to assist in meeting the survey objectives described above.

The apparent resistivity data acquired in the field were inverted[3] using the RES2DINV software (Loke and Barker, 1996) to provide a true-depth resistivity section. Data manipulation undertaken during pre-processing is to erase obviously erratic data points (minimal). The correlation between the measured and calculated resistivity data is shown in **Appendix A**. These inversion statistics show very good correlation, indicating good quality data and reliable inversion. The resulting true resistivity pseudo-sections are used for the interpretation.

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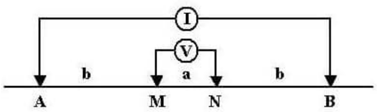
1 Tomography is imaging by sections or sectioning, through the use of any kind of penetrating wave.

2 The Schlumberger array is a type of electrode configuration for a DC resistivity survey and is defined by its electrode array geometry. The Schlumberger array consists of four (two outer current and two inner potential) placed in line around a common midpoint. The spacing between the current electrodes are increased relative to the spacing between the potential electrodes and are typically much larger (up to five times) than the spacing between the potential electrodes (Source: https://openei.org/wiki/DC_Resistivity_Survey_(Schlumberger_Array))

$$\rho_A = \frac{V}{I}\pi\frac{b(b+a)}{a} \approx \frac{V}{I}\pi\frac{b^2}{a} \quad \text{if } a << b$$



3 Geophysical inversion is a mathematical algorithm that can be used to recover the subsurface distribution of a physical properties from field-collected data.

The resistivity scale has been normalised across all profiles, to allow for direct comparison of the data. The data was acquired over the same lithology types and can be cross correlated.

Elevation changes along the profile are minimal and are corrected for during the data inversion.

The survey was targeted around the existing pilot bores to allow for the inverted resistivity to be correlated with the lithological logs for ground-truthing.

3.3 Expected Relative Resistivity

Typically, the resistivity of massive basalt is expected to be high, especially where dry. However, basalt often has fractures within a hard rock matrix (secondary porosity), which lowers the resistivity (increases conductivity) due to the greater water content.

The resistivity of the surrounding sandstone is expected to be lower than the basalt due to the inherent ion exchange capacity of the silt and fine sand particles that the formation comprises (McNeill, 1980). However, the resistivity of the fractured basalt at depth (aquifer zone), whilst expected to have slightly lower resistivity that the dry surficial basalt and any massive basalt, should still maintain a sufficient contrast in resistivity to delineate the extent of the basalt from the surrounding sandstone along the ERT profiles.

3.4 ERT1

The resistivity data for profile ERT1 are shown from southeast to northwest in **Figure 3**. The four resistivity sections are displayed on a single A3 page in **Appendix B** for ease of reference. This profile was acquired first and was located as such to define the basalt distribution along the longest line, with the pilot bore near the centre of the bore to allow for correlation. The relative resistivity distribution from high to low resistivity is as follows:

- ***High resistivity (65-300 Ohm.m)*** - across the higher lying areas up to a maximum depth of 25 mBGL (35 mAMSL) is interpreted as dry sand or loam material in the shallow subsurface.
- ***Intermediate resistivity (15-65 Ohm.m)*** - represents the highly fractured pillow lava basalt at depth (lower resistivity of 15-24 Ohm.m). The pillow lava at shallow depth (correlated from the drilling log) indicates a slightly higher resistivity (24-65 Ohm.m). A layer of this slightly higher resistivity also occurs at depths of 20-70 mBGL (50-0 mAMSL) to the southwest and 30-90 mBGL (20 to -40 mAMSL) towards the northeast. This is interpreted as a sheetlike basalt feature, but would need to be confirmed through drilling.
- ***Low resistivity (2-15 Ohm.m)*** - adjacent to and in between these higher resistivity zones is interpreted as the Nihotupu mudstone / sandstone.

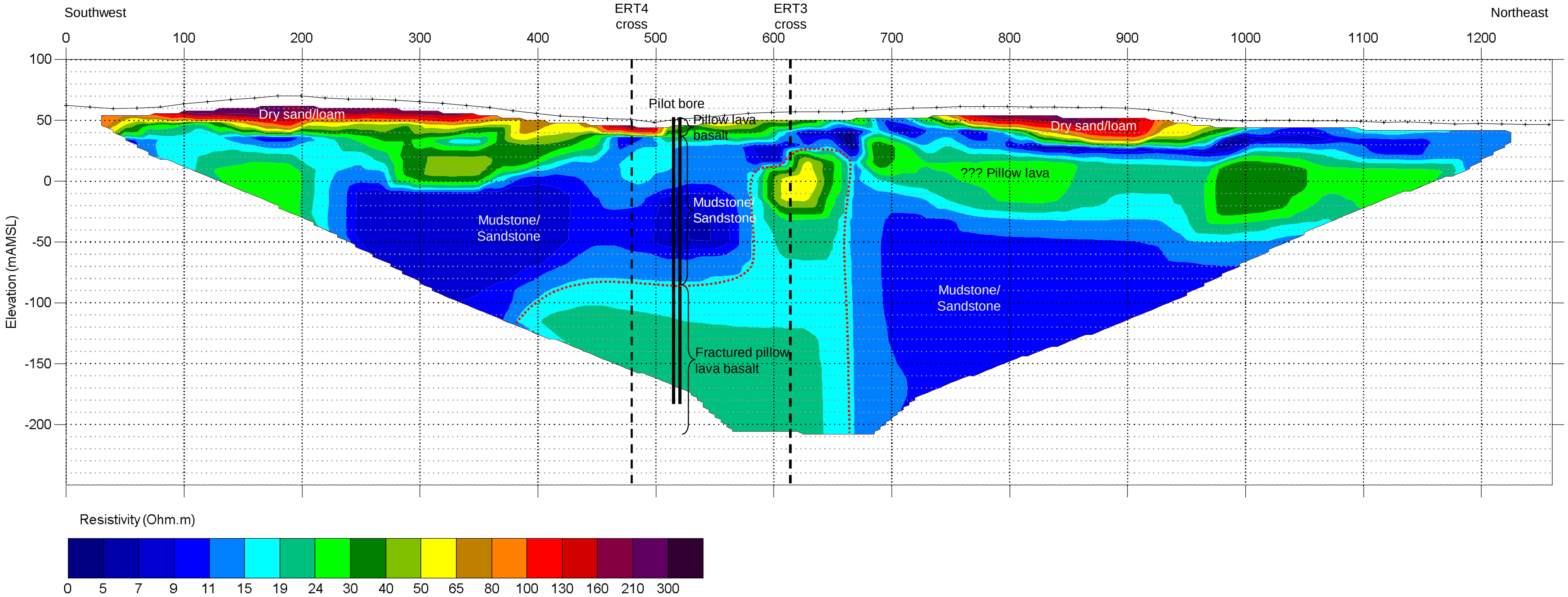


Figure 3. Inverted resistivity profile ERT1.

The top of the basalt has been interpreted as the interpolated surface with resistivity of approximately 15 Ohm.m, based on correlation with the pilot bore data, and has been indicated on **Figure 3** as a red dotted line. This agrees with the interpretation of ERT2 (next profile) and is considered acceptable, even though the resistivity contrast between the basalt and sandstone is relatively low.

The resistivity distribution shows a thick, broad basalt bulge at depth that is fairly extensive laterally and then extends into an almost vertical dyke-like structure with a cross-sectional width of approximately 100 m and centred at approximately 620 m along the profile.

3.5 ERT2

Profile ERT2 was located to cross ERT 1, across the pilot bore location, and the inverted profile is shown from northwest to southeast in **Figure 4**. The profile was slightly shorter due to space consideration, which resulted in a slight decrease in depth of investigation. However, the general relative resistivity distribution is similar to that of profile ERT1:

- ***High resistivity (65-300 Ohm.m)*** - dry sand/loam across the higher lying areas up to a depth ~20 mBGL (25 mAMSL).
- ***Intermediate resistivity (15-65 Ohm.m) -*** highly fractured pillow lava basalt at depth. The pillow lava extends towards the surface similar to the dyke like feature observed on profile ERT1 at a distance of approximately 450 m. Similar to ERT 1, the distribution of the lava is irregular. The pillow lava at shallow depth as correlated with the drilling log is laterally continuous along this profile with the deeper (25-55 mBGL) slightly higher resistivity (24-65 Ohm.m) layer, interpreted as a sheetlike basalt feature.
- ***Low resistivity (2-15 Ohm.m) -*** Nihotupu sandstone adjacent to and in between the higher resistivity basalt.

Profile ERT2 crosses profile ERT1 at the bore location and the correlation between the two profiles is good, showing the intermediate shallow resistivity for the pillow lava, the low resistivity corresponding to the sandstone and the intermediate resistivity corresponding to the fractured basalt at depth.

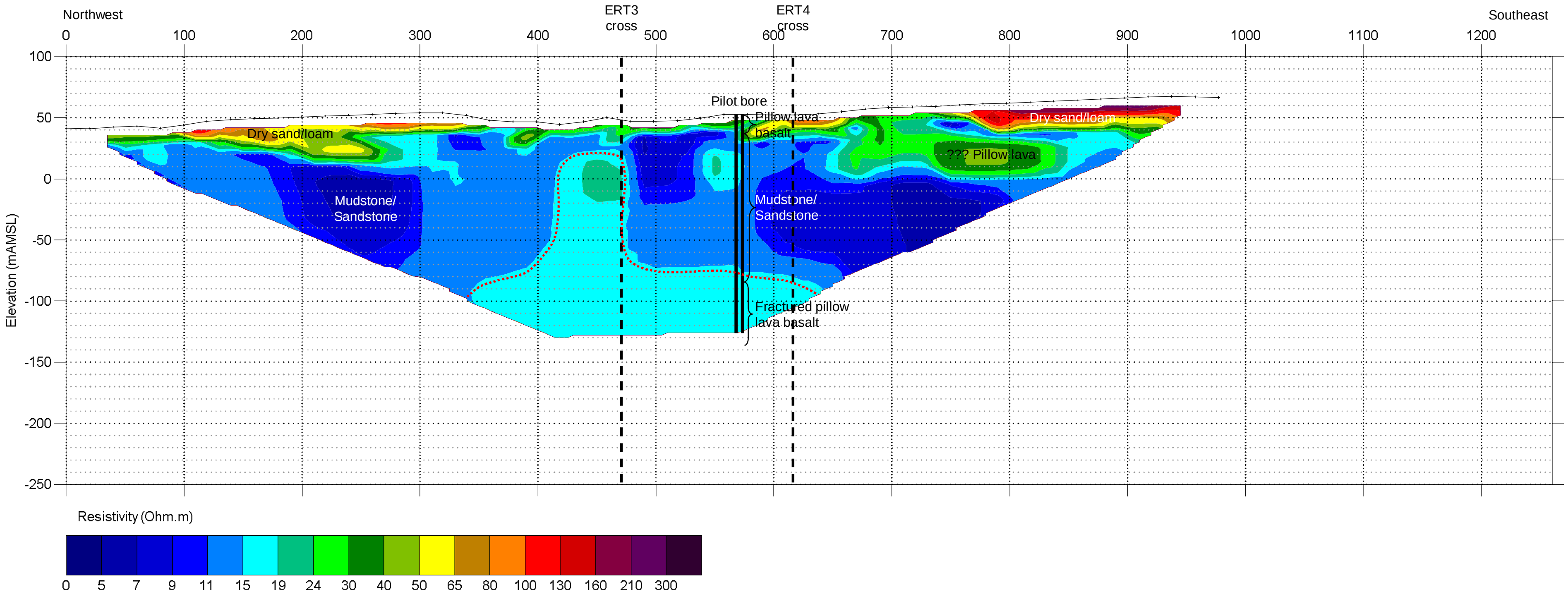


Figure 4. Inverted resistivity profile ERT2.

Similar to ERT1, the interpolated surface of 15 Ohm.m resistivity has been delineated as the top of the basalt along this profile, due to the good correlation with the bore data, as indicated in **Figure 4**. Furthermore, the resistivity distribution shows a thick, broad basalt bulge at depth that is laterally extensive and then extends into an almost vertical dyke-like structure with a cross-sectional width of approximately 70 m and centred at approximately 450 m along this profile.

3.6 ERT3

Profile ERT3 was located west-east to cross the two dyke-like features that were delineated along profiles ERT1 and ERT2. The resistivity data for profile ERT3 is shown from west to east in **Figure 5**. The general relative resistivity distribution is similar to that of profile ERT1 and ERT2:

- ***High resistivity (65-300 Ohm.m)*** - dry sand/loam across the higher lying areas up to a depth ~15 mBGL (40 mAMSL).
- ***Intermediate resistivity (15-65 Ohm.m)*** - highly fractured pillow lava basalt at depth. The pillow lava shape is more amorphous, and the top of the basalt occurs closer to surface in general with a broader lateral extent. The intermediate resistivity pillow lava intersected in the bore is shown in the shallow subsurface, even though the bore is 60 m south of the profile. The intermediate resistivity layer at intermediate depth, interpreted as a sheetlike pillow lava occurs at depths of 30-80 mBGL (30 to -20 mAMSL).
- ***Low resistivity (2-15 Ohm.m)*** - Nihotupu sandstone adjacent to and in between the higher resistivity basalt.

Profile ERT1 crosses profile ERT3 at chainage 670 m and the correlation between the two profiles is good, showing intermediate resistivity for the pillow lava at shallow depth and the intermediate resistivity of the highly fractured basalt at depth, separated by low resistivity corresponding to the sandstone. The resistivity of the fractured basalt along profile ERT3 shows marginally less variation, but the same general trend of slightly higher resistivity closer to the surface. This is likely as a result of anisotropy related to the irregular shape of the basalt feature and the large electrode spacing (20 m).

Profile ERT2 crosses profile ERT3 at chainage 550 m and the correlation between the two profiles is good, showing low resistivity sandstone underlying the thin layer of intermediate resistivity shallow basalt. The fractured basalt near the pilot bore location occurs at approximately 130 mBGL (-80 mAMSL).

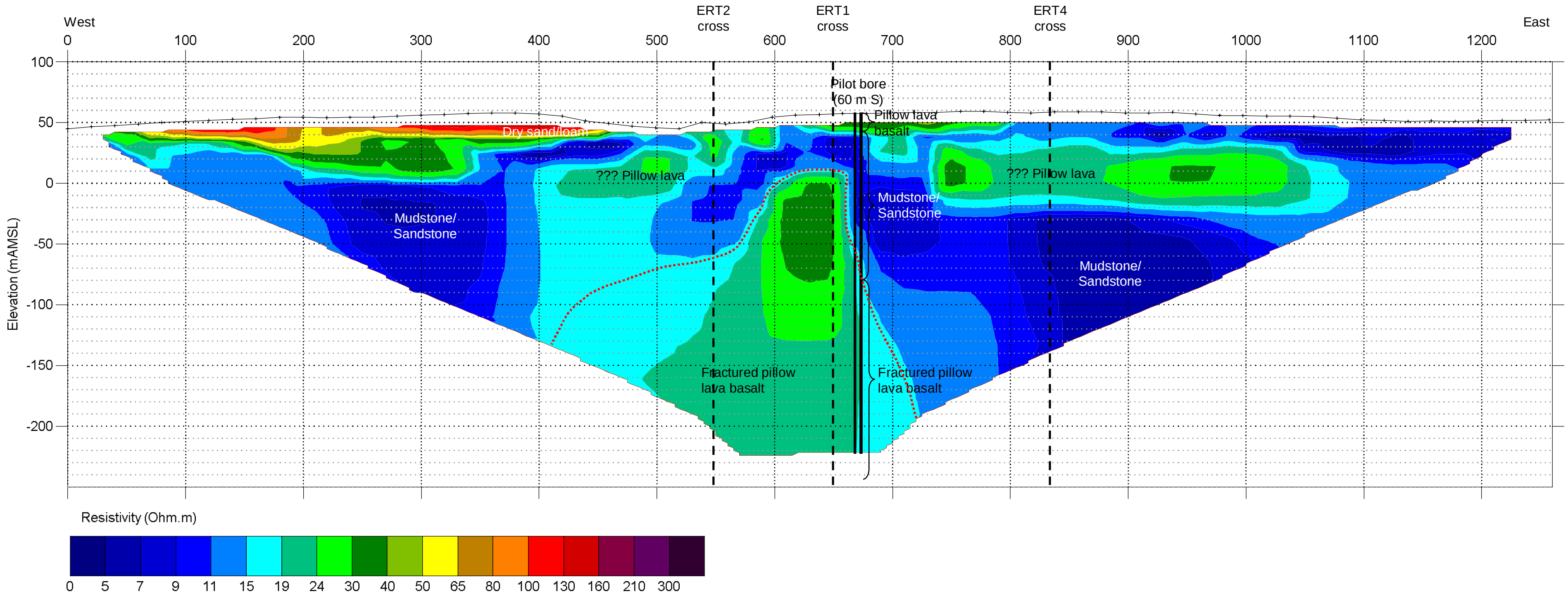


Figure 5. Inverted resistivity profile ERT3.

The correlation between the three ERT profiles is good and hence the interpolated 15 Ohm.m surface was delineated as the top of basalt surface along this profile as well. The lateral extent of the deep fractured basalt could not be accurately delineated. The profile line was located along the top of the dyke-like features identified along profiles ERT1 and ERT2, and likely extends to shallow subsurface. However, as a conservative measure the basalt surface was delineated to resemble the same basalt bulge at depth as delineated on the other two profiles. The extension of this deeper basalt bulge to the near surface (20 mBGL, 30 mAMSL) between chainage 400 and 550 m has thus been excluded from basalt and water volume calculations. The basalt extent is thus underestimated rather than overestimated which will result in a smaller basalt volume and associated water storage capacity.

Similar to the other ERT profiles, the resistivity distribution shows a thick, broad basalt bulge at depth that is laterally extensive and occurs at shallower depth than along the other two ERT profiles, which is consistent with the delineated dyke-like feature. A central dyke-like feature within the basalt bulge occurs at chainage 580-660 m.

3.7 ERT4

Profile ERT4 were located to cross profiles ERT1 and ERT2 south of ERT3 to attempt to cover the lack of data within the quadrant southwest of the pilot bore. The resistivity data for profile ERT4 is shown from southwest to northeast in **Figure 6**. The general relative resistivity distribution is similar to that of profile ERT1, ERT2 and ERT3:

- ***High resistivity (65-300 Ohm.m)*** - dry sand/loam across the higher lying areas up to a depth ~50 mBGL (40 mAMSL), is more extensive, both laterally and vertically than that along the other profiles. This is due to the increased elevation along the southwestern half of the profile.
- ***Intermediate resistivity (15-65 Ohm.m)*** - highly fractured pillow lava basalt at depth is located towards the southwestern half of the profile. The pillow lava shape is similar to that of profile ERT3, but is located further west. The intermediate resistivity, shallow pillow lava correlated with the bore data is also laterally continuous with the deeper (25-55 mBGL) slightly higher resistivity (24-65 Ohm.m) layer, similar to profile ERT2.
- ***Low resistivity (2-15 Ohm.m)*** - Nihotupu sandstone adjacent to and in between the higher resistivity basalt, is extensive towards the northwestern half of the profile.

Profile ERT1 crosses profile ERT4 at approximately 750 m along the profile and profile ERT2 crosses profile ERT4 at approximately 800 m. The resistivity distribution where these profiles cross does not correlate well. The resistivity shows a lower resistivity consistent with what has been interpreted as sandstone. The resistivity is however towards the higher end of the resistivity range for the sandstone (14.6-14.9 Ohm.m) and it is likely that as a result of the relatively low contrast between the sandstone and highly fractured basalt resistivity, as well as anisotropy and large electrode interpolation distance, the higher resistivity associated with the basalt is not clearly delineated along this part of the profile.

The cross between profile ERT3 and ERT4 is located at chainage 840 m. The correlation between the two profiles is good, showing low resistivity sandstone above and below the intermediate resistivity sheetlike basalt.

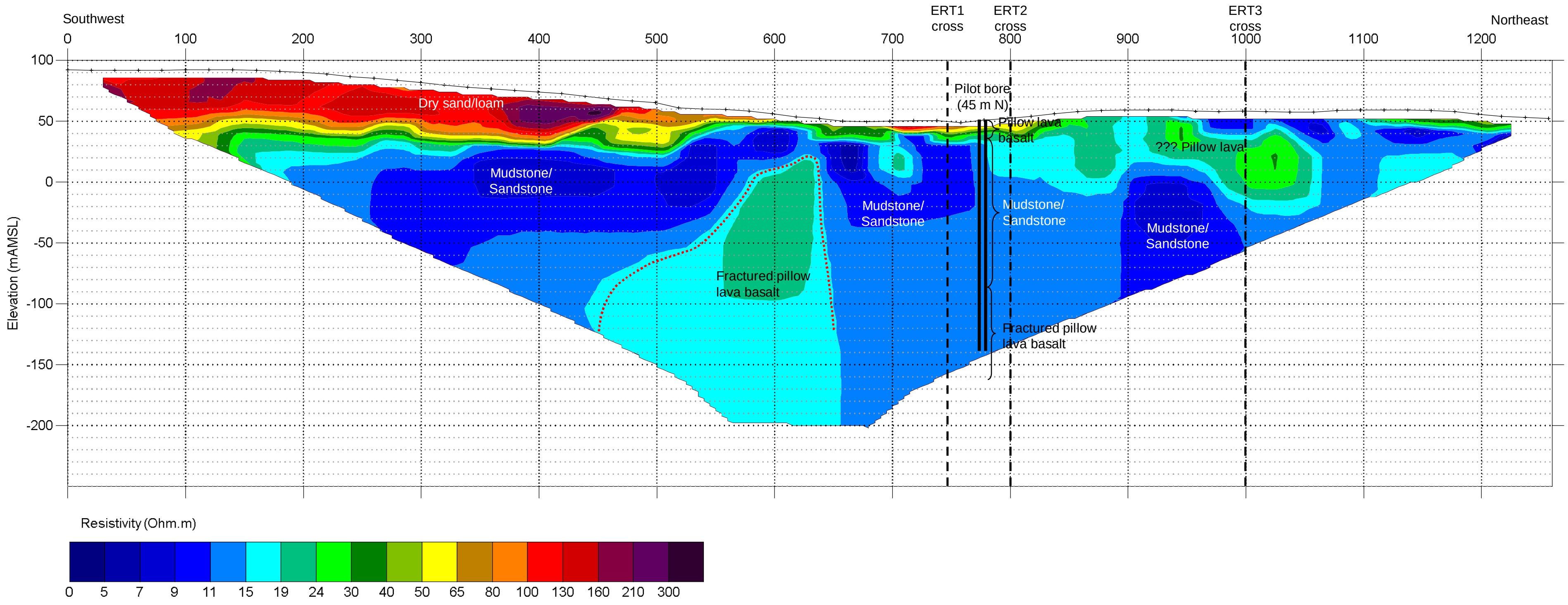


Figure 6. Inverted resistivity profile ERT4.

The highly fractured deep basalt has been delineated based on the correlation between the other three profiles and limited to the 15 Ohm.m surface to allow for a more conservative analysis even though the true extent is likely to be more extensive.

Similar to the other ERT profiles, the resistivity distribution shows a thick, broad basalt bulge at depth, with less lateral extent towards the northeast.

4. Analysis of Deep Basalt and Water Volume

The ERT profiles obtained allow for delineation of the underlying basalt along these profile lines, based on the contrast between the intermediate resistivity of the highly fractured basalt and the low resistivity of the surrounding mudstone / sandstone. The extent of the basalt was well defined on the four ERT profiles and the three-dimensional extent of the basalt were derived as follows:

- The elevation (in mAMSL) of the interpreted basalt surface was extracted from the resistivity profiles and location coordinates assigned to each data point (x, y and z coordinates). The lowest elevation of the basalt was delineated as -150 mAMSL, which is equivalent to the elevation of the bottom of the pilot bore. ERT profiles ERT1, ERT3 and ERT4 indicate that there is fractured basalt below this level, and it is known that bedrock has not been intersected during the drilling, so the basalt likely extends deeper down. However, the basalt volume was constrained to the bottom of the bore because that is the confirmed maximum bottom elevation of the basalt.
- The coordinates and elevation derived were used to define the interpolated basalt surface in the software Surfer, using the Kriging interpolation method.
- The volume of the basalt was estimated using the volume calculation function of surfer.

The three-dimensional delineation of the basalt surface is shown in **Figure 7** to **Figure 10**.

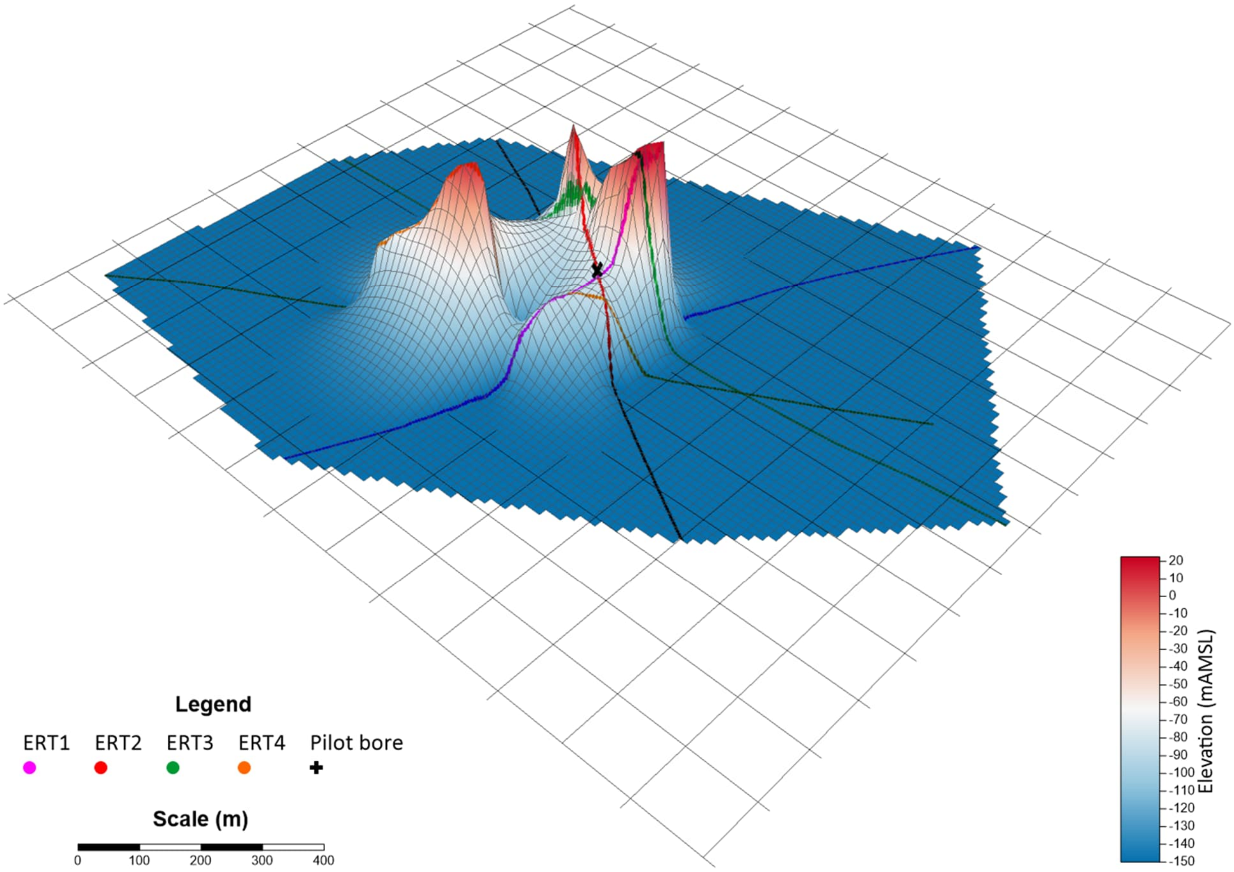


Figure 7. Basalt surface with ERT1 and ERT2 in foreground looking northward.

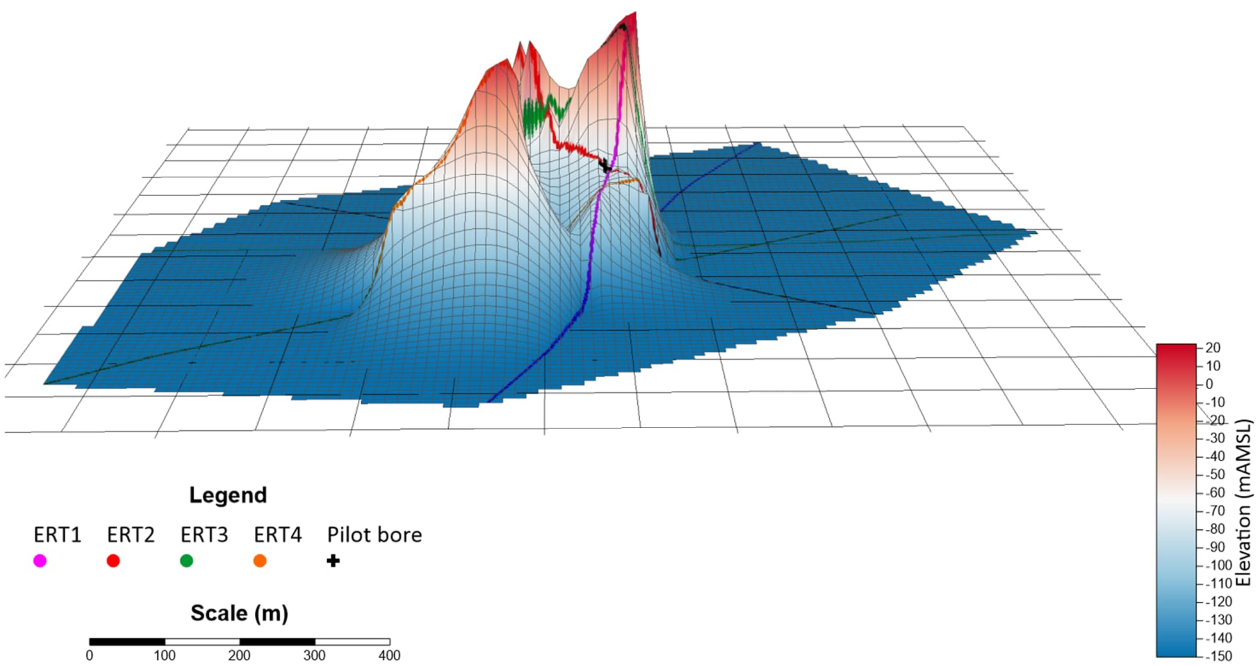


Figure 8. Basalt surface with ERT2 in foreground looking northeastward.

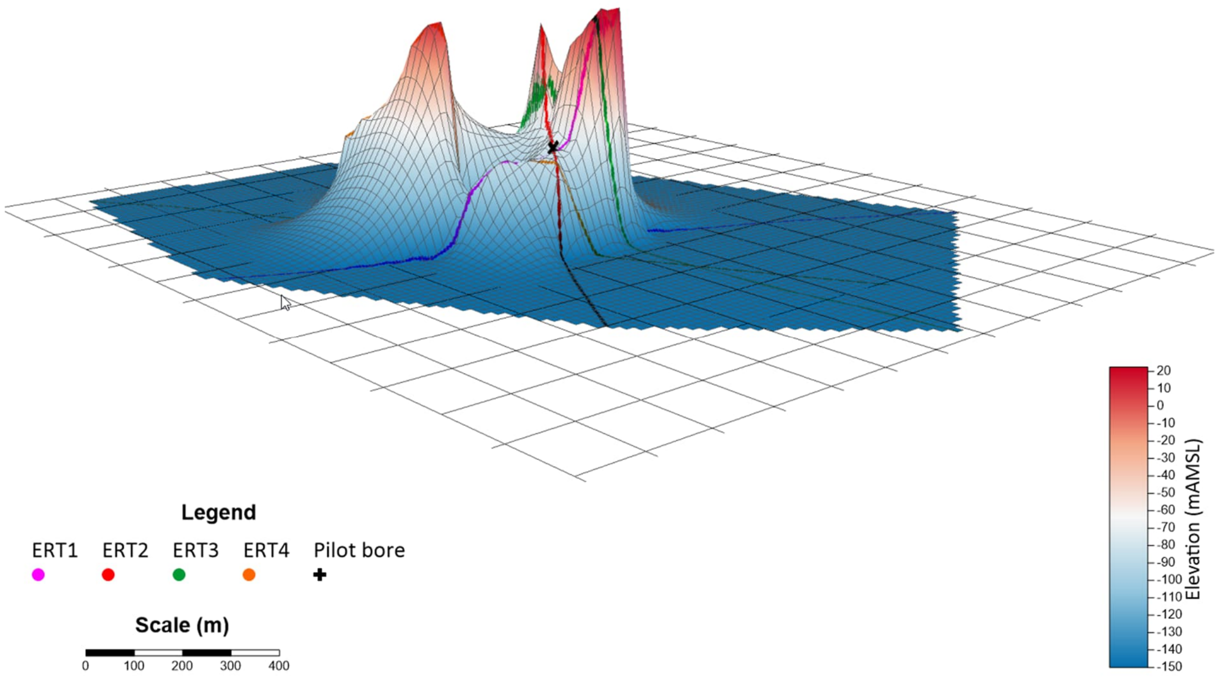


Figure 9. Basalt surface looking northward.

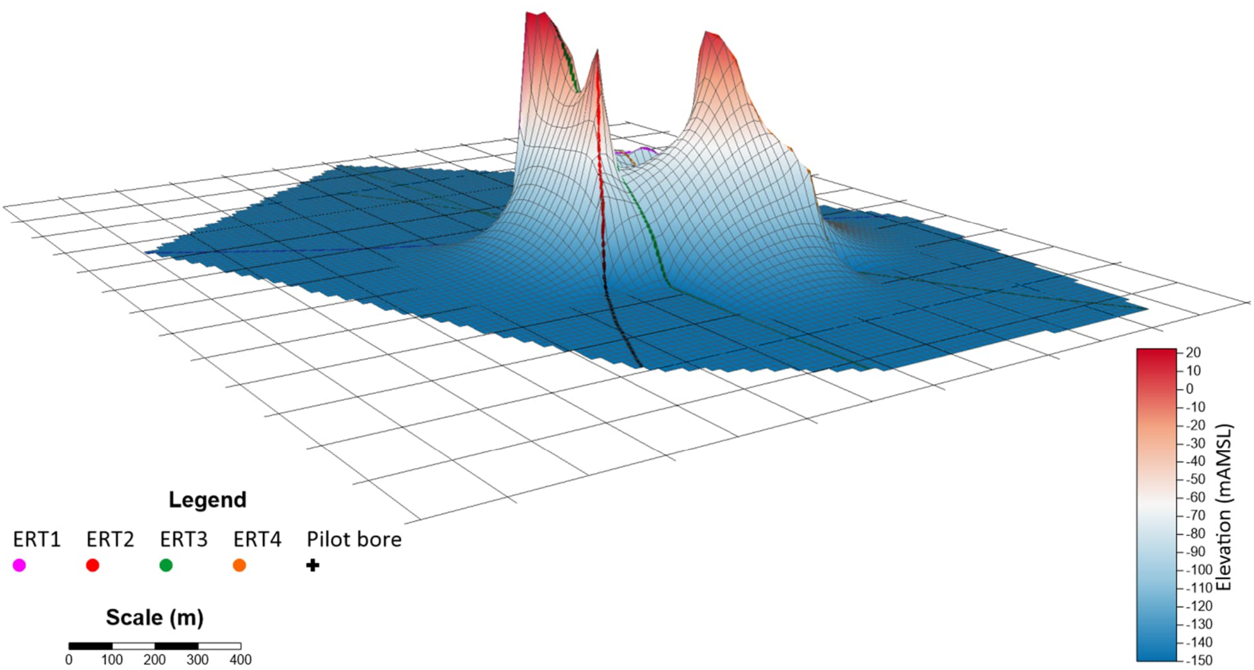


Figure 10. Basalt surface with ERT2 in foreground looking southeastward.

The volume of the basalt has been estimated using the volume function on the Surfer software, as described above. The volume of basalt is approximately 10.19 Mm^3. As mentioned previously this is considered a conservative estimation of the basalt because the basalt delineation on the ERT profiles were constrained to the minimum level and the base elevation was set to -150 mAMSL, even though the basalt is likely to extend deeper than this.

The water storage potential of the basalt can be estimated using the porosity of the basalt. Freeze and Cherry (1979) estimated porosity of fractured basalt to be between 5 and 50% for scoriaceous basalt. The porosity is not known but based on the low relative resistivity of this fractured basalt and the high airlift yield, the porosity of the basalt is considered to be within the medium range for basalt. The potential water volume that can be stored in the basalt aquifer has been estimated using a range of conservative porosity values, as summarised in **Table 1**. The likely storage volume varies from approximately 500,000 m^3 for 5% porosity to 1,000,000 m^3 for 10% porosity.

Table 1. Potential water storage volume of the 10.2 Mm^3 basalt based on varying porosity values.

Porosity (%)	Potential water storage volume (m^3)
5	500,000
10	1,000,000

4.1 Shallow Basalt Resource

The basalt and water storage estimation were constrained to the deeper, highly fractured basalt intersected in the bore, as a conservative measure, as discussed previously. A shallower, horizontal layer of similar resistivity to the deeper basalt occurs within the shallow subsurface along all four ERT profiles. This likely a shallow basalt layer that is linked to the shallow pillow lava that has been intersected in the pilot bore, as observed on ERT profiles ERT2 and ERT4. This basalt layer varies in thickness between 45 and 60 m and seems to be disconnected from the deeper basalt. The lateral extent is likely limited, similar to the deeper basalt, but could be considered as a separate aquifer and add additional water resources.

5. Conclusions & Recommendations

Resistivity data was acquired along four profiles at the Property to delineate the extent of the underlying basalt aquifer as a means to define the volume of the underlying basalt, with the specific aim of estimating water storage volumes within the basalt. Groundwater and surface water will be used for the irrigation of the proposed golf course at Muriwai Downs. Optimising the supply from groundwater would result in a lower reliance on surface water for irrigation.

A pilot bore drilled into the basalt indicated highly fractured basalt at depths of 120-200 mBGL. The initial airlift yield testing indicated high transmissivity for the basalt, but with a finite lateral extent of the basalt that is likely to limit the sustainable groundwater supply (PDP, 2021). The water storage capacity of the basalt could be estimated based on the volume of the basalt and expected porosity of the formation.

The contrast in electrical resistivity between the basalt and surrounding sandstone of the Nihotupu Formation were used to delineate the basalt extent. The top elevation of the deeper basalt as derived from the ERT data and a base level of -150 mAMSL, referenced to the bottom of the bore, were used to estimate the basalt volume. The likely storage potential of the bore was estimated using a range of porosity values. The basalt volume is approximately 10.19 Mm^3, with an associated water storage volume of 500,000 m^3 to 1,000,000 m^3 for 5 and 10% porosity, based on the relatively low resistivity and the high transmissivity as derived from the airlift testing of the bore. The estimated storage volume is sufficient as an alternative underground storage for irrigation water for the golf course.

Our recommendations are as follows:

- Drilling and hydraulic testing to confirm the likely sustainable use from the aquifer.
- The shallow basalt should be investigated as a separate smaller reservoir.

6. References

Edbrooke. S.W (compiler) 2001: Geology of the Auckland area. Institute of Geological & Nuclear Sciences 1:250 000 geological map 3. 1 sheet +74 p. Lower Hutt, New Zealand. Institute of Geological & Nuclear Sciences

Freeze, R. A. and Cherry, J. A., 1979. Groundwater. Prentice-Hall, Inc. Englewood Cliffs, New Jersey 07632.

Loke M. H. and Barker R. D., 1996. Rapid least-squares inversion of apparent resistivity pseudosections by a quasi-Newton method. Geophysical Prospecting, Volume 44, Issue 1, pp 131-152.

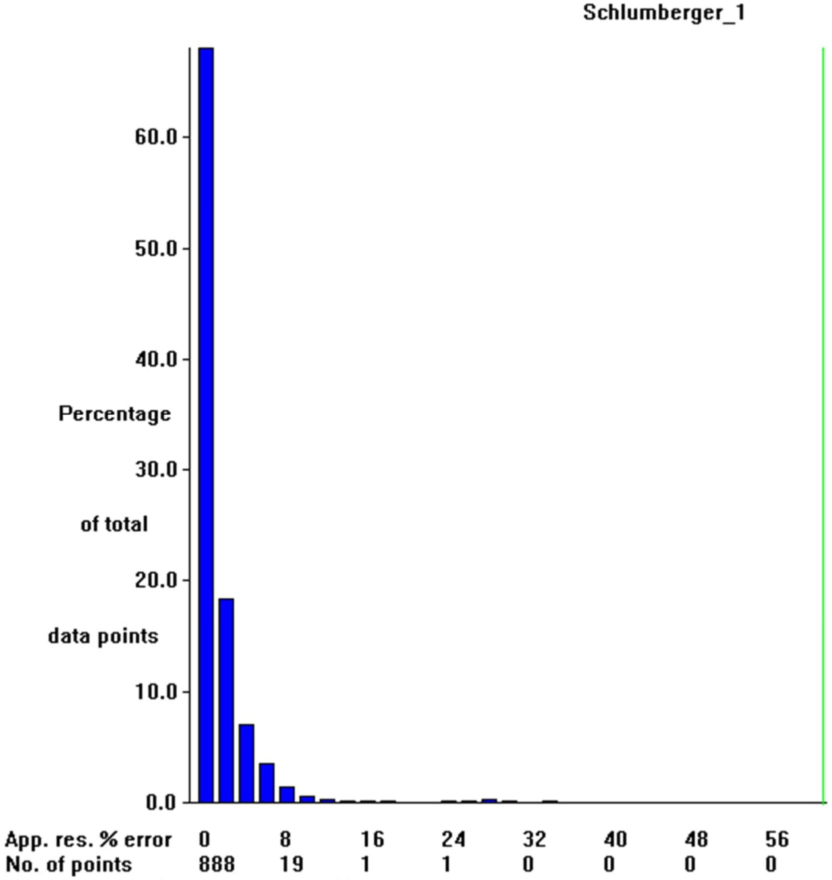
McNeill J. D., 1980. Electrical conductivity of soils and rocks. Geonics limited. Technical Note TN-5.

PDP, 2021. Muriwai Downs Golf Course: Groundwater Supply Production Bore & Assessment of Environmental Effects. Technical Letter Proposal to Bears Home Project Management Ltd.

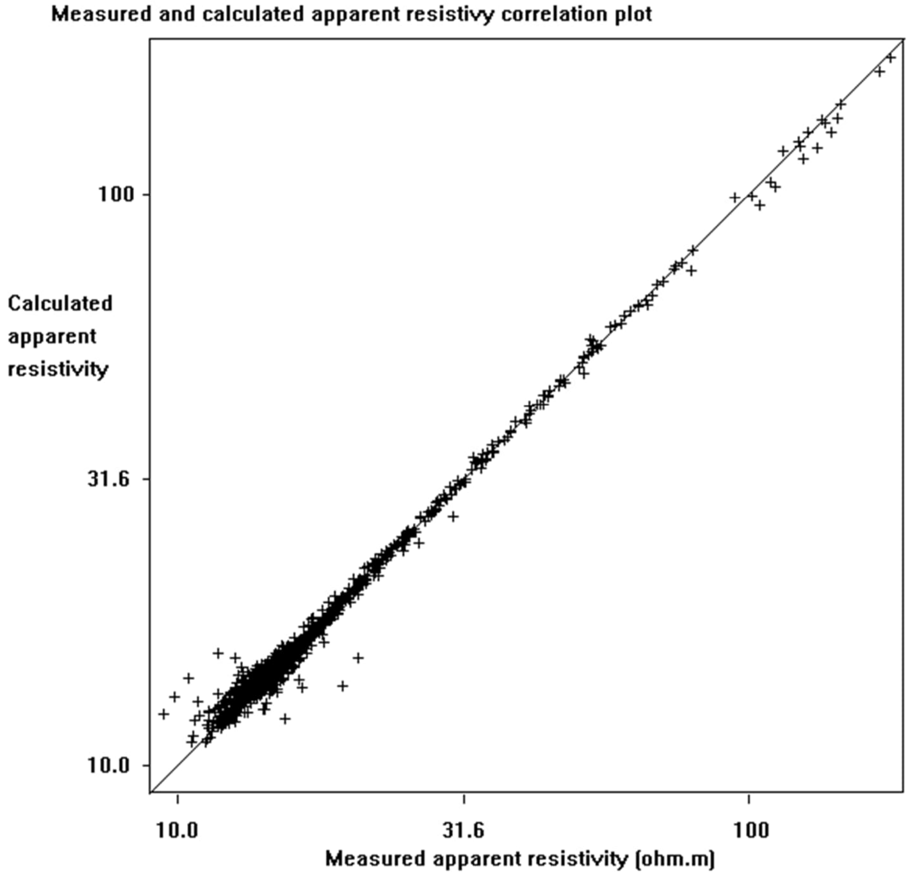
Scantec, 2021. Magnetometer Survey, 610 Muriwai Rd, Muriwai. Technical letter report to PDP.

Appendix A. Correlation Statistics for ERT Inversion

ERT1



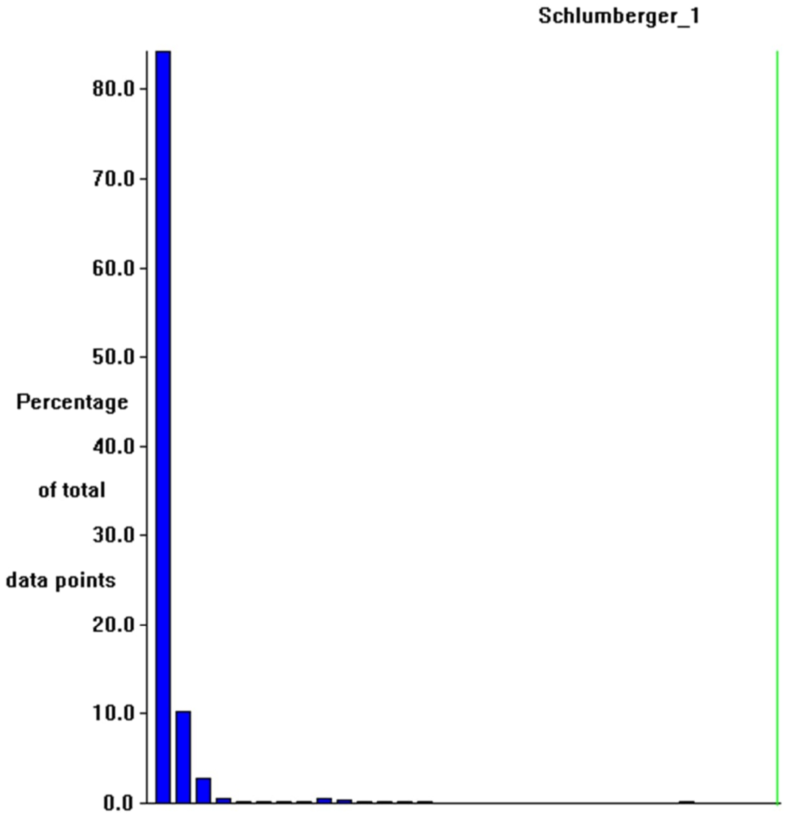
Total number of data points is 1305
Number of data points selected is 1305
Maximum error 34.7.
Maximum error selected 34.7.
Minimum value 0.00.
Use the left and right arrows keys to move the green data selection line.



L1-norm data misfit = 2.07%, L2-norm data misfit = 3.63%
+ : data point removed

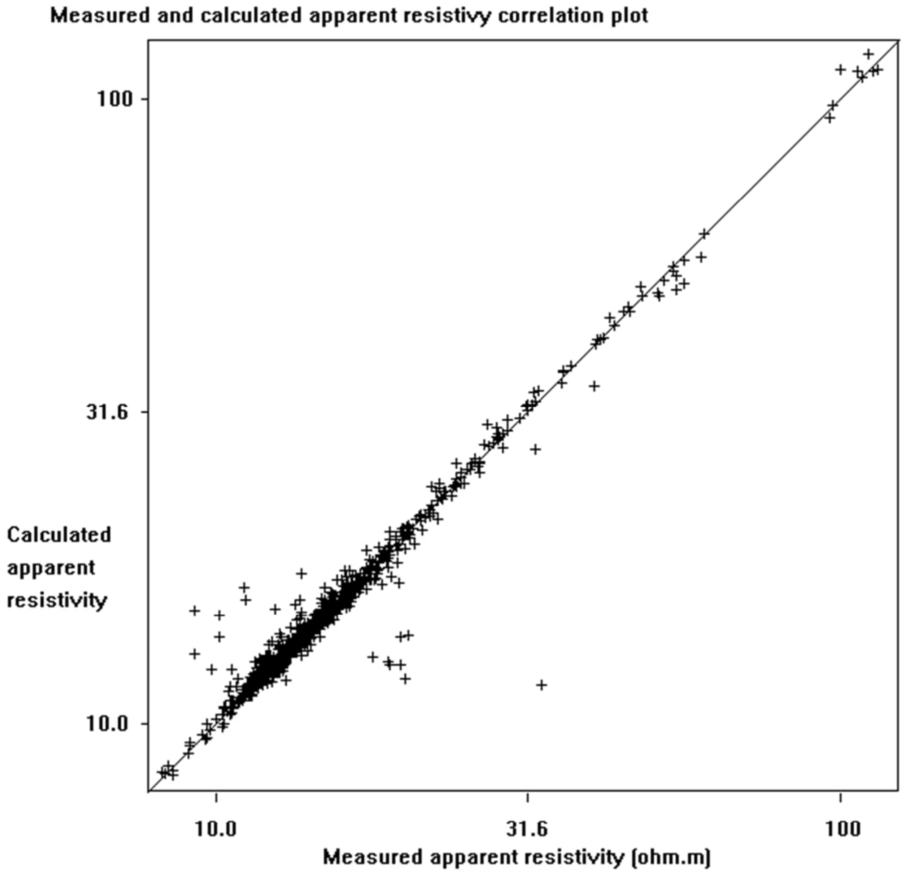
WWLA

ERT2



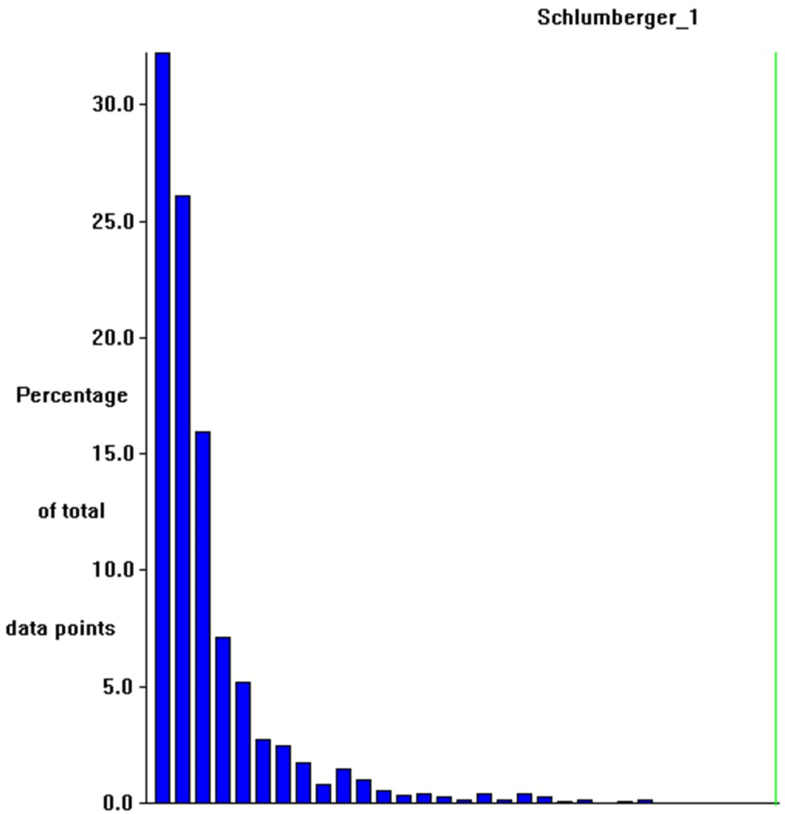
App. res. % error	0	16	32	48	64	80	96	112
No. of points	701	1	4	1	0	0	0	0

Total number of data points is 832
Number of data points selected is 832
Maximum error 106.1.
Maximum error selected 106.1.
Minimum value 0.00.
Use the left and right arrows keys to move the green data selection line.

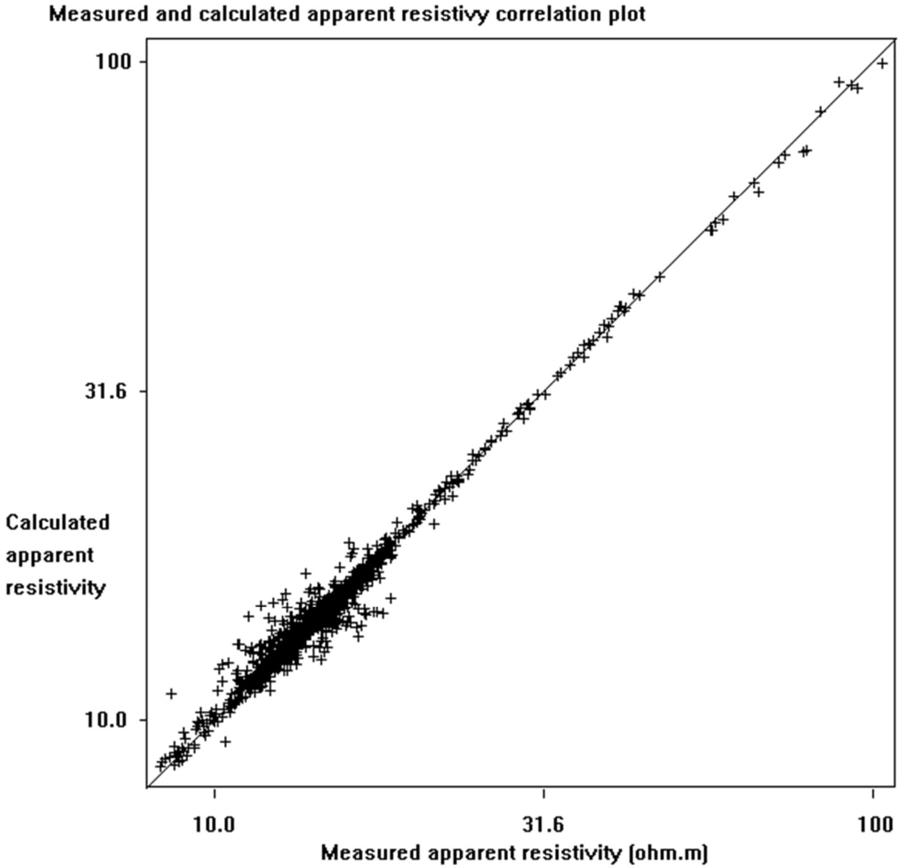


L1-norm data misift = 3.04%, L2-norm data misfit = 7.13%
+ : data point removed

ERT3

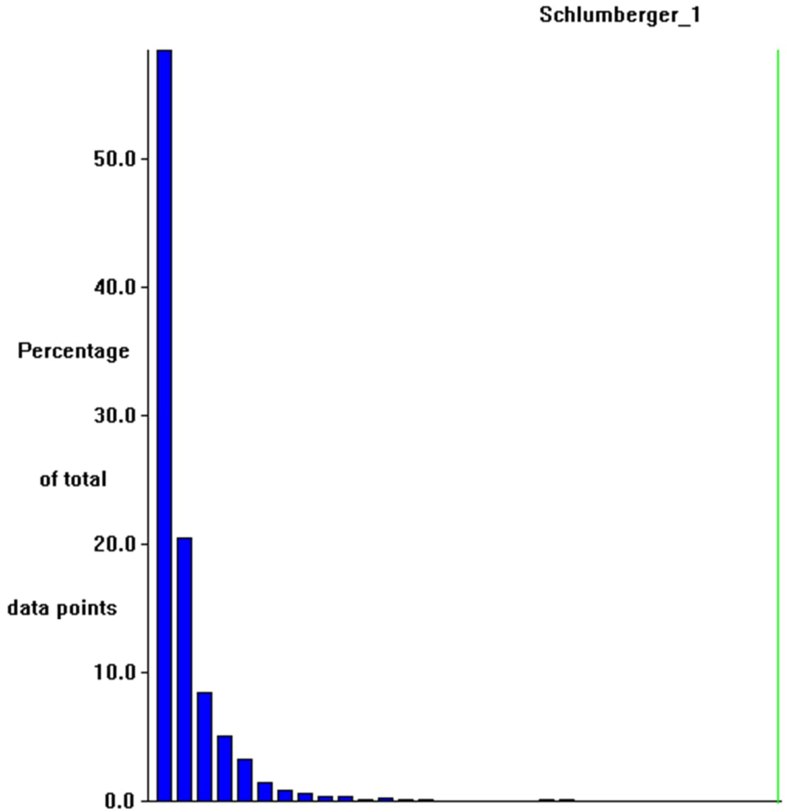


App. res. % error 0 4 8 12 16 20 24 28
No. of points 411 66 10 4 5 1 2 0
Total number of data points is 1276
Number of data points selected is 1276
Maximum error 24.6.
Maximum error selected 24.6.
Minimum value 0.00.
Use the left and right arrows keys to move the green data selection line.

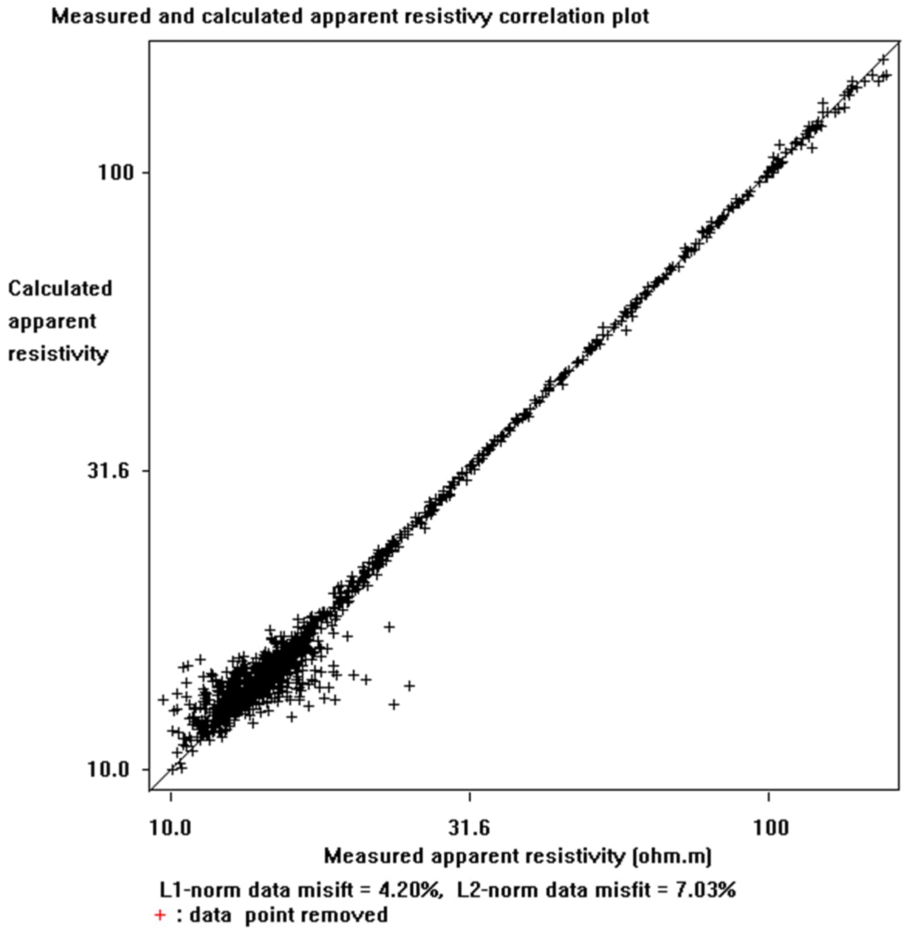


L1-norm data misift = 2.68%, L2-norm data misfit = 4.28%
+ : data point removed

ERT4

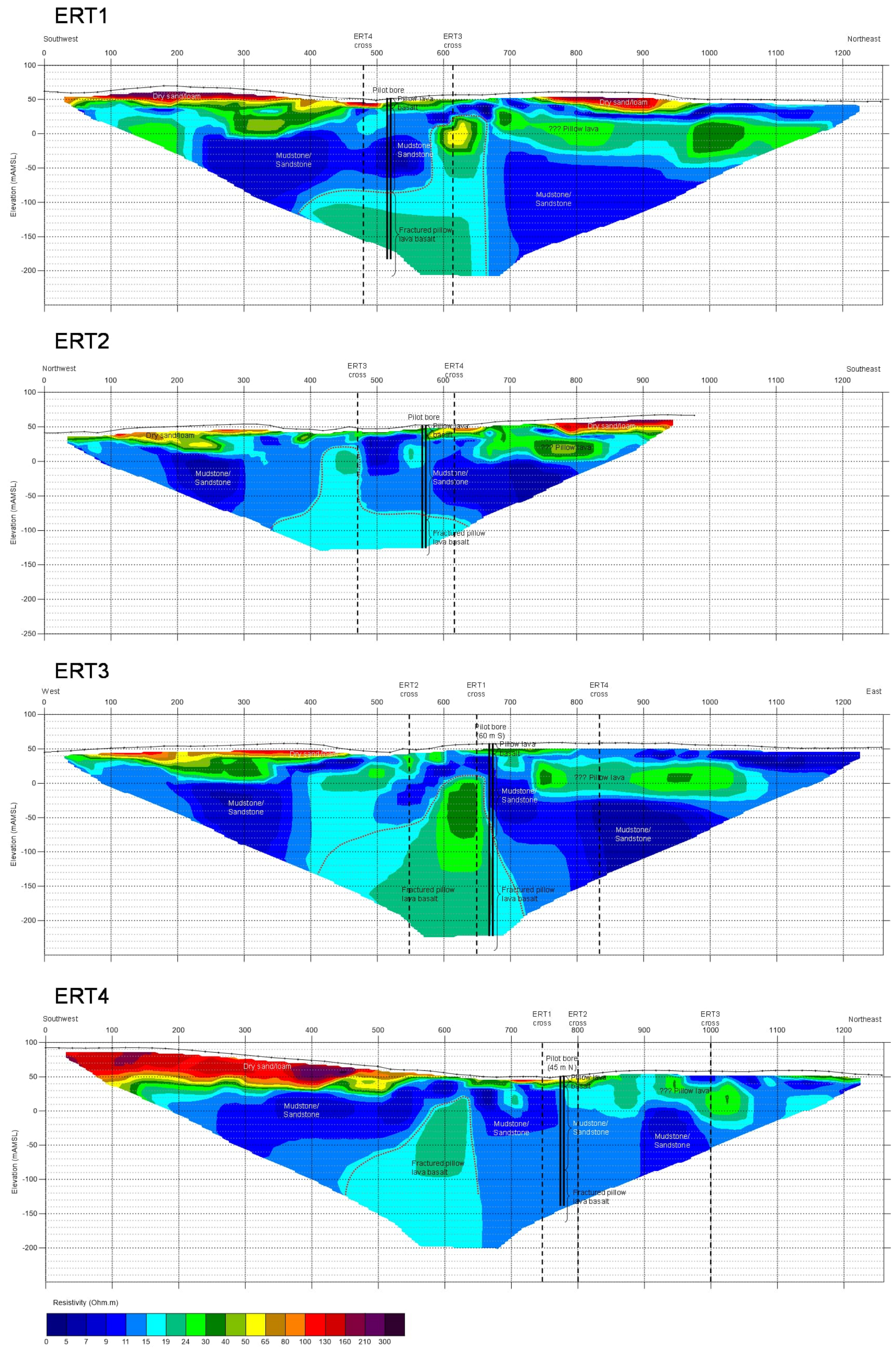


App. res. % error 0 12 24 36 48 60 72 84
No. of points 734 41 5 1 0 1 0 0
Total number of data points is 1256
Number of data points selected is 1256
Maximum error 61.1.
Maximum error selected 61.1.
Minimum value 0.00.
Use the left and right arrows keys to move the green data selection line.



Appendix B. Compiled ERT Map and Profiles


N
Rauratau Stream
ERT1
ERT2
ERT3
ERT4
0
100
200
300 m
Legend
Pilot bore
ERT profiles
Streams
Roads
Property Extent


ERT1
Southwest
Northeast
ERT4 cross
ERT3 cross
Pilot bore
Dry sand/loam
Mudstone/ Sandstone
Fractured pillow lava basalt
??? Pillow lava
Elevation (mAMSL)
ERT2
Northwest
Southeast
ERT3 cross
ERT4 cross
ERT3
West
East
ERT2 cross
ERT1 cross
Pillow lava
ERT4
ERT1 cross
ERT2 cross
ERT3 cross
Resistivity (Ohm.m)
0
5
7
9
11
15
19
24
30
40
50
65
80
100
130
160
210
300