BEFORE THE HEARING PANEL APPOINTED BY KAIPARA DISTRICT COUNCIL

Under the	Resource Management Act 1991
In the matter	of the hearing of submissions on Proposed Private Plan Change 84: Mangawhai Hills Limited

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REBUTTAL EVIDENCE OF CALLUM BERNARD SANDS ON BEHALF OF KAIPARA DISTRICT COUNCIL

(Geotechnical)

13 May 2024

SIMPSON GRIERSON

Warren Bangma
T: +64-9-358 2222
warren.bangma@simpsongrierson.com
Private Bag 92518 Auckland

1. INTRODUCTION

1.1 My full name is Callum Bernard Sands.

1.2 I prepared the Geotechnical Suitability Review dated 9 April 2024 that is **attached** to the section 42A Report as Appendix 2.

1.3 I am a Chartered Geotechnical Engineer with Hawthorn Geddes Engineers & Architects Limited, where I am the lead geotechnical engineer and one of four company Directors.

1.4 I graduated from The University of Auckland with a Bachelor of Engineering (Honours) in Civil Engineering, in 2019. I completed my bachelor's degree from 2015 to 2018. I am a Chartered Professional Engineer (CPEng), and a Chartered Member of Engineering New Zealand in the field of geotechnical engineering; Engineering New Zealand registration number 1161318.

1.5 I have over 5 years of experience working as a geotechnical engineer in Northland, New Zealand. During this time, I have undertaken and/or supervised numerous geotechnical suitability assessments for proposed subdivisions over a wide range of Northland terrain and geology.

2. CODE OF CONDUCT

2.1 I confirm that I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2023 and have complied with it in preparing this evidence. I confirm that the issues addressed in this evidence are within my area of expertise and I have not omitted material facts known to me that might alter or detract from my evidence.

3. SCOPE OF EVIDENCE

3.1 This statement of rebuttal evidence on behalf of Kaipara District Council responds to various matters arising from the statement of evidence of Lee Buhagiar (geotechnical engineer) on behalf of the applicant dated 29 April 2024 and the statement of planning evidence of Ms Neal and Ms McGrath (planning) on behalf of the applicant dated 29 April 2024.

4. EVIDENCE OF MR BUHAGIAR and MS NEAL AND MS MCGRATH

4.1 In my Geotechnical Suitability Review I:

(a) Reviewed the geotechnical related information provided with PPC84 as lodged, and undertook an independent preliminary site walkover assessment and desktop review with the intent of assessing the suitability, from a geotechnical perspective, of the land within PPC84 being developed to provide for 400 to 600 residential lots.

(b) I concluded that, based on my review, and the information available to me at that time that:

(i) Parts of the site may not be suitable for large-scale high density development due to the presence of areas with high potential slope stability risk and also areas with potential risk of subsidence. I mapped the approximate spatial extent of these areas, and included this in my report.

(ii) These areas might be more suitable for lifestyle sized blocks of 1-2hectares.

(iii) I recommended that further investigation and assessment, including subsoil investigation be

> undertaken in respect of the areas I had identified as being subject to high and moderate geotechnical hazard risk, as well as the 60 Ha not previously investigated.

4.2 Based on this, Mr Clease in the section 42A Report indicated that he did not support re-zoning those parts of the site to provide for the density of development proposed by the applicant. However, he would update this position (through rebuttal evidence) in the event that further geotechnical information was provided by the applicant through its evidence-in-chief.[1]

4.3 I have reviewed:

(a) The evidence-in-chief of Mr Buhagiar (Geotechnical Engineer) on behalf of the applicant dated 29 April 2024;

(b) The geotechnical assessment prepared by Wiley Geotechnical for the Mangawhai Church Trust (referred to by Mr Buhagiar in his evidence); and

(c) The evidence-in-chief of Ms Neal and Ms McGrath (planning) on behalf of the applicant dated 29 April 2024, including their Recommended Revised Mangawhai Hills Structure Plan (**MHSP**) and their Recommended Revised Mangawhai Hills Development Area Provisions (**MHDA Provisions**).

4.4 For the reasons that follow, as a result of the further and more detailed assessment that has been undertaken by Mr Buhagiar, and the revisions to the MHSP and MHDA provisions proposed by Ms Neal and Ms McGrath the concerns raised in my Geotechnical Suitability Report have now been addressed.

[1] Section 42A Report, paragraphs 76-79.

4.5 In my Geotechnical Suitability Report, I identified ten matters requiring clarification. These matters are listed in paragraphs 18(a) to 18(j) of Mr Buhagiar's evidence. In my opinion, an assessment of these matters is essential to ensuring a comprehensive geotechnical investigation and assessment of the plan change has been undertaken, and to corroborate the validity of PPC84.

4.6 Mr Buhagiar in his evidence has provided an assessment of these matters. This has included additional deep subsoil testing, cone penetrometer testing, and a review of the Causeway Church geotechnical report prepared by Wiley Geotechnical that provides information on that part of the site. I consider the assessment provided in Mr Buhagiar's evidence to be better aligned with the guidelines presented in the MBIE Module 2 document on proposed plan changes. I also consider that it provides clarity as to the geotechnical risk of the overall site, including the 60 Ha not previously tested.

4.7 Overall, the outcome of Mr Buhagiar's assessment is that:

(a) He assesses the site as having a low to moderate risk of slope instability. This is subject to two exceptions where areas are identified as having moderate to high risk.

(b) These areas of moderate to high risk have been identified in the revised MHSP and the corresponding MHDA Provisions.

4.8 Bay way of response to this:

(a) In relation to the Geotechnical report for the Mangawhai Church Trust, a copy of this report dated 13 December 2020 is **attached** to my evidence as **attachment A**. This provides further information in relation to the geotechnical suitability of re-zoning this part of the PPC84 area, noting that it is not owned by the applicant. In relation to that report:

(i) I do not agree with the statements made by Mr Buhagiar in paragraphs 40 and 50 of his evidence whereby he concludes that the site is underlain by firm clays and is not underlain by soft soils. Results of the testing within the Wiley Geotechnical prepared for Mangawhai Church Trust, dated 13 December 2020 identify the presence of organics on the site, as well as soft clays. The CPTs presented in both the Wiley report and Mr Buhagiar's evidence suggest the same.

(ii) Notwithstanding the above, as discussed further below, it is my opinion that the consolidation risk for the site is low, and that the proposed PC84 provisions and section 106 of the Resource Management Act 1991 (**RMA**) will adequately address this hazard.

(b) I generally agree with the Buhagiar's geotechnical hazard mapping. For completeness, I am of the opinion that there might exist other isolated areas presenting moderate to high slope stability risk. Additionally, I believe that the area designated by Mr Buhagiar may extend beyond its current boundaries. Nonetheless, overall, I agree with Mr Buhagiar that these areas can be further refined as part of the subsequent resource consent stage rather than at the proposed plan change stage.

(c) Overall, based on the further information that has been provided and the changes outlined to the MHSP and MHDA provisions I agree with Mr Buhagiar and the applicant's planners Ms Neal and Ms McGrath that:

(i) It is appropriate from a geotechnical perspective to re-zone the land in the manner that is proposed; and

(ii) The MHDA provisions outlined in PC84, together with section 106 of the RMA are suitable for addressing/managing the potential risks from natural hazards and ensuring the implementation of geotechnically stable building designs.

Callum Bernard Sands

13 May 2024

Attachment A: Report by Wiley Geotechnical for the Mangawhai Church Trust dated 13 December 2020

13 December 2020

Mangawhai Church Trust
c-/ Rob Reid
rwrassist@gmail.com

RE: Geotechnical Investigation for Causeway Church Development at Lot 1 DP 15117, Urlich Drive, Mangawhai

Wiley Geotechnical Limited (WGL) was requested by Rob Reid acting on behalf of Mangawhai Church Trust to provide a geotechnical investigation to provide support and provide recommendations the proposed development of a Worship Centre and associated driveway and carpark. WGL has previously carried out geotechnical investigations on the site and issued two preliminary reports for the proposed development (Ref 17296 & 17296_2, dated 23/03/18 & 10/10/20). The preliminary reports provided guidance in determining a suitable position and layout of the development. We have been provided with an updated scheme plan which illustrates the main worship centre and carpark being situated to the north west of the site.

WGL carried out ten additional boreholes and nine Scala testing. WGL re-visited the site in December 2020 to carry out further ground investigations to support this report and provide foundation and earthworks recommendations for the development. We understand it is proposed to create a level platform for the proposed worship centre via cut and fill earthworks. Initial discussions with the design team, we understand the worship centre shall comprise of a steel portal framed, light weight clad structure placed upon a concrete foundation, which consist of a waffle slab (Rib-Raft).

Site Description

The site comprises an approximate area of 9.56 Ha and is located to the western side of Mangawhai village. The Kaipara District Plan maps illustrates the site to be in the designated rural area. Urban and residential properties bound the north east and south east boundaries of the site with the remainder of the site bounded by undeveloped rural properties. Access to the property is currently provided by Urlich Drive elevating to and ceasing at the entrance to the property. Drainage from the majority of the site is provided by natural overland flow paths and small gully formations which trend towards the south-western boundary.

Regional Geology

The GNS map for the site indicates that the site is predominantly underlain by sedimentary rocks of the Pakiri Formation (Waitemata Group) (PF) comprising “alternating thick-bedded, volcanic rich, graded sandstone and siltstone with volcaniclastic grit beds.”

The map illustrates the south central and south eastern lower lying areas of the site to be underlain by alluvium of the Tauranga Group comprising “Poorly consolidated mud, sand, gravel and peat deposits of alluvial, swamp and estuarine origins”.

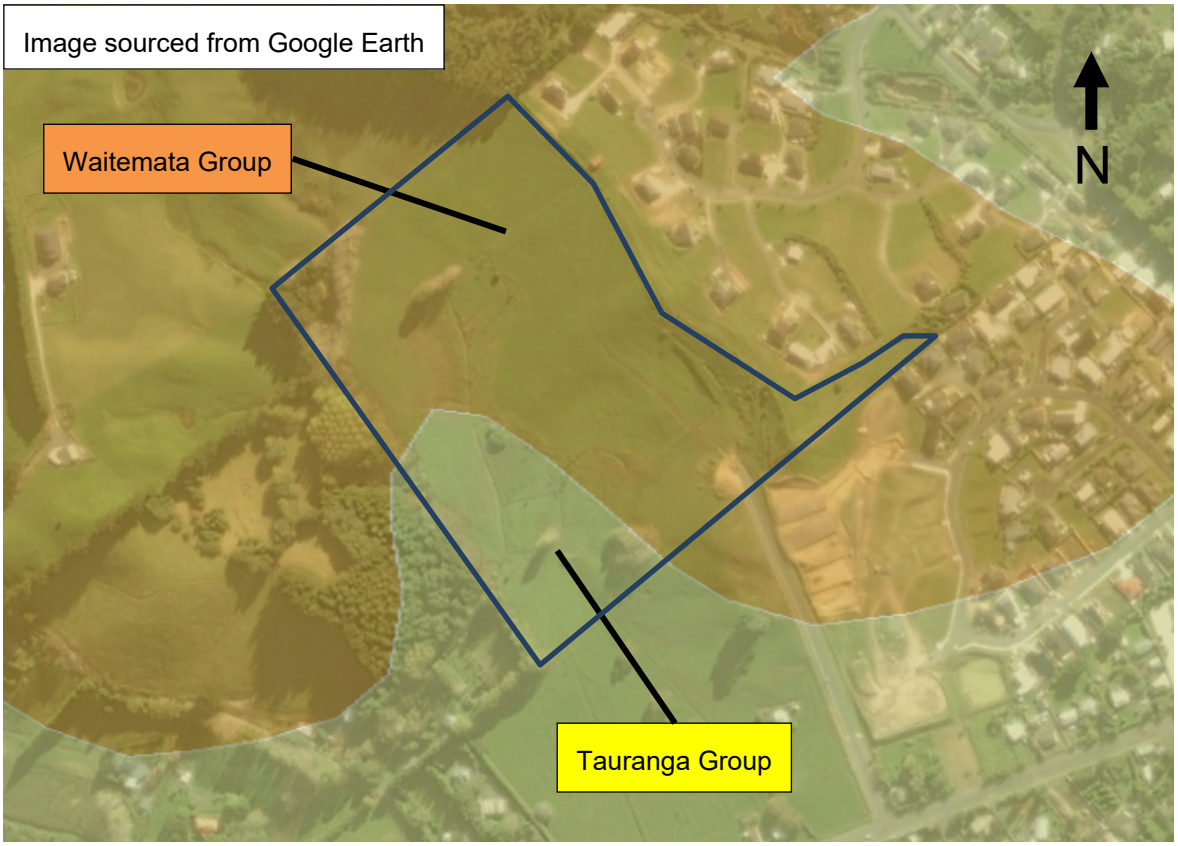


Figure 1: Mapped Site Geology

Historical Aerial Photography

Historic aerial photography dating back to 2006 was reviewed using available Google Earth images. It appears that minor earthworks were potentially carried out between 2010 and 2013 creating what seems to be drainage channels in the lower lying areas of the site to the south west. These drainage channels are still evident in the most recent aerial photograph (2019). Other than this, it appears no obvious development or earthworks have been carried out since 2006 with the current site generally remaining as is.

Geomorphology

The prominent feature of the site is a ridgeline formation generally trending in a northwest to southeast direction along the north eastern boundary with moderate to steep south west facing slopes. A spur formation extends off the ridgeline trending to the south west through the site and tapering off. A man made cut excavation appears to have been carried towards the eastern boundary with a very steep cut face which has grassed over. It is unknown where the cut excavation fill material has been placed; however, some is suspected to have been placed to the north of the cut to reduce the steeper gradient. No evidence of significant historical slope failures were observed along the ridgeline and spur formations, and no evidence of shallow soil movement and soil creep was observed across the natural geomorphology.

A natural broad gully formation extends from the centre of the site towards the lower lying western area. Rushes were observed in the lower lying area indicating wetter conditions being typically present. Wetland vegetation and swampy ground was observed in the lower lying area towards the south west of the site. Overland flow paths and ephemeral open channel drains lead to a main watercourse running through the base of the lower lying western area trending in a north to south direction. This watercourse exits the site along the south western boundary.

Additional drains were created in the vicinity of the proposed development during the latter half of 2020. Groundwater flows were observed by the contractors during the earthworks excavations. WGL inspected the drains a later date with small water flows still present. This indicated the presence of a potential spring or perched groundwater table further upslope trending down towards the development area indicating the need for suitable drainage design to be implemented with the development. Recommendations regarding drainage are outlined further below.

Field Exploration and Subsurface Conditions

WGL previously carried a series of geotechnical investigations between March 2018 and December 2020 comprising 19 hand auger boreholes with shear vane testing, 10 Scala Penetrometers and six Cone Penetration Tests (CPT) which were carried out by a subcontracted drilling company. The approximate locations of these tests are illustrated below in Figure 2 &3.

The hand auger exploration points provide data to characterise near surface soils. They were carried out up to a maximum depth of 4.2 m. The soils encountered generally consisted of topsoil underlain by slightly to moderately sandy, slightly to moderately clayey silt grading into alternating layers of clayey silt and sandy silt. This is further underlain by alternating layers of weathered siltstone and sandstone material. Colluvium was encountered at depths between 0.4 m and 0.9 m in boreholes HA2, HA3, HA4 and HA8 with the presence of tephra material encountered across the upper parts of boreholes within and below topsoil. Alluvium of the Tauranga Group was observed to be overlying the Pakiri Formation of the Waitemata Group in the lower lying areas as outline in the approximate geological boundary below. Relatively lower shear vane values were encountered in boreholes HA4, HA10, HA11 and HA14. Borehole HA10 specifically recorded the lowest shear vane values. Borehole HA1 encountered significantly lower shear strengths than the remaining test points; however, this is located outside of the proposed development area. Organic silt was encountered in borehole HA8 where relatively lower shear vane strength were also recorded. Groundwater was encountered at depths between 1.2 m and 2.8 m in boreholes HA1 to HA5 inclusive and HA8. Scala Penetrometer tests were carried out across the prosed driveway and car parking area.

The CPT probe gathers raw data including cone tip resistance, friction sleeve resistance and pore water pressure at 2 cm intervals during the test. This information is used to infer the soil type, soil density, strength and ground water conditions. These inferred parameters and can be used in design when determining settlement and liquefaction risk or design of piled foundations and other geotechnical analysis. The six CPTs were extended to depths between 4.9 m and 6.6 m. None of the CPTs achieved the target a depth of 15 m as all encountered practical refusal at shallower depths due to max tip/friction pressure or the anchors pulling out of the ground. The inferred soils encountered generally consisted of topsoil underlain by interbedded layers of clay and silty clay with occasional layers of sandy silt. The inferred subsoil generally grades into sand and silty sand towards the base of the investigations before practical refusal was encountered. The inferred shear strength of the subsoil from the CPTs generally

consisted of firm to stiff silt and clay in the upper 4-5 m with values ranging from 20-50 kPa grading into very stiff to hard material with depth (>200 kPa).

Based on this, it is our opinion that the material encountered and inferred in our subsurface investigation is broadly consistent with published geologic mapping. The bore logs are presented as an appendix to this report and are written in general accordance with the New Zealand Geotechnical Society field classification guidelines (NZGS, 2005). The CPT analysis data is also attached as an appendix to this report.

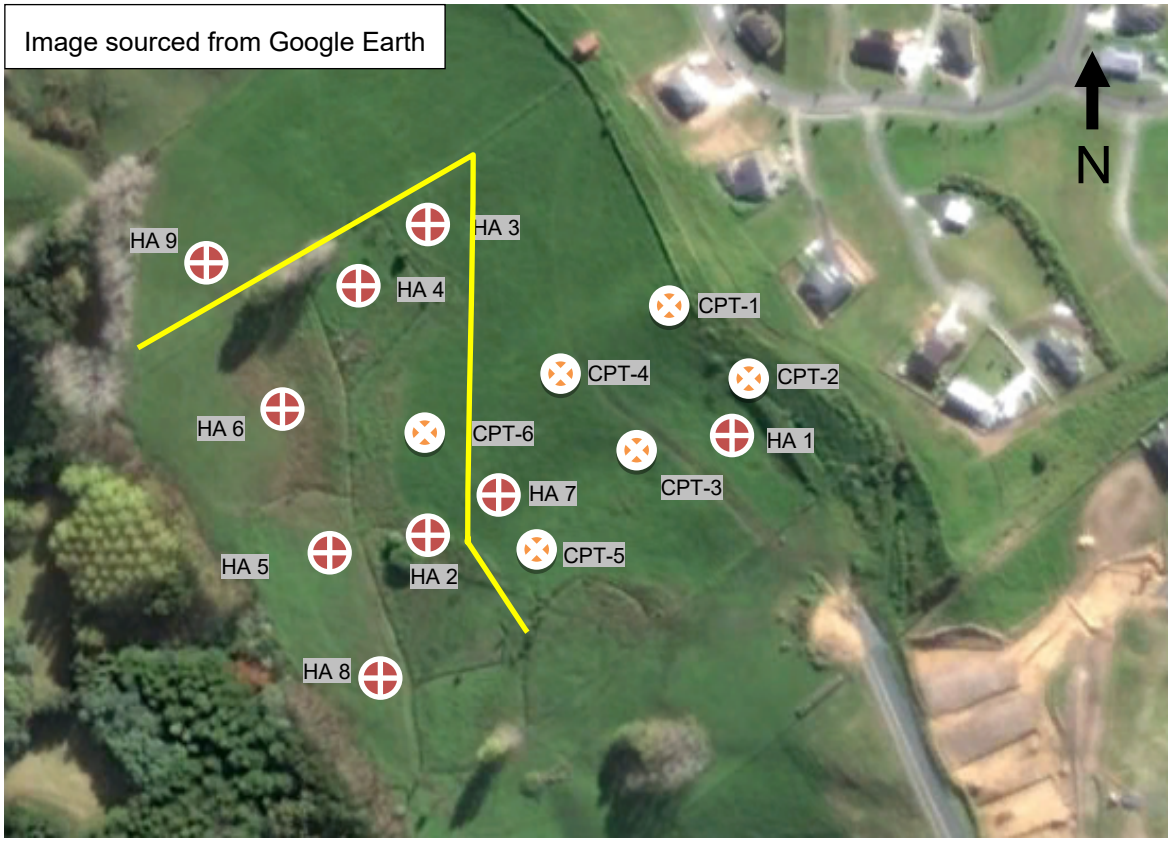


Figure 2: Approximate Subsurface Exploration Locations & Rough Geological Boundary

Figure 3: Approximate Subsurface Exploration Locations

Scala Results

Scala blows/100mm at Urlich Drive, Mangawhai				
(m)	Scala 2 (SP2)	Scala 3 (SP3)	Scala 4 (SP4)	Scala 5 (SP5)
0.1	1	1	1	1
0.2	2	2	3	1
0.3	3	3	4	3
0.4	3	3	3	3
0.5	2	2	4	2
0.6	2	2	3	1
0.7	2	2	2	2
0.8	1	1	2	2
0.9	1	1	1	1
(m)	Scala 6 (SP6)	Scala 7 (SP7)	Scala 8 (SP8)	Scala 10 (SP10)
0.1	2	1	1	1
0.2	3	2	4	2

0.3	1	1	4	3
0.4	4	1	5	4
0.5	6	1	6	3
0.6	5	1	4	3
0.7	4	2	2	2
0.8	4	1	2	1
0.9	3	1	1	1

(m)	Scala 11 (SP11)
0.1	2
0.2	2
0.3	1
0.4	1
0.5	1
0.6	1
0.7	1
0.8	1
0.9	1

Expansive Soils

Based on our field assessment of the soils encountered onsite, and our experience in the area, we consider that the Expansive Site Class for this site is likely to be “M - moderate” - in accordance with AS 2870. Accordingly, the minimum footing depth for future foundations would likely have to be 600 mm below cleared ground level.

Conclusions and Recommendations

Based on the findings of our geotechnical investigation and site assessment, it is our opinion that the proposed development is feasible from a geotechnical point of view, provided the recommendations presented in this report and standard development practices are incorporated in the design and construction of the project.

Site Suitability

The geotechnical investigation generally indicates that the subsoil conditions present across the western side of the site are suitable for the proposed development. Some localised areas, such as the location of borehole HA10, showed relatively weaker soil in the borehole shear vane tests which was discussed earlier in this report. Depending on the proposed earthwork cut and fill plans, this relatively weaker material may end up being removed and utilised as engineered fill. Otherwise, remediation measures

such as undercutting and replacing it back as engineered fill could be carried out so that a consistent strength soil material is present across the building platform.

The presence of tephra soil encountered presents a limiting issue which would have to be remediated. Based on our technical and local knowledge, tephra like this has a relatively lower percolation rate leading to greater surface runoff of stormwater and more extended periods of saturated topsoil. This aligns with our observations on site of surface material being soft to walk and drive upon across the lower areas of the site. However, this observation of softer surficial soil does correlate directly to subsoil strengths encountered in the subsoil below the topsoil and colluvium. The colluvium and tephra is not considered suitable to utilise as engineered fill, and therefore would have to be handled separately like the topsoil during earthworks. This is due to tephra typically having a very low remoulded strength, and so it would most likely have to be reused as landscaping fill upon the site. The alluvial soil can be somewhat more temperamental than the Waitemata soil when utilising as engineered fill material. This would just mean that further work compacting the alluvial soil may be necessary as well as additional drying or wetting, depending on the time of year, so as to achieve a suitable moisture content close to optimum.

The alluvial soil to the south western side of the site, encountered in borehole HA8, is not considered suitable for development. This, however, is situated towards the downstream side of drains and watercourses in the property where development is unlikely and stormwater management elements shall likely be situated and employed.

Foundations

Based on our geotechnical investigations we envisage that specific engineering design shall be required for future structures on the site. Cohesive material was generally encountered in the vicinity of the proposed development with shear strengths ranging between 68 kPa and an inferred >200 kPa. Shear strengths would be expected to dramatically increase as the subsoil grades into inferred weathered rock material. Based on boreholes HA3, HA10, HA12, HA13 and the nearby CPT data the weathered rock would be expected to range in depth from 1.0 m depth and 6.5 m. We would expect that a future shallow concrete foundation, such as a Rib-Raft would be specifically design by a Chartered Structural Engineer utilising an ultimate bearing capacity of 150-200 kPa. This shall depend on the final earthwork cut and fill plans and the proposed remediation measures for the weaker soil encountered, such as the location of borehole HA10. Over excavation over the cut side of the proposed platform may be required so as to ensure that a similar subsoil strength is achieved. This is because the engineered fill can likely be much stronger than insitu soil and present a risk of differential settlement. A cut on the order of 0.5 m may be employed depending on the insitu soil strengths recorded in the boreholes over the proposed cut depth. We would envisage the superstructure portal frame base loads being supported upon pile foundations embedded to a depth between 2-3 m, depending on final earthwork plans. An ultimate bearing capacity of 600 kPa is expected to be available for the pile foundations. If larger bearing capacities are required pile foundations may be extended down to bear upon weather rock material where an ultimate bearing capacity exceeding 1 MPa would be expected.

The subsoil material is generally considered to be suitable to excavate and use as engineered fill across the site with the exception of the colluvium encountered which contains tephra material. An iterative process is most likely going to be required with communication between the geotechnical engineer, the civil engineer and the structural engineer through the design phase. This is due to the key role in which the earthworks cut and fill plans play in determining what final bearing capacities may be utilised by the structural for the foundation design as well as

Earthworks

We recommend that all topsoil and tephra material is stripped and removed from the cut areas prior to excavating the insitu soil material. The excavated insitu soil should be handled separately to the topsoil material. No topsoil or tephra should be used as, mixed with or remain below any engineered fill material. We recommend tephra is only utilised as landscape fill material. The stripped topsoil may be reused once fill placement is complete and be placed at a maximum height of 200 mm. The cut excavation areas should be graded to allow the flow of stormwater away from the area. Suitable erosion and sediment control methodologies should be employed. Any sloping ground that is excavated into should be battered back to a maximum slope of 3:1 (H:V). This should be assessed by a geotechnical engineer. Once cut excavation are complete planting or re-grassing of the areas should be carried out, or long term erosion and sediment control measures implemented.

Engineered fill placement may commence once the excavation to expose insitu soil has been carried out and certified. We expect the fill to primarily comprise of slightly sandy, moderately clayey silt material and potentially weathered siltstone/sandstone material. The cut material to be used as fill must contain less than 5% organics. We recommend that engineered toe bunds are created at the downslope end of proposed fill areas with a minimum base depth of 0.5 m below ground level and a minimum width of 1.0 m extending the full length of the embankment. A perforated novacoil pipe should be placed behind the toe of the fill and surrounded by drainage metal with all fully wrapped in geotextile cloth material for a width of 0.2 m and depth of 0.5 m. The outlet of the novacoil should convey water to an approved stormwater outlet point. A maximum slope angle of 3:1 (H:V) should be maintained for all sloping ground of fill material. We recommend that the fill material is benched in vertical lifts of 1 m. The fill material should be placed in lifts no greater than 300 mm and compacted using a sheep's foot roller compacter. The level of compaction may be assessed by determining the percentage of maximum dry density (MDD), by determining the shear strength of the soil or incorporating a combination of both. We recommend testing in accordance with NZS 4431:1989. At this stage it is anticipated that compaction should achieve 95% of the MDD of the material, based on lab tests of the site soil material. This may be confirmed onsite using either a nuclear density meter (NDM). The shear strength of the fill material at each lift should have an average value of 150 kPa measured by a shear vane, with no measurement below 120 kPa. Depending on the time of year the stripped material may require either drying or wetting to achieve optimise moisture content prior to placing as fill. We recommend that reseeding or placement of topsoil material is carried out on completed fill earthworks and sloping ground so as to reduce the risk of erosion.

We recommend WGL, or a Geotechnical Engineer familiar with this report, inspect all excavations prior to the placing of the fill material and intermittently inspect and strength test the engineered fill. The contractor should liaise with the geotechnical engineer prior to commencing earthworks. WGL should review all earthwork plans prior to submittal for council consent.

Slope Stability

The site is predominantly situated on moderately sloping ground with the central and western areas grading to gentle slopes leading to the lower lying western side of the site. Localised areas with steeper slopes are situated towards the south eastern side of the site, namely the suspected man made cut excavation discussed previously. The cut slope face, which has since been grassed over, is not

considered stable in in its current state. We recommend that this slope is over excavated and battered so as to finish with a maximum 3:1 (H:V) slope gradient if development in this vicinity is proposed.

The proposed development area of the worship centre and carpark is located downslope to the west where no slope stability issues are considered to be present.

Carpark Area

The proposed carpark area for the worship centre is proposed to be situated downslope and to the west of the building area. We understand at this point that a flexible proprietary pavement design system is envisaged to be utilised. The Scala Penetrometer results are outlined above and indicate that generally a blow count of 2-3 per 100 mm is present across the area which would equate to between 3-5 CBR. The notable exceptions are SP7 & SP11 which neared an average of 1 blow count per 100 mm depth which would equate to a CBR value between 1.5 and 2. The pavement design engineer can liaise with WGL with regards what CBR values to utilise and potential earthwork remediation measures which could be carried out to allow for a greater design strength of subgrade.

Wastewater

We would envisage that future structures would connect into the Mangawhai wastewater reticulation system EcoCare. This would be likely be more suited to the site as it would leave the remaining land open to further development of structures or recreation areas.

The method of effluent being directed to a disposal field on site would likely require significant areas. A Secondary wastewater system would be required in this case. The final onsite wastewater disposal system must conform to G13 of the NZ Building code. Any treated material must be dispersed in a controlled manner across a relatively level discharge area in order to maximise the efficient infiltration of material without compromising the stability of any slopes. To this end, the effluent disposal fields would have to be located clear of all building locations.

In terms of AS/NZS: 1547-2000) a Soil Category of 4 should be adopted (i.e. Clay loams – imperfectly drained). If the tephra material is present on a wastewater field then removal or ploughing of the soil may be required to ensure suitable percolation in the subsoil.

Stormwater

Section 12.10.8 of the KDC District Plan outlines that a site greater than 5 hectares in size may carry out a permitted activity as long as stormwater runoff from impermeable surfaces is disposed of on site or discharged to an existing watercourse. The district plan does clearly stipulate that creating impervious areas on this particular site as part of future development would require attenuation of stormwater to pre-development levels. However, it is noted that a discharge consent may be required from Northland Regional Council.

We would consider that attenuation of stormwater would be required considering the downstream setup. Residential properties are located within the vicinity of the downstream section of the watercourse which continues to connect into the tidal estuary. An open discussion with KDC and NRC shall be required to assess the envisaged requirements. Assessment of the downstream section of the watercourse beyond the site would have to also be carried out to assess potential risks of flooding and erosion from an increase in stormwater peak flows and stormwater volumes.

It is envisaged that a large stormwater detention pond or wetland would be constructed to the south western area of the site to attenuate stormwater runoff from the future impervious areas. Based on our

preliminary investigation and visual assessment we generally think this would be a suitable method with a raised bund surrounding the perimeter and the inner area over excavated.

Drainage

Due to the gradients across the site it is envisaged that concrete lined cut off or simple v-drains would need to be constructed upslope of the future building platforms to help catch stormwater run-off from the upslope areas. We would expect drain should have a minimum width of 500 mm and depth of 150 mm, be fully lined with 50 mm thickness of concrete and discharge downslope clear of building areas in to the proposed stormwater detention pond / wetland or on to a section of rock rip rap to protect against any scour.

A counterfort/subsoil drain will be required to intercept groundwater from effecting the building site and help improve the overall stability. We envisage the location shall be at the base of the upslope cut excavation for the proposed building platform extending the entire upslope side of the platform and building area. We recommend a trench with a minimum depth of 2.5 m, reducing in depth towards the downslope side of the platform and outlet point, and width of 500 mm with a 110 mm punched PVC pile (Novoflow or similar) at the base backfilled with suitable drainage metal. The depth of the counterfort drain shall be confirmed by the geotechnical engineer once earthwork plans have been produced. The base and sides of the trench should have a layer of geotextile cloth (Bidim A29, Cirtex AS410 or a similar approved product) folding over the top to essentially encapsulate the drainage rock. The counterfort drain and surface cut of drain may be designed to be situated together.

Plan Review

We recommend that WGL review all earthwork and development plans once finalised prior to submittal to council for building and resource consent to ensure our recommendations have been interpreted and implemented correctly.

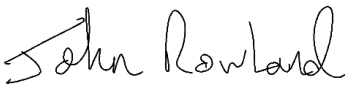
LIMITATIONS

(i) This report has been prepared for the use of our client, Rob Reid and their professional advisers and the relevant Regional Authorities in relation to the specified project brief described in this report. No liability is accepted for the use of any part of the report for any other purpose or by any other person or entity.

(ii) Assessments made in this report are based on the ground conditions indicated from published sources, site inspections and subsurface investigations described in this report based on accepted normal methods of site investigations. Variations in ground conditions may exist between test locations and therefore have not been taken into account in the report. If variations are found during excavation or at foundation preparation stage WGL should be notified immediately so we can amend our recommendations.

(iii) This Limitation should be read in conjunction with the IPENZ/ACENZ Standard Terms of Engagement.

We trust that this information meets your current requirements. Please do not hesitate to contact the undersigned on 021 0399 385 or matt@wileygeotechnical.co.nz if you require any further information.



John Rowland, BEng, MEngNZ

Associate Geotechnical Engineer

Matt Wiley, CPEng, CMEngNZ

Principal Engineer

Attachments:

- Bore Logs

- CPT Data Results

WILEY GEOTECHNICAL LTD

BOREHOLE No. 1

SITE: Moir Street, Mangawhai

REF: 17296

Sheet 1 of 1

REDUCED LEVEL (RL) / INFERRED GEOLOGY	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	SAMPLE TYPE	WATER CONTENT (%)	WATER LEVEL	CORRECTED VANE SHEAR STRENGTH (kPa) ● Peak Field Vane ○ Remoulded Field vane 50 100 150	SCALA PENETROMETER BLOWS / 100 mm 5 10 15
	TOPSOIL/TEPHRA slightly sandy, dark brown							
Pakiri Formation of the Waitemata Group	SILT slightly sandy, slightly clayey, slightly plastic, dark brown/ grey becoming light brown/grey moderately plastic with orange/brown staining moderately sandy moderately clayey silt horizon/ alternating with sandy silts, water		1			V	41 ○ 106 ● 46 ○ 96 ● 10 ○ 46 ● 5 ○ 55 ● 25 ○ 52 ● 27 ○ 52 ●	
	SILT/CLAY highly plastic, light grey with orange/ brown mottling		2				38 ○ 55 ● 22 ○ 38 ●	
	E.O.B: 3.0 m		3				30 ○ 55 ● 27 ○ 55 ●	
			4					
			5					

NOTES Groundwater was encountered at 1.2 m depth

LOGGED BY: MW & CS

DATE DRILLED: 22-Mar-18

DRILL METHOD 50 mm Hand Auger

WILEY GEOTECHNICAL LTD

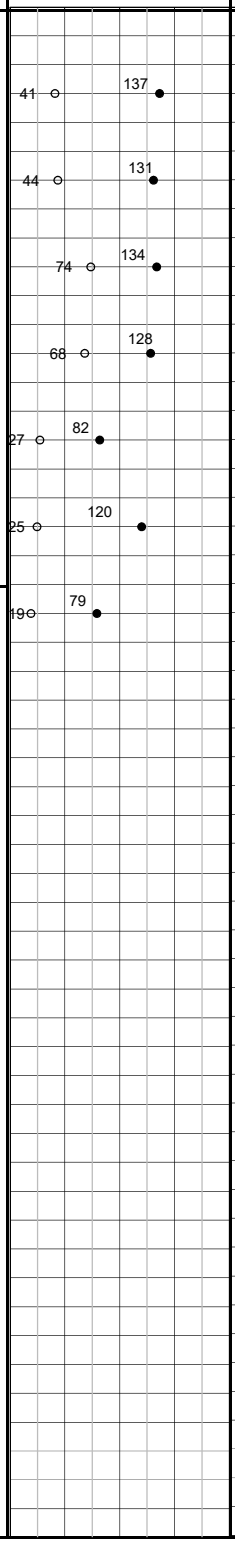
BOREHOLE No. 2

SITE:Moir Street, Mangawhai

REF: 17296

Sheet 1 of 1

REDUCED LEVEL (RL) / INFERRED GEOLOGY	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	SAMPLE TYPE	WATER CONTENT (%)	WATER LEVEL	CORRECTED VANE SHEAR STRENGTH (kPa) ●Peak Field Vane ○Remoulded Field vane 50 100 150	SCALA PENETROMETER BLOWS / 100 mm 5 10 15
	TOPSOIL/TEPHRA slightly sandy, fine, dark brown							
	TEPHRA grey, silty							
Alluvium of the Tauranga Group & Pakiri Formation of the Waitemata Group	SILT slightly clayey, moderately sandy, fine to coarse grained, light grey							
	occasional brown organics							
	becoming coarse grained, hole squeezing from 0.8- 1.2 m		1					
	white clasts							
	increased organics, light brown groundwater					V		
	E.O.B: 2.0 m		2					
			3					
			4					
			5					



NOTES Groundwater was encountered at 2.0 m depth

LOGGED BY: MW & CS

DATE DRILLED: 22-Mar-18

DRILL METHOD 50 mm Hand Auger

WILEY GEOTECHNICAL LTD

BOREHOLE No. 3

SITE: Causeway Church, Moir Street, Mangawhai

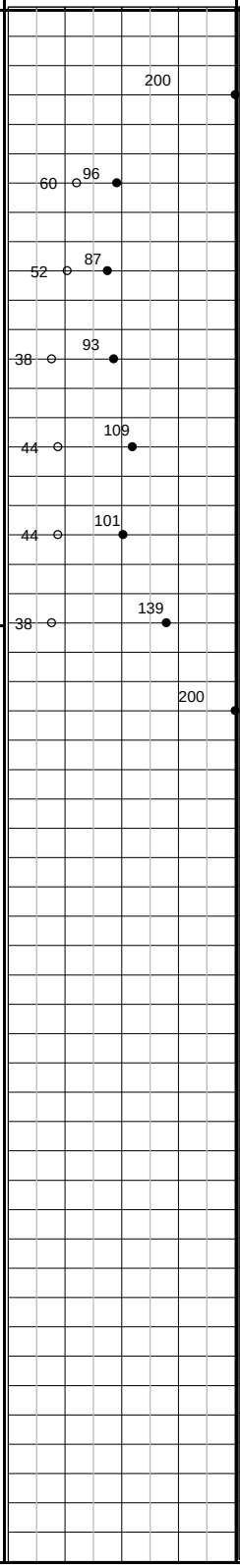
REF: 17296

Sheet 1 of 1

REDUCED LEVEL (RL) / INFERRED GEOLOGY	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	SAMPLE TYPE	WATER CONTENT (%)	WATER LEVEL	CORRECTED VANE SHEAR STRENGTH (kPa) ● Peak Field Vane ○ Remoulded Field vane	SCALA PENETROMETER BLOWS / 100 mm
Colluvium	TOPSOIL slightly sandy, dark brown							
	SILT slightly sandy, friable, possible tephra, dark grey with orange brown mottling							
Alluvium of the Tauranga Group	SILT moderately clayey, moderately plastic, light greyish brown, dessication cracking to 0.7 m depth							
	light grey with orange brown mottling		1					
	becomes sandy, decreased clay							
	light brown occasional organics, moist		2					
	groundwater encountered					V		
WG	SILT slightly clayey, slightly plastic, light grey and brown with orange brown mottling, grading into alternating layers of siltstone and sandstone							
	E.O.B: 2.4 m		3					
			4					
			5					

CORRECTED VANE SHEAR STRENGTH (kPa) — 50 100 150

SCALA PENETROMETER BLOWS / 100 mm — 5 10 15



NOTES Groundwater was encountered at 2.1 m depth
WG = Pakiri Formation of the Waitemata Group
Practical refusal encountered at 2.4 m depth

LOGGED BY: MW & CS
DATE DRILLED: 5-Oct-20
DRILL METHOD 50 mm Hand Auger

WILEY GEOTECHNICAL LTD

BOREHOLE No. 4

SITE: Causeway Church, Moir Street, Mangawhai

REF: 17296

Sheet 1 of 1

REDUCED LEVEL (RL) / INFERRED GEOLOGY	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	SAMPLE TYPE	WATER CONTENT (%)	WATER LEVEL	CORRECTED VANE SHEAR STRENGTH (kPa) ● Peak Field Vane ○ Remoulded Field vane	SCALA PENETROMETER BLOWS / 100 mm
Colluvium	TOPSOIL sandy, dark brown, friable, tephra SILT slightly to moderately sandy, slightly clayey, slightly plastic, dark grey with orange brown mottling becoming light grey						41 ○ 112 ● 52 ○ 106 ● 49 ○ 79 ●	
Alluvium of the Tauranga Group	SILT moderately clayey, moderately plastic, organic stained, brown occasional organics (roots) slightly sandy highly clayey, highly plastic light grey and green sandy layer, decreased clay water seepage		1 2			V	52 ○ 71 ● 52 ○ 68 ● 66 ○ 79 ● 57 ○ 93 ● 60 ○ 90 ● 44 ○ 101 ●	
	E.O.B: 3.0 m		3 4 5				71 ○ 126 ●	

NOTES Groundwater was encountered at 2.8 m depth.

LOGGED BY: MW & CS

DATE DRILLED: 5-Oct-20

DRILL METHOD 50 mm Hand Auger

WILEY GEOTECHNICAL LTD

BOREHOLE No. 5

SITE: Causeway Church, Moir Street, Mangawhai

REF: 17296

Sheet 1 of 1

REDUCED LEVEL (RL) / INFERRED GEOLOGY	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	SAMPLE TYPE	WATER CONTENT (%)	WATER LEVEL	CORRECTED VANE SHEAR STRENGTH (kPa) ● Peak Field Vane ○ Remoulded Field vane 50 100 150	SCALA PENETROMETER BLOWS / 100 mm 5 10 15
Alluvium of the Tauranga Group	TOPSOIL slightly sandy, dark brown SILT slightly sandy, slightly clayey, slightly plastic, light brown slight seepage increased moisture occasional organics organic staining (non-compressible) groundwater encountered		1 2			V	33 ○ 71 ● 35 ○ 79 ● 44 ○ 87 ● 44 ○ 101 ● 35 ○ 82 ● 22 ○ 79 ● 46 ○ 85 ●	
	E.O.B: 2.1 m		3 4 5					

NOTES Groundwater was encountered at 2.0 m depth.

LOGGED BY: MW & CS

DATE DRILLED: 5-Oct-20

DRILL METHOD 50 mm Hand Auger

WILEY GEOTECHNICAL LTD

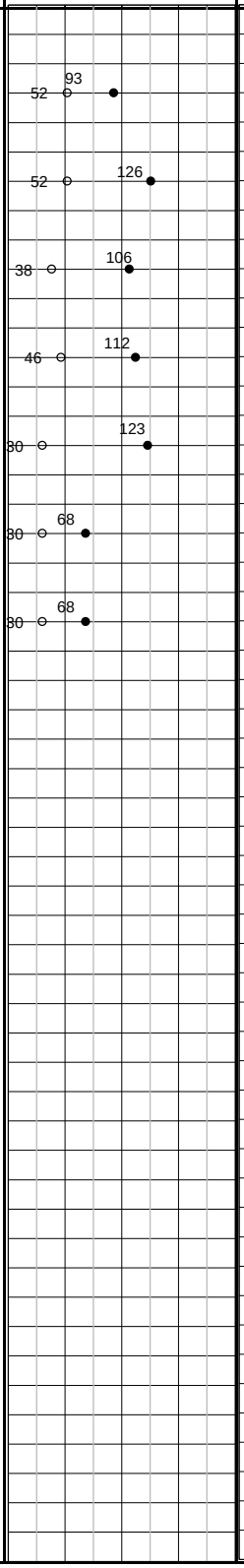
BOREHOLE No. 6

SITE: Causeway Church, Moir Street, Mangawhai

REF: 17296

Sheet 1 of 1

REDUCED LEVEL (RL) / INFERRED GEOLOGY	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	SAMPLE TYPE	WATER CONTENT (%)	WATER LEVEL	CORRECTED VANE SHEAR STRENGTH (kPa) ● Peak Field Vane ○ Remoulded Field vane 50 100 150	SCALA PENETROMETER BLOWS / 100 mm 5 10 15
Alluvium of the Tauranga Group	TOPSOIL sandy, dark brown							
	SILT moderately sandy, fine to medium, slightly clayey, low plasticity, friable, brown with occasional dark brown staining							
	moist to wet increased clay, increased plasticity		1					
	light brown with orange brown mottling							
	E.O.B: 2.1 m		2					
			3					
			4					
			5					



NOTES Groundwater was not encountered.

LOGGED BY: MW & CS

DATE DRILLED: 5-Oct-20

DRILL METHOD 50 mm Hand Auger

WILEY GEOTECHNICAL LTD

BOREHOLE No. 7

SITE: Causeway Church, Moir Street, Mangawhai

REF: 17296

Sheet 1 of 1

REDUCED LEVEL (RL) / INFERRED GEOLOGY	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	SAMPLE TYPE	WATER CONTENT (%)	WATER LEVEL	CORRECTED VANE SHEAR STRENGTH (kPa) ● Peak Field Vane ○ Remoulded Field vane	SCALA PENETROMETER BLOWS / 100 mm
Pakiri Formation of the Waitemata Group	TOPSOIL slightly sandy, dark brown						50 100 150	5 10 15
	SILT slightly sandy, slightly clayey, slightly plastic, light brown with orange brown mottling						● 200	
	increased clay, increased plasticity						● 200	
			1				● 200	
	alternating layers of clayey silt and sandy silt						● 200	
							○ 98 ● 161	
							○ 85 ● 139	
			2				○ 71 ● 126	
	E.O.B: 2.1 m							
			3					
			4					
			5					

NOTES Groundwater was not encountered.

LOGGED BY: MW & CS

DATE DRILLED: 5-Oct-20

DRILL METHOD 50 mm Hand Auger

WILEY GEOTECHNICAL LTD

BOREHOLE No. 8

SITE: Causeway Church, Moir Street, Mangawhai

REF: 17296

Sheet 1 of 1

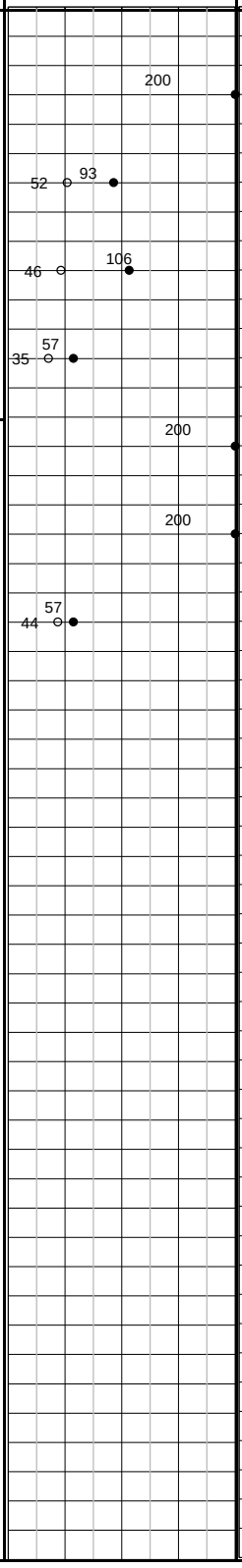
REDUCED LEVEL (RL) / INFERRED GEOLOGY	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	SAMPLE TYPE	WATER CONTENT (%)	WATER LEVEL
Colluvium	TOPSOIL dark brown, 150 mm SILT tephra, low plasticity, friable, light grey with orange brown mottling					
Alluvium of the Tauranga Group	SILT moderately clayey, moderately plastic, light brown with orange brown staining, occasional, organic streaks increased clay, increased plasticity light brown slight water seepage		1			V
	SILT organics layer 10-20%, dark brown					
	SAND medium to coarse, slightly silty, dense, dark grey, wet, potential estuarine deposits		2			
	E.O.B: 2.1 m		3			
			4			
			5			

CORRECTED VANE SHEAR STRENGTH (kPa)

● Peak Field Vane

○ Remoulded Field vane

50 100 150



SCALA PENETROMETER BLOWS / 100 mm

5 10 15

NOTES Groundwater was encountered at 1.4 m depth

LOGGED BY: MW & CS

DATE DRILLED: 5-Oct-20

DRILL METHOD 50 mm Hand Auger

WILEY GEOTECHNICAL LTD

BOREHOLE No. 9

SITE: Causeway Church, Moir Street, Mangawhai

REF: 17296

Sheet 1 of 1

REDUCED LEVEL (RL) / INFERRED GEOLOGY	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	SAMPLE TYPE	WATER CONTENT (%)	WATER LEVEL	CORRECTED VANE SHEAR STRENGTH (kPa) ● Peak Field Vane ○ Remoulded Field vane	SCALA PENETROMETER BLOWS / 100 mm
Pakiri Formation of the Waitemata Group	TOPSOIL dark brown, 150 mm SILT moderately clayey, slightly sandy, moderately plastic, slightly clayey, slightly plastic, light brown with orange brown staining alternating layers of clayey silt and sandy silt slight increase in moisture		1 2				76 ○ 147 ● 79 ○ 134 ● 74 ○ 126 ● 63 ○ 117 ● 68 ○ 112 ● 66 ○ 123 ● 60 ○ 112 ●	
	E.O.B: 2.1 m		3 4 5					

NOTES Groundwater was not encountered.

LOGGED BY: MW & CS

DATE DRILLED: 5-Oct-20

DRILL METHOD 50 mm Hand Auger

WILEY GEOTECHNICAL LTD

BOREHOLE No. 9

SITE: Moir Street, Mangawhai

REF: 17296

Sheet 1 of 1

REDUCED LEVEL (RL) / INFERRED GEOLOGY	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	SAMPLE TYPE	WATER CONTENT (%	WATER LEVEL	CORRECTED VANE SHEAR STRENGTH (kPa) ● Peak Field Vane ○ Remoulded Field vane 50 100 150	SCALA PENETROMETER BLOWS / 100 mm 5 10 15
	TOPSOIL tephra, dark brown & grey, friable							
Alluvium of the Tauranga Group	SILT slightly sandy, fine grained, hard, friable, dark grey & brown, occasional gum fragments						● 200	
	abundant layer of kauri gum						● 200	
	moderately sandy		1				○ 42 ● 144	
	brown, organics (alluvium) occasional clay layers						○ 45 ● 105	
							○ 54 ● 111	
	organic staining, occasional organics less than 5%		2				○ 51 ● 90	
	occasional organics, occasional white & grey clasts, light grey & light brown						○ 63 ● 105	
							○ 45 ● 90	
Waitemata Group	SILT moderately sandy, slightly clayey, slightly plastic, grey & green with orange/brown staining		3				○ 60 ● 111	
	E.O.B: 3.0 m						○ 60 ● 129	
			4					
			5					

NOTES Groundwater was not encountered.
Pakiri Formation of the Waitemata Group

LOGGED BY: MW & CC
DATE DRILLED: 11-Dec-20
DRILL METHOD 50 mm Hand Auger

WILEY GEOTECHNICAL LTD

BOREHOLE No. 10

SITE: Urlich Drive, Mangawhai

REF: 17296

Sheet 1 of 1

REDUCED LEVEL (RL) / INFERRED GEOLOGY	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	SAMPLE TYPE	WATER CONTENT (%	WATER LEVEL	CORRECTED VANE SHEAR STRENGTH (kPa) ● Peak Field Vane ○ Remoulded Field vane 50 100 150	SCALA PENETROMETER BLOWS / 100 mm 5 10 15
	TOPSOIL slightly sandy, friable, dark brown							
Alluvium of the Tauranga Group & Pakiri Formation of the Waitematas	SILT slightly sandy, low plasticity, friable, light grey with orange/brown staining occasional organics, light grey inclusions, sandy layer							
	SILT moderately sandy, slightly plastic, light grey with orange/brown mottling occasional clayey layers, moist to wet slight water seepage, occasional dark brown organics less than 5%		1					
	CLAY silty, moderately plastic, light grey/brown with occasional dark brown organic staining occasional white specs slightly to moderately sandy, occasional grey clasts greenish grey		2					
	SILT moderately clayey, moderately plastic, moderately sandy, fine to medium grained, light green/grey decreased clay slight water seepage weathered sandstone grading into rock		3 4					
	E.O.B: 4.2 m		5					

NOTES Groundwater was not encountered.
Practical refusal at 4.2 m depth.

LOGGED BY: MW & CC
DATE DRILLED: 11-Dec-20
DRILL METHOD 50 mm Hand Auger

WILEY GEOTECHNICAL LTD

BOREHOLE No. 11

SITE: Urlich Drive, Mangahwai

REF: 17296

Sheet 1 of 1

REDUCED LEVEL (RL) / INFERRED GEOLOGY	DESCRIPTION OF SOIL	SOIL SYMBOL
	TOPSOIL silty, friable, dark brown	
Alluvium of the Tauranga Group	SILT slightly clayey, slightly plastic, slightly sandy, brown with orange/brown staining	
	desiccation cracking to 0.9 m, moderately sandy, moderately plastic	
	occasional brown organic staining increased moisture	
	decreased sand, increased clay	
	E.O.B: 2.1 m	

DEPTH (m) 1 2 3 4 5

SAMPLE TYPE

WATER CONTENT (%

WATER LEVEL

CORRECTED VANE SHEAR STRENGTH (kPa)

● Peak Field Vane

○ Remoulded Field vane

50 100 150

200

42 69

33 63

30 60

42 90

60 105

48 108

SCALA PENETROMETER BLOWS / 100 mm

5 10 15

NOTES Groundwater was not encountered.

LOGGED BY: MW & CC

DATE DRILLED: 10-Dec-20

DRILL METHOD 50 mm Hand Auger

WILEY GEOTECHNICAL LTD

BOREHOLE No. 12

SITE: Urlich Drive, Mangawhai

REF: 17296

Sheet 1 of 1

REDUCED LEVEL (RL) / INFERRED GEOLOGY	DESCRIPTION OF SOIL	SOIL SYMBOL
	TOPSOIL friable, dark brown	
Alluvium of the Tauranga Group	SILT slightly sandy, fine grained, low plasticity, dark grey, occasional orange/brown mottling & organics sandy, light grey/brown	
	SAND slightly silty, low plasticity, light grey with occasional orange/brown mottling, dense	
	E.O.B: 1.2 m	

DEPTH (m) | SAMPLE TYPE | WATER CONTENT (%) | WATER LEVEL

CORRECTED VANE SHEAR STRENGTH (kPa)

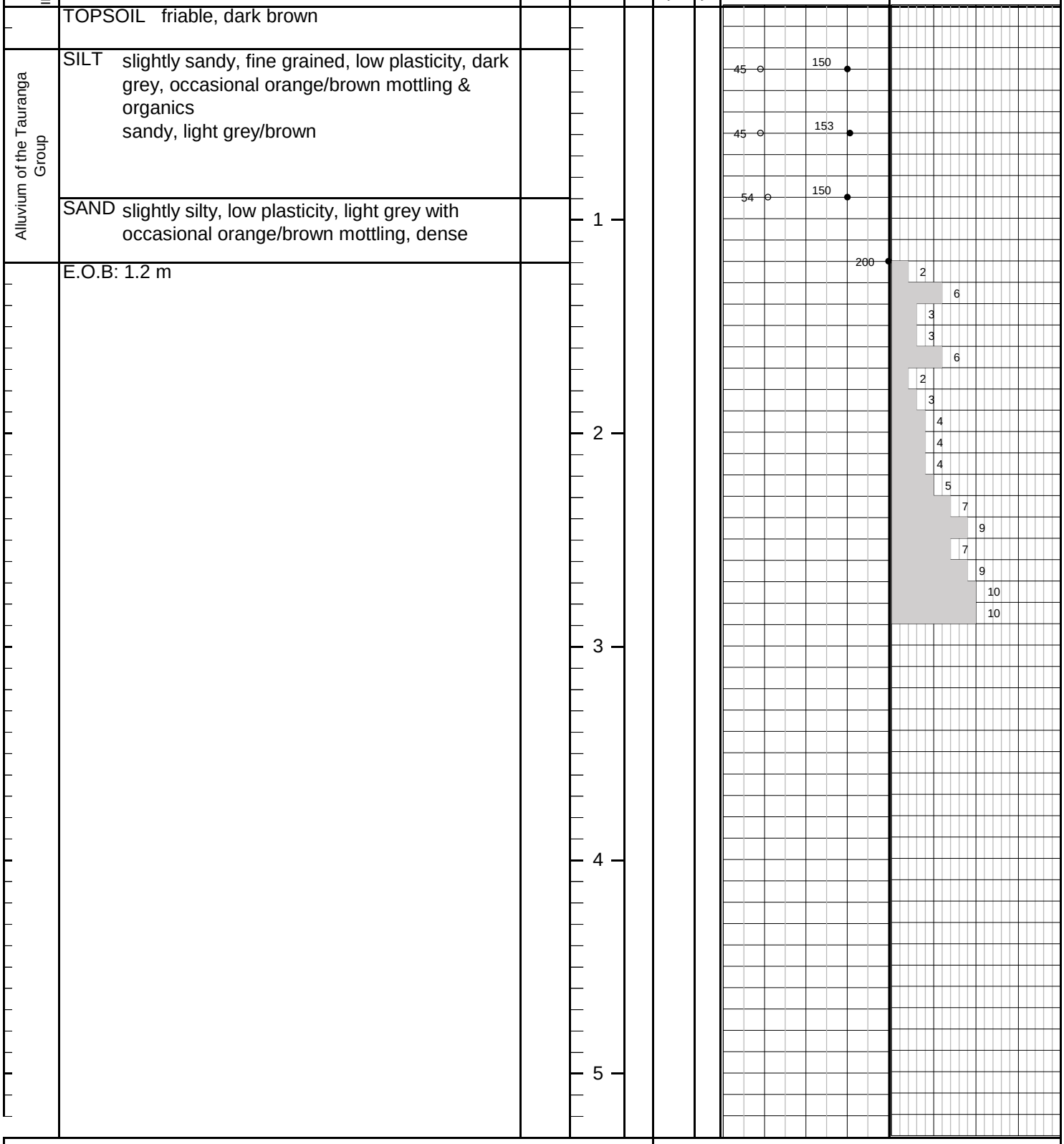
● Peak Field Vane

○ Remoulded Field vane

50 100 150

SCALA PENETROMETER BLOWS / 100 mm

5 10 15



NOTES Groundwater was not encountered.
Practical refusal at 1.2 m depth. Scala continued.

LOGGED BY: MW & CC

DATE DRILLED: 11-Dec-20

DRILL METHOD 50 mm Hand Auger

WILEY GEOTECHNICAL LTD

BOREHOLE No. 13

SITE: Urlich Drive, Mangawhai

REF: 17296

Sheet 1 of 1

REDUCED LEVEL (RL) / INFERRED GEOLOGY	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	SAMPLE TYPE	WATER CONTENT (%)	WATER LEVEL	CORRECTED VANE SHEAR STRENGTH (kPa) ● Peak Field Vane ○ Remoulded Field vane 50 100 150	SCALA PENETROMETER BLOWS / 100 mm 5 10 15
FILL	GRAVEL topsoil, reddish brown rock, dark brown							
Alluvium of the Tauranga Group	SILT slightly sandy, friable, dark grey with orange/brown mottling						200	
	becoming light brown						200	
	dense, sandy						200	
	dense sand, potentially sandstone		1					
	E.O.B: 1.0 m		2					
			3					
			4					
			5					

NOTES Groundwater was not encountered.
Practical refusal at 1.0 m depth.

LOGGED BY: MW & CC
DATE DRILLED: 11-Dec-20
DRILL METHOD 50 mm Hand Auger

WILEY GEOTECHNICAL LTD

BOREHOLE No. 14

SITE: Urlich Drive, Mangawhai

REF: 17296

Sheet 1 of 1

REDUCED LEVEL (RL) / INFERRED GEOLOGY	DESCRIPTION OF SOIL	SOIL SYMBOL
	TOPSOIL slightly sandy, friable, dark brown	
Alluvium of the Tauranga Group	SILT sandy, low plasticity, dark grey light brown with occasional orange/brown mottling whitish grey	
	SILT moderately sandy, slightly clayey, light grey with orange/brown mottling & occasional organics occasional clay, organics occasional wood fragments becoming light brown large cream clasts & increased moisture	
	E.O.B: 2.1 m	

DEPTH (m) 1 2 3 4 5

SAMPLE TYPE

WATER CONTENT (%

WATER LEVEL

CORRECTED VANE SHEAR STRENGTH (kPa)

● Peak Field Vane

○ Remoulded Field vane

50 100 150

200

200

48 ○ 135 ●

30 ○ 51 ●

42 ○ 60 ●

51 ○ 99 ●

39 ○ 105 ●

SCALA PENETROMETER BLOWS / 100 mm

5 10 15

NOTES Groundwater was not encountered.

LOGGED BY: MW & CC

DATE DRILLED: 10-Dec-20

DRILL METHOD 50 mm Hand Auger

WILEY GEOTECHNICAL LTD

BOREHOLE No. 15

SITE: Urlich Drive, Mangawhai

REF: 17296

Sheet 1 of 1

REDUCED LEVEL (RL) / INFERRED GEOLOGY	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	SAMPLE TYPE	WATER CONTENT (%	WATER LEVEL	CORRECTED VANE SHEAR STRENGTH (kPa) ● Peak Field Vane ○ Remoulded Field vane 50 100 150	SCALA PENETROMETER BLOWS / 100 mm 5 10 15
	TOPSOIL/TEPHRA dark grey/brown, friable, dry							
Alluvium of the Tauranga Group	SILT slightly clayey, slightly plastic, very to slightly sandy, light grey/brown with occasional dark brown organic staining whitish grey slightly to moderately sandy occasional orange/brown nodules occasional white clasts & rootlets occasional slightly sandy horizons		1 2				45 ○ 171 ● 45 ○ 141 ● 54 ○ 141 ● 60 ○ 135 ● 48 ○ 114 ● 45 ○ 105 ● 30 ○ 63 ●	
	E.O.B: 2.1 m		3 4 5					

NOTES Groundwater was not encountered.

LOGGED BY: MW & CC

DATE DRILLED: 10-Dec-20

DRILL METHOD 50 mm Hand Auger

WILEY GEOTECHNICAL LTD

BOREHOLE No. 16

SITE: Urlich Drive, Mangawhai

REF: 17296

Sheet 1 of 1

REDUCED LEVEL (RL) / INFERRED GEOLOGY	DESCRIPTION OF SOIL	SOIL SYMBOL	DEPTH (m)	SAMPLE TYPE	WATER CONTENT (%	WATER LEVEL	CORRECTED VANE SHEAR STRENGTH (kPa) ● Peak Field Vane ○ Remoulded Field vane 50 100 150	SCALA PENETROMETER BLOWS / 100 mm 5 10 15
	FILL/TOPSOIL dark brown							
Alluvium of the Tauranga Group	SILT tephra, friable, light grey/brown							
	SILT slightly clayey, low plasticity, slightly sandy, light grey with orange/brown mottling occasional brown staining & organics increased clay, increased plasticity		1				● 200 ● 200 ○ 78 ● 168 ○ 60 ○ 105 ○ 63 ○ 105 ○ 63 ○ 102 ○ 75 ● 144	
	SILT moderately clayey slightly sandy horizon, slight water seepage slightly sandy layer, fine to coarse grained		2					
	E.O.B: 2.1 m		3 4 5					

NOTES Groundwater was not encountered.

LOGGED BY: MW & CC

DATE DRILLED: 11-Dec-20

DRILL METHOD 50 mm Hand Auger

WILEY GEOTECHNICAL LTD

BOREHOLE No. 17

SITE: Urlich Drive, Mangawhai

REF: 17296

Sheet 1 of 1

REDUCED LEVEL (RL) / INFERRED GEOLOGY	DESCRIPTION OF SOIL	SOIL SYMBOL
	TOPSOIL slightly sandy, very fine grained, friable, dark brown	
Alluvium of the Tauranga Group	SILT very slighlty sandy, grey/brown with occasional orange/brown mottling (tephra)	
	SILT moderately clayey, moderately plastic, sligtly sandy, light grey with orange/brown mottling occasional sandy slight water seepage occasional dark/brown organics occasional sandy horizons	
	E.O.B: 2.1 m	

DEPTH (m): 1, 2, 3, 4, 5

SAMPLE TYPE

WATER CONTENT (%

WATER LEVEL

CORRECTED VANE SHEAR STRENGTH (kPa)

● Peak Field Vane

○ Remoulded Field vane

50 100 150

200
69 135
60 135
60 99
63 150
60 141
200

SCALA PENETROMETER BLOWS / 100 mm

5 10 15

NOTES Groundwater was not encountered.

LOGGED BY: MW & CC

DATE DRILLED: 11-Dec-20

DRILL METHOD 50 mm Hand Auger

WILEY GEOTECHNICAL LTD

BOREHOLE No. 18

SITE: Urlich Drive, Mangawhai

REF: 17296

Sheet 1 of 1

REDUCED LEVEL (RL) / INFERRED GEOLOGY	DESCRIPTION OF SOIL	SOIL SYMBOL
	TOPSOIL tephra, dark brown/grey, extremely friable, dry	
Pakiri Formation of the Waitematas	SILT tephra, whitish grey with occasional orange/brown staining	
	SILT moderately sandy, fine to coarse grained, slightly clayey, low plasticity, light grey with occasional orange/brown staining & occasional dark brown organic streaks	
	SILT moderately clayey, moderately plastic, light grey with orange/brown mottling	
	E.O.B: 2.1 m	

DEPTH (m) 1 2 3 4 5

SAMPLE TYPE

WATER CONTENT (%

WATER LEVEL

CORRECTED VANE SHEAR STRENGTH (kPa)

● Peak Field Vane

○ Remoulded Field vane

50 100 150

200 200 200 200

60 114

96 153

66 105

SCALA PENETROMETER BLOWS / 100 mm

5 10 15

NOTES Groundwater was not encountered.

LOGGED BY: MW & CC

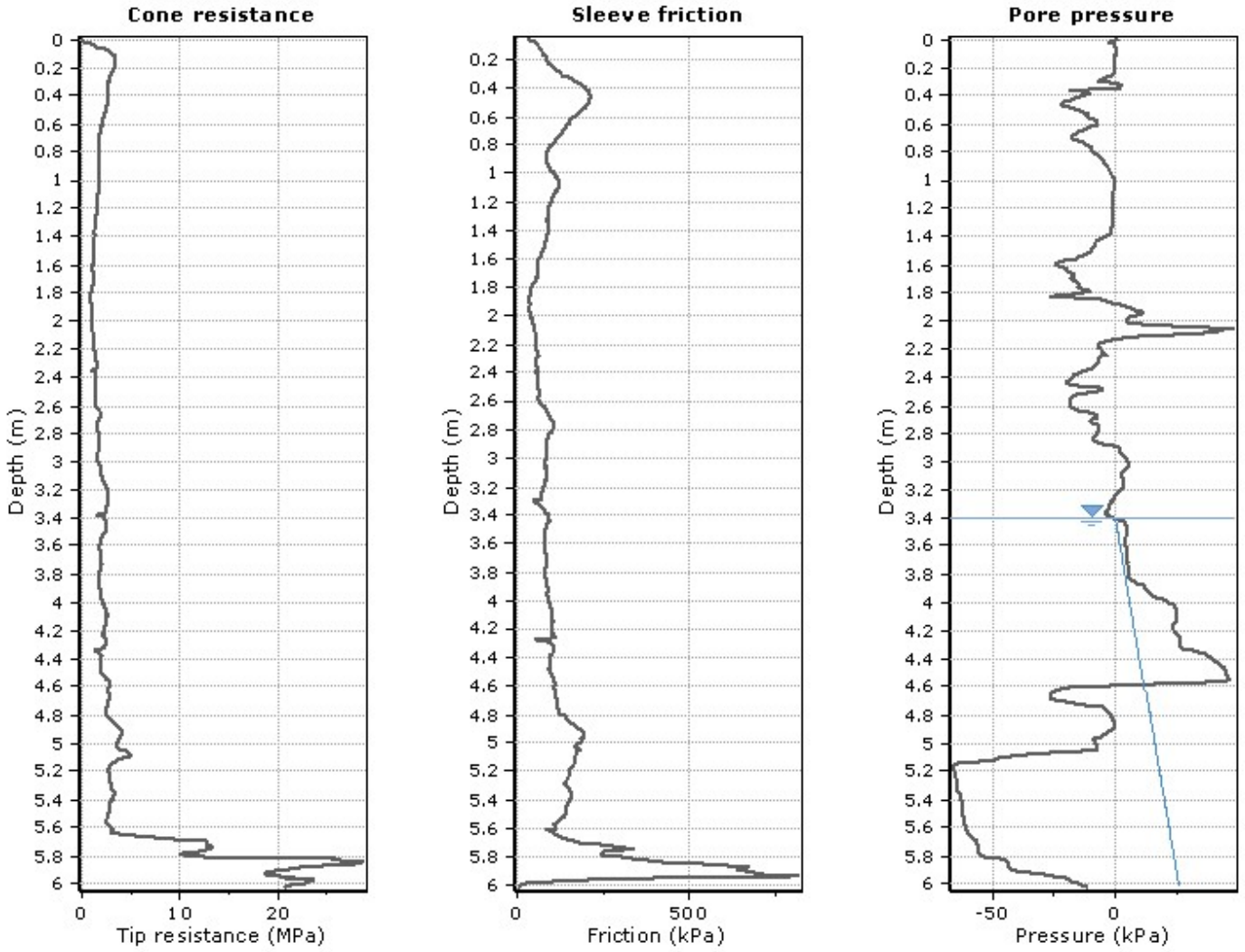
DATE DRILLED: 11-Dec-20

DRILL METHOD 50 mm Hand Auger

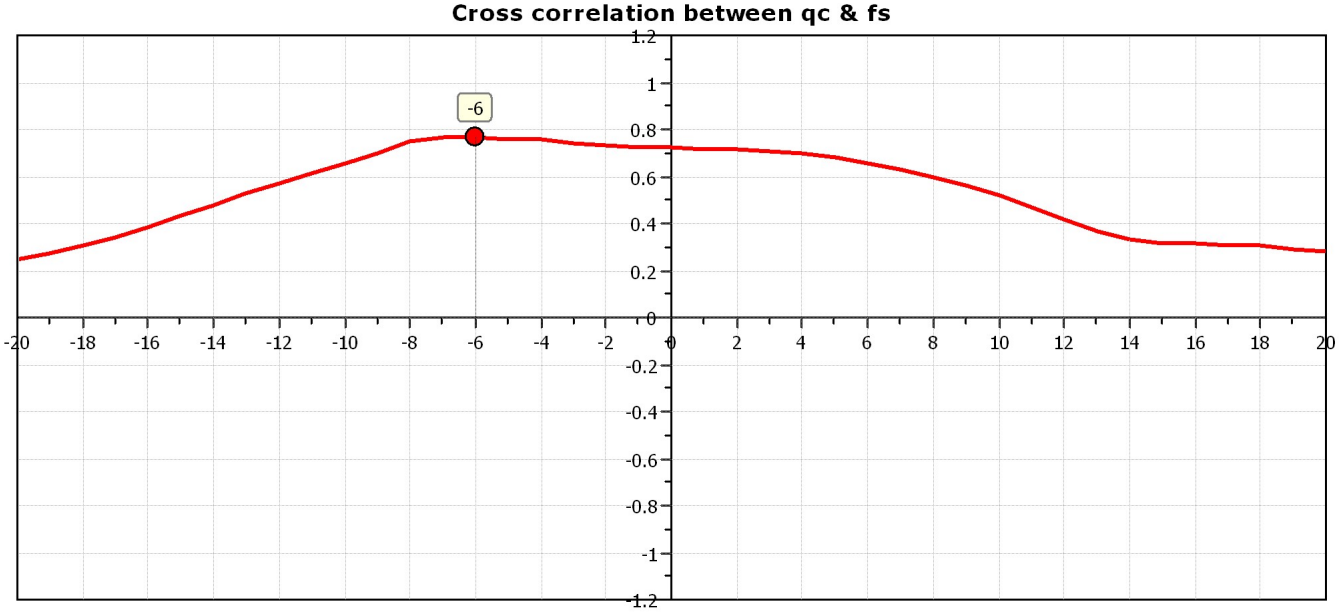
Wiley Geotechnical Ltd
http://wileygeotechnical.co.nz/

CPT: moir st mangawhai_cpt01
Total depth: 6.02 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**



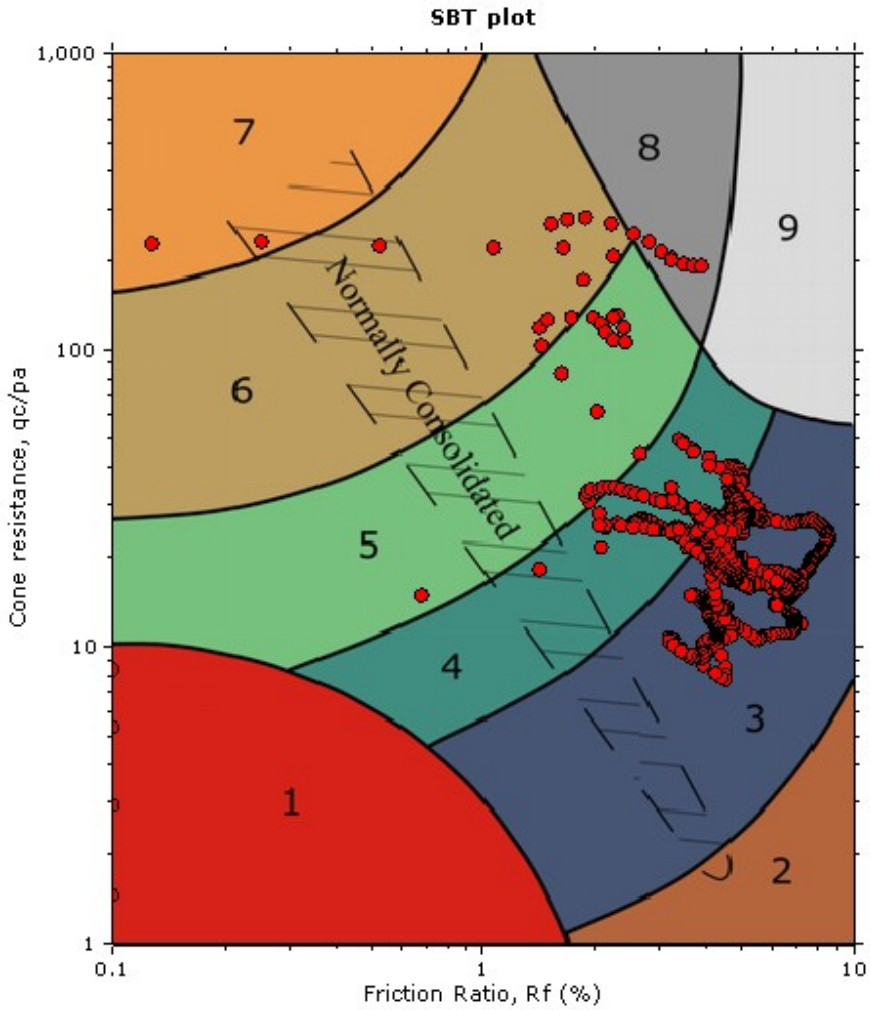
The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).

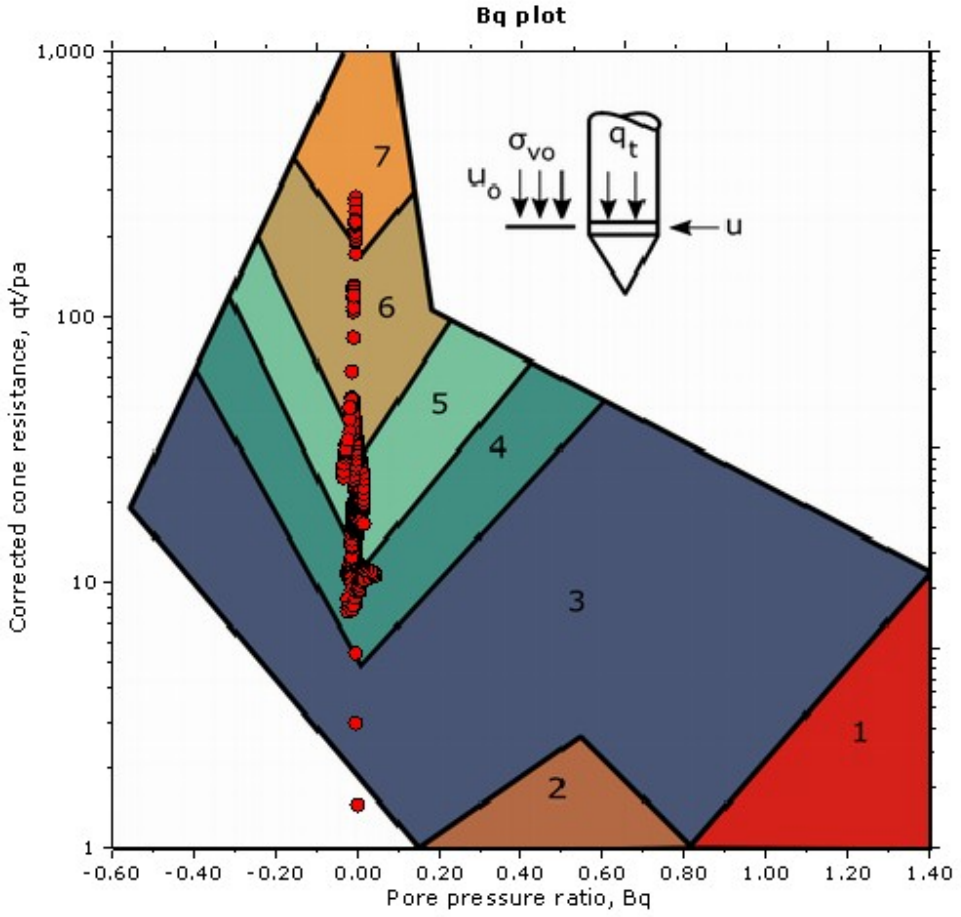


CPT: moir st mangawhai_cpt01
Total depth: 6.02 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**

SBT - Bq plots



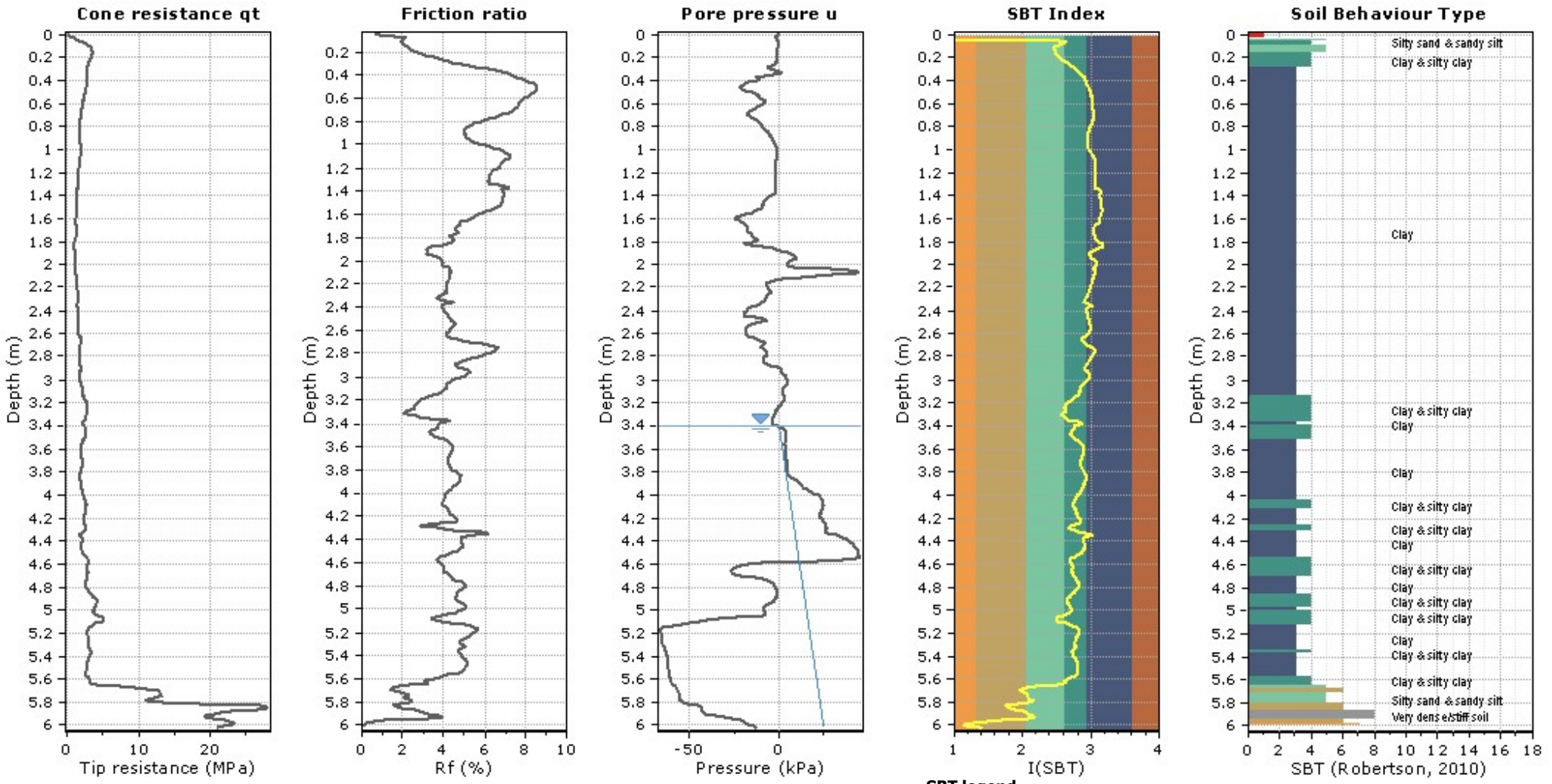


SBT legend

1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

CPT: moir st mangawhai_cpt01
Total depth: 6.02 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**

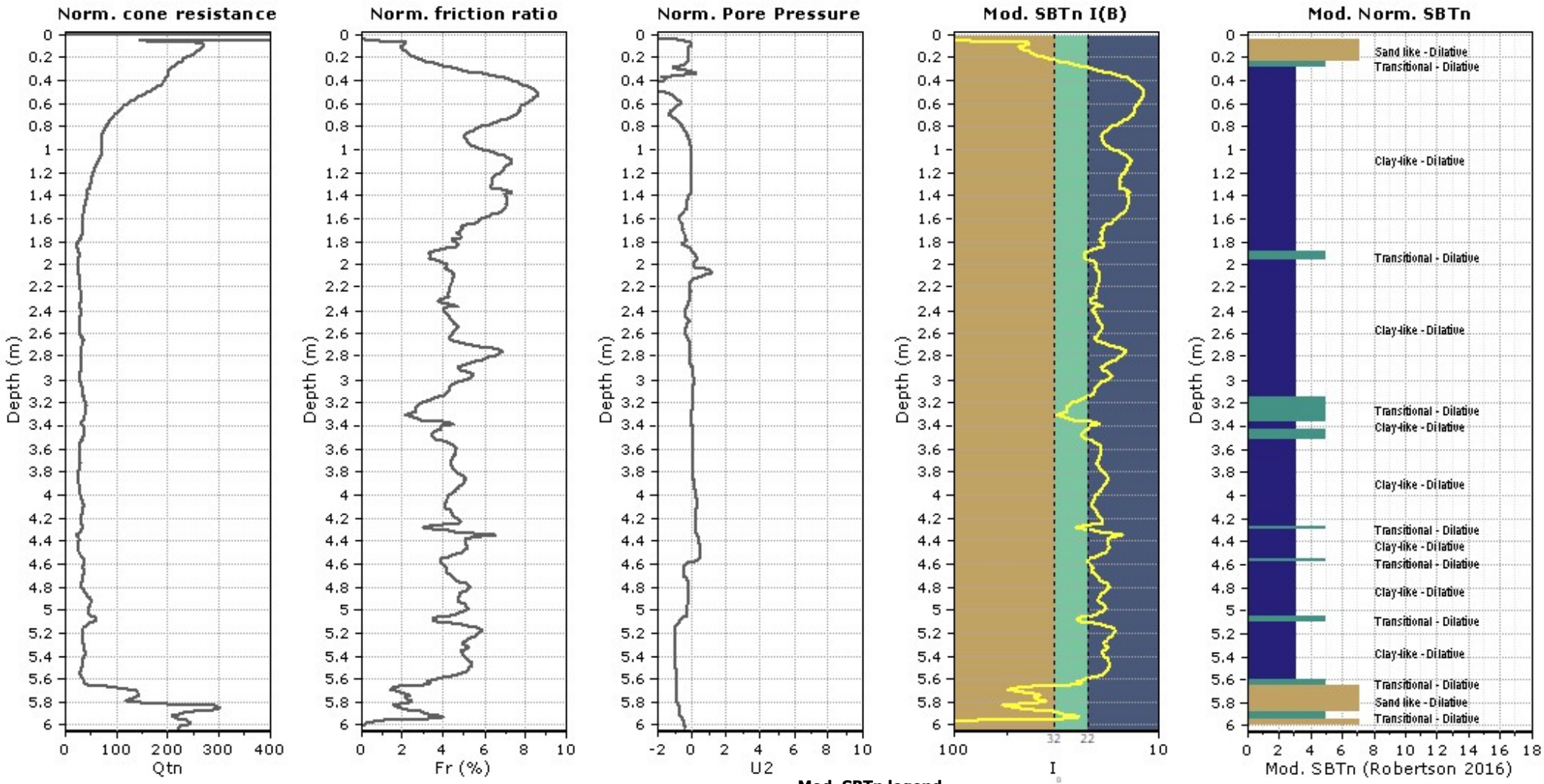


SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

CPT: moir st mangawhai_cpt01
Total depth: 6.02 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**

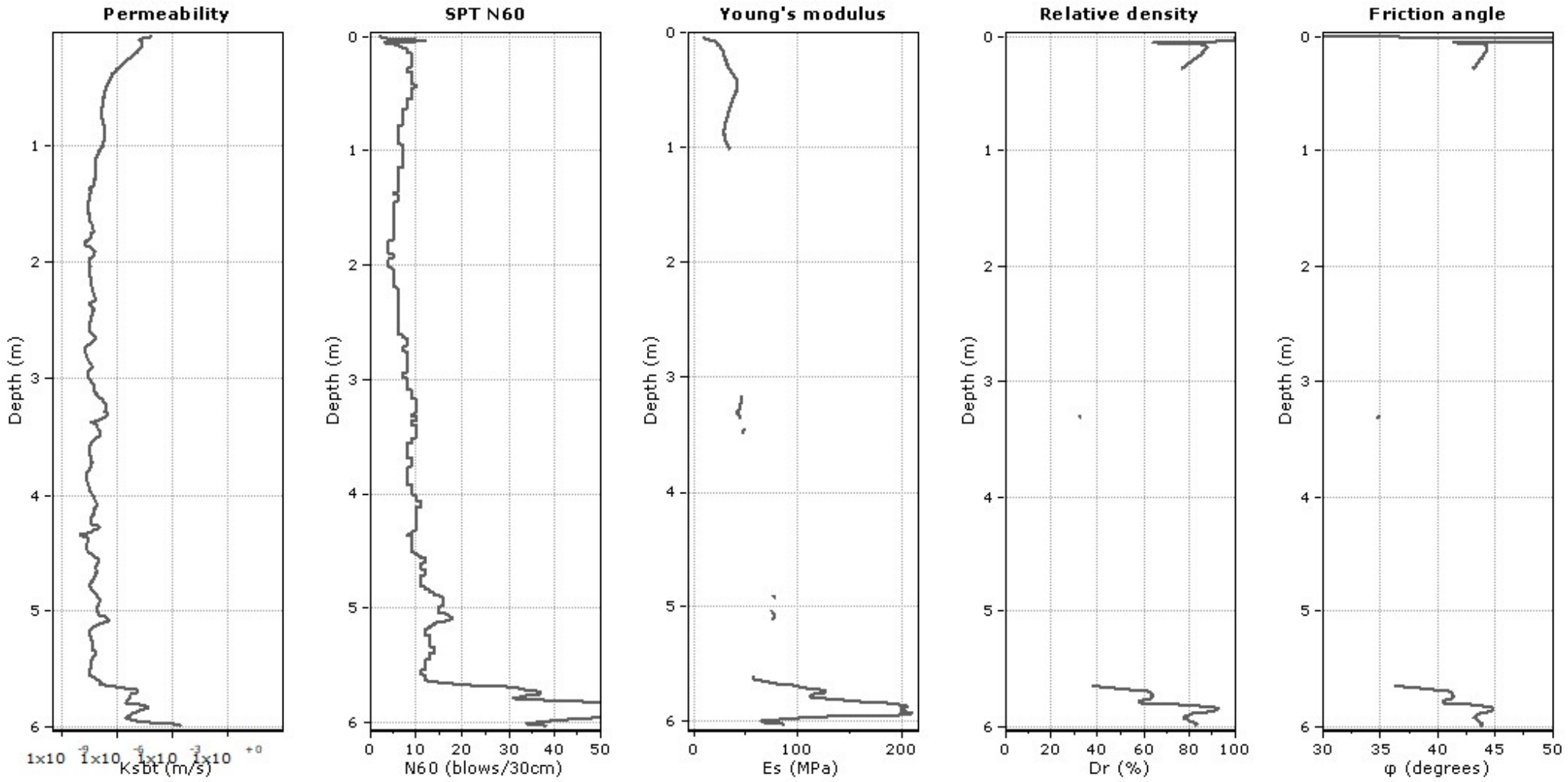


Mod. SBTn legend

1. CCS: ClayLike - Contractive, Sensitive
2. CC: Clay-like - Contractive
3. CD: Clay-Like: Dilative
4. TC: Transitional - Contractive
5. TD: Transitional - Dilative
6. SC: Sand-like - Contractive
7. SD: Sand-like - Dilative

CPT: moir st mangawhai_cpt01
Total depth: 6.02 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**

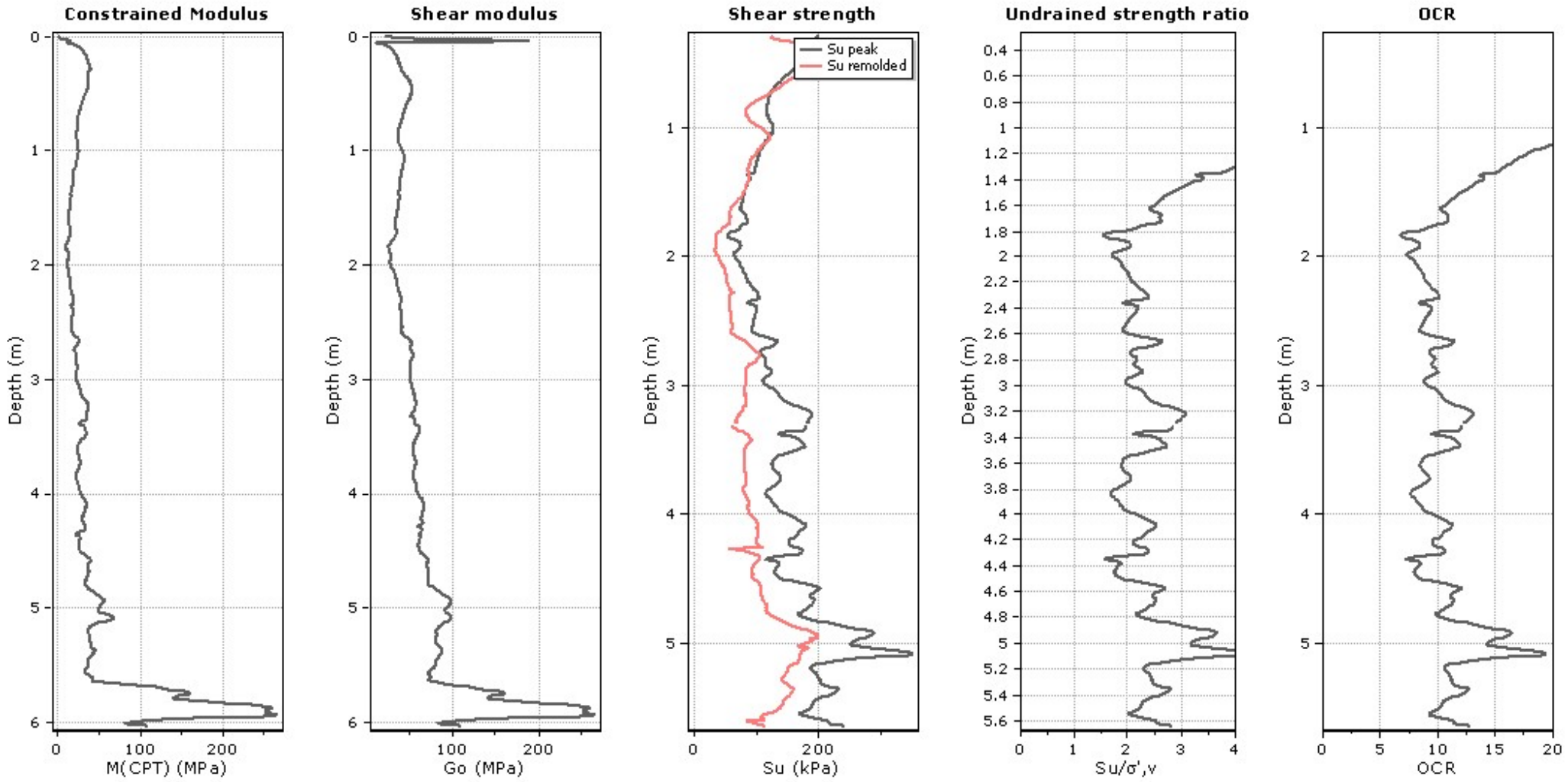


Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative density constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

CPT: moir st mangawhai_cpt01
Total depth: 6.02 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**

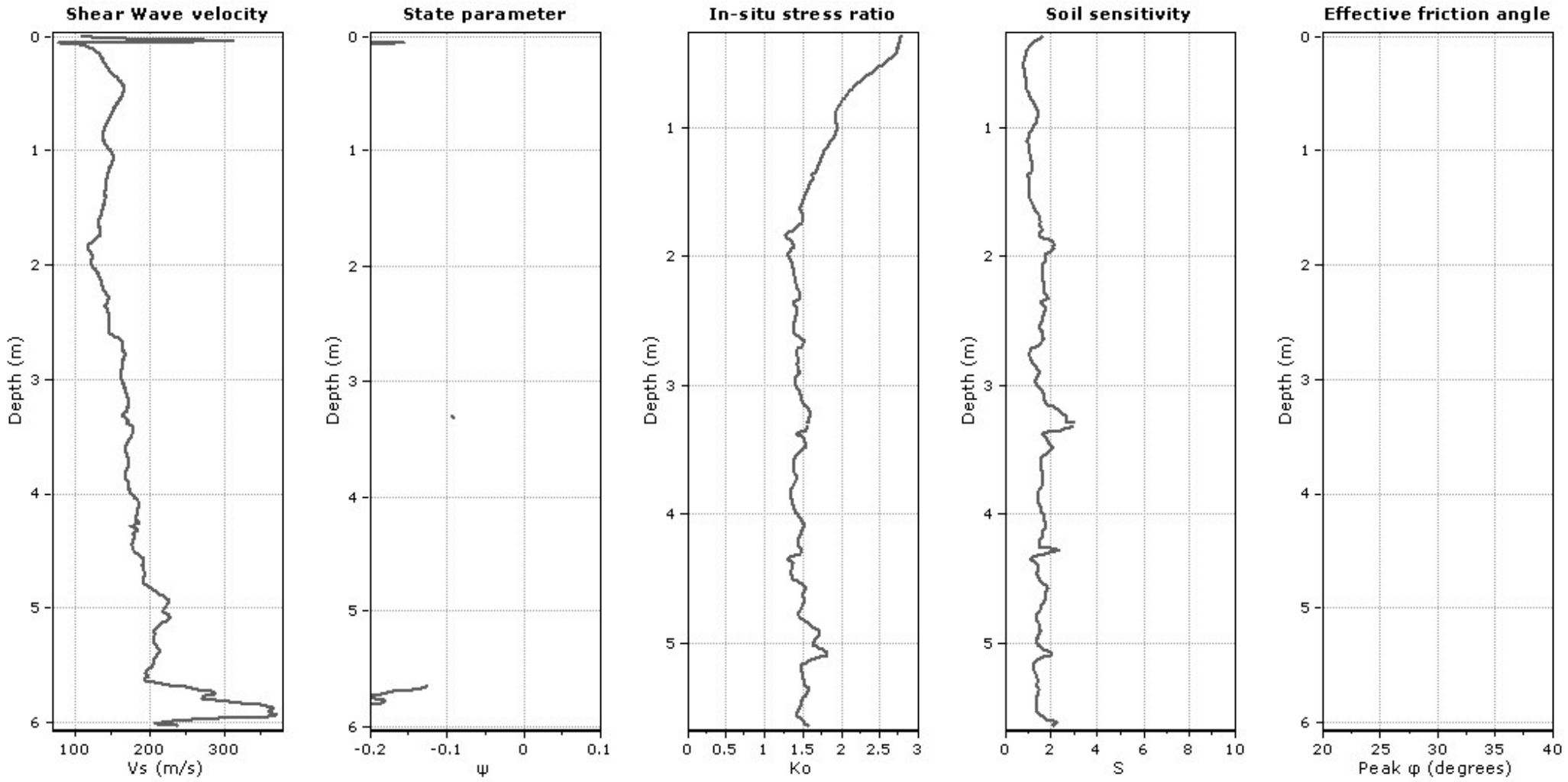


Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14
OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

CPT: moir st mangawhai_cpt01
Total depth: 6.02 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**

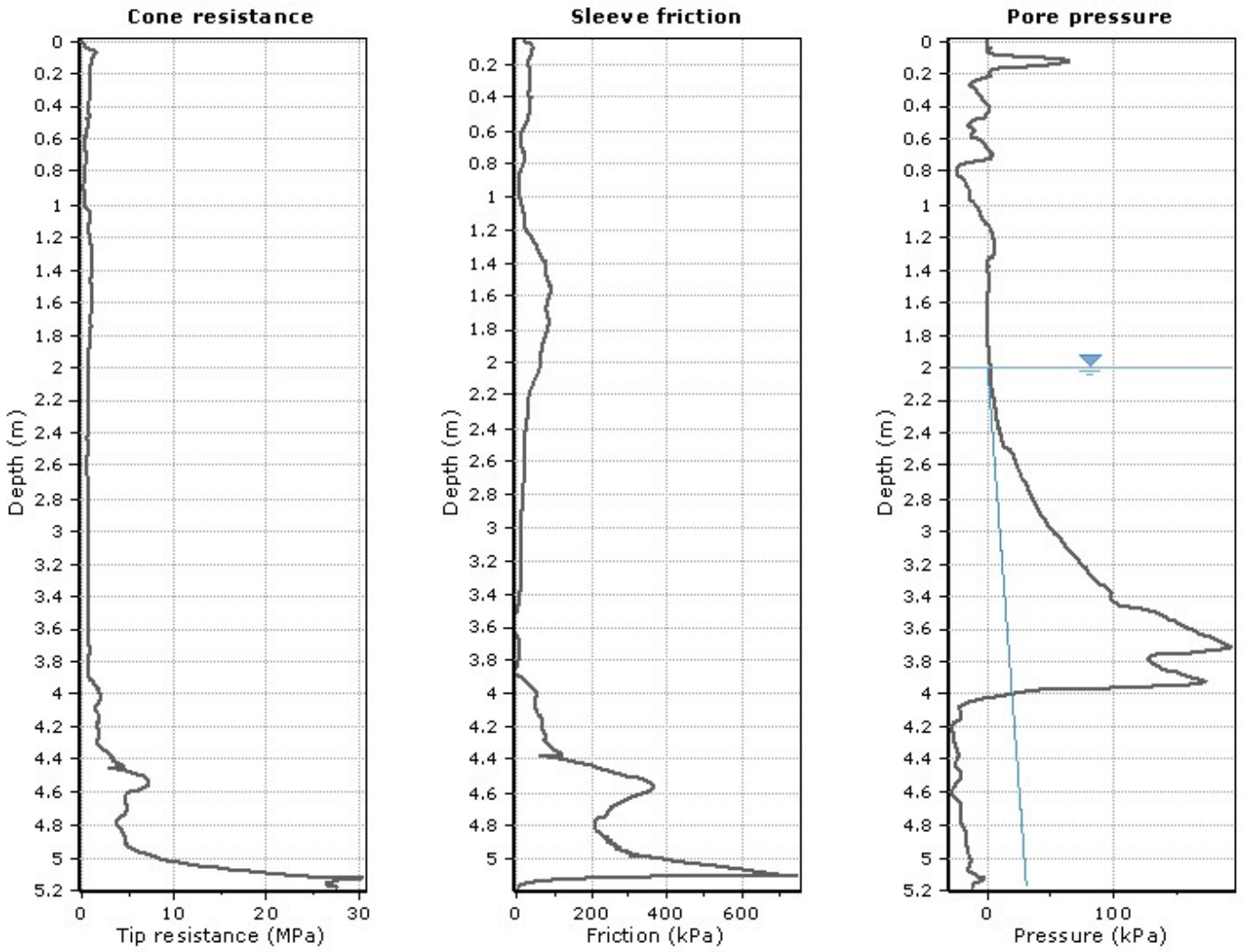


Calculation parameters

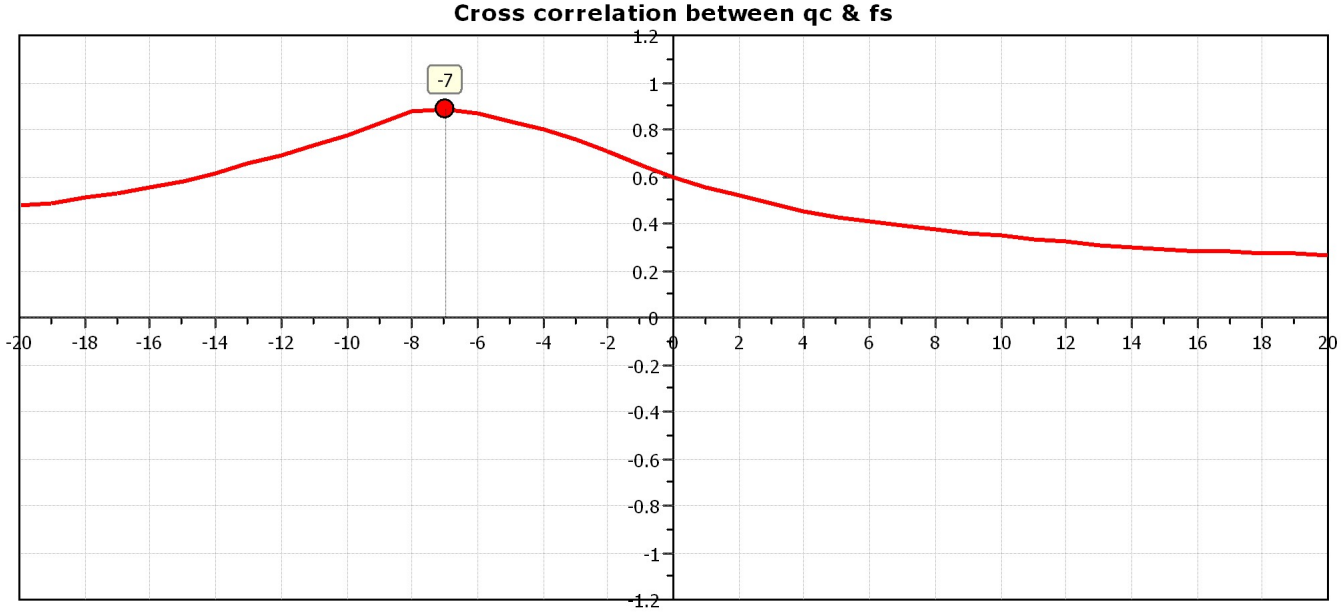
Soil Sensitivity factor, N_S: 7.00
User defined estimation data

CPT: moir st mangawhai_CPT02
Total depth: 5.18 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

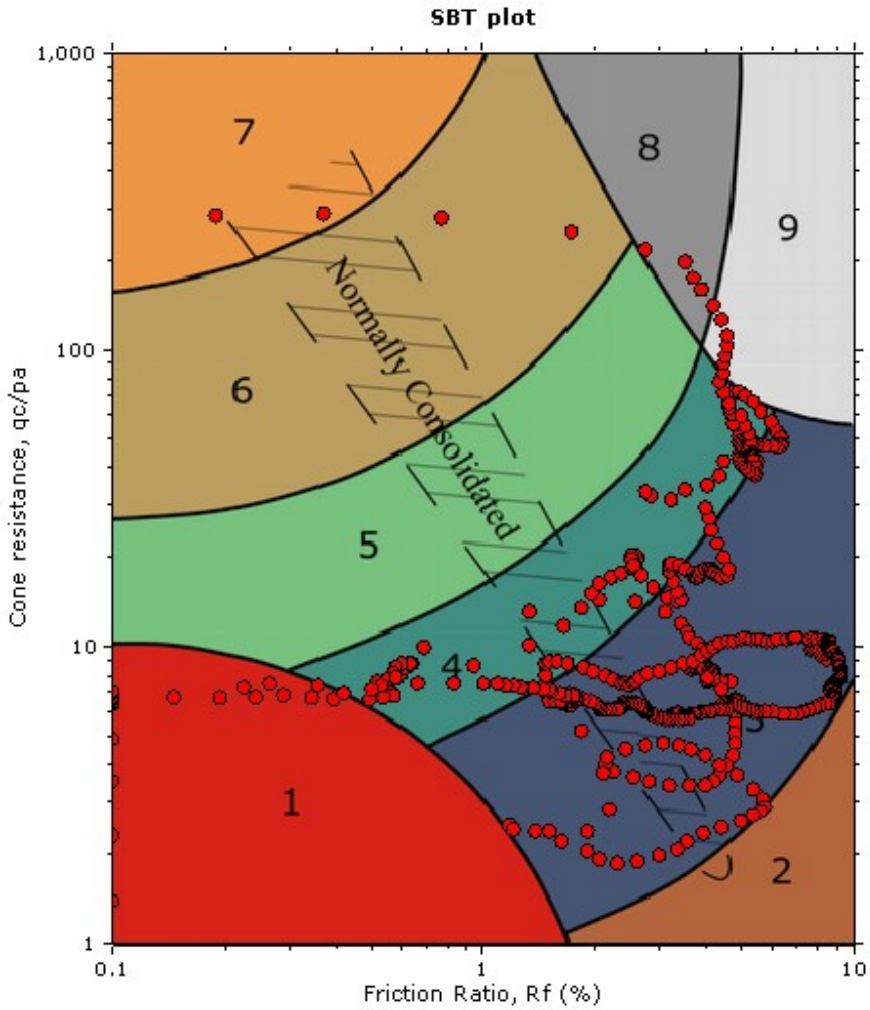
Project: **Causeway Chruch**
Location: **Moir Street**

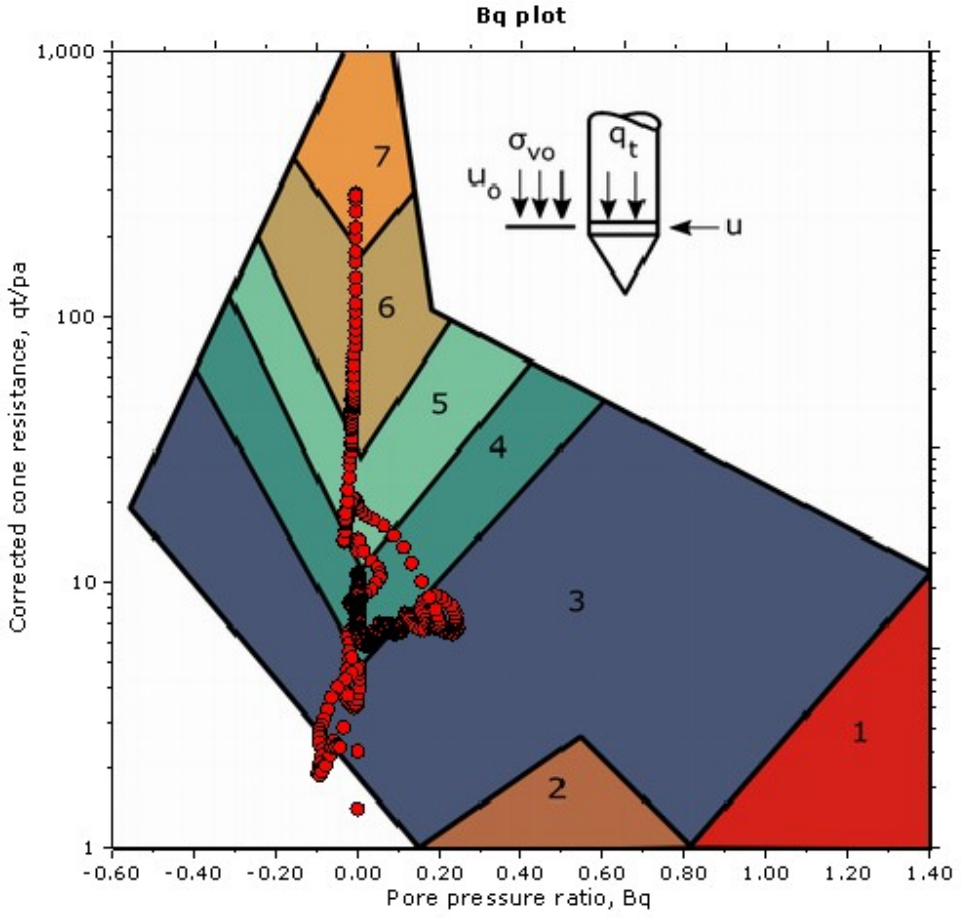


The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).



SBT - Bq plots



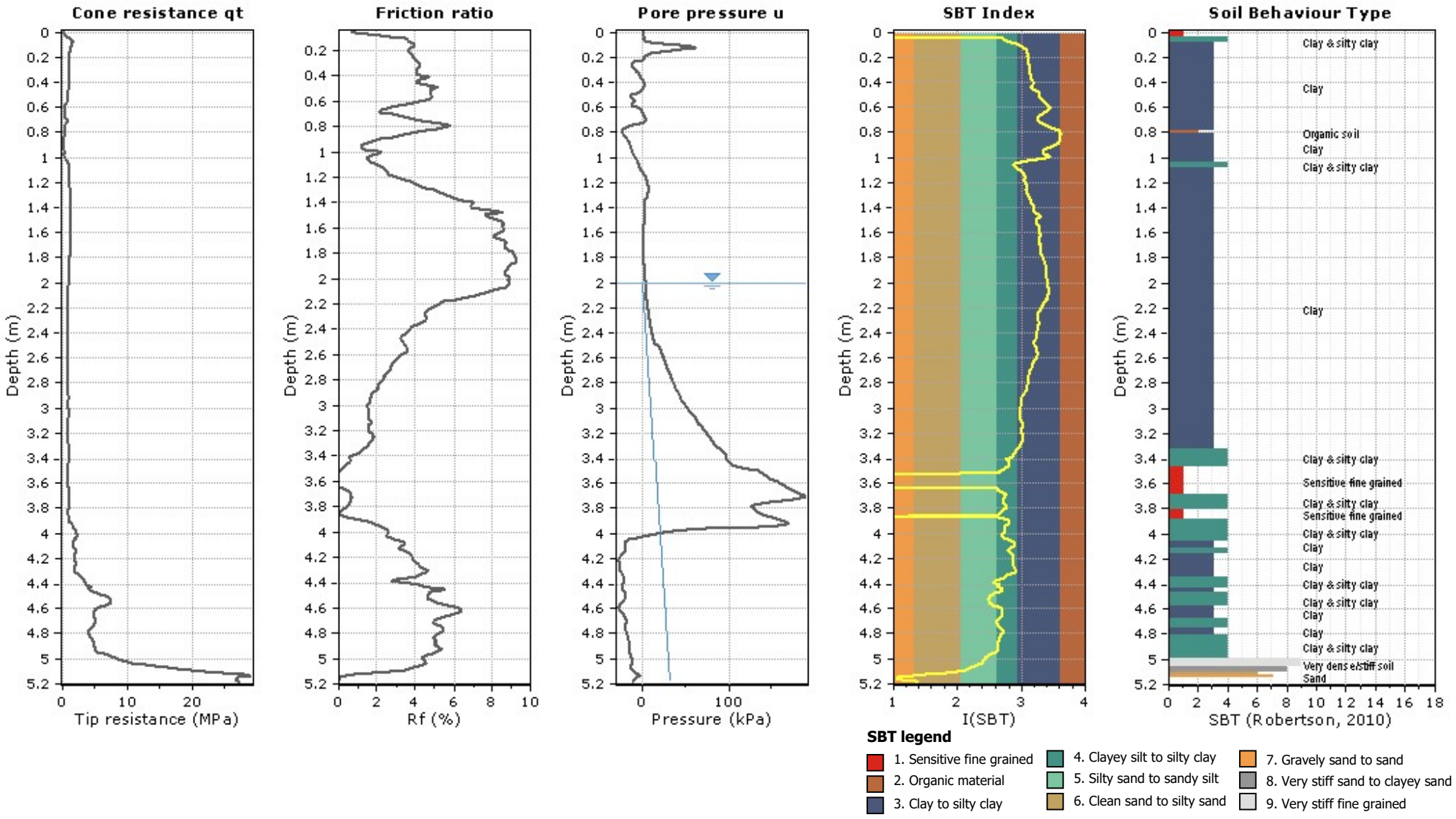


SBT legend

1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

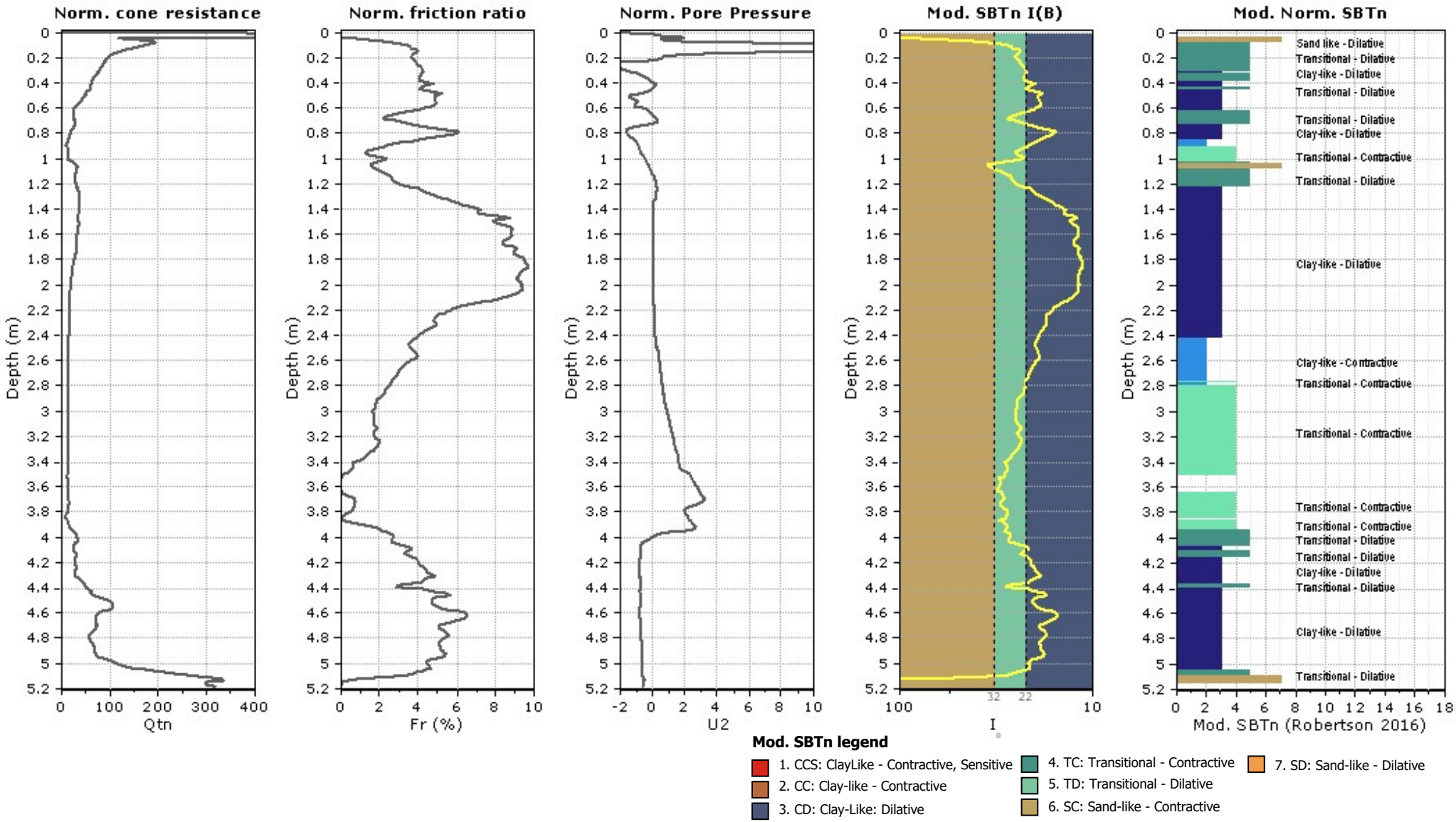
CPT: moir st mangawhai_CPT02
Total depth: 5.18 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**



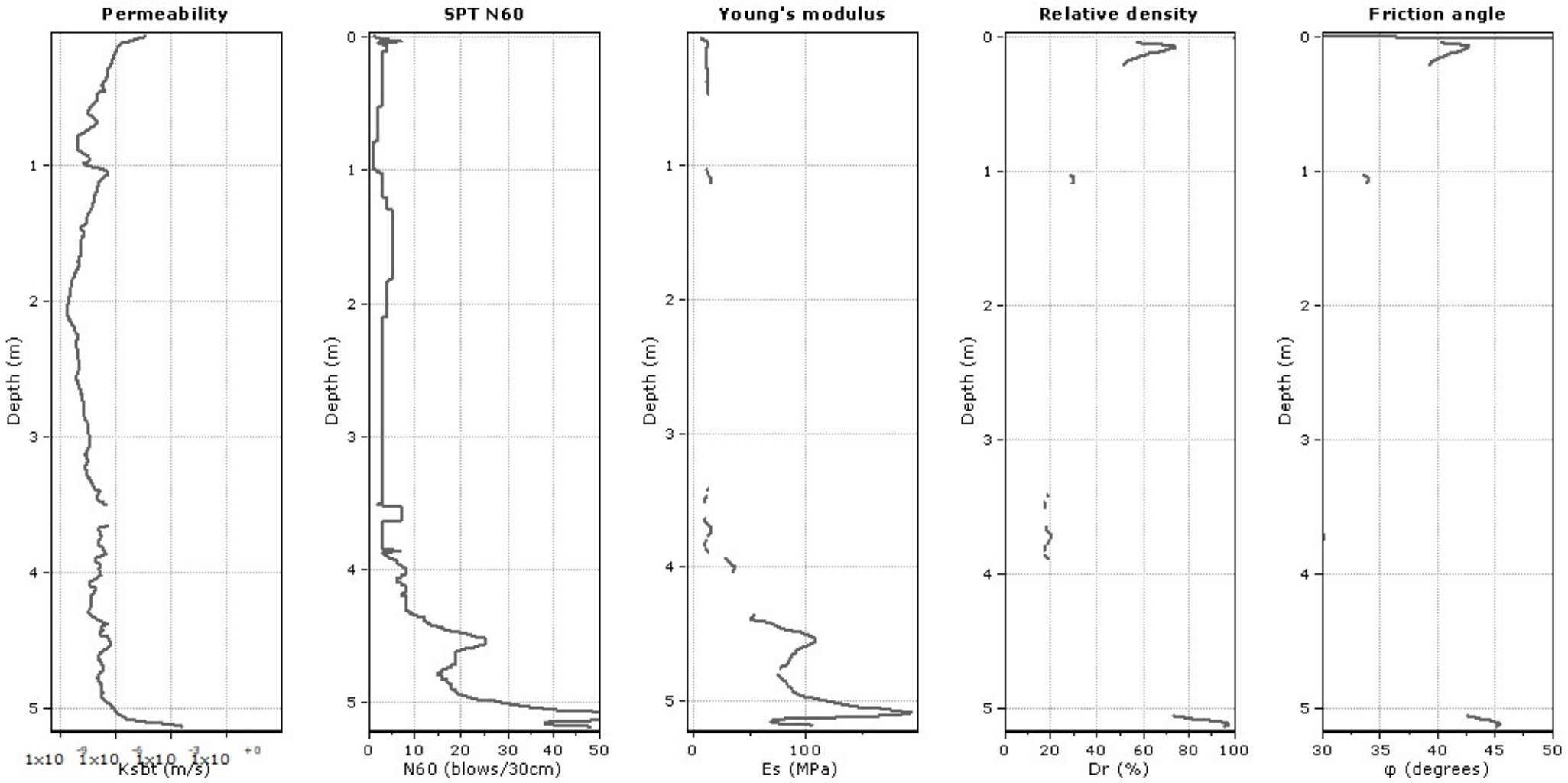
CPT: moir st mangawhai_CPT02
Total depth: 5.18 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**



CPT: moir st mangawhai_CPT02
Total depth: 5.18 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**

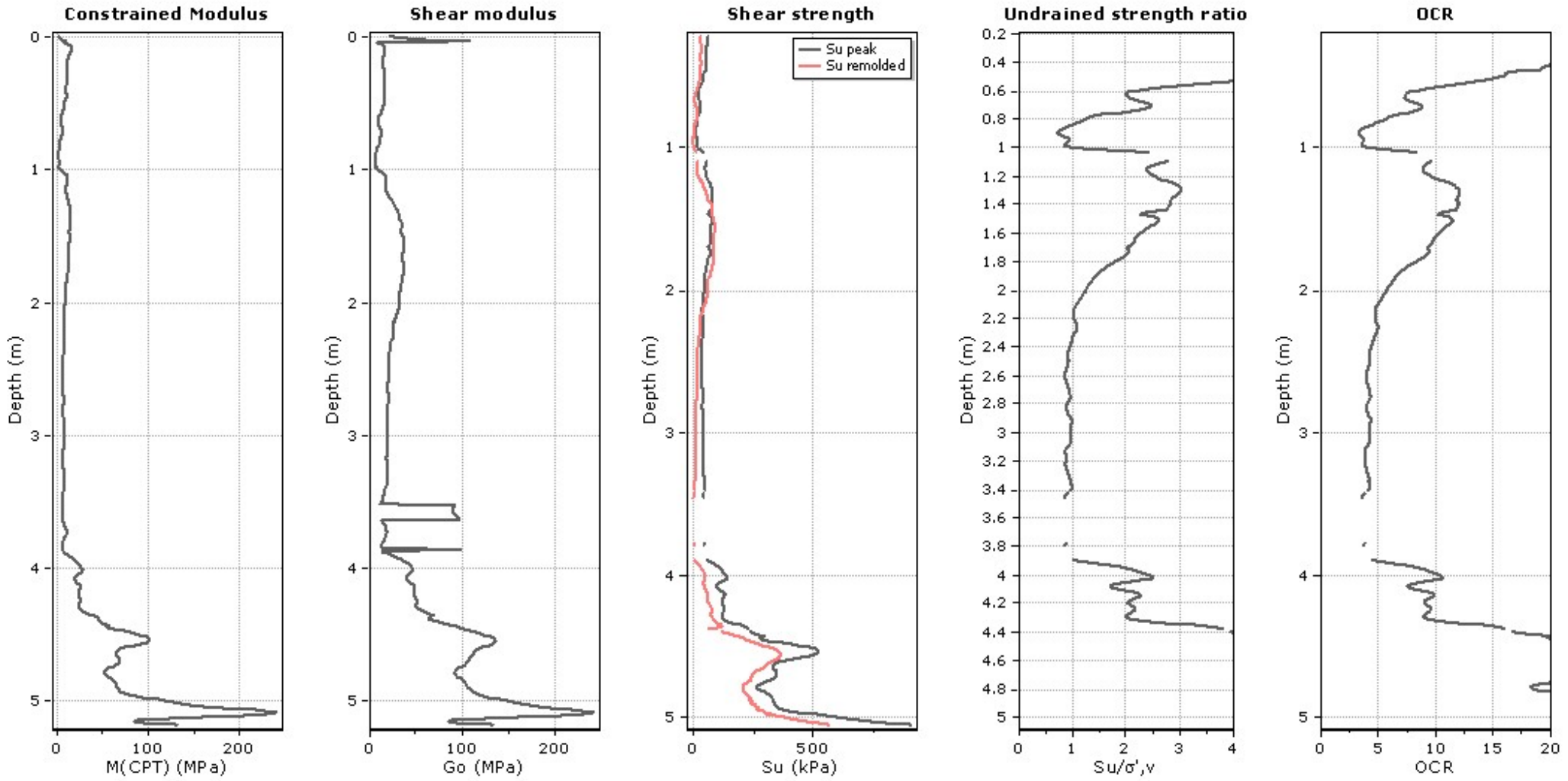


Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative density constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

CPT: moir st mangawhai_CPT02
Total depth: 5.18 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**

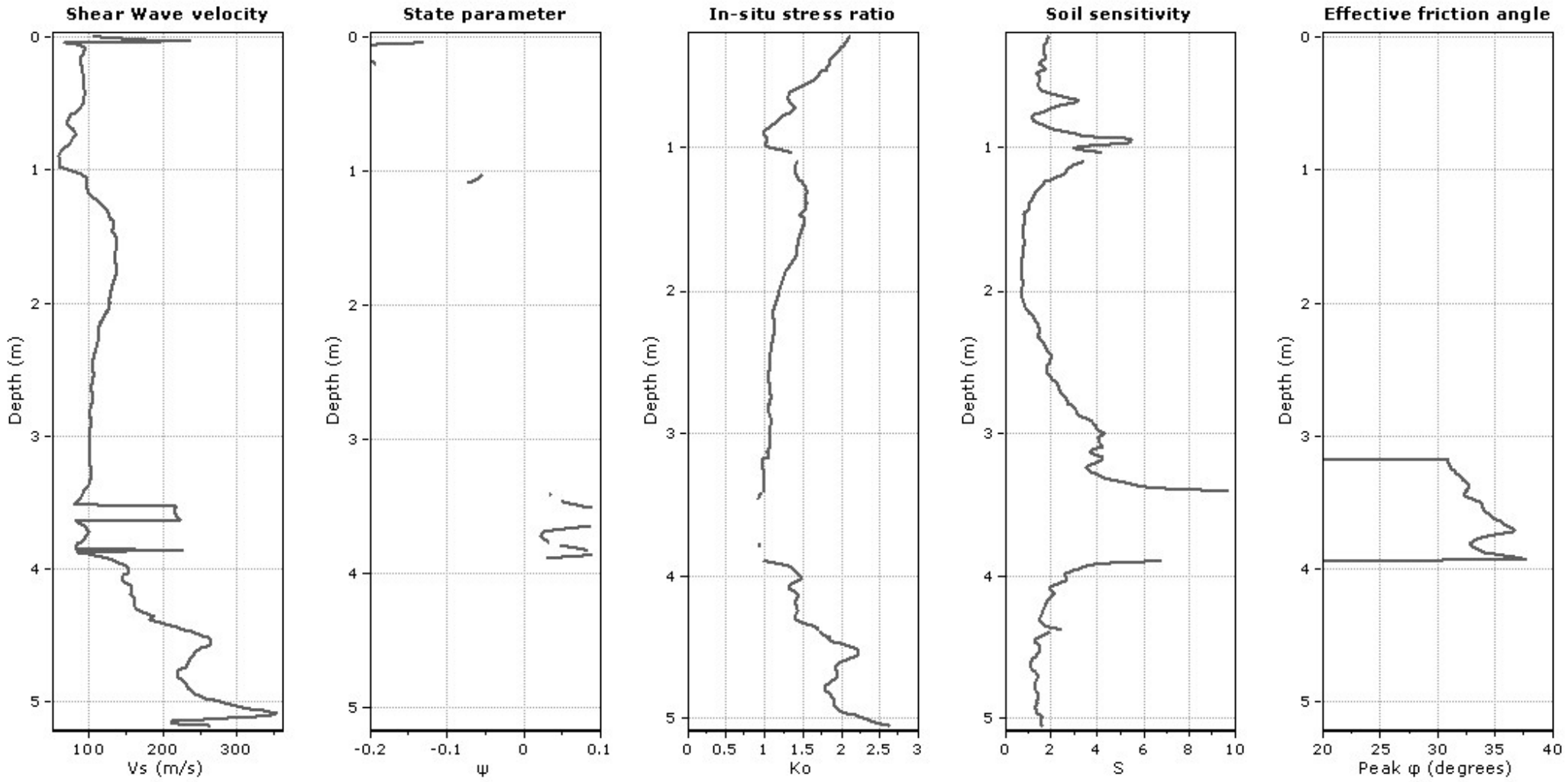


Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14
OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

CPT: moir st mangawhai_CPT02
Total depth: 5.18 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**

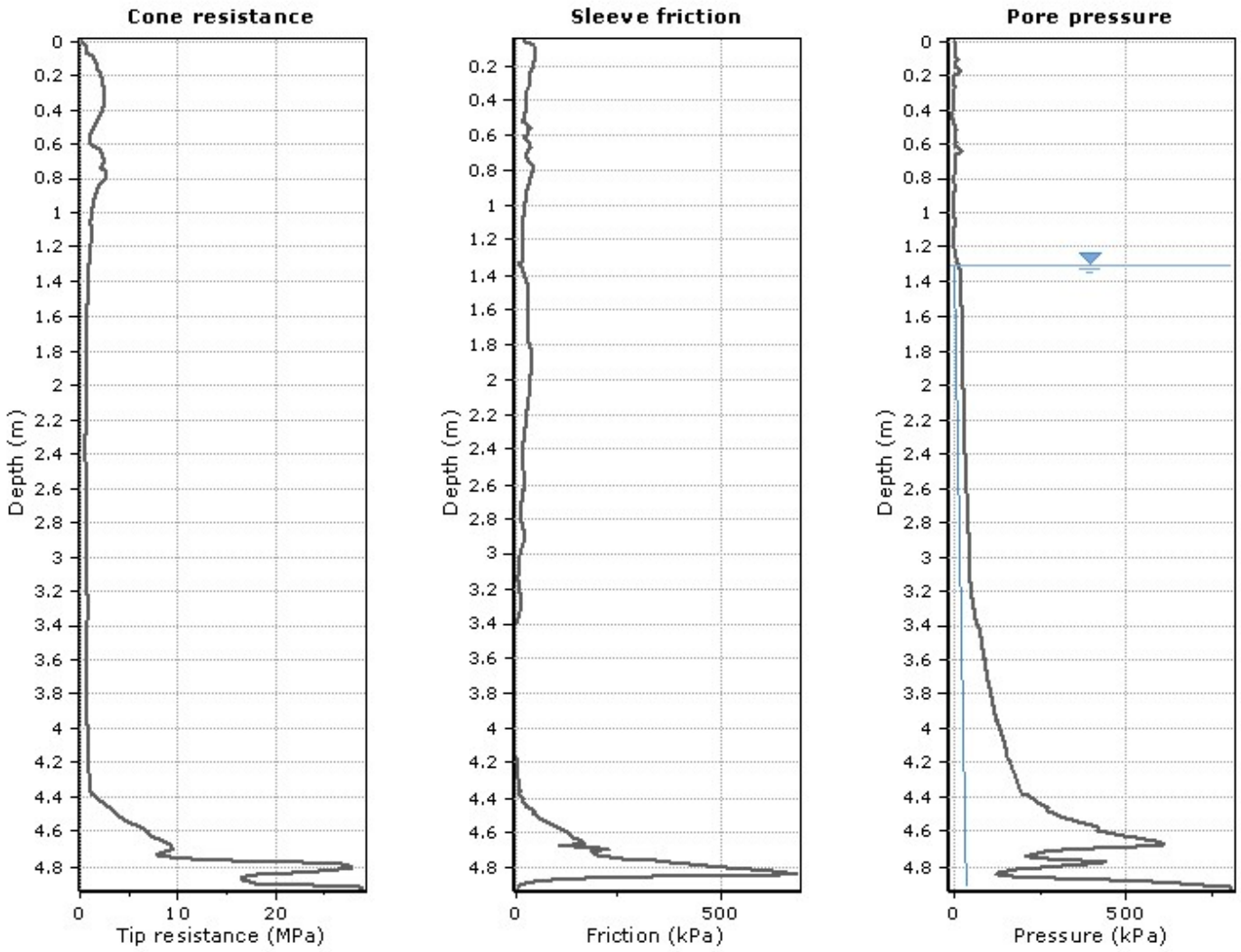


Calculation parameters

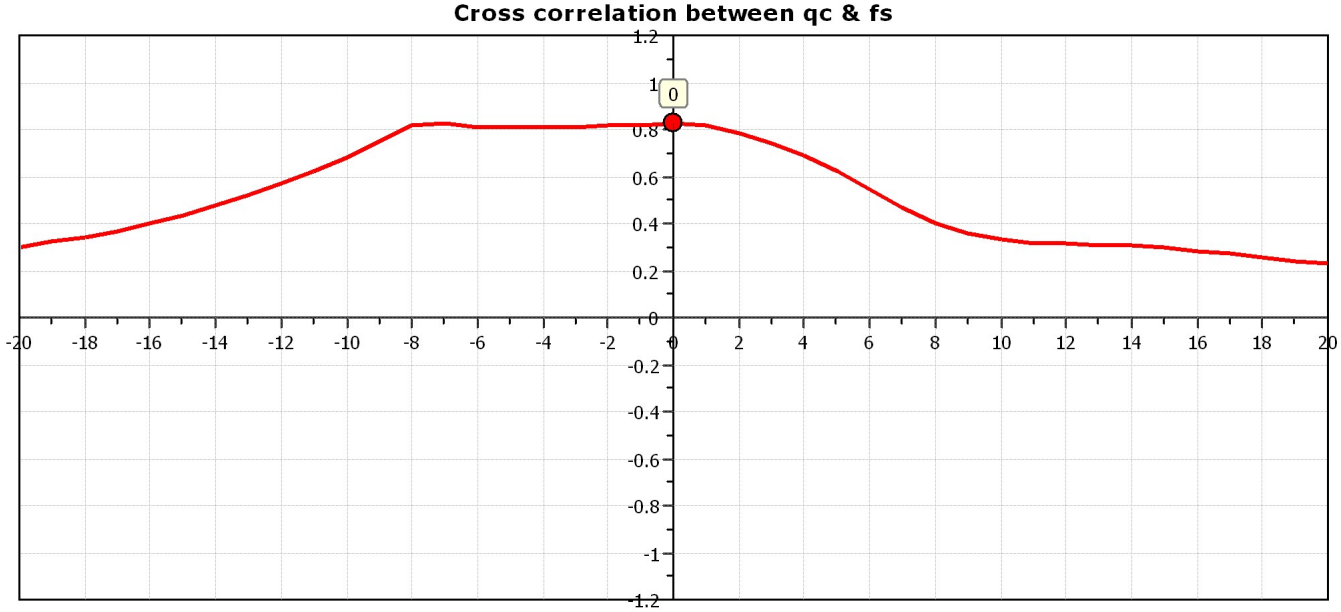
Soil Sensitivity factor, N_S: 7.00
User defined estimation data

CPT: moir st mangawhai_CPT03
Total depth: 4.92 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**



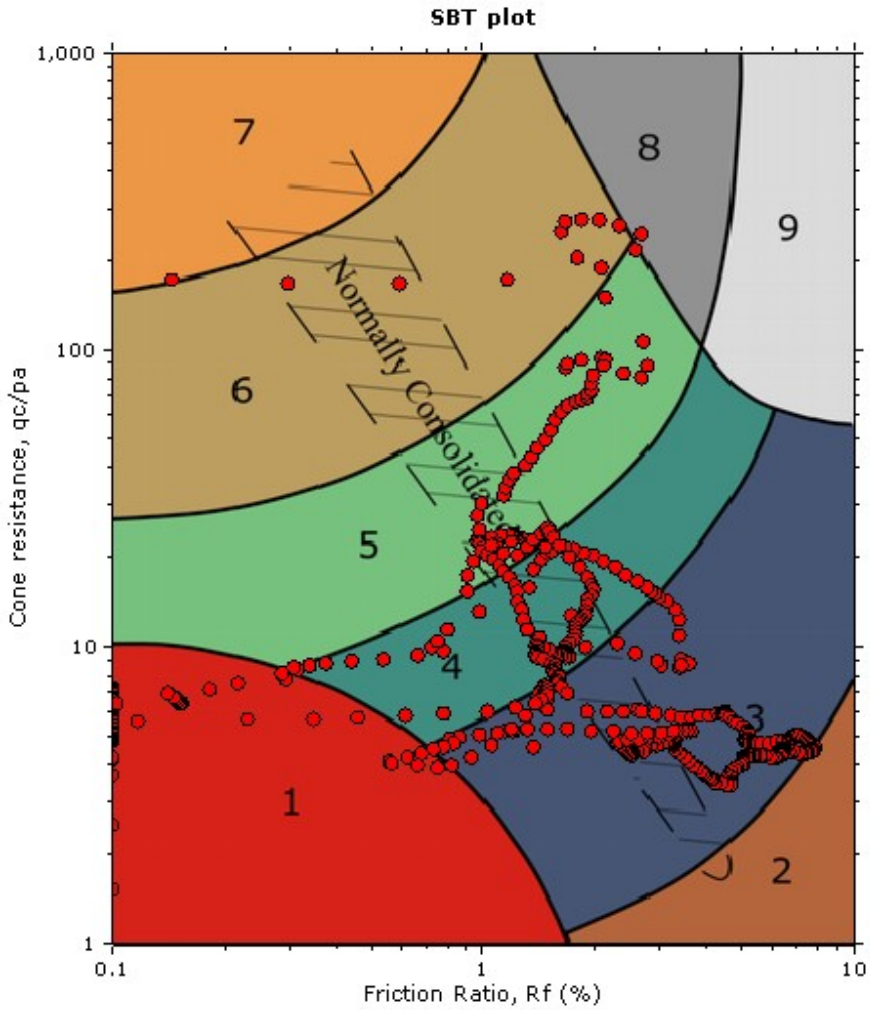
The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).

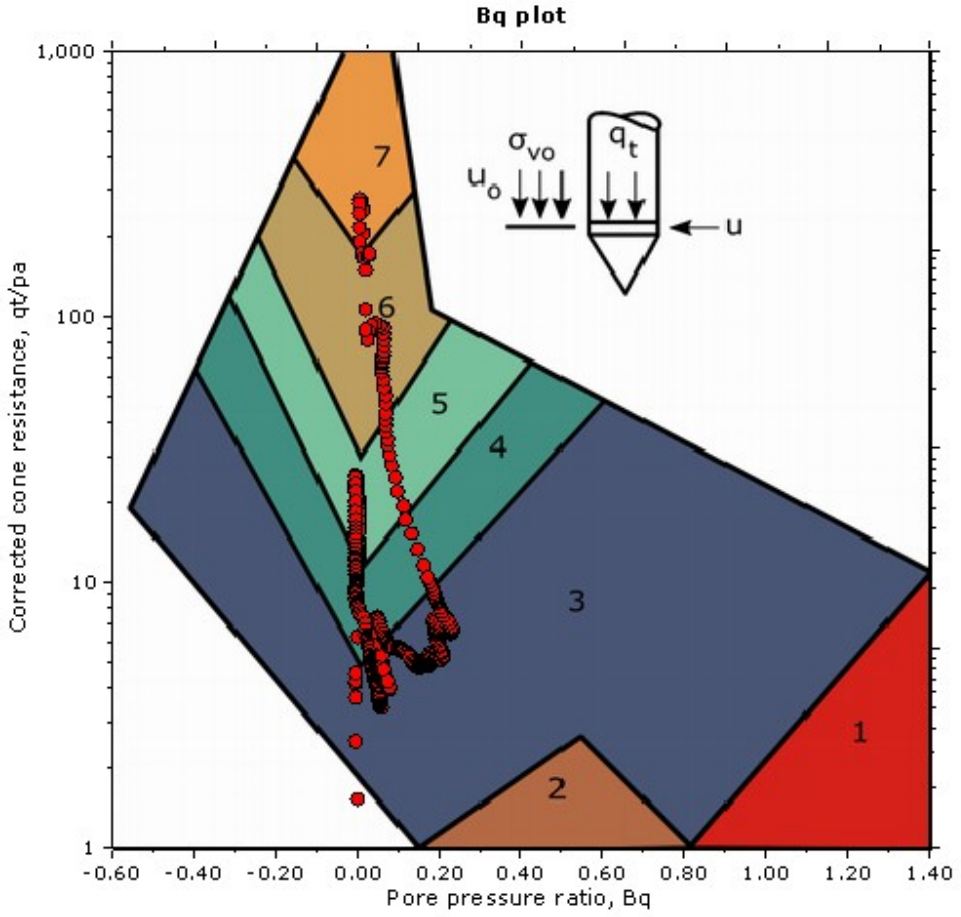


CPT: moir st mangawhai_CPT03
Total depth: 4.92 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**

SBT - Bq plots



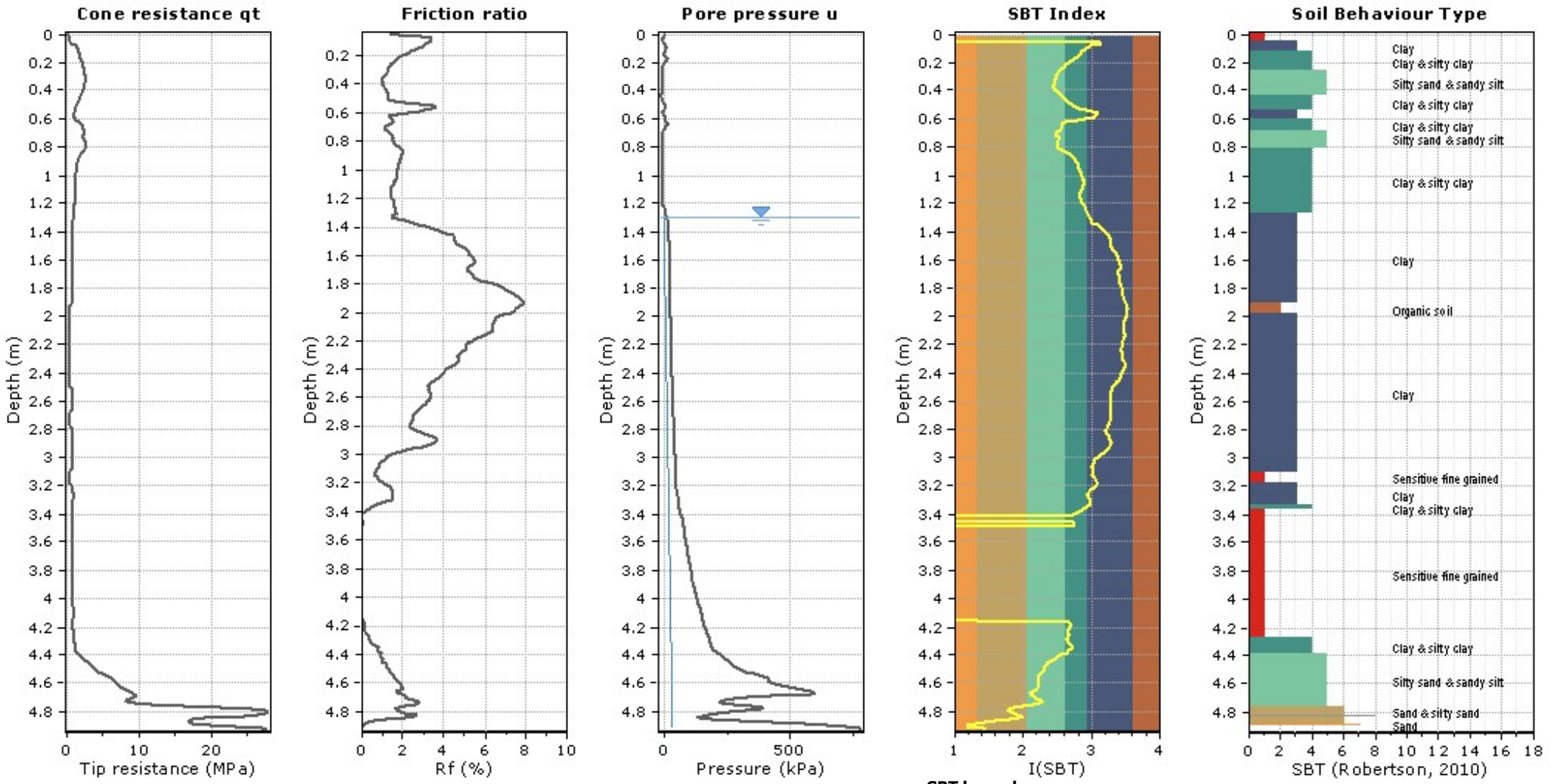


SBT legend

1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

CPT: moir st mangawhai_CPT03
Total depth: 4.92 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**

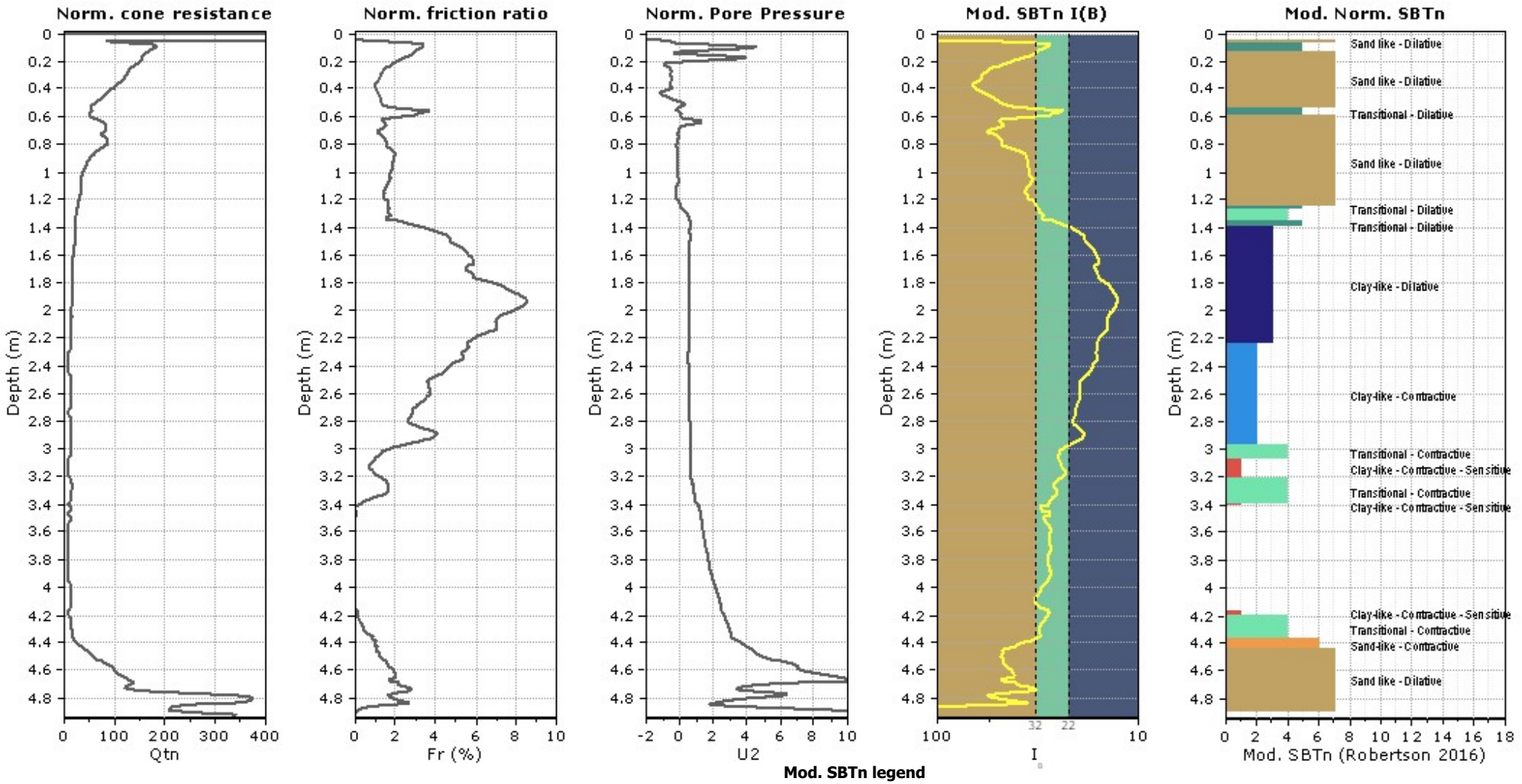


SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

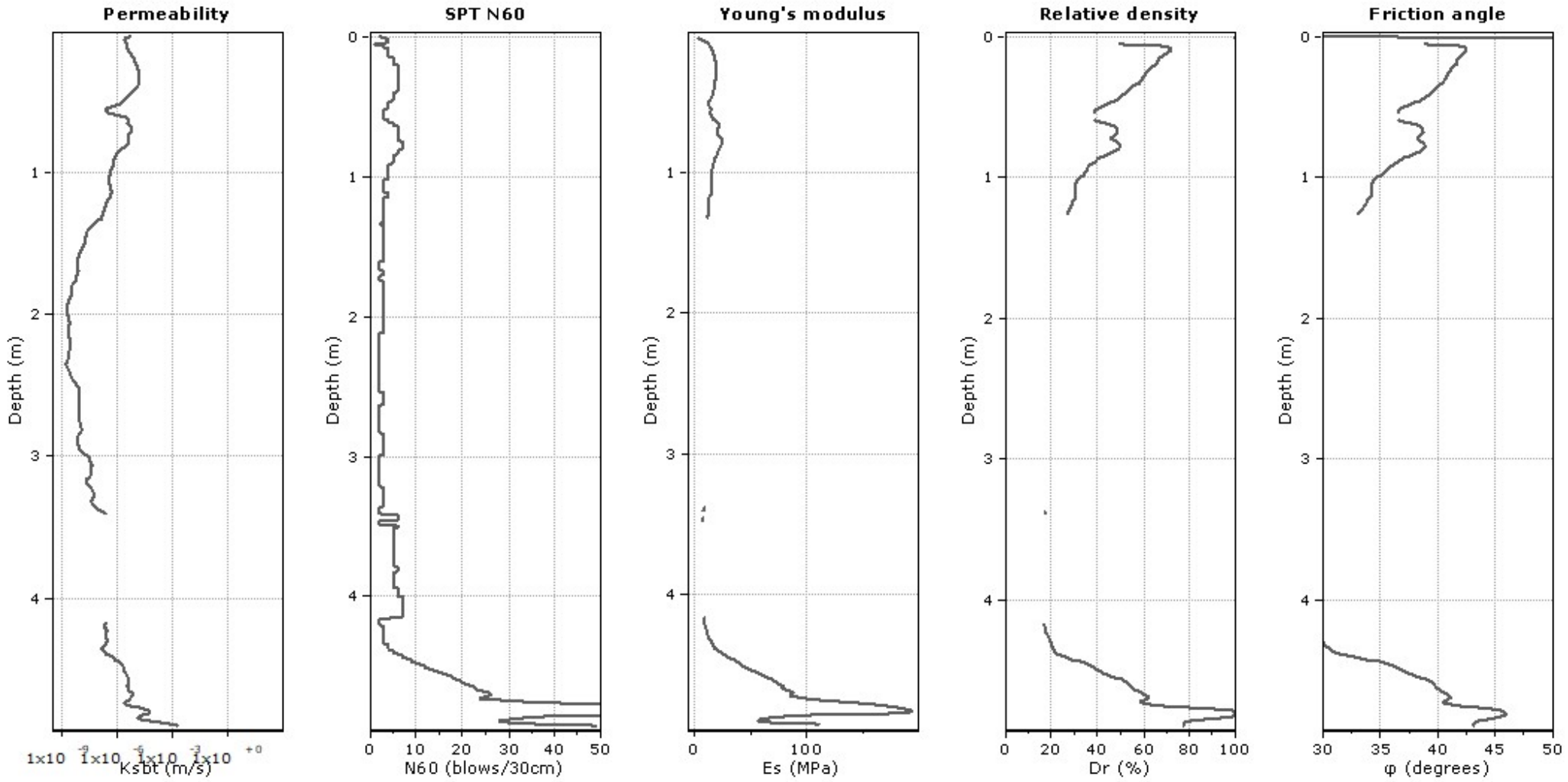
CPT: moir st mangawhai_CPT03
Total depth: 4.92 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**



CPT: moir st mangawhai_CPT03
Total depth: 4.92 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**

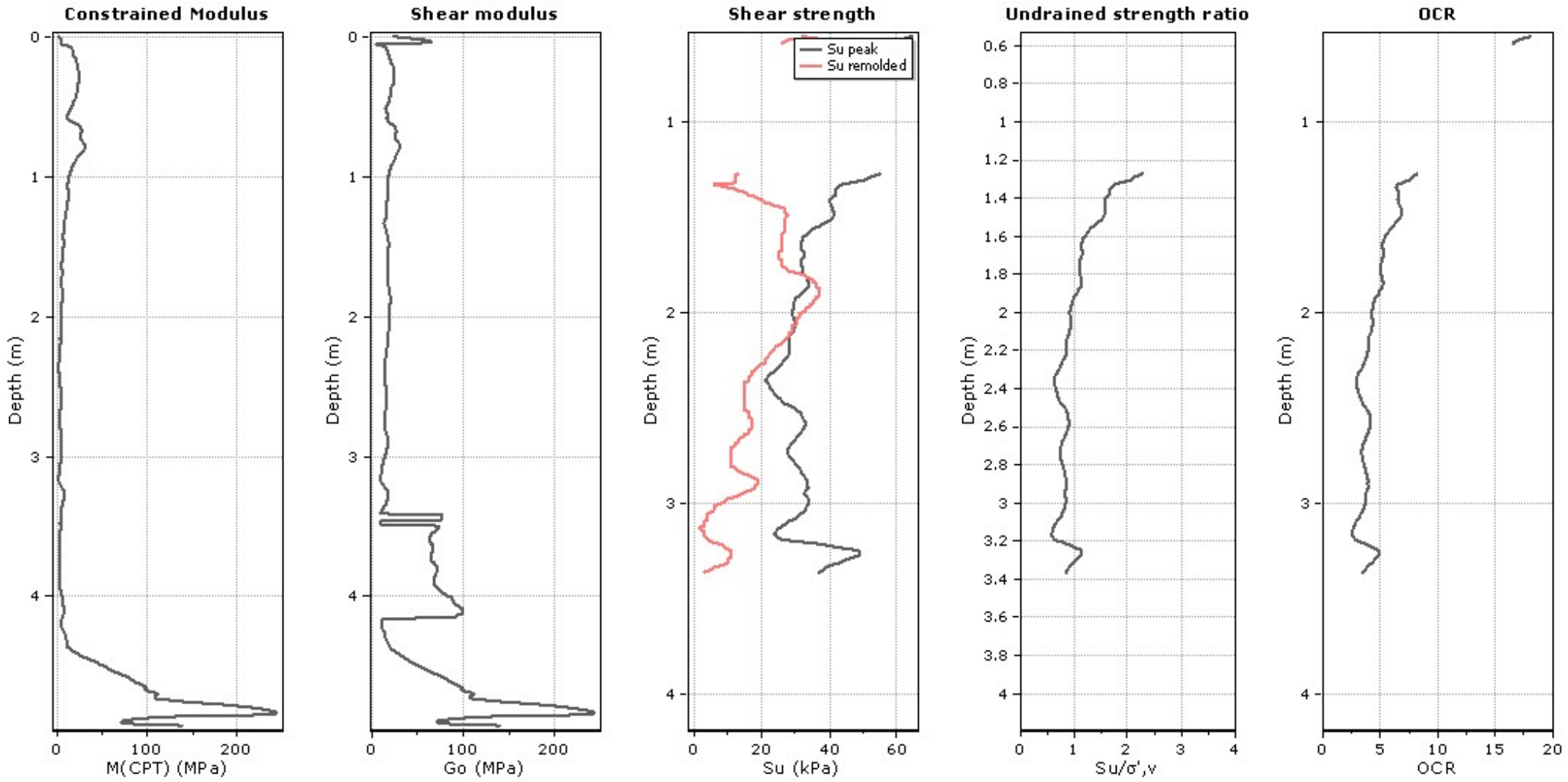


Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative density constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

CPT: moir st mangawhai_CPT03
Total depth: 4.92 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**

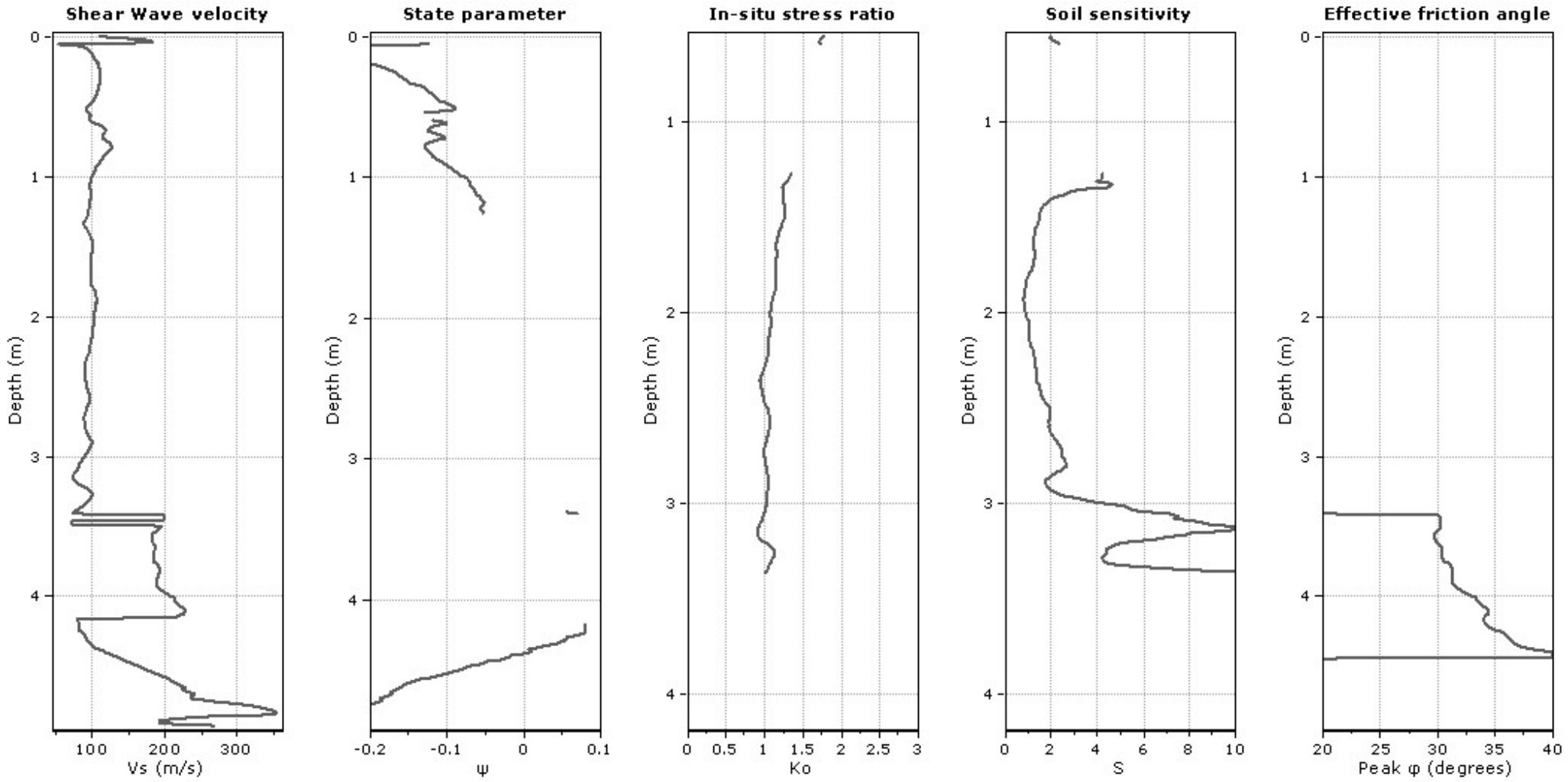


Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14
OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

CPT: moir st mangawhai_CPT03
Total depth: 4.92 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**

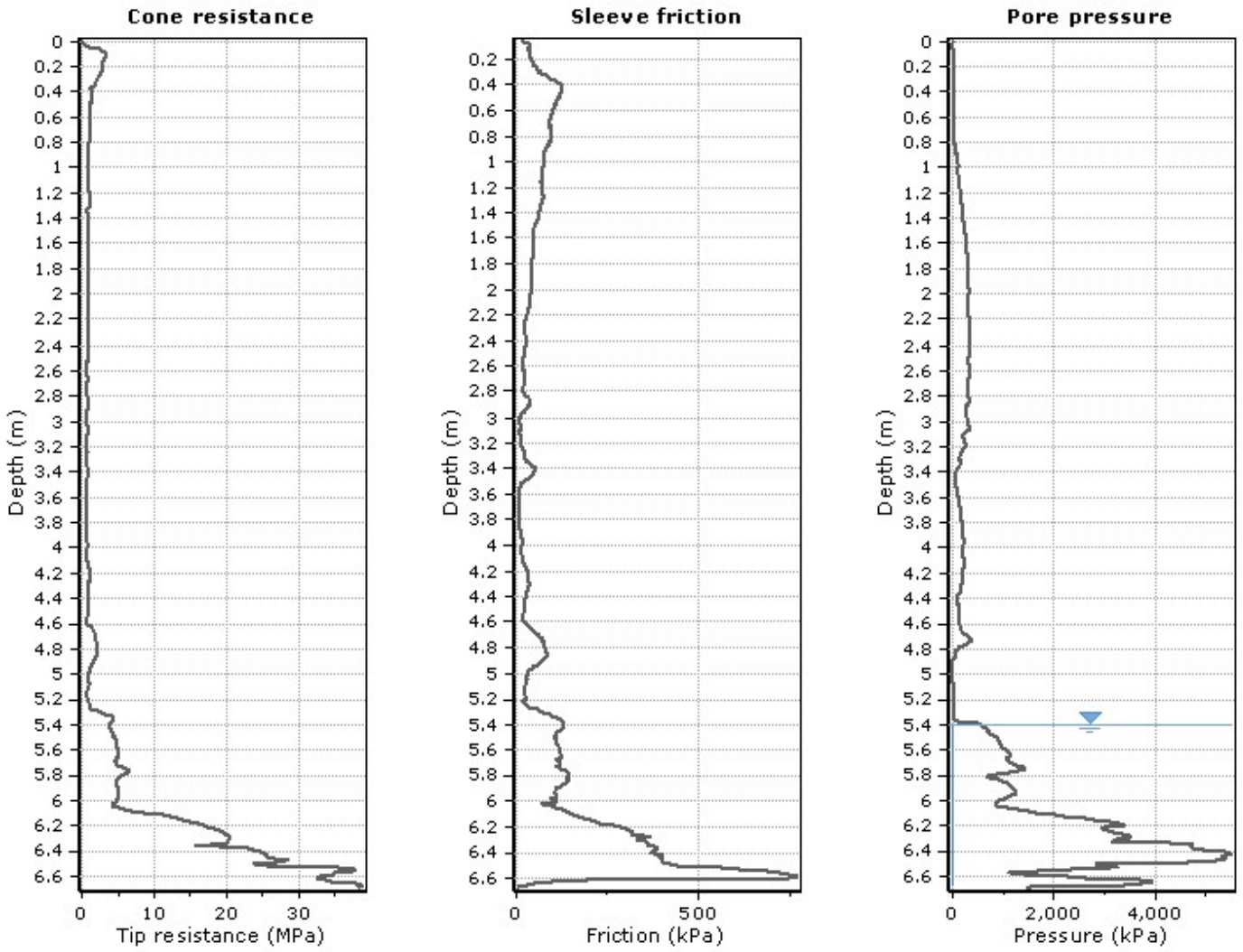


Calculation parameters

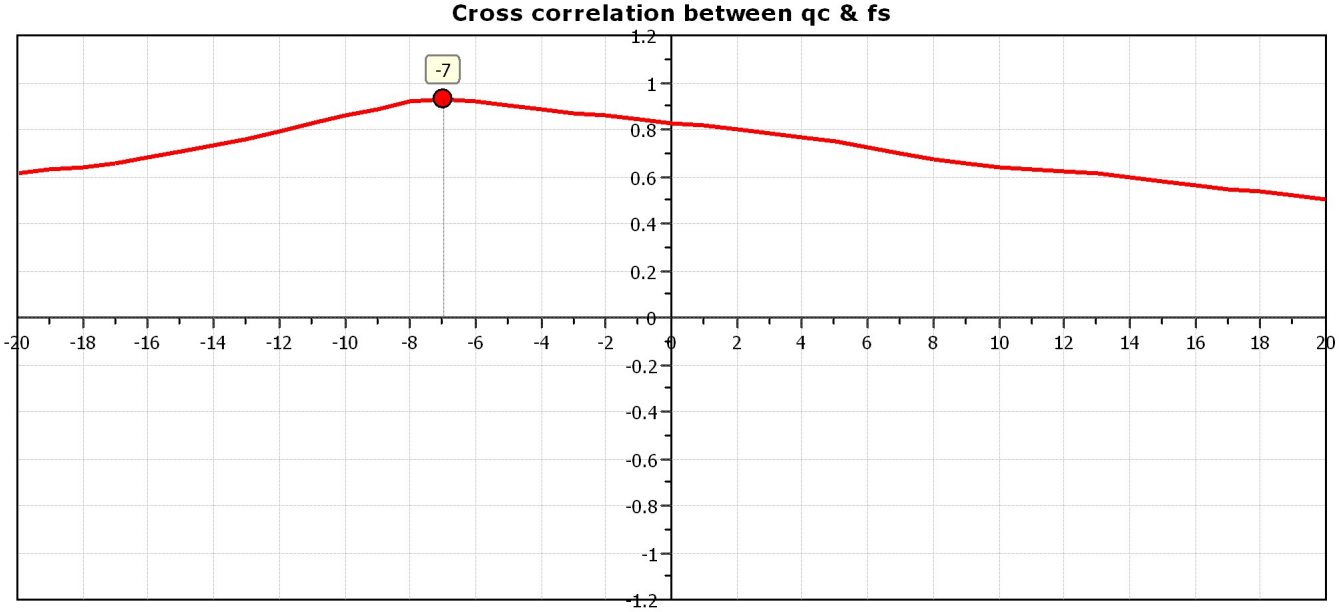
Soil Sensitivity factor, N_S: 7.00
User defined estimation data

CPT: moir st mangawhai_CPT04
Total depth: 6.68 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

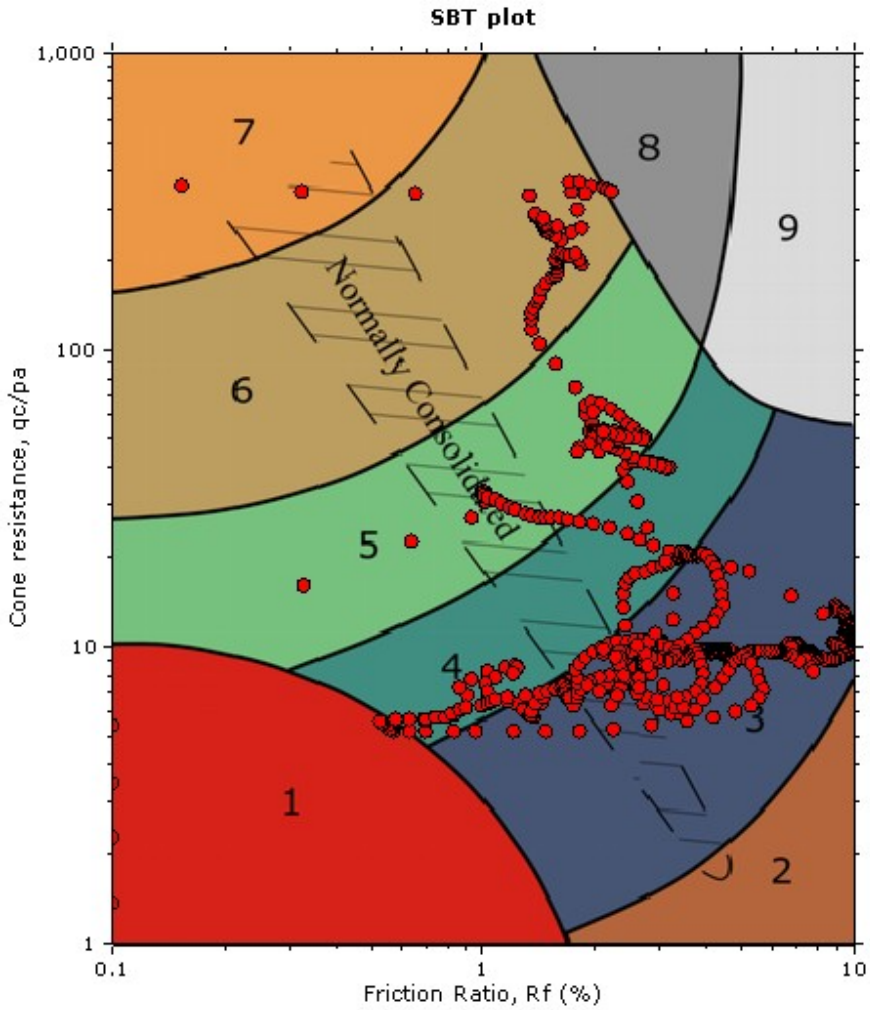
Project: **Causeway Chruch**
Location: **Moir Street**

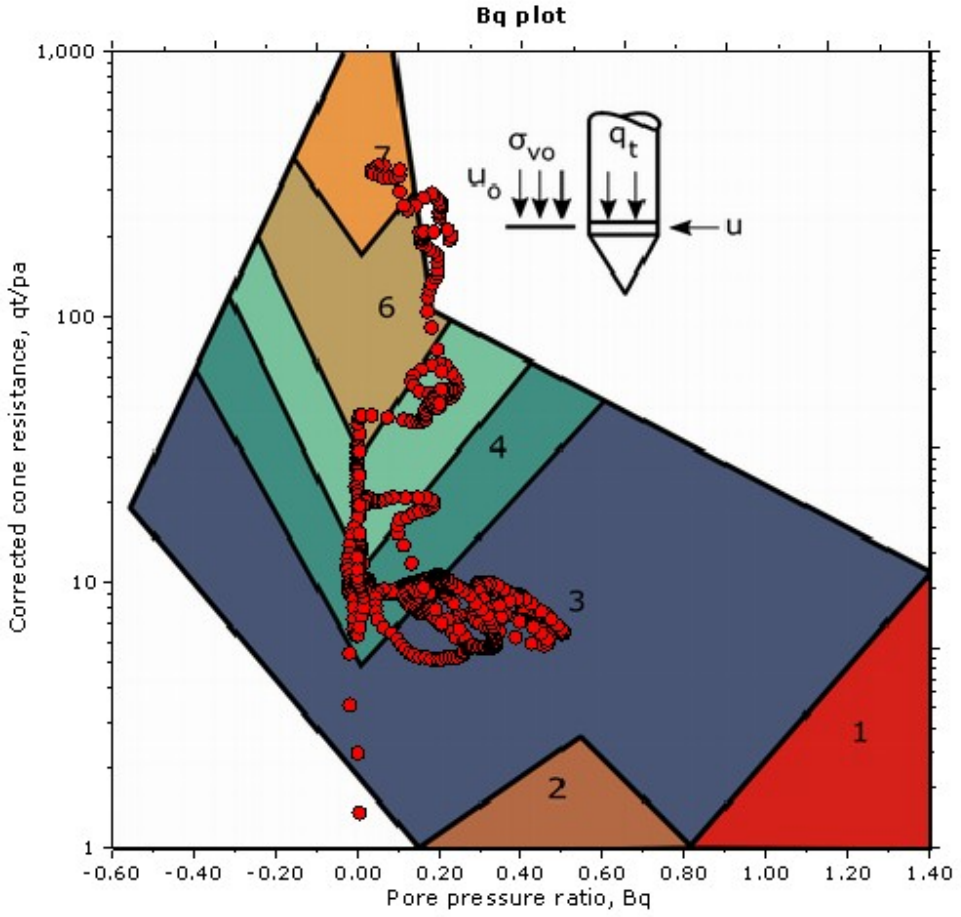


The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).



SBT - Bq plots



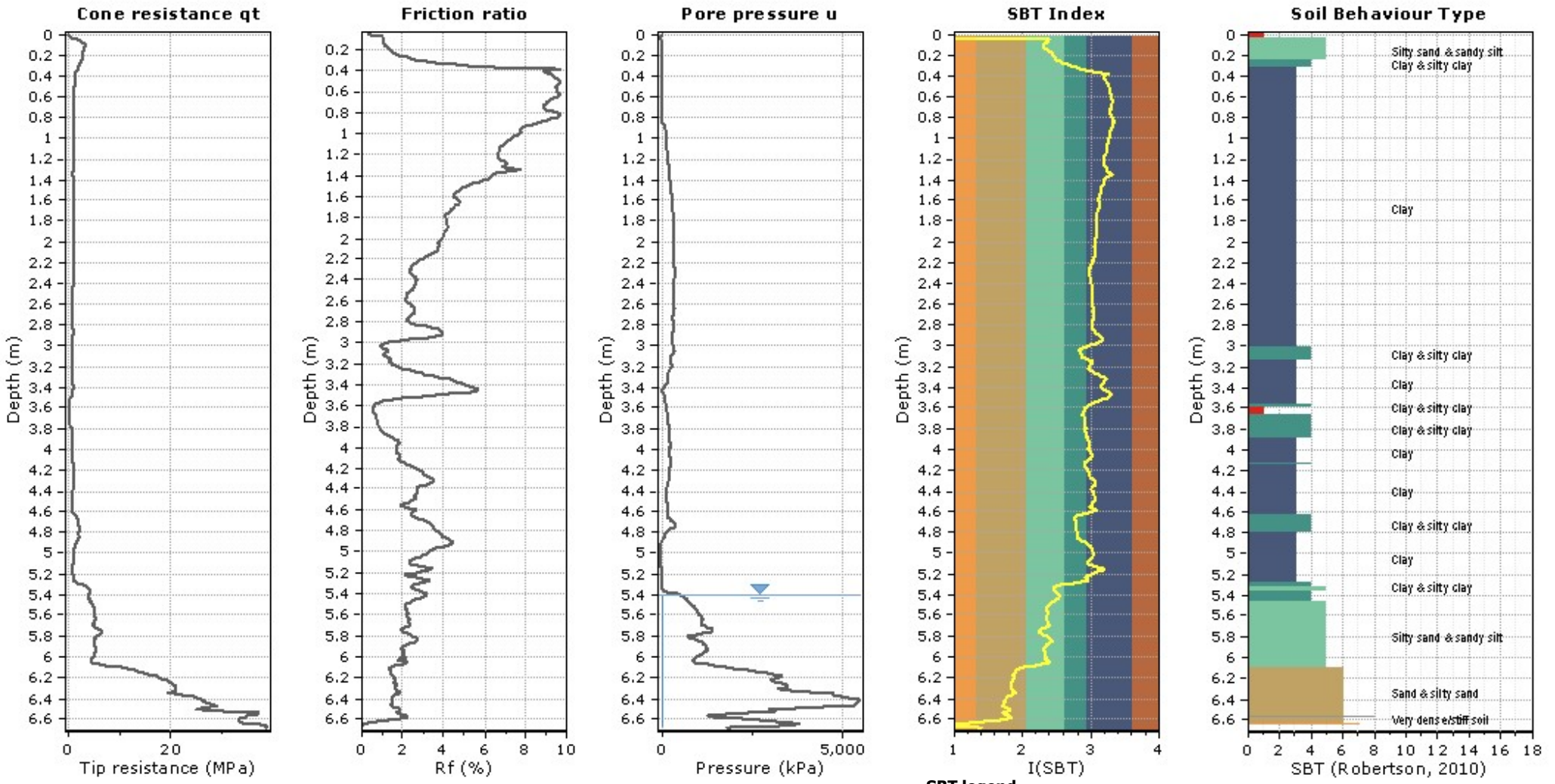


SBT legend

1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

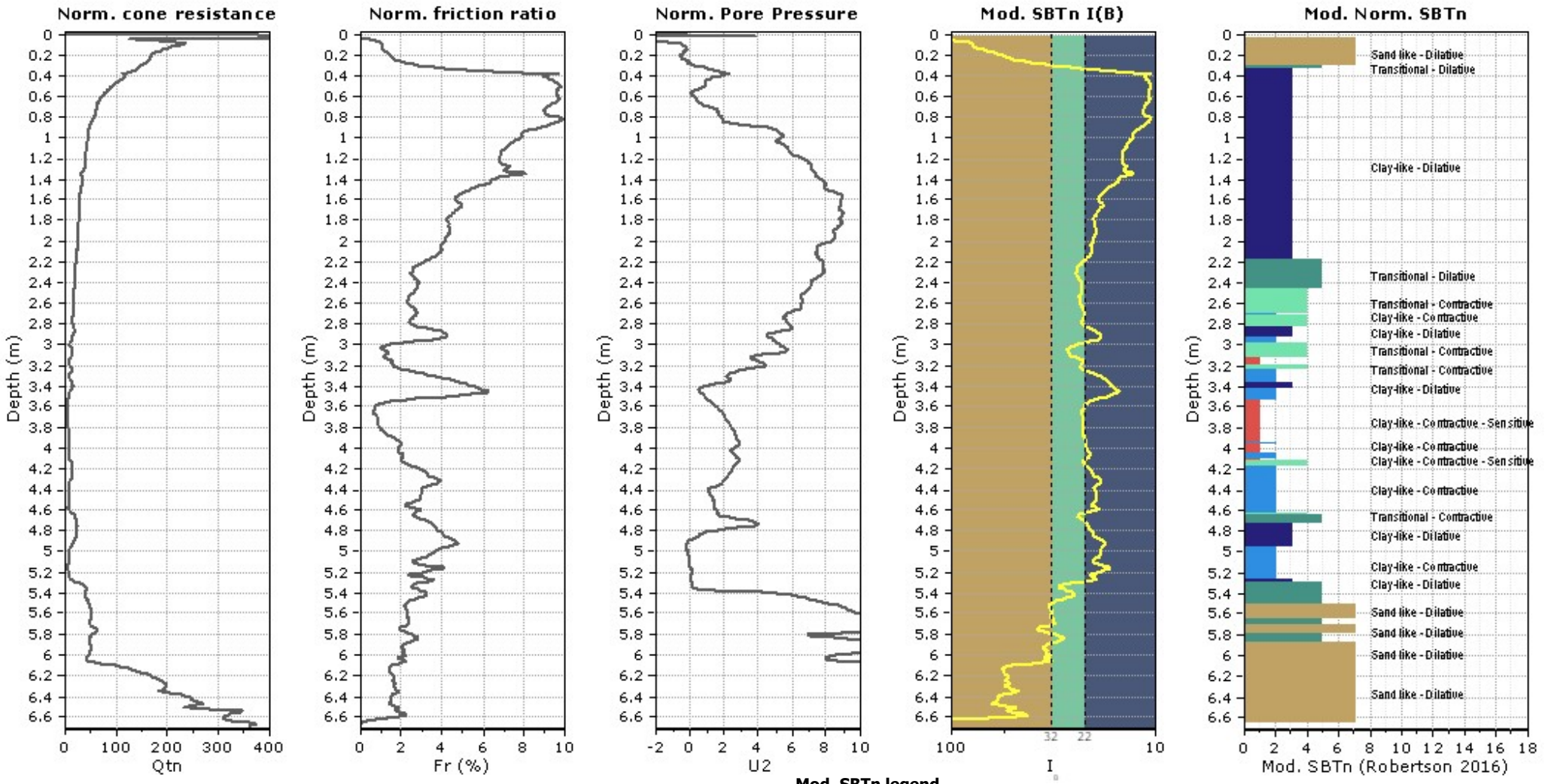
CPT: moir st mangawhai_CPT04
Total depth: 6.68 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**



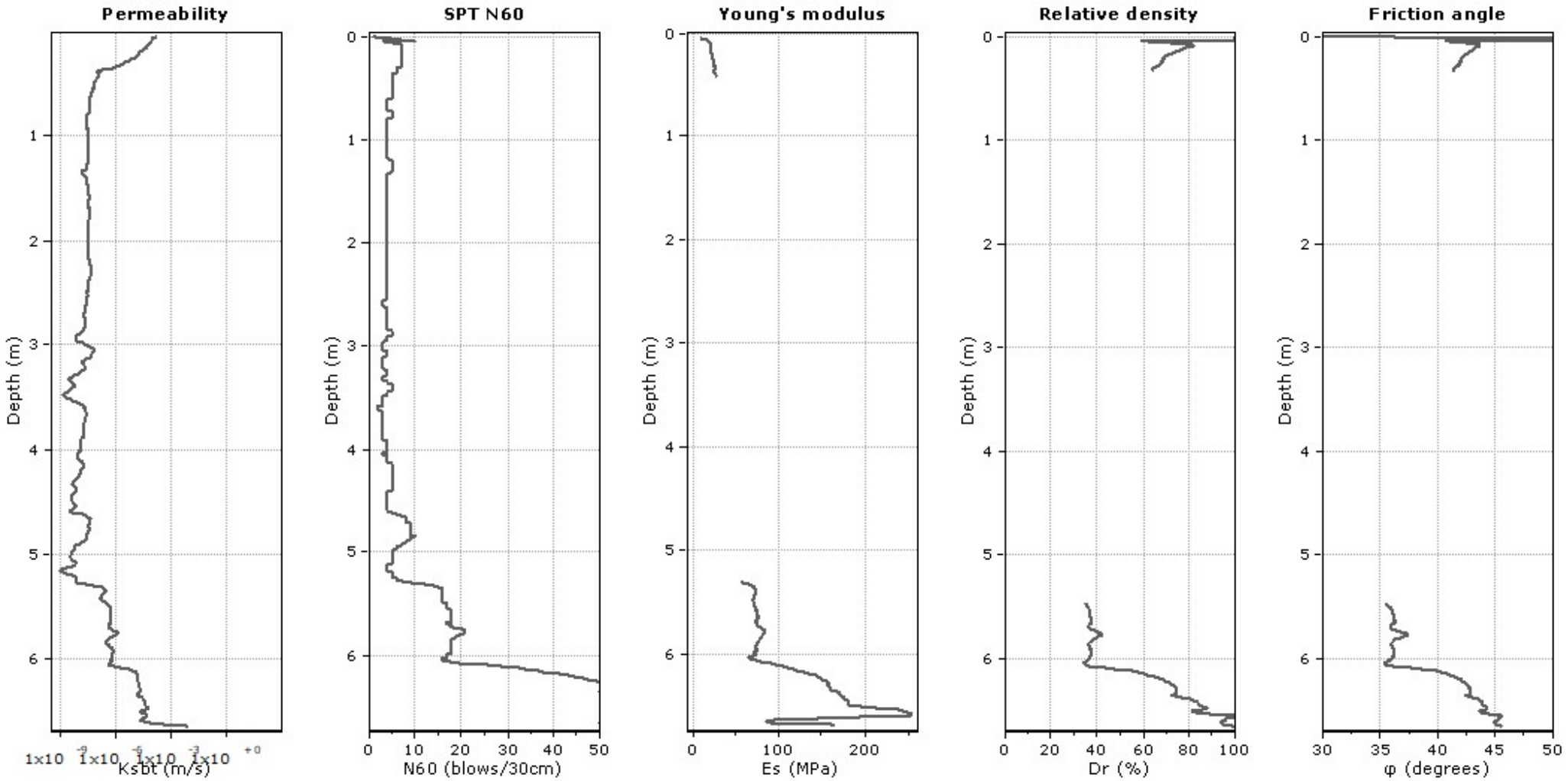
CPT: moir st mangawhai_CPT04
Total depth: 6.68 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**



CPT: moir st mangawhai_CPT04
Total depth: 6.68 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**

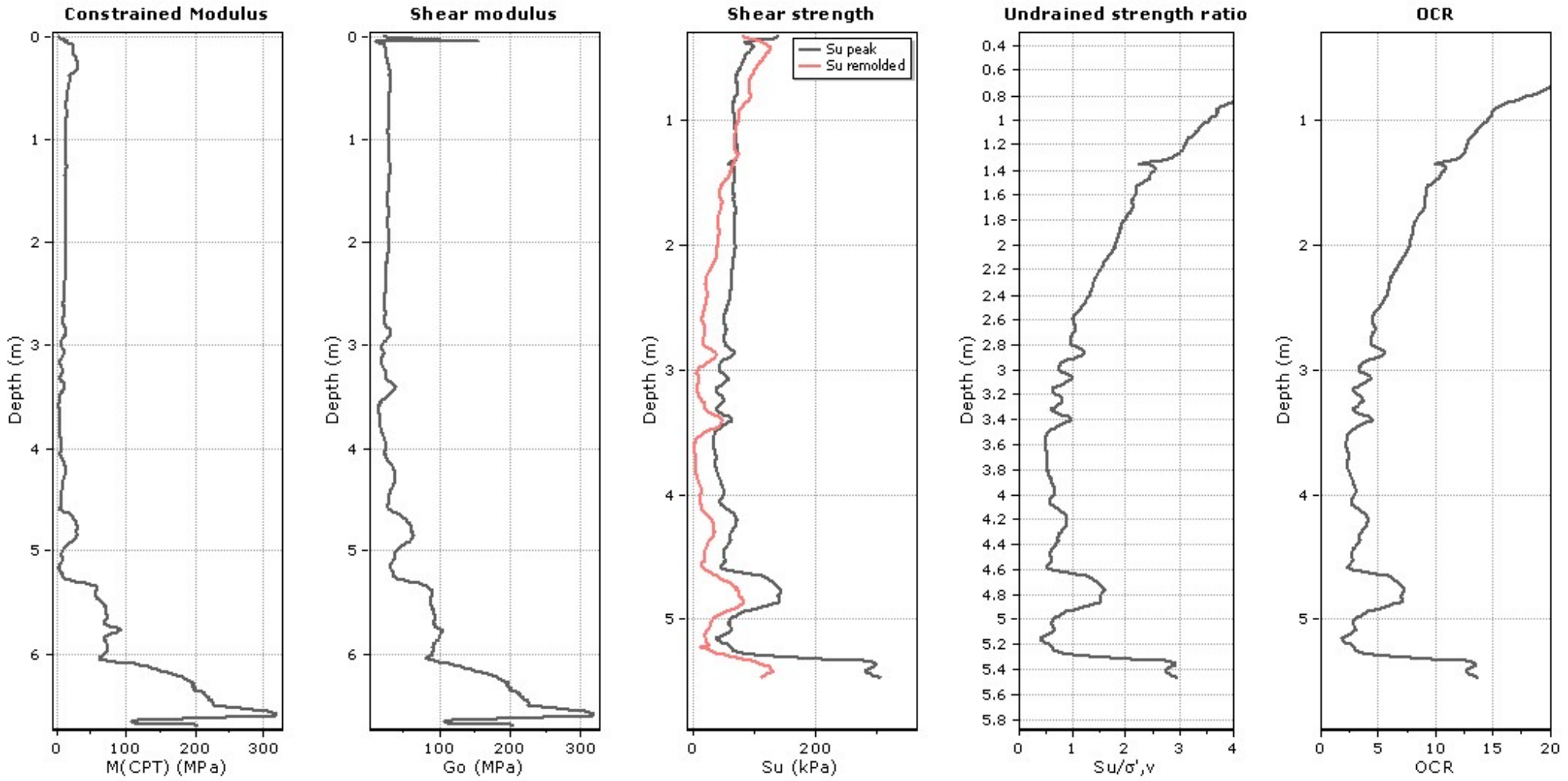


Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative density constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

CPT: moir st mangawhai_CPT04
Total depth: 6.68 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**

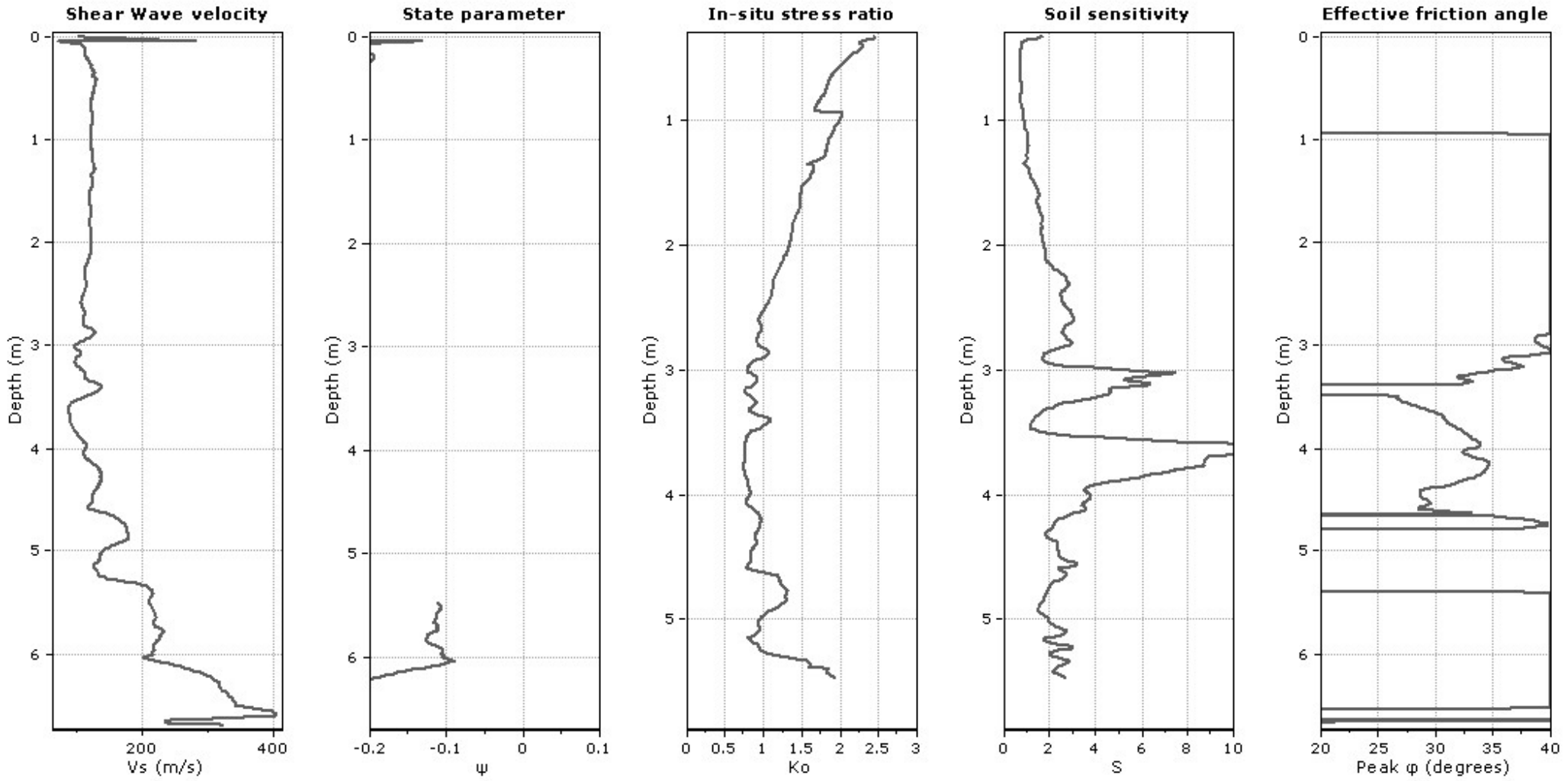


Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14
OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

CPT: moir st mangawhai_CPT04
Total depth: 6.68 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**

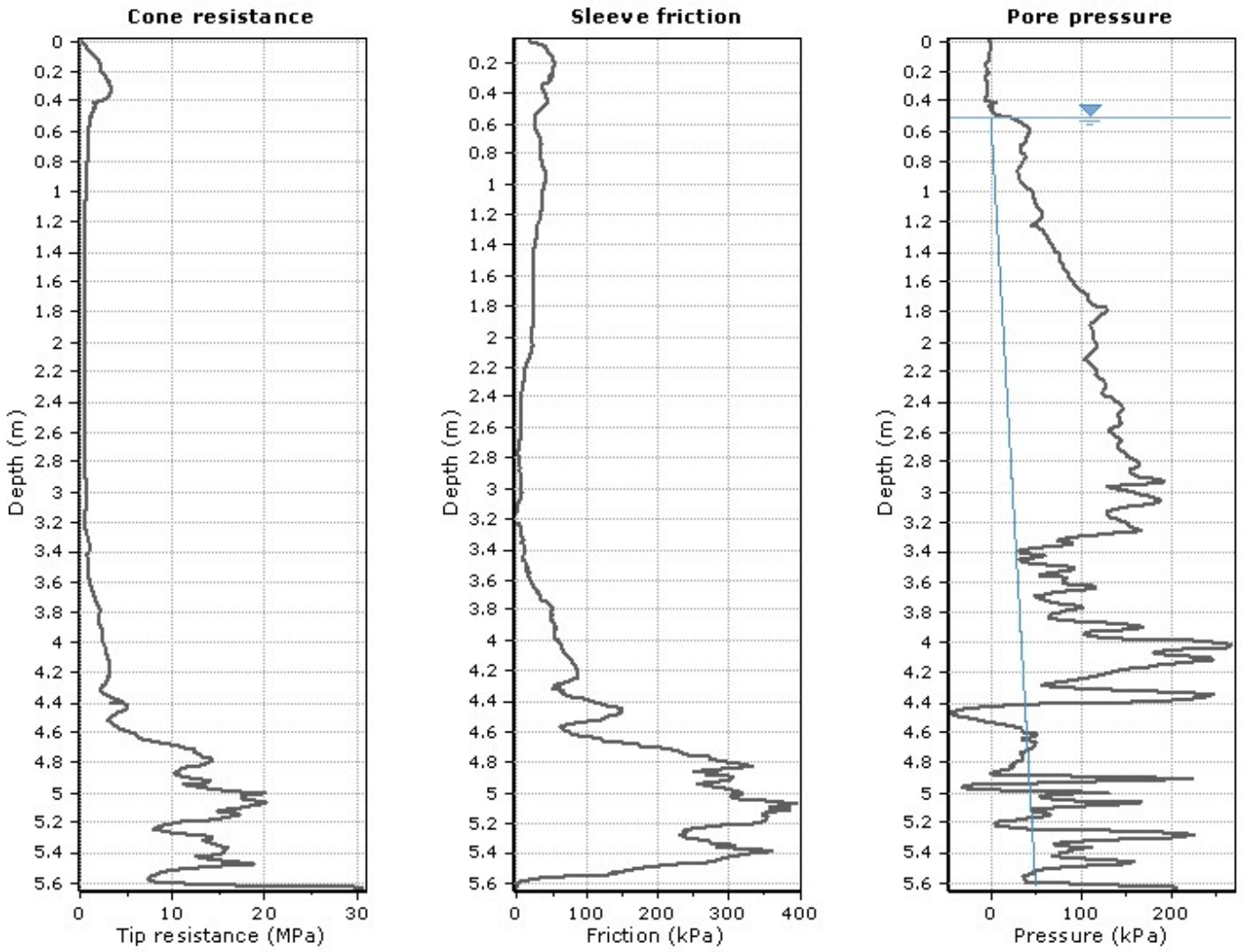


Calculation parameters

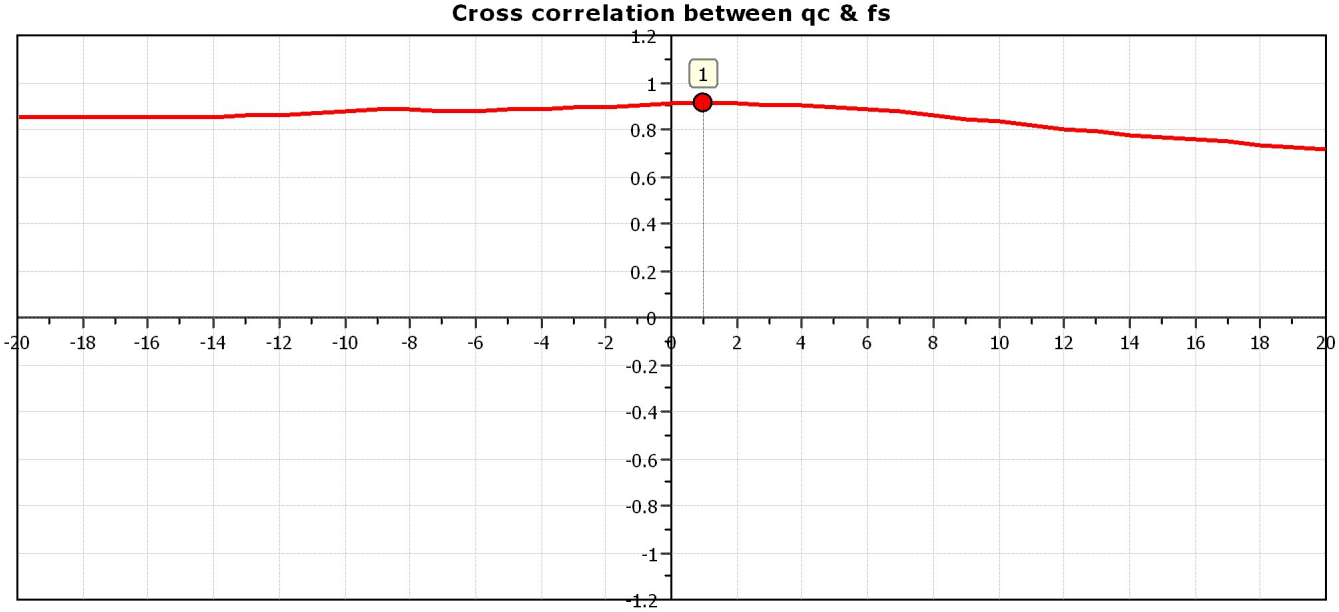
Soil Sensitivity factor, N_S: 7.00
User defined estimation data

CPT: moir st mangawhai_CPT05
Total depth: 5.63 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**



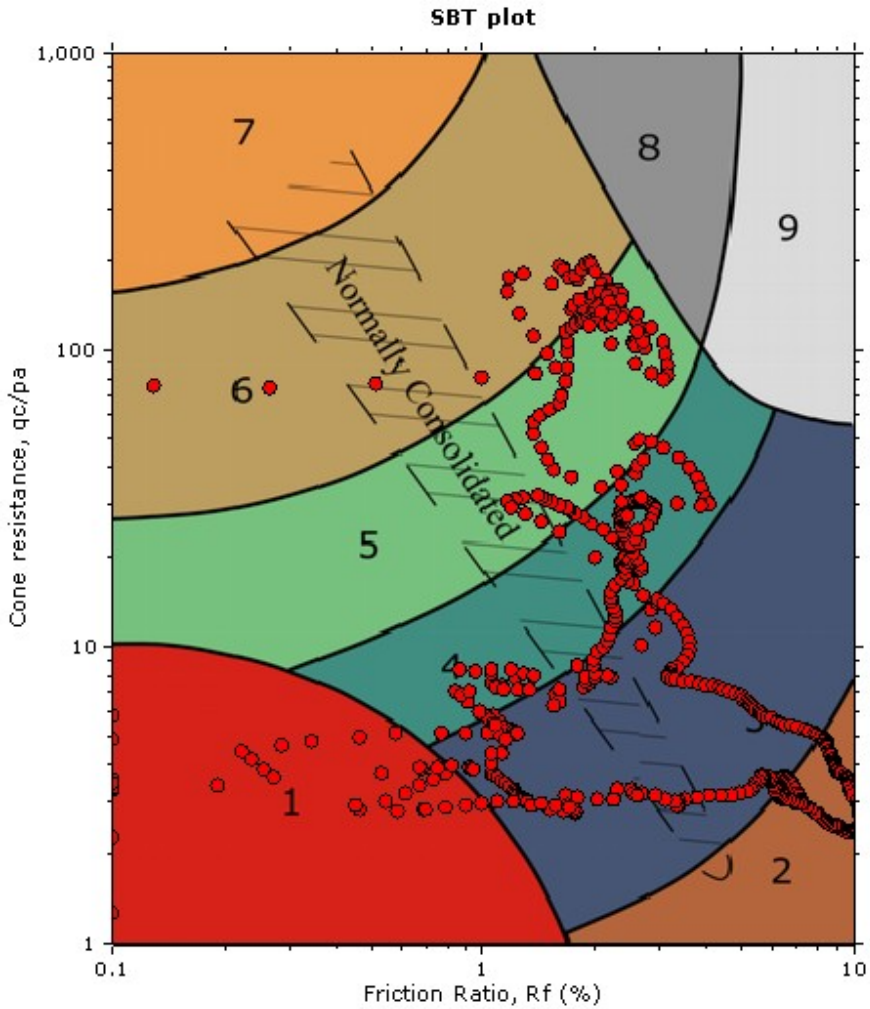
The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).

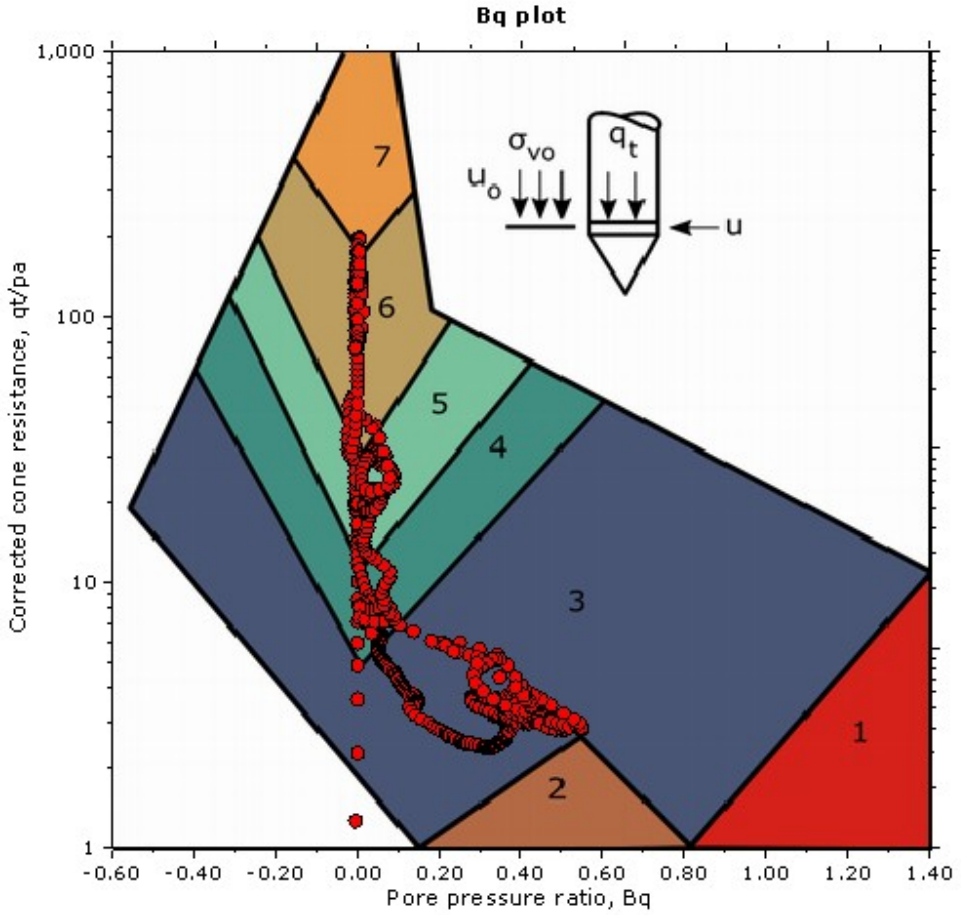


CPT: moir st mangawhai_CPT05
Total depth: 5.63 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**

SBT - Bq plots



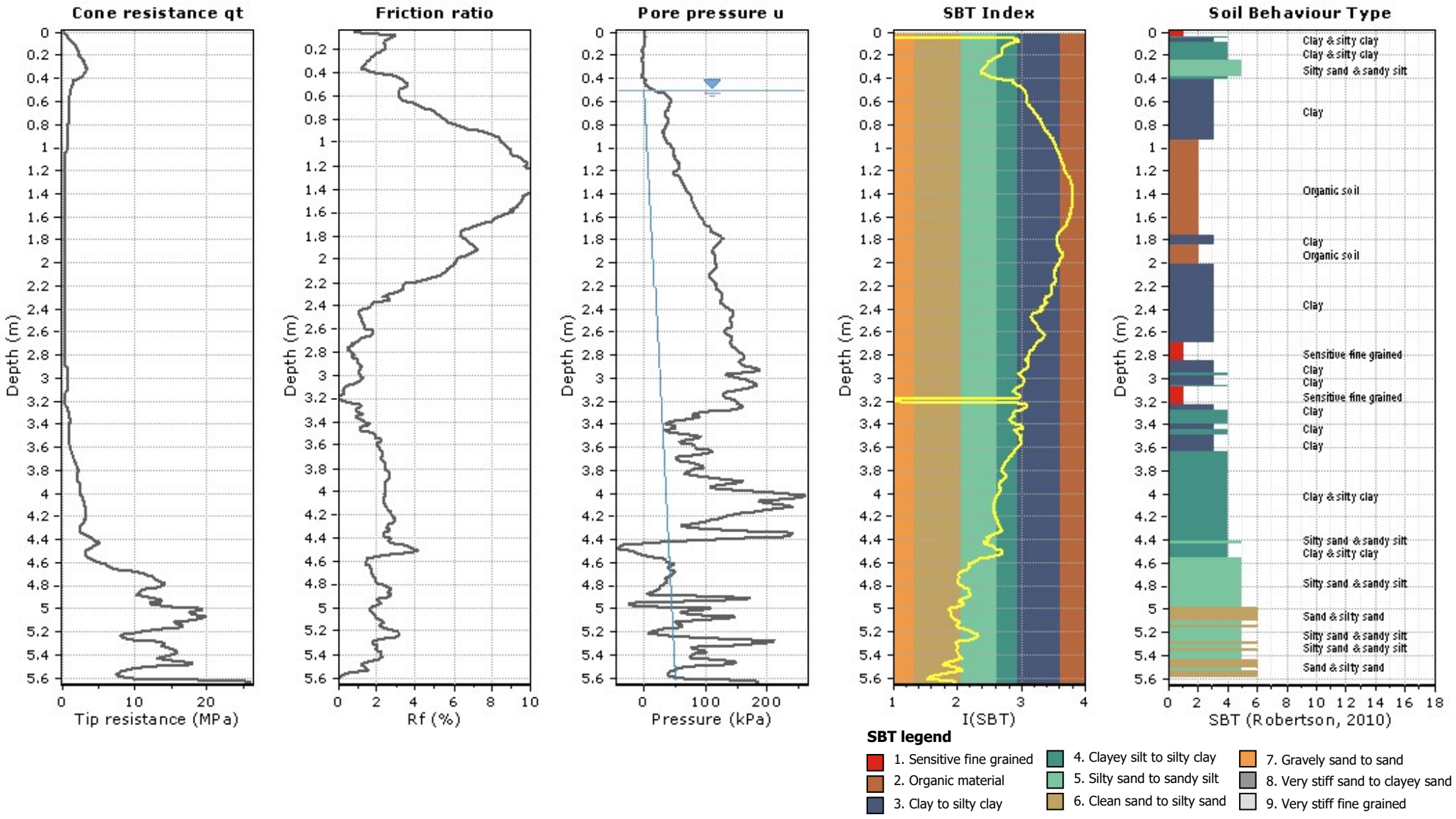


SBT legend

1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

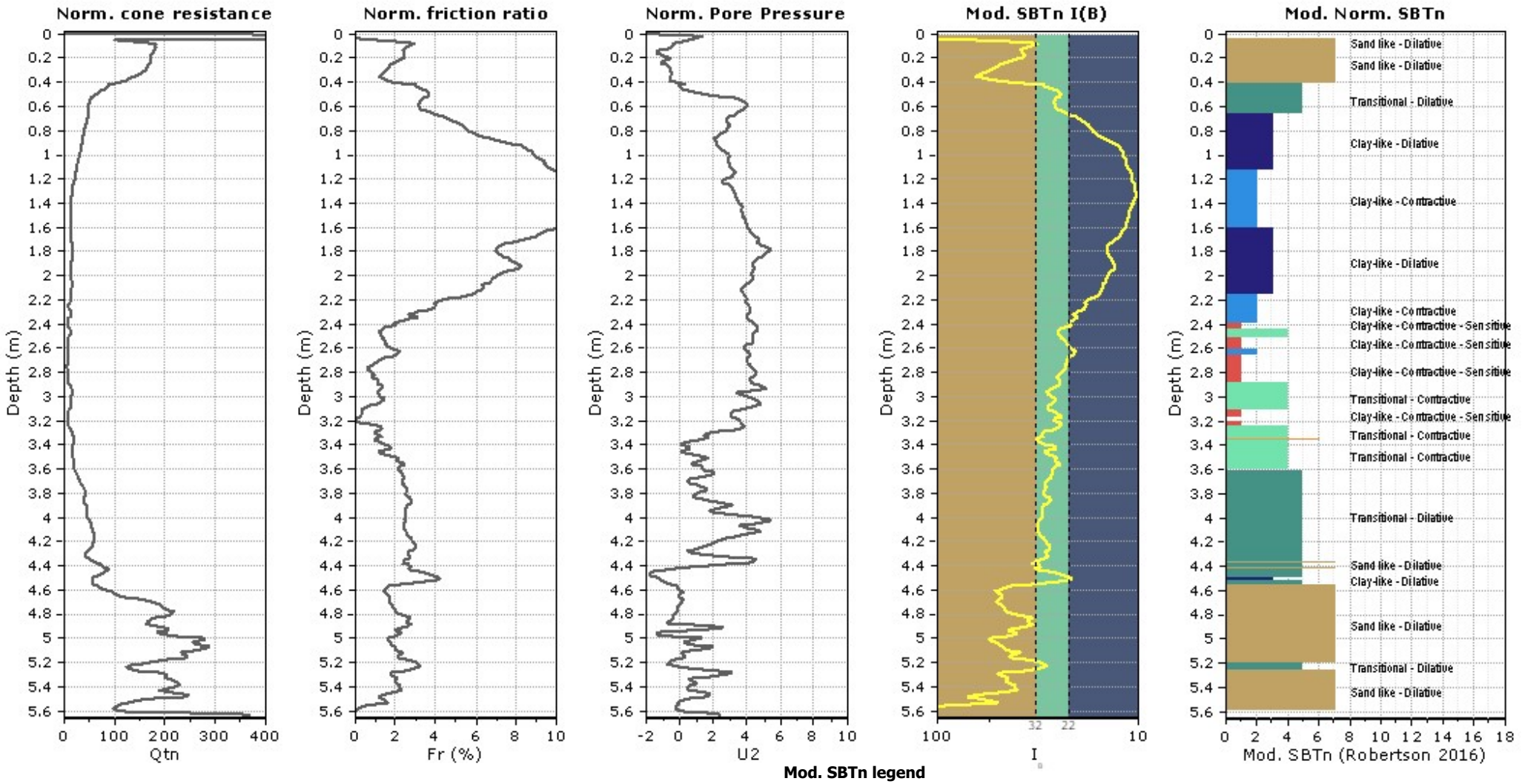
CPT: moir st mangawhai_CPT05
Total depth: 5.63 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**



CPT: moir st mangawhai_CPT05
Total depth: 5.63 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**

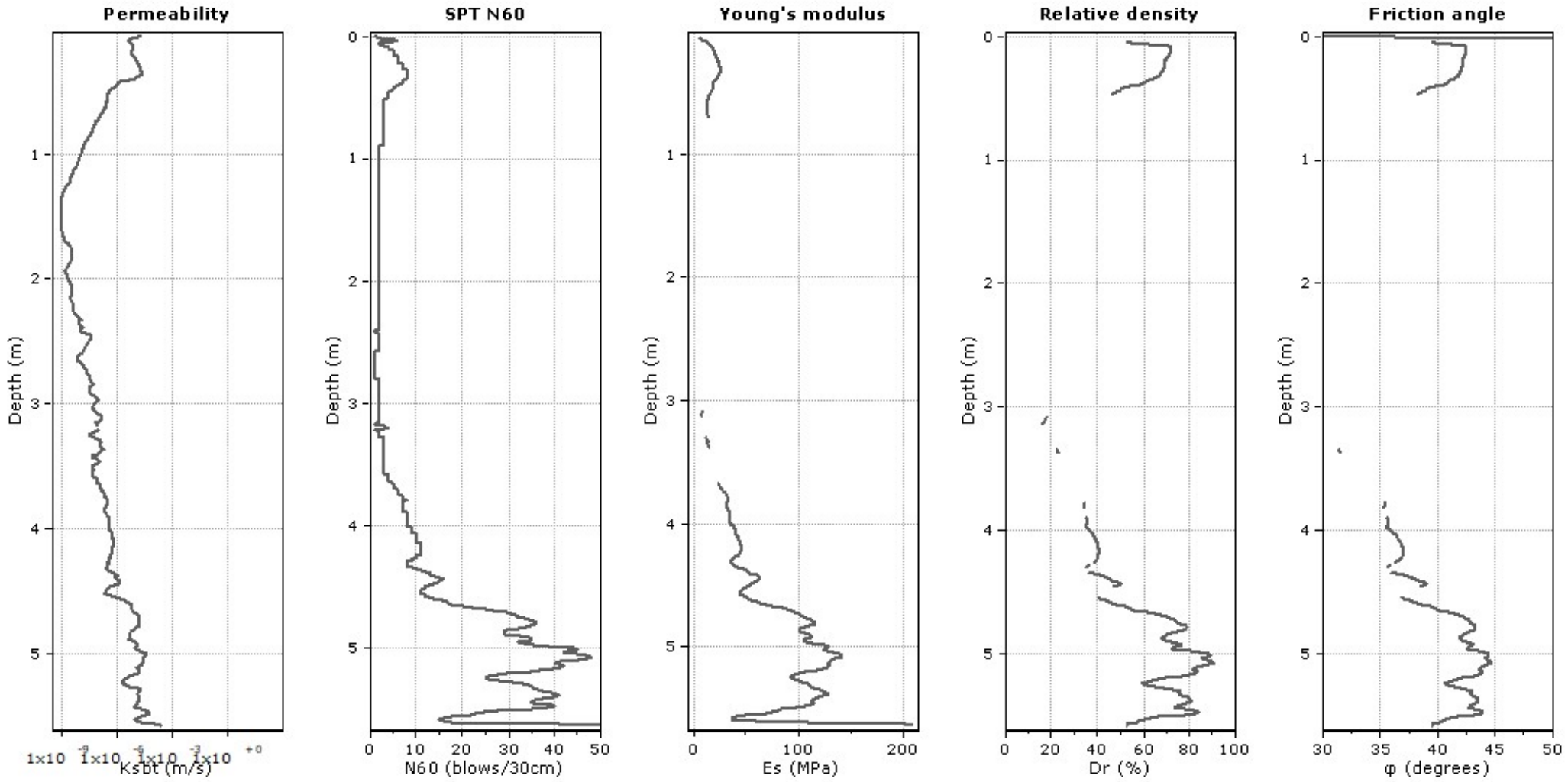


Mod. SBTn legend

1. CCS: ClayLike - Contractive, Sensitive
2. CC: Clay-like - Contractive
3. CD: Clay-Like: Dilative
4. TC: Transitional - Contractive
5. TD: Transitional - Dilative
6. SC: Sand-like - Contractive
7. SD: Sand-like - Dilative

CPT: moir st mangawhai_CPT05
Total depth: 5.63 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**

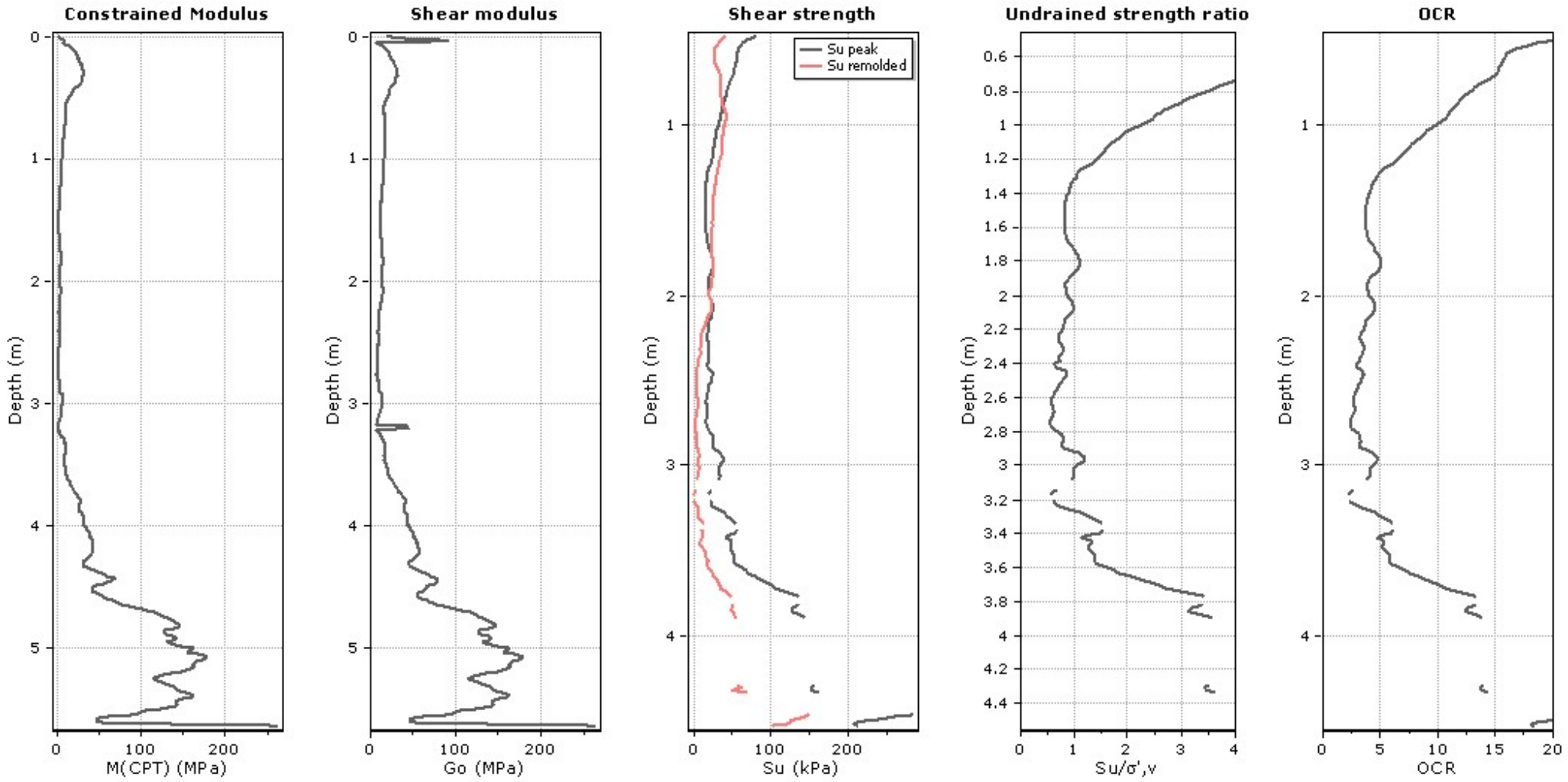


Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative density constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

CPT: moir st mangawhai_CPT05
Total depth: 5.63 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**

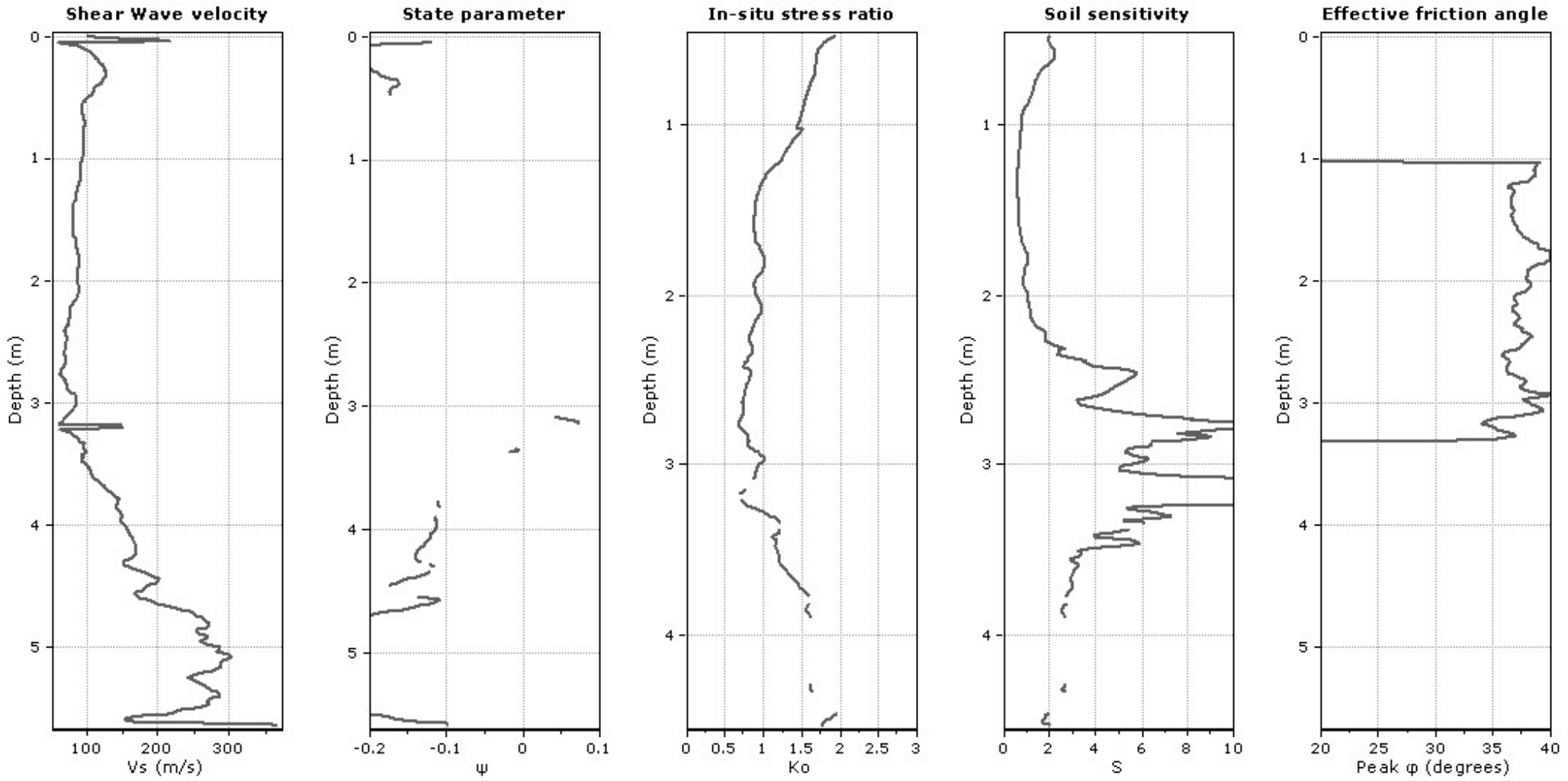


Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14
OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

CPT: moir st mangawhai_CPT05
Total depth: 5.63 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**

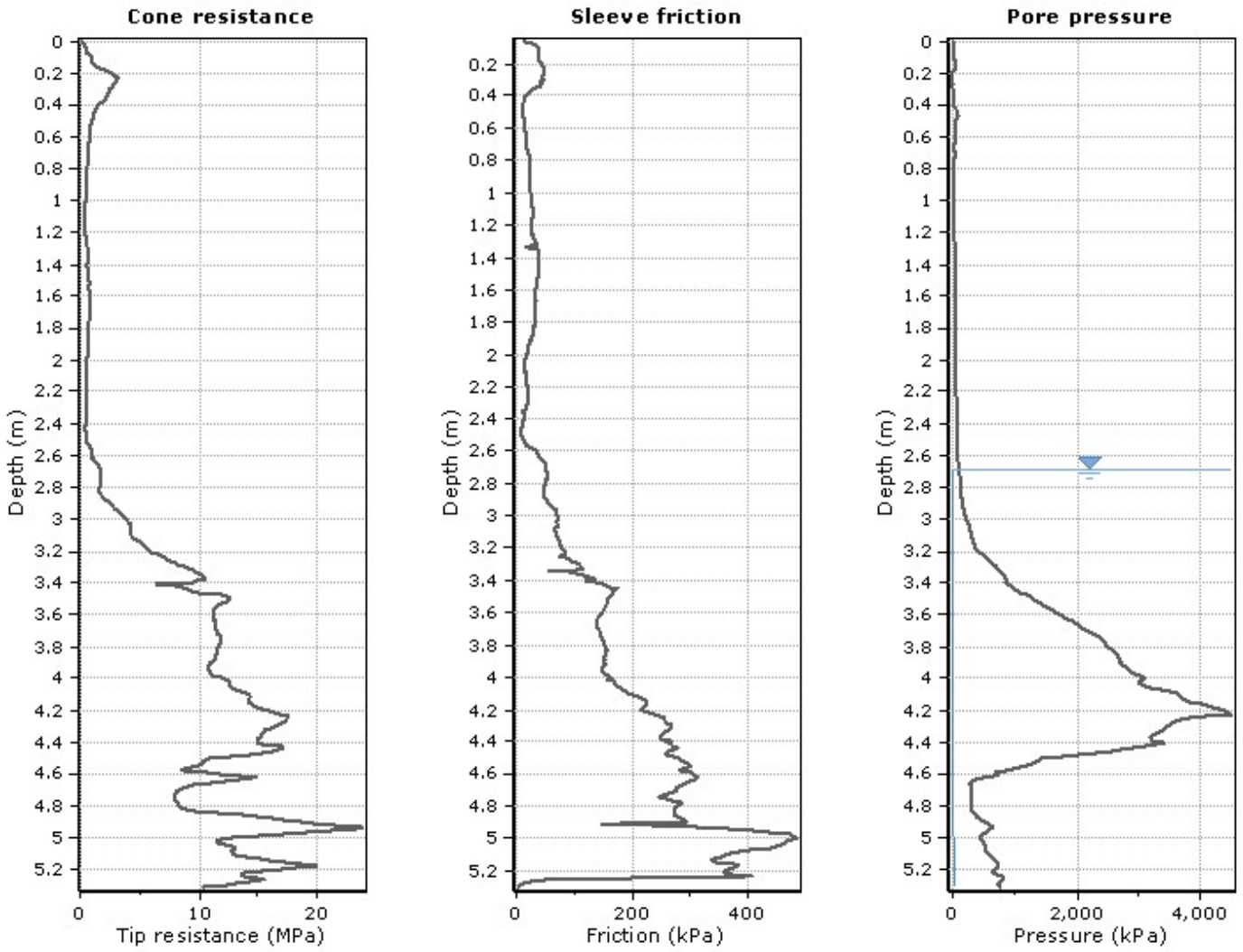


Calculation parameters

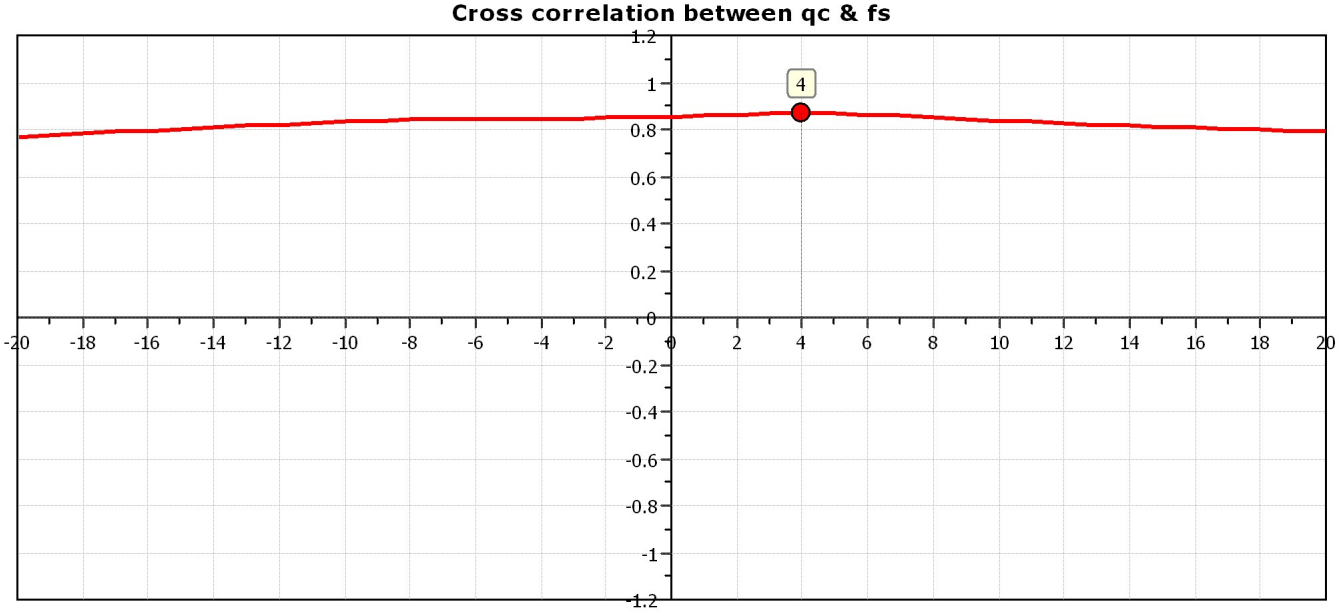
Soil Sensitivity factor, N_S: 7.00
User defined estimation data

CPT: moir st mangawhai_CPT06
Total depth: 5.31 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

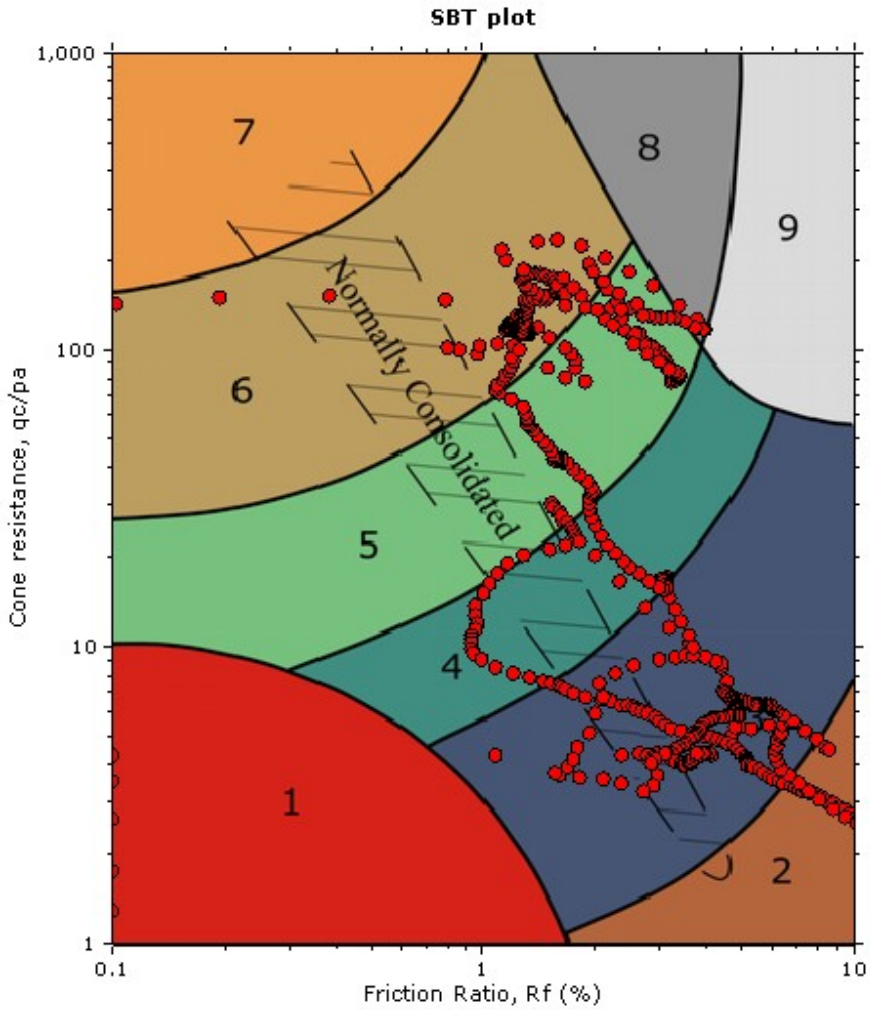
Project: **Causeway Chruch**
Location: **Moir Street**

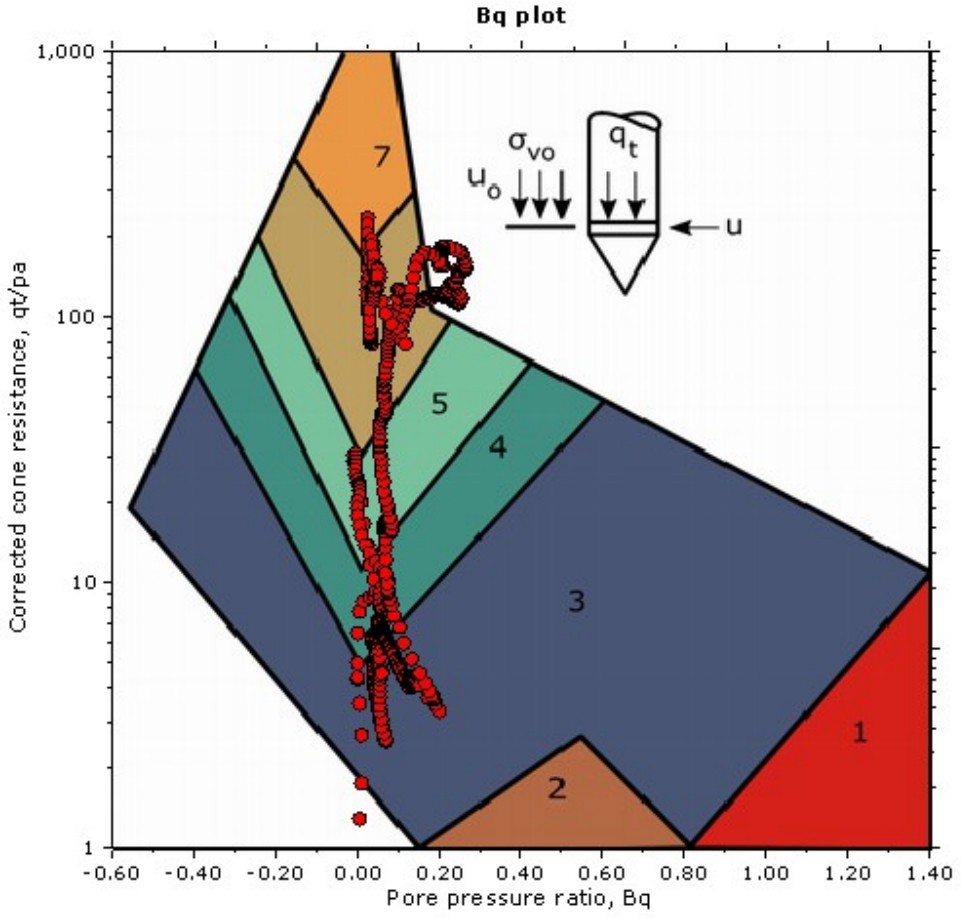


The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).



SBT - Bq plots



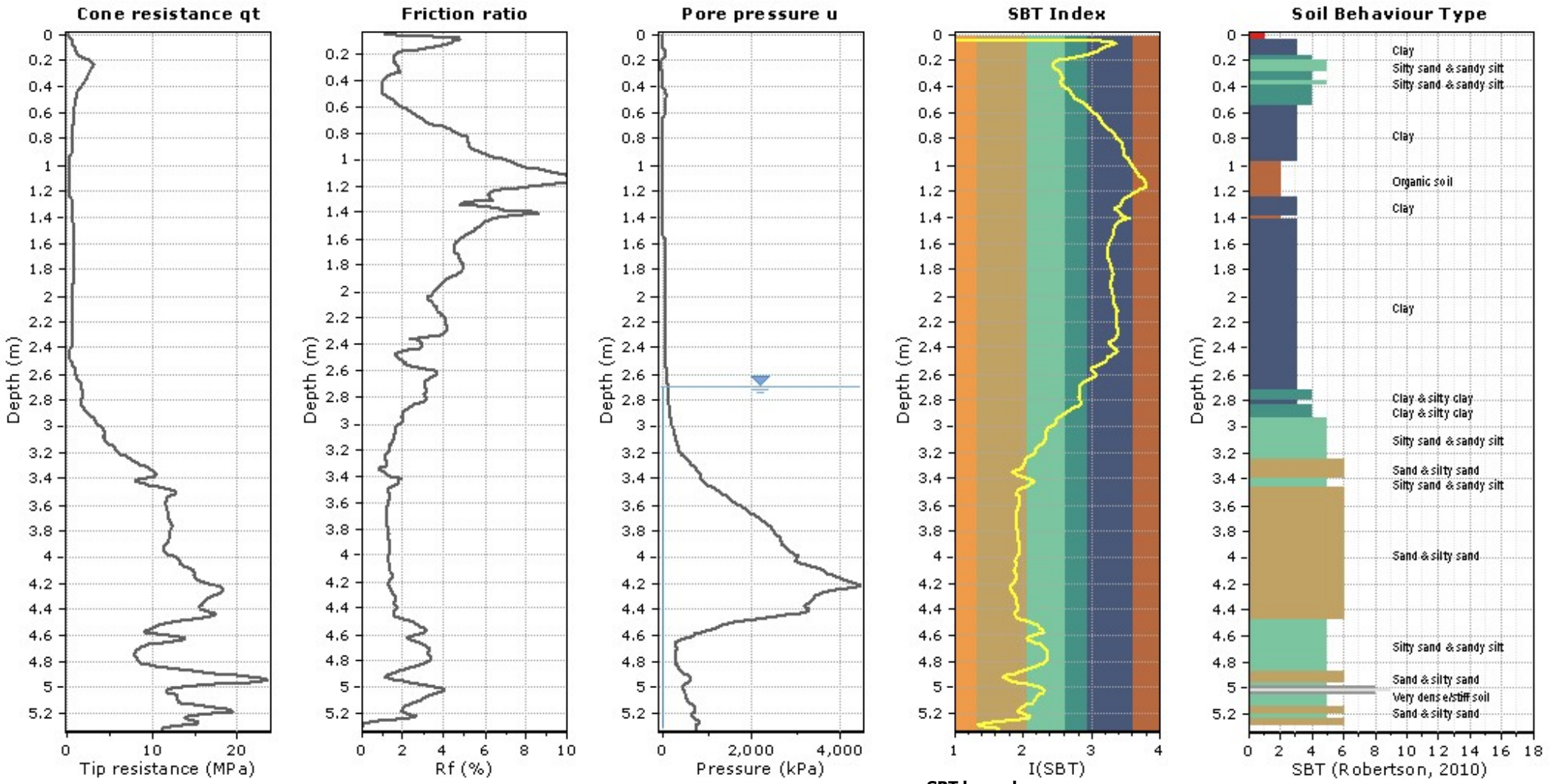


SBT legend

1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

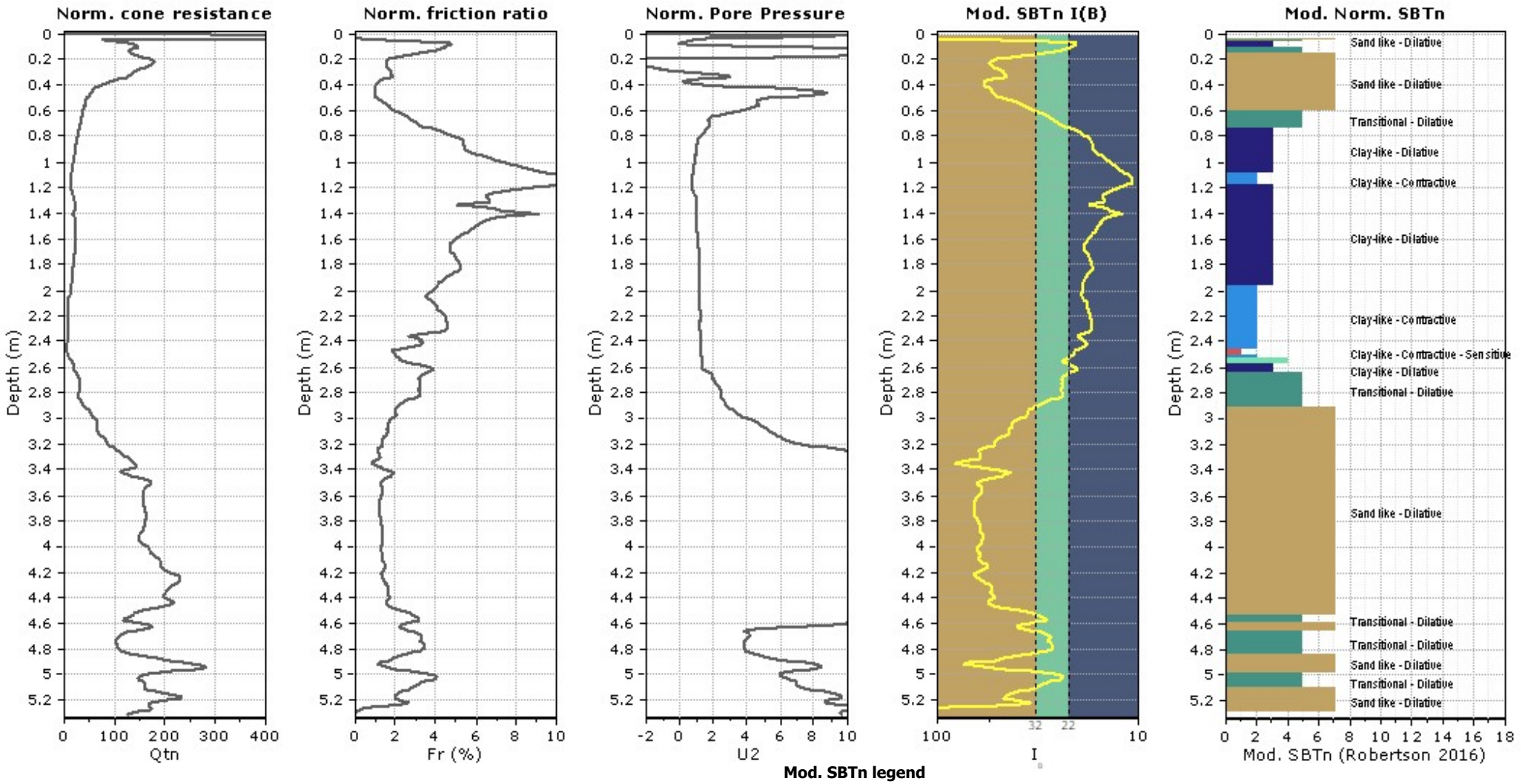
CPT: moir st mangawhai_CPT06
Total depth: 5.31 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**



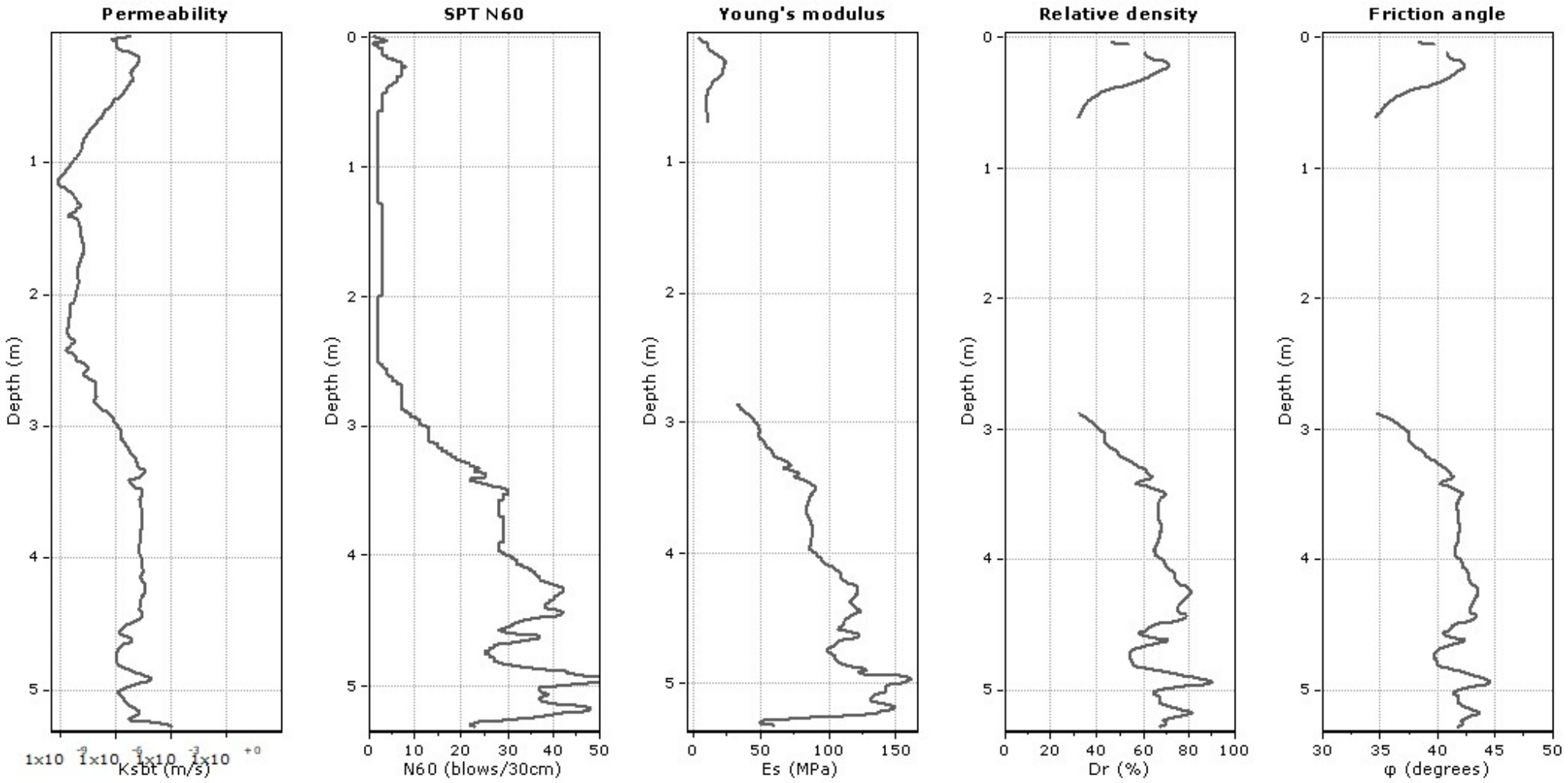
CPT: moir st mangawhai_CPT06
Total depth: 5.31 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**



CPT: moir st mangawhai_CPT06
Total depth: 5.31 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**

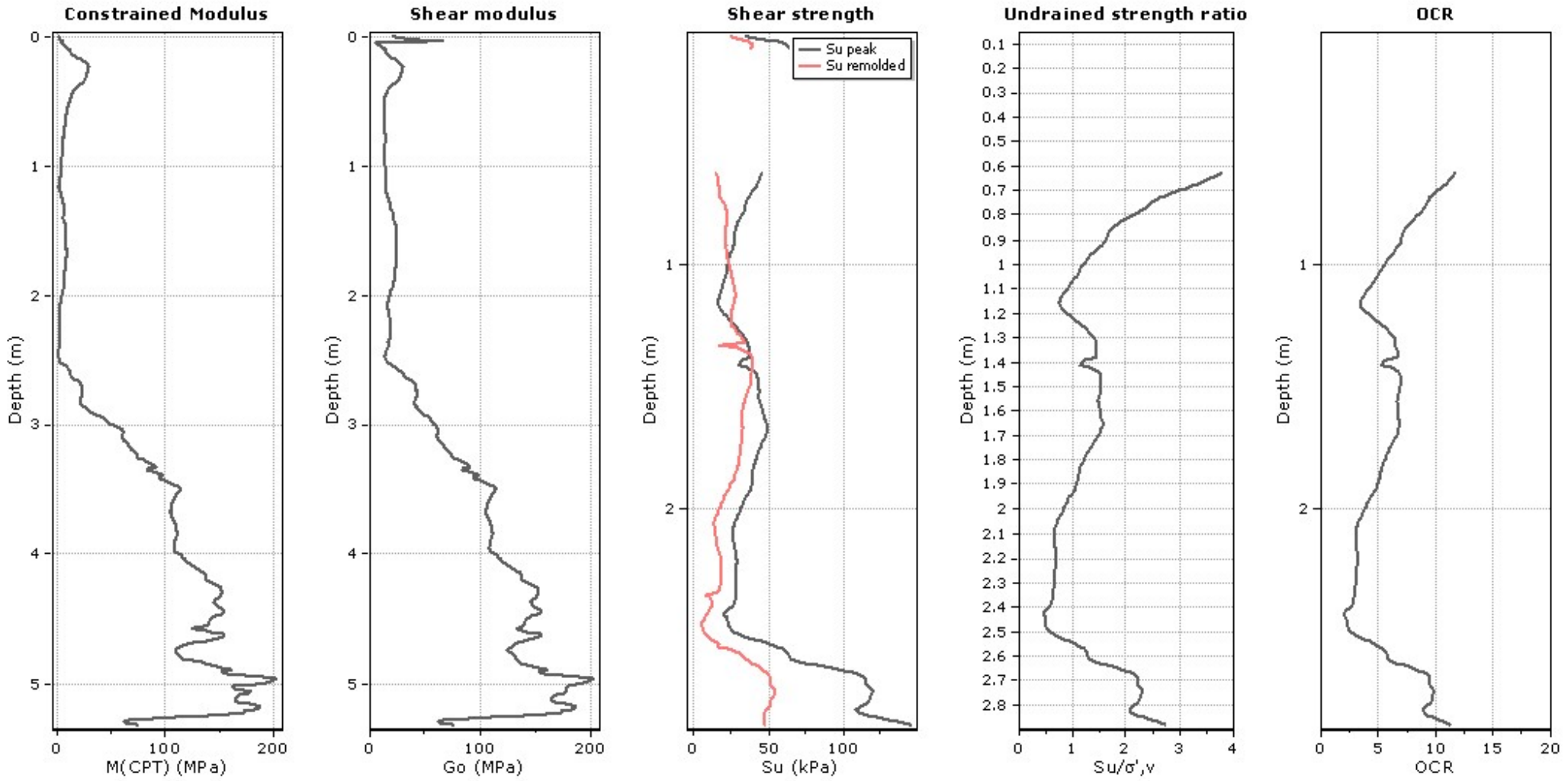


Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative density constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

CPT: moir st mangawhai_CPT06
Total depth: 5.31 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**

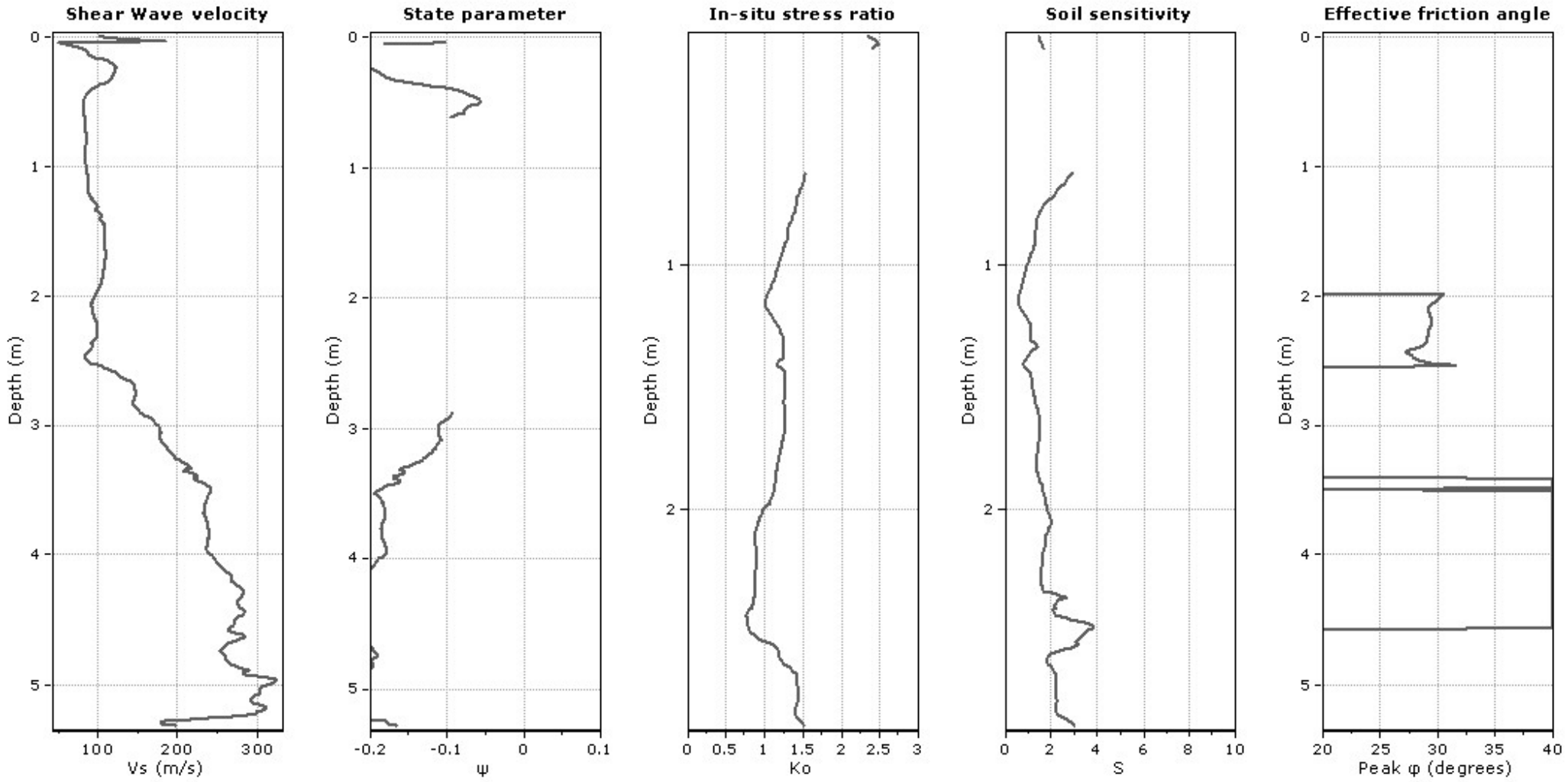


Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14
OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

CPT: moir st mangawhai_CPT06
Total depth: 5.31 m, Date: 15/11/2017
Surface Elevation: 0.00 m
Cone Type: Subtraction
Cone Operator: Prodrill

Project: **Causeway Chruch**
Location: **Moir Street**



Calculation parameters

Soil Sensitivity factor, N_S: 7.00
User defined estimation data