Christchurch City Council

Lyn Christie Place Complex BE 0727 EQ2

Detailed Engineering Evaluation

Quantitative Assessment Report

Christchurch City Council

Lyn Christie Place Complex

Quantitative Assessment Report

30 Wildwood Ave, Wainoni, Christchurch

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Summary

Lyn Christie Place Complex
30 Wildwood Ave, Wainoni, Christchurch
BE 0727 EQ2

Detailed Engineering Evaluation
Quantitative Report - Summary
Final

Background

This is a summary of the quantitative report for the Lyn Christie Place Housing Complex and is based on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011. This assessment covers the 30 residential units.

Key Damage Observed

The damage to the buildings mainly results from the slab settlements causing distortion of the buildings causing cracks in wall and ceiling linings.

Damage to block masonry veneers around windows was also observed throughout the site.

Critical Structural Weaknesses

No critical structural weaknesses were found in any of the buildings.

Indicative Building Strength

None of the buildings on the site are considered to be earthquake prone.

All of the Blocks have a capacity of 52% NBS as limited by the in-plane capacity of the internal walls between the lounge and the bedroom and the kitchen and the bathroom.

Recommendations

It is recommended that all buildings be strengthened to at least 67% NBS.

A geotechnical site investigation should be carried out to determine the liquefaction potential of the site and the thickness of the underlying landfill, if future building on the site is anticipated.

Remediation of the foundations of Blocks A and B should be considered.

Contents

1 Introduction

Opus International Consultants Limited have been engaged by the Christchurch City Council to undertake a detailed seismic assessment of the Lyn Christie Place Complex, located at 30 Wildwood Ave, Wainoni, Christchurch following the Canterbury Earthquake Sequence which began in September 2010.

The purpose of the assessment is to determine if the buildings in the village are classed as being earthquake prone in accordance with the Building Act 2004.

The seismic assessment and reporting have been undertaken based on the qualitative and quantitative procedures detailed in the Detailed Engineering Evaluation Procedure (DEEP) document (draft) issued by the Structural Engineering Society (SESOC) [3] [4].

2 Compliance

This section contains a brief summary of the requirements of the various statutes and authorities that control activities in relation to buildings in Christchurch at present.

2.1 Canterbury Earthquake Recovery Authority (CERA)

CERA was established on 28 March 2011 to take control of the recovery of Christchurch using powers established by the Canterbury Earthquake Recovery Act enacted on 18 April 2011. This act gives the Chief Executive Officer of CERA wide powers in relation to building safety, demolition and repair. Two relevant sections are:

Section 38 – Works

This section outlines a process in which the chief executive can give notice that a building is to be demolished and if the owner does not carry out the demolition, the chief executive can commission the demolition and recover the costs from the owner or by placing a charge on the owners' land.

Section 51 – Requiring Structural Survey

This section enables the chief executive to require a building owner, insurer or mortgagee to carry out a full structural survey before the building is re-occupied.

We understand that CERA require a detailed engineering evaluation to be carried out for all buildings (other than those exempt from the Earthquake Prone Building definition in the Building Act). CERA have adopted the Detailed Engineering Evaluation Procedure (DEEP) document (draft) issued by the Structural Engineering Society (SESOC) on 19 July 2011. This document sets out a methodology for both initial qualitative and detailed quantitative assessments.

It is anticipated that a number of factors, including the following, will determine the extent of evaluation and strengthening level required:

1. The importance level and occupancy of the building.

2. The placard status and amount of damage.
3. The age and structural type of the building.
4. Consideration of any critical structural weaknesses.

Christchurch City Council requires any building with a capacity of less than 34% of New Building Standard (including consideration of critical structural weaknesses) to be strengthened to a target of 67% as required under the CCC Earthquake Prone Building Policy.

2.2 Building Act

Several sections of the Building Act are relevant when considering structural requirements:

Section 112 - Alterations

This section requires that an existing building complies with the relevant sections of the Building Code to at least the extent that it did prior to the alteration. This effectively means that a building cannot be weakened as a result of an alteration (including partial demolition).

The Earthquake Prone Building policy for the territorial authority shall apply as outlined in Section 2.3 of this report.

Section 115 – Change of Use

This section requires that the territorial authority is satisfied that the building with a new use complies with the relevant sections of the Building Code 'as near as is reasonably practicable'.

This is typically interpreted by territorial authorities as being 67% of the strength of an equivalent new building or as near as practicable. This is also the minimum level recommended by the New Zealand Society for Earthquake Engineering (NZSEE).

Section 121 – Dangerous Buildings

This section was extended by the Canterbury Earthquake (Building Act) Order 2010, and defines a building as dangerous if:

1. In the ordinary course of events (excluding the occurrence of an earthquake), the building is likely to cause injury or death or damage to other property; or
2. In the event of fire, injury or death to any persons in the building or on other property is likely because of fire hazard or the occupancy of the building; or
3. There is a risk that the building could collapse or otherwise cause injury or death as a result of earthquake shaking that is less than a 'moderate earthquake' (refer to Section 122 below); or
4. There is a risk that other property could collapse or otherwise cause injury or death; or

5. A territorial authority has not been able to undertake an inspection to determine whether the building is dangerous.

Section 122 – Earthquake Prone Buildings

This section defines a building as earthquake prone (EPB) if its ultimate capacity would be exceeded in a 'moderate earthquake' and it would be likely to collapse causing injury or death, or damage to other property.

A moderate earthquake is defined by the building regulations as one that would generate loads 33% of those used to design an equivalent new building.

Section 124 – Powers of Territorial Authorities

This section gives the territorial authority the power to require strengthening work within specified timeframes or to close and prevent occupancy to any building defined as dangerous or earthquake prone.

Section 131 – Earthquake Prone Building Policy

This section requires the territorial authority to adopt a specific policy for earthquake prone, dangerous and insanitary buildings.

2.3 Christchurch City Council Policy

Christchurch City Council adopted their Earthquake Prone, Dangerous and Insanitary Building Policy in October 2011 following the Darfield Earthquake on 4 September 2010.

1. The policy includes the following:
2. A process for identifying, categorising and prioritising Earthquake Prone Buildings, commencing on 1 July 2012;
3. A strengthening target level of 67% of a new building for buildings that are Earthquake Prone;
4. A timeframe of 15-30 years for Earthquake Prone Buildings to be strengthened; and,
5. Repair works for buildings damaged by earthquakes will be required to comply with the above.

The council has stated their willingness to consider retrofit proposals on a case by case basis, considering the economic impact of such a retrofit.

If strengthening works are undertaken, a building consent will be required. A requirement of the consent will require upgrade of the building to comply 'as near as is reasonably practicable' with:

- The accessibility requirements of the Building Code.
- The fire requirements of the Building Code. This is likely to require a fire report to be submitted with the building consent application.

Where an application for a change of use of a building is made to Council, the building will be required to be strengthened to 67% of New Building Standard or as near as is reasonably practicable.

2.4 Building Code

The Building Code outlines performance standards for buildings and the Building Act requires that all new buildings comply with this code. Compliance Documents published by The Department of Building and Housing can be used to demonstrate compliance with the Building Code.

On 19 May 2011, Compliance Document B1: Structure was amended to include increased seismic design requirements for Canterbury as follows:

- increase in the basic seismic design load for the Canterbury earthquake region (Z factor increased to 0.3 equating to an increase of 36 – 47% depending on location within the region);
- Increased serviceability requirements.

2.5 Institution of Professional Engineers New Zealand (IPENZ) Code of Ethics

One of the core ethical values of professional engineers in New Zealand is the protection of life and safeguarding of people. The IPENZ Code of Ethics requires that:

Members shall recognise the need to protect life and to safeguard people, and in their engineering activities shall act to address this need.

1.1 Giving Priority to the safety and well-being of the community and having regard to this principle in assessing obligations to clients, employers and colleagues.

1.2 Ensuring that responsible steps are taken to minimise the risk of loss of life, injury or suffering which may result from your engineering activities, either directly or indirectly.

All recommendations on building occupancy and access must be made with these fundamental obligations in mind.

3 Earthquake Resistance Standards

For this assessment, the building's earthquake resistance is compared with the current New Zealand Building Code requirements for a new building constructed on the site. This is expressed as a percentage of new building standard (%NBS). The loadings are in accordance with the current earthquake loading standard NZS1170.5 [1].

A generally accepted classification of earthquake risk for existing buildings in terms of %NBS that has been proposed by the NZSEE 2006 [2] is presented in Figure 1 below.

Description	Grade	Risk	%NBS	Existing Building Structural Performance	Improvement of Structural Performance: Legal Requirement	Improvement of Structural Performance: NZSEE Recommendation
Low Risk Building	A or B	Low	Above 67	Acceptable (improvement may be desirable)	The Building Act sets no required level of structural improvement (unless change in use) This is for each TA to decide. Improvement is not limited to 34%NBS.	100%NBS desirable. Improvement should achieve at least 67%NBS
Moderate Risk Building	B or C	Moderate	34 to 66	Acceptable legally. Improvement recommended		Not recommended. Acceptable only in exceptional circumstances
High Risk Building	D or E	High	33 or lower	Unacceptable (Improvement required under Act)	Unacceptable	Unacceptable

Figure 1: NZSEE Risk Classifications Extracted from table 2.2 of the NZSEE 2006 AISPBE Guidelines

Table 1 below compares the percentage NBS to the relative risk of the building failing in a seismic event with a 10% risk of exceedance in 50 years (i.e. 0.2% in the next year).

Table 1: %NBS compared to relative risk of failure

Percentage of New Building Standard (%NBS)	Relative Risk (Approximate)
>100	<1 time
80-100	1-2 times
67-80	2-5 times
33-67	5-10 times
20-33	10-25 times
<20	>25 times

3.1 Minimum and Recommended Standards

Based on governing policy and recent observations, Opus makes the following general recommendations:

3.1.1 Occupancy

The Canterbury Earthquake Order[1] in Council 16 September 2010, modified the meaning of "dangerous building" to include buildings that were identified as being EPB's. As a result of this, we would expect such a building would be issued with a Section 124 notice, by the Territorial Authority, or CERA acting on their behalf, once they are made aware of our

[1] This Order only applies to buildings within the Christchurch City, Selwyn District and Waimakariri District Councils authority.

assessment. Based on information received from CERA to date and from the DBH guidance document dated 12 June 2012 [6], this notice is likely to prohibit occupancy of the building (or parts thereof), until its seismic capacity is improved to the point that it is no longer considered an EPB.

3.1.2 Cordoning

Where there is an overhead falling hazard, or potential collapse hazard of the building, the areas of concern should be cordoned off in accordance with current CERA/territorial authority guidelines.

3.1.3 Strengthening

Industry guidelines (NZSEE 2006 [2]) strongly recommend that every effort be made to achieve improvement to at least 67%NBS. A strengthening solution to anything less than 67%NBS would not provide an adequate reduction to the level of risk.

It should be noted that full compliance with the current building code requires building strength of 100%NBS.

3.1.4 Our Ethical Obligation

In accordance with the IPENZ code of ethics, we have a duty of care to the public. This obligation requires us to identify and inform CERA of potentially dangerous buildings; this would include earthquake prone buildings.

4 Background Information

4.1 Building Descriptions

The site contains 30 residential units constructed in 1974. A site plan showing the locations of the units is shown in Figure 2. All of the units are single-storey, timber-framed buildings with 190mm masonry block firewalls between adjacent units. Cladding is light-weight metal on the roofs and 100mm block masonry veneer on the walls. Foundations are piled perimeter ring beam footings with an in-filled concrete slab on grade. Interior walls are lined with 10mm GIB foil or chipboard and ceilings are lined with 10mm GIB board.

We note that previous settlement (prior to the earthquakes), and subsequent remedial work, to some of the blocks has occurred. The floor slabs are not attached to the walls.

Figure 2: Site plan of Lyn Christie Place.

Figure 3 shows the floor plan of typical unit taken from original drawings.

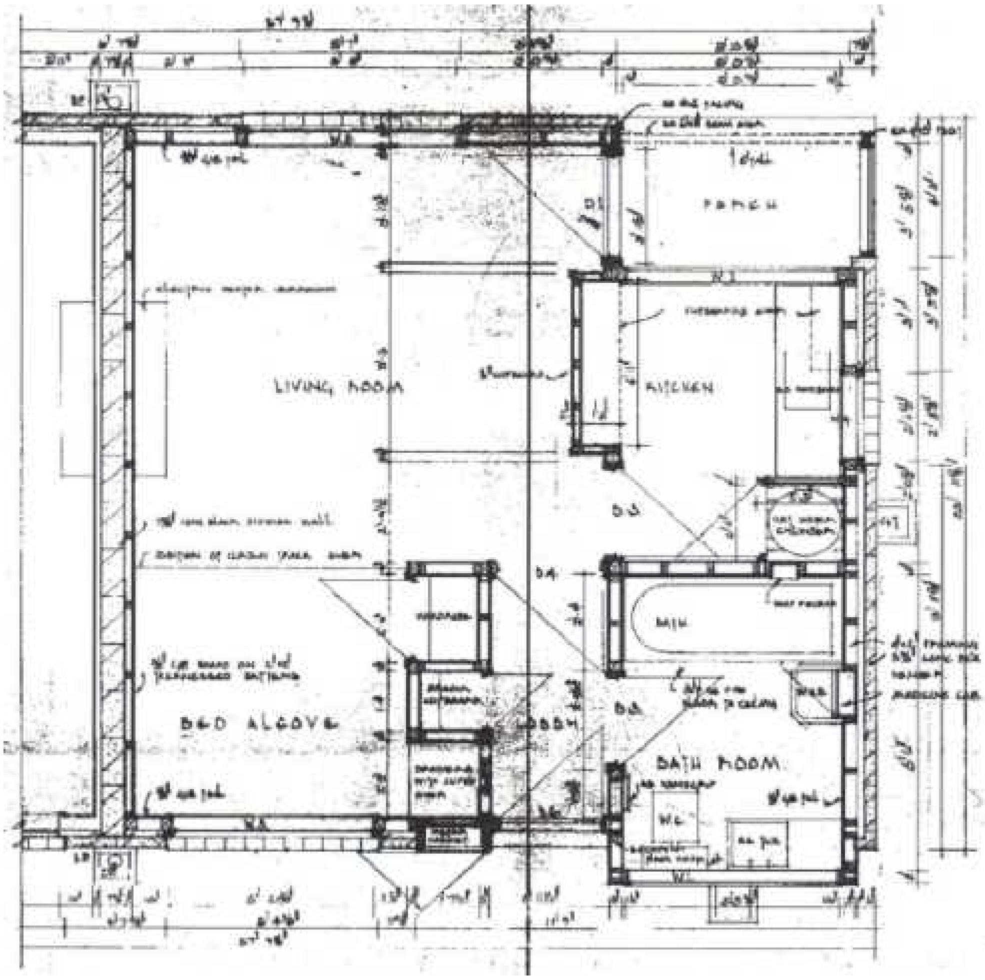

Figure 3: Floor plan of a typical unit.

4.2 Survey

4.2.1 Post 22 February 2011 Rapid Assessment

The extent of rapid assessments following the February earthquake and other events is unknown.

4.2.2 Further Inspections

A further assessment of the site was undertaken on November 7th, 2012 by Opus International Consultants. A summary of the damage to the units is provided in section 5.

4.2.3 Level Survey

A level survey of Blocks A and B was undertaken on 7 November, 2012. The results of the survey are outlined and discussed in section 8.

4.2.4 Geotechnical Survey

A geotechnical site walkover was conducted on November 21st, 2012 to supplement a geotechnical desktop study. A summary of the geotechnical findings is given in section 8.

4.3 Original Documentation

Copies of the following construction drawings were provided by CCC:

- Site Plan for Blocks A, B, C, D and E.
- Site Plan for Blocks F, G and H.
- Floor Plans for Blocks A, B and C, D, E, F and G and H.
- Typical unit cross-section and typical unit floor plan.

The drawings have been used to confirm the structural systems, investigate potential critical structural weaknesses (CSW) and identify details which required particular attention.

Copies of the design calculations were not provided.

5 Structural Damage

This section outlines the damage to the buildings that was observed during site visits. It is not intended to be a complete summary of the damage sustained by the buildings due to the earthquakes. Some forms of damage may not be noticeable during a visual inspection due to being 'hidden' behind cladding, interior linings, etc.

5.1 Residual Displacements

The level survey found evidence of differential settlement in the foundation slabs of Blocks A and B, resulting in a floor slope in the order of 0.5%-0.7%. The results are outlined in more detail in Section 8.

5.2 Foundations

Some slab settlement in the order of 20mm-30mm was noticed around the site due to differential ground settlements.

5.3 Primary Gravity Structure

Deformation of some timber framing was noticed as a result of slab settlements mentioned in the previous paragraph.

5.4 Primary Lateral-Resistance Structure

Some minor cracking of GIB-lined walls was noticed, this could be the result of the earthquakes and/or the slab settlements mentioned in Section 5.2.

5.5 Non Structural Elements

Some stepping and cracking of block masonry veneers was observed around the site.

6 General Observations

The buildings appeared to have performed as reasonably expected during the earthquakes. They have suffered distributed amounts of minor damage which is consistent with the heavy nature of the cladding and the age of the buildings.

7 Detailed Seismic Assessment

The detailed seismic assessment has been based on the NZSEE 2006 [2] guidelines for the "Assessment and Improvement of the Structural Performance of Buildings in Earthquakes" together with the "Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury, Part 2 Evaluation Procedure" [3] draft document prepared by the Engineering Advisory Group on 19 July 2011, and the SESOC guidelines "Practice Note – Design of Conventional Structural Systems Following Canterbury Earthquakes" [5] issued on 21 December 2011.

As the majority of the residential units (all but Units 1 and 2) have the same floor plan, the analysis was simplified by conducting the analysis of each multi-unit block once for each cladding type (brick veneer or block veneer).

7.1 Critical Structural Weaknesses

The term Critical Structural Weakness (CSW) refers to a component of a building that could contribute to increased levels of damage or cause premature collapse of a building. During the initial qualitative stage of the assessment the following potential CSW's were identified for each of the buildings and have been considered in the quantitative analysis.

No critical structural weaknesses were identified in the buildings.

7.2 Quantitative Assessment Methodology

The assessment assumptions and methodology have been included in Appendix 3. A brief summary follows:

Hand calculations were performed to determine seismic forces from the current building codes. These forces were distributed to walls by tributary area and relative rigidity. The capacities of the walls were calculated and used to estimate the % NBS.

7.3 Limitations and Assumptions in Results

Our analysis and assessment is based on an assessment of the building in its undamaged state. Therefore the current capacity of the building may be lower than that stated.

The results have been reported as a %NBS and the stated value is that obtained from our analysis and assessment. Despite the use of best national and international practice in this analysis and assessment, this value contains uncertainty due to the many assumptions and simplifications which are made during the assessment. These include:

- Simplifications made in the analysis, including boundary conditions such as foundation fixity.
- Assessments of material strengths based on limited drawings, specifications and site inspections
- The normal variation in material properties which change from batch to batch.
- Approximations made in the assessment of the capacity of each element, especially when considering the post-yield behaviour.

7.4 Assessment

A summary of the structural performance of the buildings is shown in Table 2. Note that the values given generally represent the worst performing elements in the building, where these effectively define the building's capacity. Other elements within the building may have significantly greater capacity when compared with the governing elements. This will be considered further when developing the strengthening options.

Table 2: Summary of seismic performance.

Block		**Failure Mode, or description of limiting criteria based on displacement capacity of critical element.**	**% NBS based on calculated capacity.**
Blocks A-E	Along	Bracing capacity of walls between the lounge and bedroom and kitchen and bathroom.	52%
	Across	Bracing capacity of walls to the side of the rear hallway.	63%
Block F-H	Along	Bracing capacity of walls between the lounge and bedroom and kitchen and bathroom.	52%
	Across	Bracing capacity of walls to the side of the rear hallway.	61%

8 Summary of Geotechnical Appraisal

8.1 General

The site was used as a landfill in the early 1940's. The Units are built on top of approximately 2m of landfill which was capped as a part of the Lyn Christie Place development. The units have had some historical difficulties relating to ground settlements from the landfill which are identified in a report prepared by MWH in 2001. If any ground disturbance is planned, care should be taken as there may be soil contamination.

Investigation data from a cone penetrometer test (CPT) within 100m of the site showed the expected stratigraphy below Lyn Christie Place to be as indicated in. The groundwater level recorded on the CPT was 1.0m.

Table 3: Inferred ground conditions.

Stratigraphy	Thickness (m)	Depth Encountered from (m) below ground, based on well M35/1499
Landfill of uncontrolled materials, uncompacted	2.0	0
Organic, sensitive fine-grained material	1.0	2.0
Soft CLAY with loose silty SAND	1.0	3.0
Medium dense silty SAND	1.5	4.0
Soft CLAY with occasional SILT	0.5	5.5
Medium dense silty SAND	2.0	6.0
Dense SAND	3.0	8.0
Loose to medium dense SAND	2.0	11.0
Dense to very dense SAND	>5.0	13.0

Geological maps show the site to be close to the border between the Springsteen Formation and the Christchurch Formation. The Springsteen Formation includes postglacial fluvial and over-bank sediments accumulated along the inland margin of the Christchurch Formation. These sediments consist of poorly-graded (well sorted) gravel, sand and silt. The Springsteen Formation has a maximum thickness of 20m.

A summary of the level survey undertaken by Opus Surveyors in November 2012 is given in Table 4.

Table 4: Results from the level survey.

Unit No.	Slope %	Direction of down slope
1 / Block A	0.56	NW
2 / Block A	0.66	SE
3 / Block B	0.67	NW
4 / Block B	0.59	SW
5 / Block B	0.71	W
6 / Block B	0.49	W
7 / Block B	0.55	NE

8.2 Liquefaction Potential

Liquefaction analyses were carried out for three CPT's located near to Lyn Christie Place. During a 500 year the site is categorised as high to very high risk and liquefaction settlements in the order of 130mm are likely to occur, resulting in moderate land damage.

8.3 Summary

The site walk-over on the 21st of November 2012 found evidence of differential ground settlement in the form of cracking of pavements, footpaths and lawns. The nature of the evidence suggested that a significant portion of the settlement observed may have been due to long term settlement related to the land fill that the site is founded on with only minor additional settlement due to the Canterbury earthquakes. It is concluded that the damage to the floor slabs of the units and the ground is from long term settlement of the underlying landfill. There is little evidence that liquefaction contributed to the damage.

The residual slopes of the Blocks A and B indicate that a floor re-level is necessary as the slope is greater than the maximum limits specified in The Building Act 2004 and the Ministry of Business, Innovation and Employment (formerly the Department of Housing) guidelines[2].

Evidence from nearby sites suggests that significant liquefaction settlement is likely to have occurred under the site after the 22 February 2011 earthquake. However, site evidence suggests that liquefaction generated settlements are minimal compared to the long term settlements related to the underlying landfill. It is therefore concluded that the landfill cap likely alleviated any significant differential settlements that may have resulted due to liquefaction.

8.4 Further Work

Further investigation is recommended to gain a better understanding of the site-specific liquefaction hazard and to assess the thickness of the landfill in relation possible remedial measures. The investigation would include:

- An evaluation of a 2001 report by MWH with regards to the landfill.
- 4 CPT's to a depth of 20m.
- 2 hand augers at each building block to verify the thickness of the landfill.
- Assessment and reporting.

9 Conclusions

- None of the buildings on site are considered to be Earthquake Prone.

- All Blocks have a capacity of 52% NBS as governed by the in-plane shear capacity of internal walls of the building between the lounge and bedroom and kitchen and bathroom.

[2] Guidance on house repairs and reconstruction following the Canterbury earthquake, Department of Building and Housing ,2010.

- All Blocks are deemed to be a 'moderate risk' building in a design seismic event according to NZSEE guidelines. Their level of risk is 5-10 times that of a 100% NBS building (Figure 1).
- All Blocks have experienced some differential settlement with the residual slope in the foundations of Blocks A and B exceeding the maximum limits recommended by the Ministry of Business, Innovation and Employment (formerly the Department of Housing).
- We note that there may be some soil toxicity on site.

10 Recommendations

- A strengthening works scheme be developed to increase the seismic capacity of all buildings to at least 67% NBS. The scheme will need to consider compliance with accessibility and fire requirements.
- A geotechnical site investigation should be carried out to determine the liquefaction potential of the site and the thickness of the underlying landfill, if future building on the site is anticipated. This would be required in order to quantify the risk and for the design of new foundation systems.
- Remediation of the foundations of Blocks A and B should be considered.

11 Limitations

- This report is based on an inspection of the buildings and focuses on the structural damage resulting from the 22nd February Canterbury Earthquake and its subsequent aftershocks only. Some non-structural damage may be described but this is not intended to be a complete list of damage to non-structural items.
- Our professional services are performed using a degree of care and skill normally exercised, under similar circumstances, by reputable consultants practicing in this field at this time.
- This report is prepared for the Christchurch City Council to assist in the assessment of any remedial works required for the Lyn Christie Complex. It is not intended for any other party or purpose.

12 References

[1] NZS 1170.5: 2004, Structural design actions, Part 5 Earthquake actions, Standards New Zealand.

[2] NZSEE (2006), Assessment and improvement of the structural performance of buildings in earthquakes, New Zealand Society for Earthquake Engineering.

[3] Engineering Advisory Group, Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury, Part 2 Evaluation Procedure, Draft Prepared by the Engineering Advisory Group, Revision 5, 19 July 2011.

[4] Engineering Advisory Group, *Guidance on Detailed Engineering Evaluation of Non-residential buildings, Part 3 Technical Guidance*, Draft Prepared by the Engineering Advisory Group, 13 December 2011.

[5] SESOC (2011), Practice Note – Design of Conventional Structural Systems Following Canterbury Earthquakes, Structural Engineering Society of New Zealand, 21 December 2011.

[6] DBH (2012), Guidance for engineers assessing the seismic performance of non-residential and multi-unit residential buildings in greater Christchurch, Department of Building and Housing, June 2012.

Appendix 1 - Photographs

Lyn Christie Place		
No.	Item description	Photo
1	Unit Front Elevation - Typical	
2	Unit Back Elevation – Typical Blocks A, B, C, D and E.	

3	Unit Back Elevation – Typical Blocks F, G and H.	
4	Unit Side Elevation - Typical	
5	Unit Roof Framing View - Typical	

6	Unit Interior View - Typical	

Appendix 2 - Geotechnical Appraisal

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7 December 2012

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6-QUCC2.13/55AC

Dear Matt

Lyn Christie Place - Geotechnical Desk Study

1 Introduction

Christchurch City Council (CCC) has requested Opus International Consultants (Opus) to provide a geotechnical desk study and walkover inspection of Lyn Christie Place, blocks A-H, located at 30 Wildwood Avenue, Wainoni.

The purpose of the geotechnical study is to assess the current ground conditions, the potential geotechnical hazards that may be present at the site, and determine whether further subsurface geotechnical investigations are necessary. The geotechnical desk study comprises a site walkover and a preliminary liquefaction assessment.

This Geotechnical Desk Study forms part of a Detailed Engineering Evaluation prepared by Opus, and has been undertaken without the benefit of any site specific investigations and is therefore preliminary in nature.

2 Desktop Study

2.1 Site Description

The site comprising of Blocks A-H with 30 Units which consists of 28 Studios and 2 bedsits at Lyn Christie Place, is located at the North eastern end of Wildwood Avenue approximately 60 metres south of the Pannell Avenue/ Wildwood Avenue intersection in the Wainoni suburb of Christchurch City. The Avon River is located approximately 650 metres to the northwest of the site.

The site was used as a landfill in the early 1940's. It is understood that the units, drive way and a car parking facilities are built in 1974 as well as the stone block retaining wall bordering the east side of the property. The complex was built on approximately two meters of landfill, as reported by Montgomery Watson Harza (MWH) who conducted the investigations of Lyn Christie Place for the Council back in 2001. The landfill is assumed to be capped as part of the Lyn Christie Place development. A veneer of capping was apparently replaced in the 2000's for environmental reason. A summary of the of the MWH report as part of an CCC Agenda 10 Nov 2003 is attached in the appendices and the report is being sort to source any potential geotechnical information it may include. This report will not address any environmental issues associated with the site.

The retirement housing units comprise of eight main blocks of single storey structures with lightweight aluminium roofing and concrete cinderblock external walls which are founded on a perimeter piled concrete ring beam foundation with an in filled concrete slab on grade. The piles are assumed to penetrate the landfill in to natural ground.

As reported in 2001 (MWH), the units have been in some issues from the underlying landfill, notable floor slab settlement, which were apparently remediated by injecting quick setting resin under the floor slabs (CCC Agenda 10 Nov 2003).

2.2 Available Structural Drawings

Although no geotechnical report or records associated with the construction of the complex were found, the Property Unit of the CCC commissioned MWH to undertake some exploratory drilling to ascertain the potential causes of the slumping and property damage back in 2001 (details regarding the MWH report are not available at this stage).

Foundation detail plans showing the layout of the units have been made available and these include room type details within the units. Copies of CCC drawings are included in Appendix D.

Based on the Christchurch City Council's drawings the foundations beneath the retirement housing units consist of an external perimeter piled concrete ring beam footings with an in filled concrete slab on grade. The external perimeter ring beam footings (180x250x510deep) are sitting on pre-tensioned rectangular piles of dimension 100mm by 80mm wide. The length of these piles is currently unknown but it is expect the piles traverse the landfill and capping and are some 2 to 3m in length.

2.3 Regional Geology

The published geological map of the area, (Geology of the Christchurch Urban Area 1:25,000, Brown and Weeber, Map 1, 1992) shows that Lyn Christie Place, located in Wainoni Christchurch, is developed on the border of the Springston Formation, adjacent to the area mapped as Christchurch Formation (east of the project site). See Figure C.1

The Springston Formation includes postglacial fluvial and over-bank sediments accumulated along the inland margin of the Christchurch Formation (deposits ceased circa 3000 years BP). These deposits consist of poorly graded (well sorted) gravel, sand and silt. The Springston formation has a maximum thickness of 20 m.

Reference to the historic "blackmaps" drawing on the Project Orbit website indicated the site bordered onto a swamp.

2.4 Expected Ground Conditions

A review of the geotechnical investigation data from Project Orbit showed one cone penetrometer test (CPT 142) surrounding the area of interest within a 100 metre radius (refer to the Site

Location Plan in Appendix A1). The expected stratigraphy below Lyn Christie Place, inferred from local CPT soil behaviour type (SBT), is shown in Table 2 below. Thees ground conditions needs to be confirmed by specific testing on the site.

Table 2: Ground Conditions

Stratigraphy	Thickness (m)	Depth encountered from below ground level (m)
Landfill of uncontrolled materials, uncompacted	2.0	Surface
Organic, sensitive fine grained material	1.0	2.0
Soft Clay with loose silty Sand	1.0	3.0
Medium dense silty SAND	1.5	4.0
Soft CLAY with occasional SILT	0.5	5.5
Medium dense silty SAND	2.0	6.0
Dense SAND	3.0	8.0
Loose to medium dense SAND	2.0	11.0
Dense to very dense SAND	>5.0	13.0

Groundwater table

The level recorded on the CPT in-situ test log indicates that the groundwater is approximately 1 meter beneath the ground surface.

2.5 Seismic and liquefaction potential

2.5.1 Risk of seismic activity

GNS Science indicates an elevated risk of seismic activity is expected in the Canterbury region as a result of the earthquake sequence following the 4 September 2010 earthquake. Recent advice (Geonet) indicates there is currently a 13% probability that a magnitude 6 or greater earthquake may occur in the next 12 months in the Canterbury region. Ground damage may occur in such an event, dependent on the location of the epicentre. It is expected that the probability of occurrence is likely-to decrease with time, following periods of reduced seismic activity.

2.5.2 Design earthquakes

The site has been subjected to strong seismic shaking with a number of recent earthquakes, especially the 22 February 2011 earthquake which produced very strong shaking in Christchurch. The nearest seismic strong motion recording station to the site is at the Pages Road Pumping Station (PRPC) approximately 500m south-southwest of the site. The peak ground accelerations recorded at the PRPC station were 0.22g for the 4th September 2010 earthquake and 0.66g for the 22nd February 2011 earthquake.

In order to proceed with the liquefaction assessment, the following three acceleration values were taken into account with the relevant design earthquakes:

1) 0.08g, from the Serviceability Limit State (SLS) scenario (using Ch = 1.12 [site subsoil class D], Z = 0.3[for the Canterbury earthquake region], Ru = 0.25 for 1/25 Annual Probability of Exceedance, Mag 7.5 design earthquake).

2) 0.34g, from the Ultimate Limit State (ULS) scenario (using Ch = 1.12 [site subsoil class D], Z = 0.3[for the Canterbury earthquake region], Ru = 1.0 for 1/500 Annual Probability of Exceedance, Mag 7.5 design earthquake).
3) 0.57g, from the conditional peak ground accelerations (PGA), developed for conventional liquefaction assessments by Bradley Seismic Ltd. and the University of Canterbury (Mag 6.3 for the 22nd February 2010 earthquake).

2.5.3 Information from ECAN studies

Table 1

Type of information from project orbit database (EQC)	Description
Liquefaction and Lateral Spreading observed:	Aerial photography shows Moderate-Severe Observed Liquefaction
Observed ground crack locations	From LiDAR observations there are no observations of cracks. However, 100 m south east of the site a number of < 50 mm cracks have been observed from this data.
LiDAR and digital elevation models	Ground surface elevation from LiDAR observation: 13.0 - 13.5 m + ChCh datum at the north side and 11.0 - 11.5 m at the south side.
Vertical ground models	According to the vertical elevation model, the groundlevel has been moved downwards in between -0.2 and -1.5 m
Horizontal ground movement	Direction of the horizontal ground movement is to west, 270 - 290 degrees
Groundwater Surface Elevation	Ground water surface 0 - 2 m deep.
Borehole logs (pre september 2010)	Nearest borehole available M35_1927 available 150 m south west of Lyn Christie.
CCC Borehole logs	An Ecan Borehole M35_1927 is available 140 m south of the units.
CERA Residential zoning maps	The site located in the green zone.
DBH Residential Foundation Technical	DBH Residential Technical category is N/A
CCC CBD Geological sections	EQC report for Wainoni is relevant. This document provides technical information for land damage following the 4 September 2010 and 22 Februari 2011 earthquakes in Canterbury.
EQC Suburban investigation Areas (post eq)	EQC Factual Geotechnical report for Avonside: The EQC report for Avonside provides technical information for land damage following the 2010 / 2011 earthquakes in Canterbury. The factual report collates geotechnical investigation data from boreholes, soil tests, seismic surveys for this suburb. This factual report will be followed by an interpretive report that analyses the data. The two sets of reports will provide information that will assist
EQC Suburban Investigation Areas (pre eq)	" "
Cadestrial boundaries	The site is on the west border of Wainoni and lies within Avonside.

2.5.4 Liquefaction Hazard

Liquefaction Analysis has been completed for three CPTs located nearby the Lyn Christie Place Retirement Village, see appendix E.

The overall assessment of the CPTs surrounding Lyn Christie Place reveals that under SLS conditions the site is categorised as no risk as liquefaction is unlikely to occur and no land damage is expected to occur. However, under both ULS and conditional PGA conditions the site is categorised as high to very high risk and settlements in the order of 130mm are likely to occur. As liquefaction is very likely to occur during an ULS seismic event moderate land damage is likely to occur.

While site observations of ground settlement was prevalent it is difficult to distinguish liquefaction settlement from landfill settlement. Liquefaction settlement may have a low differential distortion especially with the landfill capping any not generate obvious ground features. It is significant that the units with piled foundation have not exhibited any marked structural damage indicating little differential settlement at some 3m depth. Liquefaction settlement would occur below this depth.

3 Site Walkover Inspection

A walkover inspection of the exterior of the buildings and surroundings at Lyn Christie place was carried out by an Opus Geotechnical Engineer on 21 November 2012. The purpose of the walkover was to observe (differential) settlement of the landscape and find evidence of defects caused by liquefaction after the earthquakes of 2010/2011 and aftershocks and attempt to distinguish these from the on-going ground settlement from the landfill. Internal parts of the buildings have not been inspected during this site walk-over; this part is reported separately by a structural engineer.

Observations (21 November 2012)

Several signs of ground movement were observed at the drive way, the footpaths, doorsteps and grass lawn of the individual units and simultaneously a significant amount of defects have been observed, mainly major cracks in the asphalt pavement. There is some evidence of liquefaction observed from observations of various sand bulges in the grass fields but little evidence that the majority of defects are solely due to liquefaction settlement. There was little apparent damage to the external building structure founded on the shallow piles. Site Photographs and Inspection of these defects have been attached to this report, see appendix A3.

Block A (units 1 and 2)

- Major crack in pavement footpath and sand bulge (No 1 south side of block A)
- Cracks in the pavement of the footpath (No 1 south)
- Minor Cracks in pavement (No 1)
- Doorstep settlement and settlement under waste water trap next to the doorstep (No 1)
- Cracking in the mortar of the concrete masonry wall (south-east corner of No 1)
- Asphalt unlevelled at doorstep (No 2)
- Crack of the pavement (No 2)
- Settlement of the gully pot (No 2)
- Rotation of the pole of the clothesline (west of No 2)
- General settlement of garden

Block B (units 3,4,5,6 and 7)

- Repairs of cracks visible, depression of the pavement (bend of the drive way near No 3)
- Crack visible in the mortar of the concrete masonry wall (south-east corner of No 3)
- Cross cracks around the corner of the pavement of footpath (No 5 and No 6)
- Depression of +/- 10 cm along the concrete foundation slab (No 5 and No 6)
- Vertical displacement and depression under gully pot (No 4)
- Defect of a waste water trap (No 4)

Block C (units 8, 9, 10, 11, 12 and 13)

- Settlement of gully pot and cracks in kerb (Car parking next to No 8, near No 7)
- Crack in the kerb, 1.0 cm wide (Car parking next to No 8)
- Rotation of the gully pot +/- 10 degrees (detail at car park north of No 7)
- Bulging of the pavement of the footpath; the grass field is bumpy (No 10 north)
- Pavement of the footpath pushed up (north of No 10)

- Block retaining wall, no defects observed (opposite No 13)
- Distinctive rotation of the pole of a clothesline (in between No 13 and No 14)

Block D (units 14, 15 and 16)

- Differential settlement and minor cracks 1 – 2 mm (at doorstep of No 14)
- Crack between foundation slab and doorway, window cracked (eastside of No 14)
- Minor cracks on footpath (west face of units No 14 and No 15)
- Settlement under the waste water trap (No 16)
- Again, ground level depression under waste water trap (No 16)
- Horizontal cracks in in the mortar of the concrete masonry (No 16)
- Retaining wall next to lawn, grass lawn is bumpy no obvious visual indication of movement observed (east of block C – F)
- bumpy ground level visible (east of block C – F)

Block E (units 17,18 and 19)

- Minor cracks in the pavement of the footpath 1 – 2 mm (between No 17 and No 19)
- Cracks in the doorstep 1 – 2 mm (No 17)
- Settlement under the waste water trap (near no 17)
- Distinctive rotation of the pole of a clothesline (between No 16 and no 17)
- Crack in asphalt of the doorstep (No 18)

Block F (units 20,21,22,23)

- Rotation of the pole of the clothesline (No 23)
- Cracks in the masonry wall, next to the doorstep (No 23)
- Depression of the grass near garden shed (No 20 - 23)

Block G (units 24, 25,26)

- Several cracks along the footpath, most of these cracks are considered to be existing before the earth quake event and caused by long term consolidation settlement (between No 24 and No 26)
- Some minor cracks along the edge of the footpath (between No 24 – No 26)
- Existing and recent cracks in pavement footpath (between No 24 – 26
- Recent crack along the footpath (No 24 – No 26)

Block H (units 27,28,29,30)

- Settlement under waste water trap (corner of No 24)
- Minor cracks in pavement of the footpath (No 27)
- Visible rotation of the street light towards east (No 30)
- Cracks in pavement (next to No 29 and No 30)

4 Level Survey

A floor level survey was carried out in the housing blocks A and B; based on these measurements floor deflections are derived and displayed in Table 3. It should be noted that these measurements do not necessarily reflect settlement within the piled peripheral footings. It is understood that cracking has occurred in these floor slabs and the structural connection to the peripheral footing are not robust.

Table 3: Results Floor Level Survey and floor detection

Unit No / Block No	Floor Variance (mm)	Space between measured variance (m)	Direction of differential settlement	Floor deflection (%)
1 / Block A	34	6.06	Northwest	0.56
2 / Block A	46	6.94	Southeast	0.66
3 / Block B	34	5.05	Northwest	0.67
4 / Block B	46	7.75	Southwest	0.59
5 / Block B	36	5.05	West	0.71
6 / Block B	18	3.64	West	0.49
7 / Block B	38	6.94	Northeast	0.55

The maximum allowable slope between any two points (greater than two metres apart) which indicates that no foundation re-level is considered necessary is 0.5% (1 in 200). The floor deflection exceeds this point in the units of both Block A and B.

5 Discussion and recommendations

- The 21/11/2012 site walk-over found evidence of (differential) settlement of the landscape: cracking in the pavement of the driveway, car parking, footpath and lawn were observed. The length, shape, vegetation and position of these pavement cracks indicate evidence of sub-surface long term settlement from the landfill with perhaps some minor additional displacement from the earthquake inertia and liquefaction.

- The general conclusion is that the damage to the floor slabs of the dwelling units and the grounds is from settlement caused by the underlying landfill. There is little evidence that liquefaction was a significant cause for that damage.

- Most of the variance measurements made across the Blocks A and B floor slabs, indicate that a floor re-level is necessary as the deflection across the floor is greater than the maximum limits specified in the Building Act and the Department of Building and Housing November 2011 guidelines for revised guidance on repairing and rebuilding houses affected by the Canterbury Earthquake sequence.

- The buildings at the site are single storey and timber framed, with either concrete block or brick veneer walls. In general the existing piled foundations have performed well in the recent seismic events, but cracking of the in filled floor slabs have been observed from the outside of the buildings caused by differential settlement recorded in the level survey. This has been reported again as far as back at 2001.

- If the nearby ground investigations are representative, significant liquefaction settlement is likely to have occurred under the site after the 22 February 2011 earthquake. Apart from one sand boil there is no evidence to indicate liquefaction generated significant settlement on site over on going settlements from the landfill. Liquefaction settlements would have occurred under the piled foundations of the peripheral footings but there is no evidence of strength distortion in the dwellings. It can only be concluded that the presence of the landfill cap alleviated any detrimental differential settlements from liquefaction at the surface and the close centre piled foundation aided in locally densifying the underlying sands.

- Recent calculations using nearby ground investigation confirms that liquefaction is very likely to occur under the site during an ULS seismic event but as with the recent earthquakes little detrimental differential settlement should occur at the surface

Remedial works may include re-levelling of the units of structural damage. A number of approaches could be considered:-

- The floor slabs be re-levelled using engineered resin – a temporary solution with on-going landfill settlement
- Re-level and support the floor slab on close centred micropiles
- Reconstruction and redesign of the floor to be a suspended floor slab to be tied/structurally connected to the external concrete perimeter ring beam foundation.

6 Proposed ground investigations

Subject to evaluating the 2001 MWH report on the landfill, it is recommended that in order to further understand the future of the buildings with the Lyn Christie complex and to confirm remedial works, a site specific investigation is undertaken including CPTs, hand augers and scalas. The site investigation data will enable a liquefaction assessment to be undertaken and can localise the thickness of the landfill and underlying weak soils to aid remedial measures. The investigation should focus on the observed area of ground damage in the centre of the site.

The information obtained from the liquefaction assessment and site walkover will help Christchurch City Council understand and separate the future risk of liquefaction and potential ground damage from the underlying landfill for Lyn Christie Place. It will further identify and detail
concept repair options for the buildings.

Further ground investigations can be helpful to classify the local soil strata, soil properties and ground water table. With this factual information a detailed assessment can be carried out to decide on the future of the complex.

The scope of the proposed site specific geotechnical investigations will be:

- Evaluate MWH 2001 report on the landfill
- 4 Cone Penetrometer Tests (CPT's) to a depth of 20m
- 2 Hand augers at each building block (total 16) to verify the thickness of the landfill.
- Assessment and reporting

7 Limitation

This report has been prepared solely for the benefit of Christchurch City Council as our client with respect to the particular brief given to us. Data or opinions in this desk study may not be used in other contexts, by any other party or for any other purpose.

It is recognised that the passage of time affects the information and assessment provided in this document. Opus's opinions are based upon information that existed at the time of the production of this Desk Study. It is understood that the Services provided allowed Opus to form no more than an opinion on the actual conditions of the site at the time the site was visited and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings or any laws or regulations.

8 References

- Brown, LJ; Webber, JH 1992: Geology of the Christchurch Urban Area. Scale 1:25,000. Institute of Geological and Nuclear Sciences geological map, 1 sheet + 104p.

  http://ecan.govt.nz/services/online-services/tools-calculators/Pages/well-card.aspx
- Project Orbit, 2011: Interagency/organisation collaboration portal for Christchurch recovery effort. https://canterburyrecovery.projectorbit.com/SitePages/Home.aspx
- GNS Science reporting on Geonet Website: http://www.geonet.org.nz/canterbury-quakes/aftershocks/ updated on 9 September 2012.
- Revised Guidance on repairing and rebuilding houses affected by the Canterbury earthquake sequence. Dept. of Building and Housing November 2011.
- Montgomery Watson Harza 2001: Report regarding Lyn Christie Housing Complex - CCC Agenda 10 Nov 2003.

Appendices:

Appendix A1: Site Location Plan
Appendix A2: Floor Level Survey
Appendix A3: Site Walkover inspection notes and photos
Appendix B1: Location plan of available ground investigation
Appendix B2: Environment Canterbury (ECAN) Borehole Logs and EQC CPT plots
Appendix C: Geology
Appendix D: Available drawings
Appendix E: Liquefaction assessment
Appendix F: CCC Agenda 10 Nov 2003.

Report by P Cohen

Yours sincerely

OPUS

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Appendix A:

Appendix A1: Site Location Plan
Appendix A2: Floor Level Survey
Appendix A3: Site Walkover inspection notes and photos

SOURCE: Christchurch City Council
canterburyrecovery.projectorbit.com (Accessed on 21/11/12)

CCC reference BE 0727 – Blocks A-H
Lyn Christie Place
28 Studios, 2 Bedsits

Opus International Consultants Ltd Auckland Office The Westhaven 100 Beaumont St, Auckland New Zealand Tel: +64 9 355 9500 Fax: +64 9 355 9680 OPUS	**Project:**	Lyn Christie Place Geotechnical Desktop Study	**Figure A.1 Site Location Plan**
	Project No.:	6-QUCC2.13/55AC	**Drawn:** Opus Geotechnical Engineer
	Client:	Christchurch City Council	**Date:** 21/11/2012

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OPUS

Project:	Lyn Christie Place Geotechnical Desktop Study
Project No.:	6-QUCC2.13/55AC
Client:	Christchurch City Council

Figure A.2 Floor Level Survey

Drawn: Opus Geotechnical Engineer

Date: 21/11/2012

Appendix A.3: Site Photographs

Photos of observed defects during site walkover 21-11-2012 :

DRIVE WAY

Figure 1 Street view of the Lyn Christie Place (units 27-30 block H; drive way on the left side)

Block A (units 1 and 2)

Figure 2 Major crack in pavement footpath at sand bulge (footpath towards unit No 1 (south side of block A, facing north)

Figure 3 Close-up of sand bulge and cracks in the pavement (footpath towards unit No 1 southside of block A, facing north)

Figure 4 Doorstep settlement; settlement under waste water trap (unit No 1 Block A)

Figure 5 Minor Cracks in pavement and detail below (unit No 1 block A on the right, facing south / towards block D No 17-19)

Figure 6 Cracking in the mortar of the concrete masonry wall (around the corner of unit No 1 block A facing north)

Figure 7 Rotation of the pole of the clothesline (west of unit No 2 Block A facing west)

Figure 8 Settlement of the gully pot (unit No 2 Block A)

Figure 9 Crack of the pavement (unit No2 Block A)

Figure 10 Crack of the pavement (unit No2 Block A, facing south-west)

Figure 11 Cracks of drive way and repair (Block B, unit No 3 facing south)

Block B (units 3,4,5,6 and 7)

Figure 12 End of the drive way (unit No 3 Block B facing south)

Figure 13 Bend on the end of the drive way, repairs of cracks visible general depression of the pavement visible (Unit No 3 of Block B facing north)

Figure 14 Bend on the end of drive way facing east, various repair work of asphalt cracks (Unit No 3 block B facing east)

Figure 15 West of block B, facing east

Figure 16 Cracking (at doorstep of unit 5 Block B facing south)

Figure 17 Detail of cracking (at doorstep of unit 5 Block B facing south)

Figure 18 Close-up of the concrete foundation; depression of +/- 10 cm along the concrete foundation slab (unit No 5 and No 6 Block B)

Figure 19 Cross cracks around the corner of the pavement of footpath (unit No 5 and No 6 of Block B)

Figure 20 Differential settlement (total +/- 10 cm) of doorstep unit No 5 Block B

Figure 21 Close-up of gully pot; vertical displacement and depression under gully pot (unit No 4 block B)Figure 22 Defect of a waste water trap (unit No 4 block B)

Figure 23 45 degrees crack visible in the mortar of the concrete masonry wall (south-east corner of unit No 3, facing west)

Block C (units 8, 9, 10, 11, 12 and 13)

Figure 24 Block retaining wall, no defects observed (opposite unit No 13, Block C)

Figure 26 Distinctive rotation of the pole clothesline (in between unit No 13 and No 14, block C and D)

Figure 27 Bulging of the pavement of the footpath, the grass field is bumpy (No 10 north of block C facing west)

Figure 28 Pavement of the footpath pushed up, possibly due to a sand well. There is a safety cone placed next to the footpath to indicate this defect (north of unit No 10 Block C, facing east).

Figure 29 Setttlement of gully pot and cracks in kerb (Car parking next to No 8 (near No 7 facing north-east)

Figure 30 idem (Car parking in front of No 7 (Block B), facing south-east)

Figure 31 Detail of a crack in the kerb, 1.0 cm wide (Car parking next to No 8, west of Block C, facing East)

Figure 32 Other detail of crack in kerb (to No 8, west of Block C, facing East)

Figure 33 Rotation of the gully pot (detail at car park north of unit No 7, Block B/C)
Figure 34 idem

Block D (units 14,15 and 16)

Figure 35 Differential settlement and minor cracks at (doorstep of unit No 14 Block D)
Figure 36 Crack between foundation slab and doorway, window cracked (eastside of unit No 14, block D facing south)
Figure 37 Minor cracks on footpath (west face of units No 14 and No 15 Block D facing north)
Figure 38 Settlement under the waste water trap (unit No 16 Block D, facing south)
Figure 39 Again, ground level depression under waste water trap (No 16 of block D)
Figure 40 Horizontal cracks in in the mortar of the concrete masonry (No 16 of block D)
Figure 41 Retaining wall next to lawn, grass lawn is bumpy (east of block C – F facing south, no obvious visual indication of movement observed)
Figure 42 Retaining wall next to lawn (east of block C – F)
Figure 43 Detail of the retaining wall, bumpy ground level visible (east of block C – F)

Block E (units 17,18 and 19)

Figure 44 Minor cracks in the pavement of the footpath (betwee n Unit No 17 and No 19 Block E)
Figure 45 Cracks in the doorstep (No 17 Block E)
Figure 46 Settlement under the waste water trap (near no 17 block E)
Figure 47 Distinctive rotation of the pole of the clothesline (between unit No 16 and no 17 block D and E)
Figure 48 Crack in asphalt of the doorstep (No 18 Block E, facing east)

Block F (units 20,21,22,23)

Figure 49 Rotation of the pole of the clothesline (No 23 of block F facing south)
Figure 50 Detail retaining wall along the grass lawn, no significant defects observed (near unit No 22 and No 23 block F)
Figure 51 Cracks in the masonry wall, next to the doorstep of (unit No No 23 Block F)

Block G (units 24, 25,26)

Figure 52 Several cracks along the footpath, most of these cracks are considered to be existing before the earth quake event and caused by long term consolidation settlement (between unit No 24 and No 26 Block G)
Figure 53 Some minor cracks on along the edge of the footpath (between unit No 24 – No 26 of block G)
Figure 54 Existing and recent cracks in pavement footpath (between No 24 – 26
Figure 55 Recent crack along the footpath (unit No 24 – No 26, block G)

Block H (units 27,28,29,30)

Figure 56 Settlement under waste water trap (corner of unit No 24, Block H)
Figure 57 Crack perpendicular to the drive way (unit No 3, between block B and block H)
Figure 58 Minor cracks in pavement (No 27, Block H, facing north-east
Figure 59 Visible rotation of the street light towards east (unit 30 facing north east)
Figure 60 Cracks in pavement (next to No 29 and No 30 block H

Figure 1 Street view of the Lyn Christie Place (units 27-30 block H; drive way on the left side)

Figure 2 Major crack in pavement footpath at sand bulge (footpath towards unit No 1 (south side of block A, facing north)

Figure 3 Close-up of sand bulge and cracks in the pavement (footpath towards unit No 1 southside of block A, facing north)

Figure 4 Doorstep settlement; settlement under waste water trap (unit No 1 Block A)

Figure 5 Minor Cracks in pavement and detail below (unit No 1 block A on the right, facing south / towards block D No 17-19)

Figure 6 Cracking in the mortar of the concrete masonry wall (around the corner of unit No 1 block A facing north)

Figure 7 Rotation of the pole of the clothesline (west of unit No 2 Block A facing west)

Figure 8 Settlement of the gully pot (unit No 2 Block A)

Figure 9 Crack of the pavement (unit No2 Block A)

Figure 10 Crack of the pavement (unit No2 Block A, facing south-west)

Figure 11 Cracks of drive way and repair (Block B, unit No 3 facing south)

Figure 12 End of the drive way (unit No 3 Block B facing south)

Figure 13 Bend on the end of the drive way, repairs of cracks visible general depression of the pavement visible (Unit No 3 of Block B facing north)

Figure 14 Bend on the end of drive way facing east, various repair work of asphalt cracks (Unit No 3 block B facing east)

Figure 15 West of block B, facing east

Figure 16 Cracking (at doorstep of unit 5 Block B facing south)

Figure 17 Detail of cracking (at doorstep of unit 5 Block B facing south)

Figure 18 Close-up of the concrete foundation; depression of +/- 10 cm along the concrete foundation slab (unit No 5 and No 6 Block B)

Figure 19 Cross cracks around the corner of the pavement of footpath (unit No 5 and No 6 of Block B)

Figure 20 Differential settlement (total +/- 10 cm) of doorstep unit No 5 Block B

Figure 21 Close-up of gully pot; vertical displacement and depression under gully pot (unit No 4 block B)

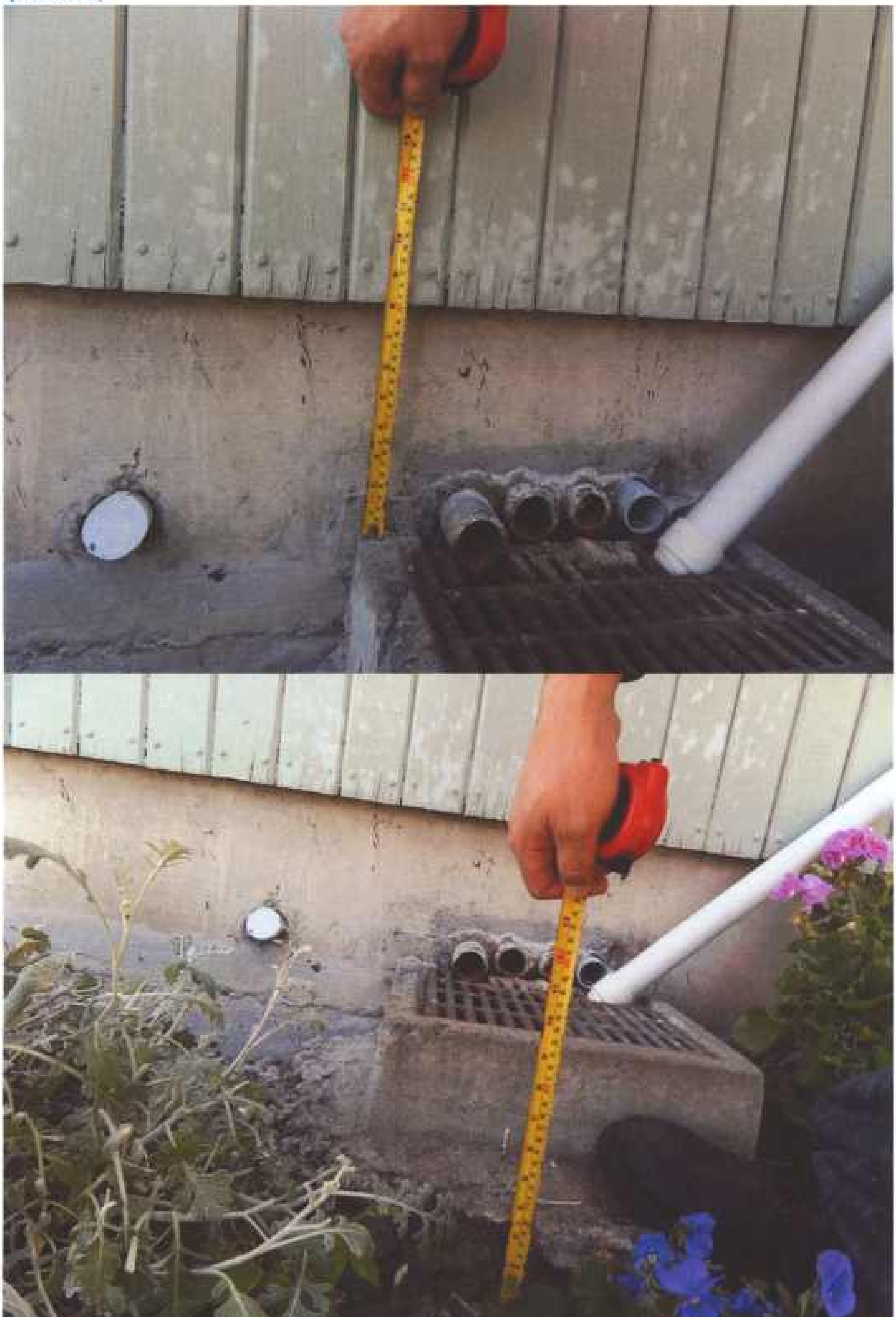


Figure 22 Defect of a waste water trap (unit No 4 block B)

Figure 23 45 degrees crack visible in the mortar of the concrete masonry wall (south-east corner of unit No 3, facing west)

C

Figure 24 Block retaining wall, no defects observed (opposite unit No 13, Block C)

Figure 25 Settlement under west side of the mini-container, also cracks along the concrete (opposite unit No 13 of Block C)

Figure 26 Distinctive rotation of the pole clothesline (in between unit No 13 and No 14, block C and D)

Figure 27 Bulging of the pavement of the footpath, the grass field is bumpy (No 10 north of block C facing west)

Figure 28 Pavement of the footpath pushed up, possibly due to a sand well. There is a safety cone placed next to the footpath to indicate this defect (north of unit No 10 Block C, facing east).

Figure 29 Setttlement of gully pot and cracks in kerb (Car parking next to No 8 (near No 7 facing north-east)

Figure 30 idem (Car parking in front of No 7 (Block B), facing south-east)

Figure 31 Detail of a crack in the kerb, 1.0 cm wide (Car parking next to No 8, west of Block C, facing East)

Figure 32 Other detail of crack in kerb (to No 8, west of Block C, facing East)

Figure 33 Rotation of the gully pot (car park north of unit No 7, Block B/C)

Figure 34 Rotation of the gully pot (detail at car park north of unit No 7, Block B/C)

Figure 35 Differential settlement and minor cracks at (doorstep of unit No 14 Block D)

Figure 36 Crack between foundation slab and doorway, window cracked (eastside of unit No 14, block D facing south)

Figure 37 Minor cracks on footpath (west face of units No 14 and No 15 Block D facing north)

Figure 38 Settlement under the waste water trap (unit No 16 Block D, facing south)

Figure 39 Again, ground level depression under waste water trap (No 16 of block D)

Figure 40 Horizontal cracks in in the mortar of the concrete masonry (No 16 of block D)

Figure 41 Retaining wall next to lawn, grass lawn is bumpy (east of block C – F facing south, no obvious visual indication of movement observed)

Figure 42 Retaining wall next to lawn (east of block C – F)

Figure 43 Detail of the retaining wall, bumpy ground level visible (east of block C – F)

Figure 44 Minor cracks in the pavement of the footpath (betwee n Unit No 17 and No 19 Block E)

Figure 45 Cracks in the doorstep (No 17 Block E)

Figure 46 Settlement under the waste water trap (near no 17 block E)

Figure 47 Distinctive rotation of the pole of the clothesline (between unit No 16 and no 17 block D and E)

Figure 48 Crack in asphalt of the doorstep (No 18 Block E, facing east)

Figure 49 Rotation of the pole of the clothesline (No 23 of block F facing south)

Figure 50 Detail retaining wall along the grass lawn, no significant defects observed (near unit No 22 and No 23 block F)

Figure 51 Cracks in the masonry wall, next to the doorstep of (unit No No 23 Block F)

Figure 52 Several cracks along the footpath, most of these cracks are considered to be existing before the earth quake event and caused by long term consolidation settlement (between unit No 24 and No 26 Block G)

Figure 53 Some minor cracks on along the edge of the footpath (between unit No 24 – No 26 of block G)

Figure 54 Existing and recent cracks in pavement footpath (between No 24 – 26 block G)

Figure 55 Recent crack along the footpath (unit No 24 – No 26, block G)

Figure 56 Settlement under waste water trap (corner of unit No 24, Block H)

Figure 57 Crack perpendicular to the drive way (unit No 3, between block B and block H)

Figure 58 Minor cracks in pavement (No 27, Block H, facing north-east)

Figure 59 Visible rotation of the street light towards east (unit 30 facing north east)

Figure 60 Cracks in pavement (next to No 29 and No 30 block H)

Appendix B:

Appendix B1: Earthquake Damaged Zone Plan
Appendix B2: Location plan of available ground investigation
Appendix B3: Environment Canterbury (ECAN) Borehole Logs and EQC CPT plots

SOURCE: canterburyrecovery.projectorbit.com (Accessed on 19/09/12)

Opus International Consultants Ltd Auckland Office The Westhaven 100 Beaumont St, Auckland New Zealand Tel: +64 9 355 9500 Fax: +64 9 355 9680	**OPUS**	**Project:** **Project No.:** **Client:**	Lyn Christie Place Geotechnical Desktop Study 6-QUCC2.13/55AC Christchurch City Council	**Figure B.1 EQ_Damaged Zone Plan** **Drawn:** Opus Geotechnical Engineer **Date:** 21/11/2012

SOURCE: canterburyrecovery.projectorbit.com (Accessed on 21/11/12)

Opus International Consultants Ltd Auckland Office The Westhaven 100 Beaumont St, Auckland New Zealand Tel: +64 9 355 9500 Fax: +64 9 355 9660 OPUS	**Project:** **Project No.:** **Client:**	Lyn Christie Place Geotechnical Desktop Study 6-QUCC2.13/55AC Christchurch City Council	**Figure B.2 Location of existing Ground investigation** **Drawn:** Opus Geotechnical Engineer **Date:** 21/11/2012

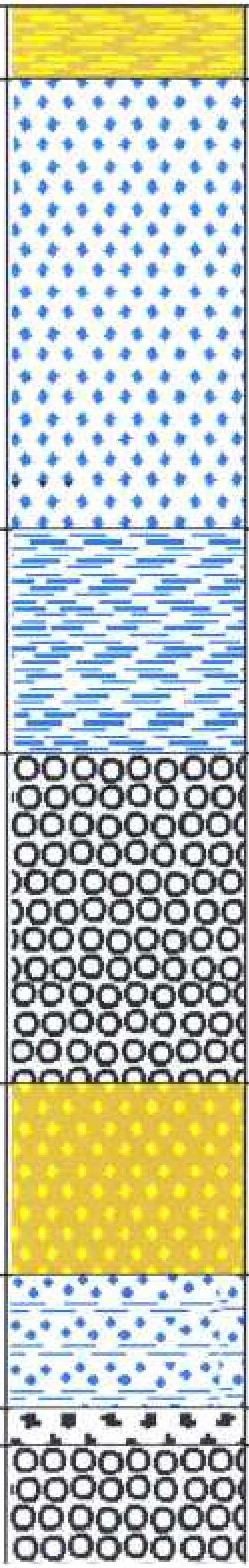
Appendix B3:

Environment Canterbury (ECAN) Borehole Logs and EQC CPT plots

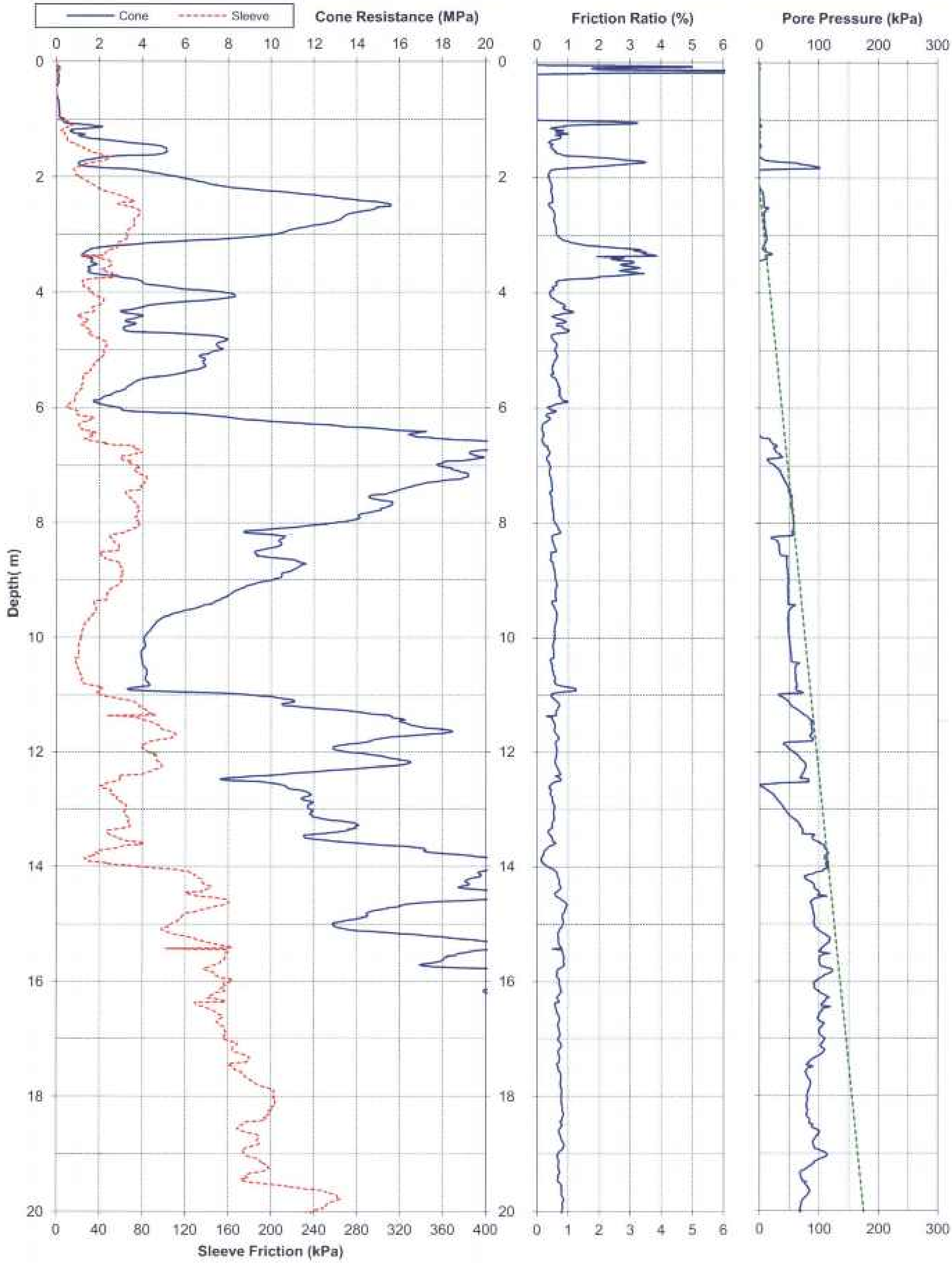
Borelog for well M35/1927

Gridref: M35:844-425 Accuracy : 4 (1=high, 5=low)
Ground Level Altitude : 2.9 +MSD
Driller : Job Osborne (& Co/Ltd)
Drill Method : Hydraulic/Percussion
Drill Depth : -86.59m Drill Date : 23/05/1999

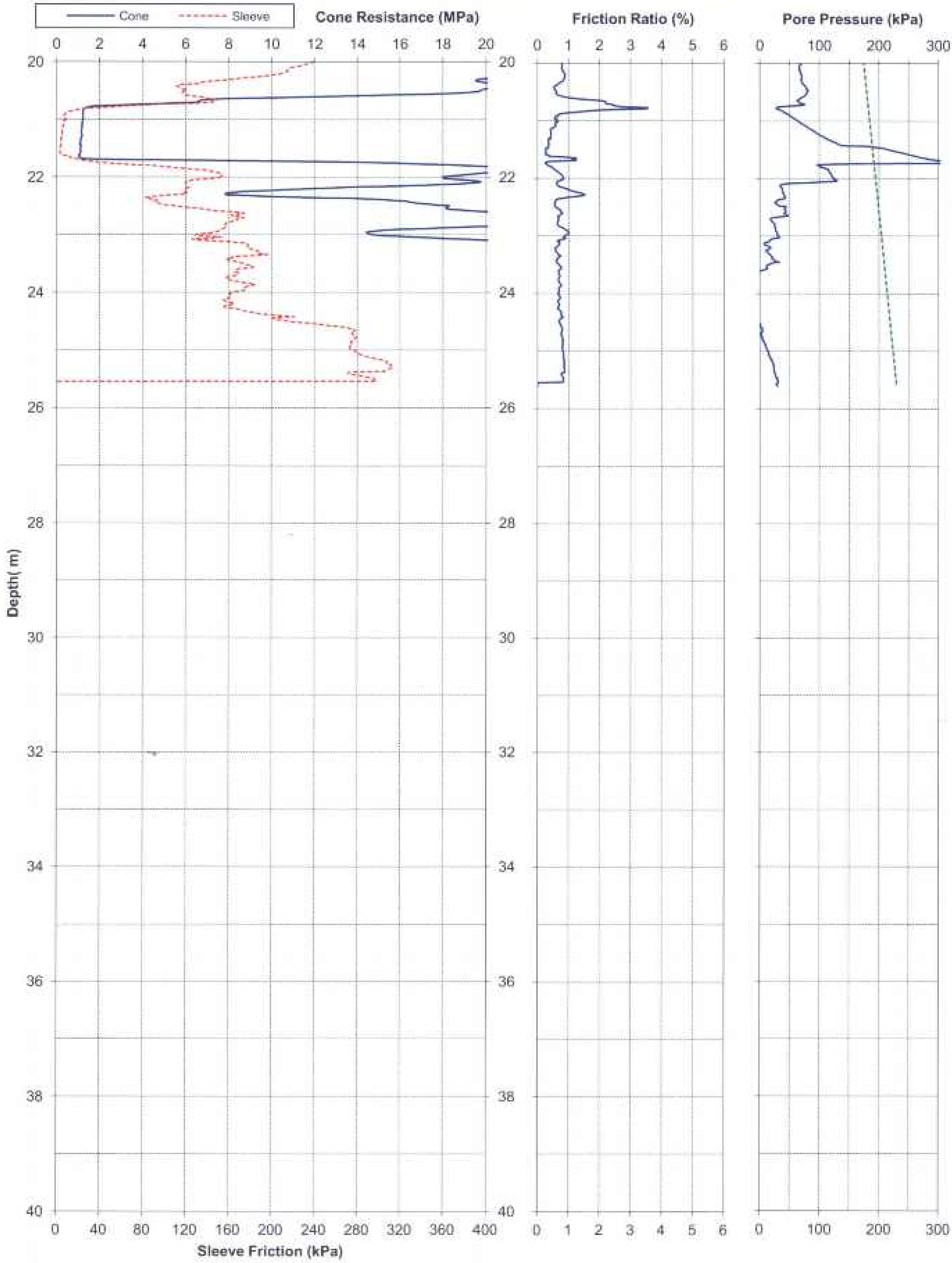
Scale(m)	Water Level	Depth(m)	Full Drillers Description
	Artesian	-3.00m	Clay, yellow
-10			
-20		- 21.5m	Sand, blue
		- 30.8m	Clay, blue
-30			
-40		- 44.5m	Gravel hard
-50		- 52.4m	Sand, yellow
		- 57.9m	Sandy clay, blue
		- 59.4m	Sand & grit, blue
-60			Gravel hard



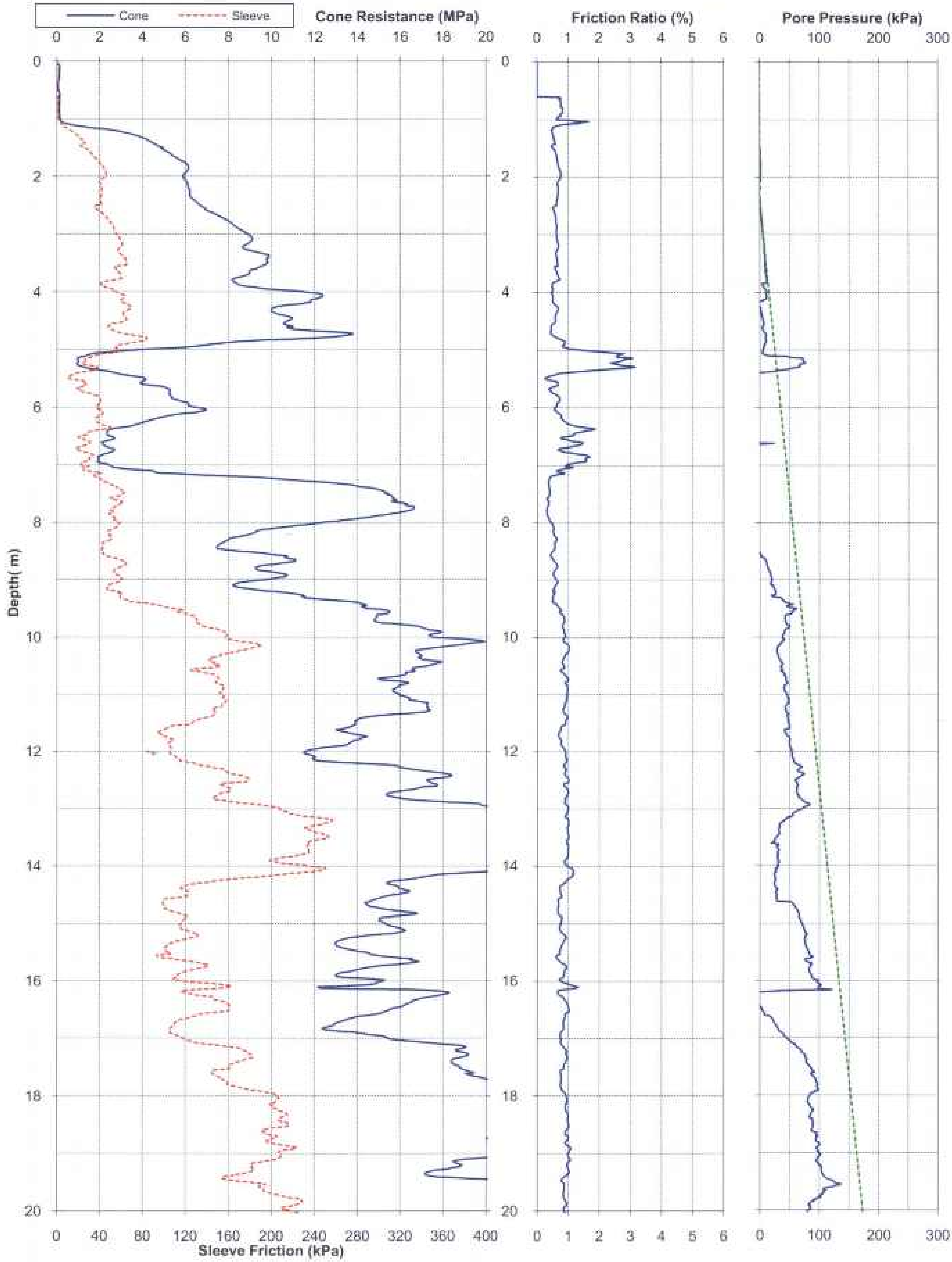
Project:	Christchurch 2011 Earthquake - EQC Ground Investigations			Page:	1 of 2	CPT-AVS-59
Test Date:	14-Jul-2011	Location:	Avonside	Operator:	Perry	
Pre-Drill:	1.2m	Assumed GWL:	2.2mBGL	Located By:	Survey GPS	
Position:	2484440.1mE	5742676.4mN	3.2mRL	Coord. System:	NZMG & MSL	
Other Tests:				Comments:		



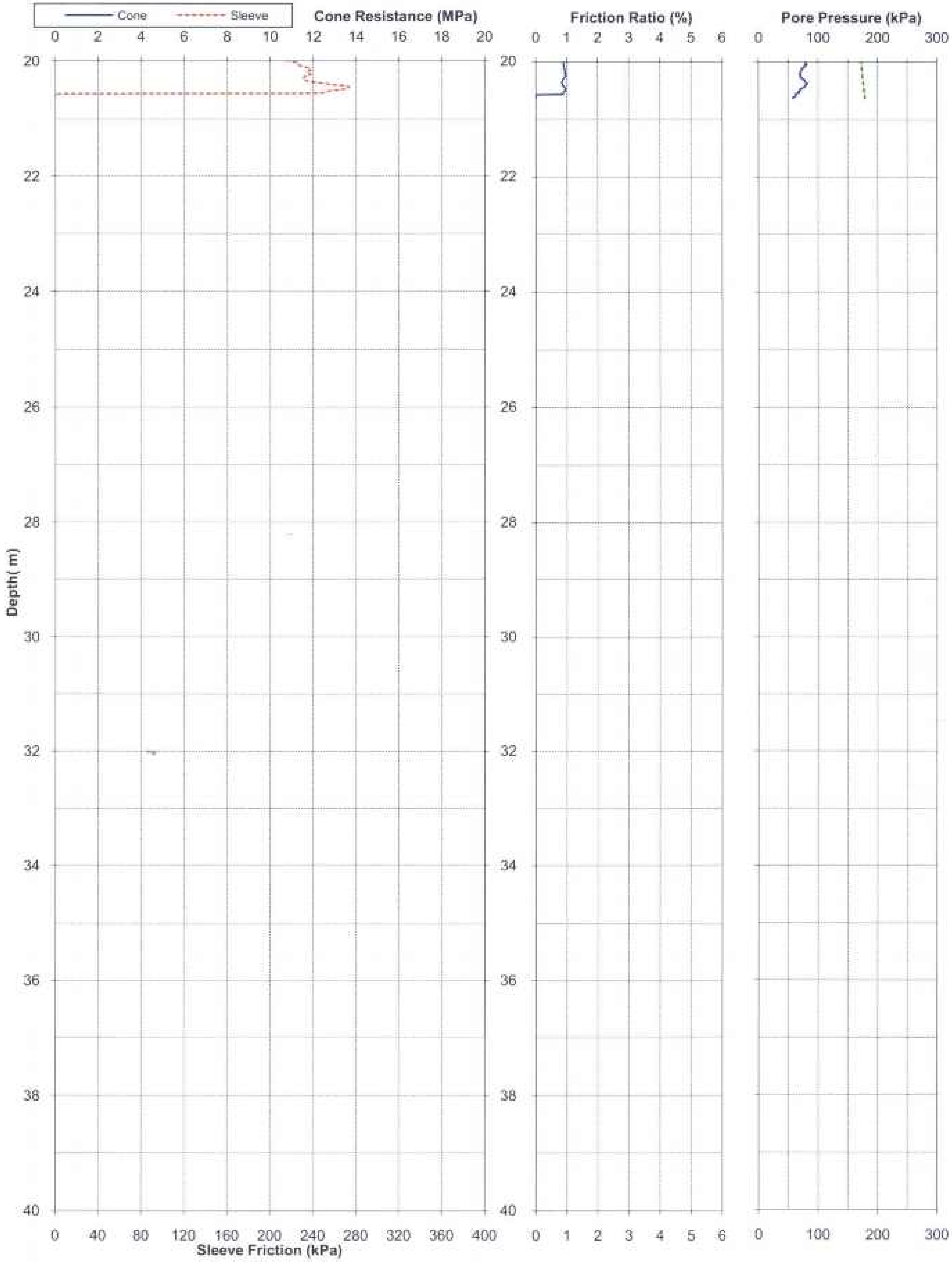
Project:	Christchurch 2011 Earthquake - EQC Ground Investigations			Page: 2 of 2	CPT-AVS-59
Test Date:	14-Jul-2011	Location:	Avonside	Operator:	Perry
Pre-Drill:	1.2m	Assumed GWL:	2.2mBGL	Located By:	Survey GPS
Position:	2484440.1mE	5742676.4mN	3.2mRL	Coord. System:	NZMG & MSL
Other Tests:				Comments:	



Project:	Christchurch 2011 Earthquake - EQC Ground Investigations			Page: 1 of 2	CPT-WAI-81
Test Date: 6-Jul-2011		Location: Wainoni		Operator: Opus	
Pre-Drill: 1.2m		Assumed GWL: 2.4mBGL		Located By: Survey GPS	
Position: 2484663.1mE	5742625mN	5.372mRL		Coord. System: NZMG & MSL	
Other Tests:				Comments:	



Project:	Christchurch 2011 Earthquake - EQC Ground Investigations			Page:	2 of 2	CPT-WAI-81
Test Date:	6-Jul-2011	Location:	Wainoni	Operator:	Opus	
Pre-Drill:	1.2m	Assumed GWL:	2.4mBGL	Located By:	Survey GPS	
Position:	2484663.1mE	5742625mN	5.372mRL	Coord. System:	NZMG & MSL	
Other Tests:				Comments:		



Appendix C:

Geology

Christchurch Urban Geology: Description and Key

Springston Formation:

The Springston Formation includes postglacial fluvial and over-bank sediments accumulated along the inland margin of the Christchurch Formation (deposition ceased circa 3000years BP). These deposits consist of poorly graded (well sorted) gravel, sand and silt. Springston Formation has a maximum recorded thickness of 20m.

From Leithfield Beach to the Rakaia River mouth Springston Formation gravel is inter-bedded with finer sediments of the Christchurch Formation. Five distinct alluvial fan surfaces have been mapped on the south bank of the Waimakariri River which form the basis for the 5 separate members described within the Springston Formation.

SOURCE: canterburyrecove...

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Project:	Lyn Christie Place Geotechnical Desktop Study
Project No.:	6-QUCC2.13/55AC
Client:	Christchurch City Council

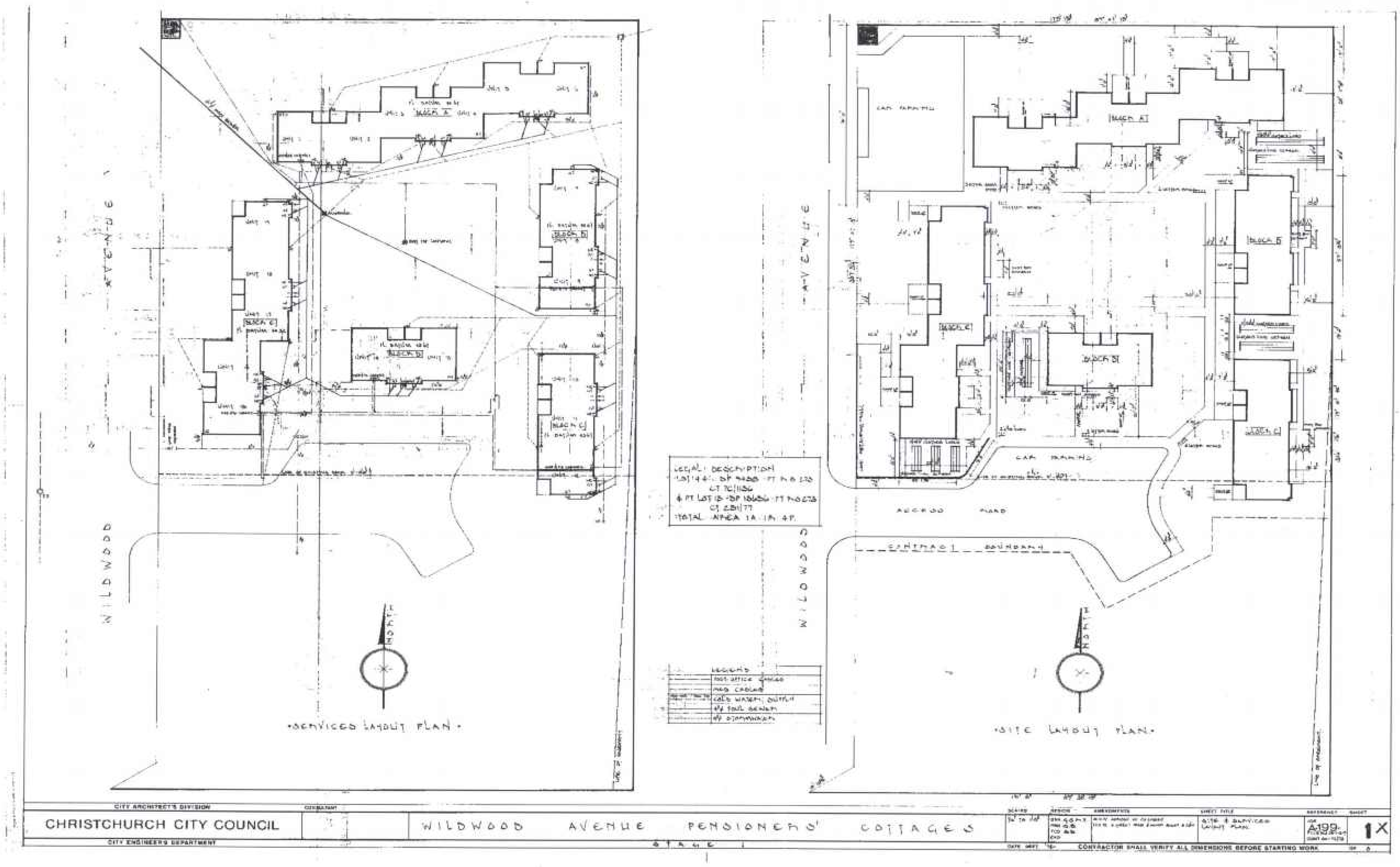
Figure C.1 Site Geology

Opus Geotechnical Engineer

5/11/2012

Appendix D:

Available Drawings
(Copy of Christchurch City Council drawings 727, 727a t/m 727h)



SOURCE: Christchurch City Council

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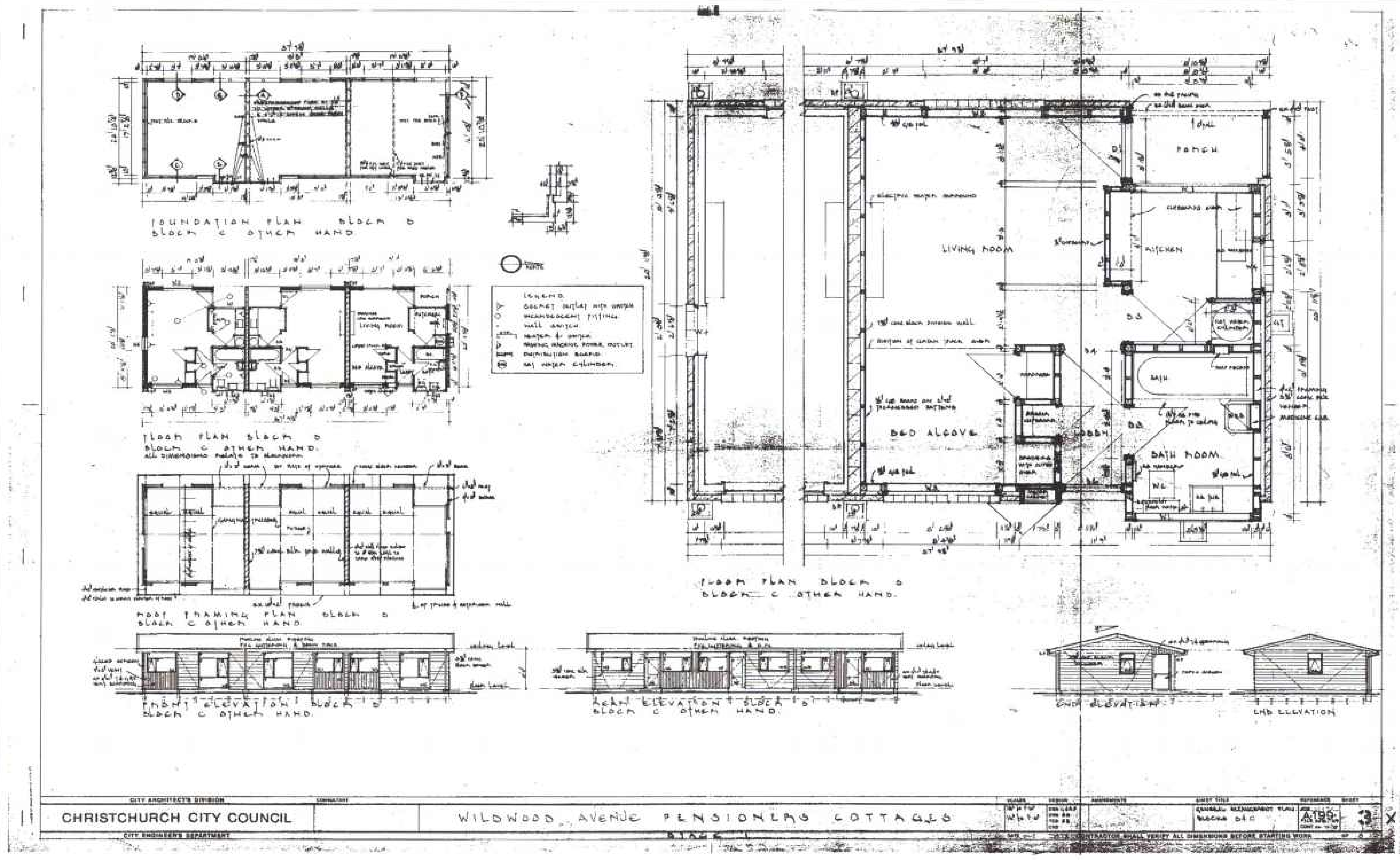
Project:	Lyn Christie Place Geotechnical Desktop Study
Project No.:	6-QUCC2.13/55AC
Client:	Christchurch City Council

Figure D.1 Available Drawing
Site and services layout plan

Drawn: Opus Geotechnical Engineer
Date: 21/11/2012



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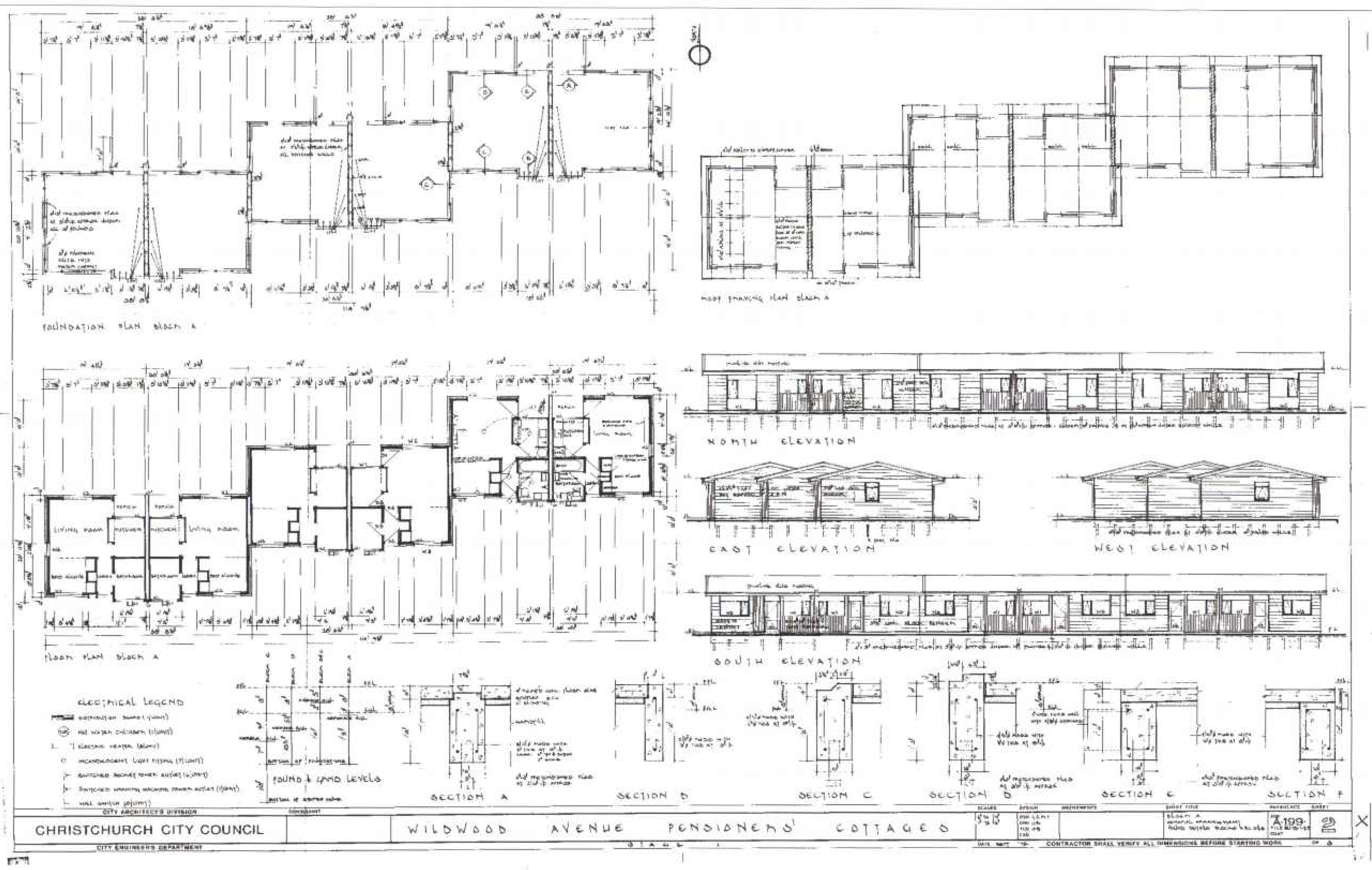
Project:	Lyn Christie Place Geotechnical Desktop Study
Project No.:	6-QUCC2.13/55AC
Client:	Christchurch City Council

Figure D.2
General arrangement plan bloc B + C

Drawn:
Date: 21/11/2012



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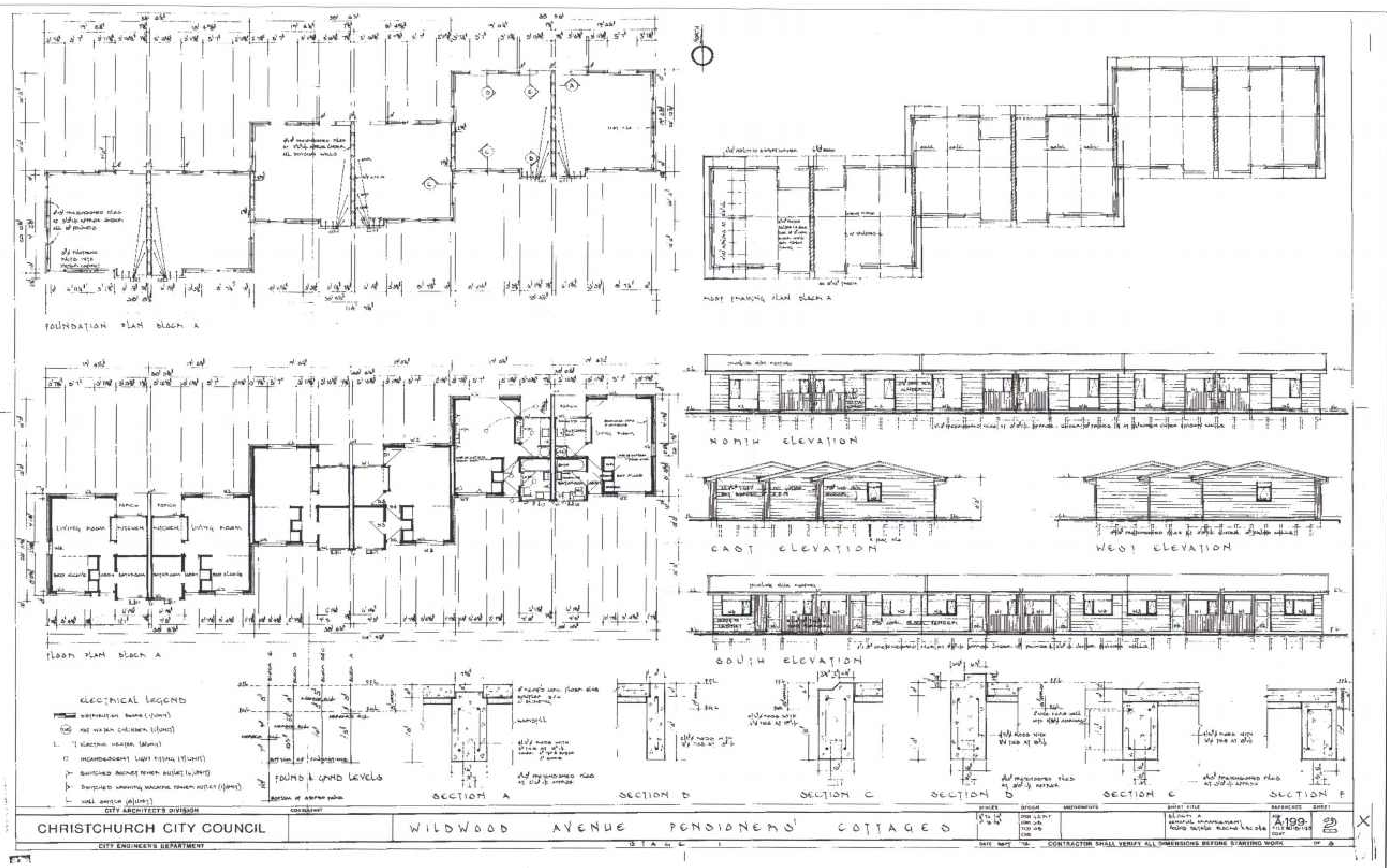
Project:	Lyn Christie Place Geotechnical Desktop Study
Project No.:	6-QUCC2.13/55AC
Client:	Christchurch City Council

Figure D.3

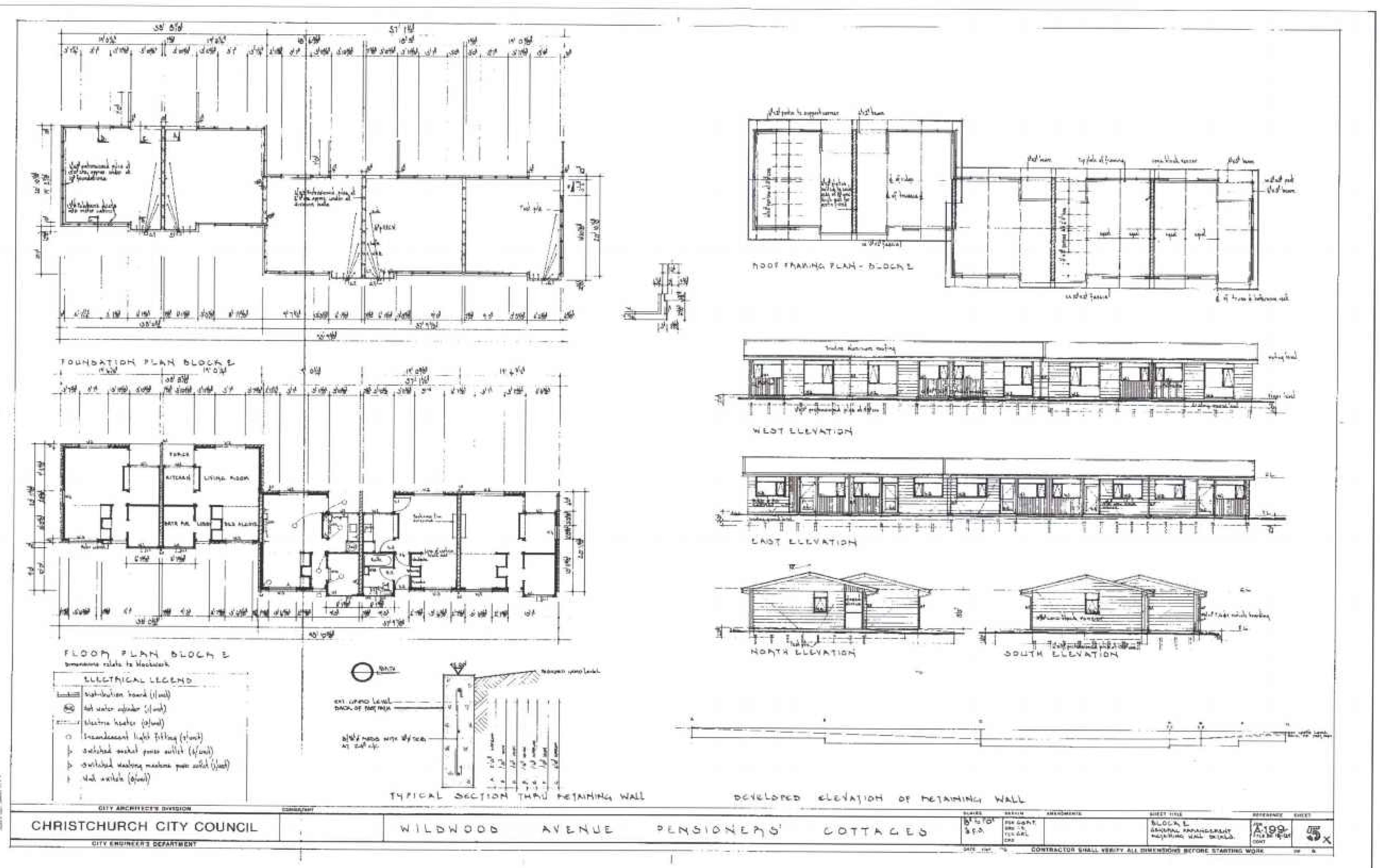
General Arrangement drawing Block "A" details blocks "A-E"

Drawn:

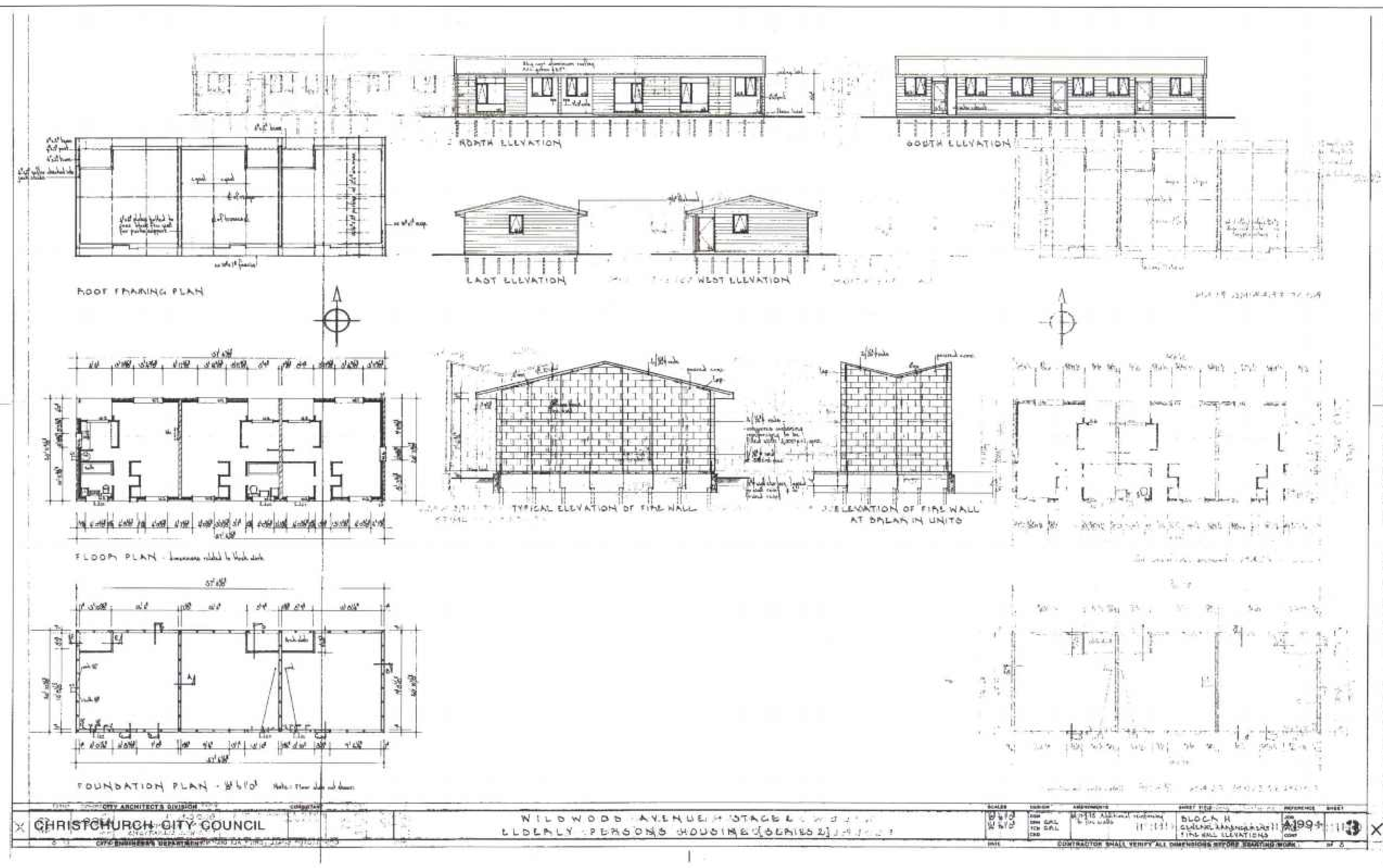
Date: 21/11/2012



Opus International Consultants Ltd Auckland Office The Westhaven 100 Beaumont St, Auckland New Zealand Tel: +64 9 355 9500 Fax: +64 9 355 9680	**Project:** **Project No.:** **Client:**	Lyn Christie Place Geotechnical Desktop Study 6-QUCC2.13/55AC Christchurch City Council	**Figure D.4** **Drawn:** **Date:** 21/11/2012	**General Arrangement drawing Block "A" (727c)**



Opus International Consultants Ltd Auckland Office The Westhaven 100 Beaumont St, Auckland New Zealand Tel: +64 9 355 9500 Fax: +64 9 355 9680	**Project:** Lyn Christie Place Geotechnical Desktop Study **Project No.:** 6-QUCC2.13/55AC **Client:** Christchurch City Council	**Figure D.5** **Drawn:** **Date:** 21/11/2012	**General Arrangement drawing Block "A" details blocks "A-E" (727d)**



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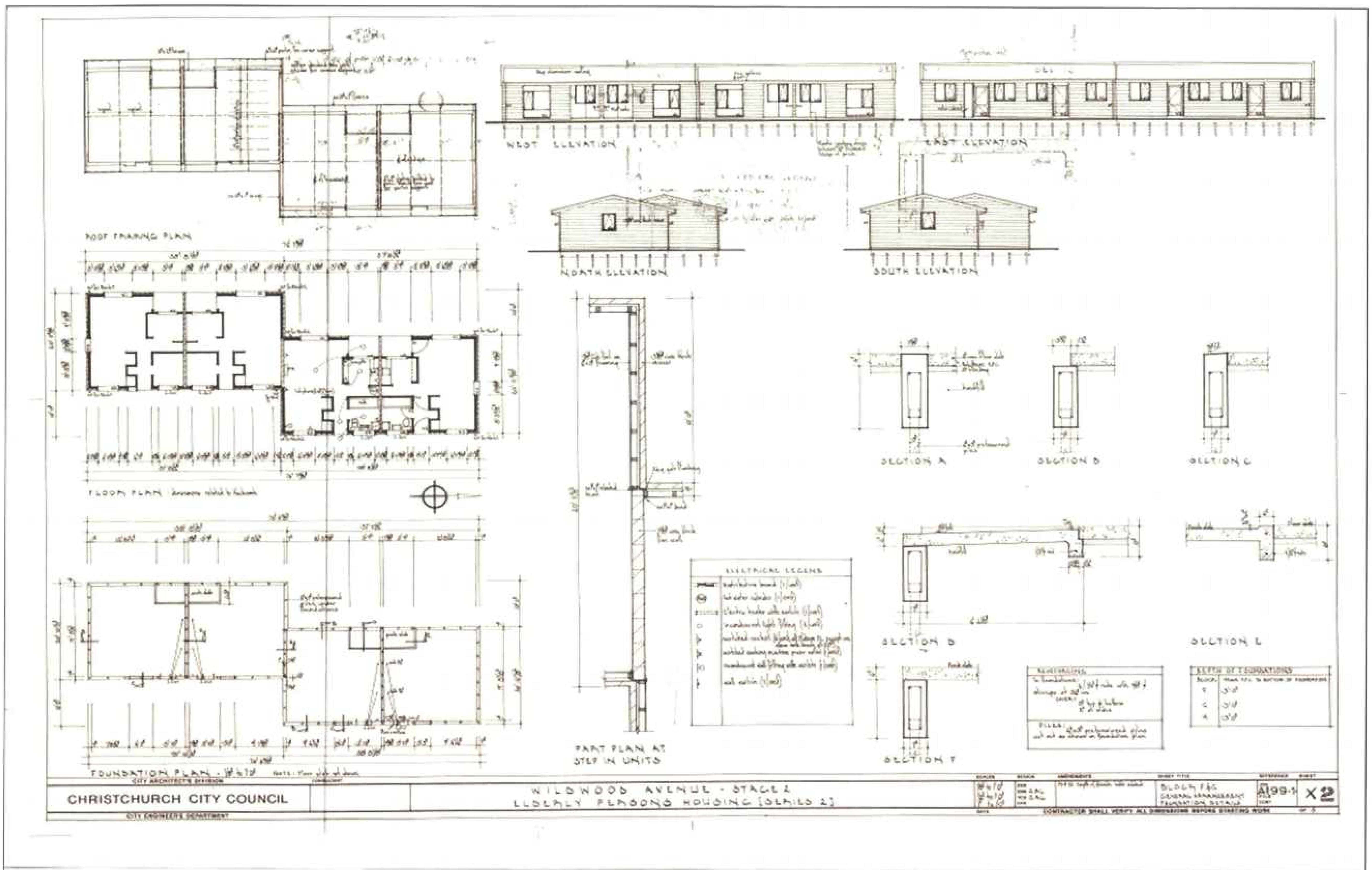
Project:	Lyn Christie Place Geotechnical Desktop Study	**Figure D.6**	**General arrangements Block "H" (727e)**
Project No.:	6-QUCC2.13/55AC	**Drawn:**	
Client:	Christchurch City Council	**Date:**	21/11/2012



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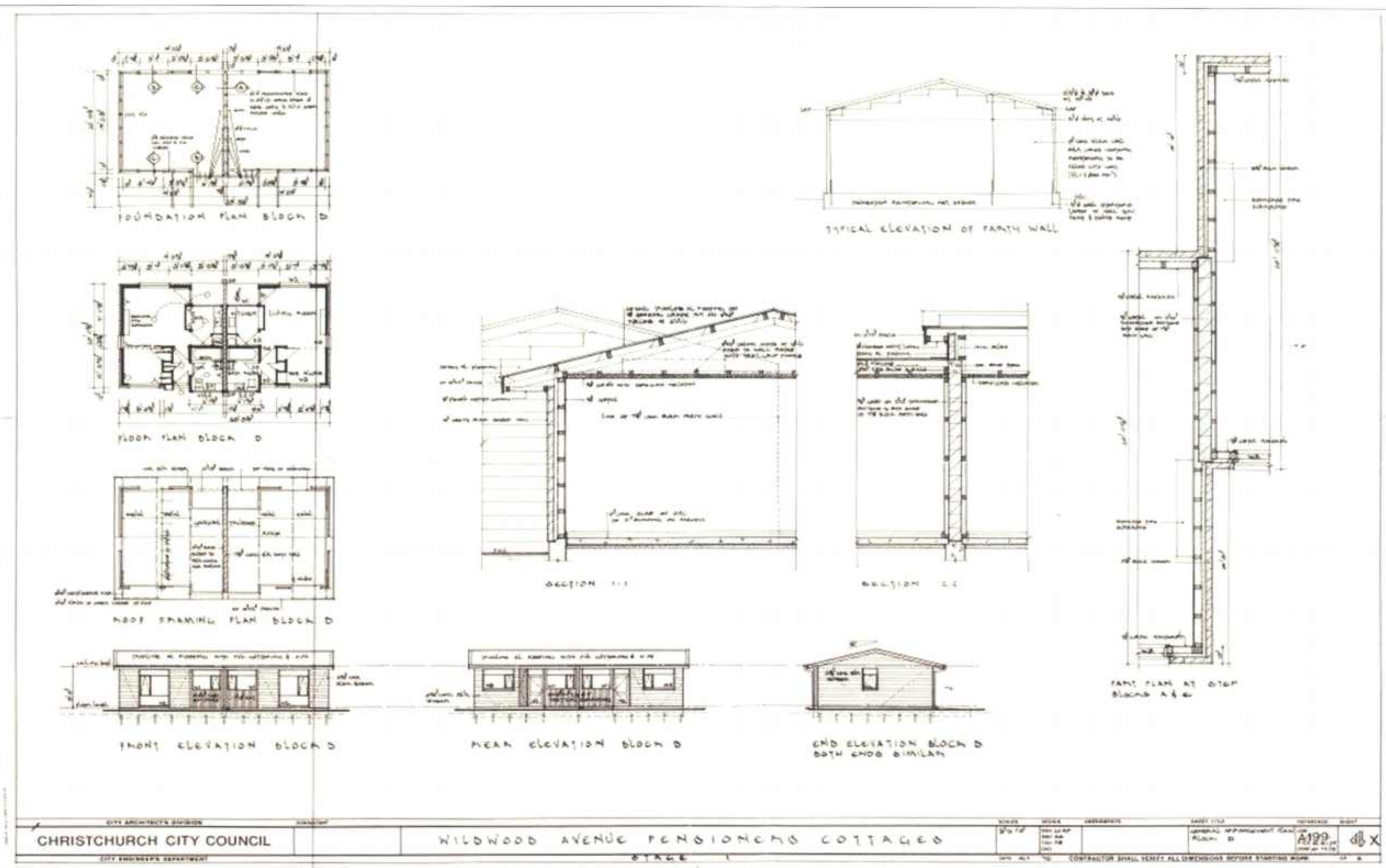
Project:	Lyn Christie Place Geotechnical Desktop Study	**Figure D.7**	**Block F + G** **General arrangements** **(727f)**
Project No.:	6-QUCC2.13/55AC	**Drawn:**	
Client:	Christchurch City Council	**Date:** 21/11/2012	



Opus International Consultants Ltd Auckland Office The Westhaven 100 Beaumont St, Auckland New Zealand Tel: +64 9 355 9500 Fax: +64 9 355 9680	**Project:** Lyn Christie Place Geotechnical Desktop Study **Project No.:** 6-QUCC2.13/55AC **Client:** Christchurch City Council	**Figure D.8** **Drawn:** **Date:** 21/11/2012	**Block D** **General arrangements** **(727g)**

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Project:	Lyn Christie Place Geotechnical Desktop Study	**Figure D.9**	**Site surface plane** **General arrangements** **(727h)**
Project No.:	6-QUCC2.13/55AC		
Client:	Christchurch City Council	**Drawn:**	
		Date: 21/11/2012	

Appendix E:

Liquefaction assessment

Appendix Liquefaction Assessment

Liquefaction Analysis has been completed for three CPTs located nearby the Lyn Christie Place Retirement Village. The following assumptions have been made when assessing the CPTs surrounding the site:

- Magnitude 7.5 design earthquake (50km from source)
- Water table during an earthquake is the same as in-situ testing, 1.0 metre beneath the surface.
- Peak Ground Acceleration (PGA) under serviceability limit state (SLS) conditions is 0.08g.
- Peak Ground Acceleration (PGA) under ultimate limit state (ULS) conditions is 0.34g.
- Liquefaction depth has been limited to 10m beneath the surface
- Robertson and Wride (NCEER 1998, 2009) has been used for the liquefaction calculation with Zhang et al. being used for the settlement analysis.

CPT 142 (AVS-59) is located approximately 25 metres west of the site and has been assessed for the overall liquefaction potential during a future seismic design earthquake.

- Under SLS conditions this site has an overall LPI of zero which is categorised as no risk. Vertical settlement is in the order of 12mm with lateral spreading considered negligible.
- Under ultimate limit state (ULS) conditions this site is categorised as very high risk and has an overall LPI of 18.3. Vertical settlement is in the order of 130mm and lateral spreading is in the order of 35mm which is expected to cause moderate land damage.
- Using the PGA of 0.57 for the magnitude M6.3 earthquake during the 22nd of February 2011, this site is categorised as very high risk and has an overall LPI of 19.4. Vertical settlement is in the order of 130mm with lateral spreading in the order of 35mm which is expected to cause moderate land damage.

CPT 1952 is located approximately 110 metres southwest of the site and has been assessed for the overall liquefaction potential during a future seismic design earthquake.

- Under SLS conditions this site is categorised as no risk with vertical settlement and lateral spreading considered negligible.
- Under ULS conditions liquefaction is likely to occur with settlement up to 50mm and lateral spreading up to 20mm occurring. This site is categorised as high risk and has an overall LPI of 7.8.
- Using the PGA of 0.57 for the magnitude M6.3 earthquake during the 22nd of February 2011, this site is categorised as high risk and has an overall LPI of 8.3. Vertical settlement is in the order of 50mm with lateral spreading in the order of 20mm.

CPT 902 (WAI_81) is located approximately 150 metres southeast of the site and has been assessed for the overall liquefaction potential during a future seismic design earthquake.

Results of the CLIQ calculations:

- Under SLS conditions this site is categorised as no risk for liquefaction as settlement and lateral movements are considered negligible.
- Under ULS conditions this site is categorised as high risk and has an overall LPI of 16.6. Vertical settlement is in the order of 120mm and lateral spreading in the order of 56mm.
- Using the PGA of 0.57 for the magnitude M6.3 earthquake during the 22nd of February 2011, this site is categorised as very high risk and has an overall LPI of 18.1. Vertical settlement is in the order of 120mm with lateral spreading in the order of 62mm which is expected to cause moderate land damage.

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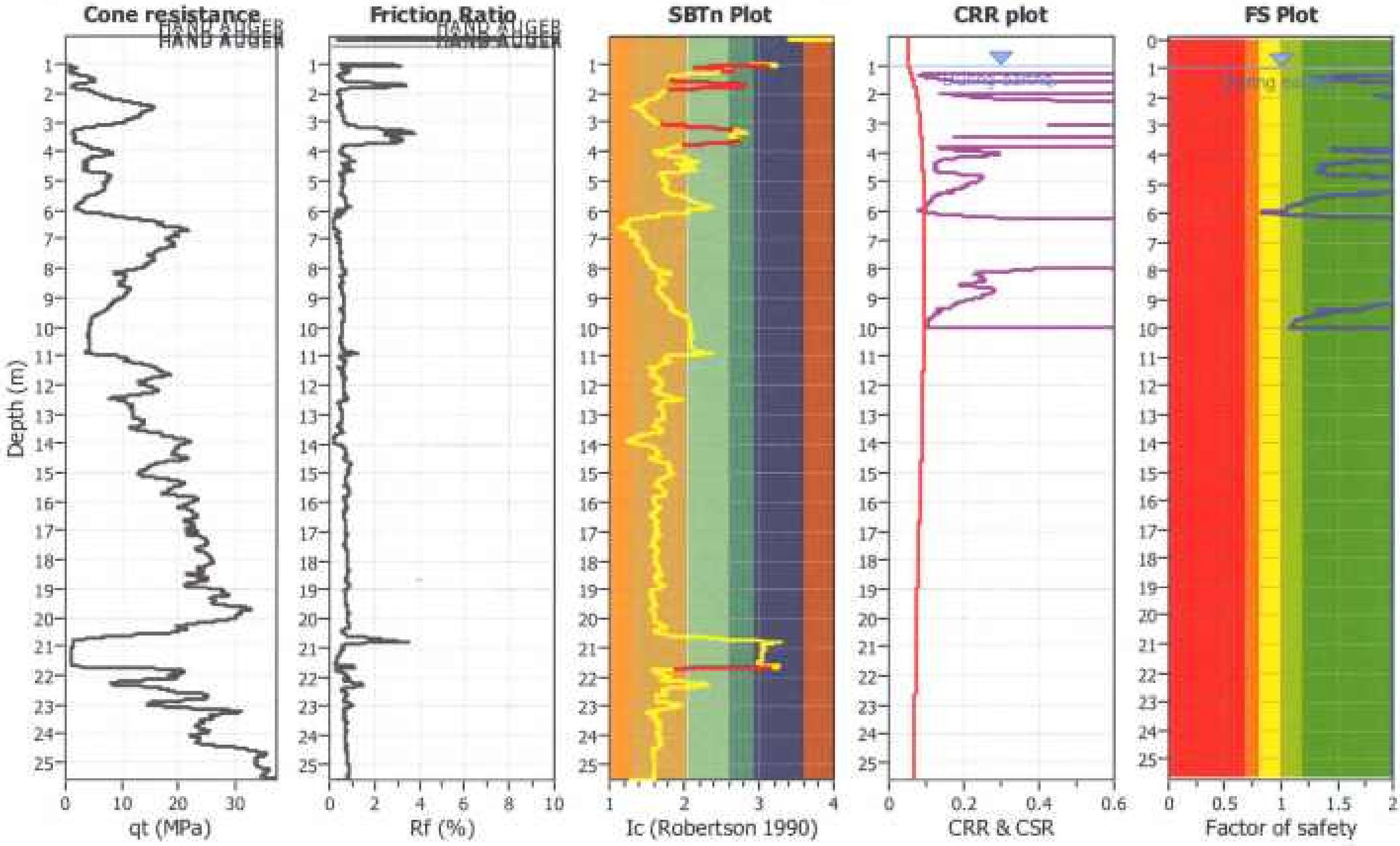
LIQUEFACTION ANALYSIS REPORT

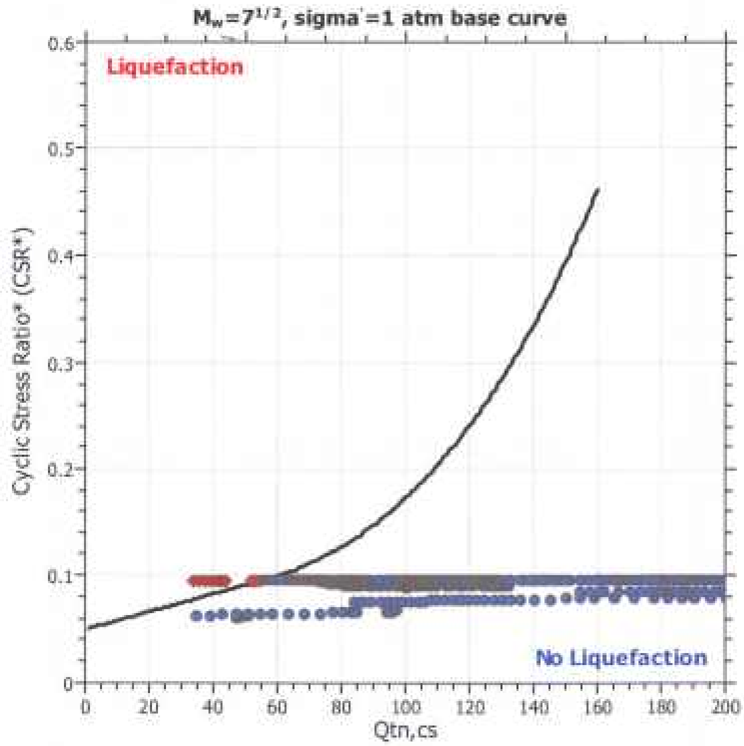
Project title : **Location :**

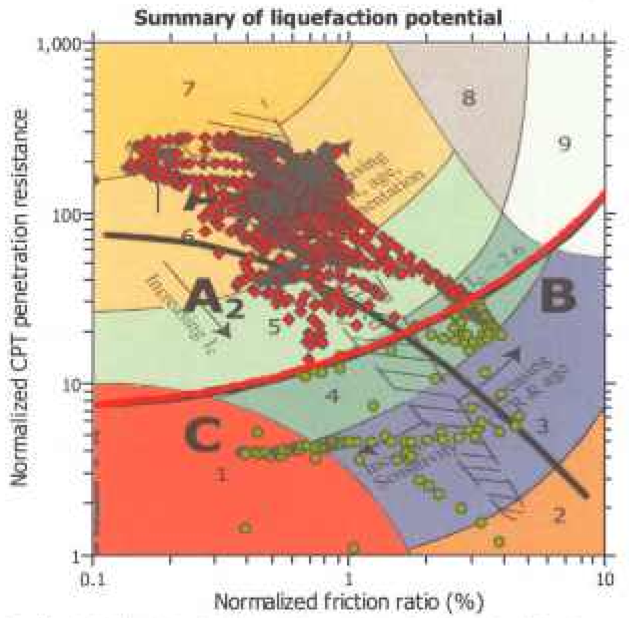
CPT file : CPT_142

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	Yes		
Peak ground acceleration:	0.08	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

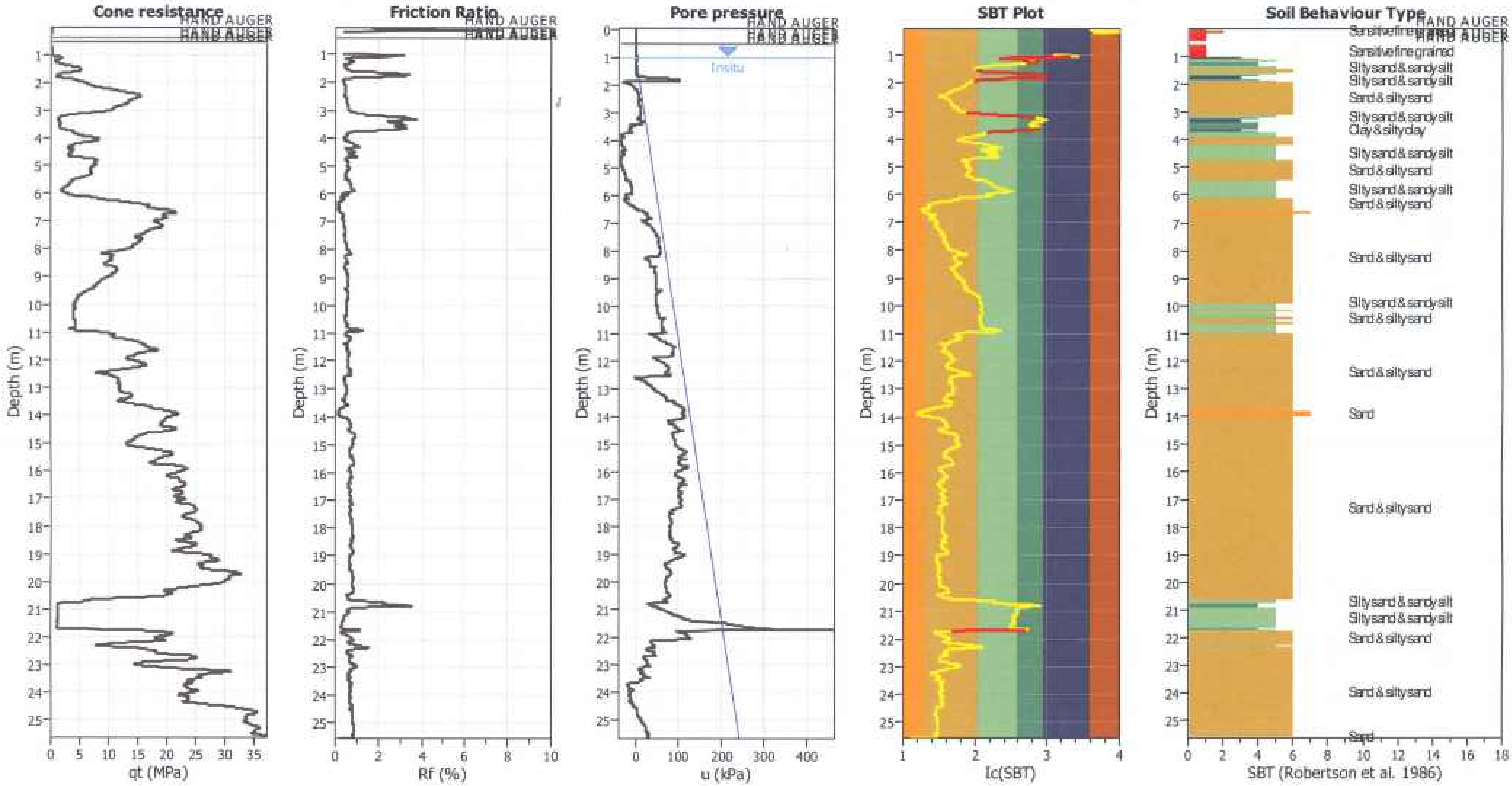






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



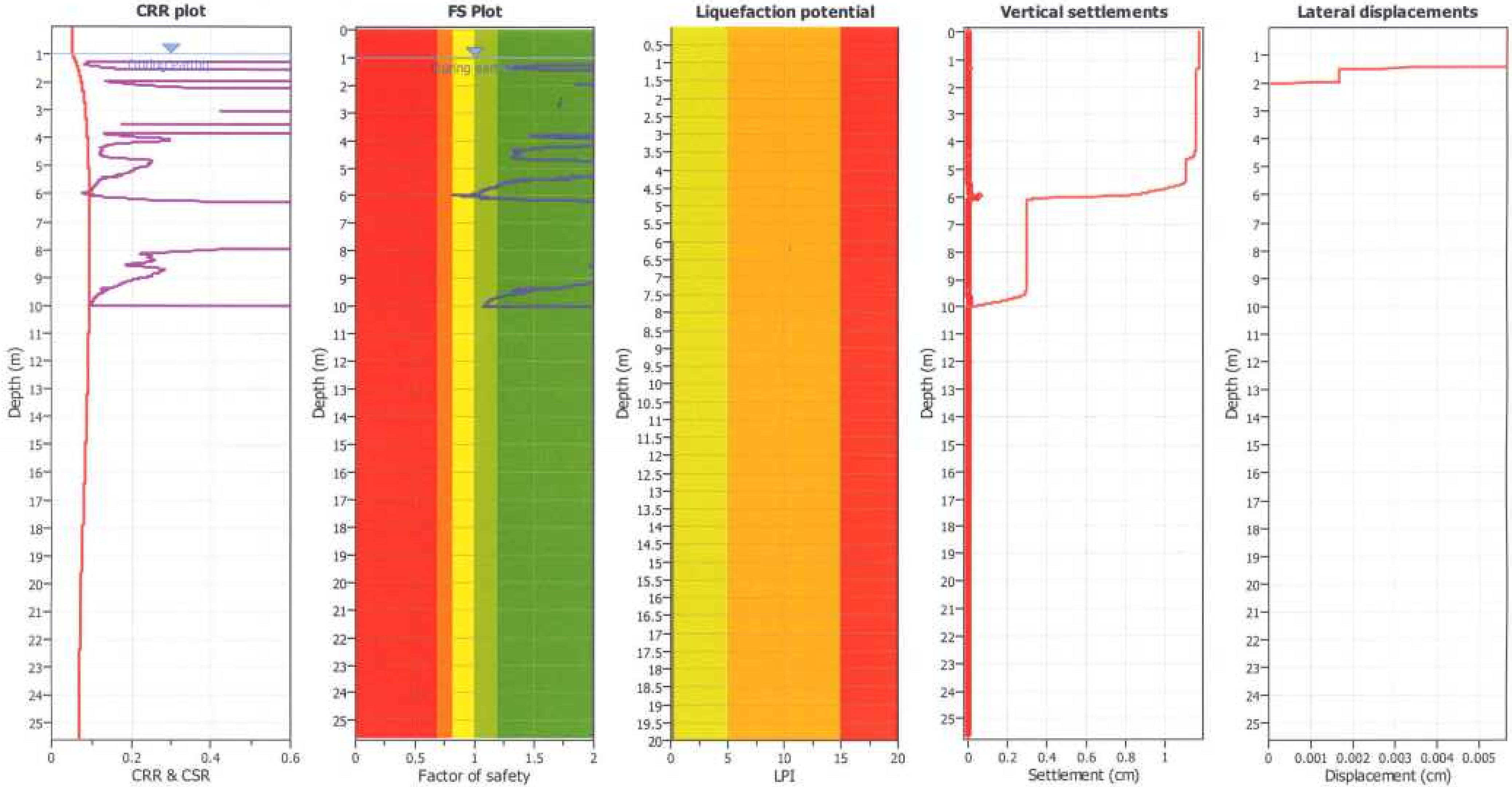
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.08	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBT legend

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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.08	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	10.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liquefaction are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

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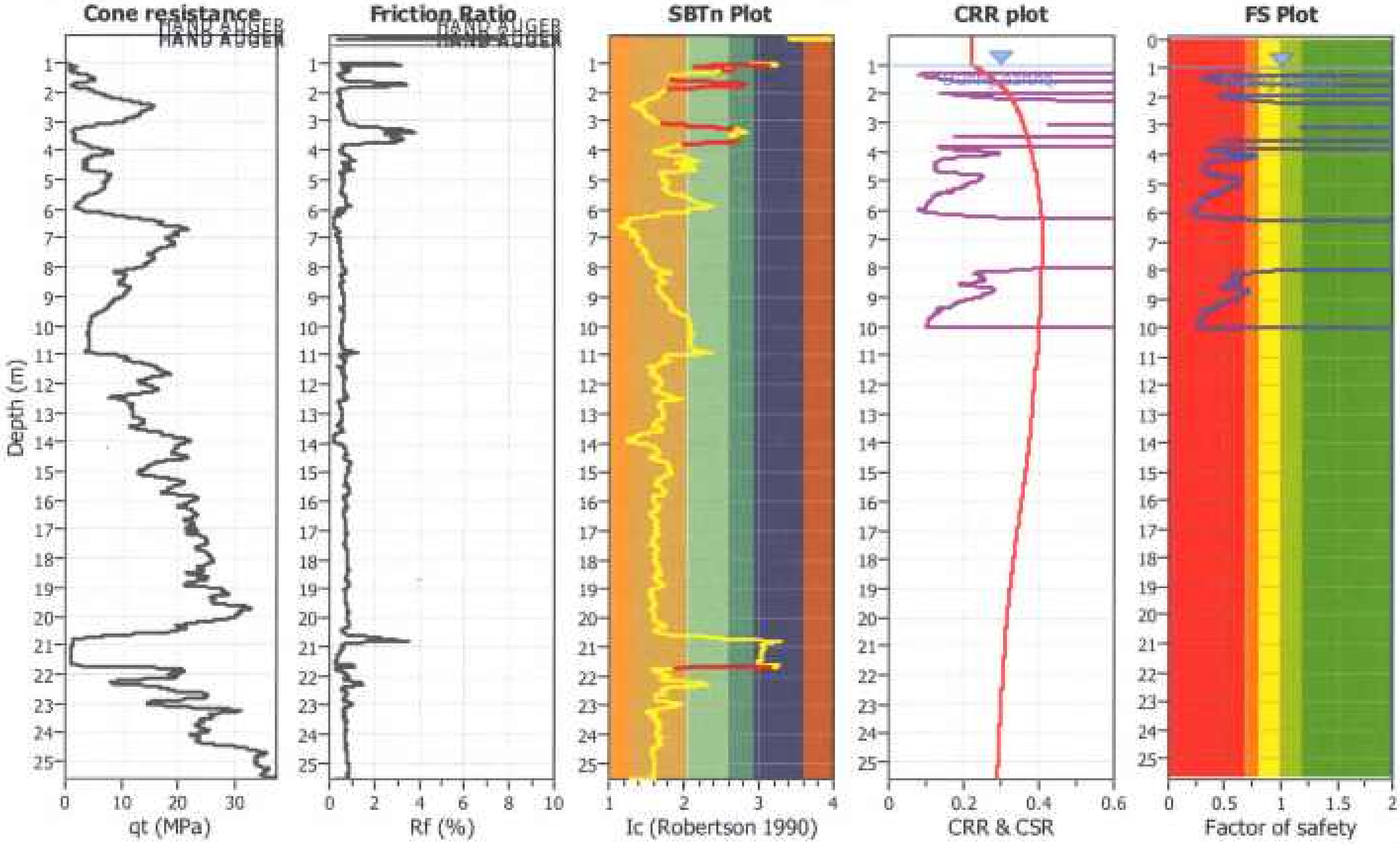
LIQUEFACTION ANALYSIS REPORT

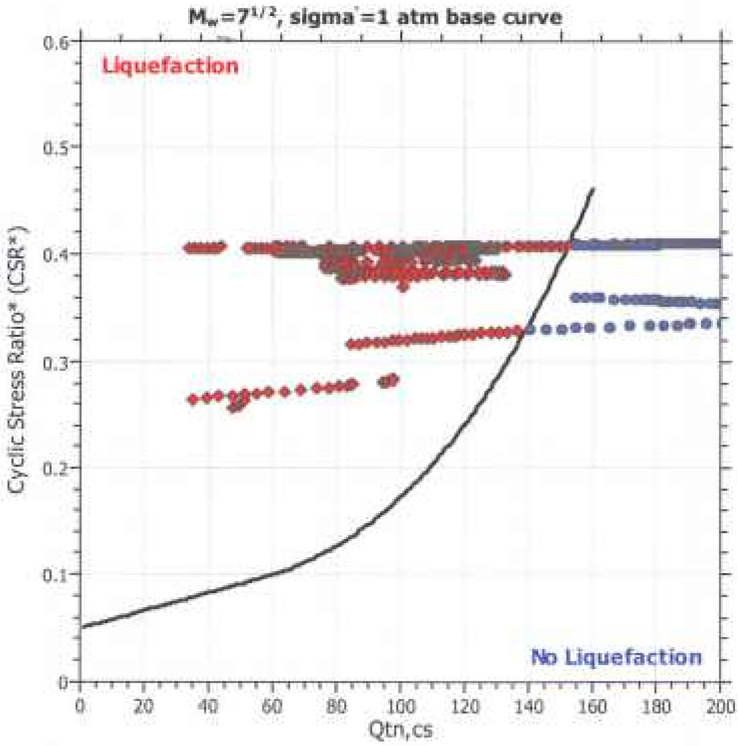
Project title : **Location :**

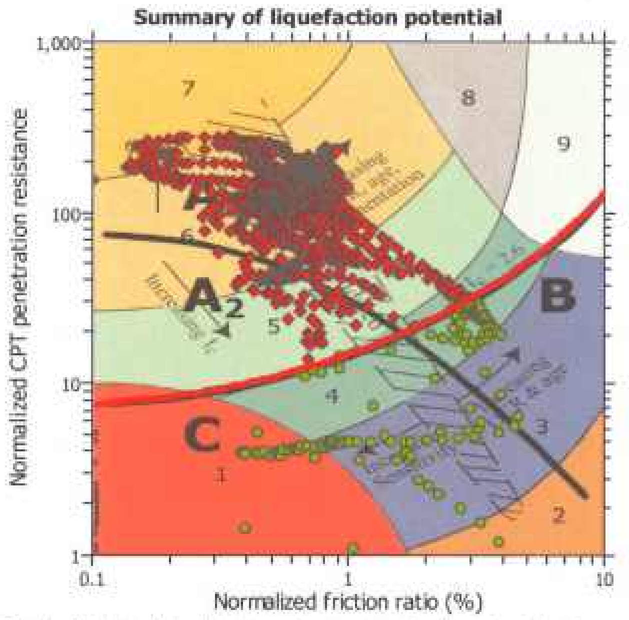
CPT file : CPT_142

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	Yes		
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

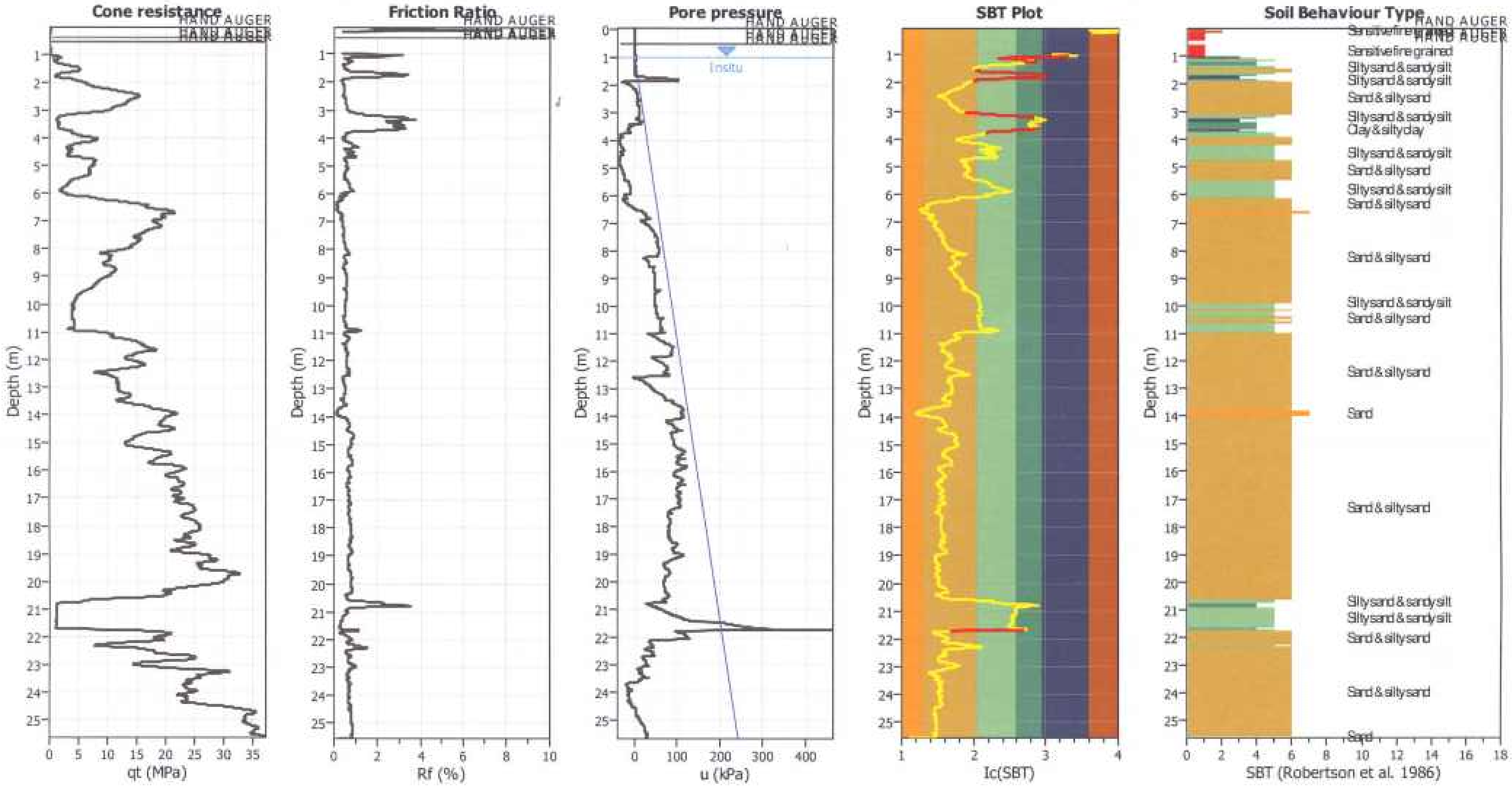






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.34	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBT legend

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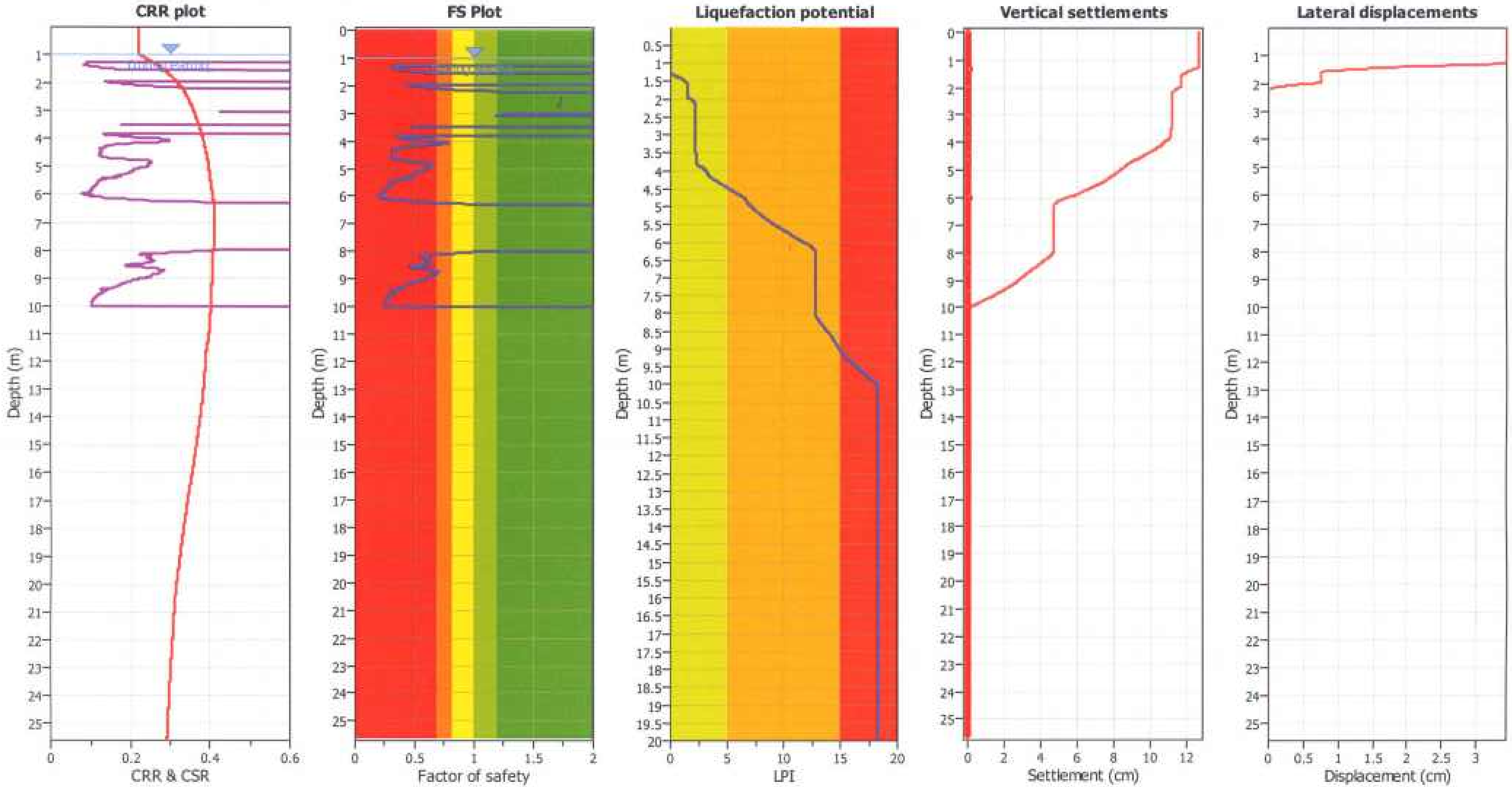
8. Very stiff sand to
9. Very stiff fine grained

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.34	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	10.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liquefaction are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

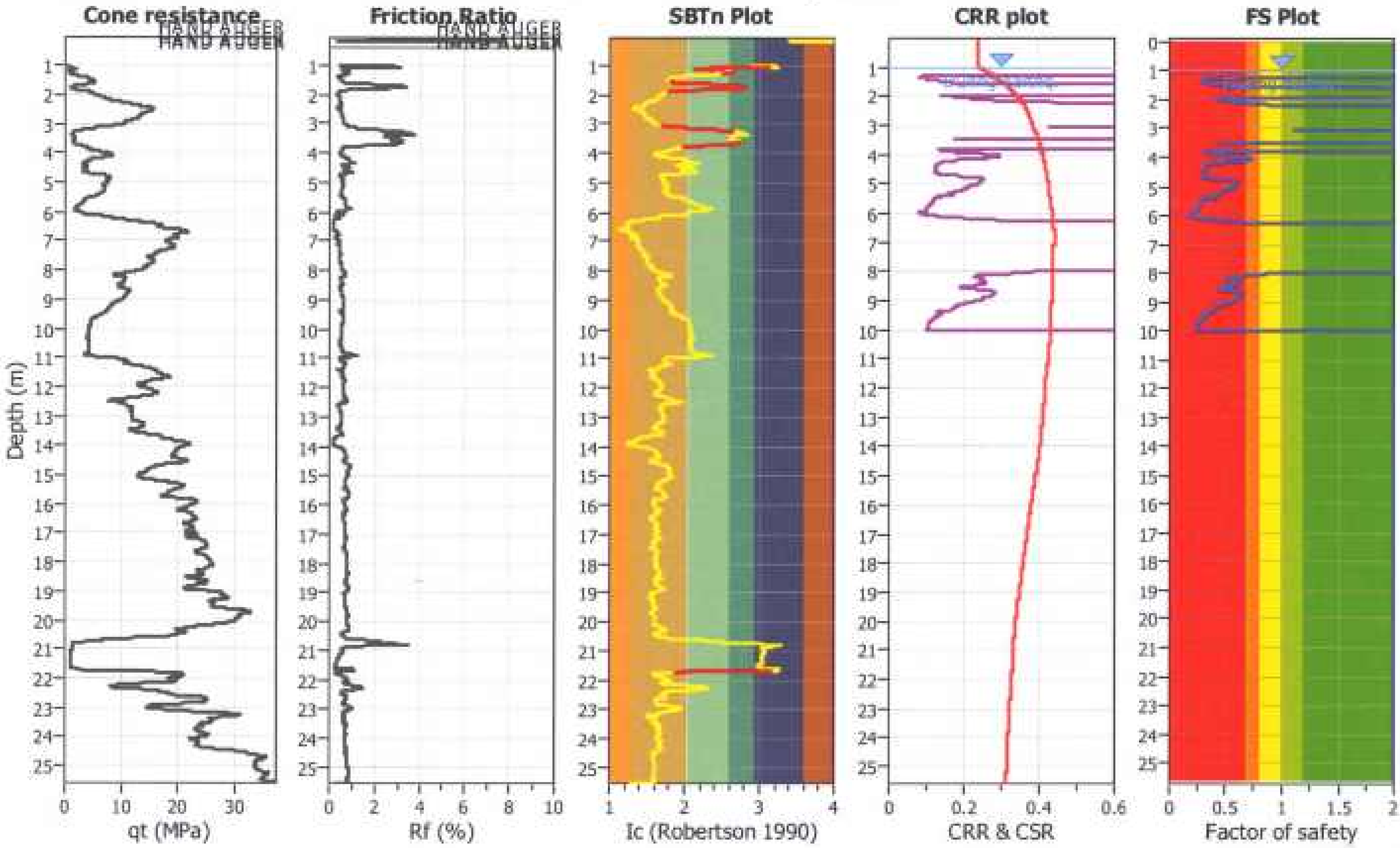
LIQUEFACTION ANALYSIS REPORT

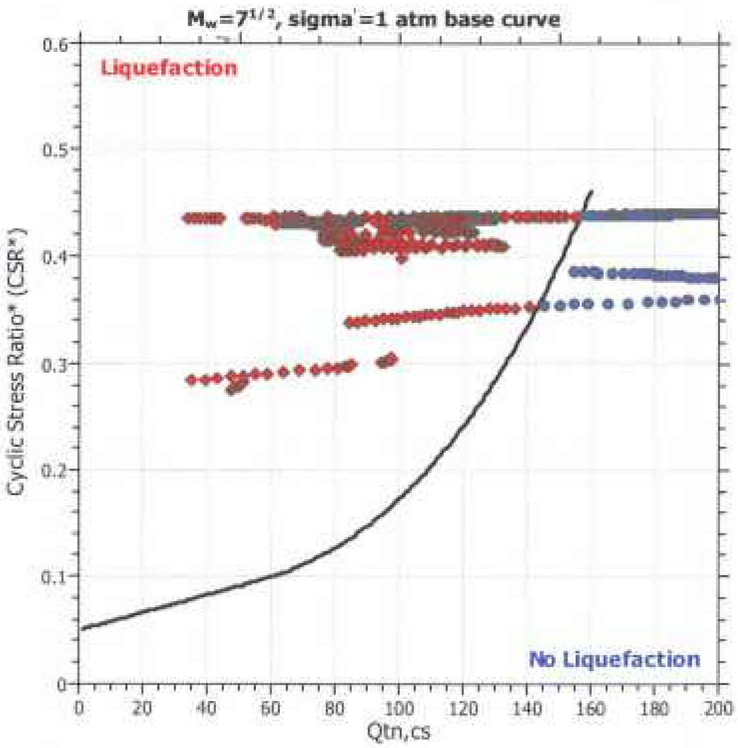
Project title : **Location :**

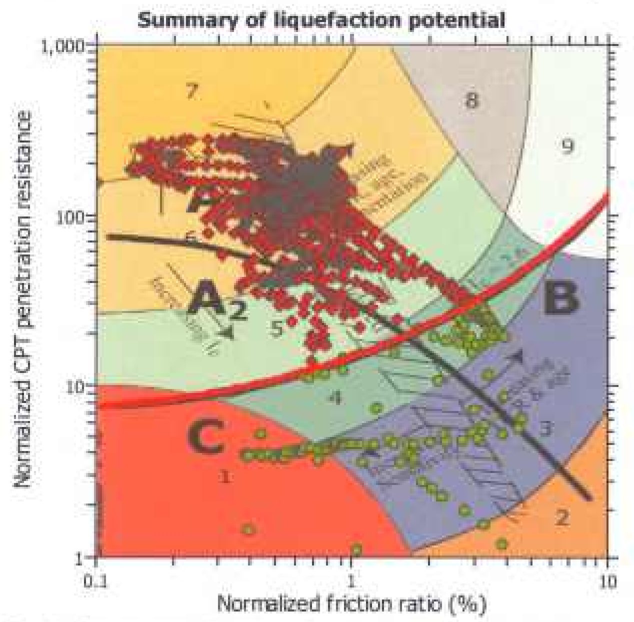
CPT file : CPT_142

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	6.30	Ic cut-off value:	2.60	Trans. detect. applied:	Yes		
Peak ground acceleration:	0.57	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

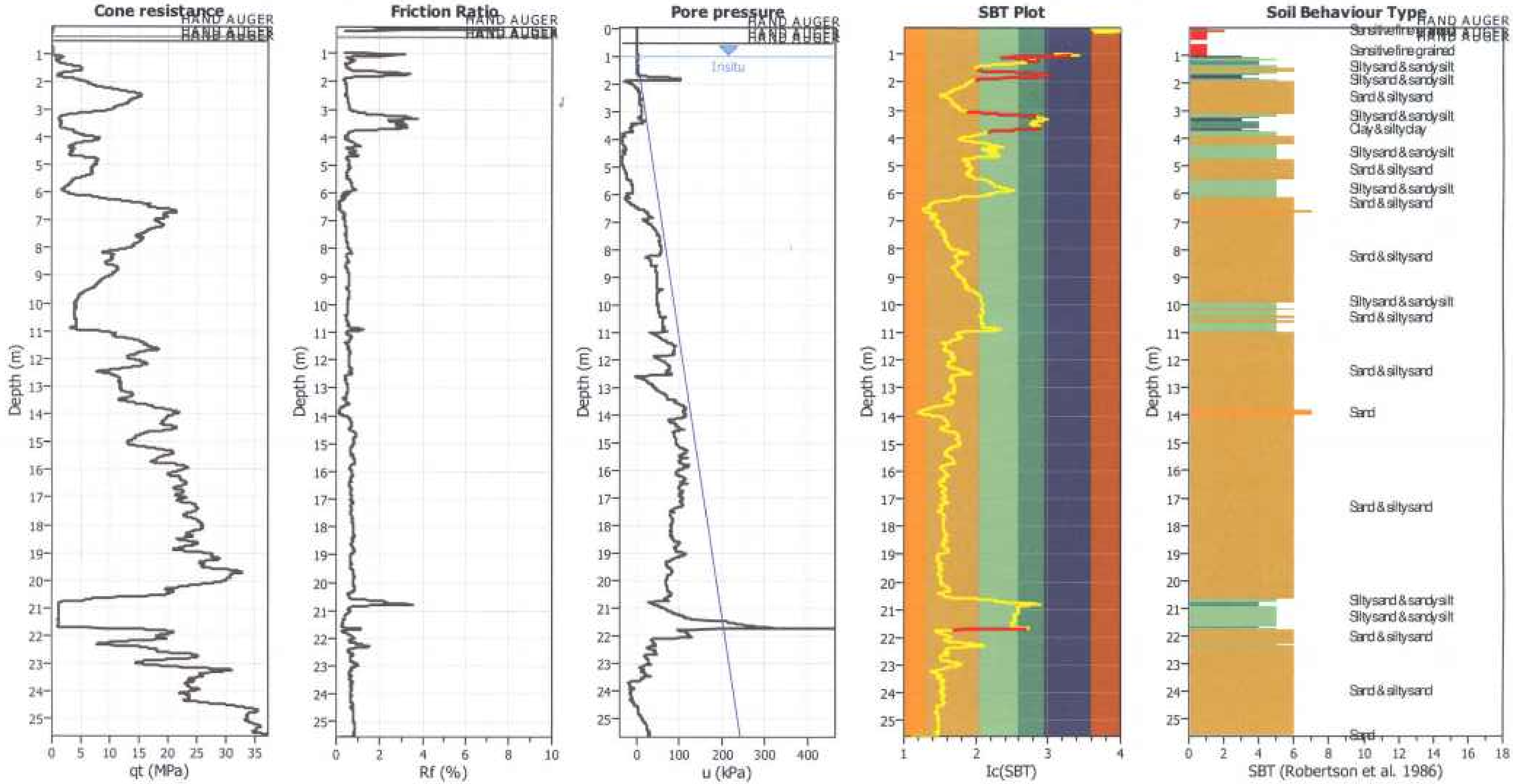






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



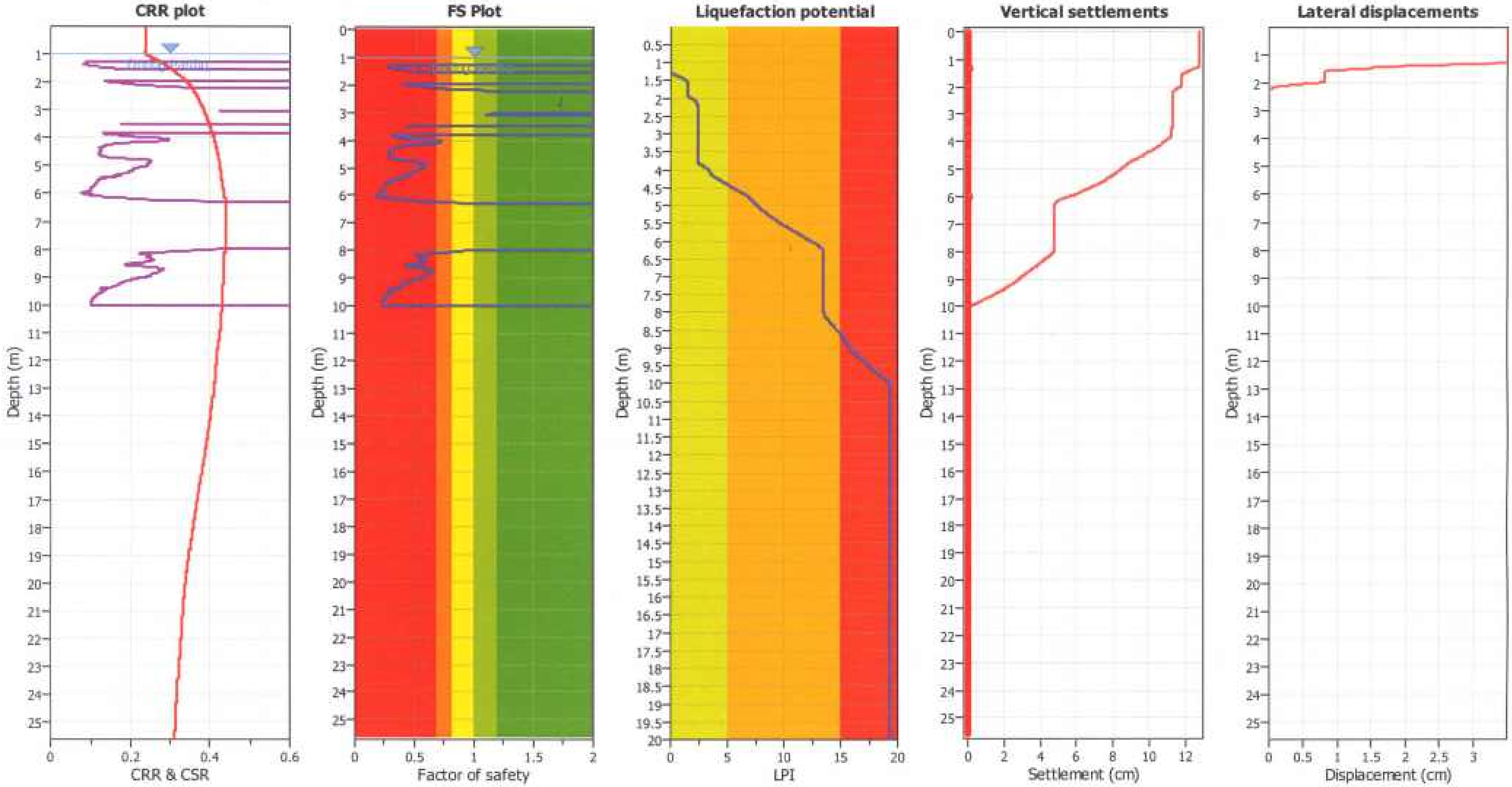
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.57	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBT legend

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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.57	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	10.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liquefaction are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

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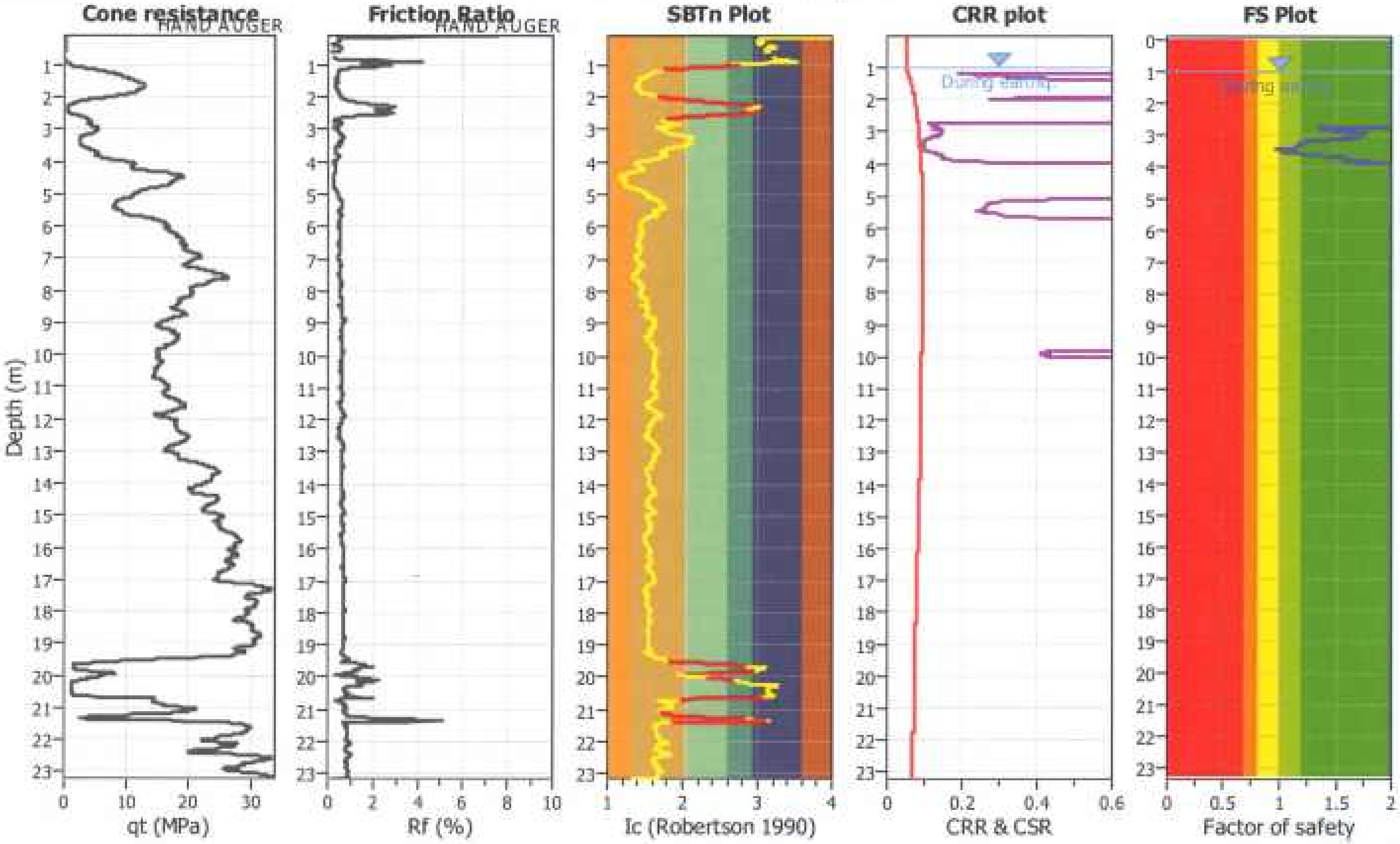
LIQUEFACTION ANALYSIS REPORT

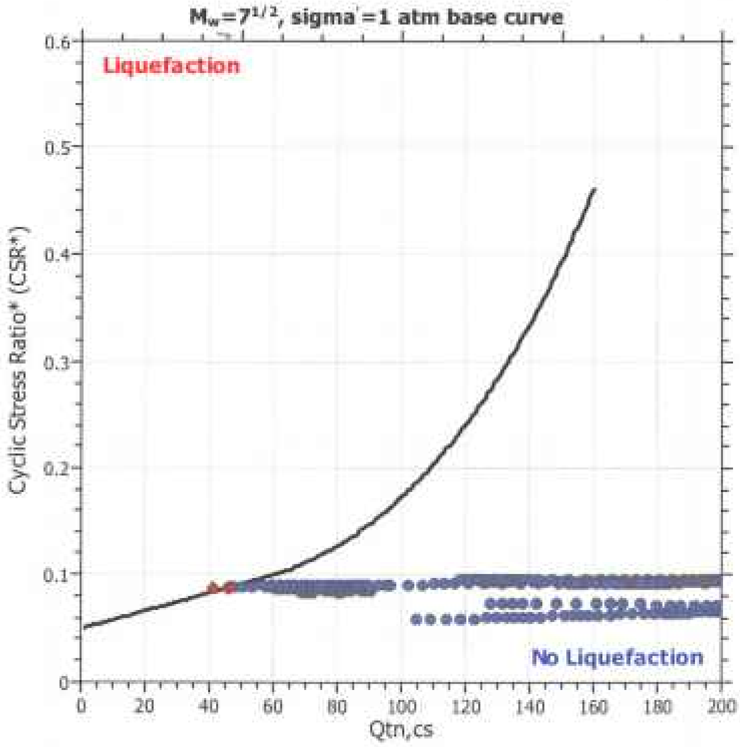
Project title : **Location :**

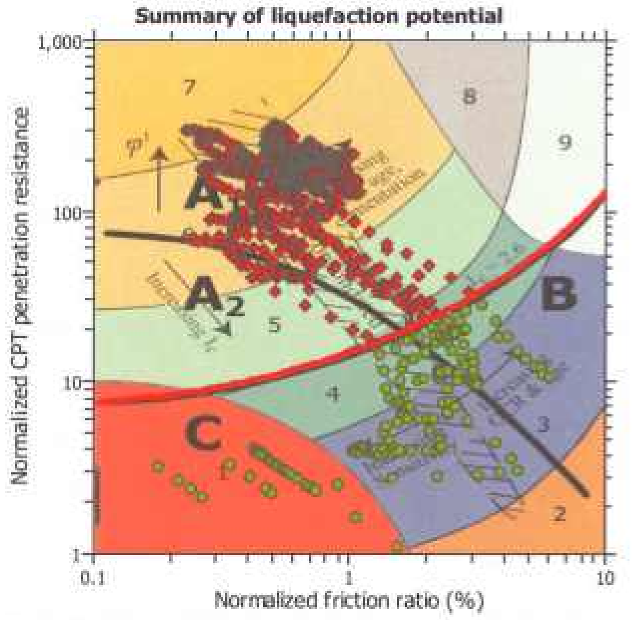
CPT file : CPT_1952_SLS

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	Yes		
Peak ground acceleration:	0.08	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

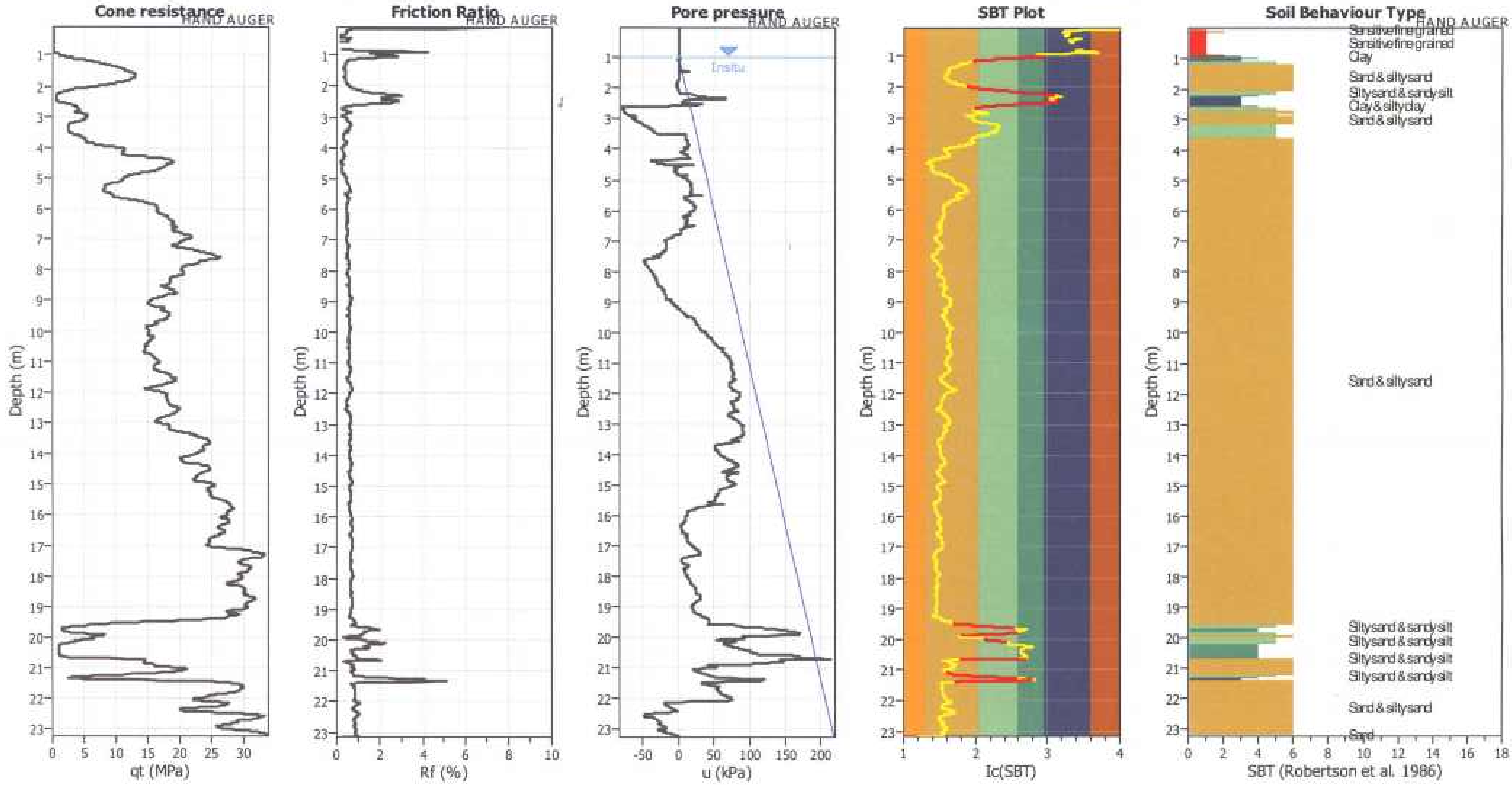






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



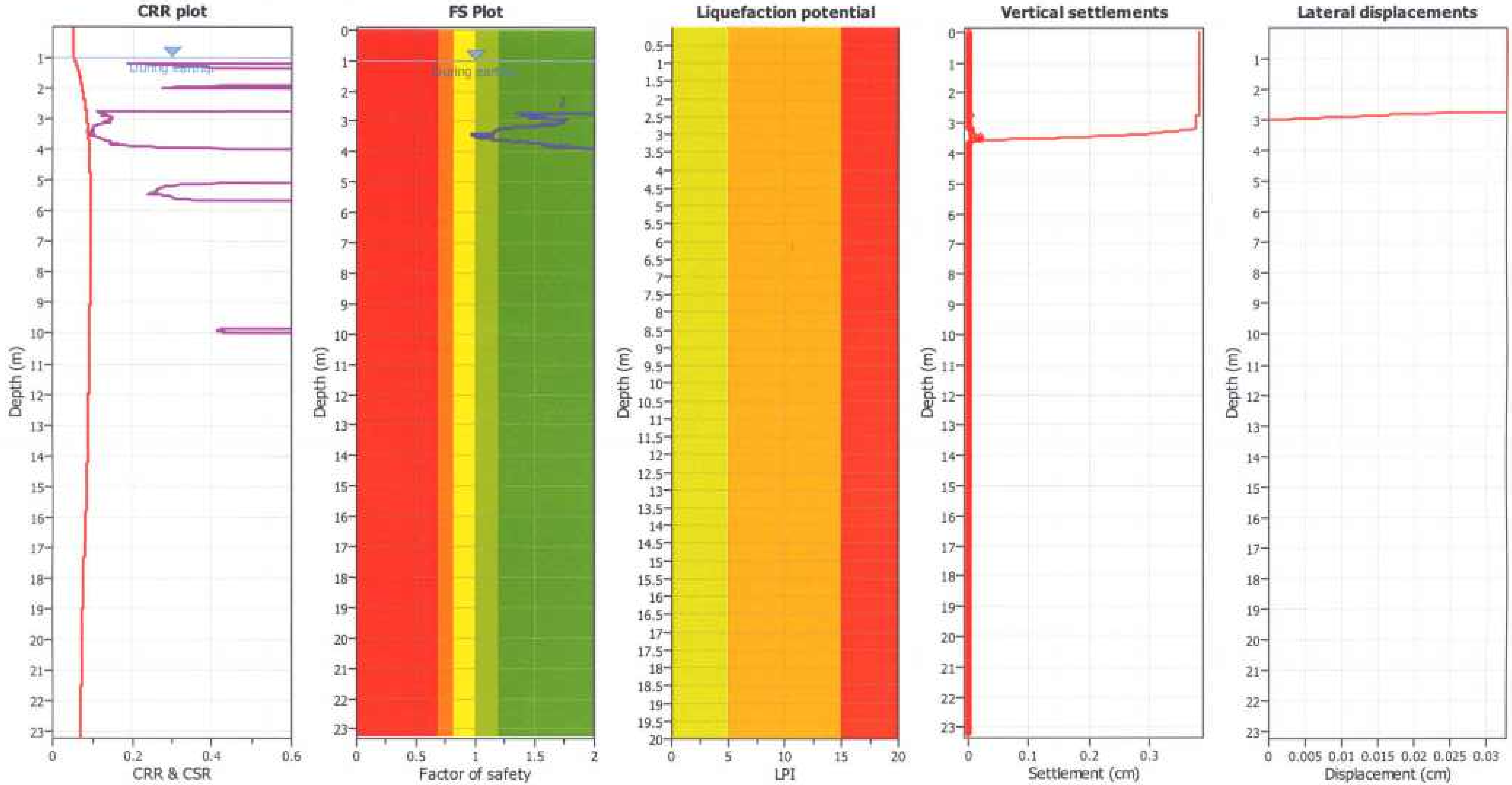
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.08	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBT legend

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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.08	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	10.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liquefaction are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

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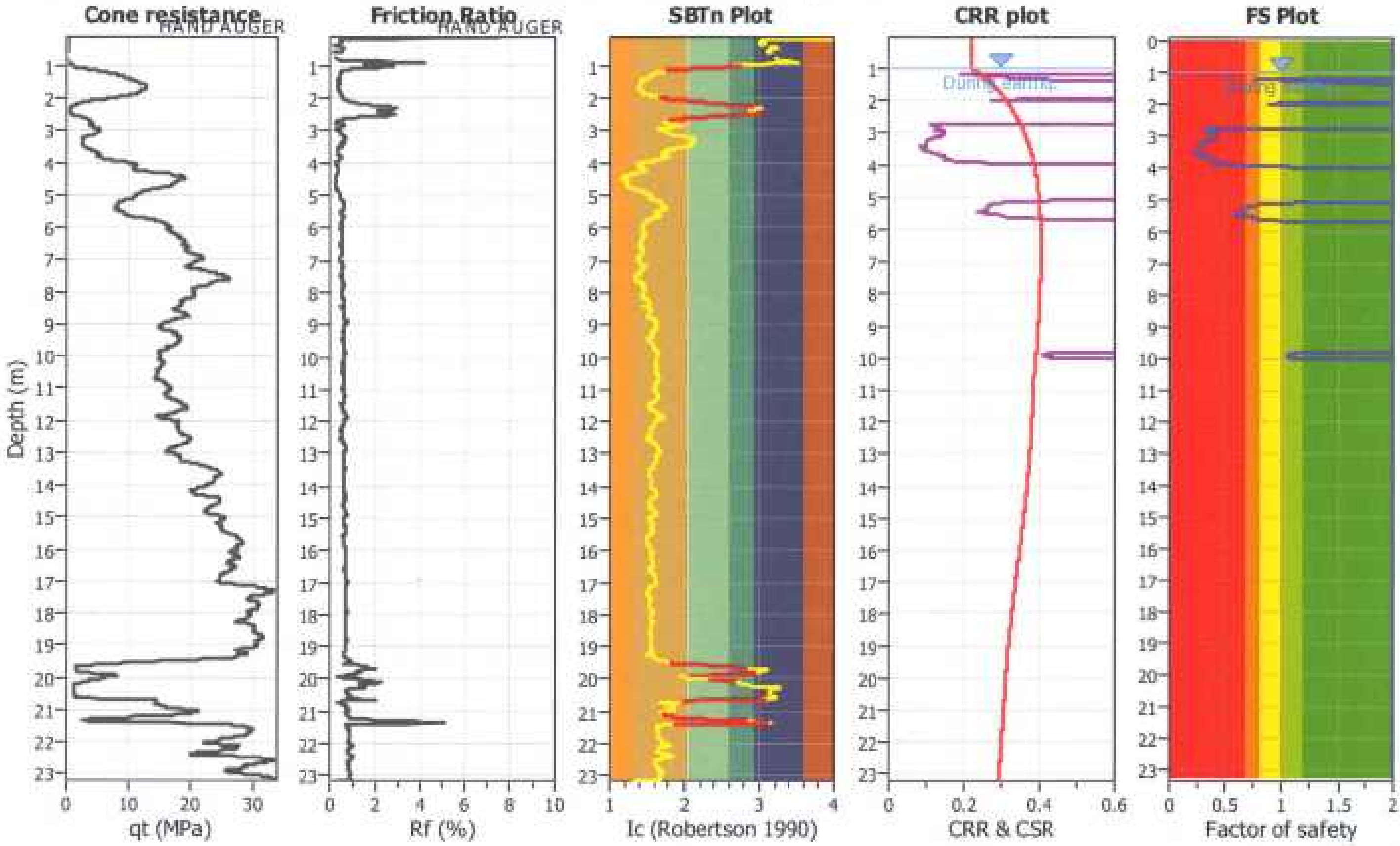
LIQUEFACTION ANALYSIS REPORT

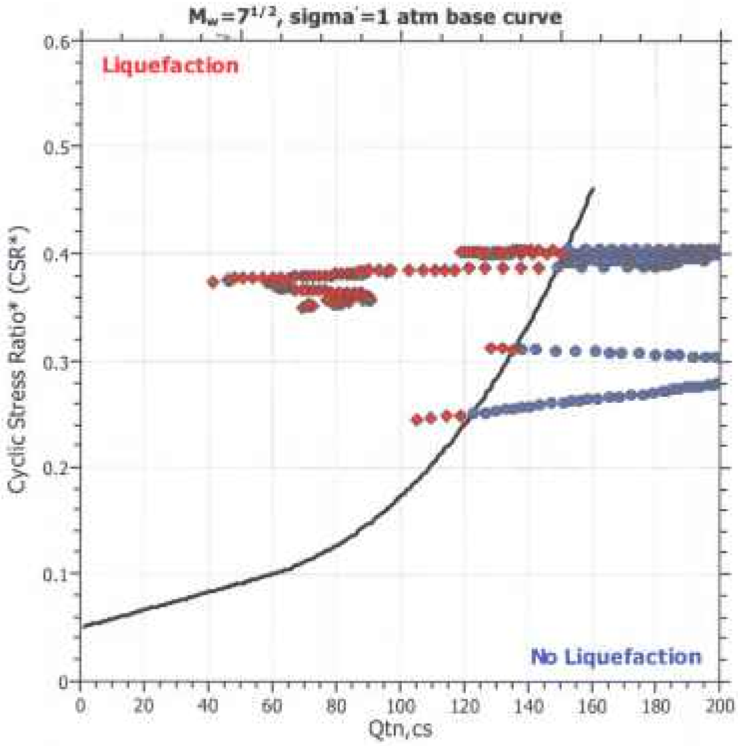
Project title : **Location :**

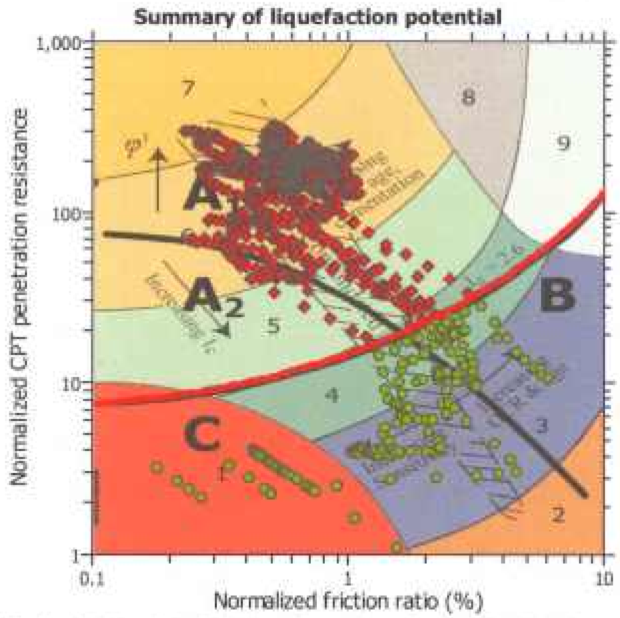
CPT file : CPT_1952_ULS

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	Yes		
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

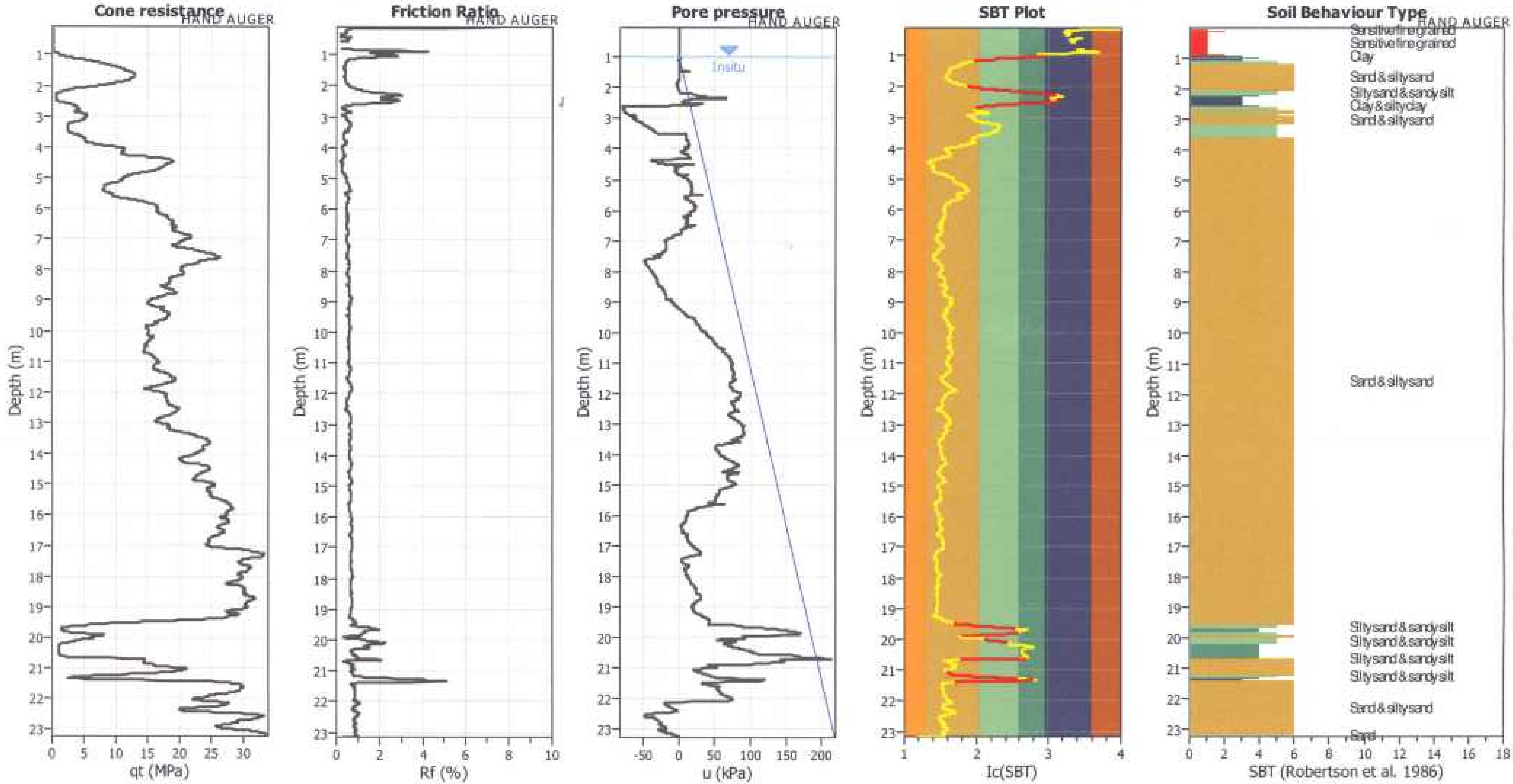






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



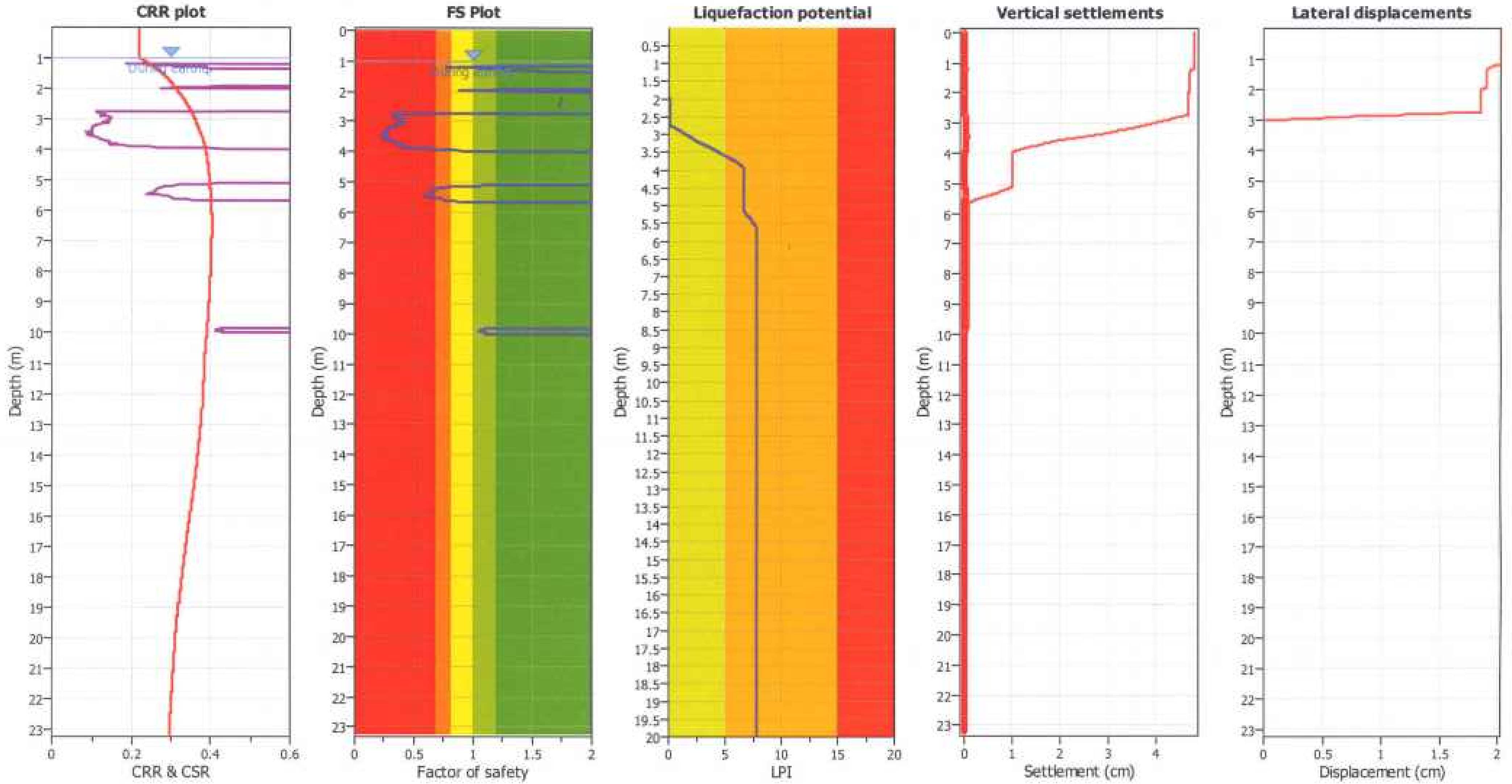
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.34	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBT legend

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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.34	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	10.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liquefaction are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

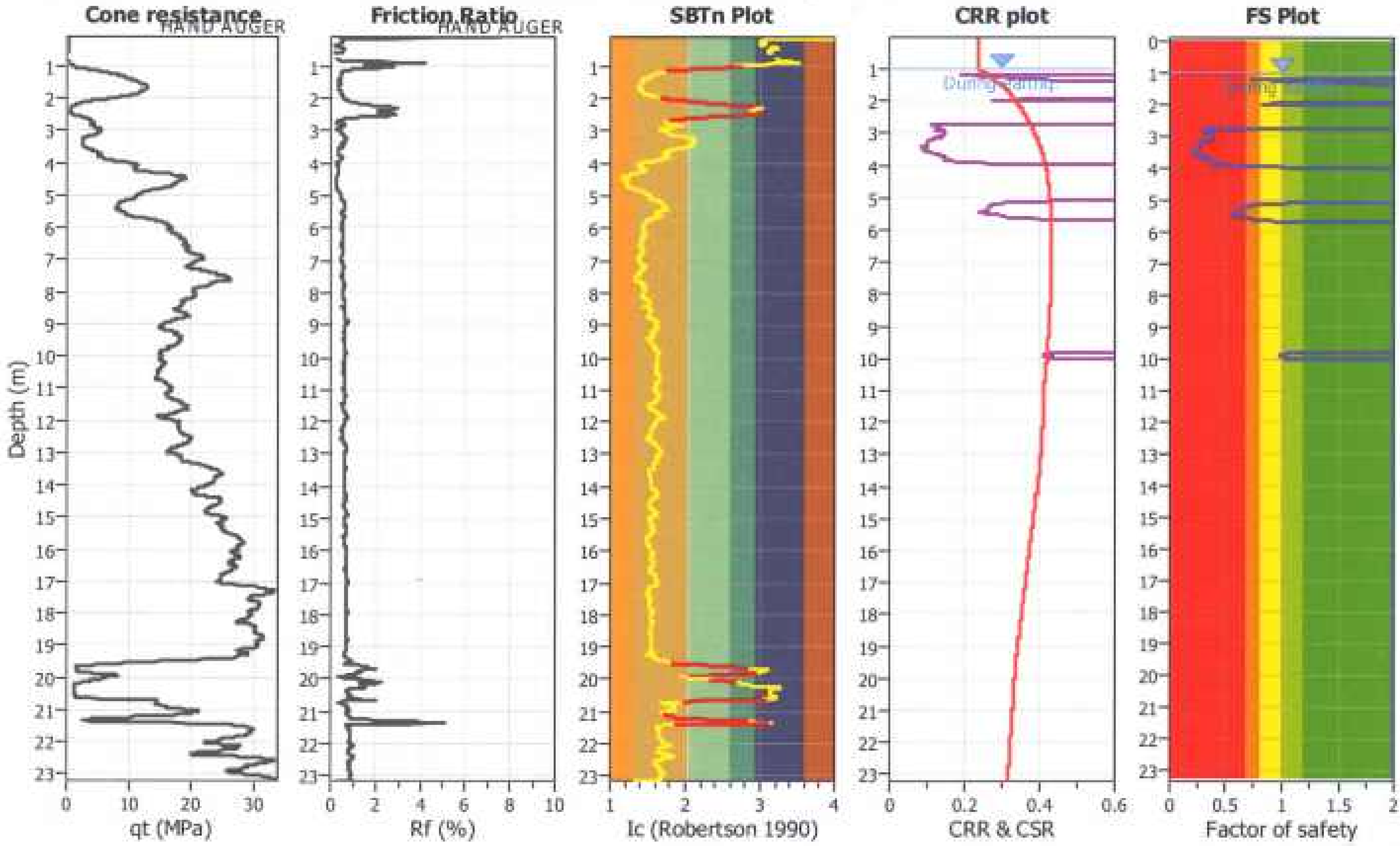
LIQUEFACTION ANALYSIS REPORT

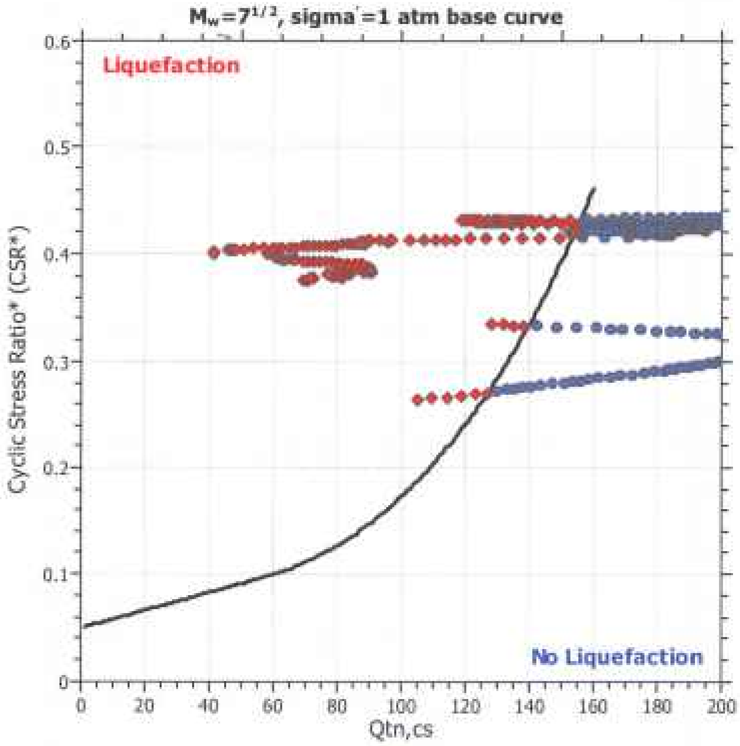
Project title : **Location :**

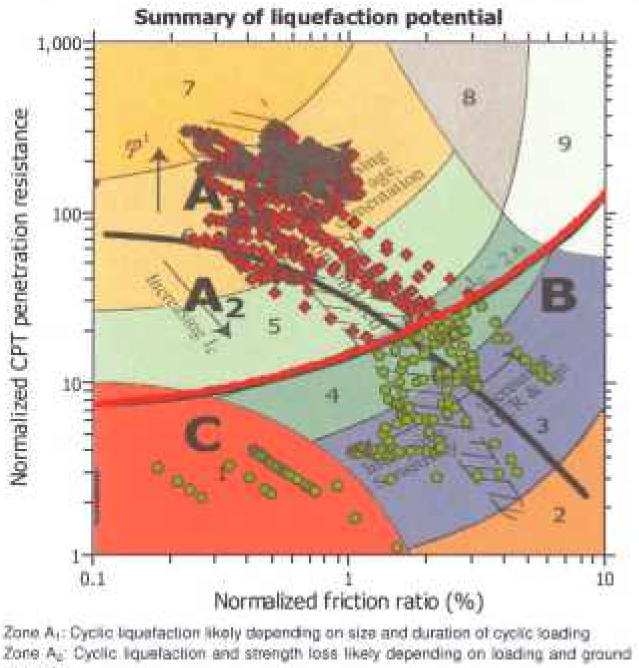
CPT file : CPT_1952_ULS

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	6.30	Ic cut-off value:	2.60	Trans. detect. applied:	Yes		
Peak ground acceleration:	0.57	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

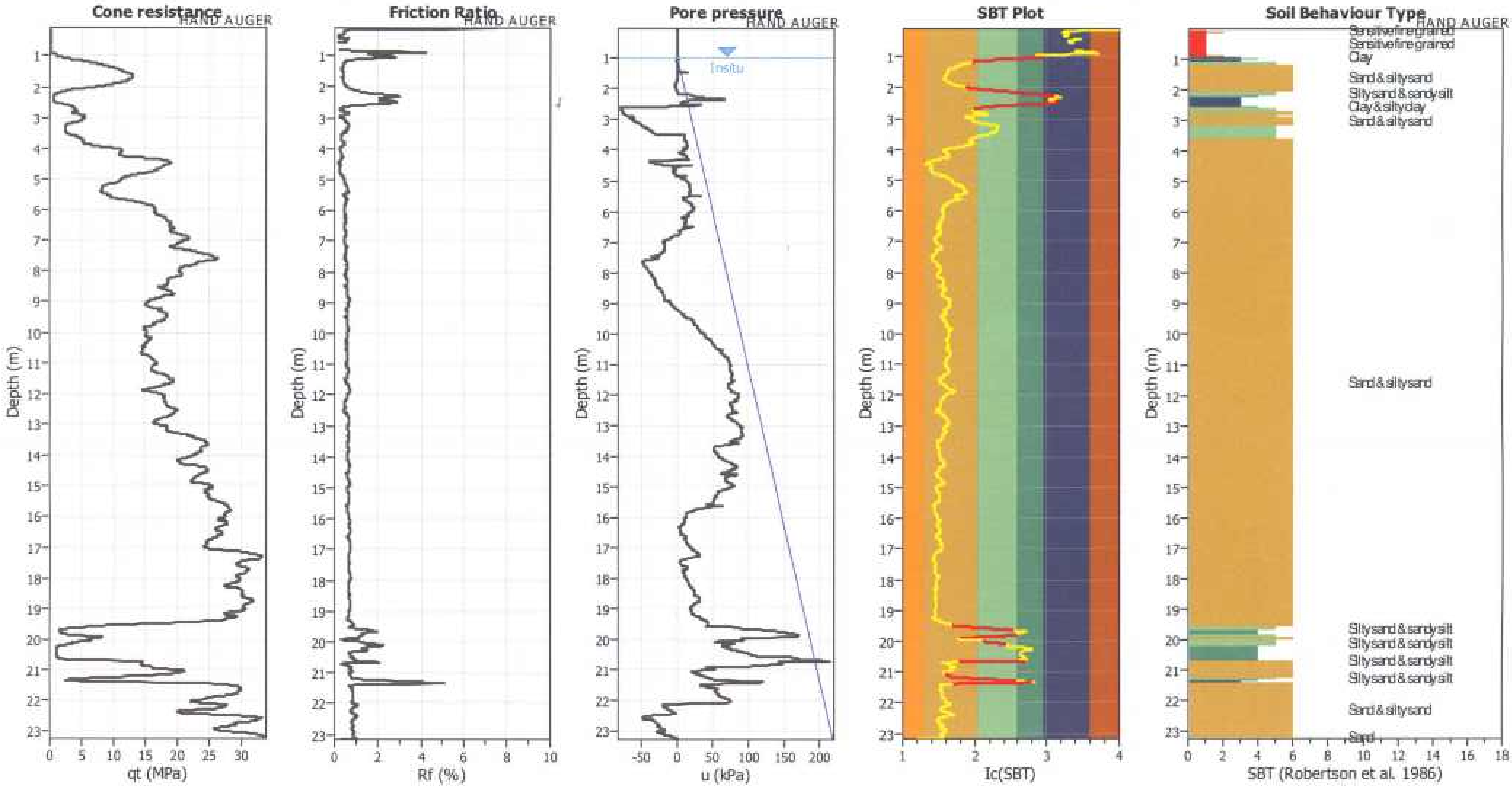






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



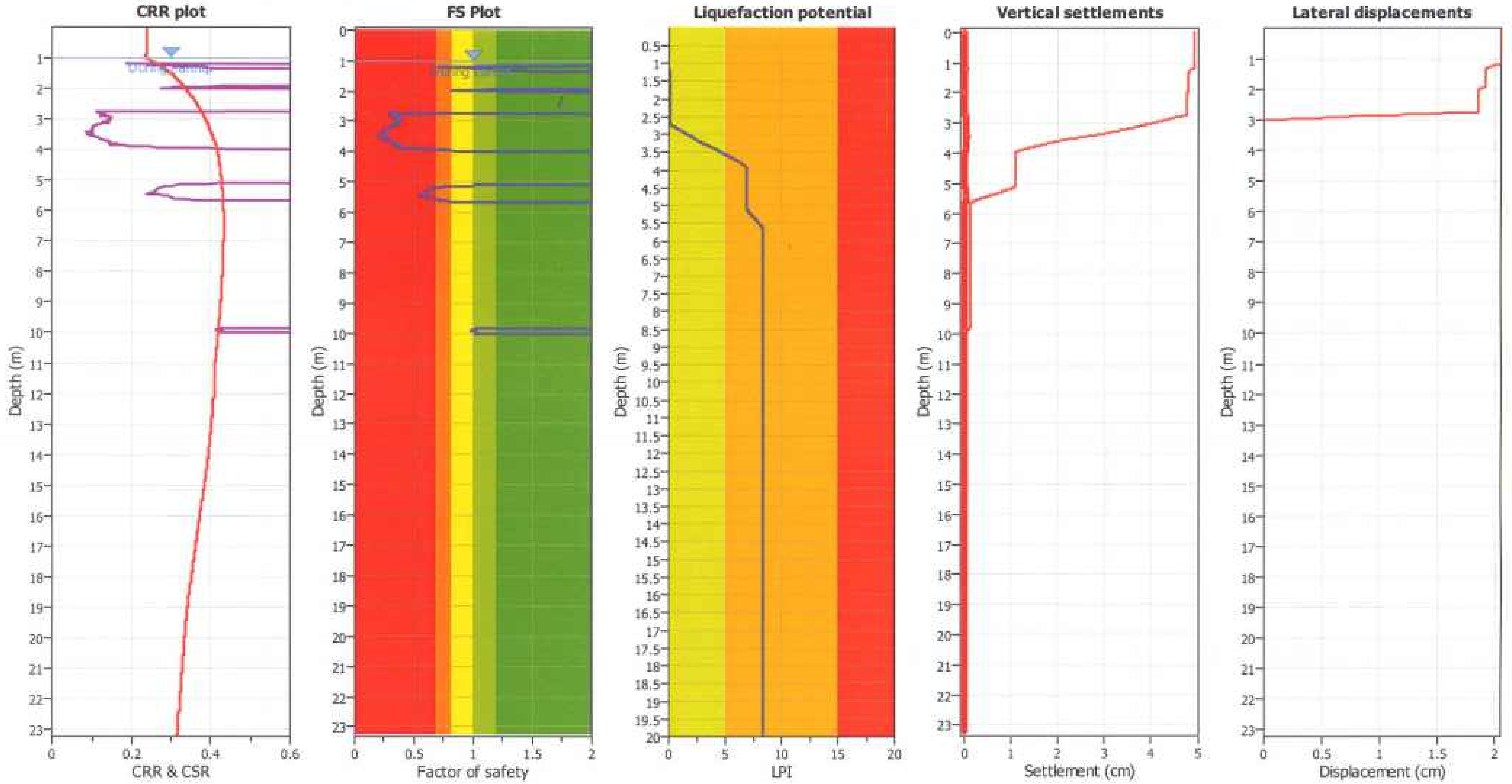
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.57	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBT legend

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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w:	6.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.57	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	10.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liquefaction are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

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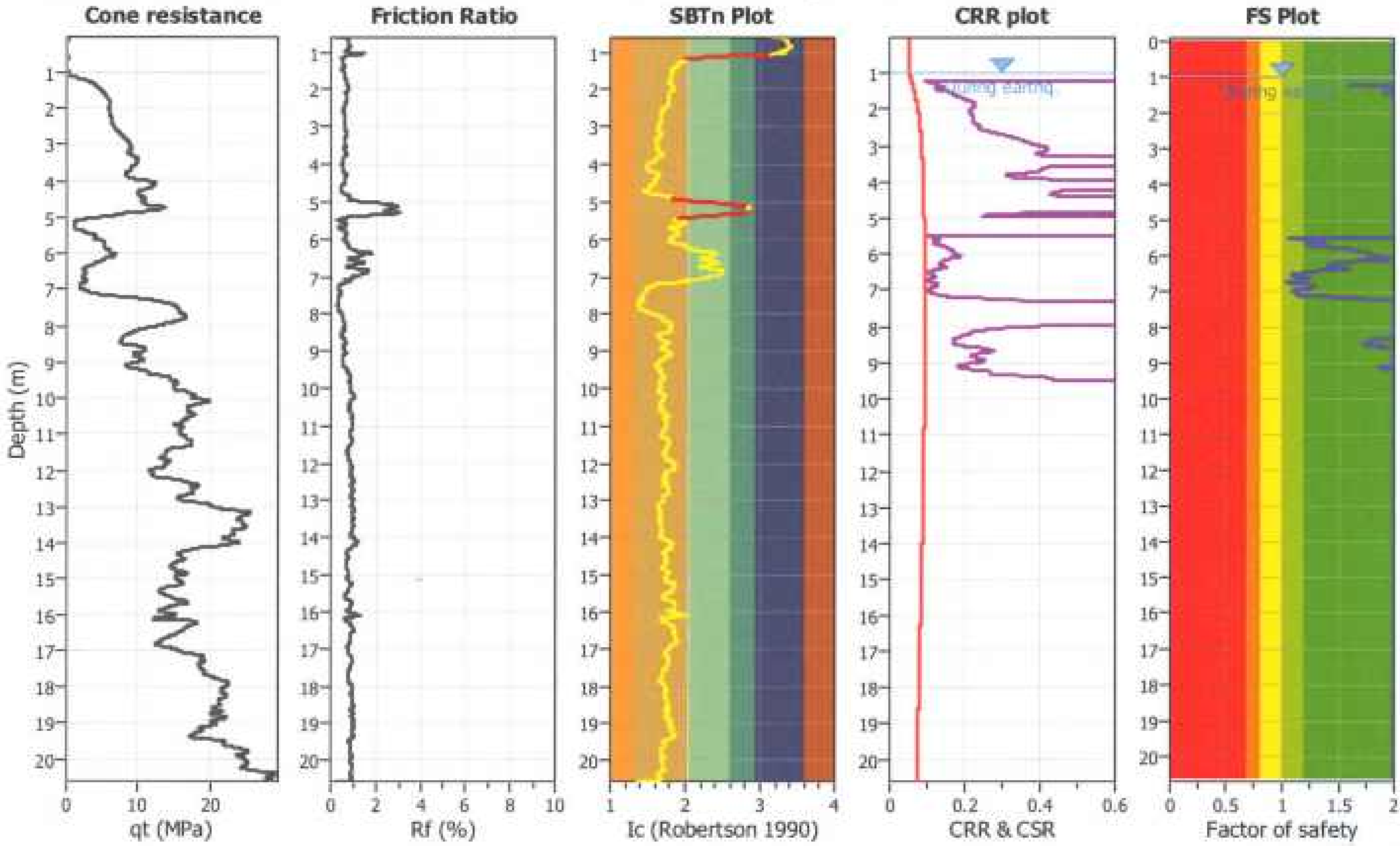
LIQUEFACTION ANALYSIS REPORT

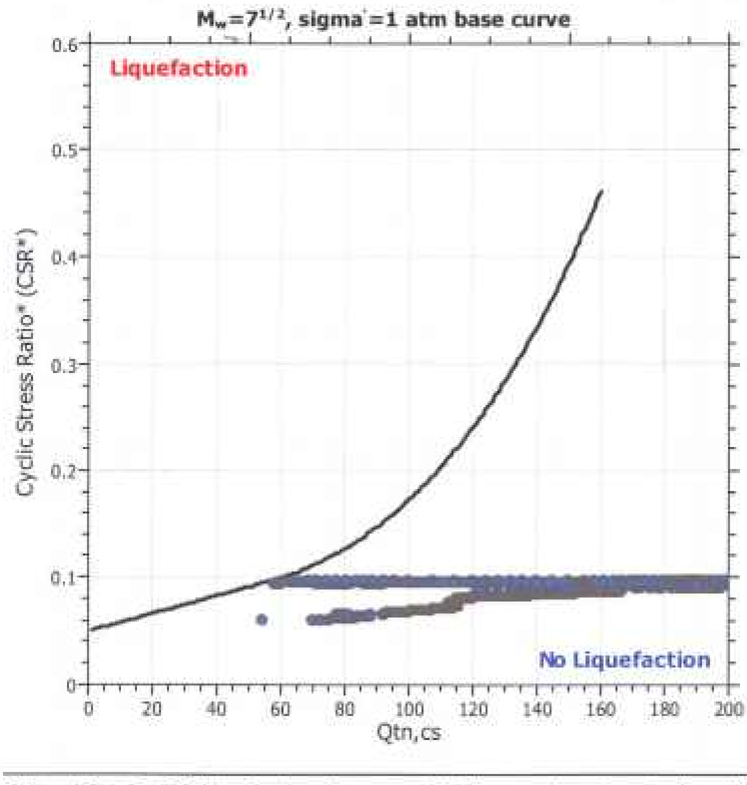
Project title : **Location :**

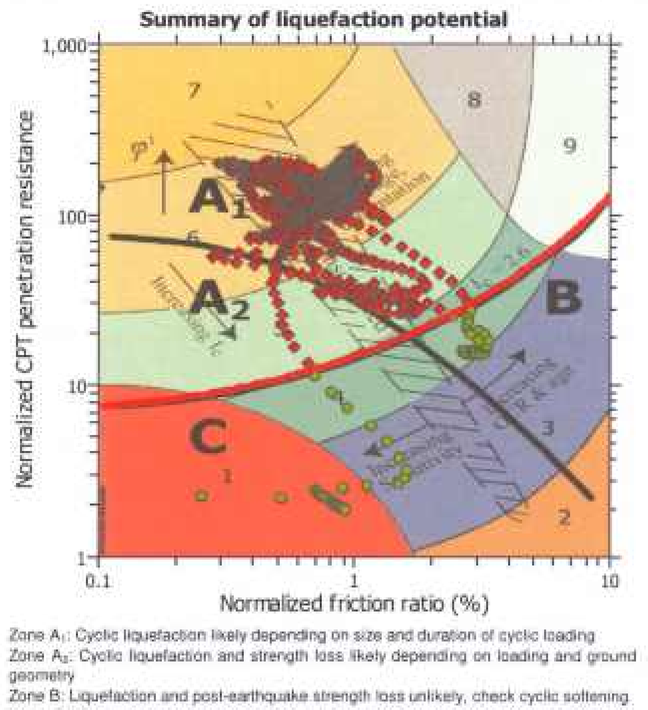
CPT file : CPT_902_SLS

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	Yes		
Peak ground acceleration:	0.08	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

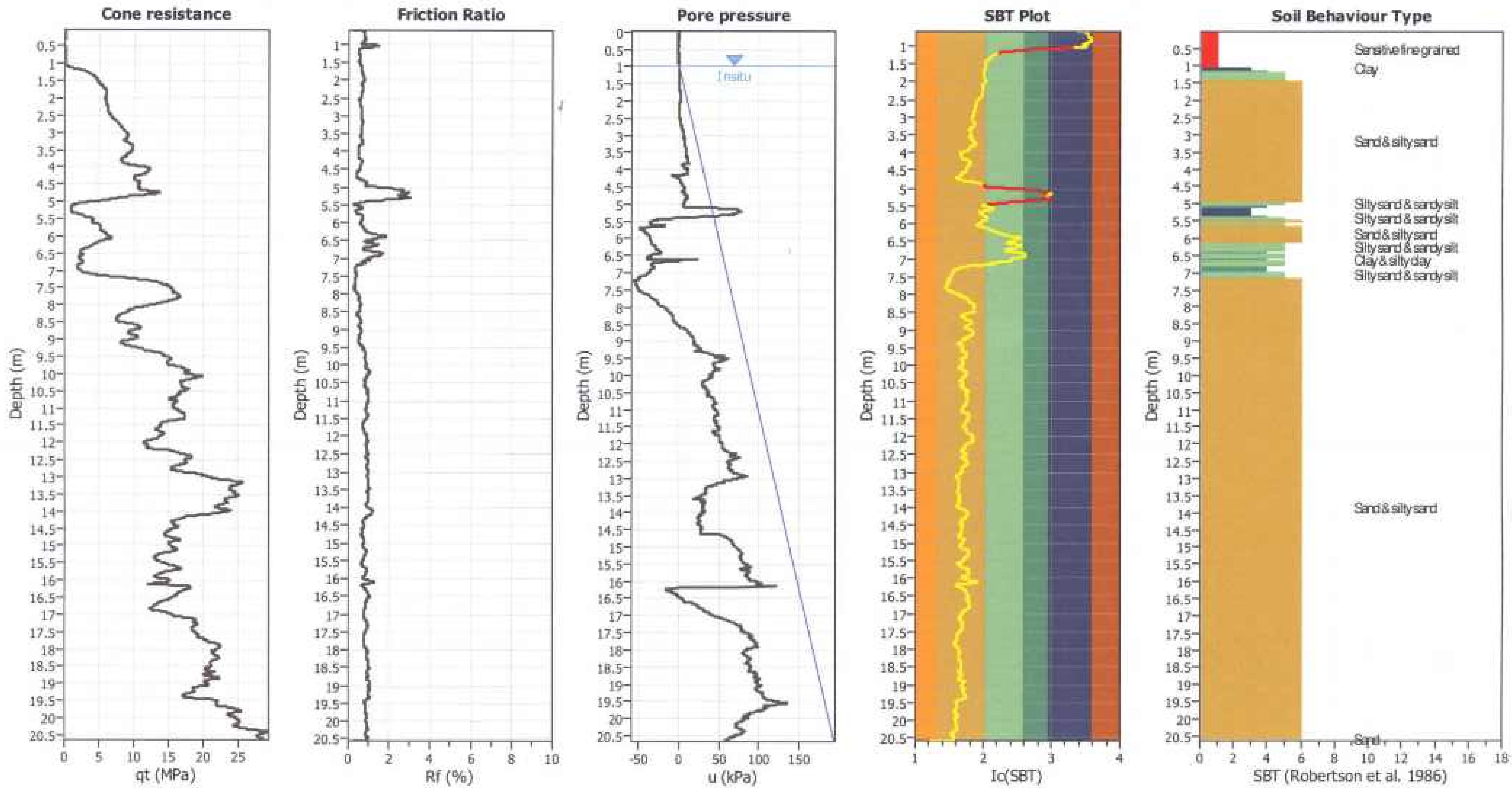






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



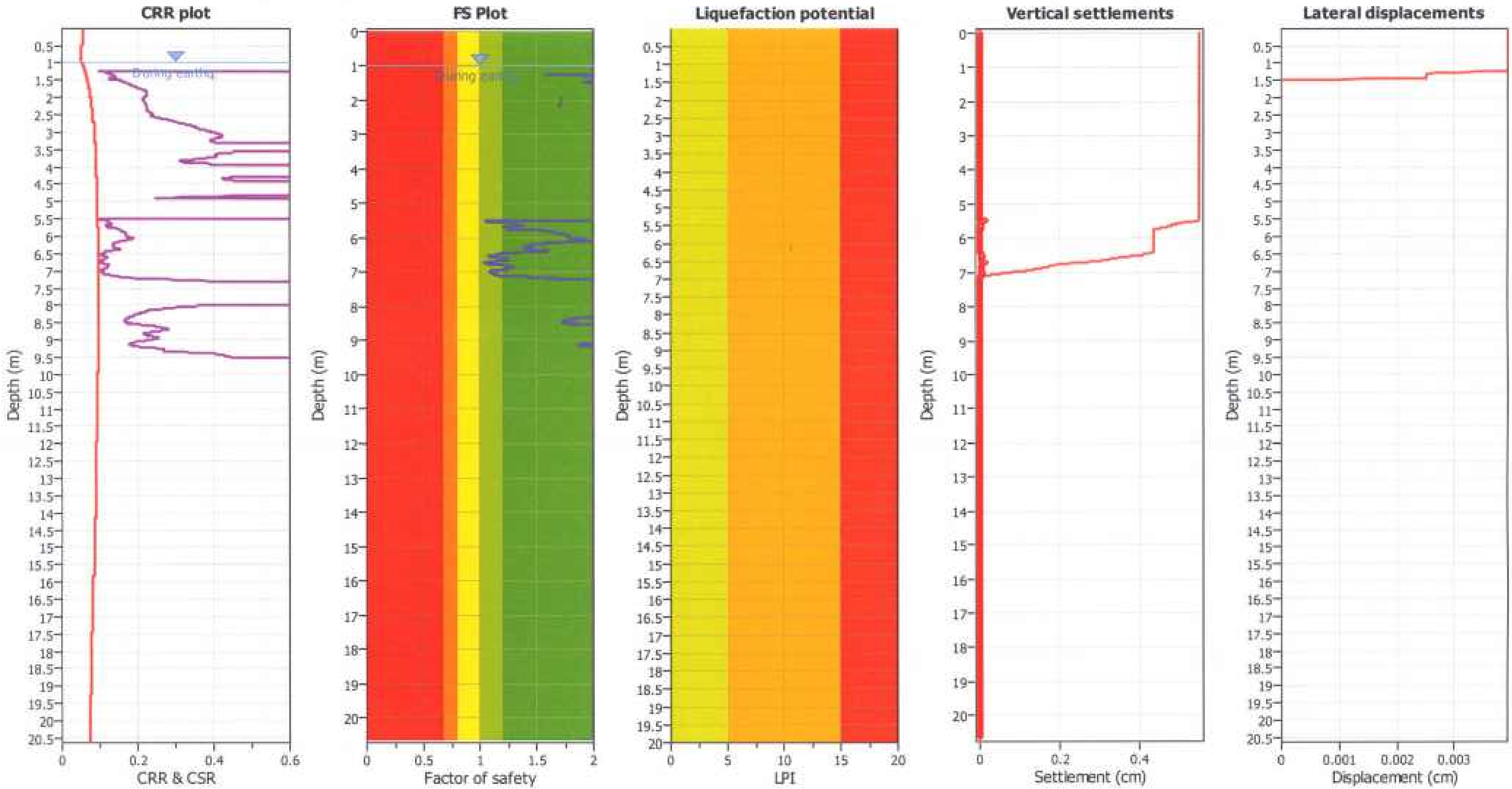
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.08	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBT legend

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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.08	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	10.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liquefaction are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

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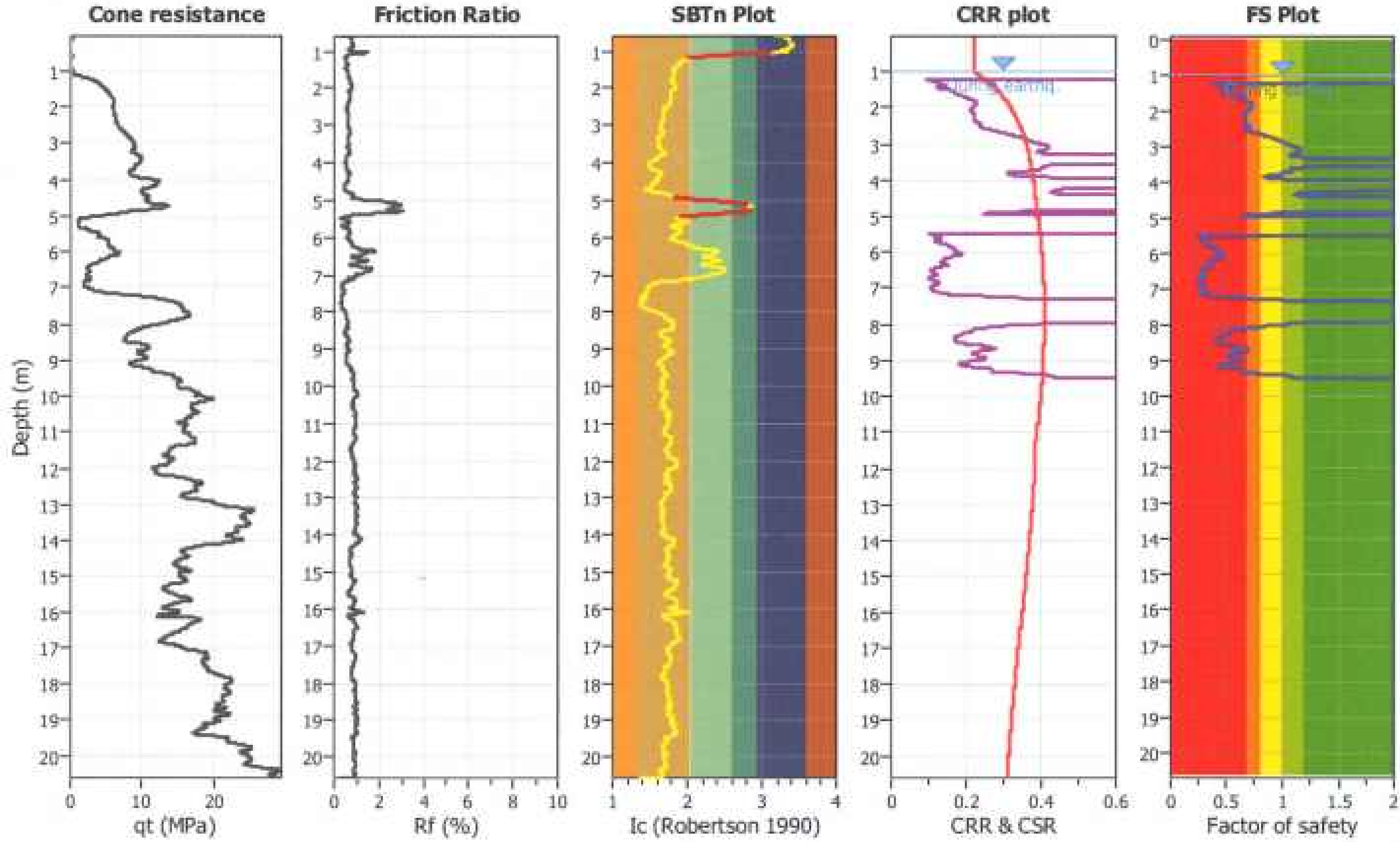
LIQUEFACTION ANALYSIS REPORT

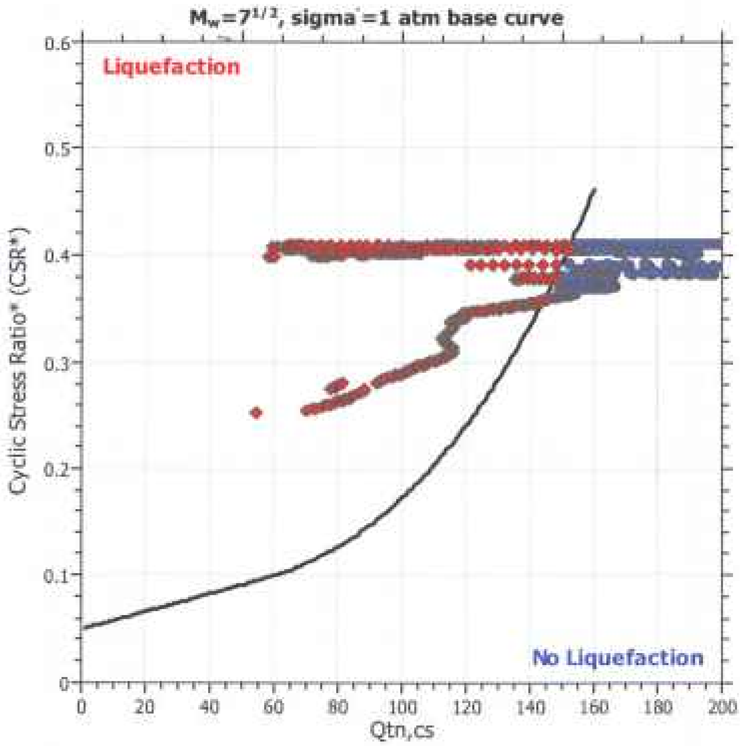
Project title : **Location :**

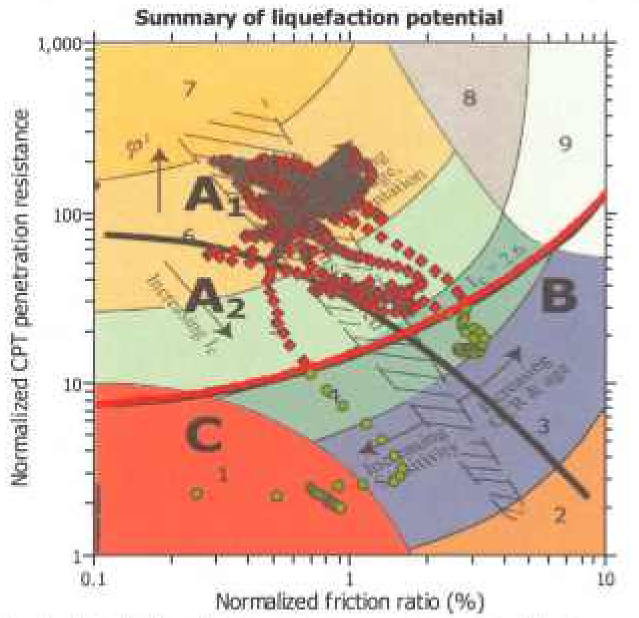
CPT file : CPT_902_ULS

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A		
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w:	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	Limit depth:	10.00 m
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		







Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
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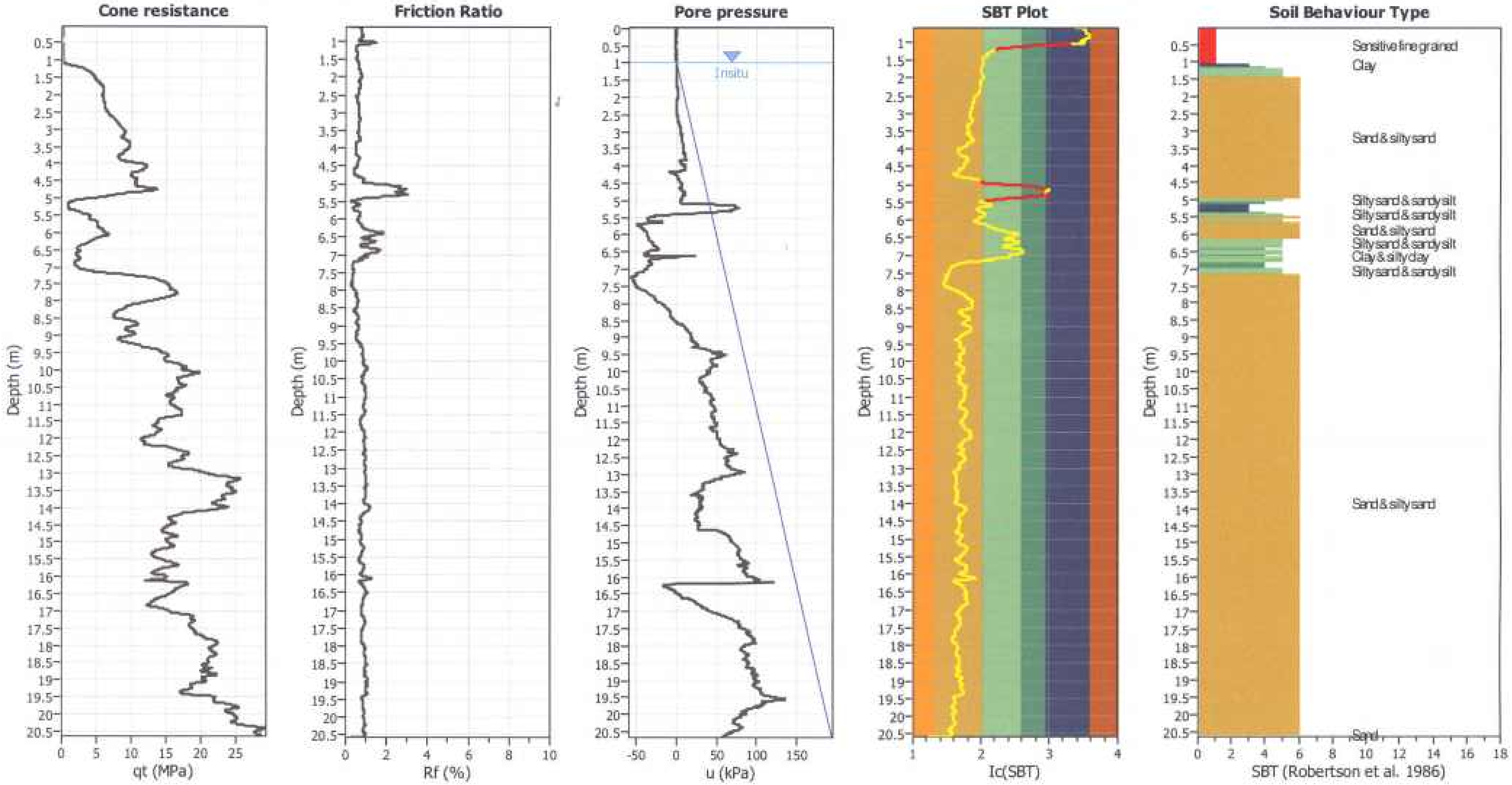
CPT basic interpretation plots



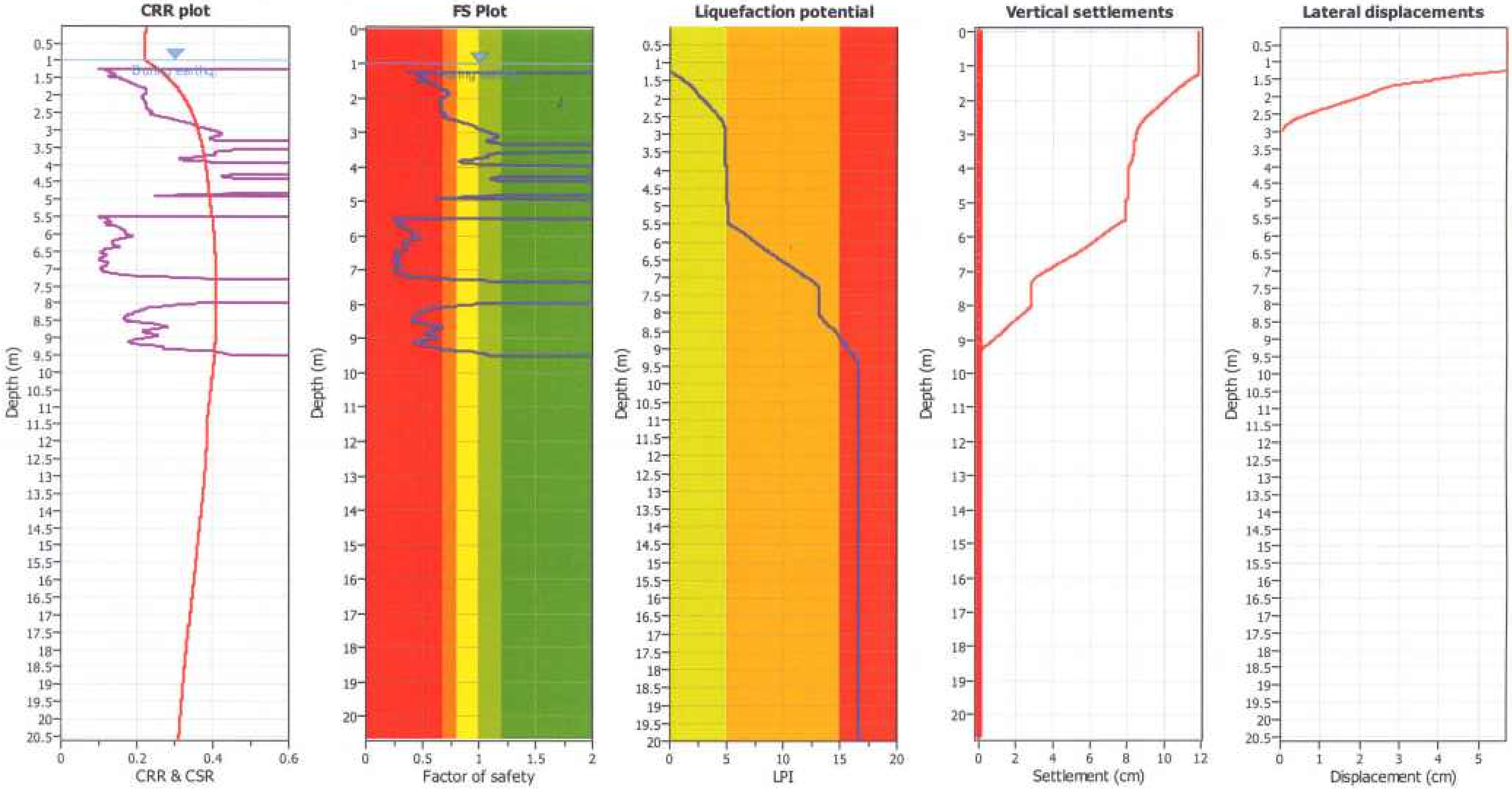
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_o applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.34	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBT legend

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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.34	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	10.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liquefaction are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

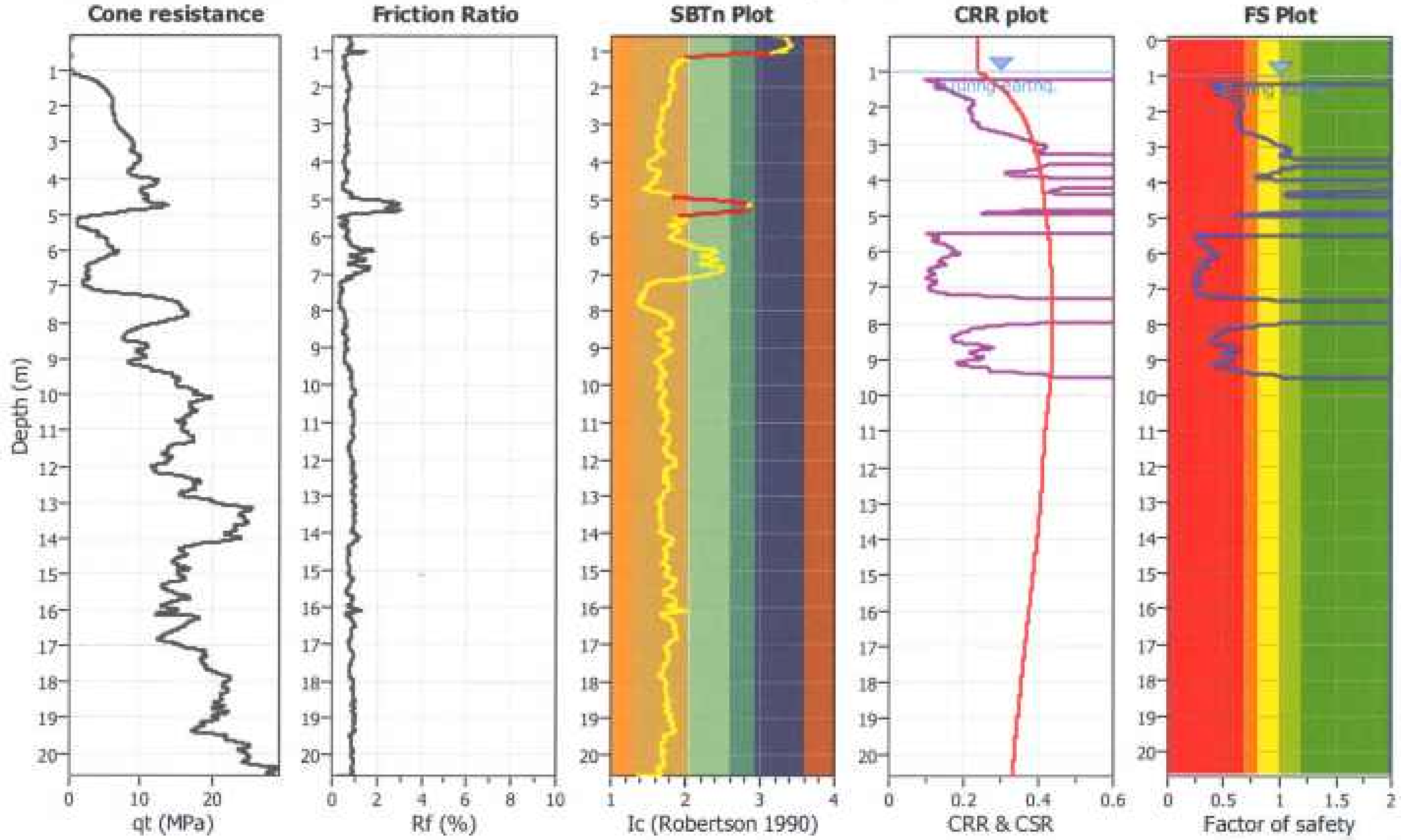
LIQUEFACTION ANALYSIS REPORT

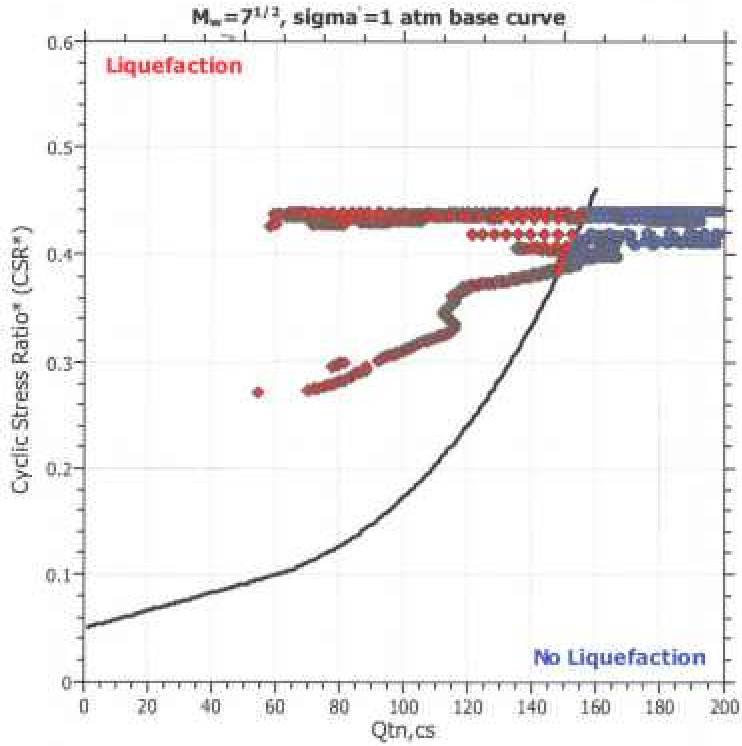
Project title : **Location :**

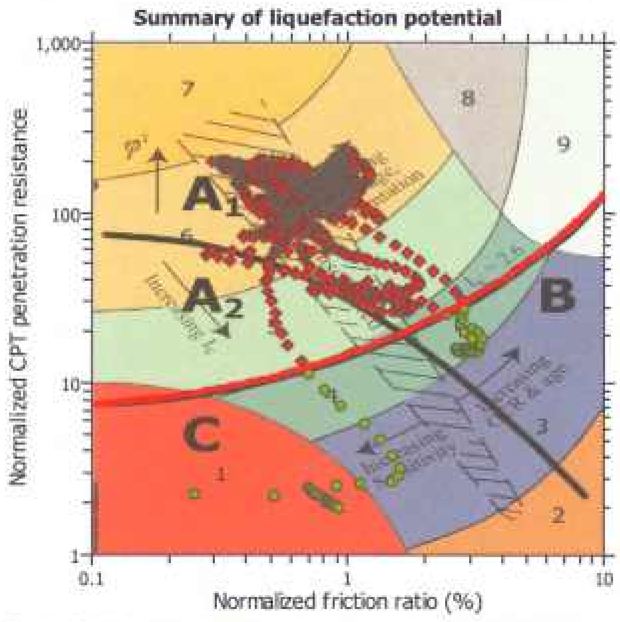
CPT file : CPT_902_ULS

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	6.30	Ic cut-off value:	2.60	Trans. detect. applied:	Yes		
Peak ground acceleration:	0.57	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

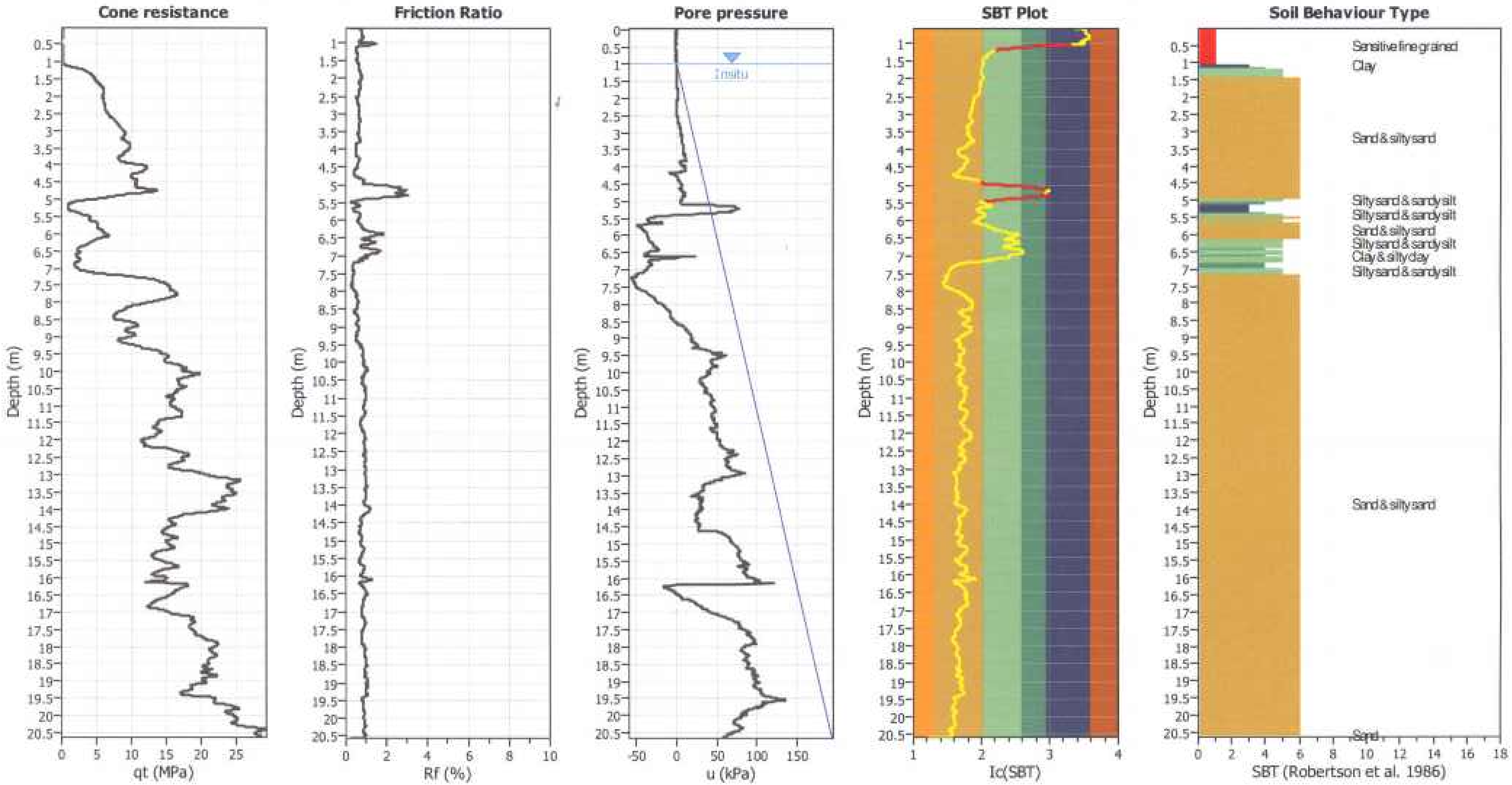






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



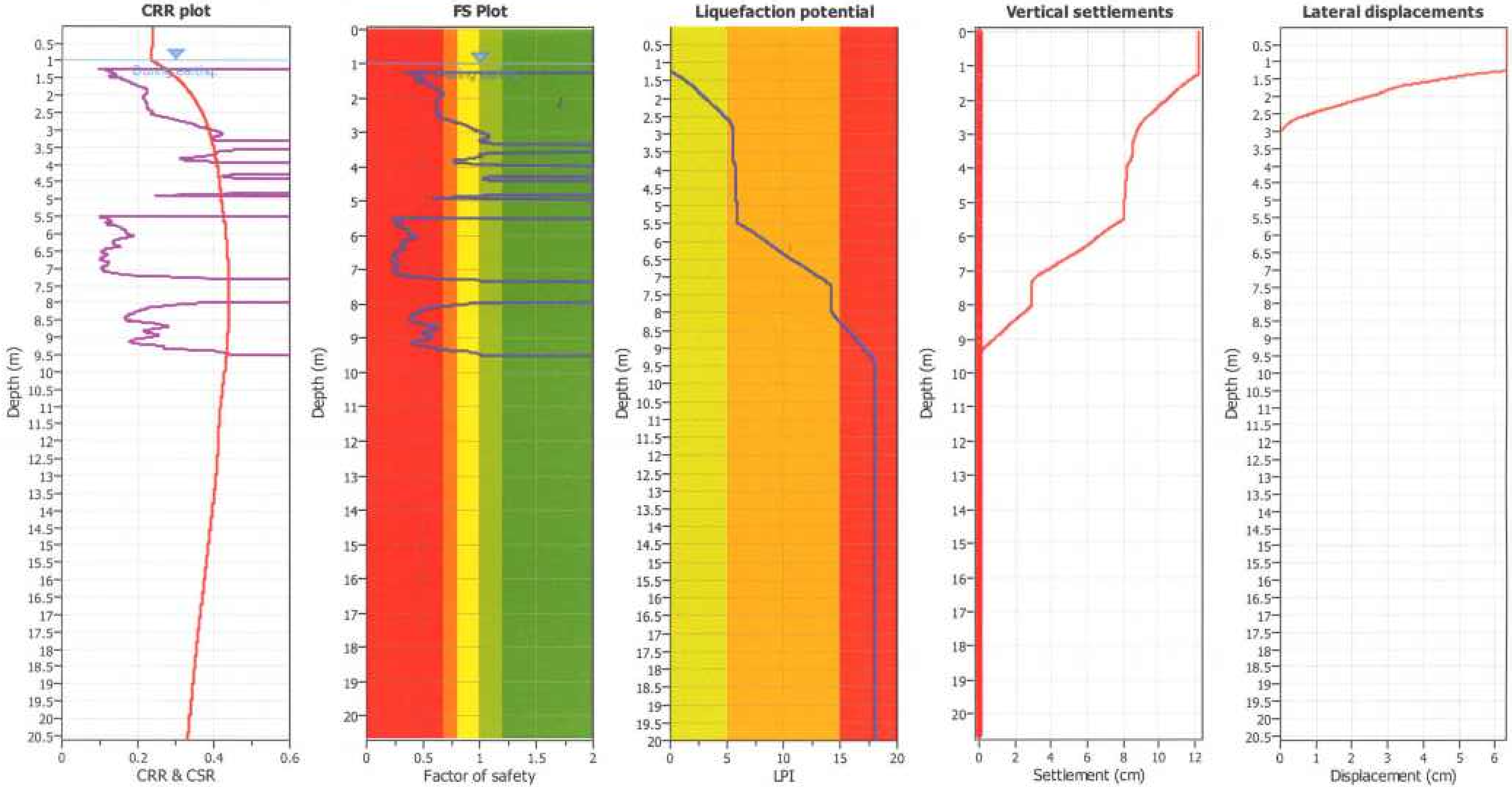
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.57	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBT legend

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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.57	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	10.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liquefaction are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

Appendix 3 - Methodology and Assumptions

Seismic Parameters

As per NZS 1170.5:

- T < 0.4s (assumed)
- Soil: Category D
- Z = 0.3
- R = 1.0 (IL2, 50 year)
- N(T,D) = 1.0

For the analyses, a μ of 2 was assumed for the residential units.

Analysis Procedure

The age and/or structural layout of the buildings meant that a rigid diaphragm assumption would be invalid for the ceiling diaphragms of all of the buildings. Base shears and capacities were therefore calculated based on tributary areas.

Capacities were based on the NZS 3604 approach where base shears are converted to bracing units (1 kN = 20 BU's) and the bracing capacities were found by assuming a certain BU/m rating for the walls along each line. Due to the unknown nature of the walls, the BU/m rating was taken as 60 BU/m for all timber walls with an aspect ratio (height : length) of less than 2:1. This was scaled down to 0 BU/m at an aspect ratio of 3.5:1 as per NZSEE guidelines. %NBS values were then found through the ratio of bracing demand to bracing capacity along each line; with the worst %NBS for each block being reported.

Additional Assumptions

Further assumptions about the seismic performance of the buildings were:

- Foundations and foundation connections had adequate capacity to resistance and transfer earthquake loads.
- Connections between all elements of the lateral load resisting systems are detailed to adequately transfer their loads sufficiently and are strong enough so as to not fail before the lateral load resisting elements.

Appendix 4 – CERA DEE Spreadsheet

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name:	Lyn Christie Place	Reviewer:	John Newall
Building Address:	Unit No: Street 30 Wildwood Ave, Wainoni	CPEng No:	1018146
Legal Description:		Company:	Opus International Consultants Ltd.
		Company project number:	6-QUCC2.13
		Company phone number:	03 363 5400
GPS south: (Degrees / Min / Sec)		Date of submission:	18-Jan-13
GPS east:		Inspection Date:	
		Revision:	Final
Building Unique Identifier (CCC):	BU 07272 EQ2	Is there a full report with this summary?	yes

Site

Site slope:	flat	Max retaining height (m):	
Soil type:	mixed	Soil Profile (if available):	
Site Class (to NZS1170.5):	D		
Proximity to waterway (m, if <100m):		If Ground improvement on site, describe:	
Proximity to clifftop (m, if < 100m):			
Proximity to cliff base (m,if <100m):		Approx site elevation (m):	

Building

No. of storeys above ground:	1	single storey = 1	Ground floor elevation (Absolute) (m):	
Ground floor split?	no		Ground floor elevation above ground (m):	
Storeys below ground	0			
Foundation type:	timber piles		if Foundation type is other, describe:	
Building height (m):			height from ground to level of uppermost seismic mass (for IEP only) (m):	
Floor footprint area (approx):	190			
Age of Building (years):	40		Date of design:	1965-1976
Strengthening present?	no		If so, when (year)?	
			And what load level (%g)?	
Use (ground floor):	multi-unit residential		Brief strengthening description:	
Use (upper floors):				
Use notes (if required):				
Importance level (to NZS1170.5):	IL2			

Gravity Structure

Gravity System:	load bearing walls		
Roof:	timber truss	truss depth, purlin type and cladding	
Floors:	timber	joist depth and spacing (mm)	
Beams:			
Columns:			
Walls:			

Lateral load resisting structure

Lateral system along:	lightweight timber framed walls	**Note: Define along and across in detailed report!**		
Ductility assumed, μ:	2.00		note typical wall length (m)	
Period along:	0.40	0.00	estimate or calculation?	estimated
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	
Lateral system across:	lightweight timber framed walls			
Ductility assumed, μ:	2.00		note typical wall length (m)	
Period across:	0.40	0.00	estimate or calculation?	estimated
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	

Separations:

north (mm):		leave blank if not relevant
east (mm):		
south (mm):		
west (mm):		

Non-structural elements

Stairs:			
Wall cladding:	brick or tile	describe (note cavity if exists)	
Roof Cladding:	Metal	describe	
Glazing:			
Ceilings:	fibrous plaster, fixed		
Services(list):			

Available documentation

Architectural	none	original designer name/date	
Structural	full	original designer name/date	
Mechanical	none	original designer name/date	
Electrical	none	original designer name/date	
Geotech report	none	original designer name/date	

Damage

Site: (refer DEE Table 4-2)

Site performance:		Describe damage:	
Settlement:	0-25mm	notes (if applicable):	
Differential settlement:	1:250-1:150	notes (if applicable):	
Liquefaction:	none apparent	notes (if applicable):	
Lateral Spread:	none apparent	notes (if applicable):	
Differential lateral spread:	none apparent	notes (if applicable):	
Ground cracks:	none apparent	notes (if applicable):	
Damage to area:	none apparent	notes (if applicable):	

Building:

	Current Placard Status:	green		
Along	Damage ratio:	0%	Describe how damage ratio arrived at:	
	Describe (summary):			
Across	Damage ratio:	0%		
	Describe (summary):			
Diaphragms	Damage?:	no	Describe:	
CSWs:	Damage?:	no	Describe:	
Pounding:	Damage?:	no	Describe:	
Non-structural:	Damage?:	yes	Describe:	Cracking of linings and firewalls.

$$Damage\_Ratio = \frac{(\%NBS\,(before) - \%NBS\,(after))}{\%NBS\,(before)}$$

Recommendations

	Level of repair/strengthening required:	minor non-structural	Describe:	Reline walls, epoxy masonry cracks.
	Building Consent required:	no	Describe:	
	Interim occupancy recommendations:	full occupancy	Describe:	
Along	Assessed %NBS before e'quakes:	52% ##### %NBS from IEP below	If IEP not used, please detail assessment methodology:	DEE
	Assessed %NBS after e'quakes:	52%		
Across	Assessed %NBS before e'quakes:	61% ##### %NBS from IEP below		
	Assessed %NBS after e'quakes:	61%		

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