CHRISTCHURCH CITY COUNCIL

PRK_1510_B001
Bishopdale Shop Toilets
Bishopdale Court

QUANTITATIVE ASSESSMENT REPORT

FINAL

- Rev B
- August 2013

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Sinclair Knight Merz
142 Sherborne Street
Saint Albans
PO Box 21011, Edgeware
Christchurch, New Zealand
Tel: +64 3 940 4900
Fax: +64 3 940 4901
Web: www.skmconsulting.com

Contents

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Approval

	Signature	Date	Name	Title
Author		3rd Sept 2013	Kelly Sutherland	Structural Engineer
Approver		3rd Sept 2013	Nicholas Calvert	Senior Structural Engineer

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1. Executive Summary

1.1. Background

A Quantitative Assessment was carried out on the shop toilets located at Bishopdale Mall, Bishopdale Court, Bishopdale. The building is a 4.1 m x 5 m reinforced masonry toilet block with a lightweight roof. An aerial photograph illustrating the area is shown below in Figure 1. Detailed descriptions outlining the building and construction type is given in Section 5 of this report.

- **Figure 1 Aerial Photograph of Bishopdale mall**

This report for the building structures is based on the Engineering Advisory Group's "Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings" (from July 2011) and our visual inspection on 8 August 2013.

1.2. Key Damage Observed

Non-structural damage was noted to one block wall. Refer to Section 5.4 for a detailed account of the damage.

1.3. Critical Structural Weaknesses

No critical structural weaknesses have been identified.

1.4. Indicative Building Strength

As described in the Engineering Advisory Group's "Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings" (from July 2011) we have assessed the capacity of the building using the quantitative method. Our assessment included consideration of geotechnical conditions, existing earthquake damage to the buildings and structural engineering calculations to assess both strength and ductility/resilience.

The assessments were based on the following:

- On-site visual investigation to assess the extent of existing earthquake damage including a cover meter survey to determine the presence of steel.
- Qualitative assessment of critical structural weaknesses (CSWs) based on our inspection.
- Geotechnical Interpretative Report produced by SKM 15 August 2013. See Appendix C for details.

The Bishopdale shop toilets have been assessed to have a seismic capacity in the order of 100% NBS and is of low risk.

1.5. Conclusions and Recommendations

Based on the findings of this assessment indicating the building is in the order of 100%NBS, no strengthening is required in order to comply with Christchurch City Council (CCC) policy – Earthquake-prone dangerous & insanitary buildings policy 2010.

It is recommended that:

a) There is no damage to the buildings that would cause them to be unsafe to occupy.

b) Barriers around the building are not necessary.

2. Introduction

Sinclair Knight Merz was engaged by Christchurch City Council to carry out a Quantitative Assessment of the seismic performance of the shop toilets at the Bishopdale mall located at Bishopdale Court, Bishopdale. An aerial view of the buildings location is found in Figure 1 Aerial Photograph of Bishopdale mall

The scope of this quantitative analysis includes the following:

- Analysis of the seismic load carrying capacity of the buildings compared with current seismic loading requirements or New Buildings Standard (NBS). It should be noted that this analysis considers the building in its damaged state where appropriate.
- Identify any critical structural weaknesses which may exist in the building and include these in the assessed %NBS of the structure.
- Preparation of a summary report outlining the areas of concern in the building

The recommendations from the Engineering Advisory Group's "Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings" (from July 2011)[*] were followed to assess the likely performance of the structures in a seismic event relative to the New Building Standard (NBS). 100% NBS is equivalent to the strength of a building that fully complies with current codes. This includes a recent increase of the Christchurch seismic hazard factor from 0.22 to 0.3[†].

At the time of this report no drawings were made available for the building. The building description below is based on our visual inspection which included a cover meter survey to confirm the presence and spacing of reinforcing in the building.

[*] EAG 2011, *Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury - Draft*, p 10
[†] http://www.dbh.govt.nz/seismicity-info

3. Compliance

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

3.1. 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 carry out a full structural survey before the building is re-occupied.

We understand that CERA will 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). It is anticipated that CERA will adopt the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011. This document sets out a methodology for both qualitative and quantitative assessments.

The qualitative assessment is a desk-top and site inspection assessment. It is based on a thorough visual inspection of the building coupled with a review of available documentation such as drawings and specifications. The quantitative assessment involves analytical calculation of the buildings strength and may require non-destructive or destructive material testing, geotechnical testing and intrusive investigation.

It is anticipated that factors determining the extent of evaluation and strengthening level required will include:

- The importance level and occupancy of the building
- The placard status and amount of damage
- The age and structural type of the building

- Consideration of any critical structural weaknesses
- The extent of any earthquake damage

3.2. Building Act

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

3.2.1. 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 any alteration. This effectively means that a building cannot be weakened as a result of an alteration (including partial demolition).

3.2.2. Section 115 – Change of Use

This section requires that the territorial authority (in this case Christchurch City Council (CCC)) be satisfied that the building with a new use complies with the relevant sections of the Building Code 'as near as is reasonably practicable'. Regarding seismic capacity 'as near as reasonably practicable' has previously been interpreted by CCC as achieving a minimum of 67%NBS however where practical achieving 100%NBS is desirable. The New Zealand Society for Earthquake Engineering (NZSEE) recommend a minimum of 67%NBS.

3.2.3. Section 121 – Dangerous Buildings

The definition of dangerous building in the Act was extended by the Canterbury Earthquake (Building Act) Order 2010, and it now defines a building as dangerous if:

- 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
- 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
- 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
- there is a risk that that other property could collapse or otherwise cause injury or death; or
- a territorial authority has not been able to undertake an inspection to determine whether the building is dangerous.

3.2.4. Section 122 – Earthquake Prone Buildings

This section defines a building as earthquake prone 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 ground shaking 33% of the shaking used to design an equivalent new building.

3.2.5. 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.

3.2.6. Section 131 – Earthquake Prone Building Policy

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

3.3. Christchurch City Council Policy

Christchurch City Council adopted their Earthquake Prone, Dangerous and Insanitary Building Policy in 2006. This policy was amended immediately following the Darfield Earthquake of the 4th September 2010.

The 2010 amendment includes the following:

- A process for identifying, categorising and prioritising Earthquake Prone Buildings, commencing on 1 July 2012;
- A strengthening target level of 67% of a new building for buildings that are Earthquake Prone. Council recognises that it may not be practicable for some repairs to meet that target. The council will work closely with building owners to achieve sensible, safe outcomes;
- A timeframe of 15-30 years for Earthquake Prone Buildings to be strengthened; and,
- 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.

We anticipate that any building with a capacity of less than 34%NBS (including consideration of critical structural weaknesses) will need to be strengthened to a target of 67%NBS of new building standard as recommended by the Policy.

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.

3.4. 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.

After the February Earthquake, on 19 May 2011, Compliance Document B1: Structure was amended to include increased seismic design requirements for Canterbury as follows:

a) Hazard Factor increased from 0.22 to 0.3 (36% increase in the basic seismic design load),
b) Serviceability Return Period Factor increased from 0.25 to 0.33 (80% increase in the serviceability design loads when combined with the Hazard Factor increase),
c) The increase in the above factors has resulted in a reduction in the level of compliance of an existing building relative to a new building despite the capacity of the existing building not changing.

4. 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 likely capacity of this building has been derived in accordance with the New Zealand Society for Earthquake Engineering (NZSEE) guidelines 'Assessment and Improvement of the Structural Performance of Buildings in Earthquakes' (AISPBE), 2006. These guidelines provide an Initial Evaluation Procedure that assesses a buildings capacity based on a comparison of loading codes from when the building was designed and currently. It is a quick high-level procedure that can be used when undertaking a Qualitative analysis of a building. The guidelines also provide guidance on calculating a modified Ultimate Limit State capacity of the building which is much more accurate and can be used when undertaking a Quantitative analysis.

The New Zealand Society for Earthquake Engineering has proposed a way for classifying earthquake risk for existing buildings in terms of %NBS and this is shown in Figure 2 below.

- **Figure 2: NZSEE Risk Classifications Extracted from table 2.2 of the NZSEE 2006 AISPBE Guidelines**

Description	Grade	Risk	%NBS	Existing Building Structural Performance	Improvement of Structural Performance	
					Legal Requirement	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	Unacceptable	Unacceptable

Table 1 below provides an indication of the risk of failure for an existing building with a given percentage NBS, relative to the risk of failure for a new building that has been designed to meet current Building Code criteria (the annual probability of exceedance specified by current earthquake design standards for a building of 'normal' importance is 1/500, or 0.2% in the next year, which is equivalent to 10% probability of exceedance in the next 50 years).

- **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

5. Building Details

5.1. Building Description

The building is a single storey rectangular toilet block constructed of reinforced concrete masonry walls, 190mm thick. The building shares three walls with the neighbouring building and has been analysed in isolation. Refer to the aerial view in Figure 1 and to Appendix B for the site measurements.

The flat roof buildup was not seen but is assumed to be constructed of series of timber rafters spanning in the longitudinal direction, supporting timber purlins with ply sarking and corrugated metal sheeting. The apex roof is made up of inverted T shaped steel rafters at 600 mm centres supporting polycarbonate corrugated roof cladding. It is assumed the building is founded on a ground bearing slab.

Refer to PHOTOS 1-10 for general images of the building.

5.2. Gravity load resisting system

The weight of the roof is transferred to the perimeter reinforced concrete masonry walls walls through the steel and timber rafters..

The weight of the walls and applied loads are transferred into the concrete strip footing and then directly into the ground below. The ground floor is a slab on grade

5.3. Seismic load resisting system

Horizontal forces are transferred to foundation level by means of concrete masonry walls acting as shear walls.

Horizontal forces at foundation level are resisted by friction and ground pressures between the surrounding soil and the foundations.

5.4. Building Damage

The table of damage items observed during the time of inspection is as follows:

- **Table 2 - Damage observed**

1	Vertical crack to last block on exterior wall. (PHOTO 11 & 12)

6. Available Information and Assumptions

6.1. Available Information

The building descriptions and our evaluation is based on the visual inspection of external and internal surfaces only carried out on the 8 August 2013. No drawings were made available. A cover meter survey was carried out to determine the presence, spacing and cover of reinforcing in the structure.

6.2. Survey

The building has not been surveyed. A level survey is not considered necessary as there is no visible evidence of settlement or leaning.

6.3. Design Criteria and Assumptions

The following design criteria and assumptions made in undertaking the assessment of the building includes:

- The building was built according to good practice at the time.
- The toilet block has been checked in isolation to the Bishopdale Mall building. There are no joints between the two buildings. Because the walls are shared, it is assumed that the Bishopdale Mall building will not put any additional load into the walls of the toilet block.
- The soil on site is class D as described in AS/NZS1170.5:2004, Clause 3.1.3, Soft Soil. This is a conservative assumption based on the desktop study.
- Standard design assumptions for normal type buildings as described in AS/NZS 1170.0 :2002:
  - 50 year design life.
  - Structure Importance Level 2. This level of importance is described as ‘normal’ with medium or considerable consequence for loss of human life, or considerable economic, social or environmental consequence of failure.
- Site hazard factor, Z = 0.3, NZBC, Clause B1 Structure, Amendment 11 effective from 1 August 2011.
- The building has a short period less than 0.4 seconds
- A ductility of, μ= 1.25 was used in both directions.
- The masonry walls were measured to be singly reinforced with:
  - Bars at 600 mm centres vertically
  - Bars at 800 mm centres horizontally

  It is assumed that bars will be 12mm diameter as a minimum.

- The following material properties were estimated and used in the analyses:

Table 3: Material Properties

Material	Nominal Strength
Masonry	f_m' = 12MPa
Steel Reinforcement	f_y = 300MPa

The detailed engineering analysis is a post construction evaluation therefore it has the following limitations:

- It is not likely to pick up on any concealed construction errors (if they exist).
- Other possible issues that could affect the performance of the building such as corrosion and modifications to the structure will not be identified unless they are visible and have been specifically mentioned in this report.

The detailed engineering evaluation deals only with the structural aspects of the structure. Other aspects such as building services are not covered.

7. Results and Discussion

7.1. Critical Structural Weaknesses

This building has no critical structural weaknesses.

7.2. Analysis Results

The equivalent static force method was used to analyse the demands or loads applied to this building. These were then compared to the capacities of the structural elements to assess the seismic capacity of the building. The results of the analysis are reported in the following table as %NBS.

- **Table 4: DEE Results**

Building	Seismic Resisting Element	Action	Seismic Rating %NBS
Bishopdale shop toilets	Longitudinal Direction Masonry Walls	In Plane Shear	>100%
	Transverse Direction Masonry Walls	In Plane Shear	>100%
	Masonry Walls	Out of Plane	>100%

7.3. Discussion

Bishopdale shop toilet block relies on the reinforced concrete masonry walls in both directions to provide sufficient capacity. The building shares three walls with the neighbouring building and has been analysed in isolation.

No strengthening is required to comply with the Christchurch City Council Earthquake Prone, Dangerous and Insanitary Building Policy 2010.

8. Conclusions and Recommendations

SKM carried out a quantitative assessment on the Bishopdale shop toilet building located at Bishopdale Court, Bishopdale.

This assessment concluded that the Bishopdale Shop Toilet building is 'Low Risk' having a capacity greater than or equal to 67% NBS.

- **Table 5: Quantitative assessment summary**

Description	Grade	Risk	%NBS
Bishopdale shop toilets	A	Low	>100%

It is recommended that:

a) There is no damage to the buildings that would cause them to be unsafe to occupy.
b) Barriers around the building are not necessary.

9. Limitation Statement

This report has been prepared on behalf of, and for the exclusive use of, SKM's client, and is subject to, and issued in accordance with, the provisions of the contract between SKM and the Client. It is not possible to make a proper assessment of this report without a clear understanding of the terms of engagement under which it has been prepared, including the scope of the instructions and directions given to, and the assumptions made by, SKM. The report may not address issues which would need to be considered for another party if that party's particular circumstances, requirements and experience were known and, further, may make assumptions about matters of which a third party is not aware. No responsibility or liability to any third party is accepted for any loss or damage whatsoever arising out of the use of or reliance on this report by any third party.

Without limiting any of the above, in the event of any liability, SKM's liability, whether under the law of contract, tort, statute, equity or otherwise, is limited in as set out in the terms of the engagement with the Client.

It is not within SKM's scope or responsibility to identify the presence of asbestos, nor the responsibility of SKM to identify possible sources of asbestos. Therefore for any property pre-dating 1989, the presence of asbestos materials should be considered when costing remedial measures or possible demolition.

Should there be any further significant earthquake event, of a magnitude 5 or greater, it will be necessary to conduct a follow-up investigation, as the observations, conclusions and recommendations of this report may no longer apply Earthquake of a lower magnitude may also cause damage, and SKM should be advised immediately if further damage is visible or suspected.

10. Site Inspection Report Photos

PHOTO 1: Exterior front view

PHOTO 2: Exterior front view

PHOTO 3: Exterior side view

PHOTO 4: Exterior view of entrance

PHOTO 5: Exterior view of entrance

PHOTO 6: Interior view of hip roof

	
PHOTO 7: Exterior view of roof	PHOTO 8: Exterior view of side wall
	
PHOTO 9: Interior view of mens toilet	PHOTO 10: Interior view of womens toilet
	
PHOTO 11: Side wall showing crack location	PHOTO 12: Detail of previous photo (probably earthquake damage)

Appendix A CERA Standardised Report Forms

Detailed Engineering Evaluation Summary Data V1.14

Location

Building Name:	Bishopdale Court Mall Toilets			Reviewer:	N Calvert
	Unit	No:	Street	CPEng No:	242062
Building Address:	Bishopdale Mall		Bishopdale Court	Company:	Sinclair Knight Merz
Legal Description:				Company project number:	ZB01276.244
				Company phone number:	03 940 4919
	Degrees	Min	Sec		
GPS south:				Date of submission:	25/09/2013
GPS east:				Inspection Date:	8/08/2013
				Revision:	B
Building Unique Identifier (CCC):	PRK_1510_BLDG_001			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:	other (describe)		if Foundation type is other, describe:	Assumed slab on grade
Building height (m):	2.80		height from ground to level of uppermost seismic mass (for IEP only) (m):	
Floor footprint area (approx):	20			
Age of Building (years):			Date of design:	
Strengthening present?	no		If so, when (year)?	
			And what load level (%g)?	
Use (ground floor):	public		Brief strengthening description:	
Use (upper floors):				
Use notes (if required):	Public Toilets			
Importance level (to NZS1170.5):	IL2			

Gravity Structure

Gravity System:	load bearing walls		
Roof:	timber framed	rafter type, purlin type and cladding	Timber and steel rafters supporting lightweight roof
Floors:	concrete flat slab	slab thickness (mm)	
Beams:			
Columns:			
Walls:	partially filled concrete masonry	thickness (mm)	190

Lateral load resisting structure

Lateral system along:	partially filled CMU	**Note: Define along and across in detailed report!**	note total length of wall at ground (m):	11.2
Ductility assumed, μ:	1.25			
Period along:	0.40		estimate or calculation?	estimated
Total deflection (ULS) (mm):	5		estimate or calculation?	estimated
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	
Lateral system across:	partially filled CMU		note total length of wall at ground (m):	11.05
Ductility assumed, μ:	1.25			
Period across:	0.40		estimate or calculation?	estimated
Total deflection (ULS) (mm):	5		estimate or calculation?	estimated
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:			
Roof Cladding:	Other (specify)	describe	Lightweight metal and polycarbonate
Glazing:			
Ceilings:			
Services(list):			

Available documentation

Architectural	none	original designer name/date	
Structural	none	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:	Site performance:		Describe damage:	
(refer DEE Table 4-2)				
	Settlement:	none observed	notes (if applicable):	
	Differential settlement:	none observed	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):	refer to report for full outline		
Across	Damage ratio:	0%	$Damage\_Ratio = \frac{(\%NBS(before) - \%NBS(after))}{\%NBS(before)}$	
	Describe (summary):	refer to report for full outline		
Diaphragms	Damage?:	no	Describe:	
CSWs:	Damage?:	no	Describe:	
Pounding:	Damage?:	no	Describe:	
Non-structural:	Damage?:	yes	Describe:	minor cracking on outside wall

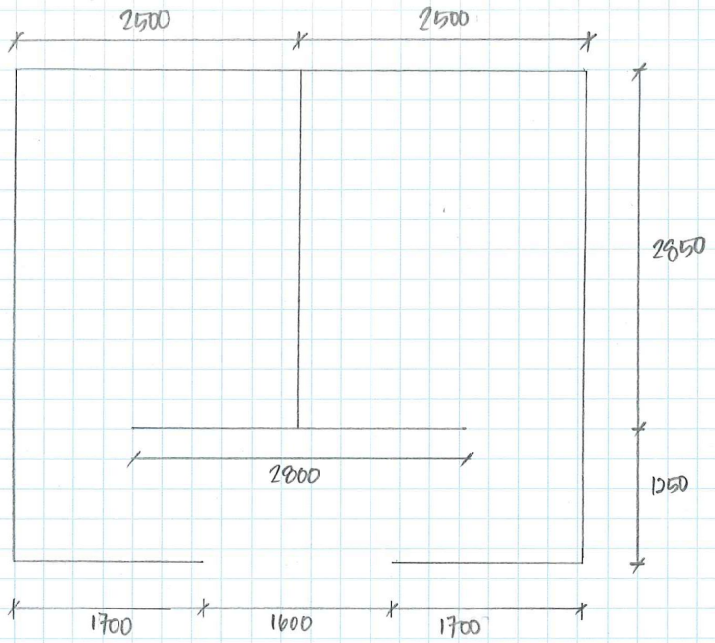
Recommendations

	Level of repair/strengthening required:	minor non-structural	Describe:	minor cracking on outside wall
	Building Consent required:	no	Describe:	
	Interim occupancy recommendations:	full occupancy	Describe:	
Along	Assessed %NBS before e'quakes:	100%	If IEP not used, please detail assessment methodology:	SKM calculations
	Assessed %NBS after e'quakes:	100%		
Across	Assessed %NBS before e'quakes:	100%		
	Assessed %NBS after e'quakes:	100%		

Appendix B As Built Sketch

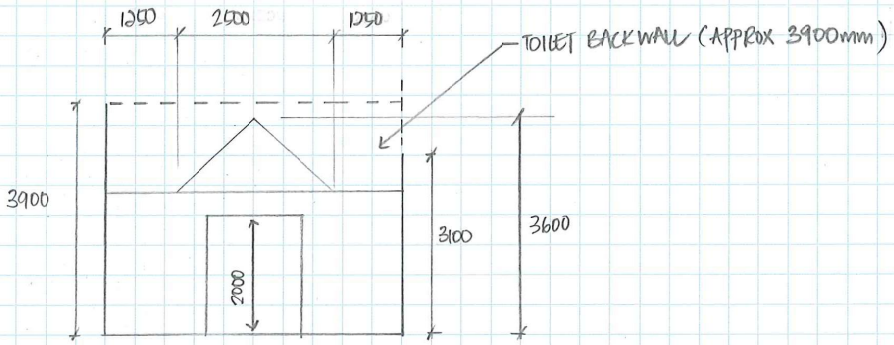
SKM

Job No. 3B01276 · 244
Calc. Series
Client CCC
Page
Job Name SHOP TOILET BISHOPDALE CRT
By TSW
Calcs Title
Date

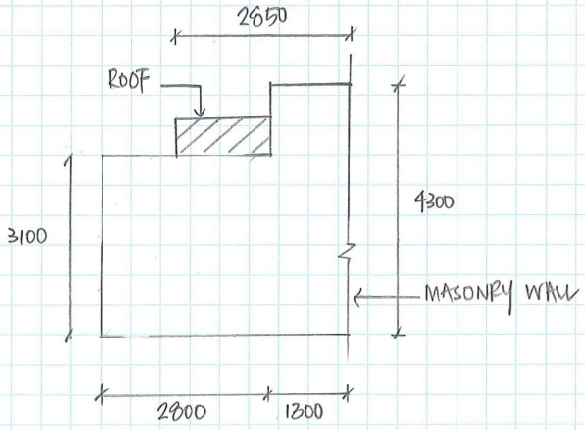


- 190 mm THICK BRICK
- REINFORCEMENT -
  - VERTICAL → EVERY 3RD CORE
  - HORIZONTAL → @ 800 CRS
- FLOOR TO CEILING = 2.4 m.

Job No. ZB01276.244
Calc. Series
Client CCC
Page
Job Name SHOP TOILET BISHOPDALE CRT
By TSW
Calcs Title
Date



FRONT ELEVATION



SIDE ELEVATION

Appendix C Geotechnical Interpretive Report

Christchurch City Council - Structural Engineering Service

Geotechnical Desk Study

SKM project number	ZB01276
SKM project site number	244
Address	Shop Toilets Bishopdale – Bishopdale Court
Report date	August 2013
Author	David Bae
Reviewer	Charlie Watts
Approved for issue	Yes

1. Introduction

This report outlines the geotechnical information that Sinclair Knight Merz (SKM) has been able to source from our database and other sources in relation to the property listed above. We understand that this information will be used as part of a quantitative Detailed Engineering Evaluation (DEE), and will be supplemented by more detailed information and investigations to allow detailed scoping of the repair or rebuild of the building.

2. Scope

This geotechnical desk top study incorporates information sourced from:

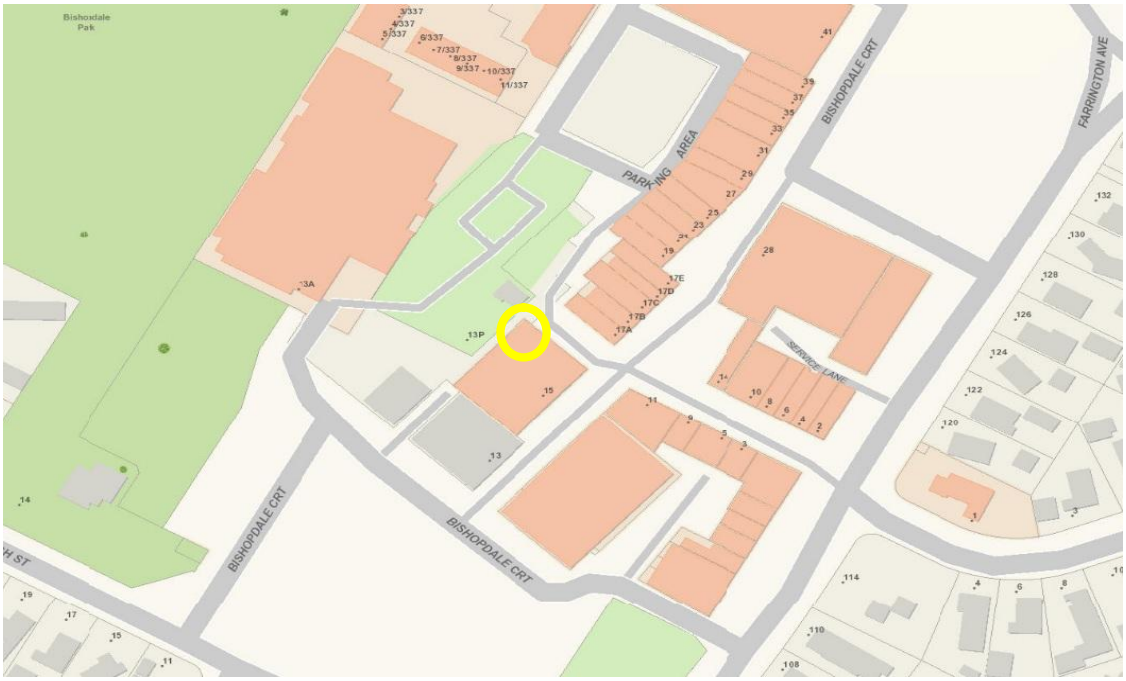
- Published geology
- Publically available borehole records
- Liquefaction records
- Aerial photography
- A preliminary site walkover

3. Limitations

This report was prepared to address geotechnical issues relating to the specific site in accordance with the scope of works as defined in the contract between SKM and our Client. This report has been prepared on behalf of, and for the exclusive use of, our Client, and is subject to, and issued in accordance with, the provisions of the contract between SKM and our Client. The findings presented in this report should not be applied to another site or another development within the same site without consulting SKM.

The assessment undertaken by SKM was limited to a desktop review of the data described in this report. SKM has not undertaken any subsurface investigations, measurement or testing of materials from the site. In preparing this report, SKM has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by our Client, and from other sources as described in the report. Except as otherwise stated in this report, SKM has not attempted to verify the accuracy or completeness of any such information.

4. Site location

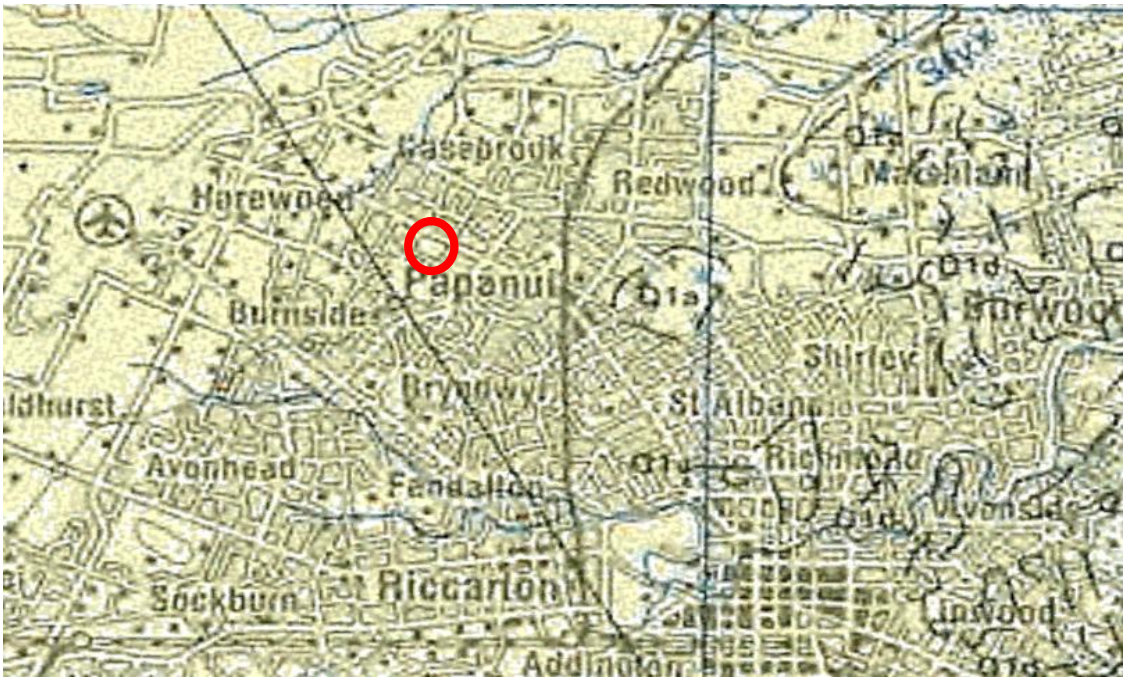


- **Figure 1 – Site location (courtesy of CERA http://maps.cera.govt.nz/advanced-viewer/?Viewer=CERA__Public)**

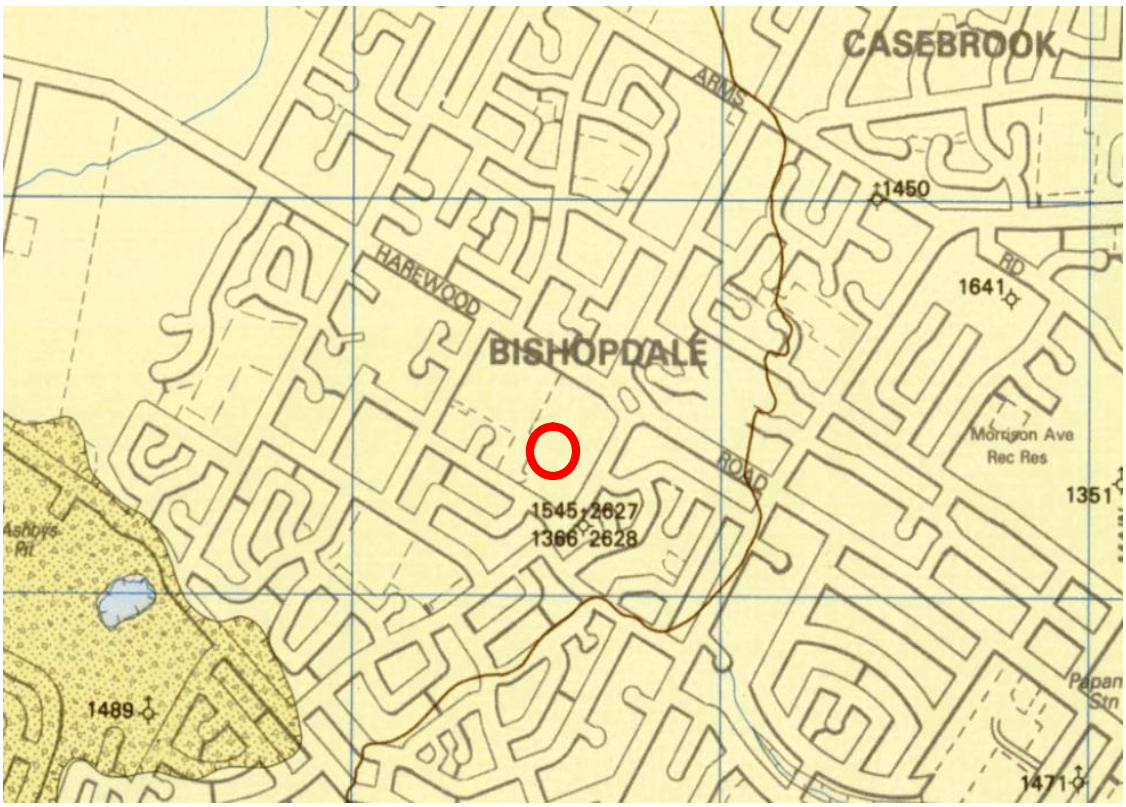
The structure is located at Bishopdale Mall, Bishopdale Court, Bishopdale; grid reference 1566551 E, 5184739 N (NZTM).

5. Review of available information

5.1 Geological maps



- **Figure 2 – Regional geological map (Forsyth et al, 2008). Site marked in red.**



- **Figure 3 – Local geological map (Brown et al, 1992). Site marked in red.**

The local and regional geological maps show the area to be underlain by Holocene deposits comprising predominantly alluvial sand and silt overbank deposits of the Springston Formation.

5.2 Liquefaction map

Following the 22 February 2011 event a drive through reconnaissance was undertaken from 23 February until 1 March by M Cubrinovsko and M Taylor of Canterbury University. The site is outside of the reconnaissance area.

5.3 Aerial photography

- **Figure 4 – Aerial photography from 24 Feb 2011 (http://maps.cera.govt.nz/advanced-viewer/?Viewer=CERA__Public)**

Aerial photography taken after the 22 February 2011 event shows no evidence of liquefaction in the vicinity of the site (<100m).

5.4 CERA classification

A review of the CERA website (http://maps.cera.govt.nz/advanced-viewer/?Viewer=CERA__Public) shows that the site is:

- Zone: Green
- Urban Non-residential

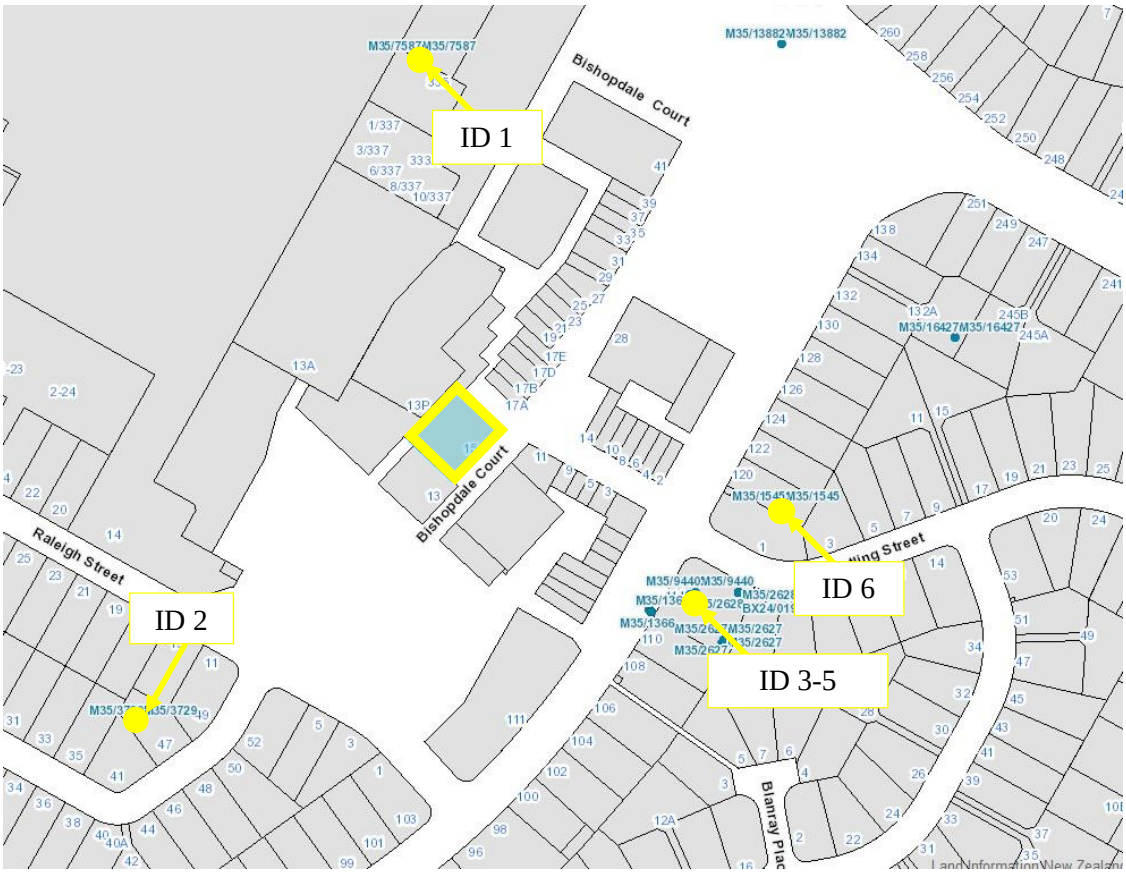
The surrounding residential area is classified as TC2.

5.5 Historical land use

In reference to historical documents (e.g. Appendix A) it is shown that the site lies within land that was recorded as marshland or swamp in 1856. It is therefore possible that soft or peat material could be present at the site.

5.6 Existing ground investigation data

- **Figure 5 – Location of local ground investigations from Project Orbit (https://canterburyrecovery.projectorbit.com, Google Earth Pro)**



- **Figure 6 – Location of local ground investigations from ECan GIS (http://canterburymaps.govt.nz/Viewer/)**

Where available logs from these investigation locations are attached to this report (Appendix B), and the results are summarised in Appendix C.

5.7 Council property files

Council files were not available at the time of writing this report.

5.8 Site walkover

An experienced SKM structural engineer visited the site on 8 August 2013.

During the external site walkover, no evidence of liquefaction or other land damage was observed on site.

6. Conclusions and recommendations

6.1 Site geology

An interpretation of the most relevant local investigation suggests that the site is underlain by:

Depth range (mBGL)	Soil type
0 – 2	Topsoil / Clay / Silt / Sand
2 – 10	Sandy Gravel
10 – 16	Clay / Organic clay or silt
16 – 25	Sandy Gravel

The ground water table is inferred to be approximately 2 m below ground level (mbgl) as indicated in the investigation data available.

6.2 Seismic site subsoil class

The site has been assessed as NZS1170.5 Class D (deep or soft soil) based on the review of published geological information and nearby borehole logs with geological descriptions of soil conditions but without geotechnical measurements. This is not the preferred method of determining soil class; however we do not believe that further geotechnical investigations would necessarily result in a revised soil class.

6.3 Building Performance

Although a detailed record of the existing foundation is not available the structure is small and the foundation a standard concrete slab on grade. The performance to date suggests that it is adequate for its current purpose.

6.4 Ground performance and properties

Based on the obtained borehole data, liquefaction risk is expected to be low at the site. The borehole data indicate that the site is underlain by a shallow layer (less than 2 m) of clay, silt and sand which is unlikely to be susceptible to liquefaction due to the depth to the water table. Additionally, the gravel and clay layers inferred to be underlying the site below the water table are not liquefiable; however there may be lenses of sand present in the sandy gravel layers that are potentially liquefiable.

There is no evidence that would suggest liquefaction occurred on site from the aerial photographs or from the external site walkover undertaken by a SKM engineer. Further site specific investigation would need to be conducted to fully assess the liquefaction risk for this site.

As all available ground investigation data are greater than 50 m away from the site, an estimation of the ground properties has not been provided in this desk study.

7. References

Brown LJ, Weeber JH, 1992. Geology of the Christchurch urban area. Scale 1:25,000. Institute of Geological & Nuclear Sciences geological map 1.

Canterbury Earthquake Recovery Authority (CERA) geospatial viewer (http://maps.cera.govt.nz/advanced-viewer/?Viewer=CERA__Public)

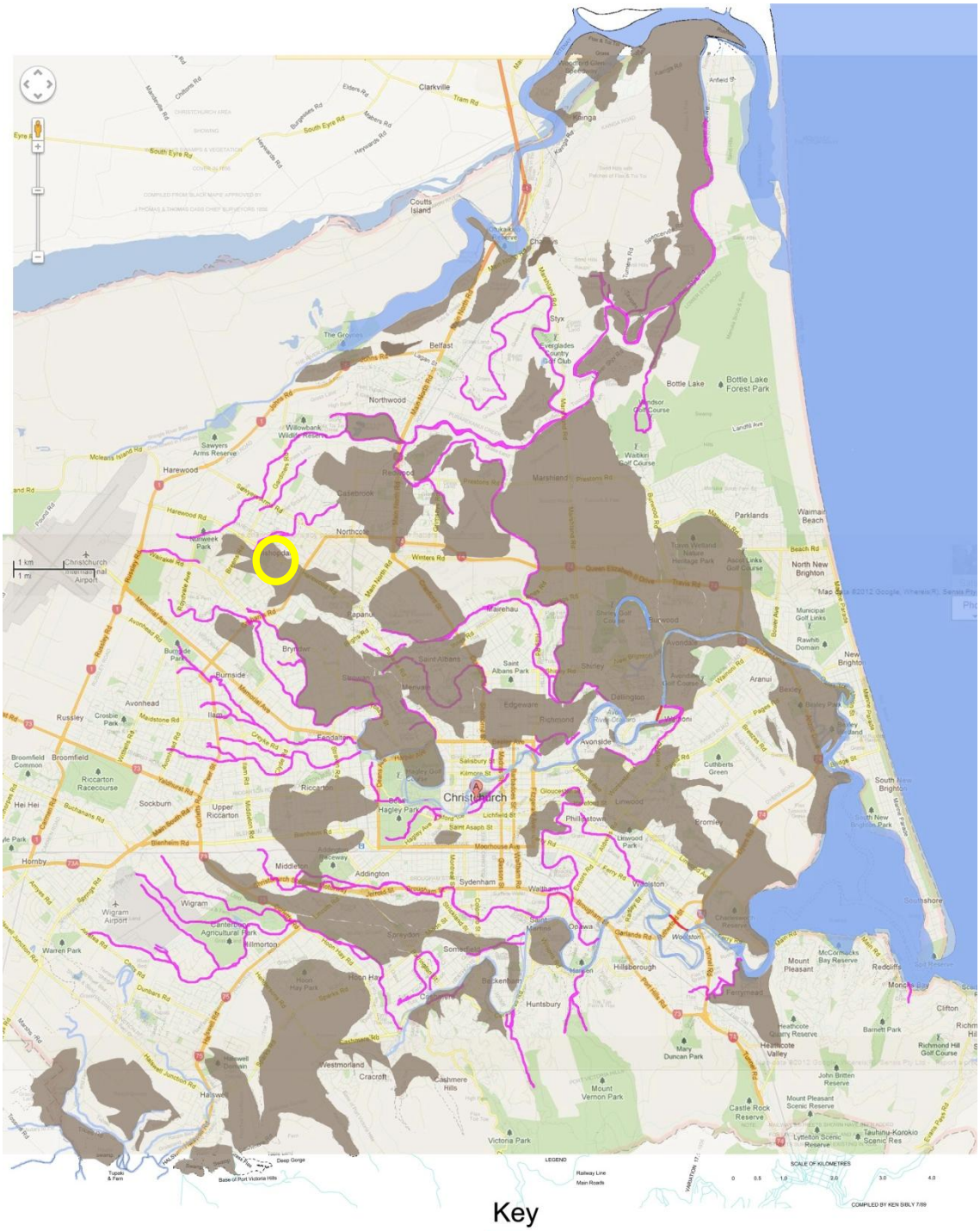
Cubrinovski & Taylor, 2011. Liquefaction map summarising preliminary assessment of liquefaction in urban areas following the 2010 Darfield Earthquake.

Forsyth PJ, Barrell DJA, Jongens R, 2008. Geology of the Christchurch area. Institute of Geological & Nuclear Sciences geological map 16.

EQC Project Orbit geotechnical viewer (https://canterburyrecovery.projectorbit.com/)

Environment Canterbury geographic information systems (http://canterburymaps.govt.nz/Viewer/)

Appendix A – Christchurch 1856 land use

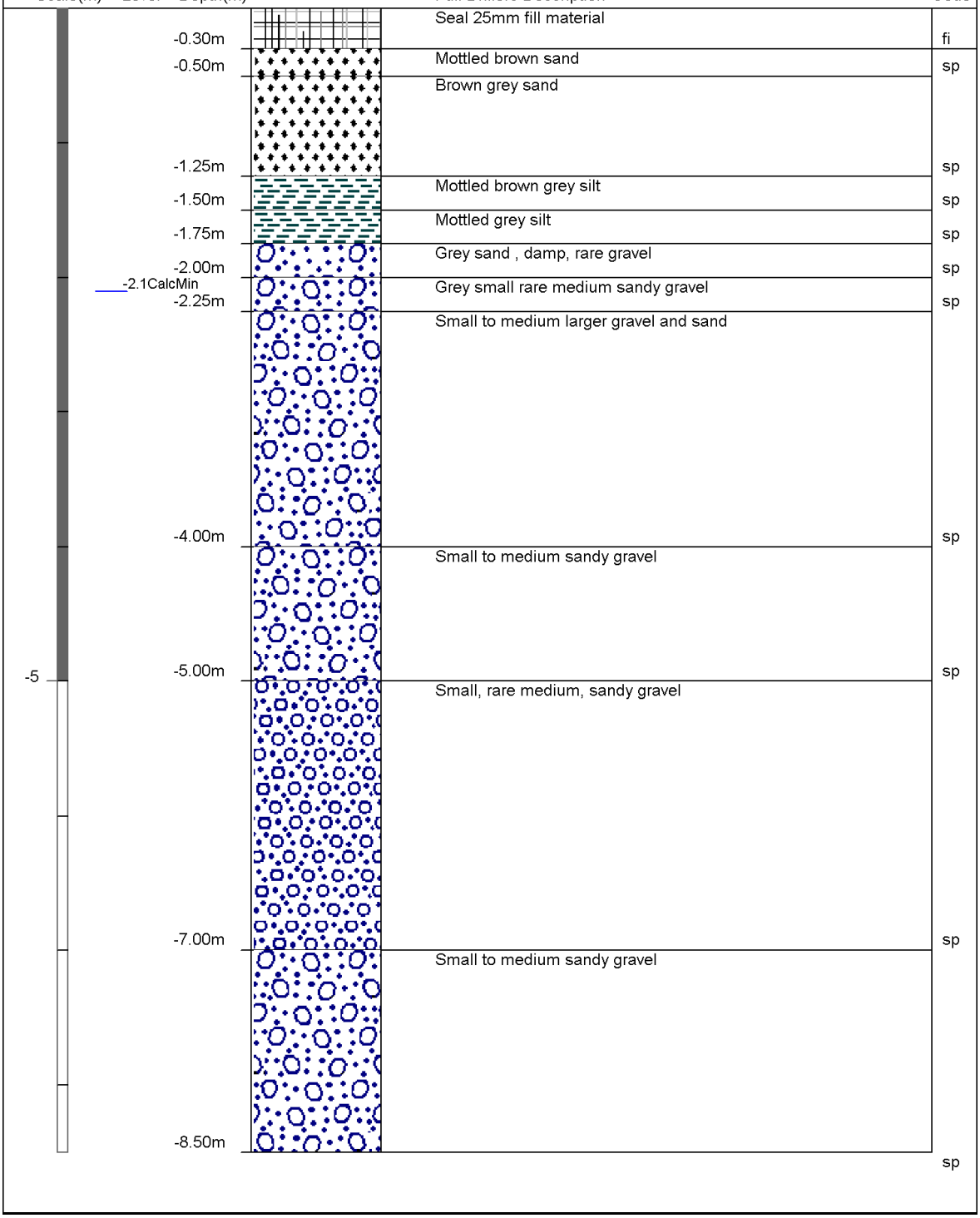


The swamps and previous creeks/rivers from 1856 have been overlayed onto a map of Christchurch in 2012

Appendix B – Existing ground investigation logs

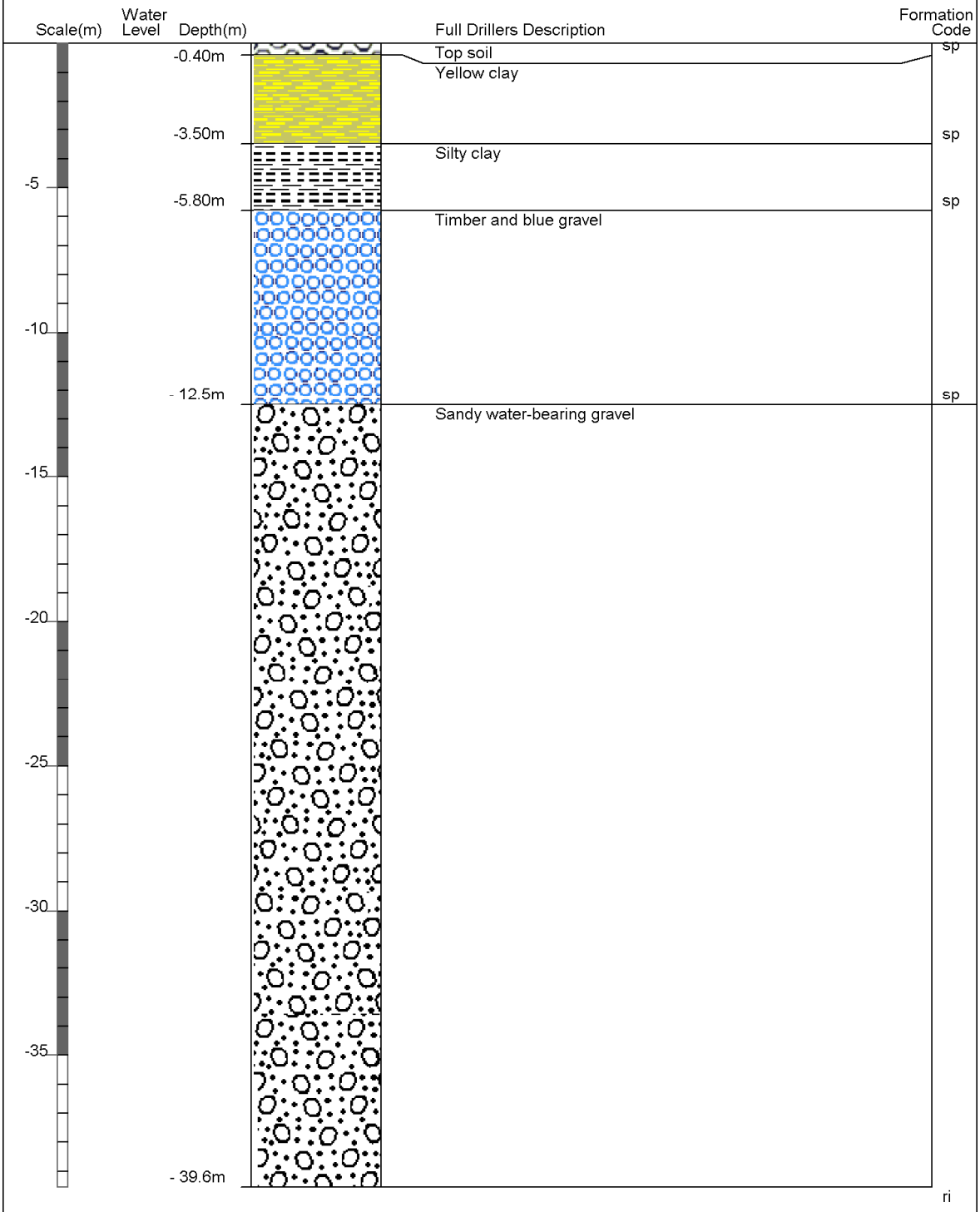
Borelog for well M35/7587

Gridref: M35:7653-4651 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 17.6 +MSD
Driller : Canterbury Drilling Company
Drill Method : Cable Tool
Drill Depth : -8.5m Drill Date : 28/01/1996



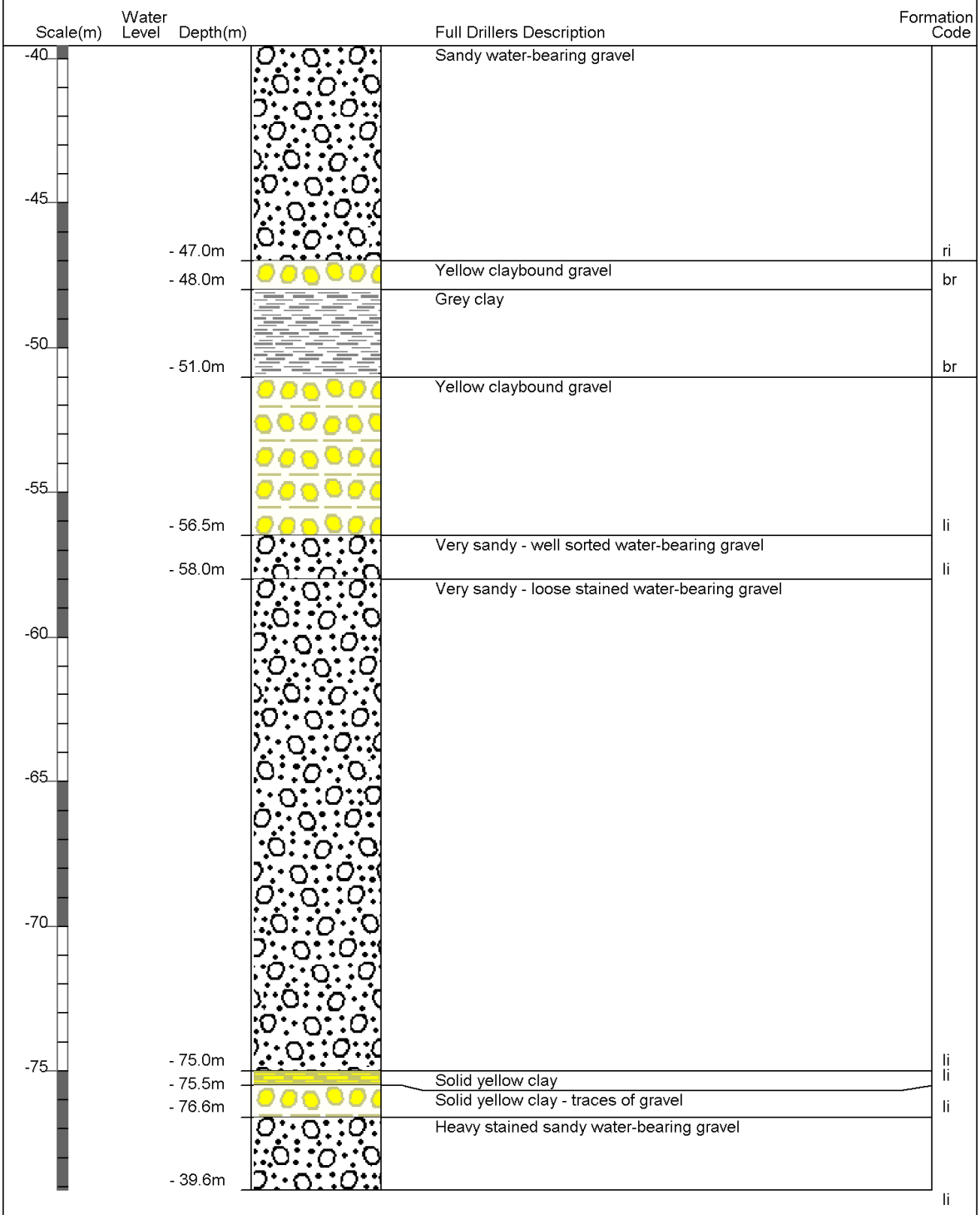
Borelog for well M35/9440 page 1 of 5

Gridref: M35:7666-4626 Accuracy : 4 (1=high, 5=low)
Ground Level Altitude : 17.1 +MSD
Driller : Clemence Drilling Contractors
Drill Method : Rotary/Percussion
Drill Depth : -197.8m Drill Date : 20/08/2003



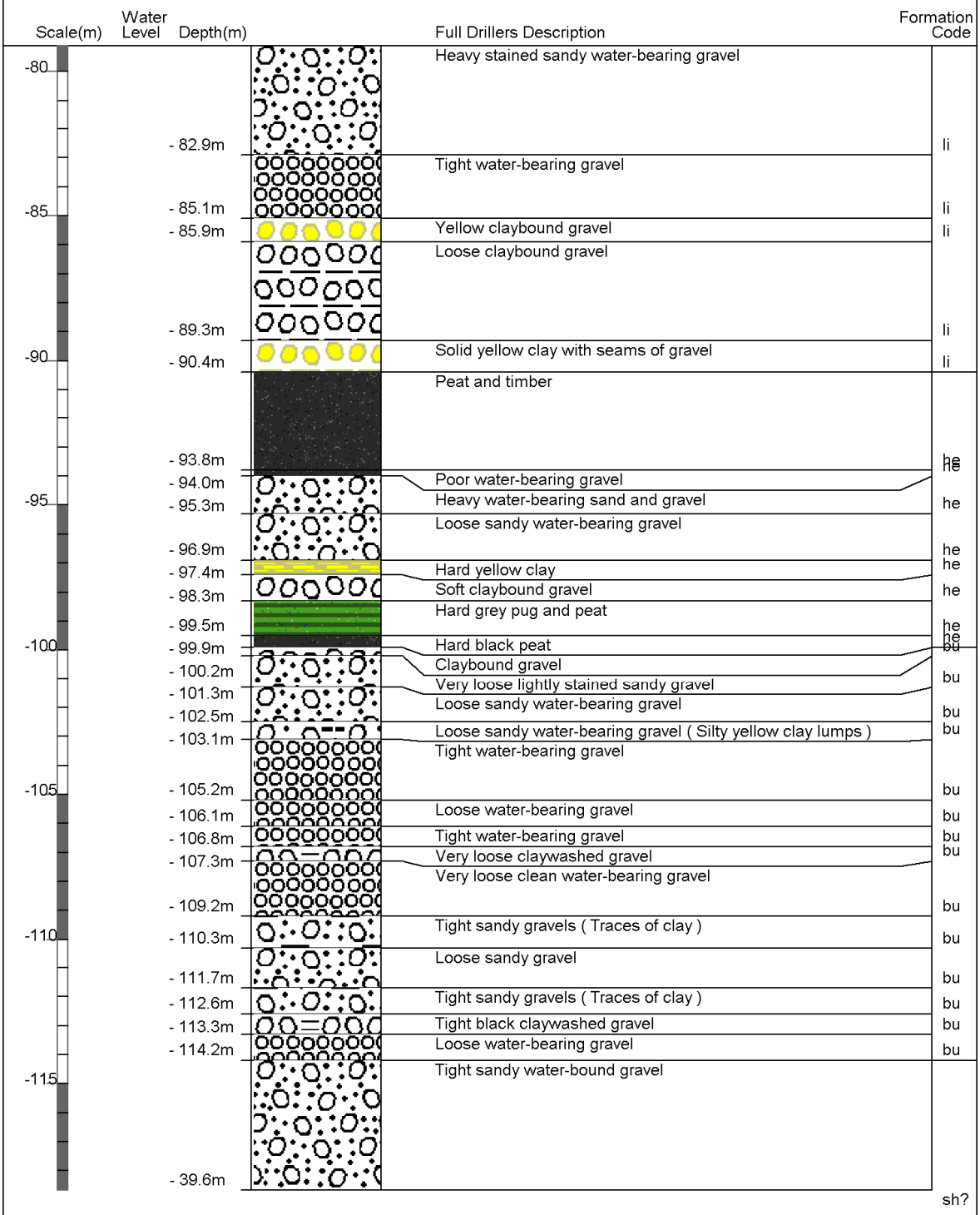
Borelog for well M35/9440 page 2 of 5

Gridref: M35:7666-4626 Accuracy : 4 (1=high, 5=low)
Ground Level Altitude : 17.1 +MSD
Driller : Clemence Drilling Contractors
Drill Method : Rotary/Percussion
Drill Depth : -197.8m Drill Date : 20/08/2003



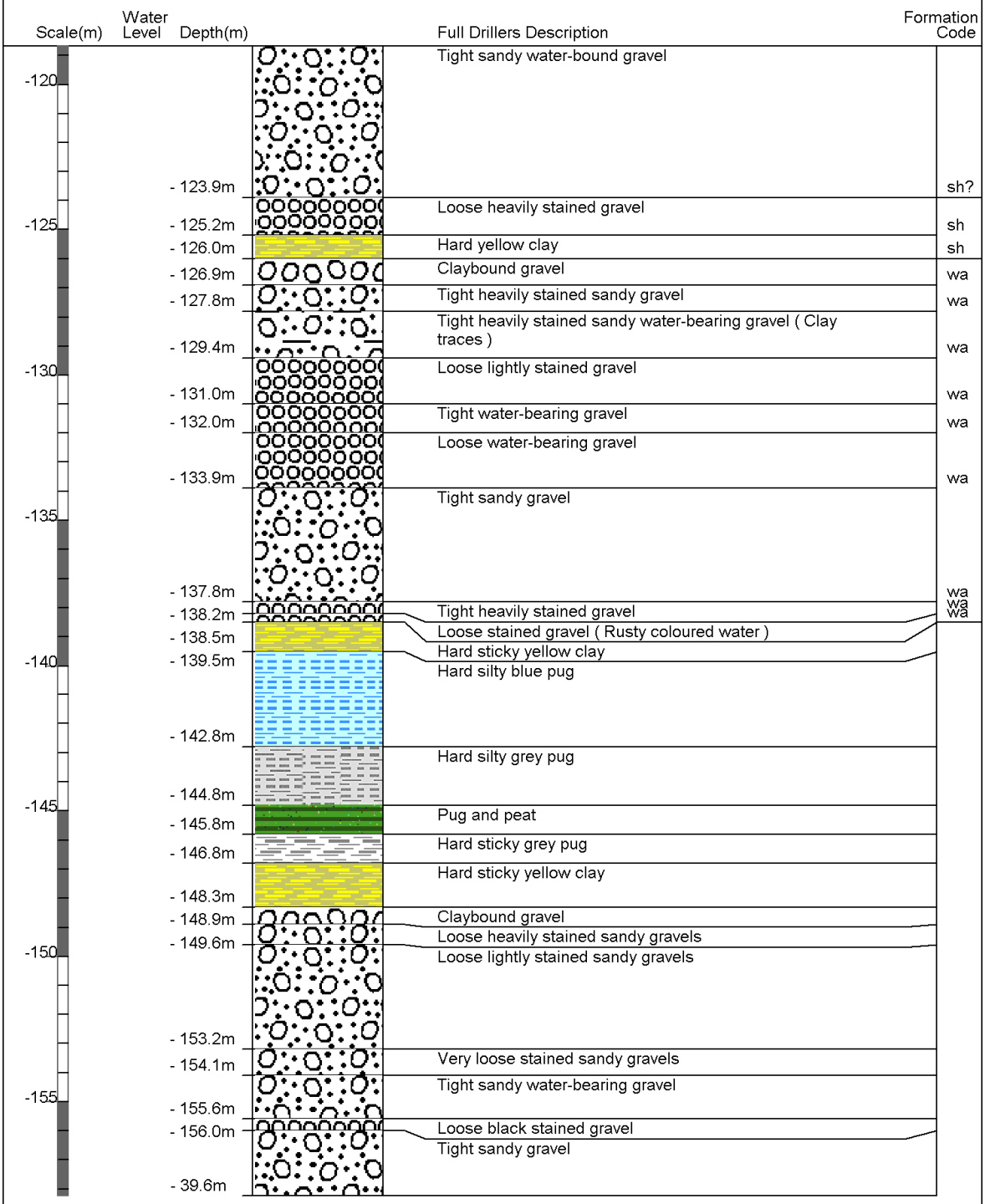
Borelog for well M35/9440 page 3 of 5

Gridref: M35:7666-4626 Accuracy : 4 (1=high, 5=low)
Ground Level Altitude : 17.1 +MSD
Driller : Clemence Drilling Contractors
Drill Method : Rotary/Percussion
Drill Depth : -197.8m Drill Date : 20/08/2003



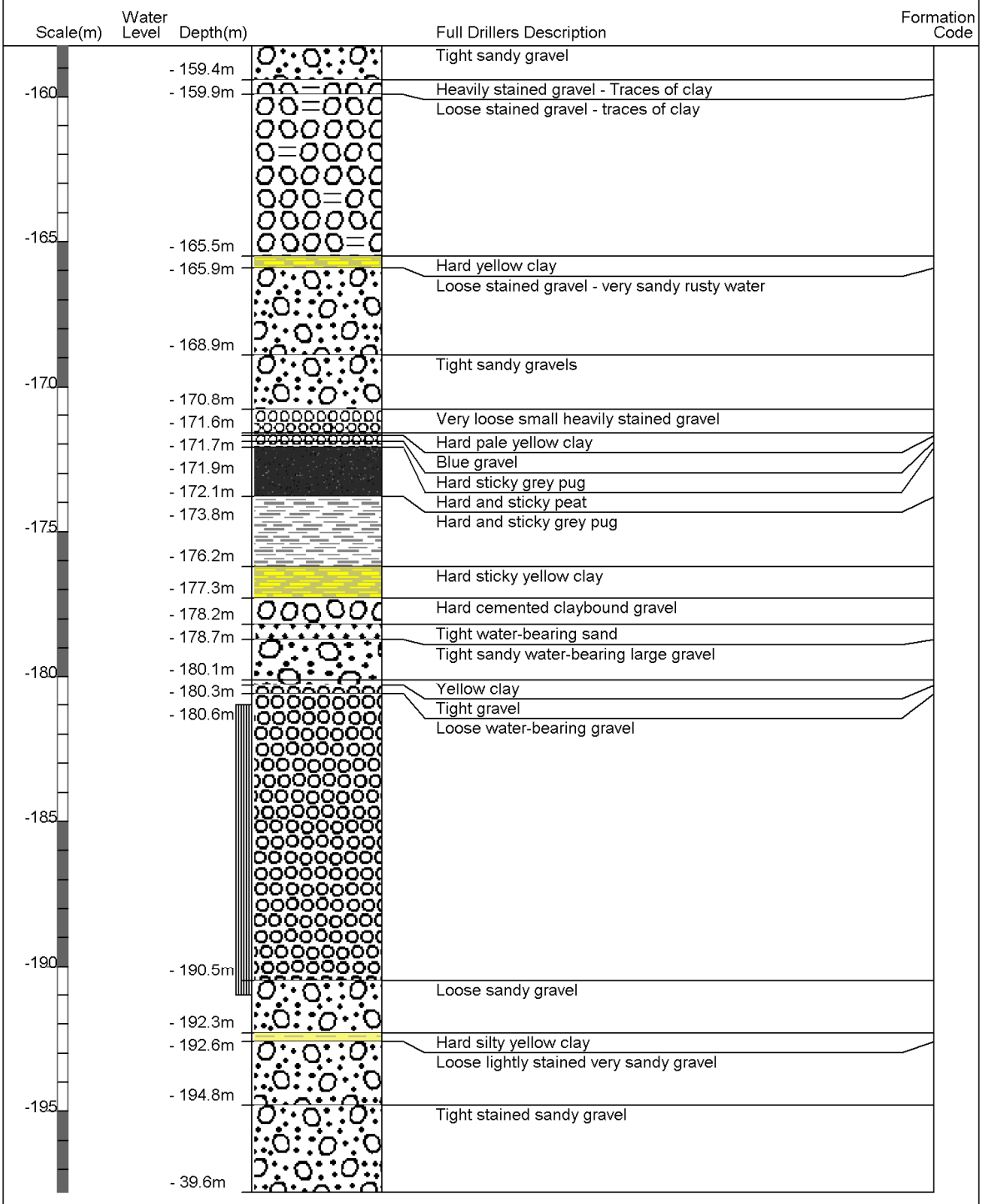
Borelog for well M35/9440 page 4 of 5

Gridref: M35:7666-4626 Accuracy : 4 (1=high, 5=low)
Ground Level Altitude : 17.1 +MSD
Driller : Clemence Drilling Contractors
Drill Method : Rotary/Percussion
Drill Depth : -197.8m Drill Date : 20/08/2003



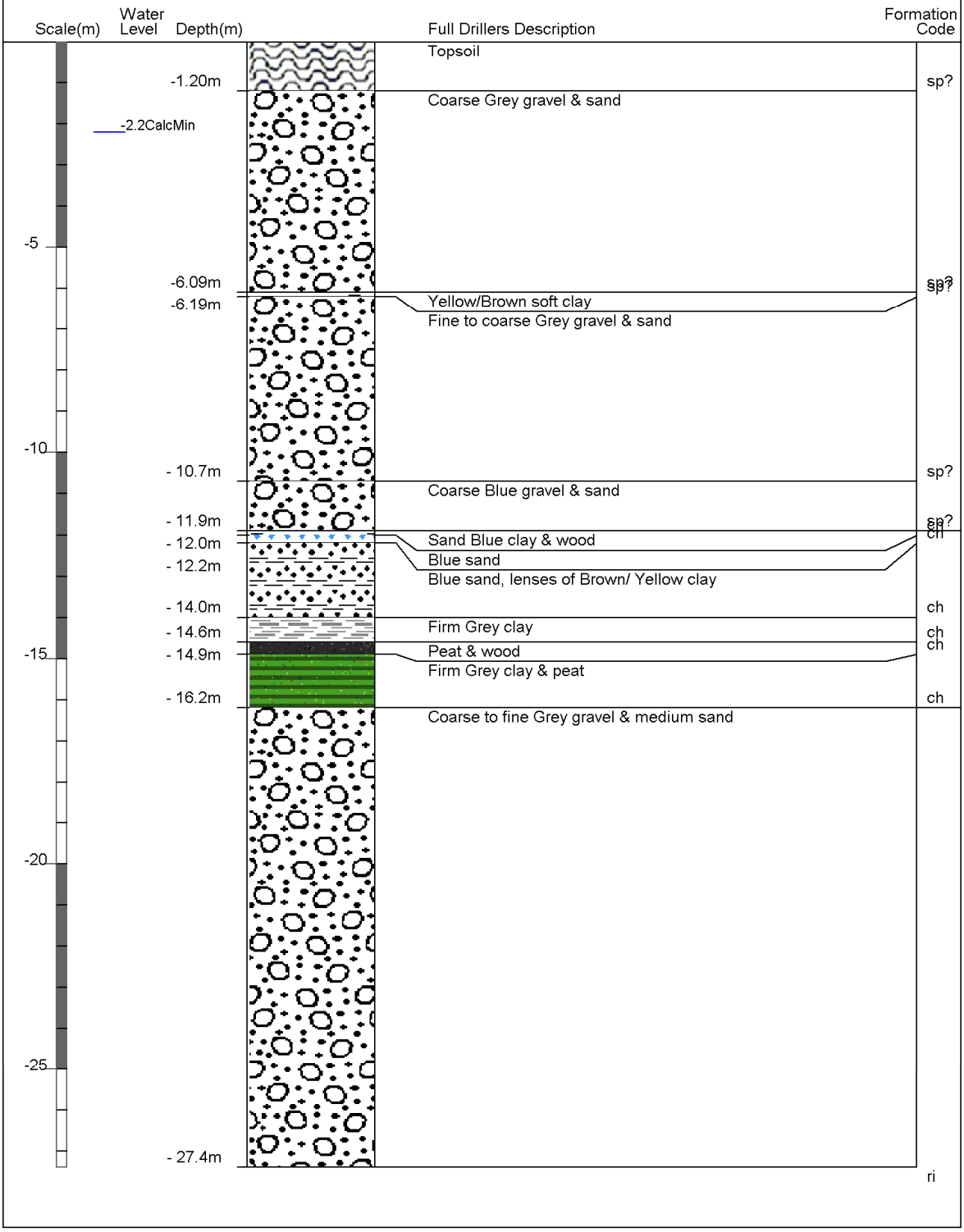
Borelog for well M35/9440 page 5 of 5

Gridref: M35:7666-4626 Accuracy : 4 (1=high, 5=low)
Ground Level Altitude : 17.1 +MSD
Driller : Clemence Drilling Contractors
Drill Method : Rotary/Percussion
Drill Depth : -197.8m Drill Date : 20/08/2003



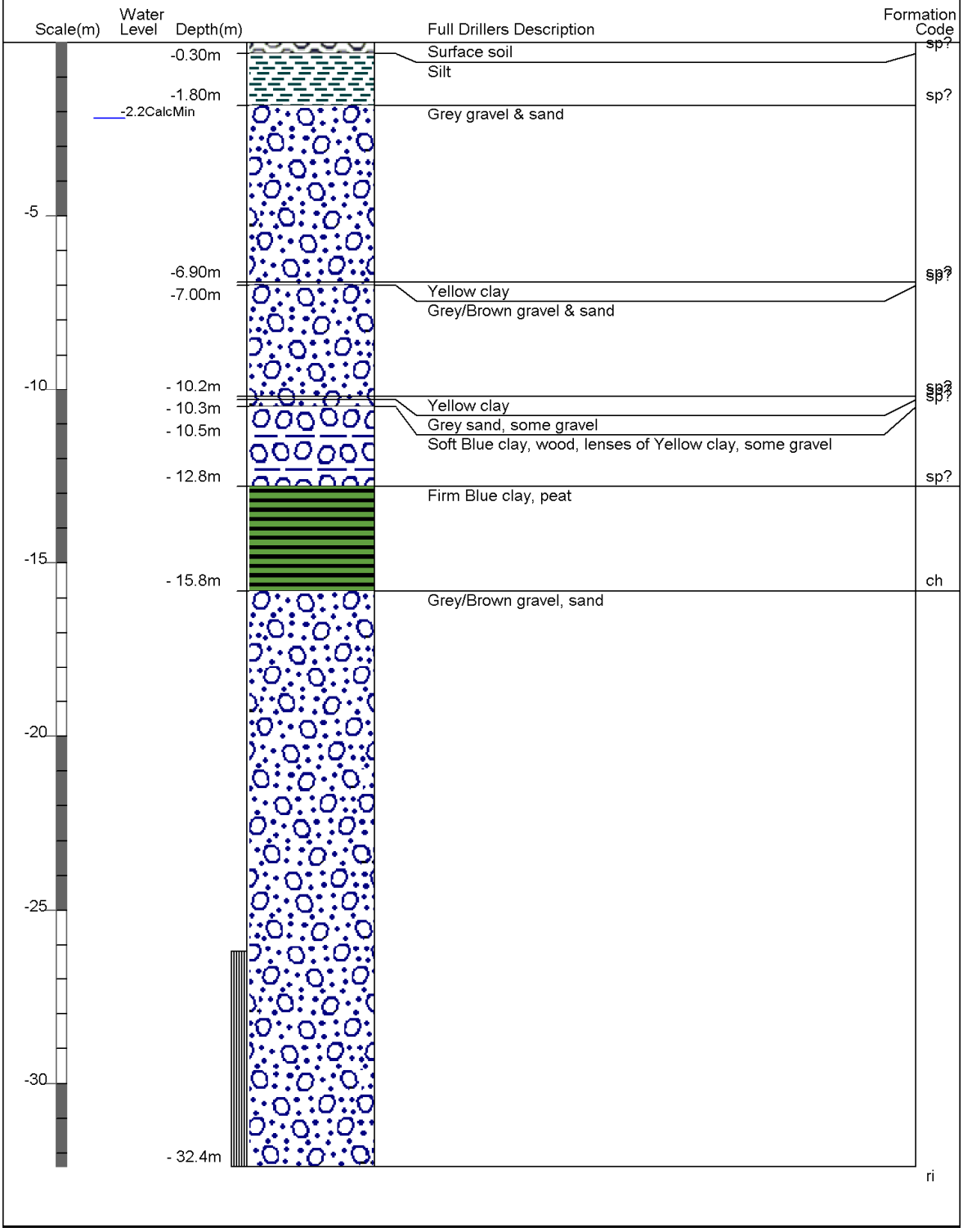
Borelog for well M35/1366

Gridref: M35:76639-46251 Accuracy : 2 (1=high, 5=low)
Ground Level Altitude : 17 +MSD
Driller : A M Bisley & Co
Drill Method : Cable Tool
Drill Depth : -27.4m Drill Date : 1/07/1962



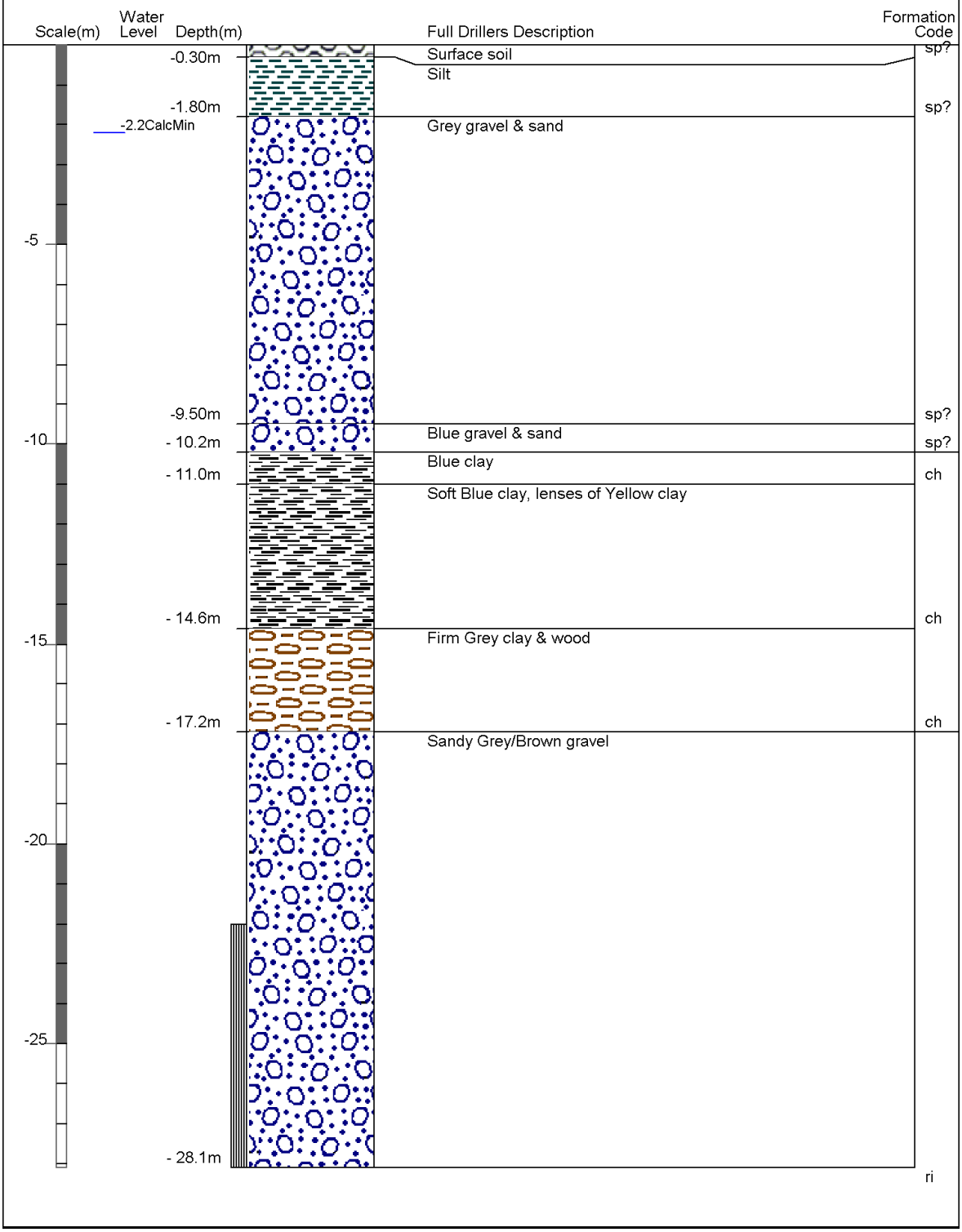
Borelog for well M35/2628

Gridref: M35:7668-4626 Accuracy : 2 (1=best, 4=worst)
Ground Level Altitude : 17.2 +MSD
Driller : A M Bisley & Co
Drill Method : Cable Tool
Drill Depth : -32.4m Drill Date : 25/08/1982



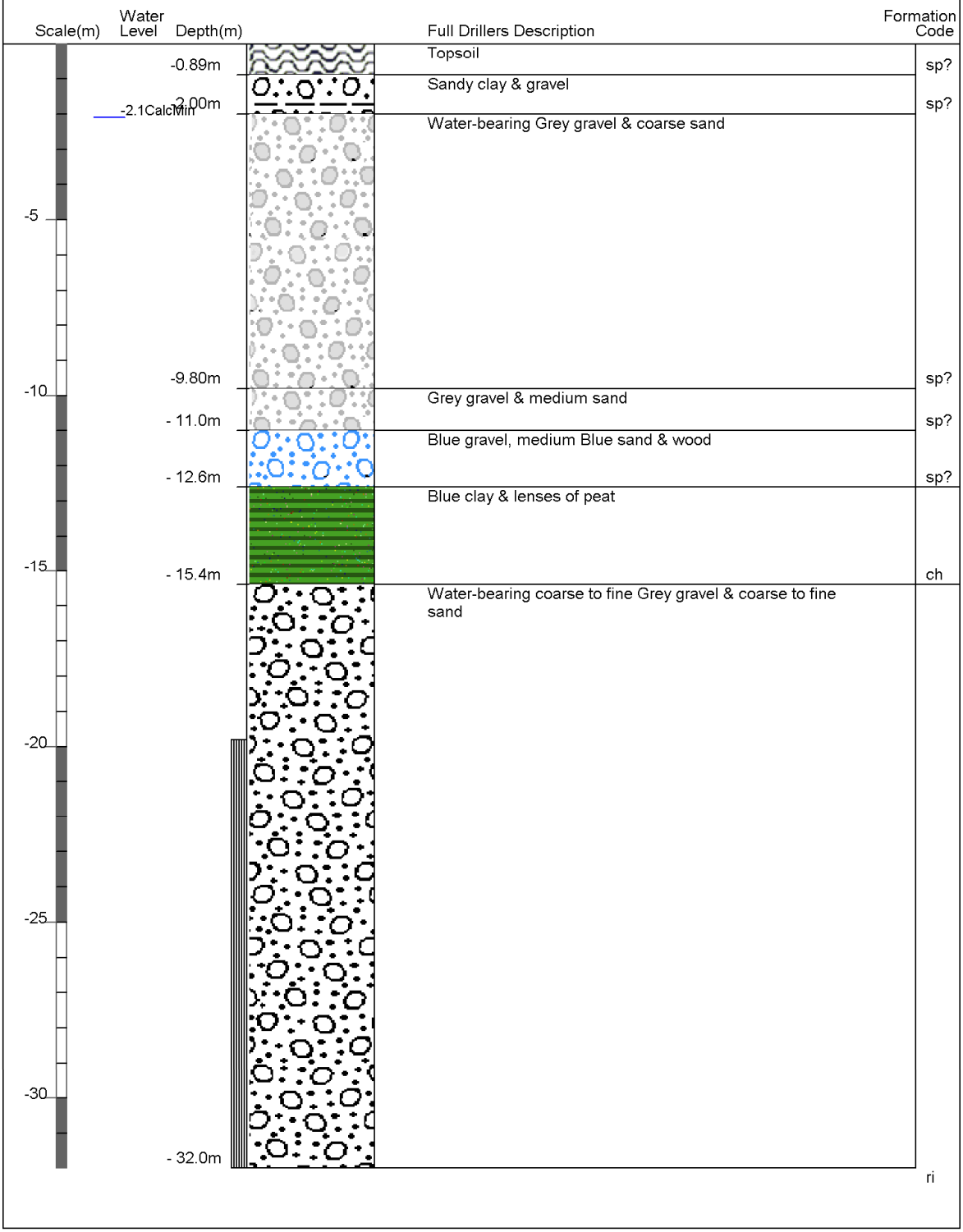
Borelog for well M35/2627

Gridref: M35:76673-46238 Accuracy : 2 (1=best, 4=worst)
Ground Level Altitude : 17.3 +MSD
Driller : A M Bisley & Co
Drill Method : Cable Tool
Drill Depth : -28.1m Drill Date : 6/09/1982



Borelog for well M35/1545

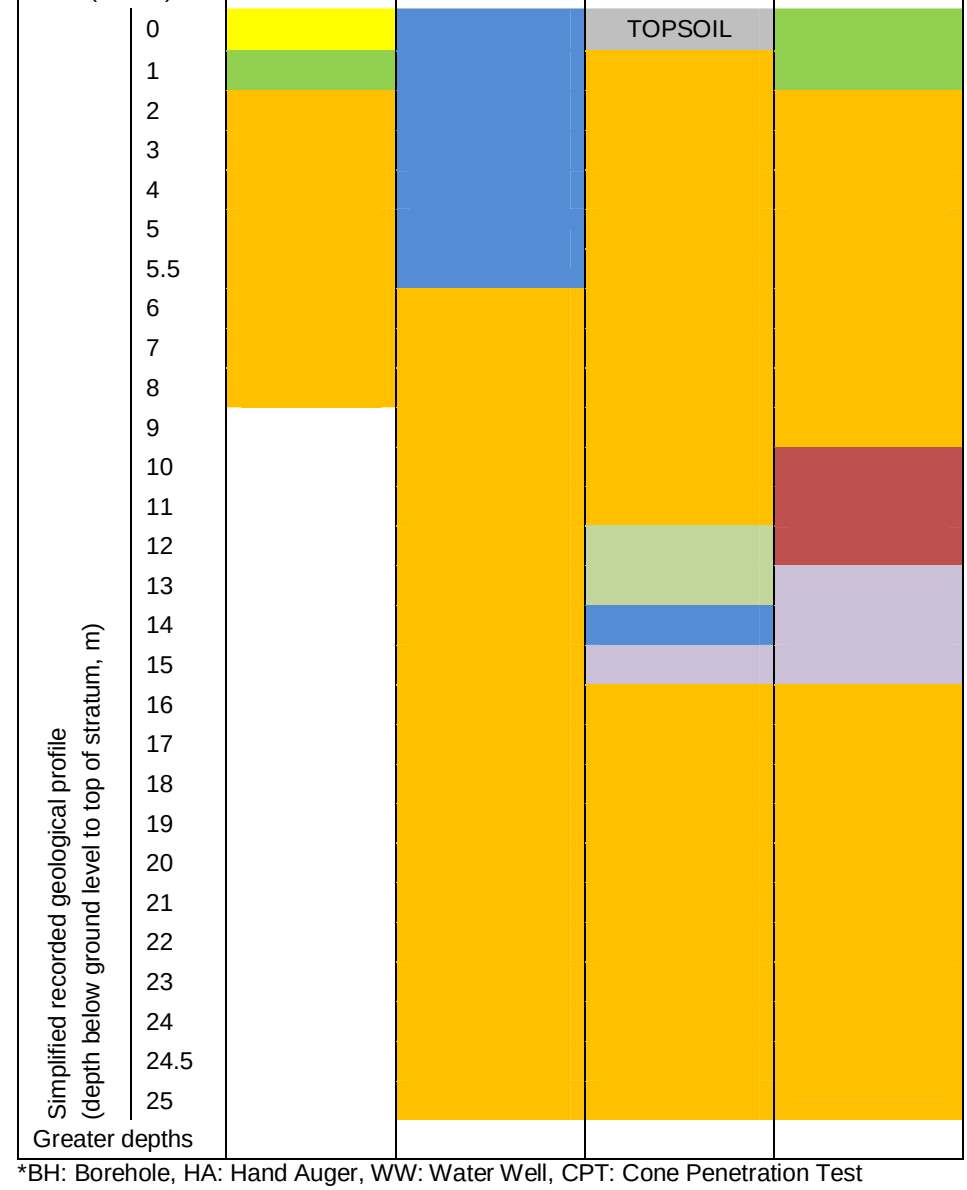
Gridref: M35:767-463 Accuracy : 4 (1=high, 5=low)
Ground Level Altitude : 17.5 +MSD
Driller : A M Bisley & Co
Drill Method : Cable Tool
Drill Depth : -32m Drill Date : 8/03/1962



Appendix C – Geotechnical Investigation Summary

Table 1 Summary of most relevant investigation data

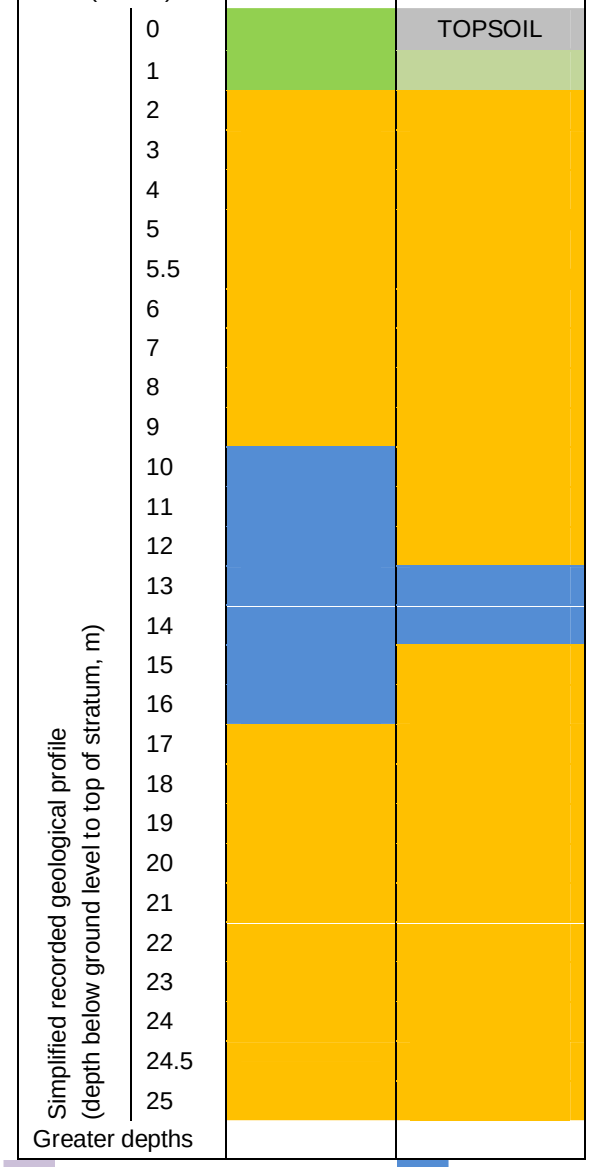
ID	1	2	3	4
Type *	WW	WW	WW	WW
Ref	M35/7587	M35/9440	M35/1366	M35/2628
Depth (m)	8.5	197.8	27.4	32.4
Distance from site (m)	~160	~140	~130	~160
Ground water level (mBGL)	2.1	N/A	2.2	2.2



*BH: Borehole, HA: Hand Auger, WW: Water Well, CPT: Cone Penetration Test

Sensitive or organic clay/silt
Clay to silty clay
Clayey silt to silt
Silty sand to sandy silt
Sand with some clay
Clean sand to silty sand
Gravelly sand to sandy gravel
Clay with some gravel

ID	5	6
Type *	WW	WW
Ref	M35/2627	M35/1545
Depth (m)	28.1	32
Distance from site (m)	~170	~160
Ground water level (mBGL)	2.2	2.1



Sensitive or organic clay/silt
Clay to silty clay
Clayey silt to silt
Silty sand to sandy silt
Clayey sand
Clean sand to silty sand
Gravelly sand to sandy gravel