Appendix A. Drawings – layout plans

DRAWING INDEX

FACILITY	DRAWING CODE	DRAWING DISCRIPTION
MAIN TUNNEL	2012061.001	DRAWING INDEX SHEET
	2012061.004	BOREHOLE LOCATION PLAN SHEET 1
	2012061.005	BOREHOLE LOCATION PLAN SHEET 2
	2012061.006	BOREHOLE LOCATION PLAN SHEET 3
	2012061.007	BOREHOLE LOCATION PLAN SHEET 4
	2012061.008	BOREHOLE LOCATION PLAN SHEET 5
	20120610.16	MAIN TUNNEL LONG SECTION– SHEET 1 OF 10
	20120610.17	MAIN TUNNEL LONG SECTION– SHEET 2 OF 10
	20120610.18	MAIN TUNNEL LONG SECTION– SHEET 3 OF 10
	20120610.19	MAIN TUNNEL LONG SECTION– SHEET 4 OF 10
	20120610.20	MAIN TUNNEL LONG SECTION– SHEET 5 OF 10
	20120610.21	MAIN TUNNEL LONG SECTION– SHEET 6 OF 10
	20120610.22	MAIN TUNNEL LONG SECTION– SHEET 7 OF 10
	20120610.23	MAIN TUNNEL LONG SECTION– SHEET 8 OF 10
	20120610.24	MAIN TUNNEL LONG SECTION– SHEET 9 OF 10
	20120610.25	MAIN TUNNEL LONG SECTION– SHEET 10 OF 10
LINK SEWER B	2011952.001	DSLSB– LINK SEWER B– LONG SECTION
LINK SEWER C	2012004.001	DSLSC– LINK SEWER C– LONG SECTION– SHEET 1 OF 3
	2012004.002	DSLSC– LINK SEWER C– LONG SECTION– SHEET 2 OF 3
	2012004.003	DSLSC– LINK SEWER C– LONG SECTION– SHEET 3 OF 3
MANGERE PS	2012043.001	DPCIN–MANGERE PS– SHAFT GEOLOGY– PLAN
	2012043.002	DPCIN–MANGERE PS– SHAFT GEOLOGY– 3D
	2012043.003	DPCIN–MANGERE PS– SHAFT GEOLOGY– SECTION A
	2012043.004	DPCIN–MANGERE PS– SHAFT GEOLOGY– SECTION B
	2012043.005	DPCIN–MANGERE PS– SHAFT GEOLOGY– SECTION C
KIWI ESPLANADE	2011879.001	DPCIN001–KIWI ESPLANADE– SHAFT GEOLOGY– PLAN
	2011879.002	DSCIN001–KIWI ESPLANADE– SHAFT GEOLOGY– 3D
	2011879.003	DSCIN001–KIWI ESPLANADE– SHAFT GEOLOGY– SECTION A
	2011879.004	DSCIN001–KIWI ESPLANADE– SHAFT GEOLOGY– SECTION B
PS23	2011880.001	DSCIN002–PS23– SHAFT GEOLOGY– PLAN
	2011880.002	DSCIN002–PS23– SHAFT GEOLOGY– 3D
	2011880.003	DSCIN002–PS23– SHAFT GEOLOGY– SECTION A
	2011880.004	DSCIN002–PS23– SHAFT GEOLOGY– SECTION B
KEITH HAY PARK	2011881.001	DSCIN003– KEITH HAY PARK– SHAFT GEOLOGY– PLAN
	2011881.002	DSCIN003– KEITH HAY PARK– SHAFT GEOLOGY– 3D
	2011881.003	DSCIN003– KEITH HAY PARK– SHAFT GEOLOGY– SECTION A
	2011881.004	DSCIN003– KEITH HAY PARK– SHAFT GEOLOGY– SECTION B
	2011881.005	DSCIN003– KEITH HAY PARK– SHAFT GEOLOGY– KHP BRANCH 9B PLAN AND SECTION
MAY ROAD	2011882.001	DSCIN004– MAY ROAD– SHAFT GEOLOGY– PLAN
	2011882.002	DSCIN004– MAY ROAD– SHAFT GEOLOGY– 3D
	2011882.003	DSCIN004– MAY ROAD– SHAFT GEOLOGY– SECTION A
	2011882.004	DSCIN004– MAY ROAD– SHAFT GEOLOGY– SECTION B
	2011882.005	DSCIN004– MAY ROAD– SHAFT GEOLOGY– SECTION C
WALMSEY PARK	2011883.001	DSCIN005– WALMSLEY PARK– SHAFT GEOLOGY– PLAN
	2011883.002	DSCIN005– WALMSLEY PARK– SHAFT GEOLOGY– 3D
	2011883.003	DSCIN005– WALMSLEY PARK– SHAFT GEOLOGY– SECTION A
	2011883.004	DSCIN005– WALMSLEY PARK– SHAFT GEOLOGY– SECTION B
HAVERSTOCK ROAD	2011884.001	DSCIN006– HAVERSTOCK ROAD– SHAFT GEOLOGY– PLAN
	2011884.002	DSCIN006– HAVERSTOCK ROAD– SHAFT GEOLOGY– 3D
	2011884.003	DSCIN006– HAVERSTOCK ROAD– SHAFT GEOLOGY– SECTION A
	2011884.004	DSCIN006– HAVERSTOCK ROAD– SHAFT GEOLOGY– SECTION B
LYON AVENUE	2011885.001	DSCIN007– LYON AVENUE– SHAFT GEOLOGY– PLAN
	2011885.002	DSCIN007– LYON AVENUE– SHAFT GEOLOGY– 3D
	2011885.003	DSCIN007– LYON AVENUE– SHAFT GEOLOGY– SECTION A
	2011885.004	DSCIN007– LYON AVENUE– SHAFT GEOLOGY– SECTION B
MT ALBERT MEMORIAL RESERVE	2011886.001	DSCIN008–MT ALBERT MEMORIAL RESERVE– SHAFT GEOLOGY– PLAN
	2011886.002	DSCIN008–MT ALBERT MEMORIAL RESERVE– SHAFT GEOLOGY– 3D
	2011886.003	DSCIN008–MT ALBERT MEMORIAL RESERVE– SHAFT GEOLOGY– SECTION A
	2011886.004	DSCIN008–MT ALBERT MEMORIAL RESERVE– SHAFT GEOLOGY– SECTION B
WESTERN SPRINGS	2011887.001	DSCIN009– WESTERN SPRINGS– SHAFT GEOLOGY– PLAN
	2011887.002	DSCIN009– WESTERN SPRINGS– SHAFT GEOLOGY– 3D
	2011887.003	DSCIN009– WESTERN SPRINGS– SHAFT GEOLOGY– SECTION A
	2011887.004	DSCIN009– WESTERN SPRINGS– SHAFT GEOLOGY– SECTION B
NORGROVE AVENUE	2011953.001	DSLSB001– NORGROVE AVENUE– SHAFT GEOLOGY– PLAN
	2011953.002	DSLSB001– NORGROVE AVENUE– SHAFT GEOLOGY– 3D
	2011953.003	DSLSB001– NORGROVE AVENUE– SHAFT GEOLOGY– SECTION A
	2011953.004	DSLSB001– NORGROVE AVENUE– SHAFT GEOLOGY– SECTION B
RAWALPINDI RESERVE	2011954.001	DSLSB002– RAWALPINDI RESERVE– SHAFT GEOLOGY– PLAN
	2011954.002	DSLSB002– RAWALPINDI RESERVE– SHAFT GEOLOGY– 3D
	2011954.003	DSLSB002– RAWALPINDI RESERVE– SHAFT GEOLOGY– SECTION A
	2011954.004	DSLSB002– RAWALPINDI RESERVE– SHAFT GEOLOGY– SECTION B
HAYCOCK AVENUE	2012006.001	DSLSC001–HAYCOCK AVENUE– SHAFT GEOLOGY– PLAN
	2012006.002	DSLSC001–HAYCOCK AVENUE– SHAFT GEOLOGY– 3D
	2012006.003	DSLSC001–HAYCOCK AVENUE– SHAFT GEOLOGY– SECTION A
	2012006.004	DSLSC001–HAYCOCK AVENUE– SHAFT GEOLOGY– SECTION B
DUNDALE AVENUE	2012007.001	DSLSC002– DUNDALE AVENUE– SHAFT GEOLOGY– PLAN
	2012007.002	DSLSC002– DUNDALE AVENUE– SHAFT GEOLOGY– 3D
	2012007.003	DSLSC002– DUNDALE AVENUE– SHAFT GEOLOGY– SECTION A
	2012007.004	DSLSC002– DUNDALE AVENUE– SHAFT GEOLOGY– SECTION B
WHITNEY AVENUE	2012008.001	DSLSC003– WHITNEY AVENUE– SHAFT GEOLOGY– PLAN
	2012008.002	DSLSC003– WHITNEY AVENUE– SHAFT GEOLOGY– 3D
	2012008.003	DSLSC003– WHITNEY AVENUE– SHAFT GEOLOGY– SECTION A
	2012008.004	DSLSC003– WHITNEY AVENUE– SHAFT GEOLOGY– SECTION B
MIRANDA AVENUE	2012009.001	DSLSC004–MIRANDA AVENUE– SHAFT GEOLOGY– PLAN
	2012009.002	DSLSC004–MIRANDA AVENUE– SHAFT GEOLOGY– 3D
	2012009.003	DSLSC004–MIRANDA AVENUE– SHAFT GEOLOGY– SECTION A
	2012009.004	DSLSC004–MIRANDA AVENUE– SHAFT GEOLOGY– SECTION B
PS25	2012010.001	DSLSC005–PS25– SHAFT GEOLOGY– PLAN
	2012010.002	DSLSC005–PS25– SHAFT GEOLOGY– 3D
	2012010.003	DSLSC005–PS25– SHAFT GEOLOGY– SECTION A
	2012010.004	DSLSC005–PS25– SHAFT GEOLOGY– SECTION B

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ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

	BY	DATE
DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
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PWCIN – PROJECT WIDE

SITE GENERAL

DRAWING INDEX SHEET

CAD FILE 2012061.001 | DATE 07.06.16

ORIGINAL SCALE A1 | CONTRACT No. 5747

REF. No. CI–GEOTECH | ISSUE

DWG. No. 2012061.001 | 3

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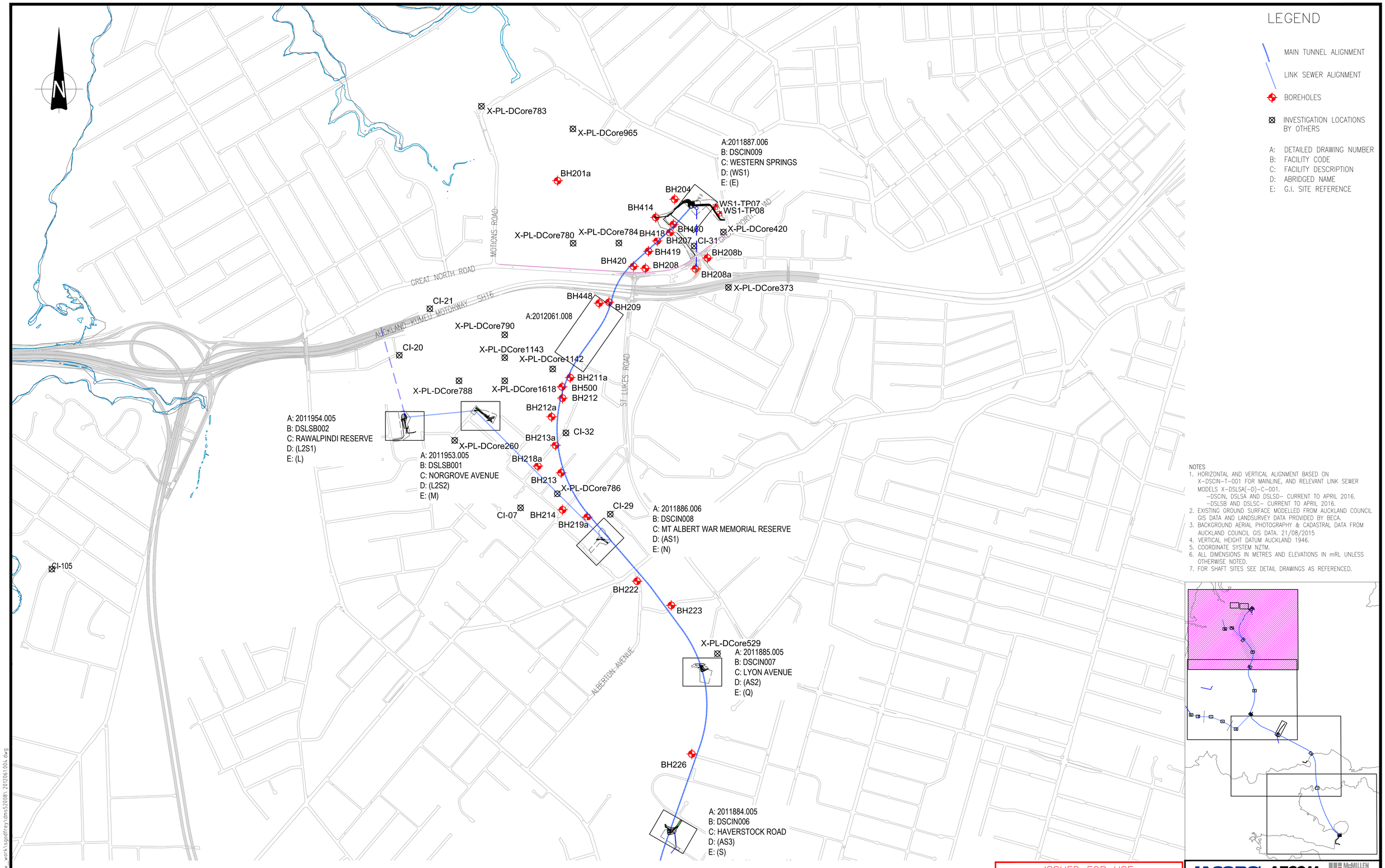

LEGEND

- MAIN TUNNEL ALIGNMENT
- LINK SEWER ALIGNMENT
- BOREHOLES
- INVESTIGATION LOCATIONS BY OTHERS

A: DETAILED DRAWING NUMBER
B: FACILITY CODE
C: FACILITY DESCRIPTION
D: ABRIDGED NAME
E: G.I. SITE REFERENCE

NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001.
   -DSCIN, DSLSA AND DSLSD- CURRENT TO APRIL 2016.
   -DSLSB AND DSLSC- CURRENT TO APRIL 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. FOR SHAFT SITES SEE DETAIL DRAWINGS AS REFERENCED.

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4	03.02.17	REVISED ISSUE ; CIGI3 BH500 ADDED	KL	ADC
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
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DWG. CHECKED	ADC	05.16
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BOREHOLE LOCATION PLAN - SHEET 1

CAD FILE 2012061.004	DATE 03.02.17
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DWG. No. 2012061.004	4

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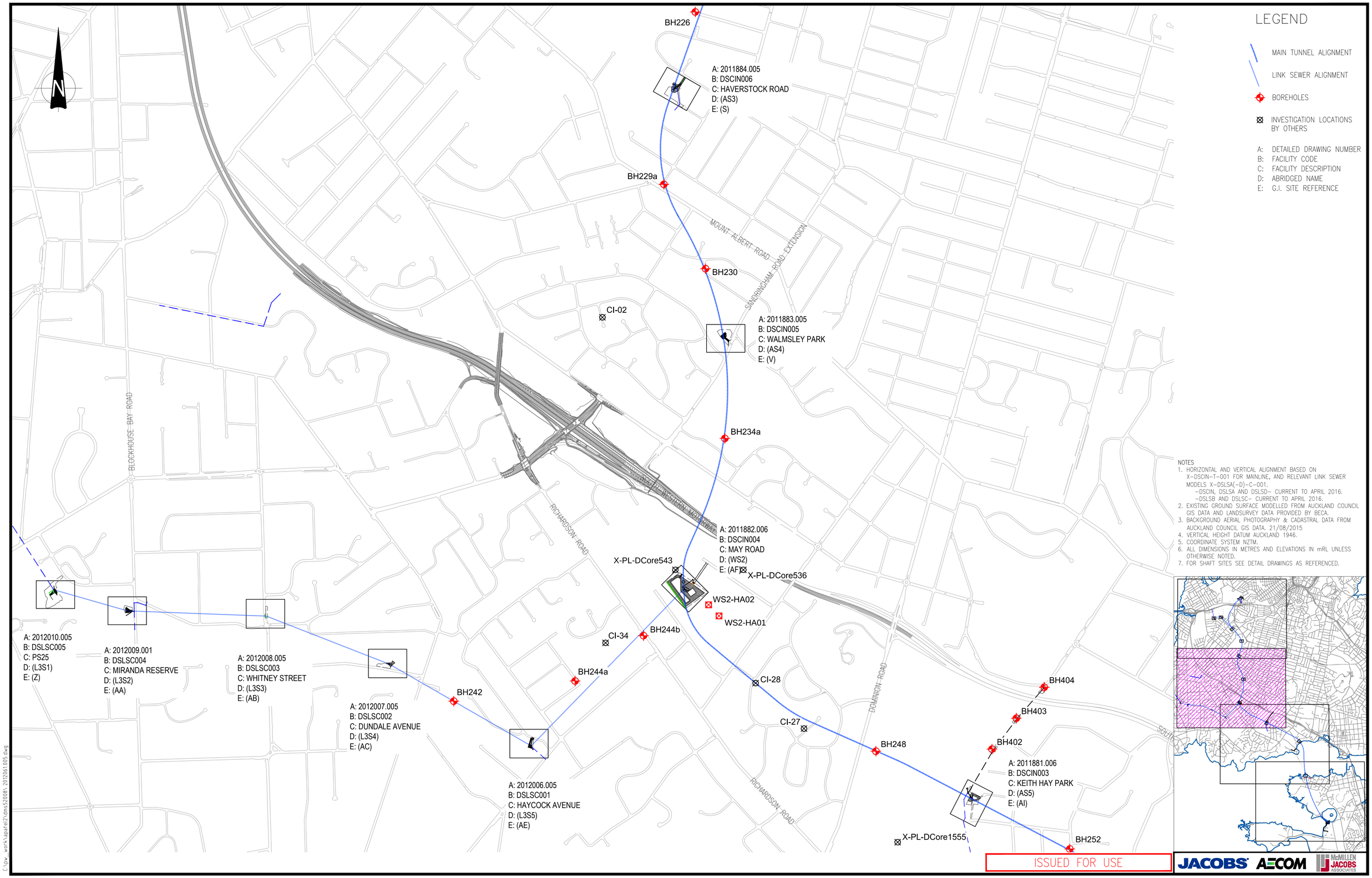

LEGEND

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5. COORDINATE SYSTEM NZTM.
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3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
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DWG. CHECKED	ADC	05.16
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BOREHOLE LOCATION PLAN – SHEET 2

CAD FILE 2012061.005	DATE 07.06.16
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REF. No. CI-GEOTECH	ISSUE
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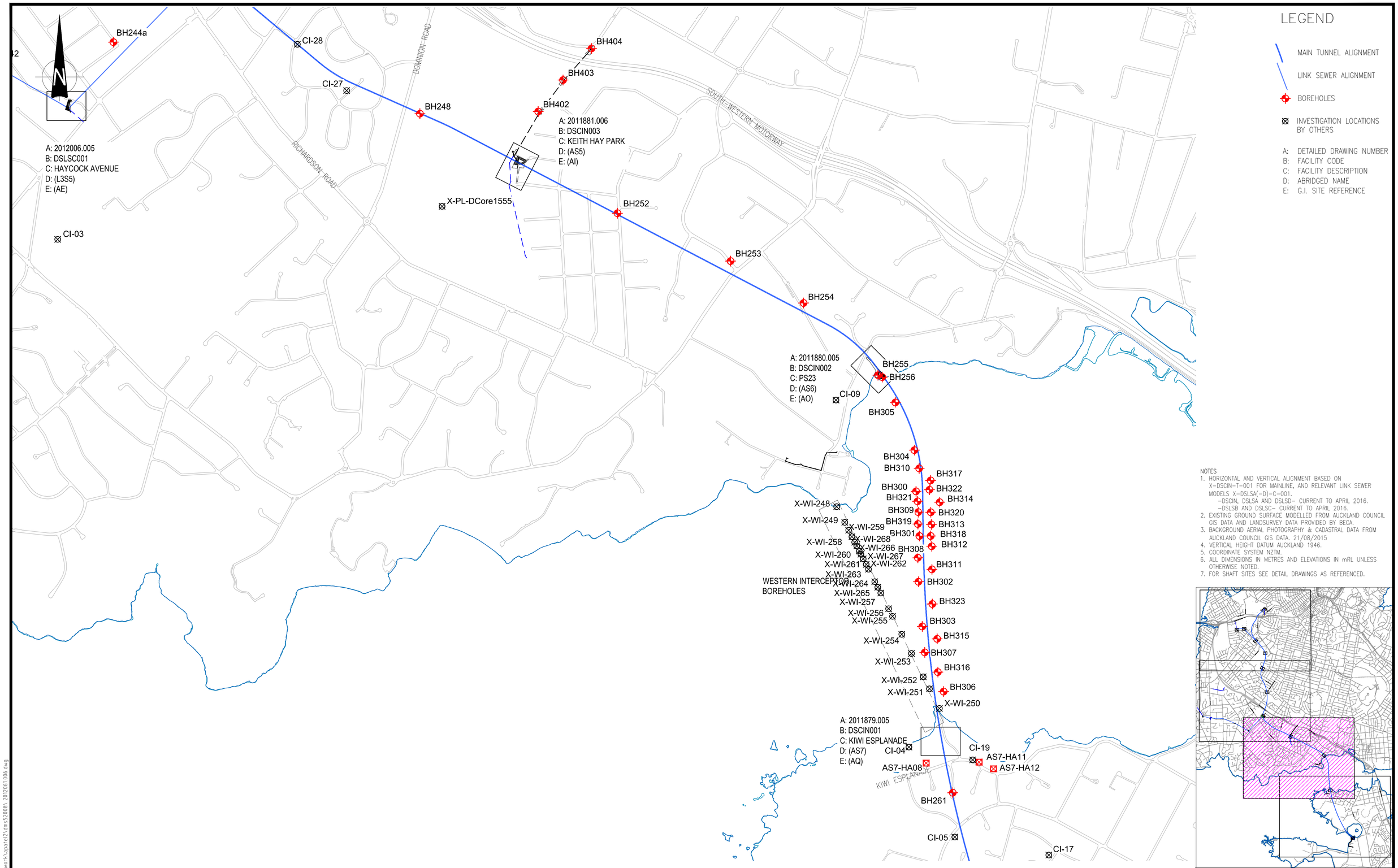

ISSUE	DATE	AMENDMENT	BY	APPD.
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2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
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BOREHOLE LOCATION PLAN – SHEET 3

CAD FILE 2012061.006	DATE 07.06.16
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REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012061.006	3

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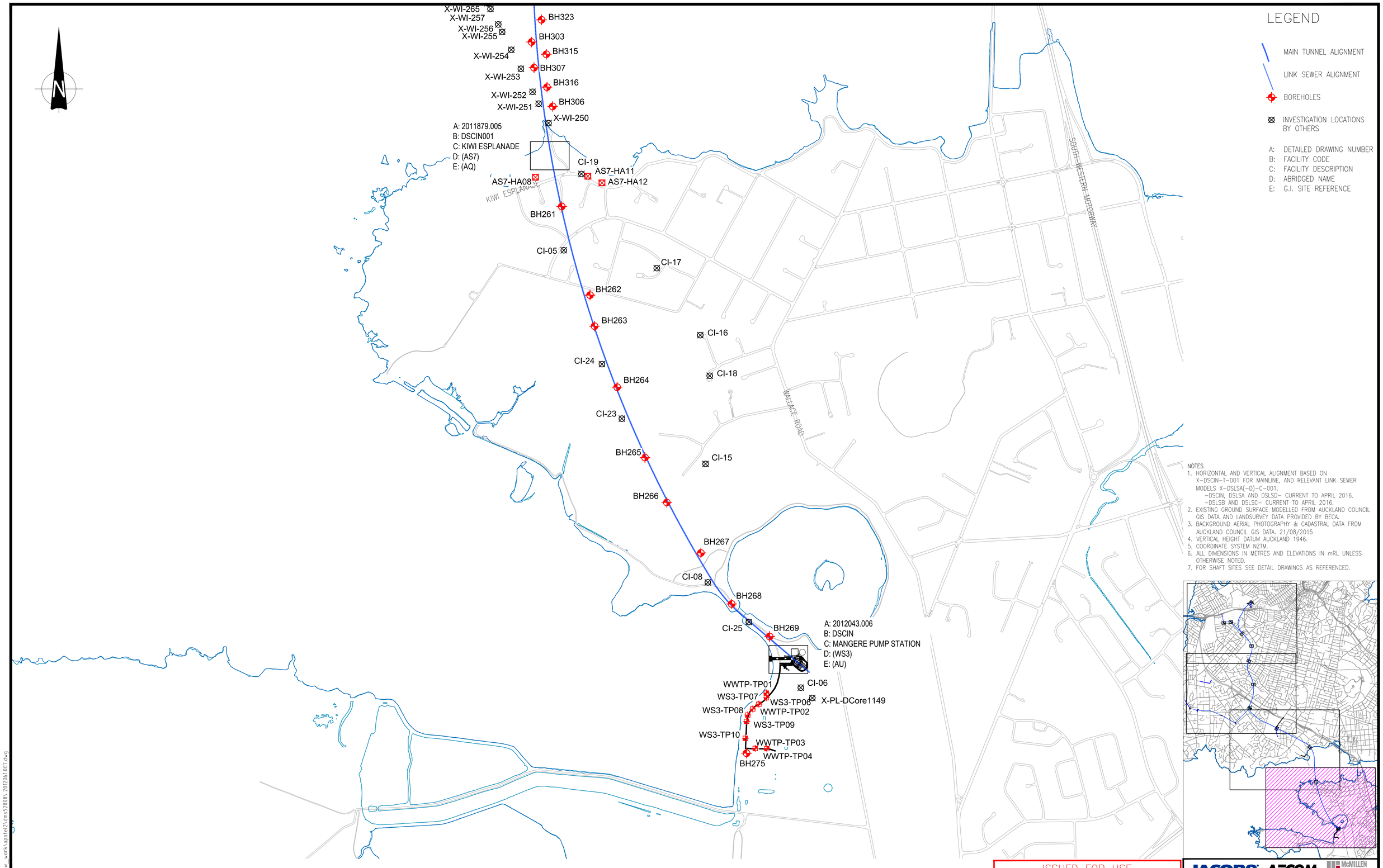

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
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PWCIN – PROJECT WIDE
SITE GENERAL
BOREHOLE LOCATION PLAN – SHEET 4

CAD FILE 2012061.007	DATE 07.06.16
ORIGINAL SCALE A1 1:7500	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012061.007	3

Plot Date: Jun 09, 2016 - 2:13pm
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LEGEND

- MAIN TUNNEL ALIGNMENT
- LINK SEWER ALIGNMENT
- BOREHOLES
- INVESTIGATION LOCATIONS BY OTHERS

A: DETAILED DRAWING NUMBER
B: FACILITY CODE
C: FACILITY DESCRIPTION
D: ABRIDGED NAME
E: G.I. SITE REFERENCE

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   -DSCIN, DSLSA AND DSLSD- CURRENT TO APRIL 2016.
   -DSLSB AND DSLSC- CURRENT TO APRIL 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA, 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. FOR SHAFT SITES SEE DETAIL DRAWINGS AS REFERENCED.

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2	03.02.17	REVISED ISSUE : CIGI3	KL	ADC
1	07.06.16	ISSUED FOR USE	AP	ADC

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
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	BY	DATE

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PWCIN – PROJECT WIDE
SITE GENERAL
BOREHOLE LOCATION PLAN – SHEET 5

CAD FILE 2012061.008	DATE 03.02.17
ORIGINAL SCALE A1 1:750	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012061.008	2

Plot Date: Jan 26, 2017 - 1:00pm
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Appendix B. Drawings – site geology plans

BH270
CI-26
X-MSPW-DH09
X-MSPW-DH10
WS3-TP04
WS3-TP13
BH272
BH422
BH274
BH401
C 005
WS3-TP12
X-MSPW-DH08
BH271
WS3-TP02
WS3-CPT01
WS3-TP14
WS3-CPT03
WS3-TP05
BH273
WS3-CPT02
WS3-TP03
BH400
A 003
WS3-TP01
B 004

SCALE 1:250 (A1) 0 5 10 15 20 25m

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LEGEND

- BH260 Machine Boreholes
- AS7-TP01 Trial Pits
- AS7-CPT01 Cone Penetration Tests And Seismic Dilatometer
- AS7-HA02 Hand Augers
- AS7-SP01 Dynamic Cone Penetrometers
- CI-21 Investigation Locations By Others
- Made Ground
- Recent Alluvium

TAURANGA GROUP
- Tauranga Group
- Kaawa Formation

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt
- Tuff / Ash / Scoria

WAITEMATA GROUP (MIOCENE)
- Residually to Highly Weathered - Cohesive Soils

- Main Tunnel Centreline And Edges
- Link Sewer Tunnel Edges
- Site Boundary
- Contours (1m Intervals)
- A – CH. 0 SECTION LINE

NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001 – CURRENT TO APRIL 2016.
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7. GEOLOGICAL BOUNDARIES FROM QMAP, AMENDED TO MATCH GROUND INVESTIGATION FINDINGS.

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
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BY		DATE

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DPCIN – MANGERE PUMPING STATION
SITE GENERAL
SHAFT GEOLOGY – PLAN

CAD FILE 2012043-001 | DATE 07.06.16
ORIGINAL SCALE A1 1:250 | CONTRACT No. 5747
REF. No. CI-GEOTECH | ISSUE
DWG. No. 2012043.001 | 3

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

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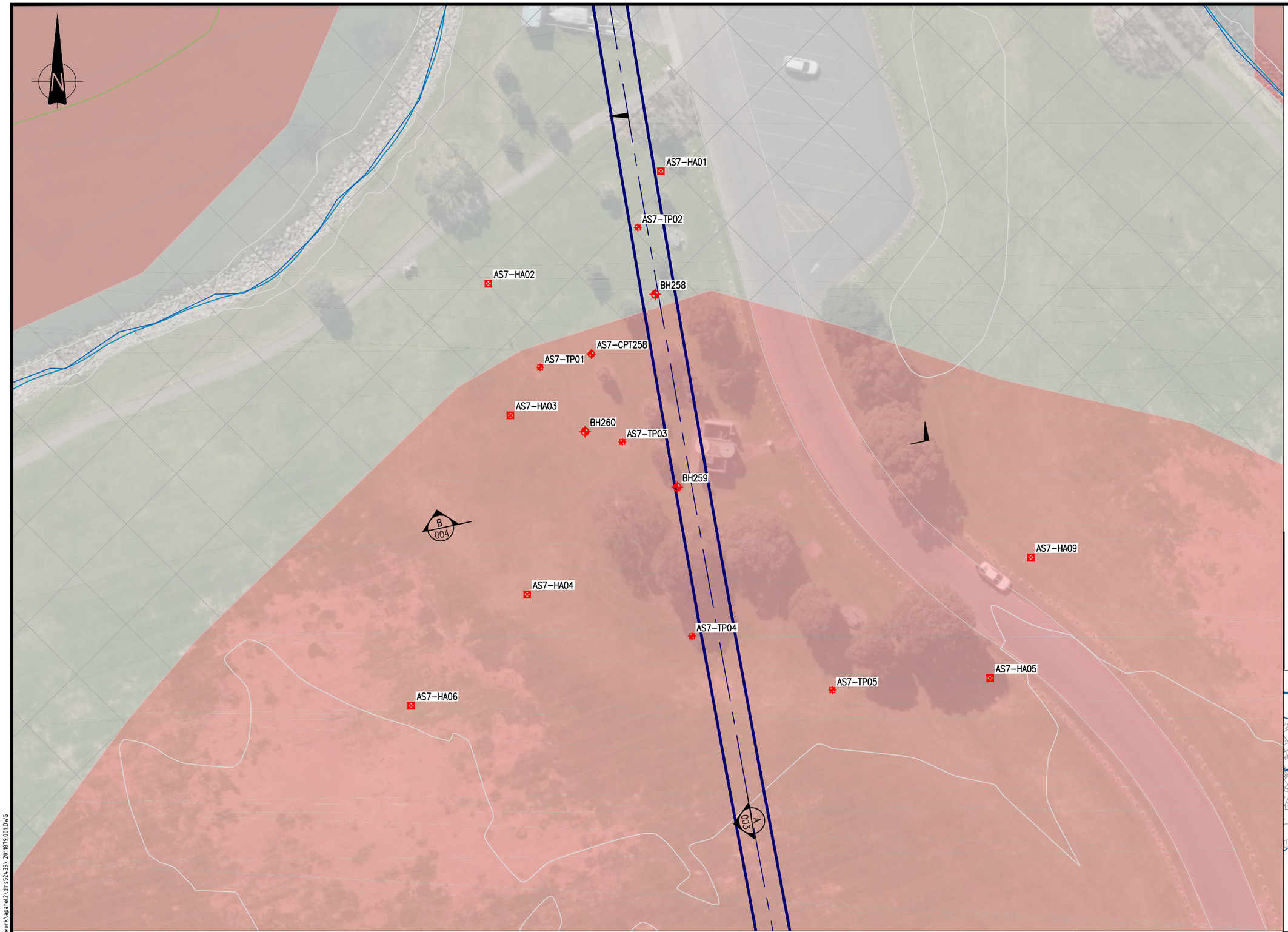

LEGEND

- BH260 — Machine Boreholes
- AS7-TP01 — Trial Pits
- AS7-CPT01 — Cone Penetration Tests And Seismic Dilatometer
- AS7-HA02 — Hand Augers
- AS7-SP01 — Dynamic Cone Penetrometers
- CI-21 — Investigation Locations By Others
- Made Ground
- Recent Alluvium

TAURANGA GROUP
- Tauranga Group
- Kaawa Formation

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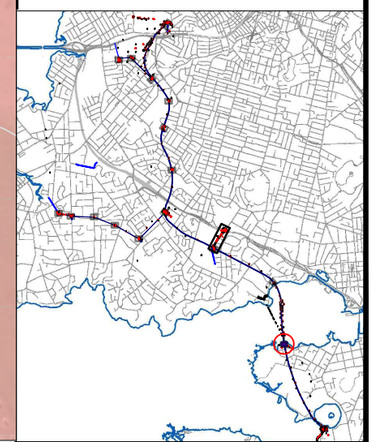

SCALE 1:250 (A1) 0 5 10 15 20 25m

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ISSUE	DATE	AMENDMENT	BY	APPD.
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DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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DSCIN001 - KIWI ESPLANADE
SITE GENERAL
SHAFT GEOLOGY - PLAN

CAD FILE 2011879.001	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011879.001	3

Plot Date: Jun 09, 2016 - 2:47pm
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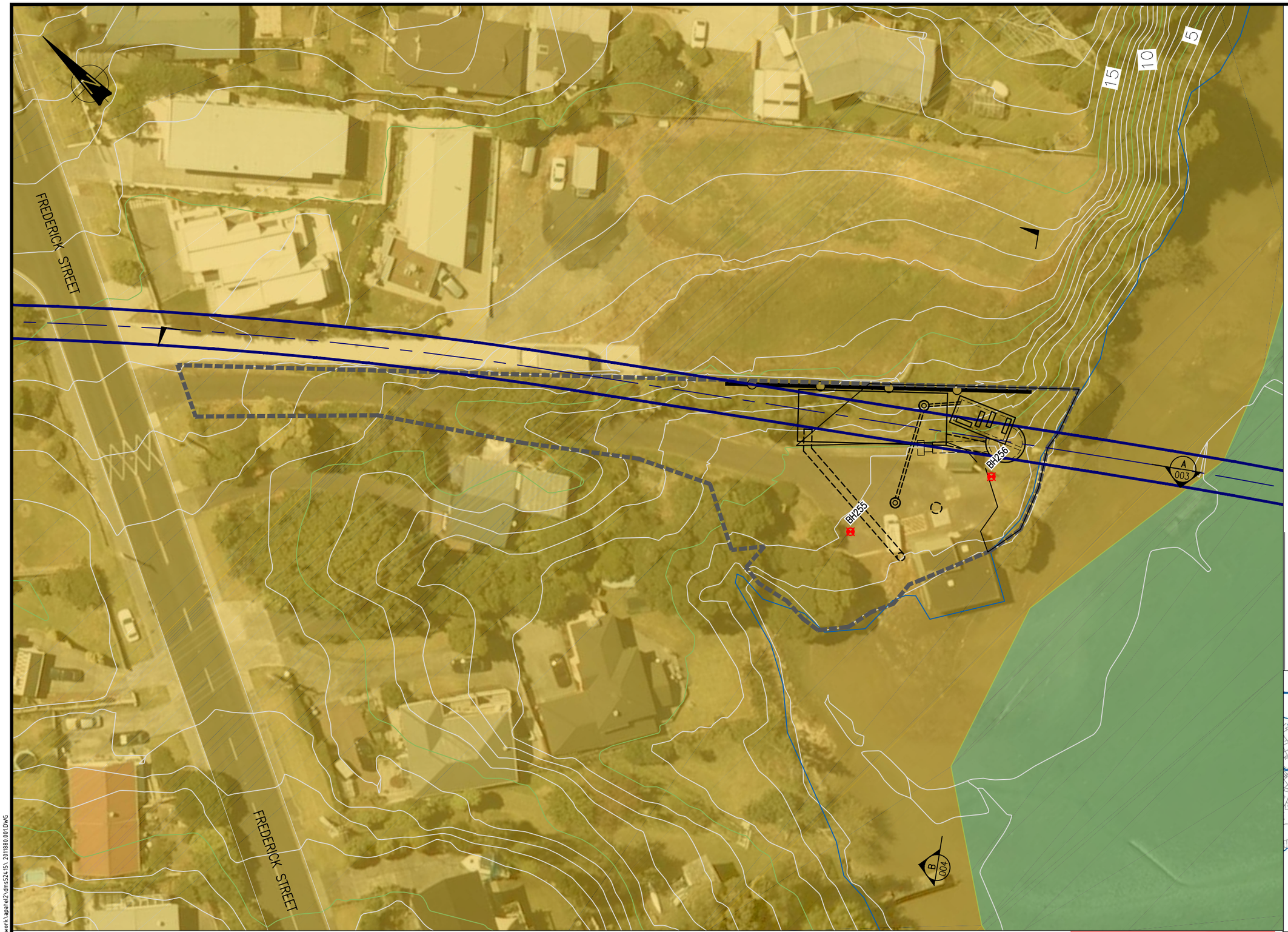


LEGEND

- BH260 — Machine Boreholes
- AS7-TP01 — Trial Pits
- AS7-CPT01 — Cone Penetration Tests And Seismic Dilatometer
- AS7-HA02 — Hand Augers
- AS7-SPD1 — Dynamic Cone Penetrometers
- CI-21 — Investigation Locations By Others
- Made Ground
- Recent Alluvium

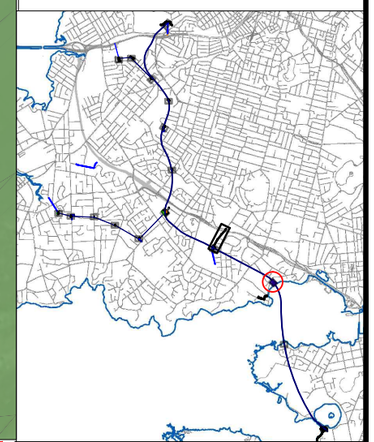
TAURANGA GROUP
- Tauranga Group
- Kaawa Formation

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt
- Tuff / Ash / Scoria

WAITEMATA GROUP (MIOCENE)
- Residually to Highly Weathered - Cohesive Soils

- Main Tunnel Centreline And Edges
- Link Sewer Tunnel Edges
- Site Boundary
- Contours (1m Intervals)
- A — CH. 0 — SECTION LINE

NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001 - CURRENT TO APRIL 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. GEOLOGICAL BOUNDARIES FROM QMAP, AMENDED TO MATCH GROUND INVESTIGATION FINDINGS.



SCALE 1:250 (A1) 0 5 10 15 20 25m

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

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Plot Date: Jun 09, 2016 - 2:55pm

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

INFRASTRUCTURE

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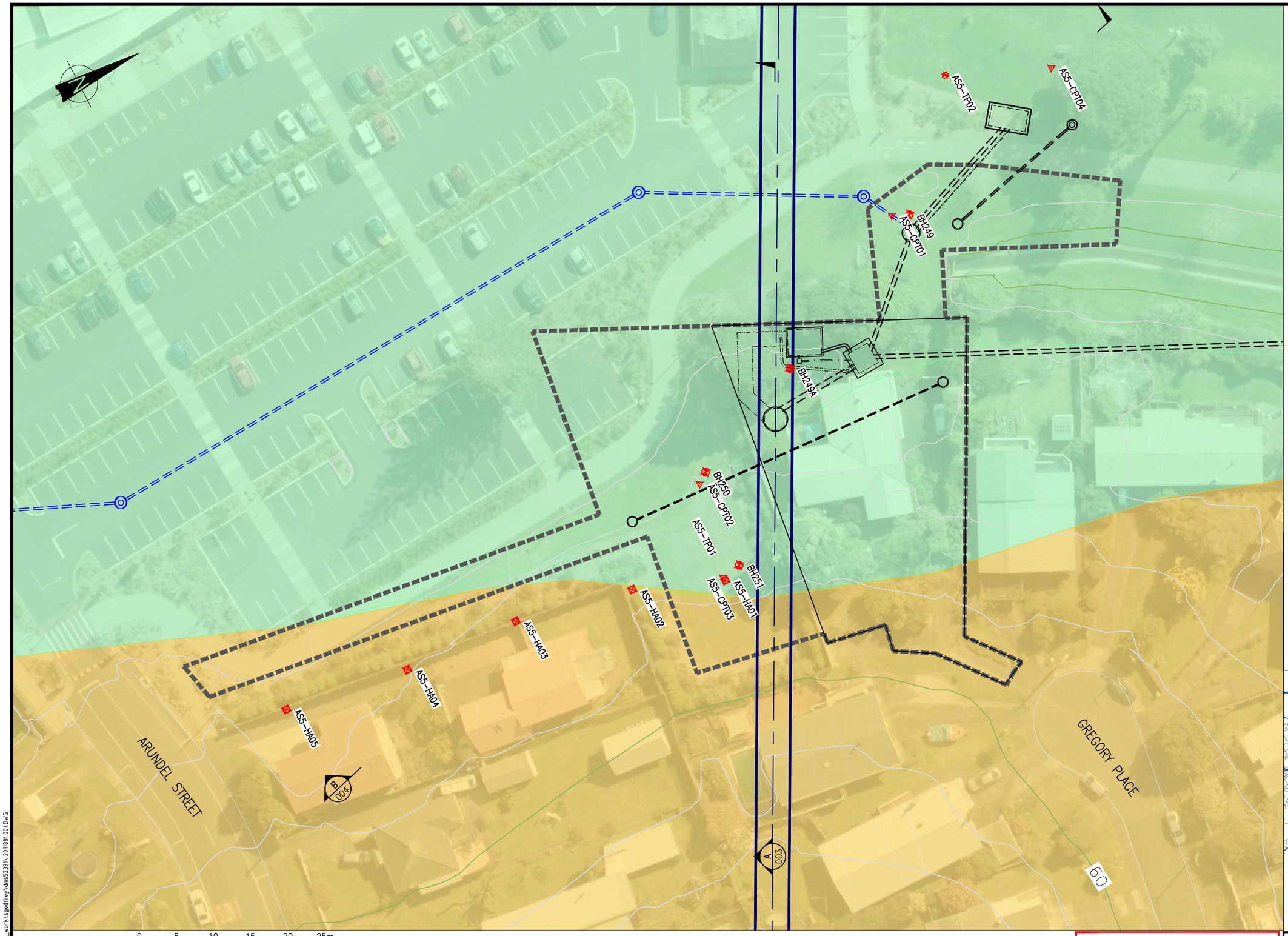
DSCIN002 - PS23
SITE GENERAL
SHAFT GEOLOGY - PLAN

CAD FILE 2011880.001	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011880.001	3



LEGEND

- BH260 — Machine Boreholes
- AS7-TP01 — Trial Pits
- AS7-CPT01 — Cone Penetration Tests And Seismic Dilatometer
- AS7-HA02 — Hand Augers
- AS7-SP01 — Dynamic Cone Penetrometers
- CI-21 — Investigation Locations By Others
- Made Ground
- Recent Alluvium

TAURANGA GROUP
- Tauranga Group
- Kaawa Formation

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt
- Tuff / Ash / Scoria

WAITEMATA GROUP (MIOCENE)
- Residually to Highly Weathered - Cohesive Soils

- Main Tunnel Centreline And Edges
- Link Sewer Tunnel Edges
- Site Boundary
- Contours (1m Intervals)
- A — CH. 0 — SECTION LINE

NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001 - CURRENT TO APRIL 2016.
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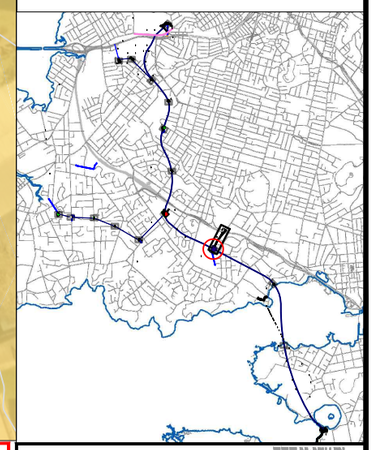
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. GEOLOGICAL BOUNDARIES FROM QMAP, AMENDED TO MATCH GROUND INVESTIGATION FINDINGS.



SCALE 1:250 (A1) 0 5 10 15 20 25m

ISSUED FOR USE

JACOBS AECOM MWH JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
4	03.02.17	REVISED ISSUE - CGI3 -BH249A ADDED	KL	ADC
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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DSCIN003 - KEITH HAY PARK
SITE GENERAL
SHAFT GEOLOGY - PLAN

CAD FILE 2011881.001	DATE 03.02.17
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011881.001	4

Plot Date: Jan 26, 2017 - 9:46am
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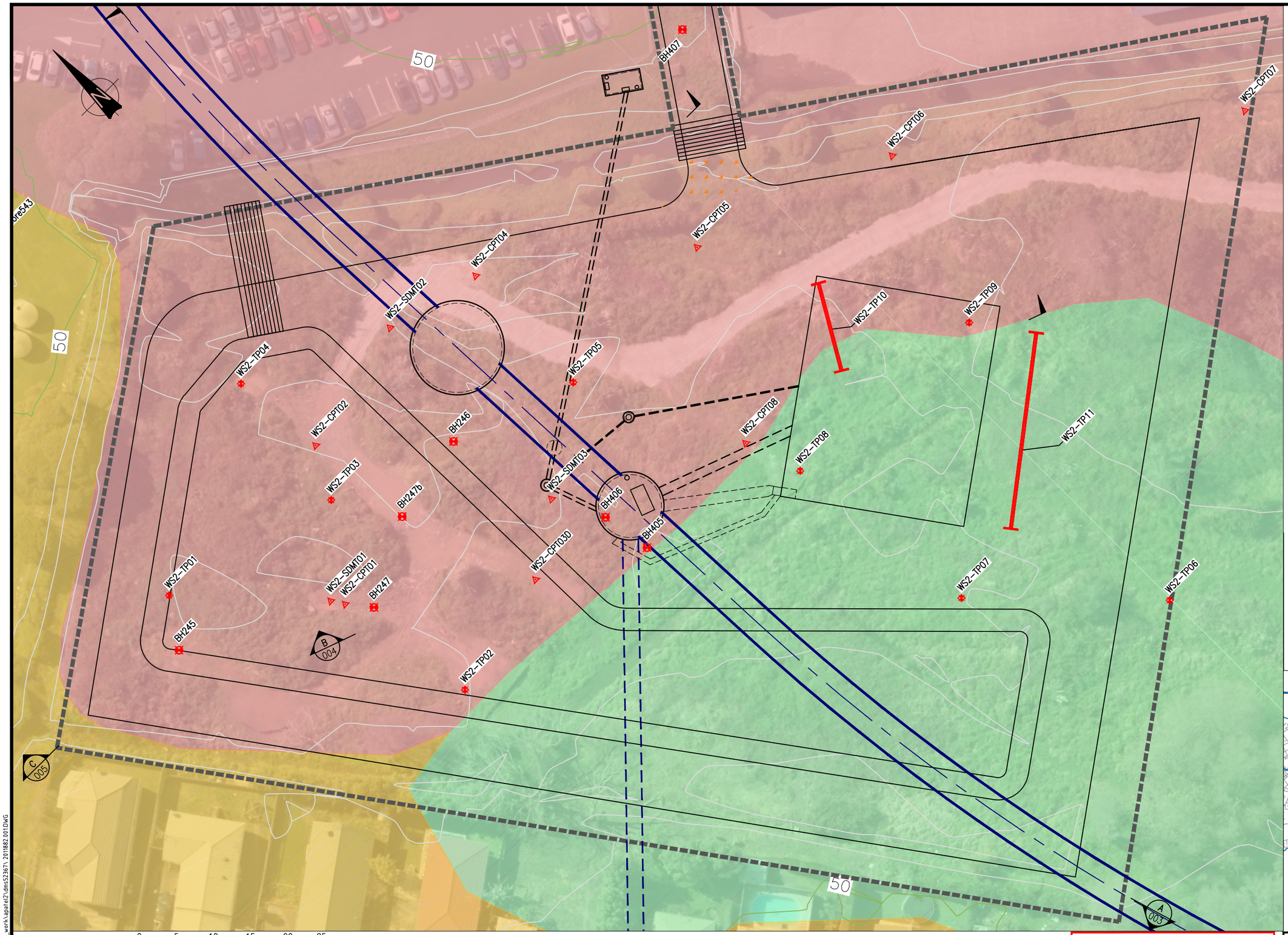

LEGEND

- BH260 — Machine Boreholes
- AS7-TP01 — Trial Pits
- AS7-CPT01 — Cone Penetration Tests And Seismic Dilatometer
- AS7-HA02 — Hand Augers
- AS7-SP01 — Dynamic Cone Penetrometers
- CI-21 — Investigation Locations By Others
- Made Ground
- Recent Alluvium

TAURANGA GROUP
- Tauranga Group
- Kaawa Formation

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt
- Tuff / Ash / Scoria

WAITEMATA GROUP (MIOCENE)
- Residually to Highly Weathered - Cohesive Soils

- Main Tunnel Centreline And Edges
- Link Sewer Tunnel Edges
- Site Boundary
- Contours (1m Intervals)
- A — CH. 0 — SECTION LINE

NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001 - CURRENT TO APRIL 2016.
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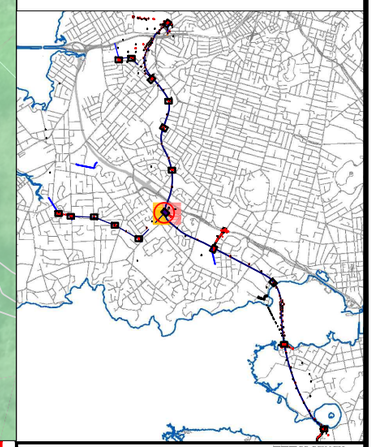
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. GEOLOGICAL BOUNDARIES FROM QMAP, AMENDED TO MATCH GROUND INVESTIGATION FINDINGS.



JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	ADC	AP
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		

OPERATIONS

INFRASTRUCTURE

Watercare

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DSCIN004 - MAY ROAD
SITE GENERAL
SHAFT GEOLOGY - PLAN

CAD FILE 2011882.001	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011882.001	3

Plot Date: Jun 10, 2016 - 7:09am
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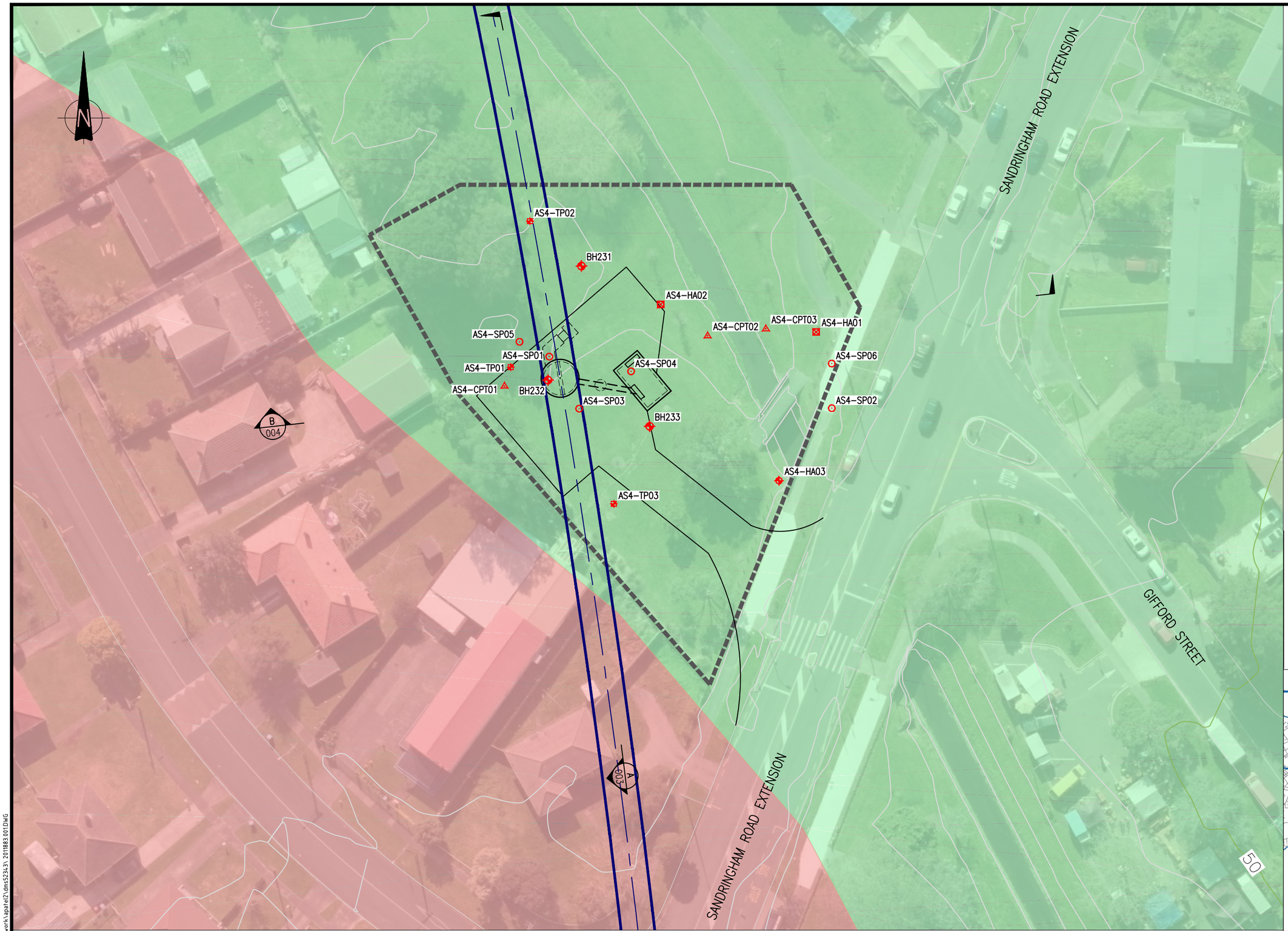


LEGEND

- BH260 — Machine Boreholes
- AS7-TP01 — Trial Pits
- AS7-CPT01 — Cone Penetration Tests And Seismic Dilatometer
- AS7-HA02 — Hand Augers
- AS7-SP01 — Dynamic Cone Penetrometers
- CI-21 — Investigation Locations By Others
- Made Ground
- Recent Alluvium

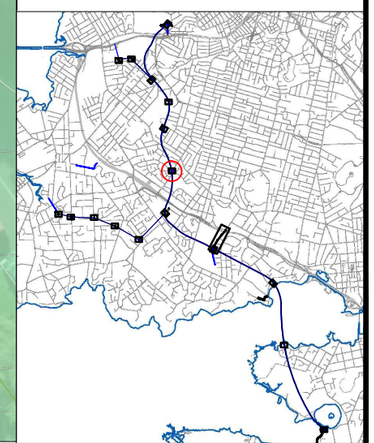
TAURANGA GROUP
- Tauranga Group
- Kaawa Formation

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt
- Tuff / Ash / Scoria

WAITEMATA GROUP (MIOCENE)
- Residually to Highly Weathered - Cohesive Soils

- Main Tunnel Centreline And Edges
- Link Sewer Tunnel Edges
- Site Boundary
- Contours (1m Intervals)
- A — CH. 0 — SECTION LINE

NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001 - CURRENT TO APRIL 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. GEOLOGICAL BOUNDARIES FROM QMAP, AMENDED TO MATCH GROUND INVESTIGATION FINDINGS.



SCALE 1:250 (A1) 0 5 10 15 20 25m

ISSUED FOR USE

JACOBS AECOM JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
BY		DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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DSCIN005 – WALMSLEY PARK
SITE GENERAL
SHAFT GEOLOGY – PLAN

CAD FILE 2011883.001	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011883.001	3

Plot Date: Jun 10, 2016 - 7:20am
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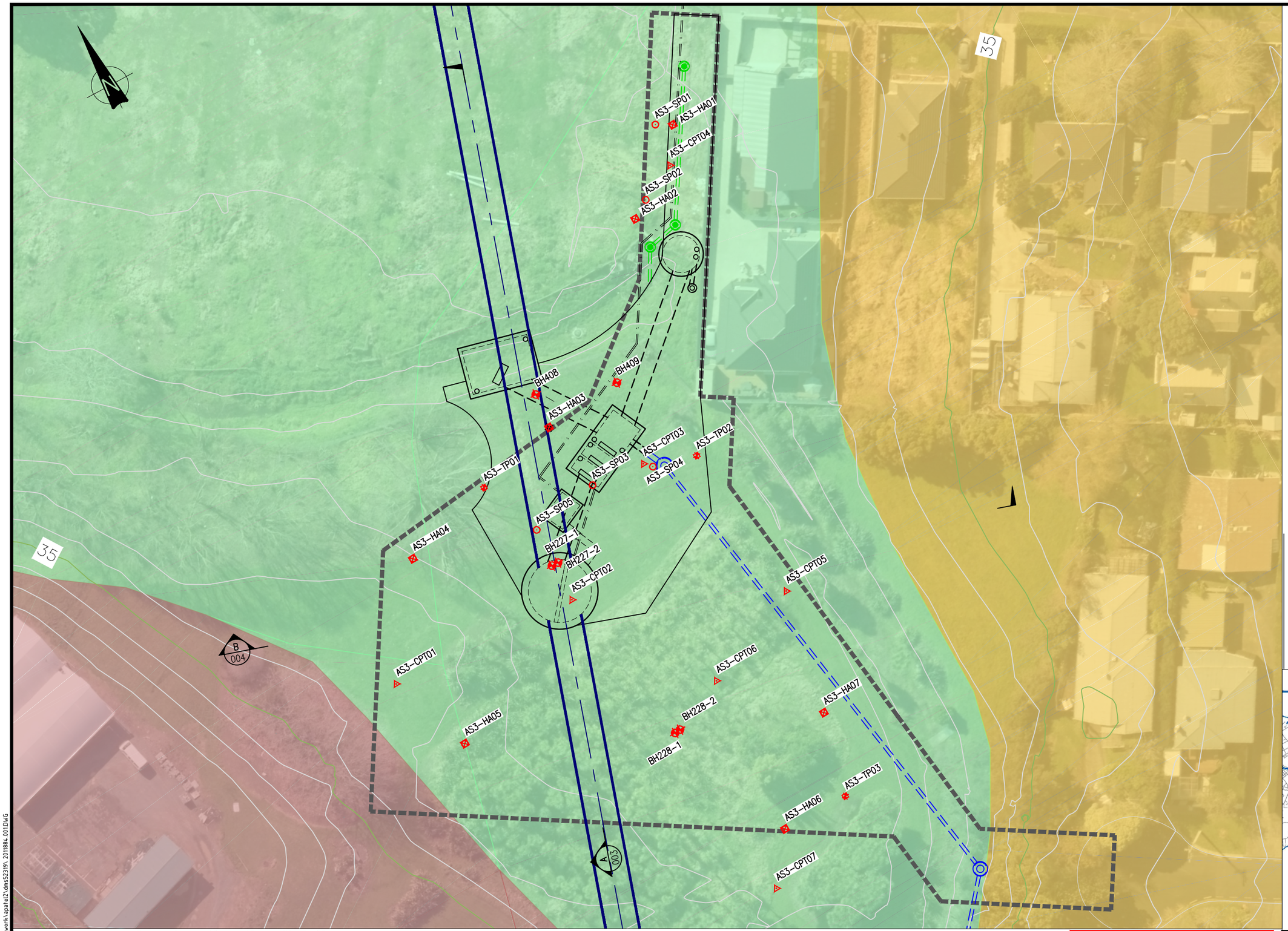


LEGEND

- BH260 — Machine Boreholes
- AS7-TPO1 — Trial Pits
- AS7-CPT01 — Cone Penetration Tests And Seismic Dilatometer
- AS7-HA02 — Hand Augers
- AS7-SPO1 — Dynamic Cone Penetrometers
- CI-21 — Investigation Locations By Others
- Made Ground
- Recent Alluvium

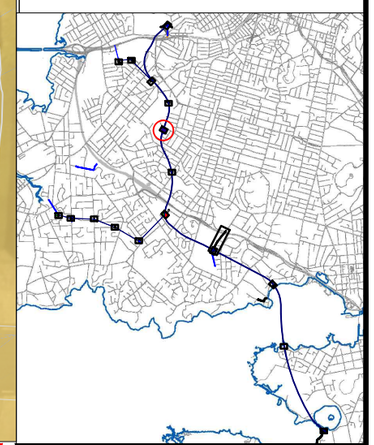
TAURANGA GROUP
- Tauranga Group
- Kaawa Formation

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt
- Tuff / Ash / Scoria

WAITEMATA GROUP (MIOCENE)
- Residually to Highly Weathered - Cohesive Soils

- Main Tunnel Centreline And Edges
- Link Sewer Tunnel Edges
- Site Boundary
- Contours (1m Intervals)
- A — CH. 0 — SECTION LINE

NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001 – CURRENT TO APRIL 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. GEOLOGICAL BOUNDARIES FROM QMAP, AMENDED TO MATCH GROUND INVESTIGATION FINDINGS.



SCALE 1:250 (A1) 0 5 10 15 20 25m

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

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Plot Date: Jun 10, 2016 - 7:44am

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15	OPERATIONS
DES. CHECKED	HM	05.16	
DRAWN	KL	04.15	
DWG. CHECKED	ADC	05.16	INFRASTRUCTURE
PROJECT LEADER	DK	05.16	
INFRAST'R APP'D			
	BY	DATE	

Watercare

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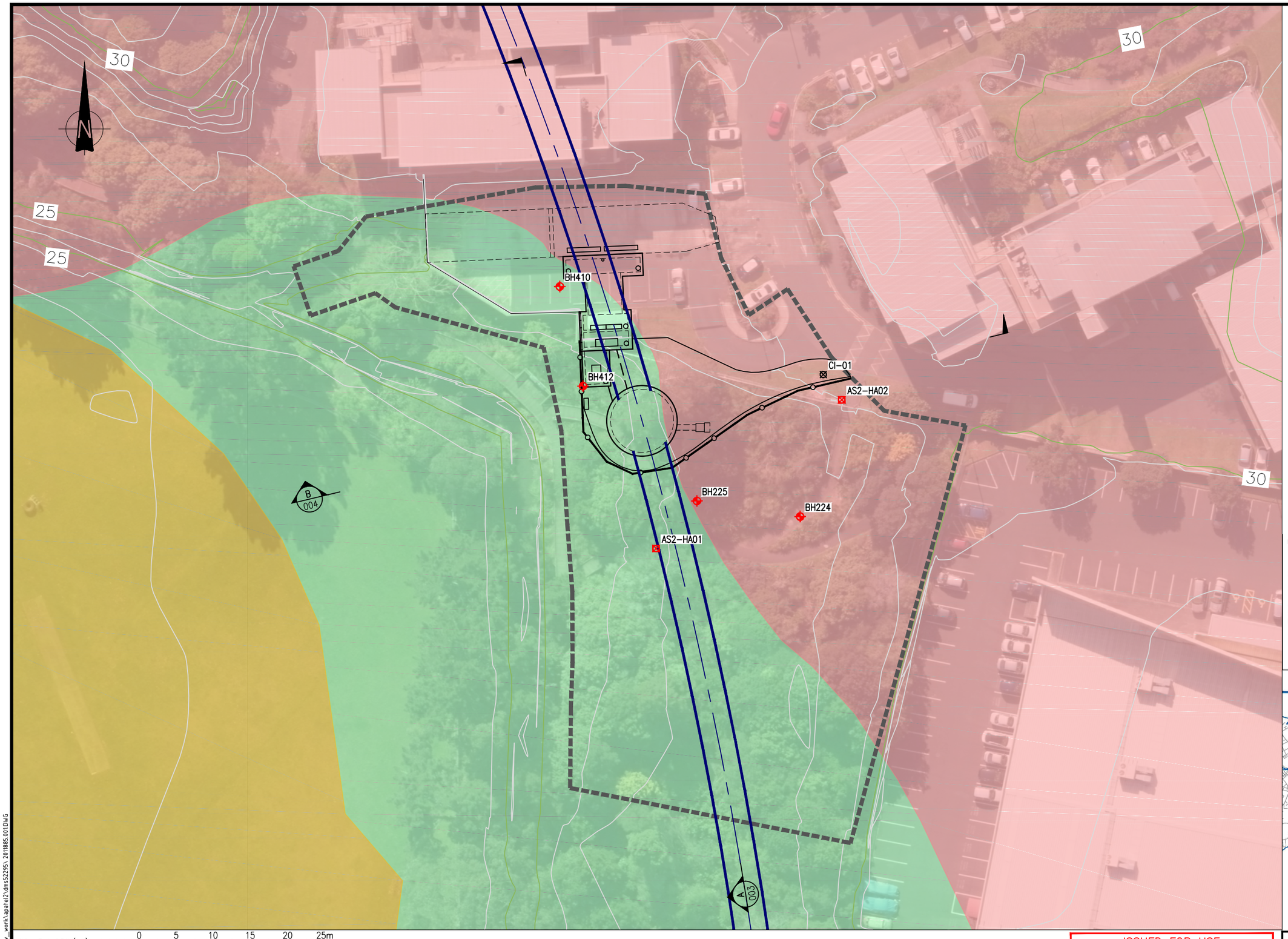
DSCIN006 – HAVERSTOCK ROAD
SITE GENERAL
SHAFT GEOLOGY – PLAN

CAD FILE 2011884.001	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011884.001	3



LEGEND

- BH260 — Machine Boreholes
- AS7-TP01 — Trial Pits
- AS7-CPT01 — Cone Penetration Tests And Seismic Dilatometer
- AS7-HA02 — Hand Augers
- AS7-SPD1 — Dynamic Cone Penetrometers
- CI-21 — Investigation Locations By Others
- Made Ground
- Recent Alluvium

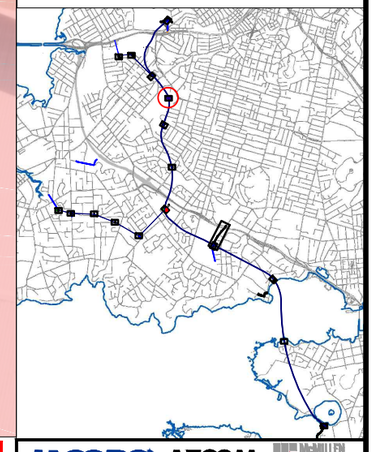
TAURANGA GROUP
- Tauranga Group
- Kaawa Formation

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt
- Tuff / Ash / Scoria

WAITEMATA GROUP (MIOCENE)
- Residually to Highly Weathered - Cohesive Soils

- Main Tunnel Centreline And Edges
- Link Sewer Tunnel Edges
- Site Boundary
- Contours (1m Intervals)
- A — CH. 0 — SECTION LINE

NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001 – CURRENT TO APRIL 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. GEOLOGICAL BOUNDARIES FROM QMAP, AMENDED TO MATCH GROUND INVESTIGATION FINDINGS.



ISSUED FOR USE

JACOBS AECOM MCMILLEN JACOBS ASSOCIATES

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Plot Date: Jun 10, 2016 - 7:52am

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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DSCIN007 – LYON AVENUE
SITE GENERAL
SHAFT GEOLOGY – PLAN

CAD FILE 2011885.001	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011885.001	3

WAIRERE AVENUE

WAIRERE AVENUE

BH413
BH219
AS1-HA01
AS1-HA04
AS1-CPT220
BH221
AS1-HA02
BH220
BH220a
AS1-HA03
20
25
B 004
A 003

SCALE 1:250 (A1) 0 5 10 15 20 25m

ISSUED FOR USE

LEGEND

- BH260 Machine Boreholes
- AS7-TP01 Trial Pits
- AS7-CPT01 Cone Penetration Tests And Seismic Dilatometer
- AS7-HA02 Hand Augers
- AS7-SP01 Dynamic Cone Penetrometers
- CI-21 Investigation Locations By Others
- Made Ground
- Recent Alluvium

TAURANGA GROUP
- Tauranga Group
- Kaawa Formation

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt
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WAITEMATA GROUP (MIOCENE)
- Residually to Highly Weathered - Cohesive Soils

- Main Tunnel Centreline And Edges
- Link Sewer Tunnel Edges
- Site Boundary
- Contours (1m Intervals)
- A – CH. 0
- SECTION LINE

NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001 – CURRENT TO APRIL 2016.
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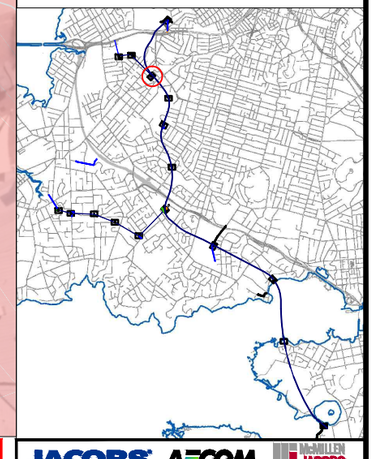
7. GEOLOGICAL BOUNDARIES FROM QMAP, AMENDED TO MATCH GROUND INVESTIGATION FINDINGS.



JACOBS AECOM McMILLEN JACOBS ASSOCIATES

C:\tpw_work\apalet2\dms522711\ 2011886.001DWG

Plot Date: Jun 19, 2016 - 8:08am

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
BY		DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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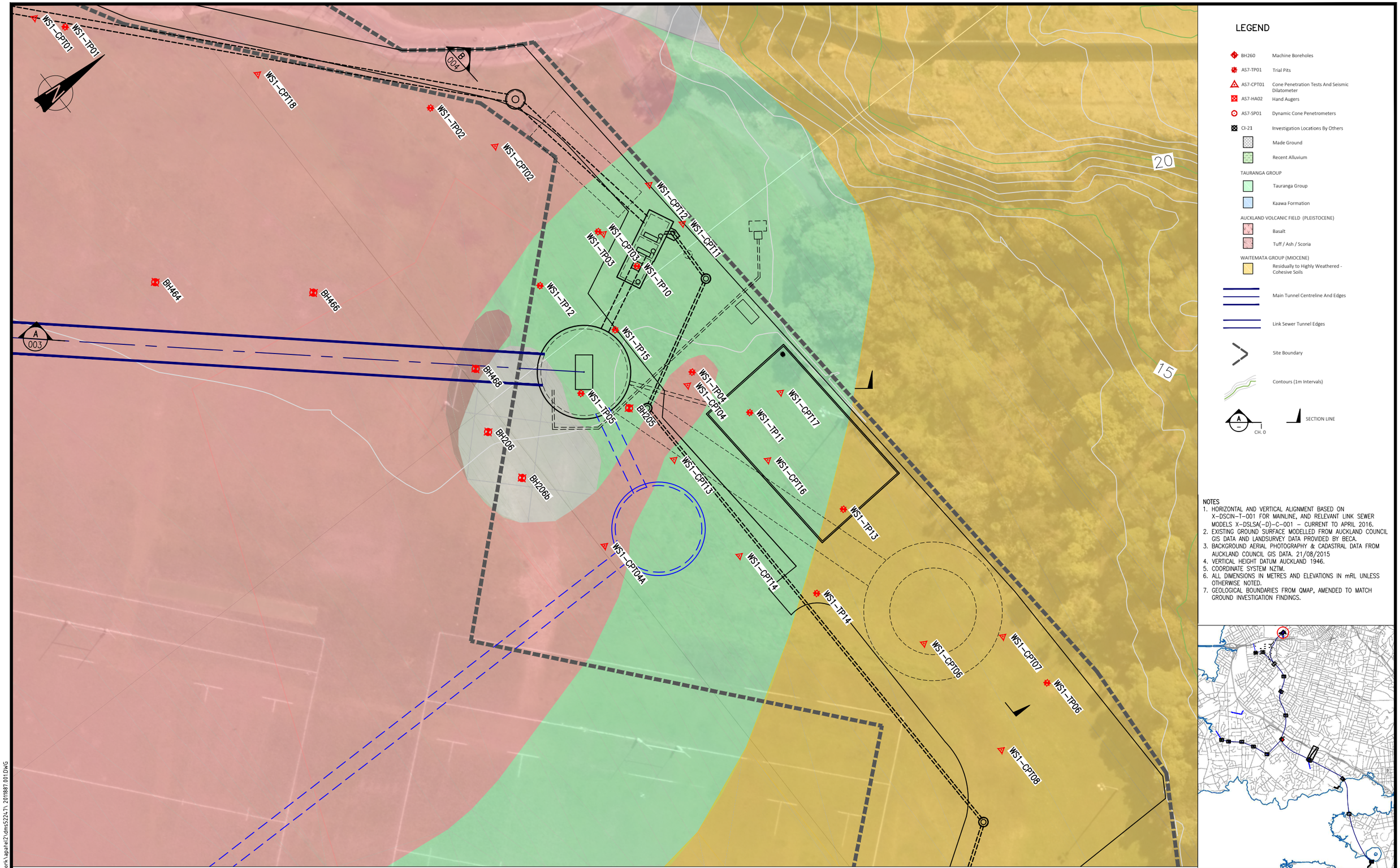
DSCIN008 – MT ALBERT WAR MEMORIAL RESERVE
SITE GENERAL
SHAFT GEOLOGY – PLAN

CAD FILE 2011886.001	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011886.001	3



LEGEND

- BH260 — Machine Boreholes
- AS7-TP01 — Trial Pits
- AS7-CPT01 — Cone Penetration Tests And Seismic Dilatometer
- AS7-HA02 — Hand Augers
- AS7-SPD1 — Dynamic Cone Penetrometers
- CI-21 — Investigation Locations By Others
- Made Ground
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TAURANGA GROUP
- Tauranga Group
- Kaawa Formation

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt
- Tuff / Ash / Scoria

WAITEMATA GROUP (MIOCENE)
- Residually to Highly Weathered - Cohesive Soils

- Main Tunnel Centreline And Edges
- Link Sewer Tunnel Edges
- Site Boundary
- Contours (1m Intervals)
- A — CH. 0 — SECTION LINE

NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001 - CURRENT TO APRIL 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. GEOLOGICAL BOUNDARIES FROM QMAP, AMENDED TO MATCH GROUND INVESTIGATION FINDINGS.

SCALE 1:250 (A1) 0 5 10 15 20 25m

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ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

INFRASTRUCTURE

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DSCIN009 - WESTERN SPRINGS
SITE GENERAL
SHAFT GEOLOGY - PLAN

CAD FILE 2011887.001	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011887.001	3

Plot Date: Jun 10, 2016 - 8:21am
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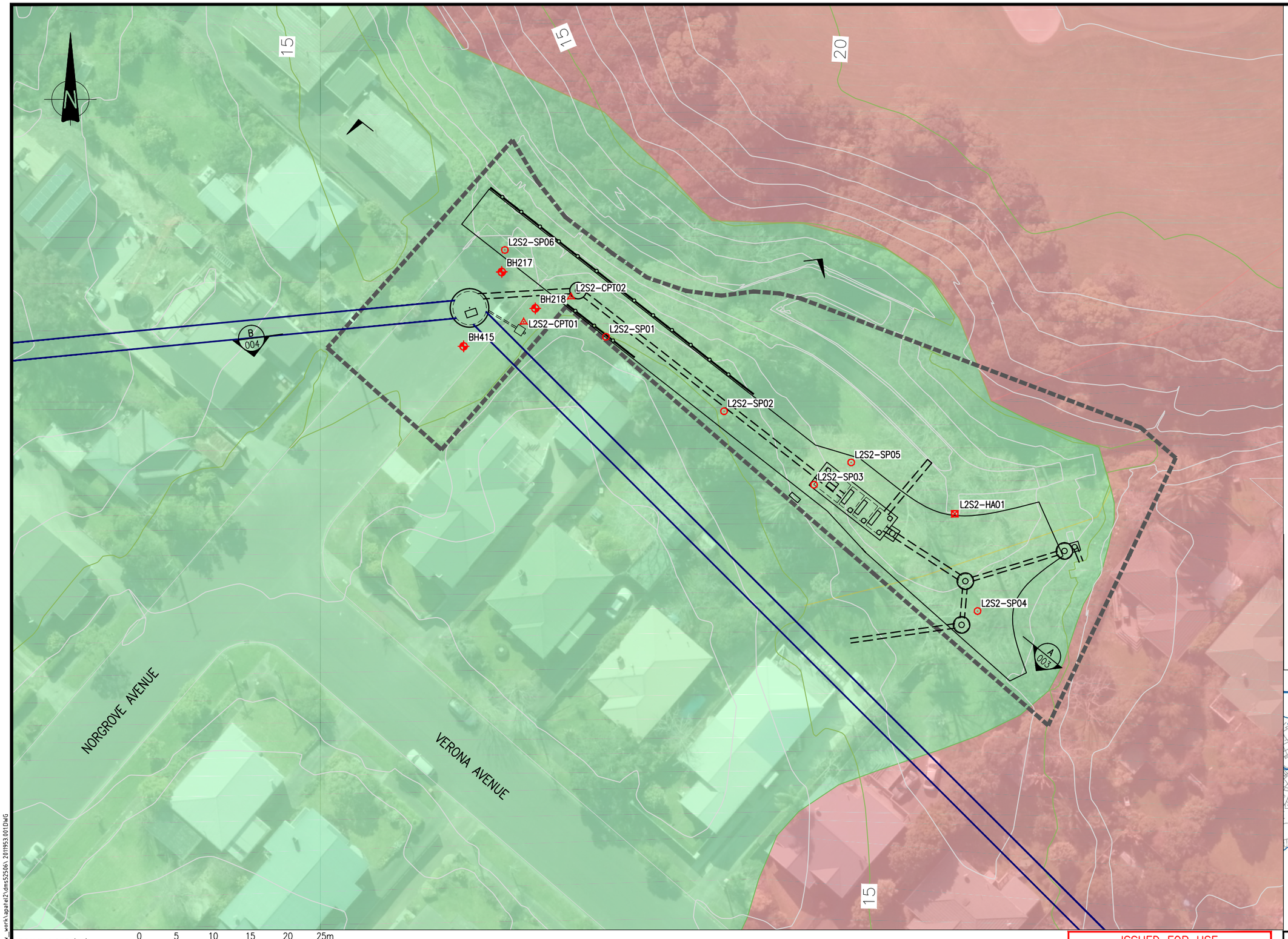

LEGEND

- BH260 — Machine Boreholes
- AS7-TP01 — Trial Pits
- AS7-CPT01 — Cone Penetration Tests And Seismic Dilatometer
- AS7-HA02 — Hand Augers
- AS7-SP01 — Dynamic Cone Penetrometers
- CI-21 — Investigation Locations By Others
- Made Ground
- Recent Alluvium

TAURANGA GROUP
- Tauranga Group
- Kaawa Formation

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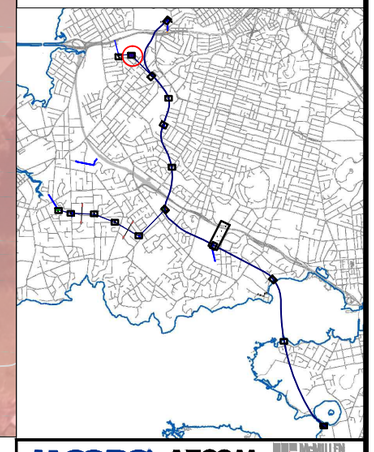
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. GEOLOGICAL BOUNDARIES FROM QMAP, AMENDED TO MATCH GROUND INVESTIGATION FINDINGS.



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Plot Date: Jun 10, 2016 - 8:38am

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2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

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DSLSB001 – NORGROVE AVENUE
SITE GENERAL
SHAFT GEOLOGY – PLAN

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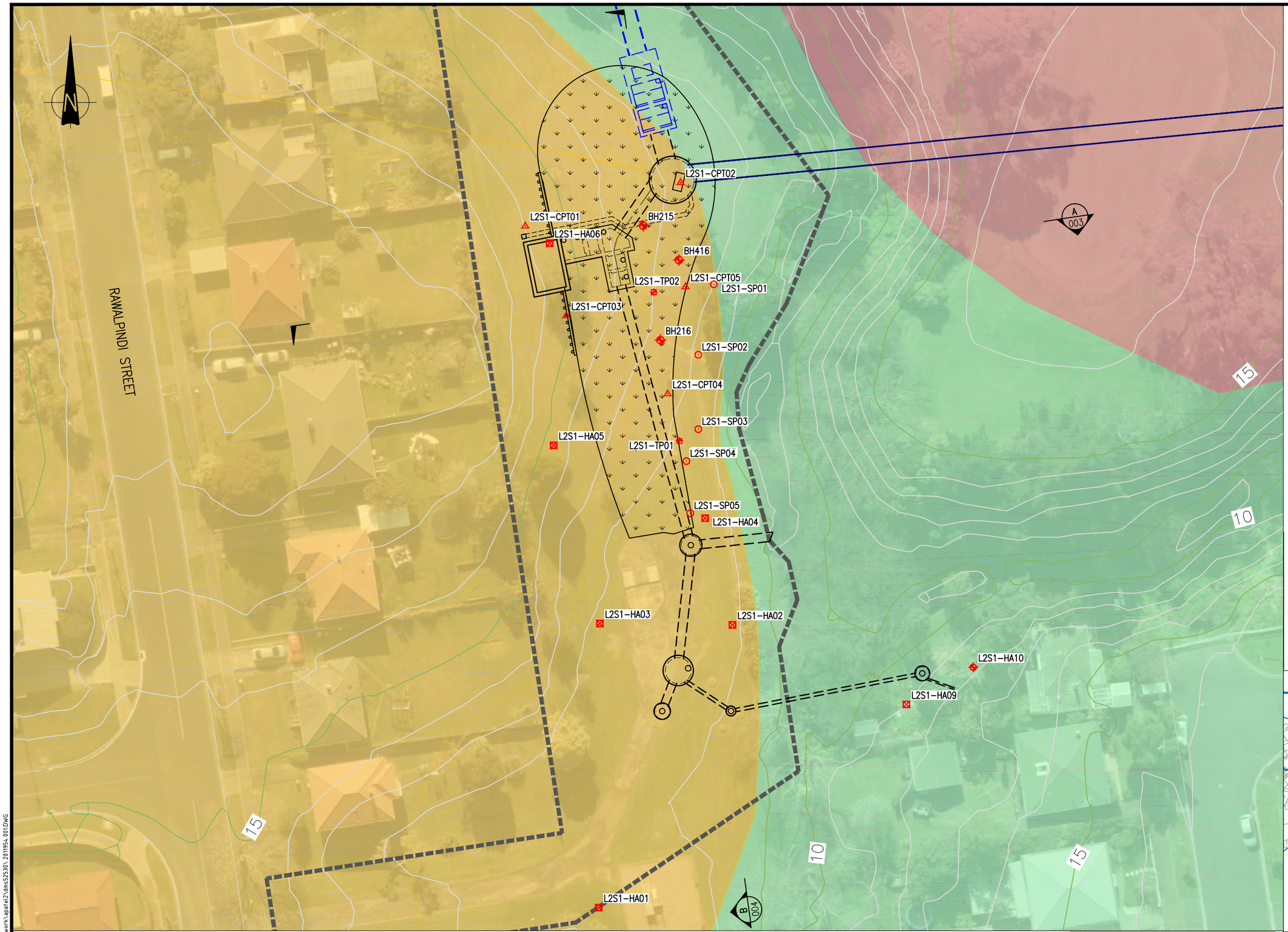

LEGEND

- BH260 — Machine Boreholes
- AS7-TP01 — Trial Pits
- AS7-CPT01 — Cone Penetration Tests And Seismic Dilatometer
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- AS7-SP01 — Dynamic Cone Penetrometers
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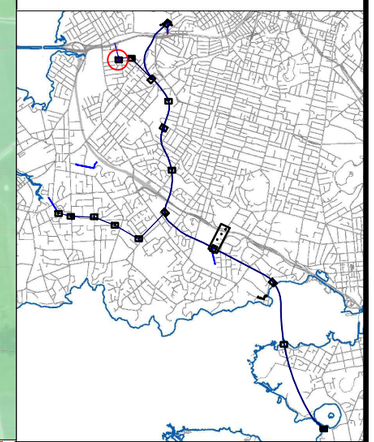

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Plot Date: Jun 10, 2016 - 8:48am

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DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
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OPERATIONS

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DSLSB002 - RAWALPINDI RESERVE
SITE GENERAL
SHAFT GEOLOGY - PLAN

CAD FILE 2011954.001	DATE 07.06.16
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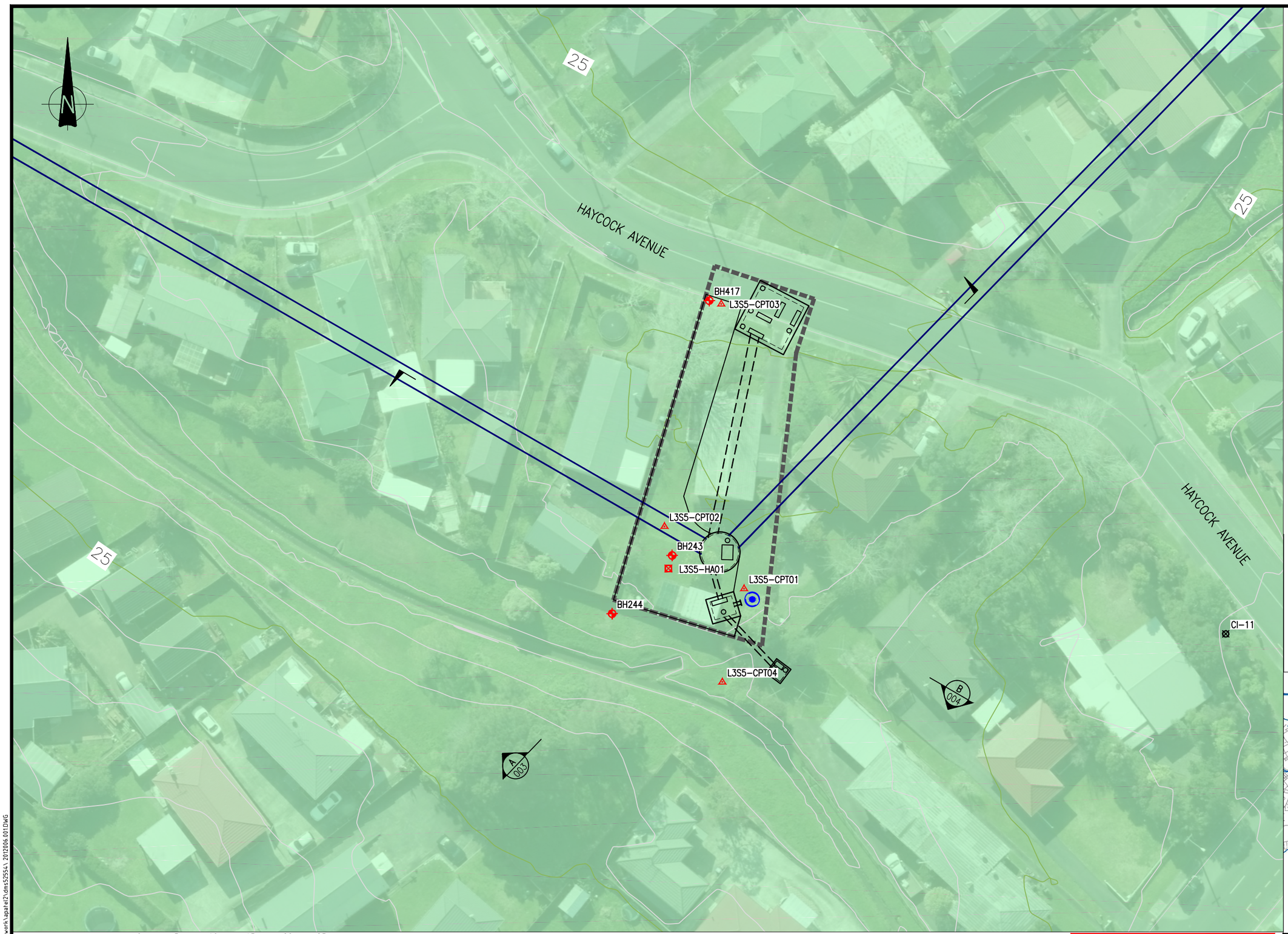

LEGEND

- BH260 — Machine Boreholes
- AS7-TP01 — Trial Pits
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- Made Ground
- Recent Alluvium

TAURANGA GROUP
- Tauranga Group
- Kaawa Formation

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
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WAITEMATA GROUP (MIOCENE)
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- Contours (1m Intervals)
- A — CH. 0 — SECTION LINE

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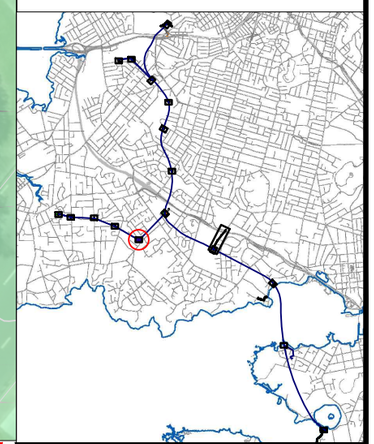

SCALE 1:250 (A1) 0 5 10 15 20 25m

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ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

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DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
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OPERATIONS

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DSLSC001 - HAYCOCK AVENUE
SITE GENERAL
SHAFT GEOLOGY - PLAN

CAD FILE 2012006.001	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
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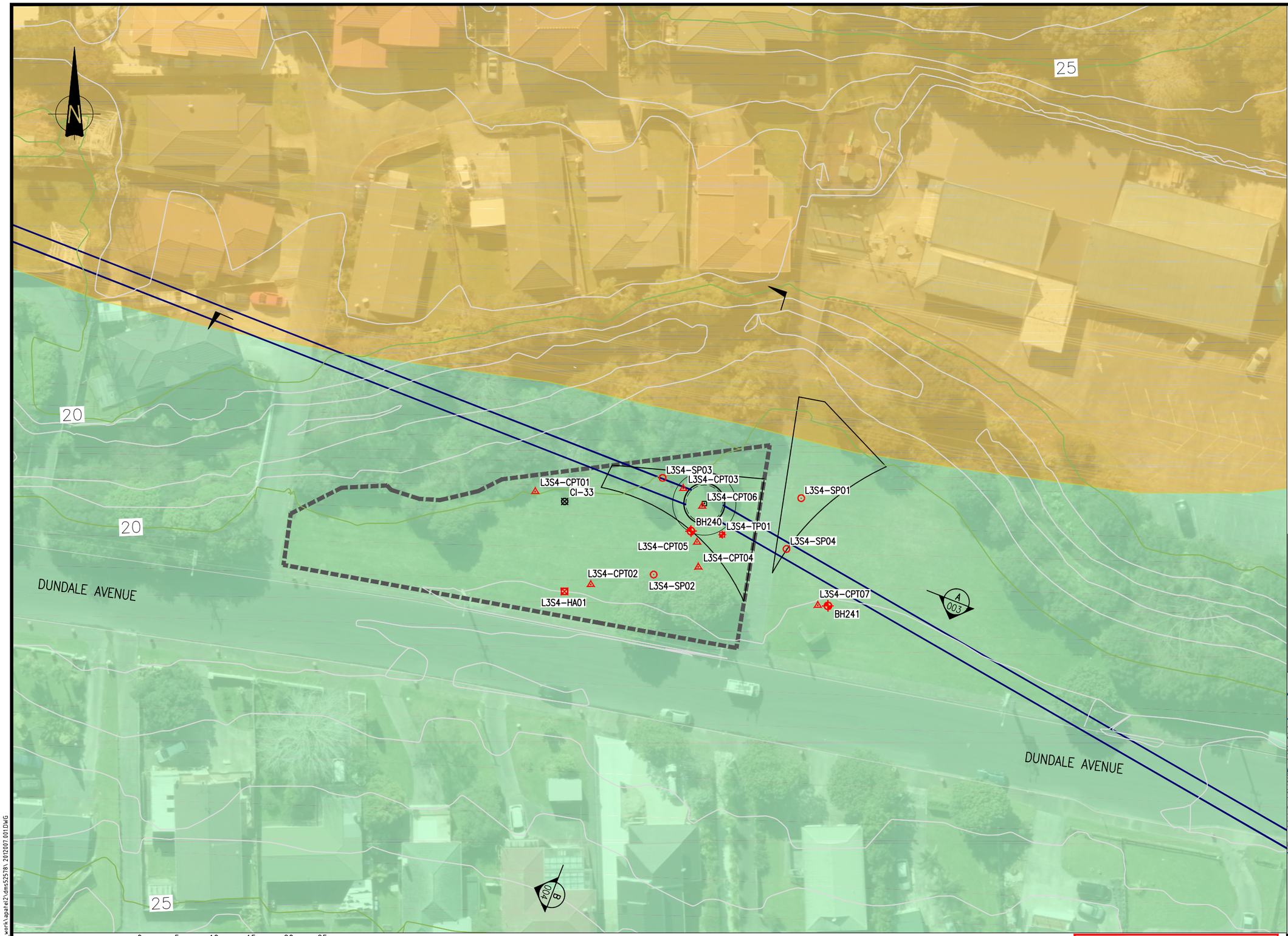

LEGEND

- BH260 — Machine Boreholes
- AS7-TP01 — Trial Pits
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- AS7-SP01 — Dynamic Cone Penetrometers
- CI-21 — Investigation Locations By Others
- Made Ground
- Recent Alluvium

TAURANGA GROUP
- Tauranga Group
- Kaawa Formation

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt
- Tuff / Ash / Scoria

WAITEMATA GROUP (MIOCENE)
- Residually to Highly Weathered - Cohesive Soils

- Main Tunnel Centreline And Edges
- Link Sewer Tunnel Edges
- Site Boundary
- Contours (1m Intervals)
- A — CH. 0 — SECTION LINE

NOTES
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3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
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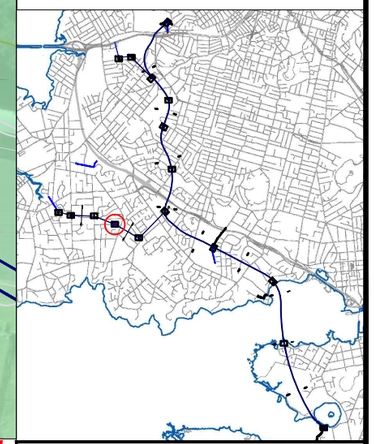
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. GEOLOGICAL BOUNDARIES FROM QMAP, AMENDED TO MATCH GROUND INVESTIGATION FINDINGS.



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Plot Date: Jun 10, 2016 - 9:14am

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DRAWN	KL	04.15	OPERATIONS
DWG. CHECKED	ADC	05.16	
PROJECT LEADER	DK	05.16	
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DSLSC002 - DUNDALE AVENUE
SITE GENERAL
SHAFT GEOLOGY - PLAN

CAD FILE 2012007.001	DATE 07.06.16
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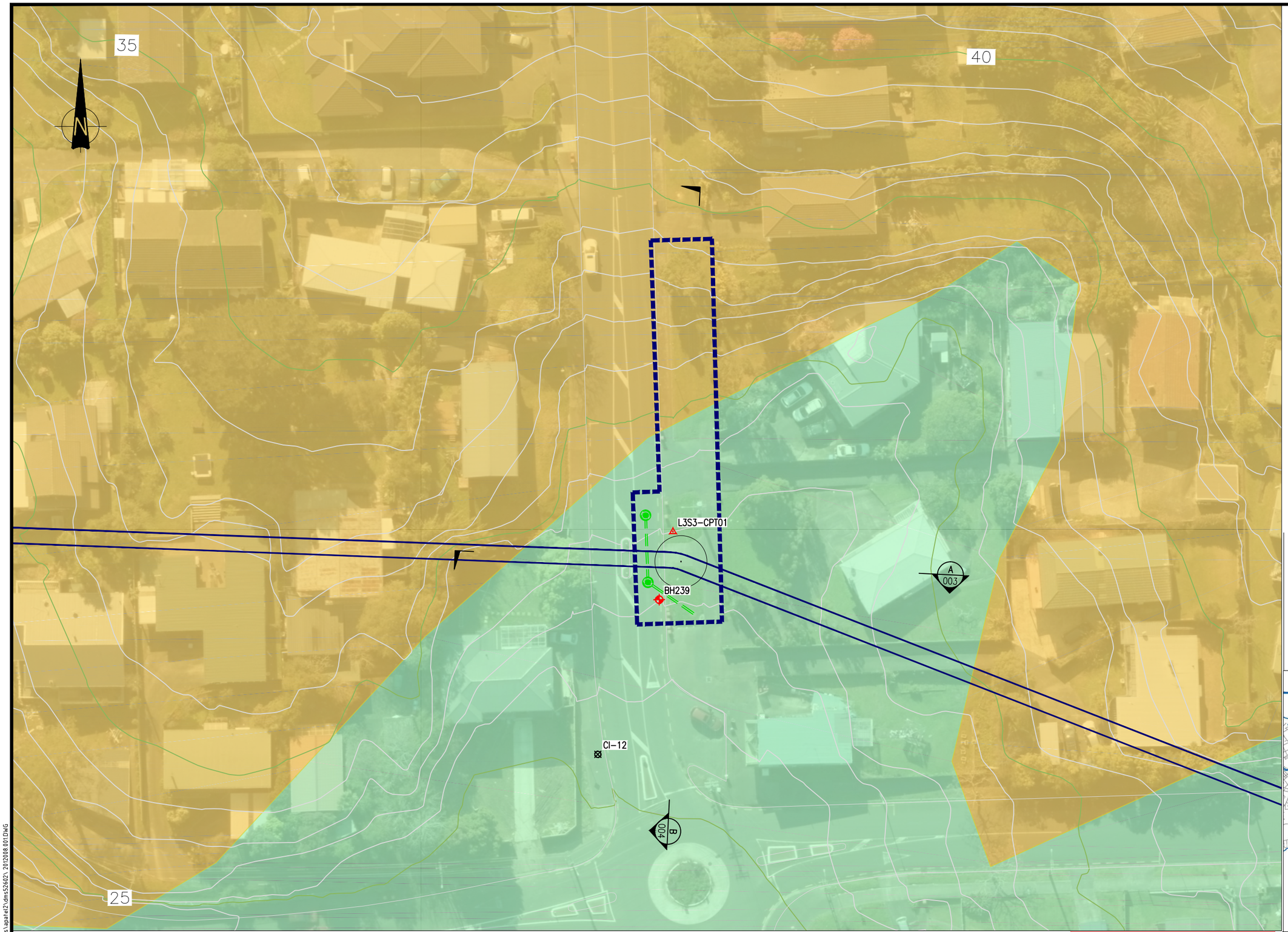

SCALE 1:250 (A1) 0 5 10 15 20 25m

ISSUED FOR USE

LEGEND

- BH260 — Machine Boreholes
- AS7-TP01 — Trial Pits
- AS7-CPT01 — Cone Penetration Tests And Seismic Dilatometer
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- AS7-SP01 — Dynamic Cone Penetrometers
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- Made Ground
- Recent Alluvium

TAURANGA GROUP
- Tauranga Group
- Kaawa Formation

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt
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WAITEMATA GROUP (MIOCENE)
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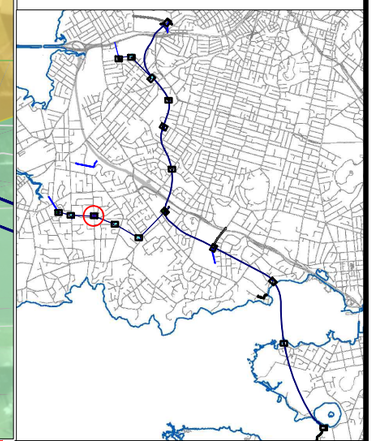

JACOBS AECOM MAUNSELL AECOM JACOBS ASSOCIATES

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Plot Date: Jun 13, 2016 - 2:52pm

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1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
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	BY	DATE

OPERATIONS

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DSLSC003 - WHITNEY STREET
SITE GENERAL
SHAFT GEOLOGY - PLAN

CAD FILE 2012008.001	DATE 07.06.16
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REF. No. CI-GEOTECH	ISSUE
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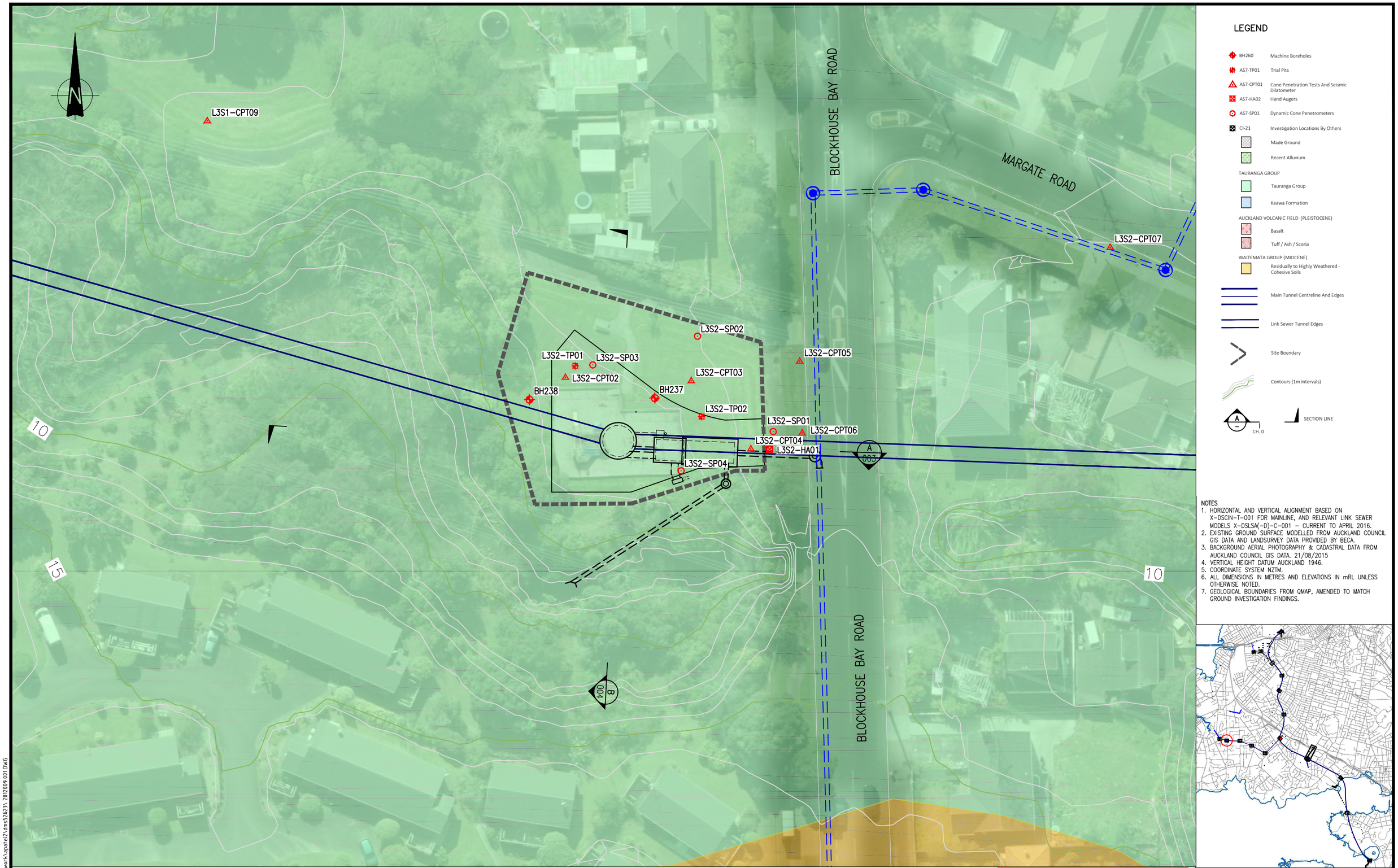

LEGEND

- BH260 — Machine Boreholes
- AS7-TP01 — Trial Pits
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Plot Date: Jun 10, 2016 - 9:38am

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1		PRELIMINARY	KL	

	BY	DATE
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DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
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OPERATIONS

INFRASTRUCTURE

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DSLSC004 - MIRANDA RESERVE
SITE GENERAL
SHAFT GEOLOGY - PLAN

CAD FILE 2012009.001	DATE 07.06.16
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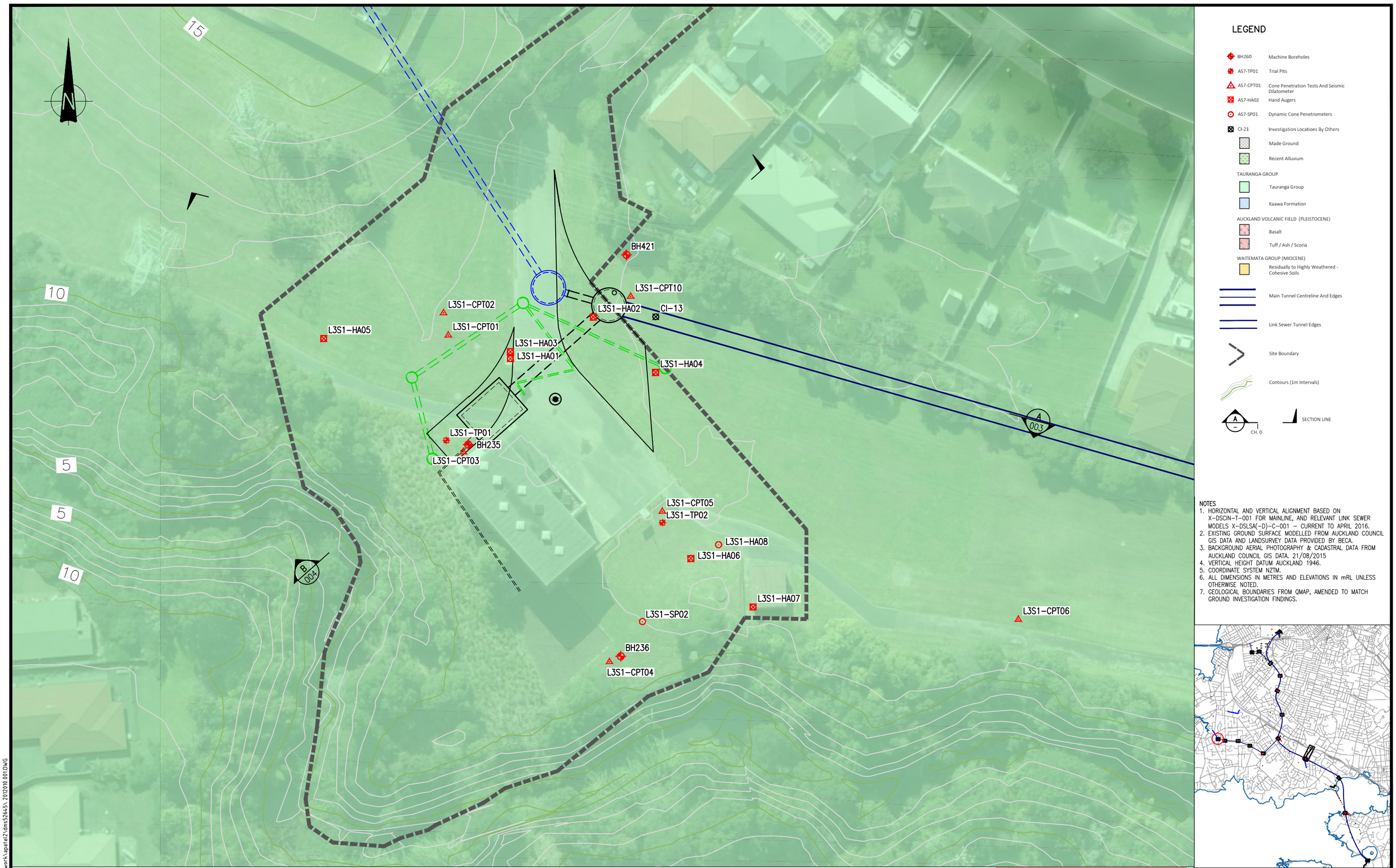

LEGEND

- BH260 — Machine Boreholes
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ISSUED FOR USE

JACOBS AECOM MAUNSELL AECOM JACOBS ASSOCIATES

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Plot Date: Jun 10, 2016 - 9:53am

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DESIGNED	RR	04.15
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PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

INFRASTRUCTURE

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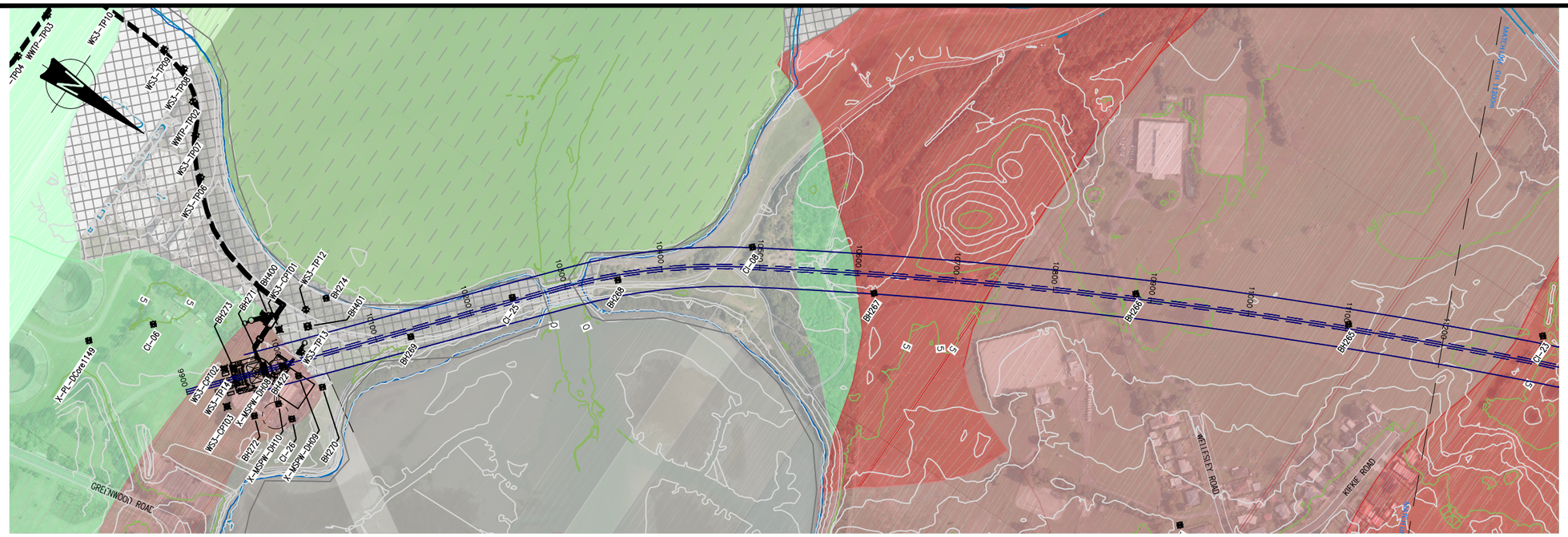
DSLSC005 – PS25
SITE GENERAL
SHAFT GEOLOGY – PLAN

CAD FILE 2012010.001	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012010.001	3

Appendix C. Drawings – tunnel and link sewer long sections



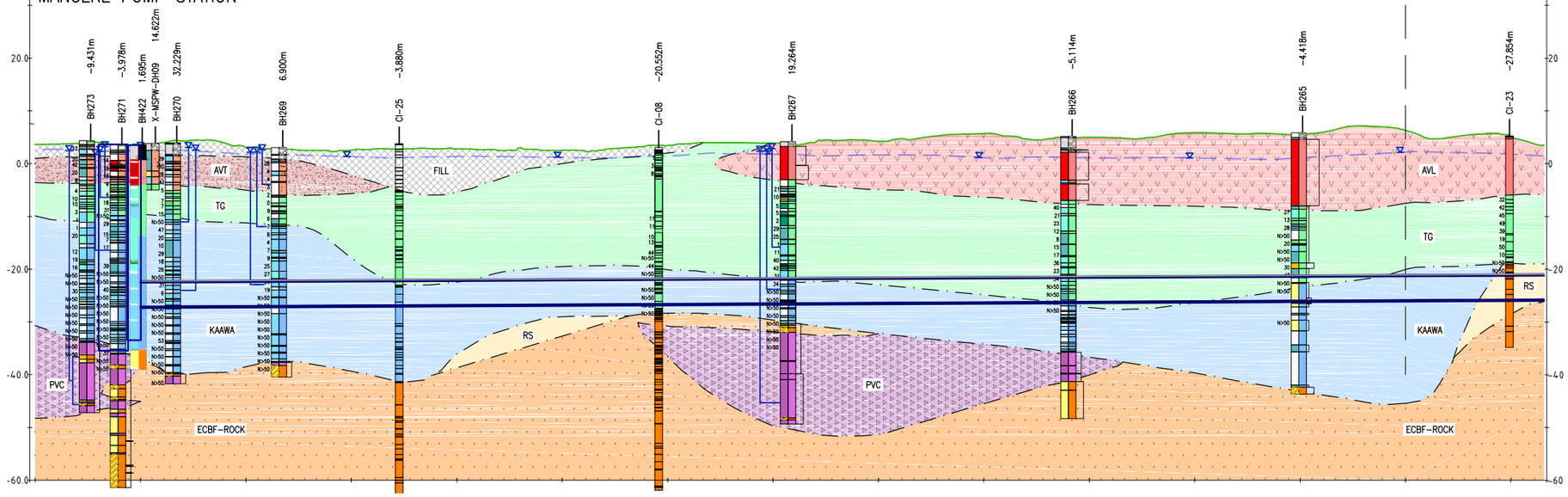
LEGEND

BH215 —6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT	PLAN AND SECTION	BH RIGHT	
No core			Made Ground (FILL)
Fill and topsoil			Recent Alluvium (Q1a)
Basalt			TAURANGA GROUP
Other volcanics			Undifferentiated Tauranga Group (TG)
Clay and clay dominated mixtures			Kaawa Formation (KAAWA)
Organic clay and organic clay dominated mixtures			AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
Peat			Basalt (AVL)
Silt and silt dominated mixtures			Tuff / Ash / Scoria (AVT)
Organic silt and organic silt dominated mixtures			WAITEMATA GROUP (MIOCENE)
Sand and sand dominated mixtures (clean)			Residually to Highly Weathered - Cohesive Soils (RS)
Sand and sand dominated mixtures (with fines)			Residually to Highly Weathered - Granular Soils (RS)
Organic sand and organic sand dominated mixtures			Parnell Volcaniclastic Conglomerate (PVC)
Sandstone			Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
Mudstone			
Interbedded mudstone and sandstone			
Conglomerate			
Coal			

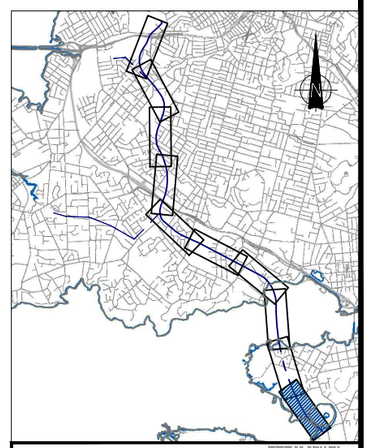
STANDPIPE PIEZOMETER RESPONSE ZONE
VW PIEZOMETER TIP DEPTH
FORMATION
CPT TIP RESISTANCE
SPT N
LITHOLOGY
FORMATION
ROCK STRENGTH
INTERPRETED PIEZOMETRIC SURFACE AT TUNNEL HORIZON
TUNNEL AND CORRIDOR

DSCIN MANGERE PUMP STATION



CHAINAGE (m)	9900	10000	10100	10200	10300	10400	10500	10600	10700	10800	10900	11000	11100	11200	11300
GROUND LEVEL (mRL)	3.64	3.66	3.09	2.55	2.78	2.54	3.47	3.89	4.25	5.71	5.00	5.88	5.57	6.31	5.18
CROWN LEVEL (mRL)		-22.25	-22.15	-22.05	-21.95	-21.85	-21.75	-21.65	-21.55	-21.45	-21.35	-21.25	-21.15	-21.05	-20.95
INVERT LEVEL (mRL)		-27.05	-26.95	-26.85	-26.75	-26.65	-26.55	-26.45	-26.35	-26.25	-26.15	-26.05	-25.95	-25.85	-25.75

NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY. FOR DETAILED GEOTECHNICAL INFORMATION REFER TO THE GEOTECHNICAL FACTUAL REPORT. (PWCIN-DEL-REP-GT-J-100047)



ISSUED FOR USE

JACOBS AECOM MAUNSELL AECOM JACOBS

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15	
DES. CHECKED	HM	05.16	
DRAWN	KL	04.15	
DWG. CHECKED	ADC	05.16	
PROJECT LEADER	DK	05.16	
INFRAST'R APP'D			

OPERATIONS

INFRASTRUCTURE

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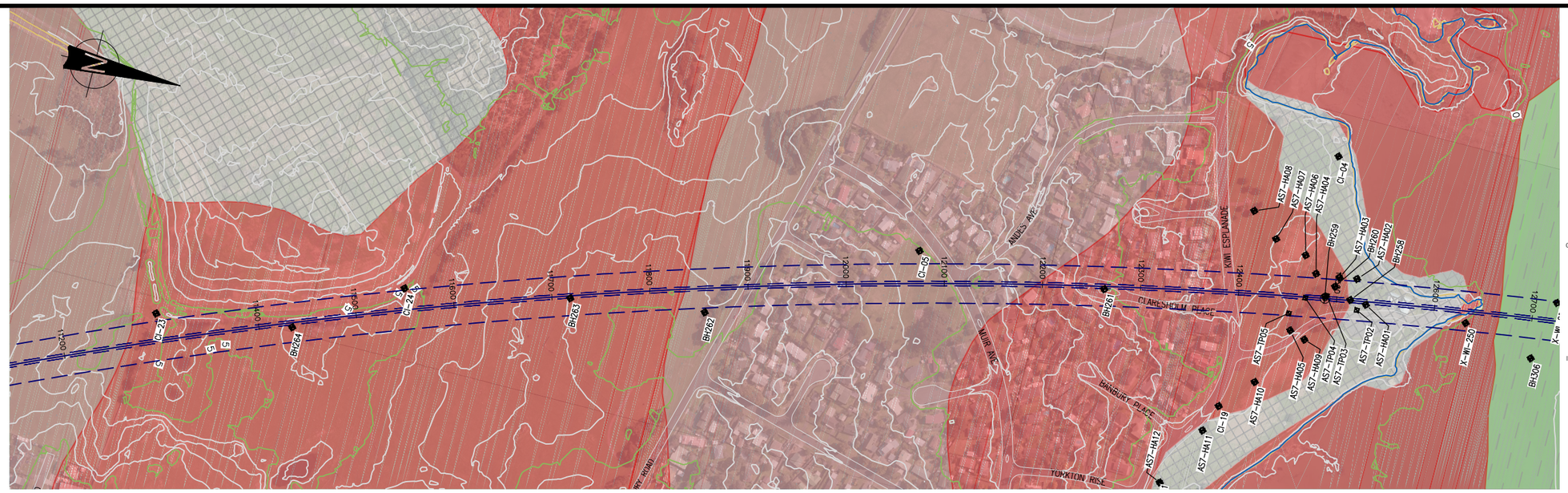
DSCIN – CENTRAL INTERCEPTOR TUNNEL
SITE GENERAL
MAIN TUNNEL LONG SECTION – SHEET 1 OF 10

CAD FILE 2012061.016	DATE 07.06.16
ORIGINAL SCALE A1 1:2500	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012061.016	3

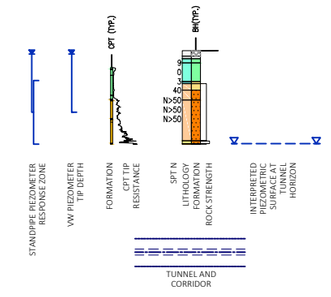
Plot Date: Jun 10, 2016 - 10:53am C:\pw_work\apatel2\dms52028\2012061016.dwg

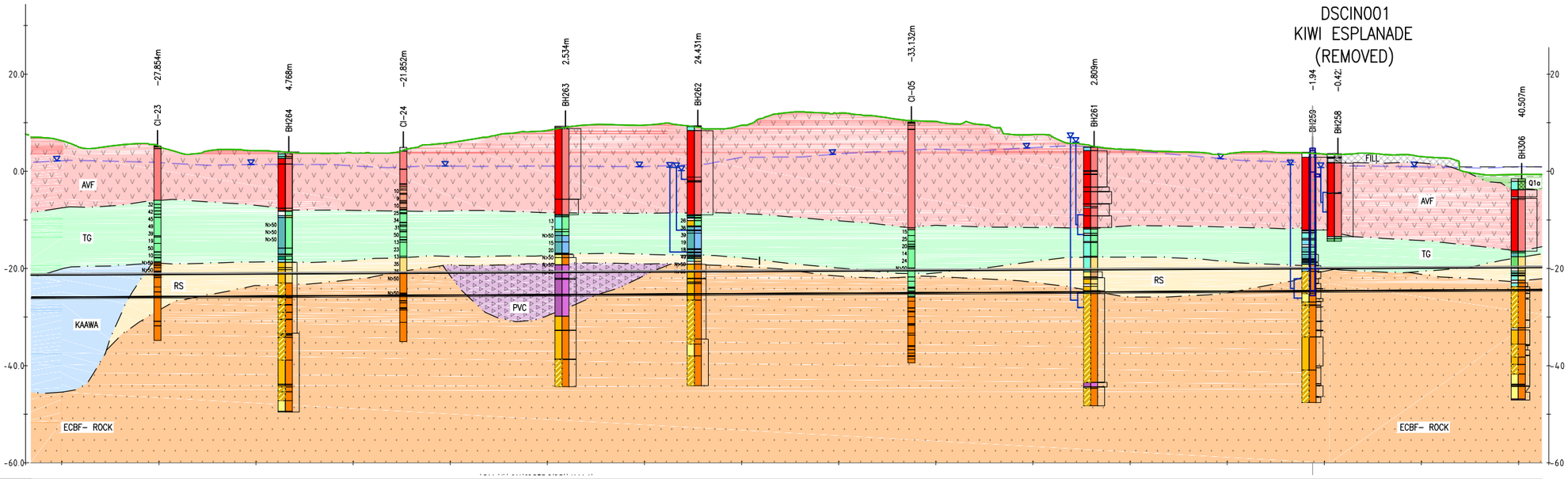


LEGEND

BH215 –6m Borehole ID and offset from section. (Negative numbers are into the page.)

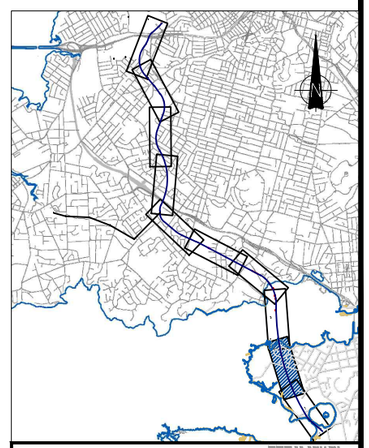
BH LEFT	PLAN AND SECTION	BH RIGHT	
No core			Made Ground (FILL)
Fill and topsoil			Recent Alluvium (Q1a)
Basalt			TAURANGA GROUP
Other volcanics			Undifferentiated Tauranga Group (TG)
Clay and clay dominated mixtures			Kaawa Formation (KAAWA)
Organic clay and organic clay dominated mixtures			AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
Peat			Basalt (AVL)
Silt and silt dominated mixtures			Tuff / Ash / Scoria (AVT)
Organic silt and organic silt dominated mixtures			WAITEMATA GROUP (MIOCENE)
Sand and sand dominated mixtures (clean)			Residually to Highly Weathered - Cohesive Soils (RS)
Sand and sand dominated mixtures (with fines)			Residually to Highly Weathered - Granular Soils (RS)
Organic sand and organic sand dominated mixtures			Sandstone
Mudstone			Parnell Volcaniclastic Conglomerate (PVC)
Interbedded mudstone and sandstone			Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
Conglomerate			
Coal			





CHAINAGE (m)	11200	11300	11400	11500	11600	11700	11800	11900	12000	12100	12200	12300	12400	12500	12600	12700
GROUND LEVEL (mRL)	6.31	5.18	4.25	3.75	5.93	8.43	9.50	9.47	11.98	10.26	7.57	4.51	3.55	3.55	3.05	-0.64
CROWN LEVEL (mRL)	-21.05	-20.95	-20.85	-20.75	-20.65	-20.55	-20.45	-20.35	-20.25	-20.15	-20.05	-19.95	-19.85	-19.75	-19.65	-19.55
INVERT LEVEL (mRL)	-25.85	-25.75	-25.65	-25.55	-25.45	-25.35	-25.25	-25.15	-25.05	-24.95	-24.85	-24.75	-24.65	-24.55	-24.45	-24.35

NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY. FOR DETAILED GEOTECHNICAL INFORMATION REFER TO THE GEOTECHNICAL FACTUAL REPORT. (PWCIN-DEL-REP-GT-J-100047)



ISSUED FOR USE

JACOBS AECOM JACOBS

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
BY		DATE

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INFRASTRUCTURE

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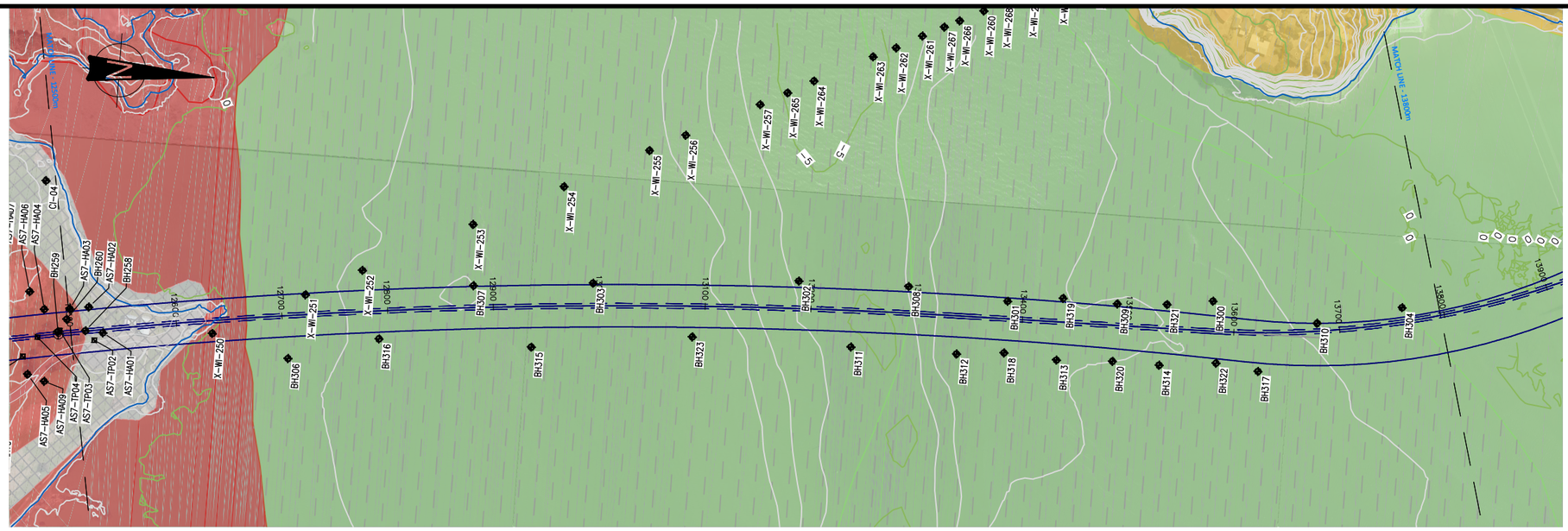
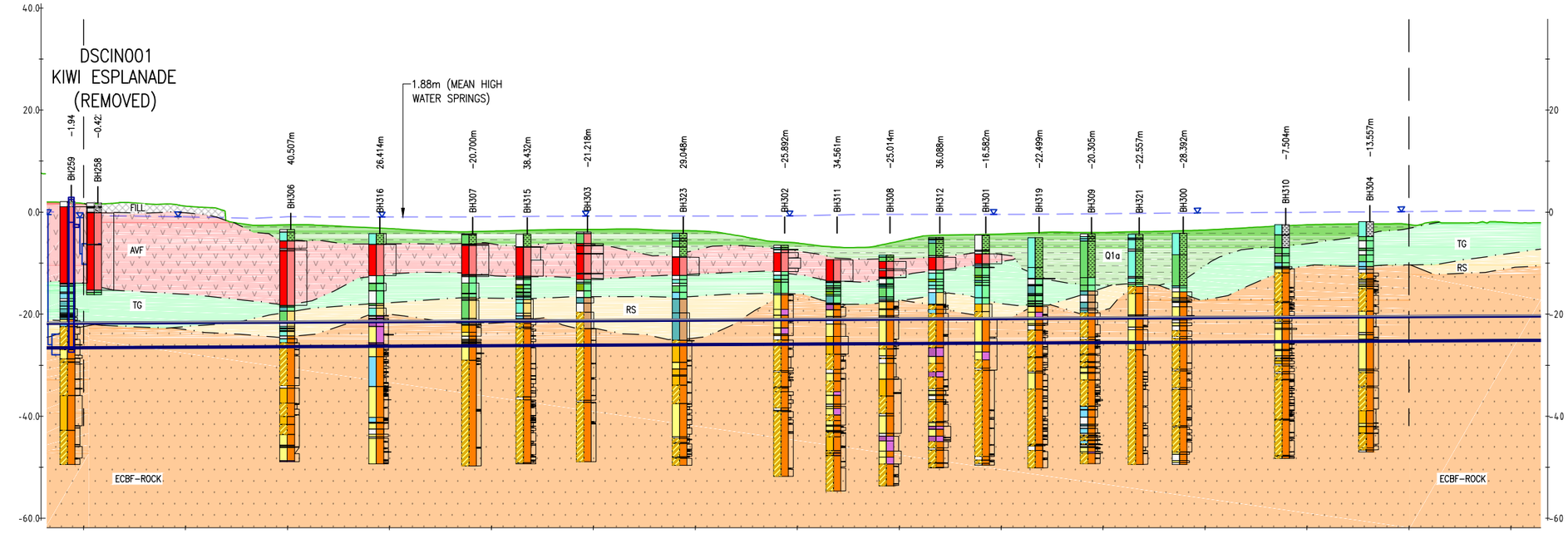
DSCIN – CENTRAL INTERCEPTOR TUNNEL
SITE GENERAL
MAIN TUNNEL LONG SECTION – SHEET 2 OF 10

CAD FILE 2012061.017	DATE 07.06.16
ORIGINAL SCALE A1 1:2500	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012061.017	3

Plot Date: Jun 09, 2016 - 12:03pm C:\pw_work\apatel2\dms520281_2012061017.dwg



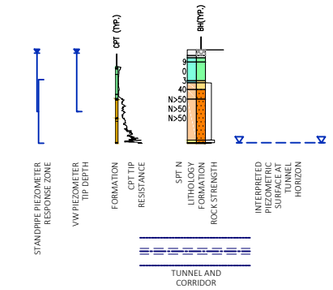


CHAINAGE (m)	12500	12600	12700	12800	12900	13000	13100	13200	13300	13400	13500	13600	13700	13800	13900
GROUND LEVEL (mRL)	3.55	3.05	-0.64	-1.37	-1.87	-1.52	-1.80	-4.18	-3.83	-2.44	-2.12	-1.65	-0.63	-0.58	-0.18
CROWN LEVEL (mRL)	-19.75	-19.65	-19.55	-19.45	-19.35	-19.25	-19.15	-19.05	-18.95	-18.85	-18.75	-18.65	-18.55	-18.45	-18.35
INVERT LEVEL (mRL)	-24.55	-24.45	-24.35	-24.25	-24.15	-24.05	-23.95	-23.85	-23.75	-23.65	-23.55	-23.45	-23.35	-23.25	-23.15

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

	BH LEFT	PLAN AND SECTION	BH RIGHT	
No core				Made Ground (FILL)
Fill and topsoil				Recent Alluvium (Q1a)
Basalt				TAURANGA GROUP
Other volcanics				Undifferentiated Tauranga Group (TG)
Clay and clay dominated mixtures				Kaawa Formation (KAAWA)
Organic clay and organic clay dominated mixtures				AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
Peat				Basalt (AVL)
Silt and silt dominated mixtures				Tuff / Ash / Scoria (AVT)
Organic silt and organic silt dominated mixtures				WAITEMATA GROUP (MIOCENE)
Sand and sand dominated mixtures (clean)				Residually to Highly Weathered - Cohesive Soils (RS)
Sand and sand dominated mixtures (with fines)				Residually to Highly Weathered - Granular Soils (RS)
Organic sand and organic sand dominated mixtures				Parnell Volcaniclastic Conglomerate (PVC)
Sandstone				Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
Mudstone				
Interbedded mudstone and sandstone				
Conglomerate				
Coal				



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
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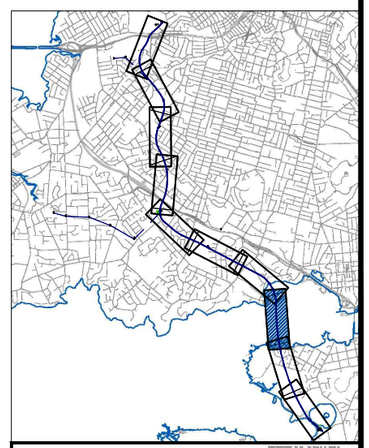

ISSUED FOR USE

Plot Date: Jun 09, 2016 - 12:10pm

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
BY		DATE

OPERATIONS

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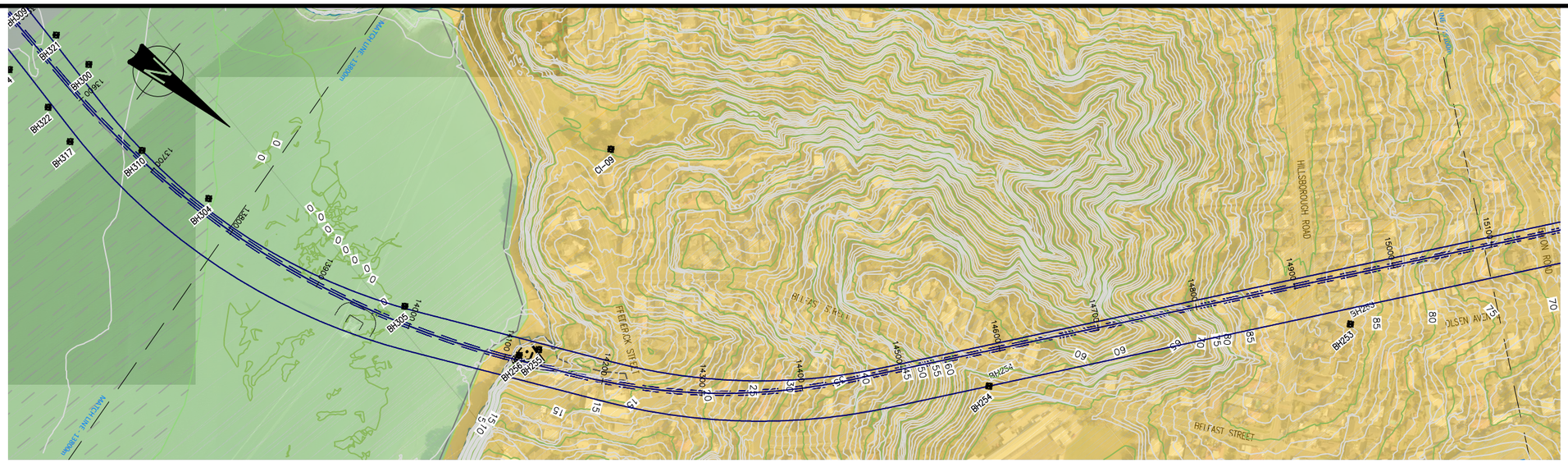
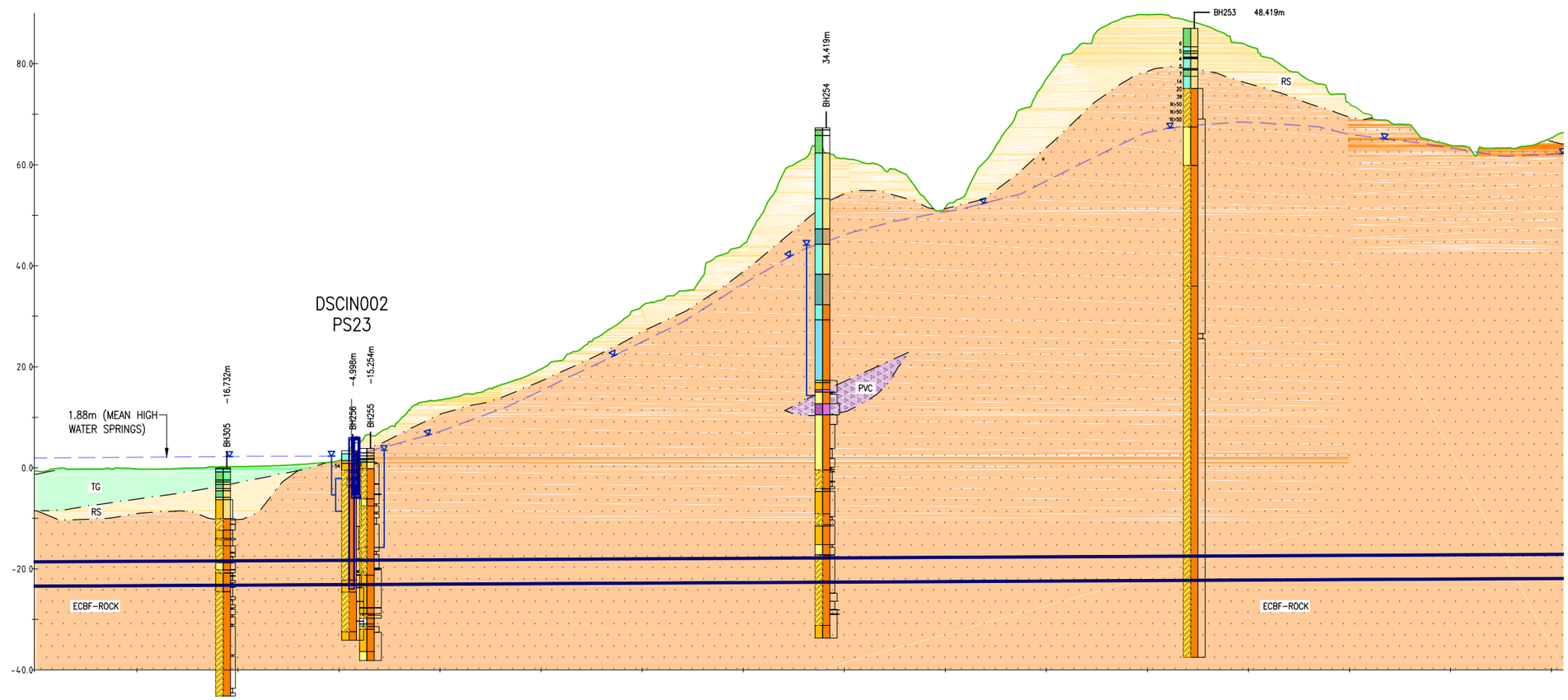
DSCIN – CENTRAL INTERCEPTOR TUNNEL
SITE GENERAL
MAIN TUNNEL LONG SECTION – SHEET 3 OF 10

CAD FILE 2012061.018	DATE 07.06.16
ORIGINAL SCALE A1 1:2500	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012061.018	3





CHAINAGE (m)	13800	13900	14000	14100	14200	14300	14400	14500	14600	14700	14800	14900	15000	15100	15200	15300
GROUND LEVEL (mRL)	-0.58	-0.18	0.25	1.37	13.41	19.46	31.83	44.10	61.25	51.20	76.63	89.72	83.62	72.33	63.93	65.23
CROWN LEVEL (mRL)	-18.45	-18.35	-18.25	-18.15	-18.05	-17.95	-17.85	-17.75	-17.65	-17.55	-17.45	-17.35	-17.25	-17.15	-17.05	-16.95
INVERT LEVEL (mRL)	-23.25	-23.15	-23.05	-22.95	-22.85	-22.75	-22.65	-22.55	-22.45	-22.35	-22.25	-22.15	-22.05	-21.95	-21.85	-21.75

LEGEND

BH215 –6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT | PLAN AND SECTION | BH RIGHT

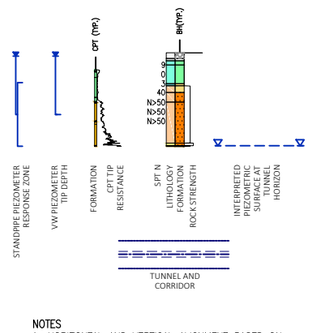
- No core
- Fill and topsoil
- Basalt
- Other volcanics
- Clay and clay dominated mixtures
- Organic clay and organic clay dominated mixtures
- Peat
- Silt and silt dominated mixtures
- Organic silt and organic silt dominated mixtures
- Sand and sand dominated mixtures (clean)
- Sand and sand dominated mixtures (with fines)
- Organic sand and organic sand dominated mixtures
- Sandstone
- Mudstone
- Interbedded mudstone and sandstone
- Conglomerate
- Coal

- Made Ground (FILL)
- Recent Alluvium (Q1a)

TAURANGA GROUP
- Undifferentiated Tauranga Group (TG)
- Kaawa Formation (KAAWA)

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt (AVL)
- Tuff / Ash / Scoria (AVT)

WAITEMATA GROUP (MIOCENE)
- Residually to Highly Weathered - Cohesive Soils (RS)
- Residually to Highly Weathered - Granular Soils (RS)
- Parnell Volcaniclastic Conglomerate (PVC)
- Moderately Weathered to Unweathered ECBF (ECBF-ROCK)



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
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6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
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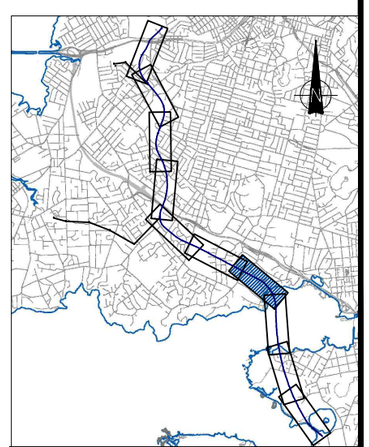

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	27.11.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		

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INFRASTRUCTURE

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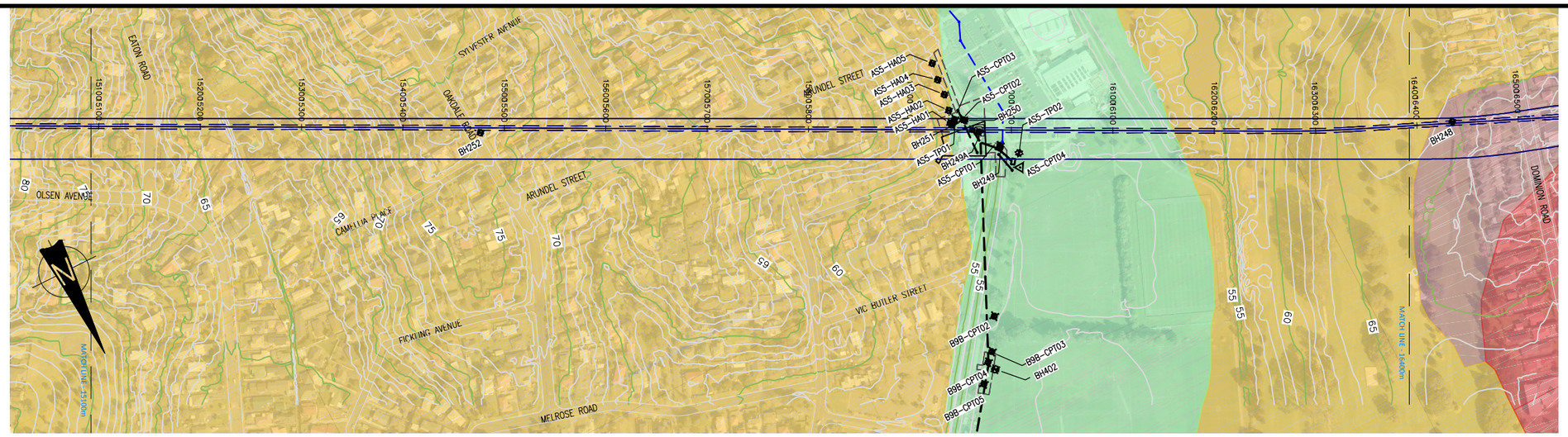
DSCIN – CENTRAL INTERCEPTOR TUNNEL
SITE GENERAL
MAIN TUNNEL LONG SECTION – SHEET 4 OF 10

CAD FILE 2012061.019	DATE 07.06.16
ORIGINAL SCALE A1 1:2500	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012061.019	3

Plot Date: Jun 09, 2016 - 12:22pm C:\pw_work\apatel2\dms520281\2012061019.dwg



LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT | PLAN AND SECTION | BH RIGHT

- No core
- Fill and topsoil
- Basalt
- Other volcanics
- Clay and clay dominated mixtures
- Organic clay and organic clay dominated mixtures
- Peat
- Silt and silt dominated mixtures
- Organic silt and organic silt dominated mixtures
- Sand and sand dominated mixtures (clean)
- Sand and sand dominated mixtures (with fines)
- Organic sand and organic sand dominated mixtures
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- Mudstone
- Interbedded mudstone and sandstone
- Conglomerate
- Coal

- Made Ground (FILL)
- Recent Alluvium (Q1a)

TAURANGA GROUP
- Undifferentiated Tauranga Group (TG)
- Kaawa Formation (KAAWA)

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt (AVL)
- Tuff / Ash / Scoria (AVT)

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- Residually to Highly Weathered - Granular Soils (RS)
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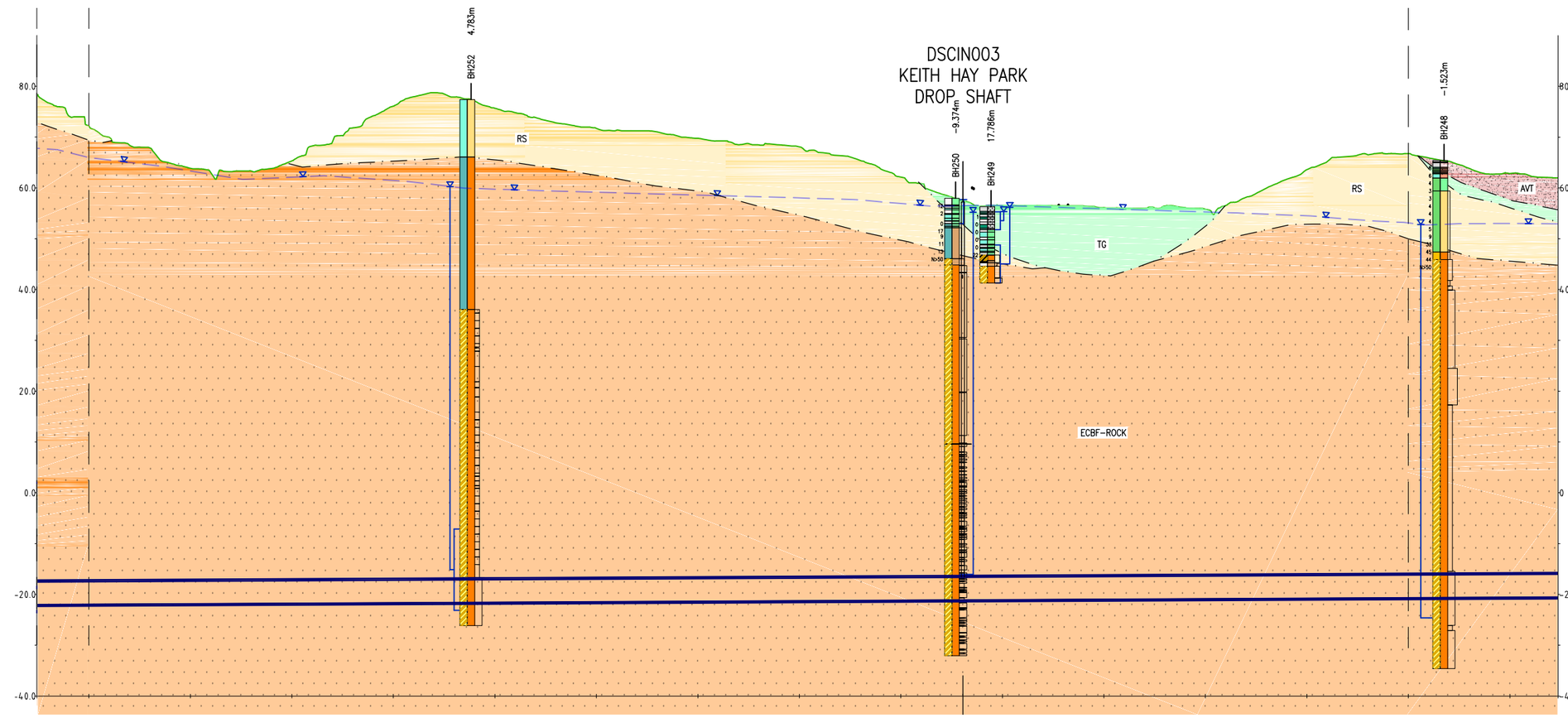
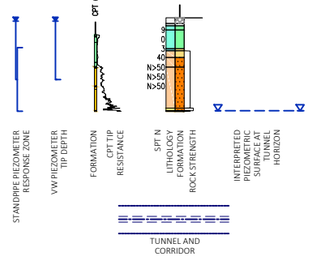
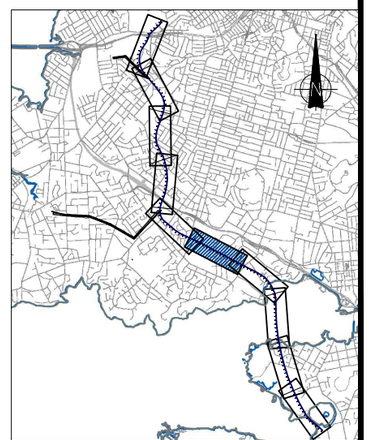
- Moderately Weathered to Unweathered ECBF (ECBF-ROCK)



CHAINAGE (m)	15100	15200	15300	15400	15500	15600	15700	15800	15900	16000	16100	16200	16300	16400	16500
GROUND LEVEL (mRL)	72.33	63.93	65.23	76.04	75.76	71.83	69.76	68.14	62.17	56.56	56.09	55.88	63.48	66.76	62.87
CROWN LEVEL (mRL)	-17.15	-17.05	-16.95	-16.85	-16.75	-16.65	-16.55	-16.45	-16.35	-16.25	-16.15	-16.05	-15.95	-15.85	-15.75
INVERT LEVEL (mRL)	-21.95	-21.85	-21.75	-21.65	-21.55	-21.45	-21.35	-21.25	-21.15	-21.05	-20.95	-20.85	-20.75	-20.65	-20.55



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY. FOR DETAILED GEOTECHNICAL INFORMATION REFER TO THE GEOTECHNICAL FACTUAL REPORT. (PWCIN-DEL-REP-GT-J-100047)



ISSUED FOR USE

JACOBS AECOM JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
4	03.02.17	REVISED ISSUE ; CIGI3	KL	ADC
3	07.06.16	ISSUED FOR USE	AP	ADC
2	27.11.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

	BY	DATE
DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		

OPERATIONS

INFRASTRUCTURE

Watercare

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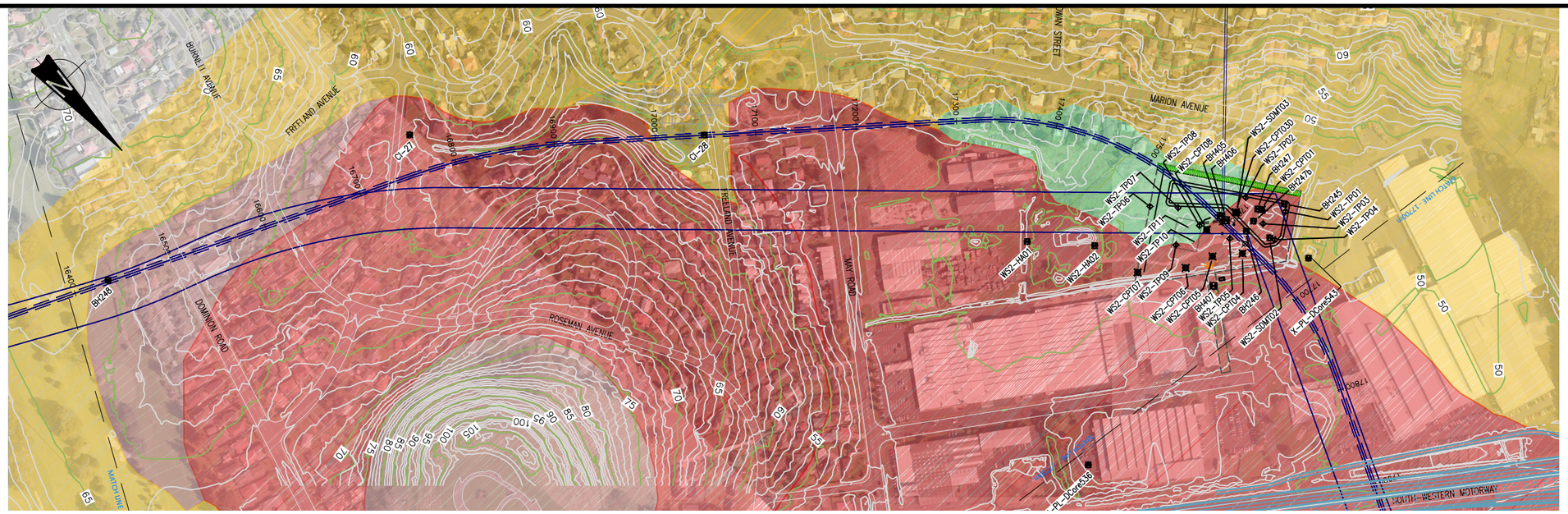
DSCIN – CENTRAL INTERCEPTOR TUNNEL
SITE GENERAL
MAIN TUNNEL LONG SECTION – SHEET 5 OF 10

CAD FILE 2012061.020	DATE 03.02.17
ORIGINAL SCALE A1 1:2500	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012061.020	4

Plot Date: Jan 26, 2017 - 12:33pm C:\pw_work\sgodfrey\dms520281\2012061020.dwg



LEGEND

BH215 –6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT | PLAN AND SECTION | BH RIGHT

- No core
- Fill and topsoil
- Basalt
- Other volcanics
- Clay and clay dominated mixtures
- Organic clay and organic clay dominated mixtures
- Peat
- Silt and silt dominated mixtures
- Organic silt and organic silt dominated mixtures
- Sand and sand dominated mixtures (clean)
- Sand and sand dominated mixtures (with fines)
- Organic sand and organic sand dominated mixtures
- Sandstone
- Mudstone
- Interbedded mudstone and sandstone
- Conglomerate
- Coal

Made Ground (FILL)
Recent Alluvium (Q1a)

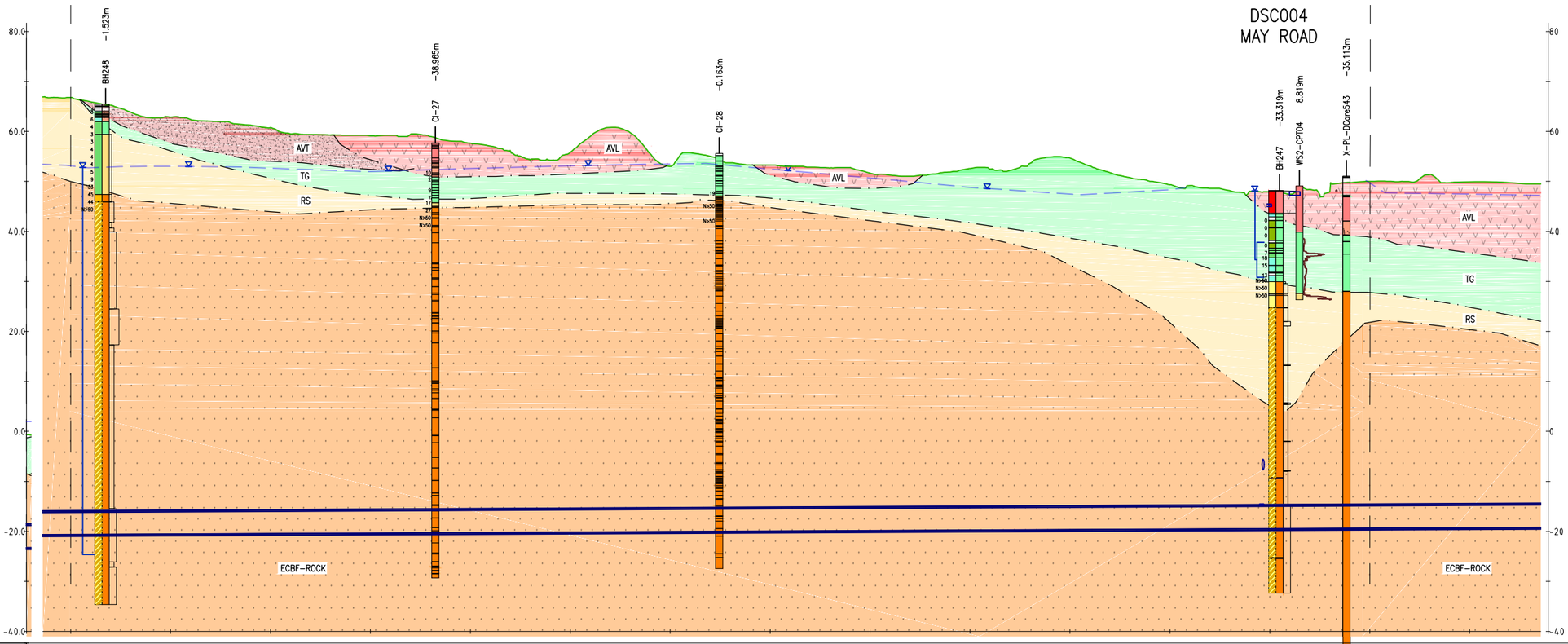
TAURANGA GROUP
- Undifferentiated Tauranga Group (TG)
- Kaawa Formation (KAAWA)

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt (AVL)
- Tuff / Ash / Scoria (AVT)

WAITEMATA GROUP (MIOCENE)
- Residually to Highly Weathered - Cohesive Soils (RS)
- Residually to Highly Weathered - Granular Soils (RS)
- Parnell Volcaniclastic Conglomerate (PVC)
- Moderately Weathered to Unweathered ECBF (ECBF-ROCK)

STANDPIPE PIEZOMETER RESPONSE ZONE
VW PIEZOMETER TIP DEPTH
FORMATION
CPT TIP RESISTANCE
CPT (TYP.)
SPT N
LITHOLOGY
FORMATION
ROCK STRENGTH
BH(TYP.)
INTERPRETED PIEZOMETRIC SURFACE AT TUNNEL HORIZON
TUNNEL AND CORRIDOR

DSC004
MAY ROAD



CHAINAGE (m)	16400	16500	16600	16700	16800	16900	17000	17100	17200	17300	17400	17500	17600	17700	17800	17900
GROUND LEVEL (mRL)	66.76	62.87	60.69	59.16	57.67	55.62	53.02	53.25	51.72	52.55	54.74	49.37	47.94	50.00	49.90	49.51
CROWN LEVEL (mRL)	-15.85	-15.75	-15.65	-15.55	-15.45	-15.35	-15.25	-15.15	-15.05	-14.95	-14.85	-14.75	-14.65	-14.55	-14.45	-14.35
INVERT LEVEL (mRL)	-20.65	-20.55	-20.45	-20.35	-20.25	-20.15	-20.05	-19.95	-19.85	-19.75	-19.65	-19.55	-19.45	-19.35	-19.25	-19.15

NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001, DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
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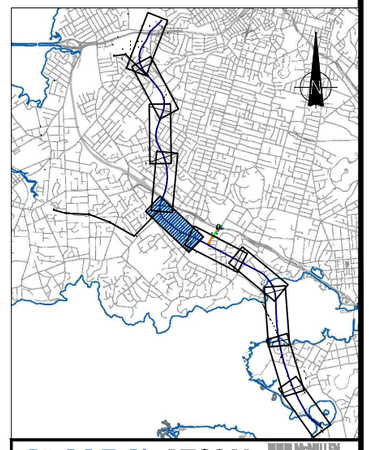

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

C:\pw_work\apatel2\dms52028\2012061021.dwg

Plot Date: Jun 09, 2016 - 1:26pm

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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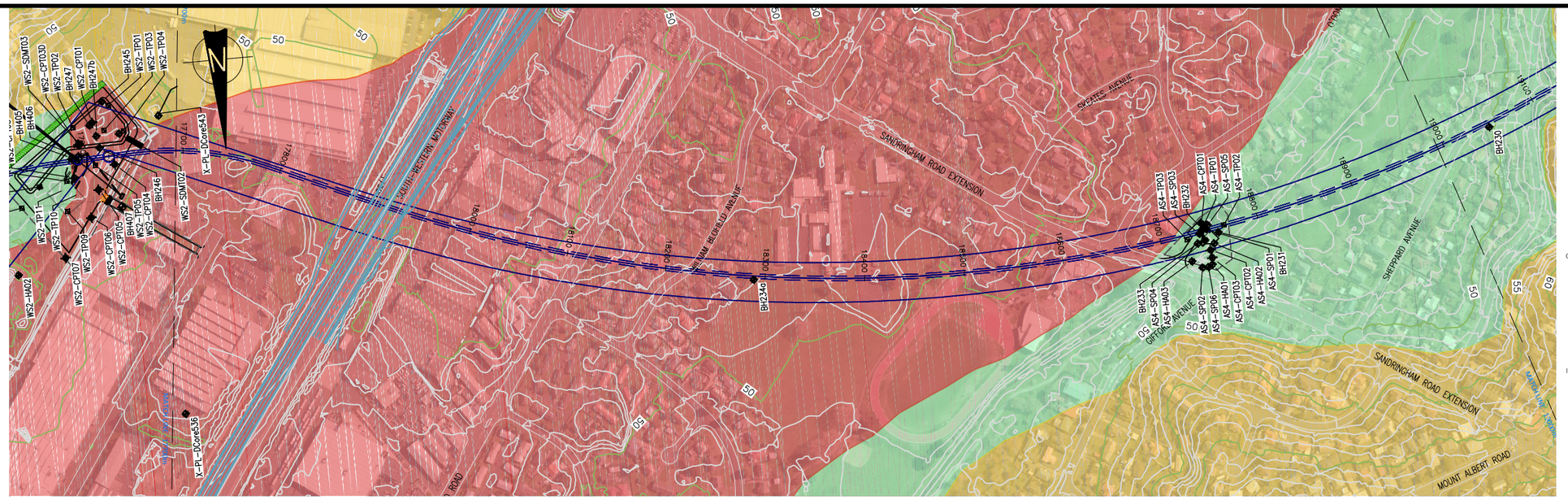
DSCIN – CENTRAL INTERCEPTOR TUNNEL
SITE GENERAL
MAIN TUNNEL LONG SECTION – SHEET 6 OF 10

CAD FILE 2012061.021	DATE 07.06.16
ORIGINAL SCALE A1 1:2500	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012061.021	3



LEGEND

BH215 –6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT | PLAN AND SECTION | BH RIGHT

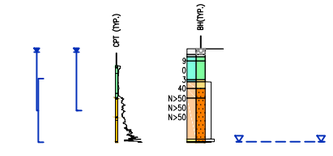
- No core
- Fill and topsoil
- Basalt
- Other volcanics
- Clay and clay dominated mixtures
- Organic clay and organic clay dominated mixtures
- Peat
- Silt and silt dominated mixtures
- Organic silt and organic silt dominated mixtures
- Sand and sand dominated mixtures (clean)
- Sand and sand dominated mixtures (with fines)
- Organic sand and organic sand dominated mixtures
- Sandstone
- Mudstone
- Interbedded mudstone and sandstone
- Conglomerate
- Coal

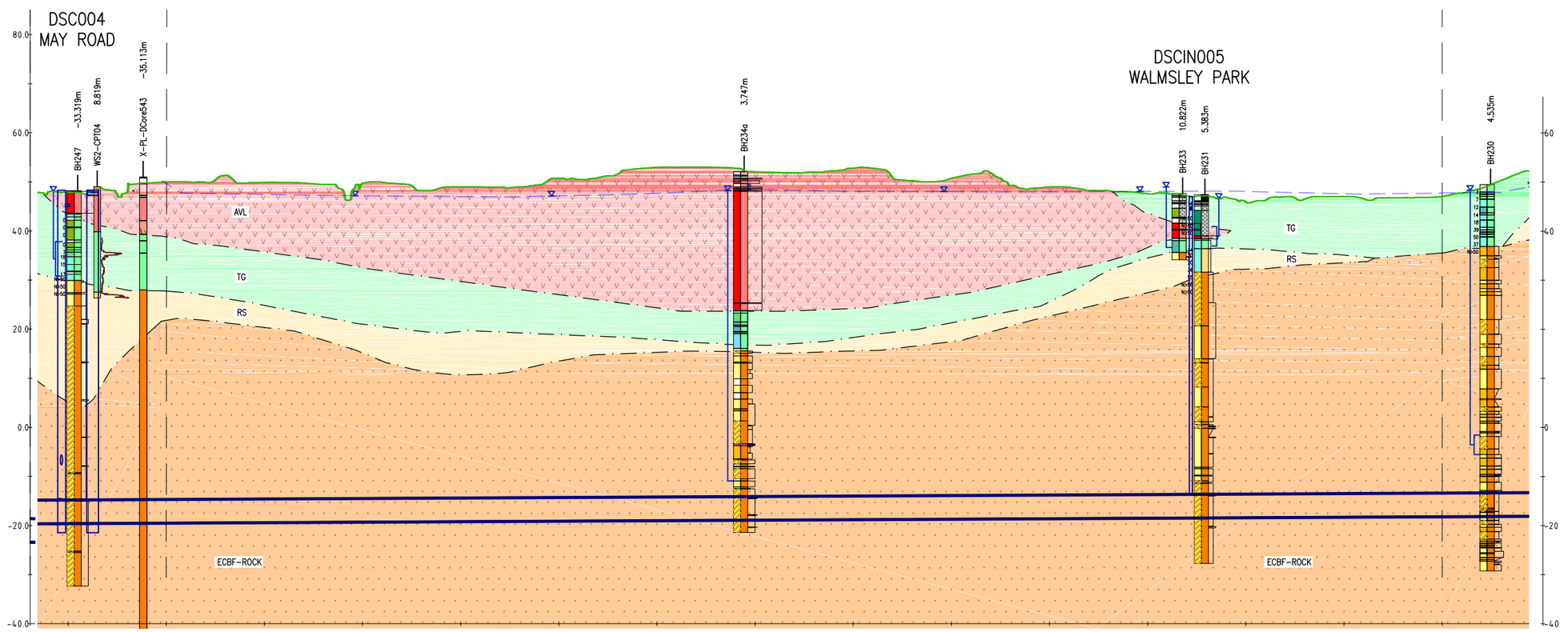
- Made Ground (FILL)
- Recent Alluvium (Q1a)

TAURANGA GROUP
- Undifferentiated Tauranga Group (TG)
- Kaawa Formation (KAAWA)

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt (AVL)
- Tuff / Ash / Scoria (AVT)

WAITEMATA GROUP (MIOCENE)
- Residually to Highly Weathered - Cohesive Soils (RS)
- Residually to Highly Weathered - Granular Soils (RS)
- Parnell Volcaniclastic Conglomerate (PVC)
- Moderately Weathered to Unweathered ECBF (ECBF-ROCK)





CHAINAGE (m)	17600	17700	17800	17900	18000	18100	18200	18300	18400	18500	18600	18700	18800	18900	19000	19100
GROUND LEVEL (mRL)	47.94	50.00	49.90	49.51	49.00	50.75	52.97	52.07	52.77	50.71	49.00	47.61	46.03	47.00	47.00	52.13
CROWN LEVEL (mRL)	-14.65	-14.55	-14.45	-14.35	-14.25	-14.15	-14.05	-13.95	-13.85	-13.75	-13.65	-13.55	-13.45	-13.35	-13.25	-13.15
INVERT LEVEL (mRL)	-19.45	-19.35	-19.25	-19.15	-19.05	-18.95	-18.85	-18.75	-18.65	-18.55	-18.45	-18.35	-18.25	-18.15	-18.05	-17.95

NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-0)-C-001. DESIGNS CURRENT TO MAY 2016.
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4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
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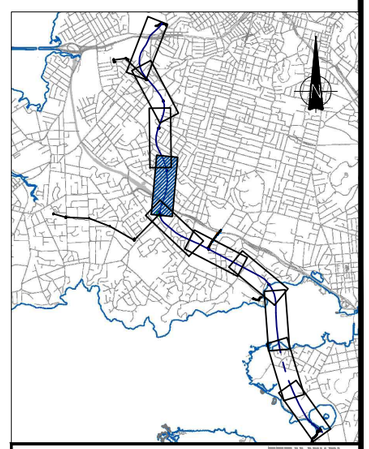

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15	OPERATIONS
DES. CHECKED	HM	05.16	
DRAWN	KL	04.15	
DWG. CHECKED	ADC	05.16	
PROJECT LEADER	DK	05.16	INFRASTRUCTURE
INFRAST'R APP'D			

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DSCIN – CENTRAL INTERCEPTOR TUNNEL
SITE GENERAL
MAIN TUNNEL LONG SECTION – SHEET 7 OF 10

CAD FILE 2012061.022 | DATE 07.06.16
ORIGINAL SCALE A1 1:2500 | CONTRACT No. 5747
REF. No. CI-GEOTECH | ISSUE
DWG. No. 2012061.022 | 3

Plot Date: Jun 09, 2016 - 1:31pm
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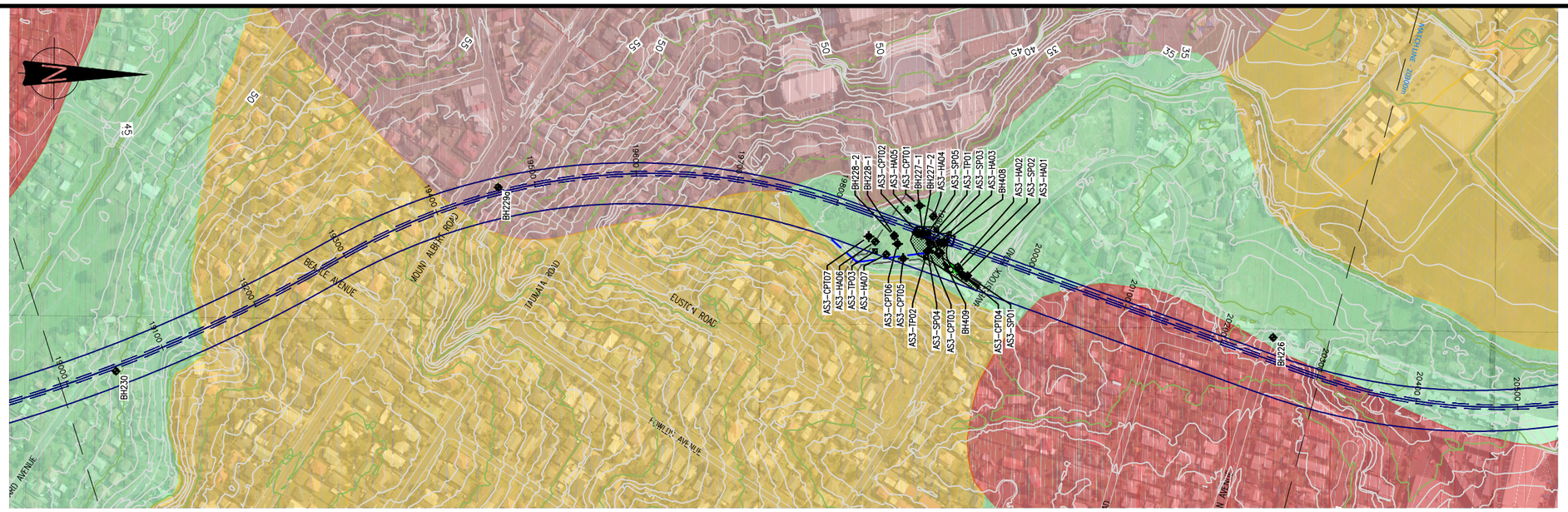

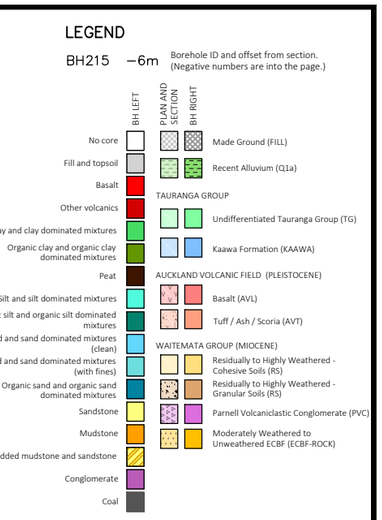

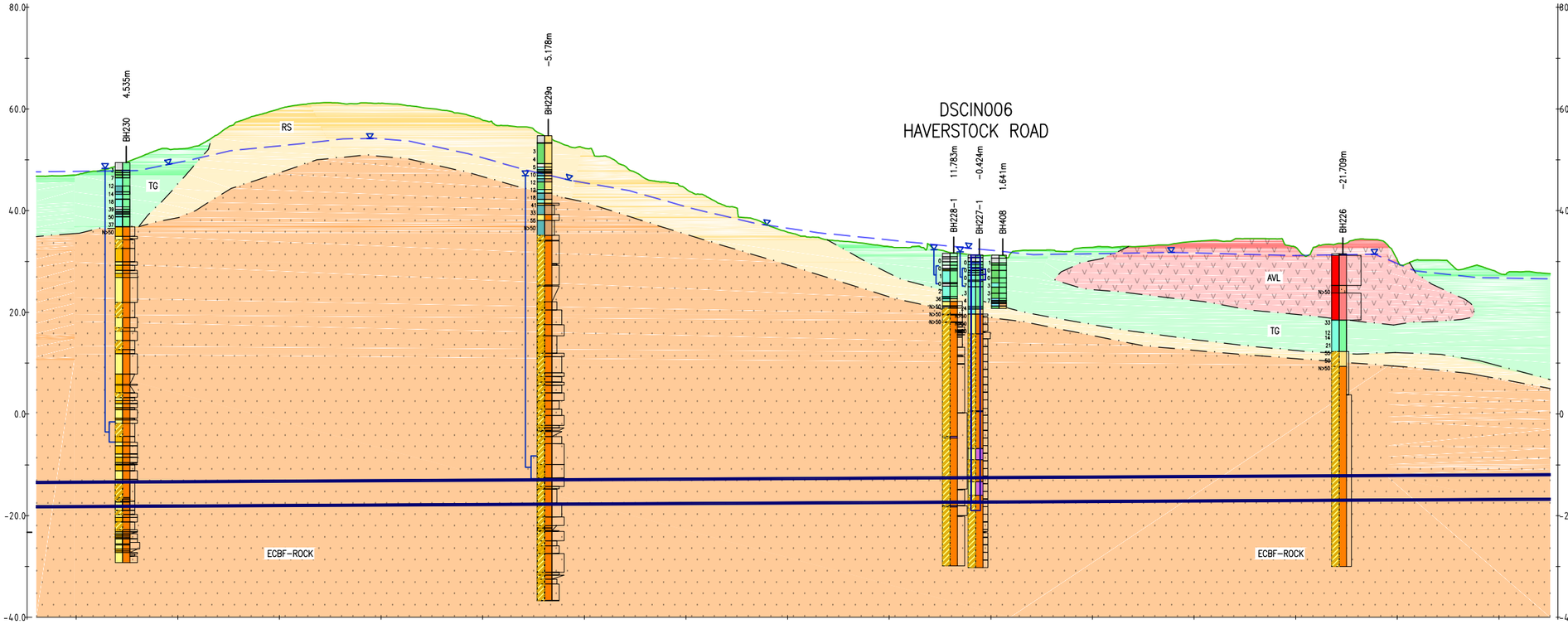

CHAINAGE (m)	19000	19100	19200	19300	19400	19500	19600	19700	19800	19900	20000	20100	20200	20300	20400
GROUND LEVEL (mRL)	47.00	52.13	59.96	61.12	57.92	52.38	44.49	35.84	32.96	31.22	32.79	33.93	32.88	30.79	27.83
CROWN LEVEL (mRL)	-13.25	-13.15	-13.05	-12.95	-12.85	-12.75	-12.65	-12.55	-12.45	-12.35	-12.25	-12.15	-12.05	-11.95	-11.85
INVERT LEVEL (mRL)	-18.05	-17.95	-17.85	-17.75	-17.65	-17.55	-17.45	-17.35	-17.25	-17.15	-17.05	-16.95	-16.85	-16.75	-16.65

NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X–DSCIN–T–001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X–DSLSA(–D)–C–001. DESIGNS CURRENT TO MAY 2016.
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4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
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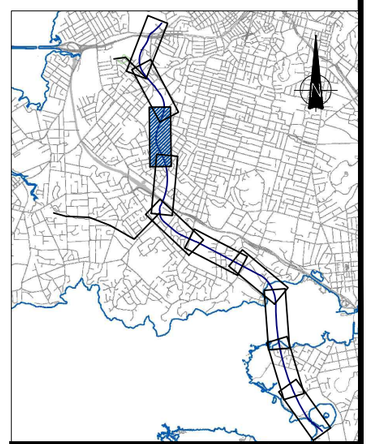
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY. FOR DETAILED GEOTECHNICAL INFORMATION REFER TO THE GEOTECHNICAL FACTUAL REPORT. (PWCIN–DEL–REP–GT–J–100047)



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ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15	
DES. CHECKED	HM	05.16	
DRAWN	KL	04.15	
DWG. CHECKED	ADC	05.16	
PROJECT LEADER	DK	05.16	
INFRAST'R APP'D			
	BY	DATE	

OPERATIONS

INFRASTRUCTURE

Watercare

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DSCIN – CENTRAL INTERCEPTOR TUNNEL
SITE GENERAL
MAIN TUNNEL LONG SECTION – SHEET 8 OF 10

CAD FILE 2012061.023	DATE 07.06.16
ORIGINAL SCALE A1 1:2500	CONTRACT No. 5747
REF. No. CI–GEOTECH	ISSUE
DWG. No. 2012061.023	3

Plot Date: Jun 09, 2016 - 1:37pm
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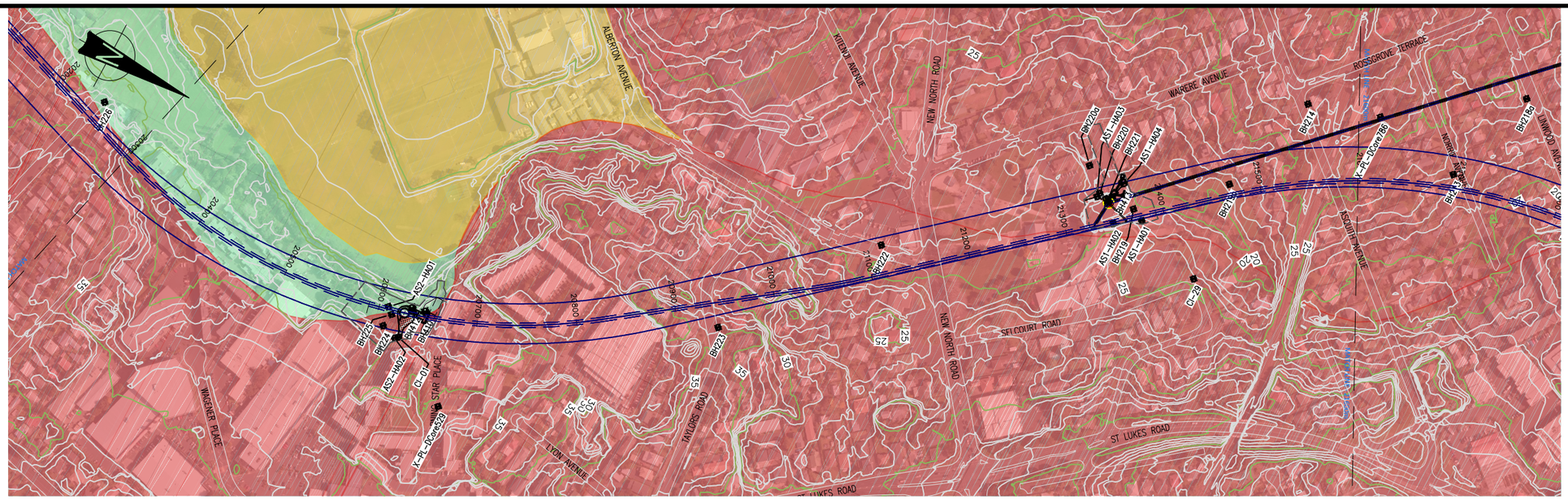
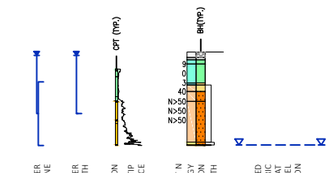


LEGEND

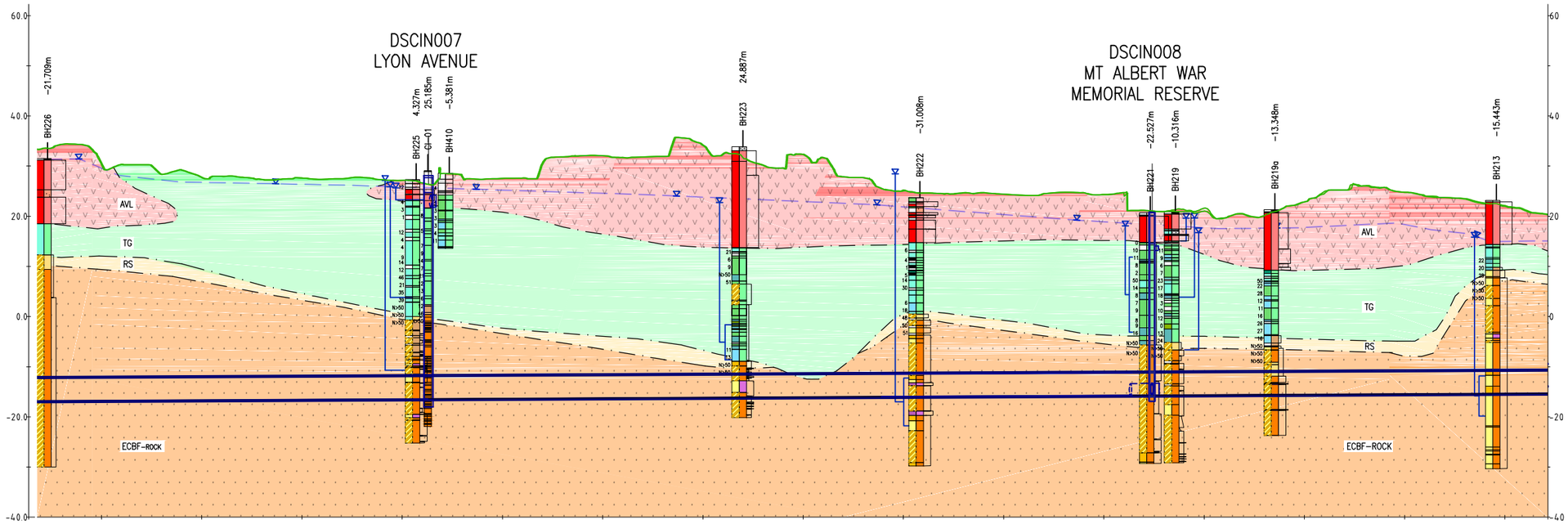
BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

	BH LEFT	PLAN AND SECTION	BH RIGHT
No core			Made Ground (FILL)
Fill and topsoil			Recent Alluvium (Q1a)
Basalt		TAURANGA GROUP	
Other volcanics			Undifferentiated Tauranga Group (TG)
Clay and clay dominated mixtures			Kaawa Formation (KAAWA)
Organic clay and organic clay dominated mixtures		AUCKLAND VOLCANIC FIELD (PLEISTOCENE)	
Peat			Basalt (AVL)
Silt and silt dominated mixtures			Tuff / Ash / Scoria (AVT)
Organic silt and organic silt dominated mixtures		WAITEMATA GROUP (MIOCENE)	
Sand and sand dominated mixtures (clean)			Residually to Highly Weathered - Cohesive Soils (RS)
Sand and sand dominated mixtures (with fines)			Residually to Highly Weathered - Granular Soils (RS)
Organic sand and organic sand dominated mixtures			Parnell Volcaniclastic Conglomerate (PVC)
Sandstone			Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
Mudstone			
Interbedded mudstone and sandstone			
Conglomerate			
Coal			



DSCIN007 LYON AVENUE

DSCIN008 MT ALBERT WAR MEMORIAL RESERVE



CHAINAGE (m)	20300	20400	20500	20600	20700	20800	20900	21000	21100	21200	21300	21400	21500	21600	21700
GROUND LEVEL (mRL)	30.79	27.83	27.63	27.16	27.53	32.09	34.27	32.36	25.03	24.39	24.31	21.02	22.85	24.77	22.13
CROWN LEVEL (mRL)	-11.95	-11.85	-11.75	-11.65	-11.55	-11.45	-11.35	-11.25	-11.15	-11.05	-10.95	-10.85	-10.75	-10.65	-10.55
INVERT LEVEL (mRL)	-16.75	-16.65	-16.55	-16.45	-16.35	-16.25	-16.15	-16.05	-15.95	-15.85	-15.75	-15.65	-15.55	-15.45	-15.35

NOTES
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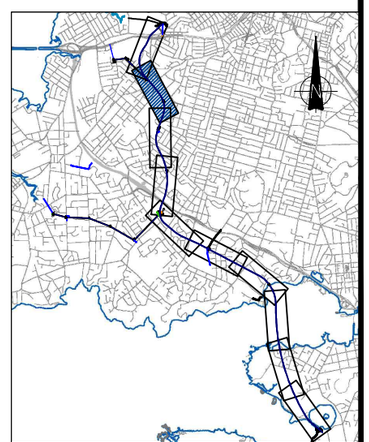

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ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

	BY	DATE
DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		

OPERATIONS

INFRASTRUCTURE

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DSCIN – CENTRAL INTERCEPTOR TUNNEL
SITE GENERAL
MAIN TUNNEL LONG SECTION – SHEET 9 OF 10

CAD FILE 2012061.024	DATE 07.06.16
ORIGINAL SCALE A1 1:2500	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012061.024	3

Plot Date: Jun 09, 2016 - 1:51pm
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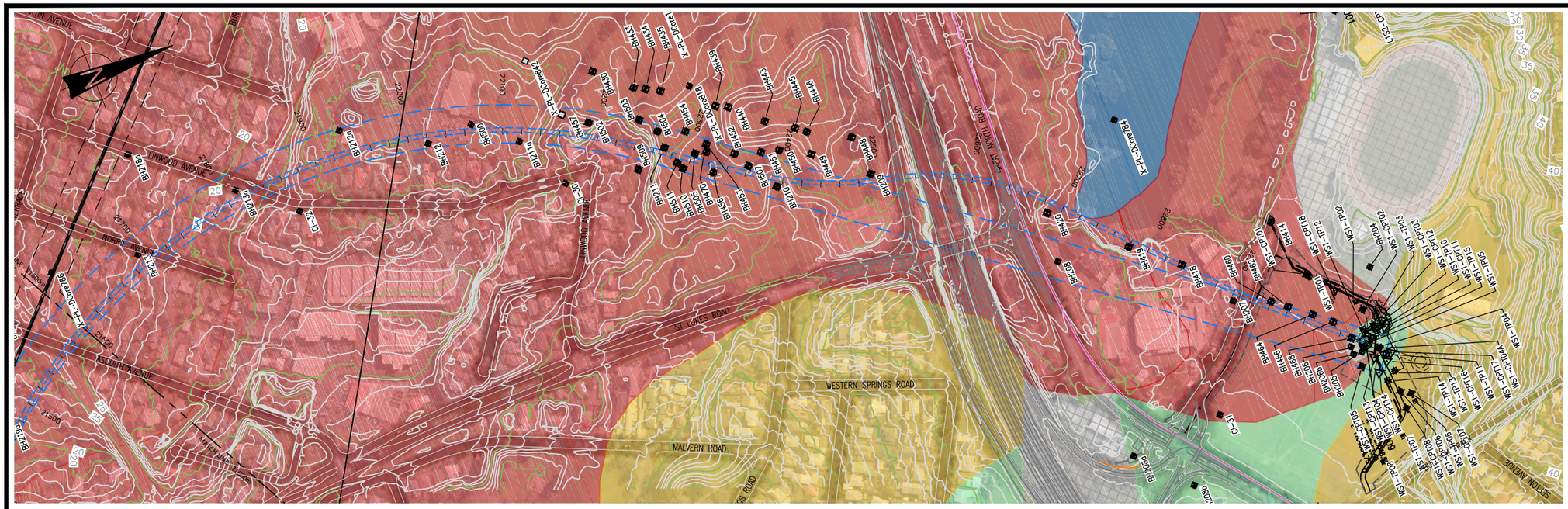
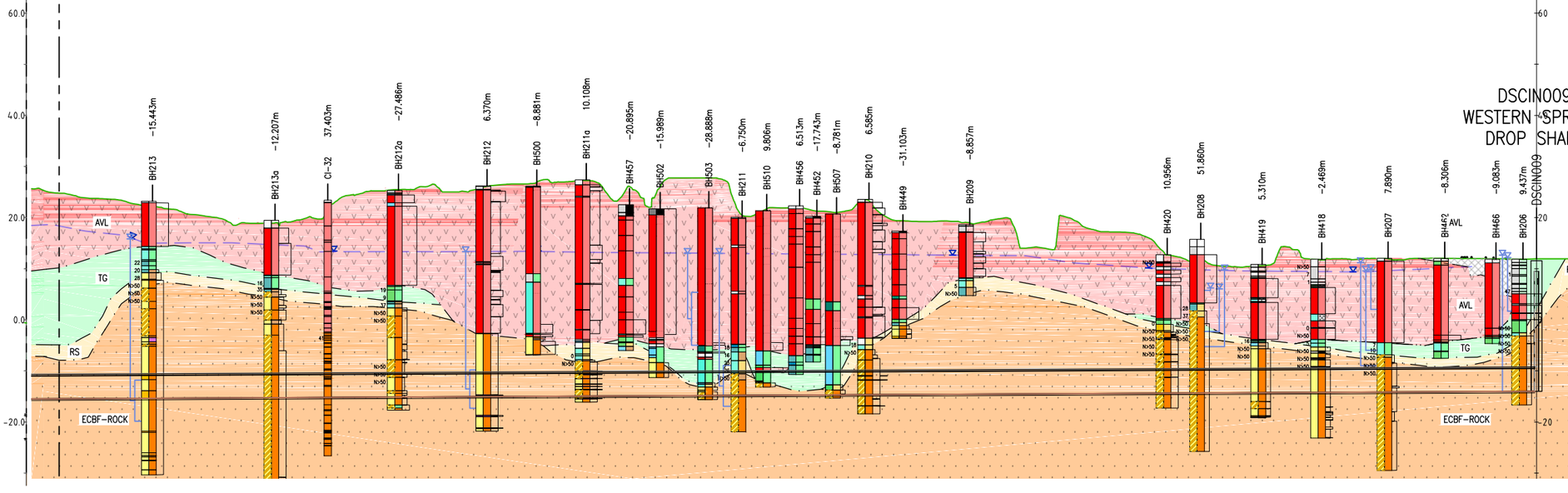




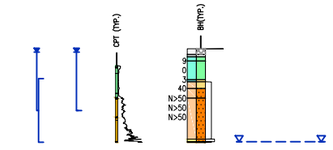
CHAINAGE (m)	21600	21700	21800	21900	22000	22100	22200	22300	22400	22500	22600	22700	22800	22900	23000	23067
GROUND LEVEL (mRL)	24.77	22.13	18.94	24.97	25.09	27.00	27.75	21.99	22.28	18.83	19.23	12.27	14.30	12.01	11.96	
CROWN LEVEL (mRL)	-10.65	-10.55	-10.45	-10.35	-10.25	-10.15	-10.05	-9.95	-9.85	-9.75	-9.65	-9.55	-9.45	-9.35	-9.25	
INVERT LEVEL (mRL)	-15.45	-15.35	-15.25	-15.15	-15.05	-14.95	-14.85	-14.75	-14.65	-14.55	-14.45	-14.35	-14.25	-14.15	-14.05	

LEGEND

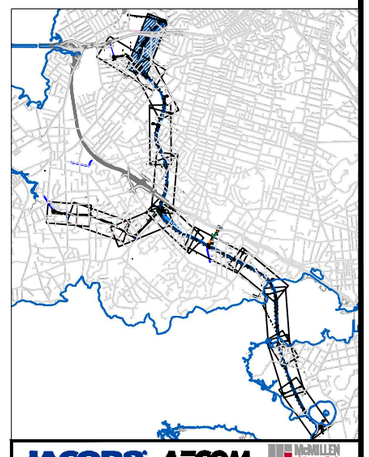
BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT | PLAN AND SECTION | BH RIGHT

- No core
- Fill and topsoil — Made Ground (FILL)
- Basalt — Recent Alluvium (Q1a)
- Other volcanics — TAURANGA GROUP
- Clay and clay dominated mixtures — Undifferentiated Tauranga Group (TG)
- Organic clay and organic clay dominated mixtures — Kaawa Formation (KAAWA)
- Peat — AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Silt and silt dominated mixtures — Basalt (AVL)
- Organic silt and organic silt dominated mixtures — Tuff / Ash / Scoria (AVT)
- Sand and sand dominated mixtures (clean) — WAITEMATA GROUP (MIOCENE)
- Sand and sand dominated mixtures (with fines) — Residually to Highly Weathered - Cohesive Soils (RS)
- Organic sand and organic sand dominated mixtures — Residually to Highly Weathered - Granular Soils (RS)
- Sandstone — Parnell Volcaniclastic Conglomerate (PVC)
- Mudstone — Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
- Interbedded mudstone and sandstone
- Conglomerate
- Coal



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X−DSCIN−T−001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X−DSLSA(−D)−C−001. DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY. FOR DETAILED GEOTECHNICAL INFORMATION REFER TO THE GEOTECHNICAL FACTUAL REPORT. (PWCIN−DEL−REP−GT−J−100047)



ISSUED FOR USE

JACOBS AECOM MCMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
4	03.02.17	REVISED ISSUE ; CIGI3	KL	ADC
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1				

		DATE
DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		

OPERATIONS

INFRASTRUCTURE

Watercare

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DSCIN − CENTRAL INTERCEPTOR TUNNEL
SITE GENERAL
MAIN TUNNEL LONG SECTION − SHEET 10 OF 10

CAD FILE 2012061.025	DATE 03.02.17
ORIGINAL SCALE A1 1:2500	CONTRACT No. 5747
REF. No.	ISSUE
DWG. No. 2012061.025	4

Plot Date: Jan 31, 2017 - 1:02pm
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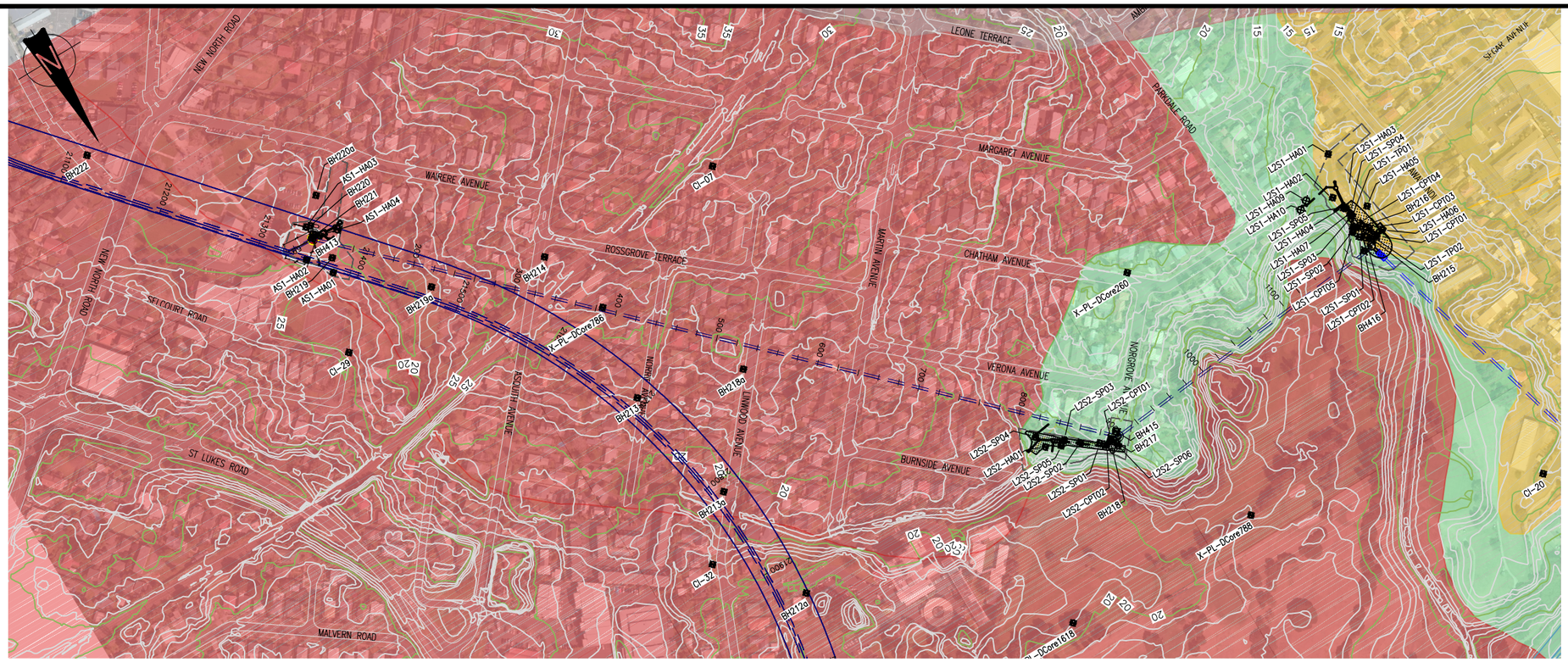
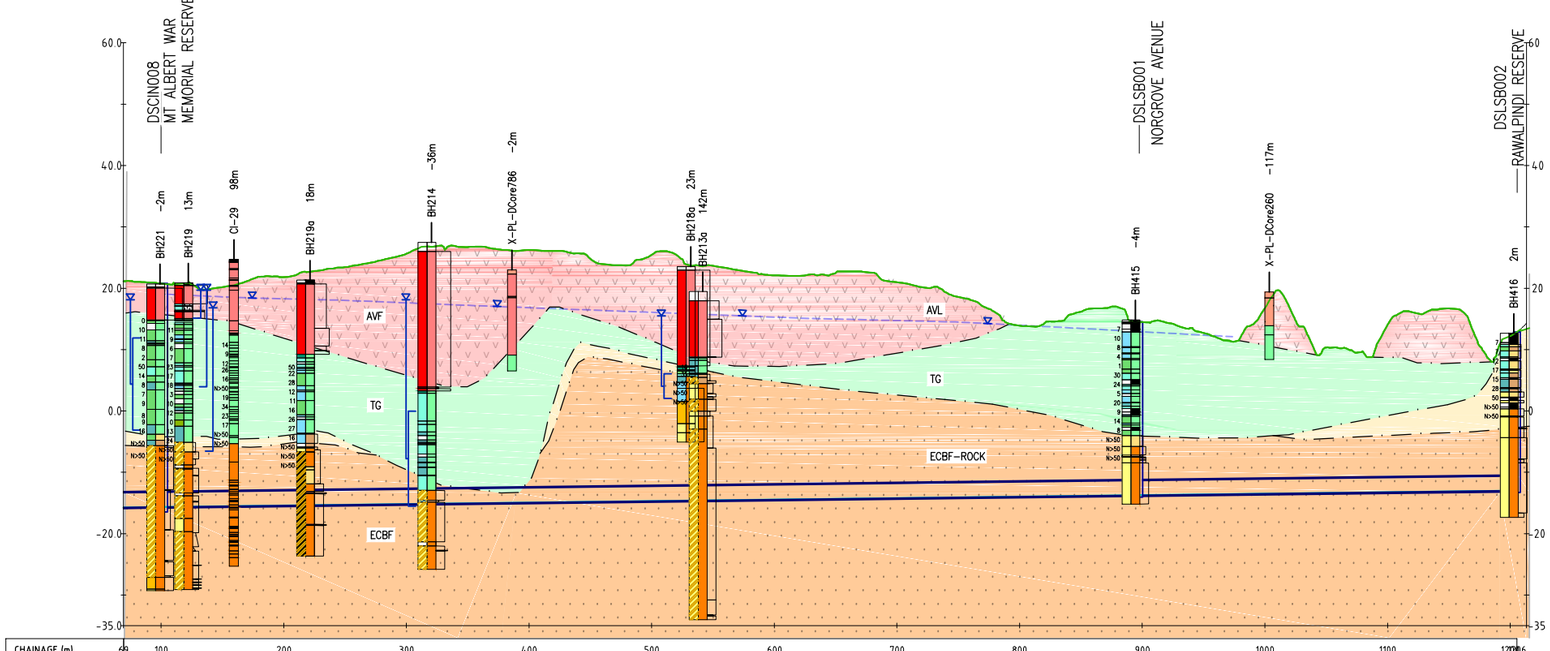




LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT | PLAN AND SECTION | BH RIGHT

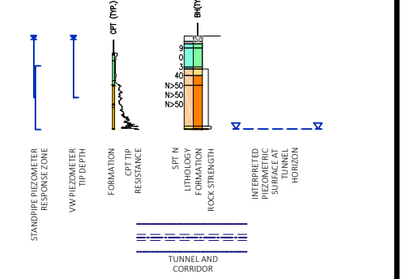
- No core
- Fill and topsoil
- Basalt
- Other volcanics
- Clay and clay dominated mixtures
- Organic clay and organic clay dominated mixtures
- Peat
- Silt and silt dominated mixtures
- Organic silt and organic silt dominated mixtures
- Sand and sand dominated mixtures (clean)
- Sand and sand dominated mixtures (with fines)
- Organic sand and organic sand dominated mixtures
- Sandstone
- Mudstone
- Interbedded mudstone and sandstone
- Conglomerate
- Coal

- Made Ground (FILL)
- Recent Alluvium (Q1a)

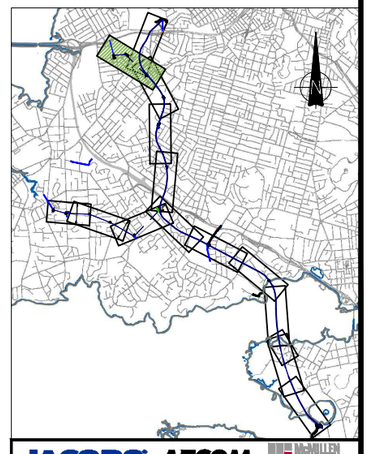
TAURANGA GROUP
- Undifferentiated Tauranga Group (TG)
- Kaawa Formation (KAAWA)

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt (AVL)
- Tuff / Ash / Scoria (AVT)

WAITEMATA GROUP (MIOCENE)
- Residually to Highly Weathered - Cohesive Soils (RS)
- Residually to Highly Weathered - Granular Soils (RS)
- Parnell Volcaniclastic Conglomerate (PVC)
- Moderately Weathered to Unweathered ECBF (ECBF-ROCK)



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001 DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY. FOR DETAILED GEOTECHNICAL INFORMATION REFER TO THE GEOTECHNICAL FACTUAL REPORT. (PWCIN-DEL-REP-GT-J-100047)



ISSUED FOR USE

JACOBS AECOM MAUNSELL AECOM JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

	BY	DATE
DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		

OPERATIONS

INFRASTRUCTURE

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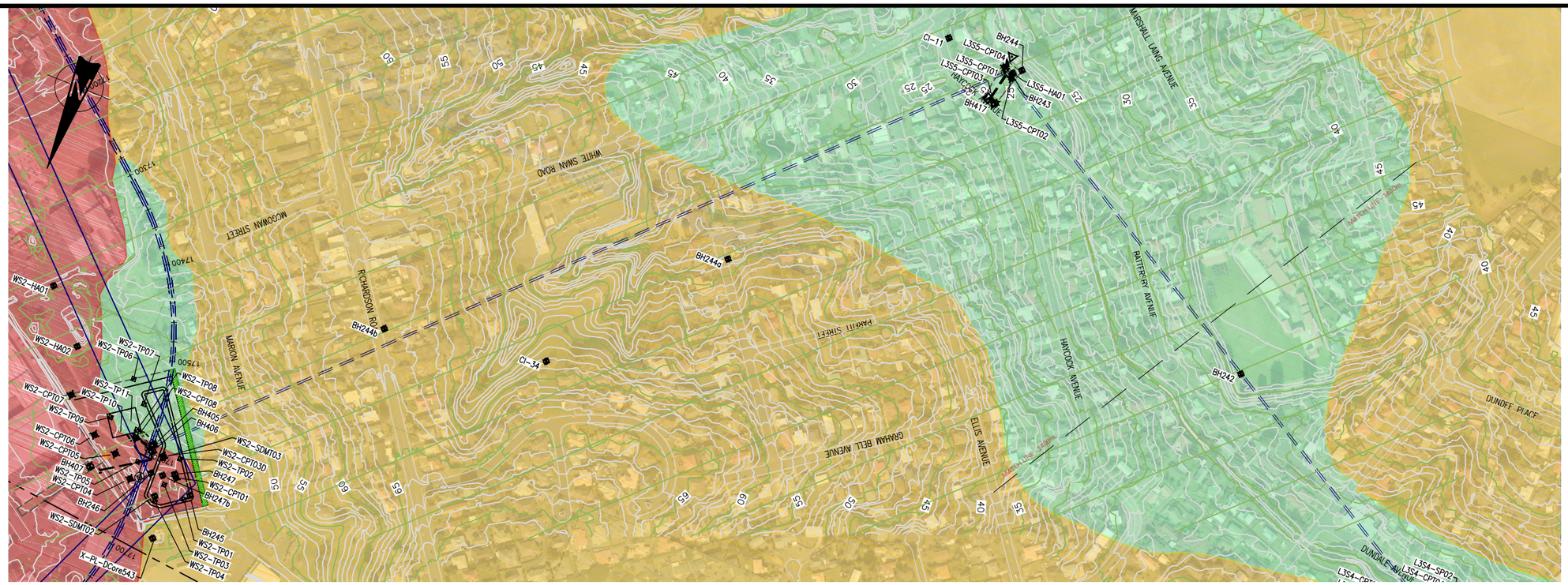
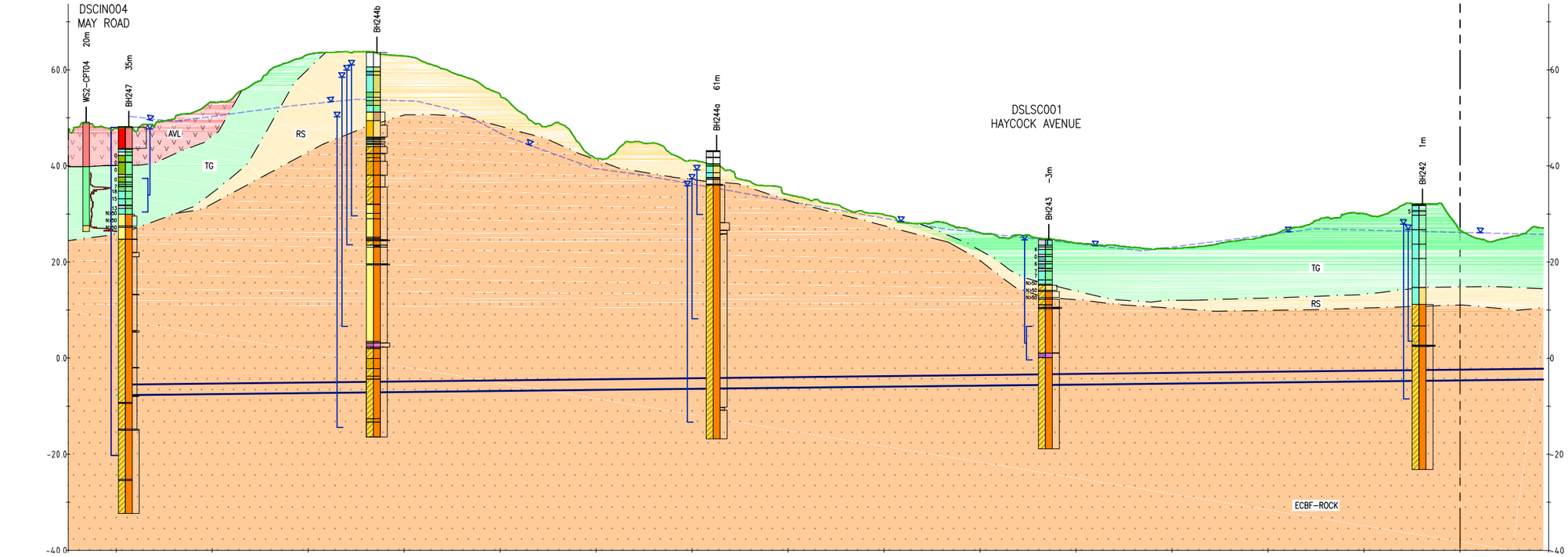
DSLSB – DRAINAGE SEWER LINK SEWER B
SITE GENERAL
LINK SEWER B LONG SECTION

CAD FILE 2011952.001 | DATE 07.06.16
ORIGINAL SCALE A1 1:2500 | CONTRACT No.
REF. No. CI-GEOTECH | ISSUE
DWG. No. 2011952.001 | 3



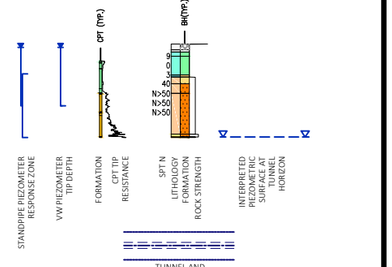


CHAINAGE (m)	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
GROUND LEVEL (mRL)	47.81	53.28	63.16	62.84	54.80	41.55	41.13	34.02	29.83	26.06	23.92	22.75	25.54	30.06	26.57	25.33
CROWN LEVEL (mRL)	-5.57	-5.35	-5.13	-4.90	-4.68	-4.46	-4.24	-4.01	-3.79	-3.57	-3.35	-3.13	-2.91	-2.69	-2.46	-2.24
INVERT LEVEL (mRL)	-7.67	-7.45	-7.23	-7.01	-6.78	-6.56	-6.34	-6.12	-5.90	-5.67	-5.45	-5.23	-5.01	-4.78	-4.56	-4.34

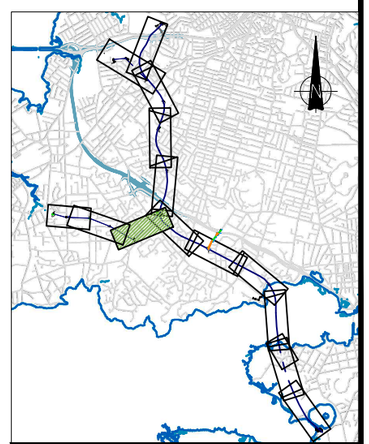
LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

	BH LEFT	PLAN AND SECTION	BH RIGHT
No core			Made Ground (FILL)
Fill and topsoil			Recent Alluvium (Q1a)
Basalt		TAURANGA GROUP	
Other volcanics			Undifferentiated Tauranga Group (TG)
Clay and clay dominated mixtures			Kaawa Formation (KAAWA)
Organic clay and organic clay dominated mixtures		AUCKLAND VOLCANIC FIELD (PLEISTOCENE)	
Peat			Basalt (AVL)
Silt and silt dominated mixtures			Tuff / Ash / Scoria (AVT)
Organic silt and organic silt dominated mixtures		WAITEMATA GROUP (MIOCENE)	
Sand and sand dominated mixtures (clean)			Residually to Highly Weathered - Cohesive Soils (RS)
Sand and sand dominated mixtures (with fines)			Residually to Highly Weathered - Granular Soils (RS)
Organic sand and organic sand dominated mixtures			Parnell Volcaniclastic Conglomerate (PVC)
Sandstone			Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
Mudstone			
Interbedded mudstone and sandstone			
Conglomerate			
Coal			



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY. FOR DETAILED GEOTECHNICAL INFORMATION REFER TO THE GEOTECHNICAL FACTUAL REPORT. (PWCIN-DEL-REP-GT-J-100047)



ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		

OPERATIONS

INFRASTRUCTURE

Watercare

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DSLSC – DRAINAGE SEWER LINK SEWER C
SITE GENERAL
LINK SEWER C LONG SECTION – SHEET 1 OF 3

CAD FILE 2012004.001	DATE 07.06.16
ORIGINAL SCALE A1 1:2500	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012004.001	3

Plot Date: Jun 09, 2016 - 2:37pm
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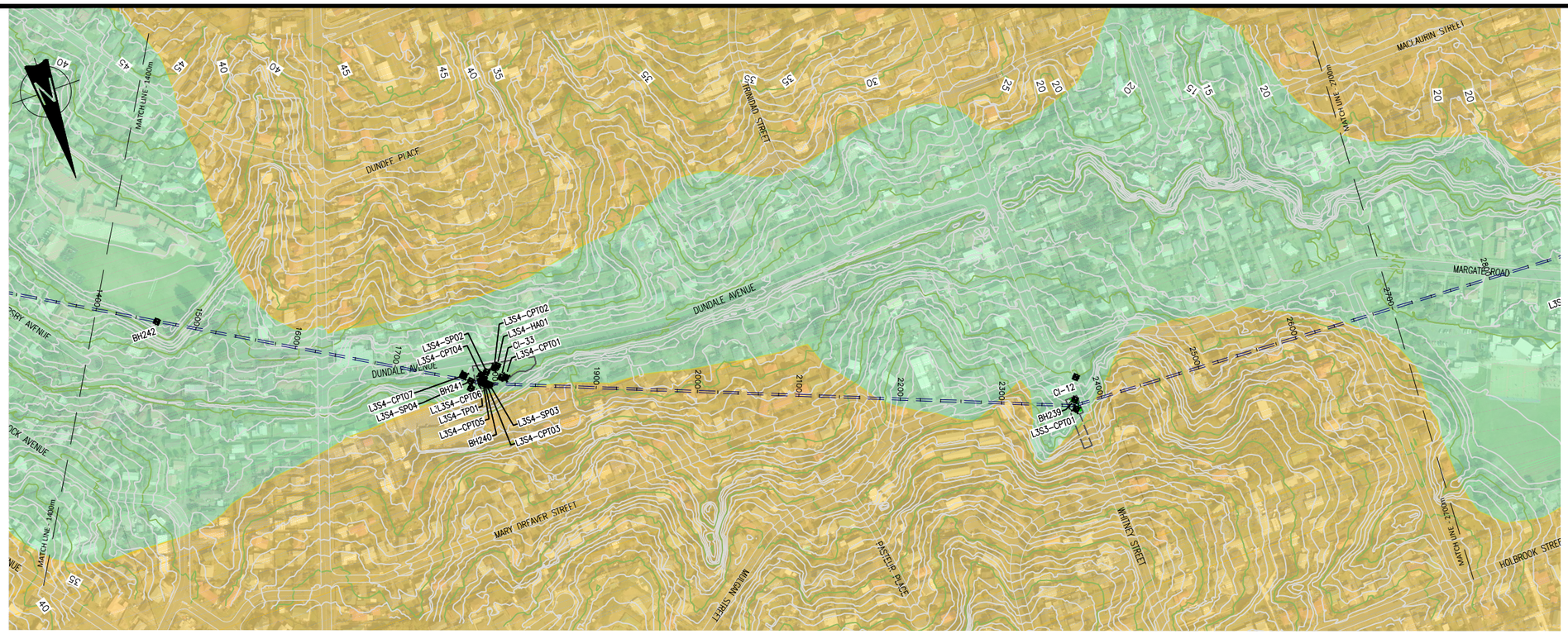
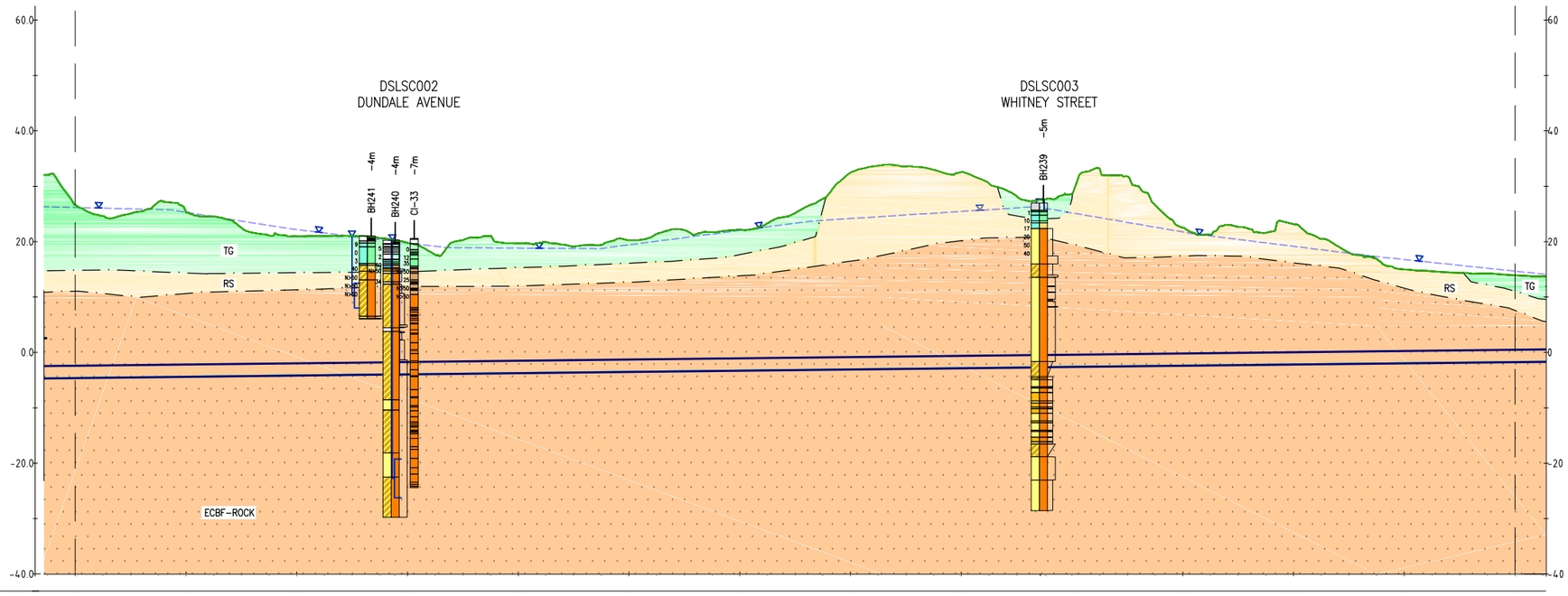


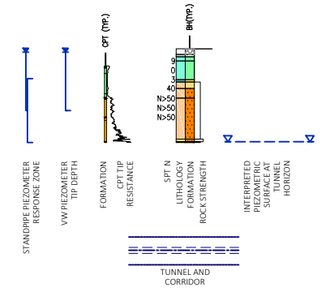


CHAINAGE (m)	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700	2800
GROUND LEVEL	26.57	25.33	20.99	19.81	19.70	20.25	22.16	32.46	32.56	28.67	22.53	23.17	14.99	13.94
CROWN LEVEL	-2.46	-2.24	-2.02	-1.80	-1.58	-1.36	-1.14	-0.91	-0.69	-0.47	-0.25	-0.02	0.20	0.42
INVERT LEVEL	-4.56	-4.34	-4.12	-3.90	-3.67	-3.45	-3.23	-3.01	-2.78	-2.56	-2.34	-2.12	-1.90	-1.67

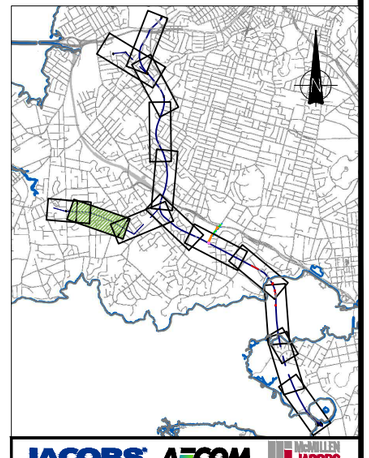
LEGEND

BH215 –6m Borehole ID and offset from section. (Negative numbers are into the page.)

	BH LEFT	PLAN AND SECTION	BH RIGHT
No core			Made Ground (FILL)
Fill and topsoil			Recent Alluvium (Q1a)
Basalt		TAURANGA GROUP	
Other volcanics			Undifferentiated Tauranga Group (TG)
Clay and clay dominated mixtures			Kaawa Formation (KAAWA)
Organic clay and organic clay dominated mixtures		AUCKLAND VOLCANIC FIELD (PLEISTOCENE)	
Peat			Basalt (AVL)
Silt and silt dominated mixtures			Tuff / Ash / Scoria (AVT)
Organic silt and organic silt dominated mixtures		WAITEMATA GROUP (MIOCENE)	
Sand and sand dominated mixtures (clean)			Residually to Highly Weathered - Cohesive Soils (RS)
Sand and sand dominated mixtures (with fines)			Residually to Highly Weathered - Granular Soils (RS)
Organic sand and organic sand dominated mixtures			Parnell Volcaniclastic Conglomerate (PVC)
Sandstone			Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
Mudstone			
Interbedded mudstone and sandstone			
Conglomerate			
Coal			



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY. FOR DETAILED GEOTECHNICAL INFORMATION REFER TO THE GEOTECHNICAL FACTUAL REPORT. (PWCIN-DEL-REP-GT-J-100047)



ISSUED FOR USE

JACOBS AECOM MAUNSELL AECOM JACOBS

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15	OPERATIONS
DES. CHECKED	HM	05.16	
DRAWN	KL	04.15	
DWG. CHECKED	ADC	05.16	
PROJECT LEADER	DK	05.16	
INFRAST'R APP'D			INFRASTRUCTURE

Watercare

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DSLSC – DRAINAGE SEWER LINK SEWER C
SITE GENERAL
LINK SEWER C LONG SECTION – SHEET 2 OF 3

CAD FILE 2012004.002	DATE 07.06.16
ORIGINAL SCALE A1 1:2500	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012004.002	3

Plot Date: Jun 09, 2016 - 2:47pm
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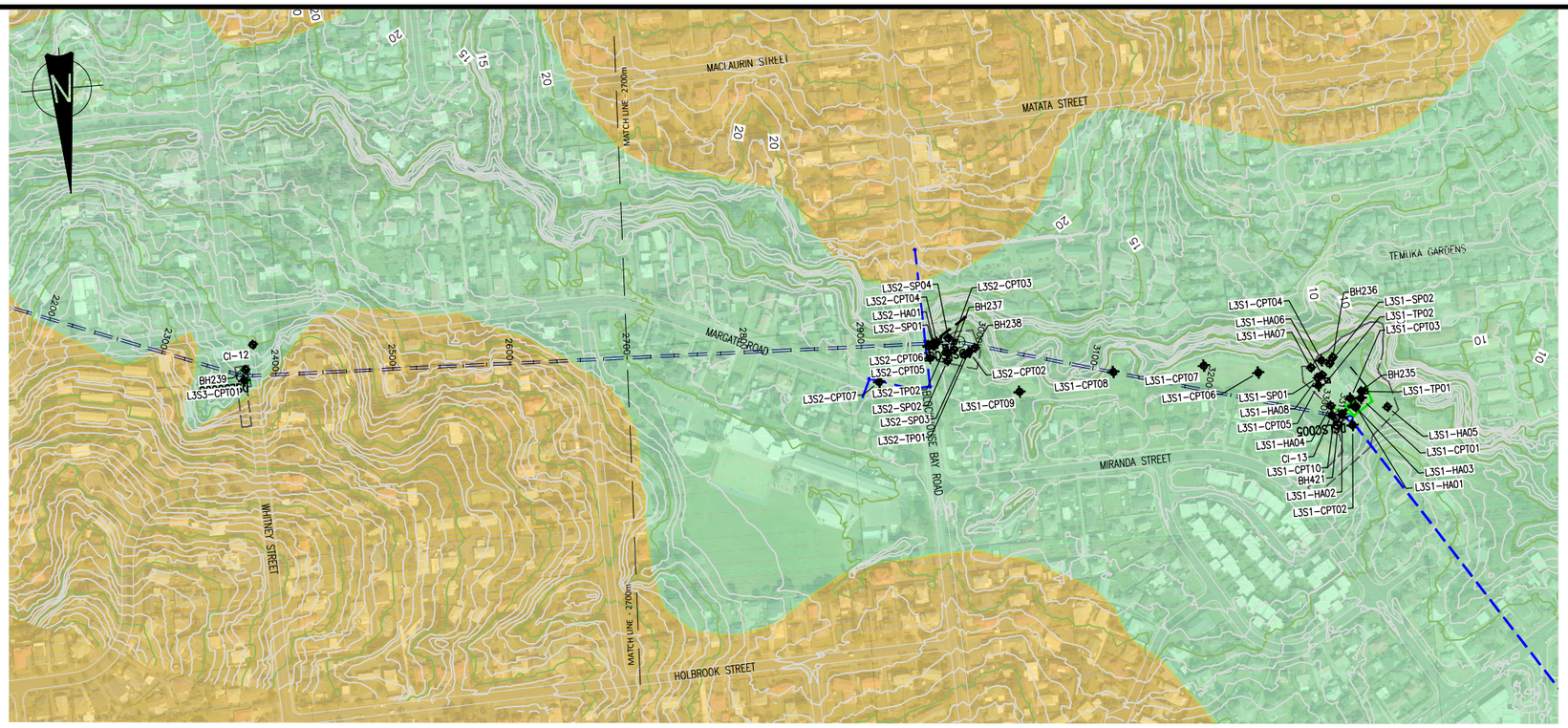
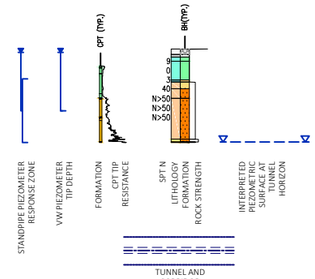
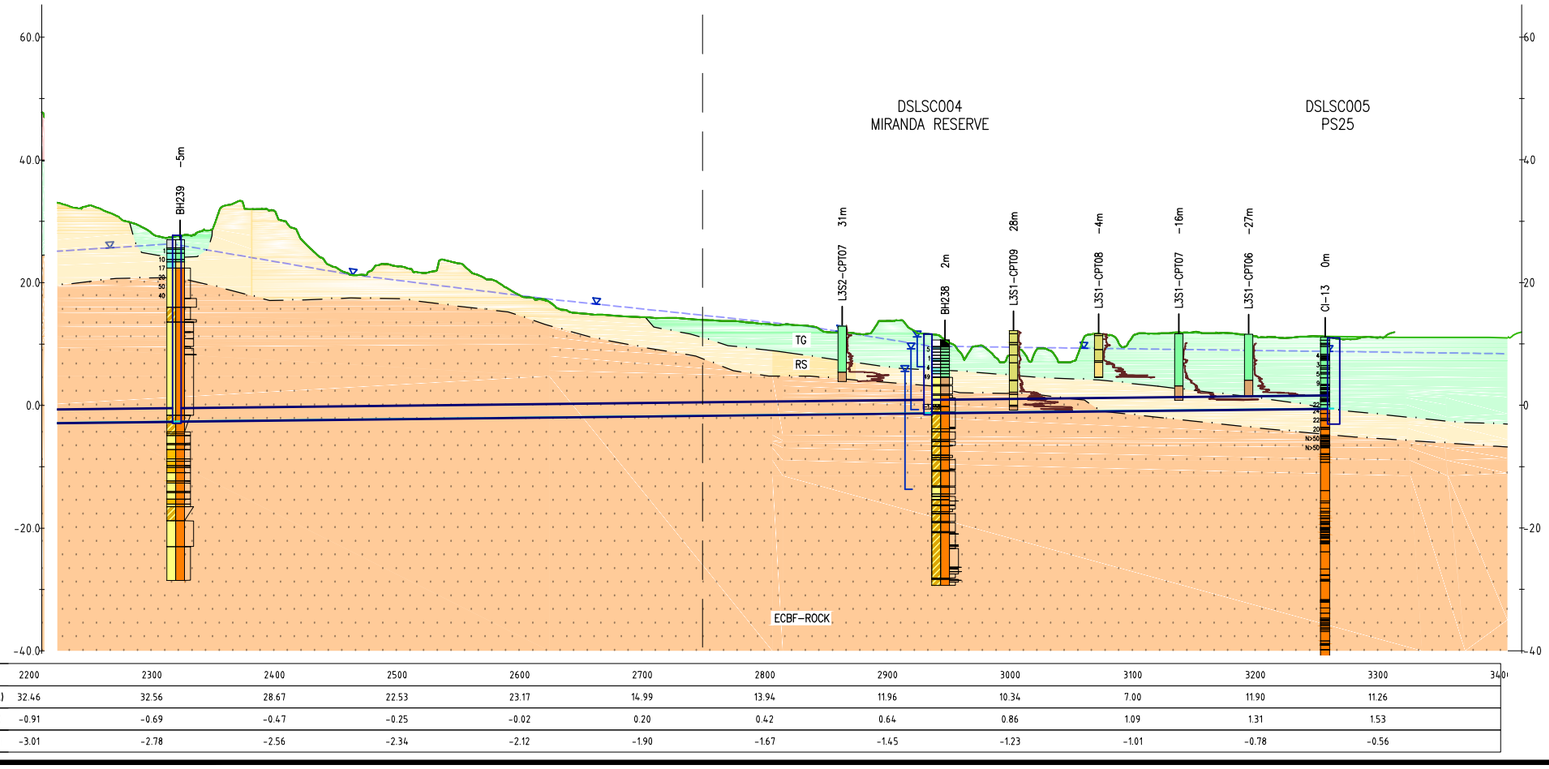


LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

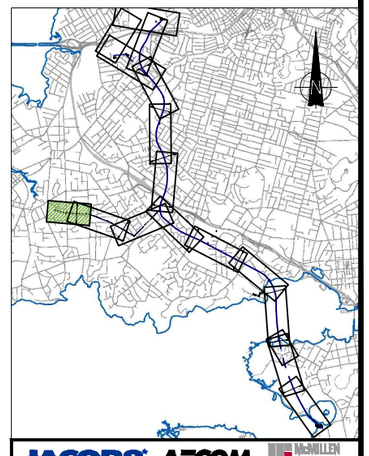
	BH LEFT	PLAN AND SECTION	BH RIGHT	
No core				Made Ground (FILL)
Fill and topsoil				Recent Alluvium (Q1a)
Basalt				TAURANGA GROUP
Other volcanics				
Clay and clay dominated mixtures				Undifferentiated Tauranga Group (TG)
Organic clay and organic clay dominated mixtures				Kaawa Formation (KAAWA)
Peat				AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
Silt and silt dominated mixtures				Basalt (AVL)
Organic silt and organic silt dominated mixtures				Tuff / Ash / Scoria (AVT)
Sand and sand dominated mixtures (clean)				WAITEMATA GROUP (MIOCENE)
Sand and sand dominated mixtures (with fines)				Residually to Highly Weathered - Cohesive Soils (RS)
Organic sand and organic sand dominated mixtures				Residually to Highly Weathered - Granular Soils (RS)
Sandstone				Parnell Volcaniclastic Conglomerate (PVC)
Mudstone				Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
Interbedded mudstone and sandstone				
Conglomerate				
Coal				





CHAINAGE (m)	2200	2300	2400	2500	2600	2700	2800	2900	3000	3100	3200	3300	3400
GROUND LEVEL (mRL)	32.46	32.56	28.67	22.53	23.17	14.99	13.94	11.96	10.34	7.00	11.90	11.26	
CROWN LEVEL (mRL)	-0.91	-0.69	-0.47	-0.25	-0.02	0.20	0.42	0.64	0.86	1.09	1.31	1.53	
INVERT LEVEL (mRL)	-3.01	-2.78	-2.56	-2.34	-2.12	-1.90	-1.67	-1.45	-1.23	-1.01	-0.78	-0.56	

NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY. FOR DETAILED GEOTECHNICAL INFORMATION REFER TO THE GEOTECHNICAL FACTUAL REPORT. (PWCIN-DEL-REP-GT-J-100047)



ISSUED FOR USE

JACOBS AECOM MWILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REIEW	KL	ADC
1		PRELIMINARY		

		DATE
DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		

OPERATIONS

INFRASTRUCTURE

Watercare

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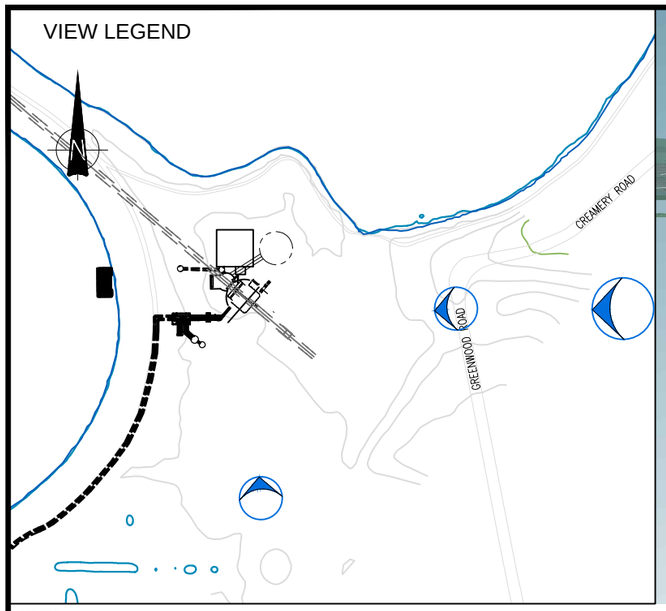
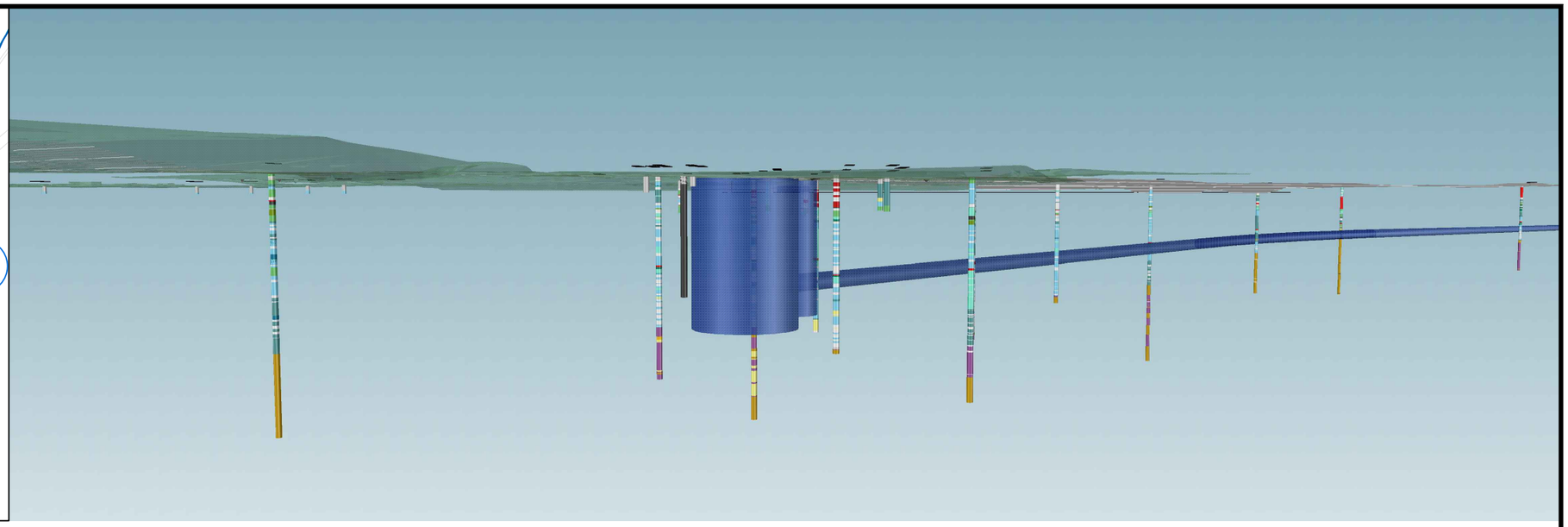
DSLSC – DRAINAGE SEWER LINK SEWER C
SITE GENERAL
LINK SEWER C LONG SECTION – SHEET 3 OF 3

CAD FILE 2012004.003	DATE 07.06.16
ORIGINAL SCALE A1 1:2500	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012004.003	3

Plot Date: Jun 13, 2016 - 1:19pm
C:\users\apatel2\dms52193\ 2012004.003.dwg

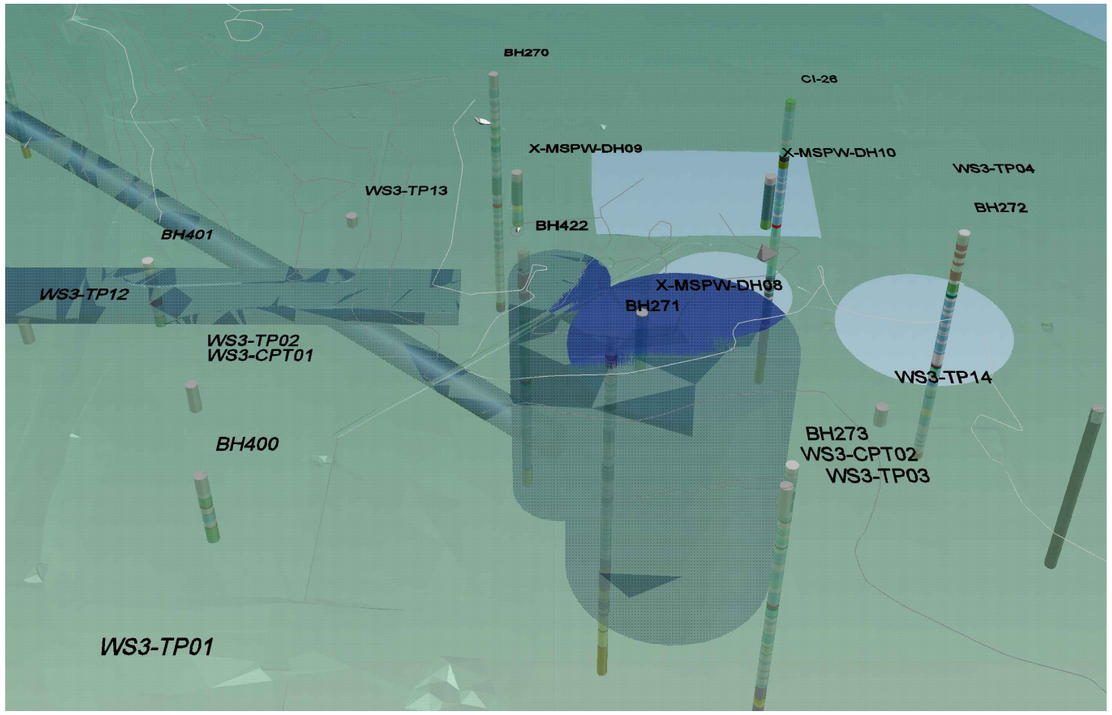
Appendix D. Drawings – shaft sections



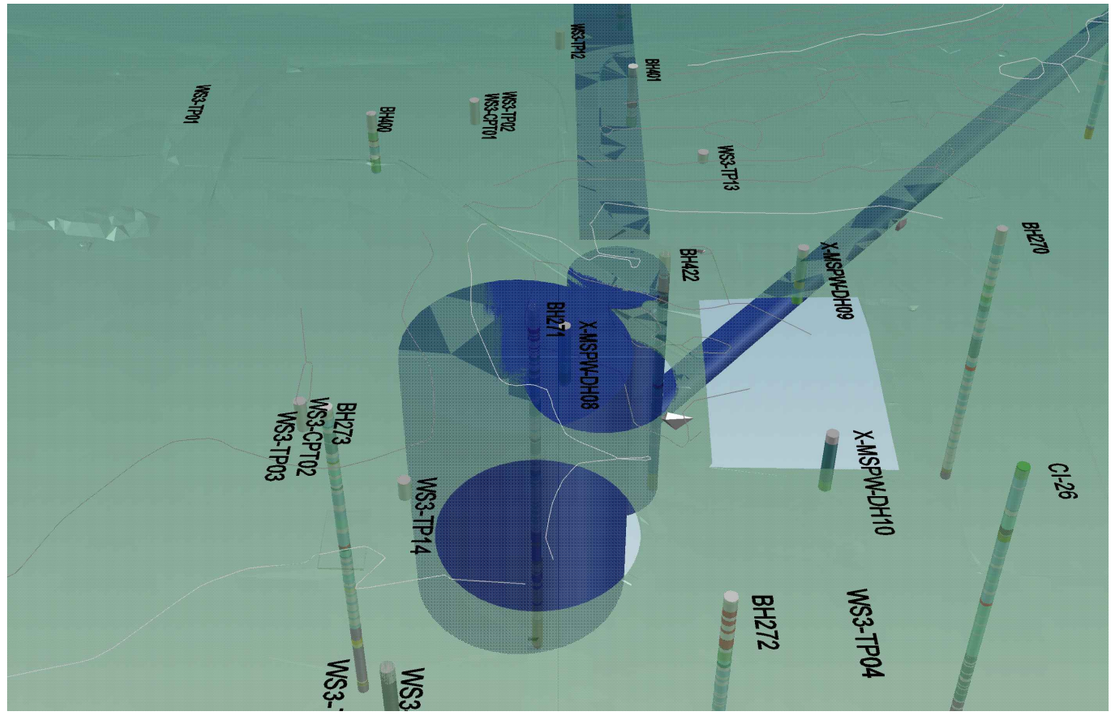


EAST – OVERVIEW

NOTES:
1. GROUND CONTOURS ARE FROM AUCKLAND COUNCIL GIS SOURCE, 2006 DATASET.
2. GROUND SURFACE SHOWN FROM SITE SURVEY BY BECA, 2015.
3. TUNNEL AND SHAFTS ARE FROM DETAILED DESIGN MODEL TO MAY 2016 AND ARE INDICATIVE ONLY.
4. 3D BOREHOLE STICKS ARE EXTRACTED DIRECTLY FROM CI PROJECT GEOTECHNICAL DATABASE, AND ARE COLOURED BY GEOLOGICAL FORMATION – REFER TO LONG SECTIONS FOR KEY.



SOUTH VIEW



EAST VIEW

ISSUED FOR USE

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ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

	BY	DATE
DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		

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INFRASTRUCTURE

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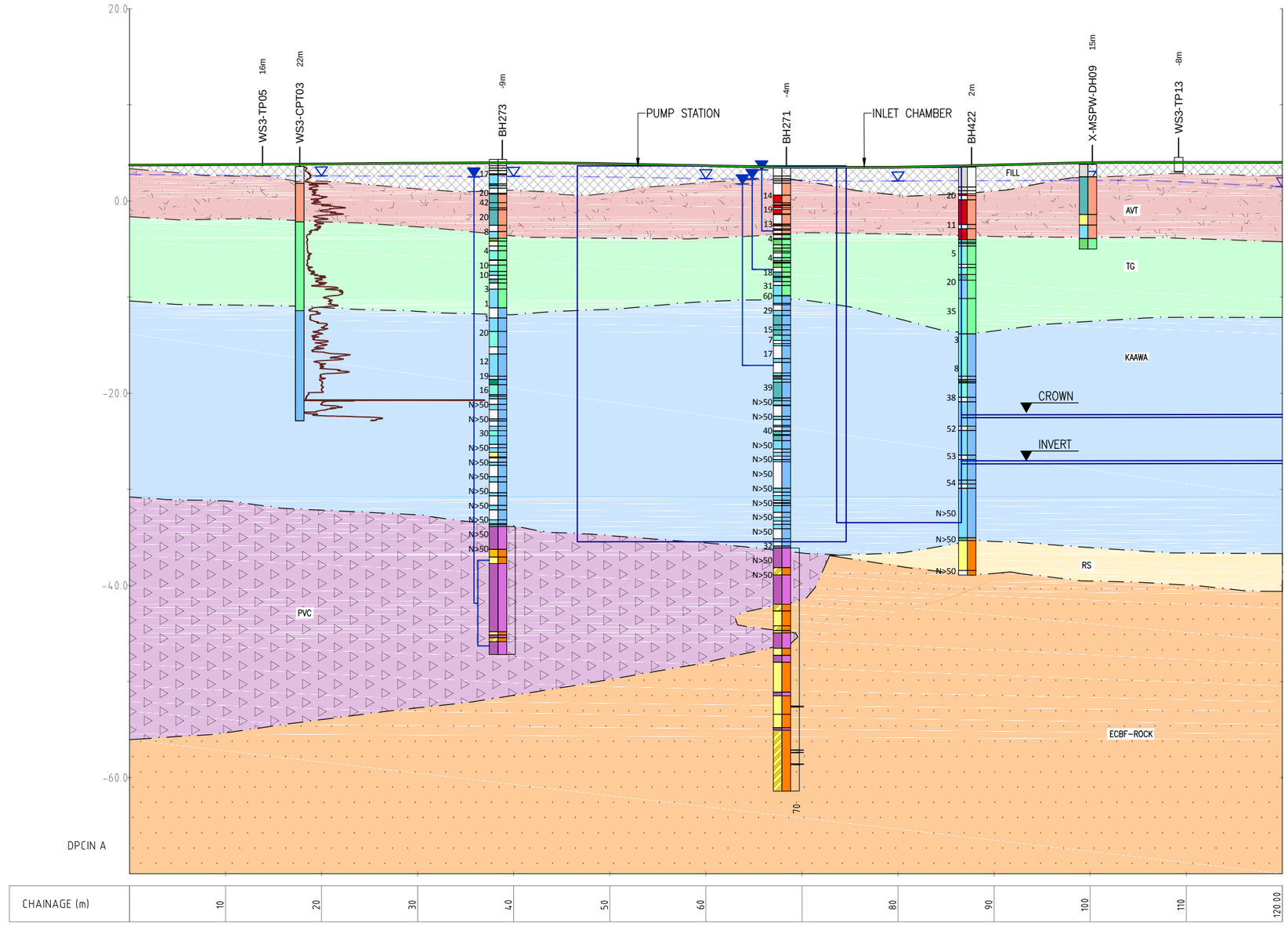
DPCIN – MANGERE PUMPING STATION
SITE GENERAL
SHAFT GEOLOGY – 3D

CAD FILE 2012043-002	DATE 07.06.16
ORIGINAL SCALE A1 N.T.S.	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012043.002	3

Plot Date: Jun 09, 2016 - 11:41am C:\pw_work\apatel2\dms52070\2012043-002.DWG

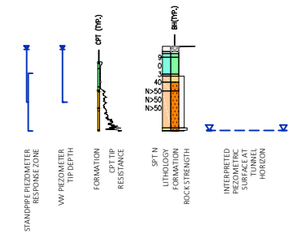


HBSI Profile - DPCIN A

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT	PLAN AND SECTION	BH RIGHT	
No core			Made Ground (FILL)
Fill and topsoil			Recent Alluvium (Q1a)
Basalt			TAURANGA GROUP
Other volcanics			Undifferentiated Tauranga Group (TG)
Clay and clay dominated mixtures			Kaawa Formation (KAAWA)
Organic clay and organic clay dominated mixtures			AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
Peat			Basalt (AVL)
Silt and silt dominated mixtures			Tuff / Ash / Scoria (AVT)
Organic silt and organic silt dominated mixtures			WAITEMATA GROUP (MIOCENE)
Sand and sand dominated mixtures (clean)			Residually to Highly Weathered - Cohesive Soils (RS)
Sand and sand dominated mixtures (with fines)			Residually to Highly Weathered - Granular Soils (RS)
Organic sand and organic sand dominated mixtures			Parnell Volcaniclastic Conglomerate (PVC)
Sandstone			Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
Mudstone			
Interbedded mudstone and sandstone			
Conglomerate			
Coal			



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

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ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	
PROJECT LEADER	DK	
INFRAST'R APP'D		05.16
	BY	DATE

OPERATIONS

INFRASTRUCTURE

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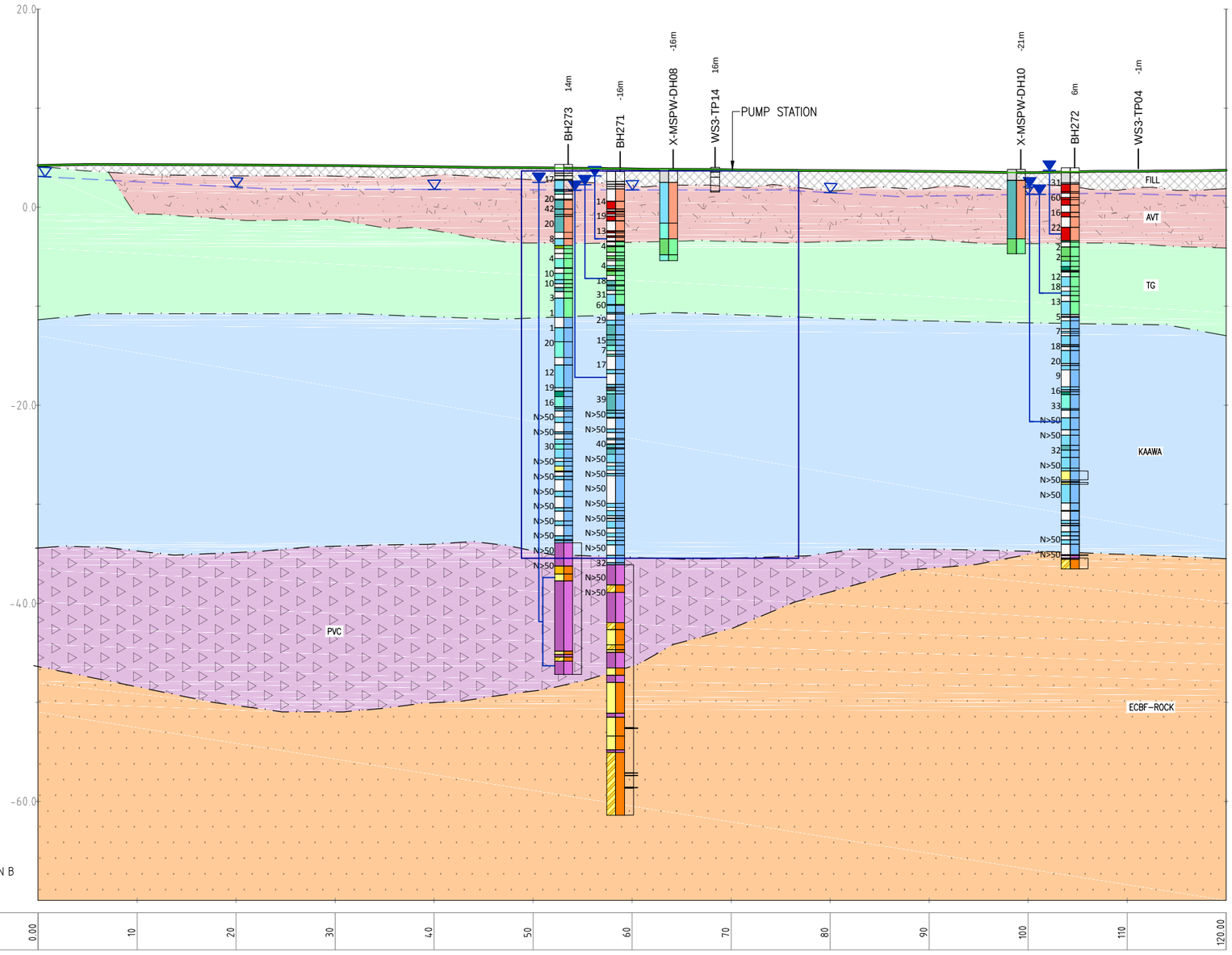
DPCIN – MANGERE PUMPING STATION
SITE GENERAL
SHAFT GEOLOGY – SECTION A

CAD FILE 2012043-003 DATE 07.06.16
ORIGINAL SCALE A1 1:250 CONTRACT No. 5747
REF. No. CI-GEOTECH ISSUE
DWG. No. 2012043.003 3

Plot Date: Jun 10, 2016 - 10:37am C:\pw_work\apatel\2dms52070\ 2012043-003.DWG



HBSI Profile - DPCIN B

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT | PLAN AND SECTION | BH RIGHT

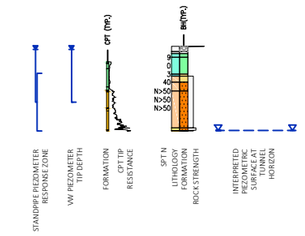
- No core
- Fill and topsoil
- Basalt
- Other volcanics
- Clay and clay dominated mixtures
- Organic clay and organic clay dominated mixtures
- Peat
- Silt and silt dominated mixtures
- Organic silt and organic silt dominated mixtures
- Sand and sand dominated mixtures (clean)
- Sand and sand dominated mixtures (with fines)
- Organic sand and organic sand dominated mixtures
- Sandstone
- Mudstone
- Interbedded mudstone and sandstone
- Conglomerate
- Coal

- Made Ground (FILL)
- Recent Alluvium (Q1a)

TAURANGA GROUP
- Undifferentiated Tauranga Group (TG)
- Kaawa Formation (KAAWA)

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt (AVL)
- Tuff / Ash / Scoria (AVT)

WAITEMATA GROUP (MIOCENE)
- Residually to Highly Weathered - Cohesive Soils (RS)
- Residually to Highly Weathered - Granular Soils (RS)
- Parnell Volcaniclastic Conglomerate (PVC)
- Moderately Weathered to Unweathered ECBF (ECBF-ROCK)



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
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4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	
PROJECT LEADER	DK	
INFRAST'R APP'D		05.16

OPERATIONS

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DPCIN – MANGERE PUMPING STATION
SITE GENERAL
SHAFT GEOLOGY – SECTION B

CAD FILE 2012043-004	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012043.004	3

Plot Date: Jun 09, 2016 - 11:51am C:\pw_work\apatel2\dms520701_2012043-004.DWG

NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
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3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY. FOR DETAILED GEOTECHNICAL INFORMATION REFER TO THE GEOTECHNICAL FACTUAL REPORT. (PWCIN-DEL-REP-GT-J-100047)

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

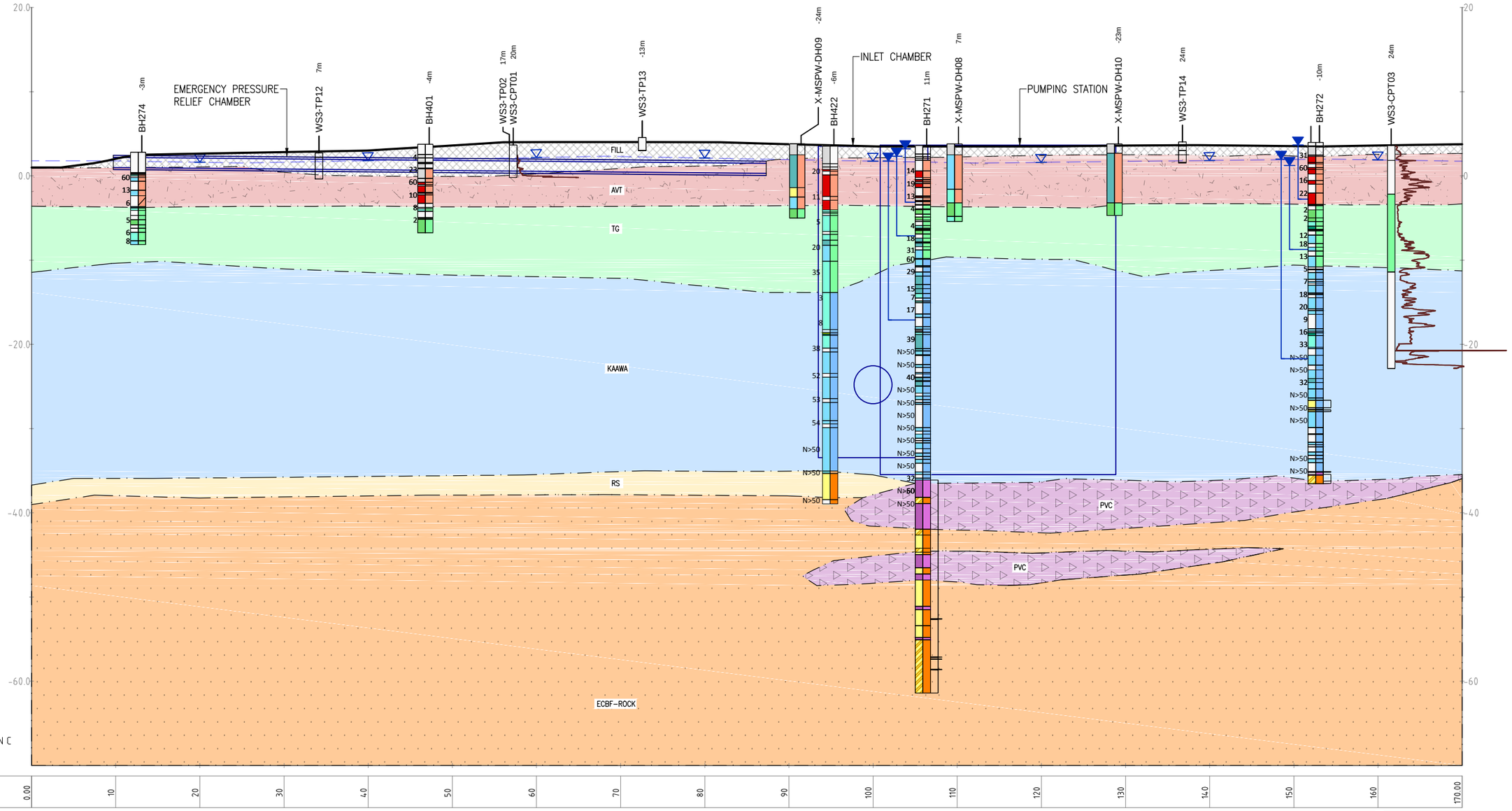
BH LEFT | PLAN AND SECTION | BH RIGHT

- No core / Fill and topsoil / Basalt / Other volcanics / Clay and clay dominated mixtures / Organic clay and organic clay dominated mixtures / Peat / Silt and silt dominated mixtures / Organic silt and organic silt dominated mixtures
- Made Ground (FILL)
- Recent Alluvium (Q1a)
- TAURANGA GROUP
- Undifferentiated Tauranga Group (TG)
- Kaawa Formation (KAAWA)
- AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt (AVL)
- Tuff / Ash / Scoria (AVT)

BH LEFT | PLAN AND SECTION | BH RIGHT

- Sand and sand dominated mixtures (clean)
- Sand and sand dominated mixtures (with fines)
- Organic sand and organic sand dominated mixtures
- Sandstone
- Mudstone
- Interbedded mudstone and sandstone
- Conglomerate
- Coal
- WAITEMATA GROUP (MIOCENE)
- Residually to Highly Weathered - Cohesive Soils (RS)
- Residually to Highly Weathered - Granular Soils (RS)
- Parnell Volcaniclastic Conglomerate (PVC)
- Moderately Weathered to Unweathered ECBF (ECBF-ROCK)

STANDPIPE PIEZOMETER RESPONSE ZONE | VW PIEZOMETER TIP DEPTH | FORMATION | CPT (mPa) CPT TIP RESISTANCE | SPT N LITHOLOGY FORMATION ROCK STRENGTH | BH(mPa) | INTERPRETED PIEZOMETRIC SURFACE FOR SHAFT MODEL HORIZON



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ISSUED FOR USE

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ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		

OPERATIONS

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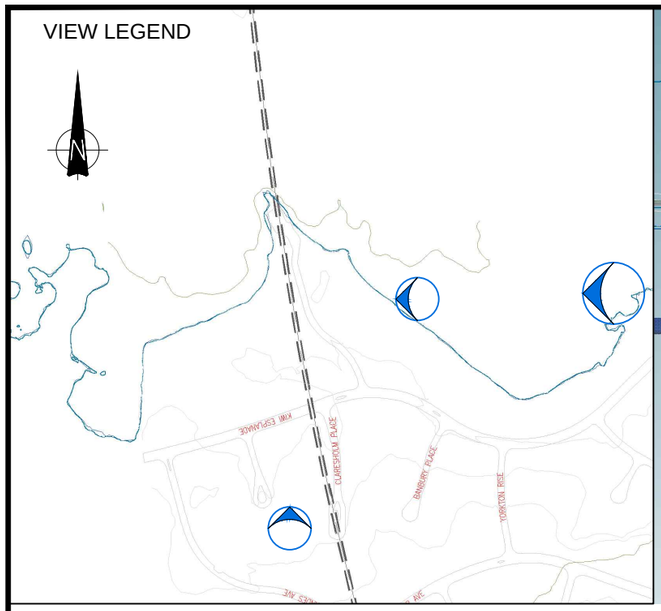
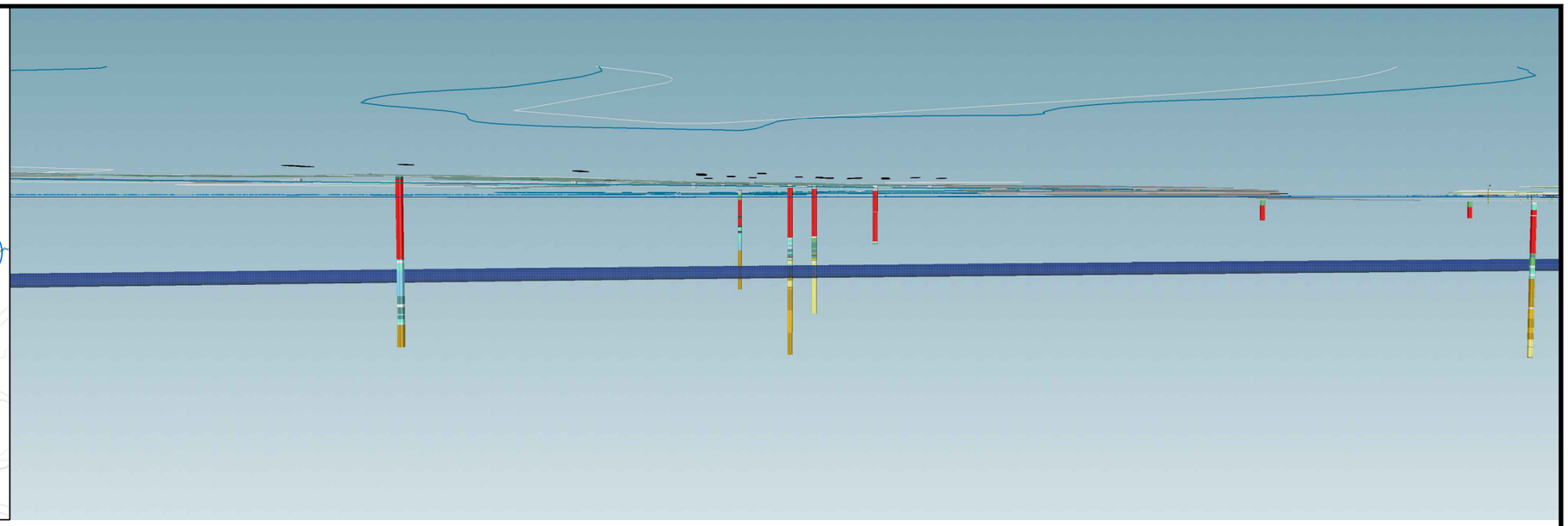
DPCIN – MANGERE PUMPING STATION
SITE GENERAL
SHAFT GEOLOGY – SECTION C

CAD FILE 2012043-005	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012043.005	3

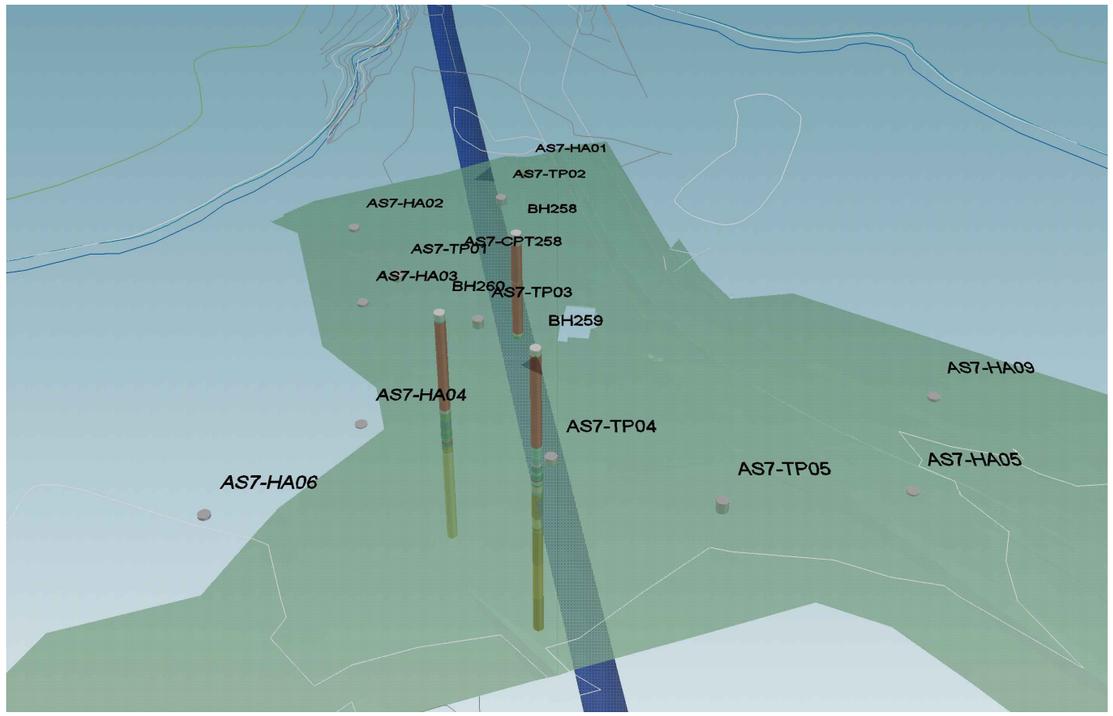
Plot Date: Jun 10, 2016 - 10:39am C:\pw_work\apatel\2\dms52070\2012043-005.DWG



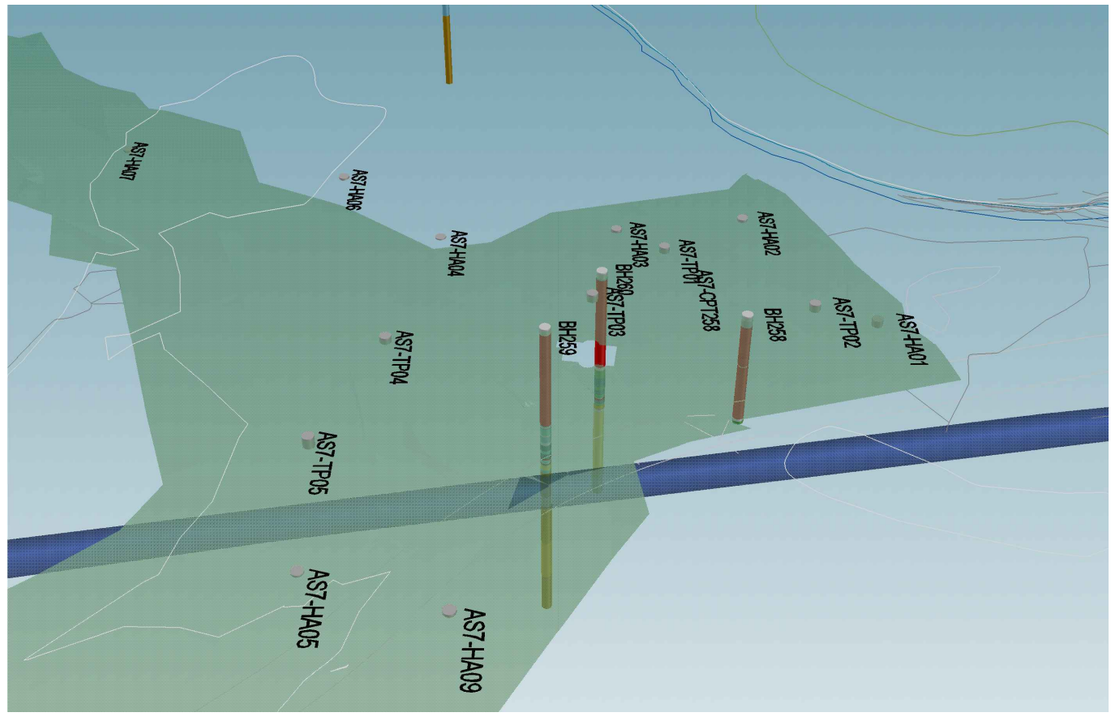


1. GROUND CONTOURS ARE FROM AUCKLAND COUNCIL GIS SOURCES, 2013 DATASET FOR 50m CORRIDOR AND 2006 DATASET BEYOND THAT.
2. GROUND SURFACE SHOWN FROM SITE SURVEY BY BECA, 2015.
3. TUNNEL AND SHAFTS ARE FROM PRELIMINARY DESIGN MODEL, MAY 2016 AND ARE INDICATIVE ONLY.
4. 3D BOREHOLE STICKS ARE EXTRACTED DIRECTLY FROM CI PROJECT GEOTECHNICAL DATABASE, AND ARE COLOURED BY GEOLOGICAL FORMATION – REFER TO LONG SECTIONS FOR KEY.

EAST – OVERVIEW



SOUTH VIEW



EAST VIEW

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED OF USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

INFRASTRUCTURE

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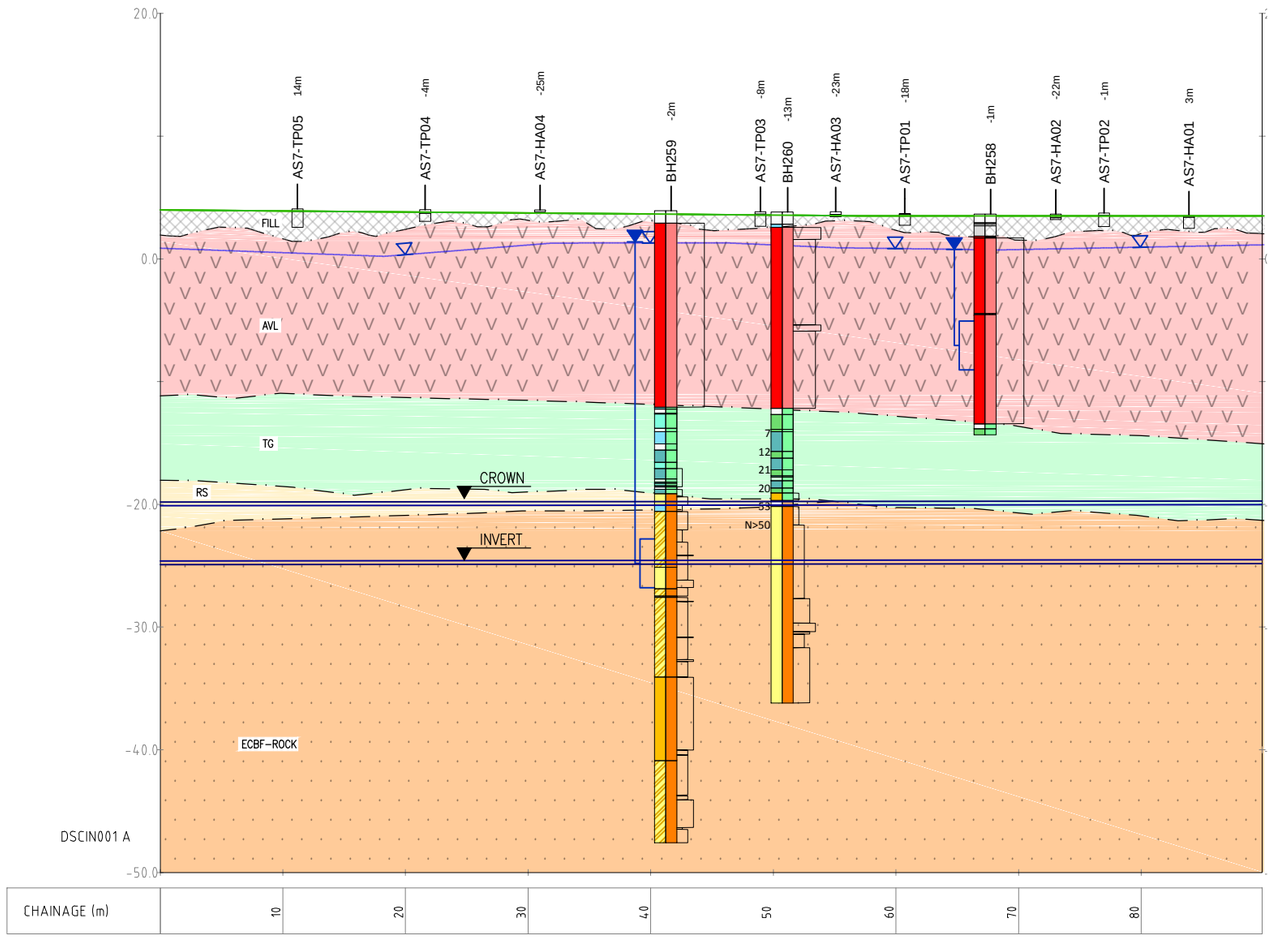
DSCIN001 – KIWI ESPLANADE
SITE GENERAL
SHAFT GEOLOGY – 3D

CAD FILE 2011879.002	DATE 07.06.16
ORIGINAL SCALE A1 N.T.S.	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011879.002	3

Plot Date: Jun 09, 2016 - 2:49pm C:\pw_work\apatel2\dms524391_2011879.002.DWG



HBSI Profile - DSCIN001 A

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT | PLAN AND SECTION | BH RIGHT

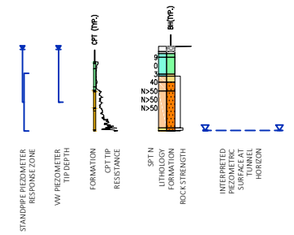
- No core
- Fill and topsoil
- Basalt
- Other volcanics
- Clay and clay dominated mixtures
- Organic clay and organic clay dominated mixtures
- Peat
- Silt and silt dominated mixtures
- Organic silt and organic silt dominated mixtures
- Sand and sand dominated mixtures (clean)
- Sand and sand dominated mixtures (with fines)
- Organic sand and organic sand dominated mixtures
- Sandstone
- Mudstone
- Interbedded mudstone and sandstone
- Conglomerate
- Coal

- Made Ground (FILL)
- Recent Alluvium (Q1a)

TAURANGA GROUP
- Undifferentiated Tauranga Group (TG)
- Kaawa Formation (KAAWA)

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt (AVL)
- Tuff / Ash / Scoria (AVT)

WAITEMATA GROUP (MIOCENE)
- Residually to Highly Weathered - Cohesive Soils (RS)
- Residually to Highly Weathered - Granular Soils (RS)
- Parnell Volcaniclastic Conglomerate (PVC)
- Moderately Weathered to Unweathered ECBF (ECBF-ROCK)



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
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3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

ISSUED FOR USE

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1		PRELIMINARY	KL	

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DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

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INFRASTRUCTURE

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DSCIN001 – KIWI ESPLANADE
SITE GENERAL
SHAFT GEOLOGY – SECTION A

CAD FILE 2011879.003	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
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Plot Date: Jun 10, 2016 - 11:31am
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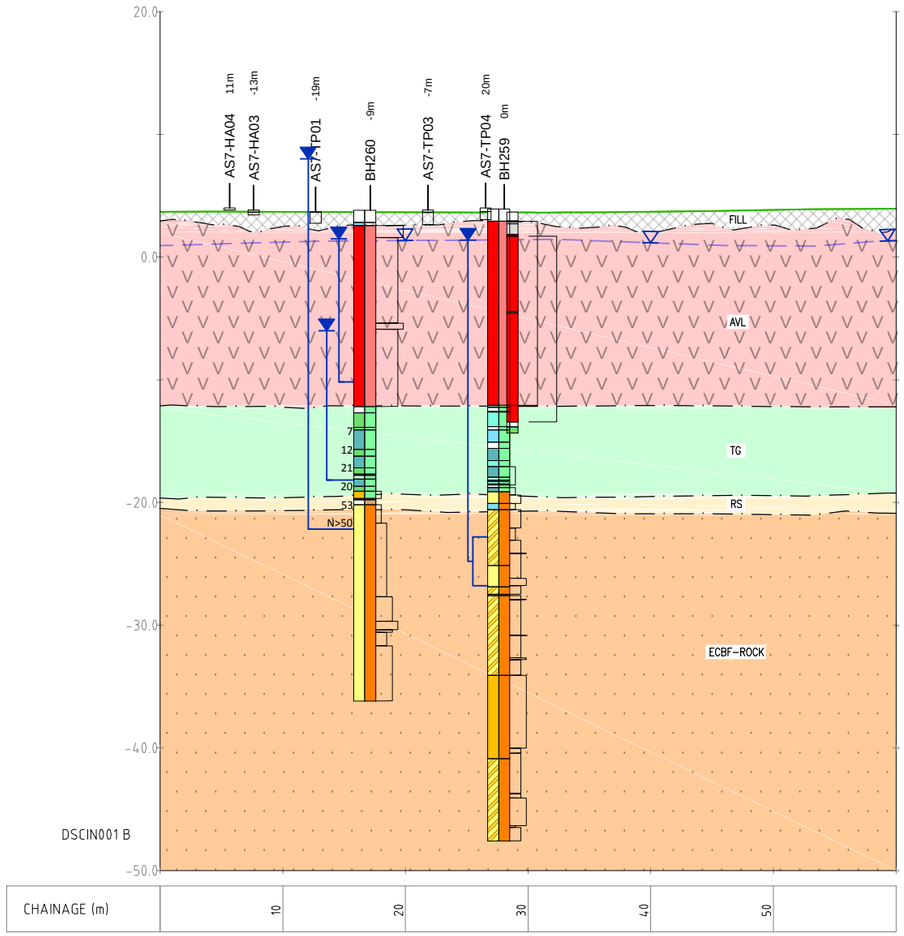


HBSI Profile - DSCIN001 B

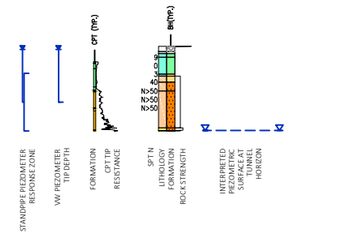
LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT | PLAN AND SECTION | BH RIGHT

- No core
- Fill and topsoil
- Basalt
- Other volcanics
- Clay and clay dominated mixtures
- Organic clay and organic clay dominated mixtures
- Peat
- Silt and silt dominated mixtures
- Organic silt and organic silt dominated mixtures
- Sand and sand dominated mixtures (clean)
- Sand and sand dominated mixtures (with fines)
- Organic sand and organic sand dominated mixtures
- Sandstone
- Mudstone
- Interbedded mudstone and sandstone
- Conglomerate
- Coal

Made Ground (FILL)
Recent Alluvium (Q1a)
TAURANGA GROUP
Undifferentiated Tauranga Group (TG)
Kaawa Formation (KAAWA)
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
Basalt (AVL)
Tuff / Ash / Scoria (AVT)
WAITEMATA GROUP (MIOCENE)
Residually to Highly Weathered - Cohesive Soils (RS)
Residually to Highly Weathered - Granular Soils (RS)
Parnell Volcaniclastic Conglomerate (PVC)
Moderately Weathered to Unweathered ECBF (ECBF-ROCK)



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

ISSUED FOR USE

JACOBS AECOM MWH JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		

OPERATIONS
INFRASTRUCTURE

Watercare

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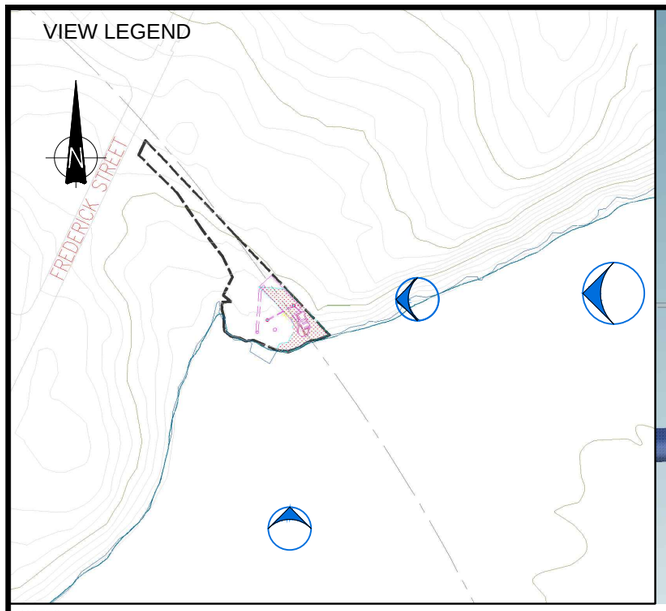
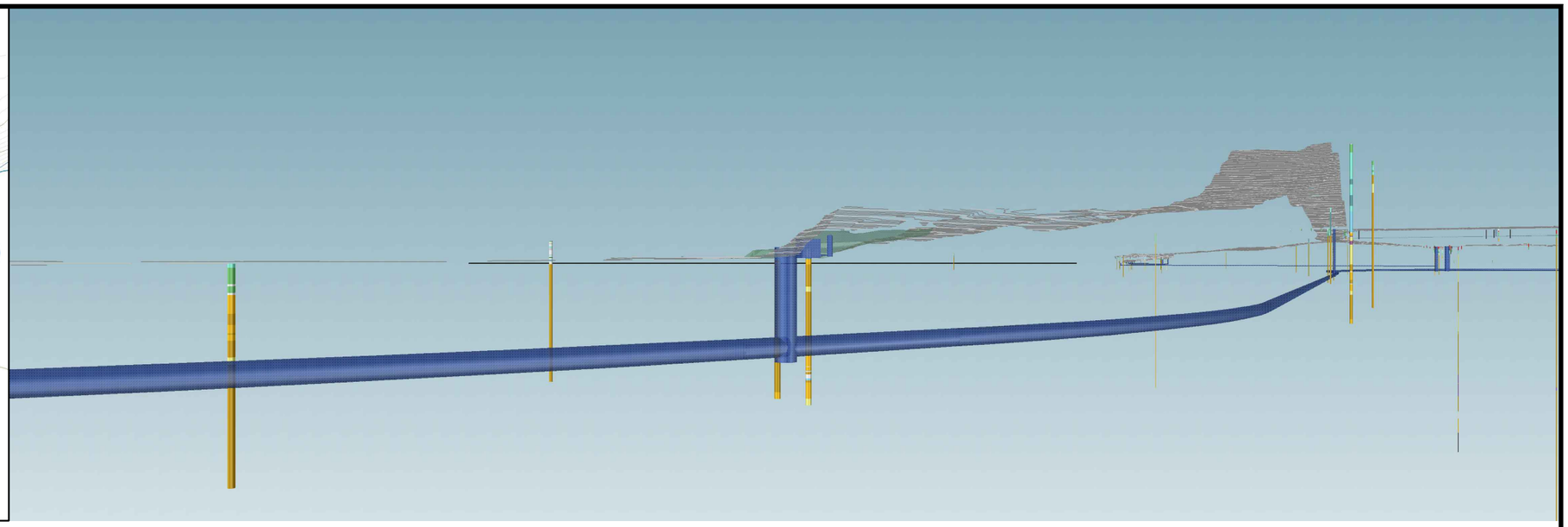
DSCIN001 – KIWI ESPLANADE
SITE GENERAL
SHAFT GEOLOGY – SECTION B

CAD FILE 2011879.004	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011879.004	3

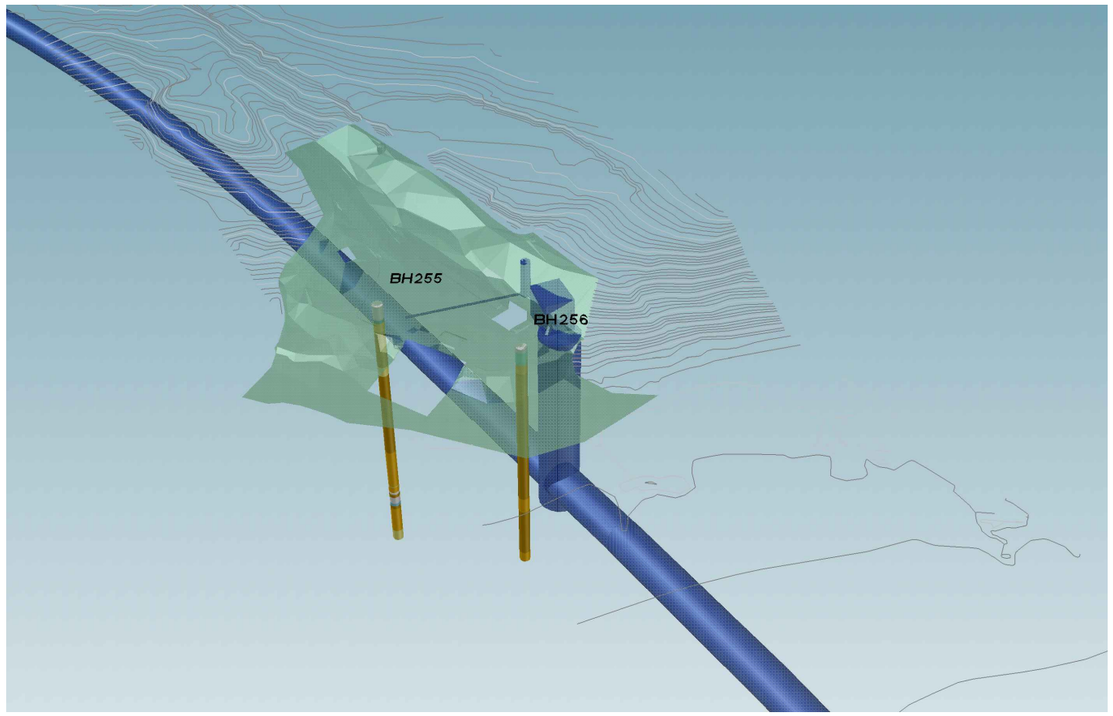
Plot Date: Jun 10, 2016 - 11:33am C:\pw_work\apatel2\dms52439\ 2011879.004.DWG



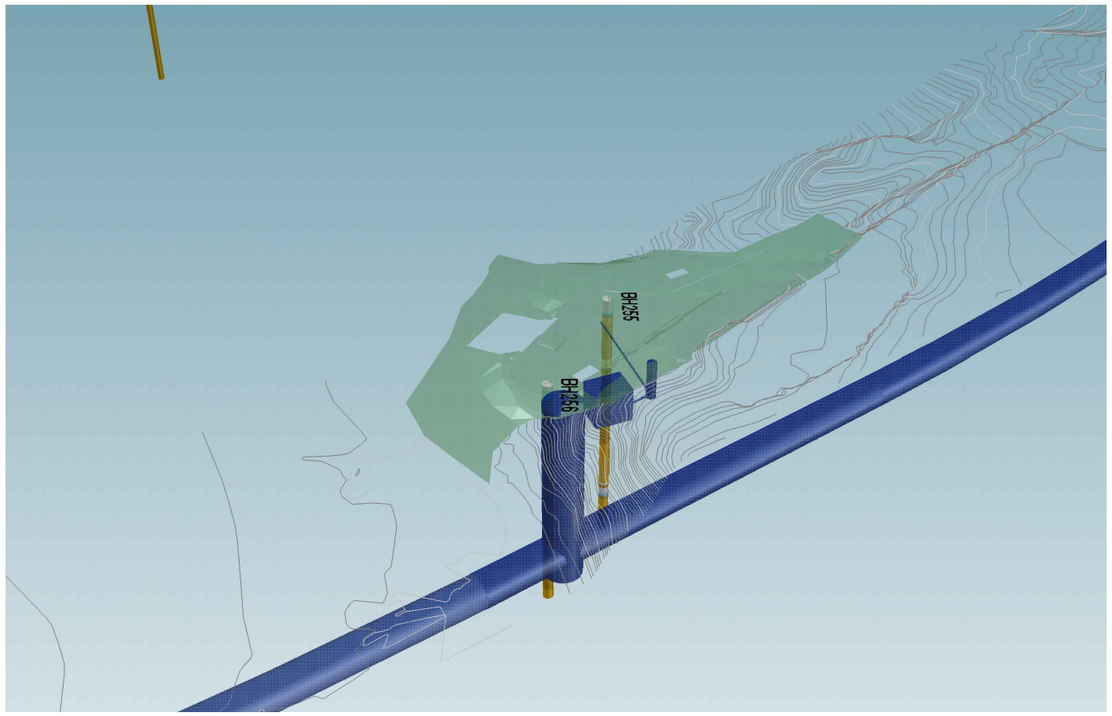


EAST – OVERVIEW

NOTES:
1. GROUND CONTOURS ARE FROM AUCKLAND COUNCIL GIS SOURCES.
2. GROUND SURFACE SHOWN FROM SITE SURVEY BY BECA, 2015.
3. TUNNEL AND SHAFTS ARE FROM DETAILED DESIGN MODEL TO MAY 2016 AND ARE INDICATIVE ONLY.
4. 3D BOREHOLE STICKS ARE EXTRACTED DIRECTLY FROM CI PROJECT GEOTECHNICAL DATABASE, AND ARE COLOURED BY GEOLOGICAL FORMATION – REFER TO LONG SECTIONS FOR KEY.



SOUTH VIEW



EAST VIEW

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

INFRASTRUCTURE

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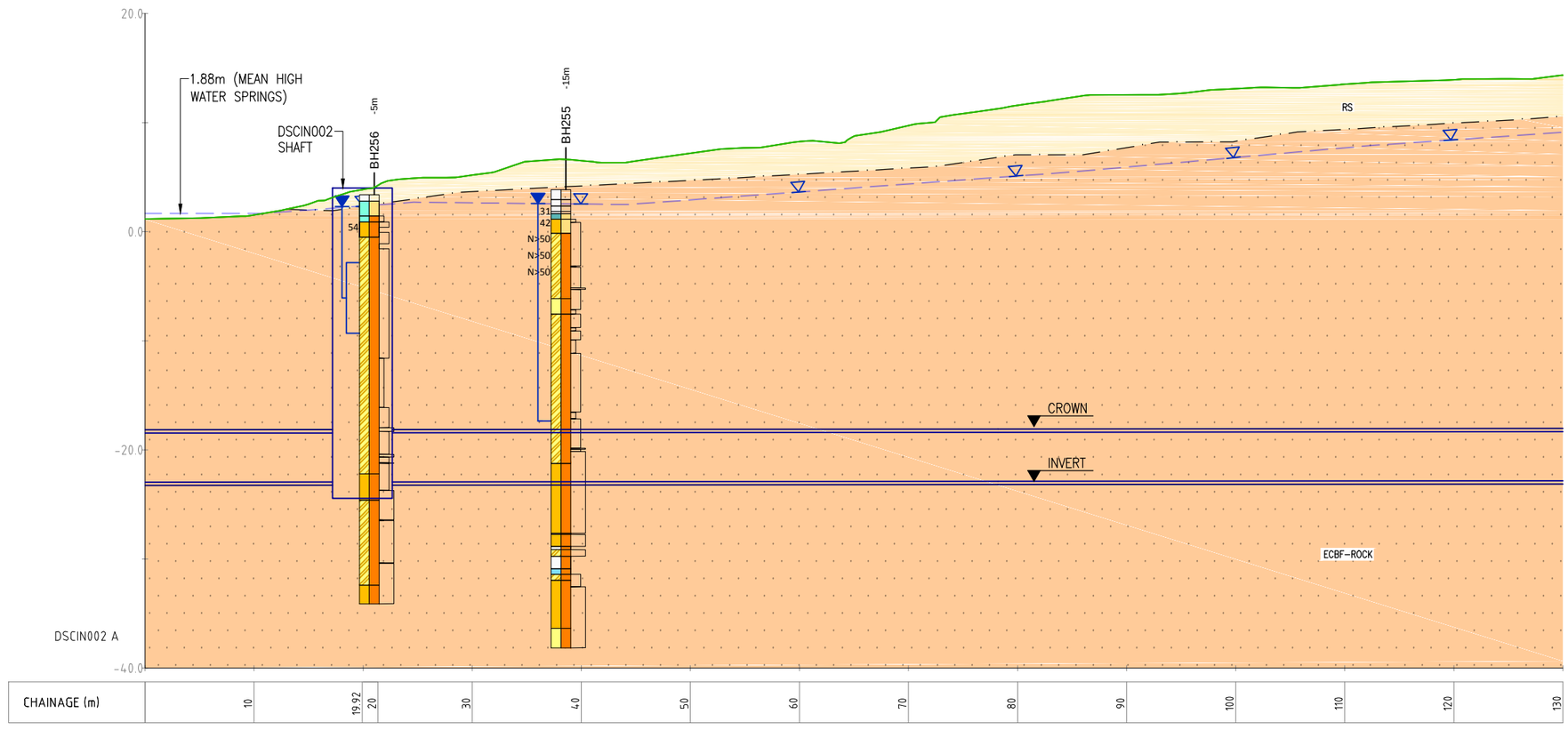
DSCIN002 – PS23
SITE GENERAL
SHAFT GEOLOGY – 3D

CAD FILE 2011880.002 | DATE 07.06.16
ORIGINAL SCALE A1 N.T.S. | CONTRACT No. 5747
REF. No. CI–GEOTECH | ISSUE
DWG. No. 2011880.002 | 3

Plot Date: Jun 09, 2016 - 2:57pm C:\pw_work\apatel2\dms524\15\2011880.002.DWG

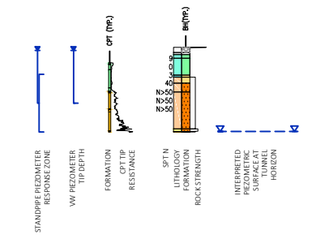


HBSI Profile - DSCIN002 A

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT	PLAN AND SECTION	BH RIGHT	
No core			Made Ground (FILL)
Fill and topsoil			Recent Alluvium (Q1a)
Basalt			TAURANGA GROUP
Other volcanics			
Clay and clay dominated mixtures			Undifferentiated Tauranga Group (TG)
Organic clay and organic clay dominated mixtures			Kaawa Formation (KAAWA)
Peat			AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
Silt and silt dominated mixtures			Basalt (AVL)
Organic silt and organic silt dominated mixtures			Tuff / Ash / Scoria (AVT)
Sand and sand dominated mixtures (clean)			WAITEMATA GROUP (MIOCENE)
Sand and sand dominated mixtures (with fines)			Residually to Highly Weathered - Cohesive Soils (RS)
Organic sand and organic sand dominated mixtures			Residually to Highly Weathered - Granular Soils (RS)
Sandstone			Parnell Volcaniclastic Conglomerate (PVC)
Mudstone			Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
Interbedded mudstone and sandstone			
Conglomerate			
Coal			



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
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3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
BY		DATE

OPERATIONS

INFRASTRUCTURE

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DSCIN002 – PS23
SITE GENERAL
SHAFT GEOLOGY – SECTION A

CAD FILE 2011880.003	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011880.003	3

Plot Date: Jun 09, 2016 - 2:58pm
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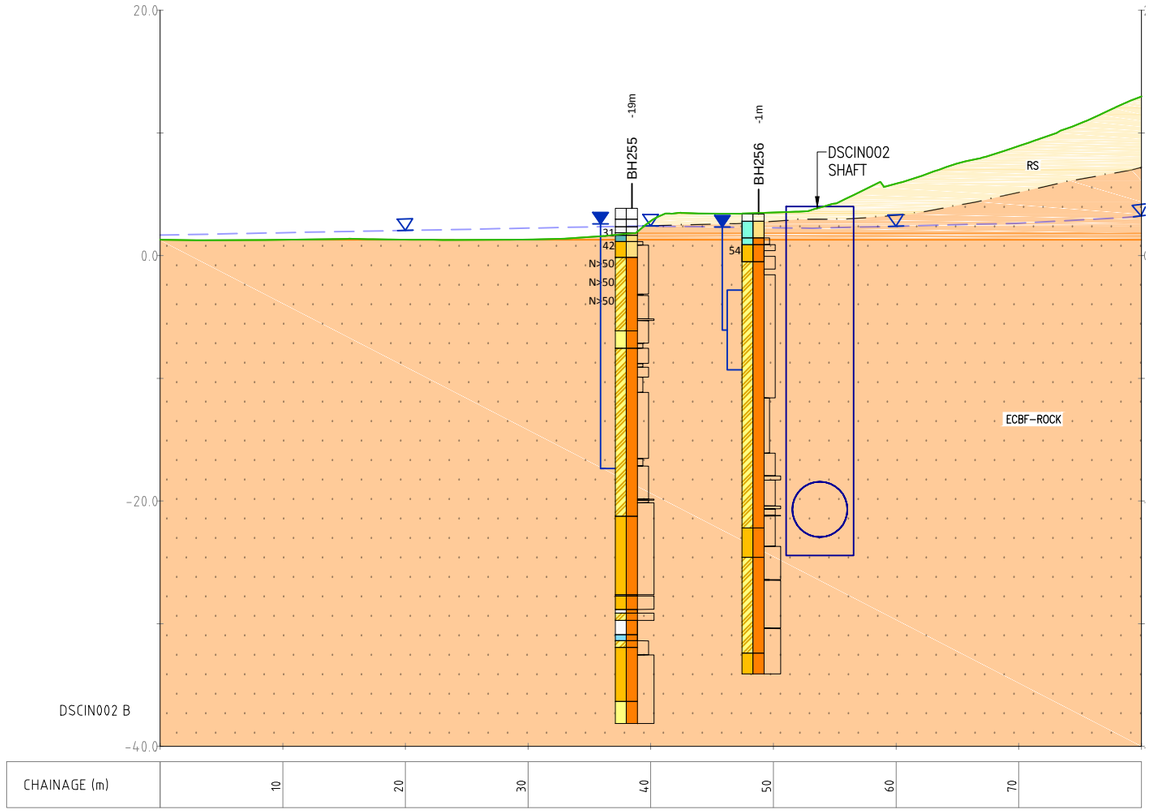
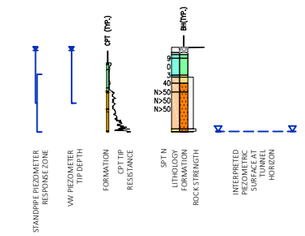


HBSI Profile - DSCIN002 B

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT	PLAN AND SECTION	BH RIGHT	
			No core
			Made Ground (FILL)
			Fill and topsoil
			Recent Alluvium (Q1a)
			Basalt
			TAURANGA GROUP
			Other volcanics
			Undifferentiated Tauranga Group (TG)
			Clay and clay dominated mixtures
			Organic clay and organic clay dominated mixtures
			Kaawa Formation (KAAWA)
			Peat
			AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
			Silt and silt dominated mixtures
			Basalt (AVL)
			Organic silt and organic silt dominated mixtures
			Tuff / Ash / Scoria (AVT)
			Sand and sand dominated mixtures (clean)
			WAITEMATA GROUP (MIOCENE)
			Sand and sand dominated mixtures (with fines)
			Residually to Highly Weathered - Cohesive Soils (RS)
			Organic sand and organic sand dominated mixtures
			Residually to Highly Weathered - Granular Soils (RS)
			Sandstone
			Parnell Volcaniclastic Conglomerate (PVC)
			Mudstone
			Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
			Interbedded mudstone and sandstone
			Conglomerate
			Coal



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
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4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		

OPERATIONS

INFRASTRUCTURE

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DSCIN002 – PS23
SITE GENERAL
SHAFT GEOLOGY – SECTION B

CAD FILE 2011880.004	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011880.004	3

Plot Date: Jun 10, 2016 - 6:49am
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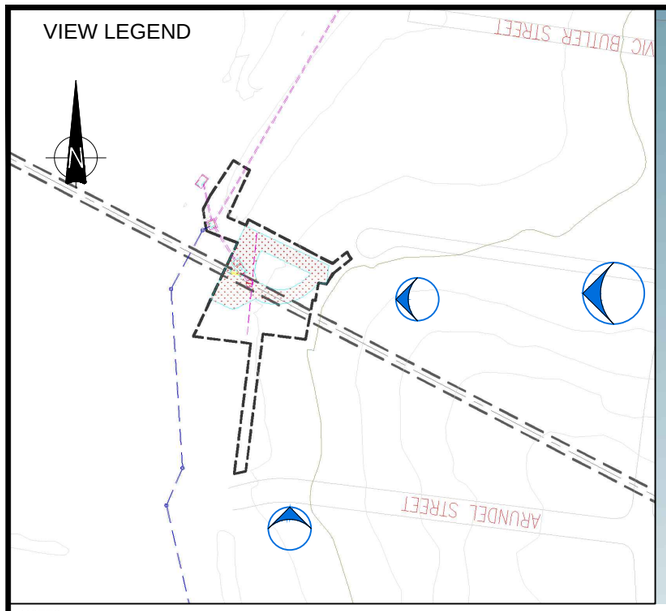
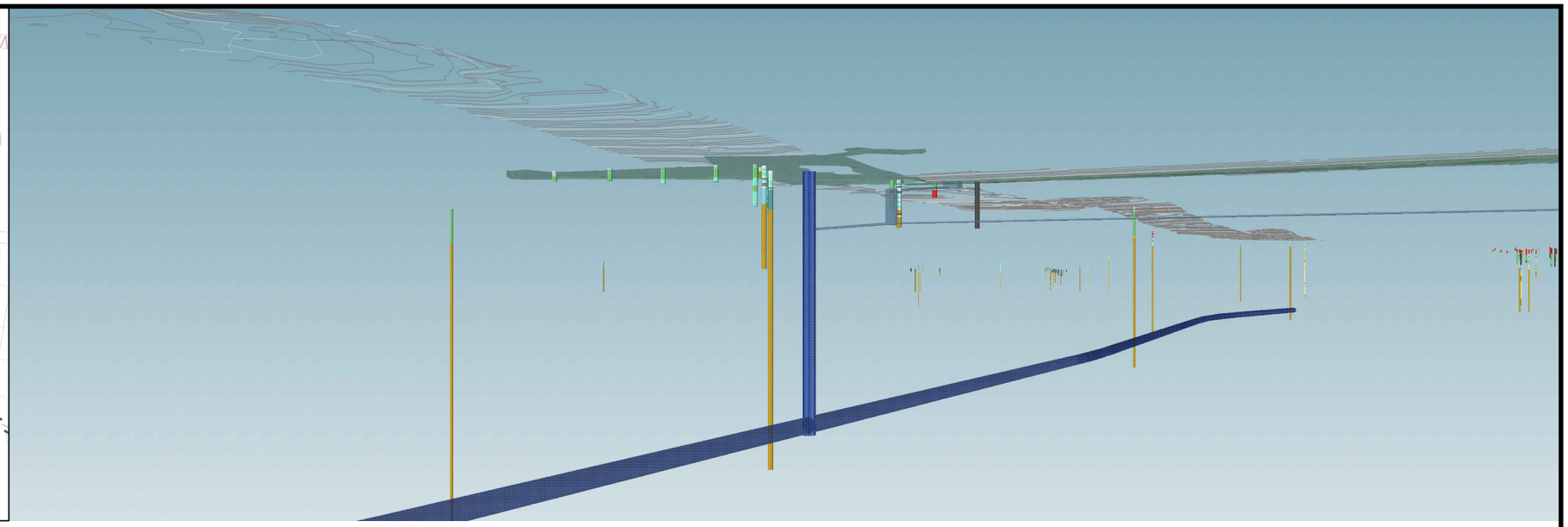
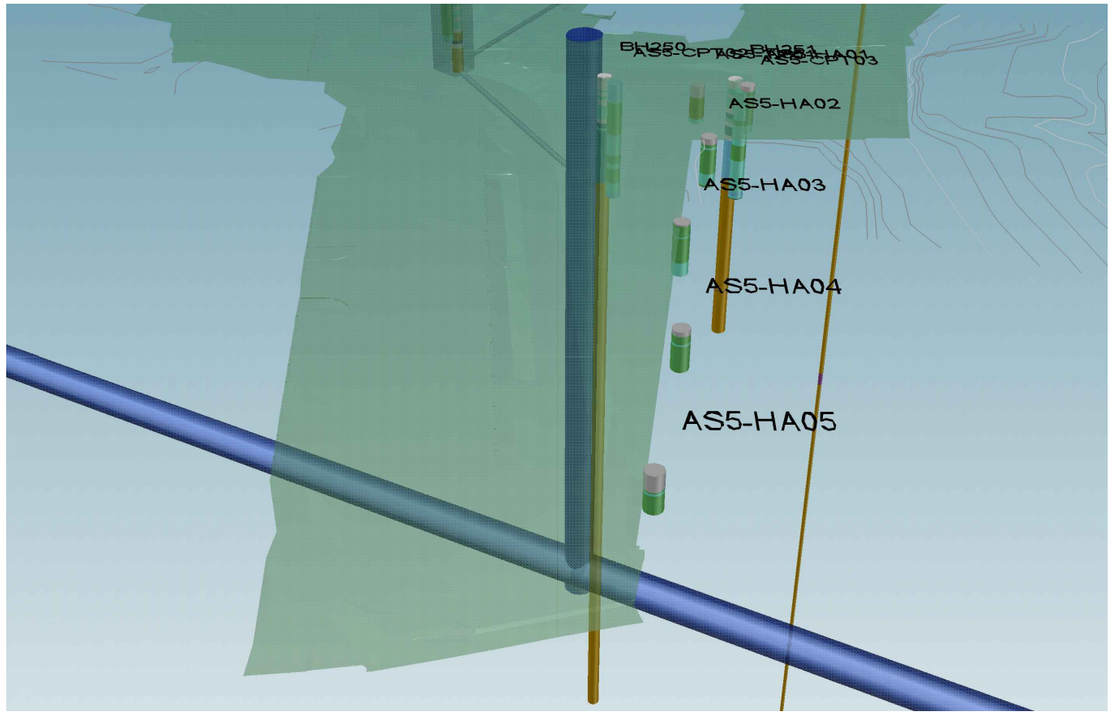


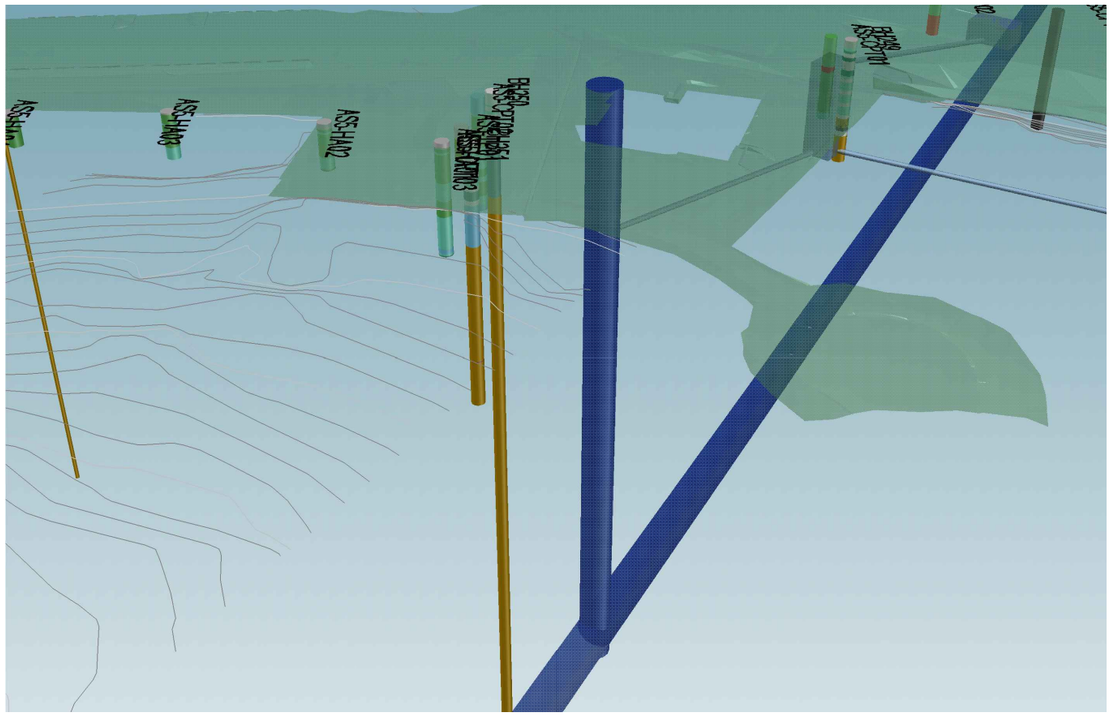


EAST – OVERVIEW

NOTES:
1. GROUND CONTOURS ARE FROM AUCKLAND COUNCIL GIS SOURCES.
2. GROUND SURFACE SHOWN FROM SITE SURVEY BY BECA, 2015.
3. TUNNEL AND SHAFTS ARE FROM DETAILED DESIGN MODEL TO MAY 2016 AND ARE INDICATIVE ONLY.
4. 3D BOREHOLE STICKS ARE EXTRACTED DIRECTLY FROM CI PROJECT GEOTECHNICAL DATABASE, AND ARE COLOURED BY GEOLOGICAL FORMATION – REFER TO LONG SECTIONS FOR KEY.



SOUTH VIEW



EAST VIEW

ISSUED FOR USE

JACOBS AECOM MULLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
BY		DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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DSCIN003 – KEITH HAY PARK
SITE GENERAL
SHAFT GEOLOGY – 3D

CAD FILE 2011881.002	DATE 07.06.16
ORIGINAL SCALE A1 N.T.S.	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011881.002	3

Plot Date: Jun 10, 2016 - 6:59am
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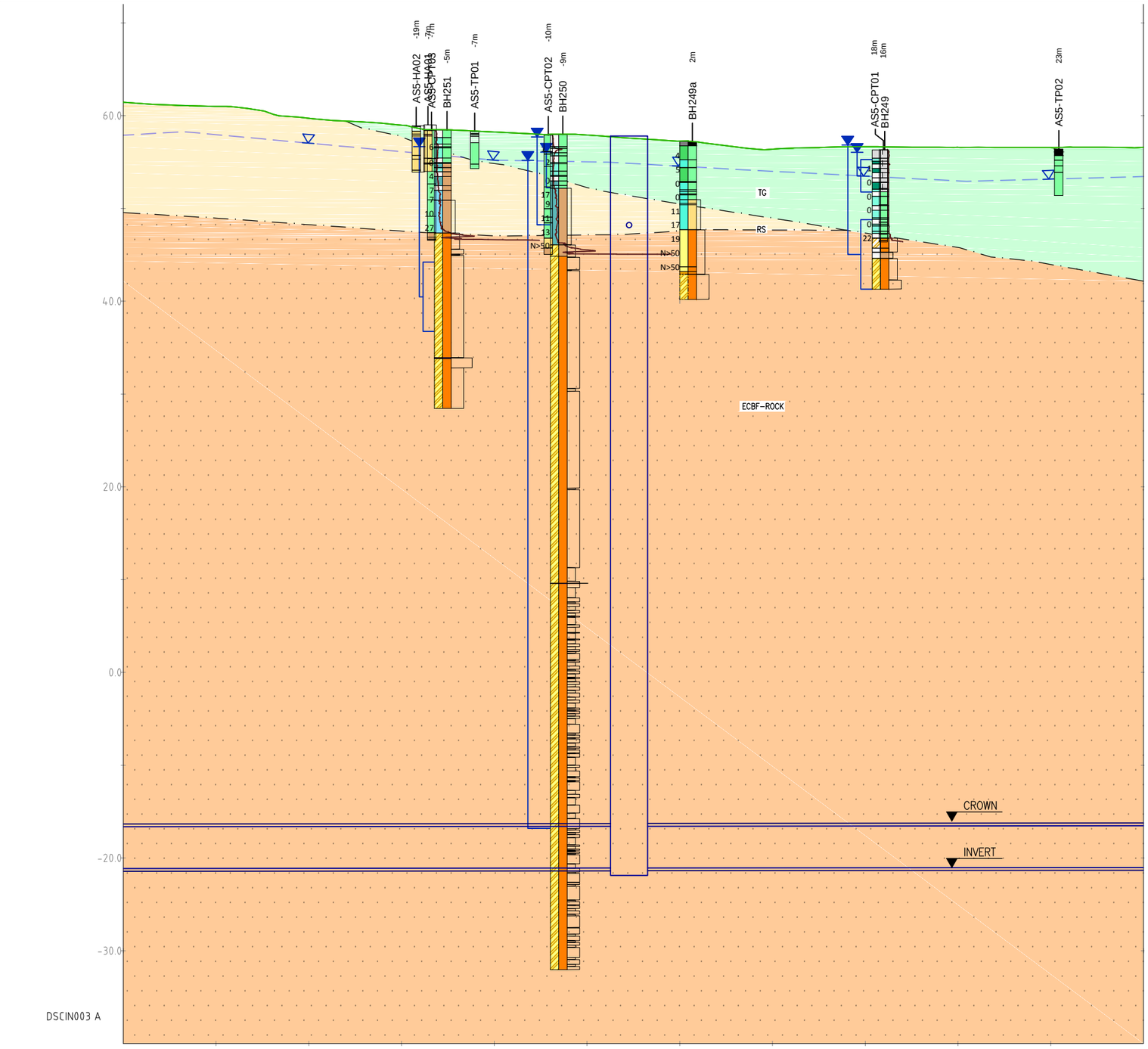


HBSI Profile - DSCIN003 A

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT | PLAN AND SECTION | BH RIGHT

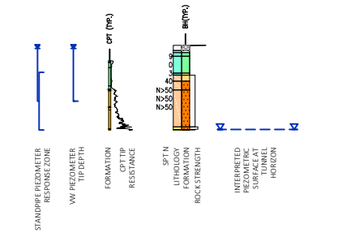
- No core
- Fill and topsoil
- Basalt
- Other volcanics
- Clay and clay dominated mixtures
- Organic clay and organic clay dominated mixtures
- Peat
- Silt and silt dominated mixtures
- Organic silt and organic silt dominated mixtures
- Sand and sand dominated mixtures (clean)
- Sand and sand dominated mixtures (with fines)
- Organic sand and organic sand dominated mixtures
- Sandstone
- Mudstone
- Interbedded mudstone and sandstone
- Conglomerate
- Coal

- Made Ground (FILL)
- Recent Alluvium (Q1a)

TAURANGA GROUP
- Undifferentiated Tauranga Group (TG)
- Kaawa Formation (KAAWA)

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt (AVL)
- Tuff / Ash / Scoria (AVT)

WAITEMATA GROUP (MIOCENE)
- Residually to Highly Weathered - Cohesive Soils (RS)
- Residually to Highly Weathered - Granular Soils (RS)
- Parnell Volcaniclastic Conglomerate (PVC)
- Moderately Weathered to Unweathered ECBF (ECBF-ROCK)



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
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5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
4	03.02.17	REVISED ISSUE - CGI3	KL	ADC
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

	BY	DATE
DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		

OPERATIONS

INFRASTRUCTURE

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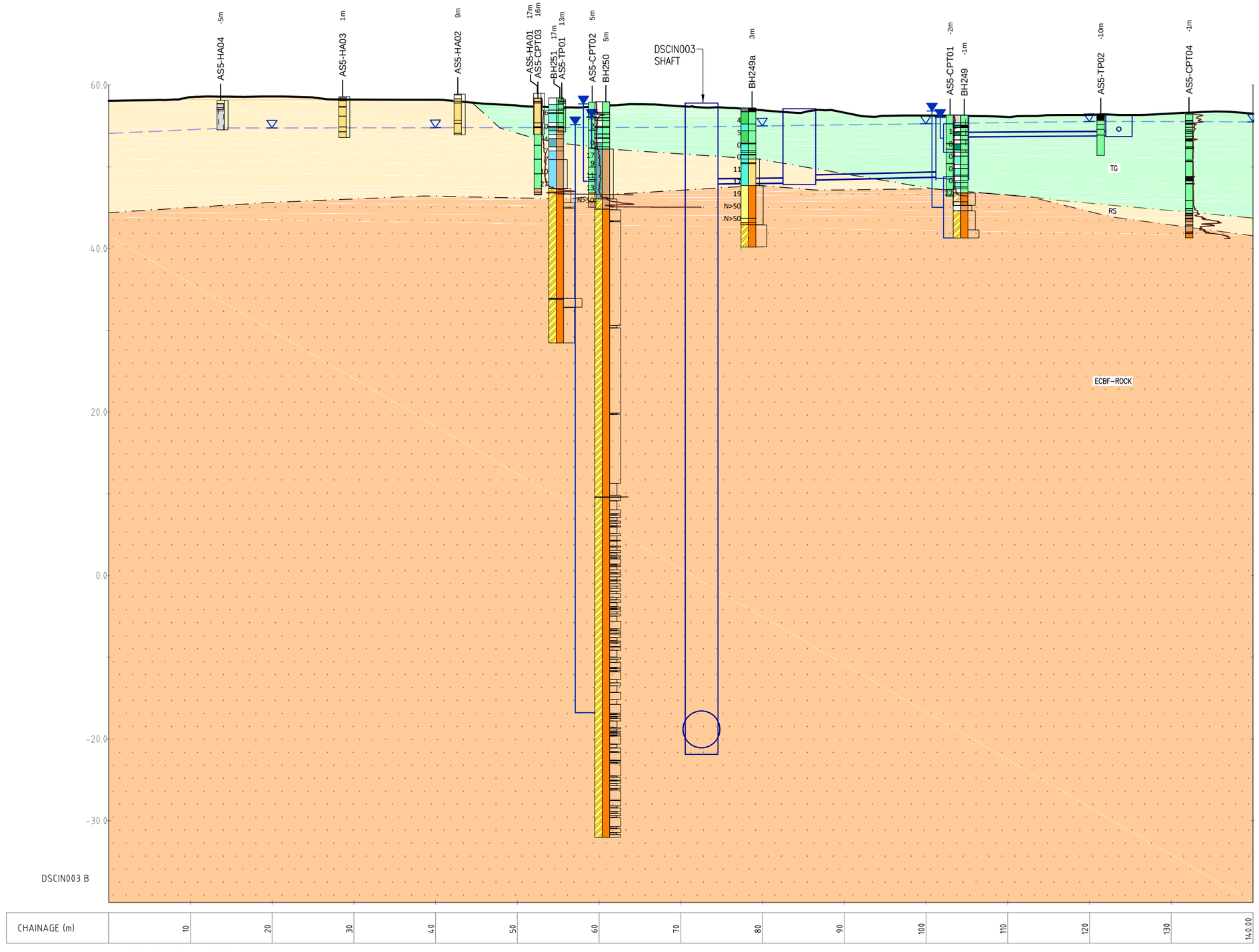
DSCIN003 - KEITH HAY PARK
SITE GENERAL
SHAFT GEOLOGY - SECTION A

CAD FILE 2011881.003 | DATE 03.02.17
ORIGINAL SCALE A1 1:250 | CONTRACT No. 5747
REF. No. CI-GEOTECH | ISSUE
DWG. No. 2011881.003 | 4

Plot Date: Jan 26, 2017 - 10:13am C:\pw_work\sgodfrey\dms5239\1\2011881003.DWG



HBSI Profile - DSCIN003 B

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT | PLAN AND SECTION | BH RIGHT

- No core
- Fill and topsoil
- Basalt
- Other volcanics
- Clay and clay dominated mixtures
- Organic clay and organic clay dominated mixtures
- Peat
- Silt and silt dominated mixtures
- Organic silt and organic silt dominated mixtures
- Sand and sand dominated mixtures (clean)
- Sand and sand dominated mixtures (with fines)
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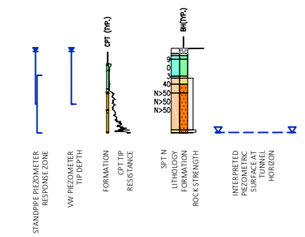
- Mudstone
- Interbedded mudstone and sandstone
- Conglomerate
- Coal

Made Ground (FILL)
Recent Alluvium (Q1a)
TAURANGA GROUP
Undifferentiated Tauranga Group (TG)
Kaawa Formation (KAAWA)
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
Basalt (AVL)
Tuff / Ash / Scoria (AVT)
WAITEMATA GROUP (MIOCENE)
Residually to Highly Weathered - Cohesive Soils (RS)
Residually to Highly Weathered - Granular Soils (RS)
Parnell Volcaniclastic Conglomerate (PVC)
Moderately Weathered to Unweathered ECBF (ECBF-ROCK)



NOTES
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ISSUED FOR USE

JACOBS AECOM MAUNSELL AECOM JACOBS

ISSUE	DATE	AMENDMENT	BY	APPD.
4	03.02.17	REVISED ISSUE - CGI3	KL	ADC
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS
INFRASTRUCTURE

Watercare

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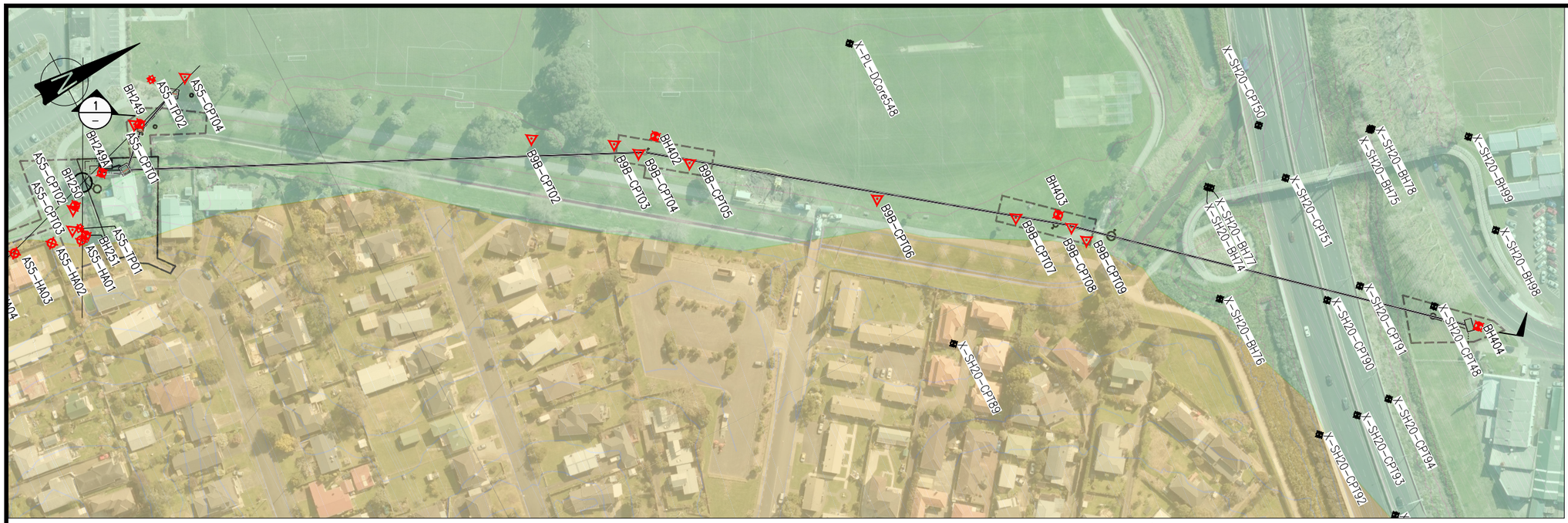
DSCIN003 - KEITH HAY PARK
SITE GENERAL
SHAFT GEOLOGY - SECTION B

CAD FILE 2011881.004 | DATE 03.02.17
ORIGINAL SCALE A1 1:250 | CONTRACT No. 5747
REF. No. CI-GEOTECH | ISSUE
DWG. No. 2011881.004 | 4

Plot Date: Jan 26, 2017 - 10:21am C:\pw_work\sgodfrey\dms5239\\ 2011881004.DWG



LEGEND

BH215 —6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT | PLAN AND SECTION | BH RIGHT

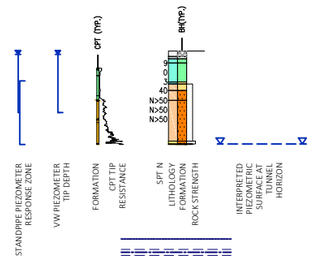
- No core
- Fill and topsoil
- Basalt
- Other volcanics
- Clay and clay dominated mixtures
- Organic clay and organic clay dominated mixtures
- Peat
- Silt and silt dominated mixtures
- Organic silt and organic silt dominated mixtures
- Sand and sand dominated mixtures (clean)
- Sand and sand dominated mixtures (with fines)
- Organic sand and organic sand dominated mixtures
- Sandstone
- Mudstone
- Interbedded mudstone and sandstone
- Conglomerate
- Coal

- Made Ground (FILL)
- Recent Alluvium (Q1a)

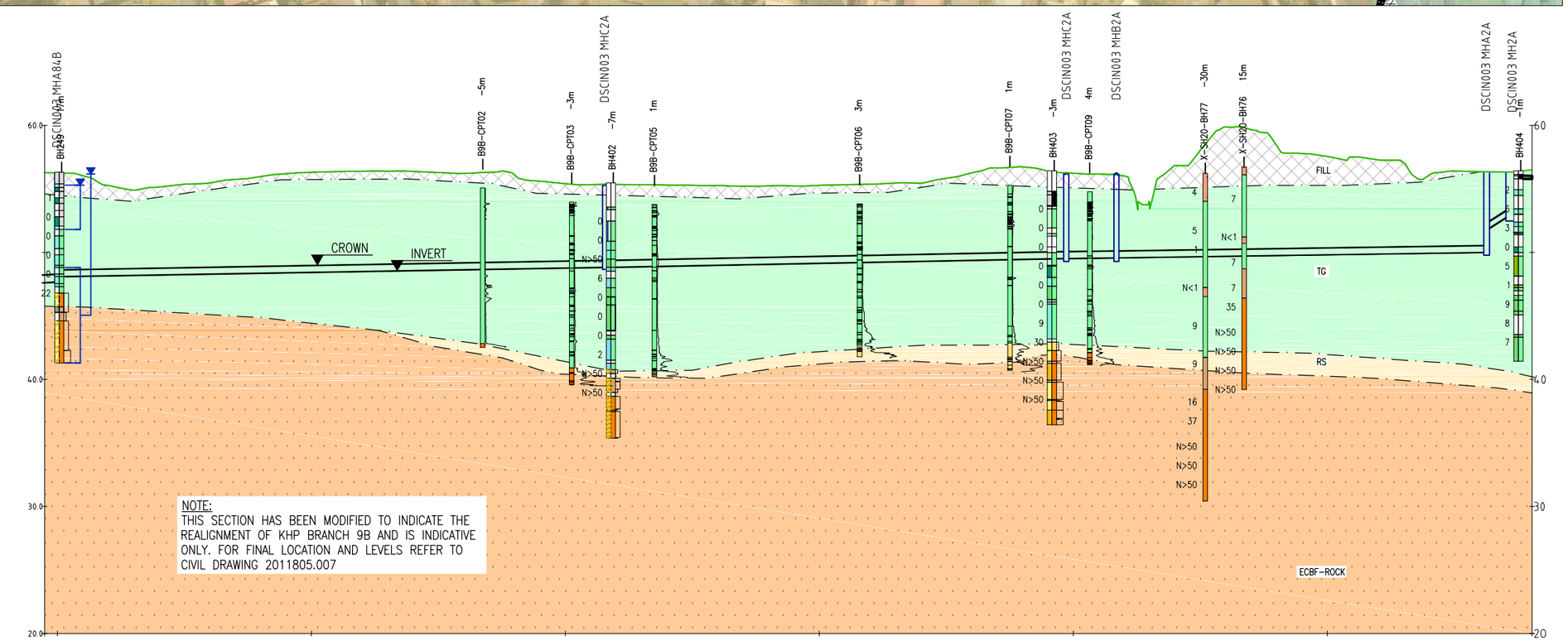
TAURANGA GROUP
- Undifferentiated Tauranga Group (TG)
- Kaawa Formation (KAAWA)

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt (AVL)
- Tuff / Ash / Scoria (AVT)

WAITEMATA GROUP (MIOCENE)
- Residually to Highly Weathered - Cohesive Soils (RS)
- Residually to Highly Weathered - Granular Soils (RS)
- Parnell Volcaniclastic Conglomerate (PV)
- Moderately Weathered to Unweathered ECBF (ECBF-ROCK)



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY. FOR DETAILED GEOTECHNICAL INFORMATION REFER TO THE GEOTECHNICAL FACTUAL REPORT. (PWCIN-DEL-REP-GT-J-100047)



NOTE:
THIS SECTION HAS BEEN MODIFIED TO INDICATE THE REALIGNMENT OF KHP BRANCH 9B AND IS INDICATIVE ONLY. FOR FINAL LOCATION AND LEVELS REFER TO CIVIL DRAWING 2011805.007

CHAINAGE (m)	100	200	300	400	500	600
GROUND LEVEL (mRL)	56.24	56.30	55.41	55.28	56.23	57.55
CROWN LEVEL (mRL)	48.66	49.00	49.35	49.72	50.10	50.39
INVERT LEVEL (mRL)	48.09	48.43	48.78	49.15	49.53	49.82

ISSUED FOR USE

ISSUE	DATE	AMENDMENT	BY	APPD.
4	03.02.17	REVISED ISSUE – CGI3	KL	ADC
3	07.06.16	ISSUED FOR USE	AP	ADC
2	27.11.15	ISSED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		

OPERATIONS

INFRASTRUCTURE

Watercare

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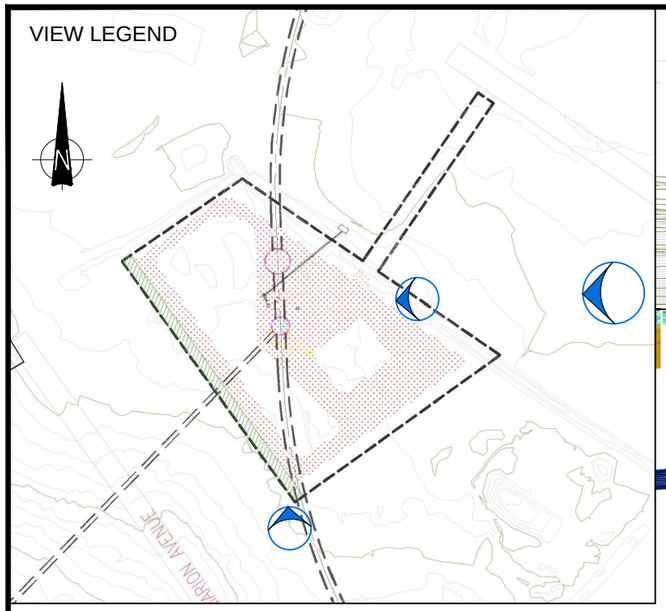
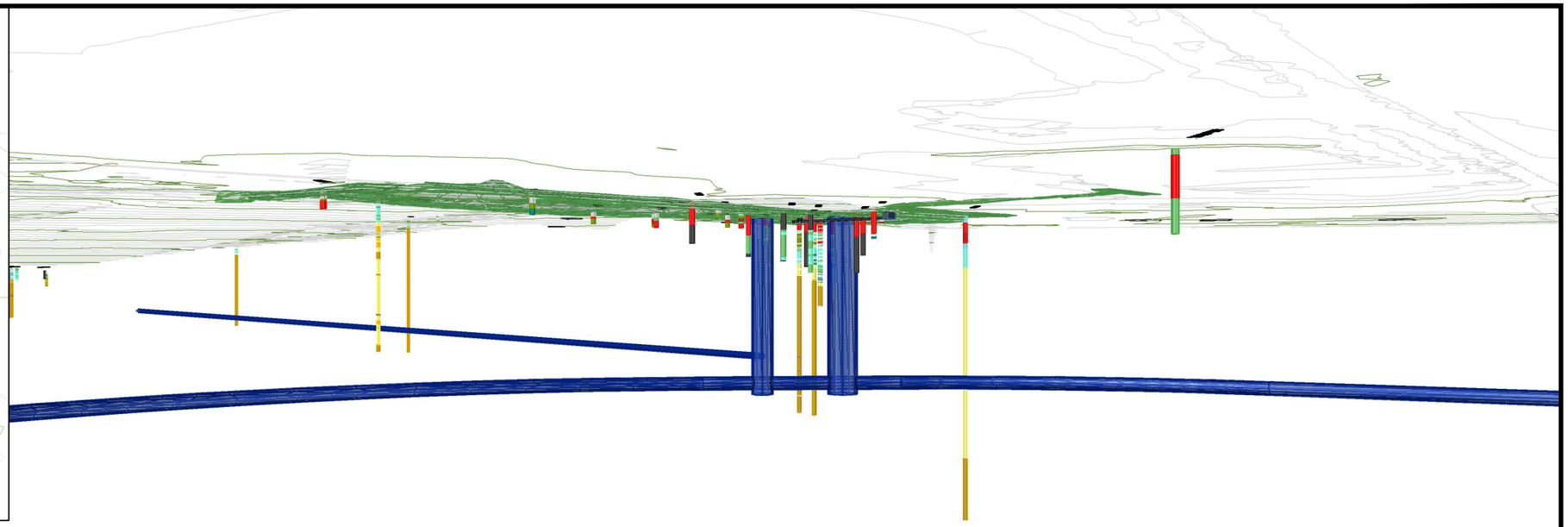
DSCIN003 – KEITH HAY PARK
SITE GENERAL
SHAFT GEOLOGY – KHP BRANCH 9B– PLAN AND SECTION

CAD FILE 2011881.005	DATE 03.02.17
ORIGINAL SCALE A1 1:1000	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011881.005	4

Plot Date: Jan 26, 2017 - 10:45am C:\pw_work\sgodfrey\dms5239\1\2011881005.DWG

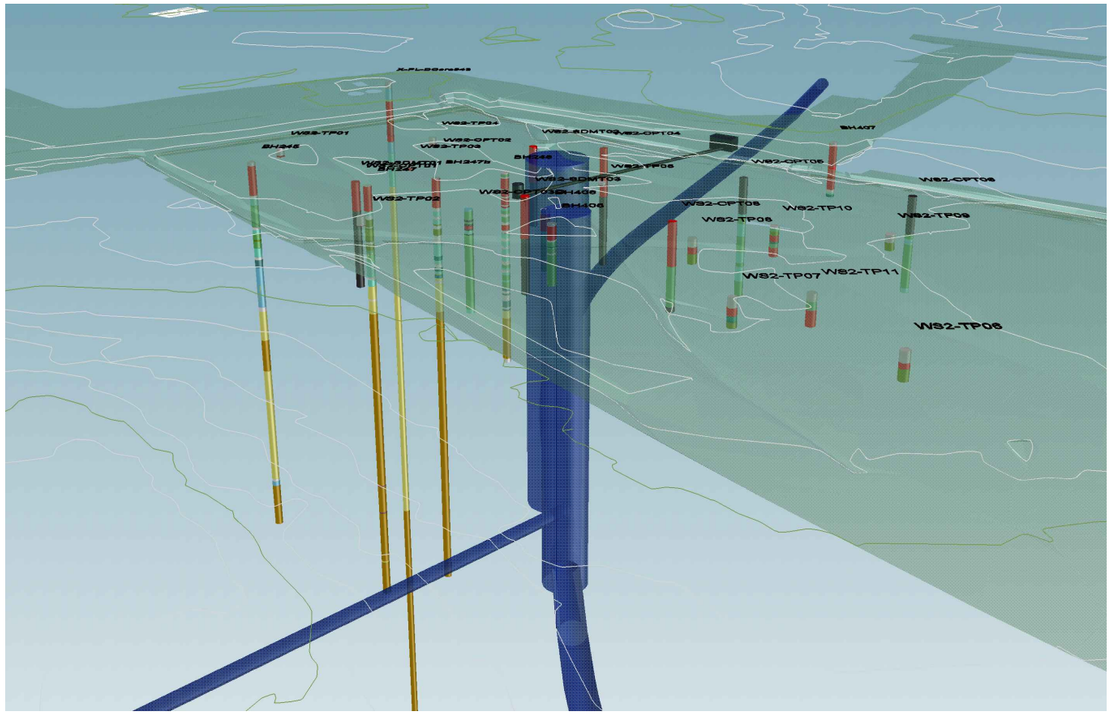
VIEW LEGEND



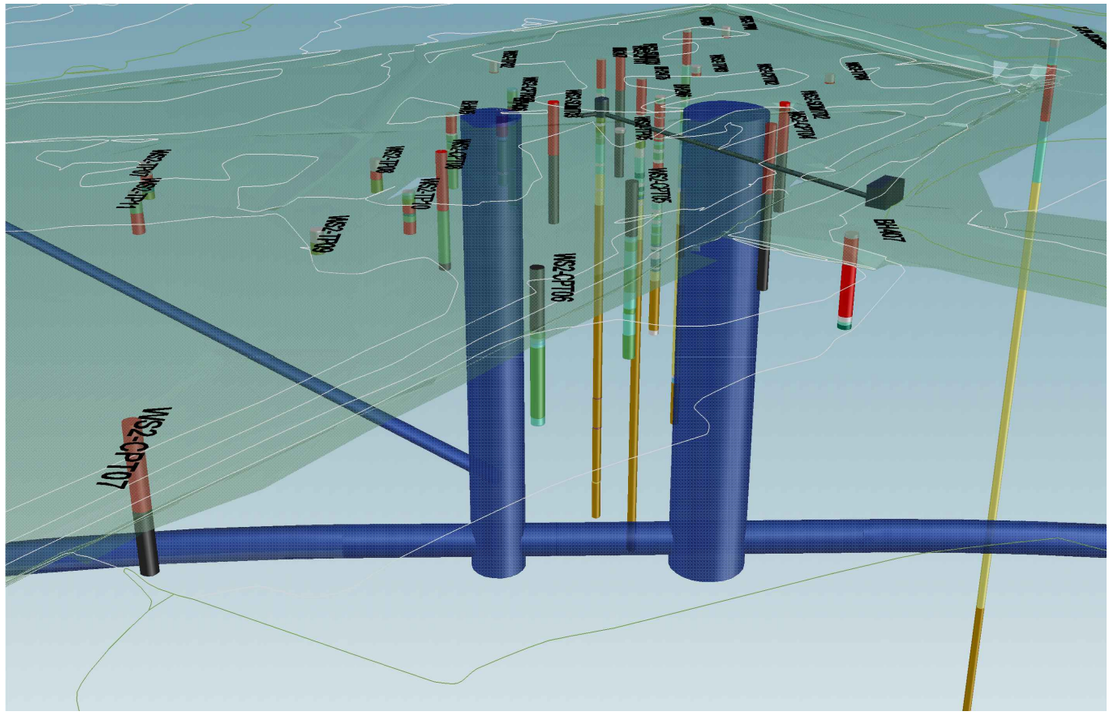


EAST – OVERVIEW

NOTES:
1. GROUND CONTOURS ARE FROM AUCKLAND COUNCIL GIS SOURCES.
2. GROUND SURFACE SHOWN FROM SITE SURVEY BY BECA, 2015.
3. TUNNEL AND SHAFTS ARE FROM DETAILED DESIGN MODEL TO MAY 2016 AND ARE INDICATIVE ONLY.
4. 3D BOREHOLE STICKS ARE EXTRACTED DIRECTLY FROM CI PROJECT GEOTECHNICAL DATABASE, AND ARE COLOURED BY GEOLOGICAL FORMATION – REFER TO LONG SECTIONS FOR KEY.



SOUTH VIEW



EAST VIEW

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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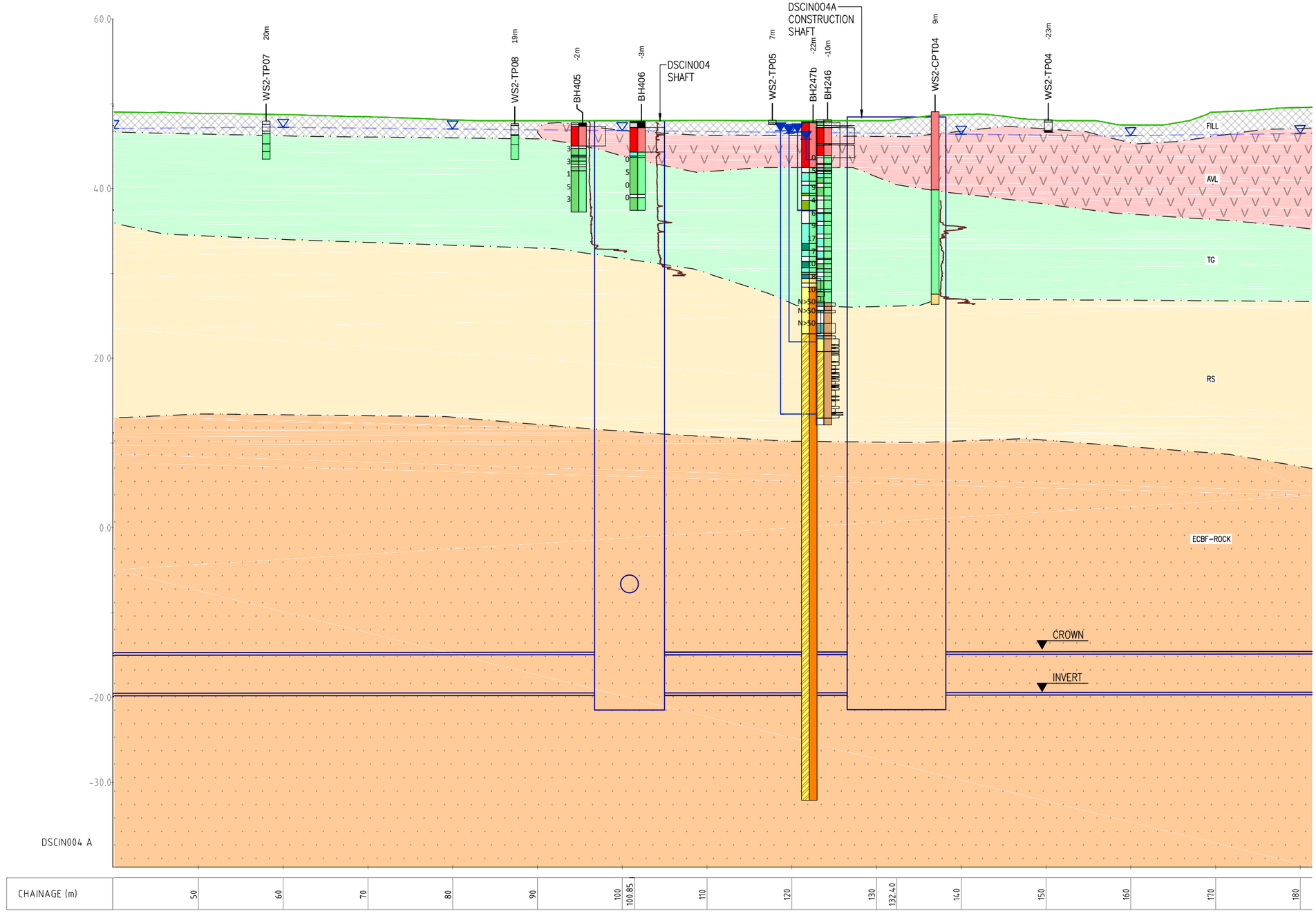
DSCIN004 – MAY ROAD
SITE GENERAL
SHAFT GEOLOGY – 3D

CAD FILE 2011882.002	DATE 07.06.16
ORIGINAL SCALE A1 N.T.S.	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011882.002	3

Plot Date: Jun 10, 2016 - 7:11am
C:\pw_work\apatel2\dms5236?\ 2011882.002.DWG



HBSI Profile – DSCIN004 A

LEGEND

BH215 –6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT | PLAN AND SECTION | BH RIGHT

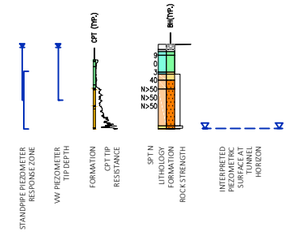
- No core
- Fill and topsoil
- Basalt
- Other volcanics
- Clay and clay dominated mixtures
- Organic clay and organic clay dominated mixtures
- Peat
- Silt and silt dominated mixtures
- Organic silt and organic silt dominated mixtures
- Sand and sand dominated mixtures (clean)
- Sand and sand dominated mixtures (with fines)
- Organic sand and organic sand dominated mixtures
- Sandstone
- Mudstone
- Interbedded mudstone and sandstone
- Conglomerate
- Coal

- Made Ground (FILL)
- Recent Alluvium (Q1a)

TAURANGA GROUP
- Undifferentiated Tauranga Group (TG)
- Kaawa Formation (KAAWA)

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt (AVL)
- Tuff / Ash / Scoria (AVT)

WAITEMATA GROUP (MIOCENE)
- Residually to Highly Weathered - Cohesive Soils (RS)
- Residually to Highly Weathered - Granular Soils (RS)
- Parnell Volcaniclastic Conglomerate (PVC)
- Moderately Weathered to Unweathered ECBF (ECBF-ROCK)



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X–DSCIN–T–001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X–DSLSA(–D)–C–001. DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
BY		DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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DSCIN004 – MAY ROAD
SITE GENERAL
SHAFT GEOLOGY – SECTION A

CAD FILE 2011882.003	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI–GEOTECH	ISSUE
DWG. No. 2011882.003	3

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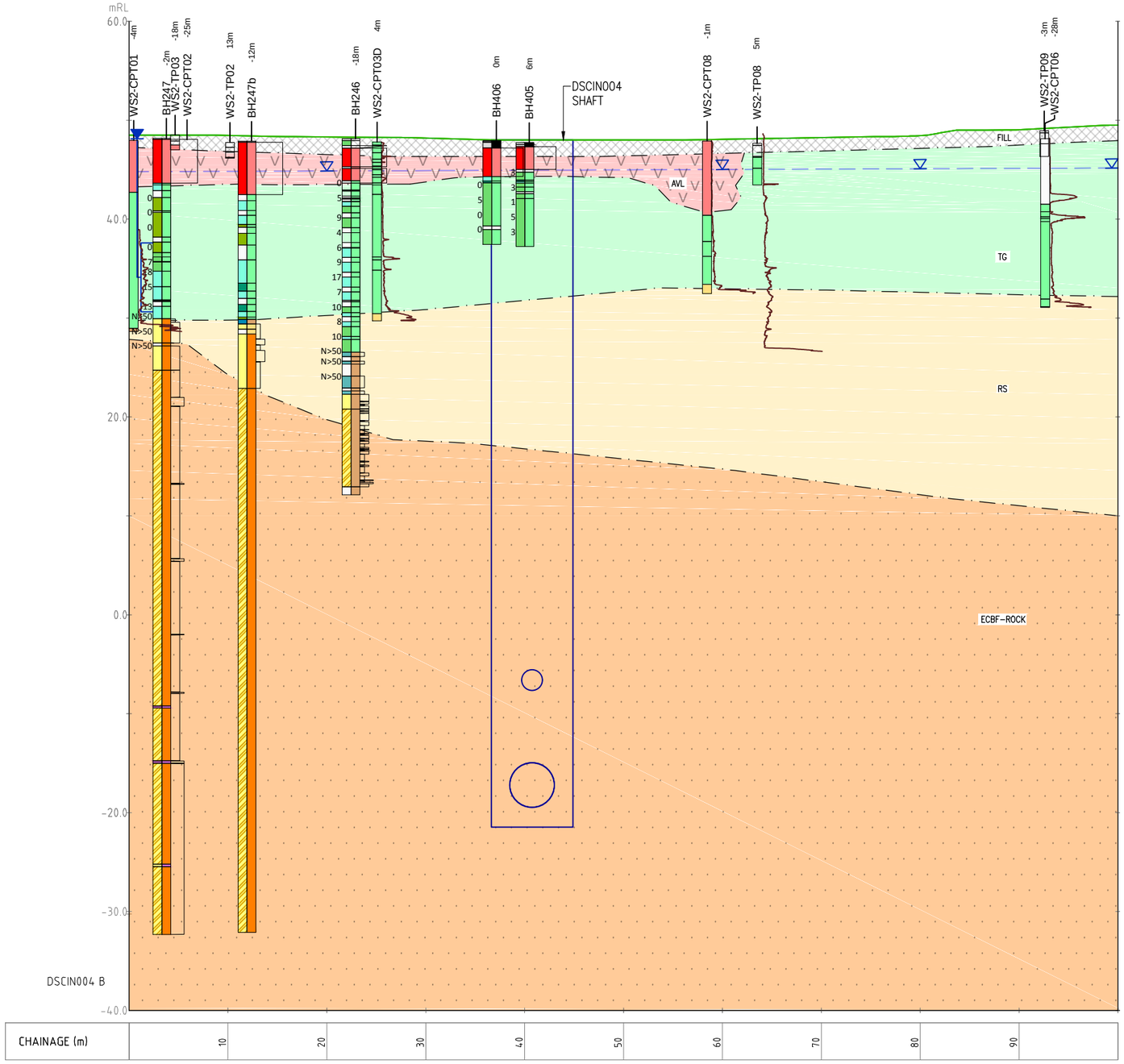

HBSI Profile - DSCIN004 B

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT | PLAN AND SECTION | BH RIGHT

- No core
- Fill and topsoil
- Basalt
- Other volcanics
- Clay and clay dominated mixtures
- Organic clay and organic clay dominated mixtures
- Peat
- Silt and silt dominated mixtures
- Organic silt and organic silt dominated mixtures
- Sand and sand dominated mixtures (clean)
- Sand and sand dominated mixtures (with fines)
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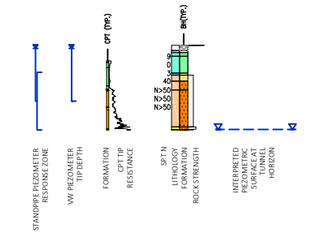
- Mudstone
- Interbedded mudstone and sandstone
- Conglomerate
- Coal

- Made Ground (FILL)
- Recent Alluvium (Q1a)

TAURANGA GROUP
- Undifferentiated Tauranga Group (TG)
- Kaawa Formation (KAAWA)

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt (AVL)
- Tuff / Ash / Scoria (AVT)

WAITEMATA GROUP (MIOCENE)
- Residually to Highly Weathered - Cohesive Soils (RS)
- Residually to Highly Weathered - Granular Soils (RS)
- Parnell Volcaniclastic Conglomerate (PVC)
- Moderately Weathered to Unweathered ECBF (ECBF-ROCK)



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

ISSUED FOR USE

JACOBS AECOM MMILLEN JACOBS

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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DSCIN004 – MAY ROAD
SITE GENERAL
SHAFT GEOLOGY – SECTION B

CAD FILE 2011882.004	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011882.004	3

Plot Date: Jun 10, 2016 - 7:15am
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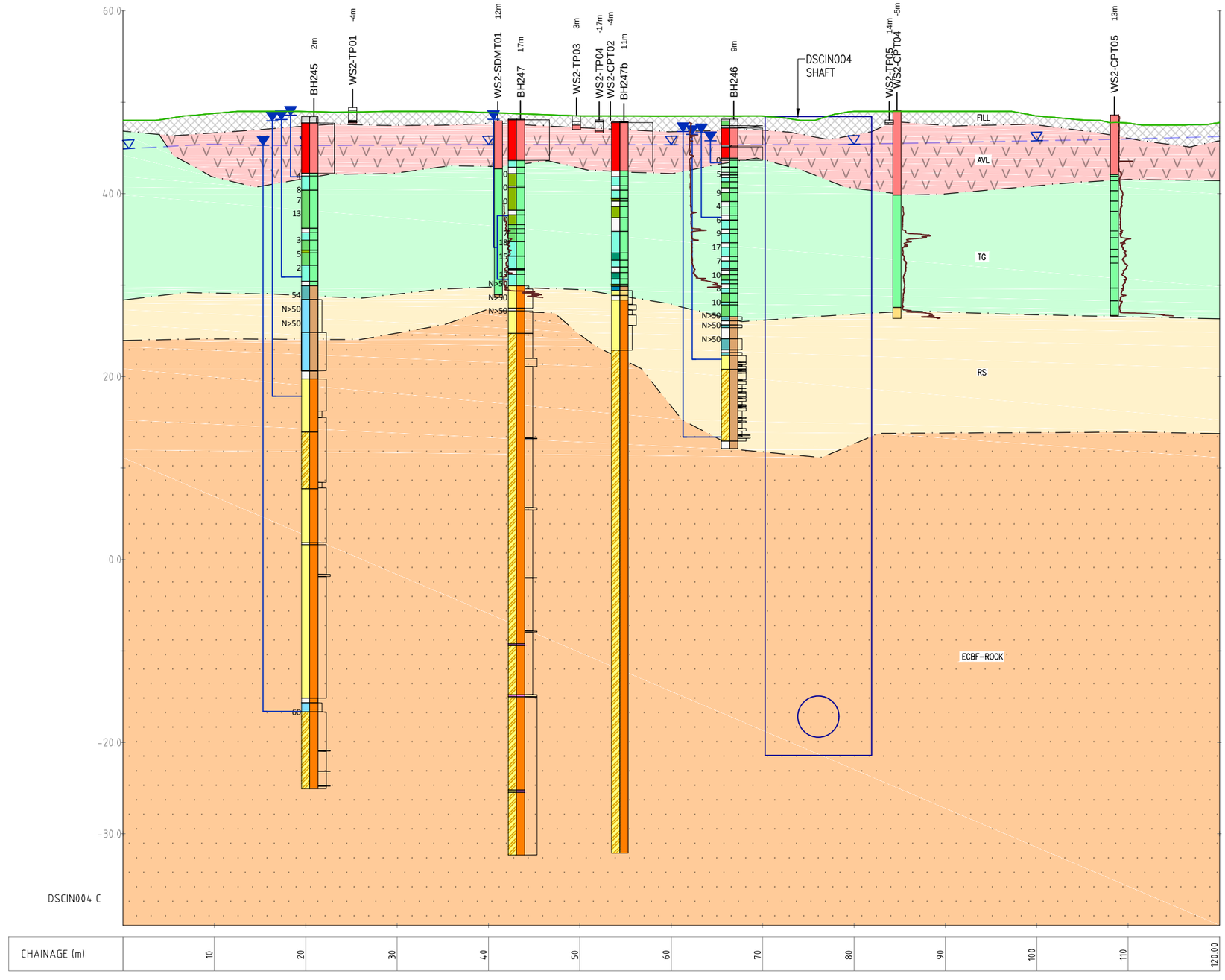


HBSI Profile - DSCIN004 C

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT | PLAN AND SECTION | BH RIGHT

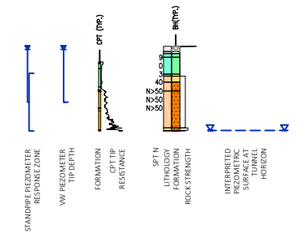
- No core
- Fill and topsoil
- Basalt
- Other volcanics
- Clay and clay dominated mixtures
- Organic clay and organic clay dominated mixtures
- Peat
- Silt and silt dominated mixtures
- Organic silt and organic silt dominated mixtures
- Sand and sand dominated mixtures (clean)
- Sand and sand dominated mixtures (with fines)
- Organic sand and organic sand dominated mixtures
- Sandstone
- Mudstone
- Interbedded mudstone and sandstone
- Conglomerate
- Coal

- Made Ground (FILL)
- Recent Alluvium (Q1a)

TAURANGA GROUP
- Undifferentiated Tauranga Group (TG)
- Kaawa Formation (KAAWA)

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt (AVL)
- Tuff / Ash / Scoria (AVT)

WAITEMATA GROUP (MIOCENE)
- Residually to Highly Weathered - Cohesive Soils (RS)
- Residually to Highly Weathered - Granular Soils (RS)
- Parnell Volcaniclastic Conglomerate (PVC)
- Moderately Weathered to Unweathered ECBF (ECBF-ROCK)



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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DSCIN004 – MAY ROAD
SITE GENERAL
SHAFT GEOLOGY – SECTION C

CAD FILE 2011882.005	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011882.005	3

Plot Date: Jun 10, 2016 - 7:17am
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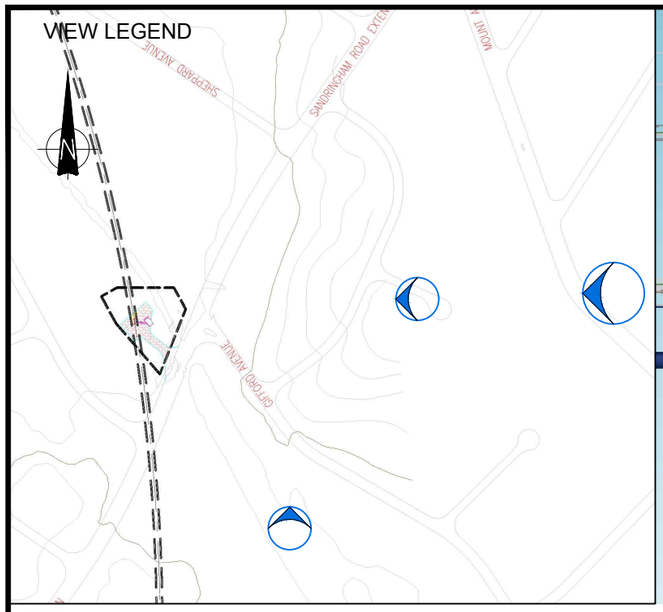
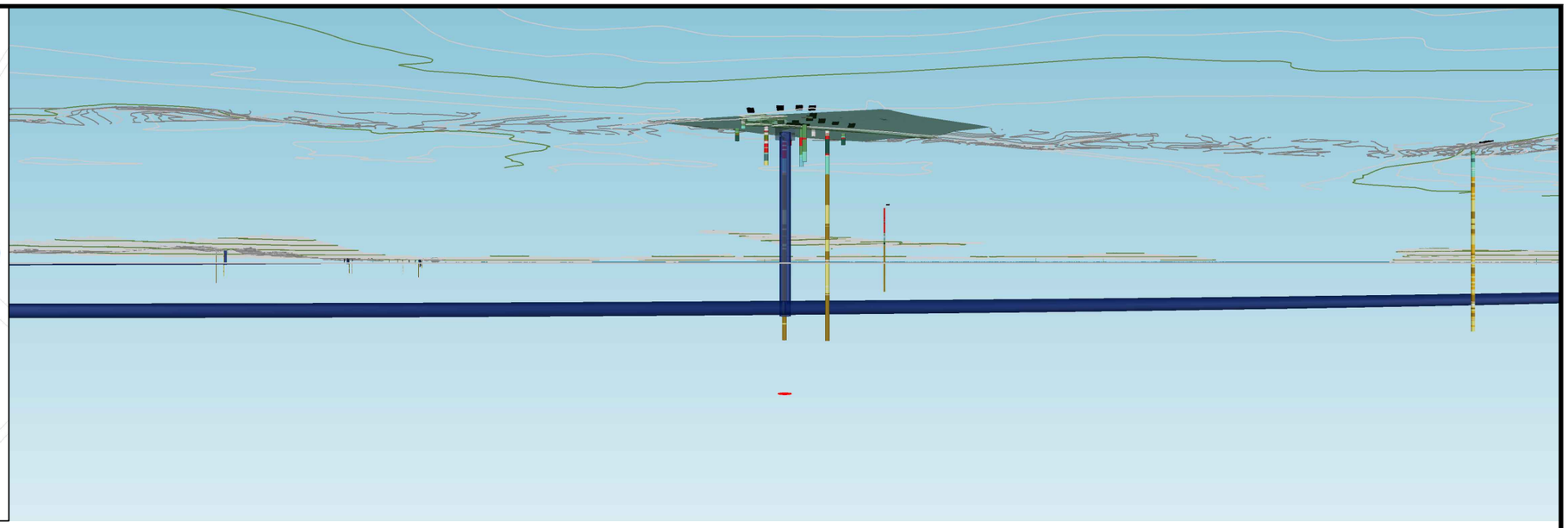
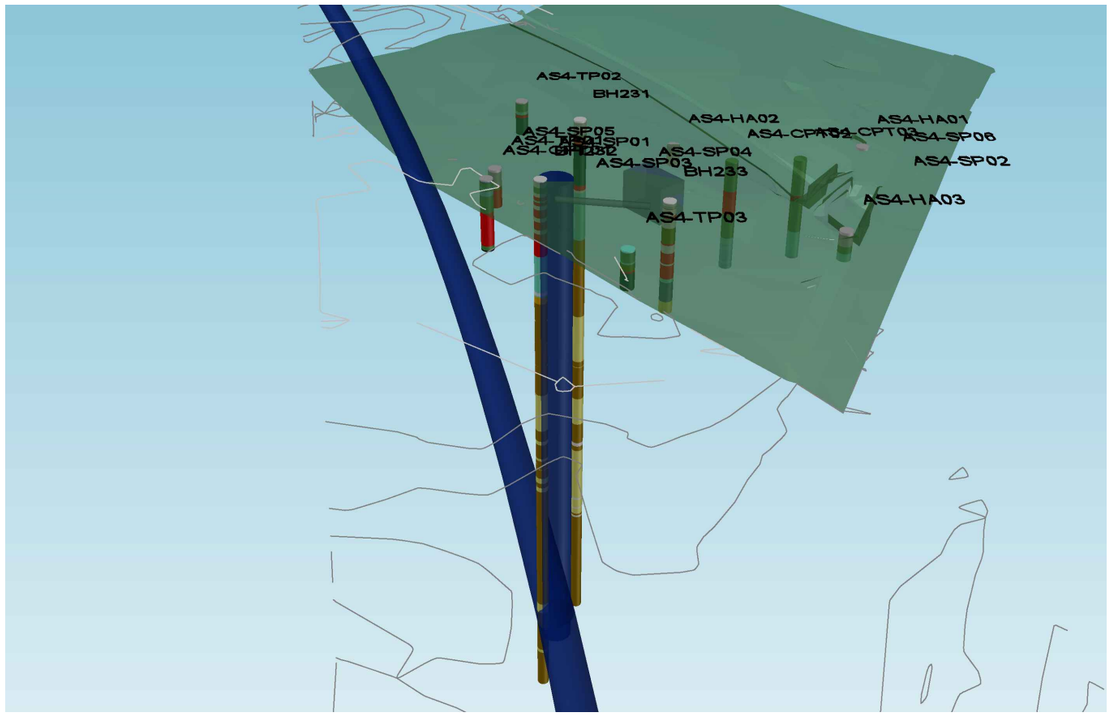


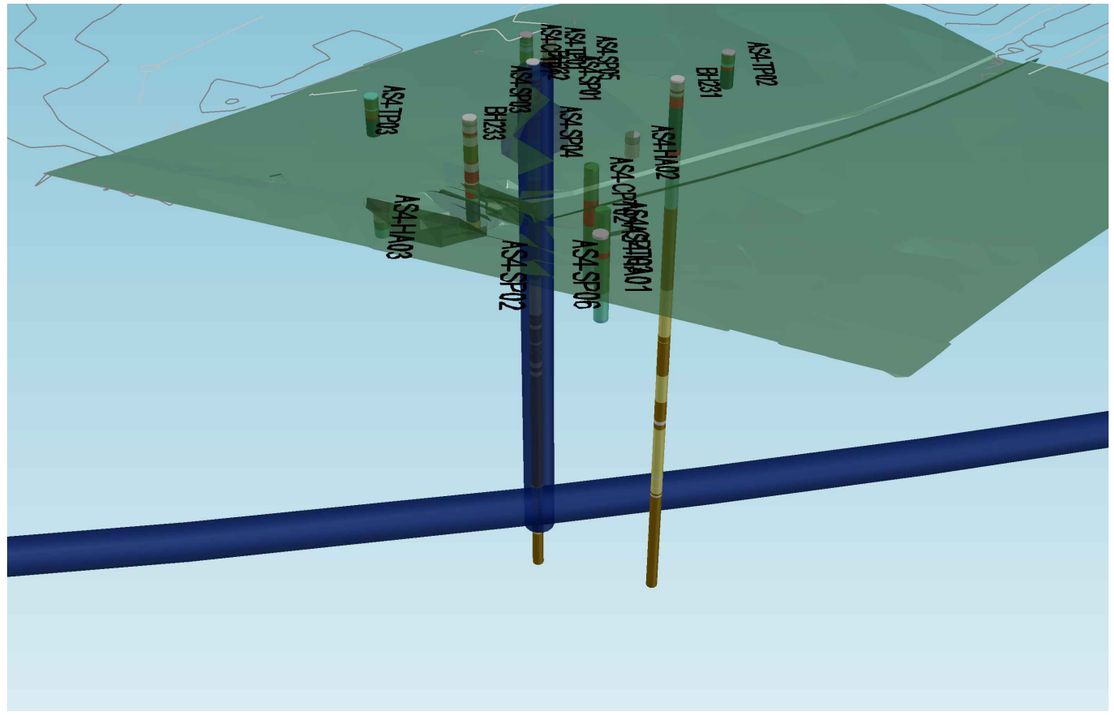


EAST – OVERVIEW

NOTES:
1. GROUND CONTOURS ARE FROM AUCKLAND COUNCIL GIS SOURCES, 2013 DATASET FOR 50m CORRIDOR AND 2006 DATASET BEYOND THAT.
2. GROUND SURFACE SHOWN FROM SITE SURVEY BY BECA, 2015.
3. TUNNEL AND SHAFTS ARE FROM DETAILED DESIGN MODEL TO MAY 2016 AND ARE INDICATIVE ONLY.
4. 3D BOREHOLE STICKS ARE EXTRACTED DIRECTLY FROM CI PROJECT GEOTECHNICAL DATABASE, AND ARE COLOURED BY GEOLOGICAL FORMATION – REFER TO LONG SECTIONS FOR KEY.



SOUTH VIEW



EAST VIEW

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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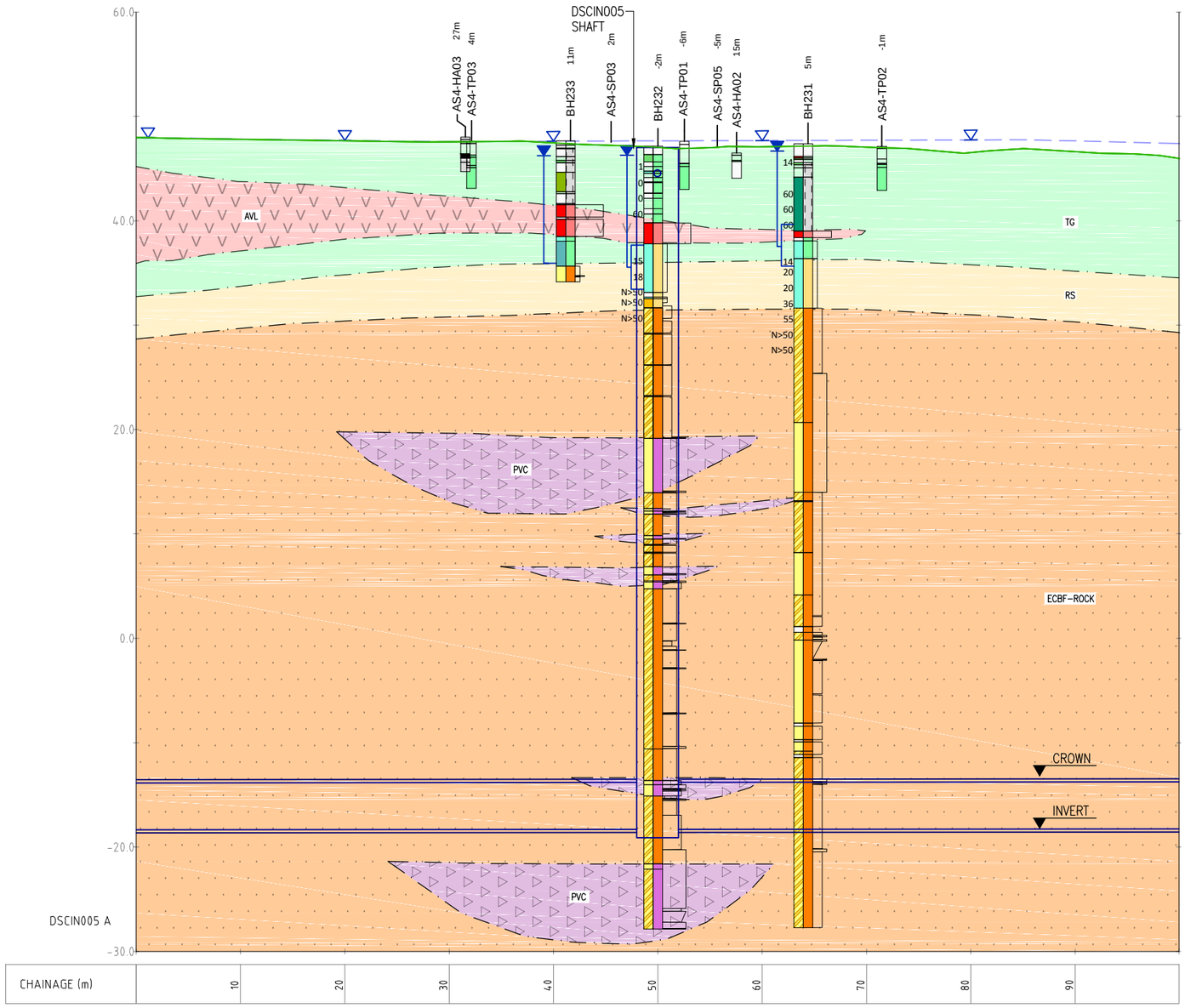
DSCIN005 – WALMSLEY PARK
SITE GENERAL
SHAFT GEOLOGY – 3D

CAD FILE 2011883.002	DATE 07.06.16
ORIGINAL SCALE A1 N.T.S.	CONTRACT No. 5747
REF. No. CI–GEOTECH	ISSUE
DWG. No. 2011883.002	3

Plot Date: Jun 10, 2016 - 11:01am C:\pw_work\dms52343\2011883.002.DWG

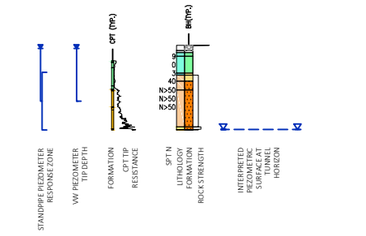


HBSI Profile - DSCIN005 A

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT	PLAN AND SECTION	BH RIGHT	
			No core
			Fill and topsoil
			Basalt
			Other volcanics
			Clay and clay dominated mixtures
			Organic clay and organic clay dominated mixtures
			Peat
			Silt and silt dominated mixtures
			Organic silt and organic silt dominated mixtures
			Sand and sand dominated mixtures (clean)
			Sand and sand dominated mixtures (with fines)
			Organic sand and organic sand dominated mixtures
			Sandstone
			Mudstone
			Interbedded mudstone and sandstone
			Conglomerate
			Coal
			Made Ground (FILL)
			Recent Alluvium (Q1a)
			TAURANGA GROUP
			Undifferentiated Tauranga Group (TG)
			Kaawa Formation (KAAWA)
			AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
			Basalt (AVL)
			Tuff / Ash / Scoria (AVT)
			WAITEMATA GROUP (MIOCENE)
			Residually to Highly Weathered - Cohesive Soils (RS)
			Residually to Highly Weathered - Granular Soils (RS)
			Parnell Volcaniclastic Conglomerate (PVC)
			Moderately Weathered to Unweathered ECBF (ECBF-ROCK)



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

ISSUED FOR USE

JACOBS AECOM MMILLEN JACOBS

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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DSCIN005 – WALMSLEY PARK
SITE GENERAL
SHAFT GEOLOGY – SECTION A

CAD FILE 2011883.003	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011883.003	3

Plot Date: Jun 10, 2016 - 7:38am
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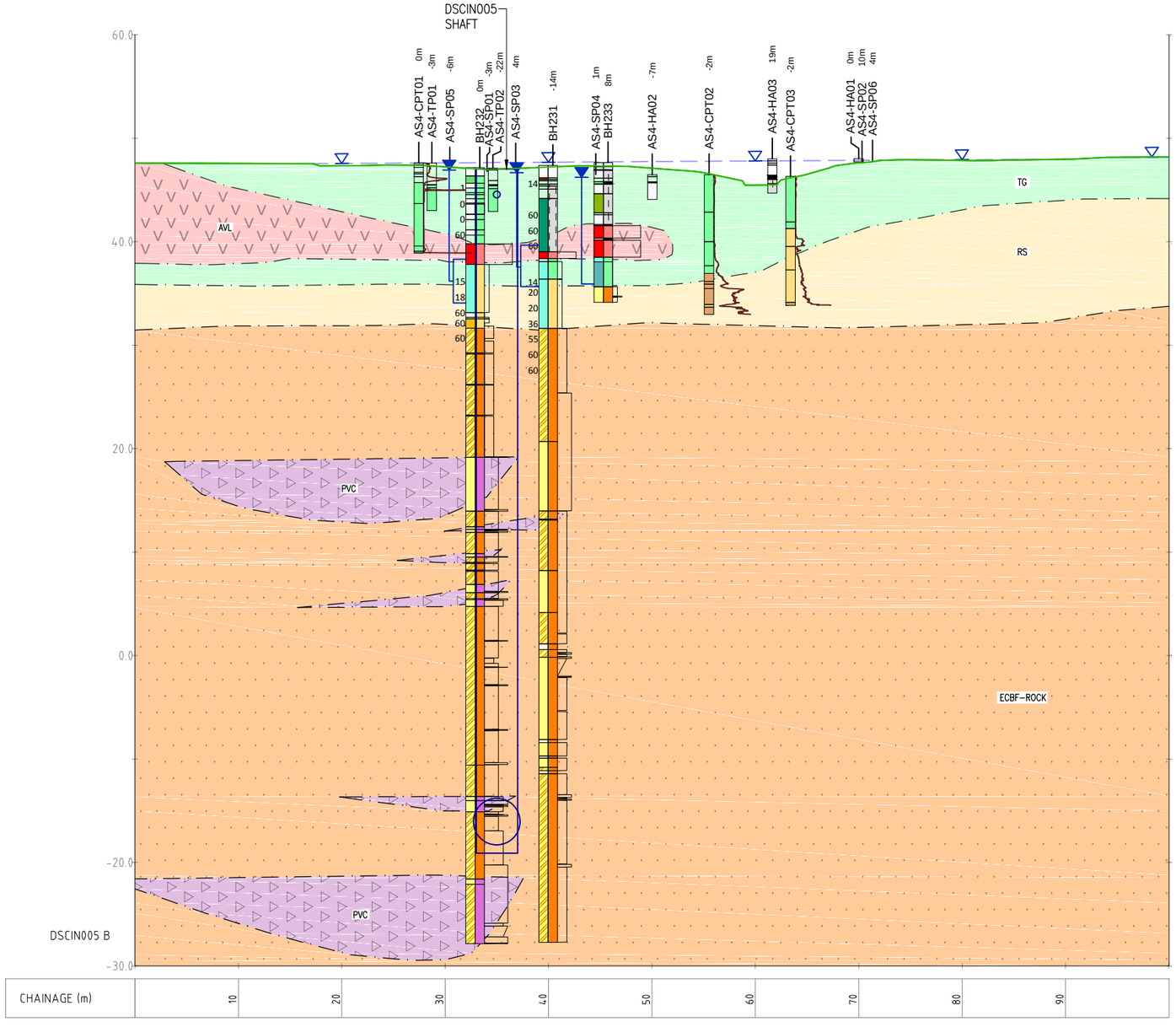


HBSI Profile - DSCIN005 B

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT | PLAN AND SECTION | BH RIGHT

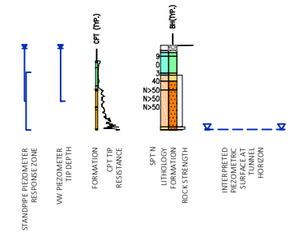
- No core
- Fill and topsoil
- Basalt
- Other volcanics
- Clay and clay dominated mixtures
- Organic clay and organic clay dominated mixtures
- Peat
- Silt and silt dominated mixtures
- Organic silt and organic silt dominated mixtures
- Sand and sand dominated mixtures (clean)
- Sand and sand dominated mixtures (with fines)
- Organic sand and organic sand dominated mixtures
- Sandstone
- Mudstone
- Interbedded mudstone and sandstone
- Conglomerate
- Coal

- Made Ground (FILL)
- Recent Alluvium (Q1a)

TAURANGA GROUP
- Undifferentiated Tauranga Group (TG)
- Kaawa Formation (KAAWA)

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Basalt (AVL)
- Tuff / Ash / Scoria (AVT)

WAITEMATA GROUP (MIOCENE)
- Residually to Highly Weathered - Cohesive Soils (RS)
- Residually to Highly Weathered - Granular Soils (RS)
- Parnell Volcaniclastic Conglomerate (PVC)
- Moderately Weathered to Unweathered ECBF (ECBF-ROCK)



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
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3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
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ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

INFRASTRUCTURE

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DSCIN005 – WALMSLEY PARK
SITE GENERAL
SHAFT GEOLOGY – SECTION B

CAD FILE 2011883.004	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011883.004	3

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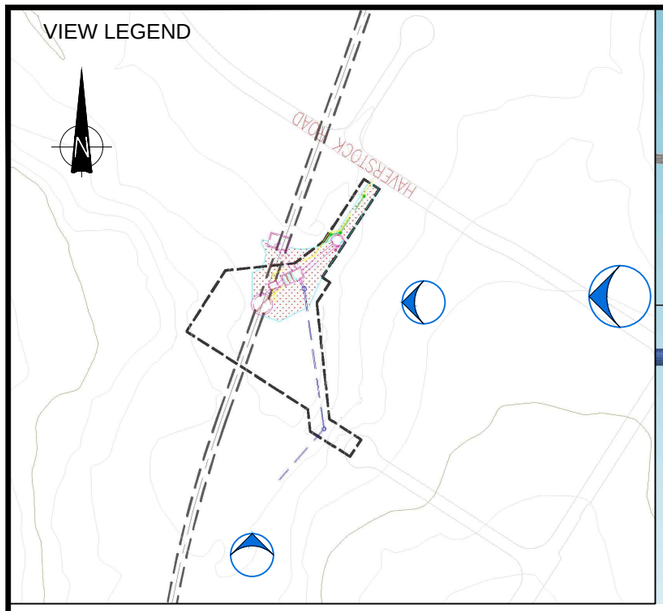
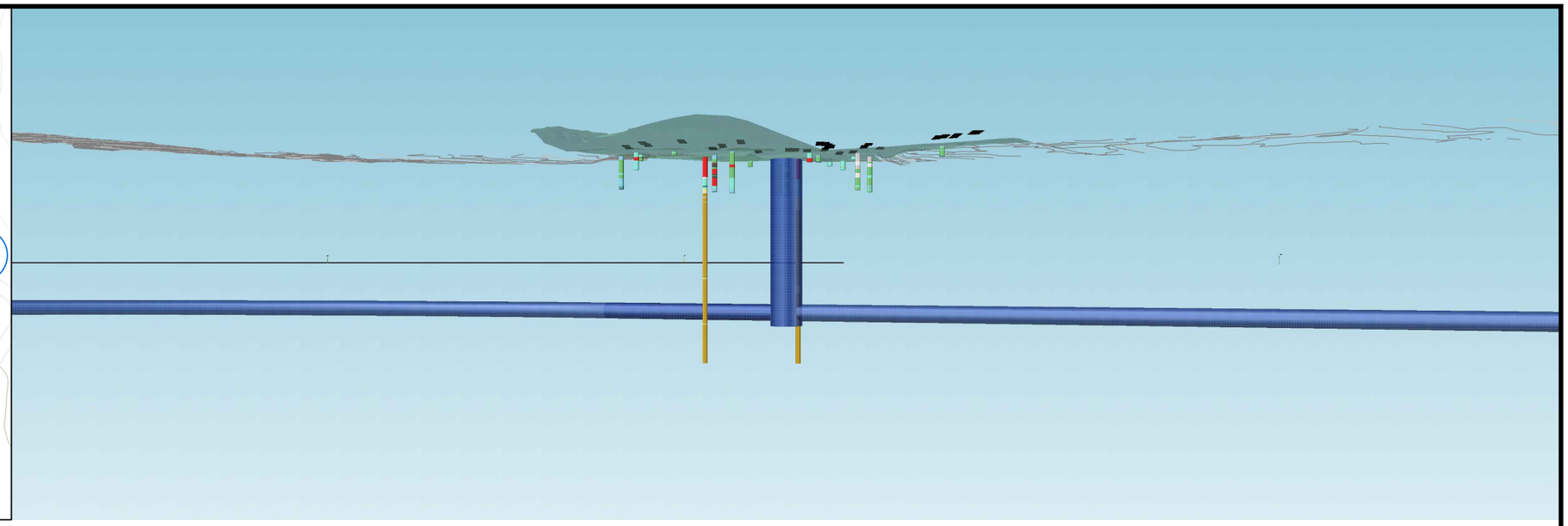
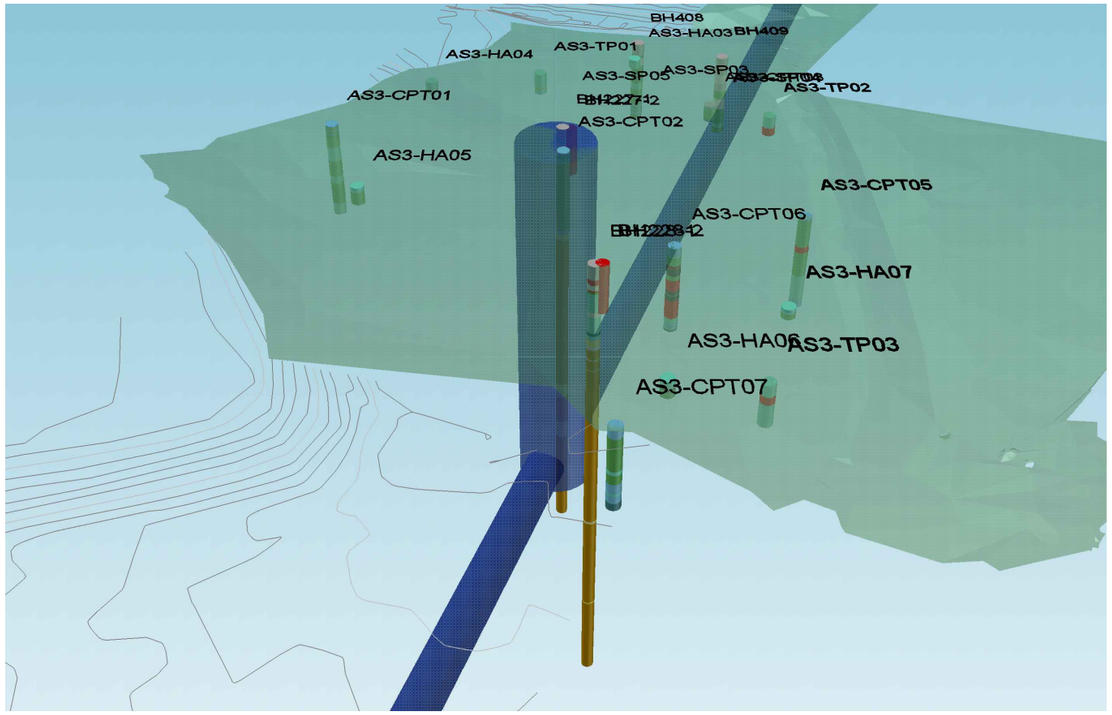


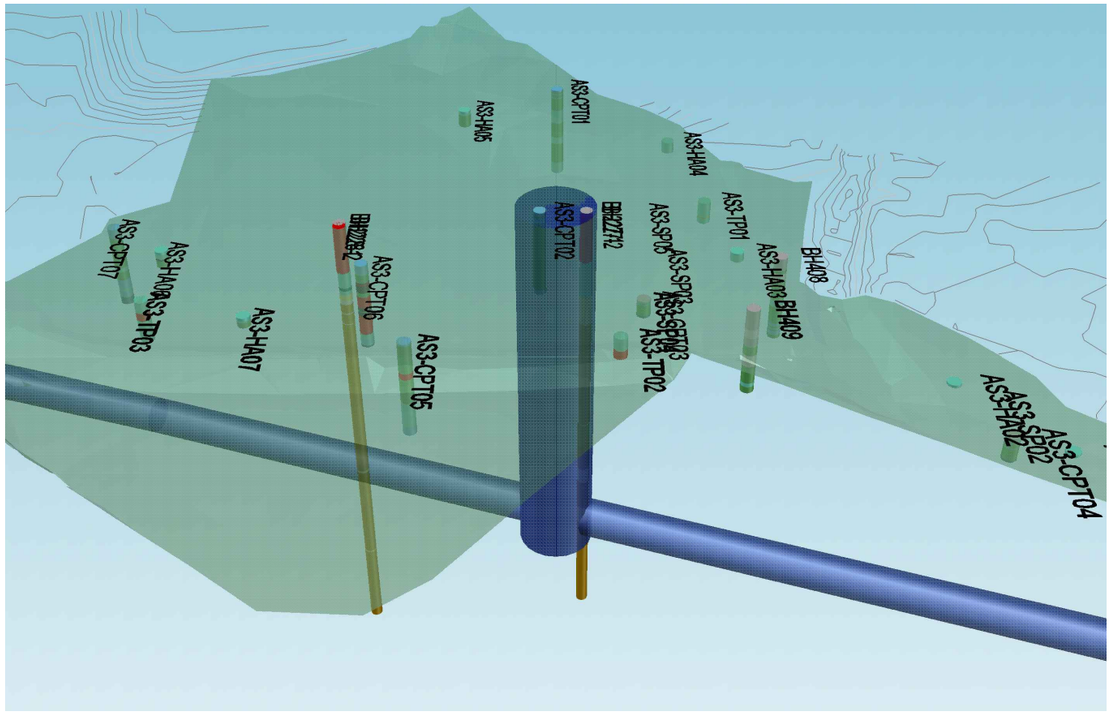


EAST – OVERVIEW

NOTES:
1. GROUND CONTOURS ARE FROM AUCKLAND COUNCIL GIS SOURCES.
2. GROUND SURFACE SHOWN FROM SITE SURVEY BY BECA, 2015.
3. TUNNEL AND SHAFTS ARE FROM DETAILED DESIGN MODEL TO MAY 2016 AND ARE INDICATIVE ONLY.
4. 3D BOREHOLE STICKS ARE EXTRACTED DIRECTLY FROM CI PROJECT GEOTECHNICAL DATABASE, AND ARE COLOURED BY GEOLOGICAL FORMATION – REFER TO LONG SECTIONS FOR KEY.



SOUTH VIEW



EAST VIEW

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
BY		DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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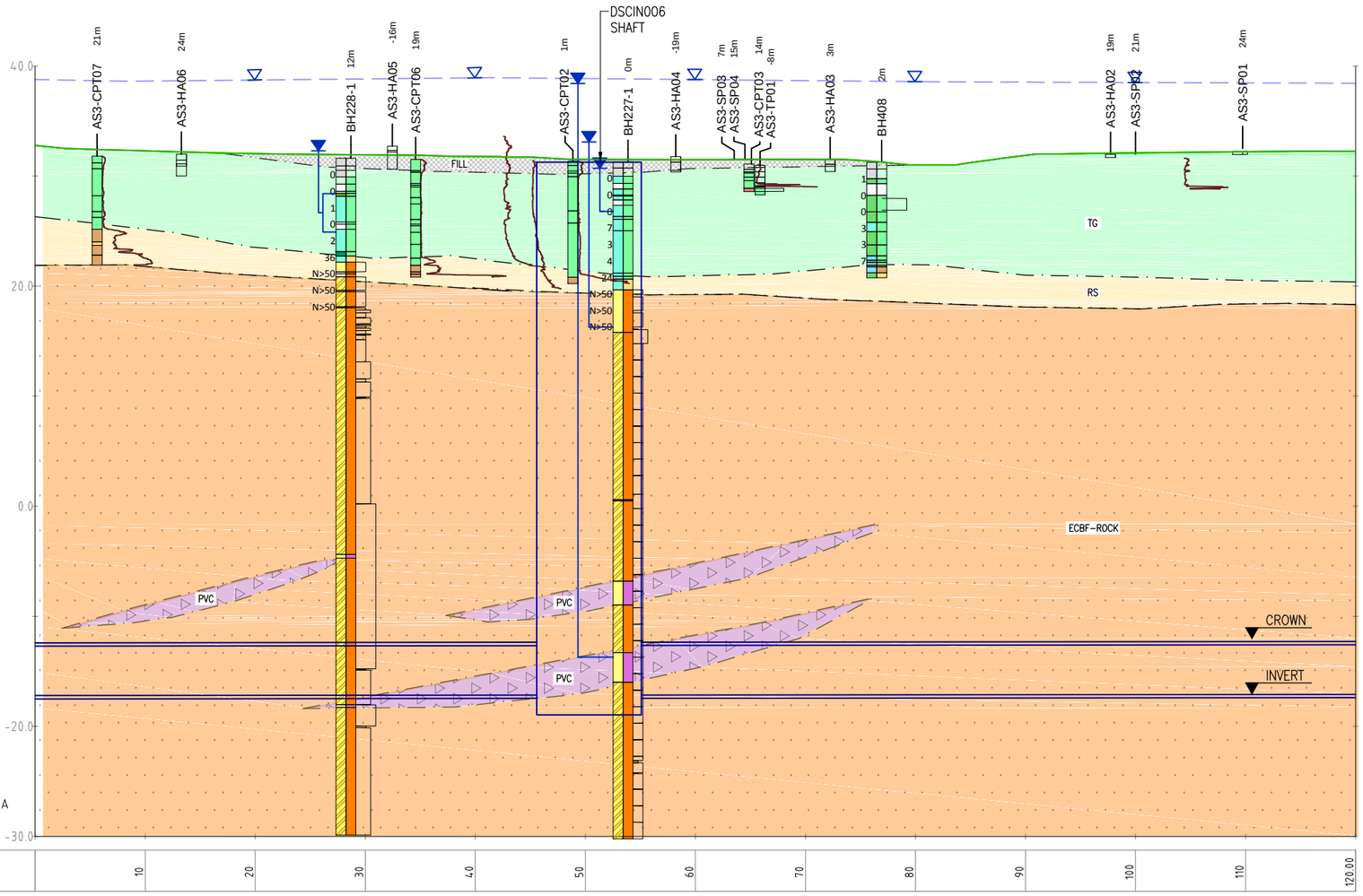
DSCIN006 – HAVERSTOCK ROAD
SITE GENERAL
SHAFT GEOLOGY – 3D

CAD FILE 2011884.002	DATE 07.06.16
ORIGINAL SCALE A1 N.T.S.	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011884.002	3

Plot Date: Jun 10, 2016 - 7:45am C:\pw_work\apatel2\dms52319\2011884.002.DWG

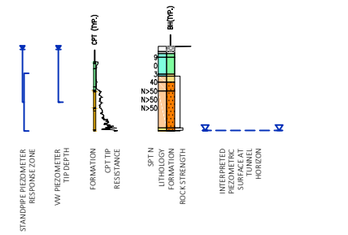


HBSI Profile - DSCIN006 A

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT	PLAN AND SECTION	BH RIGHT	
			No core
			Made Ground (FILL)
			Fill and topsoil
			Recent Alluvium (Q1a)
			Basalt
			TAURANGA GROUP
			Other volcanics
			Undifferentiated Tauranga Group (TG)
			Clay and clay dominated mixtures
			Organic clay and organic clay dominated mixtures
			Kaawa Formation (KAAWA)
			Peat
			AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
			Silt and silt dominated mixtures
			Basalt (AVL)
			Organic silt and organic silt dominated mixtures
			Tuff / Ash / Scoria (AVT)
			Sand and sand dominated mixtures (clean)
			WAITEMATA GROUP (MIOCENE)
			Sand and sand dominated mixtures (with fines)
			Residually to Highly Weathered - Cohesive Soils (RS)
			Organic sand and organic sand dominated mixtures
			Residually to Highly Weathered - Granular Soils (RS)
			Sandstone
			Parnell Volcaniclastic Conglomerate (PVC)
			Mudstone
			Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
			Interbedded mudstone and sandstone
			Conglomerate
			Coal



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
BY		DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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DSCIN006 – HAVERSTOCK ROAD
SITE GENERAL
SHAFT GEOLOGY – SECTION A

CAD FILE 2011884.003	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011884.003	3

Plot Date: Jun 10, 2016 - 7:47am
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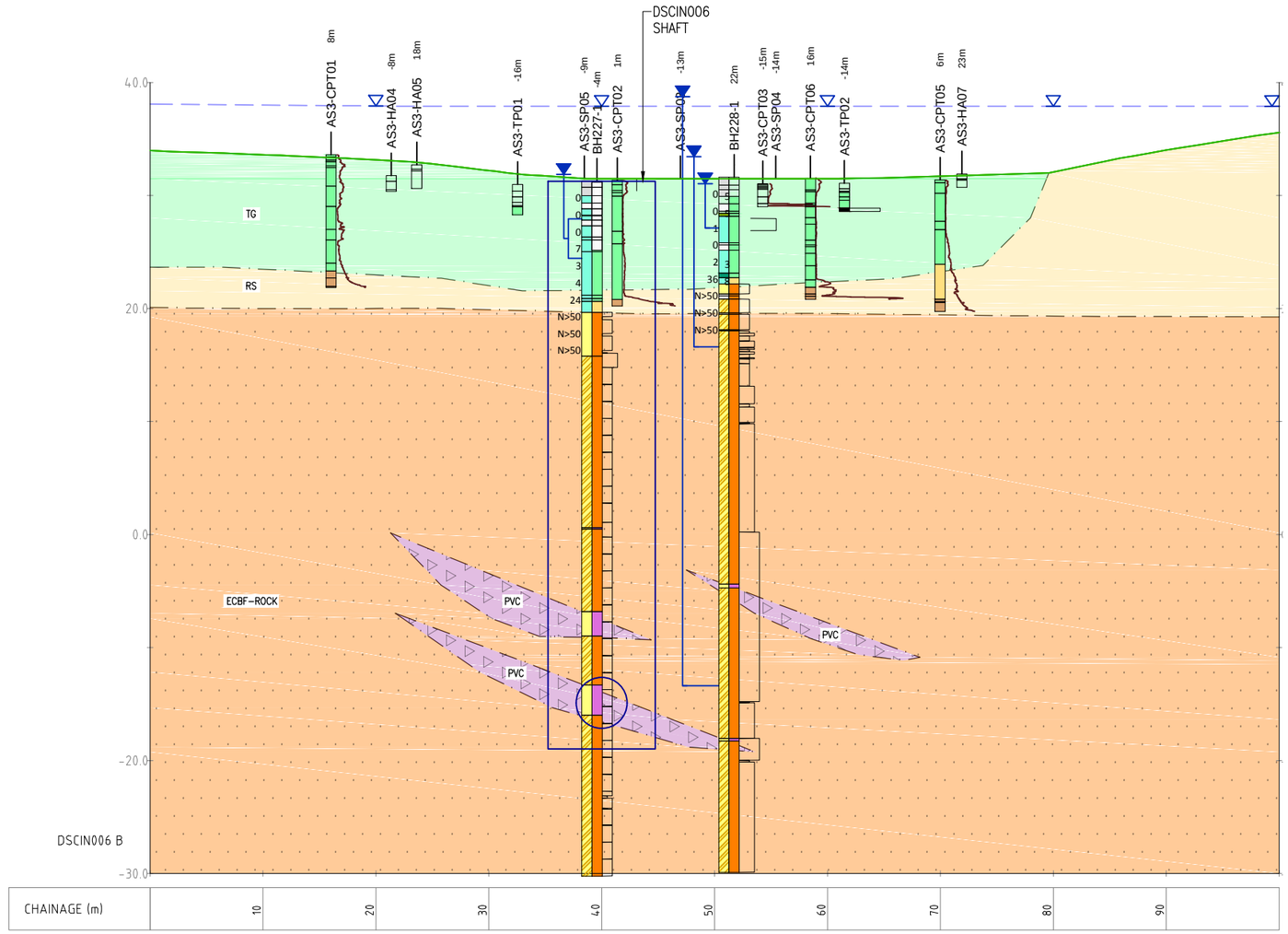
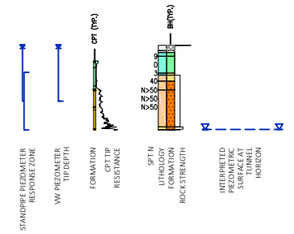


HBSI Profile - DSCIN006 B

LEGEND

BH215 –6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT	PLAN AND SECTION	BH RIGHT	
			No core
			Fill and topsoil
			Basalt
			Other volcanics
			Clay and clay dominated mixtures
			Organic clay and organic clay dominated mixtures
			Peat
			Silt and silt dominated mixtures
			Organic silt and organic silt dominated mixtures
			Sand and sand dominated mixtures (clean)
			Sand and sand dominated mixtures (with fines)
			Organic sand and organic sand dominated mixtures
			Sandstone
			Mudstone
			Interbedded mudstone and sandstone
			Conglomerate
			Coal
			Made Ground (FILL)
			Recent Alluvium (Q1a)
			TAURANGA GROUP
			Undifferentiated Tauranga Group (TG)
			Kaawa Formation (KAAWA)
			AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
			Basalt (AVL)
			Tuff / Ash / Scoria (AVT)
			WAITEMATA GROUP (MIOCENE)
			Residually to Highly Weathered - Cohesive Soils (RS)
			Residually to Highly Weathered - Granular Soils (RS)
			Parnell Volcaniclastic Conglomerate (PVC)
			Moderately Weathered to Unweathered ECBF (ECBF-ROCK)



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X–DSCIN–T–001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X–DSLSA(–D)–C–001. DESIGNS CURRENT TO MAY 2016.
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3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
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8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

ISSUED FOR USE

JACOBS AECOM MAUNSELL AECOM JACOBS

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		

OPERATIONS

INFRASTRUCTURE

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DSCIN006 – HAVERSTOCK ROAD
SITE GENERAL
SHAFT GEOLOGY – SECTION B

CAD FILE 2011884.004	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI–GEOTECH	ISSUE
DWG. No. 2011884.004	3

Plot Date: Jun 10, 2016 - 7:49am
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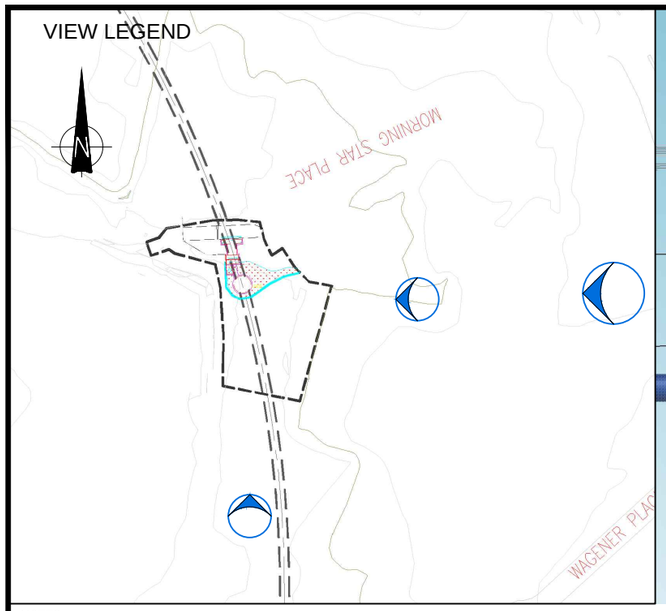
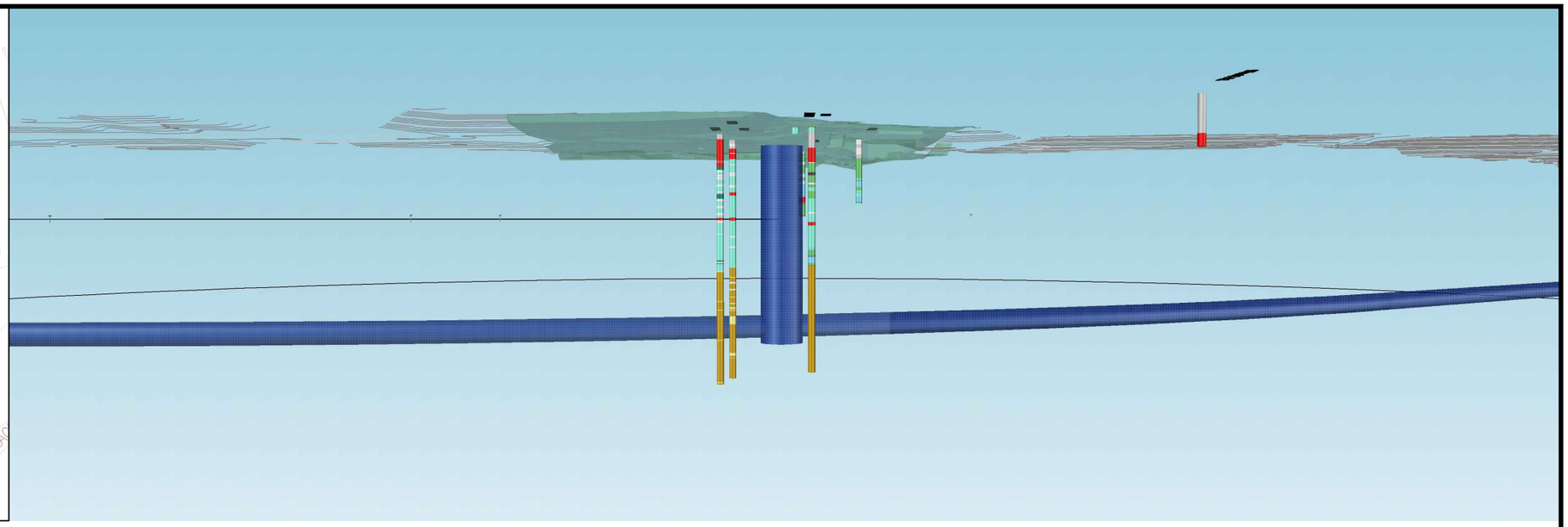
VIEW LEGEND





EAST – OVERVIEW

NOTES:
1. GROUND CONTOURS ARE FROM AUCKLAND COUNCIL GIS SOURCES.
2. GROUND SURFACE SHOWN FROM SITE SURVEY BY BECA, 2015.
3. TUNNEL AND SHAFTS ARE FROM DETAILED DESIGN MODEL TO MAY 2016 AND ARE INDICATIVE ONLY.
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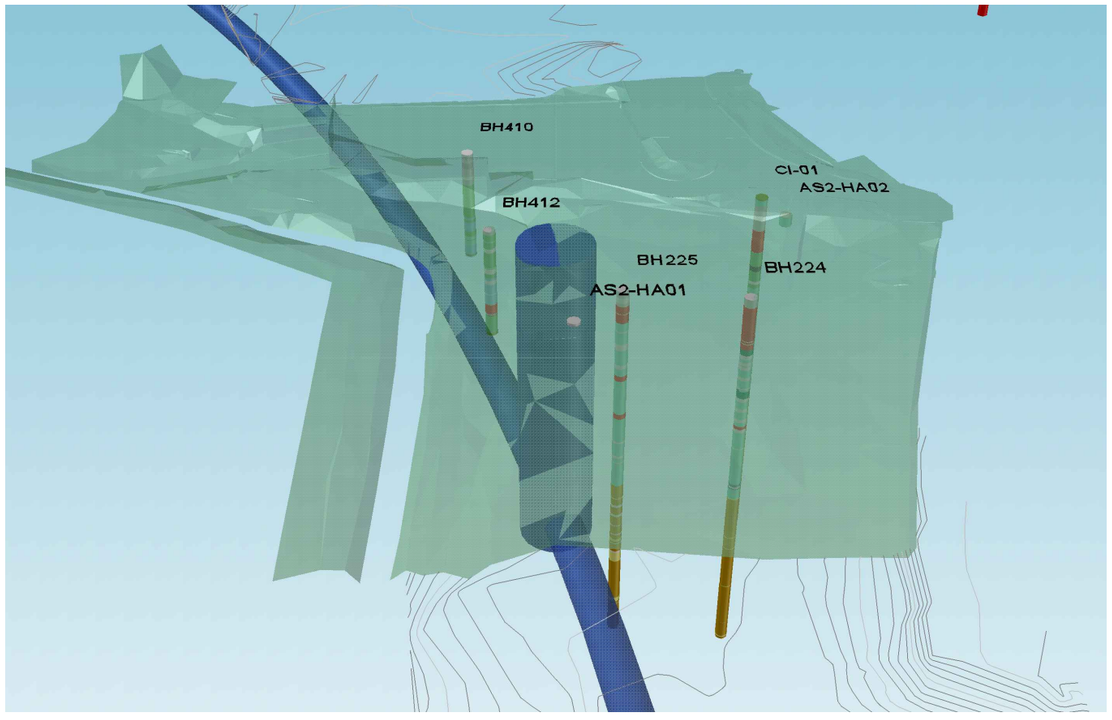
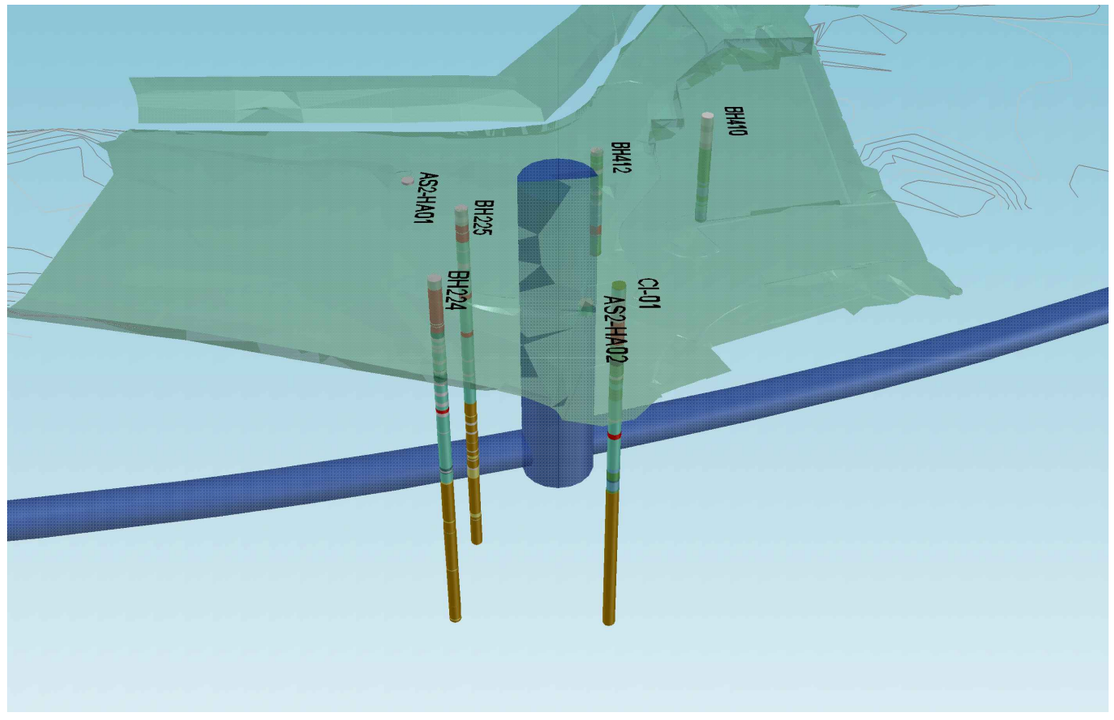


SOUTH VIEW



EAST VIEW

ISSUED FOR USE

JACOBS AECOM MWH JACOBS

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
BY		DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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DSCIN007 – LYON AVENUE
SITE GENERAL
SHAFT GEOLOGY – 3D

CAD FILE 2011885.002	DATE 07.06.16
ORIGINAL SCALE A1 N.T.S.	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011885.002	3

Plot Date: Jun 10, 2016 - 8:03am
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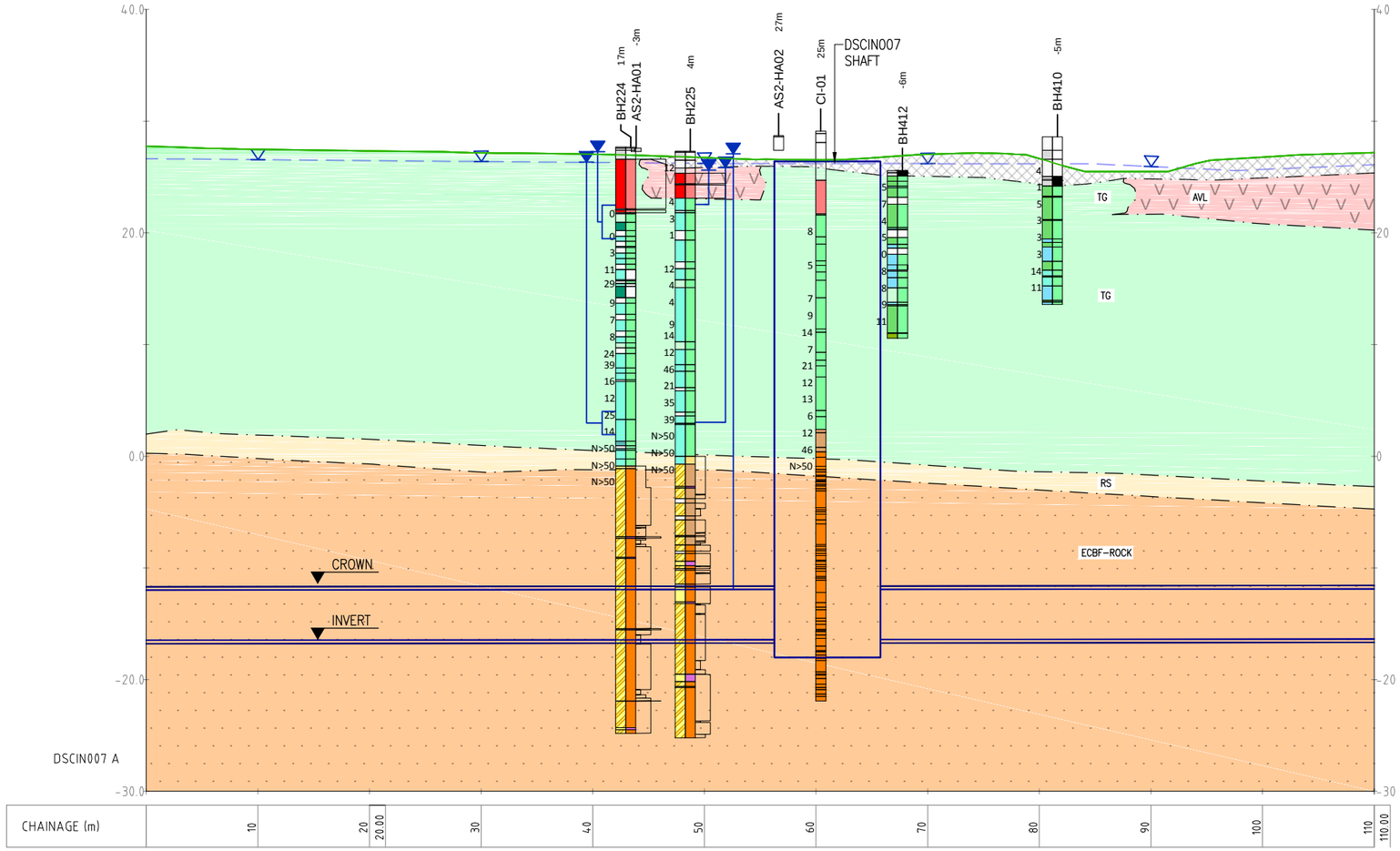
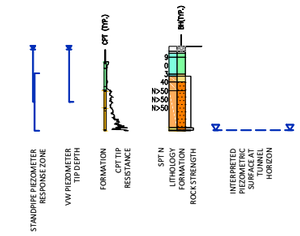


HBSI Profile - DSCIN007 A

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT	PLAN AND SECTION	BH RIGHT	
			No core
			Fill and topsoil
			Basalt
			Other volcanics
			Clay and clay dominated mixtures
			Organic clay and organic clay dominated mixtures
			Peat
			Silt and silt dominated mixtures
			Organic silt and organic silt dominated mixtures
			Sand and sand dominated mixtures (clean)
			Sand and sand dominated mixtures (with fines)
			Organic sand and organic sand dominated mixtures
			Sandstone
			Mudstone
			Interbedded mudstone and sandstone
			Conglomerate
			Coal
			Made Ground (FILL)
			Recent Alluvium (Q1a)
			TAURANGA GROUP
			Undifferentiated Tauranga Group (TG)
			Kaawa Formation (KAAWA)
			AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
			Basalt (AVL)
			Tuff / Ash / Scoria (AVT)
			WAITEMATA GROUP (MIOCENE)
			Residually to Highly Weathered - Cohesive Soils (RS)
			Residually to Highly Weathered - Granular Soils (RS)
			Parnell Volcaniclastic Conglomerate (PVC)
			Moderately Weathered to Unweathered ECBF (ECBF-ROCK)



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
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3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
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ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D	BY	DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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DSCIN007 – LYON AVENUE
SITE GENERAL
SHAFT GEOLOGY – SECTION A

CAD FILE 2011885.003	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011885.003	3

Plot Date: Jun 10, 2016 - 8:02am
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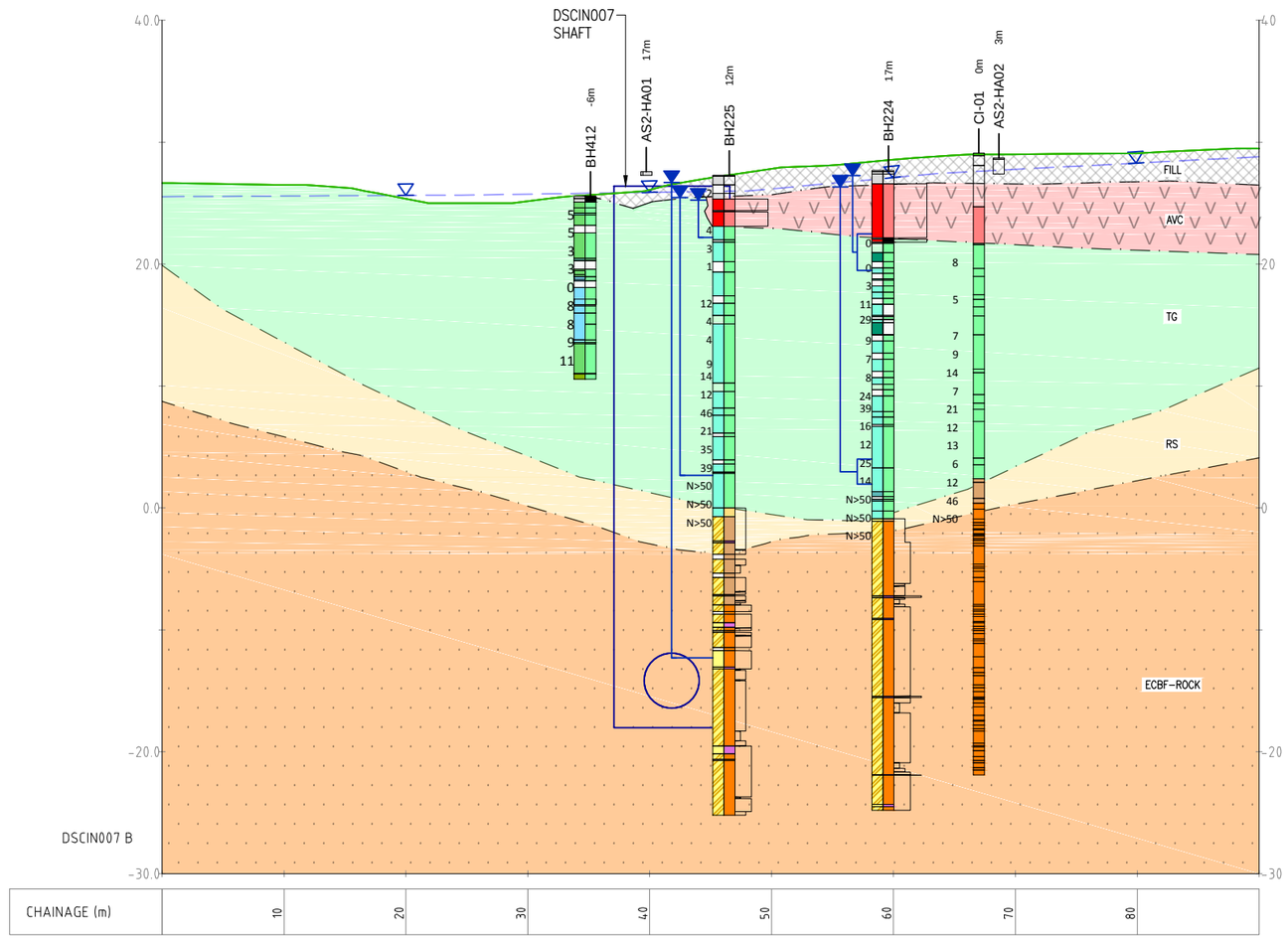
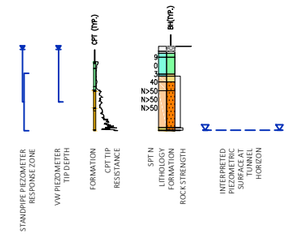


HBSI Profile - DSCIN007 B

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT	PLAN AND SECTION	BH RIGHT	
			No core
			Fill and topsoil
			Basalt
			Other volcanics
			Clay and clay dominated mixtures
			Organic clay and organic clay dominated mixtures
			Peat
			Silt and silt dominated mixtures
			Organic silt and organic silt dominated mixtures
			Sand and sand dominated mixtures (clean)
			Sand and sand dominated mixtures (with fines)
			Organic sand and organic sand dominated mixtures
			Sandstone
			Mudstone
			Interbedded mudstone and sandstone
			Conglomerate
			Coal
			Made Ground (FILL)
			Recent Alluvium (Q1a)
			TAURANGA GROUP
			Undifferentiated Tauranga Group (TG)
			Kaawa Formation (KAAWA)
			AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
			Basalt (AVL)
			Tuff / Ash / Scoria (AVT)
			WAITEMATA GROUP (MIOCENE)
			Residually to Highly Weathered - Cohesive Soils (RS)
			Residually to Highly Weathered - Granular Soils (RS)
			Parnell Volcaniclastic Conglomerate (PVC)
			Moderately Weathered to Unweathered ECBF (ECBF-ROCK)



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

ISSUED FOR USE

JACOBS AECOM MWH JACOBS ASSOCIATES

C:\pw_work\apatel2\dms5295\ 2011885.004.DWG

Plot Date Jun 10 2016 - 8:05am

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
BY		DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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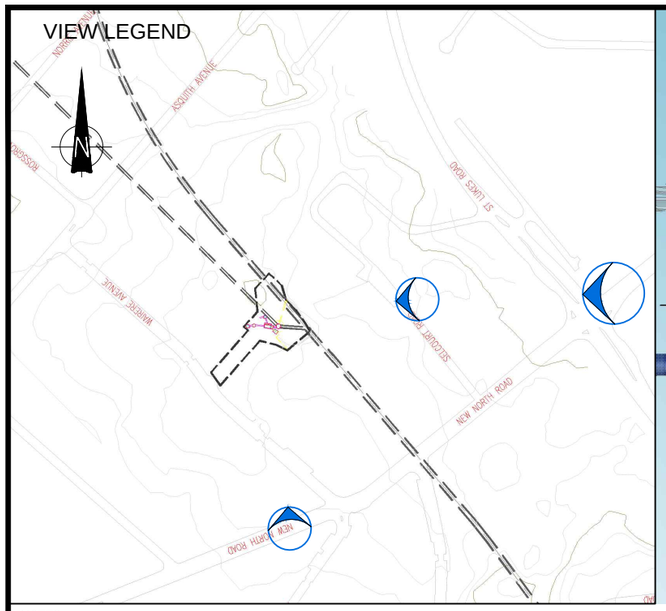
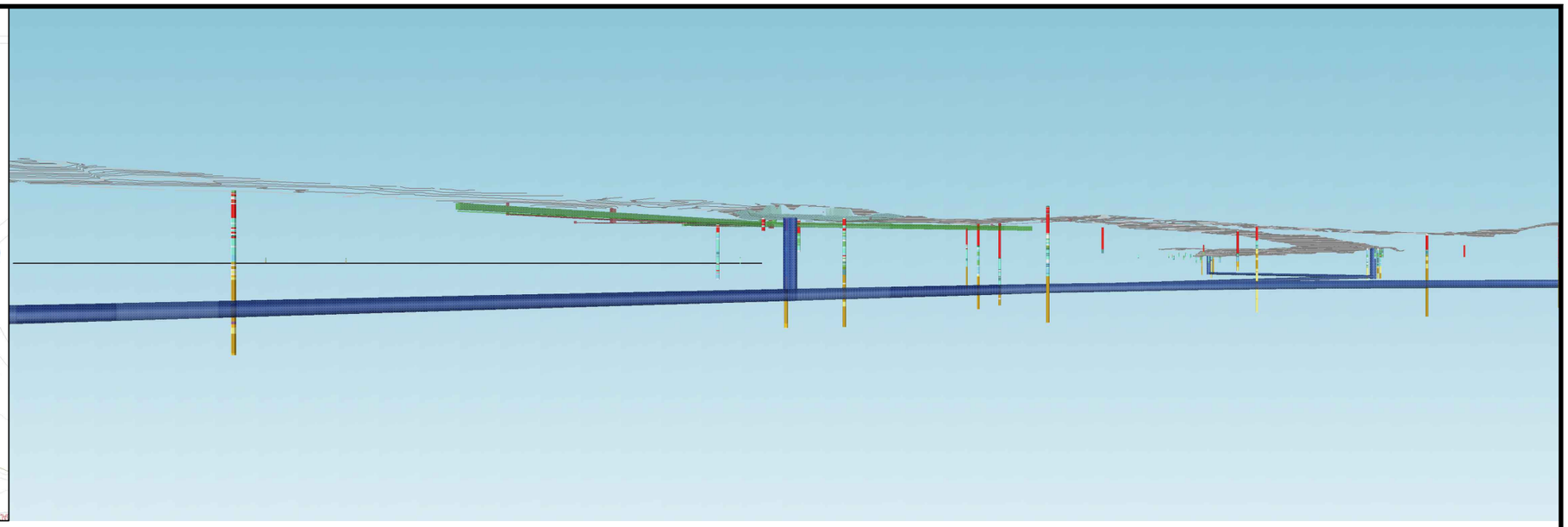
DSCIN007 – LYON AVENUE
SITE GENERAL
SHAFT GEOLOGY – SECTION B

CAD FILE 2011885.004	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011885.004	3

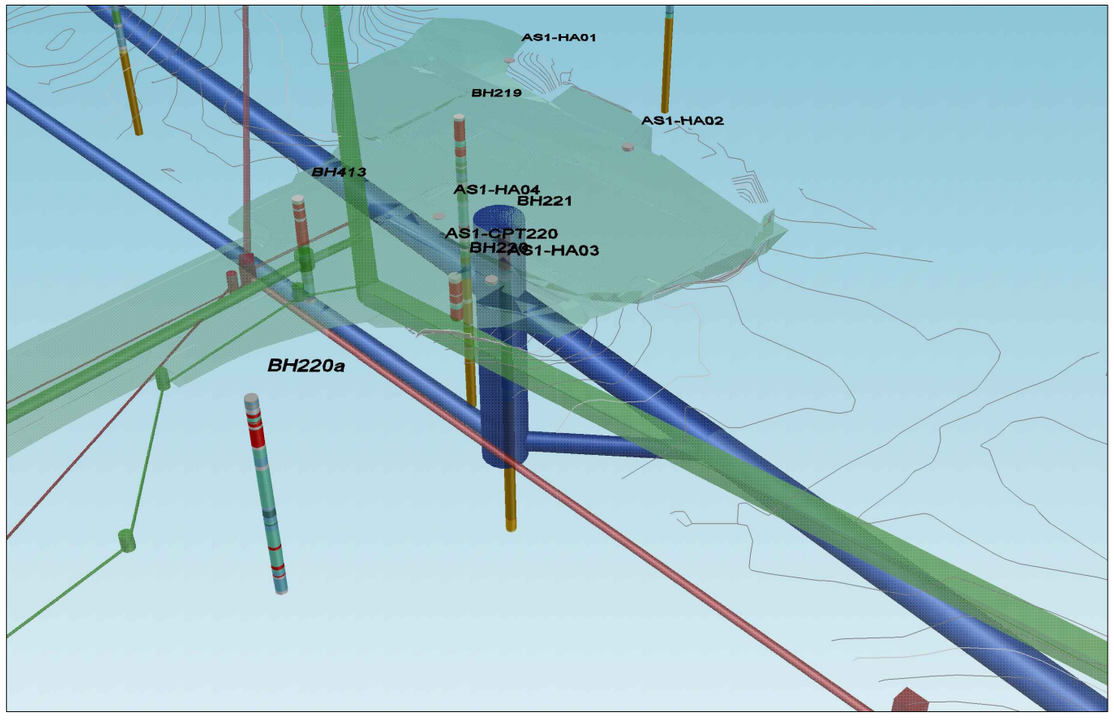
VIEW LEGEND



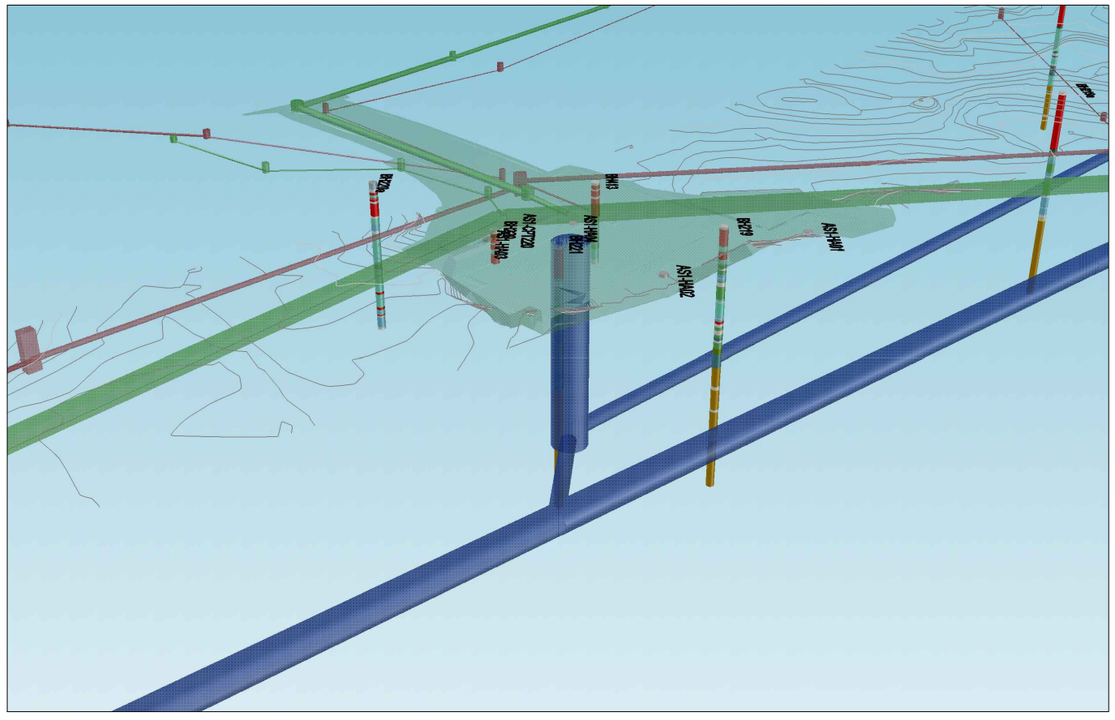


EAST – OVERVIEW

NOTES:
1. GROUND CONTOURS ARE FROM AUCKLAND COUNCIL GIS SOURCES.
2. GROUND SURFACE SHOWN FROM SITE SURVEY BY BECA, 2015.
3. TUNNEL AND SHAFTS ARE FROM DETAILED DESIGN MODEL TO MAY 2016 AND ARE INDICATIVE ONLY.
4. 3D BOREHOLE STICKS ARE EXTRACTED DIRECTLY FROM CI PROJECT GEOTECHNICAL DATABASE, AND ARE COLOURED BY GEOLOGICAL FORMATION – REFER TO LONG SECTIONS FOR KEY.



SOUTH VIEW



EAST VIEW

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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DSCIN008 – MT ALBERT WAR MEMORIAL RESERVE
SITE GENERAL
SHAFT GEOLOGY – 3D

CAD FILE 2011886.002	DATE 07.06.16
ORIGINAL SCALE A1 N.T.S.	CONTRACT No. 5747
REF. No. CI–GEOTECH	ISSUE
DWG. No. 2011886.002	3

Plot Date: Jun 10, 2016 - 8:10am
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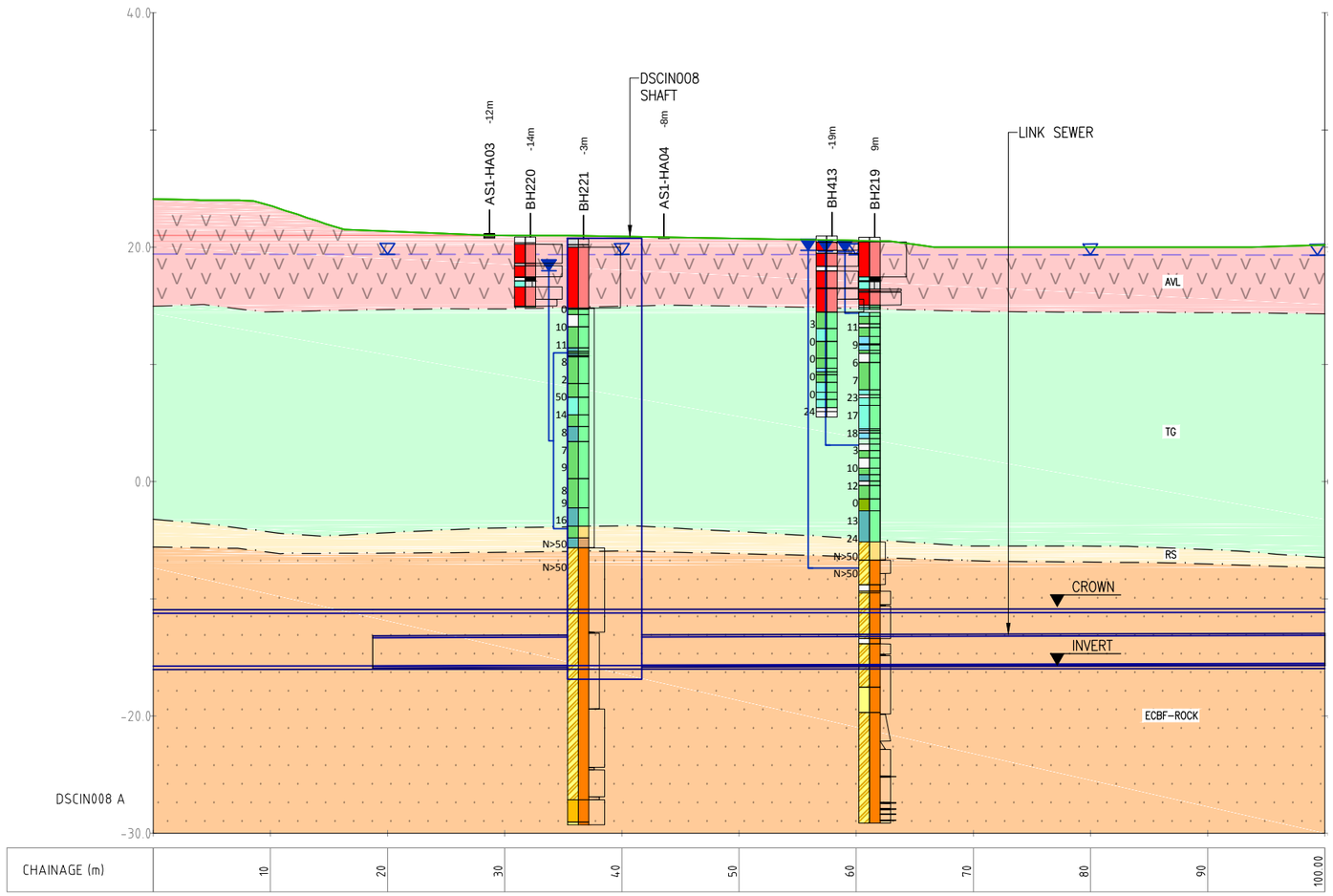
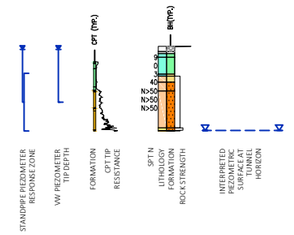


HBSI Profile - DSCIN008 A

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT	PLAN AND SECTION	BH RIGHT	
No core			Made Ground (FILL)
Fill and topsoil			Recent Alluvium (Q1a)
Basalt			TAURANGA GROUP
Other volcanics			Undifferentiated Tauranga Group (TG)
Clay and clay dominated mixtures			Kaawa Formation (KAAWA)
Organic clay and organic clay dominated mixtures			AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
Peat			Basalt (AVL)
Silt and silt dominated mixtures			Tuff / Ash / Scoria (AVT)
Organic silt and organic silt dominated mixtures			WAITEMATA GROUP (MIOCENE)
Sand and sand dominated mixtures (clean)			Residually to Highly Weathered - Cohesive Soils (RS)
Sand and sand dominated mixtures (with fines)			Residually to Highly Weathered - Granular Soils (RS)
Organic sand and organic sand dominated mixtures			Parnell Volcaniclastic Conglomerate (PVC)
Sandstone			Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
Mudstone			
Interbedded mudstone and sandstone			
Conglomerate			
Coal			



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

ISSUED FOR USE

JACOBS AECOM MAULLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		

OPERATIONS

INFRASTRUCTURE

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DSCIN008 – MT ALBERT WAR MEMORIAL RESERVE SITE GENERAL

SHAFT GEOLOGY – SECTION A

CAD FILE 2011886.003	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
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Plot Date: Jun 10, 2016 - 8:13am
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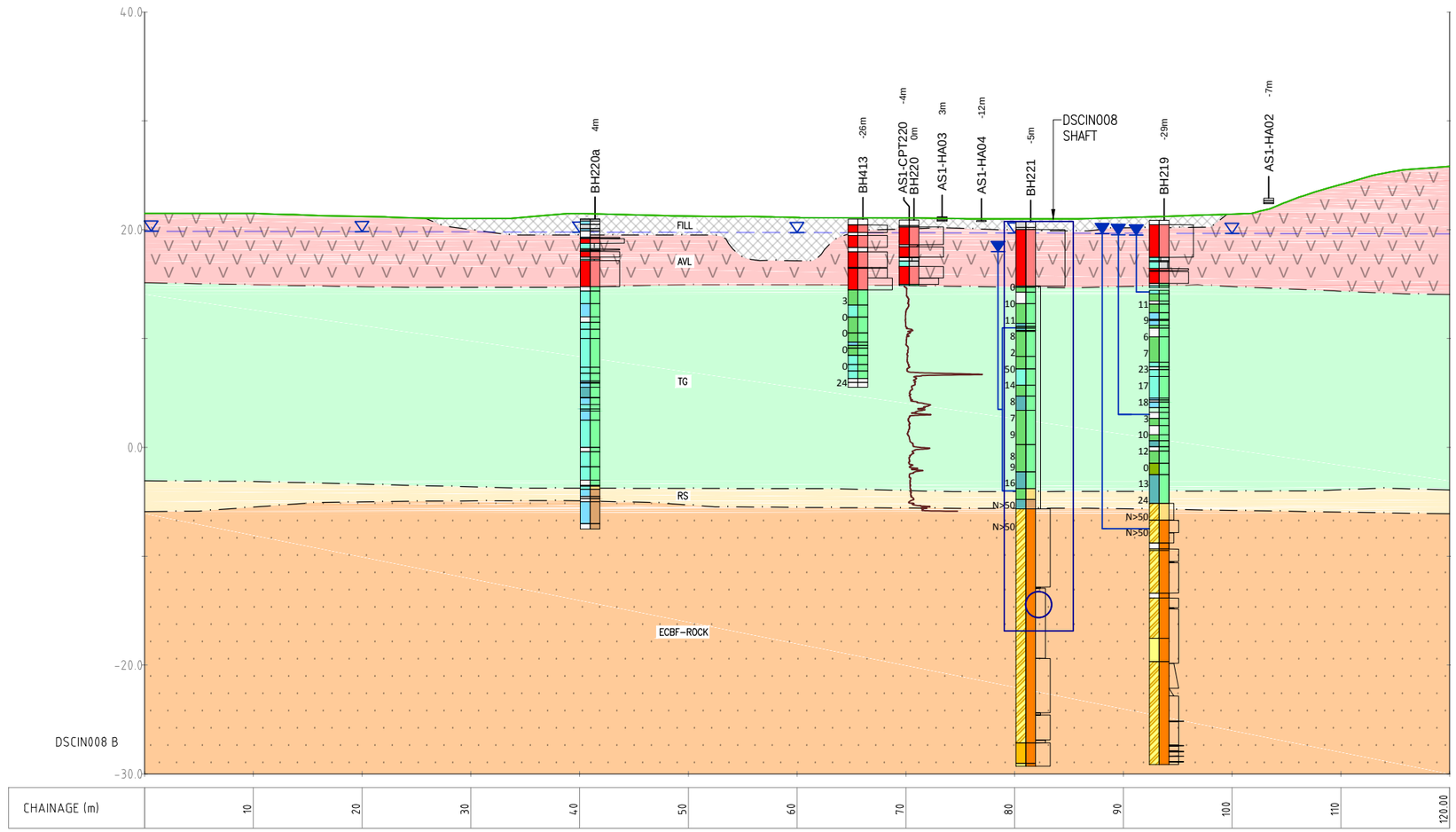
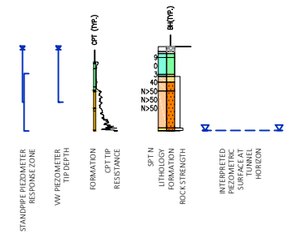


HBSI Profile - DSCIN008 B

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT	PLAN AND SECTION	BH RIGHT	
No core			Made Ground (FILL)
Fill and topsoil			Recent Alluvium (Q1a)
Basalt			TAURANGA GROUP
Other volcanics			
Clay and clay dominated mixtures			Undifferentiated Tauranga Group (TG)
Organic clay and organic clay dominated mixtures			Kaawa Formation (KAAWA)
Peat			AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
Silt and silt dominated mixtures			Basalt (AVL)
Organic silt and organic silt dominated mixtures			Tuff / Ash / Scoria (AVT)
Sand and sand dominated mixtures (clean)			WAITEMATA GROUP (MIOCENE)
Sand and sand dominated mixtures (with fines)			Residually to Highly Weathered - Cohesive Soils (RS)
Organic sand and organic sand dominated mixtures			Residually to Highly Weathered - Granular Soils (RS)
Sandstone			Parnell Volcaniclastic Conglomerate (PVC)
Mudstone			Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
Interbedded mudstone and sandstone			
Conglomerate			
Coal			



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
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3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

ISSUED FOR USE

JACOBS AECOM MWH JACOBS ASSOCIATES

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Plot Date: Jun 10, 2016 - 8:15am

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
BY		DATE

OPERATIONS

INFRASTRUCTURE

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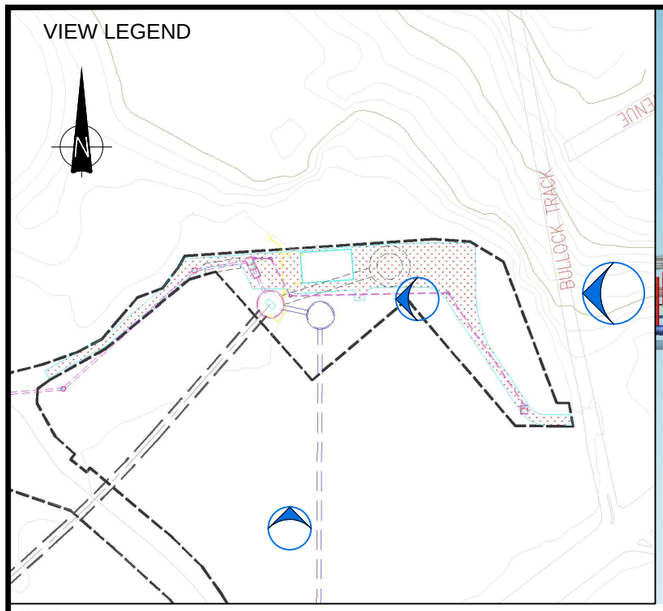
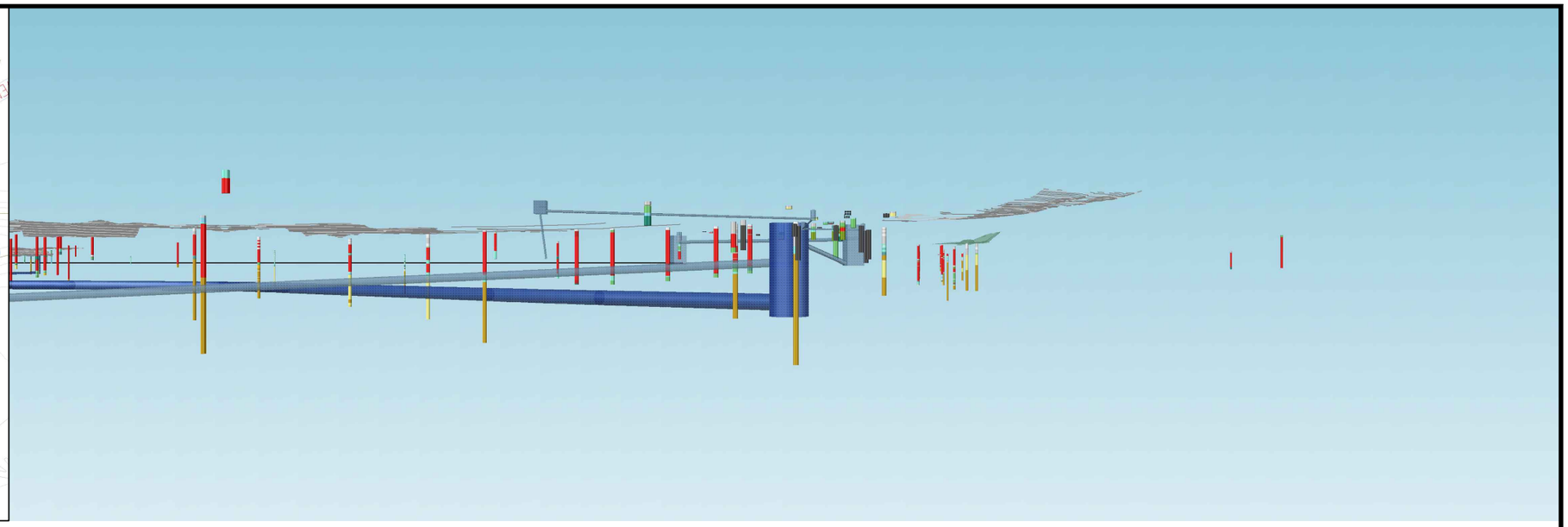
DSCIN008 – MT ALBERT WAR MEMORIAL RESERVE
SITE GENERAL
SHAFT GEOLOGY – SECTION B

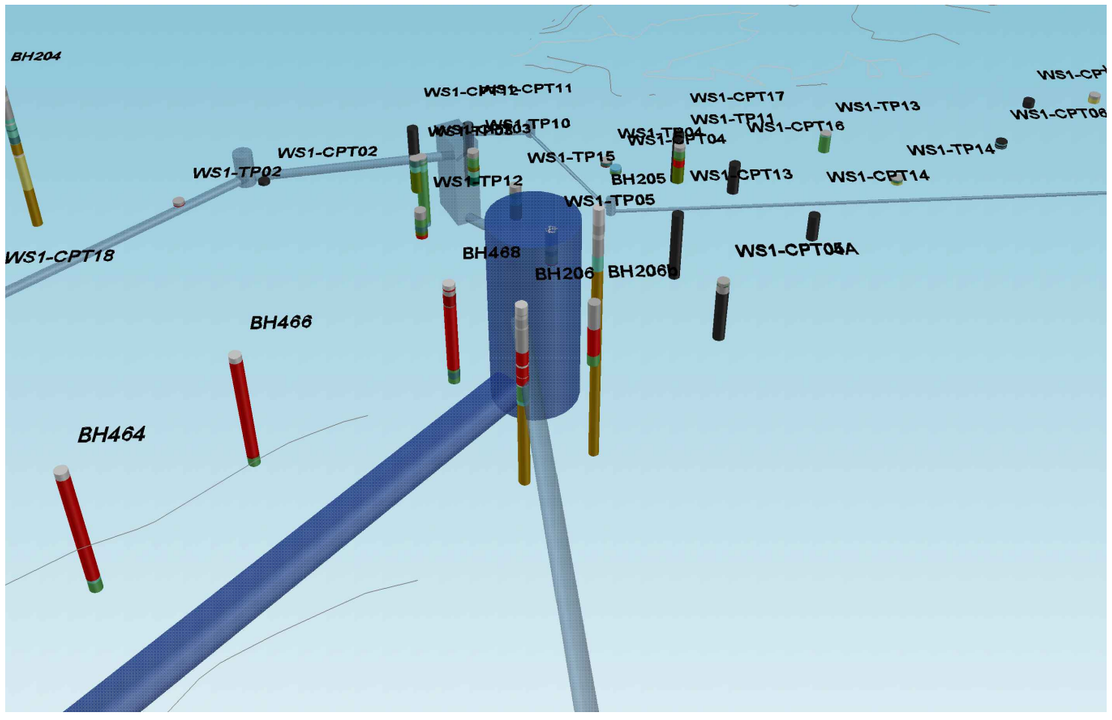
CAD FILE 2011886.004	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011886.004	3



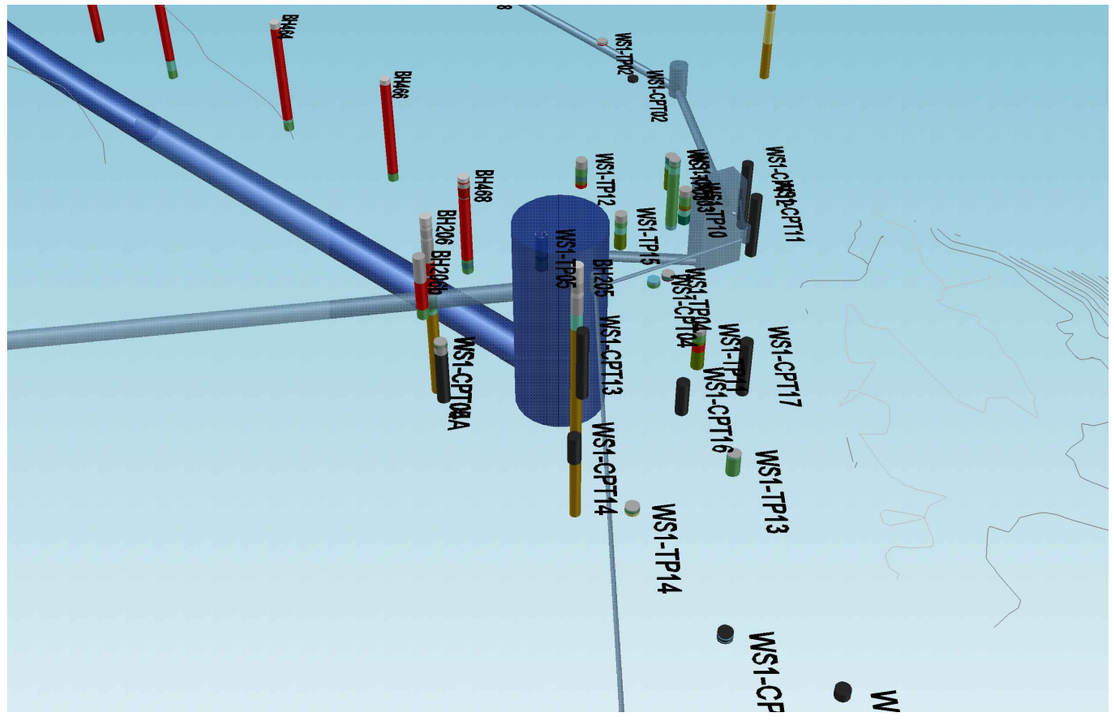


EAST – OVERVIEW

NOTES:
1. GROUND CONTOURS ARE FROM AUCKLAND COUNCIL GIS SOURCES.
2. GROUND SURFACE SHOWN FROM SITE SURVEY BY BECA, 2015.
3. TUNNEL AND SHAFTS ARE FROM DETAILED DESIGN MODEL TO MAY 2016 AND ARE INDICATIVE ONLY.
4. 3D BOREHOLE STICKS ARE EXTRACTED DIRECTLY FROM CI PROJECT GEOTECHNICAL DATABASE, AND ARE COLOURED BY GEOLOGICAL FORMATION – REFER TO LONG SECTIONS FOR KEY.



SOUTH VIEW



EAST VIEW

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
BY		DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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DSCIN009 – WESTERN SPRINGS
SITE GENERAL
SHAFT GEOLOGY – 3D

CAD FILE 2011887.002 | DATE 07.06.16
ORIGINAL SCALE A1 N.T.S. | CONTRACT No. 5747
REF. No. CI-GEOTECH | ISSUE
DWG. No. 2011887.002 | 3

Plot Date: Jun 10, 2016 - 8:23am
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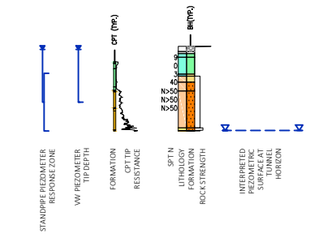
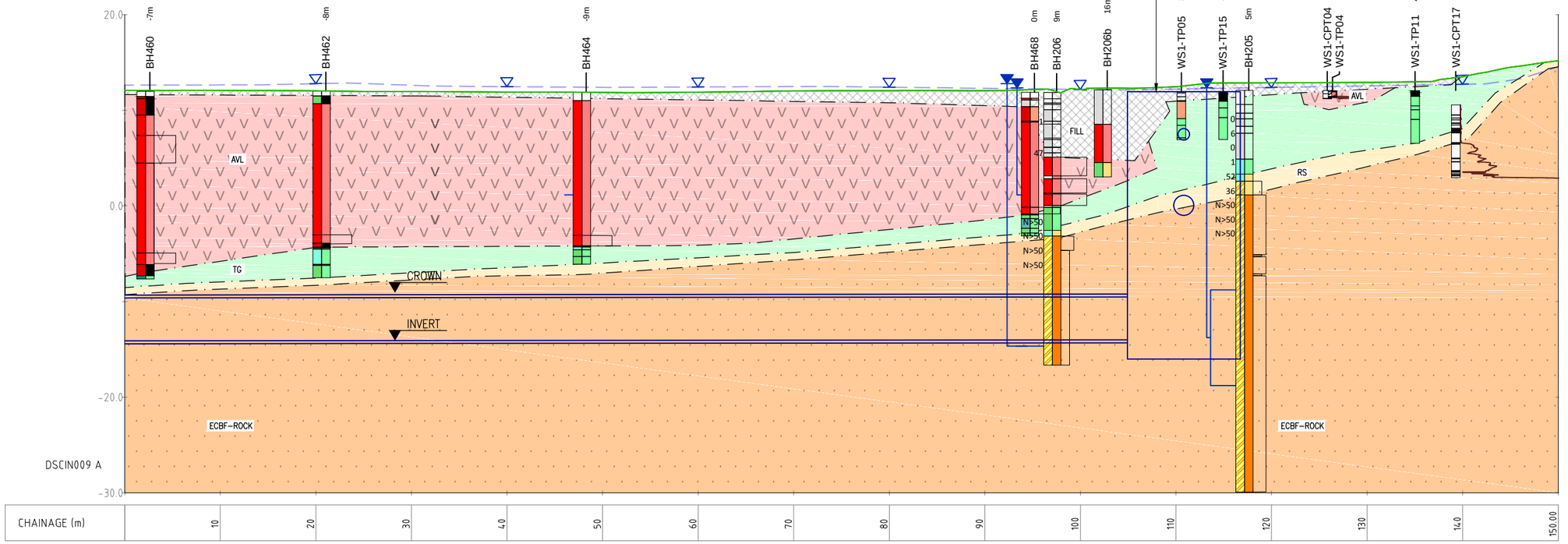
LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

	BH LEFT	PLAN AND SECTION	BH RIGHT	
No core				Made Ground (FILL)
Fill and topsoil				Recent Alluvium (Q1a)
Basalt				TAURANGA GROUP
Other volcanics				
Clay and clay dominated mixtures				Undifferentiated Tauranga Group (TG)
Organic clay and organic clay dominated mixtures				Kaawa Formation (KAAWA)
Peat				AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
Silt and silt dominated mixtures				Basalt (AVL)
Organic silt and organic silt dominated mixtures				Tuff / Ash / Scoria (AVT)
Sand and sand dominated mixtures (clean)				WAITEMATA GROUP (MIOCENE)
Sand and sand dominated mixtures (with fines)				Residually to Highly Weathered - Cohesive Soils (RS)
Organic sand and organic sand dominated mixtures				Residually to Highly Weathered - Granular Soils (RS)
Sandstone				Parnell Volcaniclastic Conglomerate (PVC)
Mudstone				Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
Interbedded mudstone and sandstone				
Conglomerate				
Coal				





HBSI Profile - DSCIN009 A

NOTES

1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
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6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		

OPERATIONS

INFRASTRUCTURE

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DSCIN009 – WESTERN SPRINGS
SITE GENERAL
SHAFT GEOLOGY – SECTION A

CAD FILE 2011887.003	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011887.003	3

Plot Date: Jun 10, 2016 - 8:25am
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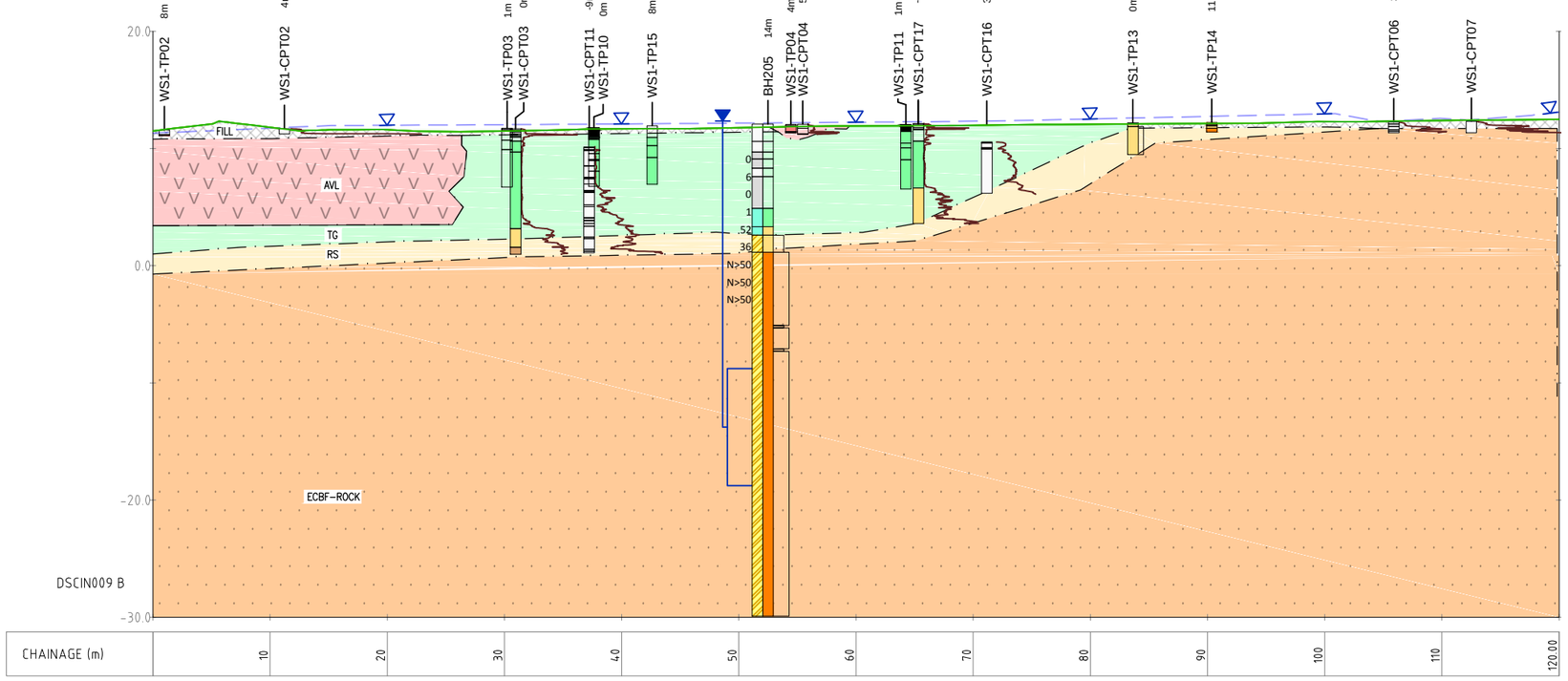


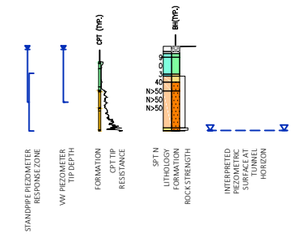
HBSI Profile - DSCIN009 B

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT | PLAN AND SECTION | BH RIGHT

- No core — Made Ground (FILL)
- Fill and topsoil — Recent Alluvium (Q1a)
- Basalt
- Other volcanics — TAURANGA GROUP
- Clay and clay dominated mixtures — Undifferentiated Tauranga Group (TG)
- Organic clay and organic clay dominated mixtures — Kaawa Formation (KAAWA)
- Peat — AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Silt and silt dominated mixtures — Basalt (AVL)
- Organic silt and organic silt dominated mixtures — Tuff / Ash / Scoria (AVT)
- Sand and sand dominated mixtures (clean) — WAITEMATA GROUP (MIOCENE)
- Sand and sand dominated mixtures (with fines) — Residually to Highly Weathered - Cohesive Soils (RS)
- Organic sand and organic sand dominated mixtures — Residually to Highly Weathered - Granular Soils (RS)
- Sandstone — Parnell Volcaniclastic Conglomerate (PVC)
- Mudstone — Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
- Interbedded mudstone and sandstone
- Conglomerate
- Coal



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X–DSCIN–T–001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X–DSLSA(–D)–C–001. DESIGNS CURRENT TO MAY 2016.
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JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15	OPERATIONS
DES. CHECKED	HM	05.16	
DRAWN	KL	04.15	
DWG. CHECKED	ADC	05.16	
PROJECT LEADER	DK	05.16	
INFRAST'R APP'D			INFRASTRUCTURE

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DSCIN009 – WESTERN SPRINGS
SITE GENERAL
SHAFT GEOLOGY – SECTION B

CAD FILE 2011887.004	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI–GEOTECH	ISSUE
DWG. No. 2011887.004	3

Plot Date: Jun 10, 2016 - 8:27am
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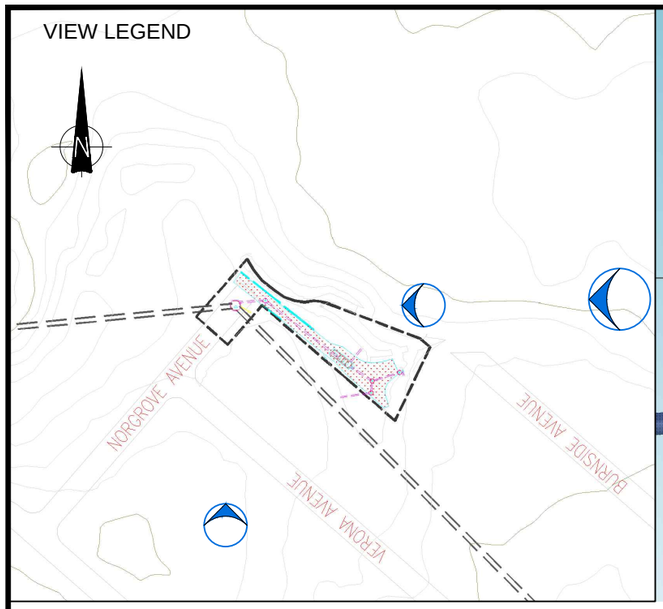
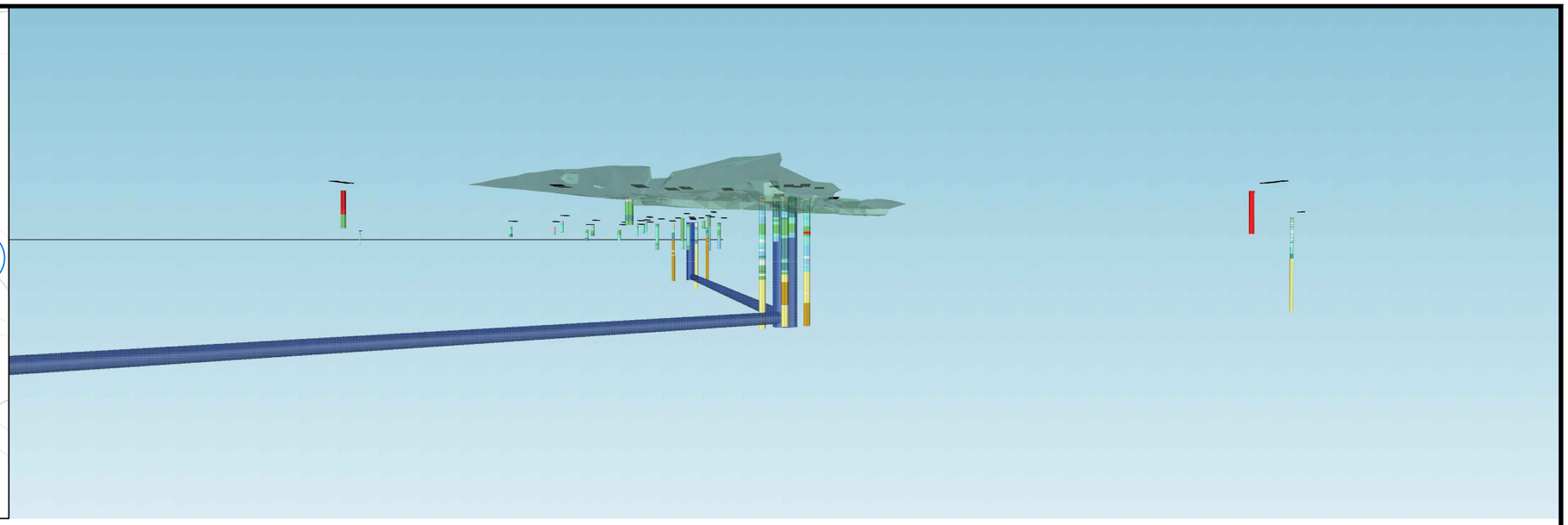
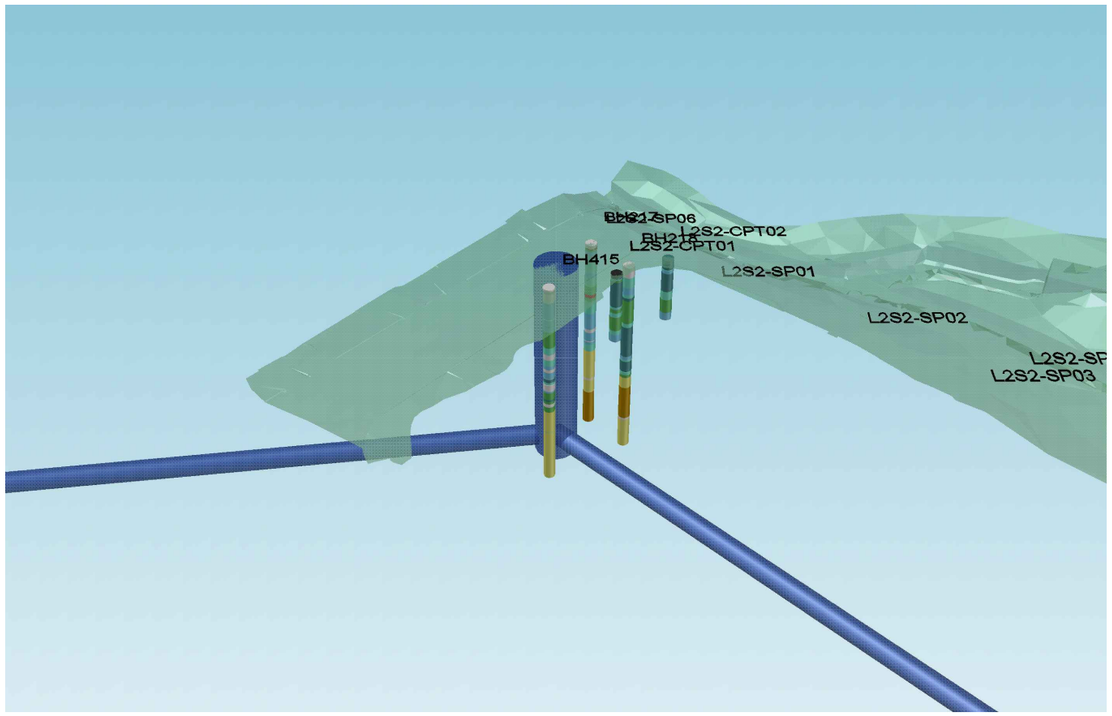


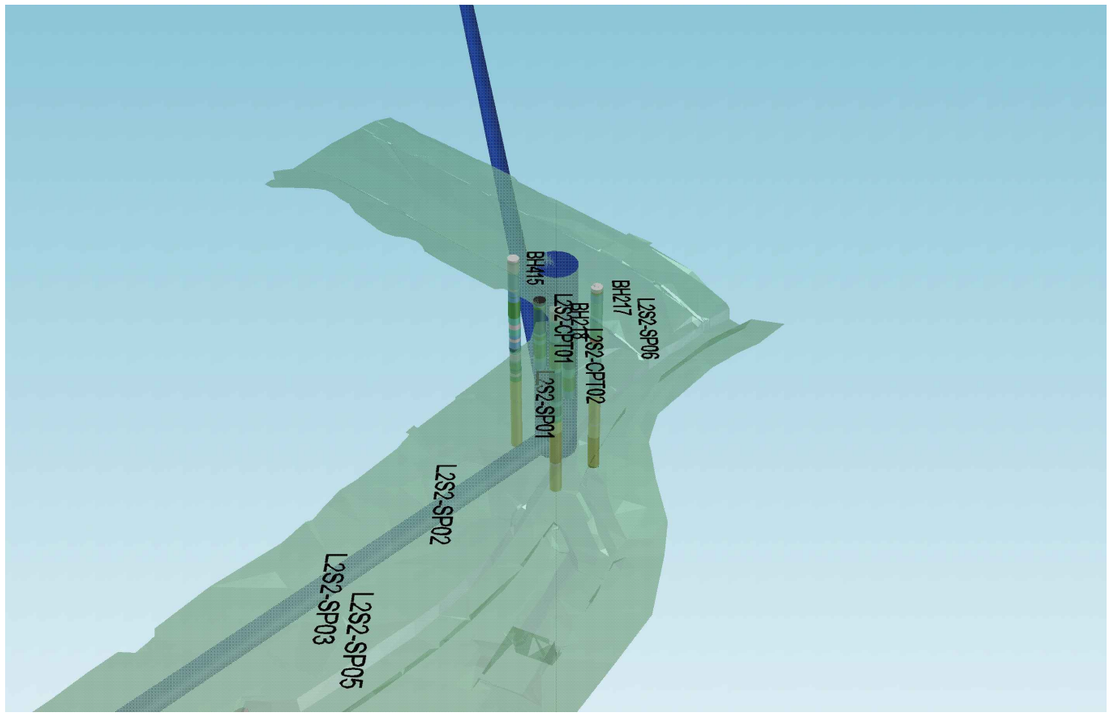


NOTES:
1. GROUND CONTOURS ARE FROM AUCKLAND COUNCIL GIS SOURCES.
2. GROUND SURFACE SHOWN FROM SITE SURVEY BY BECA, 2015.
3. TUNNEL AND SHAFTS ARE FROM DETAILED DESIGN MODEL TO MAY 2016 AND ARE INDICATIVE ONLY.
4. 3D BOREHOLE STICKS ARE EXTRACTED DIRECTLY FROM CI PROJECT GEOTECHNICAL DATABASE, AND ARE COLOURED BY GEOLOGICAL FORMATION – REFER TO LONG SECTIONS FOR KEY.

EAST – OVERVIEW



SOUTH VIEW



EAST VIEW

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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DSLSB001 – NORGROVE AVENUE
SITE GENERAL
SHAFT GEOLOGY – 3D

CAD FILE 2011953.002	DATE 07.06.16
ORIGINAL SCALE A1 N.T.S.	CONTRACT No. 5747
REF. No. CI–GEOTECH	ISSUE
DWG. No. 2011953.002	3

Plot Date: Jun 10, 2016 - 8:41am
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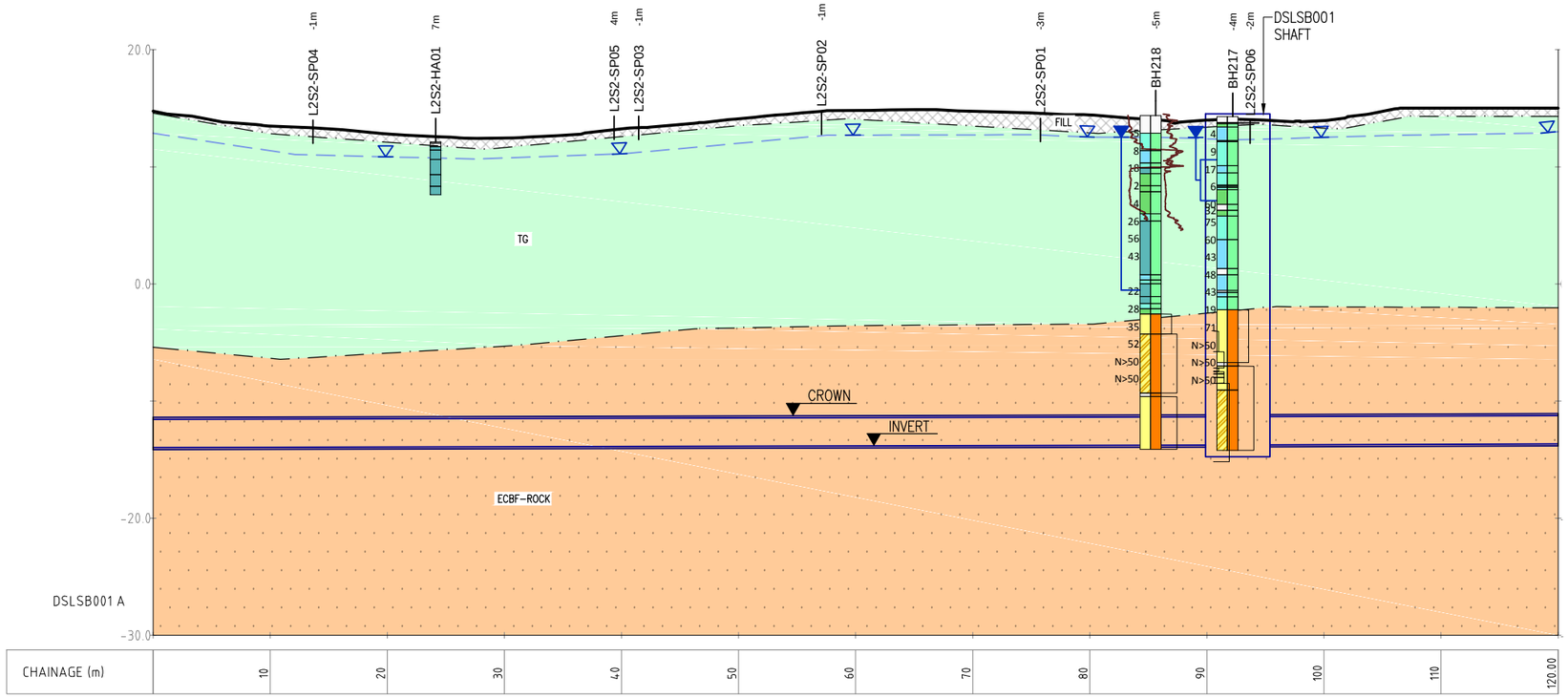
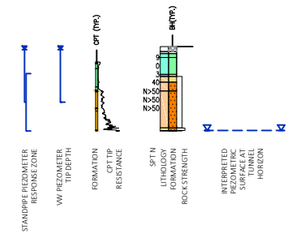


HBSI Profile - DSLSB001 A

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

	BH LEFT	PLAN AND SECTION	BH RIGHT	
No core				Made Ground (FILL)
Fill and topsoil				Recent Alluvium (Q1a)
Basalt				TAURANGA GROUP
Other volcanics				
Clay and clay dominated mixtures				Undifferentiated Tauranga Group (TG)
Organic clay and organic clay dominated mixtures				Kaawa Formation (KAAWA)
Peat				AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
Silt and silt dominated mixtures				Basalt (AVL)
Organic silt and organic silt dominated mixtures				Tuff / Ash / Scoria (AVT)
Sand and sand dominated mixtures (clean)				WAITEMATA GROUP (MIOCENE)
Sand and sand dominated mixtures (with fines)				Residually to Highly Weathered - Cohesive Soils (RS)
Organic sand and organic sand dominated mixtures				Residually to Highly Weathered - Granular Soils (RS)
Sandstone				Parnell Volcaniclastic Conglomerate (PVC)
Mudstone				Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
Interbedded mudstone and sandstone				
Conglomerate				
Coal				



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

ISSUED FOR USE

JACOBS AECOM MAULLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

	BY	DATE
DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		

OPERATIONS

INFRASTRUCTURE

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DSLSB001 – NORGROVE AVENUE
SITE GENERAL
SHAFT GEOLOGY – SECTION A

CAD FILE 2011953.003	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011953.003	3

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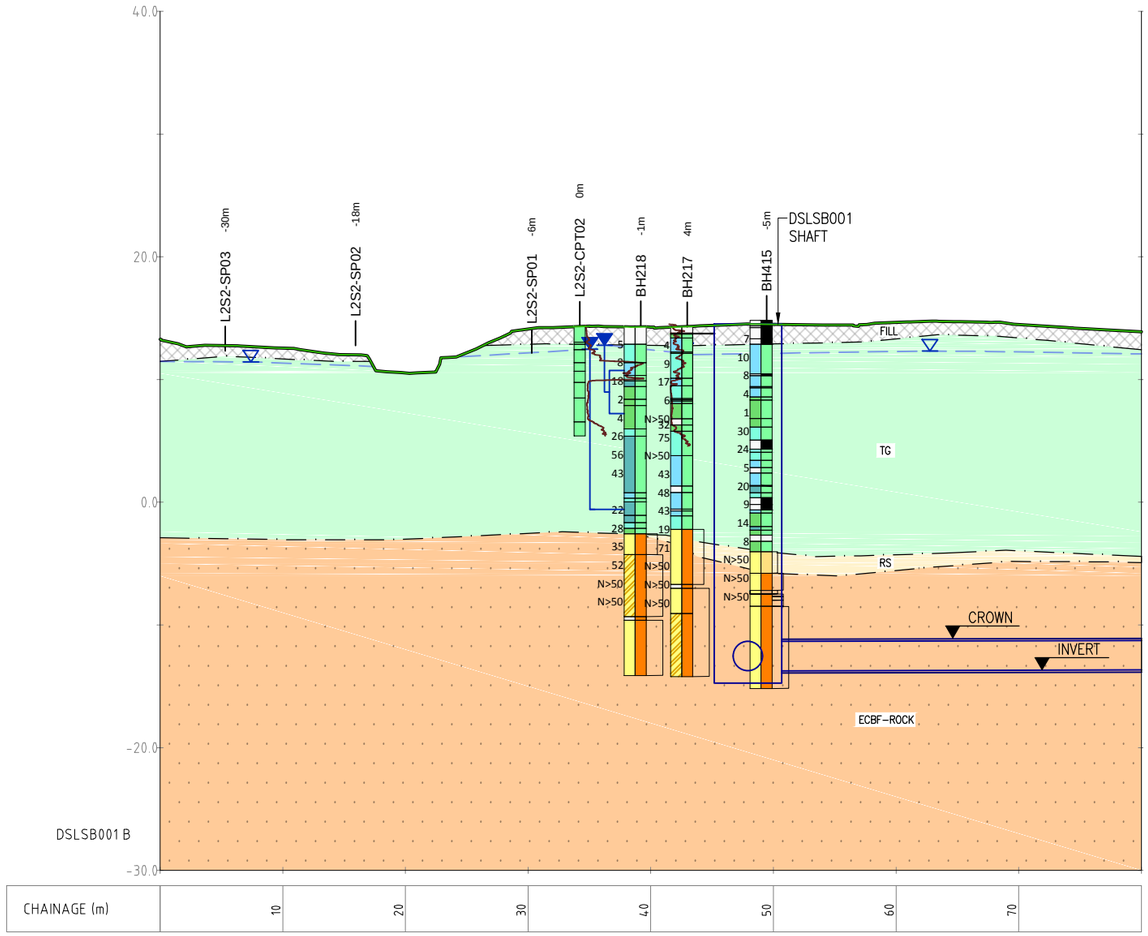
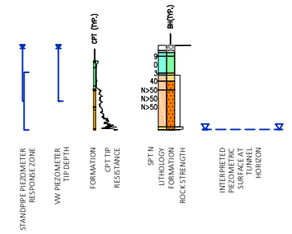


HBSI Profile - DSLSB001 B

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

	BH LEFT	PLAN AND SECTION	BH RIGHT	
No core				Made Ground (FILL)
Fill and topsoil				Recent Alluvium (Q1a)
Basalt				
Other volcanics				TAURANGA GROUP
Clay and clay dominated mixtures				Undifferentiated Tauranga Group (TG)
Organic clay and organic clay dominated mixtures				Kaawa Formation (KAAWA)
Peat				AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
Silt and silt dominated mixtures				Basalt (AVL)
Organic silt and organic silt dominated mixtures				Tuff / Ash / Scoria (AVT)
Sand and sand dominated mixtures (clean)				WAITEMATA GROUP (MIOCENE)
Sand and sand dominated mixtures (with fines)				Residually to Highly Weathered - Cohesive Soils (RS)
Organic sand and organic sand dominated mixtures				Residually to Highly Weathered - Granular Soils (RS)
Sandstone				Parnell Volcaniclastic Conglomerate (PVC)
Mudstone				Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
Interbedded mudstone and sandstone				
Conglomerate				
Coal				



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
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3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		

OPERATIONS

INFRASTRUCTURE

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DSLSB001 – NORGROVE AVENUE
SITE GENERAL
SHAFT GEOLOGY – SECTION B

CAD FILE 2011953.004	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011953.004	3

Plot Date: Jun 10, 2016 - 8:45am
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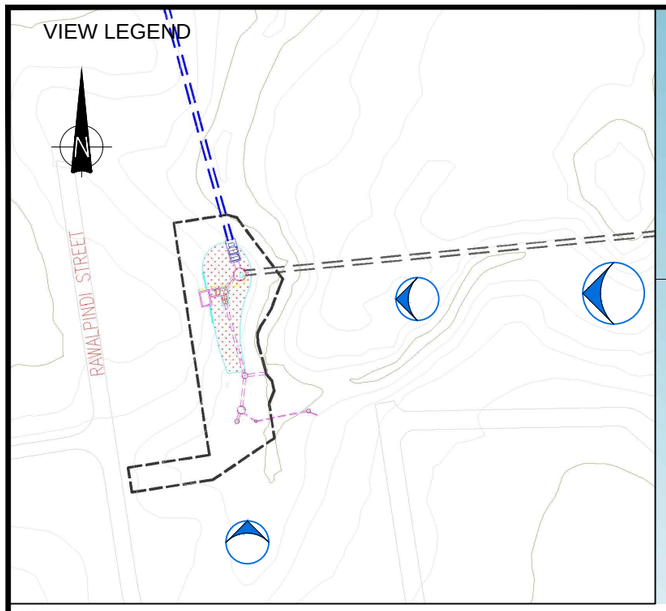
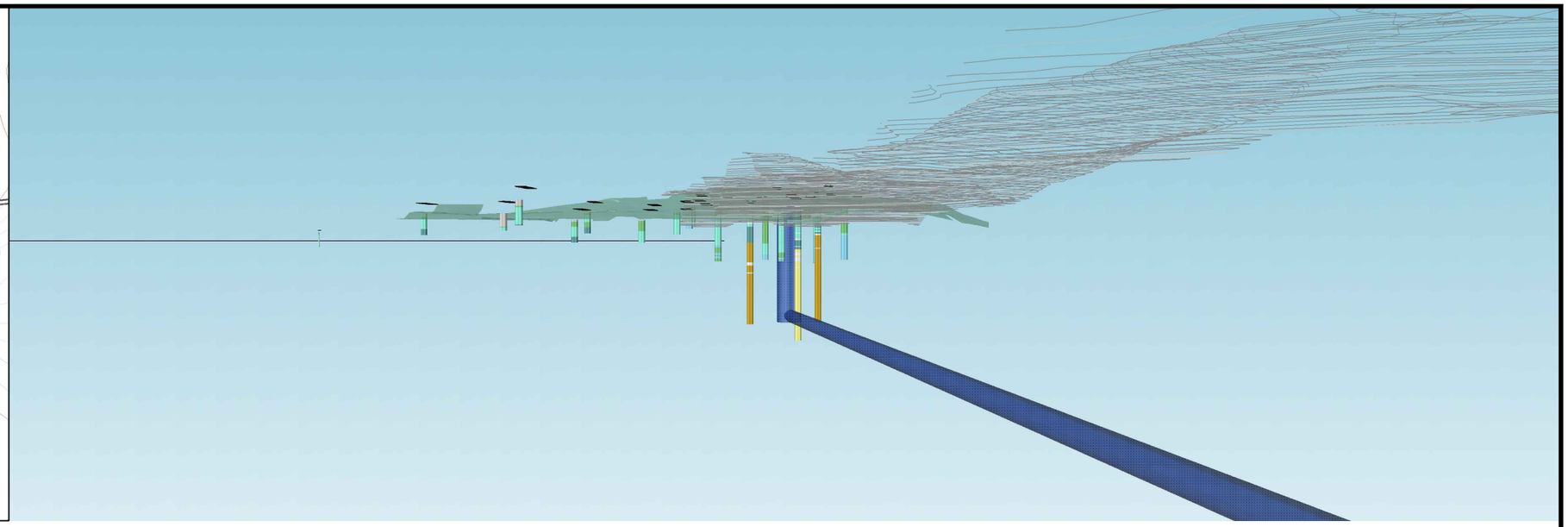
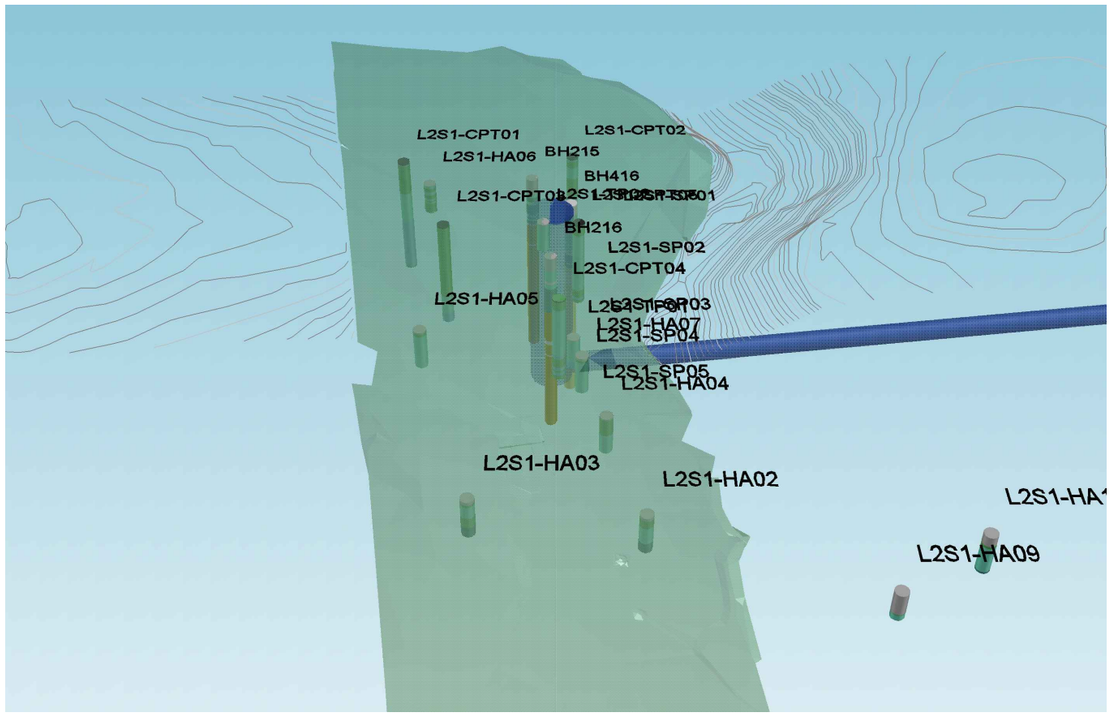


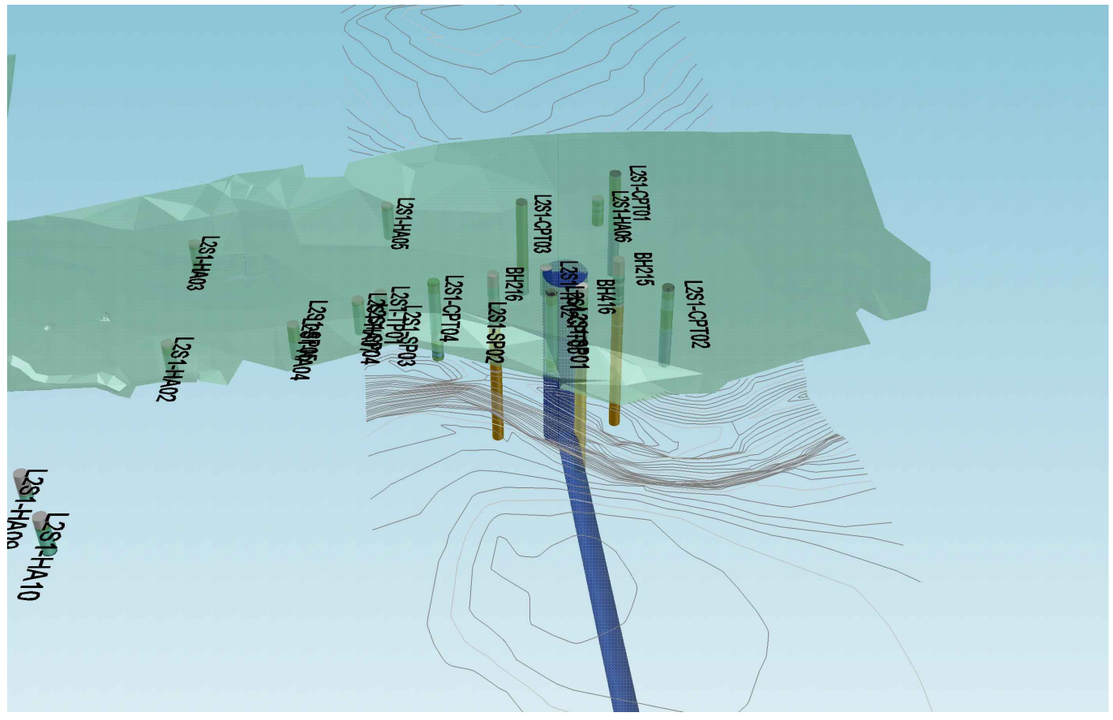


EAST – OVERVIEW

NOTES:
1. GROUND CONTOURS ARE FROM AUCKLAND COUNCIL GIS SOURCES.
2. GROUND SURFACE SHOWN FROM SITE SURVEY BY BECA, 2015.
3. TUNNEL AND SHAFTS ARE FROM DETAILED DESIGN MODEL TO MAY 2016 AND ARE INDICATIVE ONLY.
4. 3D BOREHOLE STICKS ARE EXTRACTED DIRECTLY FROM CI PROJECT GEOTECHNICAL DATABASE, AND ARE COLOURED BY GEOLOGICAL FORMATION – REFER TO LONG SECTIONS FOR KEY.



SOUTH VIEW



EAST VIEW

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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DSLSB002 – RAWALPINDI RESERVE
SITE GENERAL
SHAFT GEOLOGY – 3D

CAD FILE 2011954.002	DATE 07.06.16
ORIGINAL SCALE A1 N.T.S.	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011954.002	3

Plot Date: Jun 10, 2016 - 8:58am
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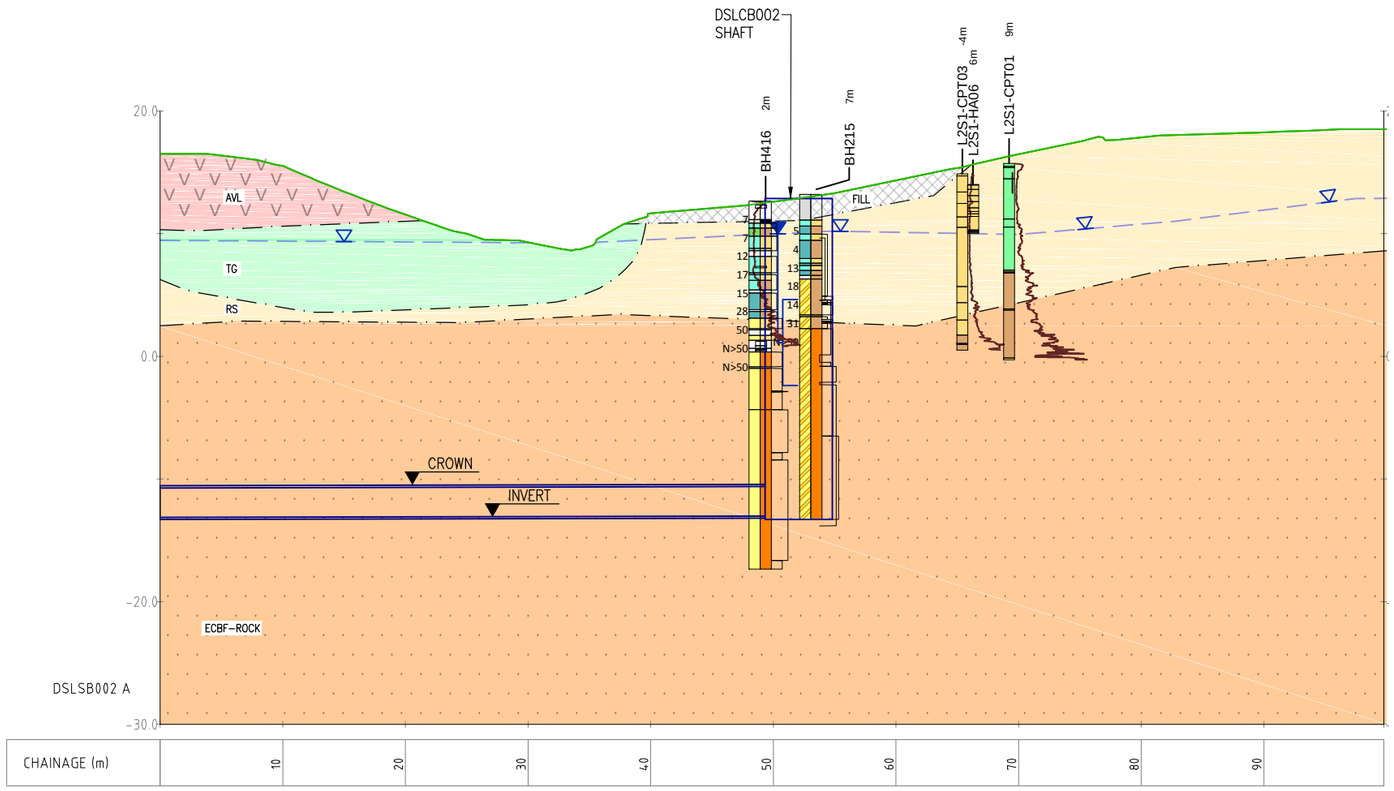


HBSI Profile - DSLSB002 A

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT | PLAN AND SECTION | BH RIGHT

- No core
- Fill and topsoil
- Basalt
- Other volcanics
- Clay and clay dominated mixtures
- Organic clay and organic clay dominated mixtures
- Peat
- Silt and silt dominated mixtures
- Organic silt and organic silt dominated mixtures
- Sand and sand dominated mixtures (clean)
- Sand and sand dominated mixtures (with fines)
- Organic sand and organic sand dominated mixtures
- Sandstone
- Mudstone
- Interbedded mudstone and sandstone
- Conglomerate
- Coal

PLAN AND SECTION | BH RIGHT

- Made Ground (FILL)
- Recent Alluvium (Q1a)

TAURANGA GROUP

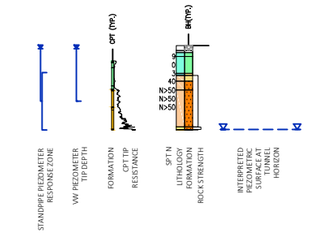
- Undifferentiated Tauranga Group (TG)
- Kaawa Formation (KAAWA)

AUCKLAND VOLCANIC FIELD (PLEISTOCENE)

- Basalt (AVL)
- Tuff / Ash / Scoria (AVT)

WAITEMATA GROUP (MIOCENE)

- Residually to Highly Weathered - Cohesive Soils (RS)
- Residually to Highly Weathered - Granular Soils (RS)
- Parnell Volcaniclastic Conglomerate (PVC)
- Moderately Weathered to Unweathered ECBF (ECBF-ROCK)



NOTES

1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

	BY	DATE
DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		

OPERATIONS

INFRASTRUCTURE

Watercare

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DSLSB002 – RAWALPINDI RESERVE
SITE GENERAL
SHAFT GEOLOGY – SECTION A

CAD FILE 2011954.003	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011954.003	3

Plot Date: Jun 10, 2016 - 8:52am
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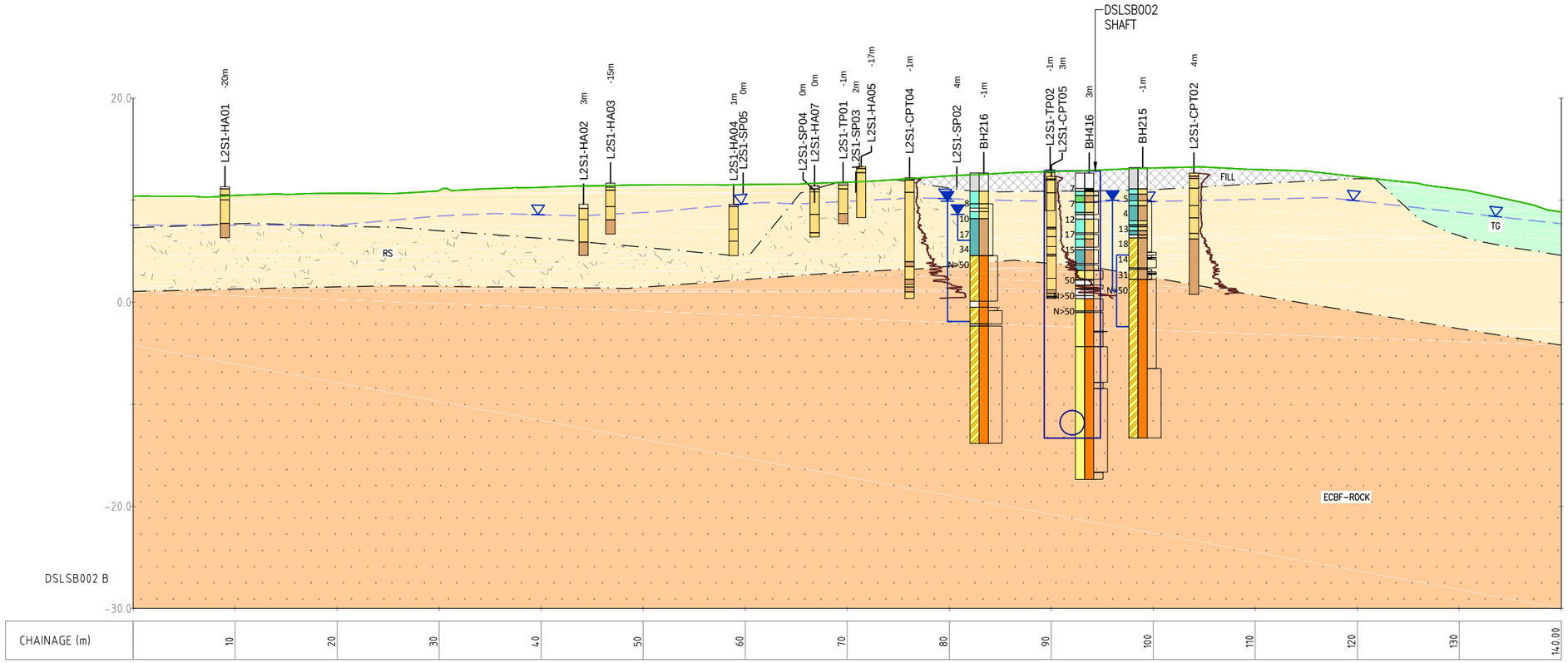
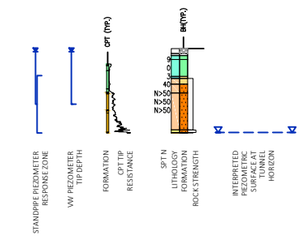


HBSI Profile - DSLSB002 B

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

	BH LEFT	PLAN AND SECTION	BH RIGHT	
No core				Made Ground (FILL)
Fill and topsoil				Recent Alluvium (Q1a)
Basalt				TAURANGA GROUP
Other volcanics				Undifferentiated Tauranga Group (TG)
Clay and clay dominated mixtures				Kaawa Formation (KAAWA)
Organic clay and organic clay dominated mixtures				AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
Peat				Basalt (AVL)
Silt and silt dominated mixtures				Tuff / Ash / Scoria (AVT)
Organic silt and organic silt dominated mixtures				WAITEMATA GROUP (MIOCENE)
Sand and sand dominated mixtures (clean)				Residually to Highly Weathered - Cohesive Soils (RS)
Sand and sand dominated mixtures (with fines)				Residually to Highly Weathered - Granular Soils (RS)
Organic sand and organic sand dominated mixtures				Parnell Volcaniclastic Conglomerate (PVC)
Sandstone				Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
Mudstone				
Interbedded mudstone and sandstone				
Conglomerate				
Coal				



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
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5. COORDINATE SYSTEM NZTM.
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ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

INFRASTRUCTURE

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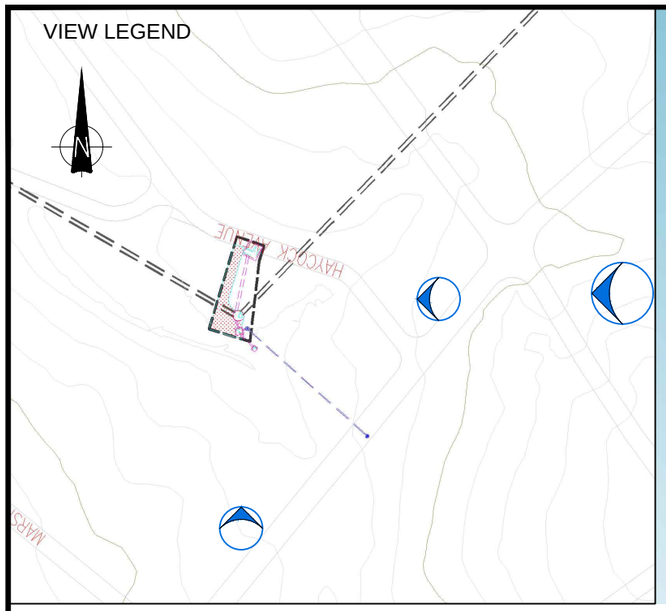
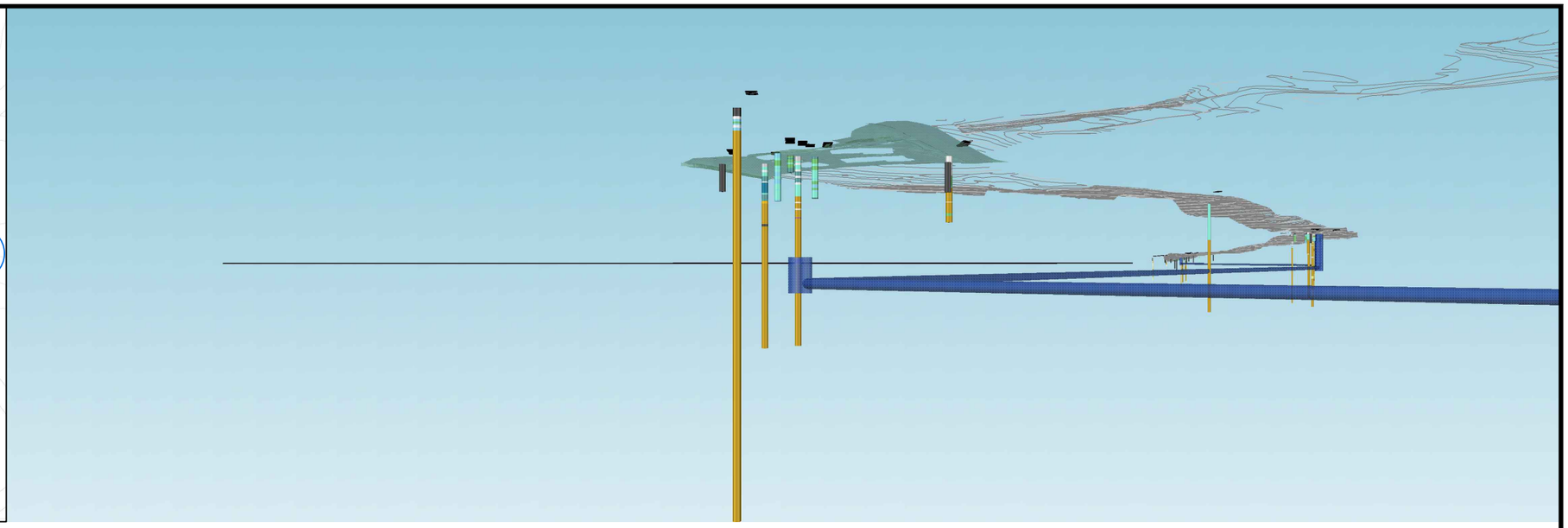
DSLSB002 – RAWALPINDI RESERVE
SITE GENERAL
SHAFT GEOLOGY – SECTION B

CAD FILE 2011954.004	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2011954.004	3

Plot Date: Jun 10, 2016 - 8:54am C:\pw_work\apatel2\dms52530\2011954.004.DWG





NOTES:
1. GROUND CONTOURS ARE FROM AUCKLAND COUNCIL GIS SOURCES.
2. GROUND SURFACE SHOWN FROM SITE SURVEY BY BECA, 2015.
3. TUNNEL AND SHAFTS ARE FROM DETAILED DESIGN MODEL TO MAY 2016 AND ARE INDICATIVE ONLY.
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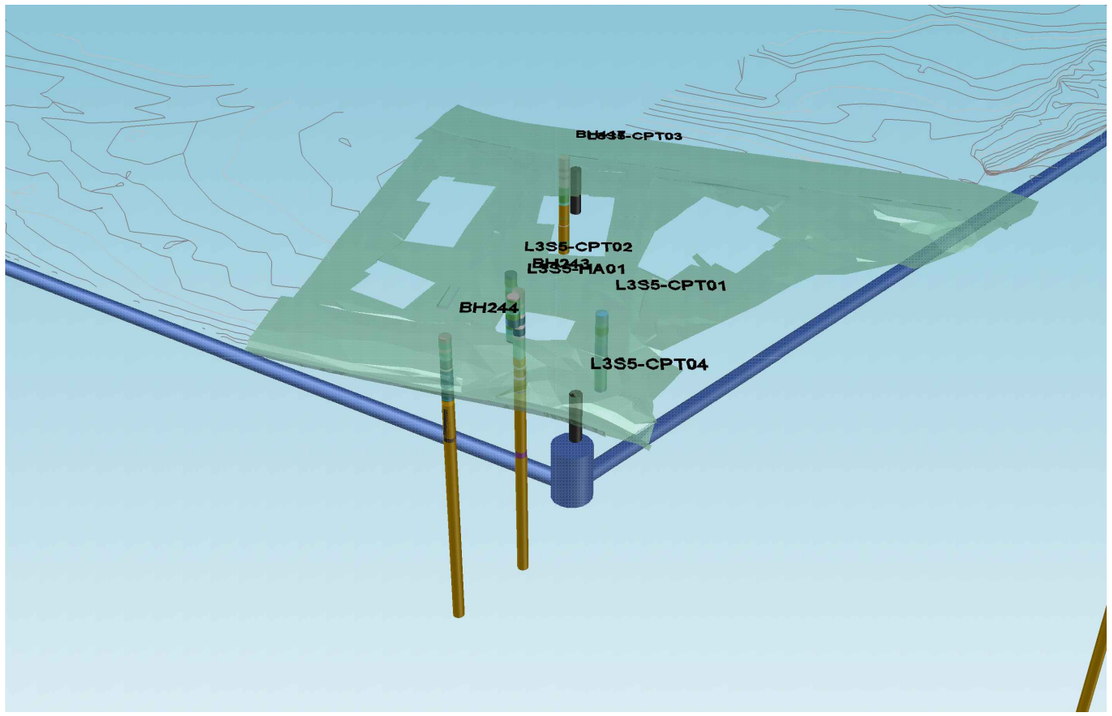
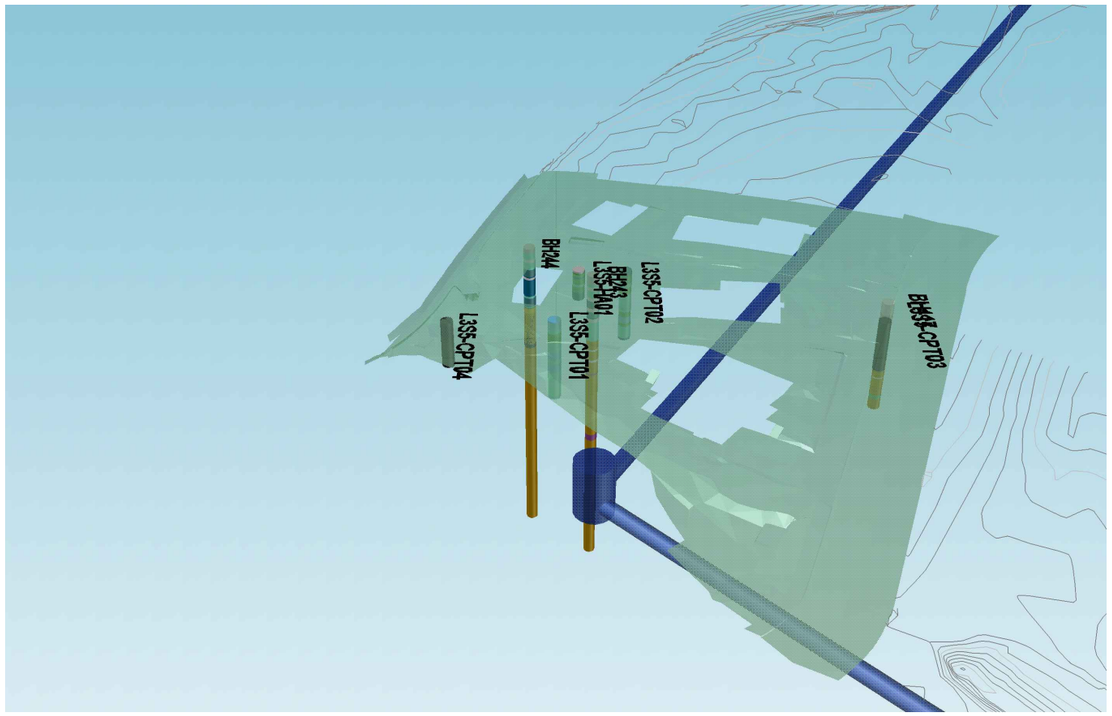
EAST – OVERVIEW



SOUTH VIEW



EAST VIEW

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
BY		DATE

OPERATIONS

INFRASTRUCTURE

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DSLSC001 – HAYCOCK AVENUE
SITE GENERAL
SHAFT GEOLOGY – 3D

CAD FILE 2012006.002	DATE 07.06.16
ORIGINAL SCALE A1 N.T.S.	CONTRACT No. 5747
REF. No. CI–GEOTECH	ISSUE
DWG. No. 2012006.002	3

Plot Date: Jun 10, 2016 - 9:00am
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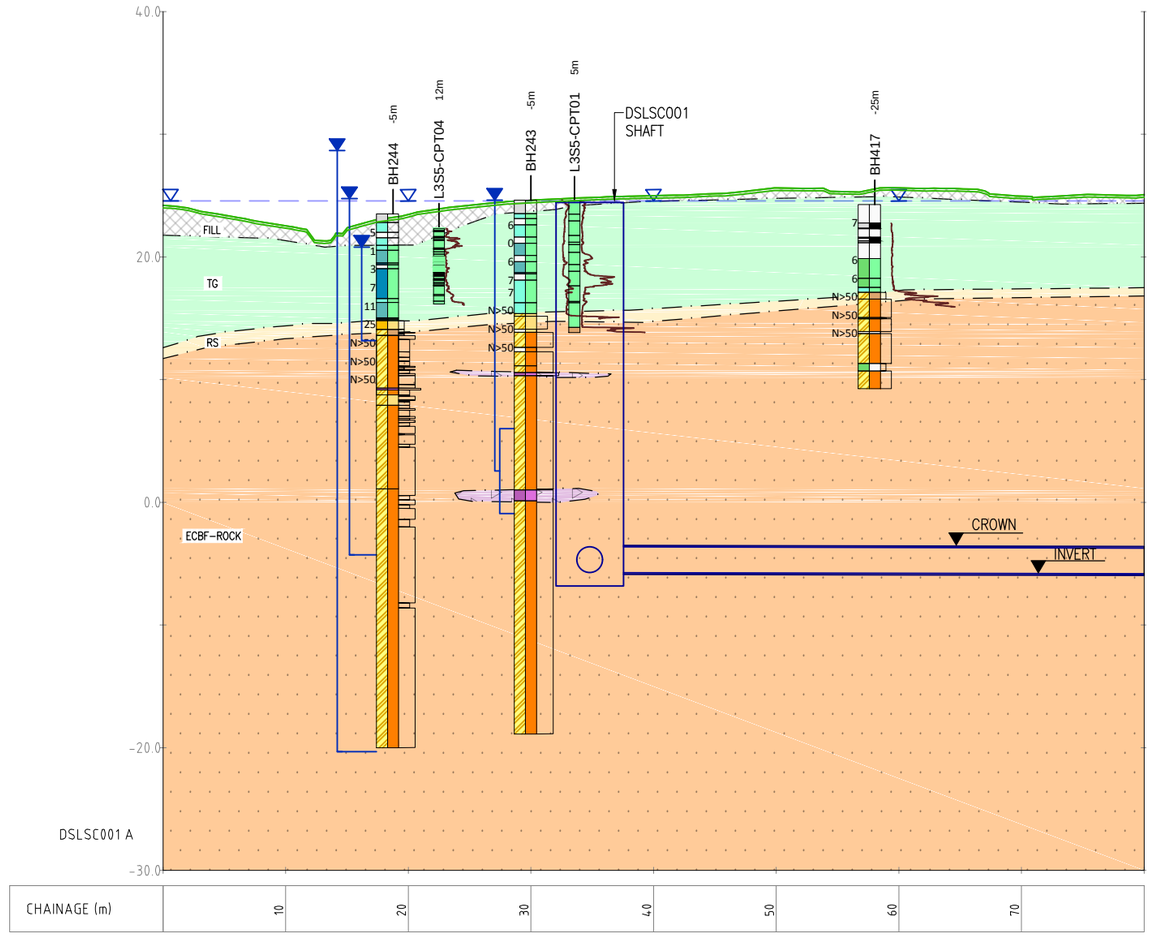
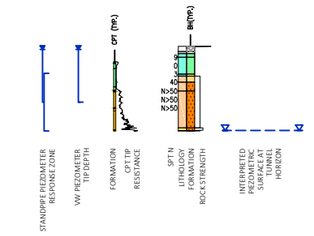


HBSI Profile - DSLSC001 A

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT	PLAN AND SECTION	BH RIGHT	
No core			Made Ground (FILL)
Fill and topsoil			Recent Alluvium (Q1a)
Basalt			TAURANGA GROUP
Other volcanics			
Clay and clay dominated mixtures			Undifferentiated Tauranga Group (TG)
Organic clay and organic clay dominated mixtures			Kaawa Formation (KAAWA)
Peat			AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
Silt and silt dominated mixtures			Basalt (AVL)
Organic silt and organic silt dominated mixtures			Tuff / Ash / Scoria (AVT)
Sand and sand dominated mixtures (clean)			WAITEMATA GROUP (MIOCENE)
Sand and sand dominated mixtures (with fines)			Residually to Highly Weathered - Cohesive Soils (RS)
Organic sand and organic sand dominated mixtures			Residually to Highly Weathered - Granular Soils (RS)
Sandstone			Parnell Volcaniclastic Conglomerate (PVC)
Mudstone			Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
Interbedded mudstone and sandstone			
Conglomerate			
Coal			



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

ISSUED FOR USE

JACOBS AECOM MAUNSELL AECOM JACOBS

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
BY		DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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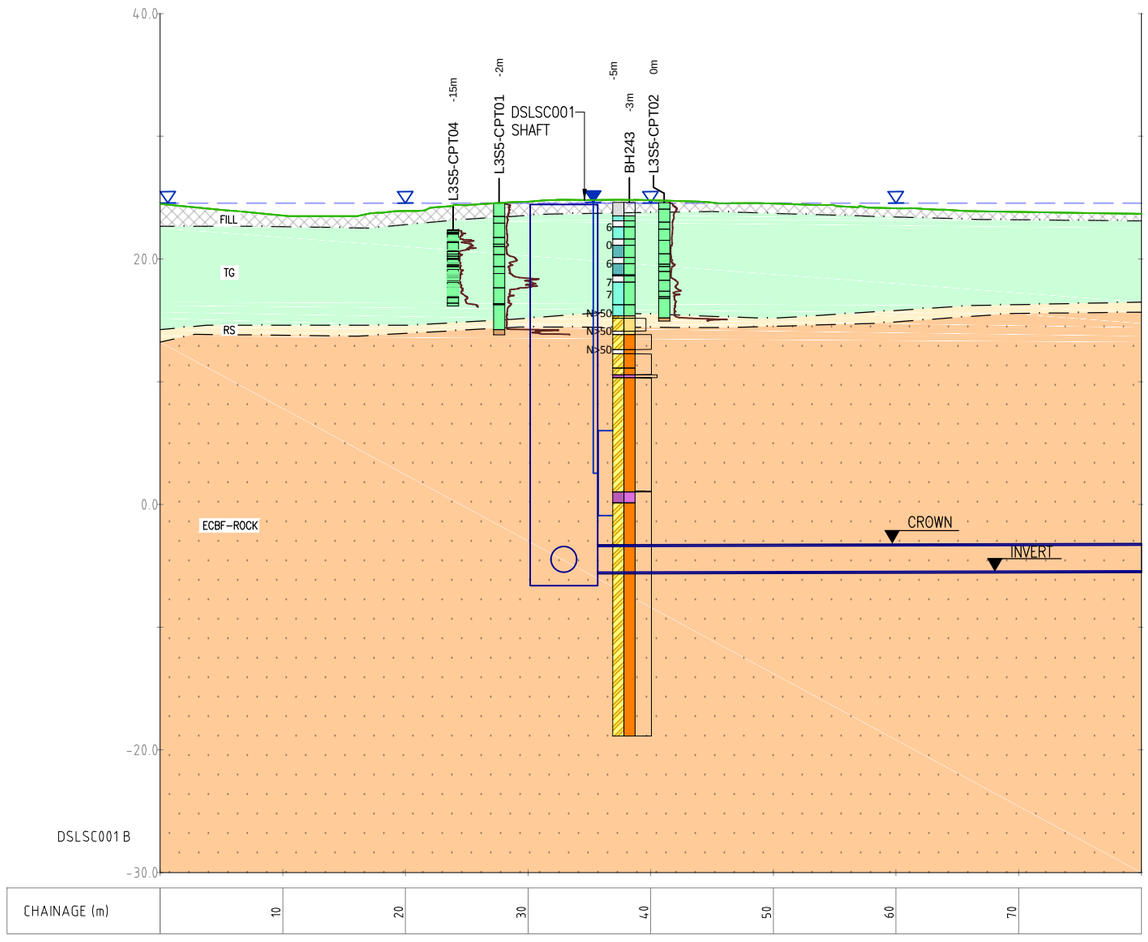
DSLSC001 – HAYCOCK AVENUE
SITE GENERAL
SHAFT GEOLOGY – SECTION A

CAD FILE 2012006.003	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012006.003	3

Plot Date: Jun 10, 2016 - 11:35am C:\pw_work\apatel2\dms525541 2012006.003.DWG

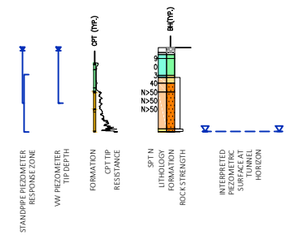


HBSI Profile - DSLSC001 B

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

	BH LEFT	PLAN AND SECTION	BH RIGHT	
No core				Made Ground (FILL)
Fill and topsoil				Recent Alluvium (Q1a)
Basalt				TAURANGA GROUP
Other volcanics				
Clay and clay dominated mixtures				Undifferentiated Tauranga Group (TG)
Organic clay and organic clay dominated mixtures				Kaawa Formation (KAAWA)
Peat				AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
Silt and silt dominated mixtures				Basalt (AVL)
Organic silt and organic silt dominated mixtures				Tuff / Ash / Scoria (AVT)
Sand and sand dominated mixtures (clean)				WAITEMATA GROUP (MIOCENE)
Sand and sand dominated mixtures (with fines)				Residually to Highly Weathered - Cohesive Soils (RS)
Organic sand and organic sand dominated mixtures				Residually to Highly Weathered - Granular Soils (RS)
Sandstone				Parnell Volcaniclastic Conglomerate (PVC)
Mudstone				Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
Interbedded mudstone and sandstone				
Conglomerate				
Coal				



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
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ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
BY		DATE

OPERATIONS

INFRASTRUCTURE

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DSLSC001 – HAYCOCK AVENUE
SITE GENERAL
SHAFT GEOLOGY – SECTION B

CAD FILE 2012006.004	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012006.004	3

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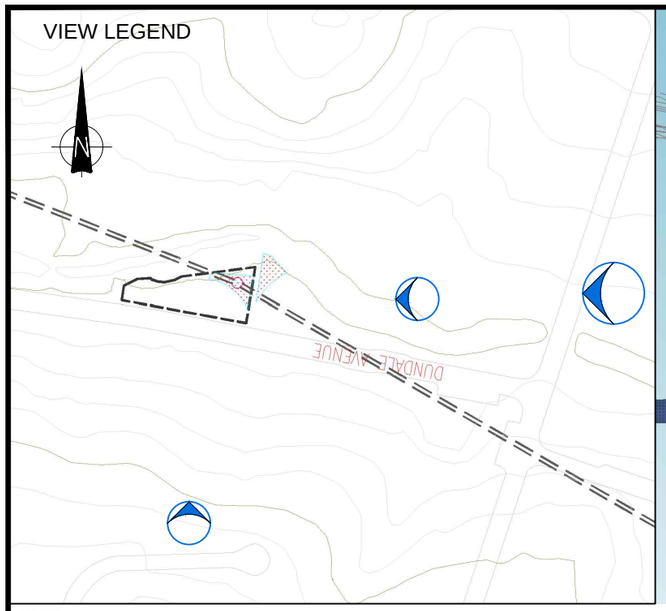
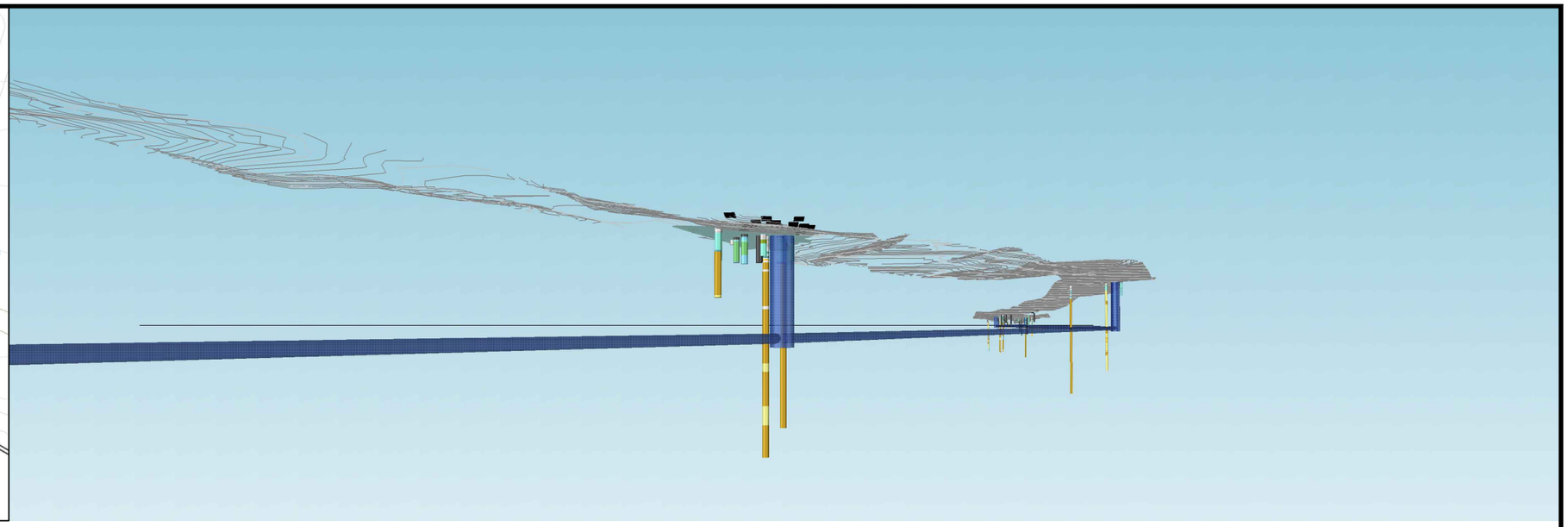
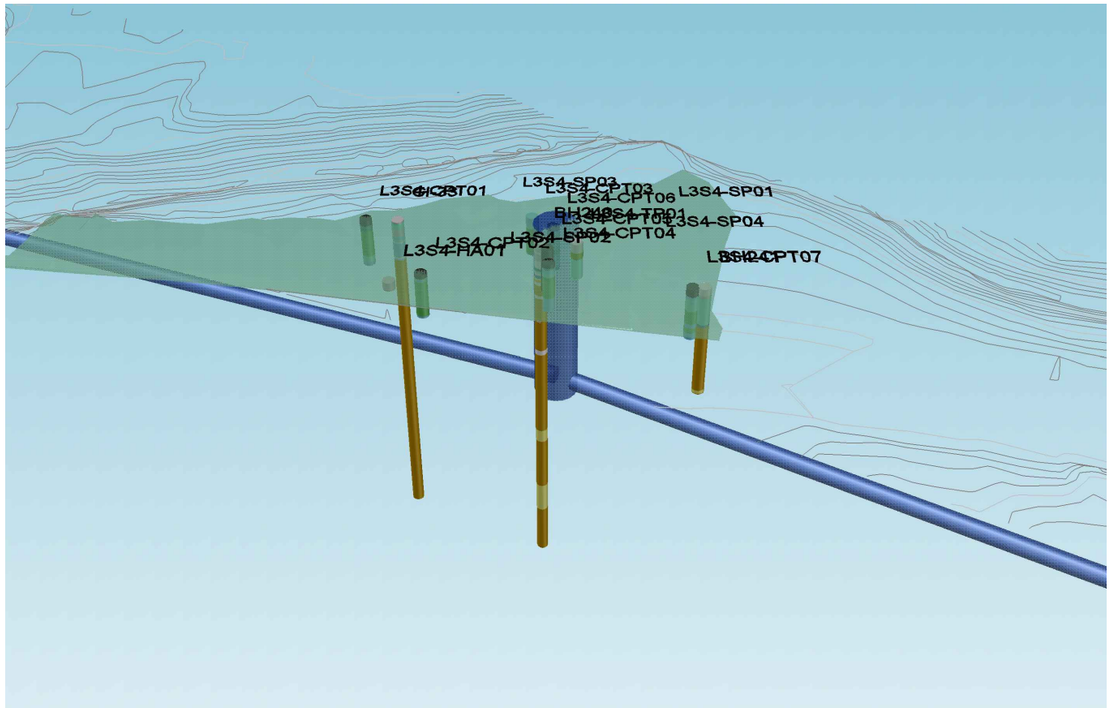


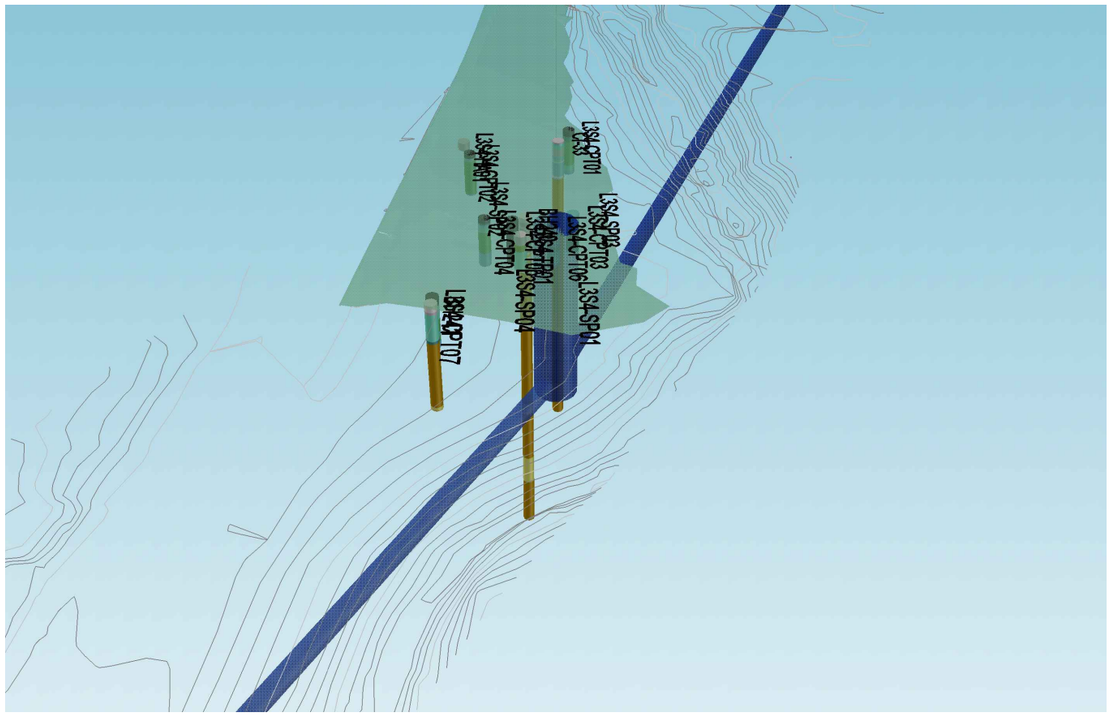


EAST – OVERVIEW

NOTES:
1. GROUND CONTOURS ARE FROM AUCKLAND COUNCIL GIS SOURCES.
2. GROUND SURFACE SHOWN FROM SITE SURVEY BY BECA, 2015.
3. TUNNEL AND SHAFTS ARE FROM DETAILED DESIGN MODEL TO MAY 2016 AND ARE INDICATIVE ONLY.
4. 3D BOREHOLE STICKS ARE EXTRACTED DIRECTLY FROM CI PROJECT GEOTECHNICAL DATABASE, AND ARE COLOURED BY GEOLOGICAL FORMATION – REFER TO LONG SECTIONS FOR KEY.



SOUTH VIEW



EAST VIEW

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

INFRASTRUCTURE

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DSLSC002 – DUNDALE AVENUE
SITE GENERAL
SHAFT GEOLOGY – 3D

CAD FILE 2012007.002	DATE 07.06.16
ORIGINAL SCALE A1 AS SHOWN	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012007.002	3

Plot Date: Jun 10, 2016 - 9:16am
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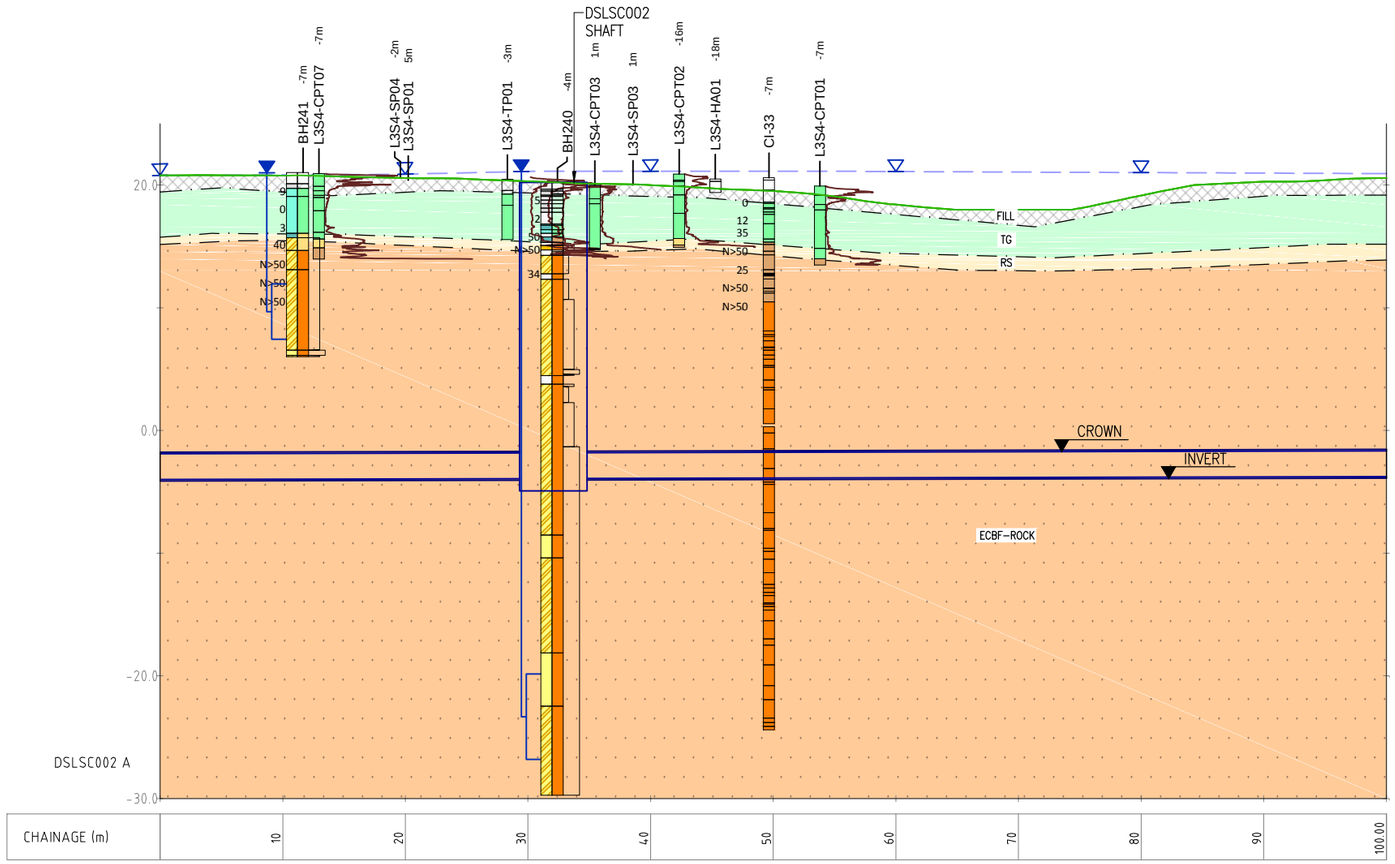


HBSI Profile - DSLSC002 A

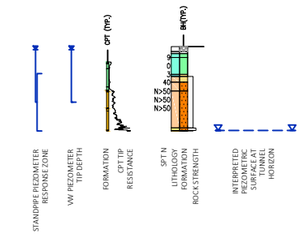
LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT | PLAN AND SECTION | BH RIGHT

- No core
- Fill and topsoil
- Basalt
- Other volcanics
- Clay and clay dominated mixtures
- Organic clay and organic clay dominated mixtures
- Peat
- Silt and silt dominated mixtures
- Organic silt and organic silt dominated mixtures
- Sand and sand dominated mixtures (clean)
- Sand and sand dominated mixtures (with fines)
- Organic sand and organic sand dominated mixtures
- Sandstone
- Mudstone
- Interbedded mudstone and sandstone
- Conglomerate
- Coal

Made Ground (FILL)
Recent Alluvium (Q1a)
TAURANGA GROUP
Undifferentiated Tauranga Group (TG)
Kaawa Formation (KAAWA)
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
Basalt (AVL)
Tuff / Ash / Scoria (AVT)
WAITEMATA GROUP (MIOCENE)
Residually to Highly Weathered - Cohesive Soils (RS)
Residually to Highly Weathered - Granular Soils (RS)
Parnell Volcaniclastic Conglomerate (PVC)
Moderately Weathered to Unweathered ECBF (ECBF-ROCK)



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
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5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		

OPERATIONS

INFRASTRUCTURE

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DSLSC002 – DUNDALE AVENUE
SITE GENERAL
SHAFT GEOLOGY – SECTION A

CAD FILE 2012007.003 | DATE 07.06.16
ORIGINAL SCALE A1 1:250 | CONTRACT No. 5747
REF. No. CI-GEOTECH | ISSUE
DWG. No. 2012007.003 | 3

Plot Date: Jun 10, 2016 - 9:21am
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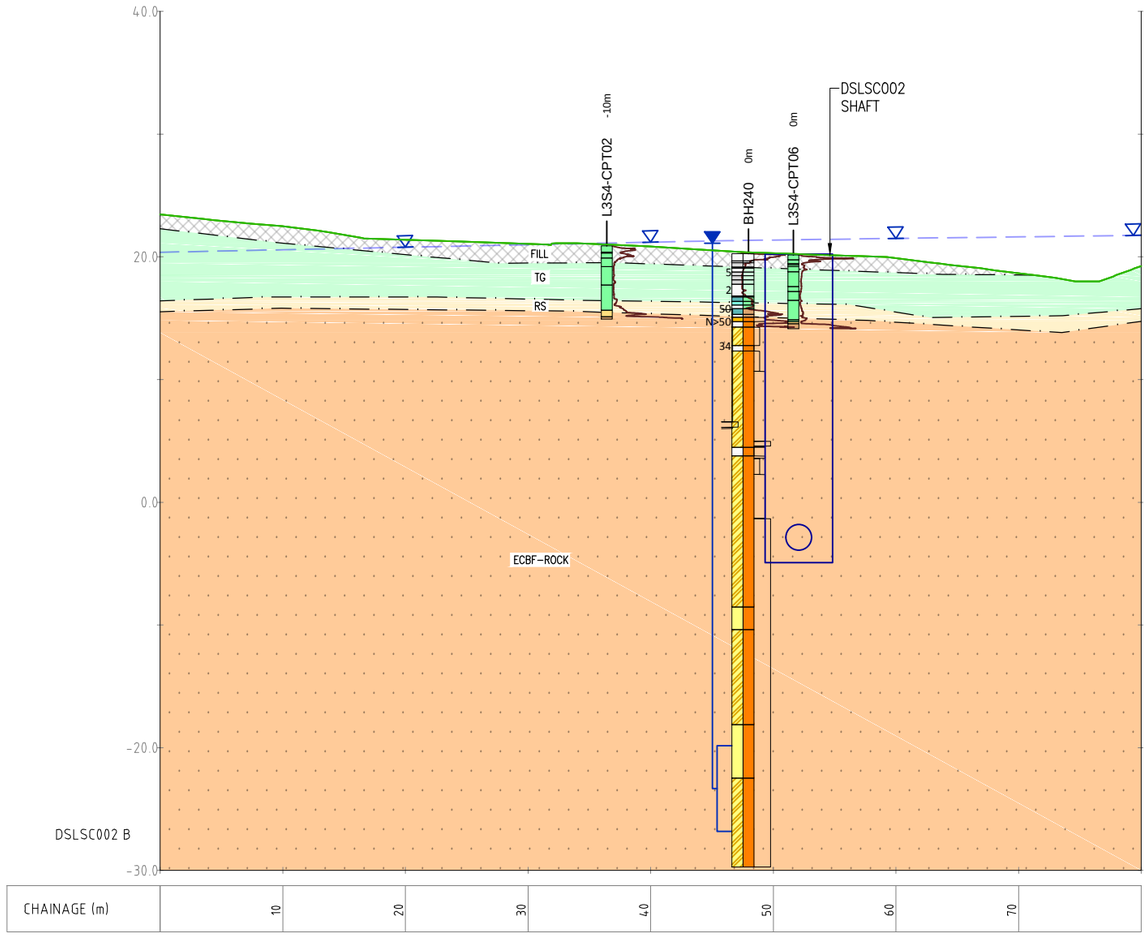
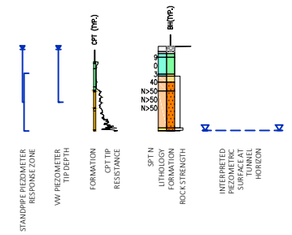


HBSI Profile - DSLSC002 B

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT	PLAN AND SECTION	BH RIGHT	
No core			Made Ground (FILL)
Fill and topsoil			Recent Alluvium (Q1a)
Basalt			TAURANGA GROUP
Other volcanics			
Clay and clay dominated mixtures			Undifferentiated Tauranga Group (TG)
Organic clay and organic clay dominated mixtures			Kaawa Formation (KAAWA)
Peat			AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
Silt and silt dominated mixtures			Basalt (AVL)
Organic silt and organic silt dominated mixtures			Tuff / Ash / Scoria (AVT)
Sand and sand dominated mixtures (clean)			WAITEMATA GROUP (MIOCENE)
Sand and sand dominated mixtures (with fines)			Residually to Highly Weathered - Cohesive Soils (RS)
Organic sand and organic sand dominated mixtures			Residually to Highly Weathered - Granular Soils (RS)
Sandstone			Parnell Volcaniclastic Conglomerate (PVC)
Mudstone			Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
Interbedded mudstone and sandstone			
Conglomerate			
Coal			



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
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ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15	
DES. CHECKED	HM	05.16	
DRAWN	KL	04.15	
DWG. CHECKED	ADC	05.16	
PROJECT LEADER	DK	05.16	
INFRAST'R APP'D			
	BY	DATE	

OPERATIONS

INFRASTRUCTURE

Watercare

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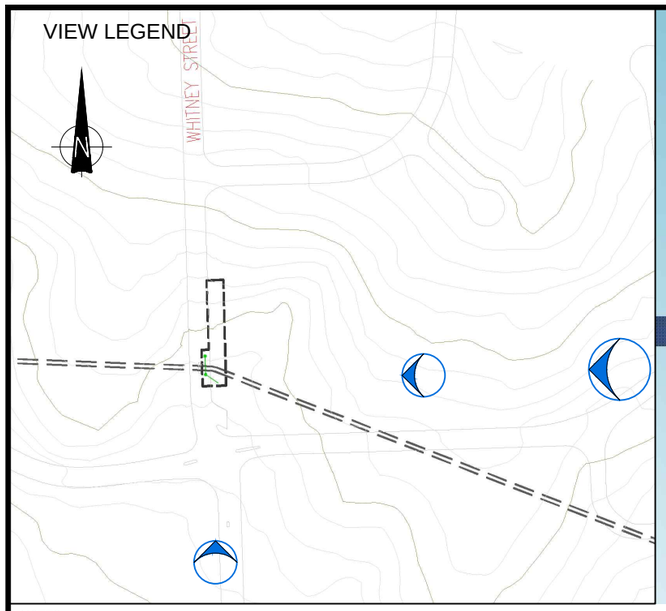
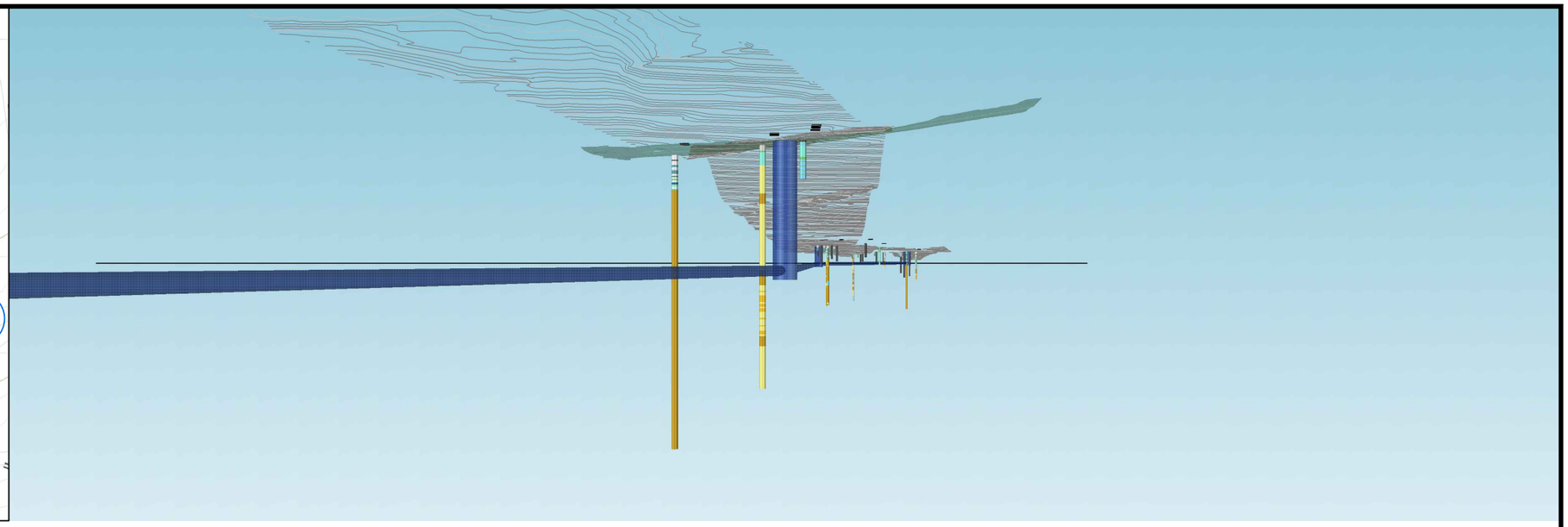
DSLSC002 – DUNDALE AVENUE
SITE GENERAL
SHAFT GEOLOGY – SECTION B

CAD FILE 2012007.004	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012007.004	3

Plot Date: Jun 19, 2016 - 11:30am C:\pw_work\apaiet2\dms525781_2012007.004.DWG





NOTES:
1. GROUND CONTOURS ARE FROM AUCKLAND COUNCIL GIS SOURCES.
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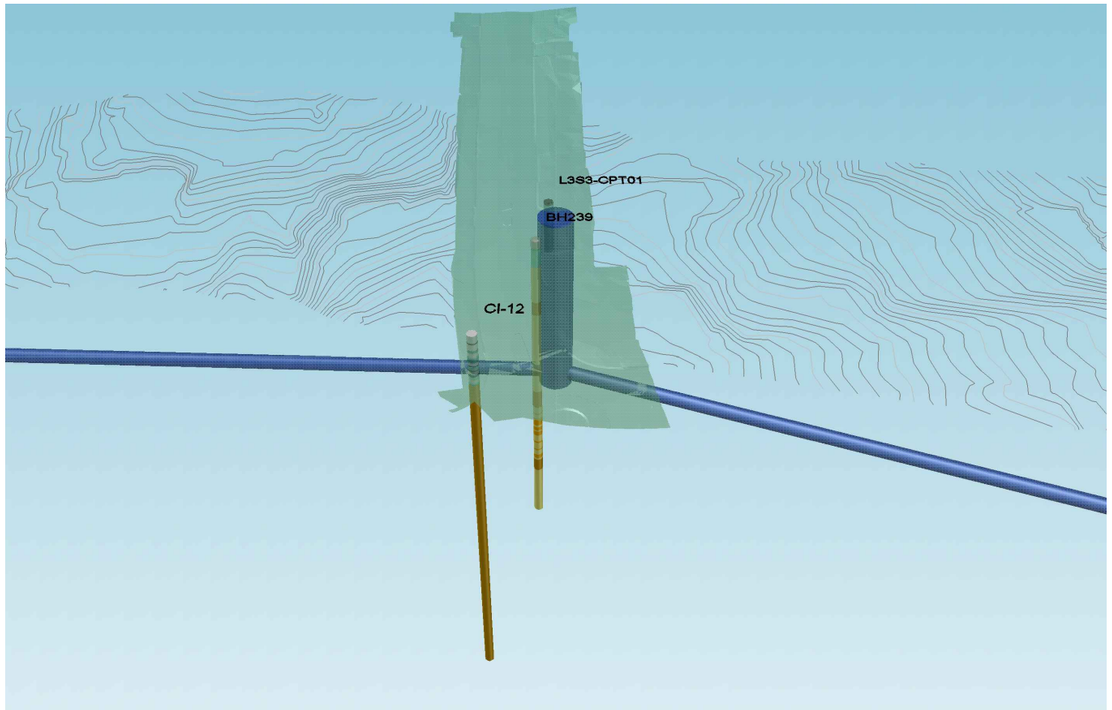
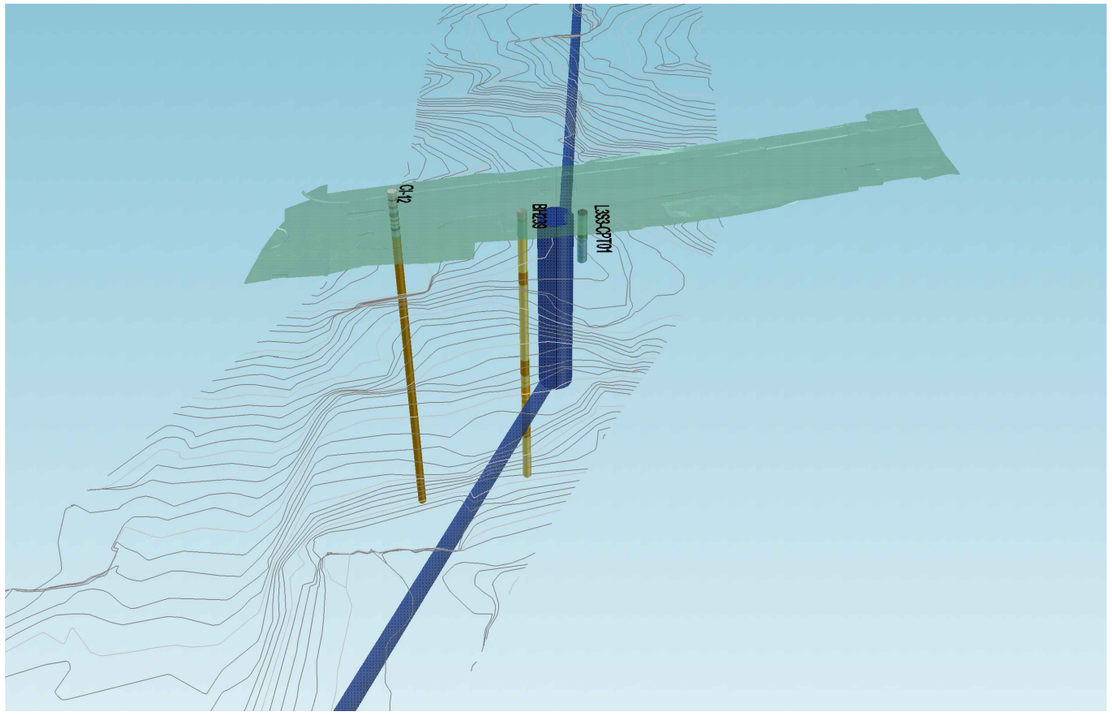
EAST – OVERVIEW



SOUTH VIEW



EAST VIEW

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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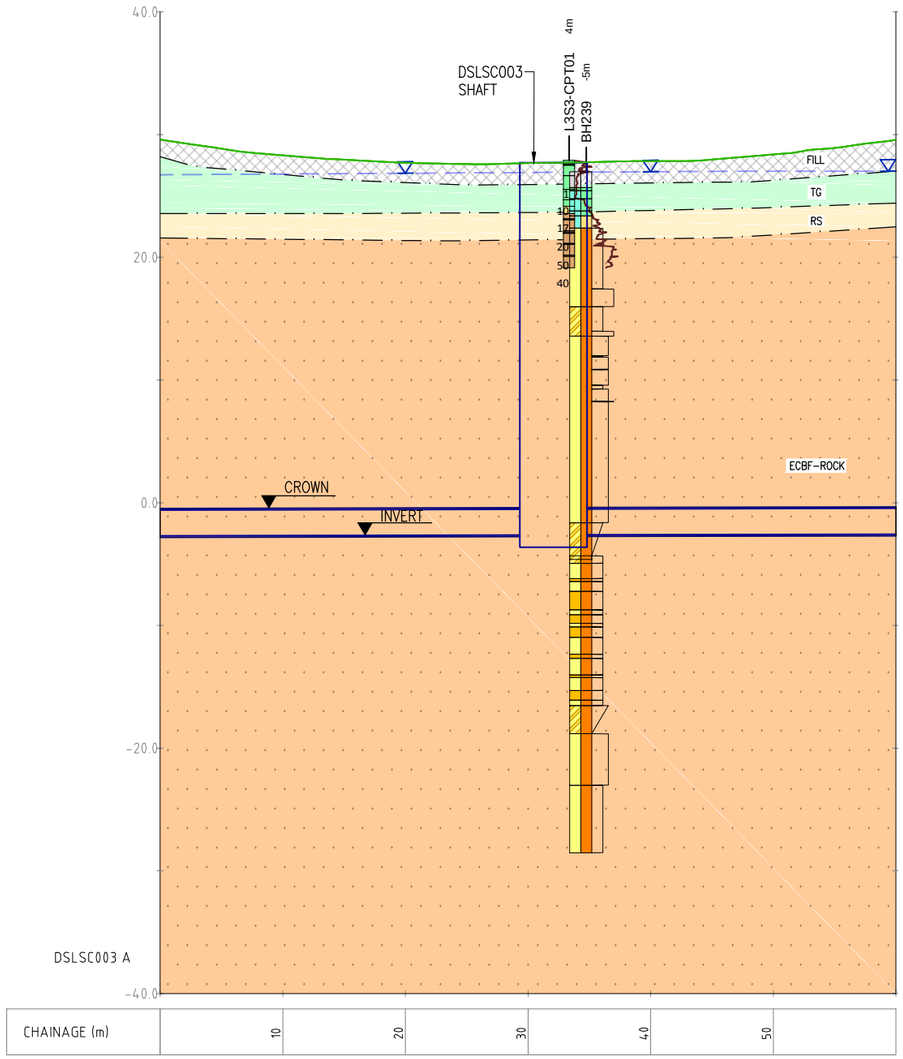
DSLSC003 – WHITNEY STREET
SITE GENERAL
SHAFT GEOLOGY – 3D

CAD FILE 2012008.002	DATE 07.06.16
ORIGINAL SCALE A1 N.T.S.	CONTRACT No. 5747
REF. No. CI–GEOTECH	ISSUE
DWG. No. 2012008.002	3

Plot Date: Jun 10, 2016 - 9:30am
C:\pw_work\sgaite2\dms52602\ 2012008.002.DWG



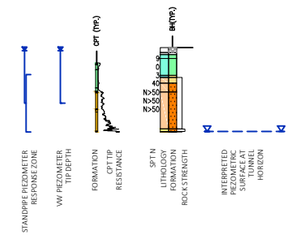
HBSI Profile - DSLSC003 A

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT | PLAN AND SECTION | BH RIGHT

- No core — Made Ground (FILL)
- Fill and topsoil — Recent Alluvium (Q1a)
- Basalt — TAURANGA GROUP
- Other volcanics — Undifferentiated Tauranga Group (TG)
- Clay and clay dominated mixtures — Kaawa Formation (KAAWA)
- Organic clay and organic clay dominated mixtures — AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
- Peat — Basalt (AVL)
- Silt and silt dominated mixtures — Tuff / Ash / Scoria (AVT)
- Organic silt and organic silt dominated mixtures — WAITEMATA GROUP (MIOCENE)
- Sand and sand dominated mixtures (clean) — Residually to Highly Weathered - Cohesive Soils (RS)
- Sand and sand dominated mixtures (with fines) — Residually to Highly Weathered - Granular Soils (RS)
- Organic sand and organic sand dominated mixtures — Parnell Volcaniclastic Conglomerate (PVC)
- Sandstone — Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
- Mudstone
- Interbedded mudstone and sandstone
- Conglomerate
- Coal



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
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3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
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2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

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DSLSC003 – WHITNEY STREET
SITE GENERAL
SHAFT GEOLOGY – SECTION A

CAD FILE 2012008.003	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012008.003	3

Plot Date: Jun 10, 2016 - 9:33am
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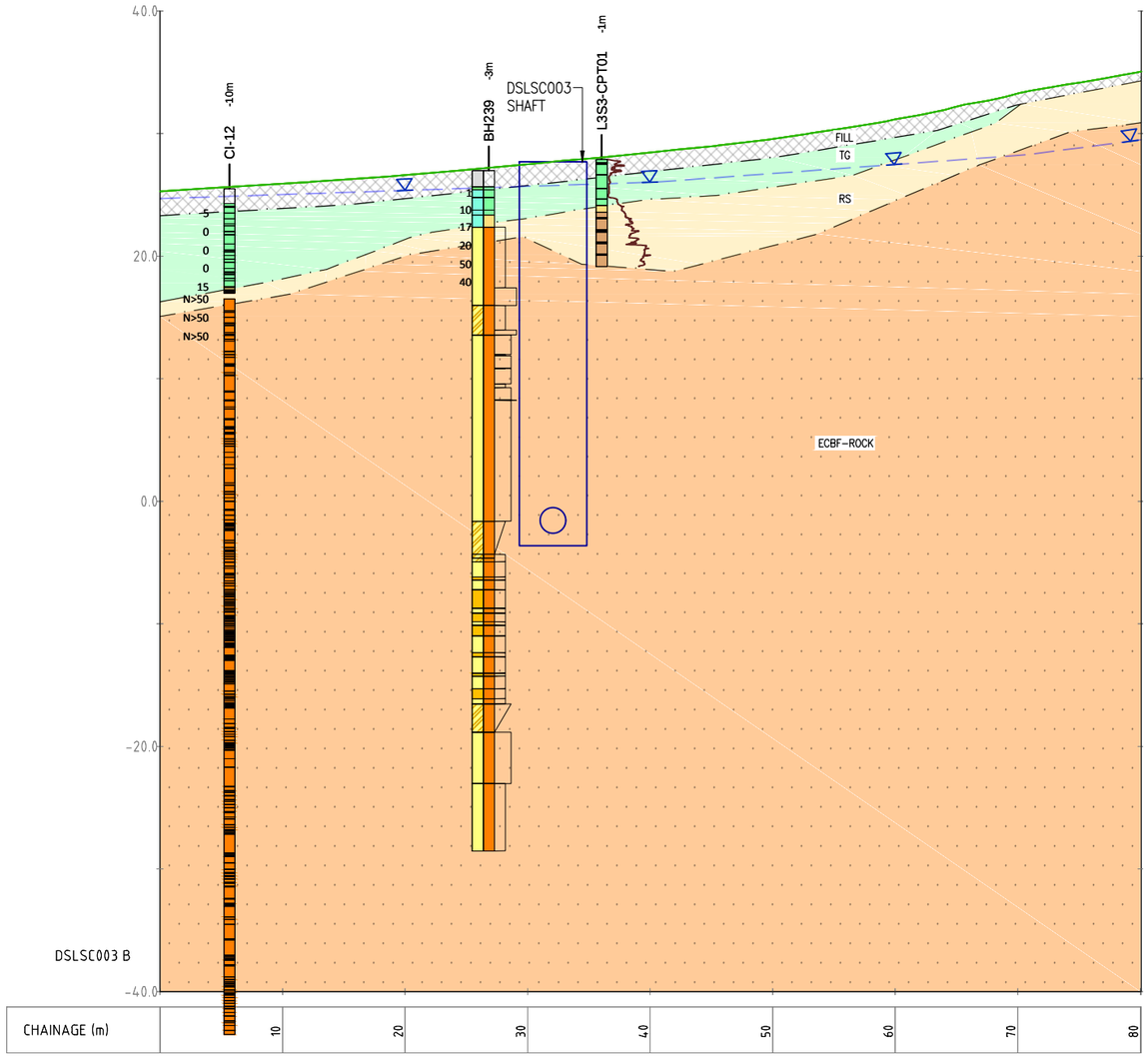
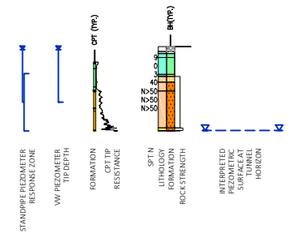


HBSI Profile - DSLSC003 B

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT	PLAN AND SECTION	BH RIGHT	
No core			Made Ground (FILL)
Fill and topsoil			Recent Alluvium (Q1a)
Basalt			TAURANGA GROUP
Other volcanics			
Clay and clay dominated mixtures			Undifferentiated Tauranga Group (TG)
Organic clay and organic clay dominated mixtures			Kaawa Formation (KAAWA)
Peat			AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
Silt and silt dominated mixtures			Basalt (AVL)
Organic silt and organic silt dominated mixtures			Tuff / Ash / Scoria (AVT)
Sand and sand dominated mixtures (clean)			WAITEMATA GROUP (MIOCENE)
Sand and sand dominated mixtures (with fines)			Residually to Highly Weathered - Cohesive Soils (RS)
Organic sand and organic sand dominated mixtures			Residually to Highly Weathered - Granular Soils (RS)
Sandstone			Parnell Volcaniclastic Conglomerate (PVC)
Mudstone			Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
Interbedded mudstone and sandstone			
Conglomerate			
Coal			



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
BY		DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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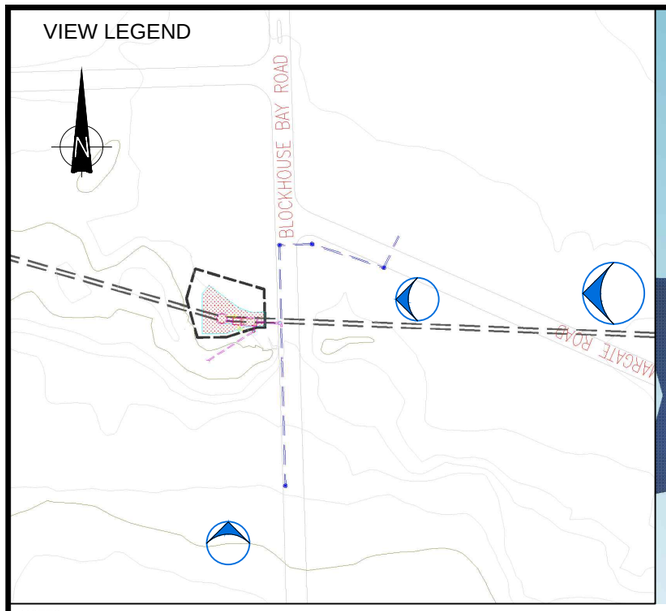
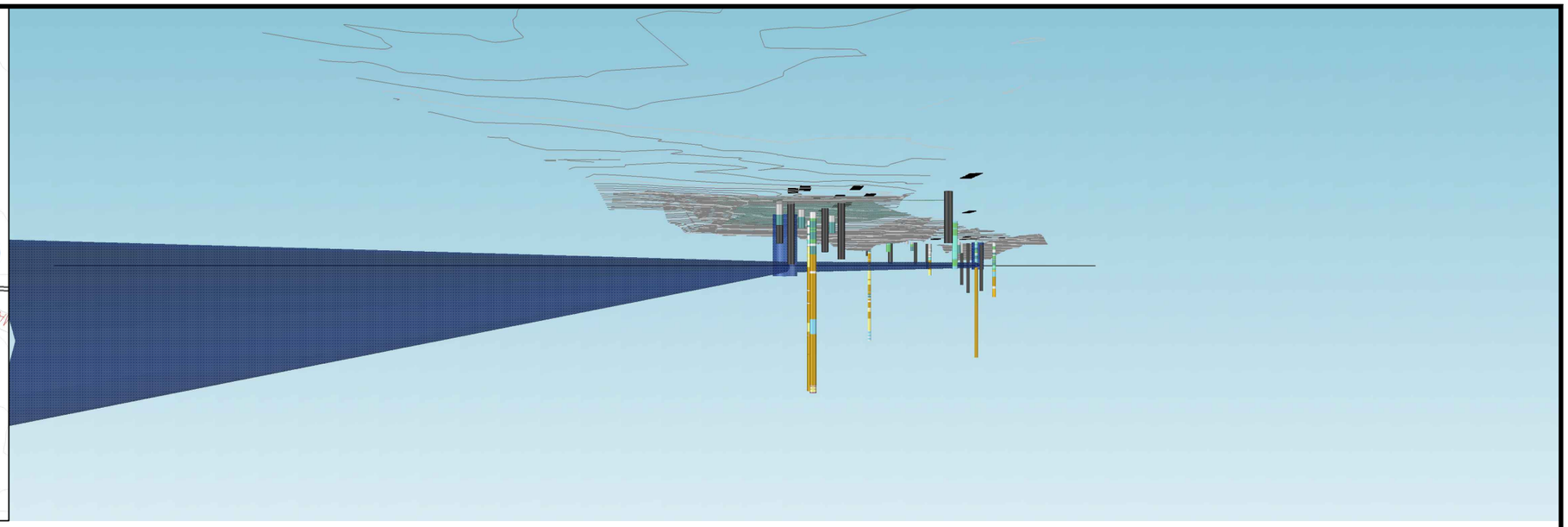
DSLSC003 – WHITNEY STREET
SITE GENERAL
SHAFT GEOLOGY – SECTION B

CAD FILE 2012008.004	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012008.004	3

Plot Date: Jun 10, 2016 - 9:34am
C:\pw_work\apatel2\dms52602\ 2012008.004.DWG

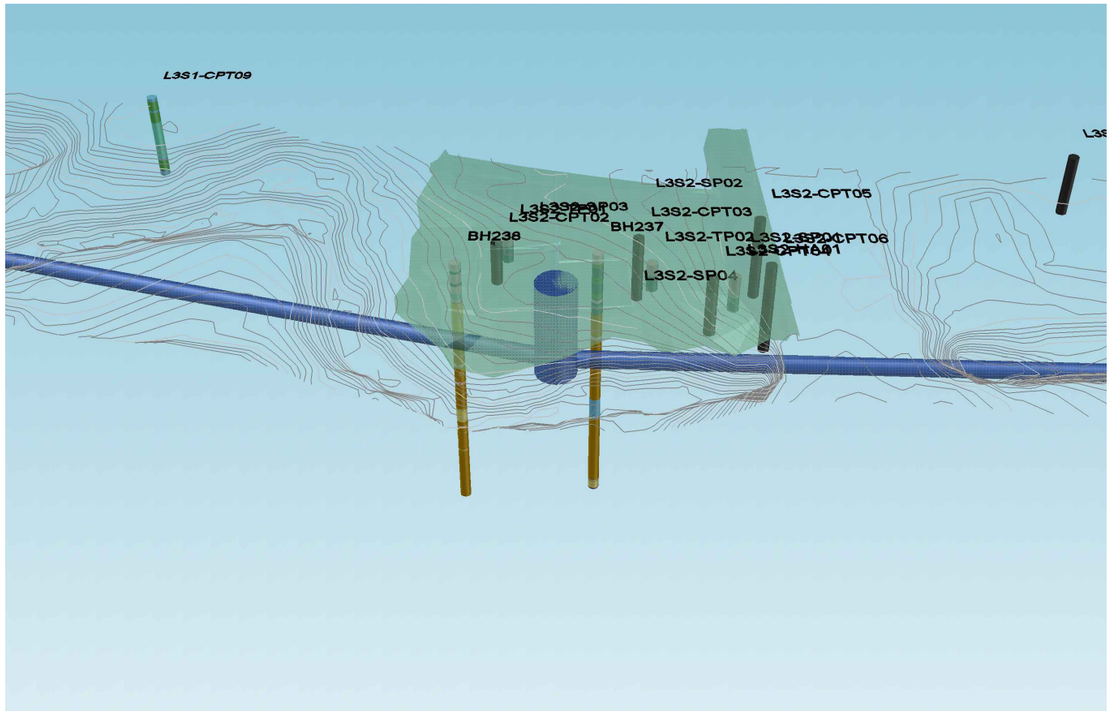
VIEW LEGEND



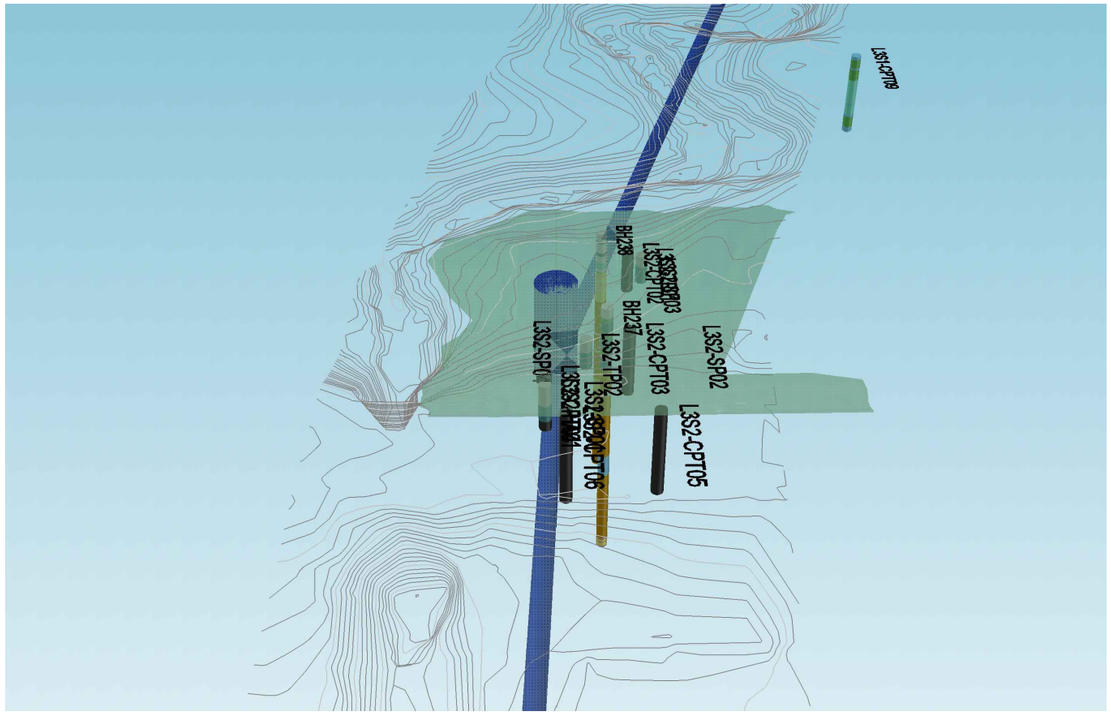


EAST – OVERVIEW

NOTES:
1. GROUND CONTOURS ARE FROM AUCKLAND COUNCIL GIS SOURCES.
2. GROUND SURFACE SHOWN FROM SITE SURVEY BY BECA, 2015.
3. TUNNEL AND SHAFTS ARE FROM DETAILED DESIGN MODEL TO MAY 2016 AND ARE INDICATIVE ONLY.
4. 3D BOREHOLE STICKS ARE EXTRACTED DIRECTLY FROM CI PROJECT GEOTECHNICAL DATABASE, AND ARE COLOURED BY GEOLOGICAL FORMATION – REFER TO LONG SECTIONS FOR KEY.



SOUTH VIEW



EAST VIEW

ISSUED FOR USE

JACOBS AECOM MULLER JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
BY		DATE

OPERATIONS

INFRASTRUCTURE

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DSLSC004 – MIRANDA RESERVE
SITE GENERAL
SHAFT GEOLOGY – 3D

CAD FILE 2012009.002	DATE 07.06.16
ORIGINAL SCALE A1 N.T.S.	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012009.002	3

Plot Date: Jun 10, 2016 - 9:48am
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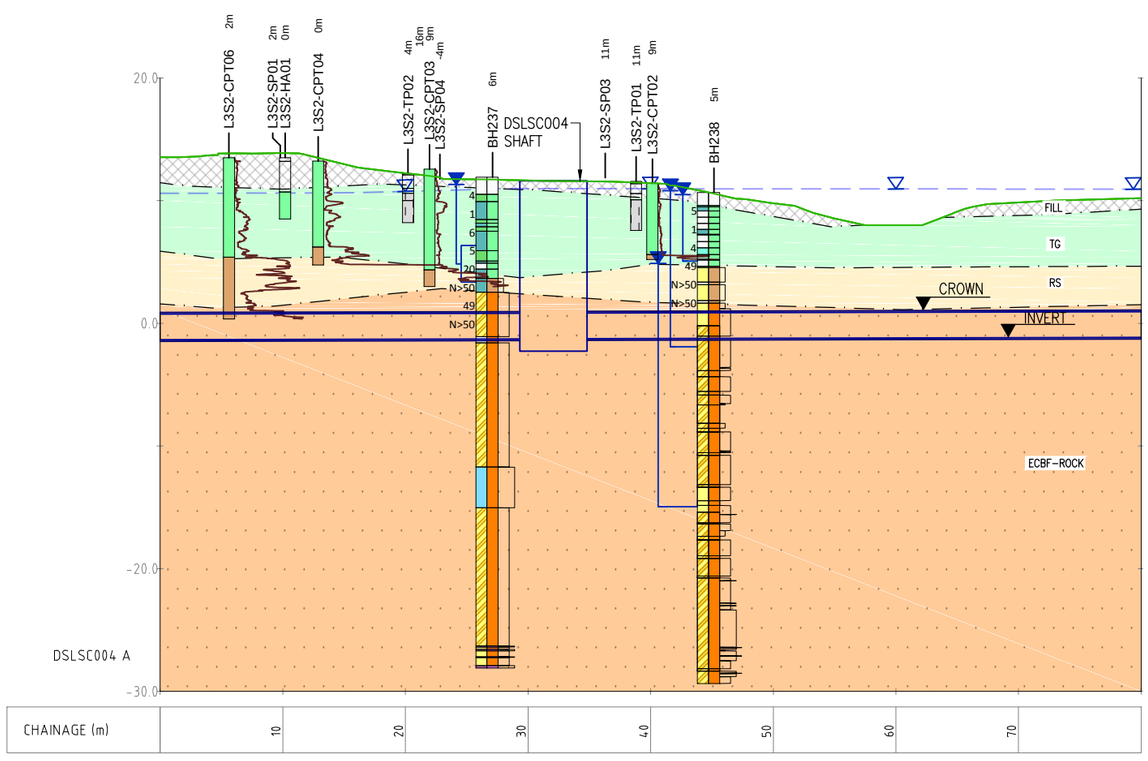
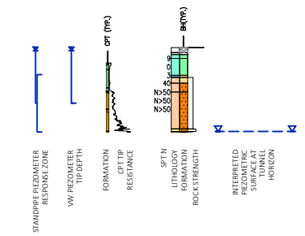


HBSI Profile - DSLSC004 A

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

	BH LEFT	PLAN AND SECTION	BH RIGHT	
No core				Made Ground (FILL)
Fill and topsoil				Recent Alluvium (Q1a)
Basalt				TAURANGA GROUP
Other volcanics				Undifferentiated Tauranga Group (TG)
Clay and clay dominated mixtures				Kaawa Formation (KAAWA)
Organic clay and organic clay dominated mixtures				AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
Peat				Basalt (AVL)
Silt and silt dominated mixtures				Tuff / Ash / Scoria (AVT)
Organic silt and organic silt dominated mixtures				WAITEMATA GROUP (MIOCENE)
Sand and sand dominated mixtures (clean)				Residually to Highly Weathered - Cohesive Soils (RS)
Sand and sand dominated mixtures (with fines)				Residually to Highly Weathered - Granular Soils (RS)
Organic sand and organic sand dominated mixtures				Parnell Volcaniclastic Conglomerate (PVC)
Sandstone				Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
Mudstone				
Interbedded mudstone and sandstone				
Conglomerate				
Coal				



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

INFRASTRUCTURE

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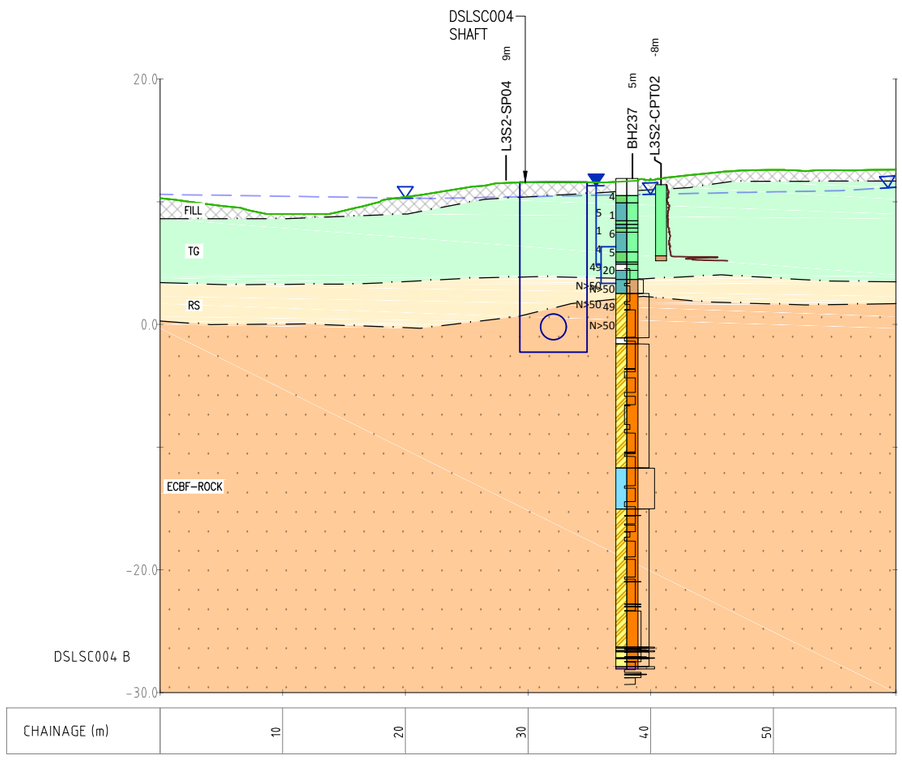
DSLSC004 – MIRANDA RESERVE
SITE GENERAL
SHAFT GEOLOGY – SECTION A

CAD FILE 2012009.003	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012009.003	3

Plot Date: Jun 10, 2016 - 11:28am C:\pw_work\apatel2\dms526231_2012009_003.DWG

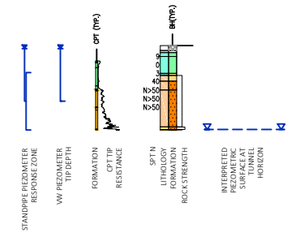


HBSI Profile - DSLSC004 B

LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT	PLAN AND SECTION	BH RIGHT	
No core			Made Ground (FILL)
Fill and topsoil			Recent Alluvium (Q1a)
Basalt			TAURANGA GROUP
Other volcanics			
Clay and clay dominated mixtures			Undifferentiated Tauranga Group (TG)
Organic clay and organic clay dominated mixtures			Kaawa Formation (KAAWA)
Peat			AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
Silt and silt dominated mixtures			Basalt (AVL)
Organic silt and organic silt dominated mixtures			Tuff / Ash / Scoria (AVT)
Sand and sand dominated mixtures (clean)			WAITEMATA GROUP (MIOCENE)
Sand and sand dominated mixtures (with fines)			Residually to Highly Weathered - Cohesive Soils (RS)
Organic sand and organic sand dominated mixtures			Residually to Highly Weathered - Granular Soils (RS)
Sandstone			Parnell Volcaniclastic Conglomerate (PVC)
Mudstone			Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
Interbedded mudstone and sandstone			
Conglomerate			
Coal			



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
BY		DATE

OPERATIONS

INFRASTRUCTURE

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DSLSC004 – MIRANDA RESERVE
SITE GENERAL
SHAFT GEOLOGY – SECTION B

CAD FILE 2012009.004	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012009.004	3

Plot Date: Jun 10, 2016 - 9:50am
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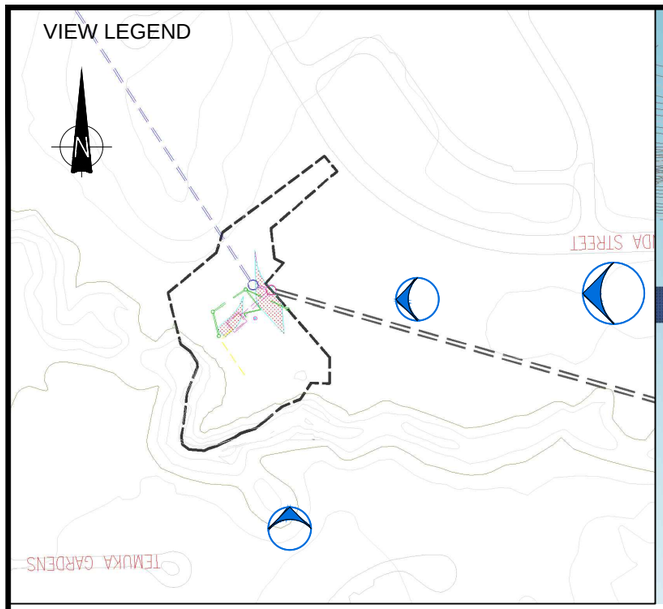
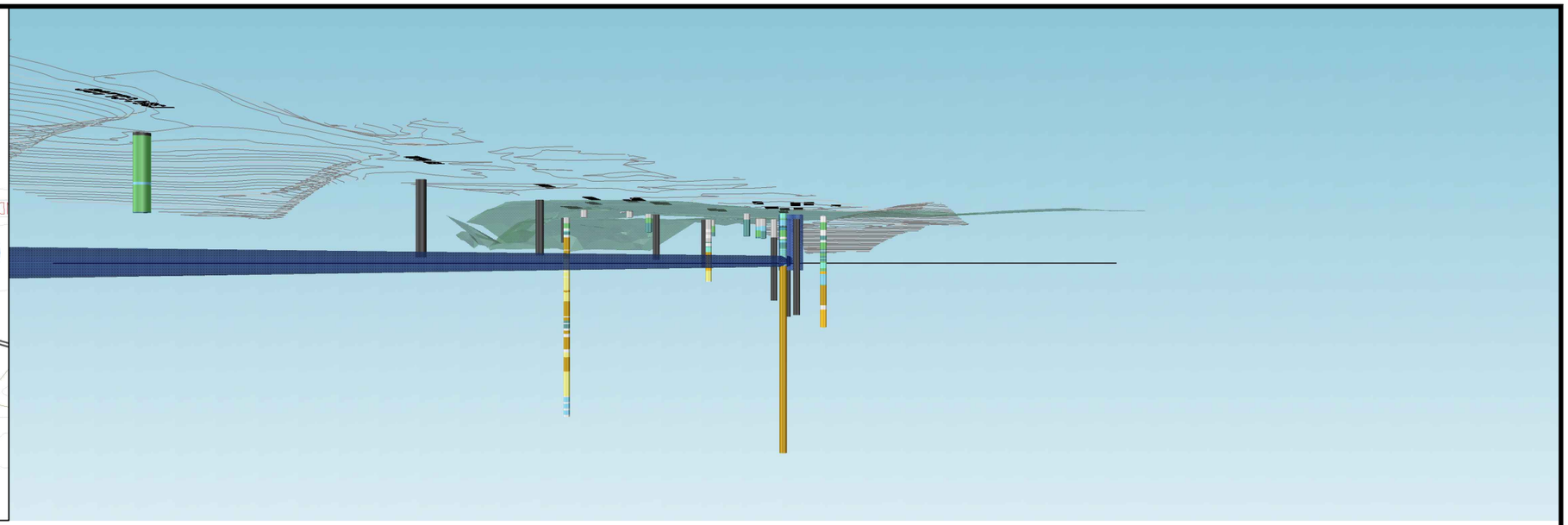
VIEW LEGEND





EAST – OVERVIEW

NOTES:
1. GROUND CONTOURS ARE FROM AUCKLAND COUNCIL GIS SOURCES.
2. GROUND SURFACE SHOWN FROM SITE SURVEY BY BECA, 2015.
3. TUNNEL AND SHAFTS ARE FROM DETAILED DESIGN MODEL TO MAY 2016 AND ARE INDICATIVE ONLY.
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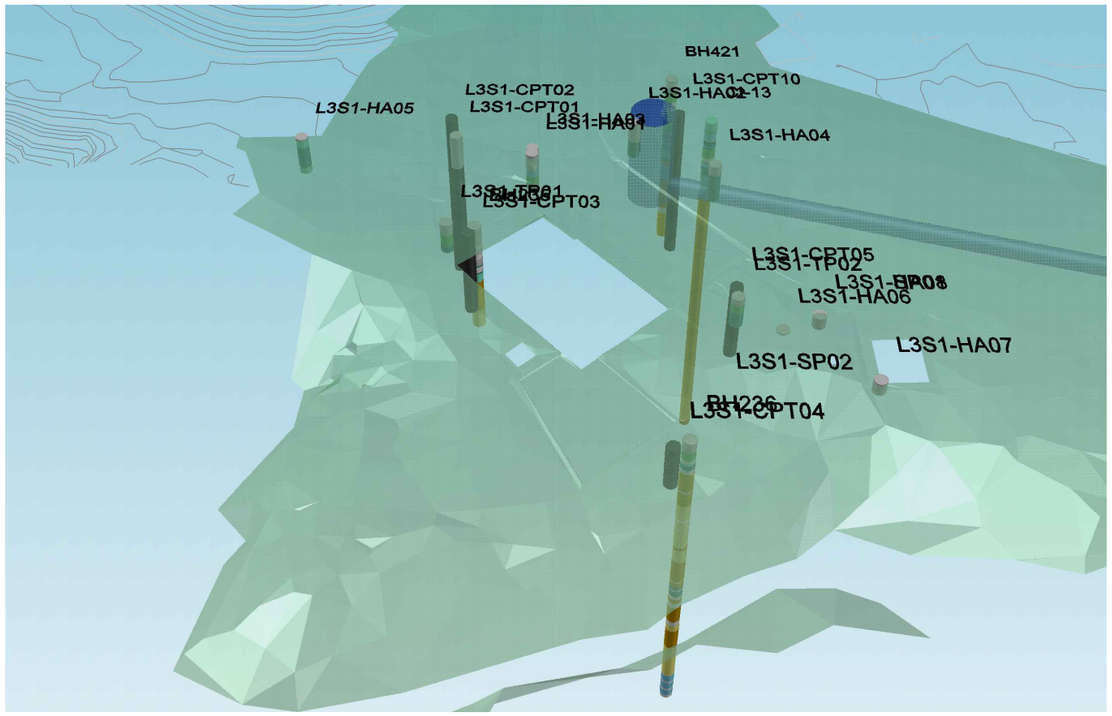
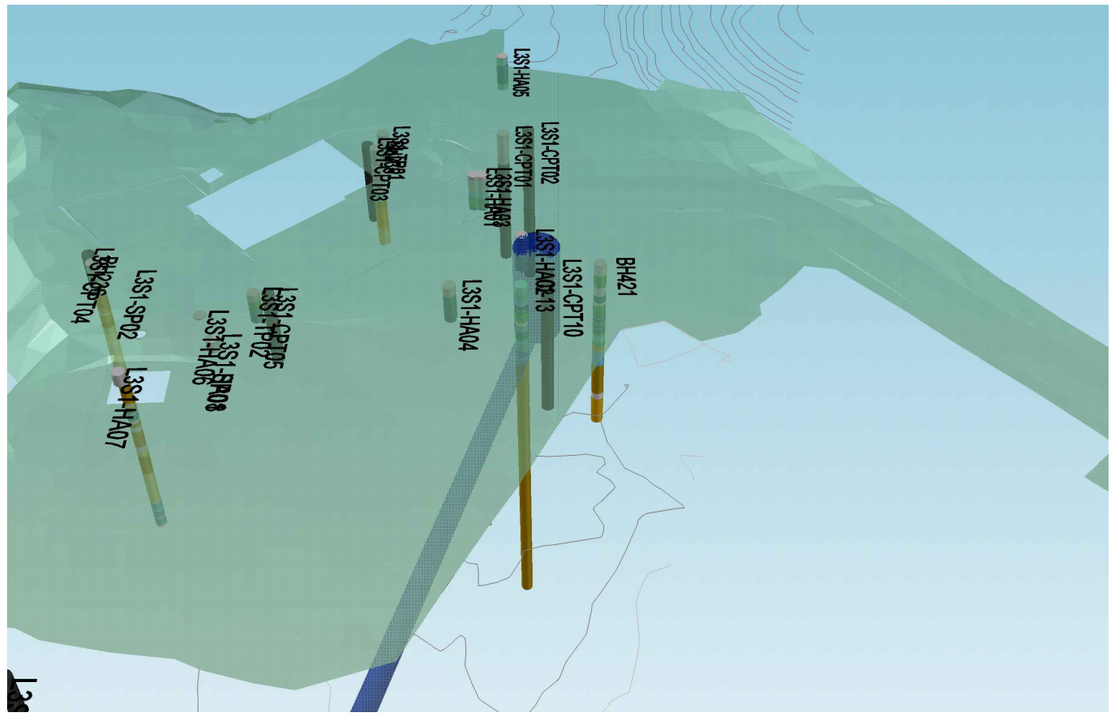


SOUTH VIEW



EAST VIEW

ISSUED FOR USE

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
BY		DATE

OPERATIONS

INFRASTRUCTURE

Watercare

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DSLSC005 – PS25
SITE GENERAL
SHAFT GEOLOGY – 3D

CAD FILE 2012010.002	DATE 07.06.16
ORIGINAL SCALE A1 N.T.S.	CONTRACT No. 5747
REF. No. CI–GEOTECH	ISSUE
DWG. No. 2012010.002	3

Plot Date: Jun 10, 2016 - 9:55am
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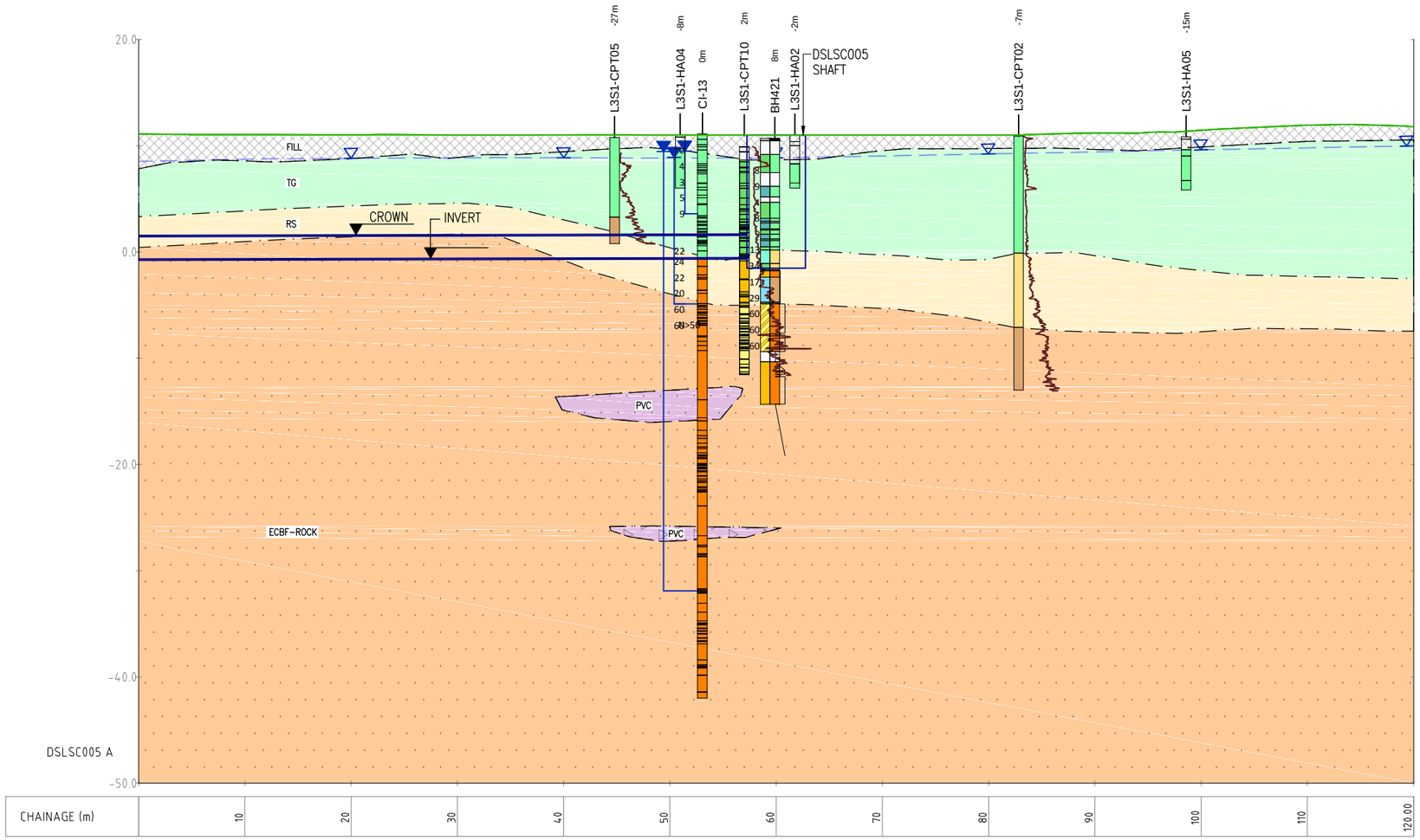
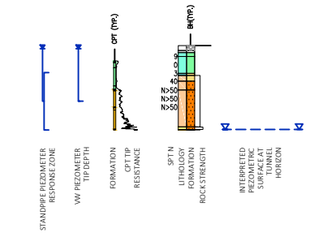


LEGEND

BH215 −6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT	PLAN AND SECTION	BH RIGHT	
No core			Made Ground (FILL)
Fill and topsoil			Recent Alluvium (Q1a)
Basalt			TAURANGA GROUP
Other volcanics			
Clay and clay dominated mixtures			Undifferentiated Tauranga Group (TG)
Organic clay and organic clay dominated mixtures			Kaawa Formation (KAAWA)
Peat			AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
Silt and silt dominated mixtures			Basalt (AVL)
Organic silt and organic silt dominated mixtures			Tuff / Ash / Scoria (AVT)
Sand and sand dominated mixtures (clean)			WAITEMATA GROUP (MIOCENE)
Sand and sand dominated mixtures (with fines)			Residually to Highly Weathered - Cohesive Soils (RS)
Organic sand and organic sand dominated mixtures			Residually to Highly Weathered - Granular Soils (RS)
Sandstone			Parnell Volcaniclastic Conglomerate (PVC)
Mudstone			Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
Interbedded mudstone and sandstone			
Conglomerate			
Coal			



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X-DSCIN-T-001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X-DSLSA(-D)-C-001. DESIGNS CURRENT TO MAY 2016.
2. EXISTING GROUND SURFACE MODELLED FROM AUCKLAND COUNCIL GIS DATA AND LANDSURVEY DATA PROVIDED BY BECA.
3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
7. NOT ALL BOREHOLE LOGS SHOWN TO AID CLARITY.
8. THE GEOTECHNICAL INFORMATION SHOWN IS FOR GUIDANCE ONLY.

ISSUED FOR USE

JACOBS AECOM McJALLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

INFRASTRUCTURE

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DSLSC005 – PS25
SITE GENERAL
SHAFT GEOLOGY – SECTION A

CAD FILE 2012010.003	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI-GEOTECH	ISSUE
DWG. No. 2012010.003	3

Plot Date: Jun 10, 2016 - 9:58am
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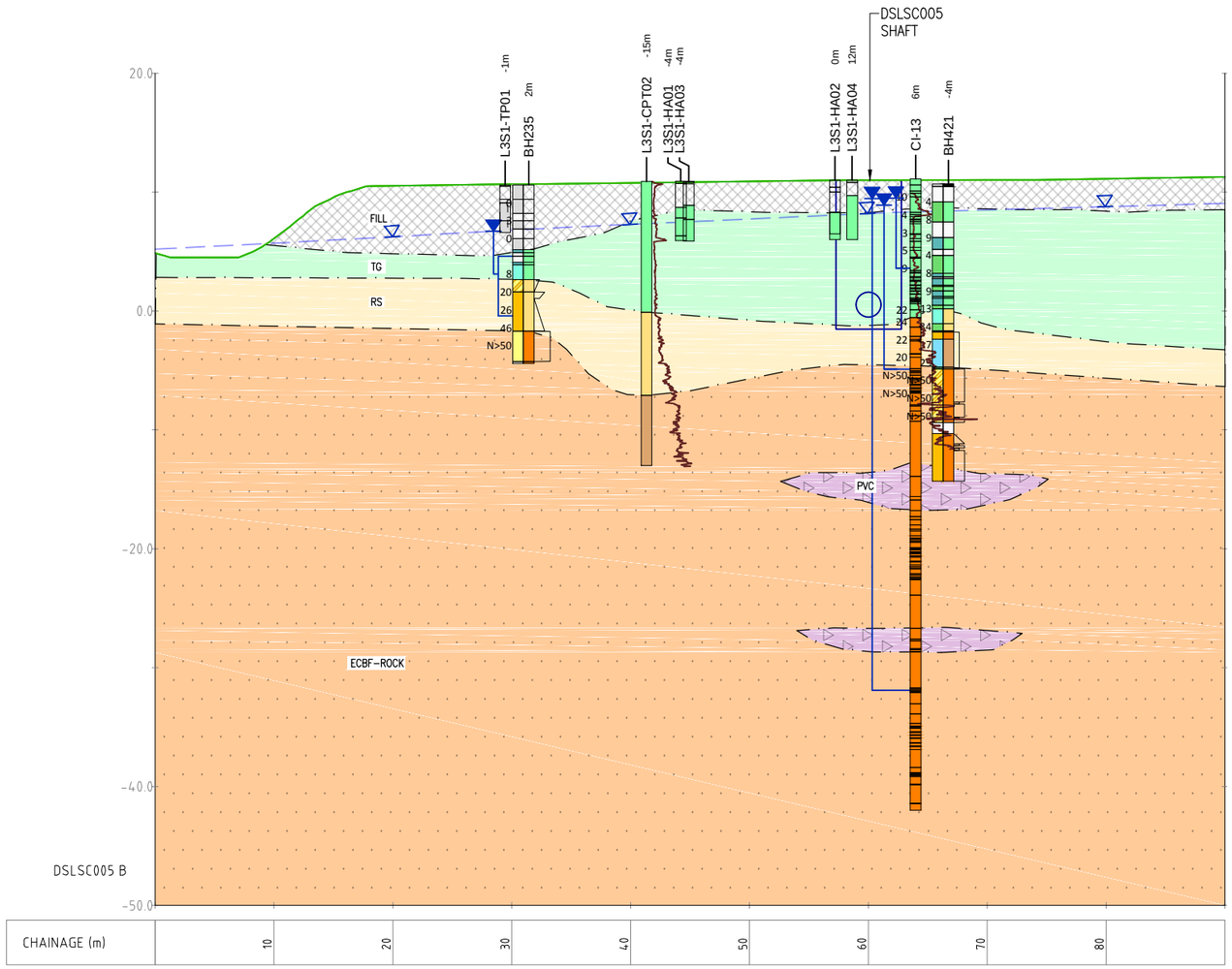
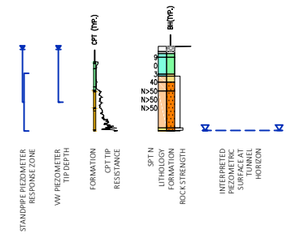


HBSI Profile - DSLSC005 B

LEGEND

BH215 –6m Borehole ID and offset from section. (Negative numbers are into the page.)

BH LEFT	PLAN AND SECTION	BH RIGHT	
No core			Made Ground (FILL)
Fill and topsoil			Recent Alluvium (Q1a)
Basalt			TAURANGA GROUP
Other volcanics			Undifferentiated Tauranga Group (TG)
Clay and clay dominated mixtures			Kaawa Formation (KAAWA)
Organic clay and organic clay dominated mixtures			AUCKLAND VOLCANIC FIELD (PLEISTOCENE)
Peat			Basalt (AVL)
Silt and silt dominated mixtures			Tuff / Ash / Scoria (AVT)
Organic silt and organic silt dominated mixtures			WAITEMATA GROUP (MIOCENE)
Sand and sand dominated mixtures (clean)			Residually to Highly Weathered - Cohesive Soils (RS)
Sand and sand dominated mixtures (with fines)			Residually to Highly Weathered - Granular Soils (RS)
Organic sand and organic sand dominated mixtures			Parnell Volcaniclastic Conglomerate (PVC)
Sandstone			Moderately Weathered to Unweathered ECBF (ECBF-ROCK)
Mudstone			
Interbedded mudstone and sandstone			
Conglomerate			
Coal			



NOTES
1. HORIZONTAL AND VERTICAL ALIGNMENT BASED ON X–DSCIN–T–001 FOR MAINLINE, AND RELEVANT LINK SEWER MODELS X–DSLSA(–D)–C–001. DESIGNS CURRENT TO MAY 2016.
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3. BACKGROUND AERIAL PHOTOGRAPHY & CADASTRAL DATA FROM AUCKLAND COUNCIL GIS DATA. 21/08/2015
4. VERTICAL HEIGHT DATUM AUCKLAND 1946.
5. COORDINATE SYSTEM NZTM.
6. ALL DIMENSIONS IN METRES AND ELEVATIONS IN mRL UNLESS OTHERWISE NOTED.
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ISSUED FOR USE

JACOBS AECOM MCJALLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
3	07.06.16	ISSUED FOR USE	AP	ADC
2	18.12.15	ISSUED FOR CLIENT REVIEW	KL	ADC
1		PRELIMINARY	KL	

DESIGNED	RR	04.15
DES. CHECKED	HM	05.16
DRAWN	KL	04.15
DWG. CHECKED	ADC	05.16
PROJECT LEADER	DK	05.16
INFRAST'R APP'D		
	BY	DATE

OPERATIONS

INFRASTRUCTURE

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DSLSC005 – PS25
SITE GENERAL
SHAFT GEOLOGY – SECTION B

CAD FILE 2012010.004	DATE 07.06.16
ORIGINAL SCALE A1 1:250	CONTRACT No. 5747
REF. No. CI–GEOTECH	ISSUE
DWG. No. 2012010.004	3

Plot Date: Jun 10, 2016 - 10:03am C:\pw_work\apatel2\dms526451\2012010.004.DWG

Appendix E. Liquefaction analyses

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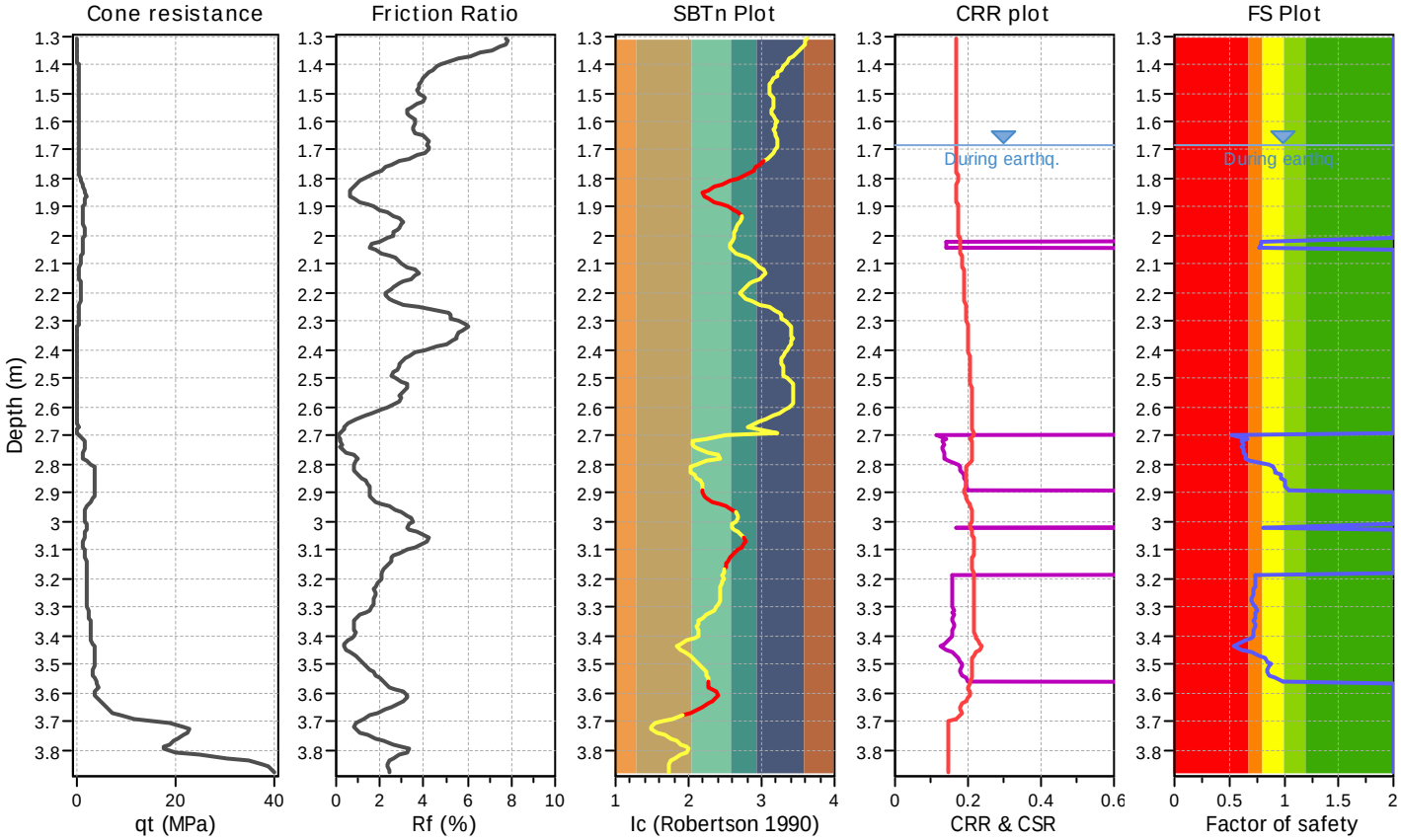
LIQUEFACTION ANALYSIS REPORT

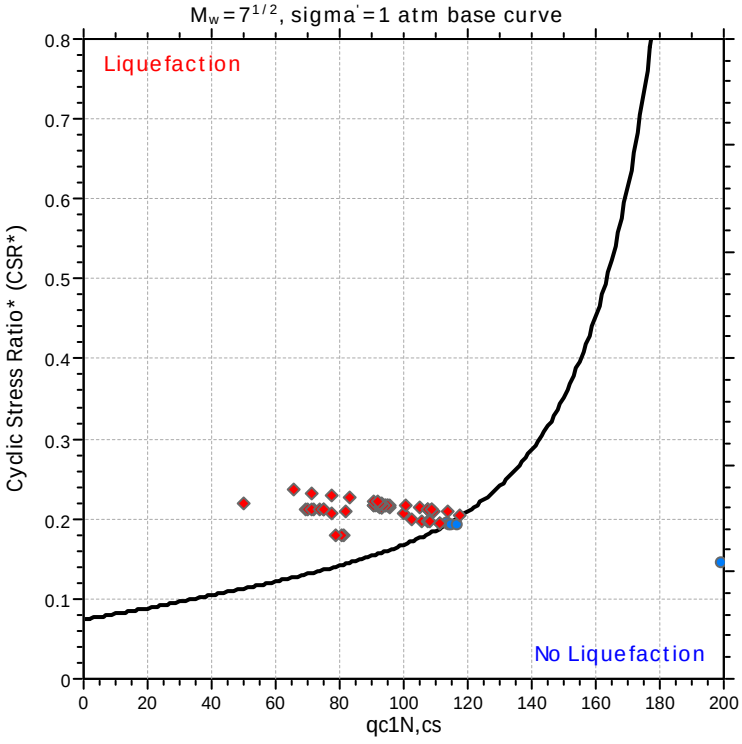
Project title : ULS 1/2500 year event (NZ1170.5) Location : DPCIN – Mangere Pump Station

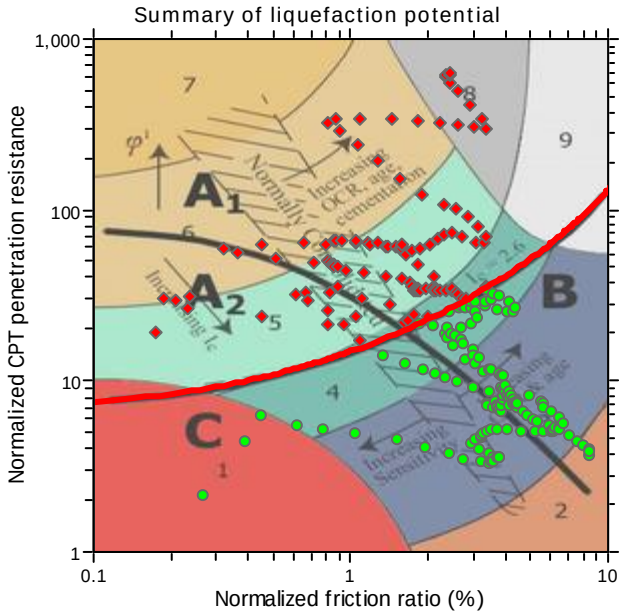
CPT file : WS3-CPT01

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.68 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.68 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

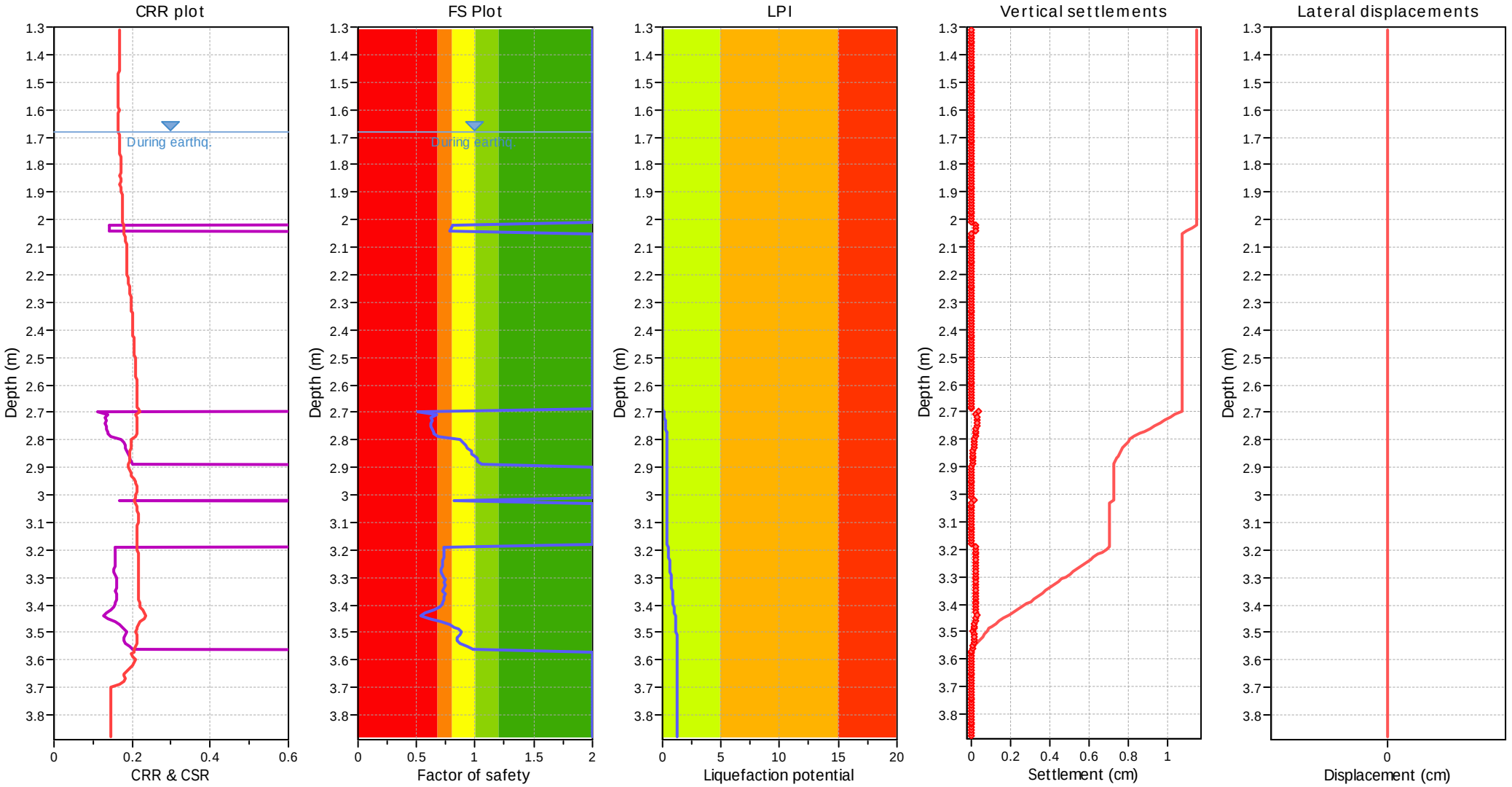






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.68 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.68 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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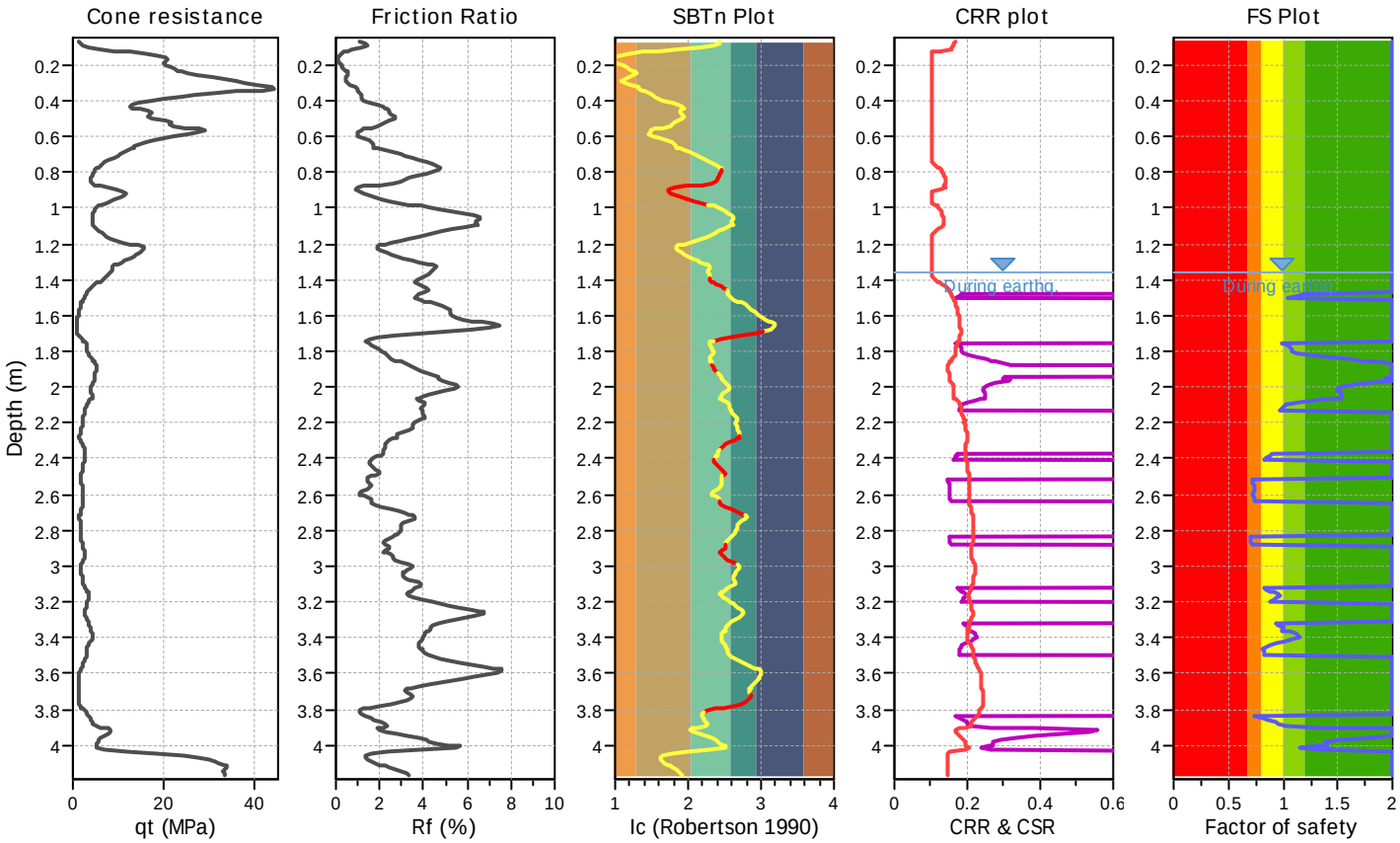
LIQUEFACTION ANALYSIS REPORT

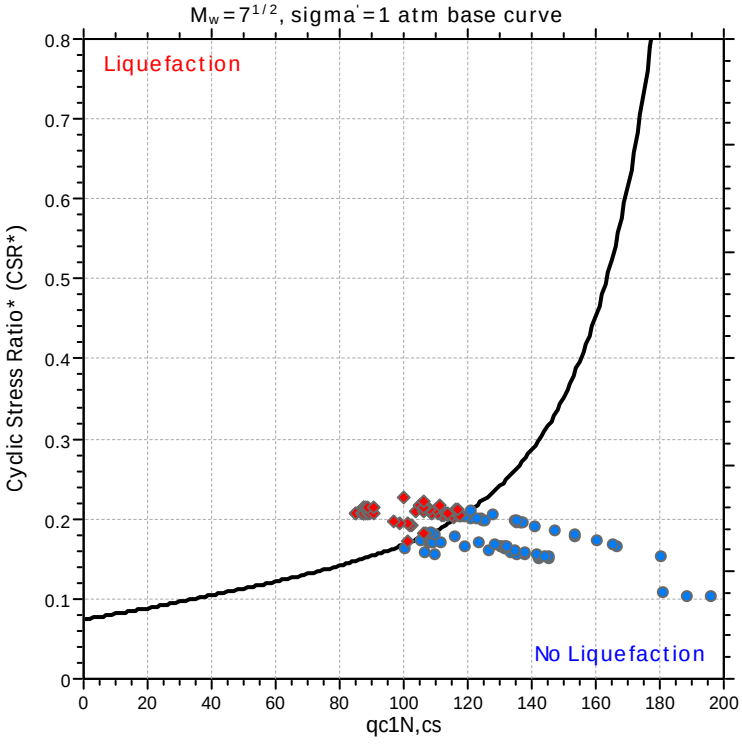
Project title : ULS 1/2500 year event (NZ1170.5) Location : DPCIN – Mangere Pump Station

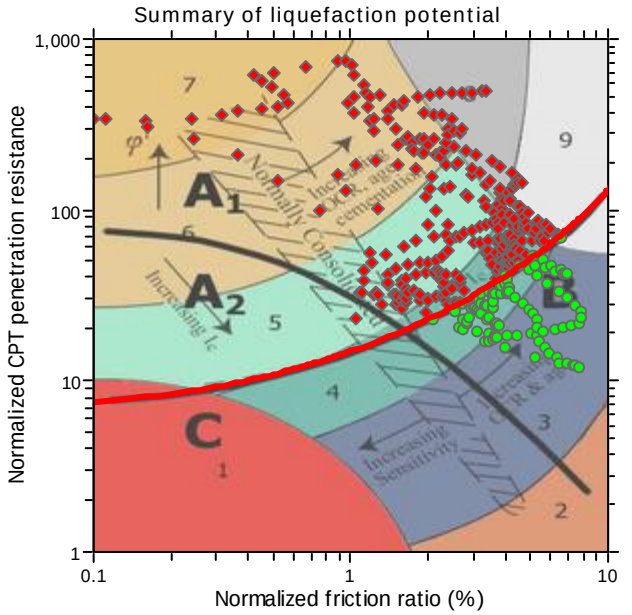
CPT file : WS3-CPT02

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.36 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.36 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

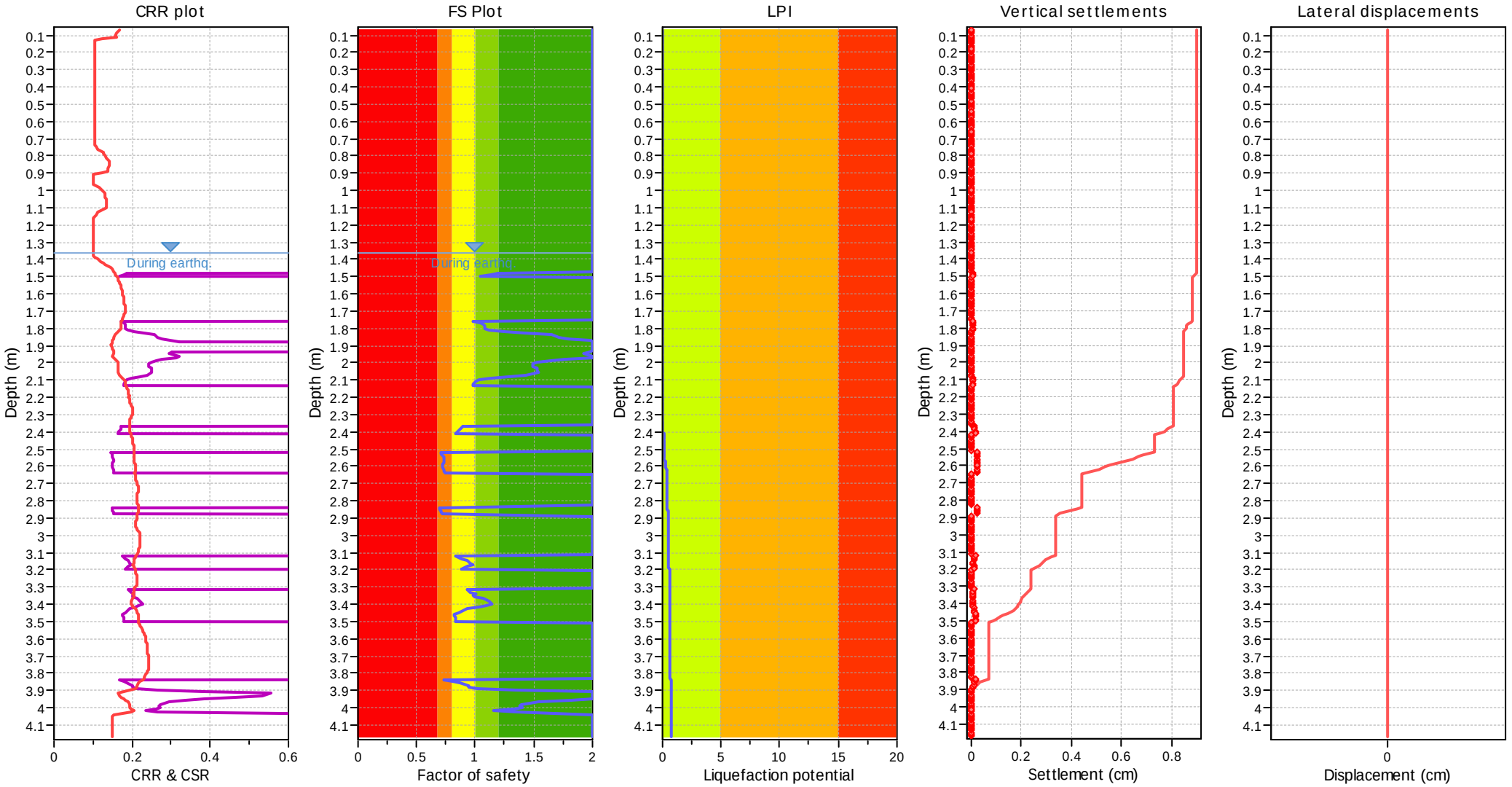






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.36 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.36 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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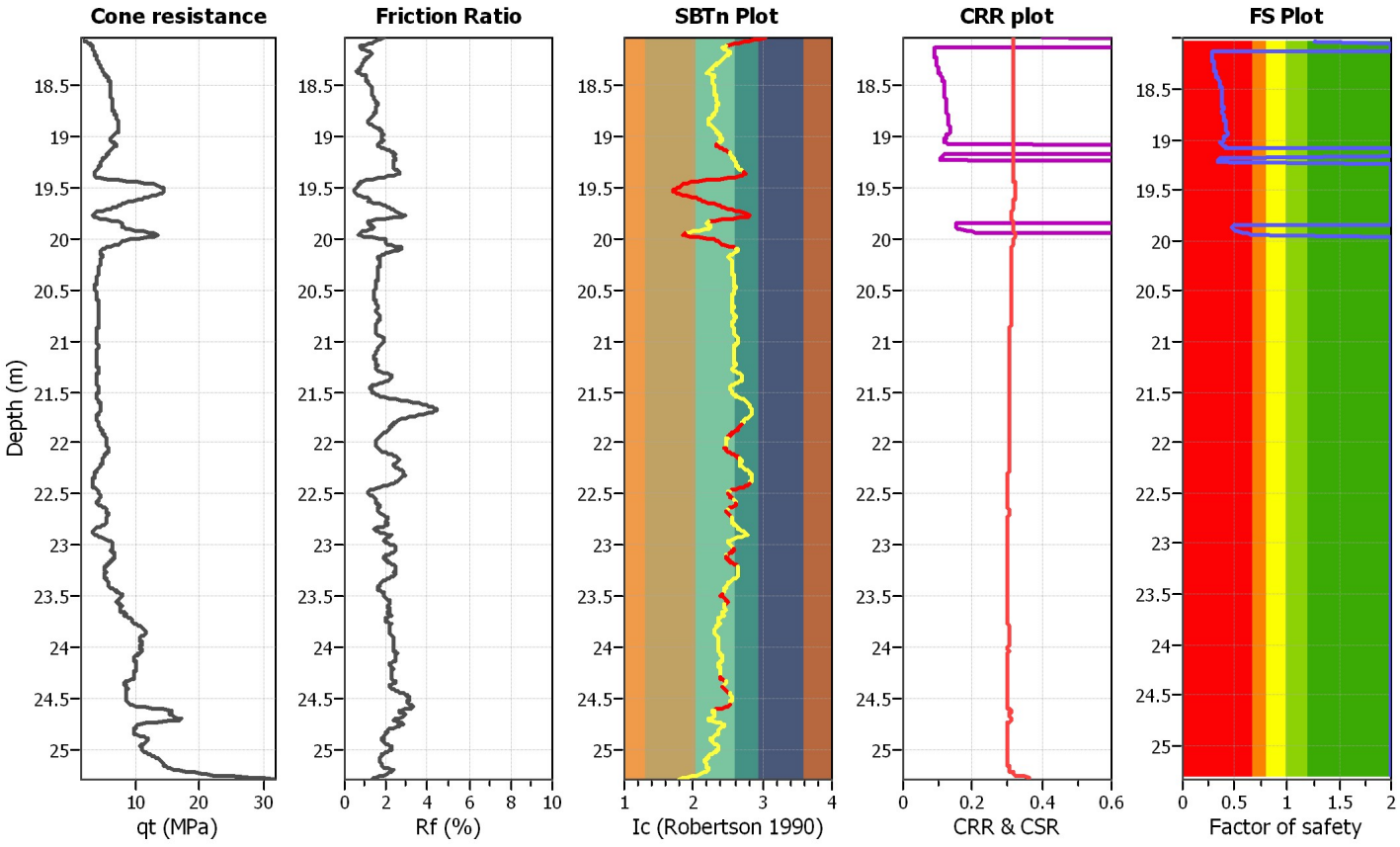
LIQUEFACTION ANALYSIS REPORT

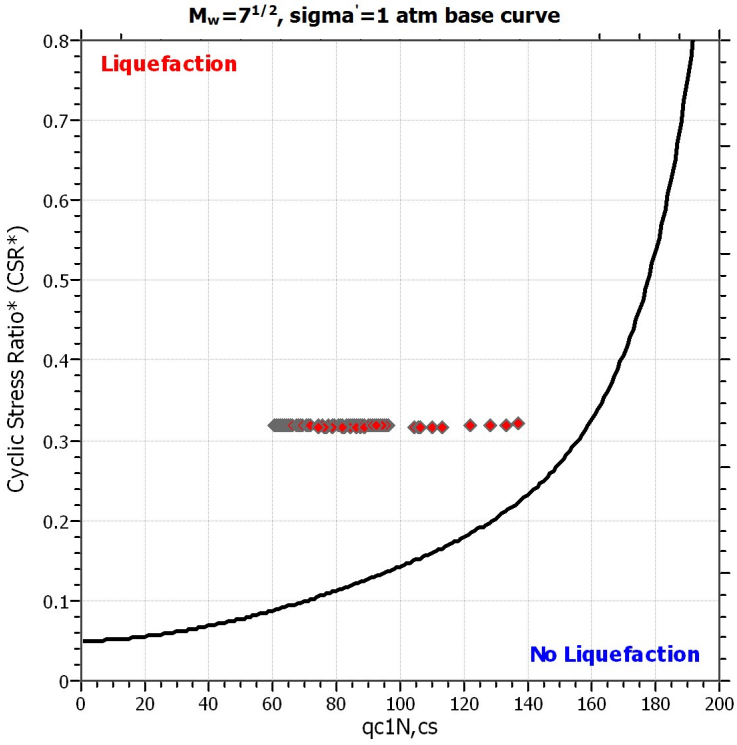
Project title : ULS 1/2500 year event (NZ1170.5) **Location : DSCIN001 – Kiwi Esplanade**

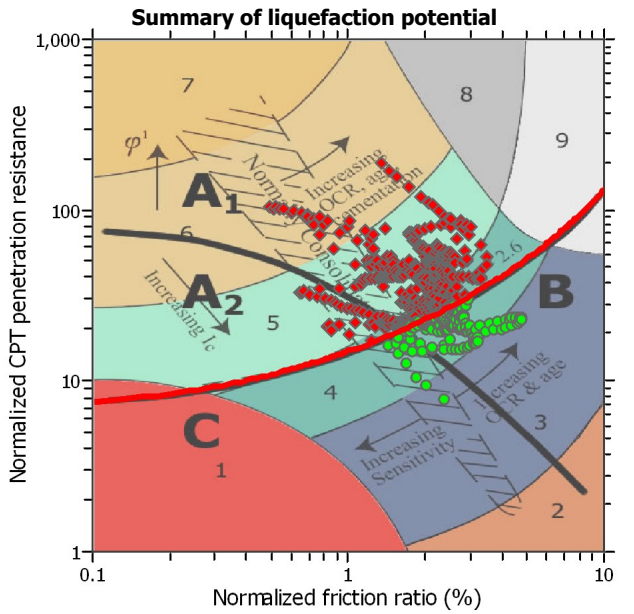
CPT file : AS7-CPT258

Input parameters and analysis data

Analysis method:	I&B (2008)	G.W.T. (in-situ):	2.48 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	I&B (2008)	G.W.T. (earthq.):	2.48 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:	20.00 m
Earthquake magnitude M_w:	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

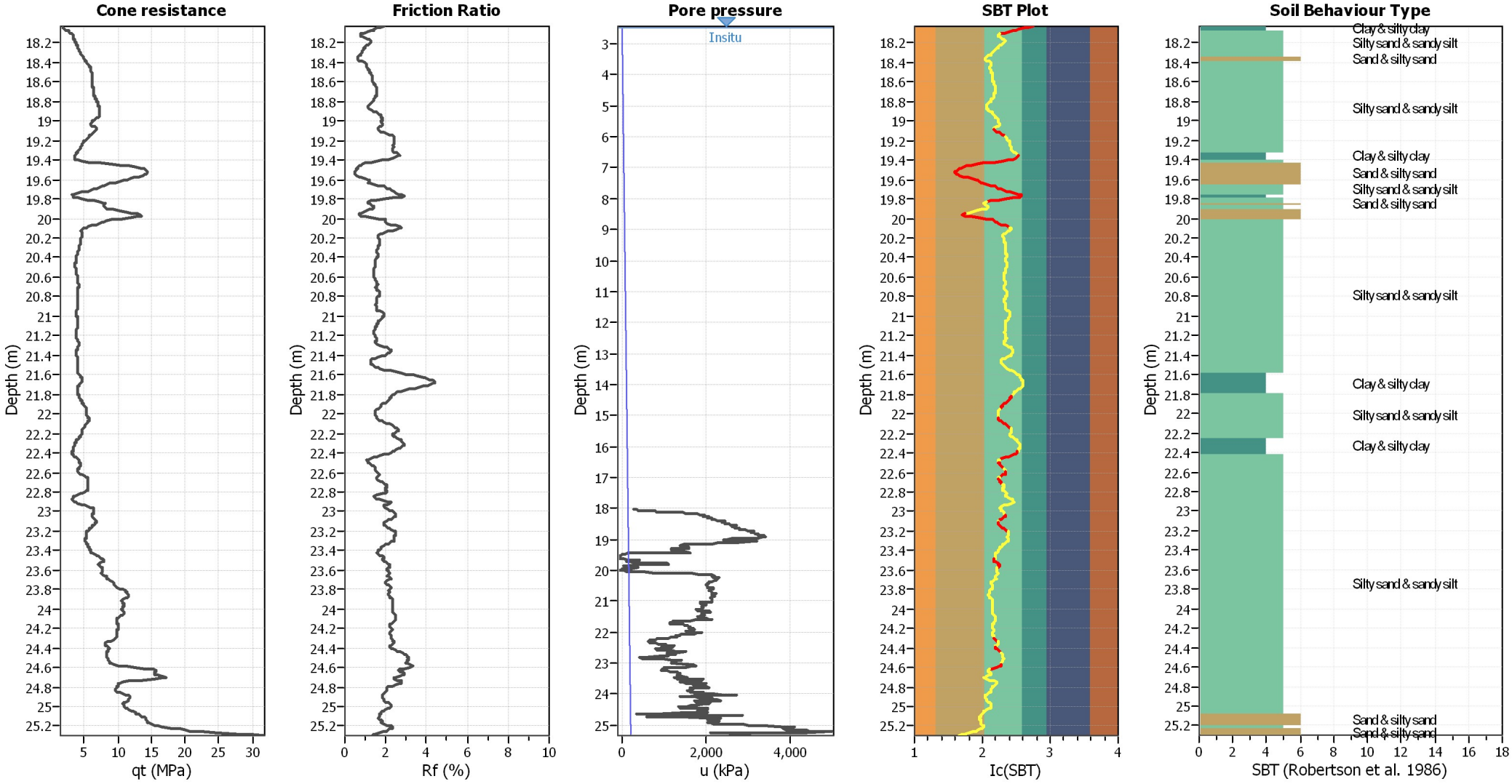






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

CPT basic interpretation plots



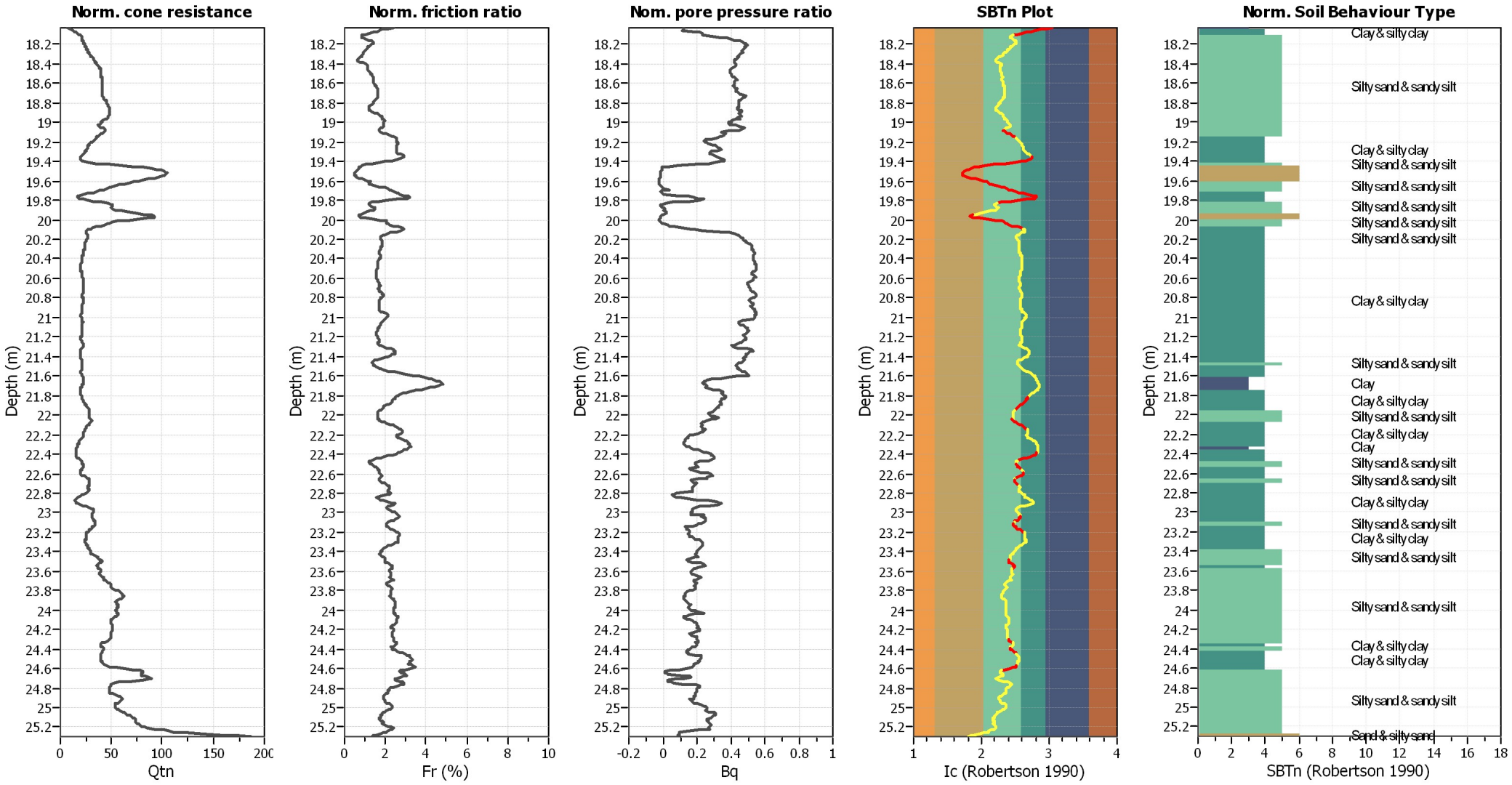
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.48 m	Fill weight:	N/A
Fines correction method:	I&B (2008)	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:	Sand & Clay
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.48 m	Fill height:	N/A	Limit depth:	20.00 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

CPT basic interpretation plots (normalized)



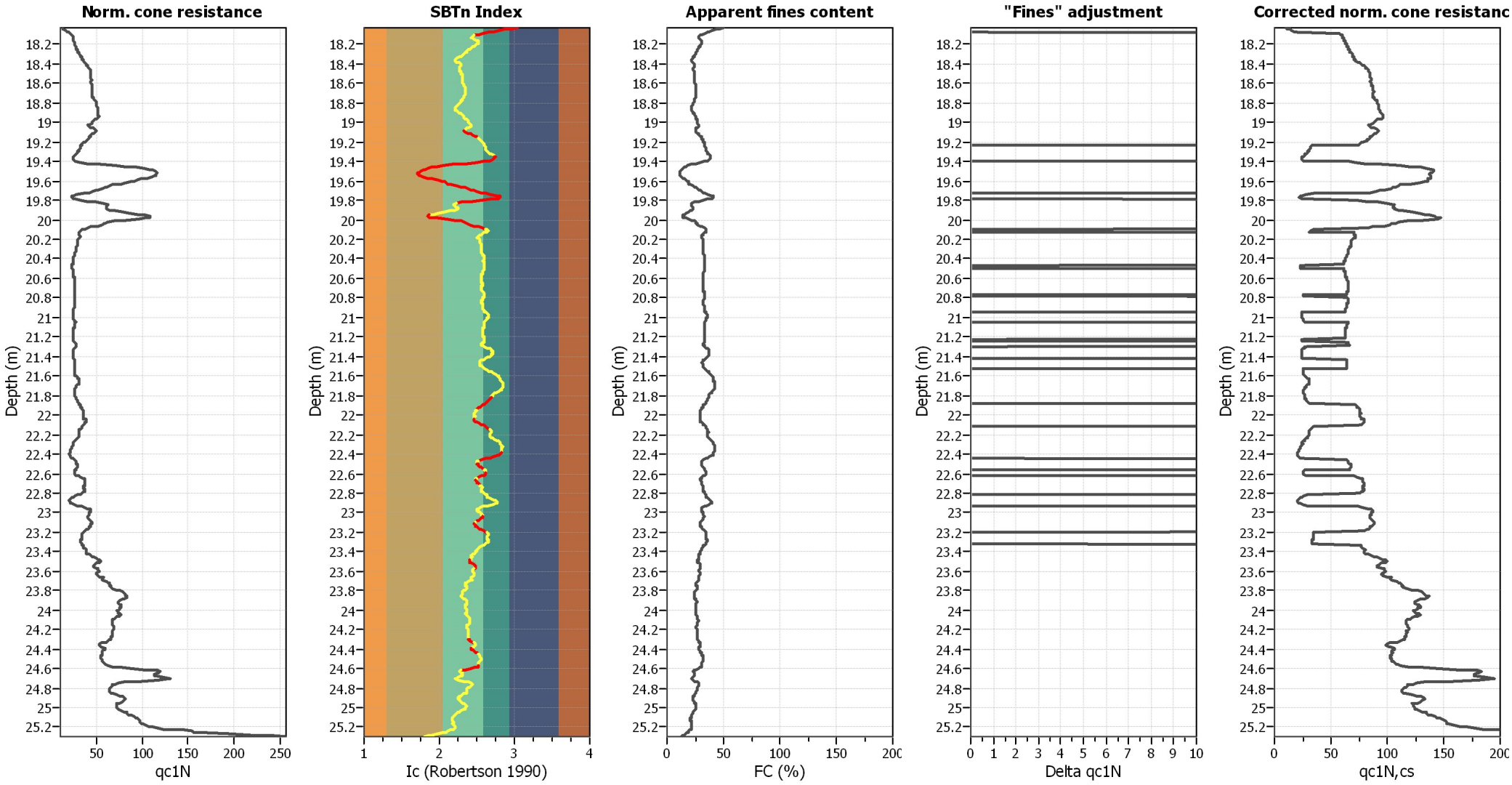
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.48 m	Fill weight:	N/A
Fines correction method:	I&B (2008)	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:	Sand & Clay
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.48 m	Fill height:	N/A	Limit depth:	20.00 m

SBTn 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

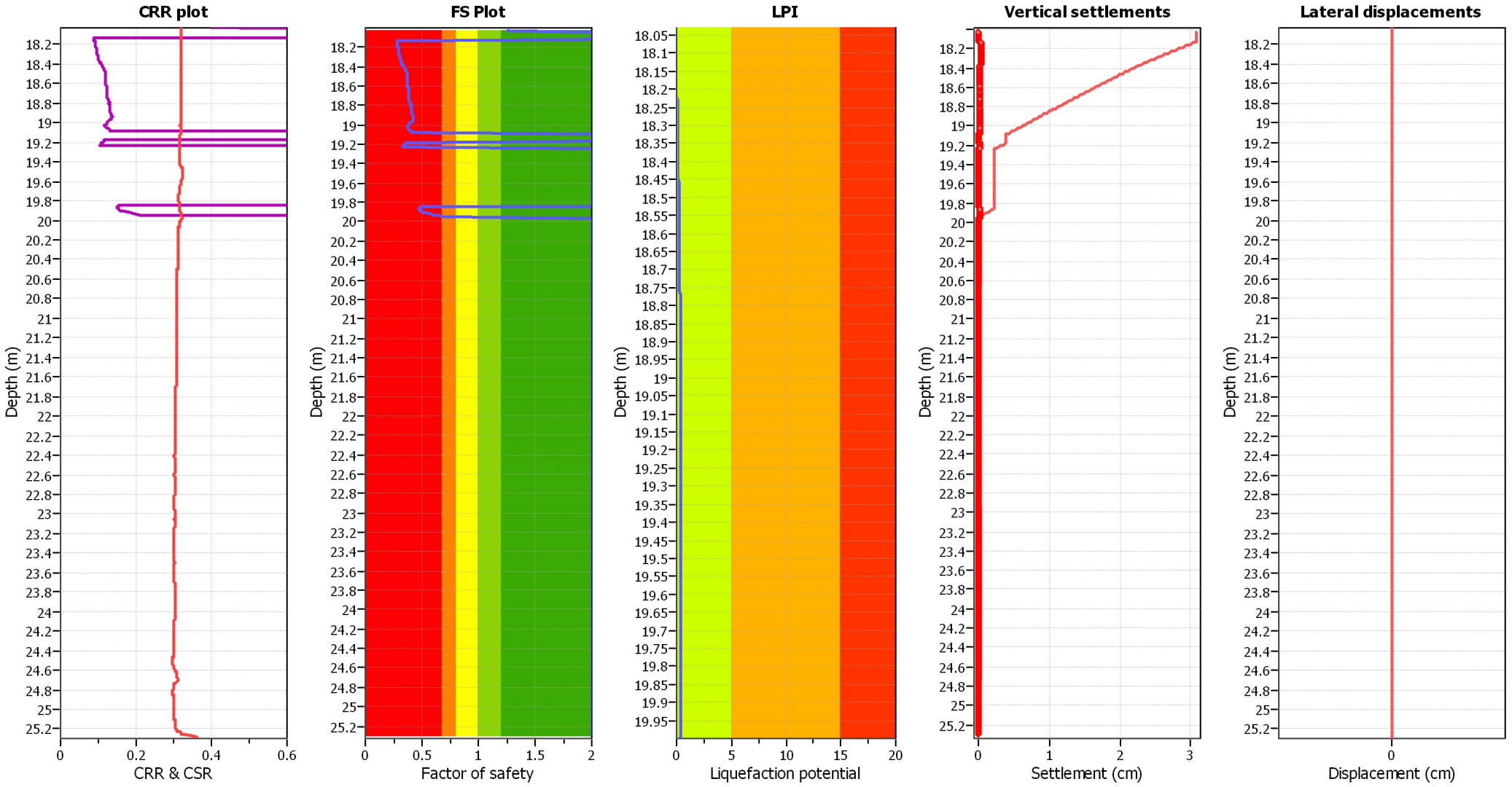
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.48 m	Fill weight:	N/A
Fines correction method:	I&B (2008)	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:	Sand & Clay
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.48 m	Fill height:	N/A	Limit depth:	20.00 m

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.48 m	Fill weight:	N/A
Fines correction method:	I&B (2008)	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:	Sand & Clay
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.48 m	Fill height:	N/A	Limit depth:	20.00 m

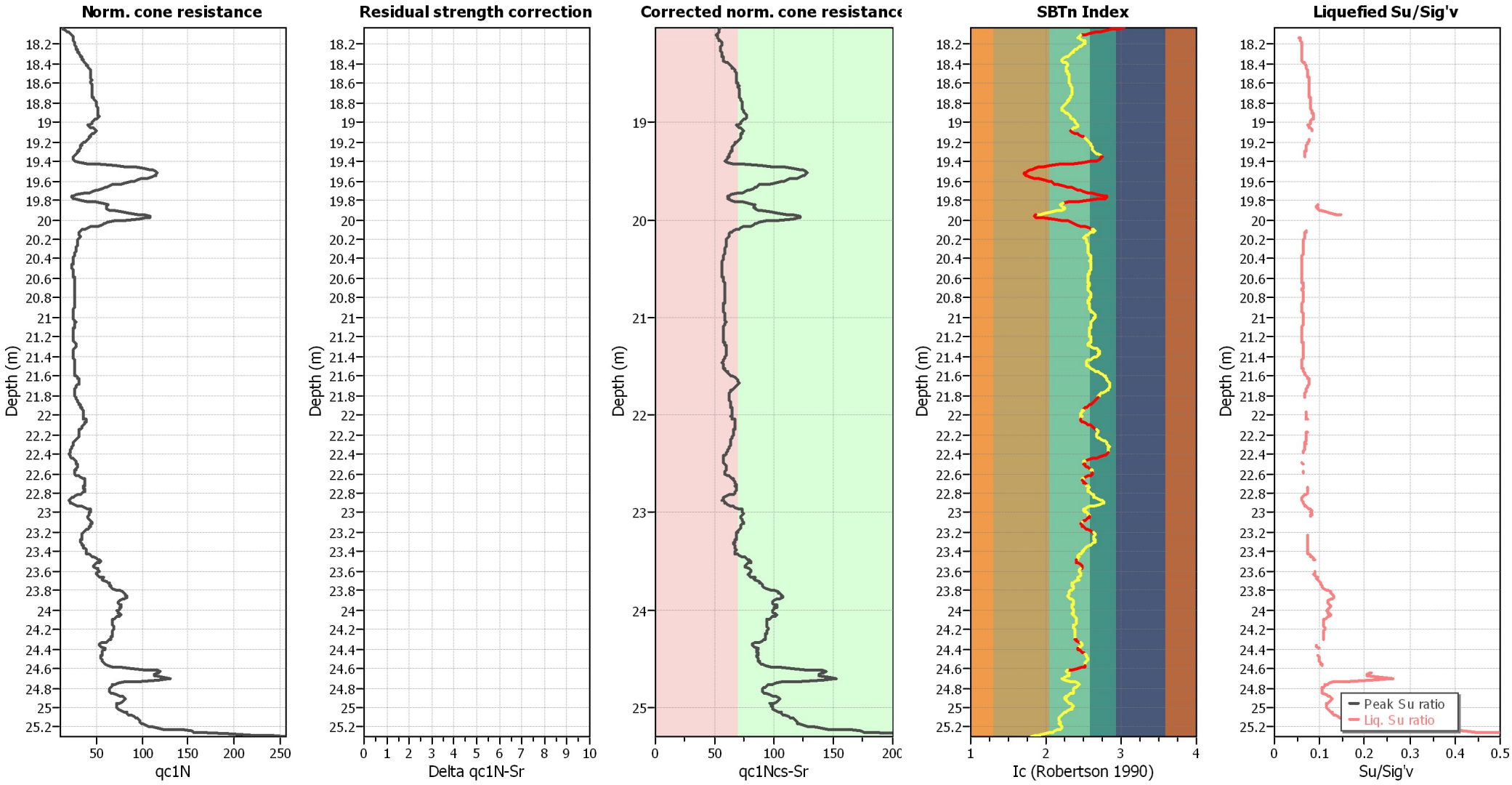
F.S. color scheme

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

LPI color scheme

- Very high risk
- High risk
- Low risk

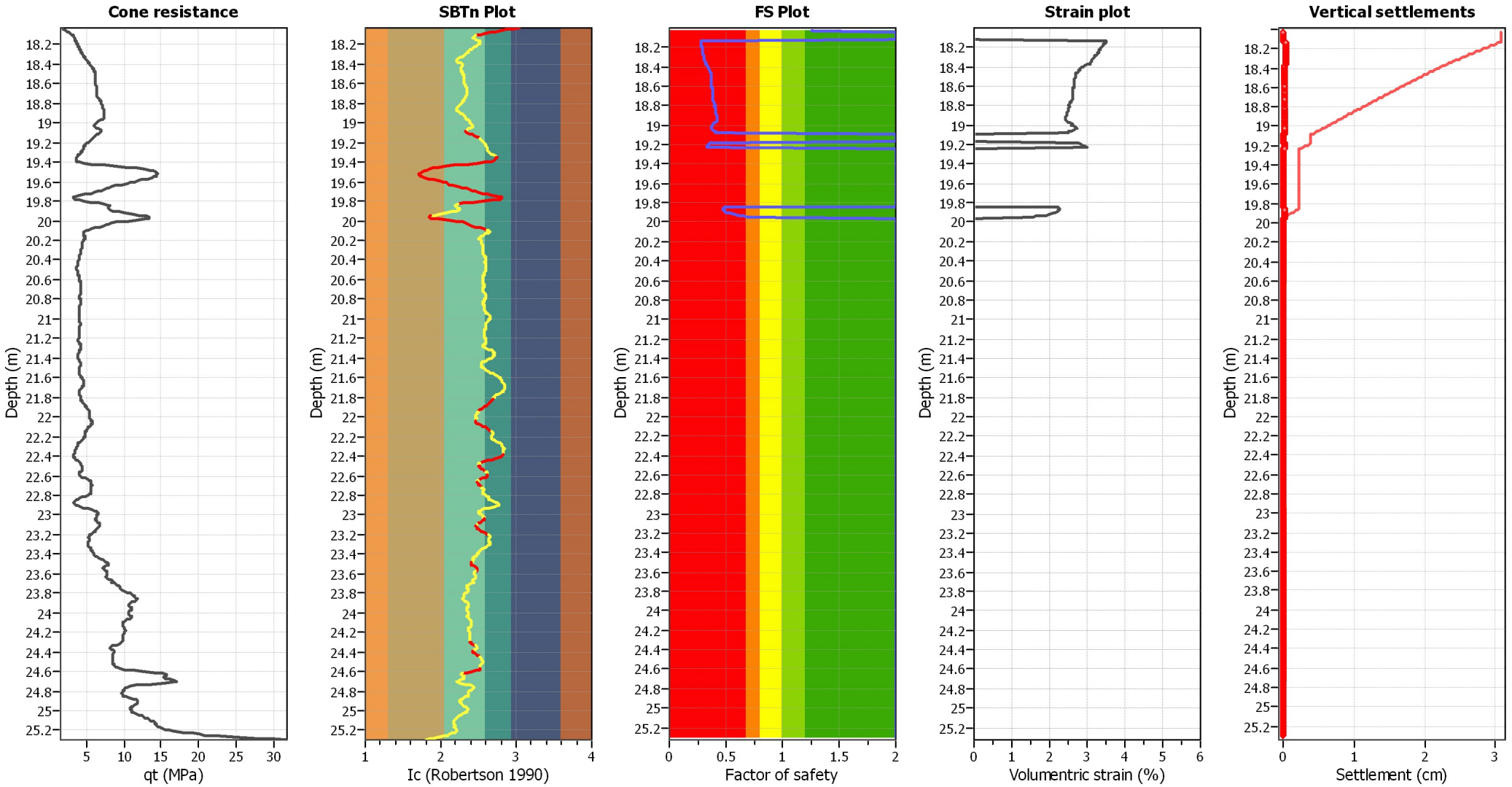
Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.48 m	Fill weight:	N/A
Fines correction method:	I&B (2008)	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:	Sand & Clay
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.48 m	Fill height:	N/A	Limit depth:	20.00 m

Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

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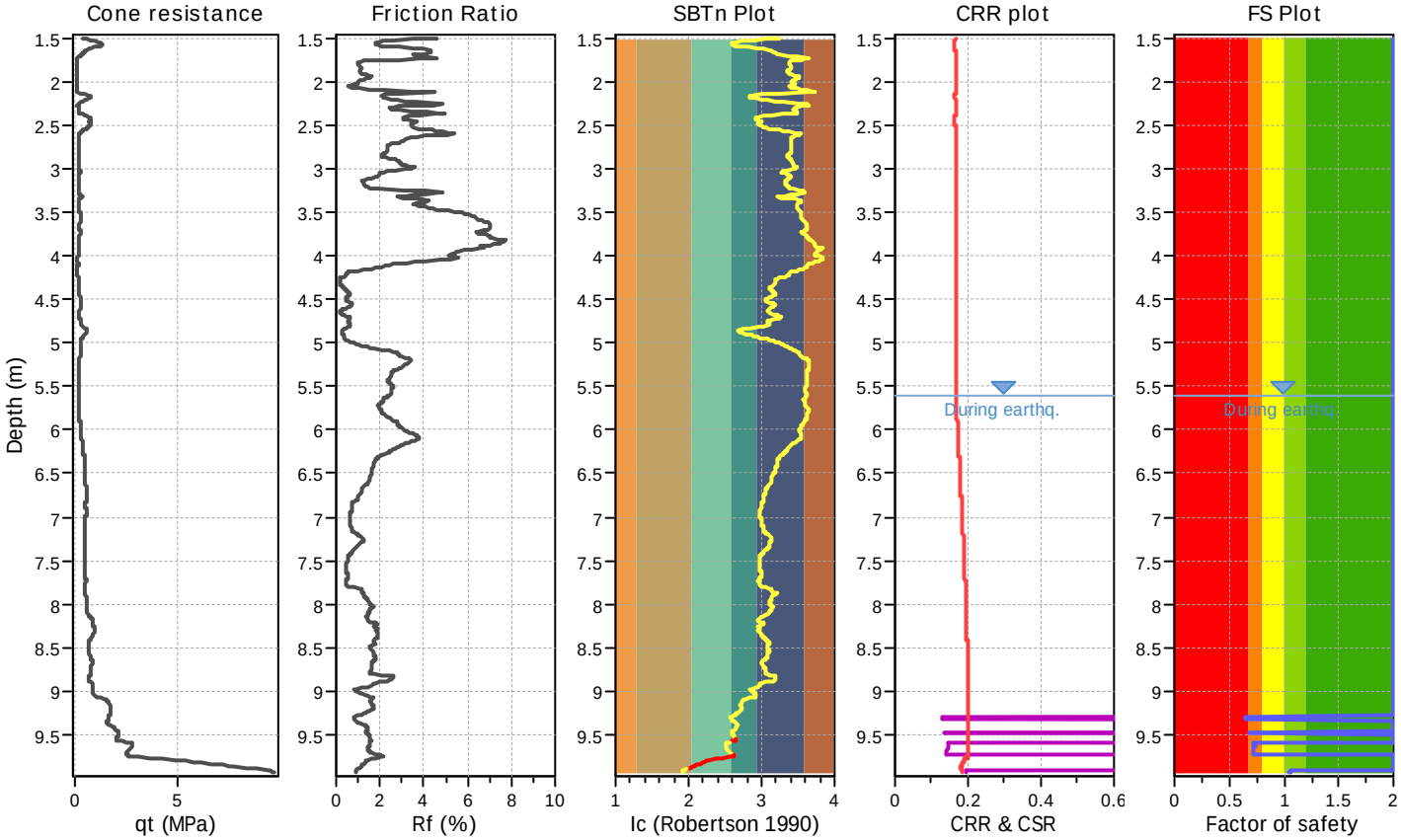
LIQUEFACTION ANALYSIS REPORT

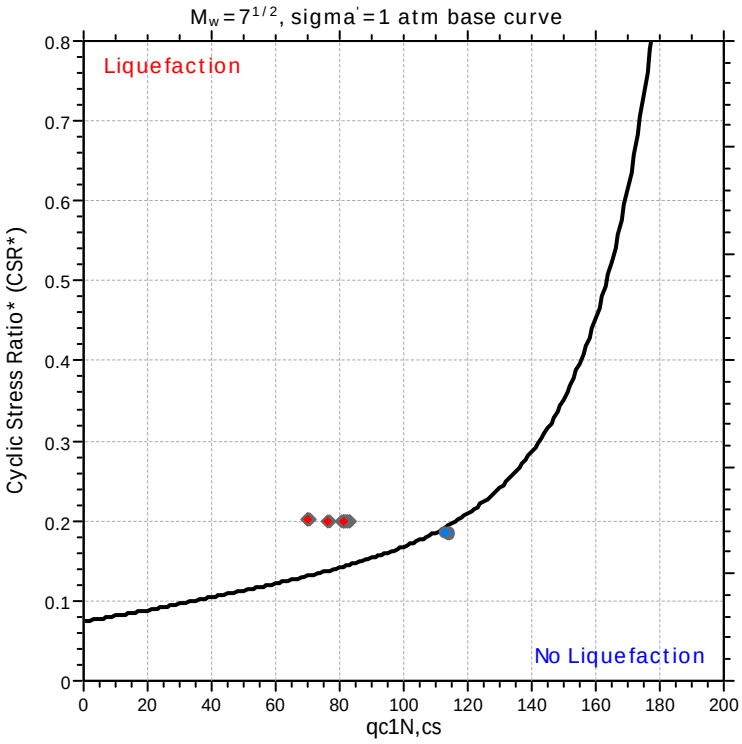
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSCIN003 – Keith Hay Park

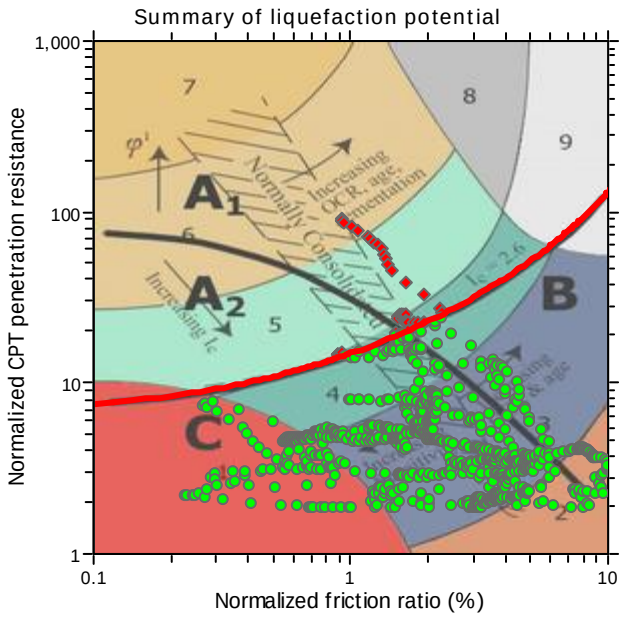
CPT file : AS5-CPT01

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	5.60 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	5.60 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

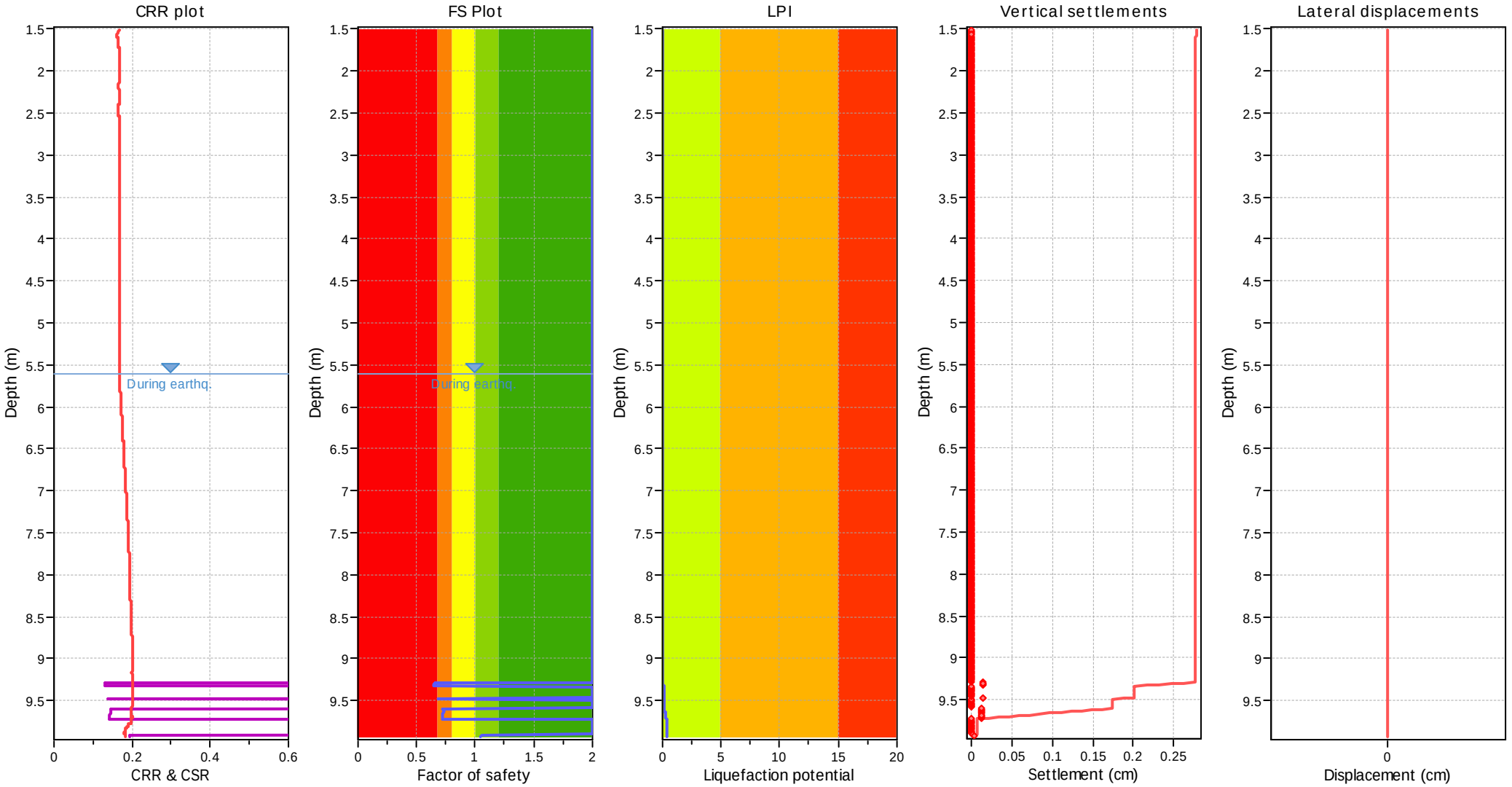






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	5.60 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.60 m	Fill height:	N/A	Limit depth:	N/A

F.S. color scheme

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

LPI color scheme

- Very high risk
- High risk
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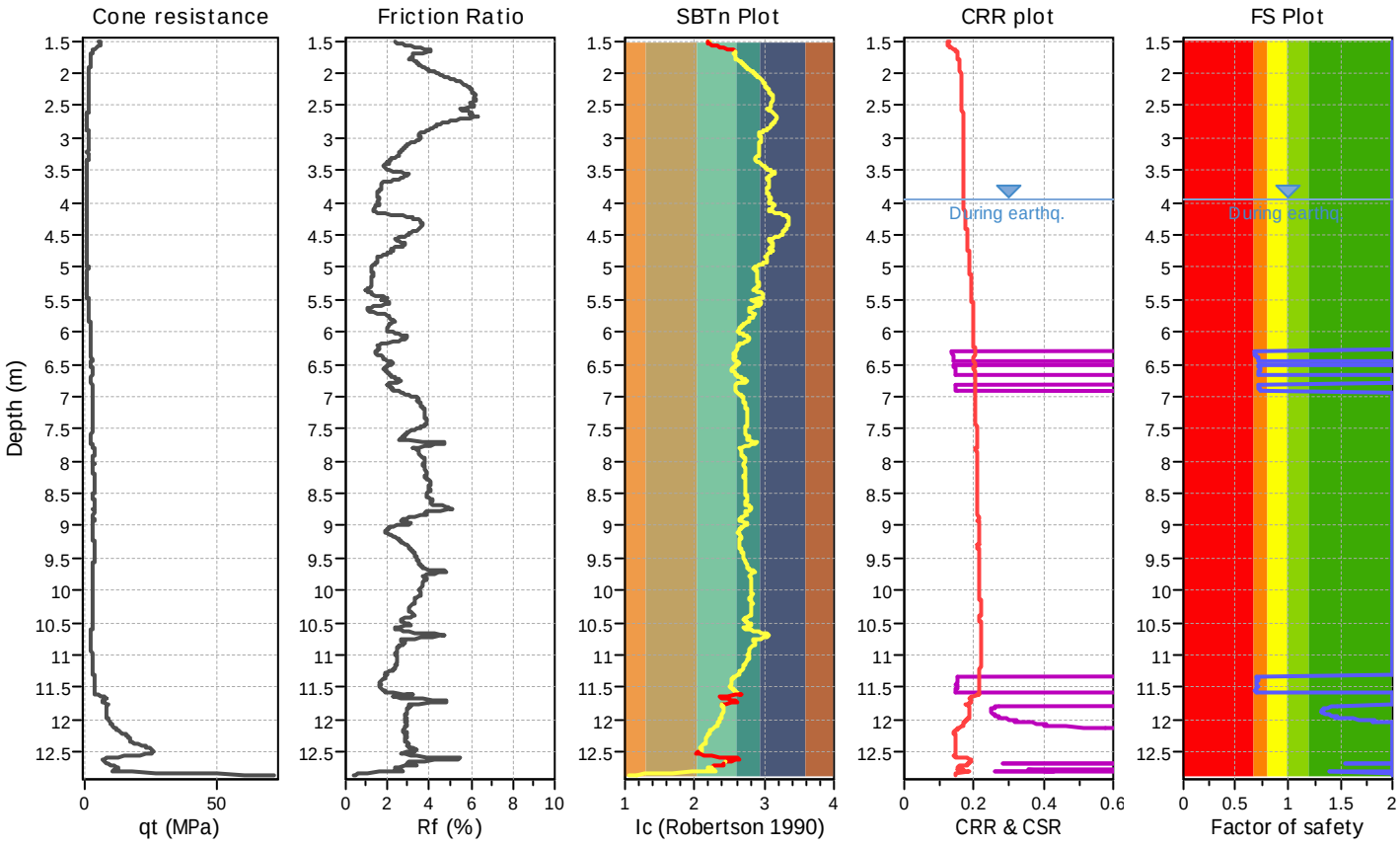
LIQUEFACTION ANALYSIS REPORT

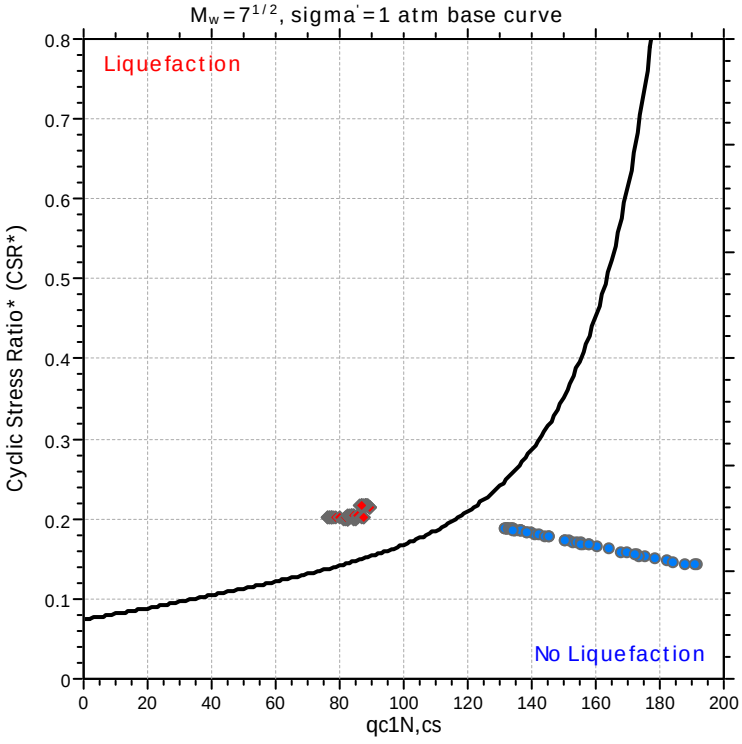
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSCIN003 – Keith Hay Park

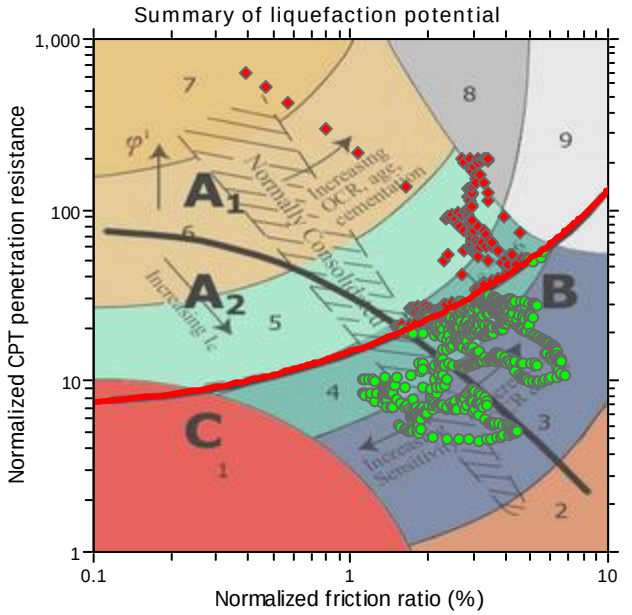
CPT file : AS5-CPT02

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	3.96 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	3.96 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

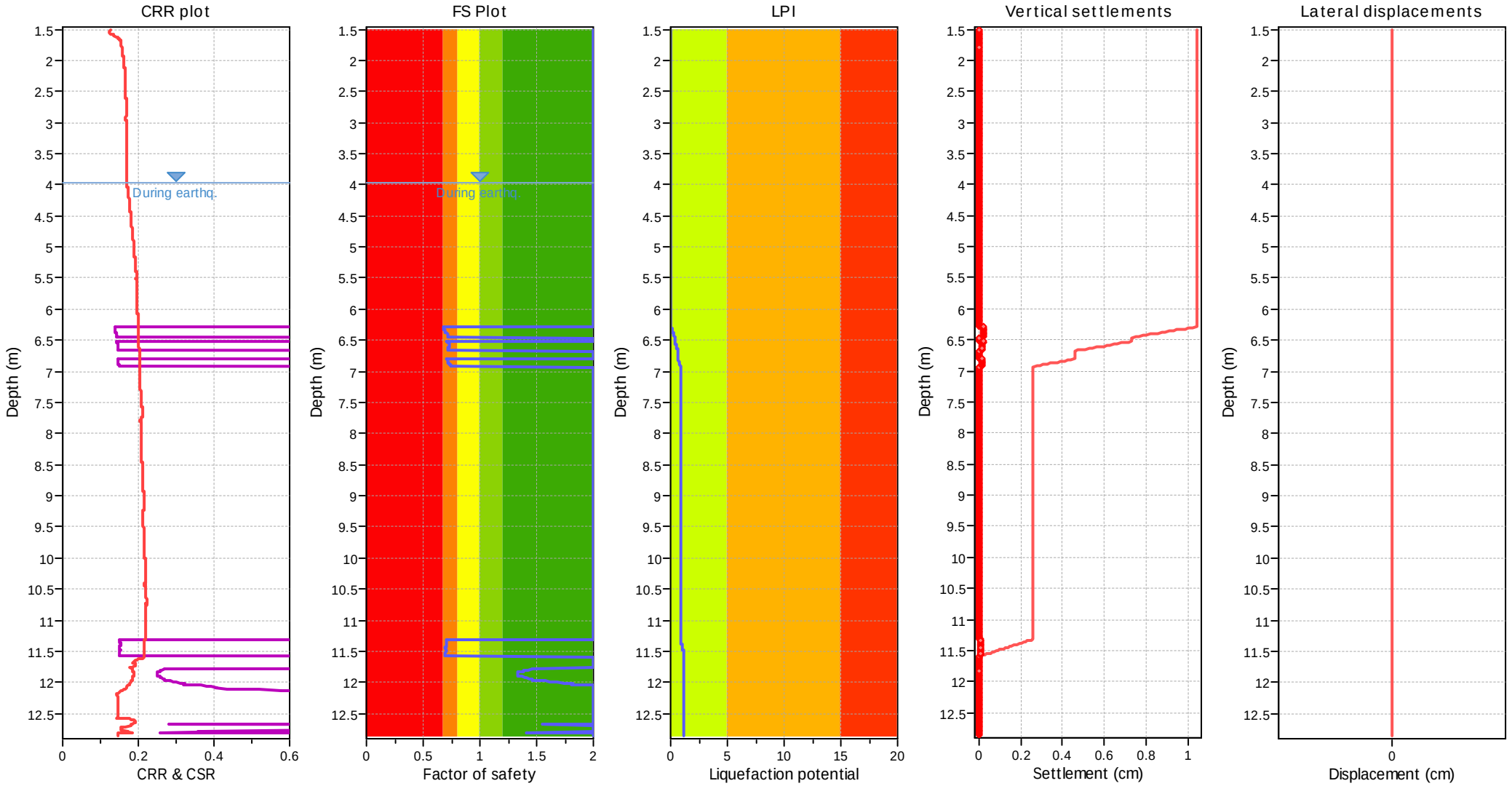






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	3.96 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	3.96 m	Fill height:	N/A	Limit depth:	N/A

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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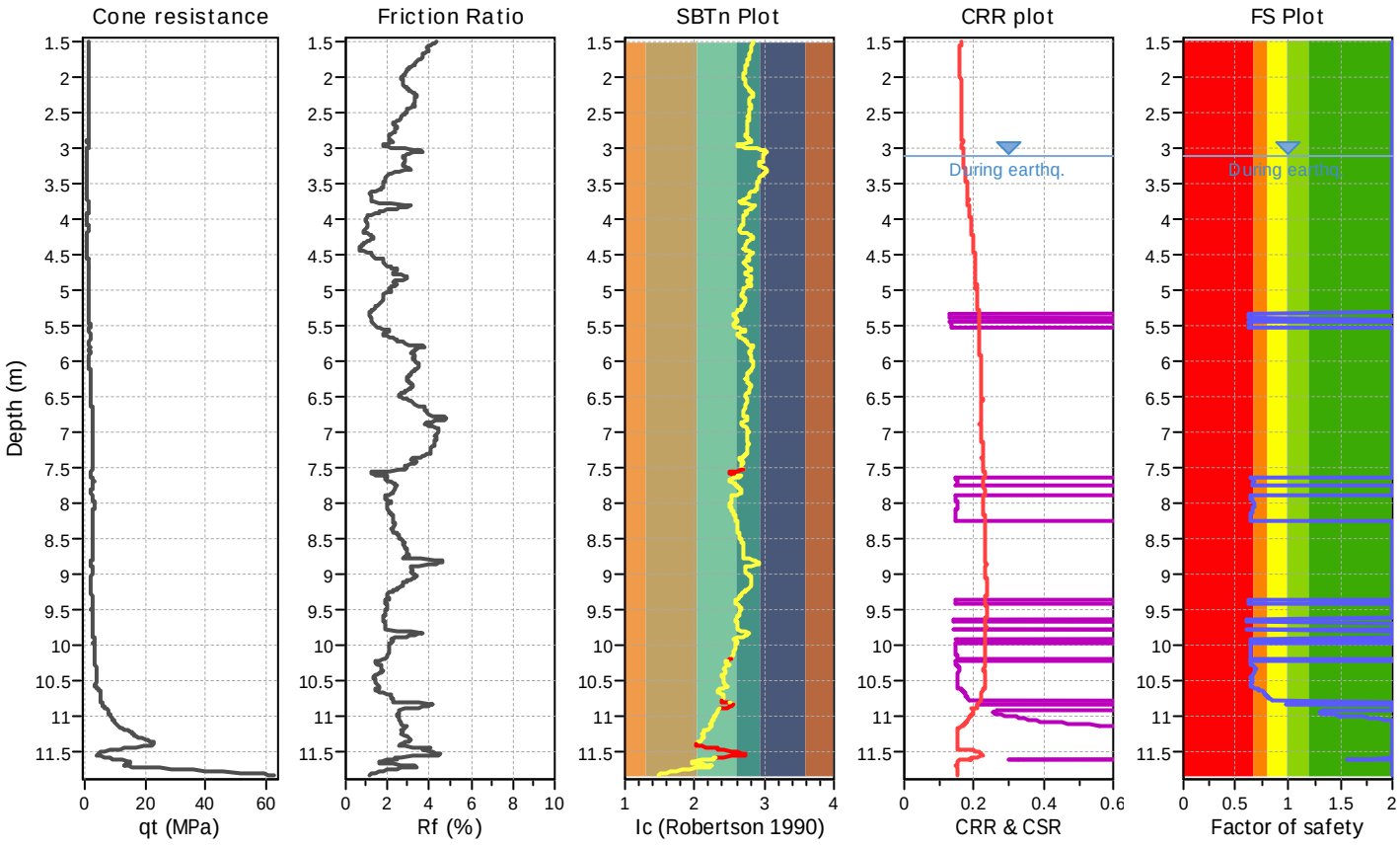
LIQUEFACTION ANALYSIS REPORT

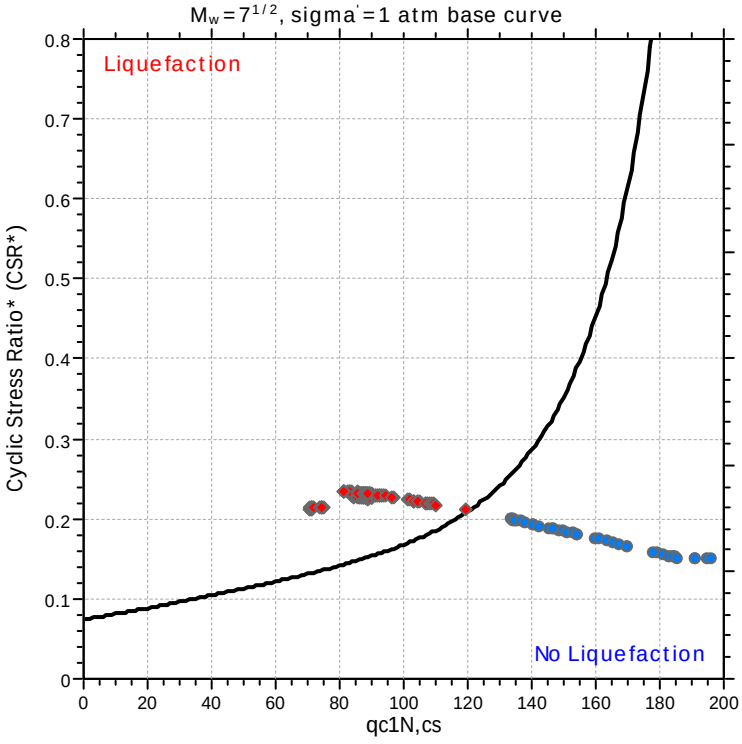
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSCIN003 – Keith Hay Park

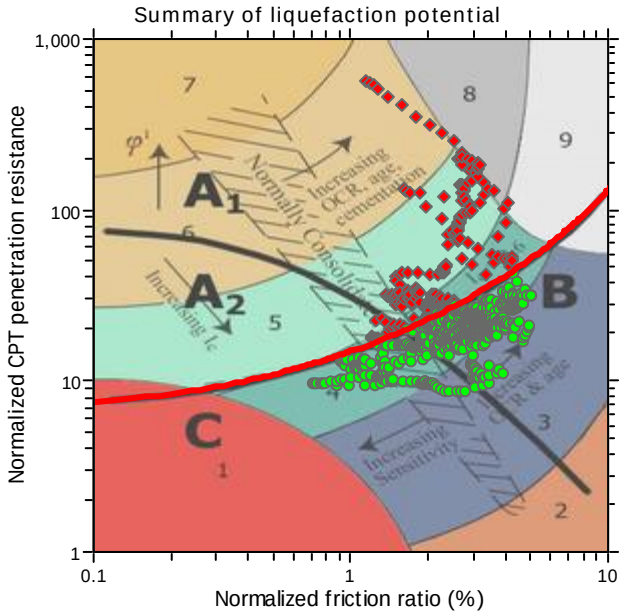
CPT file : AS5-CPT03

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	3.12 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	3.12 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

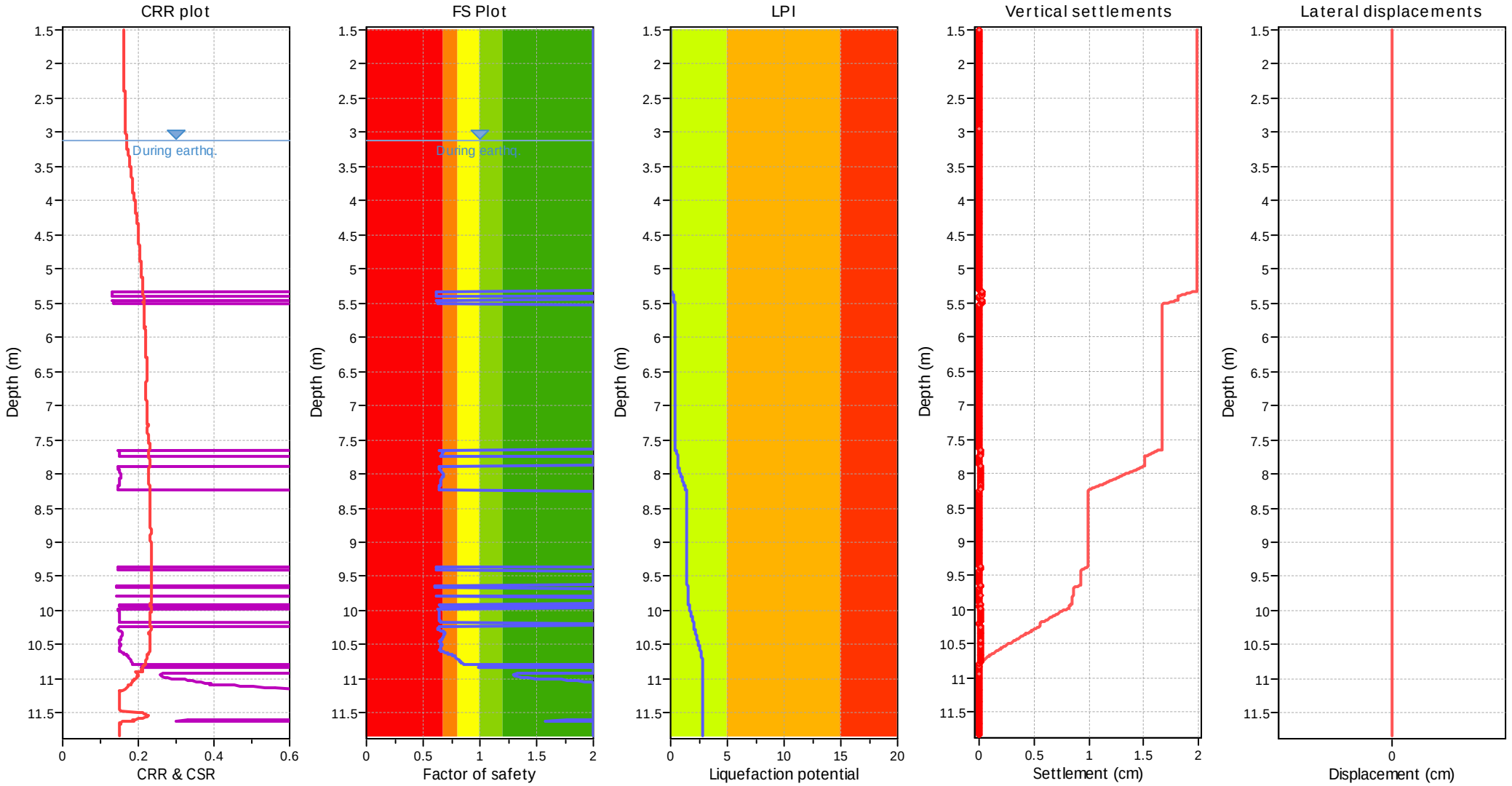






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	3.12 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	3.12 m	Fill height:	N/A	Limit depth:	N/A

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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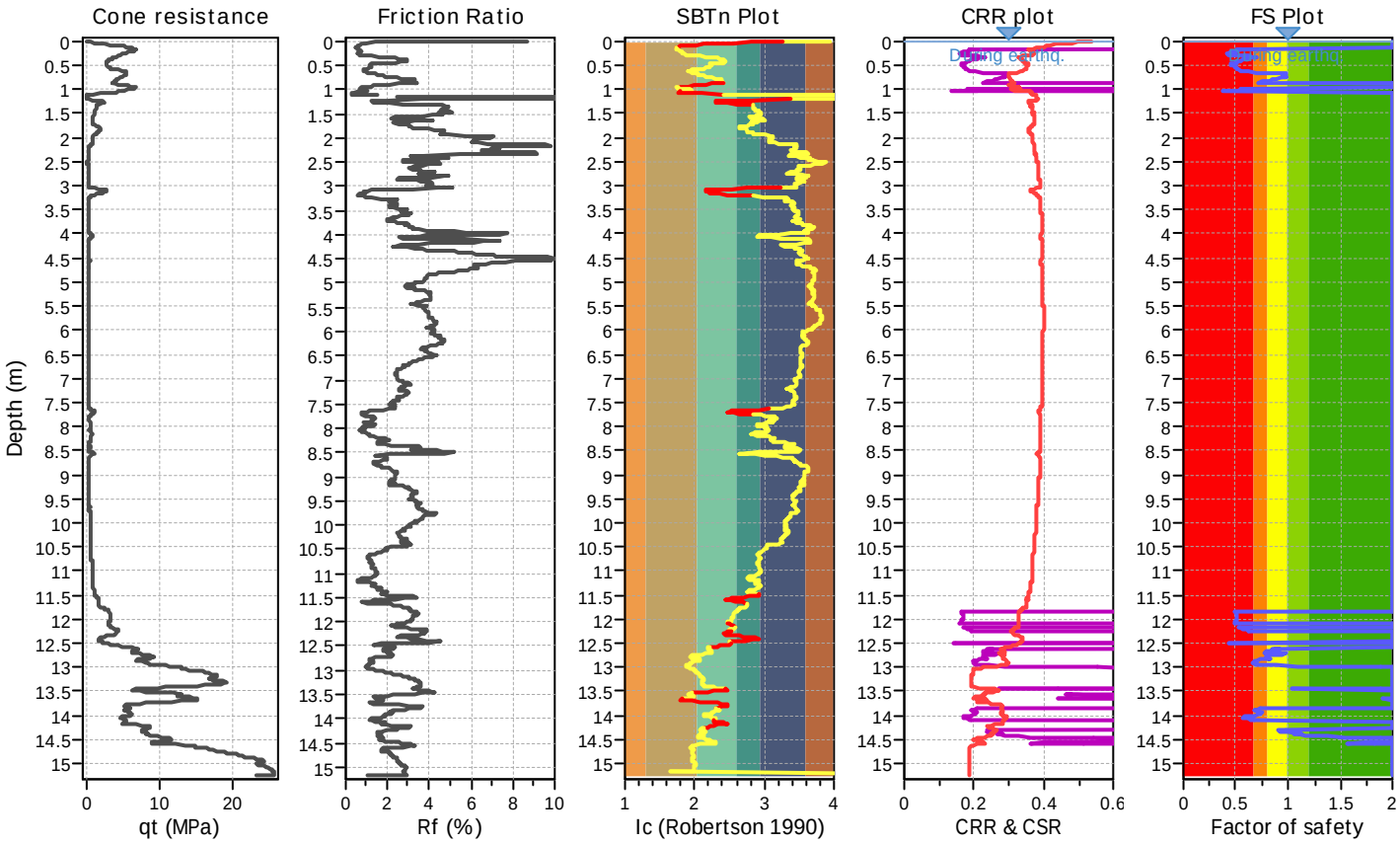
LIQUEFACTION ANALYSIS REPORT

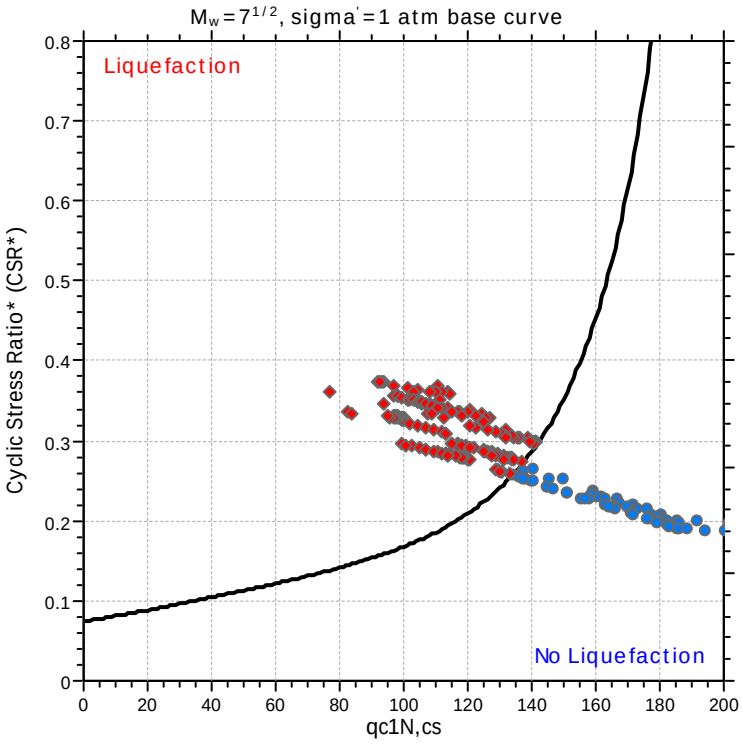
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSCIN003 – Keith Hay Park

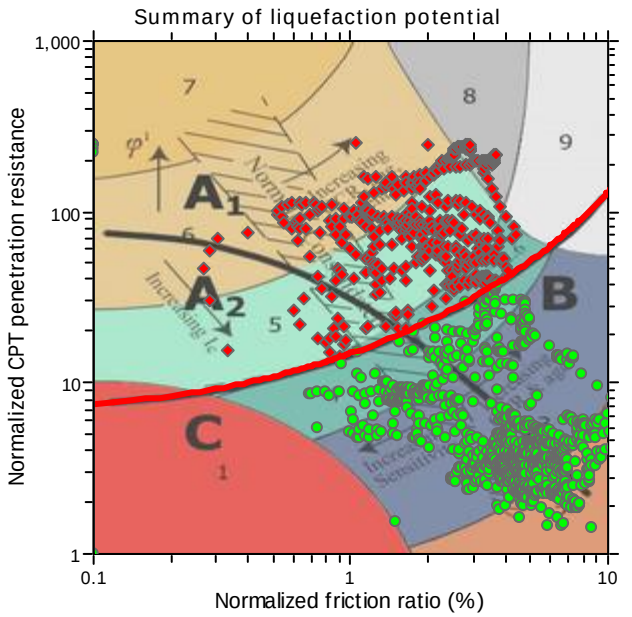
CPT file : AS5-CPT04

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

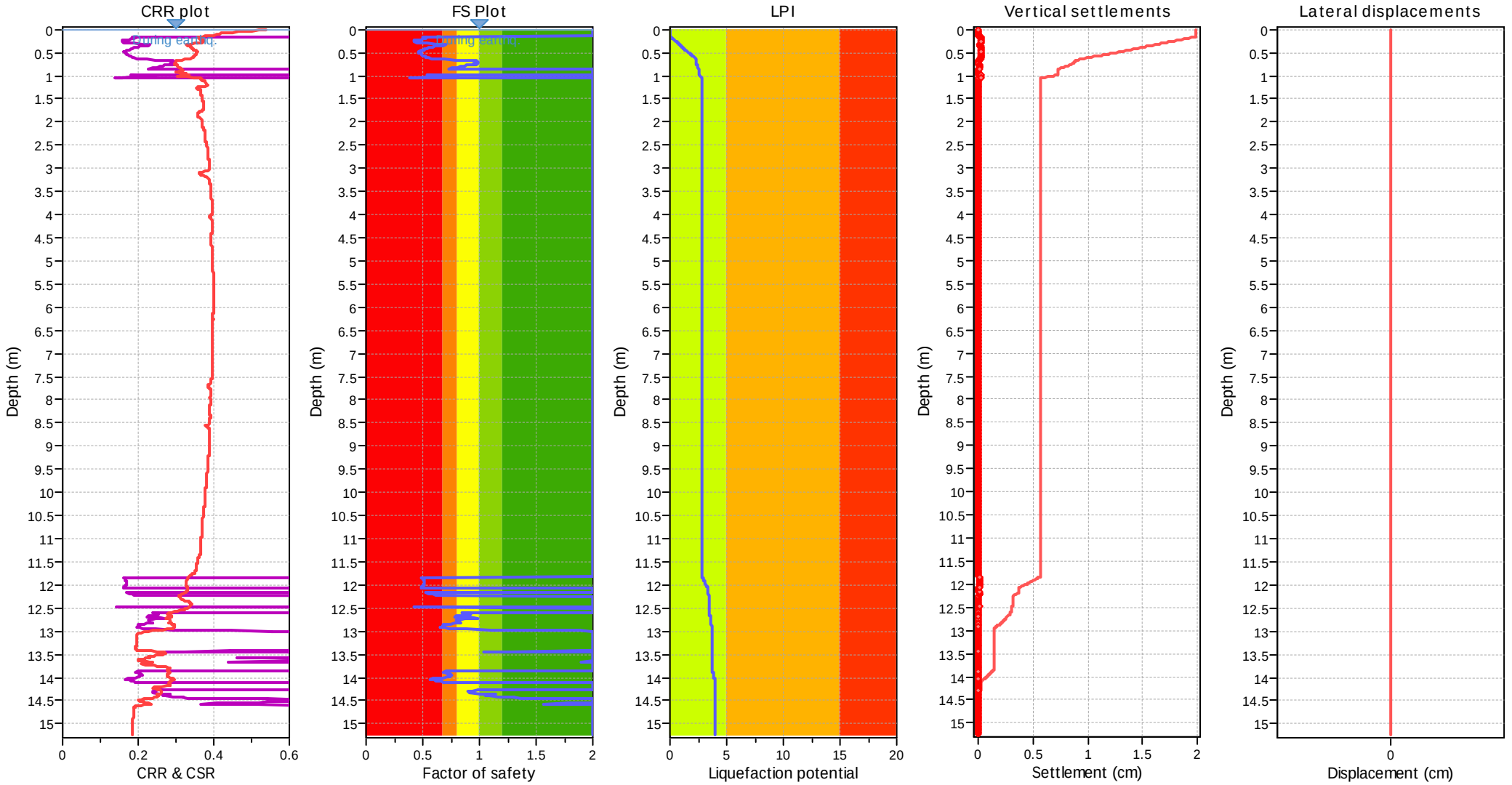






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	N/A

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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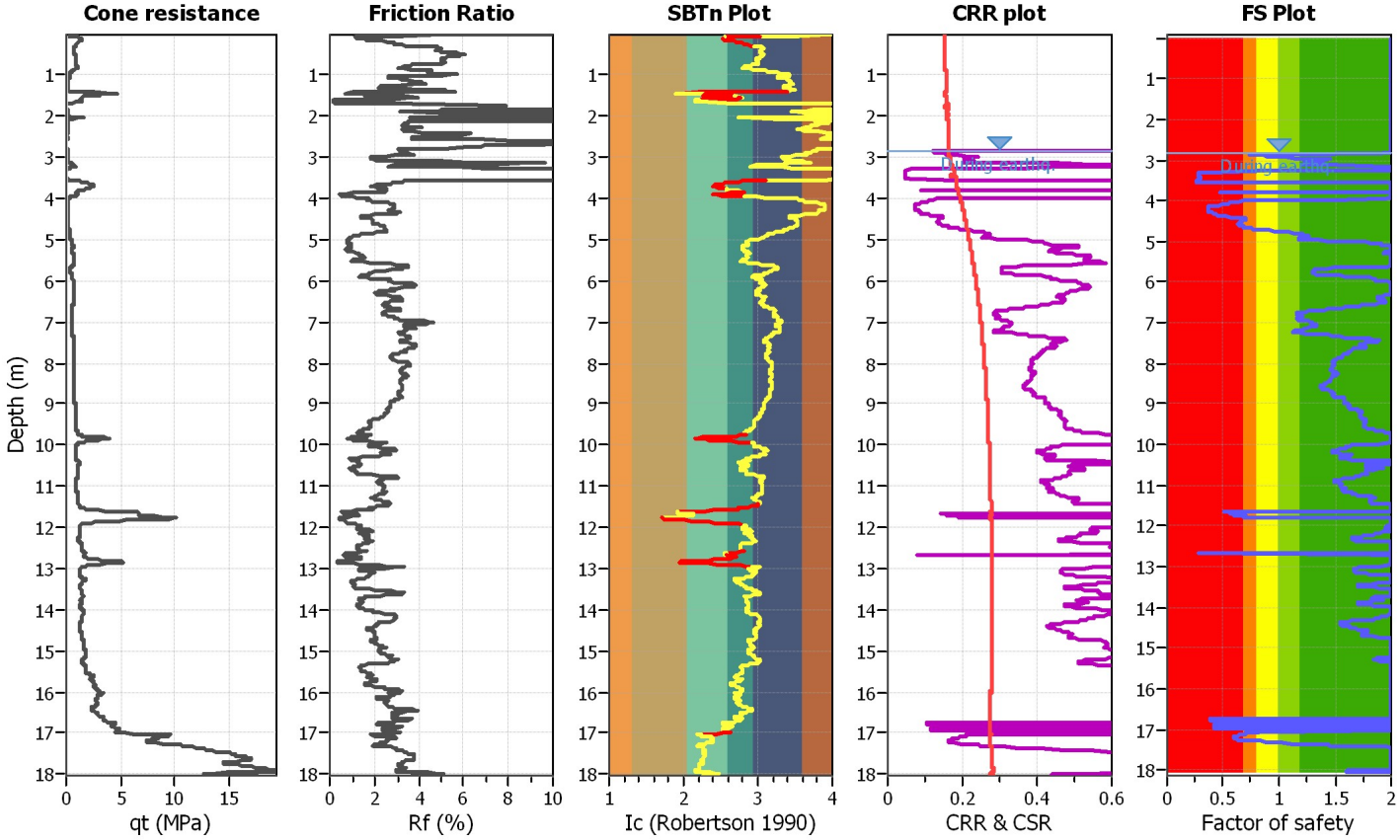
LIQUEFACTION ANALYSIS REPORT

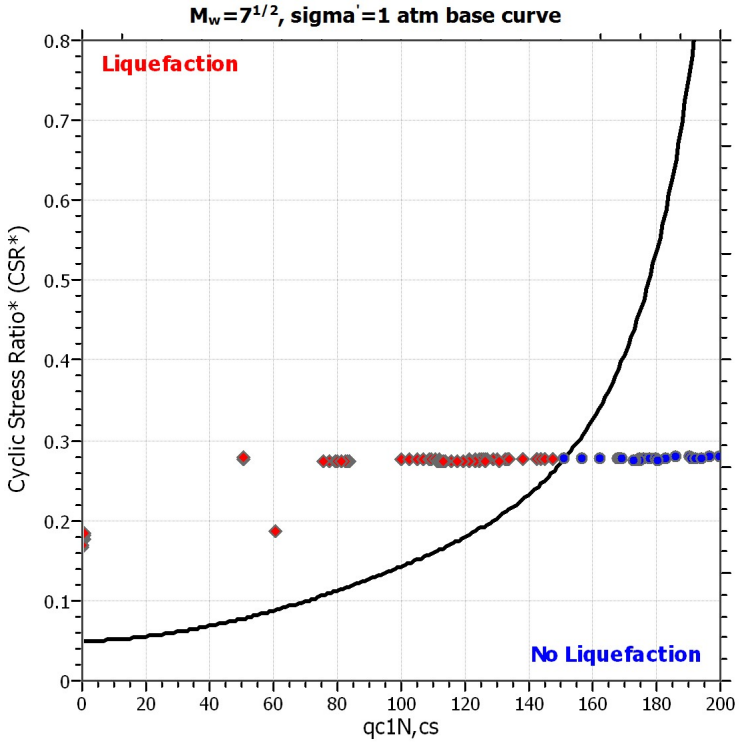
Project title : ULS 1/2500 year event (NZ1170.5) **Location : DSCIN004 – May Road**

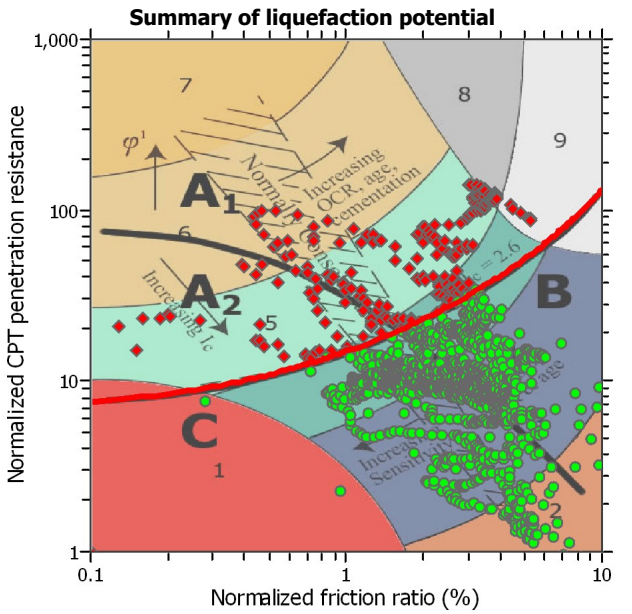
CPT file : WS2-CPT03D

Input parameters and analysis data

Analysis method:	I&B (2008)	G.W.T. (in-situ):	2.85 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	I&B (2008)	G.W.T. (earthq.):	2.85 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:	20.00 m
Earthquake magnitude M_w:	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

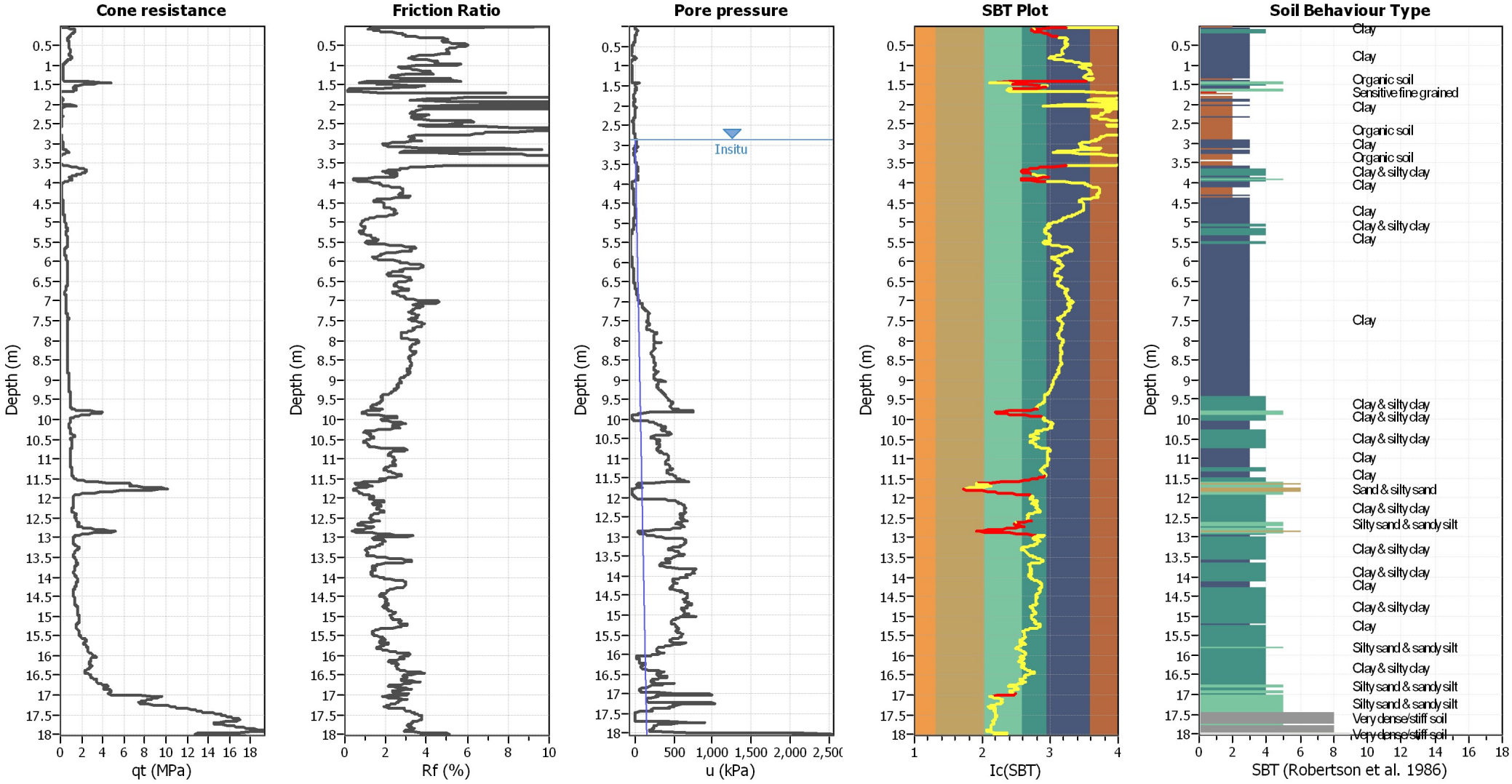






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

CPT basic interpretation plots



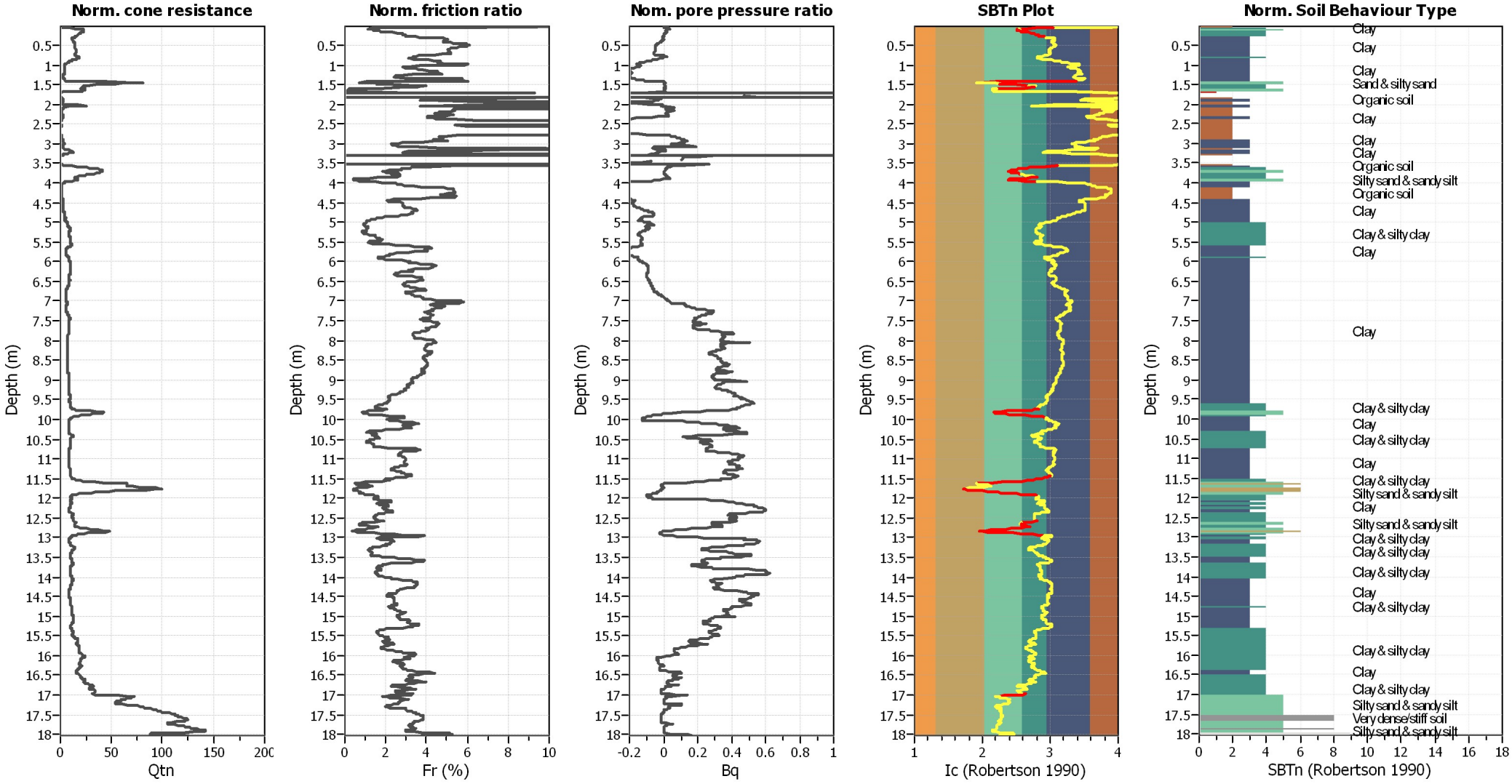
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.85 m	Fill weight:	N/A
Fines correction method:	I&B (2008)	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:	Sand & Clay
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.85 m	Fill height:	N/A	Limit depth:	20.00 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

CPT basic interpretation plots (normalized)



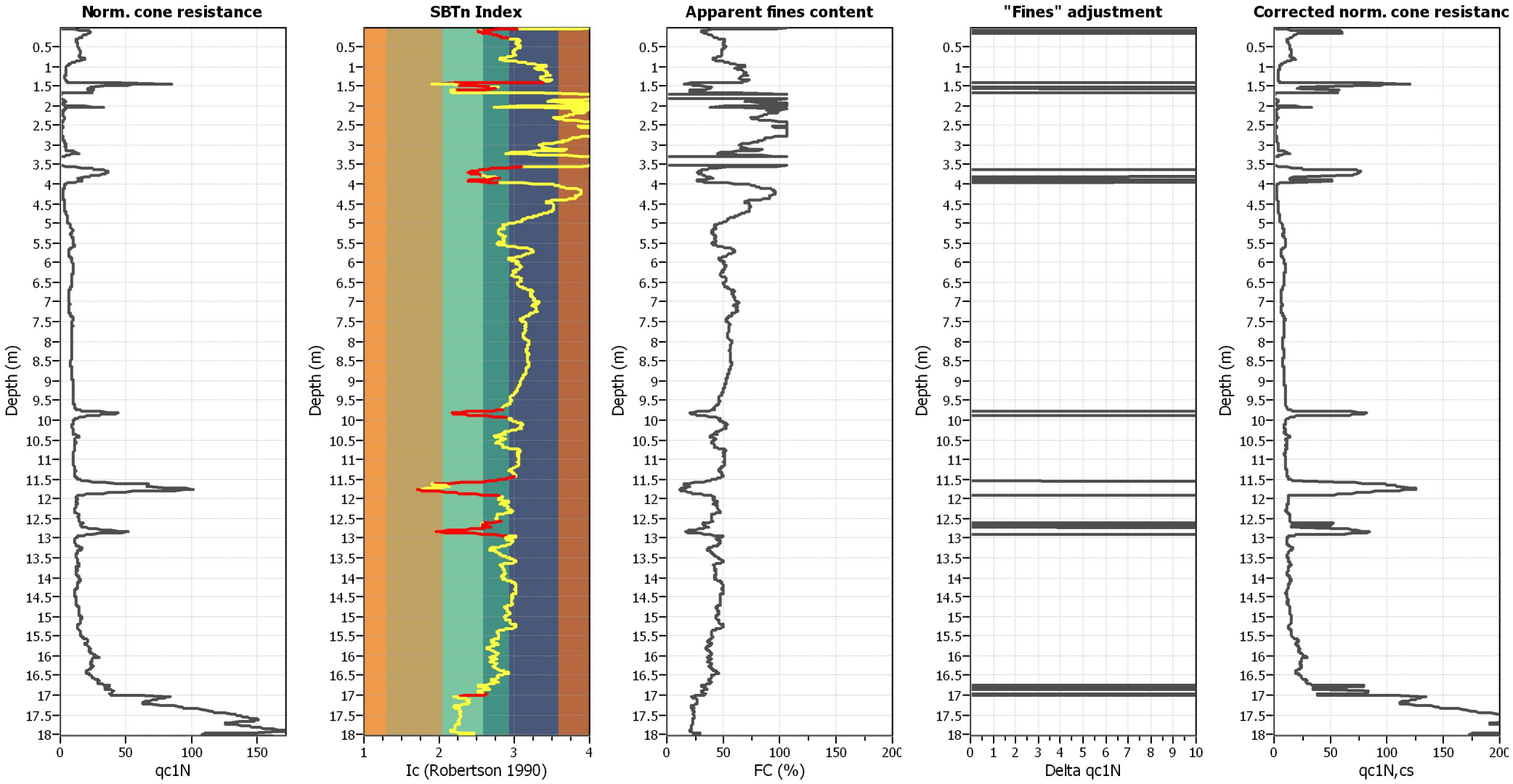
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.85 m	Fill weight:	N/A
Fines correction method:	I&B (2008)	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:	Sand & Clay
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.85 m	Fill height:	N/A	Limit depth:	20.00 m

SBTn 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

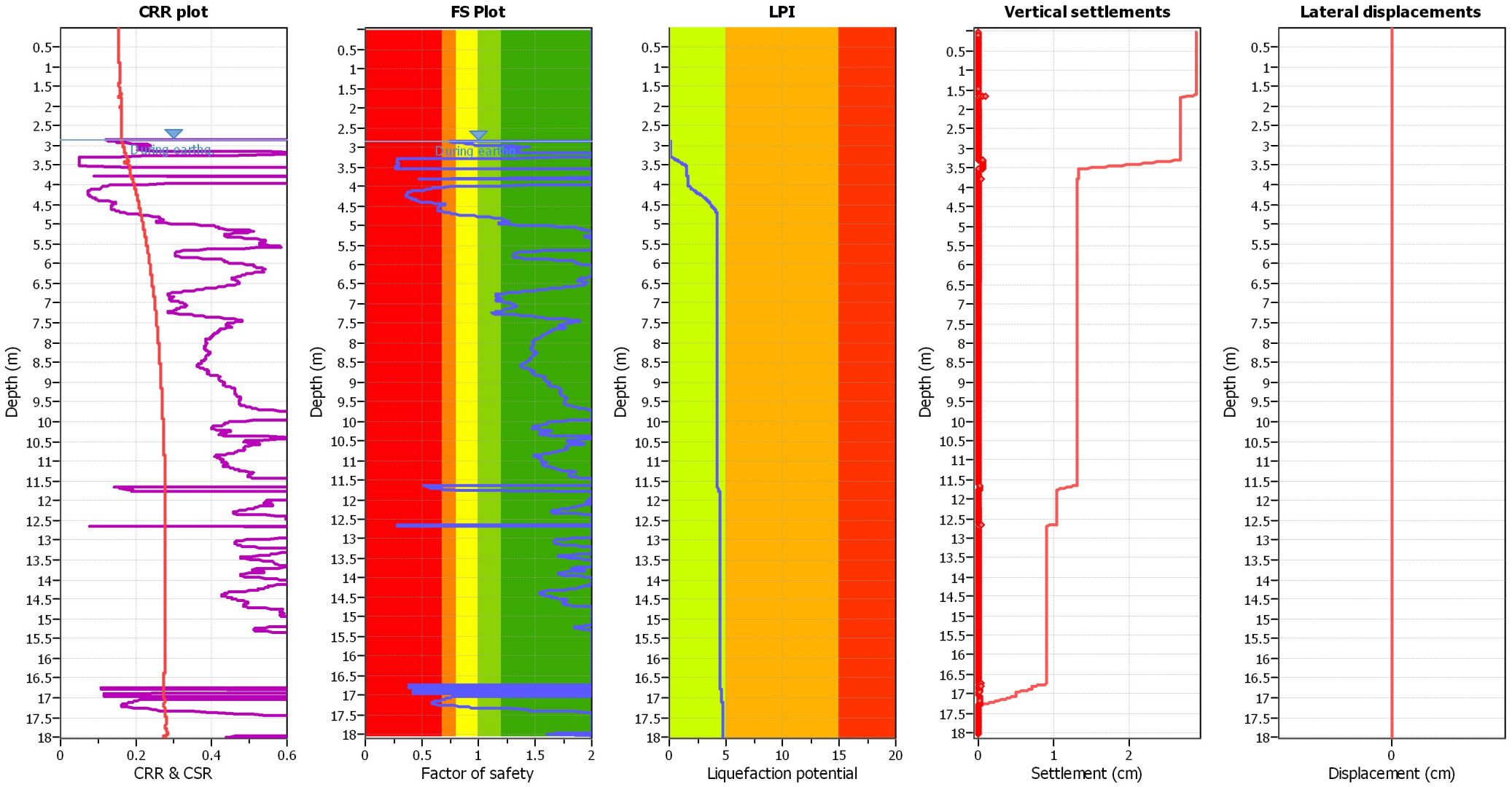
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.85 m	Fill weight:	N/A
Fines correction method:	I&B (2008)	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:	Sand & Clay
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.85 m	Fill height:	N/A	Limit depth:	20.00 m

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.85 m	Fill weight:	N/A
Fines correction method:	I&B (2008)	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:	Sand & Clay
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.85 m	Fill height:	N/A	Limit depth:	20.00 m

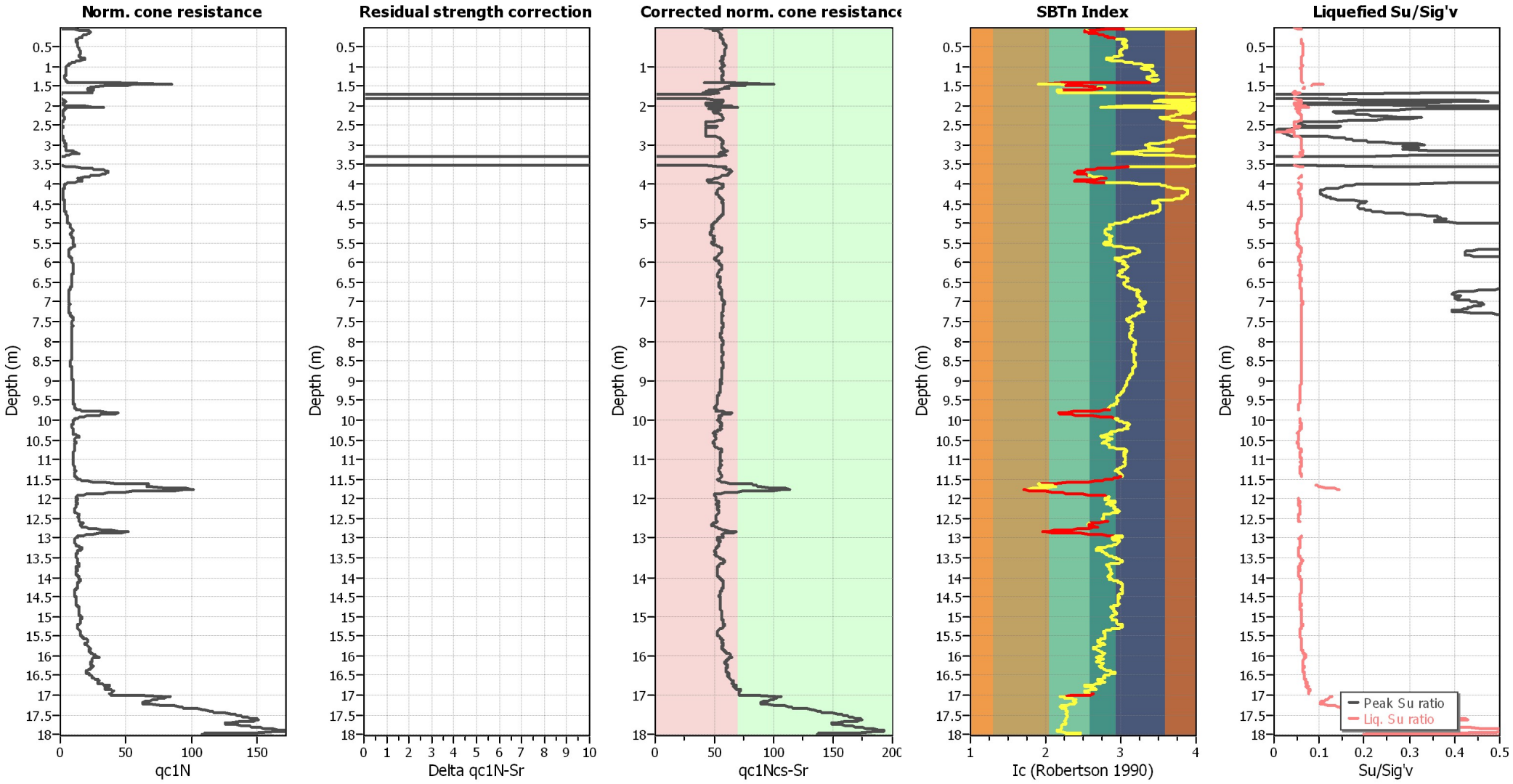
F.S. color scheme

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

LPI color scheme

- Very high risk
- High risk
- Low risk

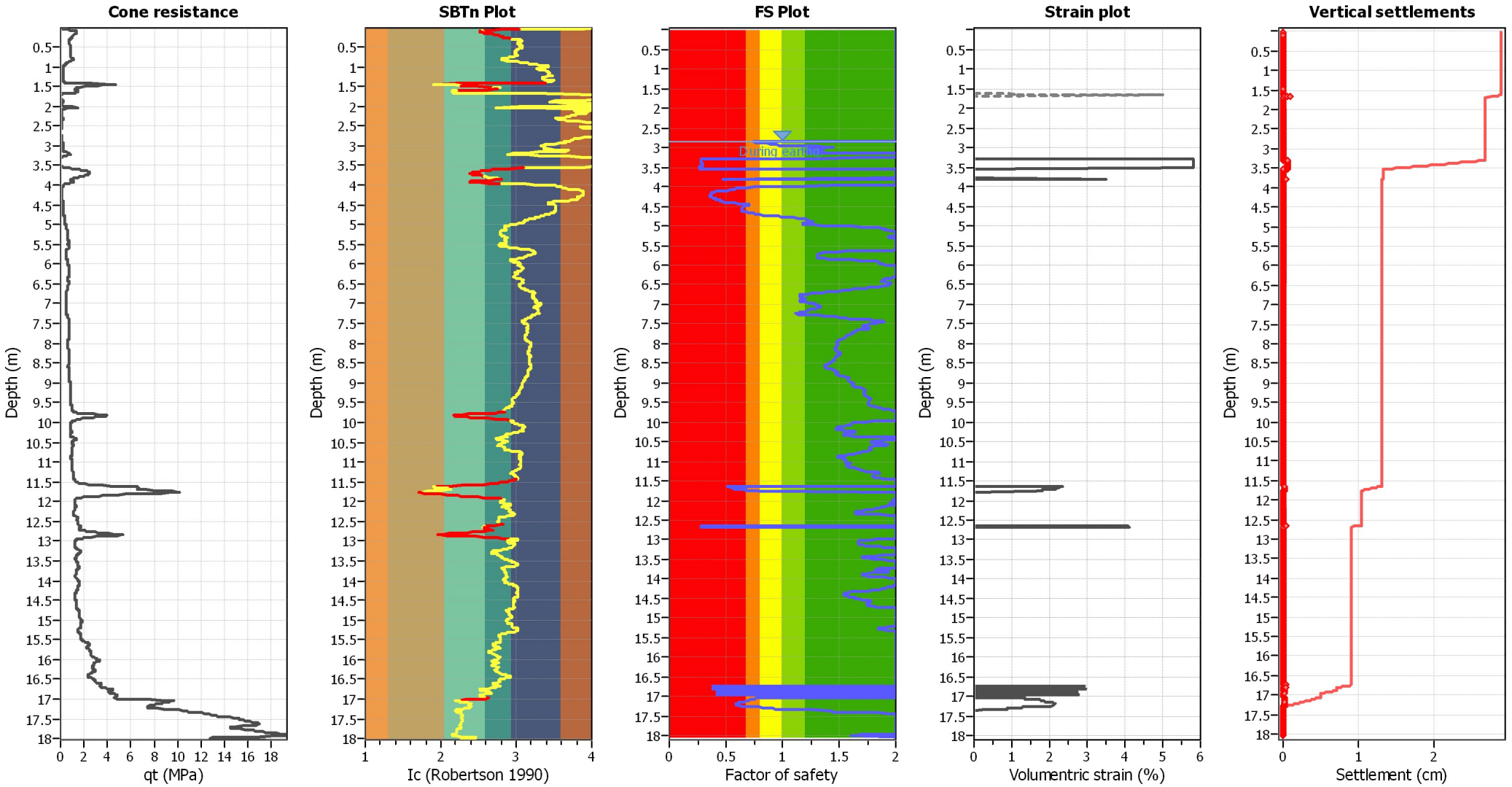
Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.85 m	Fill weight:	N/A
Fines correction method:	I&B (2008)	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:	Sand & Clay
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.85 m	Fill height:	N/A	Limit depth:	20.00 m

Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

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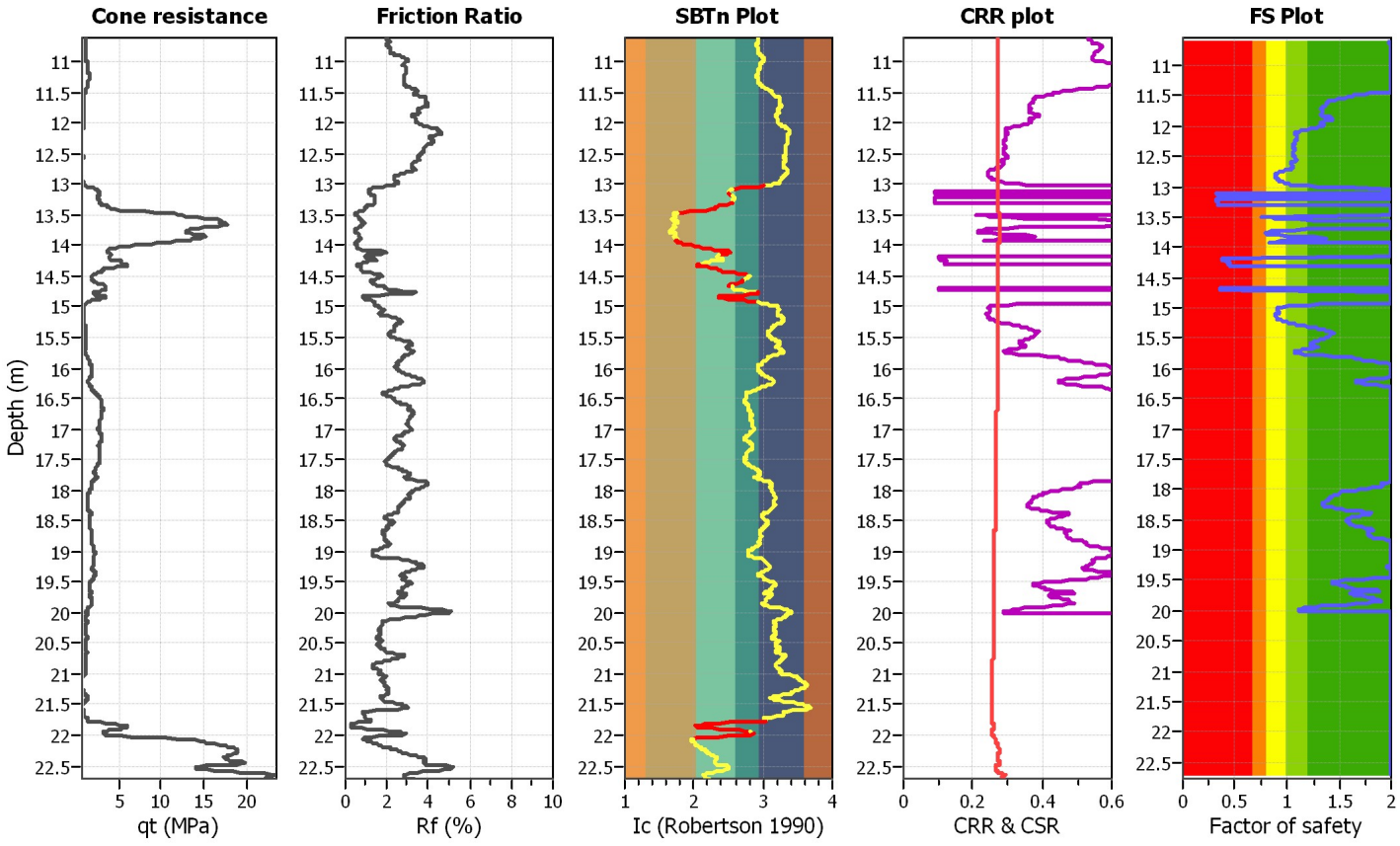
LIQUEFACTION ANALYSIS REPORT

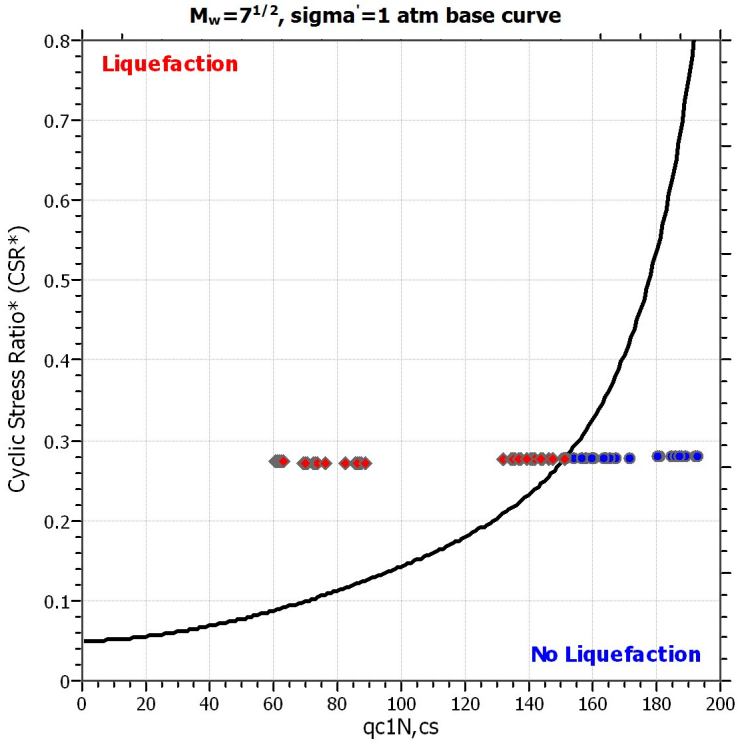
Project title : ULS 1/2500 year event (NZ1170.5) **Location : DSCIN004 – May Road**

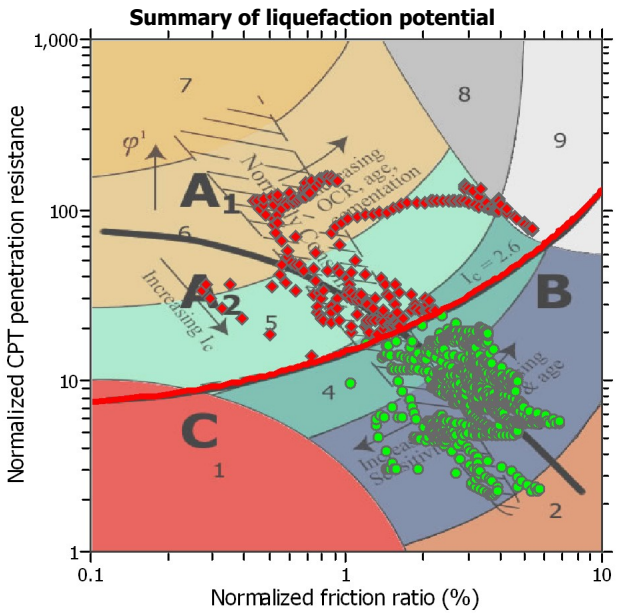
CPT file : WS2-CPT04

Input parameters and analysis data

Analysis method:	I&B (2008)	G.W.T. (in-situ):	2.60 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	I&B (2008)	G.W.T. (earthq.):	2.60 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:	20.00 m
Earthquake magnitude M_w:	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		







Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
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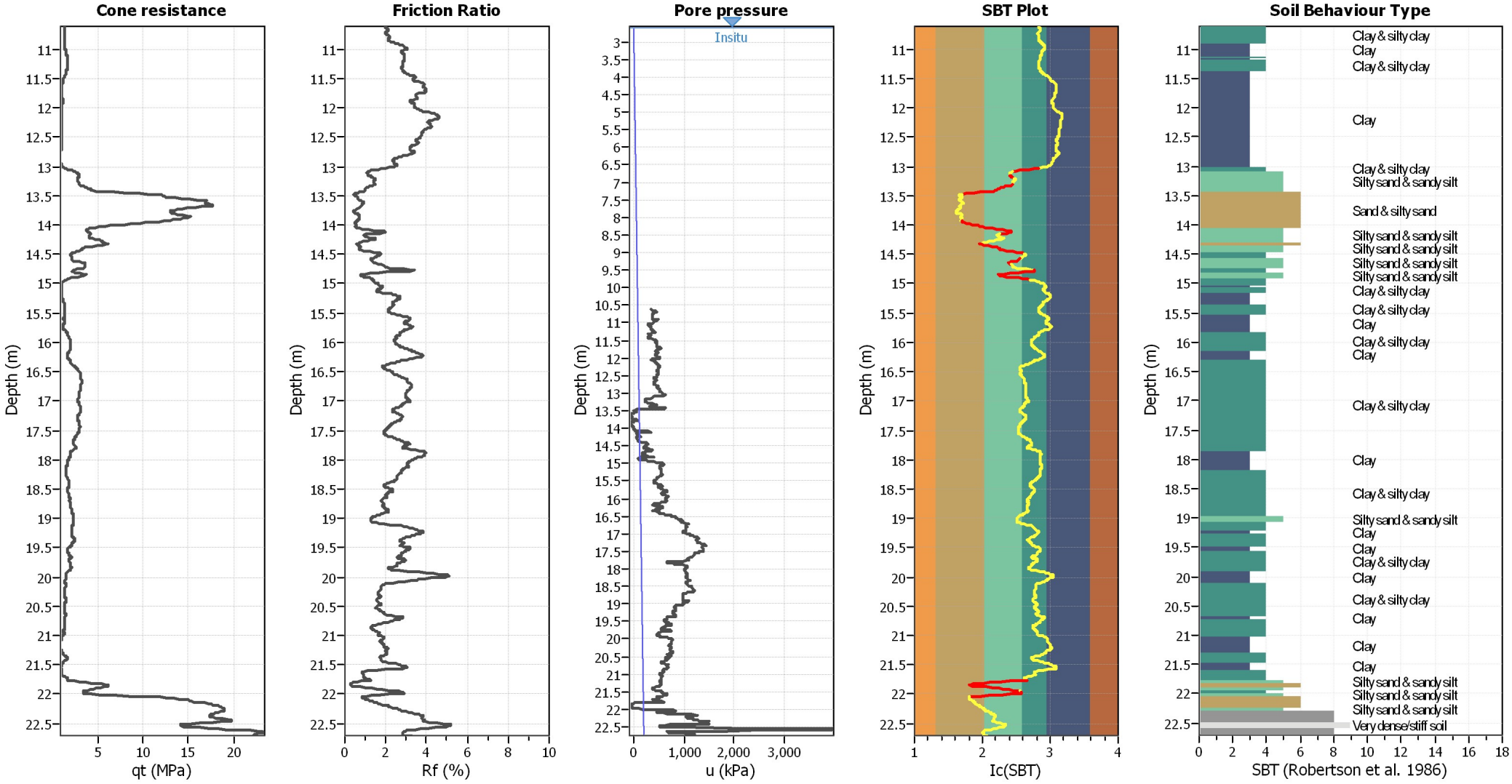
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.60 m	Fill weight:	N/A
Fines correction method:	I&B (2008)	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:	Sand & Clay
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.60 m	Fill height:	N/A	Limit depth:	20.00 m

SBT legend

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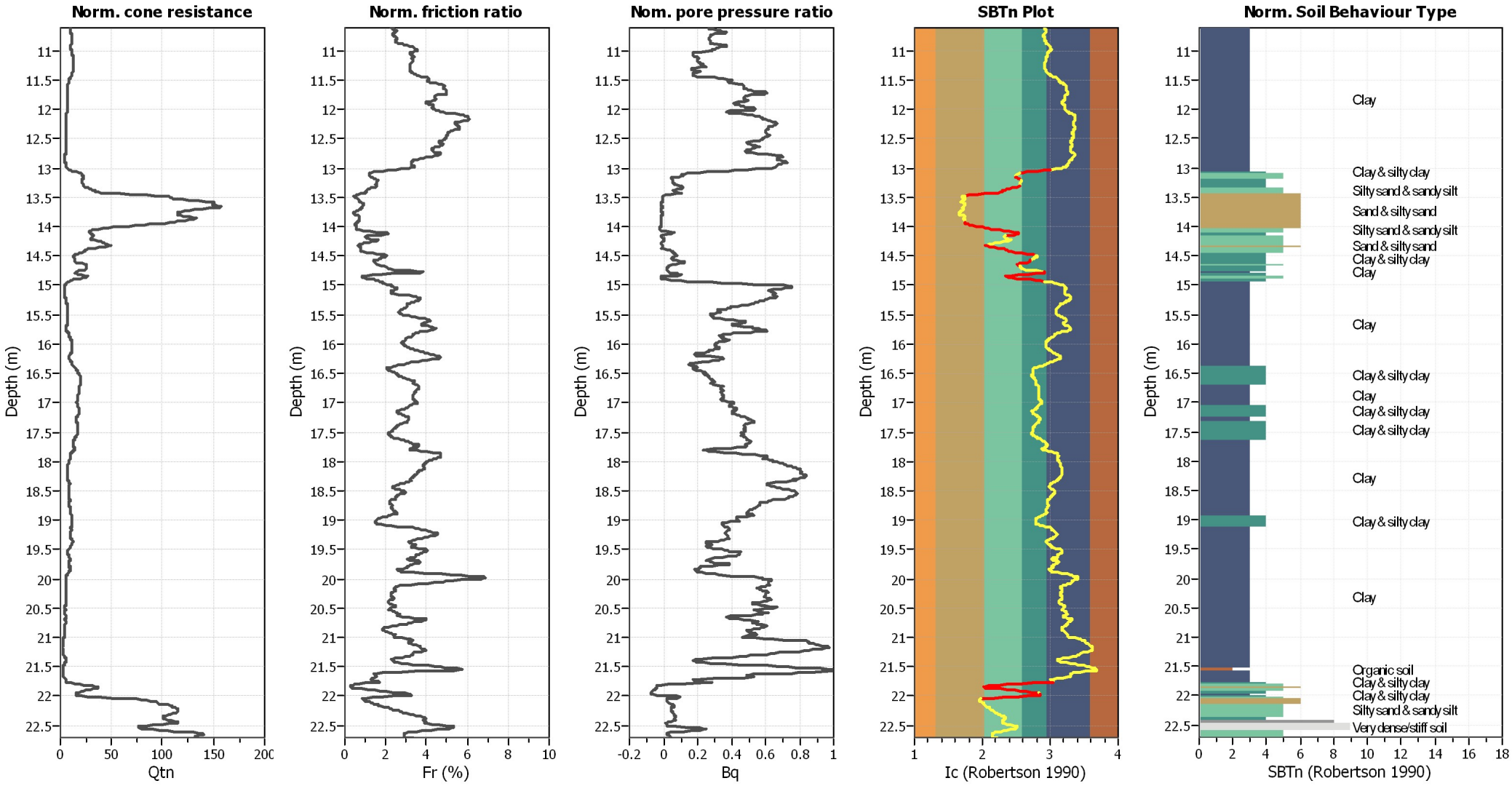
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normalized)



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.60 m	Fill weight:	N/A
Fines correction method:	I&B (2008)	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:	Sand & Clay
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.60 m	Fill height:	N/A	Limit depth:	20.00 m

SBTn legend

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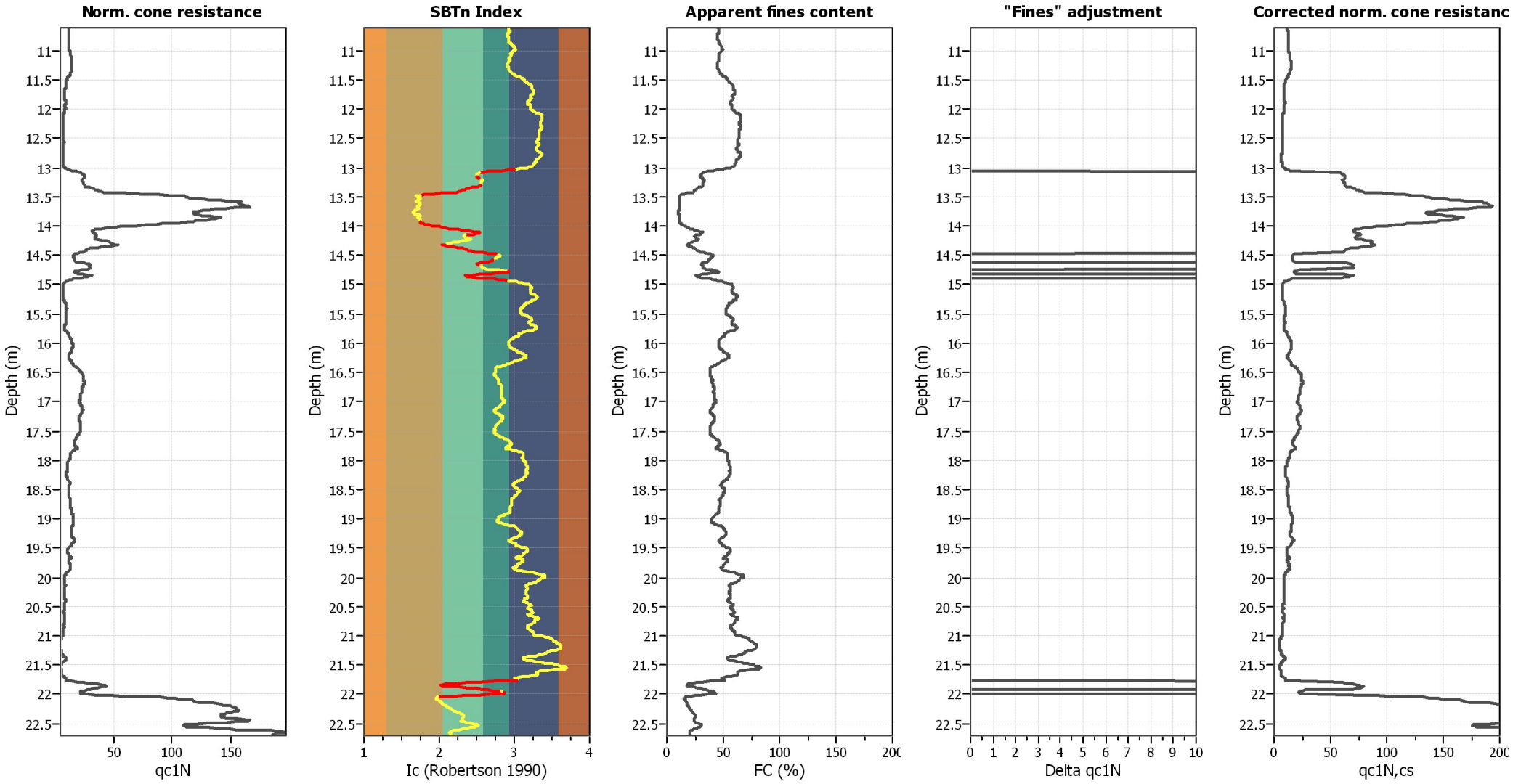
8. Very stiff sand to
9. Very stiff fine grained

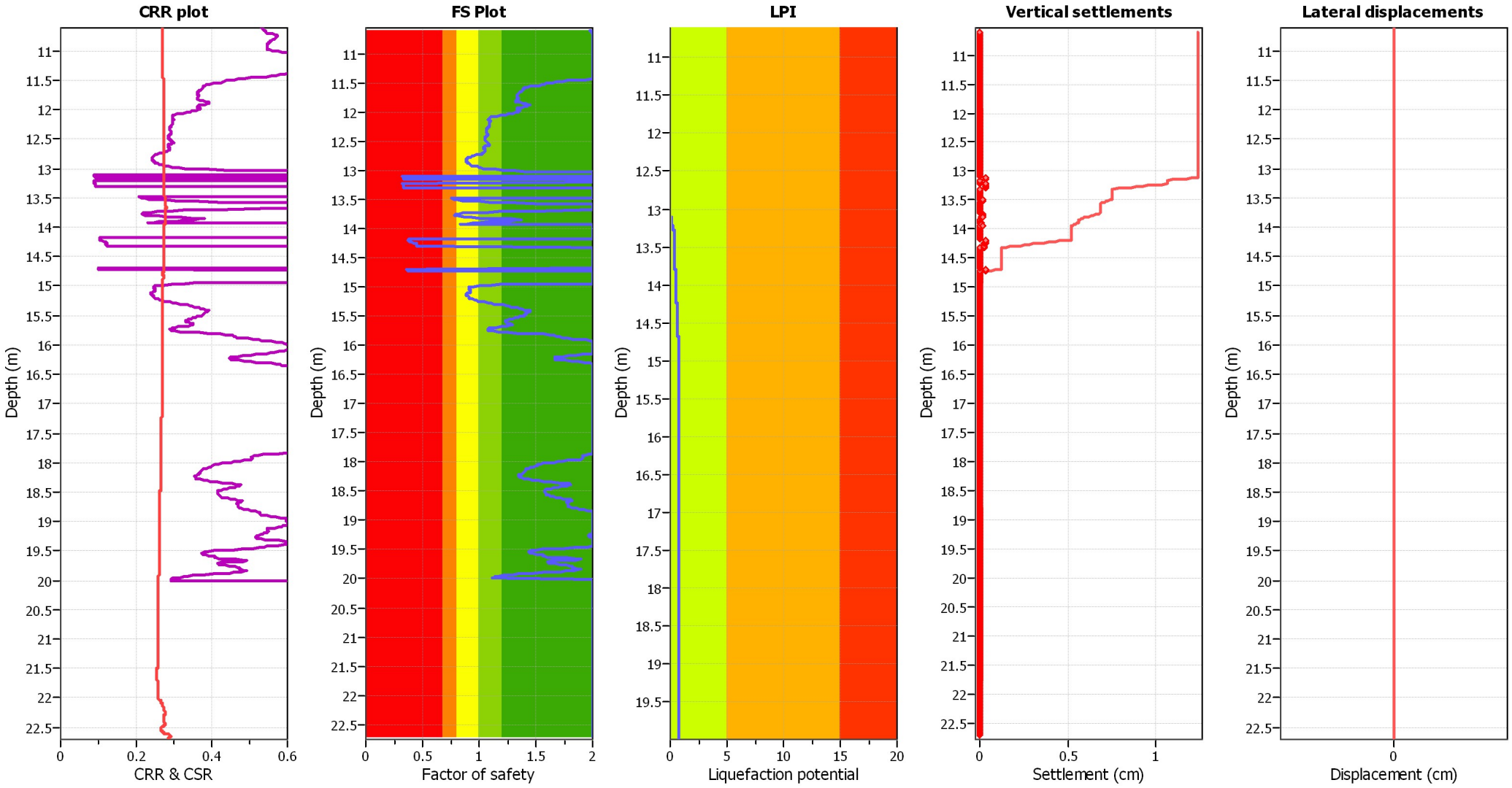
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.60 m	Fill weight:	N/A
Fines correction method:	I&B (2008)	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:	Sand & Clay
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.60 m	Fill height:	N/A	Limit depth:	20.00 m

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.60 m	Fill weight:	N/A
Fines correction method:	I&B (2008)	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:	Sand & Clay
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.60 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

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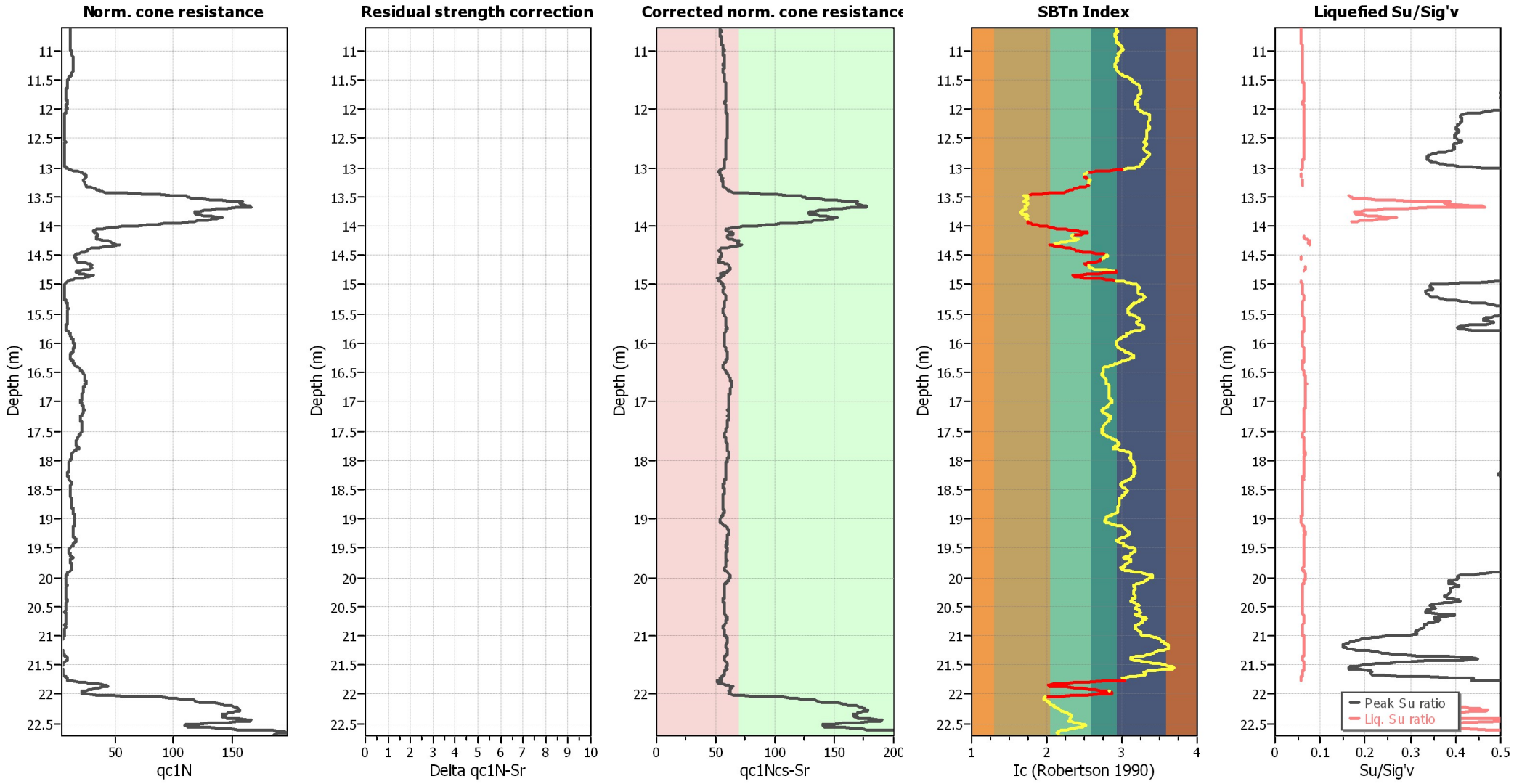
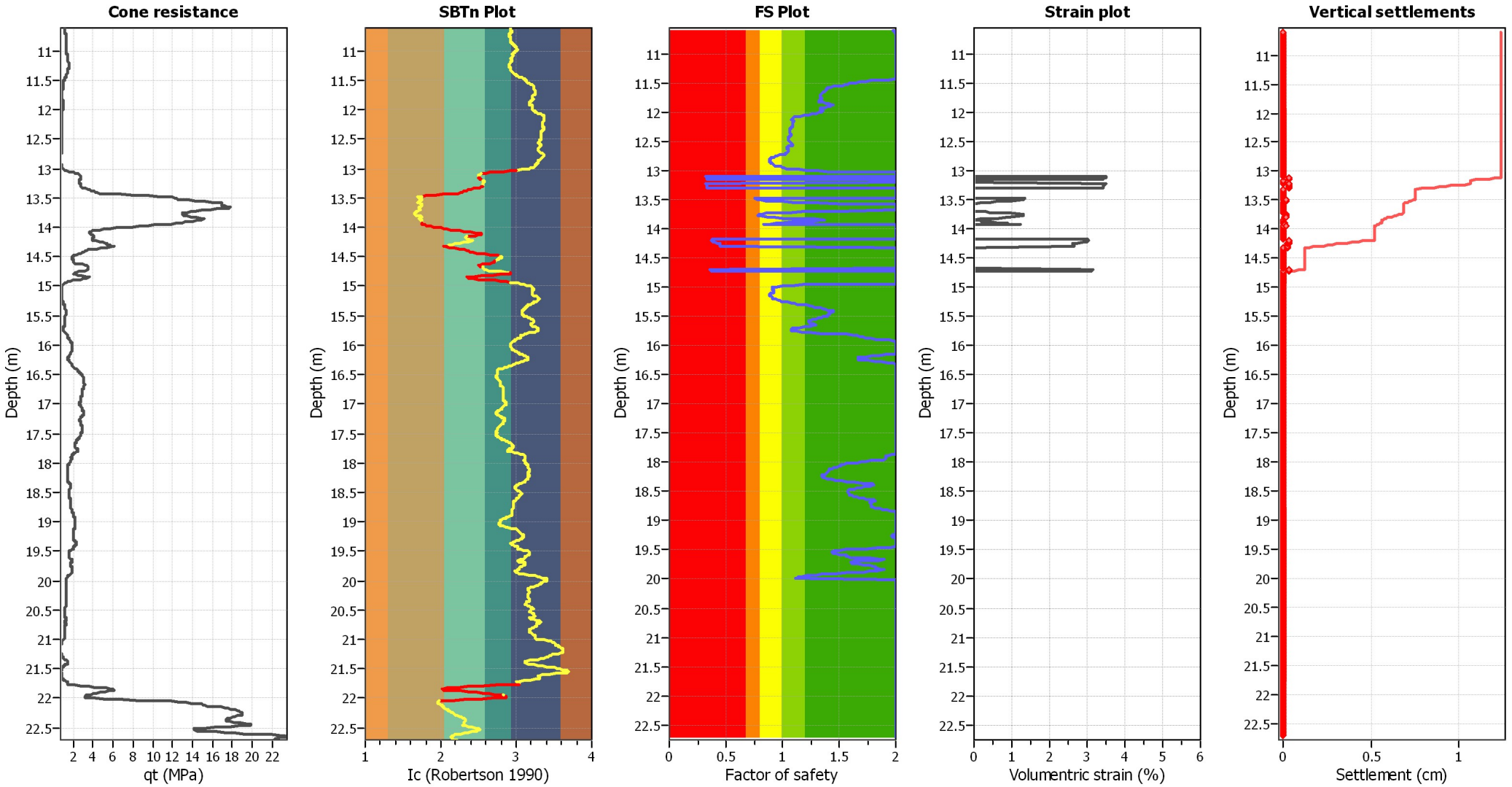


Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.60 m	Fill weight:	N/A
Fines correction method:	I&B (2008)	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:	Sand & Clay
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.60 m	Fill height:	N/A	Limit depth:	20.00 m

Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

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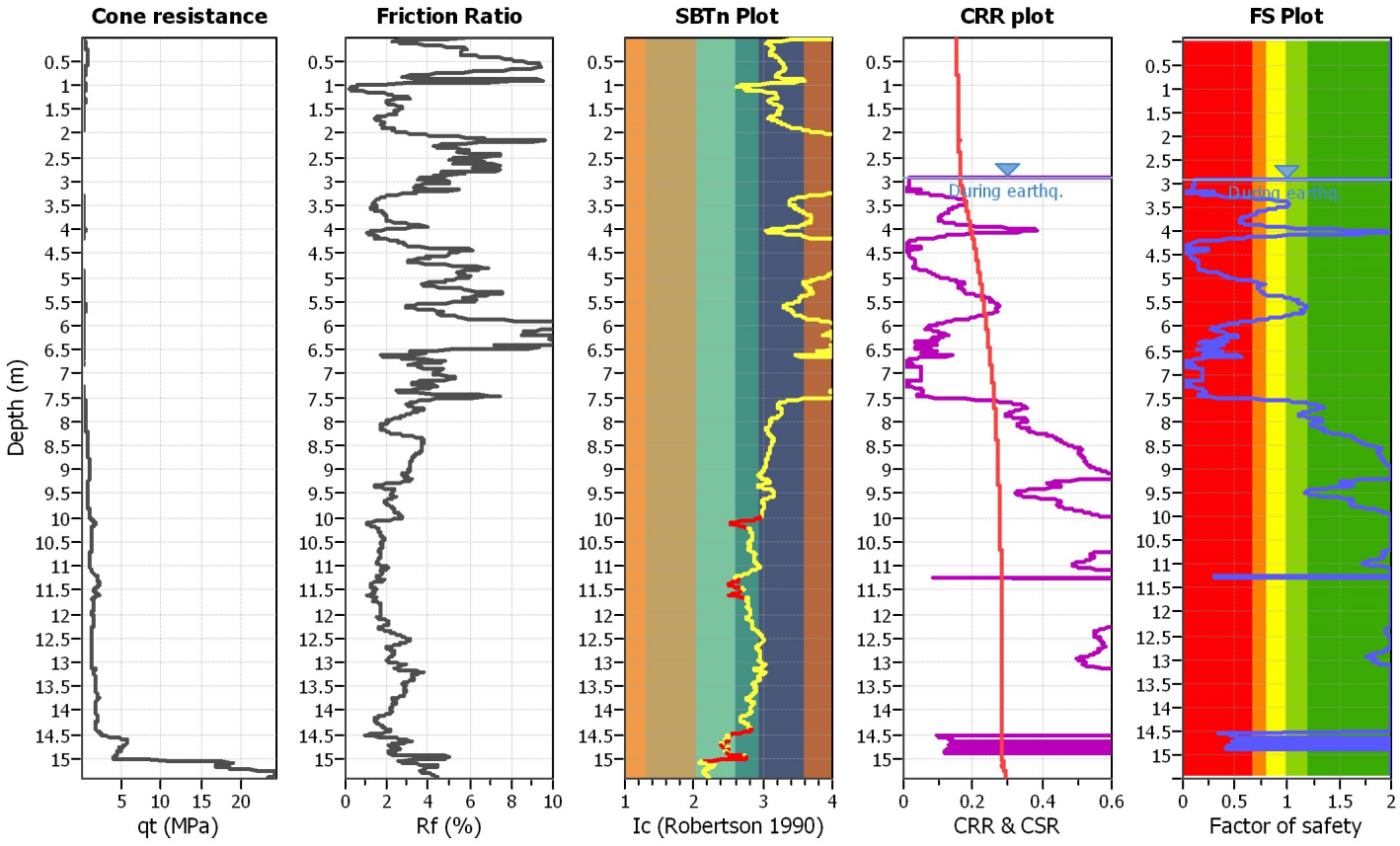
LIQUEFACTION ANALYSIS REPORT

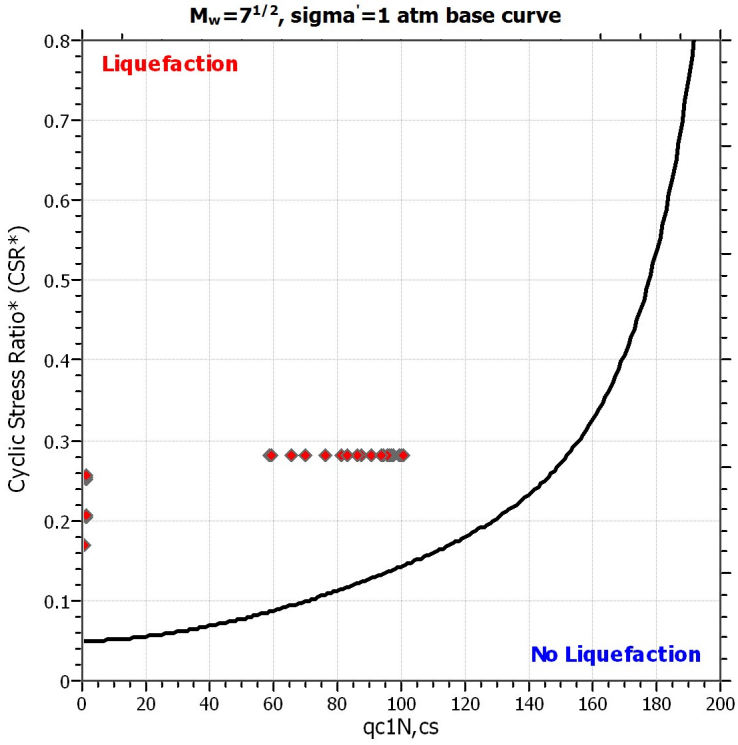
Project title : ULS 1/2500 year event (NZ1170.5) **Location : DSCIN004 – May Road**

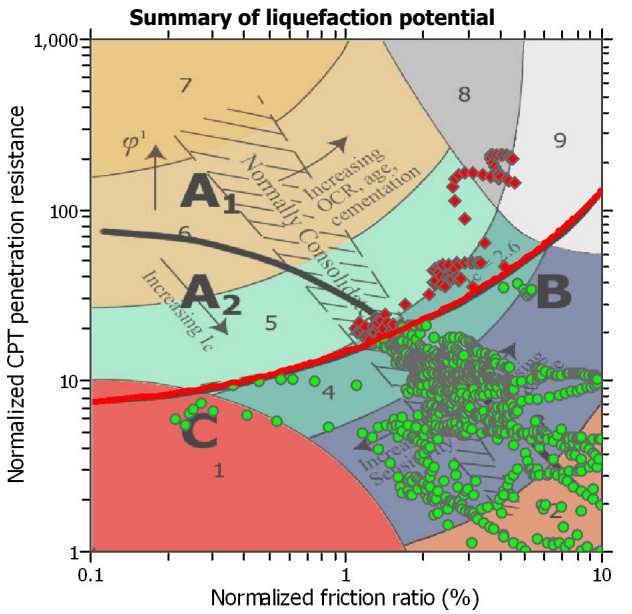
CPT file : WS2-CPT08

Input parameters and analysis data

Analysis method:	I&B (2008)	G.W.T. (in-situ):	2.92 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	I&B (2008)	G.W.T. (earthq.):	2.92 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:	20.00 m
Earthquake magnitude M_w:	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

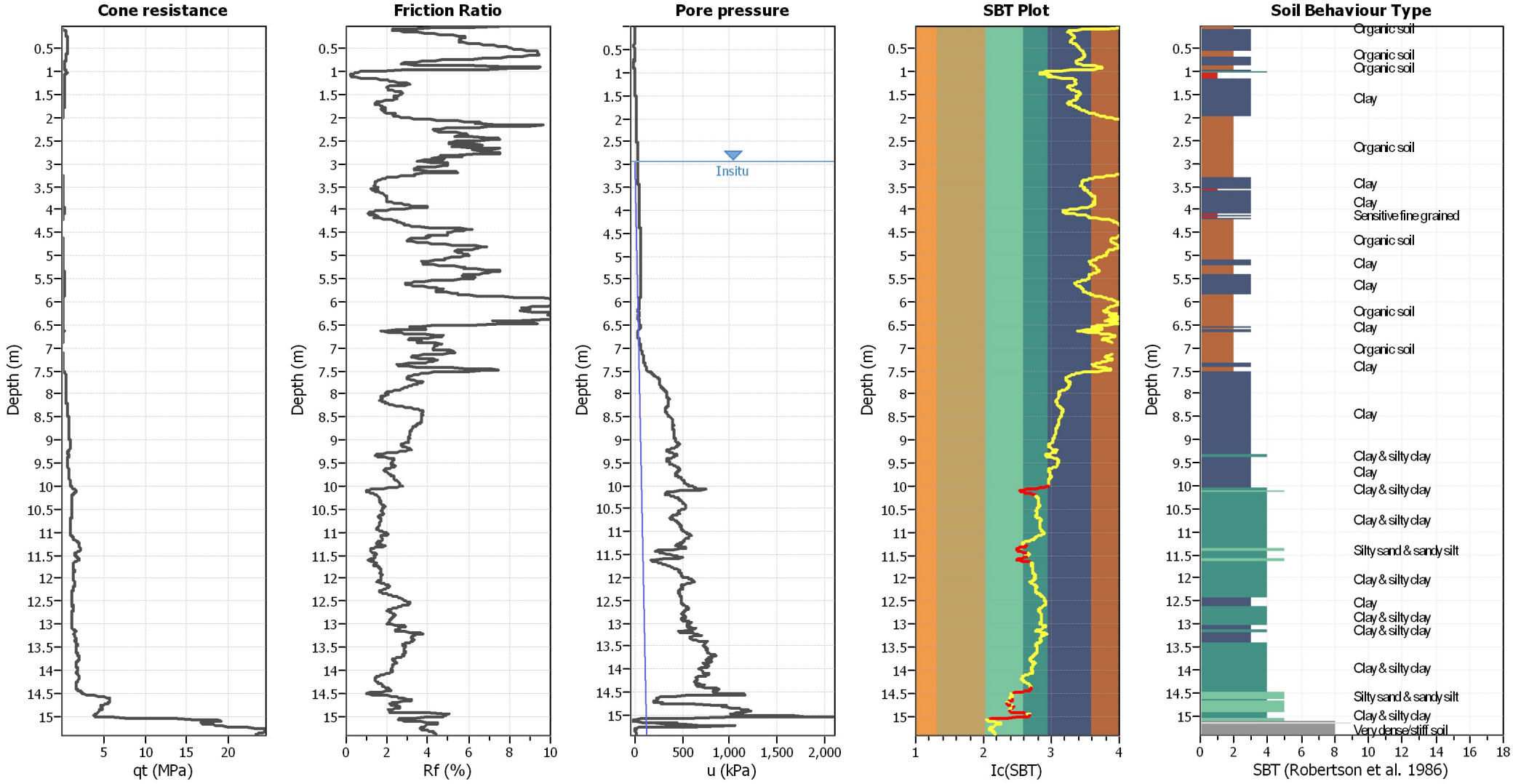






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

CPT basic interpretation plots



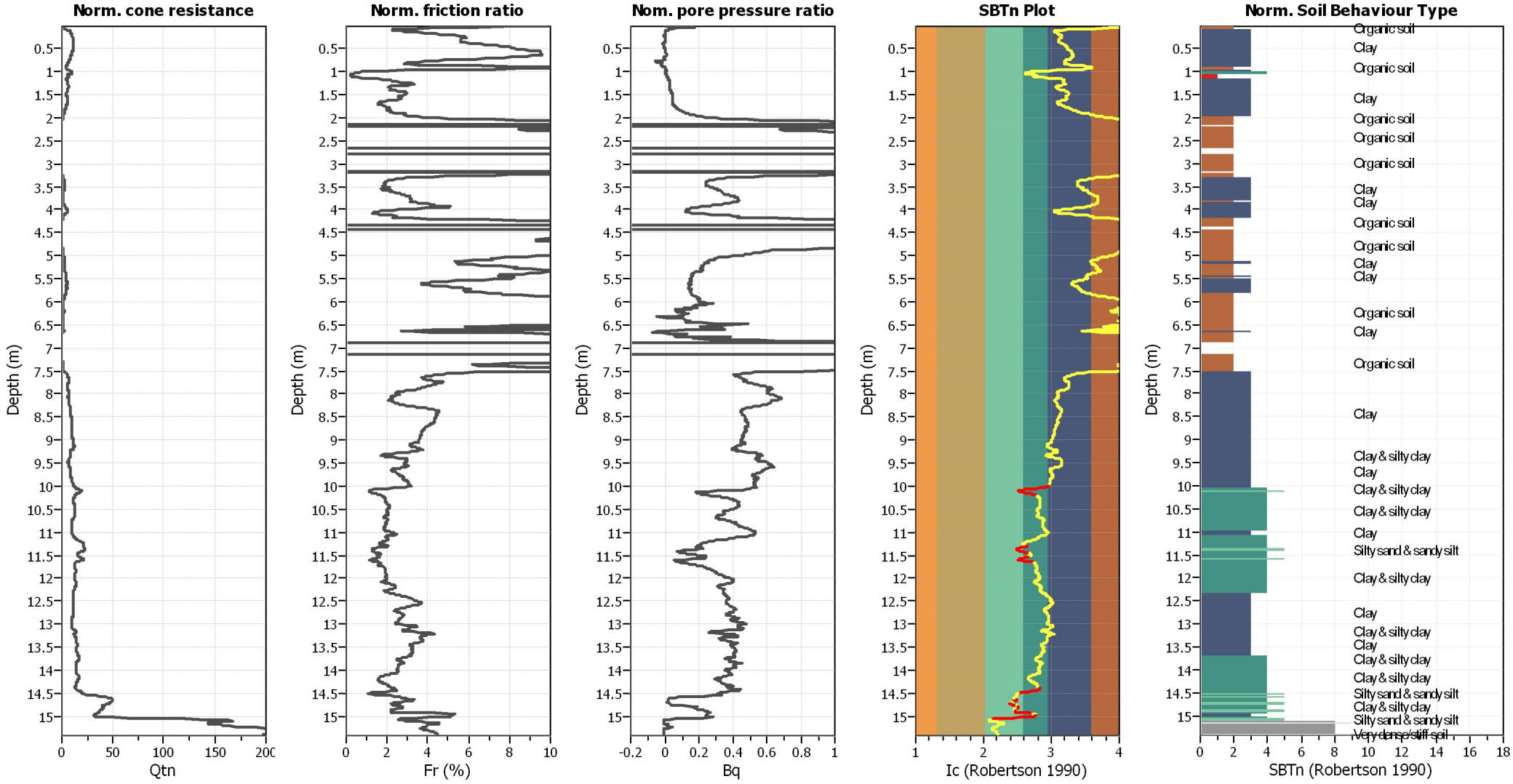
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.92 m	Fill weight:	N/A
Fines correction method:	I&B (2008)	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:	Sand & Clay
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.92 m	Fill height:	N/A	Limit depth:	20.00 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

CPT basic interpretation plots (normalized)



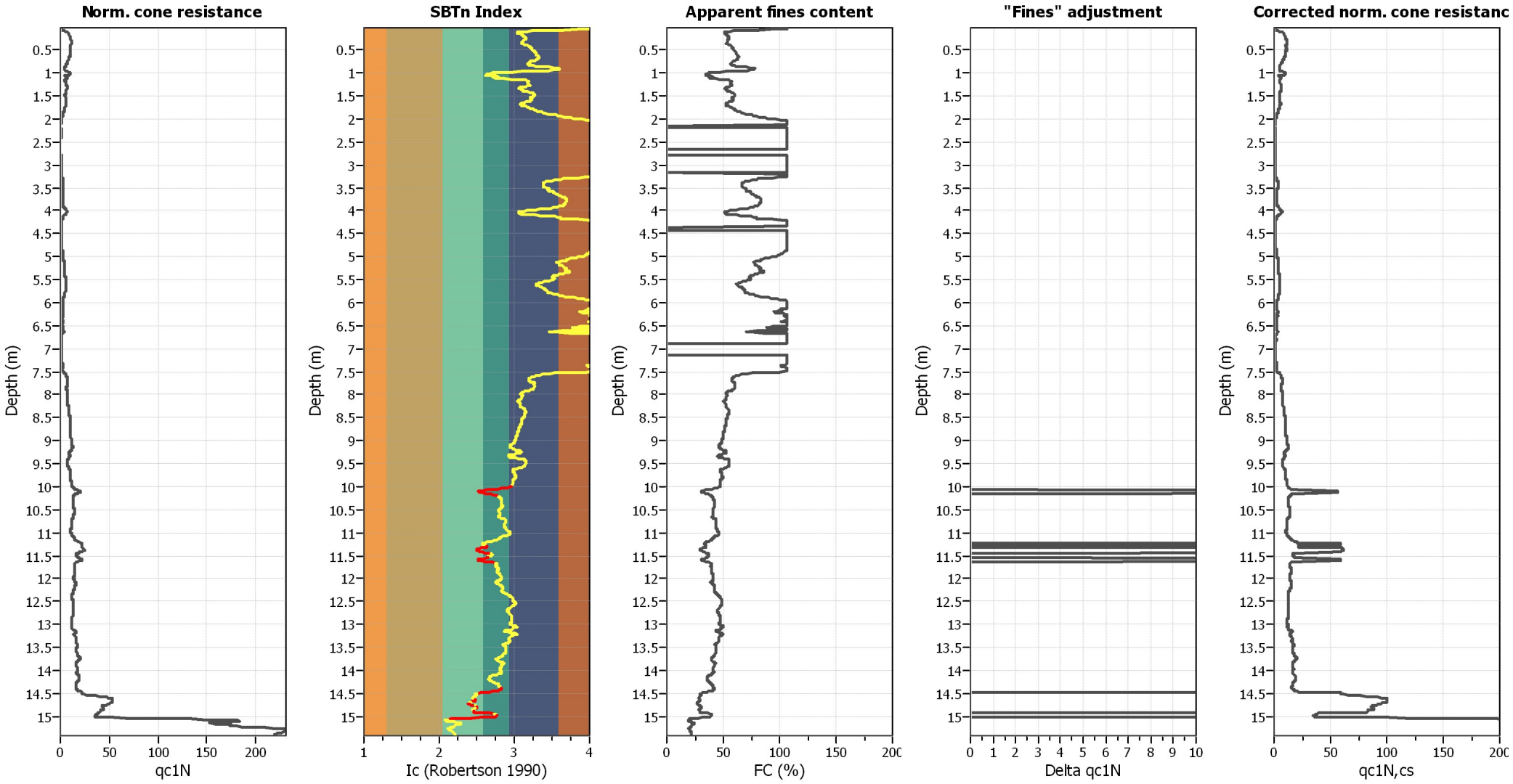
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.92 m	Fill weight:	N/A
Fines correction method:	I&B (2008)	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:	Sand & Clay
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.92 m	Fill height:	N/A	Limit depth:	20.00 m

SBTn 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

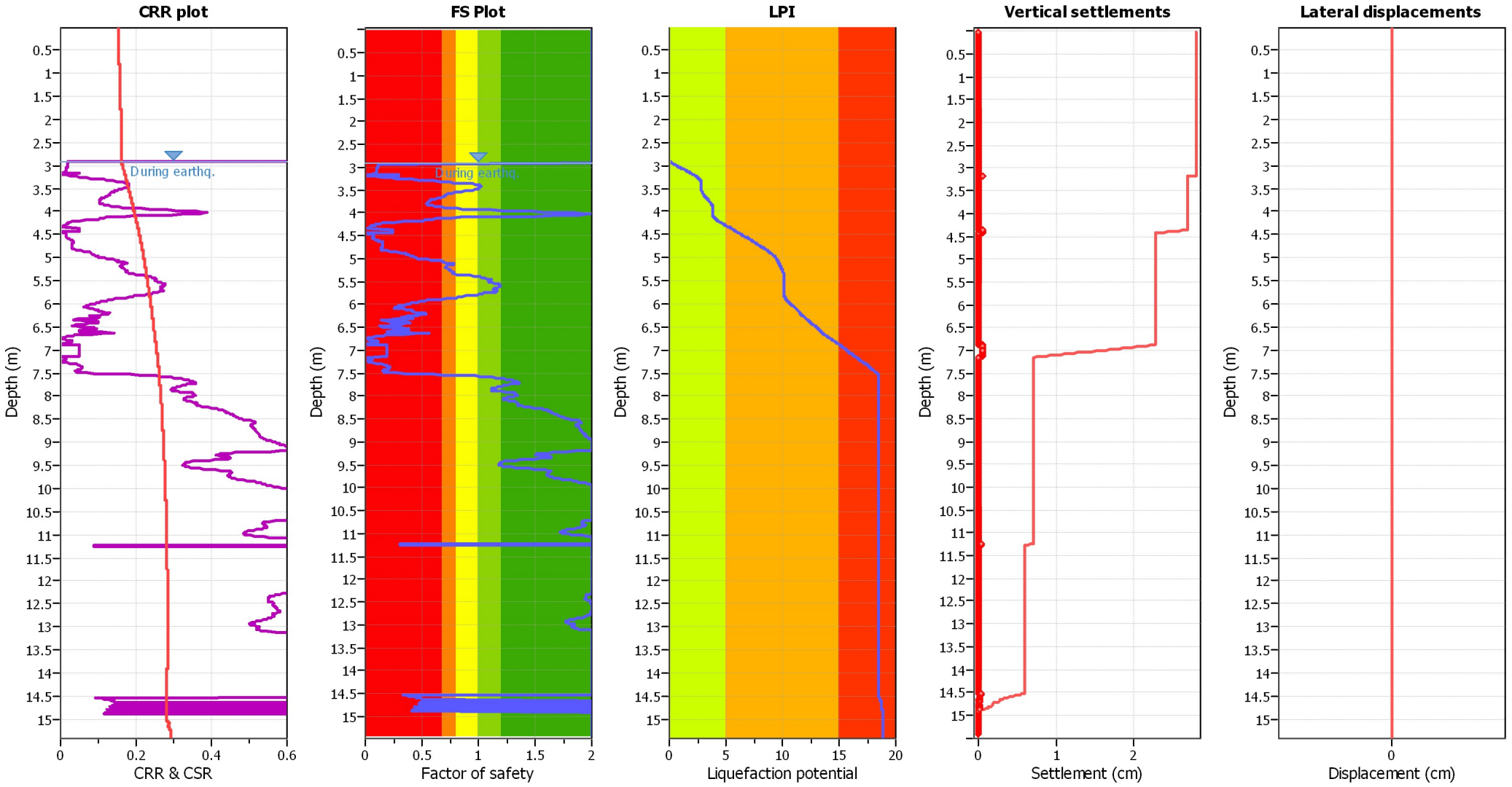
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.92 m	Fill weight:	N/A
Fines correction method:	I&B (2008)	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:	Sand & Clay
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.92 m	Fill height:	N/A	Limit depth:	20.00 m

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.92 m	Fill weight:	N/A
Fines correction method:	I&B (2008)	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:	Sand & Clay
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.92 m	Fill height:	N/A	Limit depth:	20.00 m

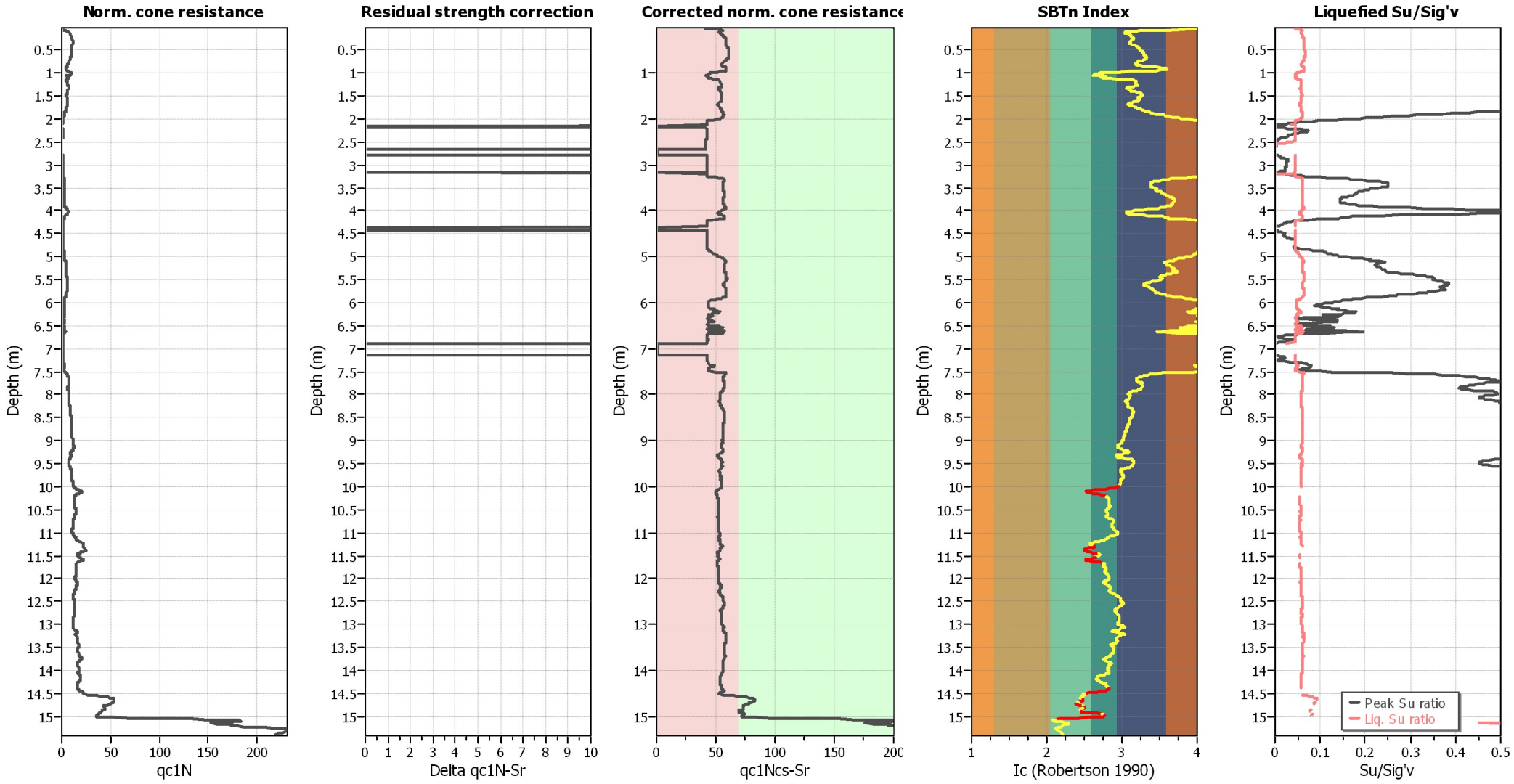
F.S. color scheme

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

LPI color scheme

- Very high risk
- High risk
- Low risk

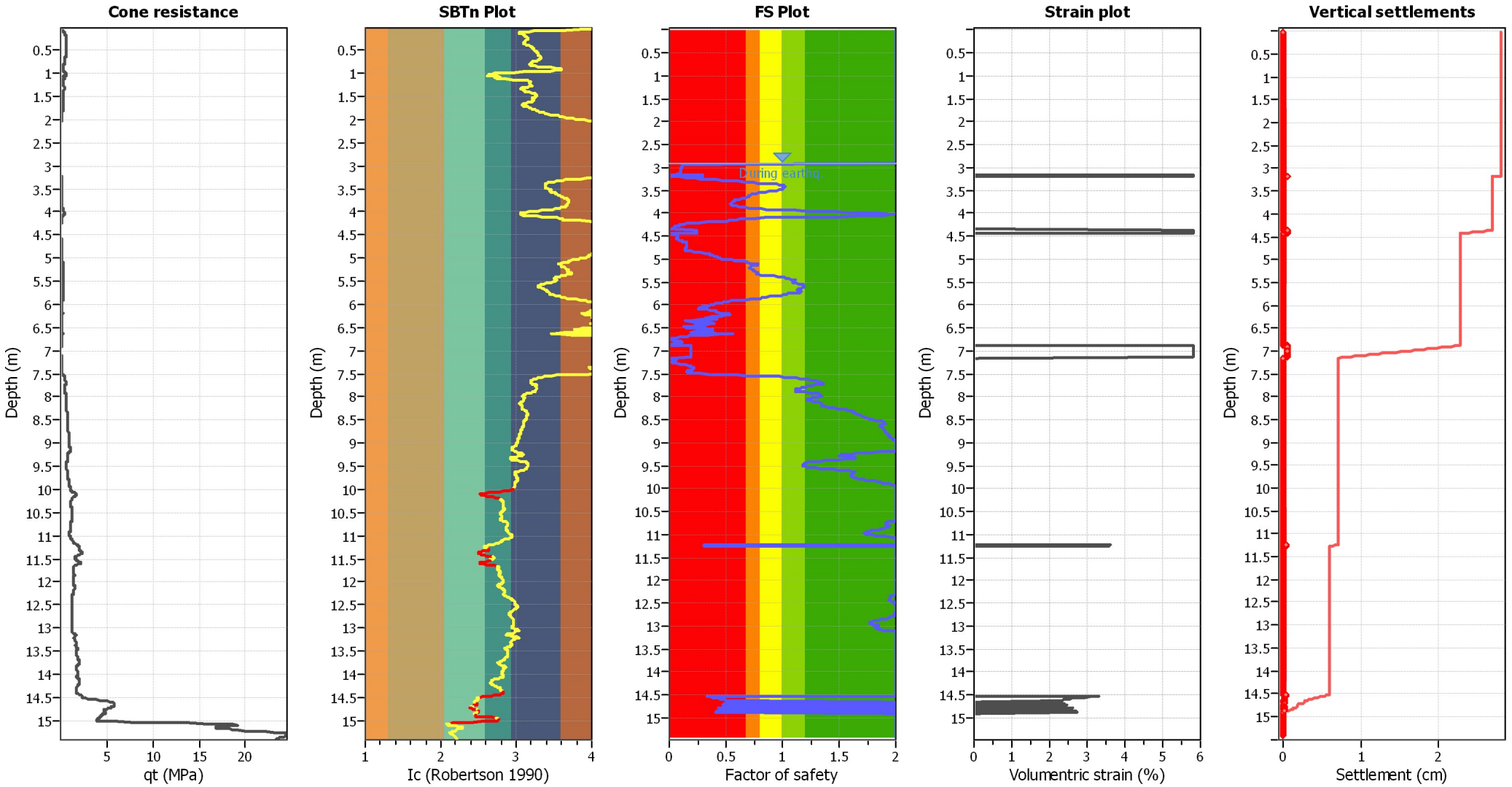
Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.92 m	Fill weight:	N/A
Fines correction method:	I&B (2008)	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:	Sand & Clay
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.92 m	Fill height:	N/A	Limit depth:	20.00 m

Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

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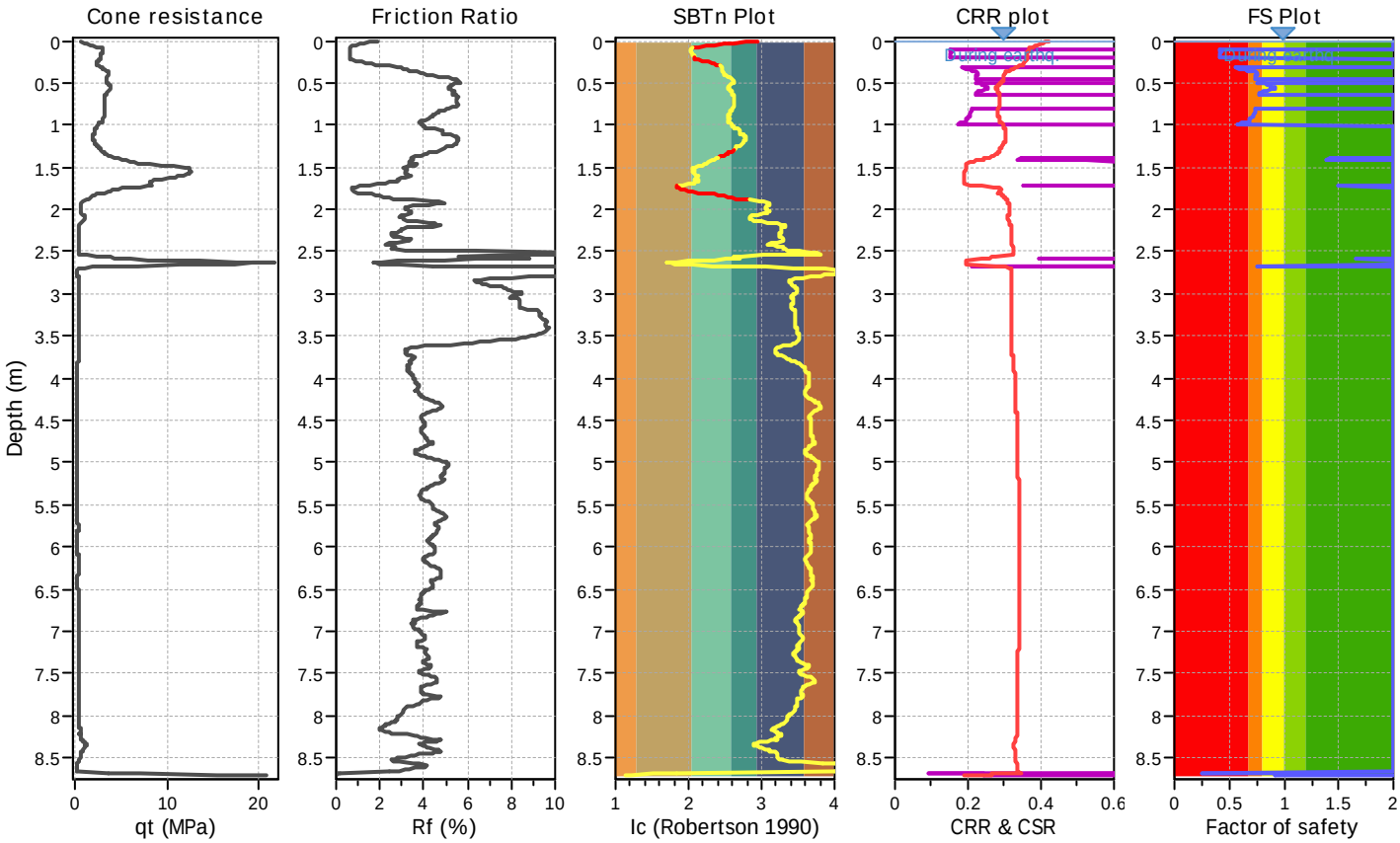
LIQUEFACTION ANALYSIS REPORT

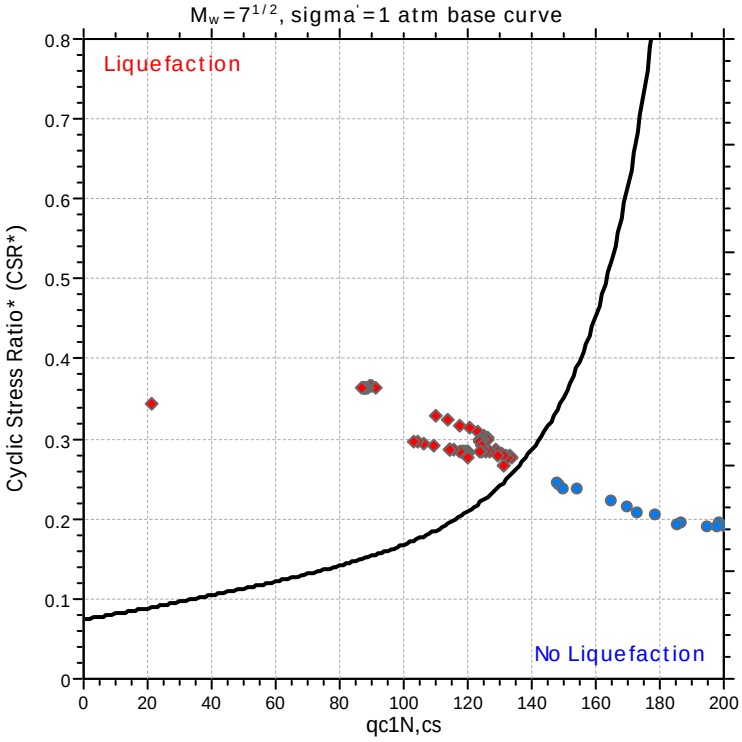
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSCIN005 – Walmsley Park

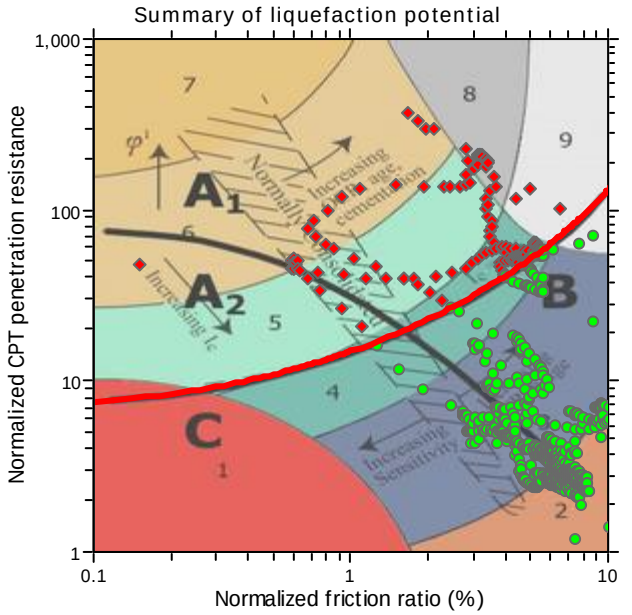
CPT file : AS4-CPT01

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.00 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

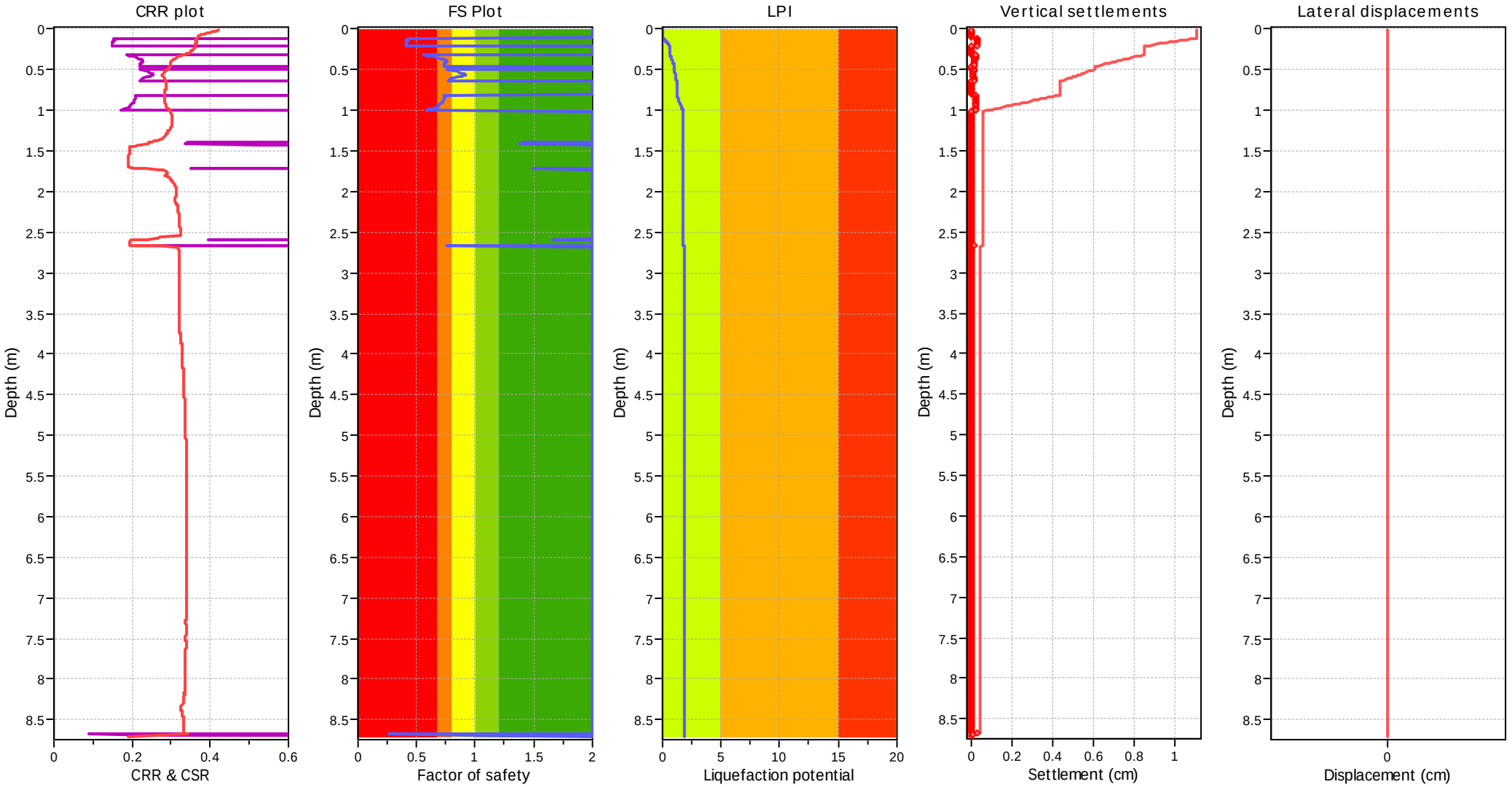






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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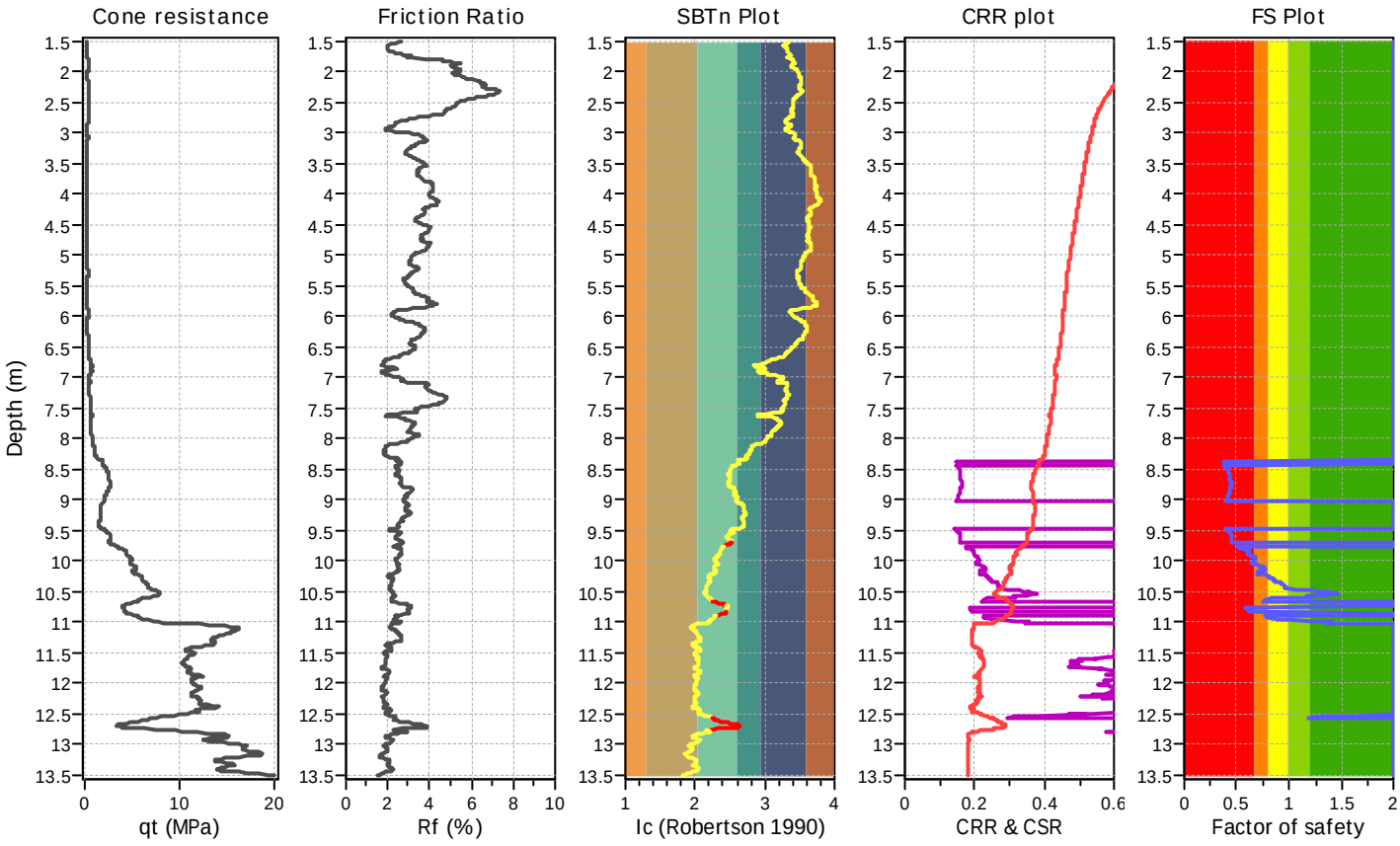
LIQUEFACTION ANALYSIS REPORT

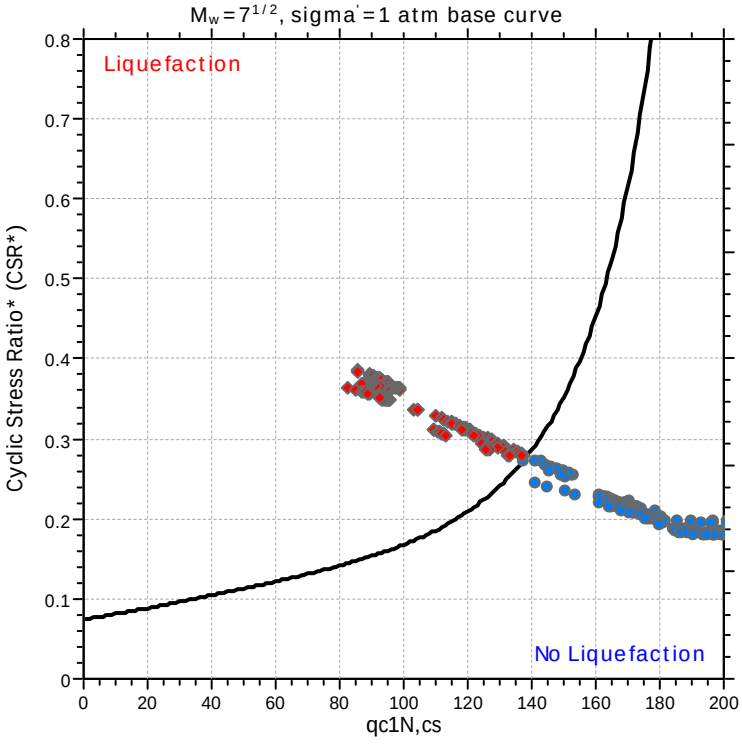
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSCIN005 – Walmsley Park

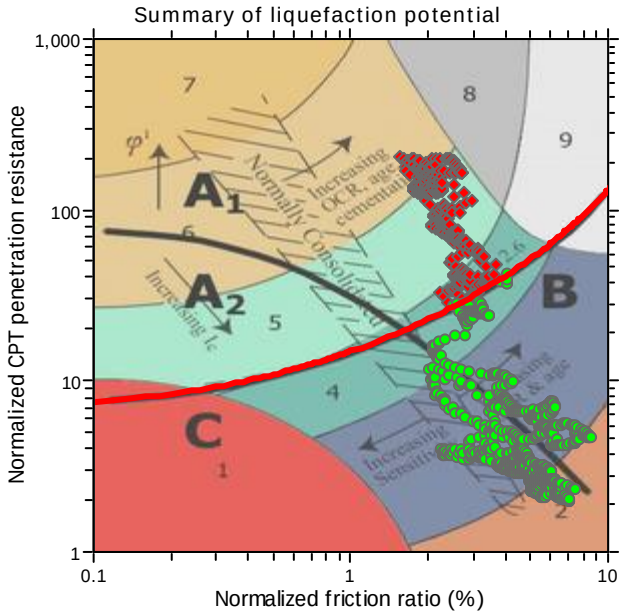
CPT file : AS4-CPT02

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	-1.28 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	-1.28 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

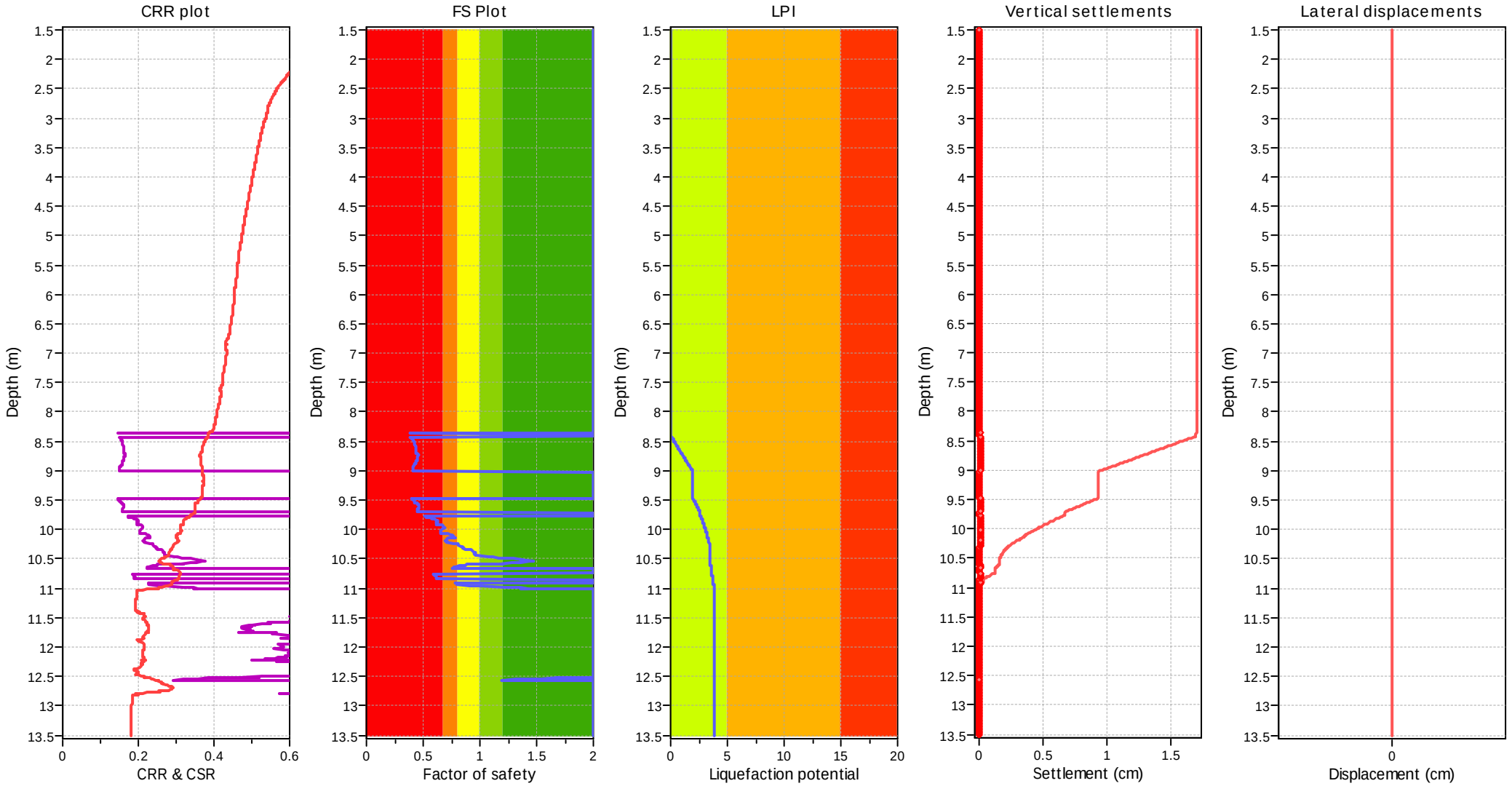






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	-1.28 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	-1.28 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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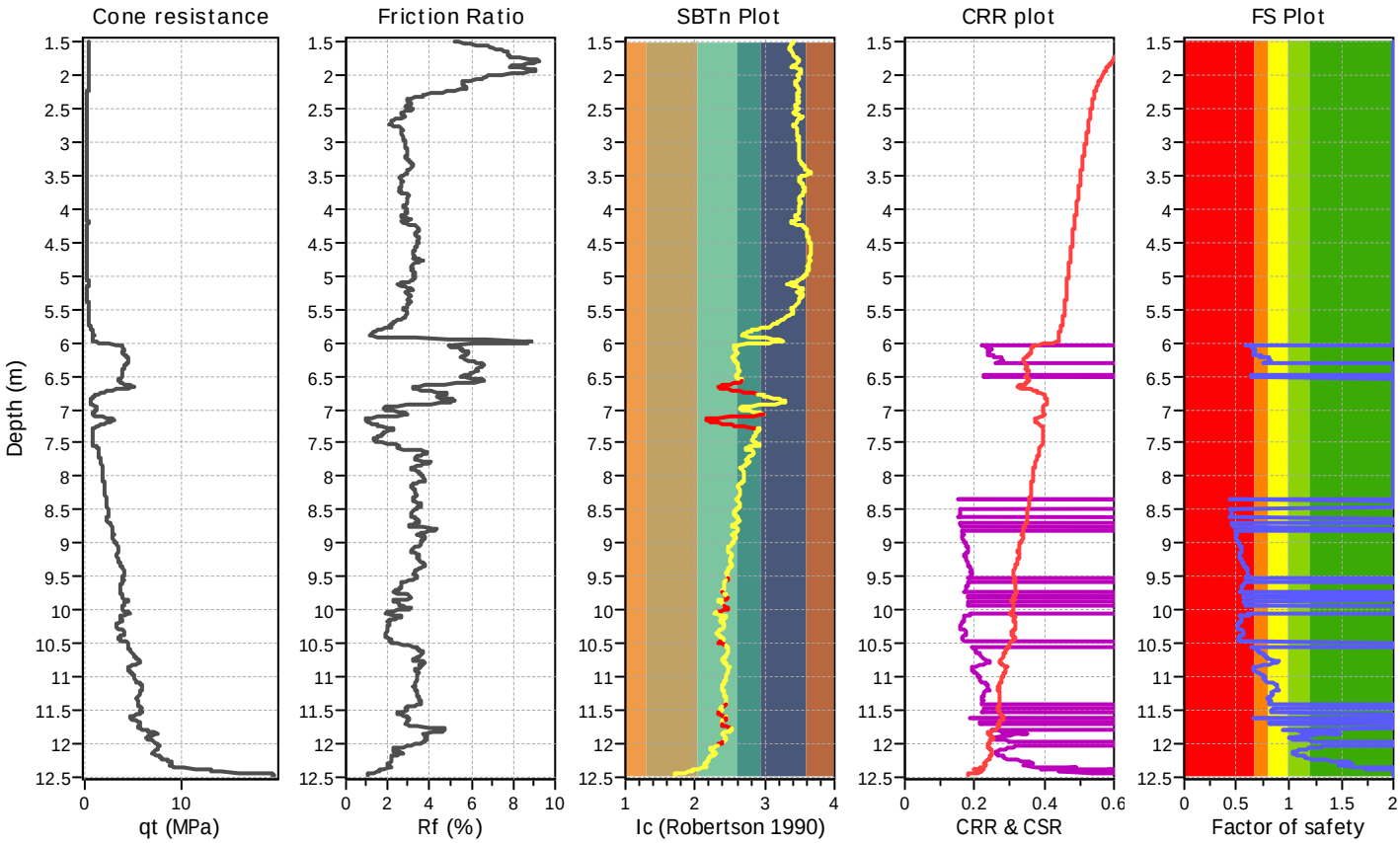
LIQUEFACTION ANALYSIS REPORT

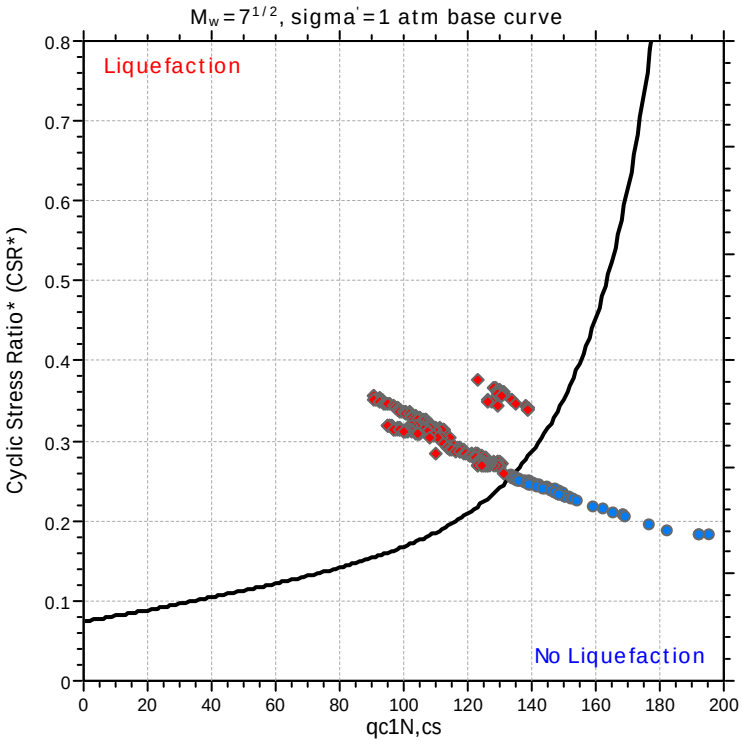
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSCIN005 – Walmsley Park

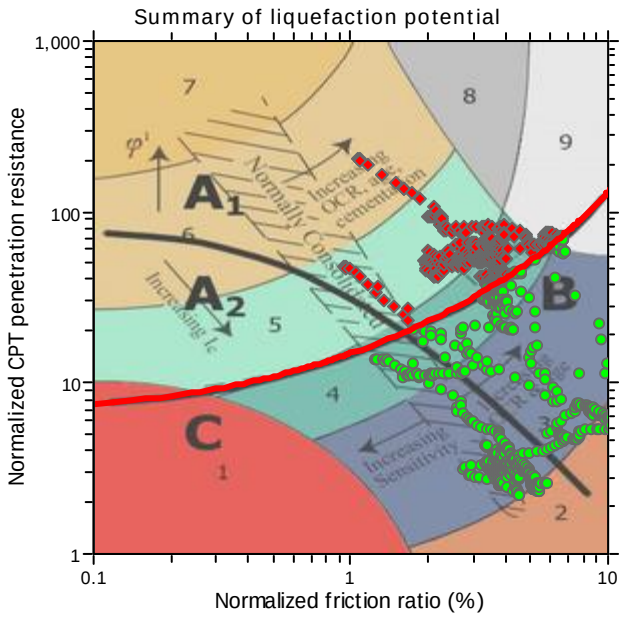
CPT file : AS4-CPT03

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	-1.58 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	-1.58 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

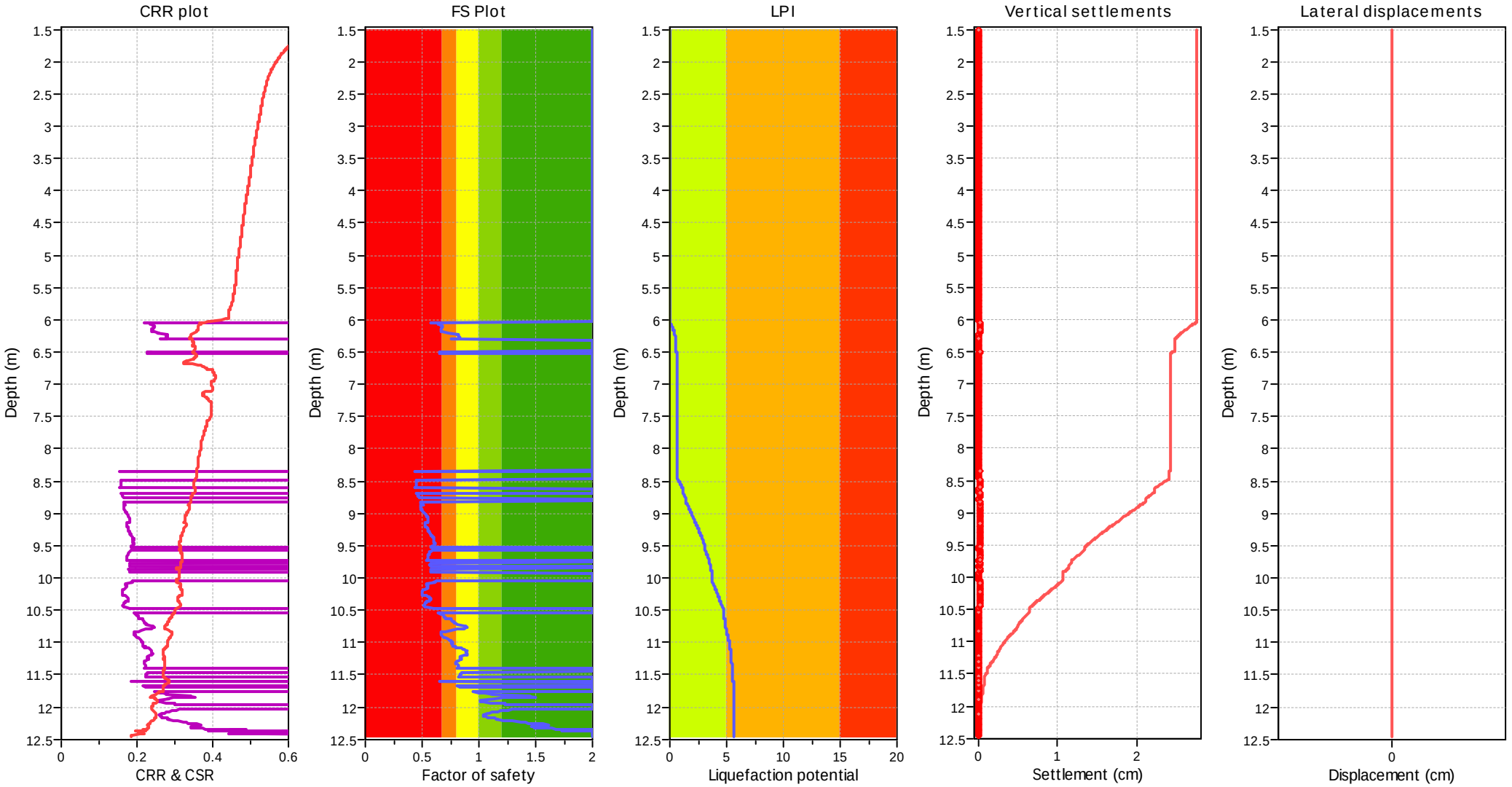






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	-1.58 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	-1.58 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
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- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
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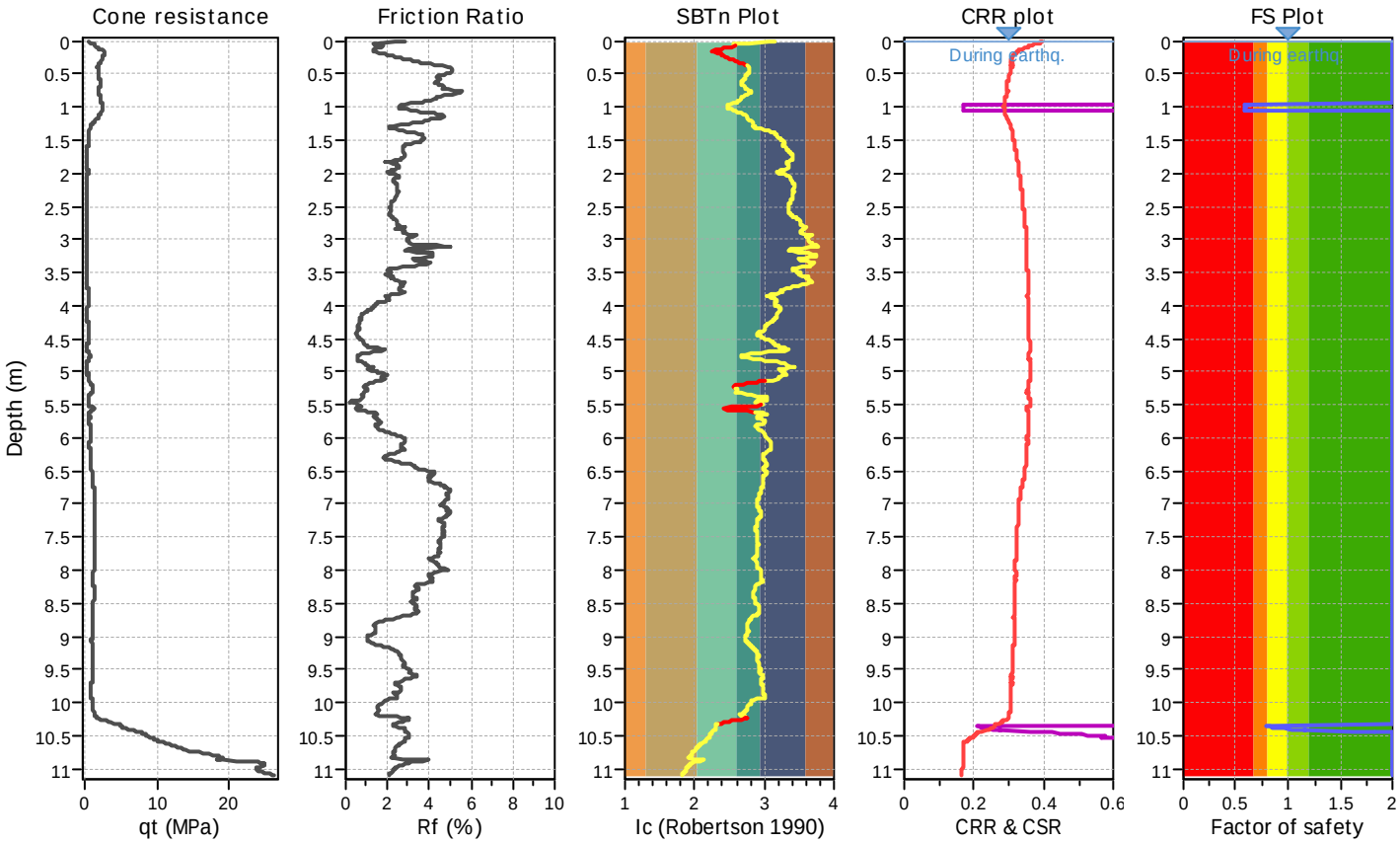
LIQUEFACTION ANALYSIS REPORT

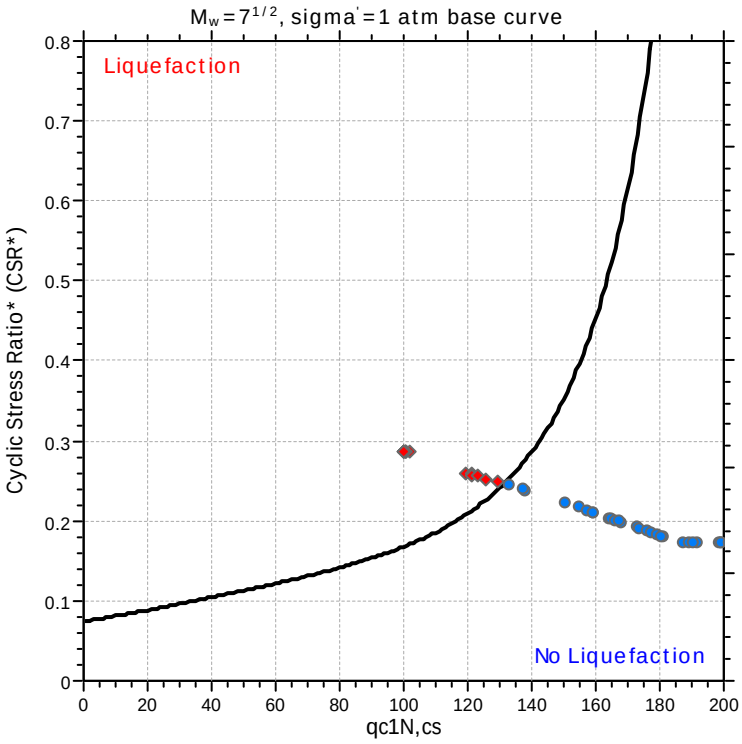
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSCIN006 û Haverstock Road

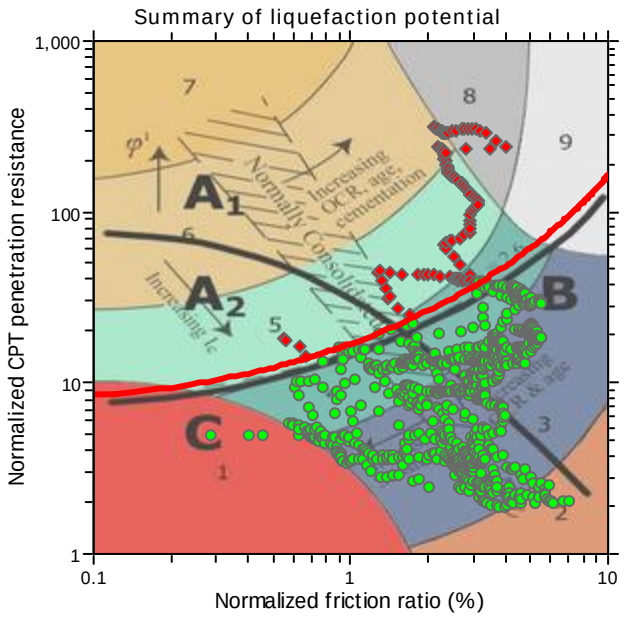
CPT file : AS3-CPT02

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.00 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.55	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.26	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
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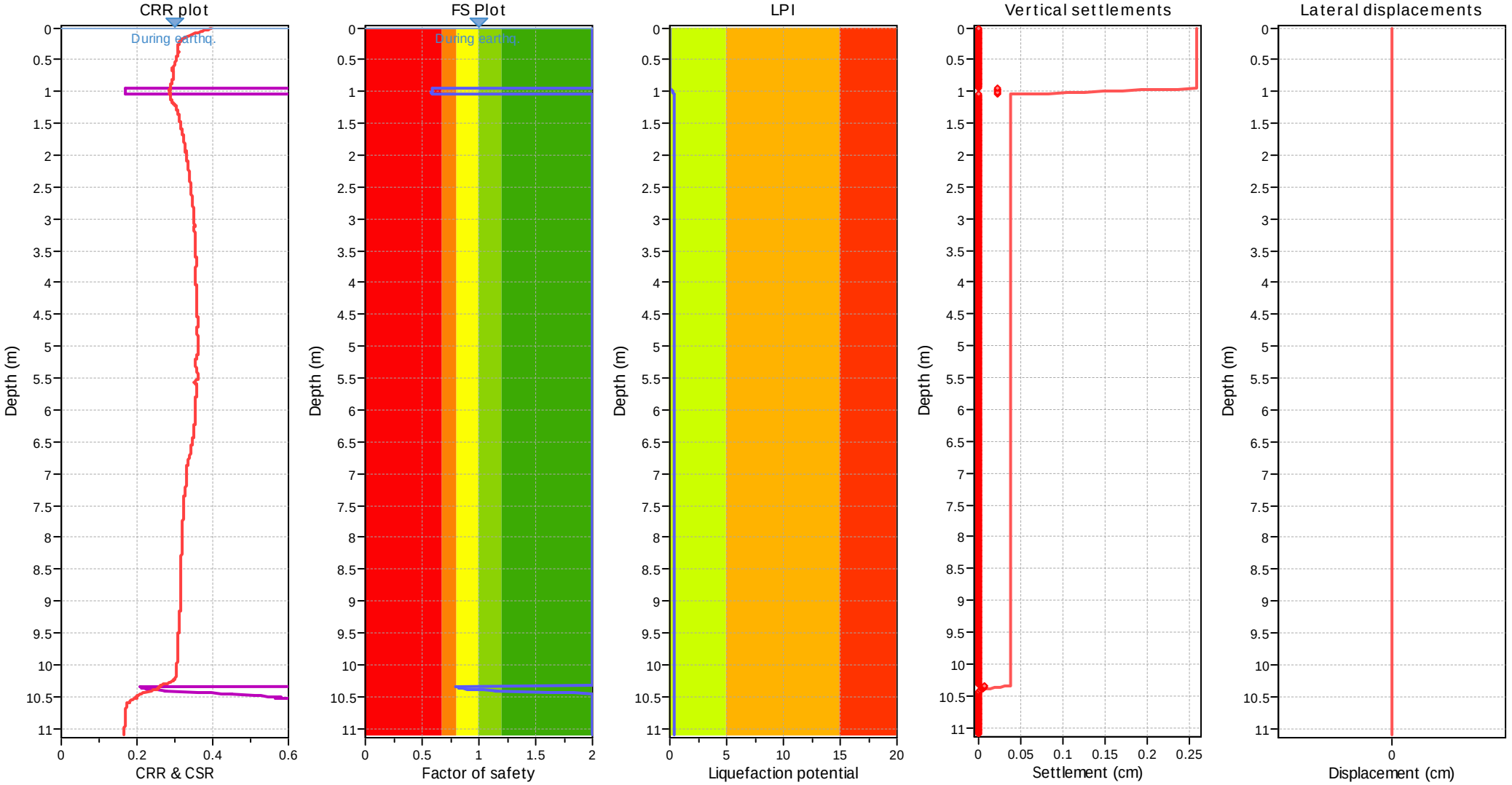
Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.55	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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

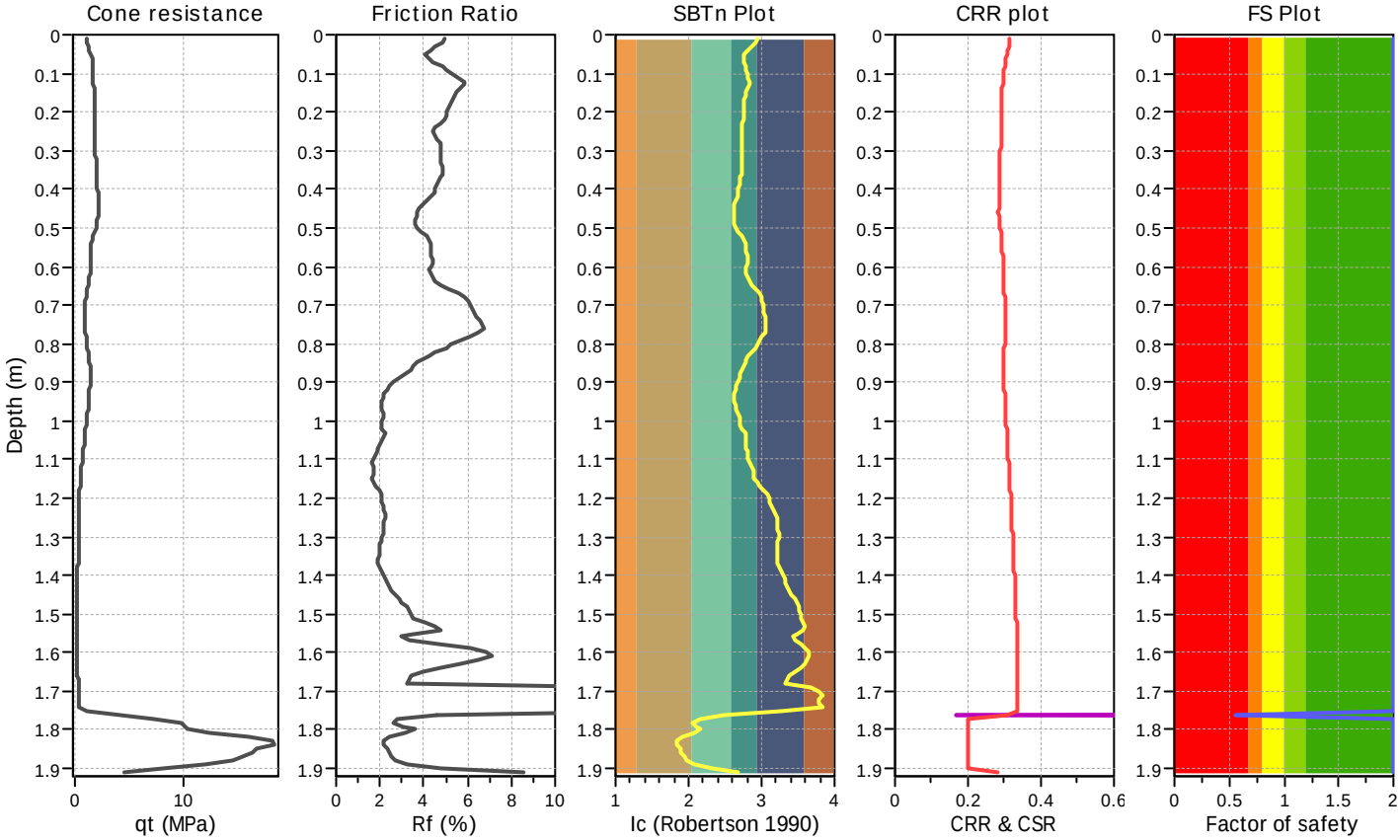
Project title : ULS 1/2500 year event (NZ1170.5)

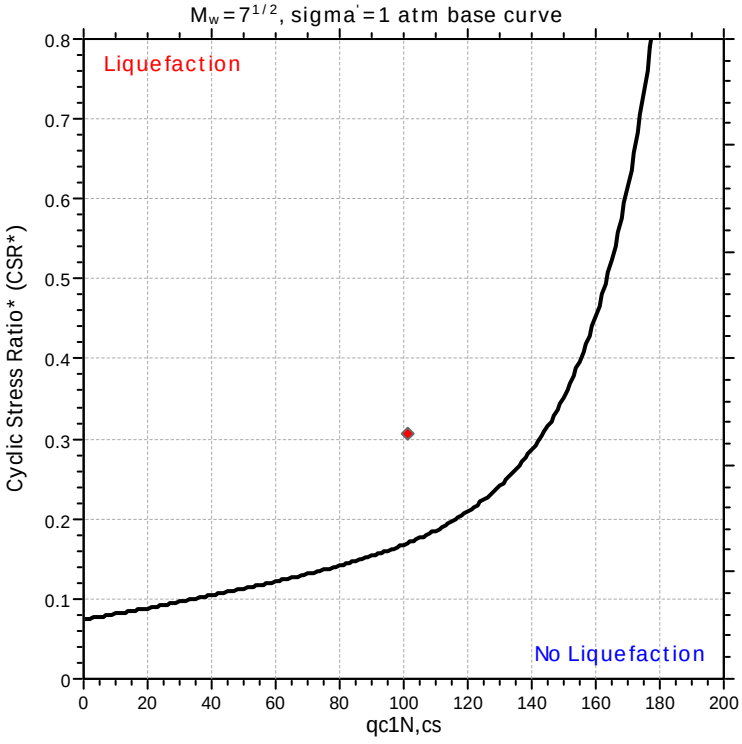
Location : DSCIN006 û Haverstock Road

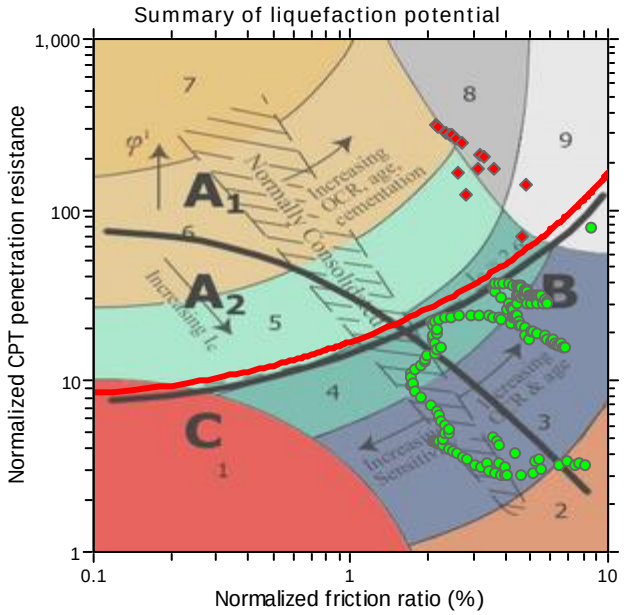
CPT file : AS3-CPT03

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.00 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.55	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

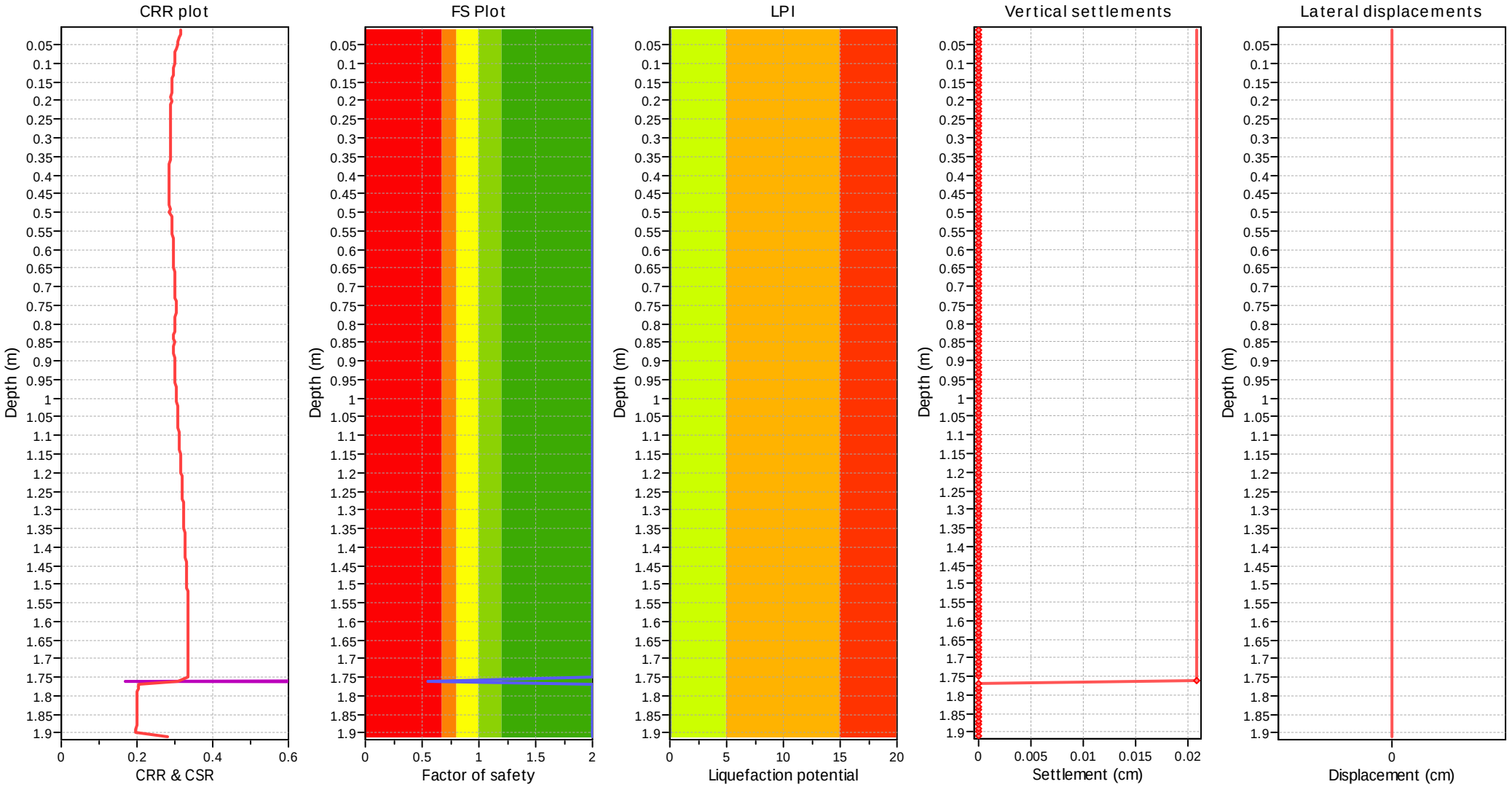






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.55	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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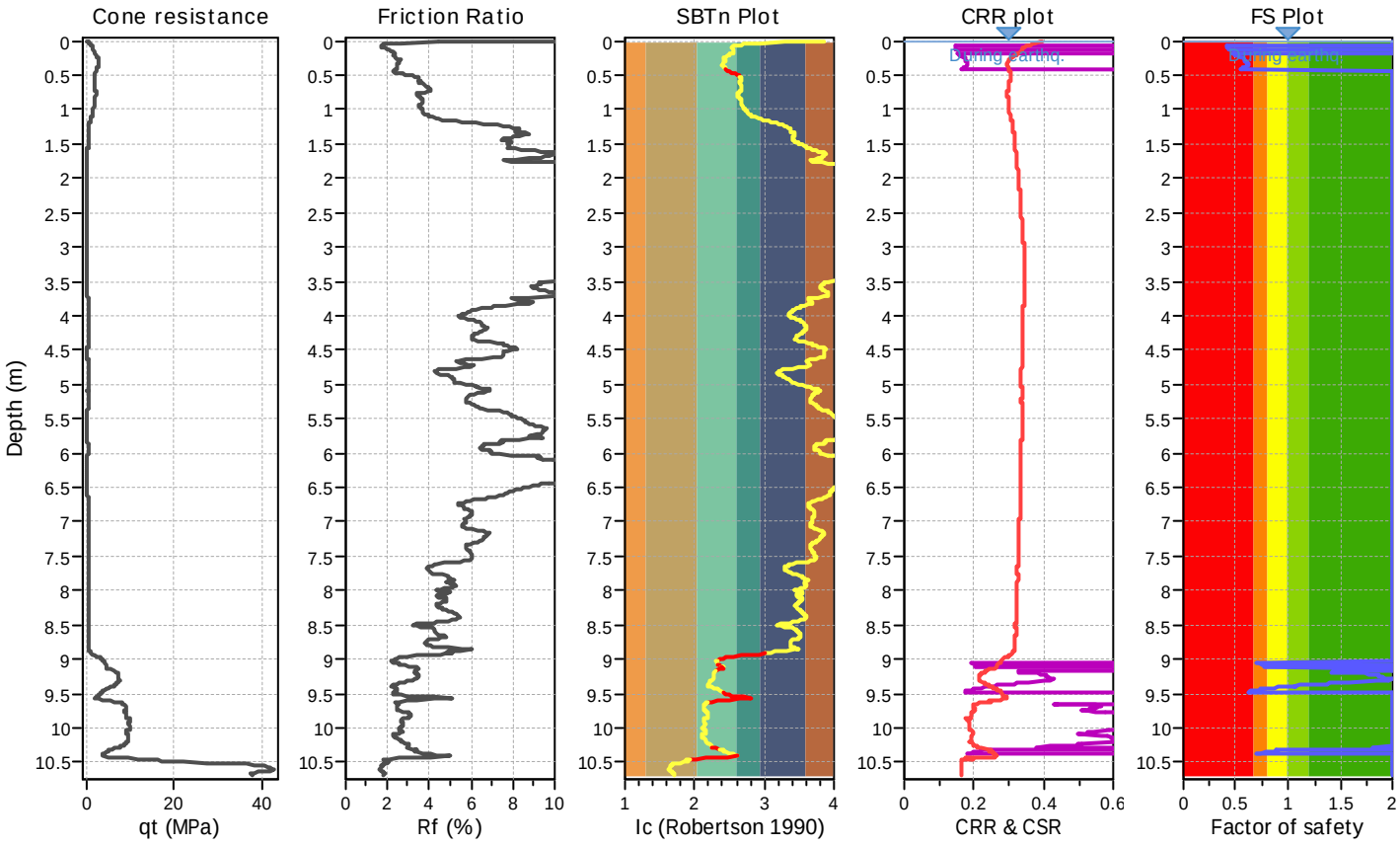
LIQUEFACTION ANALYSIS REPORT

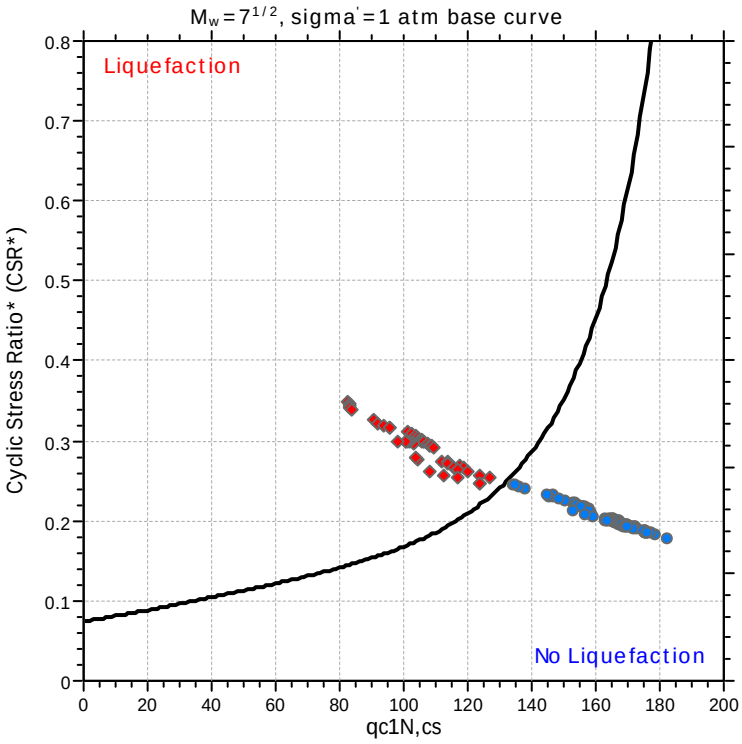
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSCIN006 û Haverstock Road

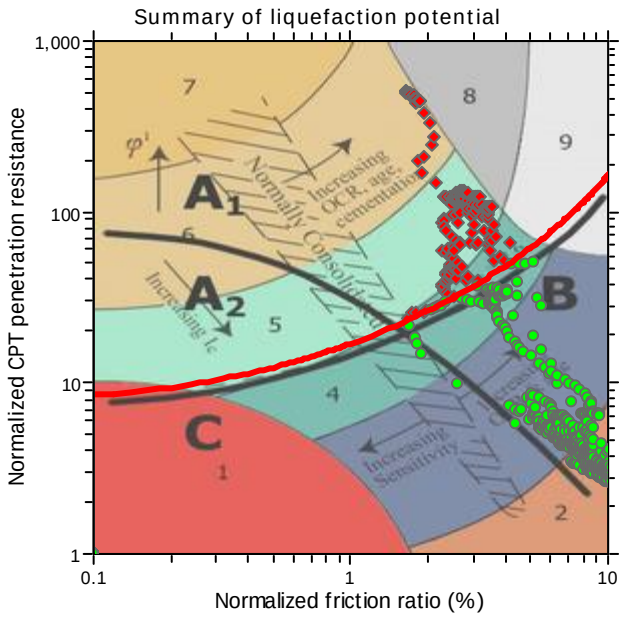
CPT file : AS3-CPT06

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.00 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.55	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

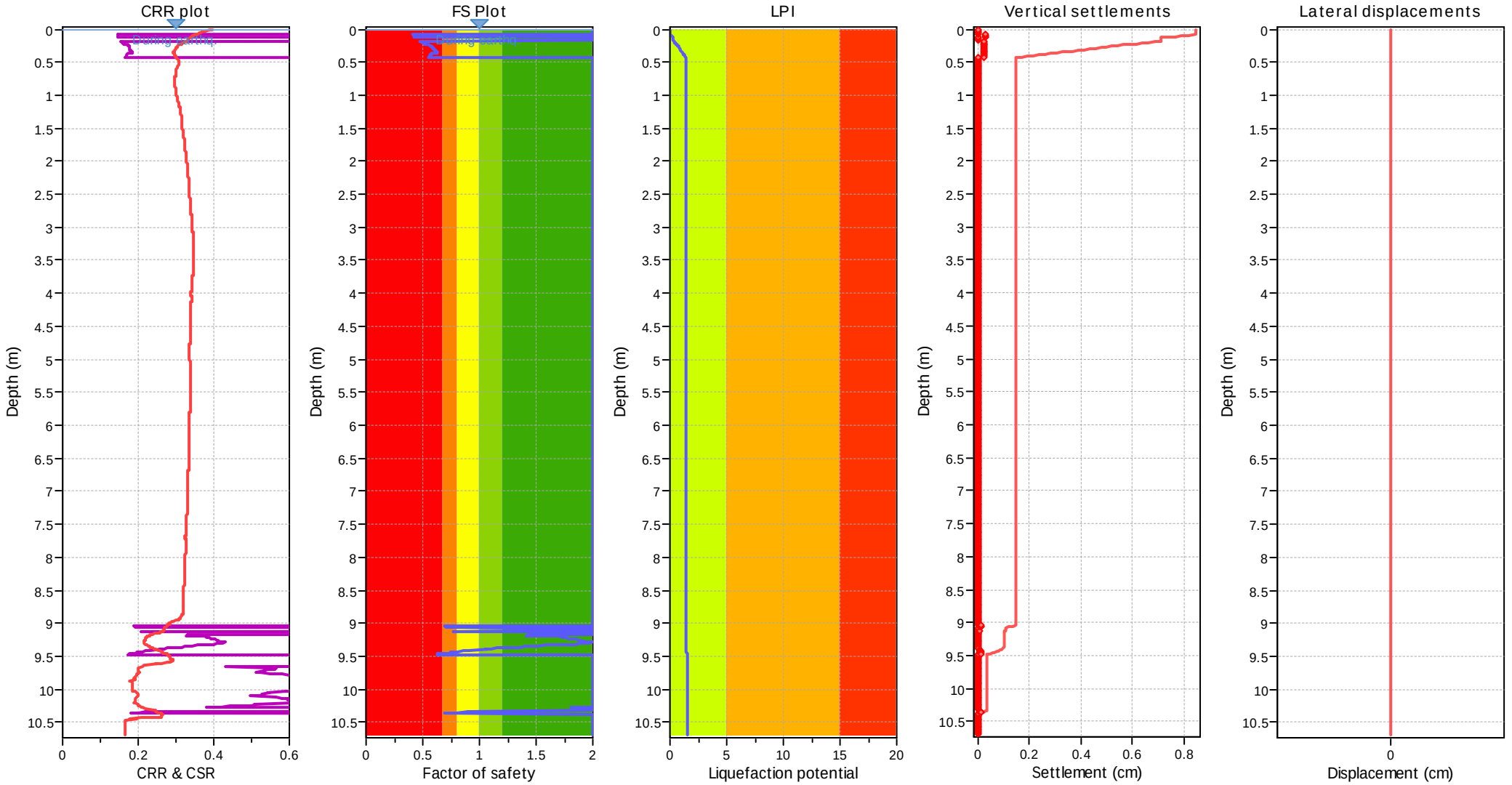






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.55	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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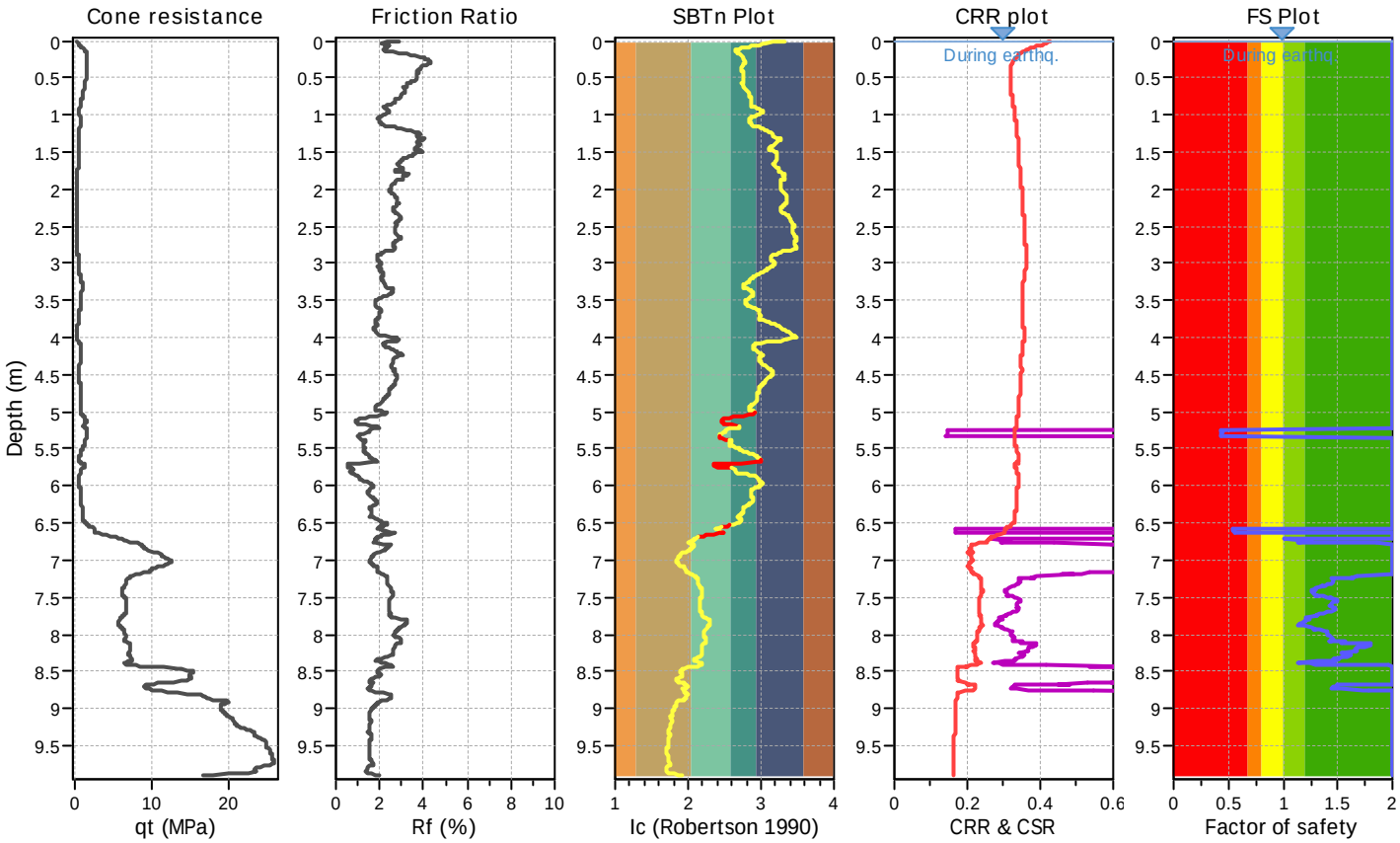
LIQUEFACTION ANALYSIS REPORT

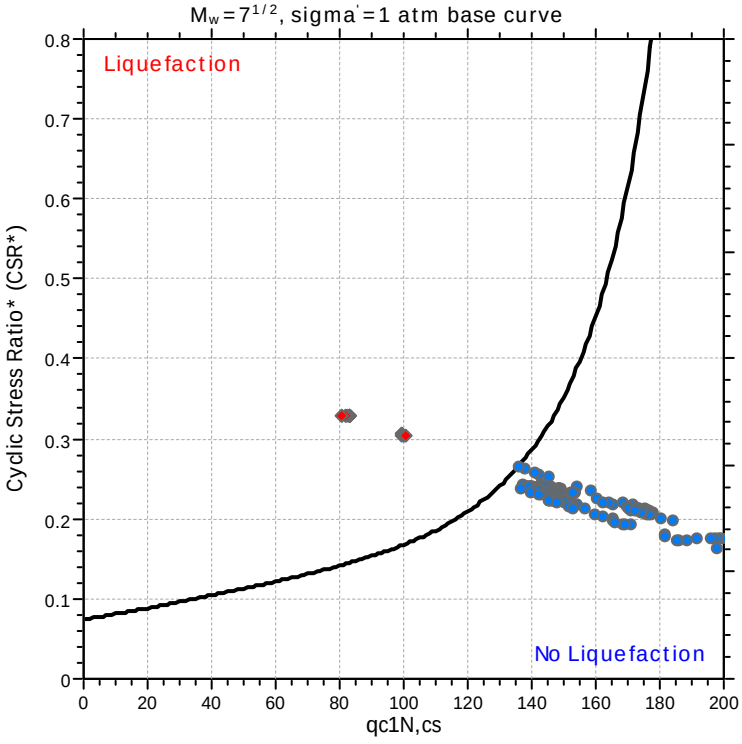
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSCIN006 û Haverstock Road

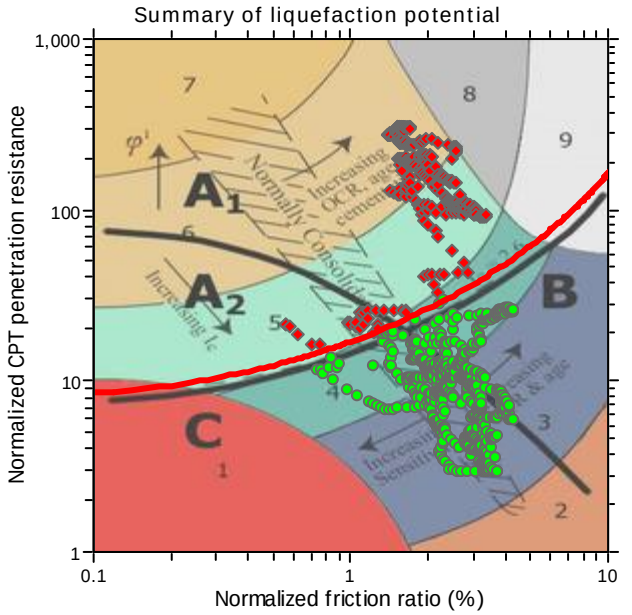
CPT file : AS3-CPT07

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.00 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.55	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

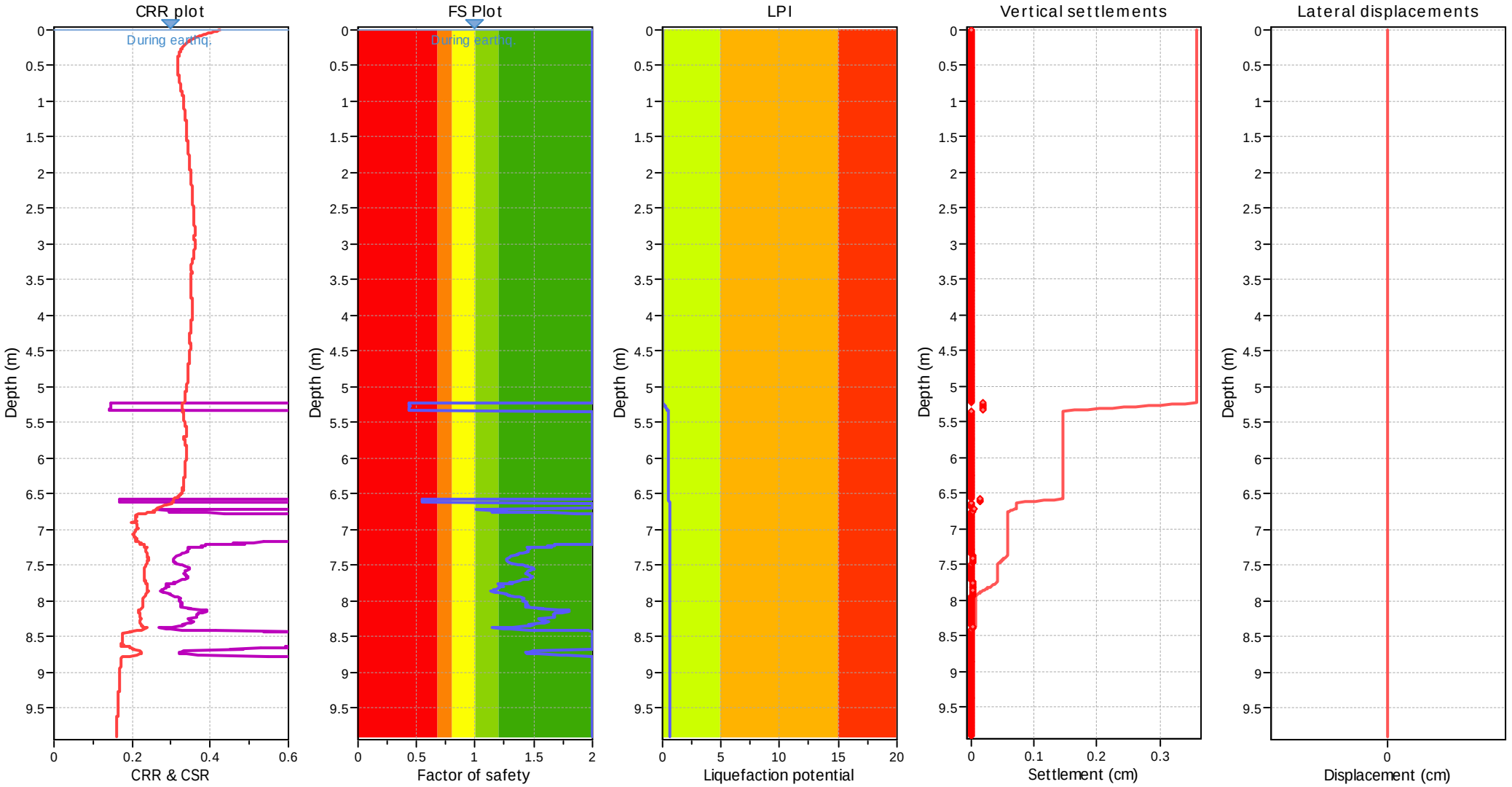






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.55	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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

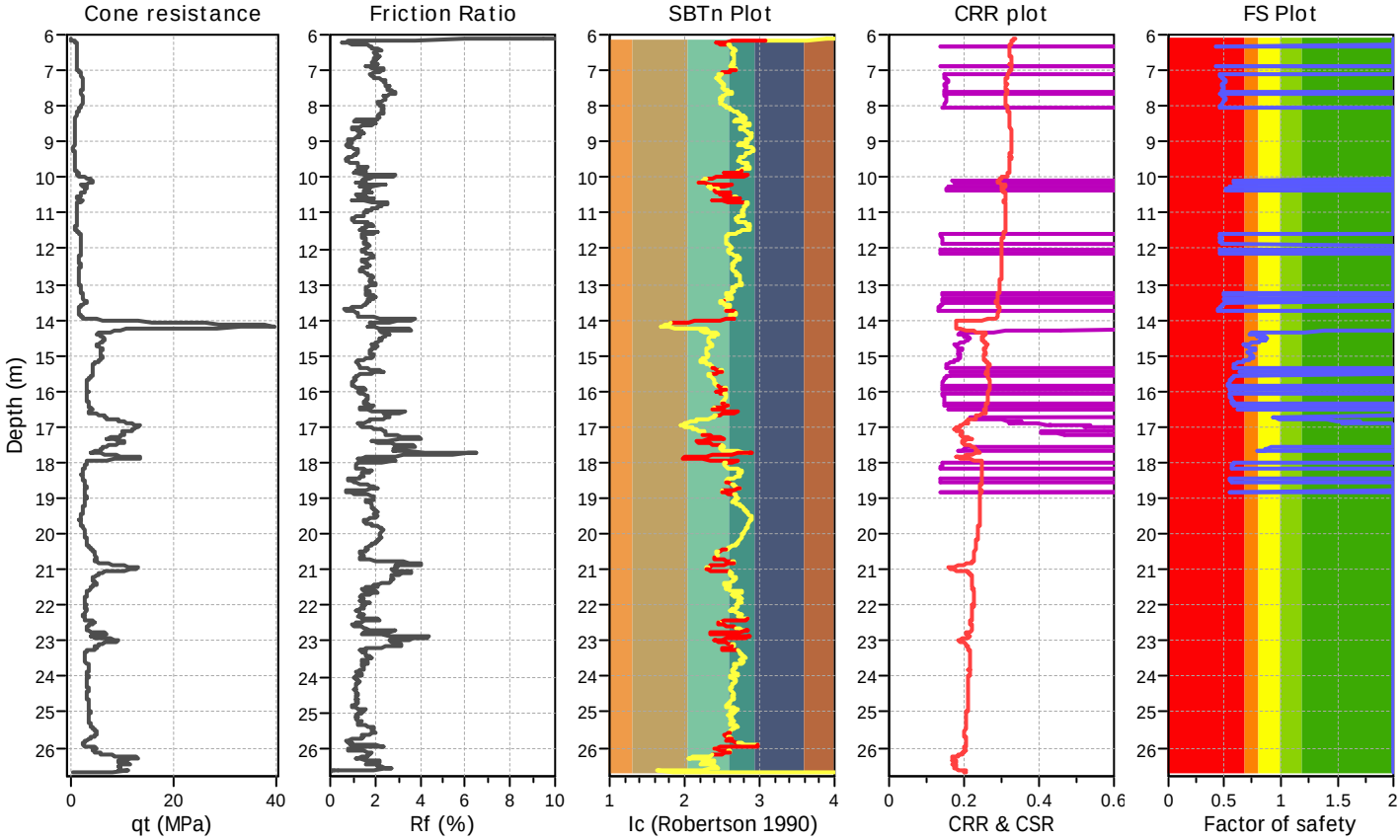
Project title : ULS 1/2500 year event (NZ1170.5)

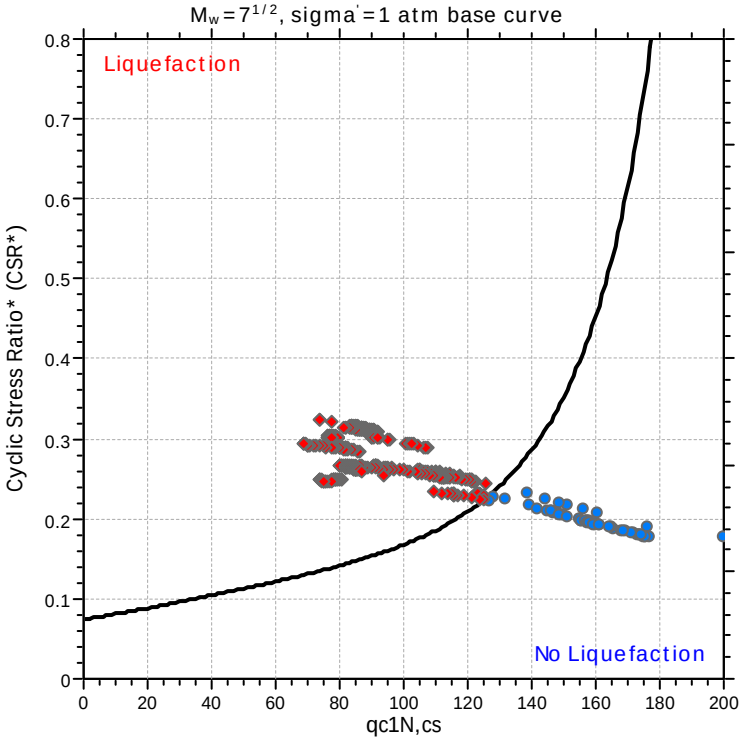
Location : DSCIN008 – Mt Albert War Memorial Reserve

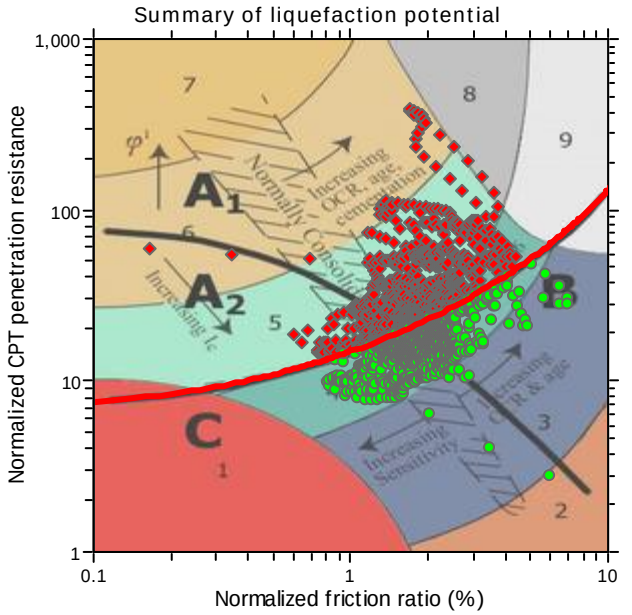
CPT file : AS1-CPT220

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

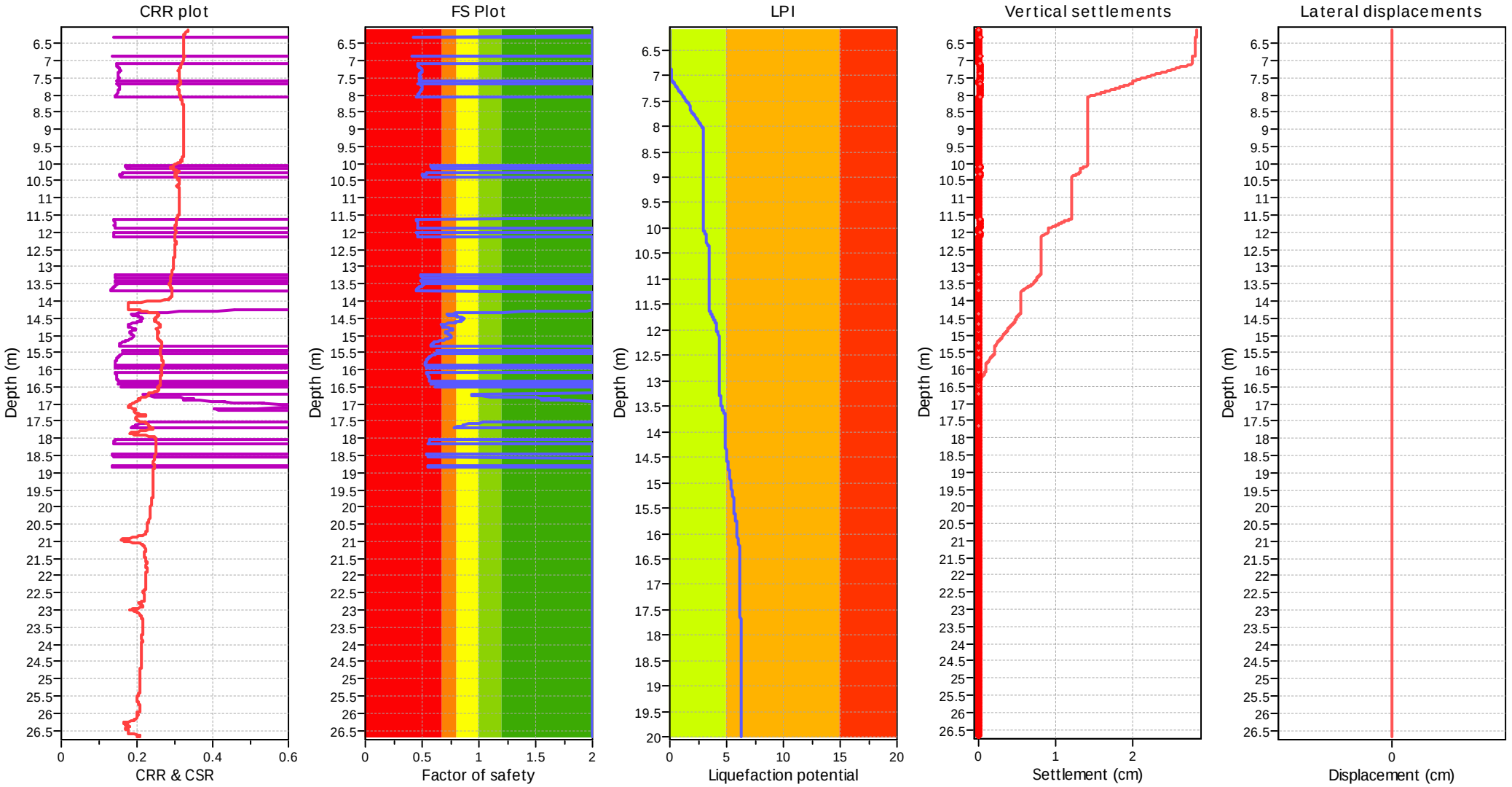






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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

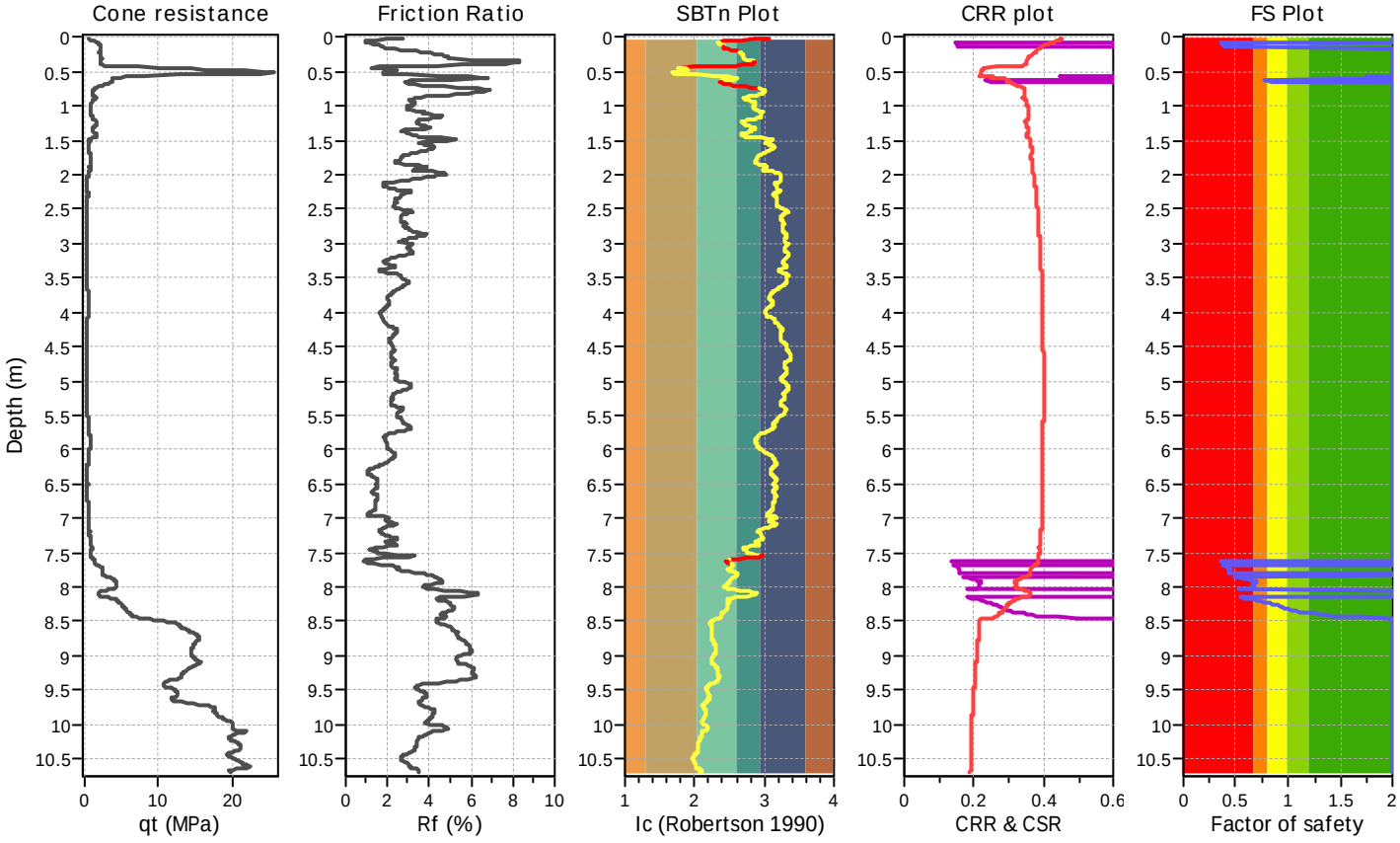
Project title : ULS 1/2500 year event (NZ1170.5)

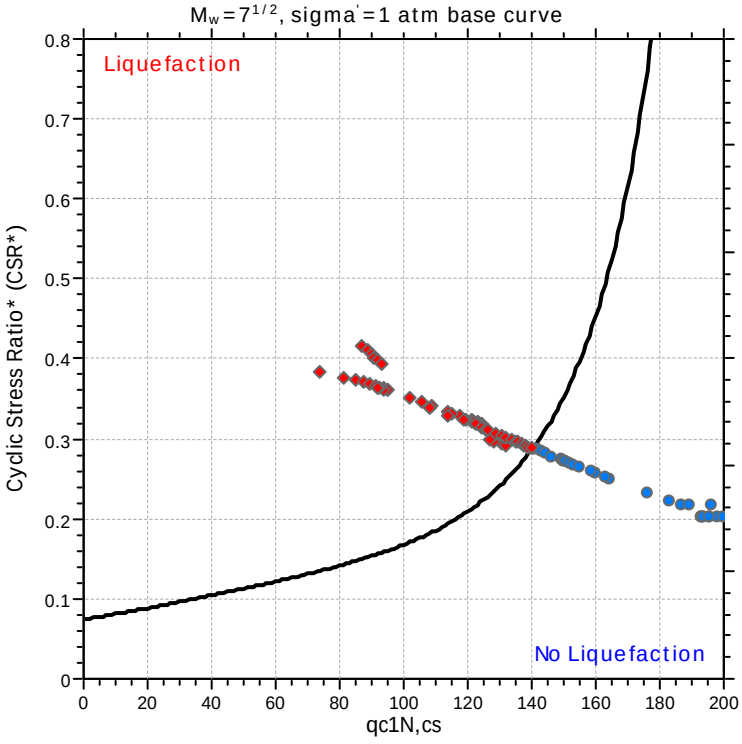
Location : DSCIN009 – Western Springs Shaft

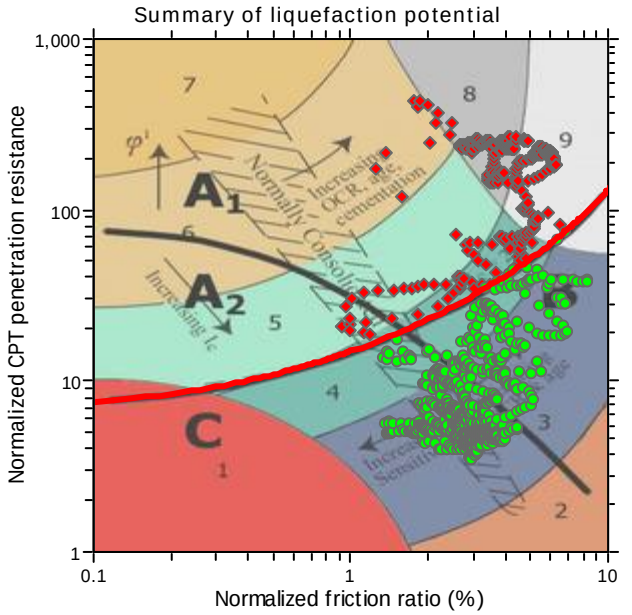
CPT file : WS1-CPT03

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.00 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

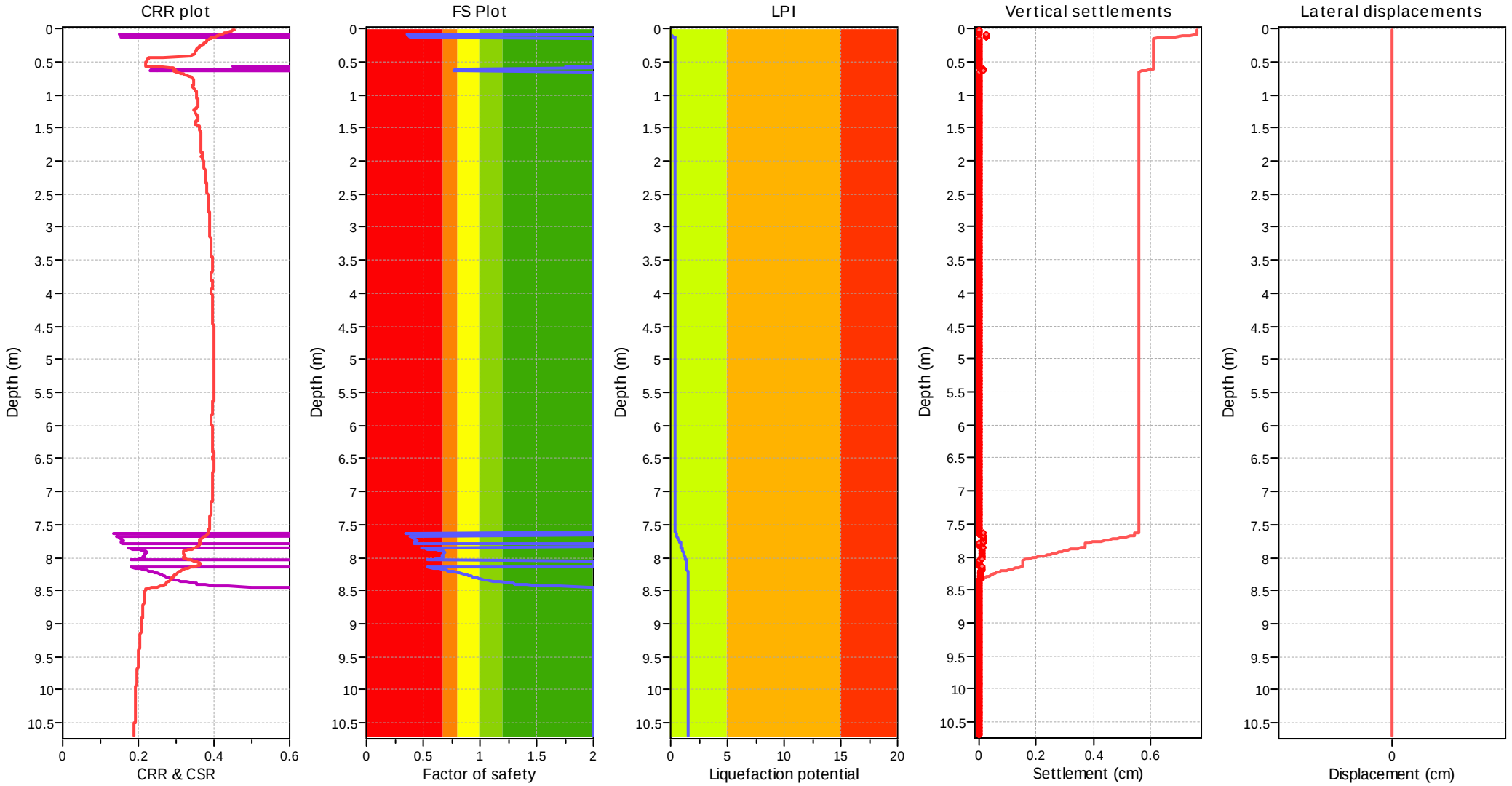






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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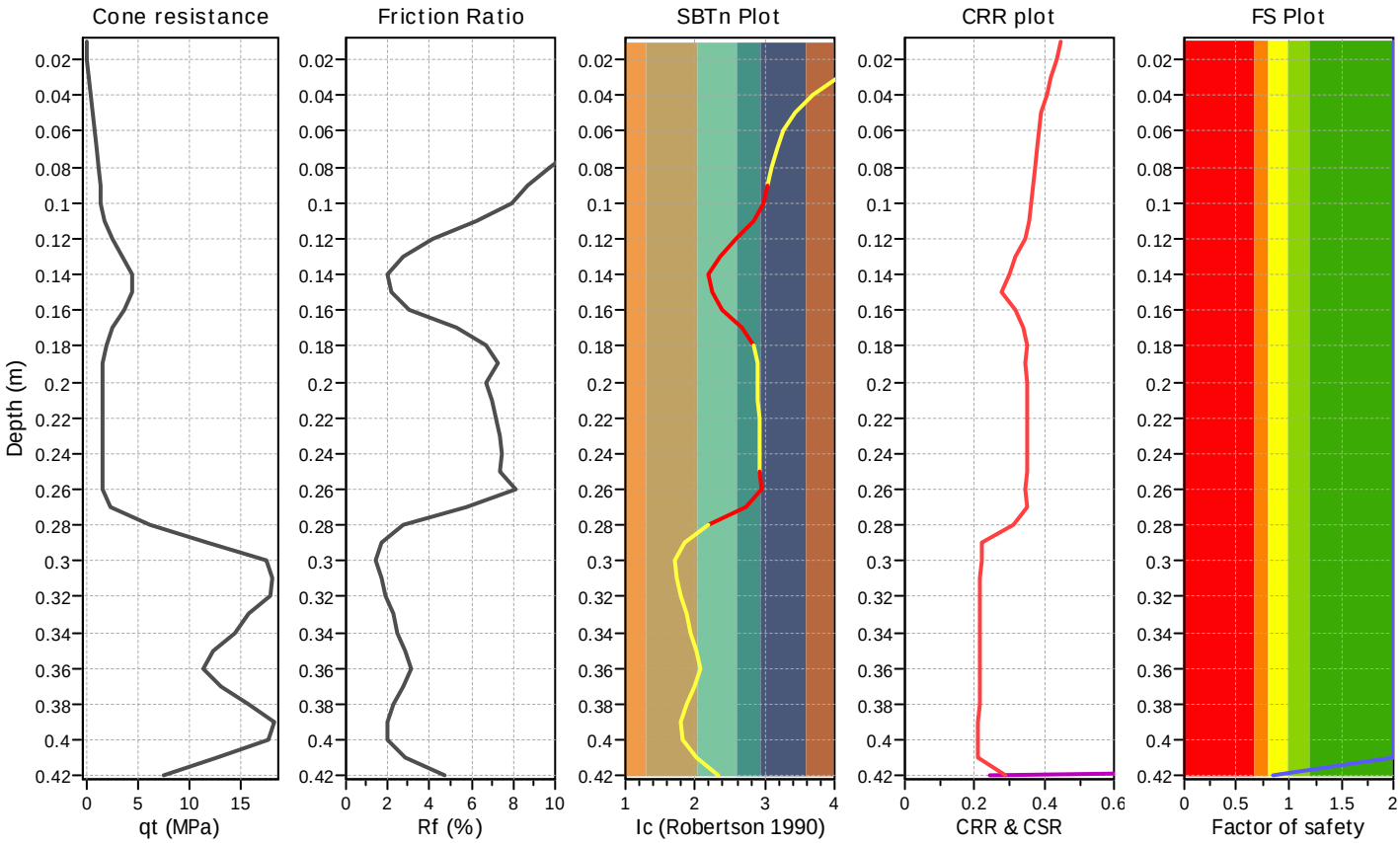
LIQUEFACTION ANALYSIS REPORT

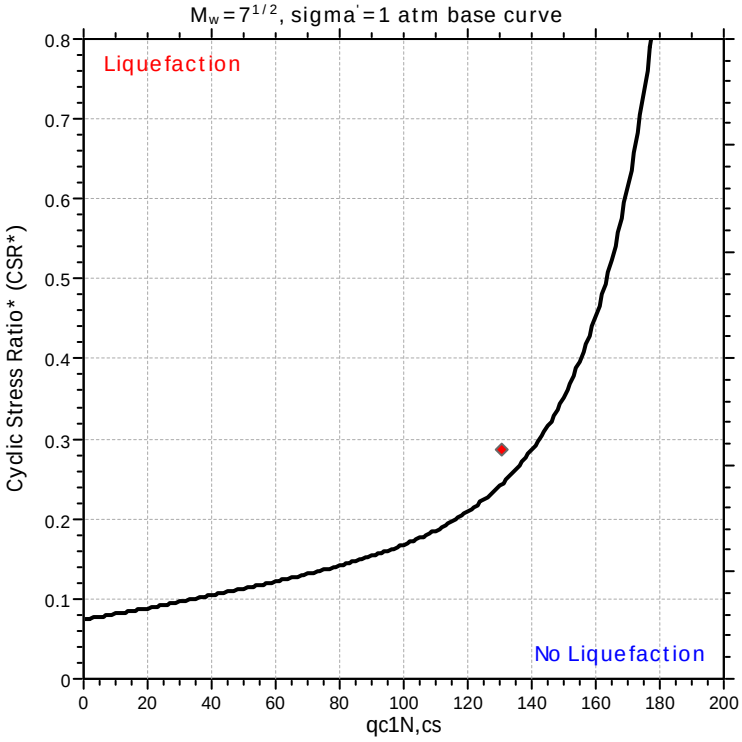
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSCIN009 – Western Springs Shaft

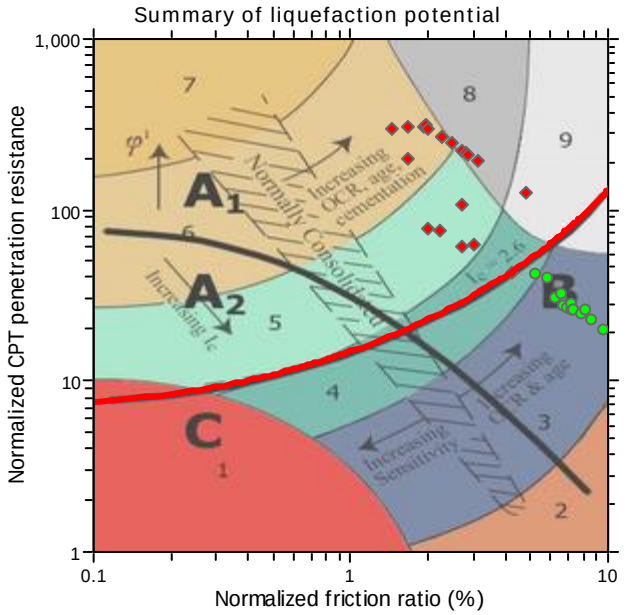
CPT file : WS1-CPT04A

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.00 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

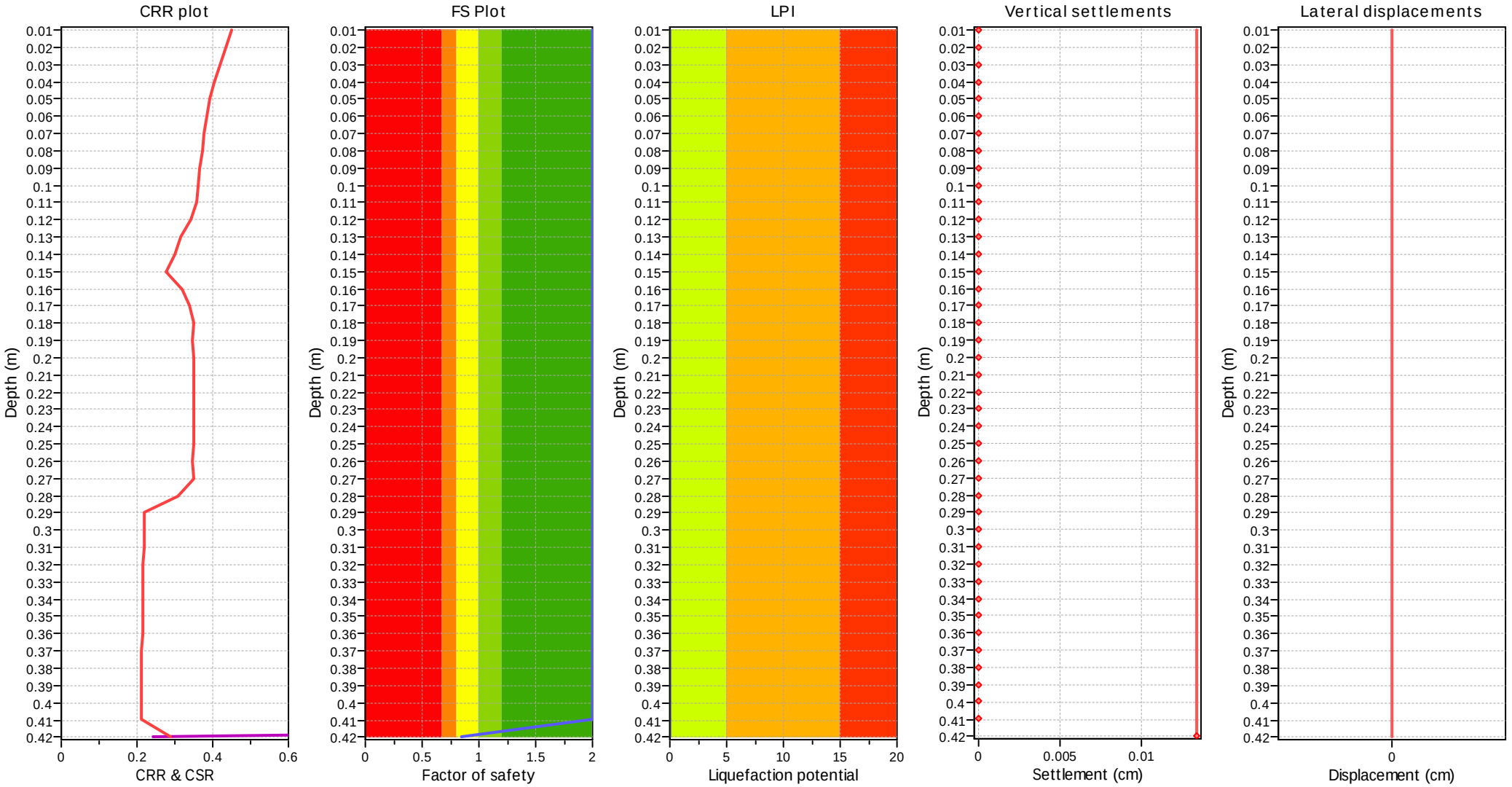






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme
- Almost certain it will liquefy
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- Liquefaction and no liq. 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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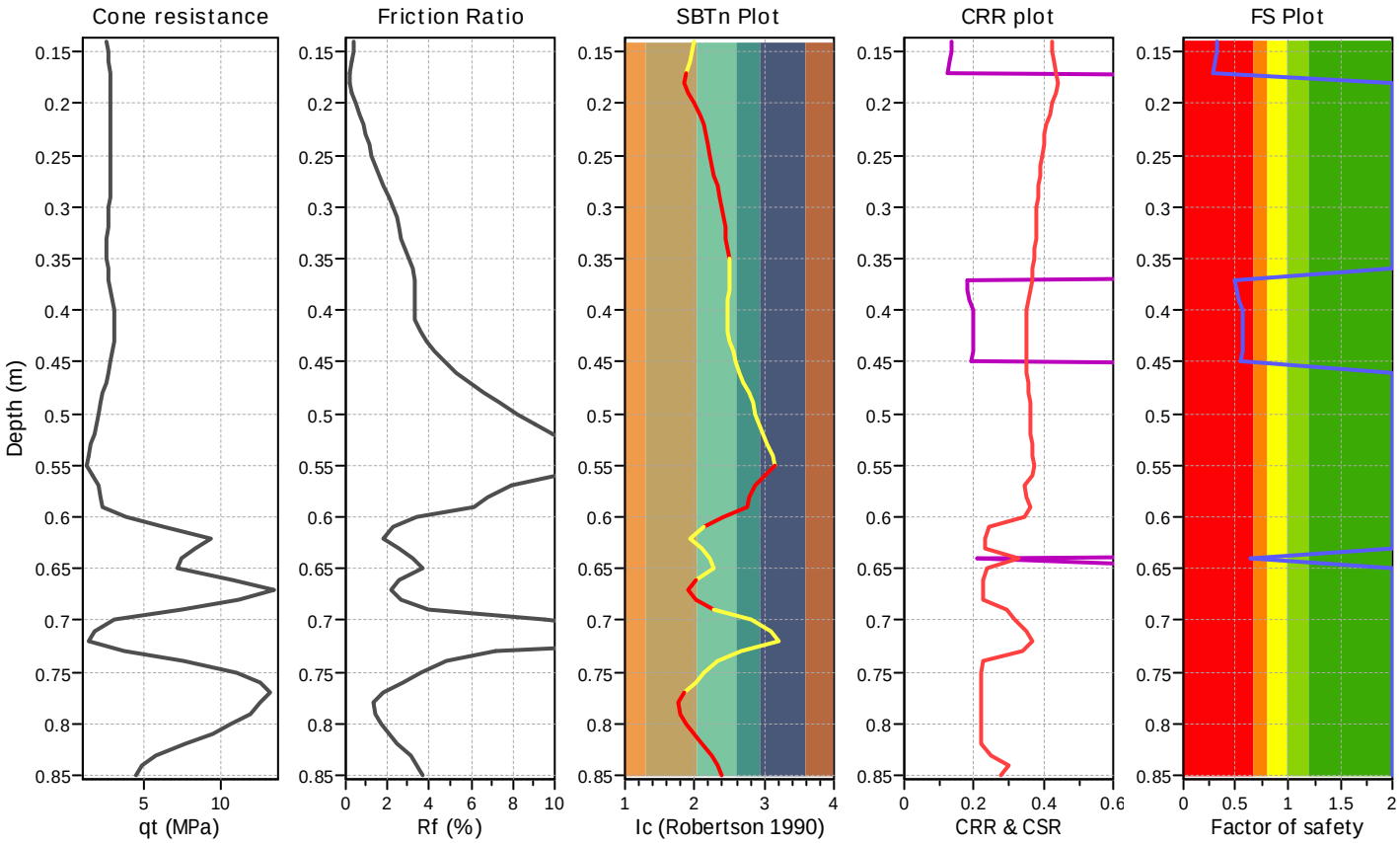
LIQUEFACTION ANALYSIS REPORT

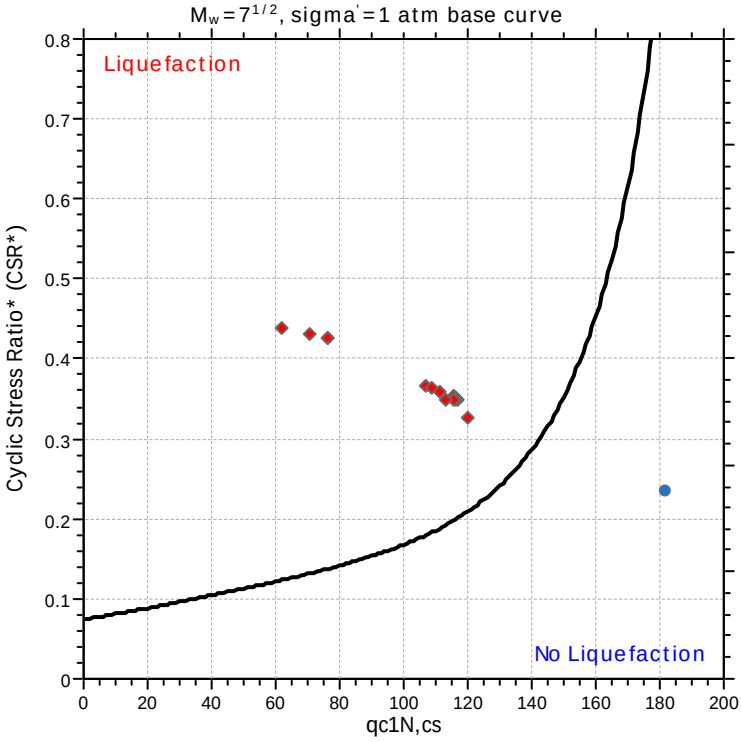
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSCIN009 – Western Springs Shaft

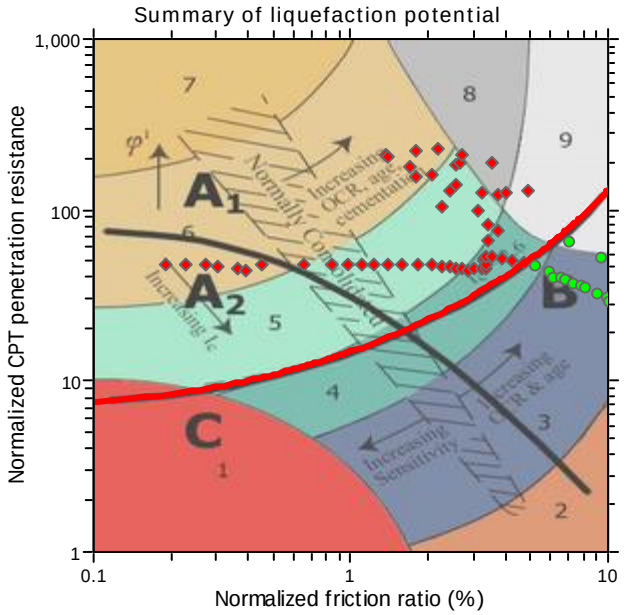
CPT file : WS1-CPT04

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.00 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

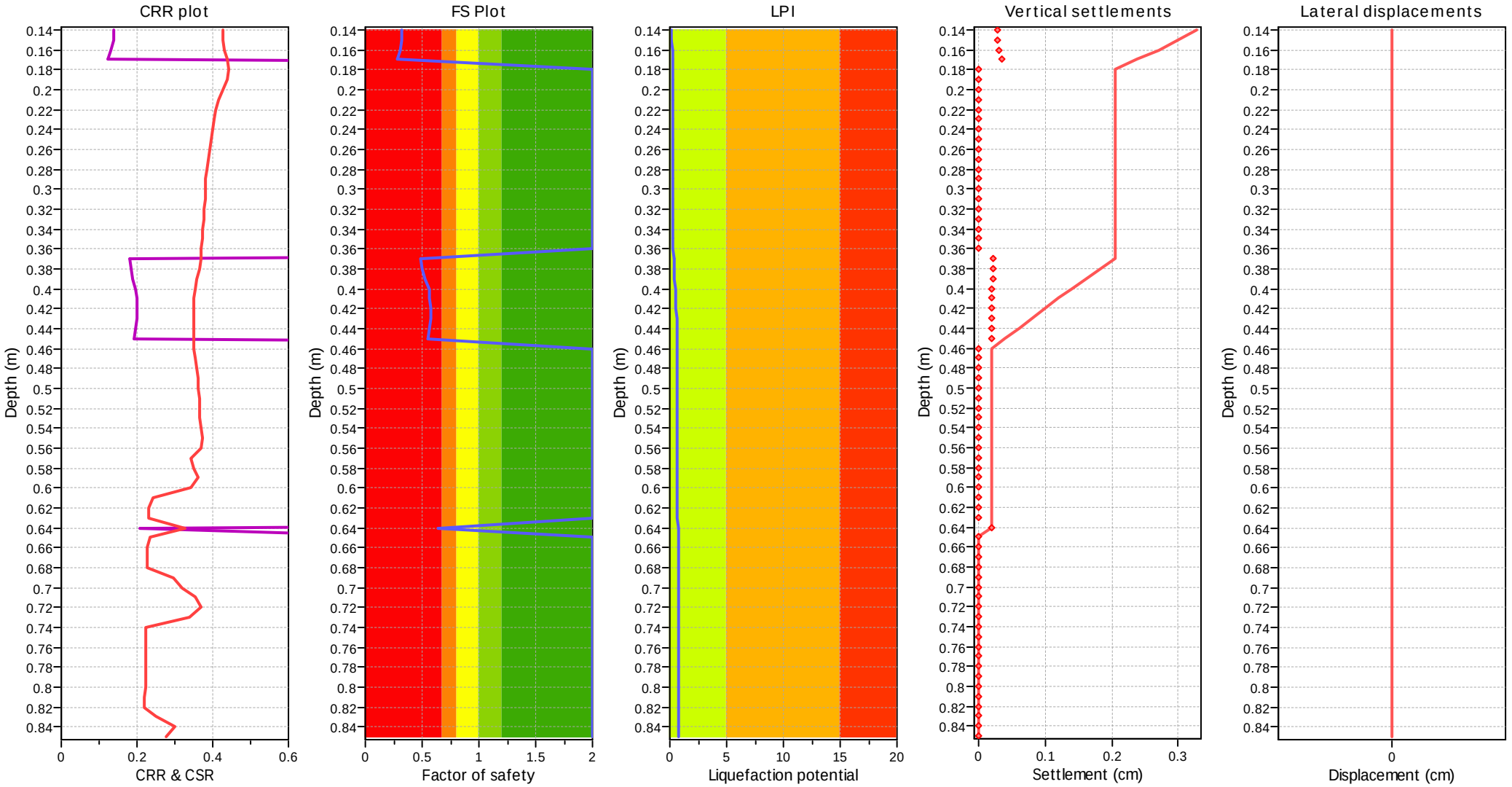






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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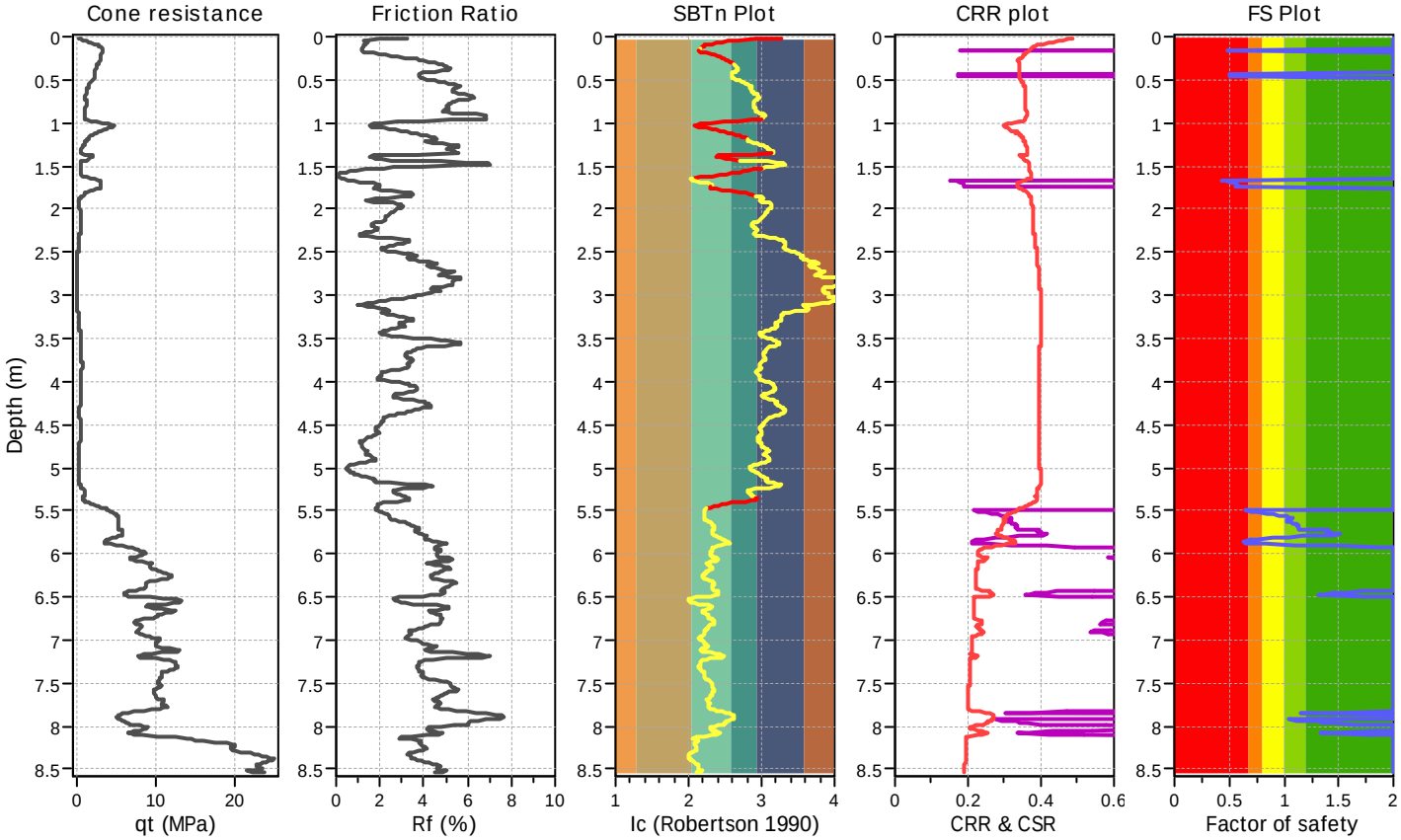
LIQUEFACTION ANALYSIS REPORT

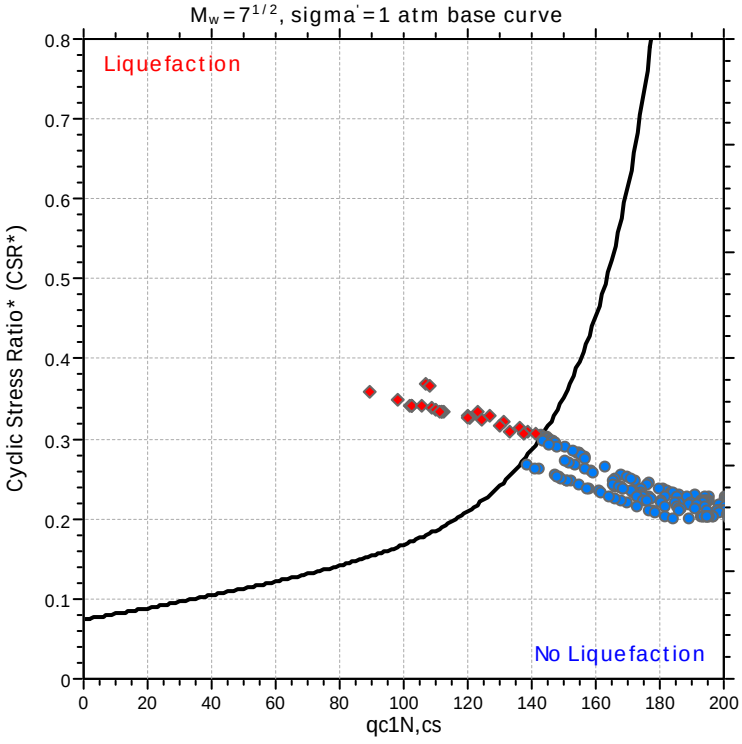
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSCIN009 – Western Springs Shaft

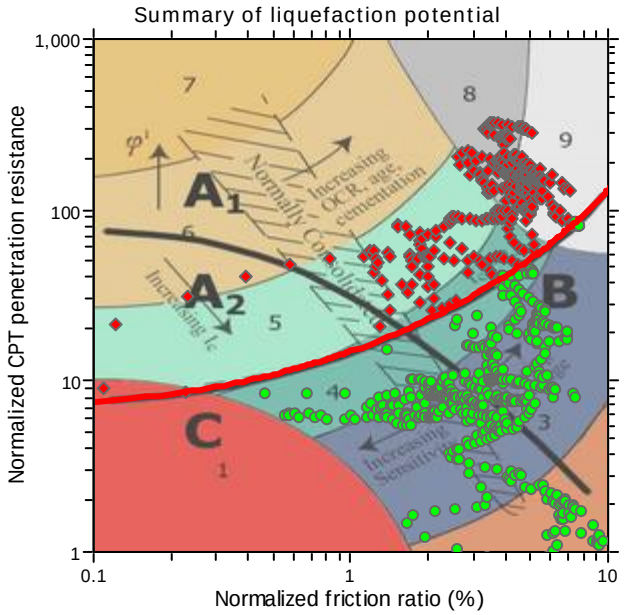
CPT file : WS1-CPT05

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.00 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

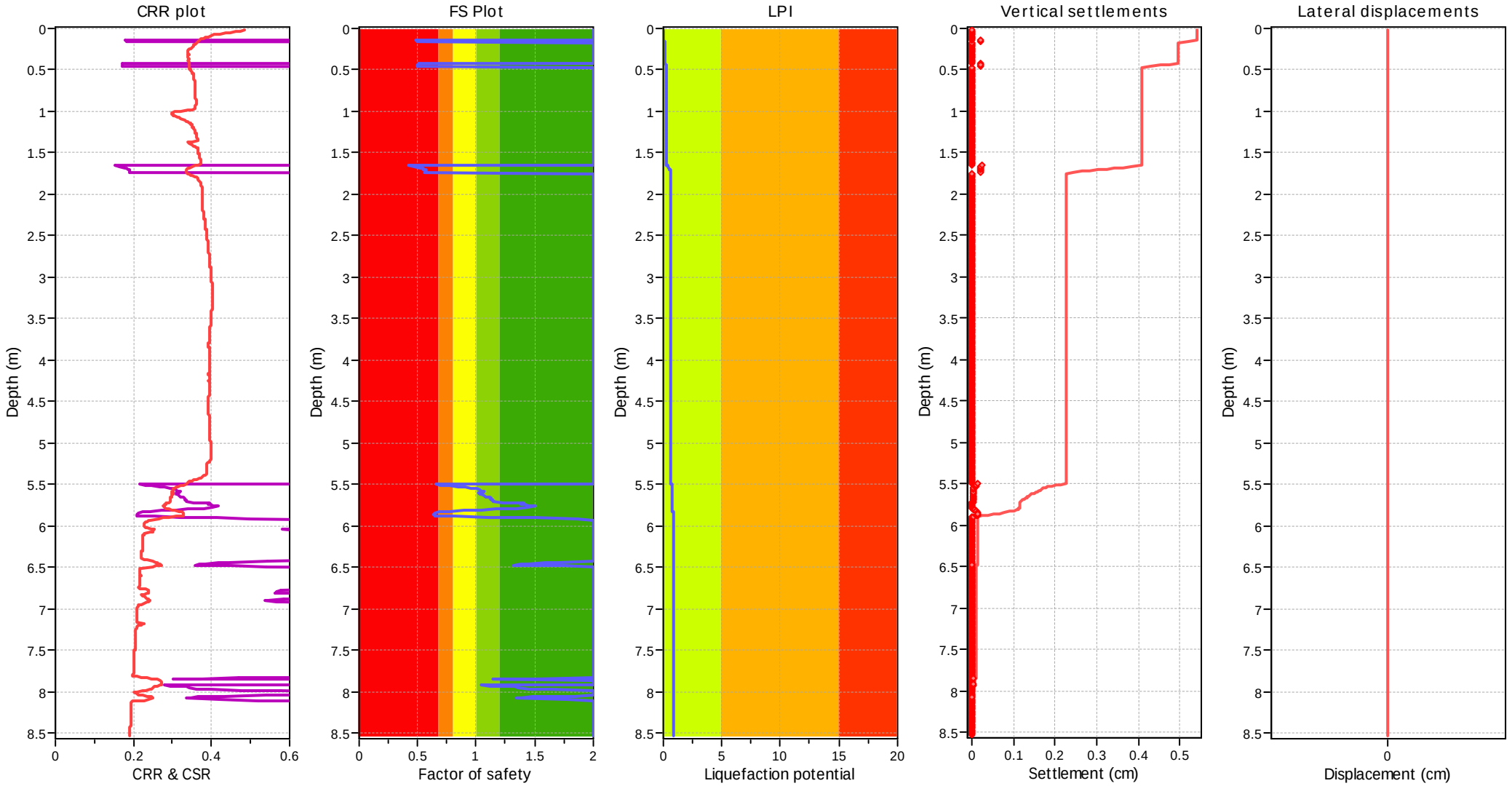






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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

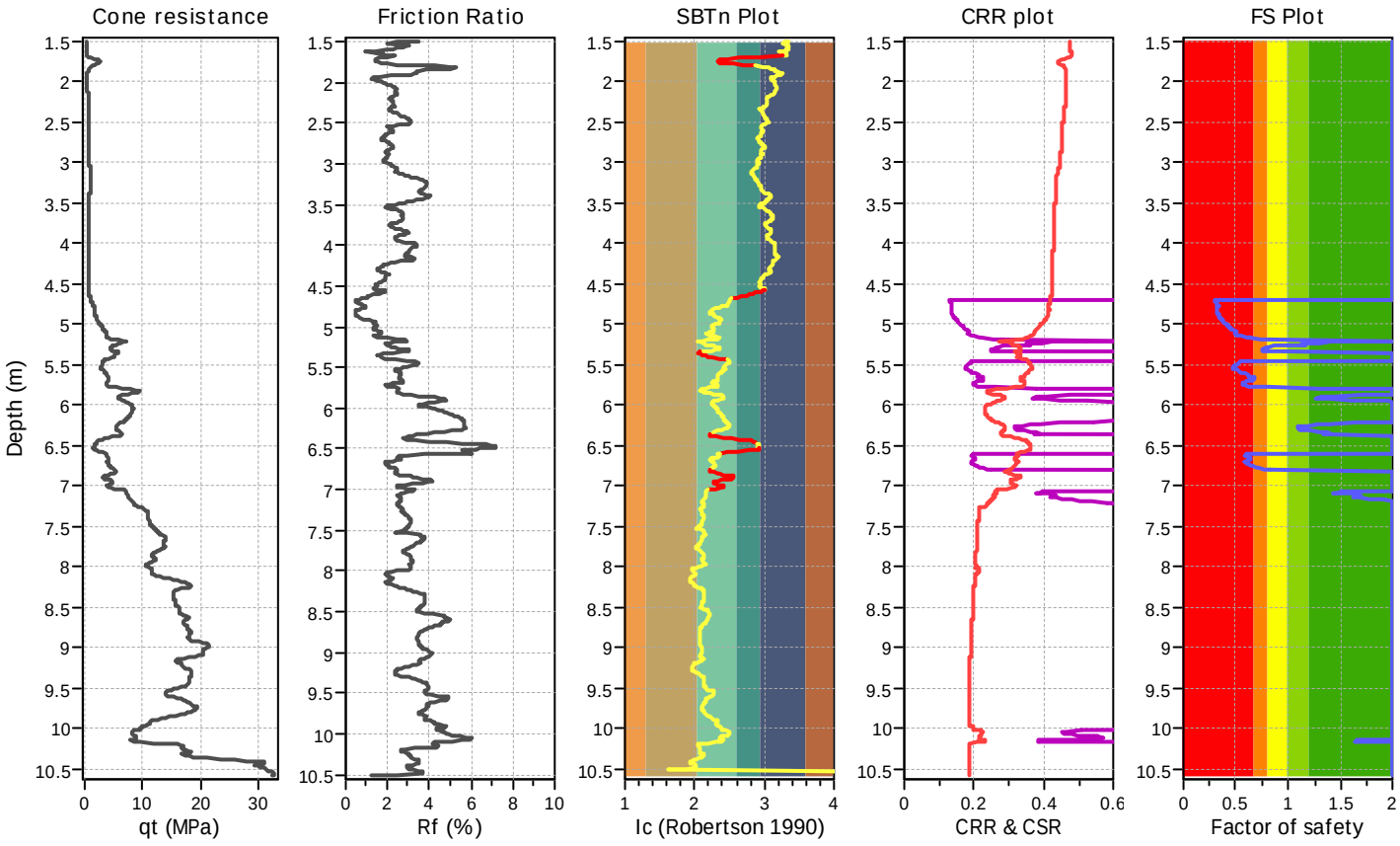
Project title : ULS 1/2500 year event (NZ1170.5)

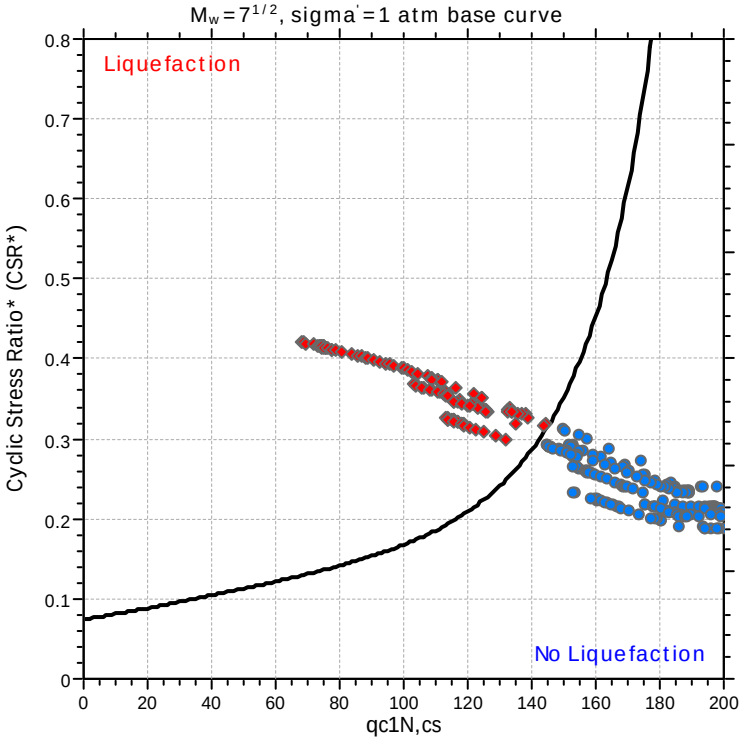
Location : DSCIN009 – Western Springs Shaft

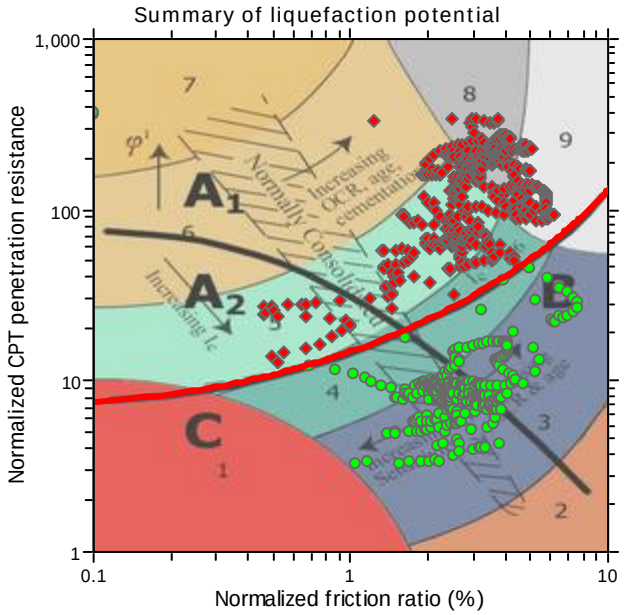
CPT file : WS1-CPT11

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.00 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

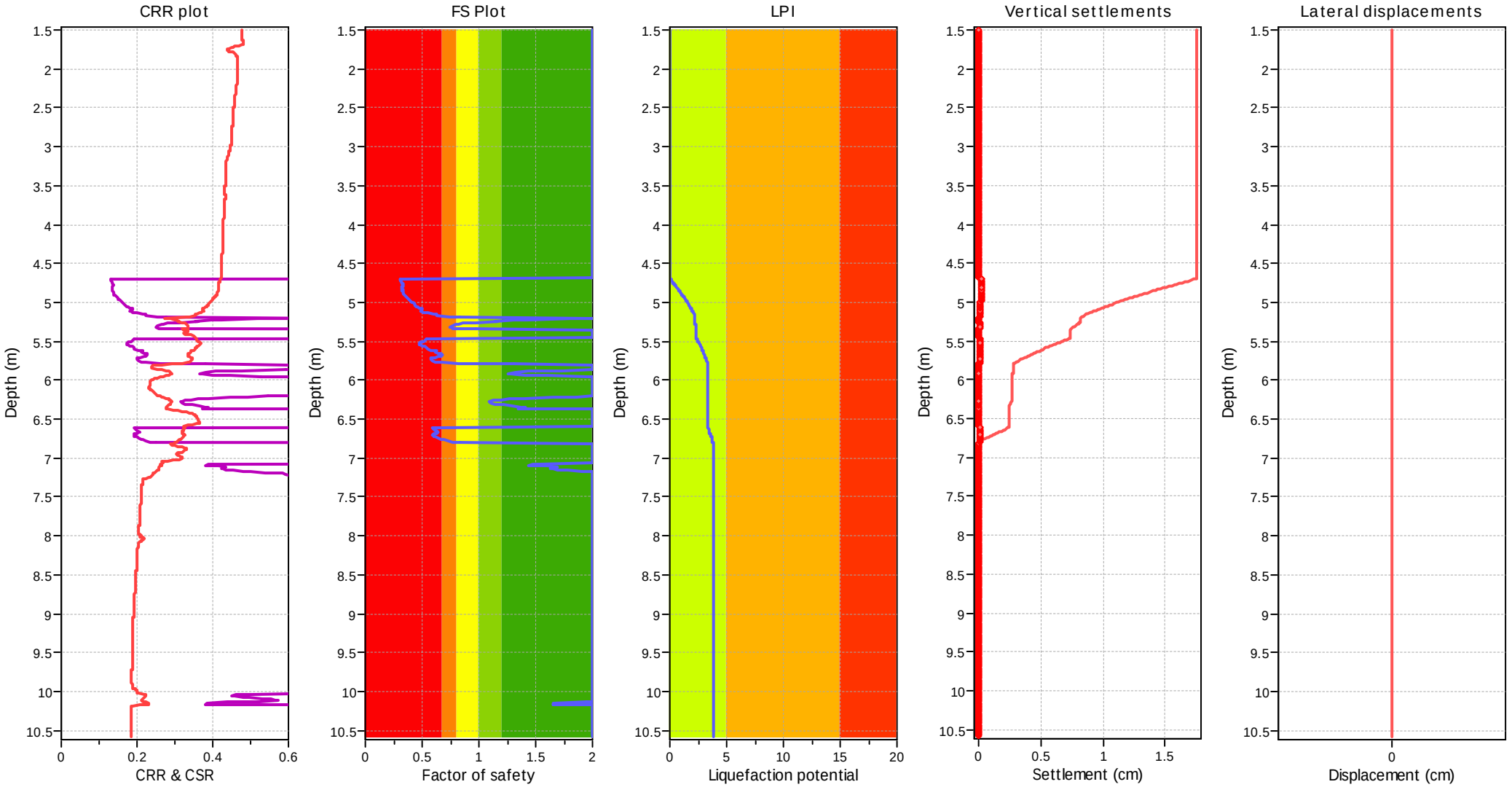






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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

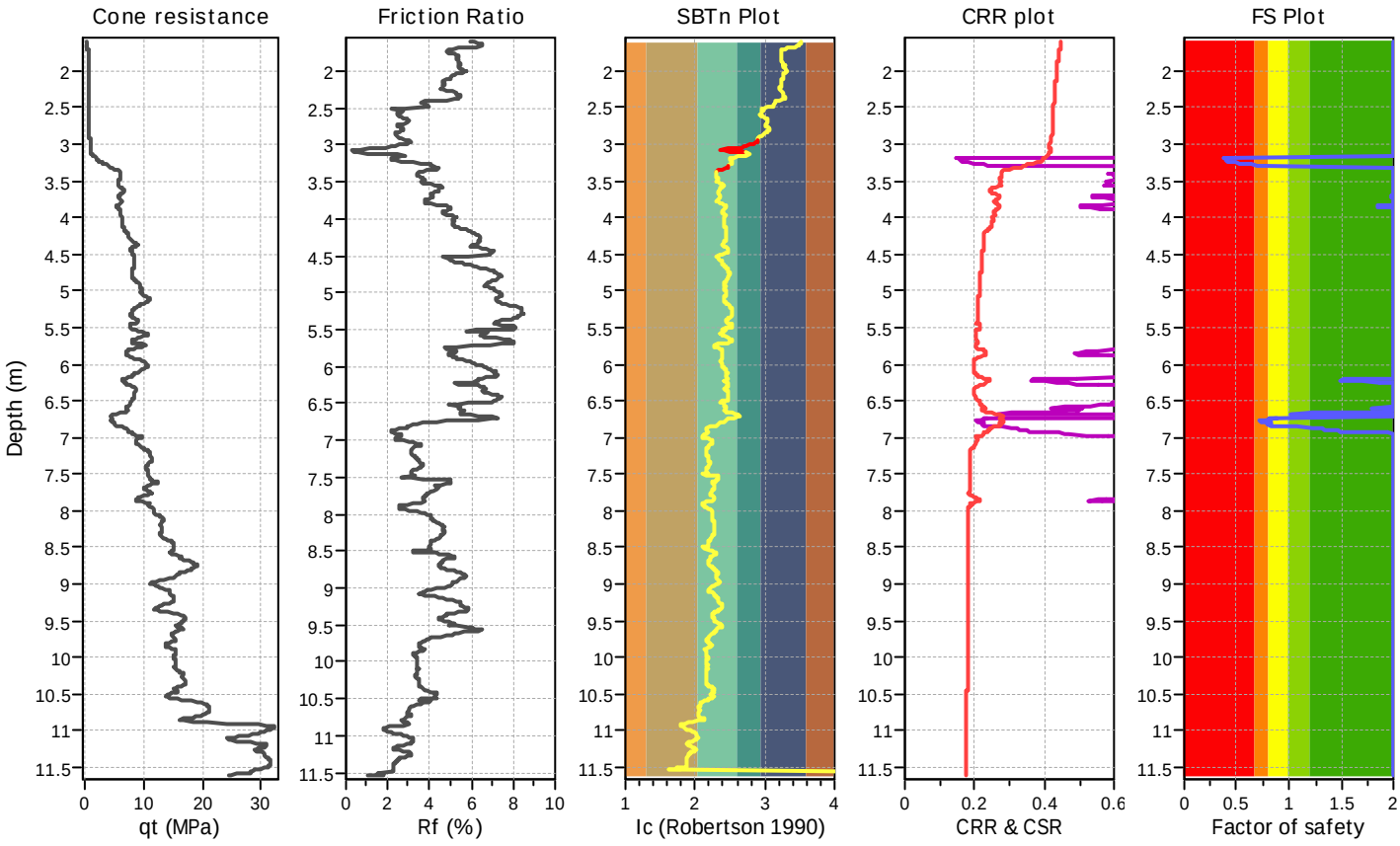
Project title : ULS 1/2500 year event (NZ1170.5)

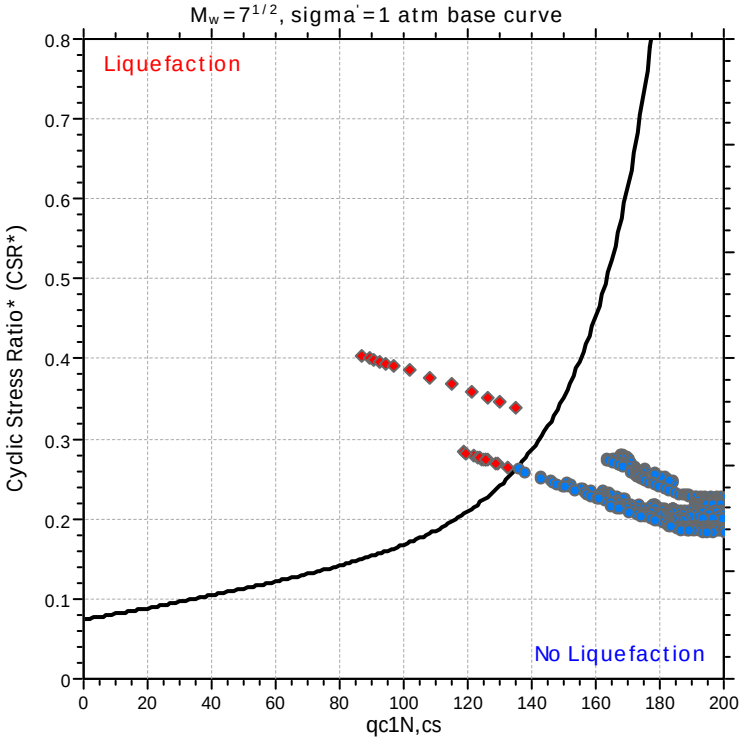
Location : DSCIN009 – Western Springs Shaft

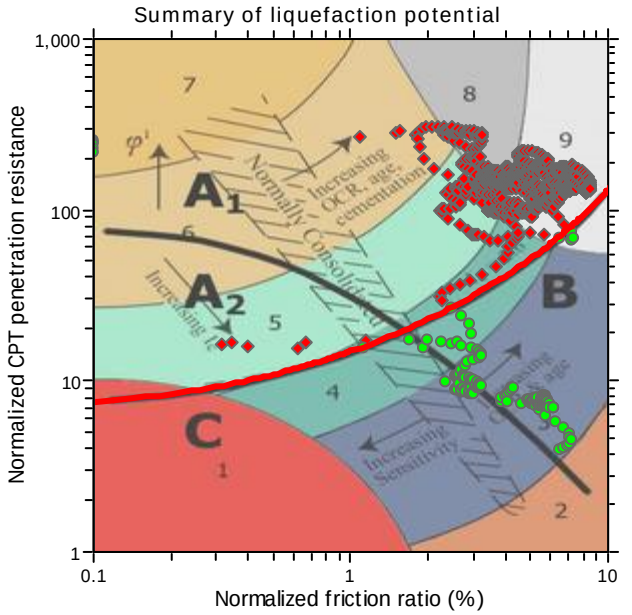
CPT file : WS1-CPT12

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.00 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

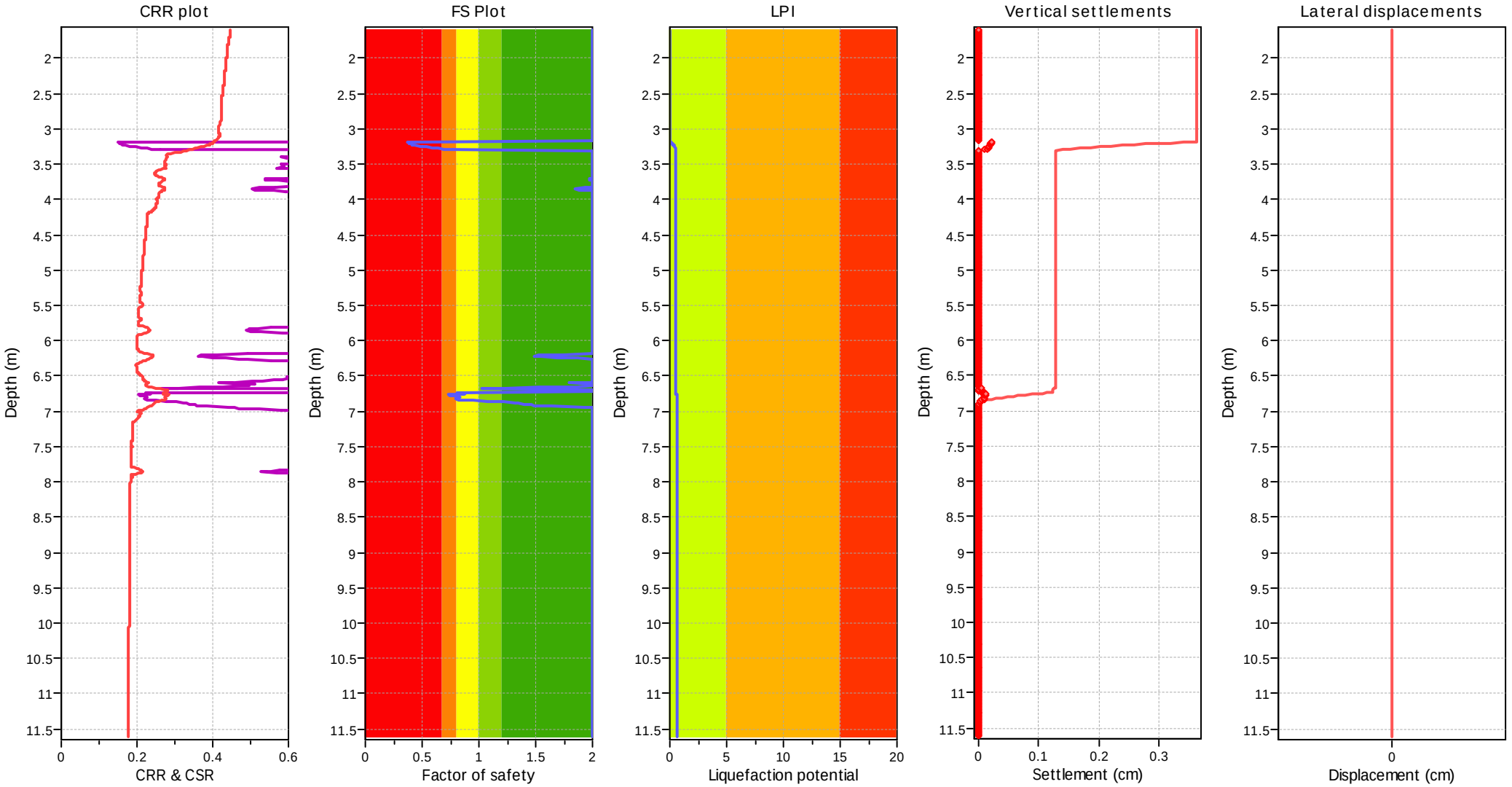






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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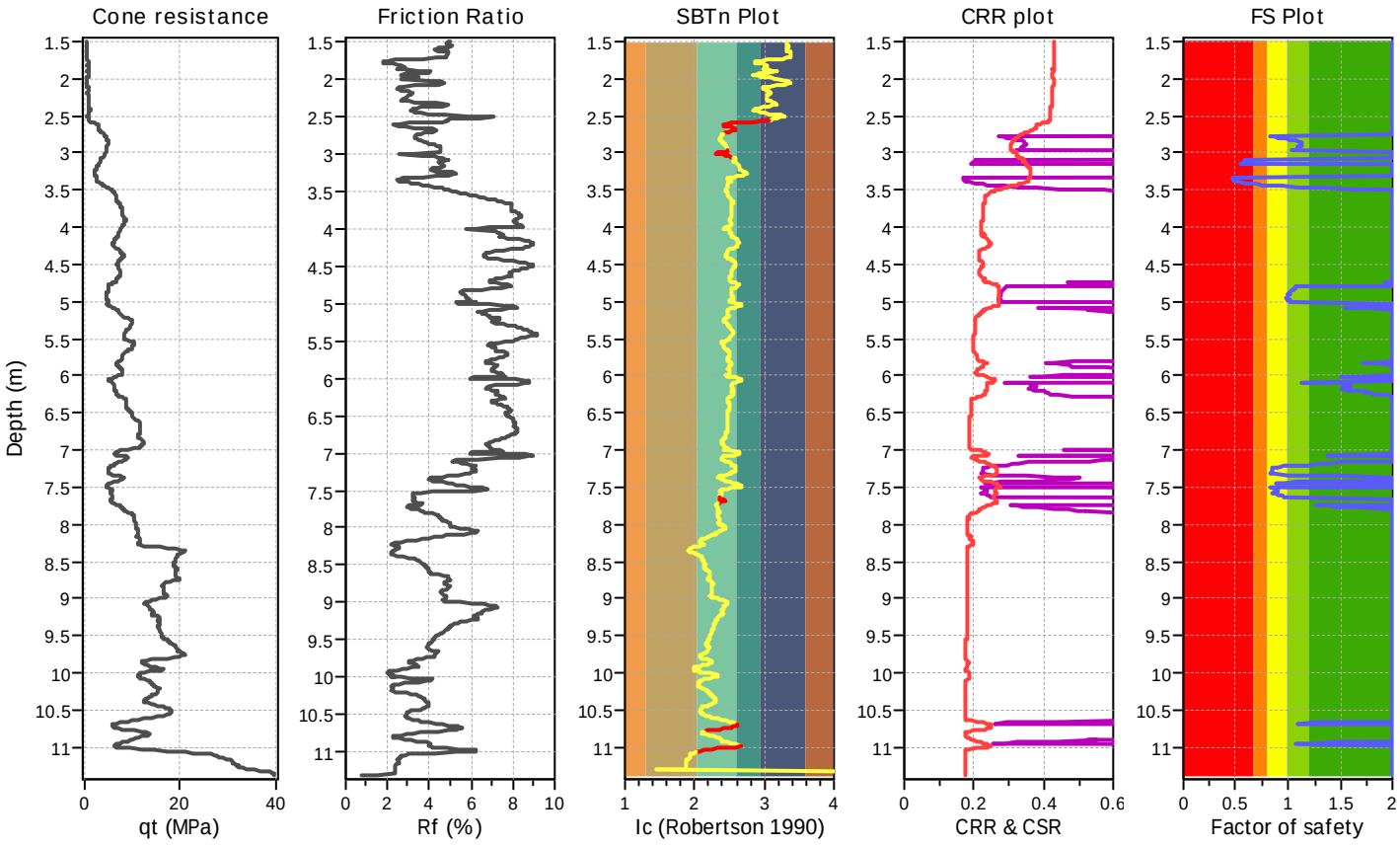
LIQUEFACTION ANALYSIS REPORT

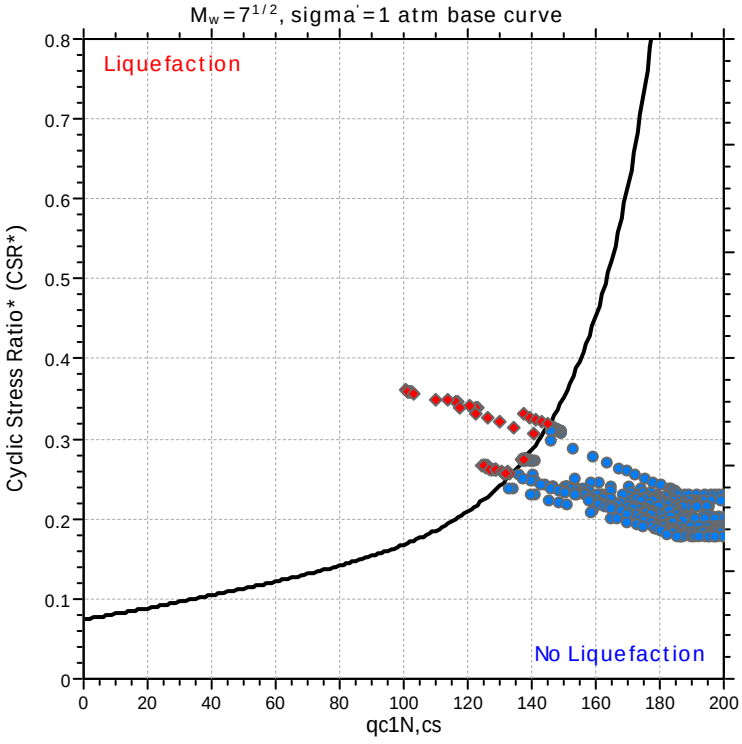
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSCIN009 – Western Springs Shaft

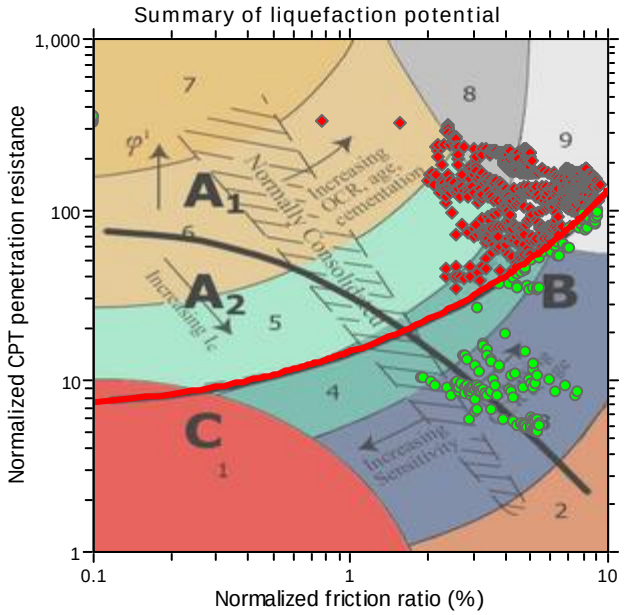
CPT file : WS1-CPT13

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.00 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

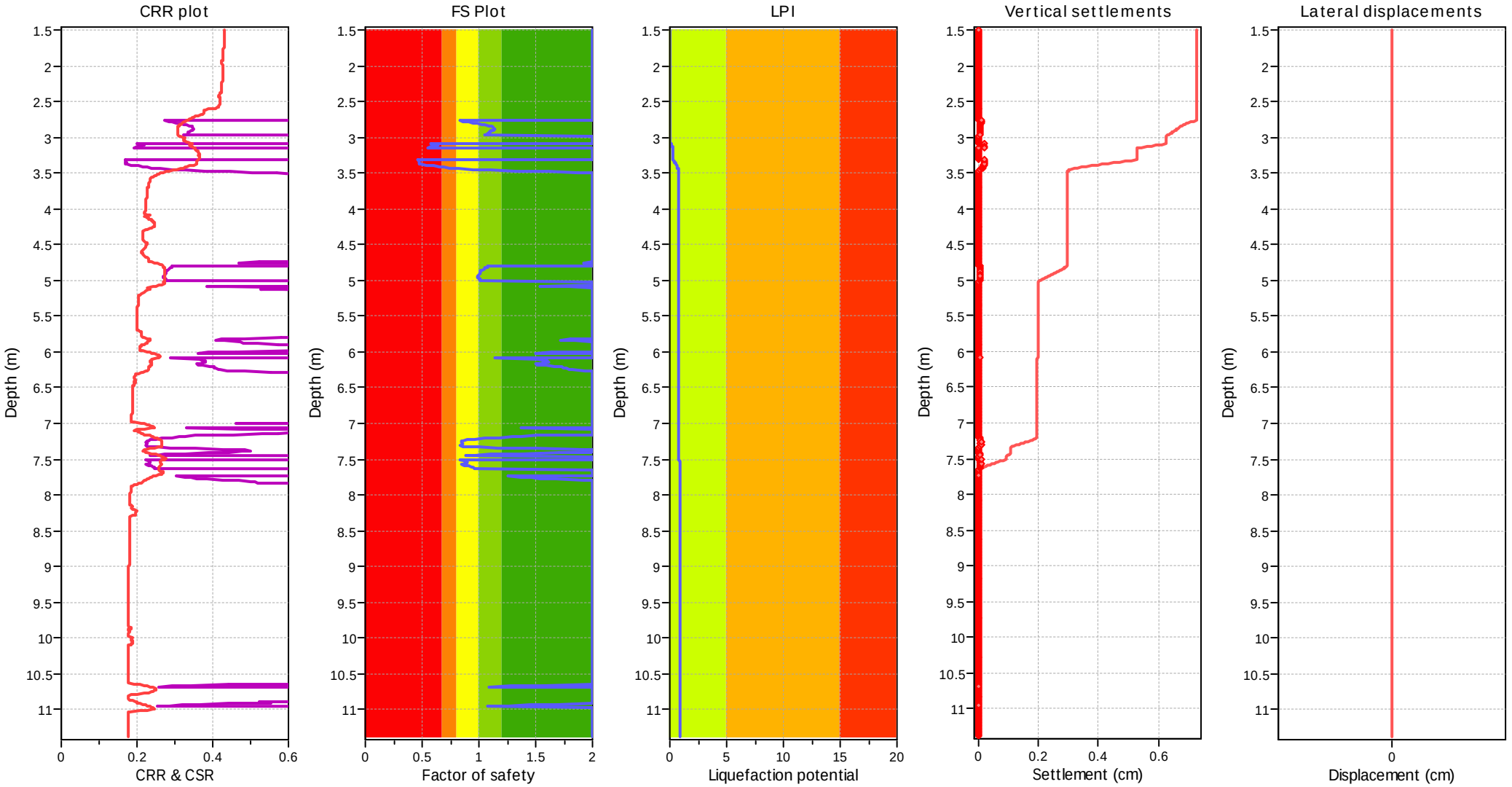






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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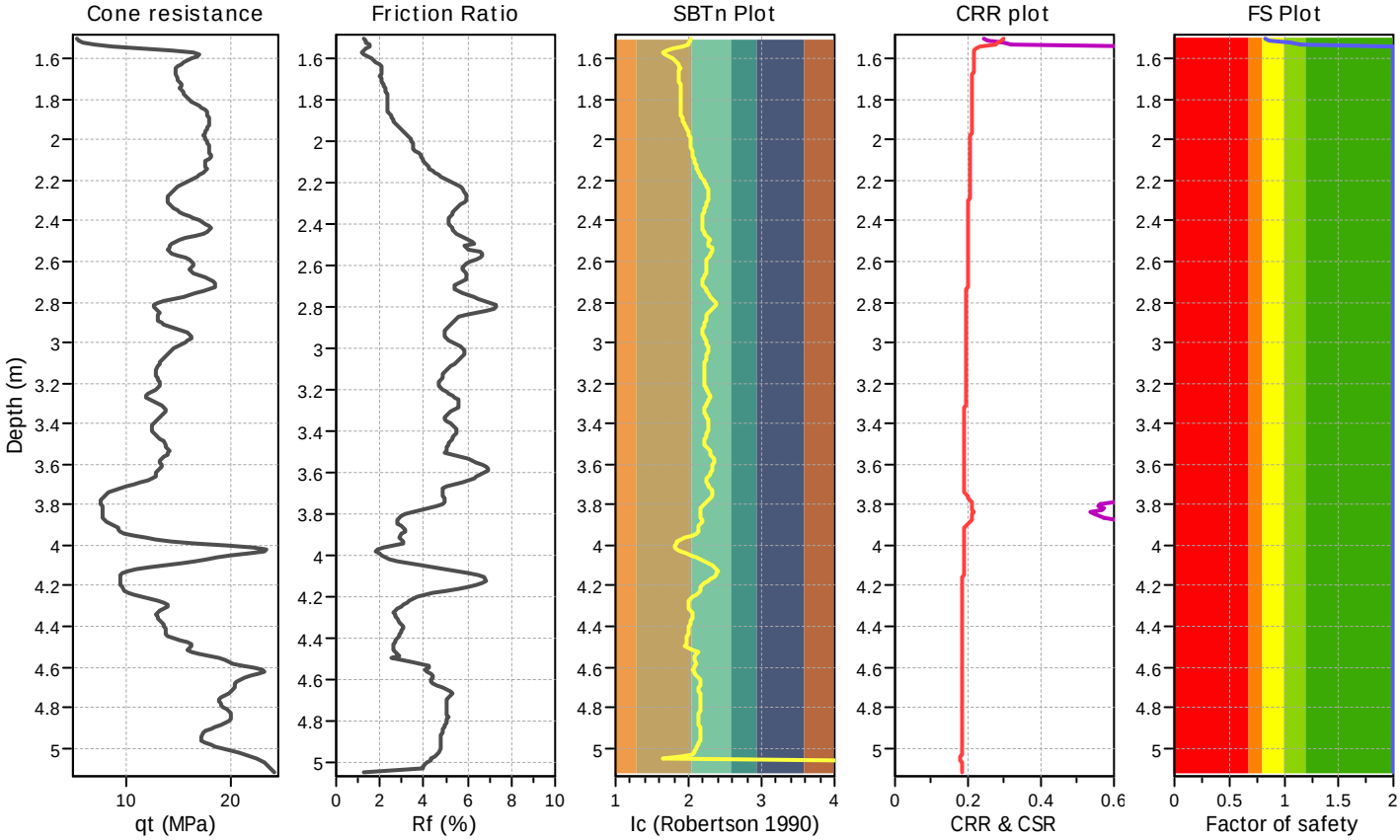
LIQUEFACTION ANALYSIS REPORT

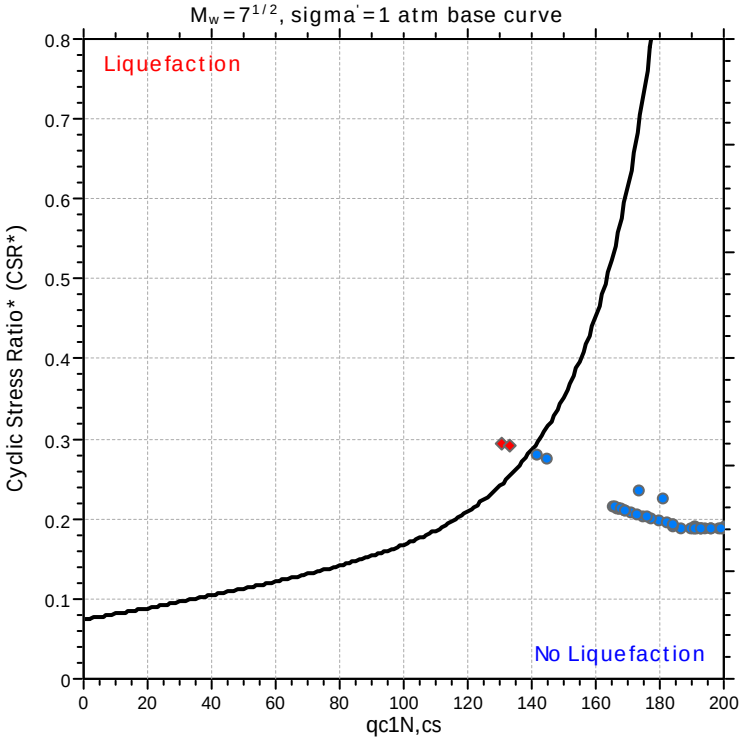
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSCIN009 – Western Springs Shaft

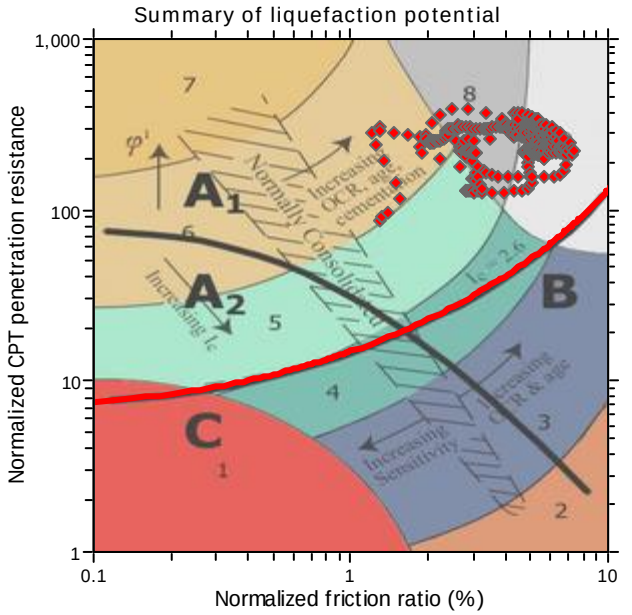
CPT file : WS1-CPT14

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.00 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

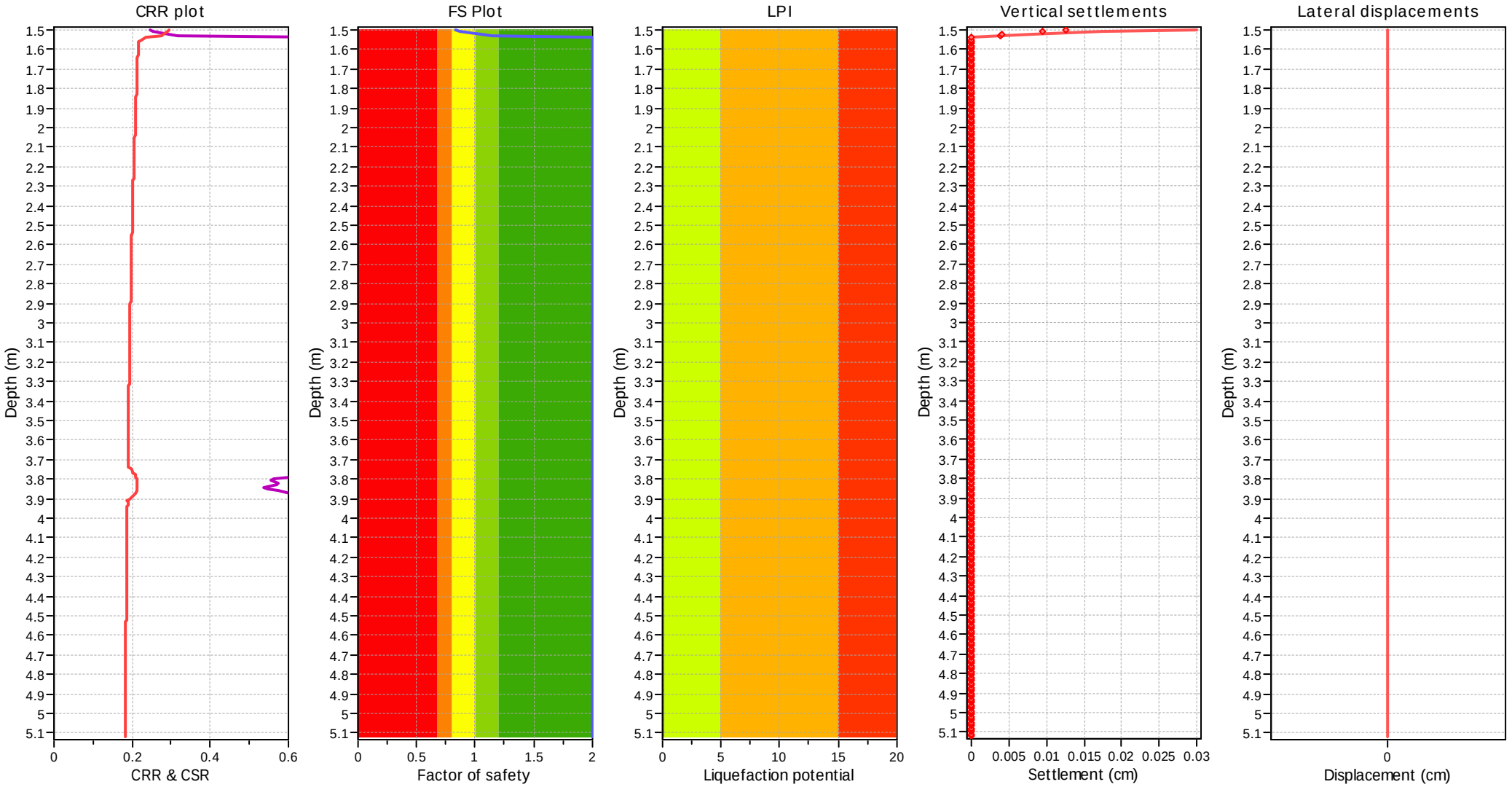






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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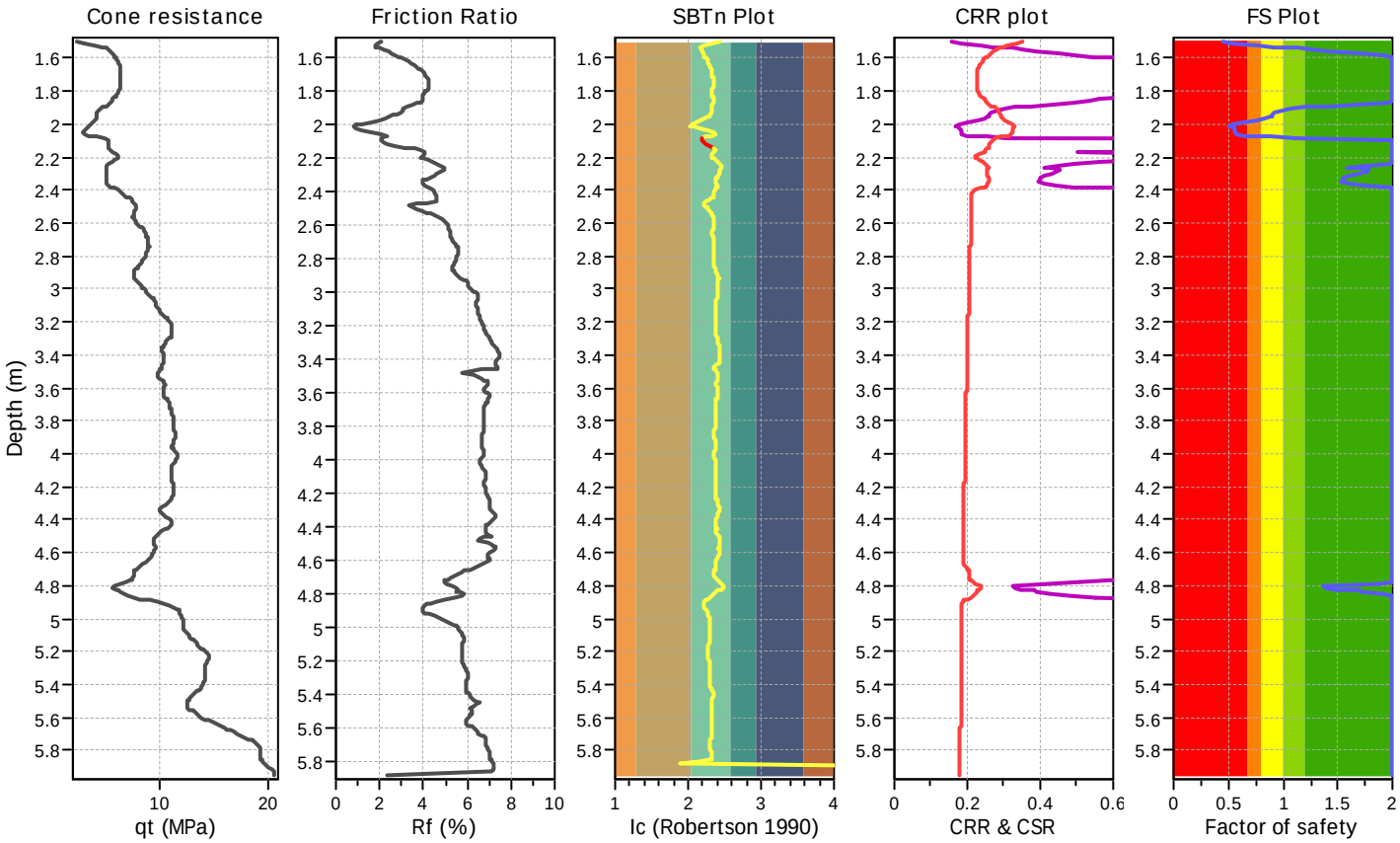
LIQUEFACTION ANALYSIS REPORT

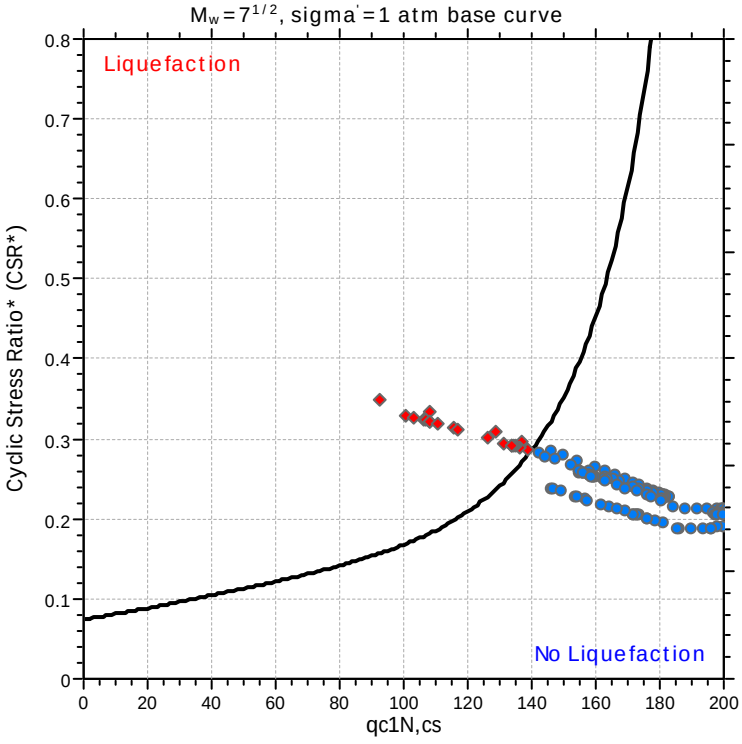
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSCIN009 – Western Springs Shaft

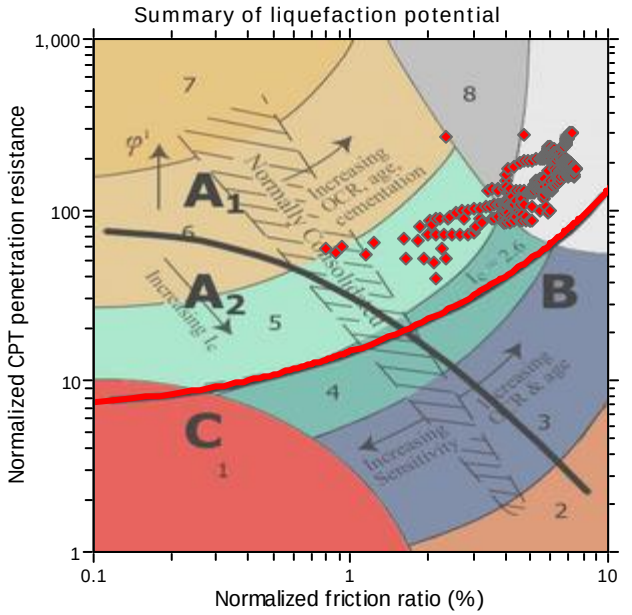
CPT file : WS1-CPT16

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.00 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

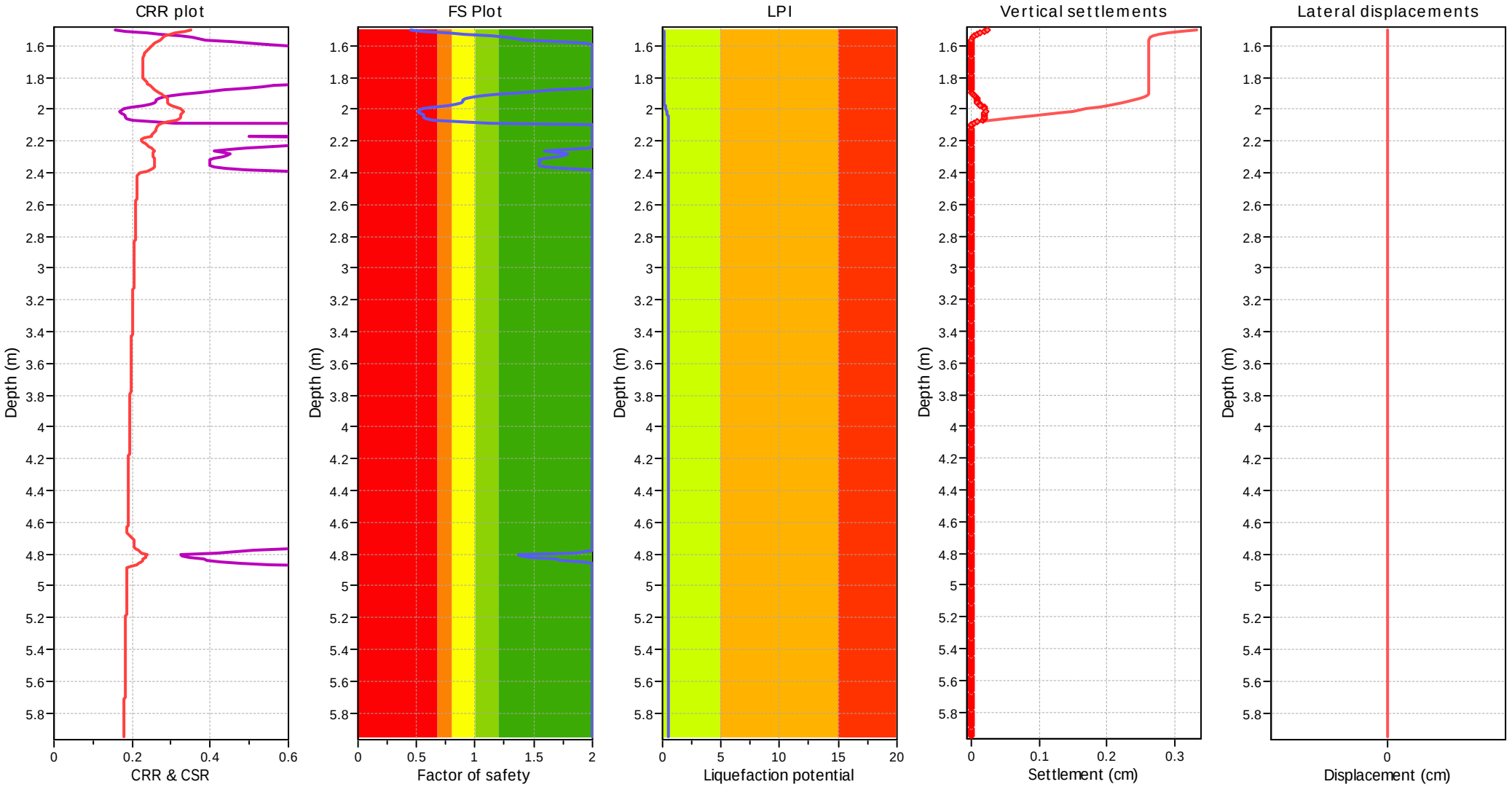






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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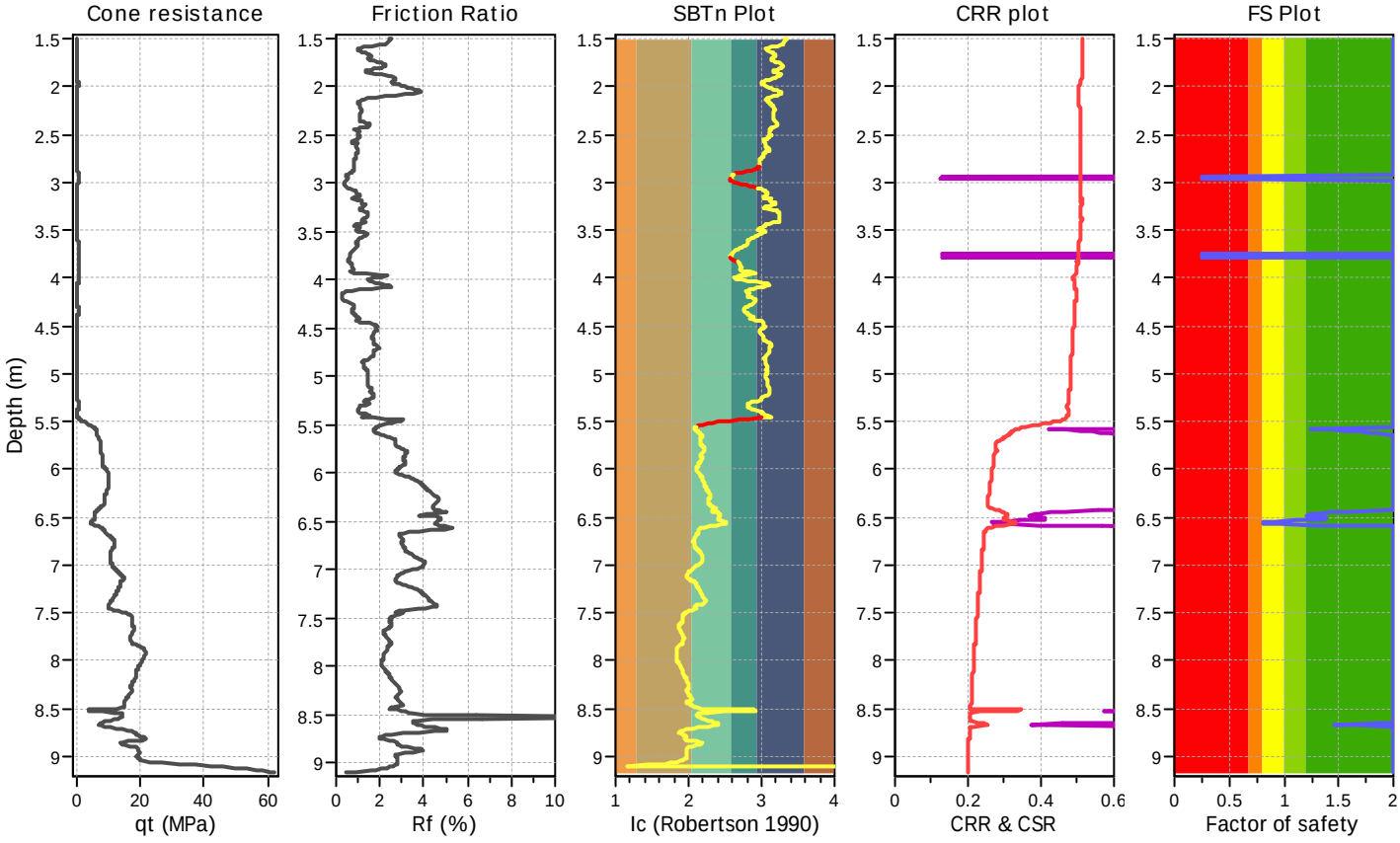
LIQUEFACTION ANALYSIS REPORT

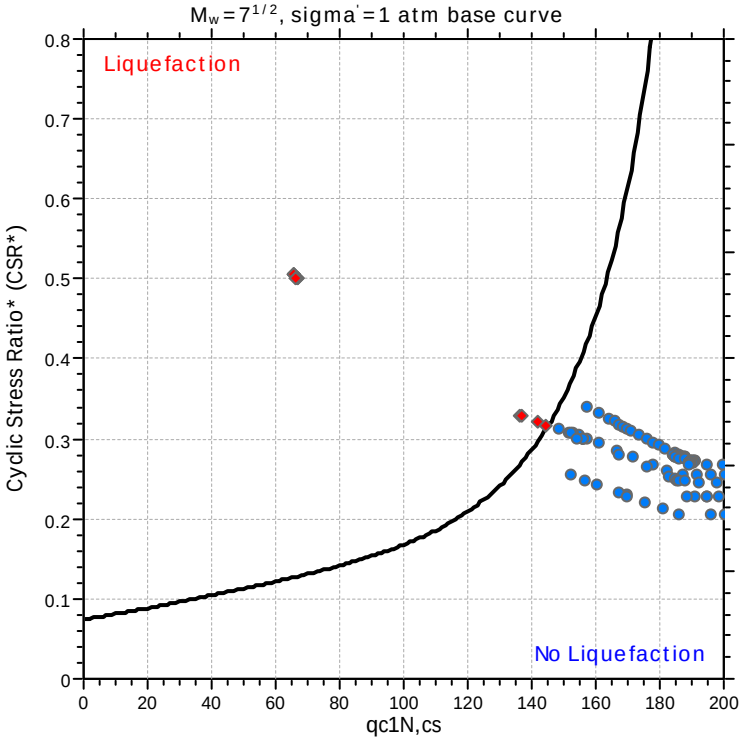
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSCIN009 – Western Springs Shaft

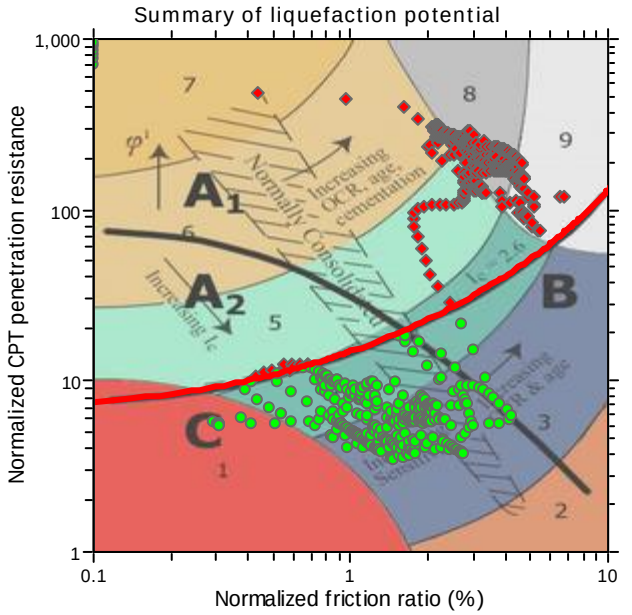
CPT file : WS1-CPT17

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.00 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

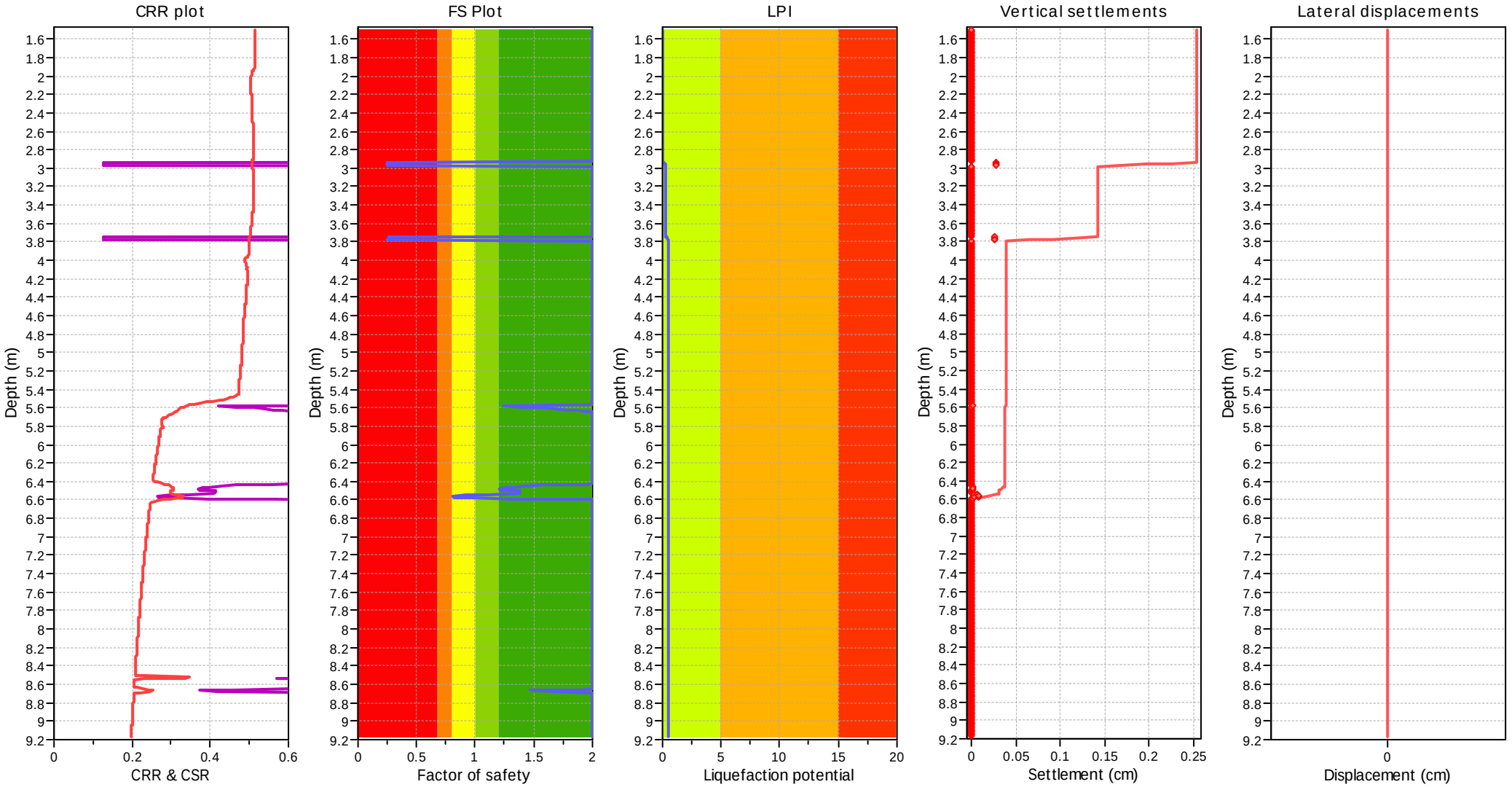






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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

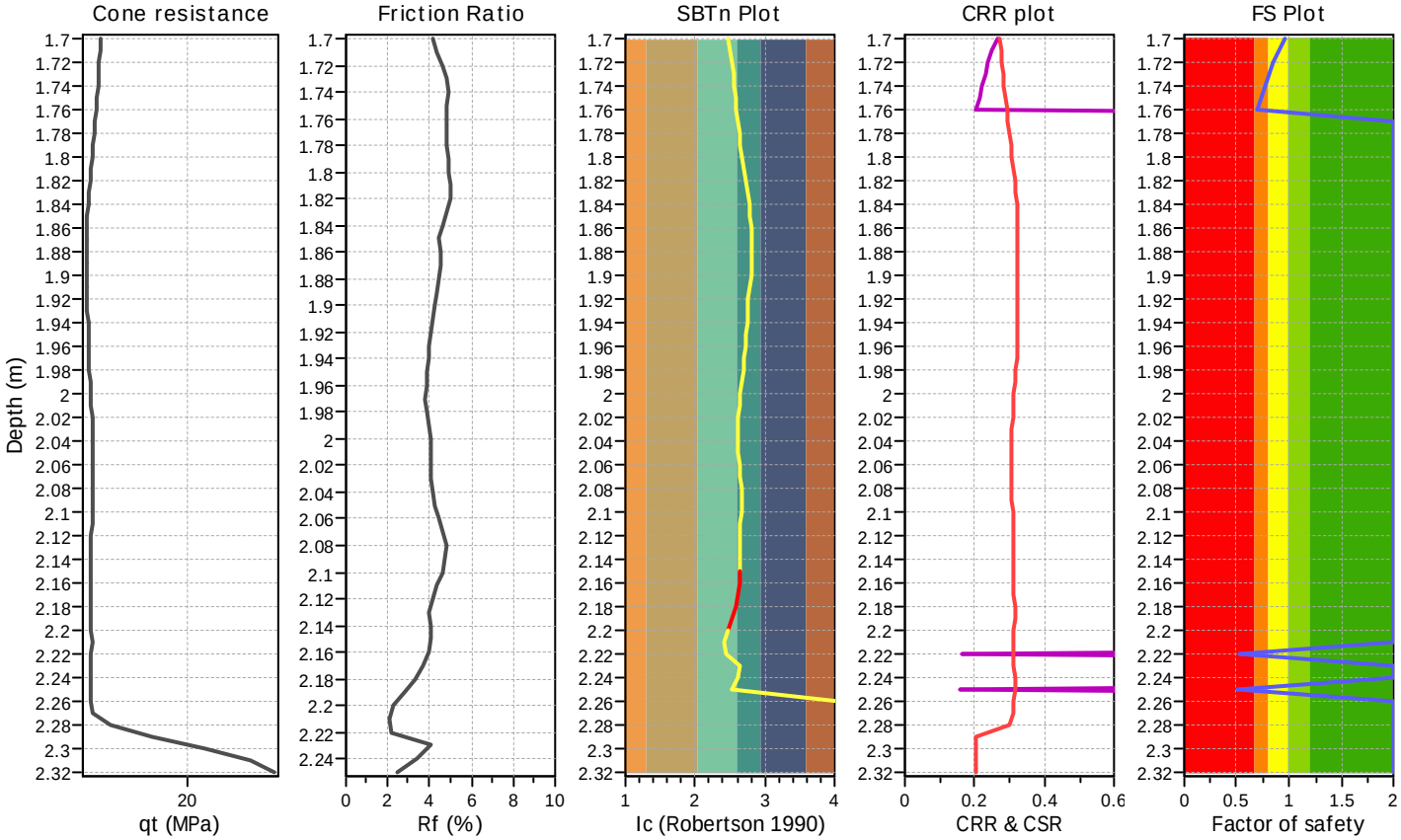
Project title : ULS 1/2500 year event (NZ1170.5)

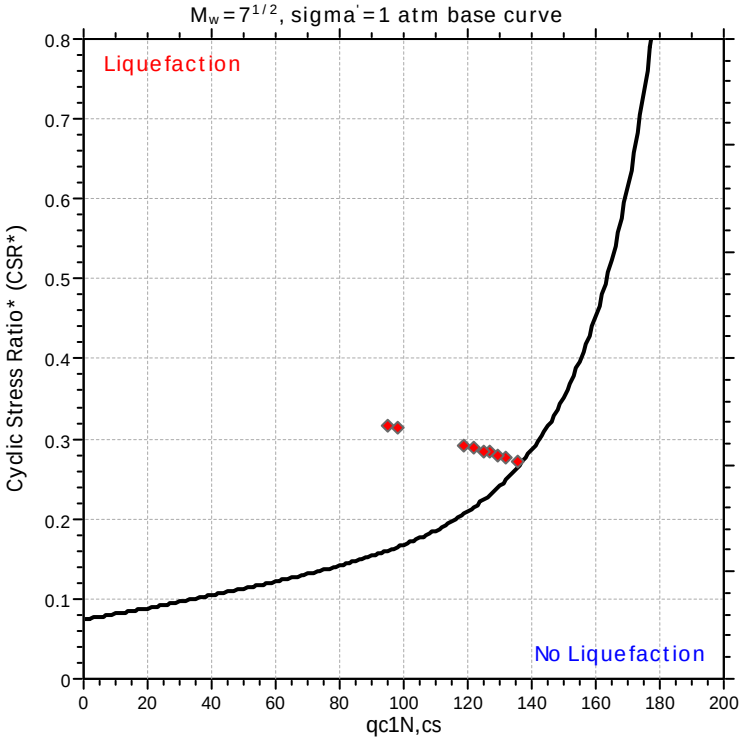
Location : DSCIN009 – Western Springs Shaft

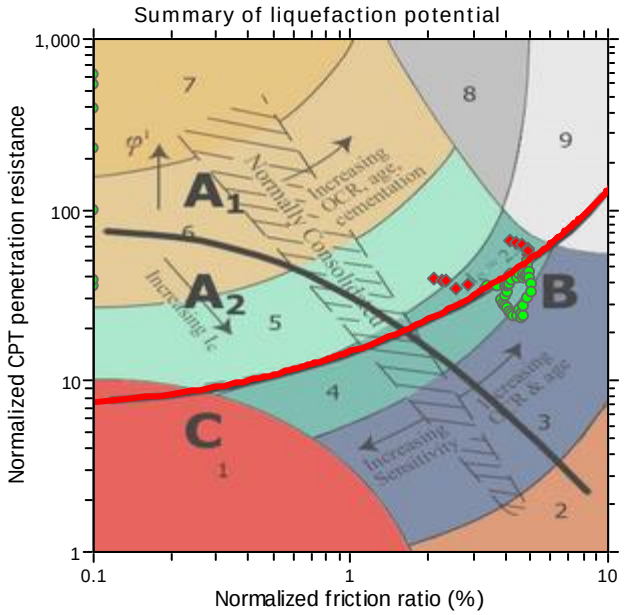
CPT file : WS1-CPT18

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.00 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

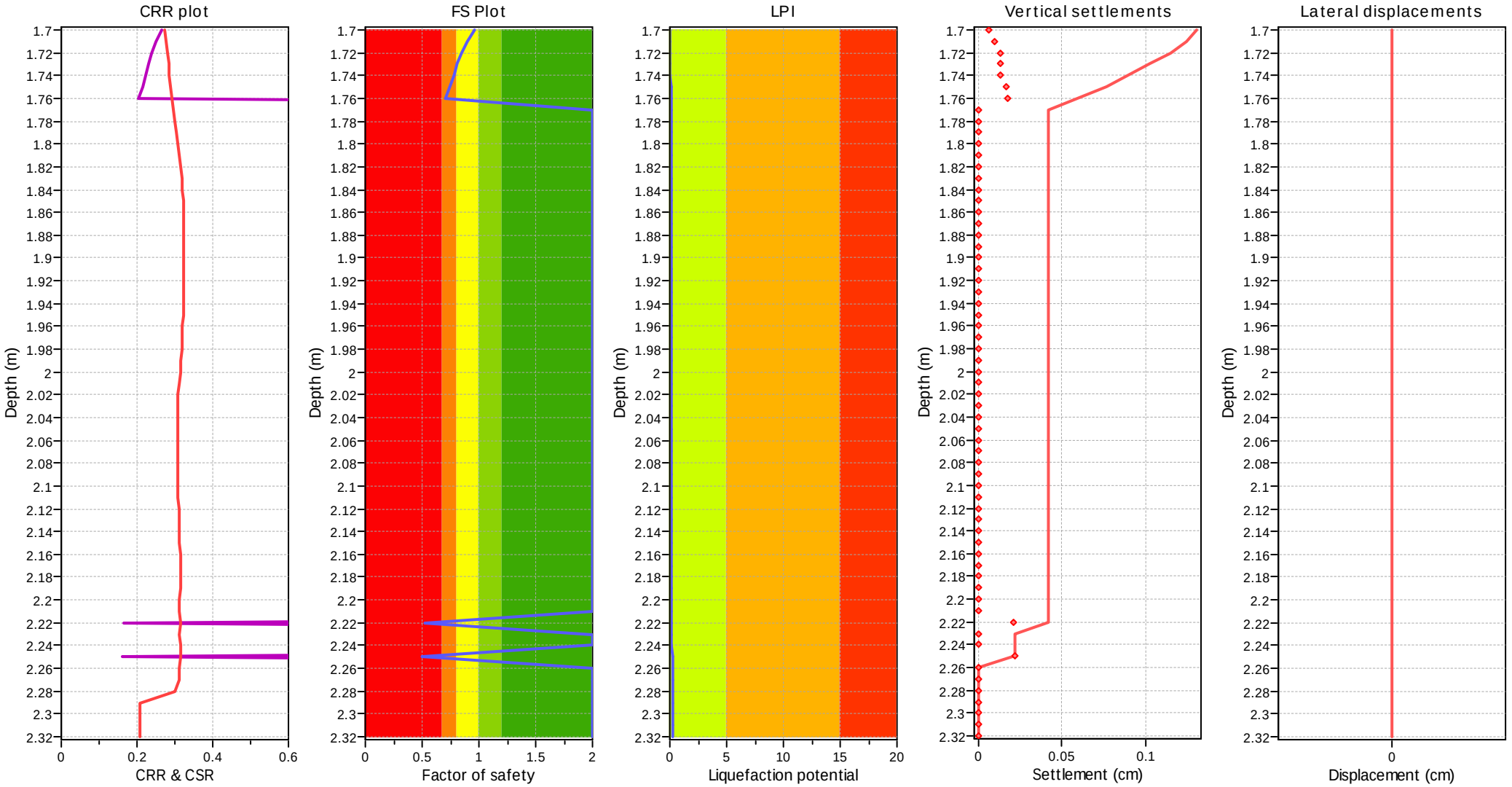






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
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- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

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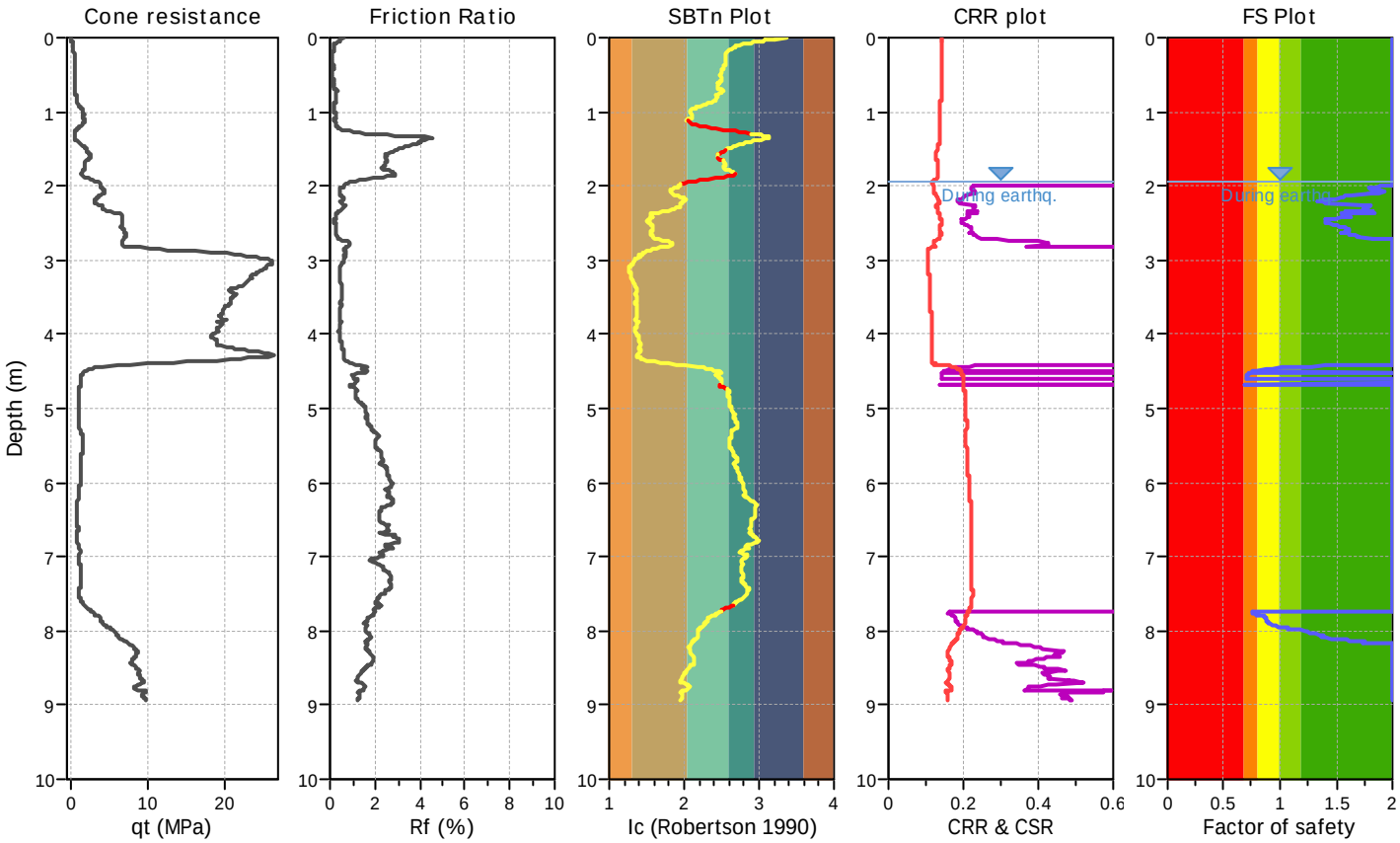
LIQUEFACTION ANALYSIS REPORT

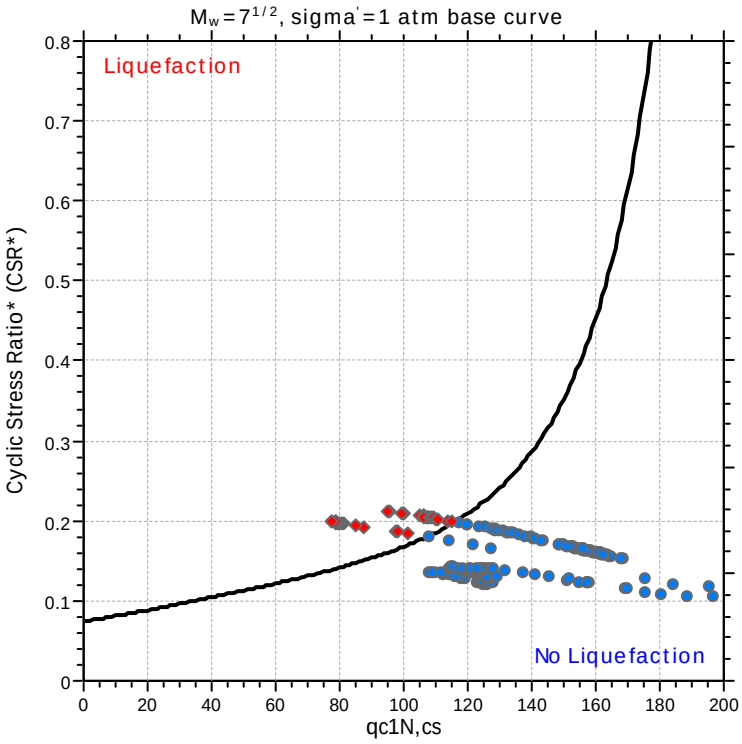
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSB001 û Norgrove Avenue

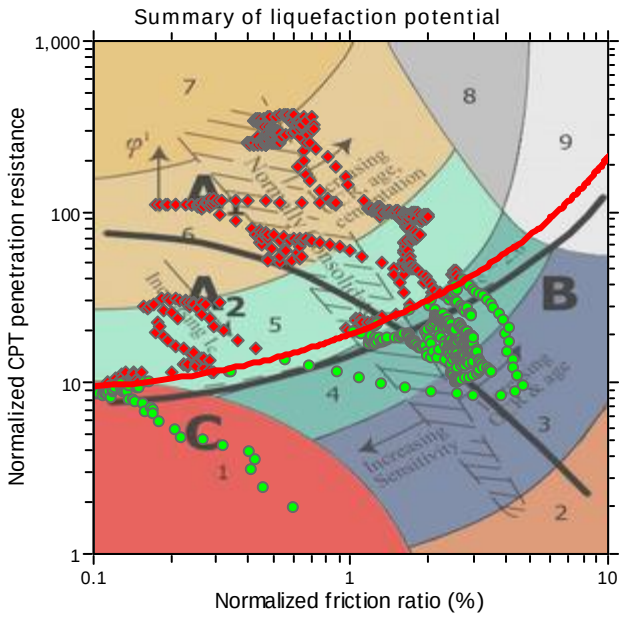
CPT file : L2S2-CPT02

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.93 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.93 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.50	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

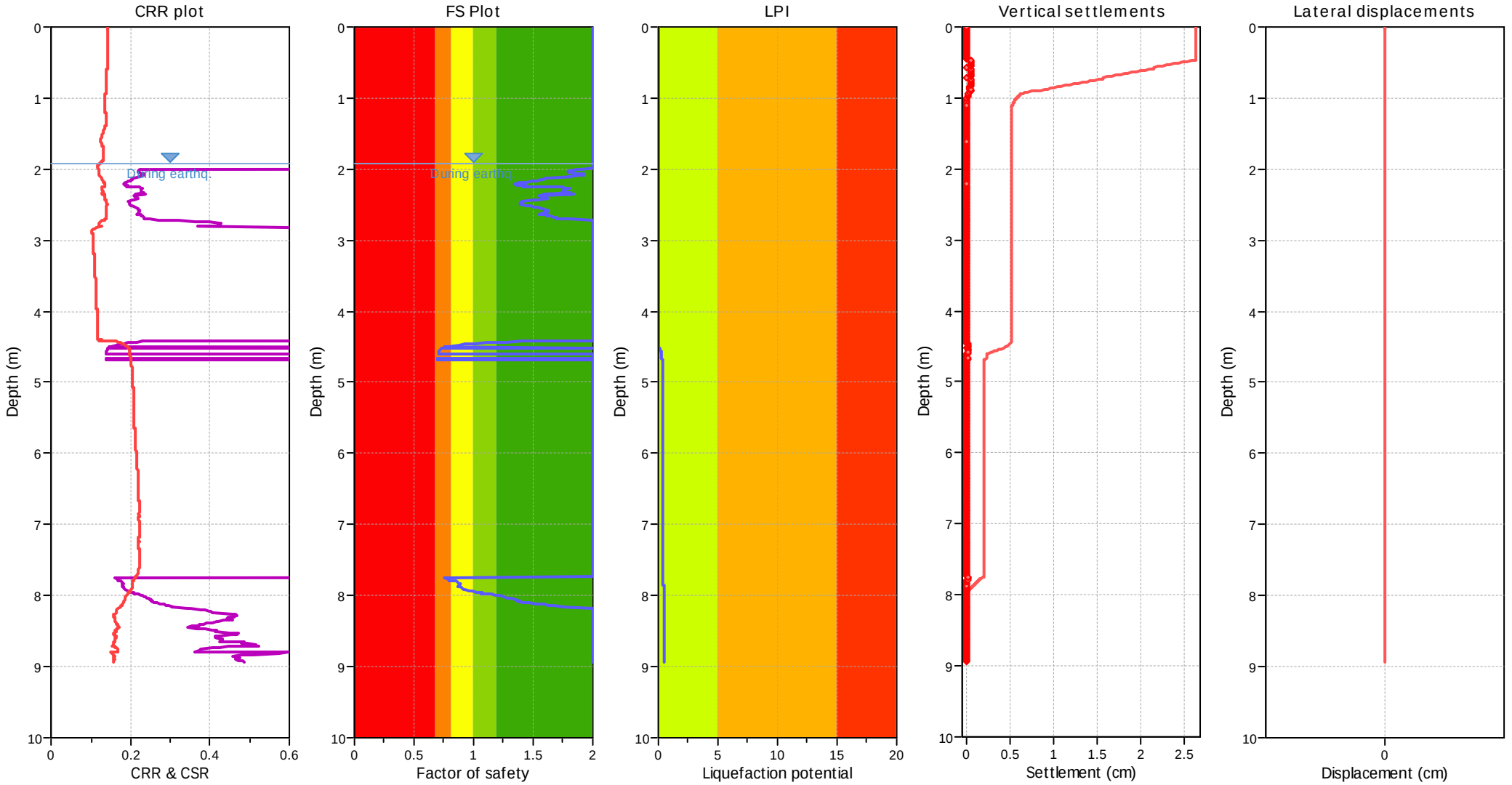






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.93 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.50	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.93 m	Fill height:	N/A	Limit depth:	N/A

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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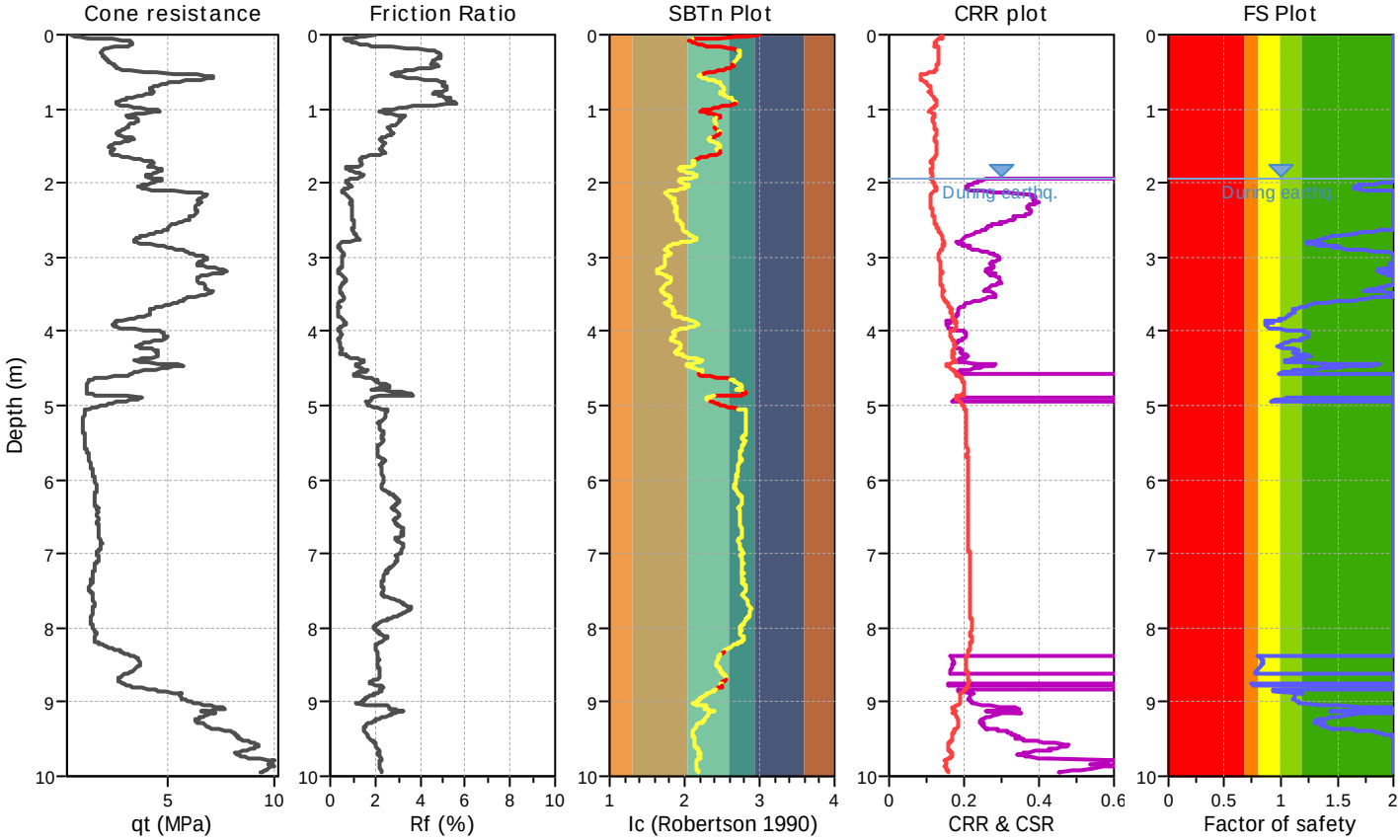
LIQUEFACTION ANALYSIS REPORT

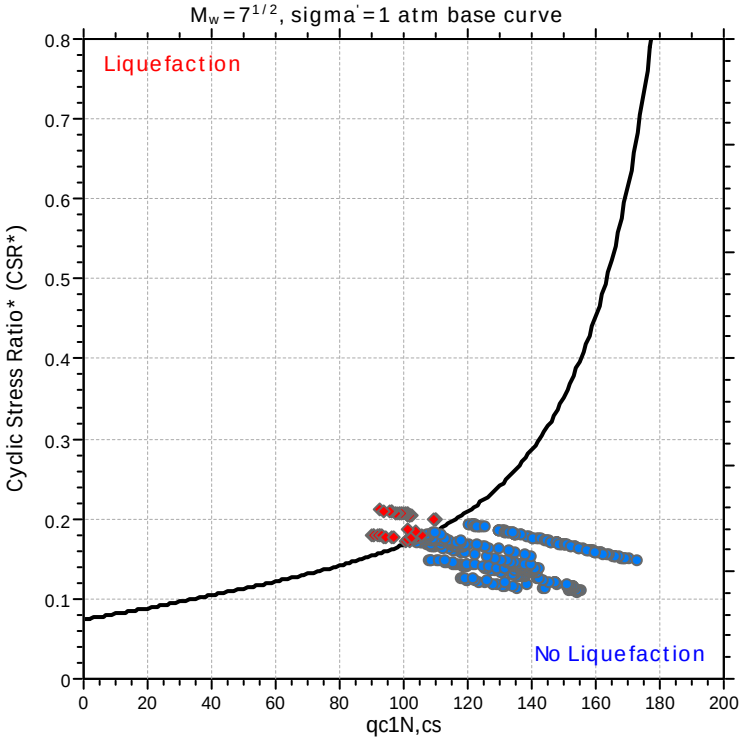
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSB001 û Norgrove Avenue

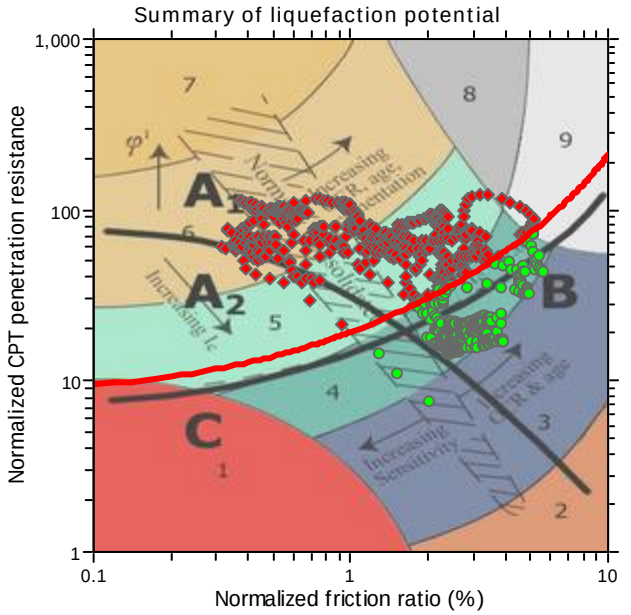
CPT file : L2S2-CPT01

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.93 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.93 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.50	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

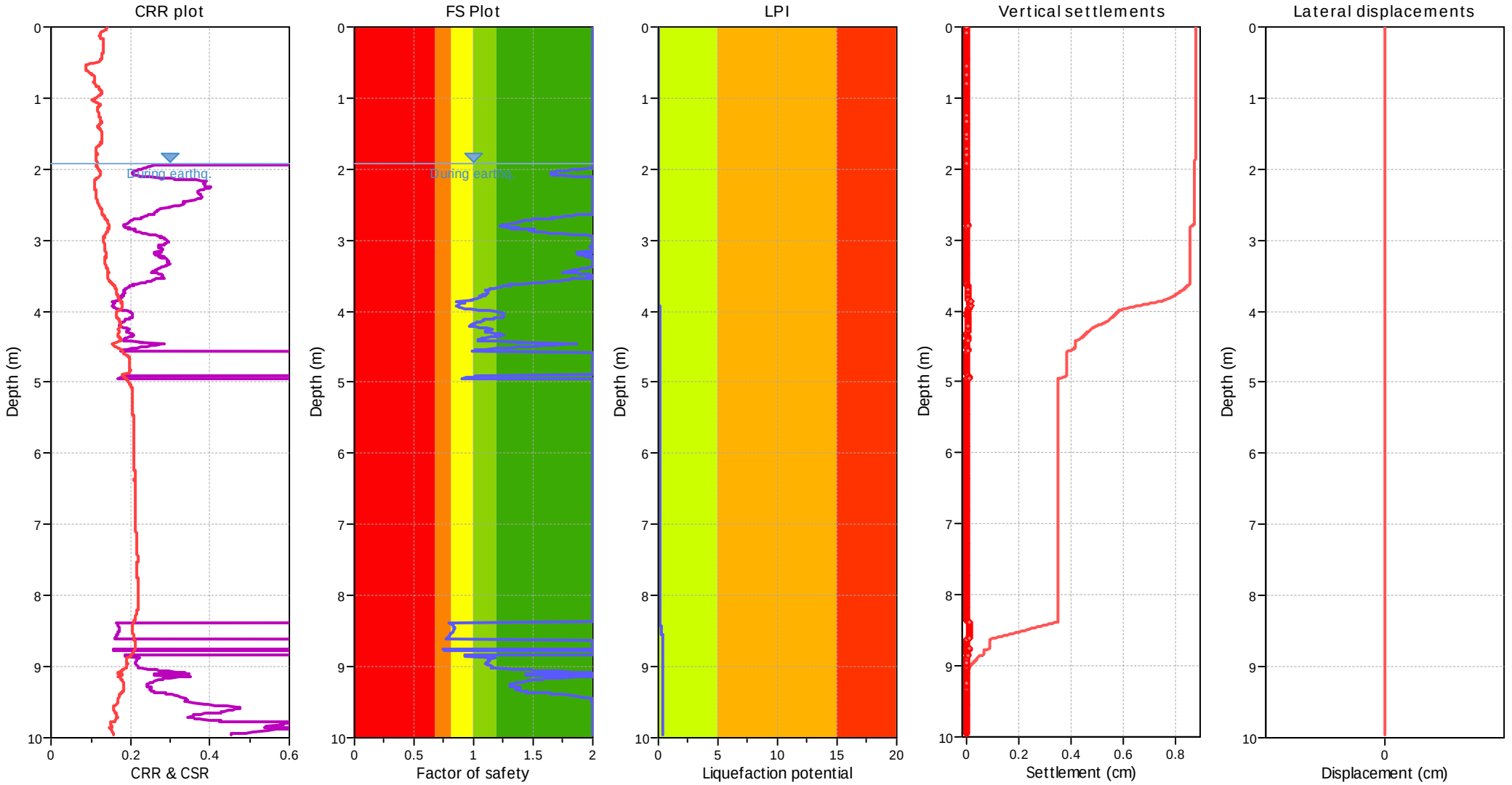






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.93 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.50	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.93 m	Fill height:	N/A	Limit depth:	N/A

F.S. color scheme

- Almost certain it will liquefy
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- Liquefaction and no liq. 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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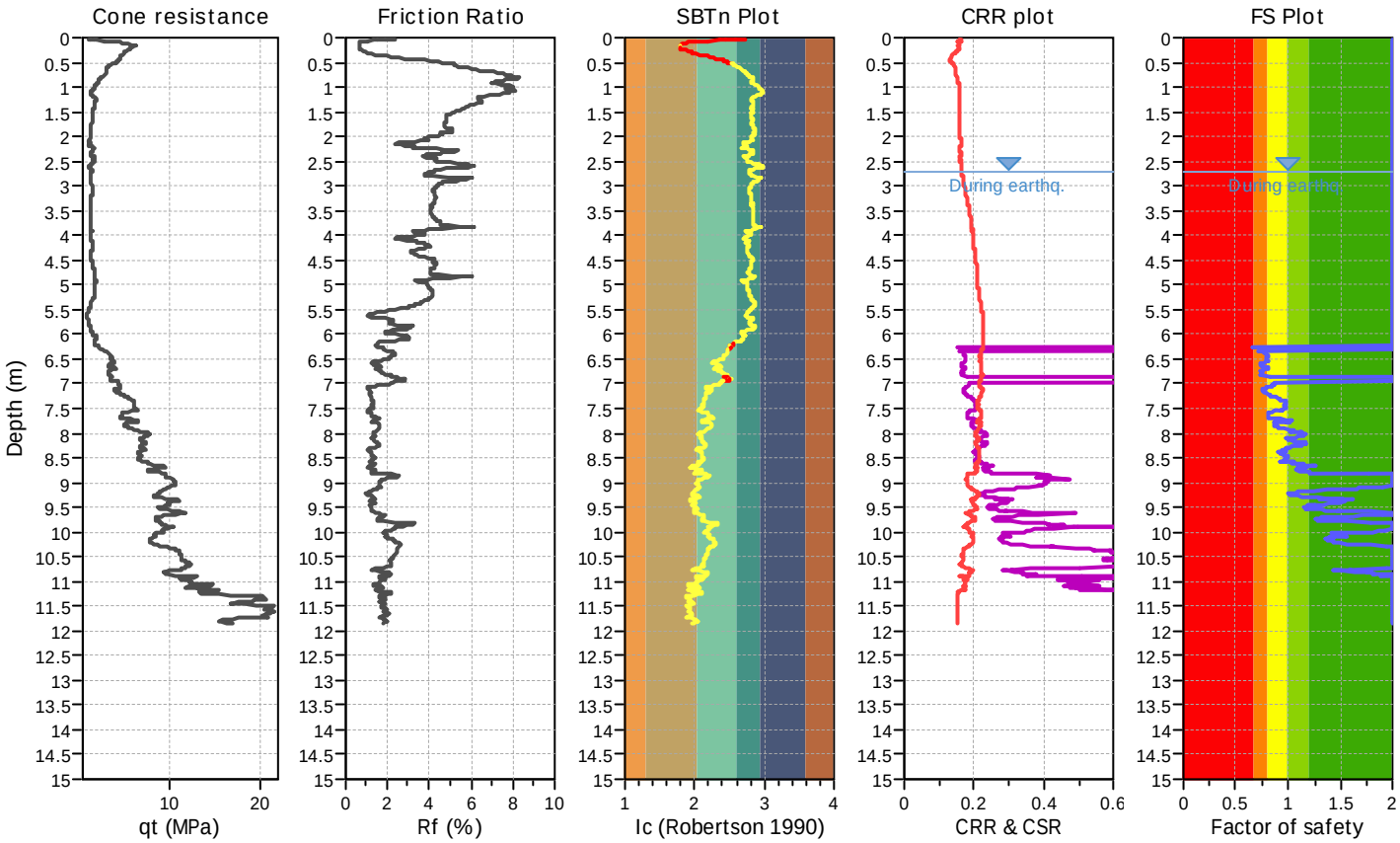
LIQUEFACTION ANALYSIS REPORT

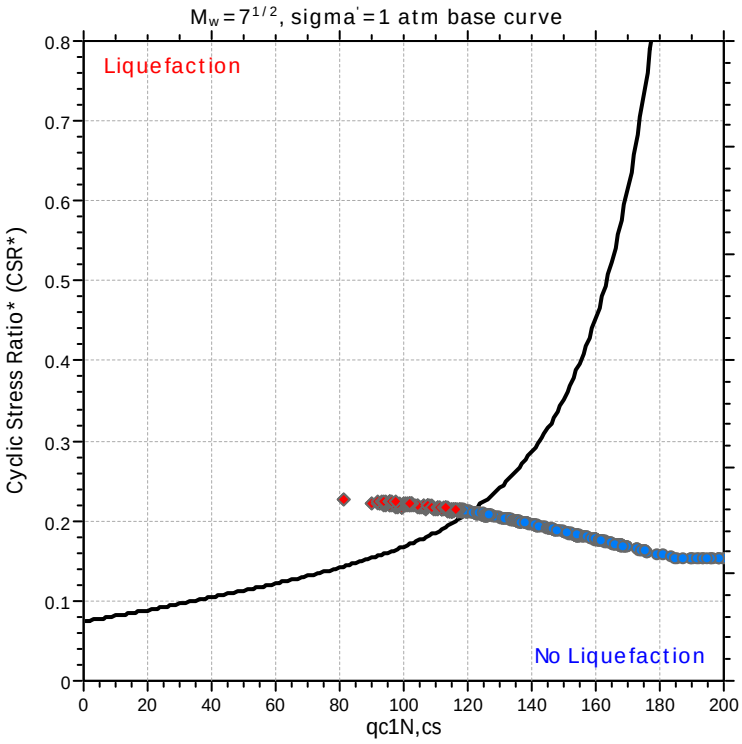
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSB002 û Rawalpindi Reserve

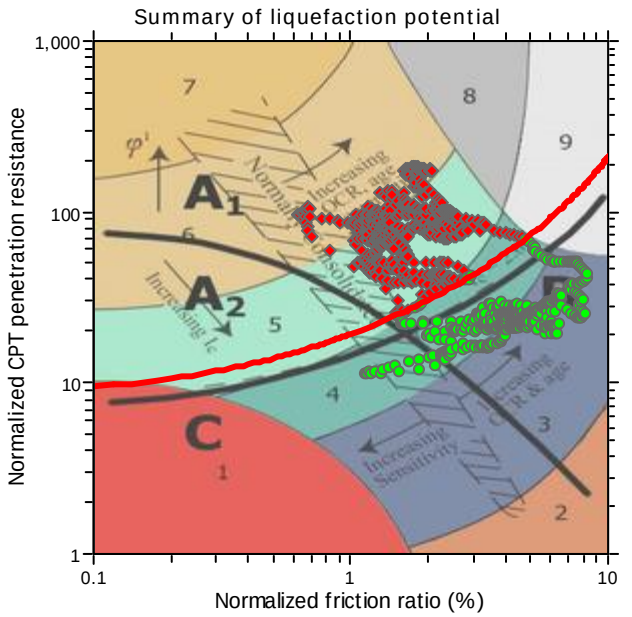
CPT file : L2S1-CPT02

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.50 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.70 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.50	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

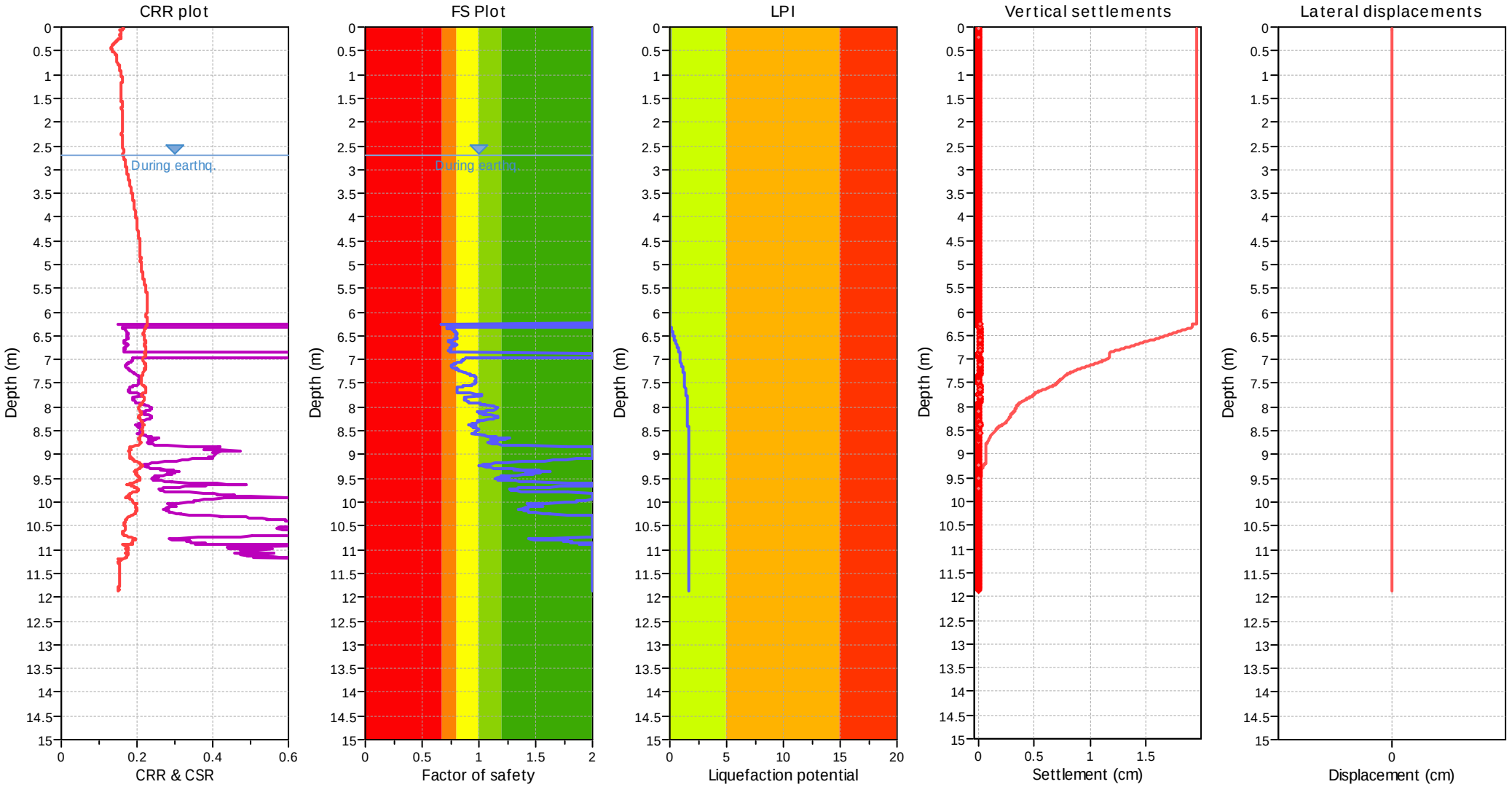






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.70 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.50	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.50 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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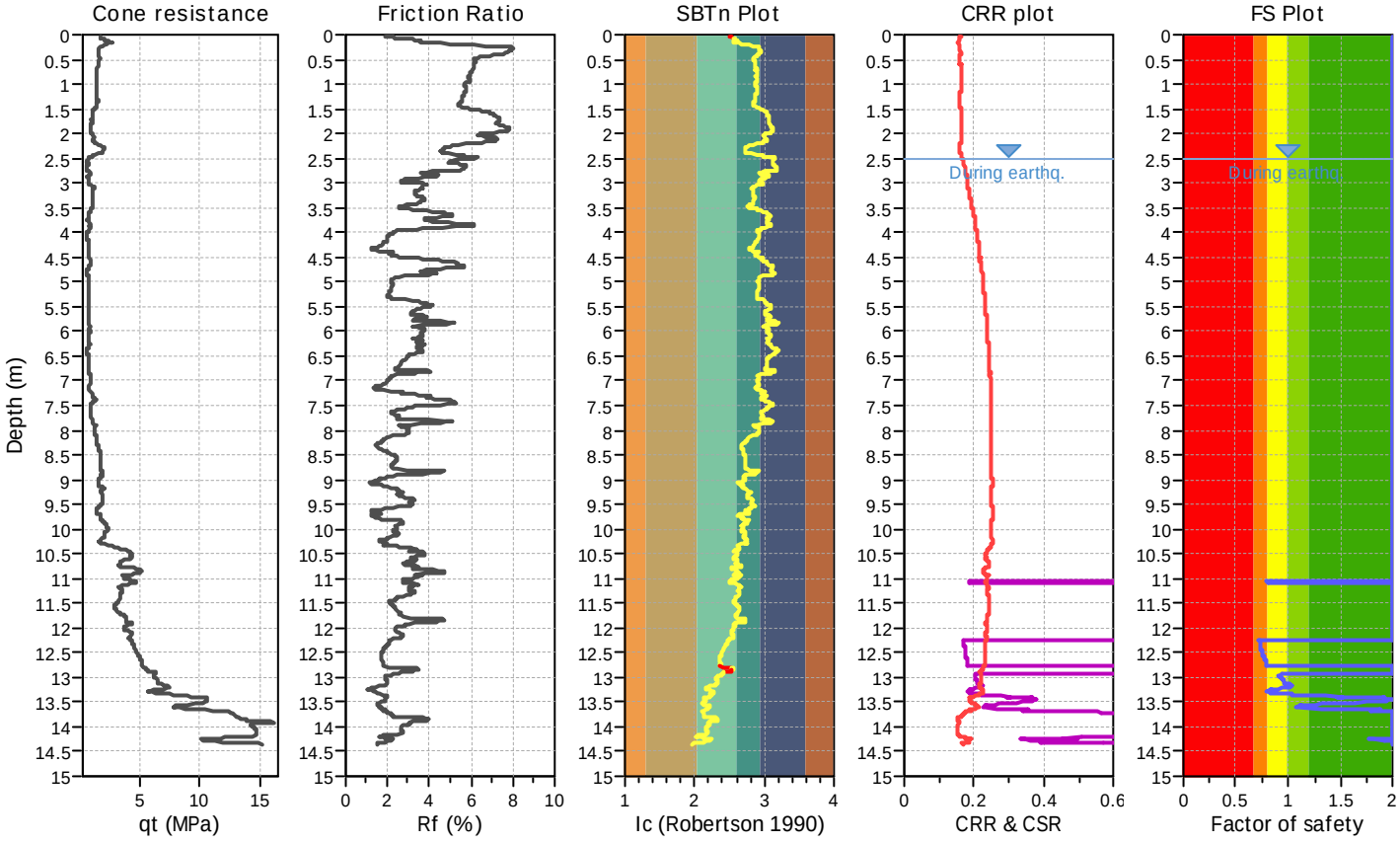
LIQUEFACTION ANALYSIS REPORT

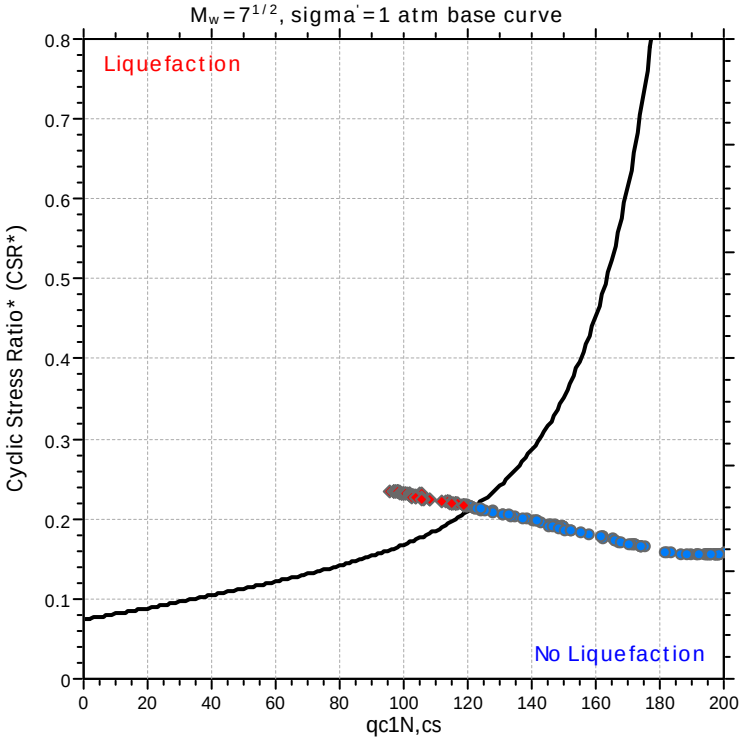
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSB002 û Rawalpindi Reserve

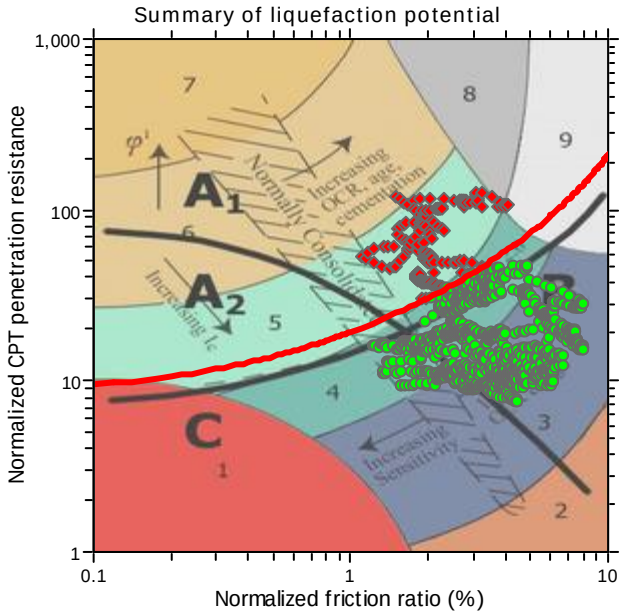
CPT file : L2S1-CPT03

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.50 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.50 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.50	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

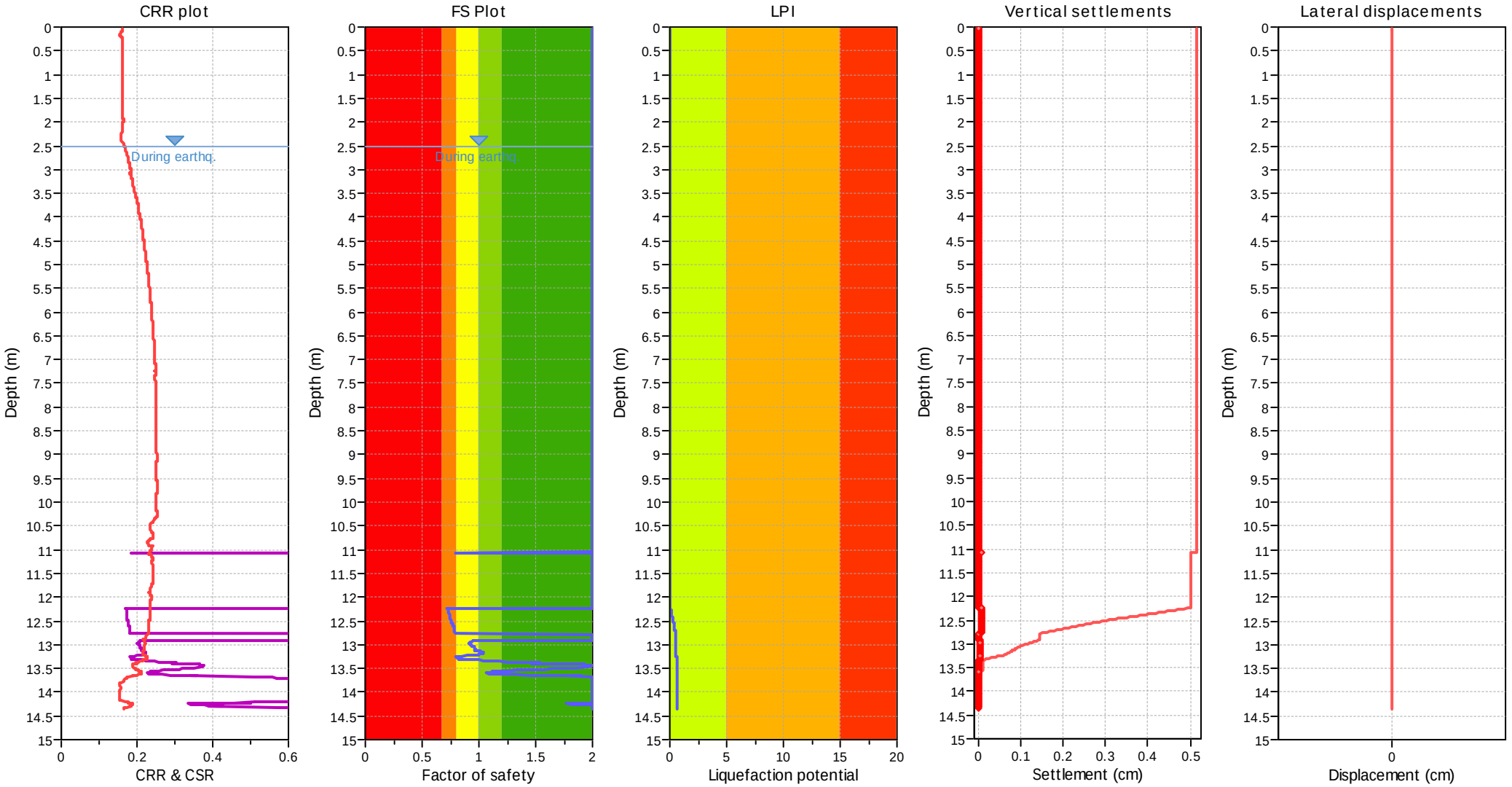






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.50	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.50 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
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- Unlike to liquefy
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LPI color scheme

- Very high risk
- High risk
- Low risk

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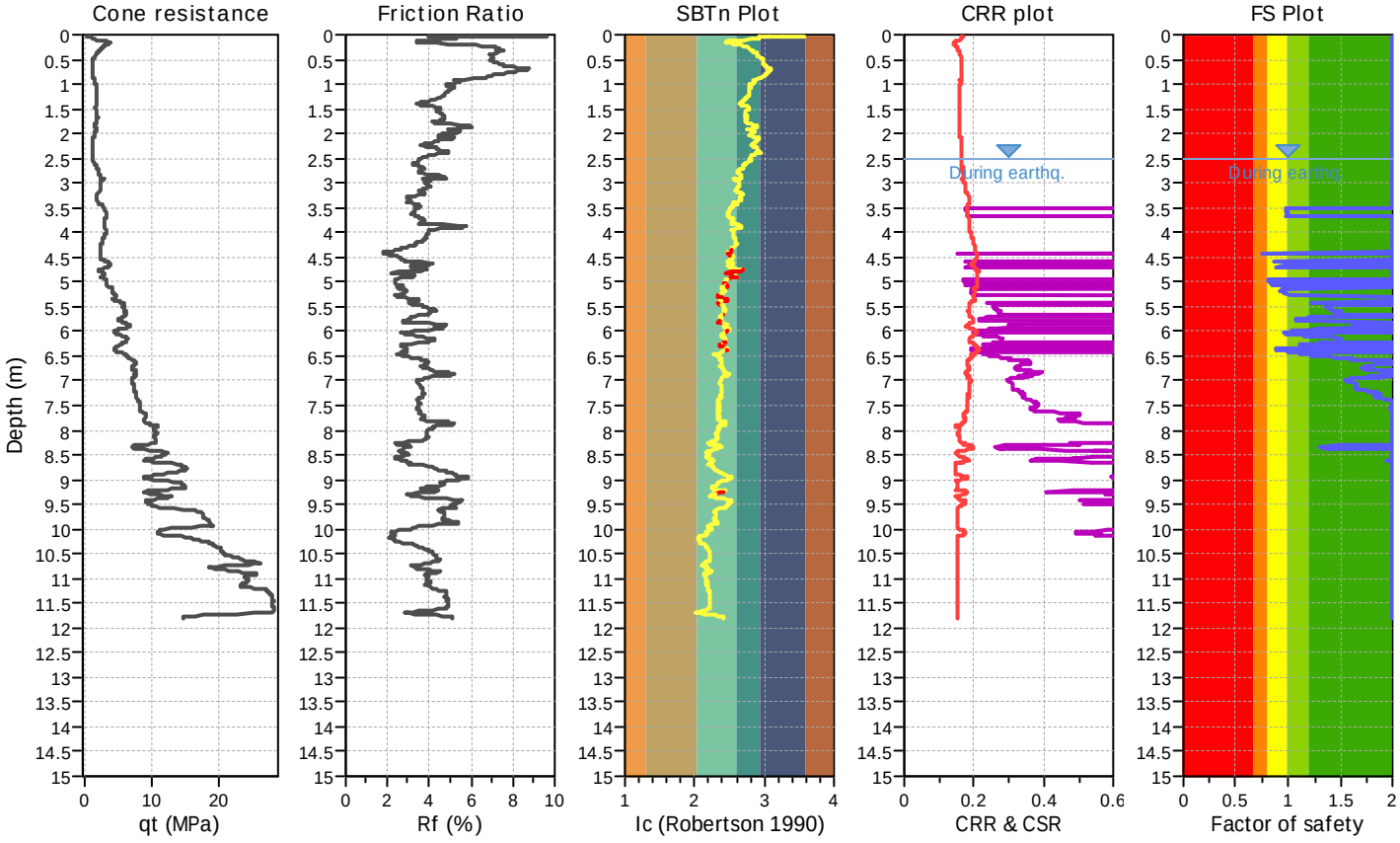
LIQUEFACTION ANALYSIS REPORT

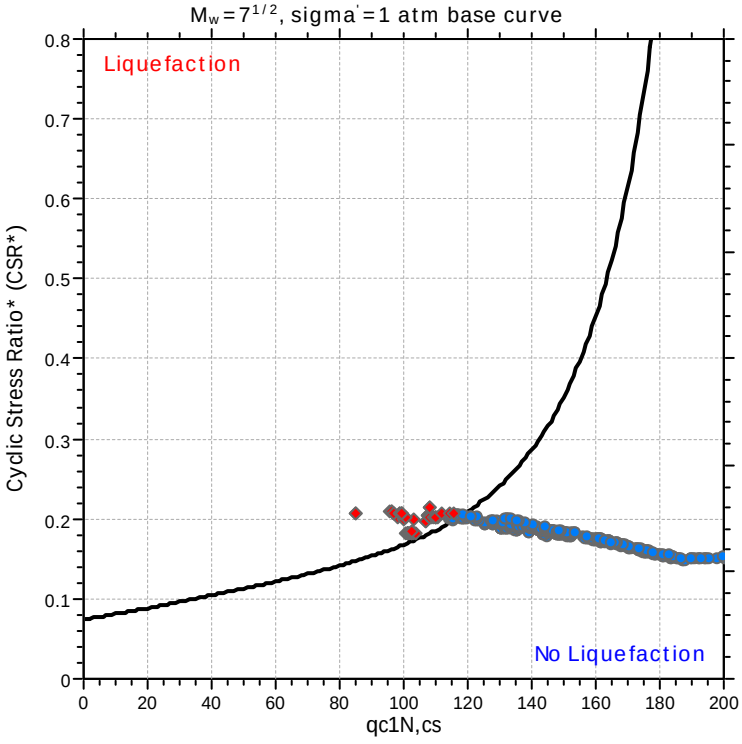
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSB002 û Rawalpindi Reserve

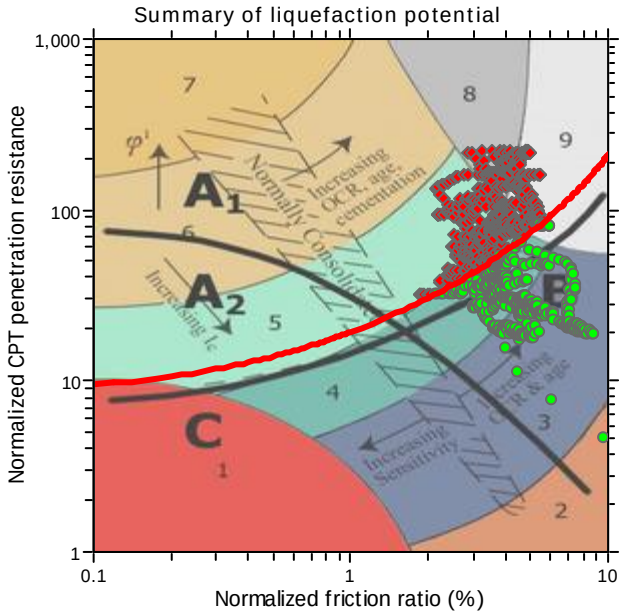
CPT file : L2S1-CPT04

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.50 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.50 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.50	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

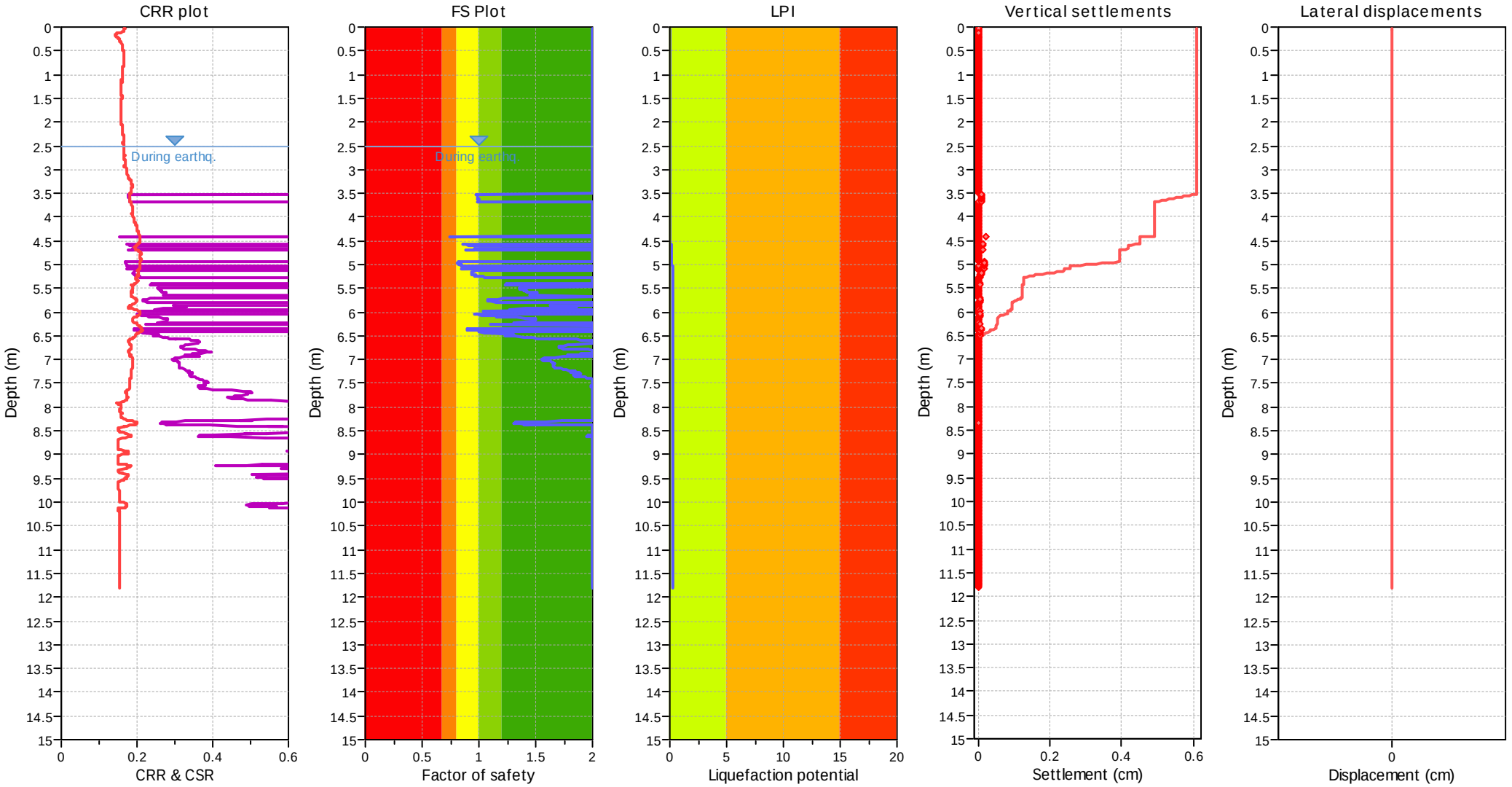






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.50	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.50 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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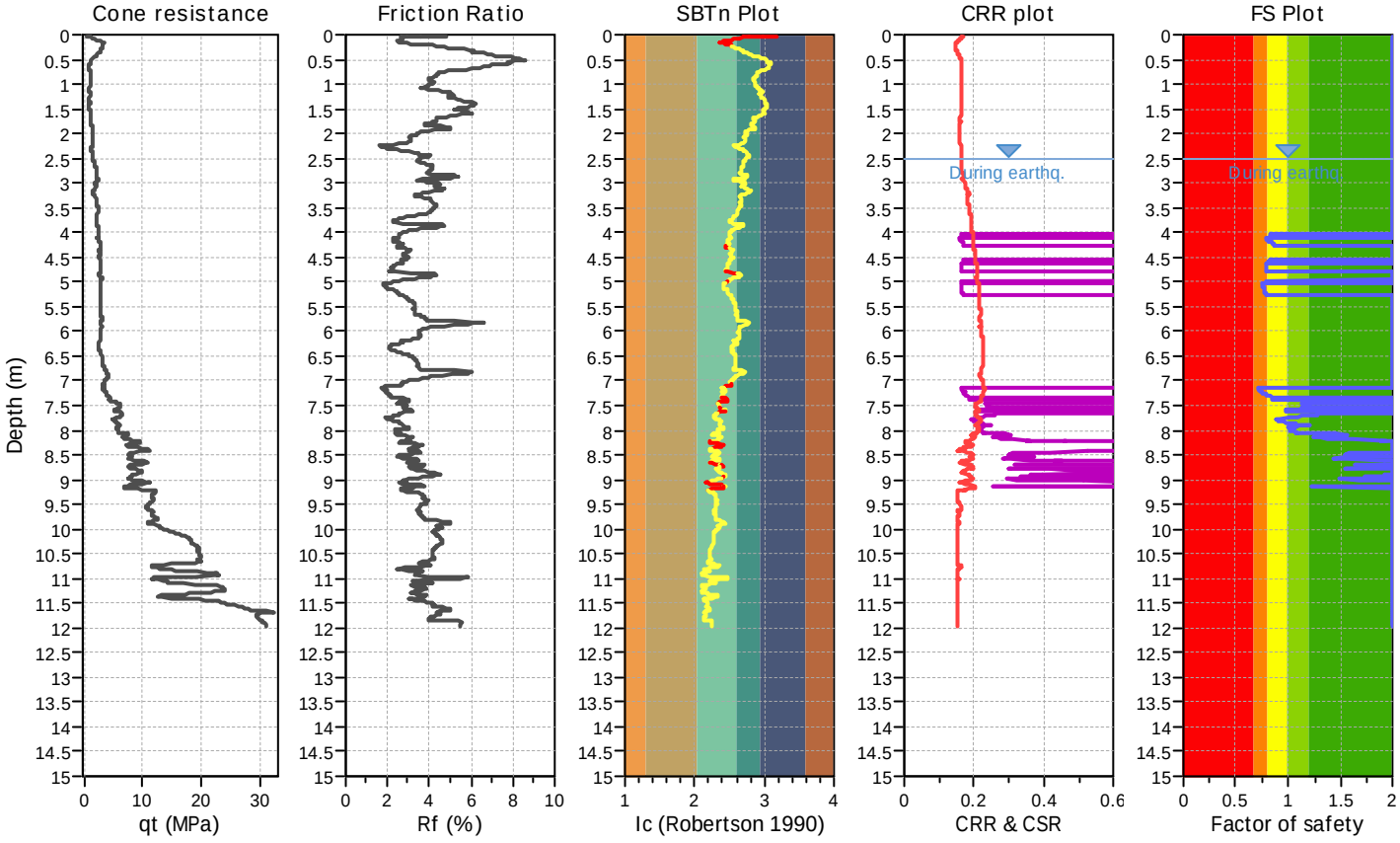
LIQUEFACTION ANALYSIS REPORT

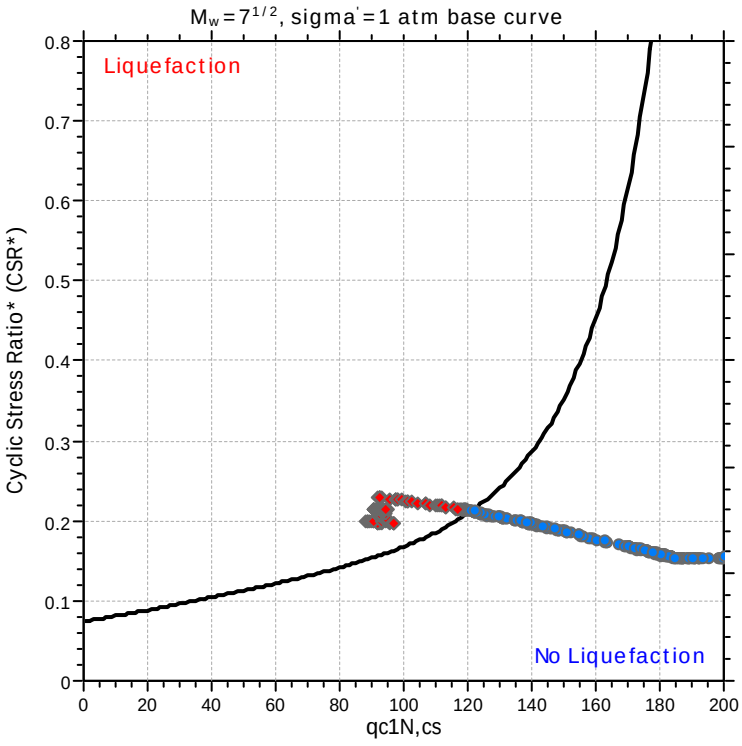
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSB002 û Rawalpindi Reserve

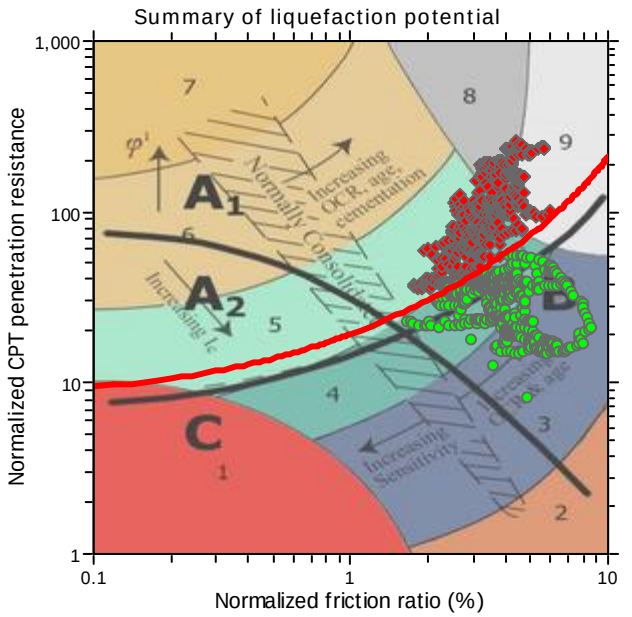
CPT file : L2S1-CPT05

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.50 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.50 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.50	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

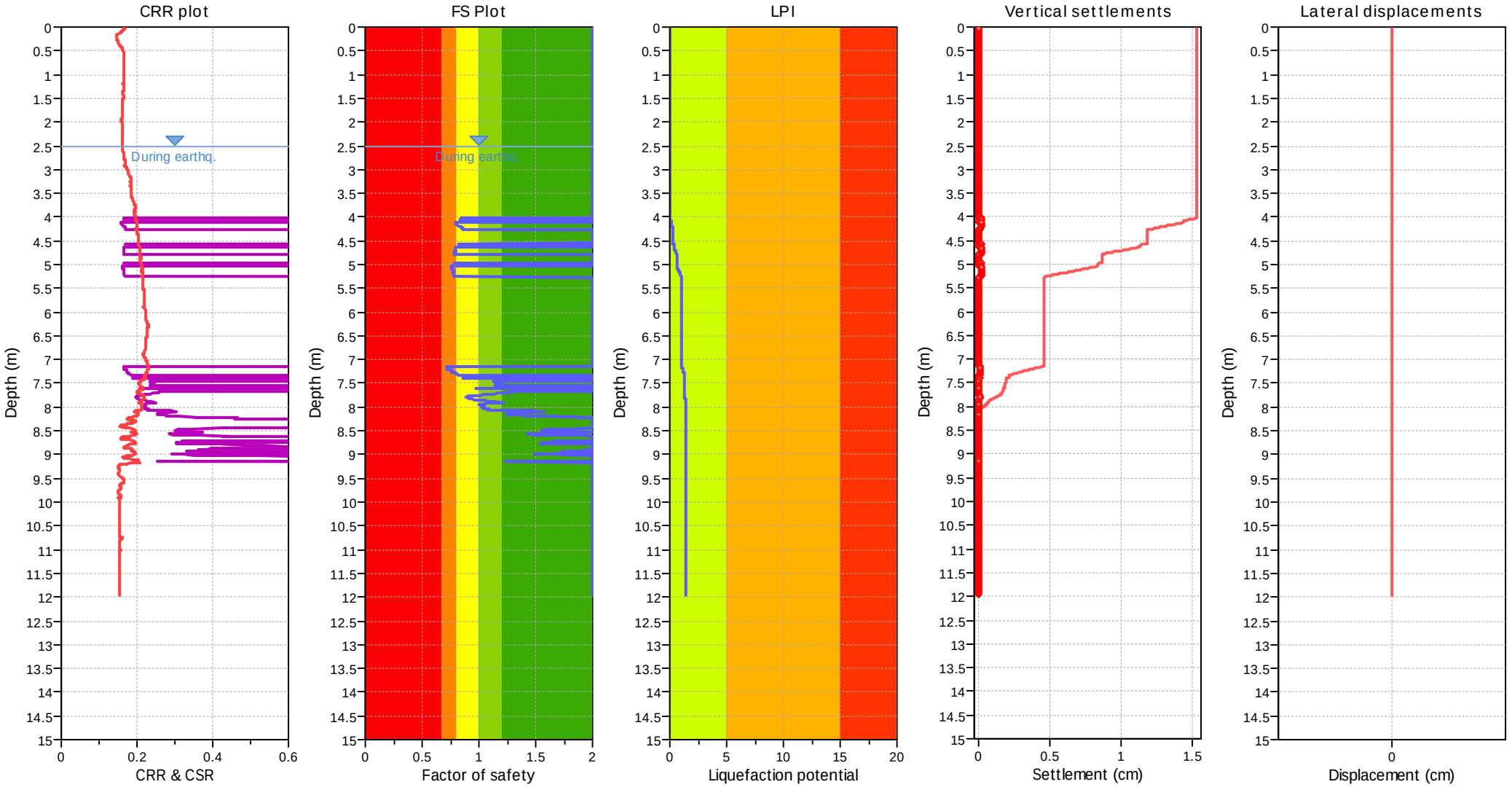






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.50	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.50 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
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- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

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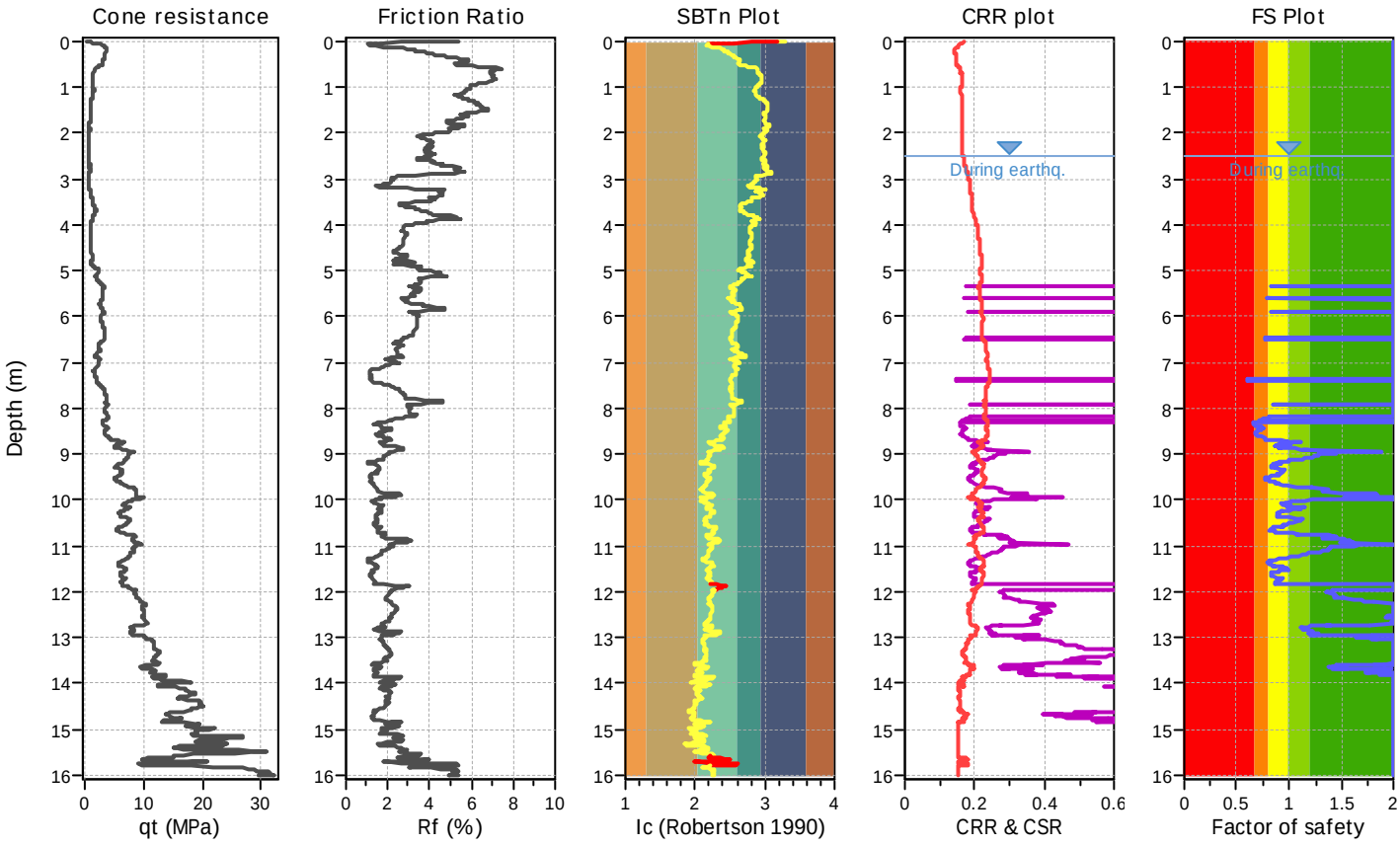
LIQUEFACTION ANALYSIS REPORT

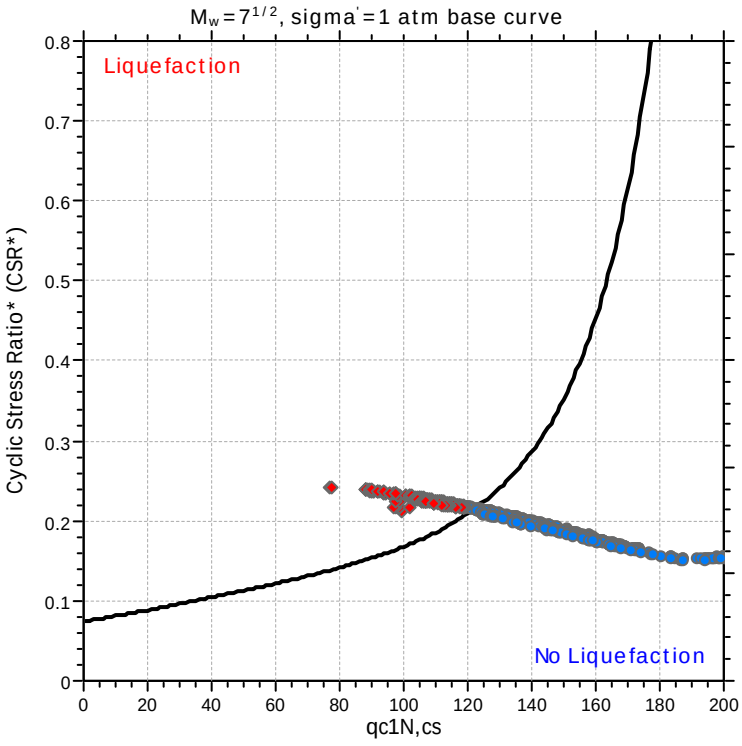
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSB002 û Rawalpindi Reserve

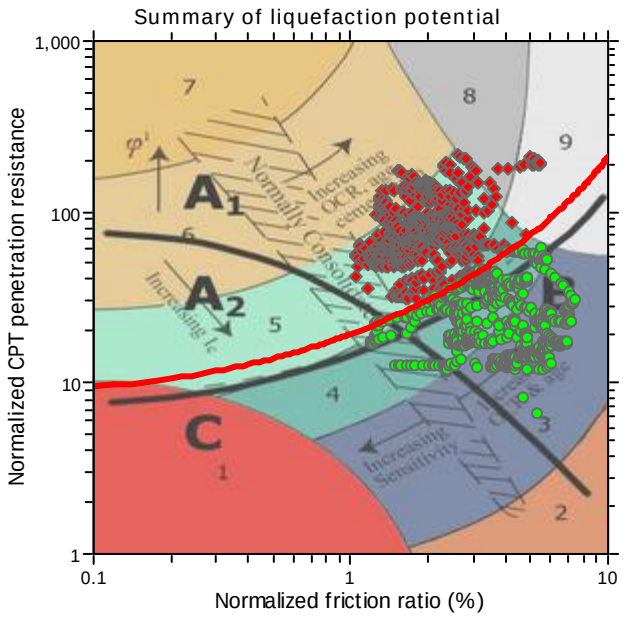
CPT file : L2S1-CPT01

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.50 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.50 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.50	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

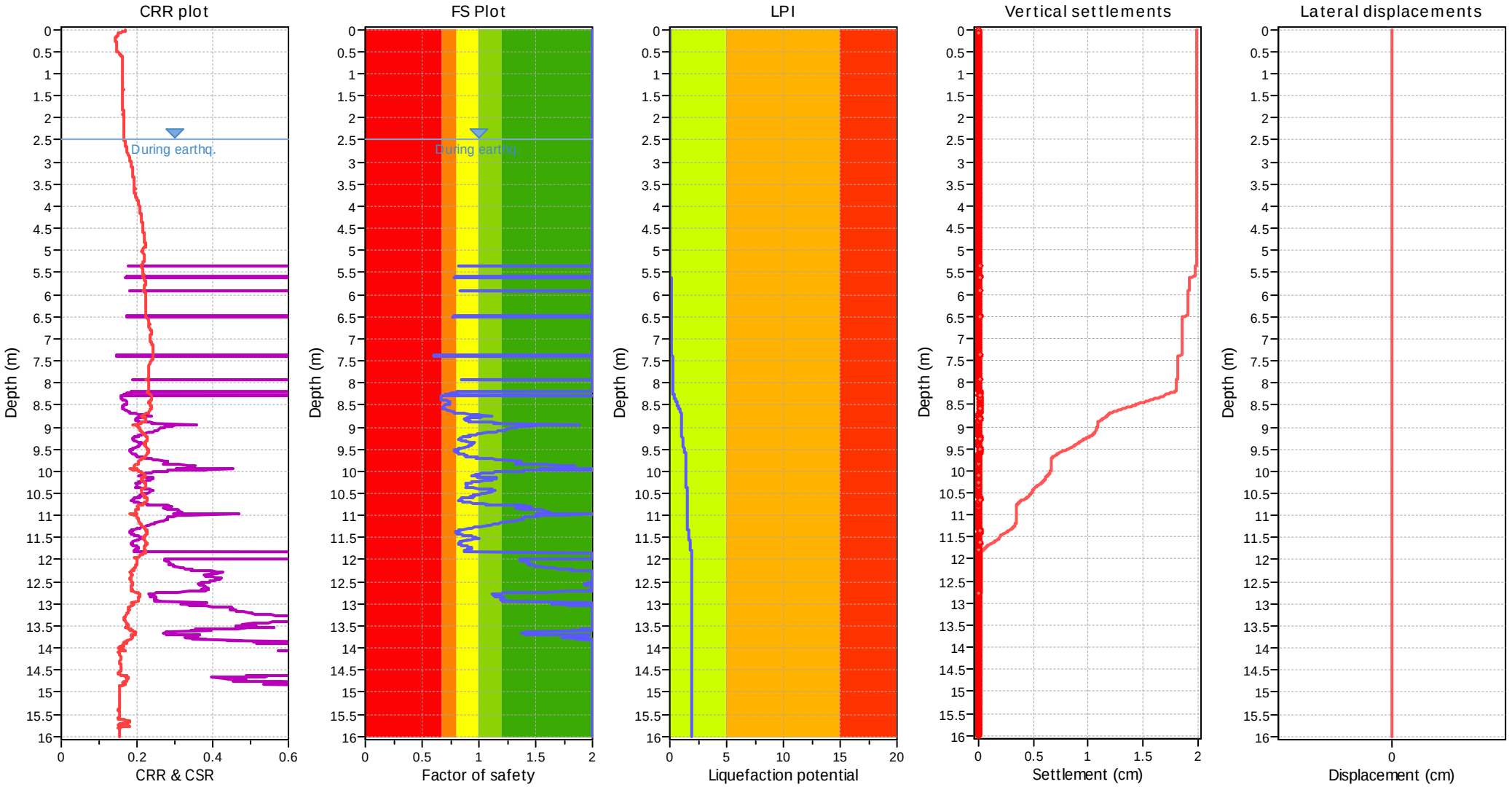






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.50	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.50 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

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- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

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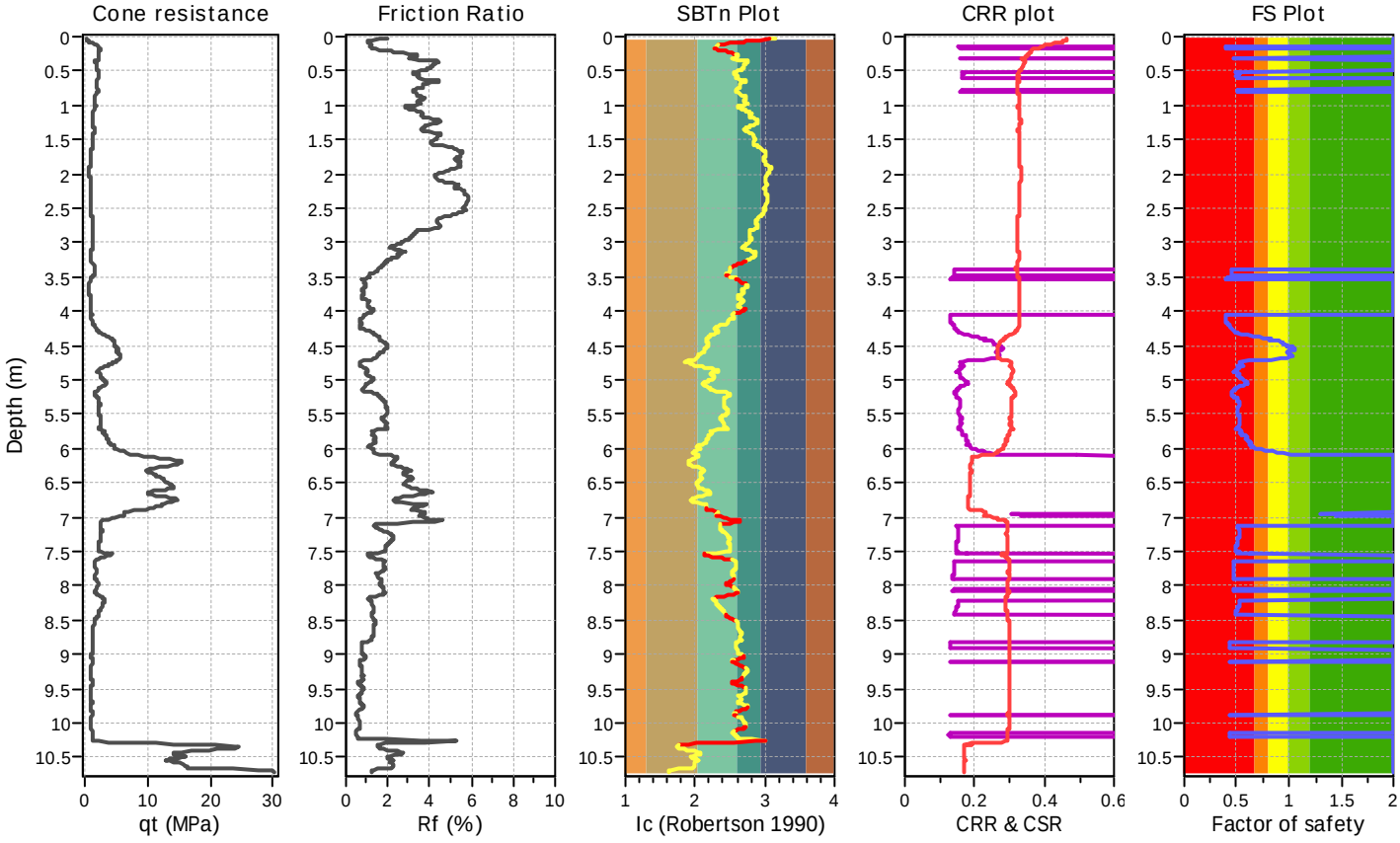
LIQUEFACTION ANALYSIS REPORT

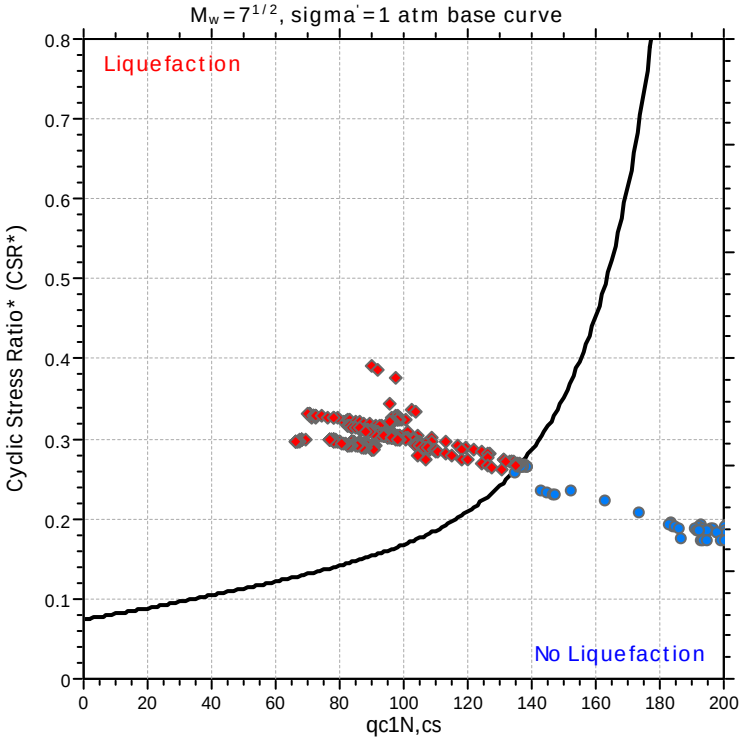
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSC001 – Haycock Avenue

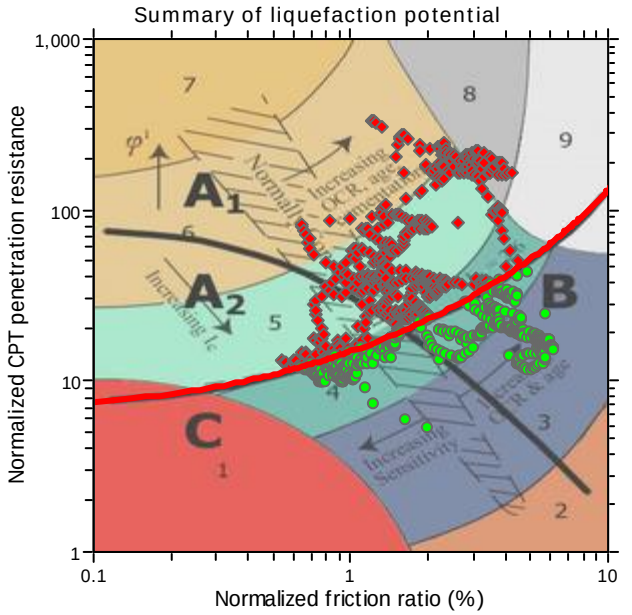
CPT file : L3S5-CPT01

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

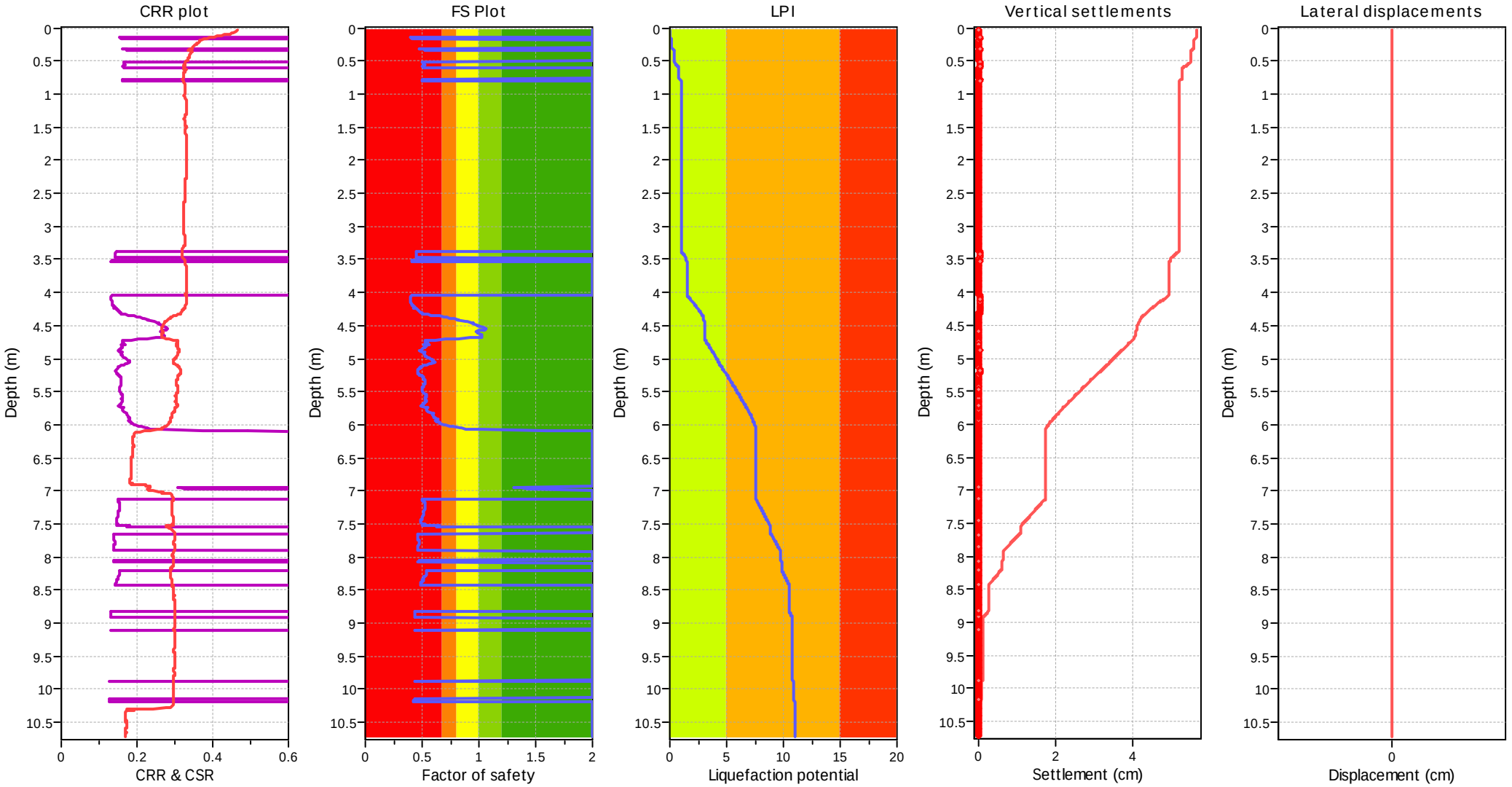






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	N/A

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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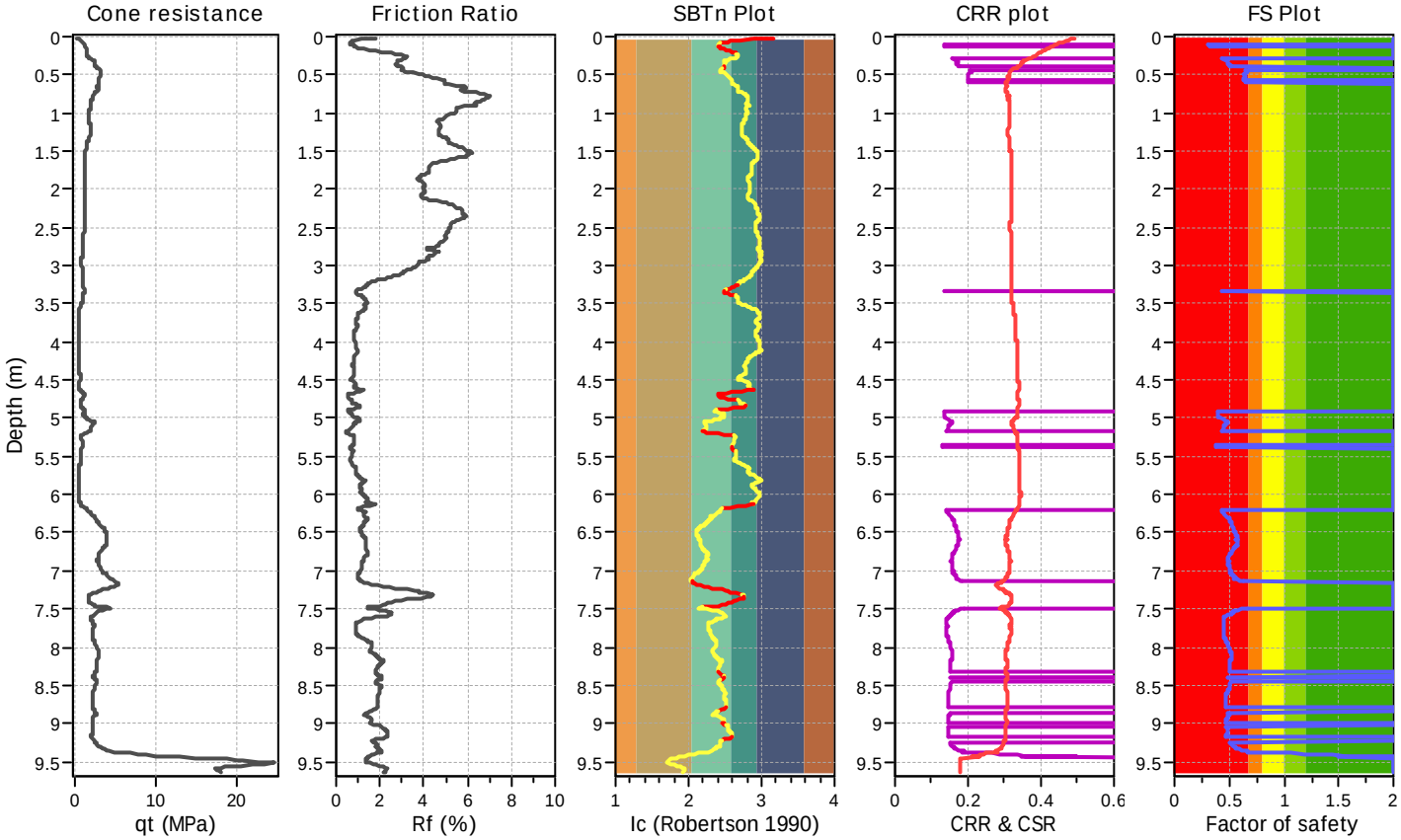
LIQUEFACTION ANALYSIS REPORT

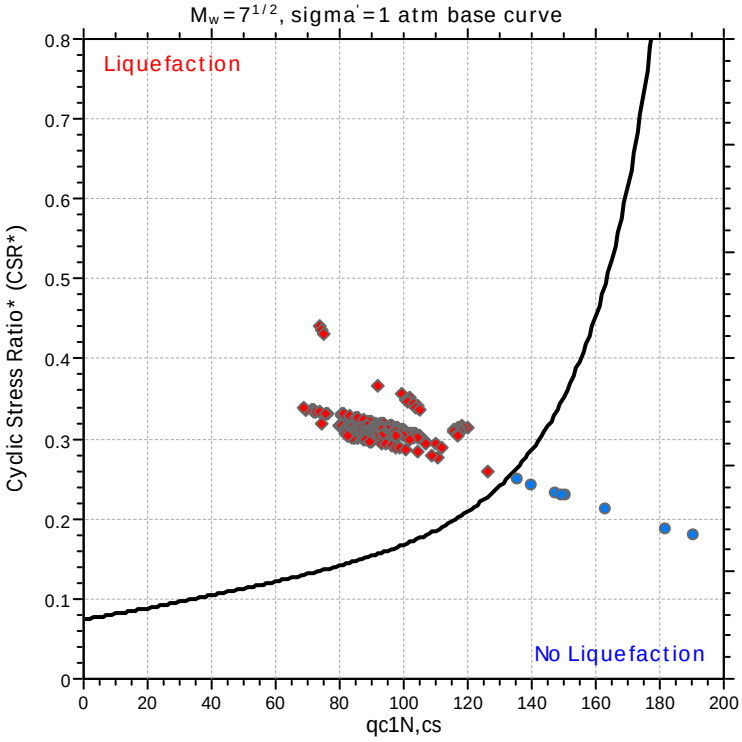
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSC001 – Haycock Avenue

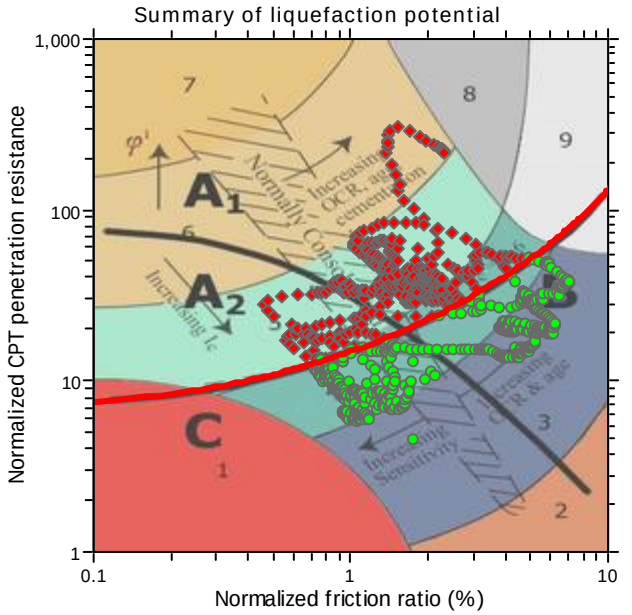
CPT file : L3S5-CPT02

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

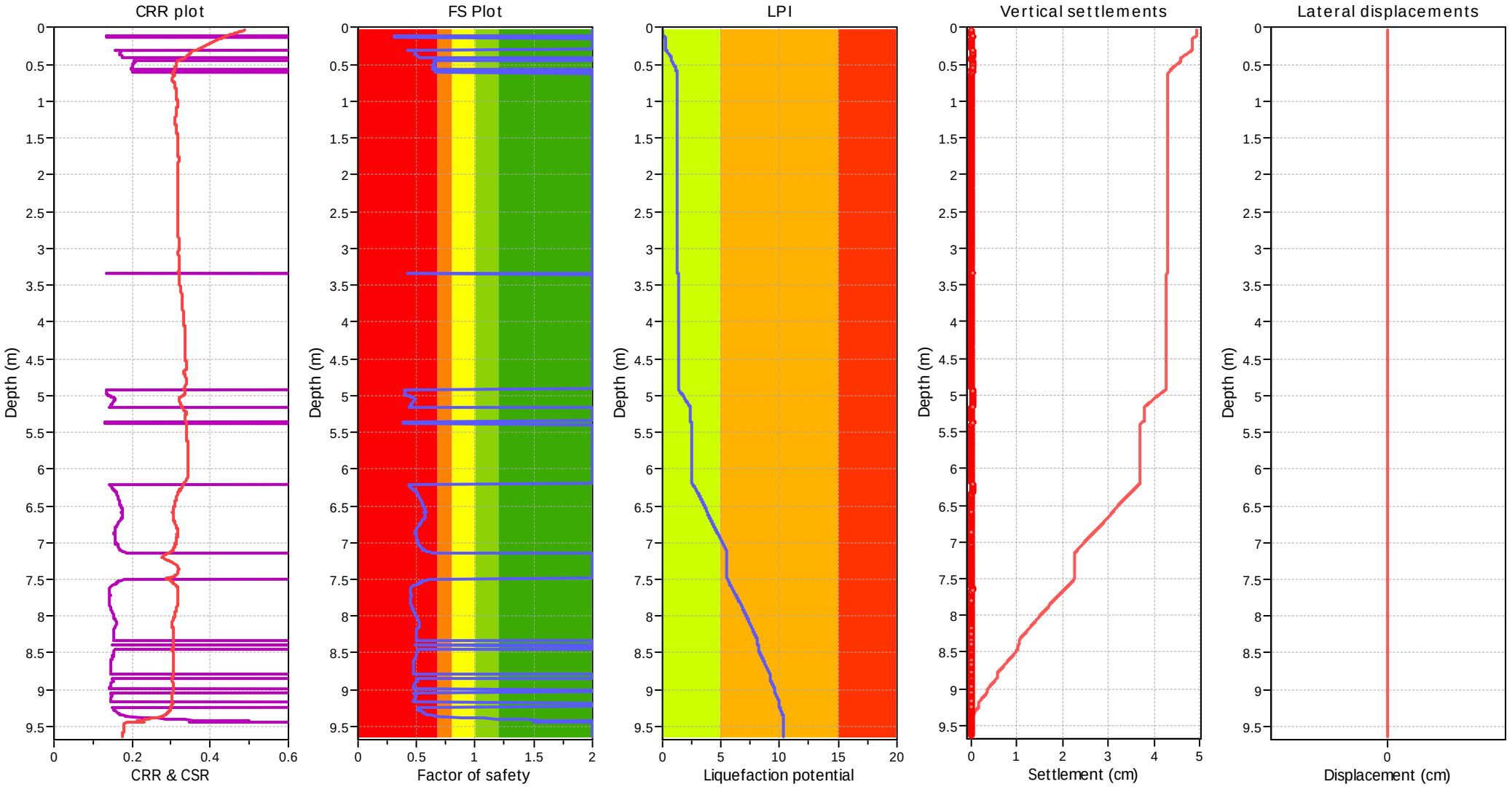






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	N/A

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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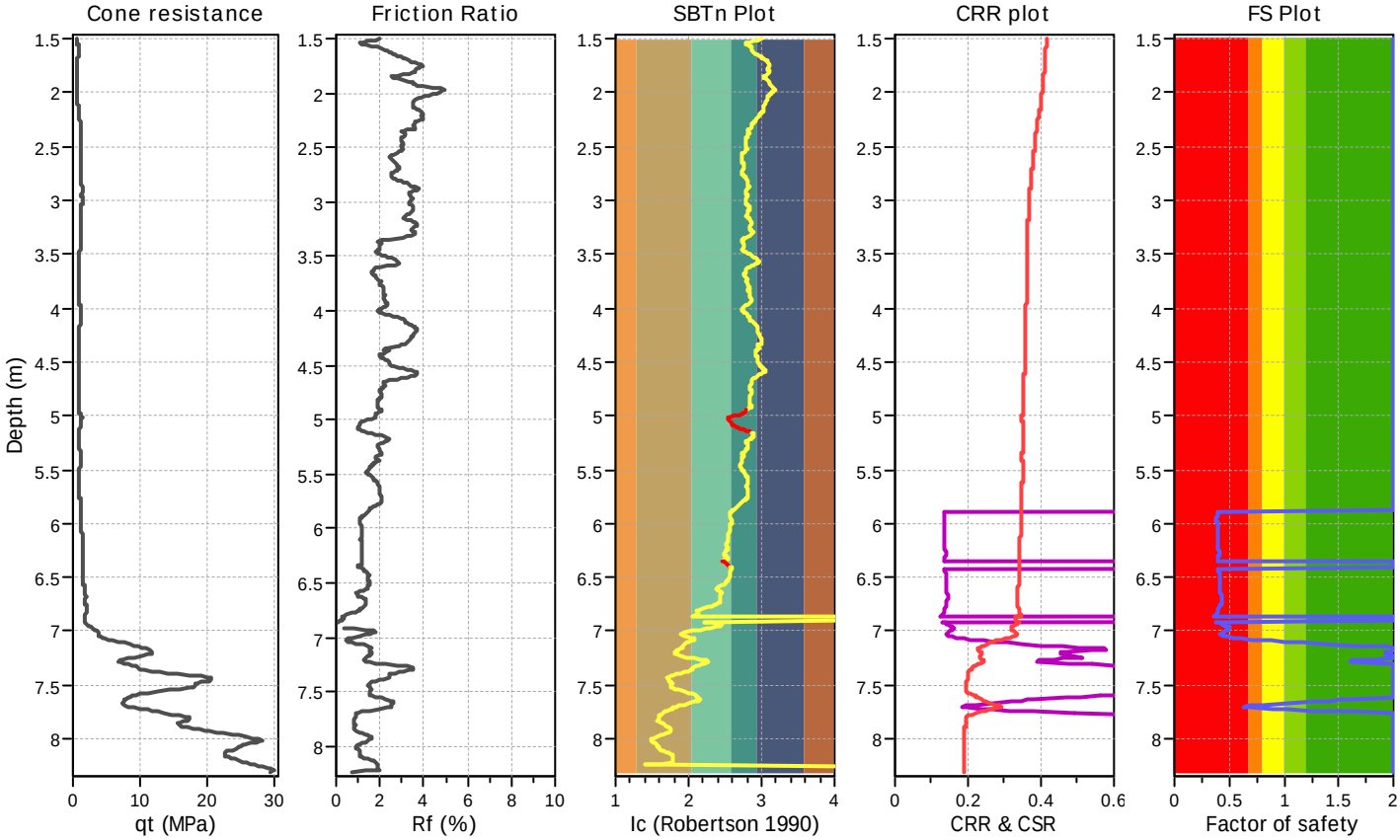
LIQUEFACTION ANALYSIS REPORT

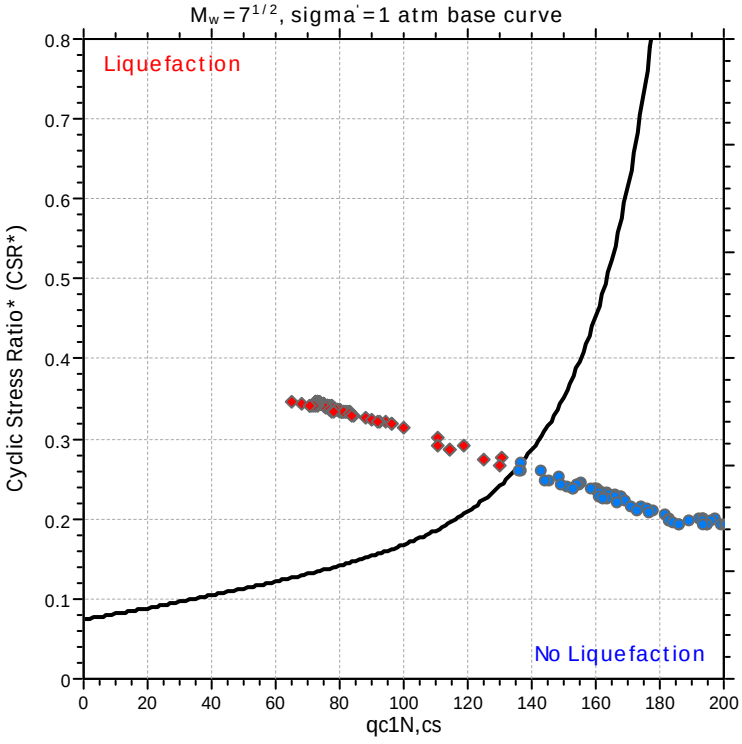
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSC001 – Haycock Avenue

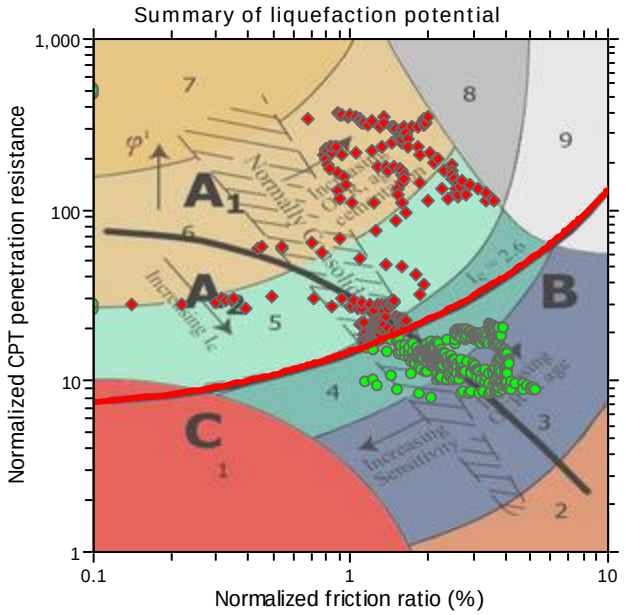
CPT file : L3S5-CPT03

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

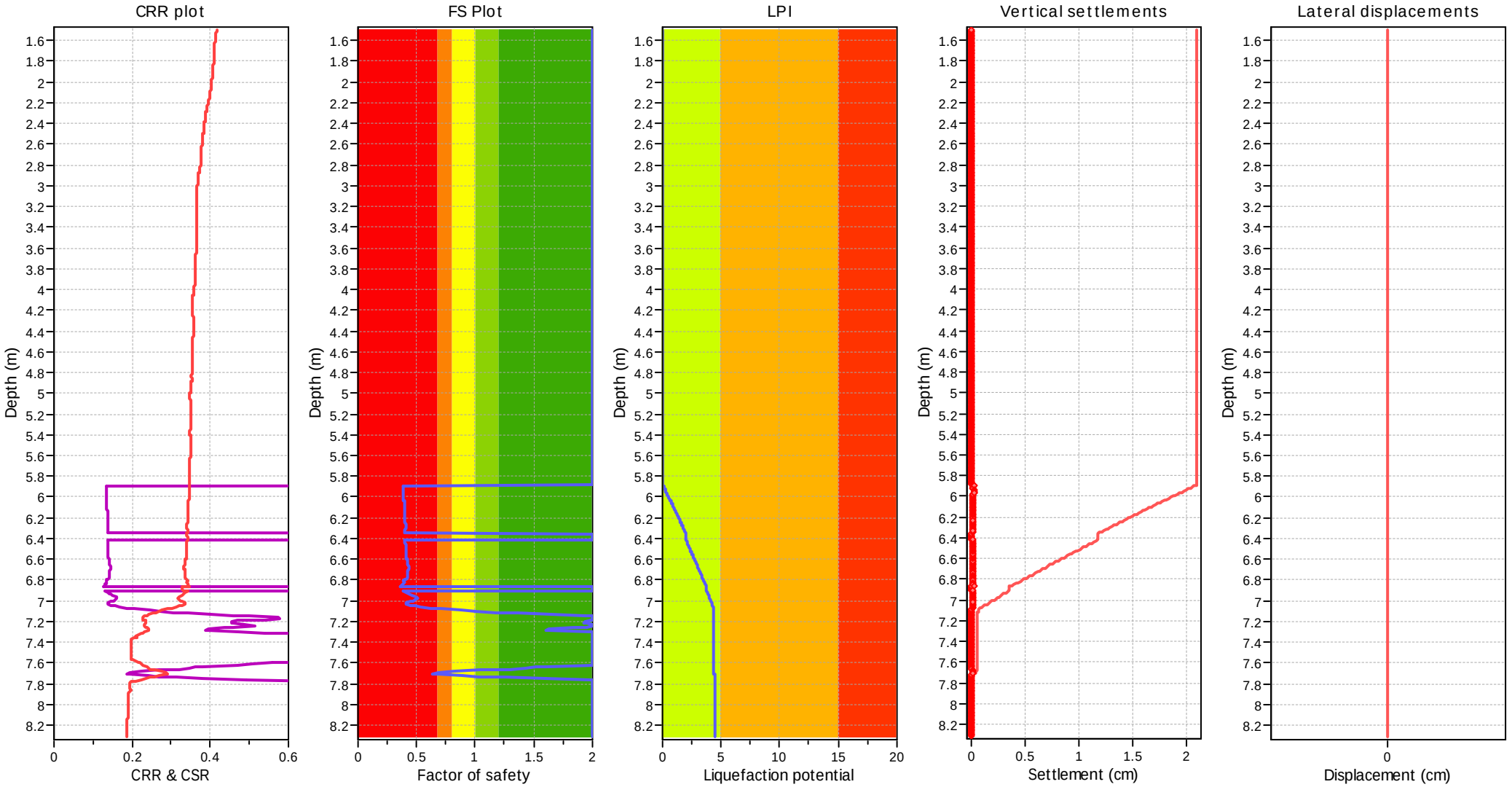






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	N/A

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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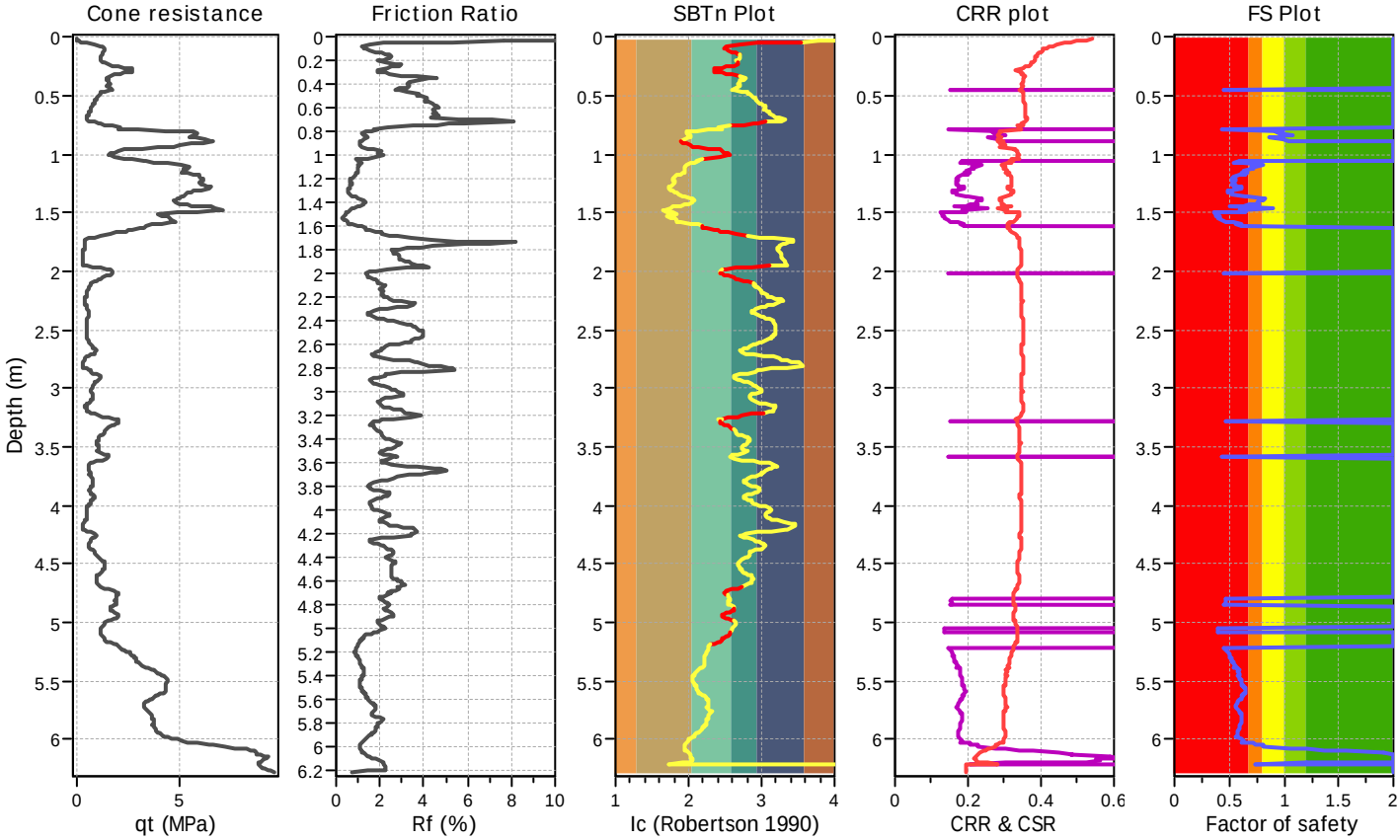
LIQUEFACTION ANALYSIS REPORT

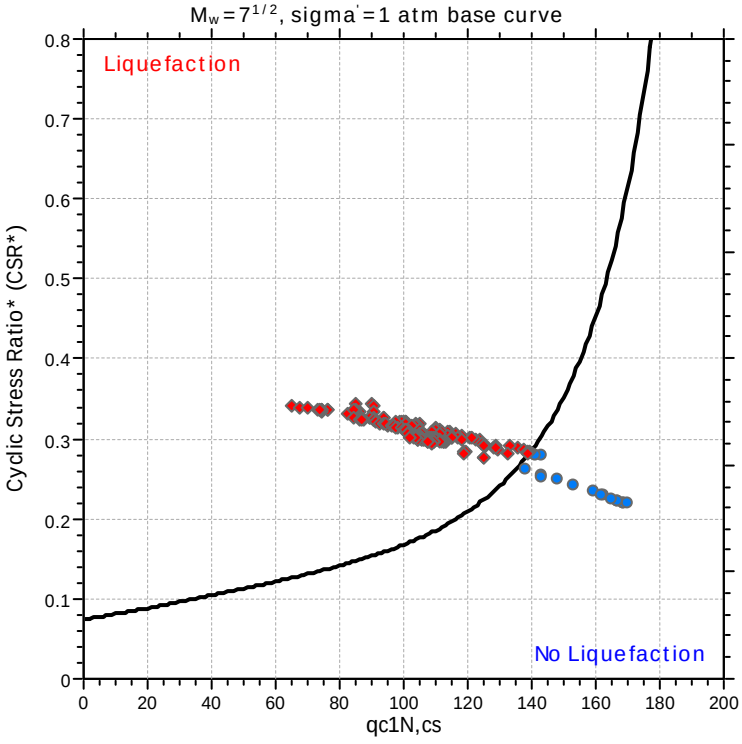
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSC001 – Haycock Avenue

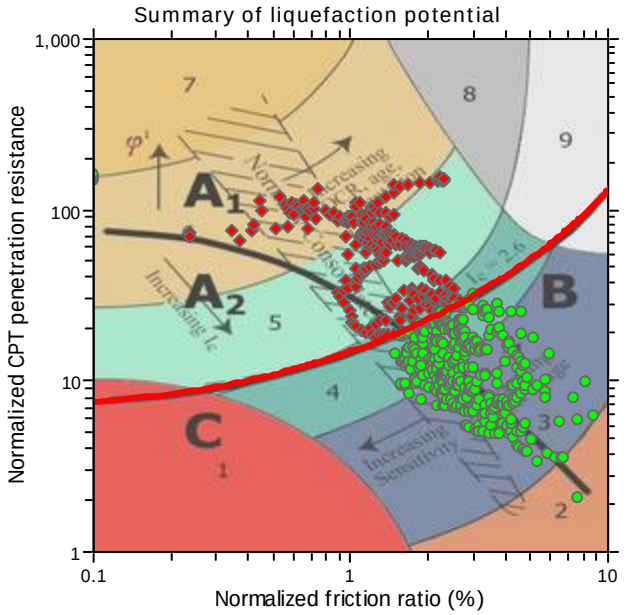
CPT file : L3S5-CPT04

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

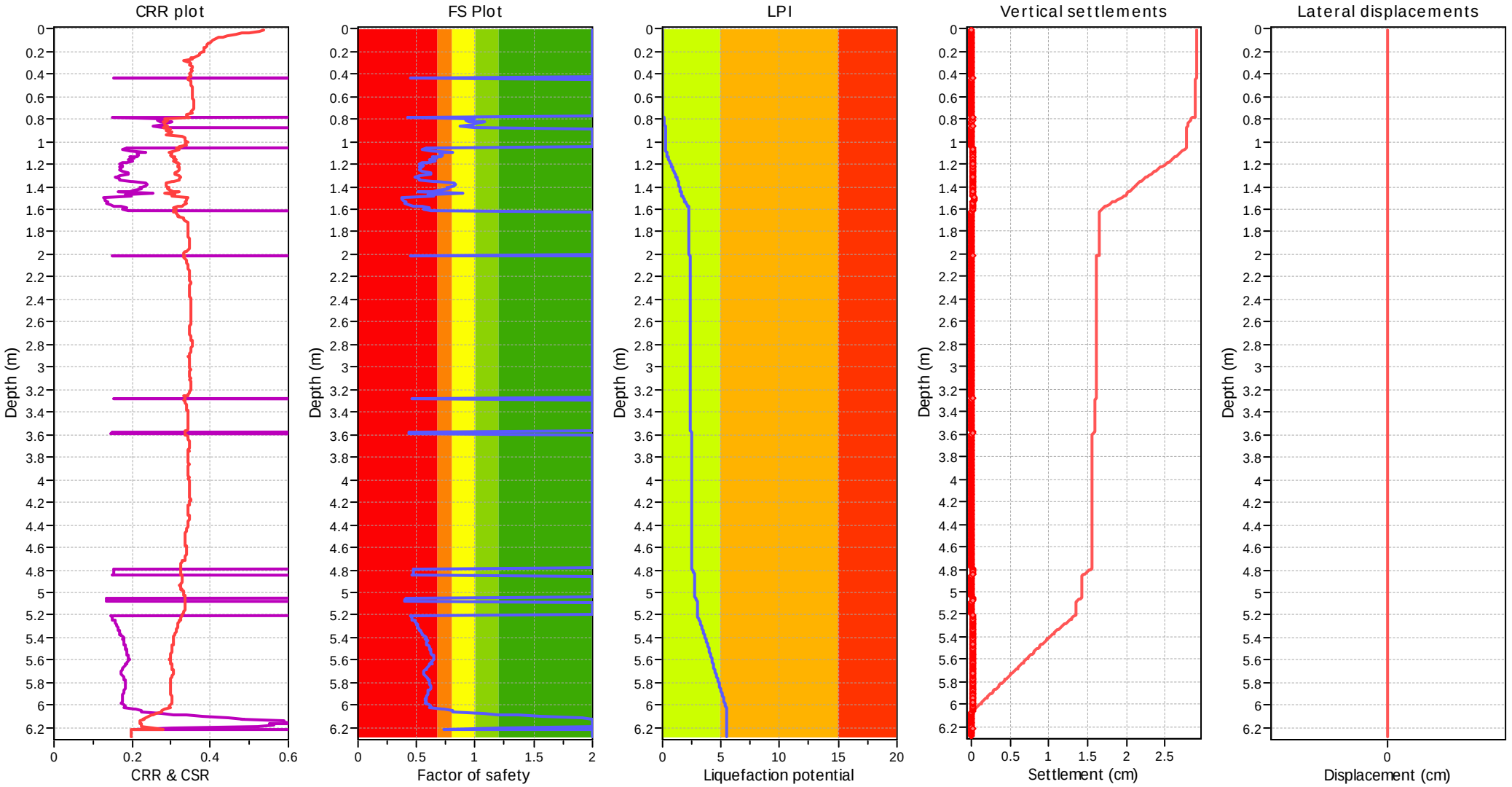






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	N/A

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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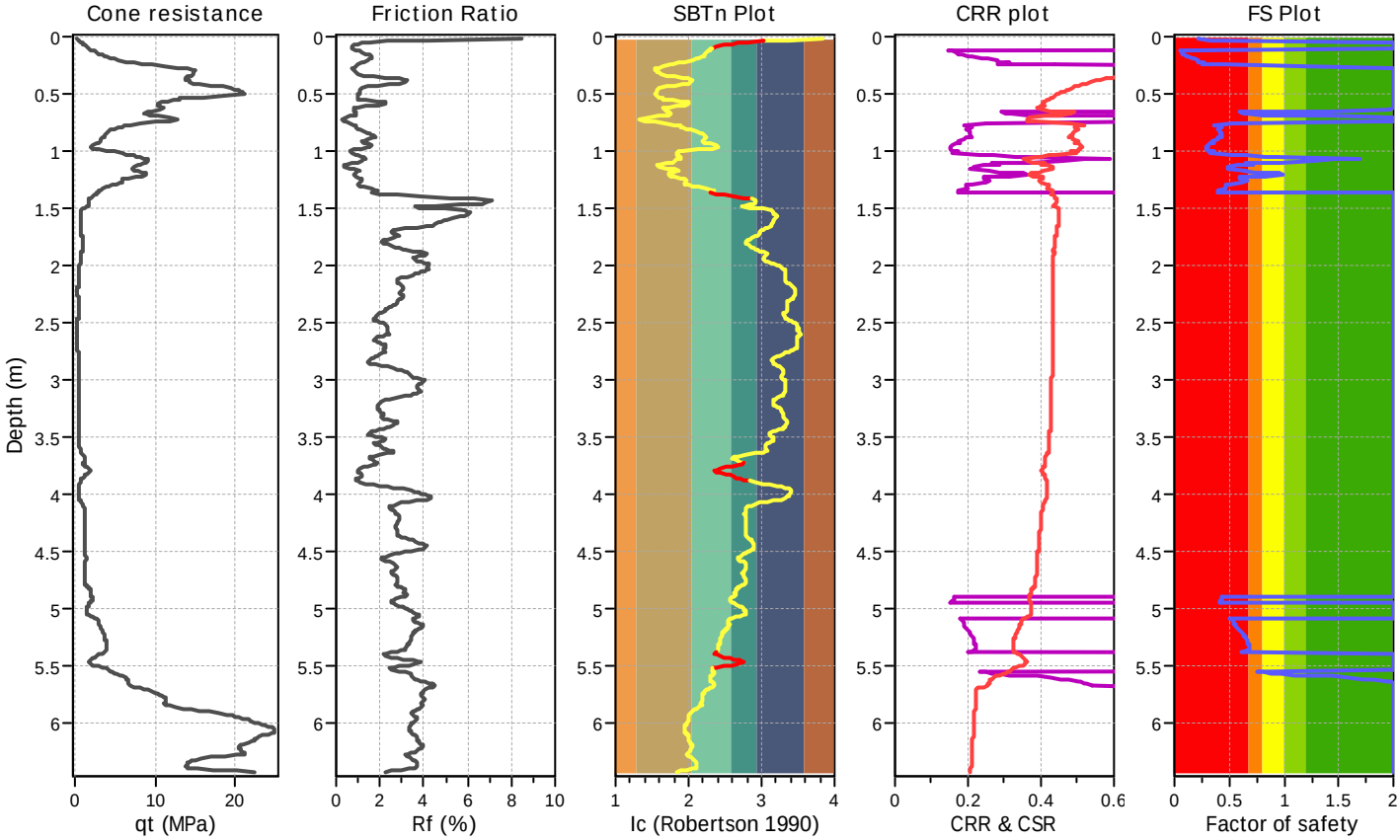
LIQUEFACTION ANALYSIS REPORT

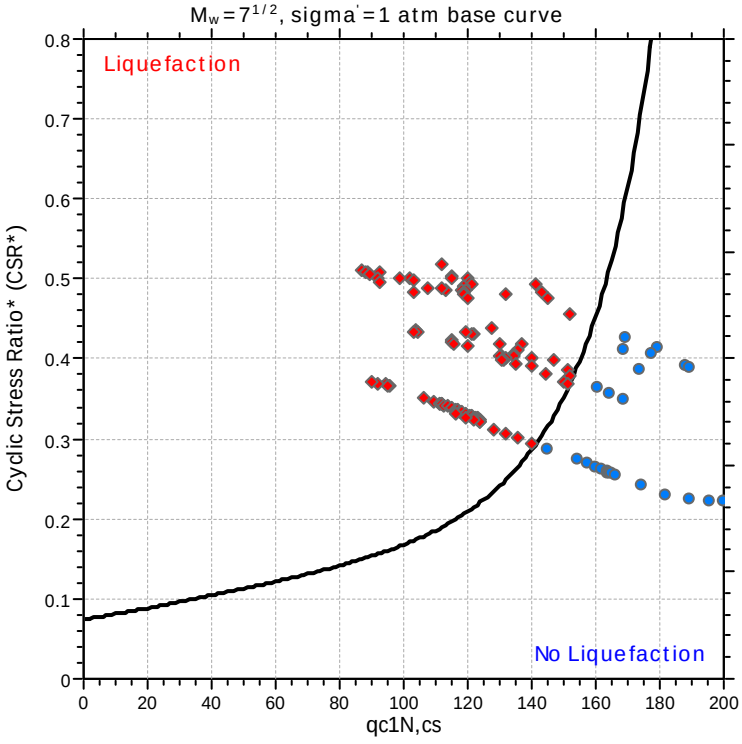
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSC002 – Dundale Avenue

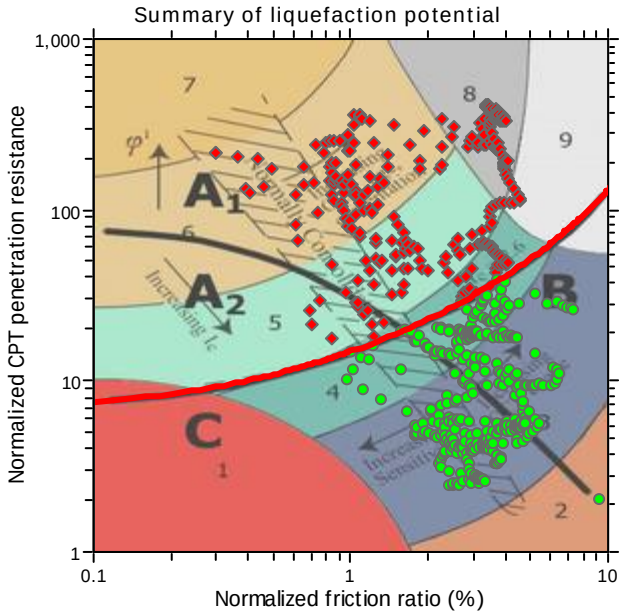
CPT file : L3S4-CPT01

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	-1.22 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	-1.22 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

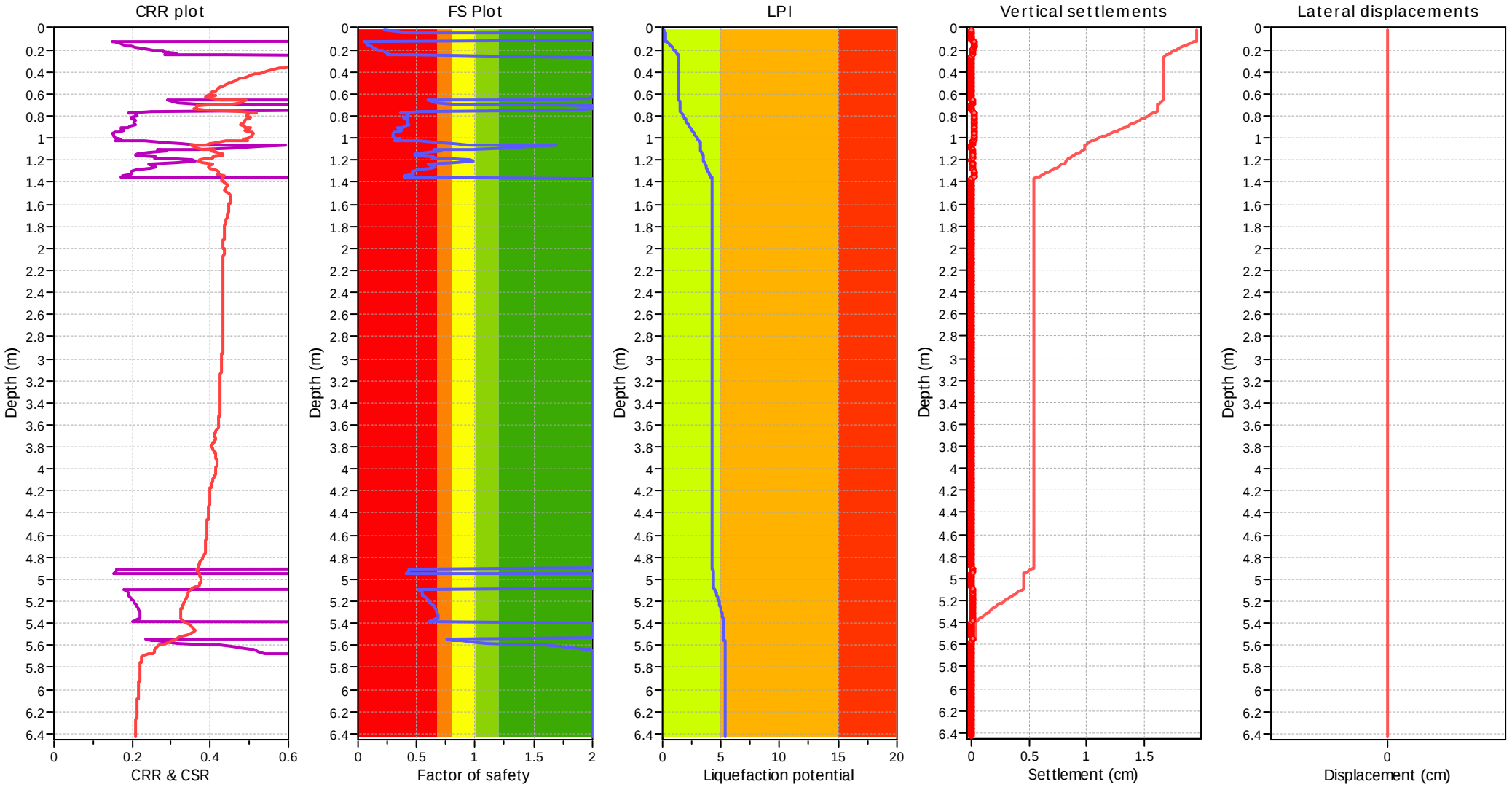






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	-1.22 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	-1.22 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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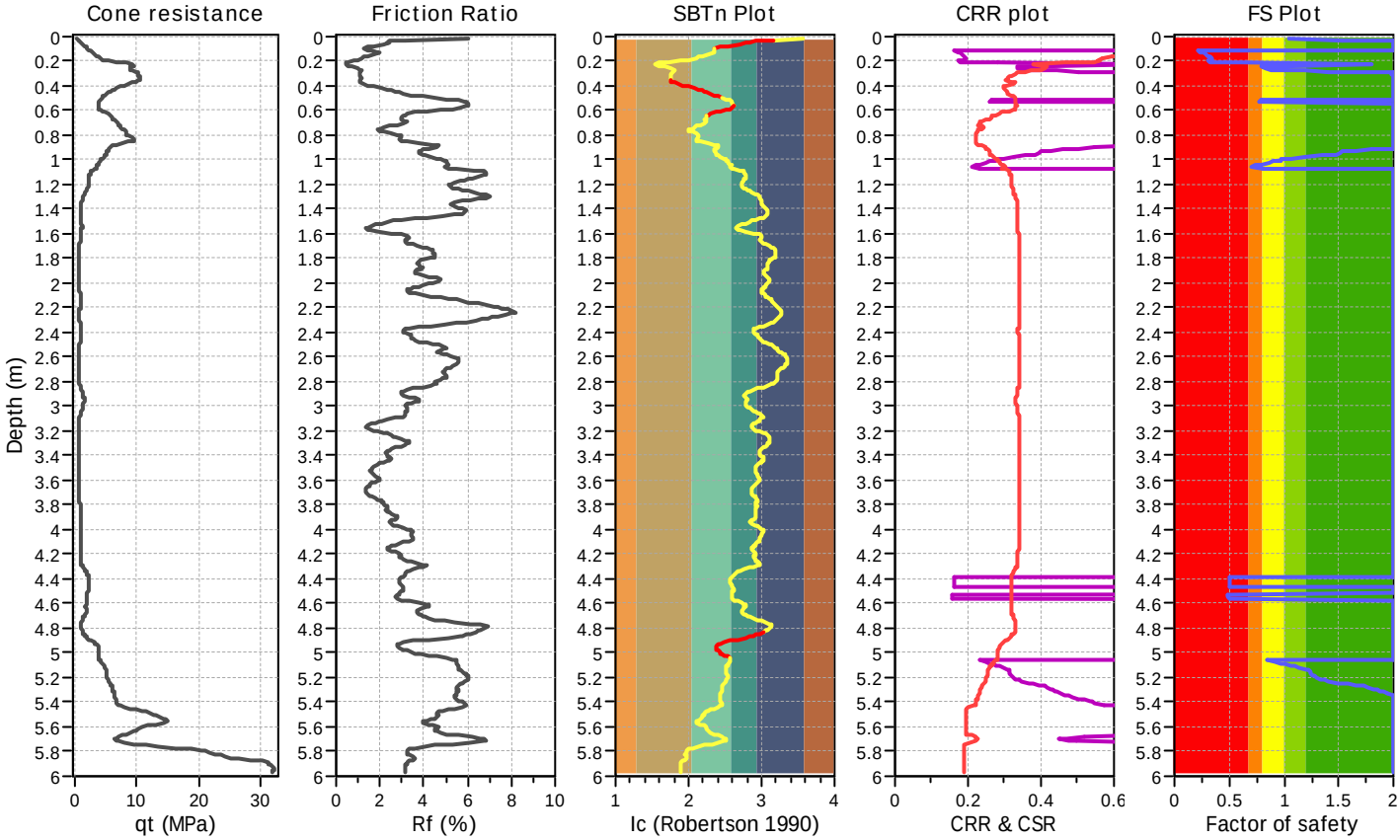
LIQUEFACTION ANALYSIS REPORT

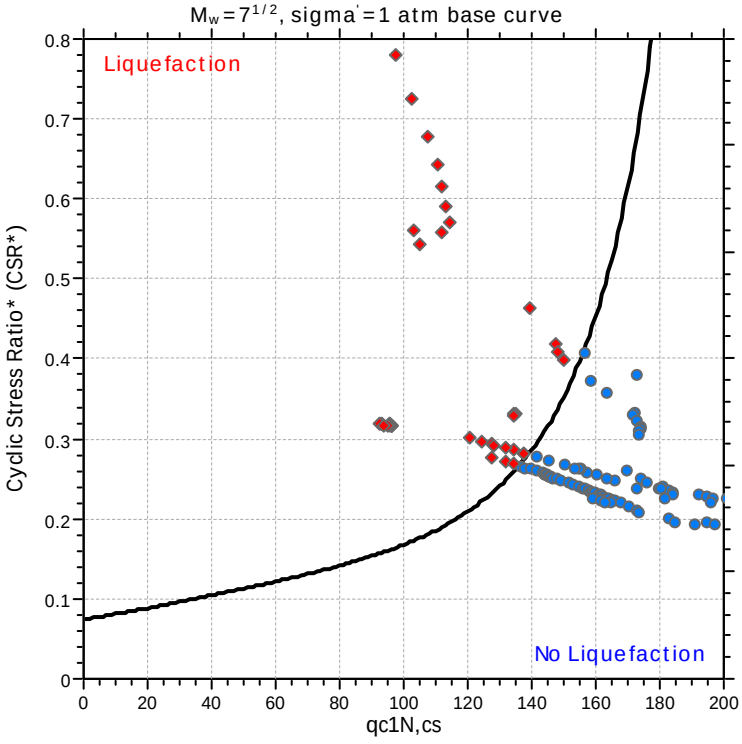
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSC002 – Dundale Avenue

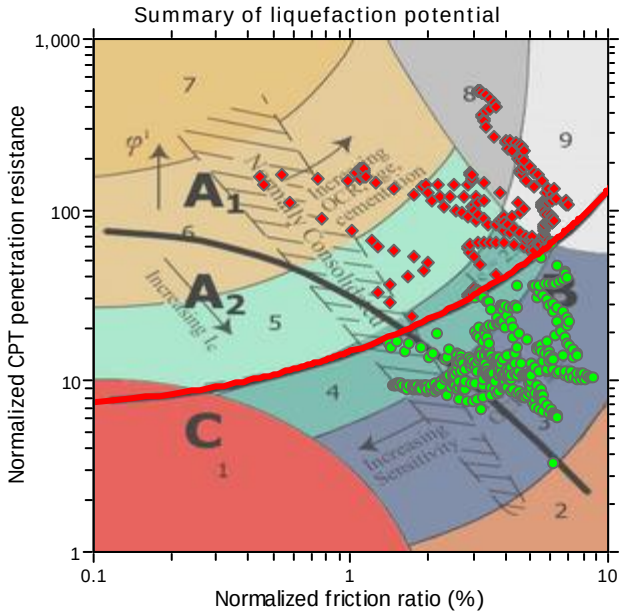
CPT file : L3S4-CPT02

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	-0.24 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	-0.24 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

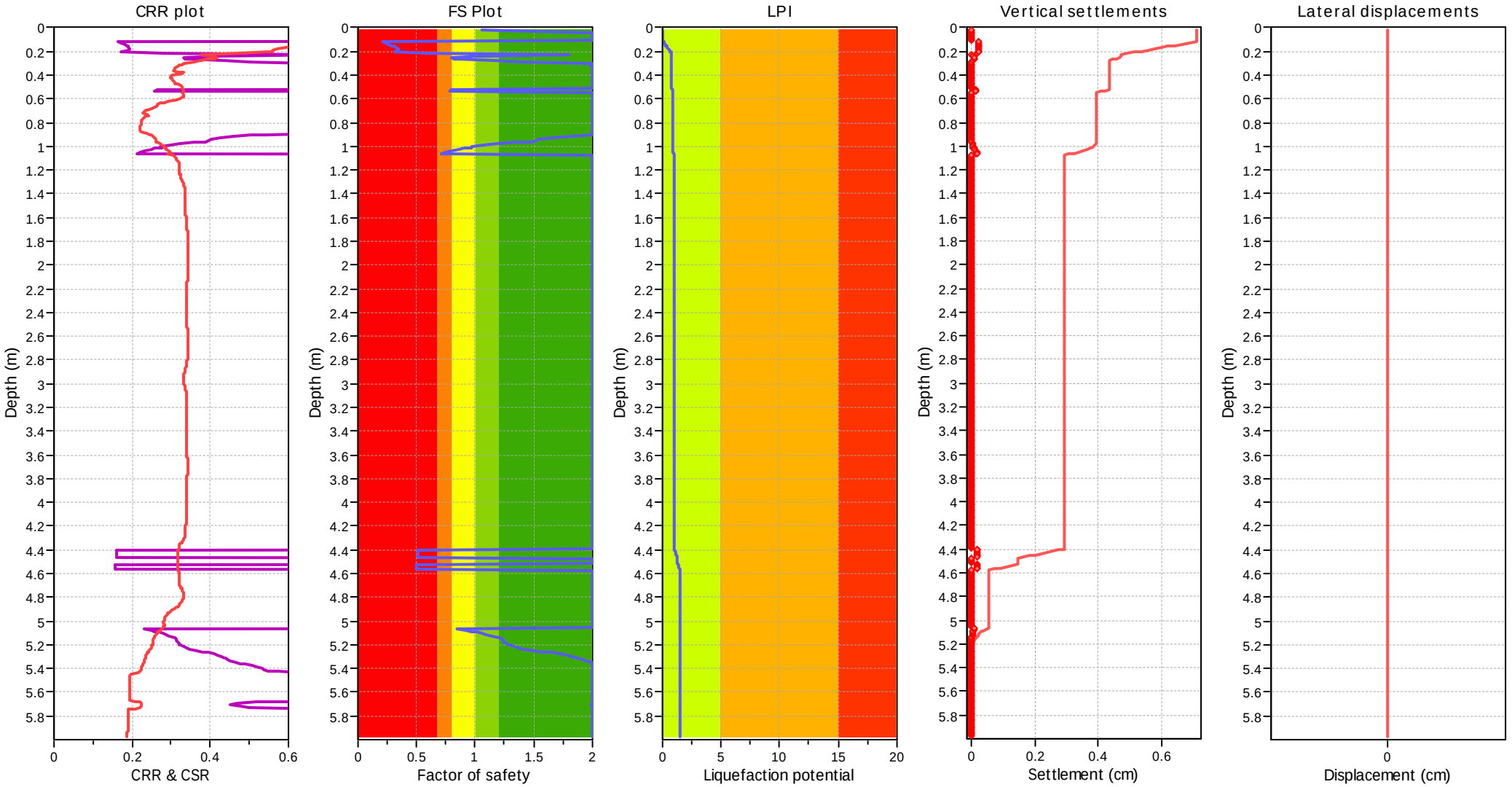






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	-0.24 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	-0.24 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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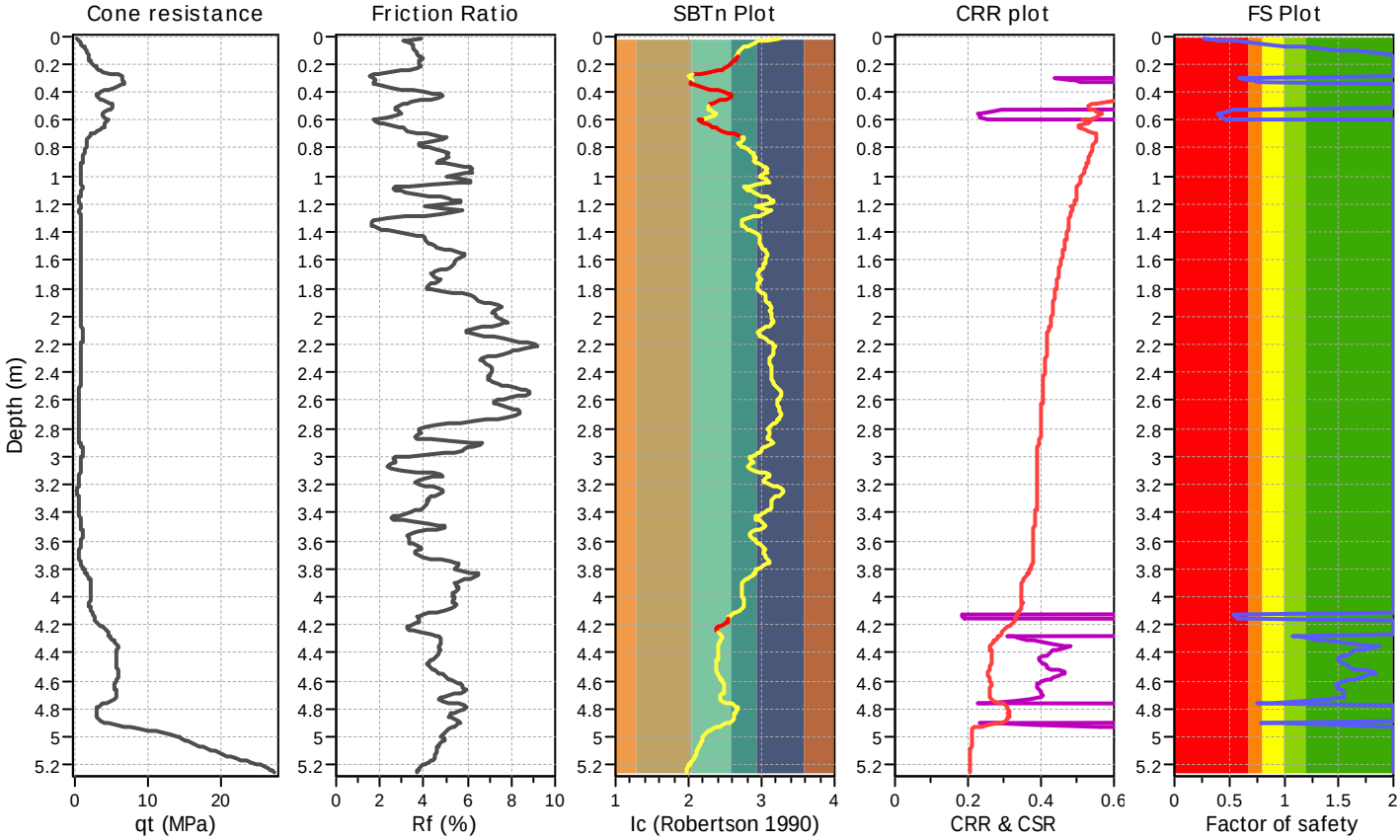
LIQUEFACTION ANALYSIS REPORT

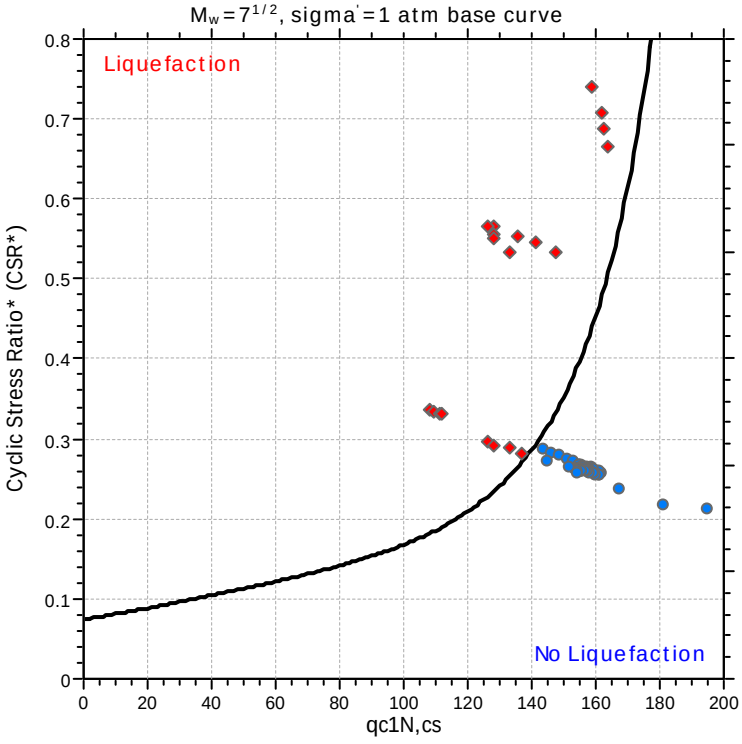
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSC002 – Dundale Avenue

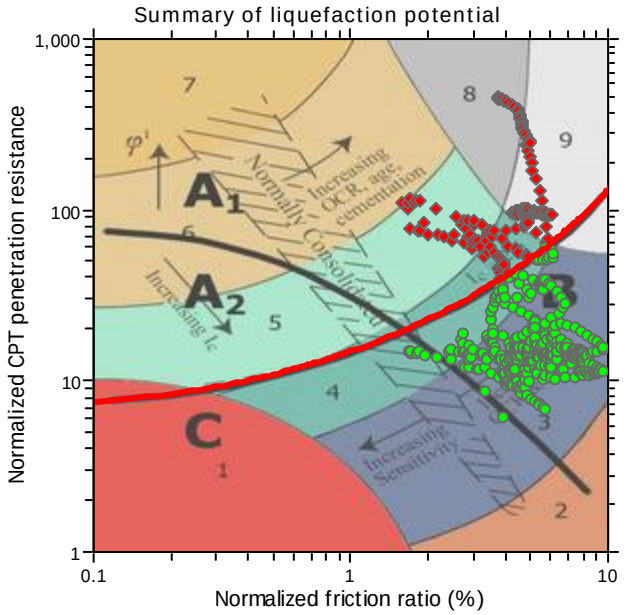
CPT file : L3S4-CPT03

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	-1.13 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	-1.13 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

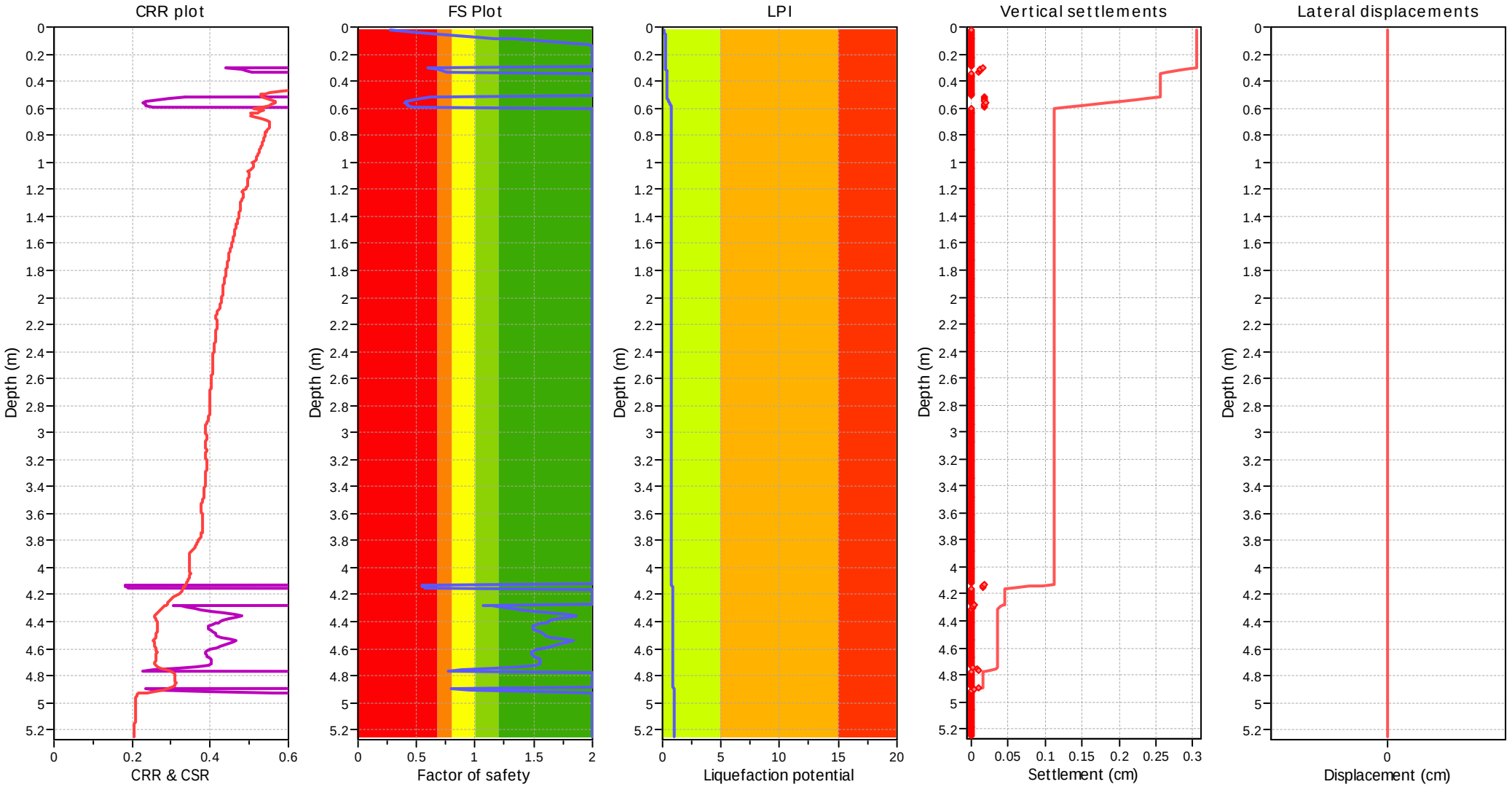






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	-1.13 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	-1.13 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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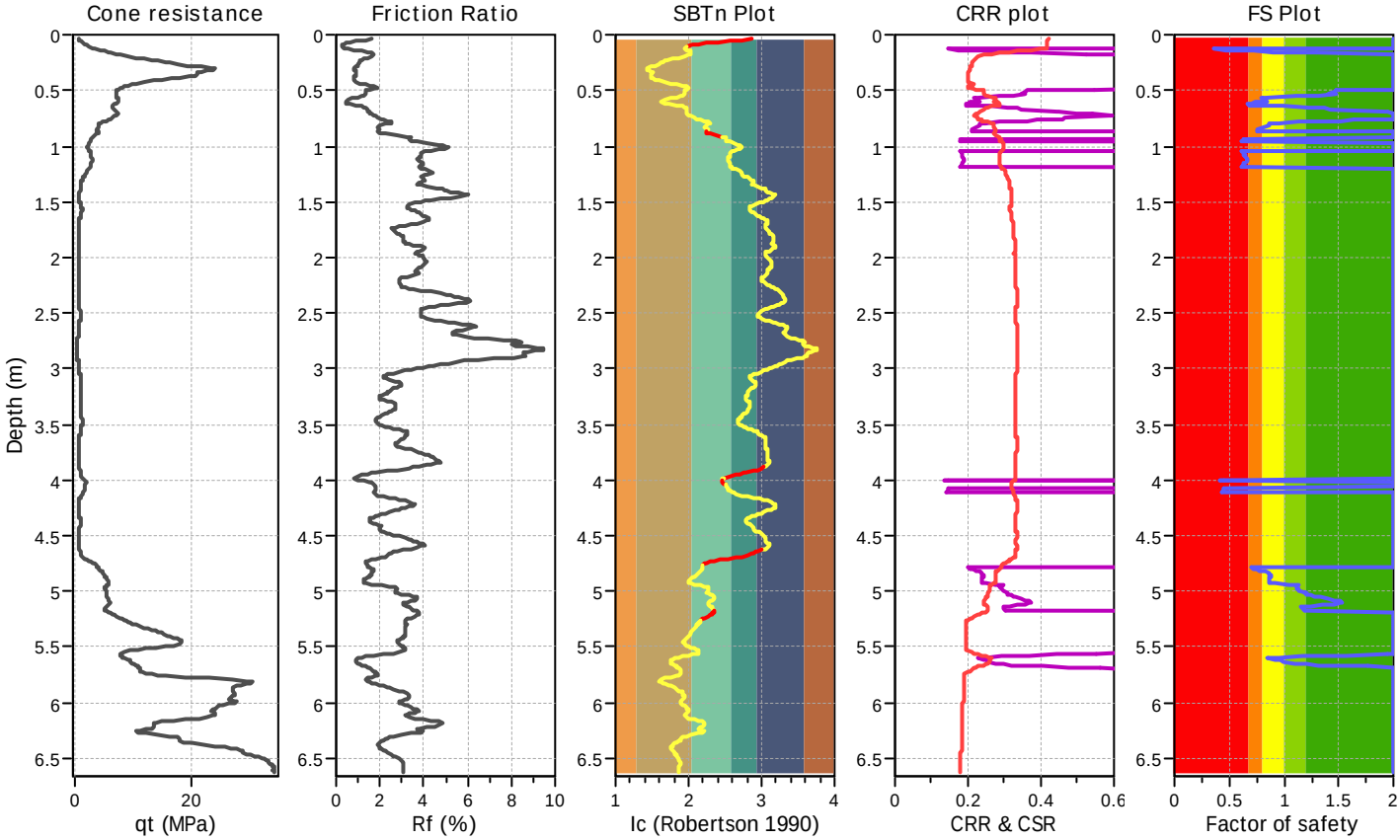
LIQUEFACTION ANALYSIS REPORT

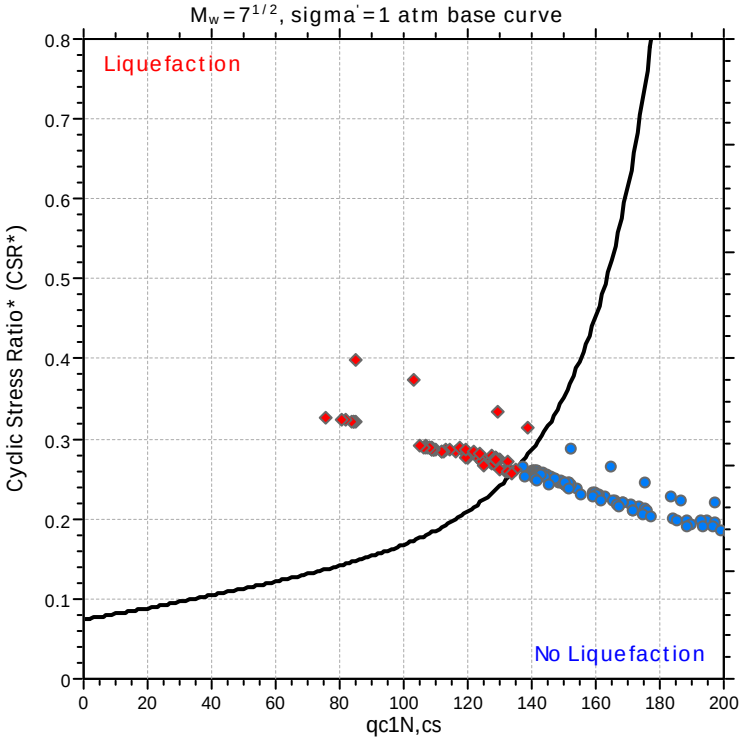
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSC002 – Dundale Avenue

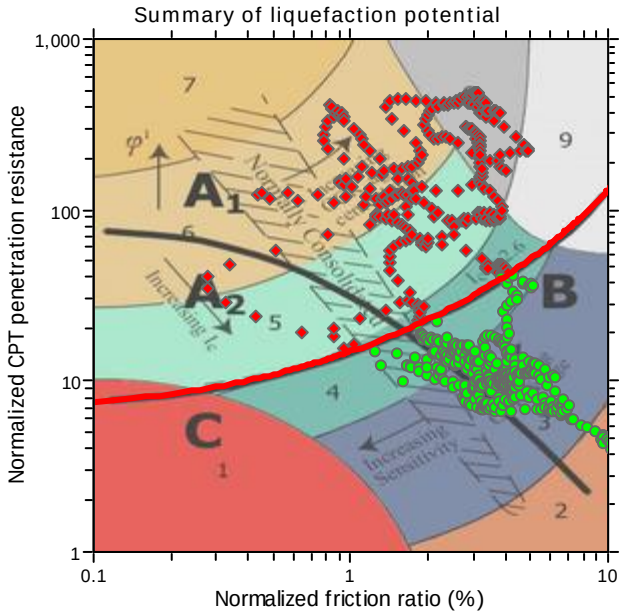
CPT file : L3S4-CPT04

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.00 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

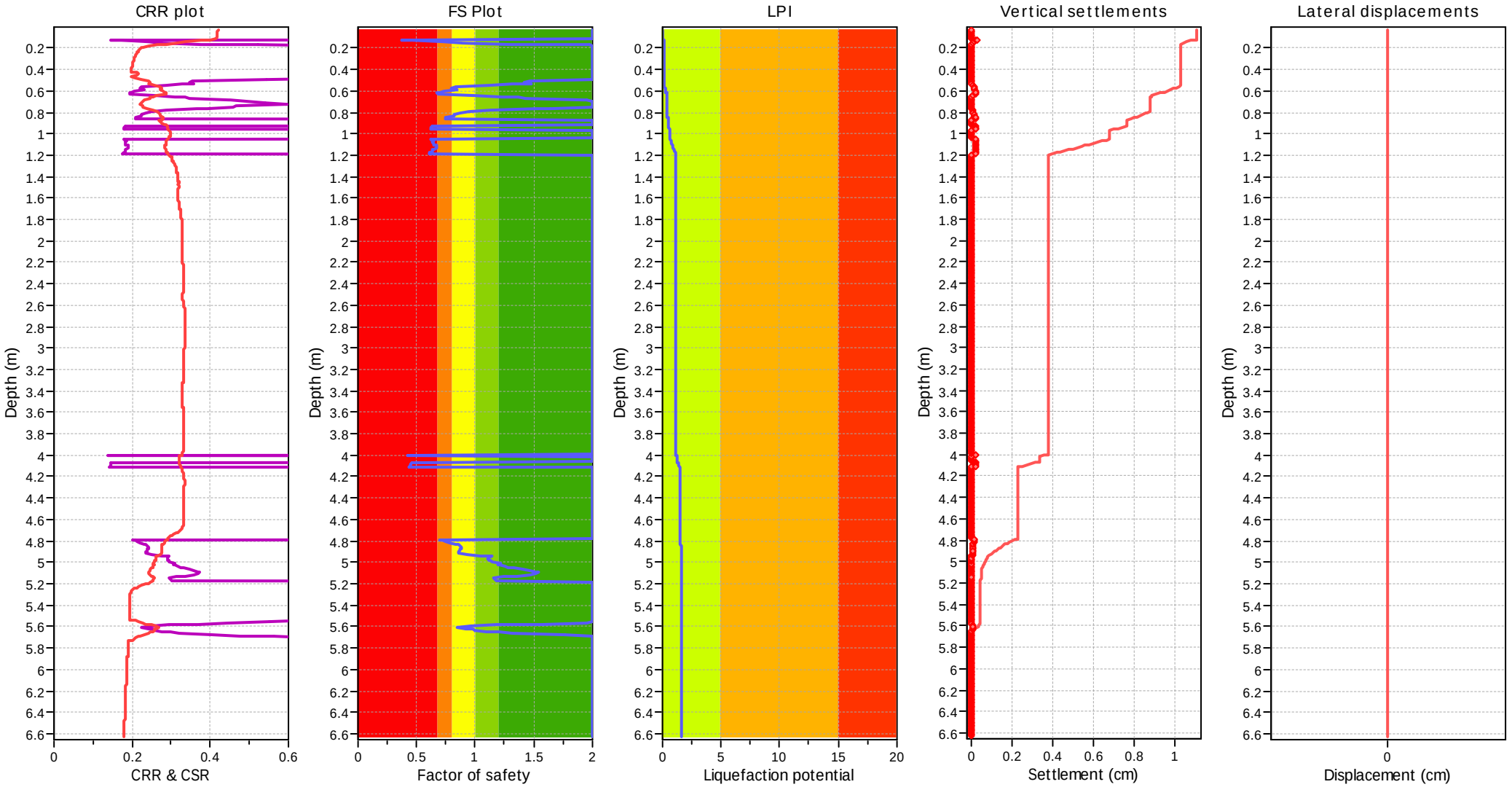






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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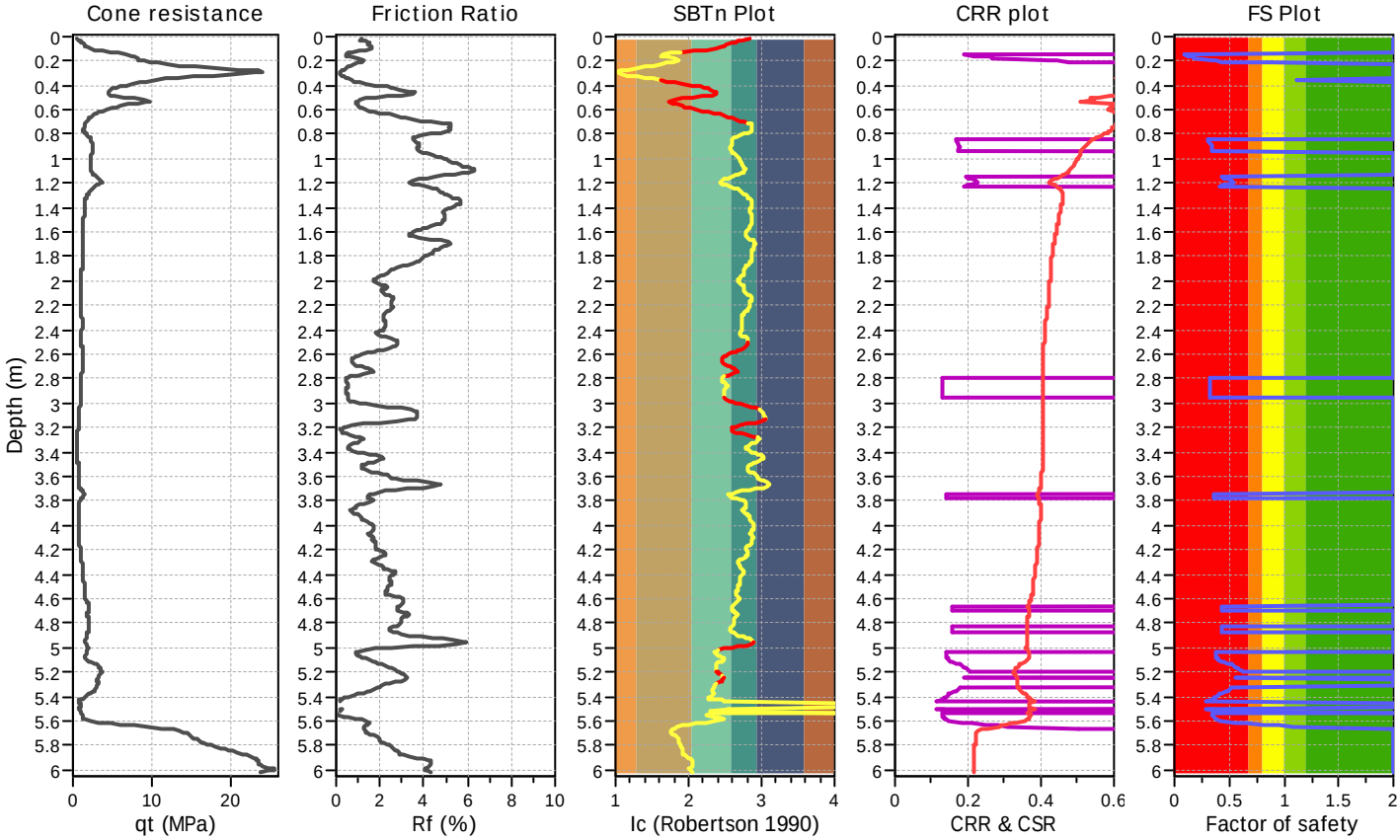
LIQUEFACTION ANALYSIS REPORT

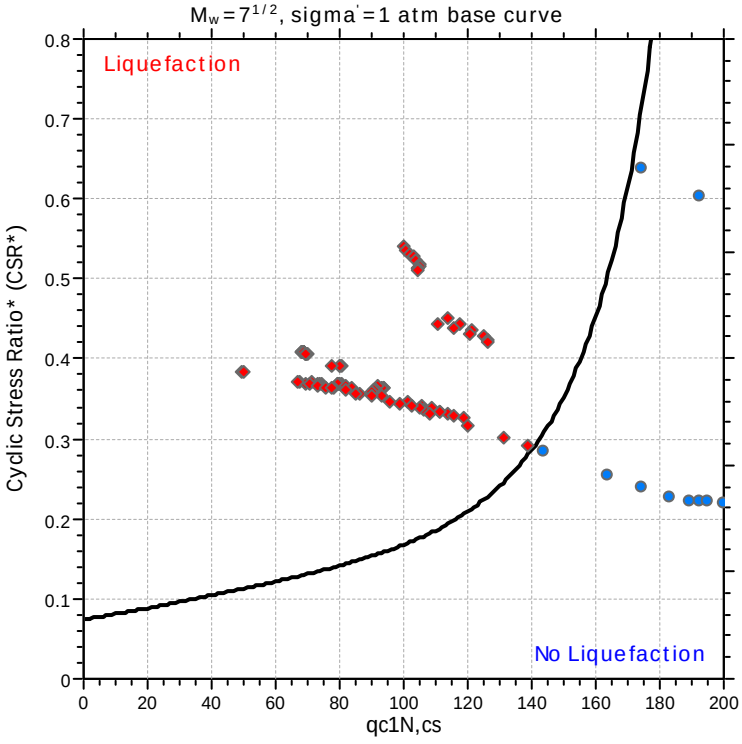
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSC002 – Dundale Avenue

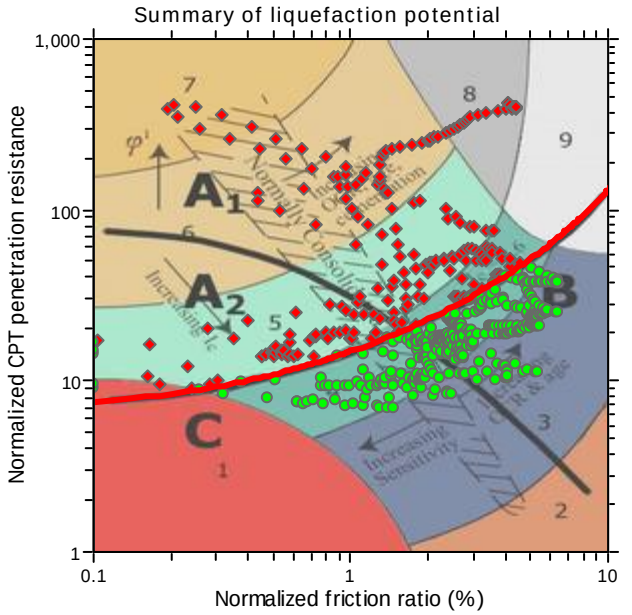
CPT file : L3S4-CPT06

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	-1.23 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	-1.23 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

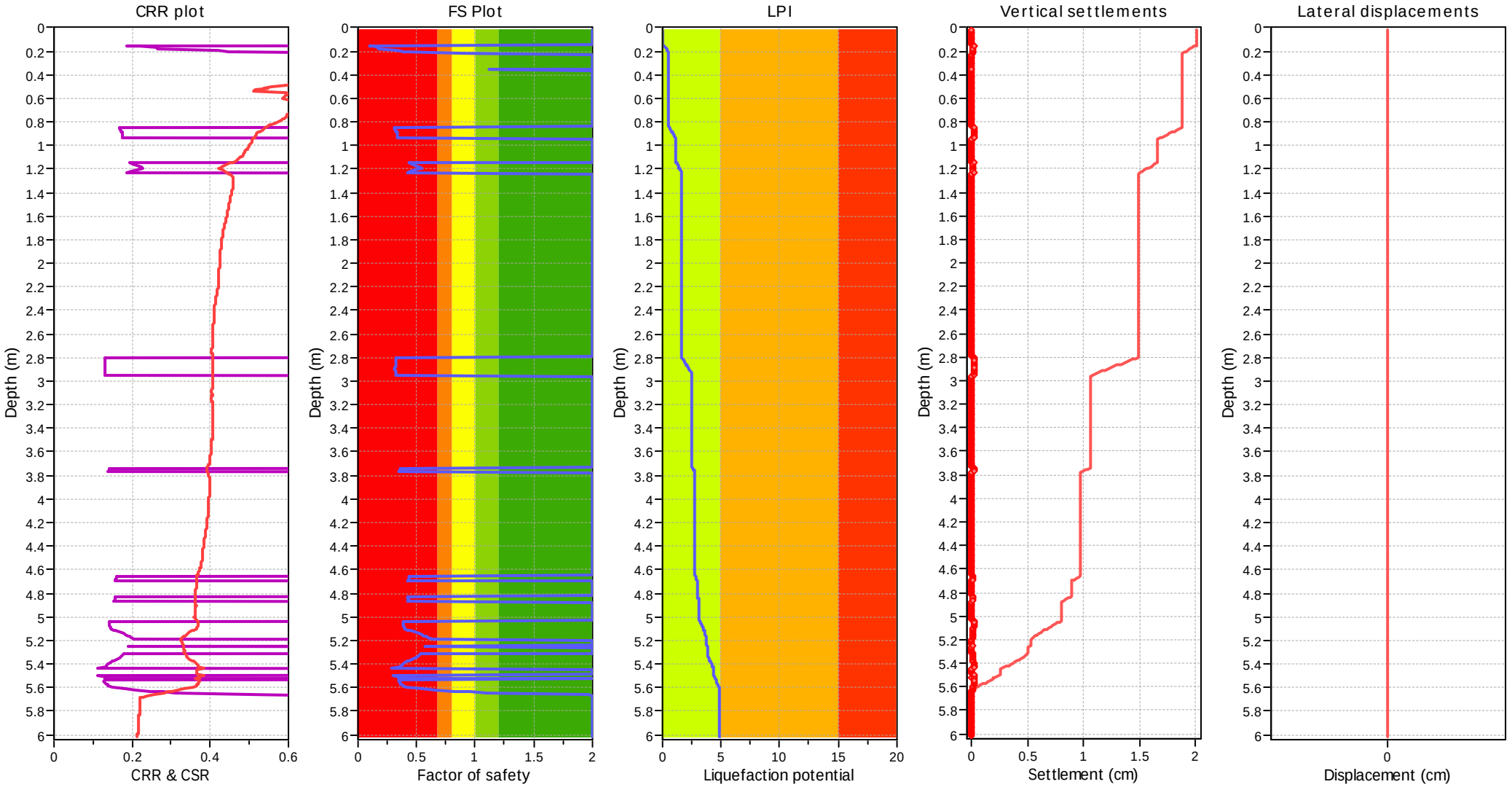






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	-1.23 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	-1.23 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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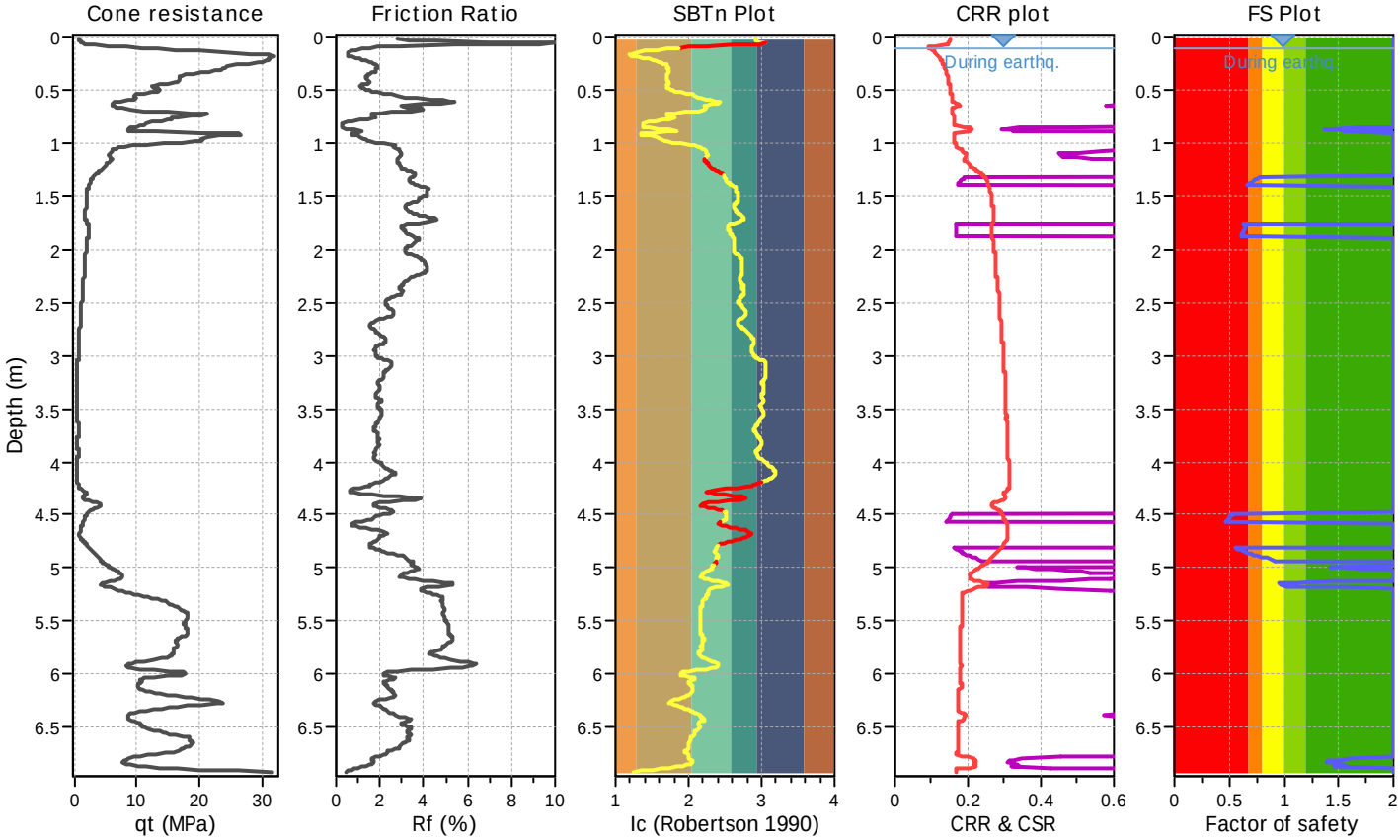
LIQUEFACTION ANALYSIS REPORT

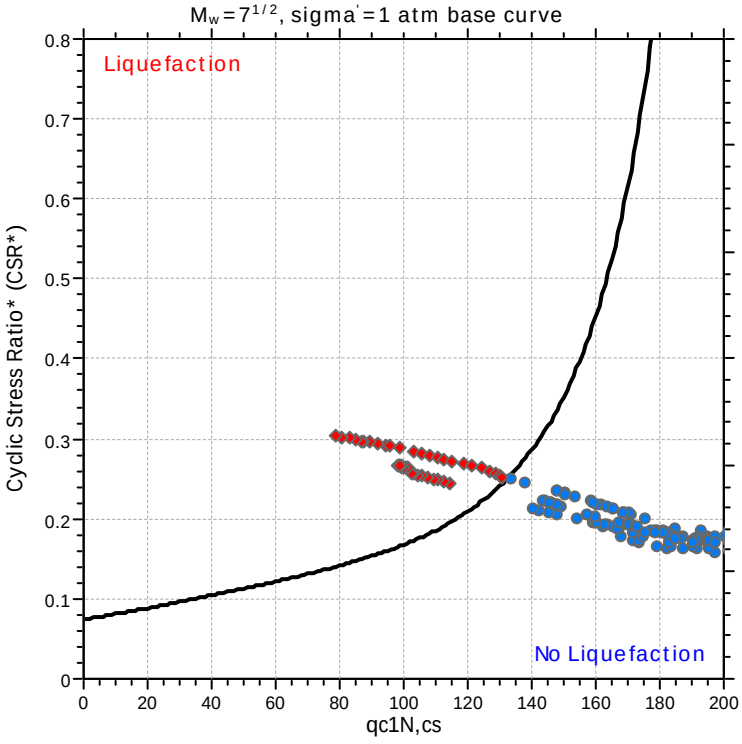
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSC002 – Dundale Avenue

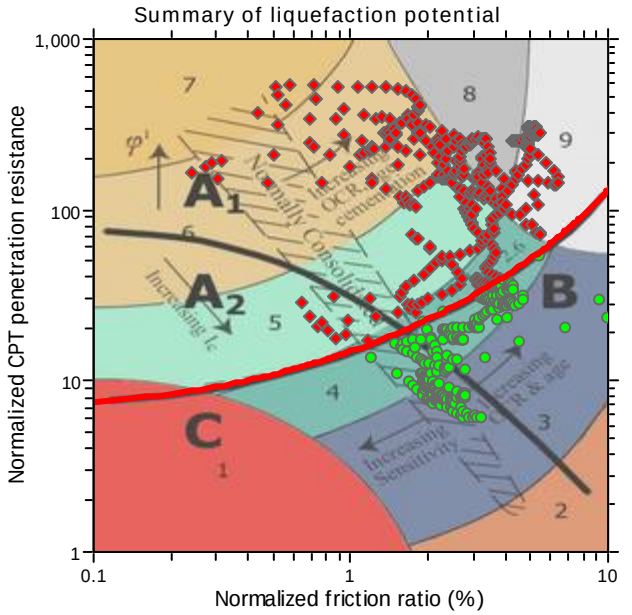
CPT file : L3S4-CPT07

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.10 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.10 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

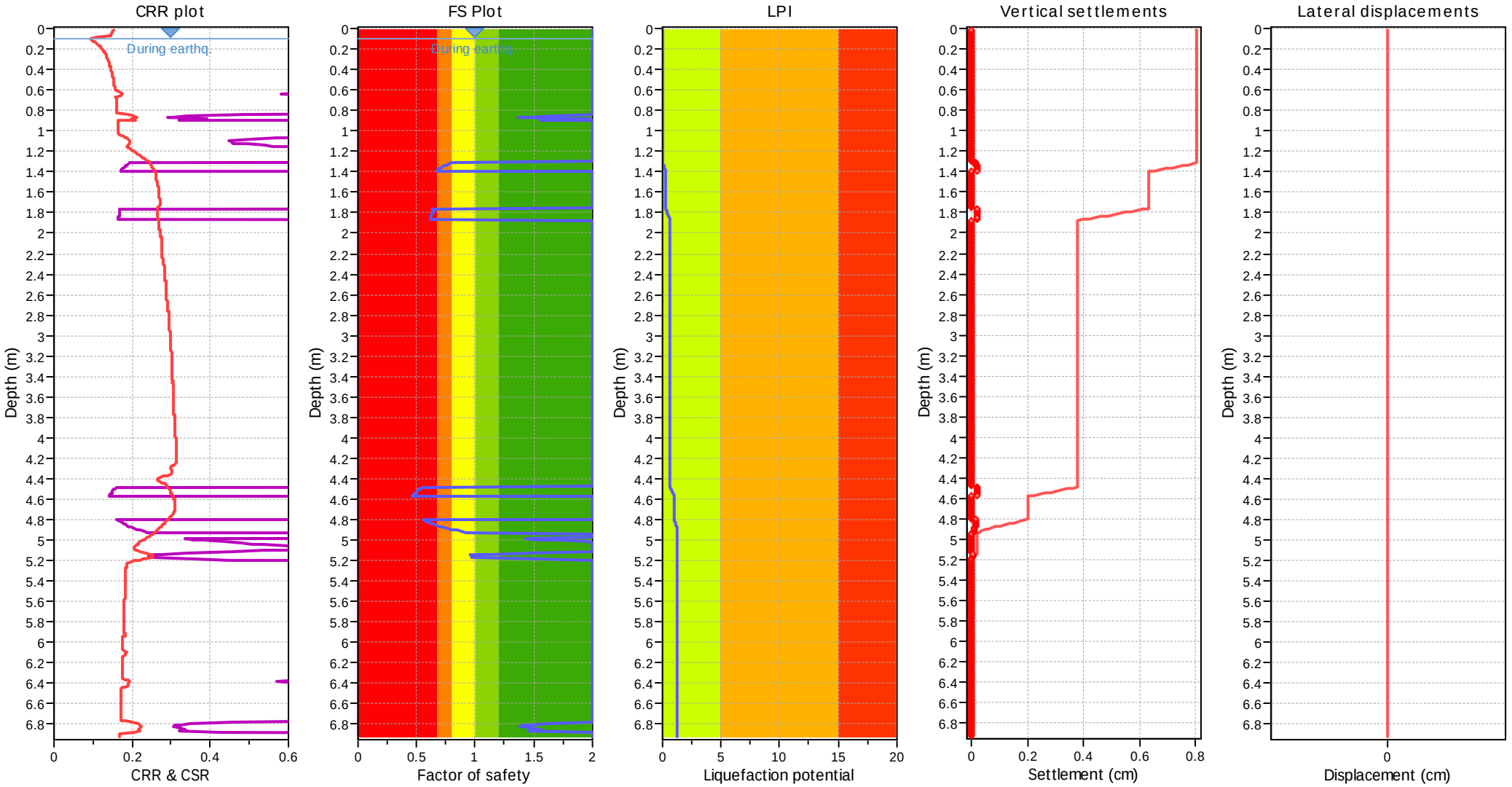






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.10 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.10 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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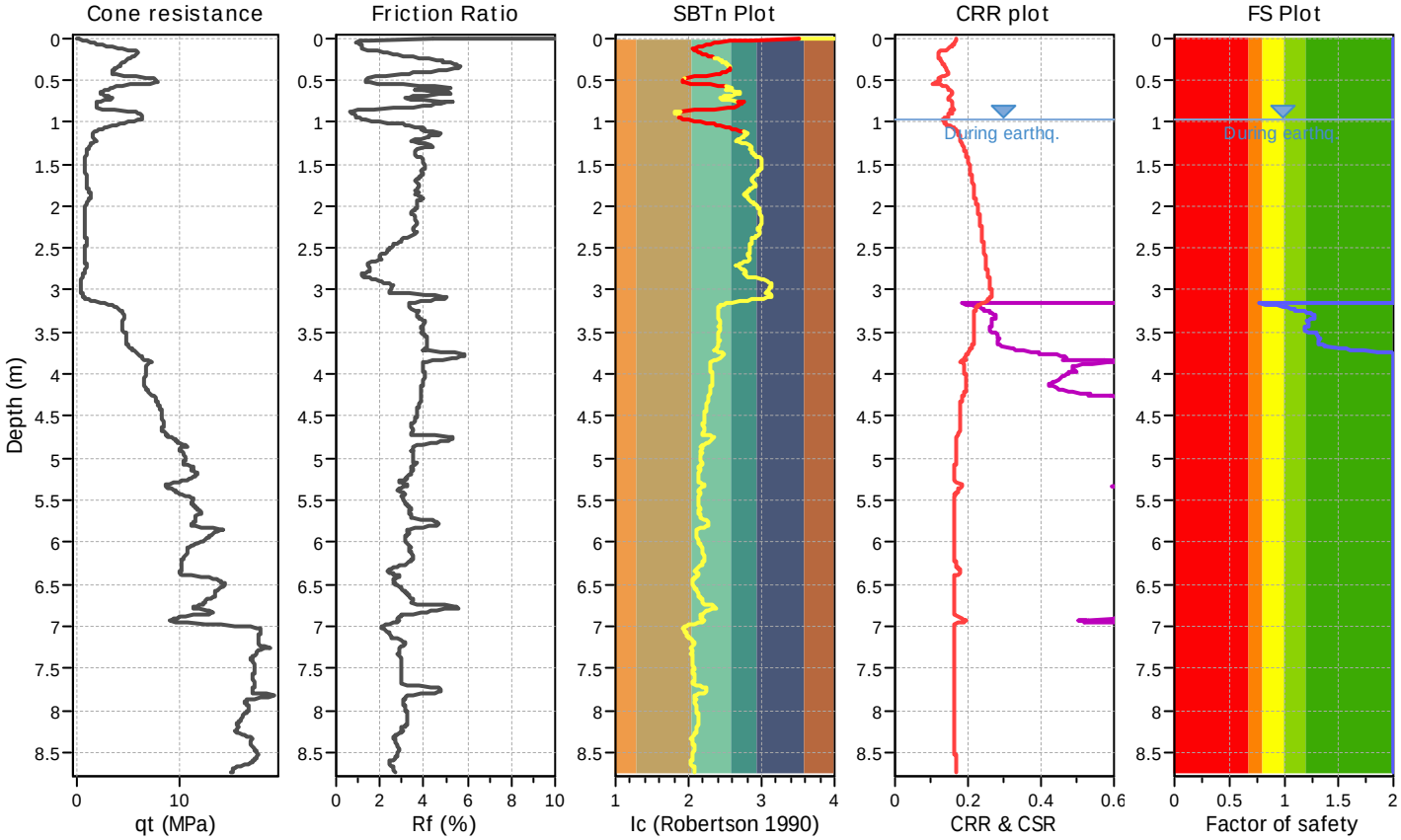
LIQUEFACTION ANALYSIS REPORT

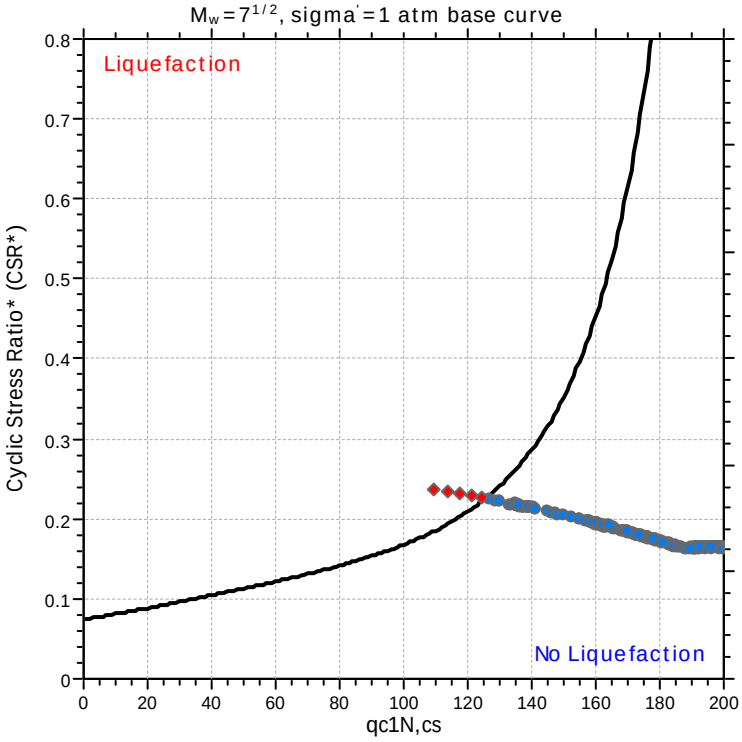
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSC003 – Whitney Street

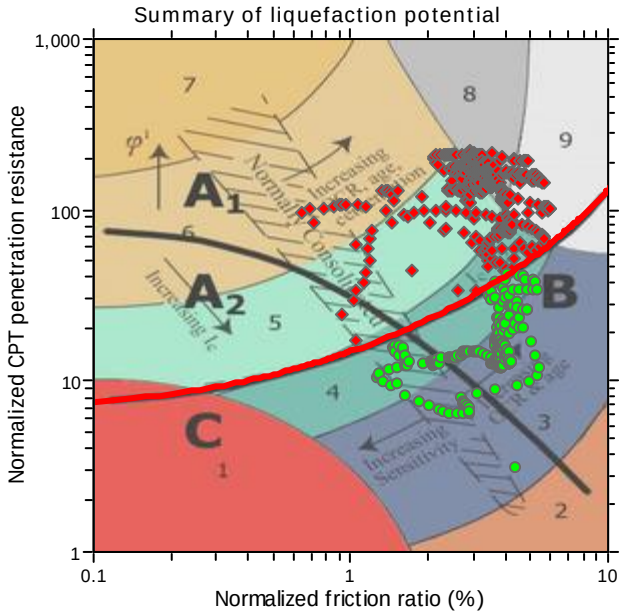
CPT file : L3S3-CPT01

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.97 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.97 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.31	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

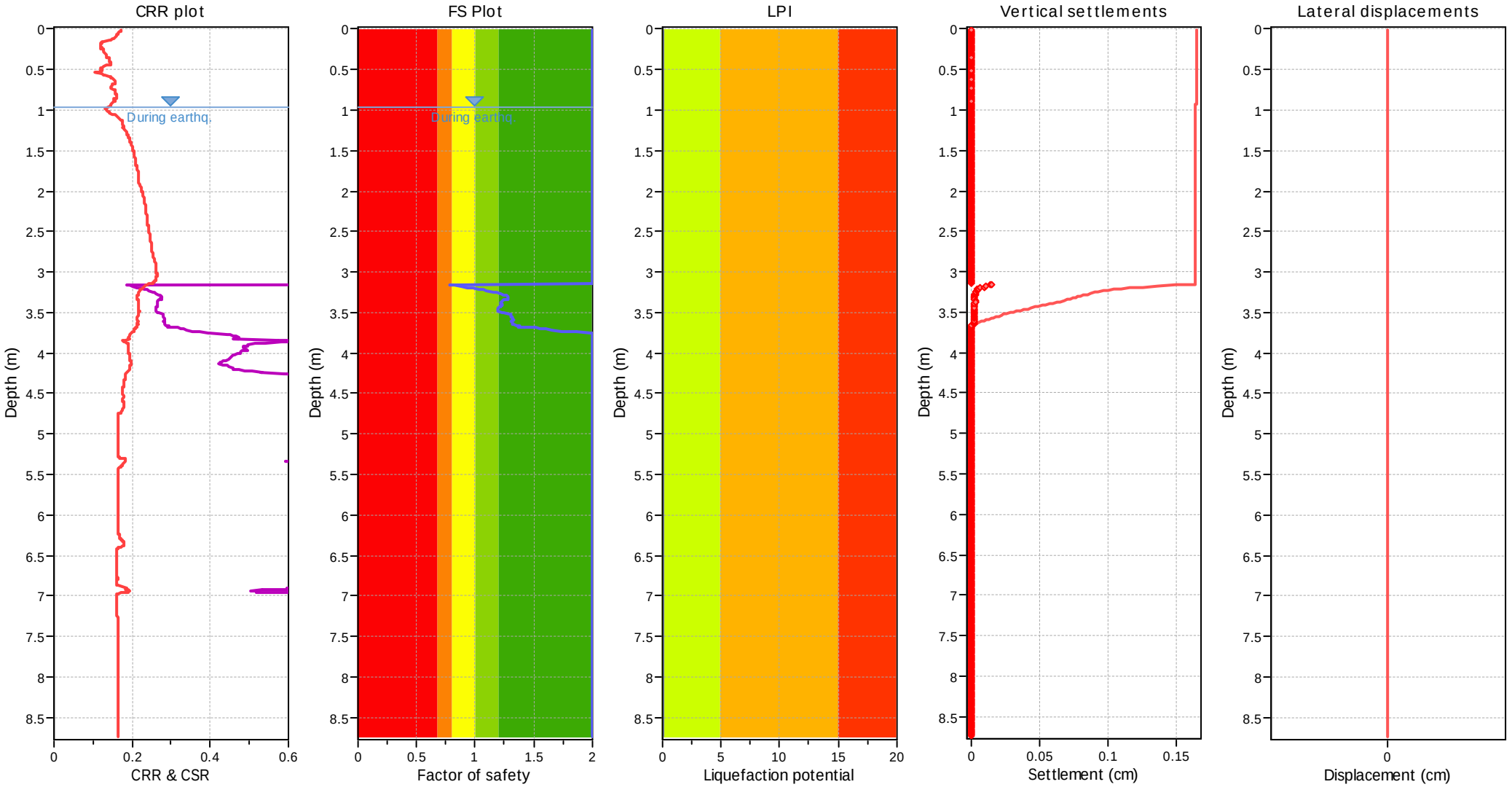






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.97 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.31	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.97 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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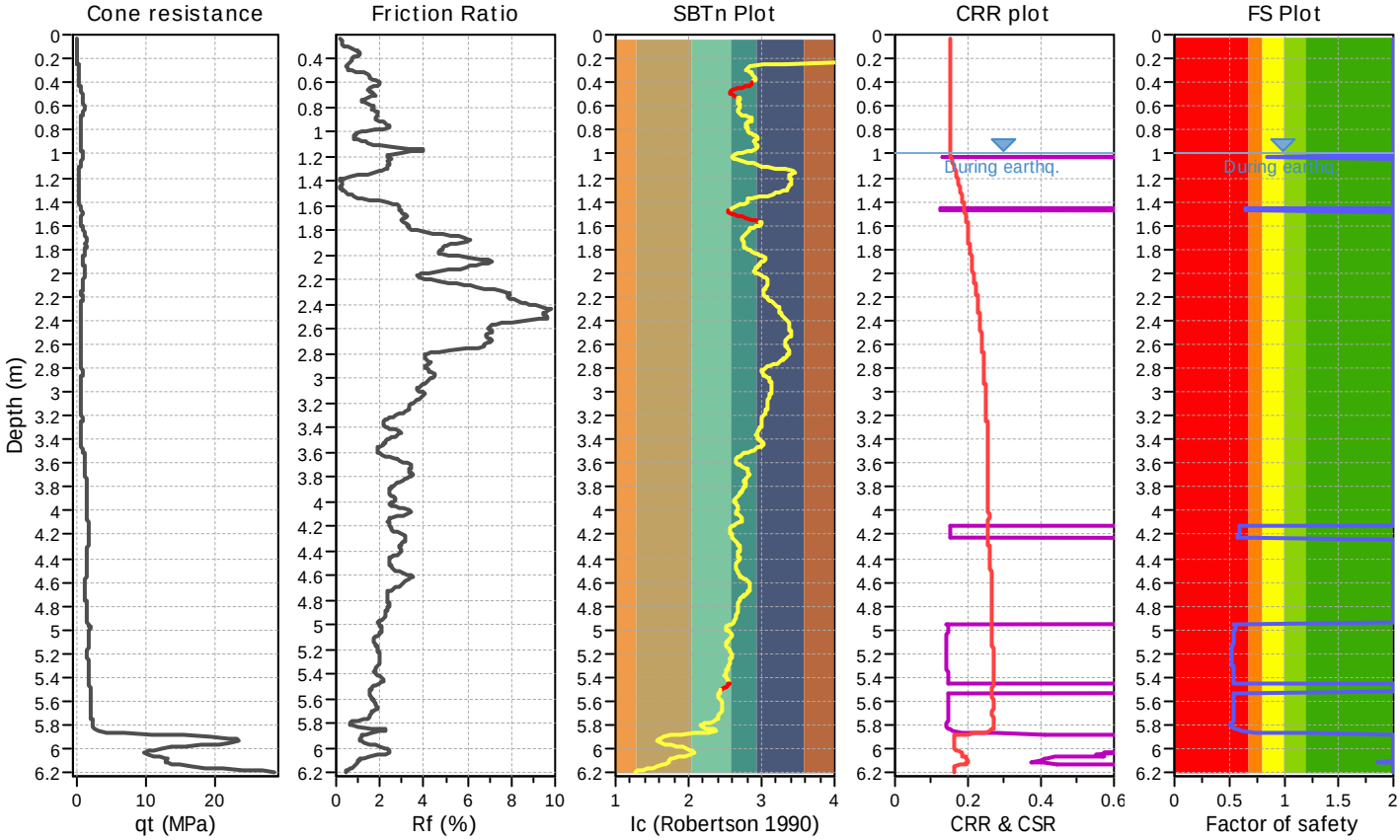
LIQUEFACTION ANALYSIS REPORT

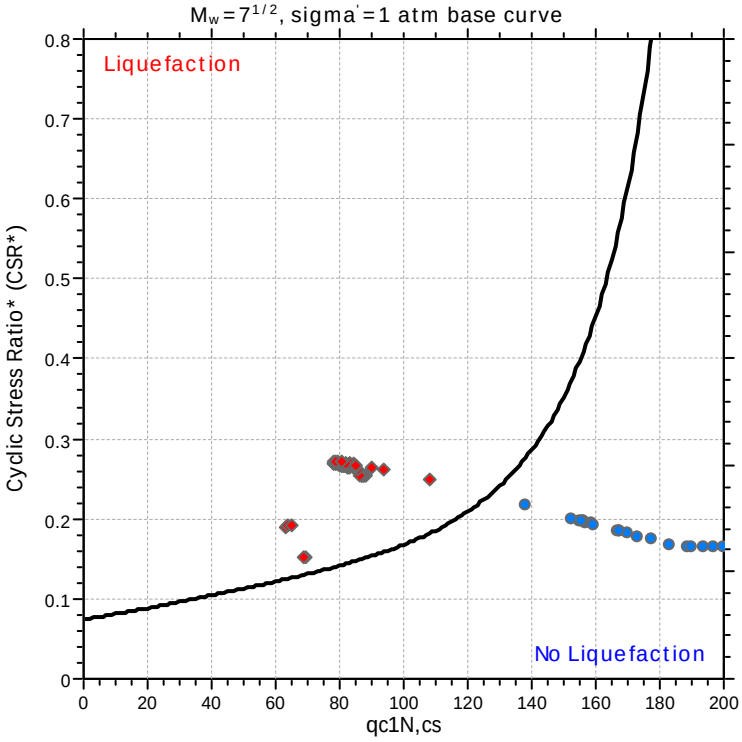
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSC004 – Miranda Reserve

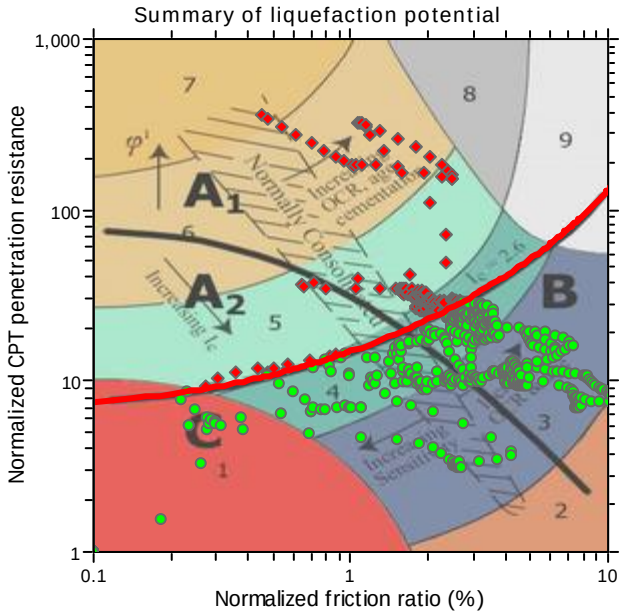
CPT file : L3S2-CPT02

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

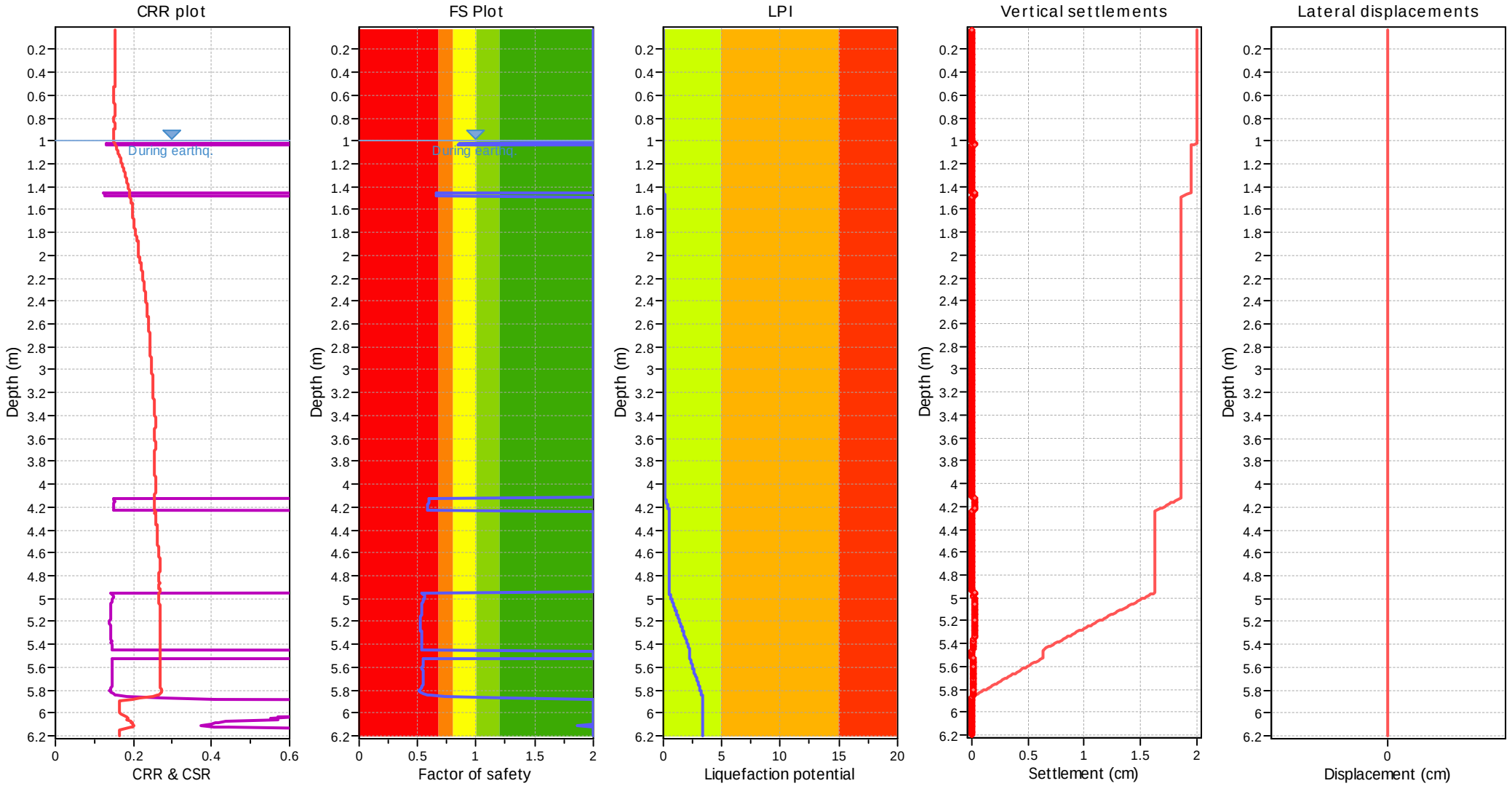






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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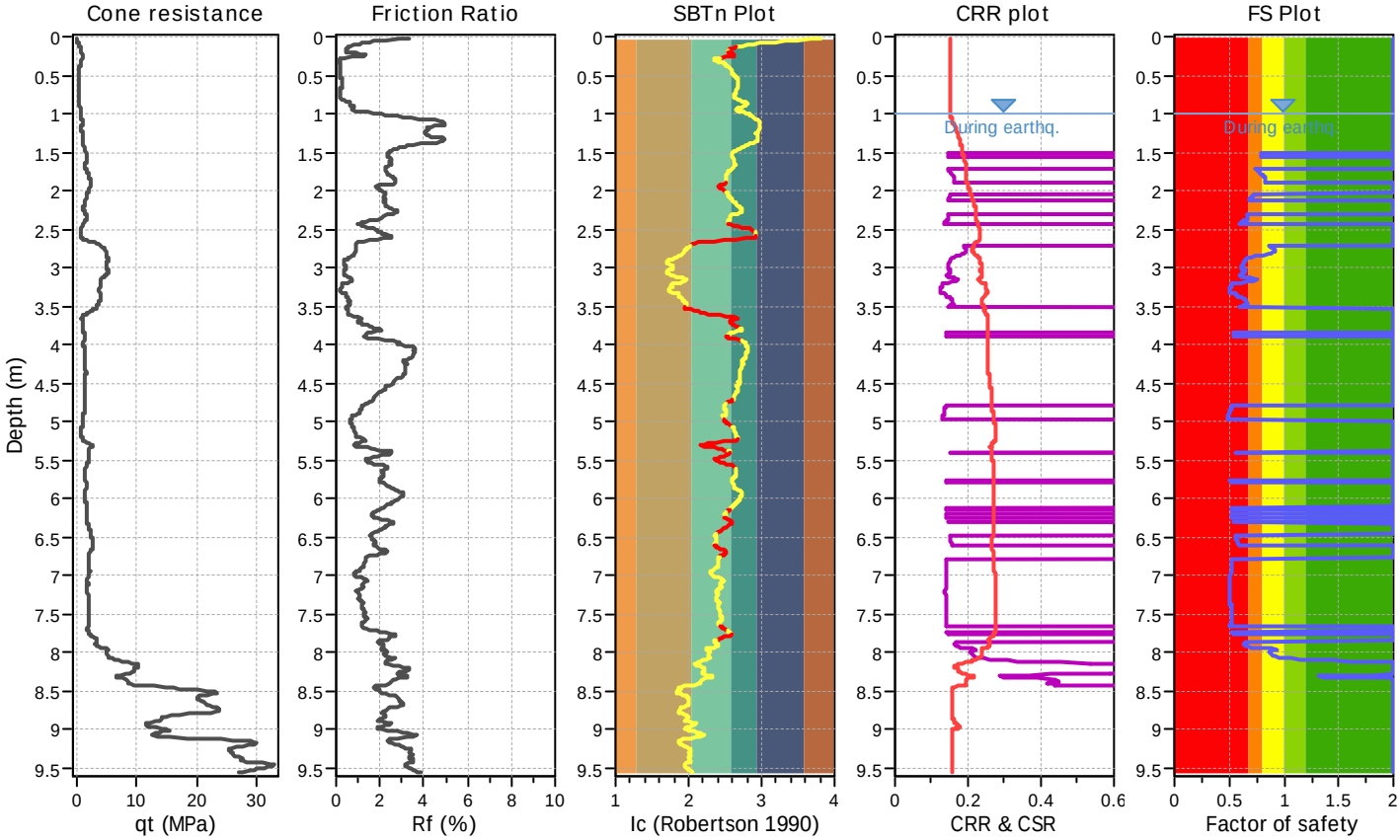
LIQUEFACTION ANALYSIS REPORT

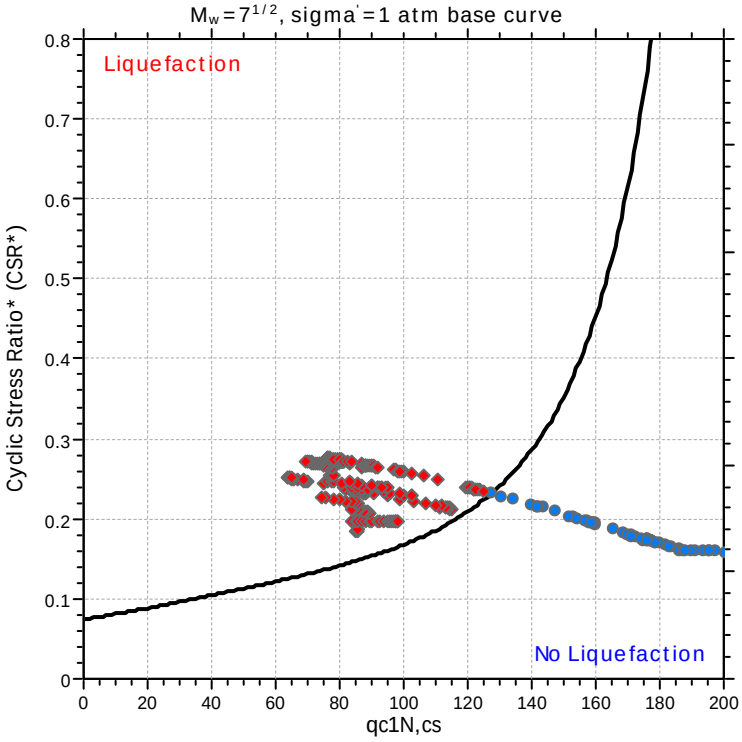
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSC004 – Miranda Reserve

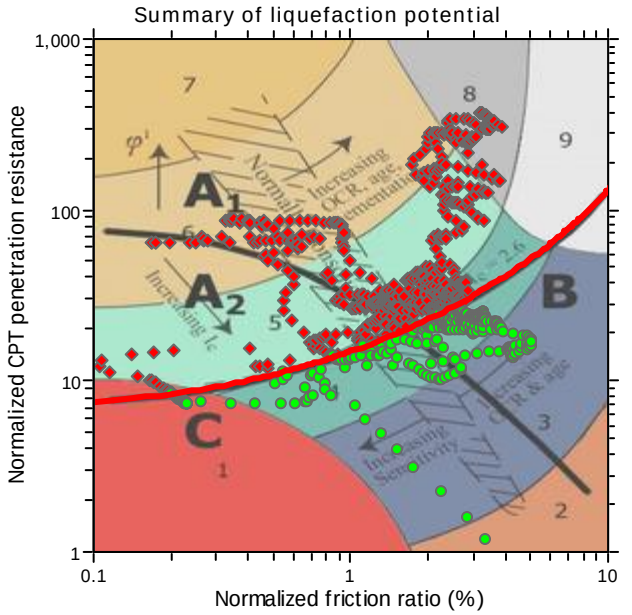
CPT file : L3S2-CPT03

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

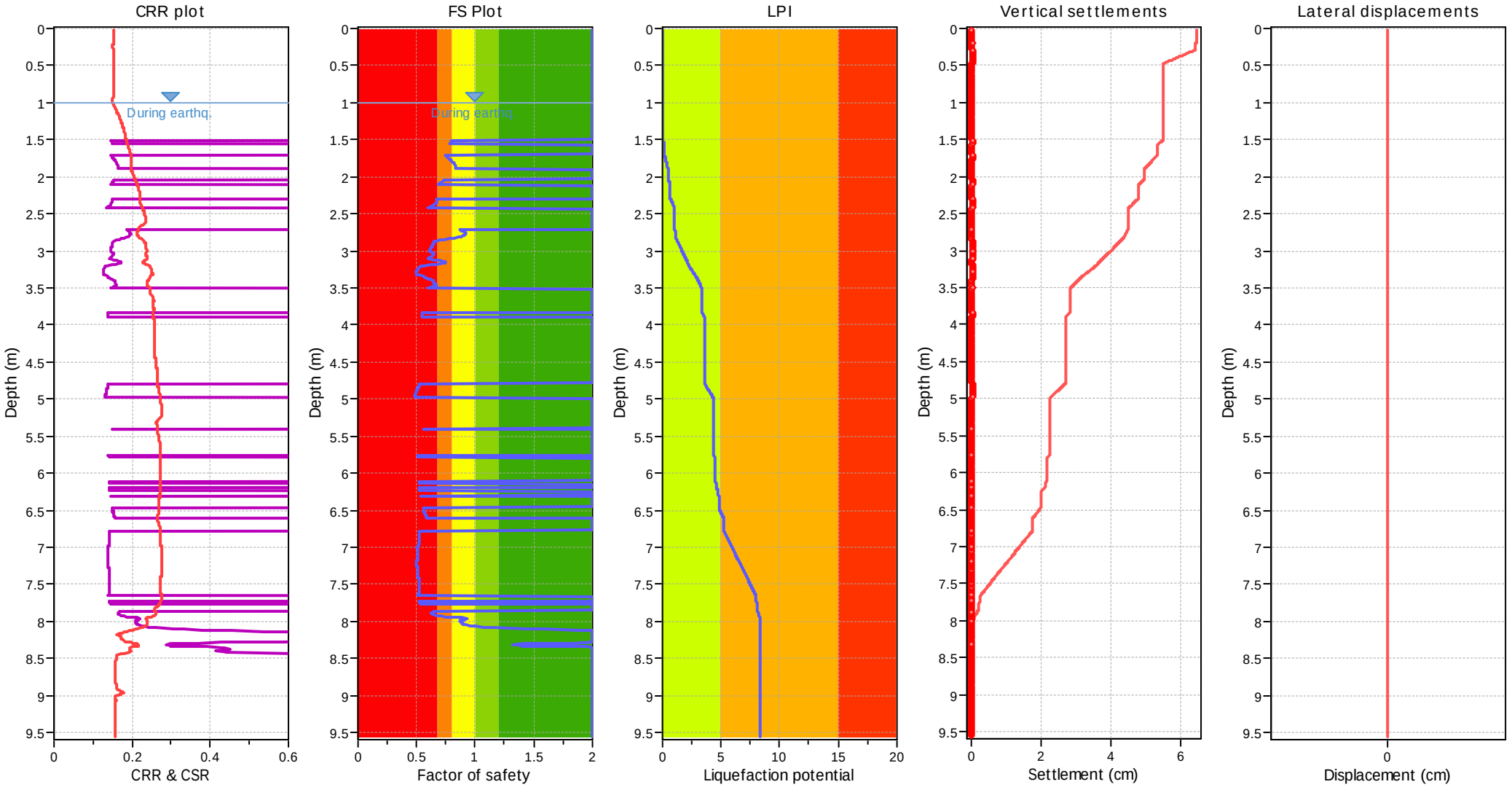






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

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- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

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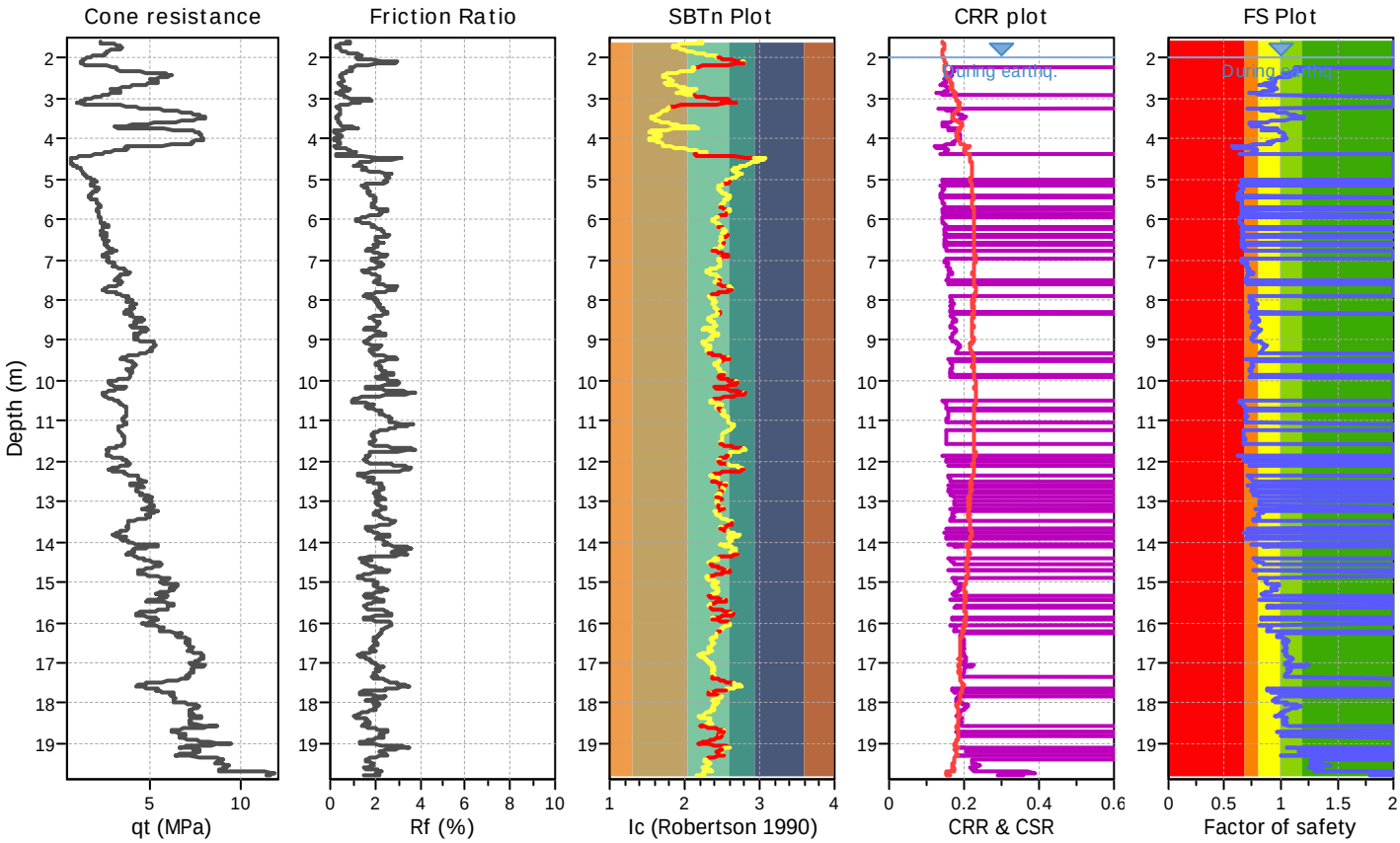
LIQUEFACTION ANALYSIS REPORT

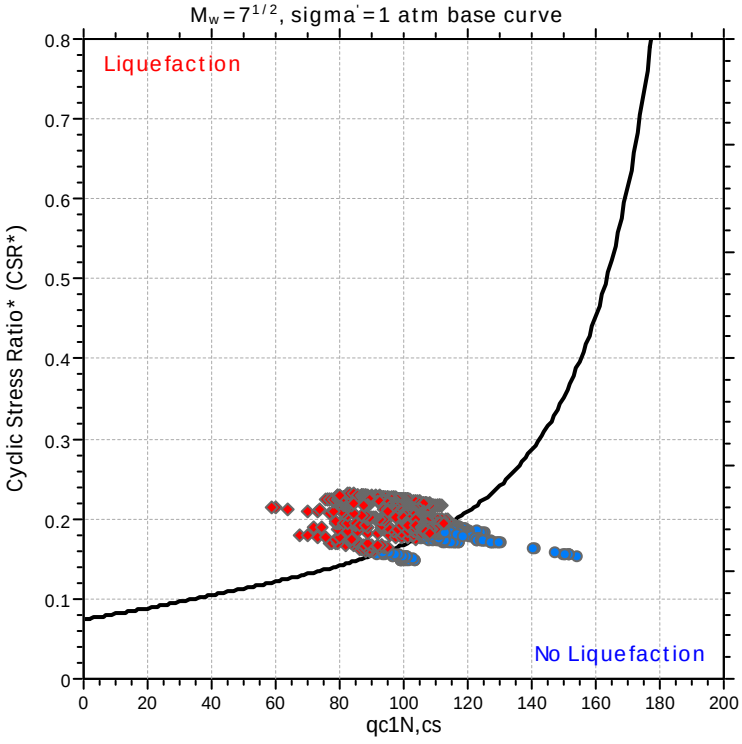
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSC005 – PS25

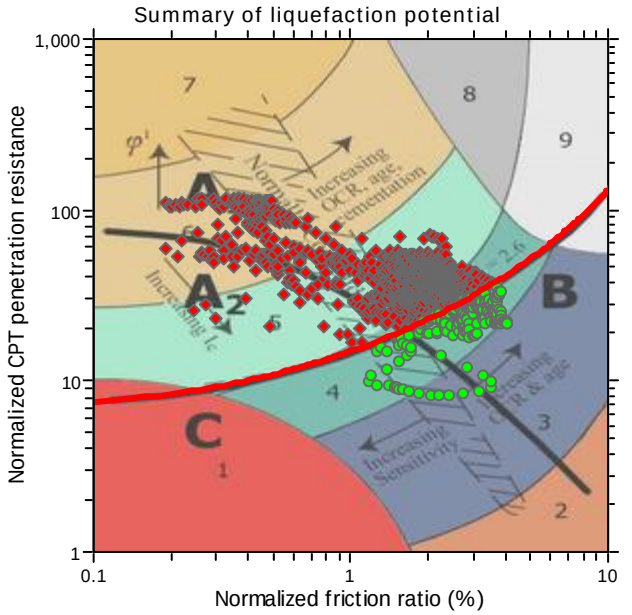
CPT file : L3S1-CPT01

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.00 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.28	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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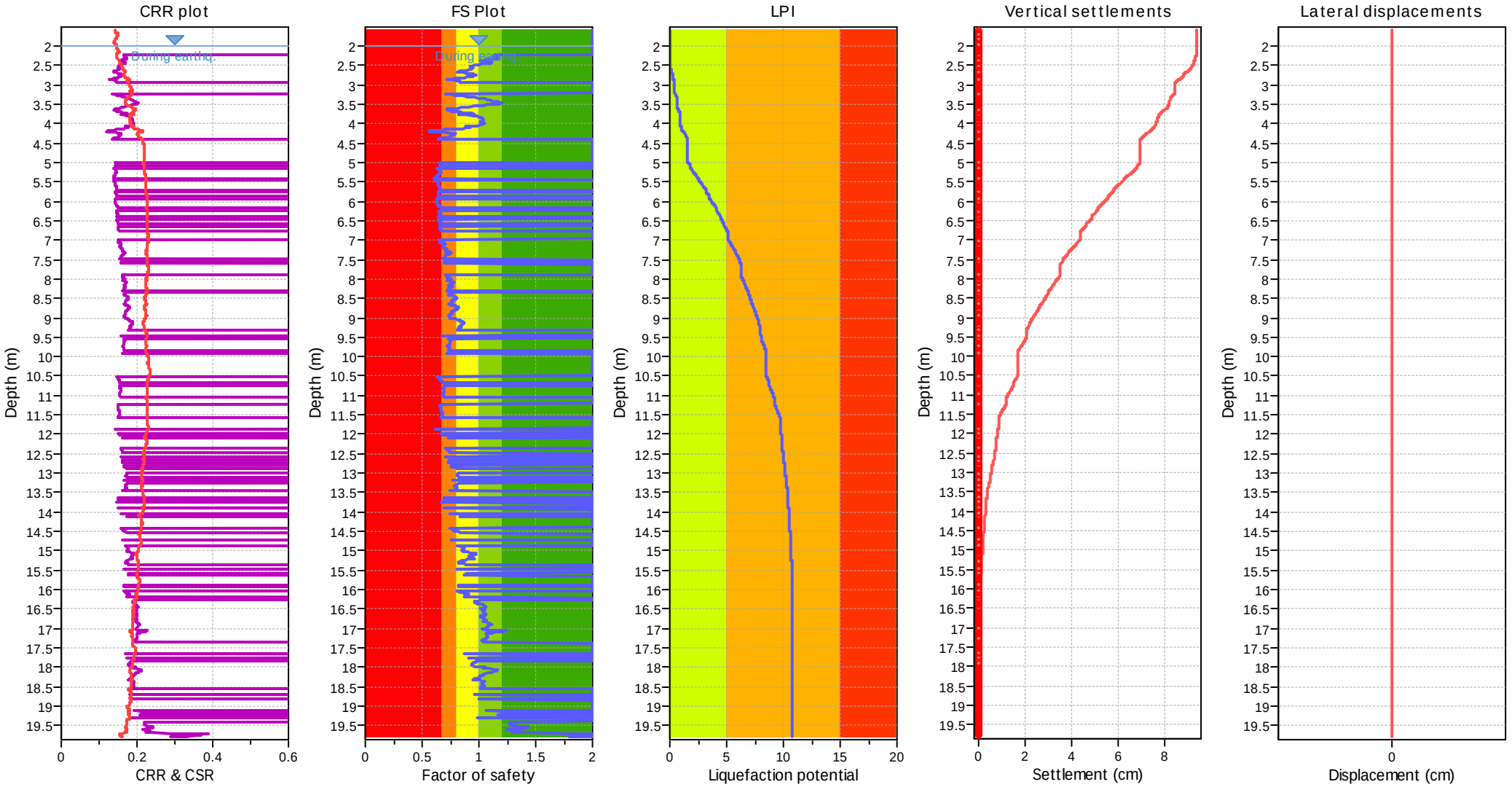
Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

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LPI color scheme

- Very high risk
- High risk
- Low risk

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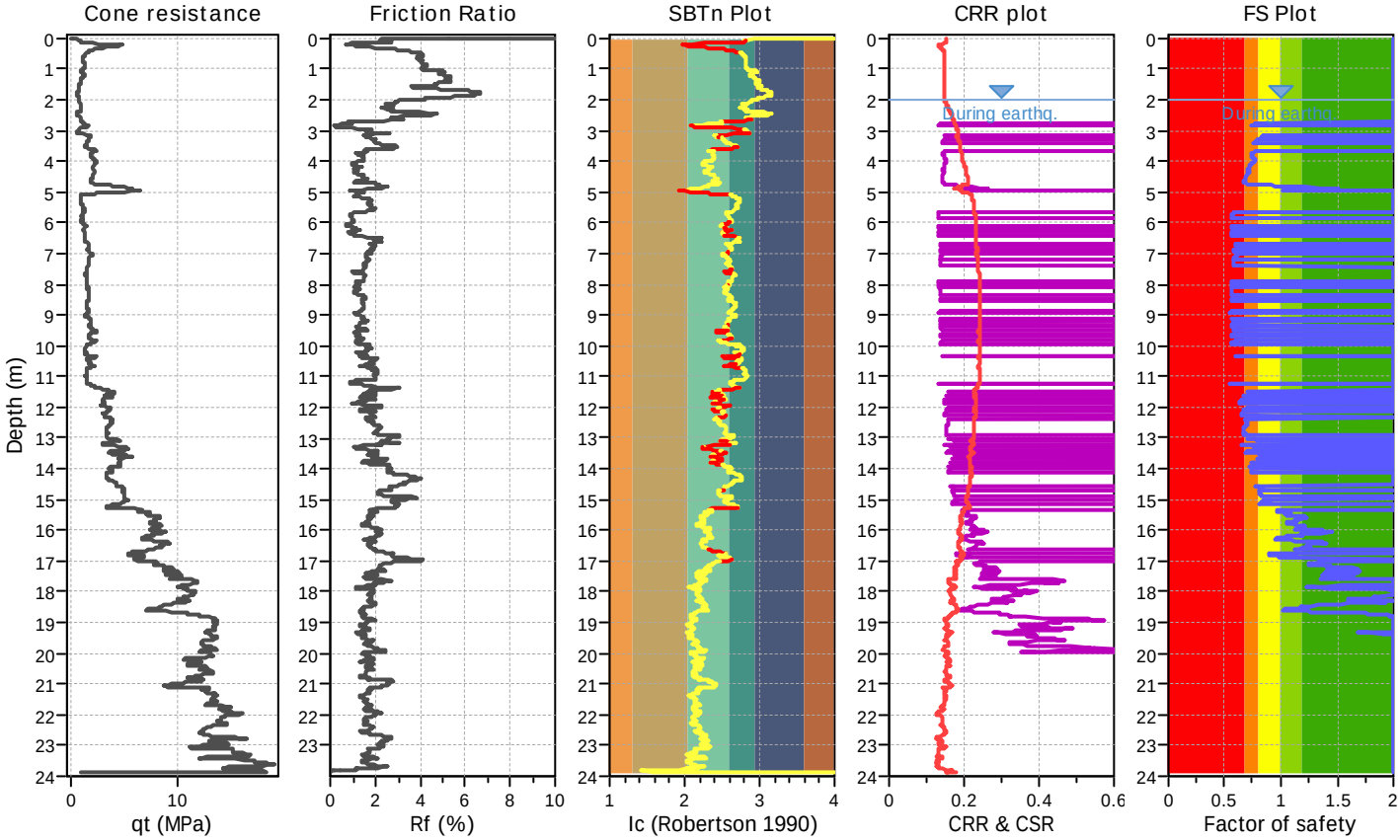
LIQUEFACTION ANALYSIS REPORT

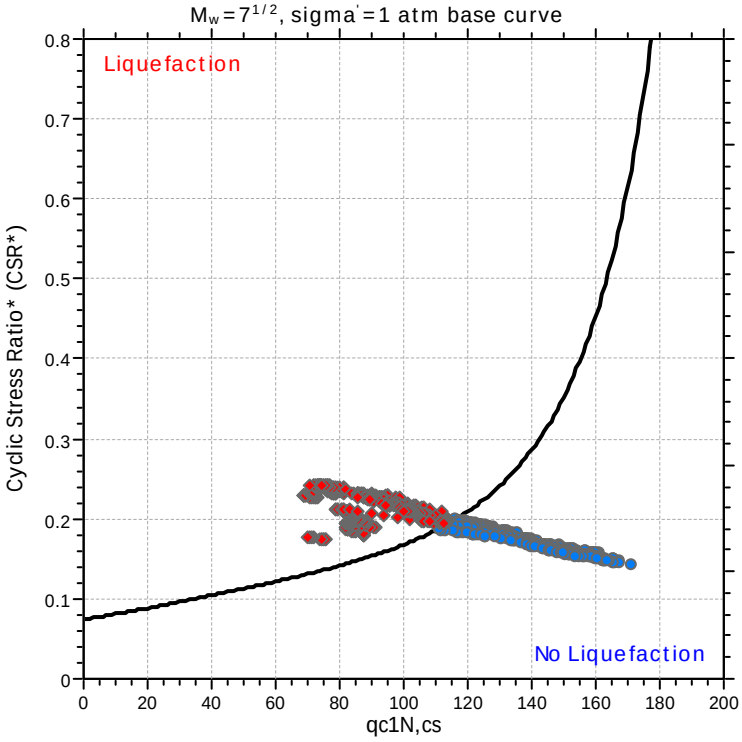
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSC005 – PS25

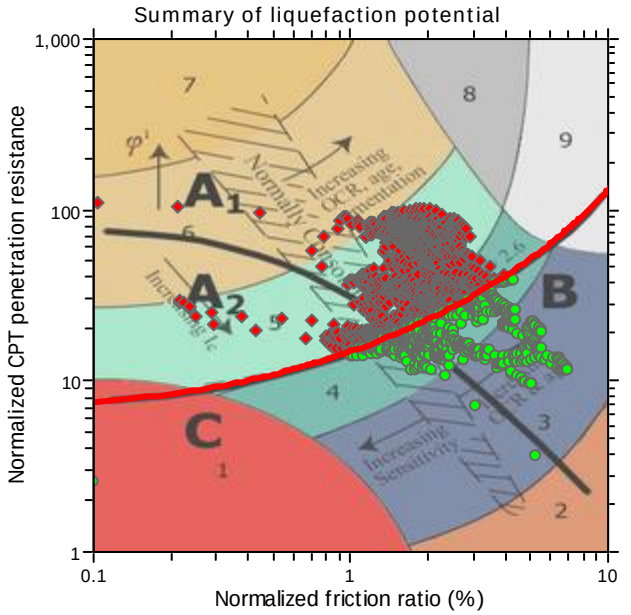
CPT file : L3S1-CPT02

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.00 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

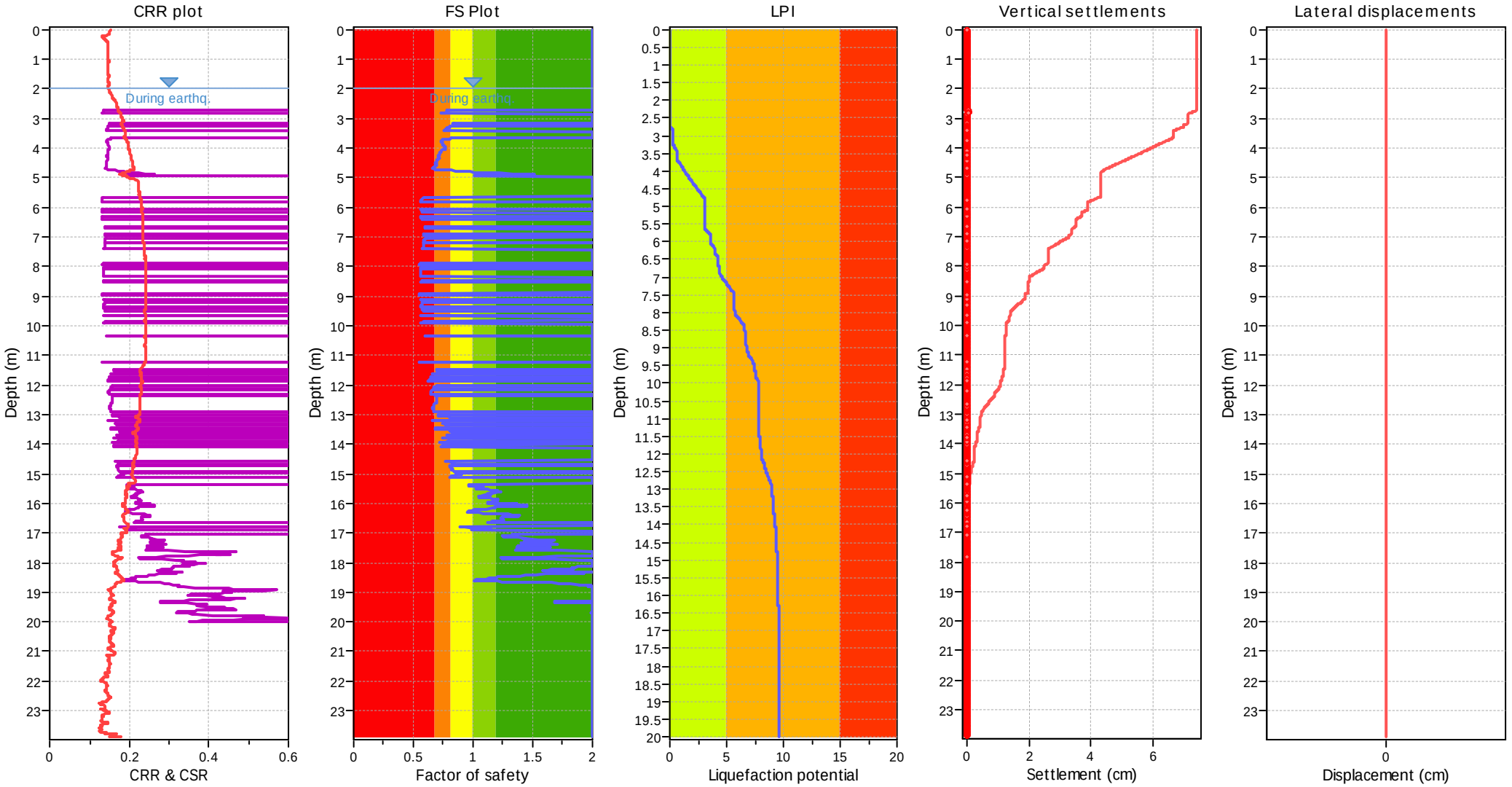






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

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LPI color scheme

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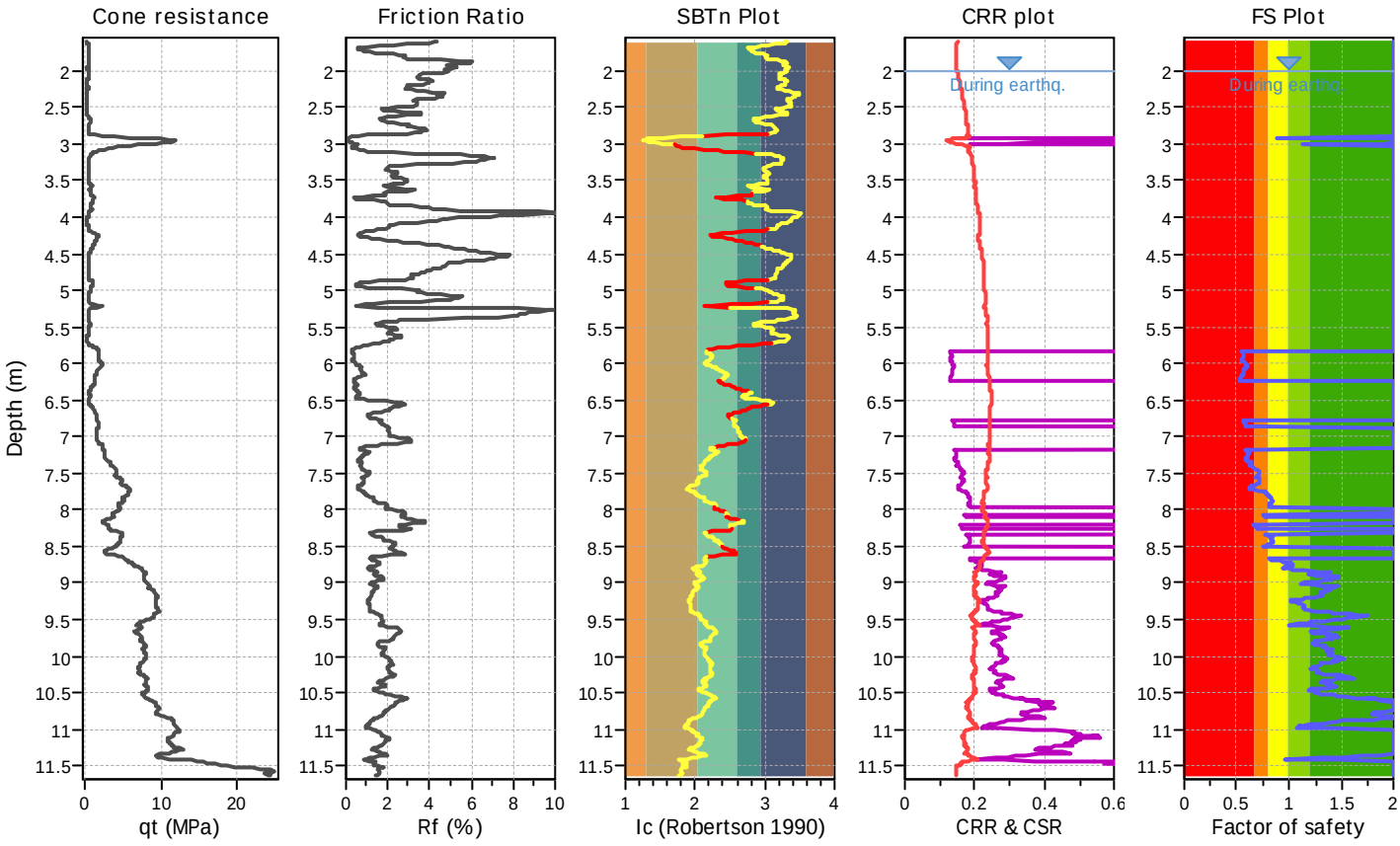
LIQUEFACTION ANALYSIS REPORT

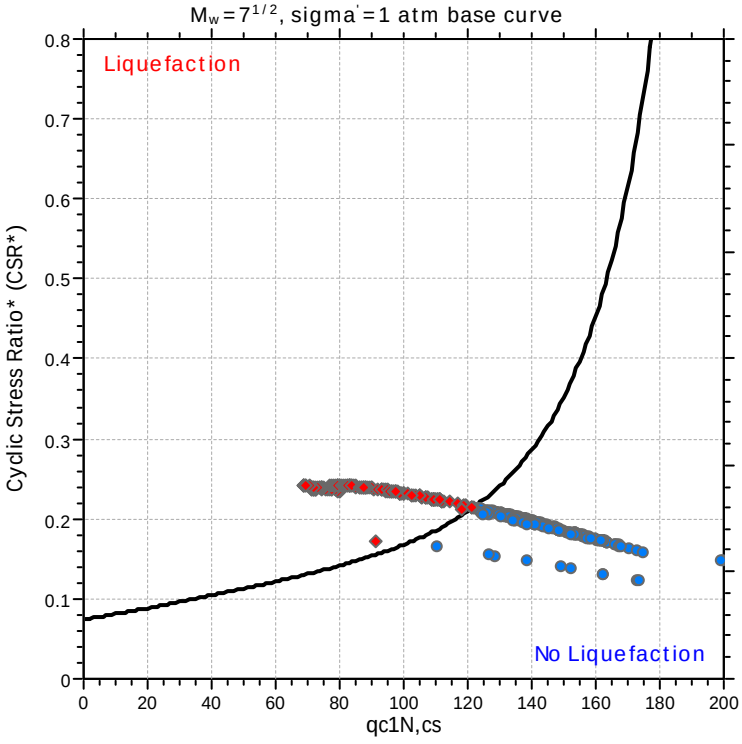
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSC005 – PS25

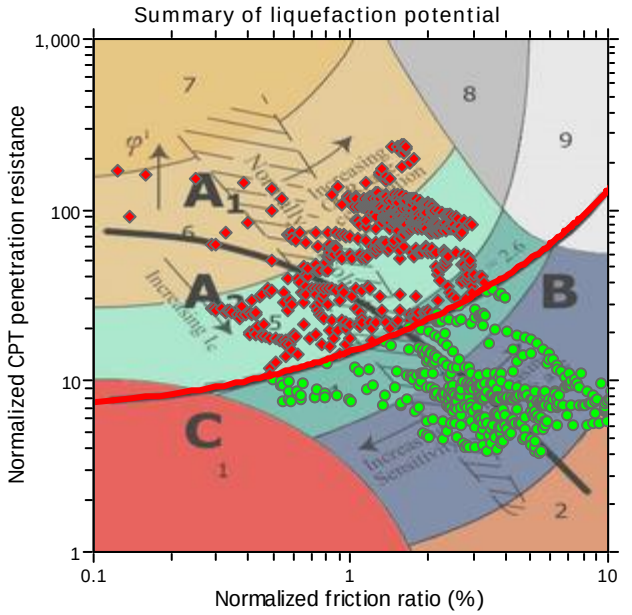
CPT file : L3S1-CPT03

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.00 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.28	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
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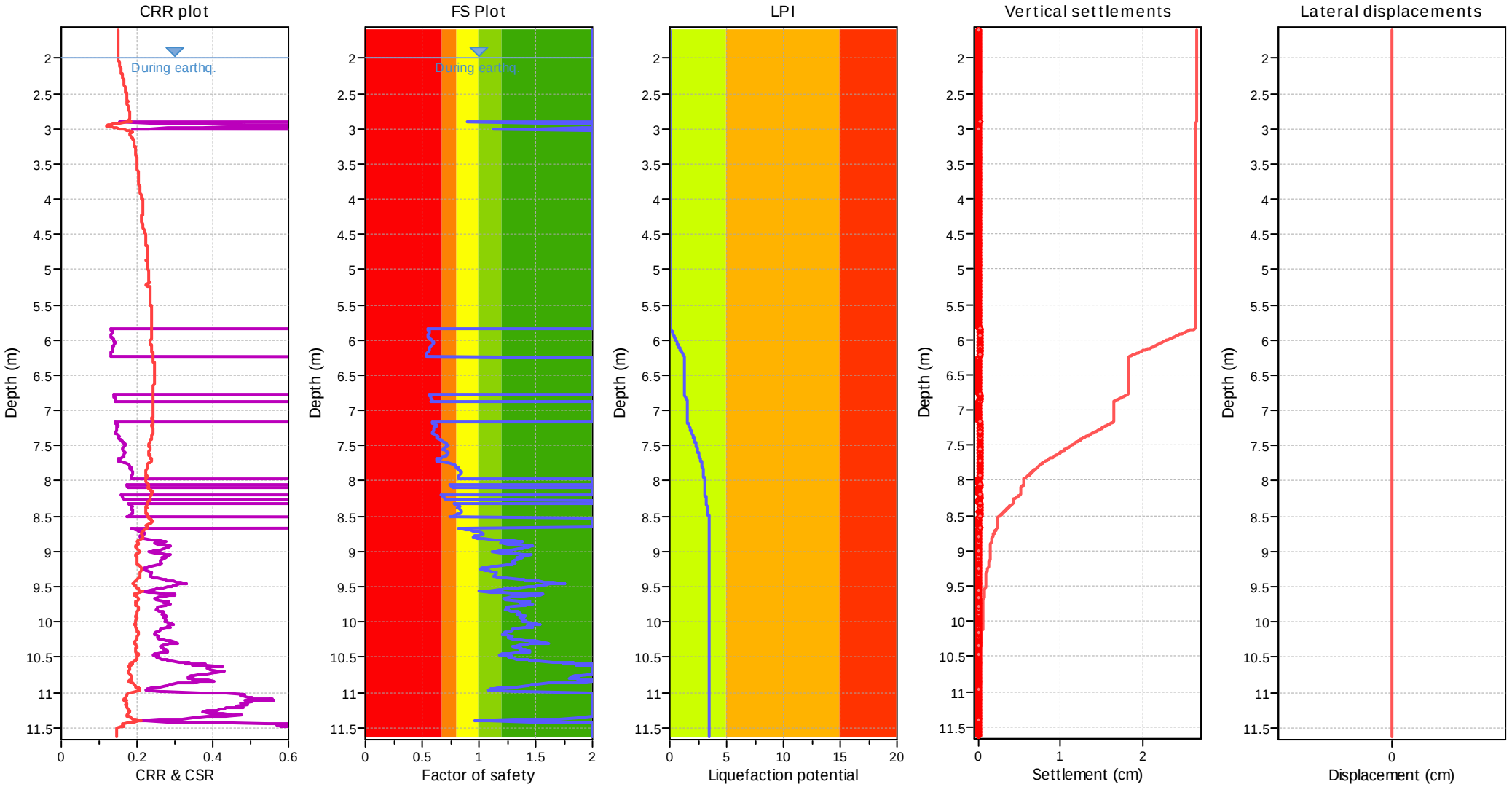
Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

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LPI color scheme

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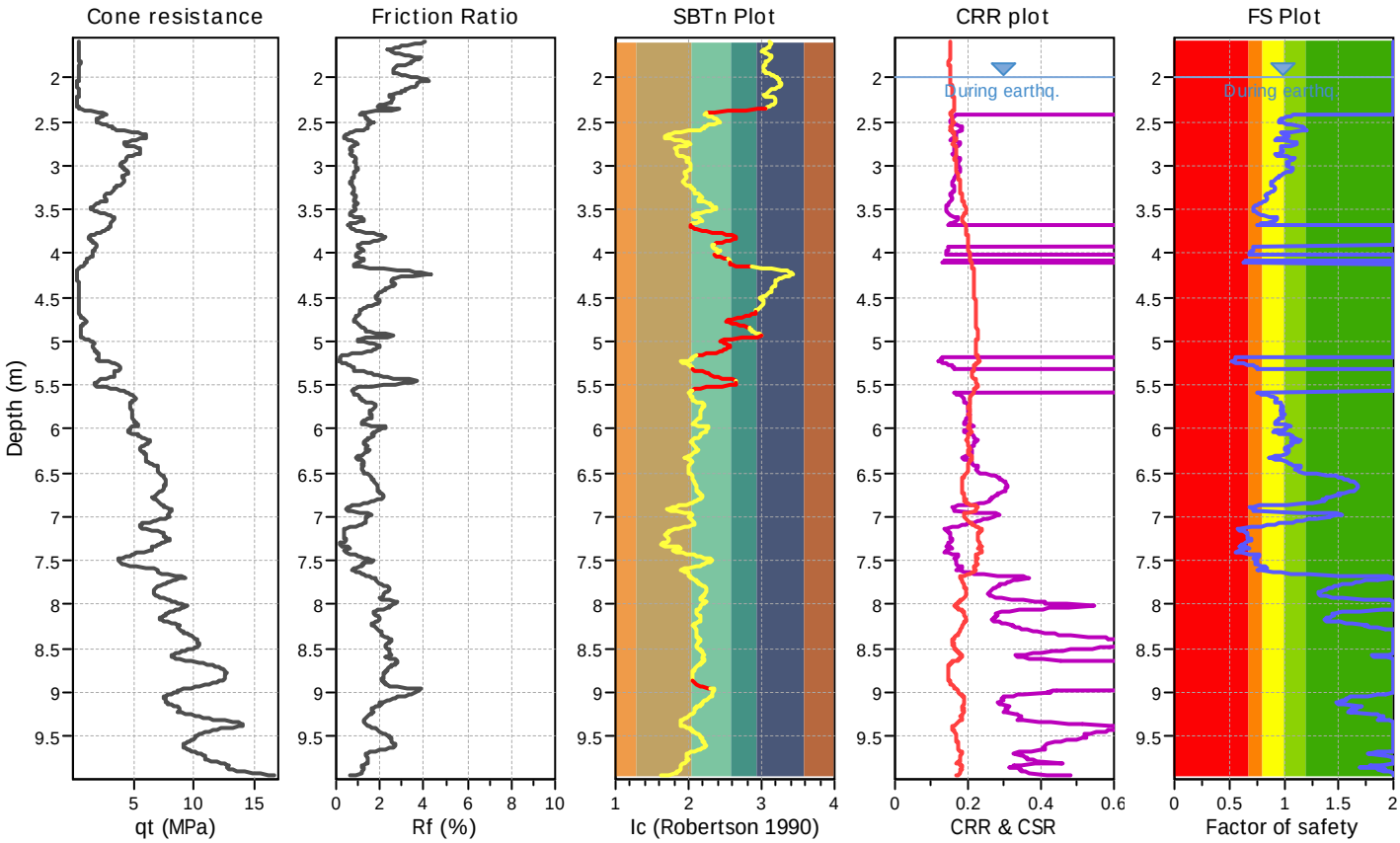
LIQUEFACTION ANALYSIS REPORT

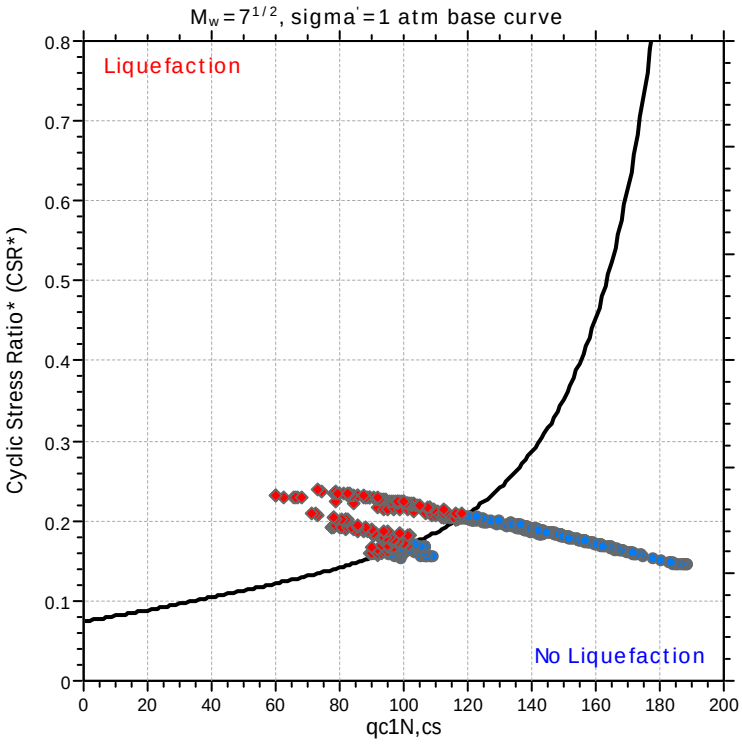
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSC005 – PS25

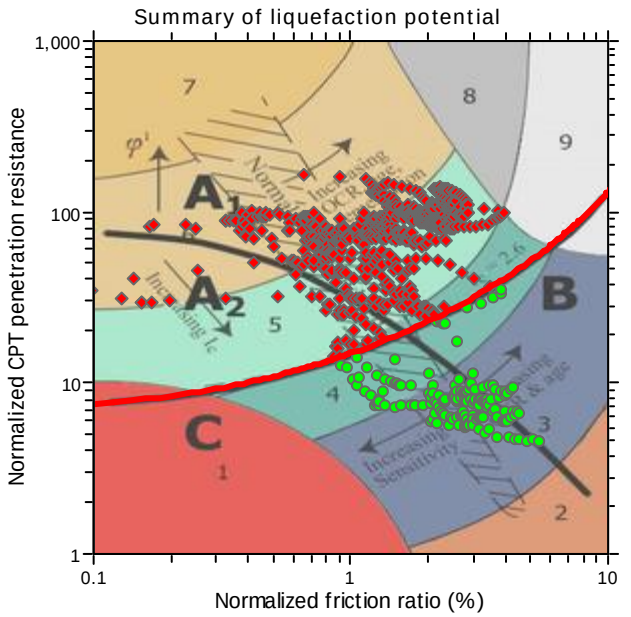
CPT file : L3S1-CPT05

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.00 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		







Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
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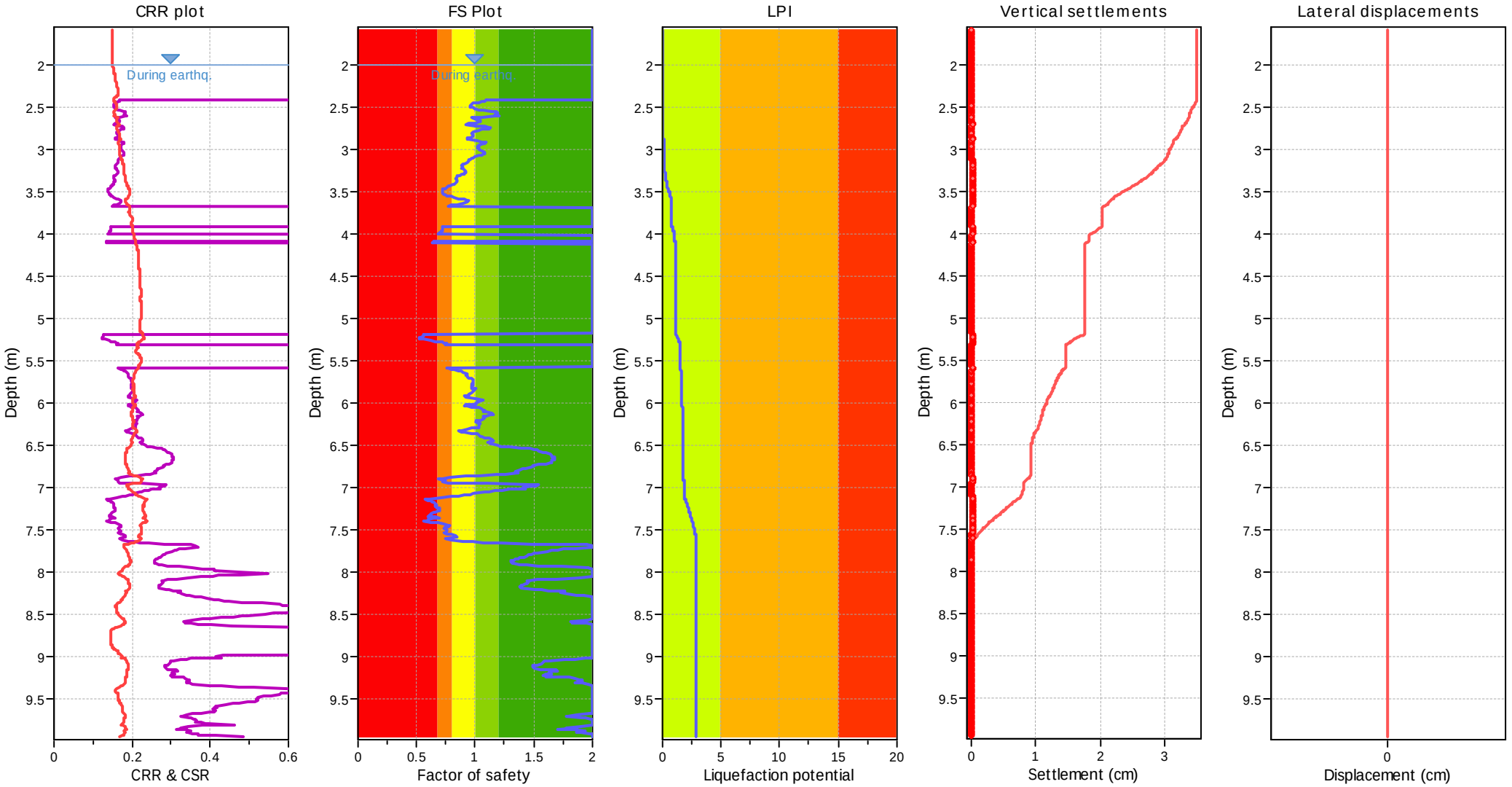
Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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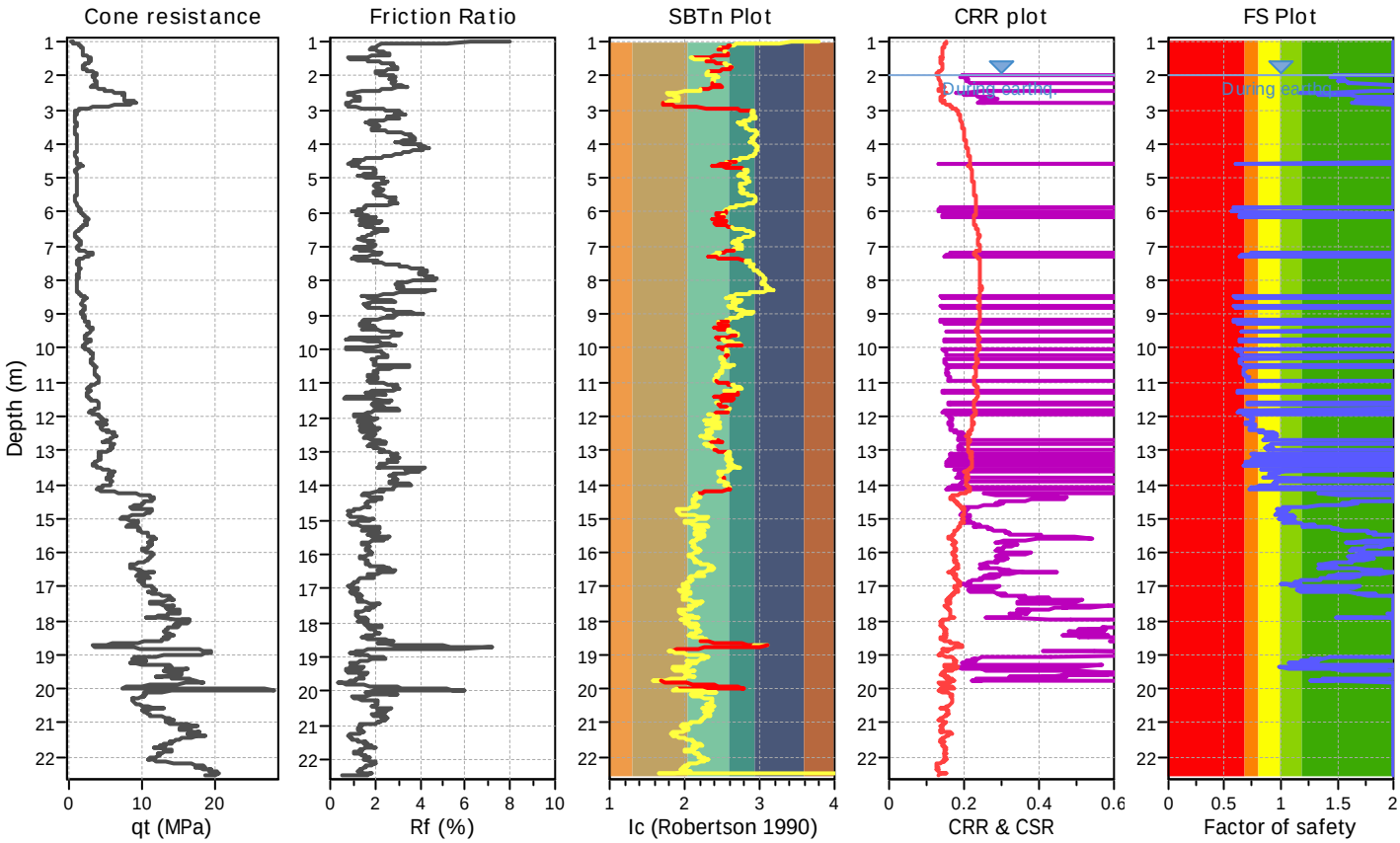
LIQUEFACTION ANALYSIS REPORT

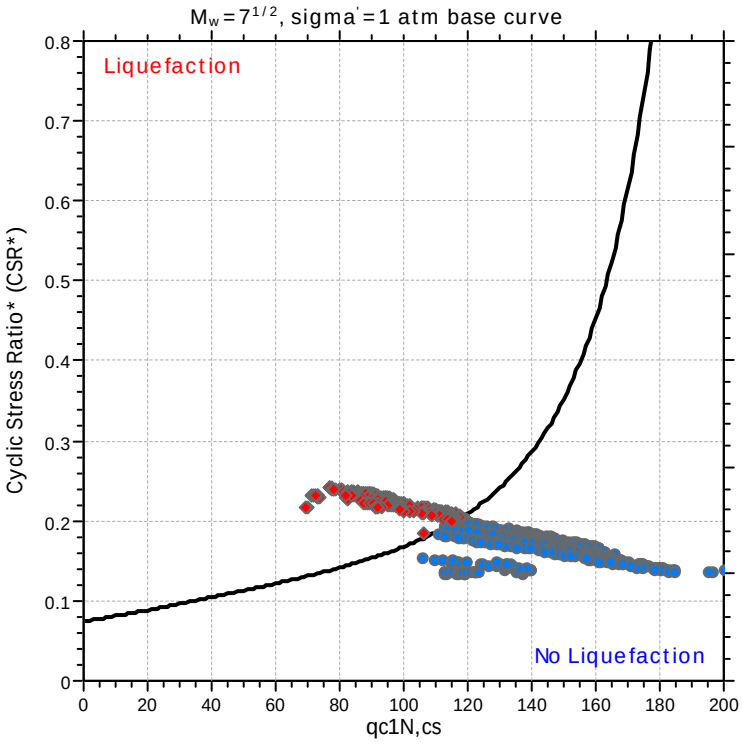
Project title : ULS 1/2500 year event (NZ1170.5) Location : DSLSC005 – PS25

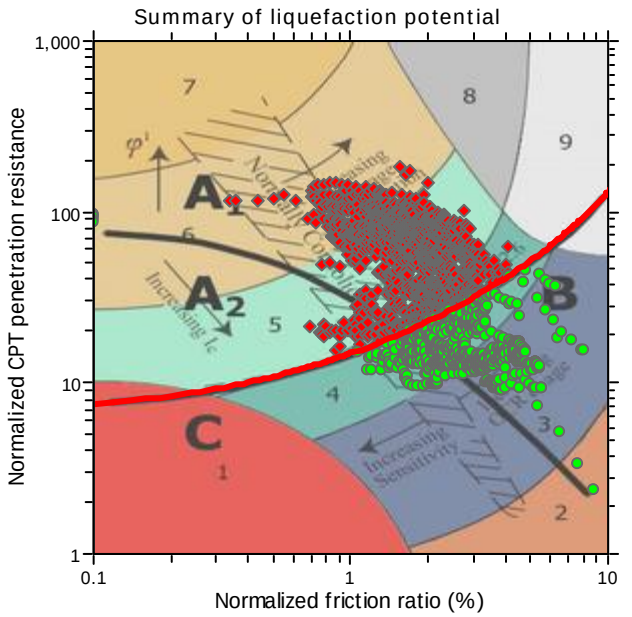
CPT file : L3S1-CPT10

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.00 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:	20.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

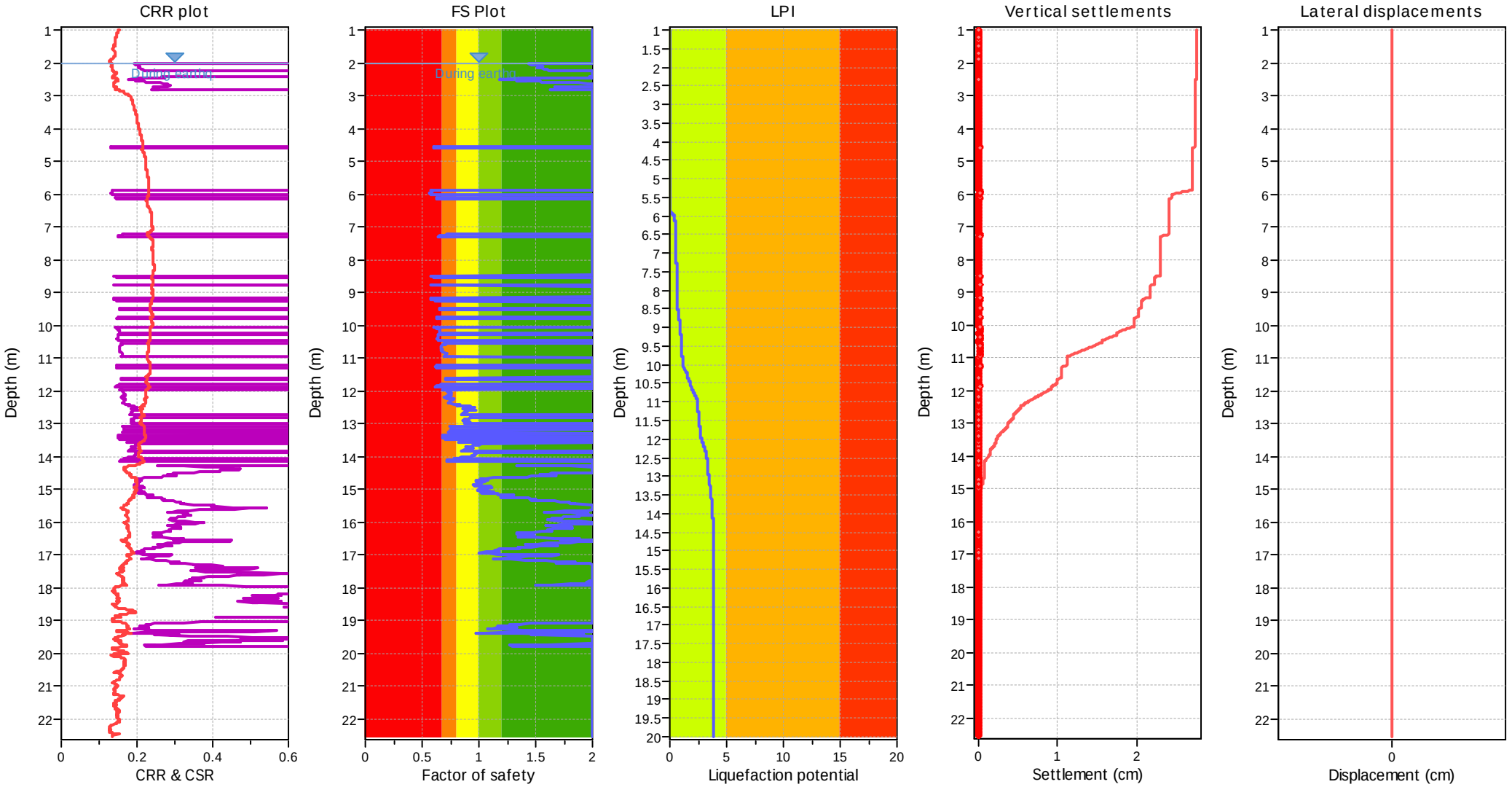






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	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:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. 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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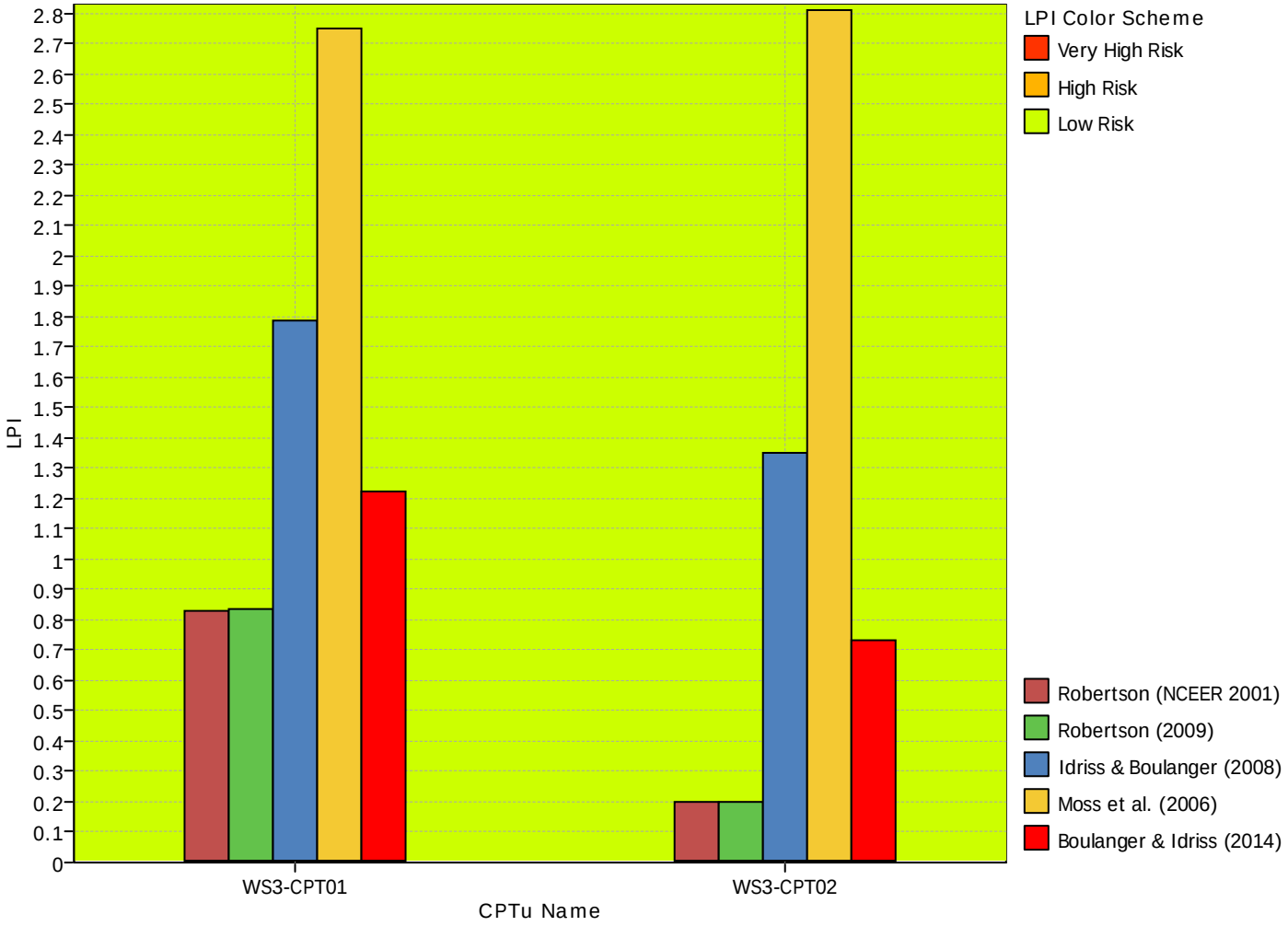
Overall Parametric Assessment Method



:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
WS3-CPT01	5.90	0.31	1.68	1.68
WS3-CPT02	5.90	0.31	1.36	1.36

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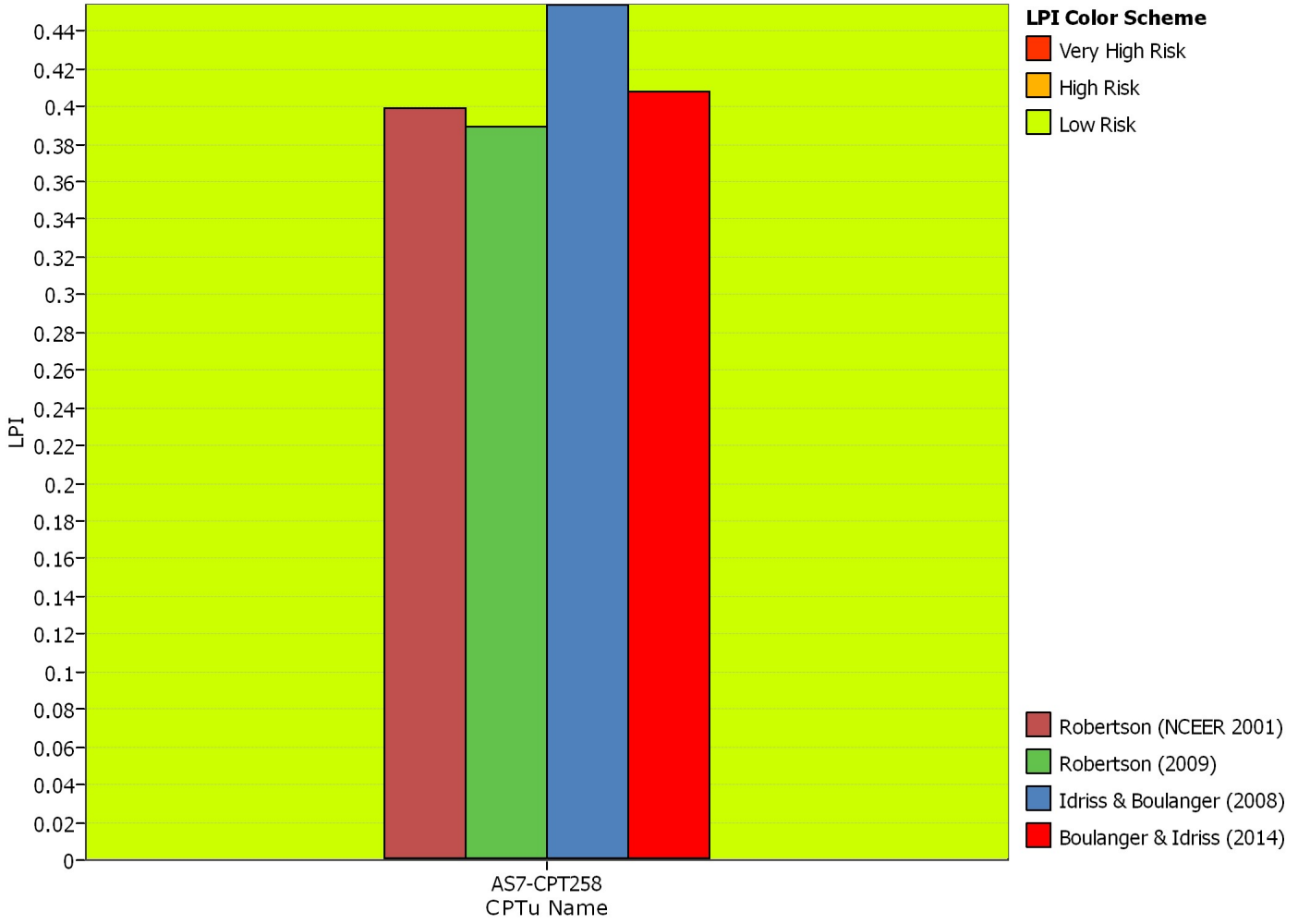
Overall Parametric Assessment Method



:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
AS7-CPT258	7.50	0.31	2.48	2.48

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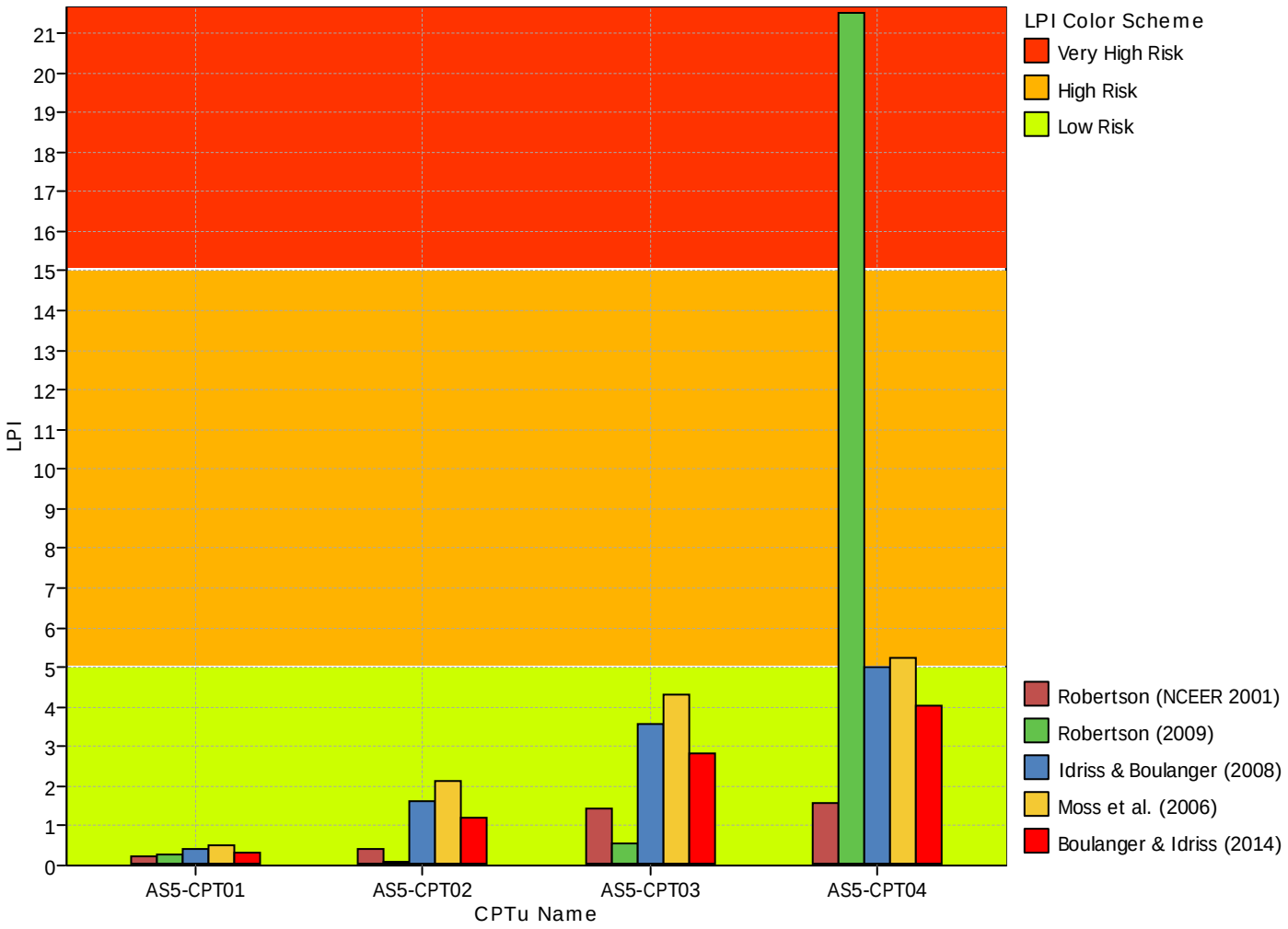
Overall Parametric Assessment Method



:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
AS5-CPT01	5.90	0.31	5.60	5.60
AS5-CPT02	5.90	0.31	3.96	3.96
AS5-CPT03	5.90	0.31	3.12	3.12
AS5-CPT04	5.90	0.31	0.00	0.00

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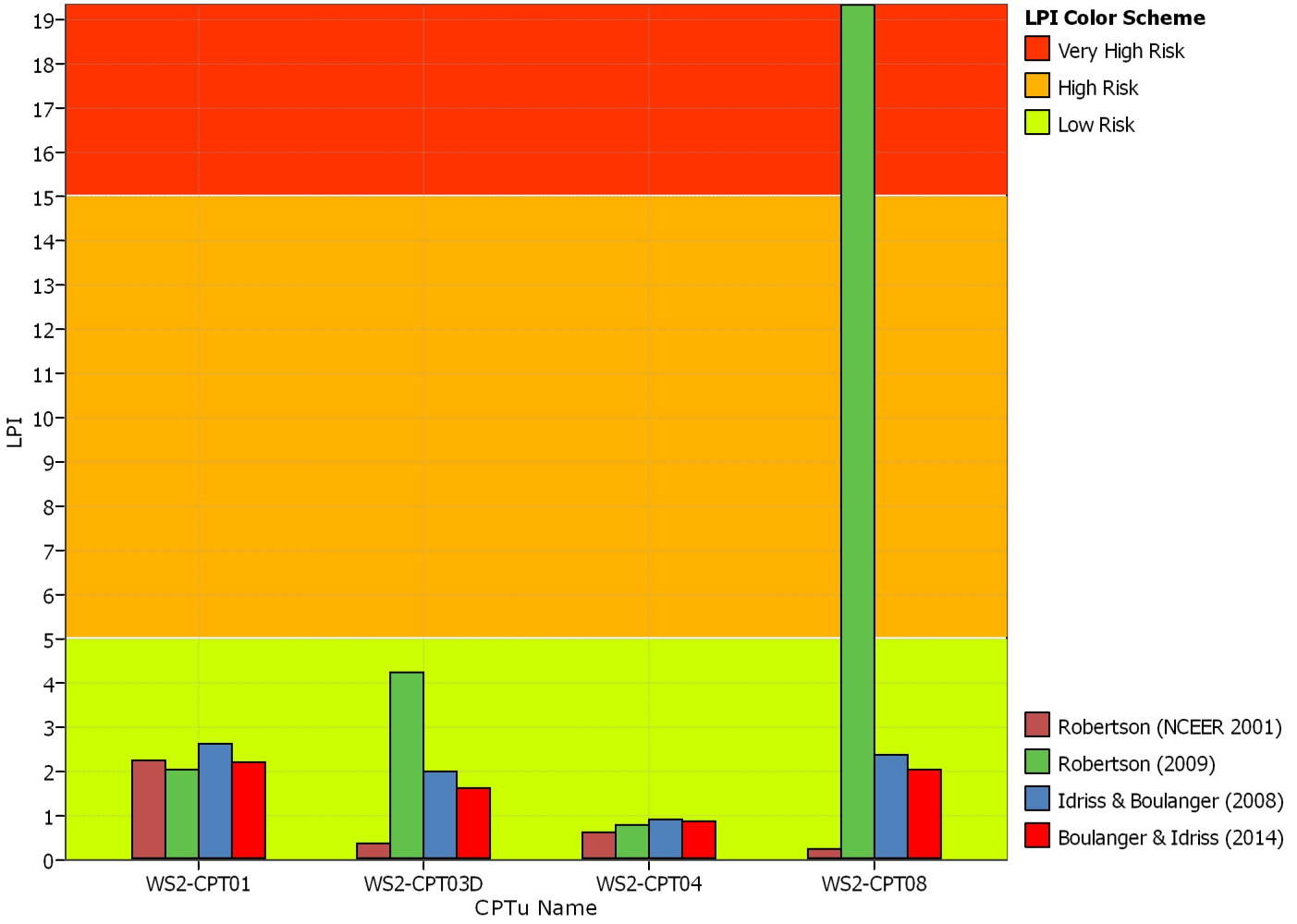
Overall Parametric Assessment Method



:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
WS2-CPT01	7.50	0.26	3.30	3.30
WS2-CPT03D	7.50	0.26	2.85	2.85
WS2-CPT04	7.50	0.26	2.60	2.60
WS2-CPT08	7.50	0.26	2.92	2.92

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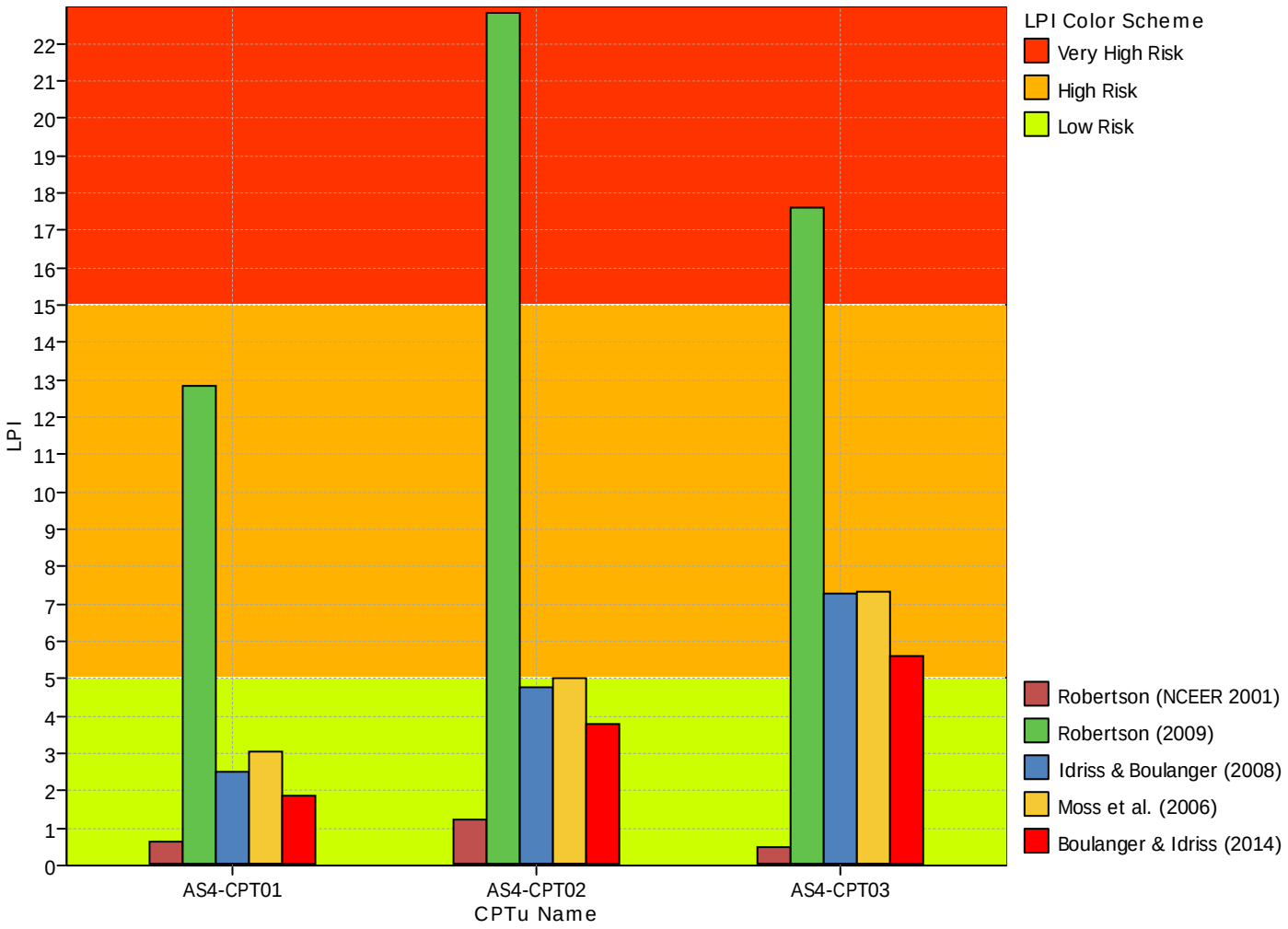

:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
AS4-CPT01	5.90	0.28	0.00	0.00
AS4-CPT02	5.90	0.28	-1.28	-1.28
AS4-CPT03	5.90	0.28	-1.58	-1.58

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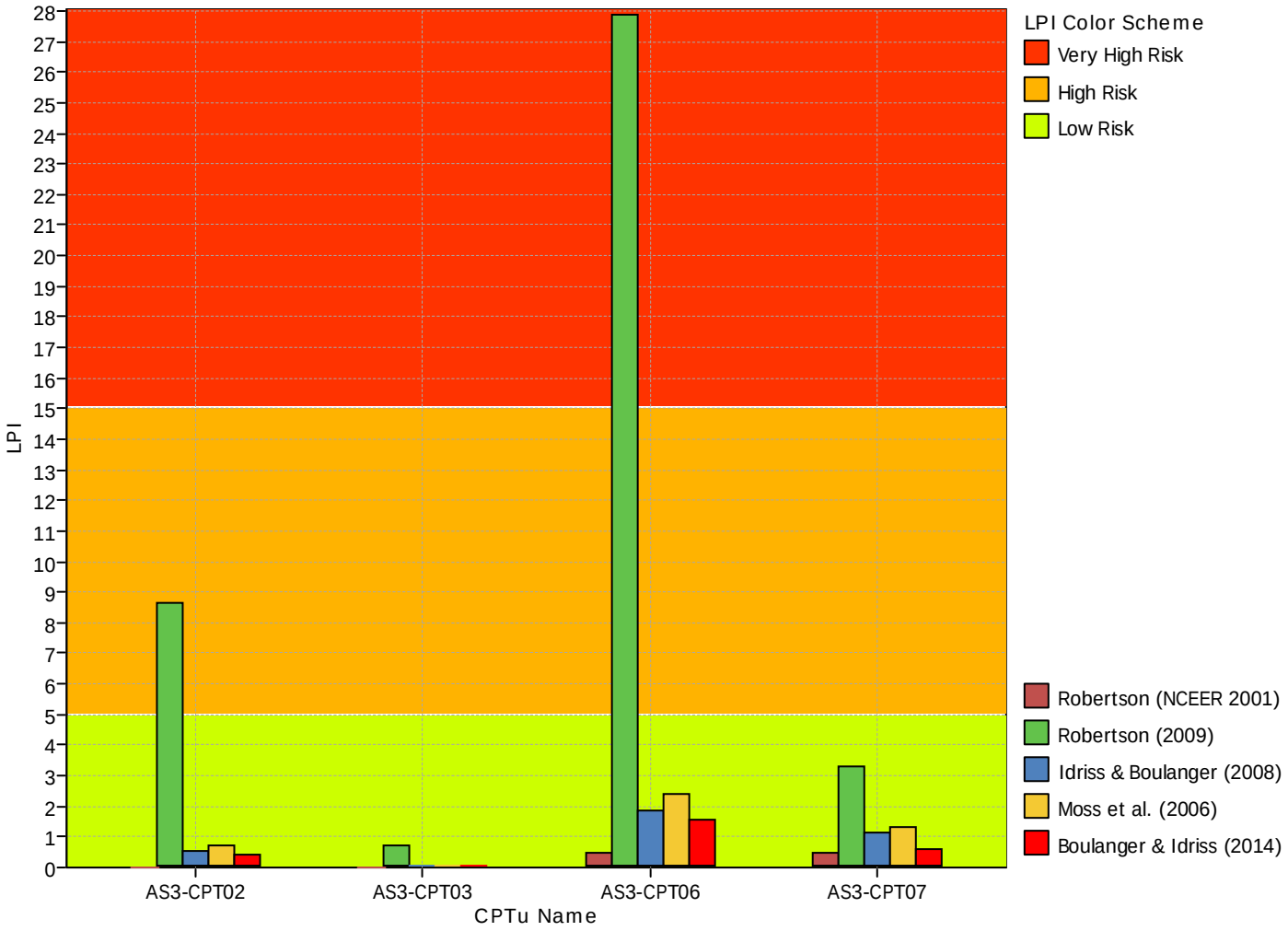
Overall Parametric Assessment Method



:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
AS3-CPT02	5.90	0.26	0.00	0.00
AS3-CPT03	5.90	0.26	0.00	0.00
AS3-CPT06	5.90	0.26	0.00	0.00
AS3-CPT07	5.90	0.26	0.00	0.00

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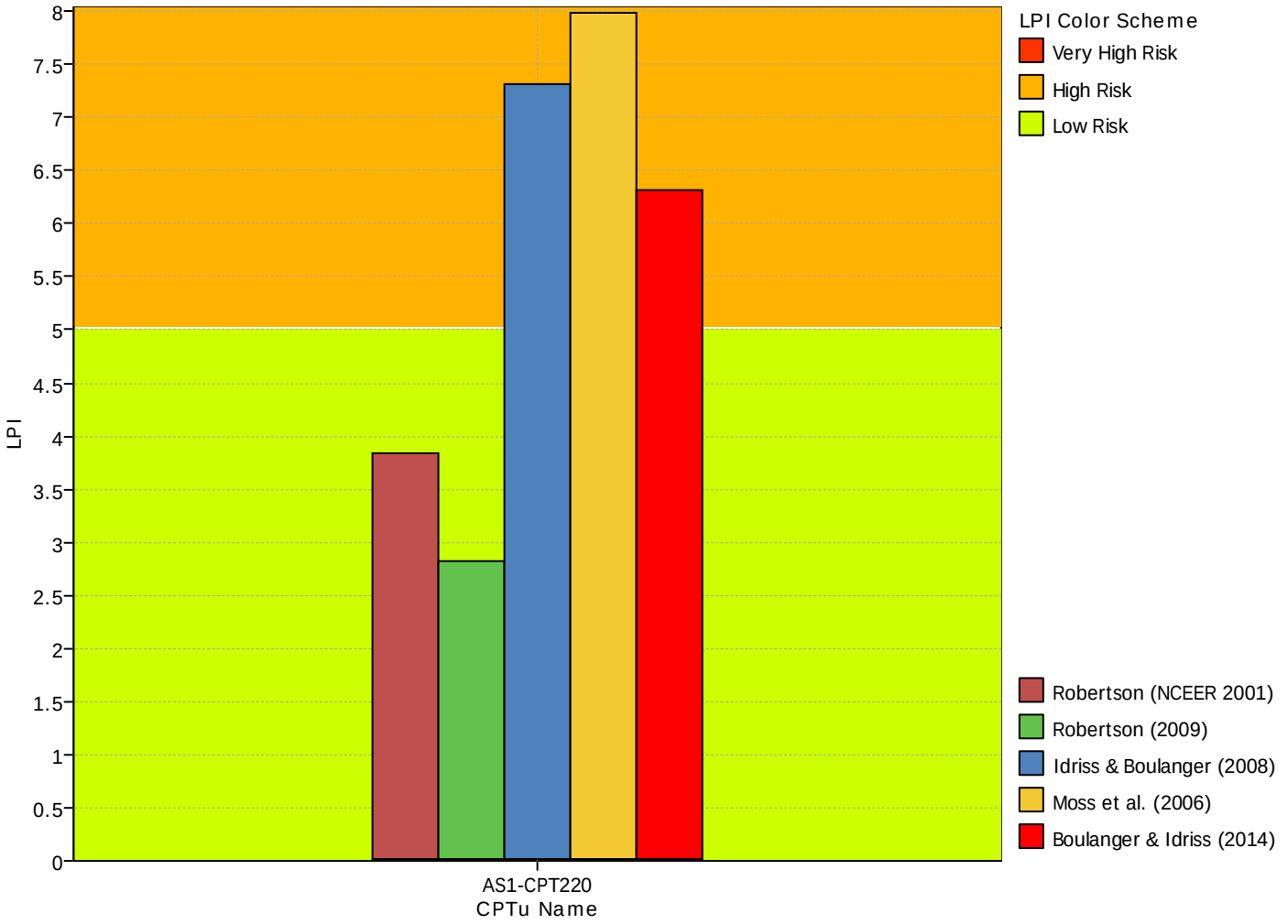

:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
AS1-CPT220	5.90	0.31	1.00	1.00

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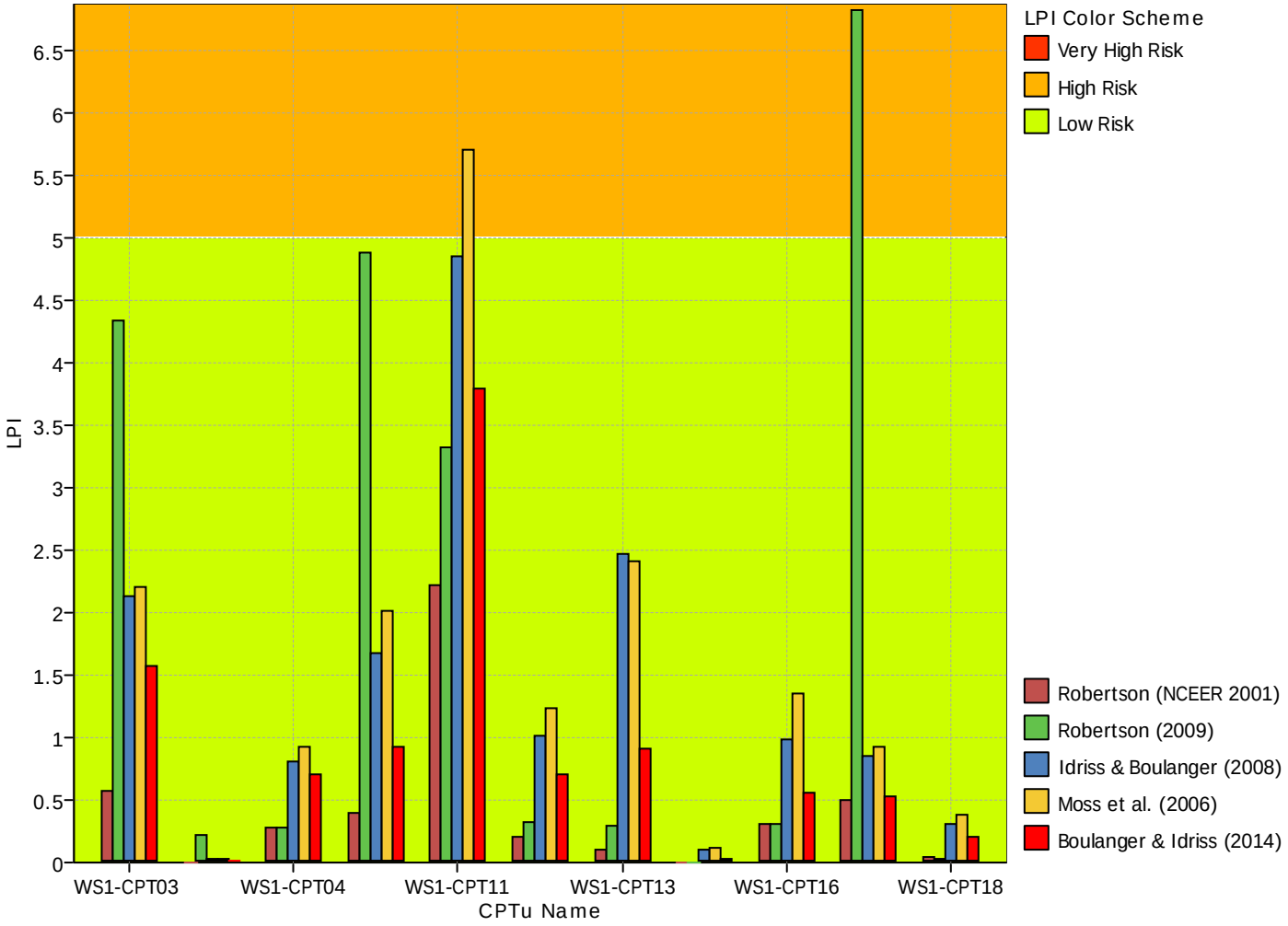

:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
WS1-CPT03	5.90	0.31	0.00	0.00
WS1-CPT04A	5.90	0.31	0.00	0.00
WS1-CPT04	5.90	0.31	0.00	0.00
WS1-CPT05	5.90	0.31	0.00	0.00
WS1-CPT11	5.90	0.31	0.00	0.00
WS1-CPT12	5.90	0.31	0.00	0.00
WS1-CPT13	5.90	0.31	0.00	0.00
WS1-CPT14	5.90	0.31	0.00	0.00
WS1-CPT16	5.90	0.31	0.00	0.00
WS1-CPT17	5.90	0.31	0.00	0.00
WS1-CPT18	5.90	0.31	0.00	0.00

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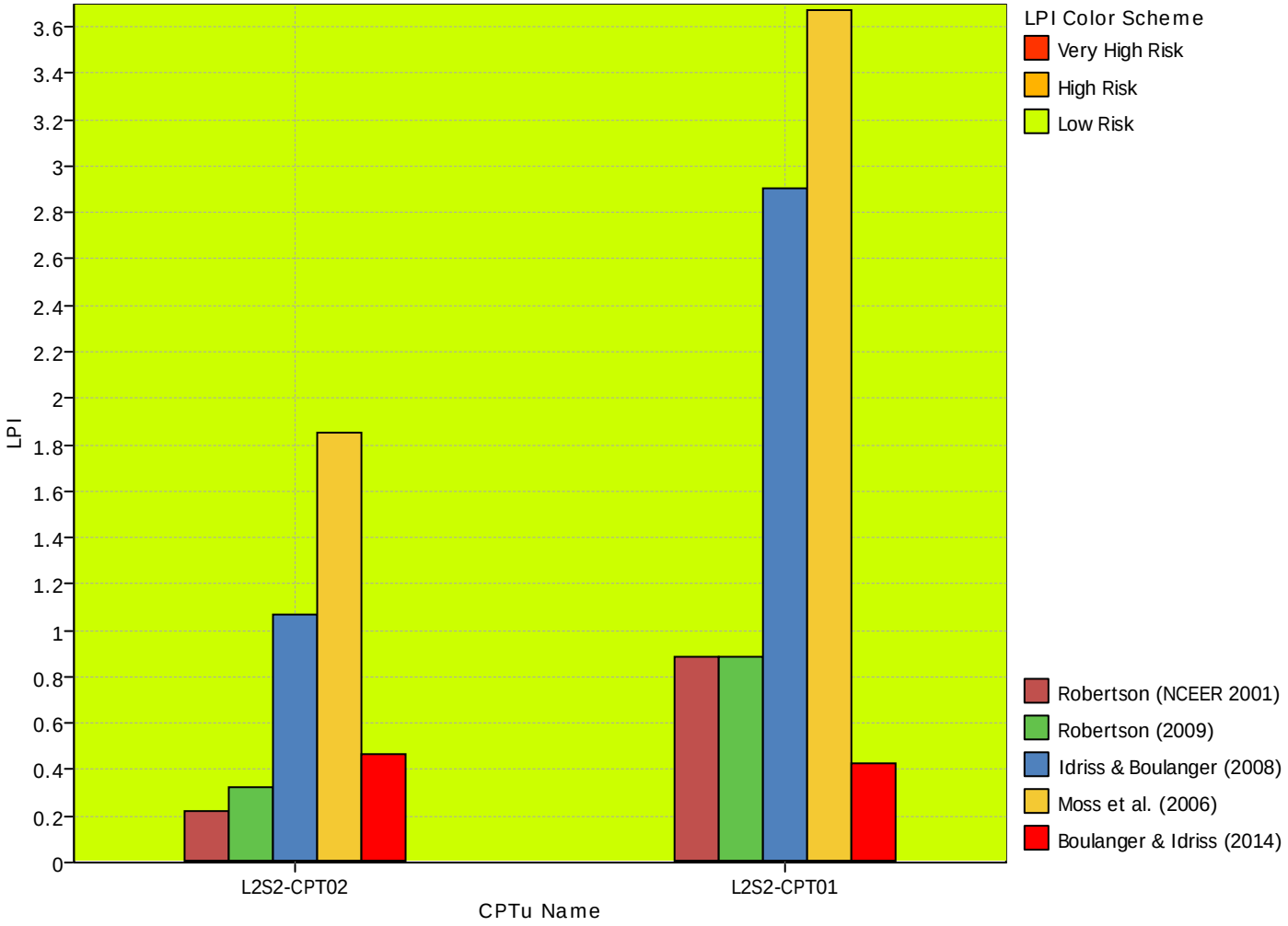

:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
L2S2-CPT02	5.90	0.26	1.93	1.93
L2S2-CPT01	5.90	0.26	1.93	1.93

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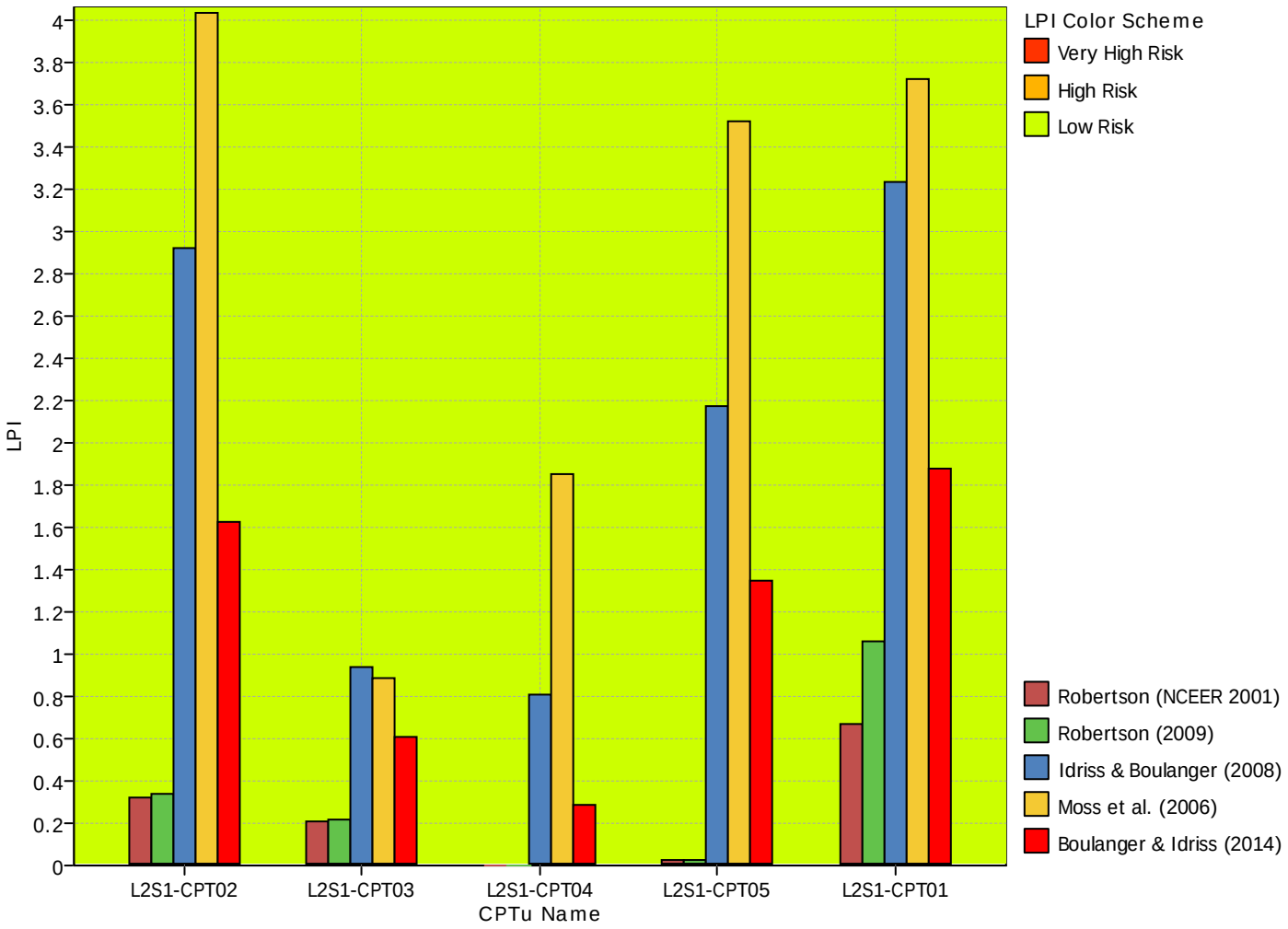

:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
L2S1-CPT02	5.90	0.31	2.50	2.70
L2S1-CPT03	5.90	0.31	2.50	2.50
L2S1-CPT04	5.90	0.31	2.50	2.50
L2S1-CPT05	5.90	0.31	2.50	2.50
L2S1-CPT01	5.90	0.31	2.50	2.50

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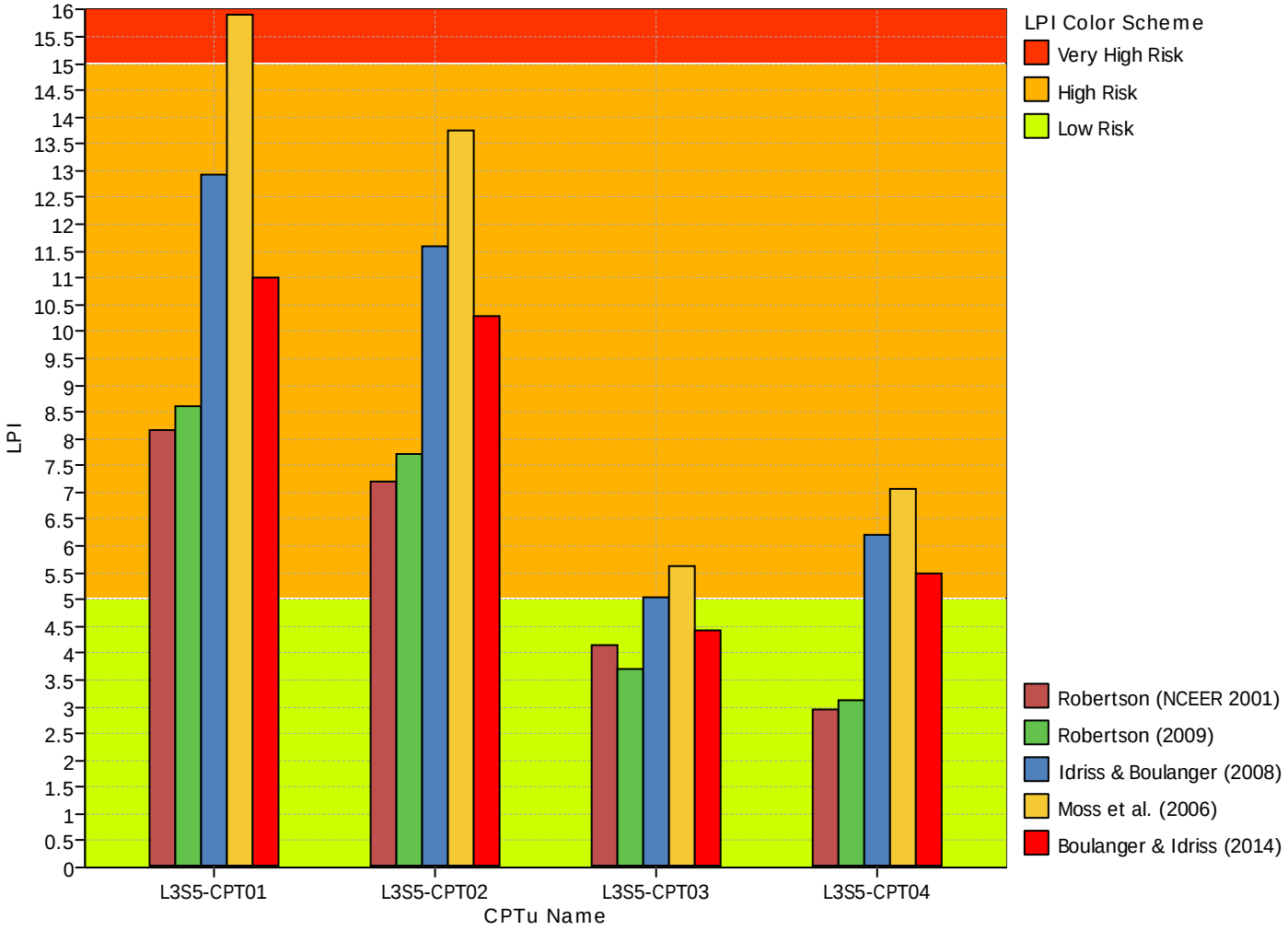

:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
L3S5-CPT01	5.90	0.28	0.00	0.00
L3S5-CPT02	5.90	0.28	0.00	0.00
L3S5-CPT03	5.90	0.28	0.00	0.00
L3S5-CPT04	5.90	0.28	0.00	0.00

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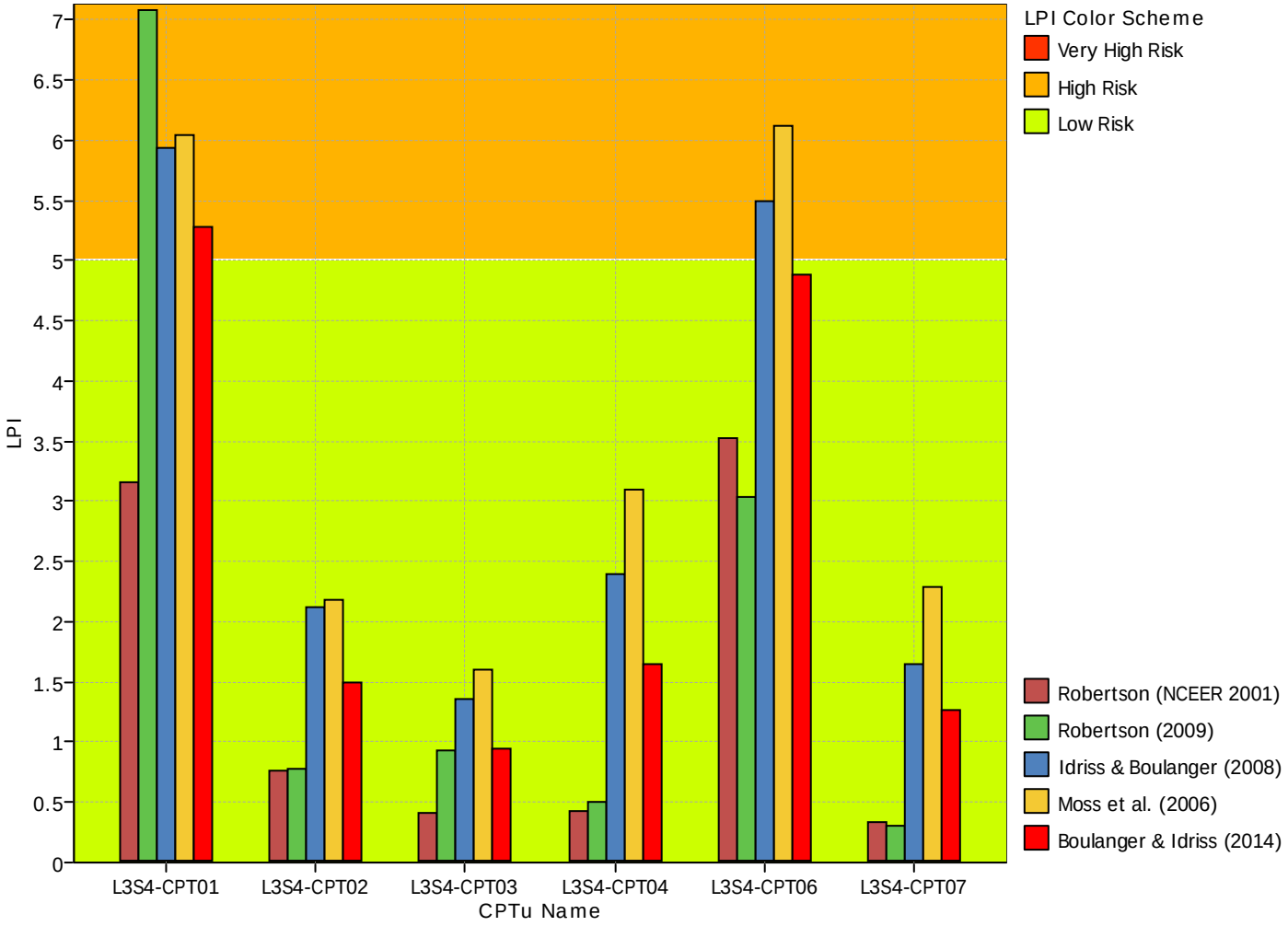

:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
L3S4-CPT01	5.90	0.28	-1.22	-1.22
L3S4-CPT02	5.90	0.28	-0.24	-0.24
L3S4-CPT03	5.90	0.28	-1.13	-1.13
L3S4-CPT04	5.90	0.28	0.00	0.00
L3S4-CPT06	5.90	0.28	-1.23	-1.23
L3S4-CPT07	5.90	0.28	0.10	0.10

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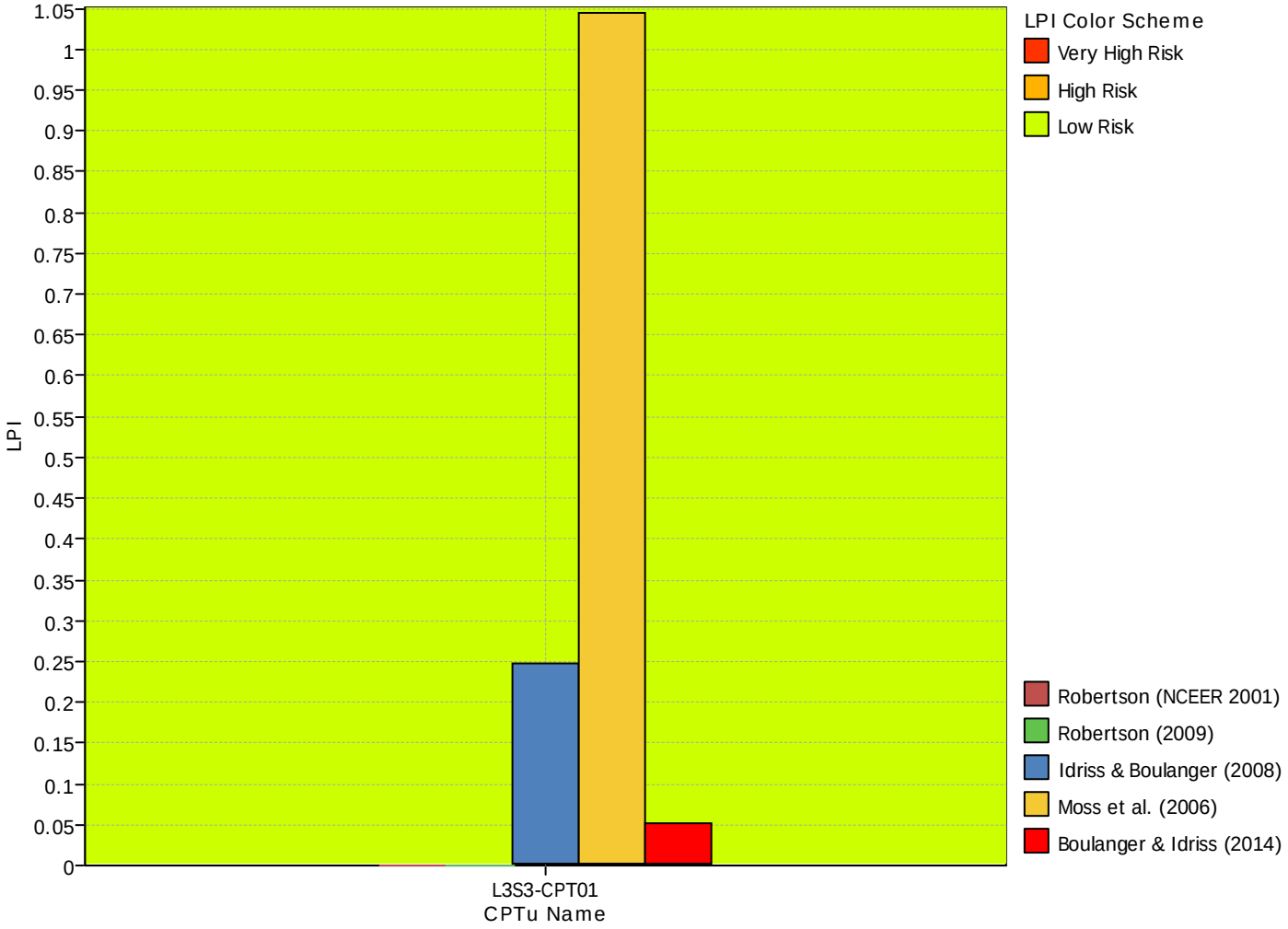

:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
L3S3-CPT01	5.90	0.31	0.97	0.97

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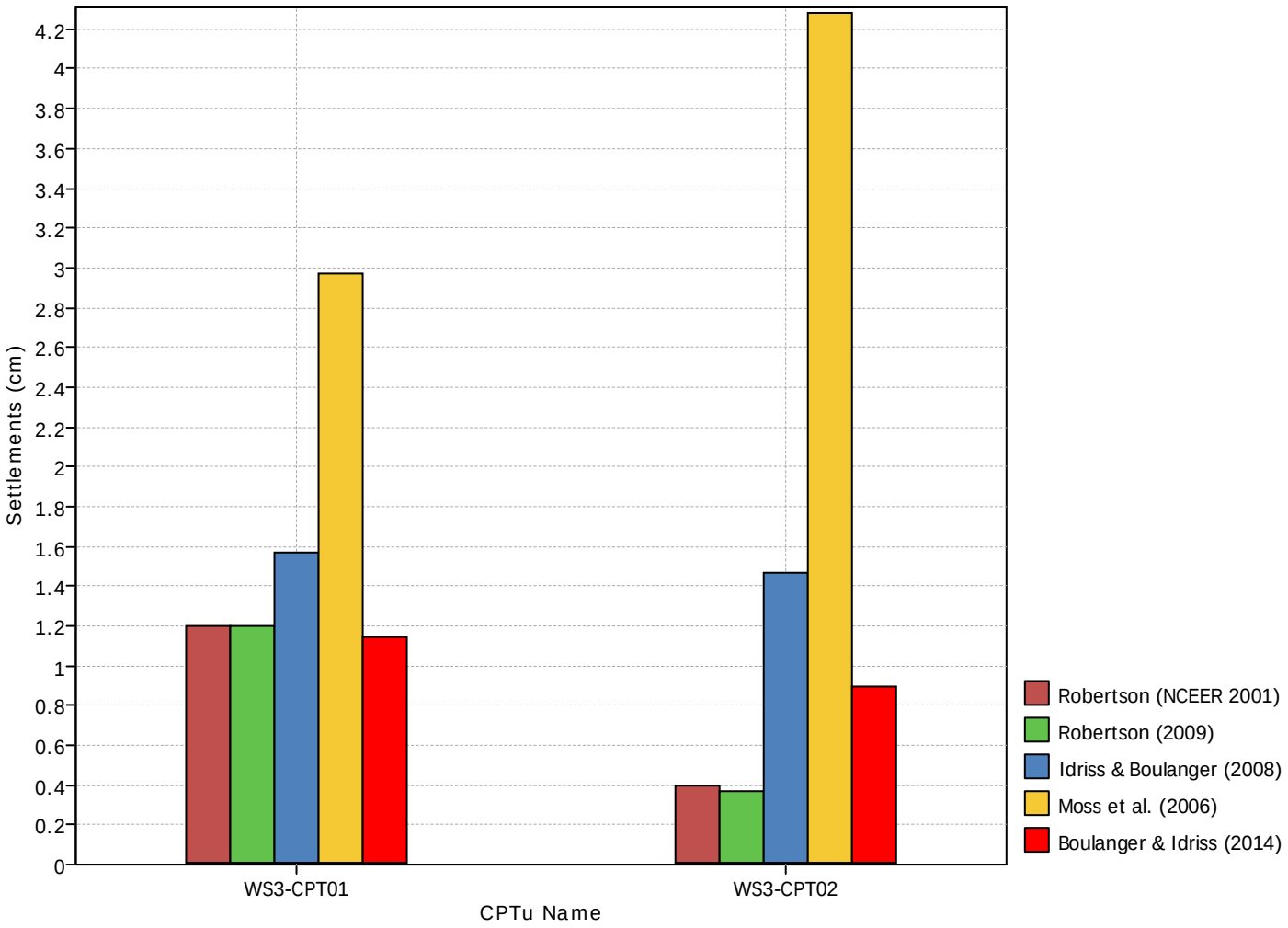

:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
WS3-CPT01	5.90	0.31	1.68	1.68
WS3-CPT02	5.90	0.31	1.36	1.36

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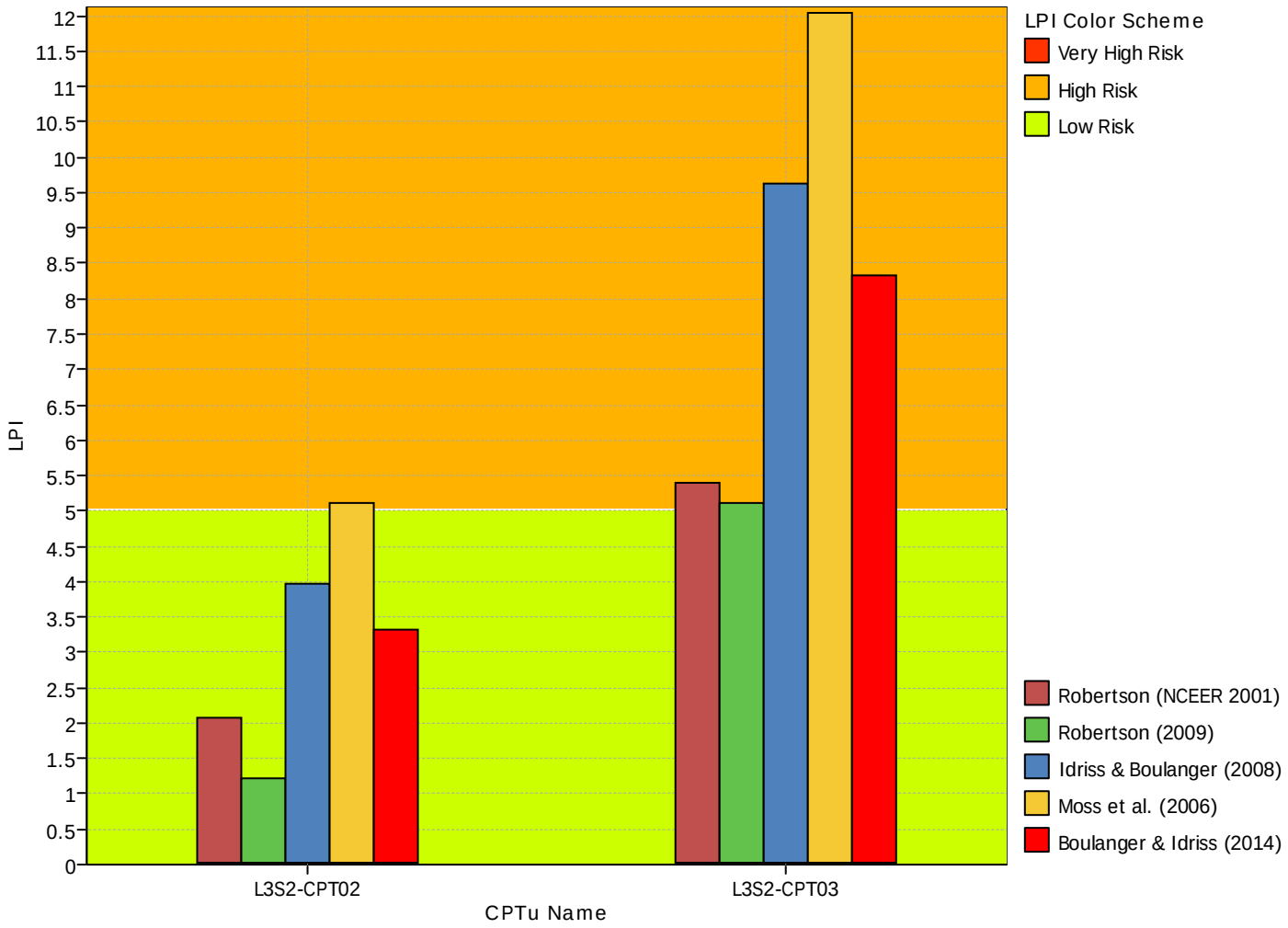
Overall Parametric Assessment Method



:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
L3S2-CPT02	5.90	0.28	1.00	1.00
L3S2-CPT03	5.90	0.28	1.00	1.00

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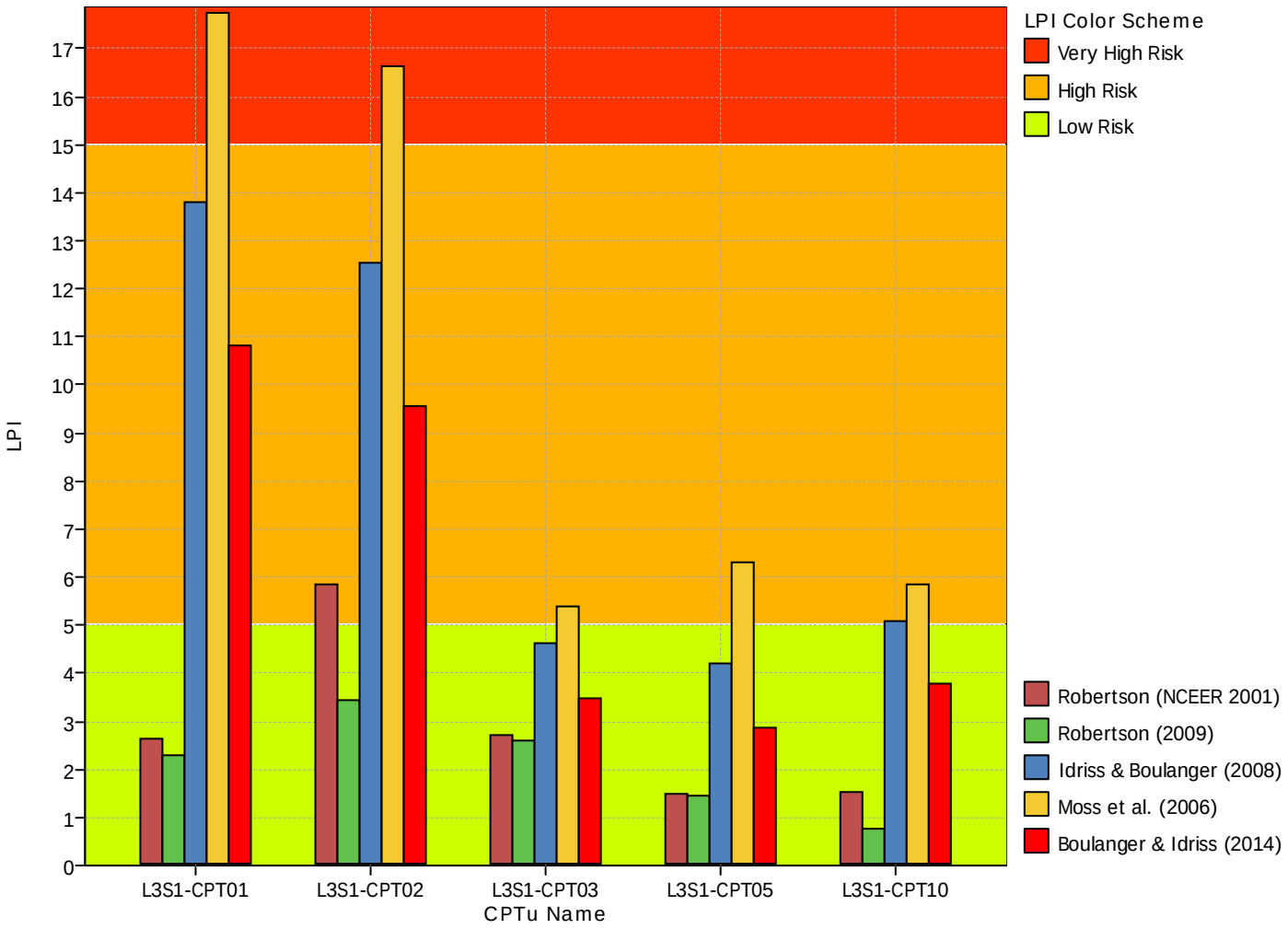

:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
L3S1-CPT01	5.90	0.28	2.00	2.00
L3S1-CPT02	5.90	0.28	2.00	2.00
L3S1-CPT03	5.90	0.28	2.00	2.00
L3S1-CPT05	5.90	0.28	2.00	2.00
L3S1-CPT10	5.90	0.28	2.00	2.00

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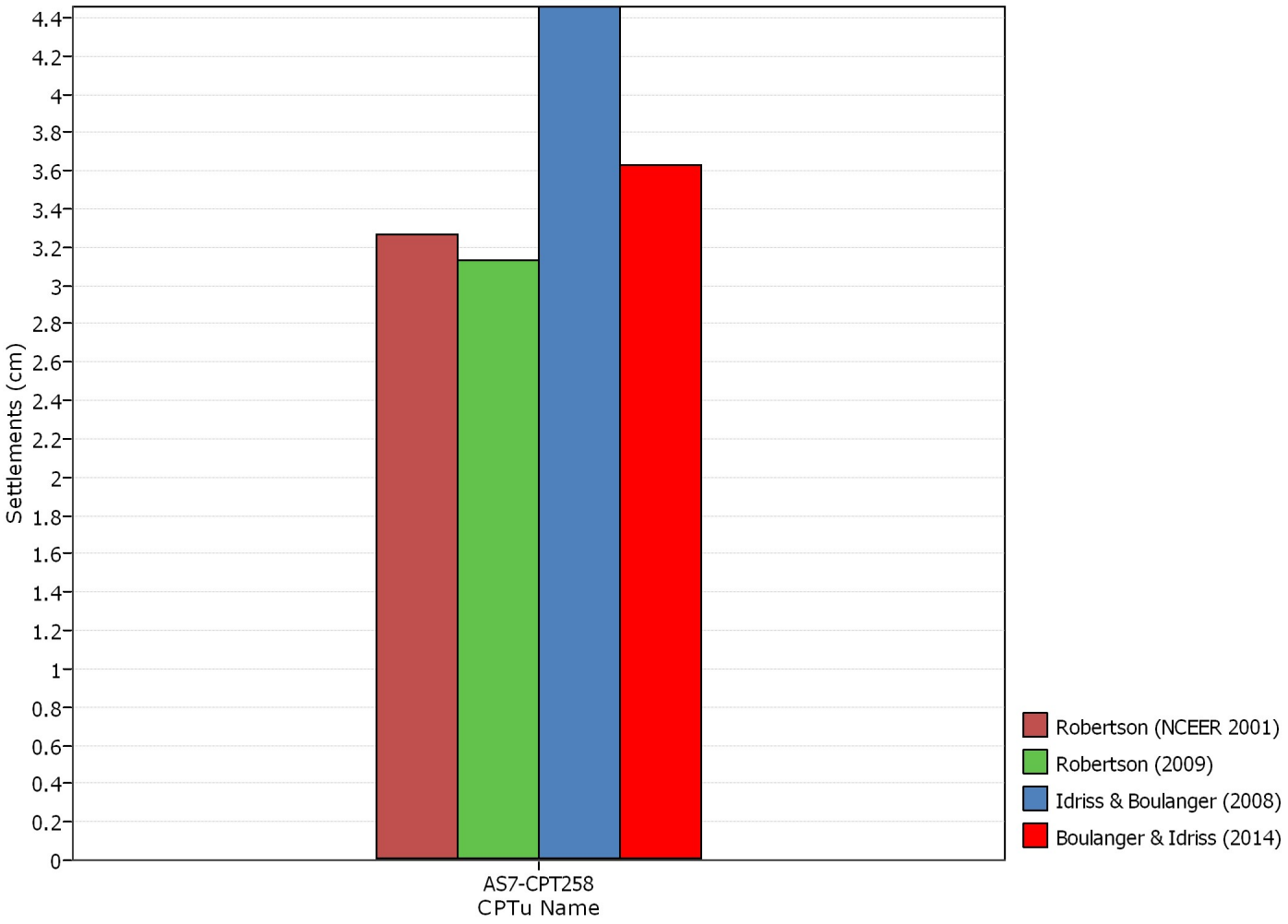
Overall Parametric Assessment Method



:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
AS7-CPT258	7.50	0.31	2.48	2.48

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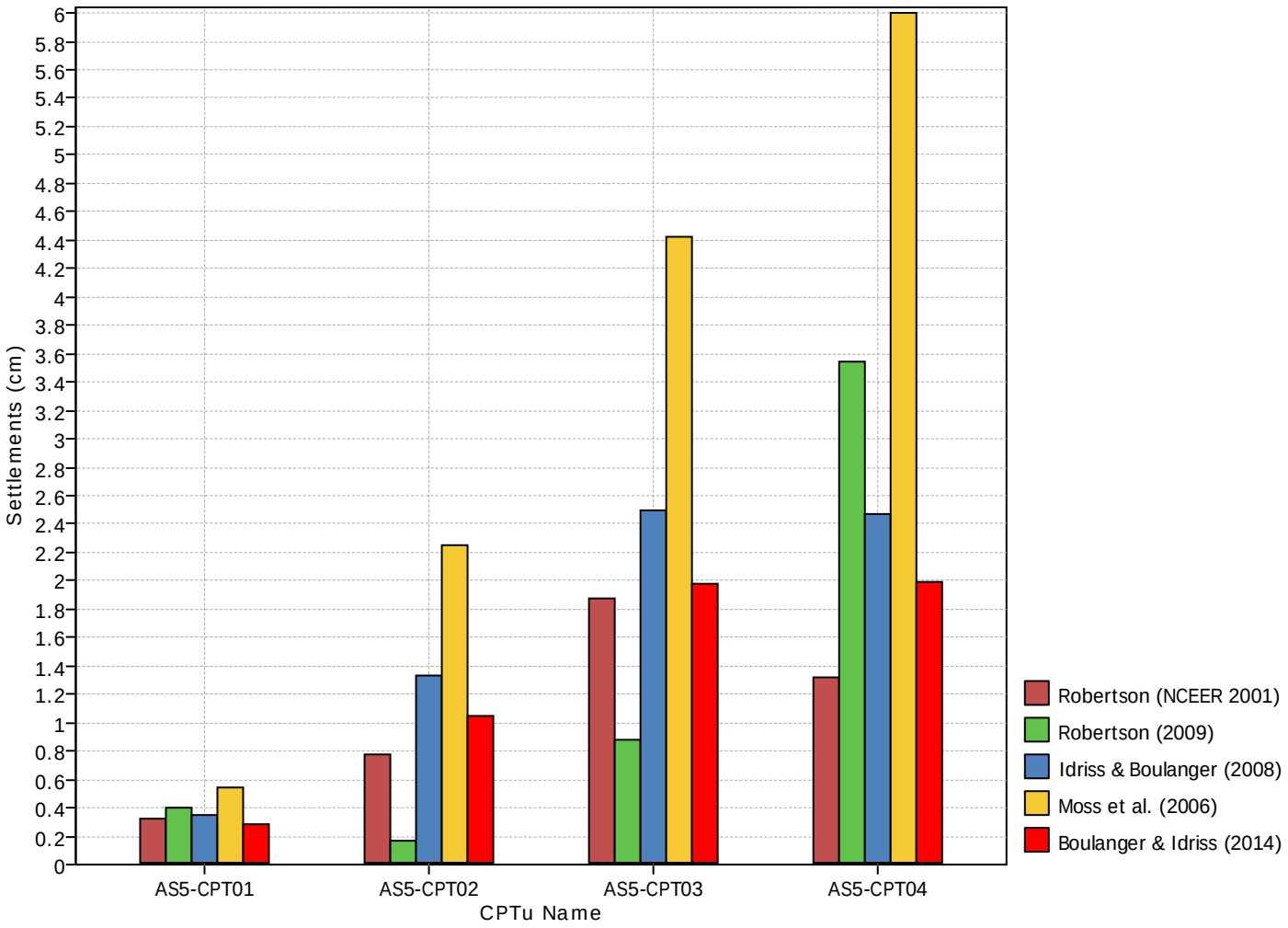
Overall Parametric Assessment Method



:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
AS5-CPT01	5.90	0.31	5.60	5.60
AS5-CPT02	5.90	0.31	3.96	3.96
AS5-CPT03	5.90	0.31	3.12	3.12
AS5-CPT04	5.90	0.31	0.00	0.00

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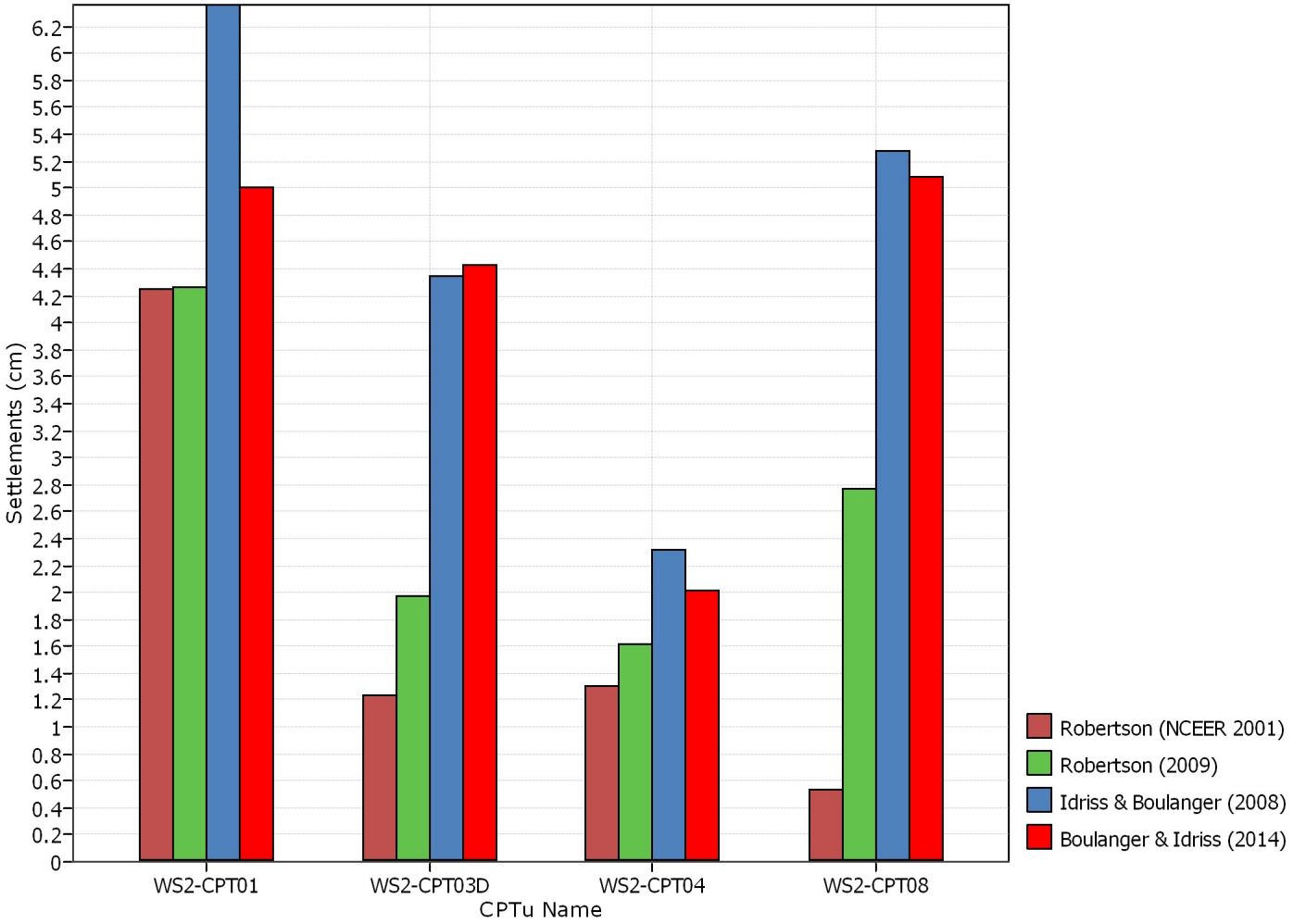
Overall Parametric Assessment Method



:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
WS2-CPT01	7.50	0.26	3.30	3.30
WS2-CPT03D	7.50	0.26	2.85	2.85
WS2-CPT04	7.50	0.26	2.60	2.60
WS2-CPT08	7.50	0.26	2.92	2.92

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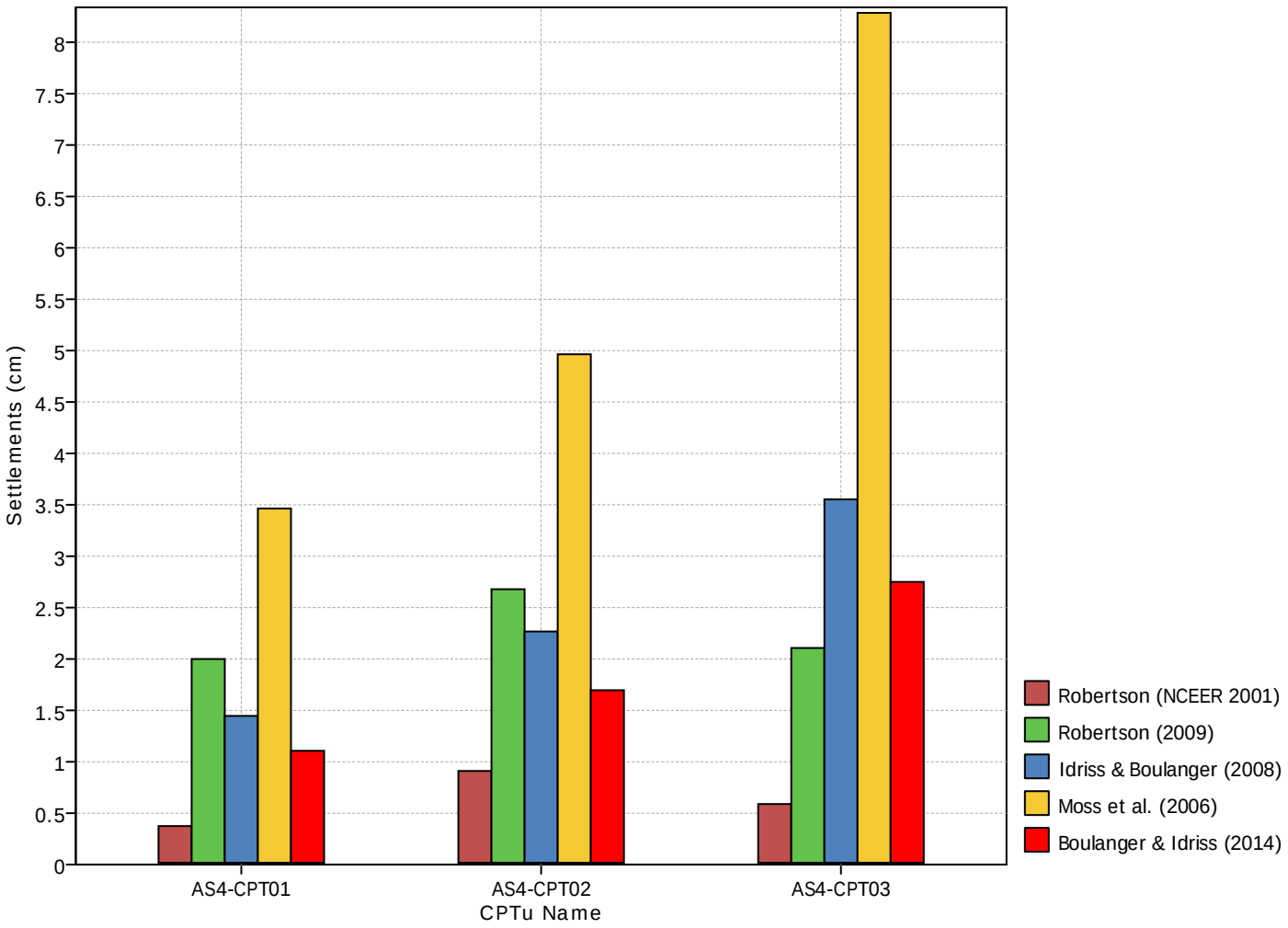
Overall Parametric Assessment Method



:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
AS4-CPT01	5.90	0.28	0.00	0.00
AS4-CPT02	5.90	0.28	-1.28	-1.28
AS4-CPT03	5.90	0.28	-1.58	-1.58

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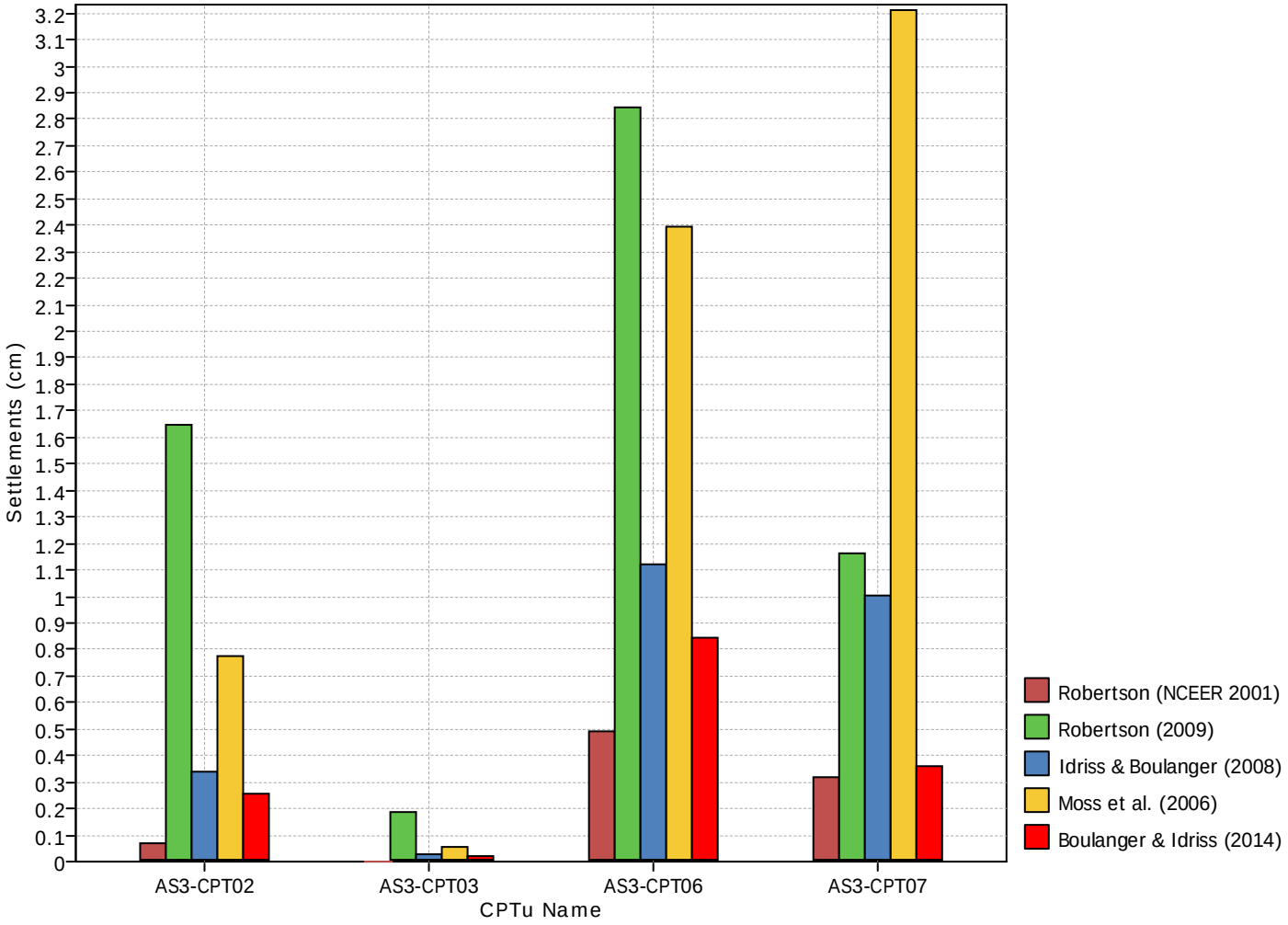
Overall Parametric Assessment Method



:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
AS3-CPT02	5.90	0.26	0.00	0.00
AS3-CPT03	5.90	0.26	0.00	0.00
AS3-CPT06	5.90	0.26	0.00	0.00
AS3-CPT07	5.90	0.26	0.00	0.00

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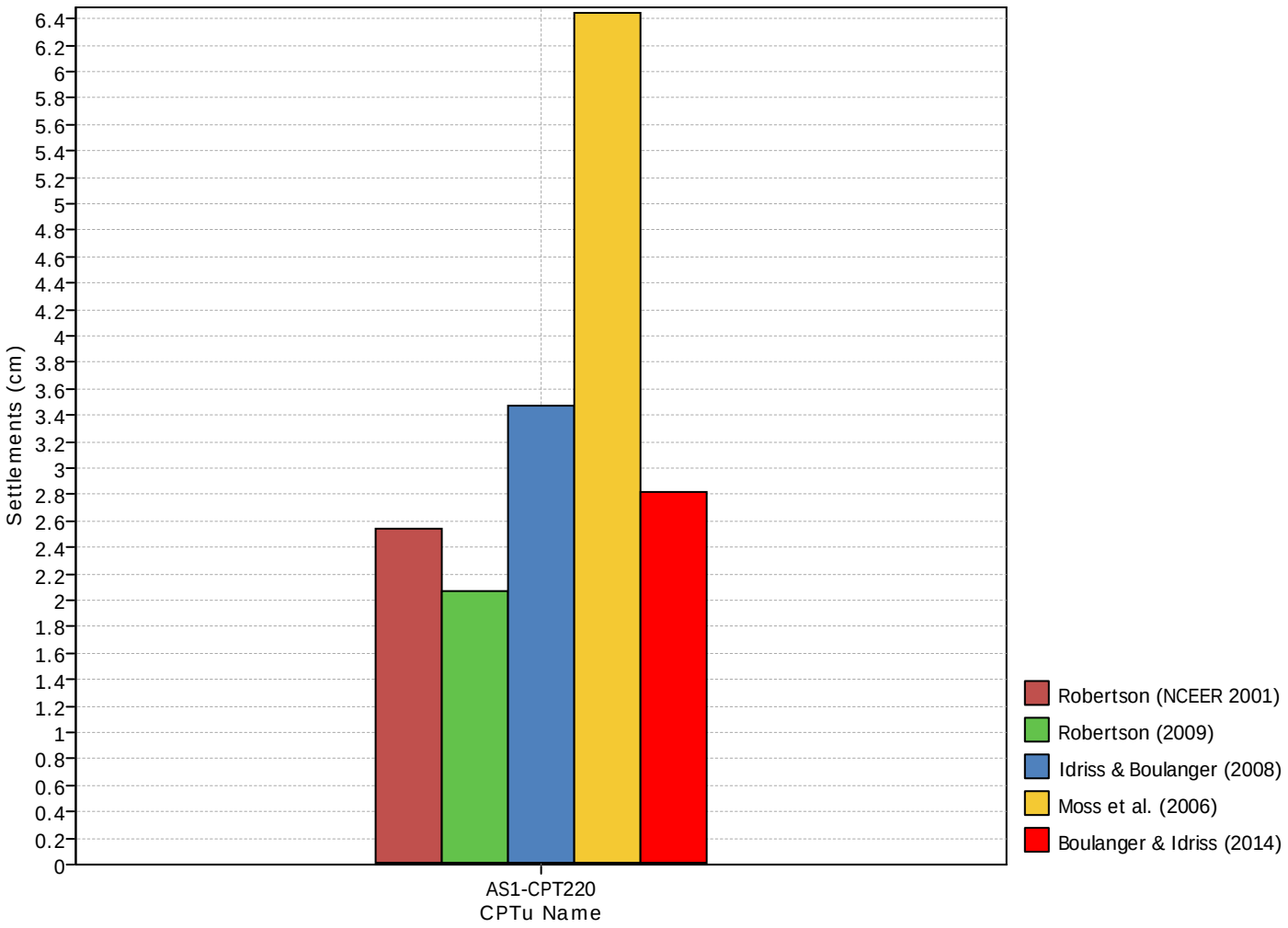
Overall Parametric Assessment Method



:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
AS1-CPT220	5.90	0.31	1.00	1.00

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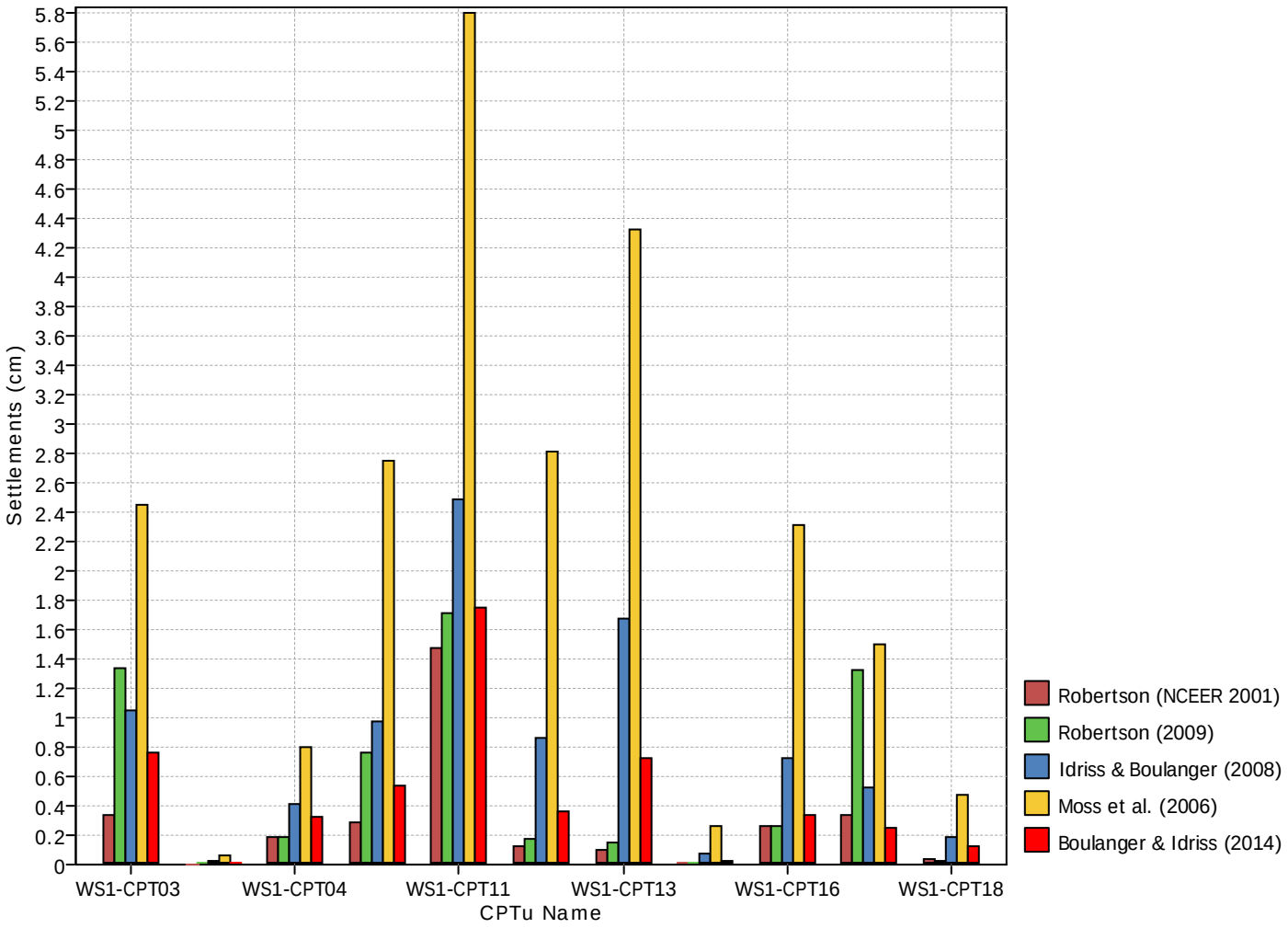

:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
WS1-CPT03	5.90	0.31	0.00	0.00
WS1-CPT04A	5.90	0.31	0.00	0.00
WS1-CPT04	5.90	0.31	0.00	0.00
WS1-CPT05	5.90	0.31	0.00	0.00
WS1-CPT11	5.90	0.31	0.00	0.00
WS1-CPT12	5.90	0.31	0.00	0.00
WS1-CPT13	5.90	0.31	0.00	0.00
WS1-CPT14	5.90	0.31	0.00	0.00
WS1-CPT16	5.90	0.31	0.00	0.00
WS1-CPT17	5.90	0.31	0.00	0.00
WS1-CPT18	5.90	0.31	0.00	0.00

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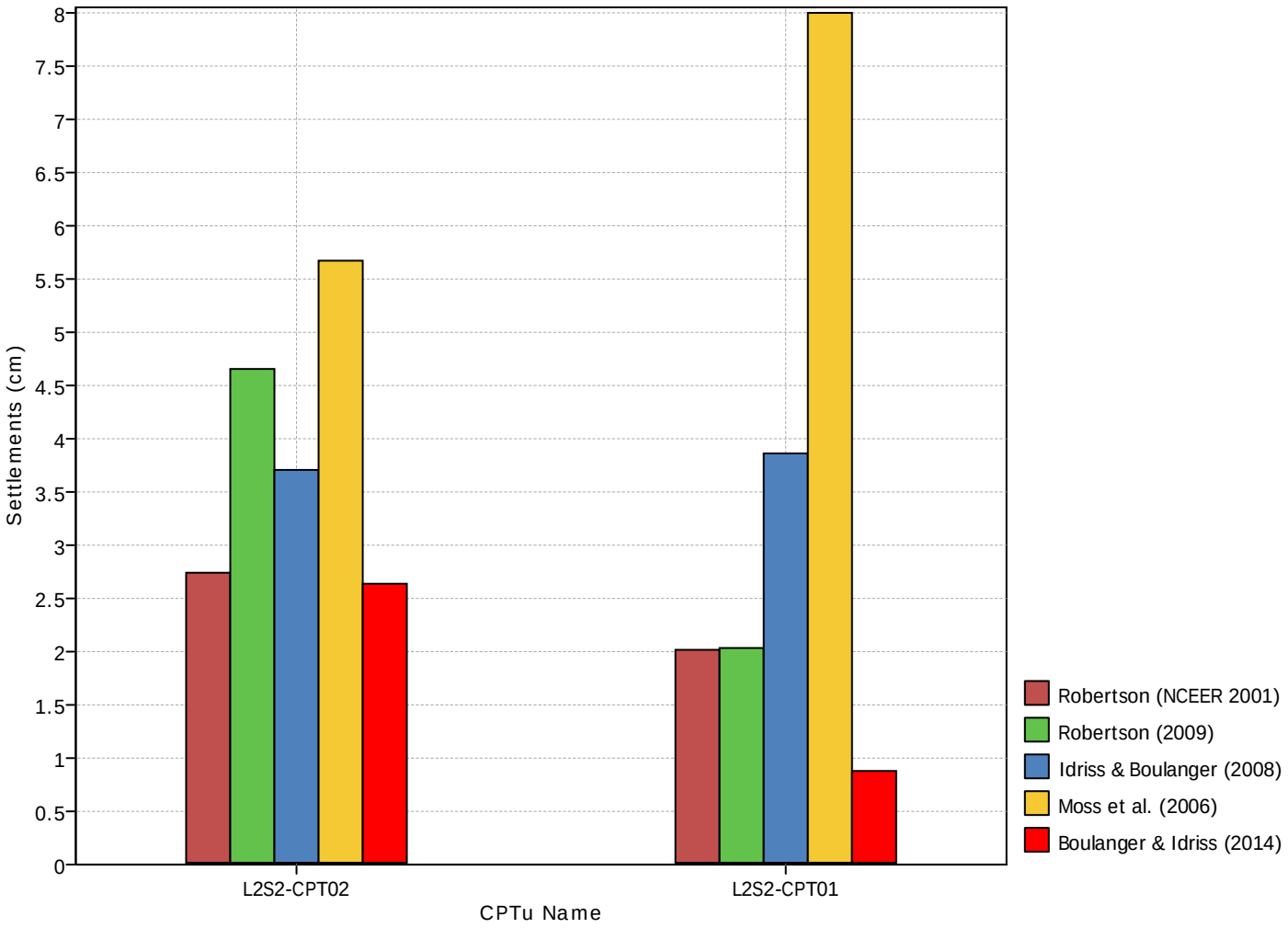

:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
L2S2-CPT02	5.90	0.26	1.93	1.93
L2S2-CPT01	5.90	0.26	1.93	1.93

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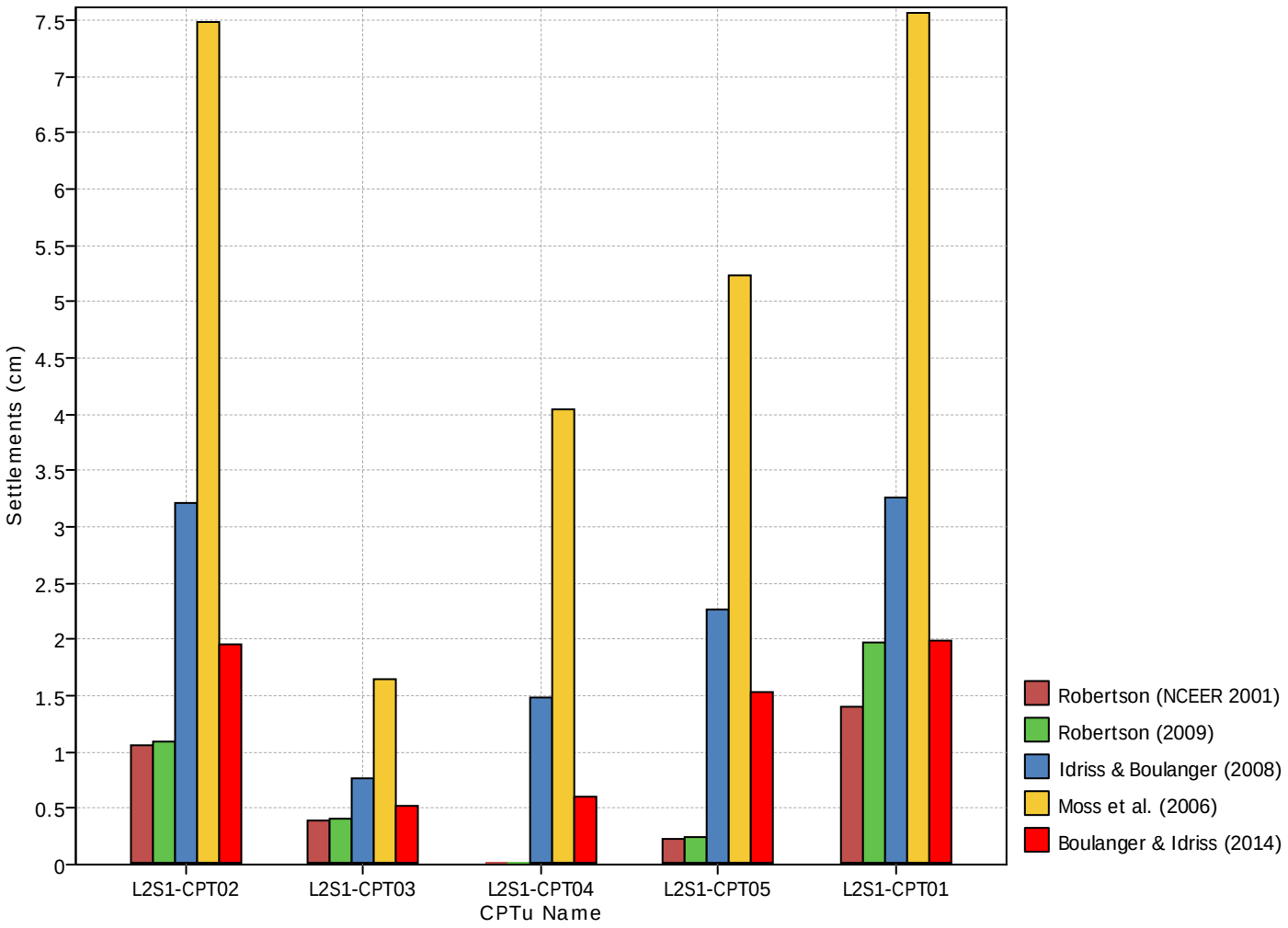

:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
L2S1-CPT02	5.90	0.31	2.50	2.70
L2S1-CPT03	5.90	0.31	2.50	2.50
L2S1-CPT04	5.90	0.31	2.50	2.50
L2S1-CPT05	5.90	0.31	2.50	2.50
L2S1-CPT01	5.90	0.31	2.50	2.50

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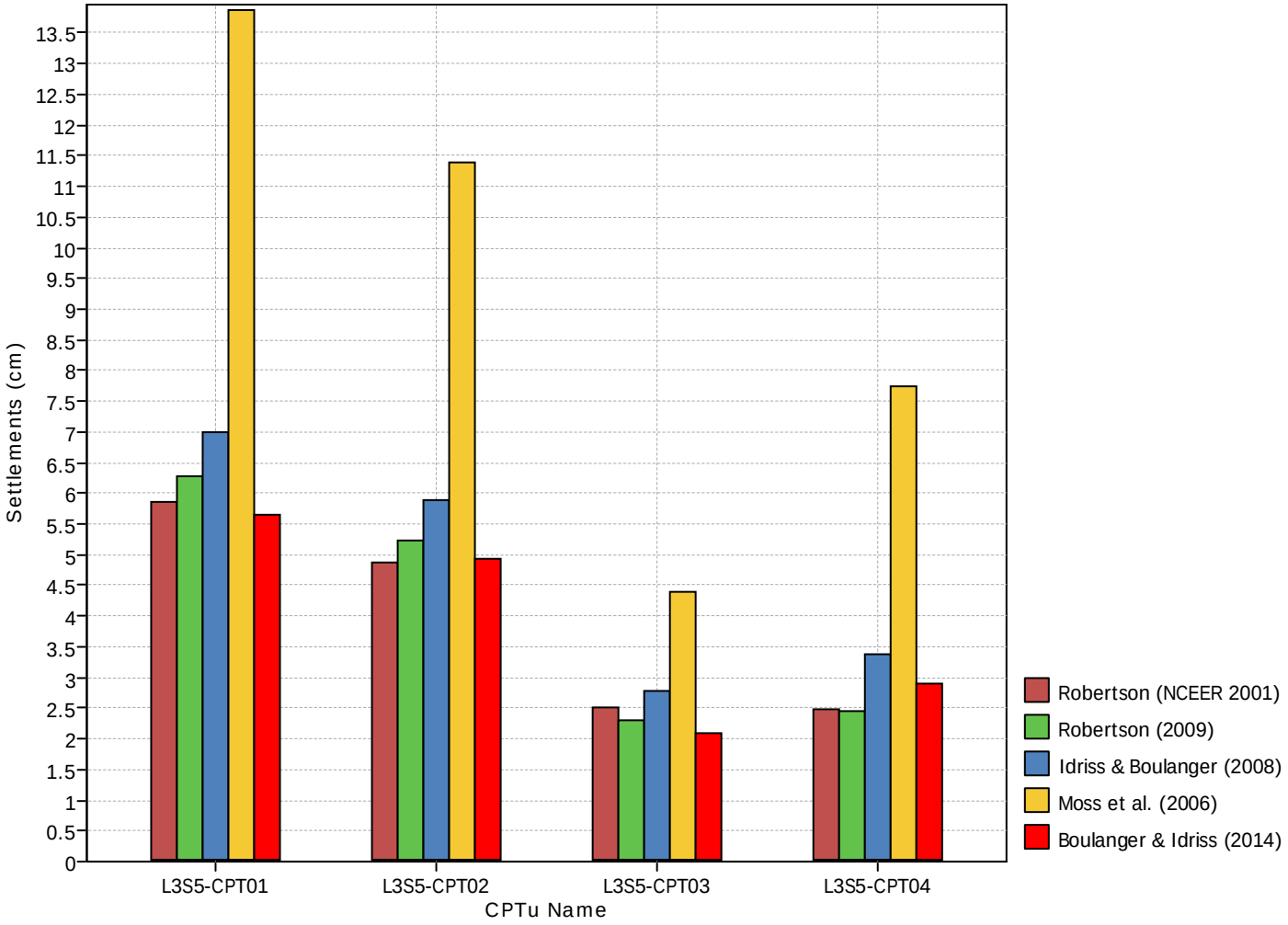

:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
L3S5-CPT01	5.90	0.28	0.00	0.00
L3S5-CPT02	5.90	0.28	0.00	0.00
L3S5-CPT03	5.90	0.28	0.00	0.00
L3S5-CPT04	5.90	0.28	0.00	0.00

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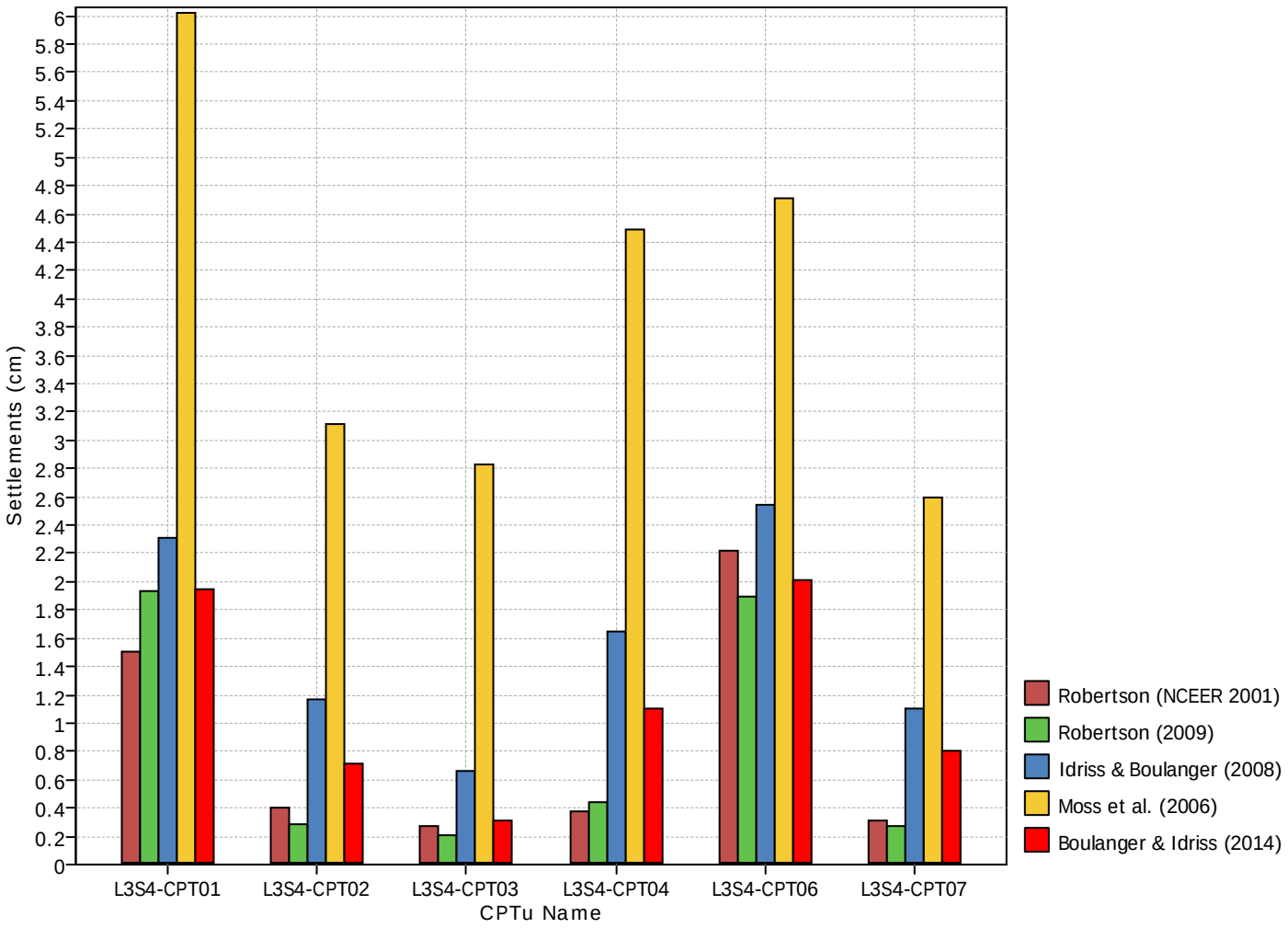

:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
L3S4-CPT01	5.90	0.28	-1.22	-1.22
L3S4-CPT02	5.90	0.28	-0.24	-0.24
L3S4-CPT03	5.90	0.28	-1.13	-1.13
L3S4-CPT04	5.90	0.28	0.00	0.00
L3S4-CPT06	5.90	0.28	-1.23	-1.23
L3S4-CPT07	5.90	0.28	0.10	0.10

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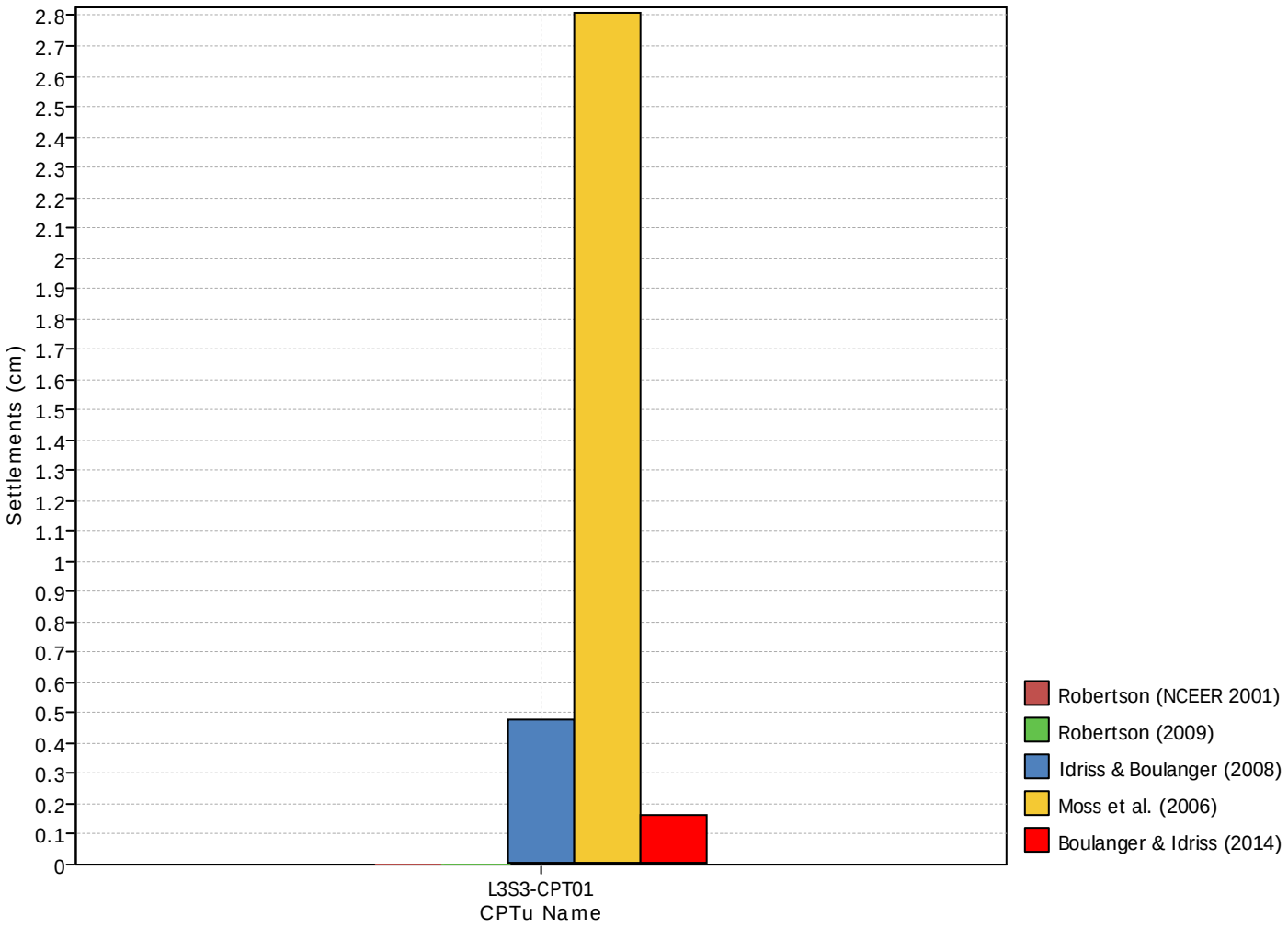

:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
L3S3-CPT01	5.90	0.31	0.97	0.97

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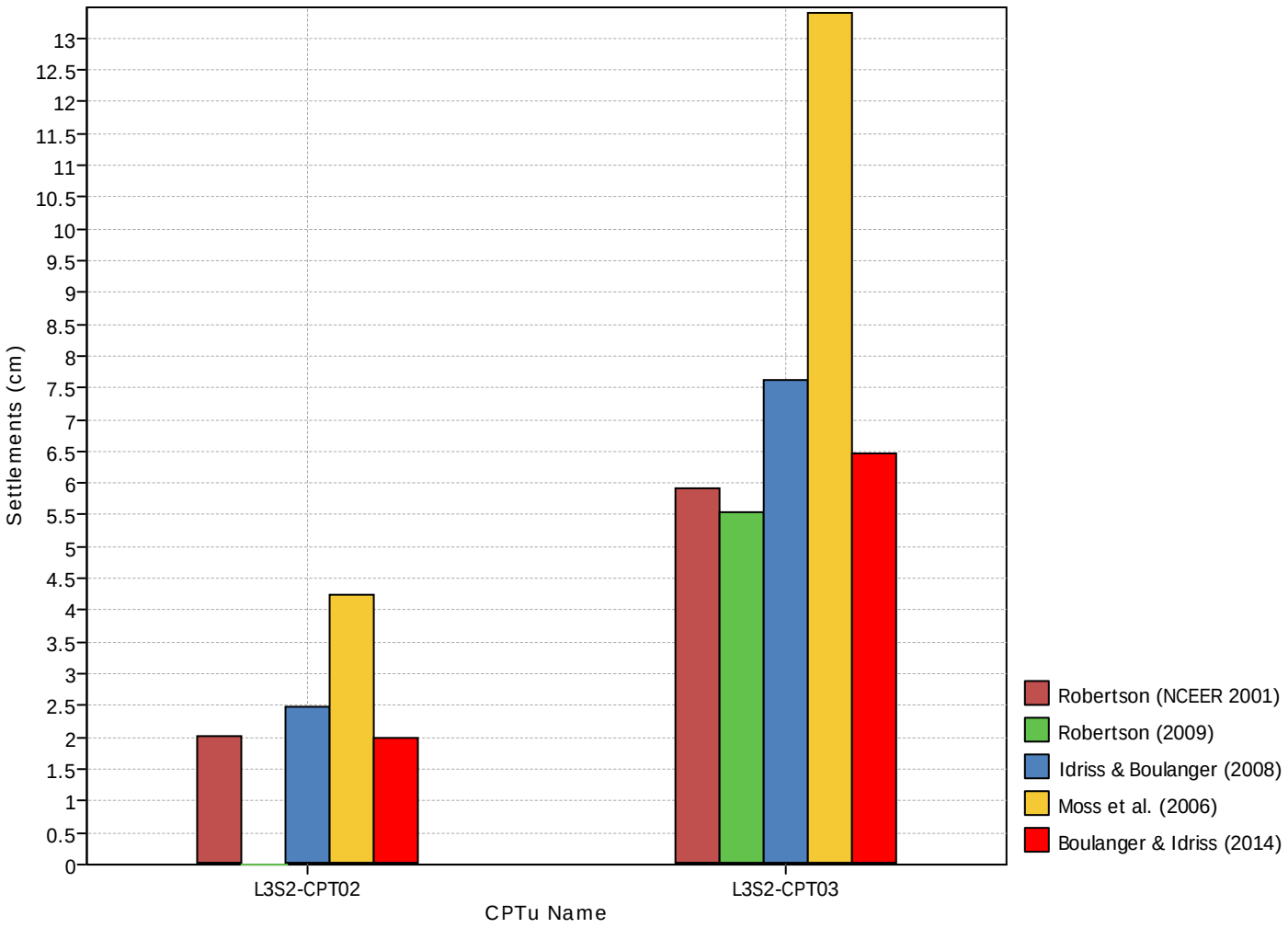

:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
L3S2-CPT02	5.90	0.28	1.00	1.00
L3S2-CPT03	5.90	0.28	1.00	1.00

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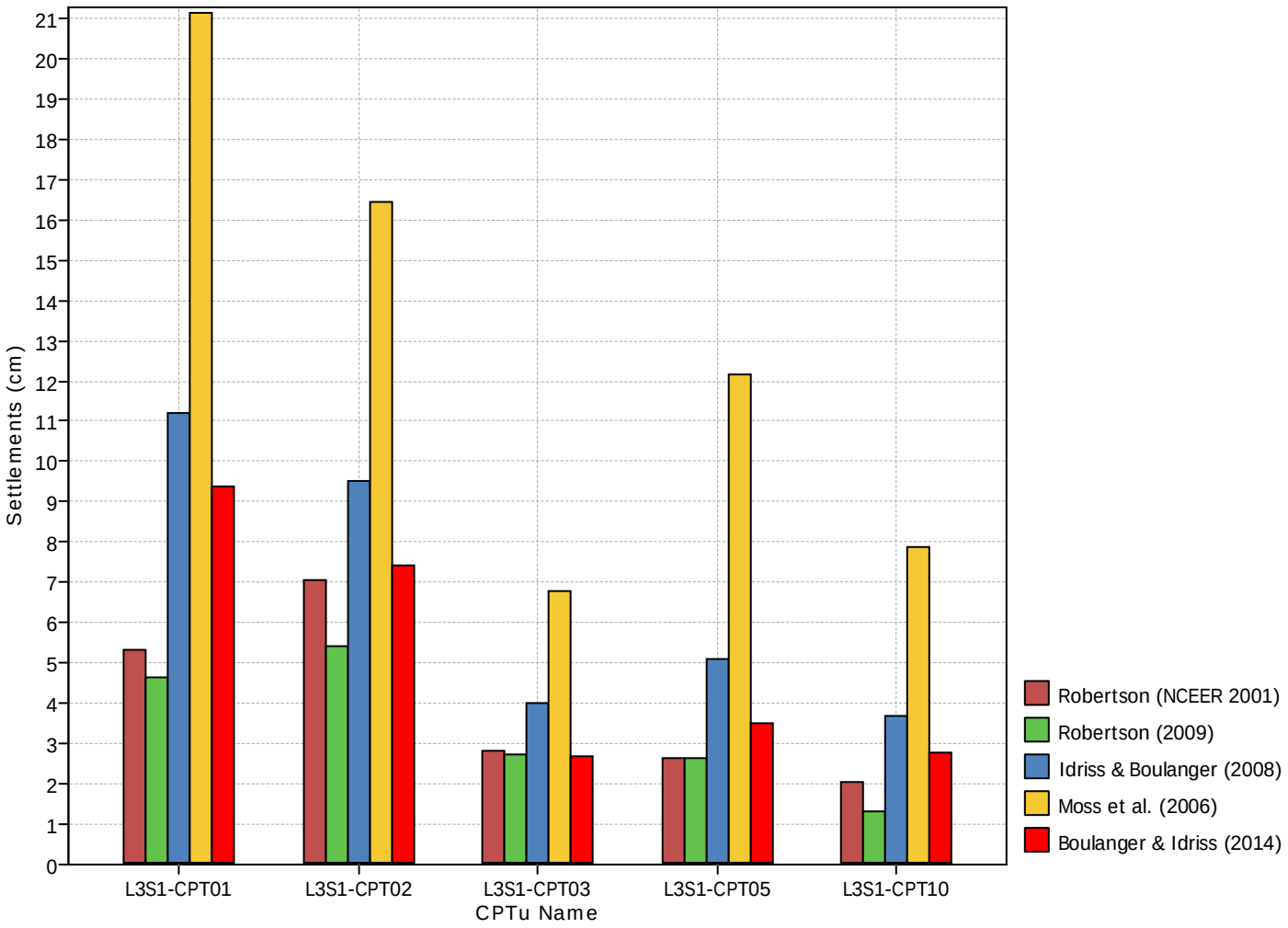


:: CPT main liquefaction parameters details ::

CPT Name	Earthquake Mag.	Earthquake Accel.	GWT in situ (m)	GWT earthq. (m)
L3S1-CPT01	5.90	0.28	2.00	2.00
L3S1-CPT02	5.90	0.28	2.00	2.00
L3S1-CPT03	5.90	0.28	2.00	2.00
L3S1-CPT05	5.90	0.28	2.00	2.00
L3S1-CPT10	5.90	0.28	2.00	2.00

Appendix F. Analysis and interpretation of aquifer test data

F.1 Site methodologies

Different aquifer tests were conducted throughout the different sites in order to calculate the hydraulic parameters of aquifers of interest. The tests used in the study were:

- ***Lugeon (Water Injection) Tests:*** were carried out as the bores were being drilled and by isolating targeted formations by means of a packer
- ***Slug Tests (Rising and Falling Head Tests):*** were carried out after the bores were completed and carried out by measuring well recovery after a volume of water (slug) was removed or added to the bore
- ***Pumping Tests (Constant Discharge Tests):*** were carried out at each of the sites by pumping water from a bore and measuring the water level response at observation bores. These test provide more accurate and reliable aquifer parameter data over a wide spatial area as the tests run for a longer time (e.g. days) and the area of aquifer material sampled by the test is significantly larger than in the other tests.

Pumping Tests were carried out at the three sites of interest (Western Springs, May Road, and Mangere WWTP) and involved 14 piezometers (pumping wells, observation bores, and vibrating wire piezometers). A total of 19 bores were Slug-Tested and a total of 11 bores were tested with Lugeon Tests.

F.2 Site details

F.2.1 Western Springs

Six boreholes were drilled at the Western Springs site using an HQ (96 mm diameter) drill bit. Out of these, 3 bores were slug tested, and 5 were tested with Lugeon tests. In addition, 5 of these bores were used in two Pumping Tests using two separate bores as pumping bores. The remainder 3 bores were used as monitoring bores; when a bore was not being pumped it was also used as a monitoring bore. Details for these bores are presented in **Table F.2**. The Western Springs site includes the bores used in the Pumping Test within the park adjacent to the Speedway (BH204, BH205, BH206, BH206b, and BH207).

Auckland Volcanic Field Basalt is present in isolated boreholes at Western Springs (BH206 and BH206b). These boreholes are characterised by an overburden fill layer up to 7 mBGL. The Puketoka Formation of the Tauranga Group (generally clayey SILTS) is often present below the fill layers albeit in BH206, where it is located below the Basalt. The basalt is located at about 4 mBGL in BH206b and 7 mBGL in BH206. In both boreholes the Basalt layer is ~4–5 m thick. Lying beneath the basalt at depths >9 mBGL is the residual to highly weathered Waitemata Group, which quickly transitions with depth to the bedded sandstones of the Waitemata East Coast Bays Formation (ECBF). These become slightly weathered ~12–15 mBGL.

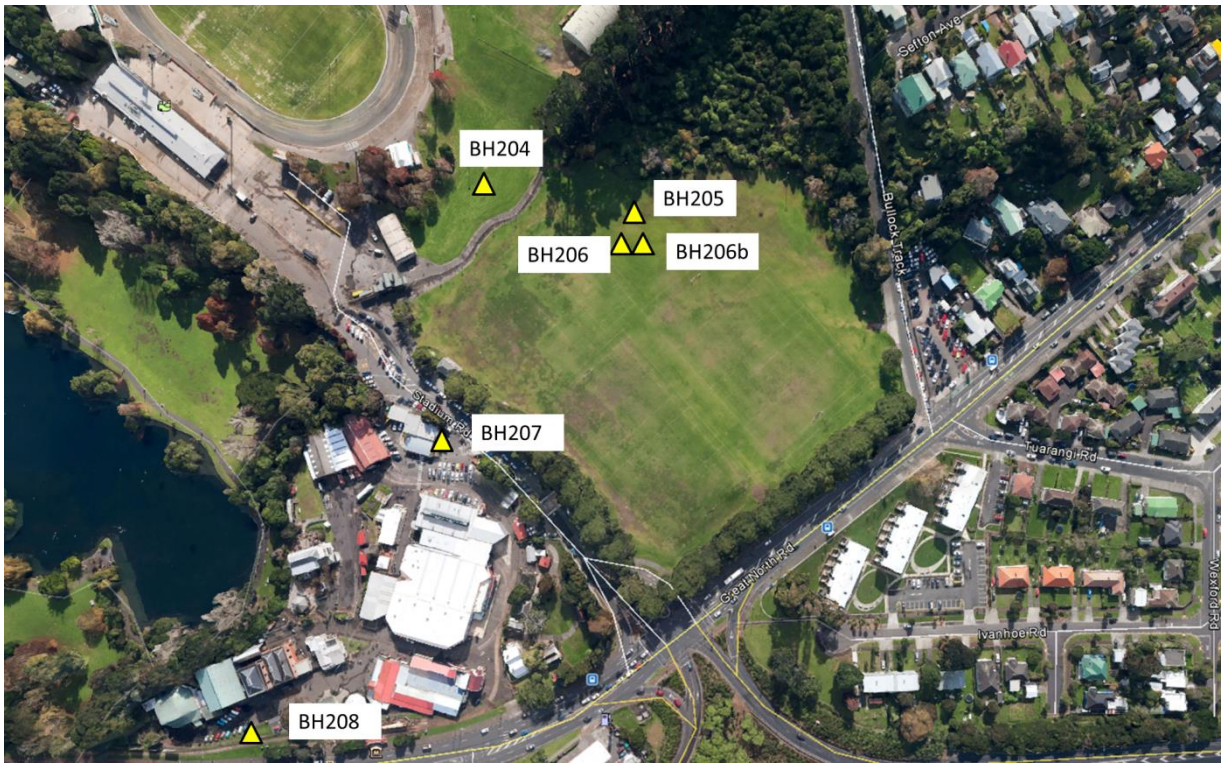


Figure F.1 : Western Springs Pumping Test site

Table F.1 : Bore names, their location, and type of hydraulic tests carried out (Y = hydraulically tested, NA = test data not available)

Bore Name	Easting	Northing	Piezo Type	Test Pumping Abstraction Bore	Test Monitoring Bore	Slug Test	Lugeon Test
BH201	1753220.38	5918807.58	VW	N	N	NA	Y
BH201b	1753432.00	5918758.00	STP	N	N	Y	NA
BH200	1753203.74	5918799.27	STP	N	N	Y	Y
BH201a	1753502.60	5918770.96	STP	N	N	Y	NA
BH204	1754013.80	5918678.13	STP	N	Y	Y	Y
BH205	1754092.90	5918656.74	STP	Y	Y	NA	Y
BH206	1754127.33	5918646.60	VW	Y	Y	NA	Y
BH206b	1754091.26	5918637.25	STP	Y	Y	Y	NA
BH207	1753991.52	5918538.45	VW	N	Y	NA	NA
BH208a	1753880.58	5918384.51	STP	N	N	Y	NA
BH208b_9m	1754156.39	5918430.45	STP	N	N	Y	NA

Notes:
STP = standpipe
VW = Vibrating Wire piezometer

F.2.2 May Road

About 6 boreholes were drilled at the May Road site using an HQ (96 mm diameter) drill bit. Only one of these boreholes was slug tested, but 5 of these bores were used in two Pumping Tests using two separate bores as pumping bores. The remainder 3 bores were used as monitoring bores. The May Road site is shown in Figure F.2. Auckland Volcanic Field Basalt is present in all boreholes at May Road. These boreholes are characterised by a thin topsoil and silty CLAY layer, with Basalt located below. Basalt ranges in depth from 0.5–6.0 mBGL. The pumping test conducted in BH247a was from a shallow (~5.5 m deep) temporary hole drilled into the Basalt formation. Beneath the Basalt lies the Puketoka Formation of the Tauranga Group (generally clayey SILTS and silty CLAYs) to depths of ~18 mBGL. Transitioning from the Puketoka Formation at depths >18 mBGL is the residual to highly weathered Waitemata Group, which quickly transitions with depth (~24 mBGL) to the slightly and un-weathered sandstones of the Waitemata East Coast Bays Formation (ECBF). The second pumping test in ECBF was conducted in BH247b, which was cased to ~25 mBGL and wash drilled to 80 mBGL.

Figure F.2 : May Road Pumping Test site

Table F.2 : Bore names, their location, and type of hydraulic tests carried out (Y = hydraulically tested, NA = test data not available)

Bore Name	Easting	Northing	Piezo Type	Test Pumping Abstraction Bore	Test Monitoring Bore	Slug Test	Lugeon Test
BH245	1753985.84	5913747.17	VW	N	Y	NA	NA
BH246	1754031.25	5913745.89	VW	N	Y	NA	NA
BH247	1754003.66	5913733.92	STP	N	N	N	NA
BH247a	1754089.64	5913708.38	STP	Y	N	NA	NA
BH247b	1754298.02	5913461.34	STP	Y	N	NA	NA
Notes: STP = standpipe							

Bore Name	Easting	Northing	Piezo Type	Test Pumping Abstraction Bore	Test Monitoring Bore	Slug Test	Lugeon Test
VW = Vibrating Wire piezometer							

F.2.3 Mangere WWTP

About 7 boreholes were drilled at the Mangere WWTP site using an HQ (96 mm diameter) drill bit. Two of these bores were slug tested and only one was Lugeon tested. One of these bores (BH 273) was used as a pumping bore with 3 bores (BH270, BH271, and BH272) completed as vibrating wire piezometers to record observations during the Pumping Test. Details for these bores are presented Table F.3. Bore logs indicated the presence of the Puketoka Formation, Kaawa Formation, and the Waitemata Group.

Puketoka Formation alluvium is present near the surface at the Mangere site. Soil materials of the Puketoka Formation are mainly non-marine sediments inter-fingering with lava of the South Auckland Volcanic Field (Institute of Geological and Nuclear Sciences, 2001). At the Mangere WWTP site, bore logs for BH273, BH 270, BH271, and BH272 show the presence of silts, gravels, and some sands to a depth of up to 15 metres Below Ground Level (mBGL), which is consistent with fine-grained material of the Upper Puketoka Formation. These sediments can be pumiceous sands and silts to the south of the site (e.g. Waiuku River) (Institute of Geological and Nuclear Sciences, 2001). The base of the Puketoka Formation is thought to consist of coarse-grained materials of varying thickness in other areas where this formation is present.

The Kaawa is an important aquifer to the south of the site, around Waiuku, Glenbrook, Pukekohe, and Puni (Crowcroft and Smaill, 2001). Prior to this study, there was limited information available about the Kaawa Formation in the Mangere area. However, corresponding shell beds were found in the Auckland Airport area, north to the Mangere lagoon and in the Middlemore area, underlying the Auckland and Grange Golf Club. Bores constructed in the Kaawa aquifer, south of the Mangere Pump Station site, are screened across coarse shell and/or sand beds with Transmissivities ranging from 30 to 500 m^2/day and storativities from 10^{-2} to 10^{-5} (Crowcroft and Smaill, 2001). The Kaawa formation rests uncomformably on the Waitemata Group.

At the site, the Waitemata Group consists of muddy flysch facies, mixed volcanic-rich and volcanic-poor flysch facies. The Kaawa Formation rests uncomformably on the Waitemata Group at the Mangere WWTP site. Under the Kaawa Formation, the Waitemata Group consists of beds of PVC (e.g. as per the BH273 bore log).

Figure F.3 : Mangere WWTP Pumping Test site

Table F.3 : Bore names, their location, and type of hydraulic tests carried out (Y = hydraulically tested, NA = test data not available)

Bore Name	Easting	Northing	Piezo Type	Test Pumping Abstraction Bore	Test Monitoring Bore	Slug Test	Lugeon Test
BH268	1757932.11	5908323.56	STP	N	N	Y	NA
BH270	1758180.93	5908131.40	VW	N	Y	NA	NA
BH272	1758259.20	5908078.85	VW	N	Y	NA	NA
BH271	1758212.02	5908066.33	VW	N	Y	NA	Y
BH273	1758231.77	5908046.75	STP	Y	Y	Y	NA
Notes: STP = standpipe VW = Vibrating Wire piezometer							

F.2.4 Tunnel alignment and secondary shafts

In addition to main hydraulic tests carried out at the location of main shafts (Western Springs, May Rd, and Mangere WWTP), slug and Lugeon tests were carried out at specific locations between the main shafts along the alignment. In general, the hydrogeology at these specific sites follows the same framework as the hydrogeology of the closest main shaft. Pumping Tests were not carried out at these sites, but slug tests (16 bores) and Lugeon tests (8 bores) were carried out to estimate hydraulic conductivity values.

Table F.4 : Bore names, their location, and type of hydraulic tests carried out (Y = hydraulically tested, NA = test data not available)

Bore Name	Easting	Northing	Piezo Type	Test Pumping Abstraction Bore	Test Monitoring Bore	Slug Test	Lugeon Test
BH219	1753692.63	5917223.64	VW	N	N	NA	Y
BH223	1754050.83	5916793.33	STP	N	N	Y	NA
BH211	1753619.09	5918046.5	STP	N	N	Y	N
BH213	1753516.46	5917491.61	STP	N	N	Y	N
BH212	1753522.29	5917817.93	STP	N	N	Y	N
BH214	1753522.61	5917329.62	STP	N	N	Y	N
BH215	1752832.58	5917727.36	STP	N	N	Y	N
BH218	1753148.89	5917763.13	STP	N	N	Y	N
BH217	1753144.38	5917768.03	STP	N	N	Y	N
BH218a	1753414.97	5917520.93	STP	N	N	Y	N
BH221	1753704.77	5917197.60	STP	N	N	Y	N
BH222	1753848.39	5917017.81	STP	N	N	Y	N
BH224_6.5	1754154.40	5916614.30	STP	N	N	Y	N
BH224_24.5	1754154.40	5916614.30	STP	N	N	Y	N
BH251	1755324.22	5912775.45	STP	N	N	Y	N
BH256	1756887.44	5911858.39	STP	N	N	Y	N
BH227	1753992.80	5915914.46	STP	N	N	Y	NA
BH228	1753996.90	5915892.88	STP	N	N	Y	NA
BH228_1	1753991.99	5915890.13	STP	N	N	Y	NA
BH228_2	1753992.78	5915890.19	STP	N	N	Y	NA
BH229a	1753953.41	5915504.96	STP	N	N	Y	NA
BH230	1754133.79	5915128.87	STP	N	N	Y	NA
BH235	1751244.07	5913690.50	STP	N	N	Y	NA
BH237	1751585.10	5913624.33	STP	N	N	Y	NA
BH241	1752750.41	5913371.05	STP	N	N	Y	NA
BH243	1753362.93	5913021.30	STP	N	N	Y	NA
BH252	1755739.40	5912564.59	STP	N	N	Y	Y
BH253	1756236.93	5912357.91	STP	N	N	NA	Y
BH258	1757149.44	5910290.44	STP	N	N	NA	Y
BH259	1757153.46	5910275.47	STP	N	N	Y	Y

Notes:
STP = standpipe
VW = Vibrating Wire piezometer

F.3 Site methodology observations

F.3.1 Western Springs

Lugeon tests at the Western Springs site were carried out by injecting water at various depths (testing interval) and at various pressures (typically 5, 10, 20, 30, 20, and 10 psi) and injection rates (0.01 - 25 L/min). These tests were carried out only in bores in which groundwater had already been encountered, and the testing interval was below the groundwater table. The testing intervals for these bores are presented Table F.5. In general (except for BH205) the Lugeon testing interval covers a longer aquifer section than the screened section after bore completion. An additional Lugeon test was carried out at BH219 near the Western Springs site.

Table F.5 : Testing interval for Lugeon Tests carried out at the Western Springs Site

Bore Name	Test Date	Testing Interval (mBGL)		Aquifer/Formation
		From	To	
BH200	10/4/2015	16.5	26.5	ECBF
BH201	09/4/2015	16.5	26.5	ECBF
BH204	12/2/2015	16.5	26.5	ECBF
BH205	18/2/2015	12	18	ECBF
BH206	27/03/2015	25.1	28.5	ECBF

Seven slug tests were carried at the Western Springs site Table F.6. Tests were carried out by either purging or injecting a small volume of water from/into the bores and then measuring their recovery. In cases where recovery was too fast (e.g. due to artesian conditions), more than one bailer volume was removed, and this could have affected the test accuracy as, for slug tests to be accurate, the removal (or addition) of water has to be instantaneous. Well recovery was measured by taking regular manual measurements at 30 second intervals as the water level recovered and/or by using a transducer which was able to continuously log water level recovery. When available, both sets of data were analysed.

Table F.6: Slug Tests carried out at the Western Springs site (ECBF = East Coast Bays Formation, AVFB = Auckland Volcanic Field Basalts, SWL = standing water level)

Bore Name	Test Date	Slug Test Type	Screen From (mBGL)	Screen To (mBGL)	SWL (mBGL)	Aquifer/Formation
BH201a	14/08/2015	RHT	22.5	26.5	8.95m	ECBF
BH201b	21/08/2015	FHT	6.10	18.10	11.540	ECBF
BH208a	19/08/2015	RHT / FHT	3.0	6.0	9.54	ECBF
BH208b (9m)	24/08/2015	RHT*	6.0	9.0	10.13	AVFB

Bore Name	Test Date	Slug Test Type	Screen From (mBGL)	Screen To (mBGL)	SWL (mBGL)	Aquifer/Formation
BH204	05/06/2015	RHT	20.5	23.5	1.255	ECBF
BH200	29/05/2015	RHT	22.0	25.0	2.463	ECBF
BH206b	29/05/2015	RHT*	5.0	7.0	0.414	AVFB

Note:

* Tests may be inaccurate because more than 1 bailer volume was removed to carry out these tests.

Two pumping tests were conducted at the Western Springs site:

1. A one day test in the Auckland Volcanic Field Basalt unit in BH206b
2. A six day test in the ECBF in BH205

Transducers were installed in the pumping bore to record drawdown and recovery during the test. When not being pumped, these bores were used as observation wells for other pumping tests. Vibrating Wires (VW) were installed in BH206 (VW at 10mBGL in the AVFB), BH207 (VW installed at 21mBGL in the ECBF) and BH208 (unresponsive VW). Similarly, pressure transducers were installed in BH204 (screened zone at 20.5mBGL in the ECBF), BH206b (AVFB) and BH205 (ECBF). Table F.7 summarises the pumping tests undertaken in each borehole.

Pumping Test 1 (BH206b)

Pumping test 1 was conducted in BH206b (total depth of 9.1 mBGL) starting on 7 April 2015 at 13:30. Pumping finished on 8 April 2015 at 14:30, from which a recovery period was monitored until 08:30 on 9 April 2015. The pump was positioned 7.5 mBGL and the static water level at the start of the test was 2.315 mBGL. Due to the tight nature of the lithological material, flow rates for this bore were small, and held constant at ~0.03 L/s. Only one observation bore (BH206– Vibrating Wire ~10 m deep) was used in this test, due to limited boreholes screened within the basalt formation and limited drawdown response in surrounding bores.

The drawdown response in BH206b (pumping bore) and BH206 (observation bore) are presented in Figure F.4. Both bores show a uniform drawdown and recovery period. BH206 is located ~10 m to the west of the pumping bore.

In this short distance between bores, there is ~50% reduction in peak drawdown from 1.44 m in BH206b to 0.7m in BH206.

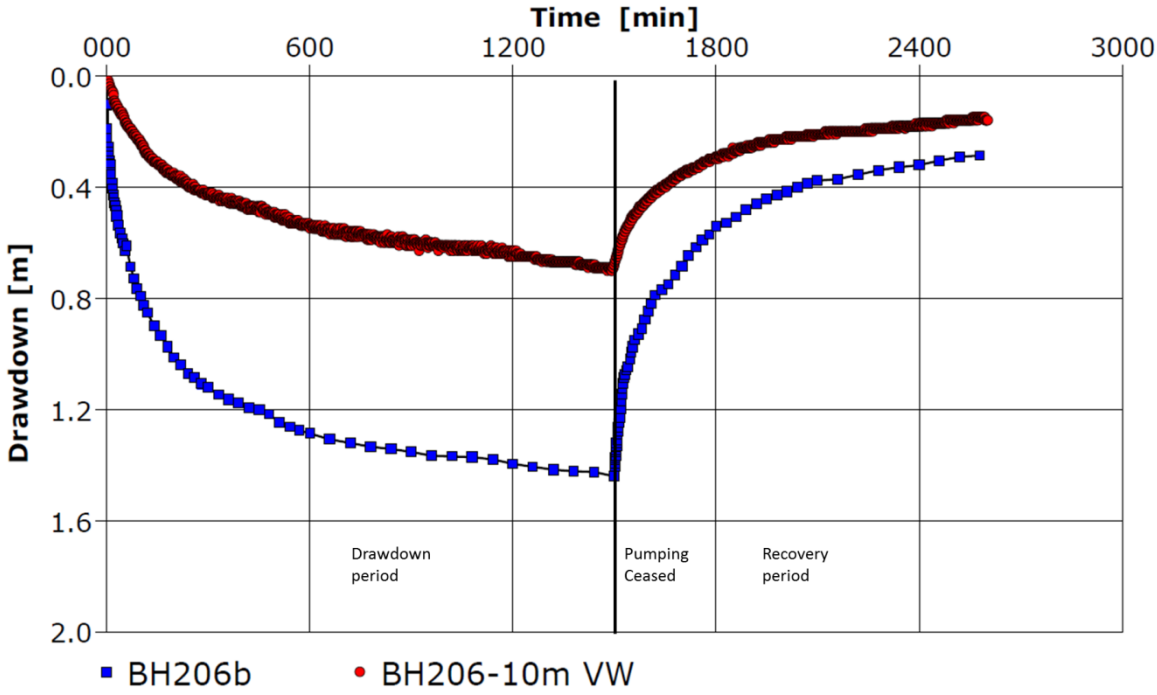


Figure F.4 : Time-Drawdown during Basalt Test

Table F.7 : Western Springs pumping test summary

Bore	Geological unit	Pumping start	Pumping end	Pumping rate (L/s)	Maximum drawdown (m)	Recovery end
BH206b	Basalt	07 Apr 15 13:30	08 Apr 15 14:30	0.03	1.44	09 Apr 15 08:30
BH205	ECBF	09 Apr 15 12:30	15 Apr 15 12:30	0.1; 0.12; 0.14	12.30	16 Apr 15 12:30

Pumping Test 2 (BH205)

Pumping test 2 was conducted in BH205 (total depth of 42 mBGL). The pump was positioned 38.2 mBGL and the static water level at the start of the test was 0.855 mBGL. Due to the tight nature of the lithological material, flow rates for this bore were also small. Initial abstraction was 0.08 L/s, which was incrementally increased over 240 minutes to 0.14 L/s. This final pumping rate was retained for the duration of the test (6 days).

Three observation bores were used in this test. These were:

- BH204–Pressure Transducer monitored well with a screened zone ~20.5 mBGL
- BH206–VW monitored well at ~25.8 mBGL
- BH207–VW monitored well at ~21 mBGL

BH208 was not used as an observation well as it exhibited no change in water levels during pumping.

The test began on 9 April 2015 at 12:30. Pumping finished on 15 April 2015 at 12:30 (6 days), from which a recovery period was monitored until 12:30 on 16 April 2015 (1 day). The time drawdown response in the observation bores are presented below in Figure F.5 and Figure F.6. BH206 and BH207 data was only available until 14 April, ~11:00, which meant a recovery period could not be analysed.

Maximum drawdown in each of the boreholes was:

- BH205 (pumping bore): 12.3 m
- BH204 (obs bore ~95 m NW of BH205): 1.16 m
- BH206 (obs bore ~32 m SSW of BH205): 1.99 m
- BH207 (obs bore ~160 m SW of BH205): 0.29 m

All observation bores exhibited patterns that suggested minor natural fluctuations in water levels (i.e. from recharge) were also occurring during the pumping test. This can be seen after test duration of ~2020 minutes and again at ~6060 minutes. The same response is not exhibited in the pumping bore.

During the pumping period, significant rainfall occurred on 11, 14–16 April. Rainfall at Mangere was recorded as 6.4 mm on the 11th (2200 elapsed minutes) and 24.4 mm between 14-16 April (6,480–10,100 elapsed minutes). The natural fluctuations in the groundwater may be due to recharge occurring within the ECBF. Tidal oscillations may also be a cause for change in water levels; however changes from peak to trough appear to be over a 1.4 day interval which negates tidal influence.

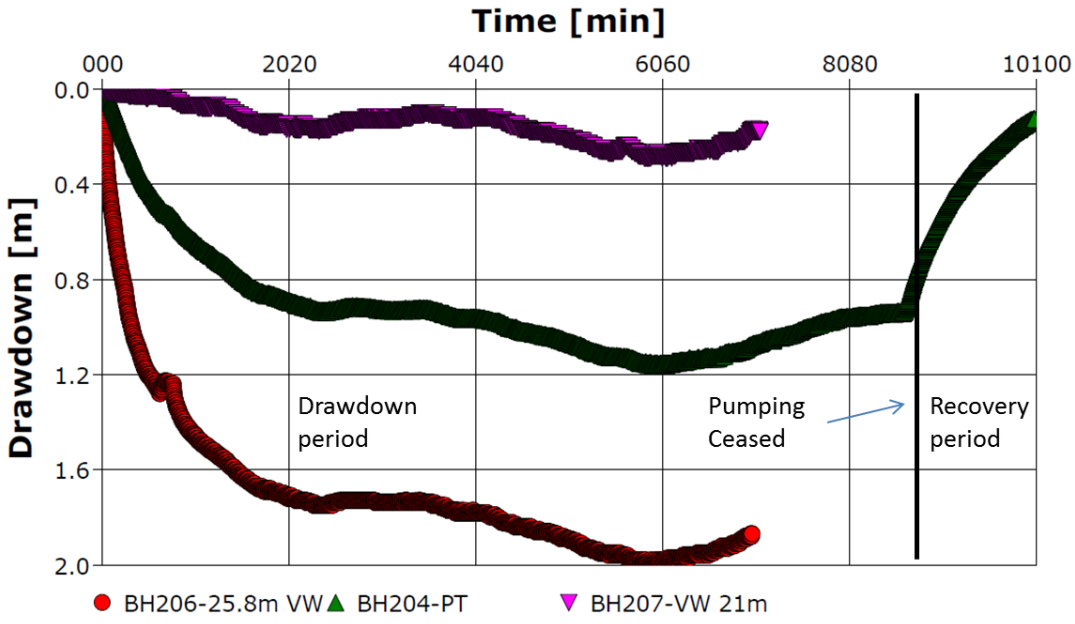


Figure F.5 : Time drawdown curves for observation bores

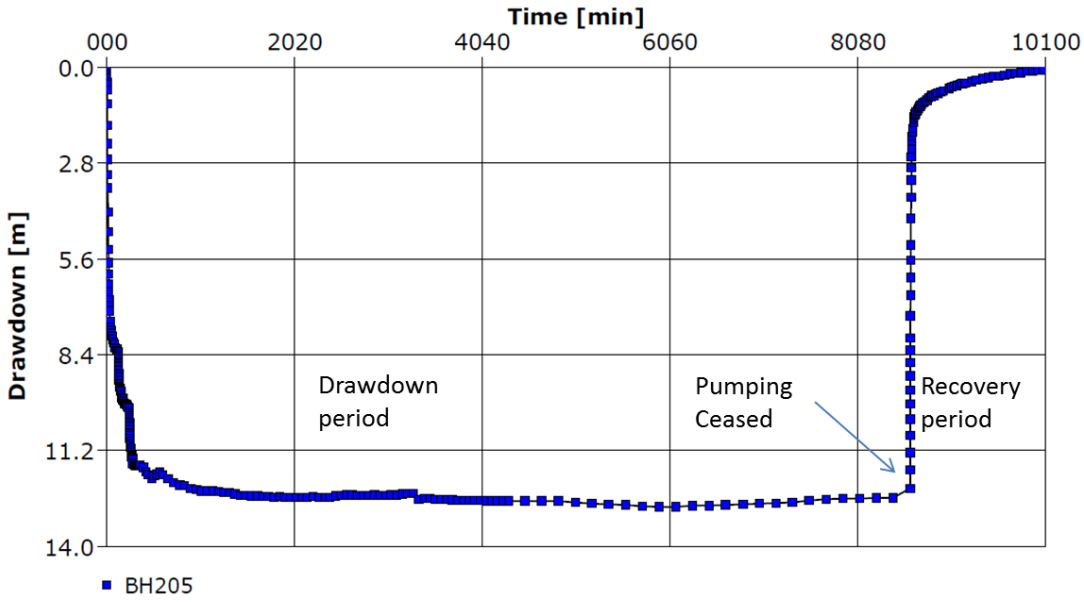


Figure F.6 : Time drawdown curve for BH205 (pumping bore)

F.3.2 May Road

No Lugeon tests were carried out at the May Road site itself (e.g. Pumping Test site) and only one slug test was carried out at the Pumping Test site and this was on BH247 (20/08/2015) which was used as a pumping bore for the Pumping Test. BH247 is completed in the AVFB unit at a depth of 5.7 mBGL however the slug test data for this test was incomplete. On the other hand, 5 slug tests were carried out at specific bores In the vicinity of the May Road Pumping Test site Table F.8.

Table F.8 : Slug Tests carried out in the vicinity of May Road (SWL = Standing Water Level)

Bore Name	Test Date	Slug Test Type	Screen From (mBGL)	Screen To (mBGL)	SWL (mBGL)	Aquifer/Formation
BH235	19/8/2015	RHT	6.8	9.8	3.68	Puketoka/ECBF
BH237	19/8/2015	RHT	5.0	8.0	11.84	Puketoka Formation
BH241	24/8/2015	RHT*	9.2	12.2	0.02	ECBF
BH243	26/8/2015	RHT*	18.5	24.5	0.0	ECBF
BH252	18/08/2015	RHT	85.0	100.0	17.11	ECBF

Note:

* Tests may be inaccurate because more than 1 bailer volume was removed to carry out these tests.

Two pumping tests were conducted at May Road:

1. A one day test in the basalt in BH247a
2. A six day test in the ECBF in BH247b

Transducers were installed in the pumping bore to record drawdown and recovery during the test. When not being pumped, these bores were used as observation wells for other pumping tests. Vibrating Wires (VW) were installed in BH245 and BH246. Pressure Transducers were installed in BH247, BH247a and BH247b. Table F.9 summarises the pumping tests undertaken in each borehole.

Table F.9 : May Road pumping test summary

Bore	Geological unit	Pumping start	Pumping end	Pumping rate (L/s)	Maximum drawdown (m)	Recovery end
BH247a	Basalt	12 May 15 11:30	13 May 15 11:30	0.11; 0.14	1.55	14 May 15 08:30
BH247b	ECBF	14 May 15 11:30	20 May 15 11:30	0.6	34.14	28 May 15 11:30

Pumping Test 1 (BH247a)

Pumping test 1 was conducted in BH247a (total depth of 5.7 mBGL). The pump was positioned ~5.2 mBGL and the static water level at the start of the test was 0.43 mBGL. The flow rate in this bore was 0.11 L/s from 0–120 minutes, and ramped up to 0.14 L/s for the remainder of the test.

Only one observation bore was used in this test, due to limited boreholes screened within the basalt formation and limited drawdown response in surrounding bores. The observation bore used in this test was BH246 with a Vibrating Wire installed at about 4 m deep. BH246 also had a VW installed at 10m deep and it also exhibited a response to the Basalt test. BH246 10m VW also exhibited a near identical response in the Basalt test to the 4m VW. The total drawdown in this observation bore at both 4 and 10 m was between 0.38–0.4 m and the recovery period was similar over the same duration. For this reason, analysis of the 4 m VW (which was situated within the Basalt formation) was deemed acceptable to represent the observation bore.

The test began on 12 May at 11:30 am. Pumping finished on 13 May at 11:30, from which a recovery period was monitored until 8:30 am on the 14 May. The drawdown response in BH247a (pumping bore) and BH246-4 m VW (observation bore ~19 m WNW of BH247a) are presented in Figure F.7. Both bores exhibit a dynamic drawdown response. Initially pumping rates were set at 0.11 L/s from 0–120 minutes. A rapid drawdown of ~1.2 m in the pumping bore and 0.25 m in the observation bore was exhibited during the first 30 minutes of pumping. However after 30 minutes, the rate of drawdown began to decrease, and after ~80 minutes, drawdown actually ceased and water levels began to increase in both bores. This suggested that the abstraction rate was too low, or a recharge boundary had been encountered.

The test operator responded by increasing the abstraction rate to 0.14 L/s for the remainder of the test. Following this, the water level in BH247a declined rapidly by approximately 0.3 m in 10 minutes of which another recharge boundary was encountered when drawdown was ~1.6 m (2 mBGL). This recharge boundary resulted in a stable water table where abstraction rates were slightly less than the aquifer recharge. During the test a large portion of the area was under water (from rainfall), and a stream with standing water near BH246 may also have been a source of recharge to the Basalt. In the short (19 m) distance between bores, there is >70% reduction in peak drawdown from 1.607 m in BH247a to 0.4 m in BH246-4m VW.

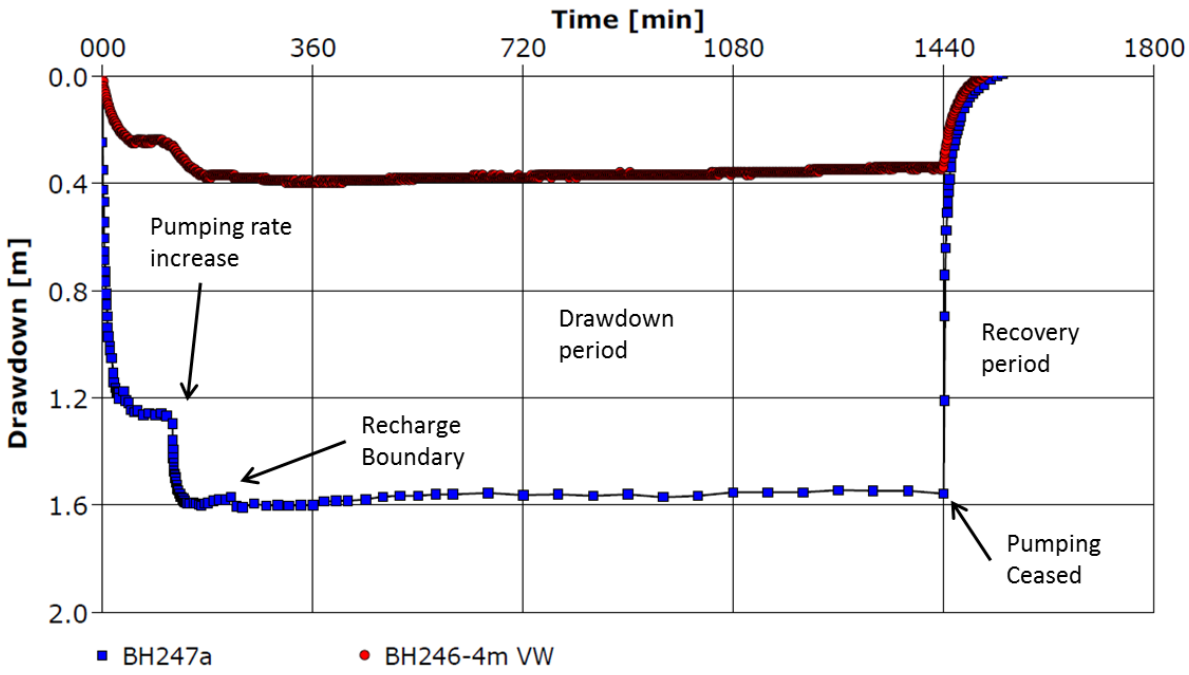


Figure F.7 : Time-Drawdown during Basalt Test

Pumping Test 2 (BH247b)

Pumping test 2 was conducted in BH247b (total depth of 80 mBGL). The pump was positioned ~30 mBGL and the static water level at the start of the test was 0.19 mBGL. The initial abstraction was 0.72 L/s, which was decreased to ~0.6 L/s and eventually to 0.5 L/s (after 1440 minutes) due to high drawdown in the pumping bore. This final pumping rate was retained for the duration of the test (6 days). Two observation bores were used in this test:

- BH245–VW monitored well at ~25.5 mBGL
- BH246–VW monitored well at ~64.5 mBGL

The test began on 14 May 2015 at 11:30. Pumping finished on 20 May 2015 at 11:30 (6 days), from which a recovery period was monitored until 11:30 on 28 May 2015 (8 days). The time drawdown response in all bores is presented in Figure F.8. In both the two observation wells and the pumping bore, an 8 day recovery resulted in water levels between 1–1.2 m below the static water level at the start of the test (i.e. a full recovery was not recorded). The maximum drawdown in each of the boreholes was:

- BH247b (pumping bore): 36.7 m
- BH245-25.5 m VW (obs bore ~28.5 m ENE of BH247b): 9.8 m
- BH246-64.5 m VW (obs bore ~19 m WNW of BH247b): 3.5 m

Observation bores exhibited trends that can be characterised well by confined aquifer assumptions. In all wells (including the pumping well), the change in abstraction rate from 0.6 to 0.5 L/s resulted in a slight reduction in drawdown levels. Fitting of Theis and Cooper Jacob I to the pumping and observation bores has been undertaken for the abstraction period from 1440–8640 minutes (at a rate of 0.5 L/s).

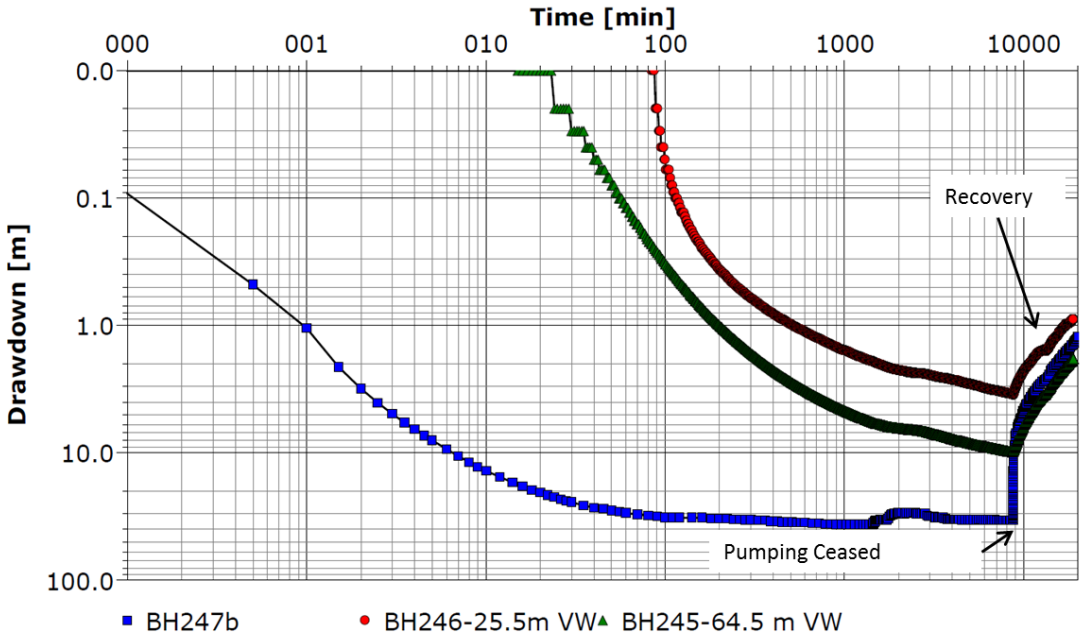


Figure F.8 : Logarithmic time drawdown curves for Pumping Test 2 (ECBF)

F.3.3 Mangere WWTP

A Lugeon test was carried out in BH271 at the Mangere WWTP on 9/5/2015. The test interval was 45 to 48 mBGL and the test was carried out in 6 pressure steps (5, 15, 35, 60, 35, and 15 psi). The test interval for this test is correlated with the unweathered Waitemata Group. In addition, two slug tests were carried out at the Mangere WWTP Pumping Test site. These were conducted on BH268 and BH273.

Table F.10 : Slug Tests carried out at the Mangere Site and its vicinity (SWL = Standing Water Level)

Bore Name	Test Date	Slug Test Type	Screen From (mBGL)	Screen To (mBGL)	SWL (mBGL)	Aquifer/Formation
BH268	26/8/2015	RHT	29.2	32.2	1.53	Kaawa Formation
BH273	26/8/2015	RHT/FHT	41	50	1.63	Waitemata Group (Parnell Volcaniclastic Conglomerate)

A pumping test at the proposed Mangere Pump Station shaft, located at the Mangere Waste Water Treatment Plant on the north east shore of the Manukau Harbour, was carried out between the 16th and the 30th of June, 2015. In this test, borehole (BH) BH273 was pumped at a constant rate of 4.17 L/s while measuring the drawdown response on BH270, BH271, and BH272. The study covers an area of approximately 1.4 ha around the Mangere Pump Station.

Pumping bore BH273

BH273 was designed with a 9 m screen (three slotted intervals spaced at 3 m intervals). The bore was pumped at 4.17 L/s for 7 days and then recovery data was logged for another 7 days. Pumping started at 11:15 am on 16/06/2015 and finalised at 11:15 am on 23/06/2015. Recovery was then measured until 11:15 am on 30/06/2015. Maximum drawdown and recovery were rapidly achieved, within 3 hours, on 23/06/2015 (elapsed time = 604800 seconds), as shown in Figure F.9.

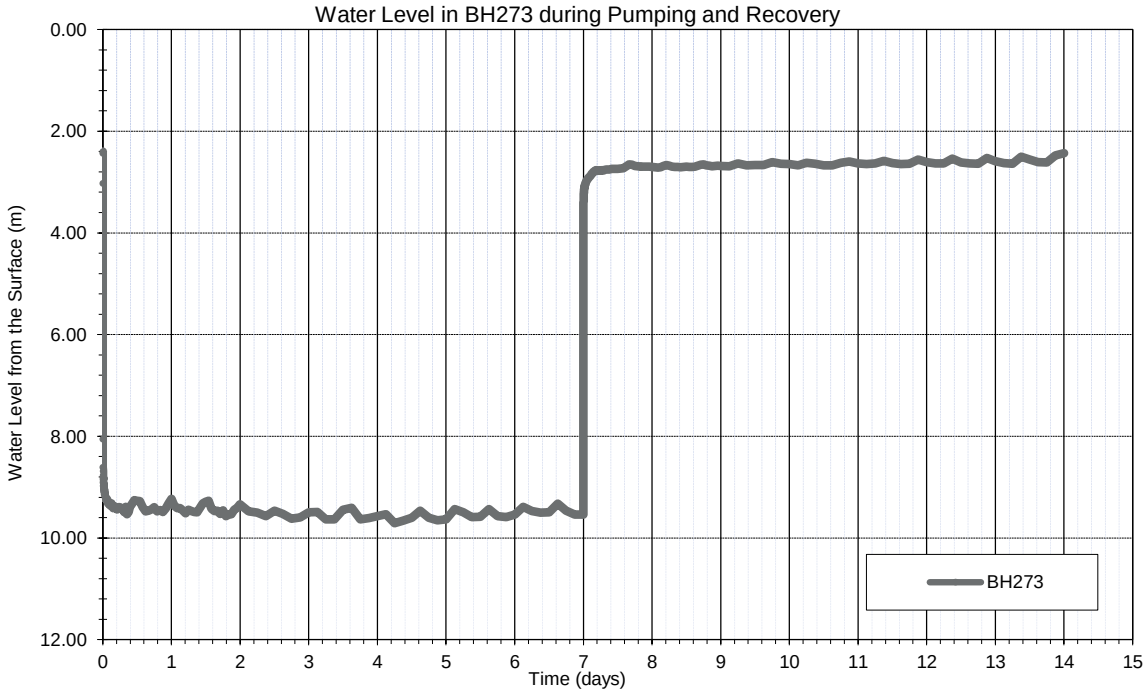


Figure F.9 : Drawdown and recovery phases for the pumped bore (273) at the Mangere Pump Station

The bore log for BH273 shows fine-grained material (mainly silts) with some gravel and sand near the surface for the first 8.2 mBGL. This sequence corresponds to the Puketoka Formation. From 8.2 mBGL to approximately 10.5 mBGL, the bore log shows the presence of clay materials, which may provide a degree of confinement to the deeper aquifer system. From 16 mBGL to the bottom of the well (41.5 mBGL), the bore log indicates mainly the presence of sand with some minor silt units, which would correspond to the Kaawa Formation or its equivalent at the site (e.g. shell beds).

During the pumping test, BH273 was screened through the Kaawa Formation. The screen assembly was 15 m long comprising three screened intervals separated by 3 m blanks, and is installed entirely within the Kaawa Formation. The top of the screen was at a depth of 22 mBGL and the bottom of the screen is at a depth of 37 mBGL. The bore logs mainly show the presence of sand at this depth (Kaawa Formation). After the pumping test was completed, the screen was removed and BH273 was developed as a piezometer targeting the Waitemata Group from 41 to 50 mBGL. Subsequent slug tests (26/8/2015) targeting the Waitemata Group were undertaken in this piezometer.

Piezometer BH270

BH270 is located about 91.8 m to the north of pumping bore BH273. At this bore, three vibrating wire piezometers were installed at depths of 7, 15, and 28 mBGL. These vibrating wires registered pressure changes throughout the pumping test.

From the surface to a depth of 7 mBGL the soil material consists mainly of fine to coarse sands and gravels (Puketoka Formation). Therefore, the aquifer above 7 mBGL was considered unconfined. Overlaying the piezometer at 15m is a 1 m layer of silty clay located at 12 mBGL. This layer would provide a degree of confinement to the Kaawa Formation equivalent, and its pressure (e.g. water level) changes are registered by a vibrating wire installed at a depth of 15 mBGL. Similarly, the vibrating wire installed at 28 mBGL sits below layers of peat (23.5 mBGL – 24.1 mBGL) and silty clay (24.3 mBGL - 24.9mBGL) which provide further confinement to this aquifer section.

Figure F.10 shows the hydraulic head in the vibrating wire piezometers in BH270, throughout the duration of pumping and after the pump is switched off. The hydraulic head represents the water pressure within the aquifer system. A decrease in hydraulic head represents a loss of water pressure (e.g. due to water extraction). The hydraulic head for the VWP installed at 15m is the highest one of all the VWP installed in this piezometer, which could be due to confining pressure conditions.

All of these piezometers show an initial decrease in hydraulic head as the pump was switched on in BH273. However, there is a sudden recovery on 20/06/2015 after 3.8 days since pumping initiated in all of these piezometers, which could be due to background influences overwhelming the pumping response. Consequently, all of these piezometers show early recovery in spite of ongoing pumping in BH273. The deeper vibrating wires (at 15 m and 28 m) present a rising head even after pumping had ceased, whereas the shallow vibrating wire shows a declining head after cessation of pumping. About 10 days after pumping cessation, the three vibrating wires show the same relative response but at different depths.

The hydrographs show that about a week after the pump was switched off, the piezometers still registered significant hydraulic head fluctuations which seem to be correlated to each other. The range of head fluctuations during the monitoring period after full recovery was about 0.44 m, and the maximum head fluctuation during the drawdown phase (while pumping) is 0.48 m. The same behaviour was registered in BH271 and BH272. This suggests that the response recorded by the vibrating wire piezometers during the testing phase, while showing a clear early time impact from pumping, is nevertheless not significantly different to what occurs under natural conditions due to rainfall recharge and atmospheric pressure changes.

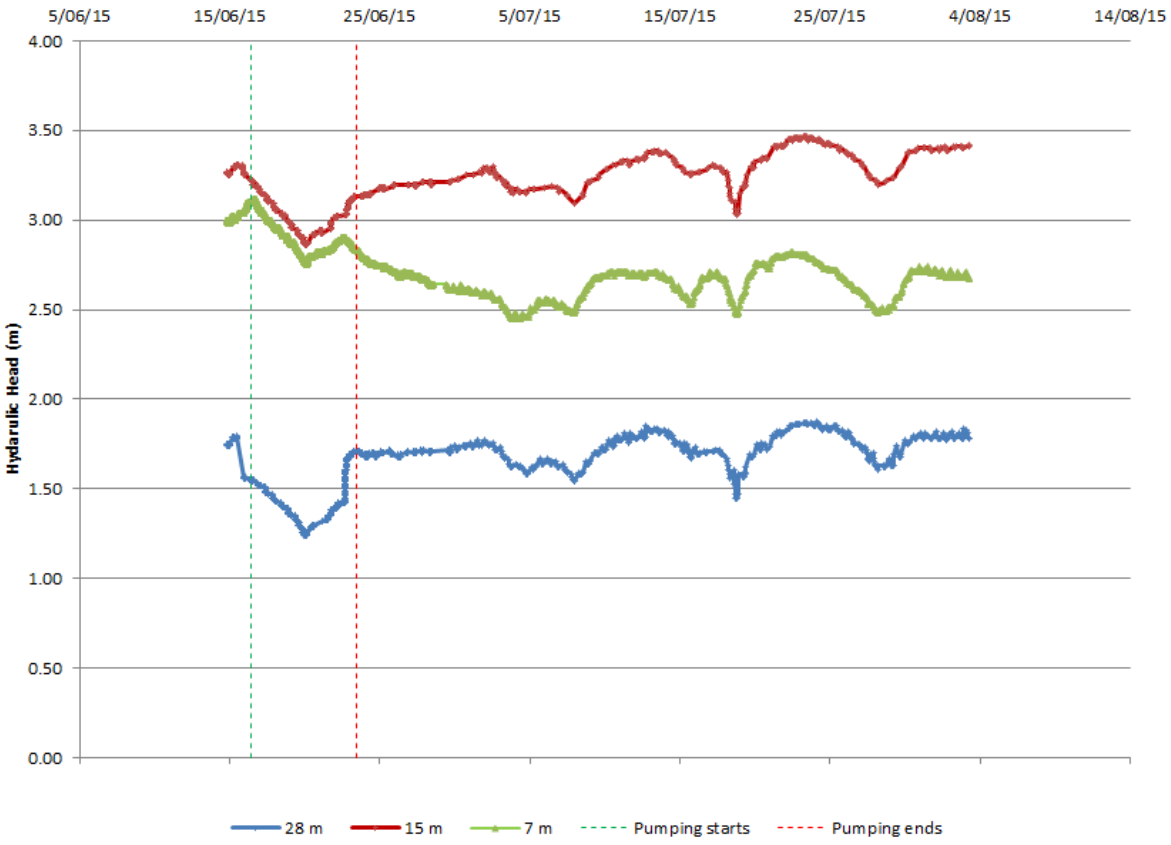


Figure F.10 : Hydraulic head in BH270 during pumping (BH273) and recovery

Piezometer BH271

BH271 is located at about 30 m to the northeast of pumping bore BH273. Three vibrating wires at depths of 6, 10, and 20 mBGL were installed at this bore. The material above the 6 mBGL piezometer is mainly fine to coarse sand and gravel. There is a thin layer of clayey silt from 1 to 1.8 mBGL but it was noted that this material also contained sand and gravel, which were part of the original fill material at the site. Since the fill material could have presented significant variation away from this bore, and the silt unit presents sand and gravel, this section of the aquifer is correlated to the Puketoka Formation with some inter fingering of the AFVB (e.g. gravels) and is regarded as unconfined.

At 8.5 mBGL there is a layer of silty clay that could be up to 1 m thick; this layer may provide a degree of confinement to this section of the Puketoka Formation. Its actual thickness is unknown because there was a core loss (could have been due to coarser unconsolidated material at this depth) that occurred as the bore was being drilled. Similarly, soil material consisting of silt, clay, and peat from 10.1 to 11.55 mBGL provide confining properties to the aquifer at 20 mBGL. At this depth, the confined aquifer would correspond to the Kaawa Formation equivalent.

Figure F.11 shows the hydraulic head in the vibrating wire piezometers in BH271 throughout the duration of pumping and after the pump is switched off. As the pump was switched on in BH273, all of the vibrating wire piezometers in BH271 show an initial decrease in hydraulic head. A similar pattern of observation trends emerged as was discussed for piezometer 270 in the previous section. However in this case, the hydraulic head recorded by the shallow VWP (installed at 6mBGL) registers the highest values. In addition, the hydraulic head for the VWP installed at 10mBGL show a consistent decline even after the pump is switched off (e.g. from 23/06 to the 3/07), which suggests external (e.g. natural) influences. In all of these piezometers, there is a sudden

recovery on 20/06/2015, which could be due to an external source of recharge. Consequently, all of these piezometers show early recovery in spite of ongoing pumping in BH273. The deeper piezometer (at 20m) presents a rising head even after pumping has ceased, whereas the shallower piezometers (at 6m and 10m) show a declining head after cessation of pumping. At about 10 days after pumping cessation, the three vibrating wires show the same relative response but at different depths.

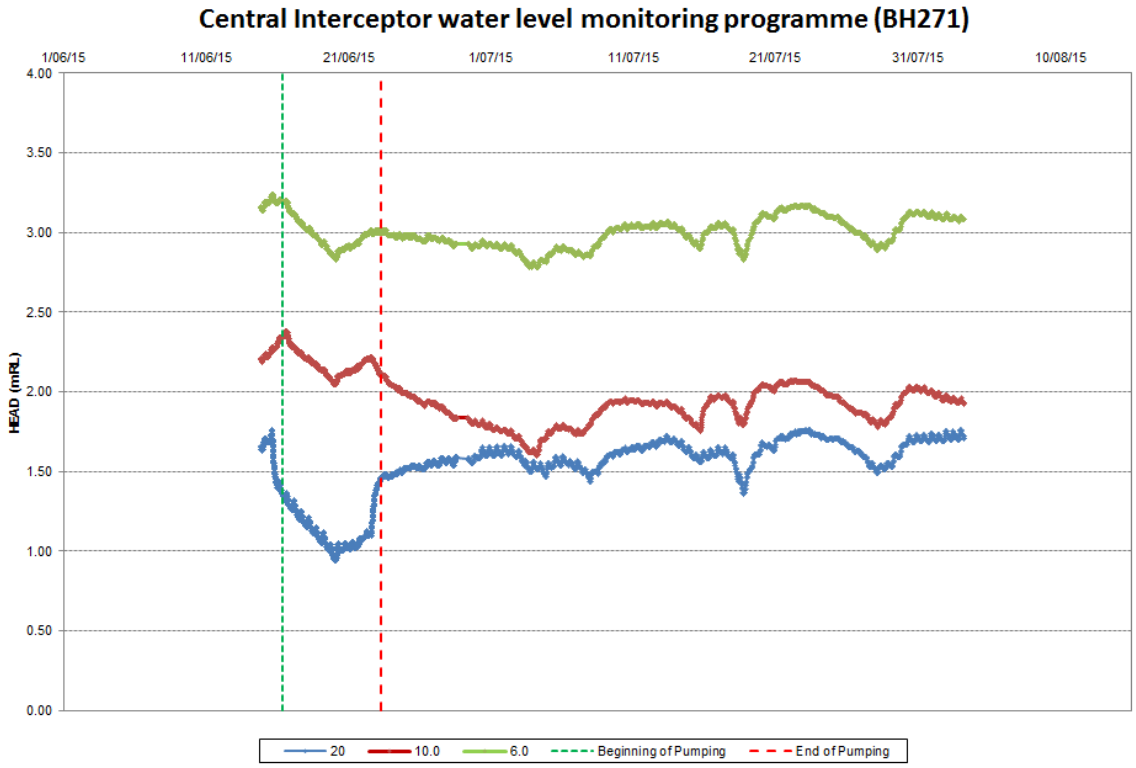


Figure F.11 : Hydraulic head in BH271 during pumping (BH273) and recovery

Piezometer BH272

BH272 is located to the northeast of BH273, at a distance of about 52 m. This piezometer has three vibrating wires installed at depths of 6, 12, and 25 mBGL. Above 6 mBGL the soil material is mainly sand and gravel with some top soil (e.g. fill material) near the surface (e.g. Puketoka Formation). Consequently, the aquifer was regarded as unconfined at 6 mBGL. A 1.4 m thick layer of silty clay is present at 9 mBGL and silt and clay units are present between 9.4 and 10.5 mBGL, which provide a degree of confinement to a 1m layer of sand between 11 and 12 mBGL. The aquifer material between 15.5 and 25 mBGL consists mainly of sand with some shell traces, except for soil consisting of peat, silt, and some clay between 22.4 and 24.3 mBGL. Consequently, the aquifer at this depth is correlated to the Kaawa Formation and is likely to behave as confined, semi-confined or leaky.

Figure F.12 shows the hydraulic head in the vibrating wire piezometers in BH272 throughout the duration of pumping in BH273, and after the pump was switched off. In this bore, the highest hydraulic head is from the shallow VWP installed at 6mBGL. In this bore, the VWP installed at 25mBGL registers higher hydraulic heads than the one for the VWP installed at 12mBGL. This suggests confinement at this depth, which registers as a high hydraulic head value (vertical head gradient). All of the vibrating wire piezometers in BH272 show an initial decrease in hydraulic head as the pump was switched on in BH273. However, in all of these piezometers, there

is a sudden recovery on 20/06/2015, which could be due to an external source of recharge. Consequently, all of these piezometers show early recovery in spite of ongoing pumping in BH273. The deeper piezometers (at 12m and 25m) present a rising head even after pumping has ceased, whereas the shallower piezometer (at 6m) shows a declining head after cessation of pumping. At about 10 days after pumping cessation, the three vibrating wires show the same relative response but at different depths.

The hydrographs on **Figure 5** show that about a week after the pump was switched off, the piezometers still registered significant hydraulic head fluctuations which seem to be correlated to each other. The range of head fluctuations during this period was about 0.44m, and the maximum head fluctuation during the drawdown phase (while pumping) is 0.77m (at 25m). This suggests that the response recorded by the vibrating wire piezometers could have been significantly affected by natural head variations (e.g. tides, atmospheric pressure changes, and recharge boundaries) rather than the pumping itself.

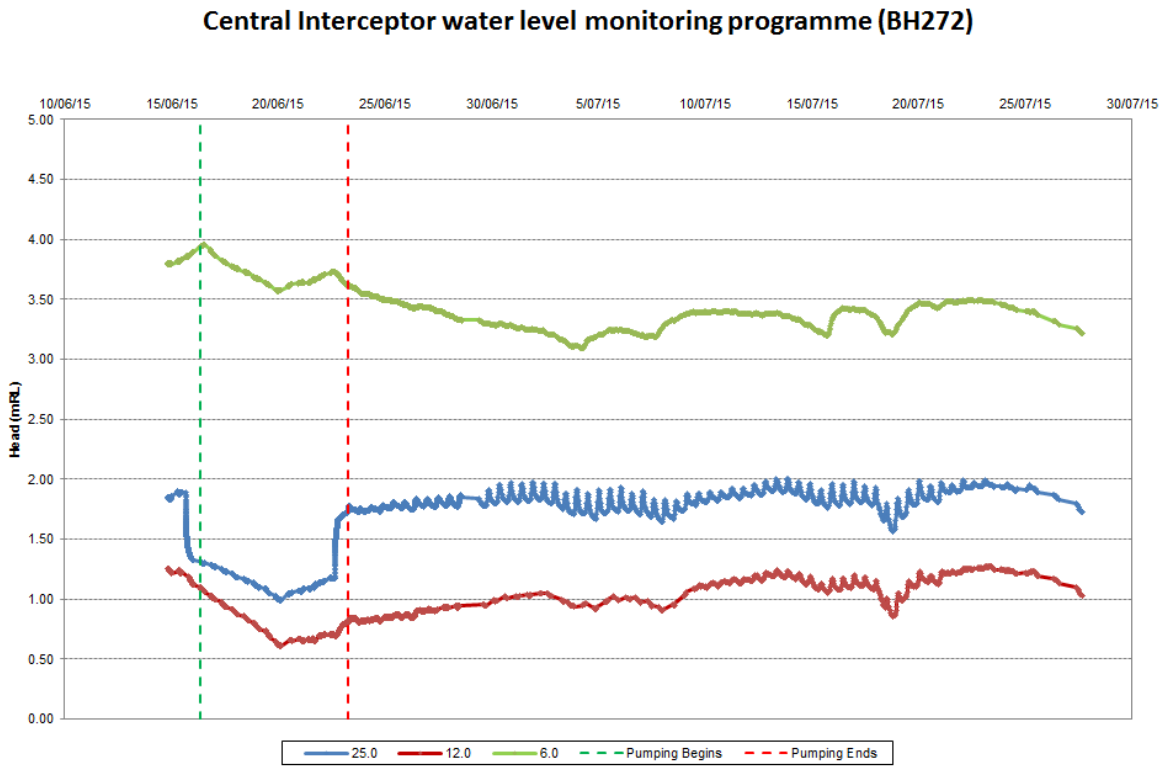


Figure F.12 : Hydraulic head in BH272 during pumping (BH273) and recovery

F.3.4 Tunnel Alignment and secondary shafts

Lugeon tests were carried out on selected bores along the alignment, Table F.11. Two Lugeon tests (BH252 on 25/2/2015 and BH253 on 12/5/2015) were carried out near the Mangere site. The test on BH252 was carried out in the 55.5-63 mBGL test interval with six pressure steps (5, 10, 20, 30, 20, 10 psi). The test on BH253 had no test interval data and only 3 pressure steps were trialled (test was incomplete). Nevertheless, an estimate was able to be calculated using data from BH252 to fill data gaps for this test. Two additional Lugeon tests were carried out on 2 bores (BH258 on 27/05/2015 and BH259 on 21/5/2015) near Kiwi Esplanade. The testing interval for BH258 reported in the test logs did not match the bore log records so an interval from 12 to 18 mBGL was selected (6 m to the depth of the completed bore). The testing for BH259 was carried out throughout 3 intervals (28-38, 35-38, and 55.5-63 mBGL) all within the Waitemata Group (ECBF).

Table F.11 : Lugeon tests throughout the tunnel alignment and secondary shafts

Bore Name	Test Date	Testing Interval (mBGL)		Aquifer/Formation
		From	To	
BH219	16/04/2015	32	40	ECBF
BH252	25/2/2015	55.5	63	ECBF
BH253*	12/05/2015	55.5	63	ECBF
BH258*	27/05/2015	12	18	AVFB
BH259_1	21/05/2015	55.5	63	ECBF
BH259_2	21/05/2015	28	38	ECBF
BH259_3	21/05/2015	35	38	ECBF

Note:

* These tests may not truly represented the tested interval as the data collected was incomplete and estimations were made to derive hydraulic parameters

About 20 slug tests were carried out on 18 bores along the tunnel alignment and secondary shafts, between May and June 2015. BH224 was tested at two intervals (6.5m and 24.5m) as this is a nested bore. No Pumping Tests were carried out at locations outside of the main shaft areas.

Table F.12 : Slug tests throughout the tunnel alignment and secondary shafts

Bore Name	Test Date	Slug Test Type	Screen From (mBGL)	Screen To (mBGL)	SWL (mBGL)	Aquifer/Formation
BH212	5/06/2015	RHT	37.0	43.0	11.668	ECBF
BH211	04/06/2015	RHT	29.6	35.6	6.345	ECBF
BH213	28/05/2015	RHT	36.0	42.0	7.86	ECBF
BH214	29/05/2015	RHT	30.0	42.0	9.895	Puketoka Formation
BH215	29/05/2015	RHT	8.8	14.8	3.551	ECBF
BH218 (Norgrove)	28/05/2015	RHT	21.0	27.8	2.156	ECBF

Bore Name	Test Date	Slug Test Type	Screen From (mBGL)	Screen To (mBGL)	SWL (mBGL)	Aquifer/Formation
BH217	28/05/2015	RHT	3.5	6.5	0.618	Puketoka Formation
BH218a	29/05/2015	RHT	17.7	20.7	4.574	ECBF
BH221	02/06/2015	RHT	9.3	23.3	1.741	Puketoka Formation
BH222	02/06/2015	RHT*	39	44.3	0	ECBF
BH223	19/08/2015	RHT	36.0	42.0	11.84	Puketoka Formation
BH224_6.5m	02/06/2015	RHT	5.5	6.5	1.145	AVBF/Puketoka Formation
BH224_24.5m	02/06/2015	RHT*	2.4	24.5	1.97	Puketoka Formation
BH227	20/08/2015	RHT	3.0	6.0	0.074	Puketoka Formation
BH228_1	20/08/2015	RHT	47.0	50.0	0	ECBF
BH228_2	20/08/2015	RHT	3.0	6.0	0.2	Puketoka Formation
BH229a	20/08/2015	RHT	63.5	66.5	10.63	ECBF
BH230	18/08/2015	RHT	51.4	54.4	25.08	ECBF
BH251	05/06/2015	RHT	14.0	20.1	1.981	ECBF
BH256	05/06/2015	RHT	5.5	12.0	1.01	ECBF

Note:

* Tests may be inaccurate because more than 1 bailer volume was removed to carry out these tests.

F.4 Units correlation at Mangere WWTP

Correlating the different aquifer units encountered at depth in the different bores is important to understand hydraulic property assignment of the aquifer and aquitard distribution, the implications this may have on dewatering and ground stability during construction, and environmental effects of this work.

The logs for bores in this pumping test show two distinct silty clay units providing a degree of confinement to the aquifer at various depths. Sometimes it is unclear whether, in the neighbouring piezometers, the deep silty clay unit directly above the pumping bore screen is directly correlated to the shallow silty clay unit, or to the deeper one. For example, the shallow silty clay unit at BH270 (9mBGL to 11.9mBGL) could be correlated either to a shallow organic clay (with silt) unit (from 8.2mBGL to 10.5 mBGL) or to a deeper sandy silt unit (18mBGL to 19.5mBGL) in BH273. In addition, there could be significant heterogeneity as the silty clay units could be occurring as lenses of material with varying thickness and depth. Consequently, it is possible that these confined aquifers are behaving as leaky aquifers and the effects of pumping the deeper (confined) aquifer at BH273 could induce a response throughout the confined and unconfined units in neighbouring piezometers. This is observed in **Figures 6-8** as the hydraulic response of piezometers installed at depths of 6m to 15m correlate to the response of deeper piezometers installed at depths greater than 20m.

The screened interval of BH273 does not cover the whole length of the confined aquifer as the well has not been drilled to the base of the aquifer and the top of the screen was arbitrarily set at 22mBGL through an existing sand unit, which means that this bore partially penetrates the confined aquifer.

In general, the screened section of BH273 correlates with the Kaawa Formation. This is particularly noticeable as many of the materials encountered at the screened depth include shell materials known to be part of the Kaawa. Similarly, the deep vibrating wire piezometers for BH270 (15m and 28m), BH271 (10m and 20m), and BH272 (12m and 25m) target units which are correlated to the Kaawa Formation. On the other hand, the shallow piezometers in BH270 (7m), BH271 (6m), and BH272 (6m) target units correlated to the Puketoka Formation. This is evidenced by the presence of alluvium material (e.g. silts, clays, sands, and gravels) in these bores.

F.5 Analyses Methodologies

F.5.1 Lugeon Tests

Lugeon test data were analysed using the general analyses method described by Hvorslev (1951) and detailed in BS 5930:1999. With this method, the hydraulic conductivity is estimated by calculating the total pressure from Gauge measurements and gravity driven pressure head during the test, and by using the injection flow rate during each of the pressure test intervals. For this method to be effective, the length of the screen has to be greater than 10 times the diameter of the bore, and this criteria was satisfied for all tests undertaken on this project.

F.5.2 Slug Tests

Rising Head and Falling Head tests were analysed using the Slug Test Hvorslev recovery method (1951). The test is intended to be used in confined aquifers although it may be extended to unconfined aquifers in many cases. The Hvorslev method is based on the slope of the base-fit line. This is calculated by taking the elapsed time for normalised head (H/H0) between 1 and 0.37.

F.5.3 Pumping Tests

Pumping test analysis methodologies varied according to the type of borehole being analysed (e.g. pumping bore vs piezometers), the type of aquifer encountered at depth (e.g. confined vs unconfined), and the type of data available. The pumping tests were analysed in the software Aquifer Test 2015 by Schlumberger Water Services.

Water levels were downloaded for the test duration, barometrically corrected (for pressure transducers) and prepared in Microsoft Excel. The water level data for the chosen bores was reviewed to identify if a drawdown and recovery response was exhibited. In situations where there was no obvious drawdown or recovery in the

observation bore (i.e. due to distance from the pumping bore or different screened aquifer zone), and water levels exhibited natural fluctuations, the data was then excluded from analysis.

Information from bore logs of the pumping and observation wells and any pumping data were input into aquifer test. This included screen length, borehole and screen radius, aquifer thickness, static water level, pumping rates and distance from the pumping bore. Both the pumping period and the recovery period were analysed if data was available. The bore logs and drawdown curves were reviewed to determine whether the system behaved as an unconfined, confined or leaky aquifer.

Western Springs Pumping Test

In observation boreholes 206, 207 and 208, VW's were nested at various depths below ground level. The bore logs were reviewed to understand the relevant lithology at depth. This indicated the most suitable VW to be used for each pumping test (i.e. within the ECBF or shallower Basalt layers). Similarly this approach was applied for boreholes 204, 205 and 206b which reviewed the screened zones of the aquifer and measured water levels with pressure transducers.

For Western Springs, a number of methods were applied. In the Basalt, unconfined aquifer tests were compared with some confined tests. While in the ECBF, only confined aquifer tests were used.

The test methods included:

- Neuman and Boulton (unconfined)
- Theis drawdown
- Theis recovery
- Cooper Jacob

Cooper Jacob I, Theis and Theis recovery were performed on each of the relevant observation wells and also on the pumping bore. The results were compiled into a summary table to determine the relevant transmissivity (m^2/d), hydraulic conductivity (m/d) and storativity.

May Road Pumping Test

In observation boreholes 245 and 246, VW's were nested at various depths below ground level. The bore logs were reviewed to understand the relevant lithology at depth. This indicated the most suitable VW to be used for each pumping test (i.e. within the ECBF or shallower Basalt layers). Similarly this approach was applied for borehole 247 which reviewed the screened zones of the aquifer and measured water levels with pressure transducers.

There was no obvious drawdown registered in BH247, which was screened within the Tauranga formation (to a depth of 17 m) and exhibited no significant response to ECBF or Basalt pumping tests. Therefore, this bore was excluded from the analysis.

For May Road, a range of test methods were used on both the Basalt and ECBF. Unconfined methods (i.e. Neuman and Boulton) were used within the Basalt only.

The test methods included:

- Theis drawdown (ECBF)
- Theis recovery (Basalt and ECBF)
- Cooper Jacob I (Basalt and ECBF)

- Neuman (Basalt)
- Boulton (Basalt)

The results from the analysis applied to observation and pumping bores were compiled into a summary table to determine the relevant transmissivity (m^2/d), hydraulic conductivity (m/d) and storativity (or specific yield for unconfined aquifers).

Mangere WWTP Pumping Test

To estimate the Transmissivity at BH273, pumping test data from this well was analysed using Theis, Cooper and Jacob, and Theis-Recovery. Since the well screen is located in the Kaawa Formation, these methods only produced hydraulic properties relevant to this formation.

The pumping test analyses methods used to analyse data from BH270, were unconfined methods for data recorded by the 7m vibrating wire (Theis with Jacobs correction), and confined or leaky methods for deeper bores (Theis, Cooper Jacobs, and Hantush). To avoid interference from potential recharge boundaries only the declining head portion of the drawdown phase was analysed. Since these aquifers experienced recovery even during the pumping phase, it was not possible to analyse recovery data.

To analyse data from BH271, unconfined methods were used for data recorded by the vibrating wire at 6m (Neuman and Theis with Jacobs correction), and confined or leaky methods for deeper piezometer depths (Theis, Cooper Jacobs, and Hantush). Only the declining head portion during the drawdown phase was analysed, to avoid interference from potential recharge boundaries. Since these aquifers experienced recovery even during the pumping phase, it was not possible to analyse recovery data.

The pumping test analyses methods used to analyse data BH272 were unconfined methods for data recorded by the vibrating wire installed at 6m (Neuman and Theis with Jacobs correction), and confined or leaky methods for deeper piezometer depths (Theis, Cooper Jacobs, and Hantush). Only the declining head portion, during the drawdown phase, was analysed to avoid interference from potential recharge boundaries. Since these aquifers experienced recovery even during the pumping phase, it was not possible to analyse recovery data.

F.6 Results

F.6.1 Lugeon Test Results

Lugeon test results are presented in Table F.13. This table shows the average and maximum hydraulic conductivity values taken from manual measurements and transducer recordings. All of these tests, except the one for BH258, were completed within the Waitemata Group (ECBF). The test for BH258 was completed within the AVFB. The average k value for the ECBF in the Western Springs area is 3.87×10^{-6} m/s (3.34 $\times 10^{-1}$ m/day) and the maximum value is 1.54×10^{-5} m/s (1.33 m/day). There was only one accurate test conducted near May Rd, and it suggested a lower hydraulic conductivity value (average = 1.18×10^{-7} m/s at BH252) for the ECBF at this location. Similar magnitudes were obtained for the hydraulic conductivity values for the ECBF at Mangere (average = 6.10×10^{-7} m/s). The test conducted in the AVFB resulted in a hydraulic conductivity value of 1.28×10^{-7} m/s.

Table F.13 : Lugeon test analyses results (hydraulic conductivity). ECBF = East Coast Bays Formation, AVFB = Auckland Volcanic Field Basalts

Bore ID	Location	From (mBGL)	To (mBGL)	Unit	Average k (m/s)	Max k (m/s)
BH200	Western Springs	16.5	26.5	ECBF	7.82×10^{-7}	1.36×10^{-6}

Bore ID	Location	From (mBGL)	To (mBGL)	Unit	Average k (m/s)	Max k (m/s)
BH201	Western Springs	16.5	26.5	ECBF	$2.47x10^{-6}$	$6.13x10^{-6}$
BH204	Western Springs	16.5	26.5	ECBF	$1.08x10^{-7}$	$1.51x10^{-7}$
BH205	Western Springs	12	18	ECBF	$1.54x10^{-5}$	$2.90x10^{-5}$
BH206	Western Springs	25.1	28.5	ECBF	$5.90x10^{-7}$	$7.73x10^{-7}$
BH219	Near Western Springs	32	40	ECBF	$8.42x10^{-8}$	$4.82x10^{-7}$
BH252	East of May Rd	55.5	63	ECBF	$1.18x10^{-7}$	$1.56x10^{-7}$
BH253*	East of May Road	55.5	63	ECBF	$3.55x10^{-6}$	$6.54x10^{-6}$
BH258*	Vicinity or on route to Mangere WWTP	12	18	AVFB	$1.28x10^{-7}$	$1.59x10^{-7}$
BH259_1	Vicinity or on route to Mangere WWTP	55.5	63	ECBF	$2.48x10^{-7}$	$3.51x10^{-7}$
BH259_2	Vicinity or on route to Mangere WWTP	28	38	ECBF	$1.65x10^{-6}$	$3.54x10^{-6}$
BH259_3	Vicinity or on route to Mangere WWTP	35	38	ECBF	$1.22x10^{-7}$	$4.61x10^{-7}$
BH271_1	Mangere WWTP	30.8	33.7	ECBF	$5.92x10^{-7}$	$1.19x10^{-6}$
BH271_2	Mangere WWTP	45	48	ECBF	$6.27x10^{-7}$	$1.70\ x10^{-6}$

Note:

* These tests may not truly represented the tested interval as the data collected was incomplete and estimations were made to derive hydraulic parameters

F.6.2 Slug Test Results

Slug Test results indicate hydraulic conductivity (k) values ranging from $1.93x10^{-8}$ m/s to $3.54x10^{-6}$ m/s for the ECBF and $1.27x10^{-7}$ m/s to $6.49x10^{-7}$ m/s for the Puketoka Formation. The Kaawa Formation has a measured k value of $3.09x10^{-6}$ m/s (BH268) and the Auckland Volcanic Field Basalts has a k value of $1.24x10^{-6}$ m/s (BH208b).

The average k value for the ECBF is $1.29x10^{-6}$ m/s in the Western Springs area, $9.82x10^{-7}$ m/s for the May Road area, and $1.10x10^{-7}$m/s for the Mangere WWTP area. The Puketoka Formation had average values of

5.54x10^{-7} m/s at Western Springs and 1.27x10^{-7}m/s at May Road (only one value). The screen of Bore 235 covers part of the Puketoka Formation and part of the ECBF, and has a hydraulic conductivity of 1.02x10^{-7} m/s. Details of the slug test analyses for each Test are presented in Appendix G.

Table F.14 : Slug test analyses results (hydraulic conductivity). ECBF = East Coast Bays Formation, AVBF = Auckland Volcanic Field Basalts

Bore ID	Location	From (mBGL)	To (mBGL)	Unit	Average k (m/s)
200	Western Springs	20.5	23.5	ECBF	1.97x10^{-7}
208a	Western Springs	3	6	ECBF	7.34x10^{-7}
201a	Western Springs	22.5	26.5	ECBF	1.59x10^{-6}
201b	Western Springs	6.10	18.10	ECBF	2.21x10^{-6}
204	Western Springs	20.5	23.5	ECBF	9.54x10^{-7}
206b	Western Springs	5	7	AVFB/Puketoka Formation	5.21x10^{-6}
208b	Western Springs	6	9	AFVB	1.24x10^{-6}
223	Western Springs	36	42	Puketoka Formation	4.79x10^{-7}
228-1	Western Springs	47	50	ECBF	3.54x10^{-6}
228-2	Western Springs	3	6	ECBF	1.88x10^{-6}
227	Western Springs	3	6	Puketoka Formation	6.30x10^{-7}
229a	Western Springs	63.5	66.5	ECBF	1.93x10^{-8}
230	Western Springs	51.4	54.4	ECBF	4.93x10^{-7}
212	South of Western Springs	37	43	ECBF	2.87x10^{-7}
213	South of Western Springs	36	42	ECBF	3.64x10^{-8}

Bore ID	Location	From (mBGL)	To (mBGL)	Unit	Average k (m/s)
211	South of Western Springs	29.6	35.6	ECBF	$2.80x10^{-7}$
214	South of Western Springs	30	42	Puketoka Formation	$4.21x10^{-7}$
215	South of Western Springs	8.8	14.8	ECBF	$3.21x10^{-7}$
218 (Norgrove Ave)	South of Western Springs	21.0	27.8	ECBF	$5.79x10^{-7}$
217	South of Western Springs	3.5	6.5	Puketoka Formation	$6.49x10^{-7}$
218a	South of Western Springs	17.7	20.7	ECBF	$3.19x10^{-7}$
221	South of Western Springs	9.3	23.3	Puketoka Formation	$1.67x10^{-7}$
222	South of Western Springs	39	44.3	ECBF	NA
224_6.5m	South of Western Springs	5.5	6.5	AVFB/Puketoka Formation	$4.97x10^{-7}$
224_24.5m	South of Western Springs	24	24.5	Puketoka Formation	$2.31x10^{-7}$
237	May Road			Puketoka Formation	$1.27x10^{-7}$
235	May Road	6.8	9.8	Puketoka/ECBF	$1.02x10^{-7}$
241	May Road	9.2	12.2	ECBF	$2.42x10^{-6}$
243	May Road	18.5	24.5	ECBF	$4.84x10^{-7}$
252	May Road	85	100	ECBF	$4.25x10^{-8}$

Bore ID	Location	From (mBGL)	To (mBGL)	Unit	Average k (m/s)
251	South of May Rd	14	20.1	ECBF	$1.98x10^{-7}$
256	South of May Rd	5.5	12	ECBF	$4.66x10^{-8}$
259	Kiwi Esplanade	27	30	ECBF	$7.51x10^{-7}$
268	Mangere WWTP	29.2	32.2	Kaawa Formation	$3.09x10^{-6}$
273	Mangere WWTP	41	50	Parnell Volcaniclastic Conglomerate	$1.10x10^{-7}$

F.7 Pumping Test Results

F.7.1 Western Springs

Pump Test 1 (BH206b, Basalt Test)

Table F.15 presents the Boulton unconfined analysis (the recovery period has been excluded for this particular analysis). The Neuman analysis is not being presented, however this analysis has a very similar fit to the Boulton analysis. Slug test calculationsAppendix H present the Theis drawdown curves and Cooper Jacob I analysis for BH206b and BH206. They are presented to show the generally good curve fitting achieved during analysis.

The results from the tests are summarised Table F.15. Average results for the Basalt formation in Western Springs were:

- Transmissivity = 1.11 m^2/d
- Hydraulic conductivity = 3.21 x 10^{-6} m/s
- Specific yield = 0.03

Confined aquifer methods were used for comparison of Transmissivity and hydraulic conductivity. The storativity values (Specific yield for unconfined aquifer) was estimated with observation bore data (e.g. VW at 10mBGL in BH206).

Table F.15 : Pumping Test Results

Borehole	Method name	T [m^2/s]	k [m/s]	SY*
BH206b (pumping)	Theis	1.08×10^{-5}	2.70×10^{-6}	-
BH206b (pumping)	Theis Recovery	7.78×10^{-6}	1.94×10^{-6}	-
BH206 (obs)	Theis	1.45×10^{-5}	3.63×10^{-6}	-

Borehole	Method name	T [m²/s]	k [m/s]	SY*
BH206 (obs)	Cooper Jacob I	1.45×10^{-5}	3.65×10^{-6}	-
BH206 (obs)	Theis Recovery	1.53×10^{-5}	3.81×10^{-6}	-
BH206 (obs)	Boulton	1.35×10^{-5}	3.38×10^{-6}	6.47×10^{-2}
BH206 (obs)	Neuman	1.34×10^{-5}	3.37×10^{-6}	1.57×10^{-3}
	Average	1.29×10^{-5}	3.21×10^{-6}	3.31×10^{-2}
	Min	7.78×10^{-6}	1.94×10^{-6}	1.57×10^{-3}
	Max	1.53×10^{-5}	3.81×10^{-6}	6.47×10^{-2}

* storativity from pumped bore has been ignored, only specific yield has been presented. Sy values are based on the observation bore results only.

Pump Test 2 (BH205, ECBF Test)

The pumping test analyses were carried out with the following graphical fits presented in Appendix H:

- Cooper Jacob I analysis for BH205 (pumping). This analysis is carried out after approximately 200 minutes, where the pumping rate of 0.14 L/s becomes constant.
- Theis analysis for BH204 (~95m from pumping bore).
- The Cooper Jacob II assessment was also applied to the three observation wells. This plots the drawdown at a specific point in time versus the distance from the pumping bore, and is useful in determining storativity of the aquifer. The chosen time was after 8640 minutes of pumping (the end of the pumping test). See Appendix H.
- A recovery analysis was undertaken on BH204 (obs bore), however this has not been presented because the available data ceased with water levels ~0.3 m below initial static levels. Assessment of the later period of recovery indicated aquifer transmissivity and hydraulic conductivity values similar to other tests. Theis recovery has been presented for the pumping bore in Appendix H. Review of water levels indicates a relatively high recharge rate in the aquifer from a drawdown of ~12 m when pumping ceased to ~2.2 m in less than 60 minutes of recovery. From this point, recovery to static water levels follows Theis assumptions.

The results from the tests are summarised in Table F.16. Average results for the ECBF formation in Western Springs were:

- Transmissivity = 4.04 m^2/d
- Hydraulic conductivity = 3.19×10^{-6} m/s
- Storativity =0.00021

The results from all the tests have been compiled into an analysis table. This includes the pumping and observation bores. See **Table 4.1** on the following page.

Table F.16 : BH205 Aquifer Test Results

Borehole	Method name	T [m²/s]	k [m/s]	S*
BH204 (obs)	Theis Recovery	$3.23x10^{-5}$	$2.3x10^{-6}$	-
BH204 (obs)	Theis	$4.18x10^{-5}$	$2.99x10^{-6}$	3.63×10^{-5}
BH204 (obs)	Cooper & Jacob I	$3.95x10^{-5}$	$2.82x10^{-6}$	5.72×10^{-5}
BH206 (obs)	Theis	$3.02x10^{-5}$	$2.15x10^{-6}$	4.80×10^{-5}
BH206 (obs)	Cooper & Jacob I	$3.36x10^{-5}$	$2.4x10^{-6}$	8.31×10^{-5}
BH207 (obs)	Theis	$8.87x10^{-5}$	$6.33x10^{-6}$	3.79×10^{-4}
BH207 (obs)	Cooper & Jacob I	$1.52x10^{-4}$	$1.08x10^{-5}$	2.88×10^{-4}
All Obs Bores	Cooper & Jacob II	$2.19x10^{-5}$	$1.56x10^{-6}$	5.78×10^{-4}
BH205 (pumping)	Theis	$1.82x10^{-5}$	$9.07x10^{-7}$	1.00×10^{-7}
BH205 (pumping)	Cooper & Jacob I	$3.01x10^{-5}$	$1.50x10^{-6}$	7.28×10^{-12}
BH205 (pumping)	Theis Recovery	$2.60x10^{-5}$	$1.50x10^{-6}$	-
	Minimum	$1.82x10^{-5}$	$9.07x10^{-7}$	3.63×10^{-5}
	Average	$4.68x10^{-5}$	$3.19x10^{-6}$	2.1×10^{-4}
	Maximum	$1.52x10^{-4}$	$1.08x10^{-5}$	5.78×10^{-4}

* Storativity values derived from the pumping bore (BH205) have been ignored, as the test solution would impose a division by zero with the pumping bore. Only the observation bores have been used to determine average, minimum and maximum statistics for storativity.

F.7.2 May Road

Pump Test 1 (BH247a, Basalt Test)

Pumping test data for bore holes BH247a and BH246 (4m VW) were analysed using the methods outlined in Section 4.5.32. Appendix H presents the Neuman, Theis recovery, and Cooper Jacob I analyses for BH247a and BH246–4m VW. These figures are presented for indication of general curve fitting achieved during analysis.

The results from the tests are summarised in Table F.17. This table also outlines some of the assumptions with the tests, where data has been excluded in order to determine suitable aquifer parameters. Average results for the Basalt formation in May Road were:

- Transmissivity = 5.94 m^2/d
- Hydraulic conductivity = 1.71 $x10^{-6}$ m/s
- Specific yield of = 0.014

Table F.17 : Basalt Pumping Test Results

Borehole	Method name	T [m²/s]	k [m/s]	SY*	Comments
BH246-4m VW (obs)	Cooper Jacob I (0-50 min)	$1.33x10^{-4}$	$6.63x10^{-6}$	-	Fitted 0-70 mins before pumping rate change
BH246-4m VW (obs)	Cooper Jacob I (100-200 min)	$3.92x10^{-5}$	$1.97x10^{-6}$	-	Fitted 100-200 mins after pumping rate change, recharge boundary then intersected at ~1.6 m drawdown
BH246-4m VW (obs)	Boulton (0-100 min)	$3.43x10^{-5}$	$1.71x10^{-6}$	1.25×10^{-2}	Fitted 0–100 mins
BH246-4m VW (obs)	Neuman	$9.87x10^{-5}$	$4.93x10^{-6}$	1.48×10^{-2}	Good fit entire duration
BH246-4m VW (obs)	Theis Recovery	$1.09x10^{-4}$	$5.46x10^{-6}$	-	Good fit
BH247a (pumping)	Boulton	$3.75x10^{-5}$	$1.88x10^{-6}$	8.04×10^{-1}	Average fit for 0–100 mins
BH247a (pumping)	Cooper Jacob I (0-50 min)	$4.39x10^{-5}$	$2.19x10^{-6}$	-	Fitted 0–70 mins before pumping rate change
BH247a (pumping)	Neuman Pumping	$6.77x10^{-5}$	$3.39x10^{-6}$	9.90×10^{-1}	Average–poor fit for entire duration
BH247a (pumping)	Theis Recovery	$5.47x10^{-5}$	$2.73x10^{-6}$	-	Good fit
	Average	$3.43x10^{-6}$	$1.71x10^{-6}$	1.25×10^{-2}	
	Min	$6.88x10^{-5}$	$3.44x10^{-6}$	1.37×10^{-2}	
	Max	$1.33x10^{-4}$	$6.63x10^{-6}$	1.48×10^{-2}	

* Storativity from Cooper Jacobs I have not been included in analysis as Basalt aquifer is unconfined. Specific yield min, average and maximum results are derived from the observation bore only.

Pump Test 2 (BH247b, ECBF Test)

Figure 12.23 presents the Theis analysis for BH247b (pumping bore). This figure shows that the analysis was carried out for the period 1440–8640 minutes, where the pumping rate of 0.5 L/s is constant. Appendix H presents the Cooper Jacob I analysis for BH245–64.5 m VW (~28.6 m from pumping bore) and BH246-25.5 m VW (19 m from pumping bore).

A recovery analysis was undertaken on all boreholes, however it must be noted that no boreholes returned to static water levels after 8 days. The later period of recovery has been assessed given the trend appears to be linear and uniform; with a T and k similar to those observed in Theis and Cooper Jacob I tests. Theis recovery has been presented in Appendix H**.** Review of water levels indicates a relatively fast recharge in the aquifer from a drawdown of ~34.3 m when pumping ceased to ~10 m after 120 minutes of recovery.

The results from the tests are summarised in **Error! Reference source not found.** This includes the pumping and observation bores. Average results for the ECBF formation in May Road were:

- Transmissivity = 2.16 m^2/d

- Hydraulic conductivity = 4.98 x10^{-7} m/s
- Storativity = 0.002

Table F.18 : BH247b ECBF Pump Test Results

Borehole	Method name	T [m²/s]	k [m/s]	S*
BH247b	Theis	$1.25x10^{-5}$	$2.49x10^{-7}$	1.18×10^{-1}
BH246-25.5 m VW	Theis	$4.18x10^{-5}$	$8.36x10^{-7}$	3.83×10^{-3}
BH245-64.5 m VW	Theis	$1.49x10^{-5}$	$2.97x10^{-7}$	6.02×10^{-4}
BH246-25.5 m VW	Cooper & Jacob I	$4.63x10^{-5}$	$9.25x10^{-7}$	3.01×10^{-3}
BH245-64.5 m VW	Cooper & Jacob I	$1.68x10^{-5}$	$3.34x10^{-7}$	4.39×10^{-4}
BH247b	Theis Recovery	$1.75x10^{-5}$	$3.50x10^{-7}$	-
BH246-25.5 m VW	Theis Recovery	$3.65x10^{-5}$	$7.29x10^{-7}$	-
BH245-64.5 m VW	Theis Recovery	$1.34x10^{-5}$	$2.69x10^{-7}$	-
	Minimum	$1.25x10^{-5}$	$2.49x10^{-7}$	4.39×10^{-4}
	Average	$2.50x10^{-5}$	$4.99x10^{-7}$	1.97×10^{-3}
	Maximum	$4.63x10^{-5}$	$9.25x10^{-7}$	3.83×10^{-3}

* Storativity values derived from the pumping bore (BH247b) have been ignored, as this is the pumping bore. Only the observation bores have been used to determine average, minimum and maximum statistics.

Mangere WWTP

The analyses of pumping test data from the Mangere WWTP area has resulted in calculated hydraulic parameters (Transmissivity, Hydraulic Conductivity, and Storativity) presented in Table F.19. Curve-matching calculations are presented in Appendix H**.**

Aquifer averages for the two aquifer units (the unconfined Puketoka Formation and the deeper, confined, Kaawa Formation) are presented in Table F.20 and Table F.21. These results take into account the thickness of the Kaawa Formation (26.6m) which was inferred from the BH273 bore logs. However, aquifer thicknesses vary at the site because there is heterogeneity in the spatial distribution of confining materials. In addition, since the pumped interval is at depths of 22-37mBGL, the hydraulic parameters for the shallow units (up to 15m) are likely to be underestimated.

Table F.19 : Mangere Pumping Test results

	Unit & BH	Transmissivity (m^2/s)	Hydraulic Conductivity (m/s)	Storativity
Cooper and Jacob I	Kaawa BH273 (pumping bore)	$3.23x10^{-3}$	$1.22x10^{-4}$	NA
Theis		$3.30x10^{-3}$	$1.25x10^{-4}$	NA
Theis-Recovery		$3.04x10^{-3}$	$1.15x10^{-4}$	NA
Theis with Jacobs Correction	Puketoka BH270	$1.50x10^{-3}$	$1.67x10^{-4}$	0.06
Neuman		$1.45x10^{-3}$	$5.09x10^{-5}$	0.06
Theis	Kaawa BH270 (15 m)	$2.31x10^{-3}$	$8.80x10^{-5}$	0.05
Cooper Jacobs I		$1.68x10^{-3}$	$6.37x10^{-5}$	0.03
Hantush		$1.04x10^{-3}$	$3.94x10^{-5}$	0.04
Theis	Kaawa BH270 (28 m)	$1.93x10^{-3}$	$7.29x10^{-5}$	0.08
Cooper Jacobs I		$1.83x10^{-3}$	$6.83x10^{-5}$	0.04
Hantush		$1.27x10^{-3}$	$1.41x10^{-4}$	0.07
Theis with Jacobs Correction	Puketoka BH271 (6 m)	$1.88x10^{-3}$	$7.06x10^{-5}$	0.53
Neuman		$1.39x10^{-3}$	$5.21x10^{-5}$	0.55
Theis	Puketoka/Kaawa BH271 (10 m)	$1.16x10^{-3}$	$8.80x10^{-5}$	0.7
Cooper Jacobs I		$2.01x10^{-3}$	$7.64x10^{-5}$	0.32
Hantush		$1.74x10^{-3}$	$6.60x10^{-5}$	0.50
Theis	Kaawa BH271 (20 m)	$2.20x10^{-3}$	$8.33x10^{-5}$	0.40
Cooper Jacobs I		$2.00x10^{-3}$	$7.52x10^{-5}$	0.21
Hantush		$2.20x10^{-3}$	$8.33x10^{-5}$	0.4
Theis with Jacobs Correction	Puketoka BH272 (6 m)	$2.43x10^{-3}$	$9.14x10^{-5}$	0.15
Neuman		$1.49x10^{-3}$	$5.67x10^{-5}$	0.17
Theis	Puketoka/Kaawa BH272 (12 m)	$1.31x10^{-3}$	$4.98x10^{-5}$	0.13
Cooper Jacobs I		$1.08x10^{-3}$	$4.05x10^{-5}$	0.07

	Unit & BH	Transmissivity (m^2/s)	Hydraulic Conductivity (m/s)	Storativity
Hantush		$1.16x10^{-3}$	$4.40x10^{-5}$	0.13
Theis	Kaawa BH272 (25 m)	$1.63x10^{-3}$	$6.13x10^{-5}$	0.21
Cooper Jacobs I		$1.35x10^{-3}$	$5.09x10^{-5}$	0.10
Hantush		$1.85x10^{-3}$	$6.94x10^{-5}$	0.21

Table F.20 presents the calculated hydraulic properties of the Puketoka Formation. Transmissivity values for the Puketoka Formation ranged from $1.39x10^{-3}$ to $2.43x10^{-3}$ m^2/s. At shallow depths, considering a saturated aquifer thickness of 6m this converts to a hydraulic conductivity of 20 to 35 m/day [2.3 to $4.1x10^{-4}$ m/s], which is consistent with the hydraulic conductivity range of a medium to coarse sand of 10 to 120 m/day [1.2 to $1.4x10^{-4}$ m/s] (Anderson, 2002) (e.g. Puketoka Formation sands). Similarly, the average storativity for this material is 0.25 which is consistent with typical publicised values of specific yield for coarse sand.

Table F.20 : Hydraulic Properties of the Puketoka Formation (up to 7 mBGLI)

Puketoka Formation (up to 7mBGLI) N° of Analyses = 6	Transmissivity (m^2/s)	Storativity
Average	$1.69x10^{-3}$	$2.54x10^{-1}$
Median	$1.49x10^{-3}$	$1.60x10^{-1}$
Min	$1.39x10^{-3}$	$6.00x10^{-2}$
Max	$2.43x10^{-3}$	$5.50x10^{-1}$

Table F.21 shows the hydraulic properties of the aquifer system as measured by vibrating wire piezometers installed at depths of 10, 12, and 15m. At these depths, the vibrating wire piezometers were installed at the interface between the Puketoka and the Kaawa formations. Transmissivity (T) values at these depths ranged between 1.04 $x10^{-3}$ and 2.31 $x10^{-3}$ m/s. In general, the lower T values resulted from applying the Hantush solution, which solves “leaky” aquifers. Since the leakage factor is unknown (e.g. it is not possible to know the flow through the aquitards separating the aquifers), these lower-end values are less reliable. The average T value for these depths is 1.67 $x10^{-3}$ m/s; considering an aquifer thickness of 3 m (e.g. presence of confining layer), this would convert to about $5.5x10^{-4}$ m/s [48 m/day], which is consistent with the hydraulic conductivity for clean medium sand (10 m/day or $1.2x10^{-4}$ m/s) (Anderson, 2002). This is consistent with alluvial sands from the Puketoka Formation or shelly sands normally present in the Kaawa formation. Storativity values at these depths are $3x10^{-2}$ to 7 $x10^{-1}$.

Table F.21 : Hydraulic Properties of the Puketoka/Kaawa Formation interface (depths up to 15mBGLI)

Puketoka/Kaawa Formation interface, (up to 15mBGLI) N° of Analyses = 12	Transmissivity (m^2/s)	Storativity
Average	1.67 $x10^{-3}$	$2.19x10^{-1}$
Median	1.71 $x10^{-3}$	$1.30x10^{-1}$
Min	1.04 $x10^{-3}$	$3.00x10^{-2}$
Max	2.31 $x10^{-3}$	$7.00x10^{-1}$

The Kaawa Formation has Transmissivity values ranging from $1.27x10^{-3}$ to $3.30x10^{-3}$, with an average of $2.11x10^{-3}$ m2/s (Table F.22). The highest transmissivity values came from the analysis of the pumped bore (BH273) with values ranging from $2.88x10^{-3}$ to $3.30x10^{-3}$ m^2/s and the lowest estimates came from BH270 at 28m.

Considering an aquifer thickness of 26.5 m (e.g. confined aquifer thickness at BH273), this converts into a hydraulic conductivity value of $7.9x10^{-5}$ m/s [6.9 m/day], which is equivalent to the hydraulic conductivity of a fine to medium sand (Anderson, 2002). This is consistent with the type of shelly sands found at these depths.

The average storativity at these depths is approximately $1.91x10^{-1}$.

Table F.22 : Hydraulic Properties of the Kaawa Formation (depths 20-37m)

Kaawa Formation (up to 37mBGLI) N° of Analyses = 17	Transmissivity (m^2/s)	Storativity
Average	$2.11x10^{-3}$	$1.91x10^{-1}$
Median	$1.93x10^{-3}$	$2.10x10^{-1}$
Min	$1.27x10^{-3}$	$4.00x10^{-2}$
Max	$3.30x10^{-3}$	$4.00x10^{-1}$

Other sites

Lugeon tests carried out along the tunnel alignment (e.g. not within the main shaft areas) focused on estimating the hydraulic conductivity of the ECBF. One Lugeon test was conducted in BH219 immediately south of the Western Springs site and another one in BH252 was carried out to the west of May Road. An additional test was carried out in BH253 but these test results were considered inaccurate due to data inadequacies. The average hydraulic conductivity results for these units are summarised are follows:

- k = $8.42x10^{-8}$ m/s for the ECBF in BH219 near the Western Springs Site
- k = $1.18x10^{-7}$ m/s for the ECBF in BH252 to the West of May Road

Lugeon tests in BH258 and BH259 (next to Kiwi Esplanade, about 2.5km North of the main testing site) targeted the AFVB and the ECBF respectively.

- k = $1.29x10^{-7}$ m/s for the AVFB at about 2.5km north of the Mangere WWTP site (BH258)
- k = $1.65x10^{-6}$ m/s [28-38m depths], $1.22x10^{-7}$ m/s [35-38m depths], and $2.48x10^{-7}$ m/s [55.5-63m depths] for the ECBF in BH259, located at about 2.5km north of the Mangere WWTP site

In general, slug tests for selected bores outside of the main shaft areas showed an ECBF average hydraulic conductivity of $3.03x10^{-7}$ m/s for bores to the south of Western Springs, $1.23 x10^{-7}$ m/s for bores to the south of May Road, and $7.51 x10^{-7}$ m/s for a bore north of Mangere (next to Kiwi Esplanade). For bores south of Western Springs, slug tests showed an average k of $3.67x10^{-7}$ m/s for screened intervals targeting the Puketoka Formation. No Pumping tests were carried out along the alignment, outside the main shaft areas. Given the proximity to the Mangere WWTP and similar order of magnitudes for ECBF k values calculated with slug tests, parameters for other units in the Kiwi Esplanade Shaft can be taken from the Mangere WWTP shaft.

Appendix G. Slug test calculations

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH206b

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	29/05/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	22.000 m
Bottom of Screen	25.000 m
Screen Length, *L*	3.000 m
Static Water Level, *H*	2.463 m
Initial Water Level, H_0	2.565 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

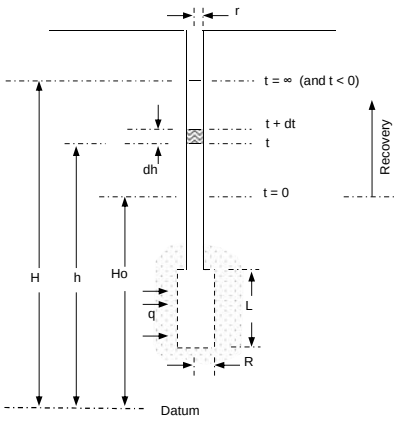
Result

Hydraulic Conductivity

***K* = 1.97E-07 m/s**

1.70E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

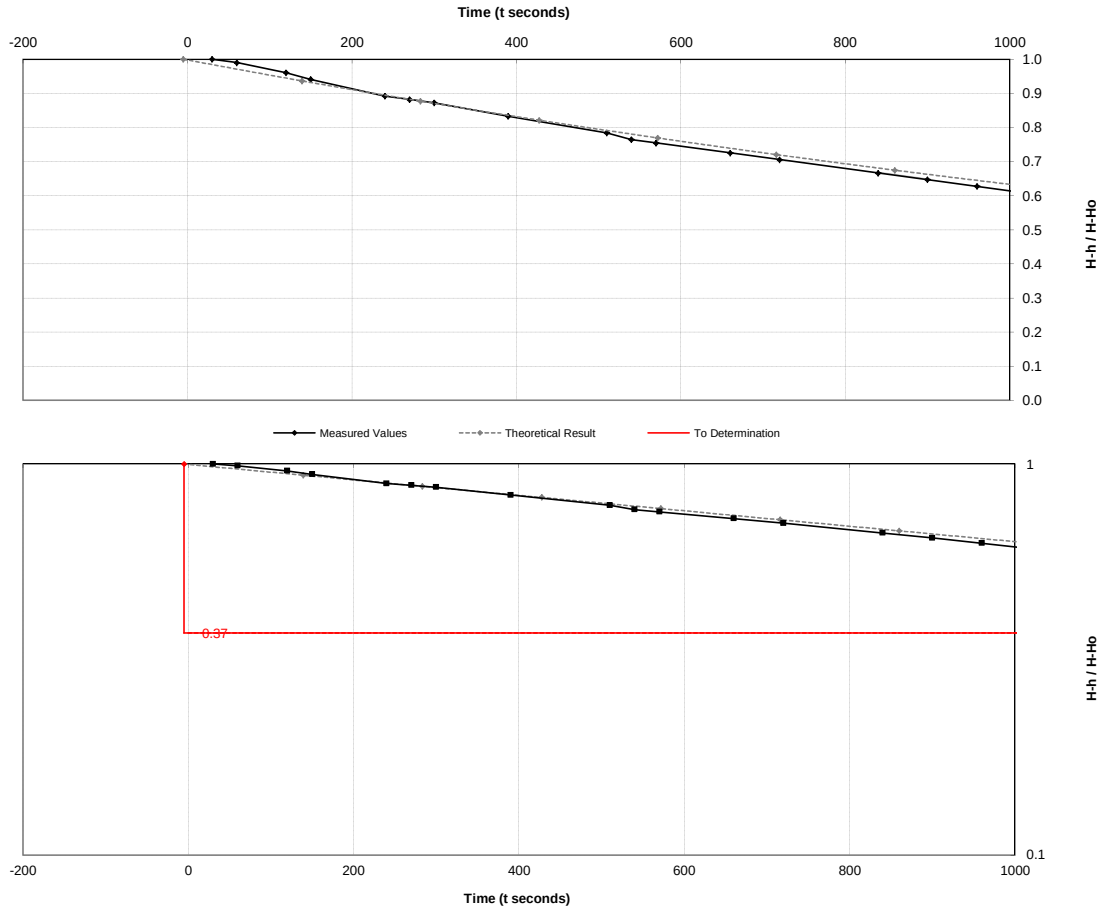
Calibrated Parameters

Intake factor, *F*	4.56
Time Factor, T_0	2,187.0

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	2.565	0.10	1.00
60	2.564	0.10	0.99
120	2.561	0.10	0.96
150	2.559	0.10	0.94
240	2.554	0.09	0.89
270	2.553	0.09	0.88
300	2.552	0.09	0.87
390	2.548	0.09	0.83
510	2.543	0.08	0.78
540	2.541	0.08	0.76
570	2.540	0.08	0.75
660	2.537	0.07	0.73
720	2.535	0.07	0.71
840	2.531	0.07	0.67
900	2.529	0.07	0.65
960	2.527	0.06	0.63
1020	2.525	0.06	0.61
1080	2.523	0.06	0.59
1200	2.519	0.06	0.55
1260	2.518	0.05	0.54
1380	2.515	0.05	0.51
1440	2.514	0.05	0.50
1500	2.512	0.05	0.48
1620	2.509	0.05	0.45
1680	2.508	0.04	0.44
1740	2.507	0.04	0.43
1800	2.505	0.04	0.41
2100	2.499	0.04	0.35
2400	2.494	0.03	0.30
2700	2.490	0.03	0.26
3000	2.485	0.02	0.22
3300	2.482	0.02	0.19
3600	2.478	0.02	0.15

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH208a

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	19/08/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	3.000 m
Bottom of Screen	6.000 m
Screen Length, *L*	3.000 m
Static Water Level, *H*	9.540 m
Initial Water Level, H_0	10.503 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

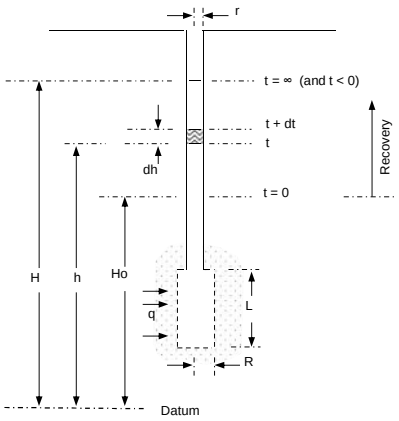
Result

Hydraulic Conductivity

***K* = 1.36E-06 m/s**

1.18E-01 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

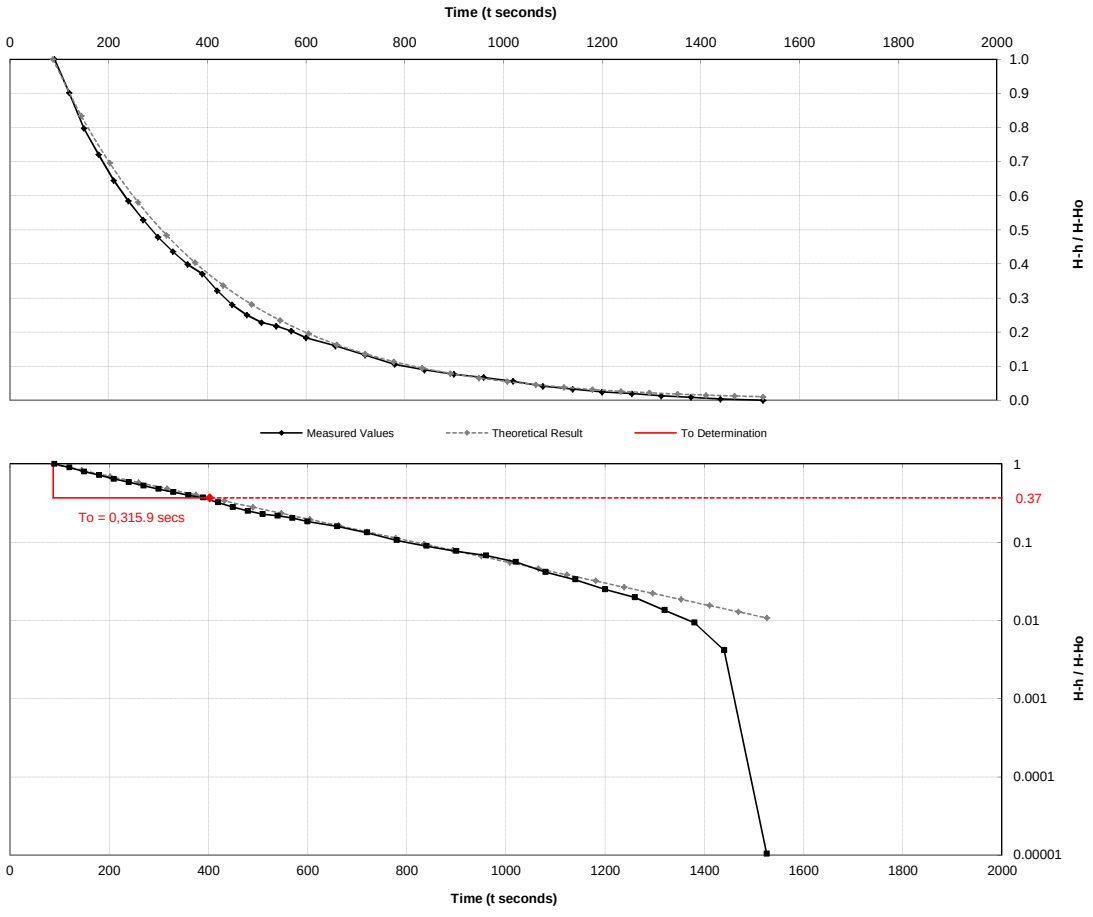
Calibrated Parameters

Intake factor, *F*	4.56
Time Factor, T_0	315.9

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
90	10.503	0.96	1.00
120	10.408	0.87	0.90
150	10.308	0.77	0.80
180	10.234	0.69	0.72
210	10.161	0.62	0.64
240	10.103	0.56	0.58
270	10.050	0.51	0.53
300	10.001	0.46	0.48
330	9.960	0.42	0.44
360	9.924	0.38	0.40
390	9.897	0.36	0.37
420	9.850	0.31	0.32
450	9.810	0.27	0.28
480	9.781	0.24	0.25
510	9.760	0.22	0.23
540	9.750	0.21	0.22
570	9.736	0.20	0.20
600	9.717	0.18	0.18
660	9.694	0.15	0.16
720	9.668	0.13	0.13
780	9.642	0.10	0.11
840	9.626	0.09	0.09
900	9.614	0.07	0.08
960	9.605	0.07	0.07
1020	9.594	0.05	0.06
1080	9.580	0.04	0.04
1140	9.572	0.03	0.03
1200	9.564	0.02	0.02
1260	9.559	0.02	0.02
1320	9.553	0.01	0.01
1380	9.549	0.01	0.01
1440	9.544	0.00	0.00
1526	9.540	0.00	0.00

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH208a

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	19/08/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	3.000 m
Bottom of Screen	6.000 m
Screen Length, *L*	3.000 m
Static Water Level, *H*	9.540 m
Initial Water Level, H_0	8.255 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

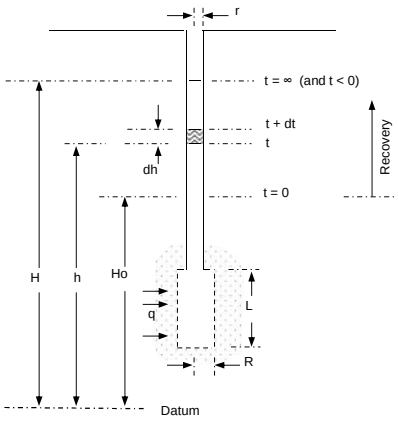
Result

Hydraulic Conductivity

***K* = 1.02E-07 m/s**

8.81E-03 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

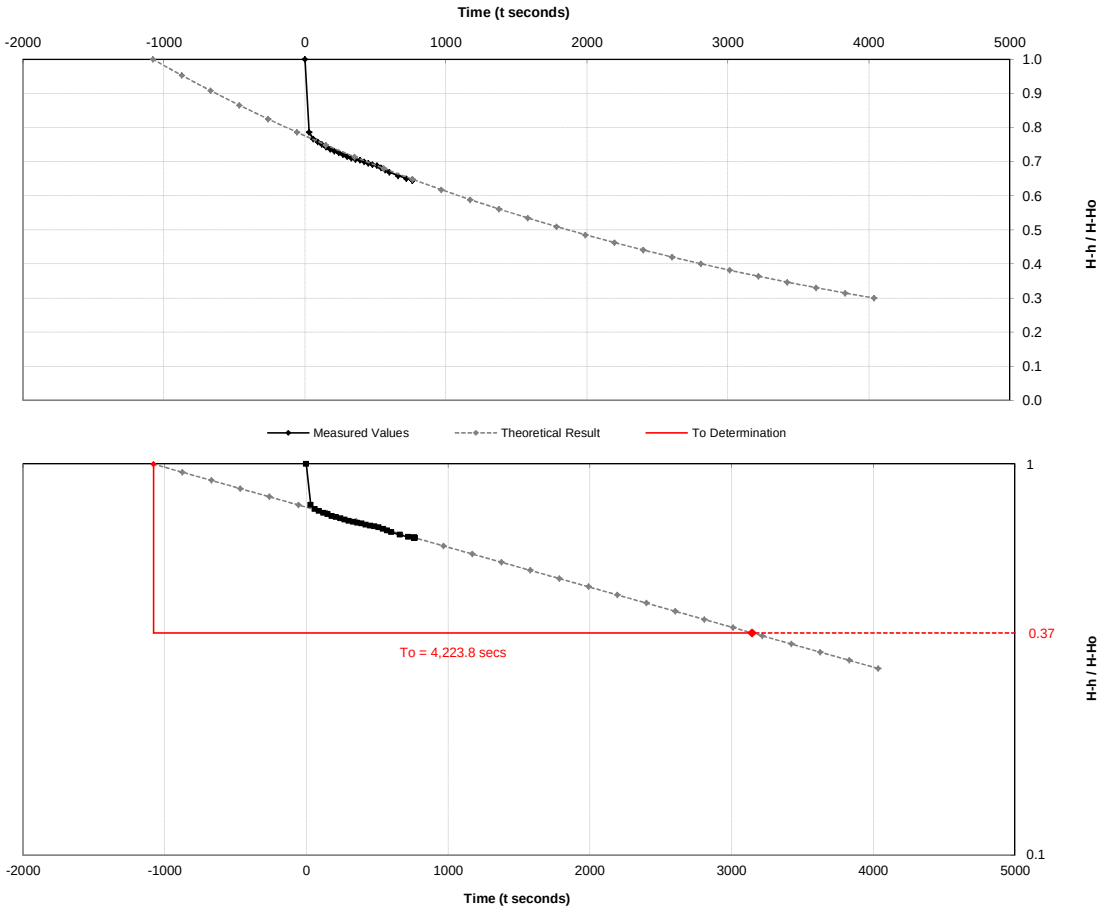
Calibrated Parameters

Intake factor, *F*	4.56
Time Factor, T_0	4,223.8

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
0	8.255	-1.28	1.00
30	8.530	-1.01	0.79
60	8.555	-0.98	0.77
90	8.566	-0.97	0.76
120	8.576	-0.96	0.75
150	8.585	-0.95	0.74
180	8.594	-0.95	0.74
210	8.601	-0.94	0.73
240	8.607	-0.93	0.73
270	8.614	-0.93	0.72
300	8.621	-0.92	0.72
330	8.627	-0.91	0.71
360	8.632	-0.91	0.71
390	8.635	-0.90	0.70
420	8.641	-0.90	0.70
450	8.646	-0.89	0.70
480	8.651	-0.89	0.69
510	8.655	-0.89	0.69
540	8.663	-0.88	0.68
570	8.672	-0.87	0.68
600	8.680	-0.86	0.67
660	8.693	-0.85	0.66
720	8.704	-0.84	0.65
763	8.709	-0.83	0.65

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH201b

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	21/08/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	6.100 m
Bottom of Screen	18.100 m
Screen Length, *L*	12.000 m
Static Water Level, *H*	11.540 m
Initial Water Level, H_0	11.640 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

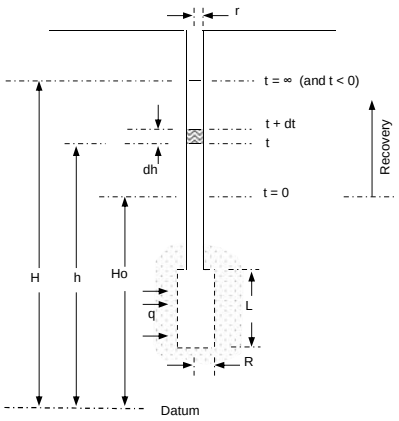
Result

Hydraulic Conductivity

***K* = 2.21E-06 m/s**

1.91E-01 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

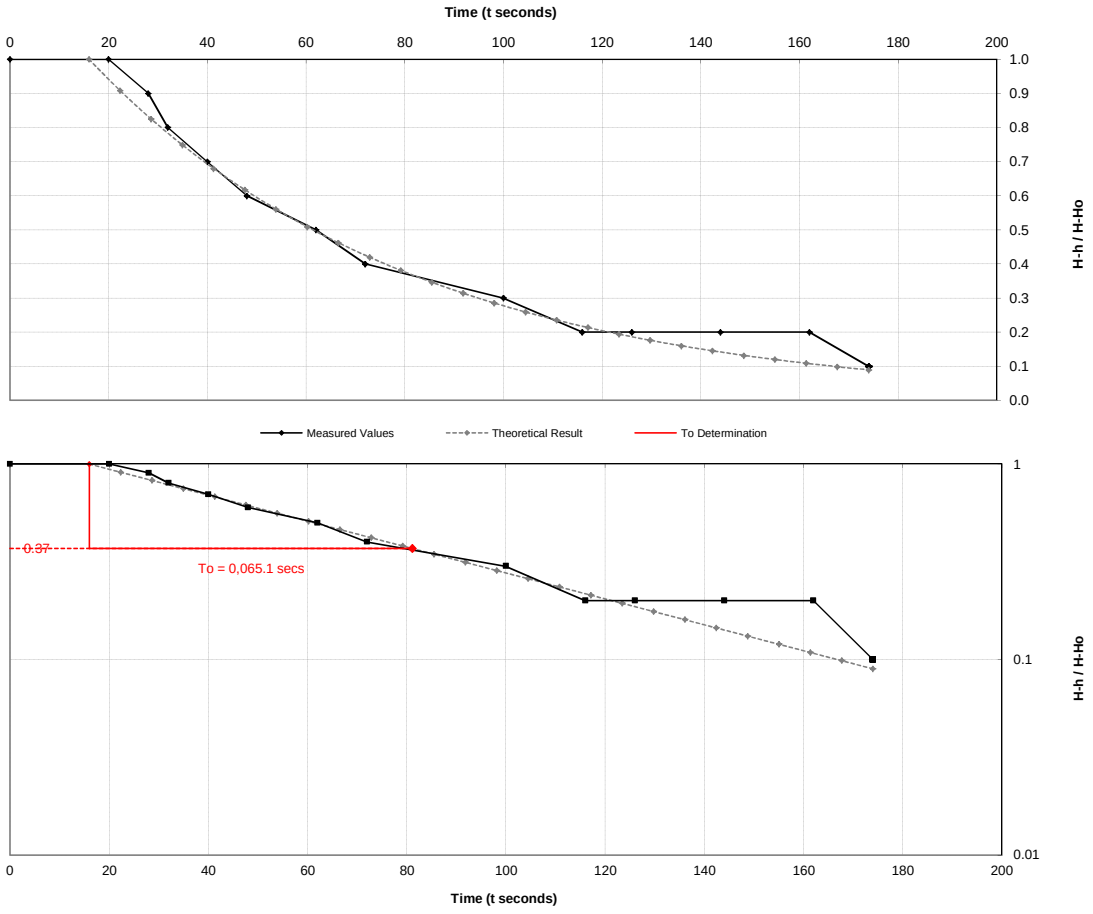
Calibrated Parameters

Intake factor, *F*	13.66
Time Factor, T_0	65.1

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
0	11.640	0.10	1.00
20	11.640	0.10	1.00
28	11.630	0.09	0.90
32	11.620	0.08	0.80
40	11.610	0.07	0.70
48	11.600	0.06	0.60
62	11.590	0.05	0.50
72	11.580	0.04	0.40
100	11.570	0.03	0.30
116	11.560	0.02	0.20
126	11.560	0.02	0.20
144	11.560	0.02	0.20
162	11.560	0.02	0.20
174	11.550	0.01	0.10

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH201b

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	21/08/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	6.100 m
Bottom of Screen	18.100 m
Screen Length, *L*	12.000 m
Static Water Level, *H*	11.560 m
Initial Water Level, H_0	11.370 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

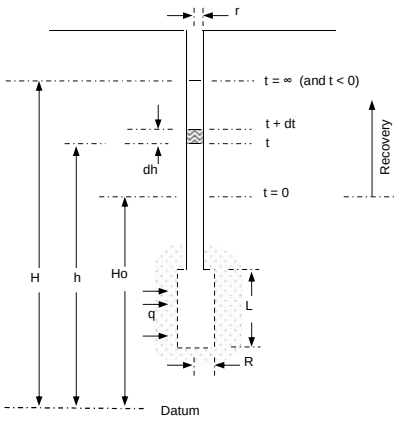
Result

Hydraulic Conductivity

***K* = 8.90E-08 m/s**

7.69E-03 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

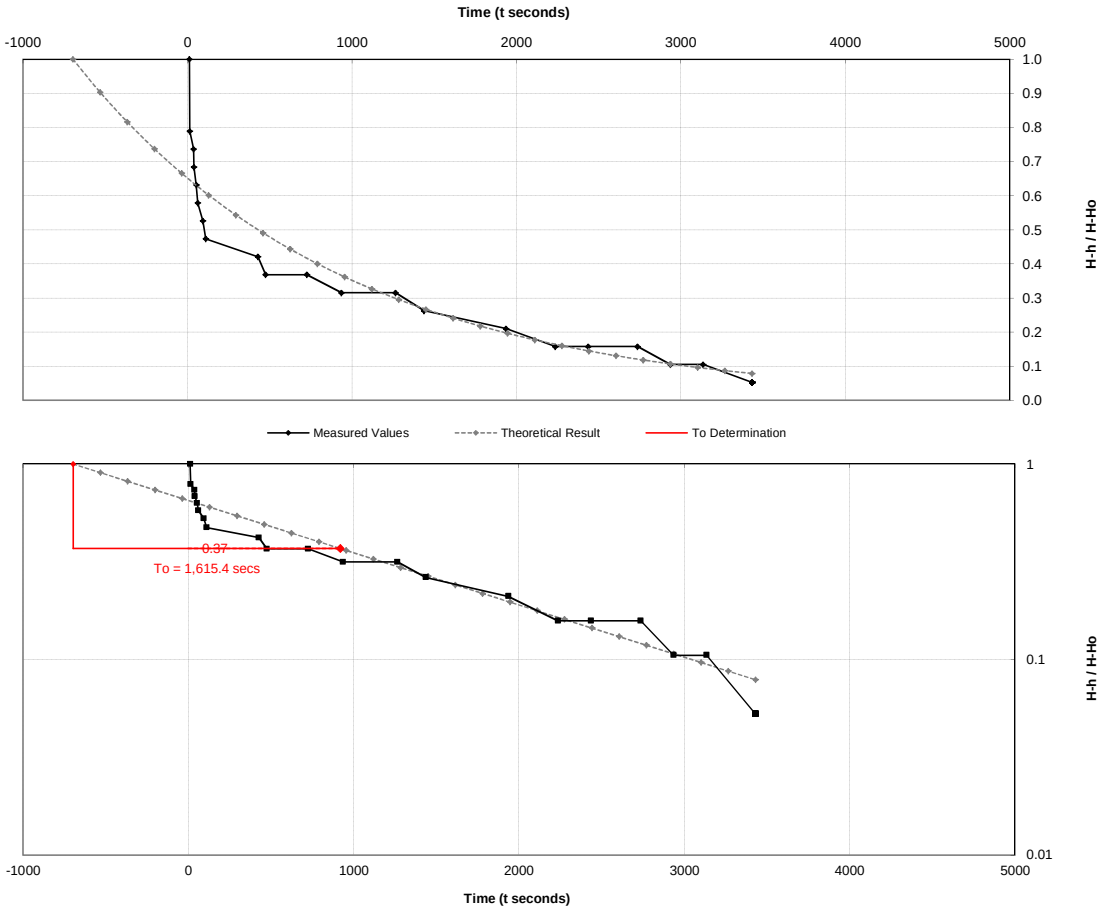
Calibrated Parameters

Intake factor, *F*	13.66
Time Factor, T_0	1,615.4

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
12	11.370	-0.19	1.00
14	11.410	-0.15	0.79
38	11.420	-0.14	0.74
40	11.430	-0.13	0.68
54	11.440	-0.12	0.63
62	11.450	-0.11	0.58
94	11.460	-0.10	0.53
112	11.470	-0.09	0.47
428	11.480	-0.08	0.42
476	11.490	-0.07	0.37
726	11.490	-0.07	0.37
936	11.500	-0.06	0.32
1266	11.500	-0.06	0.32
1438	11.510	-0.05	0.26
1936	11.520	-0.04	0.21
2236	11.530	-0.03	0.16
2436	11.530	-0.03	0.16
2736	11.530	-0.03	0.16
2936	11.540	-0.02	0.11
3136	11.540	-0.02	0.11
3432	11.550	-0.01	0.05

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH201b

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	21/08/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	6.100 m
Bottom of Screen	18.100 m
Screen Length, *L*	12.000 m
Static Water Level, *H*	11.540 m
Initial Water Level, H_0	11.640 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

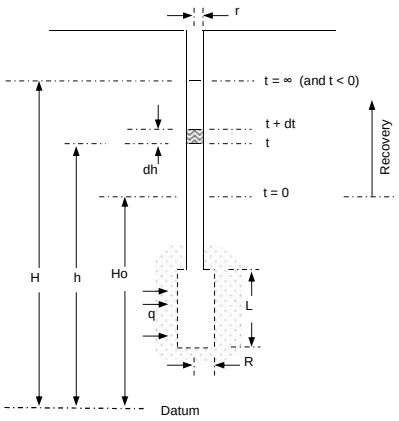
Result

Hydraulic Conductivity

***K* = 2.21E-06 m/s**

1.91E-01 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

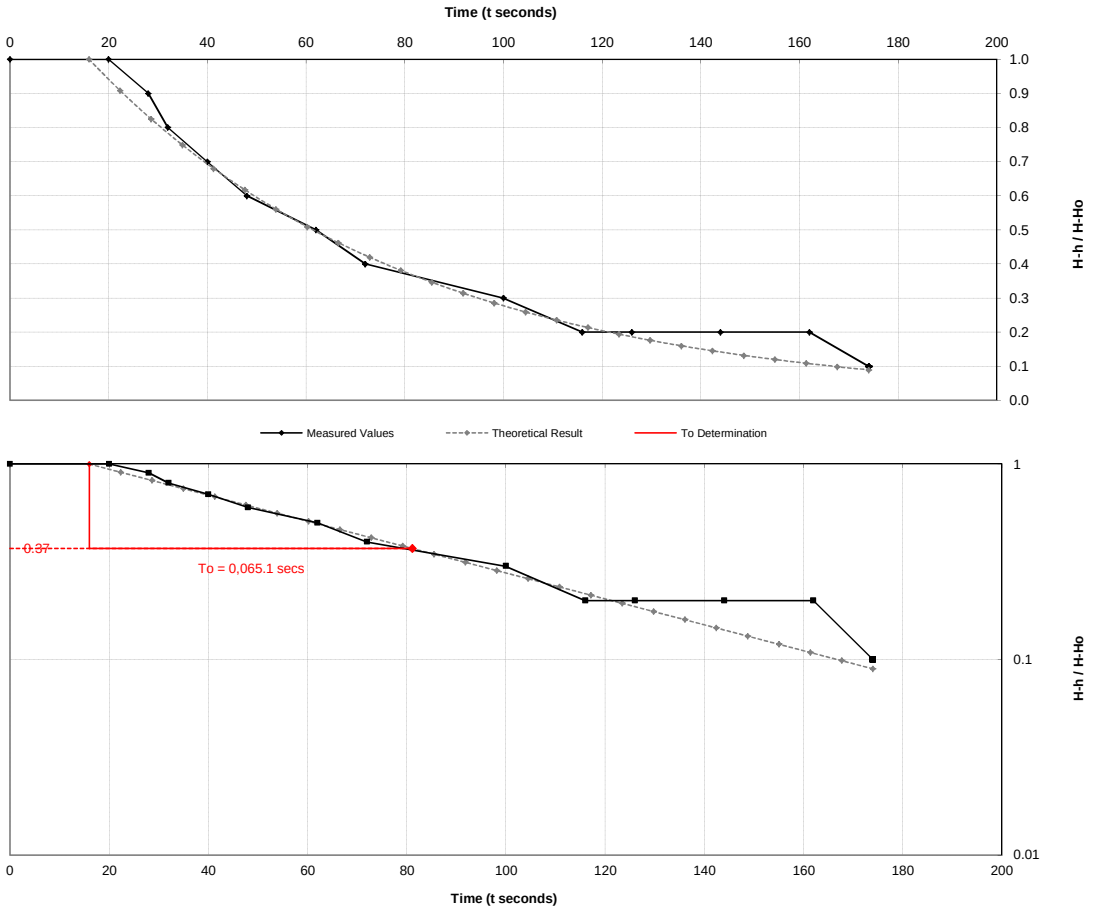
Calibrated Parameters

Intake factor, *F*	13.66
Time Factor, T_0	65.1

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
0	11.640	0.10	1.00
20	11.640	0.10	1.00
28	11.630	0.09	0.90
32	11.620	0.08	0.80
40	11.610	0.07	0.70
48	11.600	0.06	0.60
62	11.590	0.05	0.50
72	11.580	0.04	0.40
100	11.570	0.03	0.30
116	11.560	0.02	0.20
126	11.560	0.02	0.20
144	11.560	0.02	0.20
162	11.560	0.02	0.20
174	11.550	0.01	0.10

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH204

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	5/06/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	20.500 m
Bottom of Screen	23.500 m
Screen Length, *L*	3.000 m
Static Water Level, *H*	1.255 m
Initial Water Level, H_0	1.348 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

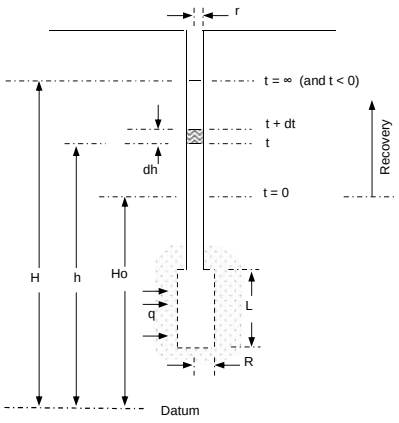
Result

Hydraulic Conductivity

***K* = 9.54E-07 m/s**

8.24E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

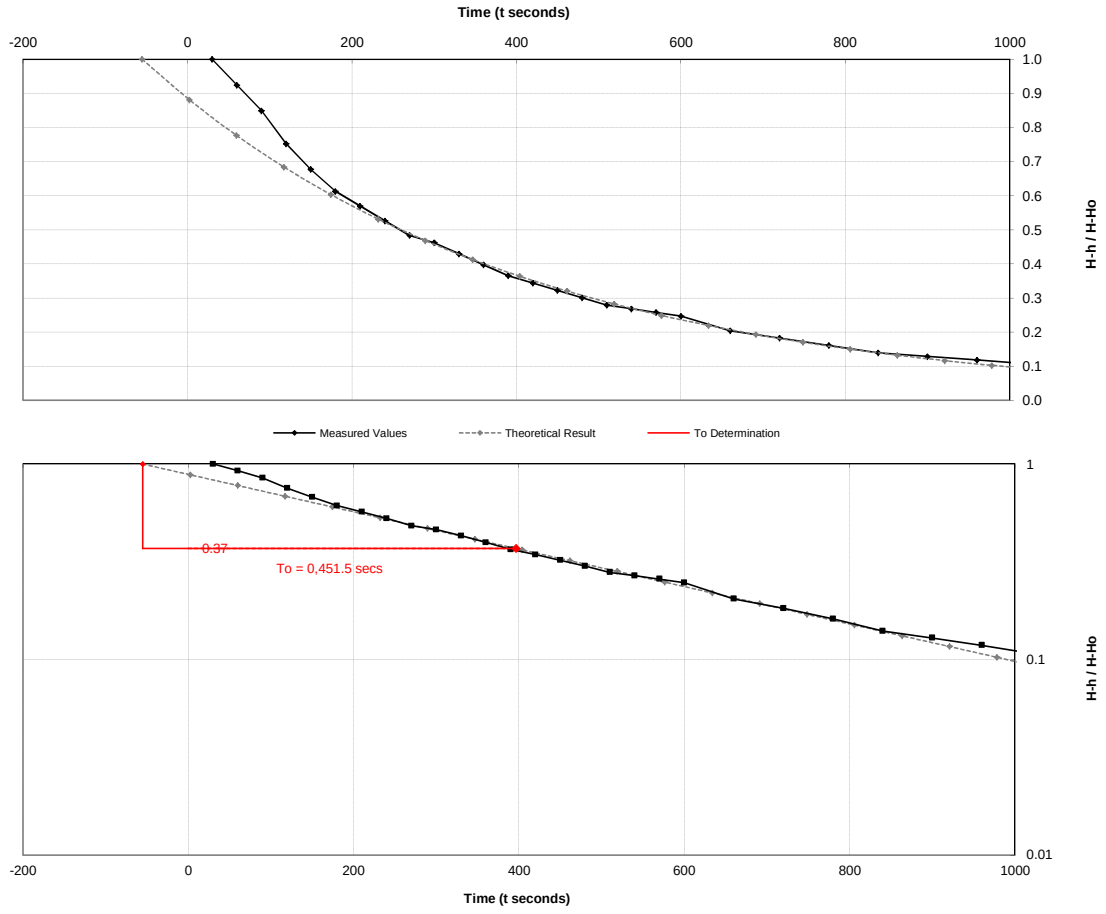
Calibrated Parameters

Intake factor, *F*	4.56
Time Factor, T_0	451.5

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	1.348	0.09	1.00
60	1.341	0.09	0.92
90	1.334	0.08	0.85
120	1.325	0.07	0.75
150	1.318	0.06	0.68
180	1.312	0.06	0.61
210	1.308	0.05	0.57
240	1.304	0.05	0.53
270	1.300	0.05	0.48
300	1.298	0.04	0.46
330	1.295	0.04	0.43
360	1.292	0.04	0.40
390	1.289	0.03	0.37
420	1.287	0.03	0.34
450	1.285	0.03	0.32
480	1.283	0.03	0.30
510	1.281	0.03	0.28
540	1.280	0.03	0.27
570	1.279	0.02	0.26
600	1.278	0.02	0.25
660	1.274	0.02	0.20
720	1.272	0.02	0.18
780	1.270	0.02	0.16
840	1.268	0.01	0.14
900	1.267	0.01	0.13
960	1.266	0.01	0.12
1020	1.265	0.01	0.11
1080	1.264	0.01	0.10
1140	1.263	0.01	0.09
1200	1.262	0.01	0.08
1260	1.262	0.01	0.08
1320	1.261	0.01	0.06
1380	1.261	0.01	0.06

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH206b

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	29/05/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	5.000 m
Bottom of Screen	7.000 m
Screen Length, *L*	2.000 m
Static Water Level, *H*	0.414 m
Initial Water Level, H_0	0.490 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

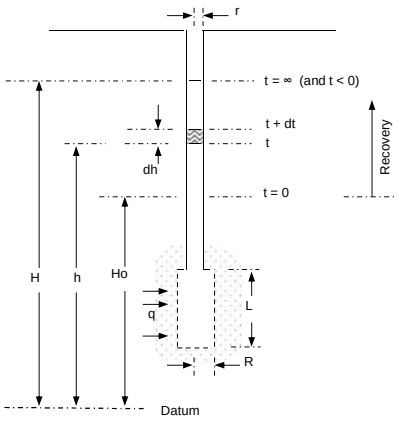
Result

Hydraulic Conductivity

***K* = 5.20E-06 m/s**

4.50E-01 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

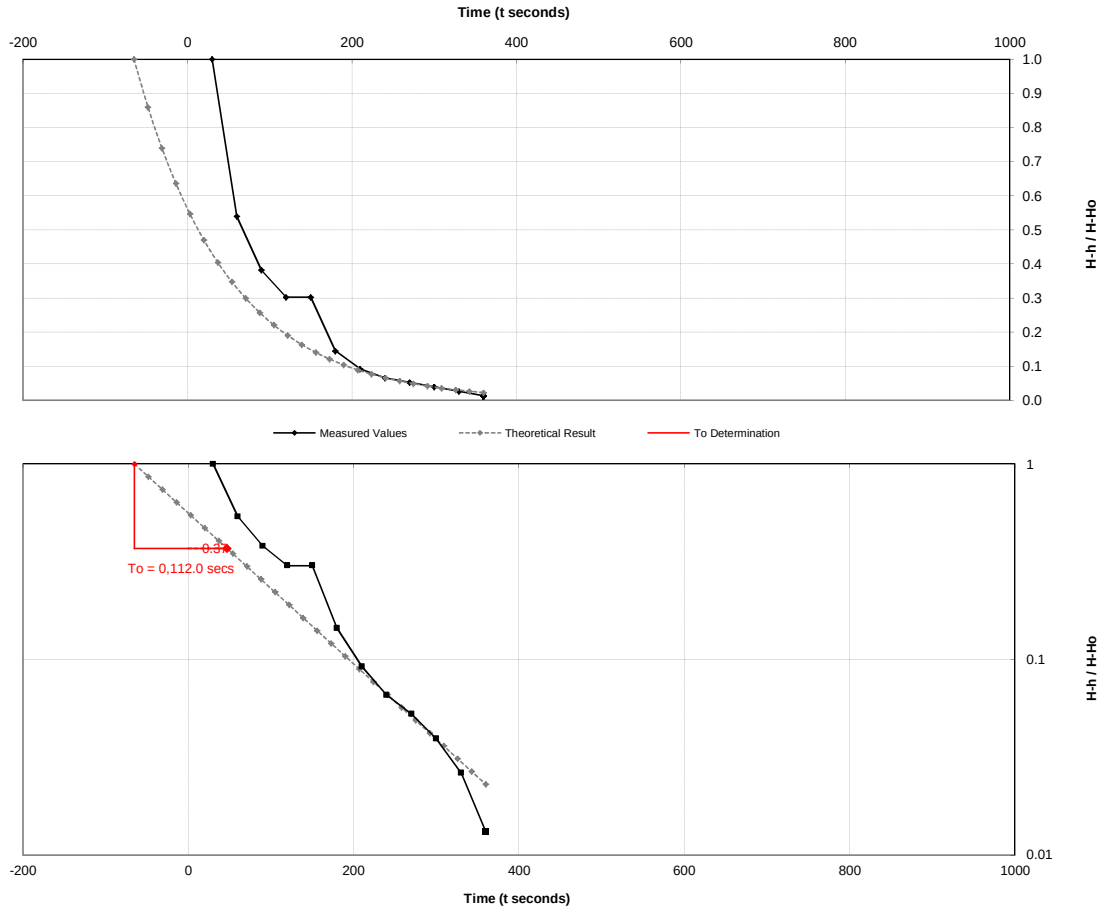
Calibrated Parameters

Intake factor, *F*	3.37
Time Factor, T_0	112.0

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	0.490	0.08	1.00
60	0.455	0.04	0.54
90	0.443	0.03	0.38
120	0.437	0.02	0.30
150	0.437	0.02	0.30
180	0.425	0.01	0.14
210	0.421	0.01	0.09
240	0.419	0.01	0.07
270	0.418	0.00	0.05
300	0.417	0.00	0.04
330	0.416	0.00	0.03
360	0.415	0.00	0.01

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH212

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	5/06/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	37.000 m
Bottom of Screen	43.000 m
Screen Length, *L*	6.000 m
Static Water Level, *H*	11.668 m
Initial Water Level, H_0	12.115 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

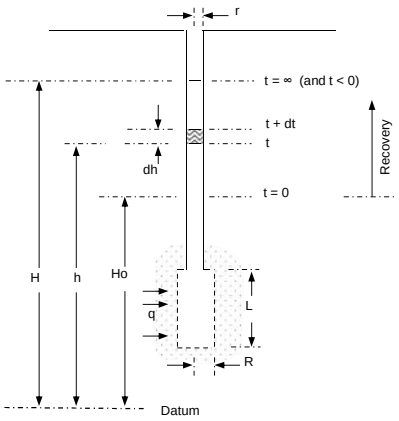
Result

Hydraulic Conductivity

***K* = 2.87E-07 m/s**

2.48E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

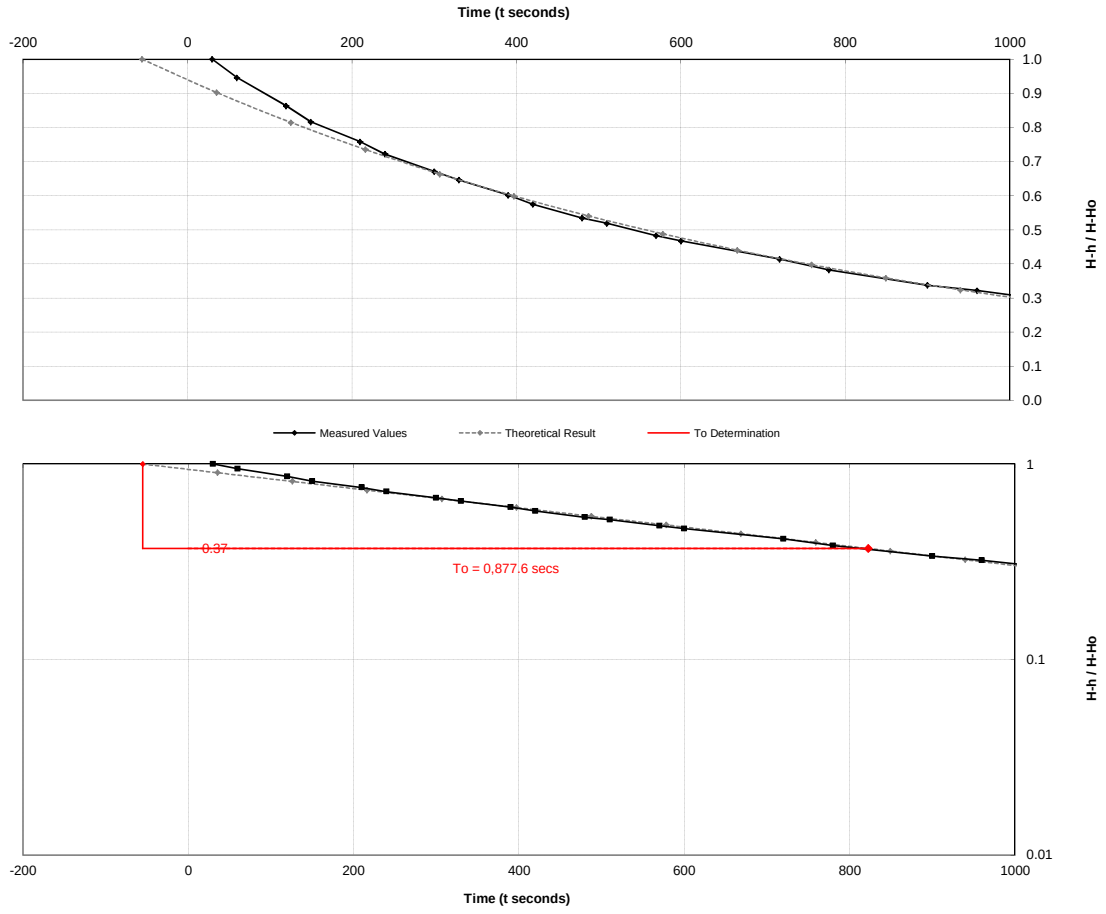
Calibrated Parameters

Intake factor, *F*	7.81
Time Factor, T_0	877.6

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	12.115	0.45	1.00
60	12.091	0.42	0.95
120	12.054	0.39	0.86
150	12.033	0.37	0.82
210	12.007	0.34	0.76
240	11.991	0.32	0.72
300	11.968	0.30	0.67
330	11.957	0.29	0.65
390	11.937	0.27	0.60
420	11.925	0.26	0.57
480	11.907	0.24	0.53
510	11.900	0.23	0.52
570	11.884	0.22	0.48
600	11.877	0.21	0.47
720	11.853	0.19	0.41
780	11.839	0.17	0.38
900	11.819	0.15	0.34
960	11.812	0.14	0.32
1080	11.795	0.13	0.28
1140	11.789	0.12	0.27
1200	11.781	0.11	0.25
1260	11.776	0.11	0.24
1320	11.770	0.10	0.23
1380	11.765	0.10	0.22
1440	11.759	0.09	0.20
1500	11.754	0.09	0.19
1560	11.750	0.08	0.18
1620	11.747	0.08	0.18
1680	11.744	0.08	0.17
1740	11.739	0.07	0.16
1800	11.735	0.07	0.15
2100	11.723	0.06	0.12
2206	11.719	0.05	0.11

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH213

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	28/05/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	36.000 m
Bottom of Screen	42.000 m
Screen Length, *L*	6.000 m
Static Water Level, *H*	7.805 m
Initial Water Level, H_0	8.310 m
Hole Radius, *R*	0.050 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

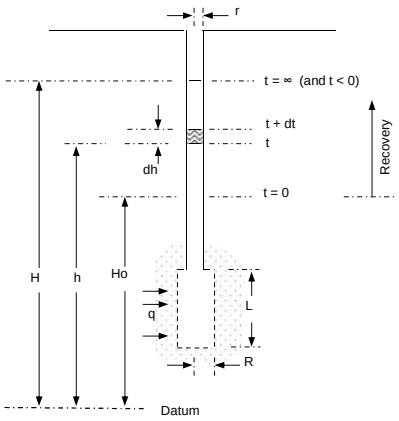
Result

Hydraulic Conductivity

***K* = 3.64E-08 m/s**

3.14E-03 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

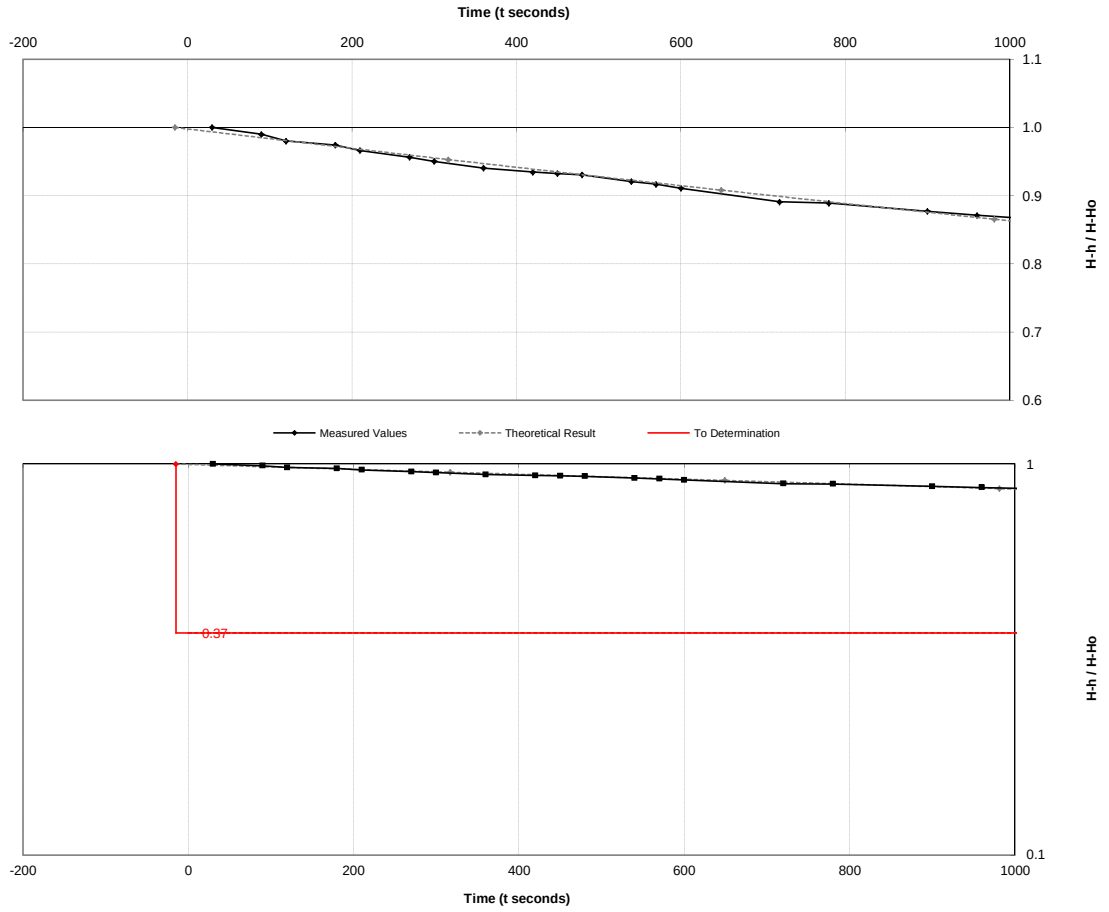
Calibrated Parameters

Intake factor, *F*	7.87
Time Factor, T_0	6,855.5

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	8.310	0.51	1.00
90	8.305	0.50	0.99
120	8.300	0.50	0.98
180	8.297	0.49	0.97
210	8.293	0.49	0.97
270	8.288	0.48	0.96
300	8.285	0.48	0.95
360	8.280	0.48	0.94
420	8.277	0.47	0.93
450	8.276	0.47	0.93
480	8.275	0.47	0.93
540	8.270	0.47	0.92
570	8.268	0.46	0.92
600	8.265	0.46	0.91
720	8.255	0.45	0.89
780	8.254	0.45	0.89
900	8.248	0.44	0.88
960	8.245	0.44	0.87
1080	8.240	0.44	0.86
1140	8.237	0.43	0.86
1260	8.230	0.43	0.84
1320	8.227	0.42	0.84
1440	8.220	0.42	0.82
1500	8.218	0.41	0.82
1620	8.213	0.41	0.81
1680	8.210	0.41	0.80
1800	8.205	0.40	0.79
2100	8.193	0.39	0.77
2400	8.180	0.38	0.74
2700	8.178	0.37	0.74
3000	8.161	0.36	0.70
3600	8.145	0.34	0.67
3900	8.135	0.33	0.65

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH211

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	4/06/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	29.600 m
Bottom of Screen	35.600 m
Screen Length, *L*	6.000 m
Static Water Level, *H*	6.345 m
Initial Water Level, H_0	6.455 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

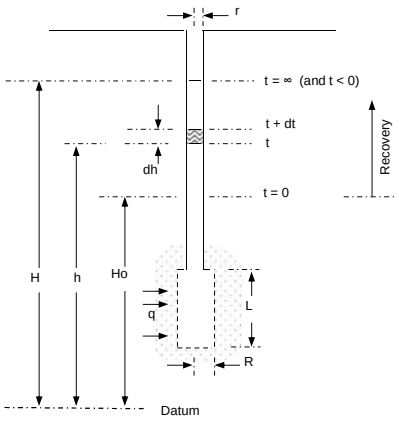
Result

Hydraulic Conductivity

***K* = 2.80E-07 m/s**

2.42E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

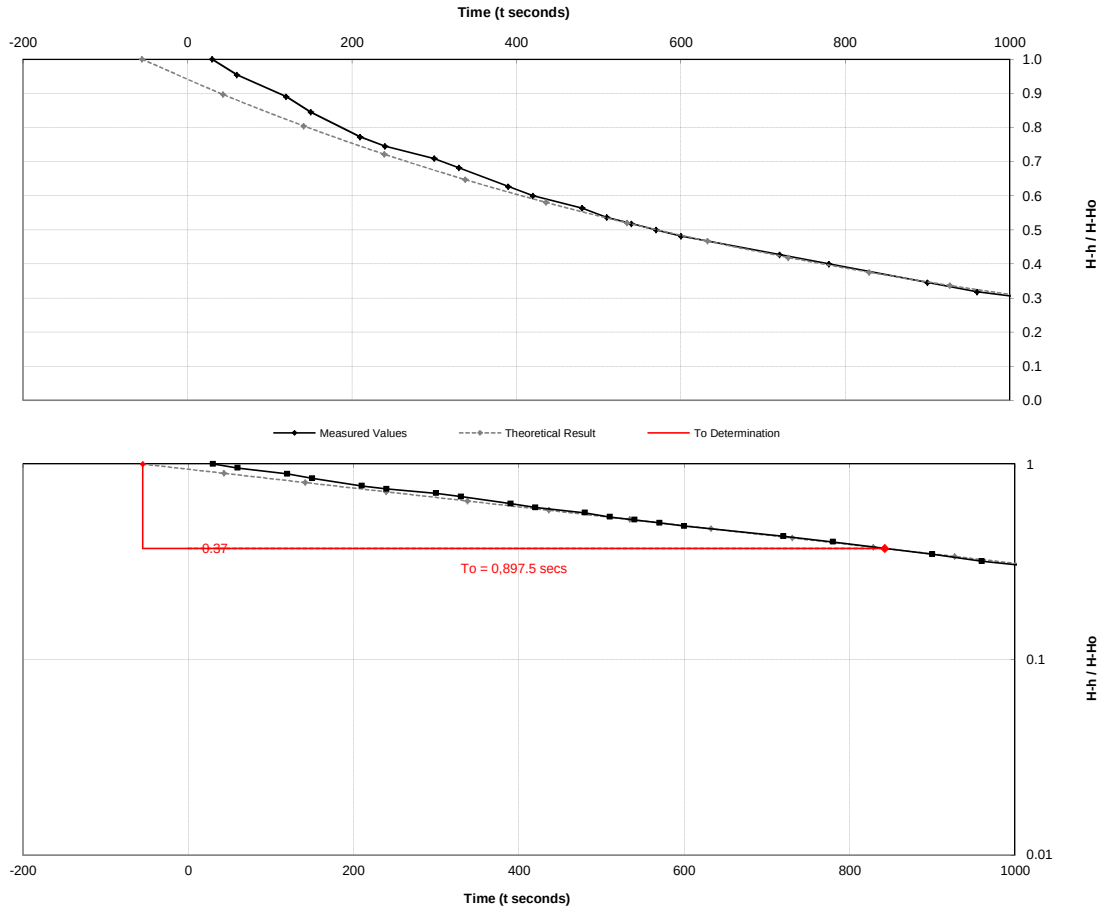
Calibrated Parameters

Intake factor, *F*	7.81
Time Factor, T_0	897.5

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	6.455	0.11	1.00
60	6.450	0.11	0.95
120	6.443	0.10	0.89
150	6.438	0.09	0.85
210	6.430	0.09	0.77
240	6.427	0.08	0.75
300	6.423	0.08	0.71
330	6.420	0.08	0.68
390	6.414	0.07	0.63
420	6.411	0.07	0.60
480	6.407	0.06	0.56
510	6.404	0.06	0.54
540	6.402	0.06	0.52
570	6.400	0.06	0.50
600	6.398	0.05	0.48
720	6.392	0.05	0.43
780	6.389	0.04	0.40
900	6.383	0.04	0.35
960	6.380	0.04	0.32
1080	6.376	0.03	0.28
1140	6.374	0.03	0.26
1260	6.371	0.03	0.24
1320	6.370	0.03	0.23
1380	6.369	0.02	0.22
1440	6.368	0.02	0.21
1500	6.367	0.02	0.20
1560	6.365	0.02	0.18
1620	6.364	0.02	0.17
1680	6.363	0.02	0.16
1740	6.362	0.02	0.15
1800	6.361	0.02	0.15
2100	6.357	0.01	0.11
2400	6.355	0.01	0.09

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH214

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	29/05/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	30.000 m
Bottom of Screen	42.000 m
Screen Length, *L*	12.000 m
Static Water Level, *H*	9.895 m
Initial Water Level, H_0	10.261 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

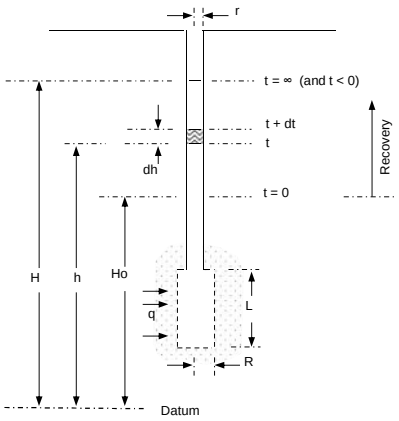
Result

Hydraulic Conductivity

***K* = 4.21E-07 m/s**

3.64E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

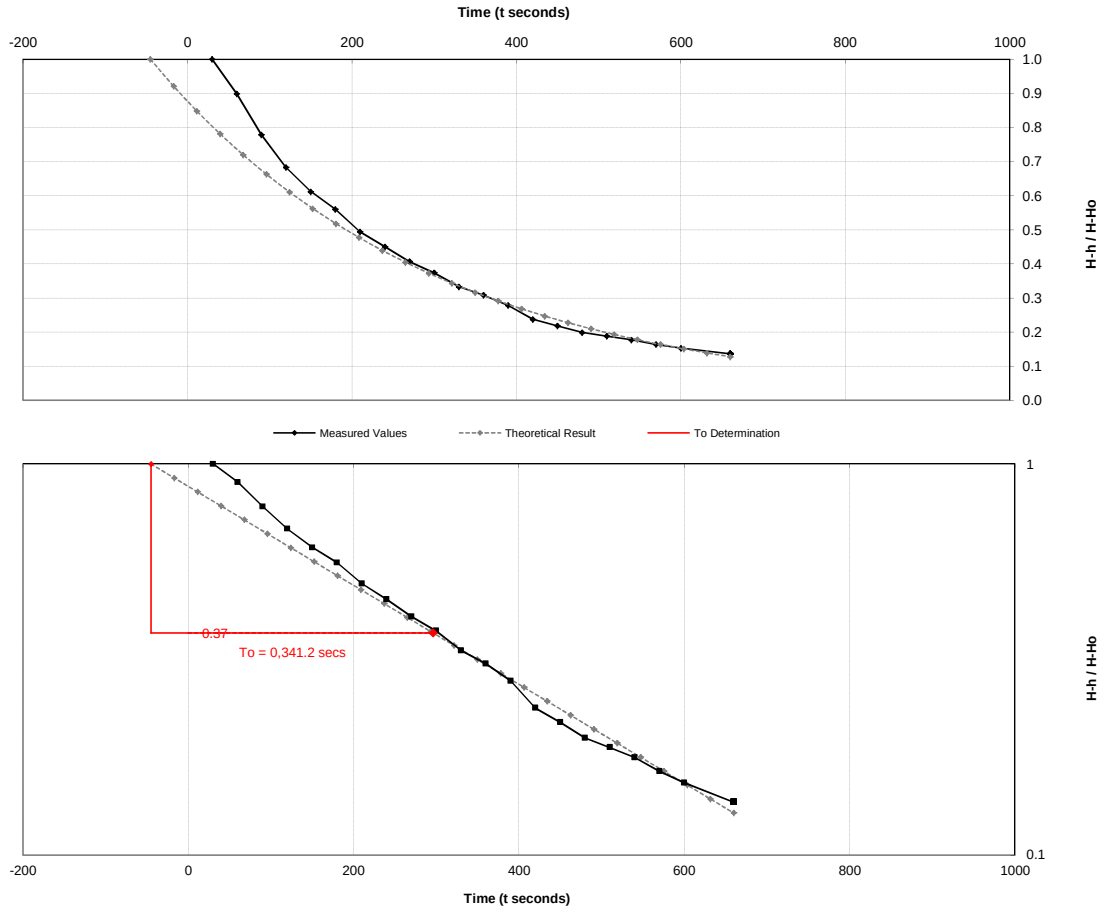
Calibrated Parameters

Intake factor, *F*	13.66
Time Factor, T_0	341.2

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	10.261	0.37	1.00
60	10.224	0.33	0.90
90	10.180	0.29	0.78
120	10.145	0.25	0.68
150	10.119	0.22	0.61
180	10.100	0.21	0.56
210	10.076	0.18	0.49
240	10.060	0.17	0.45
270	10.044	0.15	0.41
300	10.032	0.14	0.37
330	10.017	0.12	0.33
360	10.008	0.11	0.31
390	9.997	0.10	0.28
420	9.982	0.09	0.24
450	9.975	0.08	0.22
480	9.968	0.07	0.20
510	9.964	0.07	0.19
540	9.960	0.07	0.18
570	9.955	0.06	0.16
600	9.951	0.06	0.15
660	9.945	0.05	0.14

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH215

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	29/05/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	8.800 m
Bottom of Screen	14.800 m
Screen Length, *L*	6.000 m
Static Water Level, *H*	3.551 m
Initial Water Level, H_0	3.648 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

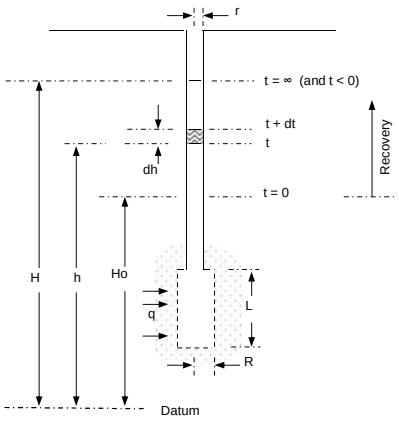
Result

Hydraulic Conductivity

***K* = 3.21E-07 m/s**

2.77E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

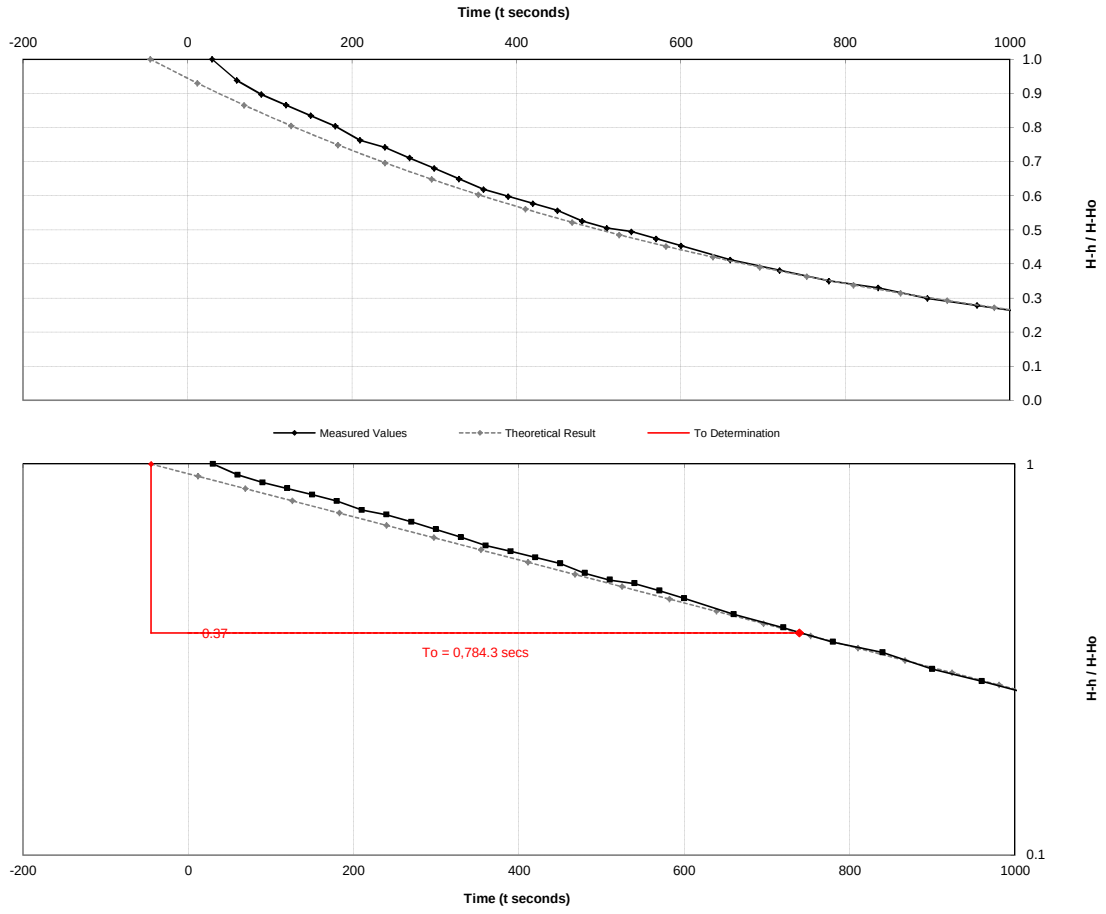
Calibrated Parameters

Intake factor, *F*	7.81
Time Factor, T_0	784.3

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	3.648	0.10	1.00
60	3.642	0.09	0.94
90	3.638	0.09	0.90
120	3.635	0.08	0.87
150	3.632	0.08	0.84
180	3.629	0.08	0.80
210	3.625	0.07	0.76
240	3.623	0.07	0.74
270	3.620	0.07	0.71
300	3.617	0.07	0.68
330	3.614	0.06	0.65
360	3.611	0.06	0.62
390	3.609	0.06	0.60
420	3.607	0.06	0.58
450	3.605	0.05	0.56
480	3.602	0.05	0.53
510	3.600	0.05	0.51
540	3.599	0.05	0.49
570	3.597	0.05	0.47
600	3.595	0.04	0.45
660	3.591	0.04	0.41
720	3.588	0.04	0.38
780	3.585	0.03	0.35
840	3.583	0.03	0.33
900	3.580	0.03	0.30
960	3.578	0.03	0.28
1020	3.576	0.02	0.26
1080	3.574	0.02	0.24
1140	3.571	0.02	0.21
1200	3.569	0.02	0.19
1260	3.567	0.02	0.16
1320	3.566	0.01	0.15
1380	3.564	0.01	0.13

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH218

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	28/05/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	21.000 m
Bottom of Screen	27.800 m
Screen Length, *L*	6.800 m
Static Water Level, *H*	2.126 m
Initial Water Level, H_0	2.278 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

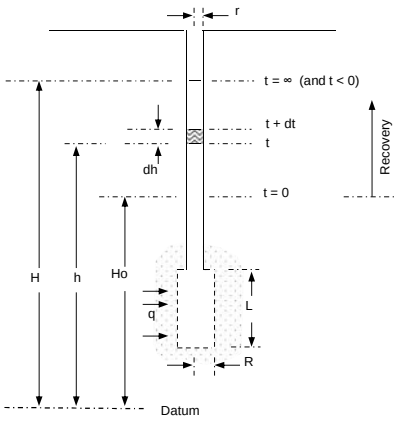
Result

Hydraulic Conductivity

***K* = 5.79E-07 m/s**

5.00E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

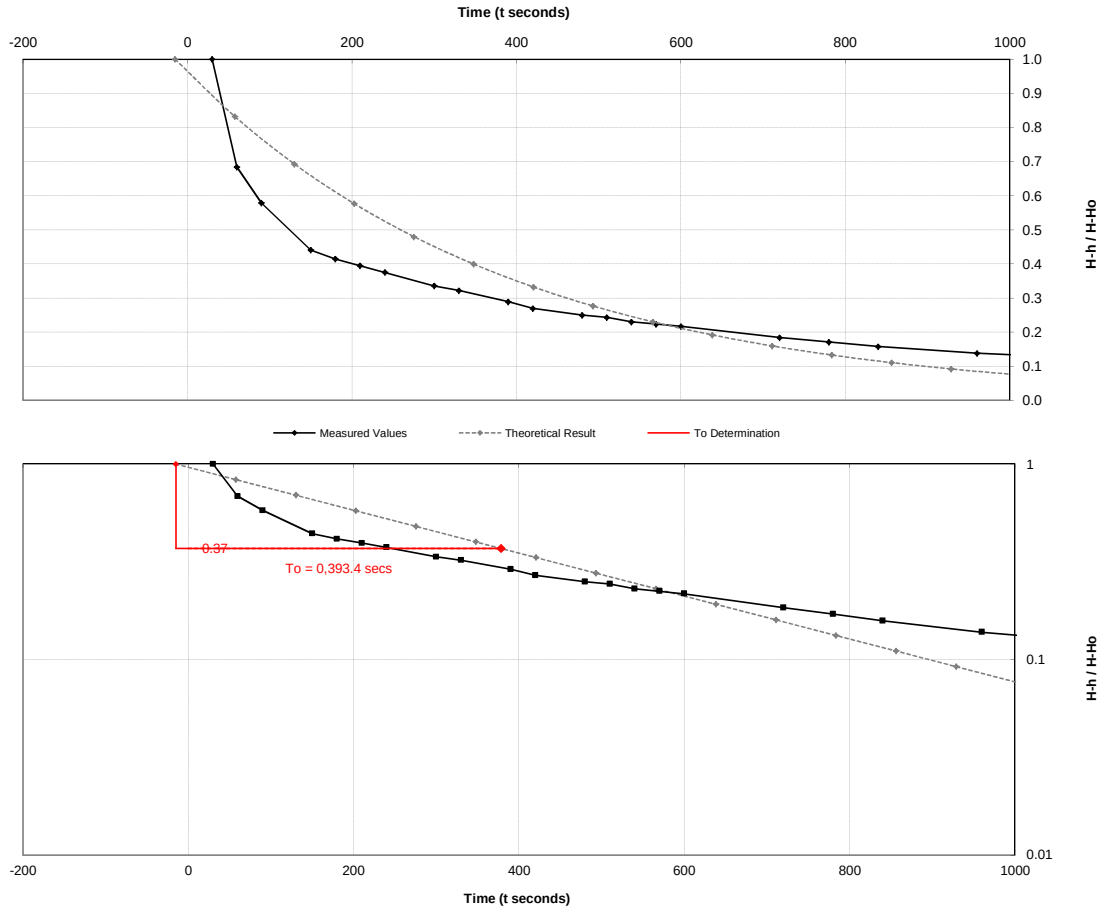
Calibrated Parameters

Intake factor, *F*	8.63
Time Factor, T_0	393.4

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	2.278	0.15	1.00
60	2.230	0.10	0.68
90	2.214	0.09	0.58
150	2.193	0.07	0.44
180	2.189	0.06	0.41
210	2.186	0.06	0.39
240	2.183	0.06	0.37
300	2.177	0.05	0.34
330	2.175	0.05	0.32
390	2.170	0.04	0.29
420	2.167	0.04	0.27
480	2.164	0.04	0.25
510	2.163	0.04	0.24
540	2.161	0.04	0.23
570	2.160	0.03	0.22
600	2.159	0.03	0.22
720	2.154	0.03	0.18
780	2.152	0.03	0.17
840	2.150	0.02	0.16
960	2.147	0.02	0.14
1080	2.145	0.02	0.13
1140	2.144	0.02	0.12
1200	2.143	0.02	0.11
1260	2.142	0.02	0.11
1320	2.141	0.02	0.10
1380	2.140	0.01	0.09
1440	2.139	0.01	0.09
1500	2.139	0.01	0.09
1560	2.138	0.01	0.08
1620	2.137	0.01	0.07
1680	2.136	0.01	0.07
1740	2.135	0.01	0.06
1800	2.134	0.01	0.05

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH217

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	28/05/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	3.500 m
Bottom of Screen	6.500 m
Screen Length, *L*	3.000 m
Static Water Level, *H*	0.618 m
Initial Water Level, H_0	0.975 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

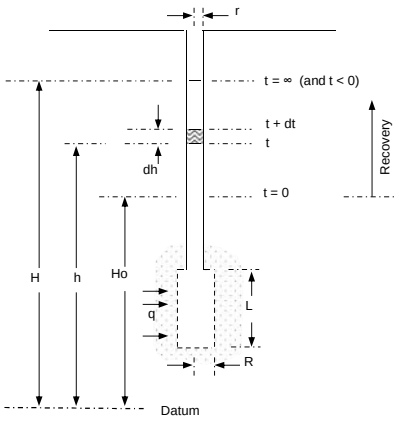
Result

Hydraulic Conductivity

***K* = 6.50E-07 m/s**

5.61E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

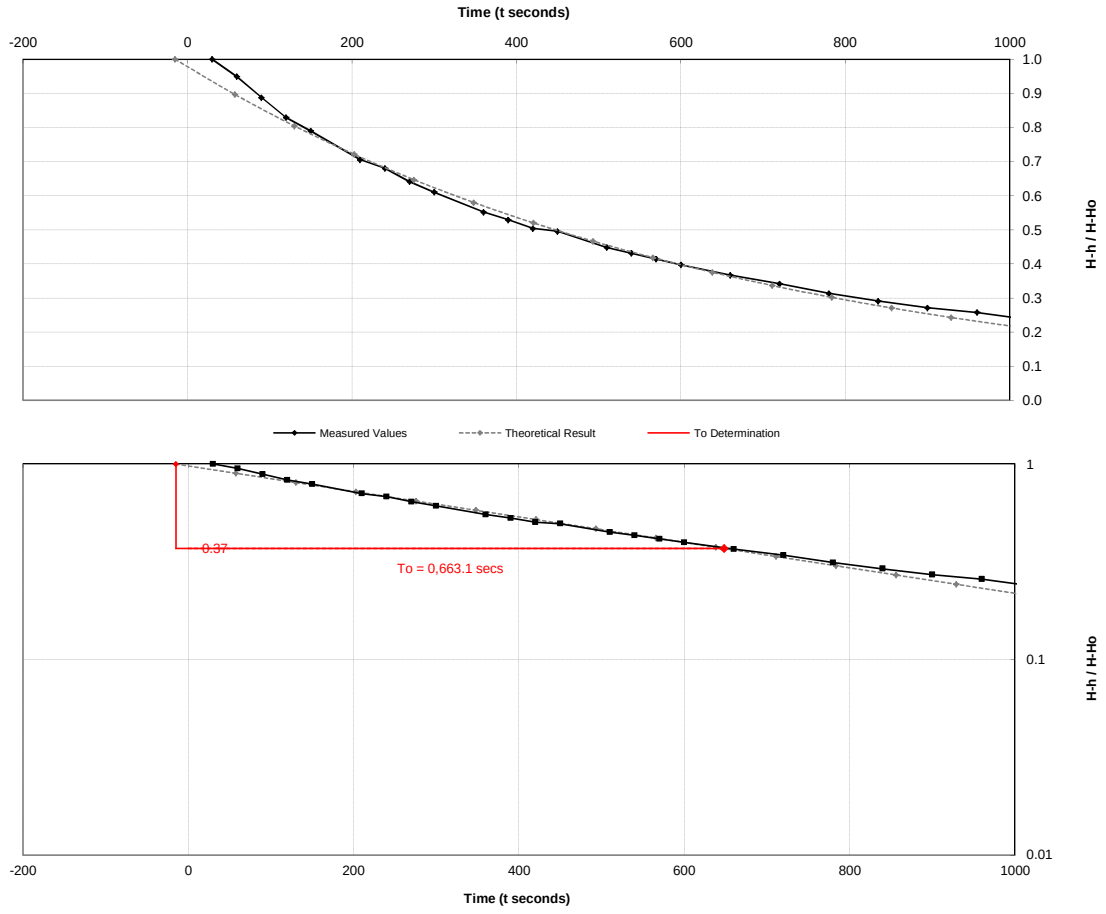
Calibrated Parameters

Intake factor, *F*	4.56
Time Factor, T_0	663.1

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	0.975	0.36	1.00
60	0.957	0.34	0.95
90	0.935	0.32	0.89
120	0.914	0.30	0.83
150	0.900	0.28	0.79
210	0.870	0.25	0.71
240	0.861	0.24	0.68
270	0.847	0.23	0.64
300	0.836	0.22	0.61
360	0.815	0.20	0.55
390	0.807	0.19	0.53
420	0.798	0.18	0.50
450	0.795	0.18	0.50
510	0.778	0.16	0.45
540	0.772	0.15	0.43
570	0.766	0.15	0.41
600	0.760	0.14	0.40
660	0.749	0.13	0.37
720	0.740	0.12	0.34
780	0.730	0.11	0.31
840	0.722	0.10	0.29
900	0.715	0.10	0.27
960	0.710	0.09	0.26
1020	0.703	0.09	0.24
1080	0.698	0.08	0.22
1140	0.693	0.08	0.21
1200	0.688	0.07	0.20
1260	0.685	0.07	0.19
1380	0.677	0.06	0.17
1440	0.674	0.06	0.16
1560	0.669	0.05	0.14
1680	0.665	0.05	0.13
1800	0.660	0.04	0.12

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH218a

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	29/05/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	17.700 m
Bottom of Screen	20.700 m
Screen Length, *L*	3.000 m
Static Water Level, *H*	4.574 m
Initial Water Level, H_0	5.090 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

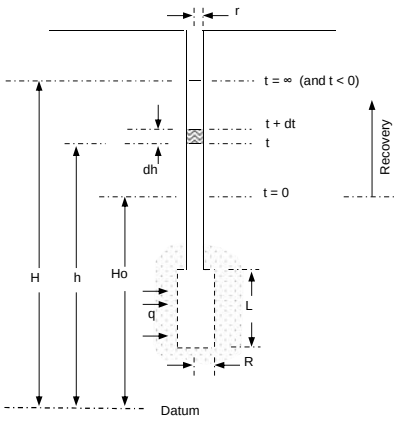
Result

Hydraulic Conductivity

***K* = 3.20E-07 m/s**

2.76E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

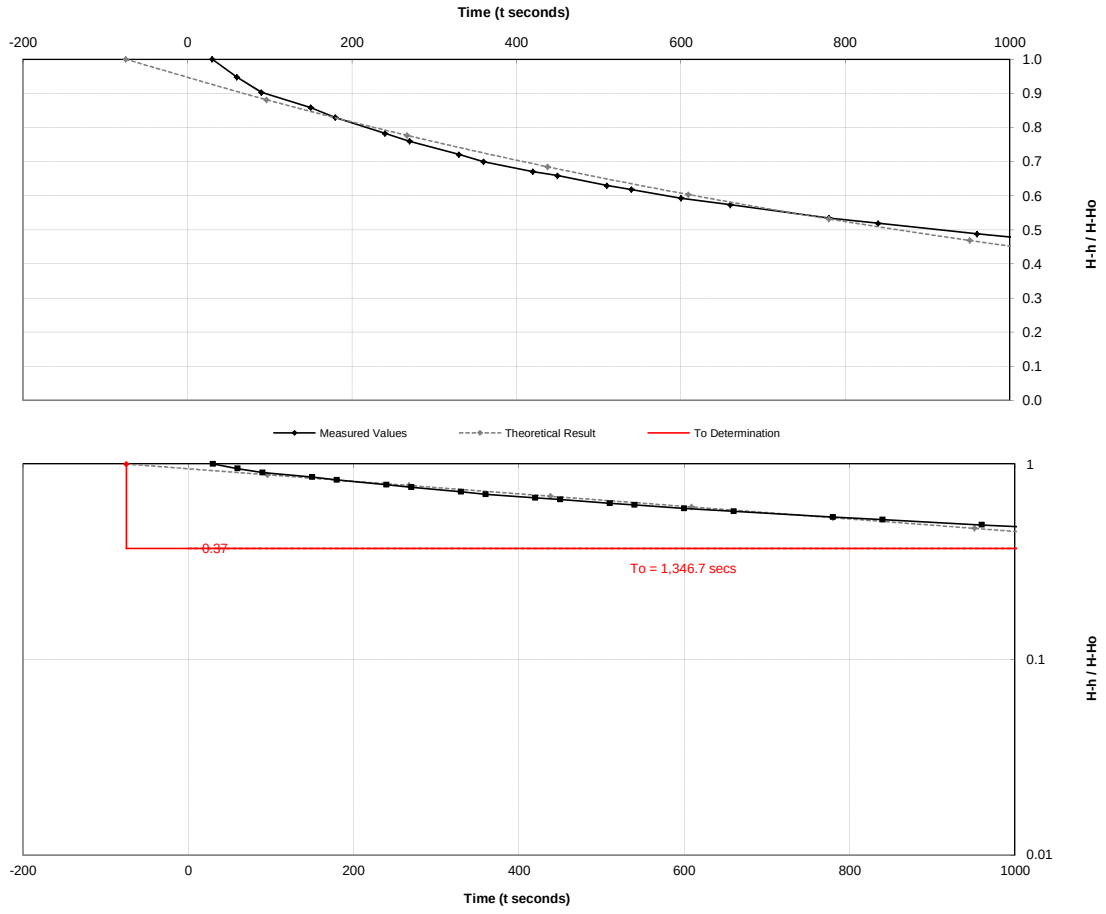
Calibrated Parameters

Intake factor, *F*	4.56
Time Factor, T_0	1,346.7

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	5.090	0.52	1.00
60	5.063	0.49	0.95
90	5.040	0.47	0.90
150	5.017	0.44	0.86
180	5.002	0.43	0.83
240	4.978	0.40	0.78
270	4.966	0.39	0.76
330	4.946	0.37	0.72
360	4.935	0.36	0.70
420	4.920	0.35	0.67
450	4.914	0.34	0.66
510	4.899	0.33	0.63
540	4.893	0.32	0.62
600	4.880	0.31	0.59
660	4.870	0.30	0.57
780	4.850	0.28	0.53
840	4.842	0.27	0.52
960	4.826	0.25	0.49
1020	4.819	0.25	0.47
1140	4.805	0.23	0.45
1200	4.799	0.23	0.44
1320	4.788	0.21	0.41
1380	4.783	0.21	0.41
1500	4.773	0.20	0.39
1560	4.769	0.20	0.38
1740	4.757	0.18	0.35
2100	4.737	0.16	0.32
2400	4.724	0.15	0.29
2700	4.712	0.14	0.27
3000	4.702	0.13	0.25
3300	4.694	0.12	0.23
3600	4.688	0.11	0.22
4200	4.676	0.10	0.20

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH208b

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	24/08/2015
Tested	EF
Checked	MVD

Test Parameters

Top of screen	6.000 m
Bottom of Screen	9.000 m
Screen Length, *L*	3.000 m
Static Water Level, *H*	10.127 m
Initial Water Level, H_0	10.055 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.016 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

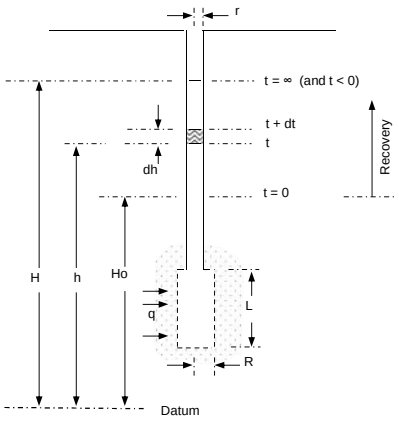
Result

Hydraulic Conductivity

***K* = 1.24E-06 m/s**

1.07E-01 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

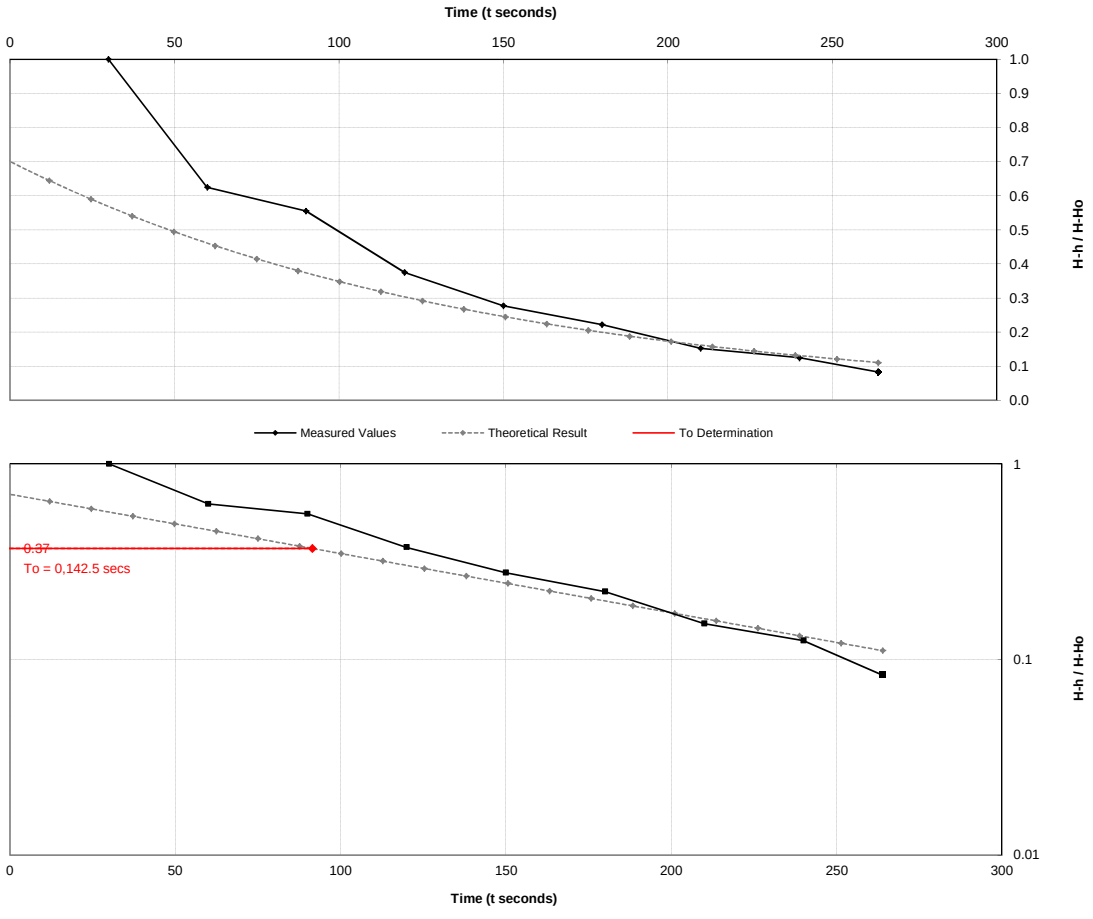
Calibrated Parameters

Intake factor, *F*	4.56
Time Factor, T_0	142.5

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	10.055	-0.07	1.00
60	10.082	-0.04	0.63
90	10.087	-0.04	0.56
120	10.100	-0.03	0.37
150	10.107	-0.02	0.28
180	10.111	-0.02	0.22
210	10.116	-0.01	0.15
240	10.118	-0.01	0.12
264	10.121	-0.01	0.08

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH223

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	19/08/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	5.000 m
Bottom of Screen	8.000 m
Screen Length, *L*	3.000 m
Static Water Level, *H*	11.840 m
Initial Water Level, H_0	11.071 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

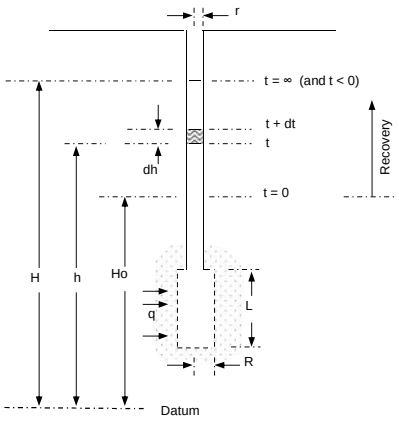
Result

Hydraulic Conductivity

***K* = 1.27E-07 m/s**

1.10E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

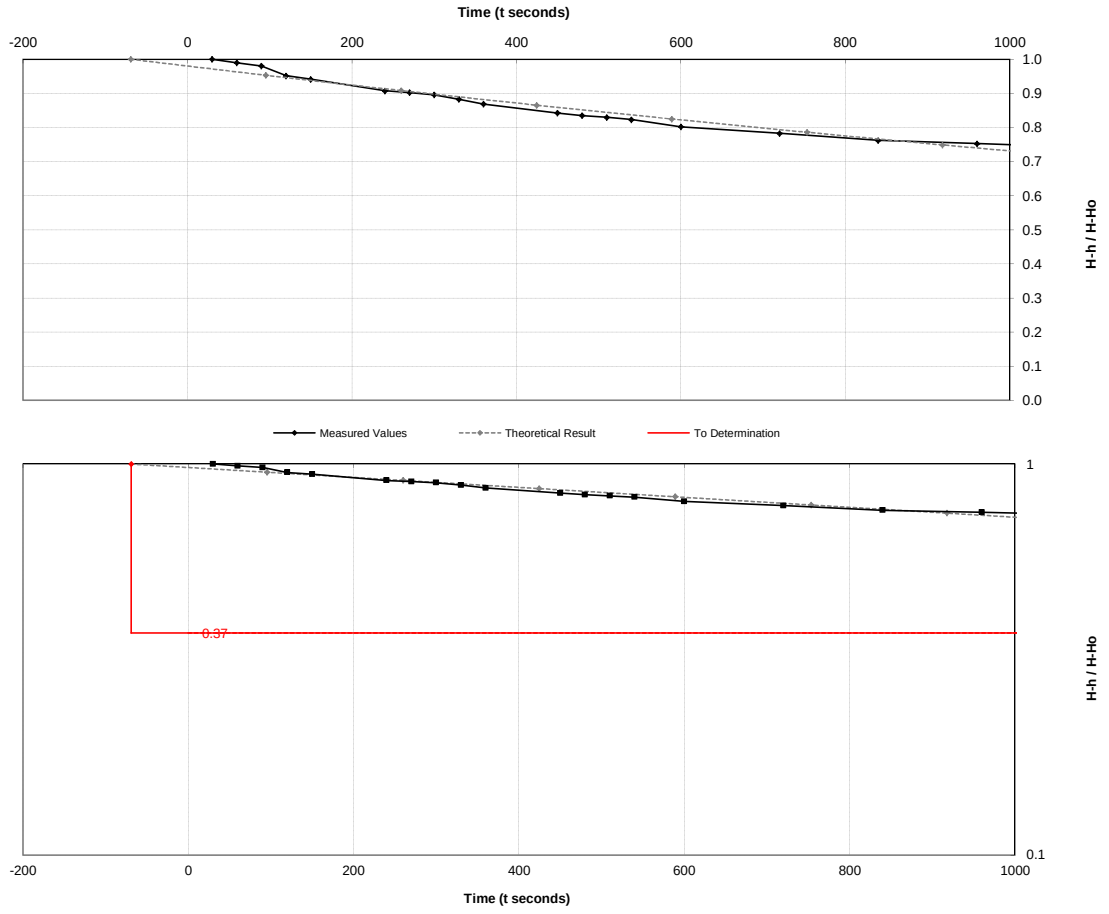
Calibrated Parameters

Intake factor, *F*	4.56
Time Factor, T_0	3,396.0

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	11.071	-0.77	1.00
60	11.079	-0.76	0.99
90	11.086	-0.75	0.98
120	11.108	-0.73	0.95
150	11.116	-0.72	0.94
240	11.142	-0.70	0.91
270	11.146	-0.69	0.90
300	11.151	-0.69	0.90
330	11.161	-0.68	0.88
360	11.172	-0.67	0.87
450	11.192	-0.65	0.84
480	11.198	-0.64	0.83
510	11.202	-0.64	0.83
540	11.207	-0.63	0.82
600	11.223	-0.62	0.80
720	11.238	-0.60	0.78
840	11.254	-0.59	0.76
960	11.261	-0.58	0.75
1320	11.285	-0.56	0.72
1440	11.294	-0.55	0.71
1560	11.304	-0.54	0.70
1680	11.311	-0.53	0.69
1800	11.318	-0.52	0.68
2040	11.334	-0.51	0.66
2160	11.340	-0.50	0.65
2280	11.348	-0.49	0.64
2400	11.355	-0.48	0.63
2880	11.375	-0.47	0.60
3000	11.381	-0.46	0.60
3300	11.403	-0.44	0.57
3600	11.421	-0.42	0.54
3900	11.439	-0.40	0.52
4034	11.444	-0.40	0.51

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH228-1

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	20/08/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	47.000 m
Bottom of Screen	50.000 m
Screen Length, *L*	3.000 m
Static Water Level, *H*	0.000 m
Initial Water Level, H_0	1.425 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

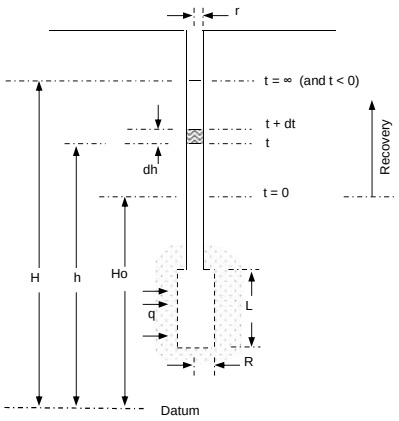
Result

Hydraulic Conductivity

***K* = 3.55E-06 m/s**

3.06E-01 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

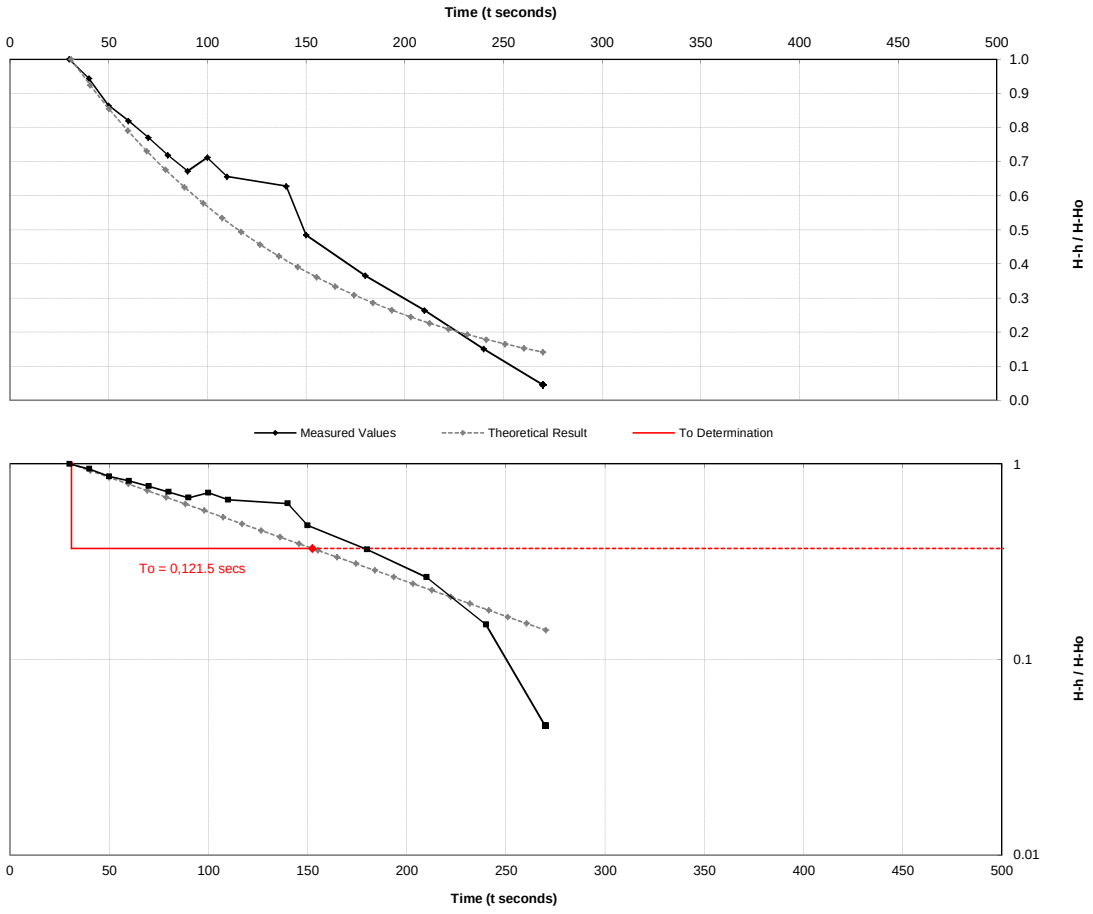
Calibrated Parameters

Intake factor, *F*	4.56
Time Factor, T_0	121.5

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	1.425	1.43	1.00
40	1.345	1.35	0.94
50	1.232	1.23	0.86
60	1.168	1.17	0.82
70	1.098	1.10	0.77
80	1.025	1.03	0.72
90	0.958	0.96	0.67
100	1.015	1.02	0.71
110	0.935	0.94	0.66
140	0.895	0.90	0.63
150	0.691	0.69	0.48
180	0.521	0.52	0.37
210	0.376	0.38	0.26
240	0.215	0.22	0.15
270	0.065	0.07	0.05

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH228-2

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	20/08/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	3.000 m
Bottom of Screen	6.000 m
Screen Length, *L*	3.000 m
Static Water Level, *H*	0.200 m
Initial Water Level, H_0	1.885 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

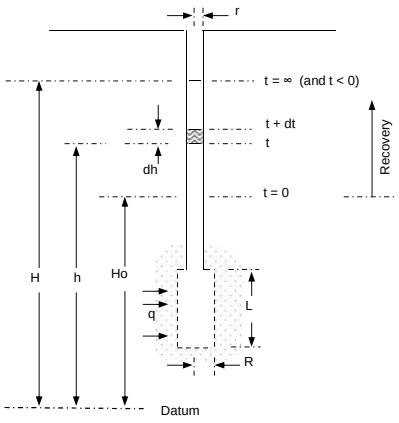
Result

Hydraulic Conductivity

***K* = 1.87E-06 m/s**

1.62E-01 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

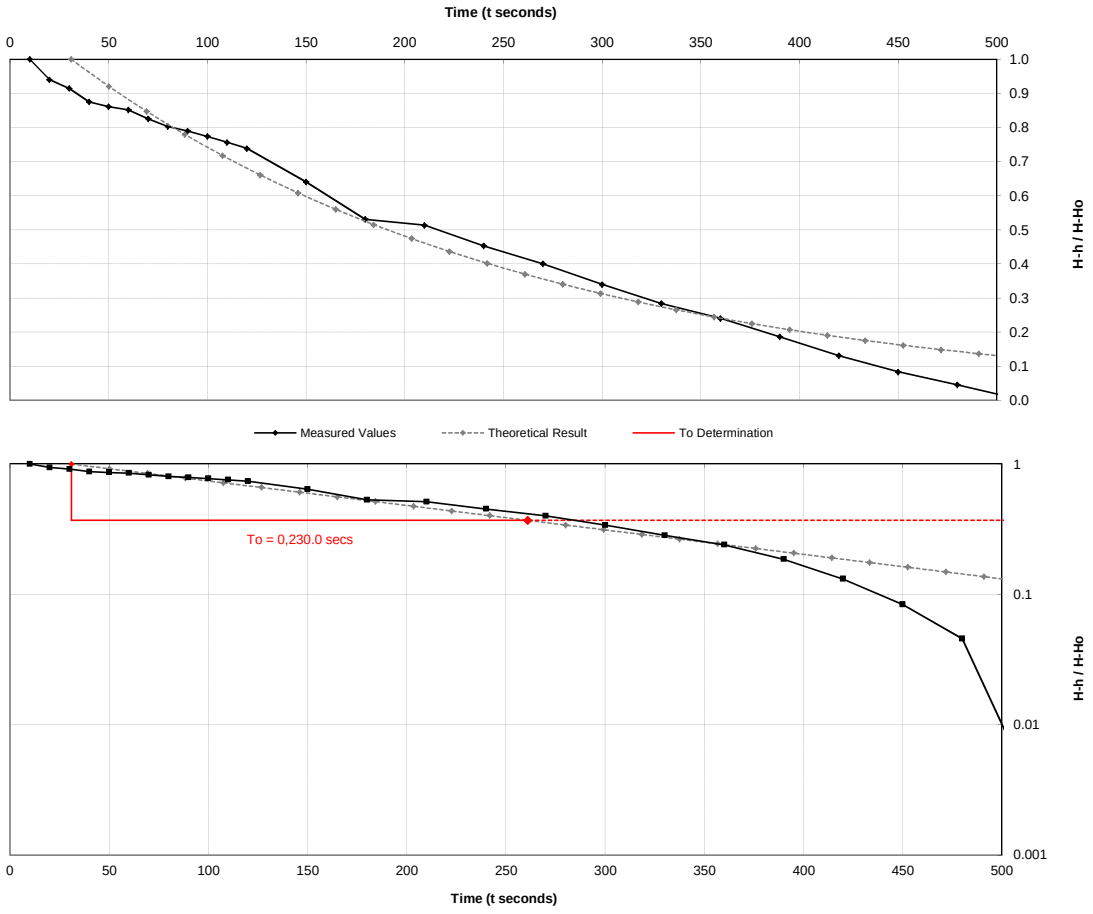
Calibrated Parameters

Intake factor, *F*	4.56
Time Factor, T_0	230.0

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
10	1.885	1.69	1.00
20	1.785	1.59	0.94
30	1.741	1.54	0.91
40	1.675	1.48	0.88
50	1.651	1.45	0.86
60	1.635	1.44	0.85
70	1.591	1.39	0.83
80	1.553	1.35	0.80
90	1.531	1.33	0.79
100	1.504	1.30	0.77
110	1.475	1.28	0.76
120	1.445	1.25	0.74
150	1.280	1.08	0.64
180	1.095	0.90	0.53
210	1.065	0.87	0.51
240	0.963	0.76	0.45
270	0.875	0.68	0.40
300	0.773	0.57	0.34
330	0.679	0.48	0.28
360	0.605	0.41	0.24
390	0.514	0.31	0.19
420	0.421	0.22	0.13
450	0.341	0.14	0.08
480	0.277	0.08	0.05
510	0.208	0.01	0.00

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH227

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	20/08/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	3.000 m
Bottom of Screen	6.000 m
Screen Length, *L*	3.000 m
Static Water Level, *H*	0.074 m
Initial Water Level, H_0	0.585 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

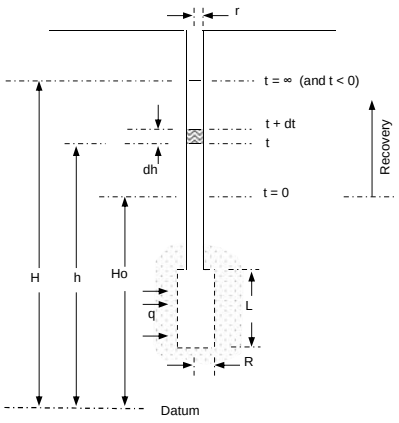
Result

Hydraulic Conductivity

***K* = 6.29E-07 m/s**

5.44E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

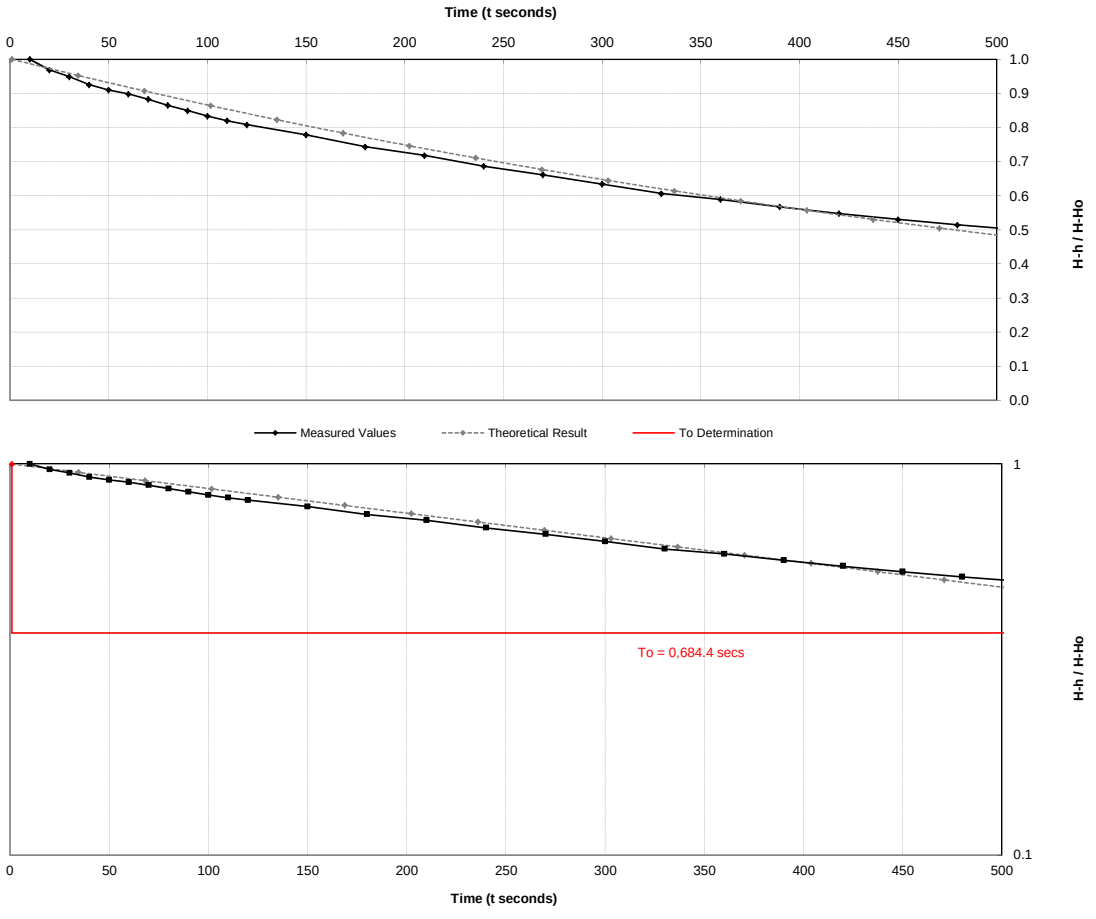
Calibrated Parameters

Intake factor, *F*	4.56
Time Factor, T_0	684.4

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
10	0.585	0.51	1.00
20	0.569	0.50	0.97
30	0.559	0.49	0.95
40	0.547	0.47	0.93
50	0.539	0.47	0.91
60	0.533	0.46	0.90
70	0.525	0.45	0.88
80	0.516	0.44	0.86
90	0.508	0.43	0.85
100	0.500	0.43	0.83
110	0.493	0.42	0.82
120	0.487	0.41	0.81
150	0.472	0.40	0.78
180	0.454	0.38	0.74
210	0.441	0.37	0.72
240	0.425	0.35	0.69
270	0.412	0.34	0.66
300	0.398	0.32	0.63
330	0.384	0.31	0.61
360	0.375	0.30	0.59
390	0.364	0.29	0.57
420	0.354	0.28	0.55
450	0.345	0.27	0.53
480	0.337	0.26	0.51
510	0.330	0.26	0.50
540	0.324	0.25	0.49
570	0.315	0.24	0.47
600	0.308	0.23	0.46
660	0.294	0.22	0.43
720	0.283	0.21	0.41
780	0.271	0.20	0.39
840	0.258	0.18	0.36

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH229a

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	20/08/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	63.500 m
Bottom of Screen	66.500 m
Screen Length, *L*	3.000 m
Static Water Level, *H*	10.630 m
Initial Water Level, H_0	9.775 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

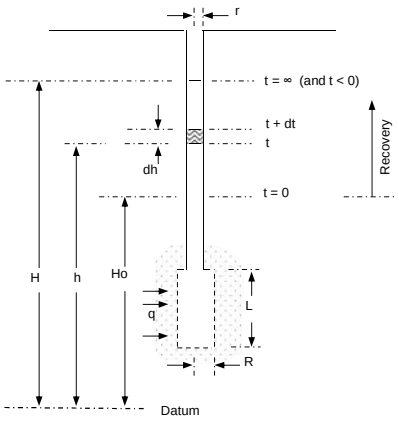
Result

Hydraulic Conductivity

***K* = 1.93E-08 m/s**

1.67E-03 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

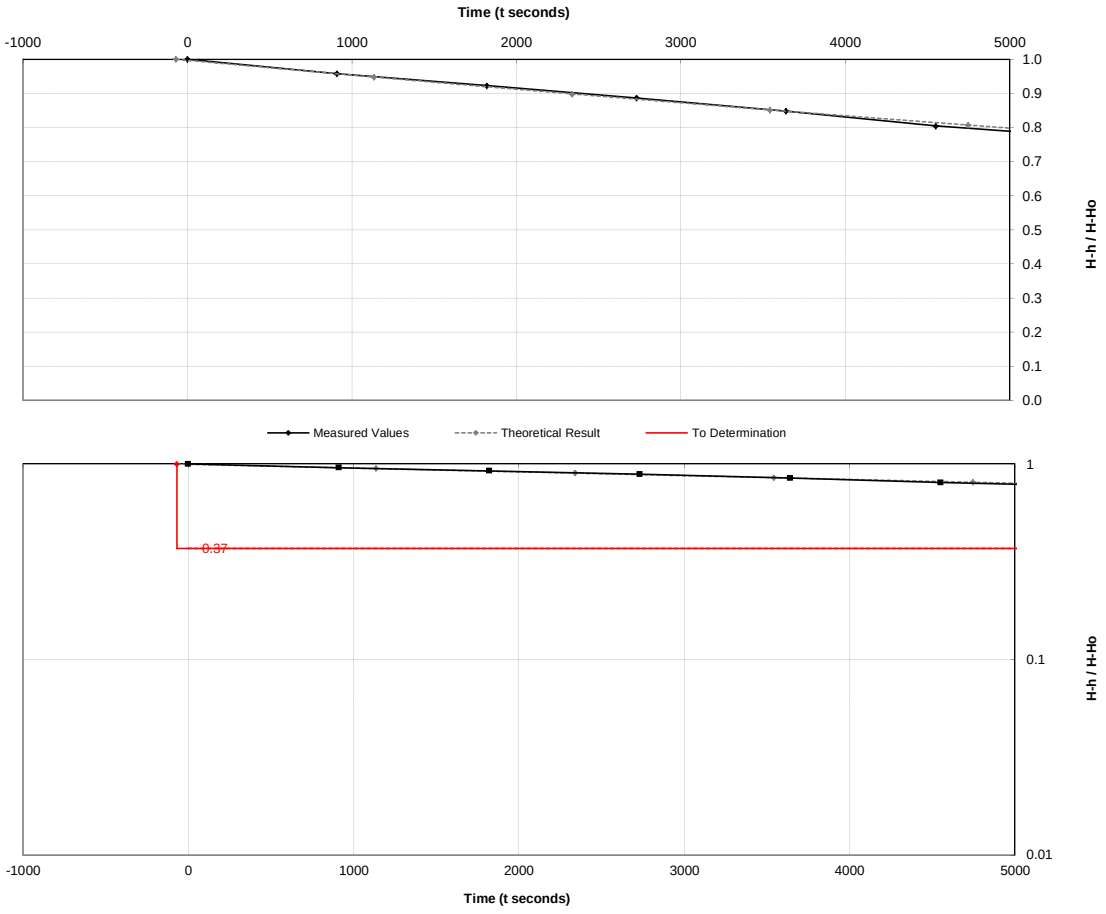
Calibrated Parameters

Intake factor, *F*	4.56
Time Factor, T_0	22,345.0

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
0	9.775	-0.86	1.00
910	9.811	-0.82	0.96
1820	9.841	-0.79	0.92
2730	9.872	-0.76	0.89
3640	9.905	-0.73	0.85
4550	9.942	-0.69	0.80
5460	9.969	-0.66	0.77
6370	10.000	-0.63	0.74
7280	10.035	-0.60	0.70
8190	10.058	-0.57	0.67
9100	10.087	-0.54	0.64
10010	10.117	-0.51	0.60
10920	10.145	-0.49	0.57
11830	10.169	-0.46	0.54
12740	10.198	-0.43	0.51
13650	10.224	-0.41	0.47
14560	10.245	-0.39	0.45
15470	10.273	-0.36	0.42
16380	10.297	-0.33	0.39
17290	10.323	-0.31	0.36
18200	10.349	-0.28	0.33
19110	10.372	-0.26	0.30
20020	10.393	-0.24	0.28
20930	10.419	-0.21	0.25
21840	10.438	-0.19	0.22
22750	10.460	-0.17	0.20
23660	10.486	-0.14	0.17
24570	10.503	-0.13	0.15
25480	10.523	-0.11	0.13
26390	10.546	-0.08	0.10
27300	10.564	-0.07	0.08
28210	10.581	-0.05	0.06
30027	10.619	-0.01	0.01

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH223

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	20/08/2015
Tested	EF
Checked	MVD

Test Parameters

Top of screen	36.000 m
Bottom of Screen	42.000 m
Screen Length, *L*	6.000 m
Static Water Level, *H*	23.790 m
Initial Water Level, H_0	23.595 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

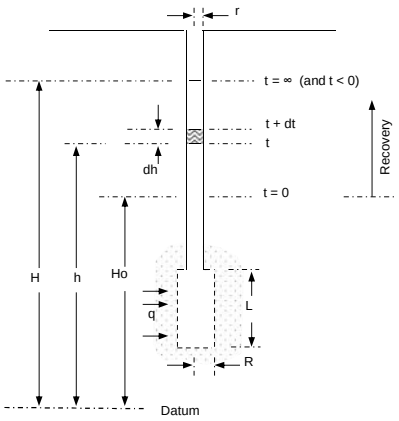
Result

Hydraulic Conductivity

***K* = 4.79E-07 m/s**

4.14E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

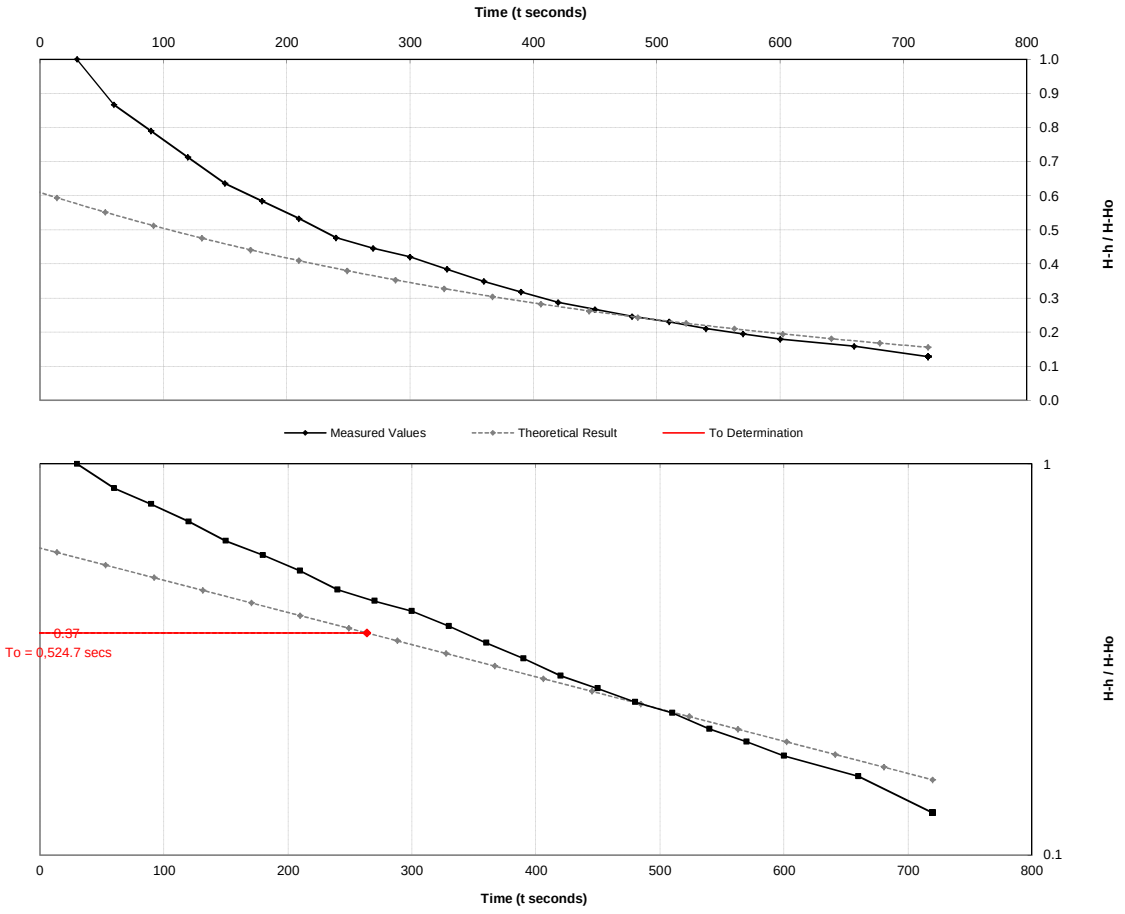
Calibrated Parameters

Intake factor, *F*	7.81
Time Factor, T_0	524.7

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	23.595	-0.20	1.00
60	23.621	-0.17	0.87
90	23.636	-0.15	0.79
120	23.651	-0.14	0.71
150	23.666	-0.12	0.64
180	23.676	-0.11	0.58
210	23.686	-0.10	0.53
240	23.697	-0.09	0.48
270	23.703	-0.09	0.45
300	23.708	-0.08	0.42
330	23.715	-0.07	0.38
360	23.722	-0.07	0.35
390	23.728	-0.06	0.32
420	23.734	-0.06	0.29
450	23.738	-0.05	0.27
480	23.742	-0.05	0.25
510	23.745	-0.04	0.23
540	23.749	-0.04	0.21
570	23.752	-0.04	0.19
600	23.755	-0.03	0.18
660	23.759	-0.03	0.16
720	23.765	-0.02	0.13

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH230

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	18/08/2015
Tested	EF
Checked	MT

Test Parameters

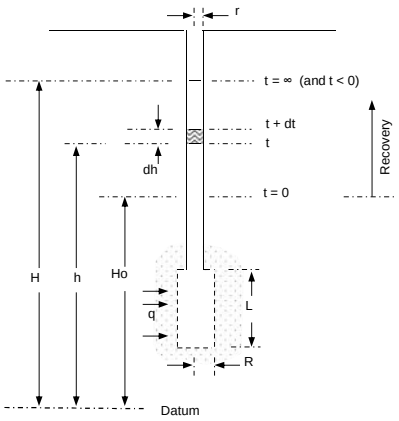
Top of screen	51.400 m
Bottom of Screen	54.400 m
Screen Length, *L*	3.000 m
Static Water Level, *H*	47.900 m
Initial Water Level, H_0	47.210 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

Result

Hydraulic Conductivity
***K* = 3.89E-05 m/s**
3.36E+00 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

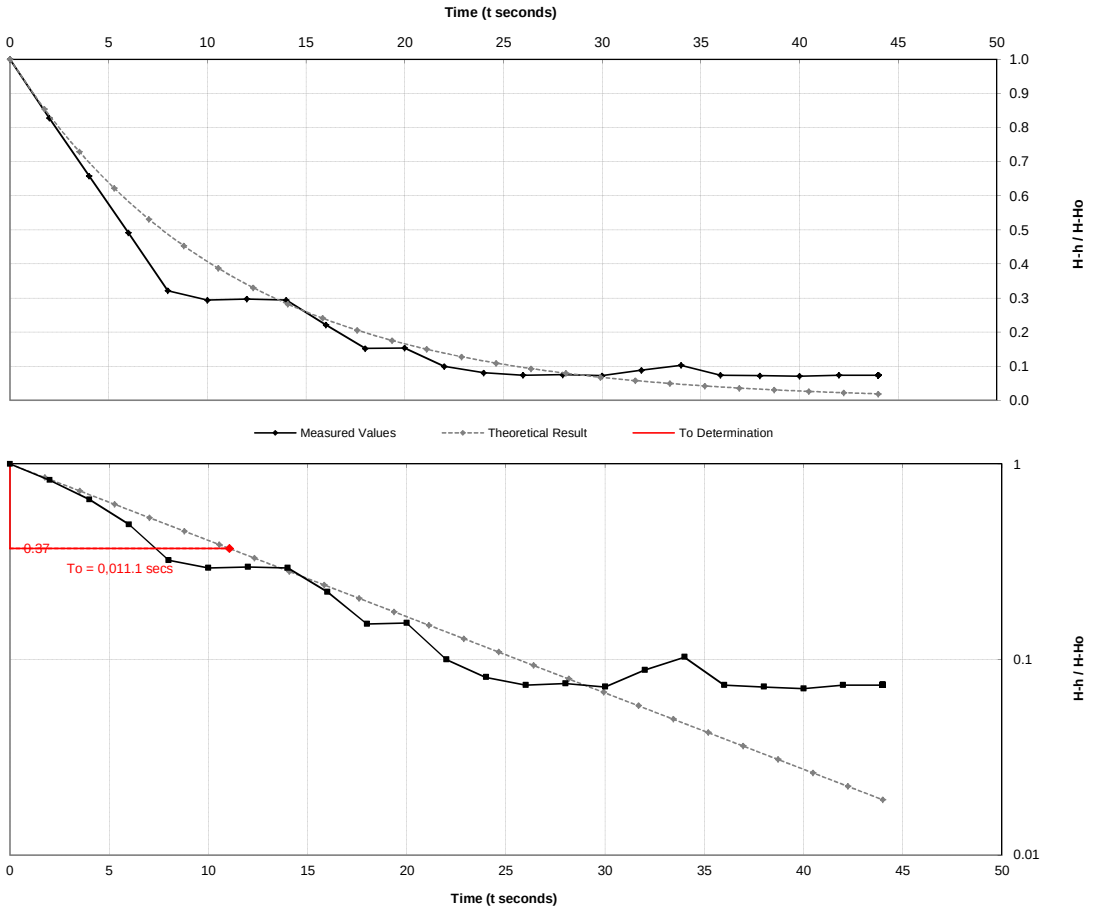
Calibrated Parameters

Intake factor, *F*	4.56
Time Factor, T_0	11.1

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
0	47.210	-0.69	1.00
2	47.329	-0.57	0.83
4	47.446	-0.45	0.66
6	47.561	-0.34	0.49
8	47.678	-0.22	0.32
10	47.697	-0.20	0.29
12	47.695	-0.20	0.30
14	47.697	-0.20	0.29
16	47.747	-0.15	0.22
18	47.795	-0.10	0.15
20	47.794	-0.11	0.15
22	47.831	-0.07	0.10
24	47.844	-0.06	0.08
26	47.849	-0.05	0.07
28	47.848	-0.05	0.08
30	47.850	-0.05	0.07
32	47.839	-0.06	0.09
34	47.829	-0.07	0.10
36	47.849	-0.05	0.07
38	47.850	-0.05	0.07
40	47.851	-0.05	0.07
42	47.849	-0.05	0.07
44	47.849	-0.05	0.07

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH221

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	2/06/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	9.300 m
Bottom of Screen	23.300 m
Screen Length, *L*	14.000 m
Static Water Level, *H*	1.741 m
Initial Water Level, H_0	2.218 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

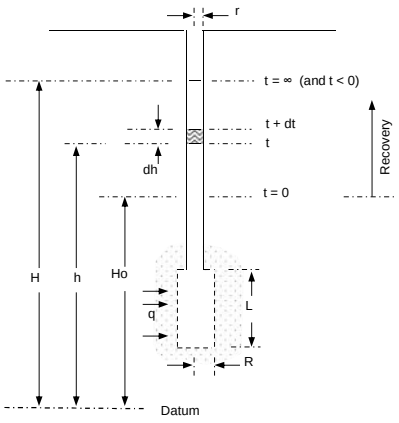
Result

Hydraulic Conductivity

***K* = 1.66E-07 m/s**

1.44E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

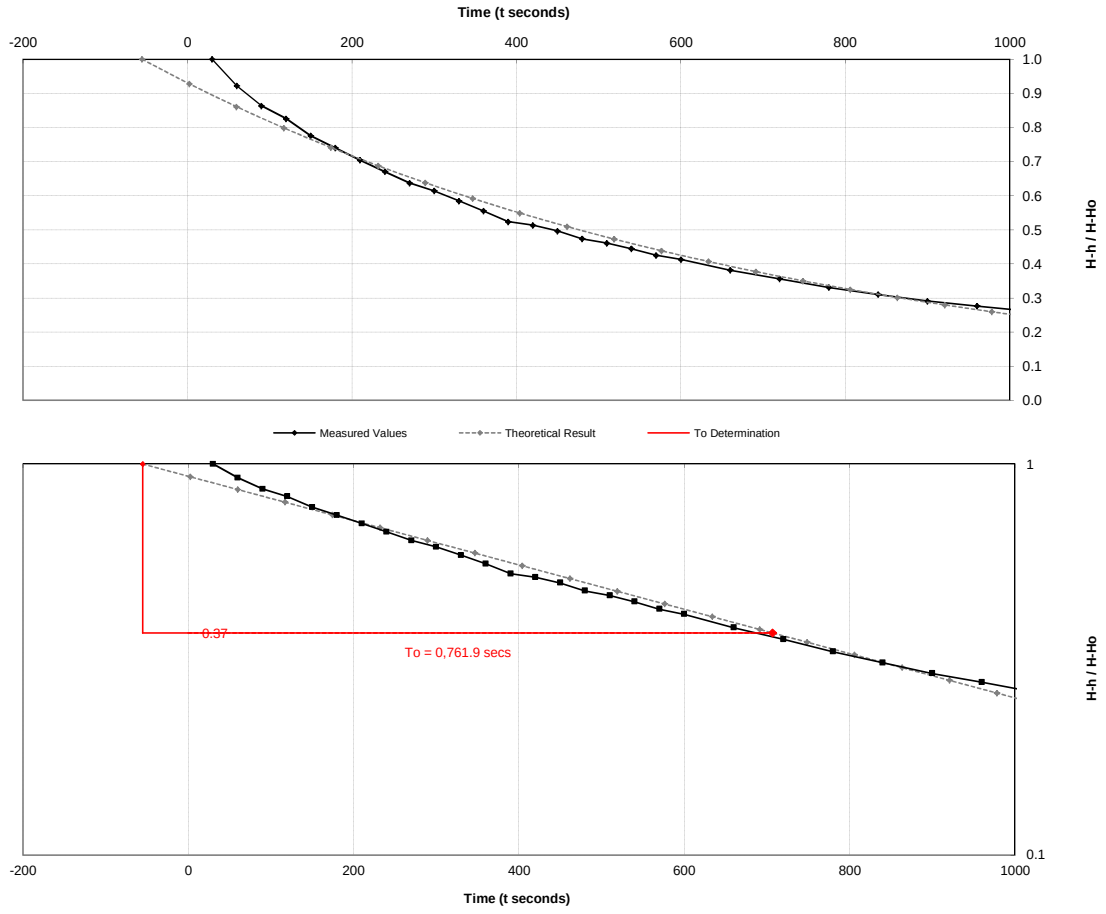
Calibrated Parameters

Intake factor, *F*	15.50
Time Factor, T_0	761.9

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	2.218	0.48	1.00
60	2.181	0.44	0.92
90	2.153	0.41	0.86
120	2.135	0.39	0.83
150	2.111	0.37	0.78
180	2.094	0.35	0.74
210	2.077	0.34	0.70
240	2.061	0.32	0.67
270	2.045	0.30	0.64
300	2.034	0.29	0.61
330	2.020	0.28	0.58
360	2.006	0.27	0.56
390	1.991	0.25	0.52
420	1.986	0.25	0.51
450	1.978	0.24	0.50
480	1.967	0.23	0.47
510	1.961	0.22	0.46
540	1.953	0.21	0.44
570	1.944	0.20	0.43
600	1.938	0.20	0.41
660	1.923	0.18	0.38
720	1.911	0.17	0.36
780	1.899	0.16	0.33
840	1.889	0.15	0.31
900	1.880	0.14	0.29
960	1.873	0.13	0.28
1020	1.866	0.13	0.26
1080	1.859	0.12	0.25
1140	1.855	0.11	0.24
1200	1.849	0.11	0.23
1260	1.843	0.10	0.21
1320	1.838	0.10	0.20
1380	1.835	0.09	0.20

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH222

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	2/06/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	39.000 m
Bottom of Screen	44.300 m
Screen Length, *L*	5.300 m
Static Water Level, *H*	0.000 m
Initial Water Level, H_0	2.218 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

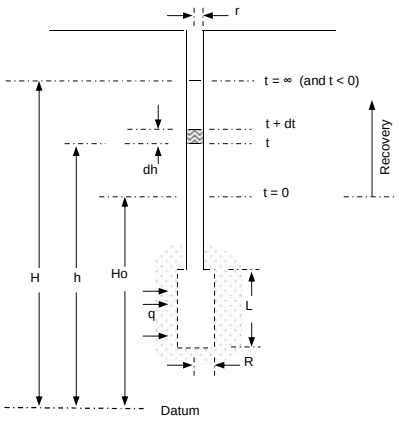
Result

Hydraulic Conductivity

***K* = 2.01E-07 m/s**

1.74E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

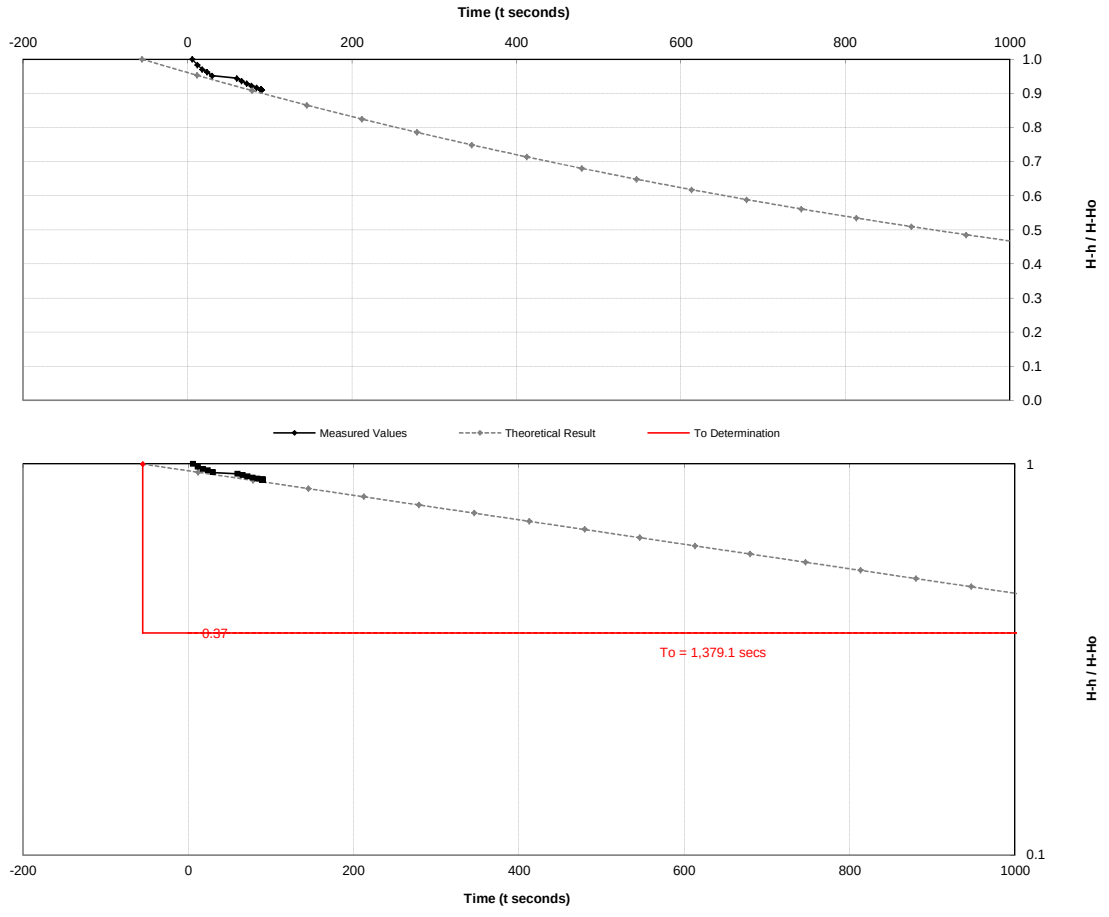
Calibrated Parameters

Intake factor, *F*	7.08
Time Factor, T_0	1,379.1

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
6	2.218	2.22	1.00
12	2.181	2.18	0.98
18	2.153	2.15	0.97
24	2.135	2.14	0.96
30	2.111	2.11	0.95
60	2.094	2.09	0.94
66	2.077	2.08	0.94
72	2.061	2.06	0.93
78	2.045	2.05	0.92
84	2.034	2.03	0.92
90	2.020	2.02	0.91

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH224_6.5m

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	2/06/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	5.500 m
Bottom of Screen	6.500 m
Screen Length, *L*	1.000 m
Static Water Level, *H*	1.145 m
Initial Water Level, H_0	1.456 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

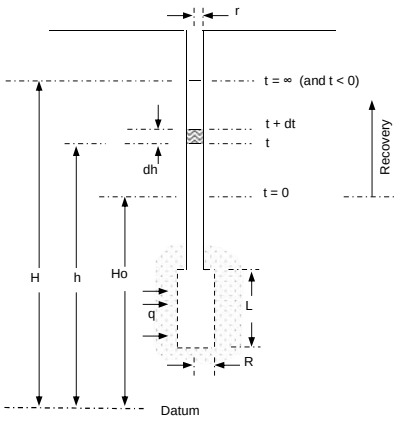
Result

Hydraulic Conductivity

***K* = 4.97E-07 m/s**

4.29E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

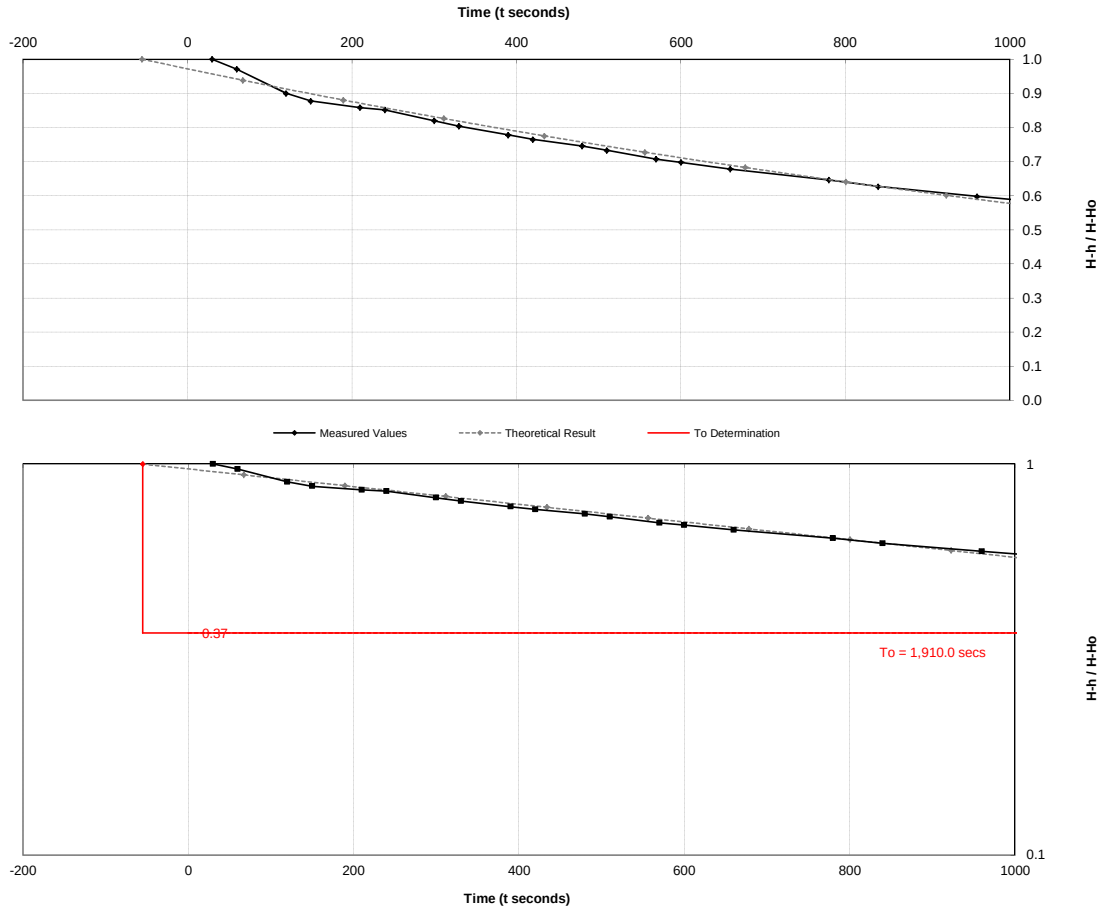
Calibrated Parameters

Intake factor, *F*	2.07
Time Factor, T_0	1,910.0

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	1.456	0.31	1.00
60	1.447	0.30	0.97
120	1.425	0.28	0.90
150	1.418	0.27	0.88
210	1.412	0.27	0.86
240	1.410	0.27	0.85
300	1.400	0.26	0.82
330	1.395	0.25	0.80
390	1.387	0.24	0.78
420	1.383	0.24	0.77
480	1.377	0.23	0.75
510	1.373	0.23	0.73
570	1.365	0.22	0.71
600	1.362	0.22	0.70
660	1.356	0.21	0.68
780	1.346	0.20	0.65
840	1.340	0.20	0.63
960	1.331	0.19	0.60
1020	1.327	0.18	0.59
1140	1.318	0.17	0.56
1200	1.315	0.17	0.55
1320	1.309	0.16	0.53
1380	1.306	0.16	0.52
1500	1.295	0.15	0.48
1560	1.292	0.15	0.47
1620	1.290	0.15	0.47
1680	1.290	0.15	0.47
1740	1.287	0.14	0.46
1800	1.285	0.14	0.45
2100	1.275	0.13	0.42
2400	1.265	0.12	0.39
2700	1.257	0.11	0.36
3000	1.249	0.10	0.33

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH224_24.5m

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	2/06/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	24.000 m
Bottom of Screen	24.500 m
Screen Length, *L*	0.500 m
Static Water Level, *H*	1.970 m
Initial Water Level, H_0	2.193 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

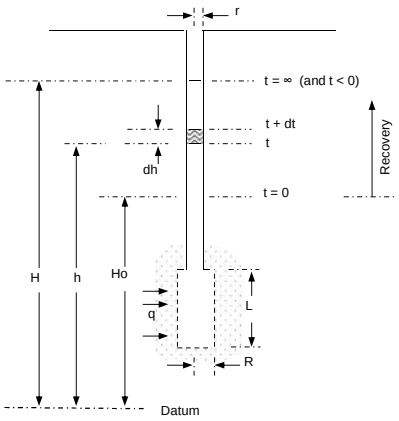
Result

Hydraulic Conductivity

***K* = 2.32E-07 m/s**

2.00E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

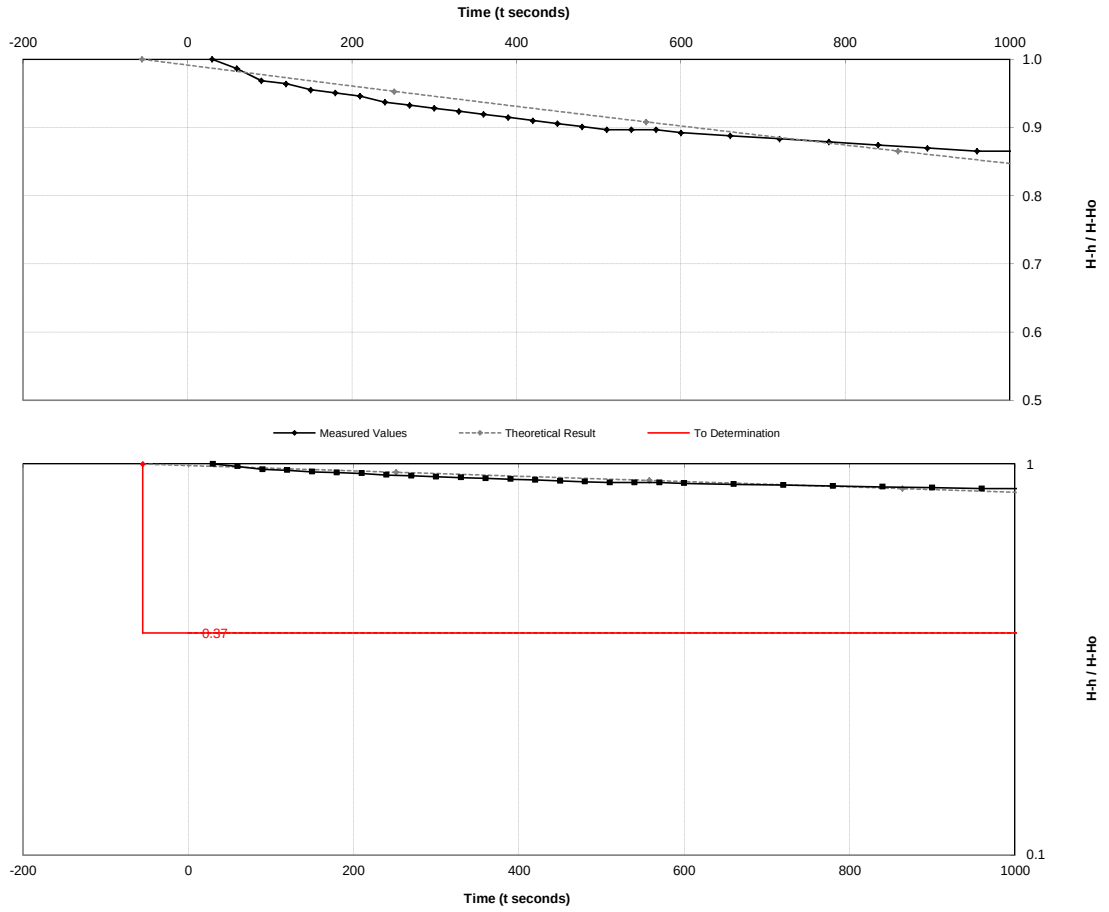
Calibrated Parameters

Intake factor, *F*	1.34
Time Factor, T_0	6,324.8

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	2.193	0.22	1.00
60	2.190	0.22	0.99
90	2.186	0.22	0.97
120	2.185	0.22	0.96
150	2.183	0.21	0.96
180	2.182	0.21	0.95
210	2.181	0.21	0.95
240	2.179	0.21	0.94
270	2.178	0.21	0.93
300	2.177	0.21	0.93
330	2.176	0.21	0.92
360	2.175	0.21	0.92
390	2.174	0.20	0.91
420	2.173	0.20	0.91
450	2.172	0.20	0.91
480	2.171	0.20	0.90
510	2.170	0.20	0.90
540	2.170	0.20	0.90
570	2.170	0.20	0.90
600	2.169	0.20	0.89
660	2.168	0.20	0.89
720	2.167	0.20	0.88
780	2.166	0.20	0.88
840	2.165	0.20	0.87
900	2.164	0.19	0.87
960	2.163	0.19	0.87
1020	2.163	0.19	0.87
1080	2.163	0.19	0.87

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH251

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	5/06/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	14.000 m
Bottom of Screen	20.100 m
Screen Length, *L*	6.100 m
Static Water Level, *H*	1.981 m
Initial Water Level, H_0	2.111 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

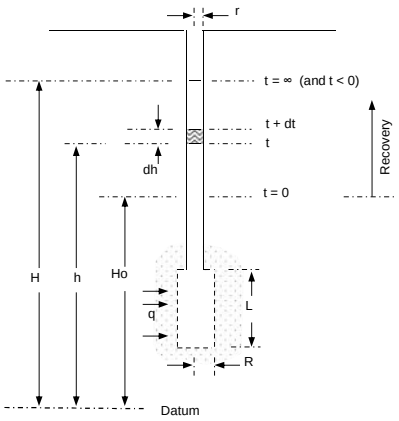
Result

Hydraulic Conductivity

***K* = 1.98E-07 m/s**

1.71E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

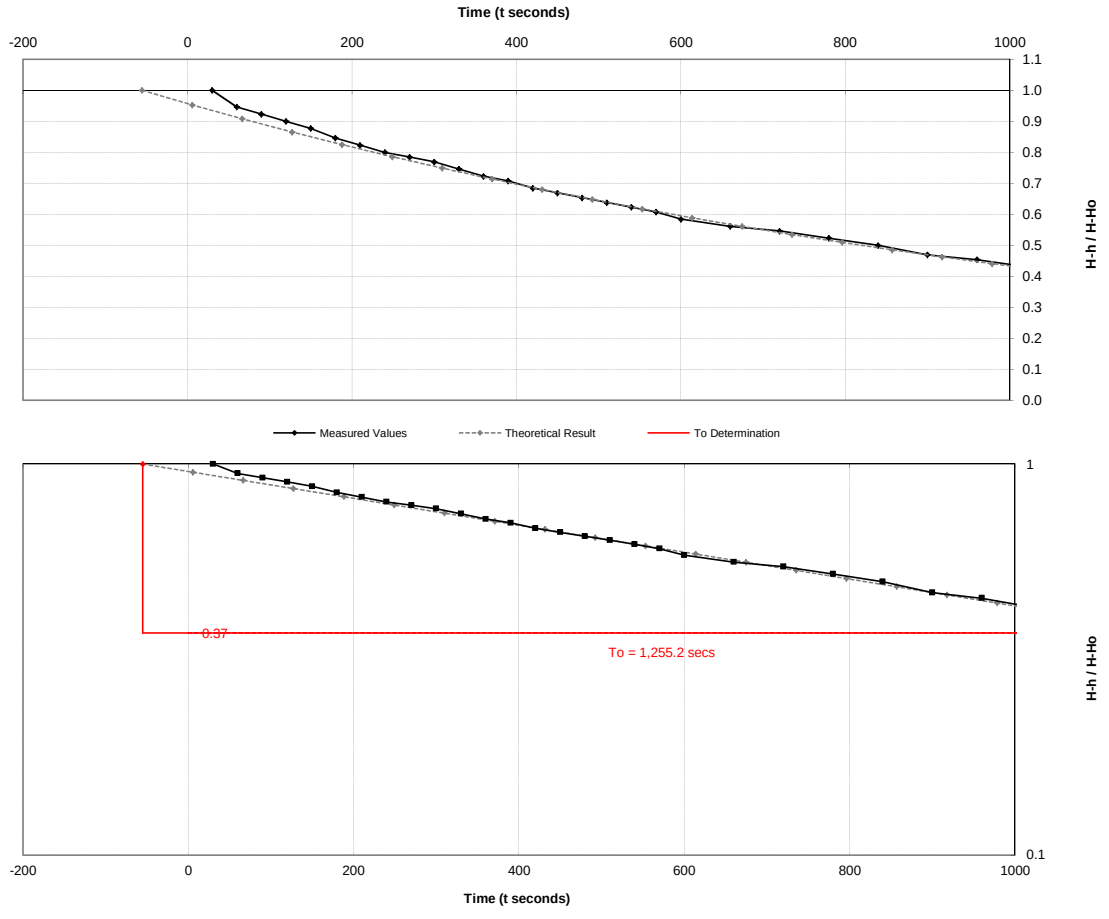
Calibrated Parameters

Intake factor, *F*	7.91
Time Factor, T_0	1,255.2

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	2.111	0.13	1.00
60	2.104	0.12	0.95
90	2.101	0.12	0.92
120	2.098	0.12	0.90
150	2.095	0.11	0.88
180	2.091	0.11	0.85
210	2.088	0.11	0.82
240	2.085	0.10	0.80
270	2.083	0.10	0.78
300	2.081	0.10	0.77
330	2.078	0.10	0.75
360	2.075	0.09	0.72
390	2.073	0.09	0.71
420	2.070	0.09	0.68
450	2.068	0.09	0.67
480	2.066	0.08	0.65
510	2.064	0.08	0.64
540	2.062	0.08	0.62
570	2.060	0.08	0.61
600	2.057	0.08	0.58
660	2.054	0.07	0.56
720	2.052	0.07	0.55
780	2.049	0.07	0.52
840	2.046	0.06	0.50
900	2.042	0.06	0.47
960	2.040	0.06	0.45
1020	2.037	0.06	0.43
1080	2.035	0.05	0.42
1140	2.032	0.05	0.39
1200	2.030	0.05	0.38
1260	2.028	0.05	0.36
1320	2.026	0.04	0.35
1380	2.024	0.04	0.33

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH256

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	5/06/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	5.500 m
Bottom of Screen	12.000 m
Screen Length, *L*	6.500 m
Static Water Level, *H*	1.010 m
Initial Water Level, H_0	1.550 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

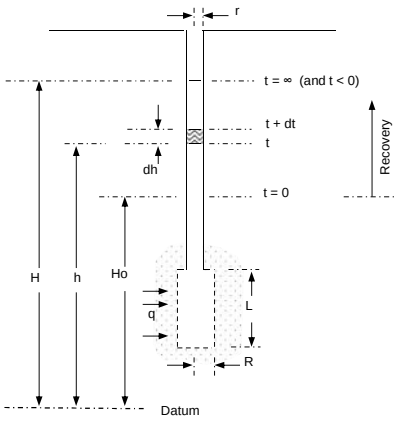
Result

Hydraulic Conductivity

***K* = 4.66E-08 m/s**

4.03E-03 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

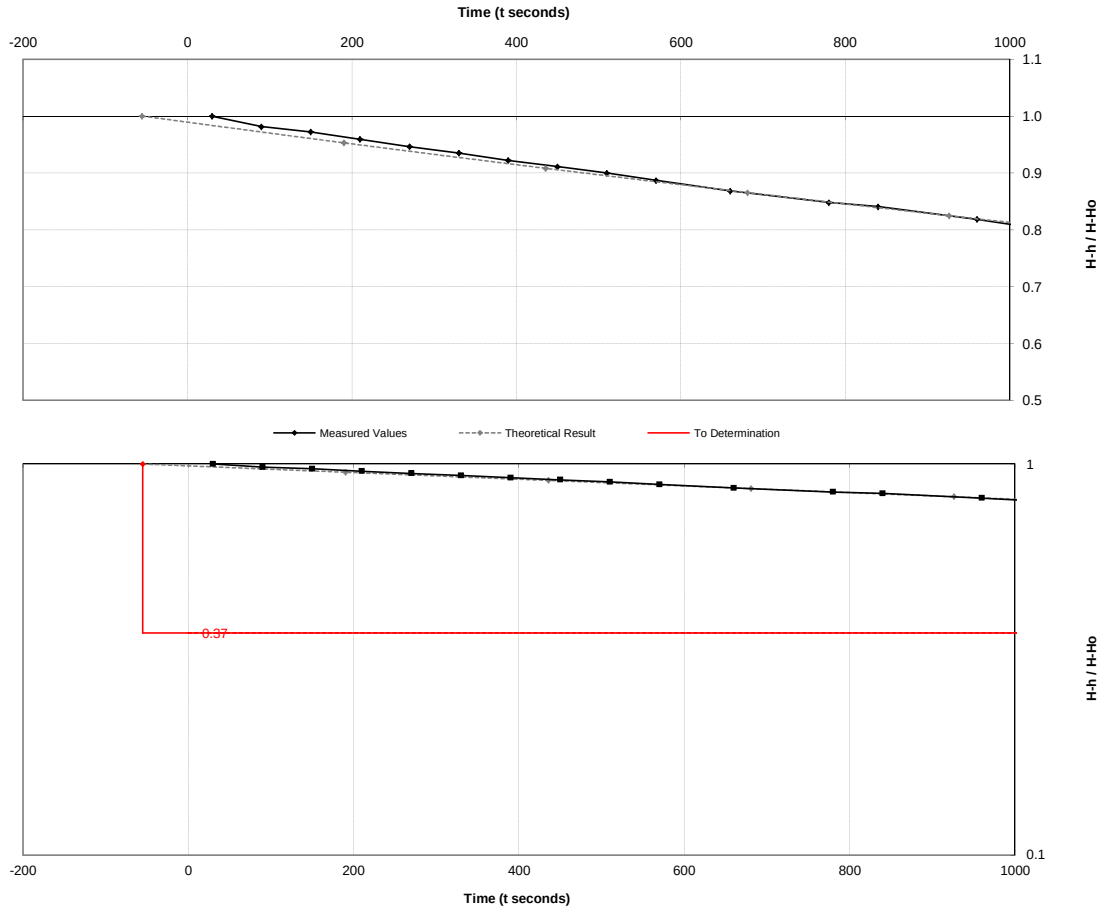
Calibrated Parameters

Intake factor, *F*	8.32
Time Factor, T_0	5,064.8

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	1.550	0.54	1.00
90	1.540	0.53	0.98
150	1.535	0.53	0.97
210	1.528	0.52	0.96
270	1.521	0.51	0.95
330	1.515	0.51	0.94
390	1.508	0.50	0.92
450	1.502	0.49	0.91
510	1.496	0.49	0.90
570	1.489	0.48	0.89
660	1.479	0.47	0.87
780	1.468	0.46	0.85
840	1.464	0.45	0.84
960	1.452	0.44	0.82
1020	1.445	0.44	0.81
1140	1.434	0.42	0.79
1200	1.428	0.42	0.77
1260	1.423	0.41	0.76
1320	1.417	0.41	0.75
1380	1.413	0.40	0.75
1440	1.407	0.40	0.74
1500	1.400	0.39	0.72
1560	1.394	0.38	0.71
1620	1.390	0.38	0.70
1680	1.385	0.38	0.69
1740	1.378	0.37	0.68
1800	1.375	0.37	0.68
2100	1.349	0.34	0.63
2400	1.327	0.32	0.59
2700	1.305	0.30	0.55
3000	1.285	0.28	0.51
3300	1.263	0.25	0.47
3600	1.246	0.24	0.44

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH237

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	19/08/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	5.000 m
Bottom of Screen	8.000 m
Screen Length, *L*	3.000 m
Static Water Level, *H*	11.840 m
Initial Water Level, H_0	11.071 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

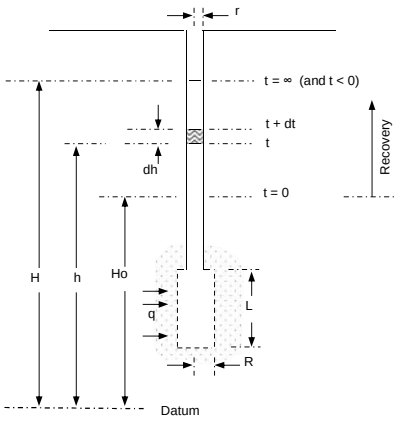
Result

Hydraulic Conductivity

***K* = 1.27E-07 m/s**

1.10E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

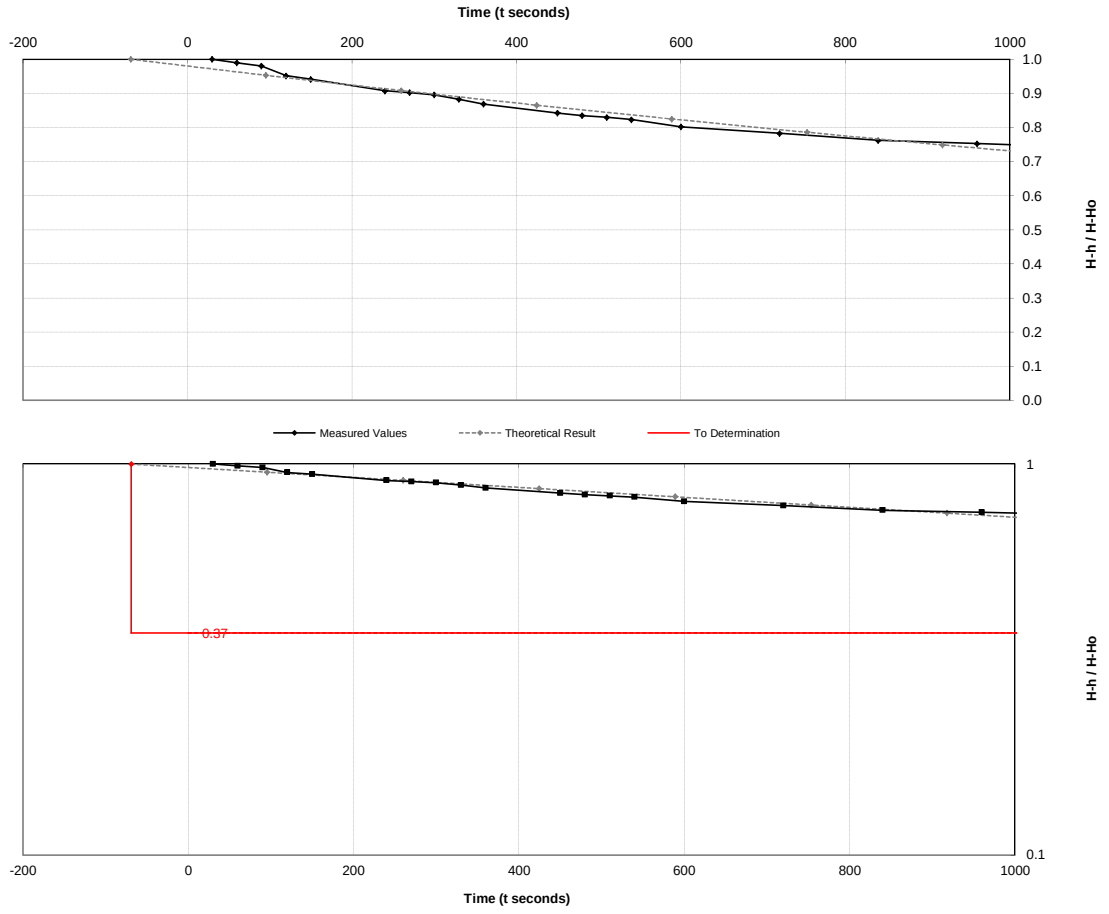
Calibrated Parameters

Intake factor, *F*	4.56
Time Factor, T_0	3,396.0

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	11.071	-0.77	1.00
60	11.079	-0.76	0.99
90	11.086	-0.75	0.98
120	11.108	-0.73	0.95
150	11.116	-0.72	0.94
240	11.142	-0.70	0.91
270	11.146	-0.69	0.90
300	11.151	-0.69	0.90
330	11.161	-0.68	0.88
360	11.172	-0.67	0.87
450	11.192	-0.65	0.84
480	11.198	-0.64	0.83
510	11.202	-0.64	0.83
540	11.207	-0.63	0.82
600	11.223	-0.62	0.80
720	11.238	-0.60	0.78
840	11.254	-0.59	0.76
960	11.261	-0.58	0.75
1320	11.285	-0.56	0.72
1440	11.294	-0.55	0.71
1560	11.304	-0.54	0.70
1680	11.311	-0.53	0.69
1800	11.318	-0.52	0.68
2040	11.334	-0.51	0.66
2160	11.340	-0.50	0.65
2280	11.348	-0.49	0.64
2400	11.355	-0.48	0.63
2880	11.375	-0.47	0.60
3000	11.381	-0.46	0.60
3300	11.403	-0.44	0.57
3600	11.421	-0.42	0.54
3900	11.439	-0.40	0.52
4034	11.444	-0.40	0.51

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH235

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	19/08/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	6.800 m
Bottom of Screen	9.800 m
Screen Length, *L*	3.000 m
Static Water Level, *H*	3.675 m
Initial Water Level, H_0	4.105 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

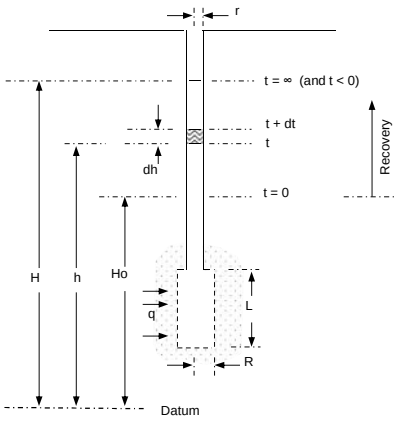
Result

Hydraulic Conductivity

***K* = 1.02E-07 m/s**

8.84E-03 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

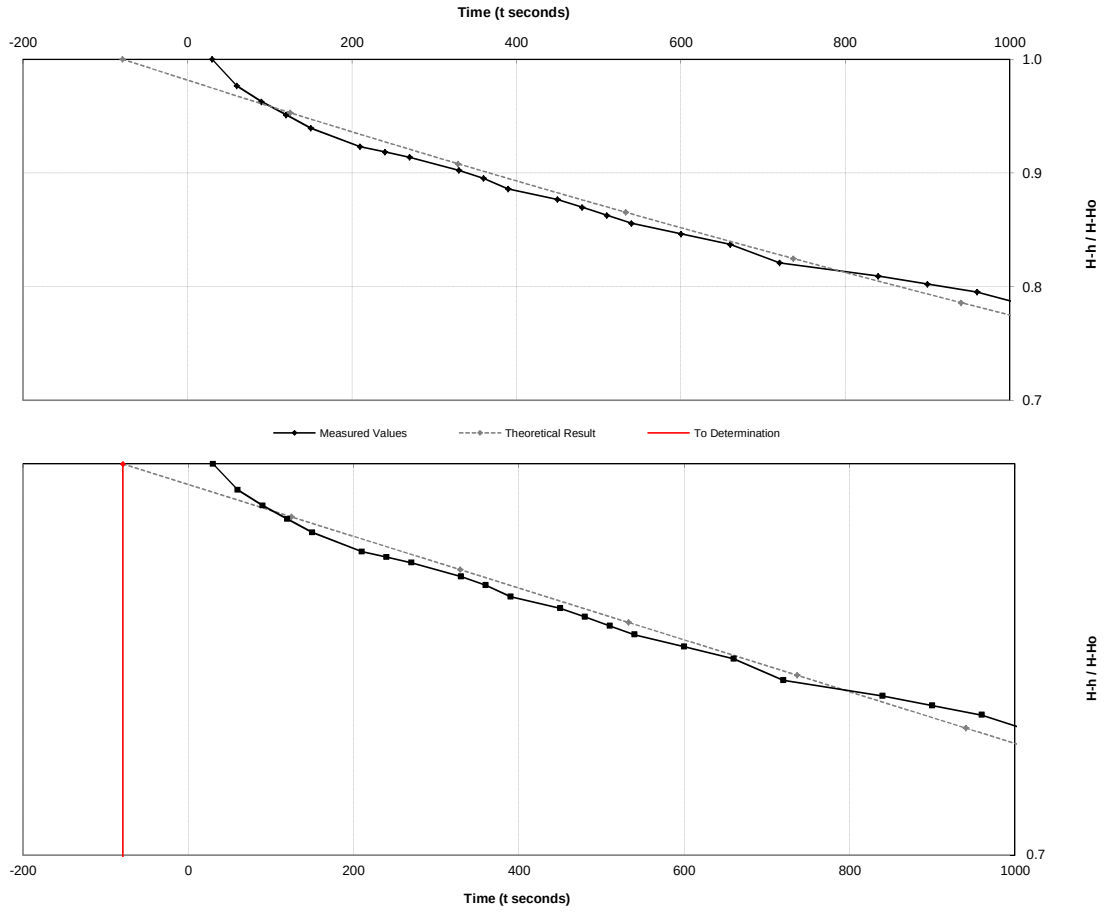
Calibrated Parameters

Intake factor, *F*	4.56
Time Factor, T_0	4,209.8

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	4.105	0.43	1.00
60	4.095	0.42	0.98
90	4.089	0.41	0.96
120	4.084	0.41	0.95
150	4.079	0.40	0.94
210	4.072	0.40	0.92
240	4.070	0.40	0.92
270	4.068	0.39	0.91
330	4.063	0.39	0.90
360	4.060	0.39	0.90
390	4.056	0.38	0.89
450	4.052	0.38	0.88
480	4.049	0.37	0.87
510	4.046	0.37	0.86
540	4.043	0.37	0.86
600	4.039	0.36	0.85
660	4.035	0.36	0.84
720	4.028	0.35	0.82
840	4.023	0.35	0.81
900	4.020	0.35	0.80
960	4.017	0.34	0.80
1020	4.012	0.34	0.78
1260	3.994	0.32	0.74
1320	3.991	0.32	0.73
1380	3.987	0.31	0.73
1500	3.979	0.30	0.71
1740	3.966	0.29	0.68
1800	3.962	0.29	0.67
2400	3.931	0.26	0.60
2700	3.914	0.24	0.56
3000	3.900	0.23	0.52
3300	3.893	0.22	0.51
3600	3.883	0.21	0.48

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH241

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	24/08/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	9.200 m
Bottom of Screen	12.200 m
Screen Length, *L*	3.000 m
Static Water Level, *H*	0.020 m
Initial Water Level, H_0	1.250 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

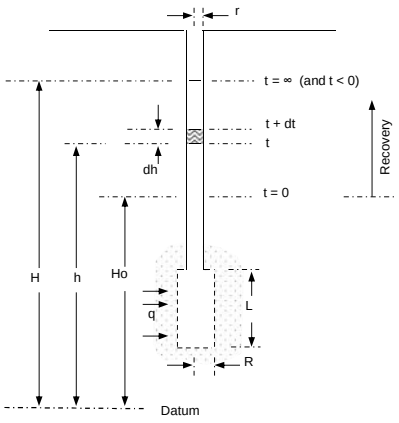
Result

Hydraulic Conductivity

***K* = 2.42E-06 m/s**

2.09E-01 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

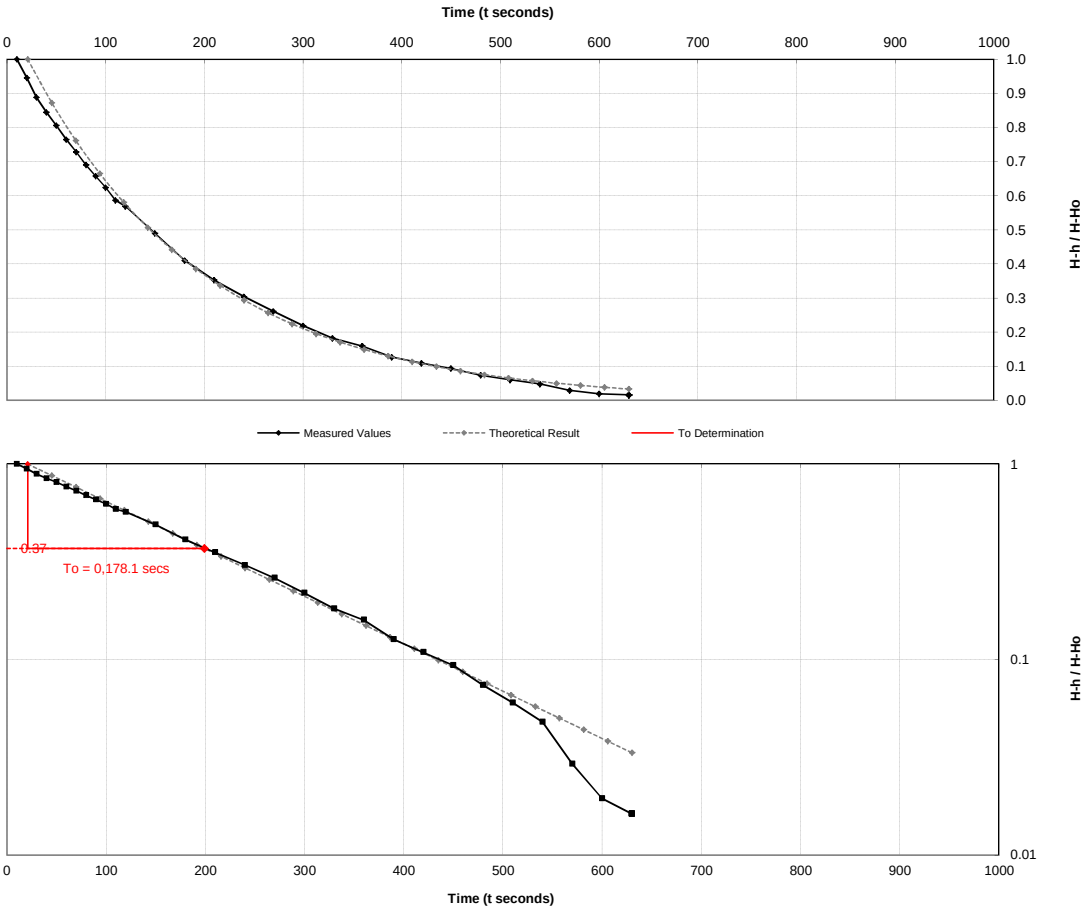
Calibrated Parameters

Intake factor, *F*	4.56
Time Factor, T_0	178.1

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
10	1.250	1.23	1.00
20	1.183	1.16	0.95
30	1.113	1.09	0.89
40	1.059	1.04	0.84
50	1.012	0.99	0.81
60	0.961	0.94	0.77
70	0.916	0.90	0.73
80	0.869	0.85	0.69
90	0.829	0.81	0.66
100	0.788	0.77	0.62
110	0.742	0.72	0.59
120	0.720	0.70	0.57
150	0.623	0.60	0.49
180	0.525	0.51	0.41
210	0.454	0.43	0.35
240	0.394	0.37	0.30
270	0.341	0.32	0.26
300	0.289	0.27	0.22
330	0.244	0.22	0.18
360	0.216	0.20	0.16
390	0.176	0.16	0.13
420	0.154	0.13	0.11
450	0.135	0.12	0.09
480	0.111	0.09	0.07
510	0.094	0.07	0.06
540	0.079	0.06	0.05
570	0.056	0.04	0.03
600	0.044	0.02	0.02
630	0.040	0.02	0.02

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH243

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	26/08/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	18.500 m
Bottom of Screen	24.500 m
Screen Length, *L*	6.000 m
Static Water Level, *H*	0.000 m
Initial Water Level, H_0	1.325 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

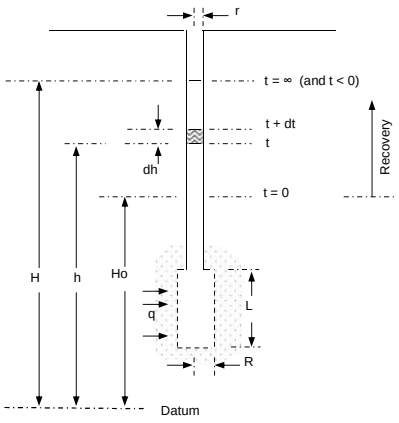
Result

Hydraulic Conductivity

***K* = 4.84E-07 m/s**

4.18E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

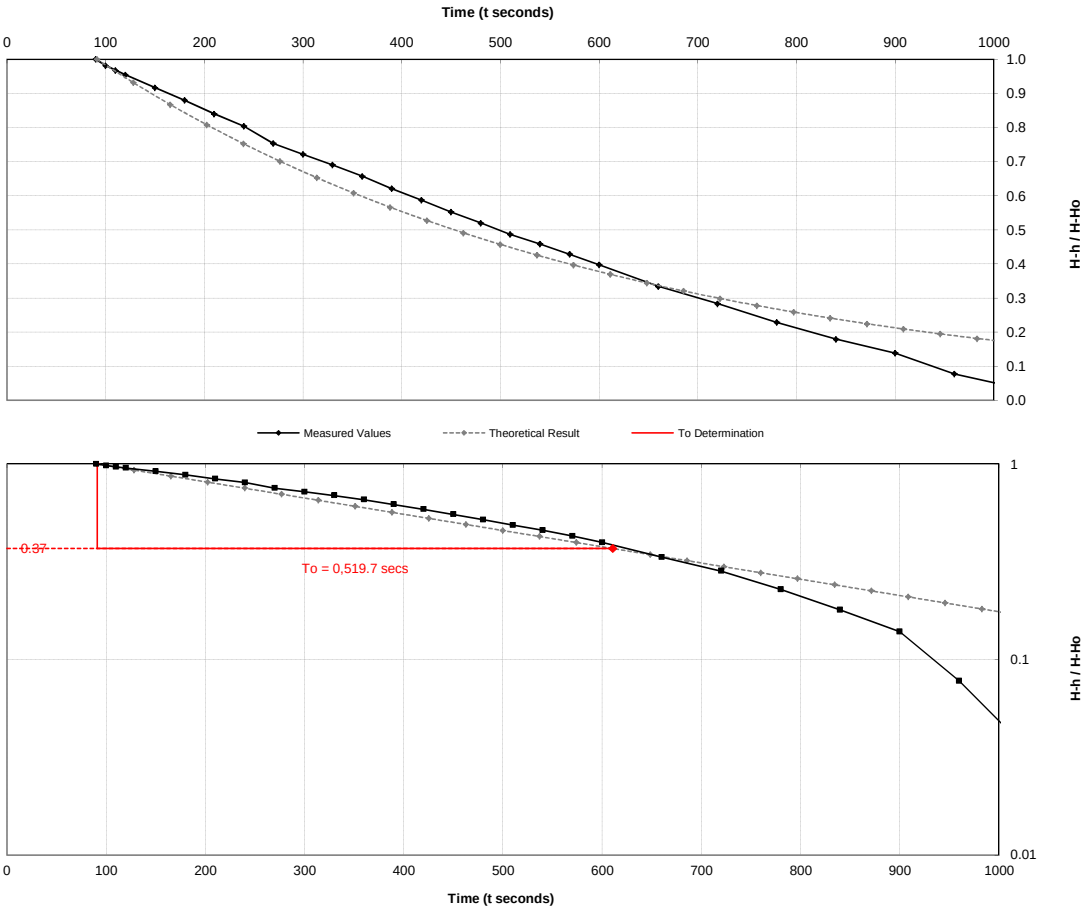
Calibrated Parameters

Intake factor, *F*	7.81
Time Factor, T_0	519.7

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
90	1.325	1.33	1.00
100	1.301	1.30	0.98
110	1.282	1.28	0.97
120	1.265	1.27	0.95
150	1.215	1.22	0.92
180	1.166	1.17	0.88
210	1.113	1.11	0.84
240	1.065	1.07	0.80
270	0.998	1.00	0.75
300	0.956	0.96	0.72
330	0.915	0.92	0.69
360	0.871	0.87	0.66
390	0.823	0.82	0.62
420	0.778	0.78	0.59
450	0.732	0.73	0.55
480	0.689	0.69	0.52
510	0.645	0.65	0.49
540	0.608	0.61	0.46
570	0.568	0.57	0.43
600	0.527	0.53	0.40
660	0.443	0.44	0.33
720	0.376	0.38	0.28
780	0.303	0.30	0.23
840	0.238	0.24	0.18
900	0.184	0.18	0.14
960	0.103	0.10	0.08
1020	0.051	0.05	0.04

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH252

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	18/08/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	85.000 m
Bottom of Screen	100.000 m
Screen Length, *L*	15.000 m
Static Water Level, *H*	17.105 m
Initial Water Level, H_0	17.615 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

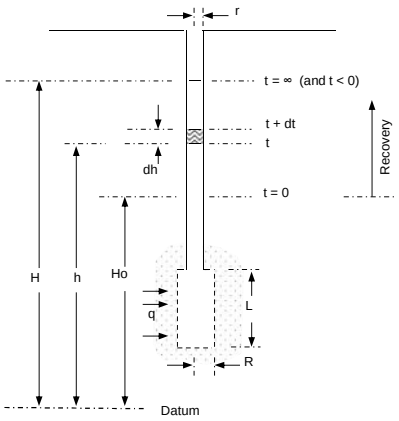
Result

Hydraulic Conductivity

***K* = 4.25E-08 m/s**

3.67E-03 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

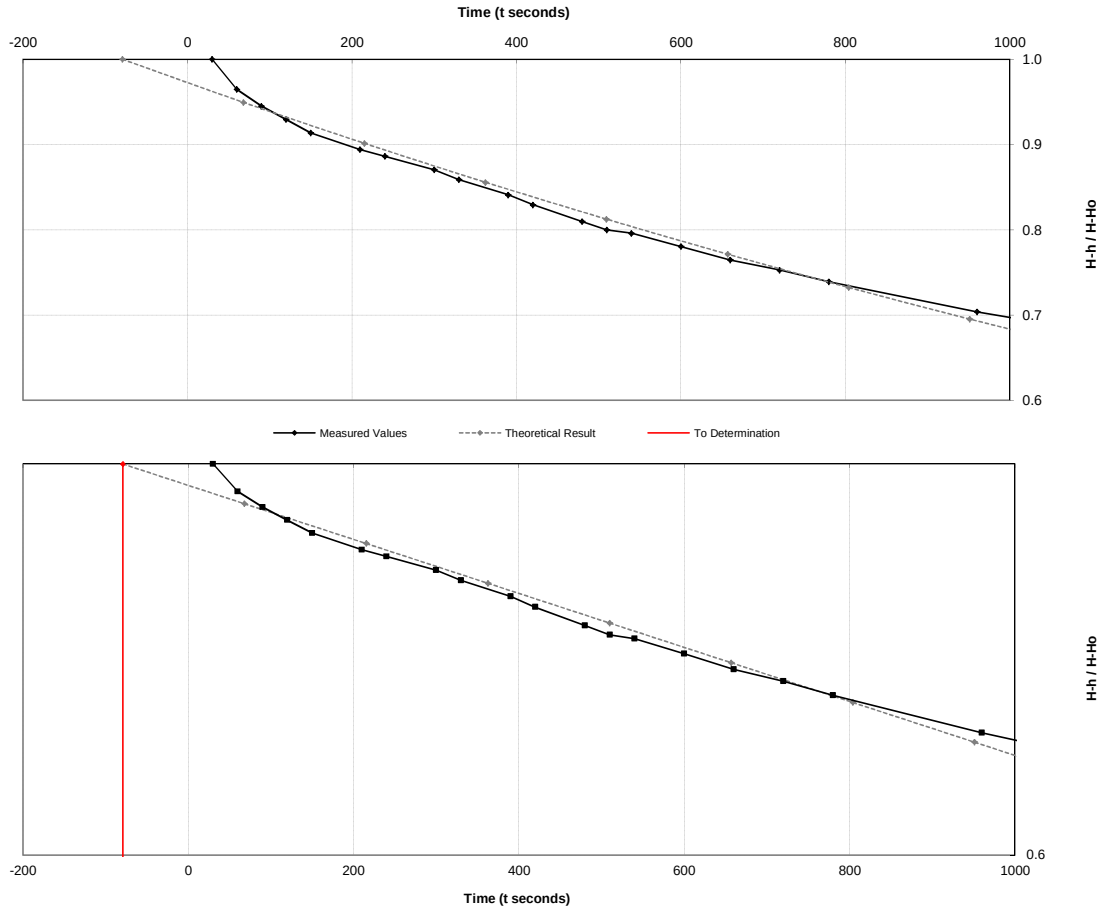
Calibrated Parameters

Intake factor, *F*	16.41
Time Factor, T_0	2,818.9

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	17.615	0.51	1.00
60	17.597	0.49	0.96
90	17.587	0.48	0.95
120	17.579	0.47	0.93
150	17.571	0.47	0.91
210	17.561	0.46	0.89
240	17.557	0.45	0.89
300	17.549	0.44	0.87
330	17.543	0.44	0.86
390	17.534	0.43	0.84
420	17.528	0.42	0.83
480	17.518	0.41	0.81
510	17.513	0.41	0.80
540	17.511	0.41	0.80
600	17.503	0.40	0.78
660	17.495	0.39	0.76
720	17.489	0.38	0.75
780	17.482	0.38	0.74
960	17.464	0.36	0.70
1020	17.459	0.35	0.69
1080	17.454	0.35	0.68
1140	17.448	0.34	0.67
1320	17.431	0.33	0.64
1380	17.426	0.32	0.63
1440	17.421	0.32	0.62
1560	17.413	0.31	0.60
1620	17.407	0.30	0.59
1680	17.403	0.30	0.58
2400	17.357	0.25	0.49
2700	17.341	0.24	0.46
3000	17.325	0.22	0.43
3300	17.310	0.20	0.40
3600	17.295	0.19	0.37

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH259

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	24/08/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	27.000 m
Bottom of Screen	30.000 m
Screen Length, *L*	3.000 m
Static Water Level, *H*	2.453 m
Initial Water Level, H_0	2.964 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

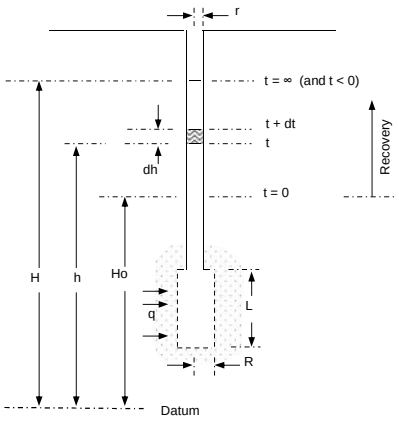
Result

Hydraulic Conductivity

***K* = 7.51E-07 m/s**

6.49E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

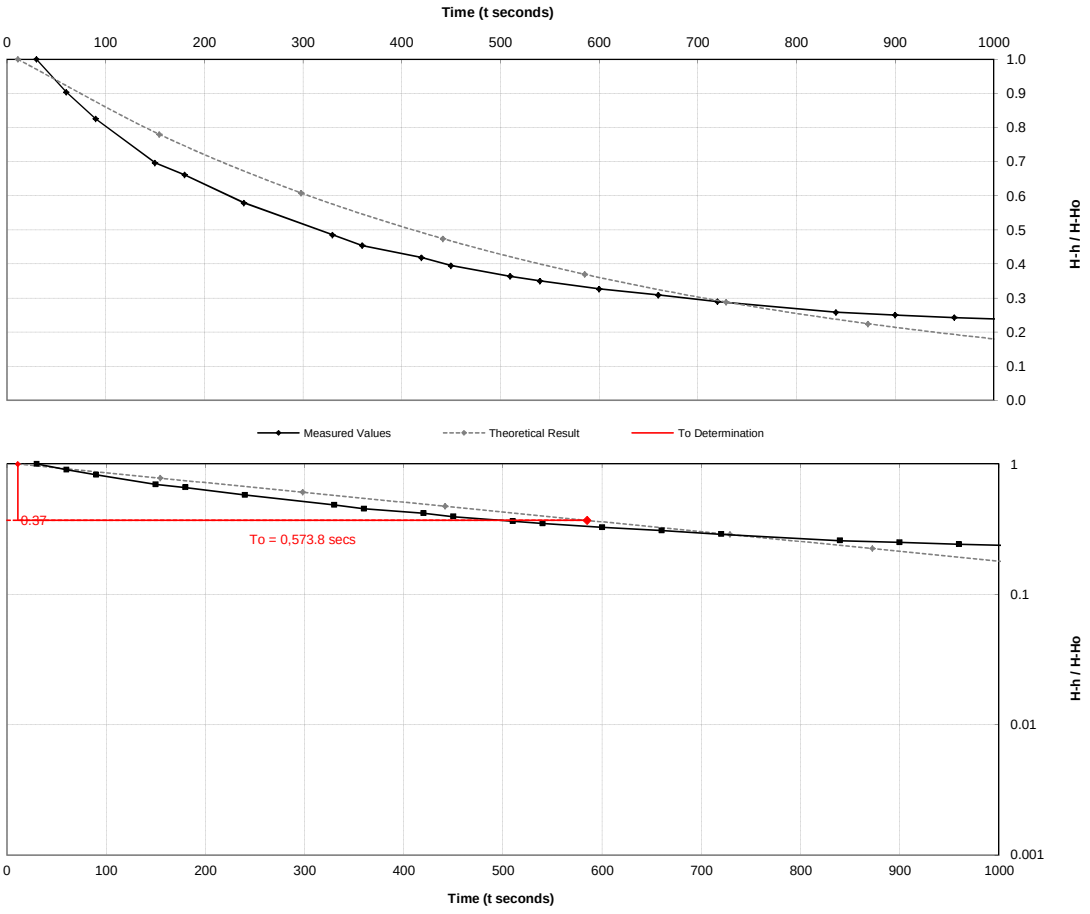
Calibrated Parameters

Intake factor, *F*	4.56
Time Factor, T_0	573.8

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	2.964	0.51	1.00
60	2.915	0.46	0.90
90	2.875	0.42	0.83
150	2.809	0.36	0.70
180	2.791	0.34	0.66
240	2.749	0.30	0.58
330	2.701	0.25	0.49
360	2.685	0.23	0.45
420	2.667	0.21	0.42
450	2.655	0.20	0.40
510	2.639	0.19	0.36
540	2.632	0.18	0.35
600	2.620	0.17	0.33
660	2.611	0.16	0.31
720	2.601	0.15	0.29
840	2.585	0.13	0.26
900	2.581	0.13	0.25
960	2.577	0.12	0.24
1080	2.571	0.12	0.23
1140	2.568	0.12	0.23
1200	2.565	0.11	0.22
1320	2.560	0.11	0.21
1380	2.558	0.11	0.21
1440	2.556	0.10	0.20
1560	2.553	0.10	0.20
1620	2.552	0.10	0.19
1680	2.551	0.10	0.19
1800	2.549	0.10	0.19
2100	2.542	0.09	0.17
2400	2.539	0.09	0.17
3000	2.533	0.08	0.16
3300	2.530	0.08	0.15
3600	2.528	0.08	0.15

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH268

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	26/08/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	29.200 m
Bottom of Screen	32.200 m
Screen Length, *L*	3.000 m
Static Water Level, *H*	1.525 m
Initial Water Level, H_0	1.891 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

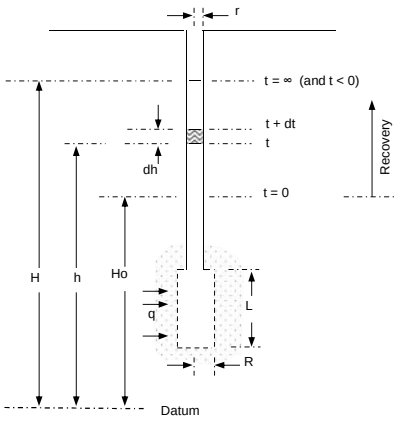
Result

Hydraulic Conductivity

***K* = 3.09E-06 m/s**

2.67E-01 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

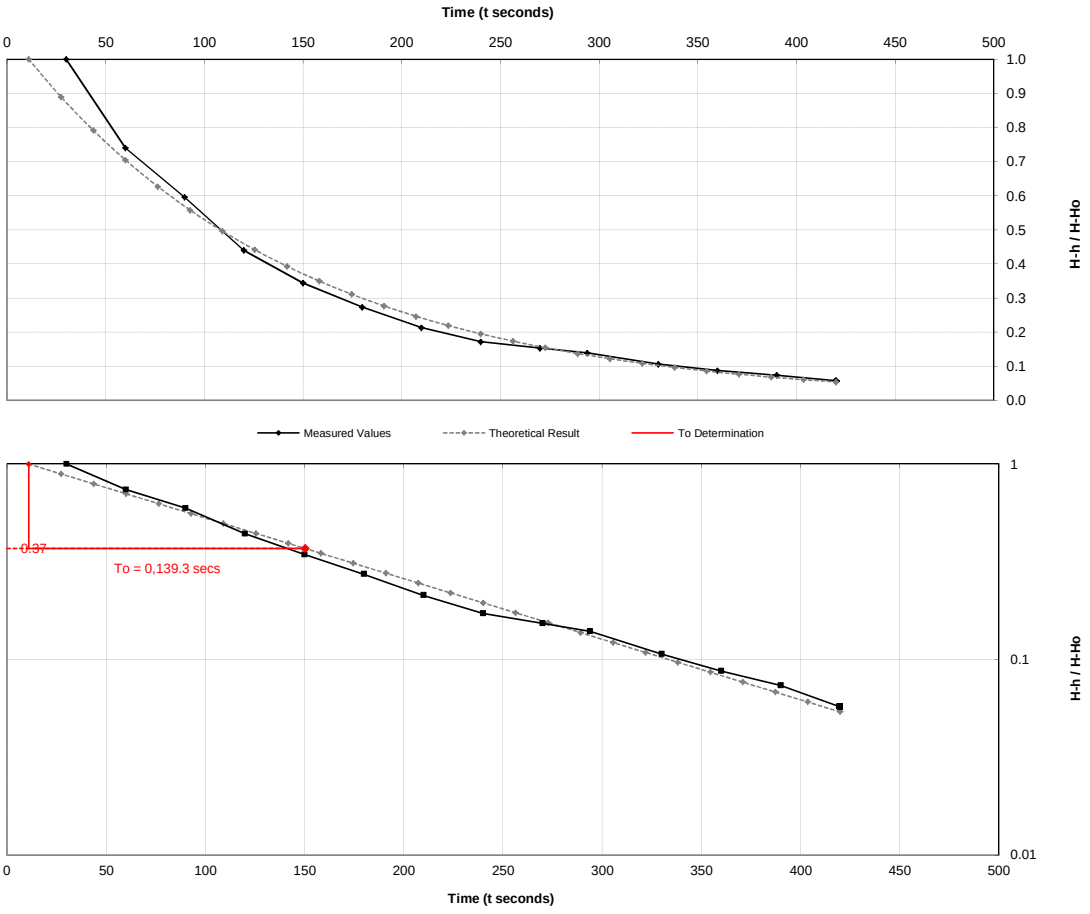
Calibrated Parameters

Intake factor, *F*	4.56
Time Factor, T_0	139.3

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	1.891	0.37	1.00
60	1.796	0.27	0.74
90	1.743	0.22	0.60
120	1.686	0.16	0.44
150	1.651	0.13	0.34
180	1.625	0.10	0.27
210	1.603	0.08	0.21
240	1.588	0.06	0.17
270	1.581	0.06	0.15
294	1.576	0.05	0.14
330	1.564	0.04	0.11
360	1.557	0.03	0.09
390	1.552	0.03	0.07
420	1.546	0.02	0.06

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH273

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	26/08/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	41.000 m
Bottom of Screen	50.000 m
Screen Length, *L*	9.000 m
Static Water Level, *H*	1.629 m
Initial Water Level, H_0	1.182 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

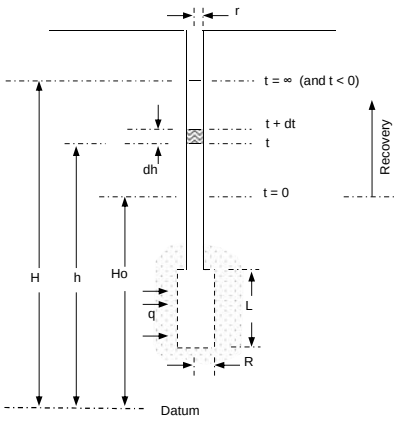
Result

Hydraulic Conductivity

***K* = 7.68E-08 m/s**

6.63E-03 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

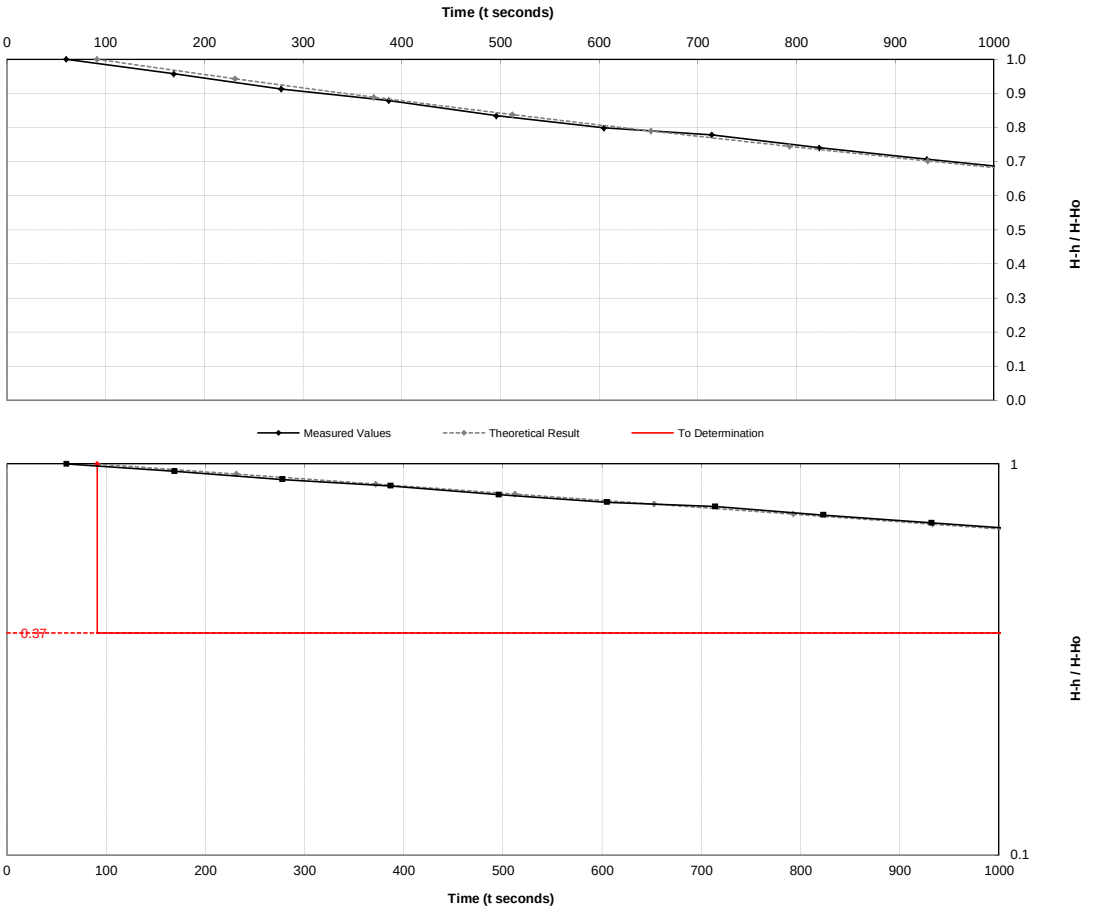
Calibrated Parameters

Intake factor, *F*	10.80
Time Factor, T_0	2,366.9

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
60	1.182	-0.45	1.00
169	1.201	-0.43	0.96
278	1.221	-0.41	0.91
387	1.236	-0.39	0.88
496	1.256	-0.37	0.83
605	1.272	-0.36	0.80
714	1.281	-0.35	0.78
823	1.298	-0.33	0.74
932	1.313	-0.32	0.71
1041	1.327	-0.30	0.68
1150	1.341	-0.29	0.64
1259	1.347	-0.28	0.63
1368	1.360	-0.27	0.60
1477	1.371	-0.26	0.58
1586	1.381	-0.25	0.55
1695	1.392	-0.24	0.53
1804	1.401	-0.23	0.51
1913	1.401	-0.23	0.51
2022	1.401	-0.23	0.51
2131	1.423	-0.21	0.46
2240	1.423	-0.21	0.46
2349	1.423	-0.21	0.46
2458	1.443	-0.19	0.42
2567	1.443	-0.19	0.42
2676	1.443	-0.19	0.42
2785	1.460	-0.17	0.38
2894	1.460	-0.17	0.38
3003	1.476	-0.15	0.34
3112	1.476	-0.15	0.34
3221	1.476	-0.15	0.34
3330	1.488	-0.14	0.32
3439	1.488	-0.14	0.32
3600	1.498	-0.13	0.29

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS Borehole Variable Head Permeability Test

Borehole ID

BH273

Project Details

Project Name	Central Interceptor
Project Number	AE04725
Test Date	26/08/2015
Tested	EF
Checked	MT

Test Parameters

Top of screen	41.000 m
Bottom of Screen	50.000 m
Screen Length, *L*	9.000 m
Static Water Level, *H*	4.614 m
Initial Water Level, H_0	4.963 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

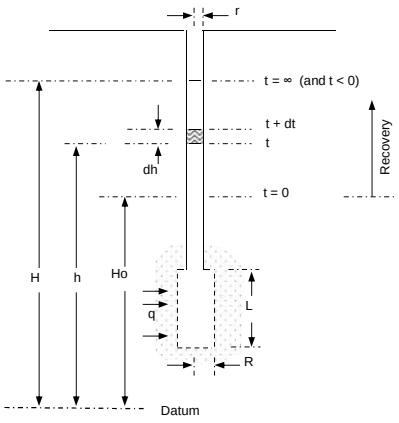
Result

Hydraulic Conductivity

***K* = 1.42E-07 m/s**

1.23E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

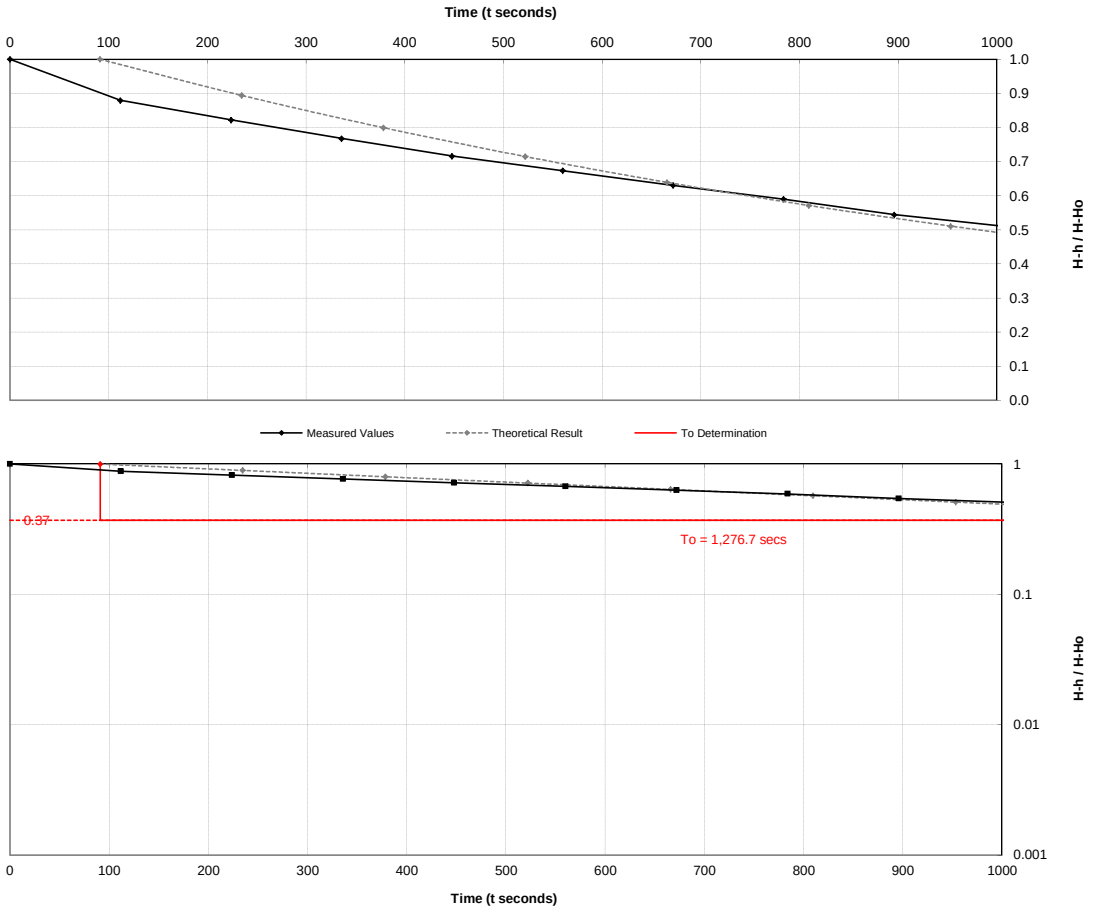
Calibrated Parameters

Intake factor, *F*	10.80
Time Factor, T_0	1,276.7

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
0	4.963	0.35	1.00
112	4.921	0.31	0.88
224	4.901	0.29	0.82
336	4.882	0.27	0.77
448	4.864	0.25	0.72
560	4.849	0.24	0.67
672	4.834	0.22	0.63
784	4.820	0.21	0.59
896	4.804	0.19	0.54
1008	4.792	0.18	0.51
1120	4.782	0.17	0.48
1232	4.769	0.16	0.44
1344	4.757	0.14	0.41
1456	4.750	0.14	0.39
1568	4.735	0.12	0.35
1680	4.728	0.11	0.33
1792	4.720	0.11	0.30
1904	4.711	0.10	0.28
2016	4.700	0.09	0.25
2128	4.697	0.08	0.24
2240	4.690	0.08	0.22
2352	4.679	0.07	0.19
2464	4.675	0.06	0.17
2576	4.667	0.05	0.15
2688	4.657	0.04	0.12
2800	4.653	0.04	0.11
2912	4.646	0.03	0.09
3024	4.643	0.03	0.08
3136	4.639	0.03	0.07
3248	4.630	0.02	0.05
3360	4.625	0.01	0.03
3472	4.624	0.01	0.03
3684	4.615	0.00	0.00

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS® Borehole Variable Head Permeability Test

Borehole ID

BH503

Project Details

Project Name	Central Interceptor
Project Number	IZ027500
Test Date	14/11/2016
Tested	CJS
Checked	MT

Test Parameters

Top of screen	27.200 m
Bottom of Screen	28.000 m
Screen Length, *L*	0.800 m
Static Water Level, *H*	0.000 m
Initial Water Level, H_0	36.878 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

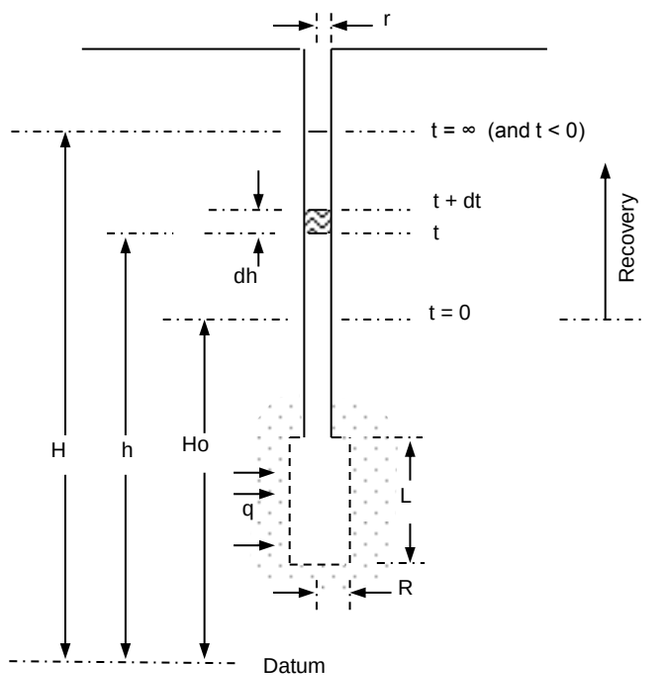
Result

Hydraulic Conductivity

***K* = 1.98E-06 m/s**

1.71E-01 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

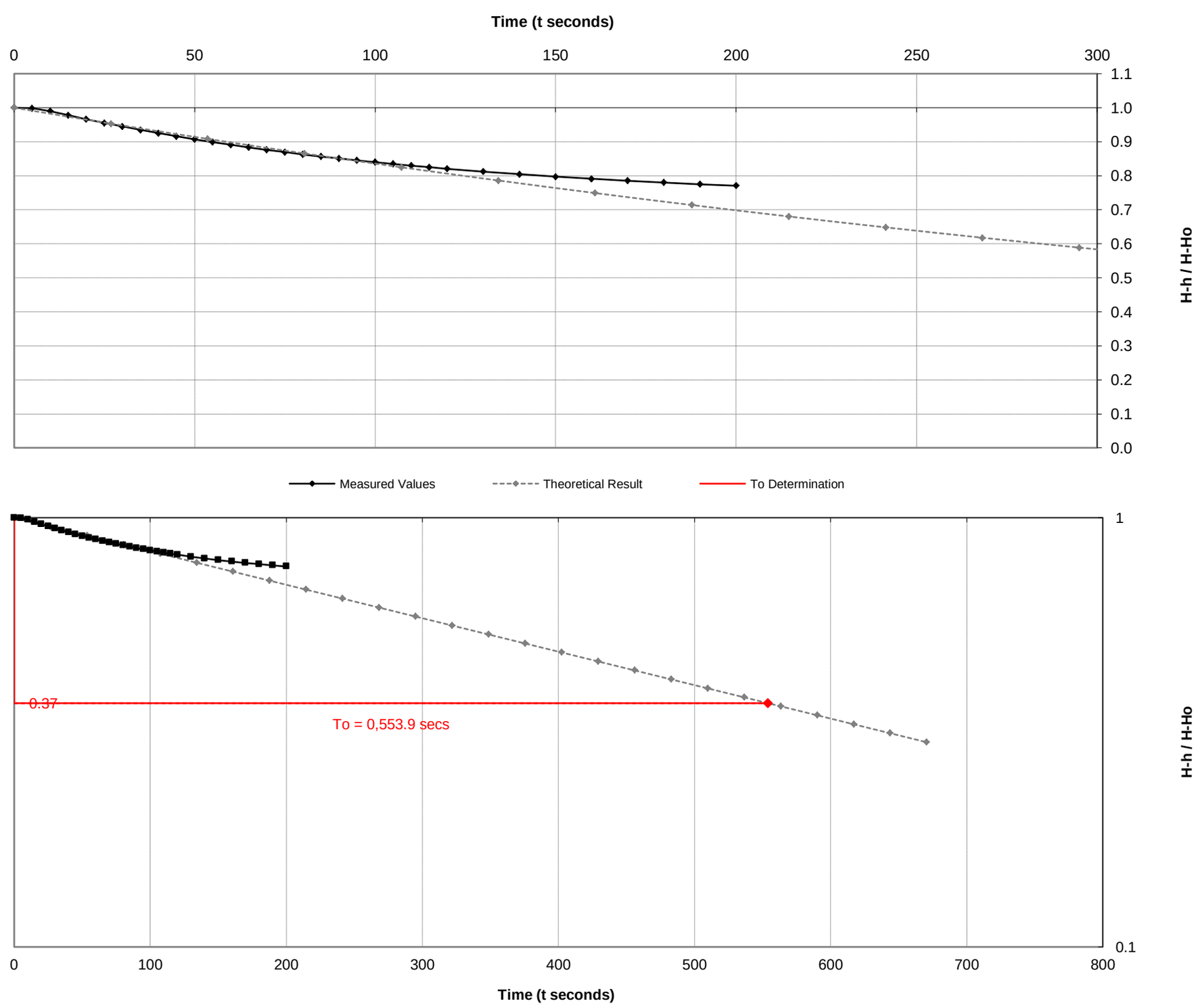
Calibrated Parameters

Intake factor, *F*	1.79
Time Factor, T_0	553.9

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
0	36.878	36.88	1.00
5	36.813	36.81	1.00
10	36.503	36.50	0.99
15	36.057	36.06	0.98
20	35.630	35.63	0.97
25	35.221	35.22	0.96
30	34.834	34.83	0.94
35	34.466	34.47	0.93
40	34.112	34.11	0.92
45	33.776	33.78	0.92
50	33.455	33.46	0.91
55	33.152	33.15	0.90
60	32.860	32.86	0.89
65	32.582	32.58	0.88
70	32.316	32.32	0.88
75	32.064	32.06	0.87
80	31.823	31.82	0.86
85	31.593	31.59	0.86
90	31.374	31.37	0.85
95	31.173	31.17	0.85
100	30.969	30.97	0.84
105	30.779	30.78	0.83
110	30.593	30.59	0.83
115	30.421	30.42	0.82
120	30.254	30.25	0.82
130	29.943	29.94	0.81
140	29.662	29.66	0.80
150	29.403	29.40	0.80
160	29.169	29.17	0.79
170	28.958	28.96	0.79
180	28.761	28.76	0.78
190	28.582	28.58	0.78
200	28.421	28.42	0.77

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS® Borehole Variable Head Permeability Test

Borehole ID

BH503

Project Details

Project Name	Central Interceptor
Project Number	IZ027500
Test Date	14/11/2016
Tested	CJS
Checked	MT

Test Parameters

Top of screen	21.300 m
Bottom of Screen	24.500 m
Screen Length, *L*	3.200 m
Static Water Level, *H*	0.000 m
Initial Water Level, H_0	36.621 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

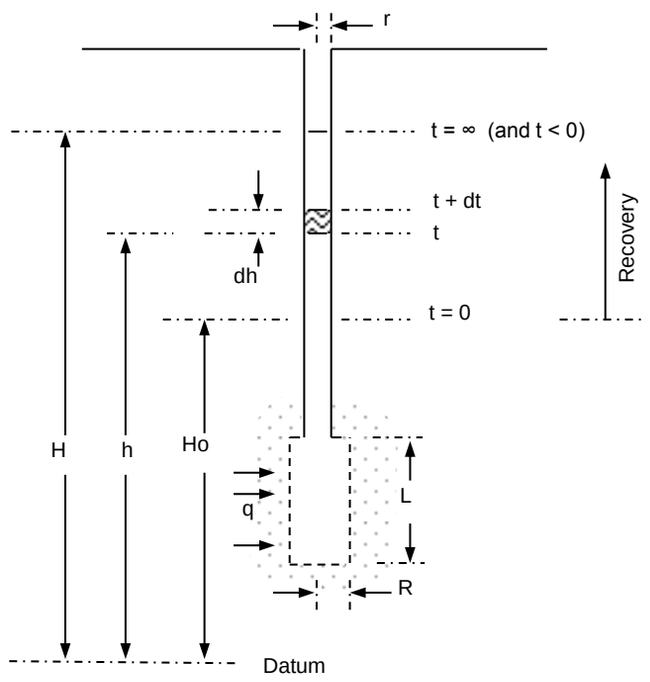
Result

Hydraulic Conductivity

***K* = 3.20E-06 m/s**

2.77E-01 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

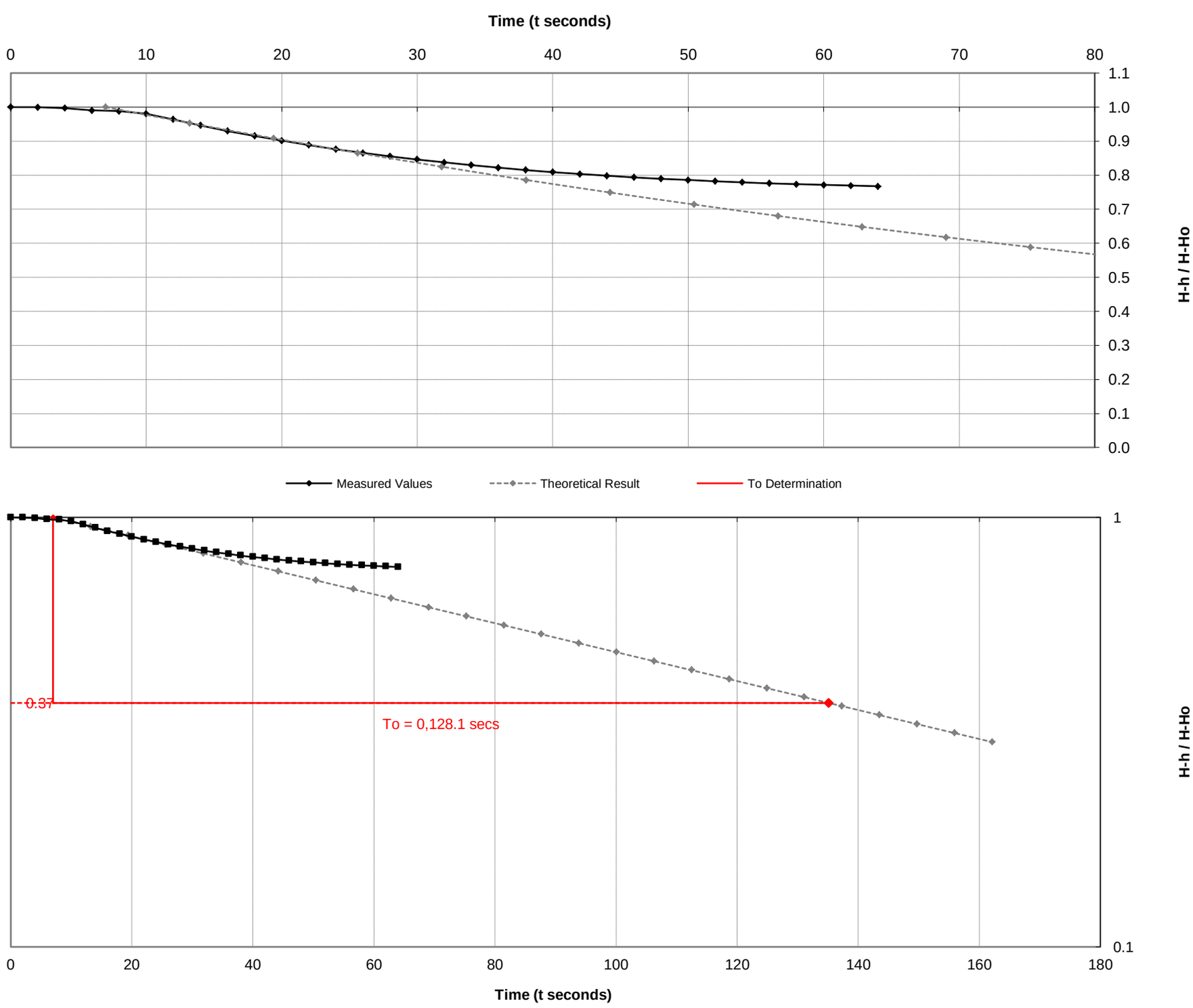
Calibrated Parameters

Intake factor, *F*	4.79
Time Factor, T_0	128.1

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
0	36.621	36.62	1.00
2	36.599	36.60	1.00
4	36.508	36.51	1.00
6	36.264	36.26	0.99
8	36.183	36.18	0.99
10	35.902	35.90	0.98
12	35.300	35.30	0.96
14	34.654	34.65	0.95
16	34.059	34.06	0.93
18	33.519	33.52	0.92
20	33.011	33.01	0.90
22	32.540	32.54	0.89
24	32.095	32.10	0.88
26	31.694	31.69	0.87
28	31.325	31.33	0.86
30	30.982	30.98	0.85
32	30.668	30.67	0.84
34	30.376	30.38	0.83
36	30.106	30.11	0.82
38	29.861	29.86	0.82
40	29.631	29.63	0.81
42	29.427	29.43	0.80
44	29.237	29.24	0.80
46	29.069	29.07	0.79
48	28.912	28.91	0.79
50	28.770	28.77	0.79
52	28.642	28.64	0.78
54	28.525	28.53	0.78
56	28.423	28.42	0.78
58	28.325	28.33	0.77
60	28.241	28.24	0.77
62	28.164	28.16	0.77
64	28.095	28.10	0.77

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS® Borehole Variable Head Permeability Test

Borehole ID

BH503

Project Details

Project Name	Central Interceptor
Project Number	IZ027500
Test Date	14/11/2016
Tested	CJS
Checked	MT

Test Parameters

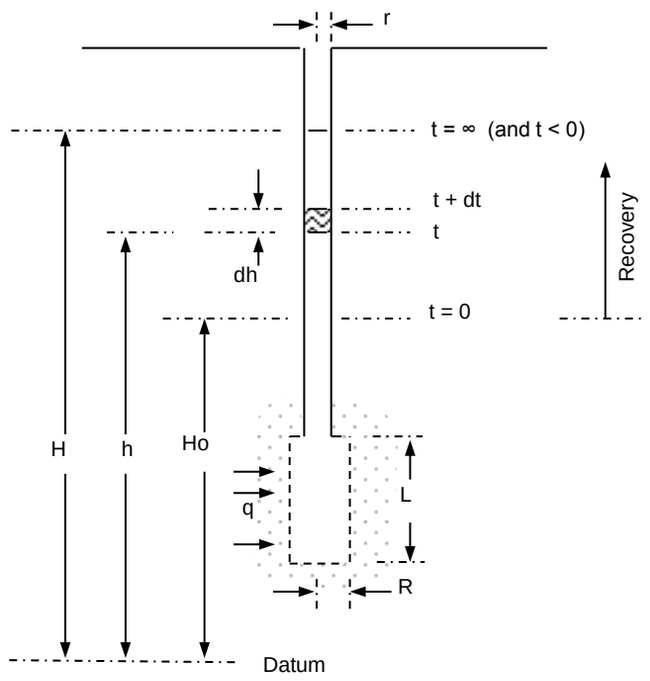
Top of screen	17.300 m
Bottom of Screen	27.100 m
Screen Length, *L*	9.800 m
Static Water Level, *H*	0.000 m
Initial Water Level, H_0	33.671 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

Result

Hydraulic Conductivity
***K* = 5.96E-07 m/s**
5.15E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

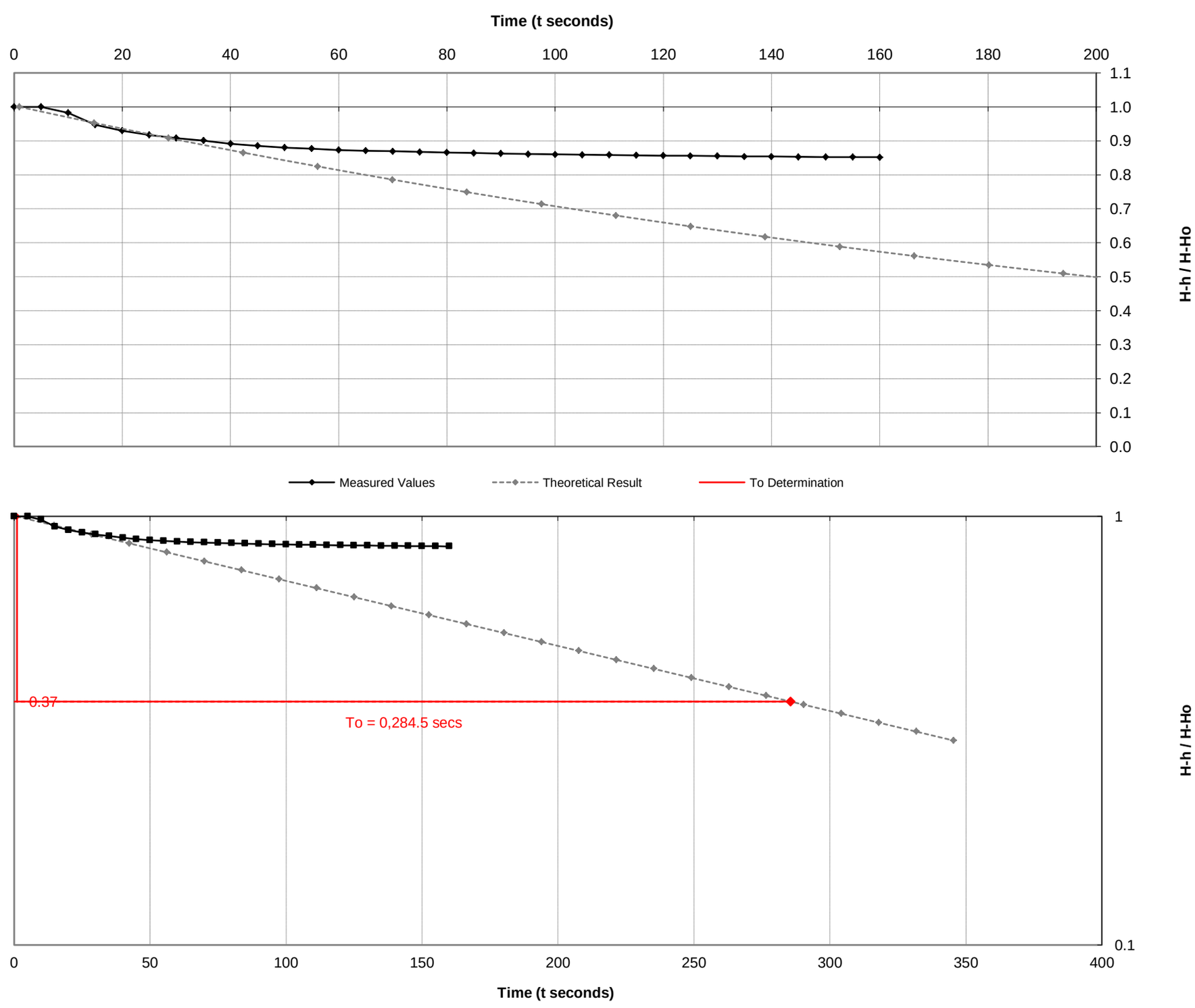
Calibrated Parameters

Intake factor, *F*	11.58
Time Factor, T_0	284.5

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
0	33.671	33.67	1.00
5	33.671	33.67	1.00
10	33.079	33.08	0.98
15	31.893	31.89	0.95
20	31.302	31.30	0.93
25	30.897	30.90	0.92
30	30.579	30.58	0.91
35	30.327	30.33	0.90
40	30.021	30.02	0.89
45	29.816	29.82	0.89
50	29.645	29.65	0.88
55	29.528	29.53	0.88
60	29.404	29.40	0.87
65	29.331	29.33	0.87
70	29.269	29.27	0.87
75	29.210	29.21	0.87
80	29.159	29.16	0.87
85	29.101	29.10	0.86
90	29.050	29.05	0.86
95	29.002	29.00	0.86
100	28.966	28.97	0.86
105	28.933	28.93	0.86
110	28.904	28.90	0.86
115	28.867	28.87	0.86
120	28.838	28.84	0.86
125	28.816	28.82	0.86
130	28.798	28.80	0.86
135	28.761	28.76	0.85
140	28.747	28.75	0.85
145	28.721	28.72	0.85
150	28.707	28.71	0.85
155	28.696	28.70	0.85
160	28.681	28.68	0.85

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS® Borehole Variable Head Permeability Test

Borehole ID

BH509

Project Details

Project Name	Central Interceptor
Project Number	IZ027500
Test Date	14/11/2016
Tested	CJS
Checked	MT

Test Parameters

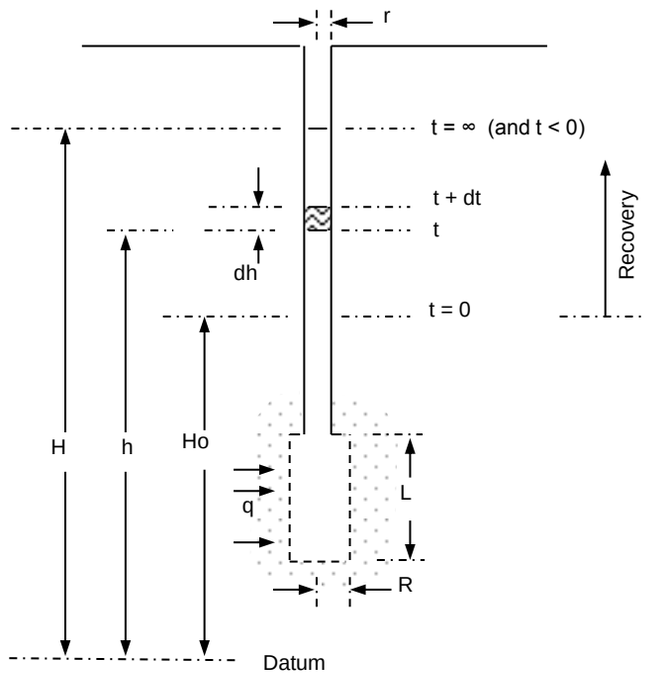
Top of screen	30.000 m
Bottom of Screen	33.000 m
Screen Length, *L*	3.000 m
Static Water Level, *H*	0.000 m
Initial Water Level, H_0	39.636 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

Result

Hydraulic Conductivity
***K* = 2.08E-06 m/s**
1.80E-01 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

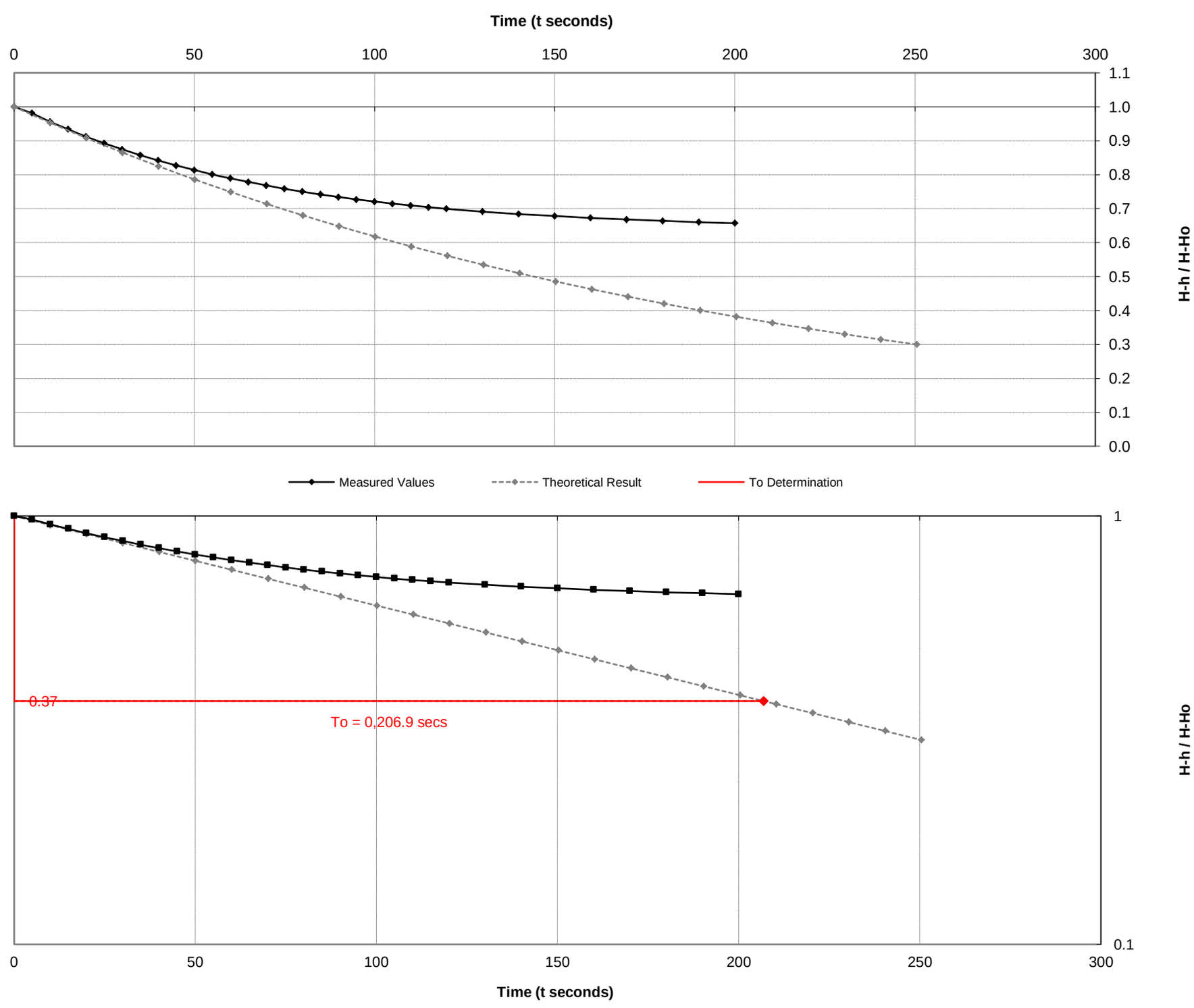
Calibrated Parameters

Intake factor, *F*	4.56
Time Factor, T_0	206.9

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
0	39.636	39.64	1.00
5	38.899	38.90	0.98
10	37.880	37.88	0.96
15	37.008	37.01	0.93
20	36.154	36.15	0.91
25	35.391	35.39	0.89
30	34.668	34.67	0.87
35	33.997	34.00	0.86
40	33.372	33.37	0.84
45	32.788	32.79	0.83
50	32.248	32.25	0.81
55	31.748	31.75	0.80
60	31.288	31.29	0.79
65	30.854	30.85	0.78
70	30.449	30.45	0.77
75	30.073	30.07	0.76
80	29.726	29.73	0.75
85	29.405	29.41	0.74
90	29.102	29.10	0.73
95	28.821	28.82	0.73
100	28.569	28.57	0.72
105	28.332	28.33	0.71
110	28.116	28.12	0.71
115	27.916	27.92	0.70
120	27.729	27.73	0.70
130	27.405	27.41	0.69
140	27.124	27.12	0.68
150	26.883	26.88	0.68
160	26.671	26.67	0.67
170	26.488	26.49	0.67
180	26.324	26.32	0.66
190	26.185	26.19	0.66
200	26.061	26.06	0.66

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS® Borehole Variable Head Permeability Test

Borehole ID

BH509

Project Details

Project Name	Central Interceptor
Project Number	IZ027500
Test Date	14/11/2016
Tested	CJS
Checked	MT

Test Parameters

Top of screen	18.000 m
Bottom of Screen	19.200 m
Screen Length, *L*	1.200 m
Static Water Level, *H*	0.000 m
Initial Water Level, H_0	40.259 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

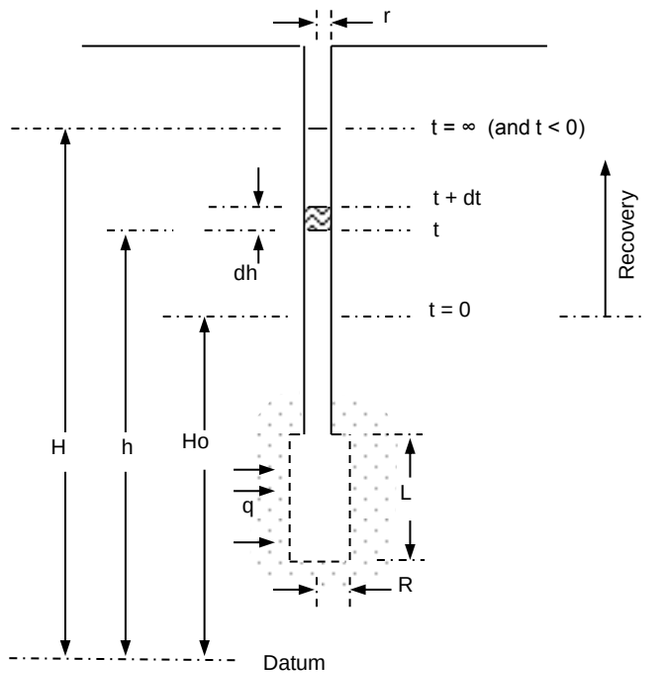
Result

Hydraulic Conductivity

***K* = 3.75E-07 m/s**

3.24E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

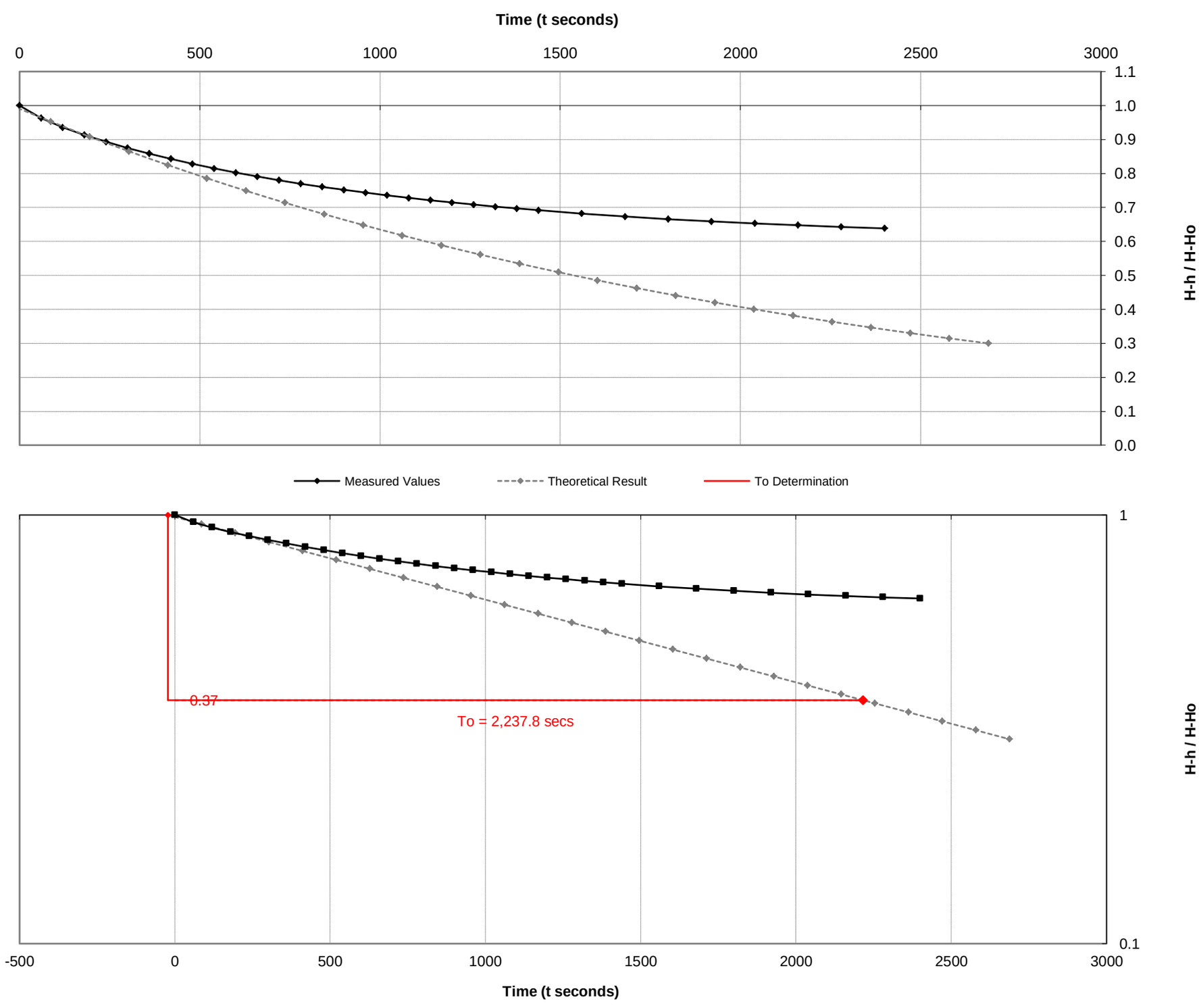
Calibrated Parameters

Intake factor, *F*	2.34
Time Factor, T_0	2,237.8

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
0	40.259	40.26	1.00
60	38.755	38.76	0.96
120	37.671	37.67	0.94
180	36.763	36.76	0.91
240	35.967	35.97	0.89
300	35.240	35.24	0.88
360	34.569	34.57	0.86
420	33.934	33.93	0.84
480	33.346	33.35	0.83
540	32.802	32.80	0.81
600	32.302	32.30	0.80
660	31.835	31.84	0.79
720	31.404	31.40	0.78
780	30.999	31.00	0.77
840	30.619	30.62	0.76
900	30.262	30.26	0.75
960	29.930	29.93	0.74
1020	29.612	29.61	0.74
1080	29.316	29.32	0.73
1140	29.032	29.03	0.72
1200	28.769	28.77	0.71
1260	28.517	28.52	0.71
1320	28.280	28.28	0.70
1380	28.057	28.06	0.70
1440	27.845	27.85	0.69
1560	27.451	27.45	0.68
1680	27.108	27.11	0.67
1800	26.801	26.80	0.67
1920	26.531	26.53	0.66
2040	26.290	26.29	0.65
2160	26.079	26.08	0.65
2280	25.885	25.89	0.64
2400	25.725	25.73	0.64

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS® Borehole Variable Head Permeability Test

Borehole ID

BH509

Project Details

Project Name	Central Interceptor
Project Number	IZ027500
Test Date	14/11/2016
Tested	CJS
Checked	MT

Test Parameters

Top of screen	34.000 m
Bottom of Screen	37.200 m
Screen Length, *L*	3.200 m
Static Water Level, *H*	0.000 m
Initial Water Level, H_0	40.285 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

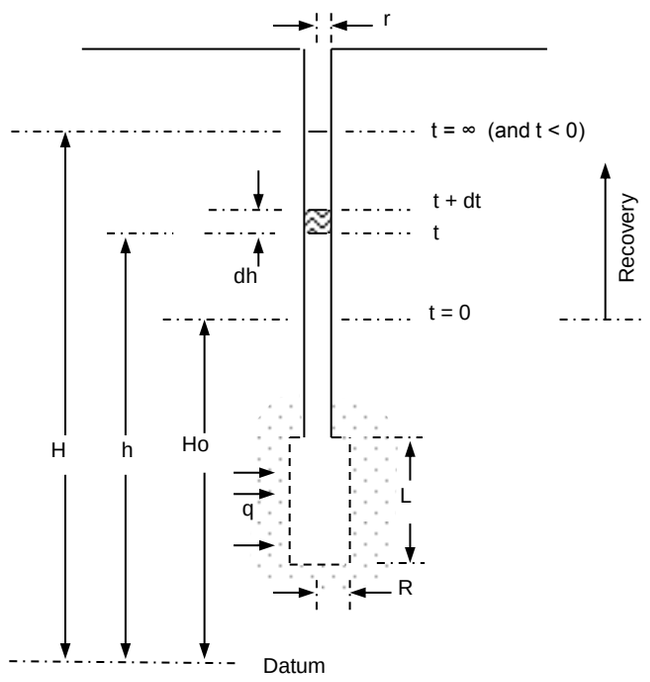
Result

Hydraulic Conductivity

***K* = 1.22E-07 m/s**

1.05E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

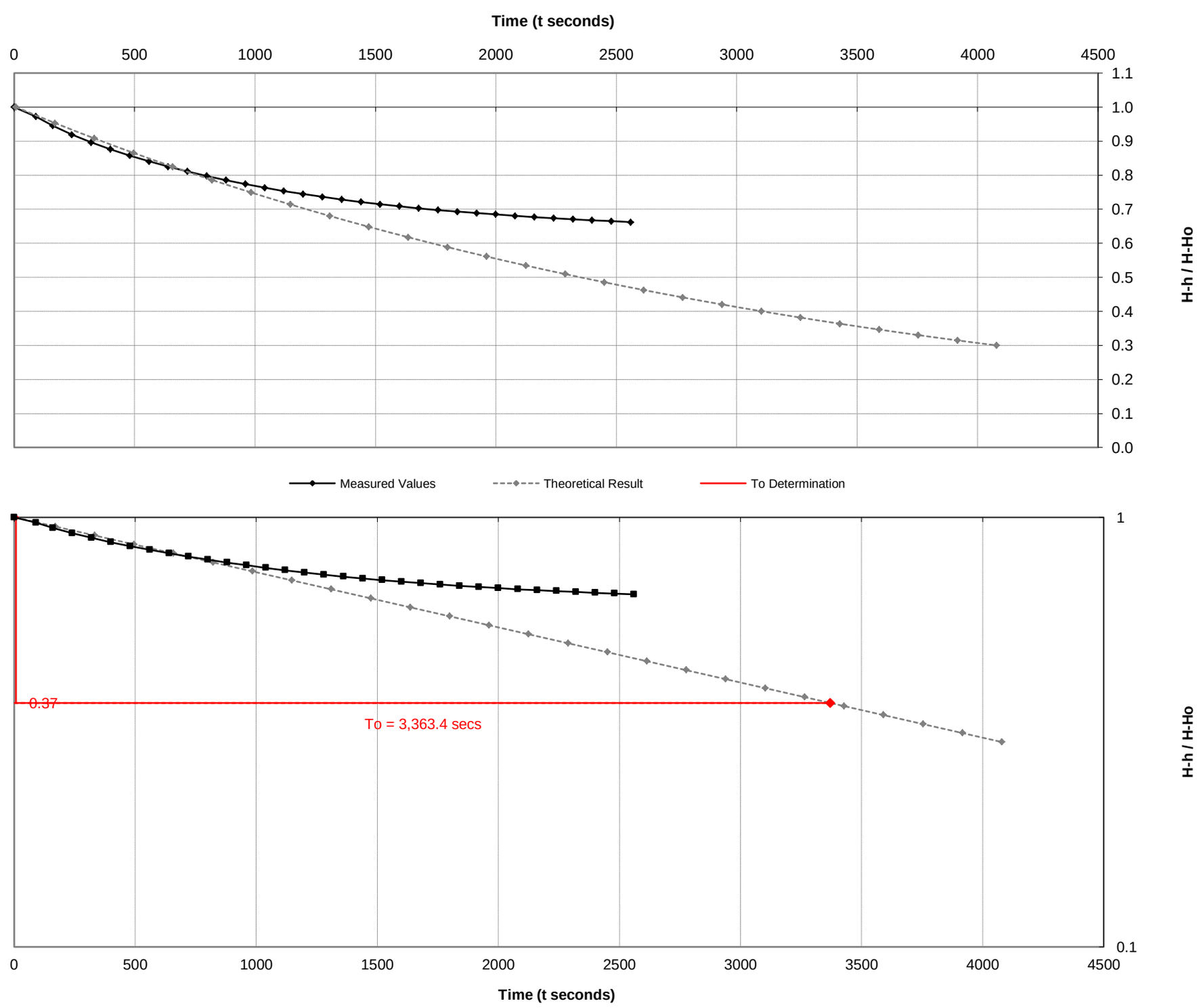
Calibrated Parameters

Intake factor, *F*	4.79
Time Factor, T_0	3,363.4

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
0	40.285	40.29	1.00
90	39.161	39.16	0.97
160	38.076	38.08	0.95
240	37.022	37.02	0.92
320	36.109	36.11	0.90
400	35.288	35.29	0.88
480	34.547	34.55	0.86
560	33.868	33.87	0.84
640	33.236	33.24	0.83
720	32.674	32.67	0.81
800	32.141	32.14	0.80
880	31.634	31.63	0.79
960	31.178	31.18	0.77
1040	30.751	30.75	0.76
1120	30.349	30.35	0.75
1200	29.988	29.99	0.74
1280	29.652	29.65	0.74
1360	29.345	29.35	0.73
1440	29.050	29.05	0.72
1520	28.783	28.78	0.71
1600	28.553	28.55	0.71
1680	28.316	28.32	0.70
1760	28.108	28.11	0.70
1840	27.922	27.92	0.69
1920	27.743	27.74	0.69
2000	27.597	27.60	0.69
2080	27.418	27.42	0.68
2160	27.272	27.27	0.68
2240	27.148	27.15	0.67
2320	27.013	27.01	0.67
2400	26.900	26.90	0.67
2480	26.798	26.80	0.67
2560	26.677	26.68	0.66

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS® Borehole Variable Head Permeability Test

Borehole ID

BH511

Project Details

Project Name	Central Interceptor
Project Number	IZ027500
Test Date	25/11/2016
Tested	CJS
Checked	MT

Test Parameters

Top of screen	22.050 m
Bottom of Screen	25.050 m
Screen Length, *L*	3.000 m
Static Water Level, *H*	0.000 m
Initial Water Level, H_0	38.566 m
Hole Radius, *R*	0.050 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

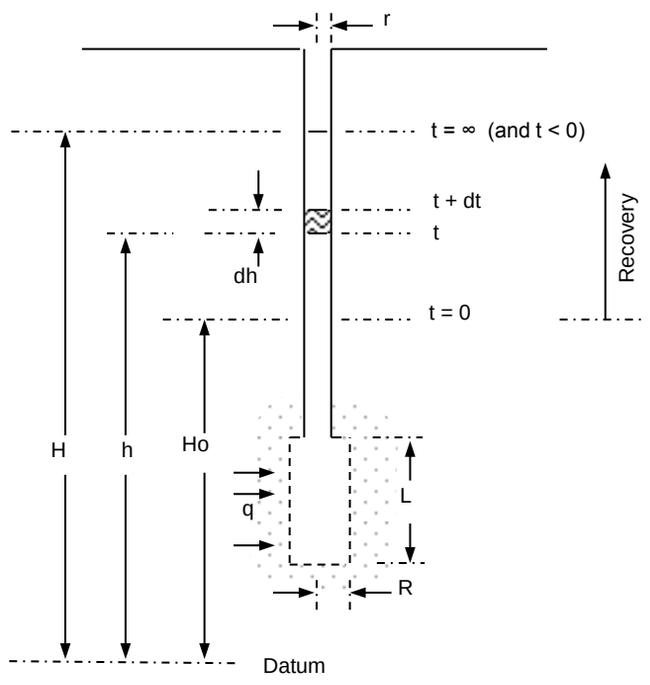
Result

Hydraulic Conductivity

***K* = 2.49E-06 m/s**

2.15E-01 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

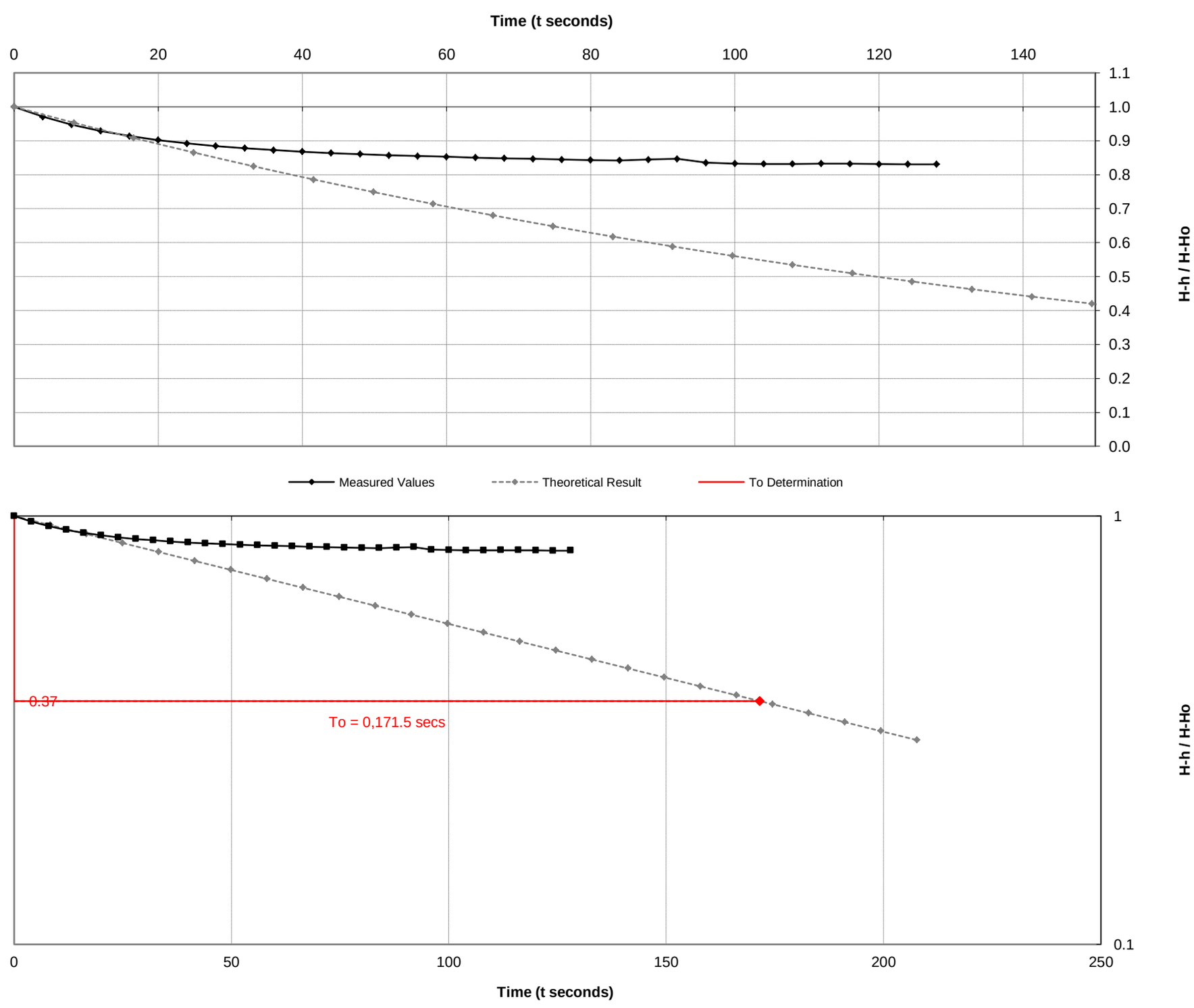
Calibrated Parameters

Intake factor, *F*	4.60
Time Factor, T_0	171.5

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
0	38.566	38.57	1.00
4	37.424	37.42	0.97
8	36.533	36.53	0.95
12	35.814	35.81	0.93
16	35.241	35.24	0.91
20	34.785	34.79	0.90
24	34.413	34.41	0.89
28	34.106	34.11	0.88
32	33.862	33.86	0.88
36	33.653	33.65	0.87
40	33.471	33.47	0.87
44	33.321	33.32	0.86
48	33.183	33.18	0.86
52	33.062	33.06	0.86
56	32.975	32.98	0.86
60	32.887	32.89	0.85
64	32.799	32.80	0.85
68	32.723	32.72	0.85
72	32.646	32.65	0.85
76	32.580	32.58	0.84
80	32.518	32.52	0.84
84	32.467	32.47	0.84
88	32.573	32.57	0.84
92	32.646	32.65	0.85
96	32.215	32.22	0.84
100	32.124	32.12	0.83
104	32.084	32.08	0.83
108	32.088	32.09	0.83
112	32.109	32.11	0.83
116	32.102	32.10	0.83
120	32.062	32.06	0.83
124	32.033	32.03	0.83
128	32.036	32.04	0.83

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS® Borehole Variable Head Permeability Test

Borehole ID

BH511

Project Details

Project Name	Central Interceptor
Project Number	IZ027500
Test Date	25/11/2016
Tested	CJS
Checked	MT

Test Parameters

Top of screen	13.300 m
Bottom of Screen	16.300 m
Screen Length, *L*	3.000 m
Static Water Level, *H*	0.000 m
Initial Water Level, H_0	38.850 m
Hole Radius, *R*	0.050 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

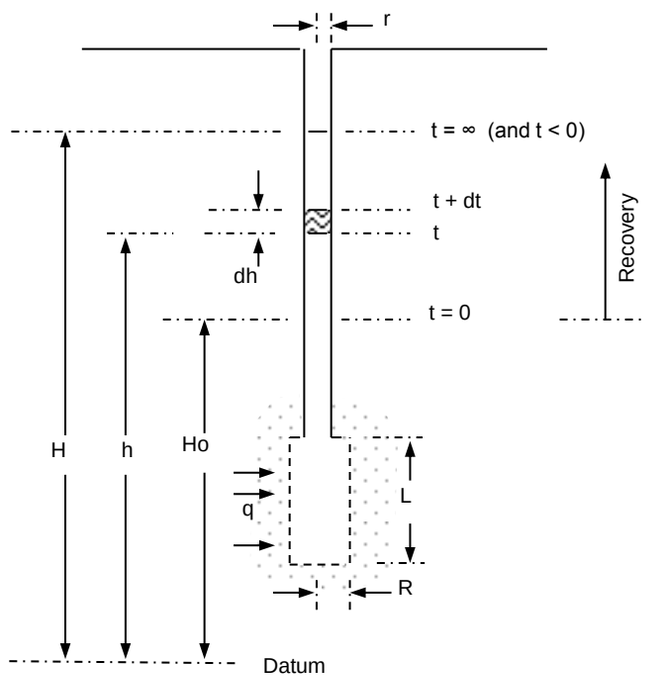
Result

Hydraulic Conductivity

***K* = 1.00E-06 m/s**

8.67E-02 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

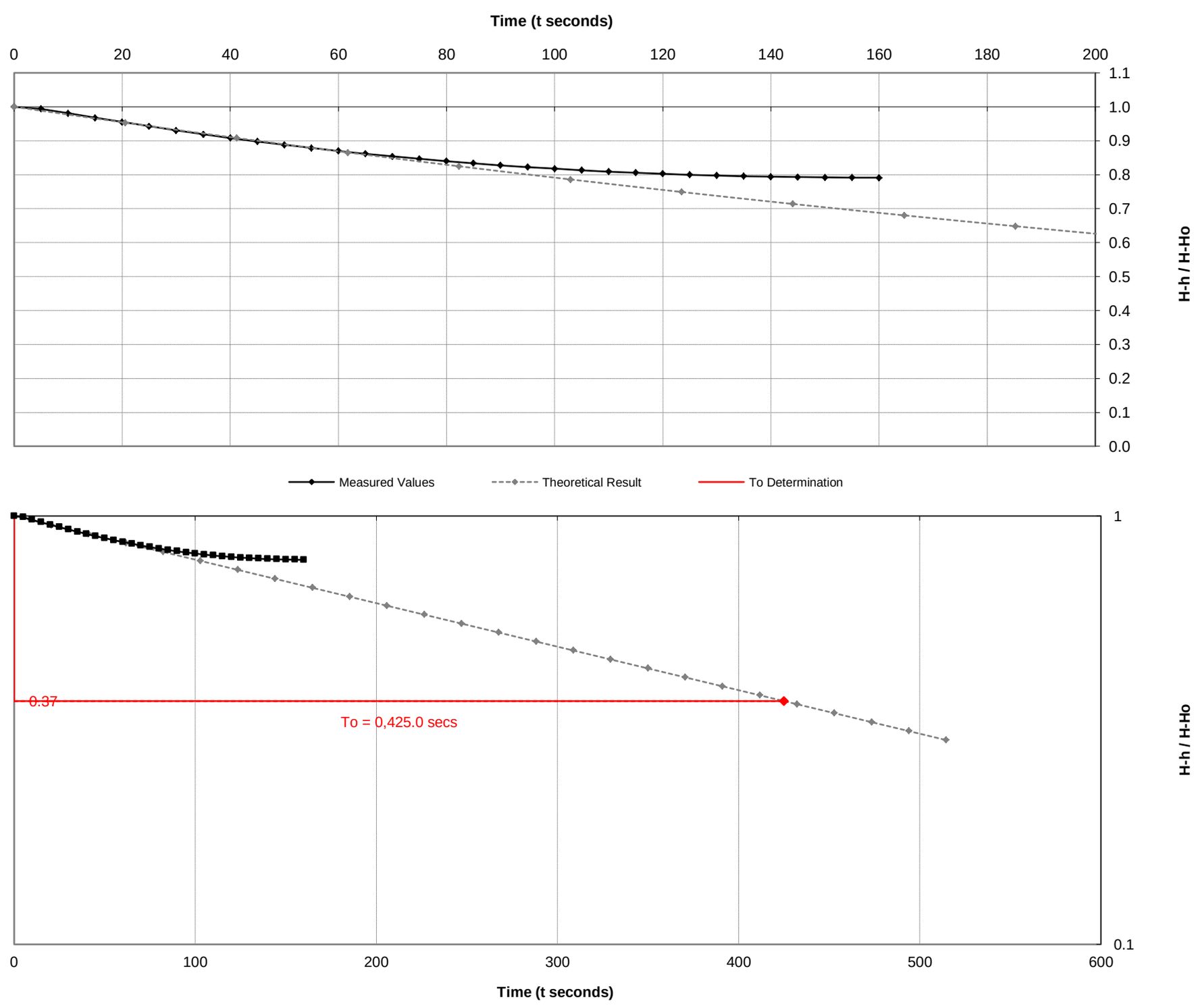
Calibrated Parameters

Intake factor, *F*	4.60
Time Factor, T_0	425.0

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
0	38.850	38.85	1.00
5	38.616	38.62	0.99
10	38.116	38.12	0.98
15	37.594	37.59	0.97
20	37.098	37.10	0.95
25	36.616	36.62	0.94
30	36.152	36.15	0.93
35	35.710	35.71	0.92
40	35.287	35.29	0.91
45	34.882	34.88	0.90
50	34.499	34.50	0.89
55	34.141	34.14	0.88
60	33.798	33.80	0.87
65	33.477	33.48	0.86
70	33.174	33.17	0.85
75	32.893	32.89	0.85
80	32.626	32.63	0.84
85	32.385	32.39	0.83
90	32.159	32.16	0.83
95	31.951	31.95	0.82
100	31.765	31.77	0.82
105	31.593	31.59	0.81
110	31.440	31.44	0.81
115	31.301	31.30	0.81
120	31.181	31.18	0.80
125	31.075	31.08	0.80
130	30.987	30.99	0.80
135	30.914	30.91	0.80
140	30.852	30.85	0.79
145	30.805	30.81	0.79
150	30.768	30.77	0.79
155	30.743	30.74	0.79
160	30.724	30.72	0.79

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

JACOBS® Borehole Variable Head Permeability Test

Borehole ID

BH511

Project Details

Project Name	Central Interceptor
Project Number	IZ027500
Test Date	14/11/2016
Tested	CJS
Checked	MT

Test Parameters

Top of screen	35.900 m
Bottom of Screen	38.900 m
Screen Length, *L*	3.000 m
Static Water Level, *H*	0.000 m
Initial Water Level, H_0	38.990 m
Hole Radius, *R*	0.048 m
Casing Radius, *r*	0.025 m

Note: If the datum is above the hole, the height/depth readings do not have to be negative numbers - as long as they are either all negative or all positive, the answer will be correct.

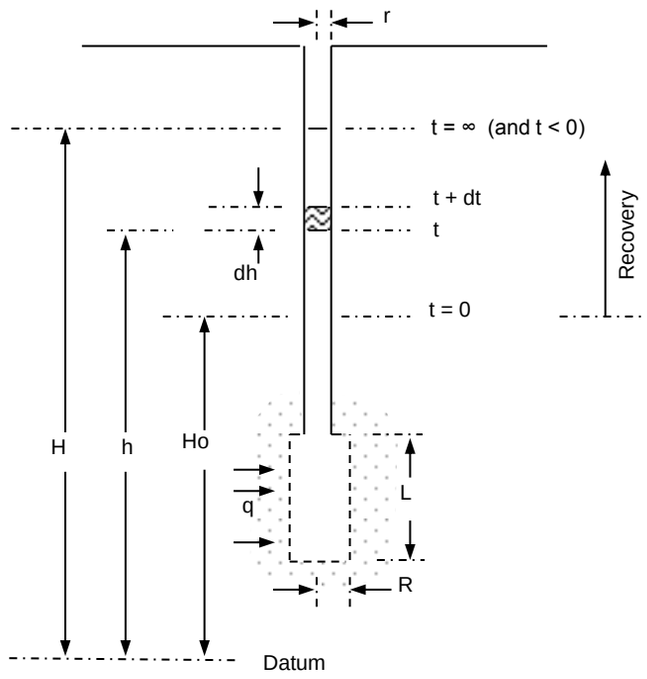
Result

Hydraulic Conductivity

***K* = 5.17E-09 m/s**

4.47E-04 m/day

Test Schematic



Hvorslev (1951) method:

$$F = \frac{2\pi L}{\ln(L/R)} \qquad K = \frac{\pi r^2}{FT_0}$$

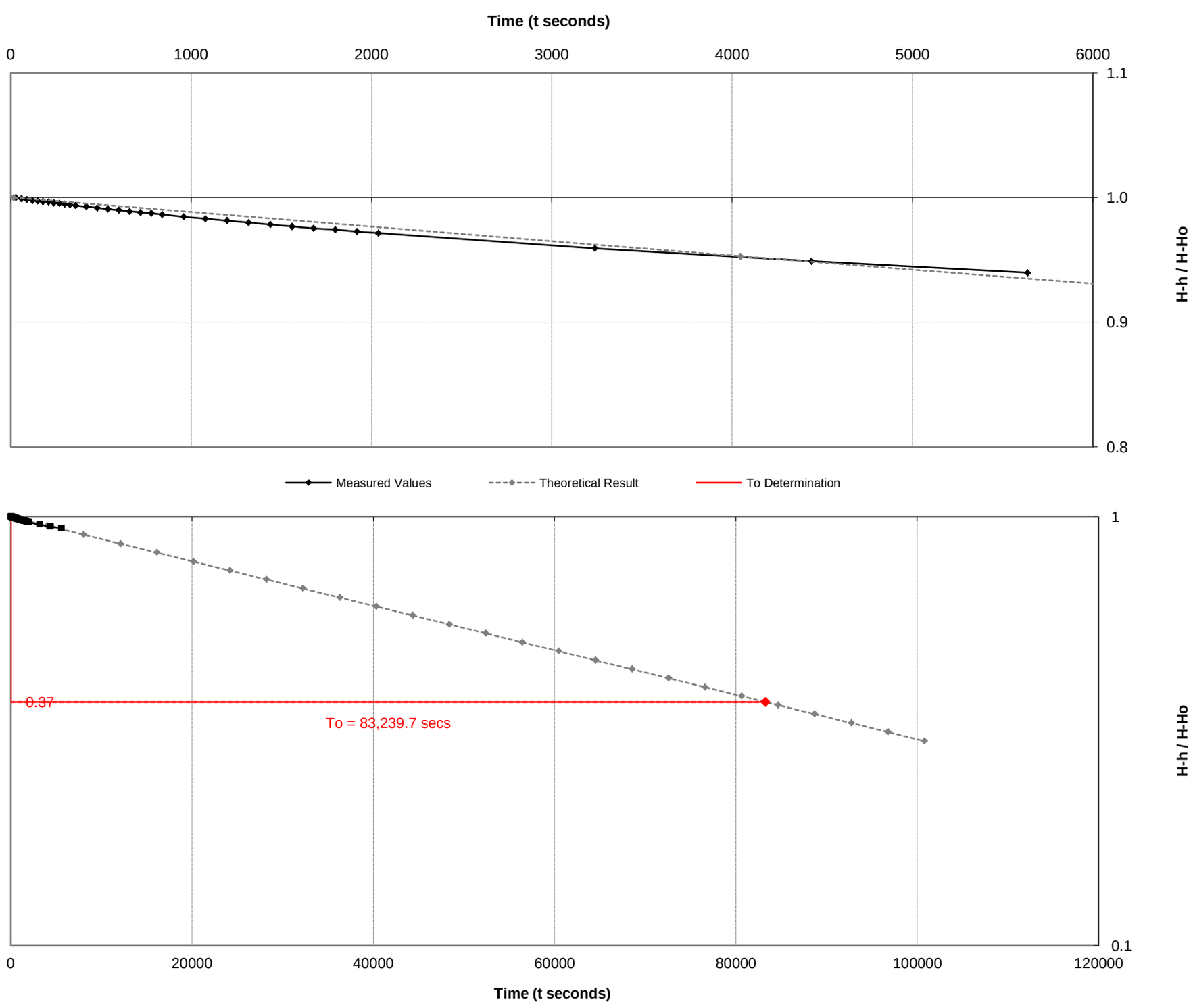
Calibrated Parameters

Intake factor, *F*	4.56
Time Factor, T_0	83,239.7

Measured Data

Time (Secs)	Depth (h) (m)	H - h (m)	H-h / H-H0
30	38.990	38.99	1.00
60	38.950	38.95	1.00
90	38.930	38.93	1.00
120	38.900	38.90	1.00
150	38.890	38.89	1.00
180	38.870	38.87	1.00
210	38.850	38.85	1.00
240	38.820	38.82	1.00
270	38.810	38.81	1.00
300	38.790	38.79	0.99
330	38.770	38.77	0.99
360	38.740	38.74	0.99
420	38.710	38.71	0.99
480	38.670	38.67	0.99
540	38.630	38.63	0.99
600	38.600	38.60	0.99
660	38.560	38.56	0.99
720	38.530	38.53	0.99
780	38.500	38.50	0.99
840	38.460	38.46	0.99
960	38.390	38.39	0.98
1080	38.330	38.33	0.98
1200	38.270	38.27	0.98
1320	38.210	38.21	0.98
1440	38.150	38.15	0.98
1560	38.090	38.09	0.98
1680	38.030	38.03	0.98
1800	37.990	37.99	0.97
1920	37.930	37.93	0.97
2040	37.880	37.88	0.97
3240	37.400	37.40	0.96
4440	37.000	37.00	0.95
5640	36.640	36.64	0.94

Graphs of Hvorslev Piezometer Test (top graph has normal axes and bottom graph has a log H-h/H-Ho axis)



Note: Hvorslev method is based on the slope of the best-fit line. This is calculated by taking the elapsed time, T_0, over 1 natural log interval of the graph, i.e. normalised head between 1 and 0.37.

Appendix H. Pumping test calculations

H.1 Western Springs

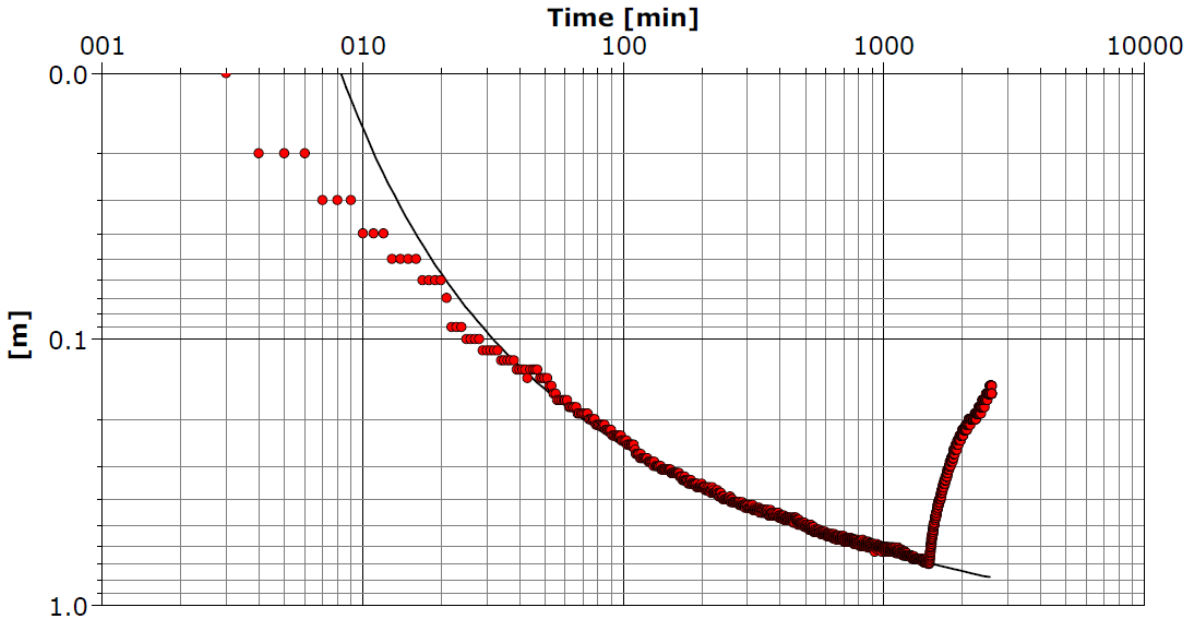


Figure H.1 : BH206 VW Drawdown versus Time (Boulton unconfined analysis)

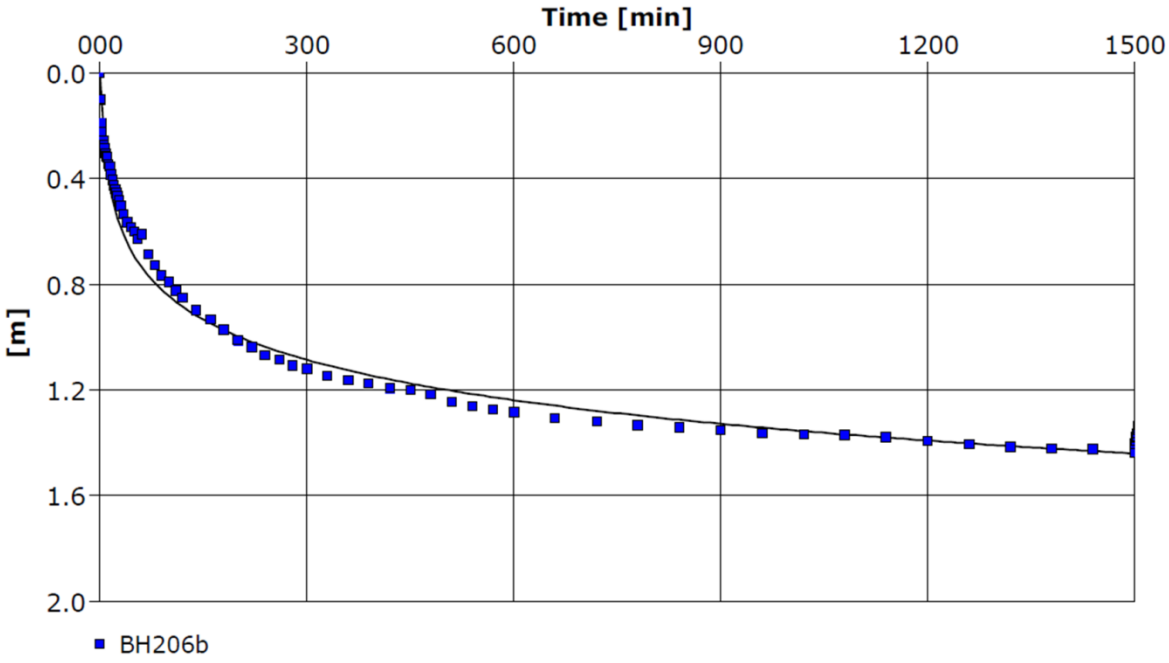


Figure H.2 : Theis assessment BH206b pumping bore

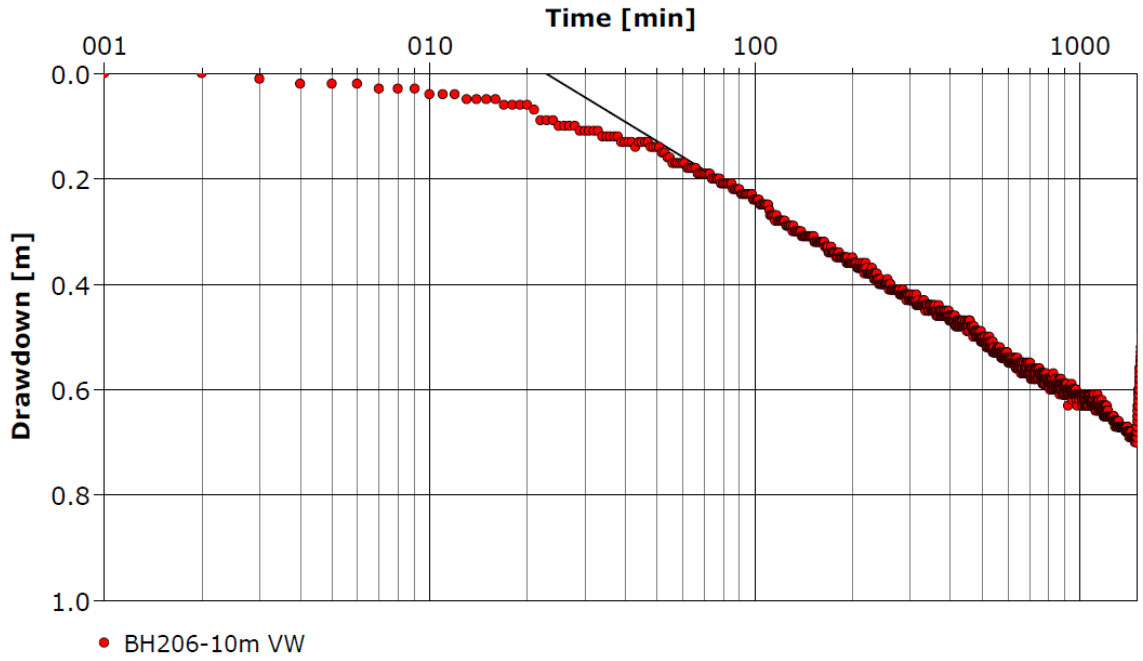


Figure H.3 : Cooper Jacob I assessment BH206 observation bore

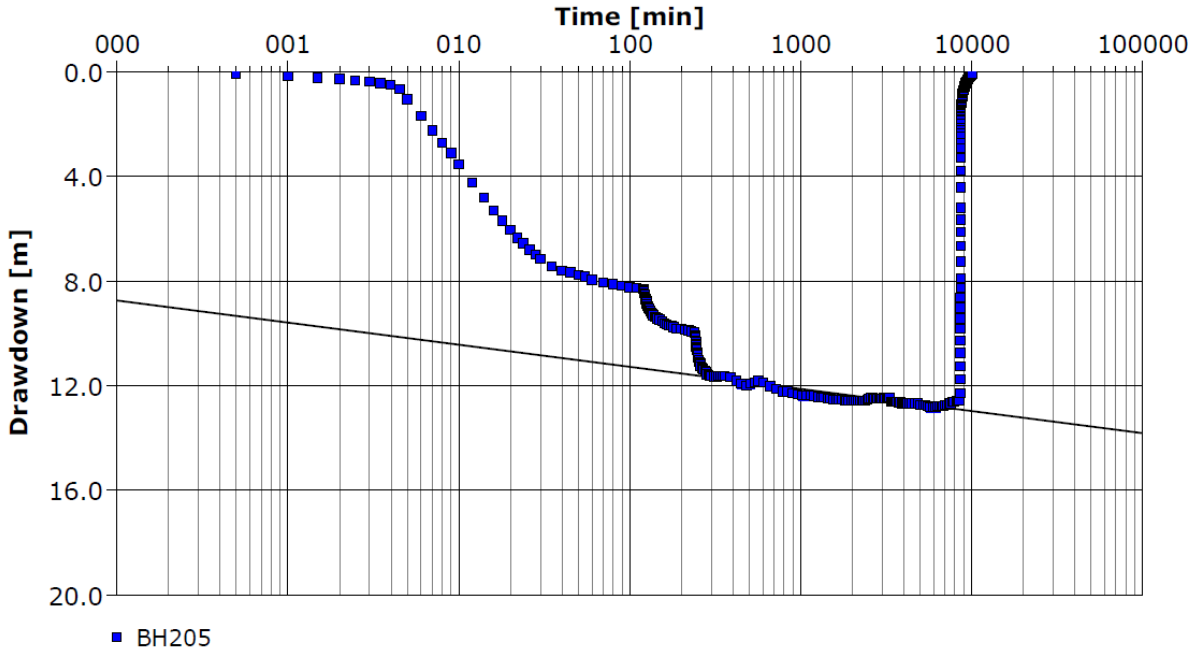


Figure H.4 : BH205 Cooper Jacob I analysis

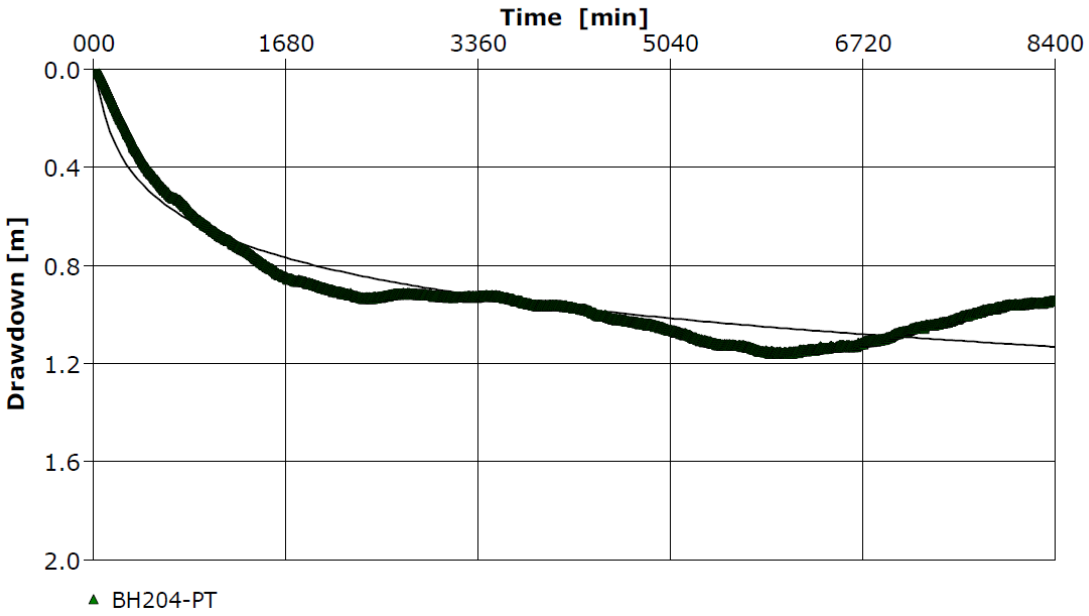


Figure H.5 : BH204 Theis drawdown analysis

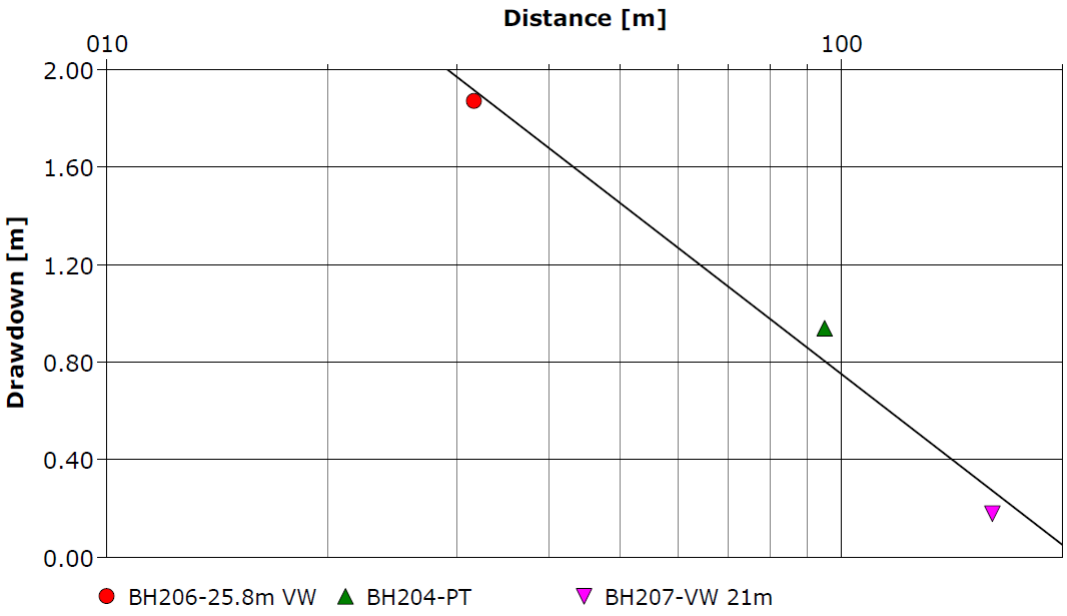


Figure H.6 : Cooper Jacob II plot for observation wells at the end of pumping

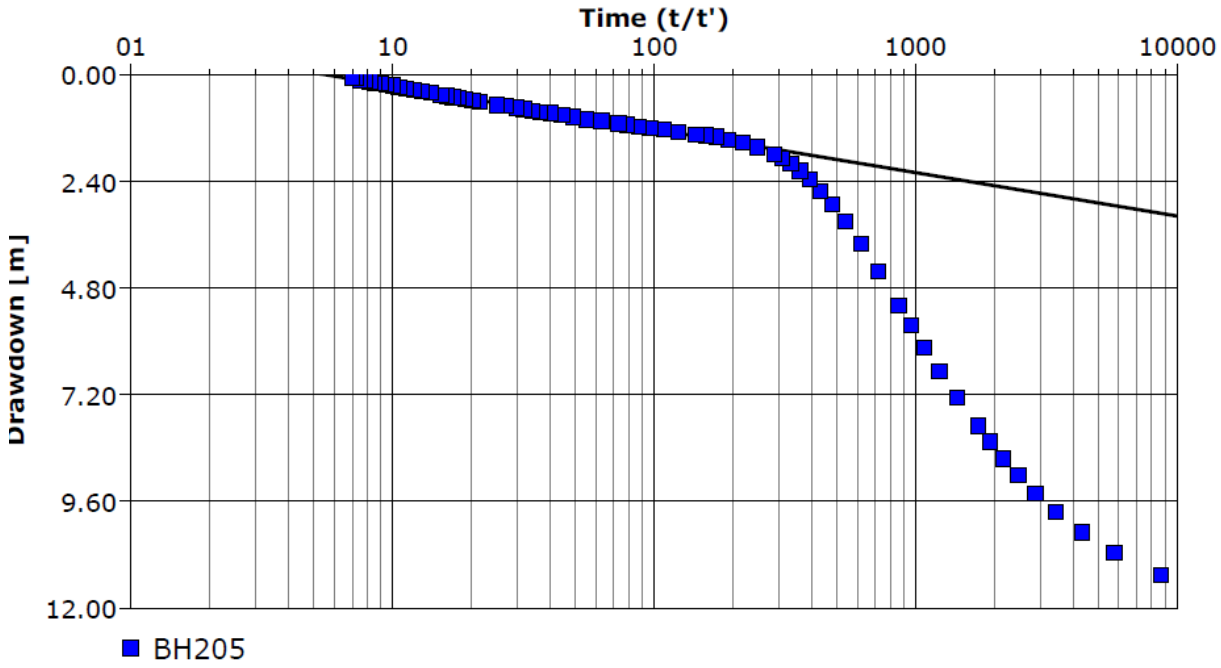


Figure H.7 : Theis recovery BH205 (pumping bore)

H.2 May Road

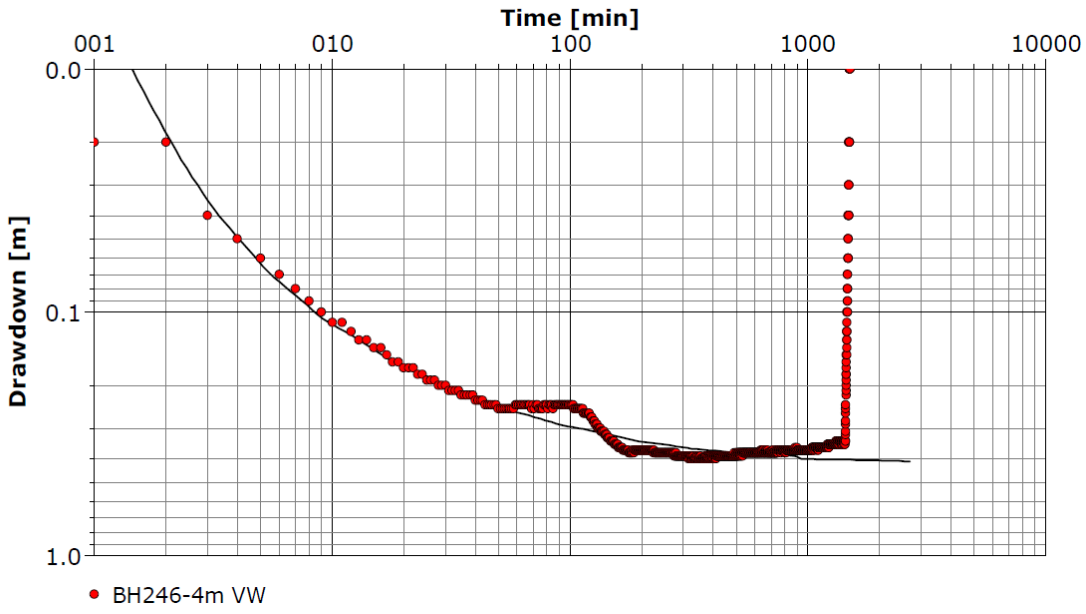


Figure H.8 : Neuman assessment BH246-4m VW observation bore

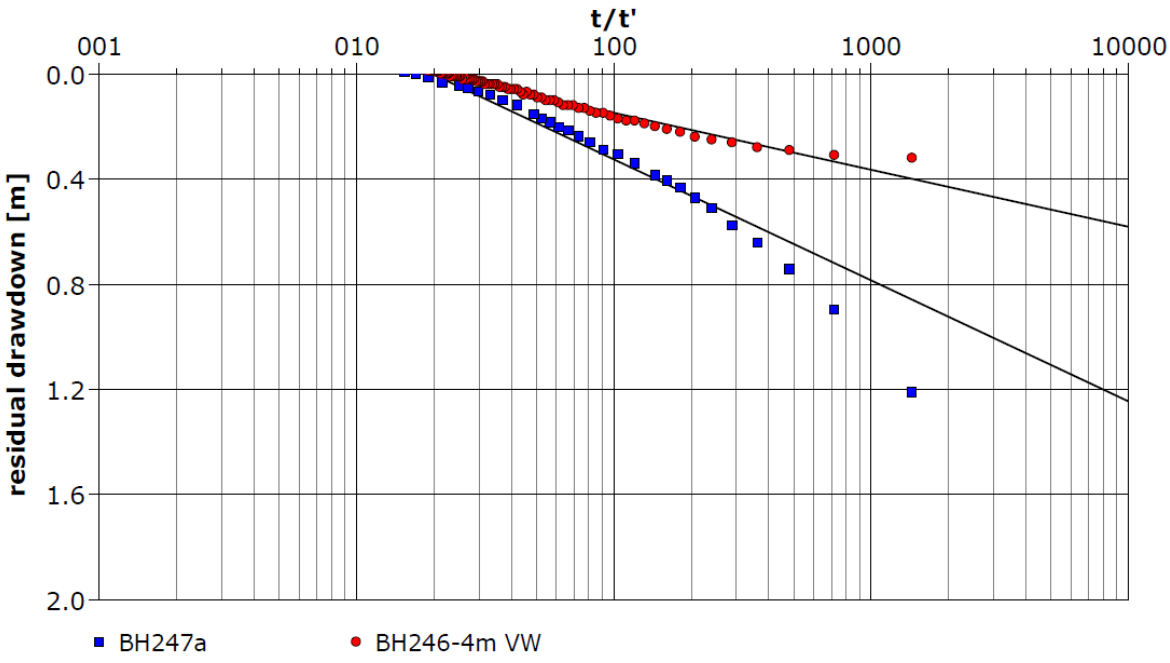


Figure H.9 : Theis recovery assessment

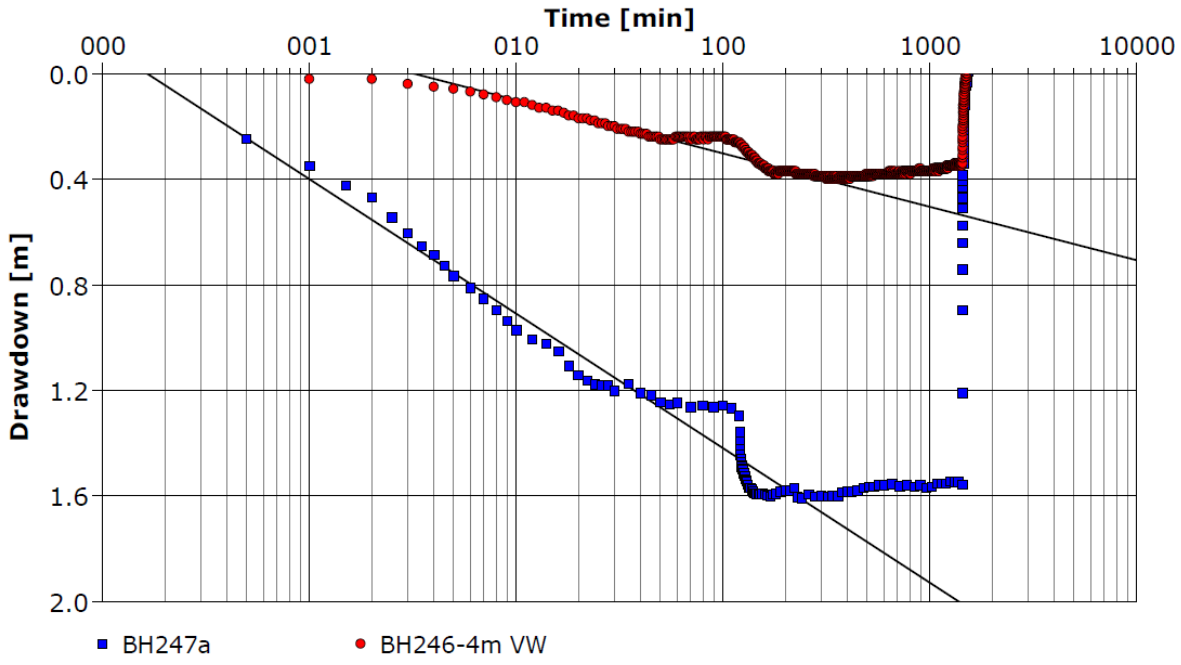


Figure H.10 : Cooper Jacob I (0–70 minute) drawdown assessment

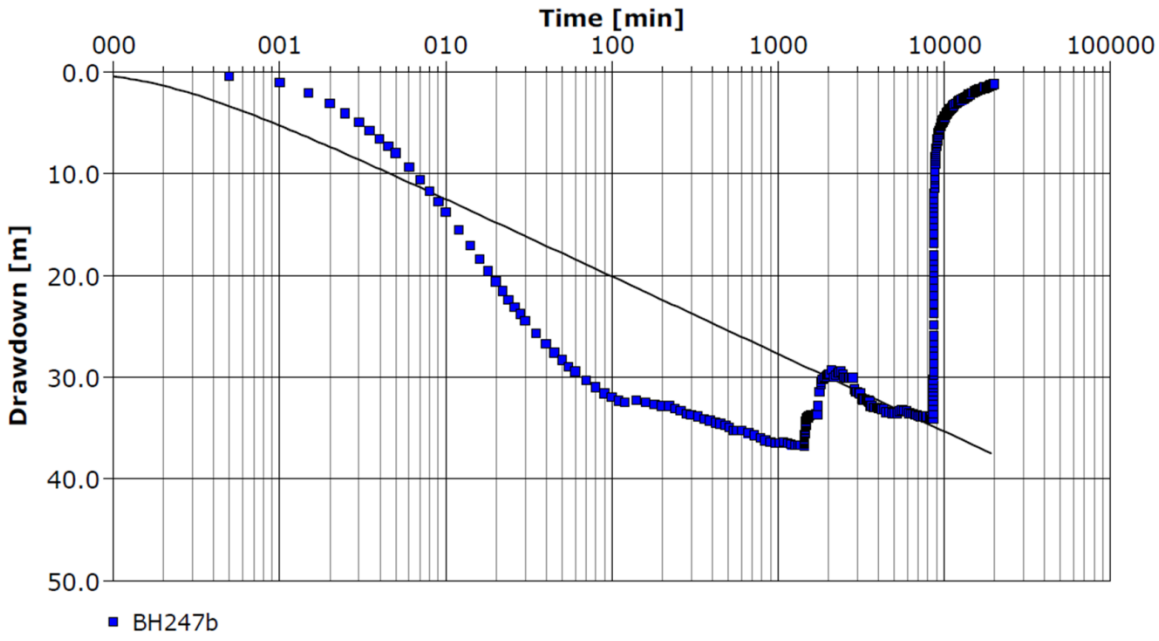


Figure 12.23. BH247b Theis analysis (1440–8640 minutes)

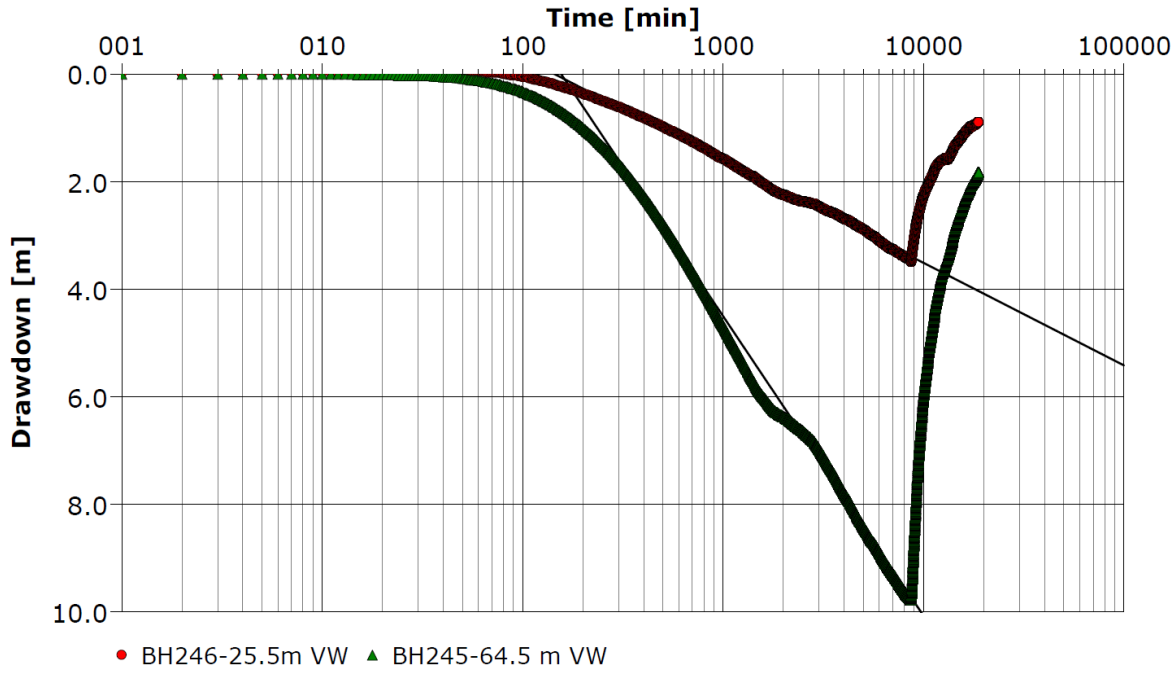


Figure H.12 : Cooper Jacob I for BH245 and BH246

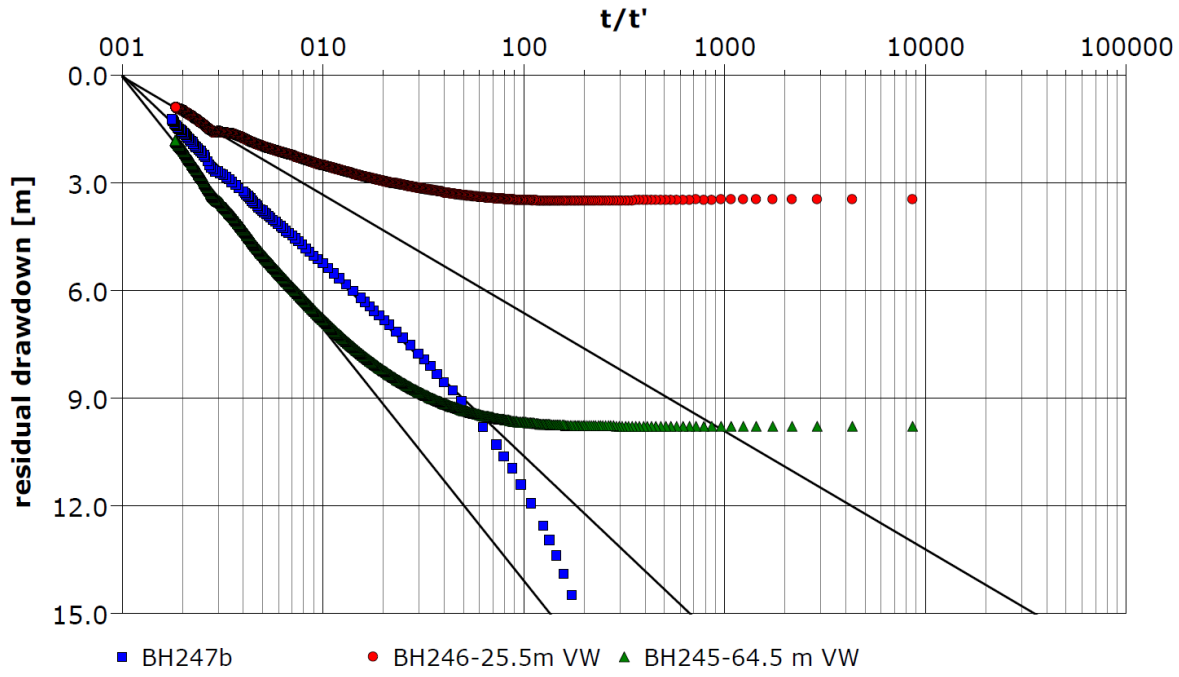
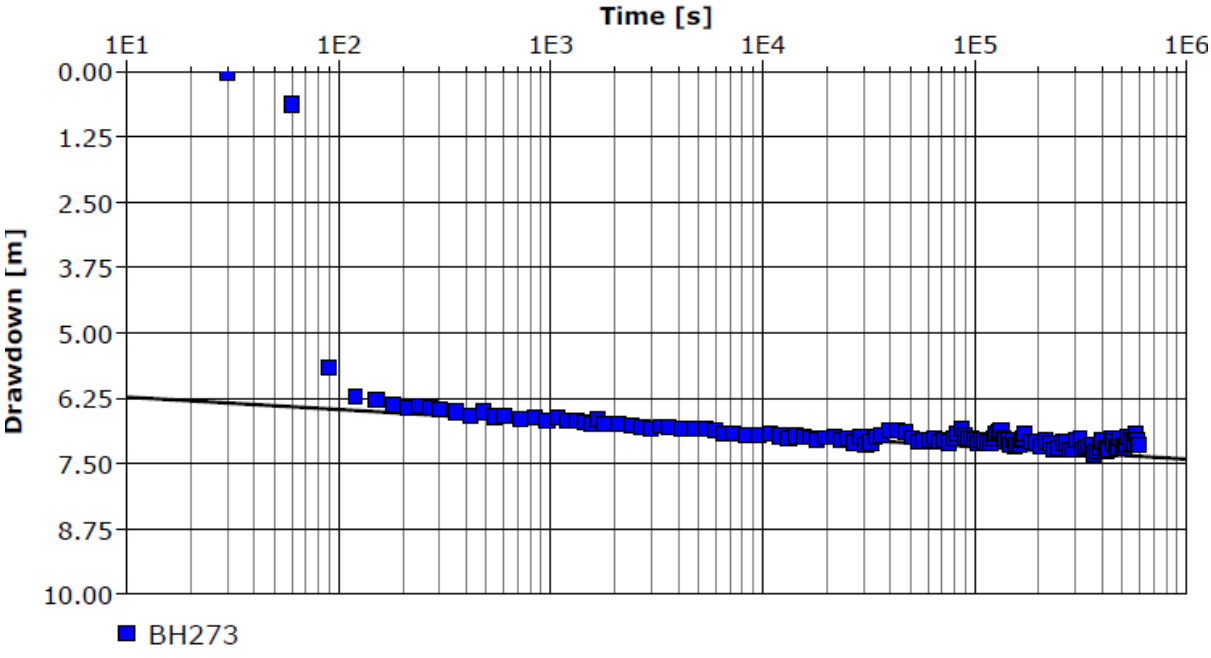


Figure H.13 : Theis recovery all bores

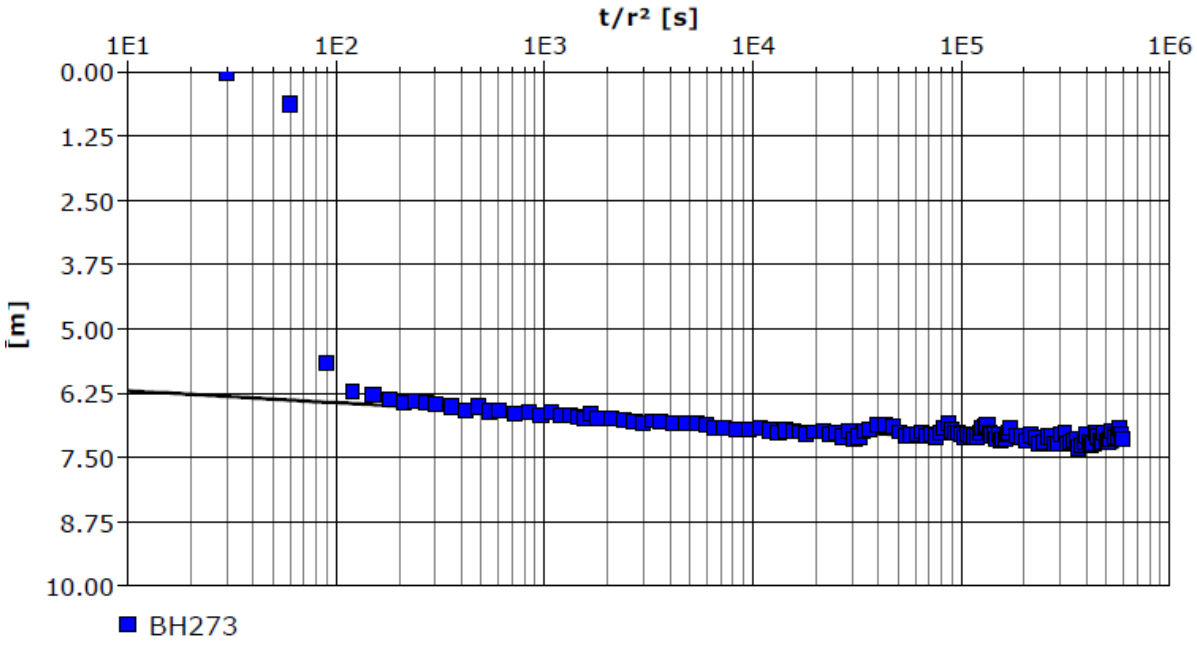
H.3 Mangere WWTP



Calculation using COOPER & JACOB

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]
BH273	278.50	10.51

Figure H.14 : Analysis of BH273 using Cooper Jacob I method



Calculation using Theis		
Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]
BH273	285.00	10.75

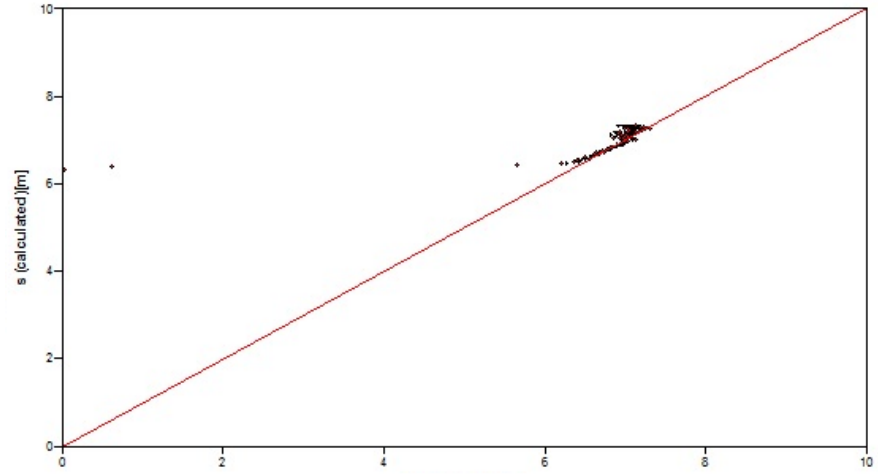
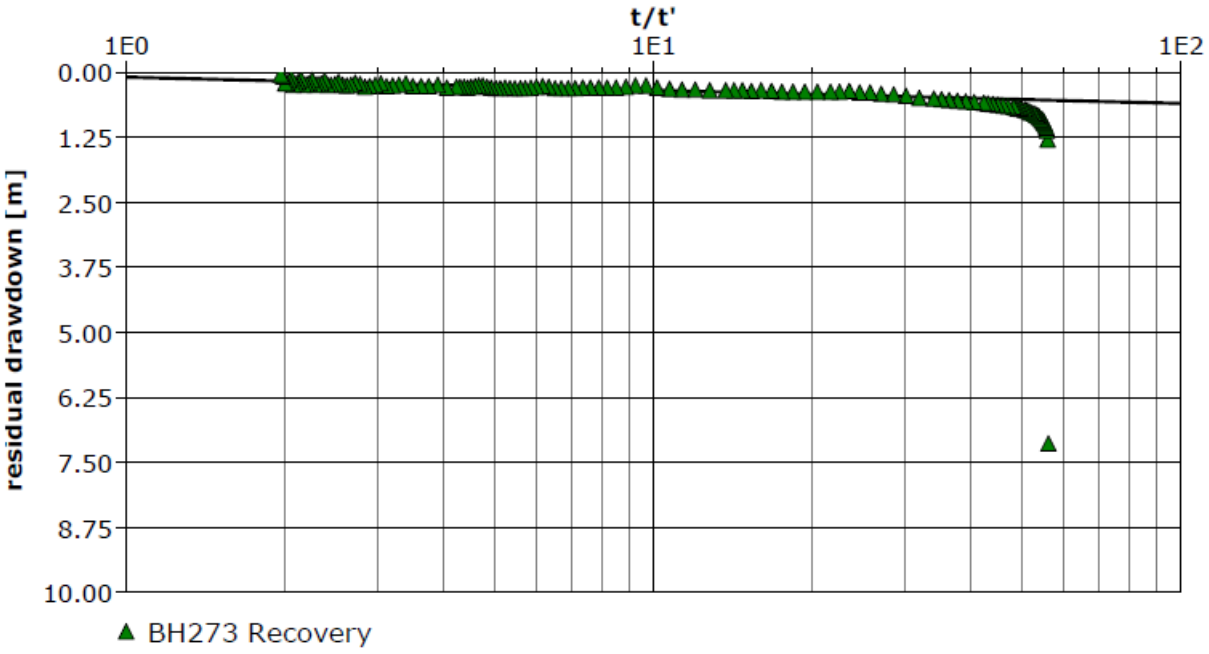
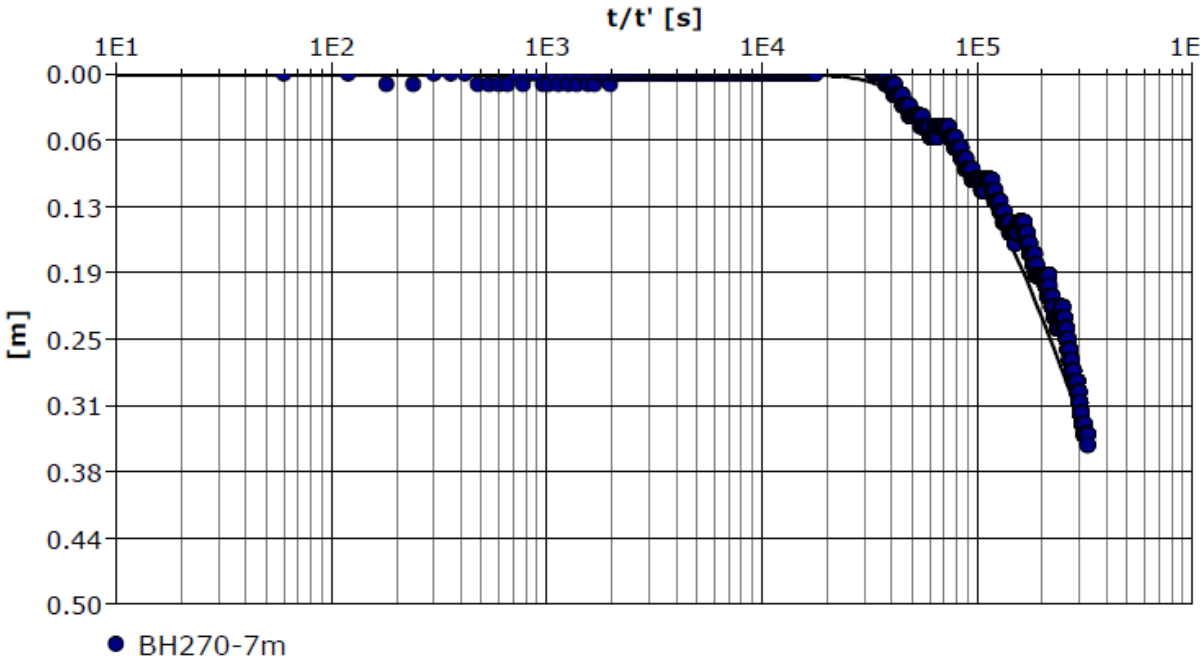


Figure H.15 : Analysis of BH273 using the Theis method



Calculation using THEIS & JACOB		
Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]
BH273 Recovery	263.40	9.94

Figure H.16 : Analysis of BH273 using the Theis Recovery method



Calculation using Theis with Jacob Correction				
Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	
BH270-7m	130.00	4.91	0.06	

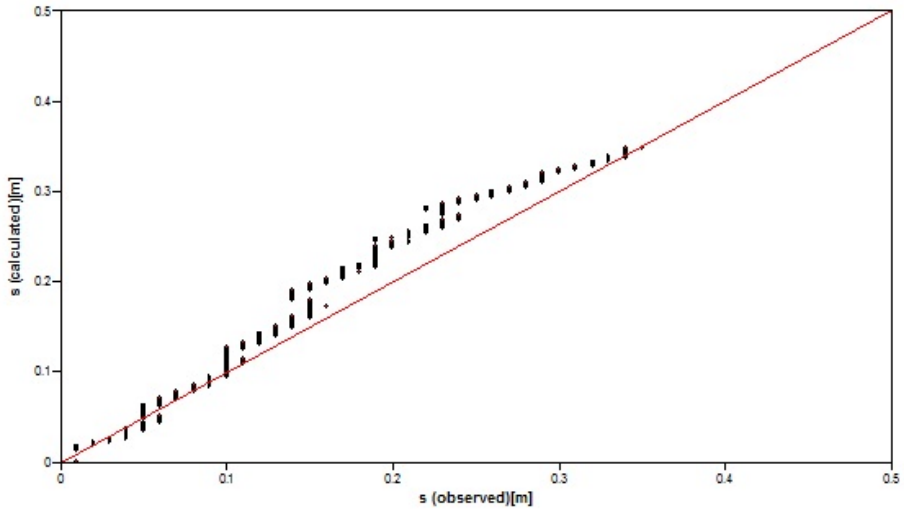
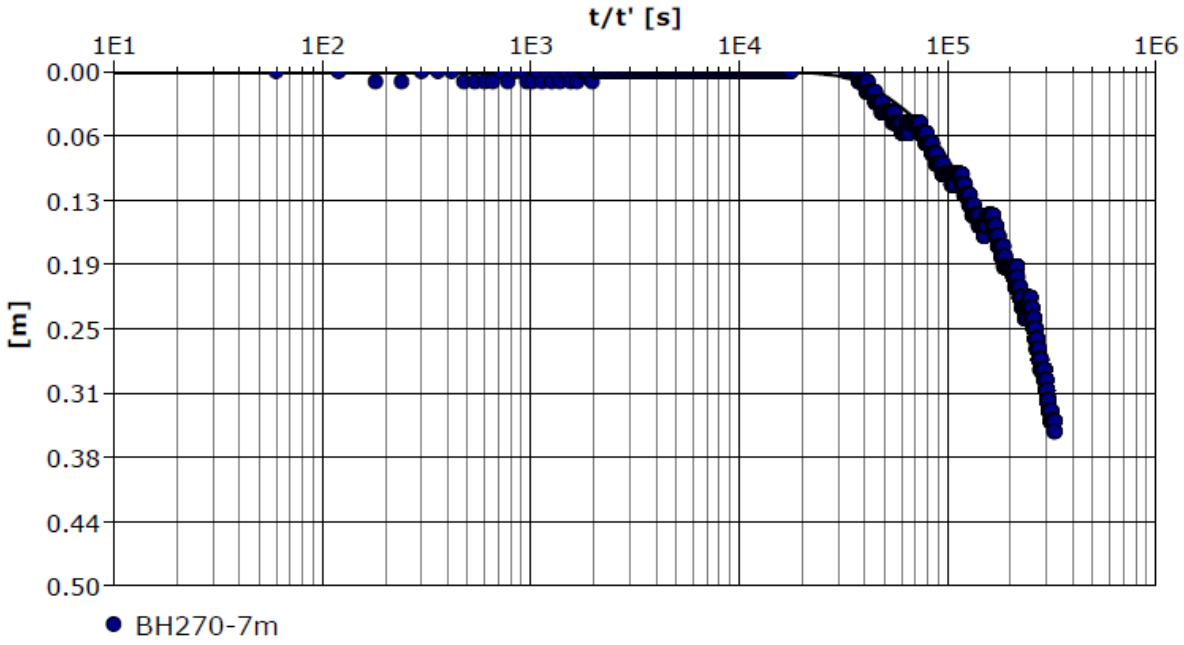


Figure H.17 : Analysis of BH270-7m using Theis with Jacobs Correction



Calculation using Neuman					
Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Specific Yield	Ratio K(v)/K(h)	Ratio Sy/S
BH270-7m	124.77	4.71	0.99	8.34×10^{-5}	1.57×10^{1}

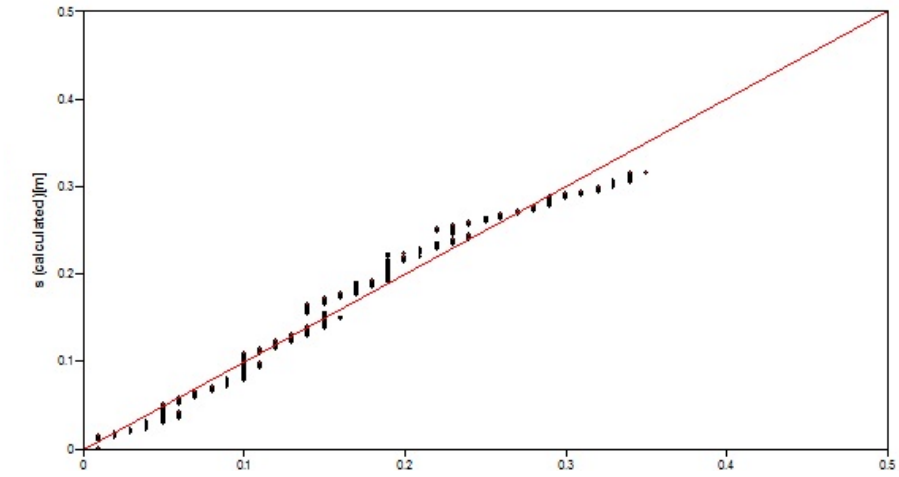
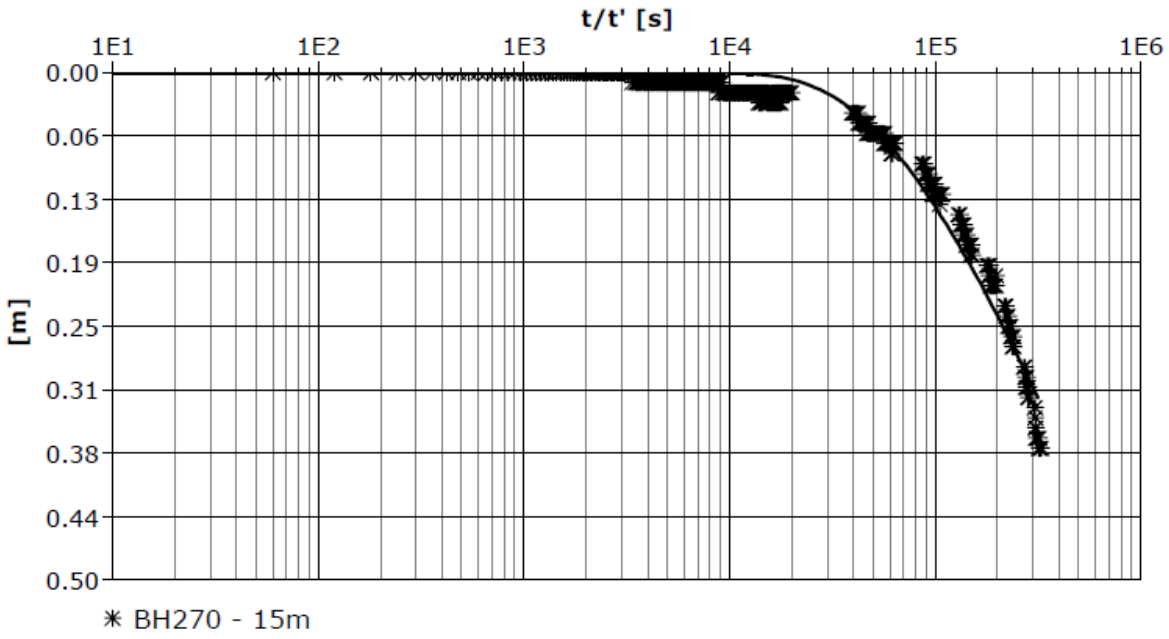


Figure H.18 : Analysis of BH270-7m using Neuman



Calculation using Theis					
Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	Ratio K(v)/K(h)	
BH270 - 15m	200.00	7.55	0.05	1.12×10^{-1}	

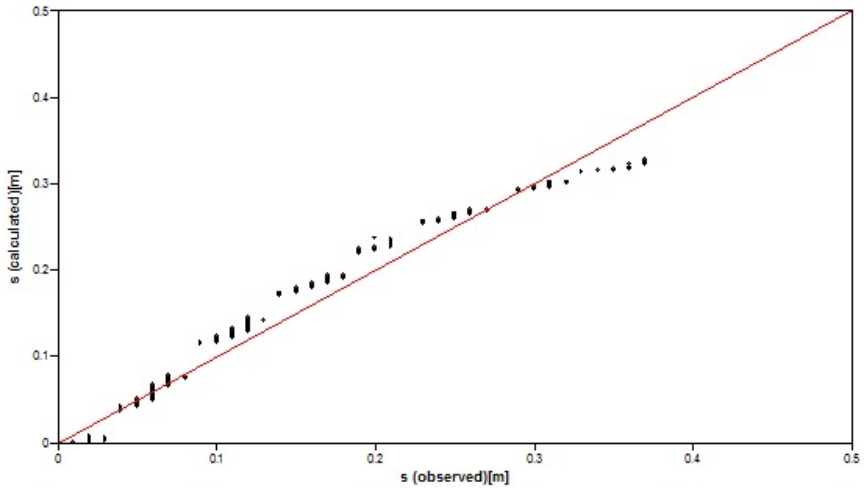
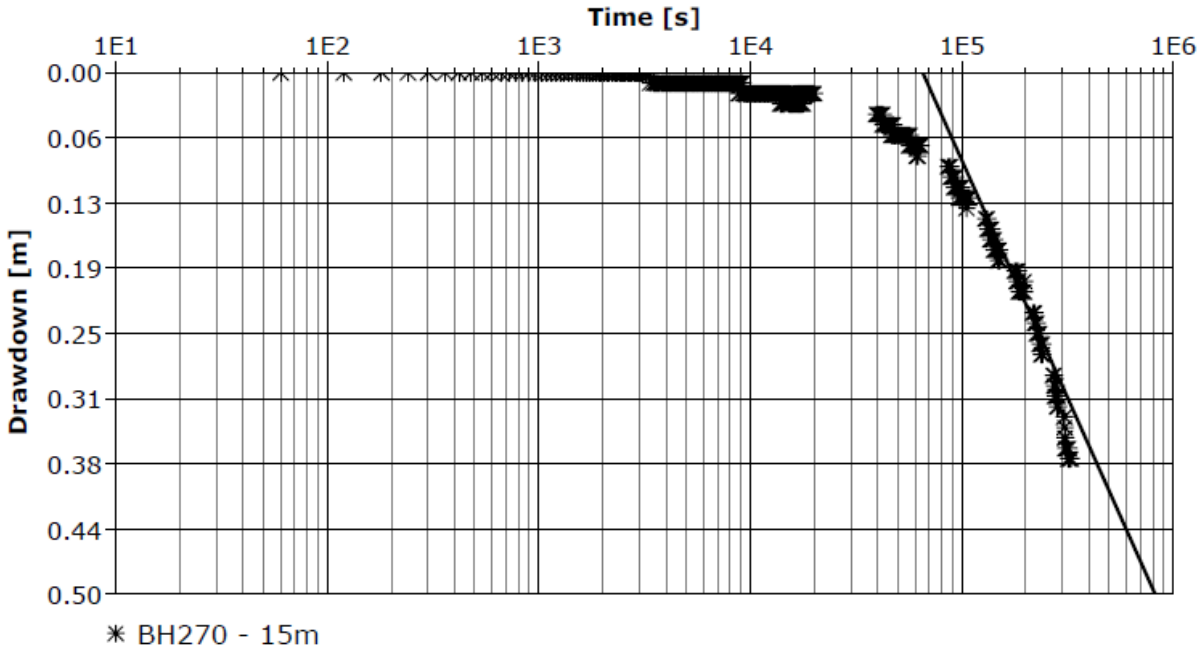
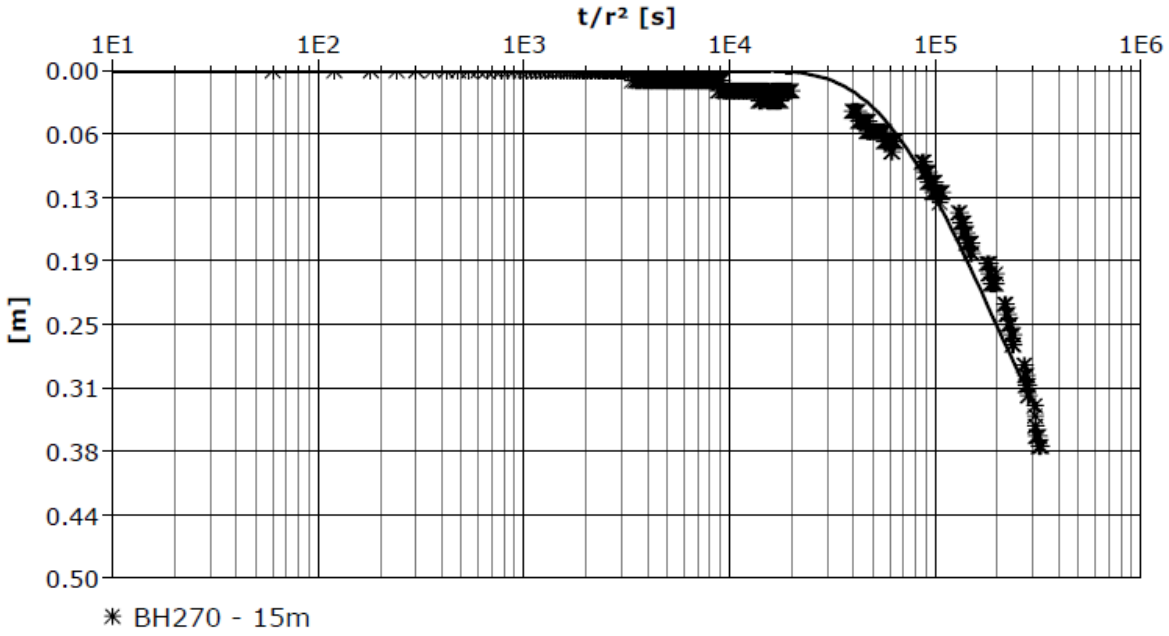


Figure H.19 : Analysis of BH270-15m using Theis



Calculation using COOPER & JACOB				
Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	
BH270 - 15m	145.00	5.47	0.03	

Figure H.20 : Analysis of BH270-15m using Cooper Jacob



Calculation using Hantush

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	Ratio K(v)/K(h)	Hydr. resistance [s]	Leakage factor [m]
BH270 - 15m	90.00	3.40	0.0400000	1.00×10^{-1}	1.00×10^{7}	102.0620726160

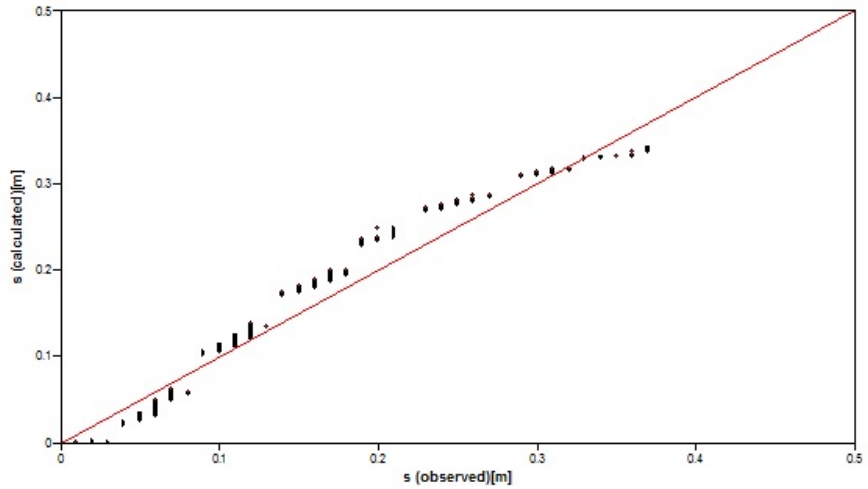
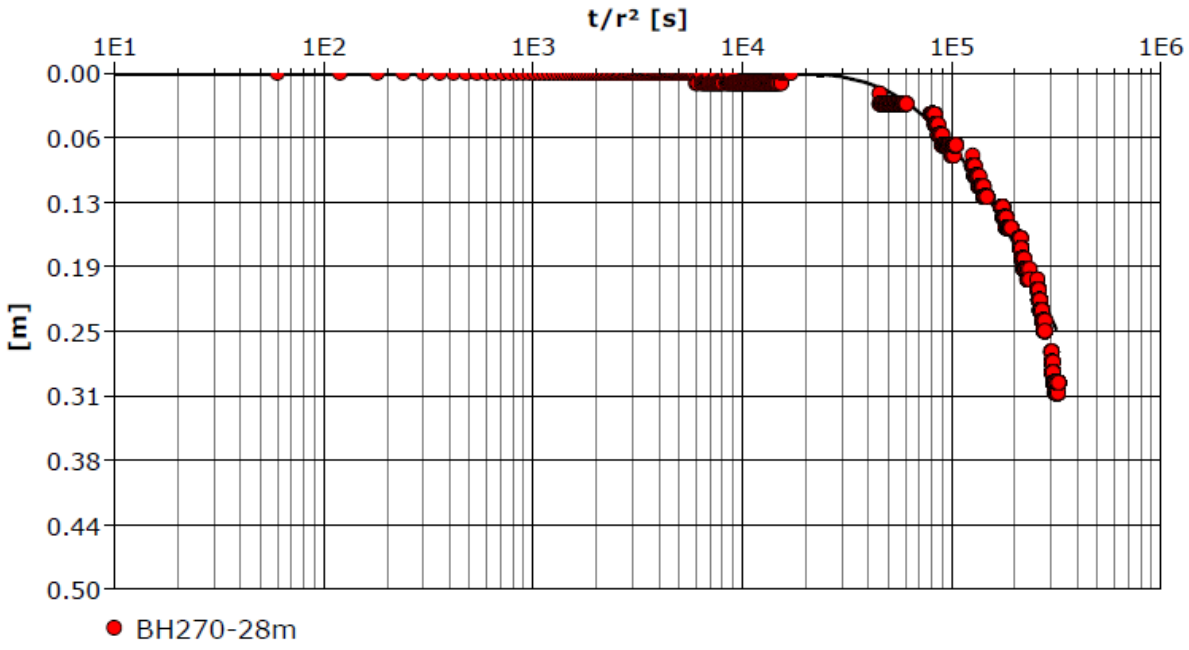


Figure H.21 : Analysis of BH270-15m using Hantush



Calculation using Theis					
Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	Ratio K(v)/K(h)	
BH270-28m	166.67	6.29	0.08	2.67×10^{-2}	

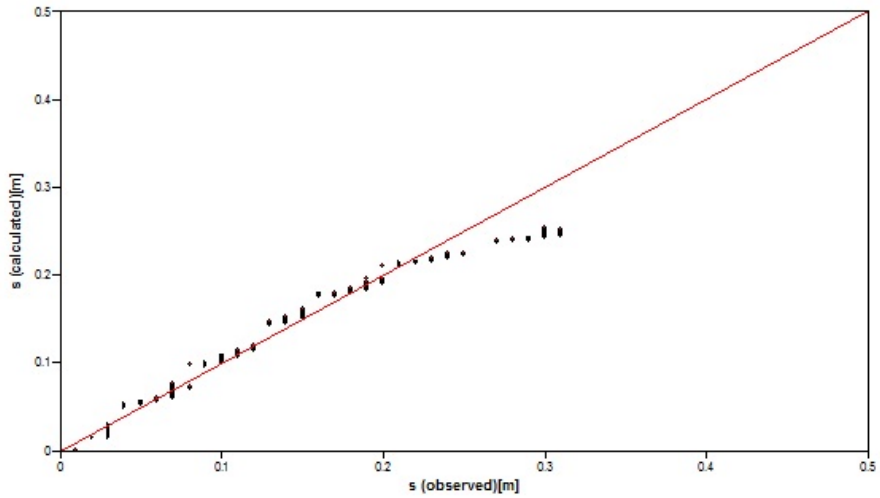
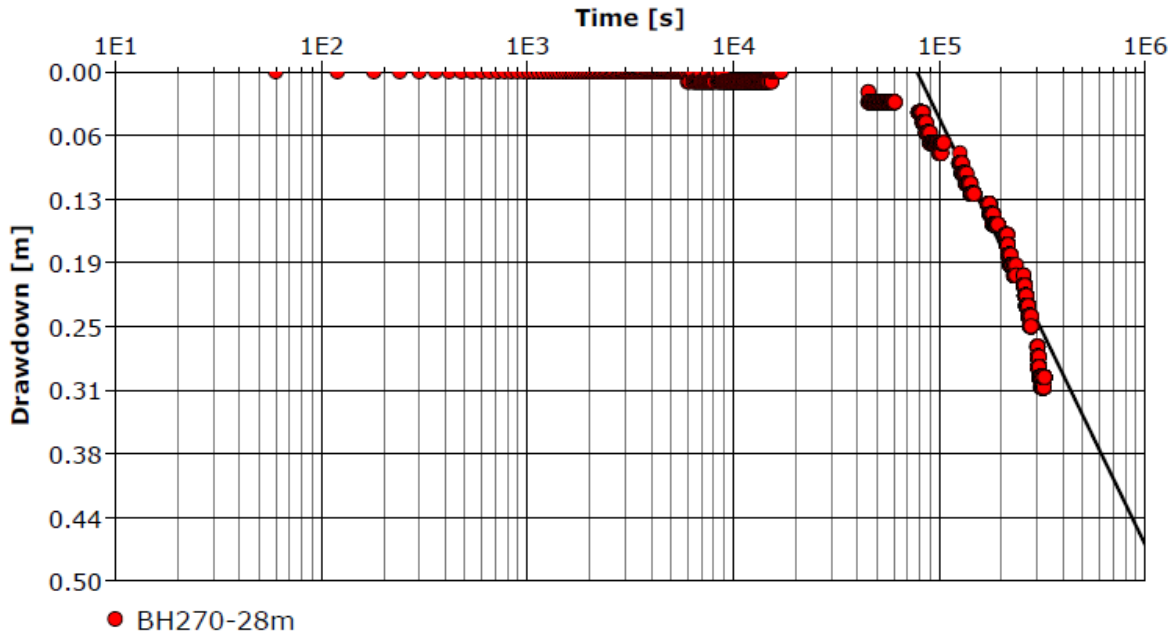
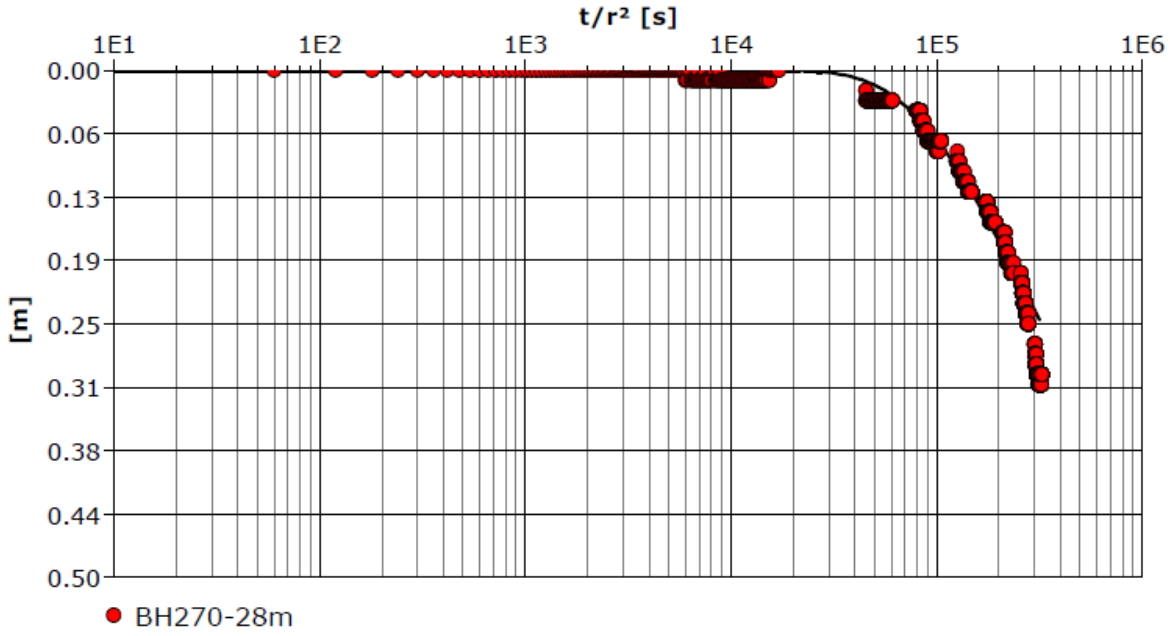


Figure H.22 : Analysis of BH270-28m using Theis



Calculation using COOPER & JACOB				
Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	
BH270-28m	157.47	5.94	0.04	

Figure H.23 : Analysis of BH270-28m using Cooper Jacob



Calculation using Hantush						
Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	Ratio K(v)/K(h)	Hydr. resistance [s]	Leakage factor [m]
BH270-28m	110.00	4.15	0.07	1.00×10^{-1}	1.00×10^{7}	112.8338667310

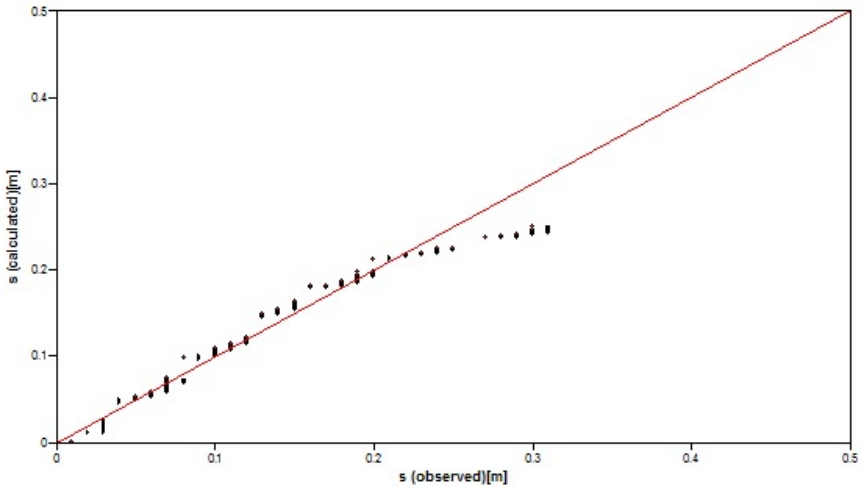
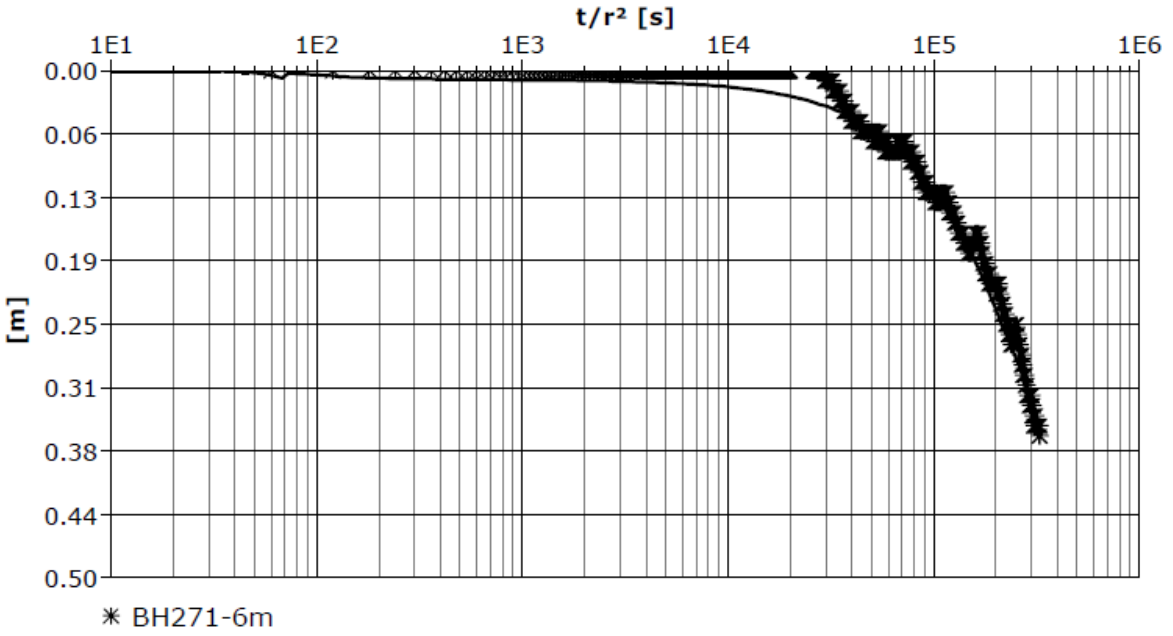


Figure H.24 : Analysis of BH270-28m using Hantush



Calculation using Neuman

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Specific Yield	Ratio K(v)/K(h)	Ratio Sy/S
BH271-6m	120.00	4.53	0.55	4.50	4.96×10^{2}

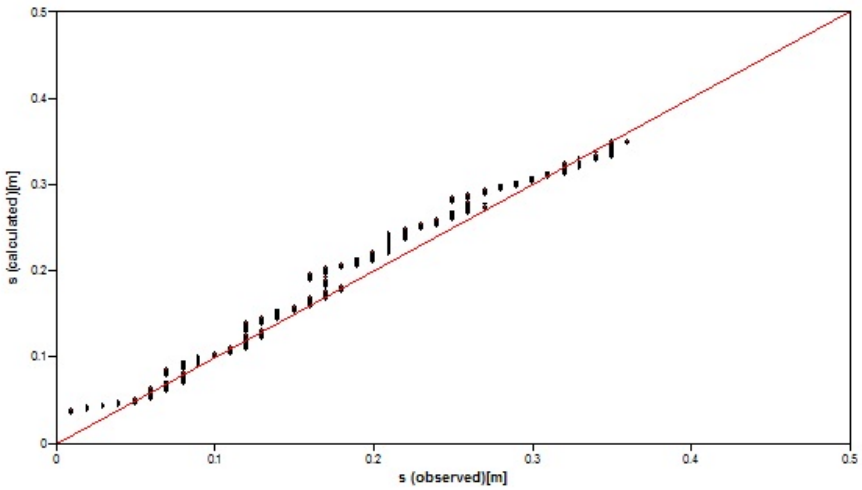
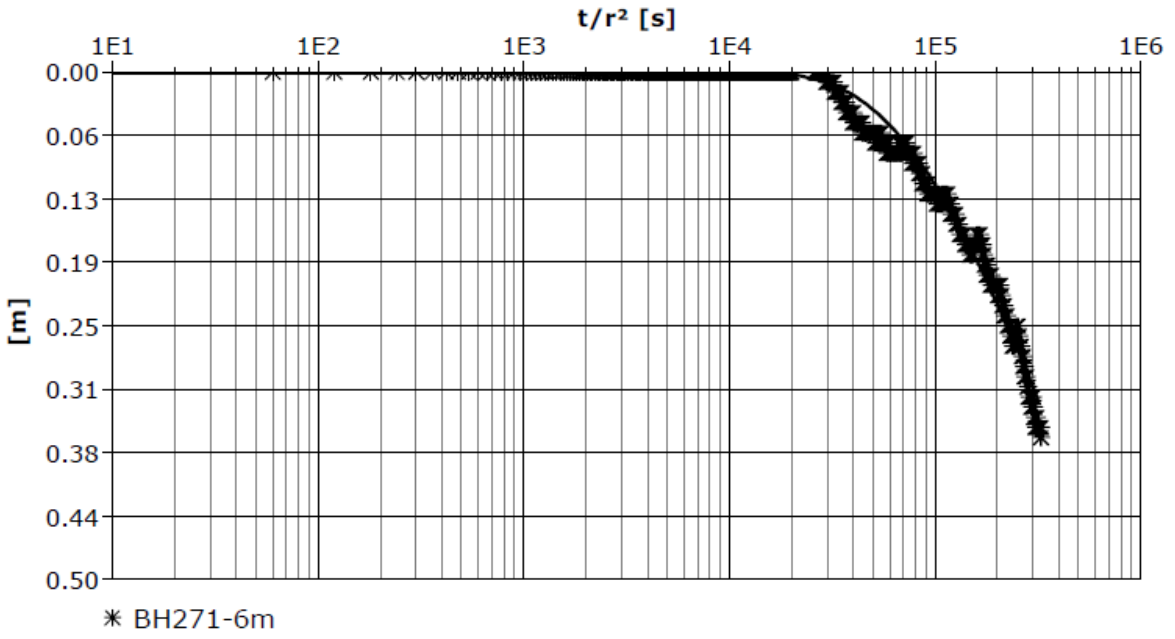


Figure H.25 : Analysis of BH271-6m using Neuman



Calculation using Theis with Jacob Correction				
Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	
BH271-6m	162.39	6.13	0.53	

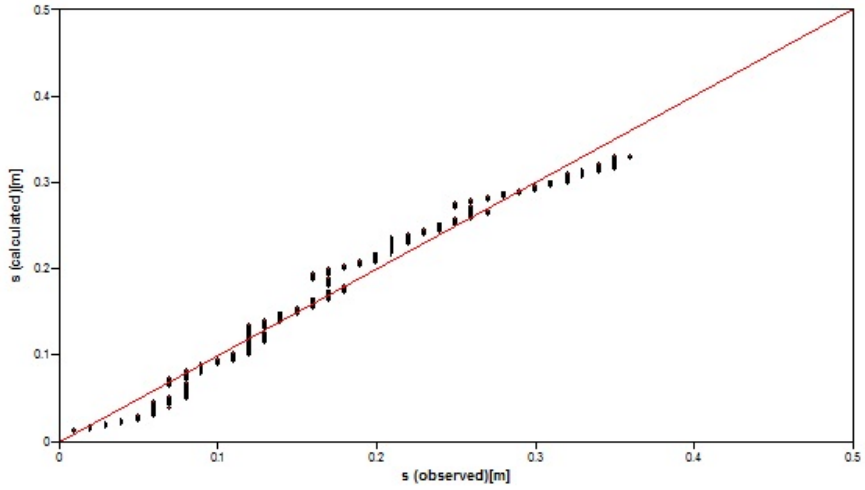
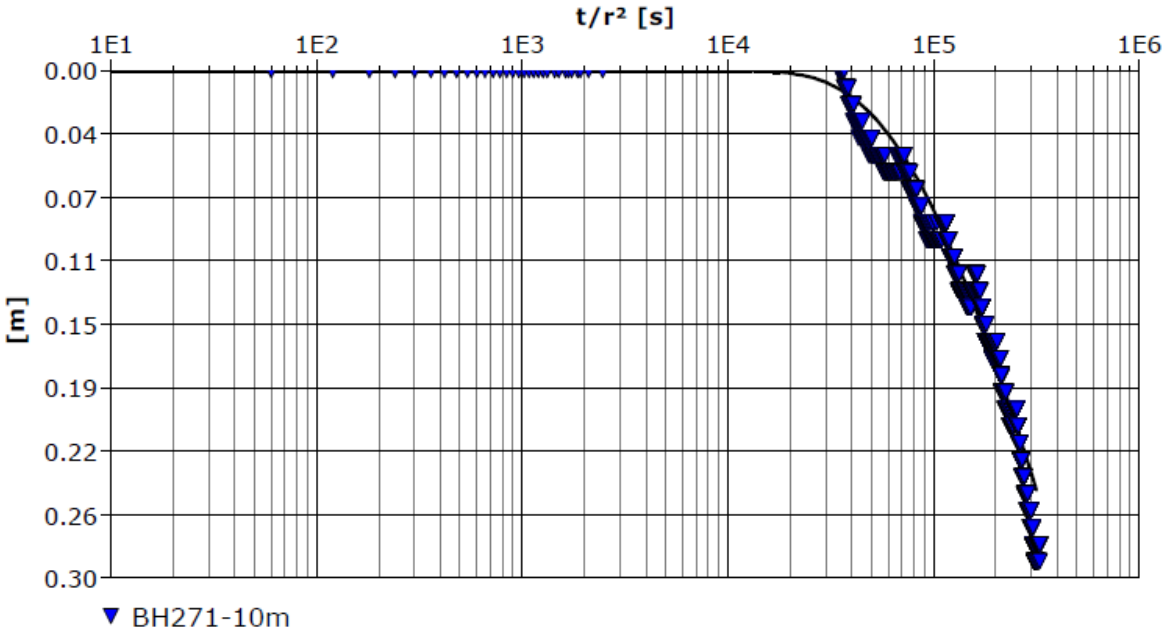


Figure H.26 : Analysis of BH271-6m using Theis with Jacobs Correction



Calculation using Theis

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	Ratio K(v)/K(h)	
BH271-10m	200.00	7.55	0.70	1.00×10^{0}	

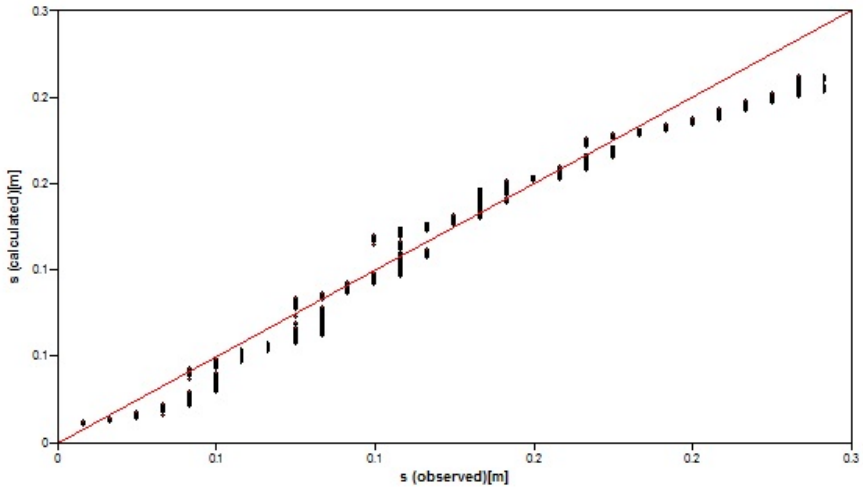
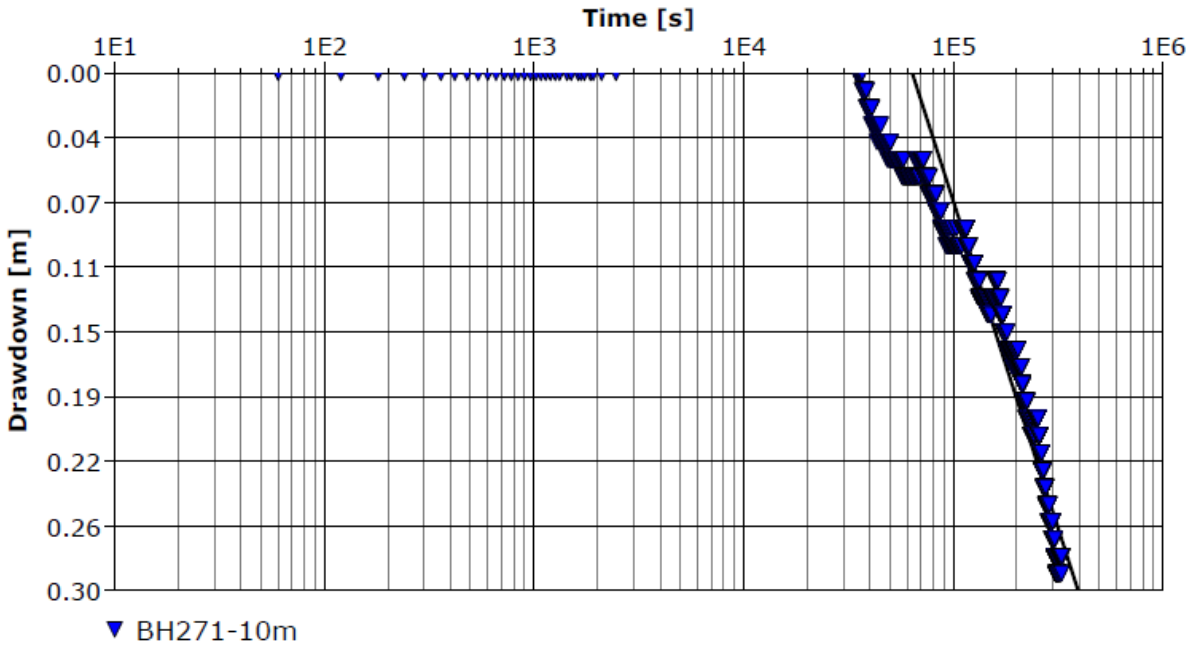
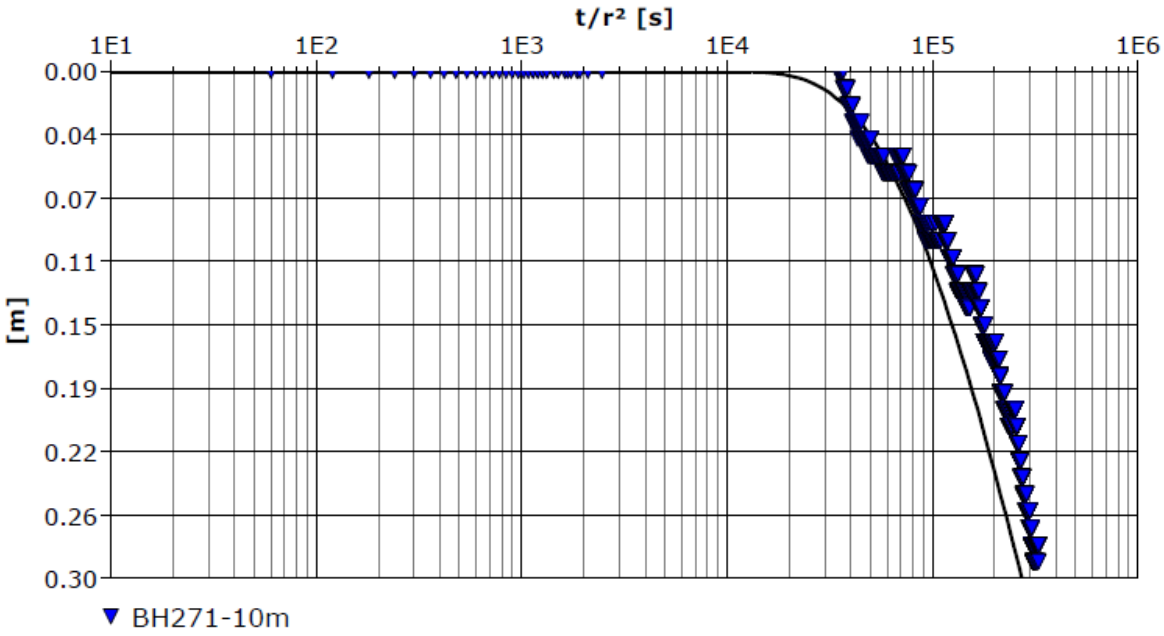


Figure H.27 : Analysis of BH271-10m using Theis



Calculation using COOPER & JACOB				
Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	
BH271-10m	174.00	6.57	0.32	

Figure H.28 : Analysis of BH271-10m using Cooper Jacob



Calculation using Hantush

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	Ratio K(v)/K(h)	Hydr. resistance [s]	Leakage factor [m]
BH271-10m	150.00	5.66	0.50	1.00×10^{-1}	1.00×10^{7}	131.7615691736

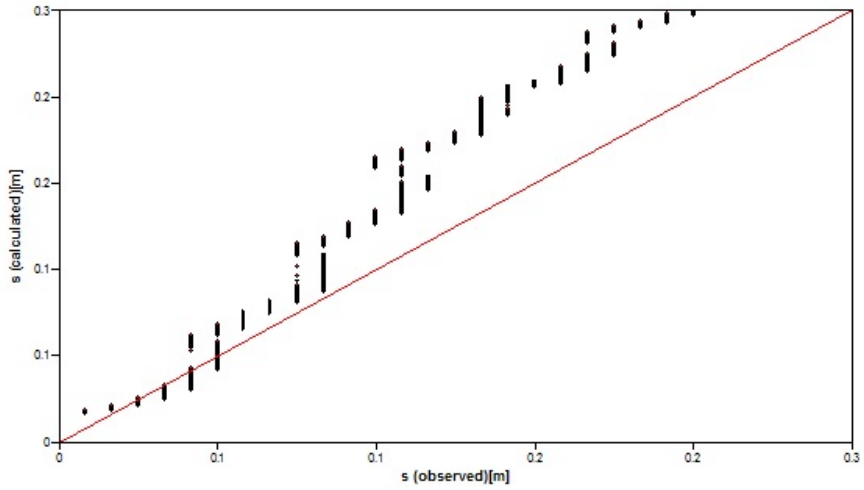
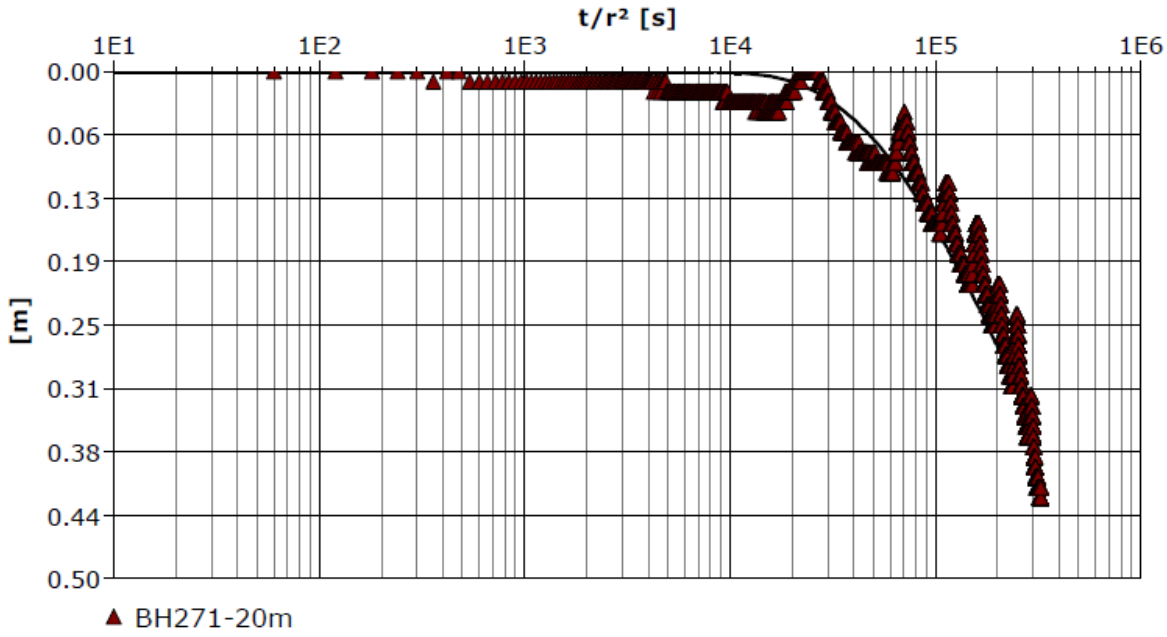


Figure H.29 : Analysis of BH271-10m using Hantush



Calculation using Theis

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	Ratio K(v)/K(h)	
BH271-20m	190.00	7.17	4.00×10^{-1}	1.00×10^{-1}	

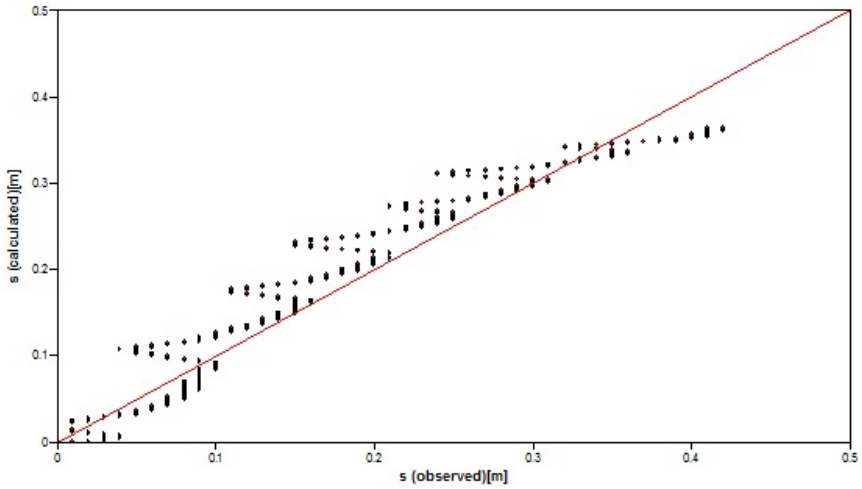
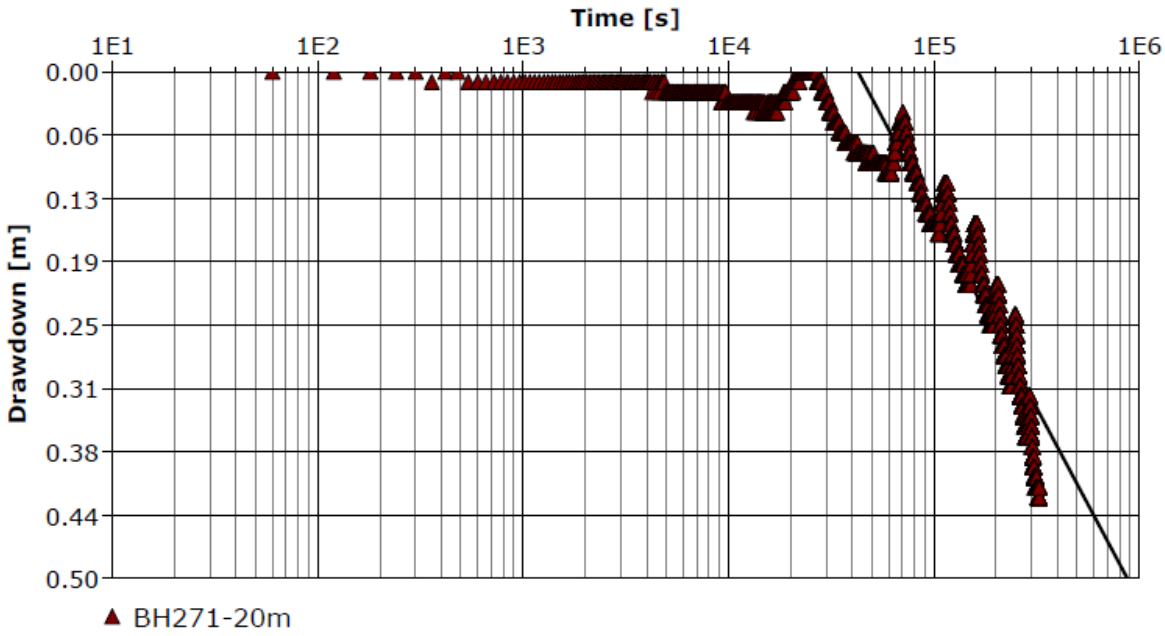
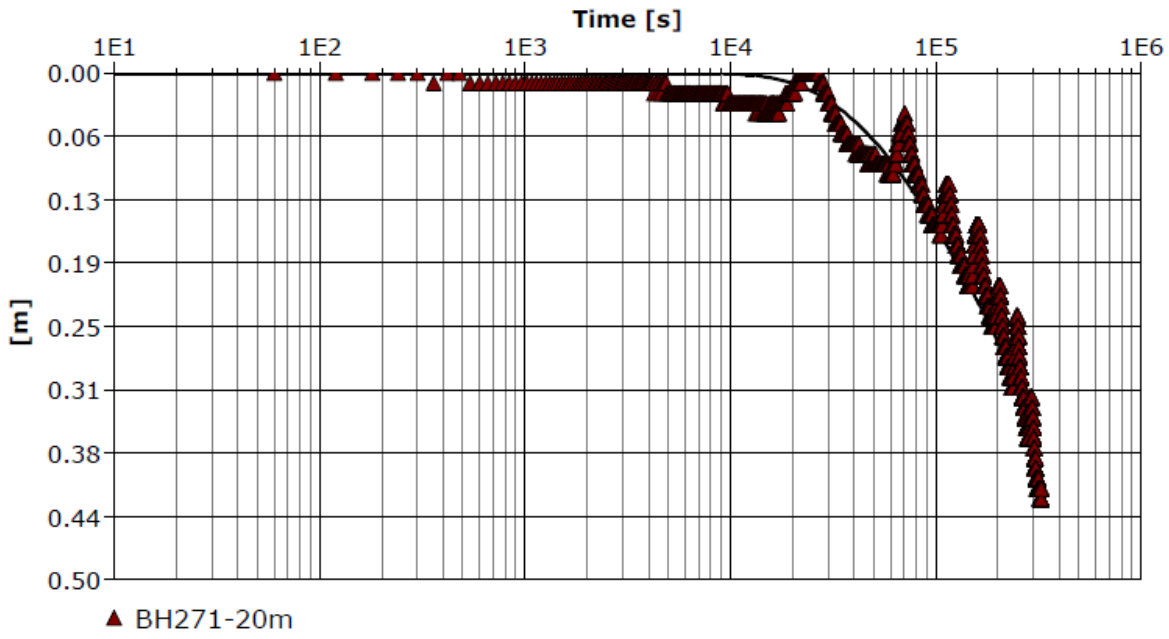


Figure H.30 : Analysis of BH271-20m using Theis



Calculation using COOPER & JACOB				
Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	
BH271-20m	173.00	6.53	2.13×10^{-1}	

Figure H.31 : Analysis of BH271-20m using Cooper Jacob



Calculation using Hantush

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	Ratio K(v)/K(h)	Hydr. resistance [s]	Leakage factor [m]
BH271-20m	190.00	7.17	0.40	1.00×10^{-1}	1.00×10^{7}	148.2927535004

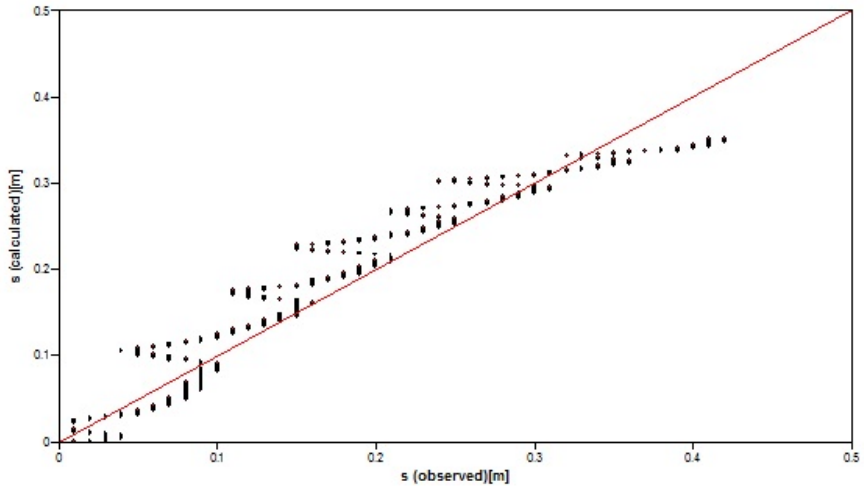
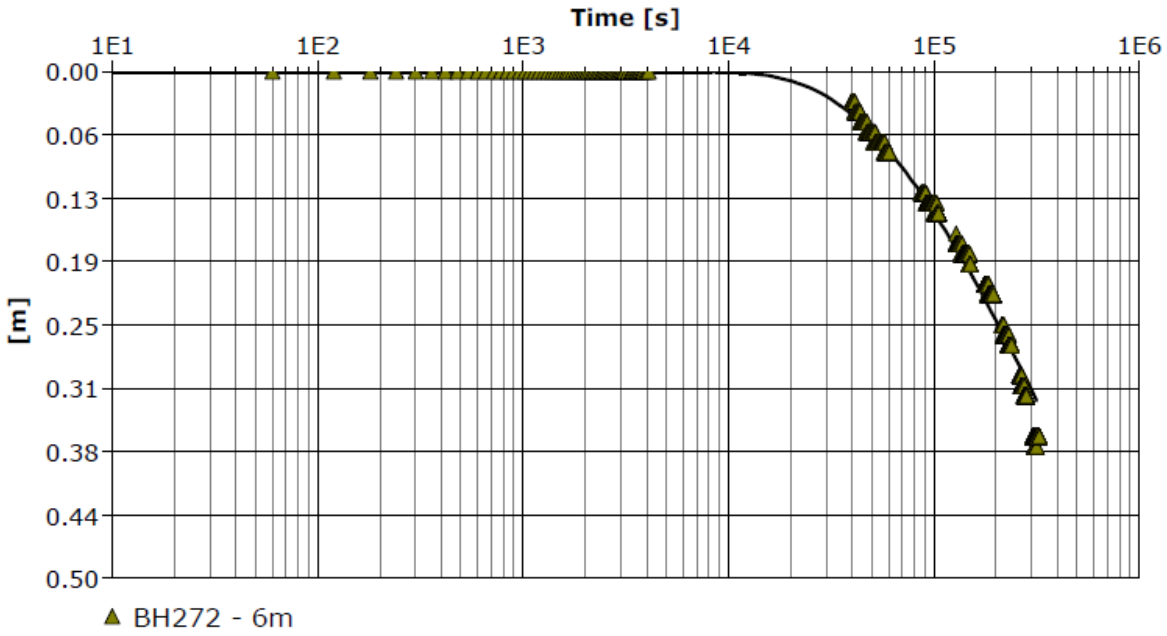


Figure H.32 : Analysis of BH271-20m using Hantush



Calculation using Theis with Jacob Correction				
Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	
BH272 - 6m	210.00	7.92	0.15	

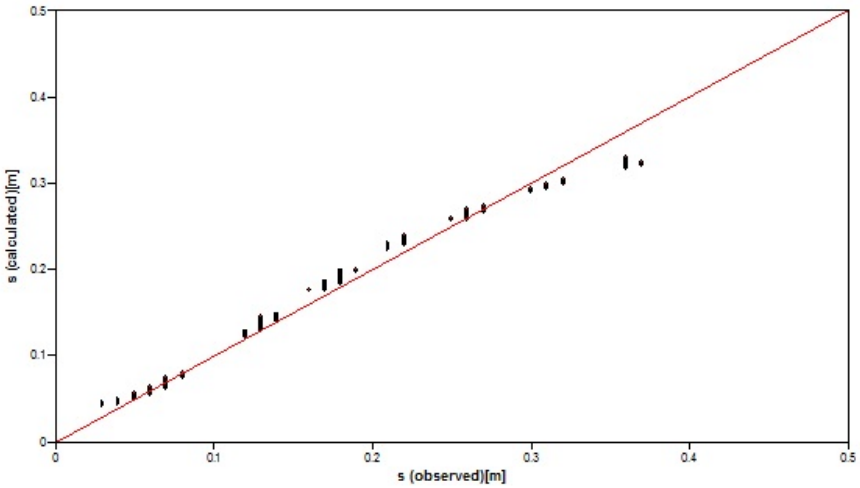
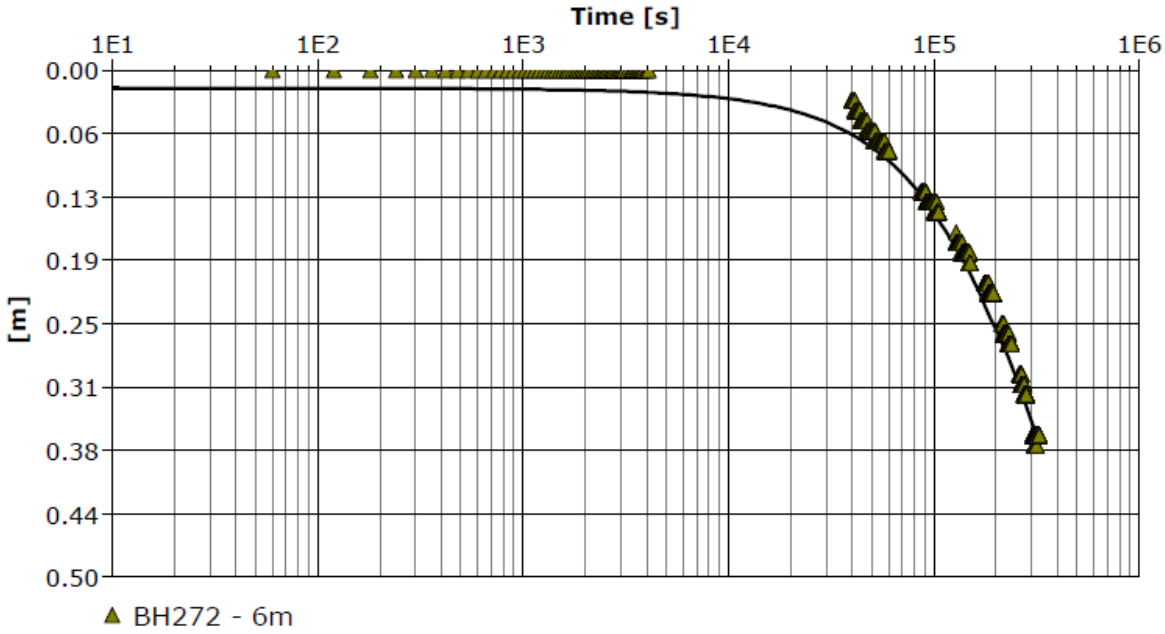


Figure H.33 : Analysis of BH272-6m using Theis with Jacob Correction



Calculation using Neuman					
Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Specific Yield	Ratio K(v)/K(h)	Ratio Sy/S
BH272 - 6m	128.91	4.86	0.17	1.00×10^{0}	3.01×10^{4}

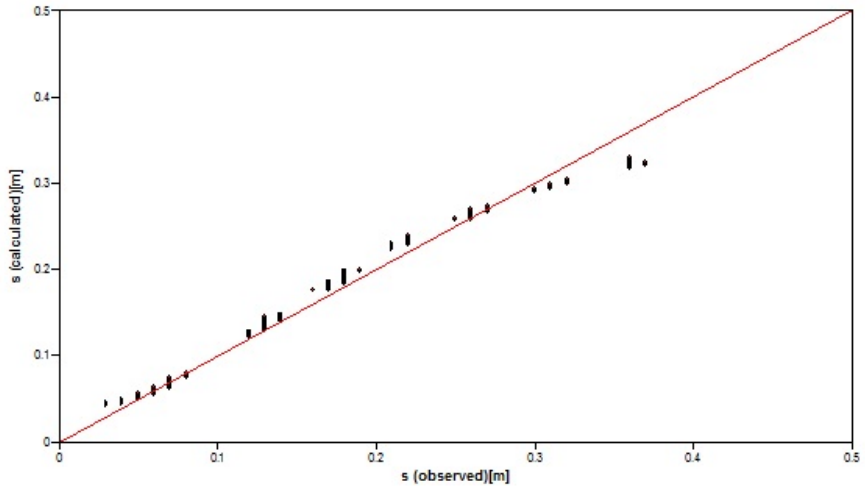
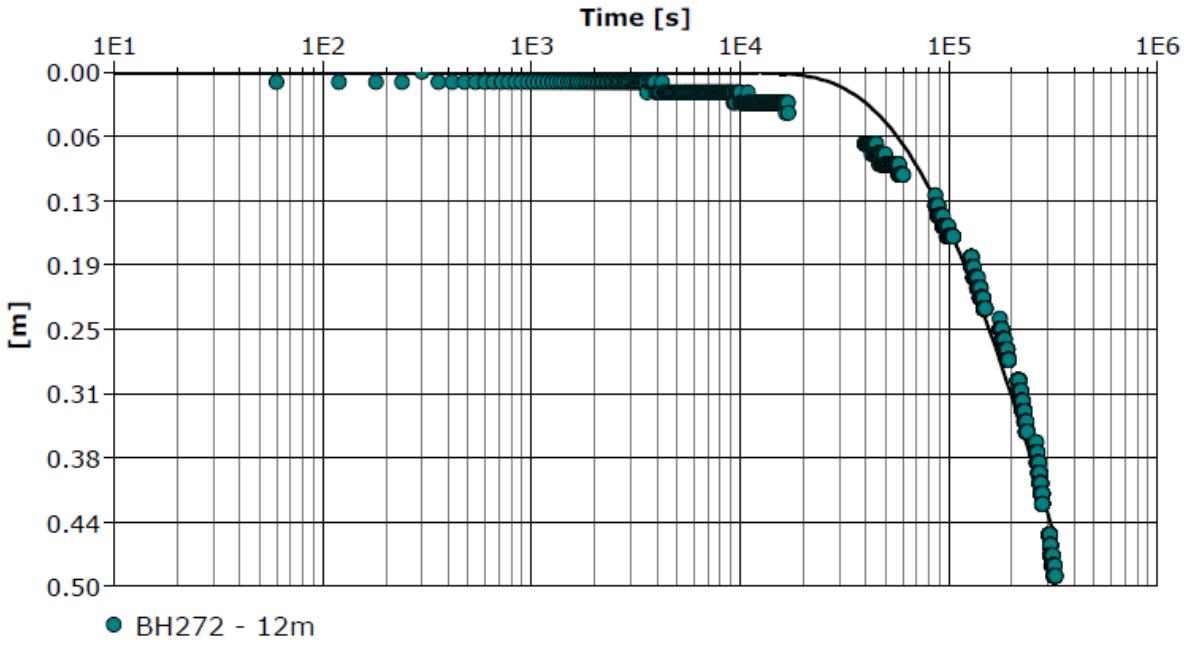


Figure H.34 : Analysis of BH272-6m using Neuman



Calculation using Theis				
Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	
BH272 - 12m	113.00	4.26	0.13	

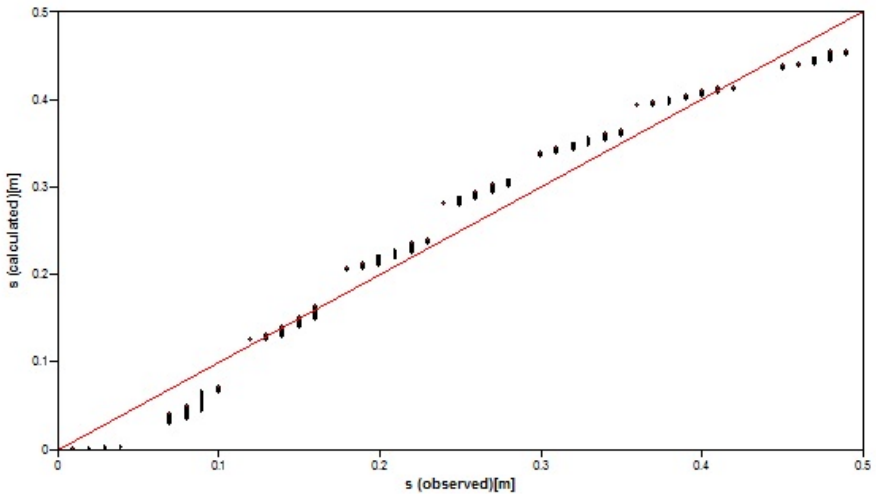
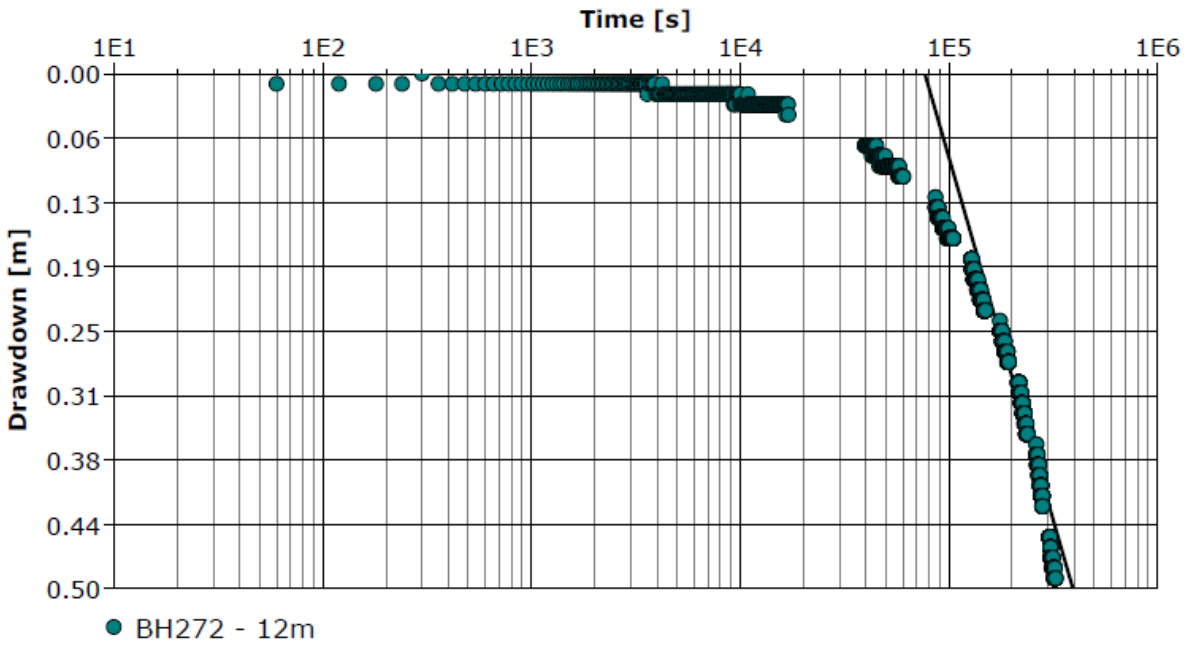


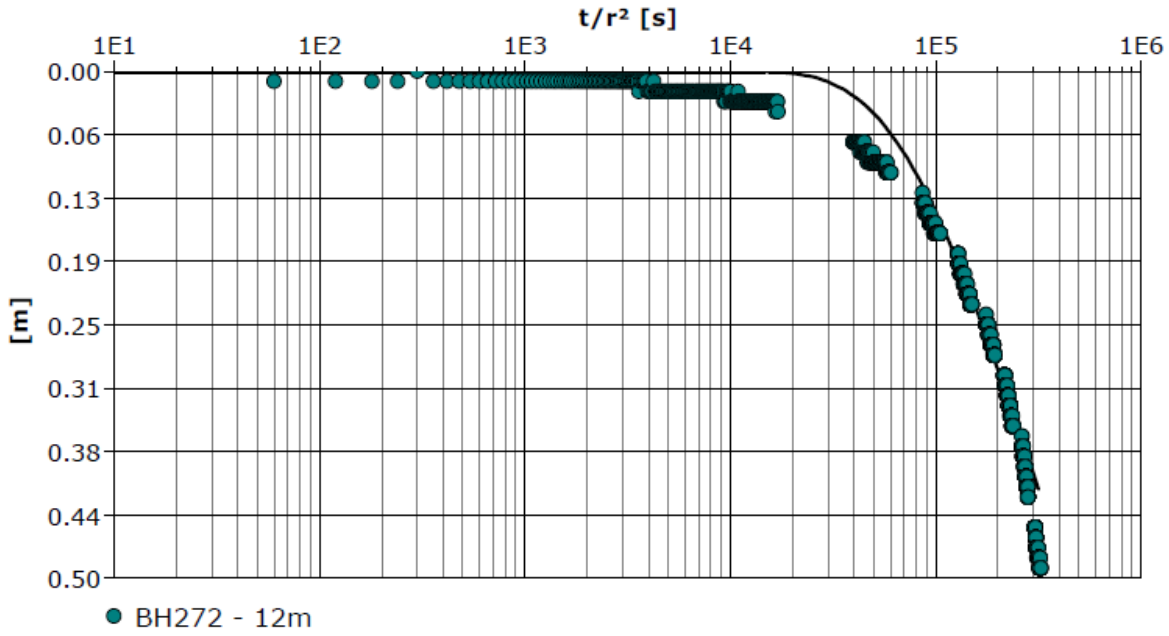
Figure H.35 : Analysis of BH272-12m using Theis



Calculation using COOPER & JACOB

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	
BH272 - 12m	93.60	3.53	0.07	

Figure H.36 : Analysis of BH272-12m using Cooper Jacob



Calculation using Hantush

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	Hydr. resistance [s]	Leakage factor [m]
BH272 - 12m	100.00	3.77	0.13	1.00×10^{7}	107.582870727984

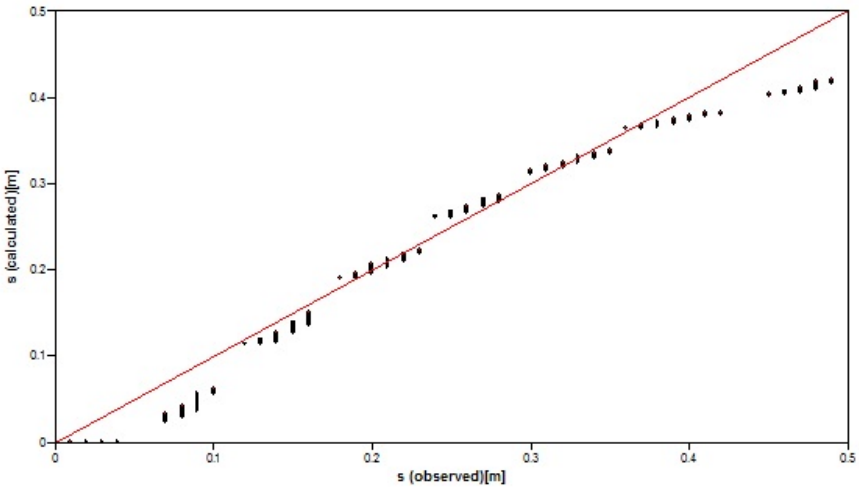
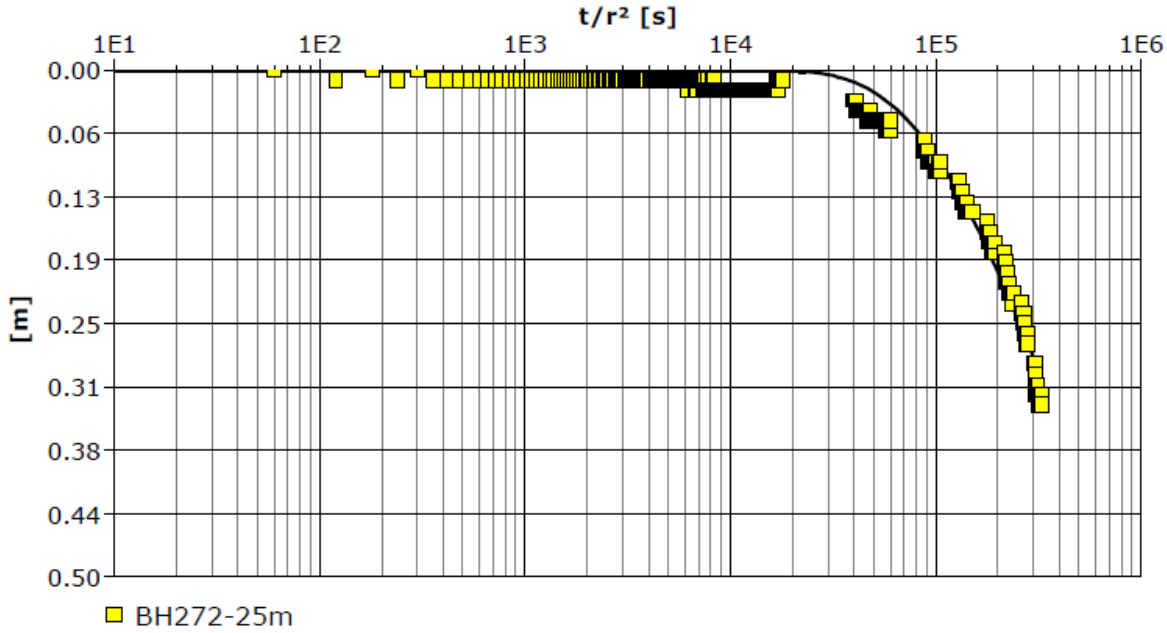


Figure H.37 : Analysis of BH272-12m using Hantush



Calculation using Theis

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	
BH272-25m	1.41×10^{2}	5.32×10^{0}	2.10×10^{-1}	

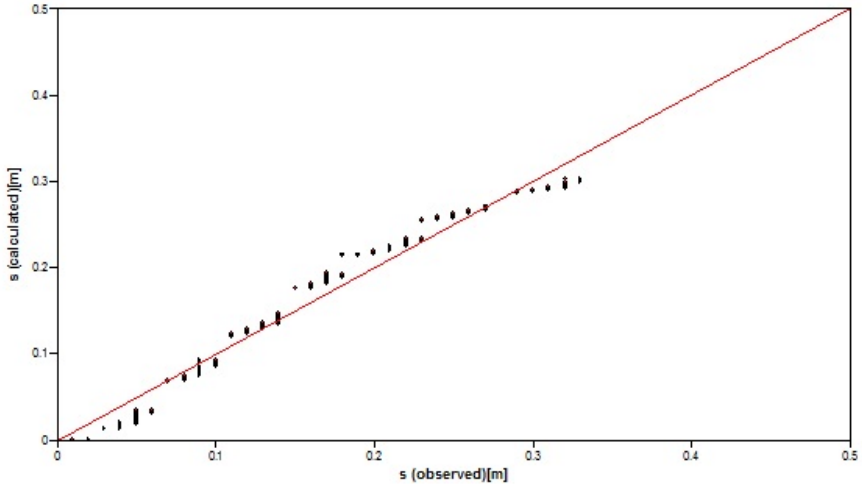
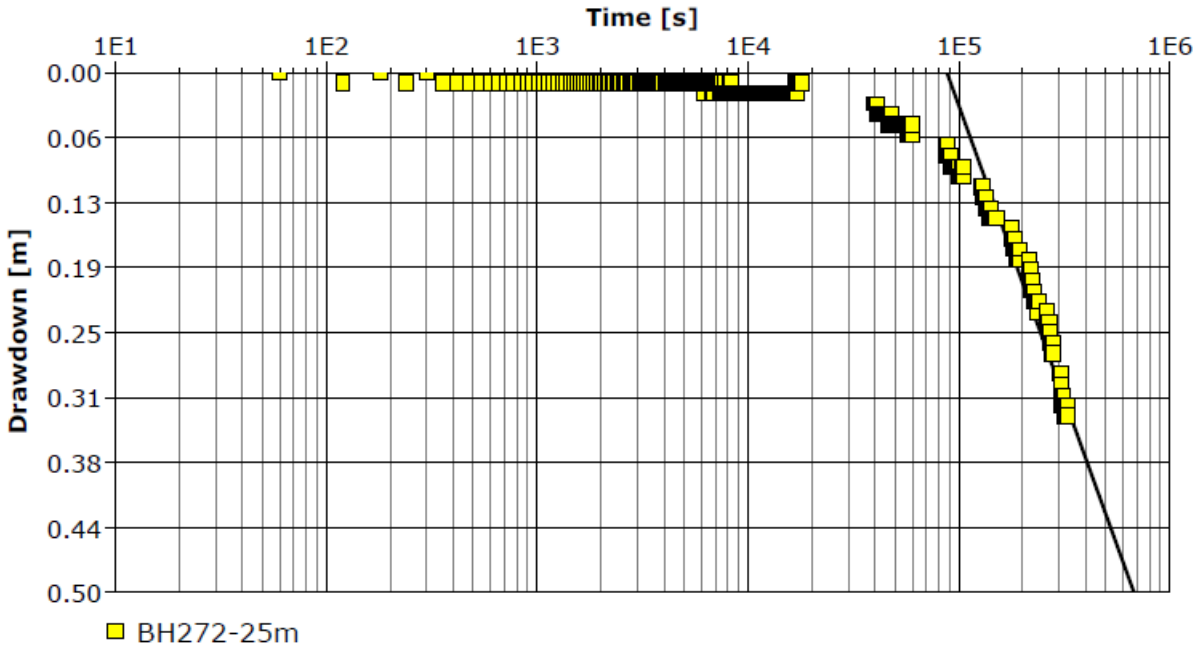


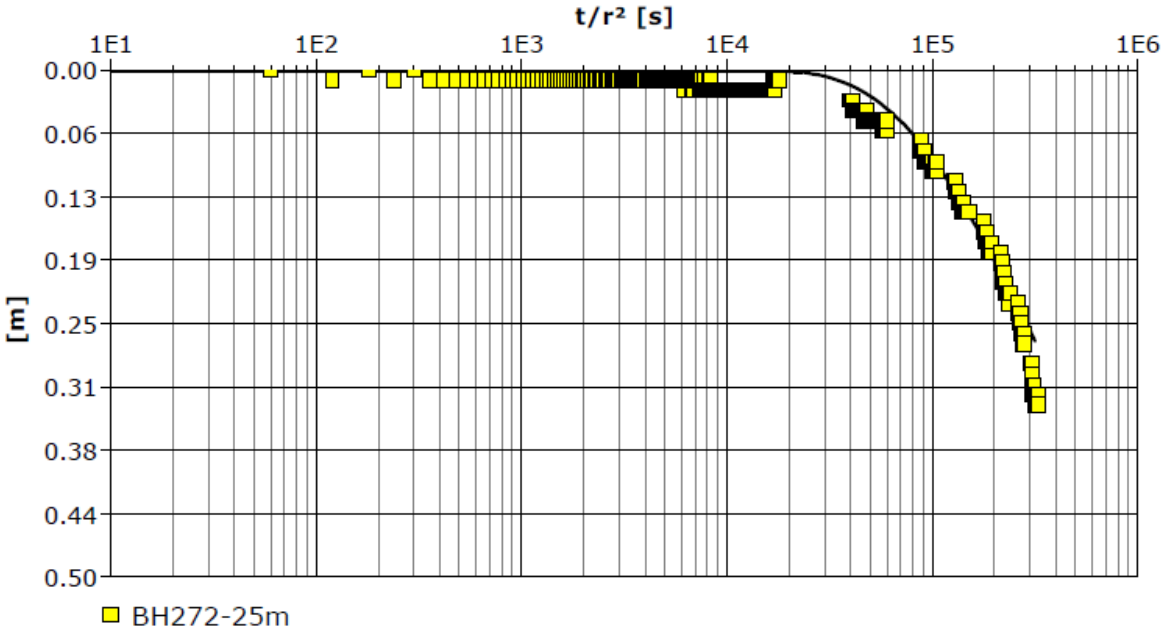
Figure H.38 : Analysis of BH272-25m using Theis



Calculation using COOPER & JACOB

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	
BH272-25m	1.17×10^{2}	4.42×10^{0}	0.10	

Figure H.39 : Analysis of BH272-25m using Cooper Jacob



Calculation using Hantush

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	Hydr. resistance [s]	Leakage factor [m]
BH272-25m	160.00	6.04	0.21	1.00×10^{7}	136.08276348795

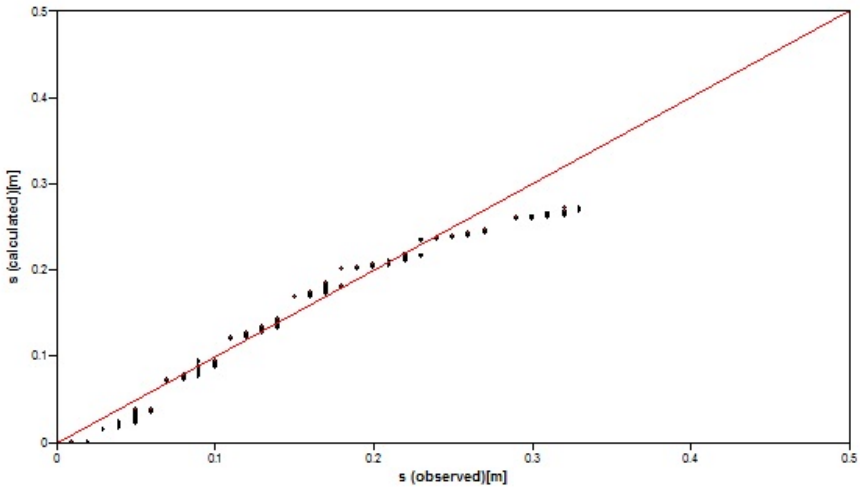


Figure H.40 : Analysis of BH272-25m using Hantush

Appendix I. Bulk and dry unit weight

Figure I.1 : Bulk Density versus Depth

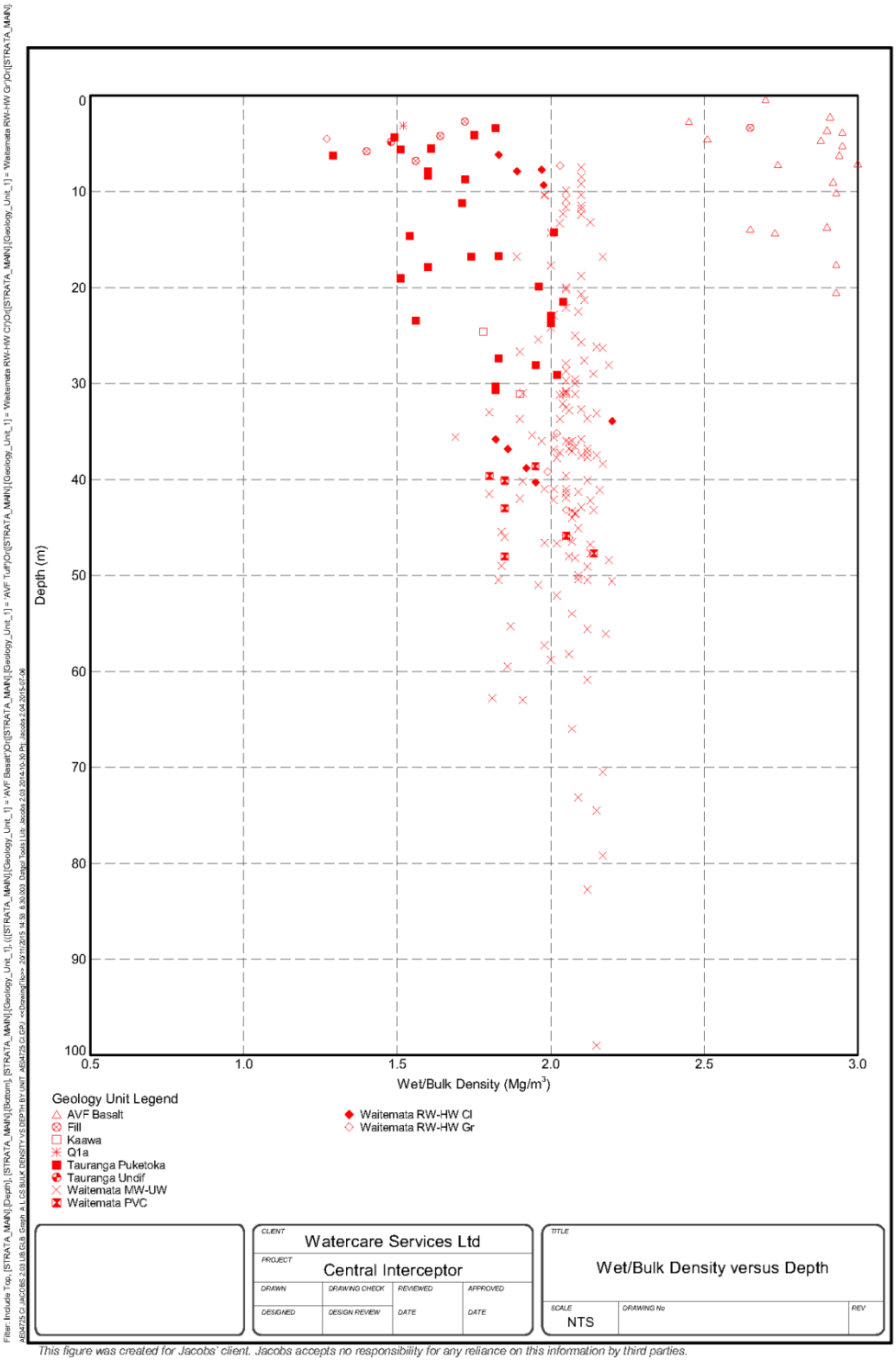


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Table I.1 : Bulk Unit Weight

Bulk Unit Weight (kN/m^3)										
Geological Unit	**Minimum**	**10th Percentile**	**25th Percentile**	**Median**	**75th Percentile**	**90th Percentile**	**Maximum**	**Mean**	**Standard deviation**	**Count**
All results in this investigation	10	17	18	20	21	21	29	20	3	237
Made Ground / Fill	14	14	15	16	17	22	26	18	4	5
Made Ground (Waterview)	-	-	-	-	-	-	-	-	-	-
Recent Alluvium / Q1a	11	12	12	13	14	15	15	13	2	2
TAURANGA GROUP										
Undifferentiated Tauranga Group	15	15	16	17	18	18	19	17	2	2
Undifferentiated Tauranga Group (Waterview)	-	-	-	-	-	-	-	-	-	-
Tauranga Estuarine	-	-	-	-	-	-	-	-	-	-
Tauranga Puketoka	10	14	16	17	19	20	20	17	2	46
Kaawa Formation	17	18	18	18	18	19	19	18	1	2
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Basalt	24	26	27	28	29	29	29	28	2	18
Basalt (Waterview)	-	-	-	-	-	-	-	-	-	-
Tuff / Ash/ Scoria	-	-	-	-	-	-	-	-	-	-
Tuff / Ash/ Scoria (Waterview)	-	-	-	-	-	-	-	-	-	-
WAITEMATA GROUP (MIOCENE)										
Residually to Highly Weathered Residual Soils - Cohesive Soils	18	18	18	19	19	19	22	19	1	12
Residually to Highly Weathered - Cohesive Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Residually to Highly Weathered - Granular Soils	12	16	20	20	20	20	20	19	3	6
Residually to Highly Weathered - Granular Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Parnell Volcaniclastic Conglomerate	18	18	18	18	20	20	211	19	1	7
Parnell Volcaniclastic Conglomerate (Waterview)	-	-	-	-	-	-	-	-	-	-
Moderately Weathered to Unweathered ECBF	17	19	20	20	21	21	22	20	1	137
Moderately Weathered to Unweathered ECBF (Waterview)	-	-	-	-	-	-	-	-	-	-

Figure I.2 : Dry Density versus Depth

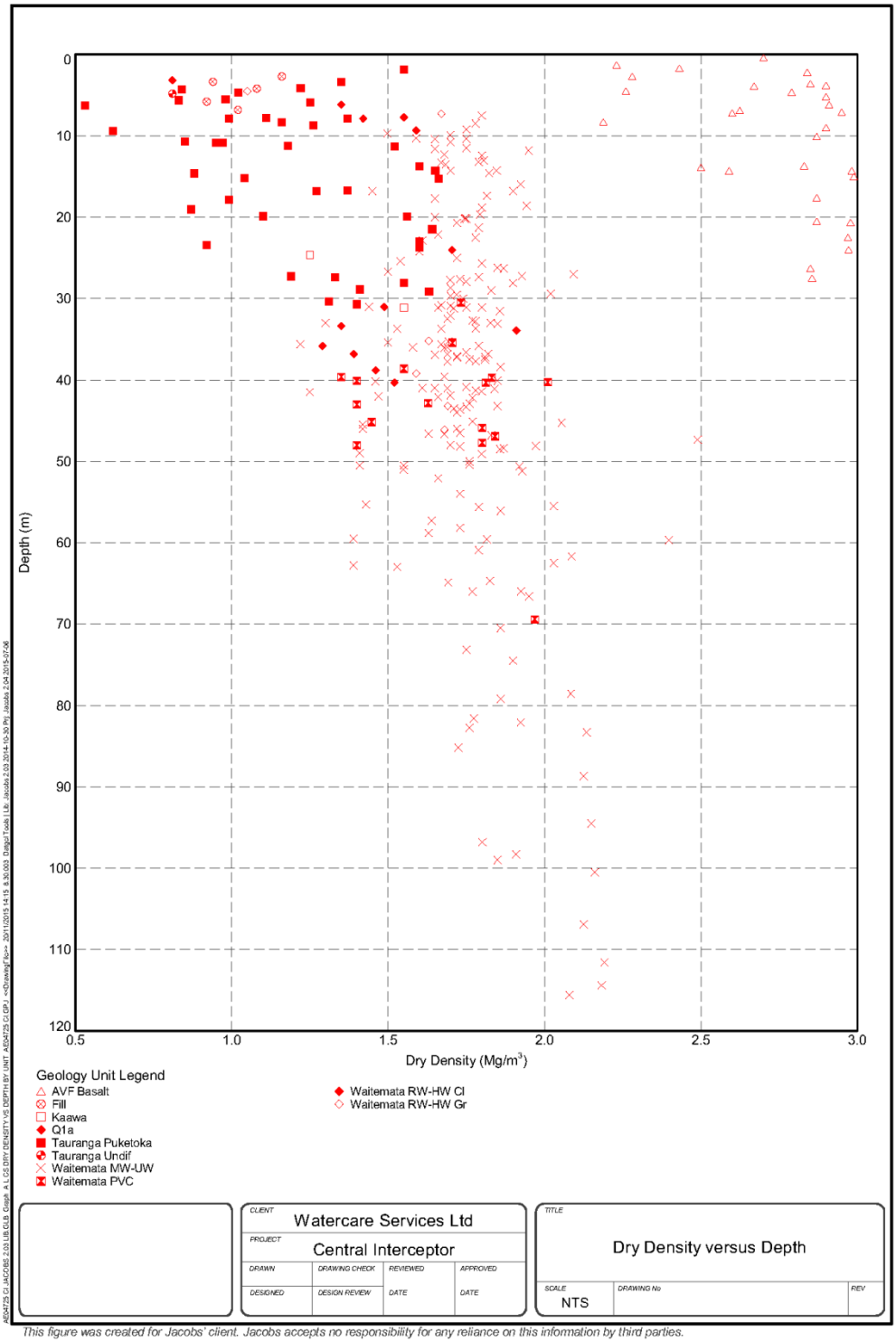

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Table I.2 : Dry Unit Weight

Dry Unit Weight (kN/m^3)										
Geological Unit	**Minimum**	**10th Percentile**	**25th Percentile**	**Median**	**75th Percentile**	**90th Percentile**	**Maximum**	**Mean**	**Standard deviation**	**Count**
All results in this investigation	2	10	14	17	18	21	29	16	5	374
Made Ground / Fill	9	9	9	10	10	11	11	10	1	6
Made Ground (Waterview)	-	-	-	-	-	-	-	-	-	-
Recent Alluvium / Q1a	4	4	5	6	7	8	8	6	2	2
TAURANGA GROUP										
Undifferentiated Tauranga Group	8	9	10	11	13	14	14	11	3	2
Undifferentiated Tauranga Group (Waterview)	-	-	-	-	-	-	-	-	-	-
Tauranga Estuarine	-	-	-	-	-	-	-	-	-	-
Tauranga Puketoka	2	8	10	12	14	16	16	12	3	85
Kaawa Formation	12	13	13	14	14	15	15	14	1	2
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Basalt	21	22	25	28	28	29	27	3	3	25
Basalt (Waterview)	-	-	-	-	-	-	-	-	-	-
Tuff / Ash/ Scoria	-	-	-	-	-	-	-	-	-	-
Tuff / Ash/ Scoria (Waterview)	-	-	-	-	-	-	-	-	-	-
WAITEMATA GROUP (MIOCENE)										
Residually to Highly Weathered Residual Soils - Cohesive Soils	13	13	13	14	15	16	19	15	1	18
Residually to Highly Weathered - Cohesive Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Residually to Highly Weathered - Granular Soils	10	13	16	16	16	17	17	15	2	6
Residually to Highly Weathered - Granular Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Parnell Volcaniclastic Conglomerate	13	14	14	17	18	19	20	16	2	16
Parnell Volcaniclastic Conglomerate (Waterview)	-	-	-	-	-	-	-	-	-	-
Moderately Weathered to Unweathered ECBF	12	15	16	17	18	19	24	17	2	185
Moderately Weathered to Unweathered ECBF (Waterview)	-	-	-	-	-	-	-	-	-	-

Appendix J. Moisture content

Figure J.1 : Moisture Content Versus Depth

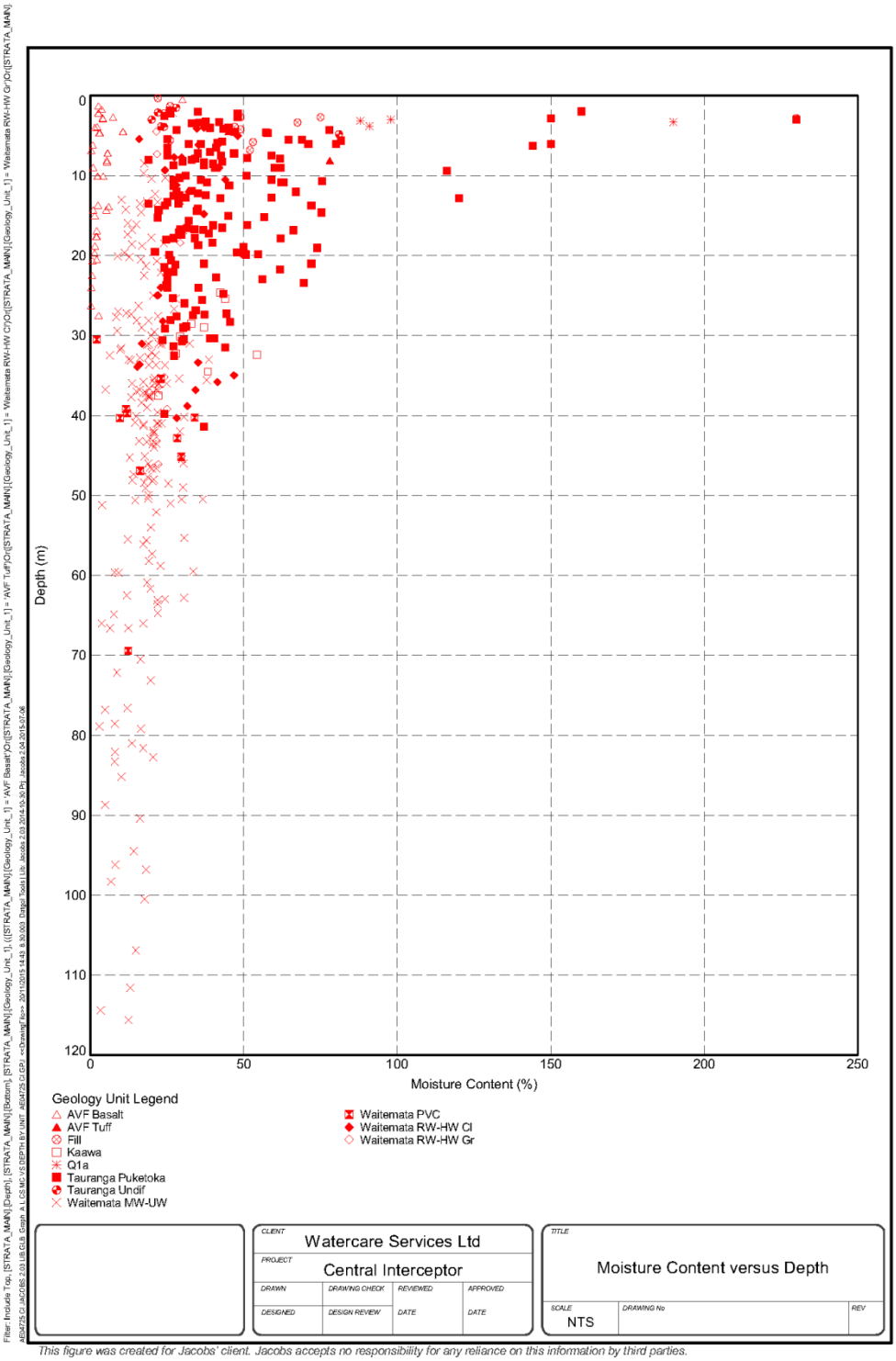

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Table J.1 : Moisture Content

Moisture Content (%)										
Geological Unit	Minimum	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile	Maximum	Mean	Standard deviation	Count
All results in this investigation	0.2	5.6	17	22	30	45	360	27	27	753
Made Ground / Fill	22	24	26	49	53	65	75	46	16	13
Made Ground (Waterview)	-	-	-	-	-	-	-	-	-	-
Recent Alluvium / Q1a	88	89	91	98	190	220	240	141	62	5
TAURANGA GROUP										
Undifferentiated Tauranga Group	20	22	23	28	37	111	230	55	64	9
Undifferentiated Tauranga Group (Waterview)	-	-	-	-	-	-	-	-	-	-
Tauranga Estuarine	-	-	-	-	-	-	-	-	-	-
Tauranga Puketoka	19	25	28	37	50	72	360	46	36	184
Kaawa Formation	22	26	27	33	40	44	54	35	9	11
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Basalt	0.2	0.8	1.5	2.3	3.8	5.7	30	3.4	4.4	51
Basalt (Waterview)	0.3	0.9	1.6	3.0	4.7	6.8	23	4.4	5.4	28
Tuff / Ash/ Scoria	45	48	53	62	70	75	78	62	16.5	2
Tuff / Ash/ Scoria (Waterview)	-	-	-	-	--	-	-	-	-	-
WAITEMATA GROUP (MIOCENE)										
Residually to Highly Weathered Residual Soils - Cohesive Soils	15	17	26	32	37	42	48	31	8.7	31
Residually to Highly Weathered - Cohesive Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Residually to Highly Weathered - Granular Soils	22	22	22	22	25	27	29	24	2.6	7
Residually to Highly Weathered - Granular Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Parnell Volcaniclastic Conglomerate	2.1	12	15	24	33	33	34	23	10	23
Parnell Volcaniclastic Conglomerate (Waterview)	12	14	15	21	24	27	31	20	5.4	17
Moderately Weathered to Unweathered ECBF	3.0	9.3	15	19	22	25	41	18	6.4	231
Moderately Weathered to Unweathered ECBF (Waterview)	7.3	15	19	21	24	27	30	21	4.4	141

Appendix K. Atterberg limit and particle size distribution

K.1 Atterberg Limits – Project Wide

Figure K.1 : Atterberg Limit - PI versus LL

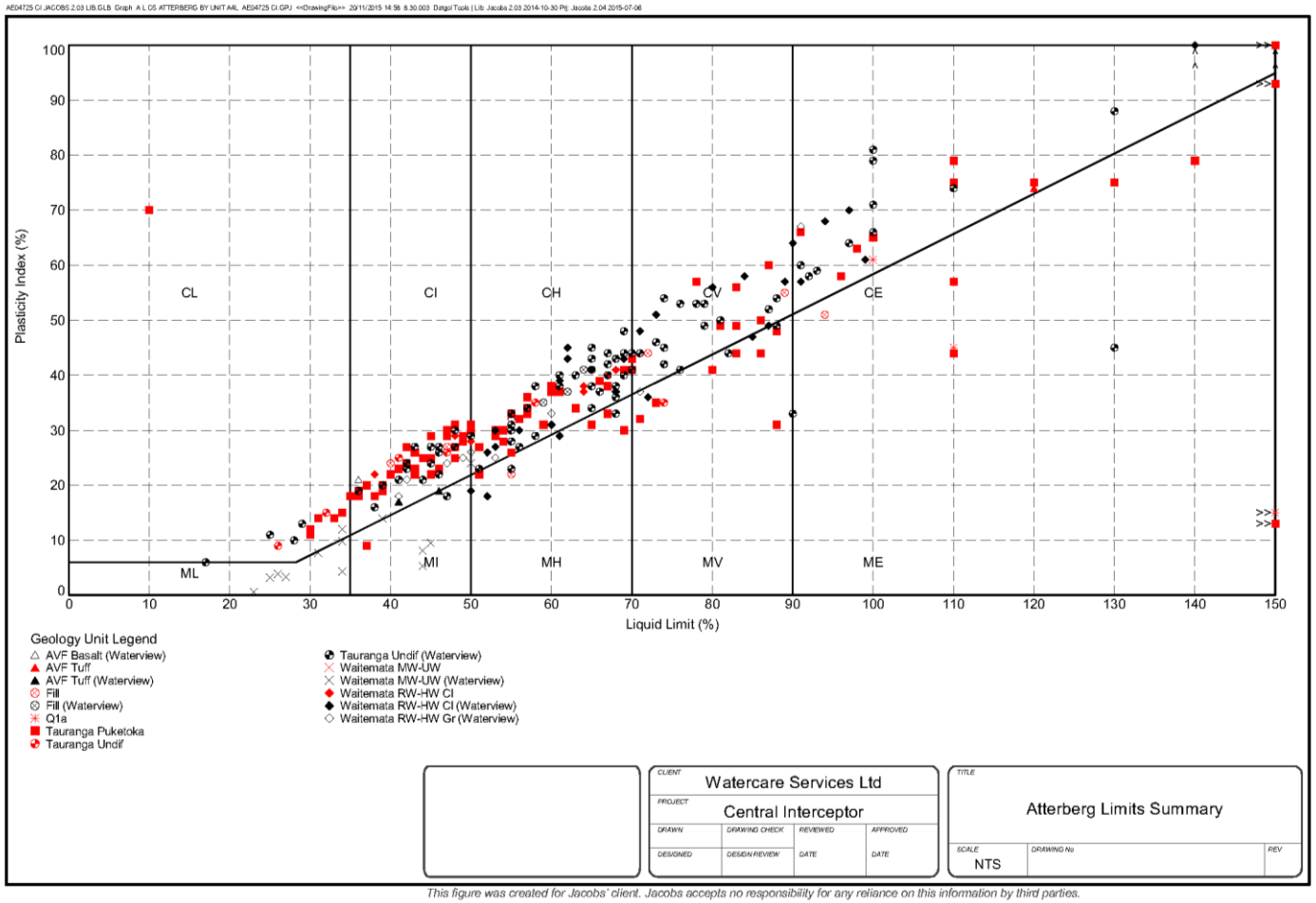

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Table K.1 : Liquid Limit

Liquid Limit (%)										
Geological Unit	Minimum	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile	Maximum	Mean	Standard deviation	Count
All results in this investigation	10	37	46	60	78	100	470	68	42	288
Made Ground / Fill	40	45	53	66	76	91	94	66	18	8
Made Ground (Waterview)	59	60	61	62	63	64	64	62	2	3
Recent Alluvium / Q1a	100	102	105	110	165	198	220	143	54	3
TAURANGA GROUP										
Undifferentiated Tauranga Group	26	30	37	47	66	168	310	84	93	7
Undifferentiated Tauranga Group (Waterview)	17	39	48	65	78	100	470	71	48	100
Tauranga Estuarine	-	-	-	-	-	-	-	-	-	-
Tauranga Puketoka	10	37	45	55	81	110	260	67	38	93
Kaawa Formation	-	-	-	-	-	-	-	-	-	-
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Basalt	-	-	-	-	-	-	-	-	-	-
Basalt (Waterview)	36	36	36	36	36	36	36	36	0	1
Tuff / Ash/ Scoria	120	120	120	120	120	120	120	120	0	1
Tuff / Ash/ Scoria (Waterview)	41	42	42	44	45	46	46	44	3	2
WAITEMATA GROUP (MIOCENE)										
Residually to Highly Weathered Residual Soils - Cohesive Soils	38	48	50	59	65	68	86	58	12	12
Residually to Highly Weathered - Cohesive Soils (Waterview)	50	53	61	72	87	94	140	74	19	30
Residually to Highly Weathered - Granular Soils	-	-	-	-	-	-	-	-	-	-
Residually to Highly Weathered - Granular Soils (Waterview)	26	41	48	55	67	73	91	57	15	15
Parnell Volcaniclastic Conglomerate	-	-	-	-	-	-	-	-	-	-
Parnell Volcaniclastic Conglomerate (Waterview)	-	-	-	-	-	-	-	-	-	-
Moderately Weathered to Unweathered ECBF	-	-	-	-	-	-	-	-	-	-
Moderately Weathered to Unweathered ECBF (Waterview)	23	25	27	34	44	45	50	35	8	13

Table K.2 : Plastic Limit

Plasticity Limit (%)										
Geological Unit	Minimum	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile	Maximum	Mean	Standard deviation	Count
All results in this investigation	11	18	21	25	32	39	270	29	19	288
Made Ground / Fill	16	19	22	28	33	37	43	28	8	8
Made Ground (Waterview)	23	23	24	24	25	25	25	24	1	3
Recent Alluvium / Q1a	39	44	52	64	65	65	65	56	12	3
TAURANGA GROUP										
Undifferentiated Tauranga Group	16	17	17	21	31	67	110	35	32	7
Undifferentiated Tauranga Group (Waterview)	11	19	21	25	32	37	270	30	26	100
Tauranga Estuarine	-	-	-	-	-	-	-	-	-	-
Tauranga Puketoka	15	18	20	24	34	45	110	29	15	93
Kaawa Formation	-	-	-	-	-	-	-	-	-	-
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Basalt	-	-	-	-	-	-	-	-	-	-
Basalt (Waterview)	15	15	15	15	15	15	15	15	0	1
Tuff / Ash/ Scoria	43	43	43	43	43	43	43	43	0	1
Tuff / Ash/ Scoria (Waterview)	24	24	25	26	26	27	27	26	2	2
WAITEMATA GROUP (MIOCENE)										
Residually to Highly Weathered Residual Soils - Cohesive Soils	16	19	21	24	27	27	42	25	6	12
Residually to Highly Weathered - Cohesive Soils (Waterview)	17	22	24	26	32	36	38	28	5	30
Residually to Highly Weathered - Granular Soils	-	-	-	-	-	-	-	-	-	-
Residually to Highly Weathered - Granular Soils (Waterview)	20	22	23	24	27	30	34	25	4	15
Parnell Volcaniclastic Conglomerate	-	-	-	-	-	-	-	-	-	-
Parnell Volcaniclastic Conglomerate (Waterview)	-	-	-	-	-	-	-	-	-	-
Moderately Weathered to Unweathered ECBF	-	-	-	-	-	-	-	-	-	-
Moderately Weathered to Unweathered ECBF (Waterview)	22	22	23	24	30	36	39	27	6	13

Table K.3 : Plastic Index

Plasticity Index (%)										
Geological Unit	**Minimum**	**10th Percentile**	**25th Percentile**	**Median**	**75th Percentile**	**90th Percentile**	**Maximum**	**Mean**	**Standard deviation**	**Count**
All results in this investigation	1	15	24	33	45	63	20	38	24	288
Made Ground / Fill	22	23	26	41	46	52	55	38	12	8
Made Ground (Waterview)	35	35	36	37	39	40	41	38	2	3
Recent Alluvium / Q1a	15	21	30	45	53	58	61	40	19	3
TAURANGA GROUP										
Undifferentiated Tauranga Group	9	13	20	26	35	97	190	48	59	7
Undifferentiated Tauranga Group (Waterview)	6	18	27	38	48	64	200	41	26	100
Tauranga Estuarine	-	-	-	-	-	-	-	-	-	-
Tauranga Puketoka	9	18	25	31	44	66	150	38	22	93
Kaawa Formation	-	-	-	-	-	-	-	-	-	-
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Basalt	-	-	-	-	-	-	-	-	-	-
Basalt (Waterview)	21	21	21	21	21	21	21	21	0	1
Tuff / Ash/ Scoria	74	74	74	74	74	74	74	74	0	1
Tuff / Ash/ Scoria (Waterview)	17	17	18	18	19	19	19	18	1	2
WAITEMATA GROUP (MIOCENE)										
Residually to Highly Weathered Residual Soils - Cohesive Soils	22	27	29	35	39	41	44	34	6	12
Residually to Highly Weathered - Cohesive Soils (Waterview)	18	27	32	45	57	64	110	46	18	30
Residually to Highly Weathered - Granular Soils	-	-	-	-	-	-	-	-	-	-
Residually to Highly Weathered - Granular Soils (Waterview)	6	19	25	32	39	43	67	31	14	15
Parnell Volcaniclastic Conglomerate	-	-	-	-	-	-	-	-	-	-
Parnell Volcaniclastic Conglomerate (Waterview)	-	-	-	-	-	-	-	-	-	-
Moderately Weathered to Unweathered ECBF	-	-	-	-	-	-	-	-	-	-
Moderately Weathered to Unweathered ECBF (Waterview)	1	3	4	8	10	14	24	8	6	13

K.2 Atterberg Limits – Site Specific

Figure K.2 : Atterberg Limits versus Depth - Site E - Western Springs (WS1)

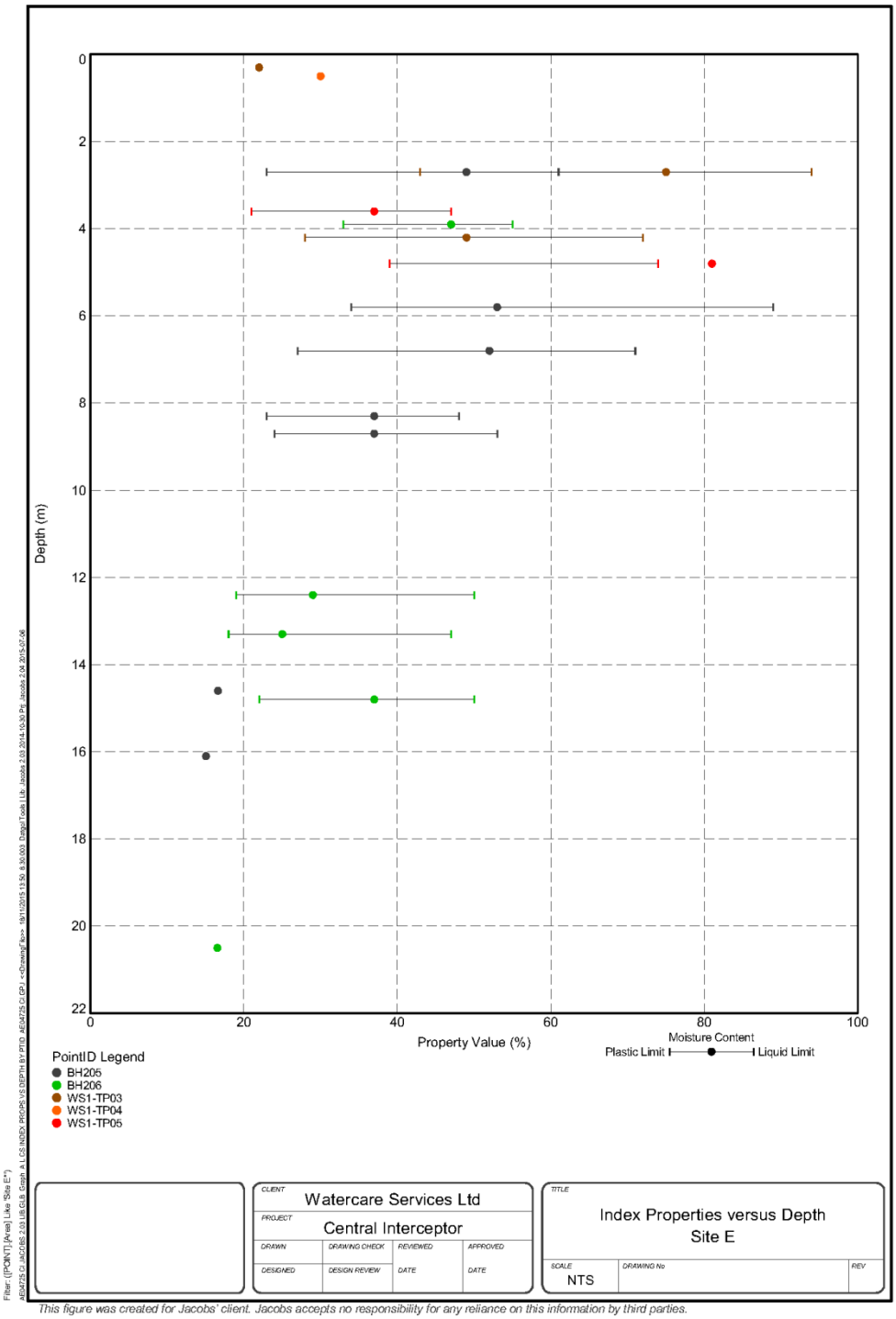

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Figure K.3 : Atterberg Limits versus Depth - Site M.2 - Norgrove (L2S2)

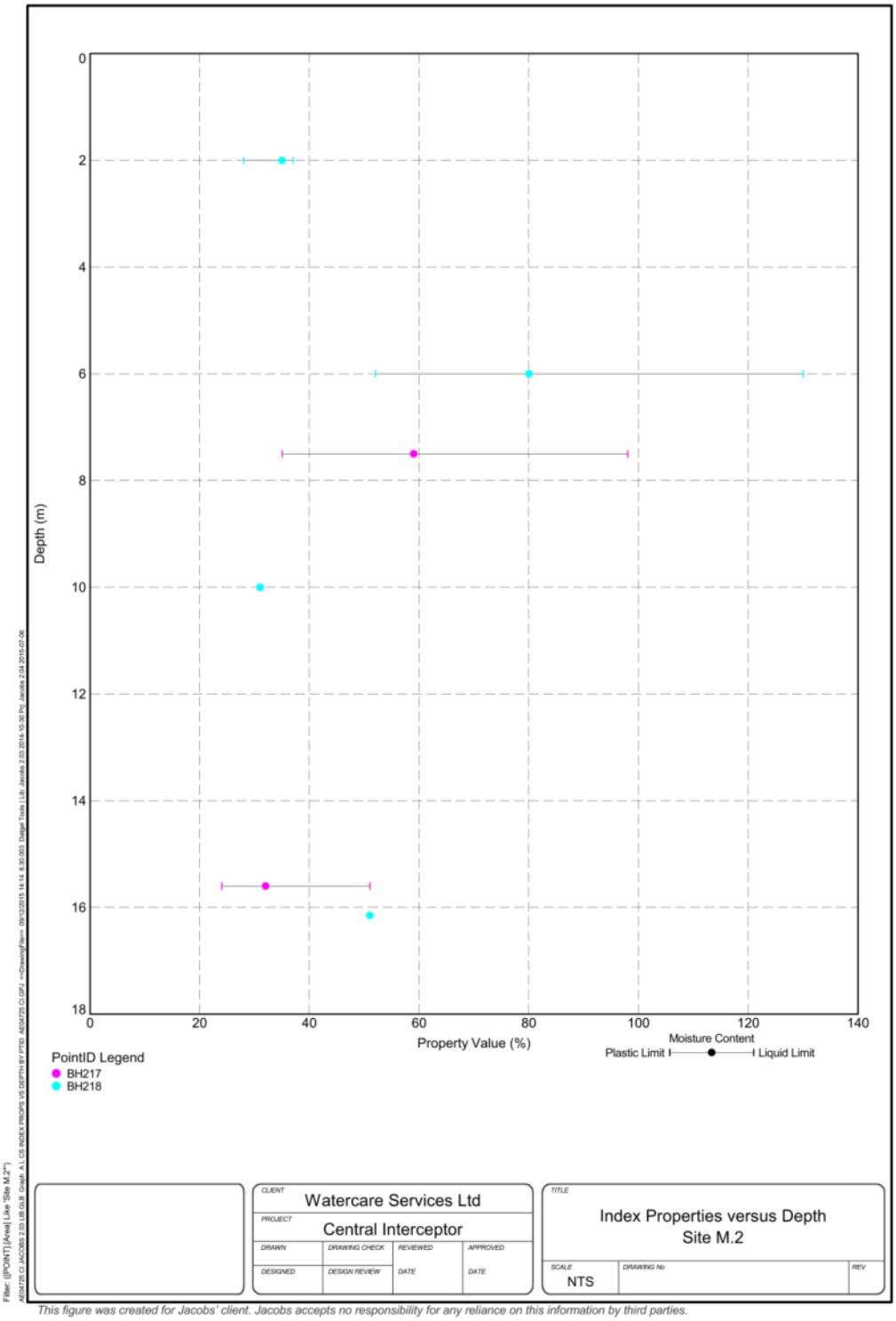

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Figure K.4 : Atterberg Limits versus Depth - Site N - Mt Albert (AS1)

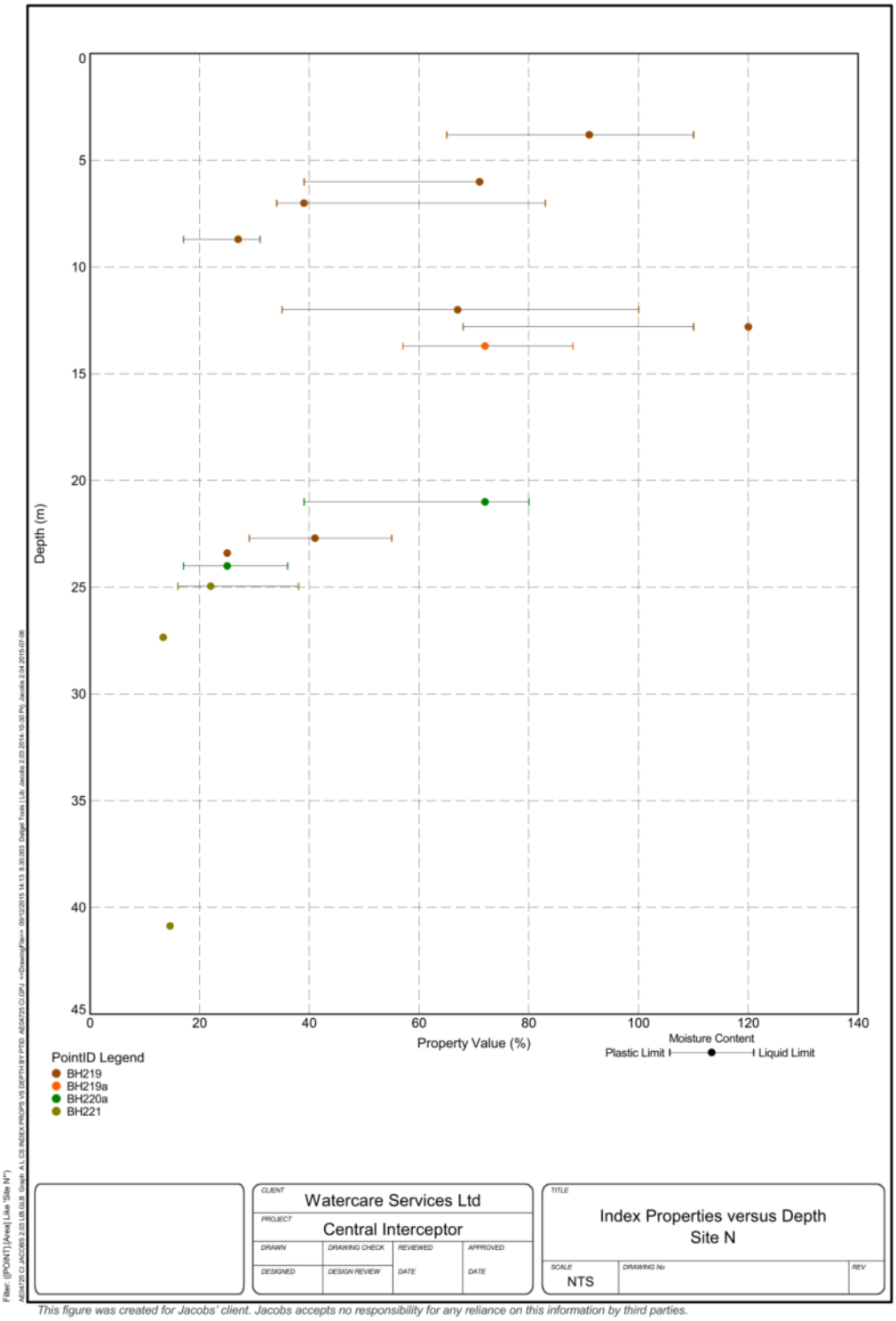

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Figure K.5 : Atterberg Limits versus Depth - Site S - Haverstock (AS3)

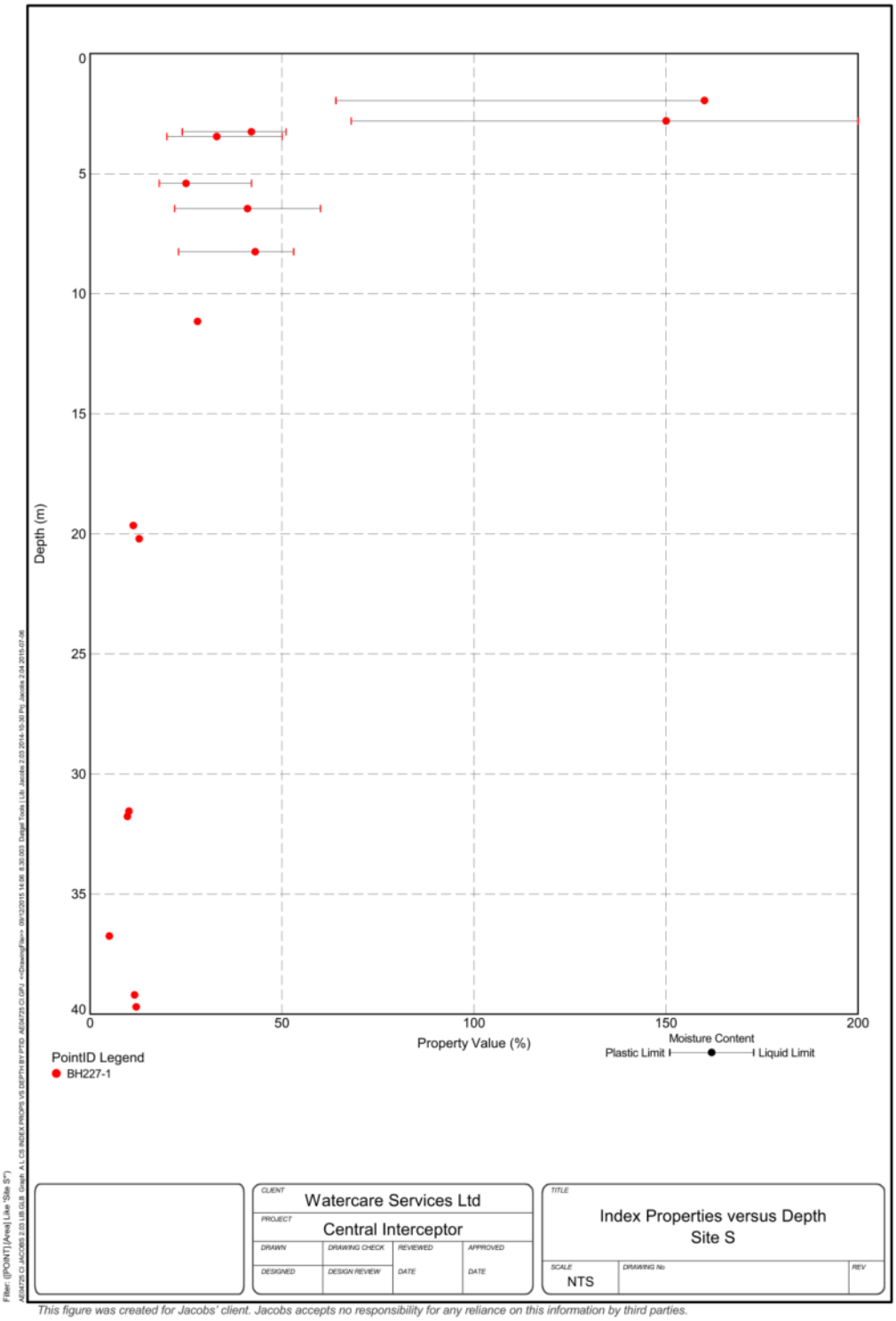

Figure K.6 : Atterberg Limits versus Depth - Site V - Walmsley Park (AS4)

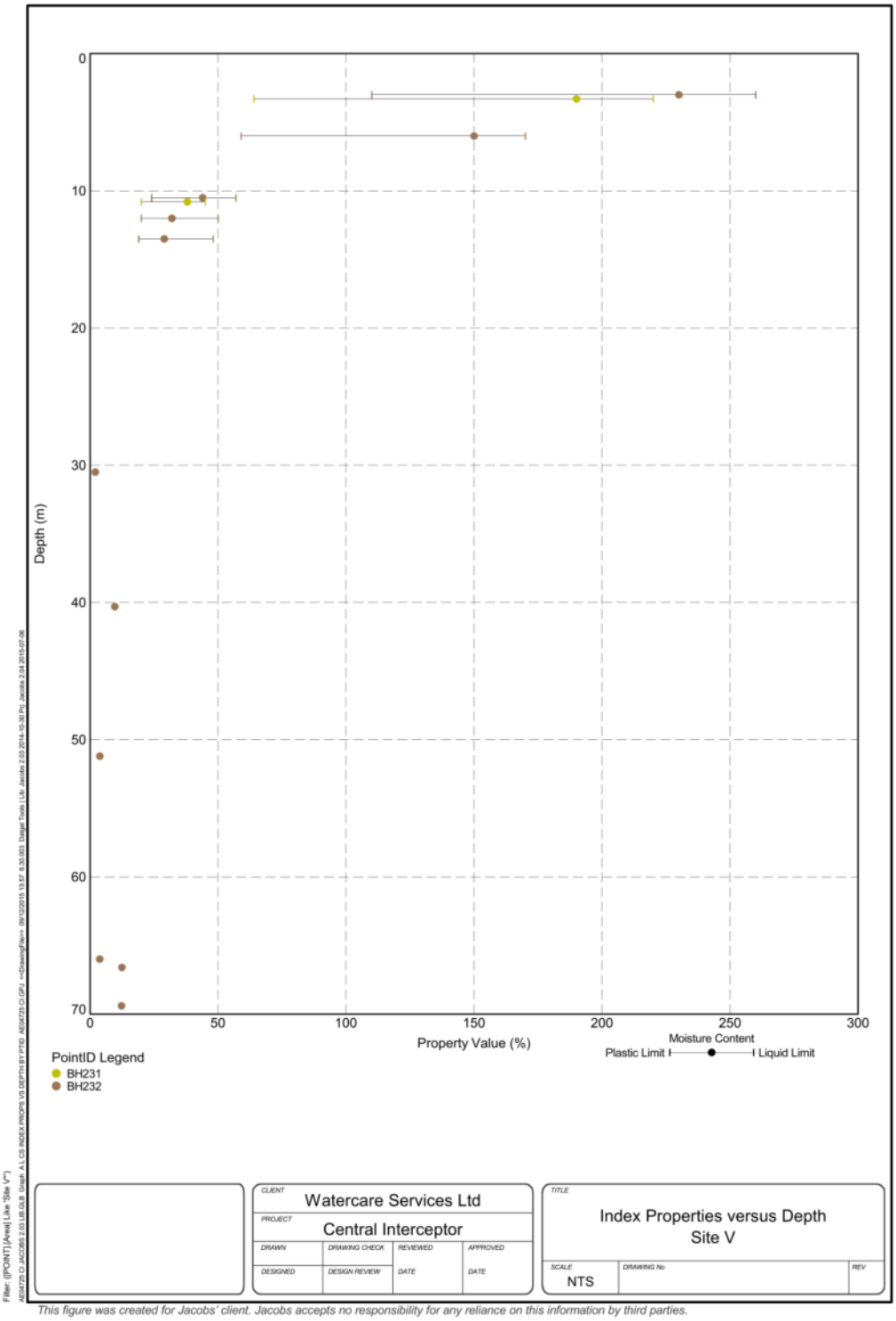

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Figure K.7 : Atterberg Limits versus Depth - Site Z.1 - PS25 (L3S1)

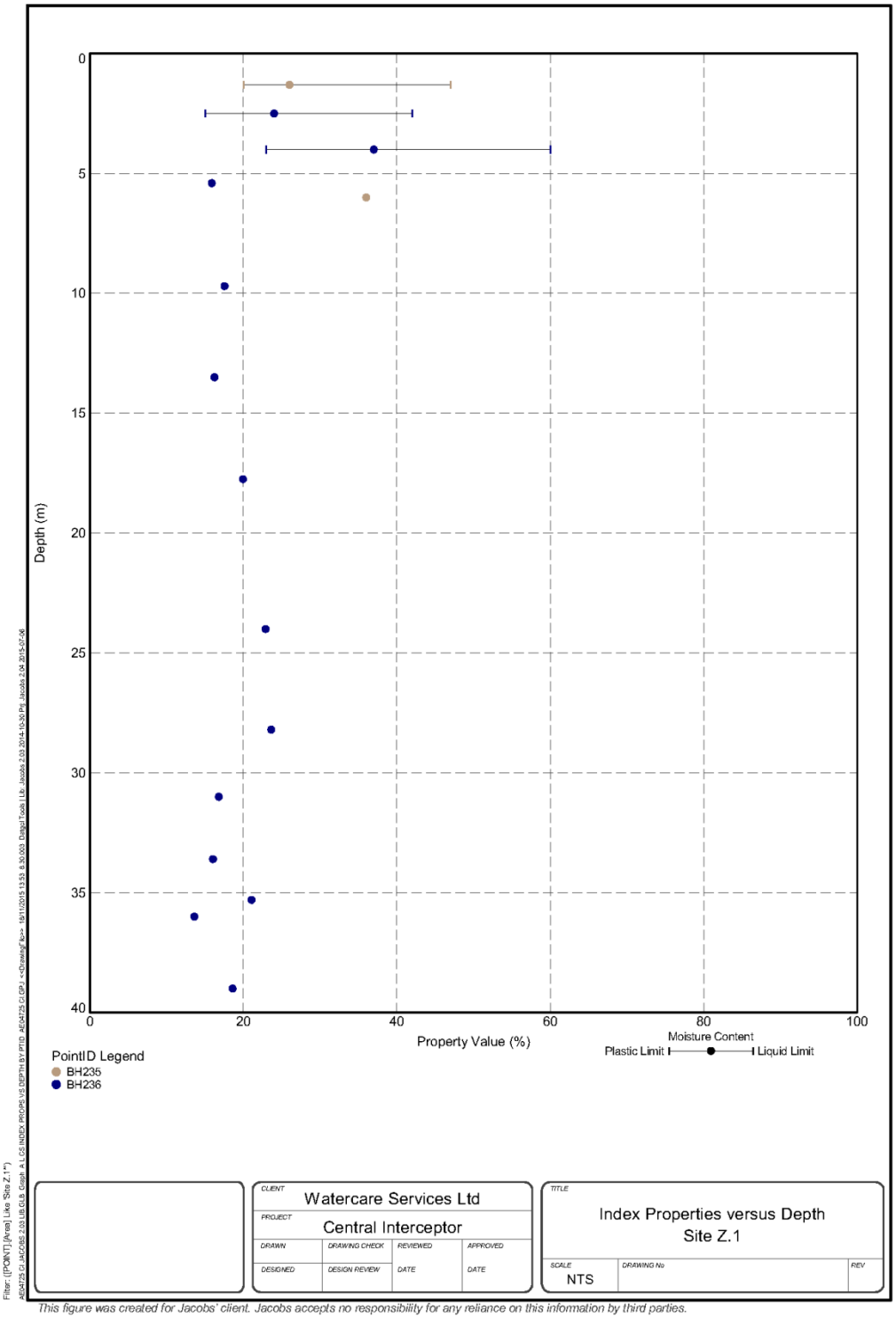

Figure K.8 : Atterberg Limits versus Depth - Site AA.1 - Miranda (L3S2)

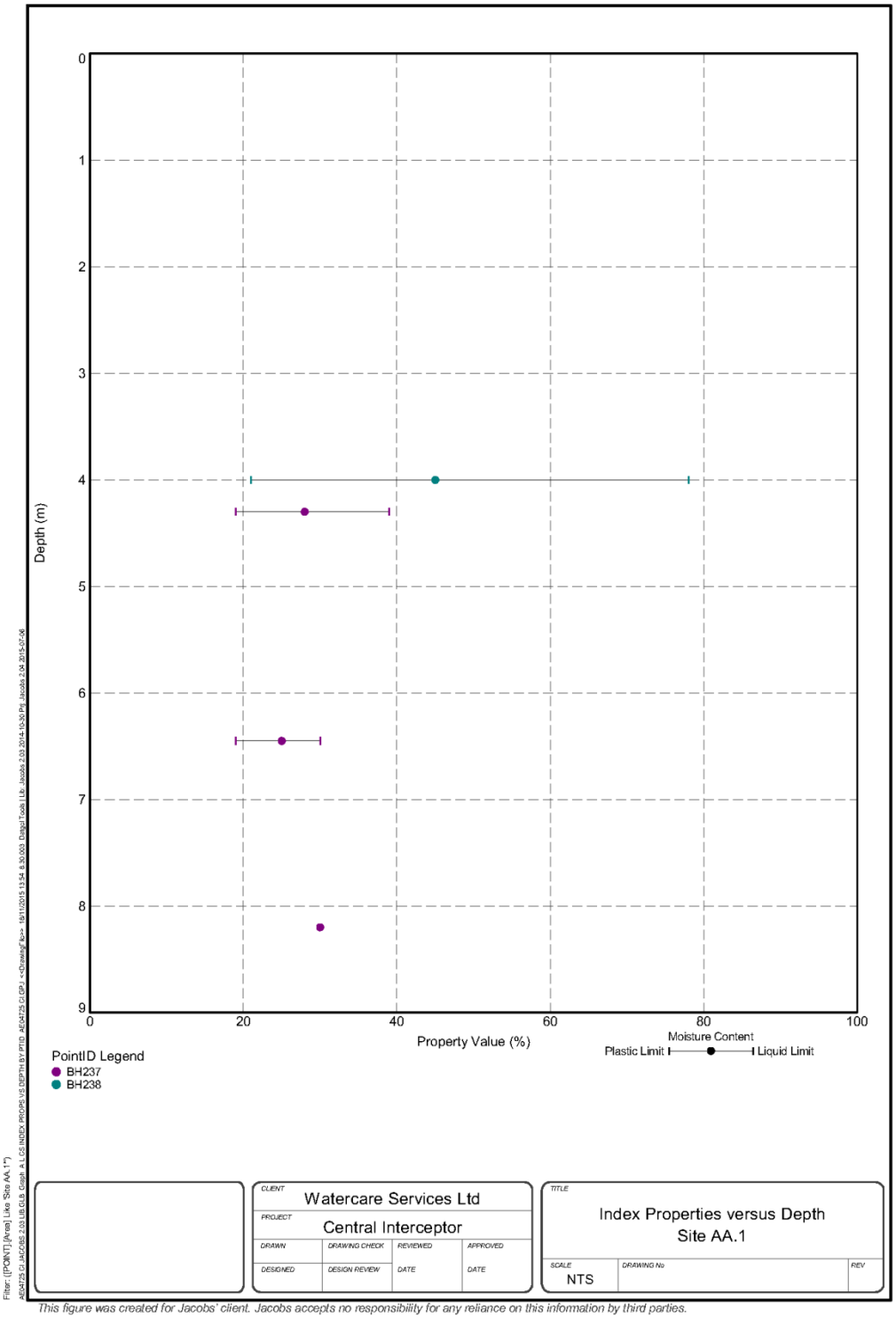
Depth (m)
0
1
2
3
4
5
6
7
8
9
0
20
40
60
80
100
Property Value (%)
Moisture Content
Plastic Limit
Liquid Limit
PointID Legend
BH237
BH238
CLIENT
Watercare Services Ltd
PROJECT
Central Interceptor
DRAWN
DRAWING CHECK
REVIEWED
APPROVED
DESIGNED
DESIGN REVIEW
DATE
DATE
TITLE
Index Properties versus Depth
Site AA.1
SCALE
NTS
DRAWING No
REV
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Figure K.9 : Atterberg Limits versus Depth - Site AF.1 - May Road (WS2)

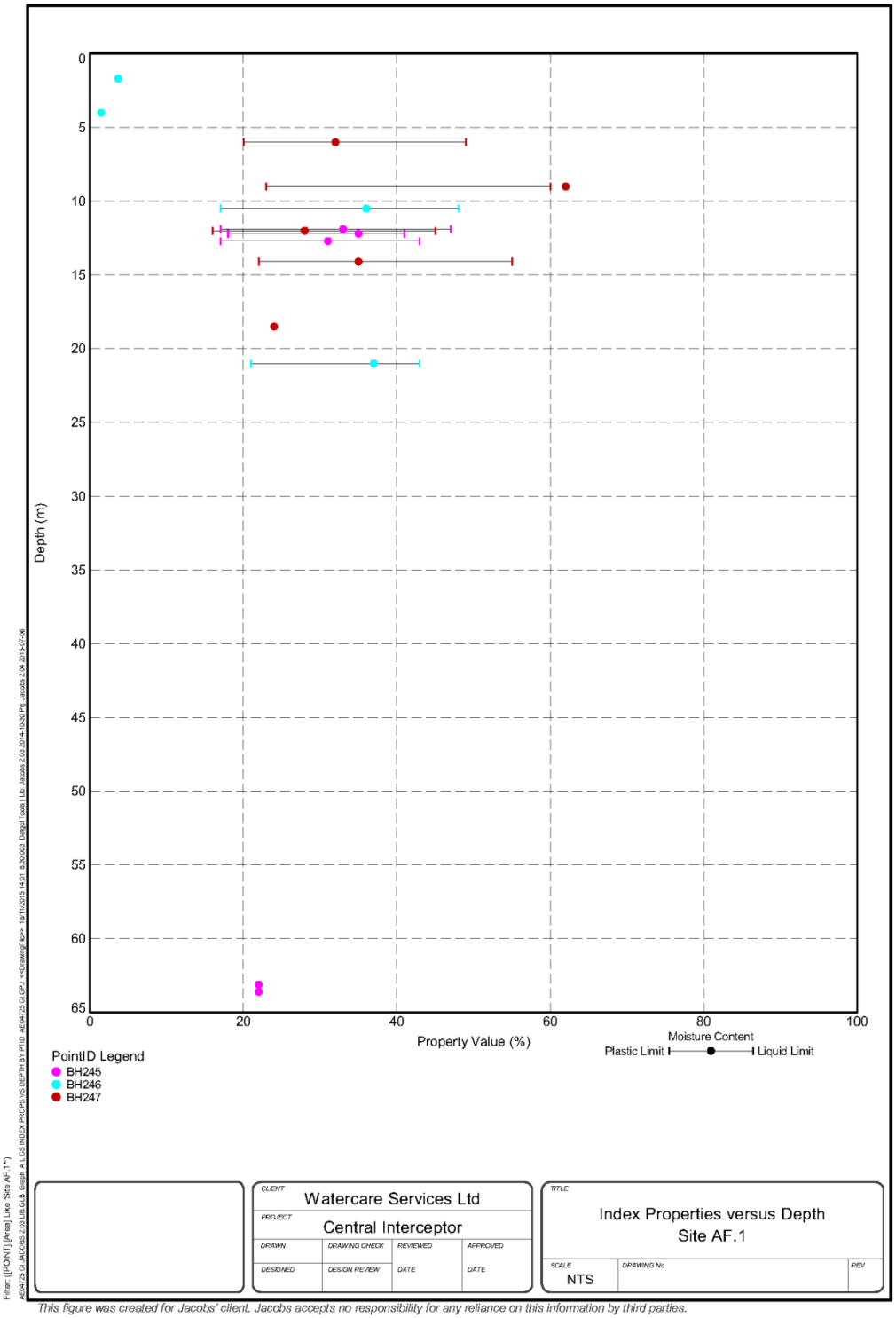

Figure K.10 : Atterberg Limits versus Depth - Site AQ - Kiwi Esplanade (AS7)

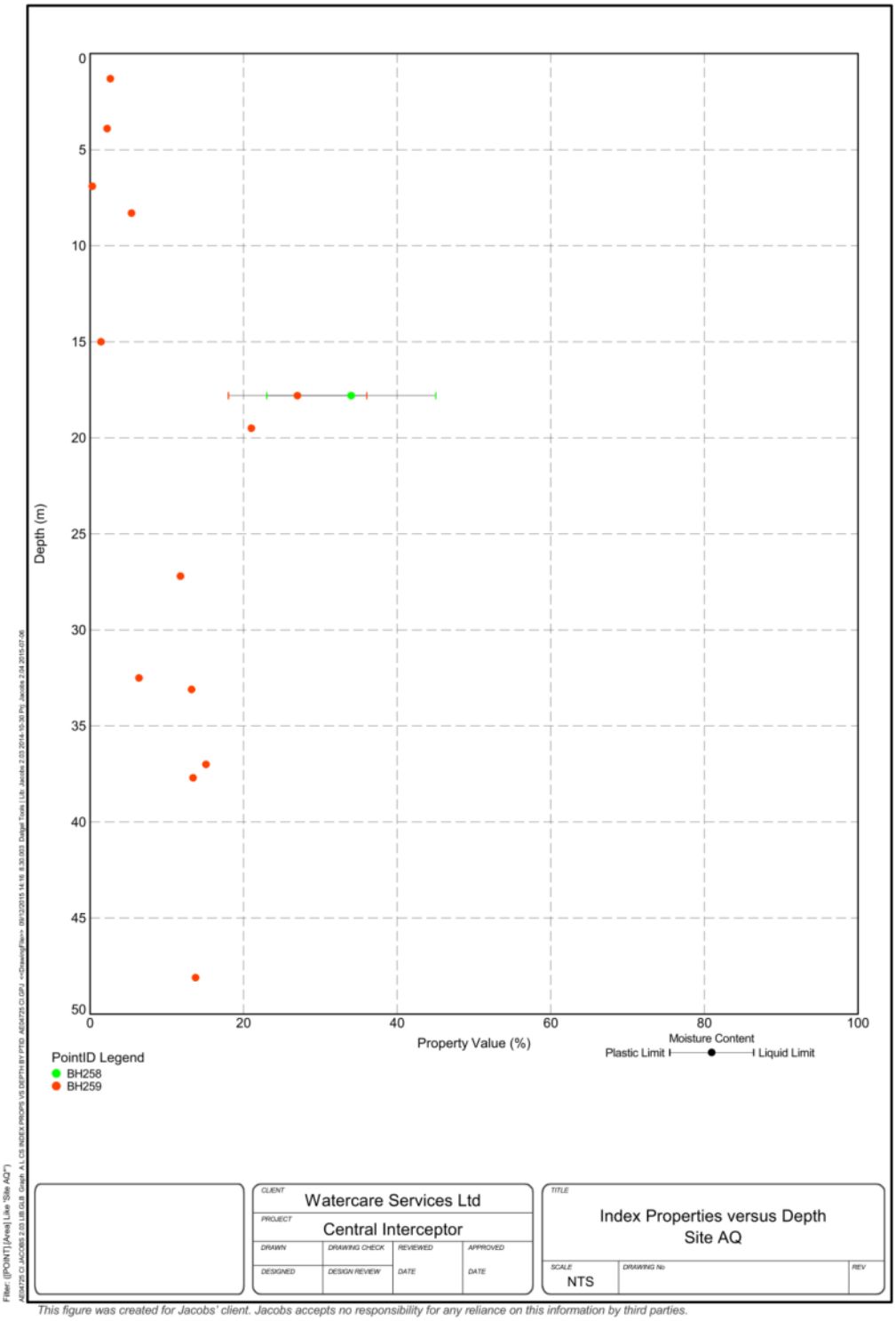

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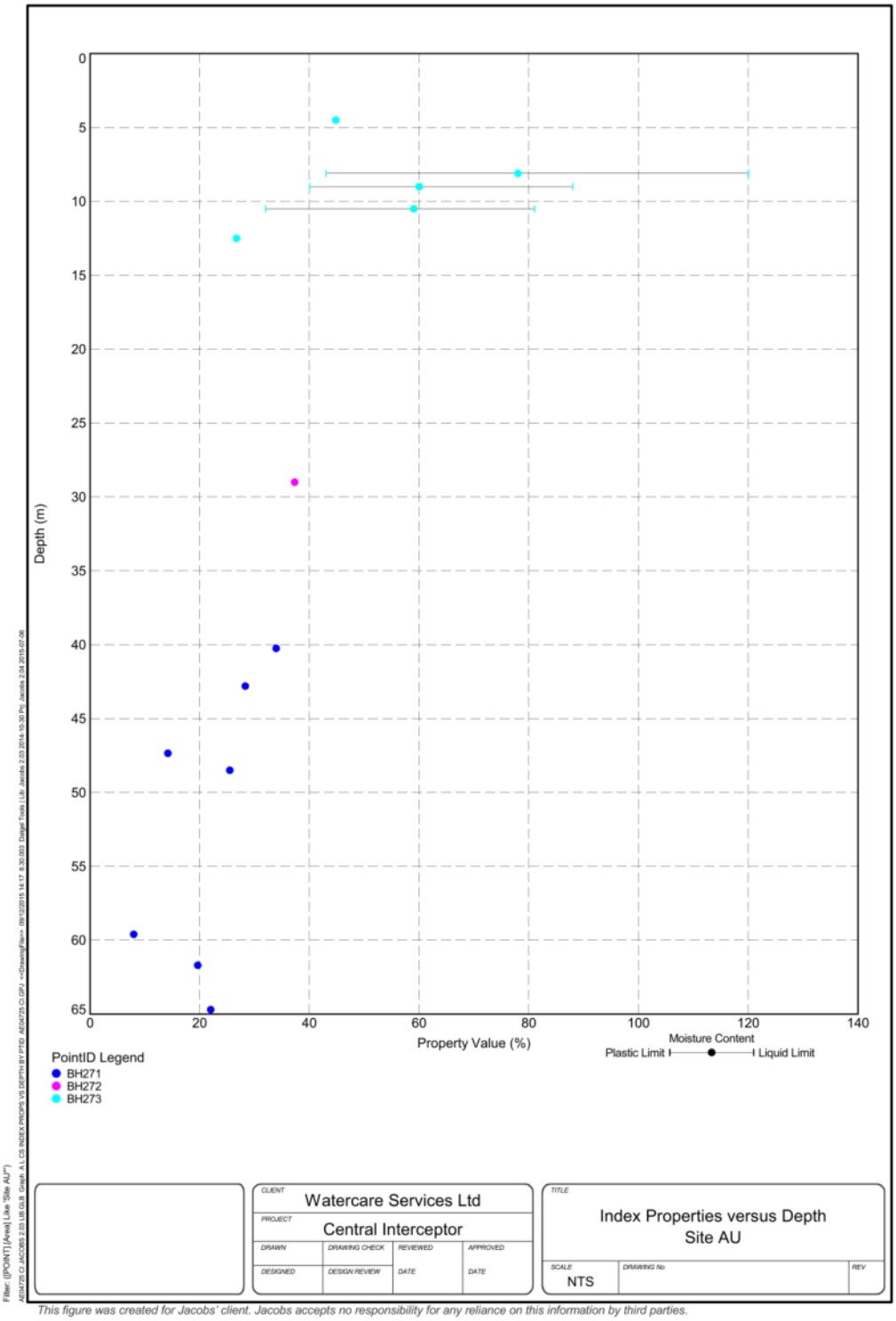
Figure K.11 : Atterberg Limits versus Depth - Site AU - Mangere WWTP (WS3)



K.3 Particle Size Distribution

Figure K.12 : PSD - Recent Alluvium

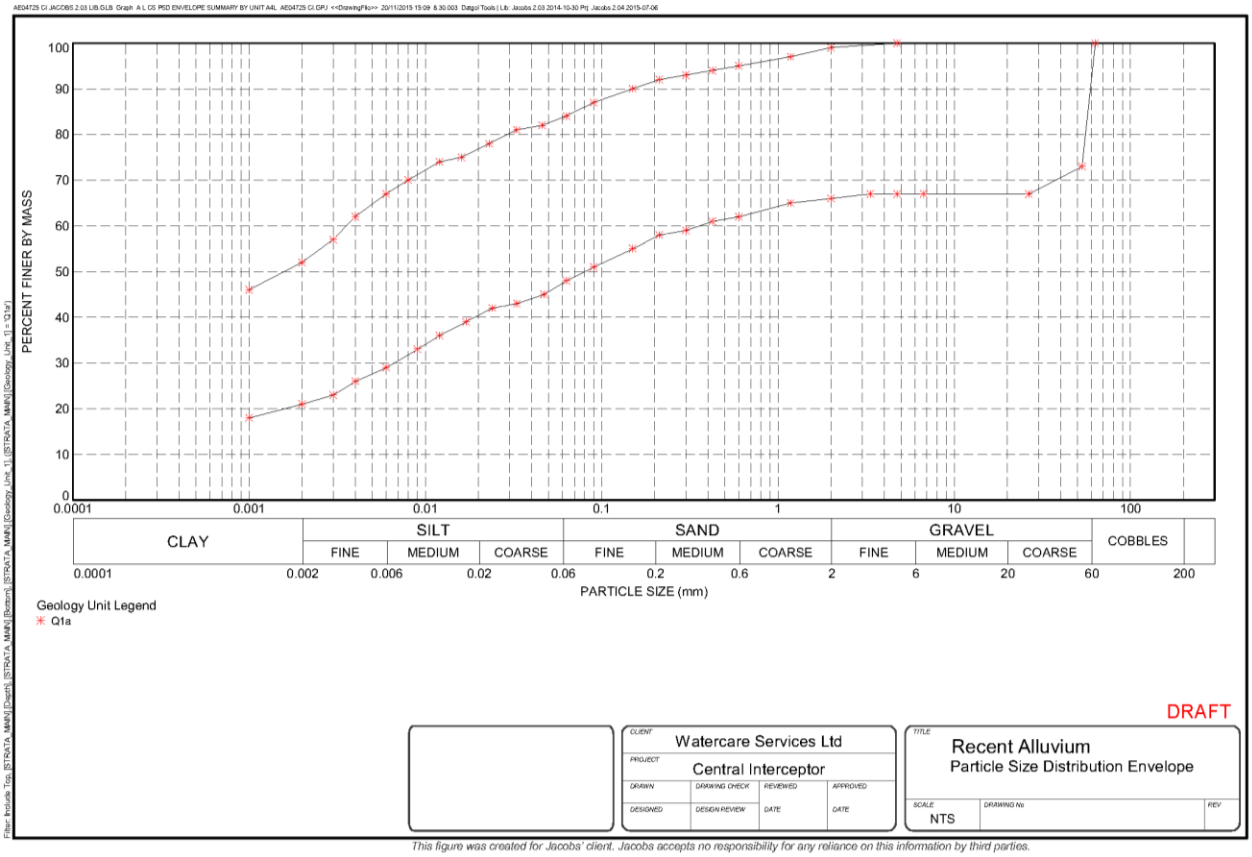


Figure K.13 : PSD - Undifferentiated Tauranga Group

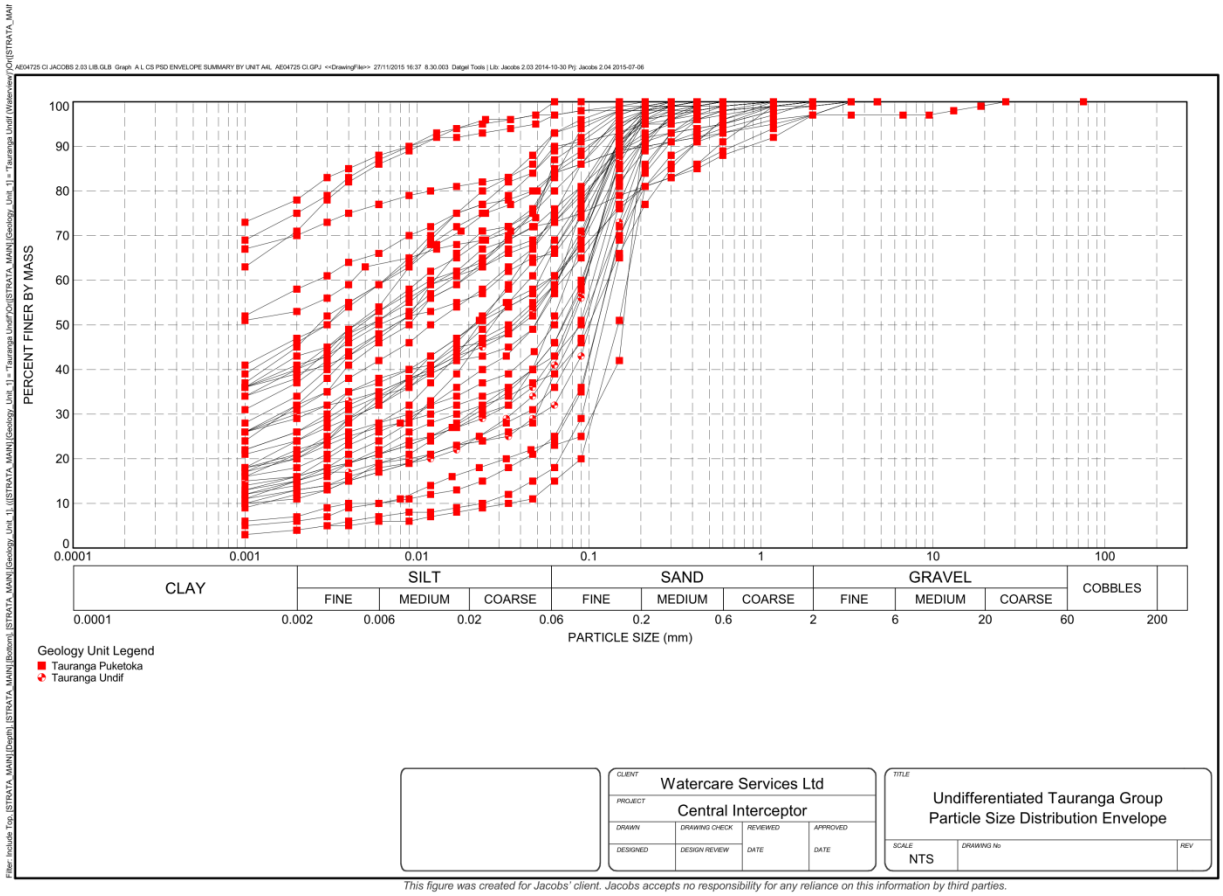


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Figure K.14 : PSD - Kaawa

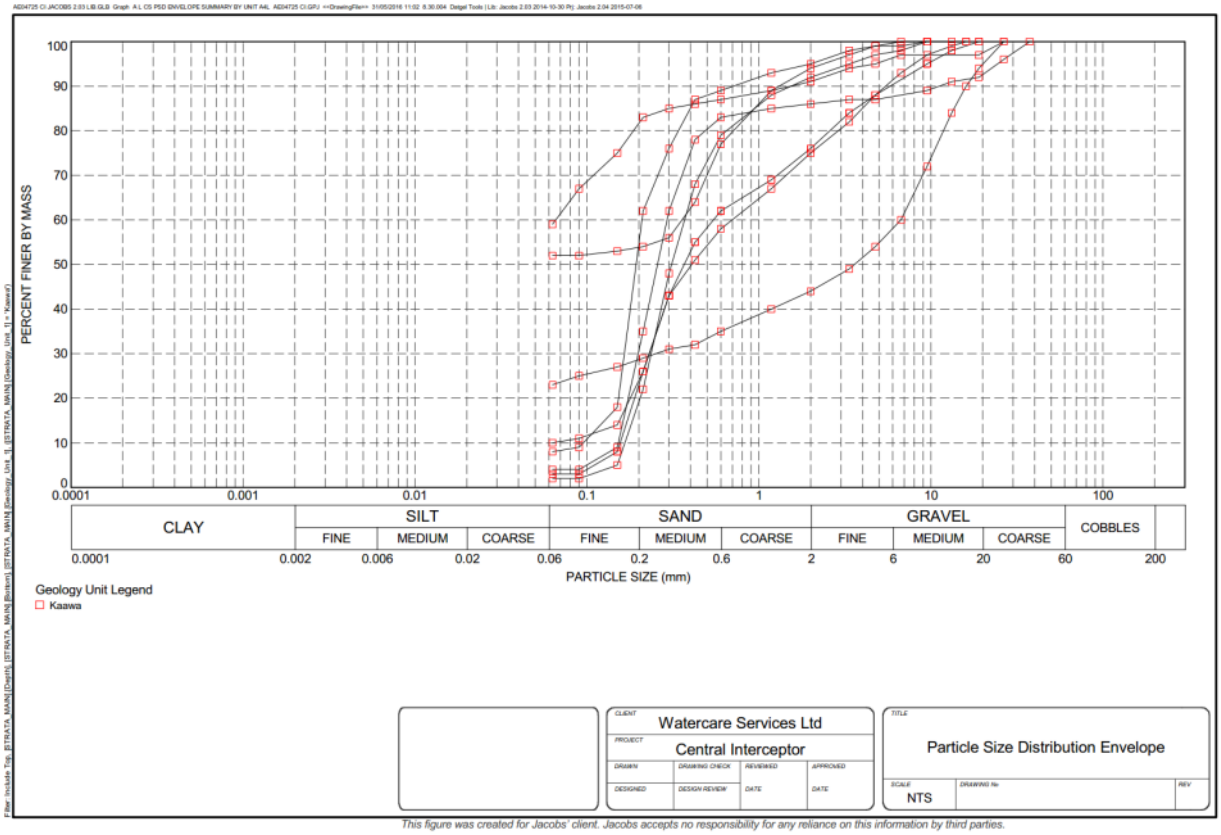

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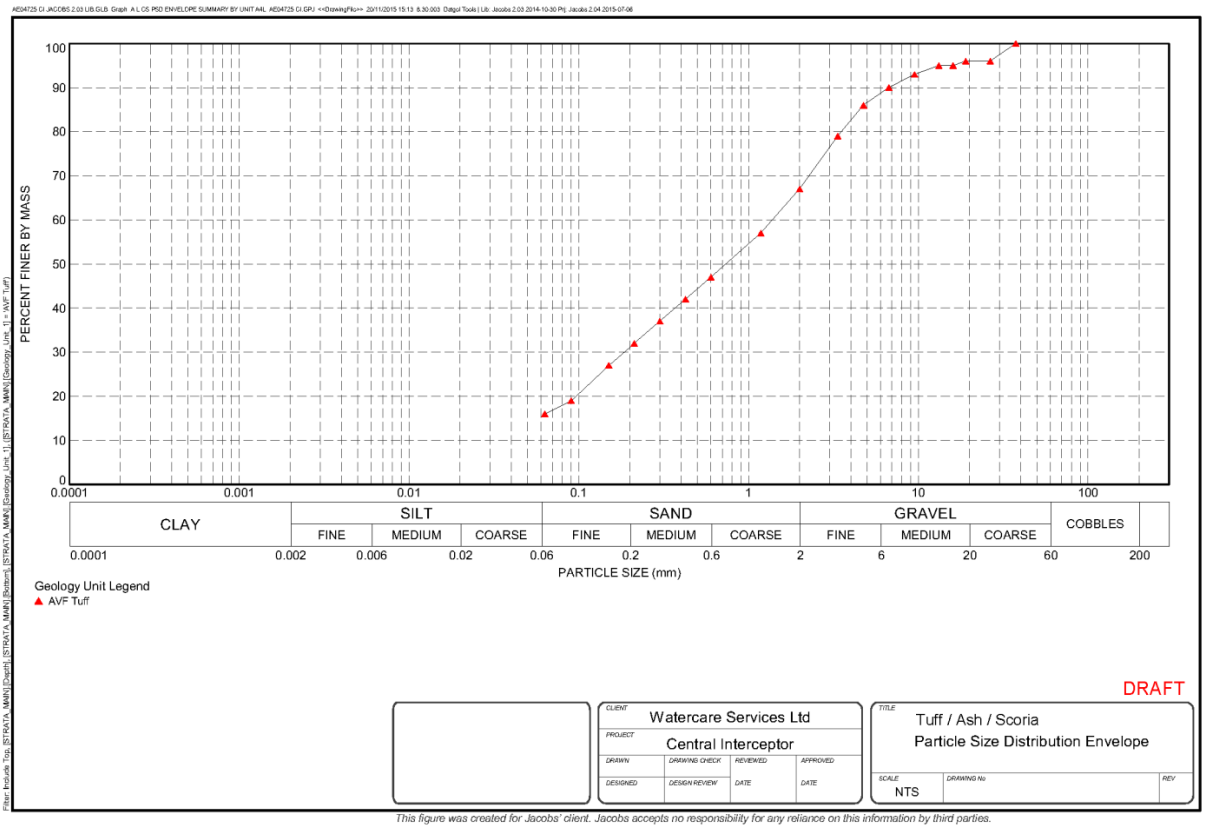
Figure K.15 : PSD - AVF Tuff / Ash / Scoria



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Appendix L. Unconfined compressive strength

Figure L.1 : UCS versus depth for all data except basalt samples

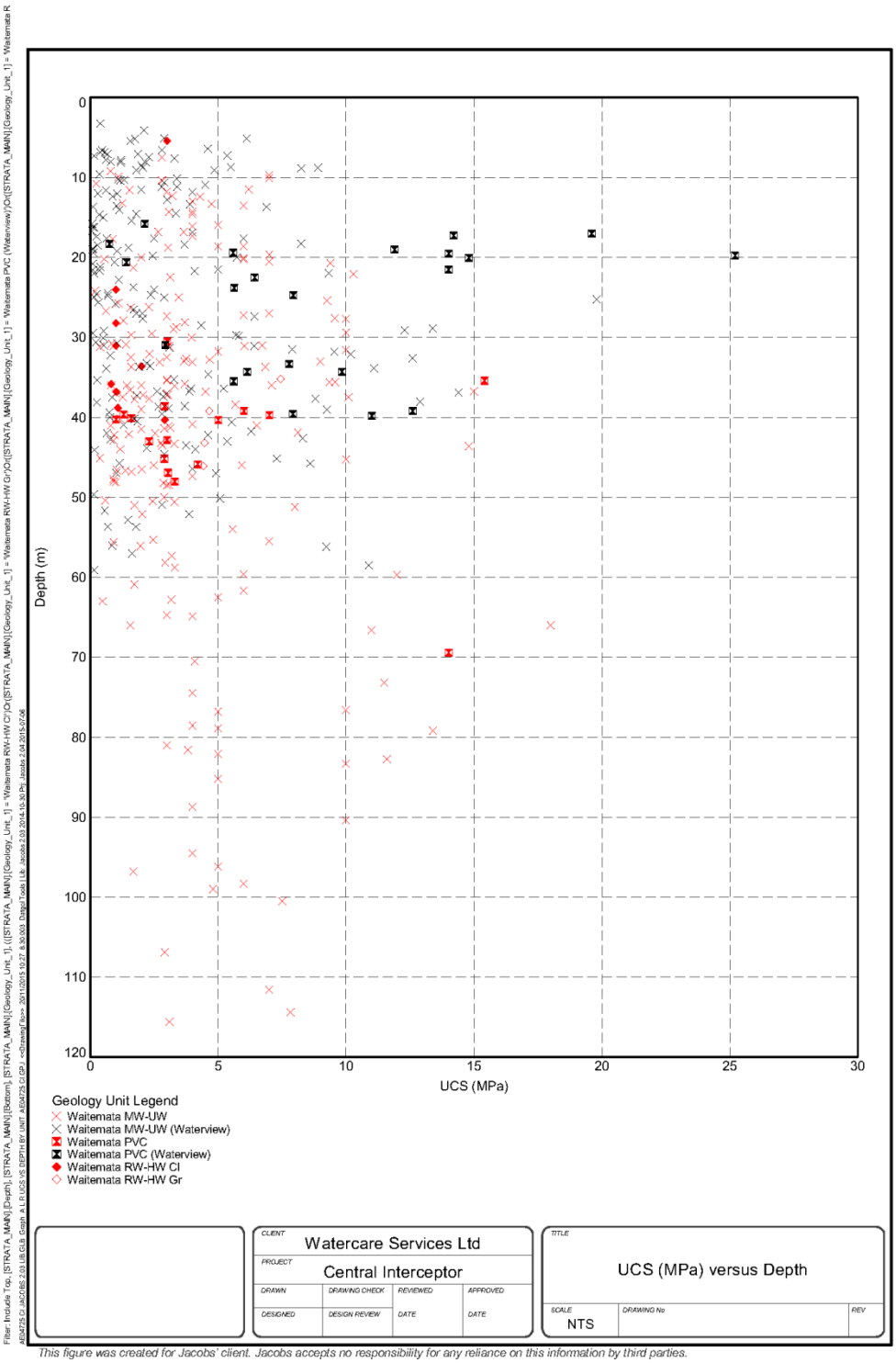

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Figure L.2 : UCS versus depth for basalt samples

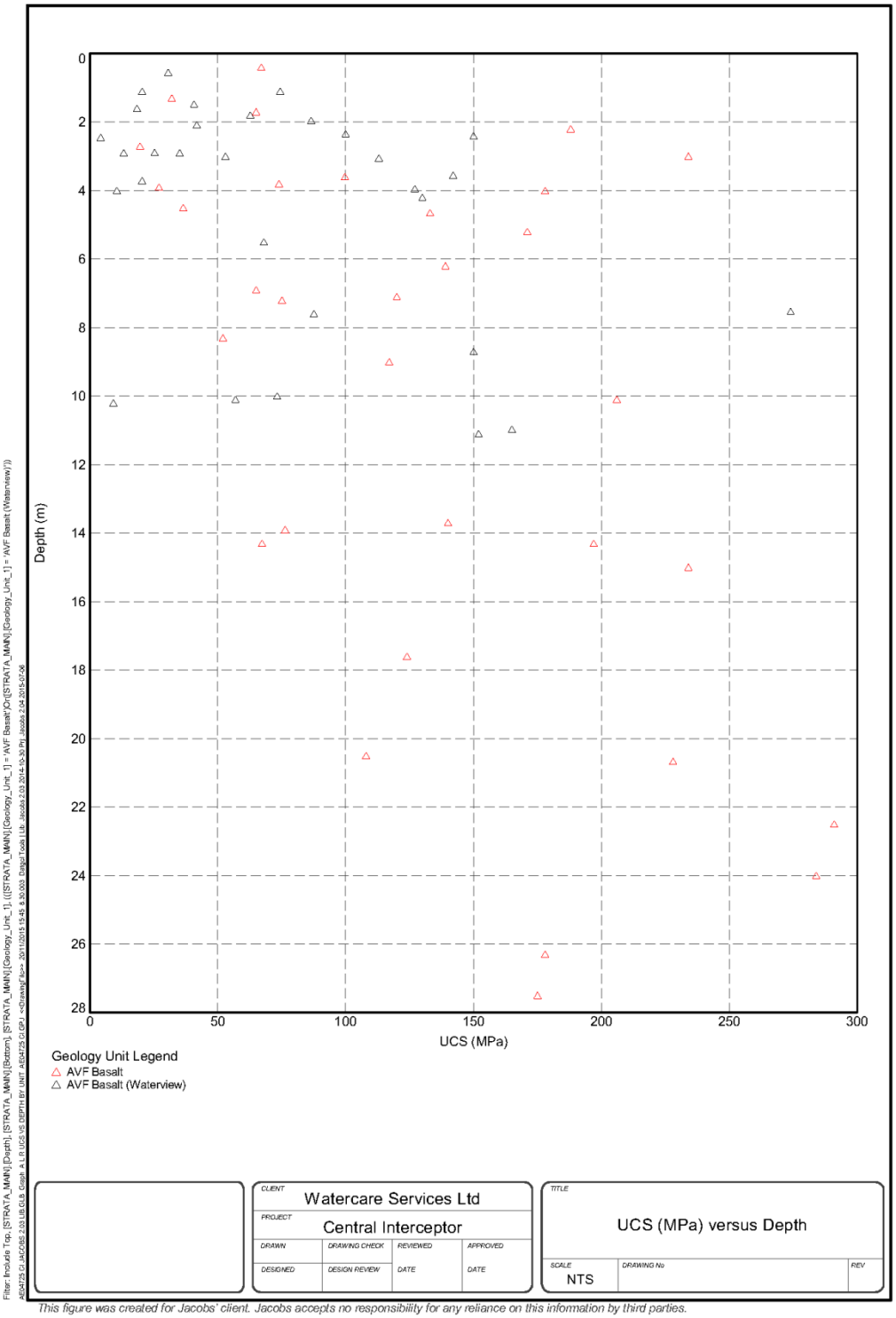

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Figure L.3 : UCS versus chainage forall data except basalt samples

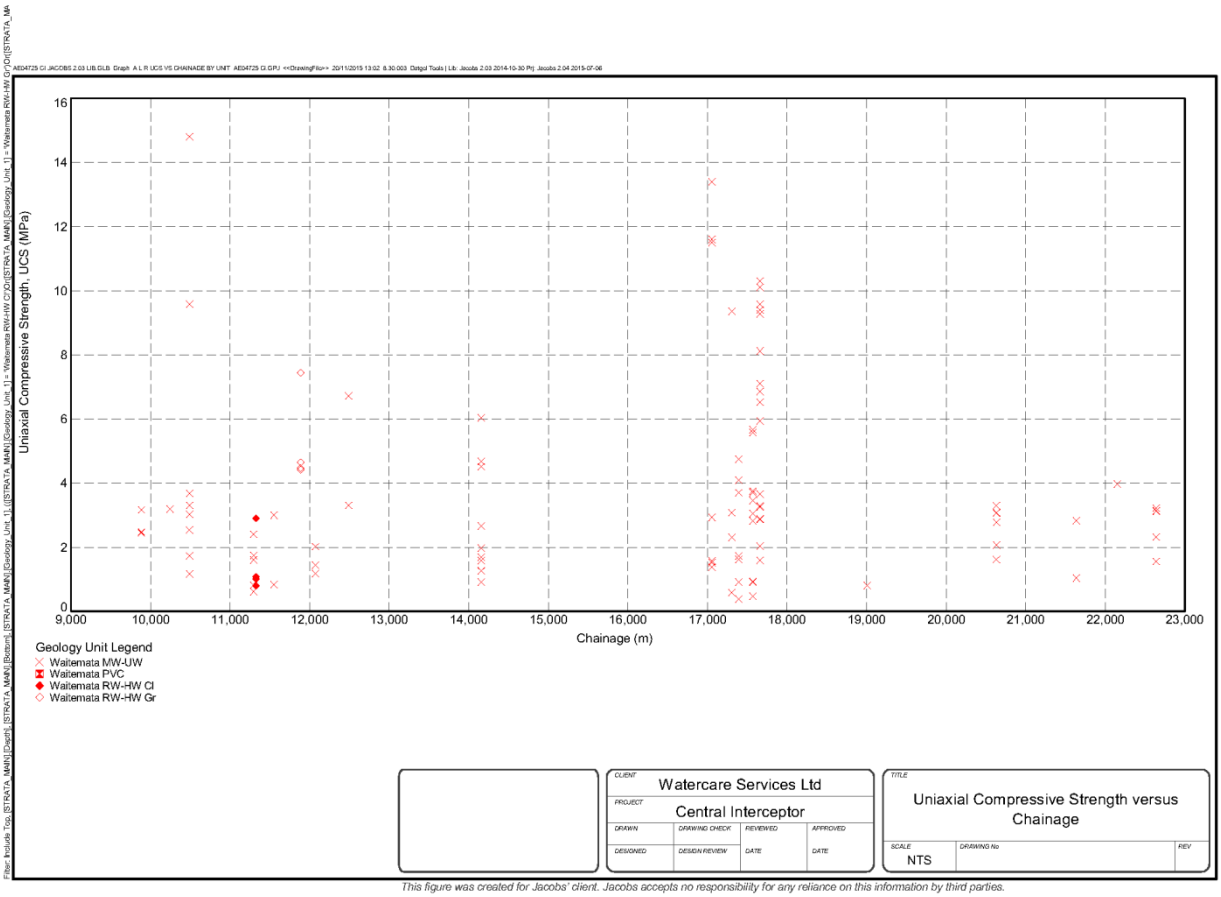

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Figure L.4 : UCS versus chainage for basalt samples

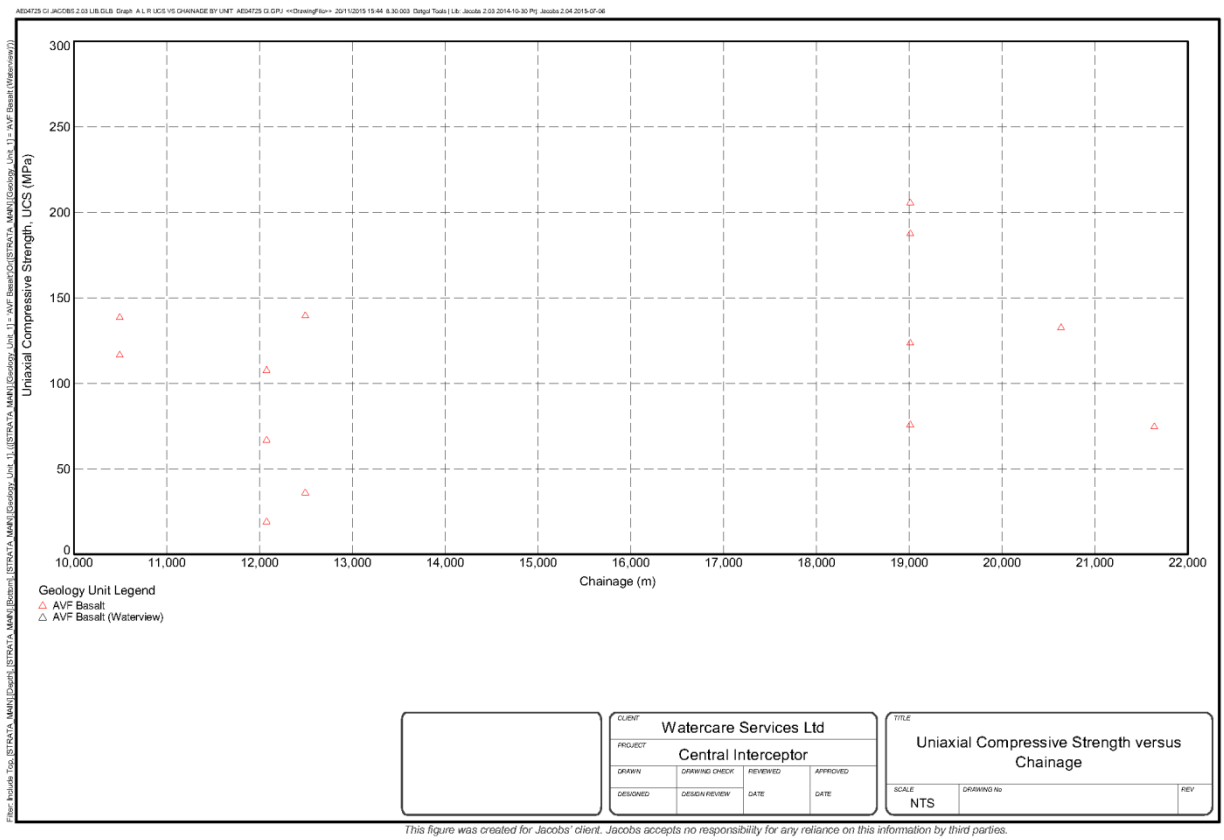

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Figure L.5 : UCS versus depth for samples at site AU - Mangere WWTP

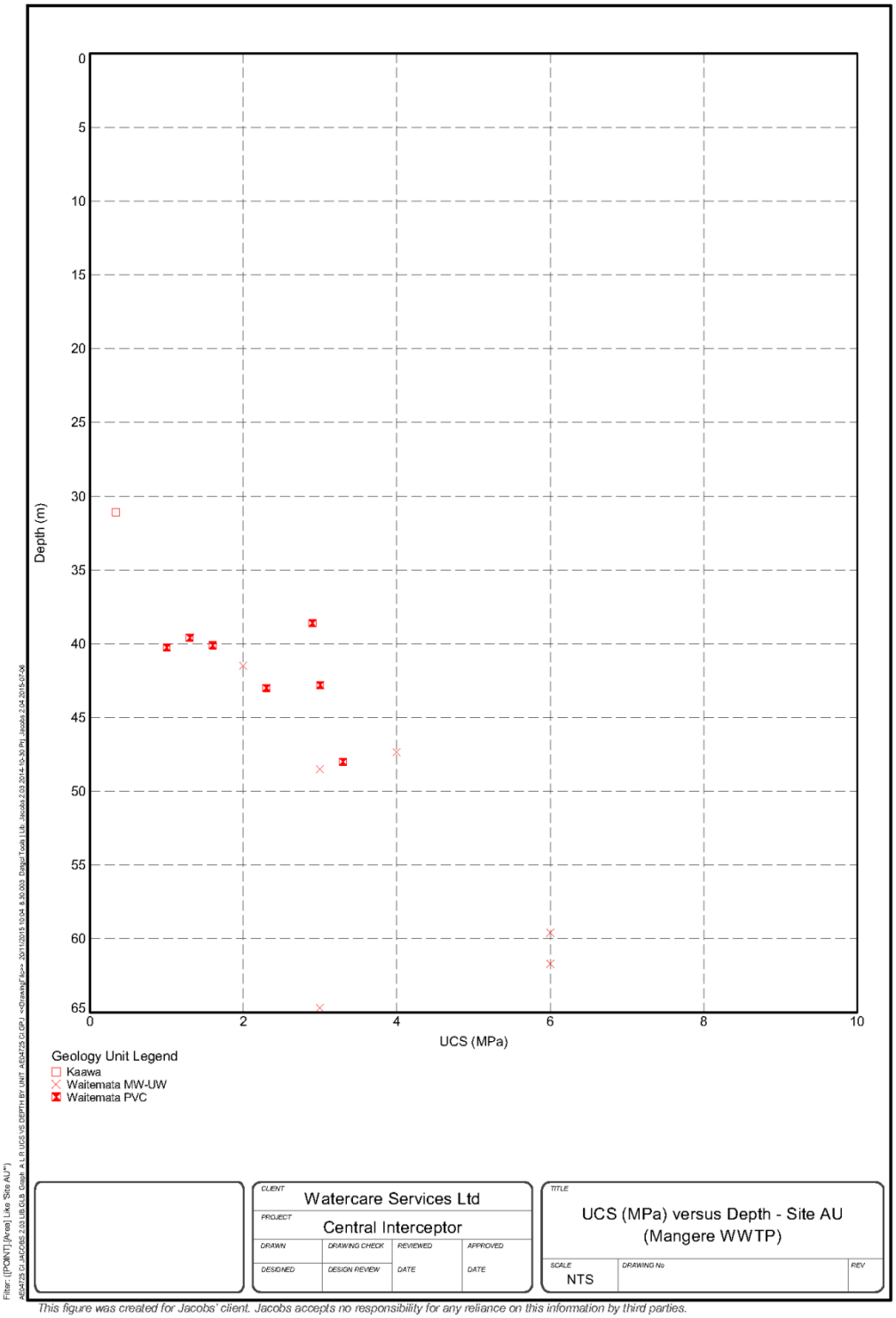

Figure L.6 : UCS versus depth at site AU - Mangere WWTP - by borehole numbers

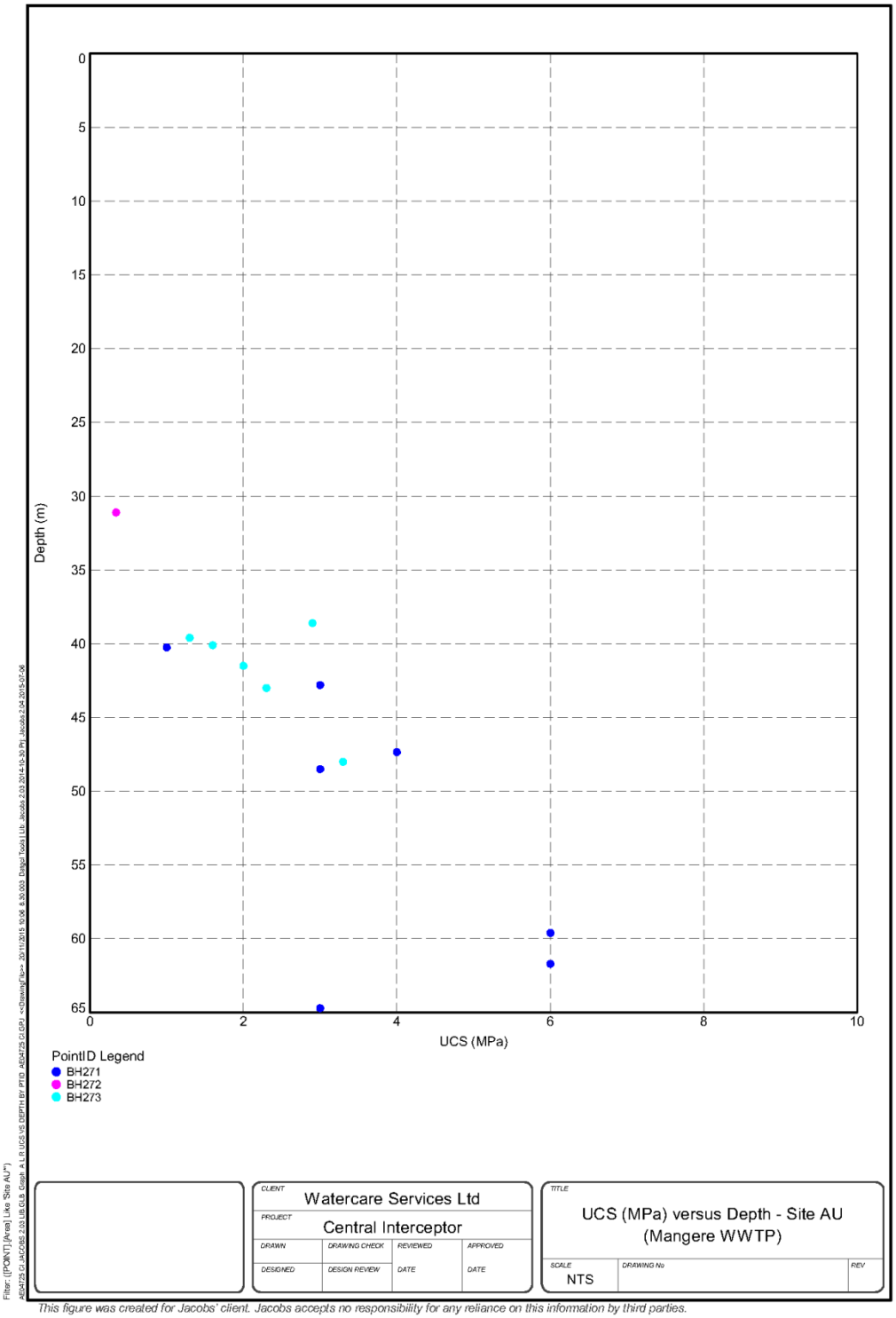

Table L.1 : Unconfined Compressive Strength

Unconfined Compressive Strength (MPa)										
Geological Unit	Minimum	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile	Maximum	Mean	Standard deviation	Count
All results in this investigation	0.1	0.6	1.6	3.3	7.8	36	291	17	43	483
TAURANGA GROUP										
Tauranga Puketoka	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	1
Kaawa Formation	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0	1
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Basalt	20	38	67	122	181	233	291	131	74	32
Basalt (Waterview)	4.2	13	27	65	124	150	274	78	61	30
WAITEMATA GROUP (MIOCENE)										
Residually to Highly Weathered Residual Soils - Cohesive Soils	0.8	1.0	1.0	1.0	2.0	2.9	3.0	1.5	0.8	9
Residually to Highly Weathered - Cohesive Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Residually to Highly Weathered - Granular Soils	-	-	-	-	-	-	-	-	-	-
Residually to Highly Weathered - Granular Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Parnell Volcaniclastic Conglomerate	1.0	1.5	2.7	3.0	5.3	11	15	4.7	4.1	16
Parnell Volcaniclastic Conglomerate (Waterview)	0.7	2.2	5.6	7.9	14	15	25	9.4	5.9	22
Moderately Weathered to Unweathered ECBF	0.2	1.0	2.0	3.3	6.0	9.4	18	4.3	3.2	193
Moderately Weathered to Unweathered ECBF (Waterview)	0.1	0.2	0.7	2.0	4.1	8.3	20	3.1	3.3	179
Sandstone[3]	0.2	0.8	2.0	3.0	6.0	7.0	7.0	3.8	2.4	13
Interbedded mudstone and sandstone[1]	0.2	1.2	3.0	4.0	6.2	10	18	5.0	3.4	77
Mudstone[1]	2.3	2.6	2.9	3.6	4.2	4.6	4.8	3.6	1.3	2

[3] Data subset of the moderately weathered to unweathered ECBF values. Only some samples with detail description on sandstone, mudstone and Interbedded mudstone and sandstone

Appendix M. Young’s modulus

Figure M.1 : Young's Modulus Versus Depth for Data Except Basalt Samples

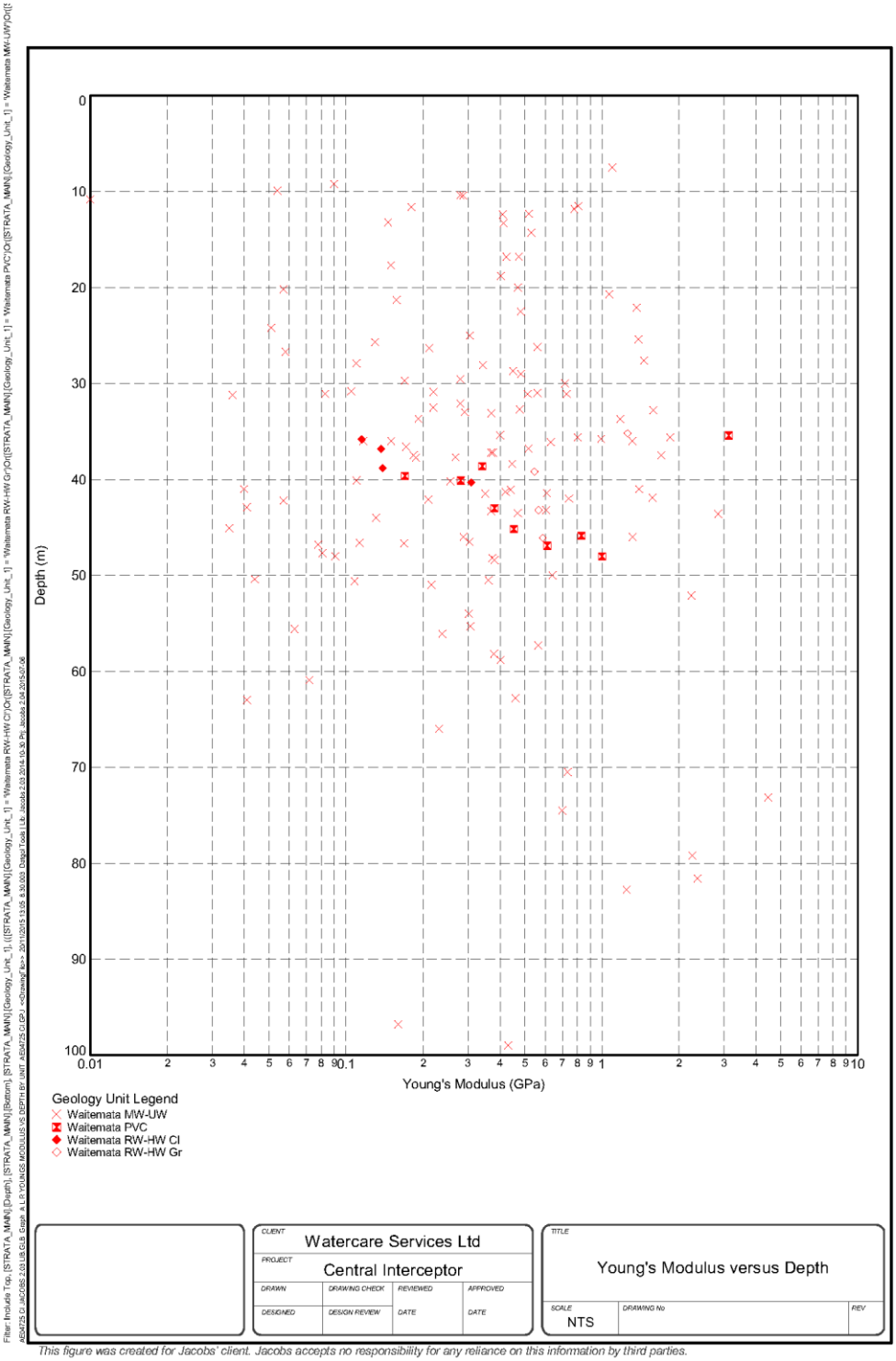

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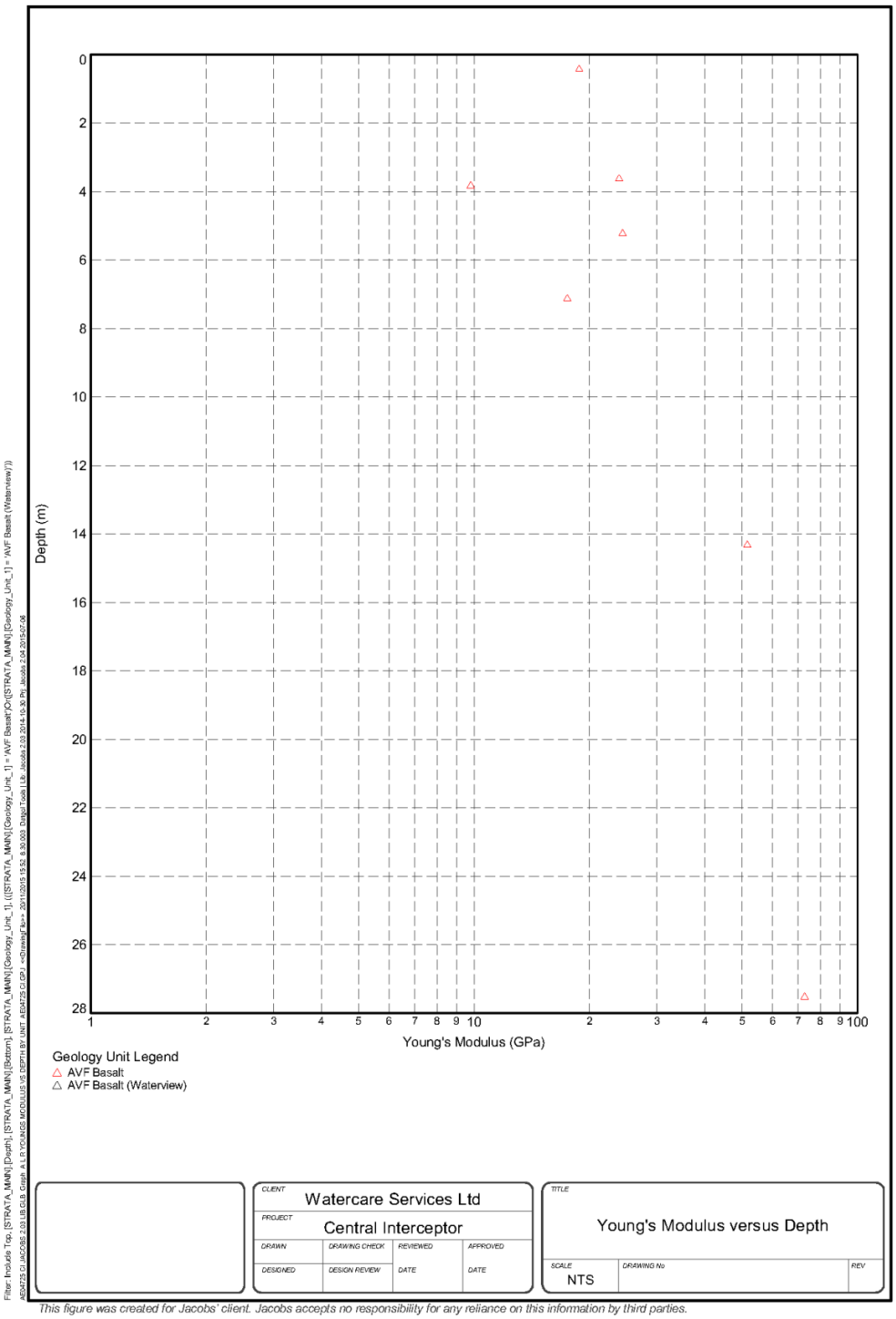
Figure M.2 : Young's Modulus versus Depth for Basalt Samples



This figure was created for Jacobs' client. Jacobs accepts no responsibility for any reliance on this information by third parties.

Table M.1 : Young's Modulus

Young's Modulus (MPa)										
Geological Unit	Minimum	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile	Maximum	Mean	Standard deviation	Count
All results in this investigation	10	81	170	379	709	1,590	72,800	1,972	7,890	151
TAURANGA GROUP										
Tauranga Puketoka	270	270	270	270	270	270	270	270	0	1
Kaawa Formation	90	90	90	90	90	90	90	90	0	1
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Basalt	9,800	14,420	18,150	23,900	38,000	60,080	72,800	31,257	20,859	7
Basalt (Waterview)	-	-	-	-	-	-	-	-	-	-
WAITEMATA GROUP (MIOCENE)										
Residually to Highly Weathered Residual Soils - Cohesive Soils	115	122	132	138	181	257	308	175	78	4
Residually to Highly Weathered - Cohesive Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Residually to Highly Weathered - Granular Soils	545	551	560	576	755	1,058	1,260	739	301	4
Residually to Highly Weathered - Granular Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Parnell Volcaniclastic Conglomerate	170	258	340	452	830	1,426	3,130	799	862	9
Parnell Volcaniclastic Conglomerate (Waterview)	-	-	-	-	-	-	-	-	-	-
Moderately Weathered to Unweathered ECBF	10	67	160	370	606	1,350	4,470	542	639	125
Moderately Weathered to Unweathered ECBF (Waterview)	-	-	-	-	-	-	-	-	-	-
Sandstone[4]	240	302	395	550	1,275	1,710	2,000	930	767	3
Interbedded mudstone and sandstone[2]	198	888	1,200	2,000	3,040	3,964	6,200	2,326	1,390	23
Mudstone[2]	2,300	2,550	2,925	3,550	4,175	4,550	4,800	3,550	1,250	2

[4] Data subset of the moderately weathered to unweathered ECBF values. Only some samples with detail description on sandstone, mudstone and Interbedded mudstone and sandstone

Table M.2 : Pressuremeter Modulus Ep

Pressuremeter Modulus, E_p (MPa)										
Geological Unit	Minimum	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile	Maximum	Mean	Standard deviation	Count
All results in this investigation	1	8	22	85	423	775	842	244	296	27
Made Ground / Fill	-	-	-	-	-	-	-	-	-	-
Made Ground (Waterview)	-	-	-	-	-	-	-	-	-	-
Recent Alluvium / Q1a	-	-	-	-	-	-	-	-	-	-
TAURANGA GROUP										
Undifferentiated Tauranga Group	-	-	-	-	-	-	-	-	-	-
Undifferentiated Tauranga Group (Waterview)	-	-	-	-	-	-	-	-	-	-
Tauranga Estuarine	-	-	-	-	-	-	-	-	-	-
Tauranga Puketoka[1)]	1	3	8	18	33	38	38	20	14	8
Kaawa Formation[1)]	6	8	12	18	62	89	106	43	45	3
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Tuff / Ash/ Scoria	-	-	-	-	-	-	-	-	-	-
Tuff / Ash/ Scoria (Waterview)	-	-	-	-	--	-	-	-	-	-
WAITEMATA GROUP (MIOCENE)										
Residually to Highly Weathered Residual Soils - Cohesive Soils	23	28	34	46	65	77	85	51	25	3
Residually to Highly Weathered - Cohesive Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Residually to Highly Weathered - Granular Soils	-	-	-	-	-	-	-	-	-	-
Residually to Highly Weathered - Granular Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Parnell Volcaniclastic Conglomerate	320	320	320	320	320	320	320	320	0	1
Parnell Volcaniclastic Conglomerate (Waterview)	-	-	-	-	-	-	-	-	-	-
Moderately Weathered to Unweathered ECBF [2)]	70	91	193	532	766	821	842	485	290	12
Moderately Weathered to Unweathered ECBF (Waterview)	-	-	-	-	-	-	-	-	-	-

[1)] Some of the test did not exhibit standard pressuremeter test curves. This could be due to the diameter of the hole being too large or very soft material being tested.

[2)] Six of the results are taken from one borehole (BH-C22) at several depths.

Table M.3 : Young's Modulus from Wireline Geophysics Correlations

Young's Modulus from Wireline Geophysics, E (MPa)										
Geological Unit	Minimum	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile	Maximum	Mean	Standard deviation	Count
All results in this investigation	165	5,101	5,624	6,061	6,511	7,231	19,455	6,504	2,302	61,017
TAURANGA GROUP										
Tauranga Undif.	2,892	3,912	4,746	5,142	5,847	6,350	19,455	5,353	1,669	4,671
Kaawa Formation	4,545	5,002	5,215	5,389	5,530	5,404	6,674	5,383	302	589
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Basalt	9,101	12,737	13,835	15,078	16,365	17,060	19,194	14,915	1,877	3,545
Basalt (Waterview)	-	-	-	-	-	-	-	-	-	-
WAITEMATA GROUP (MIOCENE)										
Residually to Highly Weathered Residual Soils - Cohesive Soils	165	3,350	3,736	4,998	5,515	5,876	7,184	4,719	1,109	1,445
Residually to Highly Weathered - Cohesive Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Residually to Highly Weathered - Granular Soils	5,546	5,680	5,751	5,859	6,034	6,363	7,101	5,962	336	545
Residually to Highly Weathered - Granular Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Parnell Volcaniclastic Conglomerate	3,931	5,384	55,692	6,040	6,721	7,822	10,015	6,291	1,003	2,689
Parnell Volcaniclastic Conglomerate (Waterview)	-	-	-	-	-	-	-	-	-	-
Moderately Weathered to Unweathered ECBF	3,195	5,344	5,705	6,082	6,453	6,852	10,167	6,076	679	47,533
Moderately Weathered to Unweathered ECBF (Waterview)	-	-	-	-	-	-	-	-	-	-

Table M.4 : Young's modulus MPa from wireline geophysics correlations by borehole

	Min of SEIS_Youngs Modulus2	Average of SEIS_Youngs Modulus2	Max of SEIS_Youngs Modulus2	StdDev of SEIS_Youngs Modulus2	Count of SEIS_Youngs Modulus
BH205	4,185	5,989	9,074	607	3,087
BH206	4,561	6,150	7,429	518	1,183
BH207	4,562	5,866	8,188	666	1,984
BH219	5,130	5,940	7,641	447	2,226
BH232	4,485	6,216	10,167	854	4,136
BH244	5,060	6,011	7,266	288	3,095
BH247	4,766	6,271	7,843	525	6,063
BH252	3,826	6,137	7,496	456	9,220
BH253	3,195	6,282	8,285	692	10,808
BH259	4,550	5,715	7,344	408	2,814
BH271	4,103	6,116	9,843	842	1,689

Appendix N. Modulus ratio

Figure N.1 : Young's Modulus versus UCS all Data Except Basalt Samples

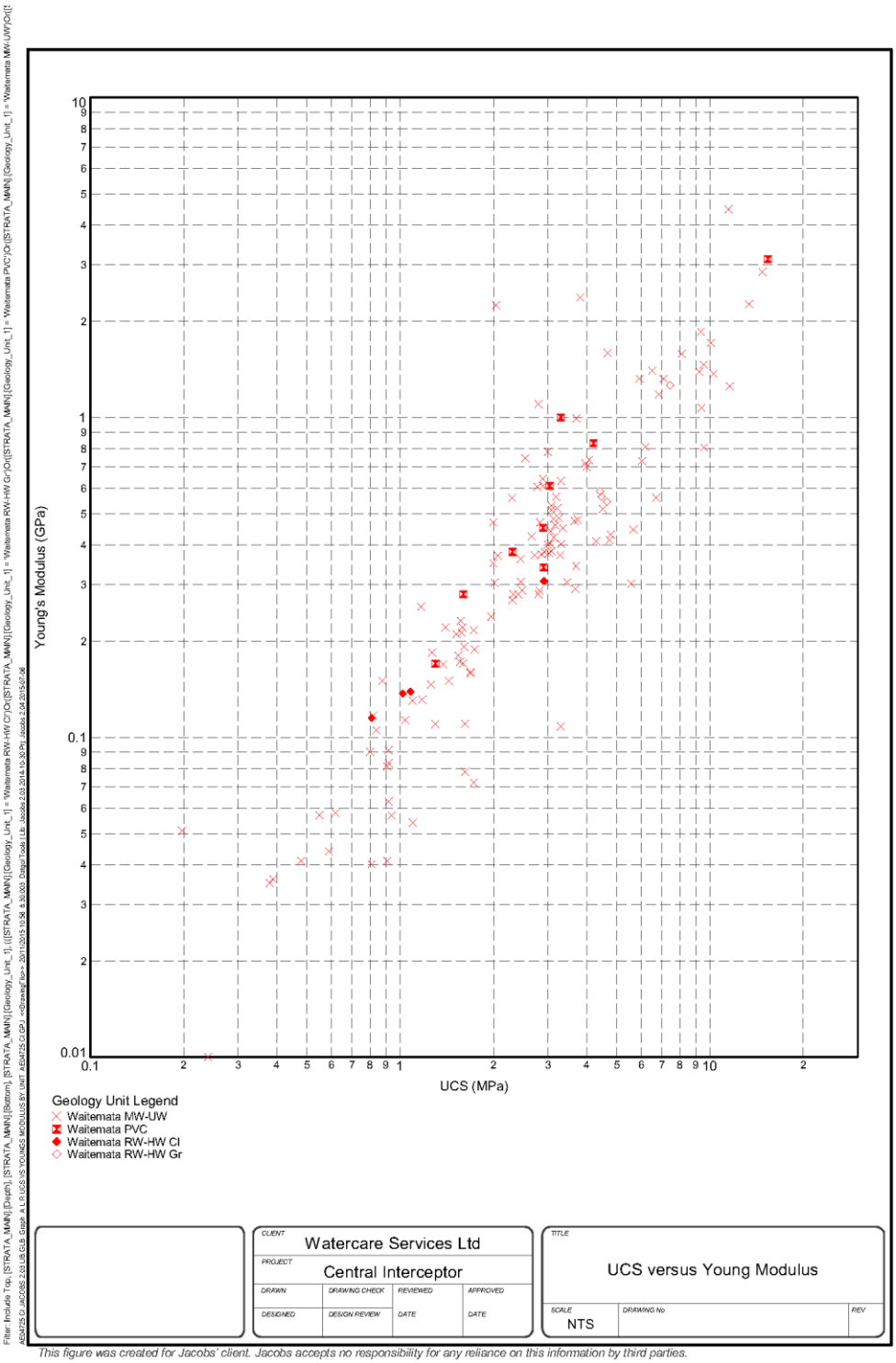


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Figure N.2 : Young's Modulus versus UCS for Basalt Samples

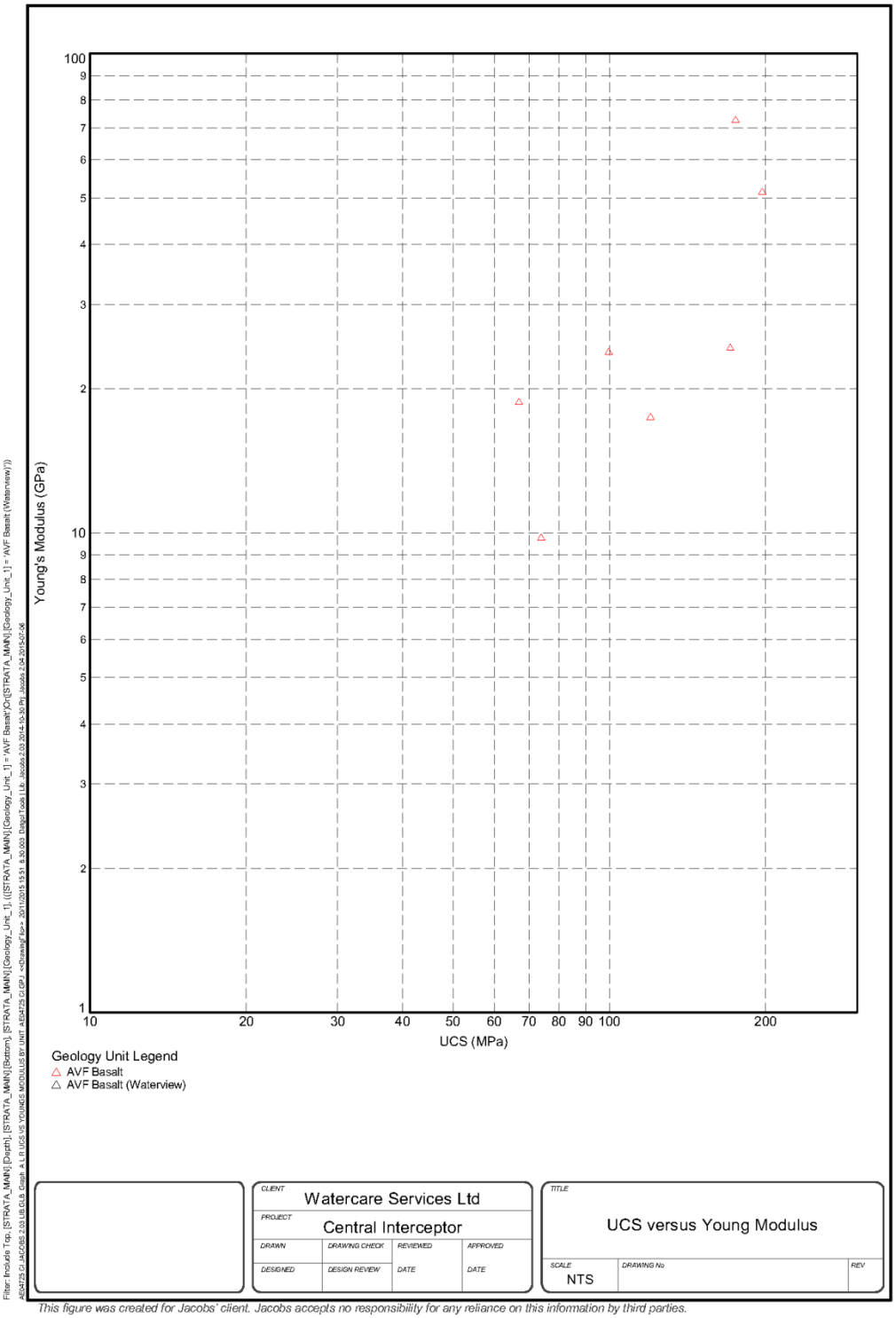

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Table N.1 : Modulus Ratio

Modulus Ratio										
Geological Unit	Minimum	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile	Maximum	Mean	Standard deviation	Count
All results in this investigation	33	84	108	133	174	240	620	150	77	151
TAURANGA GROUP										
Tauranga Puketoka	281	281	281	281	281	281	281	281	0	1
Kaawa Formation	265	265	265	265	265	265	265	265	0	1
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Basalt	133	139	144	240	271	335	416	231	94	7
Basalt (Waterview)	-	-	-	-	-	-	-	-	-	-
WAITEMATA GROUP (MIOCENE)										
Residually to Highly Weathered Residual Soils - Cohesive Soils	106	113	123	132	136	140	142	128	13	4
Residually to Highly Weathered - Cohesive Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Residually to Highly Weathered - Granular Soils	117	120	124	130	142	158	169	136	20	4
Residually to Highly Weathered - Granular Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Parnell Volcaniclastic Conglomerate	117	128	156	175	201	223	303	183	51	9
Parnell Volcaniclastic Conglomerate (Waterview)	-	-	-	-	-	-	-	-	-	-
Moderately Weathered to Unweathered ECBF	33	79	100	125	169	218	620	142	76	125
Moderately Weathered to Unweathered ECBF (Waterview)	-	-	-	-	-	-	-	-	-	-
Sandstone[5]	42	54	73	104	139	161	175	107	54	3
Interbedded mudstone and sandstone[3]	49	91	103	134	193	260	620	175	121	23
Mudstone[3]	90	105	128	167	205	228	243	167	77	2

[5] Data subset of the moderately weathered to unweathered ECBF values. Only some samples with detail description on sandstone, mudstone and Interbedded mudstone and sandstone

Appendix O. Tensile strength

Figure O.1 : Tensile Strength versus Depth for all Data Except Basalt Samples

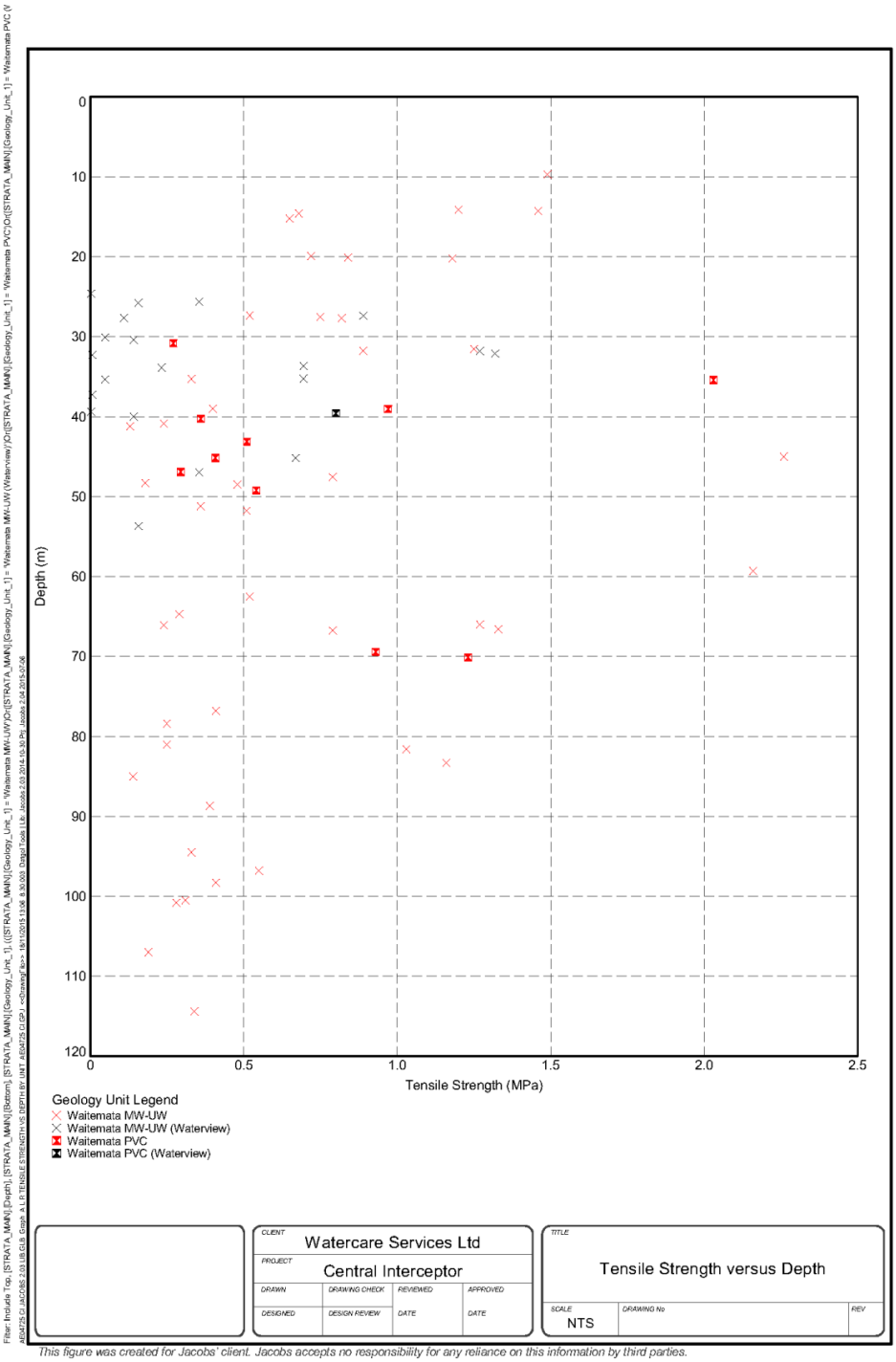

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Figure O.2 : Tensile Strength versus Depth for Basalt Samples

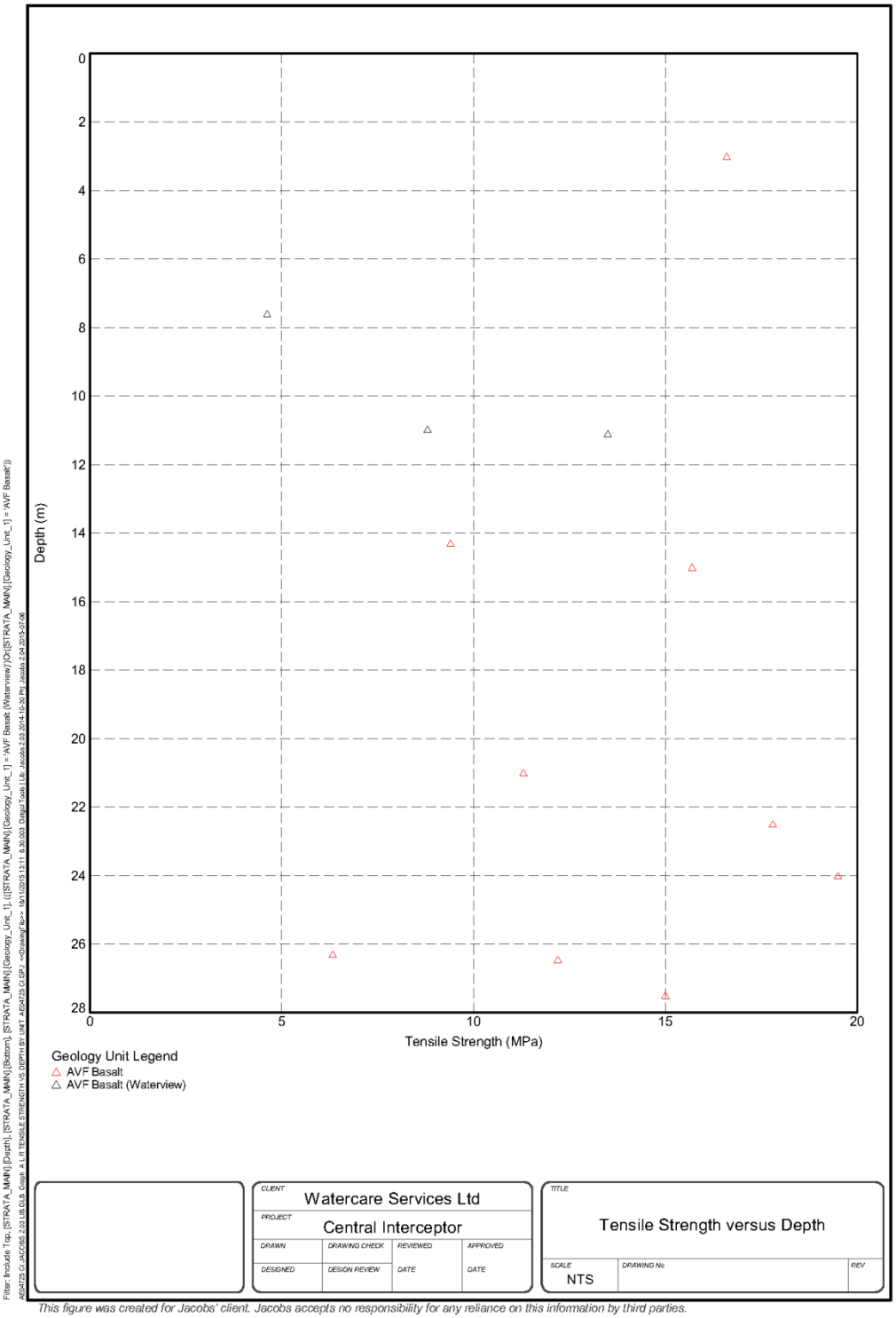

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Table O.1 : Tensile Strength

Tensile Strength (kPa)										
Geological Unit	Minimum	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile	Maximum	Mean	Standard deviation	Count
All results in this investigation	3	141	285	550	1,240	9,040	19,500	2,266	4,461	87
TAURANGA GROUP										
Tauranga Puketoka	-	-	-	-	-	-	-	-	-	-
Kaawa Formation	-	-	-	-	-	-	-	-	-	-
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Basalt	6,330	8,786	11,300	15,000	16,600	18,140	19,500	13,759	4,019	9
Basalt (Waterview)	4,620	5,456	6,710	8,800	11,150	12,560	8,973	3,627	3.6	6
WAITEMATA GROUP (MIOCENE)										
Residually to Highly Weathered Residual Soils - Cohesive Soils	-	-	-	-	-	-	-	-	-	-
Residually to Highly Weathered - Cohesive Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Residually to Highly Weathered - Granular Soils	-	-	-	-	-	-	-	-	-	-
Residually to Highly Weathered - Granular Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Parnell Volcaniclastic Conglomerate	270	292	372	525	960	1,310	2,030	754	525	10
Parnell Volcaniclastic Conglomerate (Waterview)	800	800	800	800	800	800	800	800	0	1
Moderately Weathered to Unweathered ECBF	130	240	325	520	925	1,312	2,260	699	505	44
Moderately Weathered to Unweathered ECBF (Waterview)	3	7	49	157	676	928	1,320	365	406	20
Sandstone[6]	330	372	440	790	1,020	1,316	1,490	790	400	7
Interbedded mudstone and sandstone[4]	130	220	290	520	890	1,294	2,260	682	521	37
Mudstone[4]	-	-	-	-	-	-	-	-	-	-

[6] Data subset of the moderately weathered to unweathered ECBF values. Only some samples with detail description on sandstone, mudstone and Interbedded mudstone and sandstone

Appendix P. Rock strength parameters using RocLab

Figure P.1 : Rock Strength Parametrs for Basalt (15m)

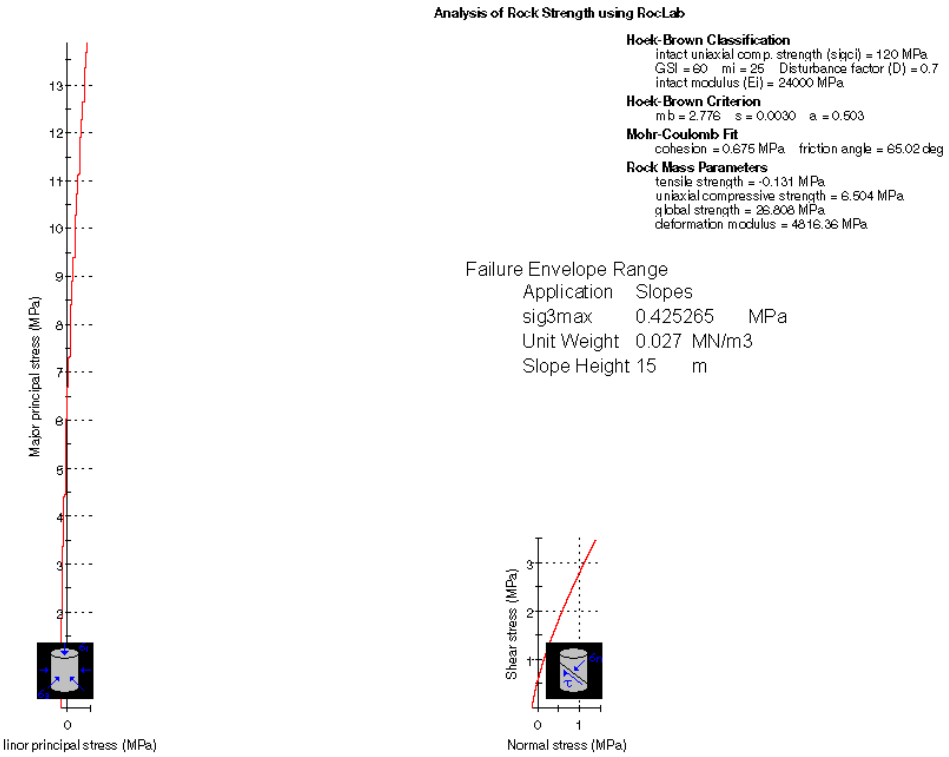


Figure P.2 : Rock Strength Parametrs for ECBF (30m)

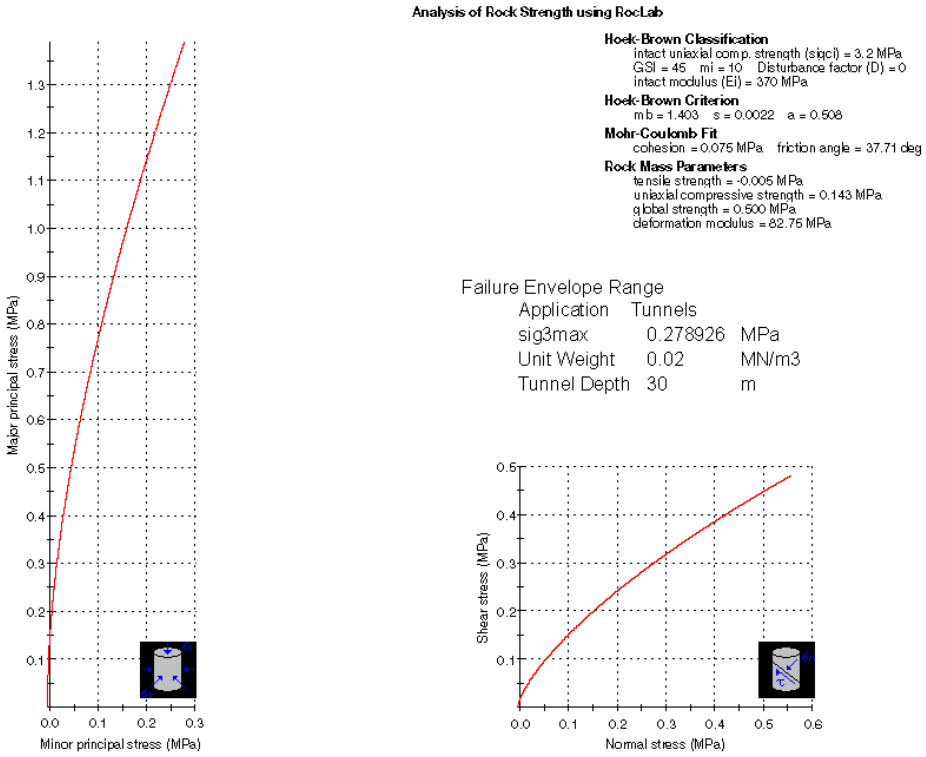


Figure P.3 : Rock Strength Parametrs for ECBF (80m)

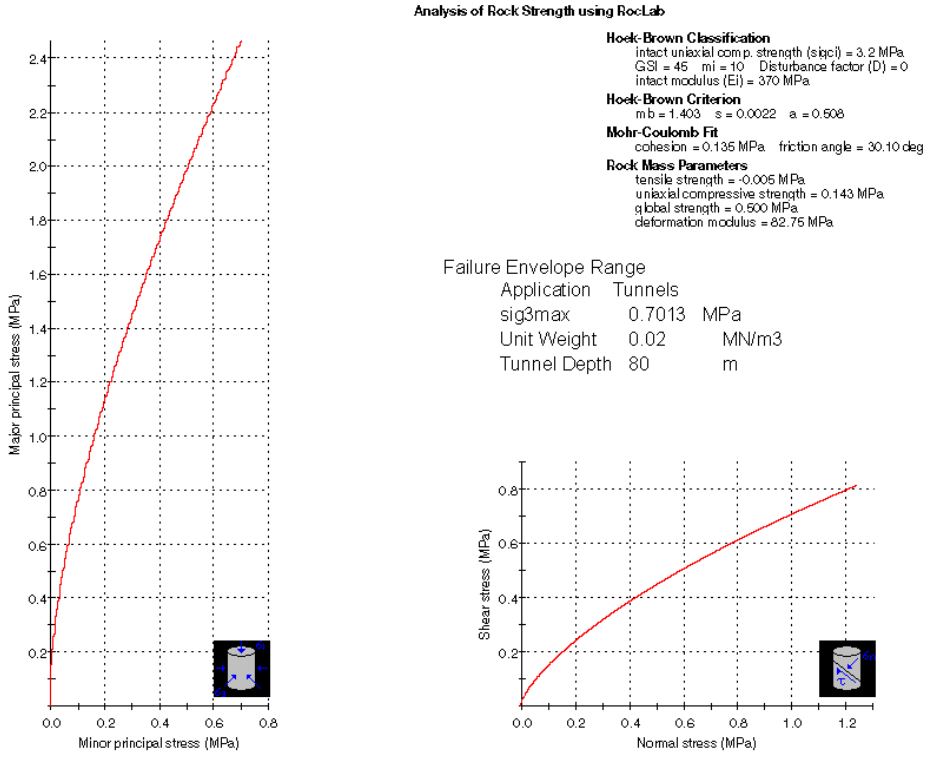


Figure P.4 : Rock Strength Parametrs for PVC (30m)

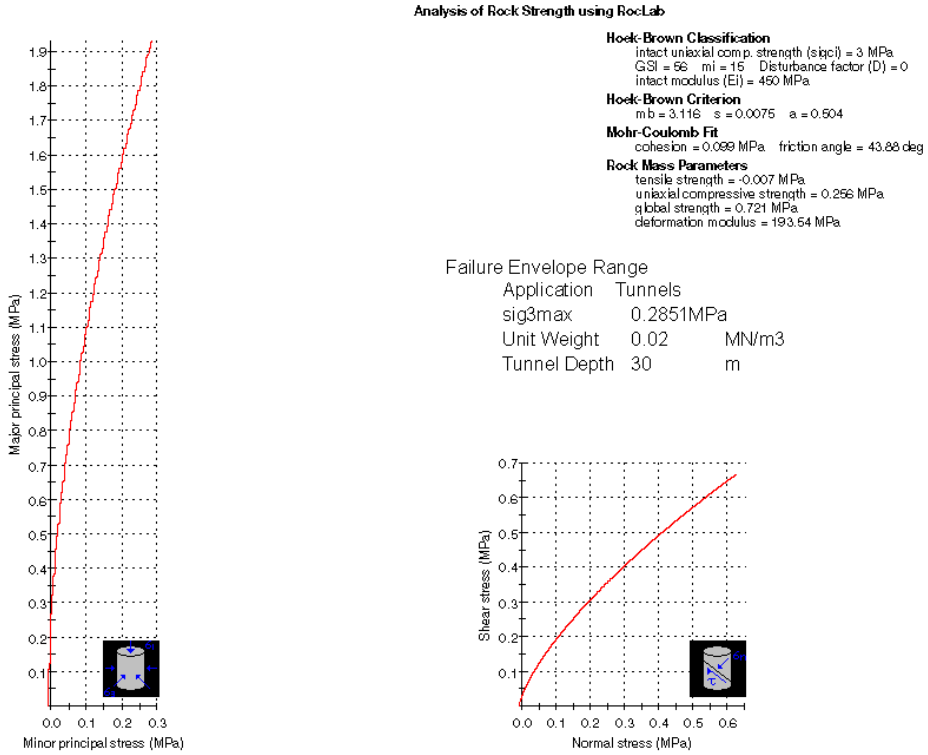
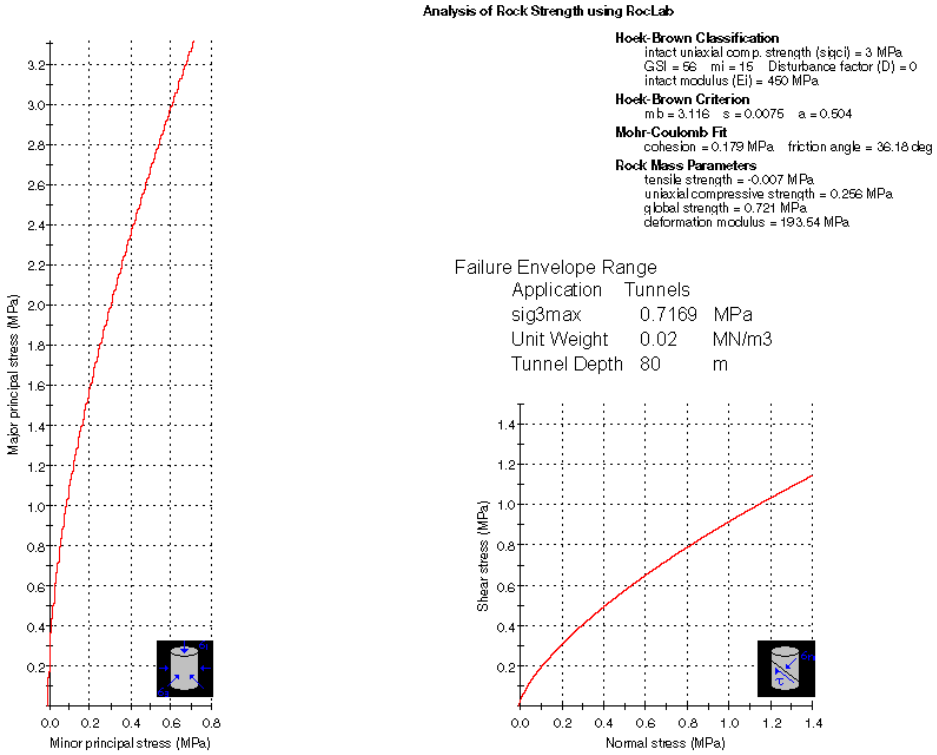


Figure P.5 : Rock Strength Parametrs for PVC (80m)



Appendix Q. Rock parameters

Table Q.1 : Results from Slake Durability Tests

Second Cycle Slake Durability Index, I_{d2} (%)										
Geological Unit	Minimum	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile	Maximum	Mean	Standard deviation	Count
All results in this investigation	0.0	14	36	60	83	90	98	57	28	33
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Basalt	-	-	-	-	-	-	-	-	-	-
Basalt (Waterview)	-	-	-	-	-	-	-	-	-	-
WAITEMATA GROUP (MIOCENE)										
Parnell Volcaniclastic Conglomerate	35	37	41	47	53	56	59	47	12	2
Parnell Volcaniclastic Conglomerate (Waterview)	75	76	78	82	83	83	84	80	3.9	3
Moderately Weathered to Unweathered ECBF	0.0	23	49	64	87	92	94	62	29	16
Moderately Weathered to Unweathered ECBF (Waterview)	7.7	10.8	24	44	67	71	98	45	27	12

Table Q.2 : Aggregate Abrasion Values using CERCHAR Abrasivity Test

CERCHAR Abrasivity Index (CAI)										
Geological Unit	Minimum	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile	Maximum	Mean	Standard deviation	Count
All results in this investigation	0.3	0.5	0.6	0.8	0.9	5.0	5.7	1.5	1.7	56
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Basalt	4.7	4.8	5.0	5.1	5.2	5.6	5.7	5.1	0.3	8
Basalt (Waterview)	5.0	5.0	5.1	5.2	5.3	5.4	5.4	5.2	0.2	2
WAITEMATA GROUP (MIOCENE)										
Parnell Volcaniclastic Conglomerate	0.7	0.8	0.8	0.8	0.9	0.9	1.0	0.8	0.1	9
Parnell Volcaniclastic Conglomerate (Waterview)	0.4	0.4	0.4	0.4	0.6	0.6	0.7	0.5	0.1	5
Moderately Weathered to Unweathered ECBF	0.4	0.6	0.6	0.7	0.8	0.9	1.9	0.8	0.3	26
Moderately Weathered to Unweathered ECBF (Waterview)	0.3	0.4	0.5	0.5	0.6	0.7	0.7	0.5	0.1	6

Table Q.3 : Results from Shore Hardness Tests

Average Shore Harness										
Geological Unit	Minimum	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile	Maximum	Mean	Standard deviation	Count
All results in this investigation	0.5	1.0	1.5	3.0	31	56	69	19	23	22
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Basalt	55	55	56	56	56	56	56	56	0.5	2
Basalt (Waterview)	60	61	62	65	67	68	69	65	4.5	2
WAITEMATA GROUP (MIOCENE)										
Parnell Volcaniclastic Conglomerate	31	31	31	31	31	31	31	31	0.4	3
Parnell Volcaniclastic Conglomerate (Waterview)	0.5	0.5	0.5	1.0	3.0	3.0	3.0	1.6	1.2	5
Moderately Weathered to Unweathered ECBF	31	31	31	31	31	31	31	31	0	2
Moderately Weathered to Unweathered ECBF (Waterview)	1.0	1.0	1.2	2.5	3.0	3.6	5.0	2.4	1.3	8

Table Q.4 : Aggregate Abrasion Values using Swedish Brittleness Test

Swedish Brittleness Value S_{20}										
Geological Unit	Minimum	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile	Maximum	Mean	Standard deviation	Count
All results in this investigation	32	59	73	81	88	95	780	107	144	23
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Basalt	32	33	35	38	40	42	43	38	6	2
Basalt (Waterview)	59	59	59	59	59	59	59	59	0	2
WAITEMATA GROUP (MIOCENE)										
Parnell Volcaniclastic Conglomerate	72	75	80	87	94	97	100	86	11	3
Parnell Volcaniclastic Conglomerate (Waterview)	76	76	76	76	76	76	76	76	0	1
Moderately Weathered to Unweathered ECBF	76	76	76	77	77	77	77	77	1	2
Moderately Weathered to Unweathered ECBF (Waterview)	68	74	81	84	90	95	780	137	186	13

Table Q.5 : Aggregate Abrasion Values using Sievers J-Value Test

Sievers J-Value										
Geological Unit	Minimum	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile	Maximum	Mean	Standard deviation	Count
All results in this investigation	14	30	335	565	1,350	3,620	42,000	3,235	9,108	20
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Basalt	18	19	21	25	28	30	31	25	7	2
Basalt (Waterview)	14	14	14	14	14	14	14	14	0	1
WAITEMATA GROUP (MIOCENE)										
Parnell Volcaniclastic Conglomerate	260	316	400	540	545	548	550	450	134	3
Parnell Volcaniclastic Conglomerate (Waterview)	340	454	625	910	1,205	1,382	1,500	917	474	3
Moderately Weathered to Unweathered ECBF	320	322	325	330	335	338	340	330	10	2
Moderately Weathered to Unweathered ECBF (Waterview)	390	542	780	1,300	3,00	15,760	42,000	6,652	12,763	9

Appendix R. Undrained shear strength

Figure R.1 : Undrained Shear Strength versus Depth (from UU triaxial data)

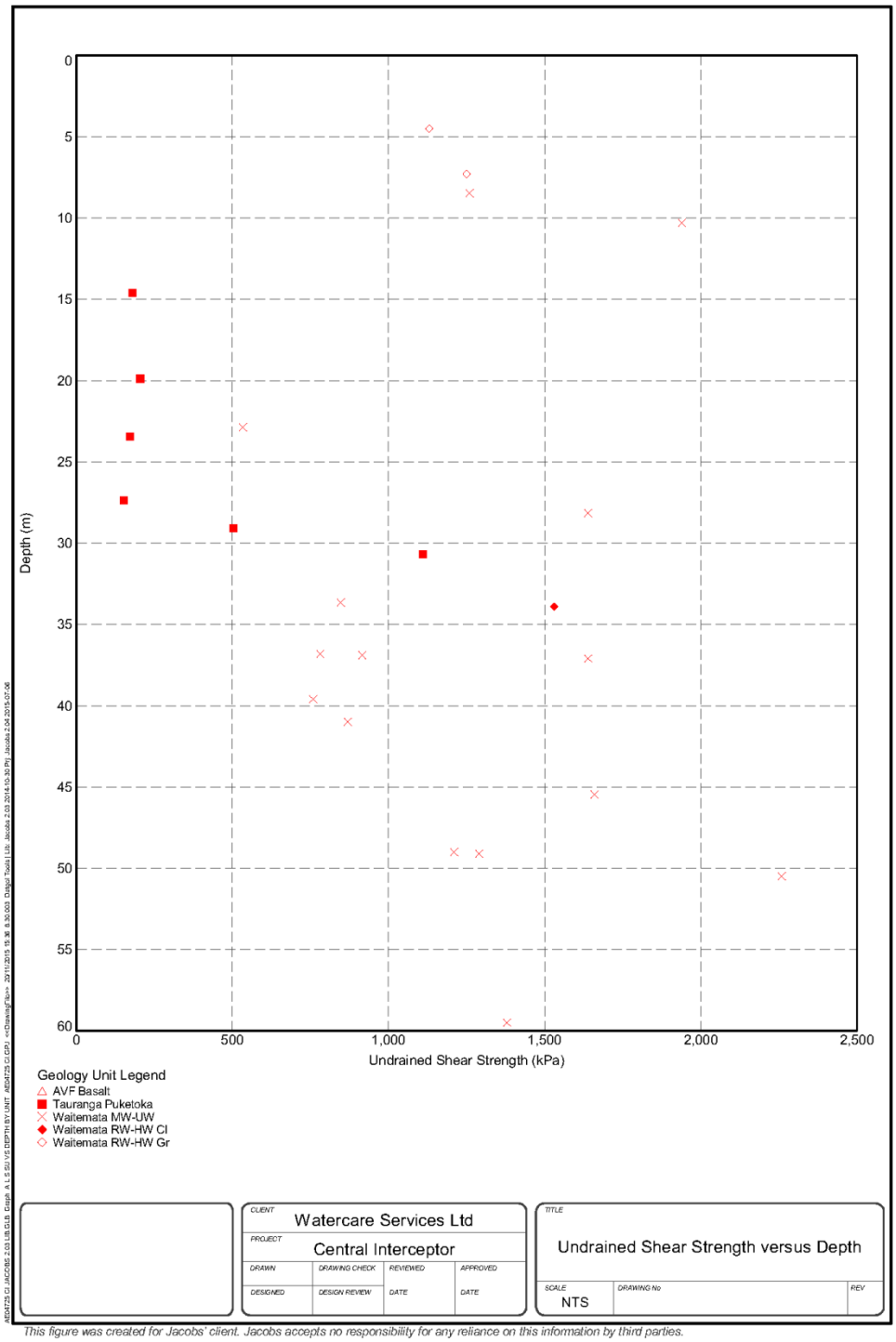


Table R.1 : Undrained Shear Strength from UU triaxial tests

Undrained shear strength (kPa)										
Geological Unit	**Minimum**	**10th Percentile**	**25th Percentile**	**Median**	**75th Percentile**	**90th Percentile**	**Maximum**	**Mean**	**Standard deviation**	**Count**
All results in this investigation	13	82	176	848	1275	1640	2260	834	641	31
Made Ground / Fill	-	-	-	-	-	-	-	-	-	-
Made Ground (Waterview)	-	-	-	-	-	-	-	-	-	-
Recent Alluvium / Q1a	-	-	-	-	-	-	-	-	-	-
TAURANGA GROUP										
Undifferentiated Tauranga Group	-	-	-	-	-	-	-	-	-	-
Undifferentiated Tauranga Group (Waterview)	-	-	-	-	-	-	-	-	-	-
Tauranga Estuarine	-	-	-	-	-	-	-	-	-	-
Tauranga Puketoka	13	36	78	161	201	473	1110	234	291	12
Kaawa Formation	-	-	-	-	-	-	-	-	-	-
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Tuff / Ash/ Scoria	-	-	-	-	-	-	-	-	-	-
Tuff / Ash/ Scoria (Waterview)	-	-	-	-	--	-	-	-	-	-
WAITEMATA GROUP (MIOCENE)										
Residually to Highly Weathered Residual Soils - Cohesive Soils	153	153	153	153	153	153	153	153	0	1
Residually to Highly Weathered - Cohesive Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Residually to Highly Weathered - Granular Soils	1130	1142	1160	1190	1120	1238	1250	1190	60	2
Residually to Highly Weathered - Granular Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Moderately Weathered to Unweathered ECBF	534	775	882	1255	1613	1744	2260	1272	439	18
Moderately Weathered to Unweathered ECBF (Waterview)	-	-	-	-	-	-	-	-	-	-

Figure R.2 : Undrained Shear Strength versus Depth (Hand Held Shear Vane) - Made Ground

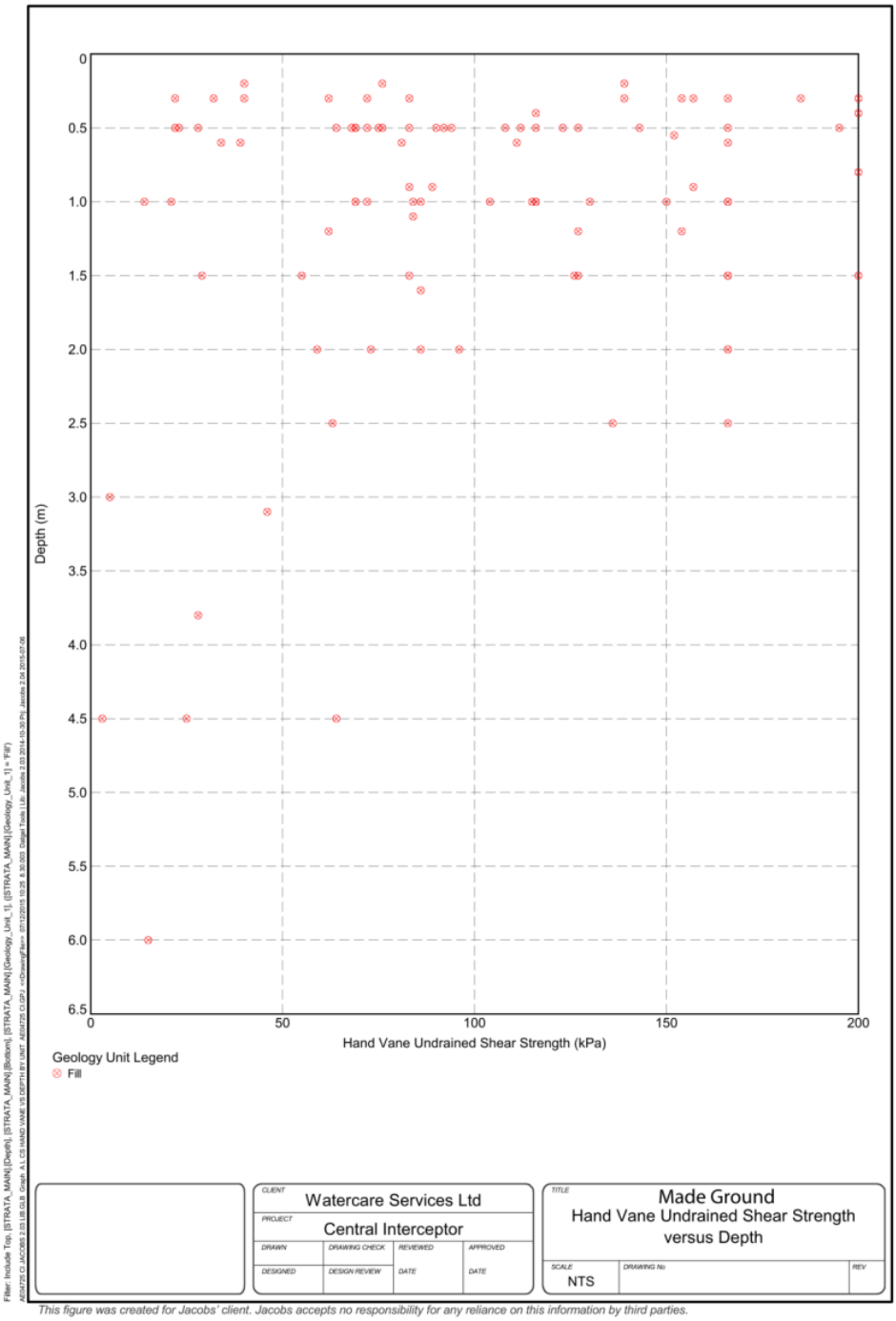


Figure R.3 : Undrained Shear Strength versus Depth (Hand Held Shear Vane) - Recent Alluvium

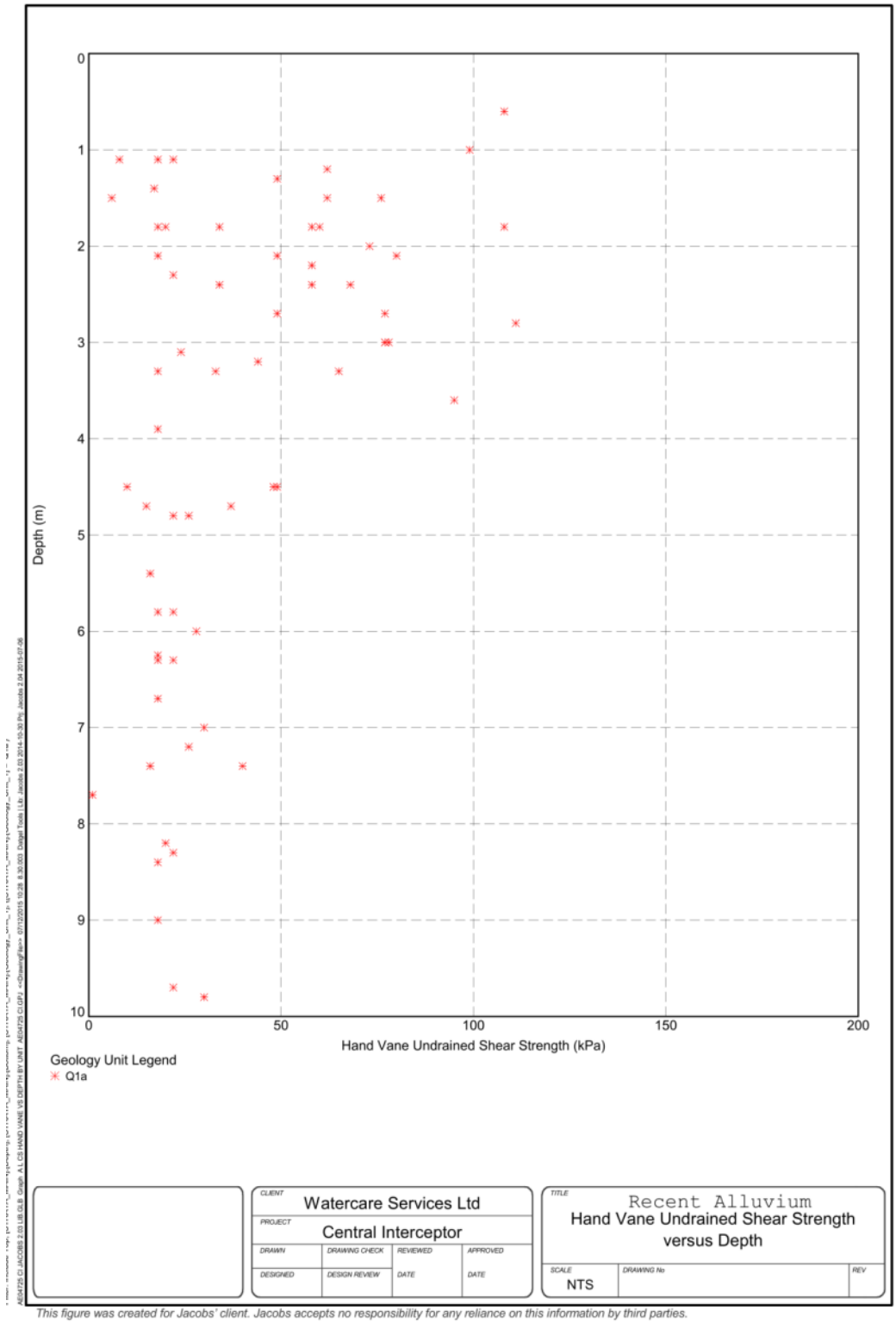


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Figure R.4 : Undrained Shear Strength versus Depth (Hand Held Shear Vane) - Tauranga Group

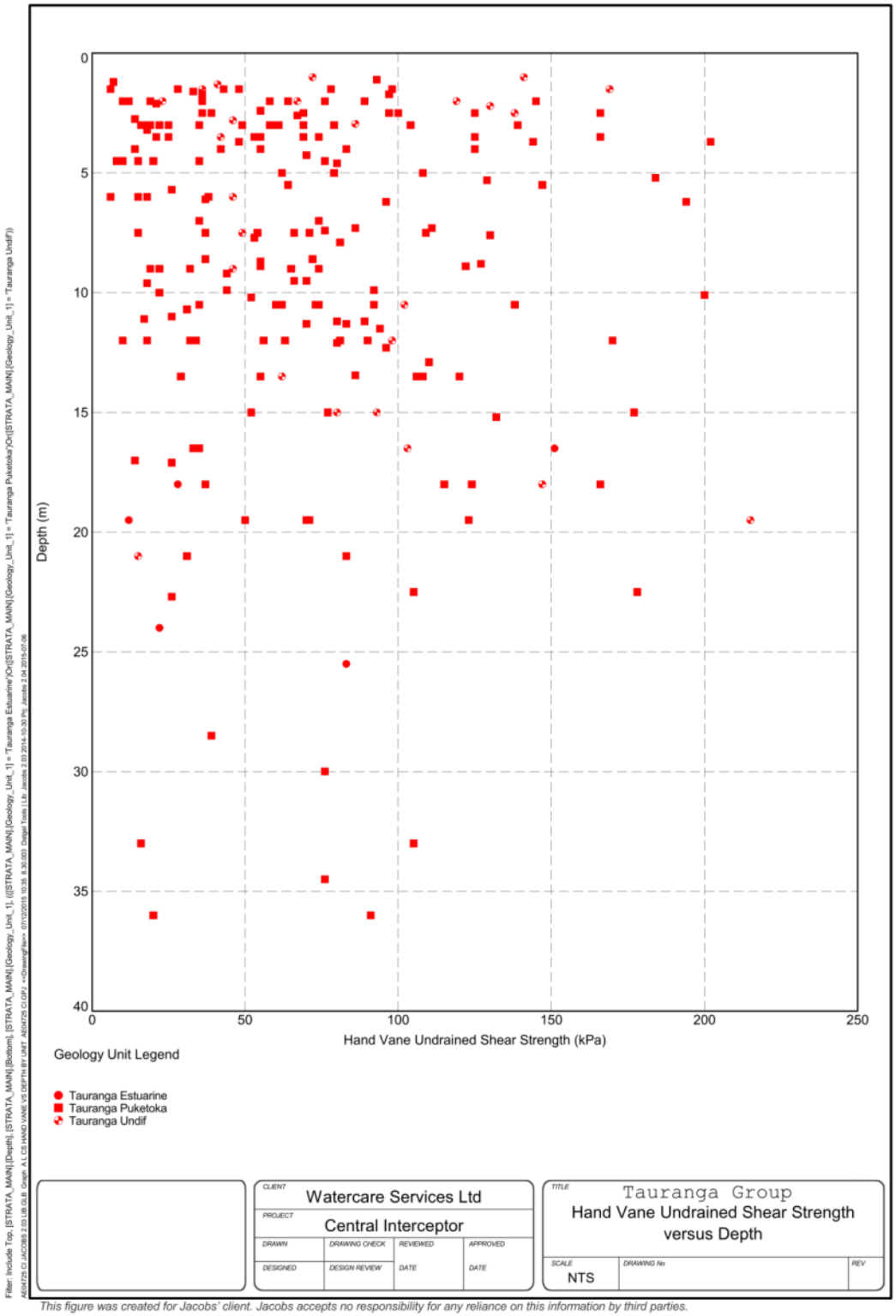

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Figure R.5 : Undrained Shear Strength versus Depth (Hand Held Shear Vane) - Kaawa

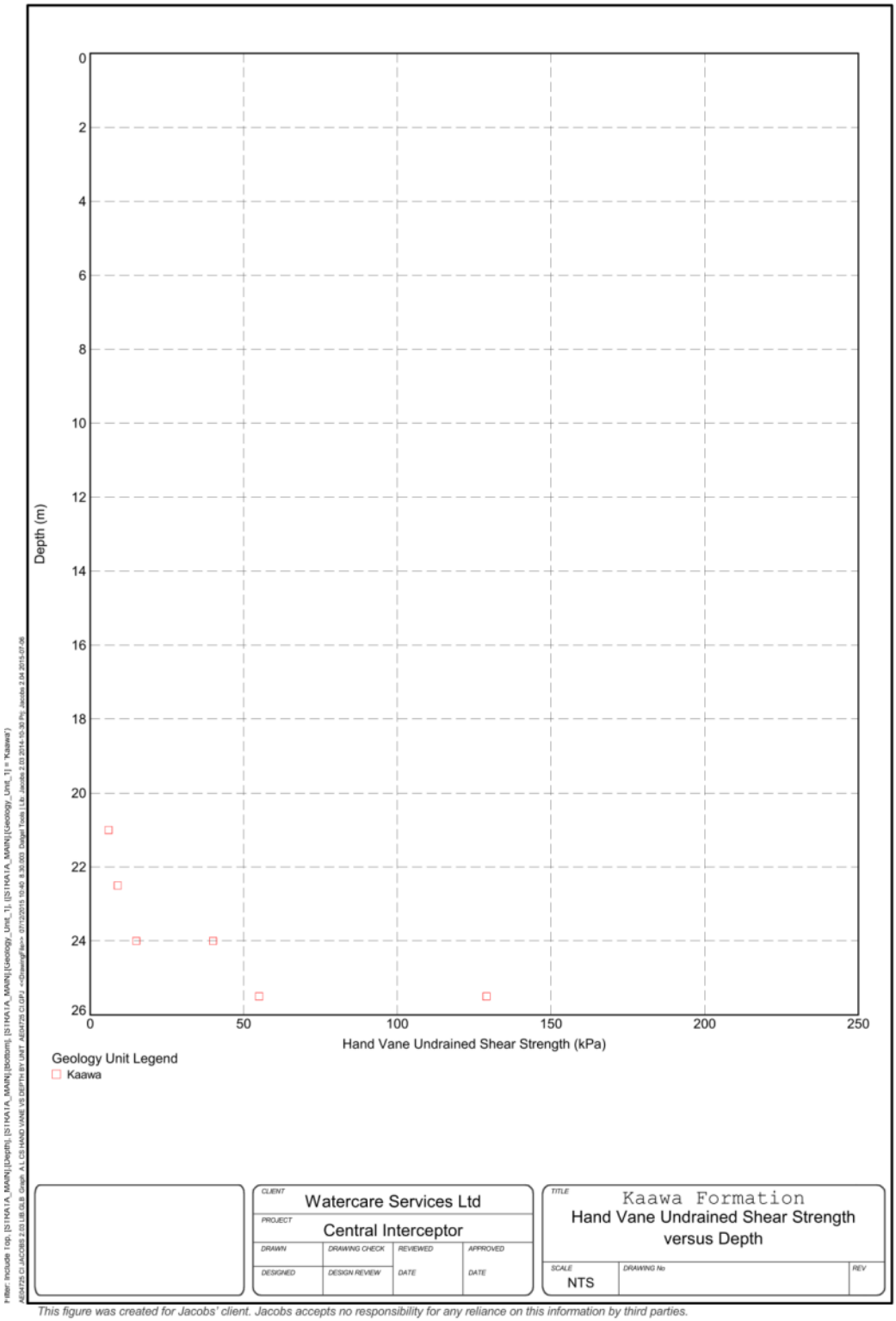

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Figure R.6 : Undrained Shear Strength versus Depth (Hand Held Shear Vane) - Tuff / Ash/ Scoria

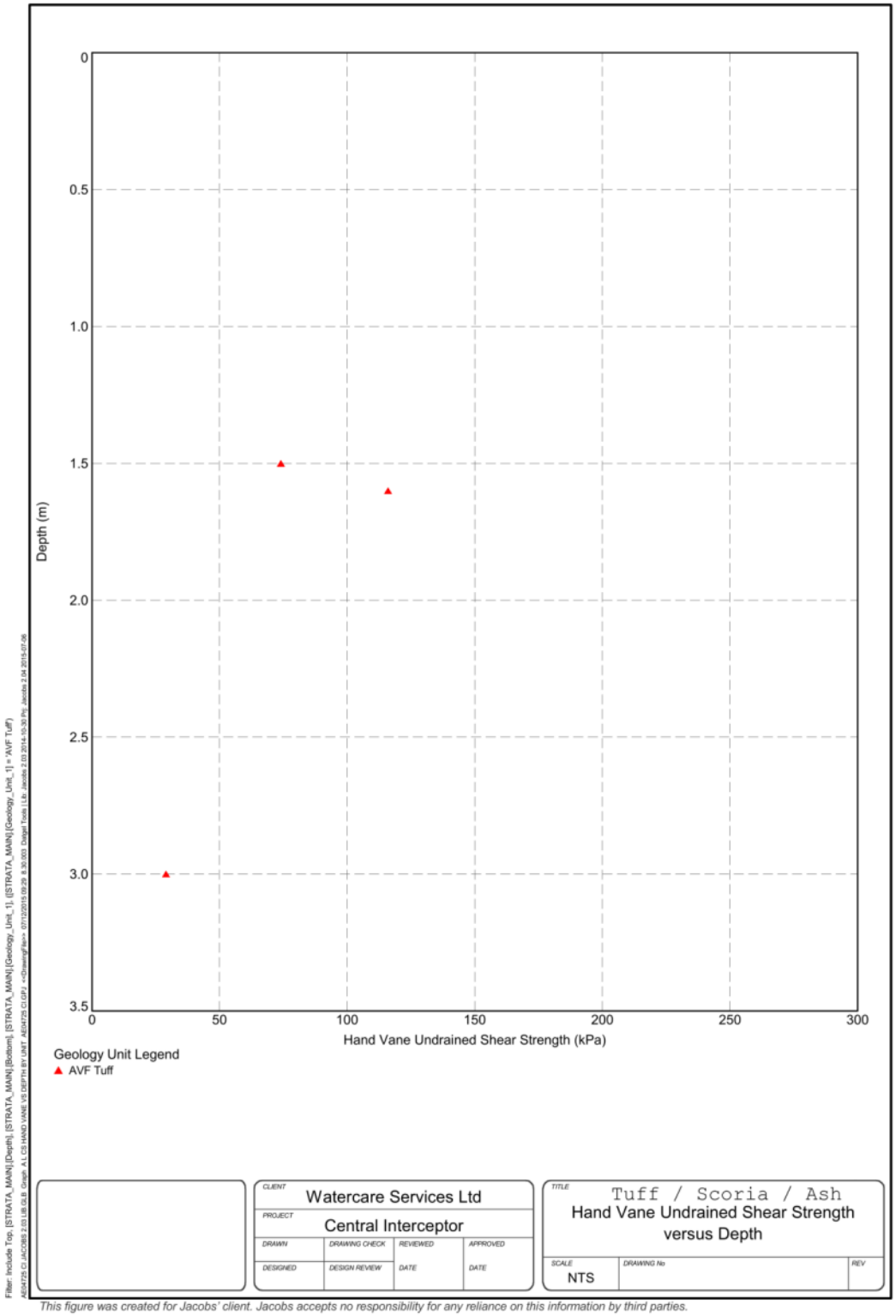

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Figure R.7 : Undrained Shear Strength versus Depth (Hand Held Shear Vane) - Residually to Highly Waterherd - Cohesive Soils

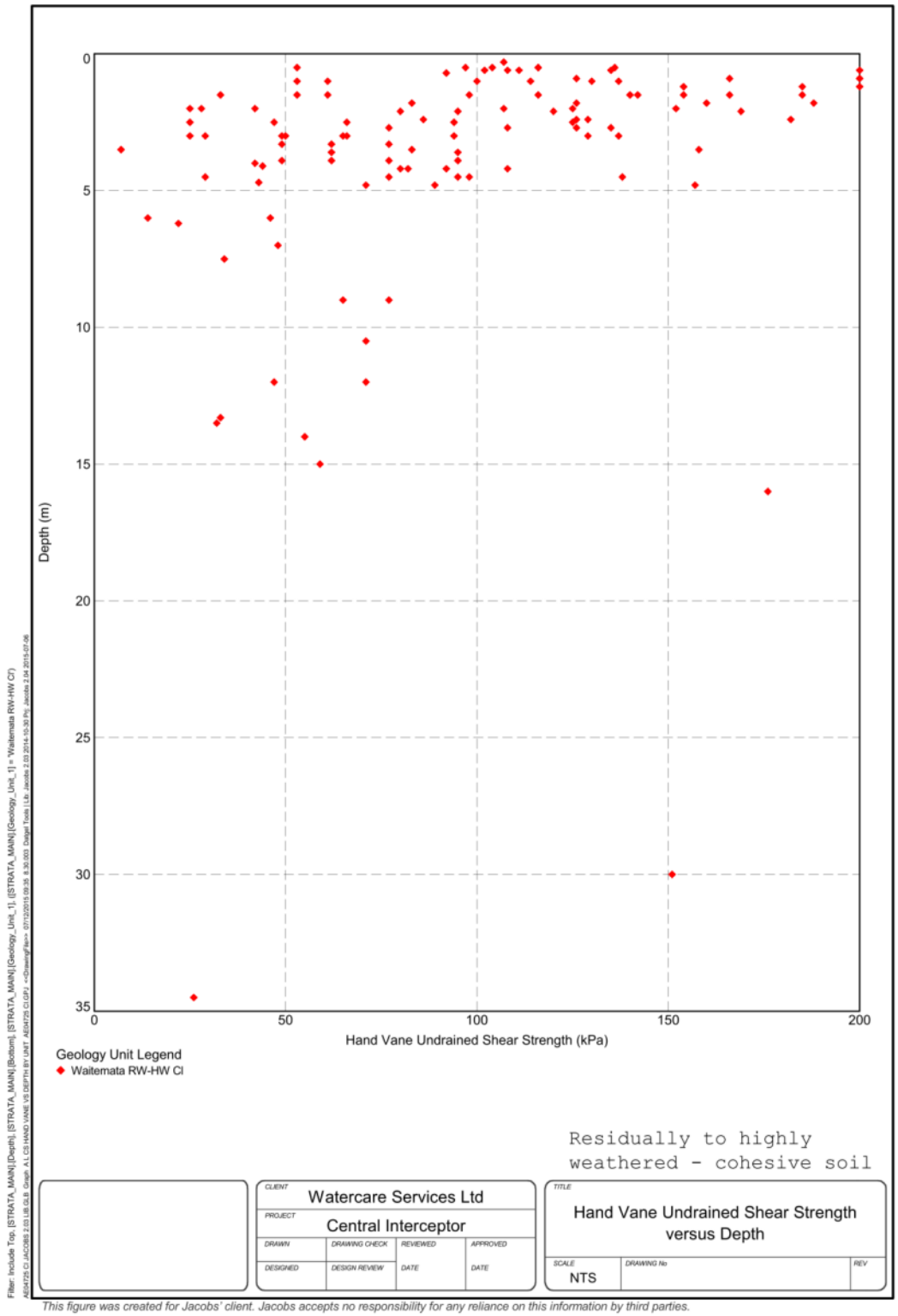

Figure R.8 : Undrained Shear Strength versus Depth (Hand Held Shear Vane) - Residually to Highly Weathered, Granular Soils

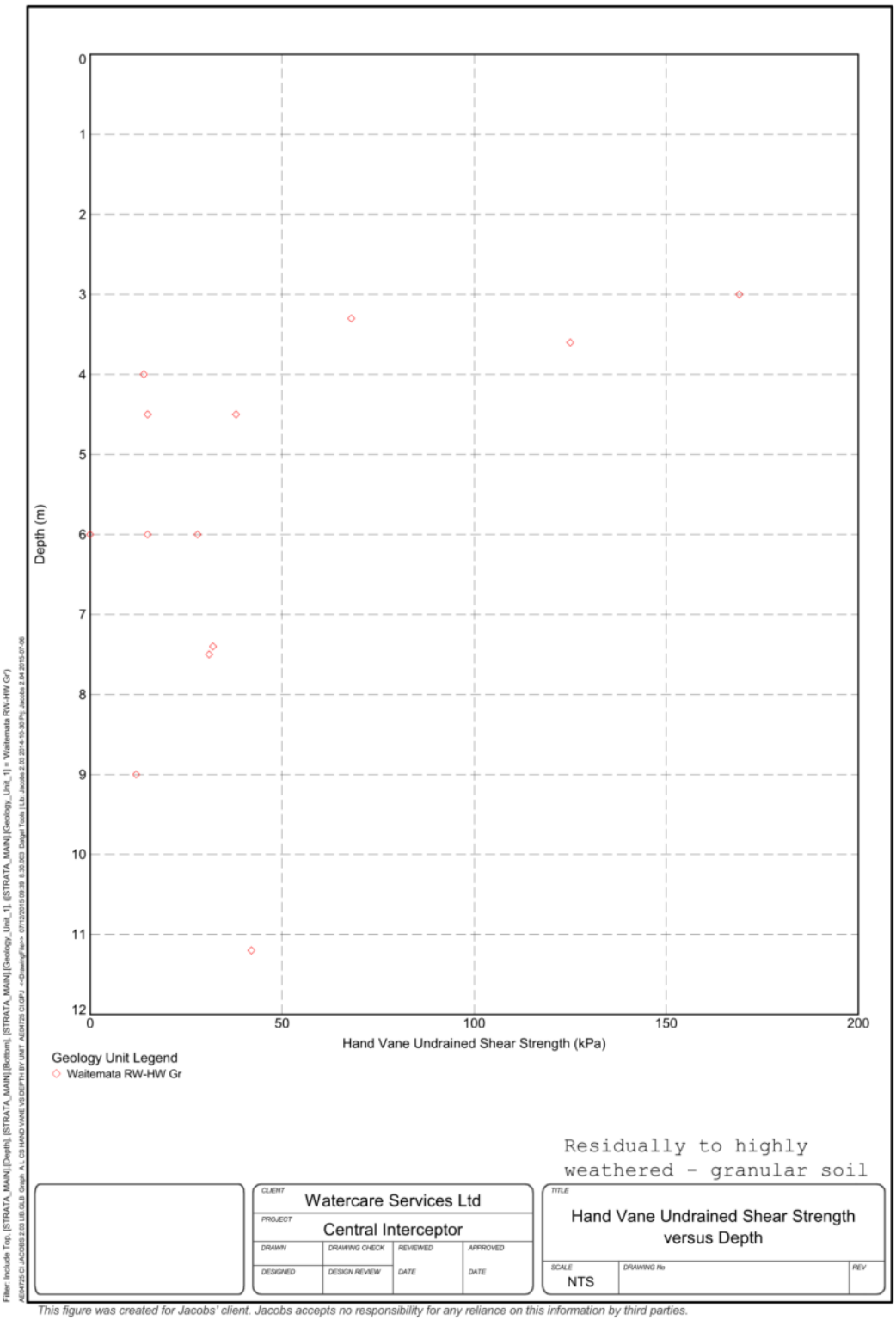

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Table R.2 : Undrained Shear Strength (Peak) from Hand Held Shear Vane Tests

Undrained shear strength (kPa)										
Geological Unit	Minimum	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile	Maximum	Mean	Standard deviation	Count
All results in this investigation	1	18	34	69	108	153	215	76	50	521
Made Ground / Fill	3	28	64	90	143	166	200	100	53	105
Made Ground (Waterview)	-	-	-	-	-	-	-	-	-	-
Recent Alluvium / Q1a	1	16	18	28	58	78	125	41	29	69
TAURANGA GROUP										
Undifferentiated Tauranga Group	15	28	46	80	103	143	215	84	49	25
Undifferentiated Tauranga Group (Waterview)	-	-	-	-	-	-	-	-	-	-
Tauranga Estuarine	12	17	24	30	70	117	151	55	49	6
Tauranga Puketoka	6	18	33	63	92	125	202	68	44	179
Kaawa Formation	6	8	11	28	51	92	129	42	43	6
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Tuff / Ash/ Scoria	29	31	34	41	53	66	74	46	17	4
Tuff / Ash/ Scoria (Waterview)	-	-	-	-	--	-	-	-	-	-
WAITEMATA GROUP (MIOCENE)										
Residually to Highly Weathered - Cohesive Soils	7	33	53	92	126	157	200	93	47	117
Residually to Highly Weathered - Cohesive Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Residually to Highly Weathered - Granular Soils	12	14	15	30	111	171	185	66	65	10
Residually to Highly Weathered - Granular Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Moderately Weathered to Unweathered ECBF	-	-	-	-	-	-	-	-	-	-
Moderately Weathered to Unweathered ECBF (Waterview)	-	-	-	-	-	-	-	-	-	-

Table R.3 : Undrained Shear Strength (Remoulded) from Hand Held Shear Vane Tests

Undrained shear strength (kPa)										
Geological Unit	Minimum	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile	Maximum	Mean	Standard deviation	Count
All results in this investigation	1	6	11	21	34	48	95	25	18	430
Made Ground	3	7	17	28	46	59	76	32	19	82

Undrained shear strength (kPa)										
Geological Unit	Minimum	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile	Maximum	Mean	Standard deviation	Count
Made Ground (Waterview)	-	-	-	-	-	-	-	-	-	-
Recent Alluvium / Q1a	2	4	6	11	23	37	52	16	13	59
TAURANGA GROUP										
Undifferentiated Tauranga Group	6	12	18	28	42	58	69	32	17	21
Undifferentiated Tauranga Group (Waterview)	-	-	-	-	-	-	-	-	-	-
Tauranga Estuarine	3	5	7	9	23	34	40	16	13	6
Tauranga Puketoka	1	6	9	18	28	37	89	20	14	160
Kaawa Formation	3	3	3	16	24	26	28	15	10	5
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Tuff / Ash/ Scoria	3	5	9	12	13	16	17	11	5	4
Tuff / Ash/ Scoria (Waterview)	-	-	-	-	--	-	-	-	-	-
WAITEMATA GROUP (MIOCENE)										
Residually to Highly Weathered Residual Soils - Cohesive Soils	1	11	17	30	44	60	77	32	18	87
Residually to Highly Weathered - Cohesive Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Residually to Highly Weathered - Granular Soils	3	4	7	21	42	71	95	32	32	6
Residually to Highly Weathered - Granular Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Moderately Weathered to Unweathered ECBF	-	-	-	-	-	-	-	-	-	-
Moderately Weathered to Unweathered ECBF (Waterview)	-	-	-	-	-	-	-	-	-	-

Appendix S. Mohr Coulomb strength parameters

Table S.1: Friction Angle and Cohesion from CU Triaxial and Direct Shear Tests

Friction Angle (°) / Cohesion (kPa)										
Geological Unit	Minimum	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile	Maximum	Mean	Standard deviation	Count
All results in this investigation	17 0	26 0	28 6	31 11	35 22	37 34	58 219	31 24	7 42	40
Made Ground / Fill	-	-	-	-	-	-	-	-	-	-
Made Ground (Waterview)	-	-	-	-	-	-	-	-	-	-
Recent Alluvium / Q1a	35 0	37 1	41 3	47 5	52 5	56 6	58 6	47 3	12 3	2
TAURANGA GROUP										
Undifferentiated Tauranga Group	28 0	28 0	28 0	28 0	30 4	32 6	33 7	29 2	2 3	3
Undifferentiated Tauranga Group (Waterview)	-	-	-	-	-	-	-	-	-	-
Tauranga Estuarine	-	-	-	-	-	-	-	-	-	-
Tauranga Puketoka	17 0	21 6	28 9	30 12	33 22	36 35	39 141	29 24	5 32	27
Kaawa Formation	28 24	29 44	30 73	31 122	33 170	34 200	35 219	31 122	3 98	2
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Tuff / Ash/ Scoria	36 0	36 0	36 0	36 0	36 0	36 0	36 0	36 0	0 0	1
Tuff / Ash/ Scoria (Waterview)	-	-	-	-	--	-	-	-	-	-
WAITEMATA GROUP (MIOCENE)										
Residually to Highly Weathered Residual Soils - Cohesive Soils	31 1	32 3	33 6	35 12	37 14	39 24	40 31	35 13	3 10	5
Residually to Highly Weathered - Cohesive Soils (Waterview)	-	-	-	-	-	-	-	-	-	-
Residually to Highly Weathered - Granular Soils	-	-	-	-	-	-	-	-	-	-
Residually to Highly Weathered - Granular Soils (Waterview)	-	-	-	-	-	-	-	-	-	-

Appendix T. Tunnel boring machine suite testing

Table T.1 : Aggregate Abrasion Values using CERCHAR Abrasivity Test

CERCHAR Abrasivity Index (CAI)										
Geological Unit	Minimum	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile	Maximum	Mean	Standard deviation	Count
All results in this investigation	0.3	0.5	0.6	0.8	0.9	5.0	5.7	1.5	1.7	56
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Basalt	4.7	4.8	5.0	5.1	5.2	5.6	5.7	5.1	0.3	8
Basalt (Waterview)	5.0	5.0	5.1	5.2	5.3	5.4	5.4	5.2	0.2	2
WAITEMATA GROUP (MIOCENE)										
Parnell Volcaniclastic Conglomerate	0.7	0.8	0.8	0.8	0.9	0.9	1.0	0.8	0.1	9
Parnell Volcaniclastic Conglomerate (Waterview)	0.4	0.4	0.4	0.4	0.6	0.6	0.7	0.5	0.1	5
Moderately Weathered to Unweathered ECBF	0.4	0.6	0.6	0.7	0.8	0.9	1.9	0.8	0.3	26
Moderately Weathered to Unweathered ECBF (Waterview)	0.3	0.4	0.5	0.5	0.6	0.7	0.7	0.5	0.1	6

Table T.2 : Aggregate Abrasion Values using Swedish Brittleness Test

Swedish Brittleness Value S_{20}										
Geological Unit	Minimum	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile	Maximum	Mean	Standard deviation	Count
All results in this investigation	32	59	73	81	88	95	780	107	144	23
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Basalt	32	33	35	38	40	42	43	38	6	2
Basalt (Waterview)	59	59	59	59	59	59	59	59	0	2
WAITEMATA GROUP (MIOCENE)										
Parnell Volcaniclastic Conglomerate	72	75	80	87	94	97	100	86	11	3
Parnell Volcaniclastic Conglomerate (Waterview)	76	76	76	76	76	76	76	76	0	1
Moderately Weathered to Unweathered ECBF	76	76	76	77	77	77	77	77	1	2
Moderately Weathered to Unweathered ECBF (Waterview)	68	74	81	84	90	95	780	137	186	13

Table T.3 : Aggregate Abrasion Values using Sievers J-Value Test

Sievers J-Value										
Geological Unit	Minimum	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile	Maximum	Mean	Standard deviation	Count
All results in this investigation	14	30	335	565	1,350	3,620	42,000	3,235	9,108	20
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Basalt	18	19	21	25	28	30	31	25	7	2
Basalt (Waterview)	14	14	14	14	14	14	14	14	0	1
WAITEMATA GROUP (MIOCENE)										
Parnell Volcaniclastic Conglomerate	260	316	400	540	545	548	550	450	134	3
Parnell Volcaniclastic Conglomerate (Waterview)	340	454	625	910	1,205	1,382	1,500	917	474	3
Moderately Weathered to Unweathered ECBF	320	322	325	330	335	338	340	330	10	2
Moderately Weathered to Unweathered ECBF (Waterview)	390	542	780	1,300	3,00	15,760	42,000	6,652	12,763	9

Table T.4 : Results from Slake Durability Tests

Second Cycle Slake Durability Index										
Geological Unit	Minimum	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile	Maximum	Mean	Standard deviation	Count
All results in this investigation	7.7	14	25	68	86	92	98	59	30	24
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Basalt	-	-	-	-	-	-	-	-	-	-
Basalt (Waterview)	-	-	-	-	-	-	-	-	-	-
WAITEMATA GROUP (MIOCENE)										
Parnell Volcaniclastic Conglomerate	-	-	-	-	-	-	-	-	-	-
Parnell Volcaniclastic Conglomerate (Waterview)	75	76	78	82	83	83	84	80	3.9	3
Moderately Weathered to Unweathered ECBF	86	87	87	89	92	93	94	90	3.0	6
Moderately Weathered to Unweathered ECBF (Waterview)	7.7	8.4	24	35	63	70	98	42	27	15

Table T.5 : Results from Shore Hardness Tests

Average Shore Harness										
Geological Unit	Minimum	10th Percentile	25th Percentile	Median	75th Percentile	90th Percentile	Maximum	Mean	Standard deviation	Count
All results in this investigation	0.5	1.0	1.5	3.0	31	56	69	19	23	22
AUCKLAND VOLCANIC FIELD (PLEISTOCENE)										
Basalt	55	55	56	56	56	56	56	56	0.5	2
Basalt (Waterview)	60	61	62	65	67	68	69	65	4.5	2
WAITEMATA GROUP (MIOCENE)										
Parnell Volcaniclastic Conglomerate	31	31	31	31	31	31	31	31	0.4	3
Parnell Volcaniclastic Conglomerate (Waterview)	0.5	0.5	0.5	1.0	3.0	3.0	3.0	1.6	1.2	5
Moderately Weathered to Unweathered ECBF	31	31	31	31	31	31	31	31	0	2
Moderately Weathered to Unweathered ECBF (Waterview)	1.0	1.0	1.2	2.5	3.0	3.6	5.0	2.4	1.3	8

Appendix U. Mineralogy

Table U.1 : Proportion clay mineral types determined by XRD analysis. Results are shown as a percentage of entire sample analysed rather than normalised to 100% between the three clay constituents shown.

Drill Hole	Sample depth	Geotechnical Unit	Logged Description	Method	Smectite (% of entire sample)	Illite (% of entire sample)	Chlorite (% of entire sample)
BH270	28.9 – 27.8	Kaawa	Silty Sand	XRD	8	-	-
BH223	46.9 – 47.2	PVC	Fine to Coarse Sandstone	XRD	21	4	3
BH263	31.8 – 32.4	PVC	Coarse Sandstone	XRD	17	-	-
BH271	40.25	PVC	Parnell Grit	XRD	3	2	2
BH271	48.5	PVC	Parnell Grit	XRD	3	3	
BH252	96.8 – 97.1	MW - UW ECBF	Mudstone	XRD	16	8	7
BH213	33.8 – 34.9	MW - UW ECBF	Fine sandy Mudstone	XRD	9	3	5
BH206	20.5 – 20.9	MW-UW ECBF	Sandstone (fine to med)	XRD	7	4	5
BH227-1	19.65 – 20.2	MW-UW ECBF	Sandstone (med)	XRD	6	1	4
BH227-1	31.77 – 32.1	MW-UW ECBF	Mudstone	XRD	3	3	3
BH253	14.25	MW-UW ECBF	Mudstone	XRD	6	6	7
BH253	107	MW-UW ECBF	Sandstone	XRD	5	4	4
BH271	47.35	MW-UW ECBF	Sandstone	XRD	4	3	-

Table U.2 : Quantitative mineralogy analysis of Waitemata Group and Kaawa Formation samples

Drill Hole	Sample depth	Geotechnical Unit	Logged Description	Method	Clay, Clay dominate grains & rock fragments, and interstitial matrix. (%)	Plagioclase / feldspathic rock fragments (%)	Quartz (%)	Volcanic Rock Fragments (%)	Carbonate (%)	Other (%)
BH223	46.9 – 48.6	PVC	Fine to Coarse Sandstone	Petrogr.	60	34	-	-	3	Opaques 3%

Drill Hole	Sample depth	Geotechnical Unit	Logged Description	Method	Clay, Clay dominate grains & rock fragments, and interstitial matrix. (%)	Plagioclase / feldspathic rock fragments (%)	Quartz (%)	Volcanic Rock Fragments (%)	Carbonate (%)	Other (%)
BH223	46.9 – 47.2	PVC	Fine to Coarse Sandstone	XRD	28	30	29	-	2	Zeolite 5% Amphibole 6%
BH263	31.8 – 32.4	PVC	Coarse Sandstone	XRD	17	46	16	-	9	Zeolite 12%
BH263	34.5 – 36	PVC	Volcaniclastic Conglomerate	Petrography	15	7	1	70	-	Pyroxene 2%, Analcime 5%
BH267	45.15 – 46.5	PVC	Volcaniclastic Sandstone	Petrography	41	3	1	55	-	
BH271	40.25	PVC	Parnell Grit	XRD	7	52	41	-		
BH271	47.35	PVC	Parnell Grit	XRD	6	44	49	-		Amphibole 1%
BH271	40.25	PVC	Coarse sandstone	Petrogr.	52	42	4			Opaques 2%
BH271	42.8	PVC	Coarse sandstone	Petrogr.	43	46	7			Opaques 4%
BH271	48.5	PVC	Coarse sandstone	Petrogr.	47	45	6			Opaques 2%
BH236	24	RW-HW ECBF	Silty fine sand	Petrogr.	39	49	4			Opaques 4%
BH236	25.5	RW-HW ECBF	Silty clayey Sand	Petrogr.	90	2	8			
BH236	28.2	RW-HW ECBF	Silty clayey Sand	Petrogr.	60	26	12			Opaques 2%
BH252	96.8 – 99.8	MW - UW ECBF	Mudstone	Petrography	84	2	6	-	3	Opaque 5%
BH252	96.8 – 99.8	MW - UW ECBF	Mudstone	Petrography	94	-	2	-	1	Opaque 3%
BH252	96.8 – 97.1	MW - UW ECBF	Mudstone	XRD	31	17	37	-	10	Amphibole 5% Zeolite <1%

Drill Hole	Sample depth	Geotechnical Unit	Logged Description	Method	Clay, Clay dominate grains & rock fragments, and interstitial matrix. (%)	Plagioclase / feldspathic rock fragments (%)	Quartz (%)	Volcanic Rock Fragments (%)	Carbonate (%)	Other (%)
BH248	81 – 82.2	MW - UW ECBF	Mudstone and Sandstone	Petrography	60	25	8	-	4	Glaucontie 2% Opaque 1%
BH213	33.8 – 34.9	MW - UW ECBF	Fine sandy Mudstone	XRD	17	23	53	-	3	Amphibole 3%
BH206	20.5 – 20.9	MW- UW ECBF	Sandstone (fine to med)	XRD	16	14	63	-	-	Amphibile 1%, Apatite 2%, Zeolite 4%
BH227 -1	19.65 – 20.2	MW- UW ECBF	Sandstone (med)	XRD	11	13	50	-	-	Amphibile 8%, Apatite 9%, Zeolite 9%
BH227 -1	31.77 – 32.1	MW- UW ECBF	Mudstone	XRD	9	20	62	-	-	Amphibile 3%, Apatite 1%, Zeolite 5%
BH253	14.25	MW- UW ECBF	Mudstone	XRD	19	16	57	-	--	Amphibile 2%, Apatite 2%, Zeolite 4%
BH253	107	MW- UW ECBF	Sandstone	XRD	13	24	49	-	-	Amphibile 11%, Pyrophyllite 2%, Zeolite 1%
BH271	47.35	MW- UW ECBF	Sandstone	XRD	7	50	41	-	-	Amphibile 2%
BH206	19.9 - 20.5	MW- UW ECBF	Sandstone (fine to med)	Petrogr.	59	31	10			
BH221	27.75 - 27.85	MW- UW ECBF	Sandstone (fine)	Petrogr.	47	25	20			Opaques 4%, Glauconte 4%
BH221	41.2 - 41.5	MW- UW ECBF	Sandstone (med)	Petrogr.	57	13	28			Opaques 2%

Drill Hole	Sample depth	Geotechnical Unit	Logged Description	Method	Clay, Clay dominate grains & rock fragments, and interstitial matrix. (%)	Plagioclase / feldspathic rock fragments (%)	Quartz (%)	Volcanic Rock Fragments (%)	Carbonate (%)	Other (%)
BH229a	78.55	MW-UW ECBF	Sandstone	Petrogr.	61	19	18			Opaques 2%
BH232	40.3	MW-UW ECBF	Sandstone	Petrogr.	50	26	20		2	Opaques 2%
BH236	13.5	MW-UW ECBF	Sandstone	Petrogr.	62	25	8			Opaques 5%
BH236	17.75	MW-UW ECBF	Sandstone	Petrogr.	53	36	8			Opaques 2%, Glauconte 1%
BH236	31.2	MW-UW ECBF	Sandstone	Petrogr.	63	22	10			Opaques 4%, Glauconte 1%
BH236	35.3	MW-UW ECBF	Sandstone	Petrogr.	47	39	12			Opaques 1%, Glauconte 1%
BH236	39.3	MW-UW ECBF	Sandstone	Petrogr.	47	41	8			Opaques 2%, Glauconte 2%
BH252	66.62	MW-UW ECBF	Mudstone	Petrogr.	90		8			Opaques 2%
BH252	72.15	MW-UW ECBF	Mudstone	Petrogr.	82		14			Opaques 4%
BH252	81	MW-UW ECBF	Sandstone	Petrogr.	56	23	18			Opaques 2%
BH252	83.3	MW-UW ECBF	Mudstone	Petrogr.	90		8			Opaques 2%

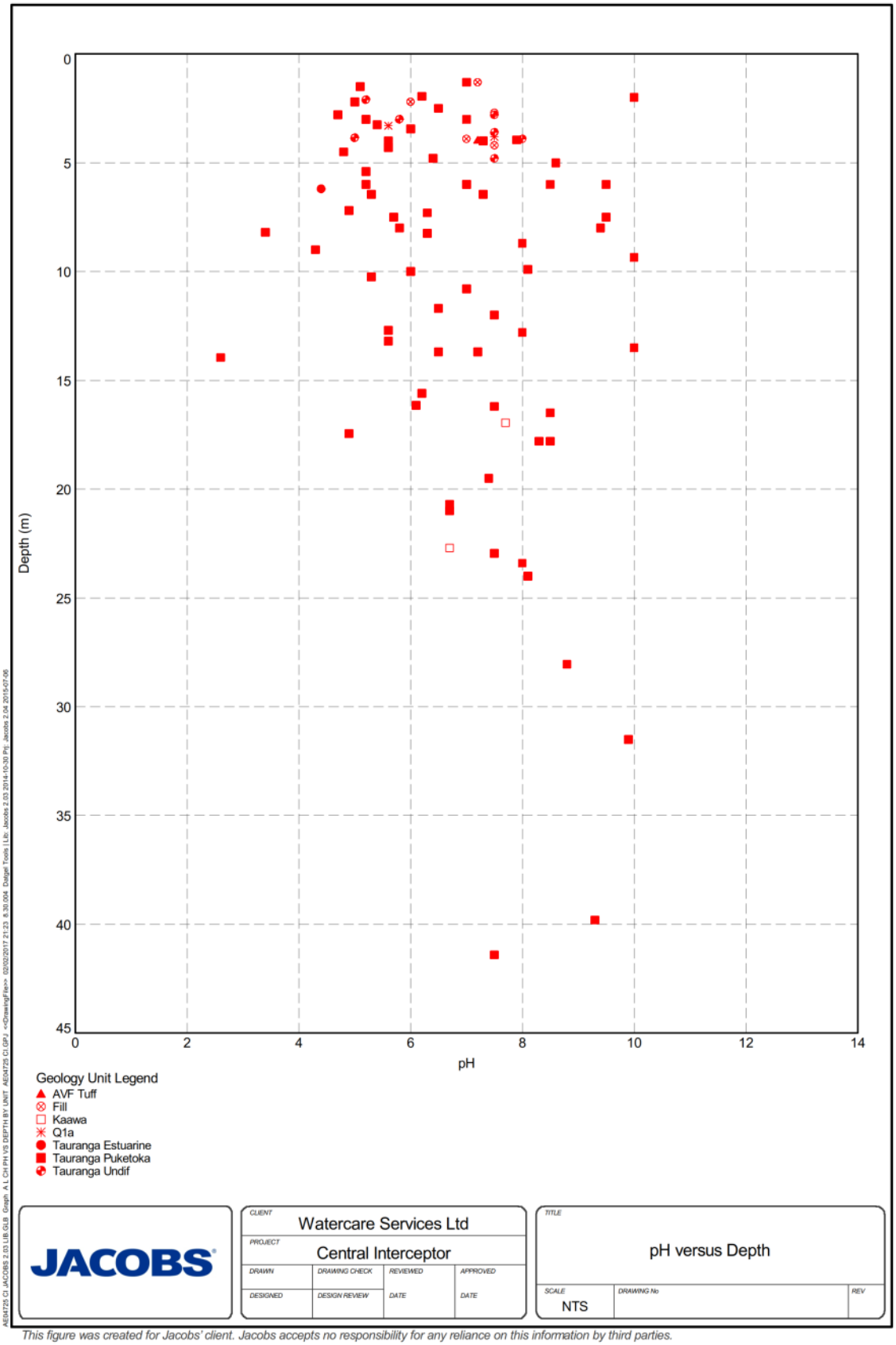
Drill Hole	Sample depth	Geotechnical Unit	Logged Description	Method	Clay, Clay dominate grains & rock fragments, and interstitial matrix. (%)	Plagioclase / feldspathic rock fragments (%)	Quartz (%)	Volcanic Rock Fragments (%)	Carbonate (%)	Other (%)
BH252	100.5	MW-UW ECBF	Mudstone	Petrogr.	87		11			Opaques 2%
BH253	14.25	MW-UW ECBF	Mudstone	Petrogr.	93		5			Opaques 2%
BH253	55.5	MW-UW ECBF	Sandstone	Petrogr.	56	26	13			Opaques 4%, Glauconte 1%
BH253	59.7	MW-UW ECBF	Sandstone	Petrogr.	86		10			Opaques 4%
BH253	98.3	MW-UW ECBF	Mudstone	Petrogr.	54	22	18			Opaques 4%, Glauconte 2%
BH253	115.6	MW-UW ECBF	Sandstone	Petrogr.	48	26	20			Opaques 4%, Glauconte 2%
BH259	27.2	MW-UW ECBF	Sandy Mudstone	Petrogr.	77		20			Opaques 3%
BH259	48.1	MW-UW ECBF	Sandstone	Petrogr.	56	32	9			Opaques 3%
BH271	47.35	MW-UW ECBF	Fine sandstone	Petrogr.	49	40	8			Opaques 3%
BH271	59.3	MW-UW ECBF	Mudstone	Petrogr.	96		2			Opaques 2%
BH271	12.85	Undif. Tauranga	Fine Sand	Petrogr.		40	56			Opaques 4%

Drill Hole	Sample depth	Geotechnical Unit	Logged Description	Method	Clay, Clay dominate grains & rock fragments, and interstitial matrix. (%)	Plagioclase / feldspathic rock fragments (%)	Quartz (%)	Volcanic Rock Fragments (%)	Carbonate (%)	Other (%)
BH269	31.8 – 33	Kaawa	Shells with coarse sand	XRD		15	8	-	77 (Aragonite 73%, Calcite 4%)	
BH270	25.9 – 27.8	Kaawa	Silty Sand	XRD	8	52	35	-	-	Gypsum 3%, Pyrite 2%
BH271	34.25	Kaawa	Shelly Sand	Petrogr.		47	24		23	Opaques 3%, Pyroxene 3%

Table U.3 : Quantitative mineralogy analysis of basalt samples

Drill Hole	Sample depth	Geotechnical Unit	Logged Description	Method	Plagioclase / feldspathic rock fragments (%)	Opaque (%)	Olivine (%)	Pyroxenes (%)	Mesostasis (Groundmass) (%)	Nepheline (%)
BH207	14.3 – 14.8	Basalt	Basalt	XRD	31		16	30		22
BH207	13.5 – 14.8	Basalt	Basalt	Petrogr.	16	10	16	35	23	
BH212	26.7 – 28.2	Basalt	Basalt	Petrogr.	23	8	22	38	5	
BH201c	24	Basalt	Basalt	XRD	19		10	56		10
BH212	26.3	Basalt	Dense basalt	Petrogr.	50	6	12	32		
BH246	3	Basalt	Dense basalt	Petrogr.			25		75	
BH259	15	Basalt	Dense basalt	Petrogr.			15		85	

Appendix V. Geochemistry



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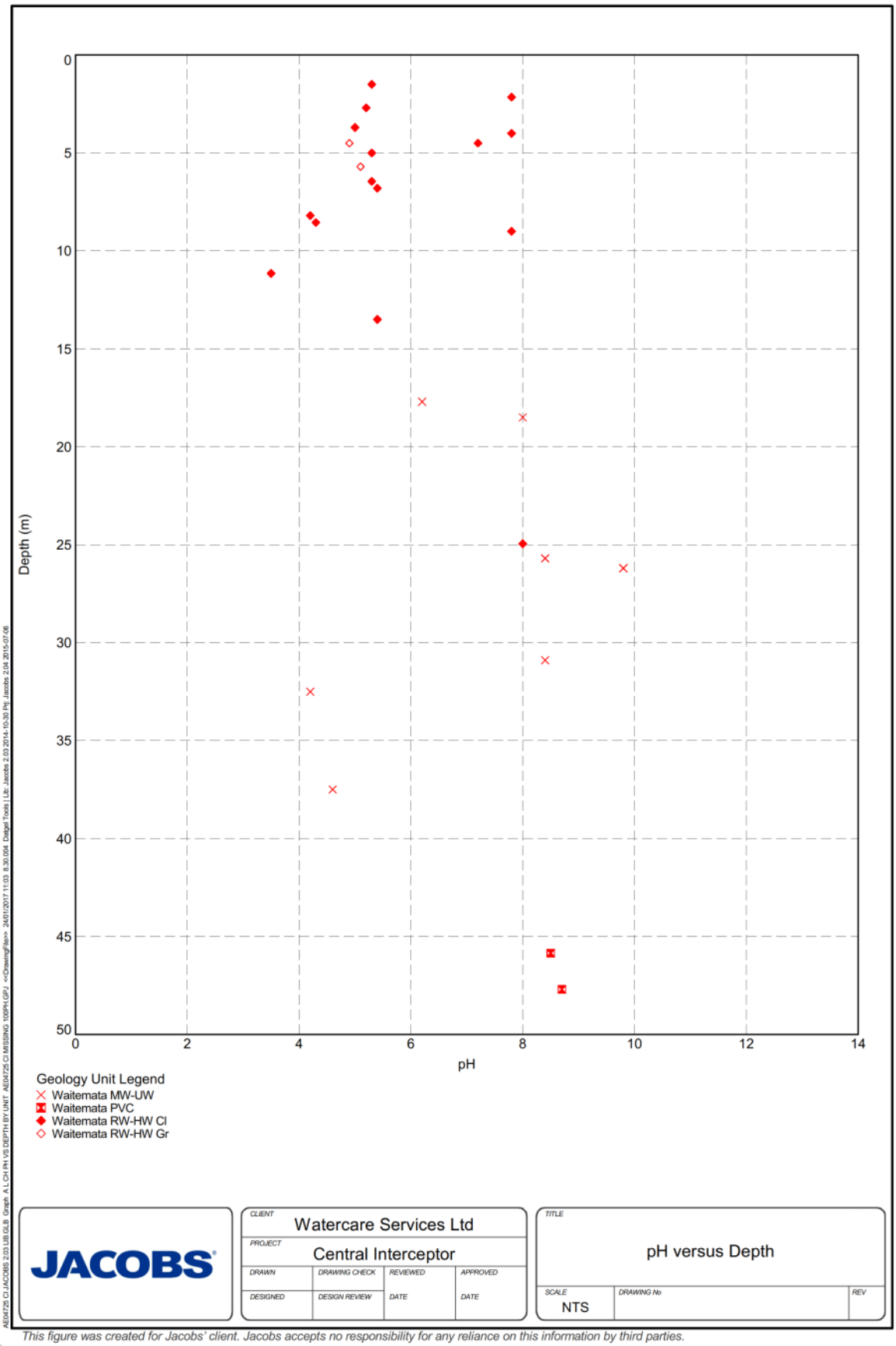

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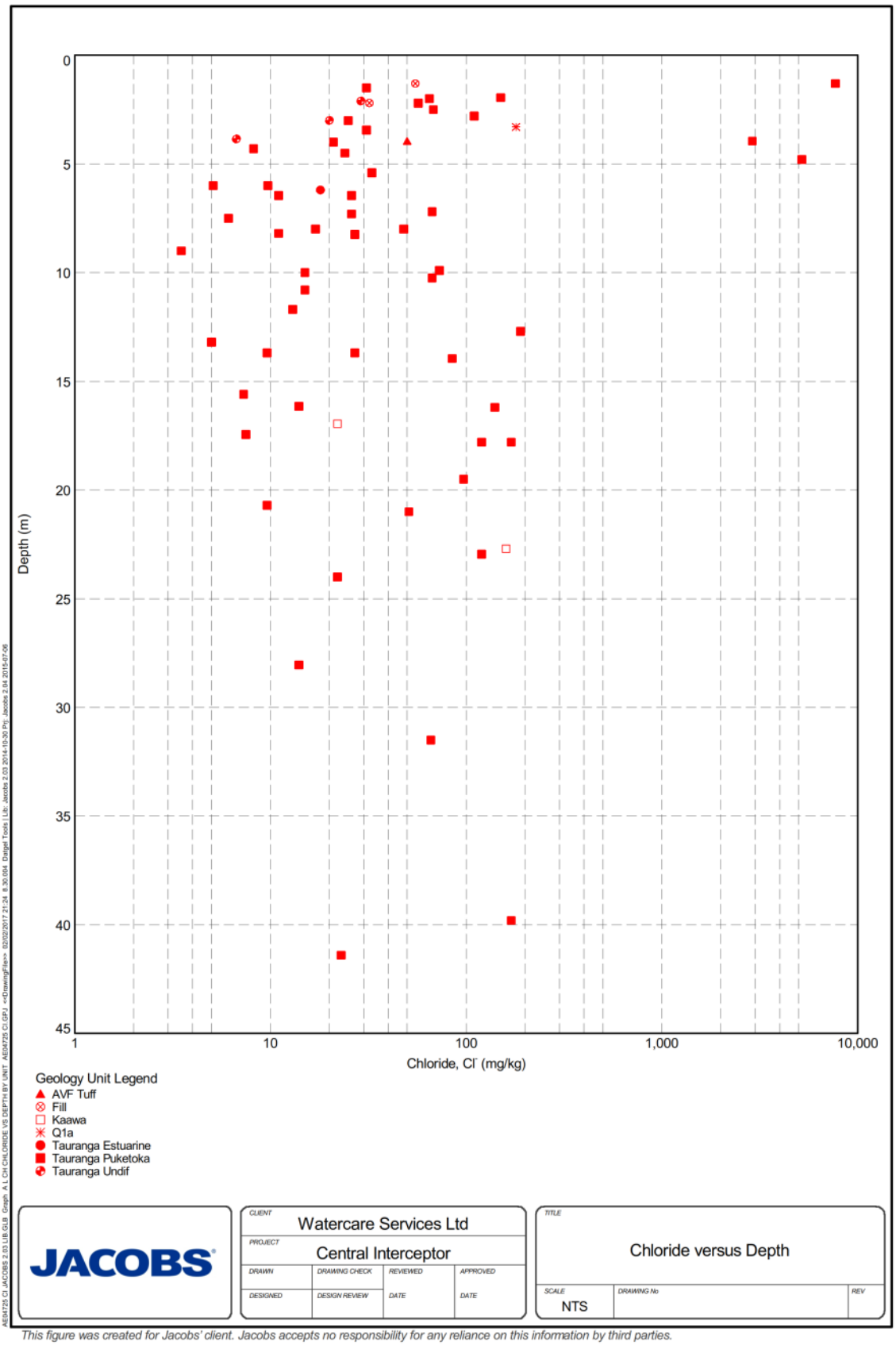

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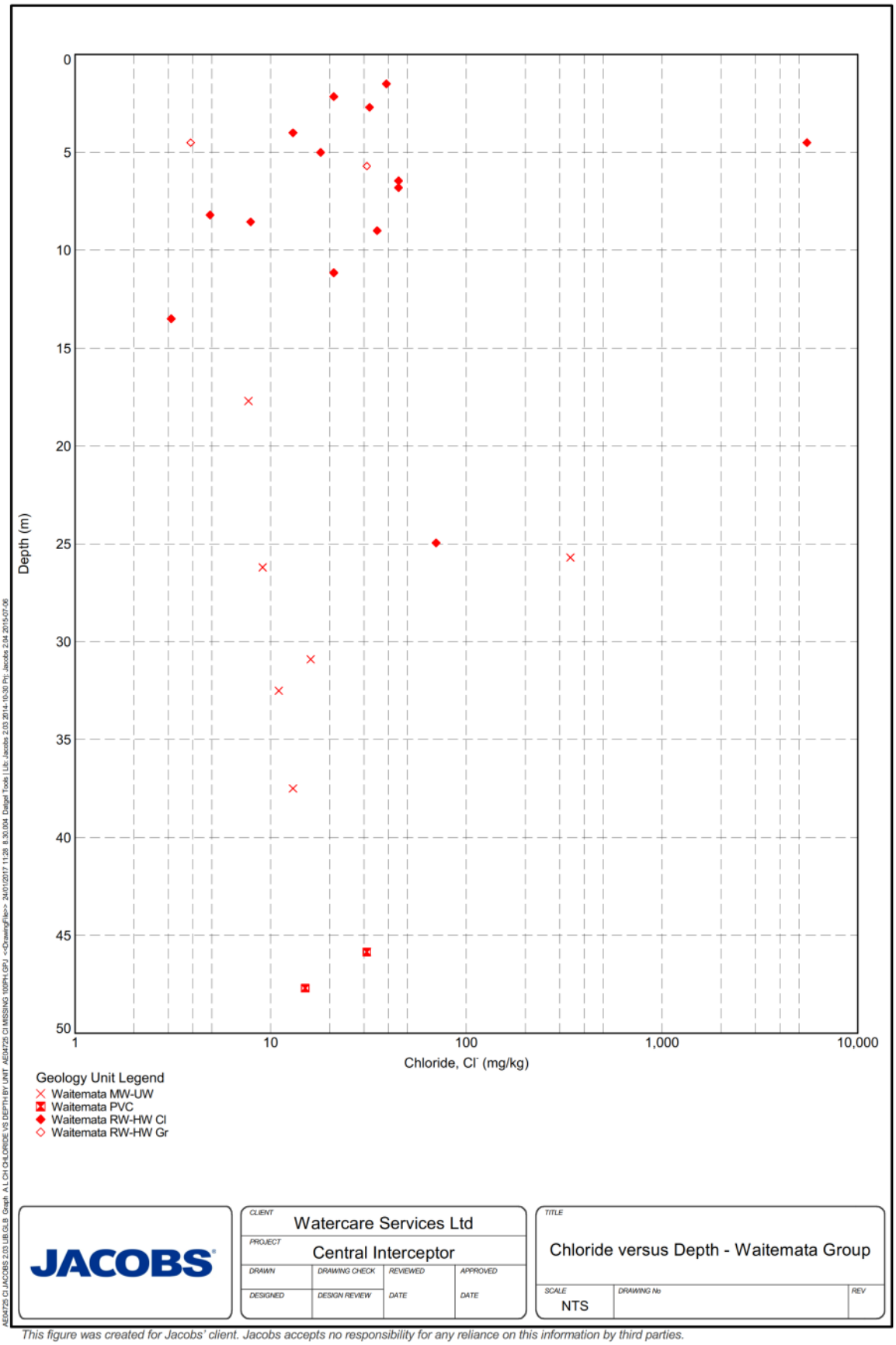

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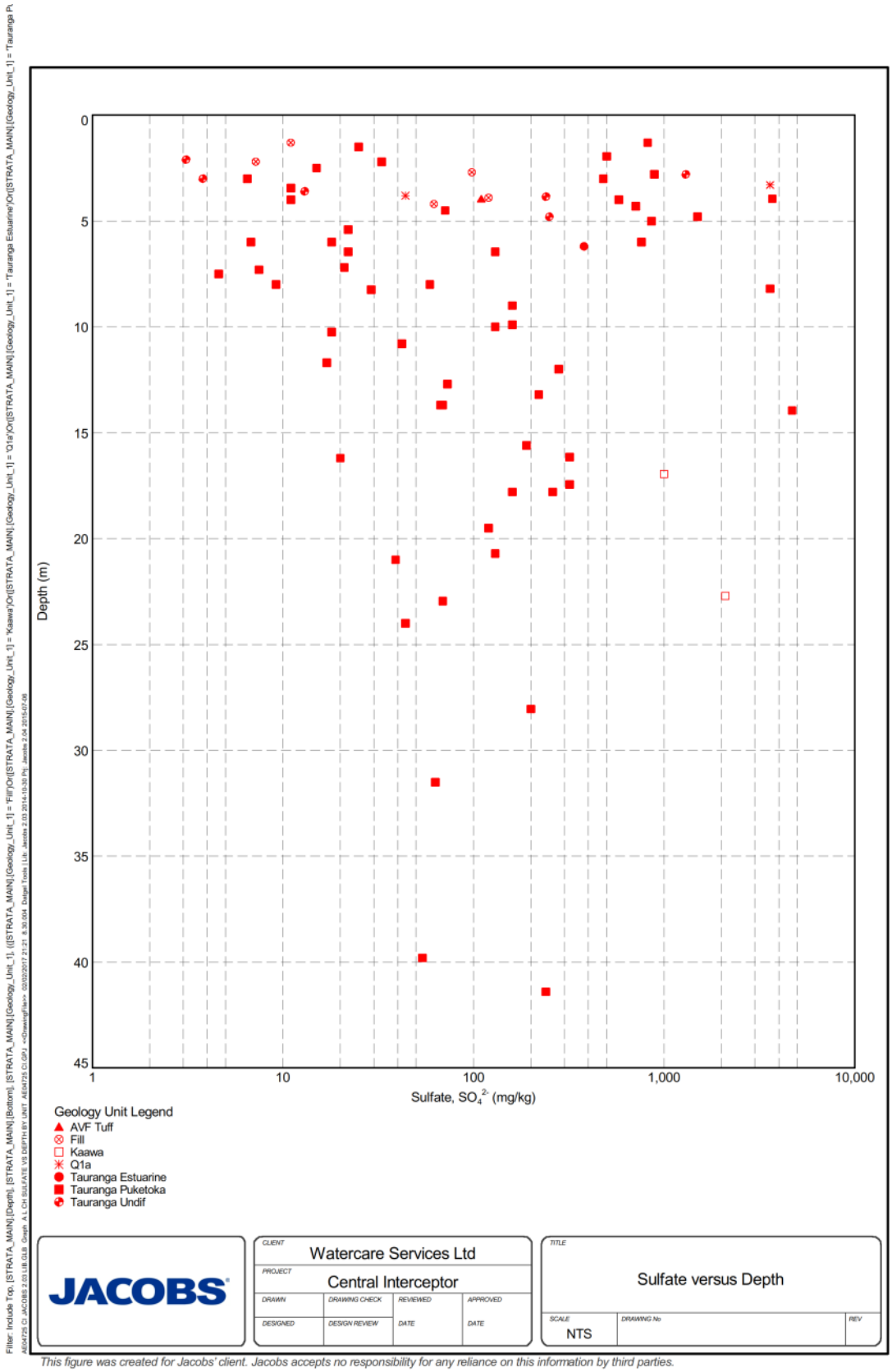
Depth (m)
0
5
10
15
20
25
30
35
40
45
1
10
100
1,000
10,000
Sulfate, SO_4^{2-} (mg/kg)
Geology Unit Legend
AVF Tuff
Fill
Kaawa
Q1a
Tauranga Estuarine
Tauranga Puketoka
Tauranga Undif
JACOBS
CLIENT
Watercare Services Ltd
PROJECT
Central Interceptor
DRAWN
DRAWING CHECK
REVIEWED
APPROVED
DESIGNED
DESIGN REVIEW
DATE
DATE
TITLE
Sulfate versus Depth
SCALE
NTS
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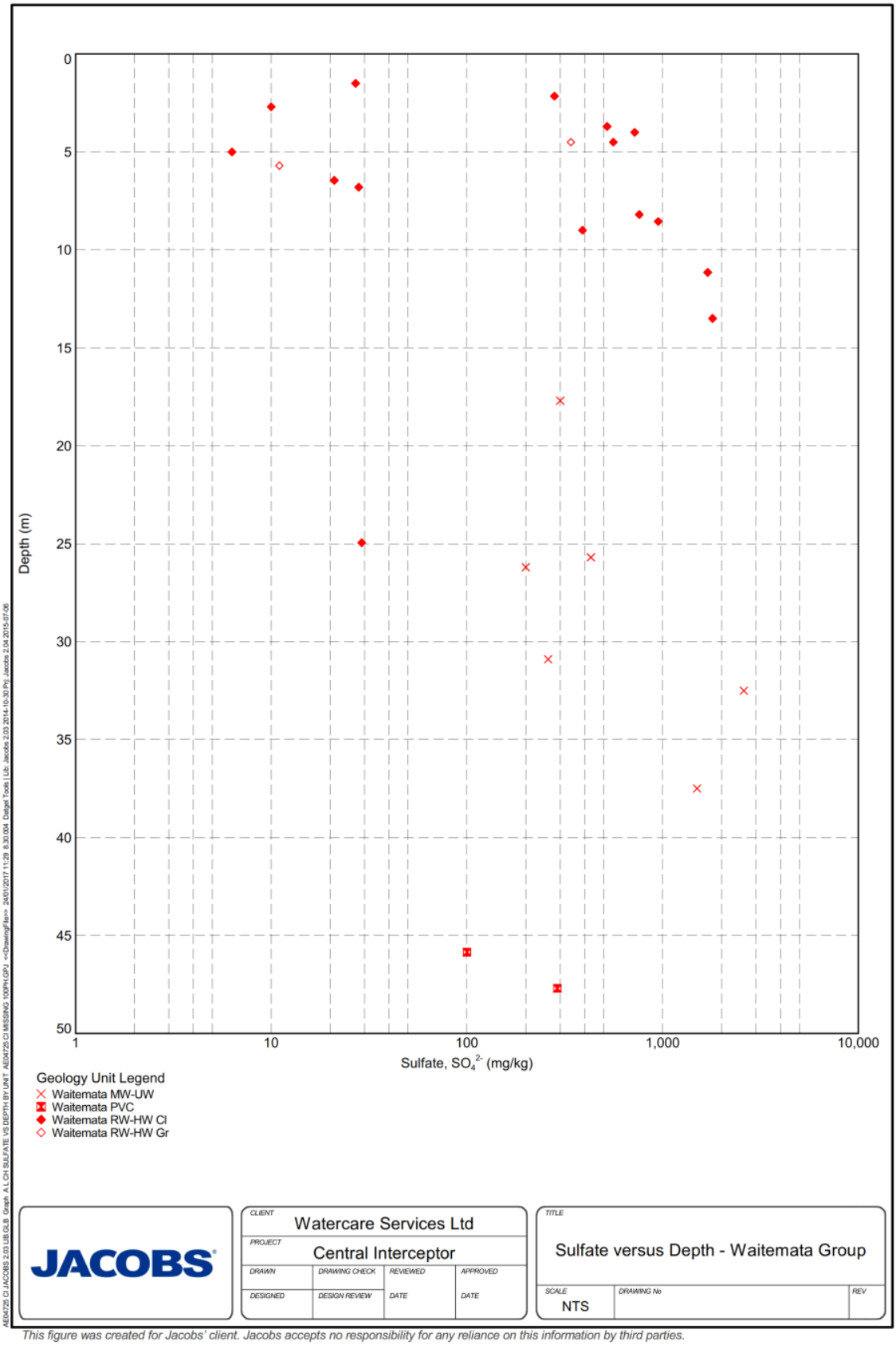
REV
This figure was created for Jacobs' client. Jacobs accepts no responsibility for any reliance on this information by third parties.



This figure was created for Jacobs' client. Jacobs accepts no responsibility for any reliance on this information by third parties.

Appendix W. Shear wave velocity assessments

Memorandum

To		Page	1 of 5
CC			
Subject	Shear Wave Velocity Data for Design of Cascade Drop Shaft (DSCIN004A) and Permanent Work Shaft (DSCIN004B) at May Rd		
From	Sajjad Anwar		
File/Ref No.		Date	27-Sep-2016 Rev 00

1.0 Investigation Data

Geotechnical ground model for the assessment of shear wave velocity at May Rd shafts site is based on following site investigation data.

Table 1 Summary of Investigation Data

Investigation Type	Identification
Cone Penetration Test (CPT)	WS2-CPT01, WS2-CPT02, WS2-CPT03D, WS2-CPT04
Scala Penetrometer (SP)	-
Hand Augers (HA)	-
Borehole (BH)	BH246(Note 1), BH247(Note 1), BH405, BH406
Test Pit (TP)	-
Seismic Dilatometer Test (sDMT)	WS2-SDMT02, WS2-SDMT03
Geological Long Section and Plan	2011882.003, 2011882.004, 2011882.005

Notes:
1. Velocity is measured in BH using downhole geophysics

2.0 Ground conditions

Based on competed site investigation work (Table 1), the inferred ground conditions generally comprised of near surface made ground (FILL), which is underlain by Basalt. Basalt is underlain by alluvium of undifferentiated Tauranga Group, which is overlying the Residual Soils (RS) of ECBF. Beneath residual soils is Moderately Weathered (MW) to Un-Weathered (UW) ECBF (ECBF-Rock).

3.0 Site Subsoil Class

Based on site natural (fundamental) period (T_n), which is assessed as greater than 0.6 sec and GIR Table 6.1, the site subsoil class above the bed rock at shaft location is assessed as 'D'.

For Bed Rock (ECBF) itself the site subsoil class is assessed as 'B'.

4.0 Soil Liquefaction Risk

Based on liquefaction assessment using CPT data, potential liquefaction risk is as follows:

- At Cascade drop shaft with ID of 7.5m (DSCIN004A) – No potential liquefaction risk
- At Permanent work shaft with ID of 10.8m (DSCIN004B) – Potential liquefaction risk at two depths: 13m to 15m bgl and 16m to 17m bgl.

For details on liquefaction analysis result and methodology refer to GIR.

5.0 Seismic Coefficient

The proposed design life of the structures is 100 years with importance level of 3. This required annual probability of exceedance of 1/25 for SLS and 1/2,500 for ULS design earthquake loading.

Using the:

- Hazard factor (Z) of 0.13 for Auckland;
- Return period factor (Rs, Ru) of 0.25 and 1.8 for 1/25 and 1/2,500 annual probability of exceedance respectively; and
- site subsoil class factor of 1.12 for class D and 1 for class B;

in equation 3.1 (1) of the NZS 1170:5 2004, the estimated seismic coefficients for seismic design of the shaft at May Rd site are:

Site subsoil class	SLS - PGA	ULS - PGA
D (above the ECBF)	0.036g	0.262g
B (at ECBF)	0.033g	0.234g

6.0 Shear Wave Velocity (Vs) Assessment

6.1 Methodology

Direct measurements of shear wave velocity (Vs) of the geological units at May Rd shafts site are made in BH246 and BH247 using the downhole geophysics. The geophysics methods in general calculate shear wave velocity (Vs) and corresponding shear modulus (G) for shear strain (γ) below 1.0E-4%. These calculated values of shear wave velocity (Vs) and corresponding shear modulus (G) should be compatible with level of the shear strain (γ) that may develop in the ground under the design earthquake shaking.

The shear wave velocity (Vs) values calculated from downhole geophysics are adjusted by making reduction of 25% accounting for the effects of the earthquakes' large shear strain (FHWA-NHI-09-010 2009).

Shear wave velocity (Vs) is also estimated in field by conducting sDMT at 2 locations (Table 1).

Attempts are also made to

i) Relate shear wave velocity (V_s) to total cone resistance (q_t) determine by CPT by using following relationship

$V_s = [\alpha_{vs}\ (q_t - \sigma_v)/p_a]^{0.5}$ (m/s) (Ref: Guide to Cone Penetration Testing 6th Edition 2015)

Where:

α_{vs} is a material factor = $10^{(0.55Ic+1.68)}$, where *Ic* is soil behaviour

σ_v = soil overburden pressure

Pa is atmospheric pressure taken as 100kPa

ii) Relate to shear modulus (G_m) using following relationship:

V_s = SQRT(G_s/ρ) (m/s)

Where

ρ = mass density of the geological units ($\rho = \gamma/g$), taken as 1.7 for Tauranga group and RS, 2.7 for Basalt and 2.0 for ECBF Rock.

G_s = Dynamic shear modulus of the geological units and is estimated using the following relationship:

G_s = 5 to 9 x G_m (Ref: Burt Look 2014)

G_m = Static shear modulus of the geological units and is estimated using following relationship

$E_m/[2(1+v_m)]$

E_m = Ground static Young's modulus taken as roughly 2 times of SPTN (from boreholes) and adjusted further based on GIR design parameters Table 9.1

v_m = Poisson's ratio of the geological units (GIR design parameters Table 9.1)

6.2 Shear Wave Velocity (Vs)

Shear wave velocities (V_s) for both shafts sites are assessed considered following two ground conditions.

1. Without Liquefaction Potential Risk
2. With Liquefaction Potential Risk

The distribution of V_s with depth for above two ground conditions at both shaft sites is shown in Figure 1. The summary of the inferred dynamic elastic (Es) and shear modulus (G_s) for the corresponding V_s values are given in Table 2.

Table 2 Summary of Dynamic Modulus and Shear Velocity Data

DSCIN004A - Cascade drop shaft

Without Liquefaction Potential Risk			
Depth (m)	G_s (MPa)	E_s (MPa)	V_s (m/s)
0 to 1.5	14	39	90
1.5 to 4	6,000	17,000	1,500
4 to 10	24	70	120
10 to 15	38	107	150
15 to 20	68	190	200
20 to 31	175	490	320
31 to invert	1380	3860	830

With Liquefaction Potential Risk			
Depth (m)	G_s (MPa)	E_s (MPa)	V_s (m/s)
NA			

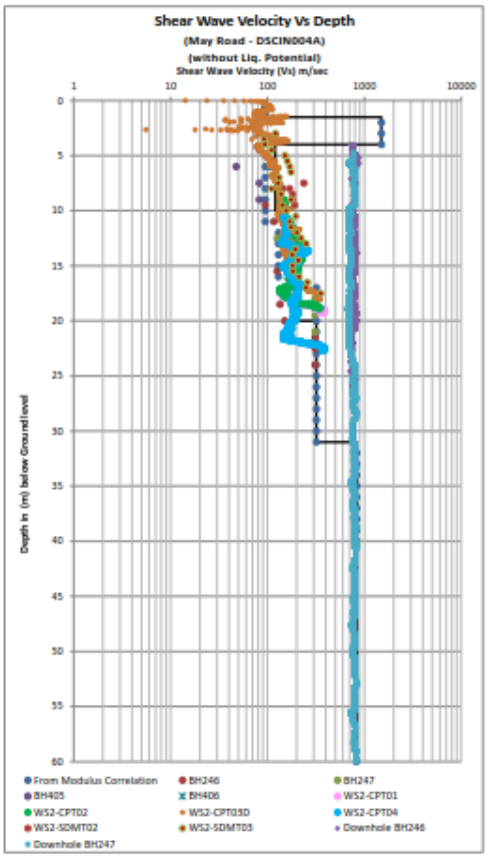
DSCIN004B – Permanent work shaft

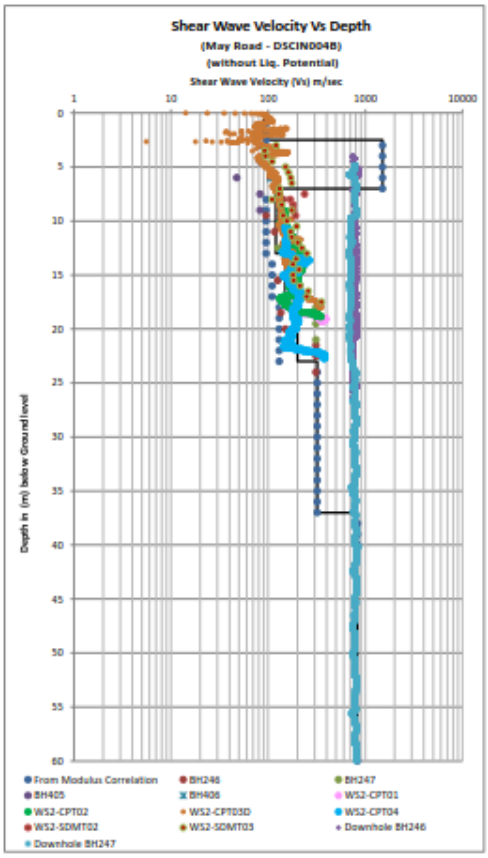
Without Liquefaction Potential Risk			
Depth (m)	G_s (MPa)	E_s (MPa)	V_s (m/s)
0 to 2.5	14	39	90
2.5 to7	6,000	17,000	1,500
7 to 13	24	70	120
13 to 18	38	107	150
18 to 23	68	190	200
23 to 37	175	490	320
37 to invert	1380	3,860	830

With Liquefaction Potential Risk			
Depth (m)	G_s (MPa)	E_s (MPa)	V_s (m/s)
0 to 2.5	14	39	90
2.5 to7	6,000	17,000	1,500
7 to 13	24	70	120
13 to 15	2	4	30
15 to 16	38	107	150
16 to 17	2	4	30
17 to 18	38	107	150
18 to 23	68	190	200
23 to 37	175	490	320
37 to invert	1380	3,860	830

Notes:

Dynamic Elastic Modulus, $E_s = G_s \times 2(1+\nu_s)$, where ν_s is taken = 0.35 to 0.40





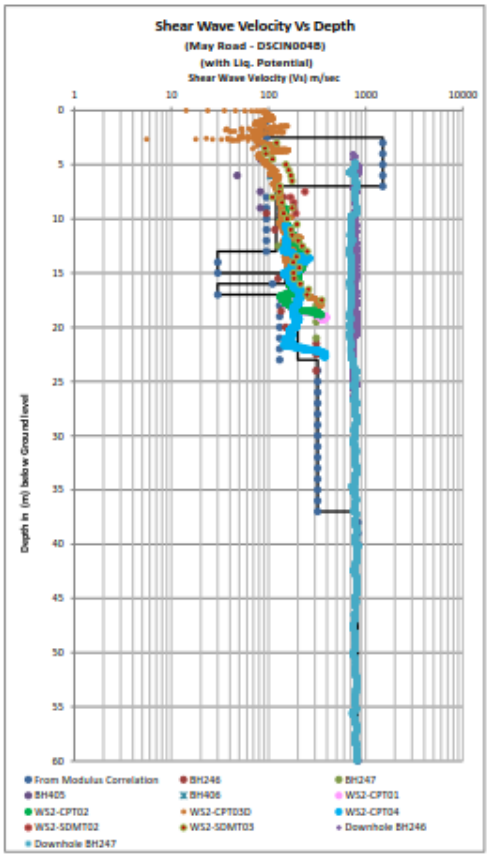


Figure 1 Shear Wave Velocity Profile

7.0 Peak Ground Velocity (PGV)

Peak ground acceleration (PGA), particularly in the horizontal direction, is the most common index of the intensity of strong ground motion at a site. The local codes (NZS 1170:5:2004) are also reliant on PGA rather than Peak ground velocity (PGV). However, PGV is used in some engineering analyses to characterize the damage potential of ground motions.

Therefore, for seismic design and analysis of underground structures including shafts, the PGV is as important as the PGA because ground strains (or the differential displacement between two points in the ground) can be estimated using the PGV.

PGA values are generally available from NZS 1170:5:2004. However, there has been little information in the past for estimating the PGV values. Previous studies have attempted to correlate the PGV with PGA by establishing PGV-to-PGA ratios (as a function of earthquake magnitudes, site soil conditions, and source-to-site distance in some cases). The proposed PGV-to-PGA ratios ranged from 0.75 to 1.5 with preference of 1.375.

However, recent study (NCHRP-12-70, 2008) has found that PGV is strongly correlated with the spectral acceleration at 1.0 second (S_1). Using published strong motion data, regression analysis was conducted and the following correlation has been recommended for design purposes.

$PGV = 0.394 \times 10^{0.434C}$

Where:

PGV is in inch/sec

$C = 4.82 + 2.16 \log_{10} S_1 + 0.013 [2.30 \log_{10} S_1 + 2.93]^2$

Note:

For details on derivation of above equation refer to FHWA-NHI-10-034 Dec 2009 report or NCHRP Report 611.

Using the spectral shape factor for the site subsoil class B and D at 1.0 second from Table 3.1 of NZS 1170:5:2004, the assessed spectral acceleration at 1.0 second (S_1) for class B and D are given below.

Site subsoil class	SLS – S_1	ULS – S_1
D (above the ECBF)	0.063g	0.452g
B (at ECBF)	0.031g	0.222g

The inferred PGV with the spectral acceleration at 1.0 second (S_1) at the May Rd site is therefore shall be:

Site subsoil class	SLS - PGV	PGV/PGA	ULS - PGV	PGV/PGA
D (above the ECBF)	0.1 m/sec	2.5	0.61 m/sec	2.3
B (at ECBF)	0.05 m/sec	1.4	0.31 m/sec	1.3

Whereas the inferred PGV with the spectral acceleration at 0.0 second (S_0) at the May Rd site will be:

Site subsoil class	SLS - PGV	PGV/PGA	ULS - PGV	PGV/PGA
D (above the ECBF)	0.05 m/sec	1.5	0.36 m/sec	1.4
B (at ECBF)	0.05 m/sec	1.5	0.32 m/sec	1.4

Memorandum

To	David Kubik	Page	1 of 5
CC	Andrew Campbell, Crystal Ham, Hamish McEwan		
Subject	Shear Wave Velocity Data for Design of DSCIN006 Shaft at Haverstock Road		
From	Sajjad Anwar		
File/Ref No.		Date	04-Oct-2016 Rev 00

1.0 Investigation Data

Geotechnical ground model for the assessment of shear wave velocity (V_s) at DSCIN006 shaft - Haverstock Rd site is based on following site investigation data (Table 1).

Table 1 Summary of Investigation Data

Investigation Type	Identification
Cone Penetration Test (CPT)	AS3-CPT01, AS3-CPT02, AS3-CPT05
Scala Penetrometer (SP)	-
Hand Augers (HA)	-
Borehole (BH)	BH227-1(Note 1), BH228-1, BH408, BH409
Test Pit (TP)	-
Seismic Dilatometer Test (sDMT)	-
Geological Long Section and Plan	2011884.003, 2011884.004

Notes:
1. Shear Wave Velocity (V_s) measured in BH using downhole geophysics

2.0 Ground conditions

Based on competed site investigation work (Table 1), the inferred ground conditions generally comprised of near surface made ground (FILL), which is underlain by undifferentiated Tauranga Group (TG) Alluvium over the Residual Soils (RS) of ECBF. Beneath residual soils is Moderately Weathered (MW) to Un-Weathered (UW) ECBF (ECBF-Rock).

3.0 Site Subsoil Class

Using the shear velocity (V_s) data (inferred from CPT), the site natural (fundamental) period (T_n) above the bed rock (ECBF) is assessed in the range of 0.3 to 0.45sec (i.e. smaller than 0.6s but greater than 0.2 sec). This indicates site subsoil class as 'C' (clause 3.1.3.4 NZS 1170.5:2004) instead of Class 'D' as mentioned in Table 6.1 of the GIR.

- For the seismic design of the DSCIN006 shaft the soil subsoil class is taken as 'C' in this memo.
- For the bed rock (ECBF) itself, the site subsoil class is assessed as 'B' – weak rock as unconfined compressive strength ranged from 1 to 10MPa.

4.0 Seismic Coefficient

The proposed design life of the structures is 100 years with importance level of 3. This required annual probability of exceedance of 1/25 for SLS and 1/2,500 for ULS design earthquake loading.

Using the:

- Hazard factor (Z) of 0.13 for Auckland;
- Return period factor (Rs, Ru) of 0.25 and 1.8 for 1/25 and 1/2,500 annual probability of exceedance respectively; and
- Site subsoil class factor of 1.33 for class 'C' and 1 for class B;

In equation 3.1 (1) of the NZS 1170:5 2004, the estimated seismic coefficients for seismic (structure) design of the DSCIN006 shaft at Haverstock Rd site are:

Table 2 Seismic Coefficient as per Site Subsoil Class

Site subsoil class	SLS - PGA	ULS - PGA
C (above the ECBF)	0.043g	0.311g
B (at ECBF)	0.033g	0.234g

5.0 Soil Liquefaction Risk

Based on liquefaction assessment using CPT data, insignificant liquefaction risk is developing at Haverstock site. For detail on liquefaction analysis and assessment method refer to GIR.

6.0 Shear Wave Velocity (Vs) Assessment

6.1 Methodology

Following methods are used to assess shear wave velocity for the design of the DSCIN006 shaft at Haverstock Rd site.

I) Downhole Geophysics

Direct measurements of shear wave velocity (Vs) of the geological units inferred to be encountered at DSCIN006 shaft at Haverstock Rd site is made in BH227-1 using the downhole geophysics. The geophysics methods in general calculate shear wave velocity (Vs) and corresponding shear modulus (G) for shear strain (γ) below 1.0E-4%. These calculated values of shear wave velocity (Vs) and corresponding shear modulus (G) should be compatible with level of the shear strain (γ) that may develop in the ground under the design earthquake shaking.

The shear wave velocity (Vs) values calculated from downhole geophysics are adjusted by making reduction of 25% accounting for the effects of the earthquakes' large shear strain (FHWA-NHI-09-010 2009).

II) Cone Penetration Test (CPT)

Indirect measurements of the shear wave velocity (V_s) of the geological units at DSCIN006 shaft is made using total cone resistance (q_t) of CPT data using following relationships:

$$V_s = [\alpha_{vs}\ (q_t - \sigma_v)/p_a]^{0.5}\ (m/s)$$ (Ref: Guide to Cone Penetration Testing 6th Edition 2015)

Where:

α_{vs} is a material factor = $10^{(0.55Ic+1.68)}$, where *Ic* is soil behaviour

σ_v = soil overburden pressure

Pa is atmospheric pressure taken as 100kPa

III) Empirical Modulus Correlation

Shear wave velocity (V_s) of the geological units at DSCIN006 shaft is also estimated empirically by correlating it to dynamic shear modulus (G_s) using following relationship:

V_s = SQRT (G_s/ρ) (m/s)

Where

ρ = mass density of the geological units ($\rho = \gamma/g$), taken as 1.7 for Tauranga group and RS, 2.7 for Basalt and 2.0 for ECBF Rock.

G_s = Dynamic shear modulus of the geological units and is estimated using the following relationship:

G_s = 5 to 9 x G_m (Ref: Burt Look 2014)

G_m = Static shear modulus of the geological units and is estimated using following relationship

$E_m/[2(1+v_m)]$

E_m = Ground static Young's modulus taken as roughly 2 times of SPTN (from boreholes) and adjusted further based on GIR design parameters Table 9.1

v_m = Poisson's ratio of the geological units (GIR design parameters Table 9.1)

6.2 Shear Wave Velocity (Vs)

Using the above methodologies, shear wave velocities (V_s) for the geological units are assessed and its distribution with depth is given in Figure 1. The summary of the inferred dynamic elastic (Es) and shear modulus (G_s) for the corresponding V_s values are given in Table 3.

Table 3 Summary of Dynamic Modulus and Shear Velocity Data

DSCIN006							
Without Liquefaction Potential Risk					With Liquefaction Potential Risk		
Depth (m)	G_s (MPa)	E_s (MPa)	V_s (m/s)		Depth (m)	G_s (MPa)	E_s (MPa)	V_s (m/s)
0 to 1.5	11	30	80		NA			
1.5 to 6	8	23	70					
6 to 10	40	107	150					
10 to 13	100	275	240					
13 to invert	1280	3580	800					
Notes:								
Dynamic Elastic Modulus, $E_s = G_s \times 2(1+\nu_s)$, where ν_s is taken = 0.35 to 0.40								

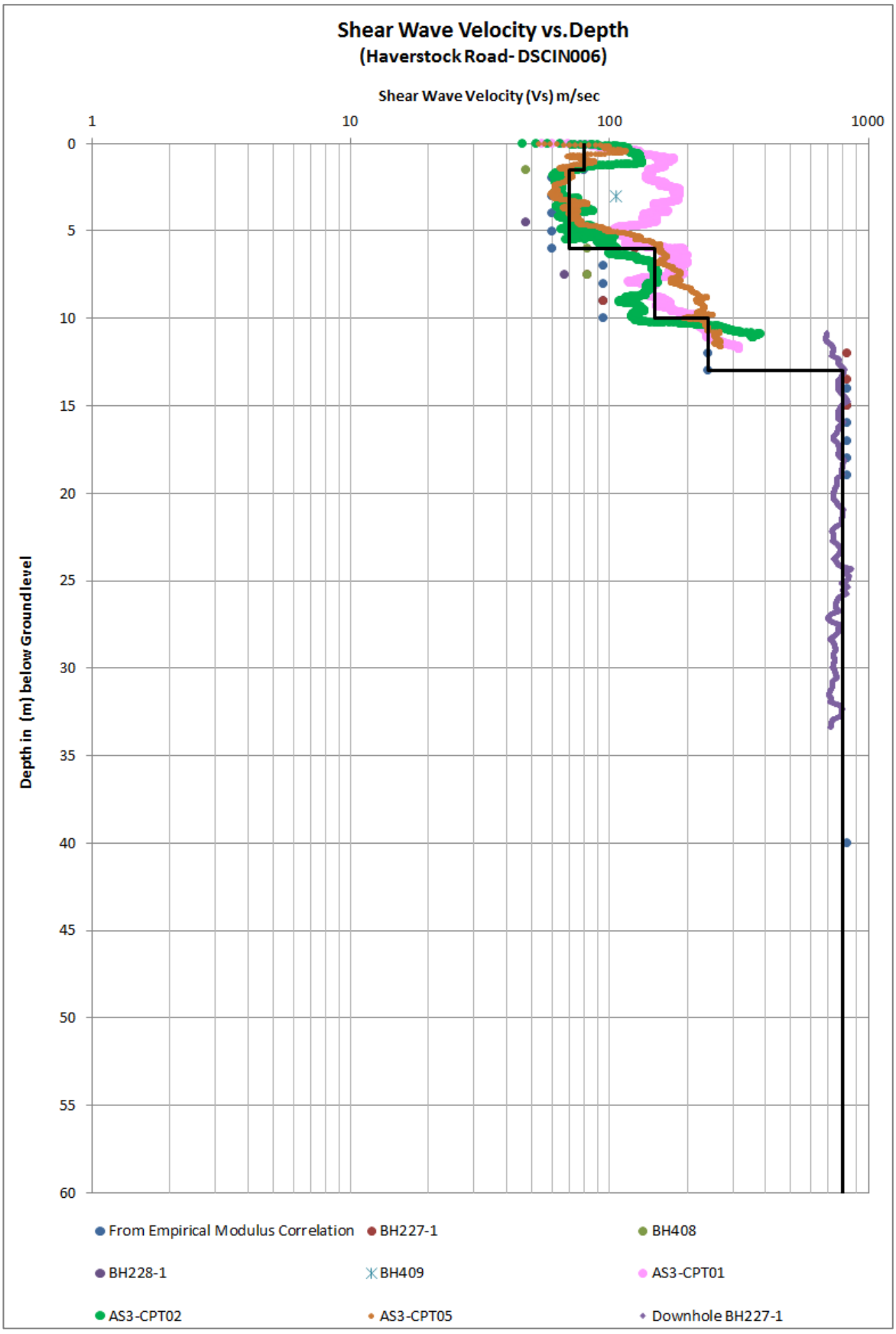


Figure 1 Shear Wave Velocity Profile

7.0 Peak Ground Velocity (PGV) Assessment

7.1 General

Peak ground acceleration (PGA), particularly in the horizontal direction, is the most common index of the intensity of strong ground motion at a site. The local codes (NZS 1170:5:2004) are also reliant on PGA rather than Peak ground velocity (PGV). However, PGV is used in some engineering analyses to characterize the damage potential of ground motions.

Therefore, for seismic design and analysis of underground structures including shafts, the PGV is as important as the PGA because ground strains (or the differential displacement between two points in the ground) can be estimated using the PGV.

7.2 Methodology

Peak ground acceleration (PGA) values are generally available from NZS 1170:5:2004. However, there has been little information available for the estimating the Peak ground velocity PGV values.

Previous studies have attempted to correlate the PGV with PGA by establishing PGV-to-PGA ratios (as a function of earthquake magnitudes, site soil conditions, and source-to-site distance in some cases). The proposed PGV-to-PGA ratios ranged from 0.75 to 1.5 with preference of 1.375.

However, recent study (NCHRP-12-70, 2008) has found that PGV is strongly correlated with the spectral acceleration at 1.0 second (S_1). Using published strong motion data, regression analysis was conducted and the following correlation has been established and recommended for design purposes:

$PGV = 0.394 \times 10^{0.434C}$ Equation - 1

Where:

PGV is in inch/sec

$C = 4.82 + 2.16 \log_{10} S_1 + 0.013 [2.30 \log_{10} S_1 + 2.93]^2$

S_1 = Spectral acceleration at 1.0 second (taken from Table 3.1 of NZS 1170:5:2004)

[Note: For details on derivation of equation1, refer to FHWA-NHI-10-034 Dec 2009 report or NCHRP Report 611].

7.3 Peak Ground Velocity (PGV)

Using the Table 3.1 of NZS 1170:5:2004, the assessed spectral acceleration at 1.0 second (S_1) for site subsoil class B and C are given below:

Site subsoil class	SLS – S_1	ULS – S_1
C (above the ECBF)	0.039g	0.278g
B (at ECBF)	0.031g	0.222g

The inferred PGV with the spectral acceleration at 1.0 second (S_1) at the DSCIN006 is therefore:

Site subsoil class	SLS		ULS	
	PGV	PGV/PGA	PGV	PGV/PGA
C (above the ECBF)	0.06 m/sec	1.3	0.38 m/sec	1.2
B (at ECBF)	0.05 m/sec	1.4	0.31 m/sec	1.3

Whereas the inferred PGV with the spectral acceleration at 0.0 second (S_0) at the DSCIN006 will be:

Site subsoil class	SLS		ULS	
	PGV	PGV/PGA	PGV	PGV/PGA
C (above the ECBF)	0.06 m/sec	1.5	0.42 m/sec	1.4
B (at ECBF)	0.05 m/sec	1.5	0.32 m/sec	1.4

Memorandum

To		Page	1 of 5
CC			
Subject	Shear Wave Velocity Data for Design of Lyon Avenue Shaft - DSCIN007		
From	Sajjad Anwar		
File/Ref No.		Date	14-Sep-2016 Rev 01

DRAFT

1.0 Investigation Data

Geotechnical ground model for the assessment of shear wave velocity at Lyon Ave site is based on following site investigation data.

Table 1 Summary of Investigation Data

Investigation Type	Identification
Cone Penetration Test (CPT)	NA
Scala Penetrometer (SP)	NA
Hand Augers (HA)	-
Borehole (BH)	BH410, BH412, BH 224, BH 225, BH CI-01
Test Pit (TP)	NA
Geological Long Section and Plan	2011885.003, 2011885.004, 2012061.024

2.0 Ground conditions

Based on competed site investigation data (Table 1), the inferred ground conditions generally comprised of Made ground (FILL) overlying undifferentiated Tauranga Group (TG) over the Residual Soils (RS) of ECBF. Residual soils are underlain by Moderately Weathered to Un-weathered ECBF (ECBF-ROCK).

However, based on layout plan of the site and Auckland region geological map, Basalt may be present under the Fill on eastern side of the shaft.

3.0 Site Subsoil Class

Based on site natural (fundamental) period (T_n), which is assessed as greater than 0.6 sec and GIR Table 6.1, the site subsoil class above the bed rock at shaft location is assessed as ‘D’. For Bed Rock (ECBF) itself the site subsoil class is assessed as ‘B’.

4.0 Soil Liquefaction Risk

Based on liquefaction assessment using borehole SPTN data, potential liquefaction risk is developing from 8 to 14m depth below ground level at vicinity of the shaft.

5.0 Seismic Coefficient

The proposed design life of the structures is 100 years with importance level of 3. This required annual probability of exceedance of 1/25 for SLS and 1/2,500 for ULS design earthquake loading.

Using the:

- Hazard factor (Z) of 0.13 for Auckland;
- Return period factor (Rs, Ru) of 0.25 and 1.8 for 1/25 and 1/2,500 annual probability of exceedance respectively; and
- site subsoil class factor of 1.12 for class D and 1 for class B;

in equation 3.1 (1) of the NZS 1170:5 2004, the estimated seismic coefficients for seismic design of the shaft at Lyon Ave site are:

Site subsoil class	SLS - PGA	ULS - PGA
D (above the ECBF)	0.036g	0.262g
B (at ECBF)	0.033g	0.234g

6.0 Shear Wave Velocity (Vs) Assessment

In the absence of direct measurement of shear wave velocity of the geological units at Lyon Ave shaft site, attempt is made to relate shear wave velocity (V_s) to shear modulus (G_m) using following relationship:

V_s (m/sec) = SQRT(G_s/ρ)

Where

ρ = mass density of the geological units ($\rho = \gamma/g$), taken as 1.7 for Tauranga group, 2.7 for Basalt and 2.0 for ECBF Rock.

G_s = Dynamic shear modulus of the geological units and is estimated using the following relationship:

$G_s = 5 \times G_m$ (Ref: Burt Look 2014)

Where

G_m = Static shear modulus of the geological units and is estimated using following relationship

$E_m/[2(1+v_m)]$

Where

E_m = Ground static Young's modulus taken as roughly 2 times of SPTN (from boreholes) and adjusted further based on GIR design parameters Table 9.1

v_m = Poisson's ratio of the geological units (GIR design parameters Table 9.1)

Shear wave velocity (V_s) is assessed considered following four ground conditions.

1. With Basalt
2. With Basalt and Liquefaction Potential
3. Without Basalt
4. Without Basalt and Liquefaction Potential

The distribution of V_s with depth for above four ground conditions is shown in Figure 1. The summary of inferred dynamic Young's (Es) and shear modulus (G_s) with corresponding V_s values are given in Table 2.

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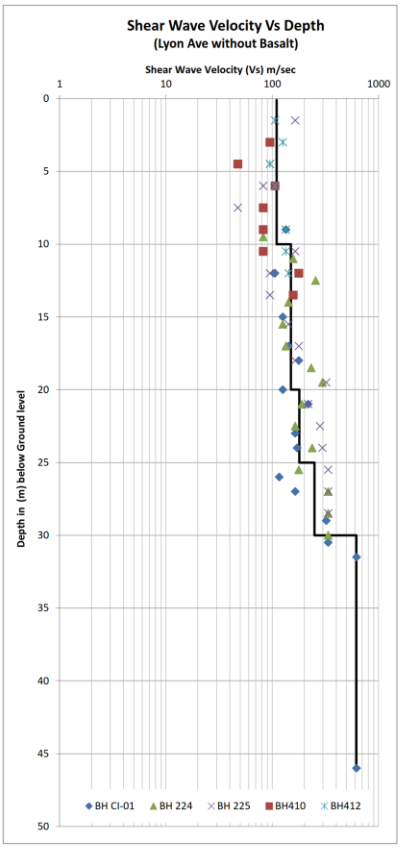

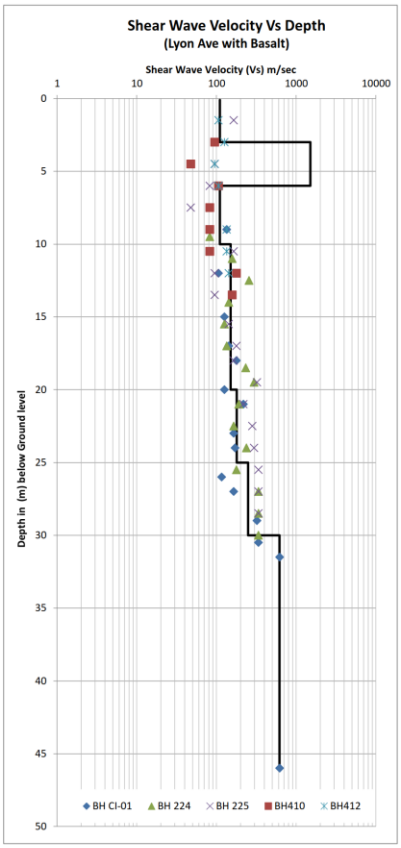

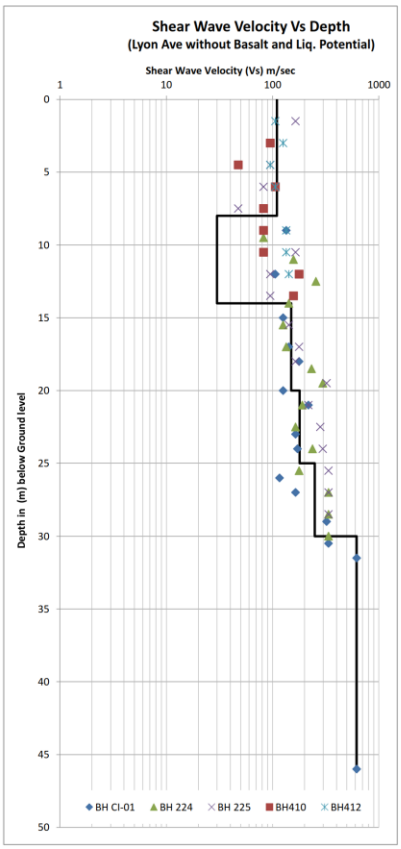

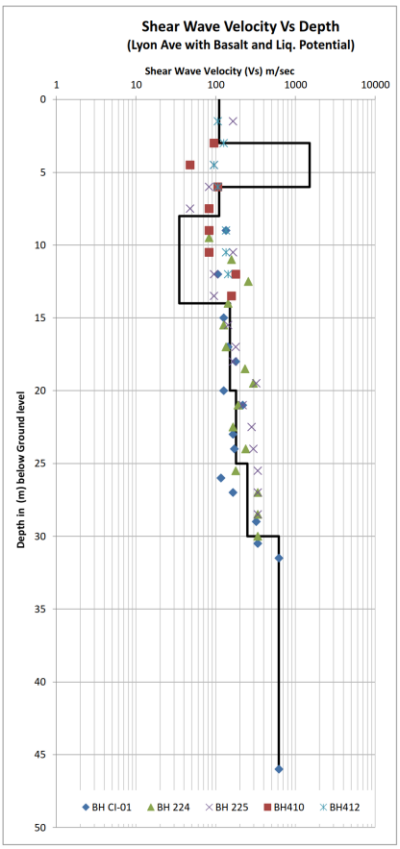

Figure 1 Shear Wave Velocity Profile

Table 2 Summary of Dynamic Modulus and Shear Velocity Data

With Basalt			
Depth (m)	G_s (MPa)	E_s (MPa)	V_s (m/s)
0 to 3	20	60	110
3 to 6	6,000	17,000	1,500
6 to 10	20	60	110
10 to 20	40	110	150
20 to 25	60	160	180
25 to 30	110	300	250
30 to invert	770	2,150	620

With Basalt and Liquefaction Potential			
Depth (m)	G_s (MPa)	E_s (MPa)	V_s (m/s)
0 to 3	20	60	110
3 to 6	6,000	17,000	1,500
6 to 8	20	60	110
8 to 14	2	4	35
14 to 20	40	110	150
20 to 25	60	160	180
25 to 30	110	300	250
30 to invert	770	2,150	620

Without Basalt			
Depth (m)	G_s (MPa)	E_s (MPa)	V_s (m/s)
0 to 10	20	60	110
10 to 20	40	110	150
20 to 25	60	160	180
25 to 30	110	300	250
30 to invert	770	2,150	620

Without Basalt and Liquefaction Potential			
Depth (m)	G_s (MPa)	E_s (MPa)	V_s (m/s)
0 to 8	20	60	110
8 to 14	2	4	35
14 to 20	40	110	150
20 to 25	60	160	180
25 to 30	110	300	250
30 to invert	770	2,150	620

Notes:

Dynamic Young's modulus, $E_s = G_s \times 2(1+\nu_s)$, where ν_s is taken = 0.35 to 0.40

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7.0 Peak Ground Velocity (PGV)

Peak ground acceleration (PGA), particularly in the horizontal direction, is the most common index of the intensity of strong ground motion at a site. The local codes (NZS 1170:5:2004) are also reliant on PGA rather than Peak ground velocity (PGV). However, PGV is used in some engineering analyses to characterize the damage potential of ground motions.

Therefore, for seismic design and analysis of underground structures including shafts, the PGV is as important as the PGA because ground strains (or the differential displacement between two points in the ground) can be estimated using the PGV.

PGA values are generally available from NZS 1170:5:2004. However, there has been little information in the past for estimating the PGV values. Previous studies have attempted to correlate the PGV with PGA by establishing PGV-to-PGA ratios (as a function of earthquake magnitudes, site soil conditions, and source-to-site distance in some cases). The proposed PGV-to-PGA ratios ranged from 0.75 to 1.5 with preference of 1.375.

However, recent study (NCHRP-12-70, 2008) has found that PGV is strongly correlated with the spectral acceleration at 1.0 second (S_1). Using published strong motion data, regression analysis was conducted and the following correlation has been recommended for design purposes.

$PGV = 0.394 \times 10^{0.434C}$

Where:

PGV is in inch/sec

$C = 4.82 + 2.16 \log_{10} S_1 + 0.013 [2.30 \log_{10} S_1 + 2.93]^2$

For details on derivation of above equation refer to FHWA-NHI-10-034 Dec 2009 report or NCHRP Report 611.

Using the spectral shape factor for the site subsoil class B and D at 1.0 second from Table 3.1 of NZS 1170:5:2004, the assessed spectral acceleration at 1.0 second (S_1) for class B and D are given below.

Site subsoil class	SLS – S_1	ULS – S_1
D (above the ECBF)	0.063g	0.452g
B (at ECBF)	0.031g	0.222g

The inferred PGV with the spectral acceleration at 1.0 second (S_1) at the Lyon Ave site is therefore shall be:

Site subsoil class	SLS - PGV	PGV/PGA	ULS - PGV	PGV/PGA
D (above the ECBF)	0.1 m/sec	2.5	0.61 m/sec	2.3
B (at ECBF)	0.05 m/sec	1.4	0.31 m/sec	1.3

Whereas the inferred PGV with the spectral acceleration at 0.0 second (S_0) at the Lyon Ave site will be:

Site subsoil class	SLS - PGV	PGV/PGA	ULS - PGV	PGV/PGA
D (above the ECBF)	0.05 m/sec	1.5	0.36 m/sec	1.4
B (at ECBF)	0.05 m/sec	1.5	0.32 m/sec	1.4

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Memorandum

To	David Kubik	Page	1 of 5
CC	Andrew Campbell, Crystal Ham, Hamish McEwan		
Subject	Shear Wave Velocity Data for Design of DSCIN008 – Shaft at Mt Albert War Memorial		
From	Sajjad Anwar		
File/Ref No.		Date	12-Oct-2016 Rev 00

1.0 Investigation Data

Geotechnical ground model for the assessment of shear wave velocity (V_s) at DSCIN008 shaft – Mt Albert War Memorial site is based on following site investigation data (Table 1).

Table 1 Summary of Investigation Data

Investigation Type	Identification
Cone Penetration Test (CPT)	AS1-CPT220
Scala Penetrometer (SP)	-
Hand Augers (HA)	-
Borehole (BH)	BH219(Note 1), BH221
Test Pit (TP)	-
Seismic Dilatometer Test (sDMT)	-
Geological Long Section and Plan	2011886.003, 2011886.004

Notes:
1. Shear Wave Velocity (V_s) measured in BH using downhole geophysics

2.0 Ground conditions

Based on completed site investigation data (Table 1) and site layout plan (2011886.001), the inferred ground conditions surrounding the DSCIN008 Shaft and other structures is generally comprised of near surface made ground (FILL), which is underlain by Basalt across the entire site. Basalt is underlain by Alluvium of undifferentiated Tauranga Group (TG), which is overlying the Residual Soils (RS) of ECBF. Beneath the RS is Moderately Weathered (MW) to Slightly Weathered (SW) ECBF (ECBF-ROCK).

3.0 Site Subsoil Class

Using the shear velocity (V_s) data (inferred from CPT), the site natural (fundamental) period (T_n) above the bed rock (ECBF) is assessed as 0.47sec (i.e. smaller than 0.6s but greater than 0.2 sec). This indicates the site subsoil class as 'C' (clause 3.1.3.4 NZS 1170.5:2004) at Mt Albert War Memorial site instead of Class 'D' as mentioned in Table 6.1 of the GIR.

- For the seismic design of the DSCIN008 - Shaft and other structures at Mt Albert War Memorial site the soil subsoil class is taken as 'C' in this memo.
- For the bed rock (ECBF) itself, the site subsoil class is assessed as 'B' – weak rock as unconfined compressive strength ranged from 1 to 10MPa.

4.0 Seismic Coefficient

The proposed design life of the structures is 100 years with importance level of 3. This required annual probability of exceedance of 1/25 for SLS and 1/2,500 for ULS design earthquake loading.

Using the:

- Hazard factor (Z) of 0.13 for Auckland;
- Return period factor (R_s, R_u) of 0.25 and 1.8 for 1/25 and 1/2,500 annual probability of exceedance respectively; and
- Site subsoil class factor of 1.33 for class C and 1 for class B; in

Equation 3.1 (1) of the NZS 1170:5 2004, the estimated seismic coefficients (PGA) for seismic design (structure) of the shaft are:

Site subsoil class	SLS - PGA	ULS - PGA
C (above the ECBF)	0.043g	0.311g
B (at ECBF)	0.033g	0.234g

5.0 Soil Liquefaction Risk

Based on CPT AS1-CPT220, the potential liquefaction risk is developing at depth from 14 to 16m below the existing ground surface.

The proposed invert level of the shaft is located below the potentially liquefiable layers. Therefore, it is anticipated that the potential liquefaction risk will not cause any foundation bearing instability.

The anticipated impact on shaft due to this liquefaction risk shall be in the context of higher lateral (k0=1) and additional down-drag load on shaft wall.

For details on liquefaction analysis and assessment method refer to GIR.

6.0 Shear Wave Velocity (V_s) Assessment

6.1 Methodology

Following methods are used to assess shear wave velocity for the design of the DSCIN008 shaft at Mt Albert War Memorial site.

I) Downhole Geophysics

Direct measurements of shear wave velocity (V_s) of the geological units inferred to be encountered at DSCIN008 shaft is made in BH219 using the downhole geophysics. The geophysics methods in general calculate shear wave velocity (V_s) and corresponding shear modulus (G_s) for shear strain (γ) below 1.0E-4%. These calculated values of shear wave velocity (V_s) and corresponding shear modulus (G_s) should be compatible with level of the shear strain (γ) that may develop in the ground under the design earthquake shaking.

The shear wave velocity (V_s) values calculated from downhole geophysics are therefore, adjusted by making reduction of 25% accounting for the effects of the earthquakes' large shear strain (FHWA-NHI-09-010 2009).

II) Cone Penetration Test (CPT)

Indirect measurements of the shear wave velocity (V_s) of the geological units at DSCIN008 shaft is made using total cone resistance (q_t) of CPT data using following relationships proposed by Robertson (2009):

$$V_s = [\alpha_{vs}\ (q_t - \sigma_v)/p_a]^{0.5}\ (m/s)$$ (Ref: Guide to Cone Penetration Testing 6th Edition 2015)

Where:

α_{vs} is a material factor = $10^{(0.55Ic+1.68)}$, where *Ic* is soil behaviour

σ_v = soil overburden pressure

Pa is atmospheric pressure and taken as 100kPa

III) Empirical Modulus Correlation

Shear wave velocity (V_s) of the geological units at DSCIN008 shaft is also estimated empirically by correlating it to dynamic shear modulus (G_s) using following relationship:

V_s = SQRT (G_s/ρ) (m/s)

Where

ρ = mass density of the geological units ($\rho = \gamma/g$), taken as 1.7 for Tauranga group and RS, 2.7 for Basalt and 2.0 for ECBF Rock.

G_s = Dynamic shear modulus of the geological units and is estimated using the following relationship:

G_s = 5 to 9 x G_m (Ref: Burt Look 2014)

G_m = Static shear modulus of the geological units and is estimated using following relationship

$E_m/[2(1+v_m)]$

E_m = Ground static Young's modulus taken as roughly 2 times of SPTN (from boreholes) and adjusted further based on GIR design parameters Table 9.1

v_m = Poisson's ratio of the geological units (GIR design parameters Table 9.1)

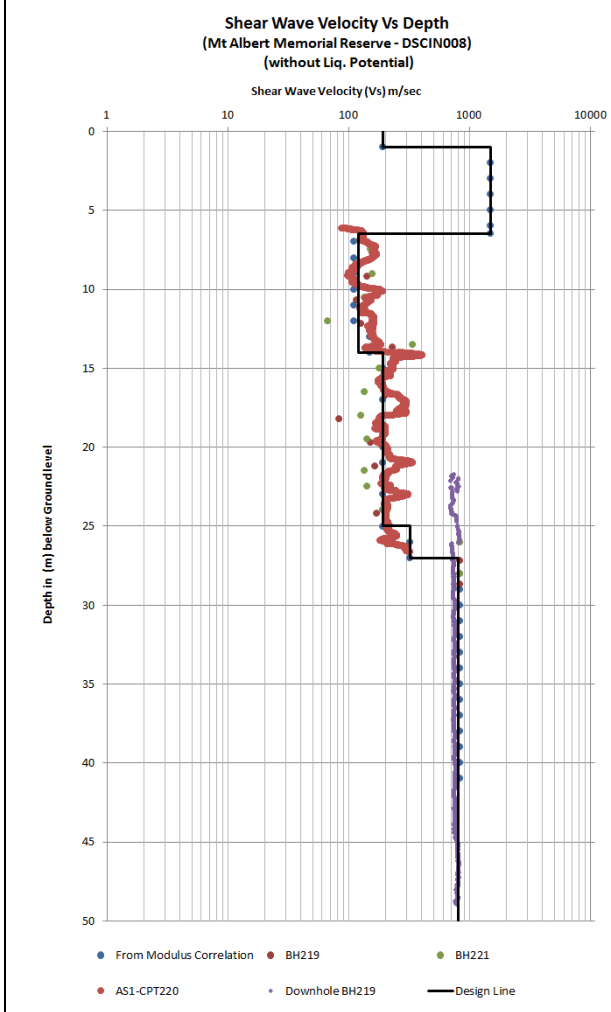
6.2 Shear Wave Velocity (Vs)

Using the above methodologies, shear wave velocities (V_s) are assessed and its distribution with depth is given in Figure 1. The summary of the inferred dynamic elastic (E_s) and shear modulus (G_s) for the corresponding V_s values are given in Table 2.

Table 2 Summary of Dynamic Modulus and Shear Velocity Data

DSCIN008 Shaft								
Without Liquefaction Potential Risk					**With Liquefaction Potential Risk**			
Depth (m)	G_s (MPa)	E_s (MPa)	V_s (m/s)		Depth (m)	G_s (MPa)	E_s (MPa)	V_s (m/s)
0 to 1	60	170	190		0 to 1	60	170	190
1 to 6.5	6,000	17,000	1,500		1 to 6.5	6,000	17,000	1,500
6.5 to 14	24	70	120		6.5 to 14	24	70	120
14 to 25	60	170	190		14 to 16	2	4	30
25 to 27	175	490	320		16 to 25	60	170	190
27 to invert	1,280	3,580	800		25 to 27	175	490	320
					27 to invert	1,280	3,580	800
Notes:								
Dynamic Elastic Modulus, $E_s = G_s \times 2(1+\nu_s)$, where ν_s is taken = 0.35 to 0.40								

Without Liquefaction Potential Risk	With Liquefaction Potential Risk



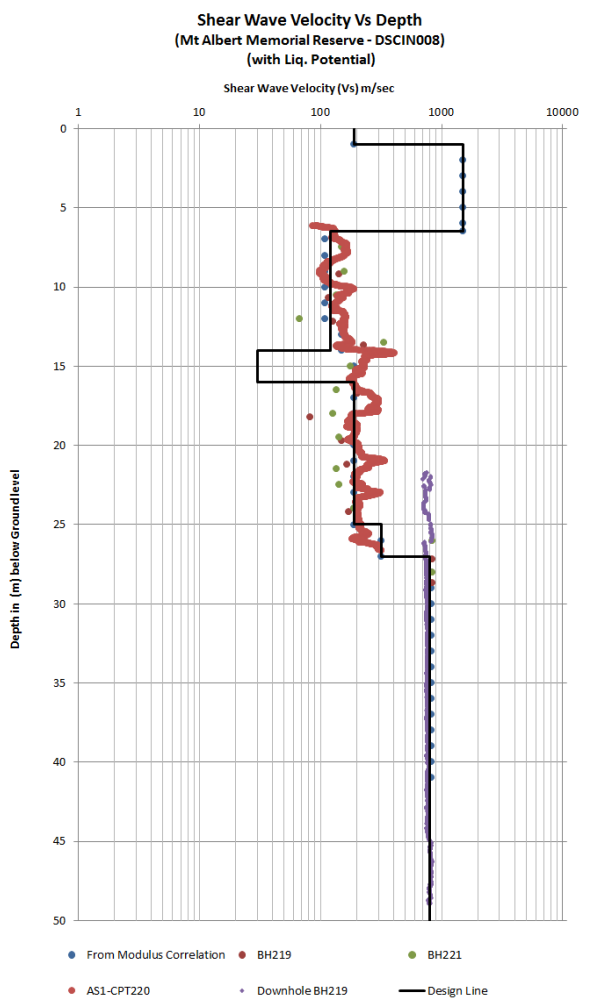


Figure 1 Shear Wave Velocity Profile

7.0 Peak Ground Velocity (PGV) Assessment

7.1 General

Peak ground acceleration (PGA), particularly in the horizontal direction, is the most common index of the intensity of strong ground motion at a site. The local codes (NZS 1170:5:2004) are also reliant on PGA rather than Peak ground velocity (PGV). However, PGV is used in some engineering analyses to characterize the damage potential of ground motions.

Therefore, for seismic design and analysis of underground structures including shafts, the PGV is as important as the PGA because ground strains (or the differential displacement between two points in the ground) can be estimated using the PGV.

7.2 Methodology

Peak ground acceleration (PGA) values are generally available from NZS 1170:5:2004. However, there has been little information available for the estimating the Peak ground velocity PGV values.

Previous studies have attempted to correlate the PGV with PGA by establishing PGV-to-PGA ratios (as a function of earthquake magnitudes, site soil conditions, and source-to-site distance in some cases). The proposed PGV-to-PGA ratios ranged from 0.75 to 1.5 with preference of 1.375.

However, recent study (NCHRP-12-70, 2008) has found that PGV is strongly correlated with the spectral acceleration at 1.0 second (S_1). Using published strong motion data, regression analysis was conducted and the following correlation has been established and recommended for design purposes:

$PGV = 0.394 \times 10^{0.434C}$ Equation - 1

Where:

PGV is in inch/sec

$C = 4.82 + 2.16 \log_{10} S_1 + 0.013 [2.30 \log_{10} S_1 + 2.93]^2$

S_1 = Spectral acceleration at 1.0 second (taken from Table 3.1 of NZS 1170:5:2004)

[Note: For details on derivation of equation1, refer to FHWA-NHI-10-034 Dec 2009 report or NCHRP Report 611].

Using the Table 3.1 of NZS 1170:5:2004, the assessed spectral acceleration at 1.0 second (S_1) for site subsoil class B and C are given below:

Site subsoil class	SLS – S_1	ULS – S_1
C (above the ECBF)	0.039g	0.278g
B (at ECBF)	0.031g	0.222g

7.3 Peak Ground Velocity (PGV)

The inferred PGV with the spectral acceleration at 1.0 second (S_1) at the DSCIN008 is given below:

Site subsoil class	SLS		ULS	
	PGV	PGV/PGA	PGV	PGV/PGA
C (above the ECBF)	0.06 m/sec	1.3	0.38 m/sec	1.2
B (at ECBF)	0.05 m/sec	1.4	0.31 m/sec	1.3

The inferred PGV with the spectral acceleration at 0.0 second (S_0) at the DSCIN008 is given below:

Site subsoil class	SLS		ULS	
	PGV	PGV/PGA	PGV	PGV/PGA
C (above the ECBF)	0.06 m/sec	1.5	0.42 m/sec	1.4
B (at ECBF)	0.05 m/sec	1.5	0.32 m/sec	1.4

Memorandum

To	David Kubik	Page	1 of 5
CC	Andrew Campbell, Crystal Ham, Hamish McEwan		
Subject	Shear Wave Velocity Data for Design of DSCIN009 Shaft at Western Spring Park		
From	Sajjad Anwar		
File/Ref No.		Date	06-Oct-2016 Rev 00

1.0 Investigation Data

Geotechnical ground model for the assessment of shear wave velocity (V_s) at DSCIN009 shaft – Western Spring Park site is based on following site investigation data (Table 1).

Table 1 Summary of Investigation Data

Investigation Type	Identification
Cone Penetration Test (CPT)	WS1-CPT01 to WS1-CPT18
Scala Penetrometer (SP)	-
Hand Augers (HA)	-
Borehole (BH)	BH205(Note 1), BH206(Note), BH206b, BH468
Test Pit (TP)	-
Seismic Dilatometer Test (sDMT)	-
Geological Long Section and Plan	2011887.003, 2011887.004

Notes:
1. Shear Wave Velocity (V_s) measured in BH using downhole geophysics

2.0 Ground conditions

Based on completed site investigation data (Table 1) and site layout plan (2011887.001), the inferred ground conditions surrounding the DSCIN009 Shaft are relatively complex but generally comprised of made ground (FILL) overlying the undifferentiated Tauranga Group (TG) over the Residual Soils (RS) of ECBF. The residual soils of ECBF are underlain by Moderately Weathered (MW) to Slightly Weathered (SUW) ECBF (ECBF-ROCK).

However, at the south face of the shaft, Basaltic intrusion is expected above the undifferentiated Tauranga Group (TG) alluvium along with the relatively thicker man ground fill.

Due to complex nature of the geology surrounding the shaft, shear wave velocity (Vs) is assessed by dividing the ground conditions into two zones i.e.

- First zone representing ground conditions to the North, East and West sides of the shaft dominated by TG over the ECBF; and
- Second zone representing ground conditions to the South side of the shaft dominated by Basalt over the ECBF.

3.0 Site Subsoil Class

Using the shear velocity (V_s) data (inferred from CPT), the site natural (fundamental) period (T_n) above the bed rock (ECBF) is assessed in the range of 0.27 to 0.40 sec (i.e. smaller than 0.6s but greater than 0.2 sec). This indicates site subsoil class as ‘C’ (clause 3.1.3.4 NZS 1170.5:2004) instead of Class ‘D’ as mentioned in Table 6.1 of the GIR.

- For the seismic design of the DSCIN009 Shaft and other underground structures the soil subsoil class is taken as 'C' in this memo.
- For the bed rock (ECBF) itself, the site subsoil class is assessed as 'B' – weak rock as unconfined compressive strength ranged from 1 to 10MPa.

4.0 Seismic Coefficient

The proposed design life of the structures is 100 years with importance level of 3. This required annual probability of exceedance of 1/25 for SLS and 1/2,500 for ULS design earthquake loading.

Using the:

- Hazard factor (Z) of 0.13 for Auckland;
- Return period factor (R_s, R_u) of 0.25 and 1.8 for 1/25 and 1/2,500 annual probability of exceedance respectively; and
- Site subsoil class factor of 1.33 for class C and 1 for class B; in

Equation 3.1 (1) of the NZS 1170:5 2004, the estimated seismic coefficients (PGA) for seismic design (structure) of the shaft at Miranda Reserve shaft are:

Site subsoil class	SLS - PGA	ULS - PGA
C (above the ECBF)	0.043g	0.311g
B (at ECBF)	0.033g	0.234g

5.0 Soil Liquefaction Risk

There is insignificant risk of liquefaction is developing at DSCIN009 Shaft - Western Spring Park site. Some patchy zones of potential liquefaction are, however assessed around the Western Spring Park site. These zones may have impact on structures other than DSCIN009 Shaft.

For detail on liquefaction analysis and assessment method refer to GIR.

6.0 Shear Wave Velocity (Vs) Assessment

6.1 Methodology

Following methods are used to assess shear wave velocity for the design of the DSCIN009 shaft at Western Spring Park site.

I) Downhole Geophysics

Direct measurements of shear wave velocity (Vs) of the geological units inferred to be encountered at DSCIN009 shaft at Western Spring Park site is made in BH205 and BH206 using the downhole geophysics. The geophysics methods in general calculate shear wave velocity (Vs) and corresponding shear modulus (Gs) for shear strain (γ) below 1.0E-4%. These calculated values of shear wave velocity (Vs) and corresponding shear modulus (Gs) should be compatible with level of the shear strain (γ) that may develop in the ground under the design earthquake shaking.

The shear wave velocity (Vs) values calculated from downhole geophysics are therefore, adjusted by making reduction of 25% accounting for the effects of the earthquakes' large shear strain (FHWA-NHI-09-010 2009).

II) Cone Penetration Test (CPT)

Indirect measurements of the shear wave velocity (V_s) of the geological units at DSCIN009 shaft is made using total cone resistance (q_t) of CPT data using following relationships proposed by Robertson (2009):

$$V_s = [\alpha_{vs}\ (q_t - \sigma_v)/p_a]^{0.5}\ (m/s)$$ (Ref: Guide to Cone Penetration Testing 6th Edition 2015)

Where:

α_{vs} is a material factor = $10^{(0.55Ic+1.68)}$, where *Ic* is soil behaviour

σ_v = soil overburden pressure

Pa is atmospheric pressure and taken as 100kPa

III) Empirical Modulus Correlation

Shear wave velocity (V_s) of the geological units at DSCIN009 shaft is also estimated empirically by correlating it to dynamic shear modulus (G_s) using following relationship:

V_s = SQRT (G_s/ρ) (m/s)

Where

ρ = mass density of the geological units ($\rho = \gamma/g$), taken as 1.7 for Tauranga group and RS, 2.7 for Basalt and 2.0 for ECBF Rock.

G_s = Dynamic shear modulus of the geological units and is estimated using the following relationship:

G_s = 5 to 9 x G_m (Ref: Burt Look 2014)

G_m = Static shear modulus of the geological units and is estimated using following relationship

$E_m/[2(1+v_m)]$

E_m = Ground static Young's modulus taken as roughly 2 times of SPTN (from boreholes) and adjusted further based on GIR design parameters Table 9.1

v_m = Poisson's ratio of the geological units (GIR design parameters Table 9.1)

6.2 Shear Wave Velocity (Vs)

Using the above methodologies, shear wave velocities (V_s) for the two ground models are assessed and its distribution with depth is given in Figure 1. The summary of the inferred dynamic elastic (Es) and shear modulus (G_s) for the corresponding V_s values are given in Table 2.

Table 2 Summary of Dynamic Modulus and Shear Velocity Data

DSCIN009 Shaft							
North, East and West Face					**South Face**			
Depth (m)	G_s (MPa)	E_s (MPa)	V_s (m/s)		Depth (m)	G_s (MPa)	E_s (MPa)	V_s (m/s)
0 to 2	21	60	110		0 to 7.5	21	60	110
2 to 7	10	30	75		7.5 to 10	6,000	17,000	1,500
7 to 9	17	50	100		10 to 13	14	40	90
9 to 11	30	80	130		13 to 15	30	80	130
11 to invert	1,280	3,580	800		15 to invert	1,280	3,850	800
Notes:								
Dynamic Elastic Modulus, $E_s = G_s$ x $2(1+\nu_s)$, where ν_s is taken = 0.35 to 0.40								

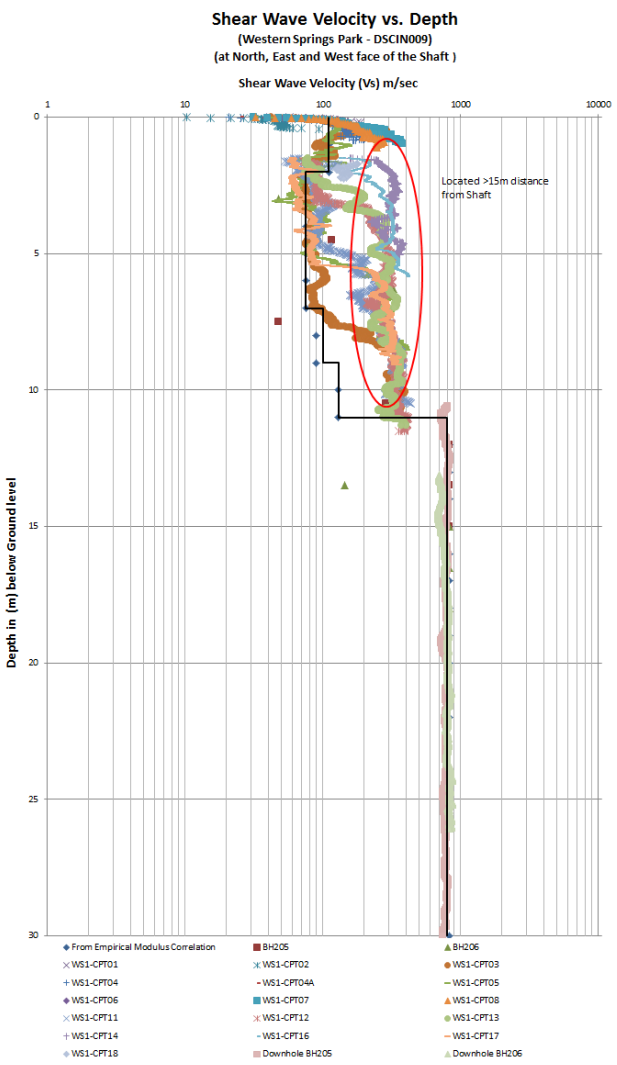
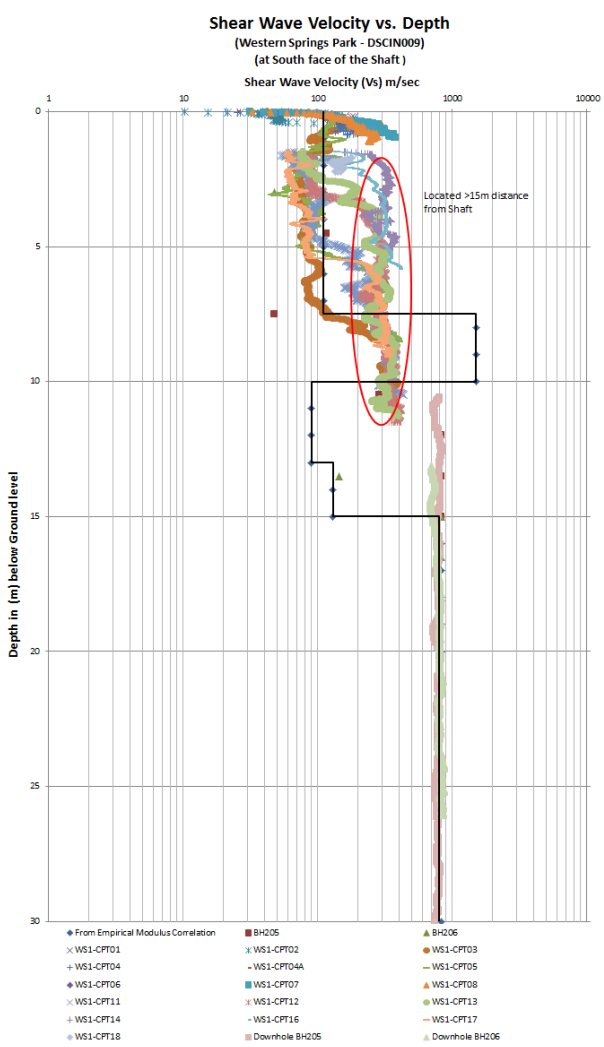
North, East and West Face	South Face
	

Figure 1 Shear Wave Velocity Profile

7.0 Peak Ground Velocity (PGV) Assessment

7.1 General

Peak ground acceleration (PGA), particularly in the horizontal direction, is the most common index of the intensity of strong ground motion at a site. The local codes (NZS 1170:5:2004) are also reliant on PGA rather than Peak ground velocity (PGV). However, PGV is used in some engineering analyses to characterize the damage potential of ground motions.

Therefore, for seismic design and analysis of underground structures including shafts, the PGV is as important as the PGA because ground strains (or the differential displacement between two points in the ground) can be estimated using the PGV.

7.2 Methodology

Peak ground acceleration (PGA) values are generally available from NZS 1170:5:2004. However, there has been little information available for the estimating the Peak ground velocity PGV values.

Previous studies have attempted to correlate the PGV with PGA by establishing PGV-to-PGA ratios (as a function of earthquake magnitudes, site soil conditions, and source-to-site distance in some cases). The proposed PGV-to-PGA ratios ranged from 0.75 to 1.5 with preference of 1.375.

However, recent study (NCHRP-12-70, 2008) has found that PGV is strongly correlated with the spectral acceleration at 1.0 second (S_1). Using published strong motion data, regression analysis was conducted and the following correlation has been established and recommended for design purposes:

$PGV = 0.394 \times 10^{0.434C}$ Equation - 1

Where:

PGV is in inch/sec

$C = 4.82 + 2.16 \log_{10} S_1 + 0.013 [2.30 \log_{10} S_1 + 2.93]^2$

S_1 = Spectral acceleration at 1.0 second (taken from Table 3.1 of NZS 1170:5:2004)

[Note: For details on derivation of equation1, refer to FHWA-NHI-10-034 Dec 2009 report or NCHRP Report 611].

Using the Table 3.1 of NZS 1170:5:2004, the assessed spectral acceleration at 1.0 second (S_1) for site subsoil class B and C are given below:

Site subsoil class	SLS – S_1	ULS – S_1
C (above the ECBF)	0.039g	0.278g
B (at ECBF)	0.031g	0.222g

7.3 Peak Ground Velocity (PGV)

The inferred PGV with the spectral acceleration at 1.0 second (S_1) at the DSCIN009 is given below.

Site subsoil class	SLS		ULS	
	PGV	PGV/PGA	PGV	PGV/PGA
C (above the ECBF)	0.06 m/sec	1.3	0.38 m/sec	1.2
B (at ECBF)	0.05 m/sec	1.4	0.31 m/sec	1.3

The inferred PGV with the spectral acceleration at 0.0 second (S_0) at the DSCIN006 is given below :

Site subsoil class	SLS		ULS	
	PGV	PGV/PGA	PGV	PGV/PGA
C (above the ECBF)	0.06 m/sec	1.5	0.42 m/sec	1.4
B (at ECBF)	0.05 m/sec	1.5	0.32 m/sec	1.4

Memorandum

To	Jason Chan, Narayana Srinivasan	Page	1 of 6
CC	Chris Treleaven, Andrew Campbell		
Subject	Seismic Design of Norgrove Ave Shaft - DSLSB001		
From	Sajjad Anwar		
File/Ref No.		Date	15-Sep-2016 Rev 01

1.0 Investigation Data

Geotechnical ground model for the seismic design of the Norgrove shaft is based on following site investigation data.

Table 1 Summary of Investigation Data

Investigation Type	Identification
Cone Penetration Test (CPT)	L2S2-CPT01, L2S2-CPT02
Scala Penetrometer (SP)	L2S2-SP01, L2S2-SP02, L2S2-SP03, L2S2-SP04, L2S2-SP05, L2S2-SP06
Hand Augers (HA)	L2S2-HA01
Borehole (BH)	BH415, BH217, BH218
Test Pit (TP)	-
Geological Long Section and Plan	2011953.003, 2011953.004, 2011953.001

2.0 Ground conditions

Based on competed site investigation work (Table 1), the inferred ground conditions generally comprised of near surface made ground fill, which is underlain by undifferentiated Tauranga Group (TG) over the Residual Soils (RS) of ECBF. Residual soils are underlain by Moderately Weathered to Un-weathered ECBF (ECBF-ROCK).However, based on layout plan of the site and Auckland region geological map, Basalt may be present under the Fill on eastern side of the shaft.

3.0 Site Subsoil Class

Based on site natural (fundamental) period (T_n), which is assessed as greater than 0.6 sec at BH415 and GIR Table 6.1, the site subsoil class above the bed rock at shaft location is assessed as 'D'. For Bed Rock (ECBF) itself the site subsoil class is assessed as 'B'.

4.0 Seismic Coefficient

The proposed design life of the structures is 100 years with importance level of 3. This required annual probability of exceedance of 1/25 for SLS and 1/2,500 for ULS design earthquake loading.

Using the:

- Hazard factor (Z) of 0.13 for Auckland;
- Return period factor (Rs, Ru) of 0.25 and 1.8 for 1/25 and 1/2,500 annual probability of exceedance respectively; and
- Site subsoil class factor of 1.12 for class D and 1 for Class B;

In equation 3.1 (1) of the NZS 1170:5 2004, the estimated seismic coefficients for seismic design of the shaft at Norgrove shaft are:

Site subsoil class	SLS - PGA	ULS - PGA
D (above the ECBF)	0.036g	0.262g
B (at ECBF)	0.033g	0.234g

5.0 Soil Liquefaction Risk

Based on liquefaction assessment using CPT data, potential liquefaction risk is developing at two levels at Norgrove Ave site i.e. from 4.5 to 5m and 8 to 9m depth. For details on liquefaction analysis result and methodology refer to GIR.

6.0 Seismic Design of Shaft

For details on seismic design methodology refer to DOC| DSLSC-DEL-REP-GT-J-100237 dated 09 Sep 2016.

6.1 Raking

In order to assess the raking deformation of the shaft axis-symmetrical Pseudo-dynamic analysis are undertaken in Rocscience software RS2 version 9.

The ground model for the Pseudo-dynamic analysis is characterised on the basis of small strain (dynamic) shear modulus (G_s).

6.1.1 Input Parameters

In the absence of direct measurement of shear wave velocity of the geological units at Norgrove Ave shaft site, attempts are made to relate dynamic shear modulus (G_s) to (i) shear wave velocity (V_s) and (ii) static shear modulus using following relationships:

i. $G_s = V_s^2 \times \rho$

Where

V_s (m/sec) = shear wave velocity and is estimated from CPT data using following relationship:

$V_s = [\alpha_{vs}\ (q_t - \sigma_v)/p_a]^{0.5}$ (m/s); where $\alpha_{vs} = 10^{(0.55\ Ic + 1.68)}$ (Ref: Guide to Cone Penetration Testing 6th Edition 2015)

ρ = mass density of the geological unit ($\rho = \gamma/g$), taken as 1.7 for Tauranga group, 2.7 for Basalt and 2.0 for ECBF Rock.

ii. $G_s = 5 \times G_m$ (Ref: Burt Look 2014)

Where

G_m = static shear modulus and is estimated using following relationship

$E_m/[2(1+v_m)]$

Where

E_m = ground static Young's modulus taken as roughly 2 times of SPTN (from boreholes) and adjusted further based on GIR design parameters Table 9.1.

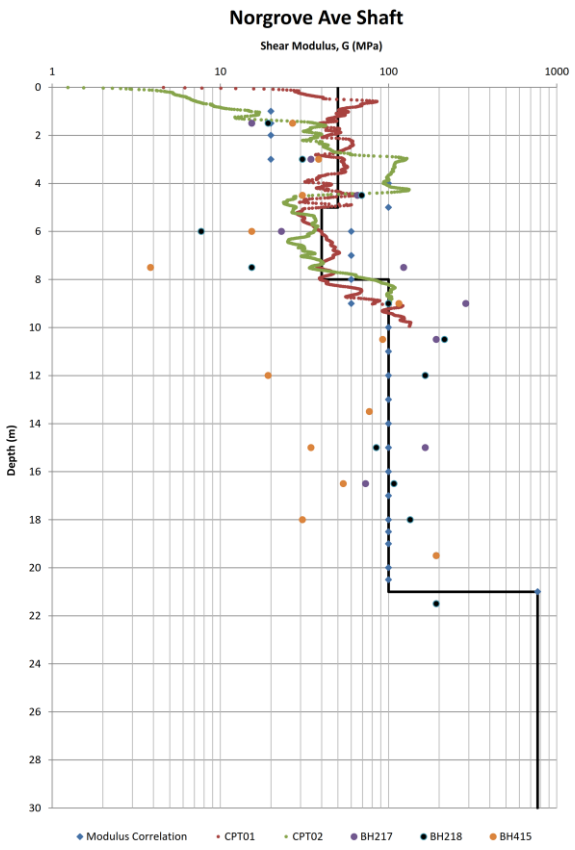
v_m = Poisson's ratio of the geological units (GIR design parameters Table 9.1)

Dynamic Shear modulus (V_s) is assessed for following two ground conditions.

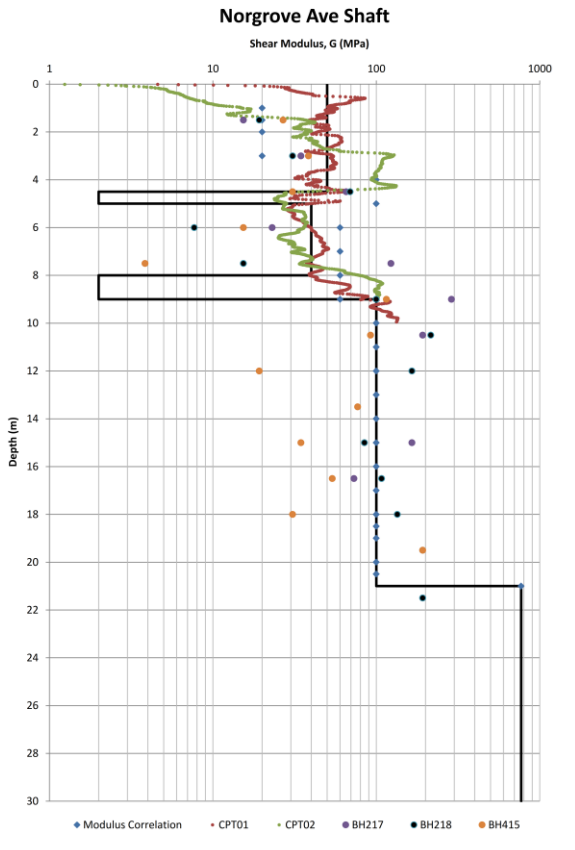
1. Without Liquefaction Potential
2. With Liquefaction Potential

Due to comparatively better repeatability and relative less destructive in testing nature the G_s values estimated from CPT data took the preference on SPTN data.

The distribution of G_s with depth for above two ground conditions is shown in Figure 1 with the summary of the proposed G_s values for the analysis model are given in Table 2.



Without Liquefaction Potential



With Liquefaction Potential

Figure 1 Dynamic Shear Modulus Profile

Table 2 Summary of Dynamic Shear Modulus

Without Liquefaction Potential			With Liquefaction Potential	
Depth (m)	G_s (MPa)		Depth (m)	G_s (MPa)
0 to 5	50		0 to 4.5	50
5 to 8	40		4.5 to 5	2
8 to 21	100		5 to 8	40
21 to invert	770		8 to 9	2
			9 to 21	100
			21 to invert	770

6.1.2 Pseudo-Dynamic Analysis

The pseudo-dynamic analysis are undertaken in Rocscience software RS2 version 9 using the methodology as described in seismic design methodology DOC| DSLSC-DEL-REP-GT-J-100237 dated 09 Sep 2016.

The pseudo-dynamic analysis model mesh of the Norgrove shaft with boundary conditions assumption is shown in Figure 2. The lateral deformation at shaft face is extracted and plotted against shaft depth as shown in Figure 3.

Figure 2 Pseudo-Dynamic Analysis RS2 Model with Boundary Conditions Assumption for Raking Effect

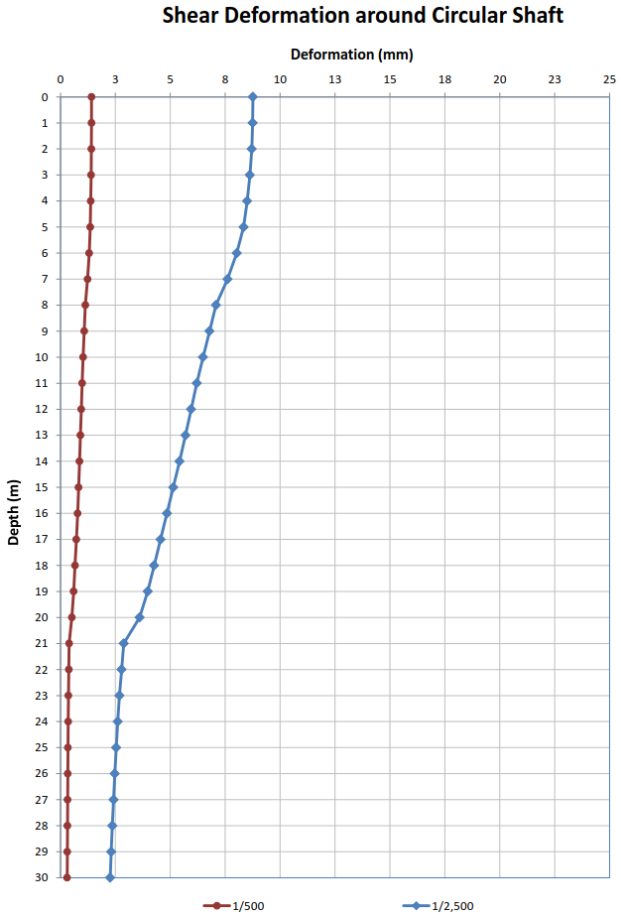


Figure 3 Lateral Displacement at Shaft Face

Based on Figure 3, the shaft is anticipated to rake laterally by 2mm at SLS and 7mm at ULS design load conditions.

6.2 Ovaling

Ovaling of the shaft is assessed following the methodology as described in seismic design methodology DOC| DSLSC-DEL-REP-GT-J-100237 dated 09 Sep 2016.

The assessed Flexibility ratio (F) ranged from 4 to 10 in soil and 78 in rock.

- For rock the flexibility ratio, F = 78 is more than 20, suggesting that the shaft-ground interaction effect can be ignored (Peck, 1972). It also suggests that the rock is about 78 times stiffer than the shaft proposed lining. In this case, the distortion to be experienced by the shaft is assumed to be equal to those of the perforated ground (i.e., cavity in-place conditions - ΔD_{cavity}.
- For soils the flexibility ratio, F ranged from 4 to 10 i.e. smaller than 20, suggesting shaft linings are stiffer than the ground or shaft lining stiffness close or equal to the surrounding ground. The effect of soil-structure interaction must therefore be taken into consideration. In this case, the distortion to be experienced by the shaft is assumed to be equal to those of the non-perforated ground (i.e., $\Delta D_{free\text{-}field}$).

The assessed ovaling/distortion to be experienced by the shaft wall (ΔD_{cavity}) at 1m interval depth along the shaft is given in Appendix A. These values (Appendix A) shall be used for Soil Structural Interaction (SSI) analyses.

Appendix A
Shaft Ovaling Deformation ΔD

CI Norgrove_Avenue Shaft

Shear Strain, γ_{max} @ **1/500 event**

Ref: FHWA-NHI-10-034, Chapetr 13

R_s = 0.25

Adjusted	1	normalise	0.65	
Not adjusted	0	Not normalise	1	
	0	**Mw = 7.5**	**1**	**D = 5.10m**

Shaft Permanent Wall Properties

Concrete Elastic Modulus (MPa)	Lining thickness, t (m)	Moment of inertia, I_n (m^4)
25,000	**0.30**	2.3.E-03

Geological Unit	Depth	γ_t	Dynamic Shear Modulus, G	Dynamic Elastic Modulus, E	σ_v = (γ_t x H)	PGA - SLS (1/500)	Adjustment factor, λ [based on Table 13-1]	Adjusted PGA [PGA x λ]	Stress reduction factor, r_d	Seismic Shear Stress, τ_{max}	Seimsic Shear Strain, γ_{max}	Flexibility Ratio, F [if F>20 use ΔD_{cavity}] [if F<20 use $\Delta D_{free\text{-}field}$]	ΔD_{cavity} $\Delta D_{cavity} = \pm 2\gamma_{max}(1-\nu_m)D$	$\Delta D_{free\text{-}field}$ $\Delta D_{free\text{-}field} = \pm(\gamma_{max}/2)D$
	m	kN/m^3	MPa	MPa	kPa	g				kPa	%		mm	mm
Made Ground (FILL)	0	15	50	140	15	0.036	1.0	0.0364	1.01	20	0.04%	5	2.8	1
	1	15	50	140	30	0.036	1.0	0.0364	1.00	19	0.04%	5	2.8	1
	2	15	50	140	45	0.036	1.0	0.0364	0.99	19	0.04%	5	2.8	1
Tauranga Group (alluvium)	3	17	50	140	62	0.036	1.0	0.0364	0.98	19	0.04%	5	2.7	1
	4	17	50	140	79	0.036	1.0	0.0364	0.97	19	0.04%	5	2.7	1
	5	17	50	140	96	0.036	1.0	0.0364	0.96	19	0.04%	5	2.7	1
	6	17	40	112	113	0.036	0.9	0.0364	0.95	18	0.05%	4	3.3	1
	7	17	40	112	130	0.036	0.9	0.0364	0.94	18	0.05%	4	3.3	1
	8	17	40	112	147	0.036	0.9	0.0364	0.92	18	0.04%	4	3.2	1
	9	17	100	280	164	0.036	0.9	0.0364	0.91	18	0.02%	10	1.3	0
	10	17	100	280	181	0.036	0.9	0.0364	0.90	17	0.02%	10	1.2	0
	11	17	100	280	198	0.036	0.9	0.0364	0.88	17	0.02%	10	1.2	0
	12	17	100	280	215	0.036	0.9	0.0364	0.87	17	0.02%	10	1.2	0
	13	17	100	280	232	0.036	0.9	0.0364	0.85	17	0.02%	10	1.2	0
	14	17	100	280	249	0.036	0.9	0.0364	0.84	16	0.02%	10	1.2	0
	15	17	100	280	266	0.036	0.8	0.0364	0.82	16	0.02%	10	1.1	0
	16	17	100	280	283	0.036	0.8	0.0364	0.81	16	0.02%	10	1.1	0
	17	17	100	280	300	0.036	0.8	0.0364	0.79	15	0.02%	10	1.1	0
	18	17	100	280	317	0.036	0.8	0.0364	0.78	15	0.02%	10	1.1	0
	19	17	100	280	334	0.036	0.8	0.0364	0.76	15	0.01%	10	1.1	0
RS of ECBF	20	20	100	280	354	0.036	0.8	0.0364	0.75	15	0.01%	10	1.0	0
	21	20	100	280	374	0.036	0.8	0.0364	0.74	14	0.01%	10	1.0	0
ECBF Rock	22	20	770	2,156	394	0.033	0.8	0.0325	0.72	13	0.00%	78	0.1	0
	23	20	770	2,156	414	0.033	0.8	0.0325	0.71	12	0.00%	78	0.1	0
	24	20	770	2,156	434	0.033	0.8	0.0325	0.70	12	0.00%	78	0.1	0
	25	20	770	2,156	454	0.033	0.8	0.0325	0.69	12	0.00%	78	0.1	0
	26	20	770	2,156	474	0.033	0.8	0.0325	0.68	12	0.00%	78	0.1	0
	27	20	770	2,156	494	0.033	0.8	0.0325	0.67	12	0.00%	78	0.1	0
	28	20	770	2,156	514	0.033	0.8	0.0325	0.66	11	0.00%	78	0.1	0
	29	20	770	2,156	534	0.033	0.8	0.0325	0.65	11	0.00%	78	0.1	0
	30	Invert Level										78	0.1	0

CI Norgrove_Avenue Shaft

Shear Strain, γ_{max} @ **1/2,500 event**

Ref: FHWA-NHI-10-034, Chapetr 13

R_u = 1.80

Shaft Permanent Wall Properties

Concrete Elastic Modulus (MPa)	Lining thickness, t (m)	Moment of inertia, I_t (m^4)
25,000	0.30	2.3.E-03

Adjusted	1	normalise	0.65
Not adjusted	0	Not normalise	1
	0	Mw = 7.5	1

D = 5.10m

Geological Unit	Depth	γ_t	Dynamic Shear Modulus, G	Dynamic Elastic Modulus, E	σ_v = (γ_t x H)	PGA - SLS (1/500)	Adjustment factor, λ [based on Table 13-1]	Adjusted PGA [PGA x λ]	Stress reduction factor, r_d	Seismic Shear Stress, τ_{max}	Seimsic Shear Strain, γ_{max}	Flexibility Ratio, F [if F>20 use ΔD_{cavity}) [if F<20 use $\Delta D_{free-field}$)	ΔD_{cavity} $\Delta D_{cavity} = \pm 2\gamma_{max}(1-\nu_m)D$	$\Delta D_{free-field}$ $\Delta D_{free-field} = \pm(\gamma_{max}/2)D$
	m	kN/m^3	MPa	MPa	kPa	g				kPa	%		mm	mm
Made Ground (FILL)	0	15	50	140	15	0.262	1.0	0.2621	1.01	141	0.28%	5	20	7
	1	15	50	140	30	0.262	1.0	0.2621	1.00	140	0.28%	5	20	7
	2	15	50	140	45	0.262	1.0	0.2621	0.99	139	0.28%	5	20	7
Taurunga Group (alluvium)	3	17	50	140	62	0.262	1.0	0.2621	0.98	137	0.27%	5	20	7
	4	17	50	140	79	0.262	1.0	0.2621	0.97	136	0.27%	5	19	7
	5	17	50	140	96	0.262	1.0	0.2621	0.96	134	0.27%	5	19	7
	6	17	40	112	113	0.262	0.9	0.2621	0.95	133	0.33%	4	24	8
	7	17	40	112	130	0.262	0.9	0.2621	0.94	131	0.33%	4	23	8
	8	17	40	112	147	0.262	0.9	0.2621	0.92	129	0.32%	4	23	8
	9	17	100	280	164	0.262	0.9	0.2621	0.91	127	0.13%	10	9	3
	10	17	100	280	181	0.262	0.9	0.2621	0.90	125	0.13%	10	9	3
	11	17	100	280	198	0.262	0.9	0.2621	0.88	123	0.12%	10	9	3
	12	17	100	280	215	0.262	0.9	0.2621	0.87	121	0.12%	10	9	3
	13	17	100	280	232	0.262	0.9	0.2621	0.85	119	0.12%	10	9	3
	14	17	100	280	249	0.262	0.9	0.2621	0.84	117	0.12%	10	8	3
	15	17	100	280	266	0.262	0.8	0.2621	0.82	115	0.12%	10	8	3
	16	17	100	280	283	0.262	0.8	0.2621	0.81	113	0.11%	10	8	3
	17	17	100	280	300	0.262	0.8	0.2621	0.79	111	0.11%	10	8	3
	18	17	100	280	317	0.262	0.8	0.2621	0.78	109	0.11%	10	8	3
	19	17	100	280	334	0.262	0.8	0.2621	0.76	107	0.11%	10	8	3
RS of ECBF	20	20	100	280	354	0.262	0.8	0.2621	0.75	105	0.10%	10	7	3
	21	20	100	280	374	0.262	0.8	0.2621	0.74	103	0.10%	10	7	3
ECBF Rock	22	20	770	2,156	394	0.234	0.8	0.2340	0.72	90	0.01%	78	1	0
	23	20	770	2,156	414	0.234	0.8	0.2340	0.71	89	0.01%	78	1	0
	24	20	770	2,156	434	0.234	0.8	0.2340	0.70	87	0.01%	78	1	0
	25	20	770	2,156	454	0.234	0.8	0.2340	0.69	86	0.01%	78	1	0
	26	20	770	2,156	474	0.234	0.8	0.2340	0.68	85	0.01%	78	1	0
	27	20	770	2,156	494	0.234	0.8	0.2340	0.67	83	0.01%	78	1	0
	28	20	770	2,156	514	0.234	0.8	0.2340	0.66	82	0.01%	78	1	0
	29	20	770	2,156	534	0.234	0.8	0.2340	0.65	81	0.01%	78	1	0
	30	Invert Level										78	1	0

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Memorandum

To	Jason Chan, Narayana Srinivasan	Page	1
CC	Chris Treleaven, Andrew Campbell		
Subject	Seismic Design of Rawalpindi Reserve Shaft - DSLSB002		
From	Crystal Ham (reviewed by Sajjad Anwar)		
File/Ref No.		Date	04-Oct-2016 REV: 00

1.0 Investigation Data

Geotechnical ground model for the seismic design of the DSLSB002 shaft at Rawalpindi Reserve is based on following site investigation data (Table 1).

Table 1 Summary of Investigation Data

Investigation Type	Identification
Cone Penetration test (CPTs)	L2S1-CPT01, L2S1-CPT02, L2S1-CPT03, L2S1-CPT04, L2S1-CPT05
Scala Penetrometer (SP)	-
Hand Augers (HAs)	-
Borehole (BHs)	BH215, BH216, BH416
Test Pit (TPs)	-
Long section drawing	2011954.001, 2011954.003, 2011954.004, 2011952.001

2.0 Ground conditions

Based on competed site investigation data (Table 1), the inferred ground conditions generally comprised of Made ground (FILL) overlying Residual Soils (RS) of ECBF. Residual soils are underlain by Moderately Weathered (MW) to Unweathered (UW) ECBF (ECBF-ROCK).

3.0 Site Subsoil Class

Using the shear velocity (V_s) data (inferred from CPT data), the site natural (fundamental) period (T_n) above the bed rock (ECBF) is assessed in the range of 0.23 to 0.37sec (i.e. smaller than 0.6s but greater than 0.2 sec). This indicates site subsoil class as 'C' (clause 3.1.3.4 NZS 1170.5:2004) instead of Class 'D' as mentioned in Table 6.1 of the GIR.

- For the seismic design of the DSLSB002 shaft and other underground structures the soil subsoil class is taken as 'C' in this memo.
- For the bed rock (ECBF) itself, the site subsoil class is assessed as 'B' – weak rock as unconfined compressive strength ranged from 1 to 10MPa.

4.0 Seismic Coefficient

The proposed design life of the structures is 100 years with importance level of 3. This required annual probability of exceedance of 1/25 for SLS and 1/2,500 for ULS design earthquake loading.

Using the:

- Hazard factor (Z) of 0.13 for Auckland;
- Return period factor (Rs, Ru) of 0.25 and 1.8 for 1/25 and 1/2,500 annual probability of exceedance respectively; and

- Site subsoil class factor of 1.33 for class C and 1 for class B; in

Equation 3.1 (1) of the NZS 1170:5 2004, the estimated seismic coefficients for seismic (structure) design of the DSLSB002 shaft at Rawalpindi Reserve are:

Table 2 Seismic Coefficient as per Site Subsoil Class

Site subsoil class	SLS - PGA	ULS - PGA
C (above the ECBF)	0.043g	0.311g
B (at ECBF)	0.033g	0.234g

5.0 Soil Liquefaction Risk

Based on liquefaction assessment using CPT data, potential liquefaction risk is developing at the shaft site from 6m to 8m depth.

For details on liquefaction analysis result and methodology refer to the GIR.

6.0 Seismic (Geotechnical) Design of the Shaft

6.1 Methodology

For details on seismic design methodology of the underground circular shaft refer to DOC| DSLSC-DEL-REP-GT-J-100237 dated 09 Sep 2016.

6.2 Raking

In order to assess the raking deformation of the shaft axis-symmetrical Pseudo-dynamic analysis are undertaken in Rocscience software RS2 version 9.

The ground model for the Pseudo-dynamic analysis is characterised on the basis of small strain (dynamic) shear modulus (G_s).

6.2.1 Dynamic Shear Modulus (Gs) Estimation

6.2.1.1 Methodology

In the absence of direct measurement of the dynamic shear modulus (G_s) following three well establish methods are used to estimate dynamic shear modulus (Gs) indirectly.

I) Downhole Geophysics

Downhole geophysical survey work has not been undertaken in boreholes at this site.

I) Cone Penetration Test (CPT)

Indirect measurements of the dynamic shear modulus (G_s) from shear wave velocity of the geological units at DSLSB002 shaft is made using total cone resistance (q_t) of CPT data using following relationships:

$$G_s = V_s^2 \times \rho$$

Where:

ρ = mass density of the geological unit ($\rho = \gamma/g$), taken as 1.7 for Tauranga group and RS, 2.7 for Basalt and 2.0 for ECBF Rock.

V_s (m/sec) = shear wave velocity and is estimated from CPT data using following relationship:

$$V_s = [\alpha_{vs}\ (q_t - \sigma_v)/p_a]^{0.5}\ (m/s)$$ (Ref: Guide to Cone Penetration Testing 6th Edition 2015)

Where:

α_{vs} is a material factor and = $10^{(0.55Ic+1.68)}$, where *Ic* is soil behaviour

σ_v = soil overburden pressure; and

P_a is atmospheric pressure and taken as = 100kPa

I) Empirical Modulus Correlation

Dynamic shear modulus (G_s) of the geological units at DSLSB002 shaft is also estimated empirically by correlating it to static shear modulus (G_m) using following relationship:

G_s = 5 to 9 x G_m (Ref: Burt Look 2014)

Where

G_m = static shear modulus and is estimated using following relationship:

$E_m/[2(1+v_m)]$

Where

E_m = Static elastic modulus taken as roughly 2 times of SPTN (from boreholes data) and adjusted further based on GIR design parameters Table 9.1.

6.2.1.2 Dynamic Shear Modulus

Using the above methodology, dynamic Shear modulus (G_s) is assessed for following two ground conditions.

1. Without potential liquefaction risk
2. With potential liquefaction risk

The distribution of G_s vs depth along with best estimate design line for above two ground conditions is shown in Figure 1. The summary of the best estimate values of G_s for the pseudo-dynamic analysis is given in Table 3.

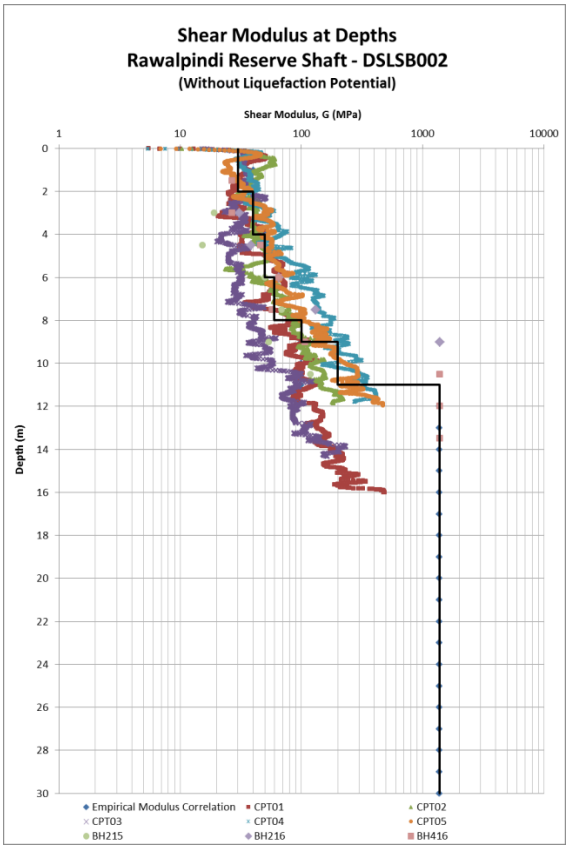
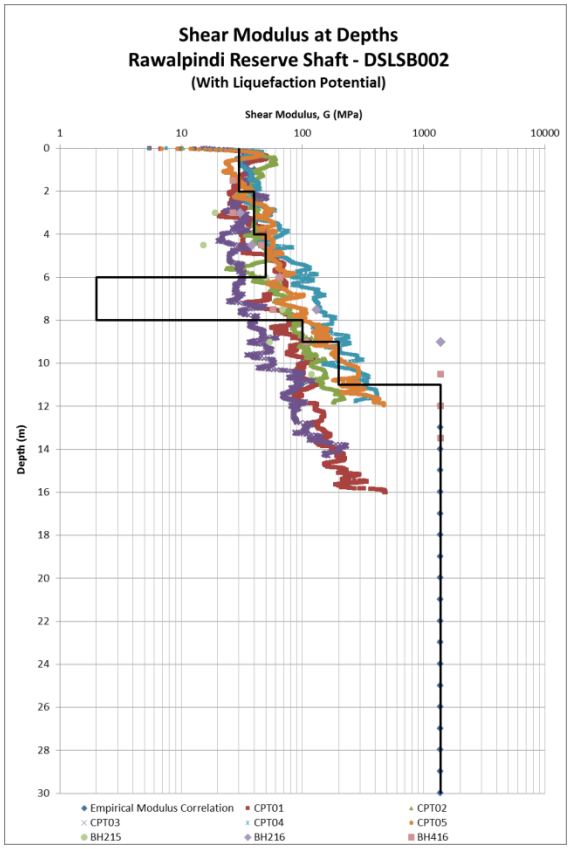
Without Liquefaction Potential	With Liquefaction Potential
	

Figure 1 Dynamic Shear Modulus Profile

Table 3 Summary of Dynamic Shear Modulus (Gs)

Without Liquefaction Potential		With Liquefaction Potential	
Depth (m)	**G_s (MPa)**	**Depth (m)**	**G_s (MPa)**
0 to 2	30	0 to 2	30
2 to 4	40	2 to 4	40
4 to 6	50	4 to 6	50
6 to 8	60	6 to 8	2
8 to 9	100	8 to 9	100
9 to 11	200	9 to 11	200
11 to invert	1380	11 to invert	1380

6.2.2 Pseudo-Dynamic Analysis

The pseudo-dynamic analysis are undertaken in Rocscience software RS2 version 9 using the methodology as described in seismic design methodology DOC| DSLSC-DEL-REP-GT-J-100237 dated 09 Sep 2016.

The pseudo-dynamic analysis model mesh of the Rawalpindi Reserve shaft with boundary conditions assumption is shown in Figure 2. The lateral deformation at shaft face is extracted and plotted against shaft depth as shown in Figure 3.

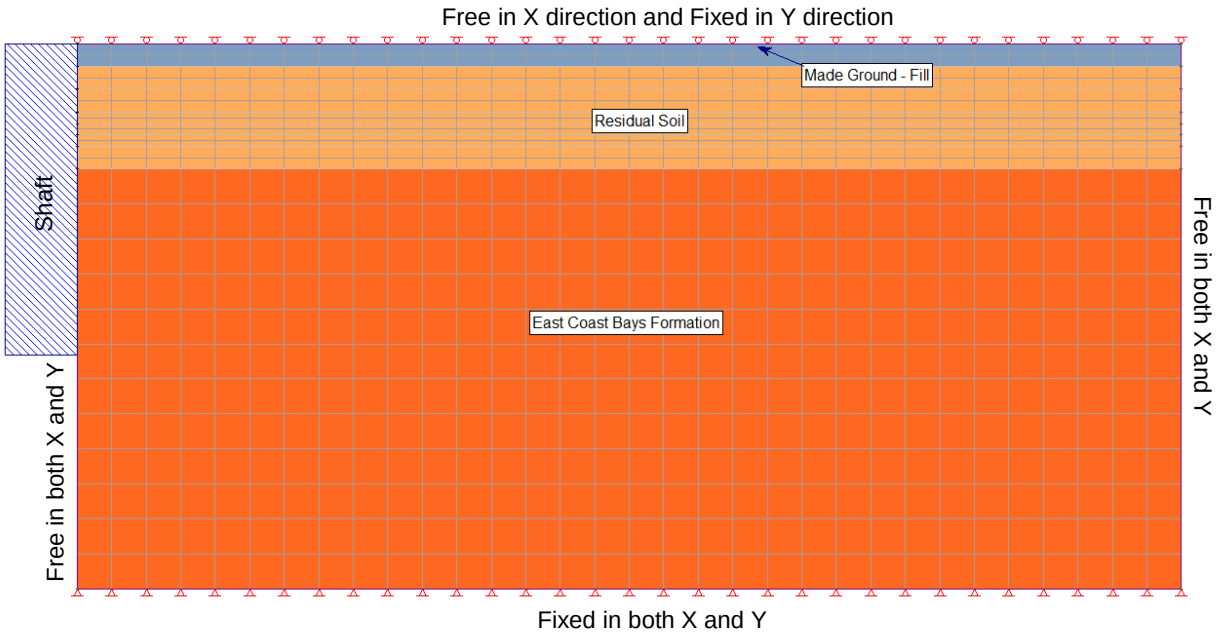


Figure 2 Pseudo-Dynamic Analysis Model with Boundary Conditions Assumptions for Raking Effect

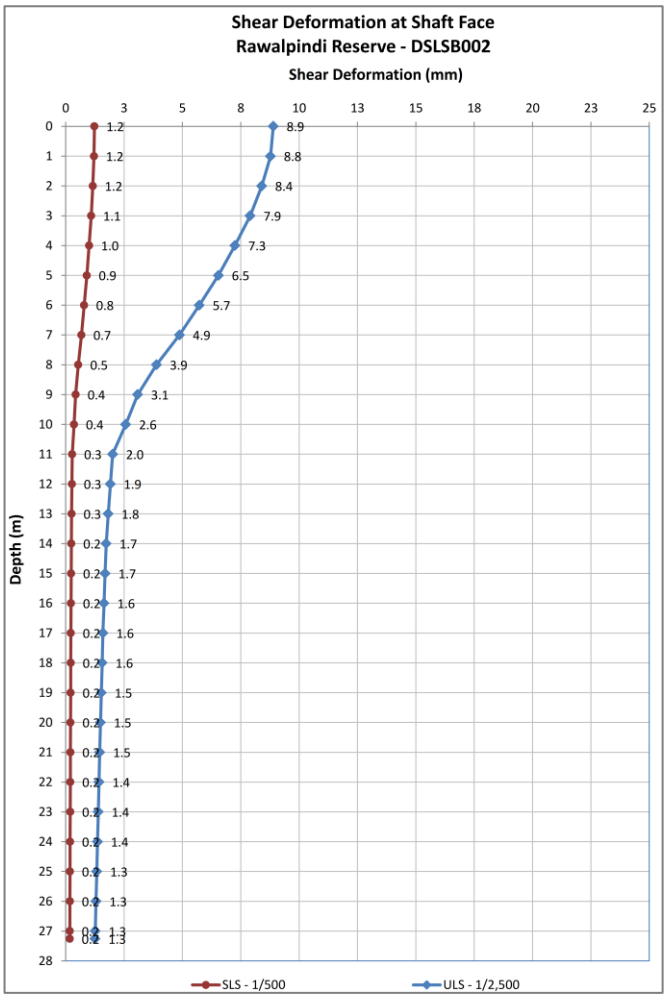


Figure 3 Lateral Deformation at Shaft Face

Based on Figure 3, the shaft is anticipated to rake laterally by 1mm at SLS and 8mm at ULS design seismic load conditions.

6.3 Ovaling

Ovaling of the shaft is assessed following the methodology as described in seismic design methodology DOC| DSLSC-DEL-REP-GT-J-100237 dated 09 Sep 2016.

The assessed Flexibility ratio (F) ranged from 8 to 39 in residual soils and 270 in ECBF rock.

- For residual soils and rock with a flexibility ratio (F) of more than 20, it suggests that the shaft-ground interaction effect can be ignored (Peck, 1972). It also suggests that the residual soils and rock is about 20 to 39 times respectively stiffer than the shaft permanent wall stiffness. In this case, the distortion to be experienced by the shaft permanent wall is assumed to be equal to those of the perforated ground (i.e., cavity in-place conditions - ΔD_{cavity}).
- For residual soils with a flexibility ratio (F) smaller than 20, it suggests that the shaft permanent wall is stiffer than the surrounding ground or shaft permanent wall stiffness is close or equal to the surrounding ground stiffness. The effect of soil-structure interaction must therefore be taken into consideration. In this case, the distortion to be experienced by the shaft permanent wall is assumed to be equal to those of the non-perforated ground (i.e., $\Delta D_{free\text{-}field}$).

Considering the permanent shaft diameter of 6.35m, the assessed ovaling/distortion to be experienced by the shaft wall (ΔD) during the SLS and ULS seismic loading at 1m interval depth along the shaft is given in Appendix A. These values (Appendix A) shall be used for Soil Structural Interaction (SSI) analyses by structure engineers.

Appendix A
Shaft Ovaling Deformation (ΔD)

DSLSB002 Shaft at Rawalpindi Reserve

Shear Strain, γ_{max} SLS 1/500 event

Ref: FHWA-NHI-10-034, Chapter 13

Site SubSoil Calss $C_{h(T=0)} = 1.33$ 'C'

$R_s = 0.25$

Adjusted	1	Normalise	0.65
Not adjusted	0	Not normalise	1
	0	**Mw = 7.5**	**1**

Shaft Permanent Wall Properties

Concrete Elastic Modulus (MPa)	Lining thickness, t (m)	Moment of inertia, I_n (m^4)
25,000	**0.30**	2.3.E-03

D = 6.35m

Geological Unit	Depth	γ_t	Dynamic Shear Modulus, G	Dynamic Elastic Modulus, E	$\sigma_{v=}$ (γ_t x H)	PGA - SLS (1/500)	Adjustment factor, λ [based on Table 13-1]	Adjusted PGA [PGA x λ]	Stress reduction factor, r_d	Seismic Shear Stress, τ_{max}	Seimsic Shear Strain, γ_{max}	Flexibility Ratio, F [if F>20 use ΔD_{cavity}) [if F<20 use $\Delta D_{free-field}$)	ΔD_{cavity} $\Delta D_{cavity} = \pm 2\gamma_{max}(1-\nu_m)D$	$\Delta D_{free-field}$ $\Delta D_{free-field} = \pm(\gamma_{max}/2)D$
	m	kN/m^3	MPa	MPa	kPa	g				kPa	%		mm	mm
Made Ground (FILL)	0	15	30	84	15	0.043	1.0	0.043	1.01	22	0.07%	5.9	6.5	2.3
	1	15	30	84	30	0.043	1.0	0.043	1.00	22	0.07%	5.9	6.5	2.3
RS of ECBF	2	17	40	112	47	0.043	1.0	0.043	0.99	22	0.05%	7.8	4.8	1.7
	3	17	40	112	64	0.043	1.0	0.043	0.98	22	0.05%	7.8	4.8	1.7
	4	17	50	140	81	0.043	1.0	0.043	0.97	21	0.04%	9.8	3.8	1.4
	5	17	50	140	98	0.043	1.0	0.043	0.96	21	0.04%	9.8	3.7	1.3
	6	17	60	168	115	0.043	0.9	0.043	0.95	21	0.03%	11.8	3.1	1.1
	7	18	60	168	133	0.043	0.9	0.043	0.94	21	0.03%	11.8	3.0	1.1
	8	18	100	280	151	0.043	0.9	0.043	0.92	20	0.02%	19.6	1.8	0.6
	9	18	200	560	169	0.043	0.9	0.043	0.91	20	0.01%	39.2	0.9	0.3
	10	18	200	560	187	0.043	0.9	0.043	0.90	20	0.01%	39.2	0.9	0.3
ECBF Rock	11	20	1380	3,864	207	0.043	0.9	0.043	0.88	19	0.00%	270.6	0.1	0.0
	12	20	1380	3,864	227	0.043	0.9	0.043	0.87	19	0.00%	270.6	0.1	0.0
	13	20	1380	3,864	247	0.043	0.9	0.043	0.85	19	0.00%	270.6	0.1	0.0
	14	20	1380	3,864	267	0.043	0.9	0.043	0.84	18	0.00%	270.6	0.1	0.0
	15	20	1380	3,864	287	0.043	0.8	0.043	0.82	18	0.00%	270.6	0.1	0.0
	16	20	1380	3,864	307	0.043	0.8	0.043	0.81	18	0.00%	270.6	0.1	0.0
	17	20	1380	3,864	327	0.043	0.8	0.043	0.79	17	0.00%	270.6	0.1	0.0
	18	20	1380	3,864	347	0.043	0.8	0.043	0.78	17	0.00%	270.6	0.1	0.0
	19	20	1380	3,864	367	0.043	0.8	0.043	0.76	17	0.00%	270.6	0.1	0.0
	20	20	1380	3,864	387	0.043	0.8	0.043	0.75	16	0.00%	270.6	0.1	0.0
	21	20	1380	3,864	407	0.043	0.8	0.043	0.74	16	0.00%	270.6	0.1	0.0
	22	20	1380	3,864	427	0.043	0.8	0.043	0.72	16	0.00%	270.6	0.1	0.0
	23	20	1380	3,864	447	0.043	0.8	0.043	0.71	16	0.00%	270.6	0.1	0.0
	24	20	1380	3,864	467	0.043	0.8	0.043	0.70	15	0.00%	270.6	0.1	0.0
	25	20	1380	3,864	487	0.043	0.8	0.043	0.69	15	0.00%	270.6	0.1	0.0
	26	20	1380	3,864	507	0.043	0.8	0.043	0.68	15	0.00%	270.6	0.1	0.0
	27	Invert Level												

DSLSB002 Shaft at Rawalpindi Reserve

Shear Strain, γ_{max} SLS 1/2,500 event

Ref: FHWA-NHI-10-034, Chapter 13

Site SubSoil Calss $C_{h(T=0)} = 1.33$ 'C'

$R_u = 1.80$

Adjusted	1	Normalise	0.65	
Not adjusted	0	Not normalise	1	
	0	**Mw = 7.5**	**1**	

Shaft Permanent Wall Properties

Concrete Elastic Modulus (MPa)	Lining thickness, t (m)	Moment of inertia, I_n (m^4)
25,000	**0.30**	2.3.E-03

D = 6.35m

Geological Unit	Depth	γ_t	Dynamic Shear Modulus, G	Dynamic Elastic Modulus, E	σ_v = (γ_t x H)	PGA - ULS (1/2,500)	Adjustment factor, λ [based on Table 13-1]	Adjusted PGA [PGA x λ]	Stress reduction factor, r_d	Seismic Shear Stress, τ_{max}	Seimsic Shear Strain, γ_{max}	Flexibility Ratio, F [if F>20 use ΔD_{cavity}] [if F<20 use $\Delta D_{free\text{-}field}$]	ΔD_{cavity} $\Delta D_{cavity} = \pm 2\gamma_{max}(1-\nu_m)D$	$\Delta D_{free\text{-}field}$ $\Delta D_{free-field} = \pm(\gamma_{max}/2)D$
	m	kN/m^3	MPa	MPa	kPa	g				kPa	%		mm	mm
Made Ground (FILL)	0	15	30	84	15	0.31	1.0	0.3112	1.01	159	0.53%	5.9	47.1	16.8
	1	15	30	84	30	0.31	1.0	0.3112	1.00	158	0.53%	5.9	46.7	16.7
RS of ECBF	2	17	40	112	47	0.31	1.0	0.3112	0.99	156	0.39%	7.8	34.8	12.4
	3	17	40	112	64	0.31	1.0	0.3112	0.98	155	0.39%	7.8	34.4	12.3
	4	17	50	140	81	0.31	1.0	0.3112	0.97	153	0.31%	9.8	27.3	9.7
	5	17	50	140	98	0.31	1.0	0.3112	0.96	152	0.30%	9.8	27.0	9.6
	6	17	60	168	115	0.31	0.9	0.3112	0.95	150	0.25%	11.8	22.2	7.9
	7	18	60	168	133	0.31	0.9	0.3112	0.94	148	0.25%	11.8	21.9	7.8
	8	18	100	280	151	0.31	0.9	0.3112	0.92	146	0.15%	19.6	13.0	4.6
	9	18	200	560	169	0.31	0.9	0.3112	0.91	144	0.07%	39.2	6.4	2.3
	10	18	200	560	187	0.31	0.9	0.3112	0.90	141	0.07%	39.2	6.3	2.2
ECBF Rock	11	20	1380	3,864	207	0.31	0.9	0.3112	0.88	139	0.01%	270.6	0.9	0.3
	12	20	1380	3,864	227	0.31	0.9	0.3112	0.87	137	0.01%	270.6	0.9	0.3
	13	20	1380	3,864	247	0.31	0.9	0.3112	0.85	134	0.01%	270.6	0.9	0.3
	14	20	1380	3,864	267	0.31	0.9	0.3112	0.84	132	0.01%	270.6	0.9	0.3
	15	20	1380	3,864	287	0.31	0.8	0.3112	0.82	130	0.01%	270.6	0.8	0.3
	16	20	1380	3,864	307	0.31	0.8	0.3112	0.81	127	0.01%	270.6	0.8	0.3
	17	20	1380	3,864	327	0.31	0.8	0.3112	0.79	125	0.01%	270.6	0.8	0.3
	18	20	1380	3,864	347	0.31	0.8	0.3112	0.78	123	0.01%	270.6	0.8	0.3
	19	20	1380	3,864	367	0.31	0.8	0.3112	0.76	121	0.01%	270.6	0.8	0.3
	20	20	1380	3,864	387	0.31	0.8	0.3112	0.75	118	0.01%	270.6	0.8	0.3
	21	20	1380	3,864	407	0.31	0.8	0.3112	0.74	116	0.01%	270.6	0.7	0.3
	22	20	1380	3,864	427	0.31	0.8	0.3112	0.72	114	0.01%	270.6	0.7	0.3
	23	20	1380	3,864	447	0.31	0.8	0.3112	0.71	112	0.01%	270.6	0.7	0.3
	24	20	1380	3,864	467	0.31	0.8	0.3112	0.70	110	0.01%	270.6	0.7	0.3
	25	20	1380	3,864	487	0.31	0.8	0.3112	0.69	109	0.01%	270.6	0.7	0.2
	26	20	1380	3,864	507	0.31	0.8	0.3112	0.68	107	0.01%	270.6	0.7	0.2
	27	Invert Level											-	-

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Memorandum

To	Jason Chan, Narayana Srinivasan	Page	1 of 6
CC	Chris Treleaven		
Subject	Seismic Design of Haycock Avenue Shaft - DSLSC001		
From	Ham Crystal (reviewed by Andrew Campbell)		
File/Ref No.		Date	06-Dec-2016 Rev. 00

1.0 Investigation Data

Geotechnical ground model for the seismic design of the Haycock Avenue shaft is based on following site investigation data.

Table 1 Summary of Investigation Data

Investigation Type	Identification
Cone Penetration Test (CPTs)	L3S5-CPT01, L3S5-CPT02, L3S5-CPT03, L3S5-CPT04
Scala Penetrometer (SP)	NA
Hand Augers (HAs)	L3S5 – HA01
Borehole (BHs)	BH243, BH244, BH417
Test Pit (TPs)	NA
Long section drawing	2012006.003, 2011881.004

2.0 Ground conditions

Based on completed site investigation data (Table 1) and site layout plan (2012006.001), the inferred ground conditions surrounding the DSLSC001-Shaft and other structures (TBC) is generally comprised of made ground Fill over the undifferentiated Tauranga Group (TG) alluvium over the Residual Soils (RS) of ECBF. The RS of ECBF are underlain by Moderately Weathered (MW) to Slightly Weathered (SW) ECBF Rock.

3.0 Site Subsoil Class

Using the shear velocity (Vs) data (inferred from CPTs), the site natural (fundamental) period (Tn) above the bed rock (ECBF) is assessed in the range of 0.25 to 0.35 sec (i.e. smaller than 0.6s but greater than 0.2 sec). This indicates site subsoil class as ‘C’ (clause 3.1.3.4 NZS 1170.5:2004) instead of Class ‘D’ as mentioned in Table 6.1 of the GIR.

For the seismic design of the DSLSC001-Shaft and other structures (TBC) the soil subsoil class is taken as ‘C’ in this memo.

For the bed rock (ECBF) itself, the site subsoil class is assessed as ‘B’ – weak rock as unconfined compressive strength ranged from 1 to 10MPa.

4.0 Seismic Coefficient

The proposed design life of the structures is 100 years with importance level of 3. This required annual probability of exceedance of 1/25 for SLS and 1/2,500 for ULS design earthquake loading.

Using the:

- Hazard factor (Z) of 0.13 for Auckland;

- Return period factor (Rs, Ru) of 0.25 and 1.8 for 1/25 and 1/2,500 annual probability of exceedance respectively; and
- Site subsoil class factor of 1.33 for class C and 1 for class B; in

Equation 3.1 (1) of the NZS 1170:5 2004, the estimated seismic coefficients for seismic design of the shaft at Haycock Avenue shaft are:

Table 2 Seismic Coefficient as per Site Subsoil Class

Site subsoil class	SLS - PGA	ULS - PGA
C (above the ECBF)	0.043g	0.311g
B (at ECBF)	0.033g	0.234g

5.0 Soil Liquefaction Risk

Based on liquefaction assessment using CPT data, potential liquefaction risk is developing at the shaft site from 5 m to 9 m depth. For details on liquefaction analysis result and methodology refer to the GIR.

6.0 Seismic Design of the Shaft

For details on seismic design methodology of the underground circular shaft refer to DOC| DSLSC-DEL-REP-GT-J-100237 dated 09 Sep 2016.

6.1 Raking

In order to assess the raking deformation of the shaft axis-symmetrical Pseudo-dynamic analysis are undertaken in Rocscience software RS2 version 9.

The ground model for the Pseudo-dynamic analysis is characterised on the basis of small strain (dynamic) shear modulus (G_s).

6.1.1 Input Parameters

In the absence of direct measurement of shear wave velocity of the geological units Haycock Avenue shaft site, attempts are made to relate dynamic shear modulus (G_s) to (i) shear wave velocity (V_s) and (ii) static shear modulus using following relationships:

i. $G_s = V_s^2 \times \rho$

Where

V_s (m/sec) = shear wave velocity and is estimated from CPT data using following relationship:

$$V_s = [\alpha_{vs}\ (q_t - \sigma_v)/p_a]^{0.5}\ \text{(m/s)};\ \text{where}\ \alpha_{vs} = 10^{(0.55\,Ic + 1.68)}$$

(Ref: Guide to Cone Penetration Testing 6th Edition 2015)

ρ = mass density of the geological unit ($\rho = \gamma/g$), taken as 1.7 for Tauranga group, 2.7 for Basalt and 2.0 for ECBF Rock.

ii. $G_s = 5 \times G_m$ (Ref: Burt Look 2014)

Where

G_m = static shear modulus and is estimated using following relationship

$$E_m/[2(1+v_m)]$$

Where

E_m = ground static Young's modulus taken as roughly 2 times of SPTN (from boreholes) and adjusted further based on GIR design parameters Table 9.1.

v_m = Poisson's ratio of the geological units (GIR design parameters Table 9.1)

Dynamic Shear modulus (V_s) is assessed for following two ground conditions.

1. Without Liquefaction Potential

2. With Liquefaction Potential

Due to comparatively better repeatability and relative less destructive in testing nature the G_s values estimated from CPT data took the preference on SPT-N data.

The distribution of G_s with depth for above two ground conditions is shown in Figure 1 with the summary of the proposed G_s values for the analysis model are given in Table 3.

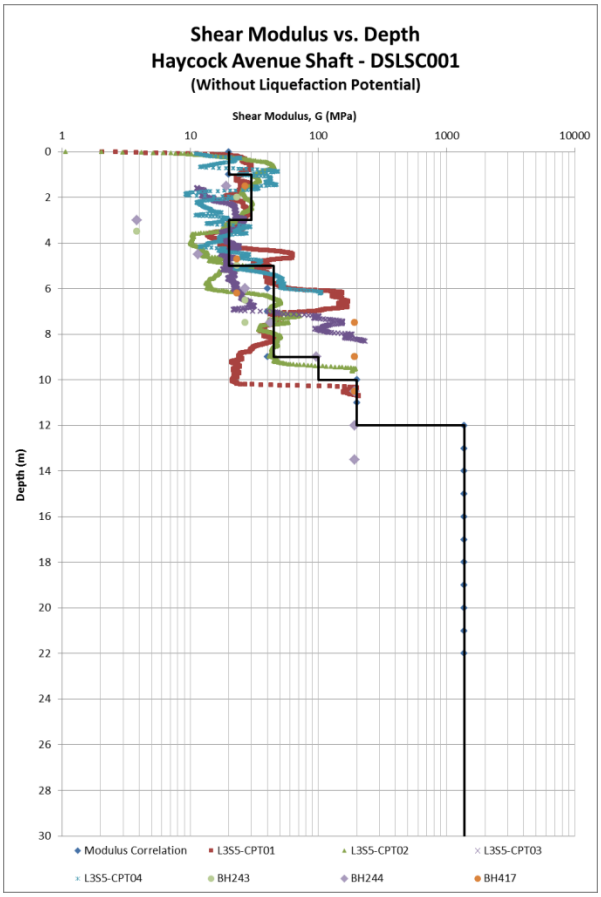
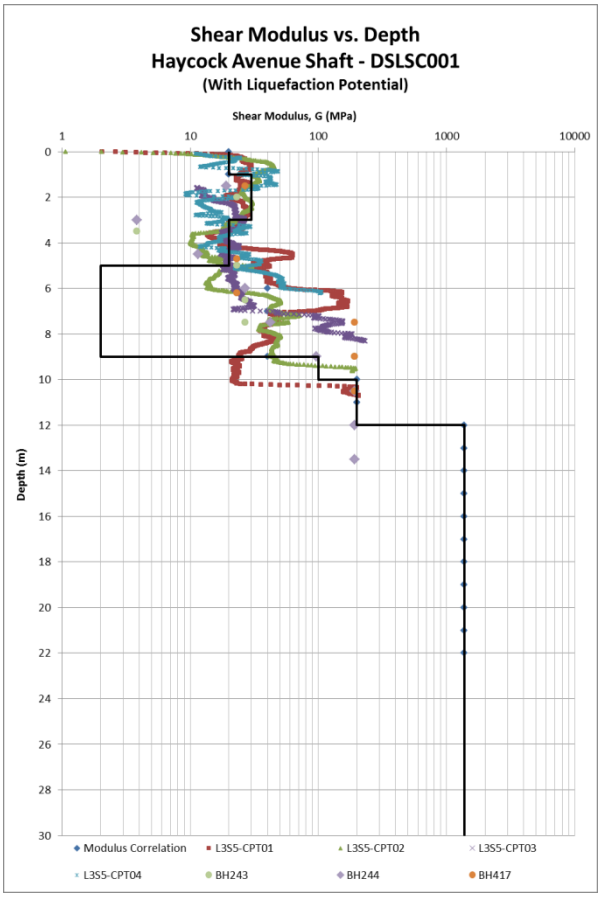
Without Liquefaction Potential	With Liquefaction Potential
	

Figure 1 Dynamic Shear Modulus Profile

Table 3 Summary of Dynamic Shear Modulus

Without Liquefaction Potential		With Liquefaction Potential	
Depth (m)	**G_s (MPa)**	**Depth (m)**	**G_s (MPa)**
0 to 1	20	0 to 1	20
1 to 3	30	1 to 3	30
3 to 5	20	3 to 5	20
5 to 9	45	5 to 9	2
9 to 10	100	9 to 10	100
10 to 12	200	10 to 12	200
12 to invert	1380	12 to invert	1380

6.1.2 Pseudo-Dynamic Analysis

The pseudo-dynamic analysis are undertaken in Rocscience software RS2 version 9 using the methodology as described in seismic design methodology DOC| DSLSC-DEL-REP-GT-J-100237 dated 09 Sep 2016.

The pseudo-dynamic analysis model mesh of the Haycock Avenue with boundary conditions assumption is shown in Figure 2. The lateral deformation at shaft face is extracted and plotted against shaft depth as shown in Figure 3.

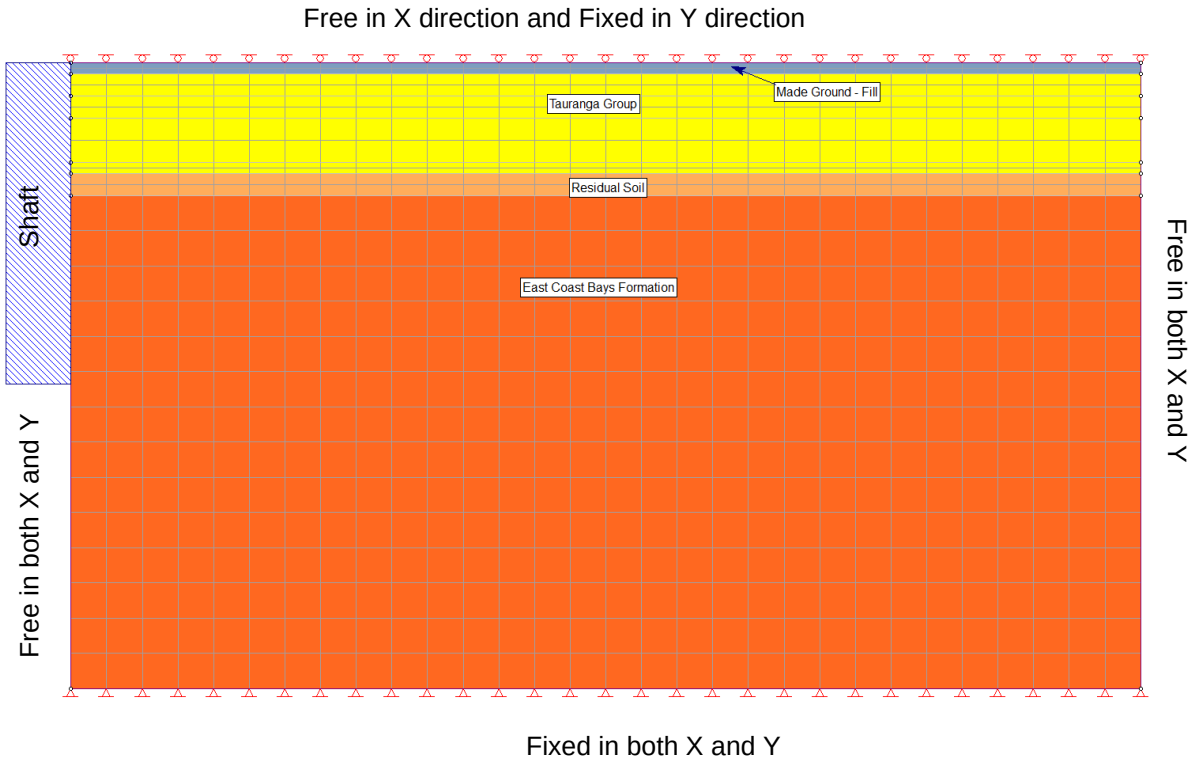


Figure 2 Pseudo-Dynamic Analysis Model with Boundary Conditions Assumptions for Raking Effect

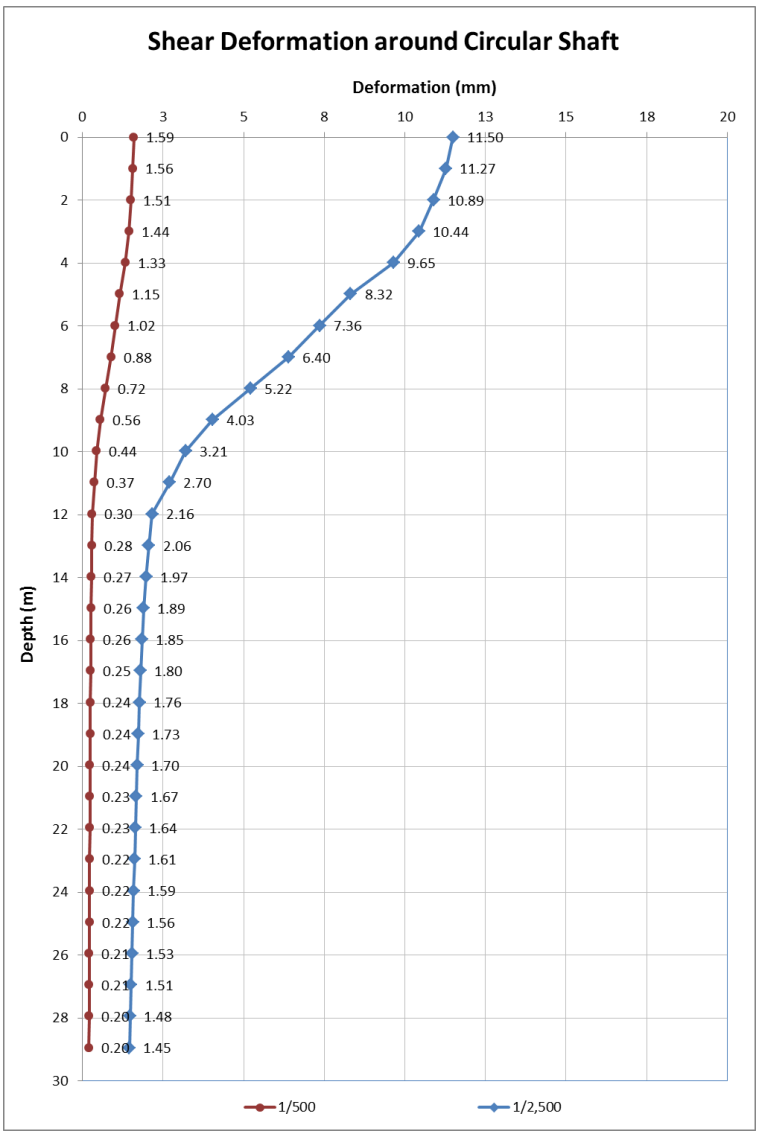


Figure 3 Lateral Deformation at Shaft Face

Based on Figure 3, the shaft is anticipated to rake laterally by 2mm at SLS and 10mm at ULS design seismic load conditions.

6.2 Ovaling

Ovaling of the shaft is assessed following the methodology as described in seismic design methodology DOC| DSLSC-DEL-REP-GT-J-100237 dated 09 Sep 2016.

The assessed Flexibility ratio (F) ranged from 3 to 17 in Tauranga soils, 34.8 in residual soils and 240 in ECBF rock.

- For residual soils and rock the flexibility ratio (F) of 34.8 and 240 respectively is more than 20, suggesting that the shaft-ground interaction effect can be ignored (Peck, 1972). It also suggests that the residual soils and rock is about 35 to 240 times respectively stiffer than the shaft permanent wall stiffness. In this case, the distortion to be experienced by the shaft permanent wall is assumed to be equal to those of the perforated ground (i.e., cavity in-place conditions - ΔD_{cavity}).
- For Tauranga soils the flexibility ratio, F ranged from 3 to 17, i.e. smaller than 20, suggesting shaft permanent wall is stiffer than the surrounding ground or shaft permanent wall stiffness is close or equal to the surrounding ground stiffness. The effect of soil-structure interaction must therefore be taken into consideration. In this case, the distortion to be experienced by the

shaft permanent wall is assumed to be equal to those of the non-perforated ground (i.e., $\Delta D_{free\text{-}field}$).

The assessed ovaling/distortion to be experienced by the shaft wall (ΔD_{cavity}) at 1m interval along the shaft depth is given in Appendix A. These values (Appendix A) shall be used for Soil Structural Interaction (SSI) analyses.

AECOM

Appendix A
Shaft Ovaling Deformation ΔD

CI Haycock Avenue Shaft

Shear Strain, γ_{max} for a 1/500 event

Ref: FHWA-NHI-10-034, Chapter 13

R_s = 0.25

Shaft Permanent Wall Properties

Concrete Elastic Modulus (MPa)	Lining thickness, t (m)	Moment of inertia, I_n (m^4)
25,000	0.30	2.3.E-03

Adjusted	1	Normalise	0.65
Not adjusted	0	Not normalise	1
	0	Mw = 7.5	1

D = 6.10m

Geological Unit	Depth	γ_t	Dynamic Shear Modulus, G	Dynamic Elastic Modulus, E	$\sigma_{v=}$ (γ_t x H)	PGA - SLS (1/500)	Adjustment factor, λ [based on Table 13-1]	Adjusted PGA [PGA x λ]	Stress reduction factor, r_d	Seismic Shear Stress, τ_{max}	Seimsic Shear Strain, γ_{max}	Flexibility Ratio, F [if F>20 use ΔD_{cavity}) [if F<20 use $\Delta D_{free-field}$)	ΔD_{cavity} $\Delta D_{cavity} = \pm 2\gamma_{max}(1-\nu_m)D$	$\Delta D_{free-field}$ $\Delta D_{free-field} = \pm(\gamma_{max}/2)D$
	m	kN/m^3	MPa	MPa	kPa	g				kPa	%		mm	mm
Made Ground (FILL)	0	15	20	56	15	0.043	1.0	0.043	1.01	24	0.12%	3.5	10.2	3.6
Taurunga Group (alluvium)	1	14	30	84	29	0.043	1.0	0.043	1.00	24	0.08%	5.2	6.7	2.4
	2	14	30	84	43	0.043	1.0	0.043	0.99	23	0.08%	5.2	6.7	2.4
	3	14	20	56	57	0.043	1.0	0.043	0.98	23	0.12%	3.5	9.9	3.5
	4	14	20	56	71	0.043	1.0	0.043	0.97	23	0.11%	3.5	9.8	3.5
	5	16	45	126	87	0.043	1.0	0.043	0.96	23	0.05%	7.8	4.3	1.5
	6	16	45	126	103	0.043	0.9	0.043	0.95	22	0.05%	7.8	4.3	1.5
	7	16	45	126	119	0.043	0.9	0.043	0.94	22	0.05%	7.8	4.2	1.5
	8	16	45	126	135	0.043	0.9	0.043	0.92	22	0.05%	7.8	4.1	1.5
	9	16	100	280	151	0.043	0.9	0.043	0.91	22	0.02%	17.4	1.8	0.7
RS of ECBF	10	18	200	560	169	0.043	0.9	0.043	0.90	21	0.01%	34.8	0.9	0.3
	11	18	200	560	187	0.043	0.9	0.043	0.88	21	0.01%	34.8	0.9	0.3
ECBF Rock	12	20	1380	3,864	207	0.033	0.9	0.033	0.87	16	0.00%	239.9	0.1	0.0
	13	20	1380	3,864	227	0.033	0.9	0.033	0.85	15	0.00%	239.9	0.1	0.0
	14	20	1380	3,864	247	0.033	0.9	0.033	0.84	15	0.00%	239.9	0.1	0.0
	15	20	1380	3,864	267	0.033	0.8	0.033	0.82	15	0.00%	239.9	0.1	0.0
	16	20	1380	3,864	287	0.033	0.8	0.033	0.81	15	0.00%	239.9	0.1	0.0
	17	20	1380	3,864	307	0.033	0.8	0.033	0.79	14	0.00%	239.9	0.1	0.0
	18	20	1380	3,864	327	0.033	0.8	0.033	0.78	14	0.00%	239.9	0.1	0.0
	19	20	1380	3,864	347	0.033	0.8	0.033	0.76	14	0.00%	239.9	0.1	0.0
	20	20	1380	3,864	367	0.033	0.8	0.033	0.75	14	0.00%	239.9	0.1	0.0
	21	20	1380	3,864	387	0.033	0.8	0.033	0.74	13	0.00%	239.9	0.1	0.0
	22	20	1380	3,864	407	0.033	0.8	0.033	0.72	13	0.00%	239.9	0.1	0.0
	23	20	1380	3,864	427	0.033	0.8	0.033	0.71	13	0.00%	239.9	0.1	0.0
	24	20	1380	3,864	447	0.033	0.8	0.033	0.70	13	0.00%	239.9	0.1	0.0
	25	20	1380	3,864	467	0.033	0.8	0.033	0.69	12	0.00%	239.9	0.1	0.0
	26	20	1380	3,864	487	0.033	0.8	0.033	0.68	12	0.00%	239.9	0.1	0.0
	27	20	1380	3,864	507	0.033	0.8	0.033	0.67	12	0.00%	239.9	0.1	0.0
	28	20	1380	3,864	527	0.033	0.8	0.033	0.66	12	0.00%	239.9	0.1	0.0
	29	20	1380	3,864	547	0.033	0.8	0.033	0.65	12	0.00%	239.9	0.1	0.0
	30	Invert Level												

CI Haycock Avenue Shaft

Shear Strain, γ_{max} for a 1/2500 event

Ref: FHWA-NHI-10-034, Chapter 13

R_s = 1.80

Adjusted	1	Normalise	0.65
Not adjusted	0	Not normalise	1
	0	**Mw = 7.5**	**1**

Shaft Permanent Wall Properties

Concrete Elastic Modulus (MPa)	Lining thickness, t (m)	Moment of inertia, I_n (m^4)
25,000	**0.30**	2.3.E-03

D = 6.10m

Geological Unit	Depth	γ_t	Dynamic Shear Modulus, G	Dynamic Elastic Modulus, E	$\sigma_{v=}$ (γ_t x H)	PGA - SLS (1/500)	Adjustment factor, λ [based on Table 13-1]	Adjusted PGA [PGA x λ]	Stress reduction factor, r_d	Seismic Shear Stress, τ_{max}	Seimsic Shear Strain, γ_{max}	Flexibility Ratio, F [if F>20 use ΔD_{cavity}) [if F<20 use $\Delta D_{free\text{-}field}$)	ΔD_{cavity} $\Delta D_{cavity} = \pm 2\gamma_{max}(1-\nu_m)D$	$\Delta D_{free\text{-}field}$ $\Delta D_{free-field} = \pm(\gamma_{max}/2)D$
	m	**kN/m^3**	**MPa**	**MPa**	**kPa**	**g**				**kPa**	**%**		**mm**	**mm**
Made Ground (FILL)	0	15	20	56	15	0.311	1.0	0.311	1.01	171	0.86%	3.5	73.1	26.1
Taurunga Group (alluvium)	1	14	30	84	29	0.311	1.0	0.311	1.00	170	0.57%	5.2	48.4	17.3
	2	14	30	84	43	0.311	1.0	0.311	0.99	169	0.56%	5.2	48.0	17.2
	3	14	20	56	57	0.311	1.0	0.311	0.98	167	0.84%	3.5	71.4	25.5
	4	14	20	56	71	0.311	1.0	0.311	0.97	165	0.83%	3.5	70.6	25.2
	5	16	45	126	87	0.311	1.0	0.311	0.96	164	0.36%	7.8	31.0	11.1
	6	16	45	126	103	0.311	0.9	0.311	0.95	162	0.36%	7.8	30.7	11.0
	7	16	45	126	119	0.311	0.9	0.311	0.94	159	0.35%	7.8	30.3	10.8
	8	16	45	126	135	0.311	0.9	0.311	0.92	157	0.35%	7.8	29.8	10.7
	9	16	100	280	151	0.311	0.9	0.311	0.91	155	0.15%	17.4	13.2	4.7
RS of ECBF	10	18	200	560	169	0.311	0.9	0.311	0.90	153	0.08%	34.8	6.5	2.3
	11	18	200	560	187	0.311	0.9	0.311	0.88	150	0.08%	34.8	6.4	2.3
ECBF Rock	12	20	1380	3,864	207	0.234	0.9	0.234	0.87	111	0.01%	239.9	0.7	0.2
	13	20	1380	3,864	227	0.234	0.9	0.234	0.85	109	0.01%	239.9	0.7	0.2
	14	20	1380	3,864	247	0.234	0.9	0.234	0.84	107	0.01%	239.9	0.7	0.2
	15	20	1380	3,864	267	0.234	0.8	0.234	0.82	105	0.01%	239.9	0.7	0.2
	16	20	1380	3,864	287	0.234	0.8	0.234	0.81	103	0.01%	239.9	0.6	0.2
	17	20	1380	3,864	307	0.234	0.8	0.234	0.79	101	0.01%	239.9	0.6	0.2
	18	20	1380	3,864	327	0.234	0.8	0.234	0.78	100	0.01%	239.9	0.6	0.2
	19	20	1380	3,864	347	0.234	0.8	0.234	0.76	98	0.01%	239.9	0.6	0.2
	20	20	1380	3,864	367	0.234	0.8	0.234	0.75	96	0.01%	239.9	0.6	0.2
	21	20	1380	3,864	387	0.234	0.8	0.234	0.74	94	0.01%	239.9	0.6	0.2
	22	20	1380	3,864	407	0.234	0.8	0.234	0.72	93	0.01%	239.9	0.6	0.2
	23	20	1380	3,864	427	0.234	0.8	0.234	0.71	91	0.01%	239.9	0.6	0.2
	24	20	1380	3,864	447	0.234	0.8	0.234	0.70	89	0.01%	239.9	0.6	0.2
	25	20	1380	3,864	467	0.234	0.8	0.234	0.69	88	0.01%	239.9	0.5	0.2
	26	20	1380	3,864	487	0.234	0.8	0.234	0.68	87	0.01%	239.9	0.5	0.2
	27	20	1380	3,864	507	0.234	0.8	0.234	0.67	85	0.01%	239.9	0.5	0.2
	28	20	1380	3,864	527	0.234	0.8	0.234	0.66	84	0.01%	239.9	0.5	0.2
	29	20	1380	3,864	547	0.234	0.8	0.234	0.65	83	0.01%	239.9	0.5	0.2
	30	Invert Level												

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Memorandum

To	Jason Chan, Narayana Srinivasan	Page	1 of 8
CC	Chris Treleaven		
Subject	Seismic Design of Dundale Ave Shaft - DSLSC002		
From	Crystal Ham (reviewed by Andrew Campbell)		
File/Ref No.		Date	06-Dec-2016 Rev. 01

1.0 Investigation Data

Geotechnical ground model for the seismic design of the DSLSC002 shaft at Dundale Avenue is based on following site investigation data (Table 1).

Table 1 Summary of Investigation Data

Investigation Type	Identification
Cone Penetration Test (CPTs)	L3S4-CPT01 to L3S4-CPT07
Scala Penetrometer (SP)	L3S4-SP01 to L3S4-SP04
Hand Augers (HAs)	L3S4-HA01
Borehole (BHs)	CI-33, BH240, BH241
Test Pit (TPs)	L3S4-TP01
Long section drawing	2012007.003, 2012007.004

2.0 Ground conditions

Based on competed site investigation data (Table 1), the inferred ground conditions generally comprised near surface made ground (FILL) underlain by Alluvium of undifferentiated Tauranga Group (TG), which is overlying the Residual Soils (RS) of ECBF. Beneath the RS is Moderately Weathered (MW) to Slightly Weathered (SW) ECBF rocks.

3.0 Site Subsoil Class

Using the shear velocity (V_s) data (inferred from CPTs), the site natural (fundamental) period (T_n) above the bed rock (ECBF) is assessed as 0.25sec (i.e. smaller than 0.6s but greater than 0.2 sec). This indicates the site subsoil class as 'C' (clause 3.1.3.4 NZS 1170.5:2004) at Dundale Avenue site instead of Class 'D' as mentioned in Table 6.1 of the GIR.

- For the seismic design of the DSLSC002 – Shaft and other structures at Dundale Avenue site the soil subsoil class is taken as 'C' in this memo.
- For the bed rock (ECBF) itself, the site subsoil class is assessed as 'B' – weak rock as unconfined compressive strength ranged from 1 to 10MPa.

4.0 Seismic Coefficient

The proposed design life of the structures is 100 years with importance level of 3. This required annual probability of exceedance of 1/25 for SLS and 1/2,500 for ULS design earthquake loading.

Using the:

- Hazard factor (Z) of 0.13 for Auckland;
- Return period factor (Rs, Ru) of 0.25 and 1.8 for 1/25 and 1/2,500 annual probability of exceedance respectively; and
- Site subsoil class factor of 1.33 for class C and 1 for class B; in

Equation 3.1 (1) of the NZS 1170:5 2004, the estimated seismic coefficients for seismic (structure) design of the DSLSB002 shaft are:

Table 2 Seismic Coefficient as per Site Subsoil Class

Site subsoil class	SLS - PGA	ULS - PGA
C (above the ECBF)	0.043g	0.311g
B (at ECBF)	0.033g	0.234g

5.0 Soil Liquefaction Risk

Based on liquefaction assessment using CPT data, potential liquefaction risk is developing at the shaft site from 4.5 to 6m depth.

For details on liquefaction analysis result and methodology refer to the GIR.

6.0 Seismic (Geotechnical) Design of the Shaft

6.1 Methodology

For details on seismic design methodology of the underground circular shaft refer to DOC| DSLSC-DEL-REP-GT-J-100237 dated 09 Sep 2016.

6.2 Raking

In order to assess the raking deformation of the shaft axis-symmetrical Pseudo-dynamic analysis are undertaken in Rocscience software RS2 version 9.

The ground model for the Pseudo-dynamic analysis is characterised on the basis of small strain (dynamic) shear modulus (G_s).

6.2.1 Dynamic Shear Modulus (Gs) Estimation

6.2.1.1 Methodology

In the absence of direct measurement of the dynamic shear modulus (G_s) following three well establish methods are used to estimate dynamic shear modulus (Gs) indirectly.

I) Downhole Geophysics

No downhole geophysical survey work has been undertaken in boreholes at this site.

II) Cone Penetration Test (CPT)

Indirect measurements of the dynamic shear modulus (G_s) from shear wave velocity of the geological units at DSLSB002 shaft is made using total cone resistance (q_t) of CPT data using following relationships:

$$G_s = V_s^2 \times \rho$$

Where:

ρ = mass density of the geological unit ($\rho = \gamma/g$), taken as 1.7 for Tauranga group and RS, 2.7 for Basalt and 2.0 for ECBF Rock.

V_s (m/sec) = shear wave velocity and is estimated from CPT data using following relationship:

$$V_s = [\alpha_{vs} \ (q_t - \sigma_v)/p_a]^{0.5} \ (m/s)$$

(Ref: Guide to Cone Penetration Testing 6th Edition 2015)

Where:

α_{vs} is a material factor and = $10^{(0.55Ic+1.68)}$, where *Ic* is soil behaviour

σ_v = soil overburden pressure; and

P_a is atmospheric pressure and taken as = 100kPa

III) Empirical Modulus Correlation

Dynamic shear modulus (G_s) of the geological units at DSLSC002 shaft is also estimated empirically by correlating it to static shear modulus (G_m) using following relationship:

$$G_s = 5 \text{ to } 9 \times G_m \text{ (Ref: Burt Look 2014)}$$

Where

G_m = static shear modulus and is estimated using following relationship:

$$E_m/[2(1+v_m)]$$

Where

E_m = Static elastic modulus taken as roughly 2 times of SPTN (from boreholes data) and adjusted further based on GIR design parameters Table 9.1.

6.2.1.2 Dynamic Shear Modulus

Using the above methodology, dynamic shear modulus (G_s) is assessed for following two ground conditions.

1. Without potential liquefaction risk
2. With potential liquefaction risk

The distribution of G_s vs depth along with best estimate design line for above two ground conditions is shown in Figure 1. The summary of the best estimate values of G_s for the pseudo-dynamic analysis is given in Table 3.

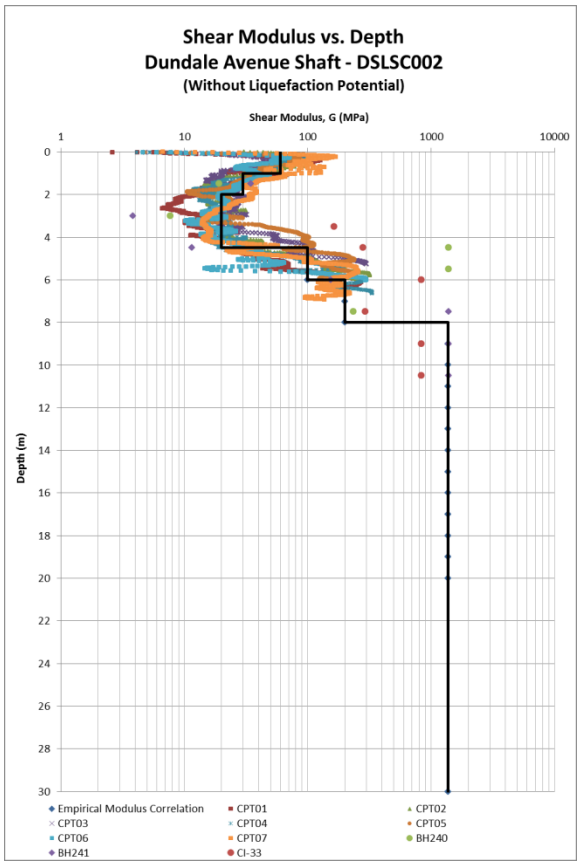
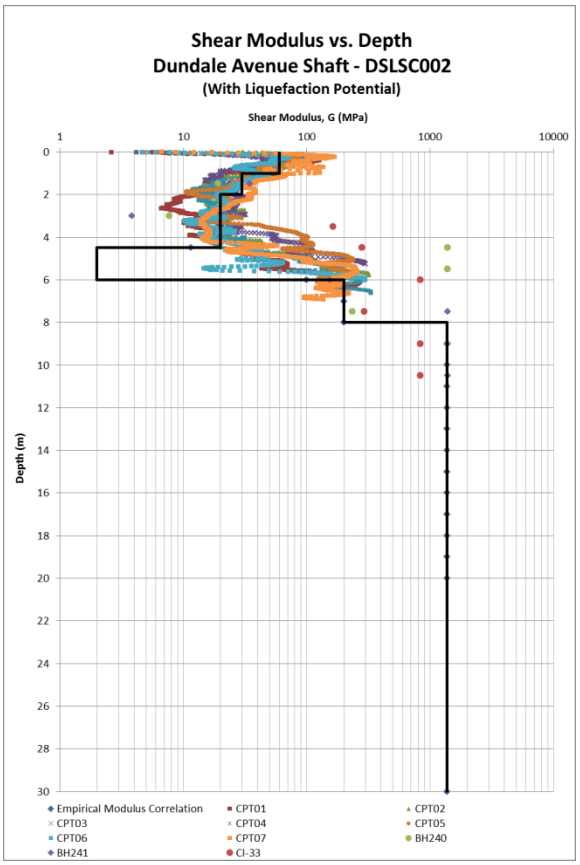
Without Liquefaction Potential	With Liquefaction Potential
	

Figure 1 Dynamic Shear Modulus Profile

Table 3 Summary of Dynamic Shear Modulus (Gs)

Without Liquefaction Potential		With Liquefaction Potential	
Depth (m)	**G_s (MPa)**	**Depth (m)**	**G_s (MPa)**
0 to 1	60	0 to 1	60
1 to 2	30	1 to 2	30
2 to 4.5	20	2 to 4.5	20
4.5 to 6	100	4.5 to 6	2
6 to 8	200	6 to 8	200
8 to invert	1380	8 to invert	1380

6.2.2 Pseudo-Dynamic Analysis

The pseudo-dynamic analysis are undertaken in Rocscience software RS2 version 9 using the methodology as described in seismic design methodology DOC| DSLSC-DEL-REP-GT-J-100237 dated 09 Sep 2016.

The pseudo-dynamic analysis model mesh of the Dundale Ave DSLSC002 shaft with boundary conditions assumption is shown in Figure 2. The lateral deformation at shaft face is extracted and plotted against shaft depth and shown in Figure 3.

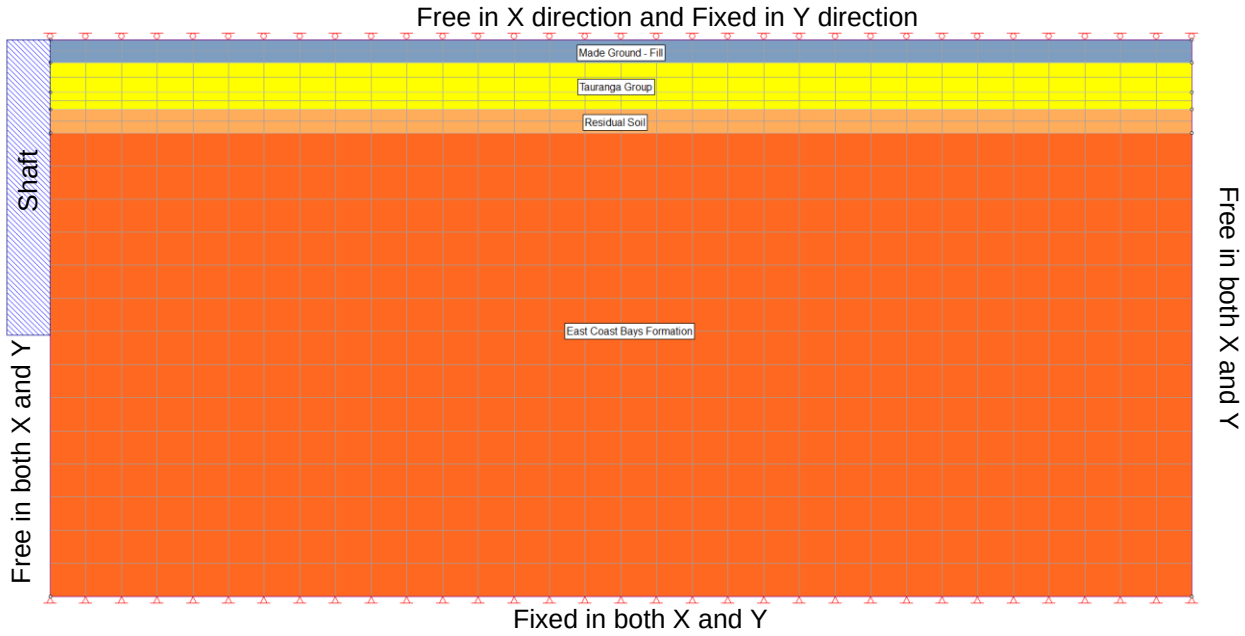


Figure 2 Pseudo-Dynamic Analysis Model with Boundary Conditions Assumptions for Raking Effect

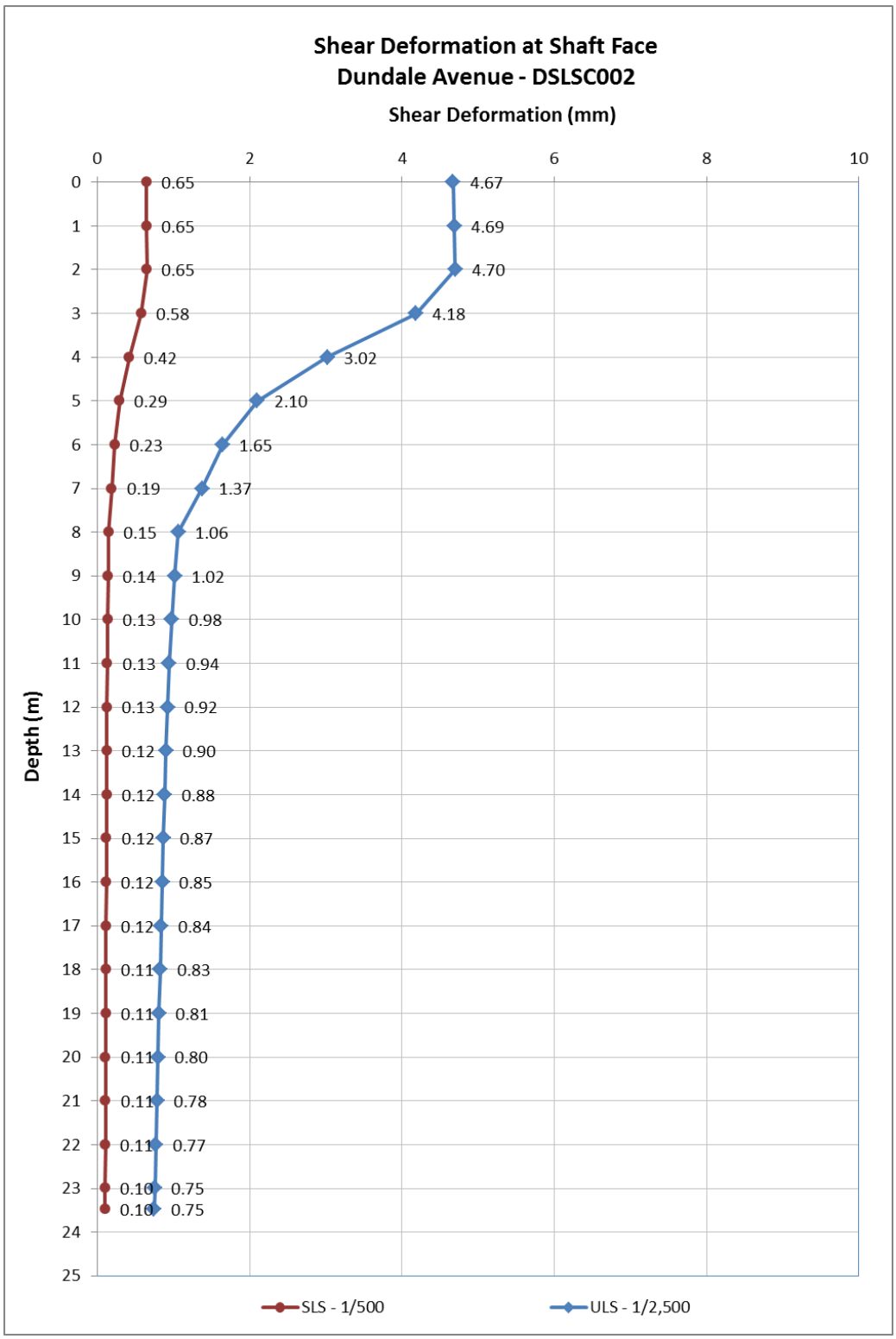


Figure 3 Lateral Deformation at Shaft Face

Based on Figure 3, the shaft is anticipated to rake laterally by 0.5mm at SLS and 4mm at ULS design seismic load conditions.

6.3 Ovaling

Ovaling of the shaft is assessed following the methodology as described in seismic design methodology DOC| DSLSC-DEL-REP-GT-J-100237 dated 09 Sep 2016.

The assessed Flexibility ratio (F) ranged from 0.5 to 2.4 in Tauranga Group soils, 4.9 in residual soils and 33.7 in ECBF rock.

- For residual soils and rock with a flexibility ratio (F) of more than 20, it suggests that the shaft-ground interaction effect can be ignored (Peck, 1972). It also suggests that ECBF rock is about 34 times respectively stiffer than the shaft permanent wall stiffness. In this case, the distortion to be experienced by the shaft permanent wall is assumed to be equal to those of the perforated ground (i.e., cavity in-place conditions - ΔD_{cavity}).
- For Tauranga Group soils and residual soils with a flexibility ratio (F) smaller than 20, it suggests that the shaft permanent wall is stiffer than the surrounding ground or shaft permanent wall stiffness is close or equal to the surrounding ground stiffness. The effect of soil-structure interaction must therefore be taken into consideration. In this case, the distortion to be experienced by the shaft permanent wall is assumed to be equal to those of the non-perforated ground (i.e., $\Delta D_{free\text{-}field}$).

Considering the permanent shaft diameter of 3.7m, the assessed ovaling/distortion to be experienced by the shaft wall (ΔD) during the SLS and ULS seismic loading at 1m interval depth along the shaft is given in Appendix A. These values (Appendix A) shall be used for Soil Structural Interaction (SSI) analyses by structure engineers.

Appendix A
Shaft Ovaling Deformation (ΔD)

DSLSC002 Shaft at Dundale Avenue

Shear Strain, γ_{max} **SLS** **1/500 event**

Ref: FHWA-NHI-10-034, Chapter 13

Site SubSoil Class **$C_{h(T=0)}$ = 1.33** **'C'**

R_s = 0.25

Adjusted	1	Normalise	0.65
Not adjusted	0	Not normalise	1
	0	**Mw = 7.5**	**1**

Shaft Permanent Wall Properties

Concrete Elastic Modulus (MPa)	Lining thickness, t (m)	Moment of inertia, I_n (m^4)
25,000	**0.35**	3.6.E-03

D = 3.70m

Geological Unit	Depth	γ_t	Dynamic Shear Modulus, G	Dynamic Elastic Modulus, E	$\sigma_{v=}$ (γ_t x H)	PGA - SLS (1/500)	Adjustment factor, λ [based on Table 13-1]	Adjusted PGA [PGA x λ]	Stress reduction factor, r_d	Seismic Shear Stress, τ_{max}	Seimsic Shear Strain, γ_{max}	Flexibility Ratio, F [if F>20 use ΔD_{cavity}) [if F<20 use $\Delta D_{free\text{-}field}$)	ΔD_{cavity} $\Delta D_{cavity} = \pm 2\gamma_{max}(1-\nu_m)D$	$\Delta D_{free\text{-}field}$ $\Delta D_{free-field} = \pm(\gamma_{max}/2)D$
	m	kN/m^3	MPa	MPa	kPa	g				kPa	%		mm	mm
Made Ground (FILL)	0	18	60	168	18	0.043	1.0	0.043	1.01	19	0.03%	1.5	1.7	0.6
	1	18	30	84	36	0.043	1.0	0.043	1.00	19	0.06%	0.7	3.3	1.2
Tauranga Group	2	17	20	56	53	0.043	1.0	0.043	0.99	19	0.09%	0.5	4.9	1.7
	3	17	20	56	70	0.043	1.0	0.043	0.98	19	0.09%	0.5	4.8	1.7
	4	17	20	56	78.5	0.043	1.0	0.043	0.97	18	0.09%	0.5	4.8	1.7
	4.5	17	21	59	87	0.043	1.0	0.043	0.97	18	0.09%	0.5	4.5	1.6
	5	17	100	280	104	0.043	1.0	0.043	0.96	18	0.02%	2.4	0.9	0.3
RS of ECBF	6	18	200	560	122	0.043	0.9	0.043	0.95	18	0.01%	4.9	0.5	0.2
	7	18	200	560	140	0.043	0.9	0.043	0.94	18	0.01%	4.9	0.5	0.2
ECBF Rock	8	20	1380	3,864	160	0.033	0.9	0.033	0.92	13	0.00%	33.7	0.0	0.0
	9	20	1380	3,864	180	0.033	0.9	0.033	0.91	13	0.00%	33.7	0.0	0.0
	10	20	1380	3,864	200	0.033	0.9	0.033	0.90	13	0.00%	33.7	0.0	0.0
	11	20	1380	3,864	220	0.033	0.9	0.033	0.88	13	0.00%	33.7	0.0	0.0
	12	20	1380	3,864	240	0.033	0.9	0.033	0.87	12	0.00%	33.7	0.0	0.0
	13	20	1380	3,864	260	0.033	0.9	0.033	0.85	12	0.00%	33.7	0.0	0.0
	14	20	1380	3,864	280	0.033	0.9	0.033	0.84	12	0.00%	33.7	0.0	0.0
	15	20	1380	3,864	300	0.033	0.8	0.033	0.82	12	0.00%	33.7	0.0	0.0
	16	20	1380	3,864	320	0.033	0.8	0.033	0.81	12	0.00%	33.7	0.0	0.0
	17	20	1380	3,864	340	0.033	0.8	0.033	0.79	11	0.00%	33.7	0.0	0.0
	18	20	1380	3,864	360	0.033	0.8	0.033	0.78	11	0.00%	33.7	0.0	0.0
	19	20	1380	3,864	380	0.033	0.8	0.033	0.76	11	0.00%	33.7	0.0	0.0
	20	20	1380	3,864	400	0.033	0.8	0.033	0.75	11	0.00%	33.7	0.0	0.0
	21	20	1380	3,864	420	0.033	0.8	0.033	0.74	11	0.00%	33.7	0.0	0.0
	22	20	1380	3,864	440	0.033	0.8	0.033	0.72	10	0.00%	33.7	0.0	0.0
	23	Invert Level										0.0	-	-

DSLSC002 Shaft at Dundale Avenue

Shear Strain, γ_{max} **ULS** **1/2,500 event**

Ref: FHWA-NHI-10-034, Chapter 13

Site SubSoil Class **$C_{h(T=0)}$ = 1.33** **'C'**

R_u = 1.80

Adjusted	1	Normalise	0.65
Not adjusted	0	Not normalise	1
	0	**Mw = 7.5**	**1**

Shaft Permanent Wall Properties

Concrete Elastic Modulus (MPa)	Lining thickness, t (m)	Moment of inertia, I_n (m^4)
25,000	**0.35**	3.6.E-03

D = 3.70m

Geological Unit	Depth	γ_t	Dynamic Shear Modulus, G	Dynamic Elastic Modulus, E	σ_v = (γ_t x H)	PGA - ULS (1/2,500)	Adjustment factor, λ [based on Table 13-1]	Adjusted PGA [PGA x λ]	Stress reduction factor, r_d	Seismic Shear Stress, τ_{max}	Seimsic Shear Strain, γ_{max}	Flexibility Ratio, F [if F>20 use ΔD_{cavity}] [if F<20 use $\Delta D_{free\text{-}field}$]	ΔD_{cavity} $\Delta D_{cavity} = \pm 2\gamma_{max}(1-\nu_m)D$	$\Delta D_{free\text{-}field}$ $\Delta D_{free-field} = \pm(\gamma_{max}/2)D$
	m	kN/m^3	MPa	MPa	kPa	g				kPa	%		mm	mm
Made Ground (FILL)	0	18	60	168	18	0.311	1.0	0.3112	1.01	138	0.23%	1.5	11.9	4.2
	1	18	30	84	36	0.311	1.0	0.3112	1.00	137	0.46%	0.7	23.6	8.4
Tauranga Group	2	17	20	56	53	0.311	1.0	0.3112	0.99	136	0.68%	0.5	35.1	12.6
	3	17	20	56	70	0.311	1.0	0.3112	0.98	134	0.67%	0.5	34.8	12.4
	4	17	20	56	87	0.311	1.0	0.3112	0.97	133	0.67%	0.5	34.5	12.3
	4.5	17	100	280	113	0.311	1.0	0.3112	0.97	132	0.13%	2.4	6.9	2.4
	5	17	100	280	104	0.311	1.0	0.3112	0.96	132	0.13%	2.4	6.8	2.4
RS of ECBF	6	18	200	560	122	0.311	0.9	0.3112	0.95	130	0.06%	4.9	3.4	1.2
	7	18	200	560	140	0.311	0.9	0.3112	0.94	128	0.06%	4.9	3.3	1.2
ECBF Rock	8	20	1380	3,864	160	0.234	0.9	0.2340	0.92	95	0.01%	33.7	0.4	0.1
	9	20	1380	3,864	180	0.234	0.9	0.2340	0.91	94	0.01%	33.7	0.4	0.1
	10	20	1380	3,864	200	0.234	0.9	0.2340	0.90	92	0.01%	33.7	0.3	0.1
	11	20	1380	3,864	220	0.234	0.9	0.2340	0.88	91	0.01%	33.7	0.3	0.1
	12	20	1380	3,864	240	0.234	0.9	0.2340	0.87	89	0.01%	33.7	0.3	0.1
	13	20	1380	3,864	260	0.234	0.9	0.2340	0.85	88	0.01%	33.7	0.3	0.1
	14	20	1380	3,864	280	0.234	0.9	0.2340	0.84	86	0.01%	33.7	0.3	0.1
	15	20	1380	3,864	300	0.234	0.8	0.2340	0.82	85	0.01%	33.7	0.3	0.1
	16	20	1380	3,864	320	0.234	0.8	0.2340	0.81	83	0.01%	33.7	0.3	0.1
	17	20	1380	3,864	340	0.234	0.8	0.2340	0.79	82	0.01%	33.7	0.3	0.1
	18	20	1380	3,864	360	0.234	0.8	0.2340	0.78	80	0.01%	33.7	0.3	0.1
	19	20	1380	3,864	380	0.234	0.8	0.2340	0.76	79	0.01%	33.7	0.3	0.1
	20	20	1380	3,864	400	0.234	0.8	0.2340	0.75	77	0.01%	33.7	0.3	0.1
	21	20	1380	3,864	420	0.234	0.8	0.2340	0.74	76	0.01%	33.7	0.3	0.1
	22	20	1380	3,864	440	0.234	0.8	0.2340	0.72	75	0.01%	33.7	0.3	0.1
	23	Invert Level										0.0	0.0	0.0

Memorandum

To	Jason Chan, Narayana Srinivasan	Page	1 of 6
CC	Chris Treleaven, Andrew Campbell		
Subject	Seismic Design of Miranda Street Shaft - DSLSC004		
From	Ham Crystal (reviewed by Sajjad Anwar)		
File/Ref No.		Date	22-Sep-2016 Rev. 01

1.0 Investigation Data

Geotechnical ground model for the seismic design of the Miranda Street shaft is based on following site investigation data.

Table 1 Summary of Investigation Data

Investigation Type	Identification
Cone Penetration test (CPT)	L3S2-CPT02, L3S2-CPT03, L3S2-CPT04, L3S2-CPT05, L3S2-CPT06, L3S2-CPT07
Scala Penetrometer (SP)	L3S2-SP01, L3S2-SP02, L3S2-SP03, L3S2-SP04,
Hand Augers (HA)	L3S2-HA01
Borehole (BH)	BH237, BH238
Test Pit (TP)	L3S2-TP01, L3S2-TP02
Long section drawing	2012009.003, 2012009.004

2.0 Ground conditions

Based on competed site investigation data (Table 1), the inferred ground conditions generally comprised of Made ground (FILL) overlying undifferentiated Tauranga Group (TG) over the Residual Soils (RS) of ECBF. Residual soils are underlain by Moderately Weathered to Un-weathered ECBF (ECBF-ROCK).

3.0 Site Subsoil Class

Using the shear velocity (V_s) data (inferred from CPT data), the site natural (fundamental) period (T_n) above the bed rock (ECBF) is assessed in the range of 0.21 to 0.37sec (i.e. smaller than 0.6s but greater than 0.2 sec). This indicates site subsoil class as 'C' (clause 3.1.3.4 NZS 1170.5:2004) instead of Class 'D' as mentioned in Table 6.1 of the GIR.

- For the seismic design of the Miranda Reserve shaft in this memo the soil subsoil class is taken as 'C'
- For the bed rock (ECBF) itself, the site subsoil class is assessed as 'B' – weak rock as unconfined compressive strength is between 1 to 10MPa.

4.0 Seismic Coefficient

The proposed design life of the structures is 100 years with importance level of 3. This required annual probability of exceedance of 1/25 for SLS and 1/2,500 for ULS design earthquake loading.

Using the:

- Hazard factor (Z) of 0.13 for Auckland;
- Return period factor (Rs, Ru) of 0.25 and 1.8 for 1/25 and 1/2,500 annual probability of exceedance respectively; and

- Site subsoil class factor of 1.33 for class C and 1 for class B; in

Equation 3.1 (1) of the NZS 1170:5 2004, the estimated seismic coefficients for seismic design of the shaft at Miranda Reserve shaft are:

Table 2 Seismic Coefficient as per Site Subsoil Class

Site subsoil class	SLS - PGA	ULS - PGA
C (above the ECBF)	0.043g	0.311g
B (at ECBF)	0.033g	0.234g

5.0 Soil Liquefaction Risk

Based on liquefaction assessment using CPT data, potential liquefaction risk is developing at the shaft site from 2m to 8m depth. For details on liquefaction analysis result and methodology refer to the GIR.

6.0 Seismic Design of the Shaft

For details on seismic design methodology of the underground circular shaft refer to DOC| DSLSC-DEL-REP-GT-J-100237 dated 09 Sep 2016.

6.1 Raking

In order to assess the raking deformation of the shaft axis-symmetrical Pseudo-dynamic analysis are undertaken in Rocscience software RS2 version 9.

The ground model for the Pseudo-dynamic analysis is characterised on the basis of small strain (dynamic) shear modulus (G_s).

6.1.1 Input Parameters

In the absence of direct measurement of shear wave velocity of the geological units at Norgrove Ave shaft site, attempts are made to relate dynamic shear modulus (G_s) to (i) shear wave velocity (V_s) and (ii) static shear modulus using following relationships:

i. $G_s = V_s^2 \times \rho$

Where

V_s (m/sec) = shear wave velocity and is estimated from CPT data using following relationship:

$V_s = [\alpha_{vs}\ (q_t - \sigma_v)/p_a]^{0.5}$ (m/s); where $\alpha_{vs} = 10^{(0.55\,Ic + 1.68)}$ (Ref: Guide to Cone Penetration Testing 6th Edition 2015)

ρ = mass density of the geological unit ($\rho = \gamma/g$), taken as 1.7 for Tauranga group, 2.7 for Basalt and 2.0 for ECBF Rock.

ii. $G_s = 5 \times G_m$ (Ref: Burt Look 2014)

Where

G_m = static shear modulus and is estimated using following relationship

$E_m/[2(1+v_m)]$

Where

E_m = ground static Young's modulus taken as roughly 2 times of SPTN (from boreholes) and adjusted further based on GIR design parameters Table 9.1.

v_m = Poisson's ratio of the geological units (GIR design parameters Table 9.1)

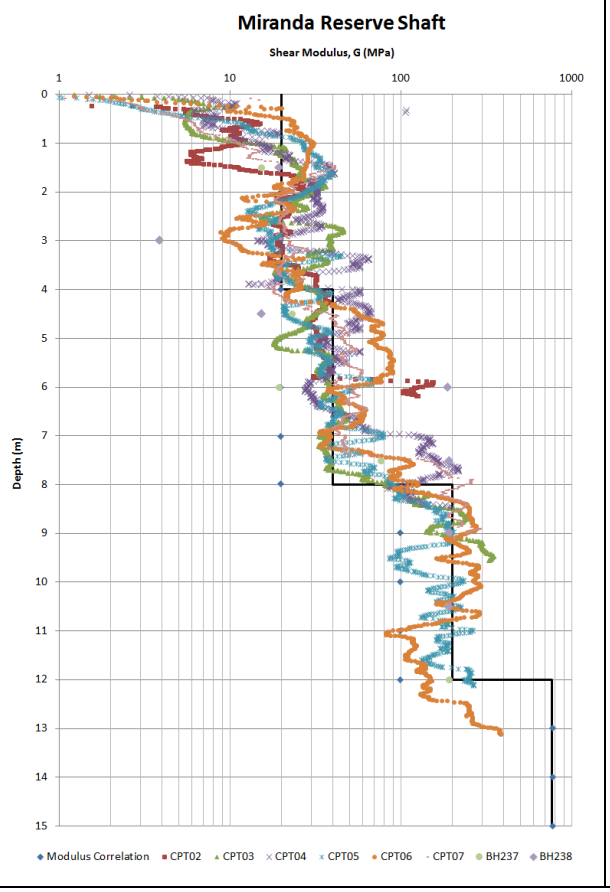
Dynamic Shear modulus (V_s) is assessed for following two ground conditions.

1. Without Liquefaction Potential
2. With Liquefaction Potential

Due to comparatively better repeatability and relative less destructive in testing nature the G_s values estimated from CPT data took the preference on SPT-N data.

The distribution of G_s with depth for above two ground conditions is shown in Figure 1 with the summary of the proposed G_s values for the analysis model are given in Table 3.

Without Liquefaction Potential	With Liquefaction Potential



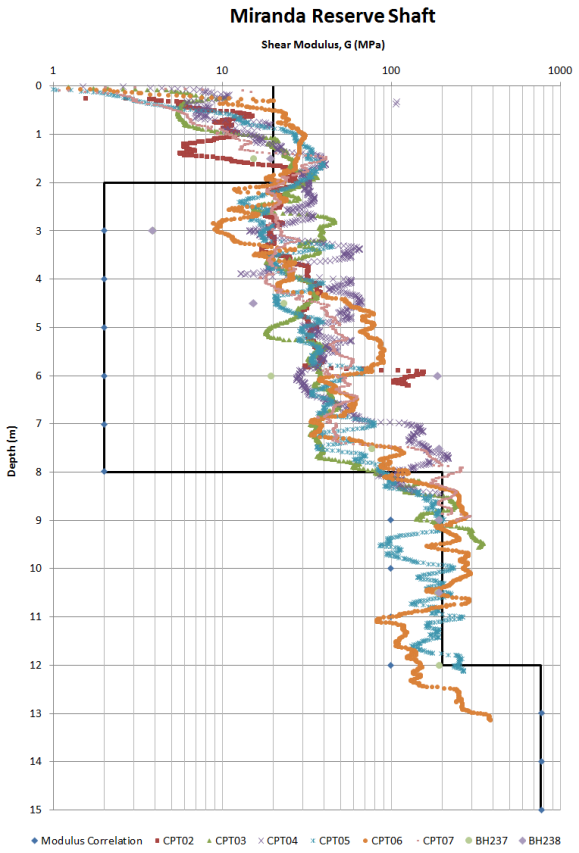


Figure 1 Dynamic Shear Modulus Profile

Table 3 Summary of Dynamic Shear Modulus

Without Liquefaction Potential		With Liquefaction Potential	
Depth (m)	**G_s (MPa)**	**Depth (m)**	**G_s (MPa)**
0 to 4	20	0 to 2	20
4 to 8	40	2 to 8	2
8 to 12	200	8 to 12	200
12 to invert	770	12 to invert	770

6.1.2 Pseudo-Dynamic Analysis

The pseudo-dynamic analysis are undertaken in Rocscience software RS2 version 9 using the methodology as described in seismic design methodology DOC| DSLSC-DEL-REP-GT-J-100237 dated 09 Sep 2016.

The pseudo-dynamic analysis model mesh of the Miranda shaft with boundary conditions assumption is shown in Figure 2. The lateral deformation at shaft face is extracted and plotted against shaft depth as shown in Figure 3.

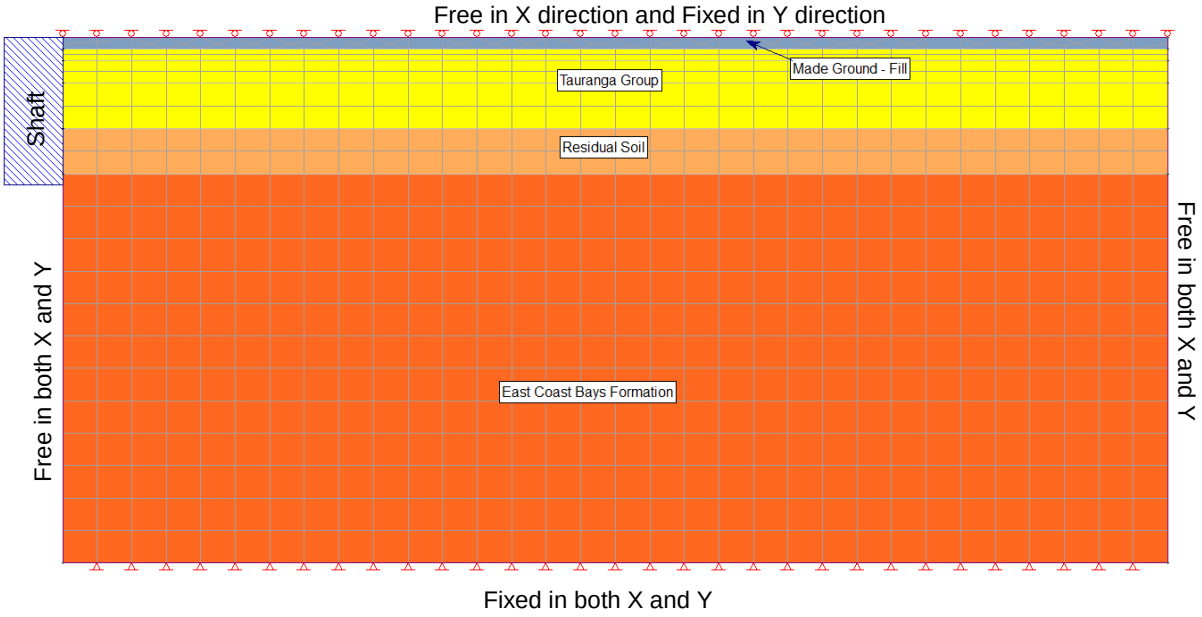


Figure 2 Pseudo-Dynamic Analysis Model with Boundary Conditions Assumptions for Raking Effect

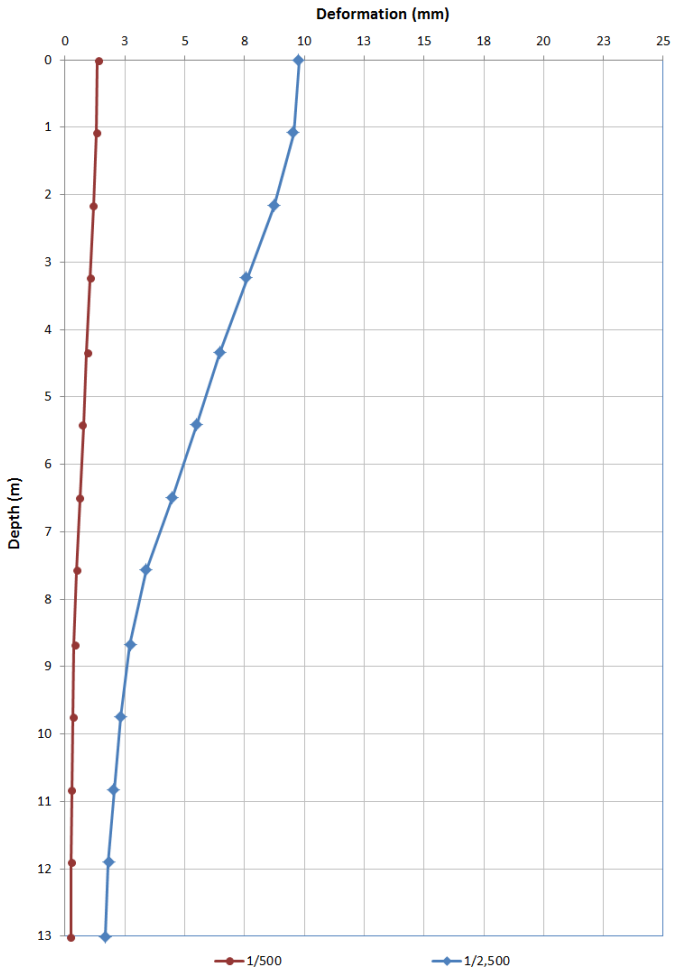


Figure 3 Lateral Deformation at Shaft Face

Based on Figure 3, the shaft is anticipated to rake laterally by 2mm at SLS and 8mm at ULS design seismic load conditions.

6.2 Ovaling

Ovaling of the shaft is assessed following the methodology as described in seismic design methodology DOC| DSLSC-DEL-REP-GT-J-100237 dated 09 Sep 2016.

The assessed Flexibility ratio (F) ranged from 2 to 4 in Tauranga soils, 20.3 in residual soils and 78 in ECBF rock.

- For residual soils and rock the flexibility ratio (F) of 20.3 and 78 respectively is more than 20, suggesting that the shaft-ground interaction effect can be ignored (Peck, 1972). It also suggests that the residual soils and rock is about 20 to 78 times respectively stiffer than the shaft permanent wall stiffness. In this case, the distortion to be experienced by the shaft permanent wall is assumed to be equal to those of the perforated ground (i.e., cavity in-place conditions - ΔD_{cavity}).
- For Tauranga soils the flexibility ratio, F ranged from 2 to 4, i.e. smaller than 20, suggesting shaft permanent wall is stiffer than the surrounding ground or shaft permanent wall stiffness is close or equal to the surrounding ground stiffness. The effect of soil-structure interaction must therefore be taken into consideration. In this case, the distortion to be experienced by the shaft permanent wall is assumed to be equal to those of the non-perforated ground (i.e., $\Delta D_{free\text{-}field}$).

The assessed ovaling/distortion to be experienced by the shaft wall (ΔD_{cavity}) at 1m interval along the shaft depth is given in Appendix A. These values (Appendix A) shall be used for Soil Structural Interaction (SSI) analyses.

Appendix A
Shaft Ovaling Deformation ΔD

CI Miranda Reserve Shaft

Shear Strain, γ_{max} for a 1/500 event

Ref: FHWA-NHI-10-034, Chapter 13

R_s = 0.25

Adjusted	1	Normalise	0.65
Not adjusted	0	Not normalise	1
	0	**Mw = 7.5**	**1**

Geological Unit	Depth	γ_t	Dynamic Shear Modulus, G	Dynamic Elastic Modulus, E	$\sigma_{v'}$ = (γ_t x H)	PGA - SLS (1/500)	Adjustment factor, λ [based on Table 13-1]	Adjusted PGA [PGA x λ]	Stress reduction factor, r_d	Seismic Shear Stress, τ_{max}	Seimsic Shear Strain, γ_{max}
	m	kN/m^3	MPa	MPa	kPa	g				kPa	%
Made Ground (FILL)	0	15	20	56	15	0.043	1.0	0.043	1.01	10	0.05%
Taurunga Group (alluviun	1	16	20	56	31	0.043	1.0	0.043	1.00	9	0.05%
	2	16	20	56	47	0.043	1.0	0.043	0.99	9	0.05%
	3	16	20	56	63	0.043	1.0	0.043	0.98	9	0.05%
	4	16	40	112	79	0.043	1.0	0.043	0.97	9	0.02%
	5	16	40	112	95	0.043	1.0	0.043	0.96	9	0.02%
	6	16	40	112	111	0.043	0.9	0.043	0.95	9	0.02%
	7	16	40	112	127	0.043	0.9	0.043	0.94	9	0.02%
RS of ECBF	8	18	200	560	145	0.043	0.9	0.043	0.92	9	0.00%
	9	18	200	560	163	0.043	0.9	0.043	0.91	9	0.00%
	10	18	200	560	181	0.043	0.9	0.043	0.90	8	0.00%
	11	18	200	560	199	0.043	0.9	0.043	0.88	8	0.00%
ECBF Rock	12	20	770	2,156	219	0.033	0.9	0.033	0.87	6	0.00%
	13	Invert Level									

Shaft Permanent Wall Properties

Concrete Elastic Modulus (MPa)	Lining thickness, t (m)	Moment of inertia, I_n (m^4)
25,000	**0.30**	2.3.E-03

D = 5.10m

Flexibility Ratio, F [if F>20 use ΔD_{cavity}) [if F<20 use $\Delta D_{free\text{-}field}$)	ΔD_{cavity} $\Delta D_{cavity} = \pm 2\gamma_{max}(1-\nu_m)D$	$\Delta D_{free\text{-}field}$ $\Delta D_{free-field} = \pm(\gamma_{max}/2)D$
	mm	mm
2.0	3.4	1.2
2.0	3.4	1.2
2.0	3.3	1.2
2.0	3.3	1.2
4.1	1.6	0.6
4.1	1.6	0.6
4.1	1.6	0.6
4.1	1.6	0.6
20.3	0.3	0.1
20.3	0.3	0.1
20.3	0.3	0.1
20.3	0.3	0.1
78.2	0.1	0.0

CI Miranda Reserve Shaft

Shear Strain, γ_{max} for a 1/2,500 event

Ref: FHWA-NHI-10-034, Chapter 13

R_u = 1.80

Adjusted	1	Normalise	0.65
Not adjusted	0	Not normalise	1
	0	**Mw = 7.5**	**1**

Shaft Permanent Wall Properties

Concrete Elastic Modulus (MPa)	Lining thickness, t (m)	Moment of inertia, I_n (m^4)
25,000	**0.30**	2.3.E-03

D = 5.10m

Geological Unit	Depth	γ_t	Dynamic Shear Modulus, G	Dynamic Elastic Modulus, E	σ_{v} = (γ_t x H)	PGA - SLS (1/500)	Adjustment factor, λ [based on Table 13-1]	Adjusted PGA [PGA x λ]	Stress reduction factor, r_d	Seismic Shear Stress, τ_{max}	Seimsic Shear Strain, γ_{max}	Flexibility Ratio, F [if F>20 use ΔD_{cavity}) [if F<20 use $\Delta D_{free\text{-}field}$)	ΔD_{cavity} $\Delta D_{cavity} = \pm 2\gamma_{max}(1-\nu_m)D$	$\Delta D_{free\text{-}field}$ $\Delta D_{free-field} = \pm(\gamma_{max}/2)D$
	m	kN/m^3	MPa	MPa	kPa	g				kPa	%		mm	mm
Made Ground (FILL)	0	15	20	56	15	0.311	1.0	0.3112	1.01	69	0.34%	2.0	24.5	8.7
Taurunga Group (alluvium	1	16	20	56	31	0.311	1.0	0.3112	1.00	68	0.34%	2.0	24.3	8.7
	2	16	20	56	47	0.311	1.0	0.3112	0.99	68	0.34%	2.0	24.1	8.6
	3	16	20	56	63	0.311	1.0	0.3112	0.98	67	0.33%	2.0	23.9	8.5
	4	16	40	112	79	0.311	1.0	0.3112	0.97	66	0.17%	4.1	11.8	4.2
	5	16	40	112	95	0.311	1.0	0.3112	0.96	65	0.16%	4.1	11.7	4.2
	6	16	40	112	111	0.311	0.9	0.3112	0.95	65	0.16%	4.1	11.5	4.1
	7	16	40	112	127	0.311	0.9	0.3112	0.94	64	0.16%	4.1	11.4	4.1
RS of ECBF	8	18	200	560	145	0.311	0.9	0.3112	0.92	63	0.03%	20.3	2.2	0.8
	9	18	200	560	163	0.311	0.9	0.3112	0.91	62	0.03%	20.3	2.2	0.8
	10	18	200	560	181	0.311	0.9	0.3112	0.90	61	0.03%	20.3	2.2	0.8
	11	18	200	560	199	0.311	0.9	0.3112	0.88	60	0.03%	20.3	2.1	0.8
ECBF Rock	12	20	770	2,156	219	0.234	0.9	0.2340	0.87	44	0.01%	78.2	0.4	0.1
	13	Invert Level												

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Memorandum

To	Jason Chan, Narayana Srinivasan	Page	1 of 6
CC	Chris Treleaven, Andrew Campbell		
Subject	Seismic Design of PS25 Shaft - DSLSC005		
From	Crystal Ham (reviewed by Sajjad Anwar)		
File/Ref No.		Date	30-Sep-2016 Rev. 02

1.0 Investigation Data

Geotechnical ground model for the seismic geotechnical design of the DSLSC005 shaft is based on following site investigation data.

Table 1 Summary of Investigation Data surrounding the DSLSC005 Shaft

Investigation Type	Identification
Cone Penetration test (CPT)	L3S1-CPT01, L3S1-CPT02, L3S1-CPT03, L3S1-CPT05, L3S1-CPT10
Scala Penetrometer (SP)	-
Hand Augers (HA)	-
Borehole (BH)	BH235, BH236(Note 1), BH421
Test Pit (TP)	-
Long section drawing	2012010.003, 2012010.004, 2012004.003

Notes:
1. Velocity is measured in BH using downhole geophysics

2.0 Ground conditions

Based on competed site investigation data (Table 1), the inferred ground conditions generally comprised of Made ground (FILL) overlying undifferentiated Tauranga Group (TG) over the Residual Soils (RS) of ECBF. Residual soils are underlain by Moderately Weathered to Un-weathered ECBF (ECBF-ROCK).

3.0 Site Subsoil Class

Using the shear velocity (V_s) data (inferred from CPT data), the site natural (fundamental) period (T_n) above the bed rock (ECBF) is assessed in the range of 0.25 to 0.48sec (i.e. smaller than 0.6s but greater than 0.2 sec). This indicates site subsoil class as 'C' (clause 3.1.3.4 NZS 1170.5:2004) instead of Class 'D' as mentioned in Table 6.1 of the GIR.

- For the seismic design of the DSLSC005 shaft the soil subsoil class is taken as 'C' in this memo.
- For the bed rock (ECBF) itself, the site subsoil class is assessed as 'B' – weak rock as unconfined compressive strength ranged from 1 to 10MPa.

4.0 Seismic Coefficient

The proposed design life of the structures is 100 years with importance level of 3. This required annual probability of exceedance of 1/25 for SLS and 1/2,500 for ULS design earthquake loading.

Using the:

- Hazard factor (Z) of 0.13 for Auckland;

- Return period factor (Rs, Ru) of 0.25 and 1.8 for 1/25 and 1/2,500 annual probability of exceedance respectively; and
- Site subsoil class factor of 1.33 for class 'C' and 1 for class B;

In equation 3.1 (1) of the NZS 1170:5 2004, the estimated seismic coefficients for seismic design of the shaft at PS25 site are:

Table 2 Seismic Coefficient as per Site Subsoil Class

Site subsoil class	SLS - PGA	ULS - PGA
C (above the ECBF)	0.043g	0.311g
B (at ECBF)	0.033g	0.234g

5.0 Soil Liquefaction Risk

Based on liquefaction assessment using CPT data, potential liquefaction risk is developing at the shaft site from 5m to 6m and 8m to 11m depth. For details on liquefaction analysis result and methodology refer to the GIR.

6.0 Seismic (Geotechnical) Design of the Shaft

6.1 Methodology

For details on seismic design methodology of the underground circular shaft refer to DOC| DSLSC-DEL-REP-GT-J-100237 dated 09 Sep 2016.

6.2 Raking

In order to assess the raking deformation of the shaft axis-symmetrical Pseudo-dynamic analysis are undertaken in Rocscience software RS2 version 9.

The ground model for the Pseudo-dynamic analysis is characterised on the basis of small strain (dynamic) shear modulus (G_s).

6.2.1 Dynamic Shear Modulus (G_s) Estimation

6.2.1.1 Methodology

In the absence of direct measurement of the dynamic shear modulus (G_s) following three well establish methods are used to estimate dynamic shear modulus indirectly.

I) Downhole Geophysics

Indirect measurements of dynamic shear modulus (G_s) from the shear wave velocity (V_s) of the geological units at DSLSC005 shaft site is made in BH236 using the downhole geophysics.

The downhole geophysics methods in general calculate shear wave velocity (V_s) and corresponding shear modulus (G_s) for shear strain (γ) below 1.0E-4%. These calculated values of shear wave velocity (V_s) and corresponding shear modulus (G_s) should be compatible with level of the shear strain (γ) that may develop in the ground under the design earthquake shaking.

The shear modulus (G_s) values calculated from downhole geophysics are therefore, adjusted by making reduction of 25% accounting for the effects of the earthquakes' large shear strain (FHWA-NHI-09-010 2009).

II) Cone Penetration Test (CPT)

Indirect measurements of the dynamic shear modulus (G_s) from the shear wave velocity (V_s) of the geological units at DSLSC005 shaft site is made using total cone resistance (q_t) of CPT data using following relationships:

$$G_s = V_s^2 \times \rho$$

Where

ρ = mass density of the geological unit ($\rho = \gamma/g$), taken as 1.7 for Tauranga group and RS, 2.7 for Basalt and 2.0 for ECBF Rock.

V_s (m/sec) = shear wave velocity indirectly measured from CPT data using following relationship:

$V_s = [\alpha_{vs} \ (q_t - \sigma_v)/p_a]^{0.5} \ (m/s)$ (Ref: Guide to Cone Penetration Testing 6th Edition 2015)

Where:

α_{vs} is a material factor and = $10^{(0.55Ic+1.68)}$, where *Ic* is soil behaviour

σ_v = soil overburden pressure; and

P_a is atmospheric pressure and taken as = 100kPa

III) Empirical Modulus Correlation

Dynamic shear modulus (G_s) of the geological units at DSLSC005 shaft site is also estimated empirically by correlating it to static shear modulus (G_m) using following relationship:

G_s = 5 to 9 x G_m (Ref: Burt Look 2014)

Where

G_m = static shear modulus and is estimated using following relationship:

$E_m/[2(1+v_m)]$

Where

E_m = Static elastic modulus taken as roughly 2 times of SPTN (from boreholes data) and adjusted further based on GIR design parameters Table 9.1.

v_m = Poisson's ratio of the geological units (GIR design parameters Table 9.1)

6.2.1.2 Dynamic Shear Modulus

Using the above methodology, dynamic Shear modulus (V_s) is assessed for following two ground conditions.

1. Without potential liquefaction risk
2. With potential liquefaction risk

The distribution of G_s vs depth along with best estimate design line for above two ground conditions is shown in Figure 1. The summary of the best estimate values of G_s for the pseudo-dynamic analysis is given in Table 3.

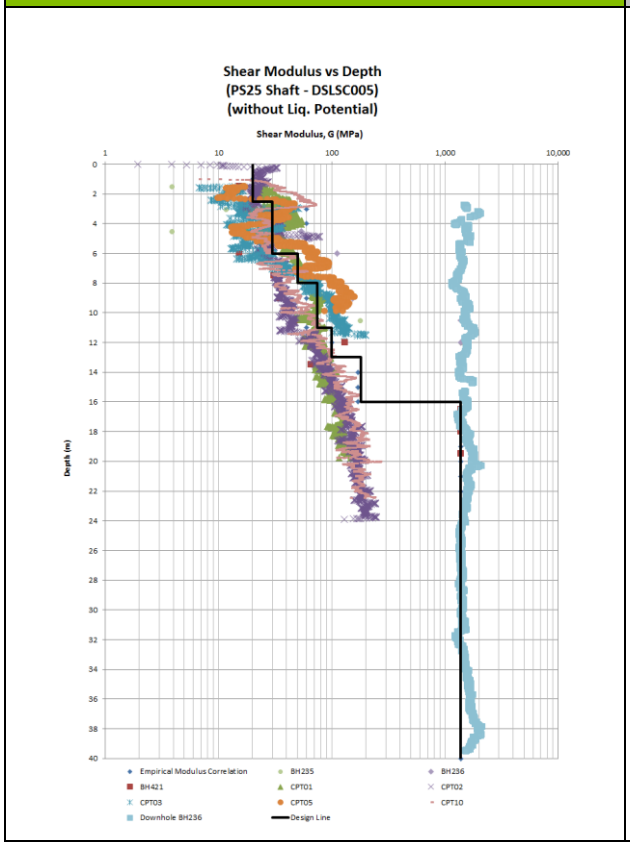
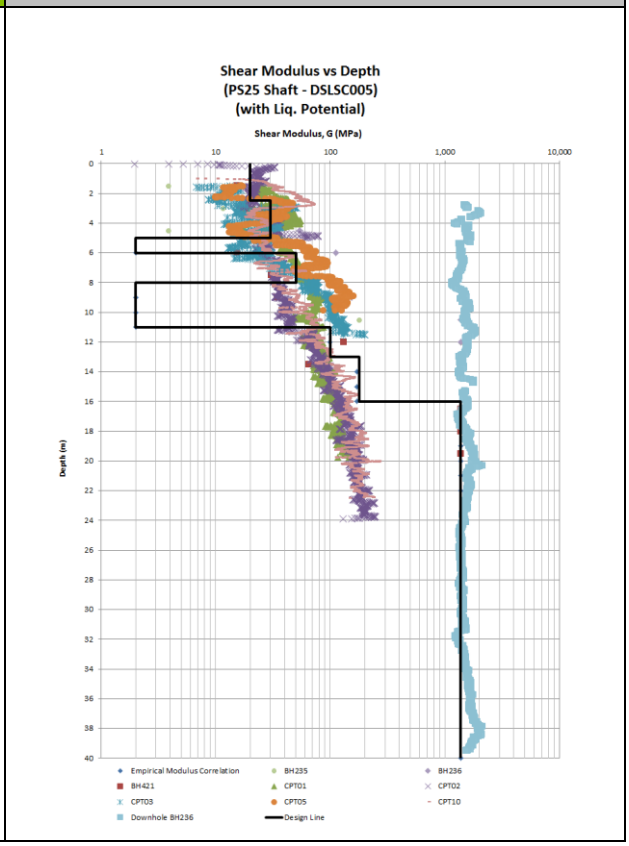
Without Potential Liquefaction Risk	With Potential Liquefaction Risk
	

Figure 1 Dynamic Shear Modulus Profile

Table 3 Summary of Dynamic Shear Modulus

Without Potential Liquefaction Risk		With Potential Liquefaction Risk	
Depth (m)	**G_s (MPa)**	**Depth (m)**	**G_s (MPa)**
0 to 2.5	20	0 to 2.5	20
2.5 to 6	30	2.5 to 5	30
		5 to 6	2
6 to 8	50	6 to 8	50
8 to11	75	8 to 11	2
11 to invert	100	11 to invert	100

6.2.2 Pseudo-Dynamic Analysis

Pseudo-dynamic analysis are undertaken in Rocscience software RS2 version 9 using the methodology described in DOC| DSLSC-DEL-REP-GT-J-100237 dated 09 Sep 2016.

6.2.2.1 PS25 – DSLSC005 Shaft

The pseudo-dynamic analysis model mesh for the shaft with boundary conditions assumption is shown in Figure 2. Following the application of dynamic load (SLS and ULS) the induced lateral deformation at the shaft face for both SLS and ULS load case is shown in Figure 3.

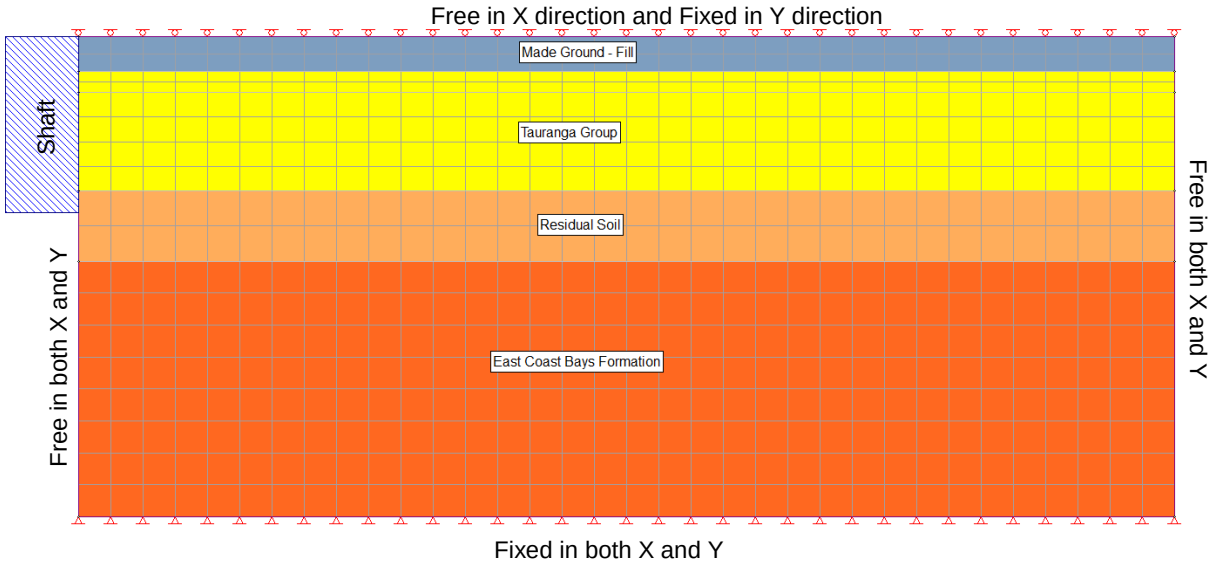


Figure 2 Pseudo-Dynamic Analysis Model with Boundary Conditions Assumptions for Raking Effect

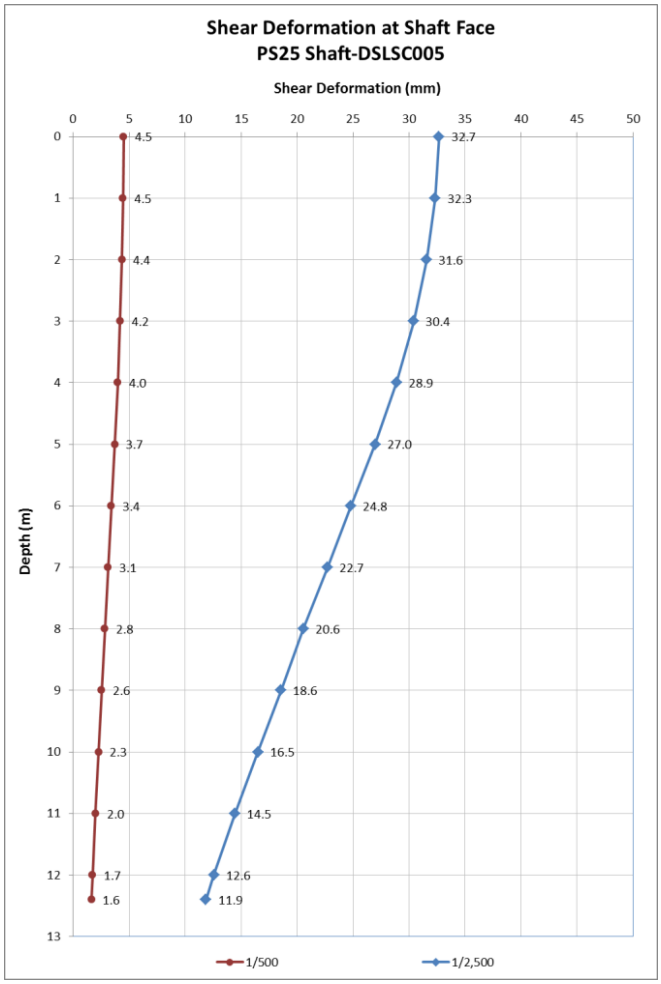


Figure 3 Lateral Deformation at Shaft Face

Based on Figure 3, the shaft is anticipated to rake laterally by 3mm at SLS and 21mm at ULS design seismic load conditions.

6.2.2.2 MH01A Manhole

The pseudo-dynamic analysis model mesh for the shaft with boundary conditions assumption is shown in Figure 4. Following the application of dynamic load (SLS and ULS) the induced lateral deformation at the shaft face for both SLS and ULS load case is shown in Figure 5.

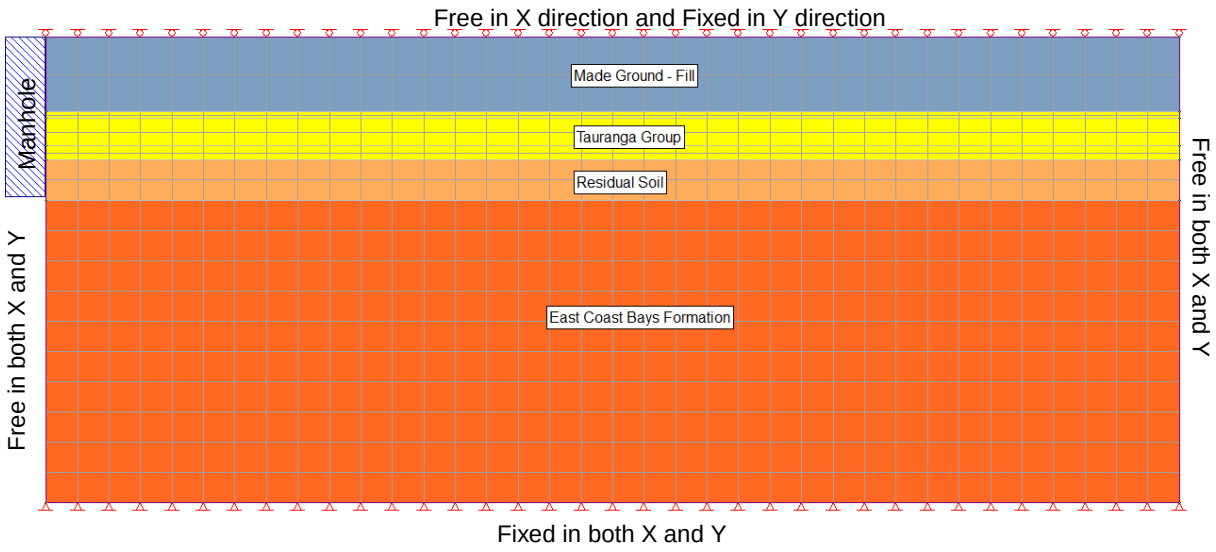


Figure 4 Pseudo-Dynamic Analysis Model with Boundary Conditions Assumptions for Raking Effect

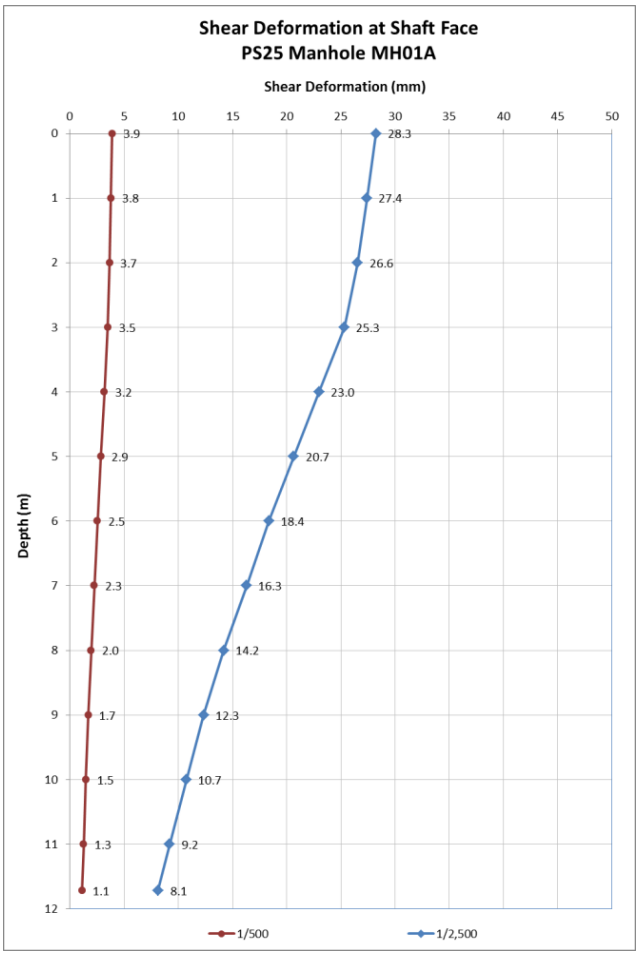


Figure 5 Lateral Deformation at Shaft Face

Based on Figure 5, the shaft is anticipated to rake laterally by 3mm at SLS and 20mm at ULS design seismic load conditions.

6.3 Ovaling

No ovaling deformation of the shaft is assessed due to non-circular shape of the shaft.