

2 October 2015

Greg Dewe  
Land Development Manager  
Fulton Hogan Land Development Limited  
29 Sir William Pickering Drive  
PO Box 39185  
Christchurch 8545

Dear Greg

**Geotechnical Completion Report – Longhurst Stages 9B and 9C Development (Lots 731 to 735, 742 to 751, 754 to 779, 986, 987, 989, 991, 992, and 999)**

This geotechnical completion report is submitted in accordance with Section 12.4.1 of the Christchurch City Council Infrastructure Design Standard.

**Introduction**

Fulton Hogan Land Development Limited (FHLD) is in the process of developing the Longhurst Residential development in Halswell in southwest Christchurch, with Stages 9B and 9C of the development nearing completion. During the geotechnical investigation stage of Stages 9B and 9C parts of development were identified as being susceptible to a varying degree to the effects of seismically induced liquefaction. See attached plan for the extent of Stages 9B and 9C.

The liquefaction risk was assessed as being variable across the site. As such a geogrid reinforced gravel capping layer has been created across Lots 735, 742 to 751, 754 to 759, and 777 to 779 in order to increase the seismic resilience of these lots.

The conditions of Aurecon's engagement are as per our original agreement relating to initial geotechnical investigation carried in October 2010, and are set out in our letter of engagement dated 29 September 2010.

**Previous Investigation**

Aurecon undertook a geotechnical site investigation across the wider 117ha FHLD Halswell West residential development site in October 2010 to support a plan change application. This investigation is described in the Aurecon Report *Geotechnical Site Investigation and Liquefaction Assessment, Halswell West Rezoning, Rev1* dated 29 November 2010 prepared for Fulton Hogan Land Development Limited (Aurecon, 2010).

Aurecon undertook further geotechnical investigations to support a subdivision application for Stage 9 of the Longhurst development between October 2011 and August 2013. This included testing in areas that are now included in Stages 9B and 9C. This investigation is described in the Aurecon Report *Longhurst and Knights Stream Park Stage 9 Geotechnical Assessment, Rev2* dated 28 April 2014 (Aurecon, 2014).

## **Liquefaction Hazard Assessment**

In the days immediately following the 4 September 2010 Darfield Earthquake and the 22 February 2011 Christchurch Earthquake Aurecon undertook a site walk over and mapping of surface manifestation of liquefaction across the entire Halswell West development (including Longhurst Stages 9B and 9C). Surface manifestation of liquefaction was observed in parts of what is now Stages 9B and 9C after both the Darfield and Christchurch Earthquakes.

A liquefaction hazard assessment was carried out as part of the site assessments using the method prescribed in the Ministry of Business, Innovation, and Employment guidelines for residential development in Canterbury following the Canterbury earthquake sequence (MIBE, 2012). Based upon this assessment:

### ***Lots 731 to 735, 742, 743, and 760 to 776***

The calculated liquefaction induced ground deformations were within the limits of a Technical Category 2 (TC2) classification.

### ***Lots 744 to 751, 754 to 759, and 777 to 779***

Lots 744 to 751, 754 to 759, and 777 to 779 in their natural form were identified as being non-compliant with the requirements of a TC2 classification based on an indexed liquefaction induced reconsolidation settlement criteria. The wider site is underlain by surficial silty-sandy soils. However the sand content increases in eastern side of Stage 9B and the thickness of the silty-sandy soils to the underlying gravels increase at the northern end of Stage 9C. This results in an increase theoretical reconsolidation settlement in these areas.

## **Liquefaction Risk Mitigation**

The following liquefaction hazard mitigation has been undertaken across the site:

### ***Lots 731 to 735, 742, 743, and 760 to 776***

No additional liquefaction risk mitigation is required for these lots other than an enhanced TC2 type of foundation system.

### ***Lots 744 to 751, 754 to 759, and 777 to 779***

In order to ensure a TC2 classification across the entire site and provide additional seismic resilience to the development shallow ground improvement works have been undertaken in Lots 744 to 751, 754 to 759, and 777 to 779. The ground improvement works have been based upon the concept of 2m thick gravel raft option presented in Section 15 of the MBIE (2012) Guidelines. With this ground improvement implemented a TC2 foundation system can be used at these sites.

Due to depth to groundwater at the site, the gravel layer has been reduced to a thickness of 1.5m to compensate for the reduction in thickness it has been reinforced with a heavy duty geotextile filter fabric and two layers of heavy duty geogrid reinforcement. This reinforced 1.5m thick gravel layer is considered to have the same engineering properties of 2m of unreinforced gravel. This gravel layer is capped with 0.2m to 0.3m of topsoil. Plans showing the location and a cross-section of this capping layer are appended to this report.

This geogrid reinforced gravel capping layer has been constructed under the supervision of the project Civil Engineer's, Davie Lovell-Smith Limited, as part of the bulk earthworks process carried out as part of the subdivision development. The geogrid reinforced gravel capping layers in lots 744 to 751 and 754 to 759 were installed as part of the wider Stage 9

earthworks. While the geogrid reinforced gravel capping layer in Lots 777 to 779 were installed as part of the earthworks carried out at the neighbouring Knights Stream Park Stage 3C.

### Technical Category Classification

We have assessed the liquefaction hazard at the site using the method recently prescribed by MBIE guidelines, observed site performance during the major seismic events in the Canterbury earthquake sequence. Based upon our geotechnical site investigations, the liquefaction hazard assessments and the implementation of a geogrid reinforced gravel capping layer (in lots 744 to 751, 754 to 759, and 777 to 779) we believe:

- **Lots 731 to 735, 742 to 751, and 754 to 779 fulfil the requirements of TC2 Classification,**
- **Lots 986, 987, 989, 991, 992, and 999 are roading and reserve areas; therefore no Technical Category Classification is applicable for these lots.**

A TC2 Classification effectively means that the MBIE believe that *‘Minor to moderate land damage from liquefaction is possible in future significant earthquakes’*. House foundations and site specific geotechnical investigations are required in accordance with the MBIE (2012) guideline documents *‘Repairing and rebuilding houses affected by the Canterbury earthquakes’* released in December 2012.

### Foundation Recommendations

The following foundation recommendations are made for residential houses to be built at the site:

#### ***Lots 731 to 735, 742, 743, and 760 to 776 – Natural Ground***

With Lots 731 to 735, 742, 743, and 760 to 776 enhanced TC2 foundation are required as outlined in Section 5 of the MBIE (2012) Guidelines. In accordance with the Guidelines standard shallow lot specific shallow geotechnical investigations will be required during the detailed house design to assess the lot specific ground conditions and bearing capacity values.

#### ***Lots 744 to 751, 754 to 759, and 777 to 779 – Capping Layer***

With Lots 744 to 751, 754 to 759, and 777 to 779 it is recommended the houses are:

- Founded directly onto the underlying gravel capping layer utilising the 200kPa bearing capacity TC2 type enhanced slab foundations (Options 2 to 4 in Section 5.3.1 of the MBIE Guidelines), or a suspended timber floor (based upon the recommendations in Section 5.3.2 of the MBIE Guidelines / NZS3604:2011) with the design pro rata to use 200kPa bearing capacity.
- To provide the best seismic resilience houses should:
  - Use light to middle weight cladding and roofing materials only.
  - The structural form should be restricted to timber frame (or light weight cold-rolled steel equivalent).

These foundations systems should be founded directly onto the underlying gravel. With the enhanced raft foundation options all topsoil and silty-sandy soil should be removed below the entire house footprint.

Due to the presence of the geogrid reinforcement within the gravel, and the capping function that the geogrid reinforced gravel raft preforms, penetrations through the geogrid should be avoided. Houses build in these lots should not have basements protruding through the capping layer. Underfloor hydraulic services and conduits (wastewater, stormwater etc.), where possible should be designed in such a way that they do not penetrate through the geogrid reinforcement either and stay within the upper 650mm of the reinforced gravel layer.

## References

Aurecon, 2010. *Geotechnical Site Investigation and Liquefaction Assessment, Halswell West Rezoning, Fulton Hogan Land Development Limited, Revision 1* - dated 29 November 2011. Aurecon New Zealand Limited, Christchurch, New Zealand.

Aurecon, 2014. *Longhurst and Knights Stream Park Stage 9 Geotechnical Assessment, Rev2* dated 28 April 2014. Aurecon New Zealand Limited, Christchurch, New Zealand.

MBIE, 2012. *Repairing and rebuilding houses affected by the Canterbury earthquakes*. Ministry of Business, Innovation and Employment, Wellington, New Zealand.

## Limitations

We have prepared this report in accordance with the brief as provided. The contents of the report are for the sole use of the Client and no responsibility or liability will be accepted to any third party. Data or opinions contained within the report may not be used in other contexts or for any other purposes without our prior review and agreement.

The recommendations in this report are based on data collected at specific locations and by using suitable investigation techniques. Only a finite amount of information has been collected to meet the specific financial and technical requirements of the Client's brief and this report does not purport to completely describe all the site characteristics and properties. The nature and continuity of the ground between test locations has been inferred using experience and judgement and it must be appreciated that actual conditions could vary from the assumed model.

Subsurface conditions relevant to construction works should be assessed by contractors who can make their own interpretation of the factual data provided. They should perform any additional tests as necessary for their own purposes.


Subsurface conditions, such as groundwater levels, can change over time. This should be borne in mind, particularly if the report is used after a protracted delay.

This report is not to be reproduced either wholly or in part without our prior written permission.

This conclusions in this report draws on investigations, analysis and conclusions from various investigations stages and numerous reports. For specific details please refer to the above mentioned references or contact the writers.

If you have any queries regarding the content of this letter, please do not hesitate to contact the undersigned.

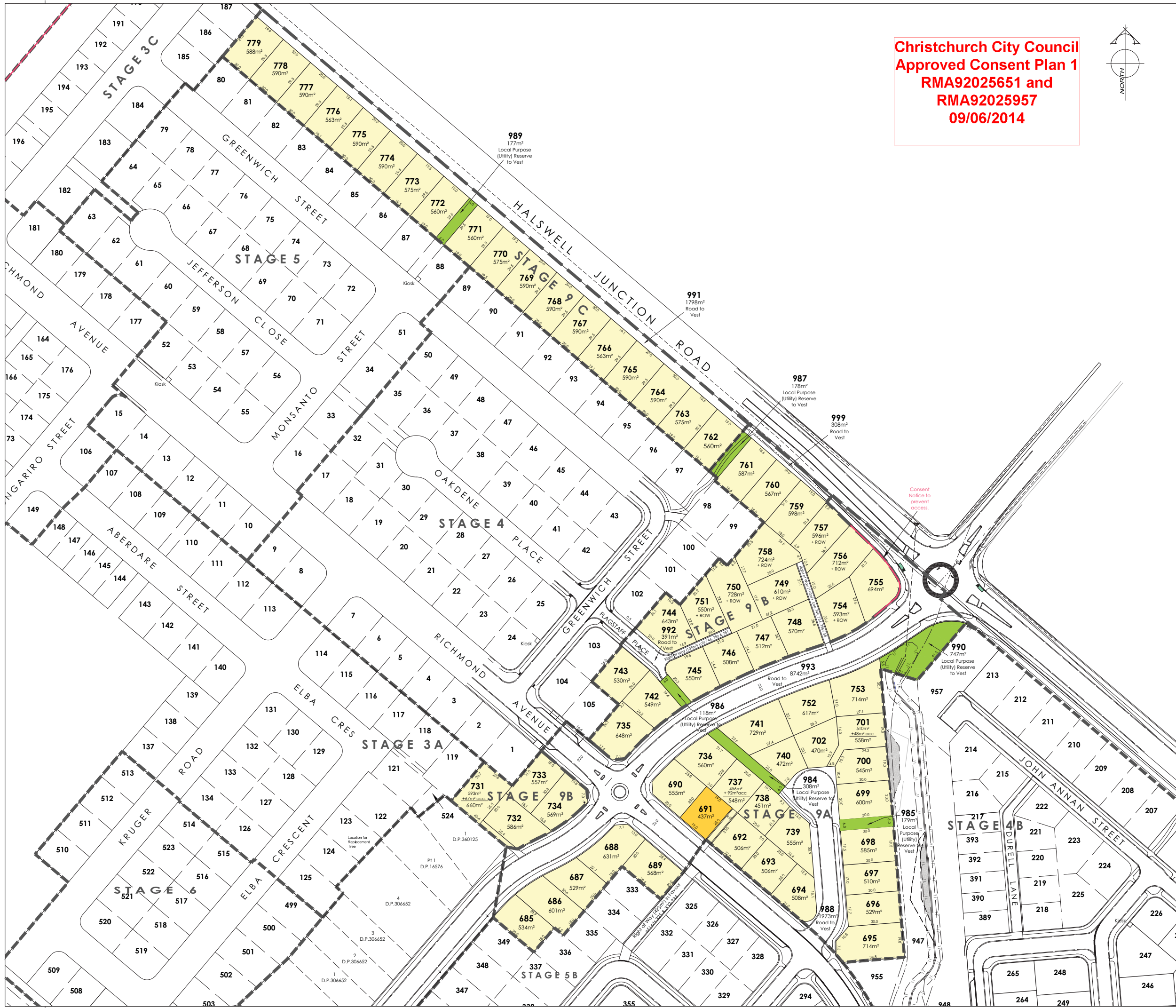
Yours sincerely



**Dr Jan Kupec**  
*PhD MSc candIng MIPENZ CPEng IntPE MRSNZ NZGS IGS ISSMGE NZSEE*  
*elect. sign*  
**Chartered Professional Geotechnical Engineer – Technical Director**

Inc: Knights Stream Park Stages 9B and 9C Site Layout Plan  
Geogrid Capping Layer Plan and Detail





AMENDMENTS:

AMENDMENT	DATE	DESCRIPTION
R1	11/3	Reserve 984 & 985 Reduced to 6m wide.
R2	12/3	Lot 994 added, Lots 754-799 amended
R3	18/3	Lots 754, 756 & 757 amended
R4	20/3	Stage 9C added, Lot 750 amended
R5	3/6	Separation strip removed

NOTES:

1)

Areas and dimensions subject to final survey and deposit of plans.

2)

Service easements to be created as required.

3)

This plan has been prepared for subdivision concept purposes only. No liability is accepted if the plan is used for any other purpose.

LEGEND

DRAINAGE RESERVE

RECREATION RESERVE

DENSITY B

DENSITY C

SCHEDULE OF AREAS

Description	Area
Residential Lots ( Lots 685-702, 731-779 )	3.8610ha
Right of Ways	538m <sup>2</sup>
	3.9148ha
Road to Vest in Christchurch City Council ( Lots , 991-993,998 & 999 )	1.2217ha
Local Purpose (Utility) Reserve to Vest in Christchurch City Council ( Lots 984-989 & 990 )	1871m <sup>2</sup>

Total Area: 5.3236ha

DAVIE LOVELL • SMITH

PLANNING SURVEYING ENGINEERING

116 Wrights Road P O Box 679 Christchurch 8140. New Zealand  
Telephone: 03 379-0793 E-mail: office@dls.co.nz

JOB TITLE:  
**Fulton Hogan Land Development Ltd**

SHEET TITLE:  
**LONGHURST  
Stage 9 A, 9 B & 9 C**

DRAWING STATUS:  
**Subdivision Consent**

SCALE: 1:1000@A1  
1:2000@A3

DATE: June 2014

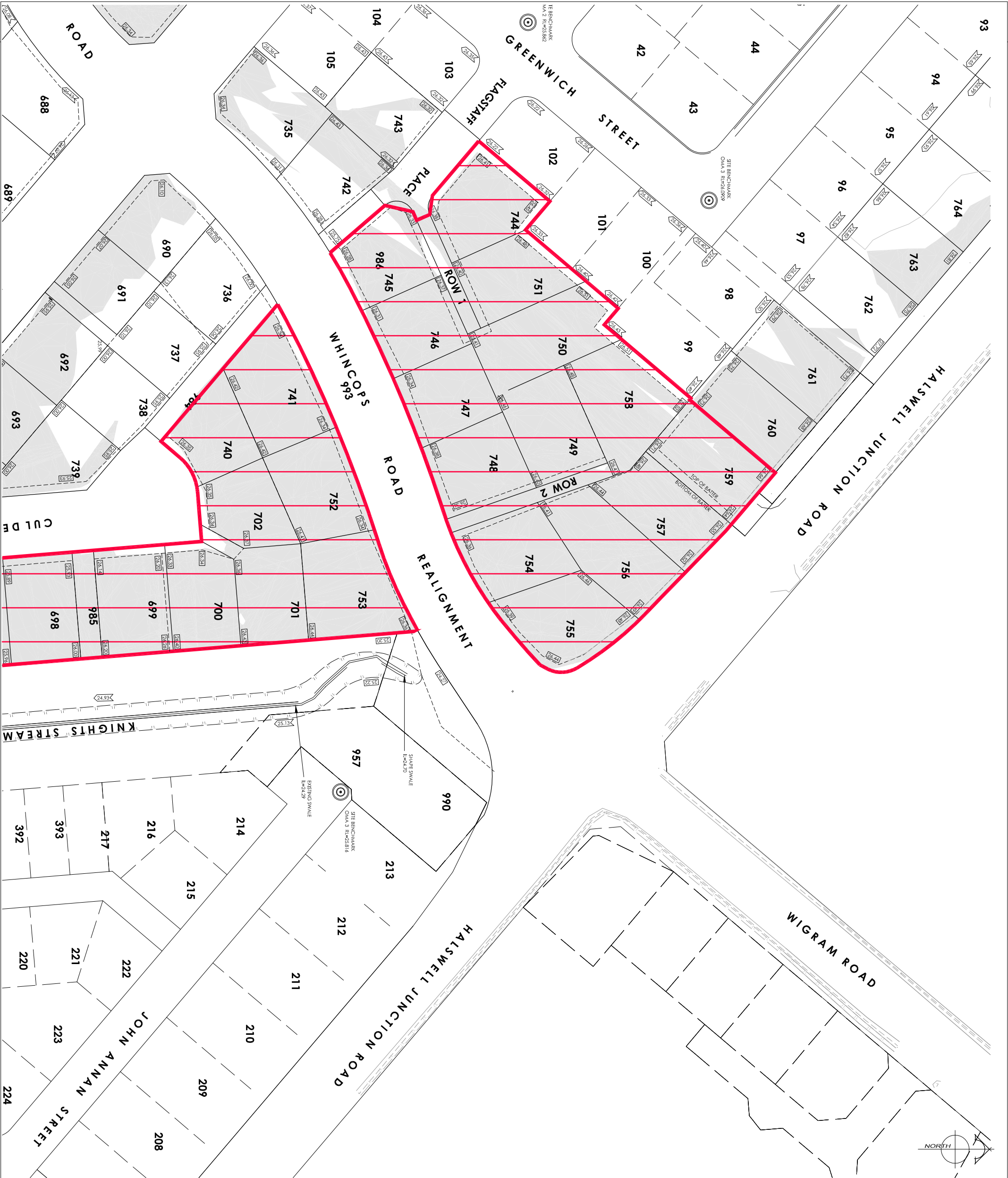
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DRAWING No: **E18485**

SHEET No: **1 of 1**

REVISION:  
**R5**





AMENDMENTS:	
AMENDMENT	DESCRIPTION
R1	26/7/2014 FINAL NUMBER
R2	27/10/2014 SHADING UPDATED, NOTE 10 ADDED
R3	31/10/2014 NO CHANGES THIS SHEET

- NOTES:
- 1) ALL WORKS IN ACCORDANCE WITH CCC IDS & CSS PARTS 1-7 2014.
  - 2) CARRIAGEWAY & FOOTPATH SURGRADE MINIMUM CBR 4 SUBGRADE TO BE INSPECTED BY THE ENGINEER PRIOR TO PLACING ANY METAL.
  - 3) CARRIAGEWAY & FOOTPATH ACCEPTANCE TESTING IN ACCORDANCE WITH CCC CSS PART 6 & CCC IDS.
  - 4) TRENCHING & INSTALLATION OF POWER & TELECOM SERVICES TO BE PROVIDED IN ACCORDANCE WITH SERVICE PROVIDERS PLANS & SPECIFICATIONS.
  - 5) ALL SERVICES TO BE FULLY SEARCHED & PILOTTED PRIOR TO TRENCHING.
  - 6) ALL UPVC PIPES (WHETHER SEWER, STORMWATER OR SUBSOIL) SHALL BE COMPAIRED TO NZS 2642:1997 & SHALL HAVE THE FOLLOWING STRENGTHS SUBCLASSIFIED AT THE STANDARD: DN100...SN16 DN150...SN16 DN225 AND LARGER ... SN8
  - 7) ORIGIN OF LEVELS  
BM, EHTCA RL=28.99, CORNER OF AWATEA & WIGRAM ROADS, LEVELS IN TERMS OF CHRISTCHURCH DRAINAGE DATUM, POST JUNE EMERGENCY LEVELS.
  - 8) ALL SUMPS TO HAVE 450mm DEEPWELL.
  - 9) SEWER & STORMWATER PIPES LAYING TO CSS S03/04 TYPE P, HAUNCHING TO BE WAJPEED IN APPROVED GEOTECHILE COMPLYING WITH NZS 177 CLASS C.
  - 10) FILLING OUTSIDE OF GROUND IMPROVEMENT AREAS TO BE IN ACCORDANCE WITH NZS 4431:1989



LEGEND : CONTOURS SHOWN ARE APPROXIMATELY  
CUT (-ve) AND FILL (+ve) AT  
0.25m INTERVALS.

- PROPOSED LEVEL
- EXISTING LEVEL
- CUT
- ENGINEERED FILL
- AREA REQUIRING GROUND IMPROVEMENT FOR TC2 COMPLIANCE. SEE SHEET E02.7 FOR DETAILS

NAME	SIGNED	DATE
DESIGNED BY	NAME REMAINS	
CHECKED BY	JUSTIN FINLAY	

DAVIE LOVELL•SMITH

PLANNING SURVEYING ENGINEERING

116 Wilkins Road P O Box 679 Christchurch 8140 New Zealand  
Telephone: 03 379-0703 E-mail: office@dlb.co.nz

JOB TITLE:  
**Fulton Hogan Land Development  
Longhurst Stage 9**

SHEET TITLE:  
**Earthworks Cut & Fill  
RMA92025651  
& RMA92025957**

DRAWING STATUS

**For Engineering Approval**

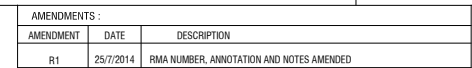
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DRAWING NO: **E18485.E02.5** SHEET NO: **R3**







- NOTES:
- 1) ALL WORKS IN ACCORDANCE WITH CCC IDS & CSS PARTS 1-7 2014.
  - 2) CARRIAGEWAY & FOOTPATH SUBGRADE MINIMUM CBR 4. SUBGRADE TO BE INSPECTED BY THE ENGINEER PRIOR TO PLACING ANY METAL.
  - 3) CARRIAGEWAY & FOOTPATH ACCEPTANCE TESTING IN ACCORDANCE WITH CCC CSS PART 6 & CCC IDS.
  - 4) TRENCING & INSTALLATION OF POWER & TELECOM SERVICES TO BE PROVIDED IN ACCORDANCE WITH SERVICE PROVIDERS PLANS & SPECIFICATIONS.
  - 5) ALL SERVICES TO BE FULLY SEARCHED & PILOTTED PRIOR TO TRENCING.
  - 6) ALL UPVC PIPES (WHETHER SEWER, STORMWATER OR SUBSOIL) SHALL CONFORM TO AS NZS 1260:1999 & SHALL HAVE THE FOLLOWING STIFFNESS NUMBERS AS SET OUT IN THE STANDARD: DN100...SN16 DN150...SN16 DN225 AND LARGER ... SN8
  - 7) ORIGIN OF LEVELS  
BM.EHC6 RL=28.99. CORNER OF AWATEA & WIGRAM ROADS.
- LEVELS IN TERMS OF CHRISTCHURCH DRAINAGE DATUM.  
POST JUNE EMERGENCY LEVELS.
- 8) ALL SUMPS TO HAVE 450mm DEEPWELL.
  - 9) GRAVEL RAFT DESIGN BASED ON THE RECOMMENDATIONS IN AURECON GEOTECHNICAL REPORT FOR SITE. CONSTRUCTION TO BE APPROVED BY DOMINIC MAHOONEY (AURECON NZ LTD).

LEGEND :

	NAME	SIGNED	DATE
DESIGNED BY	MIKE JENNINGS		
CHECKED BY	JUSTIN FINLAY		



DAVIE LOVELL•SMITH

PLANNING SURVEYING ENGINEERING

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	JOB TITLE:
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**Fulton Hogan Land Development  
Longhurst Stage 9**

1	SHEET TITLE:
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**Ground Improvement Detail  
RMA92025651  
& RMA92025957**

	DRAWING STATUS
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**For Engineering Approval**

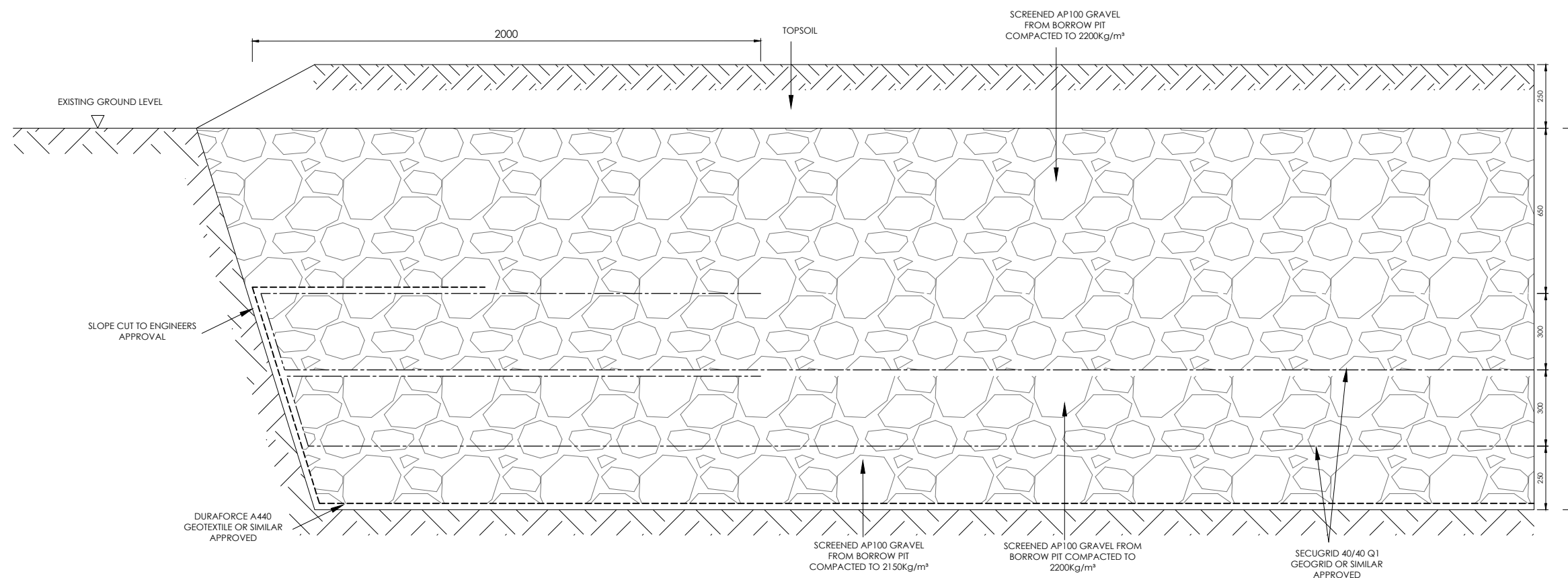
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DRAWING No : **E18485.E02.7** SHEET No: **R1**

R1

EXCAVATE UNDER ENGINEERS SUPERVISION AND REINSTATE IMMEDIATELY



### RECOMMENDED CRUST STRENGTHENING CROSS SECTION

NOT TO SCALE