C

Part C – Technical Reports

Part C – Technical Reports

The following Technical Reports are included to support the incorporation of the Cambridge C4, Te Awamutu T6 and the Te Awamutu T11 Structure Plans.

a) Cambridge C4 Structure Plan Context Report, prepared by Mitchell Daysh, dated 9 September 2020 *(Council document number 10469506)*;
b) C4 Growth Cell Transportation Assessment, prepared by Gray Matter, dated 20 December 2019 *(Council document number 10364904)*;
c) C4 Structure Plan – Concept Layout for Internal Intersection, prepared by Gray Matter, dated 10 August 2020 *(Council document number 10452899)*;
d) Geotechnical Report – Preliminary Findings, prepared by Mark T Michell Ltd, dated 3 September 2019 *(Council document number 10107014)*;
e) Ecological impacts of the proposed C4 Growth Cell, prepared by National Institute of Water & Atmospheric Research Ltd, dated July 2019 *(Council document number 10106941)*;
f) Cambridge C4 Three Waters Assessment, prepared by Te Miro Water, dated September 2020 *(Council document number 10476599)*;
g) Cambridge, Growth Cell C4 Structure Plan: Preliminary Archaeological Assessment, prepared by Clough & Associates Ltd, dated August 2019 *(Council document number 10106935)*;
h) Te Awamutu T6 Structure Plan Context Report, prepared by Boffa Miskell, dated 25 June 2020 *(Council document number 10410947)*;
i) Te Awamutu T6 Growth Cell Design Guidelines, prepared by Boffa Miskell, dated June 2020, *(Council document number 10411015)*;
j) T6 and T11 Growth Cell Structure Plan Liquefaction Desktop Study, prepared by Tonkin + Taylor, dated August 2019 *(Council document number 10373335)*;
k) Te Awamutu T6 and T11 Structure Plans Three Waters Assessment, prepared by Tonkin + Taylor, dated August 2019 *(Council document number 10373339)*;
l) Te Awamutu T6 and T11 Structure Plans Transportation Assessment, prepared by Tonkin + Taylor, dated August 2019 *(Council document number 10373344)*;
m) Te Awamutu T11 Structure Plan Context Report, prepared by Boffa Miskell, dated 25 June 2020 *(Council document number 10411036)*;
n) Te Awamutu T11 Growth Cell Design Guidelines, prepared by Boffa Miskell, dated 25 June 2020, *(Council document number 10411038)*.

WAIPA DISTRICT COUNCIL

CAMBRIDGE C4 STRUCTURE PLAN

Context Report

9 September 2020

TABLE OF CONTENTS

LIST OF APPENDICES

REPORT INFORMATION

Report Status	Draft
Our Reference	MDL000836
File Location	
Author	Ian Johnson
Review By	
Version Number	V1
Version Date	9 September

1. INTRODUCTION

1.1 BACKGROUND

The Waipā District has been identified as a high growth area in the National Policy Statement on Urban Development 2020 (NPS-UD).

Cambridge township is forecast to grow by over 14,000 people by 2050. To provide for this growth, Council has set out to prepare a structure plan for the C4 growth cell, as identified in the Waipā 2050 Growth Strategy (2017), Waipā 2018-28 Long Term Plan, and Waipā District Plan.

The growth cell extends to approximately 66ha located to the south west of Cambridge township, adjacent to the Leamington neighbourhood. Situated to the east of Cambridge Road and north of Lamb Street, the area consists of approximately 50ha of gently contoured farmland and lifestyle development adjoining a deeply incised gully to the east, beyond which is the Cambridge Park residential subdivision.

The growth cell is currently zoned Deferred Residential, indicating its potential for urban density residential development.

1.2 PURPOSE

A pre-requisite for the uplifting of the 'deferred' Residential Zone status is the preparation and approval of a Structure Plan explaining how the growth cell should be developed to ensure that it is appropriately serviced and will contribute towards the achievement of an attractive and cohesive residential neighbourhood within the Cambridge township. The purpose of this report is to explain the statutory context and key land use and design expectations identified on the Structure Plan set out within Appendix A.

While providing important direction, the Structure Plan does not prescribe detailed development controls which are more appropriately addressed through the Plan Change processes or resource consents that will follow. The development of the Structure Plan has been informed by preliminary technical reports commissioned in respect of:

- Geotechnical;
- Archaeology;
- Ecology;
- Three Waters Servicing and Infrastructure; and
- Transportation.

Copies of each of these is included in Appendix B. Consultation with statutory bodies and landowners within and adjoining the growth cell as well as the wider community was undertaken in Autumn 2020 and the feedback received has been taken into account.

2. SITE CONTEXT

2.1 GROWTH CELL C4

The following image indicates the extent of the growth cell and its relationship to the Cambridge township. Leamington itself is a predominantly residential area served by commercial activities located primarily along Shakespeare Street, industrial activities located at Matos Segedin Drive and Pope Terrace and community facilities including recreational reserves located within residential neighbourhoods and around the older parts of the township in the form of the Cambridge Green Belt.

The eastern extent of the C4 growth cell adjoins the Green Belt and presents an extensive frontage to the deeply incised un-named gully extending from the Green Belt towards the Waikato River. Being approximately 20m deep and identified as a Significant Natural Area, the gully itself is not identified for urban development. Nevertheless, it will have a key role in defining the character of future residential development in terms of visual amenity and a focus for community use.

Land outside of the gully includes two areas of former sand extraction adjacent to the gully slope. Some low density residential development has occurred in a triangular shaped enclave situated between these extraction areas. The enclave is relatively recently established. While it is not anticipated that significant change will occur within this area in the short to medium term, it is included within the Structure Plan area and a transition to higher densities can be expected over the longer term. Elsewhere the balance of the Structure Plan area is predominantly farmed pasture, with a single farmholding being situated to the south of Silverwood Lane and a number of smaller farm and lifestyle blocks being located to the north. Towards the northern end, a steep vegetated slope defines the edge of a lower lying terrace adjacent to an artificial lake. Some historical uncontrolled filling has occurred in this area.

The landform of the upper terrace consists of a gently rolling contour sloping generally towards the gully. Stands of mature trees are generally located close to existing dwellings or along accessways with the majority of the land being in open pasture with typical post and wire fencing.

2.2 IMMEDIATE LOCALITY

Beyond the Structure Plan area to the north is the Matos Segedin Industrial area which includes a range of industrial activities including a meat processing facility and composting operations. The industrial area is also adjoined by the Cambridge wastewater treatment plant. Each of these established areas has the potential to generate effects extending beyond their immediate area dependant on climatic conditions and localised wind direction. The need to manage potential reverse sensitivity effects on these established activities has informed the preparation of the Structure Plan.

Cambridge Road is a major arterial route utilised by heavy vehicles travelling between Te Awamutu and State Highway 1. The road is slightly elevated above the adjoining Structure Plan area and traffic noise, particularly from heavy vehicles, is generally high. Lamb Street also provides an arterial function for lower vehicle volumes and provides a key route of entry from the Structure Plan area into Leamington.

Extending westwards from Cambridge Road is Kaipaki Road providing an alternative route to Hamilton and also providing access to the Mystery Creek locality.

Overhead high voltage power lines run on a north-east/south-west axis immediately beyond the western extent of the Structure Plan area. Land to the south is within the Rural Zone whereas land to the west, beyond Cambridge Road is intended for future large lot residential development.

3. TECHNICAL ASSESSMENT

The following key findings follow consideration and inputs made by the Council's Cambridge C4 Growth Cell Project Group, with additional detail set out in the technical assessments provided in Appendix B:

Geotechnical

Geotechnical assessment of the underlying ground conditions has identified the general suitability of ground conditions subject to specific foundation designs being required in areas of previous filling activity. However, the analysis has also identified a need to adopt precautionary building line restriction for new buildings, structures and infrastructure in respect of the gully slope. The building line restriction ranges from 8m from the top of the slope in the northern section of the area to 14m from the top of the slope to the south of Silverwood Lane.

Three Waters

Assessment of the area has confirmed that the entirety of the area is capable of being served by extensions to the reticulated water supply and wastewater network. While gravity connections to the wastewater network would enable development from north to south through the Structure Plan area, alternative development scenarios are achievable through the use of pumping stations.

As the geotechnical assessment confirmed the extent of free draining soils, on-lot stormwater disposal is viable across the area. Calculations of anticipated run-off under storm events confirms that the broad base of the gully provides sufficient capacity to manage storm events without requiring attenuation of flows on the upper terraces.

Ecology

Ecological assessment of the un-named tributary located within the gully identified the potential for enhancement of the stream environment but also recognised that stormwater inputs from the development area could also modify the hydrological regime of the stream and its associated natural values. As the gully environment is a defined Significant Natural Area, effects on its natural and ecological values are identified in the Resource Management Act as a Matter of National Importance.

Archaeological

Historic Heritage is also a Matter of National Importance and the wider locality has a rich history of pre-European occupation, primarily represented by pā and borrow pit sites associated with Māori horticultural practices. Previous sand extraction and residential development within the Structure Plan area has destroyed some of these features but a number of borrow pits remain. Engagement with iwi representatives as part of the Structure Plan preparation has enables a deeper understanding of the significance of these features and it is expected that further consideration of the historic heritage values will occur as part of the development of plan change or resource consent processes to give effect to the Structure Plan. Given the extent of the archaeological resource it is possible that a separate Archaeological Authority may be required from Heritage New Zealand in addition to any resource consent approval.

Transportation

The gully feature separates the Structure Plan area from the existing residential areas and transport network within Leamington. Access to and from the area will therefore involve use of the adjacent arterial roads, in addition to potential off road connections for walking and cycling at the northern and southern ends. Anticipated traffic growth on the wider network indicates a need for major improvement of the Kaipaki Road/Cambridge Road intersection, including the need for realignment of the approach from Lamb Street.

Recreation

The gully environment presents a unique opportunity within the Cambridge context to establish points of entry for longer term maintenance and public access. Currently, the majority is inaccessible and unmanaged but overlooked from residential development within Cambridge Park. Points of connection to Cambridge Park at the north and the Green Belt at the south provide the opportunity to enhance connectivity between neighbourhoods. Requirements for building line restrictions along the gully edge also provide an opportunity to make connections between these points.

4. LAND USE

The developable area of the Structure Plan extends to approximately 50ha, part of which is already developed as a low density, lifestyle enclave which is unlikely to change in the short to medium term. As indicated below, additional development constraints have also been identified in preparing the Structure Plan. Taking account of these factors, the achievement of residential densities required by the Waipā District Plan indicates the long term potential for around 600 new dwellings, with approximately 42% (250 dwellings) being to the north of Silverwood Lane and 58% (350 dwellings) being to the south.

Future residents will require specific provision of recreation reserves within a walkable catchment.

The scale of development within the Structure Plan area is expected to be well served by existing commercial and community facilities within Leamington and Cambridge town centre. If demand emerges for more locally based facilities, these will be limited in scale to serve the immediate area rather than serving a wider catchment and will be located adjacent to either of the two identified neighbourhood reserves.

Consultation with the Ministry for Education has confirmed that this scale of development will not require any additional school development within the Structure Plan area.

5. KEY DESIGN PRINCIPLES

Taking account of the technical assessments undertaken, and the feedback received through community engagement, the following general design principles underpin the proposed Structure Plan:

- Local Identity - Optimising the gully environment as the focal point for recreational provision and vistas. Establishing direct connectivity with and along the gully edge through a continuous linear shared path with direct connections from internal roads and paths. Recognising heritage landmarks and natural features.
- Community Cohesion – Establishing recreational reserves where they will support higher density development, provide safe and interesting places for play and integrate with the gully.
- Connectivity – Through an internal network of roads and paths that prioritises pedestrian and cycle movement and safety while enabling accessibility for public transport services. Aligning roads and paths with vistas and connections to the gully edge reserve. Establishing physical connection to Cambridge Park and the Green Belt.
- Environmental Responsibility – Stormwater management concepts prioritise on site disposal, with the conveyance and treatment of storm events via swales integrated into the streetscape design and discharge to the gully via strategically located and ecologically friendly treatment trains. Buffer planting to the Cambridge Road frontage will reduce the visibility of the major arterial road and industrial activities to the north, minimising the potential for reverse sensitivity effects.

5.1 OPEN SPACE NETWORK

Pivotal to the establishment of local identity, community cohesion and connectivity is the establishment of a coherent framework of open spaces. The gully provides the focal point in terms of vistas and connectivity with the natural environment but it is largely inaccessible and opportunities to provide access to it and through it are likely to be long term. Nevertheless, development within the Structure Plan area provides the opportunity to establish a clear interface between the natural and built environment and provide context within which future decisions can be made regarding investment in wider access.

To achieve this, the Structure Plan provides for the establishment of a linear shared path along the entirety of the gully edge, utilising land that would otherwise be subject to building line restrictions. The path itself will require a minimum width of 3m but will sit within a linear corridor that will provide opportunities for seating and observation areas, with planted margins on the landward side to assist in stormwater management as well as define the edge of public and private space.

Wider visual connectivity to the gully and adjoining path will be required to enable passive surveillance and enhance the safety of users. This is to be achieved via an open frontage to parts of the internal road network, footpath connections from residential streets and restrictions on fencing height or design for properties bounding the route.

The gully edge reserve will anchor two neighbourhood reserves, each between 3,500m^2 to 5,000m^2. The reserves will be located within easy walking distance of residential areas developed to the north and south of Silverwood Lane. Both reserves will connect directly with the gully edge shared path without necessitating the crossing of roads. Passive surveillance of these areas will be achieved by requirements for adjoining development, which may include higher density forms of accommodation, to have a direct ground floor level outlook to the reserve. If demand emerges for small scale commercial or community activities, a location adjacent to either of the two neighbourhood reserves will support community cohesion and local identity without affecting the viability of the town centre or residential amenity values.

While the neighbourhood reserves will provide the key elements for recreational purposes, additional open space corridors providing footpath connections between residential streets and swale or rain garden designs for the streetscape design will complement the overall network. Streetscape design of these features will be expected to provide a consistent design theme throughout the Structure Plan area to reinforce local identity and ensure consistent management and maintenance. To ensure that reference points to the historical use of the Structure Plan area are not lost, future development proposals will be expected to consider how existing trees or archaeological features can be incorporated into the reserves network, streetscape design or internal footpath connections.

Along the Lamb Street and Cambridge Road periphery, a shared path will provide safe routes and connectivity to surrounding areas without affecting arterial traffic flows. The path will be established within a buffer planted margin to the Cambridge Road frontage, continuing the design approach established in the Cambridge Park subdivision. Along Lamb Street, modification of the existing berm will enable the path to be accommodated within the road corridor, offset from the property boundary to enable visibility from direct property access.

5.2 MOVEMENT NETWORK

Integrating the Structure Plan area into the wider fabric of the Cambridge township will require alterations to the surrounding road network as well as the creation of new points of connection for passive transport modes. Cambridge Road will continue to serve a major arterial function in the wider transport network and is the main access route to the Matos Segedin Industrial Area. To ensure that traffic from development of the full Structure Plan area and anticipated traffic growth on the network is able to be accommodated safely, widening of the road corridor will be required at the bend in Cambridge Road and a new roundabout will be required at the Kaipaki Road/Cambridge Road intersection. The new roundabout will incorporate the realignment of Lamb Street to provide safe directions of entry and exit. Up to 300 sections may be capable of development prior to the improvements although no new points of entry will be acceptable onto Cambridge Road.

Subject to the reduction of current speed limits, access from Lamb Street will provide direct property access to frontage properties where sightlines can be achieved, with the balance served from internal roads connecting to two new intersections onto Lamb Street.

Internally, new roads will be required. The Structure Plan identifies the preferred layout, taking account of engineering requirements and the achievement of high degrees of permeability and connectivity. All streets will be expected to provide for motorised and passive transport modes with a streetscape and pavement design to achieve low vehicle speeds and priority for pedestrian movement. With the potential for new development to have reduced on-site car parking provision, corridor design should provide for parking embayments, with landscaping and lighting design following a consistent theme and integrating with recreational space.

Maximum permeability will be achieved by the provision of footpath connections provided mid-block between residential streets, aligned to enable accessibility to and visibility of the open space network and gully system.

Shared path connections at the northern and southern end of the Structure Plan area are critical to achieving integration with Cambridge Park, across the stream, and with the Green Belt. These connections will require high visibility and prominence in the overall site layout.

5.3 STORMWATER NETWORK

While the entirety of the Structure Plan area drains towards the gully system, the natural values associated with this system require a sensitive and integrated approach to stormwater management to ensure that opportunities for ecological enhancement are taken. The entirety of the area is suitable for on-lot stormwater soakage. This will manage stormwater from private lots for the 2yr ARI events as close to the point of origin as possible to minimise the need for conveyance and treatment. Future proposals will be required to demonstrate how this will be achieved, either through engineered devices or through development controls regarding site coverage and permeability.

Public spaces such as road and reserves will, similarly, be expected to be designed to capture maximum contaminant loads at source. Swales and rain garden designs will provide for soakage or treatment prior to conveyance. Conveyance devices such as overland flowpaths and swales will be expected to be designed as part of the overall open space network rather than as engineered corridors.

Significant storm events will result in flows towards the gully. Two points of collection are proposed, one within the unformed Silverwood Lane corridor and one towards the north of the Structure plan area. Both points of collection will require careful design to address the change in elevation and slope towards the gully floor and incorporate sufficient treatment to ensure that contaminants do not reach the stream and that discharge volumes do not result in erosion or scour of the gully floor. Maximising the opportunity for soakage as part of the overall network will reduce the operational requirements of the treatment and discharge devices.

6. STATUTORY CONTEXT

6.1 TE TURE WHAIMANA O TE AWA O WAIKATO - VISION AND STRATEGY FOR THE WAIKATO RIVER

Te Ture Whaimana o Te Awa o Waikato – the Vision and Strategy for the Waikato River arises from the Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act 2010 and the Ngati Tuwharetoa, Raukawa and Te Arawa River Iwi Waikato River Act 2010 (Upper River Act).

These acts establish a co-governance regime to protect the health and wellbeing of the Waikato River for future generations.

The vision for the Waikato River is "*for a future where a healthy Waikato River sustains abundant life and prosperous communities who, in turn, are all responsible for restoring and protecting the health and wellbeing of the Waikato River, and all it embraces, for generations to come.*" The Vision and Strategy also includes objectives and strategies to achieve the vision.

The Structure Plan area includes an un-named tributary of the Waikato River. The stream is located within a deeply incised gully and is identified as part of a wider Significant Natural Area, adjoining areas that are known to have been occupied and modified by Māori horticultural practices. The wide range of values associated with the stream and its immediate locality have provided key elements to the consideration of future development, including consideration of the Vision and Strategy for the Waikato River.

In particular, the preliminary design includes high-level stormwater management solutions to ensure that water quantity and quality effects resulting from future development are appropriately mitigated and accord with best practice. This will help inform more detailed technical assessments that will be necessary to support any proposed plan change or subsequent resource consent applications under the District Plan and any regional stormwater discharge permits required under the Waikato Regional Plan.

The potential for land modification also raises issues in respect of the stability of the gully sides which could also result in increased erosion and sedimentation reaching the river. The Structure Plan is based on the establishment of an open space network that will protect the gully slope and margins and therefore secure the integrity of the natural system.

6.2 NATIONAL POLICY STATEMENT ON URBAN DEVELOPMENT (2020)

The NPS-UD is intended to ensure there is sufficient land available for future housing and business needs. The NPS-UD has identified the Hamilton area (which includes Waipā District) as a high-growth urban area.

The NPS for Urban Development requires that sufficient land for housing be available for the 'short term', 'medium term' and 'long term', and that an oversupply of land be made available. A fundamental shift in respect of on-site parking requirements is introduced, removing the requirement for minimum levels of provision. Increased development densities could result from the additional space that will be freed up, with a consequential increase in the demand for on-street parking.

The Structure Plan is a key step in ensuring that the supply of land identified within the Council's Growth Strategy is brought forward to be genuinely available for development. By providing clear guidance to landowners and potential developers, the Structure Plan identifies the anticipated pattern of development and associated infrastructure. The Plan also provides a clear basis for the identification of infrastructure improvements requiring public investment. Anticipating the shift towards reduced on-site parking, the Structure Plan signals the need for careful design of the streetscape to accommodate parking space in addition to landscaping and stormwater management devices.

6.3 WAIKATO REGIONAL POLICY STATEMENT

The RPS provides direction for the management of the resources of the region as a whole. District Plans are required to give effect to the Regional Policy Statement.

The RPS identifies the broad scale of residential growth anticipated within Waipā District and indicates urban limits within which this should be met as well as density targets to achieve the efficient use of land and resources. The Structure Plan area is within the defined urban limits for Cambridge. The proposed pattern of development provides protection for sensitive aspects of the Structure Plan area. It locates public spaces in areas that would otherwise face development restrictions and thereby increases potential yield in other parts of the area. The proposed road network and access arrangements ensures that all parts of the Structure Plan area are served by road connections that will support full urban density development.

The Structure Plan is consistent with the key objectives and policies of the RPS.

6.4 WAIPĀ DISTRICT PLAN

The Waipā District Plan outlines the strategic policy framework for the Plan, including key trends, future challenges, national directions, NPS-UD, Vision and Strategy for the Waikato River, Waipā River Agreement, National Policy Statements, National Environmental Standards, Regional and Local direction, and strategic outcomes sought. It also identifies the key resource management issues for the District and associated Objectives and Policies.

One of the key objectives is to achieve a consolidated settlement pattern that is focused in and around existing settlements of the District, which is supported by policies to ensure that all future development and subdivision in the District contributes towards achieving the anticipated settlement pattern in the Future Proof Growth Strategy and Implementation Plan 2009 and the District Growth Strategy.

The Structure Plan is consistent with the key objectives and policies of the Strategic Policy Framework section in the District Plan as it will bring forward the development of residential dwellings within a key growth cell that will contribute towards the coordinated expansion of the Cambridge township. Careful assessment of the site specific attributes and technical requirements of development and infrastructure provision has resulted in a Plan that will deliver significant growth whilst protecting ang enhancing significant features. The Structure Plan is consistent with the capacity targets of the Waipā 2050 Growth Strategy.

7. CONCLUSIONS

The Structure Plan described in and appended to this report confirms the suitability and anticipated form of development for the C4 Growth Cell.

The technical assessments underpinning the Structure Plan, as well as engagement with iwi, provide confidence that future development is viable and can be achieved whilst protecting and enhancing significant natural and cultural features. The Structure Plan identifies the anticipated pattern of development and clearly signals key land use and infrastructure elements that will require public investment in their development or ongoing ownership.

The Structure Plan is a key step towards the achievement of planned development but is sufficiently flexible to adapt to the additional technical assessments that will be needed as part of subsequent plan change or resource consent processes.

C4 Growth Cell
Transportation Assessment

Waipa District Council

ISSUE 1, 20 DECEMBER 2019

C4 Growth Cell
Transportation Assessment

Waipa District Council

Prepared by: ....

Vinish Prakash

Approved by: ....

Alastair Black

ISSUE 1, 20 DECEMBER 2019

2 Alfred Street
PO Box 14178
Hamilton, 3214
Tel: 07 853 8997

TABLE OF CONTENTS

P:\1_Projects\05_Waipa\05_142_C4-Structure-Plan\D_Deliverables\2019-11-19 C4 Structure Plan V4.Docx

EXECUTIVE SUMMARY

Background

Gray Matter Ltd has been engaged by Waipa District Council to prepare an Integrated Transport Assessment (ITA) to inform development of and assess the transportation impacts of the C4 Structure Plan. The site is located within the Waipa District just outside of Cambridge. The site is currently zoned rural. The C4 residential structure plan area is identified in the Waipa 2050 Growth Strategy and included in Appendix S1 of the District Plan.

Trip Generation

We understand that the Growth Cell could provide approximately 1,020 dwellings. Based on 85th percentile published trip generation rates the development could generate approximately 11,100 veh/day and 1,200 veh/hr.

We anticipate that most vehicles will be travelling towards Cambridge during the morning peak and returning via Cambridge during the afternoon peak. Some residents may commute to Hamilton via Kaipaki Road or to Te Awamutu via Cambridge Road.

Proposed Intersections

New intersections will be required on Lamb Street and Cambridge Road. The locations indicated in the structure plan layout (attached at Appendix 1) are based on providing minimum sight distance from the intersection and minimum separation of 90m from other intersections. The locations are based on there being no direct access from the development to the proposed roundabout at the Kaipaki Road/Cambridge Road/Lamb Street intersection. To provide safe and efficient access we recommend the structure plan includes two intersections on Lamb Street. Given the relatively high volume of traffic at the intersections we prefer that these intersections are formed as roundabouts.

Lamb Street/Kaipaki Road/Cambridge Road Intersection

Given the expected increase in traffic at the Lamb St/ Kaipaki Road/Cambridge Road intersection, a roundabout is the most appropriate form of intersection at this location. A roundabout provides a safe system solution consistent with Vision Zero and would provide a rural/urban threshold. It would be desirable to construct the roundabout prior to any development within the C4 structure plan. However, constructing the roundabout after Area C (or 300 lots) is developed and prior to any development in Area A and B is acceptable.

Recommended Infrastructure

We recommend that the following infrastructure is implemented as part of the C4 structure plan:

- A roundabout at the Kaipaki Road/Cambridge Road/Lamb Street intersection;
- 3m wide shared path on Lamb Street and Cambridge Road with links through the development;
- Roundabouts at new intersections on Lamb Street;
- Roundabout at the Lamb Street/ Shakespeare Street intersection;
- Upgrading Lamb Street and Cambridge Road to arterial road standards; and
- Walking and cycling connection via 3838 Cambridge Road.

1. INTRODUCTION

1.1. Background

Gray Matter Ltd has been engaged by Waipa District Council (Waipa DC) to prepare an Integrated Transport Assessment (ITA) to inform development of and assess the transportation impacts of Waipa DC's C4 Structure Plan.

1.2. Purpose and Basis of this Report

The purpose of this ITA is to assess the traffic and transportation impacts of the proposed development on the surrounding area.

This ITA presents an assessment of the likely traffic and transportation issues associated with the C4 structure plan. It comprises:

= A summary description of the site, and comments on the surrounding road network, including function and traffic volumes;

= Comments on the proposal, including traffic generation and access;

= Concept designs for the main intersections and typical cross-section for the arterial network;

= Evaluation of the likely traffic impacts; and

= Conclusions, including a summary of impacts and recommendations.

2. SITE AND SURROUNDING NETWORK

2.1. Site Description

The site is located within the Waipa District just outside of Cambridge. The site is currently zoned rural. The C4 residential structure plan area is identified in the Waipa 2050 Growth Strategy and included in Appendix S1 of the District Plan. The Growth Cell is intended for residential development on the Leamington side of Cambridge. Development of the growth cell is anticipated before 2035.

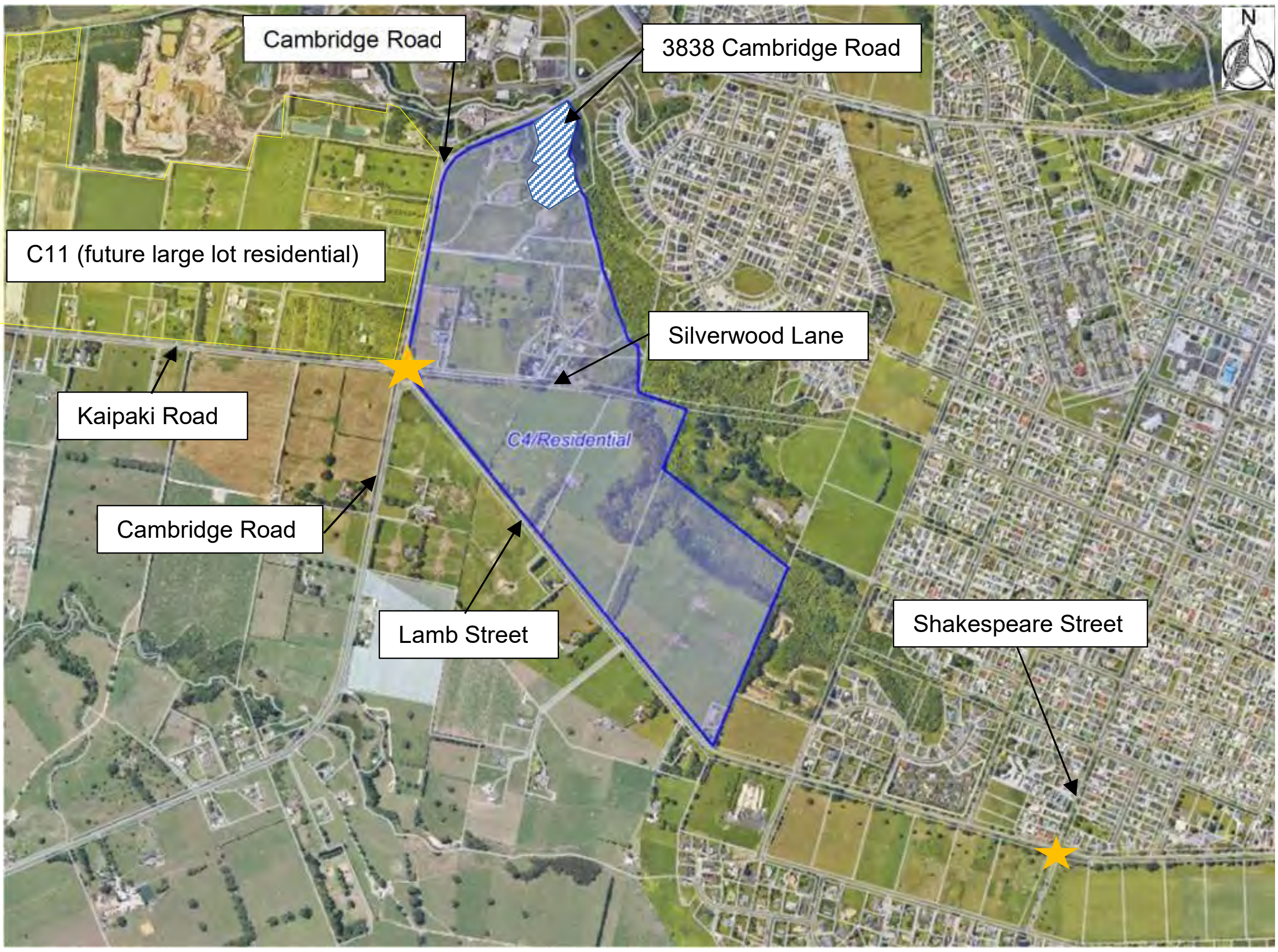


Figure 1: Site Locality

The site is bounded by Lamb Street and Cambridge Road. Silverwood Lane is entirely within the Structure Plan area.

The C11 growth cell is located west of Cambridge Road and is planned for development beyond 2035. That growth cell is intended for large lot residential development with capacity for approximately 258 dwellings.

2.2. Transport Network

The transport network surrounding the site consists of the following roads:

Road Name	Speed Limit (as at 4 November 2019)	Road Hierarchy	ONRC	Traffic Volume[1]	% HCV
Cambridge Road	80km/h	Major Arterial	Arterial	7,200 veh/day	11%
Lamb Street	80km/h	Minor Arterial	Primary Collector	2,800 veh/day	6.7%
Kaipaki Road	100 km/h	Minor Arterial	Primary Collector: Route Consistency	3,200 veh/day	10.2%
Silverwood Lane	80km/h	Local Road	Access	76 veh/day	0%
Shakespeare Street	50km/h	Minor Arterial	Primary Collector	4,955 veh/day	5.5%

Table 1: Transport Network

2.3. Crash History

We have completed a search of NZTA's crash analysis system (CAS) for crashes from 2015-2019 along Cambridge Road, Lamb Street, at the Lamb Street/Cambridge Road/Kaipaki Road/Silverwood Lane intersection and at the Lamb Street/Shakespeare Street intersection.

There have been three reported crashes at the Lamb Street/Cambridge Road/Kaipaki Road/ Silverwood Lane intersection. Two crashes have been minor injury crashes with one crash a serious injury crash. The reported crashes all appear to be related to the Lamb Street leg. We note that one minor injury crash was related to poor driver behaviour rather than the road environment.

There have been two minor injury crashes at the Lamb Street/Shakespeare Street intersection. The crashes were a result of vehicles failing stop at the intersection.

There have been two loss of control crashes on Cambridge Road north of the Kaipaki Rd/Cambridge Rd/Lamb St intersection near the horizontal curve which is posted with a 65km/h curve advisory sign. Both crashes and appear related to vehicles driving too fast for the conditions. Both crashes occurred in wet conditions.

There has been an injury crash every 1.6 years at the Lamb Street/Cambridge Road/Kaipaki Road/Silverwood Lane intersection and one crash every 2.5 years at the Lamb Street/Shakespeare Street intersection. The actual injury crash rate is slightly higher than the predicted crash rate for these intersections and this would be expected to increase with more traffic using the intersections in the future.

[1] https://mobileroad.org/desktop.html

2.4. Lamb Street Existing Cross Section

Lamb Street is a minor arterial road and has ONRC classification of primary collector. The posted speed limit is 80km/h but would likely reduce to 60km/h with development of the structure plan and associated roundabouts. The existing road reserve is 20.1m wide. The existing carriageway is approximately 7.9m wide and consists of two lanes and narrow (<0.5m) shoulders.

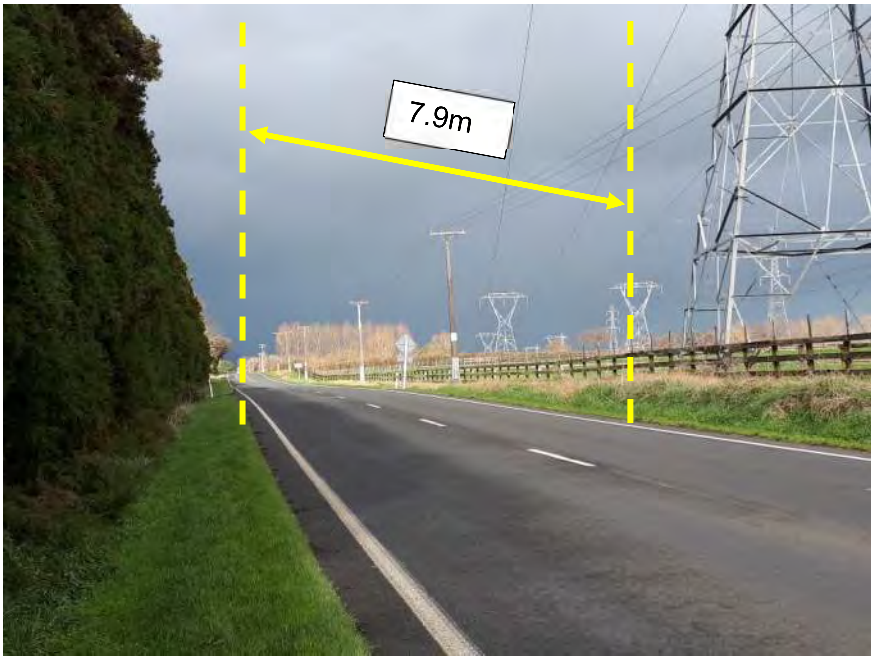


Figure 2: Existing Lamb Street carriageway

2.5. Cambridge Road Existing Cross Section

Cambridge Road is a major arterial road in the District Plan and has an ONRC classification of an arterial road. The carriageway is approximately 8.5m wide and consists of two traffic lanes and shoulders. There are right turn bays on Cambridge Road for turning into Kaipaki Road and Lamb Street and a left turn lane on Cambridge Road (south) for turning into Kaipaki Road.

2.6. Access to 3838 Cambridge Road

The vehicle crossing for access to 3838 Cambridge Road is located approximately 100m west of Matos Segedin Drive and opposite an industrial vehicle crossing (garden supplies business). There are right turn bays on Cambridge Road into Matos Segedin Drive and the garden supplies business vehicle crossing. Visibility is restricted by the horizontal and vertical alignment of Cambridge Road. The right turn bay at the industrial vehicle crossing makes access to this property potentially confusing for vehicles turning right.

Clearway Consulting completed an assessment[2] for 3838 Cambridge Road which included an assessment of speed and crashes on Cambridge Road. At the time of the assessment the speed limit on this section of Cambridge Road was 100km/h. The assessment concluded that there may be some justification for lowering the speed limit to 70km/h or 80km/h. We note that the speed limit has changed to 80km/h as part of the recent Waipa Speed Limits Bylaw update.

2.7. Lamb Street/ Kaipaki Road/ Cambridge Road Intersection

The existing intersection is a staggered “T” intersection. There is approximately 35m separation between the two intersections. The intersections are stop controlled on both the Kaipaki Road and Lamb Street approaches.

[2] Speed Limits 3838 Cambridge Road, Cambridge – Urban Village Property Limited (20 February 2014)

There are right turn bays on Cambridge Road for movements into Kaipaki Road and Lamb Street. There is a left turn deceleration lane for movements into Kaipaki Road from Cambridge Road. Silverwood Lane currently forms a "T" intersection with Lamb Street. The existing intersection layout is shown in Figure 3 below.

Based on crash prediction models[3] the estimated crash rate for the intersection is 0.334 injury crashes/year or an injury crash approximately every 3 years, we note that there have been three crashes at the intersection within the last five years (or 1.6 injury crashes/year). The intersection is performing poorer than expected.

Figure 3: Kaipaki Road/Cambridge Road/Lamb Street Intersection

2.8. Silverwood Lane/Lamb Street intersection

Silverwood Lane is local road which forms a stop controlled priority intersection with Lamb Street. There is approximately 30m separation from the Cambridge Road intersection. This does not meet minimum separation requirements for the current posted speed of 100km/h.

The traffic volume on Silverwood Lane is estimated to be 76veh/day, equivalent to trip generation for approximately eight residential dwellings. Silverwood Lane will require realignment due to the proposed roundabout and residential development within the structure plan.

[3] NZTA Crash Estimation Compendium

Figure 4: **Existing Silverwood Lane Intersection**

2.9. Lamb Street/ Shakespeare Street

The existing crossroads intersection is priority controlled with stop control on the Shakespeare Street approaches. There have been two crashes within the last five years relating to vehicles on Shakespeare Street failing to give way. There is likely to be an increase in movements at the intersection due to development within the structure plan resulting in more trips to the Leamington Village and school via Lamb Street.

During a site visit we noted that there have been some minor improvements such as kerb and channel. Given the proximity of the intersection to the school it would be prudent to provide a safe form of intersection whilst controlling speeds at the intersection.

Figure 5: **Existing Shakespeare Street Intersection**

2.10. Walking and Cycling

There are currently no walking or cycling facilities located near the C4 growth cell. There is a footpath on Lamb Street east of Rawlings Place which provides a connection to Leamington School and an existing path on Cambridge Road which terminates on Cambridge Road approximately 320m east of the Matos Segedin Drive/Cambridge Rd intersection.

3. THE PROPOSAL

3.1. Description

The C4 Growth Cell is identified in the Waipa District Growth Strategy. Through Plan Change 5 to the Waipa District Plan it has been confirmed as a Residential Zone with the timeframe for development being "now to 2035". We understand that Growth Cell C4 could accommodate 1,020 lots.

3.2. Trip Generation

We understand that the Growth Cell could provide approximately 1,020 dwellings. The NZTA Research Report 453 (RR453) provides trip generation rates for various residential activities. The 85th percentile trip generation rates and trip generation for dwellings are summarised in Table 2 based on 1,020 lots.

Activity	Units	Peak hour		Daily	
		Rate	Trips (veh/hr)	Rate	Trips (veh/day)
Dwelling (inner suburban)	1,020	1.2/unit	1,224	10.9/unit	11,118

Table 2: 85th Percentile Trip Generation

We have based our assessment on trip generation rates for inner suburban dwellings. As the site is slightly remote from Leamington, the daily trip generation could be less. For the purposes of this assessment we have assessed trip generation as approximately 11,100 veh/day and 1,200 veh/hr.

Our assessment of trip generation is based on one dwelling per lot. There is a risk that trip generation could be higher if the lots were developed as duplexes. We understand that the estimate of 1,020 lots is a conservative estimate and likely to be less once other infrastructure such as stormwater treatment wetlands, parks and open spaces have been identified.

3.3. Trip Distribution

As the subdivision layout is not yet available, we have divided the proposed residential area into three broad catchments. However, all access will via two intersections on Lamb Street.

We have considered providing access to Area A directly to Cambridge Road via a new intersection (indicated by the blue star on Figure 6). Following consultation with Waipa DC this intersection has not been included. Council's preference is that the Lamb Street/ Kaipaki Road/ Cambridge Road intersection is developed to provide access to the C4 and C11 structure plan areas. Providing another intersection on Cambridge Road would minimise travel distance for trips to/from Area A. However, it would introduce a new intersection on the major arterial network which is inconsistent with good traffic engineering practice. The intersection would also increase delay and increase the risk of crashes for trips along Cambridge Road.

The catchments are summarised in the figure and table below.

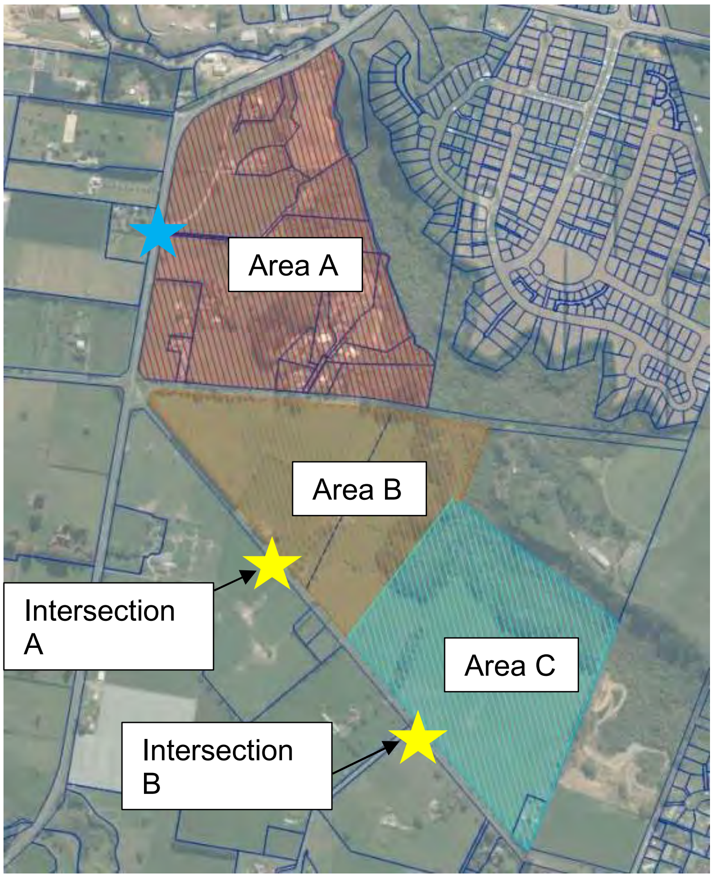


Figure 6: Development Areas (yellow star = possible intersections)

Based on the areas shown in Figure 6 we have distributed the total vehicle trips at the intersection based on percentage of land area as shown in Table 3 below.

Area	% Land Area	Lots (% of 1020 lots)	Daily trips (10.9/unit)	Peak hour (1.2/unit)
Area A	42%	428	4,665	514
Area B	28%	286	3,117	343
Area C	30%	306	3,335	367
Total		1,020	11,117	1,224

Table 3: Anticipated trip generation at intersections

We anticipate that most vehicles will be travelling towards Cambridge during the morning peak and returning via Cambridge during the afternoon peak. Some residents may commute to Hamilton via Kaipaki Road or to Te Awamutu via Cambridge Road.

The shortest route into Cambridge is north via Cambridge Road. This will require right turns out of the intersections including the Lamb St/Cambridge Rd/Kaipaki Rd intersection as well. Given that Leamington School is located south of the site we anticipate some trips to Cambridge will be via Shakespeare Street (left turn at the intersections).

Based on the above assumptions we have summarised the peak hour movements for each intersection in Table 4 (AM peak) and Table 5 (PM peak).

Intersection	AM Peak Total	Exiting (80%)		Entering (20%)	
		Left out (20%)	Right out (80%)	Left in (80%)	Right in (20%)
Intersection A	857 veh/hr	137 veh/hr	549 veh/hr	137 veh/hr	35 veh/hr
Intersection B	367 veh/hr	59 veh/hr	235 veh/hr	59 veh/hr	15 veh/hr
Total	1,224 veh/hr	196 veh/hr	784 veh/hr	196 veh/hr	50 veh/hr

Table 4: AM Peak volumes

Intersection	PM Peak Total	Exiting (20%)		Entering (80%)	
		Left out (80%)	Right out (20%)	Left in (20%)	Right in (80%)
Intersection A	857 veh/hr	137 veh/hr	35 veh/hr	137 veh/hr	549 veh/hr
Intersection B	367 veh/hr	59 veh/hr	15 veh/hr	59 veh/hr	235 veh/hr
Total	1,224 veh/hr	196 veh/hr	50 veh/hr	196 veh/hr	784 veh/hr

Table 5: PM Peak volumes

3.4. Structure Plan Access

3.4.1. Proposed Intersections

New intersections will be required on Lamb Street to serve the proposed development. The posted speed limit on both Lamb Street and Cambridge Road was reduced to 80km/h in November 2019. Therefore, we have used a design speed of 90km/h for new intersection the concept design

As part of future works, we recommend that the posted speed limit on Lamb Street is changed to 50km/h or 60km/h depending on the form of the intersections and level of direct property access.

We have summarised the intersection spacing and sight distance requirements for a 90km/h design speed in Table 6. We note that the Regional Infrastructure Technical Specification (RITS) requirement for intersection spacing is based on road hierarchy rather than speed environment.

Criteria	Reference	90km/h	Comment
Safe Intersection Sight Distance	Austroads Part 4A	214m	Based on reaction time of 2.0 seconds
Vehicle crossing separation to intersection	Waipa District Plan	200m	
Intersection spacing – same side	RITS	90m	Based on spacing for arterial roads
Intersection spacing opposite side	RITS	45m	Based on spacing for arterial roads

Table 6: Intersection design criteria

We understand Council's preference is for two intersections on Lamb Street with no direct access to Cambridge Road. Our preferred locations are shown in Figure 7 below. The locations are based on providing minimum sight distance from the intersection and minimum separation of 90m to other intersections. The layout assumes that there will be no access to the structure plan area via the Kaipaki Road/Cambridge Road/Lamb Street intersection or Cambridge Road. If an access to the C4 Growth Cell were provided at the Kaipaki Road/ Cambridge Road /Lamb Street intersection, then it is likely that only one intersection on Lamb Street would be required.

There are existing residential vehicle crossings located on the opposite side of Lamb Street which may not meet minimum separation to the new intersections. The vehicle crossings are low volume and the non-compliance is unlikely to result in significant adverse safety effects.

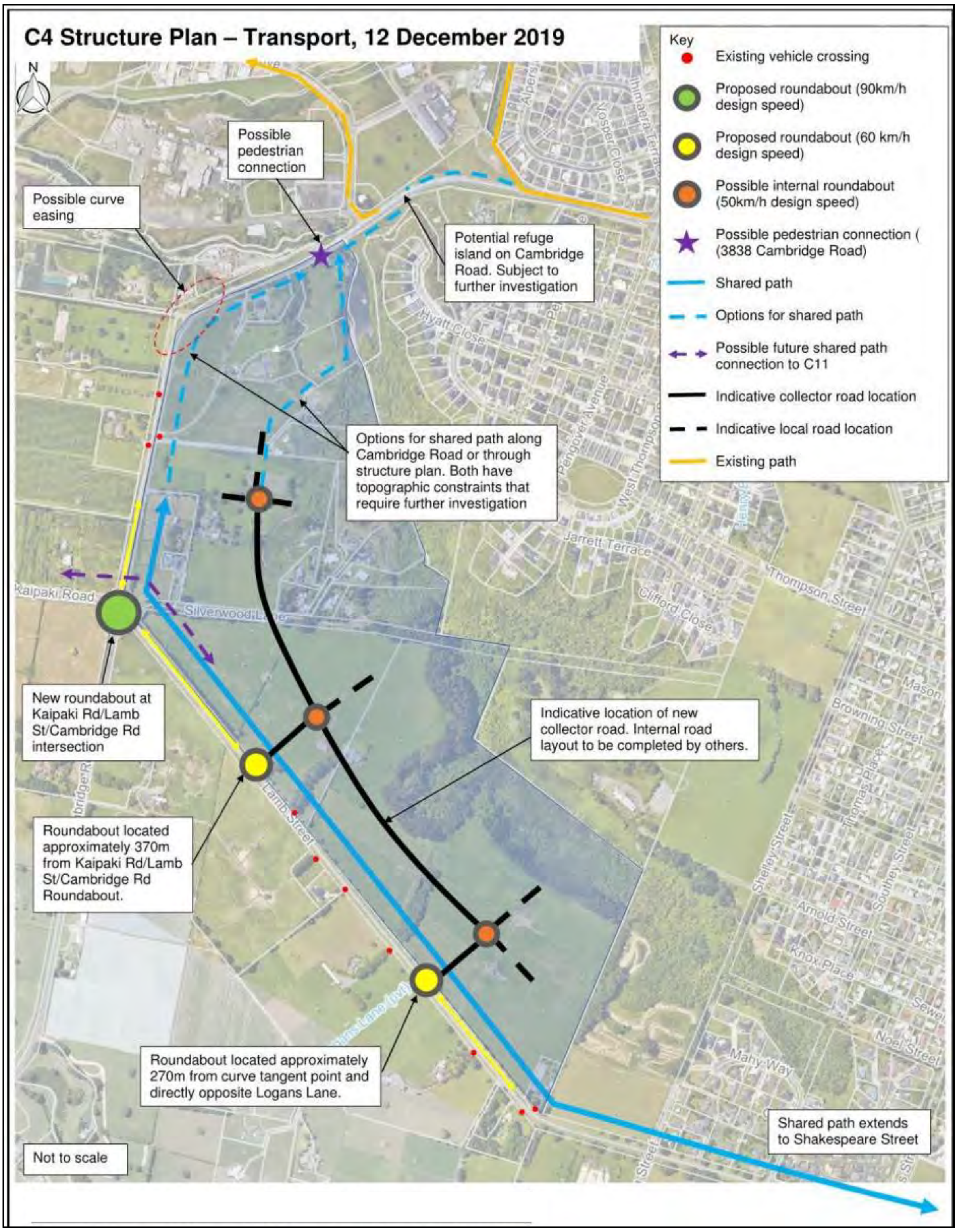


Figure 7: Structure Plan – Transport Layout (refer Appendix 1 for larger copy)

3.4.2. Arterial/ Collector Road Intersections

Austroads Guide to Traffic Management provides guidance on intersection traffic controls based on road hierarchy. Lamb Street is a minor arterial road, meaning that roundabouts and priority-controlled intersections are the most appropriate forms of intersection.

Road type	Primary arterial	Secondary arterial	Collector and local crossing road	Local street
Roundabouts				
Primary arterial	A	A	X	X
Secondary arterial	A	A	A	X
Collector & local crossing road	X	A	A	O
Local street	X	X	O	O
Traffic signals				
Primary arterial	O	O	O	X
Secondary arterial	O	O	O	X
Collector & local crossing road	O	O	X	X
Local street	X	X	X	X
***Stop* signs or *give way* signs**				
Primary arterial urban/(rural)	X/(X)	X/(O)	A	A
Secondary arterial urban/(rural)	X/(O)	X/(O)	A	A
Collector & local crossing road	A	A	A	A
Local street	A	A	A	A

A = Most likely to be an appropriate treatment
O = May be an appropriate treatment
X = Usually an inappropriate treatment.

Figure 8: Austroads Guide to Traffic Management – Intersections, Interchanges and Crossings (Table 2.6 – suitability of types of traffic control)

Austroads[4] provides guidance on warrants for turning treatments at priority-controlled intersections. The peak hour right turning volumes are likely to exceed 20 veh/hr and the Lamb Street peak hour volume is 308 veh/hr therefore, a right turn treatment is required at each of the intersections.

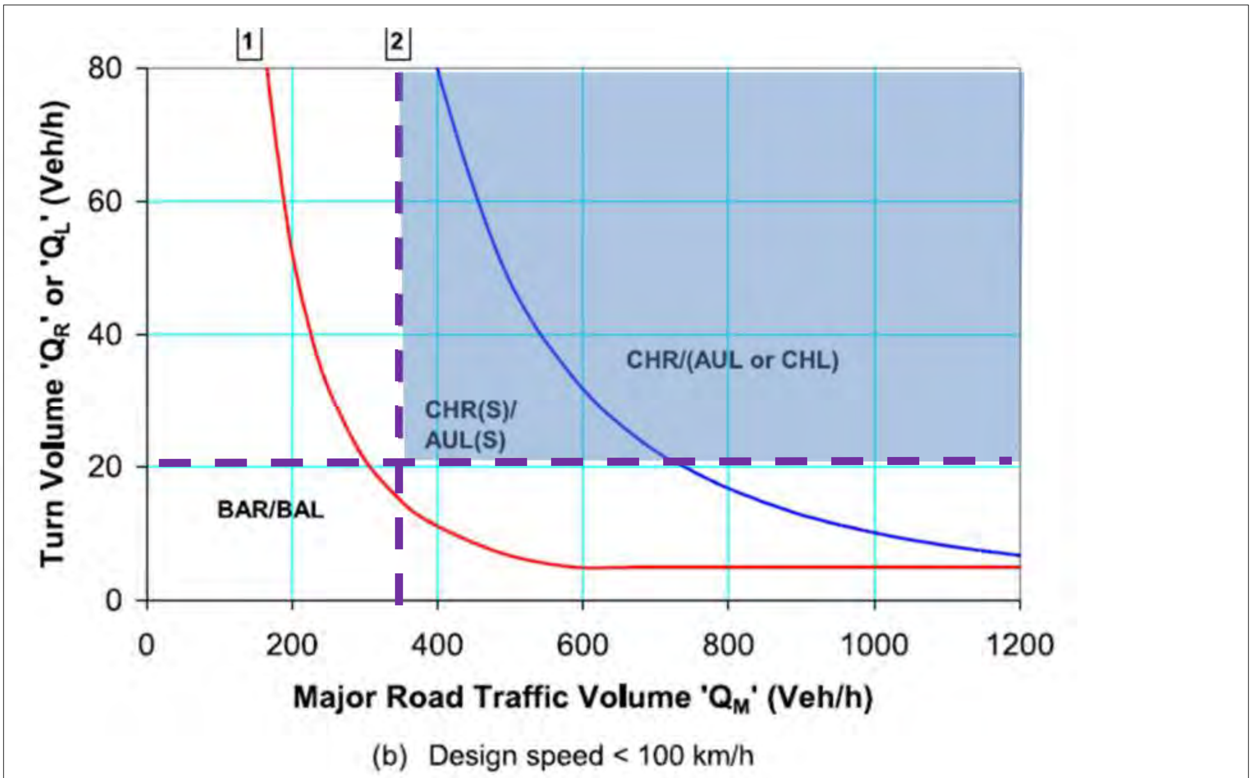


Figure 9: Austroads Turn Warrants

We have completed SIDRA traffic modelling for Intersection A which is likely to generate the most traffic during AM peak. We have tested both a priority-controlled intersection and a roundabout.

[4] Guide to Road Design Part 4: Intersections and Crossings – Figure A 10

We have assumed that 11% of AADT occurs during peak time on Lamb Street (308 veh/hr) and allowed for a 50:50 directional split on Lamb Street (154 veh/hr northbound and 154 veh/hr southbound).

The SIDRA modelling for the priority-controlled intersection shows delays and queues of just under 30sec/veh and 95%ile queues of just under 180m. The delays and queues are related to the high number of vehicles turning right out of the intersection. In practice, drivers may turn left-out to avoid long delays. Long delays can lead to driver frustration and crashes.

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Lamb St (NB)												
2	T1	154	10.0	0.084	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	50.0
3	R2	35	10.0	0.028	5.7	LOS A	0.1	0.9	0.39	0.57	0.39	45.2
Approach		189	10.0	0.084	1.1	NA	0.1	0.9	0.07	0.11	0.07	49.0
East: New Road A												
4	L2	137	10.0	0.921	21.5	LOS C	23.6	179.5	0.86	1.77	2.97	36.3
6	R2	549	10.0	0.921	27.8	LOS D	23.6	179.5	0.86	1.77	2.97	36.0
Approach		686	10.0	0.921	26.6	LOS D	23.6	179.5	0.86	1.77	2.97	36.1
North: Lamb St (SB)												
7	L2	137	10.0	0.163	4.7	LOS A	0.0	0.0	0.00	0.25	0.00	47.9
8	T1	154	10.0	0.163	0.0	LOS A	0.0	0.0	0.00	0.25	0.00	48.5
Approach		291	10.0	0.163	2.2	NA	0.0	0.0	0.00	0.25	0.00	48.3
All Vehicles		1166	10.0	0.921	16.4	NA	23.6	179.5	0.52	1.12	1.76	40.4

Table 7: SIDRA Modelling – Movement Summary

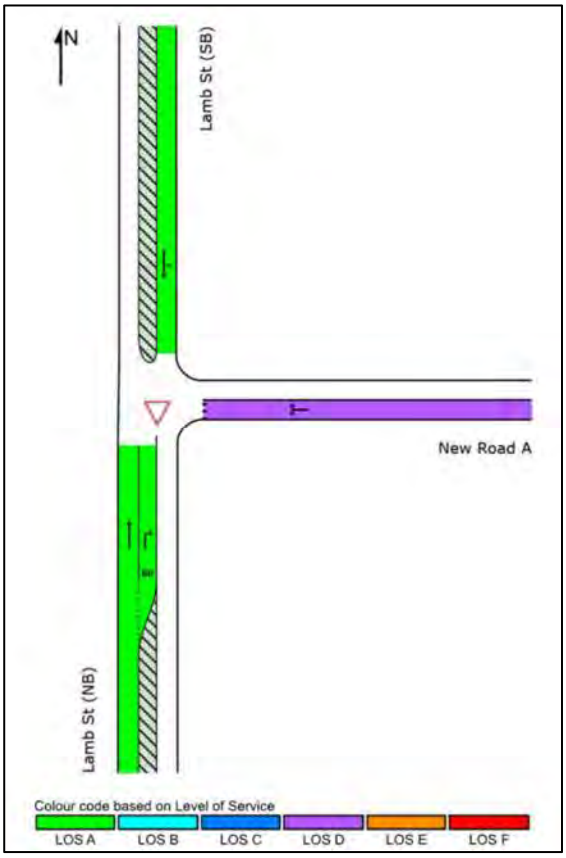


Figure 10: LOS Diagram - Priority Controlled Intersection

A roundabout is more efficient for all legs with the intersection operating at Level of Service (LOS) A. The roundabout will provide a safer intersection when compared to a priority-controlled intersection.

Movement Performance - Vehicles													
Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Lamb St (NB)												
2	T1	154	10.0	0.221	5.3	LOS A	1.5	11.4	0.73	0.67	0.73	47.2
3	R2	35	10.0	0.221	11.1	LOS B	1.5	11.4	0.73	0.67	0.73	47.8
Approach		189	10.0	0.221	6.4	LOS A	1.5	11.4	0.73	0.67	0.73	47.4
East: New Road A												
4	L2	137	10.0	0.523	3.6	LOS A	4.7	35.3	0.53	0.59	0.53	45.2
6	R2	549	10.0	0.523	8.9	LOS A	4.7	35.3	0.53	0.59	0.53	47.0
Approach		686	10.0	0.523	7.8	LOS A	4.7	35.3	0.53	0.59	0.53	46.6
North: Lamb St (SB)												
7	L2	137	10.0	0.193	2.4	LOS A	1.4	11.0	0.20	0.27	0.20	48.4
8	T1	154	10.0	0.193	1.9	LOS A	1.4	11.0	0.20	0.27	0.20	49.9
Approach		291	10.0	0.193	2.2	LOS A	1.4	11.0	0.20	0.27	0.20	49.2
All Vehicles		1166	10.0	0.523	6.2	LOS A	4.7	35.3	0.48	0.52	0.48	47.3

Table 8: SIDRA Modelling – Movement Summary

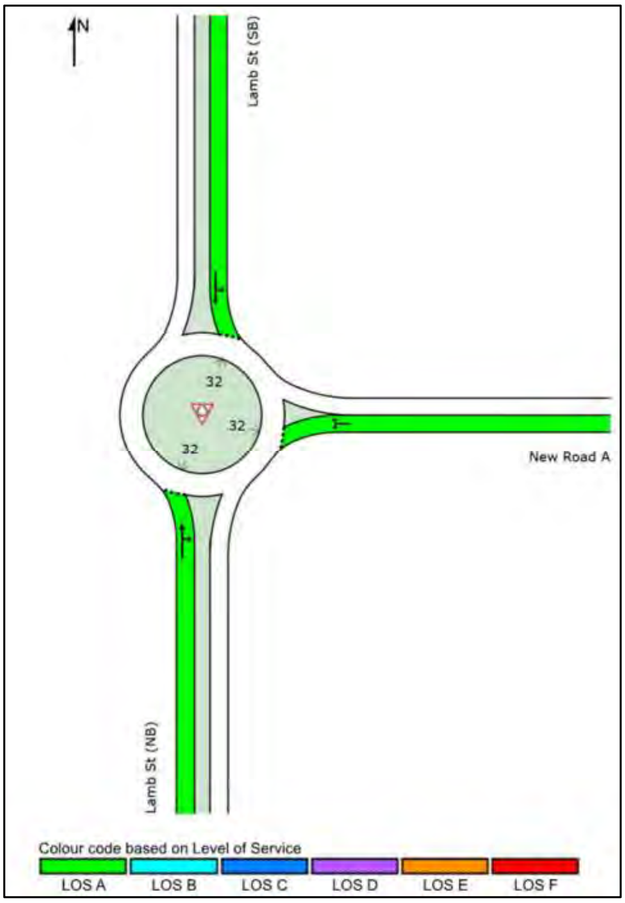


Figure 11: LOS Diagram - Roundabout

Given the relatively high volume of traffic at the intersections and better safety performance we prefer that the intersections are formed as roundabouts.

We have completed a generic concept design for an arterial road/collector road roundabout based on the design criteria summarised in Table 9. The concept layout is based on a 16m central island radius which is suitable for a design speed of 70km/h. The concept layout indicates a possible fourth leg if required (e.g. Logans Lane).

Criteria	
Design Speed	70 km/h
Central Island Radius	16m
Circulating width (single Lane)	7m
Inscribed circle diameter (ICD)	46m
Criterion 2 visibility	70m
Design vehicle	Semi-trailer

Table 9: Roundabout Design Criteria - collector road intersections

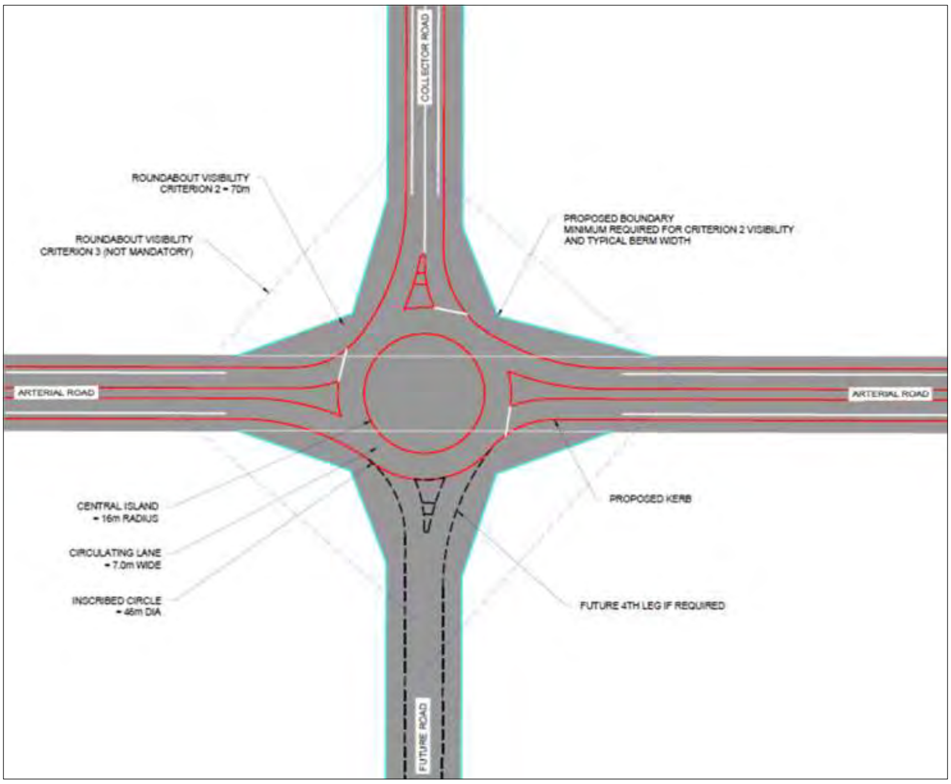


Figure 12: Typical arterial/collector road roundabout (also refer to Appendix 2)

3.5. Minor Arterial Cross Section (Lamb Street and Cambridge Road)

The District Plan does not provide specific design criteria for an arterial road.

We recommend that the Lamb Street and Cambridge Road cross-sections include two 3.5m lanes, 1.5m shoulders/on-road cycle lane on both sides and a 3m wide shared path on the development side. Typically, the District Plan[5] requires 2.1m wide utility corridor on both sides for residential roads. The proposed cross-section allows for a 2.5m wide utility corridor on the development side and a 4.6m wide berm on the opposite side of the road to allow for drainage swale or future footpath.

[5] Waipa District Plan Appendix T4 – Criteria for Public and Private Roads.

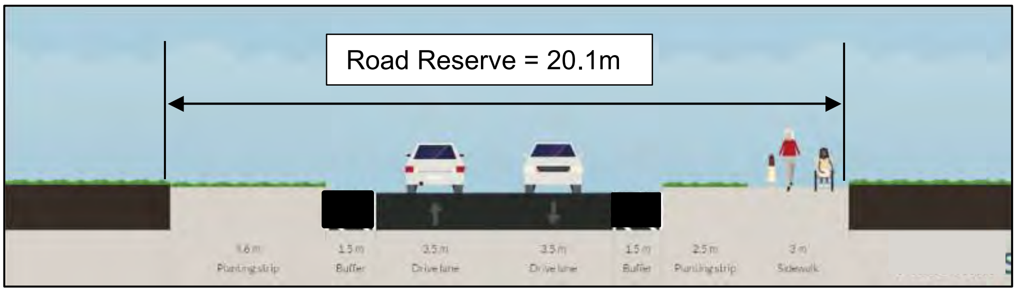


Figure 13: Proposed Cross Section for Lamb Street and Cambridge Road

Providing direct property access to a minor arterial is not consistent with its primary mobility function. We do note that the ONRC classification is Primary Collector which generally have a higher degree of property access. Providing direct property access to Lamb Street is likely to be acceptable if the posted speed on Lamb Street reduces to 50km/h.

3.6. Lamb Street/ Kaipaki Road/ Cambridge Road Intersection

3.6.1. Intersection Form

Given the increase in traffic volumes at this intersection, a roundabout appears to be the most appropriate form of intersection rather than a signalised intersection. A roundabout provides a safe system solution consistent with Vision Zero and would provide a rural/urban threshold.

The difference in safety performance between other intersections in particular traffic signals is mainly attributable to the higher potential speed of vehicles that are possible at a signalised intersection. A well-designed roundabout will achieve lower relative speeds through geometric design and should therefore experience less severe injuries when crashes do occur. In addition, the number of conflict points is greatly reduced from 32 at traffic signals to 16 at a multi-lane roundabout (for four leg intersections).

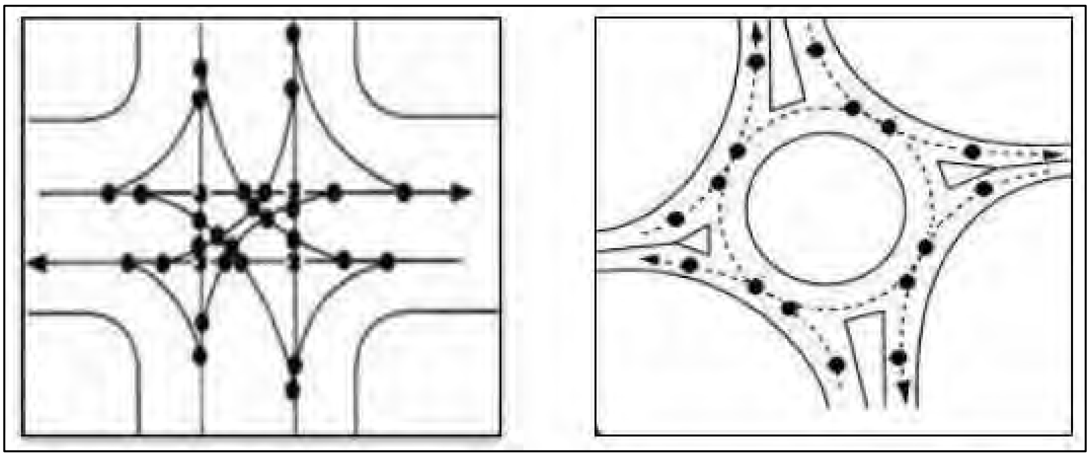


Figure 14: Vehicle conflict points. Traffic signals = 32 conflict points, multi-lane roundabout = 16 (Source: NZ Transport Agency Research Report 476)

It is important to note that most of the research is specifically relevant to urban areas with speed limits ≤50km/hr and focused on intersections with daily traffic volumes >20,000vpd. The research found that no pedestrian fatality was reported at any roundabout in New Zealand during 2005-2008, compared to 11 at traffic signal intersections. This could be a result of a reduced exposure if pedestrians are avoiding roundabouts and crossing elsewhere.

We have completed concept design for a single lane roundabout at the Kaipaki Road/Lamb Street/Cambridge Road intersection. The roundabout is based on the following design criteria.

Criteria	
Design Speed	90km/h (refer to table shown on drawing for approach design speeds)
Central Island Radius	22m
Circulating width (single Lane)	6.5m
Inscribed circle diameter (ICD)	57m
Criterion 2 visibility	70m (50km/h approach speed)
Design vehicle	Semi-trailer

Table 10: Roundabout Design Criteria

The following roundabout options have been considered (refer Appendix 2):

- Option 1: Five leg roundabout (including Silverwood Lane as a fifth leg);
- Option 2: Four leg roundabout (no Silverwood Lane approach) (two sub-options); and
- Option 3: Four leg roundabout (realigned Lamb Street approach).

Our assessment indicates that an appropriately designed roundabout can be provided as this intersection. The final location will be confirmed during detailed design. The location of the central island could be shifted which would result in affecting different properties (e.g. land take within the structure plan vs on Kaipaki Road). Our preference is to optimise the roundabout geometry by shifting the central island towards Kaipaki Road.

Land acquisition will be required for all options to comply with criterion 2 visibility. The concept plans show criterion 3 visibility requirements. This is not mandatory and could be achieved with additional land take. We note that providing visibility beyond criterion 3 can result in higher roundabout approach speeds and higher impact speeds.

Options 1 and 2A show a small radius curve (50km/h) on Cambridge Road (south) as the alignment is constrained by existing boundaries and power pylon. The approach curve could be improved during detailed design which would result in earlier visibility to the central island for approaching drivers. Option 2B results in better approach geometry when compared to the other options but requires land on Kaipaki Road.

We understand that Council's preference is a roundabout with no direct access to the structure plan. Providing a connection to Silverwood Lane at the roundabout provides more direct access to the structure plan and may reduce the need for multiple roundabouts on Lamb Street.

3.6.2. Option Assessment

We have assessed the following roundabout layouts using a high/medium/low assessment scale for a range of criteria:

- Option 1: Five leg roundabout (including Silverwood Lane as a fifth leg);
- Option 2: Four leg roundabout (no Silverwood Lane approach) (two sub-options); and
- Option 3: Four leg roundabout (realigned Lamb Street approach).

Option 2B , a four leg roundabout is the preferred option. Option 3 would be acceptable and is likely to operate efficiently and safely. The final configuration of the roundabout would be subject to detailed design.

3.6.3. Timing of Roundabout

We have completed SIDRA modelling for the existing staggered T intersection to determine when a roundabout is required at the Kaipaki Road/Cambridge Road/Lamb Street intersection. We have modelled the following three AM peak scenarios:

- Scenario A: Baseline using WRTM 2021 traffic volumes;
- Scenario B: Baseline + full development of Area C (306 lots);
- Scenario C: Baseline + full development of Area A (428 lots) and Area B (286 lots);

Scenario A operates at LOS A on both the Kaipkai Road and Lamb Street approaches. Scenario B with the addition of development traffic from Area C results in LOS B on Lamb Street. There appears to be sufficient capacity at the intersection to accommodate traffic from Area C. Adding development from Area A and Area B (Scenario C) results in LOS F on Lamb Street and LOS C on Kaipaki Road.

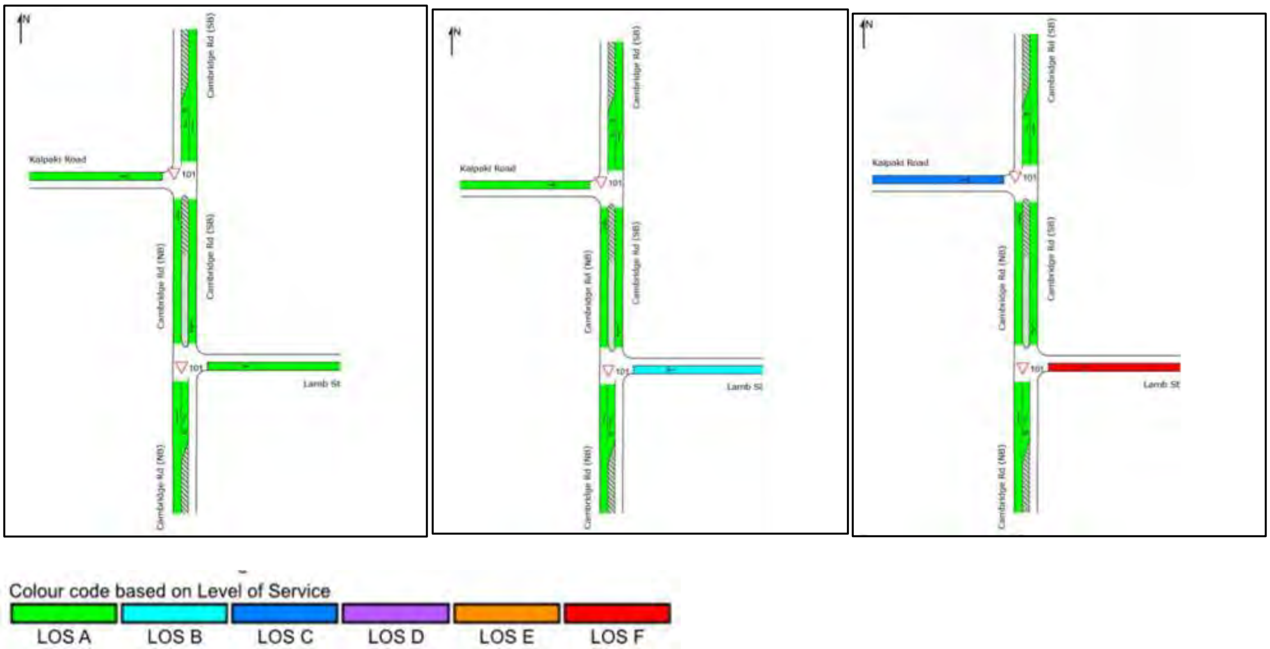


Figure 1: Lane LOS (left = Scenario A, middle = Scenario B, right = Scenario C)

We understand that it is likely that Area C will be developed first and there appears to be sufficient capacity at the existing staggered T intersection to accommodate development traffic from Area C (assumed to be 306 lots). Adding traffic from Area A and Area B results in poor LOS on Lamb Street and less than desirable LOS on Kaipaki Road. Adverse safety effects are also likely.

We note that Cambridge Road is a major arterial road and there are likely to be efficiency and safety effects during the construction of the roundabout which will result in traffic being dispersed to other parts of the traffic network during the construction period. It would be desirable to construct the roundabout prior to development within the C4 structure plan to avoid additional development traffic being dispersed to other parts of the network during the construction period.

As mentioned above a well-designed roundabout is generally a safer intersection form compared to priority controlled intersections. SIDRA modelling indicates that there is sufficient capacity at the staggered-T intersection to accommodate development traffic from Area C. It would be desirable to construct the roundabout prior to development within the C4 structure plan. However, constructing the roundabout once Area C (or approximately 300 lots) is developed but prior to any development in Area A and B is acceptable.

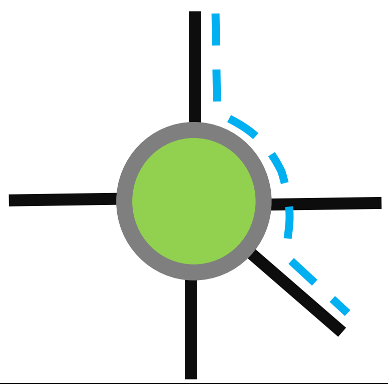
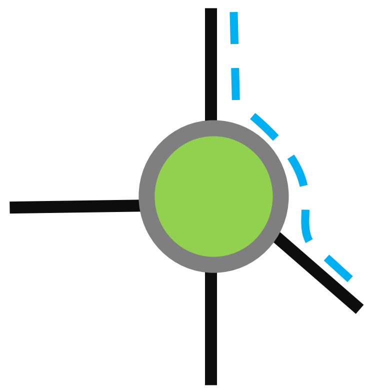
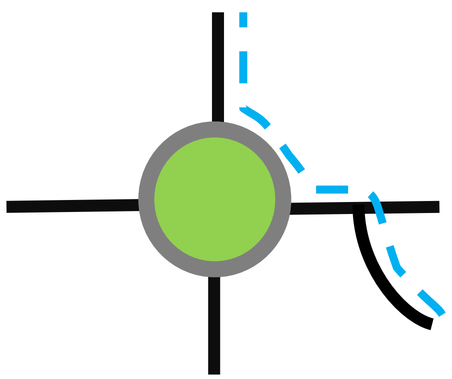
Option	Layout (blue line = shared path)	Safety	Efficiency	Cost	Pedestrians	Summary
Option 1: Five Leg roundabout (Cambridge Rd/ Kaipaki Rd/ Lamb St/ Silverwood Ln) Concept option attached at Appendix 2		<u>**Low**</u> • More roundabout approaches result in less desirable approach leg separation. • Introduces additional conflict points to this intersection	<u>**Medium**</u> • Provides direct access (gateway) to the structure plan • May only required one new intersection on Lamb Street. • Minimal impact on alignment of Lamb Street	<u>**Medium**</u> • Will require upgrading Silverwood Lane to accommodate increase in traffic (currently used for residential access only). • Likely to be more expensive than Option 2.	<u>**Medium**</u> • Will require an at grade pedestrian crossing at Silverwood Lane to provide a pedestrian connection from Lamb St to Cambridge Road (north).	<u>**Undesirable**</u> This option provides direct access to the structure plan. This option is likely to result in fewer intersections on Cambridge Road and Lamb Street. Increased risk of crashes at 5-leg roundabout.
Option 2: Four Leg roundabout (Cambridge Rd/ Kaipaki Rd/ Lamb St) Different options for land take are attached at Appendix 2 (Option 2A and 2B).		<u>**Medium**</u> • Results in two relatively close approaches (Cambridge Rd (south) and Lamb St), but complying visibility provided. • Maybe challenging for less familiar users due to closely spaced approaches.	<u>**Low**</u> • Provides no direct access from roundabout to structure plan • Likely to require two roundabouts on Lamb St introducing additional delay to that corridor	<u>**Medium**</u> • Likely to be the cheapest roundabout option, but requires two roundabouts on Lamb St	<u>**High**</u> • No at grade crossing required for a pedestrian connection from Lamb St to Cambridge Road (north)	<u>**Option 2B Preferred**</u> The option results in no direct access to the structure plan, requiring other infrastructure be provided. Access to the structure plan will be via new roundabouts on Lamb Street. Issues related to closely spaced approaches can be managed.
Option 3: Four Leg roundabout (Cambridge Rd/ Kaipaki Rd/ Silverwood Ln and re-align Lamb St) We have not yet completed a concept design for this option.		<u>**High**</u> • Provides the best roundabout layout in terms of approach geometry as the approach legs intersect at 90° • Only four roundabout approach legs, results in simpler roundabout geometry. • Likely to result in a safer roundabout layout compared to Options 1 and 2.	<u>**High**</u> • Provides direct access (gateway) to the structure plan • Only one roundabout on Lamb Street will be required.	<u>**High**</u> • Requires realigning Lamb Street – higher construction costs and greater property impact • Will require upgrading Silverwood Lane to accommodate increase in traffic (currently used for residential access only) • Likely to be the most expensive option • Realignment of Lamb Street results in inefficient land use in south east corner of roundabout (i.e. reduces subdivision yield).	<u>**Medium**</u> • Will require an at grade pedestrian crossing at Silverwood Lane to provide a pedestrian connection from Lamb St to Cambridge Road (north).	<u>**Acceptable**</u> This option provides direct access to the structure plan area. This option results in more desirable approach geometry, but is likely to be the most expensive option. Due to cost and inefficient land impacts this option is not preferred.

Table 11: Roundabout Option Assessment (blue dashed line = walking/cycling route)

3.7. Lamb Street/Shakespeare Street

Provided that safe walking and cycling facilities can be provided, a roundabout is our preferred option for this intersection. We have completed a concept design based on a 60km/h design speed, 10m central island radius, 6.3m wide circulating lane and large rigid truck design vehicle.

A pedestrian crossing facility is required on Shakespeare Street (north) to allow for a shared path connection along Lamb Street to Leamington School. Given that the intersection is located near a school we recommend considering implementing physical speed management such as raised safety platforms on the roundabout approaches. The raised safety platforms would also provide a crossing point for pedestrians.

There are vehicle crossings located near the intersection which may limit the length of splitter islands. This should be investigated during detailed design.

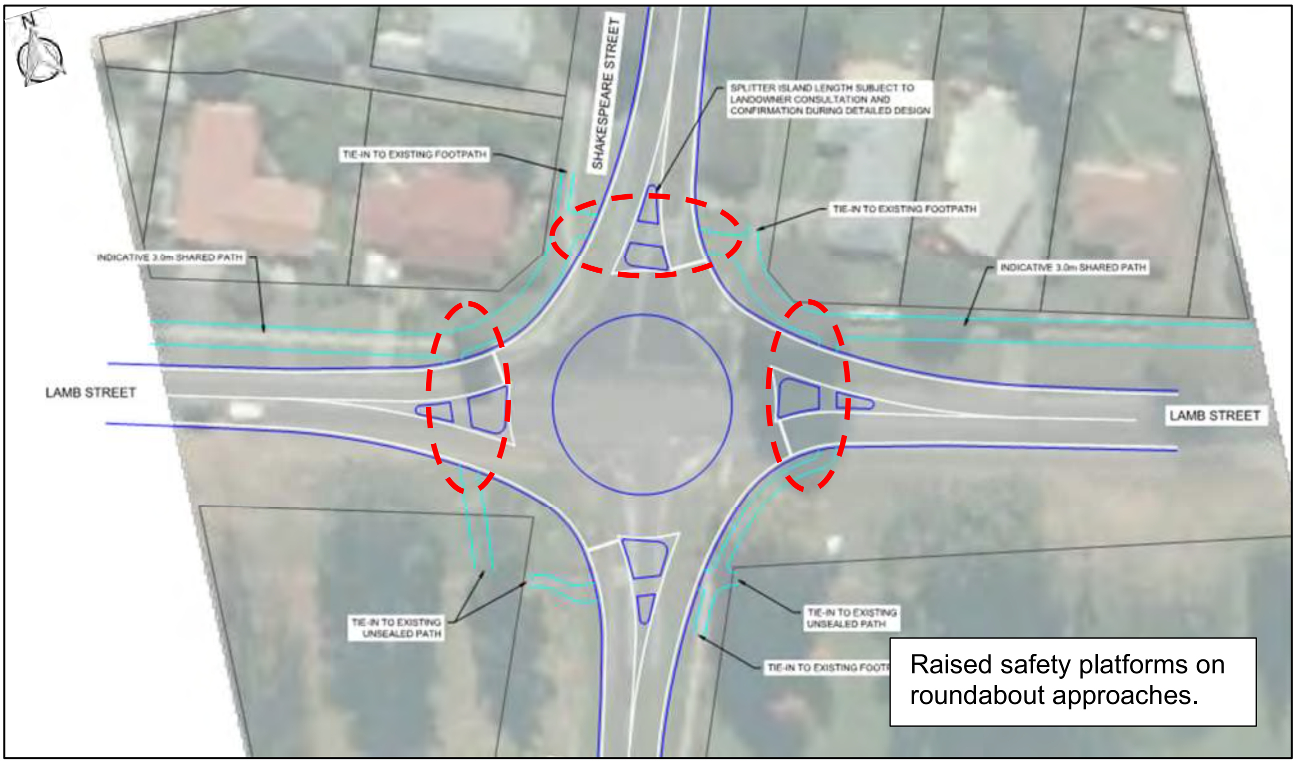


Figure 15: Lamb Street/Shakespeare Street intersection concept design

3.8. Walking and Cycling

There is likely to be an increase in walking and cycling on Lamb Street. We recommend that a shared path be provided on the development side of Lamb Street. This could be extended to provide a continuous path along Maungatautari Road to Lake Karapiro.

There are two options for a connection on Cambridge Road north of Kaipaki Road. One option is to continue the path along Cambridge Road, the other option is to provide a shared path through the development joining at 3838 Cambridge Road.

Our concept plans do not show pedestrian connections at the Cambridge Road roundabout. At this stage there is no demand for a crossing point on Cambridge Road or Lamb Street until the C11 growth cell is developed. A crossing point could be provided on Cambridge Road to provide connectivity to the future C11 growth cell.

3.9. Access to 3838 Cambridge Road

Providing a connection between 3838 Cambridge Road to the remainder of the structure plan area is likely to be very difficult due to the steep topography. The only form of access appears to be direct to Cambridge Road. The posted speed of 80km/h requires 203m sight distance[6].. The current vehicle crossing location does not comply with sight distance requirements for an 80km/h posted speed. There is unlikely to be any location that provides complying sight distance.

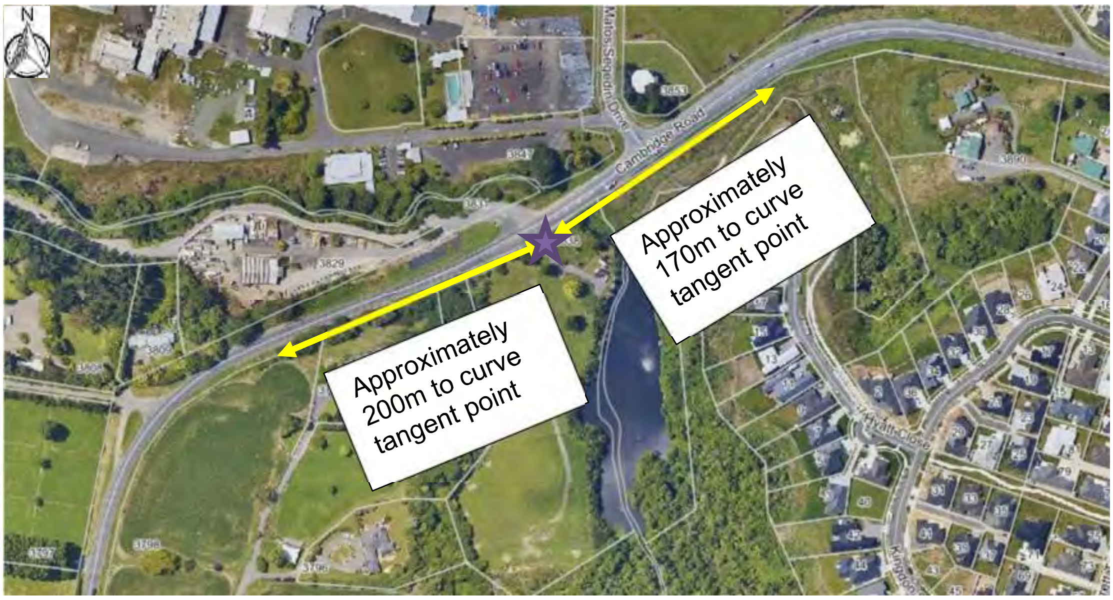


Figure 16: 3838 Cambridge Road Access (purple star = vehicle crossing)

The location of the right turn bay for access into the industrial site makes right turns in and out of 3838 Cambridge Road confusing and difficult. However, the current vehicle crossing is located directly opposite the crossing on the northern side of Cambridge Road (effectively forming a low volume crossroads intersection).

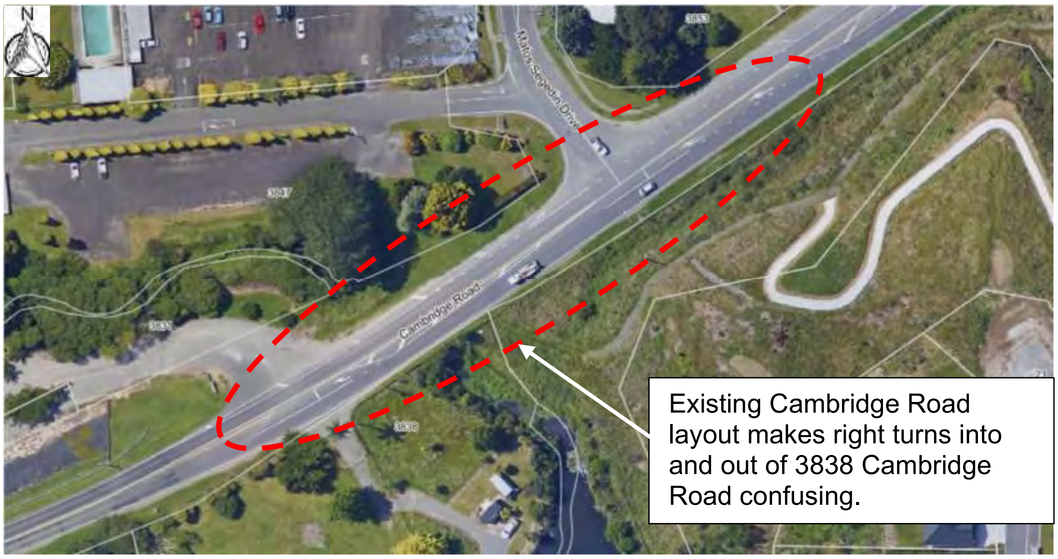


Figure 17: 3838 Cambridge Road Access (purple star = vehicle crossing)

The adverse effects of providing vehicle access to Cambridge Road will depend on the nature of the activity and trip generation of that activity. Given the location and concerns about access, it appears best suited to low trip generating activities. An alternative, could be to restrict access to left-in/left-

[6] NZTA Planning Policy Manual – Appendix 5B, Table App5B/1

out. However, this may limit use of the property and result in in appropriate u-turns elsewhere on the network.

As noted elsewhere, there is the potential for the shared path to join Cambridge Road in this area. Further investigation is required to confirm the most appropriate location for a pedestrian crossing facility.

3.10. Internal Road Layout

The internal road layout will consist of a collector road and local roads for access to individual lots. The final road layout has not been confirmed yet. The District Plan provides guidance on cross sections for residential collector roads. We recommend that the internal roads are designed to these standards.

Type and description	Road reserve width	Carriageway Width	Lane Width	Cycleway width	Street Parking widths	Kerb	Berm swale etc	Path	Utilities
Collector	25m	15m	2 x 3.5m	Both sides 1.5m	1 park per lot @ 2.5m wide	Barrier	Both sides	2 x 1.5m	Both sides 2.1m min

Table 12: Waipa District Collector Road Standards (Appendix T4)

We recommend that all internal collector road intersections are designed to allow for a central throat island. The island width should be at least 1.8m wide to shelter pedestrians. Roundabouts or raised safety platforms are preferred at crossroads intersections.

The final layout of internal intersections will need to be confirmed at detailed design stage and should include:

- Intersection design in accordance with the RITS and current design best practice.
- Providing minimum safe intersection sight distance based on the proposed internal road posted speed.
- Providing channelisation at the intersection with throat islands.
- All marking and signs are in accordance with the Traffic Control Devices Rule and MOTSAM.
- Providing appropriate street lighting at the intersections.

3.11. Parking

We anticipate that on-site parking will be provided for each lot. The District Plan requires 1 parking space per lot.

District Plan Appendix T4 recommends that residential collector road and local roads provide one on-street space per lot. The requirement for cul-de-sac is 0.75 parking spaces per lot. We recommend that each structure plan road provides sufficient on street parking. The use of recessed parking is increasingly common in residential subdivisions.

4. DISCUSSION

4.1. Efficiency

The proposed structure plan will result in an additional 1,020 lots generating approximately 11,100 veh/day.

Assuming 80% of traffic heads north to Cambridge, the traffic volume on Cambridge Road will increase in by approximately 8,900veh/day. The proposal is likely to more than double the existing traffic volume on Cambridge Road with approximately 16,000veh/day once the structure plan is fully developed.

We have completed SIDRA modelling for Intersection A on Lamb Street for both a roundabout and a priority-controlled intersection. The Sidra modelling indicates that there are likely to be delays and queues on the structure plan road during the AM peak if the intersection is formed as a priority-controlled intersection. A roundabout is more efficient and safer than a priority-controlled intersection.

We recommend that Lamb Street and Cambridge Road are upgraded to accommodate the additional traffic. Our preferred cross-section is shown below.

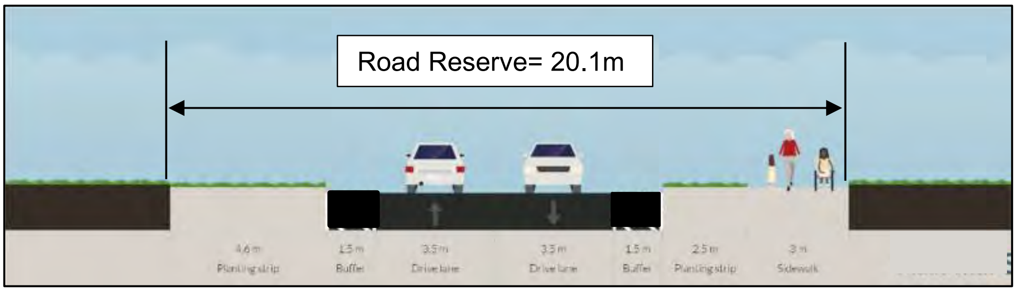


Figure 18: Proposed Cross Section for Lamb Street and Cambridge Road

4.2. Safety

There will be an increase in turning movements on Lamb Street and at the Kaipaki Road/ Cambridge Road/ Lamb Street intersection. The increase in turning movements increases the risk of crashes.

The existing staggered-T intersection could accommodate traffic from Area C (or approximately 300 lots) but is unlikely to safely accommodate traffic from the entire development. Typically, well designed roundabouts are safer compared to priority-controlled intersections as there are less conflict points and speeds are generally controlled with approach and entry geometry. Upgrading the existing intersection to a roundabout will result in a safer form of intersection.

It would be desirable to construct the roundabout prior to development within the C4 structure plan. However, constructing the roundabout once Area C (approximately 306 lots) is developed and prior to any development in Area A and B is acceptable.

4.3. Internal Road Layout

We recommend that the internal road layout is designed to meet the District Plan requirements. We anticipate that the roads forming intersections with Lamb Street and Cambridge Road are likely to be collector roads with the other roads formed to local residential road standards.

4.4. Walking and Cycling

We recommend that a shared path is provided from Leamington School to the structure plan. Further investigation is required to determine the feasibility of a shared path north of the Kaipaki Road intersection on Cambridge Road. There appears to be two options for a shared path. One option would be a shared path within the road reserve on Cambridge Road and the other option is a shared path connection within the development to 3838 Cambridge Road.

5. CONCLUSION

5.1. Summary

The C4 growth cell could yield approximately 1,020 lots. Based on typical trip generation rates this could generate approximately 11,100 veh/day and 1,200 veh/hr. The existing Kaipaki Road/ Cambridge Road/ Lamb Street intersection is not considered appropriate to accommodate all the additional traffic. Therefore, we recommend that the intersection is upgraded to a roundabout.

The structure plan should include an internal collector road that joins the arterial network at a series of roundabouts.

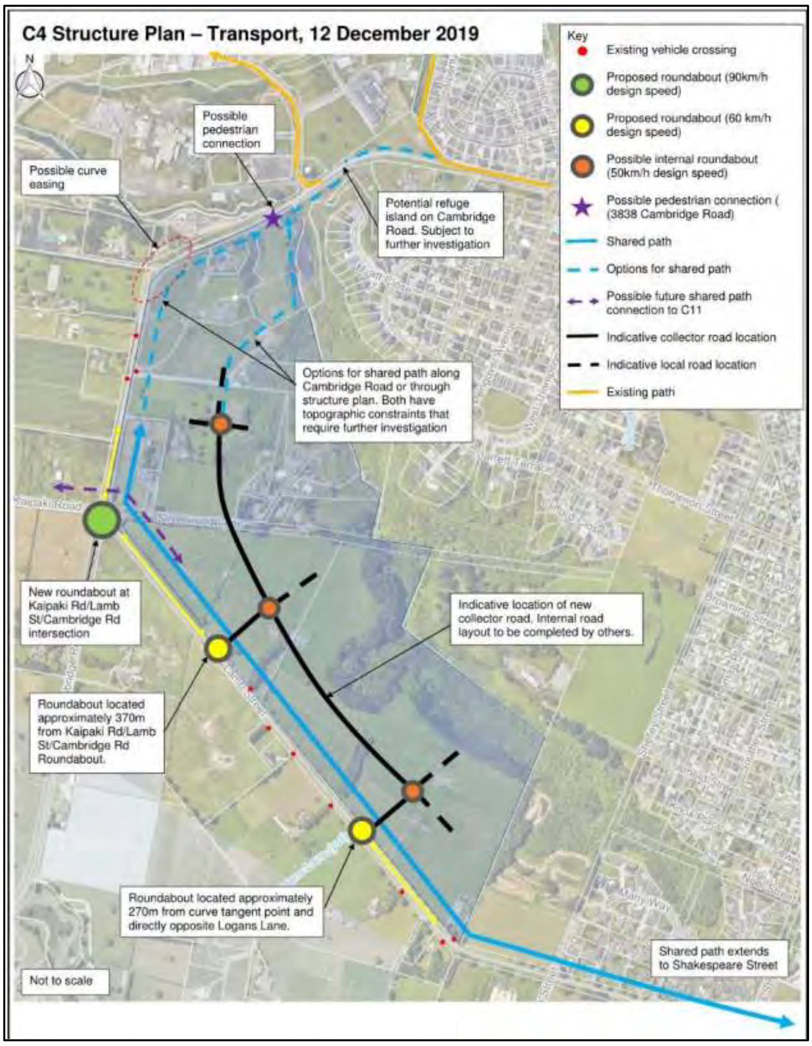


Figure 19: Structure Plan – Transport Layout (refer Appendix for larger copy))

5.2. Recommendations and Conclusion

Based on providing 1,020 lots the following transport infrastructure is required:

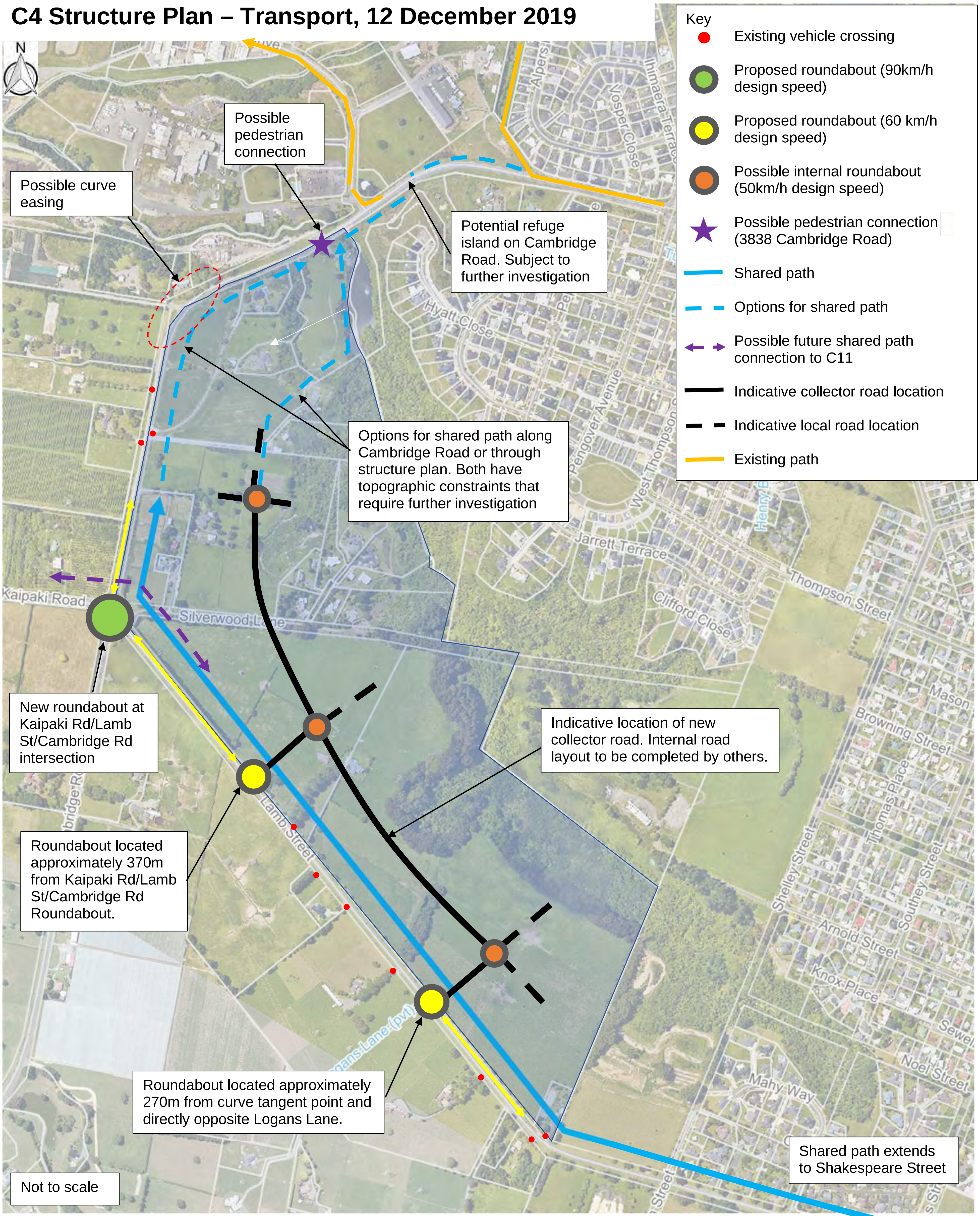
- A roundabout at the Kaipaki Road/Cambridge Road/Lamb Street intersection;
- 3m wide shared path on Lamb Street and Cambridge Road with links through the development;
- Roundabouts at new intersections on Lamb Street;
- Roundabout at the Lamb Street/ Shakespeare Street intersection;
- Upgrading Lamb Street and Cambridge Road to arterial road standards; and
- Walking and cycling connection via 3838 Cambridge Road.

Provided that the infrastructure improvements are staged in a way to suit the development, the transport effects of residential development in the C4 growth cell are likely to be acceptable.

APPENDICES

Appendix 1: Structure Plan layout

C4 Structure Plan – Transport, 12 December 2019



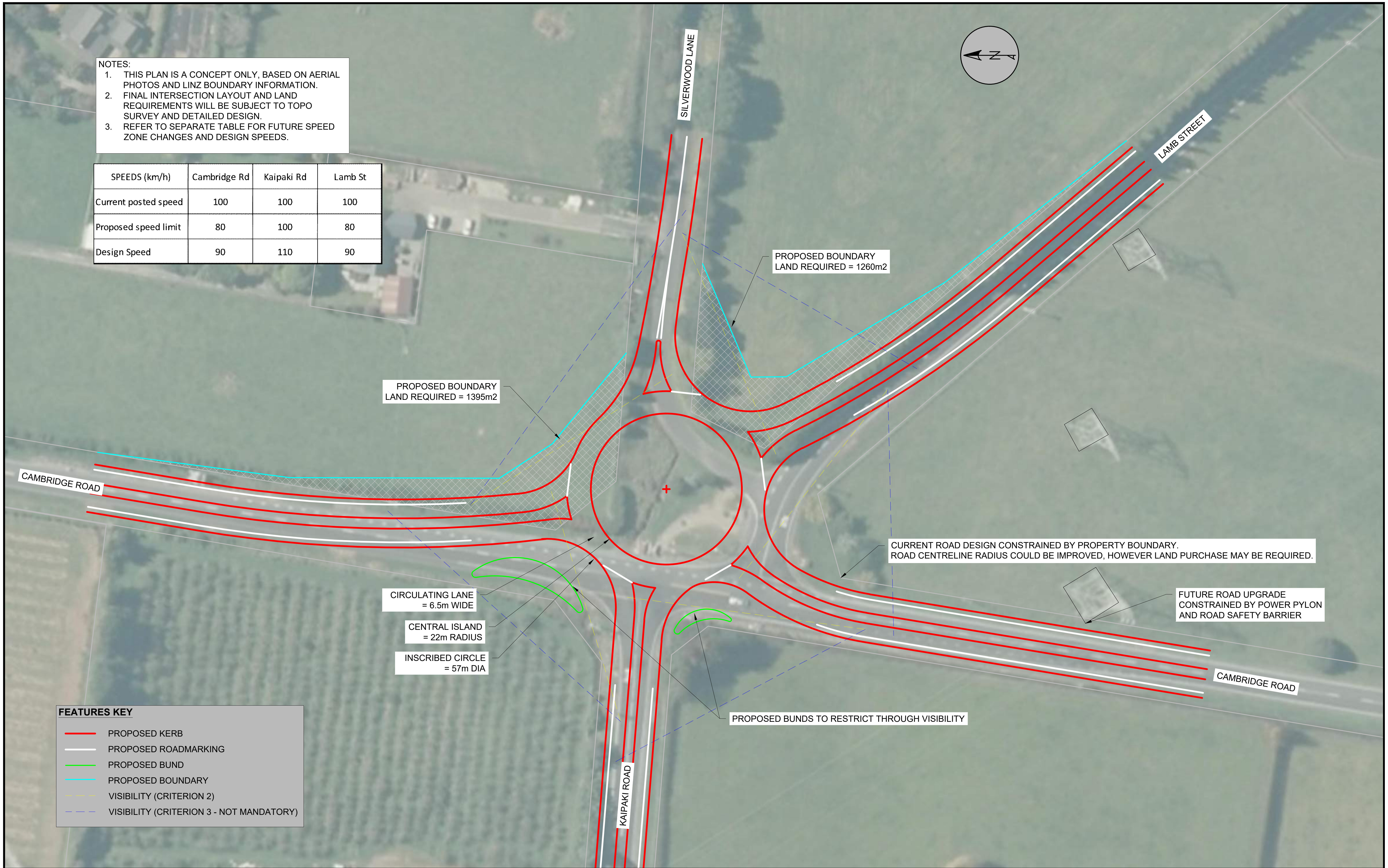
Lamb St and Cambridge Rd (north of Kaipaki Rd) typical cross section

Document Set ID: 10364904
Version: 1, Version Date: 18/02/2020

Appendix 2: Intersection Concept Drawings

NOTES:
1. THIS PLAN IS A CONCEPT ONLY, BASED ON AERIAL PHOTOS AND LINZ BOUNDARY INFORMATION.
2. FINAL INTERSECTION LAYOUT AND LAND REQUIREMENTS WILL BE SUBJECT TO TOPO SURVEY AND DETAILED DESIGN.
3. REFER TO SEPARATE TABLE FOR FUTURE SPEED ZONE CHANGES AND DESIGN SPEEDS.

SPEEDS (km/h)	Cambridge Rd	Kaipaki Rd	Lamb St
Current posted speed	100	100	100
Proposed speed limit	80	100	80
Design Speed	90	110	90



PROPOSED ROUNDABOUT CONCEPT - OPTION 1 LAMB ST / CAMBRIDGE RD / KAIPAKI RD

REF	AMENDMENT	APP'D	DATE

	BY	CHECKED	DATE
DESIGN	D. MILLS		08 / 19
DRAWN	D. MILLS	V. PRAKASH	09 / 19

RECOMMENDED ____________ DATE _/_/_

APPROVED ____________ DATE _/_/_

OFFICE: gray matter

CLIENT: Waipa DISTRICT COUNCIL

PROJECT: WAIPA DISTRICT COUNCIL C4 STRUCTURE PLAN

SHEET TITLE: LAMB ST / CAMBRIDGE RD / KAIPAKI RD PROPOSED ROUNDABOUT CONCEPT - OPTION 1

STATUS: CONCEPT

GEODETIC & VERTICAL DATUM: NZGD2000

PLAN NUMBER: 05_142_100_O

SHEET: Sketch 1

SCALE: 1:1000 (@ A3)

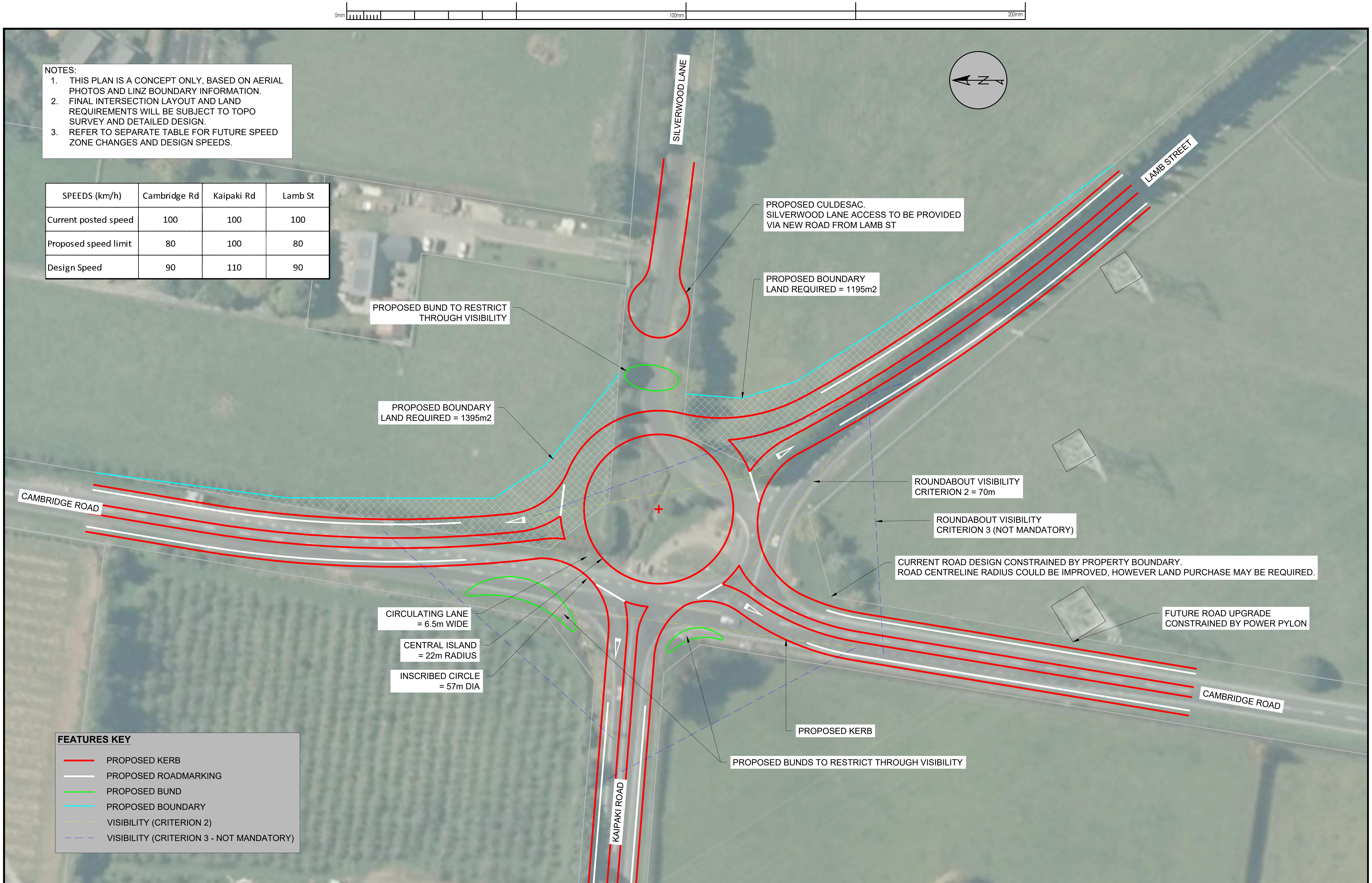
REVISION: R0

CAD FILE - KAIPAKI RD-CAMBRIDGE RD RAB CONCEPT.DWG

ORIGINAL SIZE A3

NOTES:
1. THIS PLAN IS A CONCEPT ONLY, BASED ON AERIAL PHOTOS AND LINZ BOUNDARY INFORMATION.
2. FINAL INTERSECTION LAYOUT AND LAND REQUIREMENTS WILL BE SUBJECT TO TOPO SURVEY AND DETAILED DESIGN.
3. REFER TO SEPARATE TABLE FOR FUTURE SPEED ZONE CHANGES AND DESIGN SPEEDS.

SPEEDS (km/h)	Cambridge Rd	Kaipaki Rd	Lamb St
Current posted speed	100	100	100
Proposed speed limit	80	100	80
Design Speed	90	110	90



FEATURES KEY

- PROPOSED KERB
- PROPOSED ROADMARKING
- PROPOSED BUND
- PROPOSED BOUNDARY
- VISIBILITY (CRITERION 2)
- VISIBILITY (CRITERION 3 - NOT MANDATORY)

PROPOSED ROUNDABOUT CONCEPT - OPTION 2A LAMB ST / CAMBRIDGE RD / KAIPAKI RD

REF	AMENDMENT	APP'D	DATE

	BY	CHECKED	DATE
DESIGN	D. MILLS		08 / 19
DRAWN	D. MILLS	V. PRAKASH	09 / 19

RECOMMENDED ____________________ DATE _/_/_

APPROVED ____________________ DATE _/_/_

OFFICE: gray matter

CLIENT: Waipa DISTRICT COUNCIL

PROJECT: WAIPA DISTRICT COUNCIL C4 STRUCTURE PLAN

SHEET TITLE: LAMB ST / CAMBRIDGE RD / KAIPAKI RD PROPOSED ROUNDABOUT CONCEPT - OPTION 2A

STATUS	CONCEPT
GEODETIC & VERTICAL DATUM	NZGD2000
PLAN NUMBER	05_142_100_O
SHEET	Sketch 2
SCALE	1:1000 (@ A3)
REVISION	R0

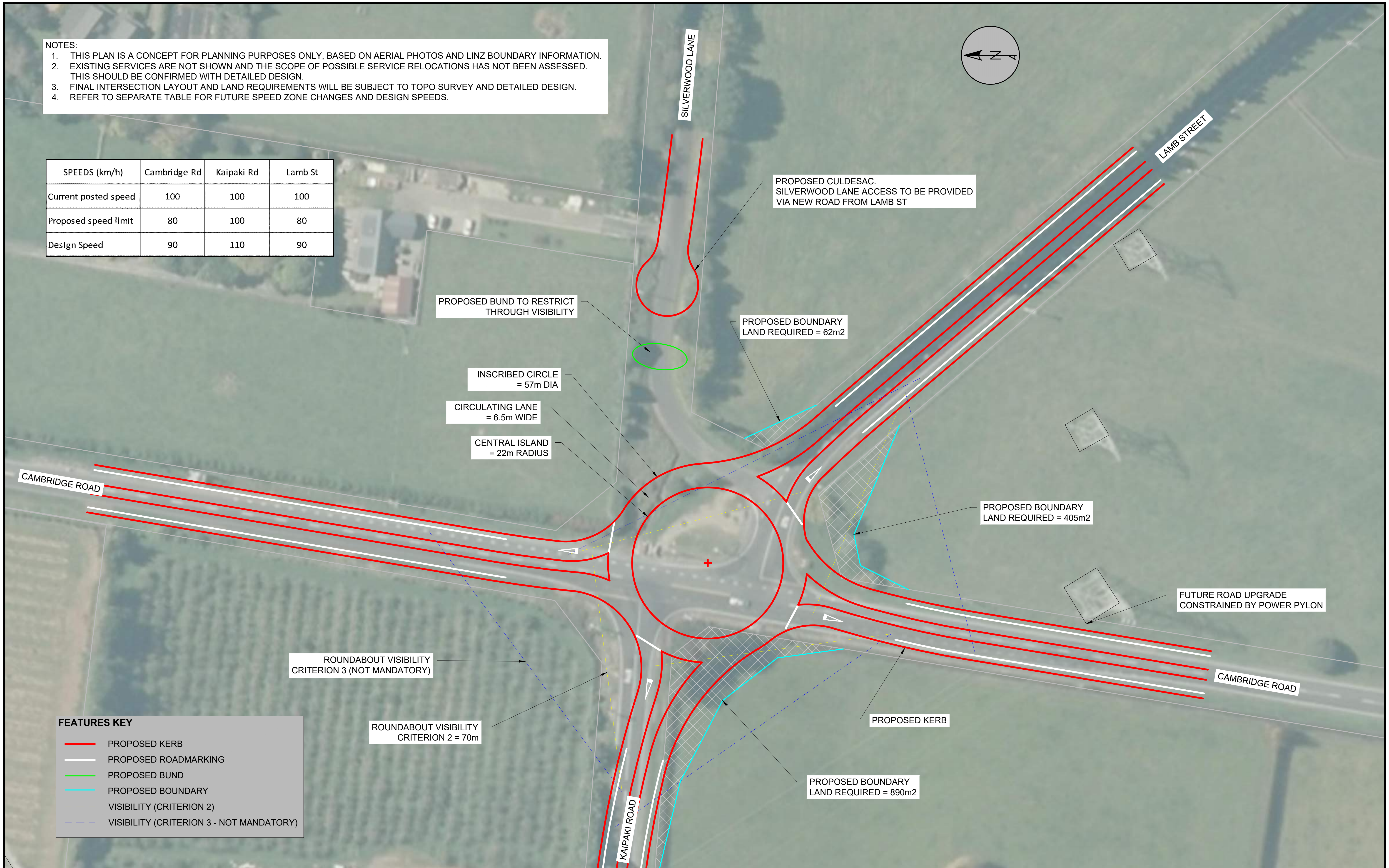
CAD FILE: KAIPAKI RD-CAMBRIDGE RD RAB CONCEPT OPTION2A.DWG

ORIGINAL SIZE A3

Document Set ID: 10364904
Version: 1, Version Date: 18/02/2020

NOTES:
1. THIS PLAN IS A CONCEPT FOR PLANNING PURPOSES ONLY, BASED ON AERIAL PHOTOS AND LINZ BOUNDARY INFORMATION.
2. EXISTING SERVICES ARE NOT SHOWN AND THE SCOPE OF POSSIBLE SERVICE RELOCATIONS HAS NOT BEEN ASSESSED. THIS SHOULD BE CONFIRMED WITH DETAILED DESIGN.
3. FINAL INTERSECTION LAYOUT AND LAND REQUIREMENTS WILL BE SUBJECT TO TOPO SURVEY AND DETAILED DESIGN.
4. REFER TO SEPARATE TABLE FOR FUTURE SPEED ZONE CHANGES AND DESIGN SPEEDS.

SPEEDS (km/h)	Cambridge Rd	Kaipaki Rd	Lamb St
Current posted speed	100	100	100
Proposed speed limit	80	100	80
Design Speed	90	110	90



PROPOSED ROUNDABOUT CONCEPT - OPTION 2B LAMB ST / CAMBRIDGE RD / KAIPAKI RD

REF	AMENDMENT	APP'D	DATE

	BY	CHECKED	DATE
DESIGN	D. MILLS		08 / 19
DRAWN	D. MILLS	V. PRAKASH	09 / 19

RECOMMENDED ______________________ DATE _/_/_

APPROVED ______________________ DATE _/_/_

OFFICE: gray matter

CLIENT: Waipa DISTRICT COUNCIL

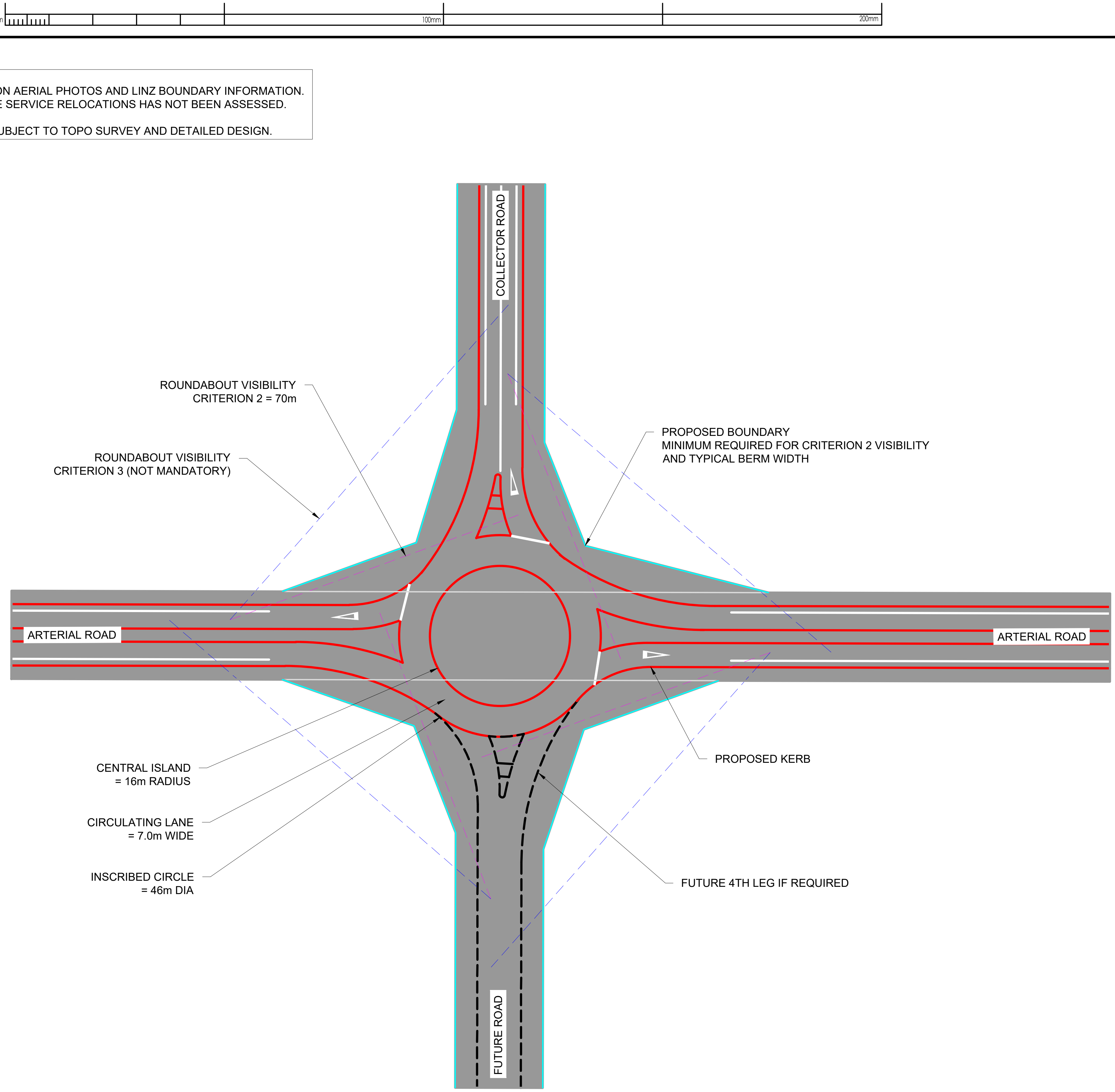
PROJECT: WAIPA DISTRICT COUNCIL
C4 STRUCTURE PLAN

SHEET TITLE: LAMB ST / CAMBRIDGE RD / KAIPAKI RD
PROPOSED ROUNDABOUT CONCEPT - OPTION 2B

STATUS	CONCEPT
GEODETIC & VERTICAL DATUM	NZGD2000
PLAN NUMBER	05_142_100_O
SHEET	Sketch 3
SCALE	1:1000 (@ A3)
REVISION	R0

ORIGINAL SIZE A3

NOTES:
1. THIS PLAN IS A CONCEPT FOR PLANNING PURPOSES ONLY, BASED ON AERIAL PHOTOS AND LINZ BOUNDARY INFORMATION.
2. EXISTING SERVICES ARE NOT SHOWN AND THE SCOPE OF POSSIBLE SERVICE RELOCATIONS HAS NOT BEEN ASSESSED. THIS SHOULD BE CONFIRMED WITH DETAILED DESIGN.
3. FINAL INTERSECTION LAYOUT AND LAND REQUIREMENTS WILL BE SUBJECT TO TOPO SURVEY AND DETAILED DESIGN.



FEATURES KEY

- PROPOSED KERB
- PROPOSED ROADMARKING
- PROPOSED BOUNDARY
- VISIBILITY (CRITERION 2)
- VISIBILITY (CRITERION 3 - NOT MANDATORY)

PROPOSED ROUNDABOUT CONCEPT - TYPICAL LAYOUT ARTERIAL ROAD / FUTURE COLLECTOR ROAD INTERSECTION

REF	AMENDMENT	APP'D	DATE

	BY	CHECKED	DATE
DESIGN	D. MILLS		10 / 19
DRAWN	D. MILLS	V. PRAKASH	10 / 19

RECOMMENDED ____________________ DATE _/_/_

APPROVED ____________________ DATE _/_/_

OFFICE: gray matter

CLIENT: Waipa DISTRICT COUNCIL

PROJECT: WAIPA DISTRICT COUNCIL C4 STRUCTURE PLAN

SHEET TITLE: ARTERIAL ROAD / FUTURE COLLECTOR ROAD INTERSECTION PROPOSED ROUNDABOUT CONCEPT - TYPICAL LAYOUT

STATUS	CONCEPT
GEODETIC & VERTICAL DATUM	NZGD2000
PLAN NUMBER	05_142_100_O
SHEET	Sketch 4
SCALE	1:1000 (@ A3)
REVISION	R0

CAD FILE - COLLECTOR RD LAMB ST RAB TYPICAL CONCEPT.DWG

ORIGINAL SIZE A3

To: Bryan Hudson, Justine Kennedy

Copy:

From: Vinish Prakash, Alastair Black

Date: 10 August 2020

Job Number: 05_152

SUBJECT: C4 Structure Plan – Concept Layout for Internal Intersection

1. INTRODUCTION

The purpose of this memo is to develop an intersection arrangement for the C4 Structure Plan that provides certainty on the layout for Council and identifies property impacts for affected landowners.

We have:

- Identified options for the intersection arrangement based on a four leg roundabout on Cambridge Road. The roundabout has been centred on existing intersection.
- Evaluated the options and selected a preferred option;
- Completed a concept design for the preferred option; and
- Identified opportunities to provide appropriate pedestrian and cycling connections.

2. OPTION DESCRIPTION AND EVALUATION

The options are based on providing a minimum 90m separation from the proposed Kaipaki/Cambridge Road roundabout. We have assumed that Silverwood Lane will be upgraded to collector road standard as part of the development, with Lamb Street maintained as a minor arterial.

Options for the 'internal layout' include:

- Option 1: Priority along Silverwood Lane with right-turn bay into Lamb St as side road
- Option 2: Priority along Lamb St with Silverwood Lane as side road
- Option 3: 4-leg mini roundabout with access to northern part of the cell

For Option 2 we have used a 175m curve radius for the realignment which is appropriate for a 70km/h design speed. A smaller curve radius (e.g. 50km/h design speed = 60m) could be applied but may require additional speed management measures on the approaches and change to the speed limit.

Our option evaluation is summarised in the table below.

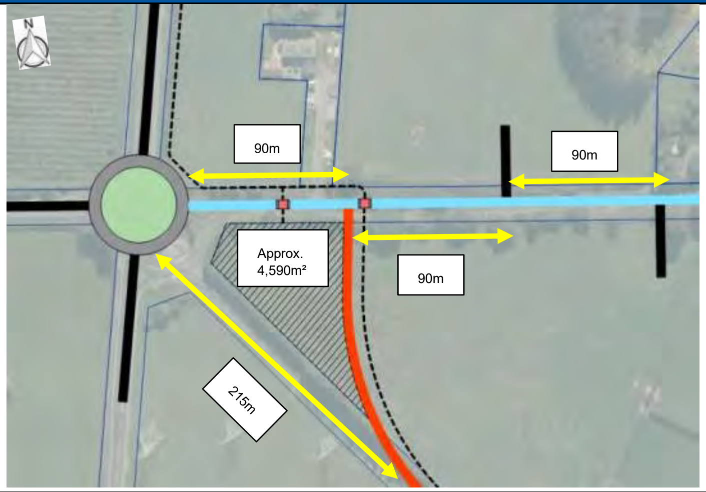
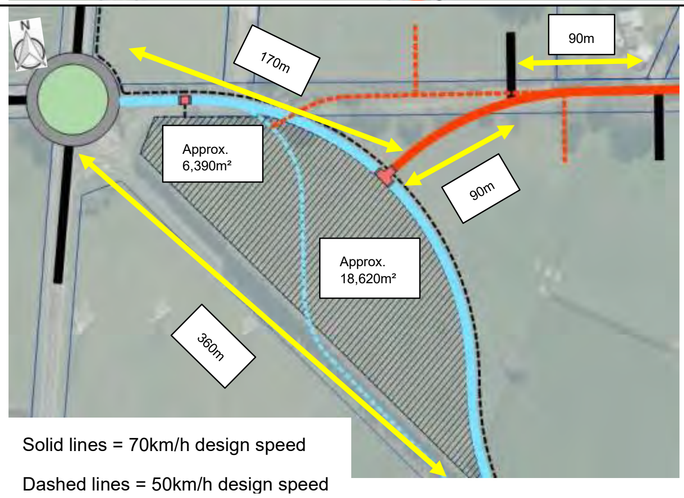
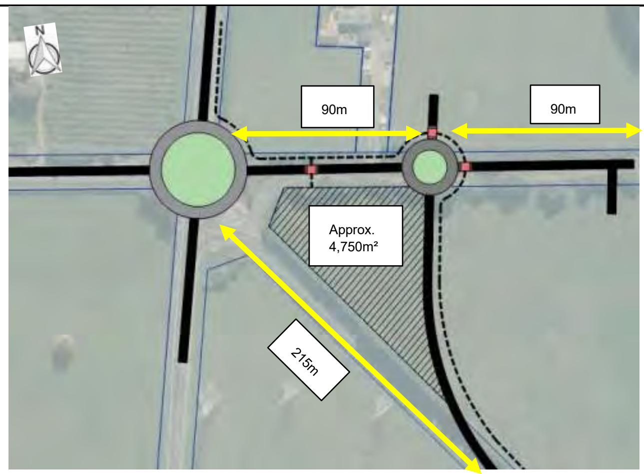
Option	Layout[1] (blue line = priority, red line = controlled, black dashed line = shared path, pink square = RSP[2])	Safety	Efficiency	Cost	Pedestrians	Summary
Option 1: Priority Silverwood Lane with right turn bay into Lamb St (side road).		__Low__ • Priority controlled intersections are typically less safe than roundabouts. • Potential crash risk if high right turn demand into Lamb St. • The safety of the intersection could be improved with raised safety platforms/ raised intersection.	__Low__ • Results in a lower hierarchy road having priority (Silverwood Lane as collector vs Lamb St as minor arterial) • Residents in the northern section of the subdivision will need to travel through multiple intersections before entering the arterial road network. • Potentially confusing to unfamiliar drivers wanting to travel along Lamb St.	__Medium__ • Requires re-aligning Lamb St • Will require upgrading Silverwood Lane to collector road standard to accommodate increase in traffic • Lamb St tie-in approx. 215m from Cambridge Rd roundabout.	__Medium__ • Will require at grade crossing at the Lamb St/ Silverwood Lane intersection. • Raised pedestrian platforms or raised intersection could be provided to improve safety.	__Undesirable__ Results in a lower hierarchy road having priority (unless hierarchy is modified). Likely to be the least efficient option if flows along Lamb St dominate. Priority controlled intersections are typically less safe than roundabouts
Option 2: Priority Lamb Street		__Medium__ • Similar to Option 1. • Providing priority on Lamb St is likely to result in a safer layout compared to Option 1. • Need to ensure sight distance is available for vehicles turning right into and out of Silverwood Lane. This impacts on the curve radius.	__Medium__ • Without speed management, may result in higher speeds along Lamb St • Residents in the northern section of the subdivision will need to travel through multiple intersections before entering the arterial road network. • Potential delays for right-turn out of Silverwood Lane.	__Medium__ • Requires re-aligning Lamb St • Will require upgrading of Silverwood Lane to collector road standard. • Lamb St tie-in approx. 360m from Cambridge Rd roundabout. • Largest land severance. • 70km/h design speed requires 175m radius curve and results in 18,620m² land severance. • 50km/h design speed reduces the curve radius to 60m and results in 6,390m² land severance • Wider road reserve required to maintain SISD within road.	__Medium__ • Similar to Option 1, although likely to be lower traffic volume on Silverwood Lane.	__Acceptable__ A priority controlled intersection with priority on Lamb St is likely to be more legible and safer than Option 1. However, this option results in a large severance area due to the curve radius needed to maintain sight distance.
Option 3: Roundabout with access to the northern part of the cell.		__High__ • Consolidates internal intersections into one. • A roundabout reduces the number of intersection conflict points and results in lower conflict speeds	__High__ • Provides most direct access for residents on the north side of the subdivision compared to Options 1 and 2. • Requires all vehicles to use the roundabout which should result in lower speeds.	__High__ • Requires re-aligning Lamb St • No realignment of Silverwood Lane • Will require upgrade of Silverwood Lane to collector road standard. • Lamb St tie-in approx. 215m from Cambridge Rd roundabout.	__Medium__ • Will require at least two at grade pedestrian crossings at the roundabout. • Raised pedestrian platforms or raised intersection could be provided to improve safety.	__Preferred__ This option results in a single intersection on Silverwood Lane improving legibility and access. A roundabout results in fewer conflict points and lower conflict speeds compared to priority intersections.

Table 1: Option Description and Evaluation

[1] Layout based on aerial photos. Further design required to confirm final layouts and severance areas

[2] RSP = Raised Safety Platform

Our preferred option is Option 3 as it results in a single intersection (roundabout) on Silverwood Lane. Roundabouts are also considered to be typically safer than priority controlled intersections.

Option 1 is undesirable given the likely road hierarchy of Lamb St (minor arterial) and Silverwood Lane (assumed as collector). Assuming that flows along Lamb St continue to dominate movements, this option is likely to be the least efficient/legible with high volumes of right-turns.

Option 2 would be acceptable, but results in a large severance area (18,620m² for 175m curve radius). The severance area reduces to 6,390m² with a smaller curve radius and implementation of speed management measures on the curve approaches.

3. INTERSECTION CONCEPT DESIGN

As agreed with Council (email dated 31st July 2020) our concept design is based on Option 3.

We outlined the design criteria for the Kaipaki Road/Cambridge Road roundabout in our ITA (dated 20 December 2019). While the design criteria are unchanged, the location of the roundabout has changed to optimise geometry for the Cambridge Road approach.

We have based the Lamb Street roundabout concept design on the following design criteria.

Criteria	Lamb Street Roundabout
Design Speed	70 km/h
Central Island Radius	10m
Circulating width (single Lane)	7.5m
Inscribed circle diameter (ICD)	35m
Criterion 2 visibility	70m (based on 50 km/h approach speed)
Design vehicle	Large Rigid Truck (refer swept right turn swept path below)

Table 2: Design Criteria

The concept design is based on the following road cross-sections:

- Lamb Street (minor arterial)
  - 26m road reserve
  - 3.5m lanes
  - 1.5m outside shoulders
  - 0.5m median/inside shoulder
  - 3m solid/flush median
- Collector Road (Silverwood Lane)
  - 3m lanes
  - 1.5m shoulder

The concept plan includes raised pedestrian platforms on the collector road approaches to the Lamb Street roundabout. A mid-block raised pedestrian platform is located between the Cambridge Road roundabout and Lamb Street roundabout to provide access to the severed land which could be used for recreation or stormwater.

Our concept layout is shown below and attached at Appendix A. The layout results in a land severance area of approximately 4,750m² plus 3,655m² of redundant road reserve.

Figure 1: Proposed Layout

Land acquisition will be required to comply with Criterion 2 visibility and to provide sufficient road reserve width. We have taken this into account in the proposed property boundaries. Criterion 3 visibility is not mandatory but could be achieved with additional land take. We note that providing visibility beyond Criterion 3 can result in higher roundabout approach speeds and higher impact speeds.

We have completed vehicle tracking analysis for a large rigid truck, an example right-turn vehicle path is provided below.

Figure 2: Swept Path - Large Rigid Truck Right Turn

4. CONCLUSION

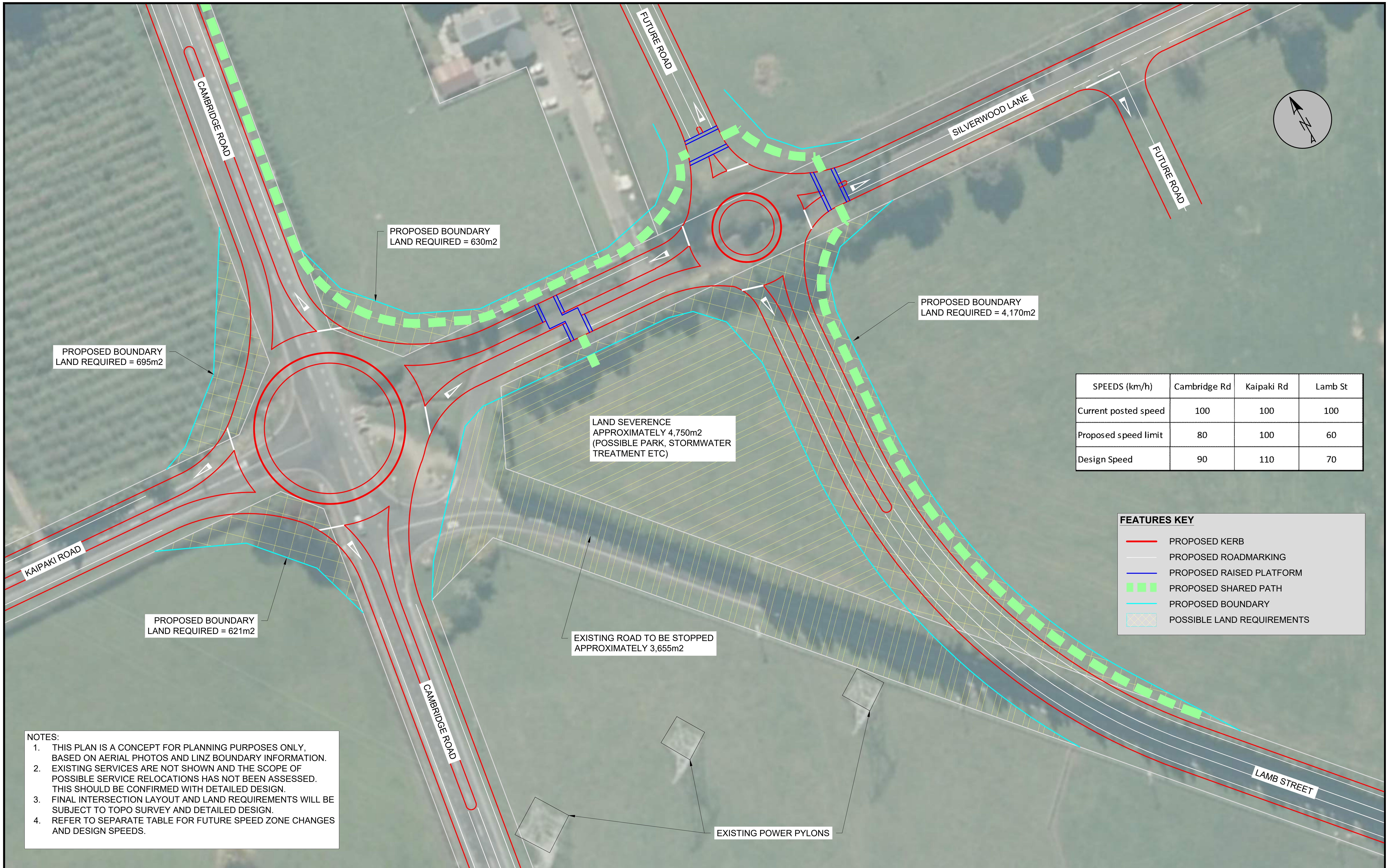
The preferred roundabout layout results in a land severance area of approximately 4,750m² plus 3,655m² of redundant road reserve.

The final layout will need to be confirmed at detailed design stage and should include:

= Intersection design in accordance with the RITS and current design best practice.
= All marking and signs are in accordance with the Traffic Control Devices Rule and MOTSAM.
= Appropriate landscaping treatments.
= Providing appropriate street lighting at the intersections.

APPENDIX A – CONCEPT PLAN

0mm 100mm 200mm



SPEEDS (km/h)	Cambridge Rd	Kaipaki Rd	Lamb St
Current posted speed	100	100	100
Proposed speed limit	80	100	60
Design Speed	90	110	70

FEATURES KEY

- PROPOSED KERB
- PROPOSED ROADMARKING
- PROPOSED RAISED PLATFORM
- PROPOSED SHARED PATH
- PROPOSED BOUNDARY
- POSSIBLE LAND REQUIREMENTS

NOTES:

1. THIS PLAN IS A CONCEPT FOR PLANNING PURPOSES ONLY, BASED ON AERIAL PHOTOS AND LINZ BOUNDARY INFORMATION.
2. EXISTING SERVICES ARE NOT SHOWN AND THE SCOPE OF POSSIBLE SERVICE RELOCATIONS HAS NOT BEEN ASSESSED. THIS SHOULD BE CONFIRMED WITH DETAILED DESIGN.
3. FINAL INTERSECTION LAYOUT AND LAND REQUIREMENTS WILL BE SUBJECT TO TOPO SURVEY AND DETAILED DESIGN.
4. REFER TO SEPARATE TABLE FOR FUTURE SPEED ZONE CHANGES AND DESIGN SPEEDS.

PROPOSED ROUNDABOUT INTERSECTIONS CONCEPT PLAN

REF	AMENDMENT	APP'D	DATE

	BY	CHECKED	DATE
DESIGN	D. MILLS	V. PRAKASH	08 / 20
DRAWN	D. MILLS	V. PRAKASH	08 / 20

RECOMMENDED: D. MILLS — DATE 10 / 08 / 20
APPROVED: A. BLACK — DATE 10 / 08 / 20

OFFICE: gray matter

CLIENT: Waipa DISTRICT COUNCIL

PROJECT: WAIPA DISTRICT COUNCIL - C4 STRUCTURE PLAN
LAMB ST / CAMBRIDGE RD / KAIPAKI RD

SHEET TITLE: PROPOSED ROUNDABOUT INTERSECTIONS
CONCEPT PLAN

STATUS	CONCEPT
GEODETIC & VERTICAL DATUM	NZGD2000
PLAN NUMBER	05_152_100_O
SHEET	Sketch 1
SCALE	1:1000 (@ A3)
REVISION	R0

CAD FILE: C4 CRB INTERSECTIONS CONCEPT.DWG

ORIGINAL SIZE A3

GEOTECHNICAL REPORT - PRELIMINARY FINDINGS

WAIPA DISTRICT COUNCIL C4 GROWTH CELL

CAMBRIDGE STREET AND LAMB STREET, CAMBRIDGE

1. Introduction

This report has been prepared on behalf of Waipa District Council (WDC) and contains the preliminary findings for the Geotechnical Soils Investigation carried out for the C4 Growth Cell, Cambridge.

The purpose of the Soils Investigation was to determine the subsurface conditions across the site and to evaluate what special conditions, if any, would be required for the foundation support of the extension of the Cambridge town boundary.

2. Site Background

The C4 Growth Cell scope area comprises approximately 66 hectares of rural sections located to the south and west of the Cambridge Park Subdivision, about 600 metres south of the Waikato River. The properties are generally near-level to slightly undulating and are bound by a 20 metre deep gully system which runs along the entire north-eastern side of the proposed development area which drains to the Waikato River situated north of the site. The location of the subject site is shown on Figure 1.

Cambridge Road forms a causeway across the gully adjacent to the northern boundary and a pond is located just east of the property which is charged by water inflow from a stream flowing through the gully from the south.

The properties located within the **northern section** of the development area are bound by Cambridge Road to the north and west and Silverwood Lane to the south. Site investigations were carried out on the following properties on northern section:

- No. 3798 Cambridge Road
- No. 3774 and 3774/1 Cambridge Road

Our company has previous carried out testing at No. 3838 Cambridge Road, the information of which is presented in our report dated 9 May, 2014 (Ref: G-13909.1). The property is located on a lower terrace within the northern section of the development area that has been partially in-filled to create near-level ground.

In the **southern section**, testing was carried out at No. 37 Lamb Street which is bound by Lamb Street to the south-west and Silverwood Lane to the north.

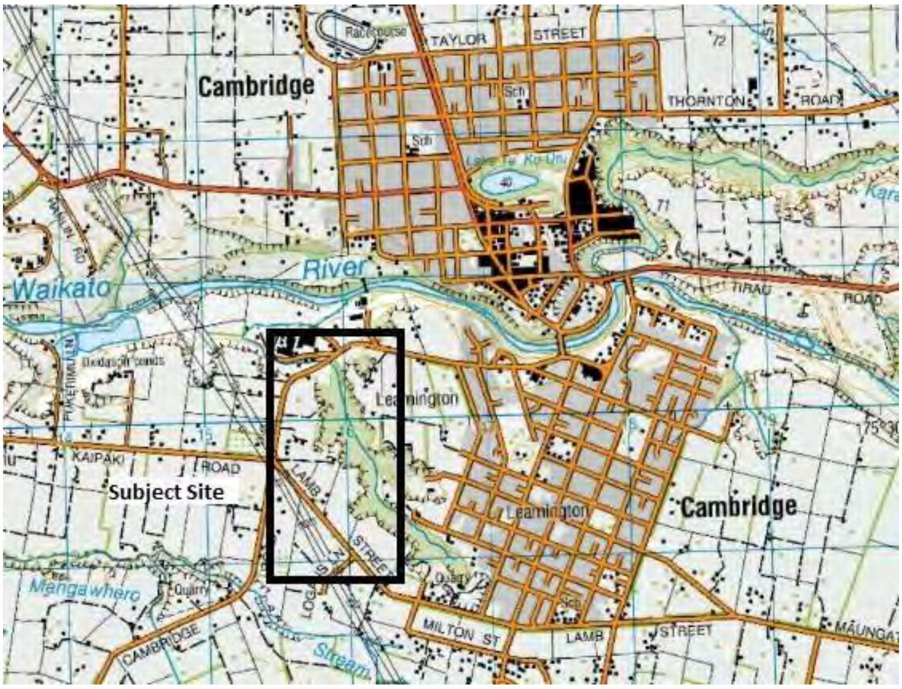


Figure 1. Topographic map denoting the subject site location (Scale 1 km grid).

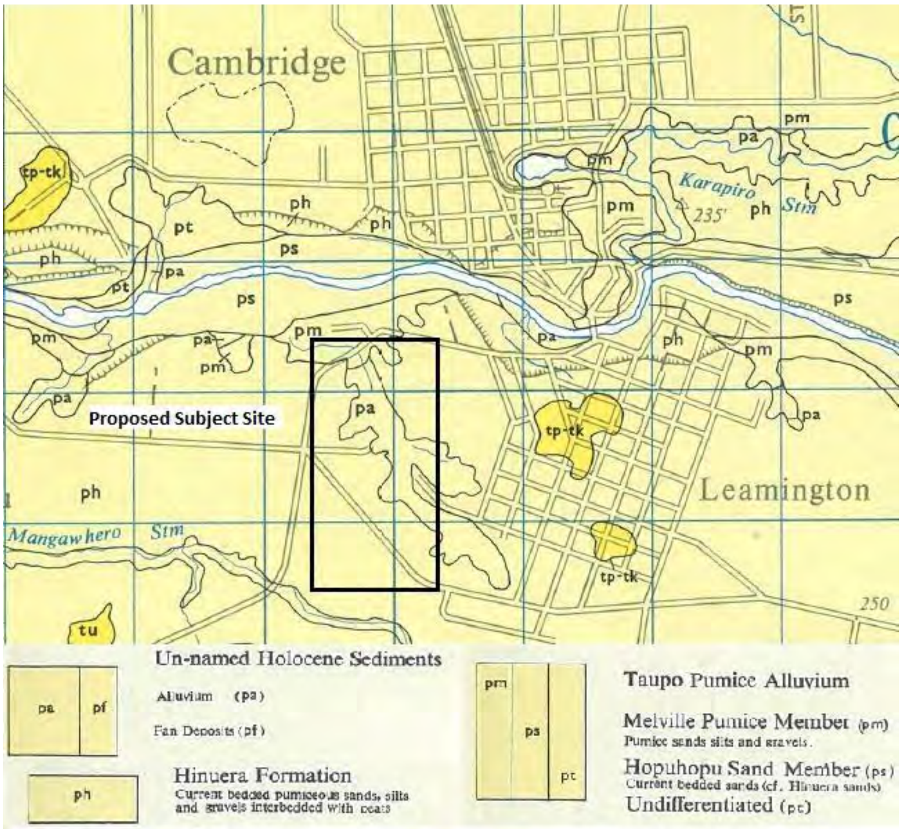


Figure 2. Geological map across project area and surrounds (NZGS Map Sheet N65). Scale 1 km grid)

2.1 Geology

The natural soils encountered across the majority of the test locations consist primarily of Loam, overlying low strength alluvial deposits known as Recent Alluvium, and older, denser alluvial material of the Hinuera Formation. Taupō Pumice Alluvium (TPA) was encountered in the testing carried out within the northern extent of the subject area, isolated to the low lying terrace located within the gully at No. 3838 Cambridge Road.

2.1.1 Loam

Silt Loam (Loess) is a product of wind-blown and redeposited alluvium and volcanic ash material and was encountered overlying the alluvial soils across the site.

2.1.2 Recent Alluvium – Holocene Sediments

The Recent Alluvium, comprising soft Silts and Sands, was deposited at a time when the Waikato River was meandering over a vast flood plain some 10,000 years. Because of the non-uniform manner in which the alluvial soils were deposited and the continually changing river channel alignments, variations in soil grain size, density and shear strength may occur within relatively short distances.

2.1.3 Hinuera Formation

The Hinuera Formation is the main geological unit which occurs across the river plains as shown in Figure 2, the NZGS Geological Map highlighting the Cambridge area. The Hinuera Formation was deposited at a time when the Waikato River was meandering over a vast flood plain some 17,000 to 22,000 years ago, with rhyolitic sands, gravels and silts being laid down in irregular patterns together with occasional slack water deposits including organic Silts and Peats.

The sand and silt soils within this unit typically have higher strengths and are representative of a relatively high energy well sorted depositional environments. However, due to the non-uniform manner in which the alluvial soils were deposited and the continually changing river channels alignments, variations in grain size and composition may occur within relatively short distances.

2.1.4 Taupō Pumice Alluvium (TPA)

TPA is a soil that has been deposited within the last 2,000 years and which is characterised by soft Silts and loose pumiceous Sands.

At the time of the Taupō Eruption of about 230 AD, a vast amount of pumice material was washed down the Waikato River, forming intermittent dams and breakout floods which have both eroded existing soils and accumulated new pumice rich sediment in other areas. This resulted in an inter-fingering of pumice rich and silica rich material to be deposited either side of the river banks as water levels receded.

2.2 Geomorphology

The geomorphology of the site is characterised by the deeply incised gully located north-east of the subject site. The gullies around the Waikato were former paleochannels of the Waikato River and act as local drainage systems (McCraw, 2011).

The generally near-level proposed development area has a general RL of 64 metres. At the gully edge, the area slopes moderately to steeply down towards the shrub-filled gully floor of approximately RL 42 metres.

2.3 Archeological Evidence

A few locations within the subject site have been registered on the New Zealand Archaeological Association, with a Māori pā (village or defensive settlement) identified within the southern end of the development area.

During the site testing, large bowl-like depressions, about 1 to 2 metres deep were encountered within the southern portion of the development area. These bowls have been identified as burrow pits and are shown on the attached 1983 aerial photograph presented on Drawing No. 16064-11. Burrow pits are areas where Māori have excavated into the subsoil to encounter the gravel or sand. Once encountered, the gravel and sand soils are removed and used to mix with soil elsewhere to create good growing mediums for their crop.

The burrow pits are recognised as archaeological horticulture site. Prior to any development, an Authority of Heritage New Zealand will be required to carry out an Archaeological Assessment. Tangata whenua will also need to be engaged during this process.

3. Site Testing

3.1 Bore Hole Testing - Geocon Geotechnical Ltd

The following report is based on soil conditions as observed during a site investigation carried out by our geologists on 11, 12, 15 and 17 July, 2019.

The subsurface conditions at the site were investigated by drilling twenty seven machine auger borings, together with Scala Penetrometer probes at the locations shown on the Site Plan Drawing Nos. 16064-01 to -03. The bore holes are designated Nos. 4 to 30 with the Bore Hole Logs and associated test results presented in Appendix A - Figs. A-4 to A-30.

Also presented are bore hole data carried out from our 2014 investigation (G-13909.1). These bore holes are designated Nos. 1 to 3 with the Bore Hole Logs and associated test results presented in Appendix A - Figs. A-1 to A-3.

The purpose of the borings and associated tests was to provide guidance as to the general subsurface soil profile together with the variability and relative density of soils within and below the proposed building site area. Actual conditions may vary across these areas.

3.2 Cone Penetration Testing (CPT) – WSP Opus International Consultants (NZ) Ltd

Cone Penetrometer Testing (CPT) analysis of the soils was also undertaken by WSP Opus International Consultants (NZ) Ltd (WSP Opus) on 23 July, 2019. Six, CPT probes were carried out within the proposed development area, with equipment provided by WSP Opus and locations as shown the Site Plan. The CPT tests are designated Nos. 9 and 14, with the test results presented in Appendix B - Figs. B-1A through B-2E.

Also presented are CPT data carried out from our 2014 investigation (G-13909.1). tests are designated Nos. 1 to 8 with the Bore Hole Logs and associated test results presented in Appendix B - Figs. B-1A to B-8E.

3.3 Piezometer Groundwater Monitoring – Perry Geotech Ltd

Two piezometers are to be installed to twenty metres depth by Perry Geotech Ltd, one each in the northern and southern section of the development areas. The piezometers are to be installed in early September at the proposed locations indicated on the attached Site Plan.

The piezometers will allow us to monitor true groundwater seasonal groundwater levels across the site.

4. Soil Descriptions

4.1 Overall Site

The near-surface soil conditions across the overall development area generally consist of Topsoil overlying soft to stiff, Silt Loam to depths of 0.4 to 1.0 metres depth. The Silt Loam overlies loose to dense, slightly silty or gravelly, fine to coarse grained Sand (Recent Alluvium and Hinuera Formation) which continue to at least the base of the 4.0 metre deep bore holes.

The deeper soils, as encountered within the CPT Nos. 9 to 14, revealed medium dense to dense Sands interbedded with firm to stiff, Silt/Clay soils to between 10 to 14 metres depth overlying medium dense to very dense Sands to at least the base of the

Soft to stiff, Silt layers were encountered within the bore holes located in the **northern portion** of the Development Area (Refer to Bore Hole Nos. 6, 7, 10, 11, 14 and 18) at depths between 2.4 and 4.0 metres below existing ground level.

Bore Holes drilled within the identified burrow pits (refer to Bore Hole Nos. 13 and 24) revealed low strength, uncontrolled Filling comprises of various layers Silt, Sand, Topsoil and Charcoal overlying loosely backfilled Filling material comprising a mixture of Sand, Silt and Gravel to at least 2.0 and 2.4 metres depth. Beneath the Filling are gravelly, fine to coarse grained Sand to at least 4.0 metres depth.

4.1 Lower Terrace

The soils encountered in the bore holes on the low lying terrace within the northern portion of the Development Area (Refer to Bore Hole Nos. 1, 2 and 4) comprises of respread Topsoil over variable strength, uncontrolled Filling comprising Topsoil, Silt, Sand, Clay and Gravel to depths between 0.2 to 6.0 metres below existing ground level. The naturally occurring soils below the Filling consist of loose to very dense, fine grained Sand (TPA) to at least the base of the 8 and 9 metre deep bore holes.

The subsoil classification of the deeper soils within the north-western location of the area as indicated by the CPT Nos. 1, 2 and 4 revealed loose to medium dense, Sand and Sand mixtures to at least the base of the 12 metre deep bore holes. Underlying the Filling in CPT Nos. 3 and 6 to 8 were generally loose to medium dense, Sands interbedded Silt/Clay Sand soils to at least the 13 to 16 metre deep test holes.

Low strength, organic soils are encountered at 2 to 7 metres in CPT Nos. 7 and 8 and at 17 to 18 metres depth in CPT No. 6.

5. Groundwater

Groundwater was not encountered within Bore Hole Nos. 1, 2, 4 to 30 during the July 2019 test drilling program. However Bore Hole No. 3 revealed groundwater at 2.9 metres depth.

Furthermore, the CPT's encountered groundwater at the depths presented in the following Table 1.

CPT No.	Groundwater depth (m)	CPT No.	Groundwater depth (m)
1	No GW	8	3.1
2	5.3	9	8.2
3	6.0	10	7.6
4	No GW	11	6.7
5	No GW	12	No GW
6	3.8	13	7.8
7	1.9	14	14.7

As the Development Area is located directly west of the deeply incised gully, true groundwater level across the site would be similar to that of the gully as shown in CPT No. 14. The shallow groundwater levels encountered within the test holes are indicative of perched groundwater.

Four representative Ground Profiles A-A to D-D were constructed through the Development Area using Waikato Regional Council website contour data. The locations of these profiles are shown on the attached Site Plan with the ground profiles presented on Drawing Nos. 16064-04 & -08. The ground profiles were carried out to diagrammatically present the soils encountered and to illustrate the position of the proposed groundwater table across the site.

Perched groundwater is generally observed in the wetter months where water draining through the soil profile is inhibited by impermeable soils such as the Silt/Clay layers revealed within the CPT holes.

6. Slope Profiles –Adjacent to Sloping Ground

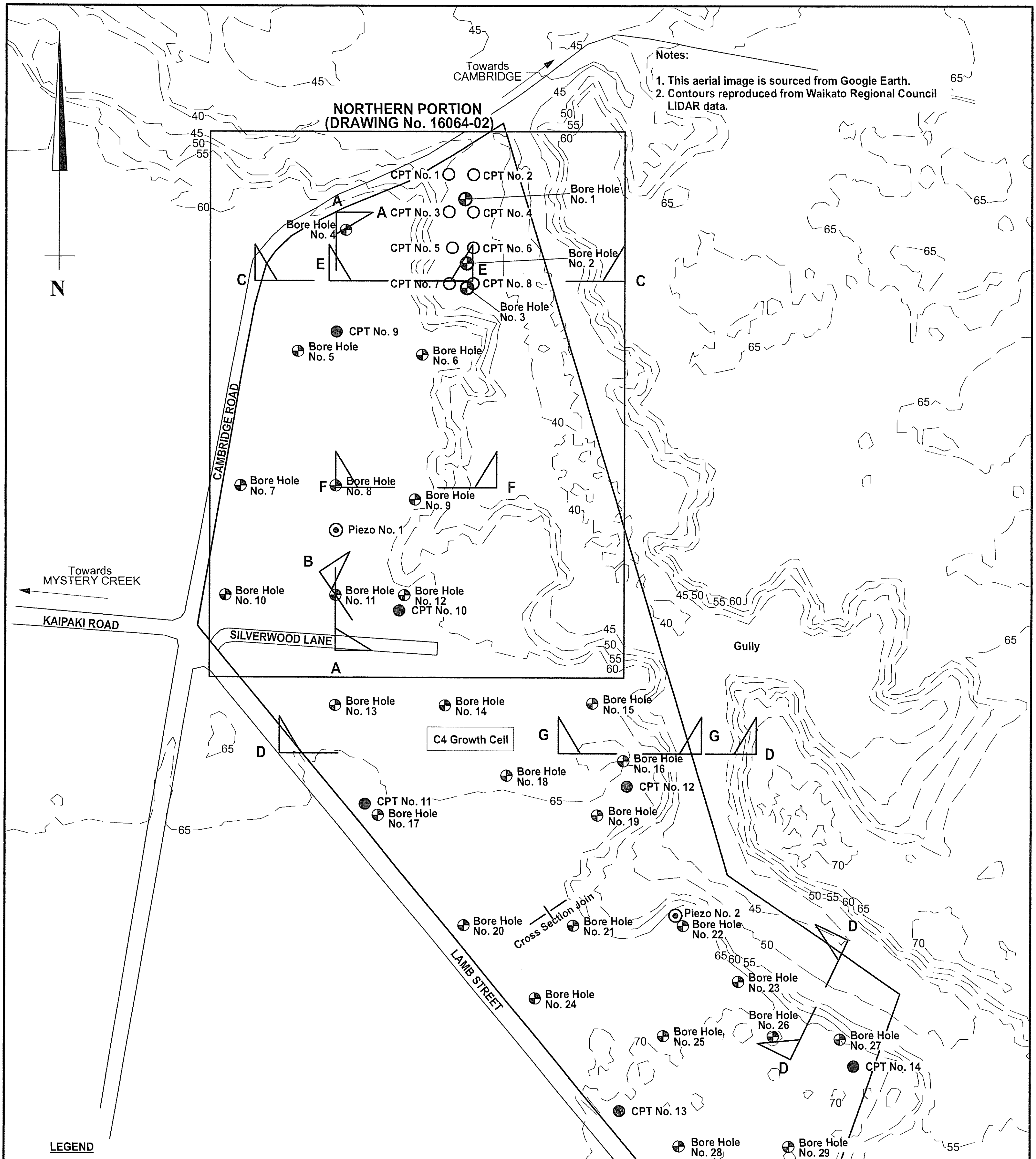
Four representative Ground Profiles E-E to H-H were plotted perpendicular to the slope using Waikato Regional Council GIS Lidar data The locations of these profiles are shown on the attached Site Plans, with the ground profiles presented on Drawing Nos. 16064-09 & -10. The ground profiles were carried out to diagrammatically present the soils encountered and to illustrate the position of the slope relative to the proposed building areas.

Relatively steep slopes are present on the western bank of incised gully. Typical slope angles encountered within the upper 10 metres vary between 20 to 55 degrees to the horizontal. The soils present at the top of these slopes consist of Silt Loam overlying loose to dense, fine to coarse grained Sands. CPT tests indicate the Sand soils generally densify from about 5 metres depth. Furthermore, the sloping ground surfaces are typically densely vegetated close to the property boundaries and further downslope.

Mark T Mitchell Ltd

Mark T Mitchell
Director

Mark T Mitchell Ltd Geotechnical Engineers 1150 Victoria Street, P.O. Box 9123, Hamilton	WAIPA DISTRICT COUNCIL Site Investigation fir C4 Growth Cell Cambridge Road and Lamb Street, Cambridge	**SITE PLAN** AERIAL PHOTO	DRAWING No. 16064-01 DATE September 2019 ISSUE DATE



LEGEND

- denotes Proposed Bore Hole locations
- " Cone Penetrometer probe Test (CPT) locations
- " 2014 Bore Hole locations (ref: 13909)
- " 2014 Cone Penetrometer probe Test (CPT) locations (ref: 13909)
- " Piezometer Locations
- 65— " Contours (5m)
- " Cross Section Locations

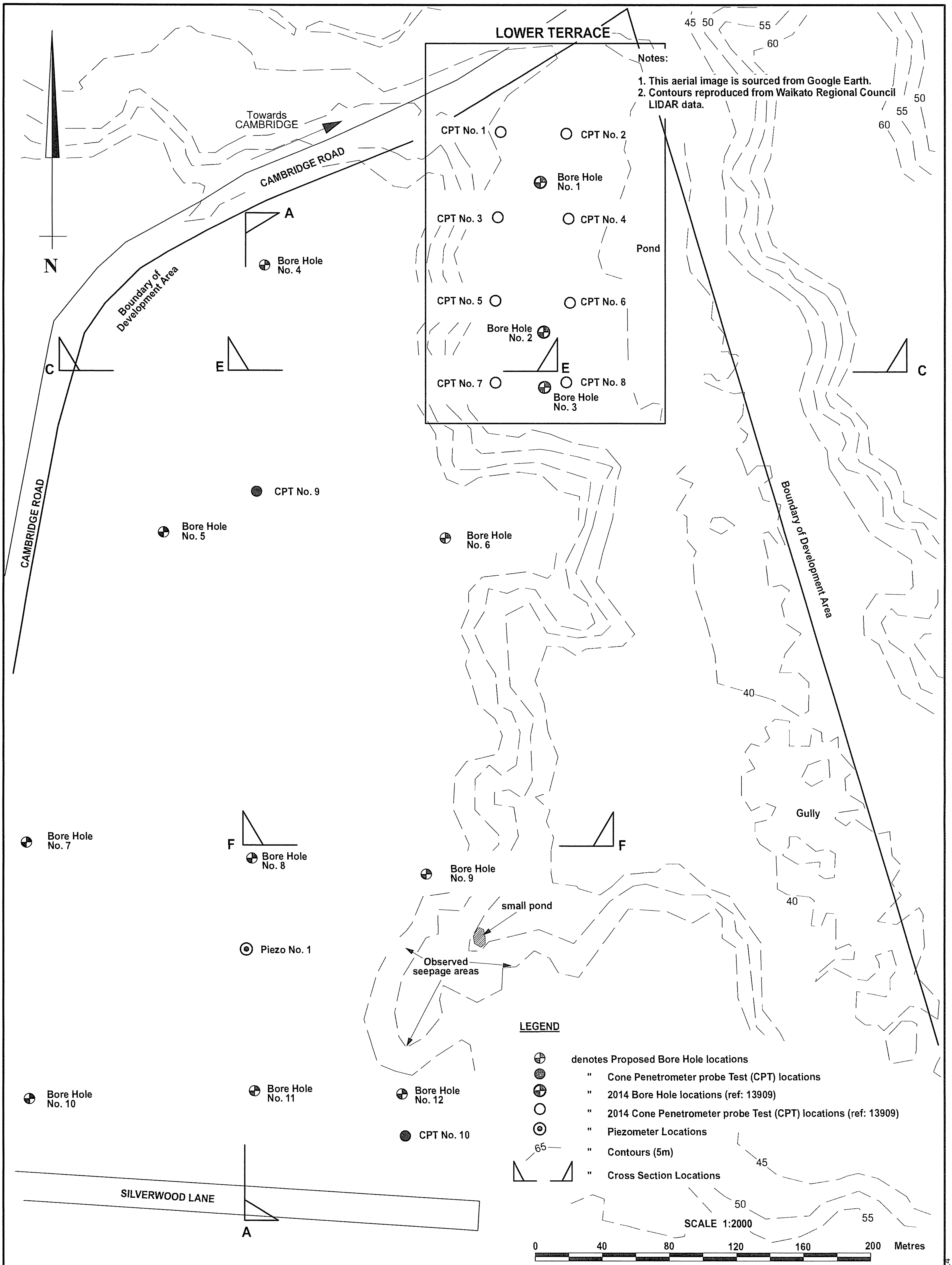
Mark T Mitchell Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

WAIPA DISTRICT COUNCIL

Site Investigation for C4 Growth Cell
Cambridge Road and Lamb Street, Cambridge

SITE PLAN

DRAWING No. 16064-02
DATE September 2019
ISSUE DATE

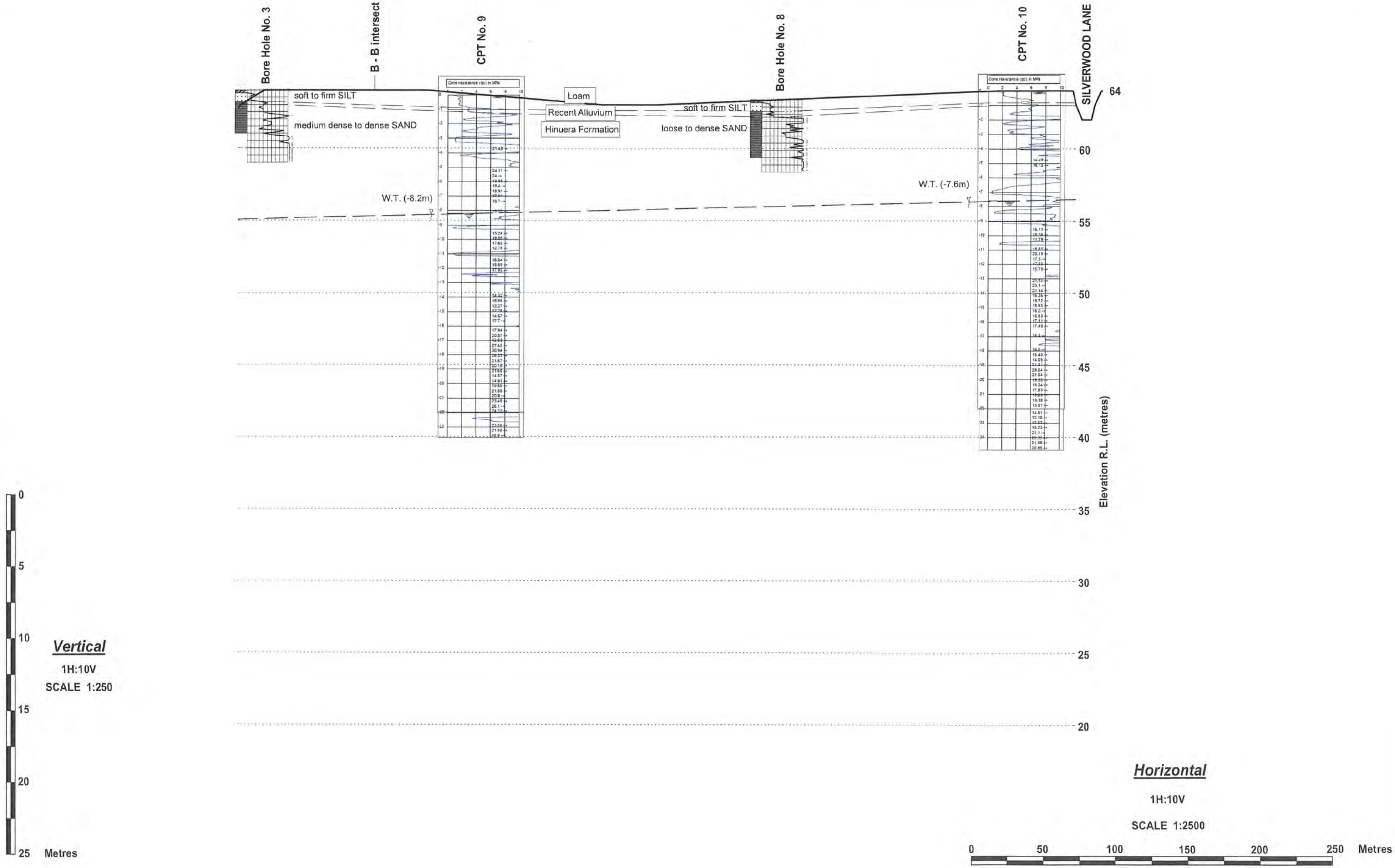


Mark T Mitchell Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

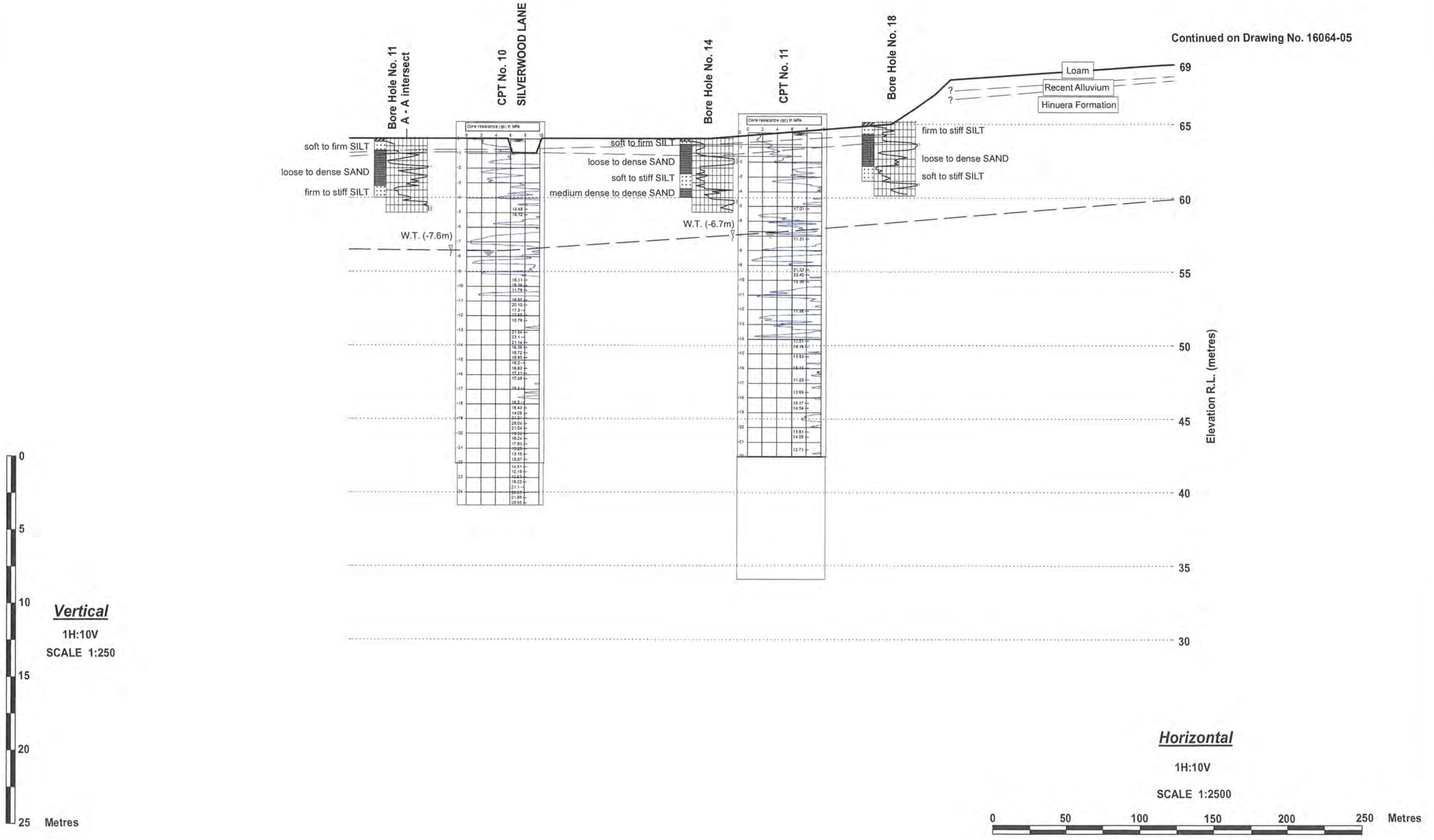
WAIPA DISTRICT COUNCIL
Site Investigation for C4 Growth Cell
Cambridge Road and Lamb Street, Cambridge

SITE PLAN
NORTHERN PORTION

DRAWING No. 16064-03
DATE September 2019
ISSUE DATE



Mark T Mitchell Ltd Consulting Geotechnical Engineers 1150 Victoria Street, P.O. Box 9123, Hamilton	WAIPA DISTRICT COUNCIL Site Investigation for C4 Growth Cell Cambridge Road and Lamb Street, Cambridge	**CROSS - SECTION 'A - A'**	DRAWING No. 16064-04 DATE September 2019 ISSUE DATE



Mark T Mitchell Ltd

Consulting Geotechnical Engineers

1150 Victoria Street, P.O. Box 9123, Hamilton

WAIPA DISTRICT COUNCIL

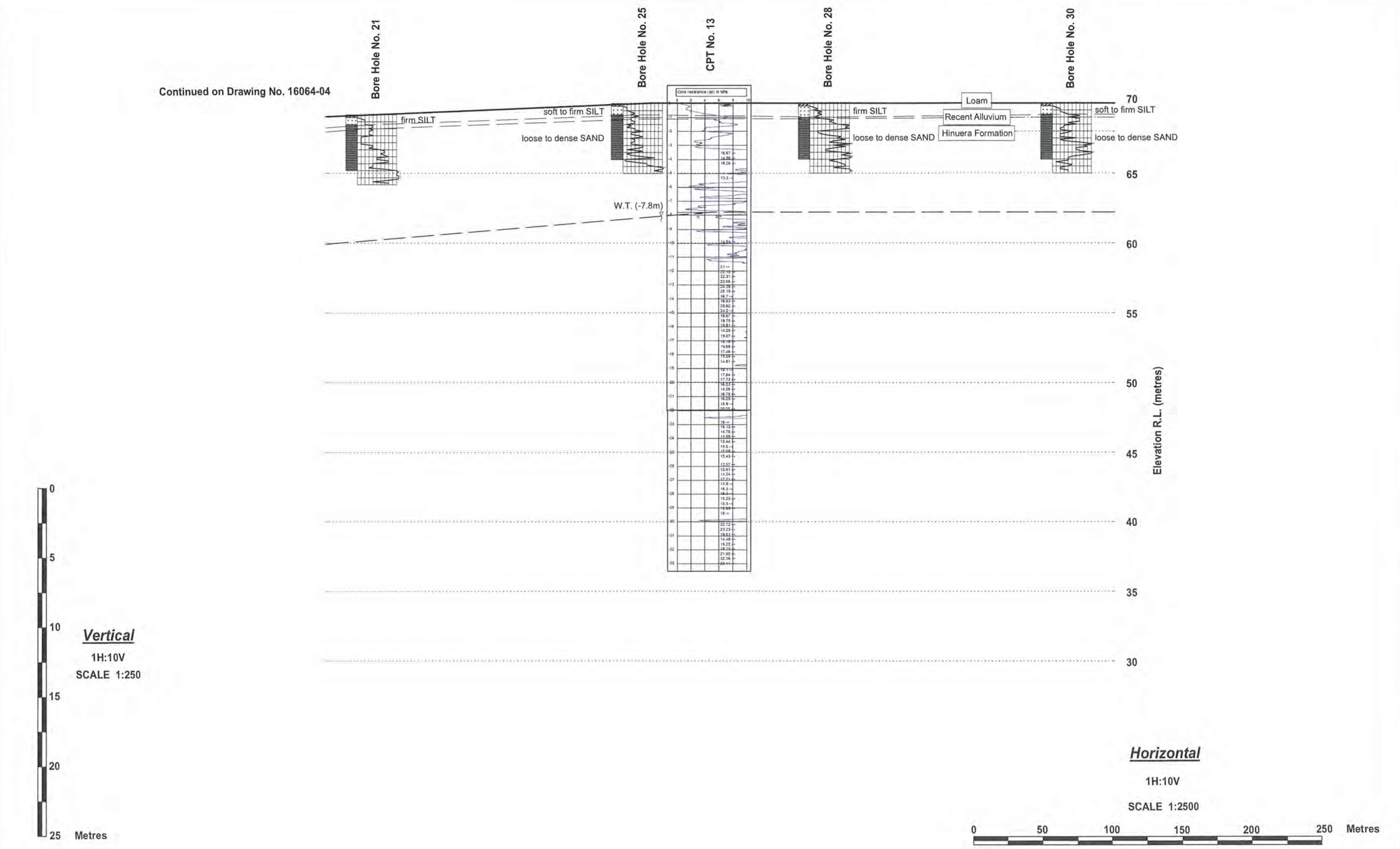
Site Investigation for C4 Growth Cell
Cambridge Road and Lamb Street, Cambridge

CROSS - SECTION 'B - B'

DRAWING No. 16064-05

DATE September 2019

ISSUE DATE



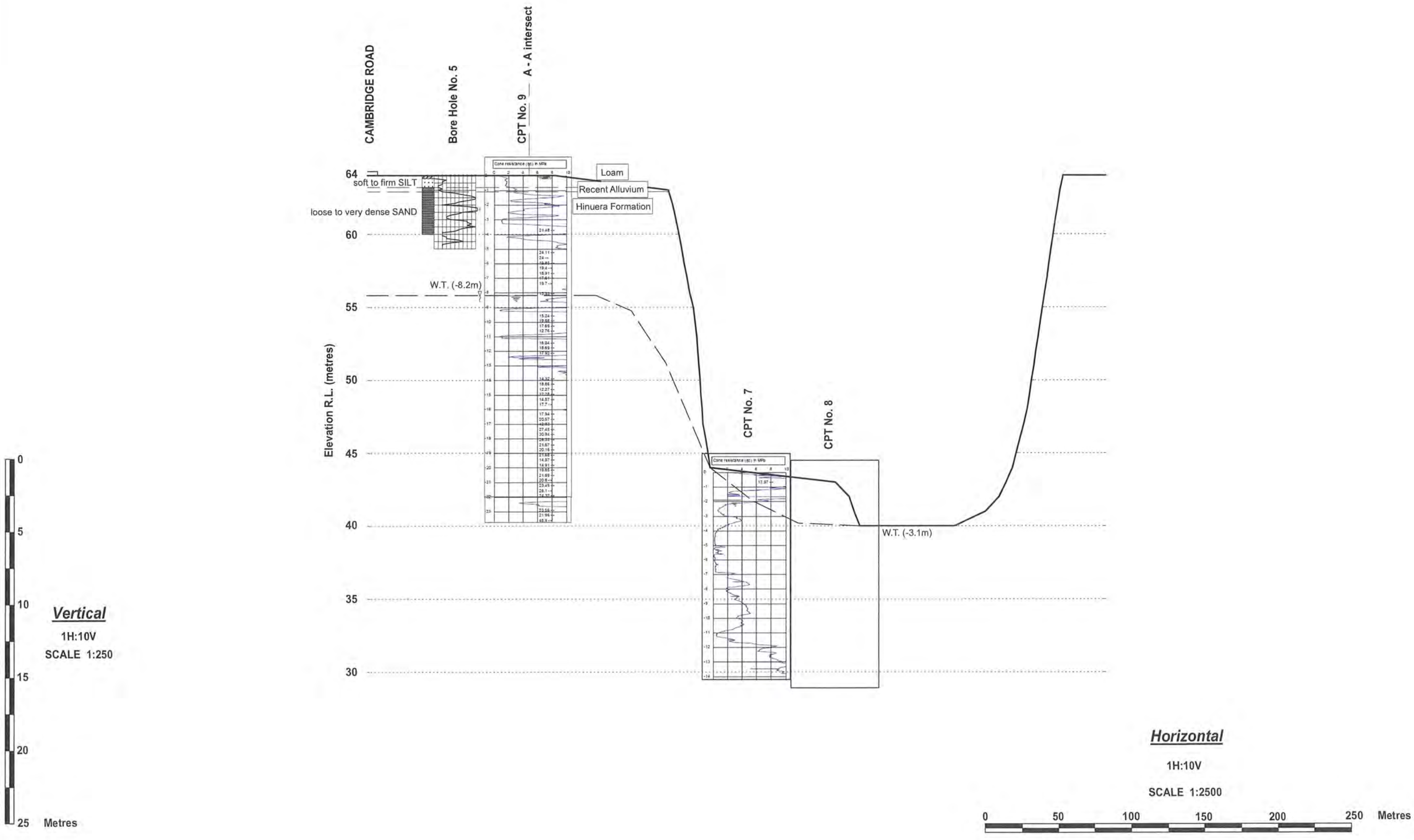
Mark T Mitchell Ltd
Consulting Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

WAIPA DISTRICT COUNCIL

Site Investigation for C4 Growth Cell
Cambridge Road and Lamb Street, Cambridge

CROSS - SECTION 'B - B' (Continued)

DRAWING No. 16064-06
DATE September 2019
ISSUE DATE



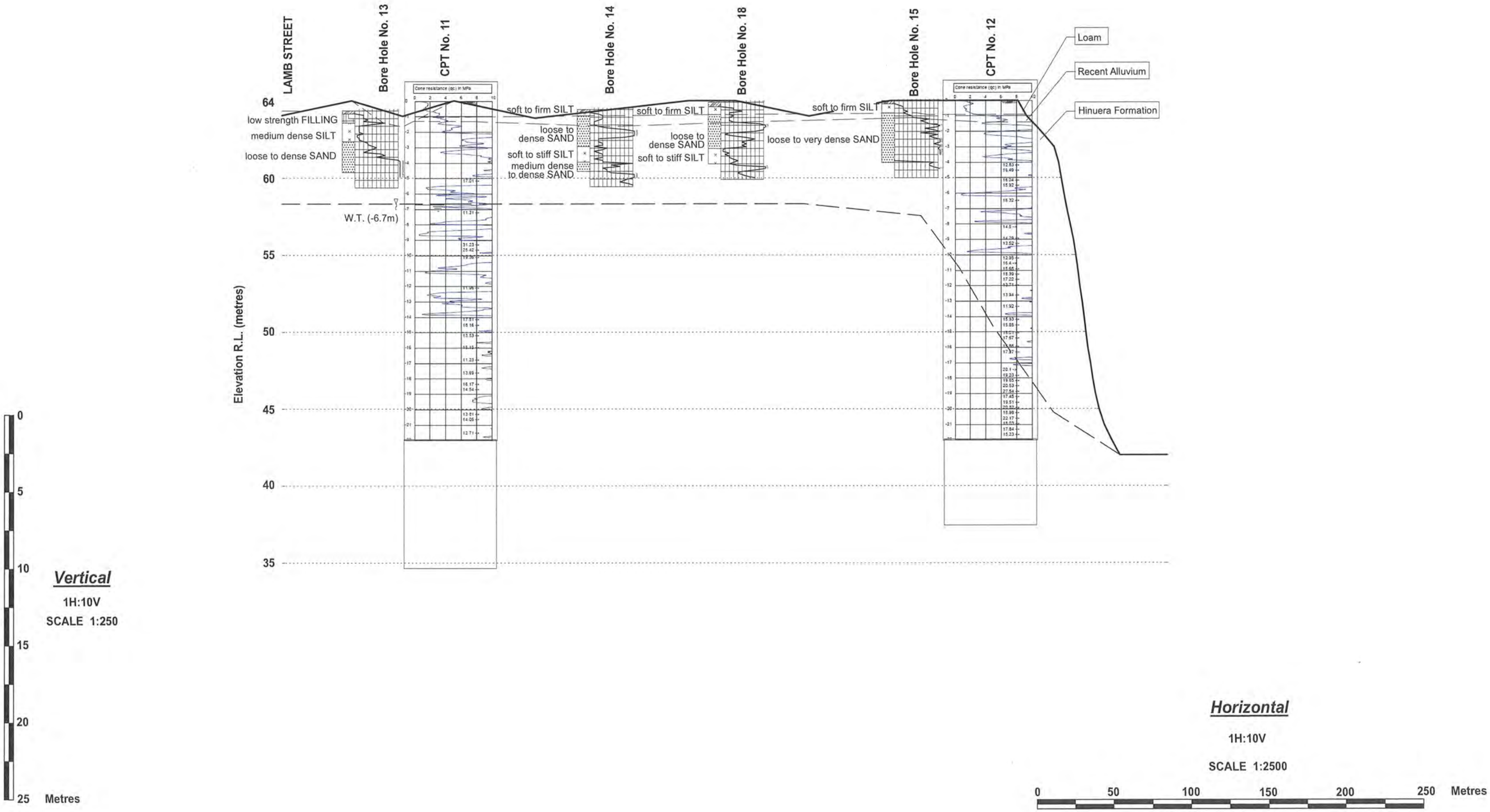
Mark T Mitchell Ltd
Consulting Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

WAIPA DISTRICT COUNCIL

Site Investigation for C4 Growth Cell
Cambridge Road and Lamb Street, Cambridge

CROSS - SECTION 'C - C'

DRAWING No. 16064-07
DATE September 2019
ISSUE DATE



Mark T Mitchell Ltd

Consulting Geotechnical Engineers

1150 Victoria Street, P.O. Box 9123, Hamilton

WAIPA DISTRICT COUNCIL

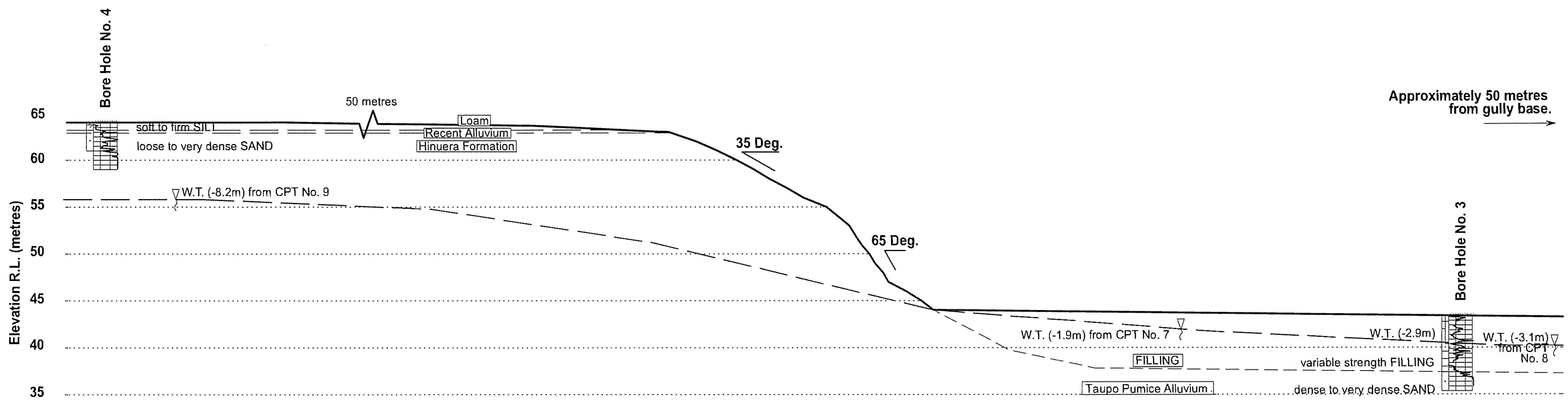
Site Investigation for C4 Growth Cell
Cambridge Road and Lamb Street, Cambridge

CROSS - SECTION 'D - D'

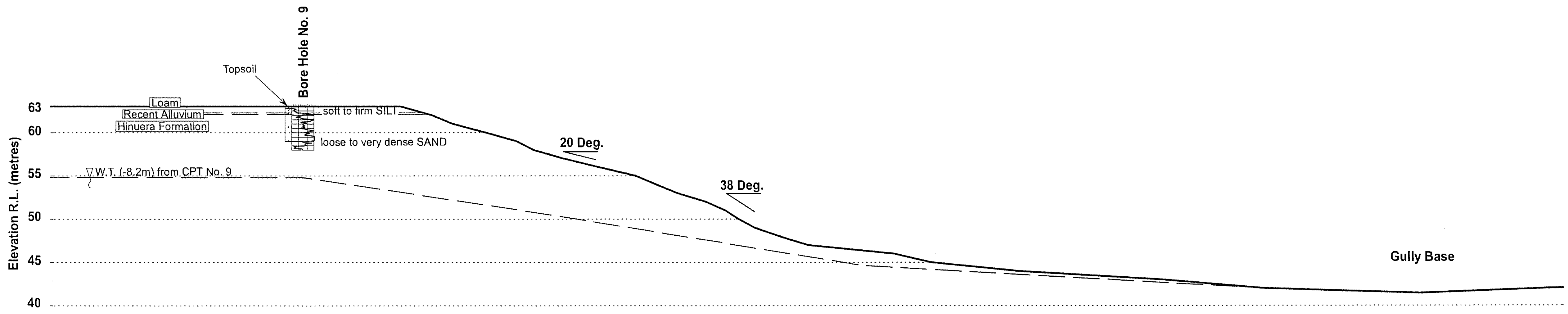
DRAWING No. 16064-08

DATE September 2019

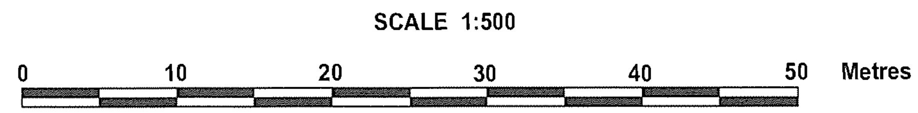
ISSUE DATE



GROUND PROFILE E-E



GROUND PROFILE F-F



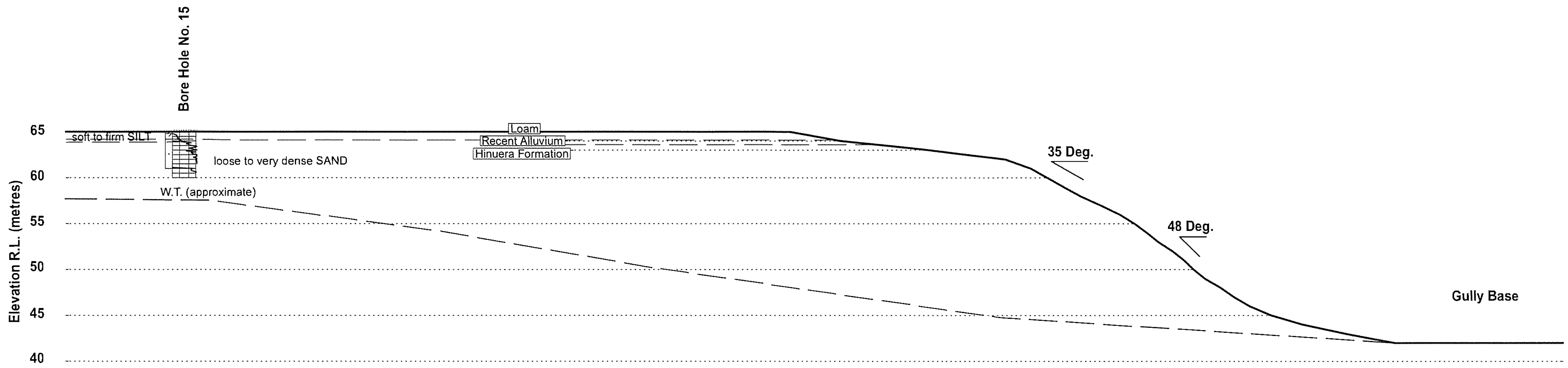
Mark T Mitchell Ltd
Consulting Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

WAIPA DISTRICT COUNCIL

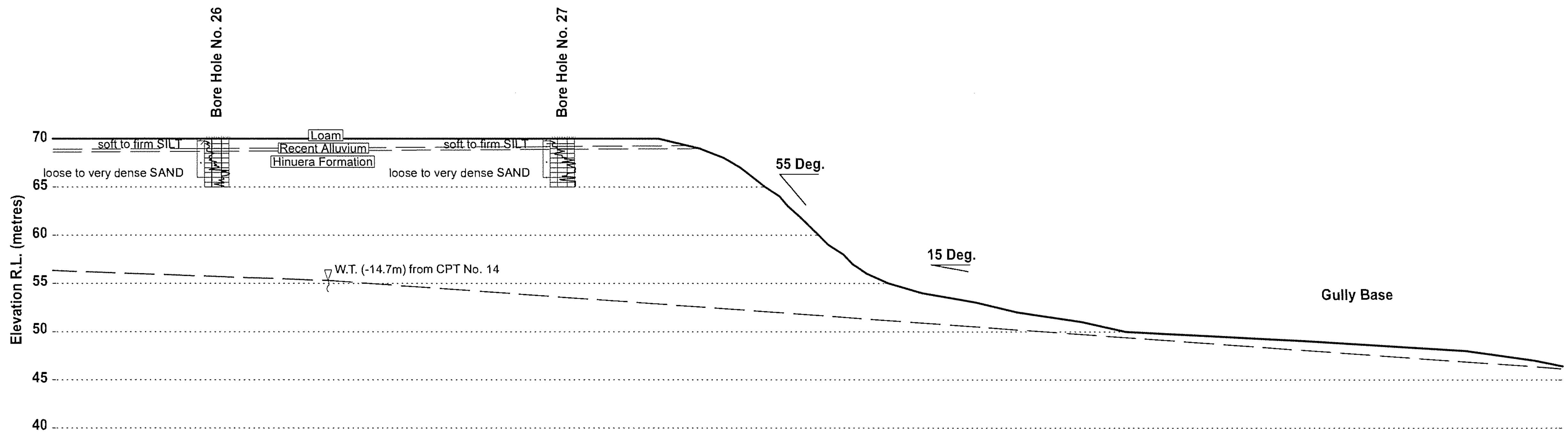
Site Investigation for C4 Growth Cell
Cambridge Road and Lamb Street, Cambridge

SLOPE STABILITY GROUND PROFILES E - E & F - F

DRAWING No. 16064-09
DATE September 2019
ISSUE DATE



GROUND PROFILE G-G

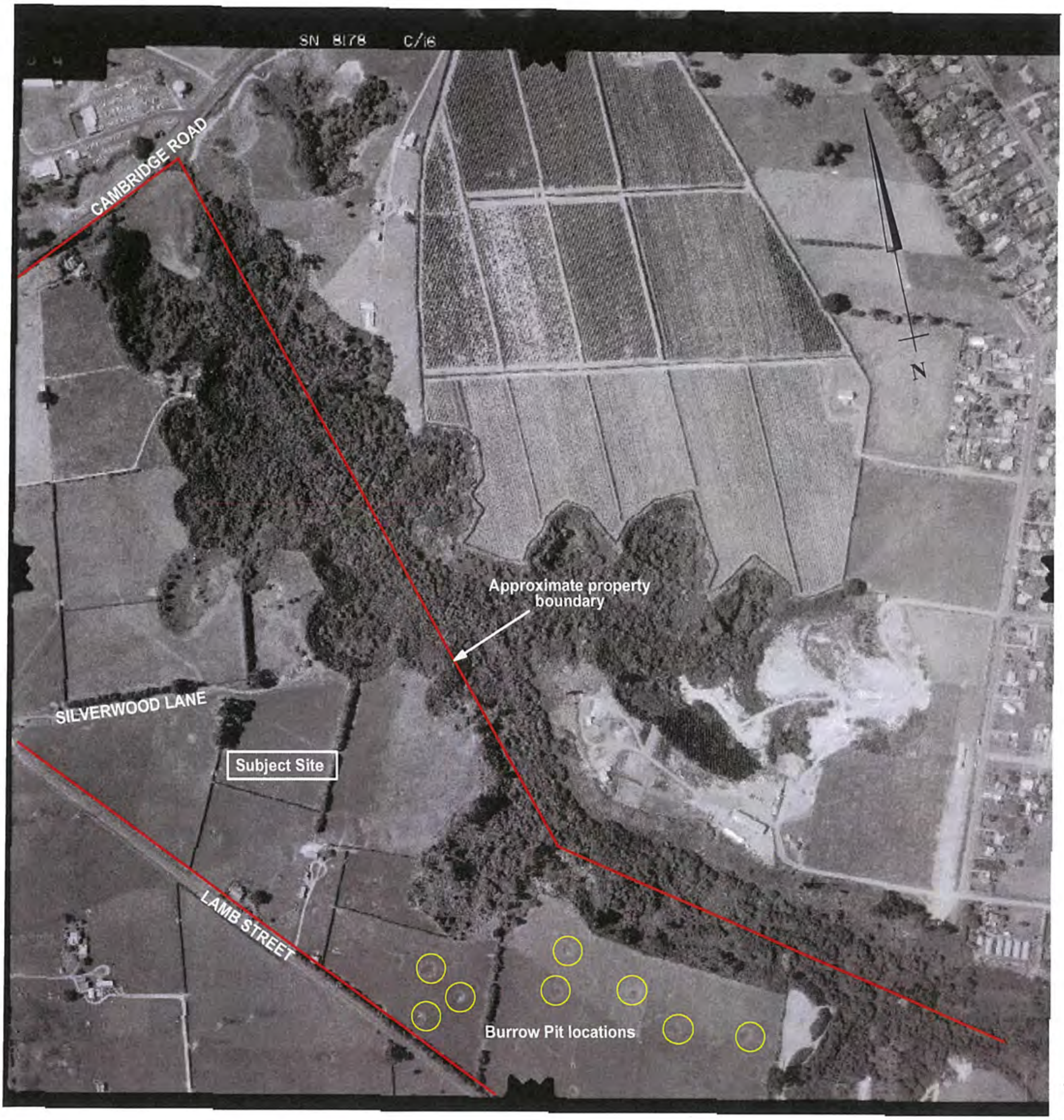


GROUND PROFILE H-H

SCALE 1:500

0 10 20 30 40 50 Metres

Mark T Mitchell Ltd Consulting Geotechnical Engineers 1150 Victoria Street, P.O. Box 9123, Hamilton	WAIPA DISTRICT COUNCIL Site Investigation for C4 Growth Cell Cambridge Road and Lamb Street, Cambridge	**SLOPE STABILITY GROUND PROFILES G - G & H - H**	DRAWING No. 16064-10 DATE September 2019 ISSUE DATE



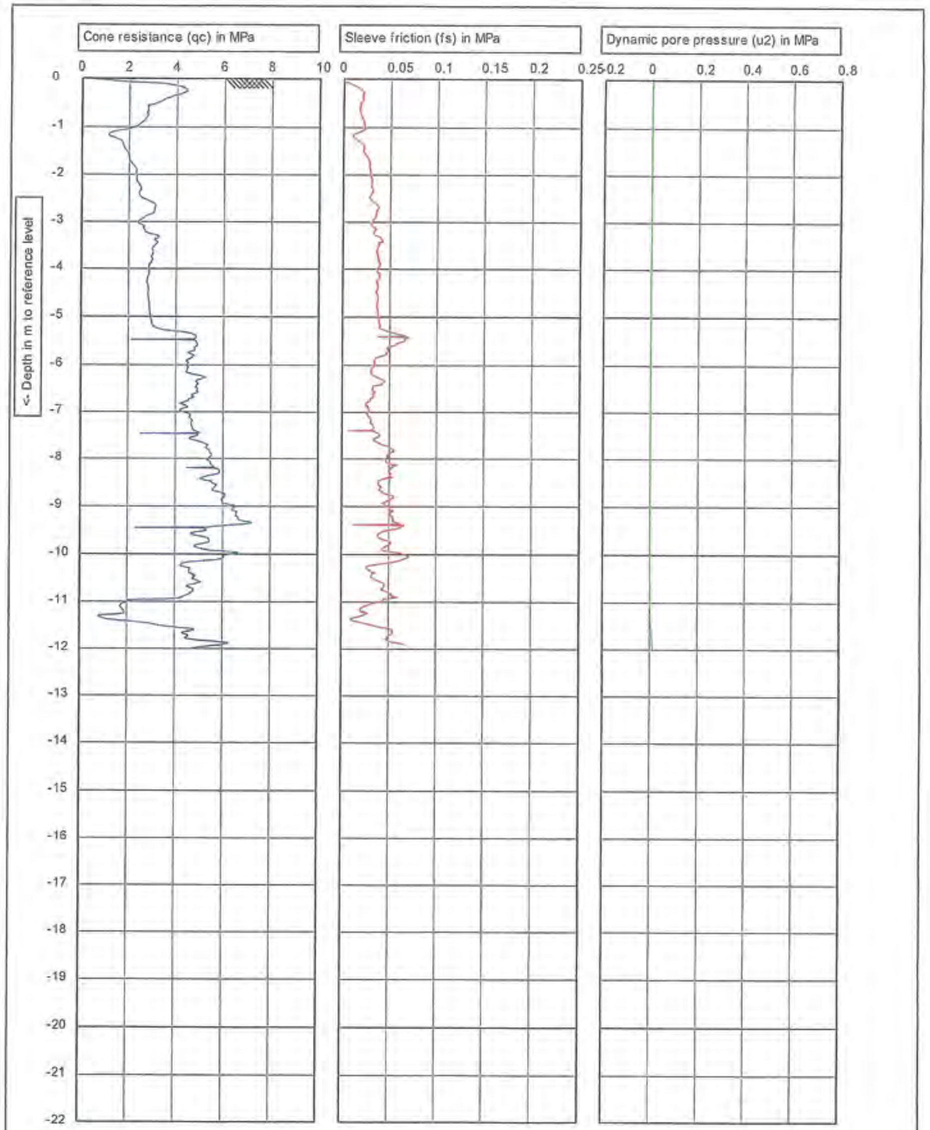
A 1983 aerial photograph of the subject site sourced from the Retrolens Website

Mark T Mitchell Ltd Geotechnical Engineers 1150 Victoria Street, P.O. Box 9123, Hamilton	WAIPA DISTRICT COUNCIL Site Investigation Cambridge Road and Lamb Street, Cambridge	HISTORIC PHOTO	DRAWING No. 16064-11 DATE September 2019 ISSUE DATE

APPENDIX B

Cone Penetration Test (CPT) Logs

CPT No. 1



Target Depth

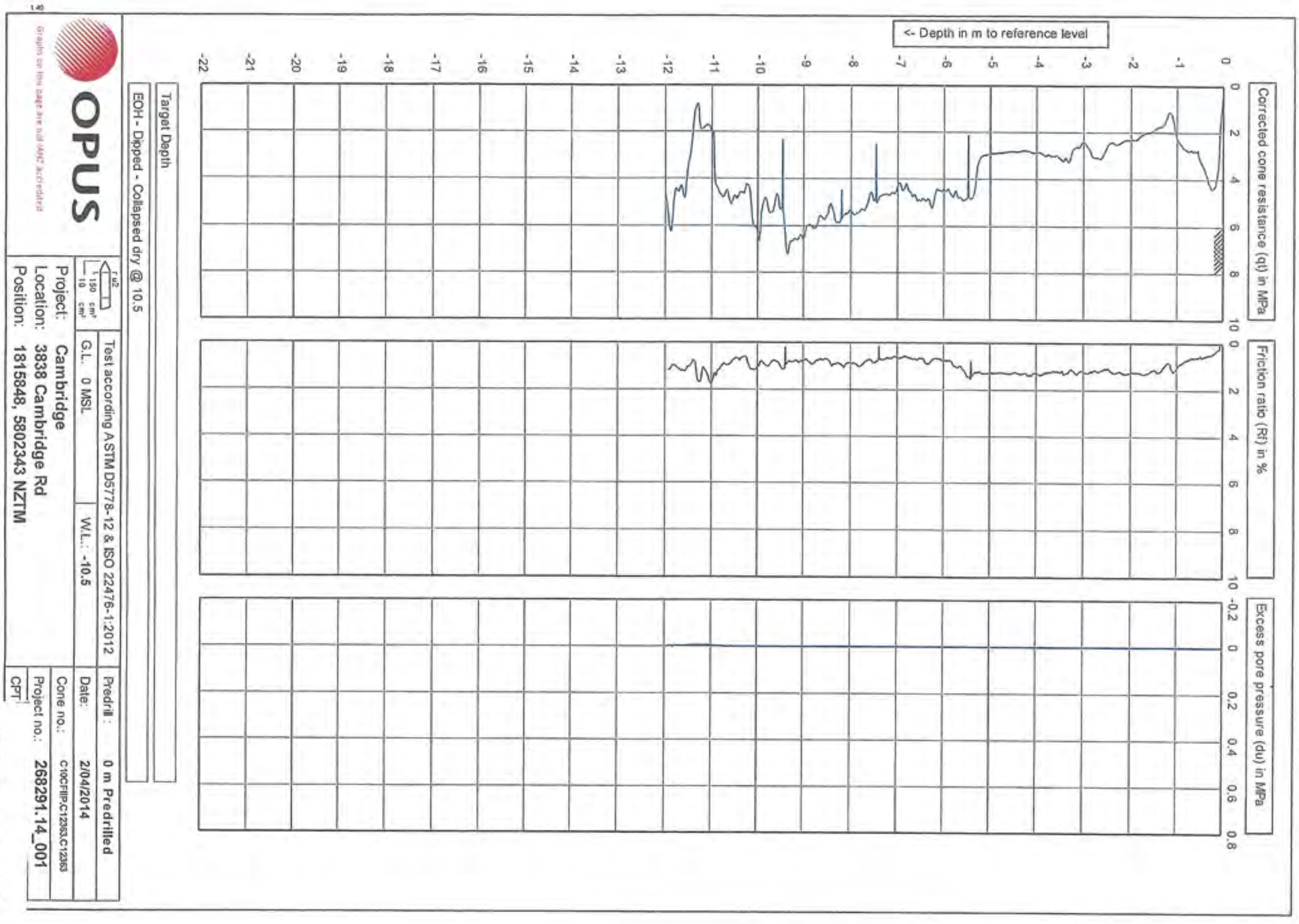
EOH - Dipped - Collapsed dry @ 10.5

OPUS

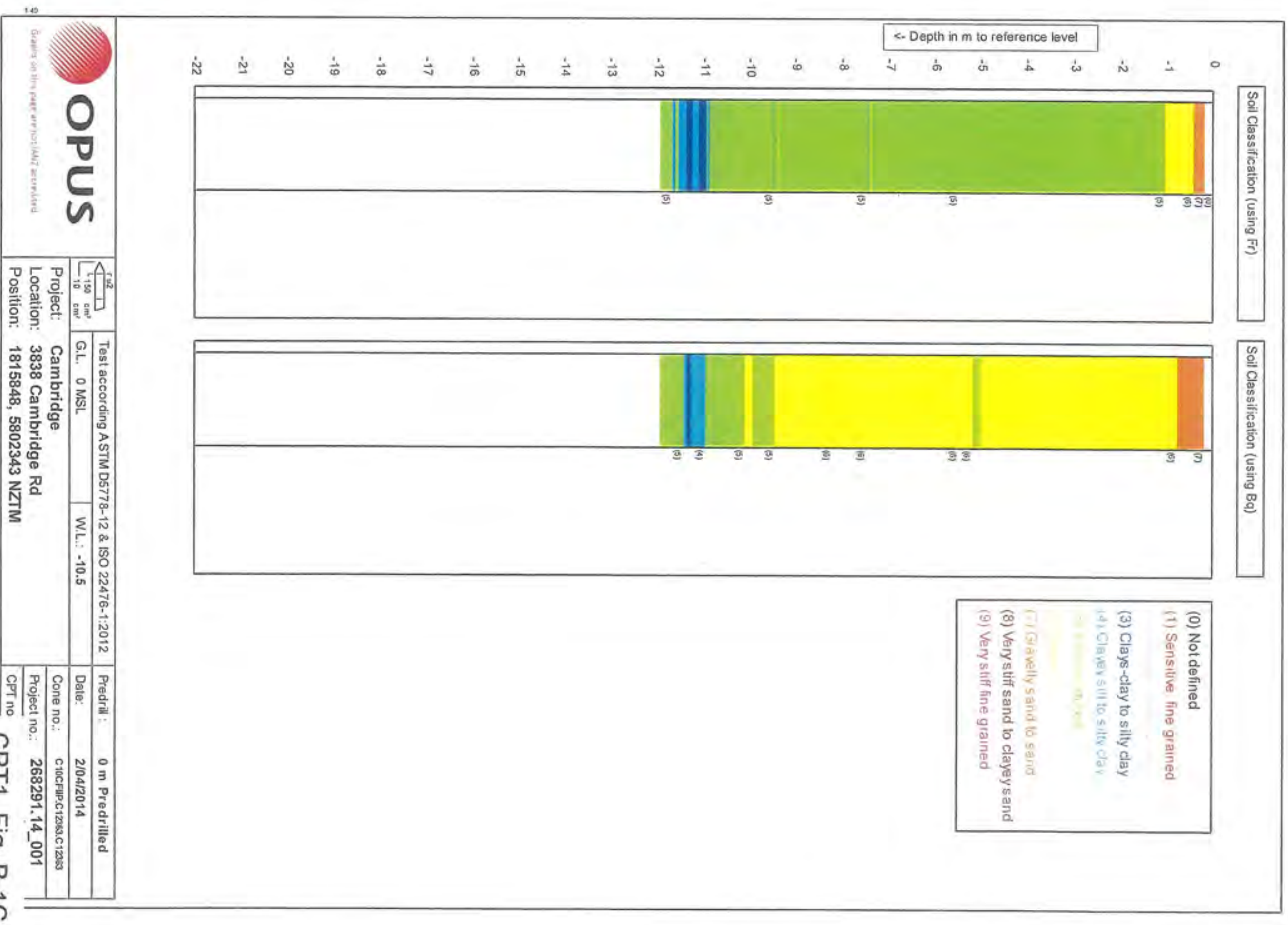
IANZ ACCREDITED LABORATORY — Graphs indicated as not accredited are outside the scope of the laboratory's accreditation

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill :	0 m Predrilled
G.L. 0 MSL	W.L.: -10.5	Date:	2/04/2014
Project:	Cambridge	Cone no.:	C10CFIIP.C12363.C12363
Location:	3838 Cambridge Rd	Project no.:	268291.14_001
Position:	1815848, 5802343 NZTM	CPT no	

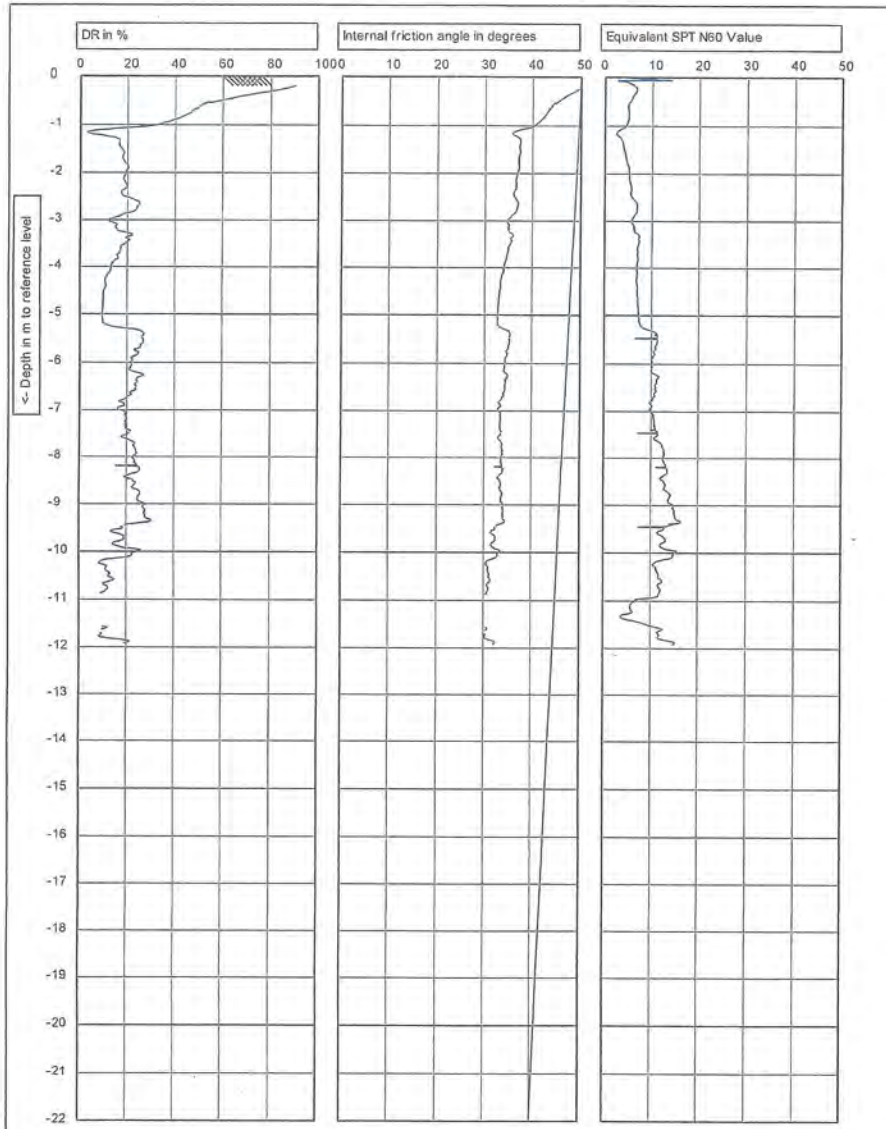
CPT1 Fig. B-1A



CPT1 Fig. B-1B



CPT1 Fig. B-1C



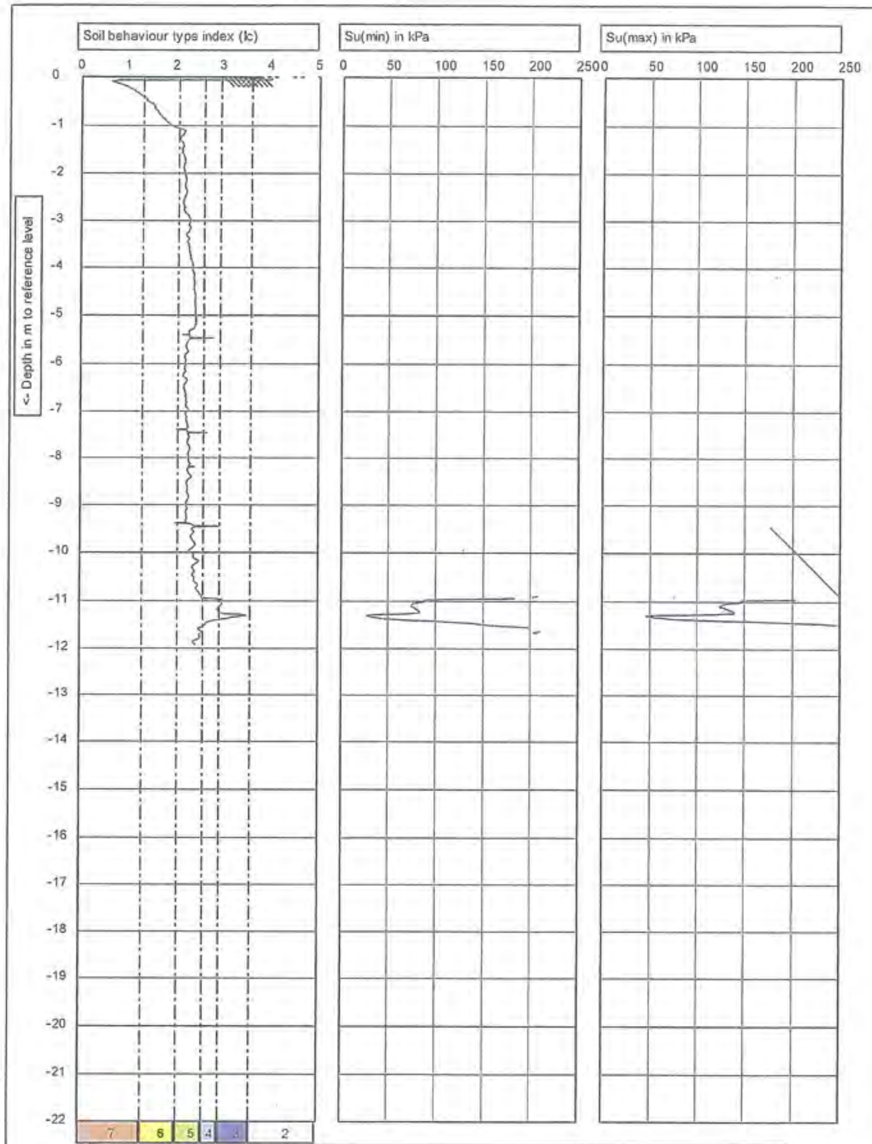
Target Depth

EOH - Dipped - Collapsed dry @ 10.5

OPUS	Test according ASTM D5778-12 & ISO 22476-1:2012	Predrill :	0 m Predrilled
	G.L. 0 MSL W.L.: -10.5	Date:	2/04/2014
	Project: Cambridge	Cone no.:	C10CFBP.C12363.C12363
	Location: 3838 Cambridge Rd	Project no.:	268291.14_001
	Position: 1815848, 5802343 NZTM	CPT n	

Graphs on this page are not IANZ accredited

CPT1 Fig. B-1D



Target Depth

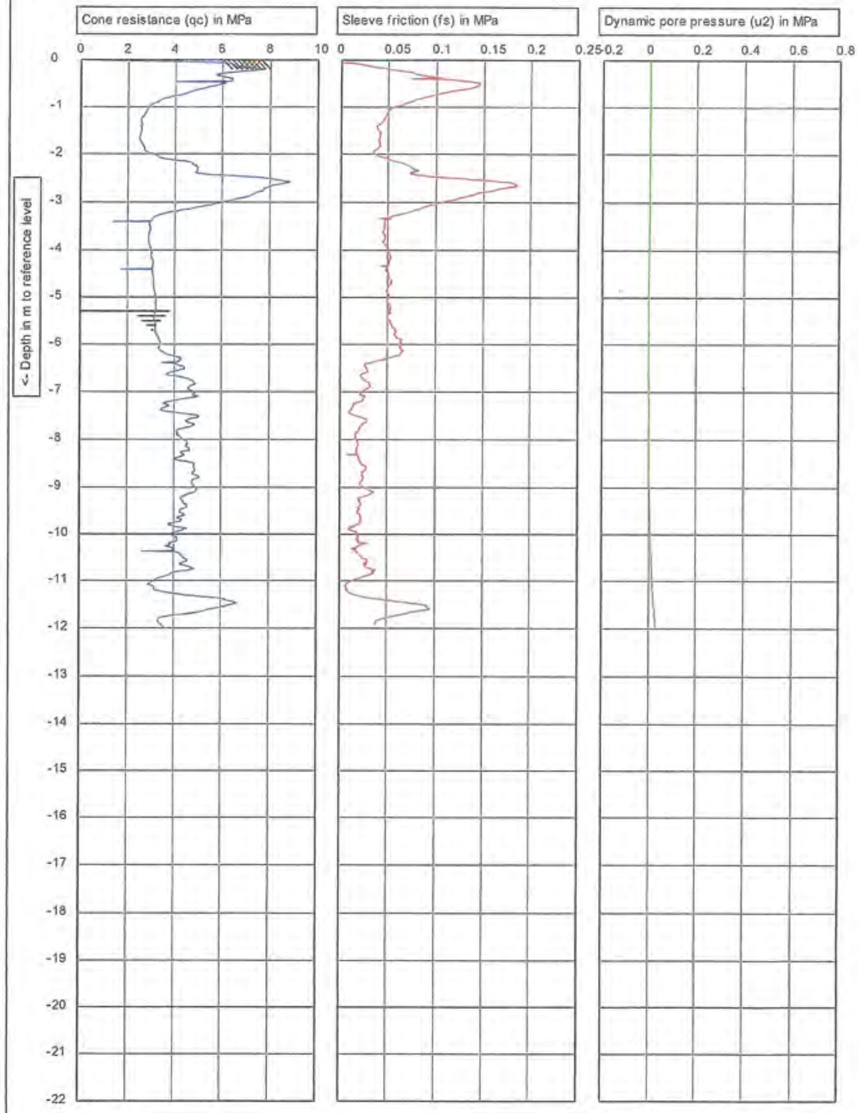
EOH - Dipped - Collapsed dry @ 10.5

OPUS	Test according ASTM D5778-12 & ISO 22476-1:2012	Predrill :	0 m Predrilled
	G.L. 0 MSL W.L.: -10.5	Date:	2/04/2014
	Project: Cambridge	Cone no.:	C10CFBP.C12363.C12363
	Location: 3838 Cambridge Rd	Project no.:	268291.14_001
	Position: 1815848, 5802343 NZTM	CPT n	

Graphs on this page are not IANZ accredited

CPT1 Fig. B-1E

CPT No. 2



Target Depth

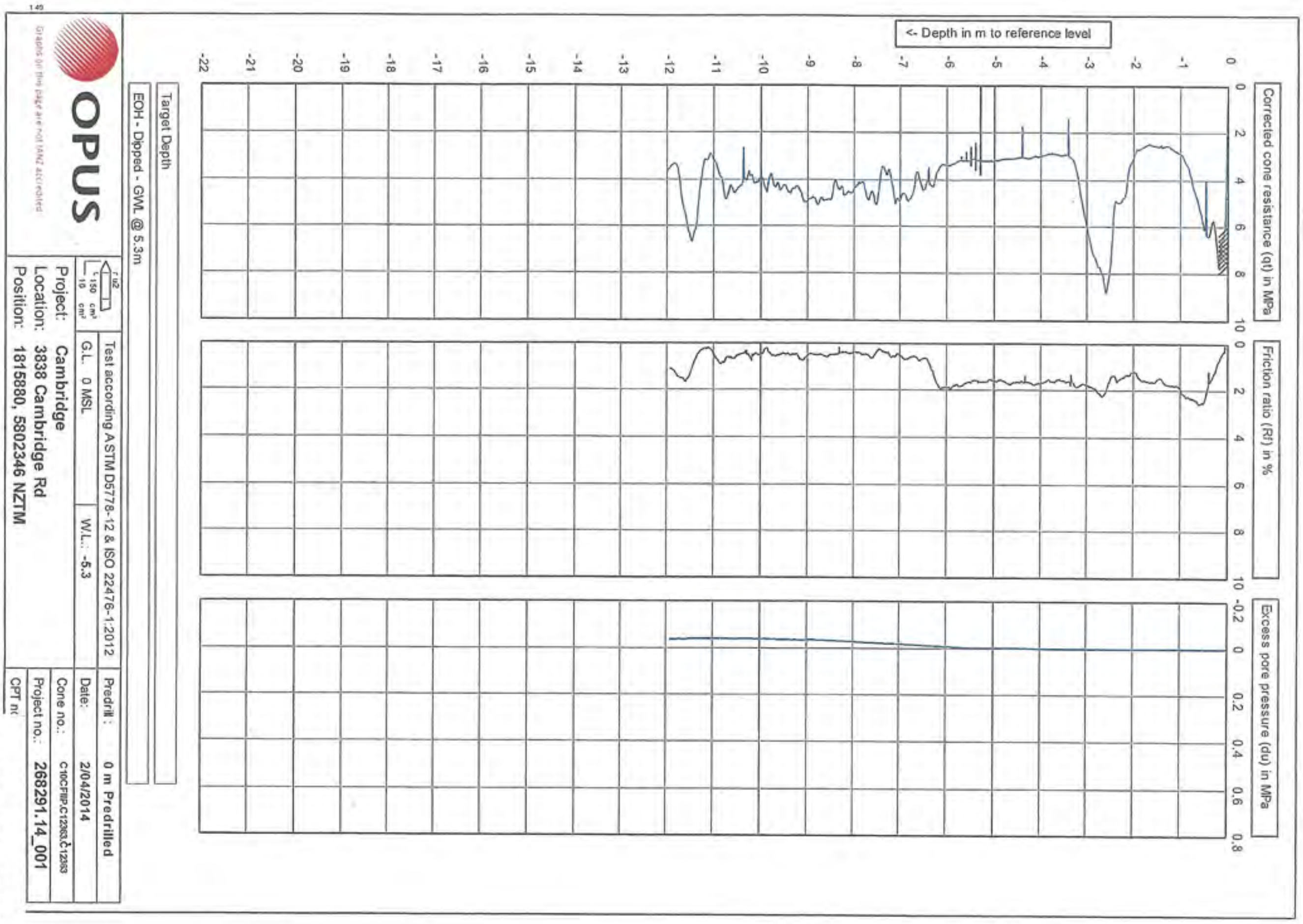
EOH - Dipped - GWL @ 5.3m

OPUS

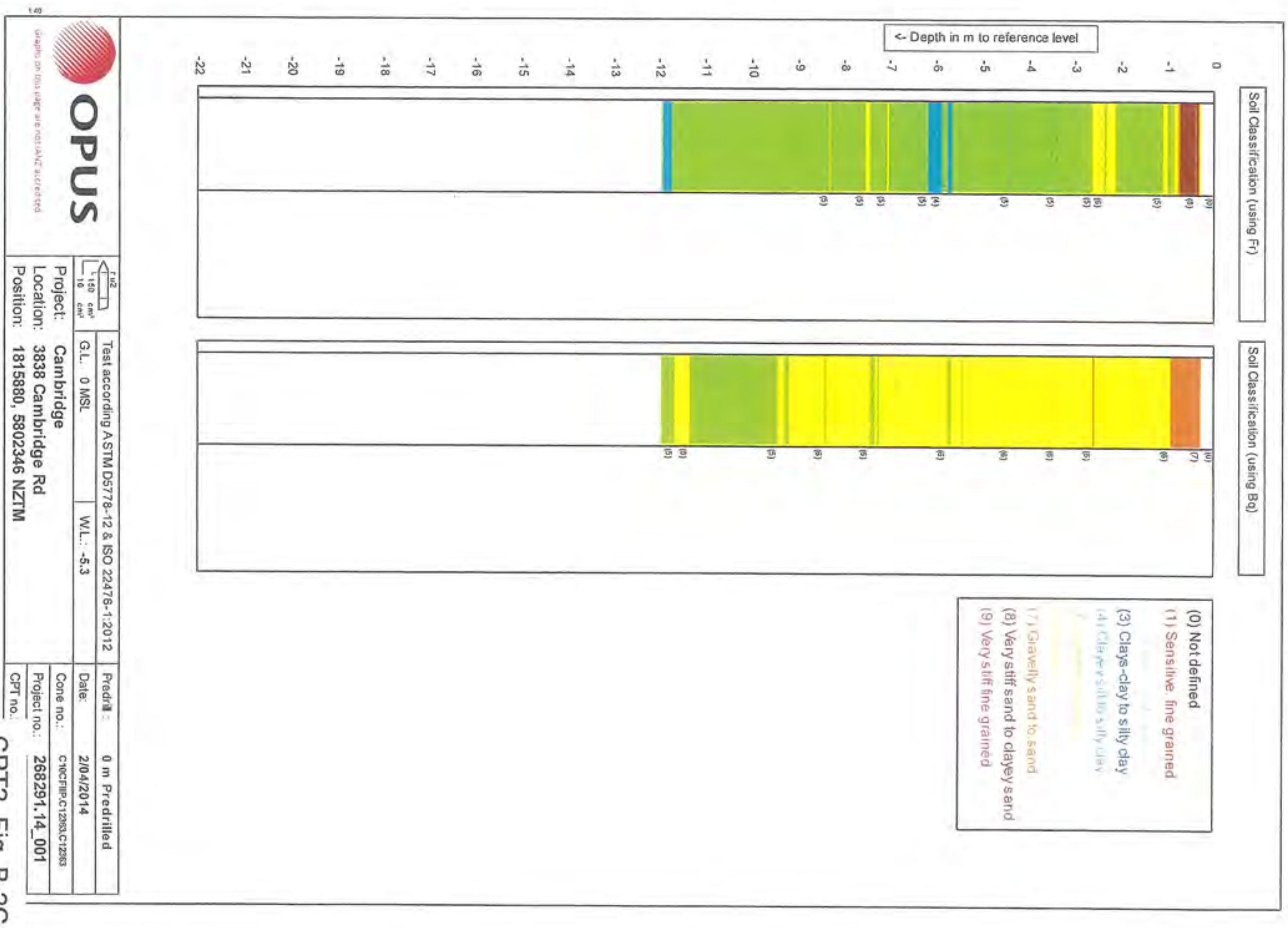
IANZ ACCREDITED LABORATORY — Graphs indicated as not accredited are outside the scope of the laboratory's accreditation

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill :	0 m Predrilled
G.L. 0 MSL	W.L.: -5.3	Date:	2/04/2014
Project:	Cambridge	Cone no.:	C10CFIIP.C12363.C12363
Location:	3838 Cambridge Rd	Project no.:	268291.14_001
Position:	1815880, 5802346 NZTM	CPT nr	

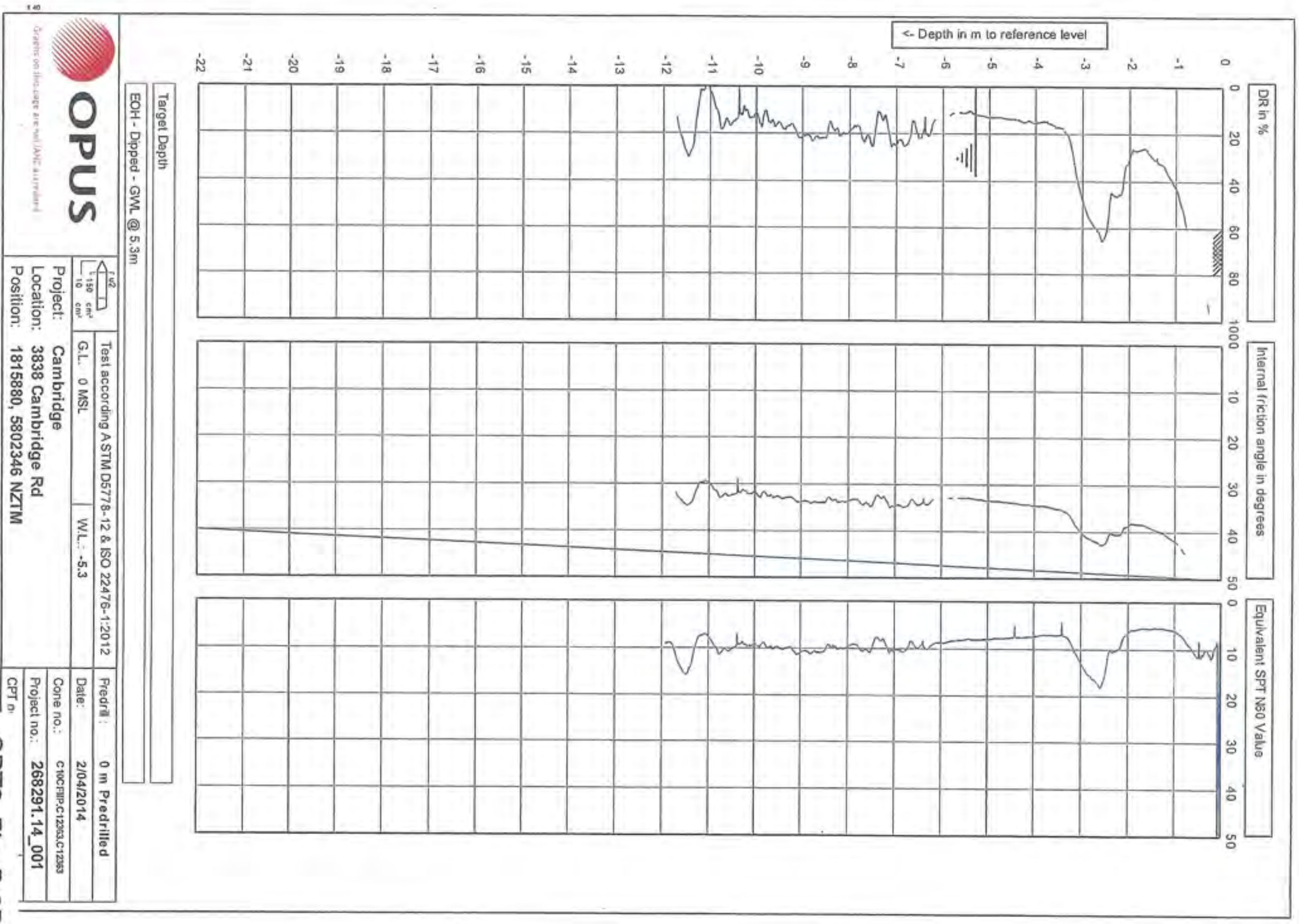
CPT2 Fig. B-2A



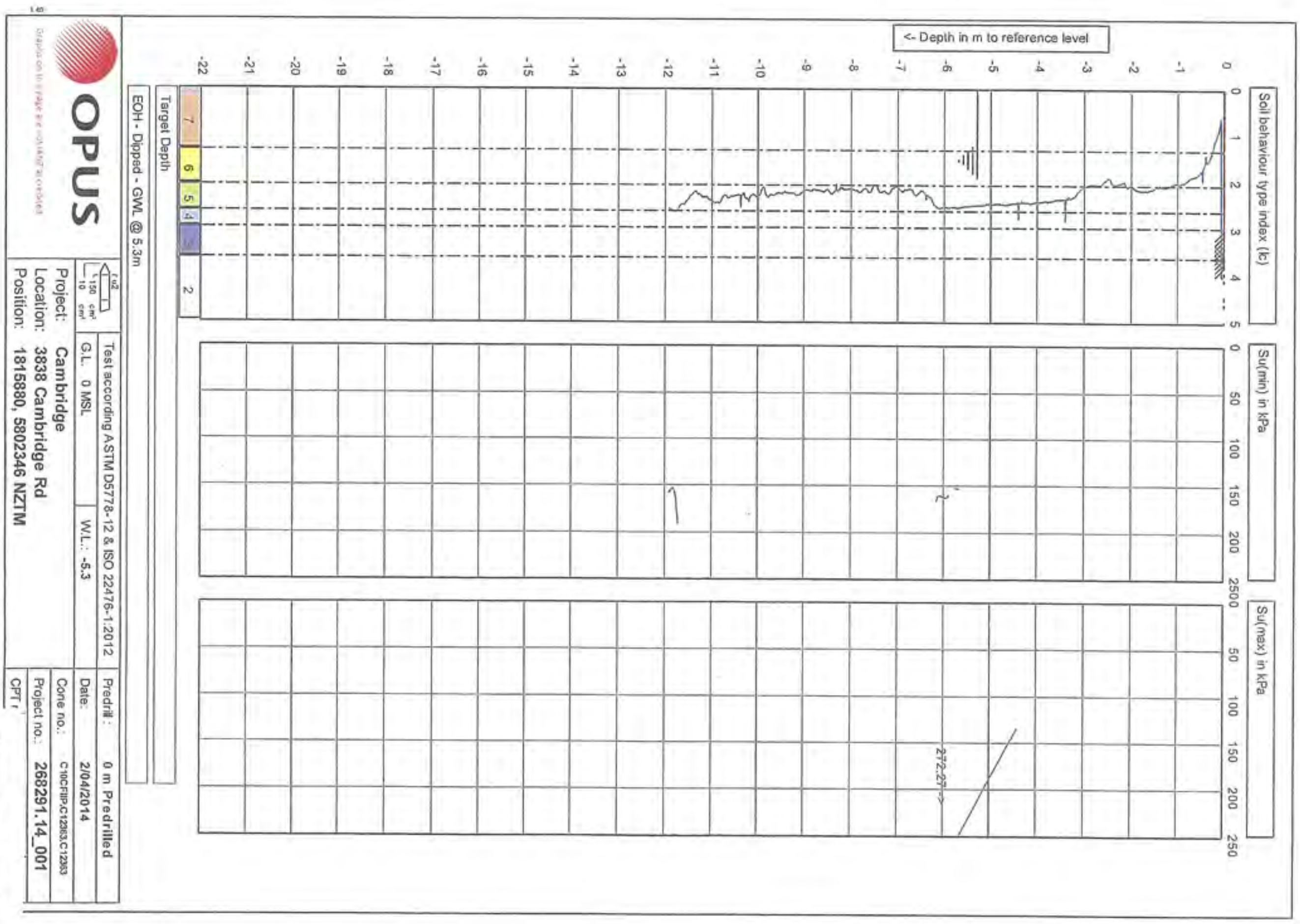
CPT2 Fig. B-2B



CPT2 Fig. B-2C



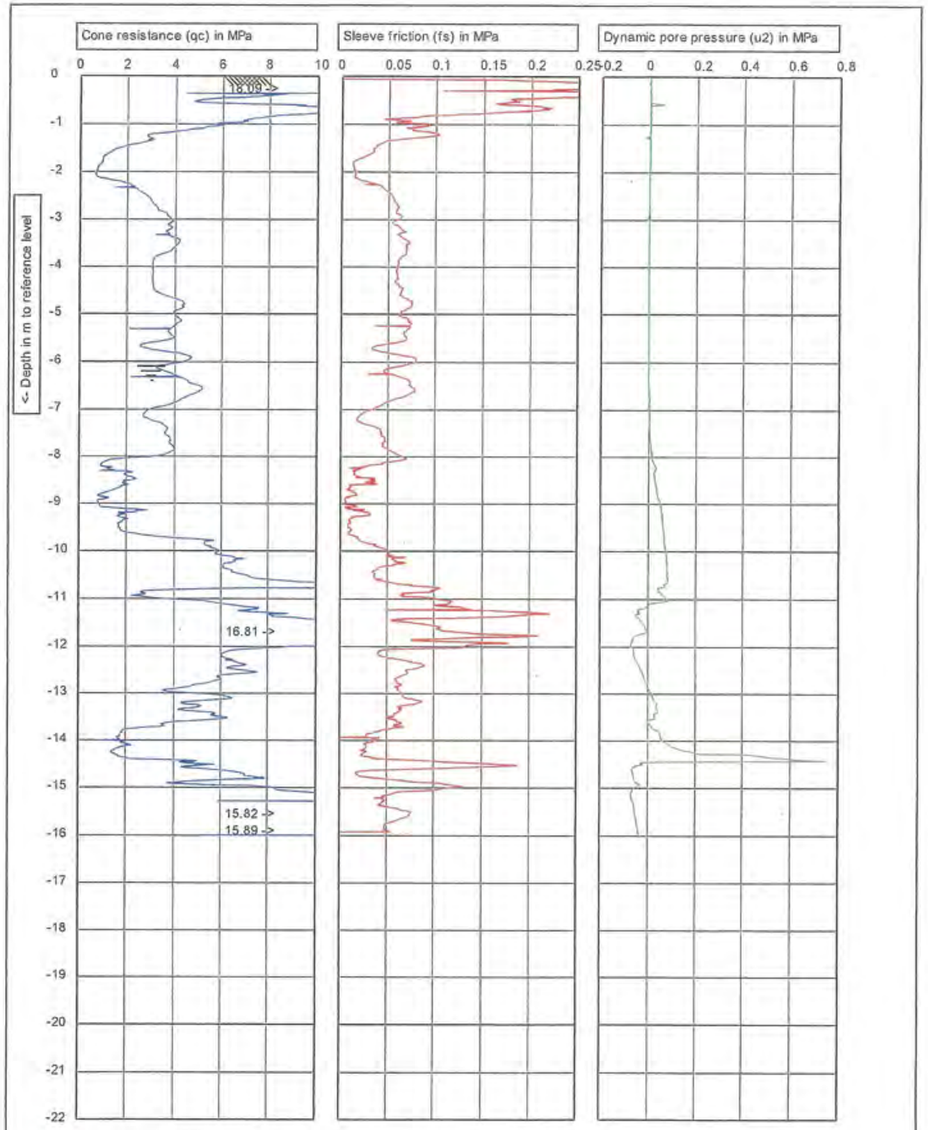
CPT2 Fig. B-2D



CPT2 Fig. B-2E

CPT No. 3

Director: Mark T Mitchell BE MS (Purdue) MIPENZ MASCE CPEng IntPE(NZ) Member ACENZ



Target Depth

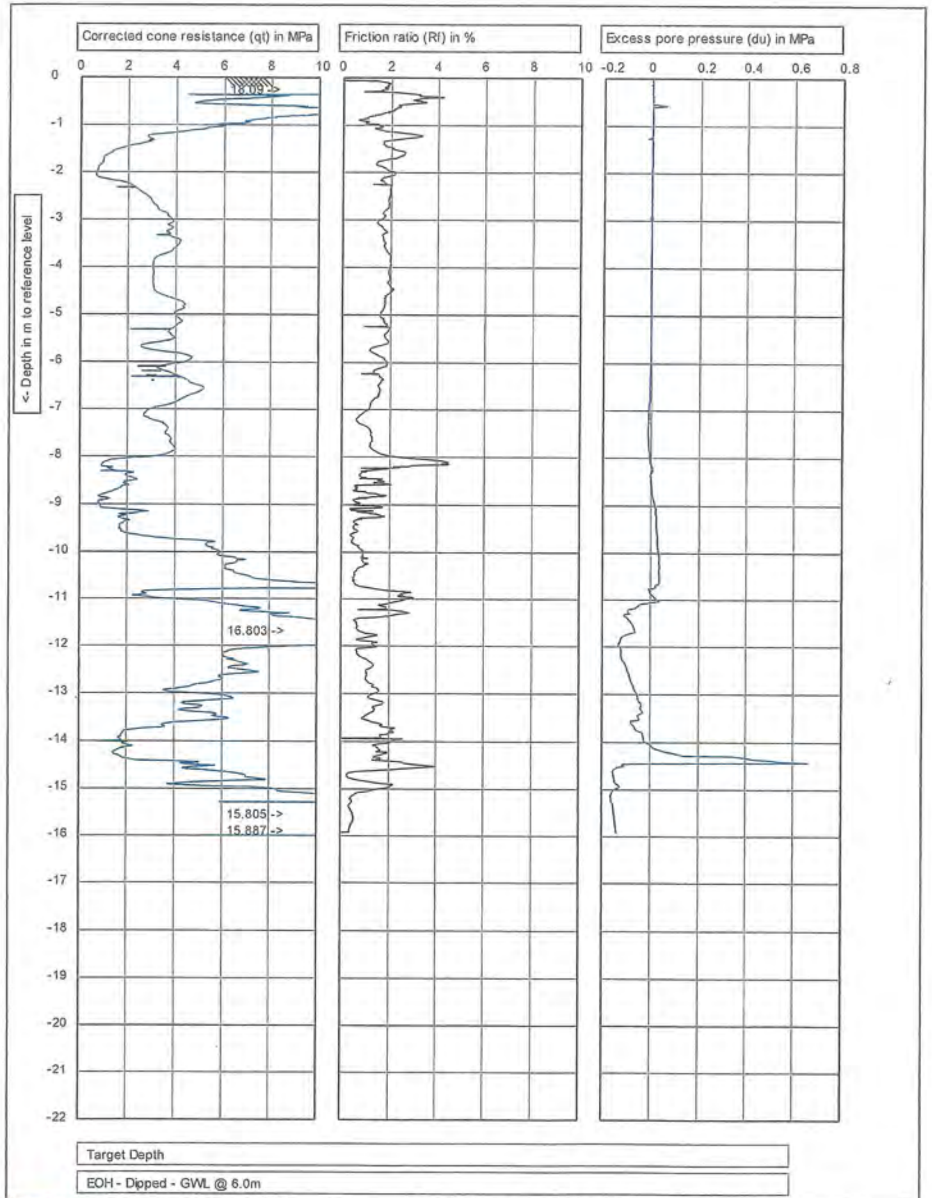
EOH - Dipped - GWL @ 6.0m

OPUS

IANZ ACCREDITED LABORATORY — Graphs indicated as not accredited are outside the scope of the laboratory's accreditation

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0 m Predrilled
G.L. 0 MSL	W.L.: -6	Date:	2/04/2014
Project:	Cambridge	Cone no.:	C10CFIIP.C12363.C12363
Location:	3838 Cambridge Rd	Project no.:	268291.14_001
Position:	1815848, 5802300 NZTM	CPT no.:	

CPT3 Fig. B-3A

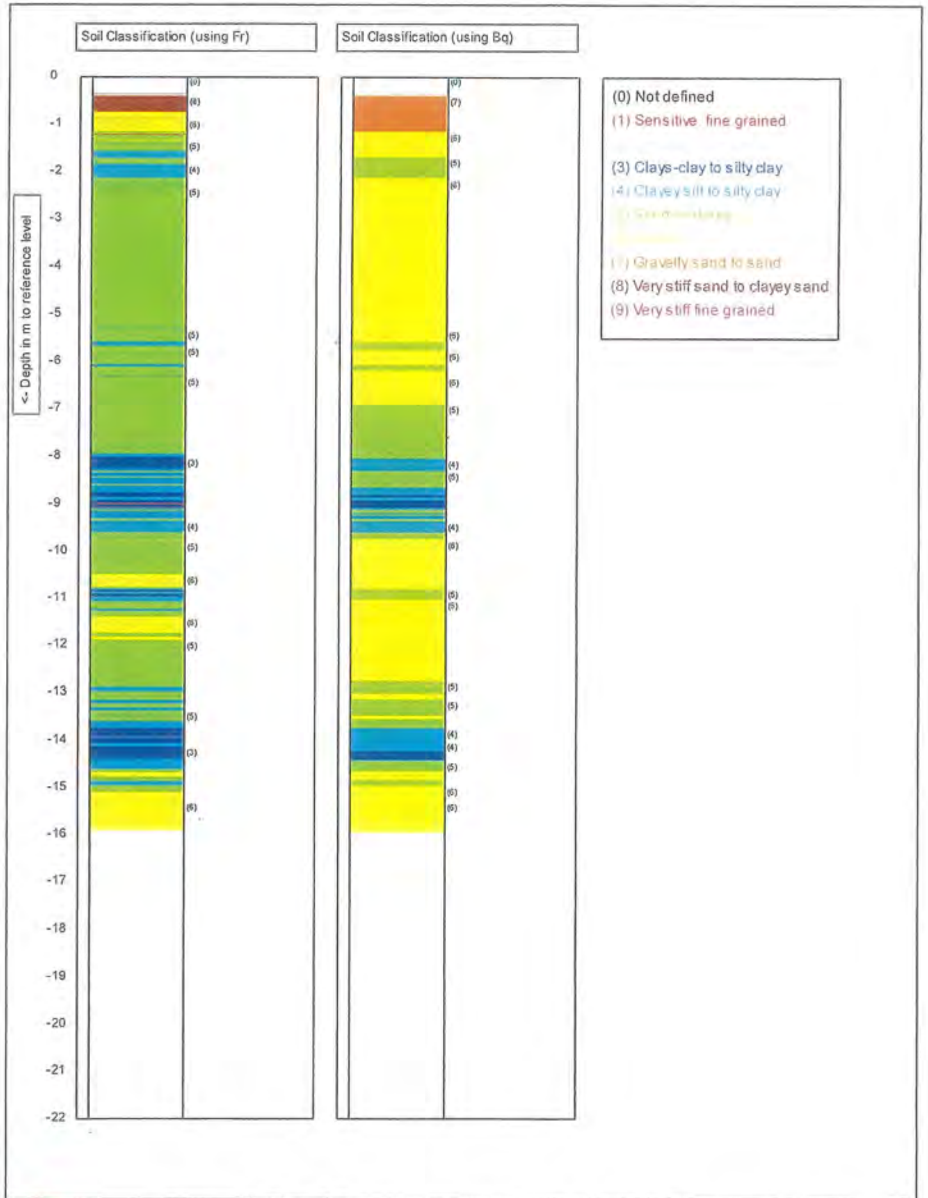


OPUS

Graphs on this page are not IANZ accredited

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0 m Predrilled
G.L. 0 MSL	W.L.: -6	Date:	2/04/2014
Project: Cambridge		Cone no.:	C10CFIIP.C12363.C12363
Location: 3838 Cambridge Rd		Project no.:	268291.14_001
Position: 1815848, 5802300 NZTM		CPT	

CPT3 Fig. B-3B

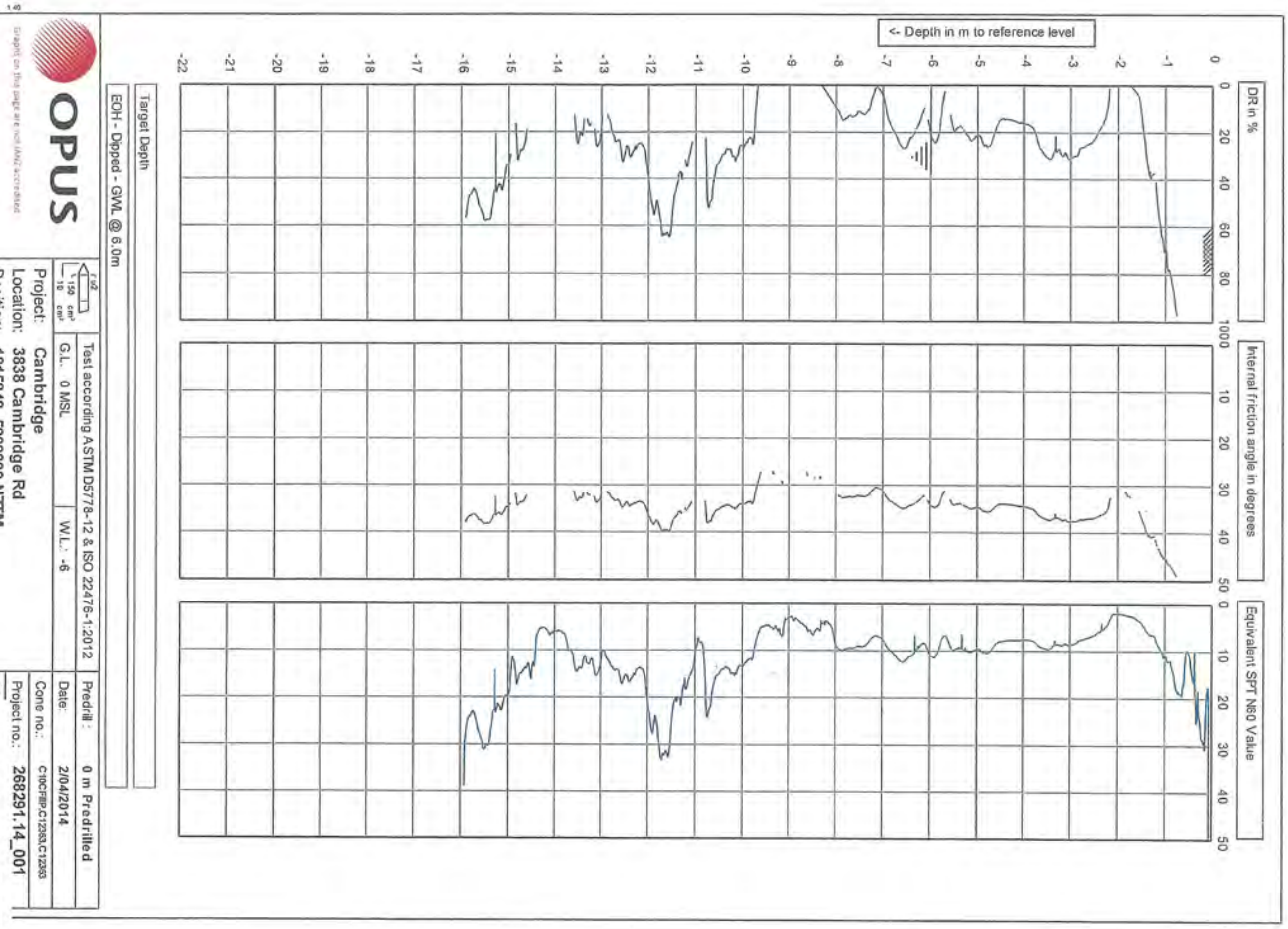


OPUS

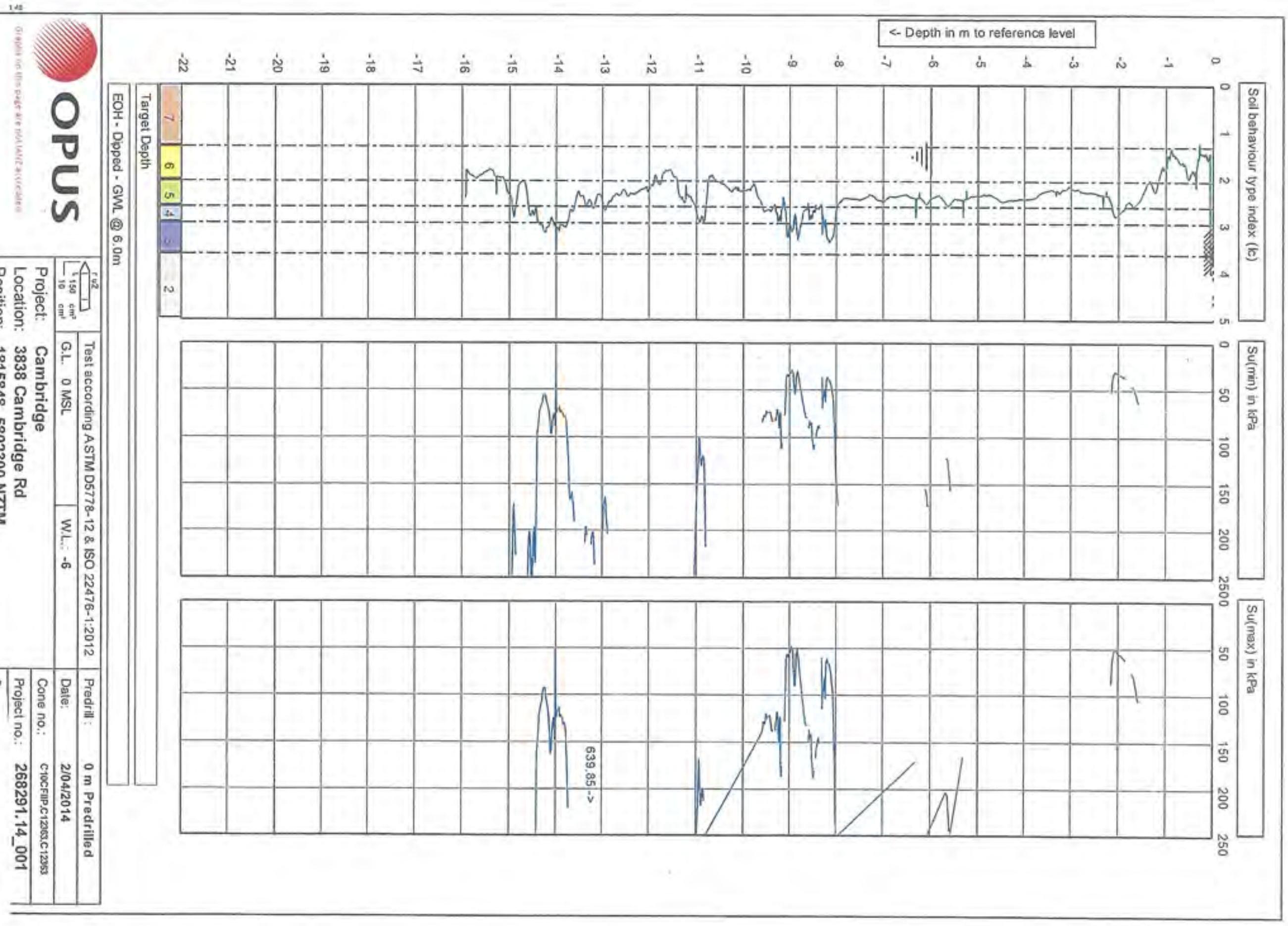
Graphs on this page are not IANZ accredited

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0 m Predrilled
G.L. 0 MSL	W.L.: -6	Date:	2/04/2014
Project: Cambridge		Cone no.:	C10CFIIP.C12363.C12363
Location: 3838 Cambridge Rd		Project no.:	268291.14_001
Position: 1815848, 5802300 NZTM		CPT no.:	

CPT3 Fig. B-3C



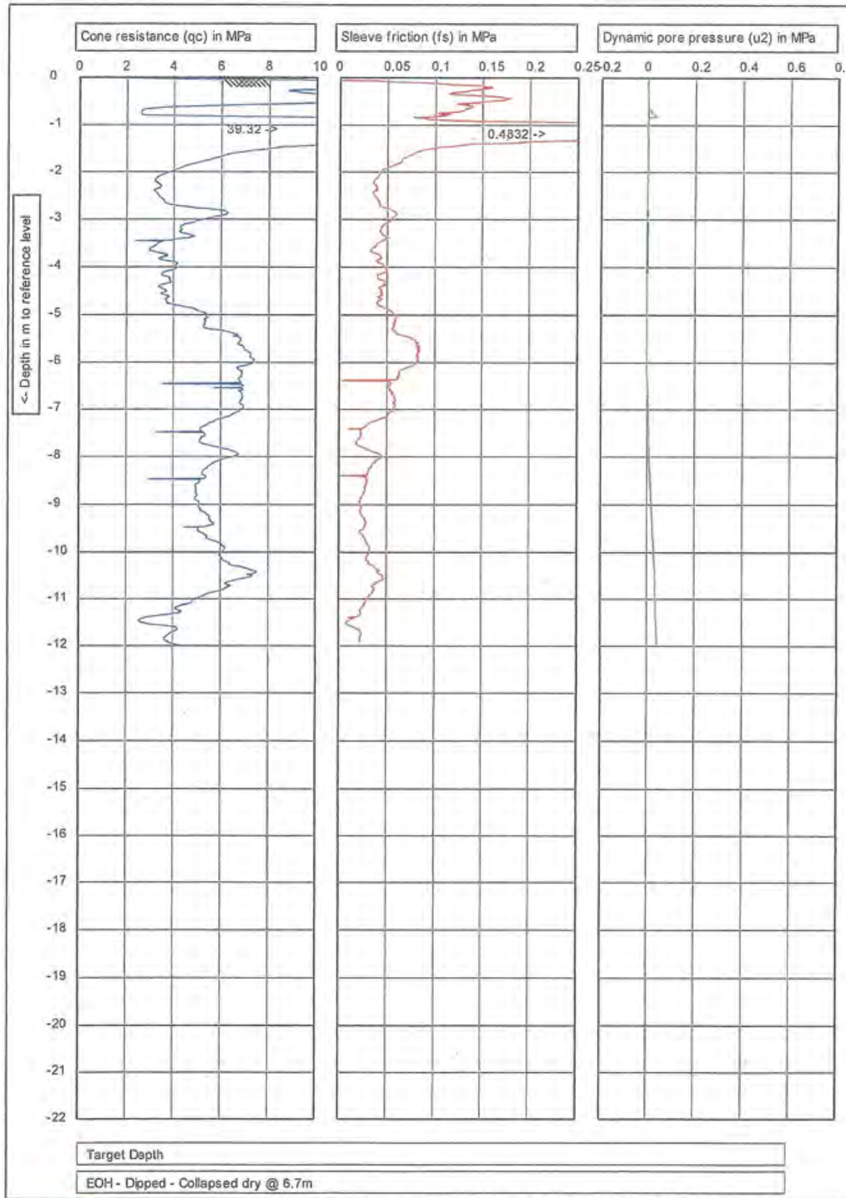
CPT3 Fig. B-3D



CPT3 Fig. B-3E

CPT No. 4

Director: Mark T Mitchell BE MS (Purdue) MIPENZ MASCE CPEng IntPE(NZ) Member ACENZ

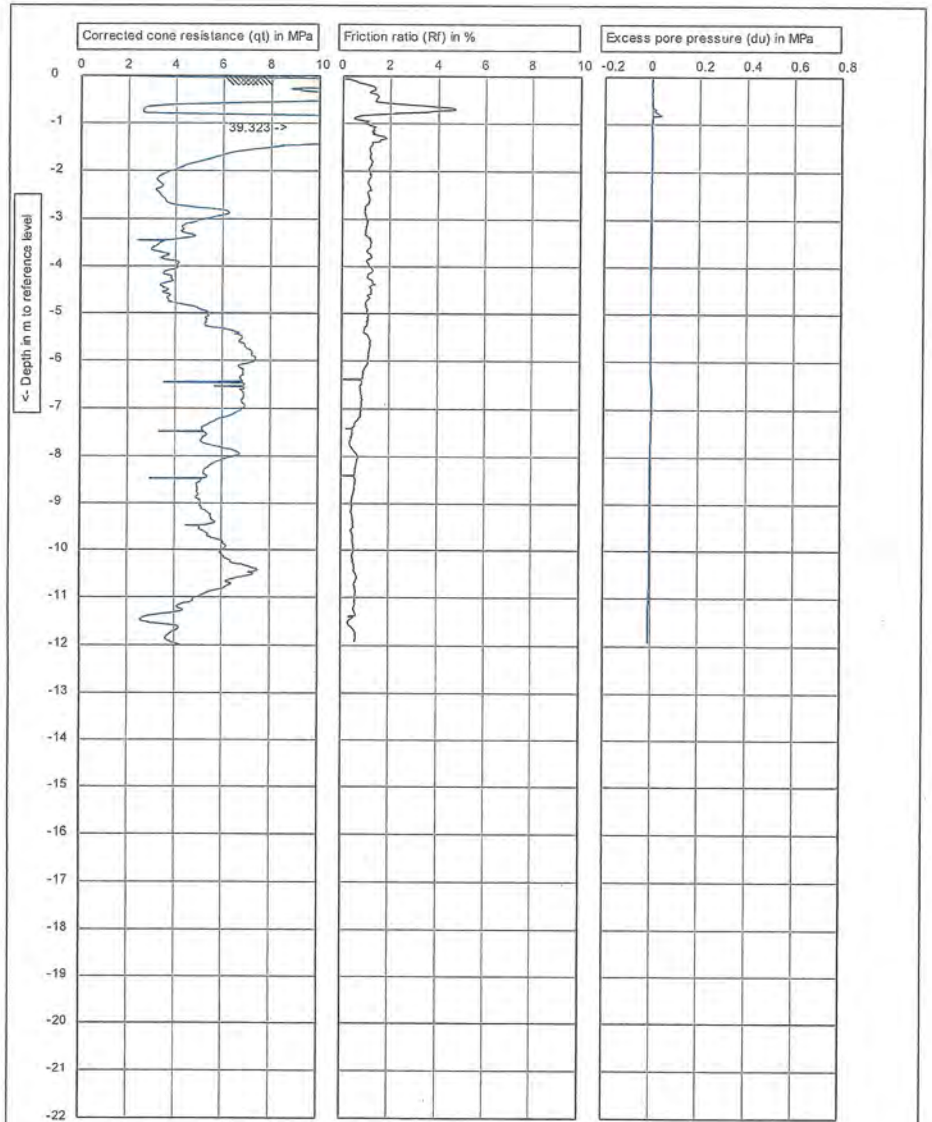


OPUS

IANZ ACCREDITED LABORATORY — Graphs indicated as not accredited are outside the scope of the laboratory's accreditation

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0 m Predrilled
G.L. 0 MSL	W.L.: -6.7	Date:	2/04/2014
Project:	Cambridge	Cone no.:	C10CFIIP.C12363.C12363
Location:	3838 Cambridge Rd	Project no.:	268291.14_001
Position:	1815884, 5802296 NZTM	Cl	

CPT4 Fig. B-4A



Target Depth

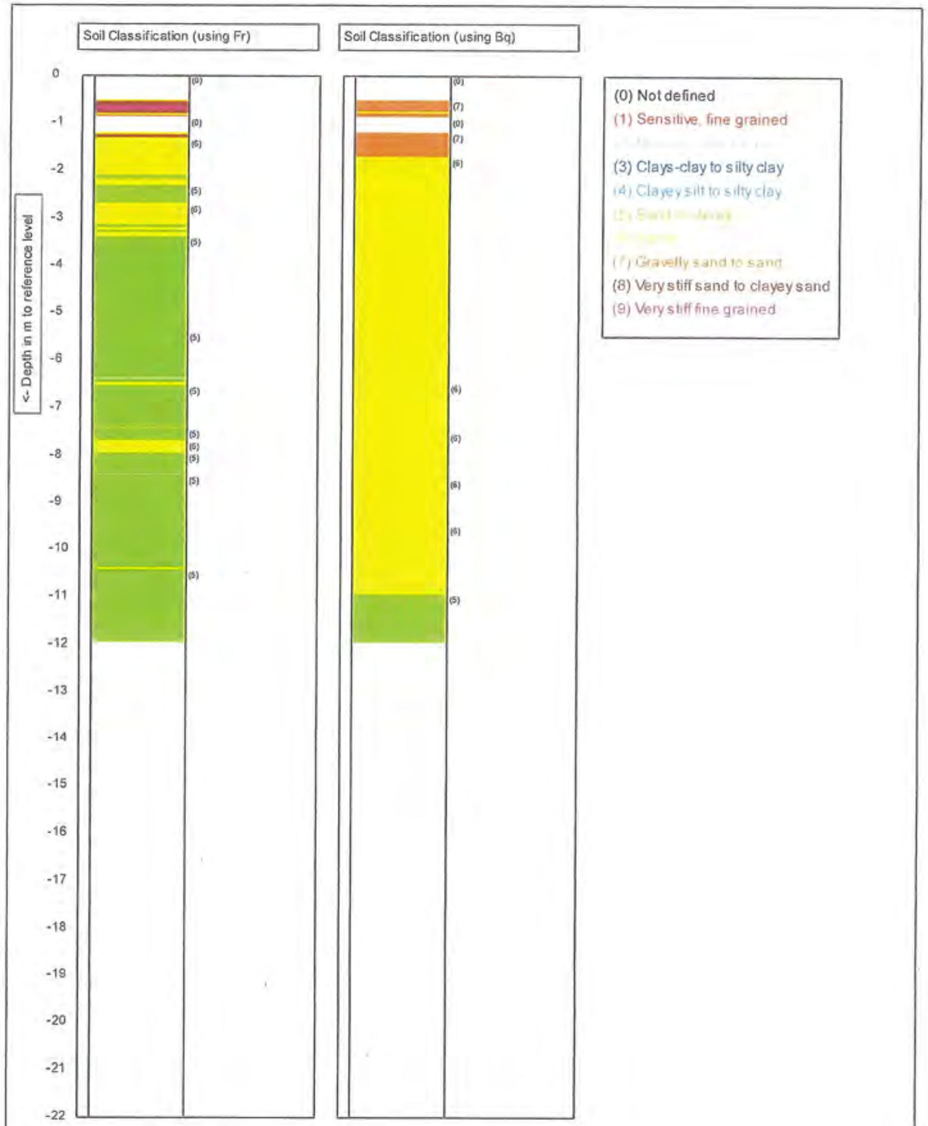
EOH - Dipped - Collapsed dry @ 6.7m

OPUS

Graphs on this page are not IANZ accredited

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill :	0 m Predrilled
G.L. 0 MSL	W.L.: -6.7	Date:	2/04/2014
Project: Cambridge		Cone no.:	C10CFIIP.C12363.C12363
Location: 3838 Cambridge Rd		Project no.:	268291.14_001
Position: 1815884, 5802296 NZTM		CP	

CPT4 Fig. B-4B

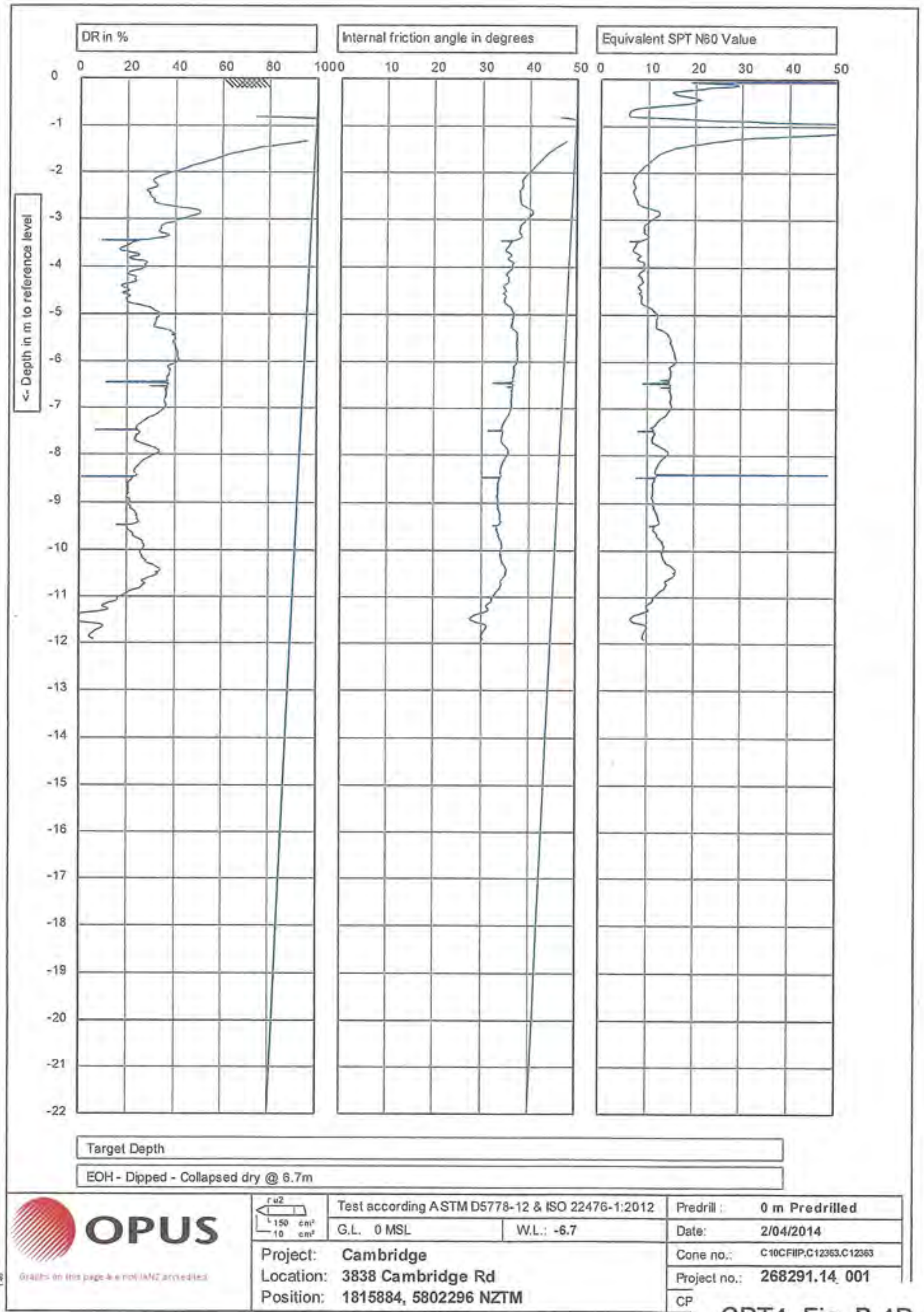


OPUS

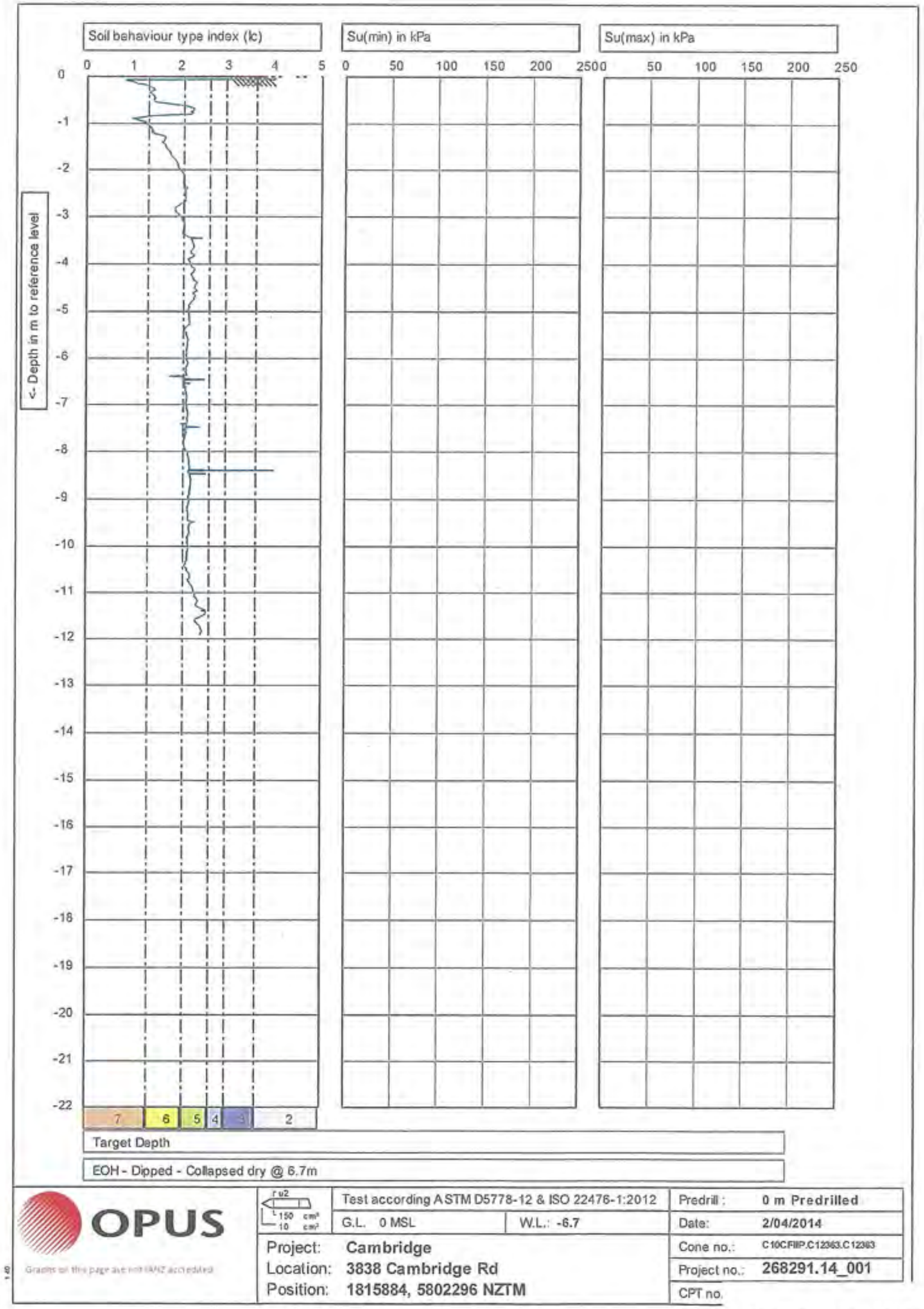
Graphs on this page are not IANZ accredited

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill :	0 m Predrilled
G.L. 0 MSL	W.L.: -6.7	Date:	2/04/2014
Project: Cambridge		Cone no.:	C10CFIIP.C12363.C12363
Location: 3838 Cambridge Rd		Project no.:	268291.14_001
Position: 1815884, 5802296 NZTM		CPT n	

CPT4 Fig. B-4C

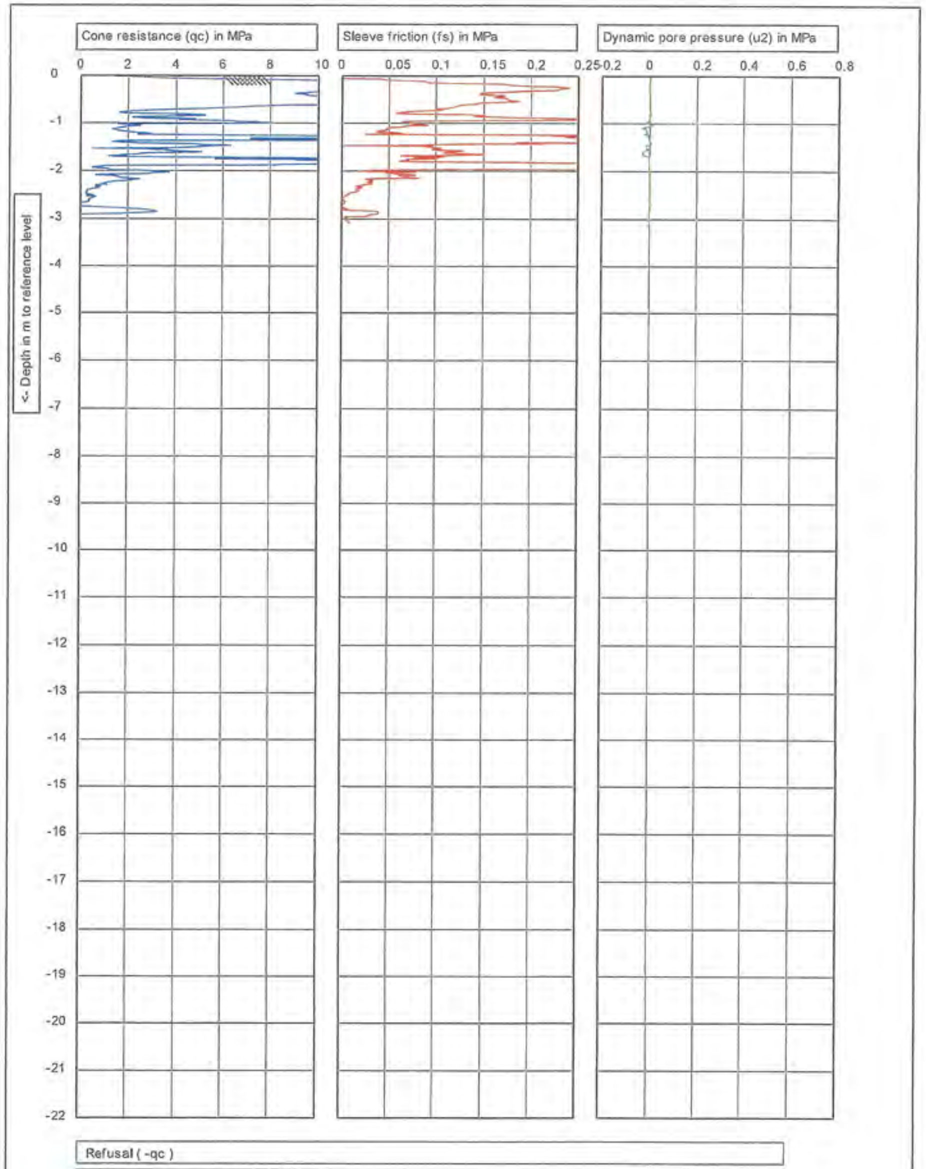


CPT4 Fig. B-4D



CPT4 Fig. B-4E

CPT No. 5



Refusal (-qc)

EOH - Dipped - Collapsed dry @ 0.5m

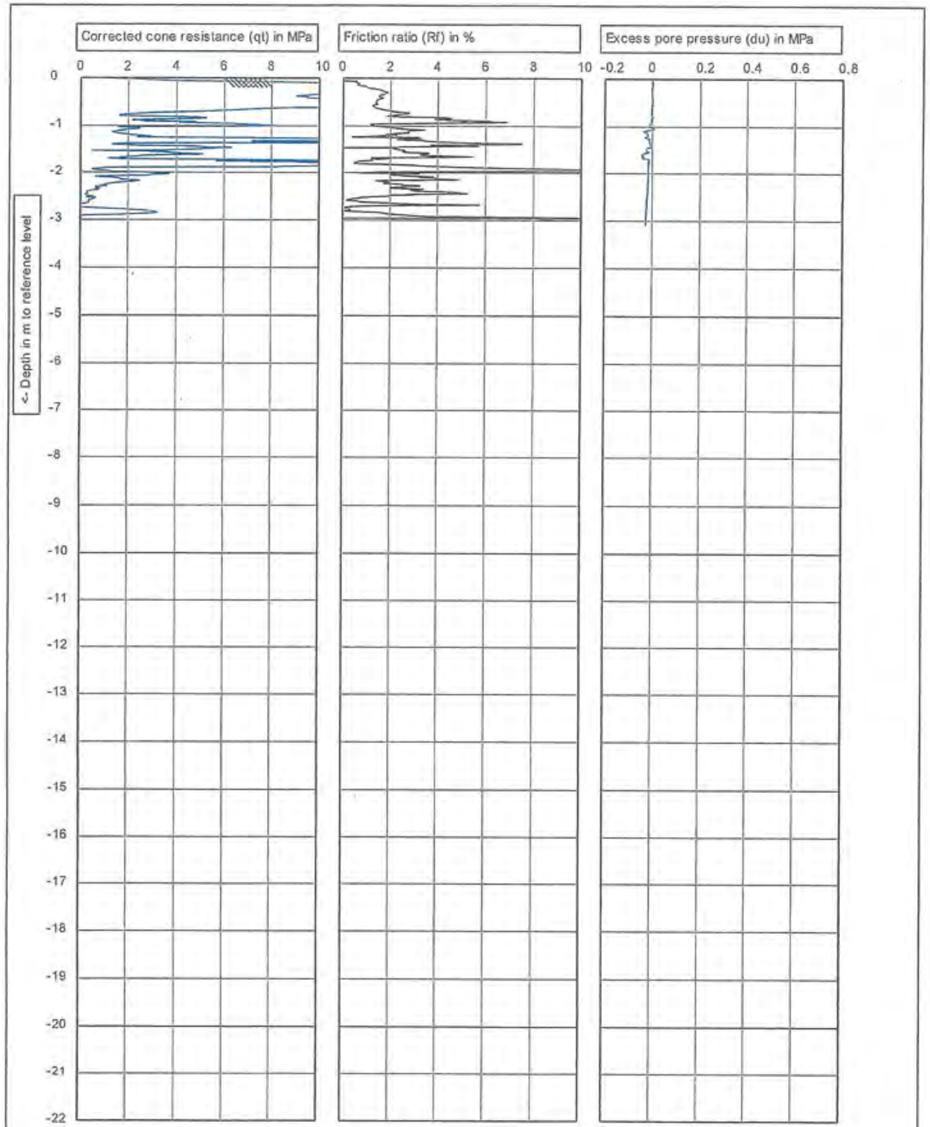
OPUS

IANZ ACCREDITED LABORATORY

Graphs indicated as not accredited are outside the scope of the laboratory's accreditation

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill :	0 m Predrilled
G.L. 0 MSL	W.L.: -0.5	Date:	2/04/2014
Project:	Cambridge	Cone no.:	C10CFIIP.C12363.C12363
Location:	3838 Cambridge Rd	Project no.:	268291.14_001
Position:	1815848, 5802242 NZTM	CPT no.	

CPT5 Fig. B-5A

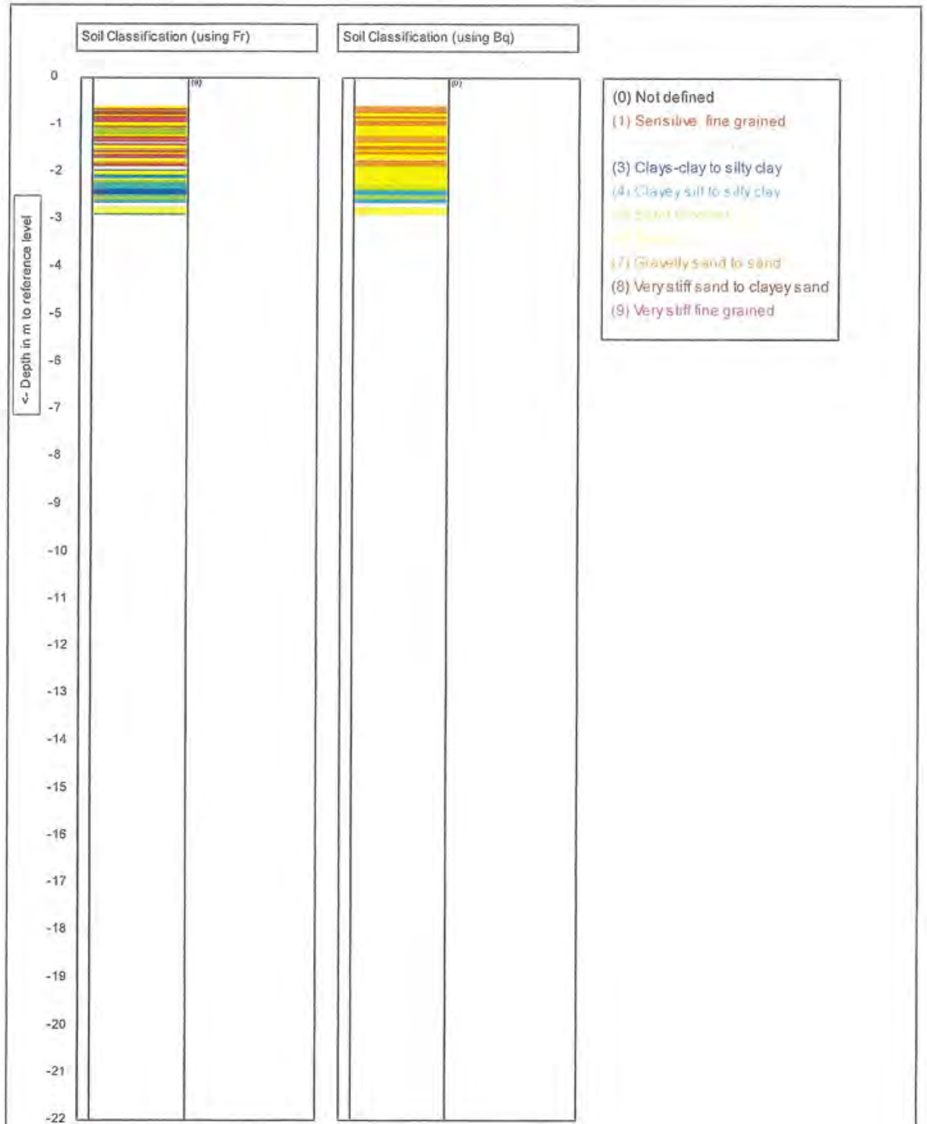


Refusal (-qc)

EOH - Dipped - Collapsed dry @ 0.5m

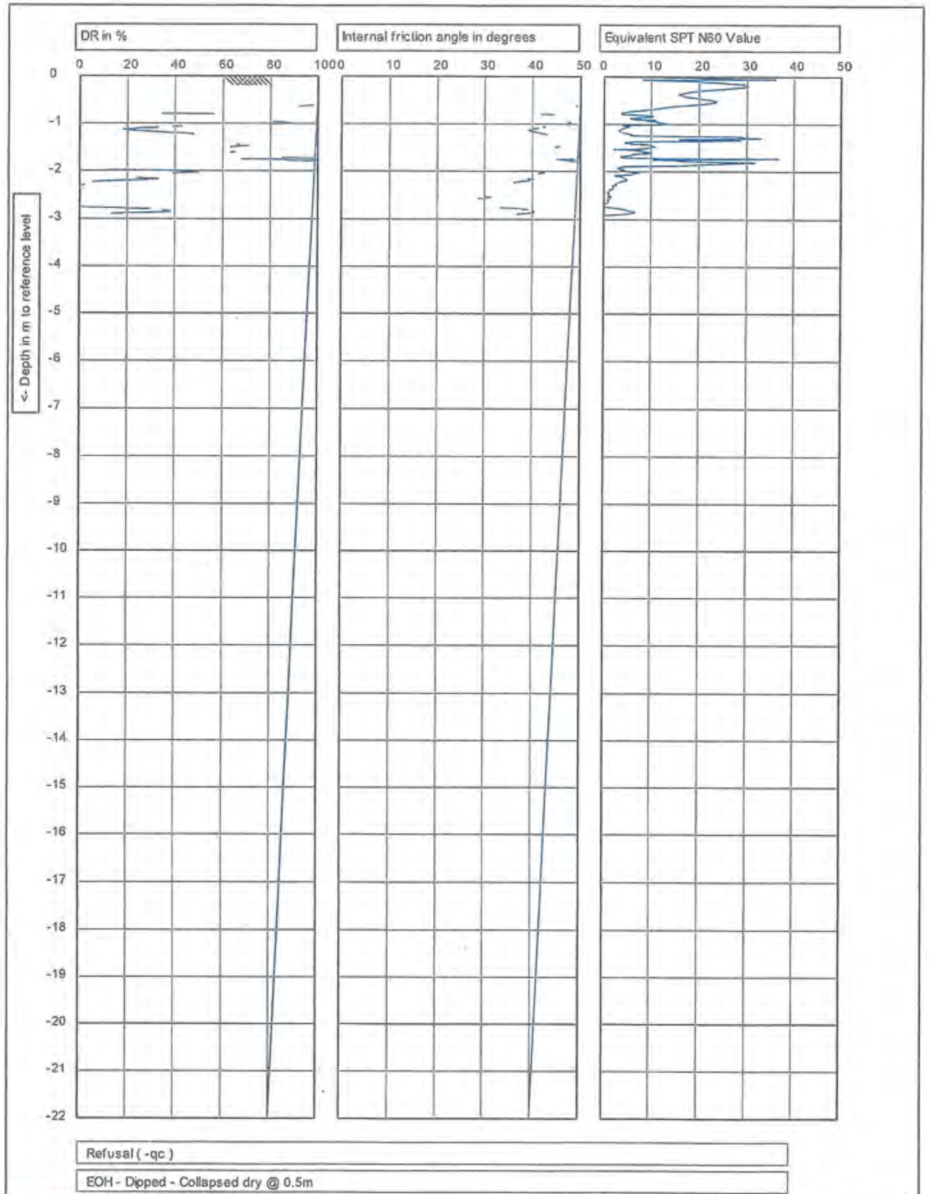
OPUS	Test according ASTM D5778-12 & ISO 22476-1:2012	Predrill :	0 m Predrilled
	G.L. 0 MSL / W.L.: -0.5	Date:	2/04/2014
	Project: Cambridge	Cone no.:	C10CFIIP.C12363.C12363
	Location: 3838 Cambridge Rd	Project no.:	268291.14_001
	Position: 1815848, 5802242 NZTM	CF	

CPT5 Fig. B-5B



OPUS	Test according ASTM D5778-12 & ISO 22476-1:2012	Predrill :	0 m Predrilled
	G.L. 0 MSL / W.L.: -0.5	Date:	2/04/2014
	Project: Cambridge	Cone no.:	C10CFIIP.C12363.C12363
	Location: 3838 Cambridge Rd	Project no.:	268291.14_001
	Position: 1815848, 5802242 NZTM	CPT	

CPT5 Fig. B-5C



OPUS

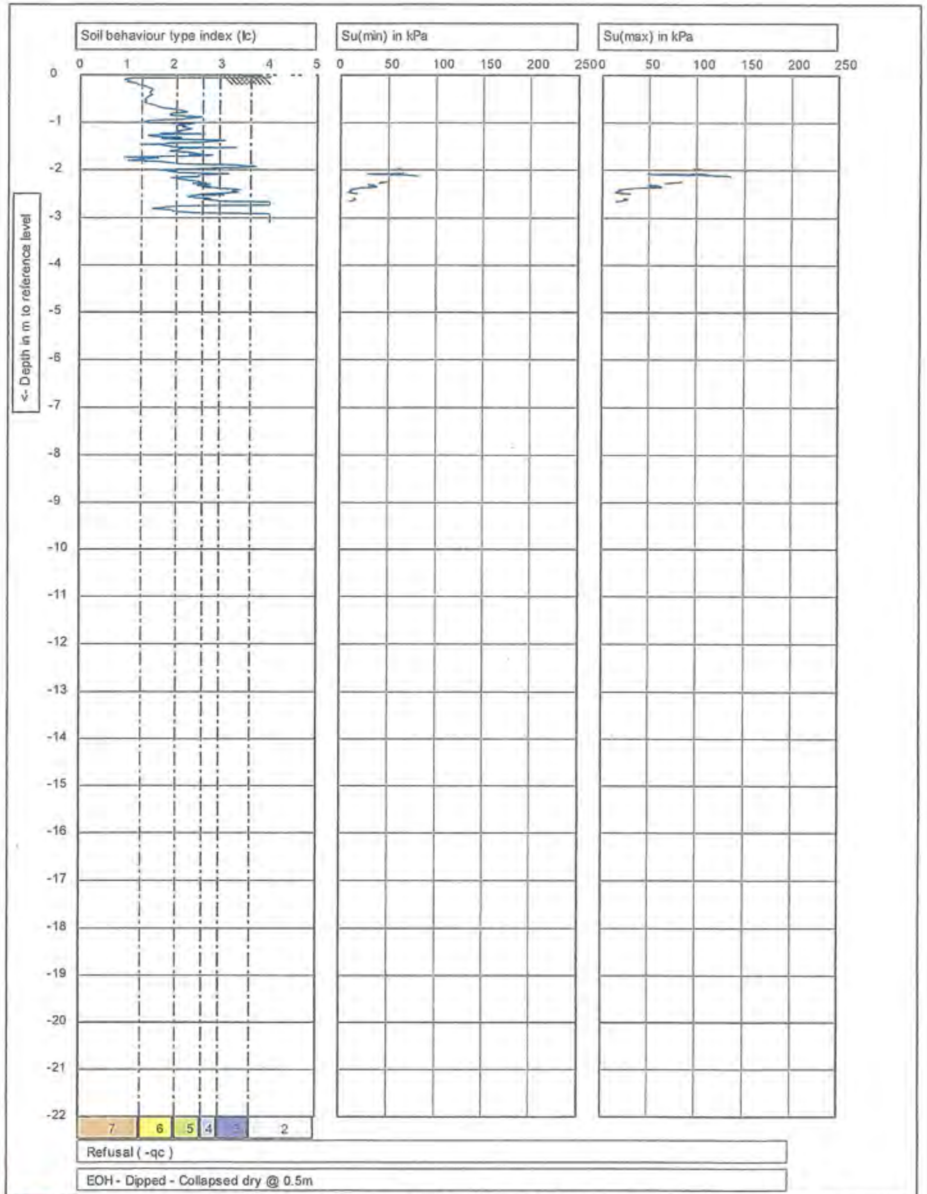
Graphs on this page are not IANZ accredited

Test according ASTM D5778-12 & ISO 22476-1:2012 | G.L. 0 MSL | W.L.: -0.5

Project: Cambridge
Location: 3838 Cambridge Rd
Position: 1815848, 5802242 NZTM

Predrill: 0 m Predrilled
Date: 2/04/2014
Cone no.: C10CFIIP.C12363.C12363
Project no.: 268291.14_001
CPT

CPT5 Fig. B-5D



OPUS

Graphs on this page are not IANZ accredited

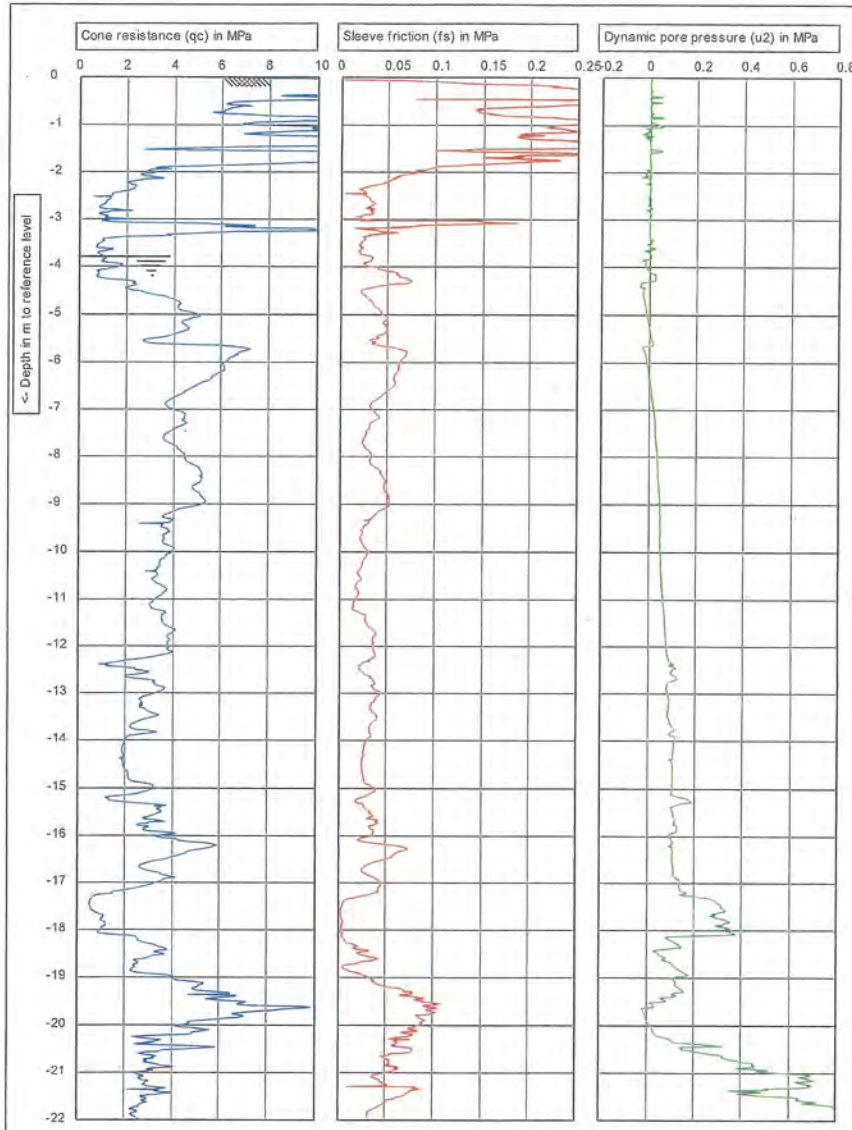
Test according ASTM D5778-12 & ISO 22476-1:2012 | G.L. 0 MSL | W.L.: -0.5

Project: Cambridge
Location: 3838 Cambridge Rd
Position: 1815848, 5802242 NZTM

Predrill: 0 m Predrilled
Date: 2/04/2014
Cone no.: C10CFIIP.C12363.C12363
Project no.: 268291.14_001
CPT

CPT5 Fig. B-5E

CPT No. 6

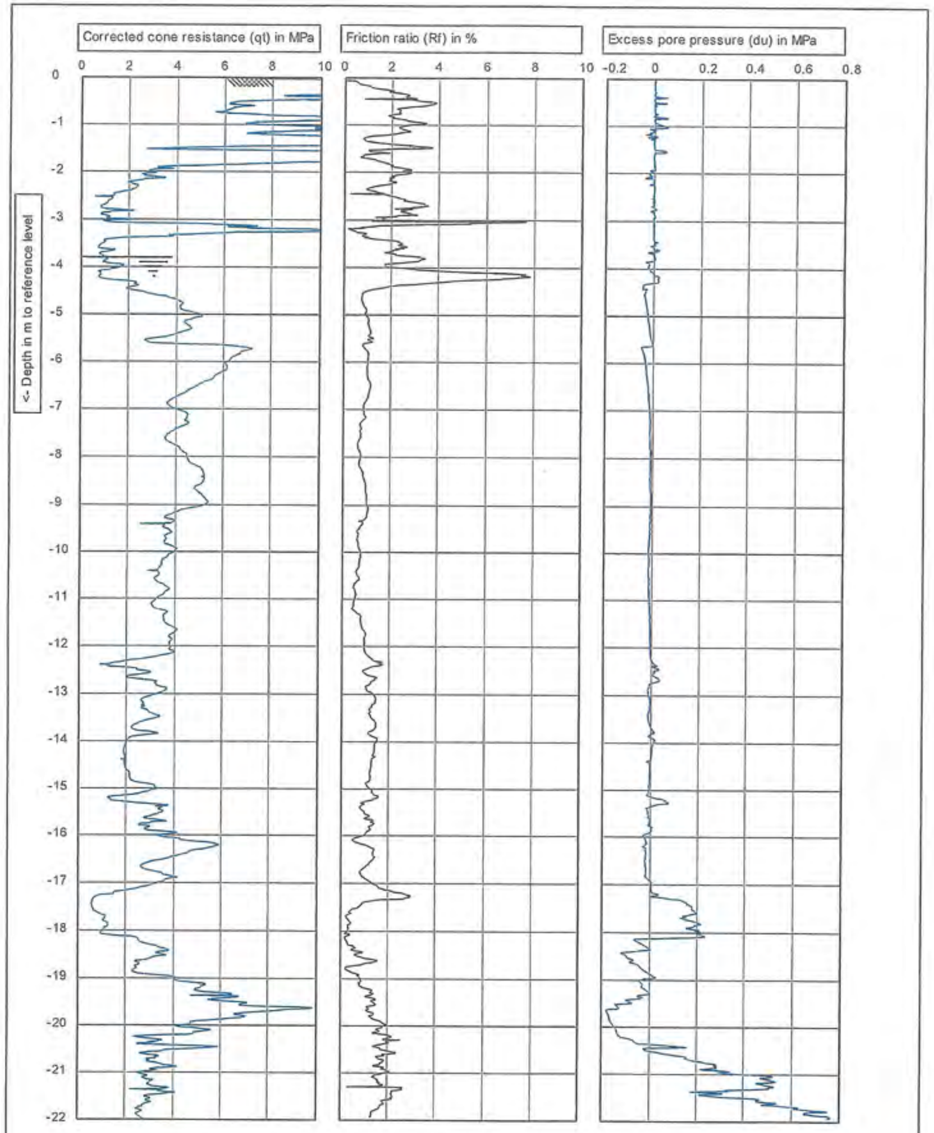


OPUS

IANZ ACCREDITED LABORATORY — Graphs indicated as not accredited are outside the scope of the laboratory's accreditation

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0 m Predrilled
G.L. 0 MSL	W.L.: -3.8	Date:	4/2/2014
Project:	Cambridge	Cone no.:	C10CFIIP.C12363.C12363
Location:	3838 Cambridge Rd	Project no.:	268291.14_001
Position:	1815878, 5802245 NZTM	CPT	

CPT6 Fig. B-6A

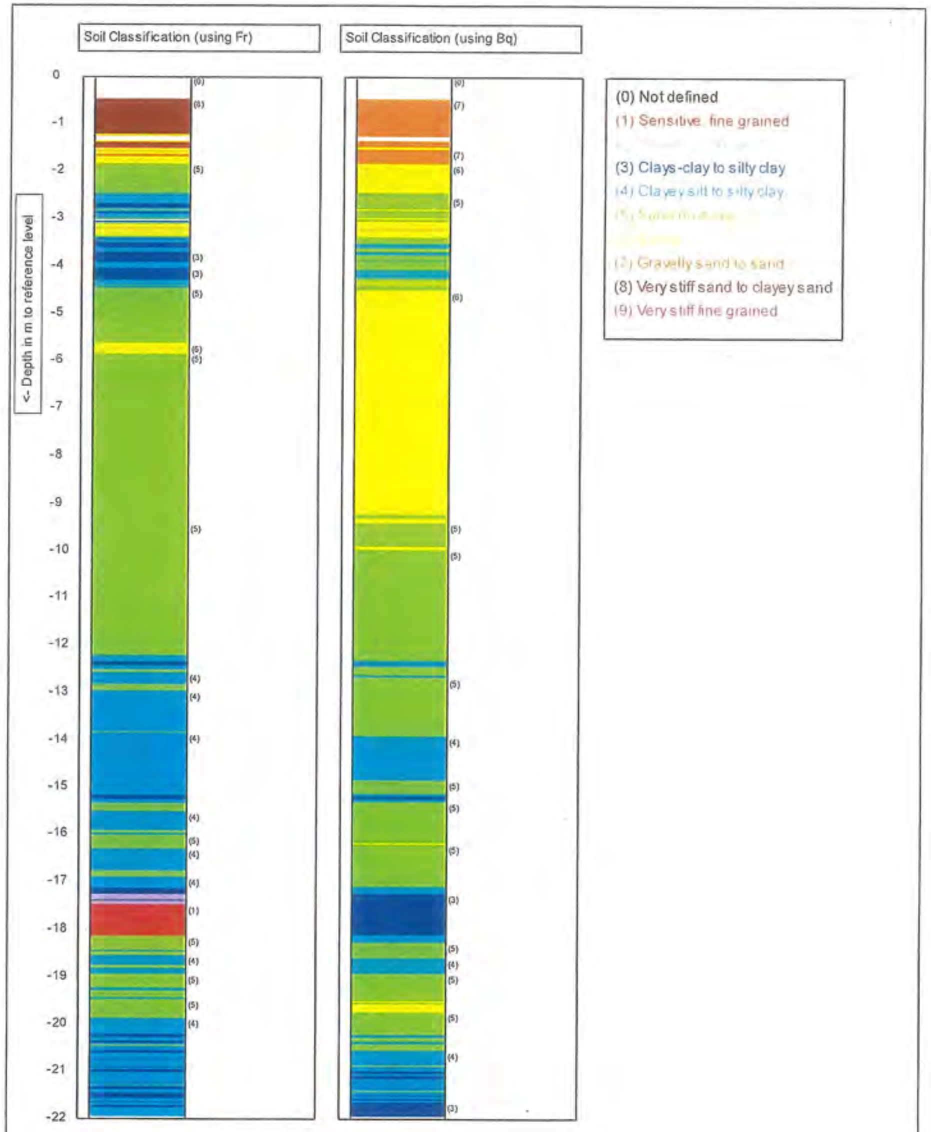


Graphs on this page are not IANZ accredited

OPUS

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill :	0 m Predrilled
G.L. 0 MSL	W.L.: -3.8	Date:	4/2/2014
Project: Cambridge		Cone no.:	C10CFIIP.C12363.C12363
Location: 3838 Cambridge Rd		Project no.:	268291.14_001
Position: 1815878, 5802245 NZTM		CPT	

CPT6 Fig. B-6B

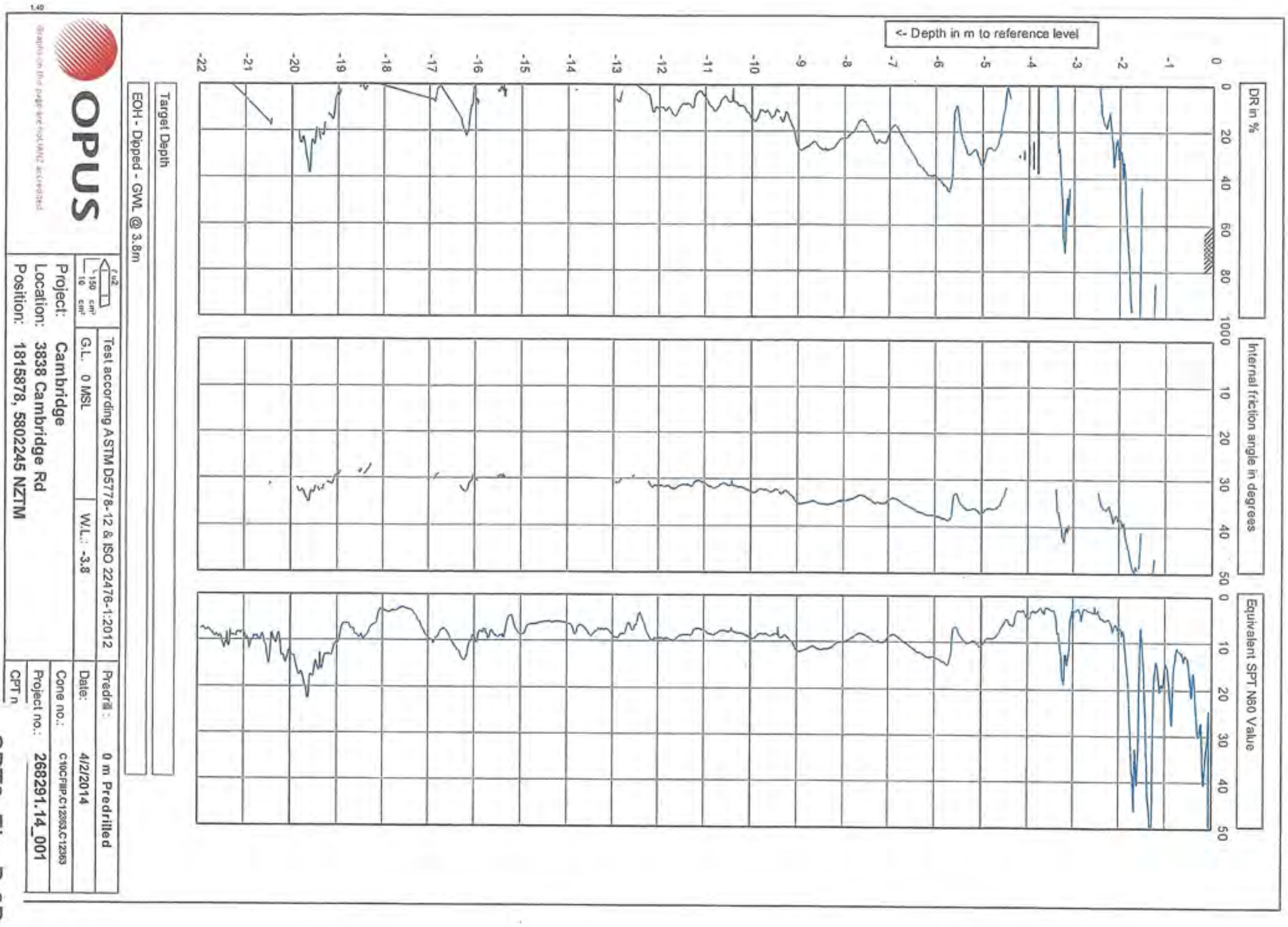


Graphs on this page are not IANZ accredited

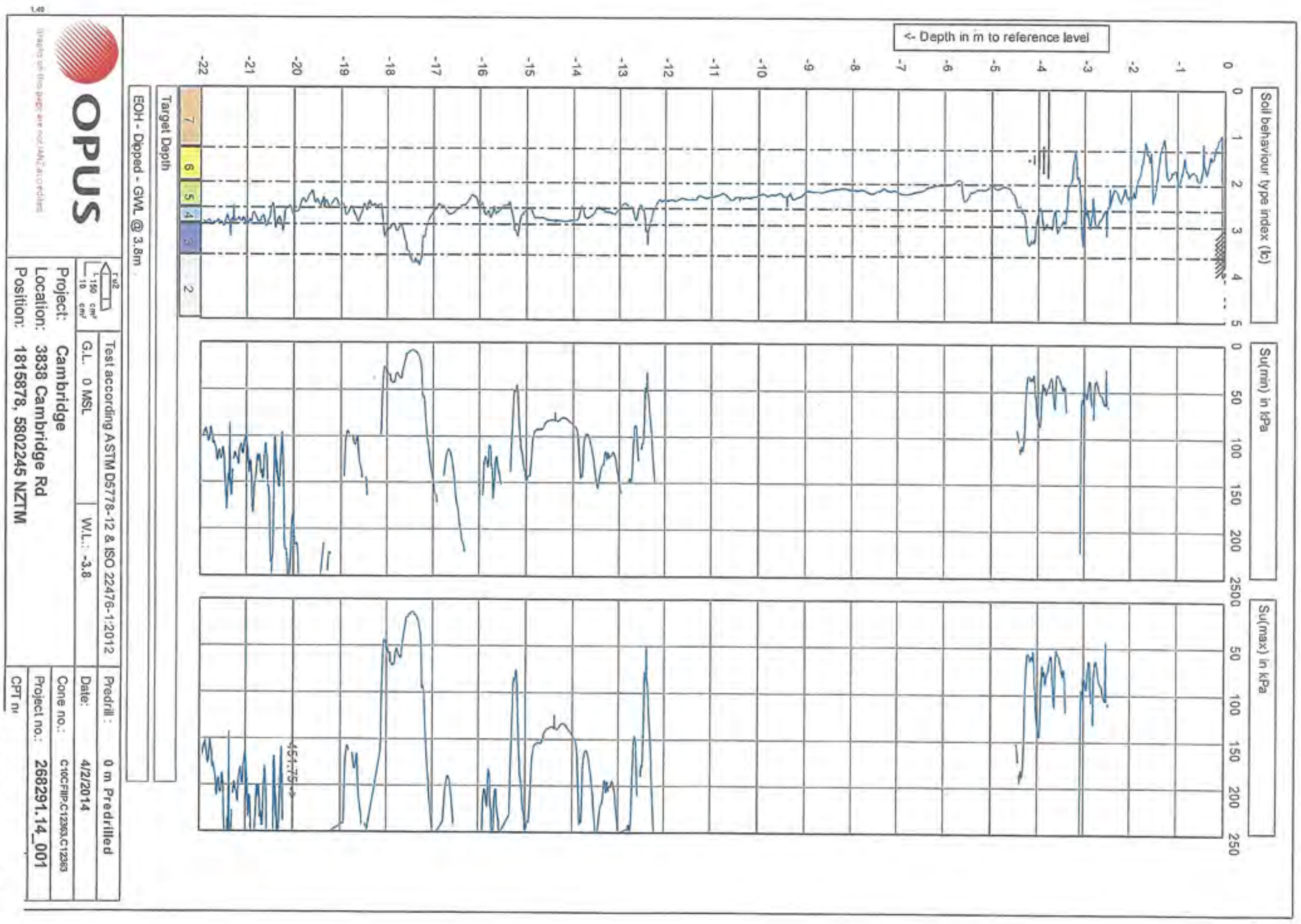
OPUS

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill :	0 m Predrilled
G.L. 0 MSL	W.L.: -3.8	Date:	4/2/2014
Project: Cambridge		Cone no.:	C10CFIIP.C12363.C12363
Location: 3838 Cambridge Rd		Project no.:	268291.14_001
Position: 1815878, 5802245 NZTM		CPT	

CPT6 Fig. B-6C

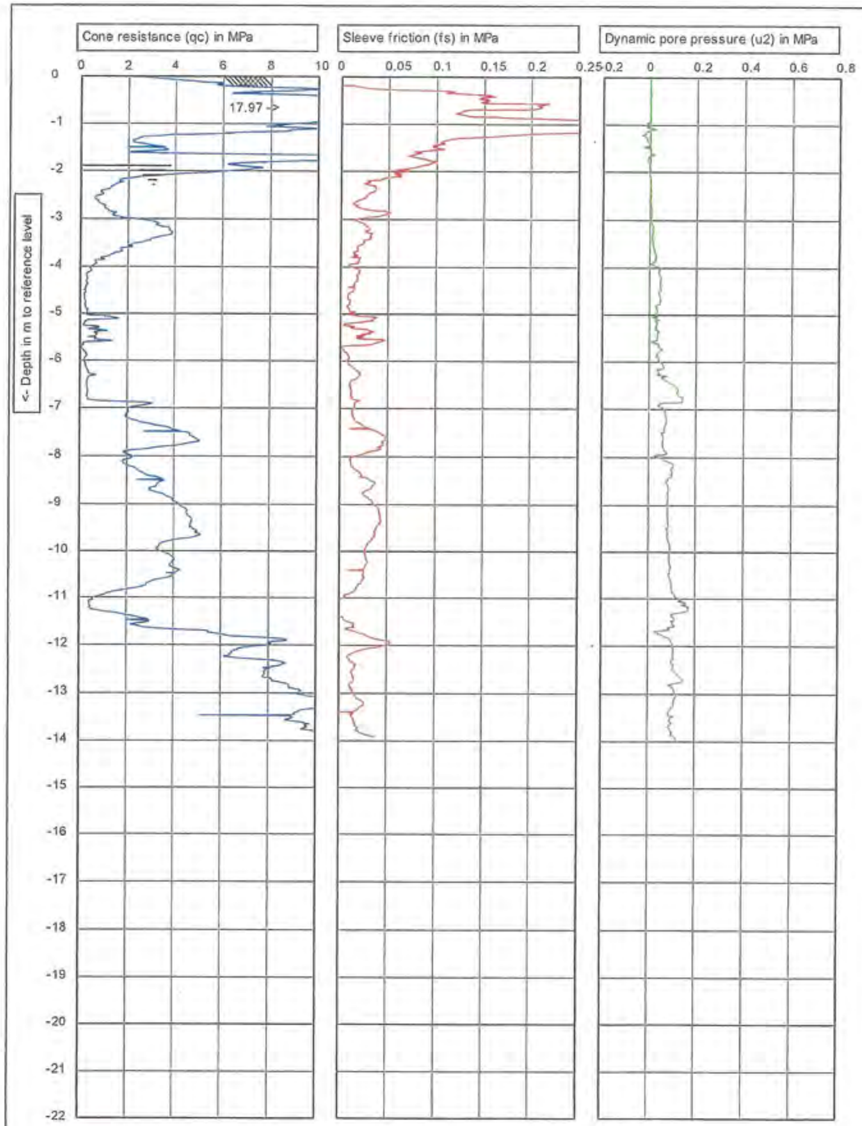


<- Depth in m to reference level
DR in %
Internal friction angle in degrees
Equivalent SPT N60 Value
Target Depth
EOH - Dipped - GWL @ 3.8m
OPUS
Test according ASTM D5778-12 & ISO 22476-1:2012
Predrill : 0 m Predrilled
G.L. 0 MSL
W.L.: -3.8
Date: 4/2/2014
Cone no.: C10CFIIP.C12363.C12363
Project: Cambridge
Location: 3838 Cambridge Rd
Position: 1815878, 5802245 NZTM
Project no.: 268291.14_001
CPT n
CPT6 Fig. B-6D



<- Depth in m to reference level
Soil behaviour type index (Ic)
Su(min) in kPa
Su(max) in kPa
Target Depth
EOH - Dipped - GWL @ 3.8m
OPUS
Test according ASTM D5778-12 & ISO 22476-1:2012
Predrill : 0 m Predrilled
G.L. 0 MSL
W.L.: -3.8
Date: 4/2/2014
Cone no.: C10CFIIP.C12363.C12363
Project: Cambridge
Location: 3838 Cambridge Rd
Position: 1815878, 5802245 NZTM
Project no.: 268291.14_001
CPT n
CPT6 Fig. B-6E

CPT No. 7



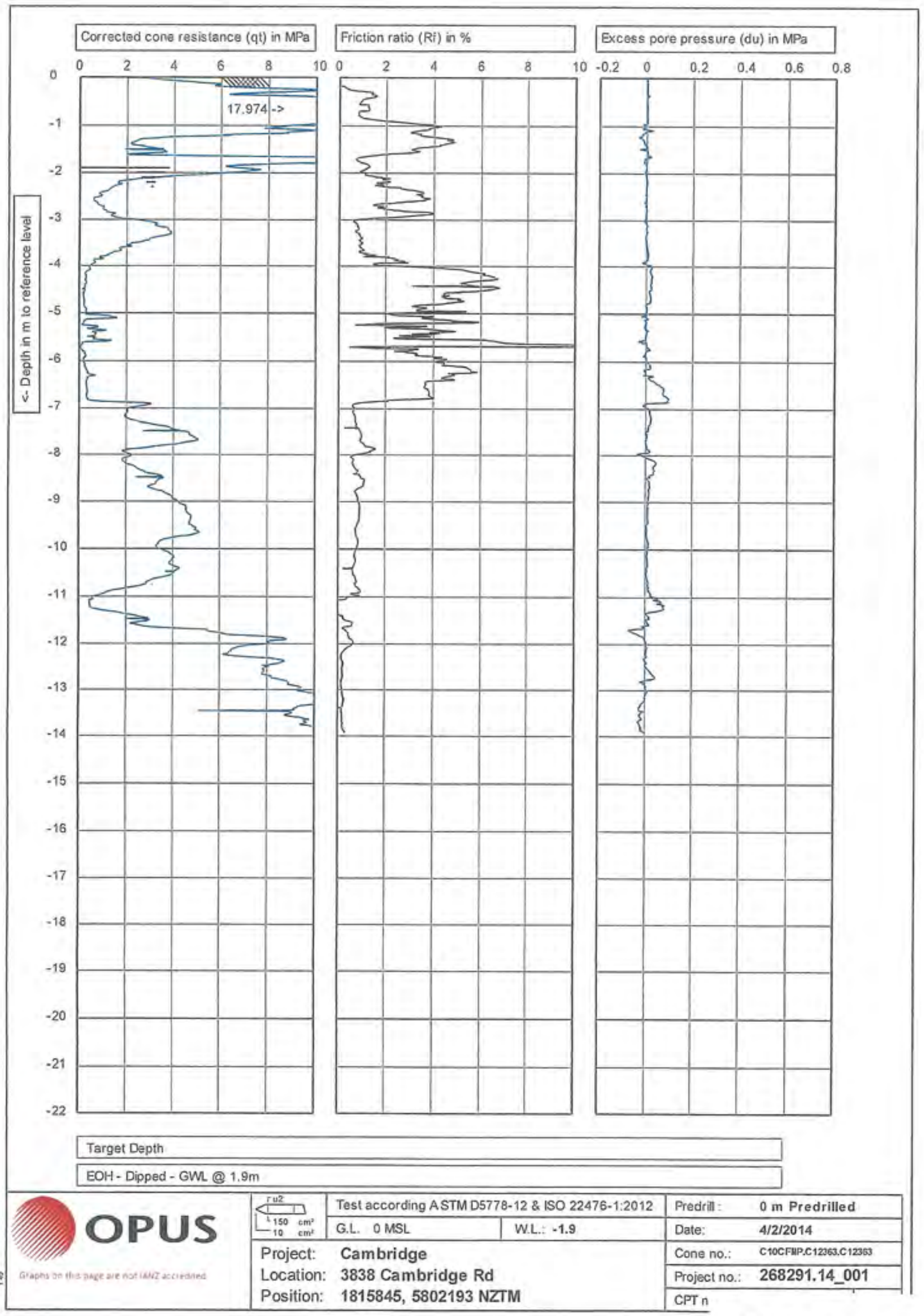
Target Depth

EOH - Dipped - GWL @ 1.9m

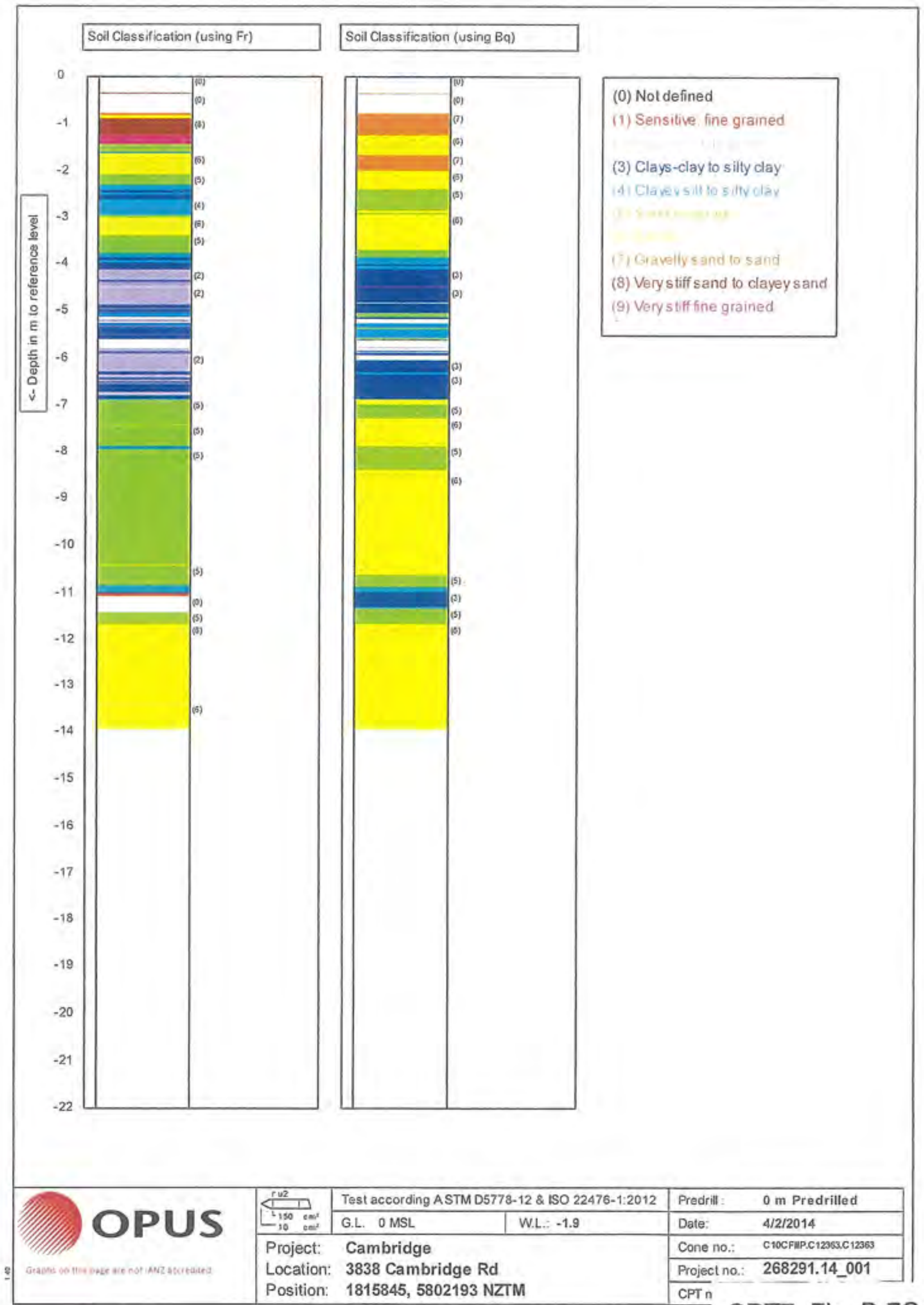
OPUS / IANZ ACCREDITED LABORATORY — Graphs indicated as not accredited are outside the scope of the laboratory's accreditation	Test according ASTM D5778-12 & ISO 22476-1:2012	Predrill :	0 m Predrilled
	G.L. 0 MSL W.L.: -1.9	Date:	4/2/2014
	Project: Cambridge	Cone no.:	C10CFIIP.C12363.C12363
	Location: 3838 Cambridge Rd	Project no.:	268291.14_001
	Position: 1815845, 5802193 NZTM	CPT no.:	

CPT7 Fig. B-7A

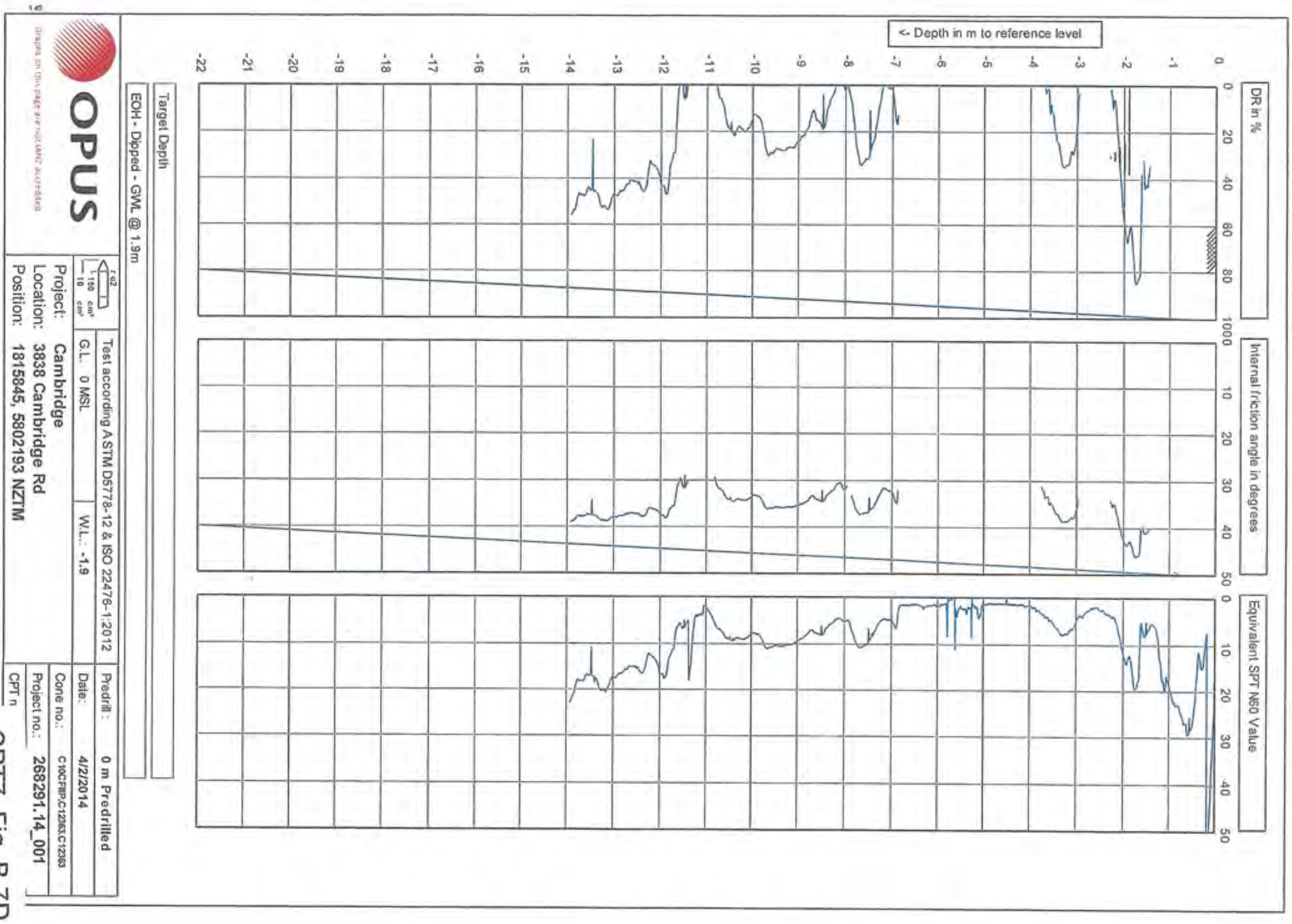
Director: Mark T Mitchell BE MS (Purdue) MIPENZ MASCE CPEng IntPE(NZ) Member ACENZ



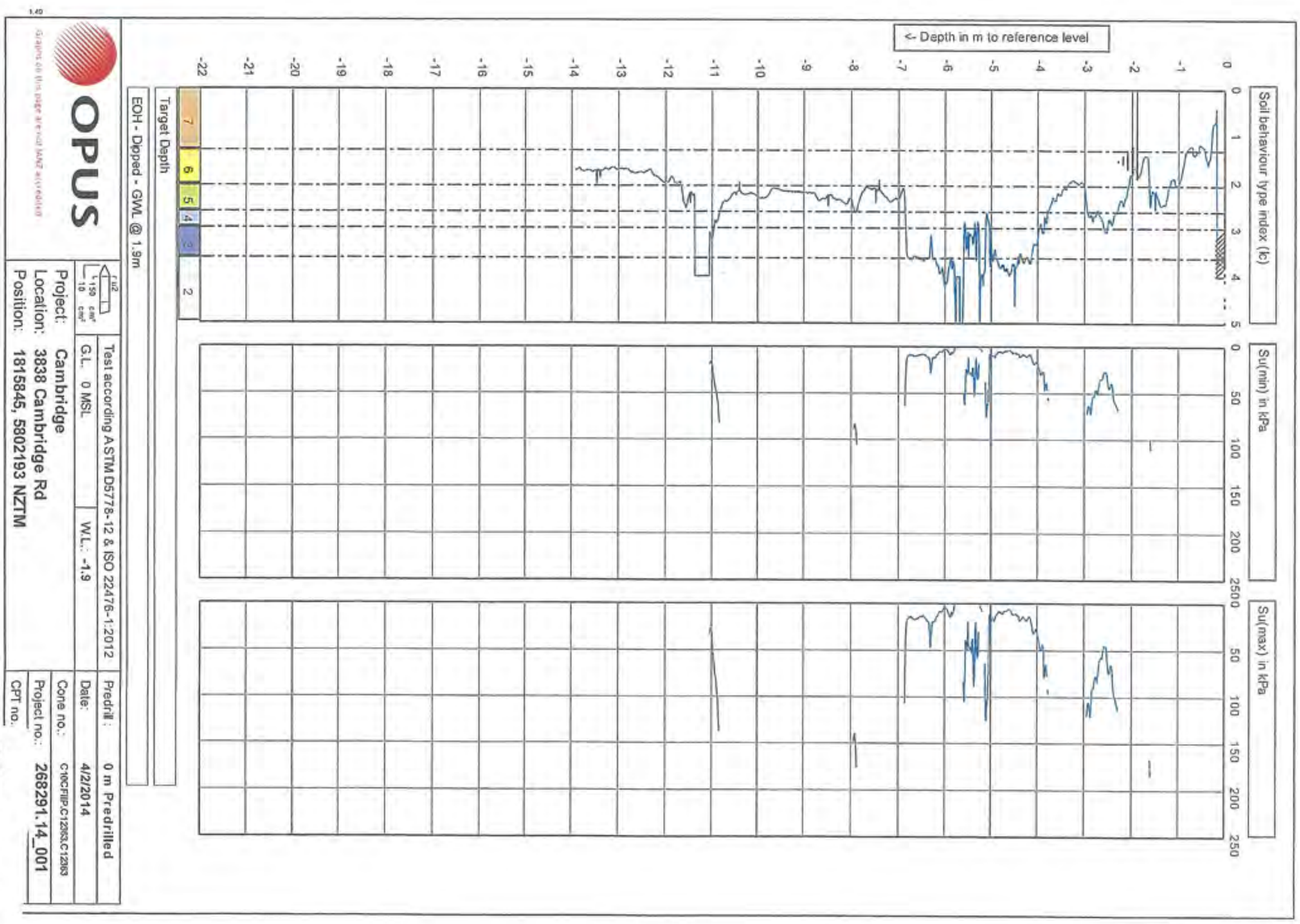
CPT7 Fig. B-7B



CPT7 Fig. B-7C

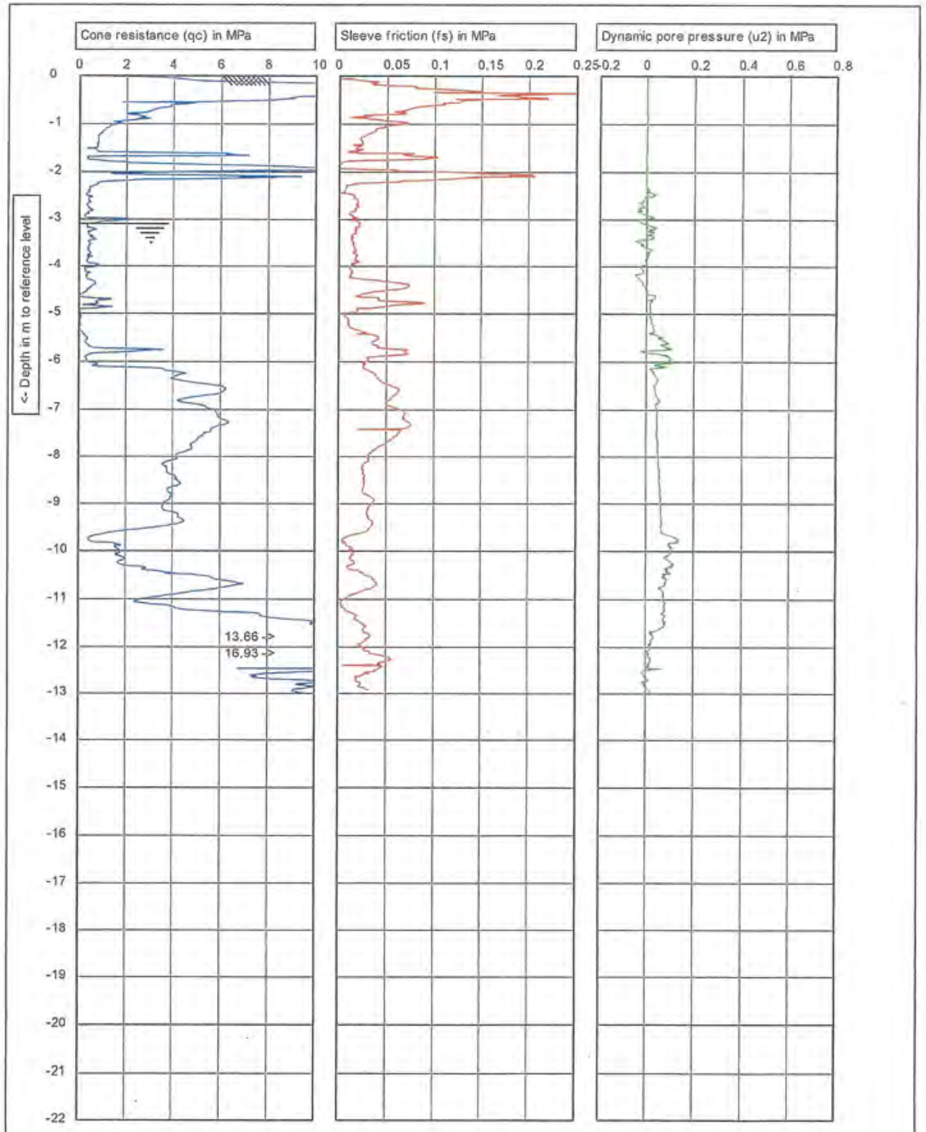


CPT7 Fig. B-7D



CPT7 Fig. B-7E

CPT No. 8



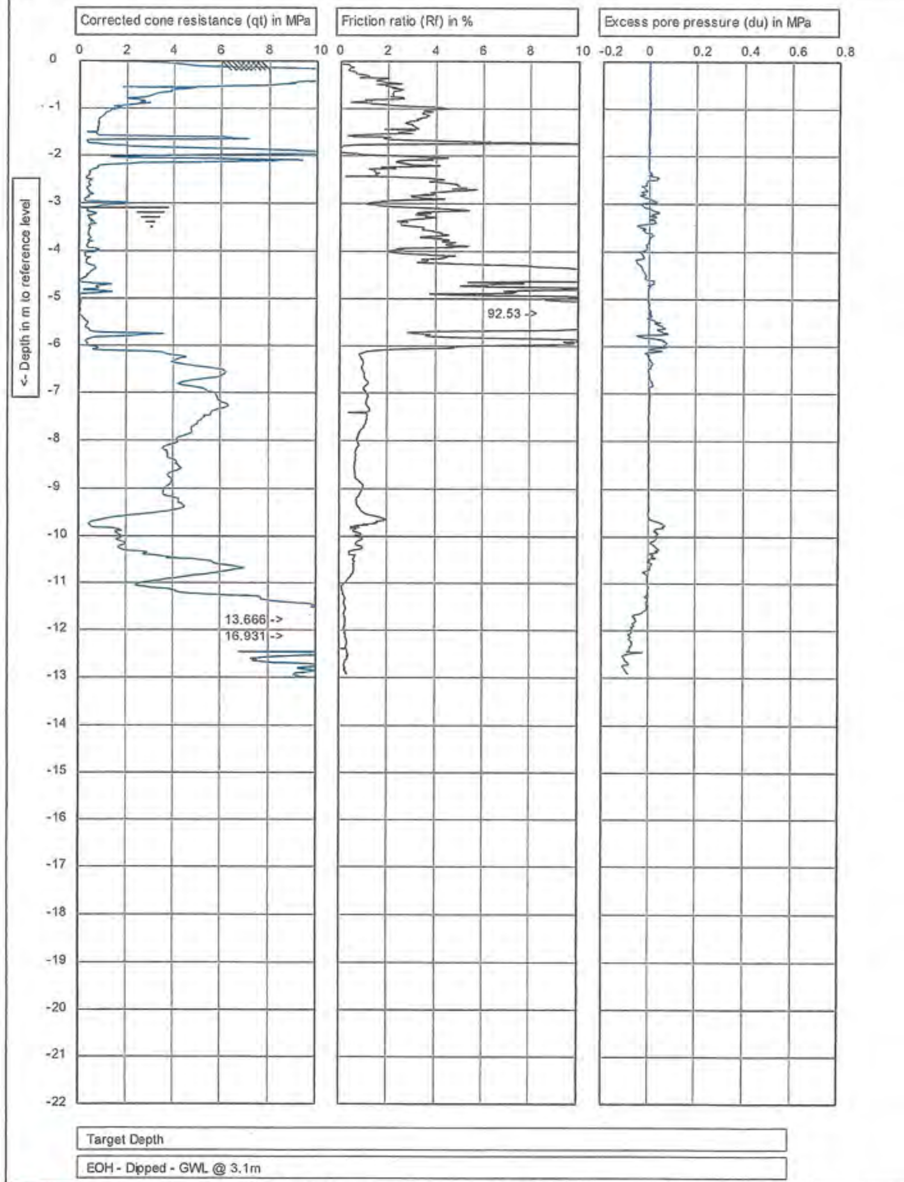
Target Depth

EOH - Dipped - GWL @ 3.1m

OPUS / IANZ Accredited Laboratory. Graphs indicated as not accredited are outside the scope of the laboratory's accreditation	Test according ASTM D5778-12 & ISO 22476-1:2012	Predrill :	0 m Predrilled
	G.L. 0 MSL W.L.: -3.1	Date:	4/2/2014
	Project: Cambridge	Cone no.:	C10CFIIP.C12363.C12363
	Location: 3838 Cambridge Rd	Project no.:	268291.14_001
	Position: 1815880, 5802197 NZTM	CPT no	

CPT8 Fig. B-8A

Director: Mark T Mitchell BE MS (Purdue) MIPENZ MASCE CPEng IntPE(NZ) Member ACENZ

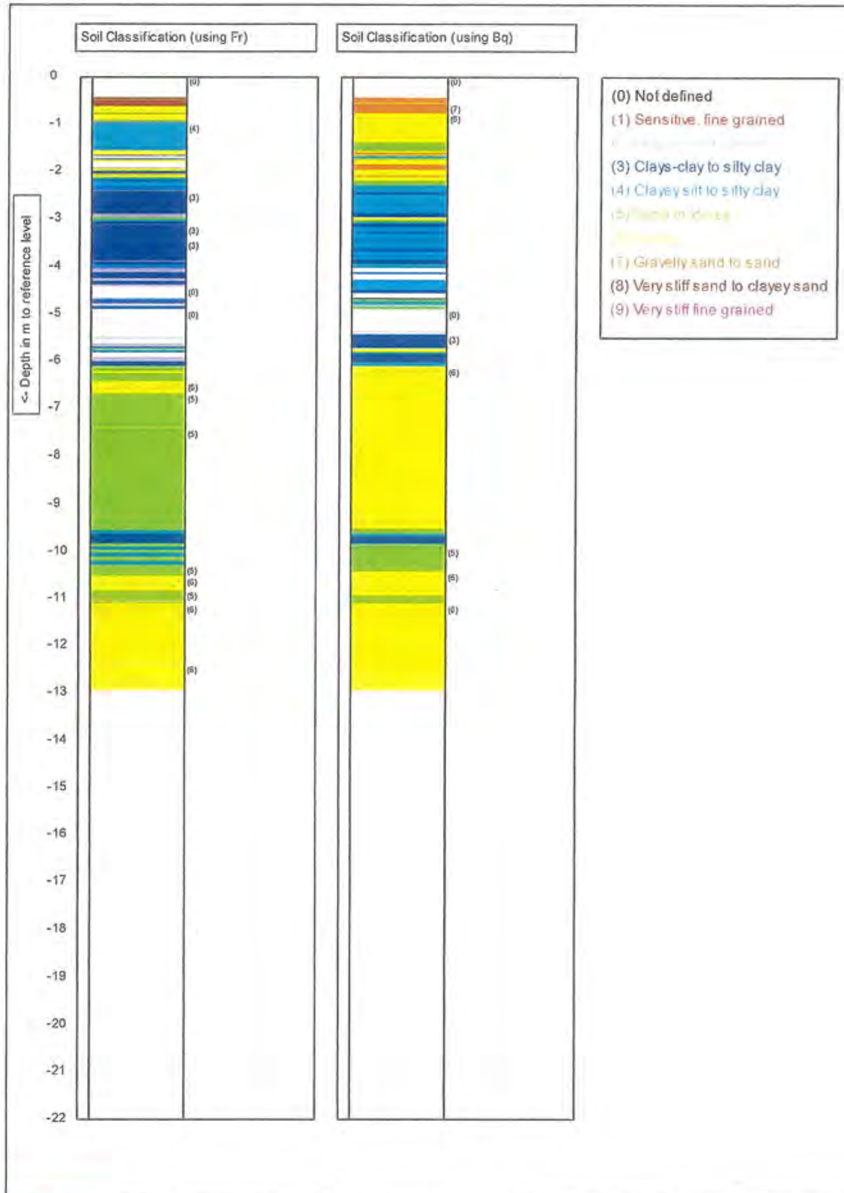


OPUS

Graphs on this page are not IANZ accredited

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill :	0 m Predrilled
G.L. 0 MSL	W.L.: -3.1	Date:	4/2/2014
Project:	Cambridge	Cone no.:	C10CFIIP.C12363.C12363
Location:	3838 Cambridge Rd	Project no.:	268291.14_001
Position:	1815880, 5802197 NZTM	CPT	

CPT8 Fig. B-8B

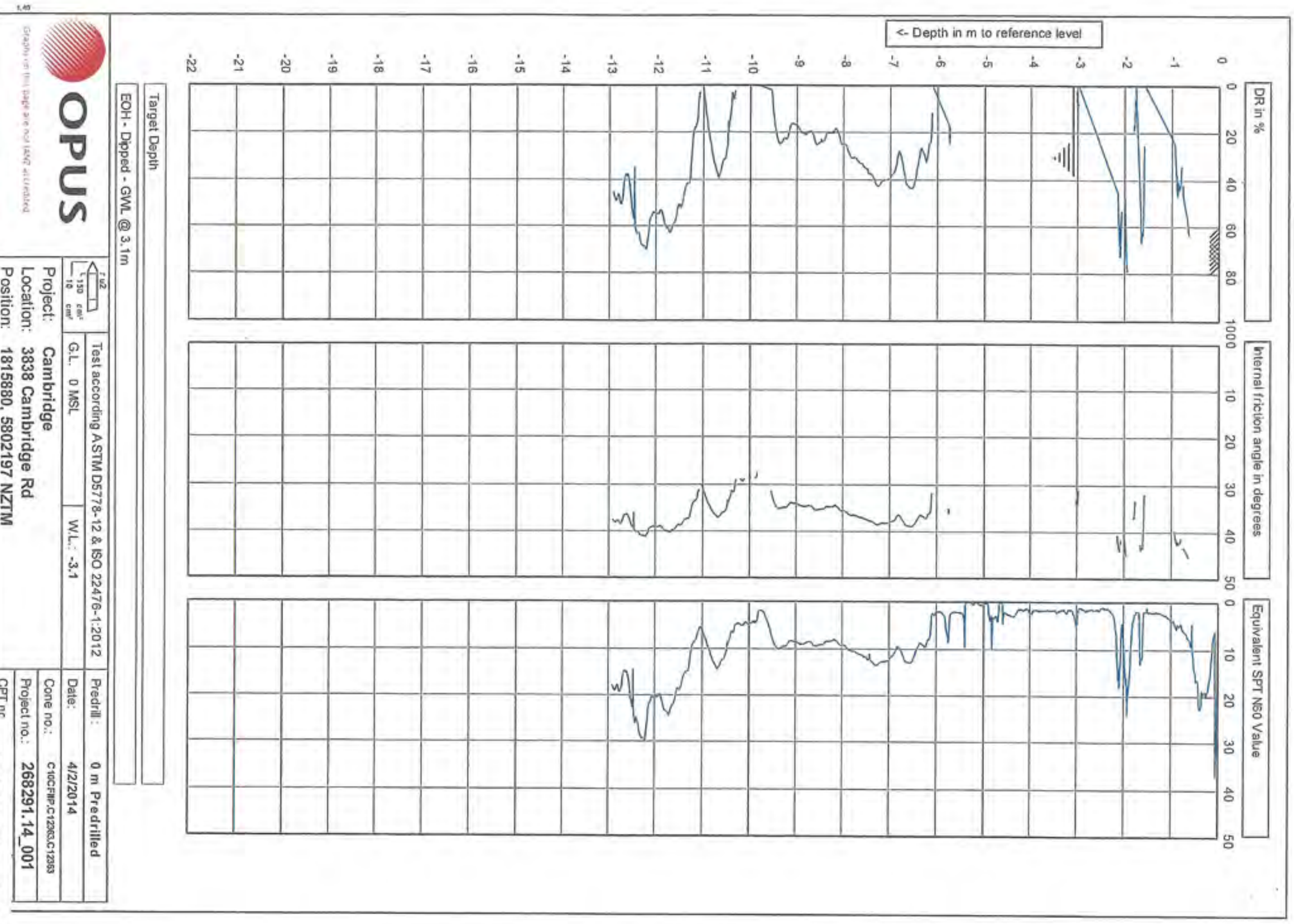


OPUS

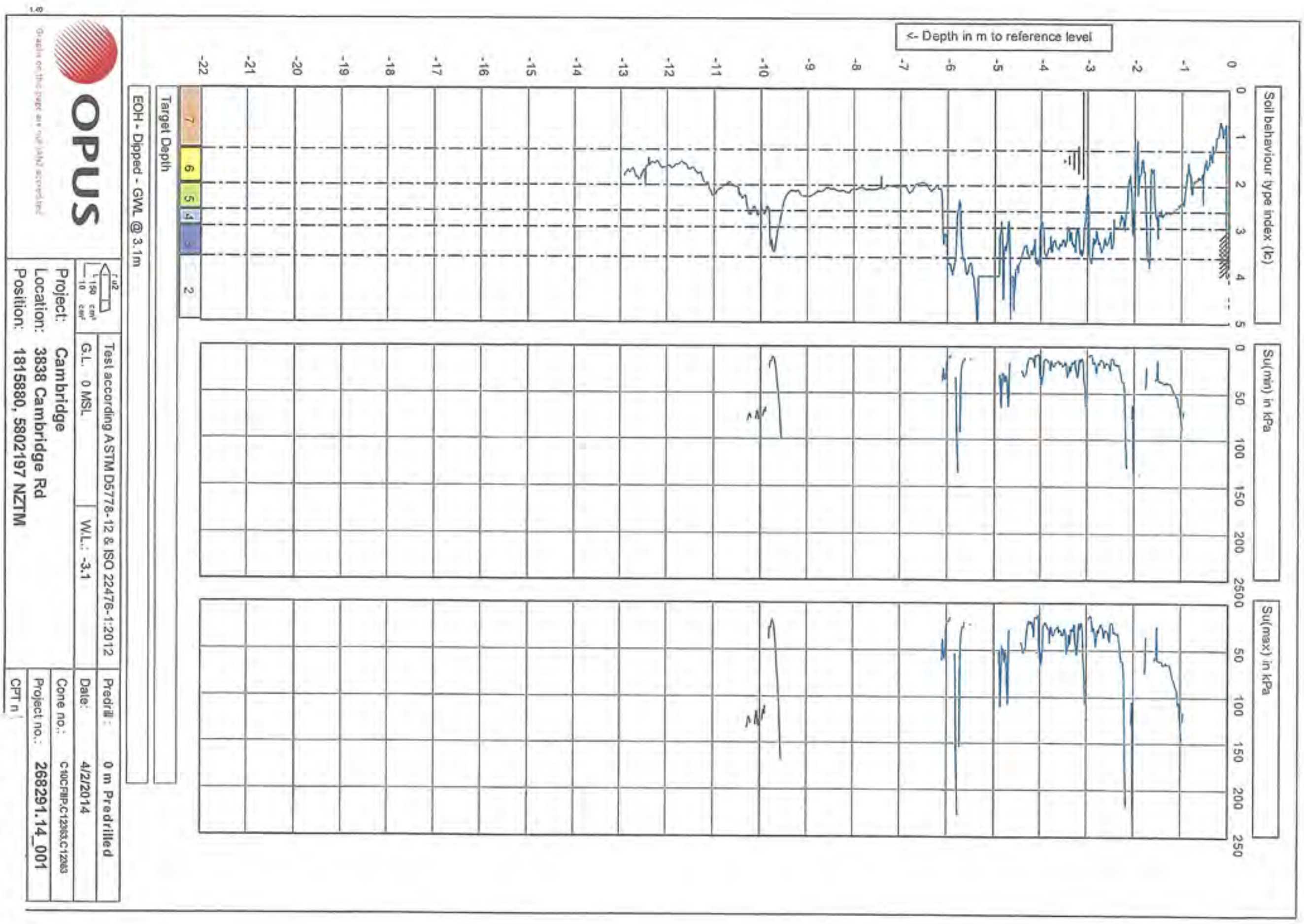
Graphs on this page are not IANZ accredited

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill :	0 m Predrilled
G.L. 0 MSL	W.L.: -3.1	Date:	4/2/2014
Project:	Cambridge	Cone no.:	C10CFBP.C12363.C12363
Location:	3838 Cambridge Rd	Project no.:	268291.14_001
Position:	1815880, 5802197 NZTM	CPT r	

CPT8 Fig. B-8C



CPT8 Fig. B-8D



CPT8 Fig. B-8E

APPENDIX A

Bore Hole Logs

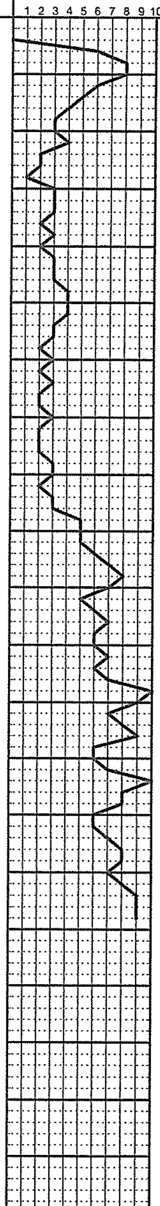
BORE HOLE LOG No. 1

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 23/04/14
RL (m): 42.7

Description	Depth (metres)	Geological Formation
FILLING: Mixture of Topsoil, Silt and Sand. Uncontrolled, moist, dark brown.	0 – ~0.2	Fill
fine SAND with minor silt. Loose to dense, dry, pumiceous, light yellowish brown. Becoming light grey & moist @ 3.3 metres.	~0.2 – ~4.3	Taupo Pumice Alluvium
fine SAND with trace silt. Medium dense to dense, moist, light greyish brown. Becoming light grey @ 6.5 metres. Contains fine pumice gravel from 7.2 metres.	~4.3 – 8	Taupo Pumice Alluvium
Bottom of Bore Hole completed 23/04/14	8	

VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)

SCALA PENETROMETER (blows/100mm)



PIEZOMETER / WATER LEVEL: Hole Collapse

NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

LOGGED BY: AP
PLOTTED BY: AP
DRILL METHOD: Machine Auger
DRILLER: JZ
LOCATION: refer Site Plan
CHECKED BY: [signature]
SHEET: 1 OF 1 Fig. No. A-1

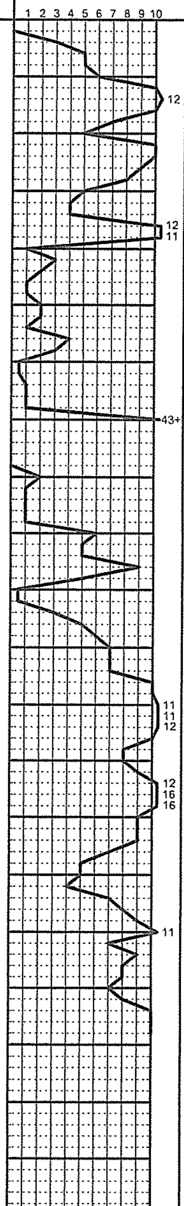
BORE HOLE LOG No. 2

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 23/04/14
RL (m): 44.2

Description	Depth (metres)	Geological Formation
TOPSOIL. Respread.	0 – ~0.2	T/S
FILLING: Mixture of Topsoil, Silts and Sands. Uncontrolled, moderate to high strength, moist, dark brown.	~0.2 – ~1.8	Filling
FILLING: Mixture of Topsoil, Wood Fibres, Silts and Sands. Uncontrolled, low to moderate strength, moist, dark brown and light grey.	~1.8 – ~3.4	Filling
FILLING: Mixture of Silt, Clay and Sand and Gravel. Uncontrolled, variable strength, wet, dark brown.	~3.4 – ~5.1	Filling
silty fine SAND. Medium dense becoming dense, saturated, dilatant, light brown.	~5.1 – ~6.9	Taupo Pumice Alluvium
fine SAND with some silt. Medium dense to dense, saturated, dilatant, grey.	~6.9 – 9	Taupo Pumice Alluvium
Bottom of Bore Hole completed 23/04/14	9	

VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)

SCALA PENETROMETER (blows/100mm)



PIEZOMETER / WATER LEVEL: Hole Collapse

NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

LOGGED BY: AP
PLOTTED BY: AP
DRILL METHOD: Machine Auger
DRILLER: JZ
LOCATION: refer Site Plan
CHECKED BY: [signature]
SHEET: 1 OF 1 Fig. No. A-2

BORE HOLE LOG No. 3

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 23/04/14
RL (m): 43.9

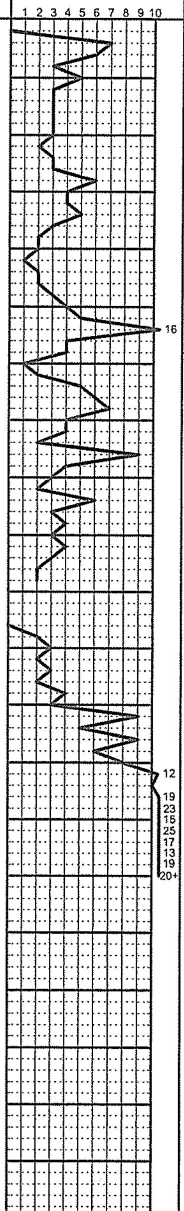
Description	Geological Formation
FILLING: Mixture of Topsoil and Silt. Uncontrolled, moist, brown.	Filling
FILLING: Mixture of Sand and Silt. Uncontrolled, poorly to moderately compacted, moist, light brown.	Filling
FILLING: Mixture of Silt, Topsoil, Sand and Gravel. Uncontrolled, low to moderate strength, moist, dark brown.	Filling
FILLING: Mixture of Sand and Silt. Uncontrolled, variable strength, wet, dark greenish grey.	Filling
FILLING: Mixture of Sand, Silt and Gravel. Uncontrolled, poorly to moderately compacted. wet, light yellowish brown.	Filling
fine SAND with some silt. Medium dense to very dense, saturated, dilatant, light grey. Becoming dark grey @ 6.2 metres. " greenish grey @ 6.6 metres. " dark greenish grey @ 6.7 metres.	Taupo Pumice Alluvium
fine SAND with some silt. Very dense, saturated, dilatant, light grey.	Taupo Pumice Alluvium
silty fine SAND. Saturated, dilatant, light yellowish brown.	Taupo Pumice Alluvium

Bottom of Bore Hole completed 23/04/14

DEPTH (metres): 1, 2, 3, 4, 5, 6, 7, 8, 9

VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)

SCALA PENETROMETER (blows/100mm)



PIEZOMETER / WATER LEVEL: After Drilling

NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

LOGGED BY: AP
PLOTTED BY: AP
DRILL METHOD: Machine Auger
DRILLER: JZ
LOCATION: refer Site Plan
CHECKED BY: [signature]
SHEET: 1 OF 1 Fig. No. A-3

BORE HOLE LOG No. 4

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 17/07/19
RL (m): 64.2

Description	Geological Formation
TOPSOIL.	TS
fine sandy SILT with trace clay. Soft to firm, moist, slightly plastic, light yellowish brown.	Loam
gravelly fine to coarse SAND. Medium dense, moist, light brown.	RA
gravelly fine to coarse SAND. Medium dense to dense, moist, brownish grey. Becoming grey @ 2.1 metres.	Hinuera Formation

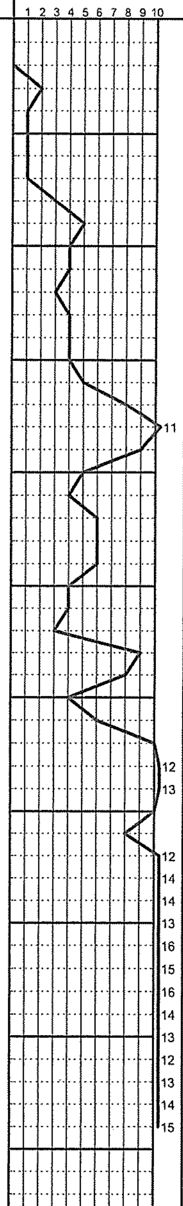
Could not retrieve sample

Bottom of Bore Hole completed 17/07/19

DEPTH (metres): 1, 2, 3, 4

VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)

SCALA PENETROMETER (blows/100mm)



PIEZOMETER / WATER LEVEL: No Groundwater

NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

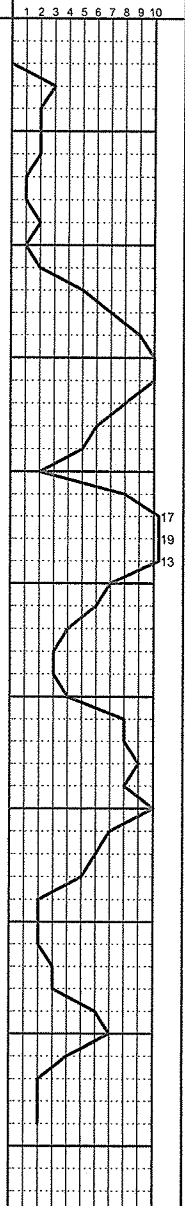
LOGGED BY: MMC
PLOTTED BY: MMC
DRILL METHOD: Machine Auger
DRILLER: PS
LOCATION: refer Site Plan
CHECKED BY: [signature]
SHEET: 1 OF 1 Fig. No. A-4

BORE HOLE LOG No. 5

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 17/07/19
RL (m): 63.5

GRAPHIC LOG / Description	DEPTH (metres)	GEOLOGICAL FORMATION	VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)	PIEZOMETER / WATER LEVEL
TOPSOIL.		TS		No Groundwater
fine sandy SILT with trace clay. Soft to stiff, moist, slightly plastic, light yellowish brown.		Loam		
silty fine SAND. Loose, moist, light brown.	1	RA		
gravelly fine to coarse SAND. Loose to very dense, moist, brownish grey.	2, 3	Hinuera Formation		
Bottom of Bore Hole completed 17/07/19	4			

SCALA PENETROMETER (blows/100mm)



NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

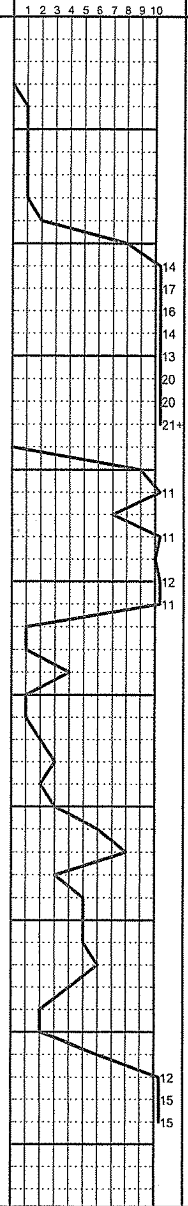
LOGGED BY:	MMC	DRILL METHOD:	Machine Auger
PLOTTED BY:	MMC	DRILLER:	PS
LOCATION:	refer Site Plan	CHECKED BY:	[signature]
SHEET:	1 OF 1	Fig. No.	A-5

BORE HOLE LOG No. 6

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 17/07/19
RL (m): 63.1

GRAPHIC LOG / Description	DEPTH (metres)	GEOLOGICAL FORMATION	VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)	PIEZOMETER / WATER LEVEL
TOPSOIL.		Topsoil		No Groundwater
fine sandy SILT with trace clay. Soft, moist, slightly plastic, light yellowish brown.		Loam		
silty fine SAND. Loose, moist, light brown.		RA		
gravelly fine to coarse SAND. Dense to very dense, moist, brownish grey.	1, 2	Hinuera Formation		
SILT. Soft to stiff, moist, slightly iron stained, slightly plastic, light grey.	3			
silty fine SAND. Medium dense to dense, moist, light grey.				
Bottom of Bore Hole completed 17/07/19	4			

SCALA PENETROMETER (blows/100mm)



NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

LOGGED BY:	MMC	DRILL METHOD:	Machine Auger
PLOTTED BY:	MMC	DRILLER:	PS
LOCATION:	refer Site Plan	CHECKED BY:	[signature]
SHEET:	1 OF 1	Fig. No.	A-6

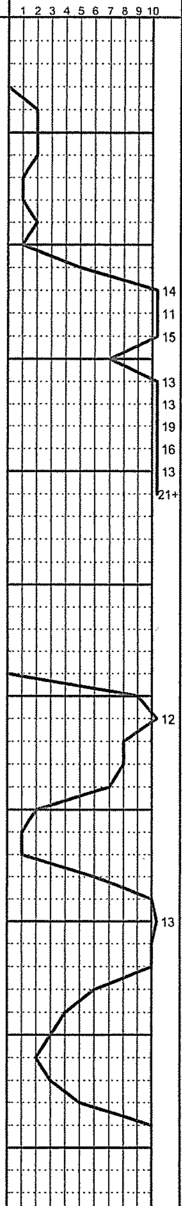
BORE HOLE LOG No. 7

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 15/07/19
RL (m): 63.1

SOIL DESCRIPTION	DEPTH (metres)	GEOLOGICAL FORMATION
TOPSOIL.		Topsoil
fine sandy SILT with trace clay. Soft to firm, moist, slightly plastic, light yellowish brown.		Loam
silty fine SAND. Loose to medium dense, moist to wet, light yellowish brown.	1	RA
gravelly fine to coarse SAND. Dense to very dense, moist, grey.	2, 3	Hinuera Formation
SILT with minor clay. Soft to stiff, moist, slightly iron stained, slightly plastic, light grey.		Hinuera Formation
silty fine SAND. Dense, moist, slightly iron stained, light grey.	4	Hinuera Formation
Bottom of Bore Hole completed 15/07/19		

VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)

SCALA PENETROMETER (blows/100mm)



PIEZOMETER / WATER LEVEL: No Groundwater

NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

LOGGED BY:	MMC	DRILL METHOD:	Machine Auger	LOCATION:	refer Site Plan
PLOTTED BY:	MMC	DRILLER:	PS	CHECKED BY:	[signature]

SHEET: 1 OF 1 Fig. No. A-7

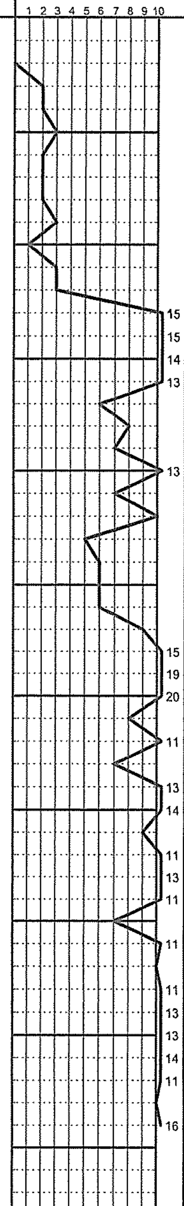
BORE HOLE LOG No. 8

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 15/07/19
RL (m): 63.5

SOIL DESCRIPTION	DEPTH (metres)	GEOLOGICAL FORMATION
TOPSOIL.		TS
fine sandy SILT. Soft to firm, moist, slightly plastic, light yellowish brown.		Loam
silty fine SAND. Loose to medium dense, moist, light brown.	1	RA
gravelly fine to coarse SAND. Medium dense to very dense, moist, light grey.	2, 3, 4	Hinuera Formation
Bottom of Bore Hole completed 15/07/19		

VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)

SCALA PENETROMETER (blows/100mm)



PIEZOMETER / WATER LEVEL: No Groundwater

NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

LOGGED BY:	MMC	DRILL METHOD:	Machine Auger	LOCATION:	refer Site Plan
PLOTTED BY:	MMC	DRILLER:	PS	CHECKED BY:	[signature]

SHEET: 1 OF 1 Fig. No. A-8

BORE HOLE LOG No. 9

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 15/07/19

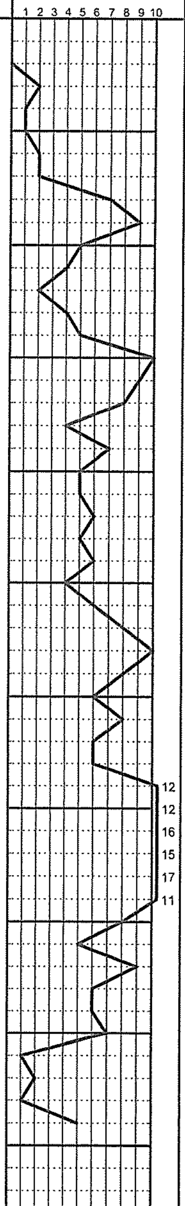
RL (m): 62.8

Description	Geological Formation
TOPSOIL.	TS
fine sandy SILT. Soft to firm, moist, slightly plastic, light yellowish brown.	Loam
gravelly fine to coarse SAND with some silt. Dense, moist, light yellowish brown.	RA
gravelly fine to coarse SAND. Loose to dense, moist, slightly iron stained, light greyish brown. " moderately iron stained @ 2.2 metres. " slightly iron stained and greyish brown @ 2.3 metres.	Hinuera Formation
Bottom of Bore Hole completed 15/07/19 (4 m)	

DEPTH (metres): 1, 2, 3, 4

VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)

SCALA PENETROMETER (blows/100mm)



PIEZOMETER / WATER LEVEL: No Groundwater

NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

LOGGED BY: MMC
PLOTTED BY: MMC
DRILL METHOD: Machine Auger
DRILLER: PS
LOCATION: refer Site Plan
CHECKED BY: [signature]
SHEET: 1 OF 1 Fig. No. A-9

BORE HOLE LOG No. 10

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 15/07/19

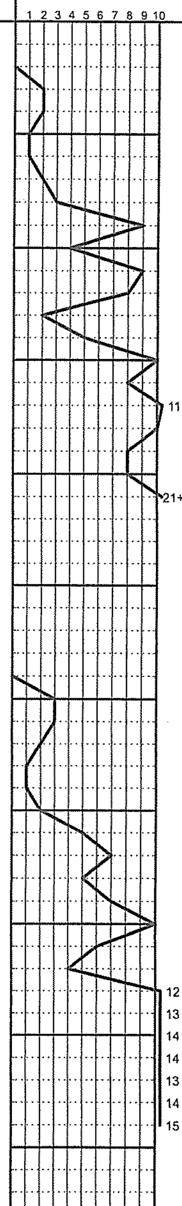
RL (m): 63.0

Description	Geological Formation
TOPSOIL.	TS
fine sandy SILT. Soft to firm, moist, slightly plastic, light yellowish brown.	Loam
gravelly fine to coarse SAND with trace silt. Loose to medium dense, moist, light brown.	RA
gravelly fine to coarse SAND. Medium dense to dense, moist, greyish brown. Becoming loose from 1.2 to 1.3 metres. " dense to very dense @ 1.5 metres.	Hinuera Formation
silty fine SAND. Loose to medium dense, moist, slightly iron stained, light grey.	Hinuera Formation
SILT with trace clay. Soft to firm, moist, slightly iron stained, slightly plastic, light grey.	Hinuera Formation
silty fine SAND. Medium dense to dense, moist, slightly iron stained, light grey.	Hinuera Formation
Bottom of Bore Hole completed 15/07/19 (4 m)	

DEPTH (metres): 1, 2, 3, 4

VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)

SCALA PENETROMETER (blows/100mm)



PIEZOMETER / WATER LEVEL: No Groundwater

NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

LOGGED BY: MMC
PLOTTED BY: MMC
DRILL METHOD: Machine Auger
DRILLER: PS
LOCATION: refer Site Plan
CHECKED BY: [signature]
SHEET: 1 OF 1 Fig. No. A-10

BORE HOLE LOG No. 11

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 15/07/19
RL (m): 64.0

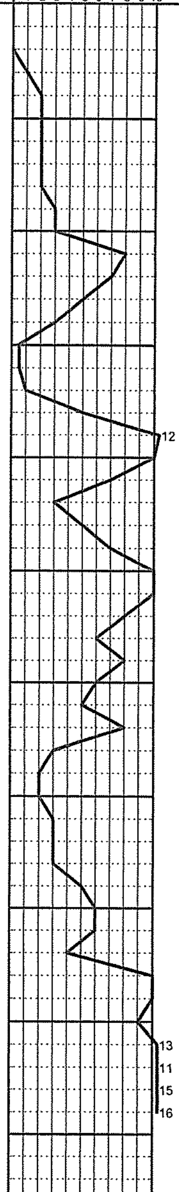
Description	Geological Formation
TOPSOIL.	TS
fine sandy SILT. Soft to firm, moist, slightly plastic, light yellowish brown.	Loam
silty fine to coarse SAND with some fine gravel. Loose to medium dense, moist, light yellowish brown.	RA
gravelly fine to coarse SAND. Very loose to dense, moist, brown. Becoming light grey @ 2.5 metres.	Hinuera Formation
SILT. Firm to stiff, moist, slightly iron stained, slightly plastic, light grey.	Hinuera Formation

Bottom of Bore Hole completed 15/07/19

DEPTH (metres): 1, 2, 3, 4

VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)

SCALA PENETROMETER (blows/100mm)



PIEZOMETER / WATER LEVEL: No Groundwater

NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

LOGGED BY:	MMC	DRILL METHOD:	Machine Auger
PLOTTED BY:	MMC	DRILLER:	PS
LOCATION:	refer Site Plan	CHECKED BY:	[signature]

SHEET: 1 OF 1 Fig. No. A-11

BORE HOLE LOG No. 12

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 15/07/19
RL (m): 63.9

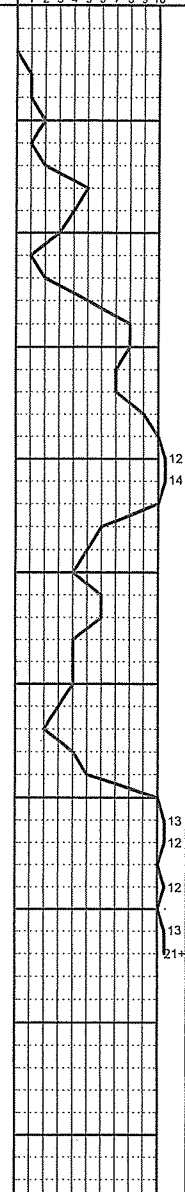
Description	Geological Formation
TOPSOIL.	TS
fine sandy SILT with trace clay. Soft to stiff, moist, slightly plastic, light yellowish brown.	Loam
gravelly fine to coarse SAND. Loose to medium dense, moist, light brown.	RA
gravelly fine to coarse SAND. Loose to dense, moist, light greyish brown. Becoming light grey @ 2.5 metres.	Hinuera Formation

Bottom of Bore Hole completed 15/07/19

DEPTH (metres): 1, 2, 3, 4

VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)

SCALA PENETROMETER (blows/100mm)



PIEZOMETER / WATER LEVEL: No Groundwater

NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

LOGGED BY:	MMC	DRILL METHOD:	Machine Auger
PLOTTED BY:	PS	DRILLER:	PS
LOCATION:	refer Site Plan	CHECKED BY:	[signature]

SHEET: 1 OF 1 Fig. No. A-12

BORE HOLE LOG No. 13

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 12/07/19
RL (m): 63.7

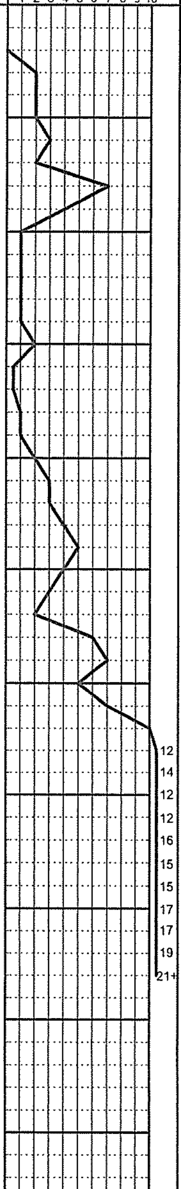
Description	Geological Formation
TOPSOIL.	TS
FILLING: Mixture of Silt, Sand and Charcoal. Uncontrolled, variable strength, moist, dark brown.	Filling
FILLING: Mixture of Silt, Sand, Clay and Gravel. Low strength, moist, slightly plastic, light yellowish brown.	Filling
fine to coarse SAND with minor fine gravel. Loose to very dense, moist, light greyish brown. Becoming grey @ 3.1 metres.	Hinuera Formation

Bottom of Bore Hole completed 12/07/19

DEPTH (metres): 1, 2, 3, 4

VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)

SCALA PENETROMETER (blows/100mm)



PIEZOMETER / WATER LEVEL: No Groundwater

NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

LOGGED BY: MMC
PLOTTED BY: PS
DRILL METHOD: Machine Auger
DRILLER: PS
LOCATION: refer Site Plan
CHECKED BY: SW
SHEET: 1 OF 1 Fig. No. A-13

BORE HOLE LOG No. 14

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 12/07/19
RL (m): 64.0

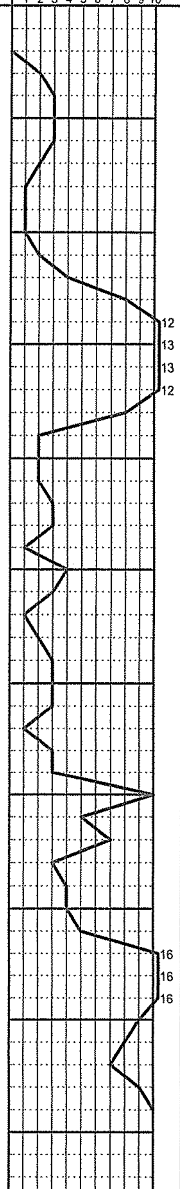
Description	Geological Formation
TOPSOIL.	TS
fine sandy SILT. Soft to firm, moist, slightly plastic, light yellowish brown.	Loam
gravelly fine to coarse SAND. Loose, moist, highly iron stained, orangey brown.	Recent Alluvium
gravelly fine to coarse SAND. Dense, moist, grey.	Hinuera Formation
silty fine SAND. Loose to medium dense, moist, slightly iron stained, light grey.	Hinuera Formation
SILT with trace clay. Soft to stiff, moist, slightly iron stained, slightly plastic, light grey. Becoming moderately iron stained @ 2.9 metres.	Hinuera Formation
silty fine SAND. Medium dense to dense, moist, slightly iron stained, light grey.	Hinuera Formation

Bottom of Bore Hole completed 12/07/19

DEPTH (metres): 1, 2, 3, 4

VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)

SCALA PENETROMETER (blows/100mm)



PIEZOMETER / WATER LEVEL: No Groundwater

NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

LOGGED BY: MMC
PLOTTED BY: MMC
DRILL METHOD: Machine Auger
DRILLER: PS
LOCATION: refer Site Plan
CHECKED BY: SW
SHEET: 1 OF 1 Fig. No. A-14

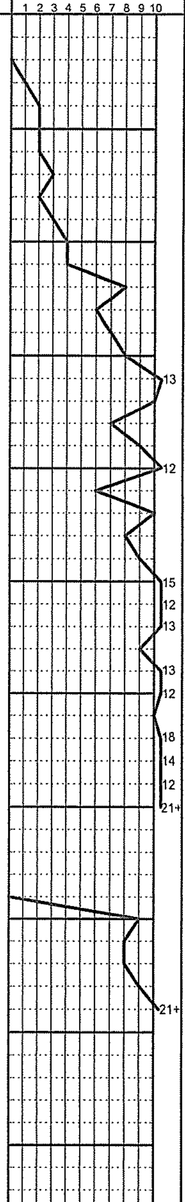
BORE HOLE LOG No. 15

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 15/07/19
RL (m): 64.5

Description	Depth (metres)	Geological Formation
TOPSOIL.		TS
fine sandy SILT. Soft to firm, moist, slightly plastic, light yellowish brown.		Loam
gravelly fine to coarse SAND. Loose to medium dense, moist, light brown. Becoming moderately iron stained @ 0.9 metres.	1	RA
gravelly fine to coarse SAND. Medium dense to very dense, moist, light brown. Becoming grey @ 2.0 metres.	2, 3	Hinuera Formation
Bottom of Bore Hole completed 15/07/19	4	

VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)

SCALA PENETROMETER (blows/100mm)



PIEZOMETER / WATER LEVEL: No Groundwater

NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

LOGGED BY: MMC
PLOTTED BY: PS
DRILL METHOD: Machine Auger
DRILLER: PS
LOCATION: refer Site Plan
CHECKED BY: [signature]
SHEET: 1 OF 1 Fig. No. A-15

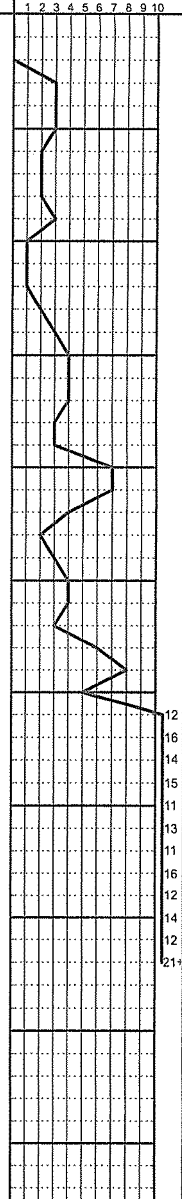
BORE HOLE LOG No. 16

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 15/07/19
RL (m): 65.1

Description	Depth (metres)	Geological Formation
TOPSOIL.		T/S
SILT with minor sand and clay. Firm to stiff, moist, light yellowish brown.		Loam
gravelly fine to coarse SAND. Loose to medium dense, moist, light brown. Becoming moderately iron stained @1.2 metres.	1	RA
gravelly fine to coarse SAND. Loose to dense, moist, light greyish brown. Becoming light grey @ 2.1 metres.	2, 3	Hinuera Formation
Bottom of Bore Hole completed 15/07/19	4	

VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)

SCALA PENETROMETER (blows/100mm)



PIEZOMETER / WATER LEVEL: No Groundwater

NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

LOGGED BY: MMC
PLOTTED BY: PS
DRILL METHOD: Machine Auger
DRILLER: PS
LOCATION: refer Site Plan
CHECKED BY: [signature]
SHEET: 1 OF 1 Fig. No. A-16

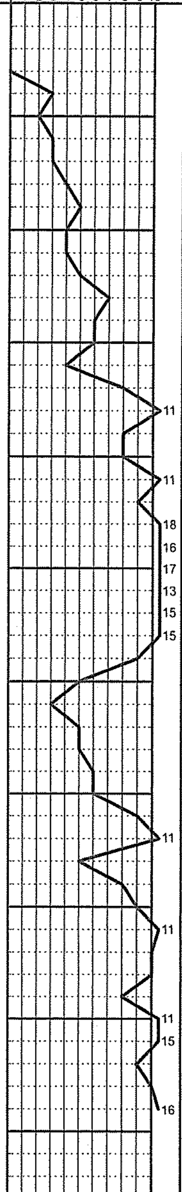
BORE HOLE LOG No. 17

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 12/07/19

RL (m): 66.3

Depth (metres)	Description	Geological Formation	Vane Shear Strength - kPa (In-situ/Remoulded)	Piezometer / Water Level
0 – ~0.3	TOPSOIL.	T/S		No Groundwater
~0.3 – ~0.8	fine sandy SILT. Firm to stiff, moist, slightly plastic, light yellowish brown.	Loam		
~0.8 – 1.0	gravelly fine to coarse SAND. Medium dense, moist, light yellowish brown.	RA		
1.0 – 4.0	gravelly fine to coarse SAND. Medium dense to very dense, moist, light greyish brown. Becoming light grey @ 3.5 metres.	Hinuera Formation		
4.0	Bottom of Bore Hole completed 12/07/19			

SCALA PENETROMETER (blows/100mm)



NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

LOGGED BY: MMC
PLOTTED BY: PS
DRILL METHOD: Machine Auger
DRILLER: PS
LOCATION: refer Site Plan
CHECKED BY: [signature]
SHEET: 1 OF 1 Fig. No. A-17

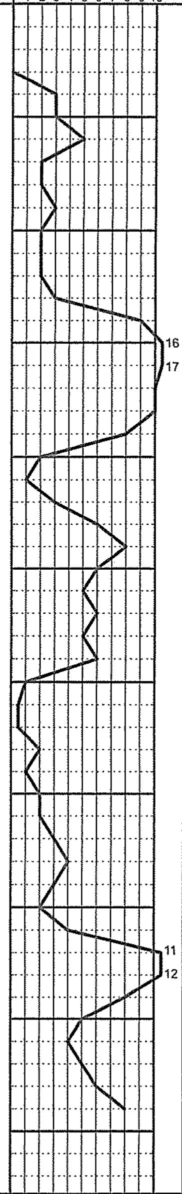
BORE HOLE LOG No. 18

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 15/07/19

RL (m): 63.9

Depth (metres)	Description	Geological Formation	Vane Shear Strength - kPa (In-situ/Remoulded)	Piezometer / Water Level
0 – ~0.3	TOPSOIL.	T/S		No Groundwater
~0.3 – ~0.8	fine sandy SILT with trace clay. Firm to stiff, moist, slightly plastic, light yellowish brown.	Loam		
~0.8 – ~1.3	silty fine to coarse SAND with minor fine to coarse gravel. Loose to medium dense, moist, light greyish brown.	RA		
~1.3 – 3.0	gravelly fine to coarse SAND. Loose to very dense, moist, light greyish brown. Becoming light grey @ 2.5 metres.	Hinuera Formation		
3.0 – 4.0	SILT. Very soft to stiff, moist, slightly plastic, slightly iron stained, light grey.			
4.0	Bottom of Bore Hole completed 15/07/19			

SCALA PENETROMETER (blows/100mm)



NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

LOGGED BY: MMC
PLOTTED BY: PS
DRILL METHOD: Machine Auger
DRILLER: PS
LOCATION: refer Site Plan
CHECKED BY: [signature]
SHEET: 1 OF 1 Fig. No. A-18

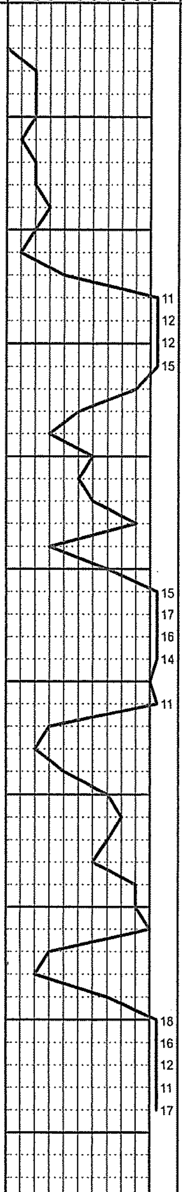
BORE HOLE LOG No. 19

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 15/07/19
RL (m): 66.4

Description	Depth (metres)	Geological Formation
TOPSOIL.		T/S
fine sandy SILT. Soft to stiff, moist, light yellowish bown.		Loam
silty fine to coarse SAND with some fine to medium gravel. Loose to medium dense, moist, light yellowish brown.	1	RA
gravelly fine to coarse SAND. Medium dense to dense, moist, slightly iron stained, light greyish brown. Becoming light brown and moderately iron stained @ 2.4 metres.	2	Hinuera Formation
silty fine SAND. Loose becoming dense, moist, slightly iron stained, light grey.	3	Hinuera Formation
Bottom of Bore Hole completed 15/07/19	4	

VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)

SCALA PENETROMETER (blows/100mm)



PIEZOMETER / WATER LEVEL: No Groundwater

NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

LOGGED BY: MMC
PLOTTED BY: PS
DRILL METHOD: Machine Auger
DRILLER: PS
LOCATION: refer Site Plan
CHECKED BY: SW
SHEET: 1 OF 1 Fig. No. A-19

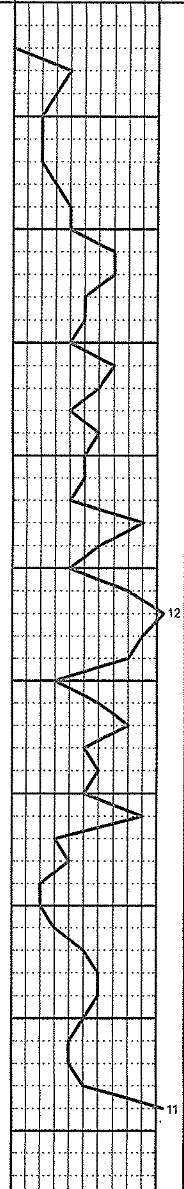
BORE HOLE LOG No. 20

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 11/07/19
RL (m): 68.6

Description	Depth (metres)	Geological Formation
TOPSOIL.		TS
fine sandy SILT. Firm to stiff, moist, light yellowish brown.		Loam
fine to coarse SAND with minor fine gravel. Loose to medium dense, moist, light yellowish brown.		RA
fine to coarse SAND with minor fine gravel. Loose to dense, moist, light brown. Containing some gravel and becoming light brownish grey @ 2.5 metres	1, 2, 3	Hinuera Formation
Bottom of Bore Hole completed 11/07/19	4	

VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)

SCALA PENETROMETER (blows/100mm)



PIEZOMETER / WATER LEVEL: No Groundwater

NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

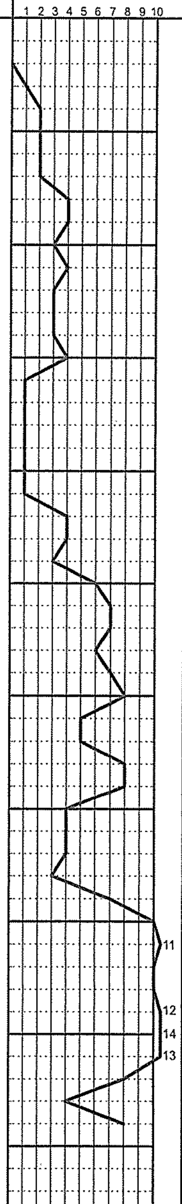
LOGGED BY: MMC
PLOTTED BY: MMC
DRILL METHOD: Machine Auger
DRILLER: PS
LOCATION: refer Site Plan
CHECKED BY: SW
SHEET: 1 OF 1 Fig. No. A-20

BORE HOLE LOG No. 21

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 11/07/19
RL (m): 69.1

Description	Depth (metres)	Geological Formation	Vane Shear Strength - kPa (In-situ/Remoulded)	Piezometer / Water Level
TOPSOIL.		T/S		No Groundwater
fine sandy SILT. Firm, moist, light yellowish brown.		Loam		
fine to coarse SAND with minor fine gravel. Loose to medium dense, moist, light yellowish brown.	1	RA		
gravelly fine to coarse SAND. Loose to dense, moist, light brownish grey. Becoming loose between 1.5 to 2.1 metres. " moist to wet and light grey @ 2.5 metres.	2, 3, 4	Hinuera Formation		
Bottom of Bore Hole completed 11/07/19				

SCALA PENETROMETER (blows/100mm)



NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

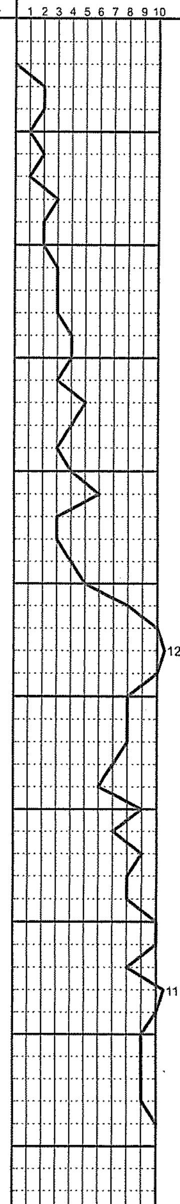
LOGGED BY: MMC
PLOTTED BY: MMC
DRILL METHOD: Machine Auger
DRILLER: PS
LOCATION: refer Site Plan
CHECKED BY: [signature]
SHEET: 1 OF 1 Fig. No. A-21

BORE HOLE LOG No. 22

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 11/07/19
RL (m): 69.1

Description	Depth (metres)	Geological Formation	Vane Shear Strength - kPa (In-situ/Remoulded)	Piezometer / Water Level
TOPSOIL.		T/S		No Groundwater
SILT with minor clay and trace fine sand. Firm, moist, slightly plastic, light yellowish brown.		Loam		
fine to coarse SAND with minor fine gravel. Loose to medium dense, moist, light yellowish brown.	1	RA		
gravelly fine to coarse SAND. Medium dense to dense, moist, greyish brown. Becoming light grey @ 2.3 metres.	2, 3, 4	Hinuera Formation		
Bottom of Bore Hole completed 11/07/19				

SCALA PENETROMETER (blows/100mm)



NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

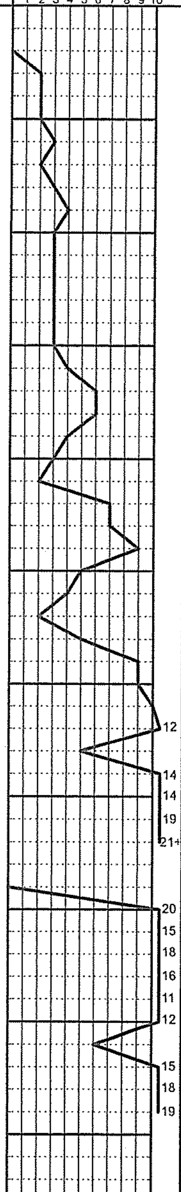
LOGGED BY: MMC
PLOTTED BY: MMC
DRILL METHOD: Machine Auger
DRILLER: PS
LOCATION: refer Site Plan
CHECKED BY: [signature]
SHEET: 1 OF 1 Fig. No. A-22

BORE HOLE LOG No. 23

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 11/07/19
RL (m): 69.1

GRAPHIC LOG / DESCRIPTION	DEPTH (metres)	GEOLOGICAL FORMATION	VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)	PIEZOMETER / WATER LEVEL
TOPSOIL.		T/S		No Groundwater
fine sandy SILT with trace clay. Firm, moist, slightly plastic, light yellowish brown.		Loam		
gravelly fine to coarse SAND. Loose to medium dense, moist, light yellowish brown.		Recent Alluvium		
fine sandy SILT with trace clay. Firm to stiff, moist, slightly plastic, light yellowish brown.	1	Recent Alluvium		
gravelly fine to coarse SAND. Loose to very dense, dry to moist, light grey.	2, 3	Hinuera Formation		
Bottom of Bore Hole completed 11/07/19	4			

SCALA PENETROMETER (blows/100mm)



NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

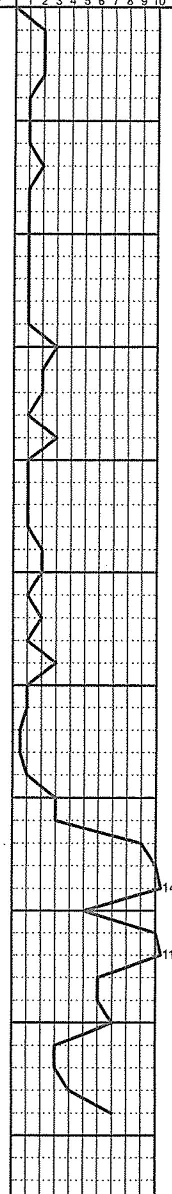
LOGGED BY: MMC
PLOTTED BY: MMC
DRILL METHOD: Machine Auger
DRILLER: PS
LOCATION: refer Site Plan
CHECKED BY: [signature]
SHEET: 1 OF 1 Fig. No. A-23

BORE HOLE LOG No. 24

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 11/07/19
RL (m): 68.7

GRAPHIC LOG / DESCRIPTION	DEPTH (metres)	GEOLOGICAL FORMATION	VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)	PIEZOMETER / WATER LEVEL
FILLING: Mixture of Silt, Sand and Topsoil. Uncontrolled, low strength, moist, brown. Containing trace medium gravel @ 0.7 metres.		Filling		No Groundwater
FILLING: Mixture of Silt, Sand, Topsoil and Charcoal. Uncontrolled, low strength, moist, brown mottled black.	1	Filling		
FILLING: Mixture of Silt, Sand and Topsoil. Uncontrolled, low strength, moist, brown.		Filling		
FILLING: Mixture of Sand, Silt and Gravel. Uncontrolled, poorly compacted, moist, dark brown.	2	Filling		
silty fine to coarse SAND with fine gravel. Very loose to loose, moist, dark brown. Becoming light brown @ 2.4 metres.	3	Hinuera Formation		
gravelly fine to coarse SAND. Medium dense to dense, moist, light grey.		Hinuera Formation		
Bottom of Bore Hole completed 11/07/19	4			

SCALA PENETROMETER (blows/100mm)



NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

LOGGED BY: MMC
PLOTTED BY: MMC
DRILL METHOD: Machine Auger
DRILLER: PS
LOCATION: refer Site Plan
CHECKED BY: [signature]
SHEET: 1 OF 1 Fig. No. A-24

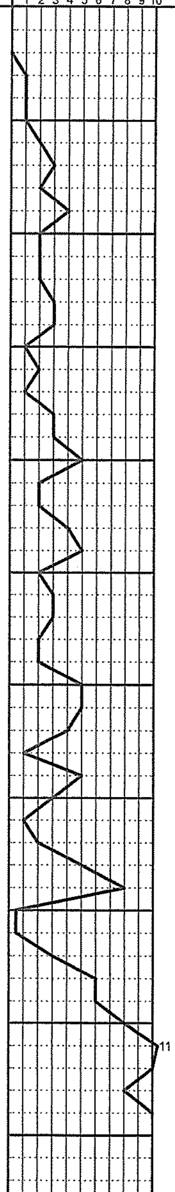
BORE HOLE LOG No. 25

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 11/07/19
RL (m): 69.8

Description	Depth (metres)	Geological Formation
TOPSOIL.		T/S
fine sandy SILT with trace clay. Soft to stiff, moist, slightly plastic, light yellowish brown.		Loam
fine to coarse SAND with some fine gravel. Loose to medium dense, moist, light yellowish brown.	1	RA
gravelly fine to coarse SAND. Loose to medium dense, dry to moist, light grey. Containing minor fine to medium gravel and becoming light grey @ 1.9 metres. Becoming very loose to dense @ 3.9 metres.	2, 3	Hinuera Formation
Bottom of Bore Hole completed 11/07/19	4	

VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)

SCALA PENETROMETER (blows/100mm)



PIEZOMETER / WATER LEVEL: No Groundwater

NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

LOGGED BY: MMC
PLOTTED BY: MMC
DRILL METHOD: Machine Auger
DRILLER: PS
LOCATION: refer Site Plan
CHECKED BY: [signature]
SHEET: 1 OF 1 Fig. No. A-25

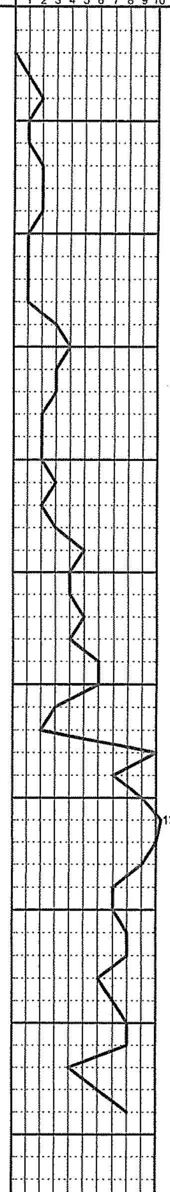
BORE HOLE LOG No. 26

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 11/07/19
RL (m): 69.6

Description	Depth (metres)	Geological Formation
TOPSOIL.		T/S
fine sandy SILT with trace clay. Soft to firm, moist, slightly plastic, light yellowish brown.	1	Loam
silty fine to coarse SAND with some gravel. Loose, moist, light yellowish brown.		RA
gravelly fine to coarse SAND. Loose to medium dense, moist, light greyish brown. Becoming light grey @ 1.8 metres. " moist to wet @ 2.0 metres. " dense @ 3.3 metres.	2, 3	Hinuera Formation
Bottom of Bore Hole completed 11/07/19	4	

VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)

SCALA PENETROMETER (blows/100mm)



PIEZOMETER / WATER LEVEL: No Groundwater

NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

LOGGED BY: MMC
PLOTTED BY: MMC
DRILL METHOD: Machine Auger
DRILLER: PS
LOCATION: refer Site Plan
CHECKED BY: [signature]
SHEET: 1 OF 1 Fig. No. A-26

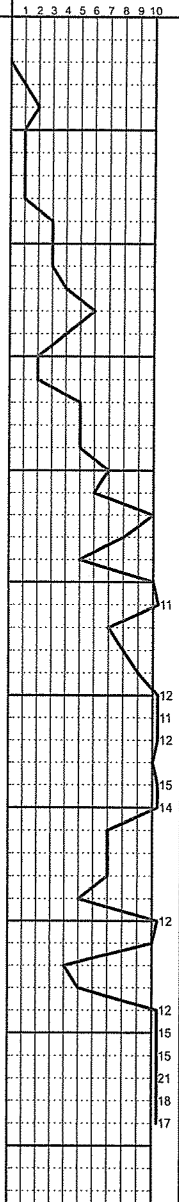
BORE HOLE LOG No. 27

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 11/07/19
RL (m): 70.0

Graphic log / Description	Depth (metres)	Geological Formation
TOPSOIL.		T/S
fine sandy SILT with trace clay. Soft to firm, moist, slightly plastic, light yellowish brown.		Loam
silty fine to coarse SAND. Loose to medium dense, moist, light yellowish brown.	1	RA
fine to coarse SAND. Loose to dense, dry to moist, light brownish grey.	2, 3	Hinuera Formation
Bottom of Bore Hole completed 11/07/19	4	

VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)

SCALA PENETROMETER (blows/100mm)



PIEZOMETER / WATER LEVEL: No Groundwater

NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

LOGGED BY: MMC
PLOTTED BY: MMC
DRILL METHOD: Machine Auger
DRILLER: PS
LOCATION: refer Site Plan
CHECKED BY: [signature]
SHEET: 1 OF 1 Fig. No. A-27

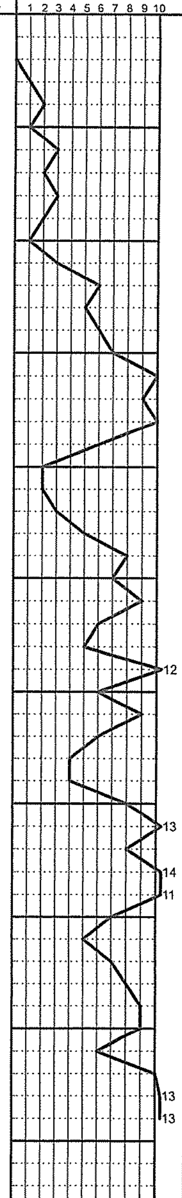
BORE HOLE LOG No. 28

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 11/07/19
RL (m): 70.3

Graphic log / Description	Depth (metres)	Geological Formation
TOPSOIL.		T/S
SILT with minor fine sand. Soft to stiff, moist, slightly plastic, light yellowish brown.		Loam
fine to coarse SAND with minor fine gravel. Loose, moist, light yellowish brown.	1	RA
fine to coarse SAND with some fine to medium gravel. Loose to dense, moist, light brownish grey.	2, 3	Hinuera Formation
Bottom of Bore Hole completed 11/07/19	4	

VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)

SCALA PENETROMETER (blows/100mm)



PIEZOMETER / WATER LEVEL: No Groundwater

NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

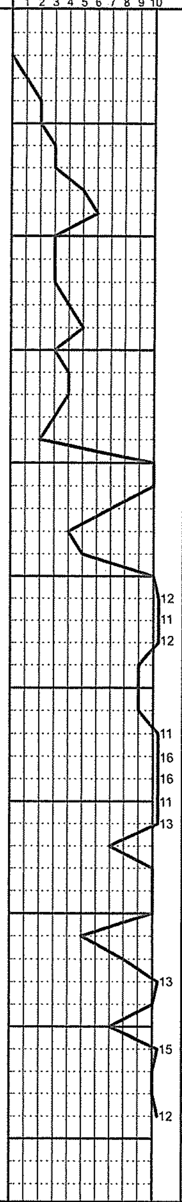
LOGGED BY: MMC
PLOTTED BY: MMC
DRILL METHOD: Machine Auger
DRILLER: PS
LOCATION: refer Site Plan
CHECKED BY: [signature]
SHEET: 1 OF 1 Fig. No. A-28

BORE HOLE LOG No. 29

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 11/07/19
RL (m): 70.2

GRAPHIC LOG / DESCRIPTION	DEPTH (metres)	GEOLOGICAL FORMATION	VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)	PIEZOMETER / WATER LEVEL
TOPSOIL.		T/S		No Groundwater
SILT with minor fine sand. Soft to stiff, moist, slightly plastic, light yellowish brown.		Loam		
fine to coarse SAND with minor fine gravel. Loose, moist, light yellowish brown.		RA		
fine to coarse SAND with some fine to medium gravel. Loose to dense, moist, light brownish grey.	1–4	Hinuera Formation		
Bottom of Bore Hole completed 11/07/19	4			

SCALA PENETROMETER (blows/100mm) 1 2 3 4 5 6 7 8 9 10



NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

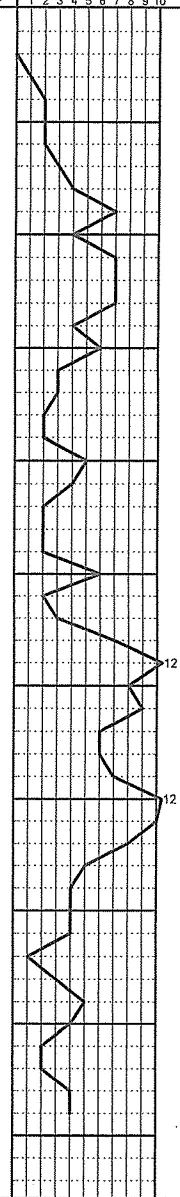
LOGGED BY: MMC	DRILL METHOD: Machine Auger	LOCATION: refer Site Plan	
PLOTTED BY: MMC	DRILLER: PS	CHECKED BY: [signature]	
		SHEET: 1 OF 1	Fig. No. A-29

BORE HOLE LOG No. 30

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064
DATE LOGGED: 11/07/19
RL (m): 70.6

GRAPHIC LOG / DESCRIPTION	DEPTH (metres)	GEOLOGICAL FORMATION	VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)	PIEZOMETER / WATER LEVEL
TOPSOIL.		T/S		No Groundwater
fine sandy SILT. Soft to stiff, moist, light yellowish brown.		Loam		
fine to coarse SAND with some fine gravel. Medium dense, moist, light yellowish brown.		RA		
fine to coarse SAND with minor fine gravel. Loose to dense, moist, greyish brown.	1–4	Hinuera Formation		
Bottom of Bore Hole completed 11/07/19	4			

SCALA PENETROMETER (blows/100mm) 1 2 3 4 5 6 7 8 9 10



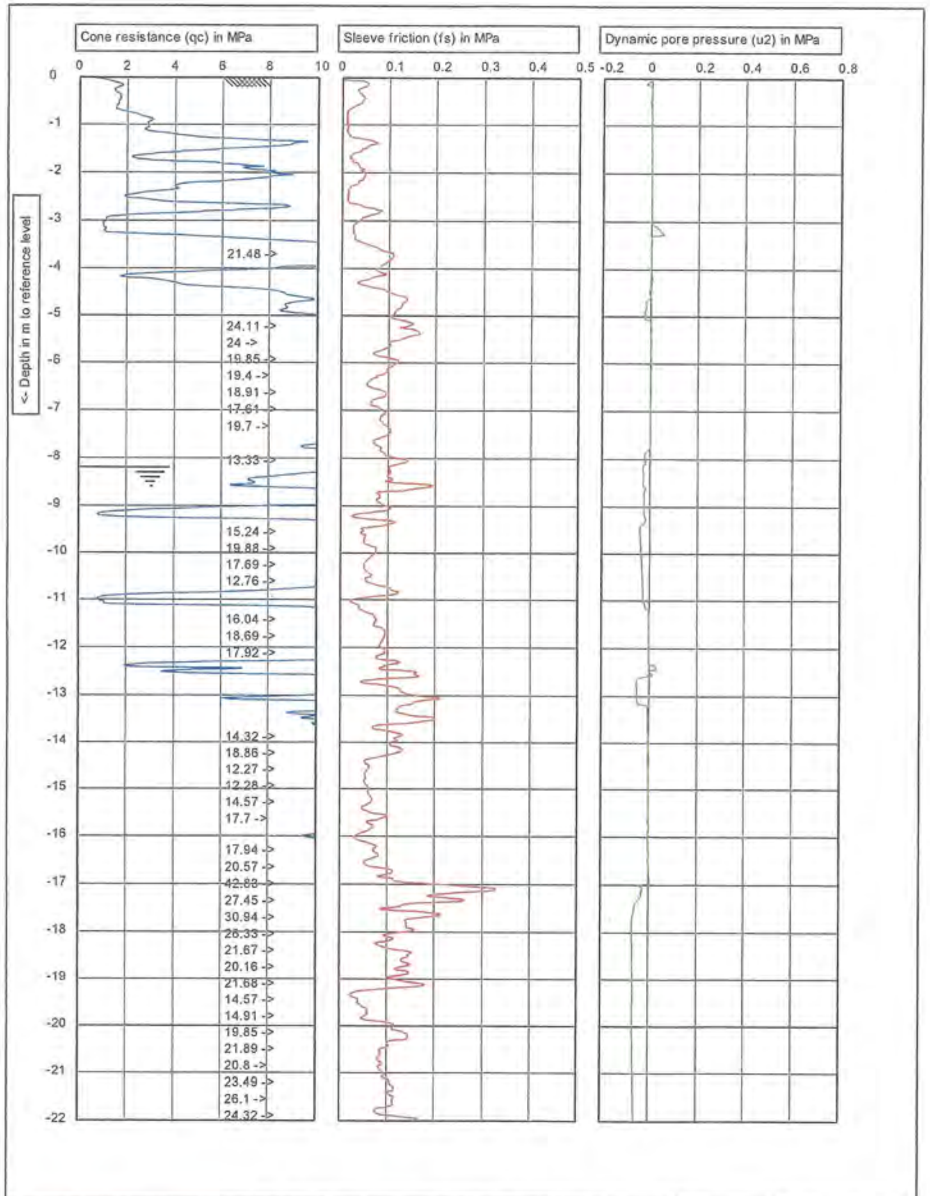
NOTES

- The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
- Scala testing was carried out in 1.0 metre depth increments.
- Hole diameters; 75mm (Machine Auger), 50mm (Hand Auger).

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

LOGGED BY: MMC	DRILL METHOD: Machine Auger	LOCATION: refer Site Plan	
PLOTTED BY: MMC	DRILLER: PS	CHECKED BY: [signature]	
		SHEET: 1 OF 1	Fig. No. A-30

CPT No. 9

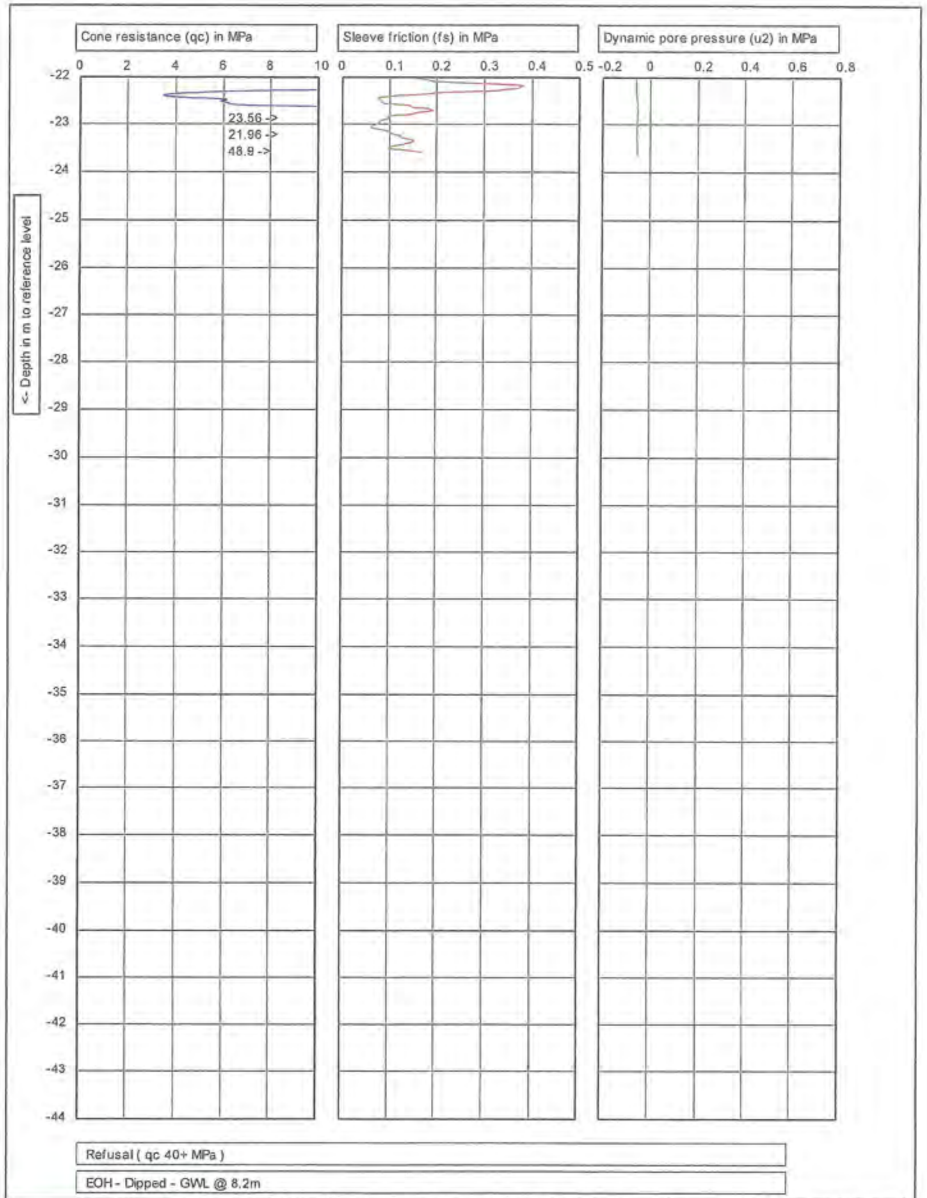


Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL	W.L.: -8.20 m	Date:	23/07/2019
Project:	C4 Growth Cell	Cone no.:	C10CFIIP.C18488
Location:	Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position:	1815680, 5802135 NZTM		

WSP OPUS

IANZ ACCREDITED LABORATORY — Graphs indicated as not accredited are outside the scope of the laboratory's accreditation

CPT9 Fig. B-9A Sheet 1

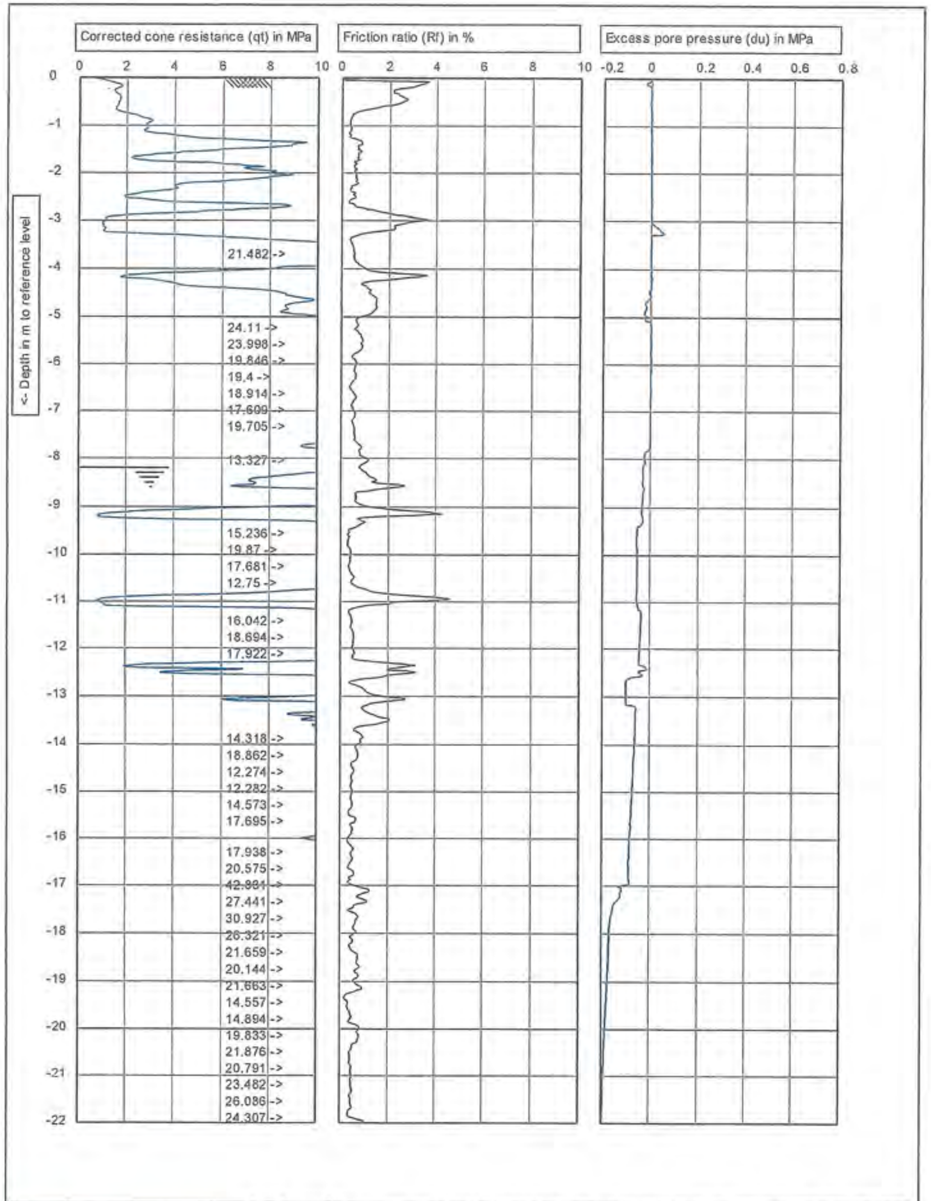


Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL	W.L.: -8.20 m	Date:	23/07/2019
Project:	C4 Growth Cell	Cone no.:	C10CFIIP.C18488
Location:	Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position:	1815680, 5802135 NZTM		

WSP OPUS

IANZ ACCREDITED LABORATORY — Graphs indicated as not accredited are outside the scope of the laboratory's accreditation

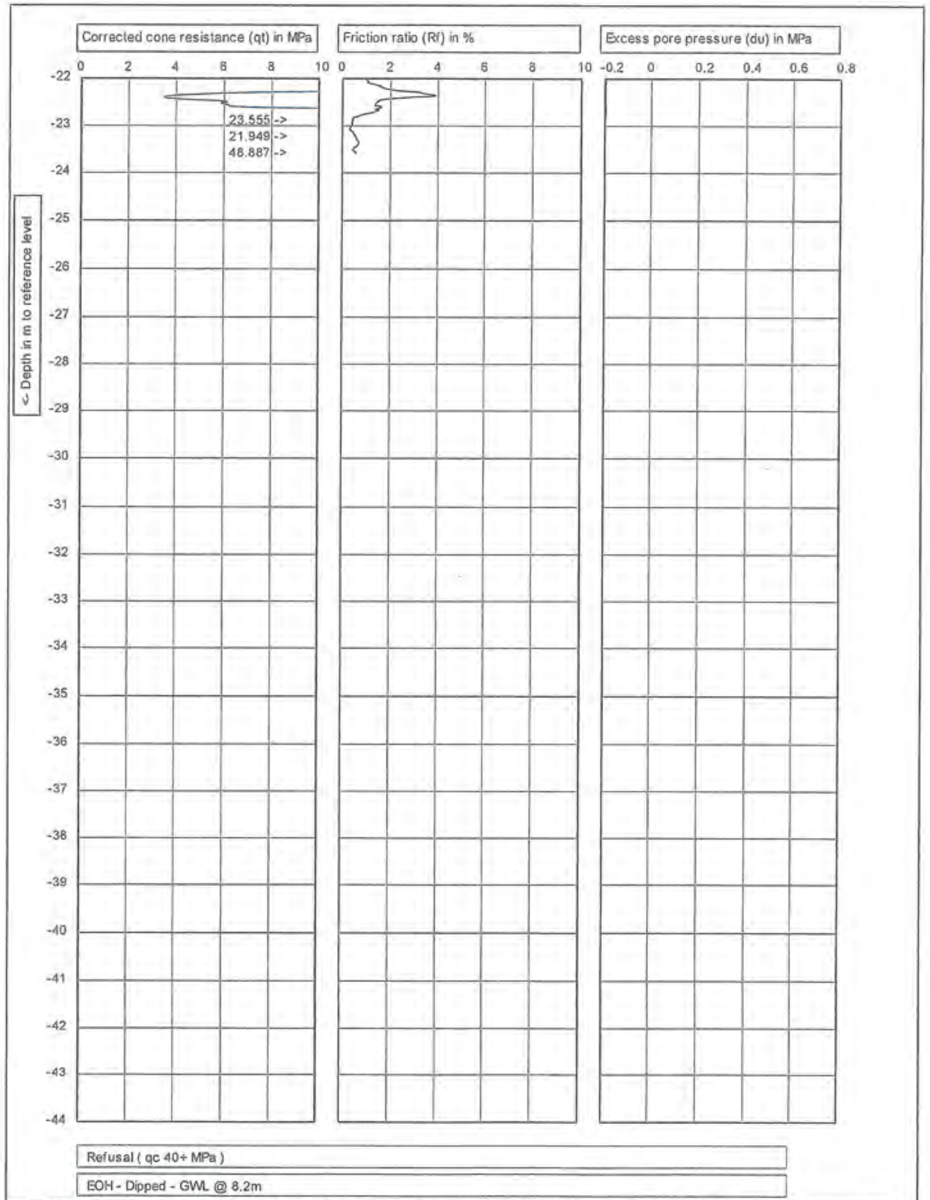
CPT9 Fig. B-9A Sheet 2



Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL	W.L.: -8.20 m	Date:	23/07/2019
Project:	C4 Growth Cell	Cone no.:	C10CFIIP.C18488
Location:	Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position:	1815680, 5802135 NZTM		

WSP OPUS

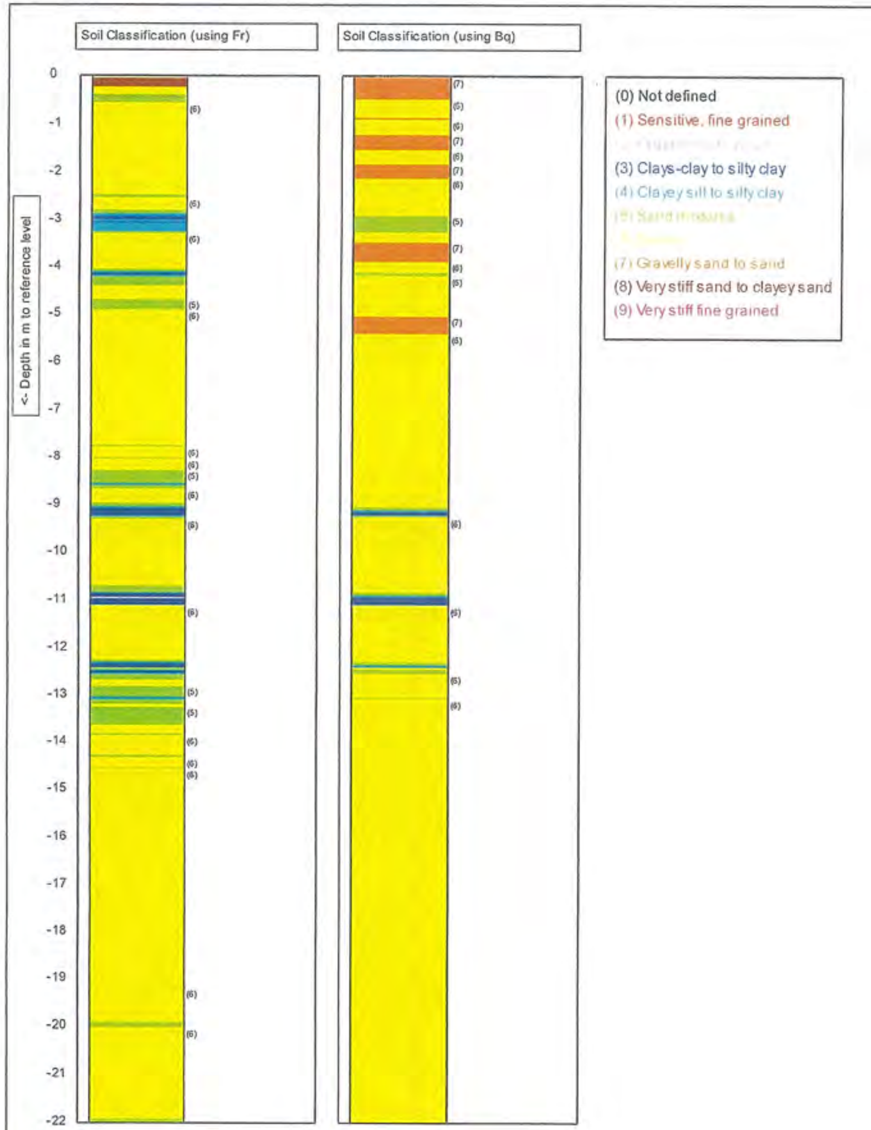
CPT9 Fig. B-9B Sheet 1



Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL	W.L.: -8.20 m	Date:	23/07/2019
Project:	C4 Growth Cell	Cone no.:	C10CFIIP.C18488
Location:	Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position:	1815680, 5802135 NZTM		

WSP OPUS

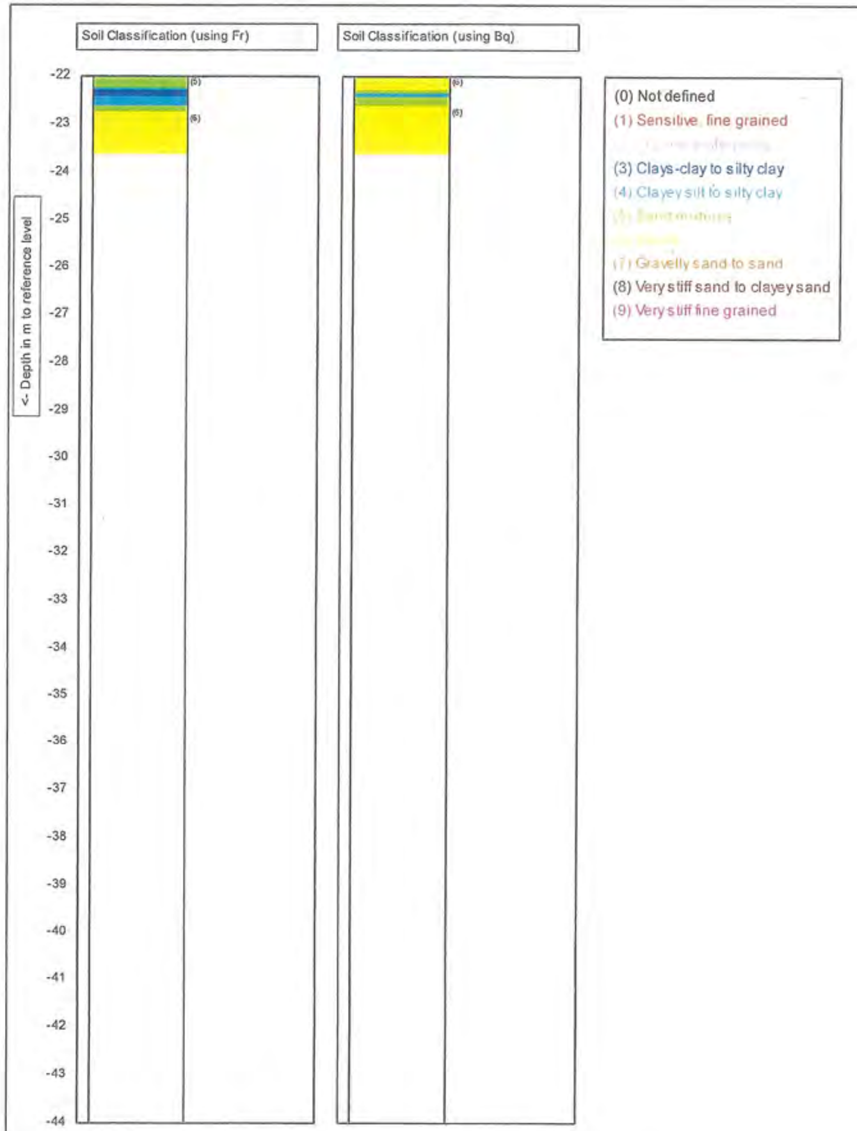
CPT9 Fig. B-9B Sheet 2



WSP OPUS	Test according ASTM D5778-12 & ISO 22476-1:2012	Predrill:	0.00 m Predrilled
	G.L.: 0.00 m MSL W.L.: -8.20 m	Date:	23/07/2019
Project:	C4 Growth Cell	Cone no.:	C10CFIIP.C18488
Location:	Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position:	1815680, 5802135 NZTM		

Graphs on this page are not IANZ accredited

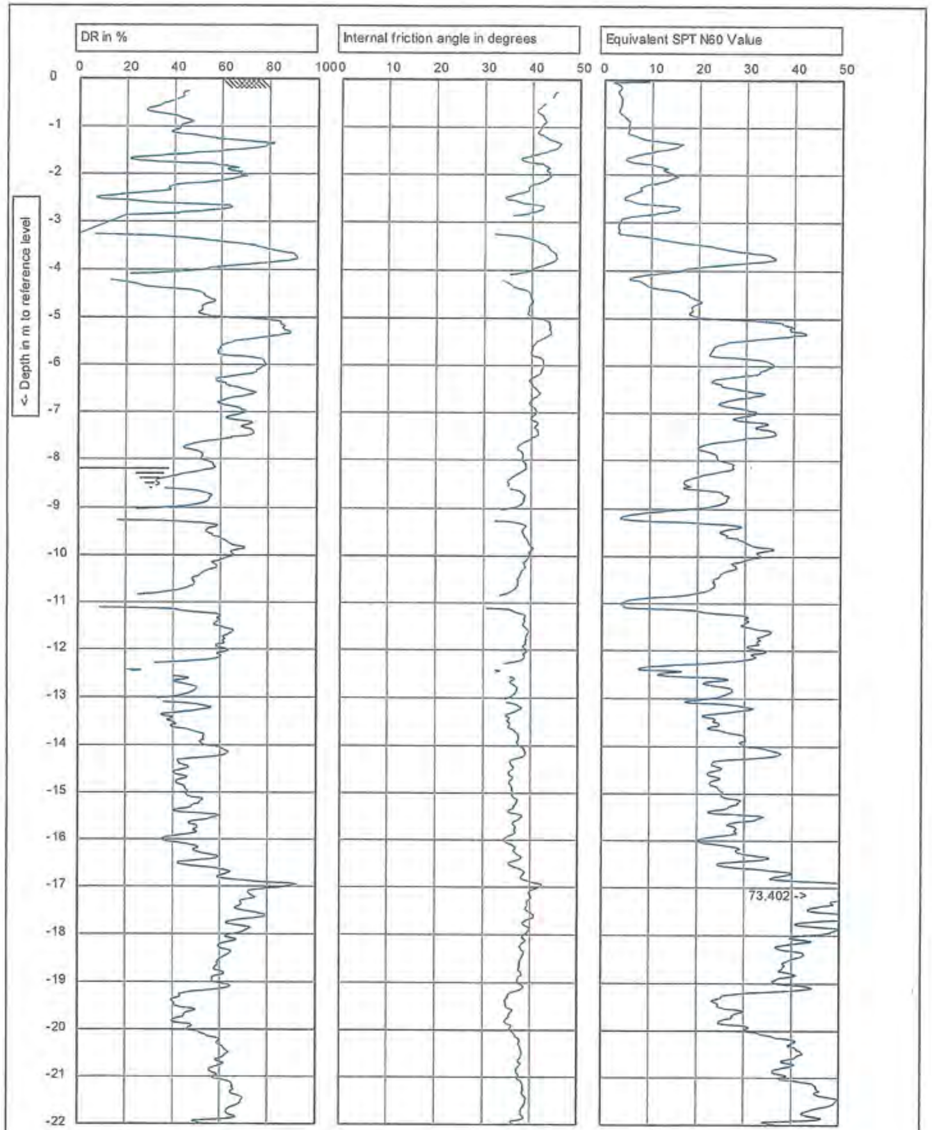
CPT9 Fig. B-9C Sheet 1



WSP OPUS	Test according ASTM D5778-12 & ISO 22476-1:2012	Predrill:	0.00 m Predrilled
	G.L.: 0.00 m MSL W.L.: -8.20 m	Date:	23/07/2019
Project:	C4 Growth Cell	Cone no.:	C10CFIIP.C18488
Location:	Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position:	1815680, 5802135 NZTM		

Graphs on this page are not IANZ accredited

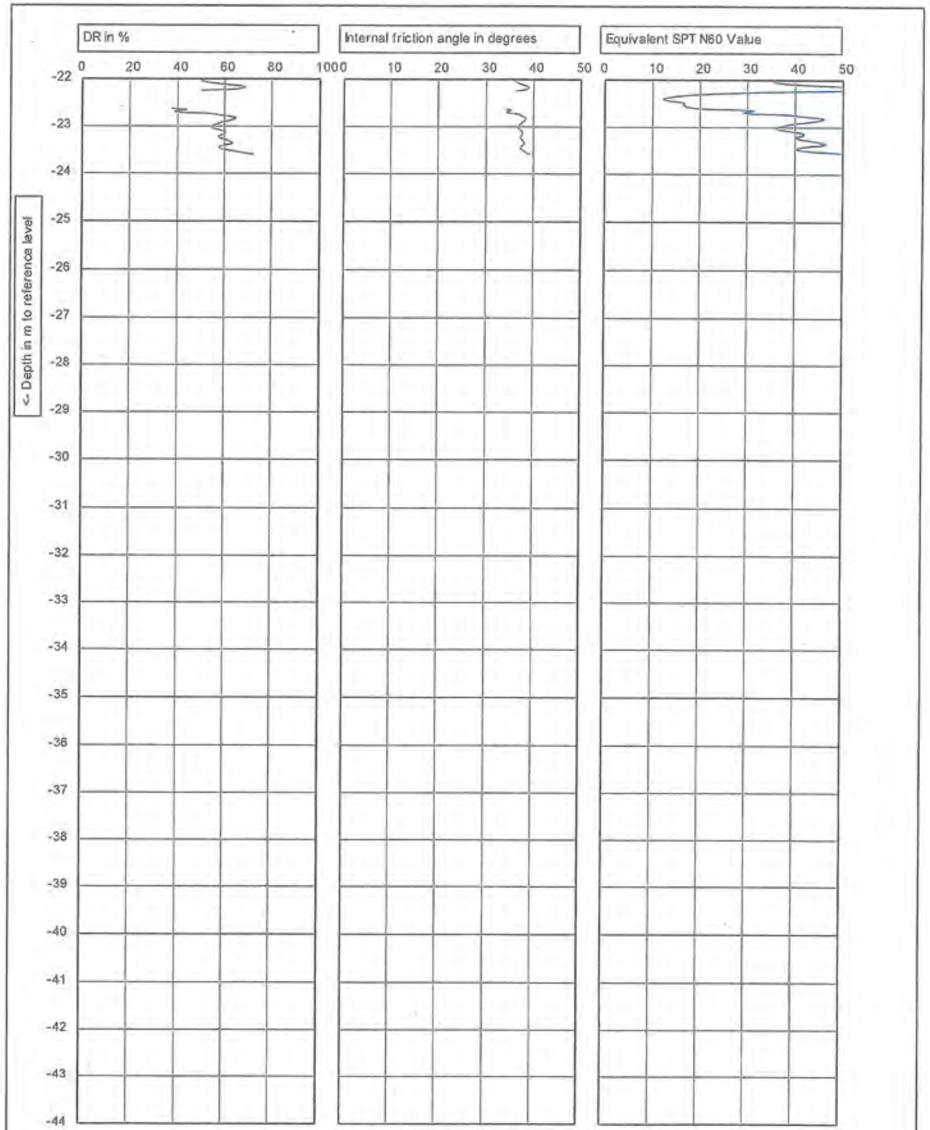
CPT9 Fig. B-9C Sheet 2



Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL	W.L.: -8.20 m	Date:	23/07/2019
Project:	C4 Growth Cell	Cone no.:	C10CFIIP.C18488
Location:	Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position:	1815680, 5802135 NZTM		

Graphs on this page are not IANZ accredited

CPT9 Fig. B-9D Sheet 1



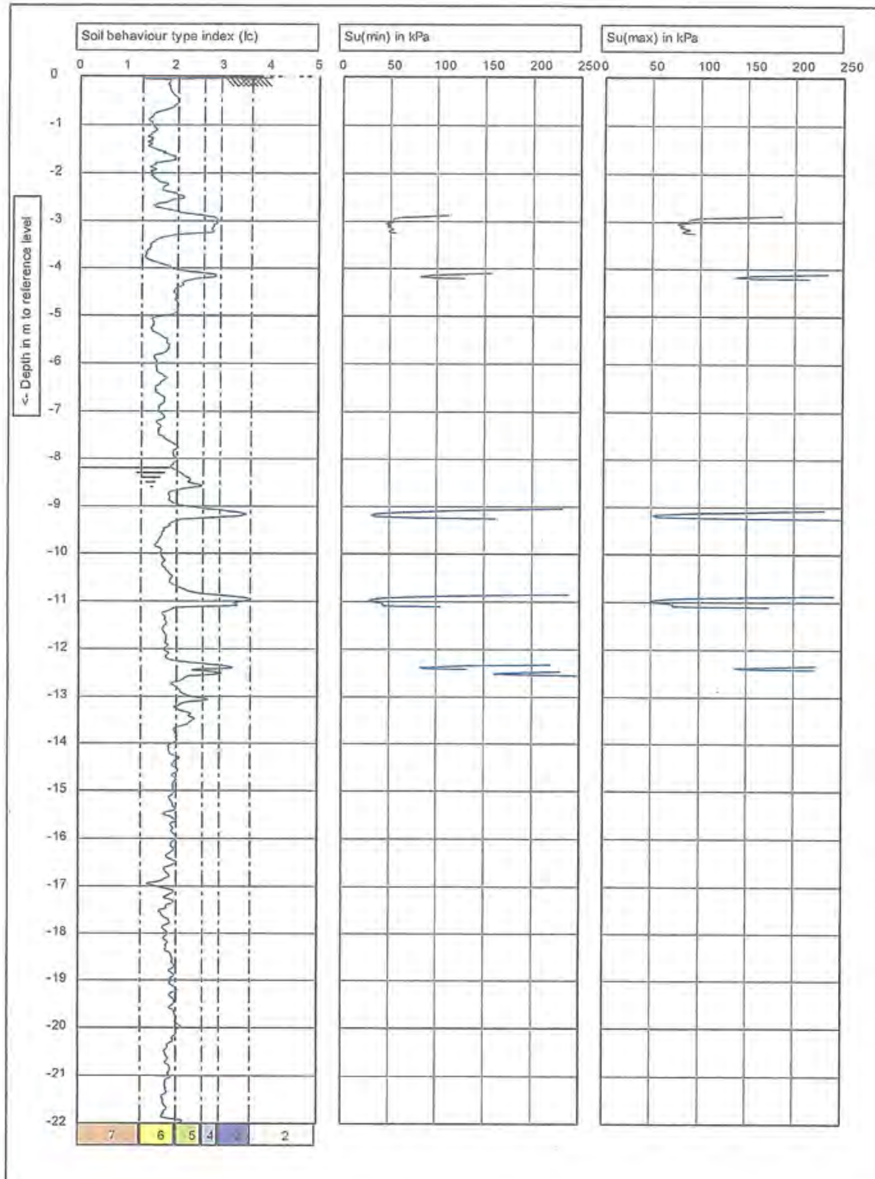
Refusal (qc 40+ MPa)

EOH - Dipped - GWL @ 8.2m

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL	W.L.: -8.20 m	Date:	23/07/2019
Project:	C4 Growth Cell	Cone no.:	C10CFIIP.C18488
Location:	Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position:	1815680, 5802135 NZTM		

Graphs on this page are not IANZ accredited

CPT9 Fig. B-9D Sheet 2



Test according ASTM D5778-12 & ISO 22476-1:2012

G.L.: 0.00 m MSL | W.L.: -8.20 m

Predrill: 0.00 m Predrilled

Date: 23/07/2019

Cone no.: C10CFIIP.C18488

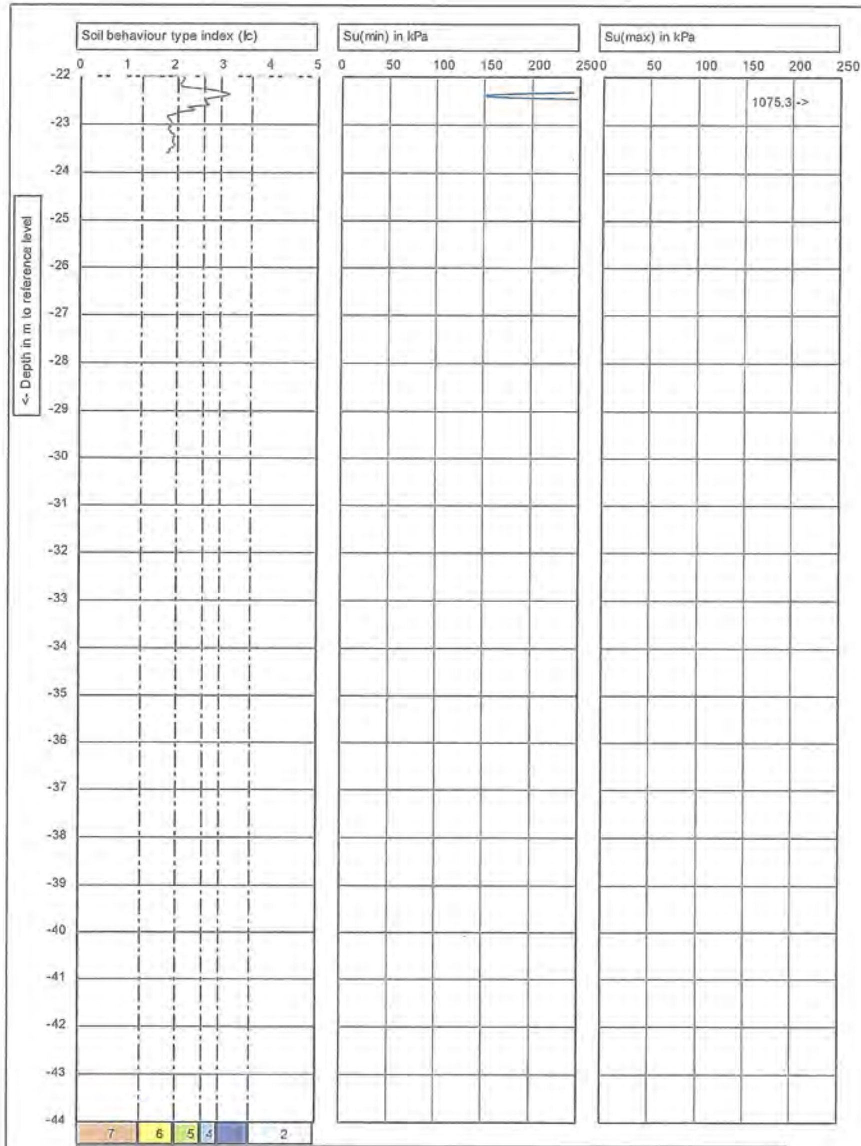
Project no.: 2-68002.00_HA4829

Project: C4 Growth Cell

Location: Leamington - Cambridge (16064)

Position: 1815680, 5802135 NZTM

CPT9 Fig. B-9E Sheet 1



Refusal (qc 40+ MPa)

EOH - Dipped - GWL @ 8.2m

Test according ASTM D5778-12 & ISO 22476-1:2012

G.L.: 0.00 m MSL | W.L.: -8.20 m

Predrill: 0.00 m Predrilled

Date: 23/07/2019

Cone no.: C10CFIIP.C18488

Project no.: 2-68002.00_HA4829

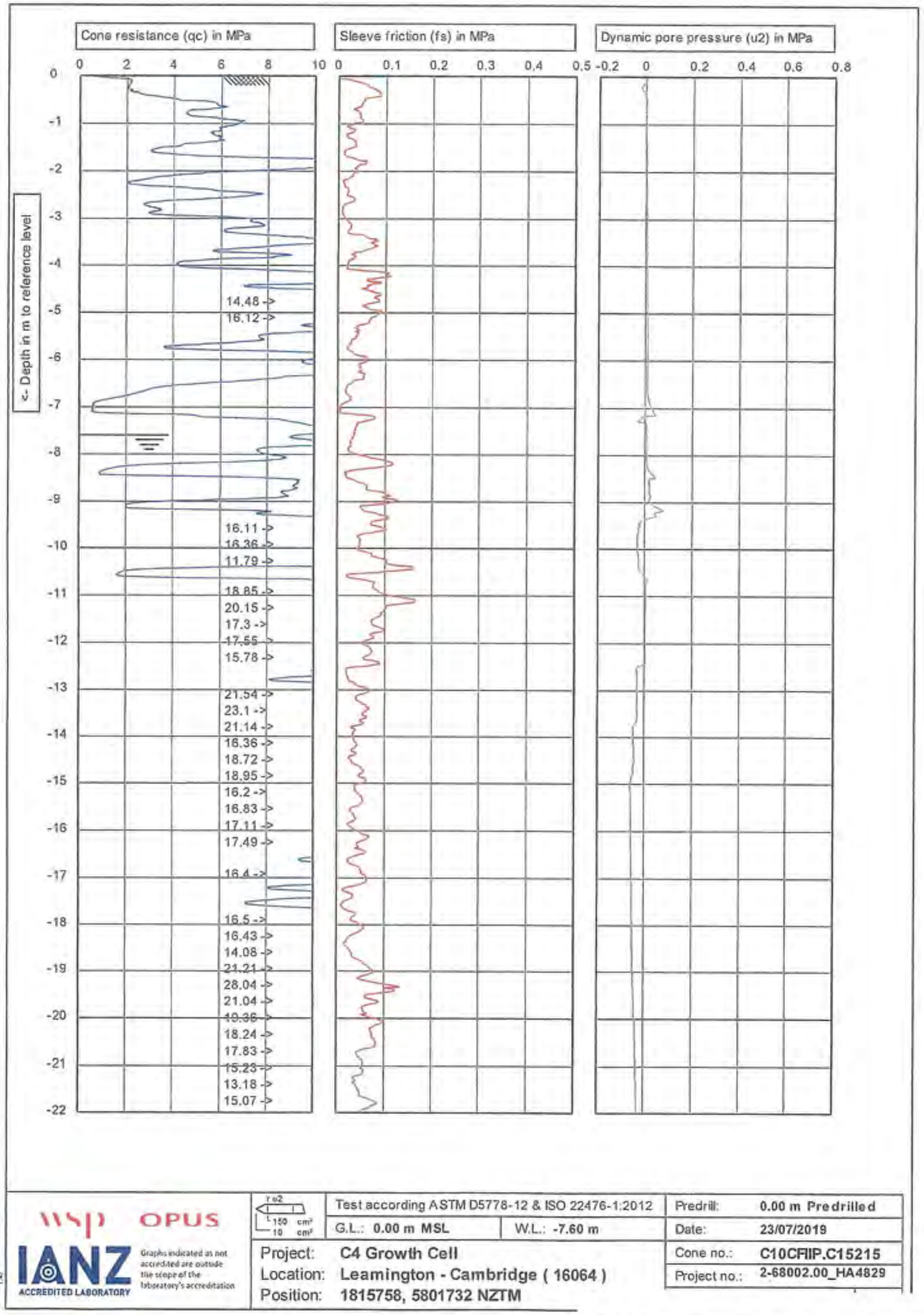
Project: C4 Growth Cell

Location: Leamington - Cambridge (16064)

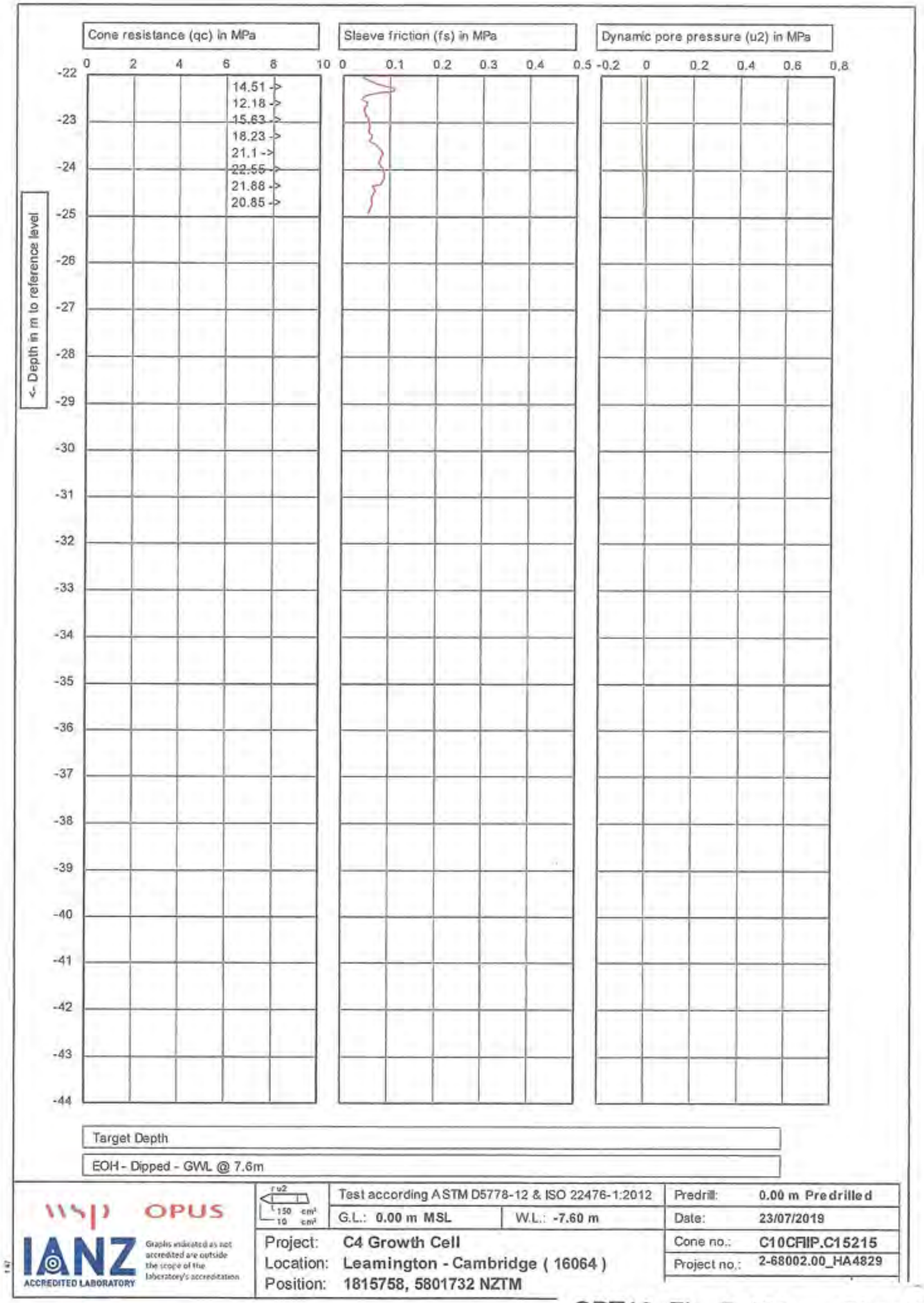
Position: 1815680, 5802135 NZTM

CPT9 Fig. B-9E Sheet 2

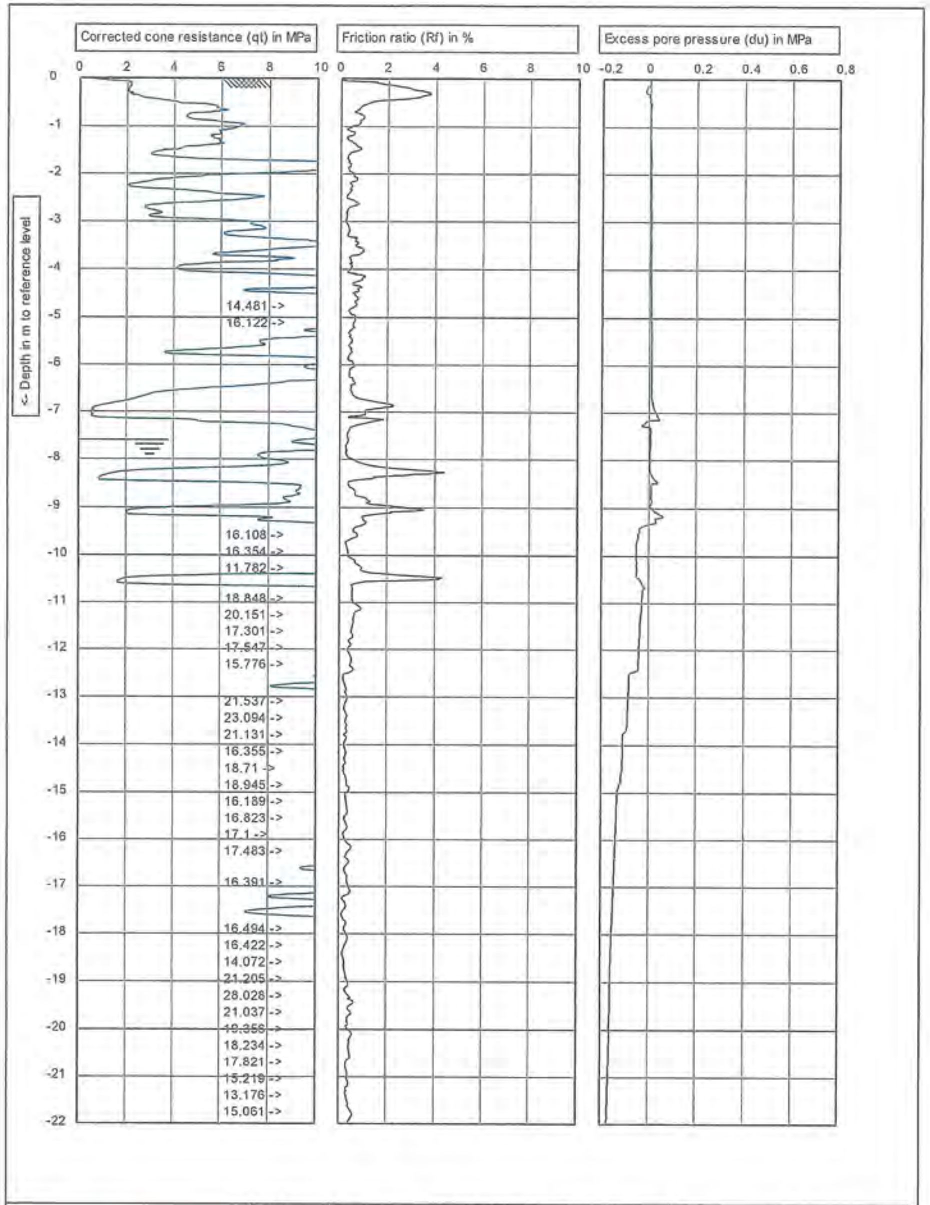
CPT No. 10



CPT10 Fig. B-10A Sheet 1



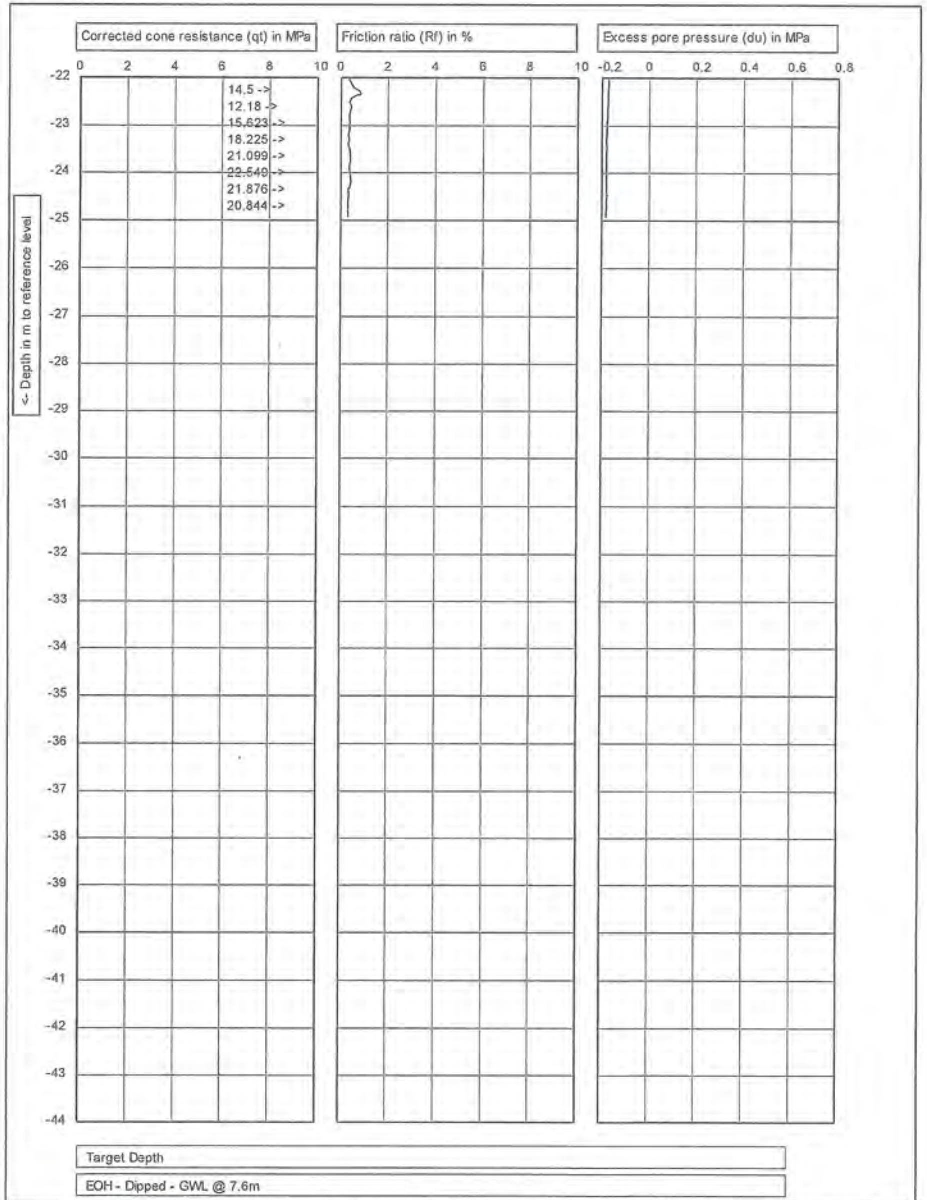
CPT10 Fig. B-10A Sheet 2



WSP OPUS

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL	W.L.: -7.60 m	Date:	23/07/2019
Project:	C4 Growth Cell	Cone no.:	C10CFIIP.C15215
Location:	Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position:	1815758, 5801732 NZTM		

CPT10 Fig. B-10B Sheet 1



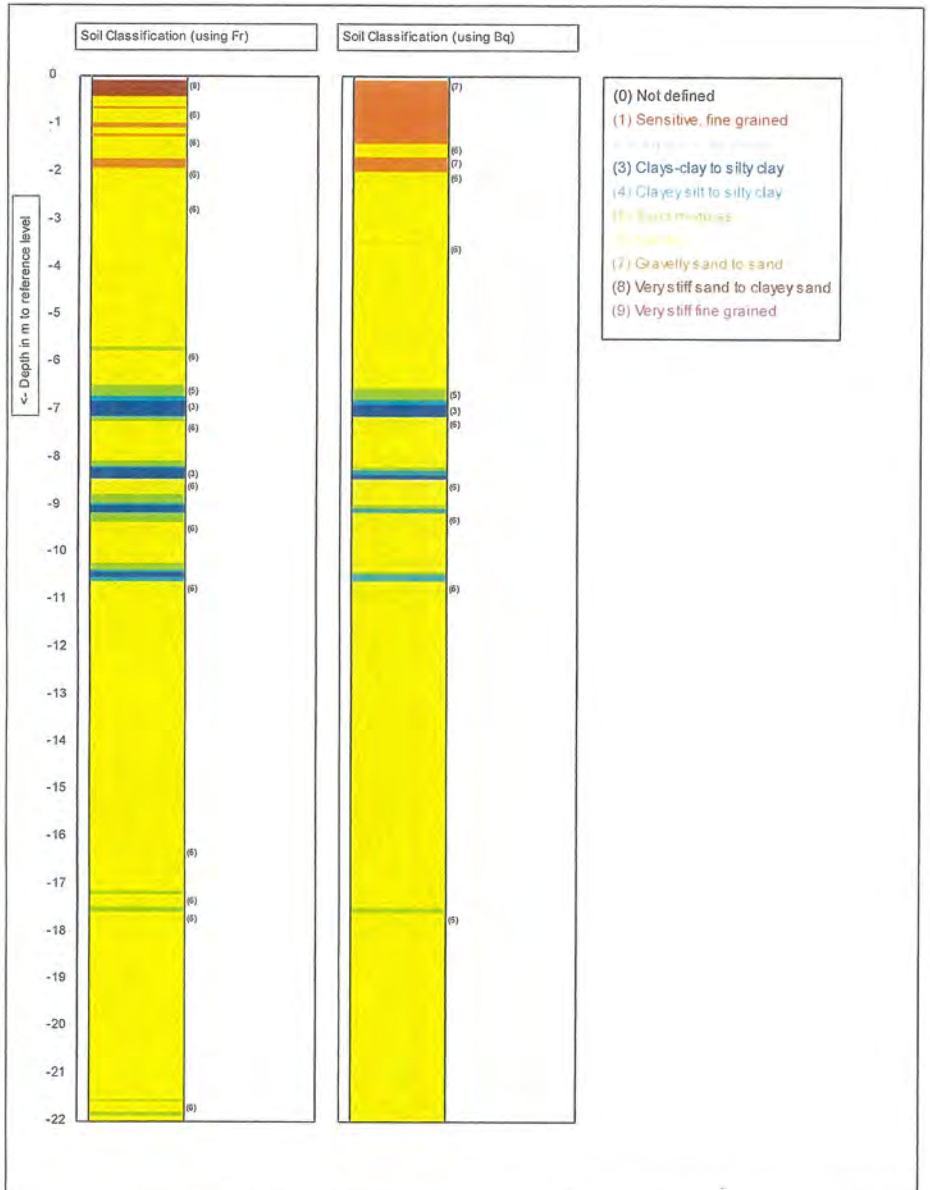
Target Depth

EOH - Dipped - GWL @ 7.6m

WSP OPUS

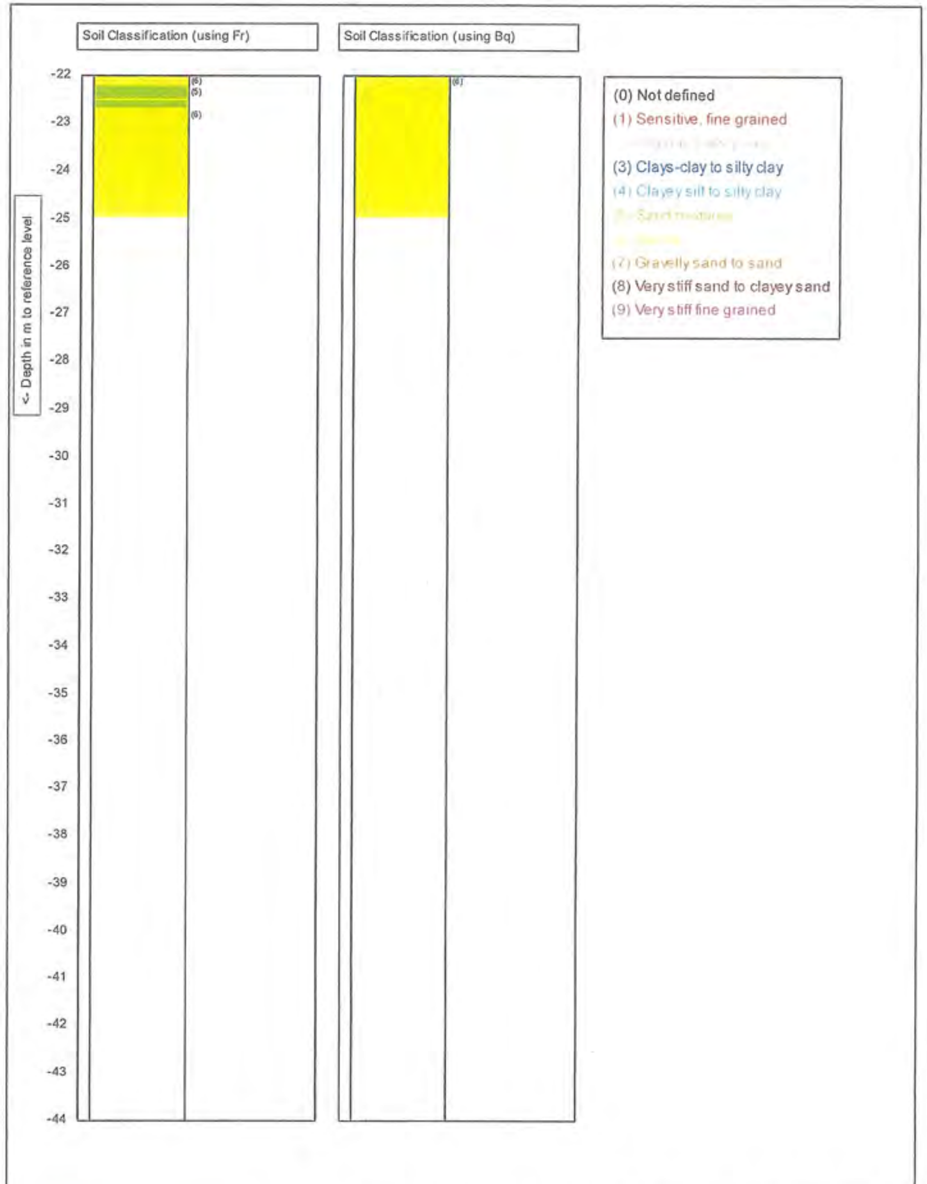
Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL	W.L.: -7.60 m	Date:	23/07/2019
Project:	C4 Growth Cell	Cone no.:	C10CFIIP.C15215
Location:	Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position:	1815758, 5801732 NZTM		

CPT10 Fig. B-10B Sheet 2



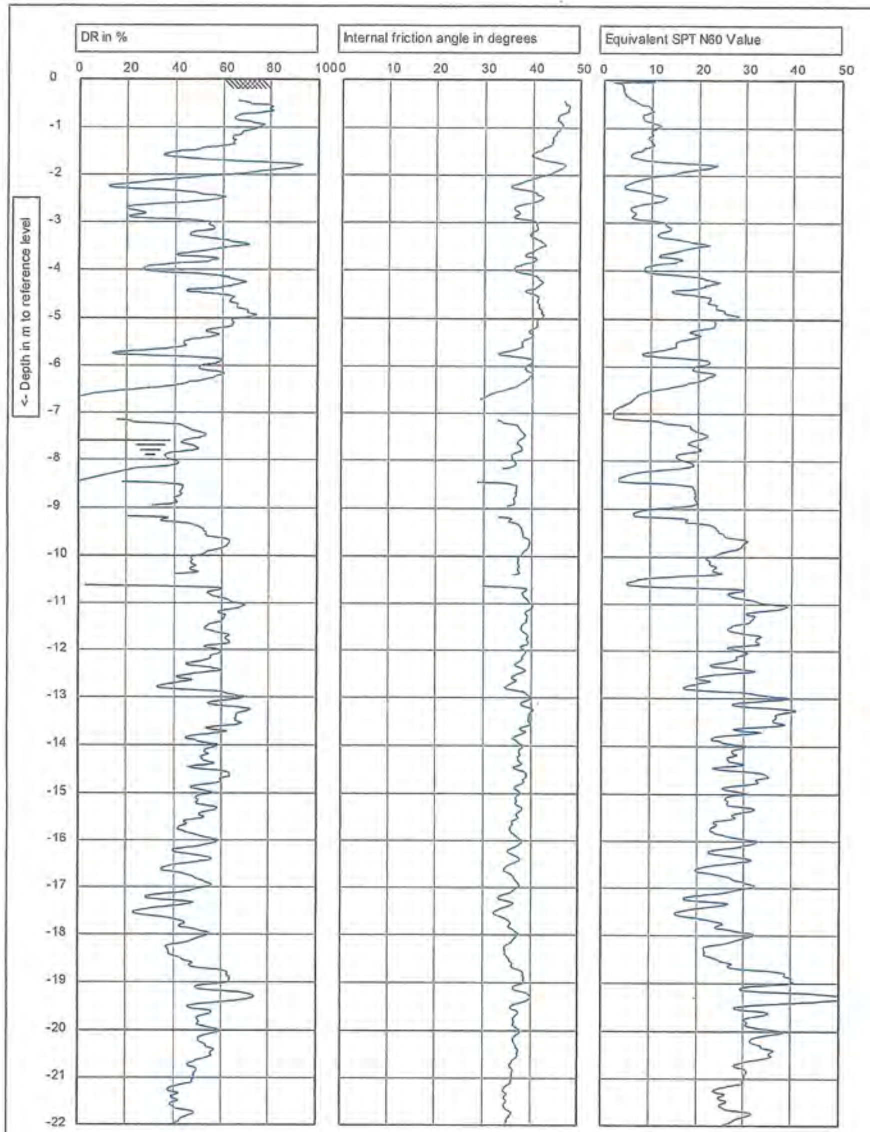
wsp OPUS	Test according ASTM D5778-12 & ISO 22476-1:2012	Predrill:	0.00 m Predrilled
Graphs on this page are not IANZ accredited	G.L.: 0.00 m MSL W.L.: -7.60 m	Date:	23/07/2019
	Project: C4 Growth Cell	Cone no.:	C10CFIIP.C15215
	Location: Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
	Position: 1815758, 5801732 NZTM		

CPT10 Fig. B-10C Sheet 1



wsp OPUS	Test according ASTM D5778-12 & ISO 22476-1:2012	Predrill:	0.00 m Predrilled
Graphs on this page are not IANZ accredited	G.L.: 0.00 m MSL W.L.: -7.60 m	Date:	23/07/2019
	Project: C4 Growth Cell	Cone no.:	C10CFIIP.C15215
	Location: Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
	Position: 1815758, 5801732 NZTM		

CPT10 Fig. B-10C Sheet 2



Test according ASTM D5778-12 & ISO 22476-1:2012

G.L.: 0.00 m MSL | W.L.: -7.60 m

Predrill: 0.00 m Predrilled

Date: 23/07/2019

Cone no.: C10CFIIP.C15215

Project no.: 2-68002.00_HA4829

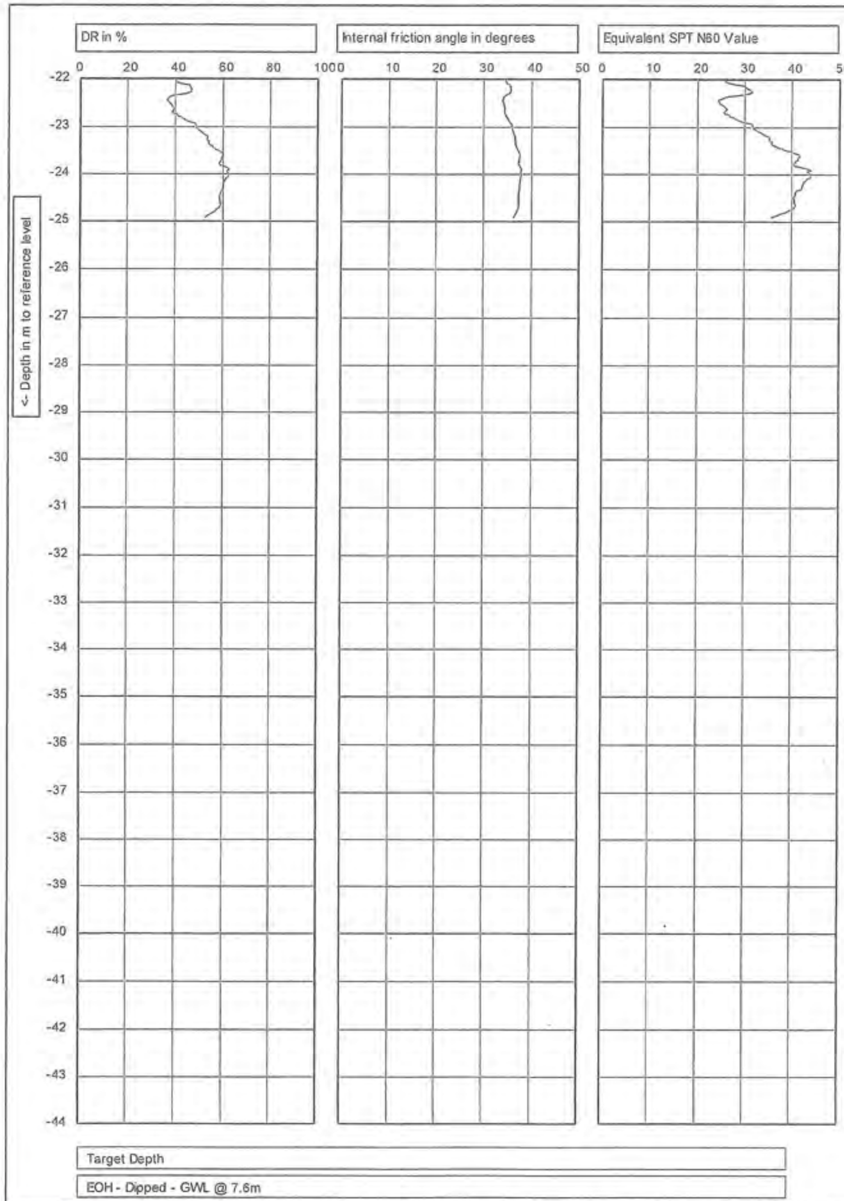
Project: C4 Growth Cell

Location: Leamington - Cambridge (16064)

Position: 1815758, 5801732 NZTM

Graphs on this page are not IANZ accredited

CPT10 Fig. B-10D Sheet 1



Test according ASTM D5778-12 & ISO 22476-1:2012

G.L.: 0.00 m MSL | W.L.: -7.60 m

Predrill: 0.00 m Predrilled

Date: 23/07/2019

Cone no.: C10CFIIP.C15215

Project no.: 2-68002.00_HA4829

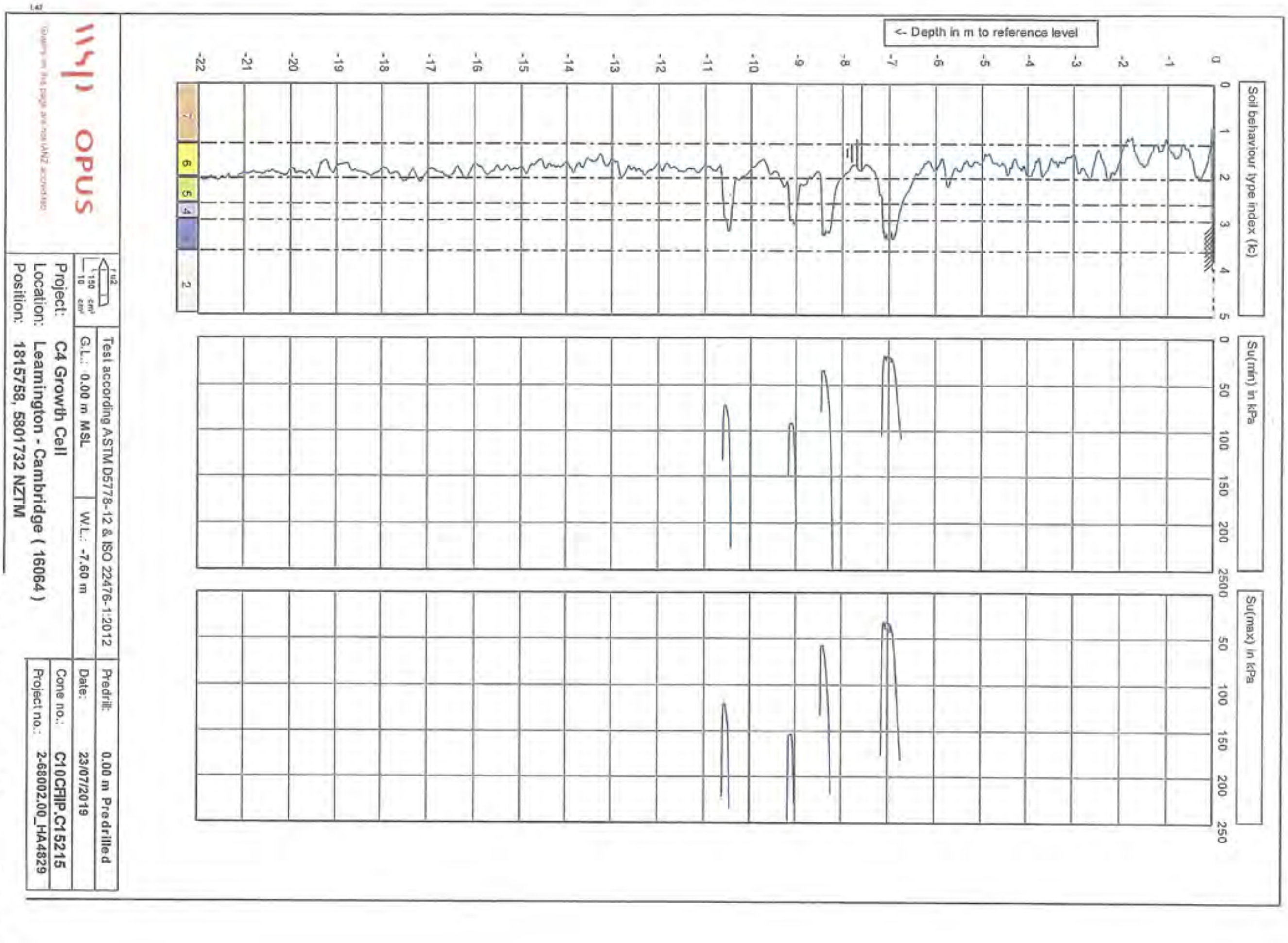
Project: C4 Growth Cell

Location: Leamington - Cambridge (16064)

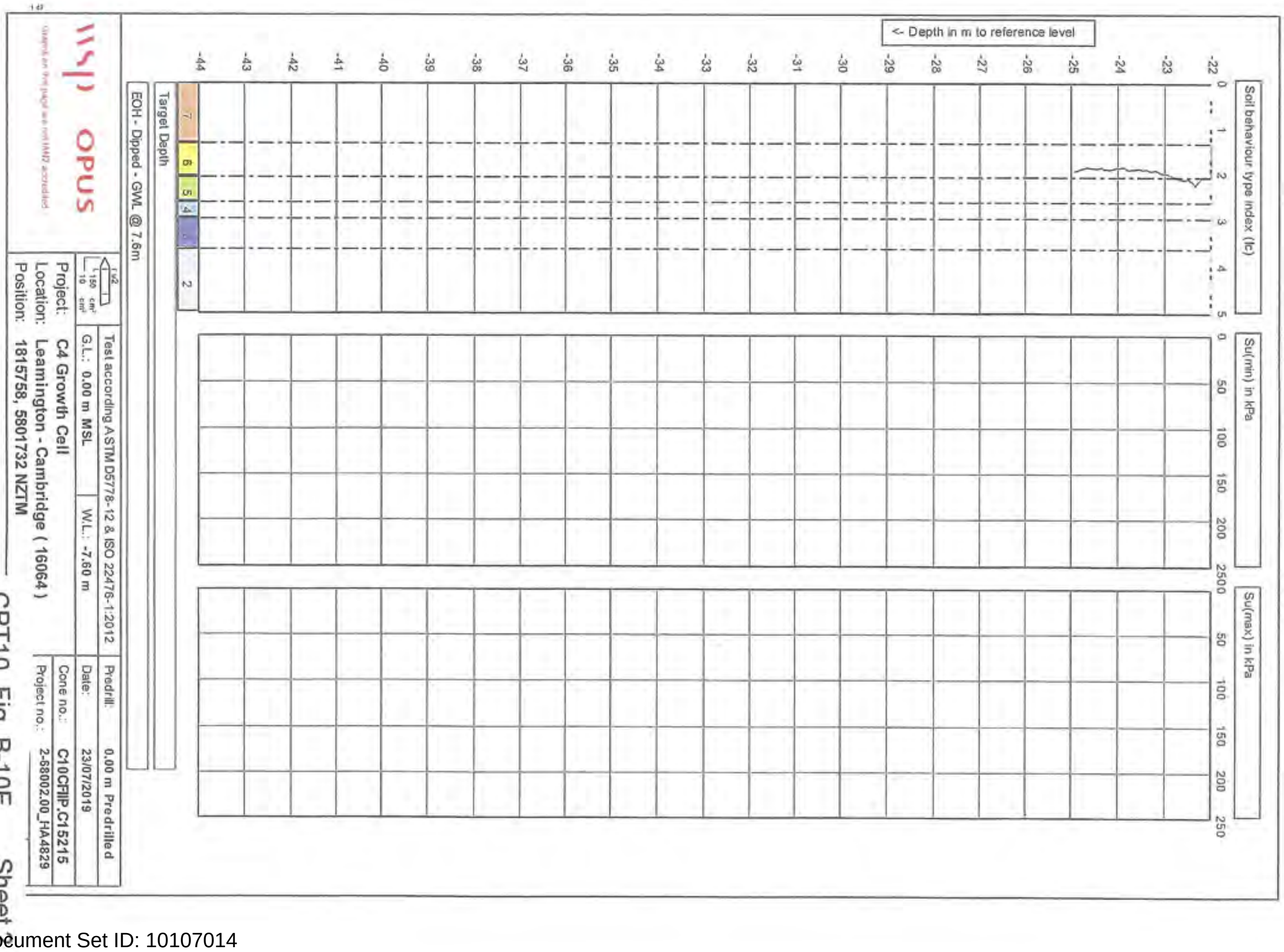
Position: 1815758, 5801732 NZTM

Graphs on this page are not IANZ accredited

CPT10 Fig. B-10D Sheet 2

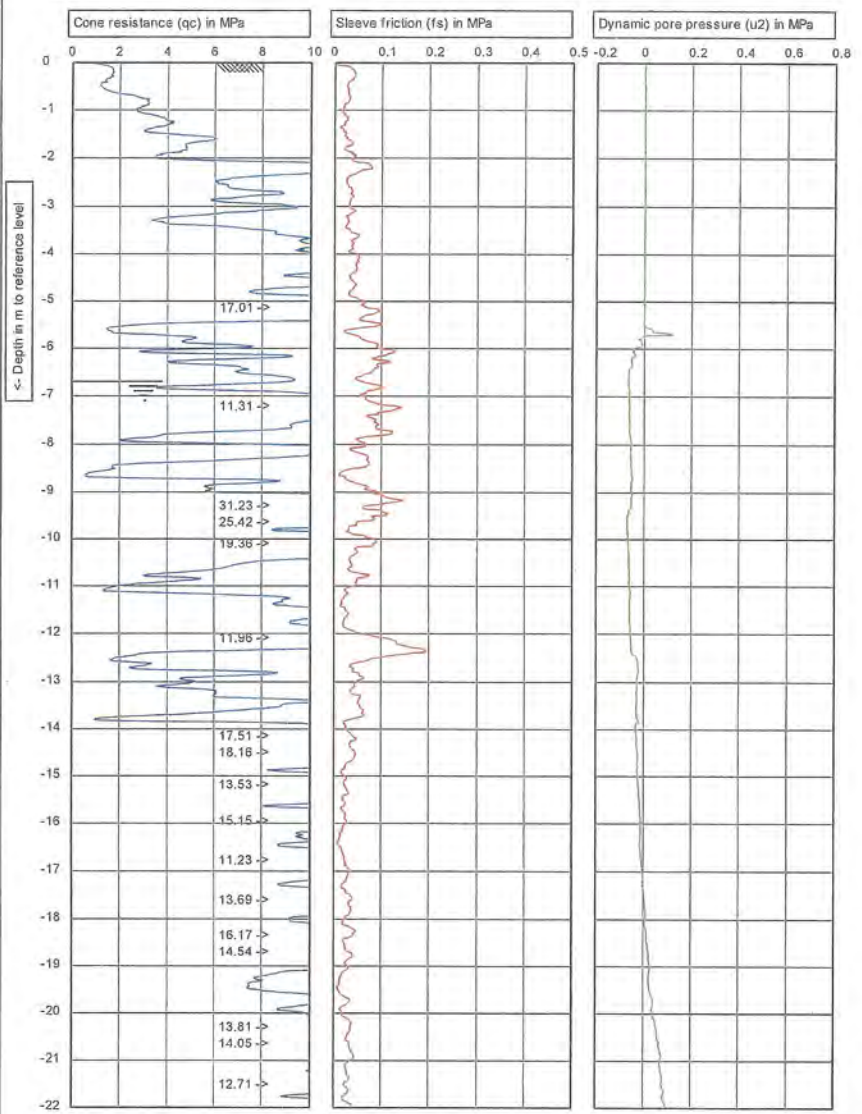


<- Depth in m to reference level
Soil behaviour type index (Ic)
Su(min) in kPa
Su(max) in kPa
WSP OPUS
Test according ASTM D5778-12 & ISO 22476-1:2012
G.L.: 0.00 m MSL
W.L.: -7.60 m
Predrill: 0.00 m Predrilled
Date: 23/07/2019
Cone no.: C10CFIIP.C15215
Project no.: 2-68002.00_HA4829
Project: C4 Growth Cell
Location: Leamington - Cambridge (16064)
Position: 1815758, 5801732 NZTM
CPT10 Fig. B-10E Sheet 1



<- Depth in m to reference level
Soil behaviour type index (Ic)
Su(min) in kPa
Su(max) in kPa
Target Depth
EOH - Dipped - GWL @ 7.6m
WSP OPUS
Test according ASTM D5778-12 & ISO 22476-1:2012
G.L.: 0.00 m MSL
W.L.: -7.60 m
Predrill: 0.00 m Predrilled
Date: 23/07/2019
Cone no.: C10CFIIP.C15215
Project no.: 2-68002.00_HA4829
Project: C4 Growth Cell
Location: Leamington - Cambridge (16064)
Position: 1815758, 5801732 NZTM
CPT10 Fig. B-10E Sheet 2

CPT No. 11

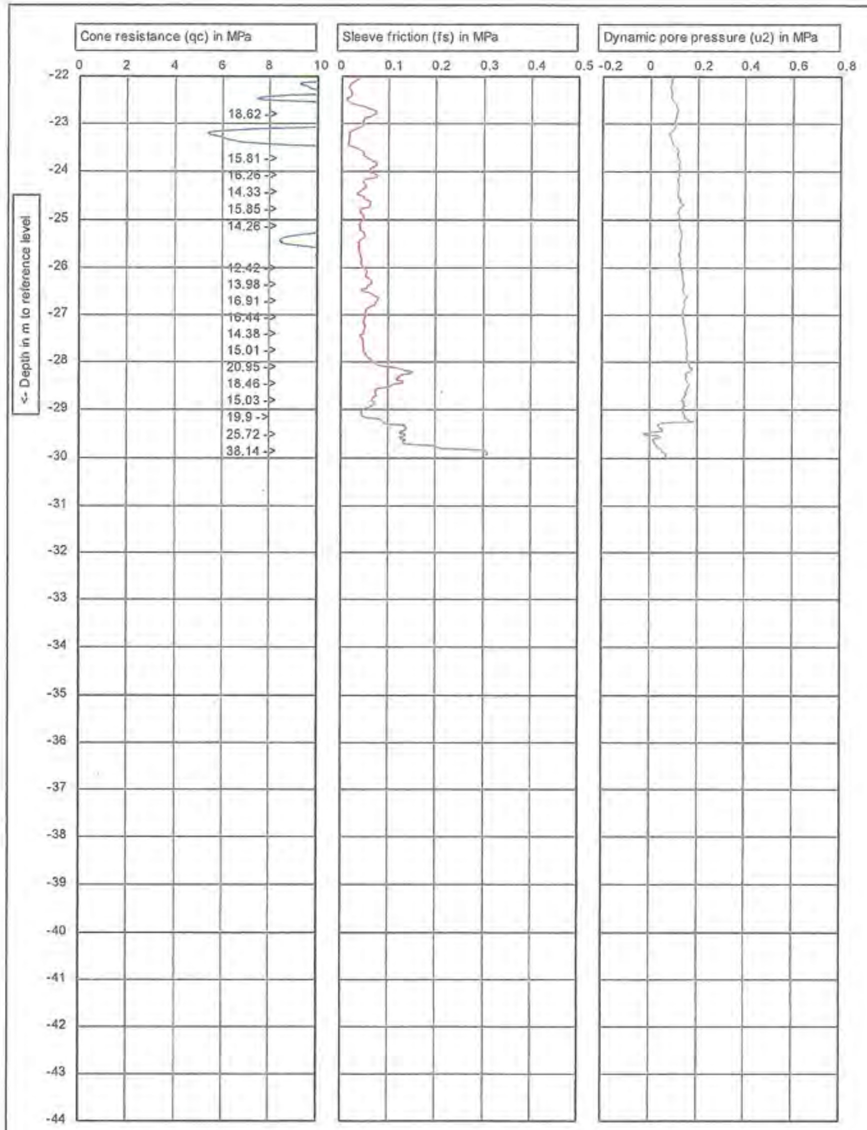


Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL	W.L.: -6.70 m	Date:	23/07/2019
Project:	C4 Growth Cell	Cone no.:	C10CFIIP.C18488
Location:	Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position:	1815729, 5801447 NZTM		

wsp OPUS

IANZ ACCREDITED LABORATORY — Graphs indicated as not accredited are outside the scope of the laboratory's accreditation

CPT11 Fig. B-11A Sheet 1



Target Depth

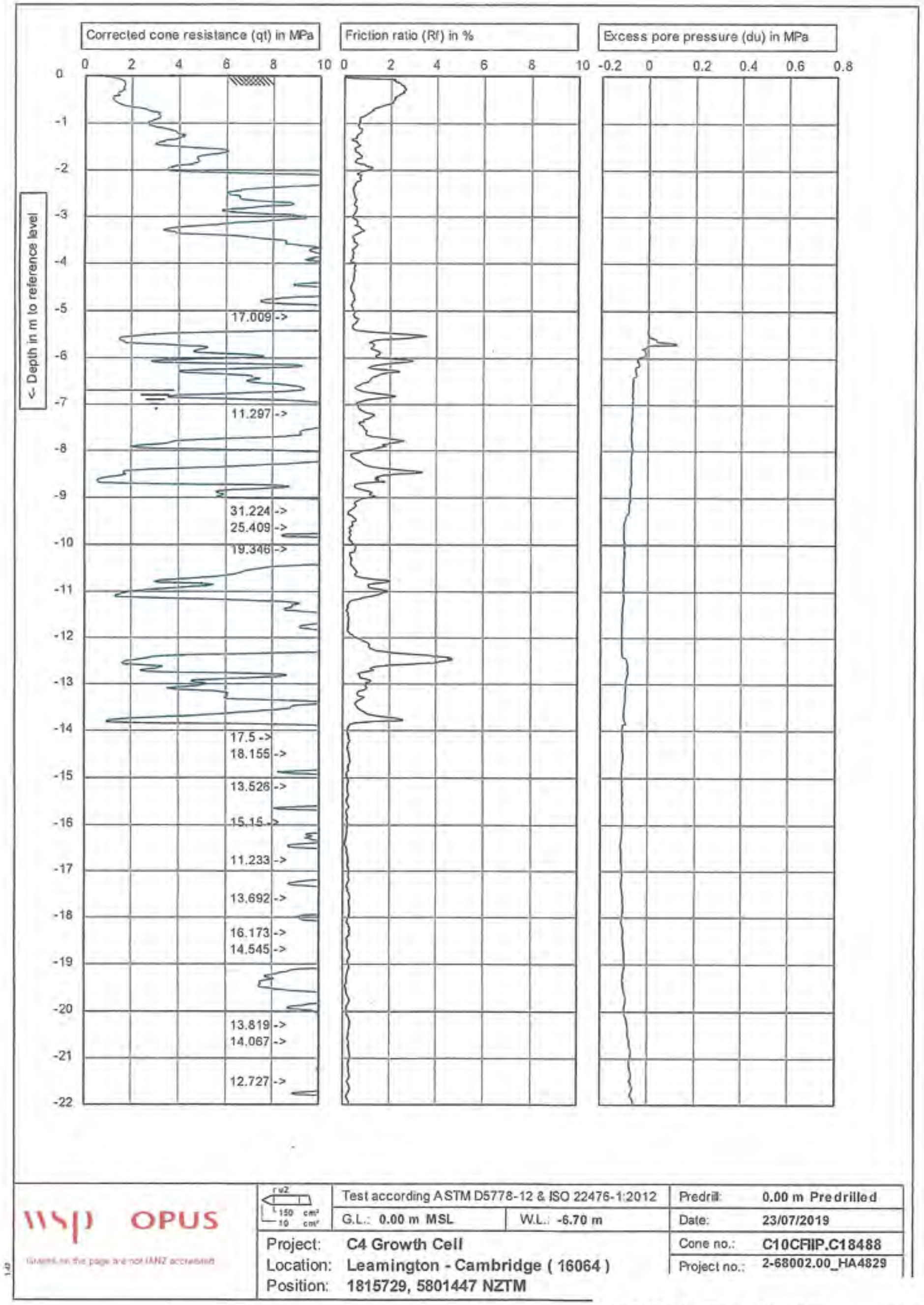
EOH - Dipped - GWL @ 6.7m

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL	W.L.: -6.70 m	Date:	23/07/2019
Project:	C4 Growth Cell	Cone no.:	C10CFIIP.C18488
Location:	Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position:	1815729, 5801447 NZTM		

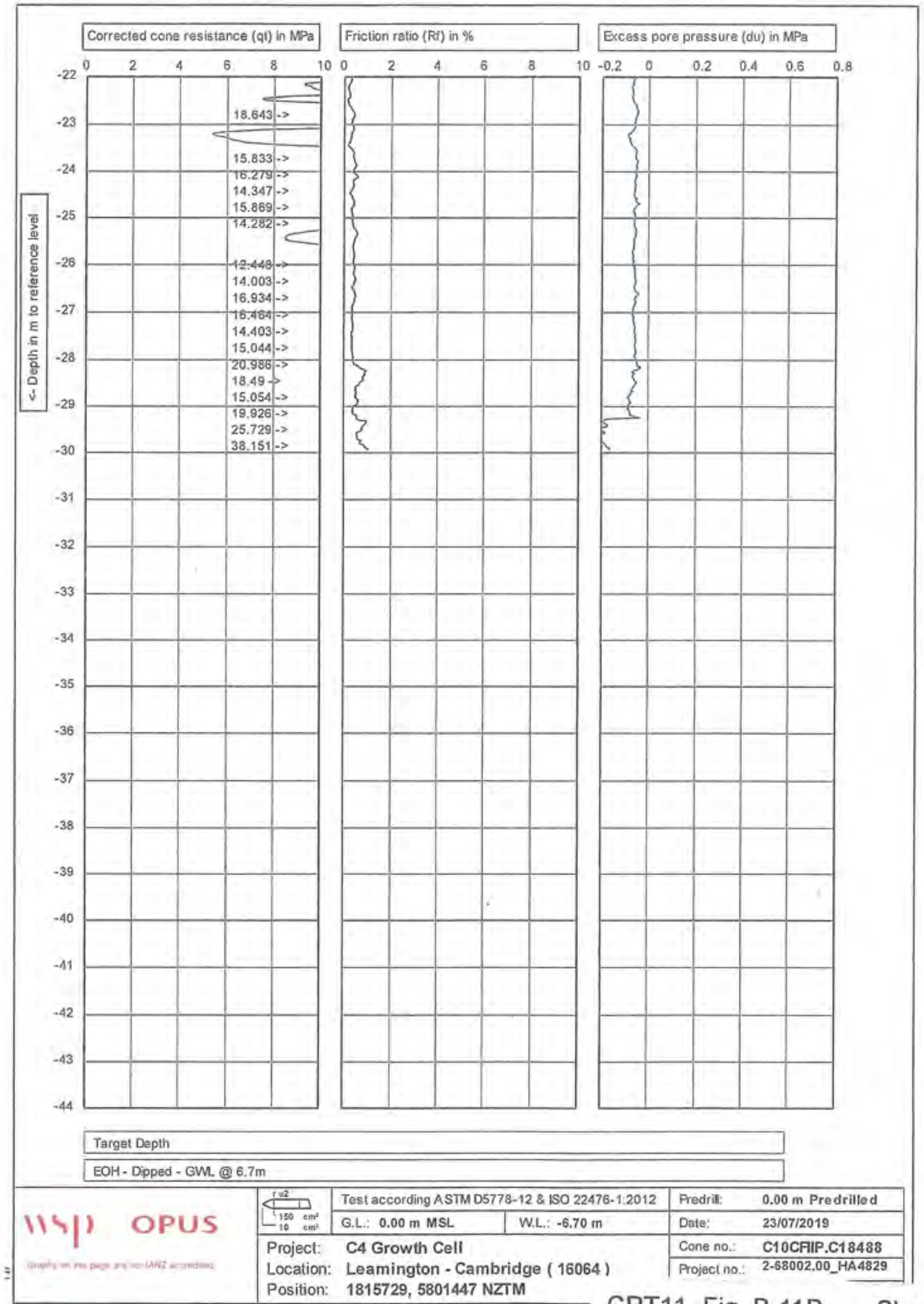
wsp OPUS

IANZ ACCREDITED LABORATORY — Graphs indicated as not accredited are outside the scope of the laboratory's accreditation

CPT11 Fig. B-11A Sheet 2

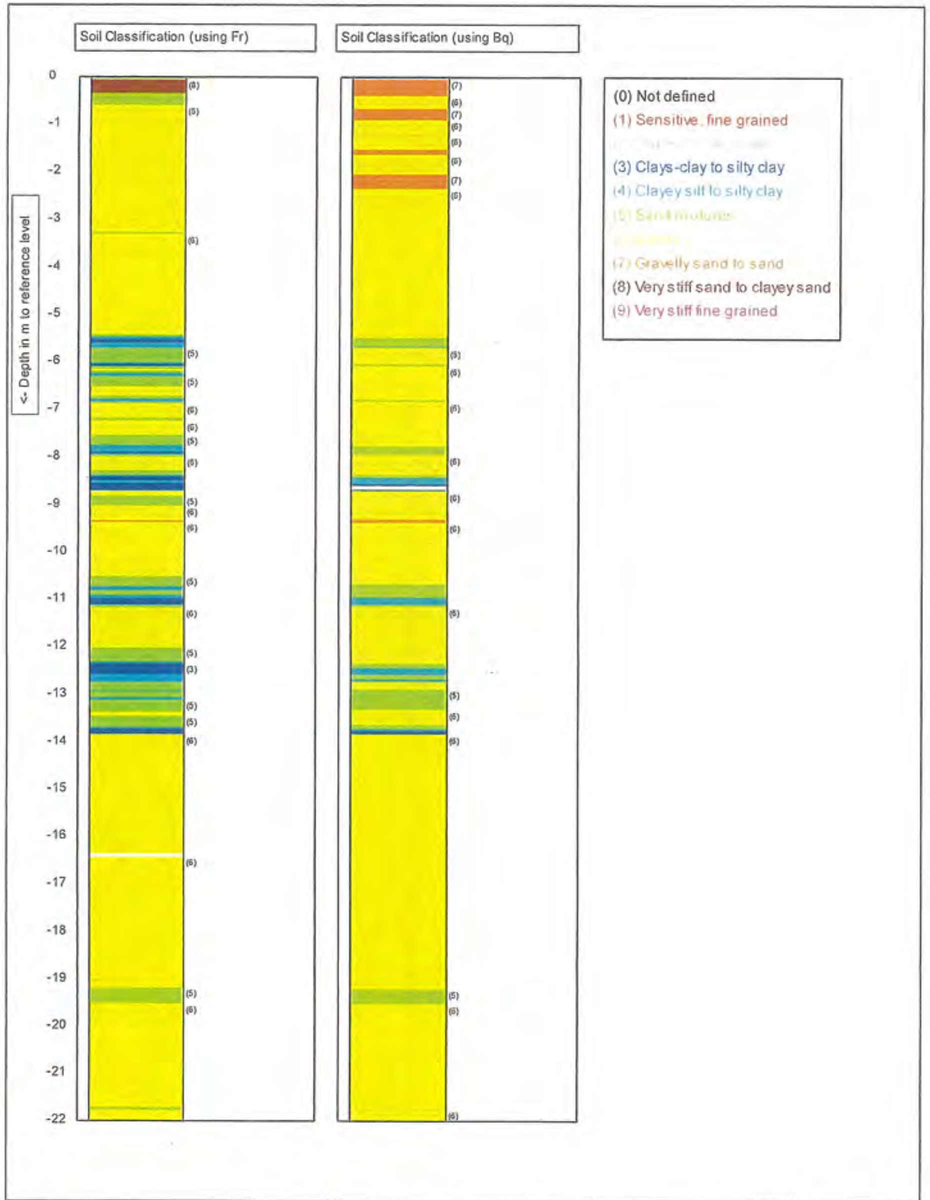


CPT11 Fig. B-11B Sheet 1



CPT11 Fig. B-11B Sheet 2

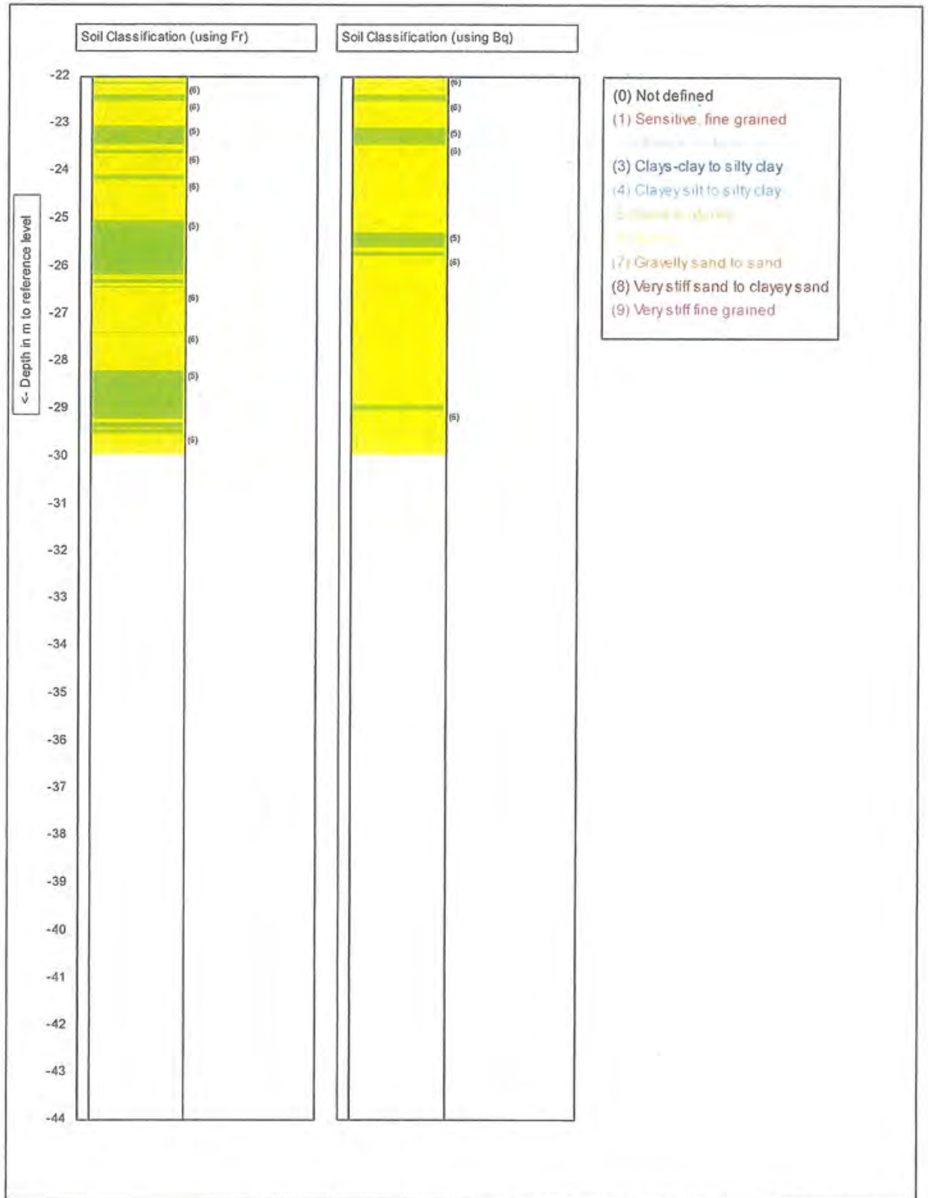
Document Set ID: 10107014
Version: 1, Version Date: 01/10/2019



Test according ASTM D5778-12 & ISO 22476-1:2012

G.L.: 0.00 m MSL	W.L.: -6.70 m	Predrill:	0.00 m Predrilled
Project: C4 Growth Cell		Date:	23/07/2019
Location: Leamington - Cambridge (16064)		Cone no.:	C10CFIIP.C18488
Position: 1815729, 5801447 NZTM		Project no.:	2-68002.00_HA4829

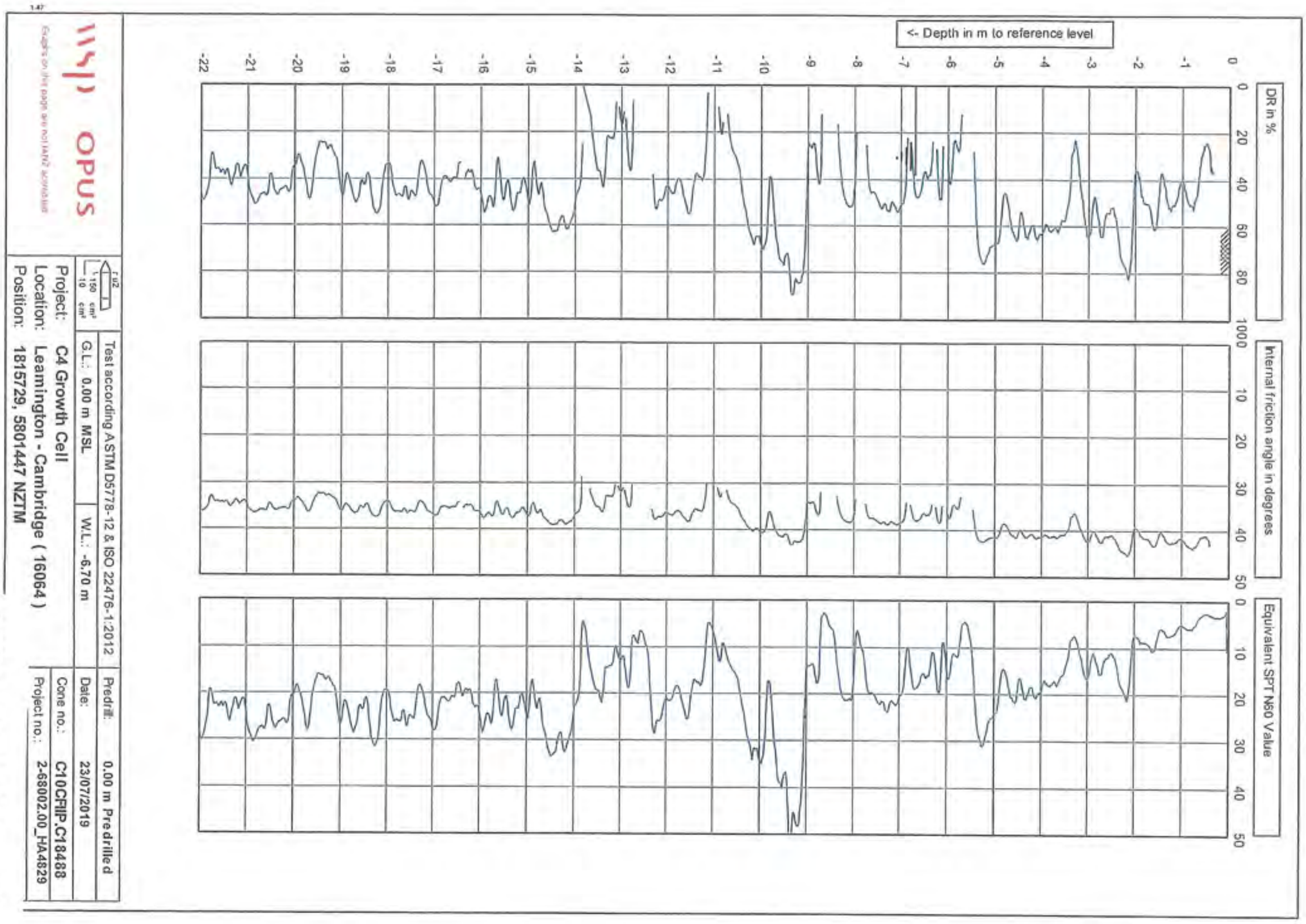
CPT11 Fig. B-11C Sheet 1



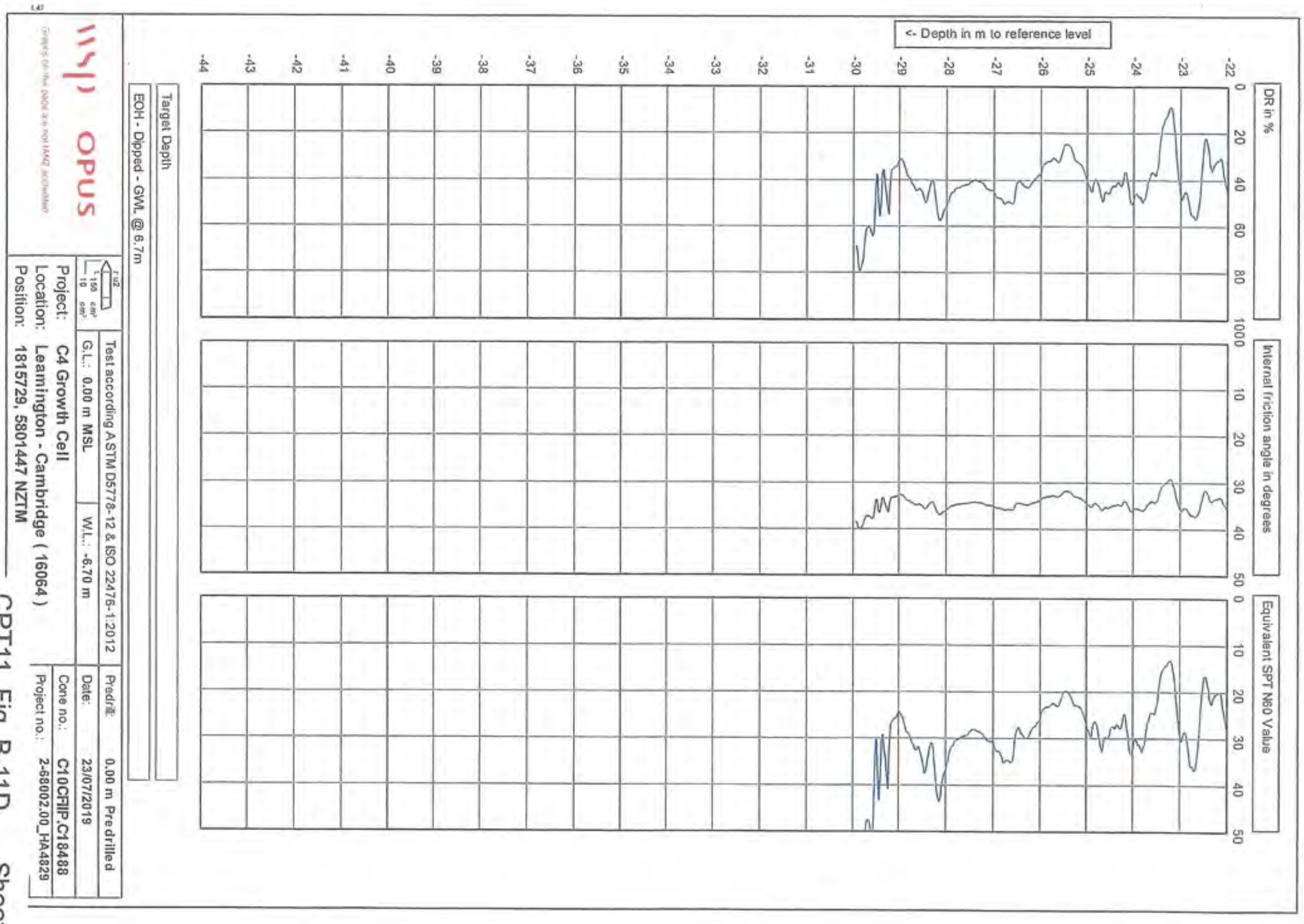
Test according ASTM D5778-12 & ISO 22476-1:2012

G.L.: 0.00 m MSL	W.L.: -6.70 m	Predrill:	0.00 m Predrilled
Project: C4 Growth Cell		Date:	23/07/2019
Location: Leamington - Cambridge (16064)		Cone no.:	C10CFIIP.C18488
Position: 1815729, 5801447 NZTM		Project no.:	2-68002.00_HA4829

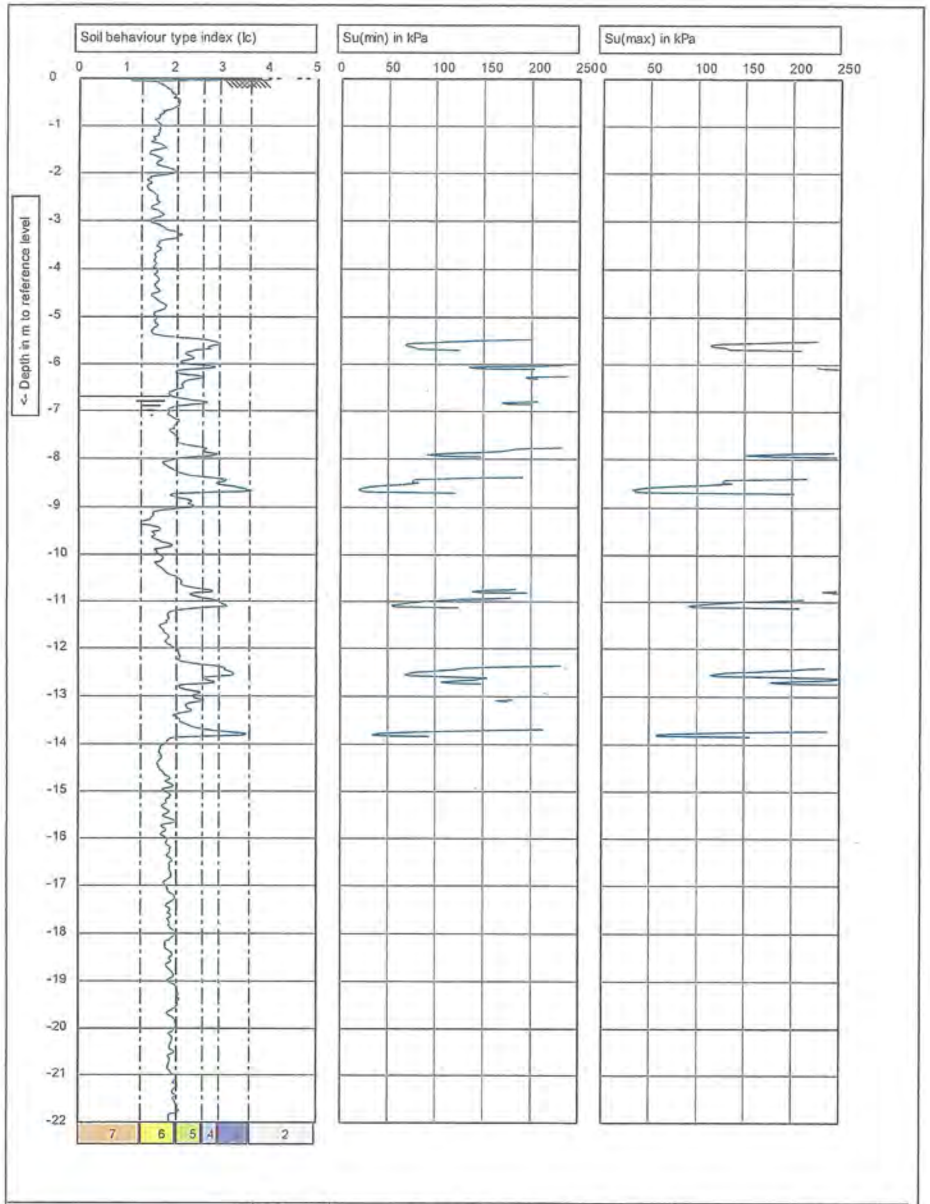
CPT11 Fig. B-11C Sheet 2



CPT11 Fig. B-11D Sheet 1



CPT11 Fig. B-11D Sheet 2

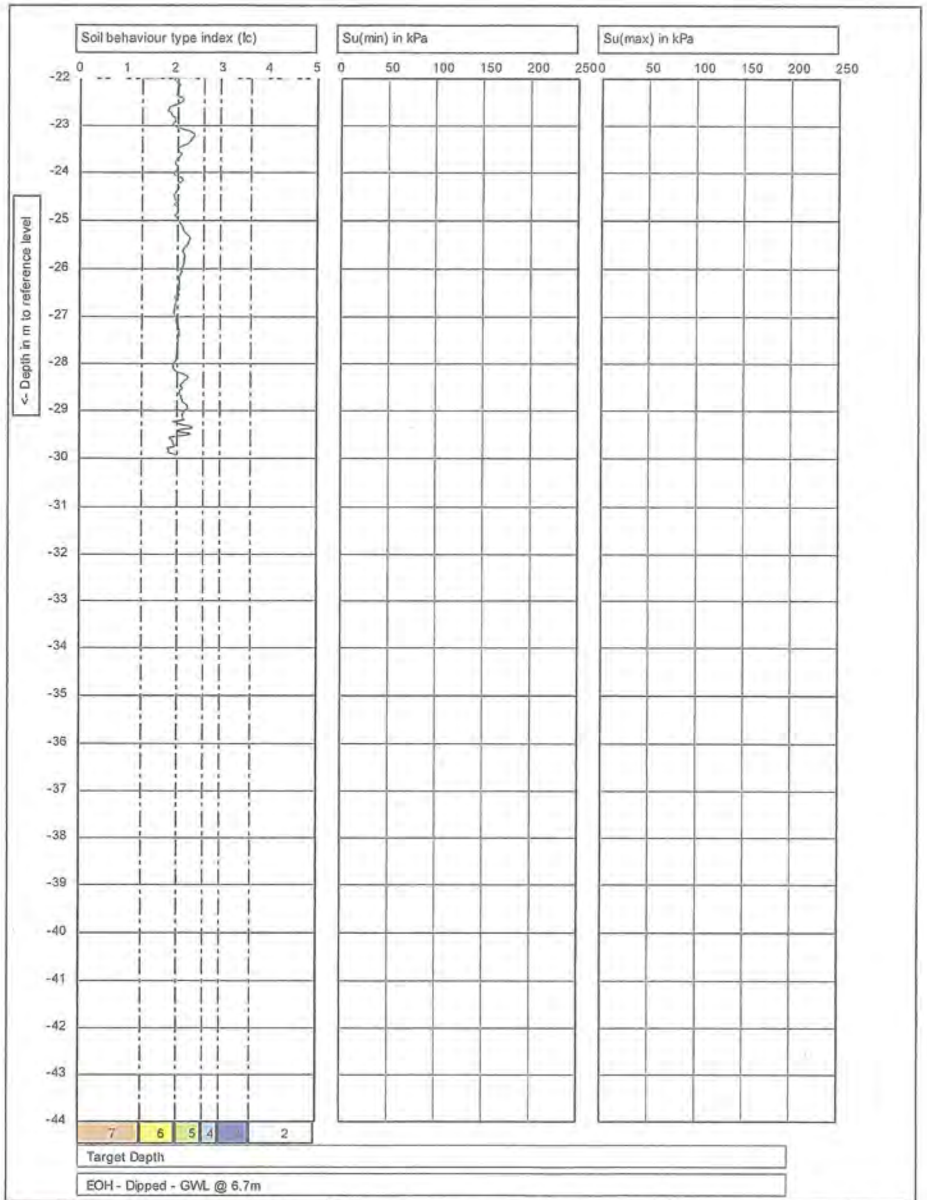


Test according ASTM D5778-12 & ISO 22476-1:2012 | G.L.: 0.00 m MSL | W.L.: -6.70 m

Predrill: 0.00 m Predrilled
Date: 23/07/2019
Cone no.: C10CFIIP.C18488
Project no.: 2-68002.00_HA4829

Project: C4 Growth Cell
Location: Leamington - Cambridge (16064)
Position: 1815729, 5801447 NZTM

CPT11 Fig. B-11E Sheet 1



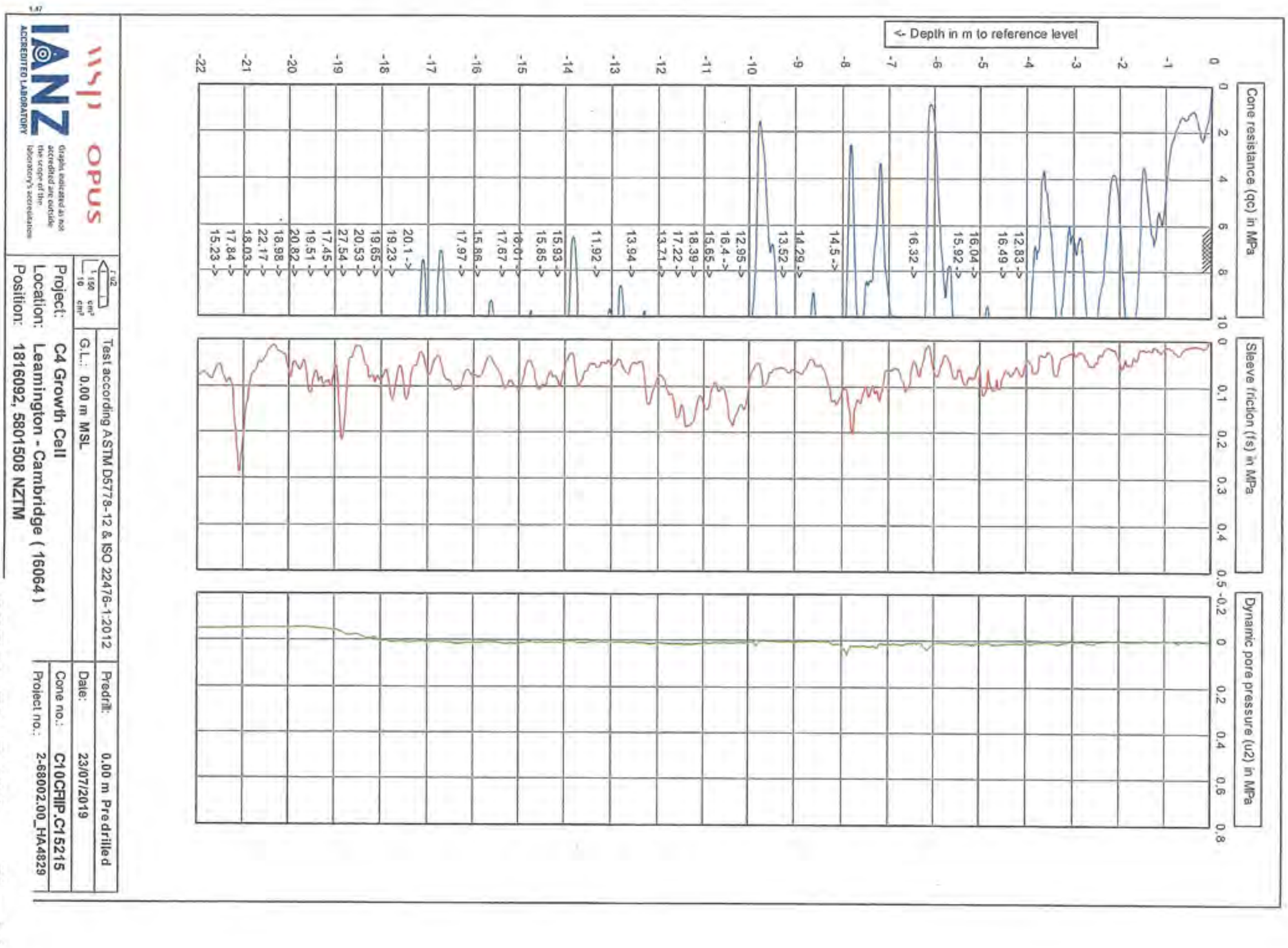
Test according ASTM D5778-12 & ISO 22476-1:2012 | G.L.: 0.00 m MSL | W.L.: -6.70 m

Predrill: 0.00 m Predrilled
Date: 23/07/2019
Cone no.: C10CFIIP.C18488
Project no.: 2-68002.00_HA4829

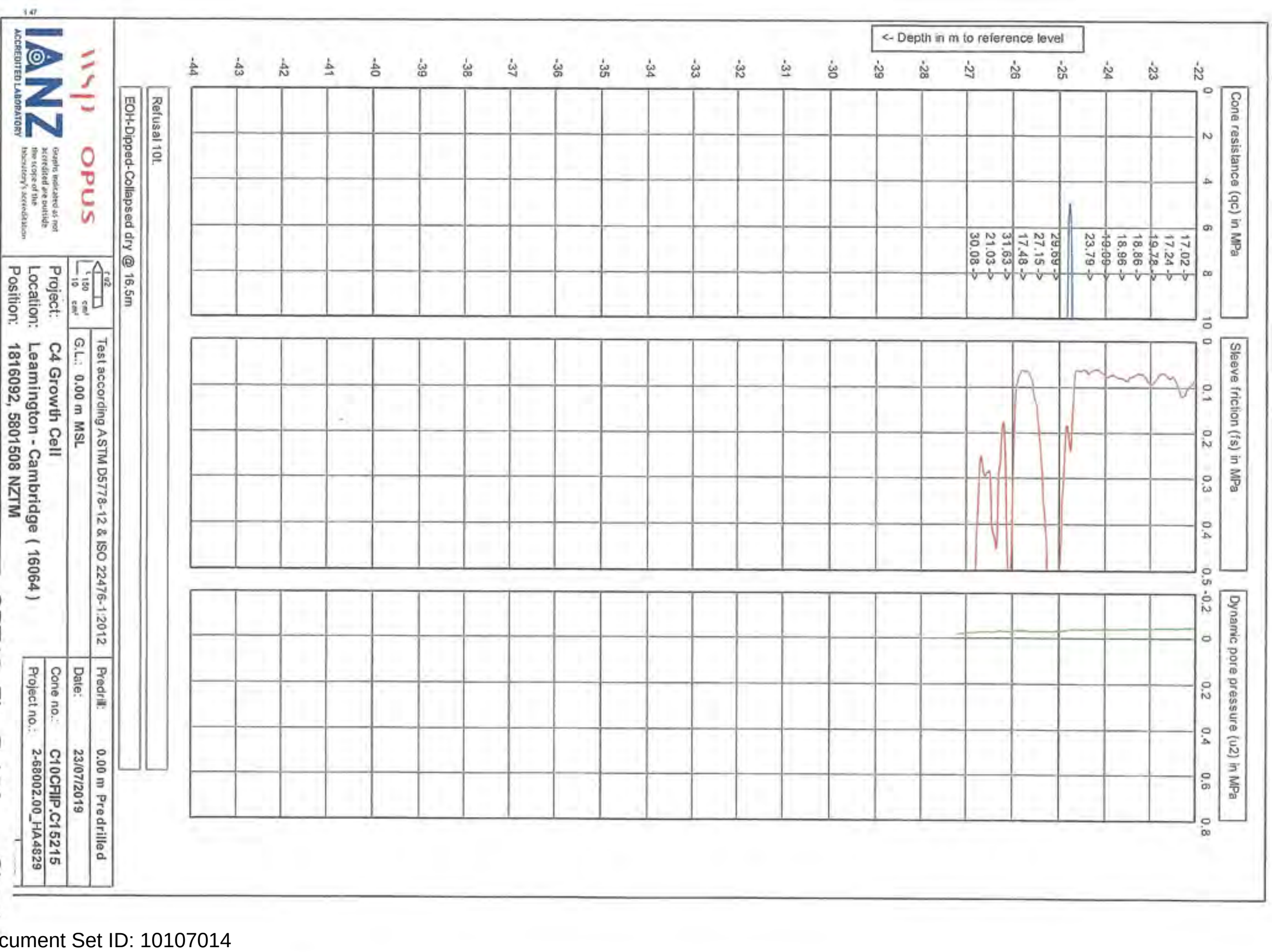
Project: C4 Growth Cell
Location: Leamington - Cambridge (16064)
Position: 1815729, 5801447 NZTM

CPT11 Fig. B-11E Sheet 2

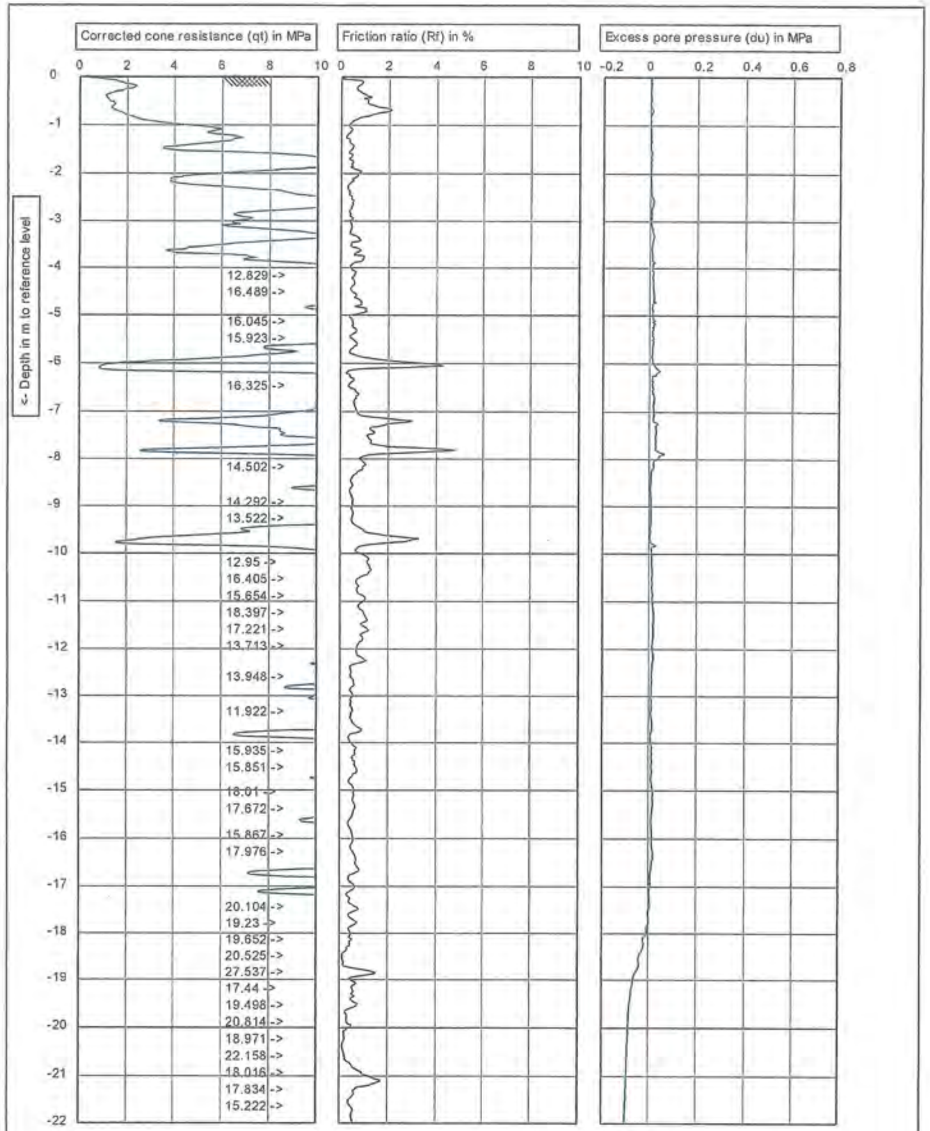
CPT No. 12



<- Depth in m to reference level
Cone resistance (qc) in MPa
Sleeve friction (fs) in MPa
Dynamic pore pressure (u2) in MPa
Test according ASTM D5778-12 & ISO 22476-1:2012
G.L.: 0.00 m MSL
Project: C4 Growth Cell
Location: Leamington - Cambridge (16064)
Position: 1816092, 5801508 NZTM
Predrill: 0.00 m Predrilled
Date: 23/07/2019
Cone no.: C10CFIIP.C15215
Project no.: 2-68002.00_HA4829
CPT12 Fig. B-12A Sheet 1

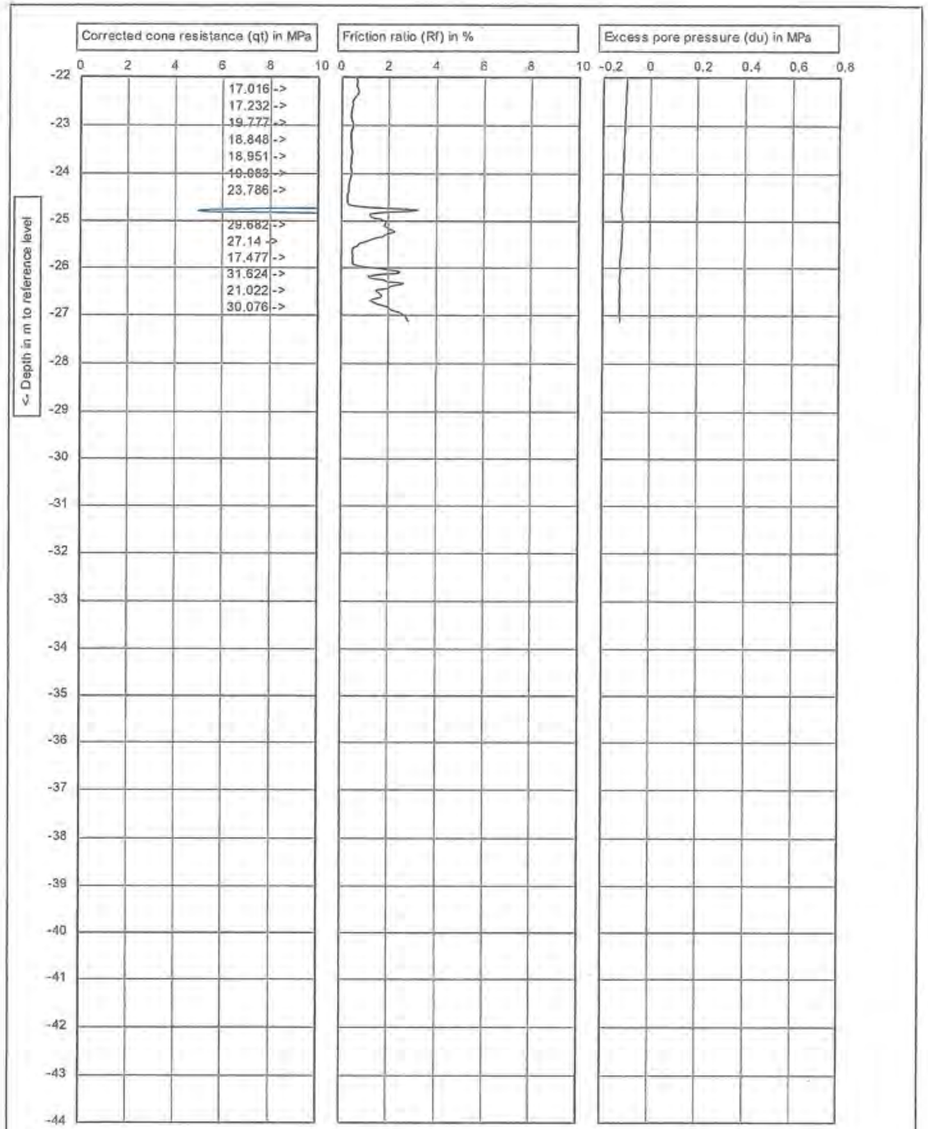


<- Depth in m to reference level
Cone resistance (qc) in MPa
Sleeve friction (fs) in MPa
Dynamic pore pressure (u2) in MPa
Refusal 10t
EOH-Dipped-Collapsed dry @ 16.5m
Test according ASTM D5778-12 & ISO 22476-1:2012
G.L.: 0.00 m MSL
Project: C4 Growth Cell
Location: Leamington - Cambridge (16064)
Position: 1816092, 5801508 NZTM
Predrill: 0.00 m Predrilled
Date: 23/07/2019
Cone no.: C10CFIIP.C15215
Project no.: 2-68002.00_HA4829
CPT12 Fig. B-12A Sheet 2



Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL		Date:	23/07/2019
Project:	C4 Growth Cell	Cone no.:	C10CFIIP.C15215
Location:	Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position:	1816092, 5801508 NZTM		

CPT12 Fig. B-12B Sheet 1

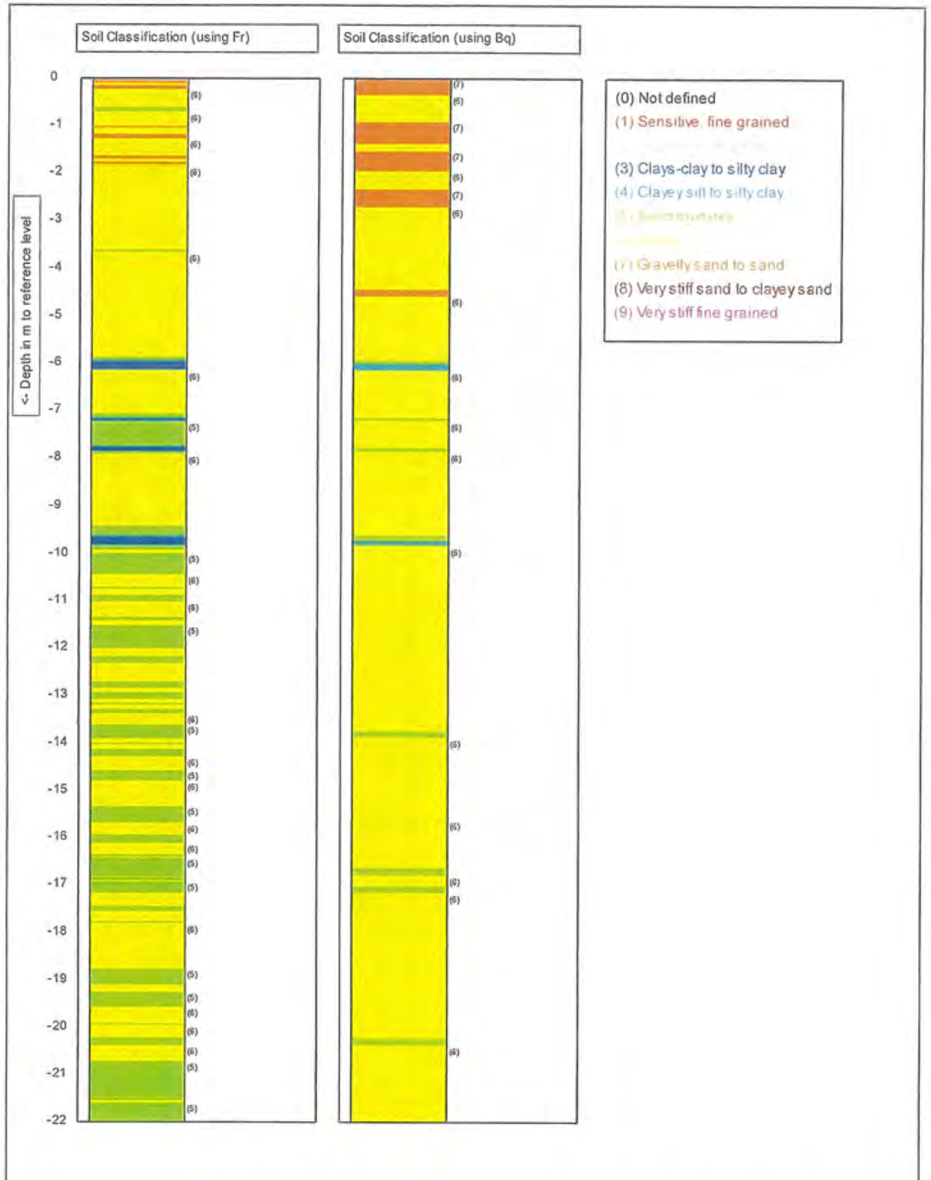


Refusal 10t

EOH-Dipped-Collapsed dry @ 16.5m

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL		Date:	23/07/2019
Project:	C4 Growth Cell	Cone no.:	C10CFIIP.C15215
Location:	Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position:	1816092, 5801508 NZTM		

CPT12 Fig. B-12B Sheet 2

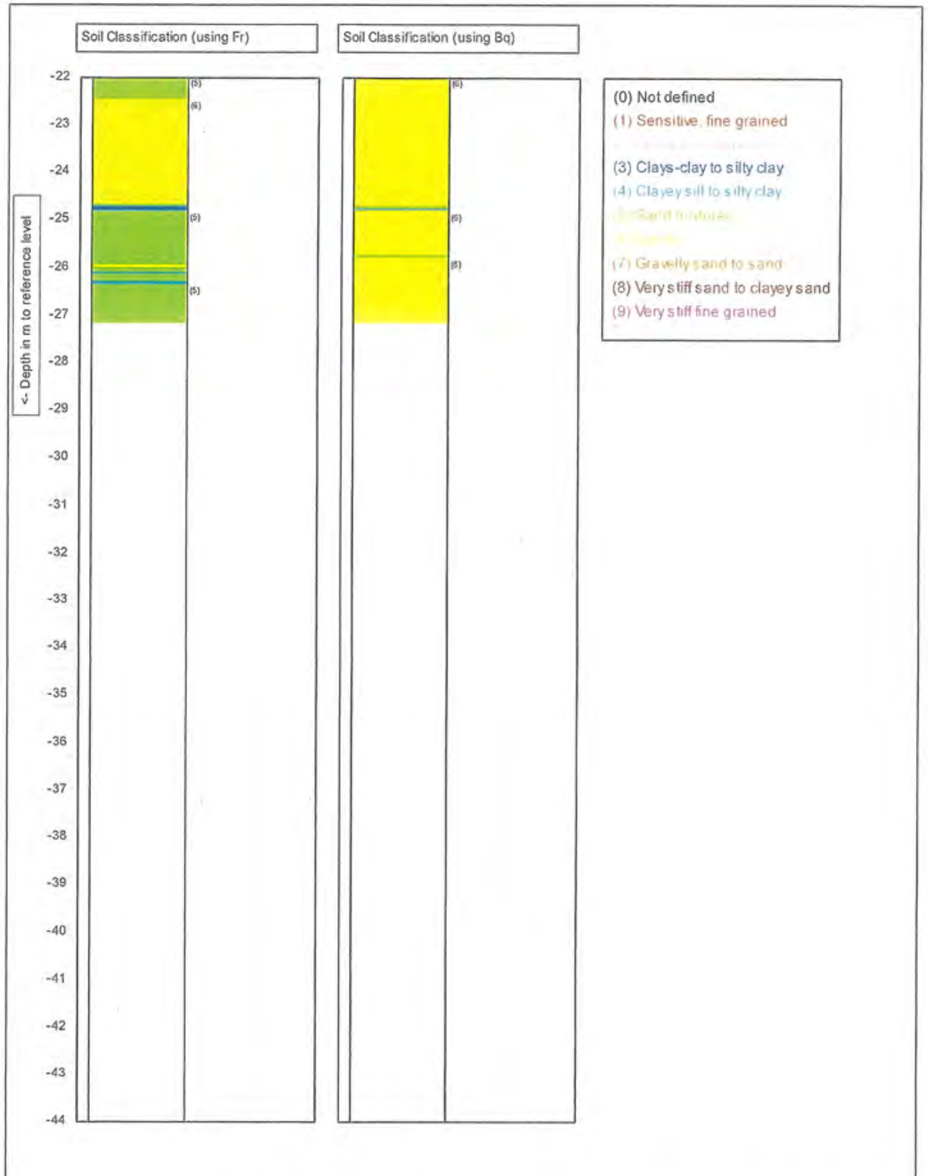


wsp OPUS

Graphs on this page are not IANZ accredited

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL		Date:	23/07/2019
Project:	C4 Growth Cell	Cone no.:	C10CFIIP.C15215
Location:	Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position:	1816092, 5801508 NZTM		

CPT12 Fig. B-12C Sheet 1

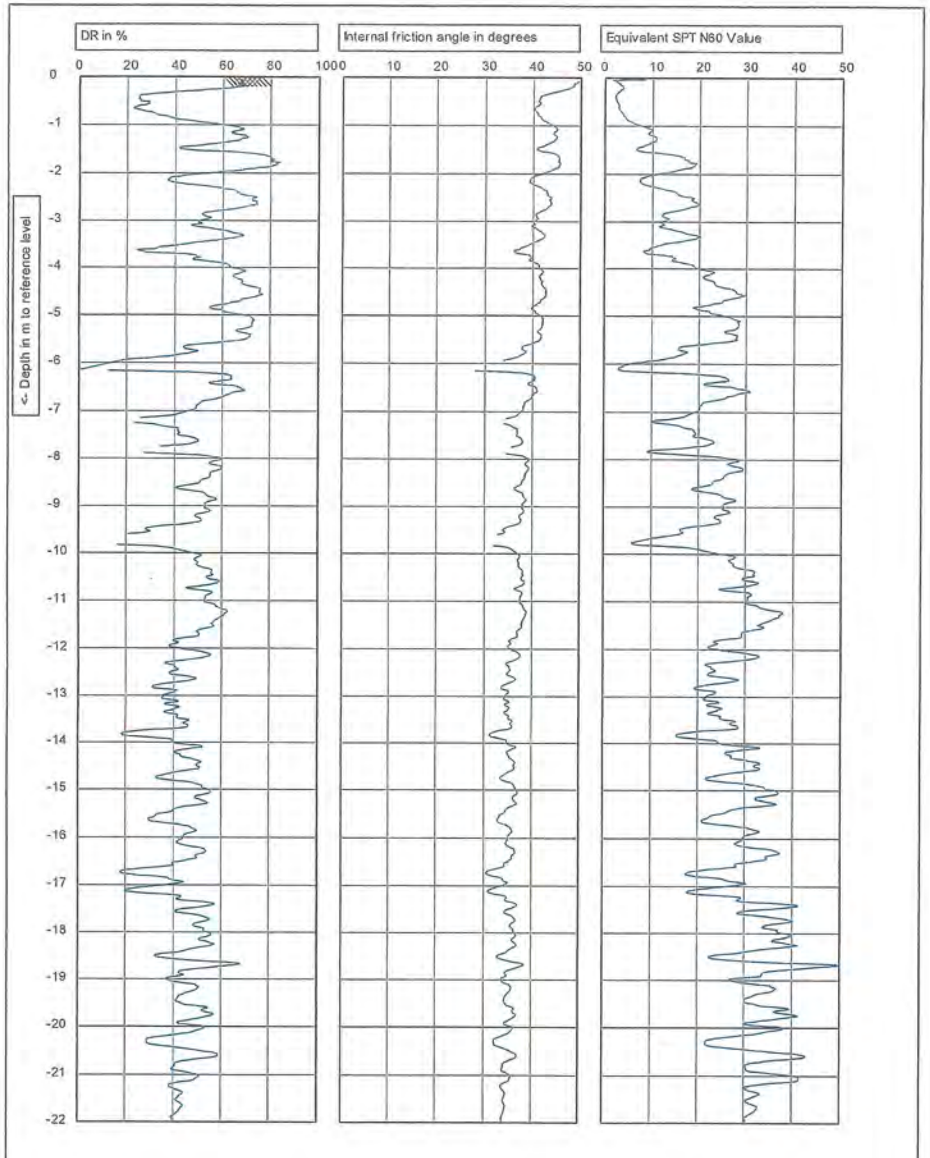


wsp OPUS

Graphs on this page are not IANZ accredited

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL		Date:	23/07/2019
Project:	C4 Growth Cell	Cone no.:	C10CFIIP.C15215
Location:	Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position:	1816092, 5801508 NZTM		

CPT12 Fig. B-12C Sheet 2



Refusal 10t.

EOH-Dipped-Collapsed dry @ 16.5m

Graphs on this page are not IANZ accredited

Test according ASTM D5778-12 & ISO 22476-1:2012

G.L.: 0.00 m MSL

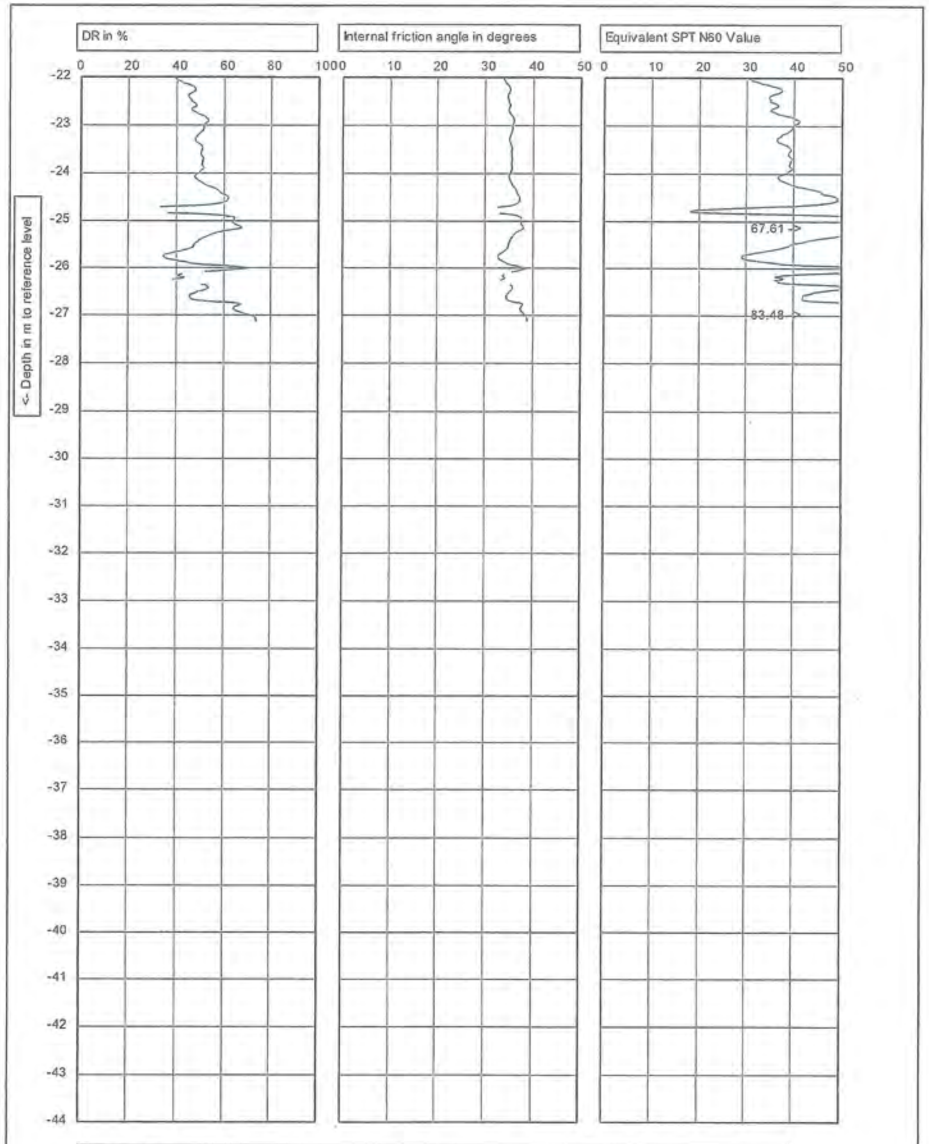
Project: C4 Growth Cell

Location: Leamington - Cambridge (16064)

Position: 1816092, 5801508 NZTM

Predrill:	0.00 m Predrilled
Date:	23/07/2019
Cone no.:	C10CFIIP.C15215
Project no.:	2-68002.00_HA4829

CPT12 Fig. B-12D Sheet 1



Refusal 10t.

EOH-Dipped-Collapsed dry @ 16.5m

Graphs on this page are not IANZ accredited

Test according ASTM D5778-12 & ISO 22476-1:2012

G.L.: 0.00 m MSL

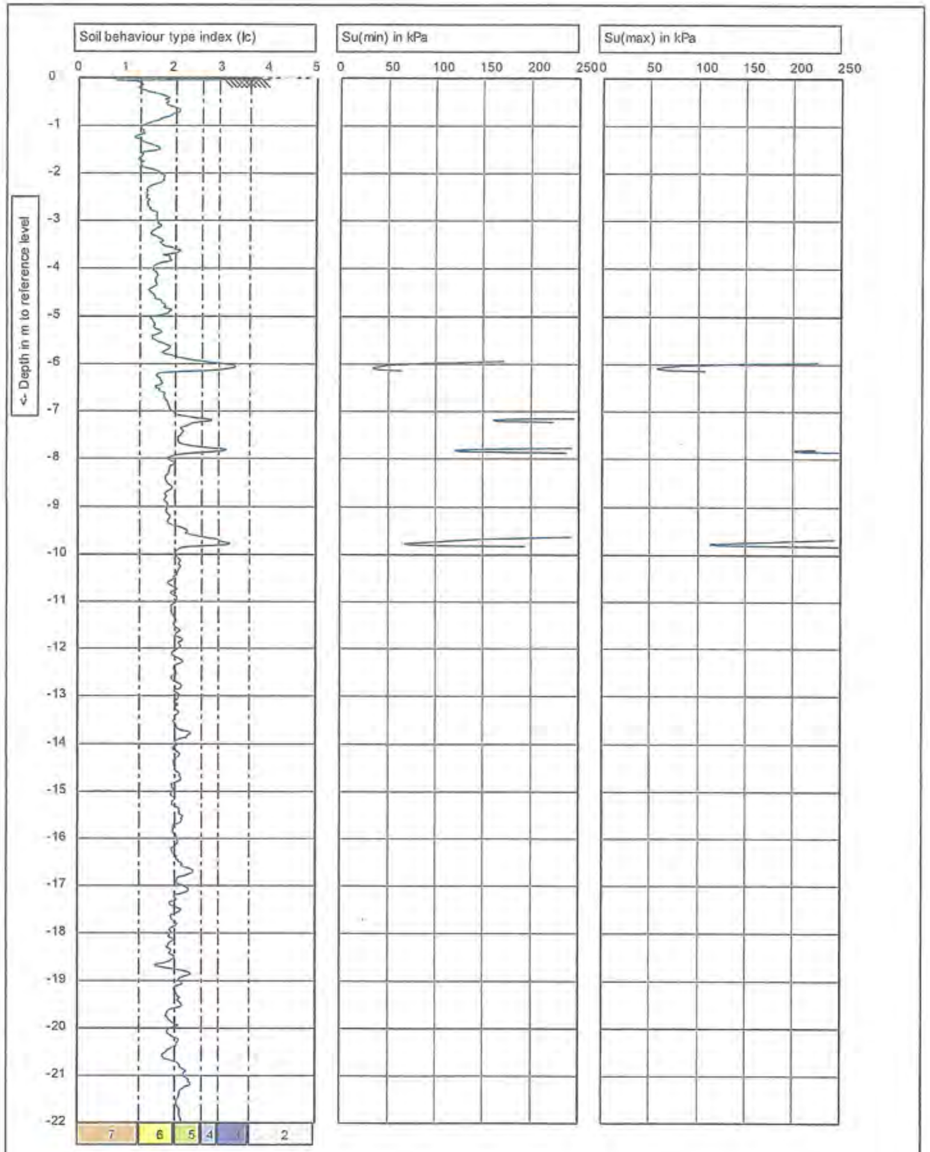
Project: C4 Growth Cell

Location: Leamington - Cambridge (16064)

Position: 1816092, 5801508 NZTM

Predrill:	0.00 m Predrilled
Date:	23/07/2019
Cone no.:	C10CFIIP.C15215
Project no.:	2-68002.00_HA4829

CPT12 Fig. B-12D Sheet 2

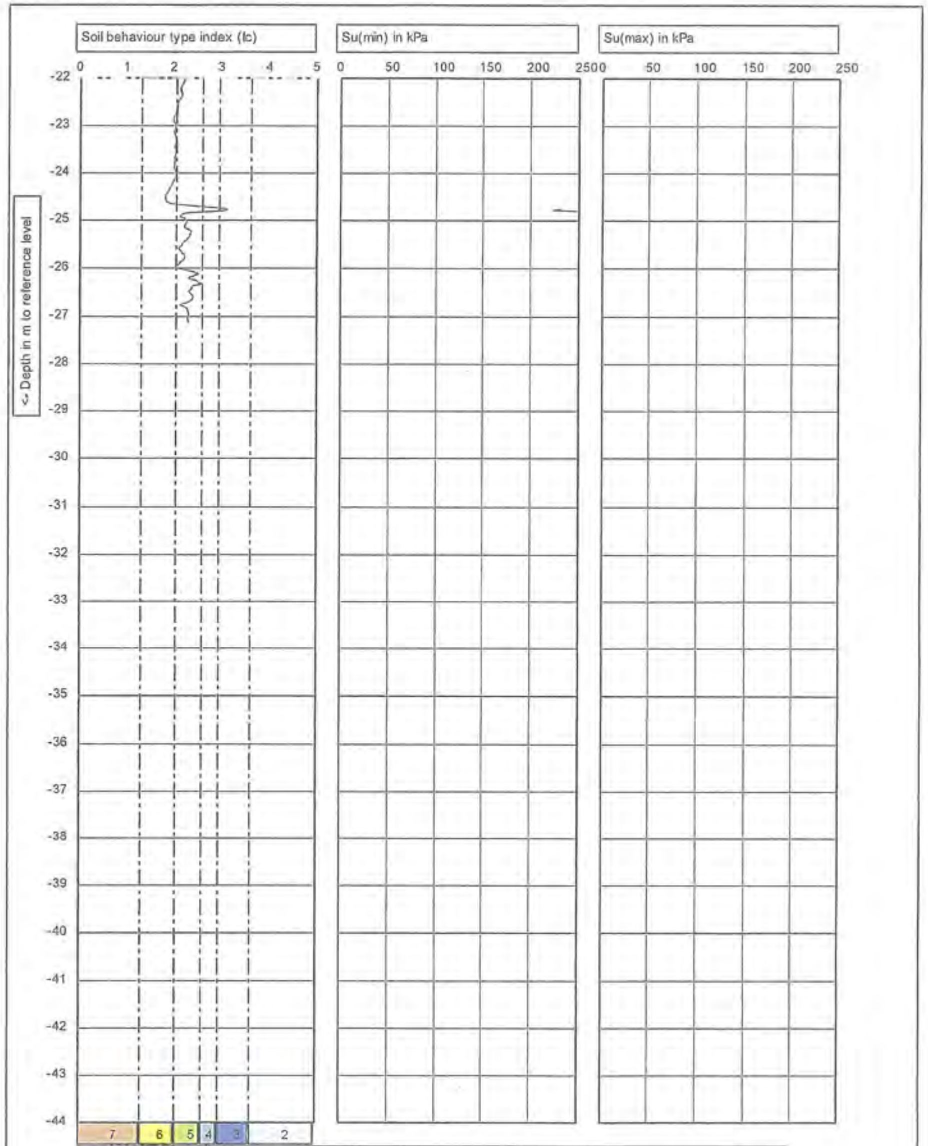


Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL		Date:	23/07/2019
Project:	C4 Growth Cell	Cone no.:	C10CFIIP.C15215
Location:	Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position:	1816092, 5801508 NZTM		

WSP OPUS

Graphs on this page are not IANZ accredited

CPT12 Fig. B-12E Sheet 1



Refusal 10t.

EOH-Dipped-Collapsed dry @ 16.5m

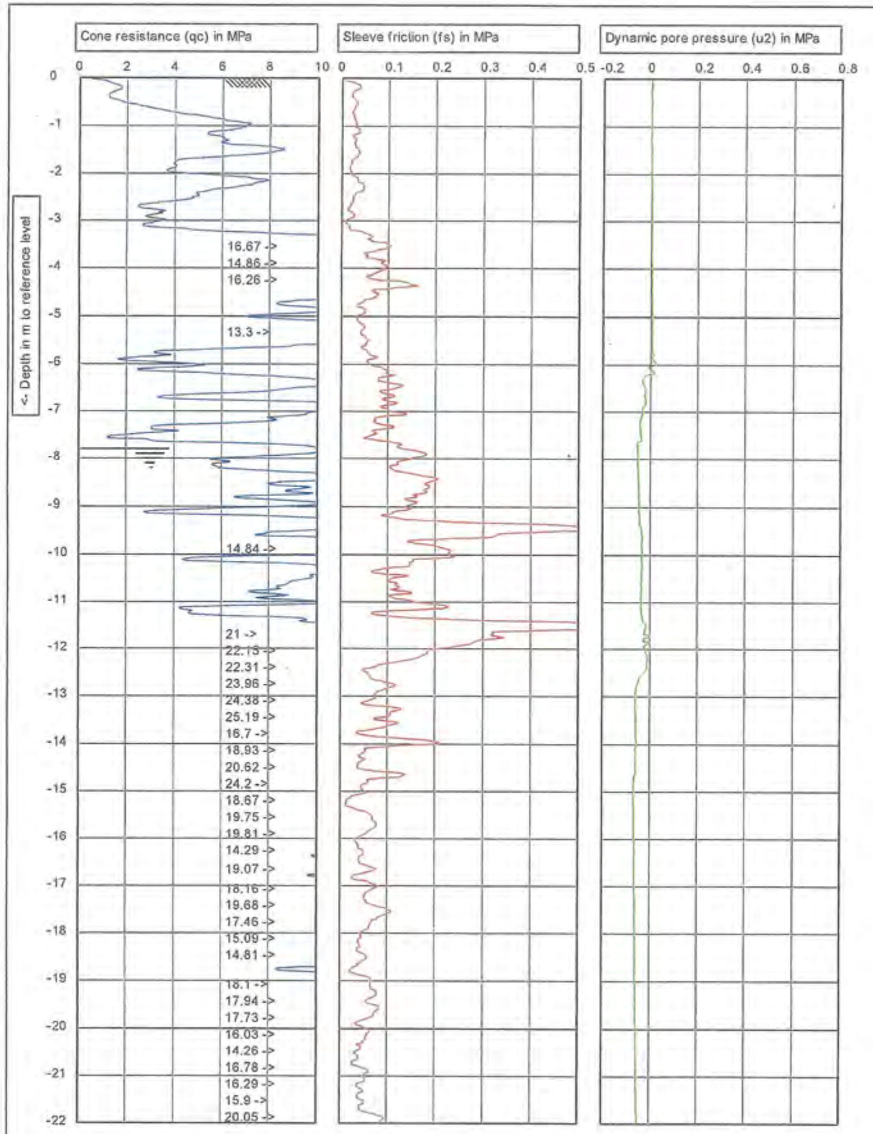
Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL		Date:	23/07/2019
Project:	C4 Growth Cell	Cone no.:	C10CFIIP.C15215
Location:	Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position:	1816092, 5801508 NZTM		

WSP OPUS

Graphs on this page are not IANZ accredited

CPT12 Fig. B-12E Sheet 2

CPT No. 13

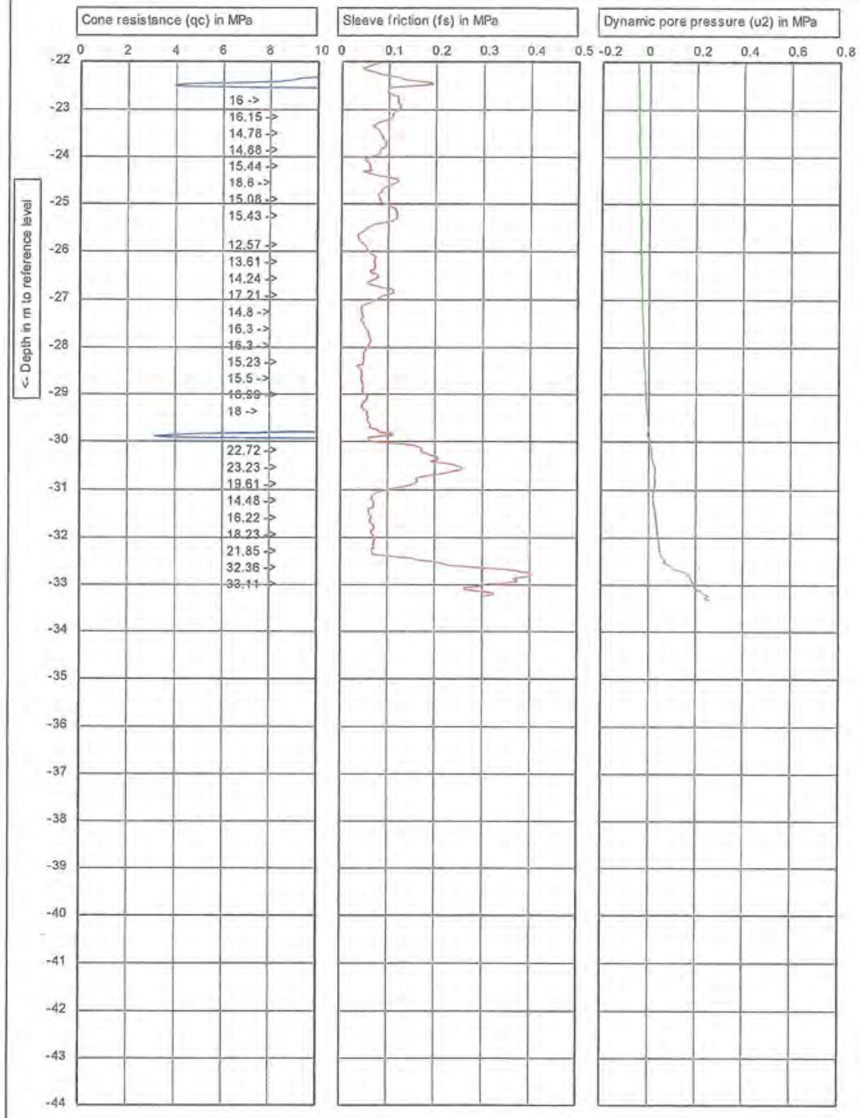


Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL	W.L.: -7.80 m	Date:	23/07/2019
Project:	C4 Growth Cell	Cone no.:	C10CFIIP.C15215
Location:	Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position:	1816054, 5801059 NZTM		

wsp OPUS

IANZ ACCREDITED LABORATORY — Graphs indicated as not accredited are outside the scope of the laboratory's accreditation

CPT13 Fig. B-13A Sheet 1



Refusal 10t.

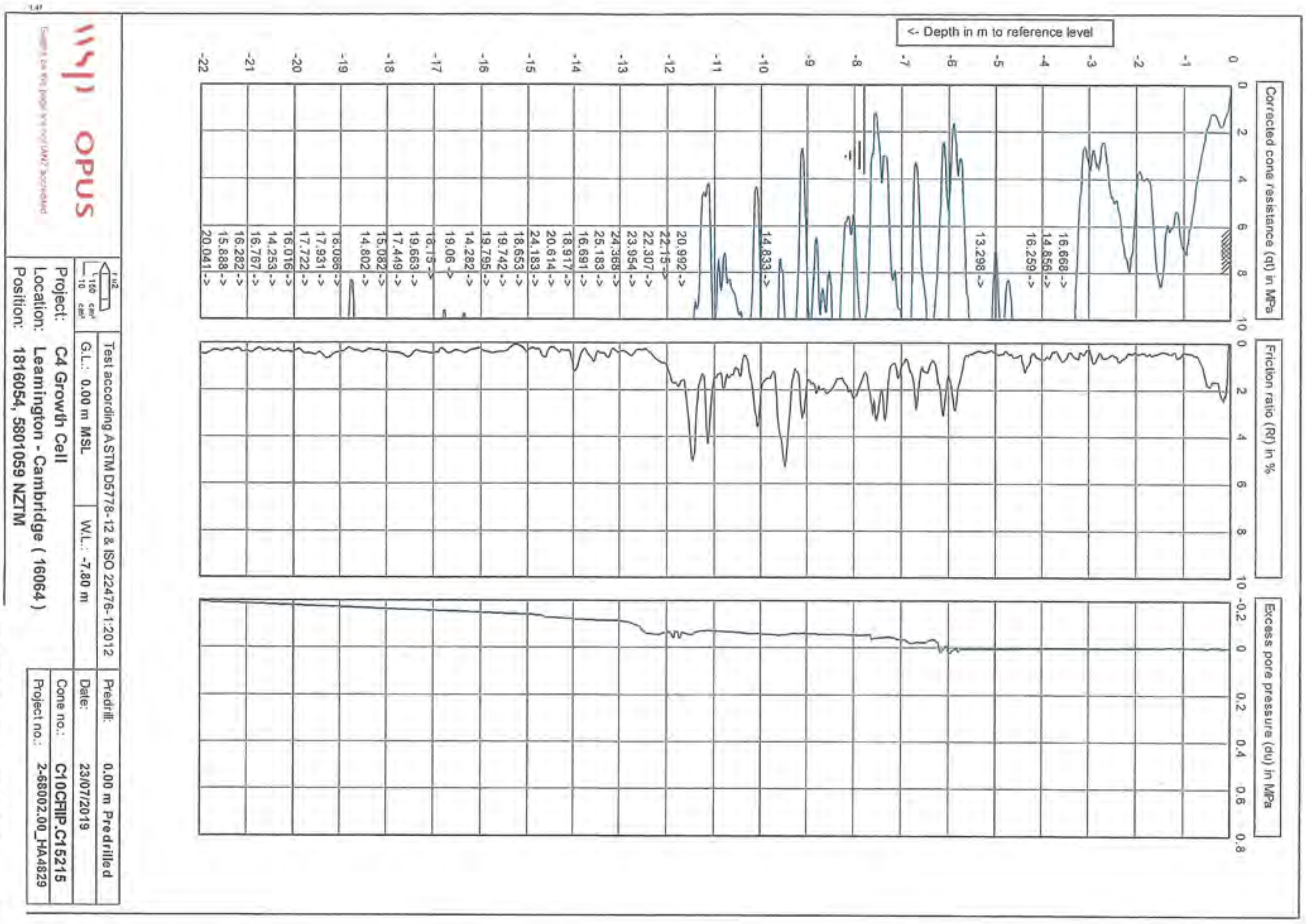
EOH - Dipped - GWL @ 7.8m

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL	W.L.: -7.80 m	Date:	23/07/2019
Project:	C4 Growth Cell	Cone no.:	C10CFIIP.C15215
Location:	Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position:	1816054, 5801059 NZTM		

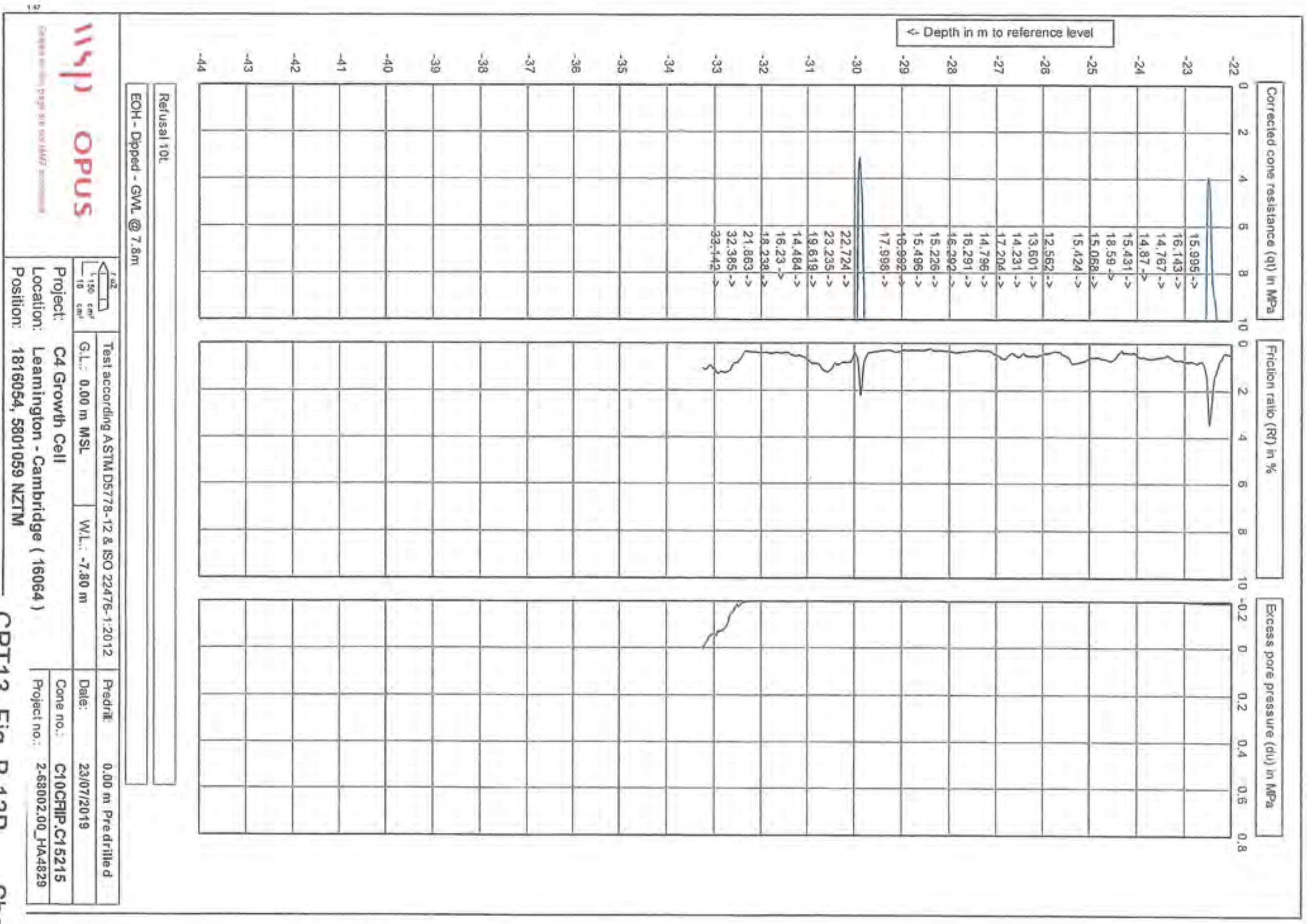
wsp OPUS

IANZ ACCREDITED LABORATORY — Graphs indicated as not accredited are outside the scope of the laboratory's accreditation

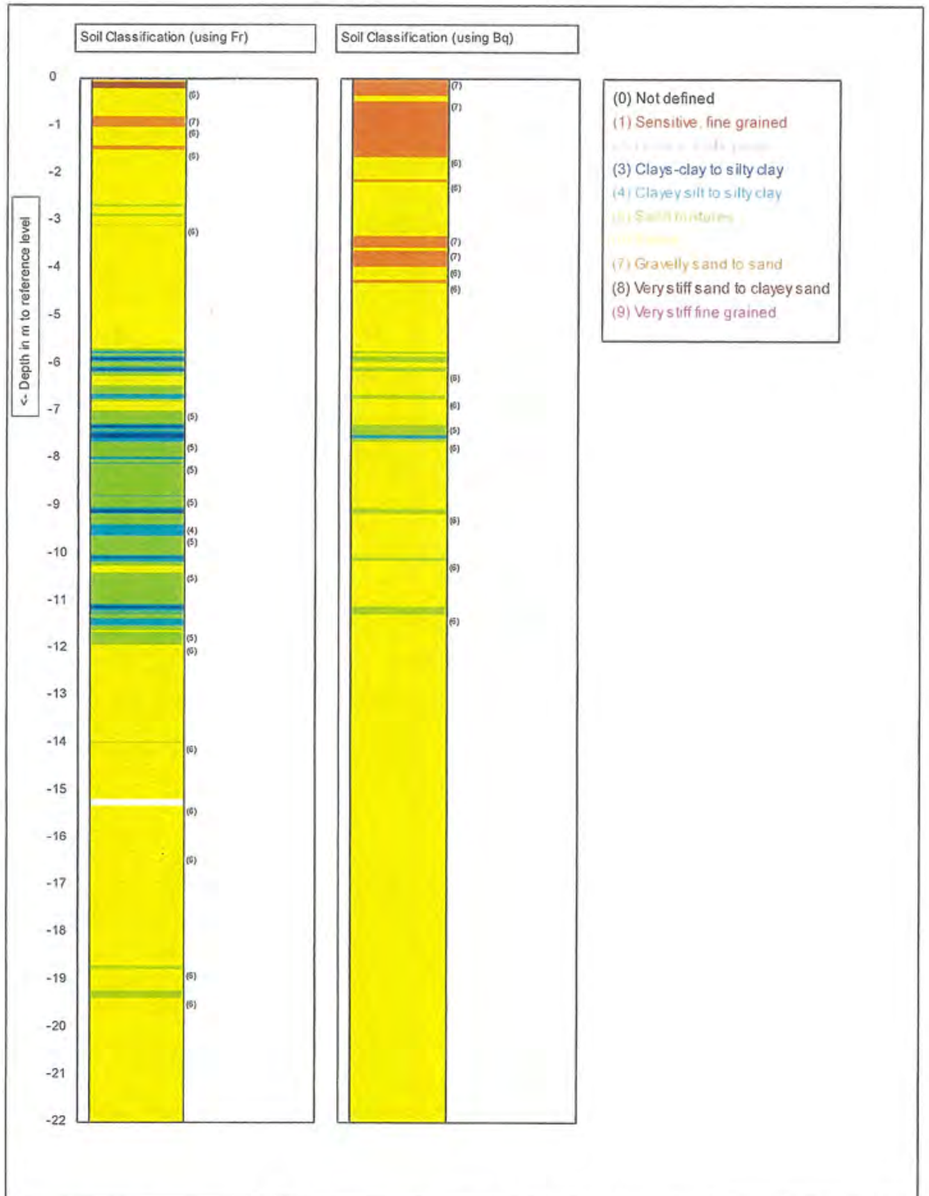
CPT13 Fig. B-13A Sheet 2



CPT13 Fig. B-13B Sheet 1



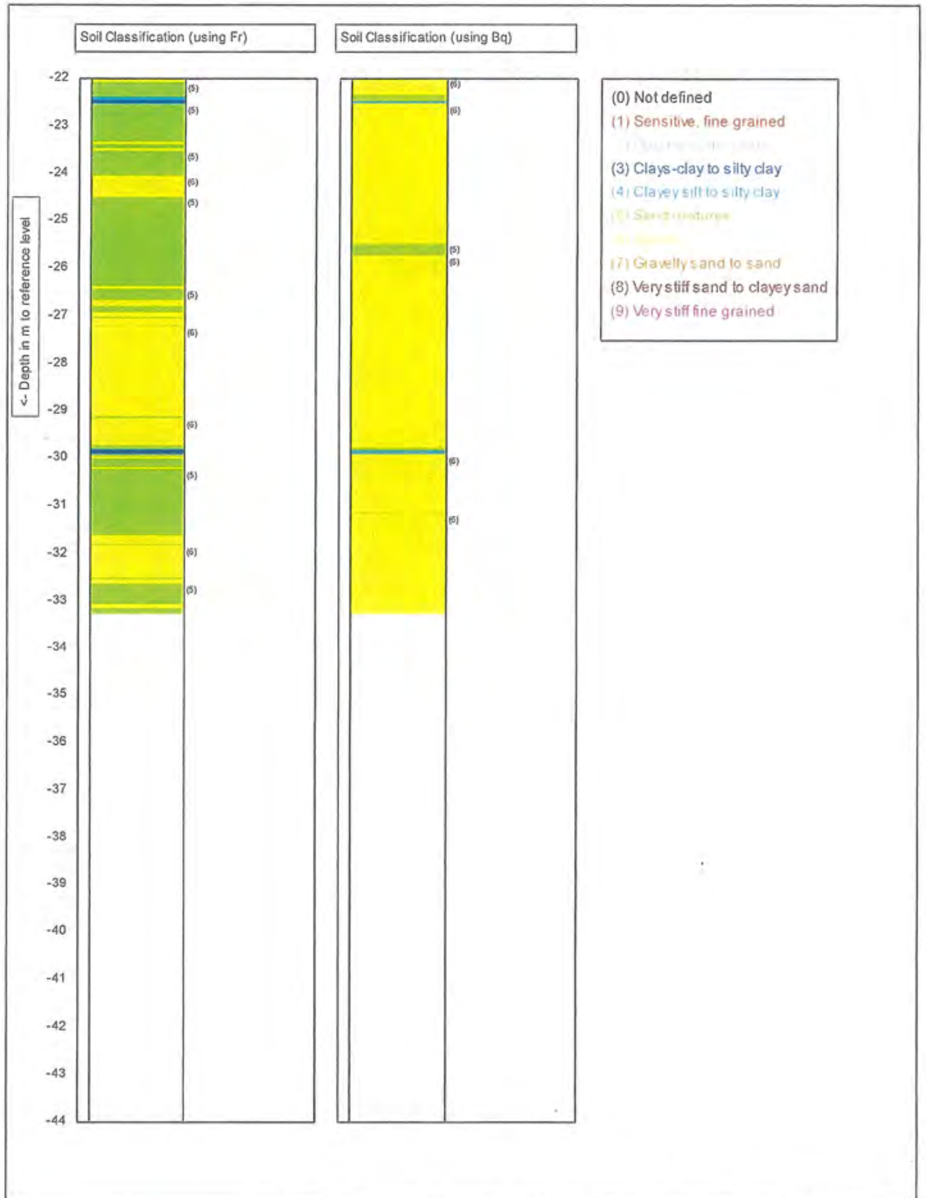
CPT13 Fig. B-13B Sheet 2



wsp OPUS		Test according ASTM D5778-12 & ISO 22476-1:2012			Predrill:	0.00 m Predrilled
		G.L.: 0.00 m MSL		W.L.: -7.80 m	Date:	23/07/2019
	Project:	C4 Growth Cell			Cone no.:	C10CFIIP.C15215
	Location:	Leamington - Cambridge (16064)			Project no.:	2-68002.00_HA4829
	Position:	1816054, 5801059 NZTM				

Graphs on this page are not IANZ accredited

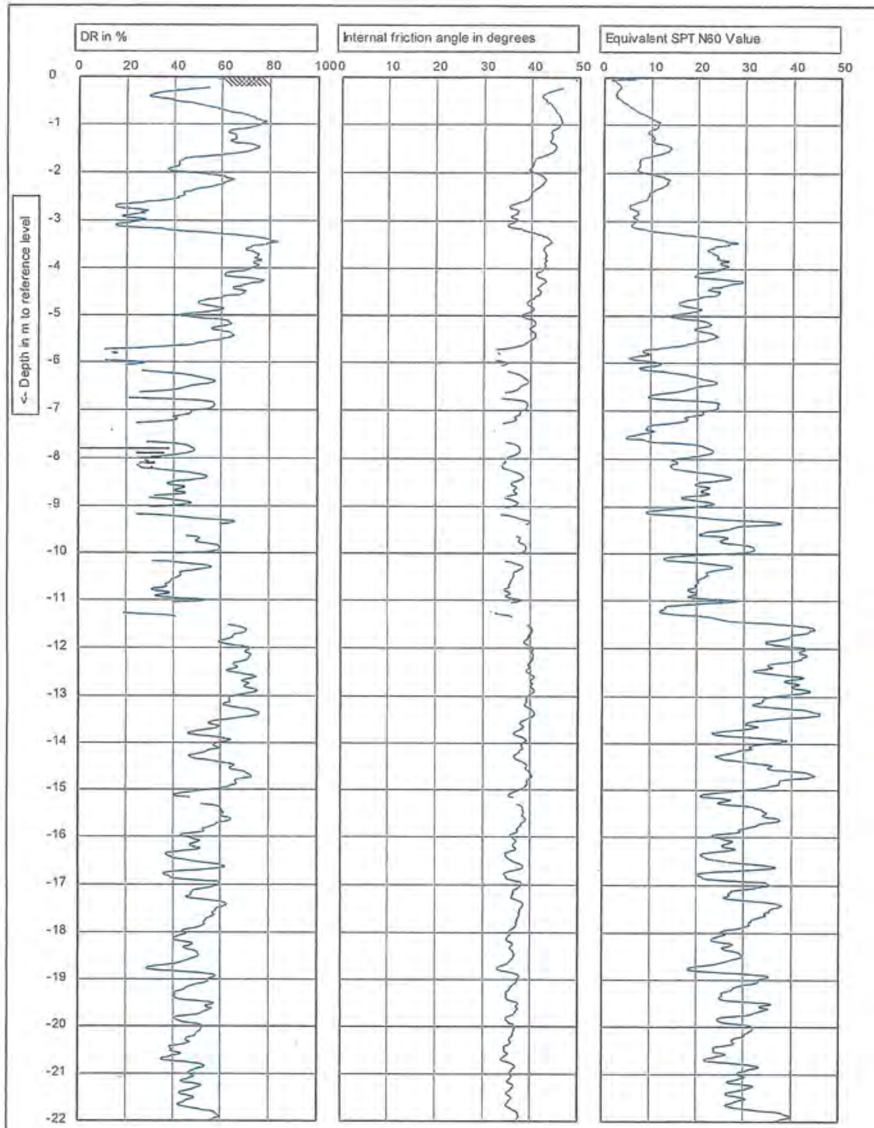
CPT13 Fig. B-13C Sheet 1



wsp OPUS		Test according ASTM D5778-12 & ISO 22476-1:2012			Predrill:	0.00 m Predrilled
		G.L.: 0.00 m MSL		W.L.: -7.80 m	Date:	23/07/2019
	Project:	C4 Growth Cell			Cone no.:	C10CFIIP.C15215
	Location:	Leamington - Cambridge (16064)			Project no.:	2-68002.00_HA4829
	Position:	1816054, 5801059 NZTM				

Graphs on this page are not IANZ accredited

CPT13 Fig. B-13C Sheet 2

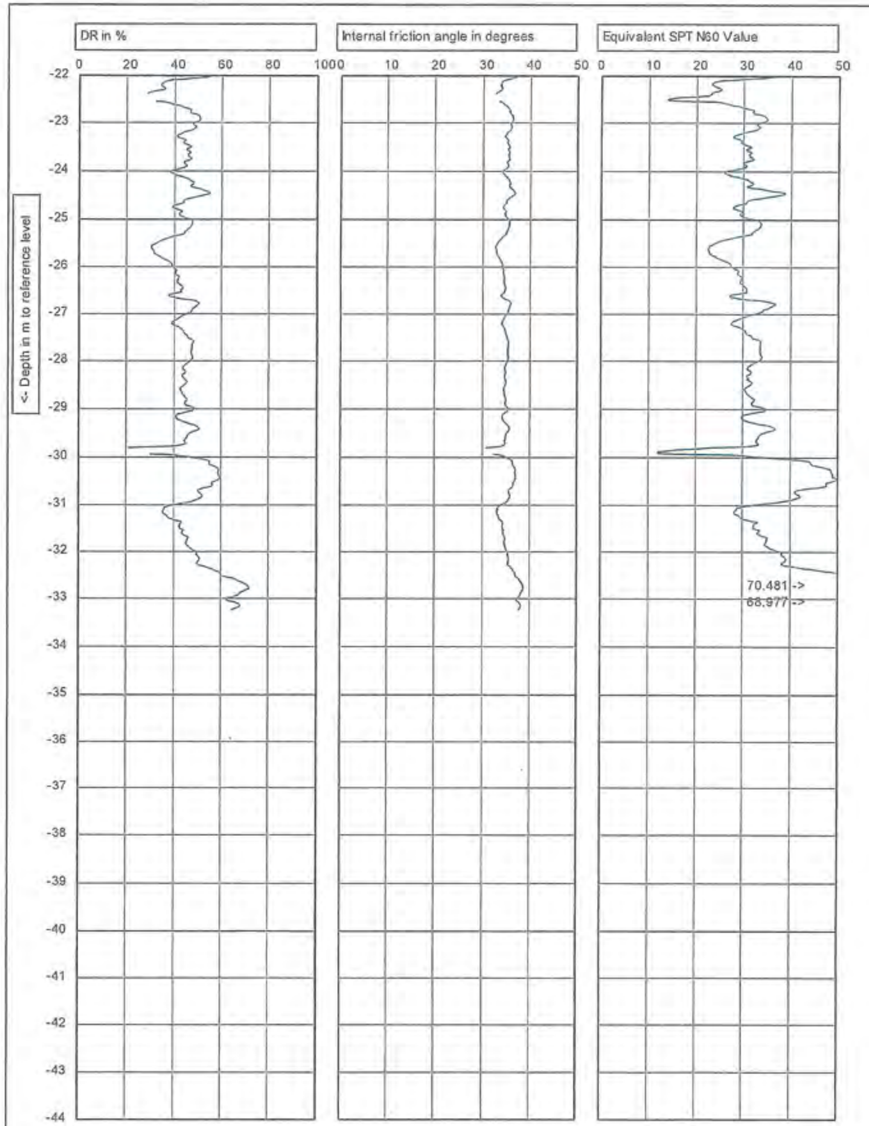


Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL	W.L.: -7.80 m	Date:	23/07/2019
Project: C4 Growth Cell		Cone no.:	C10CFIIP.C15215
Location: Leamington - Cambridge (16064)		Project no.:	2-68002.00_HA4829
Position: 1816054, 5801059 NZTM			

wsp OPUS

Graphs on this page are not IANZ accredited

CPT13 Fig. B-13D Sheet 1



Refusal 10t.

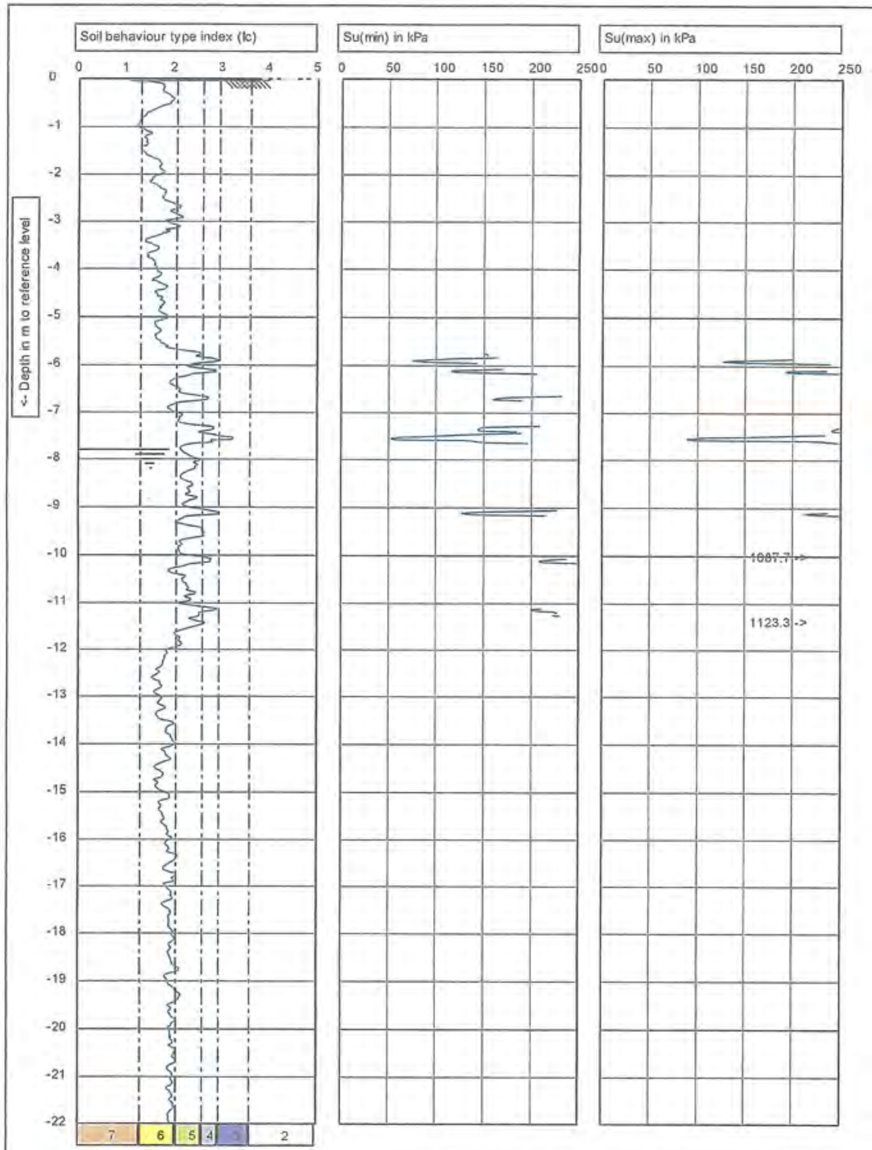
EOH - Dipped - GWL @ 7.8m

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL	W.L.: -7.80 m	Date:	23/07/2019
Project: C4 Growth Cell		Cone no.:	C10CFIIP.C15215
Location: Leamington - Cambridge (16064)		Project no.:	2-68002.00_HA4829
Position: 1816054, 5801059 NZTM			

wsp OPUS

Graphs on this page are not IANZ accredited

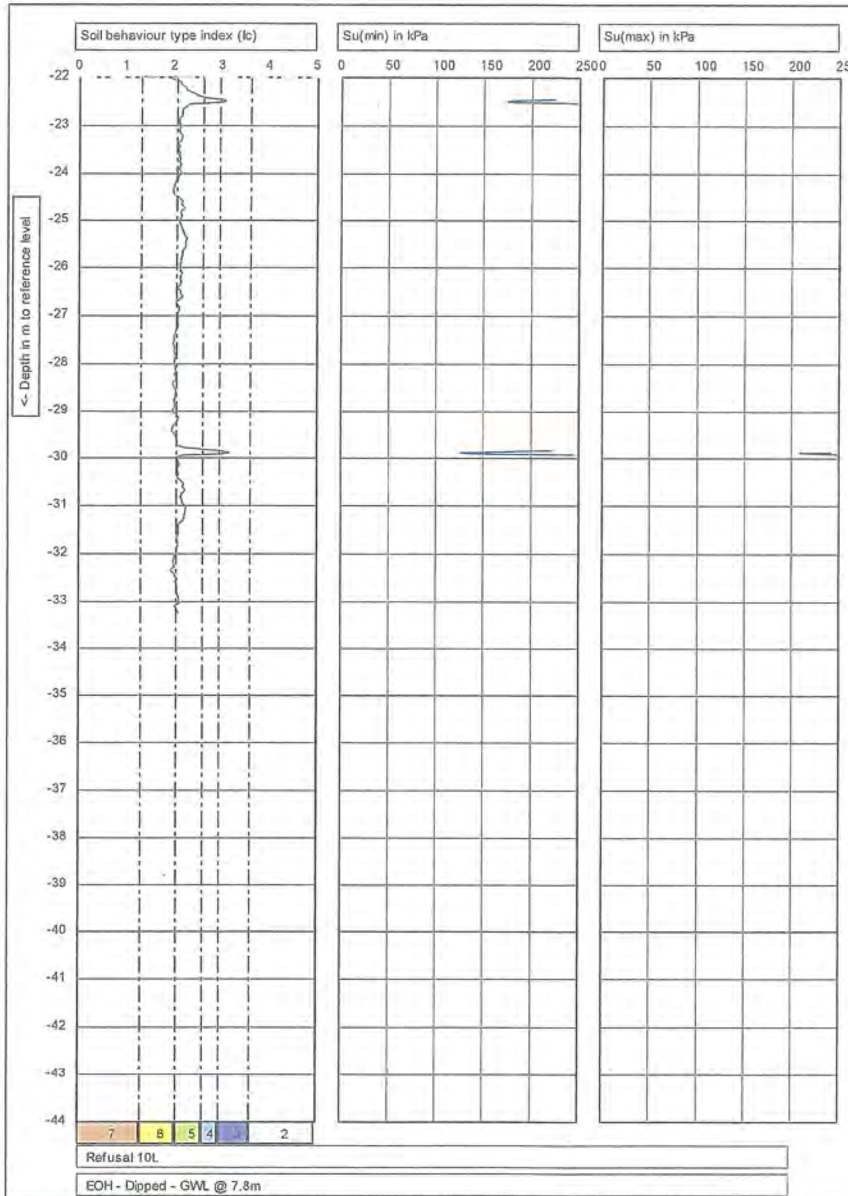
CPT13 Fig. B-13D Sheet 2



Graphs on this page are not IANZ accredited

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL	W.L.: -7.80 m	Date:	23/07/2019
Project:	C4 Growth Cell	Cone no.:	C10CFIIP.C15215
Location:	Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position:	1816054, 5801059 NZTM		

CPT13 Fig. B-13E Sheet 1



Refusal 10t.

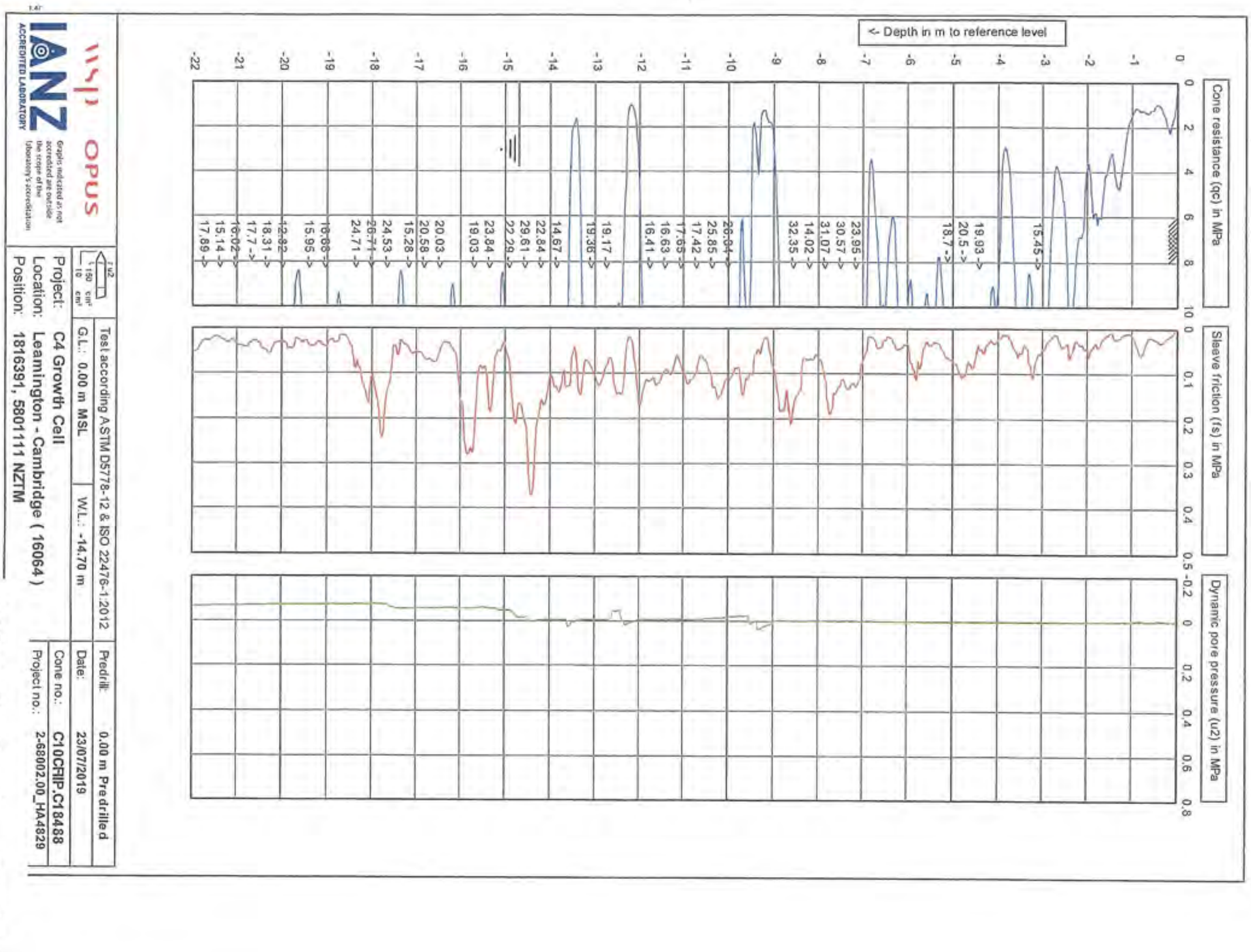
EOH - Dipped - GWL @ 7.8m

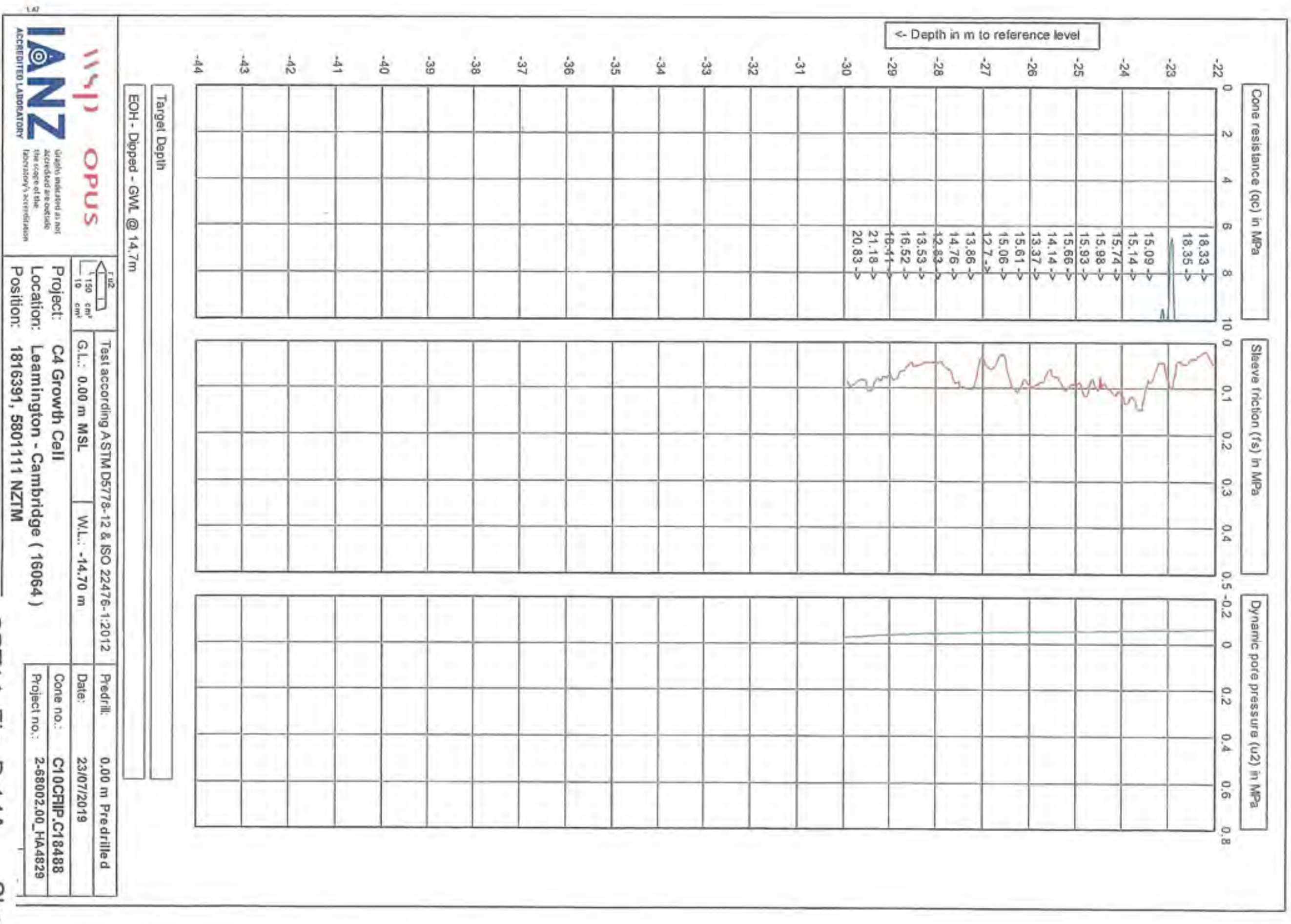
Graphs on this page are not IANZ accredited

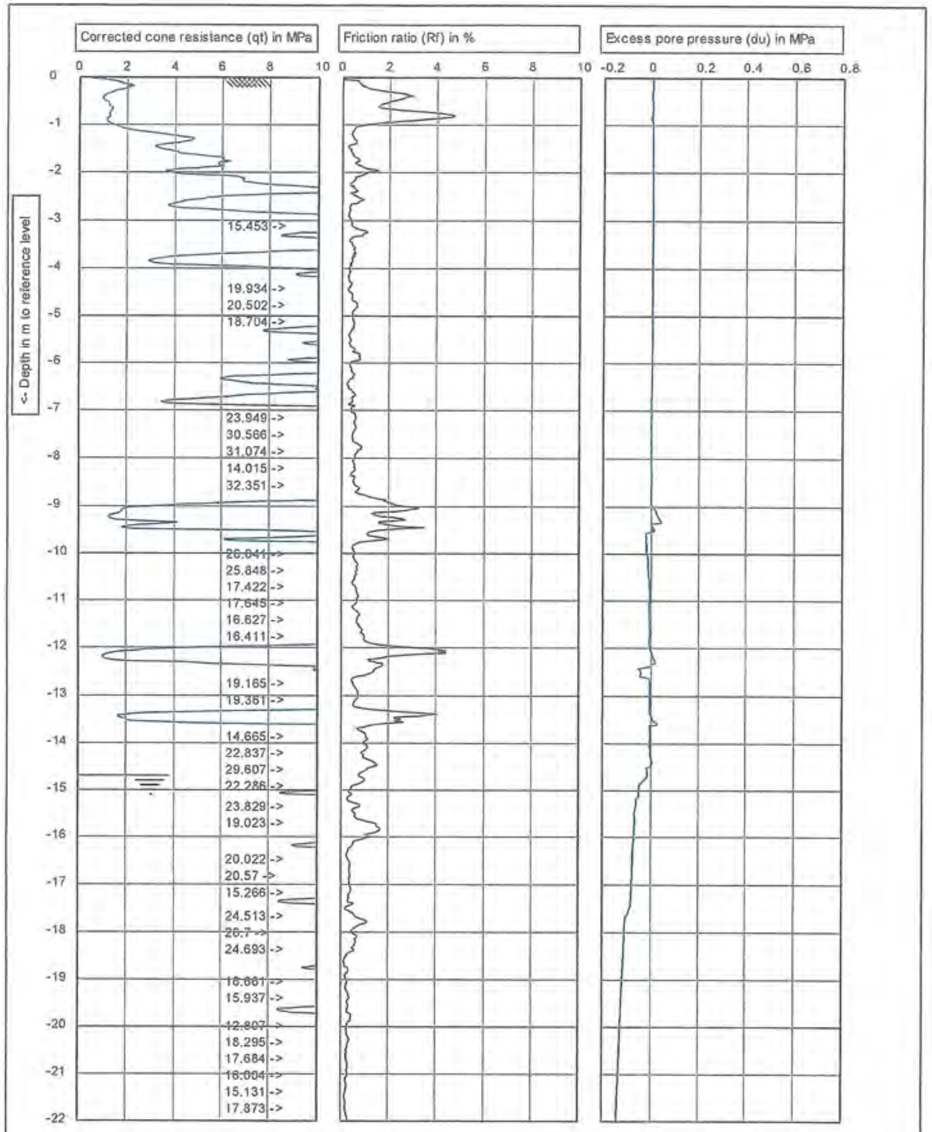
Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL	W.L.: -7.80 m	Date:	23/07/2019
Project:	C4 Growth Cell	Cone no.:	C10CFIIP.C15215
Location:	Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position:	1816054, 5801059 NZTM		

CPT13 Fig. B-13E Sheet 2

CPT No. 14

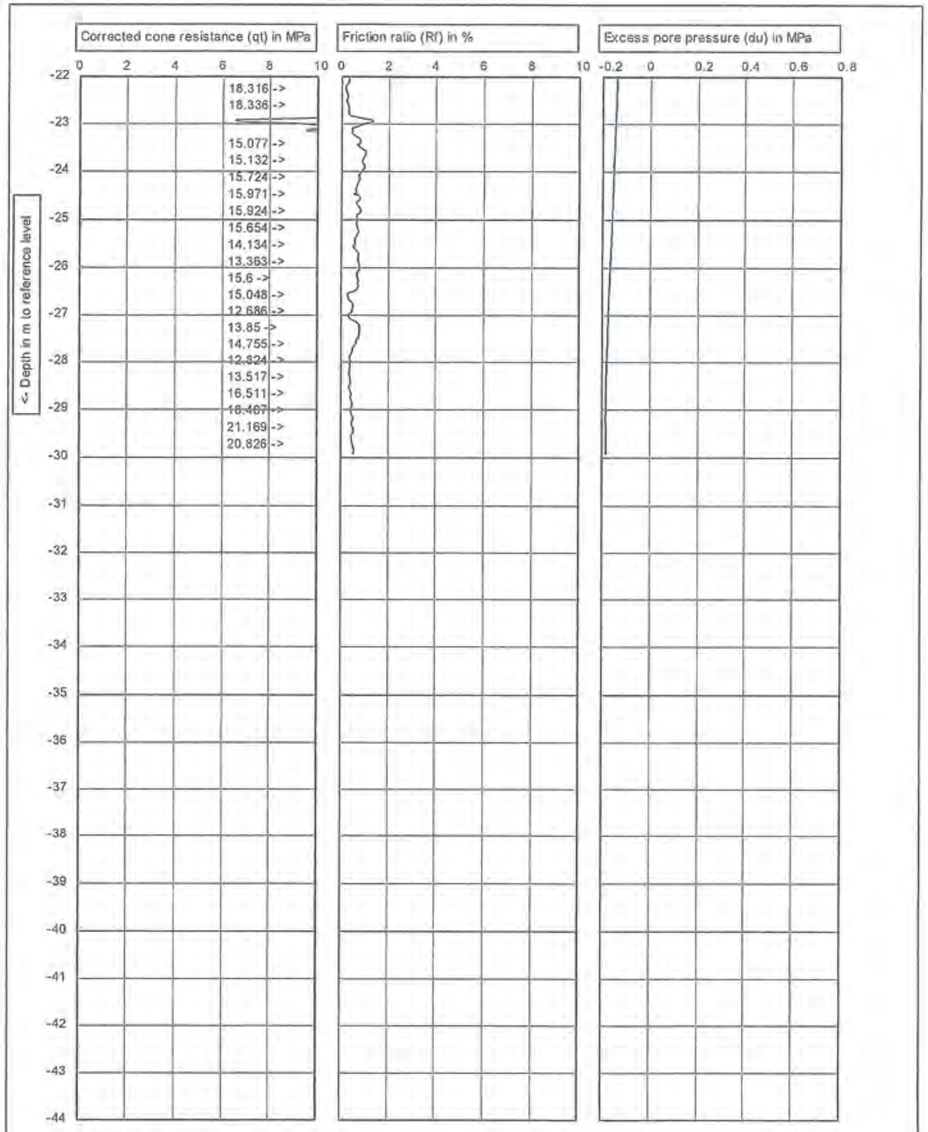

Cone resistance (qc) in MPa
Sleeve friction (fs) in MPa
Dynamic pore pressure (u2) in MPa
<- Depth in m to reference level
Test according ASTM D5778-12 & ISO 22476-1:2012
G.L.: 0.00 m MSL
W.L.: -14.70 m
Predrill: 0.00 m Predrilled
Date: 23/07/2019
Cone no.: C10CFIIP.C18488
Project no.: 2-68002.00_HA4829
Project: C4 Growth Cell
Location: Leamington - Cambridge (16064)
Position: 1816391, 5801111 NZTM
wsp OPUS
IANZ ACCREDITED LABORATORY
CPT14 Fig. B-14A Sheet 1


Cone resistance (qc) in MPa
Sleeve friction (fs) in MPa
Dynamic pore pressure (u2) in MPa
<- Depth in m to reference level
Target Depth
EOH - Dipped - GWL @ 14.7m
Test according ASTM D5778-12 & ISO 22476-1:2012
G.L.: 0.00 m MSL
W.L.: -14.70 m
Predrill: 0.00 m Predrilled
Date: 23/07/2019
Cone no.: C10CFIIP.C18488
Project no.: 2-68002.00_HA4829
Project: C4 Growth Cell
Location: Leamington - Cambridge (16064)
Position: 1816391, 5801111 NZTM
wsp OPUS
IANZ ACCREDITED LABORATORY
CPT14 Fig. B-14A Sheet2



Test according ASTM D5778-12 & ISO 22476-1:2012	Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL W.L.: -14.70 m	Date:	23/07/2019
Project: C4 Growth Cell	Cone no.:	C10CFIIP.C18488
Location: Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position: 1816391, 5801111 NZTM		

CPT14 Fig. B-14B Sheet 1

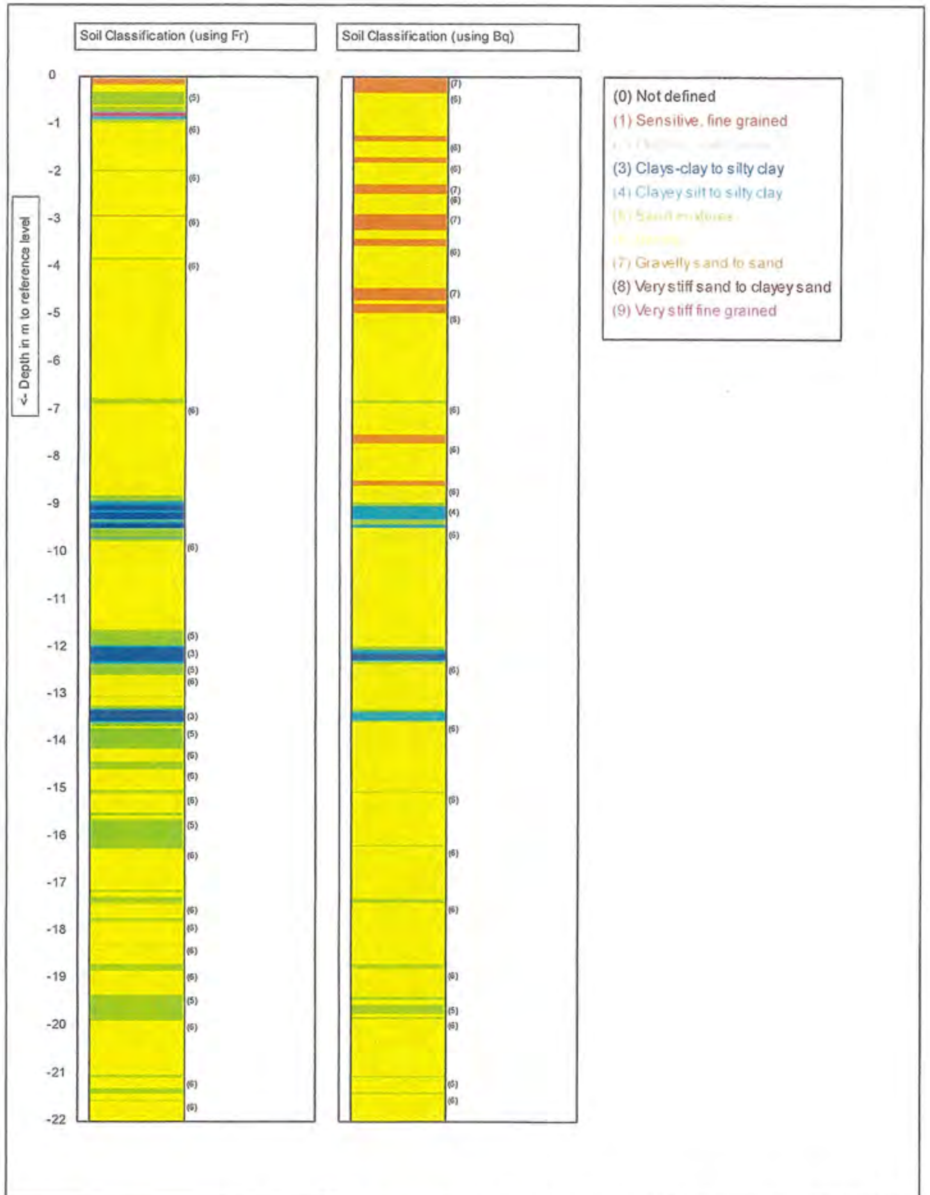


Target Depth

EOH - Dipped - GWL @ 14.7m

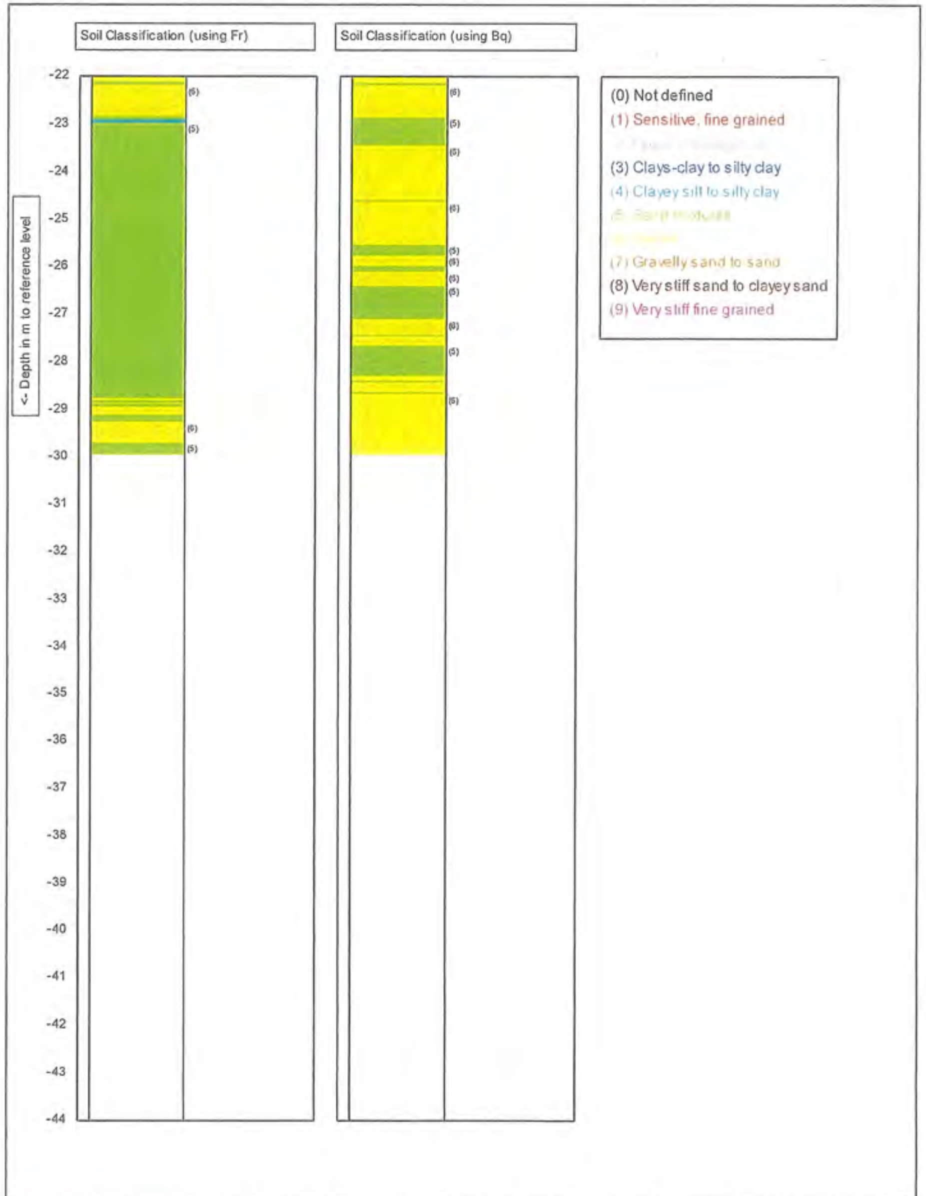
Test according ASTM D5778-12 & ISO 22476-1:2012	Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL W.L.: -14.70 m	Date:	23/07/2019
Project: C4 Growth Cell	Cone no.:	C10CFIIP.C18488
Location: Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position: 1816391, 5801111 NZTM		

CPT14 Fig. B-14B Sheet 2



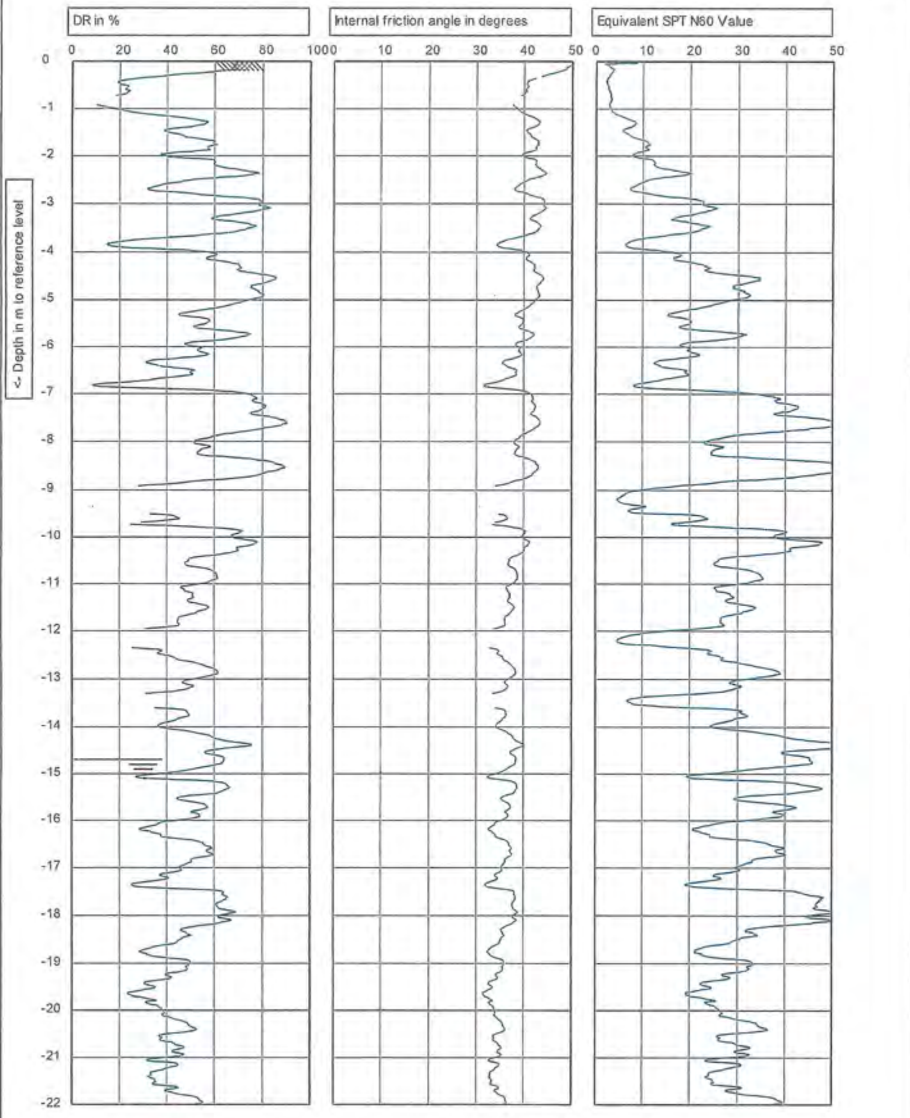
WSP OPUS	Test according ASTM D5778-12 & ISO 22476-1:2012	Predrill:	0.00 m Predrilled
Graphs on this page are not IANZ accredited	G.L.: 0.00 m MSL / W.L.: -14.70 m	Date:	23/07/2019
	Project: C4 Growth Cell	Cone no.:	C10CFIIP.C18488
	Location: Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
	Position: 1816391, 5801111 NZTM		

CPT14 Fig. B-14C Sheet 1



WSP OPUS	Test according ASTM D5778-12 & ISO 22476-1:2012	Predrill:	0.00 m Predrilled
Graphs on this page are not IANZ accredited	G.L.: 0.00 m MSL / W.L.: -14.70 m	Date:	23/07/2019
	Project: C4 Growth Cell	Cone no.:	C10CFIIP.C18488
	Location: Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
	Position: 1816391, 5801111 NZTM		

CPT14 Fig. B-14C Sheet 2

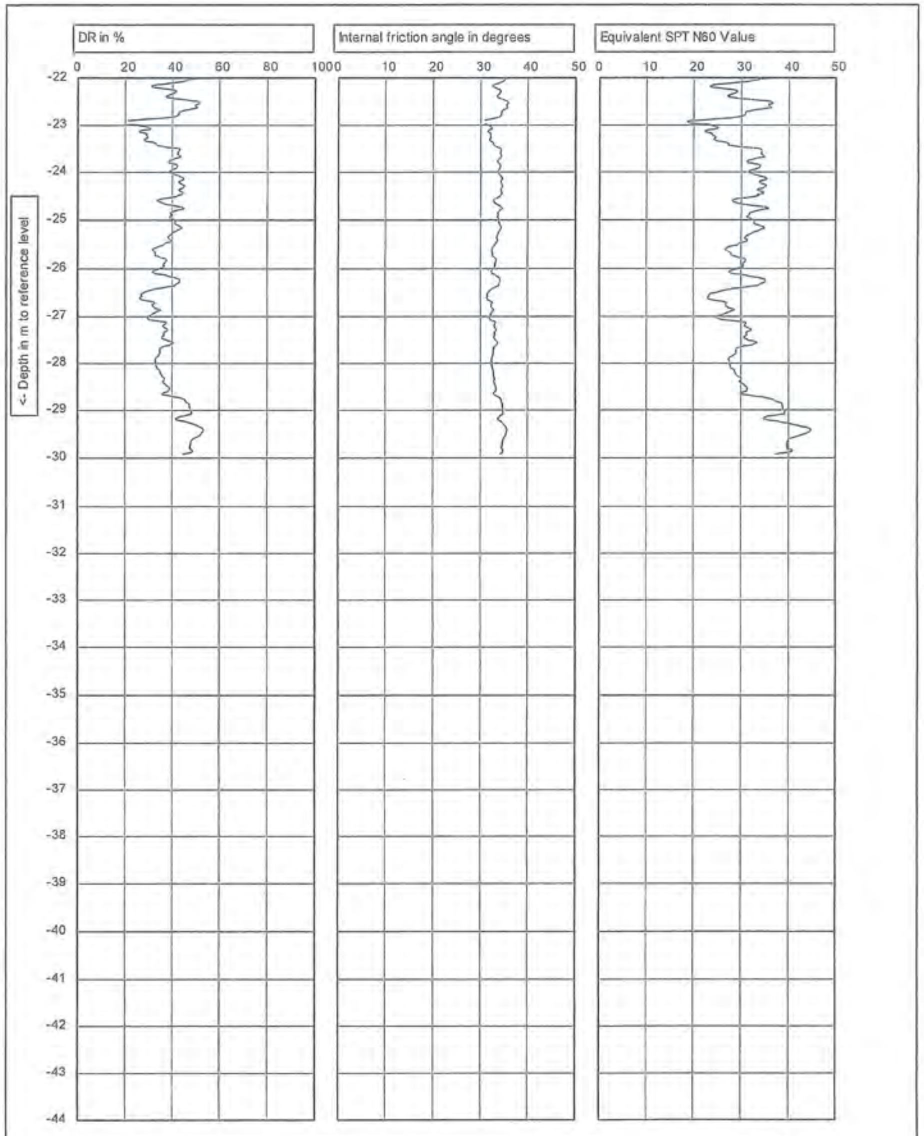


Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL	W.L.: -14.70 m	Date:	23/07/2019
Project: C4 Growth Cell		Cone no.:	C10CFIIP.C18488
Location: Leamington - Cambridge (16064)		Project no.:	2-68002.00_HA4829
Position: 1816391, 5801111 NZTM			

wsp OPUS

Graphs on this page are not IANZ accredited

CPT14 Fig. B-14D Sheet 1



Target Depth

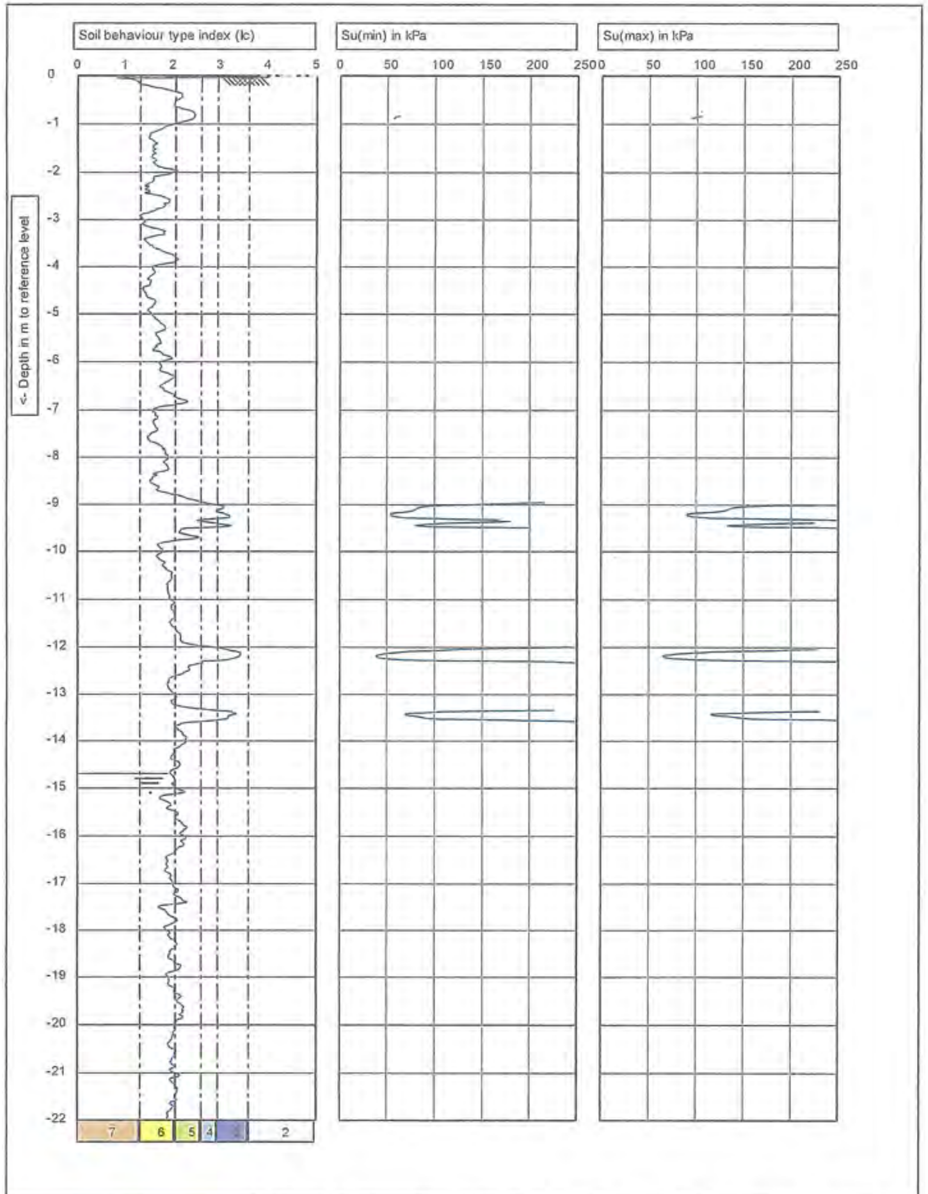
EOH - Dipped - GWL @ 14.7m

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL	W.L.: -14.70 m	Date:	23/07/2019
Project: C4 Growth Cell		Cone no.:	C10CFIIP.C18488
Location: Leamington - Cambridge (16064)		Project no.:	2-68002.00_HA4829
Position: 1816391, 5801111 NZTM			

wsp OPUS

Graphs on this page are not IANZ accredited

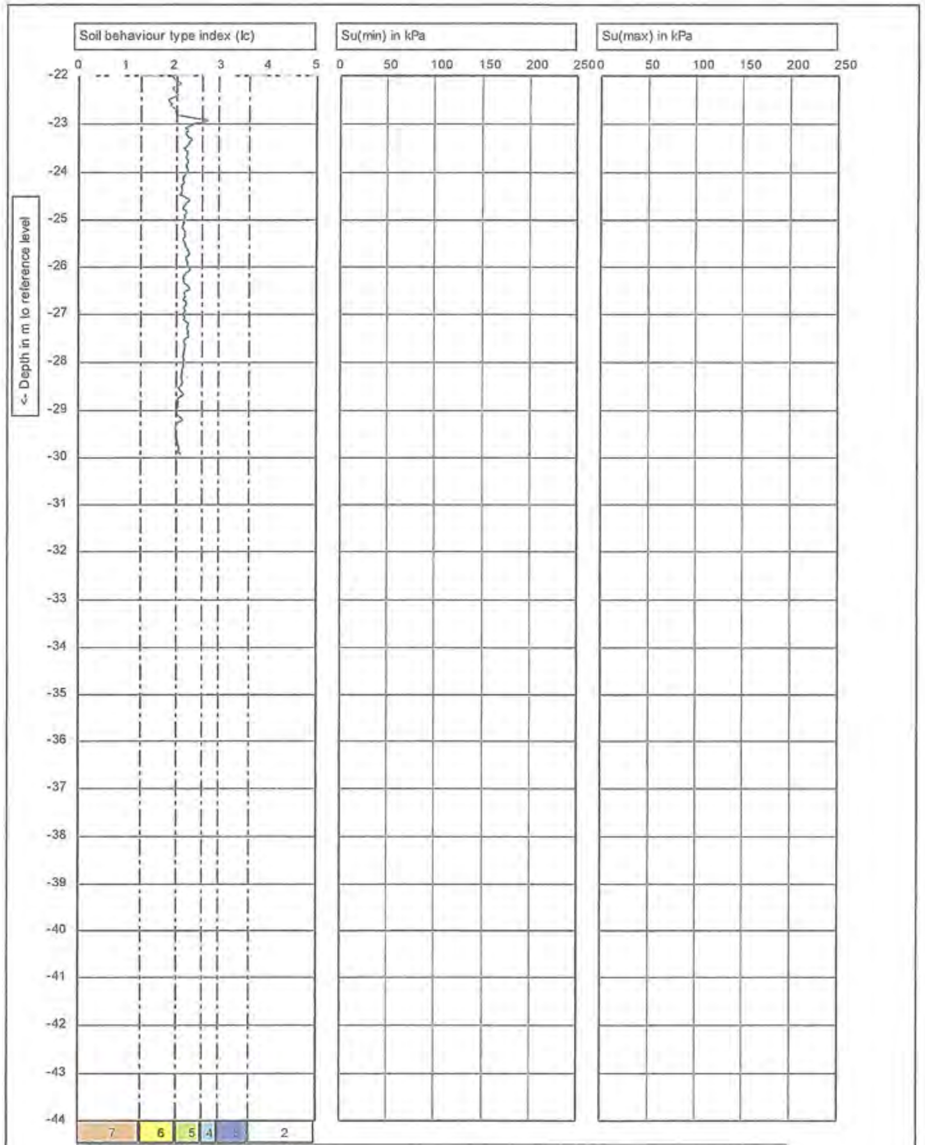
CPT14 Fig. B-14D Sheet 2



Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL	W.L.: -14.70 m	Date:	23/07/2019
Project:	C4 Growth Cell	Cone no.:	C10CFIIP.C18488
Location:	Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position:	1816391, 5801111 NZTM		

wsp OPUS

CPT14 Fig. B-14E Sheet 1



Target Depth

EOH - Dipped - GWL @ 14.7m

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
G.L.: 0.00 m MSL	W.L.: -14.70 m	Date:	23/07/2019
Project:	C4 Growth Cell	Cone no.:	C10CFIIP.C18488
Location:	Leamington - Cambridge (16064)	Project no.:	2-68002.00_HA4829
Position:	1816391, 5801111 NZTM		

wsp OPUS

CPT14 Fig. B-14E Sheet 2

Ecological impacts of the proposed C4 Growth Cell

Cambridge, Waikato

Prepared for Mitchell Daysh Limited

July 2019

Prepared by:
Eimear Egan
Cindy Baker

For any information regarding this report please contact:

Cindy Baker
Principal Scientist - Freshwater Fish
Group Manager, Freshwater Ecology
+64-7-856 1774
cindy.baker@niwa.co.nz

National Institute of Water & Atmospheric Research Ltd
PO Box 11115
Hamilton 3251

Phone +64 7 856 7026

NIWA CLIENT REPORT No:	2019206HN
Report date:	July 2019
NIWA Project:	SCJ202GOV

Quality Assurance Statement		
	Reviewed by:	Paul Franklin
	Formatting checked by:	Rachel Wright
	Approved for release by:	Scott Stephens

Contents

Tables

Figures

Executive summary

Mitchell Daysh are developing the Structure Plan for the C4 Growth Cell for Waipa District Council. The proposed C4 Growth Cell is 66ha and will be situated on the Leamington side of Cambridge with capacity for 790 dwellings. Mitchell Daysh wish to ensure that existing waterways can be used to discharge stormwater. Prior to developing the Structure Plan, Mitchell Daysh have contracted NIWA to assess freshwater ecological values that may be impacted by the C4 Growth Cell development. The proposed C4 Growth Cell development may alter the hydrological regime of the C4 Stream and, therefore, affect freshwater habitats and species. In this regard, a site visit and desktop ecological assessment was undertaken on freshwater habitats and species that may be impacted by the C4 Growth Cell development.

The C4 Growth Cell has one unnamed tributary stream within its area of influence (herein referred to as C4 Stream) and was the focus of the site assessment. The C4 Stream drains primarily urban and industrial land, although the C4 Growth Cell development largely involves converting pastoral land to residential properties. The upper reaches of the stream were characterised by more instream habitat heterogeneity containing riffle, run, pool and ephemeral seep habitats along with a wide floodplain and intact riparian margin compared to the lower reaches. Within the wider landscape, the canopy cover of the upper C4 Stream is more mature and established compared to neighbouring freshwater sites. It is likely that the most upstream habitats above the lake have the potential to accommodate a range of native fish species including black mudfish and large bodied galaxiids (banded kōkopu and giant kōkopu).

Records from the New Zealand Freshwater Fish Database showed only two species; longfin eel (declining) and shortfin eel (not threatened) have been found in the C4 Stream. Within the wider area of the C4 Stream, 11 native and 7 non-native freshwater fish species have been recorded. However, only two prior fishing records existed, neither of which surveyed the representative habitats present, and one record was 25 years old. Therefore, these existing records may not accurately represent the fish communities within the wider C4 Stream.

A culvert was identified that may be an impediment to fish passage and limit fish communities, but this could not be ascertained during the site visit. There appeared to be poor hydrological connectivity between the upstream and downstream habitats during the site visit. This is because little water movement was evident through the culvert which would have been expected given the storage capacity of the lake directly upstream. If the culvert were blocked, then additional stormwater discharges to the C4 Stream may restrict movement of stormwater through the culvert.

The magnitude of any hydrological modifications and their subsequent effects on the C4 Stream are unknown as the stormwater management plan has not been developed. No known hydrological data exists for the C4 Stream and changes in hydrological characteristics from stormwater discharges cannot be evaluated. Overall, the ecological integrity (e.g., native freshwater fish and instream habitat diversity) of the C4 Stream cannot be fully understood based on the existing data. Future recommendations are to:

- Complete updated ecological surveys to describe the freshwater fish and macroinvertebrate communities in the C4 Stream, and;
- A further assessment of the culvert under Cambridge Road to determine if it is an impediment to fish passage and to stormwater discharges;

- Collect instream hydrological data to support flow modelling and the effects of stormwater discharges on the C4 Stream;
- Consider an ecological flow assessment using RHYHABSIM or similar physical habitat model to enable habitat changes with an altered flow regime to be more accurately assessed.

1 Introduction

1.1 Background

In 2009, Waipa District Council (WDC) developed a Growth Strategy for 2050 as part of the Waipa District Plan[1]. This growth strategy was developed in response to rapid population growth within the Waipa District and to respond to changing national and regional policy direction. As part of the 2050 Growth Strategy, a number of residential Growth Cells were identified in Cambridge (Figure 1-1). The Growth Strategy 2050 was modified and accepted in March 2019 as part of Plan Change 5, and it was confirmed that the C4 Growth Cell will be a Residential Zone.

The proposed C4 Growth Cell is 66ha in size and situated south-west of Cambridge near Leamington (Figure 1-2). The C4 Growth Cell is intended for residential development with a capacity for 790 dwellings and is an alternative, along with Growth Cells C5 and C11. It is anticipated the C4 Growth Cell development will be completed by 2035.

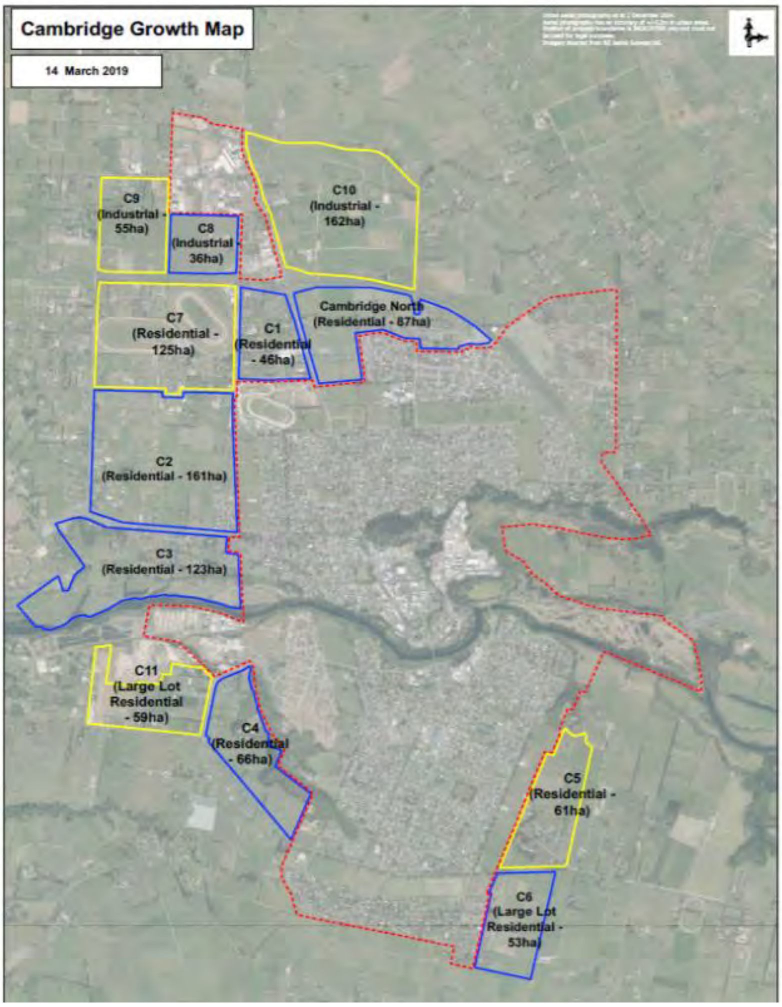


Figure 1-1: The location of the Growth Cells designated for Cambridge, Waikato.

[1] https://www.waipadc.govt.nz/our-council/Waipa2050/wdc-part-operative/Variations/Pages/Plan-Change-5---Waipa-2050-Growth-Strategy.aspx

Figure 1-2: The boundary of the C4 Growth Cell is outlined in yellow. The un-named stream (herein referred to as C4 Stream) runs parallel to eastern boundary of the C4 Growth Cell.

Mitchell Daysh Limited ("Mitchell Daysh") has been engaged by WDC in a project management capacity. Their task is to produce a Structure Plan which will determine the urban form, use and manner, in which infrastructure can be efficiently and cost-effectively developed to facilitate residential development in the C4 Growth Cell. The Structure Plan will also include factors such as connectivity to existing roading network/urban areas (including cycle and pedestrian linkages) and reserve provisions. The timeframe for the development of the Structure Plan by Mitchell Daysh is October 2019.

1.2 Environmental context

A key part to developing the Structure Plan is to identify the ecological values associated with the C4 Growth Cell. In this regard, an ecological assessment is required for WDC to understand the existing freshwater environments that must be considered prior to the development and the effects of the stormwater management plan. The proposed developments for the C4 Growth Cell primarily involve converting pastoral land to residential properties. The anticipated changes on freshwater ecosystems from creating urban areas, and the subsequent increase in impervious surfaces include:

- a reduction in base flows;
- a flashier flow regime with shorter durations and higher peaks for elevated flows;
- elevated concentrations of nutrients and contaminants;

- altered channel morphology and stability; and,
- reduced biotic richness, with increased dominance of tolerant species (Walsh et al. 2012).

To protect aquatic stream health and integrity, excess stormwater needs to be effectively managed along with ensuring appropriate base flows for the target biota are maintained. In that regard, Mitchell Daysh have contracted NIWA to carry out an initial ecological assessment to inform the Structure Plan for the C4 Growth Cell.

1.3 Report scope

The purpose of this report is to provide Mitchell Daysh with ecological information about the potential impacts of the C4 Growth Cell development on freshwater ecosystems. The timeframe for the development of the Structure Plan by Mitchell Daysh is October 2019. To meet this deadline, Mitchell Daysh understand that ecological surveys of waterways are not recommended during the winter months. Considering this, Mitchell Daysh have specified the scope of the ecological assessment and have specifically requested NIWA to:

1. Undertake a site visit of freshwater environments relevant to the C4 Growth Cell development;
2. Review existing ecological information/literature with respect to the waterways within and surrounding the project area;
3. Prepare a report detailing the existing environment based on the site visit and literature review;
4. Identify any potential ecological issues or constraints that may arise from the C4 Growth Cell Development;
5. Detail any further work and information required to accurately assess the impacts of stormwater discharges on freshwater ecosystems.

It is recognised by Mitchell Daysh that a detailed environmental assessment will be required in the future as part of the resource consenting process for the C4 Growth Cell. This detailed study is beyond the scope of this report. Therefore, this report serves to provide the background information for Mitchell Daysh to develop the relevant Structure Plan while being cognisant of the effects on aquatic environments.

2 Methods

2.1 Site visit

A site visit of freshwater habitats that may be impacted by the proposed C4 Growth Cell was undertaken on 8th June 2019. The C4 Growth Cell has one key unnamed tributary stream within its area of influence (herein referred to as C4 Stream; Figure 2-1) and was the focus of the site assessment. The C4 Stream runs in a northerly direction and discharges to the Waikato River. The C4 Stream is approximately 143 km from the Waikato River mouth. The stream is approximately 3.17 km in length with a catchment area of 8.03 km^2. The catchment geology is predominantly soft sediment.

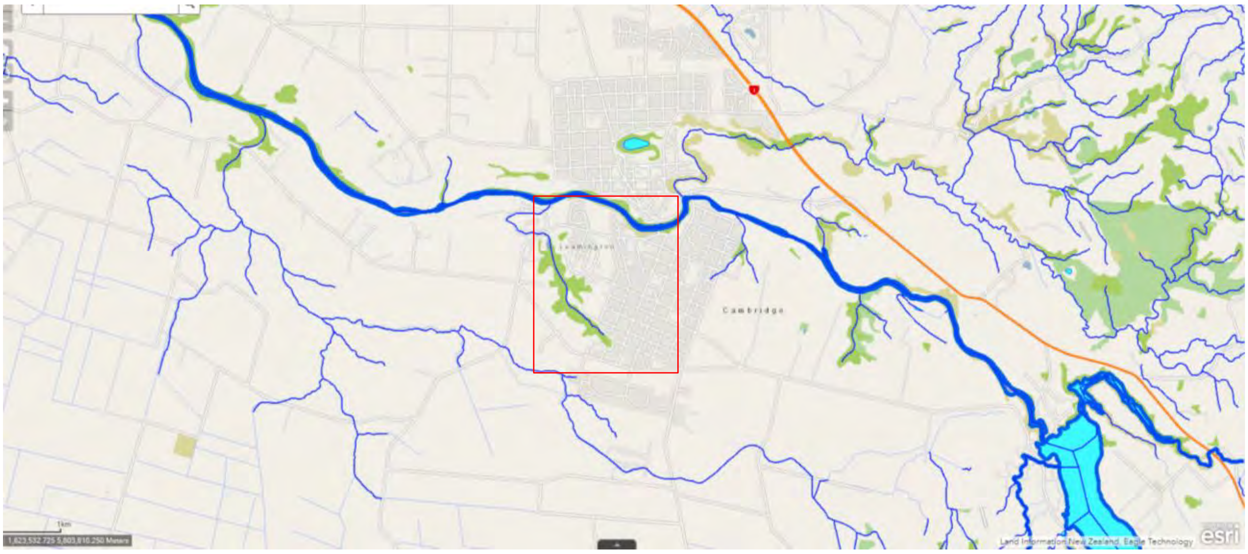


Figure 2-1: Location of the C4 Stream (defined by red box) west of the Leamington township. Freshwater environments in the wider landscape are denoted by the blue lines.

For the visual assessment, the C4 Stream was subdivided into two sections herein referred to as upper and lower reaches with three-four sites surveyed in each reach (Figure 2-2). These reaches were delineated by changes in habitat types, enabling longitudinal changes in ecological values along the C4 Stream to be characterised. The selection of sites within each reach was constrained by ease of access and permission from land owners. The structure and integrity of the freshwater habitats at each of the sites in Figure 2-2 was visually assessed.

Potential impediments to fish passage (e.g., culverts, fords) were identified and the inlets and outlets of instream structures were inspected where possible. Barriers that prevent or delay migrations are one of the greatest threats to New Zealand's freshwater fish as connectivity between habitats can be critical to ensuring the long-term success of fish populations. Barriers to migration can restrict access to habitats required for foraging and feeding, predator avoidance, shelter, and spawning (Gibson et al. 2005). Lack of access to these habitats, particularly for migratory species, can ultimately lead to a reduction in recruitment, population decline, and a loss of biodiversity (e.g., Jellyman and Harding 2012).

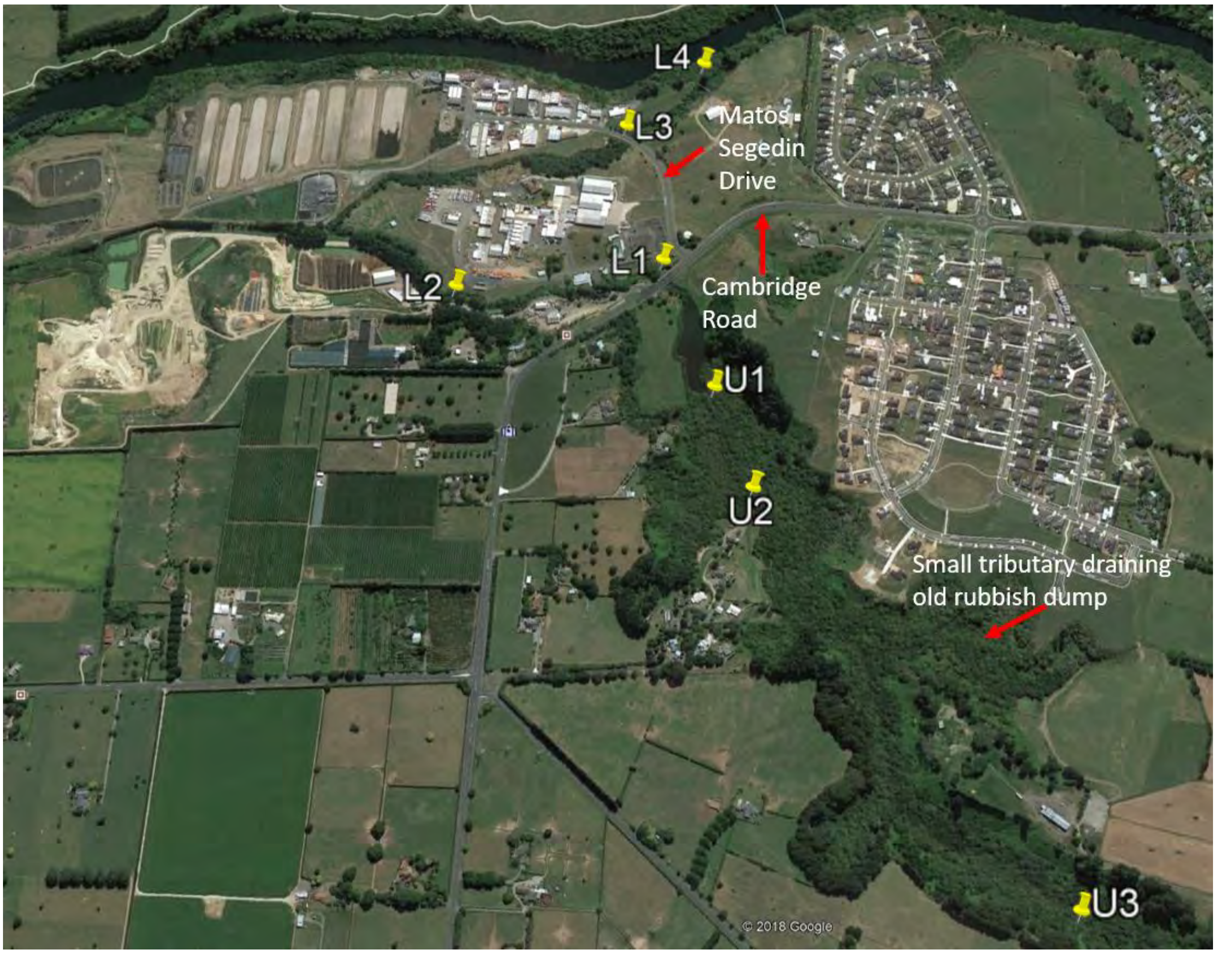


Figure 2-2: Location of the upper (U) and lower (L) sites visited in the C4 Stream that runs parallel to the eastern boundary of the C4 Growth Cell. A small tributary draining an old rubbish dump is shown as well as Cambridge Road and Matos Segedin Drive.

2.2 Review of existing ecological information

2.2.1 New Zealand Freshwater Fish Database Records

The New Zealand Freshwater Fish Database (NZFFD) was inspected to identify fish species that have previously been recorded in the C4 Stream and neighbouring tributaries of the Waikato River. Data stored in the NZFFD include the location of sample sites, the fish species present, as well as information on their abundance, size, sampling methods and a physical description of each site where records exist.

Fish records from the NZFFD can also be used to identify species distributions above and below potential barriers to fish movements (e.g., culverts). The pattern of freshwater fish distributions, together with knowledge of their migrations and movements can ascertain if fish barriers within the study area are potentially impeding fish movement.

2.2.2 Native freshwater fish habitats and ecology

The conservation status of New Zealand's freshwater fish was recently reviewed by Dunn et al. (2018). This constitutes New Zealand's current threat ranking for freshwater fishes. For freshwater fish species identified within the C4 Stream and wider area, their threat status was reported to help evaluate the ecological integrity of the C4 Stream. In the context of the C4 Growth Cell development, the most important information with respect to each native freshwater fish species is to:

- Understand the nature and timing of species movements and migrations;
- Understand the habitat requirements for spawning and rearing;
- Understand the environmental cues (i.e., hydrological regime) required for different life stages (e.g., spawning, foraging).

2.2.3 Predicted hydrological, physical and ecological characteristics of the C4 Stream

The New Zealand River Maps tool (https://shiny.niwa.co.nz/nzrivermaps/) was used to extract predicted hydrological, physical and ecological characteristics of the C4 Stream. At present, there is no gauging station on the C4 Stream and consequently, there are no empirical data available to characterise the instream hydrological conditions. The NZ River Maps tool provides the ability to visualise national-scale predictions of metrics describing hydrology, ecology, water quality and landscapes. These predictions have been generated by NIWA and represent a static snapshot of predicted values across all New Zealand river reaches. Values were extracted for two reaches, one situated in the upper site (NZ Reach number 3020716) and one in the lower site (NZ Reach number 3020374).

Seven predicted flow metrics were extracted for the C4 Stream with their associated descriptions (see Table A-1). Predicted flow duration curves were also extracted from NZ River Maps. Flow duration curves (FDCs) are a useful tool for characterising hydrological regimes and flow variability as they represent the relationship between magnitude and frequency of flow by defining the proportion of time for which any discharge is equalled or exceeded. (Booker and Snelder, 2012).

2.3 Potential effects of stormwater discharge on freshwater ecosystems

The design details of the C4 Growth Cell stormwater system, and subsequent outfall to the Waikato River, are yet to be finalised. Therefore, an analysis of the anticipated effects of stormwater discharges on the relevant freshwater ecosystems was limited. We, therefore, analyse the potential effects of stormwater discharges on aquatic communities more generally and focus the analysis in the discussion on species identified in the analysis of the NZFFD records (see section 2.2.1).

3 Results

3.1 Site visit

3.1.1 Upper section (sites U1, U2 and U3)

The Upper section of the C4 Stream at site U3 (see Figure 2-2) was relatively heterogeneous. There were faster flowing riffle habitats and deeper pools that were formed by fallen trees (Figure 3-1). The substrate was largely comprised of gravels and sand as well as organic leaf matter. The canopy was mature and contained a mix of both native and exotic species. The riparian vegetation was a mixture of native and exotic species but dominated by the weed wandering willy (*Tradescantia fluminensis*).

Along the margins of the C4 main stem, seepages and ephemeral/wetland habitats were identified (see Figure 3-1). During high flow events, these marginal habitats likely become inundated, especially considering the wide flood plain that exists. These marginal habitats are, therefore, likely connected to the main stem of the C4 Stream during periods of higher flows.

At site U2 (Figure 2-2), the habitat transitioned into a more degraded state compared to the more intact habitats found in the uppermost site (site U3). The canopy and riparian cover were increasingly dominated by willows, and deep deposits of finer sediments were observed in the main stem as well as within the bankside riparian vegetation. Riffle and pool habitats were also present here creating instream habitat heterogeneity. The network of seepages and ephemeral habitats were also observed at site U2. A man-made lake (approx. 6,931 m^2) was situated at site U1 (Figure 2-2) and is visible from Cambridge Road.

Figure 3-1: Range of freshwater habitat types identified in the upper section of the C4 Stream including riffles, pools and ephemeral seeps. Note the overhanging vegetation.

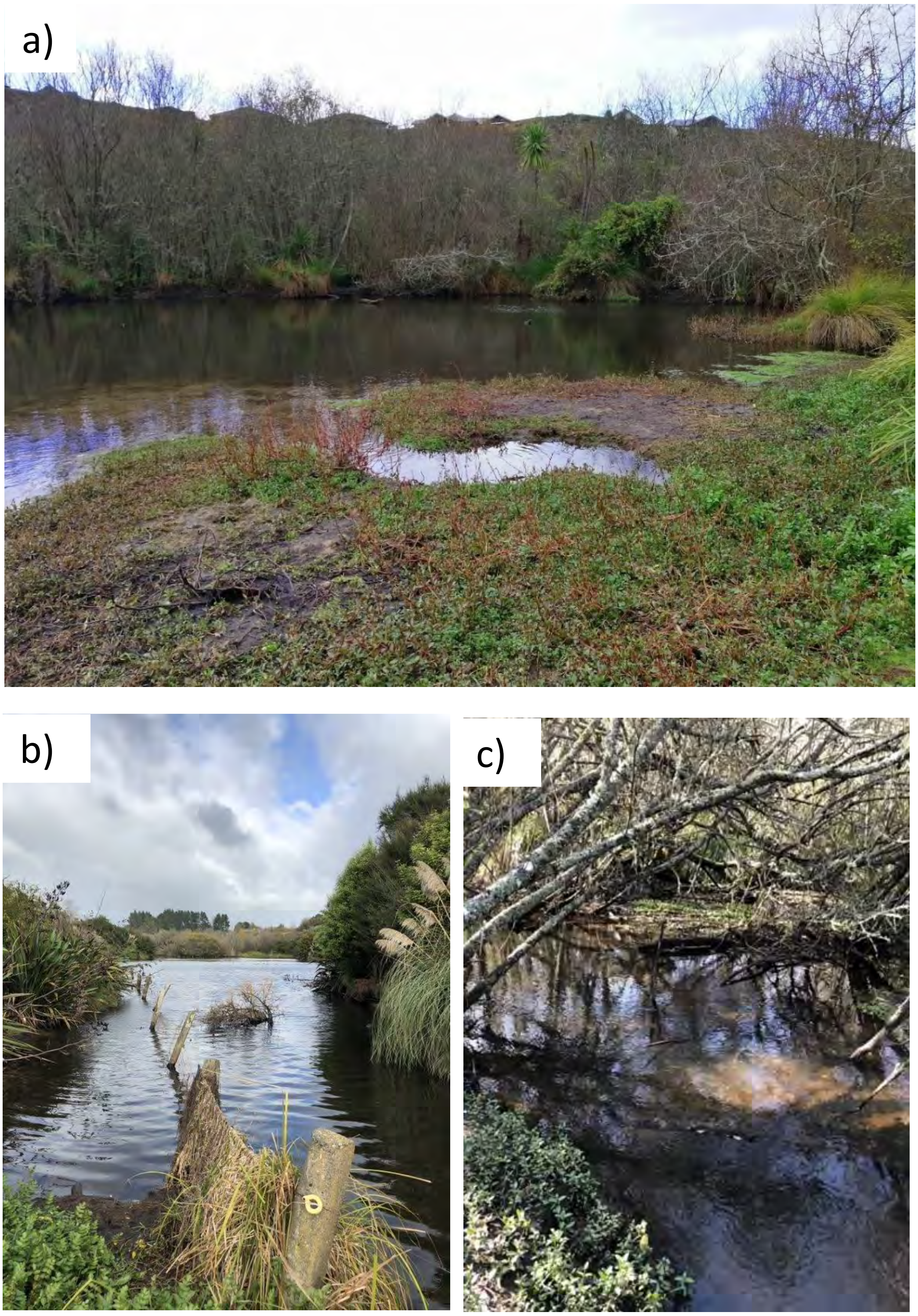


Figure 3-2: Upper section of the C4 Stream showing a) the upper lake; b) the lower lake and c) riffle habitats with overhanging vegetation.

3.1.2 Lower section (sites L1, L2, L3, L4)

The land use in the Lower section of the C4 Stream was dominated by industrial development. It was difficult to access the stream because it was largely overgrown with weeds, the banks were steep, and the river became increasingly incised (Figure 3-3). There was evidence that livestock have access to the stream in this section as well as dumping of metal scraps (Figure 3-3). A culvert exists under Matos Segedin Drive (Figure 3-4).

3.2 Fish passage assessment

Two culverts are present in the C4 Stream that could be fish passage barriers. The first culvert was located downstream from the lake where it connected the stream under Cambridge Road (Figure 3-4). The structure could not be assessed directly as both the inlet and outlet were submerged and among dense weeds and mud (Figure 3-5). Although there was a very small amount of water movement seen at the outlet (Figure 3-5), higher flows were expected considering the size and storage capacity of the lake upstream. The culvert may, therefore, be partially blocked and represent an impediment to fish movements. Further investigation of the structure is required to determine if it is a migration barrier for different fish species (see section 4.1.3).

A second culvert is located underneath Matos Segedin Drive (Figure 3-4). At the time of the assessment, this structure did not appear to be an impediment to fish passage (Figure 3-6). However, the hydrological regime of the C4 Stream may change with the development of the C4 Growth Cell and anticipated stormwater inputs will change both base flows and the magnitude and duration of flood flows. Considering many of New Zealand's native freshwater fish species are small bodied and some are weak swimmers, seemingly small obstructions and poor hydrological connectivity (i.e. due to changes in flow) can severely impede fish passage (Franklin et al. 2018).

Figure 3-3: Lower section of the C4 Stream showing steeper banks and more incised stream. The riparian vegetation was compromised and is dominated by weeds.

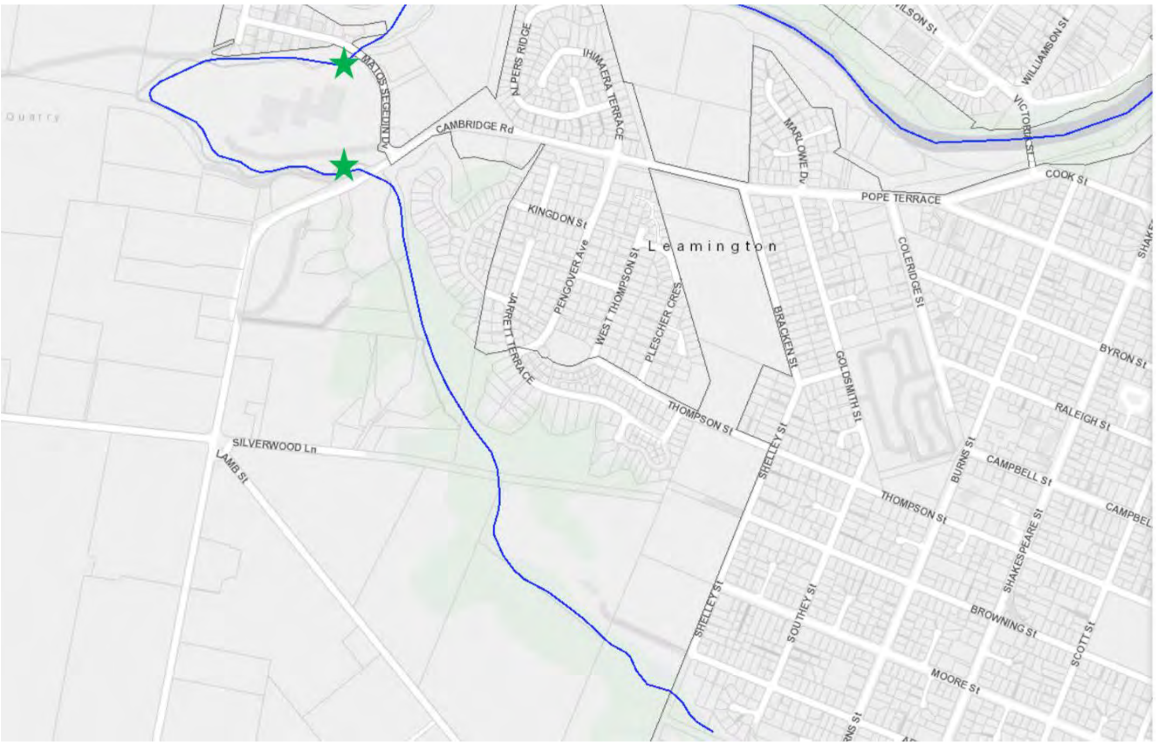


Figure 3-4: Map showing the locations of the two culverts (denoted by green stars) at Cambridge Road and Matos Segedin Drive.


Figure 3-5: The first potential fish passage barrier identified at the upper section of the C4 Stream where it intersects Cambridge Road. Both the inlet and outlet of the structure could not be seen or felt under the water.

Figure 3-6: Culvert in the C4 Stream under Matos Segedin Drive.

3.3 Review of existing ecological information

3.3.1 Species records from the New Zealand Freshwater Fish Database

There are two records in the NZFFD that found longfin eels (*Anguilla dieffenbachii*) and shortfin eels (*Anguilla australis*) in the C4 Stream (Figure 3-7). One record from 2016 found one shortfin eel in the lake above Cambridge Road, but no details on fishing method or area were provided (Figure 3-7). The second record from 1994 found shortfin eels were abundant and longfin eels were occasional in a 30 m^2 area surveyed with single pass electric fishing. This record appears to be located on a small tributary feeding into the mainstem of the C4 Stream above Cambridge Road (Figure 2-2;Figure 3-7). This small tributary drains an old landfill (now a dog park) and stormwater pond, and the stream contained high levels of iron flock that was not observed in the mainstem of the C4 Stream.

These fishing records show a low biodiversity within the C4 Stream given that 18 species of freshwater fish are known to occur in the wider area. Eleven of these are native species (Figure 3-7) and seven are introduced (Figure 3-8). Five of the native freshwater fish species identified within the wider study are classified as At Risk – Declining (īnanga, giant kōkopu, black mudfish, longfin eel and torrentfish) while six native freshwater fish are classified as Not Threatened (Table 3-1). The low biodiversity recorded in the C4 Stream may be because of several reasons:

- The record in the upper stream section is 25 years old;
- The fishing location in the smaller tributary was not representative of the habitat heterogeneity observed in the mainstem during the site visit;
- The fishing method was inadequate to survey the full fish community present;
- The culvert under Cambridge Road represents a migration barrier.

It is likely that all factors are responsible for the low fish biodiversity. In particular, fish sampling protocols indicate a 150 m stretch of stream is needed to be electric fished to ensure all habitats will be represented (Joy et al. 2013). That said, the fact that only eels, the two species most adept at passing instream obstacles were found upstream of the Cambridge Road culvert indicates the culvert requires further assessment to determine if it is indeed a fish passage barrier.

Of importance is the variety of habitats present in the C4 Stream, presently there are no fishing records from the lower more degraded section of the stream below Cambridge Road, the lake immediately above Cambridge Road, and the wetland/ephemeral and perennial habitats in the upper reaches of the main stem. If there are no passage barriers, the lake appeared suitable habitat for colonisation of undesirable exotic species such as koi carp, catfish, gambusia, and rudd. The infestation of these species would lower the ecological value of the lake and wider stream system. Based on the habitat types present, an updated fish survey of the C4 Stream targeting the aforementioned habitats is deemed necessary to assess its current ecological values and predict the impacts of the proposed growth cell.

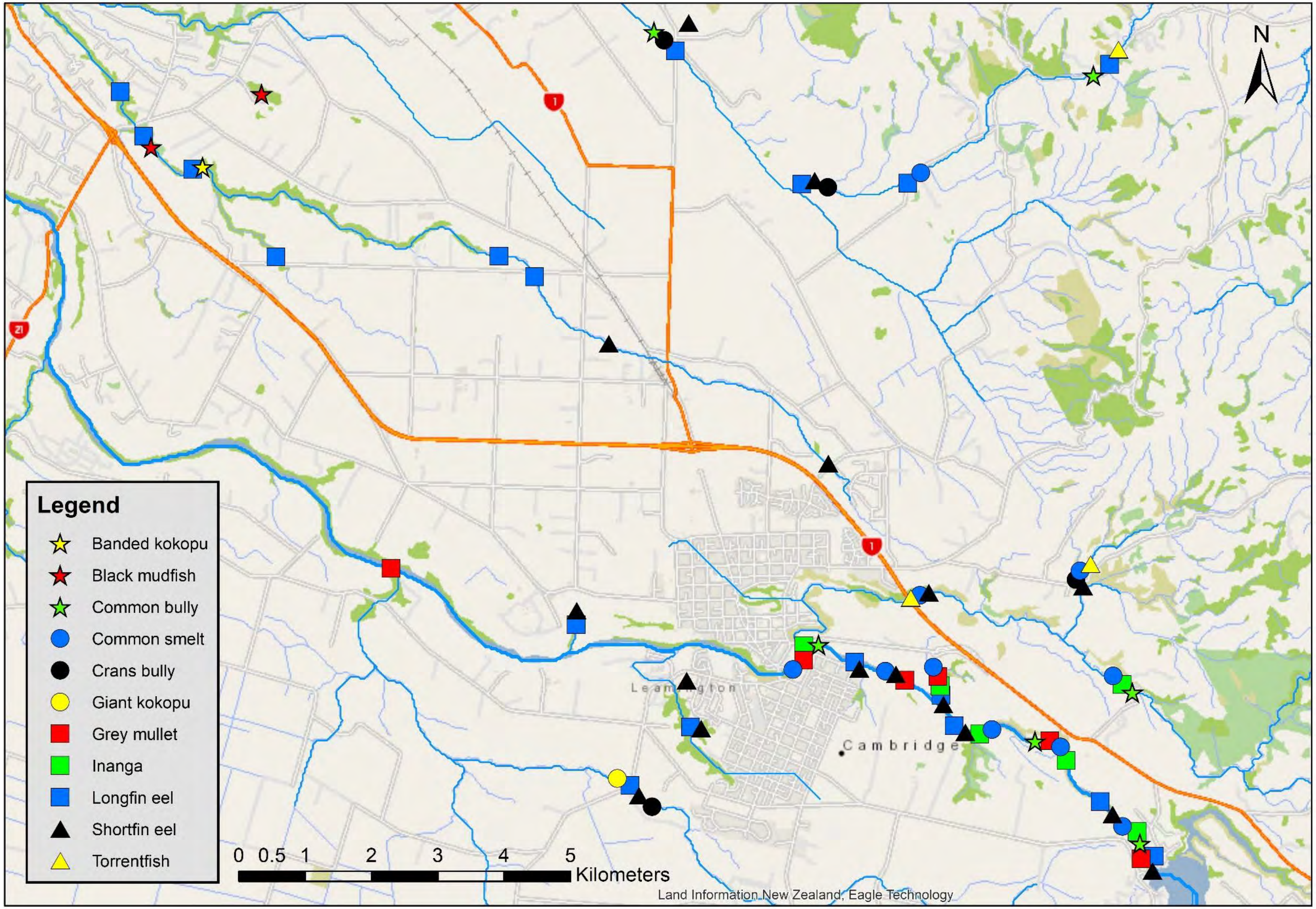


Figure 3-7: Map showing the distribution of native freshwater fish species in the C4 Stream and wider area.

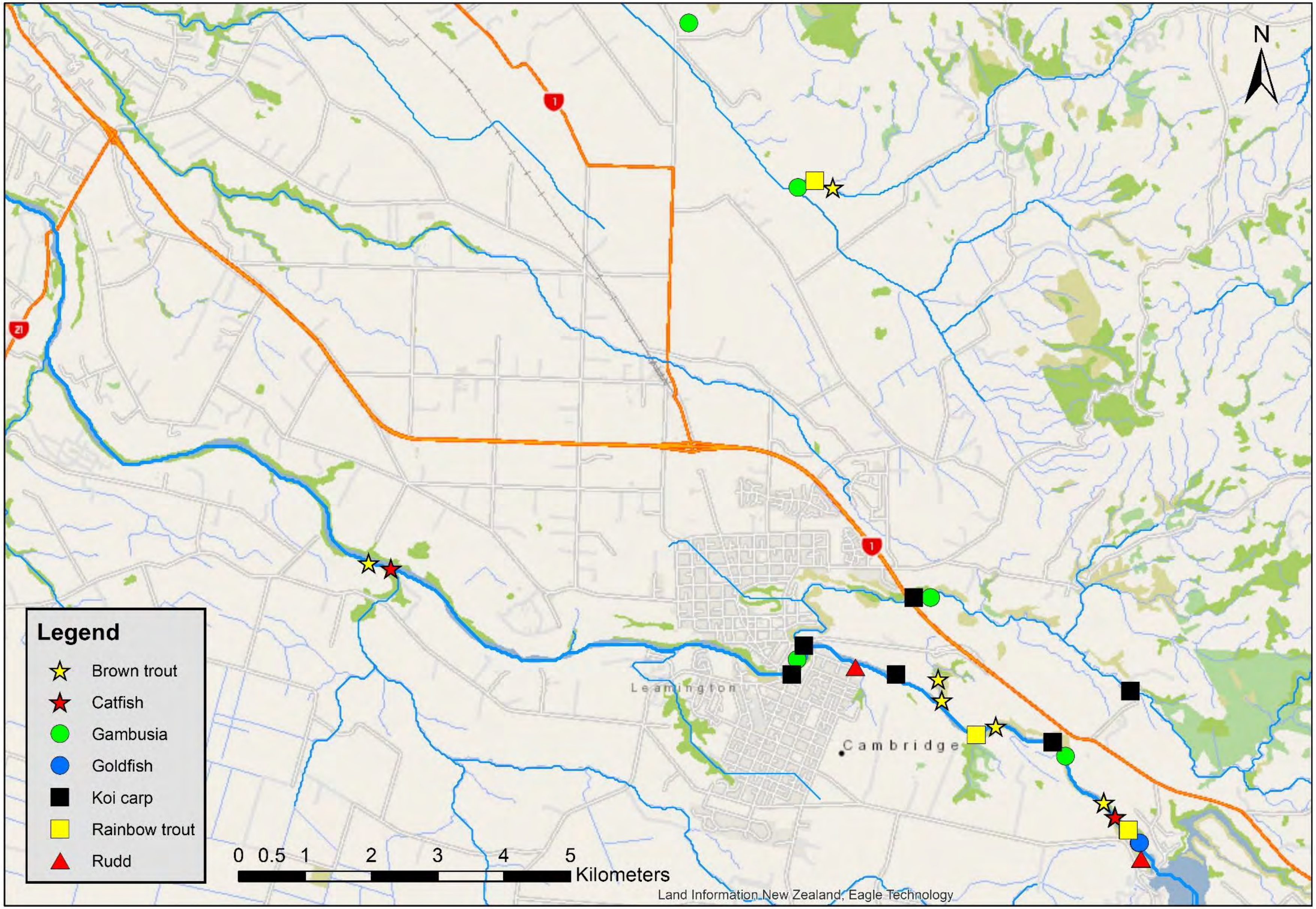


Figure 3-8: Map showing the distribution of exotic freshwater fish species in the C4 stream and in the wider area.

Table 3-1: Freshwater fish species that have been recorded in the New Zealand Freshwater Fish Database from the C4 Stream and surrounding area. Species are organised in alphabetical order by their common name.

Native/introduced	Common name	Scientific name	Life history type	Conservation status
Native	Banded kōkopu	*Galaxias fasciatus*	Diadromous and Non-diadromous	Not Threatened
	Black mudfish	*Neochanna diversus*	Non-diadromous	At Risk - Declining
	Common bully	*Gobiomorphus cotidianus*	Diadromous and Non-diadromous	Not Threatened
	Common smelt	*Retropinna retropinna*	Diadromous and Non-diadromous	Not Threatened
	Cran's bully	*Gobiomorphus basalis*	Non-diadromous	Not Threatened
	Giant kōkopu	*Galaxias argenteus*	Diadromous and Non-diadromous	At Risk - Declining
	Grey mullet	*Mugil cephalus*	Diadromous	Not Threatened
	Īnanga	*Galaxias maculatus*	Diadromous and Non-diadromous	At Risk - Declining
	Longfin eel	*Anguilla dieffenbachii*	Diadromous	At Risk - Declining
	Shortfin eel	*Anguilla australis*	Diadromous	Not Threatened
	Torrentfish	*Cheimarrichthys fosteri*	Diadromous	At Risk - Declining
Introduced	Brown trout	*Salmo trutta*	Non-diadromous	Introduced and naturalised
	Catfish	*Ameiurus nebulosus*	Non-diadromous	Introduced and naturalised
	Gambusia	*Gambusia* affinis	Non-diadromous	Introduced and naturalised
	Goldfish	*Carassius auratus*	Non-diadromous	Introduced and naturalised
	Koi carp	*Cyprinus carpio*	Non-diadromous	Introduced and naturalised
	Rainbow trout	*Oncorhynchus mykiss*	Non-diadromous	Introduced and naturalised
	Rudd	*Scardinius erythrophthalmus*	Non-diadromous	Introduced and naturalised

3.4 Overview of key species ecology

The ecology and life histories of eight native freshwater fish species (longfin eel; shortfin eel; banded kōkopu; giant kōkopu; īnanga; black mudfish; smelt and common bullies) are summarised below (Table 3-1). These species were chosen because they are resident in neighbouring streams and they were considered the most likely to be present in the C4 Stream. Therefore, these species are the most likely to be impacted by developments associated with the C4 Growth Cell.

3.4.1 Longfin and shortfin eels

Longfin and shortfin eels must migrate between marine and freshwater environments to complete their lifecycle. For these species, adult development and growth occurs in freshwater, and once maturity is reached they migrate downstream, through estuaries and into the marine environment. Reproduction is thought to occur somewhere in the Western Pacific Ocean. The larvae are then transported back to New Zealand on ocean currents. In the Waikato River, glass eels enter from July through to December (Jellyman et al. 2009). Longfin and shortfin eels transition into a pigmented juvenile eel (called an elver) and are on average one year-old once they reach the dam at Karapiro (Martin and Bowman, 2016). Once suitable habitat has been located, both species typically reside in the vicinity until maturity which can take over a decade.

The key factors known to influence the downstream migration of eels are increases in water level and flow associated with rainfall, and lunar periodicity, with maximum activity just before the last quarter (Todd 1981). However, rainfall and flow have been shown to be the best predictors of eel migrations (Boubée et al. 2001). Both longfin and shortfin eels have been recorded in the C4 Stream and are using this as rearing habitat until sexual maturity is reached. Therefore, maintaining a flashy or elevated flow regime in the stream will be important for stimulating the downstream migration of adult eels.

Shortfin and longfin elvers are skilled climbers, longfins reputedly more-so than shortfins (McDowall 2000). Elvers climb by attaching themselves to the substrate using friction and surface tension and undulating their bodies in an anguilliform motion as when swimming, but with their bodies in continuous contact with the substrate (Jellyman 1977). They often take advantage of rough substrate by wiggling between raised areas to provide greater surface area for adhesion. However, their ability to climb vertical surfaces is largely limited to when they are < 120 mm (Jellyman 1977; Jellyman et al. 2017). Based on their adept climbing abilities the culvert under Matos Segedin Drive is not considered a barrier for either eel species, however, the culvert under Cambridge Road requires further assessment.

3.4.2 Galaxiid species (giant kōkopu, banded kōkopu and īnanga)

Īnanga, banded kōkopu and giant kōkopu are typically considered diadromous as both marine and freshwater environments are used to complete their lifecycle. Banded and giant kōkopu generally spawn within the streams they reside in, whilst adult inanga migrate down to the estuary to spawn. Larval dispersal and development occur in the marine environment, followed by inward migration of juveniles (whitebait) to freshwater where most feeding and growth occurs (McDowall 1990). Recent research from the Waikato River shows there is considerable flexibility in the life history of īnanga, banded kōkopu and giant kōkopu with many populations completing their lifecycle in freshwater (David et al. 2019) i.e., they have facultative diadromy. In the Waikato River Catchment, a high proportion of banded kōkopu and giant kōkopu residing in tributaries upstream of Huntly are non-diadromous meaning their entire life (including their larval life) was completed in freshwater.

Furthermore, David et al. (2019) identfied the first population of non-migratory īnanga collected from a river within New Zealand (several lake populations of īnanga are known to exist, and in Chile many riverine *G. maculatus* are non-diadromous). These results suggest that in the Waikato River catchment, galaxiids with diadromous and non-diadromous life-history types need to be accounted and provided for in the restoration and proteciton of their habitats.

Giant kōkopu spawning occurs within rivers and streams during elevated flows following rainfall events. Spawning has only been recorded from two sites in Aotearoa-NZ, an urban stream in Hamilton and the Awaawaroa Wetland on Waiheke Island. Spawning is known to occur from late April to late June, but it possibly extends later (Franklin et al. 2015). Little is known about their spawning habits with most information to date coming from studies on a single population in the Waikato Region (Franklin et al. 2015). Currently, the known spawning vegetation is *Tradescantia fluminensis* (wandering willie), an invasive perennial herb; and *Carex germinata* but it is highly likely that giant kōkopu use other species of native and exotic grasses, sedges and rushes for spawning (Franklin et al. 2015).

Figure 3-9: Giant kōkopu (*Galaxias argenteus*) are one of the large-bodied Galaxiids found in the wider area.

Banded kōkopu (Figure 3-10) also spawn along bankside margins during elevated flows (Charteris et al. 2003) but can be quite variable in the selection of their spawning sites/habitats. Spawning sites for banded kōkopu include a mixture of small vegetation, gravel and woody debris (Charteris et al. 2003). Few spawning sites are known for banded kōkopu, but a site was recently identified in a tributary of the Waikato River (see Figure 3-11).

Both giant and banded kōkopu typically prefer low velocity pool habitats and do not have a preference for a particular substrate type. Their preference for very low velocity water may be related to their feeding habits, as both species sit at the water surface feeding on terrestrial insects that get trapped at the air/water interface (West et al. 2005). The surface waves produced by the struggling insect allows the kōkopu species to compute the direction and distance of their prey via their lateral line system (Halstead 1995). Both species are considered climbing galaxiids but banded kōkopu can overcome significant instream structures (e.g., waterfalls), whereas giant kōkopu have limited climbing abilities (McDowall 2000).

Figure 3-10: Banded kōkopu (*Galaxias fasciatus*) are one of the large-bodied Galaxiids found in the wider area.

Figure 3-11: Banded kōkopu spawning habitat (red circle) identified in 2018 in a tributary of the Waikato River near Hamilton.

The life histories and migrations of īnanga (Figure 3-12) are the most widely understood of the galaxiid species. For diadromous populations of īnanga, mature adults (50–125 mm in length) move downstream to their spawning sites (McDowall 1990), while non-diadromous populations are thought to move upstream to spawn. For īnanga that are diadromous, spawning occurs on riparian vegetation where the salt water wedge penetrates freshwaters at high tides (McDowall 1990). Spawning is linked to lunar and tidal cycles with most spawning occurring on spring-tide events. The spawning habitats of non-diadromous īnanga are unknown but it has been suggested that īnanga do not need a tidal cue to reproduce and can instead reproduce on elevated flows (Rowe and Kelly, 2009).

Figure 3-12: Īnanga (*Galaxias maculatus*) is the most widely distributed galaxiid in New Zealand and is found in the wider area of the C4 Stream.

Īnanga reproduce over an extensive period, from January in the south of New Zealand through to July in the north, with peripheral spawning also found outside of these 'peak' spawning times (Mitchell 1991, Taylor 2002). The eggs are typically deposited 10–15 cm above the highwater mark, take 2–4 weeks to develop and require humid conditions for successful development (Hickford and Schiel 2011). Īnanga have no climbing ability and must burst swim past instream obstacles.

3.4.3 Black mudfish

The black mudfish is an endemic wetland specialist but through habitat loss, pollution and sedimentation it is thought to now occupy less than 10% of its former range. Black mudfish are a particularly hardy species that can occupy waters with a wide range of pH (4–7), dissolved oxygen (as low as 0.3–1.8 mg/L; McPhail 1999) and water temperatures (up to 26°C; Thompson 1987). They can occupy ephemeral habitats by burying themselves in the sediment when it is dry and can remain dormant until surface water returns and they can re-emerge. As such, they have been known to occupy stormwater treatment wetlands where the environmental conditions may exclude less tolerant species (pers. comm. Bruno David, WRC). Mudfish are non-migratory and so passage to and from the Waikato River is not necessary.

Figure 3-13: Black mudfish (*Neochanna diversus*) are a declining species that found in the wider study area.

3.4.4 Common smelt

Common smelt (*Retropinna retropinna;* Figure 3-14) are widely spread throughout New Zealand. In the Waikato River catchment, Booker (2000) identified: (1) Non-diadromous populations (associated with lakes, e.g., Lake Taupō) and (2) diadromous populations. Booker (2000) found that the prevalence of diadromous and non-diadromous life histories was associated with changes in habitat structure and water quality. Differences include the number of gill rakers and vertebrae, size at maturity, maximum length and weight, fecundity, and relative density — as well as behavioural differences such as spawning period exist between diadromous and non-diadromous populations.

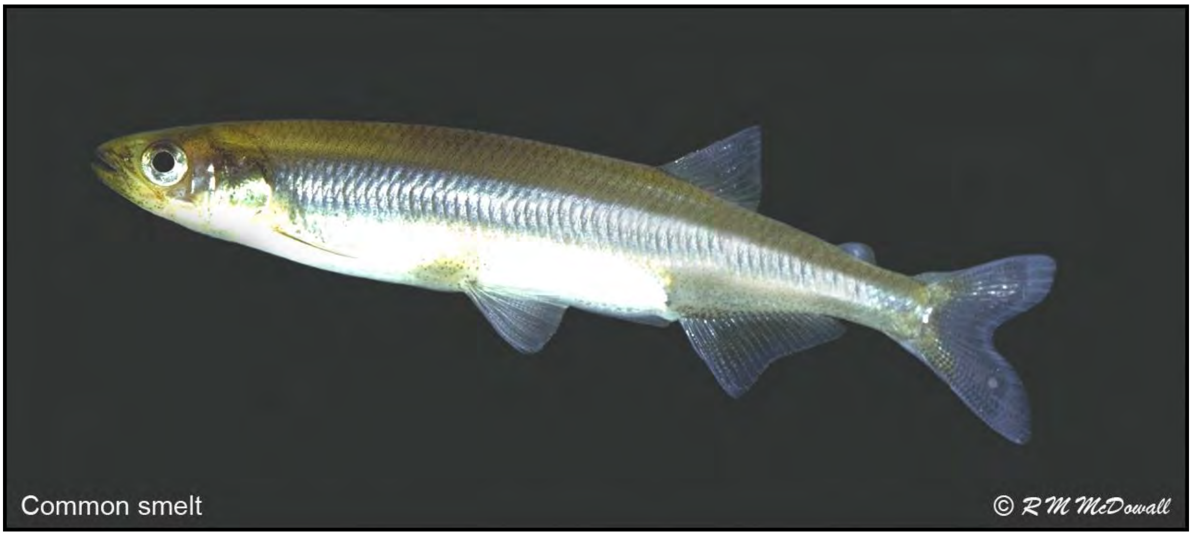


Figure 3-14: Common smelt (*Retropinna retropinna*).

Smelt are considered good swimmers and will penetrate well inland into river systems that are not too steep (e.g., the Whanganui and Manawatū Rivers). They are particularly abundant in the Waikato River catchment. They can reach 165 mm, but more commonly do not exceed 120 mm. This species can live up to four years of age, maturing at one year with an average generation time of 1.5 years. The main elements of this riverine life cycle are duplicated in lake-dwelling smelt populations (Ward et al. 2005). Spawning takes place annually in shallow, sandy margins of lakes and sandy river banks; however, lake and riverine populations spawn at different times of the year. Smelt are very sensitive to changes in their physical environment and are one of the most sensitive native fish species in New Zealand (Rowe et al. 2002; Rowe and Kusabs 2007).

Common smelt is a diadromous species that usually spends most of its life at sea, with mature adults returning to fresh water to breed. However, this is not the case for the Waikato River. Similar to the large galaxiid species, larvae hatch in fresh water and migrate out to sea where they feed and grow before returning to freshwater as juveniles for growth to adulthood (McDowall 2010). Once mature, adult smelt will migrate downstream and spawn in the lower reaches of the Waikato River mainstem, below Ngaruawahia (Baker & Bartels. 2011). In lake systems, these fish can choose to spawn within the lake and rear completely within freshwater.

3.4.5 Common bully

The common bully is widely found throughout New Zealand and is often observed in gently flowing streams and along the edges of lakes. Many of the people familiar with this species misname it as a "cockabully" (cockabullies are of a different family and are marine or estuarine fish). The common bully grows to about 150 mm in length, though adult fish are mostly less than 120 mm (Figure 3-15). Common bullies are considered a diadromous species, with juveniles moving out of the sea and moving upstream into rivers and lakes to grow and mature (McDowall 1990). Landlocked stocks are also common, and in some cases have probably been established by transfer from other waters. Populations in lake and lake tributaries are most likely non-diadromous and in the lower reaches of rivers they are mostly migratory (Hicks et al. 2017).

Figure 3-15: Common bully (*Gobiomorphus cotidianus*).

3.5 Hydrological, physical and ecological characteristics

The hydrological characteristics and flow duration curves for the upper and lower reaches in the C4 stream were almost identical (Table 3-2**Error! Reference source not found.**; Figure 3-16). At mean flows, the discharge at both reaches ranges between 0.09 – 0.11 $m^3 s^{-1}$ for 50% of the time (Figure 3-16).

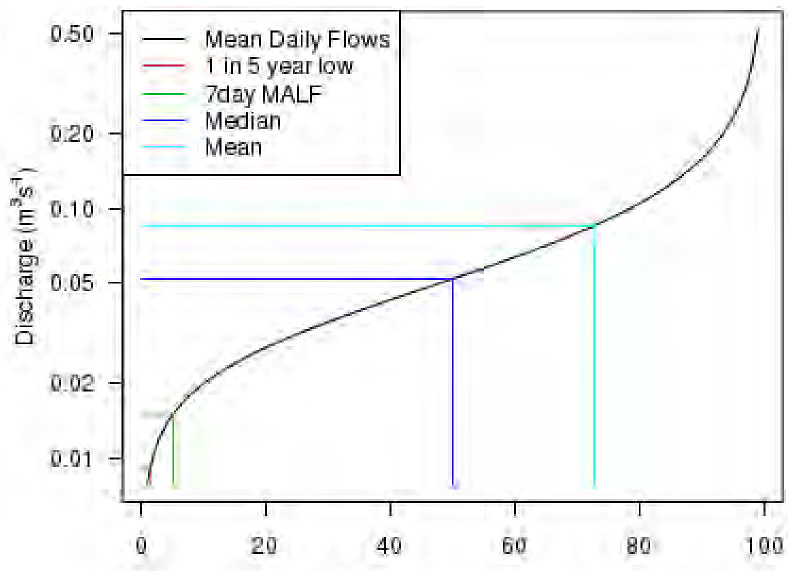
Table 3-2: The predicted hydrological characteristics for reaches in the C4 Stream above (upper) and below (lower) the proposed C4 Growth Cell development. Predictions are derived from the NZ River Maps tool. See Table A 1 for explanation of hydrological characteristics.

Hydrological characteristics	Reach	Flow (Litres/second)[2]
1 in 5-year low flow	Upper	9.05
	Lower	12.2
Mean annual low flow	Upper	15.1
	Lower	20.2
Median flow	Upper	52.2
	Lower	71.9
Mean flow	Upper	85.2
	Lower	120
February flow seasonality	Upper	0.445
	Lower	0.434

[2] All measurements are in litres per second unless otherwise stated

Hydrological characteristics	Reach	Flow (Litres/second)[2]
FRE3	Upper	11.7 events/yr^{-1}
	Lower	12.3 events/yr^{-1}
Month lowest mean flow	Upper	March
	Lower	March

a) Upper reach



b) Lower reach

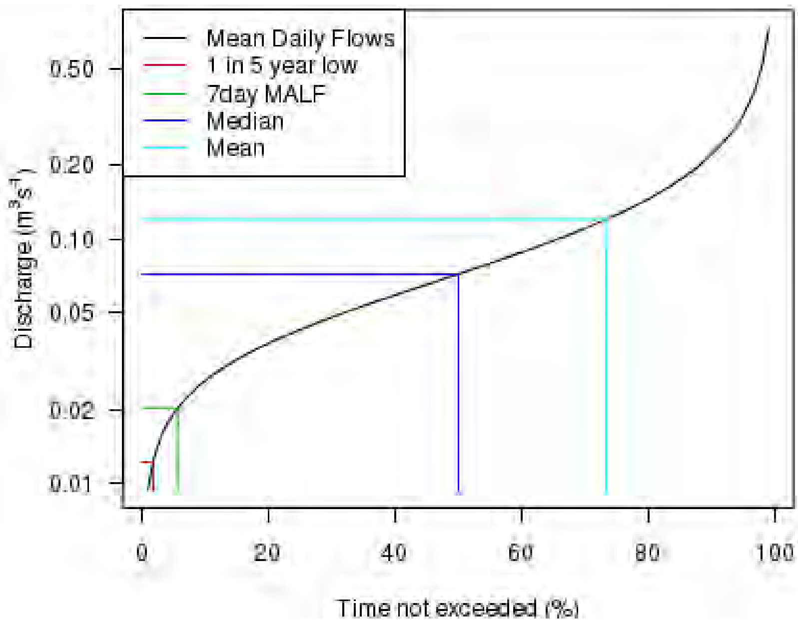


Figure 3-16: Predicted flow duration curves for five flow metrics in the upper and lower reaches of the C4 Stream. Predictions are derived from the New Zealand River Maps tool.

4 Discussion

From the site visit and synthesis of existing information, it was apparent that the habitats found in the upper reaches of the C4 Stream are likely capable of supporting black mudfish, banded kōkopu and giant kōkopu. The fallen trees and overhanging vegetation create cover and pool habitat that is preferred by banded kokopu and giant kōkopu (Baker & Smith 2007), while ephemeral wetland habitats and seeps were identified which are the preferred habitats of black mudfish. In addition, habitats suitable for both eel species, īnanga, smelt and common bullies were also present. However, there are concerns about potential fish passage impediments in the C4 Stream that may be preventing these species from colonising the upper reaches (see section 4.1.3) and there are no records of these species in the C4 Stream from the NZFFD (although survey cover is minimal).

Longitudinal changes in the habitat quality of the C4 Stream were evident with the lower sites being the most degraded. Below Cambridge Road, the C4 Stream had poor riparian and canopy cover, evidence of stock damage and large sections of homogenous habitat. This lower habitat quality suggests that any impacts from the C4 Growth Cell Development and associated stormwater inputs will be greatest upstream of the lake where instream habitat diversity, stable banks and mature riparian buffer existed.

Overall the ecological integrity of the C4 Stream cannot be fully understood without an updated survey sampling the range of habitats present, including the lake, to determine the fish communities utilising the different habitat types.

4.1 Potential issues and constraints

4.1.1 Hydrological modifications from stormwater inputs

It is likely that the proposed C4 Growth Cell development may alter the hydrological regime of the C4 Stream. However, the magnitude of any hydrological modifications and their subsequent effects are unknown as the stormwater management plan has not been developed. No known hydrological data exists for the C4 Stream and changes in the mean annual low flow (MALF) and the magnitude and duration of peak flows from stormwater discharges cannot be examined currently.

To understand the hydrological alteration of rivers from discharges (i.e., stormwater) and subsequent effects on freshwater fish, several hydrological statistics are needed. For native freshwater fish, the flow regime of rivers is important for reproduction, movement and migration all of which may be restricted to a few months of the year (McDowall 1995) and linked to the occurrence of suitable flow conditions. For example, for kōkopu species, flood flows are important for successful spawning and larval hatching in the winter months (Charteris et al. 2003; Franklin et al. 2014). Fish migration, such as the downstream migration of sexually mature eels, is cued by flow variability (Todd 1981). Therefore, low flows may affect resident fish populations by restricting upstream movement for spawning. Furthermore, in many river systems, periods of higher flows are also necessary to prevent the accumulation of periphyton and fine sediment in low velocity areas (Snelder et al. 2014) that affect fish habitat quality.

Erosion because of stormwater discharges could change the morphology of the upper site and make it more incised. The C4 Stream may be able to support increased discharges from stormwater inputs given the wide flood plain that exists. Furthermore, within the wider ecological landscape, the riparian buffer that exist in the upper sections of the C4 Stream is more established and provides increased bank stability. However, there appear to be issues with hydrological connectivity at the culvert under Cambridge Road and so increased stormwater discharges may result in flooding of the surrounding land above Cambridge Road (see section 4.1.3). Therefore, it is important that hydrological connectivity is facilitated and effectively maintained through the Cambridge Road culvert.

4.1.2 Contaminants

Contaminants associated with urban development can impact native fish ecology. Several key effects have been shown to occur even at low levels. For example, fish have their sensory systems in direct contact with the water and a variety of heavy metals (copper, cadmium, zinc, mercury, chromium and arsenic) have been shown to block sense of smell and taste in a wide variety of fish species (Klaprat et al. 1992). These heavy metals are common in domestic and industrial wastes. Baker and Montgomery (2001) found 0.5 and 2 µg/l Cd^{+2} was capable of impairing olfactory and lateral line function respectively, in migratory banded kōkopu whitebait. As many native fish present in the Waikato River are diadromous, the loss of sensory systems such as smell (olfaction) could affect habitat selection and successful recruitment by migratory juveniles. For resident fish, a loss of olfaction could result in changes to predator/prey interactions and feeding behaviour. Furthermore, heavy metals (copper, zinc and lead) are known to impact on īnanga egg development and survival (Barbee et al. 2016). Īnanga eggs exposed to these contaminants produce poorer quality larvae with reduced behavioural responses to light and poorer swimming abilities (Barbee et al. 2016). Thomas et al (2016) also showed that copper affects īnanga swimming ability and avoidance of stressors.

In general, fish species will not avoid low levels of contaminants. Richardson et al. (2001) examined the response of native fish such as īnanga, smelt and common bullies to copper (0.05 g/m^3), low dissolved oxygen (c. 2 g/m^3), and high and low ammonia (c. 8.5 and 2 g/m^3 NH_3 respectively). Only smelt showed a strong avoidance to all pollutants. Īnanga and common bullies did not avoid any contaminant except copper. Smelt have been promoted as an appropriate native species for establishing guidelines for New Zealand waterways (Rowe & Kusabs 2007) and usually their presence indicates that the water quality is suitable for most other fish. It is important that the stormwater management plan minimises additional contaminant inputs into the C4 Stream.

4.1.3 Assessment and remediation of fish passage structures

Two culverts were identified in the C4 Stream and there is a concern about whether the one under Cambridge Road is surmountable by fish, especially considering only two species with good climbing abilities (longfin eel and shortfin eel) have previously been identified in the upper section of the C4 Stream.

The removal of structures that impede fish passage is the primary and preferred solution (Franklin et al. 2018). Alternatively, replacement with a structure that has been designed to meet minimum design standards will likely offer the most sustainable and effective solution. For practical reasons many structures cannot be removed, so the addition of new features to existing structures is a more common strategy for enhancing fish passage. The remediation options available at a site will be dependent on factors including the characteristics of the existing structure, cost, accessibility, the reason(s) for reduced fish passage, and the ecological objectives for the site.

Alternatively, native fish species can benefit from natural or built barriers, and in some situations a selective barrier that provides access for climbing species over a natural or built barrier (e.g., banded and giant kōkopu), while preventing other non-climbing species (e.g., trout, rudd, koi carp) from moving upstream could be advantageous. For example, waterfalls maintain good native fish refuge from introduced species. By preventing invasive fish access, these selective barriers provide access for young native fish to protected upstream habitats and protect spawning habitats of adult fish. Furthermore, there is a seemingly high proportion of galaxiid species found in the Waikato River catchment that do not migrate to sea to complete their life cycle. This means that self-sustaining populations can be established within the Waikato River catchment and these species may benefit from a selective barrier. The lake that exists in the C4 Stream may provide ideal habitat for larval fish as for many species it is thought that if a lentic habitat such as a lake exists downstream, the larvae will not migrate to sea and instead will rear within the system.

Therefore, the lake in the C4 Stream may provide an opportunity for developing lacustrine populations of native fish species such as banded and giant kokopu, smelt and common bullies. In this regard, to complement the fish surveys, the Cambridge Road culvert requires further assessment to determine what remediation, if any, is necessary.

4.2 Future recommendations

- We recommend an ecological survey be undertaken in summer to describe the habitats and freshwater fish community in the C4 Stream. This would include a survey of the upper and lower sections of the stream and the lake. In addition, we recommend carrying out macroinvertebrate surveys in perennial stream sections.
- We recommend an assessment of the culvert under Cambridge Road. It is not clear if this structure is facilitating fish passage as species with poorer swimming and climbing abilities (such as īnanga and giant kōkopu, respectively), have not been recorded in the C4 Stream and their passage may be impeded by the culvert. The fish survey will also help determine the level of impediment this structure presents to fish passage.
- If possible, an ecological flow assessment using RHYHABSIM or similar physical habitat model is recommended to enable habitat changes with an altered flow regime to be more accurately assessed.

5 Acknowledgements

Thanks to Amber Sinton for producing the maps of freshwater fish species distributions from the New Zealand Freshwater Fish Database. We thank the landowners for access to land to complete the site visit.

6 References

Baker, C.F., Montgomery, J.C. (2001) Sensory deficits induced by cadmium in banded kokopu, *Galaxias fasciatus*, juveniles. *Environmental Biology of Fishes,* 62:455-464.

Baker, C.F., Smith, J.P. (2007) Comparison of habitat use by banded kokopu (*Galaxias fasciatus*) and giant kokopu (*Galaxias argenteus*) in restored streams within the Hakarimata Range, North Island, New Zealand. *New Zealand Journal of Marine and Freshwater Research,* 41: 25–33.

Baker, C.F., Bartels, B. (2011) Distribution of larval fish within the lower Waikato River. *NIWA Client Report* HAM2011-076: 43.

Barbee, N.C., Greig, A., Swearer, S.E. (2013) Validating the use of embryonic fish otoliths as recorders of sublethal exposure to copper in estuarine sediments. *Environmental Pollution,* 178:441-446. DOI: 10.1016/j.envpol.2013.03.064.

Booker, J.R. (2000) Smelt (*Retropinna retropinna*) displacement and population dynamics in the Waikato River system. Unpublished thesis, Masters of Science in Biological Sciences, University of Waikato. 130 p.

Booker, D.J., Snelder, T.H. (2012) Comparing methods for estimating flow duration curves at ungauged sites. *Journal of Hydrology,* 434-435:78-94. DOI: https://doi.org/10.1016/j.jhydrol.2012.02.031.

Booker, D.J., Snelder, T.H., Greenwood, M.J., Crow, S.K. (2014) Relationships between invertebrate communities and both hydrological regime and other environmental factors across New Zealand's rivers. *Ecohydrology,* 8: 13-32.

Booker, D.J., Whitehead, A.L. (2017) NZ River Maps: An interactive online tool for mapping predicted freshwater variables across New Zealand. NIWA, Christchurch. https://shiny.niwa.co.nz/nzrivermaps/

Boubée, J.A., Mitchell, C.P., Chisnall, B.L., West, D.W., Bowman, E.J., Haro, A. (2001) Factors regulating the downstream migration of mature eels (*Anguilla* spp.) at Aniwhenua Dam, Bay of Plenty. New Zealand. *New Zealand Journal of Marine and Freshwater Research,* 35: 121–134.

Collier K.J., Clapcott J., Neale, M. (2014) A macroinvertebrate attribute to assess ecosystem health for New Zealand waterways for the national objectives framework – Issues and options. Environmental Research Institute report 36, University of Waikato, Hamilton.

Chapman, A., Morgan, D.L., Beatty S.J., Gill, H.S. (2006) Variation in Life History of Land-Locked Lacustrine and Riverine Populations of *Galaxias maculatus* (Jenyns 1842) in Western Australia. *Environmental Biology of Fishes,* 77:21-37. DOI: 10.1007/s10641-006-9051-2.

Charteris, S.C., Allibone, R.M., Death, R.G. (2003) Spawning site selection, egg development, and larval drift of *Galaxias postvectis* and *G. fasciatus* in a New Zealand stream. N*ew Zealand Journal of Marine and Freshwater Research,* 37:493-505. DOI: 10.1080/00288330.2003.9517184.

Crow, S. (2018) New Zealand Freshwater Fish Database. Version 1.6. The National Institute of Water and Atmospheric Research (NIWA). Occurrence dataset https://doi.org/10.15468/ms5iqu accessed via GBIF.org on 2018-11-01.

Crow, S.K., Booker, D.J., Snelder, T.H. (2013) Contrasting influence of flow regime on freshwater fishes displaying diadromous and non-diadromous life histories. *Ecology of Freshwater Fish,* 22(1): 82–94. http://dx.doi.org/10.1111/eff.12004

David, B.O., Jarvis, M., Özkundakci, D., Collier, K.J., Hicks, A.S., Reid, M. (2019) To sea or not to sea? Multiple lines of evidence reveal the contribution of non-diadromous recruitment for supporting endemic fish populations within New Zealand's longest river. *Aquatic Conservation: Marine and Freshwater Ecosystems,*

Franklin, P., Smith, J., Baker, C., Bartels, B. (2014) Flow controls on spawning success of New Zealand's iconic galaxiid fish species. *Proceedings of the 10th International Symposium on Ecohydraulics,* Trondheim, Norway. 23-27 June 2014.

Franklin, P., Gee, E., Baker, C., Bowie, S. (2018) New Zealand Fish Passage Guidelines (2018) *NIWA Client Report,* 2018036HN: 209p.

Gibson, R.J., Haedrich, R.L., Wernerheim, C.M. (2005) Loss of fish habitat as a consequence of inappropriately constructed stream crossings. *Fisheries,* 30(1): 10-17.

Halstead, M.D.B. (1998) Sensory encoding of surface waves by the banded kokopu *Galaxias fasciatus*. Unpublished PhD Thesis, University of Auckland.

Hickford, M.J., Schiel, D.R. (2011) Synergistic interactions within disturbed habitats between temperature, relative humidity and UVB radiation on egg survival in a diadromous fish. *PLOS ONE* 6:e24318.

Hicks, A.S., Jarvis, M.G., David, B.O., Waters, J.M., Norman, M.D., Closs, G.P. (2017) Lake and species-specific patterns of non-diadromous recruitment in amphidromous fish: the importance of local recruitment and habitat requirements. *Marine and Freshwater Research,* 68(12) 2315-2323.

Jellyman, D.J. (1977) Summer upstream migration of juvenile freshwater eels in New Zealand. *New Zealand Journal of Marine and Freshwater Research,* 11:61-71.

Jellyman, D.J., Booker, D.J., Watene, E. (2009) Recruitment of *Anguilla* spp. glass eels in the Waikato River, New Zealand. Evidence of declining migrations? *Journal of Fish Biology,* 74:2014-2033. DOI: 10.1111/j.1095-8649.2009.02241.x.

Jellyman, P., Harding, J. (2012) The role of dams in altering freshwater fish communities in New Zealand. *New Zealand Journal of Marine and Freshwater Research,* 46:475-489.

Jensen, B. (2019) Stormwater Management Plan (SMP) Cambridge C1 and C2/C3 Infrastructure. Cambridge West - Pukeroro Scheme Drain and Waikato River Tributaries Catchments. *Beca Client Report prepared for Waipa District Council*, draft for - consultation, June 2019.

Joy, M., David, B., Lake, M. (2013) New Zealand Freshwater Fish Sampling Protocols, Part 1: wadeable rivers and streams. The Ecology Group – Institute of Natural Resources, Massey University.

Klaprat, D.A., Evans, R.E., Hara., T.J. (1992) Environmental contaminants and chemoreception in fishes. pp. 321-341. In: T J Hara (ed.) Fish Chemoreception, Chapman and Hall, London.

McDowall, R.M. (1990) New Zealand Freshwater Fishes. A natural history and guide. Auckland, Heinemann Reed. 553 p.

McDowall, R.M. (1995) Seasonal pulses in migrations of New Zealand diadromous fish and the potential impacts of river mouth closure. *New Zealand Journal of Marine and Freshwater Research*, 29:517-526. DOI: 10.1080/00288330.1995.9516684.

McDowall, R.M. (2010) New Zealand freshwater fishes: an historical and ecological biogeography. Springer, London.

McPhail, J.D. (1999) A fish out of water: observations on the ability of black mudfish, *Neochanna diversus*, to withstand hypoxic water and drought. *New Zealand Journal of Marine and Freshwater Research*, 33: 417–424.

McRae, N.K., Gaw, S., Glover, C.N. (2016) Mechanisms of zinc toxicity in the galaxiid fish, *Galaxias maculatus*. *Comparative Biochemistry and Physiology C-Toxicology & Pharmacology*, 179:184-190. DOI: 10.1016/j.cbpc.2015.10.010.

Poff, N.L., Allan, J.D. Bain, M.B., Karr, J.R., Prestegaard, K.L., Richter, B.D., Sparks, R.E., Stromberg, J.C. (1997) The natural flow regime. *BioScience,* 47:769-784.

Richardson, J., Williams, E.K., Hickey, C.W. (2001) Avoidance behaviour of freshwater fish and shrimp exposed to ammonia and low dissolved oxygen separately and in combination. *New Zealand Journal of Marine and Freshwater Research,* 35:625-633.

Rowe, D.K., Smith, J., Williams, E. (2002) Effects of turbidity on the feeding ability of adult riverine smelt (*Retropinna retropinna*) and īnanga (*Galaxias maculatus*). *New Zealand Journal of Marine and Freshwater Research,* 26: 143-150.

Rowe, D., Kusabs, I. (2007) Taonga and mahinga kai of the Te Arawa lakes: a review of current knowledge – Smelt. *NIWA Client Report*: HAM2007-022. April 2007: 26.

Rowe, D.K., Kelly, G. (2009) Duration of the oceanic phase for inanga whitebait (Galaxiidae) is inversely related to growth rate at sea. Pages 343-354 *in* A. Haro, K. L. Smith, R. A. Rulifson, C. M. Moffitt, R. J. Klauda, M. J. Dadswell, R. A. Cunjak, J. E. Cooper, K. L. Beal, and T. S. Avery, editors. Challenges for diadromous fishes in a dynamic global environment. *American Fisheries Society*, Halifax, Canada.

Snelder, T.H., Booker, D.J., Quinn, J.M., Kilroy, C. (2014) Predicting Periphyton Cover Frequency Distributions across New Zealand's Rivers. J*AWRA Journal of the American Water Resources Association,* 50:111-127. DOI: 10.1111/jawr.12120.

Stark J.D, Maxted J.R (2007) A user guide for the Macroinvertebrate Community Index. Prepared for the Ministry for the Environment. *Cawthron Report* No.1166. 58 p.

Taylor, M.J. (2002) The national inanga spawning database: trends and implications for spawning site management. *Science for Conservation,* 188:1-37.

Thomas, O.R., Barbee, N.C., Hassell, K.L., Swearer, S.E. (2016) Smell no evil: Copper disrupts the alarm chemical response in a diadromous fish, *Galaxias maculatus*. *Environmental Toxicology and Chemistry,* 35:2209-2214.

Thompson, F.V. (1987) Notes on the black mudfish*. Freshwater Catch,* 32: 6–10.

Todd, P.R. (1981) Timing and periodicity of migrating New Zealand freshwater eels *(Anguilla* spp.). *New Zealand Journal of Marine and Freshwater Research,* 15: 225–235.

Waikato Regional Council (2018) Waikato Stormwater Management Guideline. *Waikato Regional Council Technical Report 2018/01.*

Walsh, C.J., Roy, A.H., Feminella, J.W., Cottingham P.D., Groffman, P.M., II, R.P.M. (2005) The urban stream syndrome: current knowledge and the search for a cure. *Journal of the North American Benthological Society*, 24:706-723. DOI: 10.1899/04-028.1.

Ward, F.J., Northcote, T.G., Boubée, J.A.T. (2005) The New Zealand common smelt: biology and ecology. *Journal of Fish Biology*, 66: 1-32.

West, D.W., Jowett, I.G., Richardson, J. (2005) Growth, diet, movement, and abundance of adult banded kokopu (*Galaxias fasciatus*) in five Coromandel, New Zealand streams. *New Zealand Journal of Marine and Freshwater Research,* 39:915-929.

West, D., Crow, S., David, B., Franklin, P., Allibone, R., Closs, G., Hitchmough, R., Surrey, G., Cooper, D. (2014) *Neochanna diversus*. The IUCN Red List of Threatened Species 2014: e.T14506A545893. http://dx.doi.org/102305/IUCN.UK.2014-3.RLTS.T14506A545893.en.

Appendix A

Table A-1: Flow statistics and their calculations for the C4 Stream. These statistics are derived from the New Zealand River Maps tool.

Hydrological characteristic Ls^{-1}	Meaning
1 in 5-year low flow	One in 5-year low flow on average over all time after having applied a 7-day running average and assuming that annual low flows take a normal distribution (m^3 s^{-1}). Lower values mean less flow.
Mean annual low flow (MALF)	The mean of the annual low flow series after having applied a 7-day running average (m^3 s^{-1}). Lower values mean less flow.
Median flow	The predicted median of mean daily flow time-series over all time (m^3 s^{-1}). Lower values mean less flow.
Mean flow	Mean flow over all time (m^3 s^{-1}). Lower values mean less flow.
February flow seasonality	Mean flow in February divided by mean flow over all time. Provides an estimate of flow seasonality. Values lower than 1 indicates mean flow in February is less than overall mean flow.
FRE3 (events per year)	The average number of events per year that exceed three times the median flow (events/year). Calculated from mean daily flows with no windows applied to account for peaks that occur in quick succession. Provides an estimate of flow flashiness. Lower values mean less frequent events.
Month lowest mean flow	The month with the lowest mean flow

Cambridge C4 Growth Zone 3 Waters Assessment

September 2020

Prepared For:

Waipa District Council
Private Bag 2900
Te Awamutu
3840

Prepared By:

Te Miro Water Consultants Ltd
Unit 7, 3 Empire Court
Cambridge, 3434
Waikato

Document Set ID: 10476599
Version: 1, Version Date: 29/09/2020

DOCUMENT CONTROL RECORD

CLIENT	Waipa District Council
PROJECT	Cambridge C4 Three Waters Assessment
PROJECT NO.	19006-01
DOCUMENT	Three Waters Assessment

ISSUE AND REVISION RECORD

DATE OF ISSUE	September 2020
STATUS	Final
ORIGINATOR	Mike Chapman – Principal Engineer, Te Miro Water Ltd Matthew Farrell – Senior Civil Engineer, Harrison Grierson Ltd
REVIEWED	Britta Jensen – Principal Engineer, Te Miro Water Ltd
APPROVED FOR ISSUE	Mike Chapman – Principal Engineer, Te Miro Water Ltd

OFFICE OF ORIGIN	Suite 7, Empire Place, Cambridge
TELEPHONE	021 477 801
EMAIL	mike@temirowater.co.nz

CONTENTS

APPENDICES

EXECUTIVE SUMMARY

This report outlines the proposed stormwater solution to enable the development of the Cambridge C4 Residential Growth Cell. Water supply and wastewater servicing options are also presented. The receiving environment for the C4 growth cell is a large, steeply incised gully which runs adjacent to the site along the eastern edge of the proposed development area. An unnamed stream runs through the gully in a northerly direction towards the Waikato River. The ecology assessment states this unnamed stream is vulnerable to changes in hydrological conditions resulting from development of C4. The stream outlets to the north via an existing culvert under Cambridge Road and then flows around the Aotearoa Industrial Park before connecting to the Waikato River approximately 1500m downstream from the Cambridge Road culvert (C4 gully outlet).

The intention is to drain treated runoff from the growth cell to the unnamed tributary within the C4 gully, but the connection will not be directly to the stream. The preferred option is to outlet to the gully via appropriate outfall design and spread diffuse flow across the wide gully floor.

There are several options to manage stormwater to meet the design level of service and guiding principles outlined in the Regional Infrastructure Technical Specification, NZS 4404 2010, NZBC Clause E1, as well as the overarching management philosophies promoted in the Waikato Regional Stormwater Management Guideline (January 2018).

The development of C4 will result overtime in an increase in the impervious area due to the creation of buildings, hardstand, and roads. New impervious surfaces generate significant increases in peak flow, timing, and volume of runoff during a rain event. A typical residential subdivision is likely to result in an increase in total metals, total suspended sediments, nutrients, hydrocarbons and an increase in temperature as well as gross pollutants generated from those surfaces especially during high frequency rain events (first flush events) following prolonged dry spells.

The design philosophy will seek to implement water sensitive principles which can be integrated into the layout and landscape. The intention is to manage stormwater as close to the point of origin as possible, to minimise collection and conveyance infrastructure and to ensure no adverse impacts downstream. It is noted these impacts can be flow related (i.e. flooding or scour) and/or water quality related. The options presented in this report offer solutions which will achieve the following:

1. Protect and enhance the downstream receiving environment including fish passage in accordance with the Vision and Strategy of the Waikato-Tainui Environmental Plan.
2. Outline capacity and servicing requirements for water and wastewater.
3. Water efficiency measures and retention of stormwater on private lots and within public road reserves.
4. Recommend pre-treatment and soakage to manage water quality and primary flow up to the 10 year + cc event prior to discharge to the gully.
5. Manage normal and potentially high contaminate load profiles.
6. Help to maintain baseflows within the C4 gully stream using soakage.
7. Appropriate location and sizing of stormwater infrastructure to enable staging development.
8. Managing secondary flow paths up to the 100 year + cc event safely within the development to the gully floor outlet point.
9. Hydraulic modelling and risk assessment to assess need for flood attenuation.
10. Stability protection of the gully side from uncontrolled overland flow.
11. Avoidance of adverse impacts from flooding downstream.

Soakage testing concludes the growth area is favourable to use infiltration for stormwater management. The flood risk assessment concludes increases in runoff due to creation of new impervious surfaces has less than minor effect downstream within the gully (due to the significantly large storage area) and below the Cambridge Road culvert. The proposed solutions for stormwater management at C4 are:

1. Pre-treatment + soakage on residential lots.
2. Road drainage via reticulated network to soakage trenches within the road reserve or alternatively to communal soakage basins with forebay for pre-treatment.
3. Planted swales for park/reserve edge roads where feasible.
4. Both primary and secondary flows conveyed to the gully with appropriate outlet to encourage dispersal and fan out across the gully floor to stream.
5. Construction of each gully outlet stormwater outlet structure is likely to require a concrete manhole stilling well, combined riprap and gabion protection and potentially a directionally drilled HDPE pipe. The outlet structure will provide velocity reduction of stormwater discharges to the gully environment.
6. RITS water quality volume and initial abstraction volumes will be managed via pre-treatment and soakage systems within the development.
7. Flood attenuation basins to limit post development peak flows to predevelopment peak flows are not required due to the storage and buffering effect of the large gully directly adjacent to the C4 growth area.

1 INTRODUCTION

Te Miro Water Consultants (TMW) have been engaged by Waipa District Council to provide a Three Waters Assessment to support the C4 Structure Plan. The C4 growth cell is located to the south of Cambridge as shown in Figure 1.

FIGURE 1 LOCATION OF C4 GROWTH CELL

1.1 BACKGROUND AND PURPOSE

The Structure Plan objectives are to determine the urban form, use and way infrastructure can be efficiently, and cost effectively developed to facilitate residential development (~800 dwellings). The C4 growth cell is one of 11 growth cells currently identified for Cambridge as shown in Figure 2.

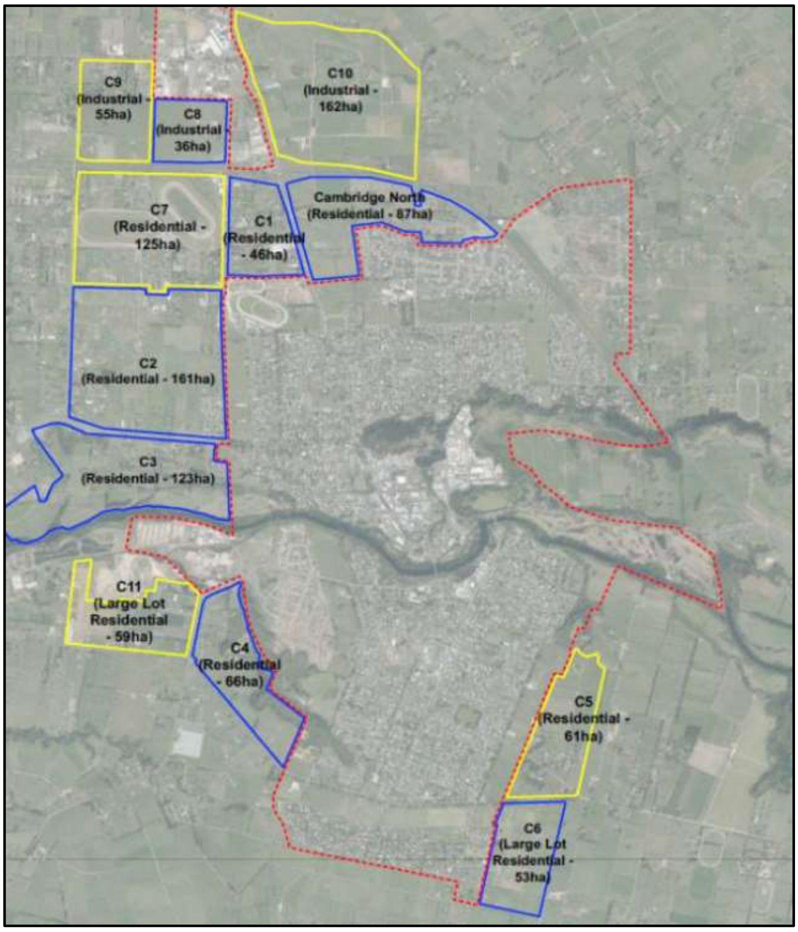


FIGURE 2 - CAMBRIDGE GROWTH CELLS

TMW have worked closely with the wider project team (WDC staff, Planning, Transport, Geo-technical etc) to determine key requirements and constraints to inform the three waters assessment.

A project start-up meeting was held with Robin Walker at WDC on 21 August 2019. The key issues identified during the meeting were:

- Overall objective for WDC is to seek ways to provide fish passage from the Waikato River up into the upper section of the C4 gully
- Consent monitoring conditions attached to the Arnold Street Stormwater outlet
- Monitoring outlet from the historic landfill
- Water supply and wastewater currently being master planned for Cambridge. The results of the master plan will influence the final solution for C4

The Three Waters Assessment will cover:

- Existing catchment conditions.
- Stormwater management options including flood modelling.
- Water supply options.
- Wastewater servicing options.
- Summary and conclusions.

1.2 DEVELOPMENT STAGING

Ideally sequencing and timing of development within C4 takes place in a coherent and efficient manner that is coordinated with the economic development of trunk 3 waters services. Council funding of infrastructure development will be generally in accordance with the programme in Waipa's Strategic Plan. A distributed stormwater solution is encouraged with more than 1 outlet to the gully to allow various pockets of land to be unlocked discreetly from one another. In this sense

There are 4 larger landowners within the growth cell as well as a cluster of rural residential property owners.

- The gully is owned by Waipa District Council which could help when requiring permission to construct any stormwater devices/outlets.
- Currently there is no detailed urban layout and the order of development is unknown. Less reliance on 'end of line' large scale communal devices will help promote development staging in a flexible manner reducing the need for multi-party ownership to form agreements to build infrastructure.

2 ASSESSMENT OF EXISTING CATCHMENT FEATURES, CONSTRAINTS, RISKS AND OPPORTUNITIES

The following section assesses the features, constraints, risks, and opportunities for the C4 growth cell. a summary is provided in the table below.

Features

1. C4 has two distinct landscape typologies:
   a. A flat remnant river terrace at 2 broad levels where growth cell development is proposed to occur and;
   b. A 20m deeply incised gully adjacent to the entire length of the C4 terrace;
2. An unnamed tributary within the gully floor draining via culvert under Cambridge Road to a channel around existing industrial area before discharging to the Waikato River;
3. The gully has been identified as:
   a. ecologically significant with sensitivity to some scour and erosion
   b. heavily vegetated with exotic and native plantings;
4. Two existing urban stormwater outfalls are present:
   a. Draining the recent Cambridge Park sub-division and
   b. Draining approximately half of the existing Leamington urban area.

Constraints

- Pipe outlet and velocity control at the base of the gully
- Water supply and wastewater trunk infrastructure
- Multiple land ownership

Risks

- Geo technical stability along gully edge and setback zone
- Reliance and positoning of public soakage systems and their on going operation and maintenance
- Timing of development aligning with construction of 3 waters trunk infrastructure and WWTP upgrades

Opportunities

- Public access through gully and connectivity with existing resdential areas
- Stream enhancement within the gully and downstream within the industrial estate
- Fish passage under Cambridge Road
- Amenity stormwater basins/wetland within public reserves
- Reserve edge roadside swales

A site walkover was undertaken on July 18th, 2019 to assist in understanding the catchment and determining objectives for the three waters design at the site. Site photos of key catchment features and different perspectives are provided in Appendix 1.

2.1 EXISTING LANDUSE CATCHMENTS AND TOPOGRAPHY

Distinct catchment and topography items include:

- The C4 structure plan area sits within a predominantly flat, well drained rural area. The existing land use is rural grazing and there is a small pocket of rural residential living. An existing aerial map and contour plan is provided in Appendix 2 and Appendix 3.
- The catchment is defined by Lamb Road and Cambridge Road to the west and north respectively.
- The total catchment area is effectively the C4 growth cell (66ha).
- The steeply incised gully (~20m deep) represents what was once a much larger tributary channel of the Waikato River. This gully now acts as a local drainage system. The gully floor is filled with dense shrubland at approximately 42mRL.
- The upper terrace which covers the developable area has a ground level of approximately 64mRL.

2.2 EXISTING OVERLAND FLOWPATHS

A review of the contour plan, aerial photos, and site visit observations, as well as consideration of nearby developments provides the following overland flow path assumptions:

- There are no obvious surface drainage networks connecting the site to the gully or farm drains within the site or culvert connectivity under Lamb Road to the west.
- The rural residential subdivision on Silverwood Lane have on lot soakage devices.
- Currently stormwater runoff would either pond on the farmland within shallow depressions and soak away during storms up to the ~10 year ARI design storm event. Storms greater that the 10 year ARI may run off overland into the gully and stream.
- Existing secondary flow paths generally follow the gradual fall of the land, being from the south-west to north east towards the gully. The site visit did not reveal any obvious ephemeral channel dissecting the grazing land to the gully edge – supporting the assumptions that most of the catchment ponds and/or disperses via soakage across the flat terrace.

A high level map of overland flow paths and contributing catchments is provided in Figure 3.

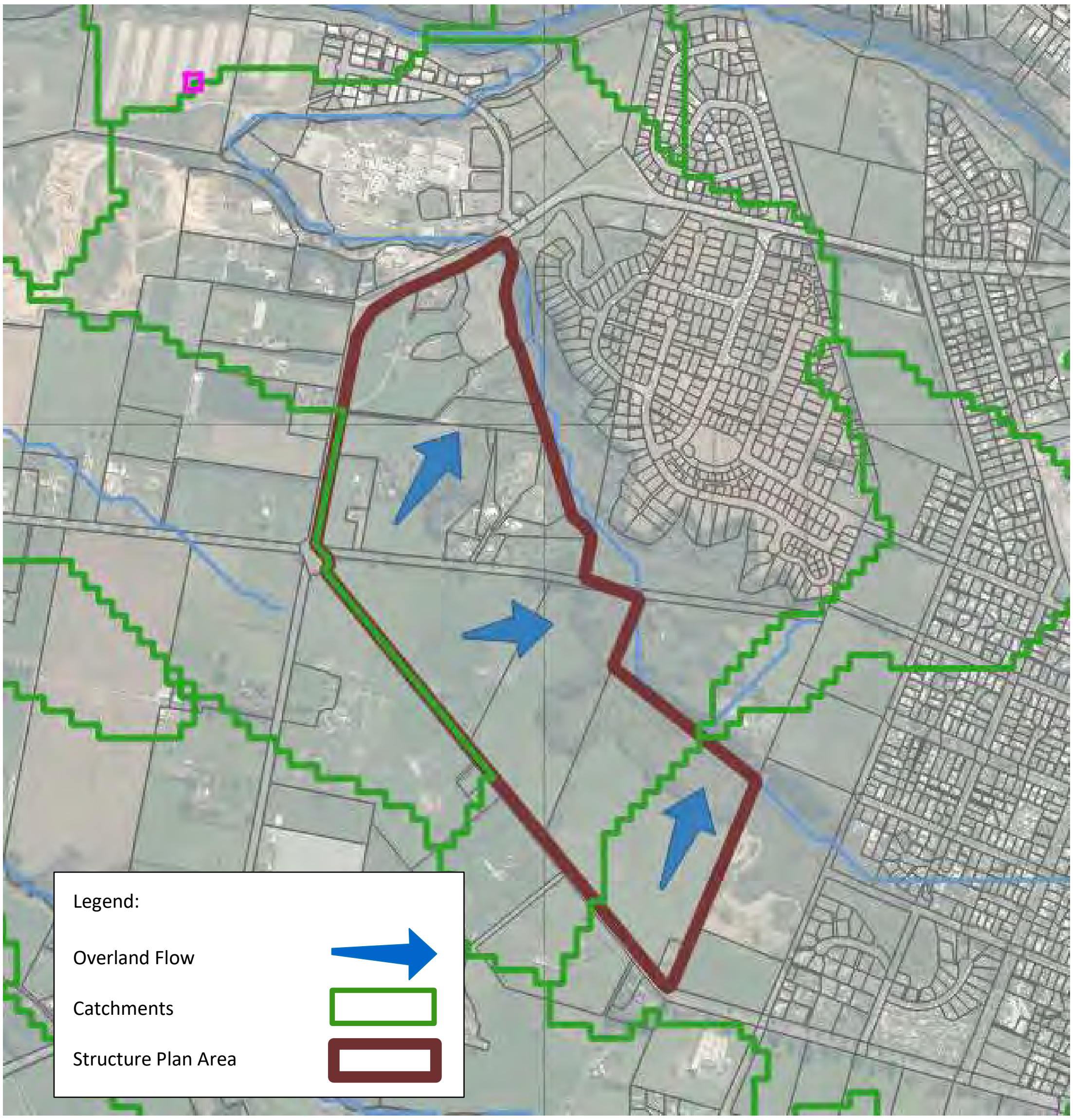


FIGURE 3 GENERAL OVERLAND FLOW PATHS AND CONTRIBUTING CATCHMENTS

2.3 EXISTING FLOOD IMPACT ASSESSMENT

A 1D/2D hydrological and hydraulic model (Infoworks ICM) of the 100 year ARI existing and post development scenario was developed to understand the present flood hazard within the gully and at the culvert outlet under Cambridge Road and immediately downstream through the industrial development. The purpose of this assessment was to determine the existing base case and in turn inform the stormwater management as part of the structure plan. The model build report and flood maps are presented in Appendix 6 and summarised as follows:

- Hydrology inputs such as rainfall depth, catchment land use type, impervious coverage etc are in accordance with the Regional Infrastructure Technical Specification (HCC, 2018) (RITS) and TR2020/07 and 06 (WRC,2020).
- The model estimates the pre-development hydrology conditions for the development area (C4) and wider catchment (existing land use which is a mix of urban and rural) which outlets to the gully including specific downstream constraints (culvert, road, 1D confined channels etc).

- The culvert under Cambridge road is included in the model with culvert details (diameter, length, invert levels etc) and 1D channel sections upstream and downstream obtained by site survey.
- Existing catchment runoff volumes are loaded directly to the basin model to derive peak waters levels within the gully and peak flows and levels at the culvert outlet.

The results of the flood modelling are summarised as:

- The expansive and deeply incised gully system will be the receiving environment for the development.
- The flat gully acts as a large attenuation basin with a fixed hydraulic control being the existing culvert and causeway on Cambridge Road.
- The downstream landuse is industrial/commercial, which is lower risk than residential landuse, notwithstanding the lower risk, the objective is to not create adverse impacts from the C4 development by increasing flows and water levels downstream.
- Other than C4 there is no future planned growth within the C4 stream catchment thereby reducing the issue of 'cumulative impacts' from a series of future unattenuated storm flows.

2.4 RECEIVING ENVIRONMENT

A site visit report by NIWA provides an assessment of the receiving environment within the gully. A summary of key items that feed into the three waters design objectives is provided below:

- Habitats in the upper reaches of the C4 Stream are likely capable of supporting black mudfish, banded kōkopu and giant kōkopu.
- The fallen trees and overhanging vegetation create cover and pool habitat that is preferred by banded kokopu and giant kōkopu (Baker & Smith 2007).
- The ephemeral wetland habitats and seeps within the broad gully floor are the preferred habitats of black mudfish. In addition, habitats suitable for both eel species, īnanga, smelt and common bullies were also present.
- There are concerns about potential fish passage impediments in the C4 Stream that may be preventing these species from colonising the upper reaches and there are no records of these species in the C4 Stream from the NZFFD (although survey cover is minimal).
- Longitudinal changes in the habitat quality of the C4 Stream were evident with the lower sites being the most degraded. Below Cambridge Road, the C4 Stream had poor riparian and canopy cover, evidence of stock damage and large sections of homogenous habitat.
- This lower habitat quality suggests that any impacts from the C4 Growth Cell Development and associated stormwater inputs will be greatest upstream of the lake where instream habitat diversity, stable banks and mature riparian buffer existed.

Overall, the ecological integrity of the C4 Stream cannot be fully understood without an updated survey sampling the range of habitats present, including the lake, to determine the fish communities utilising the different habitat types.

2.5 GROUNDWATER

Two piezometers were installed (3 September 2019) to 20m depth by Perry Geotech Ltd, one each in the northern and southern section of the development area. Three levels have been taken following installation, another on 16 September and 26 September 2019.

- Post installation (settled groundwater) depths range from 11m to ~15m depth for Piezometer 1 and 2 respectively.
- The development is located directly west of the deeply incised gully. The groundwater levels across the site are reflected by the depth of the gully with the soils draining towards the gully floor at a 1 in 10 gradient. Shallow groundwater encountered in the CPT holes are indicative of perched groundwater in wetter winter months.
- Localised perched water table encountered at approximately 4m depth.

2.6 EXISTING SOIL CAPACITY FOR SOAKAGE

A further site investigation including stormwater disposal testing was undertaken by Mark T Mitchell on October 14th and 15th 2019. The purpose of the study was to determine and evaluate the sub surface conditions within the site and assess the feasibility for on-site stormwater disposal within the C4 Growth Cell. The findings are presented in a report by Geocon Geotechnical Ltd (Mark Mitchell associate company) dated 31 October 2019.

Falling head permeability testing was carried out within the upper terrace zone at 4 locations as shown in Appendix 7 (Drawing No. 16064-20). The subsurface conditions within the test bore holes revealed:

- There is 200mm of topsoil overlying silt (loam) to between 0.4m to 0.8m depth.
- The silt underlain by gravelly fine to coarse grained sand to at least the base of the 1.5m to 3.0m deep bore holes.
- Groundwater was not encountered within the bore holes during the spring site investigation.

The results represent the theoretical soil hydraulic conductivity or ability of that soil medium to transmit water flows under a simulated water level head. The results are summarised as:

- Five of the six tests revealed consistent hydraulic conductivity (k) with values between 1.1m-2.8m per day or on average between 46mm/hr and 117mm/hr.
- The other test (A2 at 3.0m deep test) provided inconsistent results. This is likely to be on account of:
  - Heavy rainfall in the days prior to testing.
  - Perched water above silt lenses which are exposed in the gully branch located south of the test site.
  - The possibility of some deeper sands being very dense which limited pore space availability.

The results may not be fully representative of the full capacity of the silts and further testing is to be carried out such as with a ring permeater in the base of the proposed stormwater devices.

2.7 GEOLOGY

The C4 Growth Cell Geotechnical Report (Mark T Mitchell Ltd, September 2019) notes the area to be characterised by an upper alluvial terrace with covers most of the development area and a lower terrace in the northern portion of the site. The key issues related to stormwater management are summarised below:

- Bore hole information carried out across the site indicate the presence of free draining sand soils encountered to at least 0.4m to 1.0m depth. Therefore, all collected stormwater can be captured and detained within each proposed residential lot. Road areas could be discharged to a siltation pond which releases the water further to the base of the gully.
- Upper terrace: low groundwater, silt loam to 12m depth underlain by fine to coarse sands.
- Lower terrace: Uncontrolled filling overlying loose to dense fine sands. Absence of filling in holes in the north of this area. Groundwater encountered 1.9m to 6.0m below existing ground level.
- High to severe liquefaction damage on the lower terrace which could impact on any communal basin or swales.
- Building line restriction (BLR) of 8m in the north of the site and 14m in the southern portion from top of slope of the gully edge. The BLR has implications for the location of any excavated basins/swales for communal soakage devices.
- The 8m (Northern area) and 14m (Southern area) are applied between top of slope of the steeper banks (slope angles range between 20 and 55 degrees) and proposed house foundations, pools, and wastewater/stormwater fields. In addition, no retaining walls such as to form stormwater basins sides are to be constructed within the gully or gully edge.
- Upper terrace natural soils consist primarily of Loam, overlying alluvial deposits fine to coarse sands. Taupo pumice encountered in the northern extent of the subject area.

3 ASSESSMENT OF STRUCTURE PLAN IMPACTS

The following section outlines the expected impacts on three waters resulting from a change in land use from rural to urban as shown in Figure 4 below.

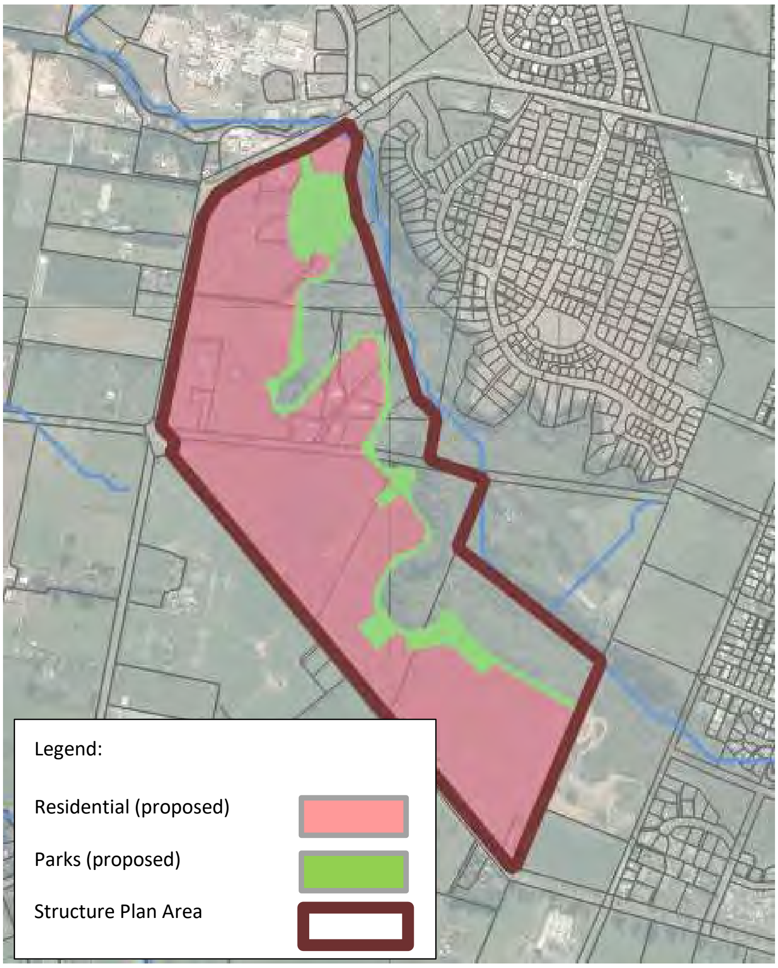


FIGURE 4: PROPOSED LAND USE

3.1 POTENTIAL STRUCTURE PLAN FLOOD IMPACTS

The existing scenario flood model was updated to incorporate the developed structure plan area (post development scenario). The post development scenario assesses the impacts of peak water level and flow within the gully and the culvert outlet under Cambridge Road and immediately downstream within the channel from residential development. The model build is presented in Appendix 6 (and Section 2.4) with summary as follows:

- The model estimates the post-development hydrology conditions for the development area in addition to the wider catchment (remaining as existing land use) which outlets to the gully including specific downstream constraints such as road culvert.
- The model included unattenuated post development hydrology conditions based on the C4 residential zoning landuse discharging to the gully and existing wider catchment (Cambridge Park and Leamington sub catchments). The model does not consider on site soakage.

- Other than C4 there is no future planned growth within the C4 stream catchment thereby reducing the issue of 'cumulative impacts' from a series of future unattenuated storm flows.

The results of the comparison between the pre and post development scenarios are presented below. The results demonstrate that the unattenuated post development flood level within the gully increases a maximum of 100mm. Further details provided in Appendix 6.

TABLE 1 ASSESSMENT OF PRE AND POST FLOOD LEVELS AND PEAK FLOWS

LOCATION	PRE – DEVELOPMENT FLOWS		POST – DEVELOPMENT FLOWS	
	Flow (m^3/s)	Level (mRL)	Flow (m3/s)	Level (mRL)
XS 1	20.20	47.30	20.20	47.32
XS 2	20.56	42.28	20.78	42.38**
XS 3	7.05*	42.27	7.19*	42.36
XS 4	7.13	40.16	7.26	40.18
XS 5	7.13	39.98	7.26	39.98

* Flows reduce at XS 4 and XS 5 due to the backwater and throttle effects of the Cambridge Road culvert.

** Maximum difference of 100mm may be partly due to the direct loading of lumped catchment runoff in the vicinity of XS 2.

In summary, the results of the comparison between the unmitigated pre and post development hydrologic and hydraulic modelling show the impacts of unattenuated flows to the gully do not have significant impacts on level or flow. The Cambridge Road culvert has a throttling effect with floodwater backing up to utilise the existing significantly large flood storage capacity within the gully. The largest increase in the order of 100mm is shown within the mid-section of the gully. However, this increase is almost unnoticeable at the gully edge. This conclusion is like the earlier Cambridge Park sub division which undertook hydraulic modelling and concluded a less than minor impact from unattenuated flows to the gully.

3.2 VOLUME AND WQ CHANGES

Volume impacts and water quality changes are expected due to the new development. However, all storm events up to the 10 year will be managed within the development using pre-treatment and soakage devices (private and public working together). Potential erosive flows within the gully will thereby be eliminated with only flood flows entering the gully via stilling outlets and rip rap basin with elongated gabion wall acting as a weir (between 10m and 20m wide) to disperse flow out across the gully floor. Section 5.5 provides an example of a stilling manhole outlet.

3.3 GROUNDWATER RECHARGE

Groundwater recharge is expected to continue via soakage devices. At detailed design, once the final location of each device is known, site specific soakage testing will be undertaken and potentially mounding assessment to ensure no adverse impacts from soakage to ground.

3.4 RECEIVING ENVIRONMENT IMPACTS

The NIWA ecological assessment highlighted the following risks to the receiving environment because of the structure plan change. It is noted that the assessment was based on the premise that existing waterways within the gully system are to be used for stormwater discharge (water and wastewater is contained at treated elsewhere):

- The hydrological regime of stream sand wetlands is altered due to development effecting freshwater habitats and species.
- Typically, urban development reduces baseflows to streams and increase both the peak flow and volume entering the watercourse as well as the timing of those flows.
- Erosion and contaminants associated with urban development can impact fish ecology. It is important that the stormwater management plan minimises additional contaminant inputs to the C4 stream.
- The culvert under Cambridge Road being an impediment to fish passage.
- No known hydrological data exists for the C4 stream, however maintaining existing flow regime following development is a preferred option to ensure no adverse impacts on stream habitat.

3.5 ASSESSMENT OF RECEIVING ENVIRONMENT USING WRC MATRIX

An assessment of impacts to the receiving environment has been undertaken based on the matrix approach (based on WRC guidelines TR2020/06 and 07 (WRC, 2020).

To undertake the assessment, the C4 site was delineated into proposed developed catchments. The purpose of this was to allocate points in relation to outlet location and the associated source control target and the low impact design (LID's) target.

The proposed structure plan residential and green space area; LID/source control assessment catchments and proposed discharge locations are presented in Figure 5.

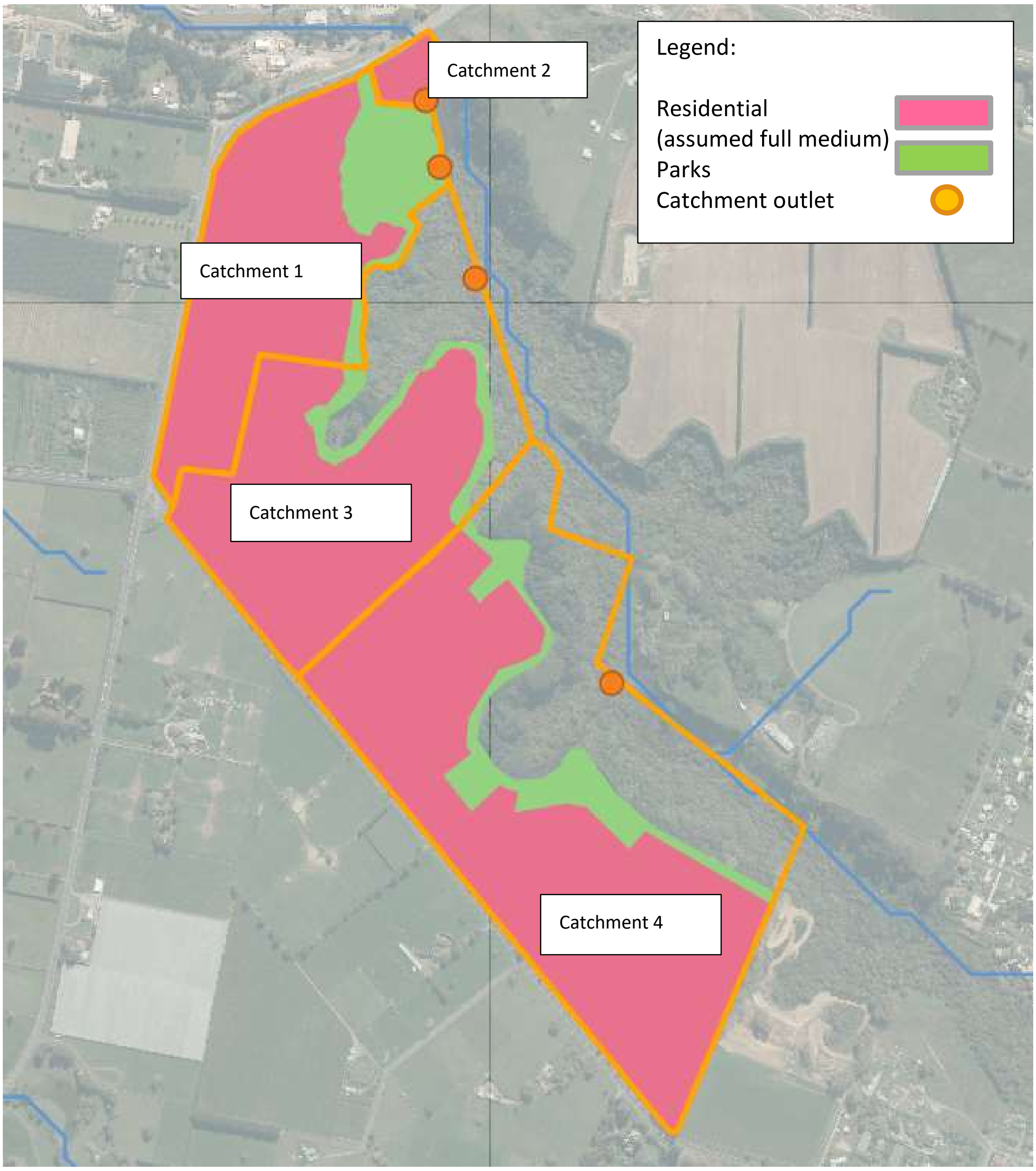


FIGURE 5 PROPOSED C4 DEVELOPMENT (RESIDENTIAL AND GREEN SPACE) AND LIDS/SOURCE CONTROL CATCHMENTS

Each catchment discharging from C4 has been assessed compared to the receiving environment. Table 2 presents the points associated with each catchment. These points and key receiving environment features are also shown in Figure 5.

TABLE 2 MINIMUM SOURCE CONTROL AND LIDS POINTS APPLIED TO EACH CATCHMENT

Catchment	Design criteria for the site	No existing natural features to protect			Justification
		Source control target	LID devices target	Total target	
Catchment 1	• Water quality treatment required • Volume control required	4	3	9	• Waterway is not present within the catchment • Ephemeral Waterway is located downstream of catchment • Erosion risk considered high • Flood risk considered low • Downstream environment considered to have significance
Catchment 2	• Water quality treatment required	4	2	8	• Waterway is not present within the catchment • Discharging into an area with a constant water level (erosion risk considered low) • Flood risk considered low • Downstream environment considered to have significance
Catchment	Design criteria for the site	Existing natural features to protect			Justification
Catchment 3	• Water quality treatment required • Volume control required	6	3	12	• Waterway is not present within the catchment • Ephemeral Waterway is located downstream of catchment • Erosion risk considered high • Flood risk considered low • Downstream environment considered to have significance
Catchment 4	• Water quality treatment required	6	3	12	• Waterway is not present within the catchment

	• Volume control required				• Ephemeral Waterway is located downstream of catchment • Erosion risk considered high • Flood risk considered low • Downstream environment considered to have significance

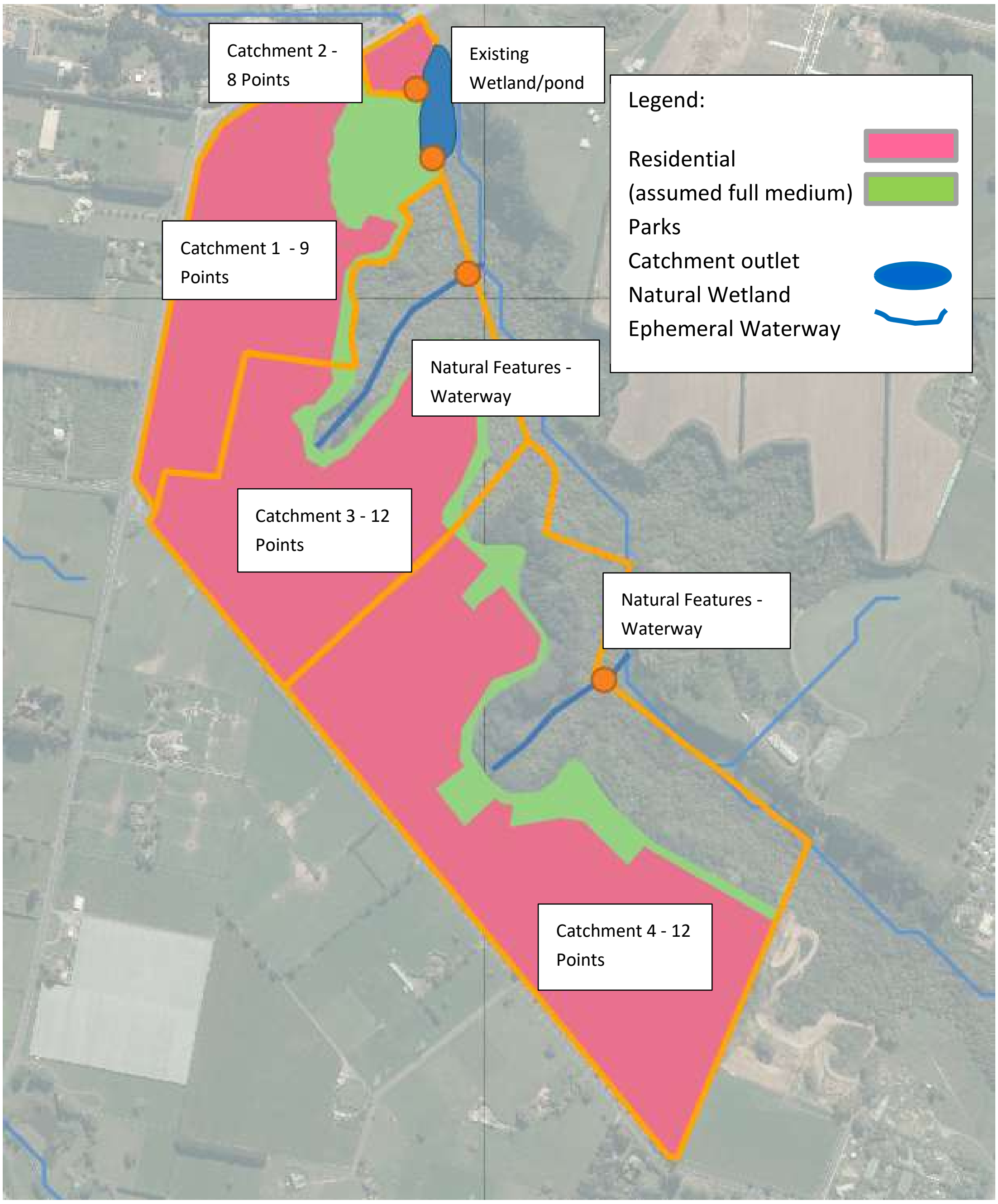


FIGURE 5: LID POINTS AND RECEIVING ENVIRONMENT

4 MITIGATION OF STRUCTURE PLAN IMPACTS

Following the assessment of effects of the proposed C4 structure plan on the receiving environment, the following Table 3 outlines the provisions that that shall be applied to the C4 Growth Area. The provisions are in accordance with the RITS (HCC, 2018) and the TR2020/06 and 07 (WRC, 2020) compliance documents.

TABLE 3 STORMWATER MANAGEMENT PROVISIONS FOR THE C4 GROWTH AREA

Storm event (ARI)	Provision	Guidance
All events	First flush – pre-treatment prior to soakage	Regional SW Guidance, RITS on-site water efficiency measures,
1/3 2yr	Water quality treatment provided by soakage	TP 10, RITS and Regional SW guidance
2yr	Soakage disposal on private lots to manage runoff from roof and driveway areas (catchments 1, 3, 4). Limited soakage within Catchment 2	RITS
10yr	Primary drainage conveyance within the residential development with pipe network and swale network for park edge roads	RITS
10yr	Soakage disposal within public devices (Final Site Testing to Confirm) for road runoff and spill from private lot soakage (see typical sizing tables)	RITS, NZBC E1, Regional SW Guidance
100yr	Safely manage secondary flows through the site via road/green network. No people or property at risk	RITS, NZBC E1, NZS 4404 and Regional rainfall runoff guidance
100yr	Controlled outlet to the gully floor and with appropriate erosion controls no peak flow attenuation requirements (as per flood risk assessment)	RITS and Regional SW Guidance

4.1 MITIGATION OF RECEIVING ENVIRONMENT EFFECTS

The following section outlines how the development within each structure plan catchment 1-4 can mitigate the effects on the receiving environment. The proposed options are indicative only and are subject to concept and detailed design as the staging of development is currently unknown. The options do however provide evidence that achieving the required outcomes is practical and feasible. Key mitigation concepts are presented in Figure 6.

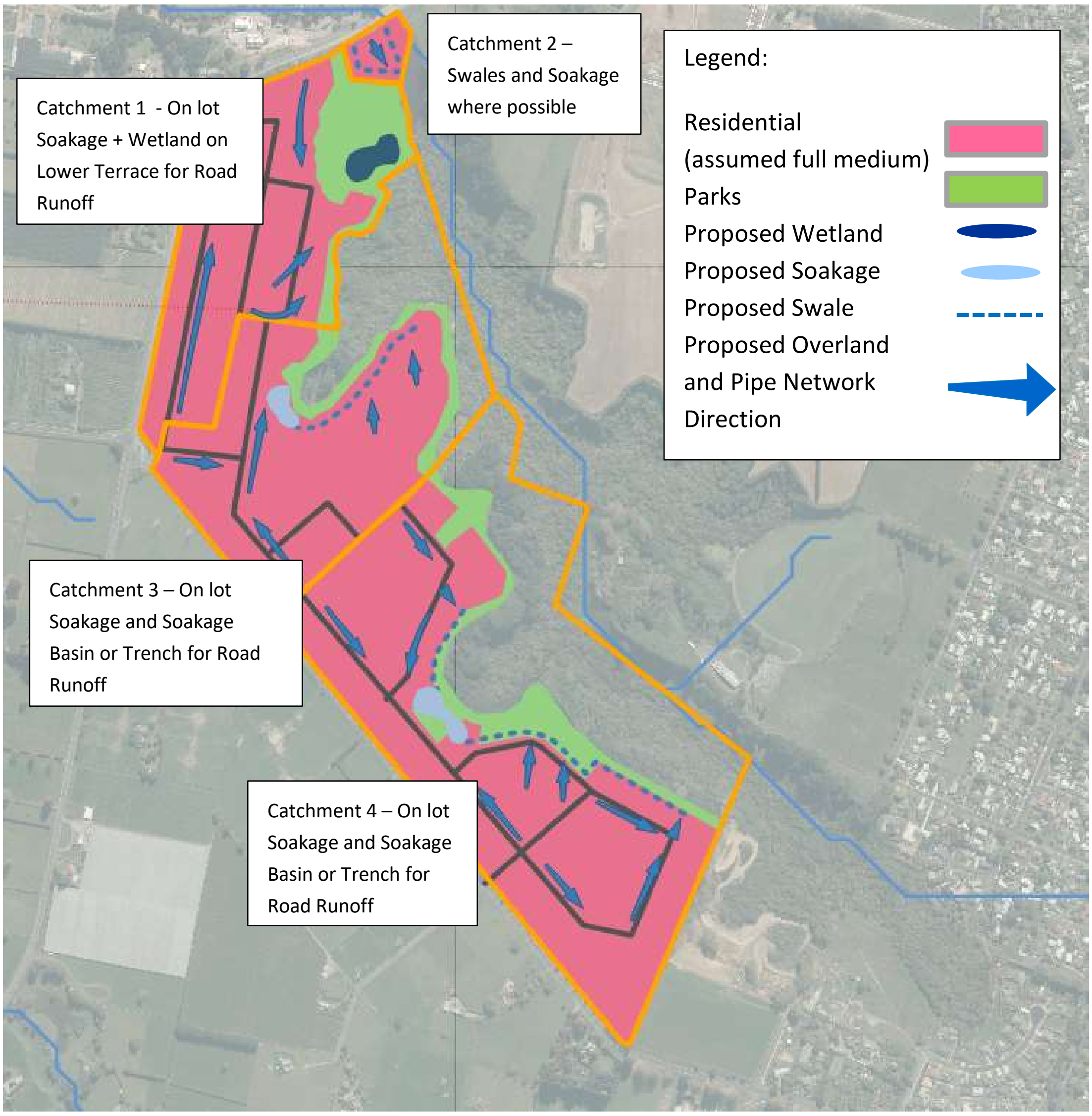


FIGURE 6: KEY STORMWATER MITIGATION CONCEPTS

4.2 CATCHMENT 1

The key source control toolbox options for Catchment 1 are presented in Table 4 with assessment undertaken on the proposed solution with area and percentage calculation provided in Appendix 8. The key outcomes for this catchment include:

- Private on lot soakage (up to 2 year) is considered favourable due to conditions on the upper terrace.
- A wetland is proposed at the base of the catchment (lower terrace) due to likely unfavourable soakage conditions and to tie in with the urban design principals with regards to the use of the open space and neighbouring stream/pond features.
- Urban design can allow for green areas due to size of developable area.
- Lot areas and site disturbance can be reduced due to size of the developable area.
- As this catchment is expected to discharge to the gully with some ecological significance, volume control up to the 10 year is considered valid.

The proposed approach for this catchment is:

- SOURCE CONTROL:
  - Utilise inert building materials
  - Reducing the total impervious surface of the site by avoiding development in or near the gully.
  - Reducing the site disturbance through utilising conventional lot sizes and confining the development to the terrace.
- LIDS CONTROL:
  - Soakage for private lot runoff (roof only) up to the 2-year ARI.
  - Adoption of wetland to treat and attenuate runoff from driveways and public roads up to the 10 year event.
  - High flows will bypass the wetland.

TABLE 4 CATCHMENT 1 SOURCE CONTROL OPTIONS

Decision leaders	Source Control – Minimum of 4 points	Proposed solution	Minimal Solution	Minimal Solution
		Toolbox Option 1	Toolbox -Option 2	Toolbox -Option 3
Developer Lead	Water re-use - *Flow detention only is 1 point in houses by use of rain tanks*	0	Rain Tanks are used for flow detention - 1	0
Developer/Council Lead	Site disturbance reduced from a conventional development approach *· 10 % reduction from a conventional development is 2 points.*	2	2	2
Developer/Council Lead	Impervious surfaces reduced from a traditional approach. Impervious surfaces reduced from a conventional development approach *- 5% reduction is 2 points.* *-10% reduction is 3 points.*	Current expected lot coverage - 3	Larger reduction in lot sizes to account for the open space - 0	Smaller reduction in lot sizes to account for the open space - 5% -2
Developer Lead	Use of building or site materials that do not contaminate *Residential roofs, gutters, down spouts made of non-contaminant* *leaching materials is 1 point.*	1	1	1
Council Lead	Protection and future preservation of existing native bush areas *Protection, preservation and, if needed, enhancement of native bush* *areas that exceed 10% of the site is given 2 points.*	Green space is not planted out -0	Green space is not planted out -0	Green space is not planted out -0
TOTAL SOURCE CONTROL		6 (out of min 4)	4 (out of min 4)	5 (out of min 4)
LIDS – Minimum of 3 points		Proposed solution	Minimal Solution	Minimal Solution
		Toolbox Option 1	Toolbox -Option 2	Toolbox -Option 3

Developer Lead	On lot devices to reduce runoff volume *Meeting the capture and infiltration requirements of the initial abstraction volume is given 2 points.* *· Meeting the capture and infiltration requirements for the site water quality storm is given 3 points.* *· Meeting the capture and infiltration requirements for the 2-year ARI event for the site is given 6 points.*	Properties to capture the 10/2 year ARI Soakage of dwelling (assumed 80% of area) = 4 points	Houses to capture the WQ Soakage (assumed 85% of area) = 2.5 points	Houses to capture the WQ Soakage (assumed 85% of area) = 2.5 points
Council Lead	Public devices to reduce runoff volume *Meeting the capture and infiltration requirements of the initial abstraction volume is given 2 points.* *· Meeting the capture and infiltration requirements for the site water quality storm is given 3 points.* *· Meeting the capture and infiltration requirements for the 2-year ARI event for the site is given 6 points.*		Public soakage basin/trench to capture the 10/2-year ARI Soakage (assumed 15% of area) = 0.5 points	Public soakage basin/trench to capture the 10/2-year ARI Soakage (assumed 15% of area) = 0.5 points
Developer Lead	Swales and filter strips *All impervious surfaces draining to swales and filter strips that have capacity for treating the water quality event and conveying the 2-year ARI event is given 3 points.*			Assume swales can capture 1/3 of development runoff = 1 point
Council Lead	Wetland *Meeting the water quality design storm criteria is given 2 points.* *Meeting extended detention and peak control requirements is given an additional 2 points.*	Treatment of Road and driveways – 1 point		
Council Lead	Urban design values *Stormwater management is designed to be an integral and well considered part of the urban design.*	A design narrative is developed for the vegetation parts of this site – 1 point	A design narrative is developed for the vegetation parts of this site – 1 point	
TOTAL SOURCE CONTROL		6 (out of min 3)	4 (out of min 3)	4 (out of min 3)
TOTAL POINTS		12 (out of min 9)	9 (out of min 9)	9 (out of min 9)

4.3 CATCHMENT 2

The key source control toolbox options for Catchment 2 are presented below with assessment undertaken on the proposed solution with area and percentage calculation provided in Appendix 7. The key outcomes for this catchment include:

- Catchment is lower in the gully and therefore soakage is considered less favourable than upper terraces.
- It is expected that there may be no specified green areas due to size of developable area.
- It is expected that the lots and site disturbance in this area will be of a conventional nature due to size.
- As this catchment is expected to discharge directly into a permanent waterway with large flood capacity, volume and peak discharge are considered not required.

The proposed approach for this catchment is:

- SOURCE CONTROL:
    - Utilise inert building materials
    - Water reuse (if soakage is not feasible) for private lots
    - Reducing the total impervious surface using permeable pavements
- LIDS CONTROL:
    - Soakage for private driveway runoff up to the 2-year ARI.
    - Adopt swales to convey flows.

Catchment 2 Table

Decision leaders	Source Control – Minimum of 4 points	Proposed solution	Minimal Solution	Minimal Solution
		Toolbox Option 1	Toolbox -Option 2	Toolbox -Option 3
Developer Lead	Water re-use	Site use for garden watering - 2 points.	Flow detention is adopted on houses - 1 point	Site use for garden watering and for non-potable inside waters uses including laundry and toilets - 3 points
Developer Lead	Use of building or site materials that do not contaminate *Residential roofs, gutters, down spouts made of non-contaminant leaching materials is 1 point.*	1	1	1
Council Lead	Impervious surfaces reduced from a traditional approach. *Impervious surfaces reduced from a conventional development approach* *5% reduction is 2 points.* *10% reduction is 3 points.*	Permeable pavements on all roads - 2.5 percent of catchment - 1 point	Permeable pavements on all roads - 5 percent of catchment - 2 point	0

TOTAL SOURCE CONTROL		4 (out of min 4)	4 (out of min 4)	4 (out of min 4)
LIDS – Minimum of 2 points		Proposed solution	Minimal Solution	Minimal Solution
		Toolbox Option 1	Toolbox -Option 2	Toolbox -Option 3
Developer Lead	On lot devices to reduce runoff volume *Meeting the capture and infiltration requirements of the initial abstraction volume is given 2 points.* *· Meeting the capture and infiltration requirements for the site water quality storm is given 3 points.* *· Meeting the capture and infiltration requirements for the 2-year ARI event for the site is given 6 points.*	Driveways capture the 2-year soakage – 1 point		
Developer Lead	Swales and filter strips *All impervious surfaces draining to swales and filter strips that have capacity for treating the water quality event and conveying the 2-year ARI event is given 3 points.*	Assume swales can capture 100% of development runoff = 3 point	Assume swales can capture 100% of development runoff = 3 point	
Developer lead	Bioretention (including tree pits) *Meeting the capture and retention requirements of the initial abstraction volume is given 2 points.* *Meeting the capture and retention requirements for the site water quality storm is given 3*			Site capture and retention requirements for the 2-year storm for all roads and driveways – 3 points

	points. *Meeting the capture and retention requirements for the 2-year storm for the site is given 6 points.*			
	Urban design values *Stormwater management is designed to be an integral and well considered part of the urban design.*		A design narrative is developed for the vegetation parts of this site – 1 point	A design narrative is developed for the vegetation parts of this site – 1 point
TOTAL SOURCE CONTROL		4 (out of min 3)	4 (out of min 3)	4 (out of min 3)
TOTAL POINTS		4 (out of min 8)	4 (out of min 8)	4 (out of min 8)

4.4 CATCHMENT 3

The key source control toolbox options for Catchment 3 are presented below with assessment undertaken on the proposed solution with area and percentage calculation provided in Appendix 7. The key outcomes for this catchment include:

- Soakage is considered favourable (up to the 2 year) due to conditions of the upper terraces.
- Urban design has ability to allow for green areas due to size of developable area.
- Lot areas and site disturbance can be reduced due to size of the developable area.
- As this catchment is expected to discharge to the mid gully with some ecological significance and potential for enhancement, volume control up to the 10 year is recommended.

The proposed approach for this catchment is:

- SOURCE CONTROL:
  - Reducing the total impervious surface of the site by avoiding development in or near the gully.
  - Reducing the site disturbance through utilising conventional lot sizes and confining the development to the terrace.
- LIDS CONTROL:
  - Utilise inert building materials
  - Soakage for private on lot runoff up to the 2-year ARI.
  - Public soakage device (basin/trenches) for road runoff and spill from private lots up to the 10-year ARI.

Catchment 3 Table

Decision leaders	Source Control – Minimum of 6 points	Proposed solution Toolbox Option 1	Minimal Solution Toolbox -Option 2	Minimal Solution Toolbox -Option 3
Developer/Council Lead	Site disturbance reduced from a conventional development approach · *10 % reduction from a conventional development is 2 points.*	2	2	2
Developer/Council Lead	Impervious surfaces reduced from a traditional approach. Impervious surfaces reduced from a conventional development approach *- 5% reduction is 2 points.* *-10% reduction is 3 points.*	Current expected lot coverage - 3	Larger reduction in lot sizes to account for the open space - 0	Smaller reduction in lot sizes to account for the open space - 5% -2
Developer Lead	Use of building or site materials that do not contaminate. *Residential roofs, gutters, down spouts made of non-contaminant leaching materials is 1 point.*	1	1	1
Council Lead	Existing streams and gullies (including ephemeral streams) are protected and enhanced *Preservation and protection of natural streams and gullies is 3 points.*	3	3	3

Council Lead	Protection and future preservation of existing native bush areas *Protection, preservation and, if needed, enhancement of native bush areas that exceed 10% of the site is given 2 points.*	2	2	2
TOTAL SOURCE CONTROL		11 (out of min 6)	8 (out of min 6)	9 (out of min 6)
LIDS – Minimum of 3 points		Proposed solution	Minimal Solution	Minimal Solution
		Toolbox Option 1	Toolbox -Option 2	Toolbox -Option 3
Developer Lead	On lot devices to reduce runoff volume *Meeting the capture and infiltration requirements of the initial abstraction volume is given 2 points.* *· Meeting the capture and infiltration requirements for the site water quality storm is given 3 points.* *· Meeting the capture and infiltration requirements for the 2-year ARI event for the site is given 6 points.*	Properties to capture the 10/2-year ARI Soakage (assumed 85% of area) = 5 points	Houses to capture the WQ Soakage (assumed 85% of area) = 2.5 points	Houses to capture the WQ Soakage (assumed 85% of area) = 2.5 points
Council Lead	On lot devices to reduce runoff volume *Meeting the capture and infiltration requirements of the initial abstraction volume is given 2 points.* *· Meeting the capture and infiltration requirements for the site*	Public soakage basin/trench to capture the 10/2-year ARI Soakage (assumed 15% of area) = 1 points	Public soakage basin/trench to capture the 10/2-year ARI Soakage (assumed 15% of area) = 1 points	Public soakage basin/trench to capture the 10/2-year ARI Soakage (assumed 15% of area) = 0.5 points

	water quality storm is given 3 points. *· Meeting the capture and infiltration requirements for the 2-year ARI event for the site is given 6 points.*			
Council Lead	Urban design values *Stormwater management is designed to be an integral and well considered part of the urban design.*		A design narrative is developed for the vegetation parts of this site – 1 point	
TOTAL SOURCE CONTROL		6 (out of min 3)	4 (out of min 3)	3 (out of min 3)
TOTAL POINTS		17 (out of min 8)	12 (out of min 8)	12 (out of min 8)

4.5 CATCHMENT 4

The key source control toolbox options for Catchment 4 are presented in the table below with assessment undertaken on the proposed solution with area and percentage calculation provided in Appendix 7 . The key outcomes for this catchment include:

- Soakage is considered favourable due to conditions of the upper terraces.
- Urban design has ability to allow for green areas due to size of developable area.
- Lots areas and site disturbance can be reduced due to size of the developable area.
- As this catchment is expected to discharge to gully with some ecological significance, volume control up to the 10 year is considered valid.

The proposed approach for this catchment is:

- SOURCE CONTROL:
  - Protection of gullies, streams, and natural open bushland.
  - Reducing the total impervious surface of the site by avoiding development in or near the gully.
  - Reducing the site disturbance through utilising conventional lot sizes and confining the development to the terrace.
- LIDS CONTROL:
  - Utilise inert building materials.
  - Soakage for private on lot runoff up to the 2-year ARI.
  - Public soakage device (basin/trenches) for road runoff and spill from private lots up to the 10-year ARI.

Catchment 4 Table

Decision leaders		Proposed solution	Minimal Solution	Minimal Solution

	Source Control – Minimum of 6 points	Toolbox Option 1	Toolbox -Option 2	Toolbox -Option 3
Developer/Council Lead	Site disturbance reduced from a conventional development approach · *10 % reduction from a conventional development is 2 points.*	2	2	2
Developer/Council Lead	Impervious surfaces reduced from a traditional approach. Impervious surfaces reduced from a conventional development approach *- 5% reduction is 2 points.* *-10% reduction is 3 points.*	Current expected lot coverage - 3	Larger reduction in lot sizes to account for the open space - 0	Smaller reduction in lot sizes to account for the open space - 5% -2
Developer Lead	Use of building or site materials that do not contaminate. *Residential roofs, gutters, down spouts made of non-contaminant leaching materials is 1 point.*	1	1	1
Council Lead	Existing streams and gullies (including ephemeral streams) are protected and enhanced *Preservation and protection of natural streams and gullies is 3 points.*	3	3	3

Council Lead	Protection and future preservation of existing native bush areas *Protection, preservation and, if needed, enhancement of native bush areas that exceed 10% of the site is given 2 points.*	2	2	2
TOTAL SOURCE CONTROL		11 (out of min 6)	8 (out of min 6)	9 (out of min 6)
LIDS – Minimum of 3 points		Proposed solution	Minimal Solution	Minimal Solution
		Toolbox Option 1	Toolbox -Option 2	Toolbox -Option 3
Developer Lead	On lot devices to reduce runoff volume *Meeting the capture and infiltration requirements of the initial abstraction volume is given 2 points.* *· Meeting the capture and infiltration requirements for the site water quality storm is given 3 points.* *· Meeting the capture and infiltration requirements for the 2-year ARI event for the site is given 6 points.*	Properties to capture the 10/2 year ARI Soakage (assumed 85% of area) = 5 points	Houses to capture the WQ Soakage (assumed 85% of area) = 2.5 points	Houses to capture the WQ Soakage (assumed 85% of area) = 2.5 points
Developer Lead	Swales and filter strips *All impervious surfaces draining to swales and filter strips that have capacity for treating the water quality event and conveying the 2-year ARI event is given 3 points.*	Public soakage basin/trench to capture the 10/2-year ARI Soakage (assumed 15% of area) = 1 points	Public soakage basin/trench to capture the 10/2-year ARI Soakage (assumed 15% of area) = 1 points	Public soakage basin/trench to capture the 10/2-year ARI Soakage (assumed 15% of area) = 0.5 points

	Urban design values *Stormwater management is designed to be an integral and well considered part of the urban design.*		A design narrative is developed for the vegetation parts of this site – 1 point	
TOTAL SOURCE CONTROL		6 (out of min 3)	4 (out of min 3)	3 (out of min 3)

5 IMPLEMENTATION

The following section outlines the proposed implementation with high-level sizing of devices to demonstrate applicability moving to the next stages.

A preliminary summary of the C4 stormwater concept design is provided below. It is noted that the concept design needs to be integrated with wider urban design elements and planning considerations. However, embedding water sensitive design principles to manage stormwater as early as possible in the design process is smart and follows international best practice.

FIRST FLUSH:

- First flush events will be managed at source via a series of pre-treatment devices prior to discharge for all catchments 1, 2, 3 and 4. Pre-treatment for on lot devices is recommended to ensure the long-term performance of the device by removing the coarse grain fragments and any large litter items. Examples include rainwater harvesting, leaf diverters, sumps, filter stops and porous surfacing. The RITS provides for on-site water efficiency measures which include a variety of pre-treatment options which shall be applied within the C4 growth area as part of building consent.
- First flush events may also be managed at source via water reuse (for Catchment 2) where soakage is unlikely to be viable.
- Green networks are encouraged within the development integrated with overland flow paths, park edge swales and planted soakage basins for amenity and passive recreational use.
- First flush events from the road network will be managed via pre-treatment devices prior to discharge to ground (soakage) for Catchment 3 and 4. Pre-treatment of public soakage devices is recommended to ensure the long-term performance of the final adopted soakage devices by removing the coarse grain fragments and any large litter items. Examples include sediment forebays built within larger soakage basins, catch pit inserts/chamber sumps, grass filter strips and planted swales.
- First flush events from the road network (Catchment 1) will be managed via pre-treatment prior to entering the wetland on the lower terrace. This could be a sediment forebay within the wetland.

PRIMARY/WQ AND EDV STORM RUNOFF:

- Soakage up to the 2 year ARI event will occur on lot for Catchments 1, 3, and 4 (noting that the small catchment 2 will soak driveway runoff only due to proposed water reuse and expected low soil permeability). This will reduce the size of the public infrastructure (drainage network, soakage basins and wetland) needed to manage and treat runoff.

- Primary flows from road runoff, including spill above the 2 year from private lots, up to the 10yr ARI will be conveyed using pipes or swales to soakage devices either communal planted basins or trenches within the road reserve (catchments 3 and 4).

- The soakage up to the 10 year (incorporating the WQ and EDV volumes) removes the potential for adverse impacts of increased contaminant and temperature discharge as well as scour erosion and sedimentation within the C4 Stream receiving environment.

- Water Quality and EDV volumes (Catchment 1) are conveyed to a wetland. The wetland and EDV treatment remove the potential for adverse impacts of increased contaminant and temperature discharge as well as scour erosion and sedimentation within the C4 Stream receiving environment. High flows bypass the wetland and discharge to the natural water body that forms part of the receiving environment.

- Water Quality and EDV volumes (Catchment 2) are recommended to be conveyed to swales. The swales remove the potential for adverse impacts of increased contaminant and temperature discharge within the C4 Stream receiving environment. Primary flows up to the 10 year for road and dwellings are also conveyed by swales and discharge to the natural water body that forms part of the receiving environment.

SECONDARY FLOW:

- Secondary flows up to the 100yr ARI + climate change (CC) event must be managed and safely conveyed within the subdivision to protect pedestrians, road users and building floor levels (meeting freeboard requirements). This requirement also covers New Zealand Building Code 50yr ARI design standard to protect buildings from flood inundation.

- No requirements for flood attenuation and peak flow control is required due to capacity of the downstream network as demonstrated by flood modelling.

5.1 SOAKAGE SIZING

Soakage disposal will form a key aspect of the stormwater solution for all catchments 1,2,3 and 4. Soakage is supported by the geotechnical review and by the stormwater disposal hierarchy outlined in the RITS. Soakage disposal is also a practical option which provides multiple benefits for the development to be implemented within both the public and private realm, including:

- Maintains the natural hydrological outcomes for the catchment (10-year pooling and soaking to ground and flows above the 10-year discharging from the site).

- Avoids the potential adverse effects on the stream receiving environment of smaller more frequent storm events up to the 10yr ARI event.

- Assists in reducing peak flows from larger storm events up to the 100yr ARI.

- Maintains base flows to the stream environment.

- Coupled with appropriate pre-treatment captures and treats contaminant runoff from impervious surfaces.

- Soakage at source reduces infrastructure requirements such as size of the stormwater primary pipe network.

The following section presents the recommended soakage approach for both public and private devices.

5.1.1 PRIVATE DEVICES

Private on-lot soakage devices considered are a viable option due to:

- The geology, soil type and residential land use and in accordance with the stormwater hierarchy promoted in the RITS.
- It is noted Cambridge Park sub-division (opposite C4) adopted on lot soakage up to the 2yr ARI event to good effect and many parts of Leamington also use on lot soakage devices prior to discharge to the C4 gully.

Private devices are recommended to have the following design considerations:

- Capture runoff from all impervious areas including roof and driveway for catchments 3 and 4.
- Capture runoff from driveways only for Catchments 2 due to specification for water reuse in this catchment.
- Capture runoff from roof only for Catchment 1 due to specification for wetland treatment in this catchment.
- Separate configurations could be adopted for clean roof water and driveway runoff using side by side soakage chambers.
- Driveway areas could also be porous (permeable pavers, porous concrete) thereby negating the need for a separate soakage device adjacent to the driveway within the lot boundary.
- Roof areas could firstly drain to a detention tank for re-use prior to out letting to the soakage device.

Given most regular rain events will be captured and returned to ground on site, there will likely be minimal actual runoff to the public network. This would only occur for events greater than the on lot device design which is recommended at a 2 year ARI event. Consideration therefore should be given to adopting kerb outlet from each lot to reduce the need or size and therefore cost of expensive storm water pipe infrastructure.

5.1.2 PUBLIC DEVICES

Stormwater runoff from the public road reserve will be managed separately to runoff from private for events less than the 2yr ARI above which the lots with spill into the public conveyance network. Options are summarised below:

- Ruoff from road pavement could be collected via traditional kerb and channel to catchpit inlets and then to a pipe network or to a park edge swale via flush or drop kerbs.
- A swale network can potentially provide treatment, conveyance, and soakage prior to discharge to a soakage basin or wetland. Due to the size of the devices it is unlikely that the site runoff can be managed by swales only, however, the use of swales will reduce the size of the end of line soakage basins and provide excellent pre-treatment benefits.
- Swales can be either side of the road, on one side (reduce need for driveway crossings) or they could be designed independently of the road network within larger green corridors linking the development.

- Disposal to ground in soakage basins (likely to be preferred by WDC over trenches) would need careful consideration as to their location, depth and runoff loading given the geotechnical constraints and set back requirements outlined in the Mark Mitchel report. Basin sizes however maybe be relatively modest to treat runoff from just the road corridor.

The following indicative sizing table is provided to assist WDC, developers and lot builders

Table 5 Soakage size estimates – assuming 100% void ratio (ie. no gravel filled devices). Sizes are considered conservative due to relatively low soakage rate (site testing may show higher soakage rates).

Catchments	Contributing Impervious Area	Assumed Soakage Rate	Assumed Storm Event	Soakage Area and Volume	Approximate Overall Device Areas
Catchment 1 – on lot (roof only)	3.7 ha (assumed 151 lots)	70mm/hr	2 year	10.3 m^2 10.3 m^3 (4.3 x 2.4 x 1m) per lot	10.3 m^3 per lot
Catchment 2 – on lot (driveway only)	0.11 ha (assumed 11 lots)	70mm/hr	2 year	6.0 m^2 2.5 m^3 (5 x 1.2 x 0.5) per lot	2.5 m^3 per lot
Catchment 3 – on lot (roof and driveways)	6.2 ha (assumed 178 lots)	70mm/hr	2 year	14.3 m^2 14.3 m^3 (5 x 2.8 x 1m) per lot	14.3 m^3 per lot
Catchment 3 – public system (road and footpaths)	1.88 ha	70mm/hr	10 year plus 10-year overflow from lots	1174 m^2 1996 m^3 (32 x 37 x 1.7m)	Basin: Device depth (3 m) Device Area 2430 m^2 Trenches: 250 m (base width 1.5 metre) Depth 0.5 metre
Catchment 4 – on lot (roof and driveways)	10.1 ha (assumed 289 lots)	70mm/hr	2 year	14.3 m^2 14.3 m^3 (5 x 2.8 x 1) per lot	14.3 m^3 per lot
Catchment 4 – public system (road and footpaths)	3.1 ha	70mm/hr	10 year plus 10-year overflow form lots	1880 m^2 3190 m^3 (50x 38 x 1.7)	Basin: Device depth (3 m) Device Area 3410 m^2 Trenches: 550 m (base width 1.5 metre) Depth 5 metre

The following assumptions have been implemented in the estimation of the soakage device volumes and areas:

1. 100% runoff from dwelling impervious areas and 90% from road surfaces.

2. Infiltration is through the device base only and based on the average values from the Geocon Report.

3. Storage required is based on volume lost to ground (over storm duration) and live storage within the device (assuming 100% void space ie. tank/'milk crate' systems).

4. Approximately 1m deep device have been assumed for on lot devices (i.e. soakage manhole/tanks) or 1.5m overall depth assuming 0.5m cover.

5. Approximately 3m deep devices have been assumed for public devices (i.e. soakage basins. The total device area is based on 1 in 4 slopes.

6. Approximately 0.5m deep devices have been assumed for soakage trenches or 1m total depth with 0.5m cover.

7. Public systems are based on critical 10 year storm durations from 10 minutes to 48hrs.

8. Private systems are based on critical 2 year storm durations from 10 minutes to 48hrs.

5.2 WETLAND DESIGN

The following Table 6 estimates the size of the wetland for Catchment 1 in the lower terrace.

TABLE 6 WETLAND AREA

Catchments	Contributing Impervious Area	Volume (WQ/2 + EDV+FB) (m^3)	Surface Area (4% of catchment) and 20% for Batters/maintenance (m^3)	Estimate of (m)	Estimate of Length (m)
Catchment 1	3.4 ha (assumed road and driveway)	1230	1662	20	80

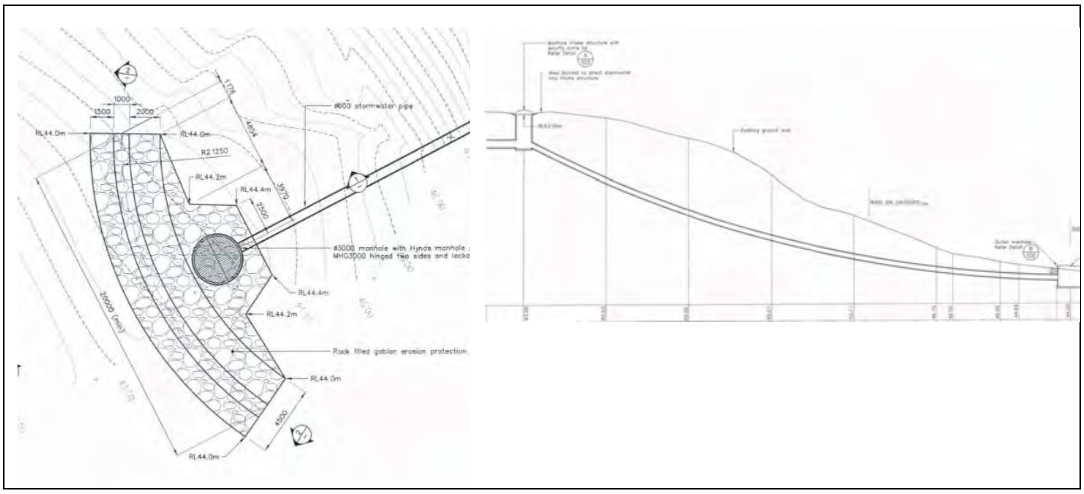
5.3 PROPOSED OUTLET DESIGN – CATCHMENTS 1, 3 & 4

Both primary and secondary flows will be conveyed to the gully base and then flows will be dispersed and fan out across flat gully to stream channel.

High velocities are expected within the pipe down the gully and at the outlet. Construction of each gully outlet structure will therefore involve the placement of a concrete manhole stilling well, combined riprap and gabion protection and potentially a directionally drilled HDPE pipe. The outlet structure will provide velocity reduction of stormwater discharges to the gully environment.

A similar outlet is recommended to that currently used for the adjacent Cambridge Park development. A selection of screen shots from the design drawings (Tonkin and Taylor, 2008) and photos from the authors site visit of the Cambridge Park outlet are provided below.

The stilling manhole is surrounded by rip rap with a gabion wall providing a ~20m wide weir for spills to fan out into the gully.


1000
1500
2000
1176
RL44.0m
RL44.0m
Ø600 stormwater pipe
4654
R2.1250
RL44.2m
RL44.4m
3970
2500
Ø3000 manhole with Hynds manhole
MHG3000 hinged two sides and locka
RL44.4m
RL44.2m
20000 (min)
Rock filled gabion erosion protection
RL44.0m
4500
RL44.0m

6 WATER SUPPLY

6.1 BACKGROUND REVIEW

The following documents were reviewed during the preparation of the water supply section:

- The Waikato LASS Regional Infrastructure Technical Specifications (RITS)
- The Waipa District Development and Subdivision Manual
- Opus Waipa District Wide Water Supply Strategy (DWWSS), 2014

Consultation with WDC staff (Robin Walker) has also been undertaken regarding existing infrastructure and programmed upgrades.

Following review of the first draft of this report, a meeting was held with the WSP Waipa Master Plan Team (Rebecca Francis, Jorge Munoz Santamaria and Mark De Lange) on the 17th March 2020 to discuss the Cambridge master plan water supply and wastewater modelling inputs and outputs and how these interrelate with the assumptions in the C4 growth cell model.

6.2 EXISTING NETWORK

The C4 area falls just outside the Cambridge municipal water supply network. There is an existing 150mm diameter PVC water supply pipe running around the Western side of C4 along Lamb Street and Cambridge Road. This supply is currently serviced by the Pukerimu Water supply scheme and is a low pressure "trickle-feed" supply that will not meet the requirements of a new residential development. WSP have included this pipe within their masterplan model network with a single demand node for the C4 growth cell.

The WDC municipal reticulation borders on the Western boundary of the C4 area, supplying the areas of Leamington to the South and Cambridge Park to the north. This network is supplied from the Karapiro Water treatment plant and conveyed to Leamington (Browning Street) in twin 375mm diameter trunk mains. The supply then flows through the Leamington network before crossing over the Victoria Street Bridge to Northern Cambridge.

It appears that the municipal network has been extended from the Pope Terrace/ Cambridge Road Roundabout to supply Aoteoroa Park/ Matos Segedin Drive area.

There is also capacity on the existing Cambridge Pipe Bridge across the Waikato River to take an additional new water pipe, however, preliminary modelling by WSP indicated that this would have minimal impact on the water networks (including C4) south of the Waikato River.

6.3 DESIGN FLOWS

The DWWSS 2014, states that WDC use a rate 261 L/person/day. This correlates with the RITS daily domestic rate of 260 L/person/day for residential subdivisions. The current peak factor for Cambridge was found to be 1.69 in 2014 and it was WDC's intention to maintain this peak factor. This is significantly lower than the RITS requirement of a peak factor of 5.

The WSP masterplan flows for the C4 cell have been determined using the demand projection for 2050. This was determined with the Peak Day model demand as a base for calculation and using the NZ1-16239247-DRAFT Gateway Approval 4 - Population Forecast Report figures, which stated the number of people per growth cell in 2050. This projection has resulted in a lower expected population of 1830 people and an average daily demand of 5.6l/s and a peak demand of 15l/s with a peak factor of 2.4. As can be seen from Table 5 the projected populations result in significantly lower flow rates than the requirements of the RITS and should be addressed as part of the additional masterplan modelling.

For the purposes of this assessment we have adopted the RITS requirements as a more conservative approach

6.4 NORMAL PEAK DEMAND

Water supply design flows based on the RITS are summarised in Table 7 below.

Table 7: RITS WATER SUPPLY DEMAND

CATCHMENT AREA (Ha)	POPULATION EQUIVALENT	PEAK FACTOR	AVERAGE DAILY FLOW (m3/D)	DOMESTIC FLOW RATE (l/s)	PEAK FLOW RATE (l/s)	FIRE FLOW RATE (l/s)
65	2925	5.00	760.50	8.80	44.01	51.41

The DWWSS 2014 identified the current peak factor for Cambridge residential areas as 1.69. The report identified this peak factor as suitable for future forecasting. If this peak factor is applied to the flow rates listed in Table 7 above, the peak flow rate and fire flows will reduce to 14.88 l/s and 33.93 l/s respectively.

6.4.1 FIRE FIGHTING DEMAND

The WDC Water Supply Bylaw 2013 states that Council is under no obligation to provide an on-demand supply for fire protection purposes at any particular flow or pressure or maintain existing pressures or flows. It is noted that this is in contradiction to Section 6.2.3.3 of the RITS which states that "Council's standard design meets the FW2 firefighting requirements at the street boundary for residential areas and provides FW3 for other zones."

It is aspirational to supply a minimum of an FW 2 Water Supply Classification within the reticulated network. The feasibility of this will be tested once the outstanding information about the existing network has been provided. PAS NZS 4509:2008 states that FW2 requires 25 l/s to be provided from a maximum of 2 fire hydrants. The fire demand should be applied on top of 60% of the peak flow.

The practical reasoning for providing an FW 2 supply is that if a building is fitted with sprinklers, then those may be supplied by the network, and subsequently the fire service upon attendance at the fire, also from the network. Even if the reticulation network does not meet the head requirements to meet FW2 flows the reticulation will need to be sized to ensure that FW2 requirements can be met using a fire tender pump.

6.4.2 WATER SUPPLY NETWORK ALLOCATION

WSP confirmed the Cambridge masterplan model includes the existing 150mm diameter pipe as a single point demand. This line runs along Lamb Street and Cambridge Road within the C4 growth cell. The WSP model was run for a period of 24 hours with a peak factor of 2.4 and the meeting with WSP indicated there most likely is capacity to supply the C4 growth cell, however more specific modelling around the C4 cell is required.

6.5 IMPACTS OF STAGING AND TIMING

The development of C4 will most likely be phased, with sales of each phase determining the development of the next phase. As the land has multiple landowners this will also impact the development staging if some owners are not willing to develop their property at the same stage as others.

WDC's intention is to extend the water network from the Cambridge Park roundabout along Cambridge Road towards the C4 growth cell. This may not align with actual development stages and it would be worthwhile investigating the option of supply from the Leamington side as well for a portion of the C4 zone. Ultimately this would be a preferred looped supply feeding C4 from Leamington and Cambridge Park.

The extent of phasing will also be influenced by the final source of water supply and base capacity that will be identified in the master plan report due in 2020.

6.6 PROPOSED WATER SUPPLY NETWORK

An initial draft reticulation concept to service the development is included in Appendix 5. This draft network is based on a preliminary development layout that mimics block sizes of the neighbouring suburbs. The water model network has been analysed with 150mm diameter pipes on both sides of the road and analysed using EPANet.

The WSP master plan model did not model the C4 area in isolation nor any connections points to C4, only the ring main that would supply C4 and the predicted demand is included in the masterplan model. WSP did however confirm that in its current configuration the network would be able to provide a supply pressure of 300kPa at the Leamington and Pope Terrace ends of the ring main. Our C4 network model includes the ring main from Leamington to Pope Terrace and assumes a connection pressure of 300kPa.

We have modelled the water demand on what we perceive to be the usable areas within the C4 growth cell. This usable area excluded the gulley areas of the C4 growth cell and resulted in a total area of 49.5Ha. The design flows used for initial modelling are in Table 8:

Table 8: DESIGN WATER SUPPLY FLOWS

USABLE CATCHMENT AREA (Ha)	POPULATION EQUIVALENT	LOTS	PEAK FACTOR	AVE. DAILY FLOW (m3/D)	DOMESTIC FLOW RATE (l/s)	PEAK FLOW RATE (l/s)	FIRE FLOW RATE (l/s)
49.5	2228	825	5.00	579.28	6.70	33.52	45.11

The results of our C4 model indicate that if the network can provide a constant supply pressure of 300kPa at Pope Terrace and Leamington (as indicated in the WSP model) there would be sufficient residual pressure within C4 during peak flows. Under fire flow conditions, however, the residual pressures within the network will drop below the RITS requirement of 200kPa.

Should the supply pressures fall below 300kPa the pressure within C4 will drop below 200kPa under normal flow conditions.

Discussions with WSP highlights the need for additional modelling of the C4 growth cell in isolation to determine what upgrades would be needed to ensure the viability of the C4 growth cell in the future. Additional modelling is also required to address the higher demand and peak flow rates as specified in the RITS

6.7 LONG TERM WATER DEMAND

It is well recognised that as growth continues, the demand for water will also increase, sometimes reaching close to the limits of sources of supply.

The figure below shows that the 2050 projected minimum pressures are currently projected to be low with C4 being less than 10m (100kPa) and Leamington and Pope terrace (Cambridge Park) being between 10-20m (100 – 200kPa). This illustrates that without upgrades the existing network will be unable to sustain the growth cells.

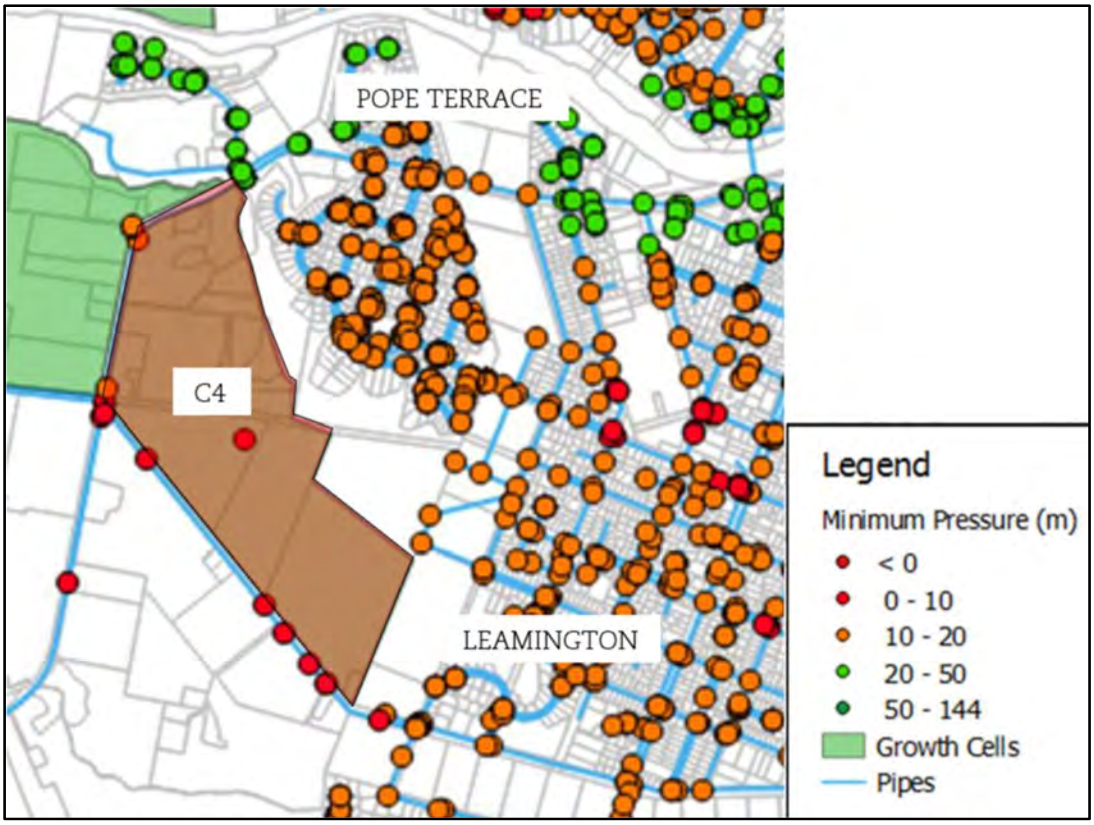


FIGURE 7 MINIMUM PRESSURES 2050 (*EXTRACTED FROM WSP MEMO TO WDC 23/09/2019)*

Some steps to mitigate this and to aid in promoting best practice in water sensitive design, water reuse, where appropriate, should be considered. If some, or all, of that water can be harvested and stored, then it can be used to offset the treated potable demand. This water can be used for non-potable building water services such as garden irrigation and toilet flushing.

The most economic time to introduce the infrastructure to enable harvesting and reuse is at the initial building development point.

The implementation of individual water metering has also shown to reduce domestic water consumption.

7 WASTEWATER

7.1 BACKGROUND REVIEW

The following documents were reviewed during the preparation of this section:

- The Waikato LASS Regional Infrastructure Technical Specifications (RITS)
- The Waipa District Development and Subdivision Manual
- NZS 4404:2010 Land Development and Subdivision Infrastructure
- Wastewater Treatment and Disposal Activity Management Plan 2015 - 2025
- Opus Wastewater Issues Report, 2013
- Opus C7 Growth Cell – Wastewater Assessment, 2017

Correspondence with WDC staff (Robin Walker) was also had regarding existing infrastructure and proposed upgrades. A meeting was also held with WSP master plan team (Rebecca Francis, Jorge Munoz Santamaria and Mark De Lange) in March 2017 to discuss their master plan and the impacts on the C4 growth cell.

7.2 EXISTING NETWORK

Currently all the wastewater generated within Cambridge is conveyed by a gravity network to the Wastewater Treatment Plant (WWTP) on the Southern bank of the Waikato River on the western border of the urban limit. The wastewater generated from the northern part of Cambridge crosses the Waikato River on the pipe bridge, west of the River Garden residential development. The gravity main across the pipe bridge was recently upgraded to a 700mm diameter CLS pipe. The northern network then joins the southern network and flows in a 600mm diameter gravity main to the WWTP.

This portion of pipe is known to surcharge and was recommended to be upgraded by 2025 in the 2013 Cambridge and Te Awamutu Wastewater Master Plan. With the current rates of development within Cambridge it is expected that the 2020 master plan will advance this upgrade.

The Aotearoa Park gravity network connects to this portion of the trunk main. Due to the surcharging, the gravity flows are collected in a wastewater pump station (WWPS) on Matos Segedin Drive and pumped 50m into a manhole on the trunk main upstream of the WWPS.

The proposed connection point for a gravity network from the C4 growth cell has been identified as the WWPS on Matos Segedin Drive. This WWPS may have spare capacity to accommodate a minor portion of the C4 development but will require major upgrades to meet the demands of the full development.

7.3 DESIGN FLOWS

Section 5.2.4.2 of the RITS sets out the following criteria for the calculation of wastewater flows:

- Domestic average daily flow is 200 litres per person per day.
- Infiltration allowance is 2,250 litres per hectare per day.
- Surface water ingress allowance is 16,500 litres per hectare per day.
- Peaking factor based on Table 5.2.
- Population equivalent as per Table 5.3. For General Residential this is 45 persons per hectare.
- Gross contributing land area upstream of the wastewater pipe is defined as the total catchment area, excluding reserve land, but including land within legal road boundaries

Average daily flow

ADF = (infiltration allowance x catchment area) + (water consumption x population equivalent)

Peak Daily Flow

PDF (l/s) = ((infiltration allowance x catchment area) + (peaking factor x water consumption x population equivalent))/86400

Peak inflow and infiltration factor

PIIF (l/s/ha) = infiltration allowance + surface water ingress

Peak wet weather flow

PWWF (l/s) = ((infiltration allowance x catchment area) + (surface water ingress x catchment area) + (peaking factor x water consumption x population equivalent))/86400

The wastewater design flows have been based on the RITS and are summarised in Table 9. We have also included the WSP master plan information.

Table 9: RITS WATER SUPPLY DEMAND

	AREA (Ha)	POPULATION EQUIVALENT	AVERAGE DAILY FLOW (m3/D)	PEAK DAILY FLOW (l/s)	PEAK WET WEATHER FLOW (l/s)	EMERGENCY STORAGE m3
C4 Growth Cell	65.0	2925	731.25	20.65	33.06	274.22
C4 Usable Area	49.5	2228	557.00	15.73	25.19	208.87
C4 WSP Masterplan	66.0	1830	-	14.0	26.6	-

For the purposes of this report we have adopted the more conservative wastewater flows from the entire C4 Growth Cell.

7.3.1 WASTEWATER NETWORK ALLOCATION

The master plan modelling carried out by WSP have identified the discharge from the C4 growth cell to be in the same manhole that the Matos Segedin WWPS discharges to. Their model shows that while this part of the network does surcharge, there is sufficient capacity for the C4 flows.

There is also capacity within the wastewater treatment plant to treat the effluent produced by the C4 zone.

7.4 PROPOSED WASTEWATER NETWORK

On-site wastewater treatment and soakage is not considered to be feasible for this site based on the anticipated volume of wastewater that will be generated.

The topography of the site is essentially three relatively flat terraces, with a steep drop down to the Aotearoa Park network on Matos Segedin Drive. There is also a large gully to the East of the site. The gulley area has been excluded from the wastewater network as we believe it will not be developed.

The preferred solution would be to drain the whole area by gravity, however as the site is generally flat there is a chance some of the pipes may be quite deep. In the situation where the gravity network becomes impractical because of extreme depths and/or significant earthwork changes the possibility of using wastewater pump stations has also been addressed as an option.

7.4.1 GRAVITY NETWORK

To accurately assess the depth limitations of a gravity network, an initial wastewater network concept was developed to service the site, this can be found in Appendix 5. This was based on a very preliminary layout that we created using similar block sizes of the neighbouring suburbs.

The site (excluding the gulley) is generally flat and for this assessment we have assumed that there will not be extensive earthworks carried out on the site other than filling in some localized areas and possibly smoothing out some of the terrace drops.

Generally, we found most of the pipeline depths to be in the 2-4m depth range. There were some deeper sections where the pipe depths were over 6m deep. We believe that in these cases further investigation in the pipeline route will result in a shallower route. An earthworks design that compliments the gravity network by falling towards the north will also reduce the pipe depths.

The network we developed shows that it is possible to create a gravity network that will be able to connect to the Matos Segedin WWPS. The network does however run through the C4 from South to North. Any development in the Southern portions of C4 would require consent from the other landowners to allow the gravity main to run through their property. Running the gravity main along Lamb St and Cambridge Road (avoiding traversing the northern properties) will result in very deep pipelines and is not feasible.

The current network to the Matos Segedin WWPS consists of a very small network of 150mm diameter pipes discharging into the WWPS. A 150mm diameter pipe normally has a Peak Wet Weather Flow (PWWF) capacity of about 14 l/s. This is assumption can be justified by the information provided by WDC that the Matos Segedin Drive WWPS has a PWWF of 8.8 l/s and pump duty of 10 l/s. As the C4 Growth Cell has an expected PWWF of 33.06 l/s, the pipe network along Matos Segedin Drive from the Cambridge Road intersection will need to be upgraded to accommodate the additional flows.

The Matos Segedin Drive WWPS does appear to be able to accommodate some additional flows with additional cycles and minor upgrading of the pumps. Ultimately the restriction is the capacity of the existing 80mm diameter rising main. The RITS restricts the flow velocity in the rising main to a maximum of 3 m/s, with pumps sized to match the PWWF. At 3 m/s this would have a maximum flow capacity of 14 l/s, 5.2 l/s above the current PWWF of 8.8 l/s. This additional capacity would only cater for about 170 additional lots.

Once the Capacity of the Matos Segedin WWPS is exceeded it would need to be completely upgraded for increased capacity, increased emergency storage, and upgraded pumps and rising main. As this would be a significant capital cost, the option of discharging from the C4 zone directly into the gravity network at an alternative location has been investigated.

To avoid having to upgrade the Matos Segedin WWPS a second gravity option of connecting to the wastewater network to the West of the River Gardens development was investigated. This option is possible however there will be some large sections of pipeline in excess of 7m depth that would most likely make it economically unfeasible.

Based on the limitations of the Matos Segadin WWPS and finding an economically feasible gravity main the possibility of a gravity network is considered unsuitable for the C4 growth cell.

7.4.2 COMBINED NETWORK

With the gravity network being unsuitable, requiring multiple landowner consents and costly upgrades to the Matos Segadin WWPS, a combined sewer network with smaller gravity networks feeding a central wastewater collection point with a pump station discharging into the existing gravity network is a possible solution.

Depending on earthworks there may be multiple WWPS. These pump stations could be operating in a “chain” with all the C4 WWPS discharging to a central, larger pump station that discharges into the same discharge point as the Matos Segadin WWPS (Figure 8). This system also allows for phased development with the first pump station being the collector and constructed with the rising main. Subsequent phases requiring a pump station will then discharge to the collector pump station.

The possibility of discharging to the Leamington WW network was investigated however there is insufficient capacity available.

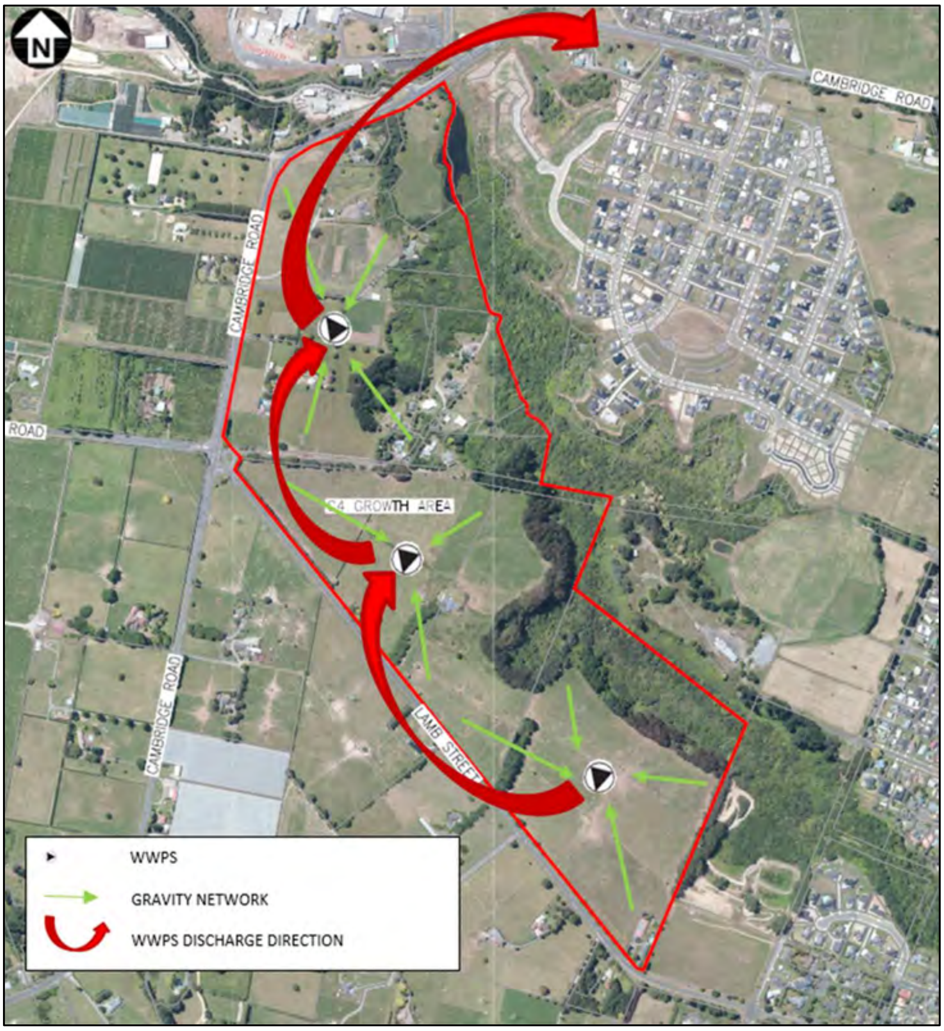


FIGURE 8 WWPS CHAIN

The use of WWPS's would mitigate the dependency of the network to travers through the C4 properties as the rising mains can be laid within the road reserves. This option is also in line with the WSP master plan assumptions and has the most flexibility in terms of phasing and earthwork modelling

8 SUMMARY WATER SUPPLY AND WASTEWATER

A summary of the recommendations from this report in respect of servicing the C4 Growth Cell, water and wastewater follows:

1. The water supply and network for the C4 growth cell needs to be modelled in detail as part of the master plan to study the impact of C4 in isolation as well as the point/s of connection. Further modelling will identify the impact of the growth cell in relation to the neighbouring networks as well as identify any upgrades required for the development of the growth cell.
2. A pumped wastewater network discharging into the gravity network upstream of the Matos Segadin WWPS is the preferred scheme for the C4 Growth cell.

3. Even if the water and wastewater infrastructure can provide for the development, water efficiency measures such as rain water harvesting and grey water recycling are well established technologies in New Zealand and can provide benefits in the form of reduced demand on water supply and wastewater treatment.

9 THREE WATERS CONCLUSIONS

9.1 STORMWATER

1. The ecology report highlights the C4 stream to be vulnerable to changes in hydrological conditions resulting from new development within C4. The geo-technical report indicates groundwater conditions that are favourable for disposal of stormwater via soakage techniques. The gully edge is however susceptible to erosion from uncontrolled surface flows and infiltration within the building setback line.

2. Peak flows above the 10 year will increase to the gully compared to the existing landuse, no adverse effects are expected on flood risk or stream habitat due to the significant storage capacity and existing culvert control under Cambridge Road as well as diffuse flows through heavily vegetated gully floor prior to flows reaching the stream. Above the 10 year, the gully stream will be out of bank.

3. Currently there are several options to manage stormwater using the principles of water sensitive design - the primary objective is however to utilise soakage techniques as the preferred approach to treat water quality and manage the primary 10 year flow in accordance with the stormwater disposal hierarchy in the RTIS. Soakage devices are proposed within each private lot which will be controlled using the WDC stormwater management bylaw. Public road reserves can be serviced using a range of techniques which include rain gardens overflowing to soakage devices, communal basins, infiltration swales, trench soakage and porous manholes. These options will be discussed with WDC and will need to be integrated with the urban design layout and roading network.

4. Currently 4 stormwater outlets are proposed within the gully floor. Flows above the final soakage design up to the 100 year + cc event will be conveyed safely within the development roading network and greenspace and are likely to be piped down the gully side to the outlet. Secondary flows must be controlled to the outlet to avoid erosion of the gully sides and outlet erosion control measures such as a stilling basin and flow dispersion implemented within the gully floor. The main stream is approximately 60m-100m from the proposed gully outlet points allowing some distance for dispersal of high flows within the existing storage area.

9.1.2 THE PREFERRED SOLUTIONS ARE:

- Private soakage disposal on each lot
- Communal soakage basins or trenches in public reserves to manage road runoff
- Primary flow reticulated to each soakage device
- Secondary flows conveyed within road or public greenspace reserves to drop structure prior to outlet to the basins floor via erosion control and energy dissipation basins

9.2 WATER SUPPLY

1. Additional modelling around the C4 Growth cell needs to be carried out and included in the Waipa Masterplan Modelling to confirm connection points, and capacity upgrades. WDC will also need to confirm timelines for any upgrades that will influence the development of this zone.

9.3 WASTEWATER

1. Options for pumped and gravity networks and discharge point have been identified as possible wastewater solutions, with the wastewater treatment plant having adequate capacity to treat all generated waste from the C4 development. The master plan model identified a discharge point with adequate capacity for the C4 growth cell.

2. The preferred wastewater option is gravity networks within the C4 growth cell, pumped along the road reserves to the gravity manhole upstream of the Matos Segadin WWPS. The number of pumps and extent of the gravity networks will be determined at the detailed design phase.

3. WDC need to include the wastewater generated from the C4 Growth Cell into their Masterplan models to determine capacity within the existing network. If there is insufficient capacity WDC will need to provide timelines for the upgrades.

10 LIMITATIONS

10.1 GENERAL

This report is for the use by Waipa District Council and should not be used or relied upon by any other person or entity or for any other project.

This report has been prepared for the project described to us and its extent is limited to the scope of work agreed between the client and Te Miro Water Limited. No responsibility is accepted by Te Miro Water Limited or its directors, servants, agents, staff or employees for the accuracy of information provided by third parties and/or the use of any part of this report in any other context or for any other purposes.

APPENDIX 1 SITE PHOTOS

Photo 1: Top Terrace C4 Existing Greenfield – Looking North

Photo 2: Top Terrace Existing Well Drained Horse Grazing

Photo 3: View East Across C4 Gully Receiving Environment

Photo 4: View North Along Gully Towards Outlet

Photo 5: Existing Pond Looking South up gully from Cambridge Rd

Photo 6: Pumice Deposits Gully Wall

Photo 7: Submerged Culvert Inlet Under Cambridge Road

Photo 8: Submerged Culvert Outlet Under Cambridge Road

APPENDIX 2 PLAN CHANGE AREA

READ DRAWINGS CAREFULLY #MEASURETWICECUTONCE

REV	DESCRIPTION	BY	DATE
A	FOR INFORMATION	GCJ	23.09.19

APPROVAL STATUS: FOR INFORMATION

DESIGNED BY: L.MCCAFFREY — DATE: 23.09.19

DRAWN BY: G.JONES — DATE: 23.09.19

APPROVED BY: — DATE:

CLIENT NAME: Waipa DISTRICT COUNCIL

PROJECT NAME: C4 STRUCTURE PLAN

DRAWING TITLE: SITE PLAN

PRODUCED BY: TE MIRO. WATER

DATE PRINTED: 25 September 2019

DRAWING SCALE: 1:7500

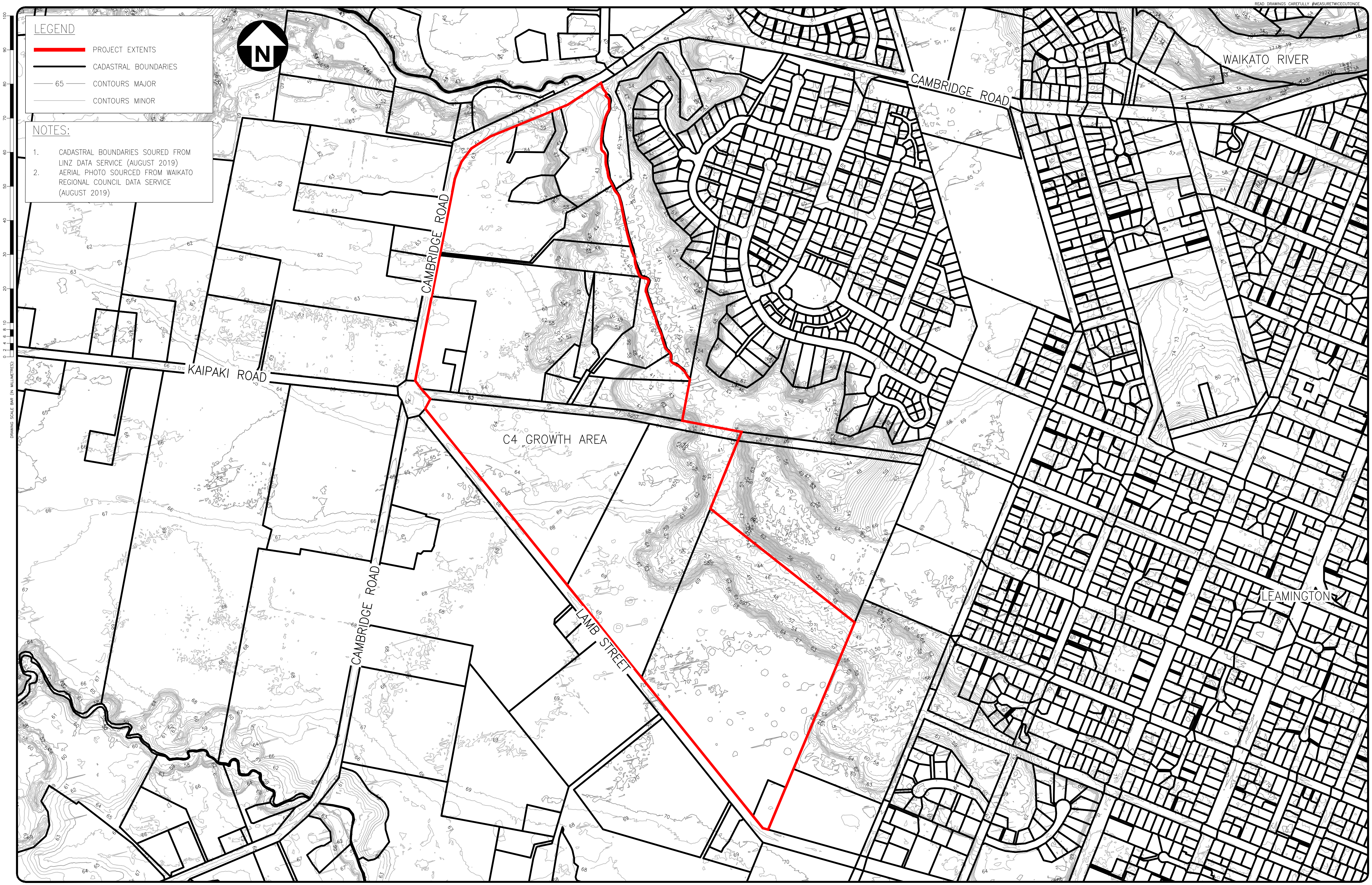
REVISION No.: A

DISCIPLINE: CIVIL ENGINEERING

DRAWING No.: 19014-SK-001

FILE NAME: 19014-SK-001.dwg

APPENDIX 3 EXISTING CONTOUR LEVELS



A	FOR INFORMATION	GCJ	23.09.19
REV	DESCRIPTION	BY	DATE

APPROVAL STATUS: FOR INFORMATION

		DATE
DESIGNED BY	L.MCCAFFREY	23.09.19
DRAWN BY	G.JONES	23.09.19
APPROVED BY		

CLIENT NAME: Waipa DISTRICT COUNCIL

PROJECT NAME: C4 STRUCTURE PLAN

DRAWING TITLE: EXISITING CONTOURS PLAN

PRODUCED BY: TE MIRO WATER

DATE PRINTED: 25 September 2019

DRAWING SCALE: 1:7500

REVISION No.: A

DISCIPLINE: CIVIL ENGINEERING

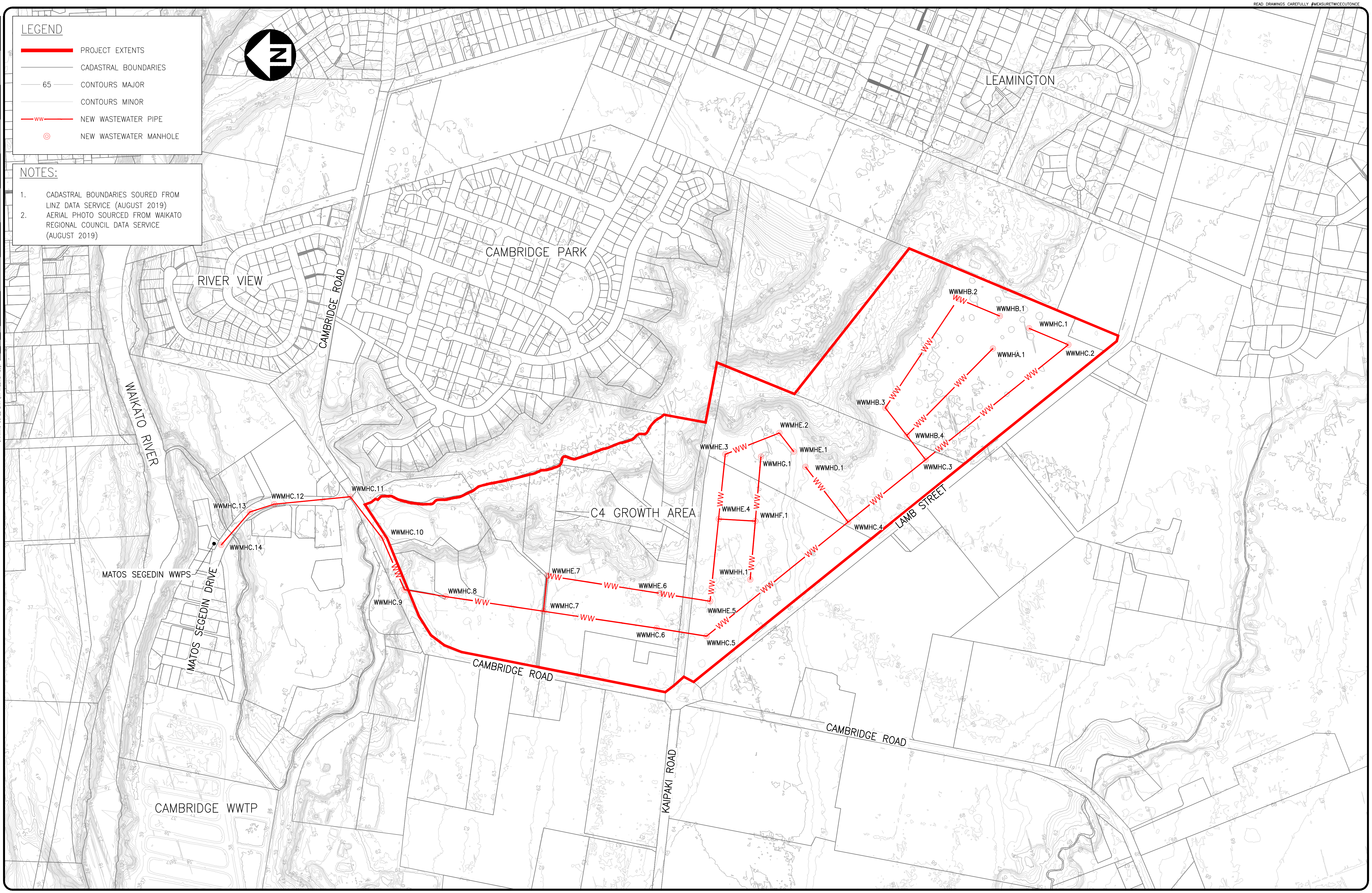
DRAWING No.: 19014-SK-002

FILE NAME: 19014-SK-002.dwg

APPENDIX 4 INDICATIVE STORMWATER PLAN

Document Set ID: 10476599
Version: 1, Version Date: 29/09/2020

APPENDIX 5 WATER AND WASTEWATER PLANS



A	FOR INFORMATION	AXZ	24.09.19
REV	DESCRIPTION	BY	DATE

APPROVAL STATUS: FOR INFORMATION

DESIGNED BY: M.FARRELL — DATE: DD.MM.YY
DRAWN BY: AXZ — DATE: 24.09.19
APPROVED BY: TBC — DATE: DD.MM.YY

CLIENT NAME: Waipa District Council

PROJECT NAME: C4 STRUCTURE PLAN

DRAWING TITLE: WASTEWATER NETWORK DRAFT PLAN OPTION A

PRODUCED BY: HG

DATE PRINTED: 3 October 2019

DRAWING SCALE: 1:7500

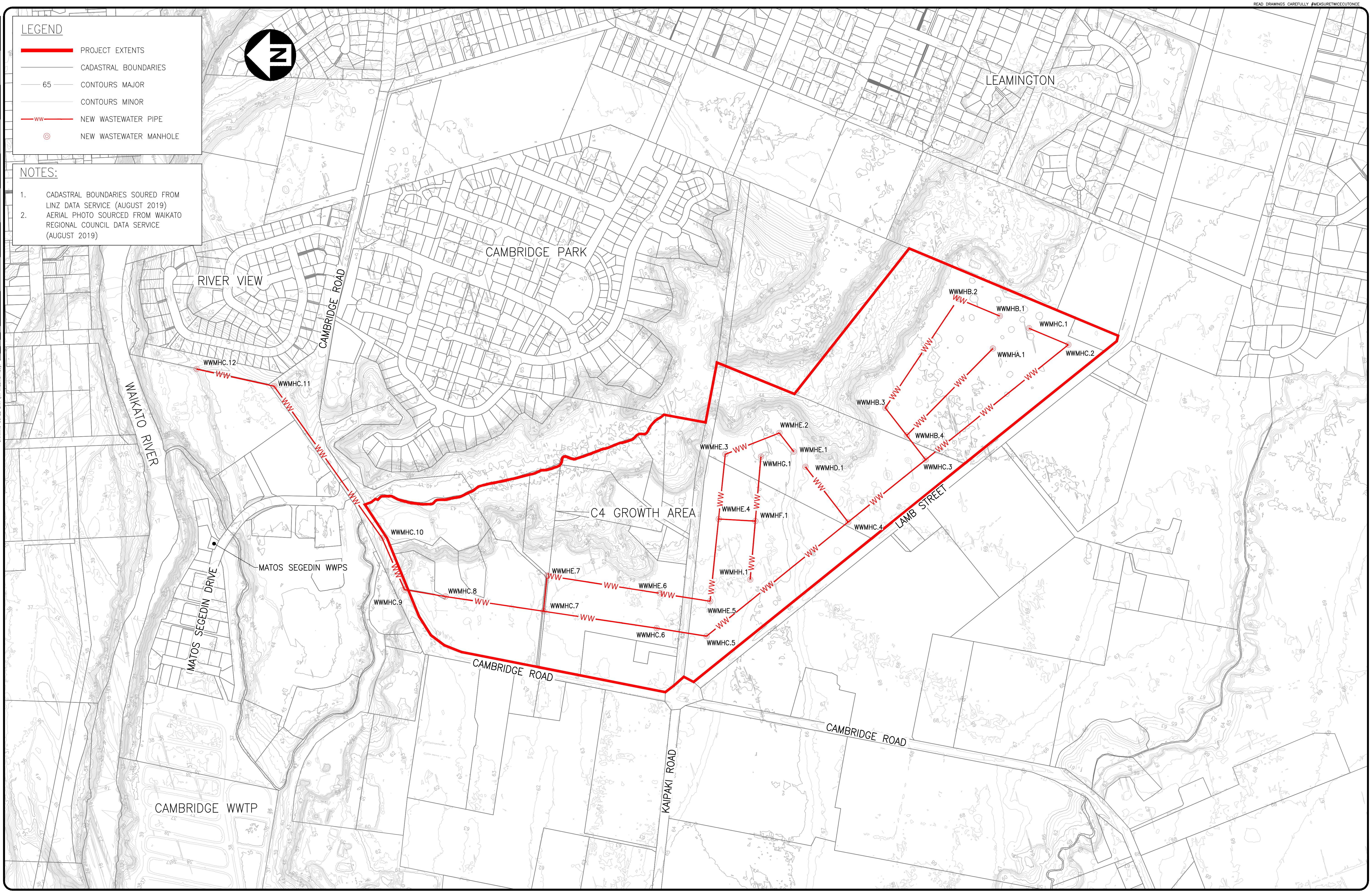
REVISION No.: A

DISCIPLINE: CIVIL ENGINEERING

DRAWING No.: 19014-SK-501

FILE NAME: 19014-SK-501.dwg

Document Set ID: 10476599
Version: 1, Version Date: 29/09/2020



A	FOR INFORMATION	AXZ	24.09.19
REV	DESCRIPTION	BY	DATE

APPROVAL STATUS: FOR INFORMATION

DESIGNED BY: M.FARRELL — DATE: DD.MM.YY

DRAWN BY: AXZ — DATE: 24.09.19

APPROVED BY: TBC — DATE: DD.MM.YY

CLIENT NAME: Waipa District Council

PROJECT NAME: C4 STRUCTURE PLAN

DRAWING TITLE: WASTEWATER NETWORK DRAFT PLAN OPTION B

PRODUCED BY: HG

DATE PRINTED: 3 October 2019

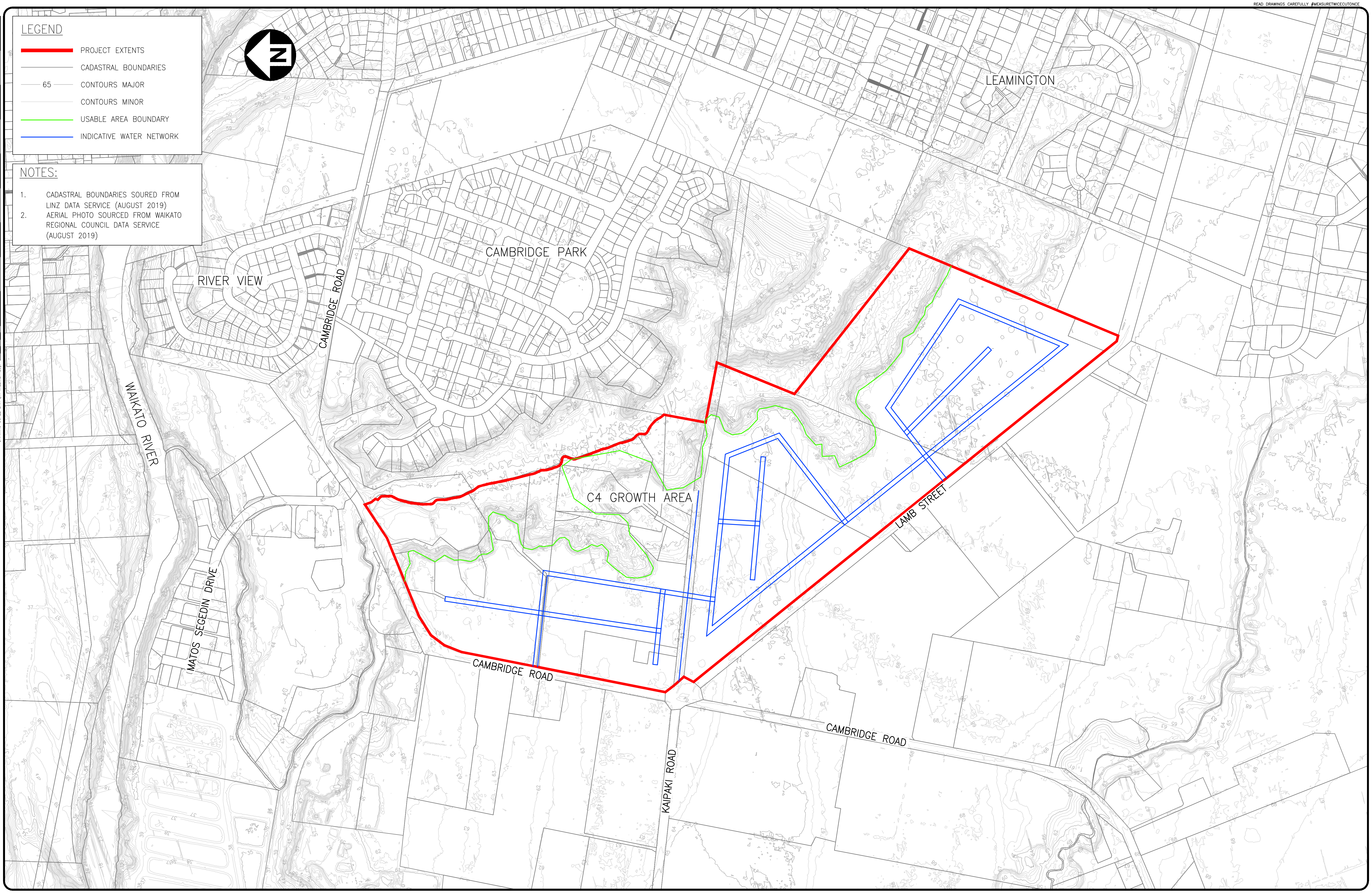
DRAWING SCALE: 1:7500

REVISION No.: A

DISCIPLINE: CIVIL ENGINEERING

DRAWING No.: 19014-SK-502

FILE NAME: 19014-SK-502.dwg



A	FOR INFORMATION	AXZ	24.09.19
REV	DESCRIPTION	BY	DATE

APPROVAL STATUS: FOR INFORMATION

DESIGNED BY: M.FARRELL — DATE: DD.MM.YY
DRAWN BY: AXZ — DATE: 24.09.19
APPROVED BY: TBC — DATE: DD.MM.YY

CLIENT NAME: Waipa DISTRICT COUNCIL

PROJECT NAME: C4 STRUCTURE PLAN

DRAWING TITLE: WATER SUPPLY NETWORK DRAFT PLAN

PRODUCED BY: HG

DATE PRINTED: 3 October 2019

DRAWING SCALE: 1:7500

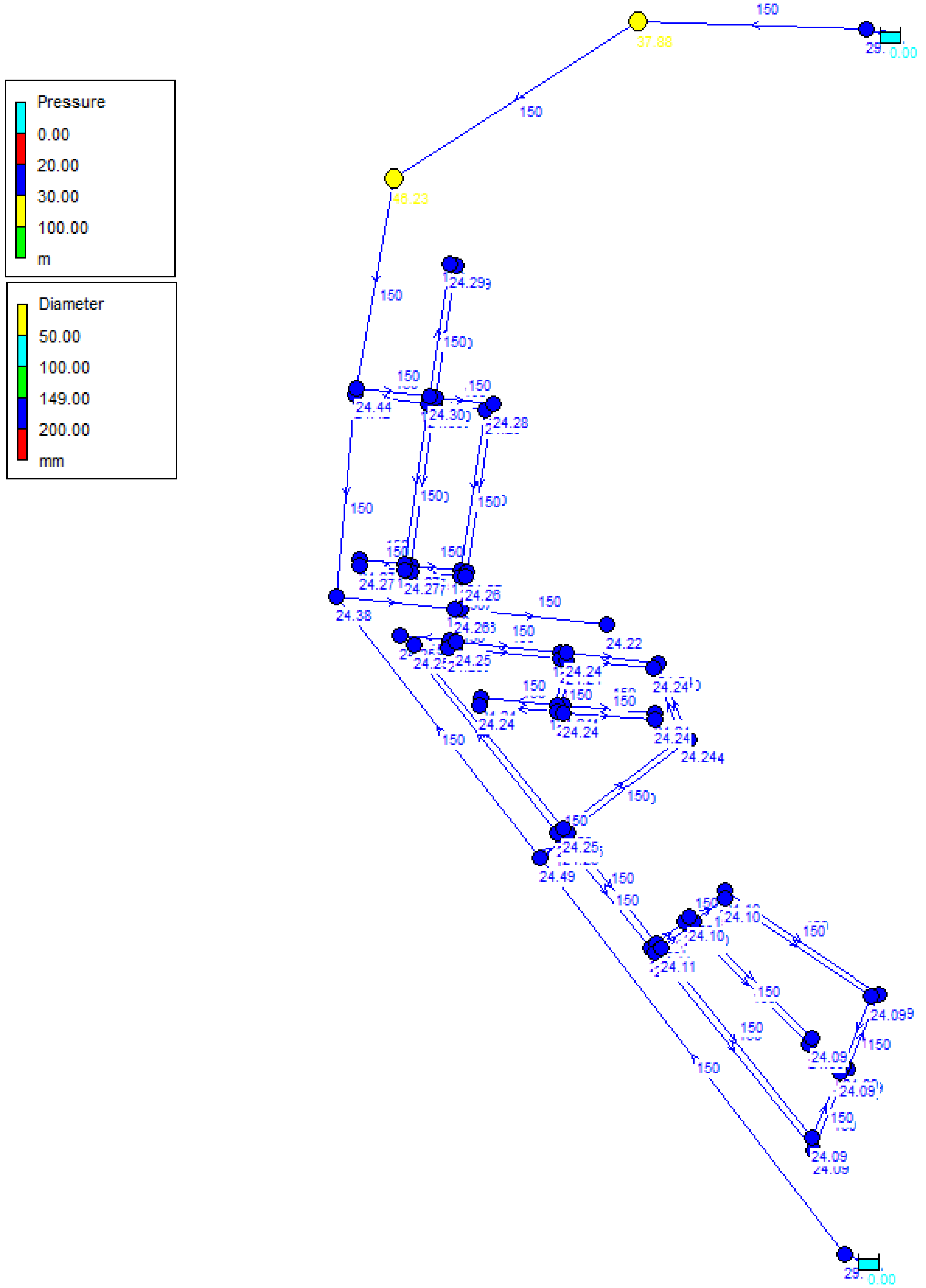
REVISION No.: A

DISCIPLINE: CIVIL ENGINEERING

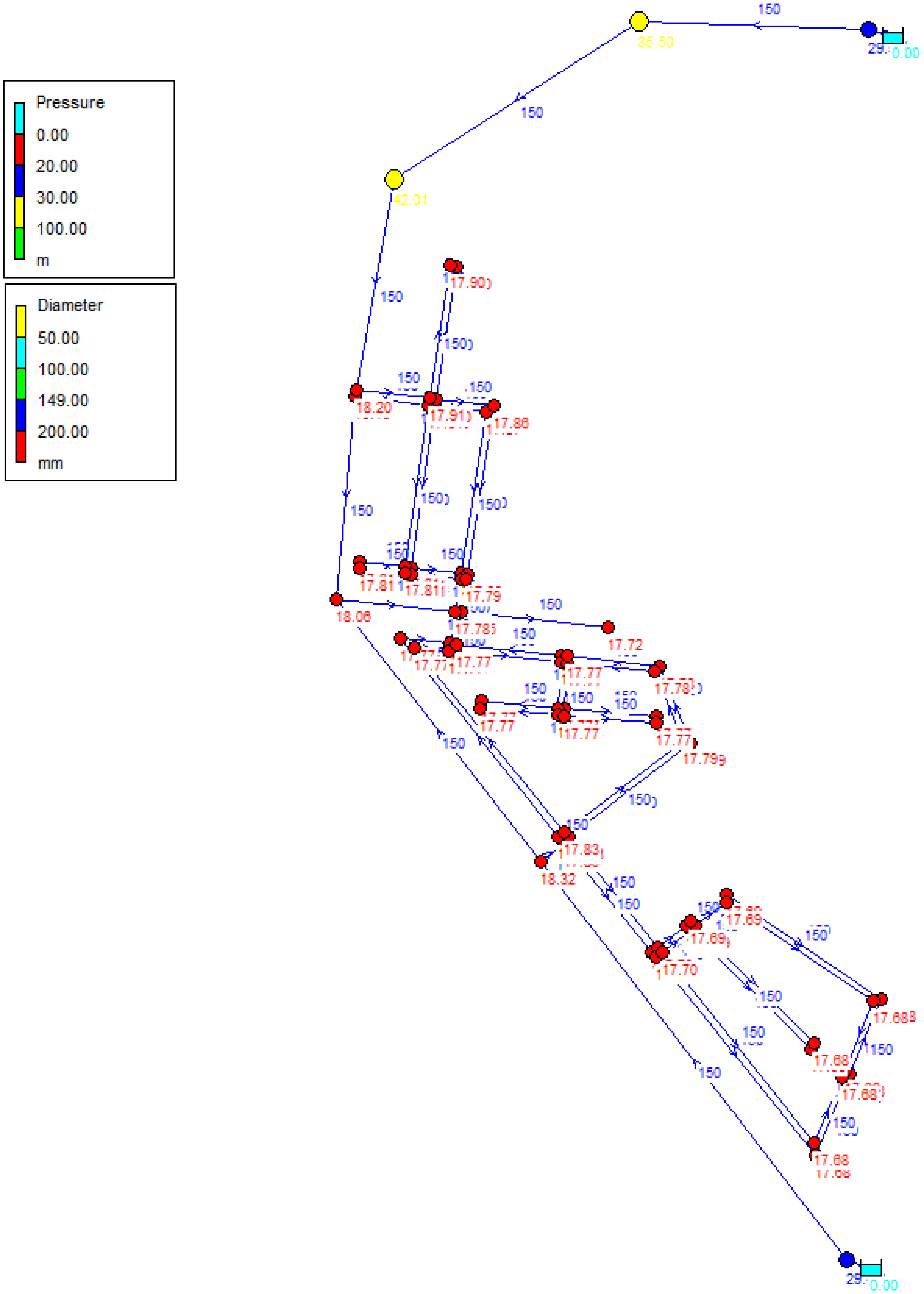
DRAWING No.: 19014-SK-600

FILE NAME: 19014-SK-600.dwg

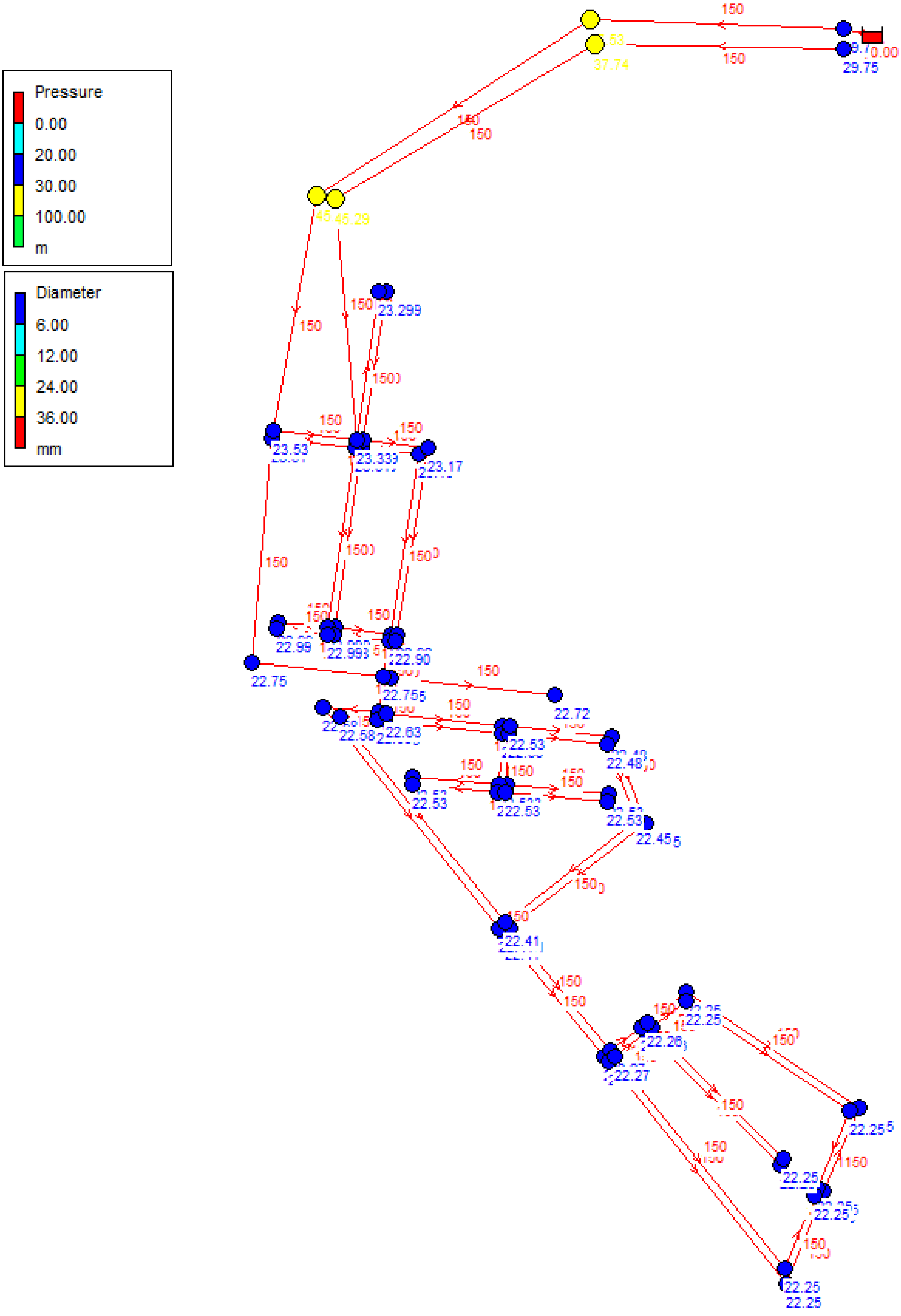
SINGLE NORTH AND SOUTH 150MM SUPPLY (Peak Flow)



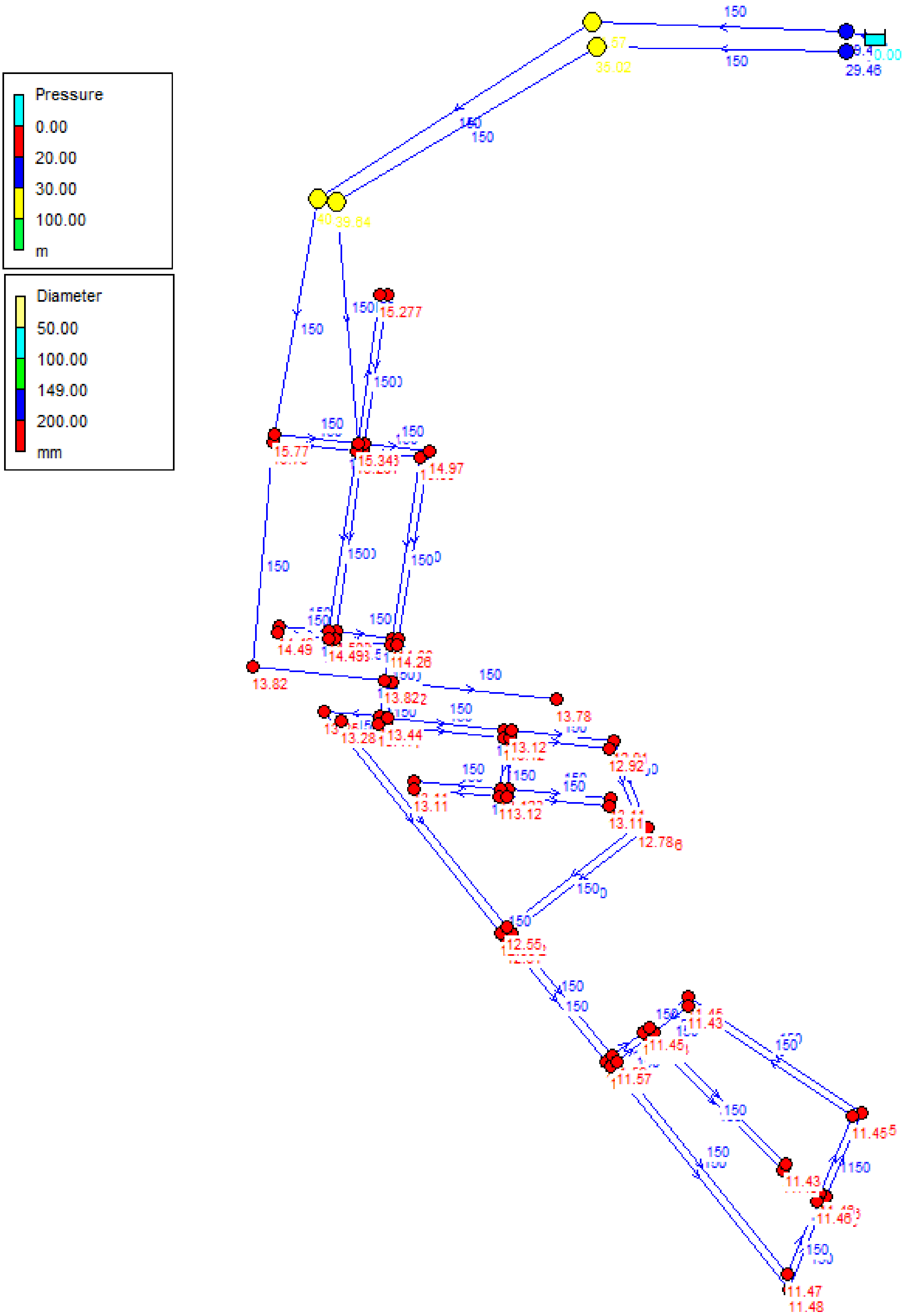
SINGLE NORTH AND SOUTH 150MM SUPPLY (Fire Flow)



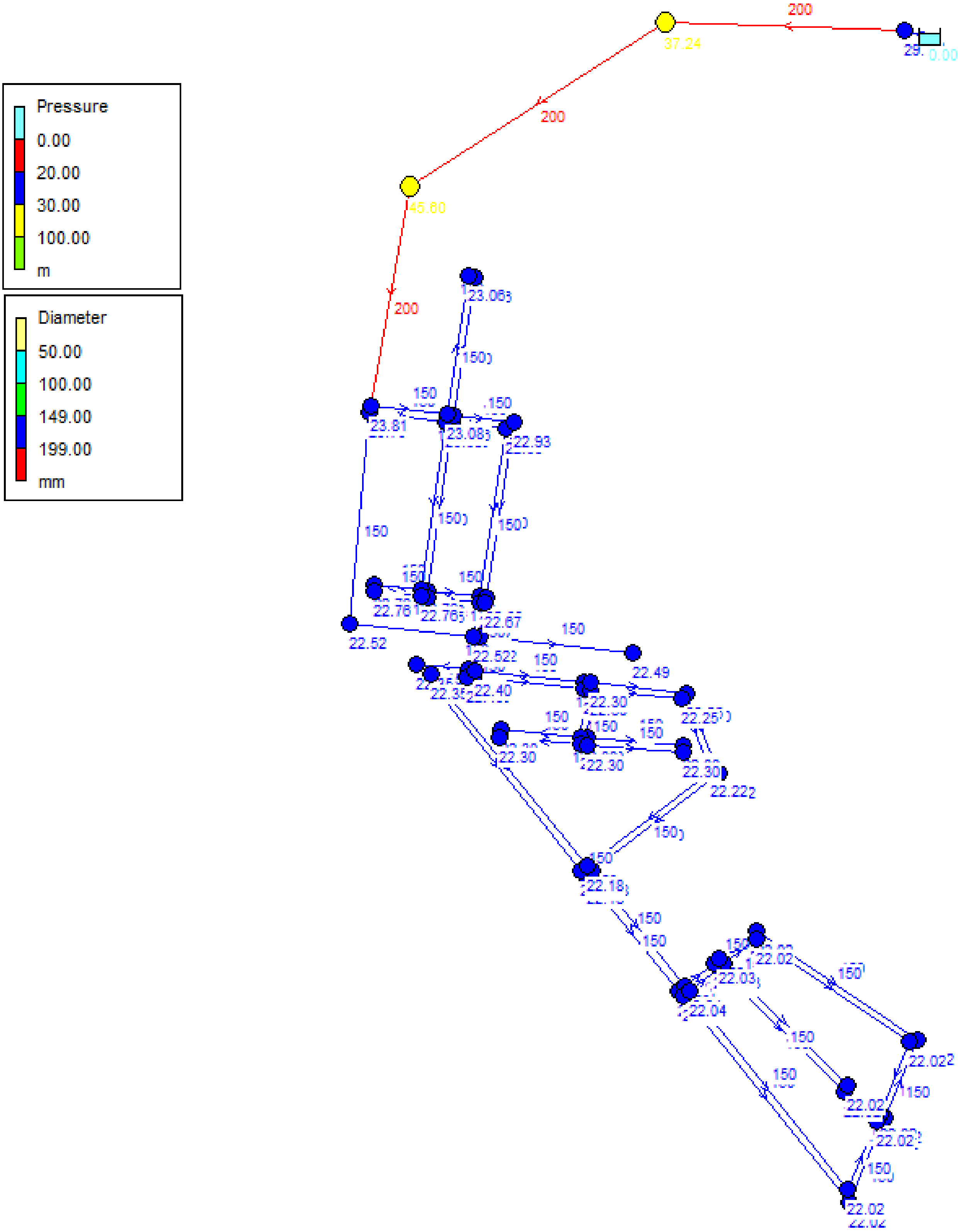
DOUBLE 150MM SUPPLY (Peak Flow)



DOUBLE 150MM SUPPLY (Fire Flow)

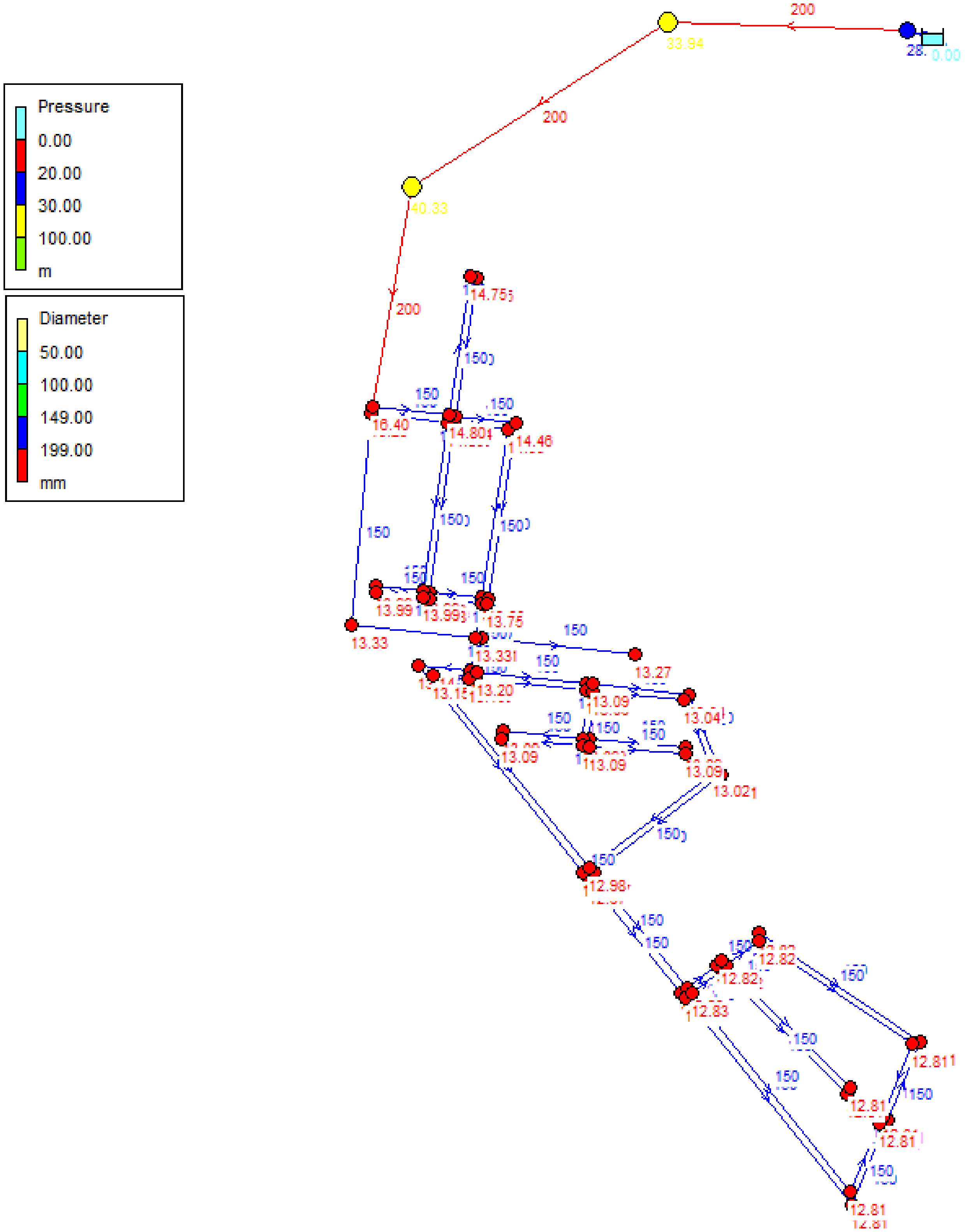


SINGLE 200MM DIAMETER SUPPLY (Peak Flow)



Document Set ID: 10476599
Version: 1, Version Date: 29/09/2020

SINGLE 200MM DIAMETER SUPPLY (Fire Flow)



APPENDIX 6 FLOOD MODEL BUILD

Technical Memo

C4 – MASTER PLANNING, CAMBRIDGE

Flood Risk Assessment

TO:	Mike Chapman – Te Miro Water Ltd	**HG PROJECT NO :**	1610-146182-01
FROM:	Saeed Ghavidelfar; Mona Liao	**DATE:**	20 December 2019

1.0 EXECUTIVE SUMMARY

Harrison Grierson was commissioned by Te Miro Water Ltd to carry out a flood risk assessment for 3 Waters Master Planning of C4 Growth Cell, located at the south western boundary of the Cambridge town (Figure1).

This flood risk assessment aims to inform Waipa District Council whether it is needed to undertake post development flow attenuation as a design consideration for this area. In this way, a coupled 1D-2D MIKE FLOOD model was developed to evaluate the flood impact of the C4 development site.

The results of the assessment showed that

- The C4 development may not have any adverse impact on the downstream since the expansive gully system adjacent to the growth area, which is owned by WDC and will be the receiving environment for the development, provides a natural storage area.
- The increase of water level in the gully and the maximum flow through the culvert downstream of the gully is marginal.
- There is no need to undertake a post development flow attenuation for C4 growth cell.

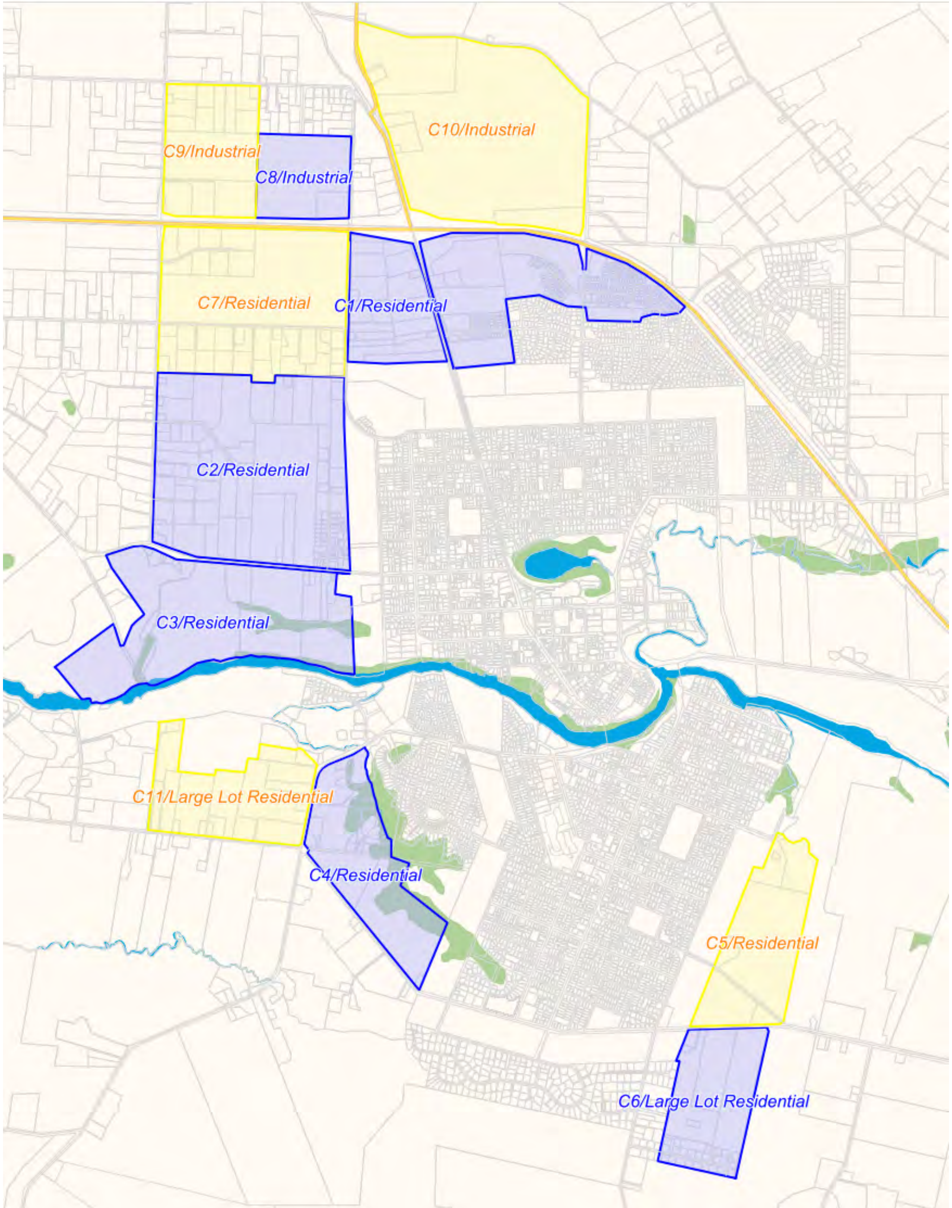


Fig 1. Cambridge Future Growth Cells (Future Growth Waipa 2050)

2.0 HYDRAULIC MODEL BUILD

A coupled 1D/2D DHI MIKE FLOOD model was developed for pre-development and post-development scenarios to assess the flood impact of residential development at C4 growth cell. For this assessment, the catchment was modelled in MIKE URBAN, while a river reach along with a culvert downstream of the gully was modelled in MIKE 11. These two models were coupled with a MIKE 21 model, representing the 2D surface, in MIKE FLOOD in order to present a fully coupled model which is capable of showing the changes of water level and flow across the catchment due to the changes of land use at the C4 growth cell.

To develop the model, initially an overland flow path analysis was carried to understand the full extent of the catchment. Then, the subcatchments through the area were delineated based on the OLFP analysis and the existing pipe network. Figure 2 shows the overland flow path, and the delineated subcatchments with the loading points.

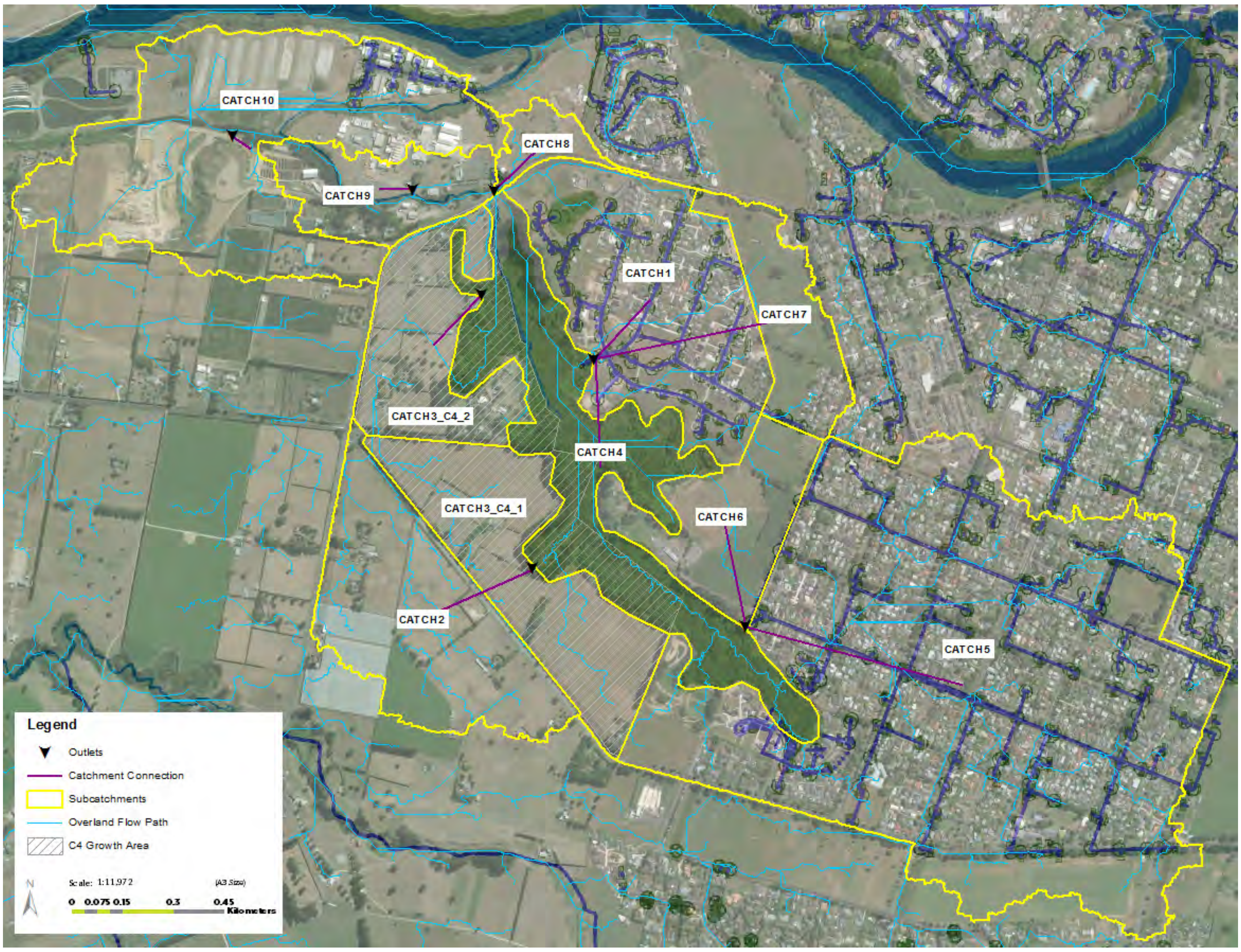


Fig 2. Subcatchments

To calculate stormwater runoff for each subcatchment, the model parameters including rainfall, Curve Number (CN), time of concentration, initial abstraction were estimated based on Waikato stormwater runoff modelling guideline (TR2018/02). The S-MAP soil database and aerials were used to identify the soil type and CN for each subcatchment. In general, the catchment is covered by a well-drained B type soil while in some areas more impervious C type soil is also available. Figure 3 shows the S-MAP soil classification across the site, while Table 1 presents the assigned CN for each soil type.

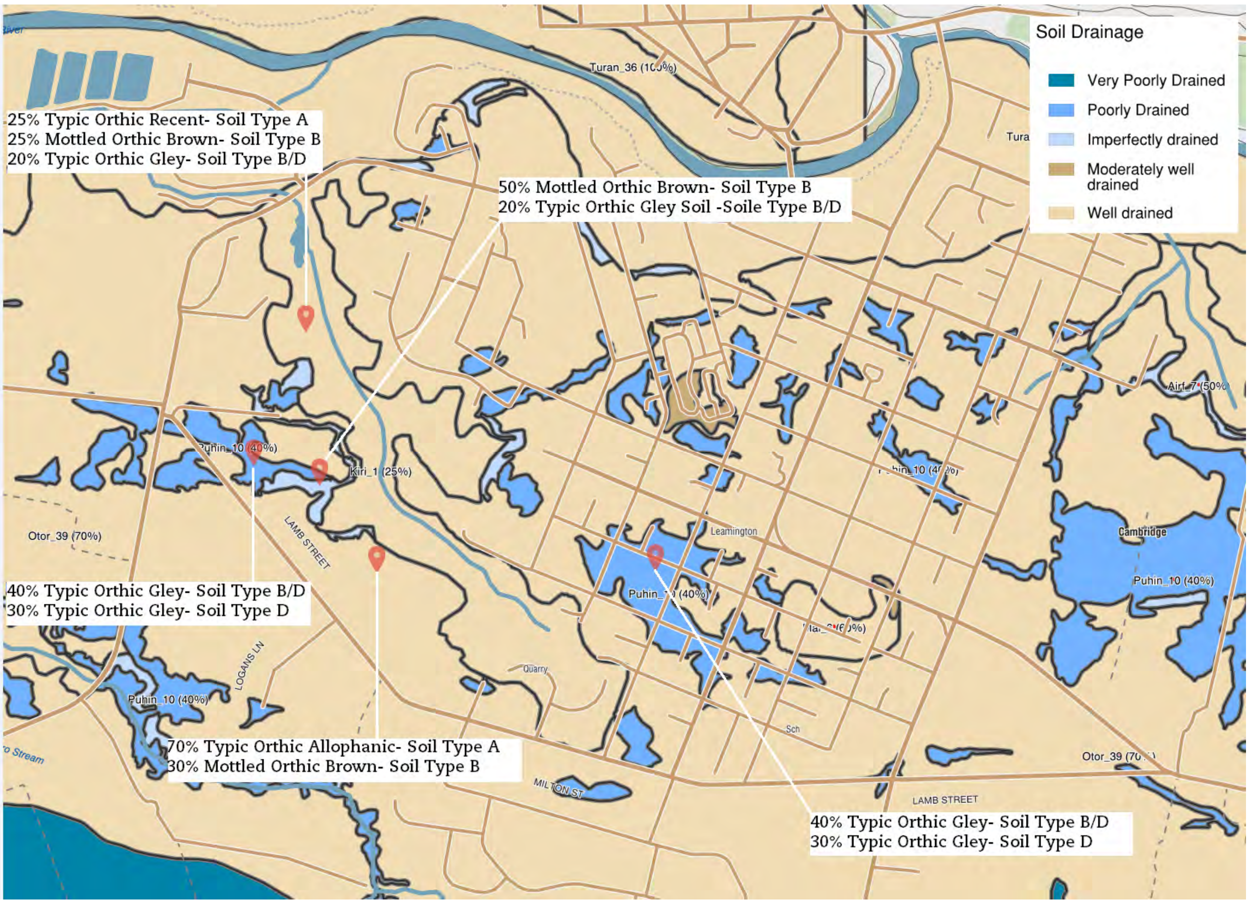


Fig 3. Soil type through the catchment (Source S-MAP)

TABLE 1: ESTIMATED CN		
SOIL TYPE	**PERVIOUS**	**IMPERVIOUS**
Soil Type B	69	98
Soil Type C	79	98

Table 2 and 3 provide the subcatchment characteristics for pre-development and post-development scenarios, respectively.

TABLE 2: SUBCATCHMENT CHARACTERISTICS (PRE-DEVELOPMENT)

CATCH_ID	SOIL TYPE	IMPERVIOUS AREA (%)	TOTAL AREA (HA)	COMPOSITE CN	COMPOSITE INITIAL ABSTRACTION (MM)	TIME OF CONCENTRATION (HR)
CATCH1	B	60	42.66	86.4	2	0.45
CATCH2	B	10	34.56	71.9	5	0.93
CATCH3_C4_1	B	10	29.67	71.9	5	0.75
CATCH3_C4_2	B	10	21.19	71.9	5	0.75
CATCH4	B	5	42.59	70.45	5.3	0.55
CATCH5	C	60	155.46	90.4	1.3	1.18
CATCH6	B	10	18.84	71.9	5	0.58
CATCH7	B	10	14.18	71.9	5	0.78
CATCH8	B	10	4.50	71.9	5	0.63
CATCH9	B	50	14.76	83.5	2.5	0.36
CATCH10	B	50	61.12	83.5	2.5	0.61

TABLE 3: SUBCATCHMENT CHARACTERISTICS (POST-DEVELOPMENT)

CATCH_ID	SOIL TYPE	IMPERVIOUS AREA (%)	TOTAL AREA (HA)	COMPOSITE CN	COMPOSITE INITIAL ABSTRACTION (MM)	TIME OF CONCENTRATION (HR)
CATCH1	B	60	42.66	86.4	2	0.45
CATCH2	B	10	34.56	71.9	5	0.93
CATCH3_C4_1	B	60	29.67	86.4	2	0.47
CATCH3_C4_2	B	60	21.19	86.4	2	0.47
CATCH4	B	5	42.59	70.45	5.3	0.55
CATCH5	C	60	155.46	90.4	1.3	1.18
CATCH6	B	10	18.84	71.9	5	0.58
CATCH7	B	10	14.18	71.9	5	0.78
CATCH8	B	10	4.50	71.9	5	0.63
CATCH9	B	50	14.76	83.5	2.5	0.36
CATCH10	B	50	61.12	83.5	2.5	0.61

Design 24-hour rainfall depths are derived from HIRDS Version 4 for a 100yr ARI event. Site specific rainfall profile was generated using the alternating block method (Chicago nested rainfall method) based on the HIRDS v4 data. This standard 24-hour temporal rainfall pattern has a peak rainfall intensity at mid-duration while shorter duration rainfall bursts with a range of durations from 10 minutes to 24 hours are nested within the 24-hour temporal pattern.

Climate change is also accounted for in the post-development calculations using RCP 6.0 (2031-2050) as this is considered a medium to high prediction result. The climate change is only applied to the C4 subcatchments in the post-development scenario in order to allow for an accurate flood impact assessment for the development.

Table 4 shows the rainfall depths, while Figures 4 and 5 present 100yr ARI design storm for the existing and the future climate change scenarios.

TABLE 4: 24HR RAINFALL DEPTHS (MM)

RAINFALL EVENT	RAINFALL DEPTH (MM)- EXISTING	RAINFALL DEPTH- CLIMATE CAHNGE RCP 6
100YR	152	161

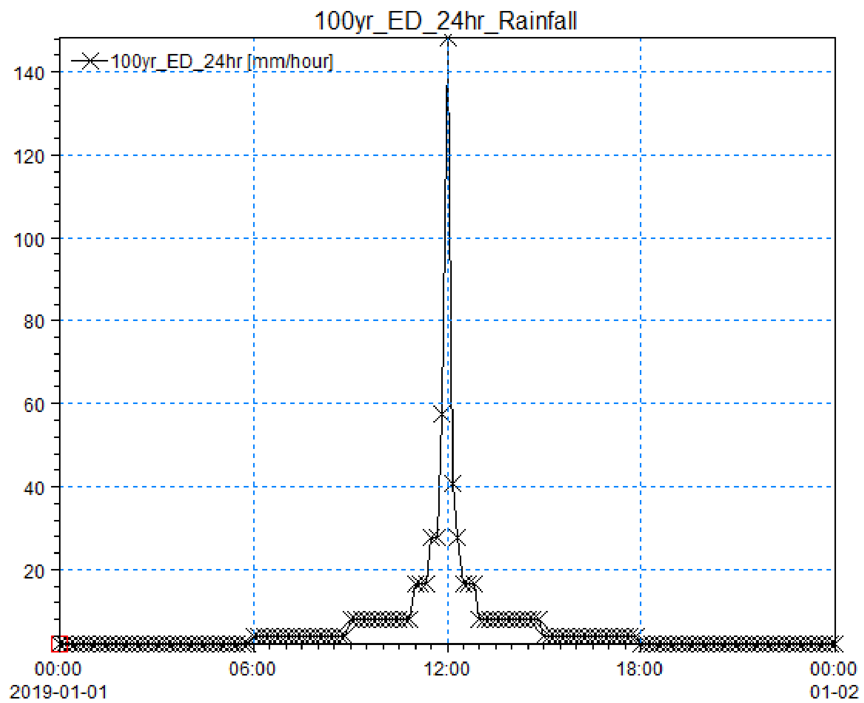


Fig 4. Design storm –existing scenario

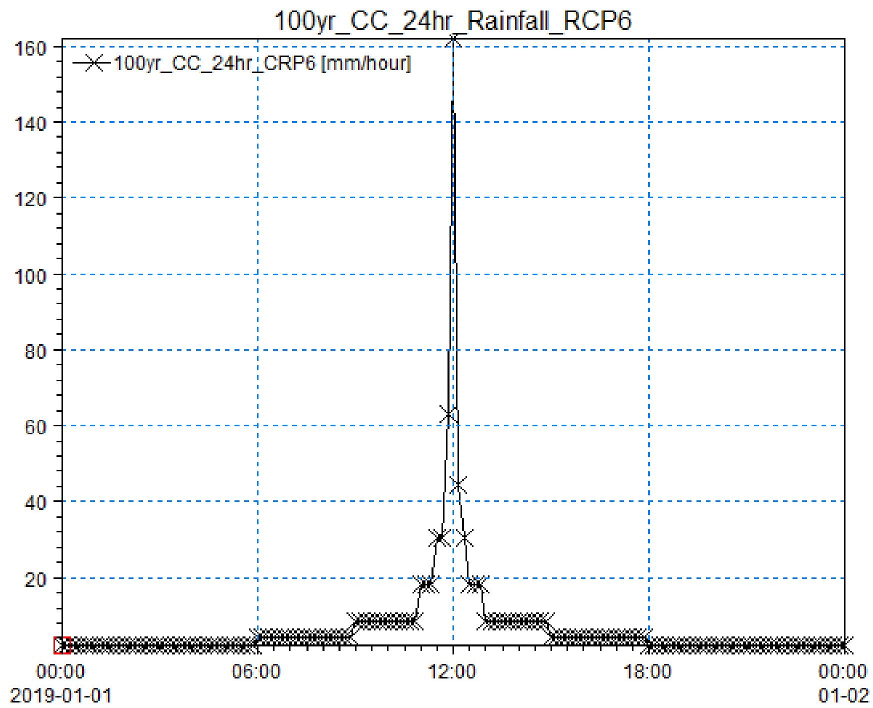


Fig 5. Design storm –climate change scenario

The culvert and a section of stream downstream of the gully, was modelled in MIKE 11 as 1D river reach (Figure 6). The river reach was coupled with MIKE 21 2D Surface in MIKE FLOOD. The culvert dimension and the ground level at two cross sections upstream and downstream of the site were obtained through a site survey. For other cross sections upstream and downstream of the site, the ground level was estimated based on the LiDAR and the survey cross sections.

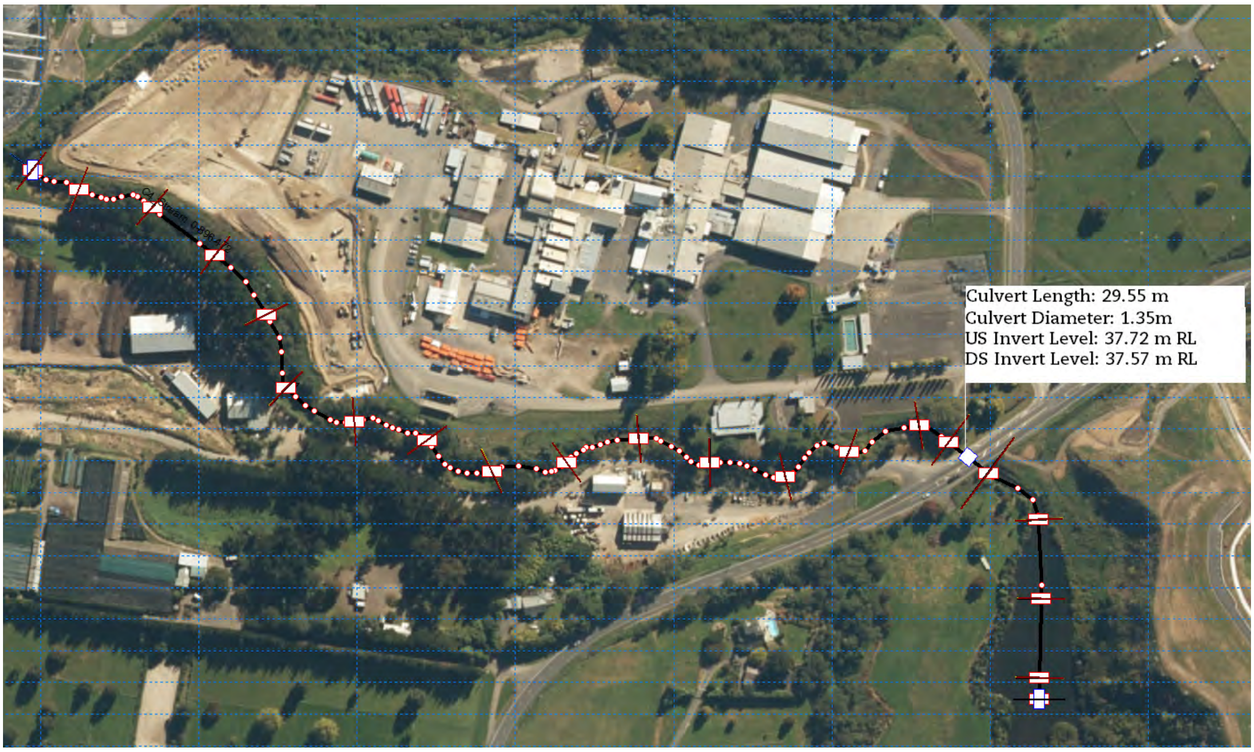


Fig 6. MIKE 11 1D model

LiDAR 2018 was used to generate the 2x2m grid in the MIKE 21 model. The surface roughness was assumed to be 0.05 all across the catchment, while manning roughness for the river reach was 0.03.

Figure 7 presents the coupled 1D/2D model extent in the MIKE FLOOD.

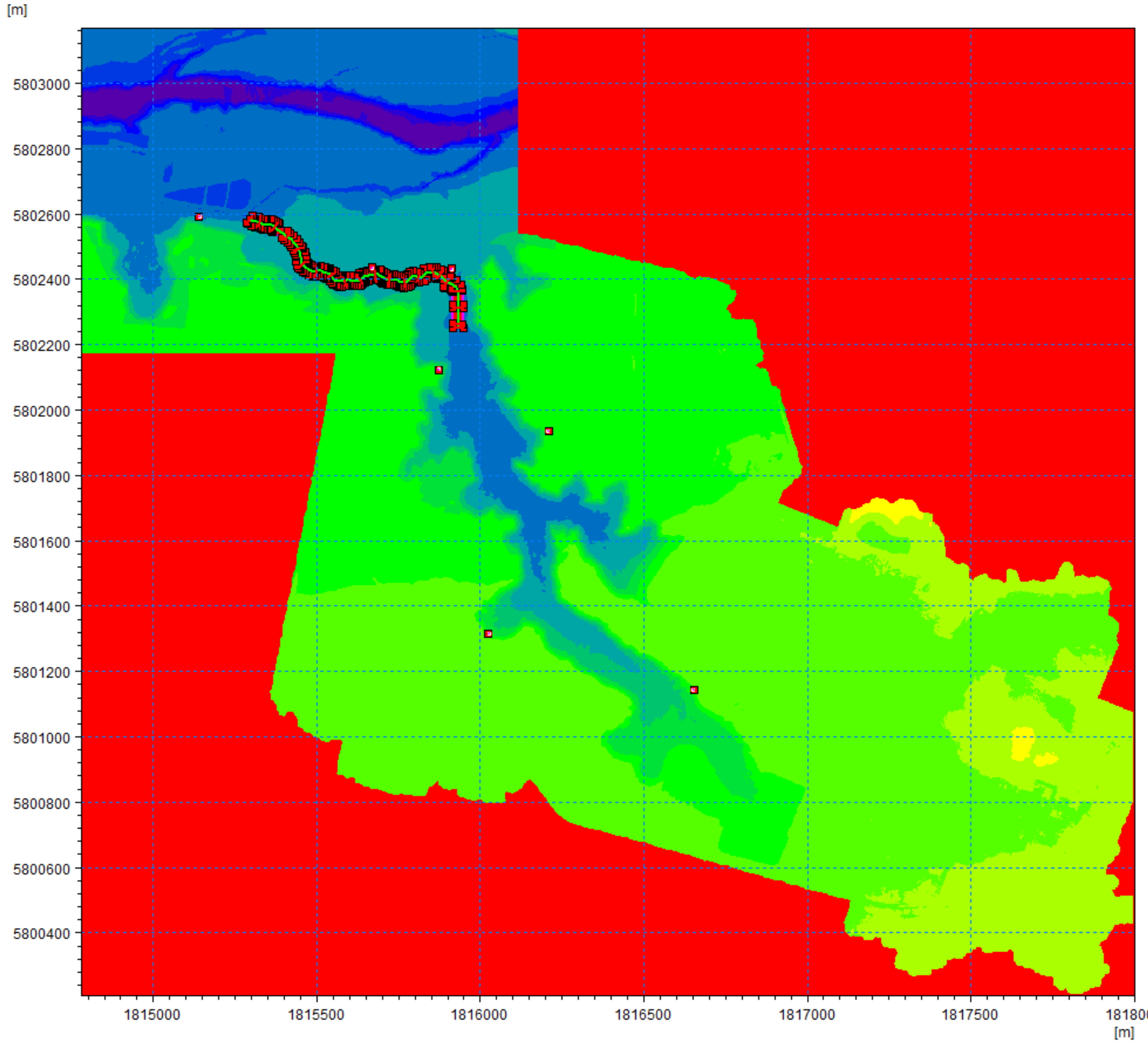


Fig 7. MIKE FLOOD model

3.0 MODELLING RESULTS

The model results are presented in appendix 1.

Map 146182-00-001 presents the comparison of maximum water level and maximum flow across the catchment for the pre-development and post-development scenarios, while Map 146182-00-002 compares the flood extent through the pre- and post-development scenarios.

Comparing the results of pre-development model with the post-development models shows that:

- The development in C4 growth cell may not make any significant adverse impact on the upstream or downstream maximum water level and flood extent, while the maximum water level changes are within the range of 100 mm of pre-development levels both at the upstream and downstream of the site. This is because the expansive gully system adjacent to the growth area provides a large natural storage area.
- Since the post-development max flow and max water level is not significantly higher than the pre-development, there is no need for any flow attenuation through the site.

4.0 CONCLUSIONS

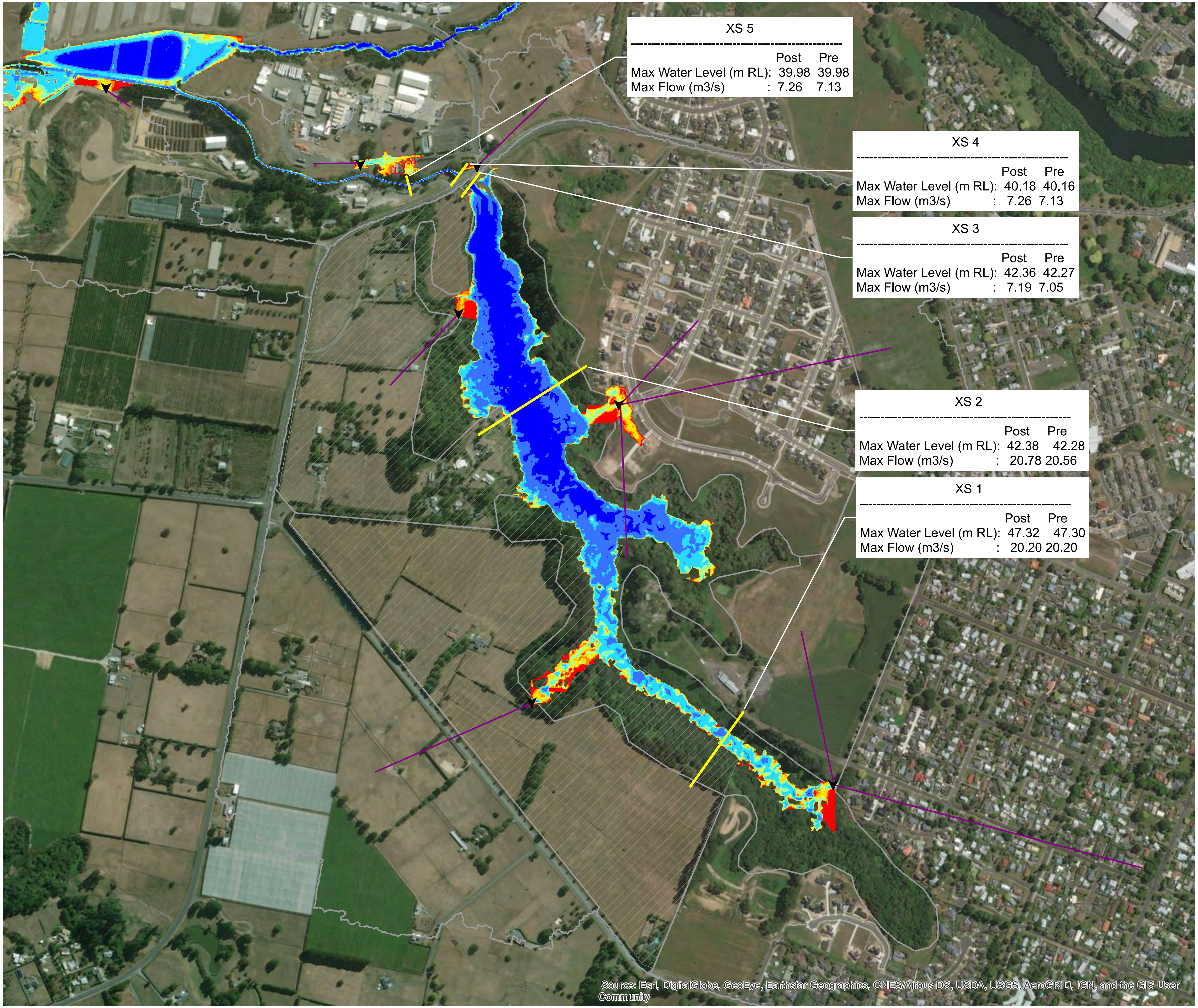
In order to evaluate the flood impact of residential development at the C4 growth cell at Cambridge, a coupled 1D/2D MIKE FLOOD model was developed.

The pre-development and post development models were re-run for the 100yr ARI event. Comparing the post developments results with the pre development showed that

- The residential development at C4 growth cell may not have any major adverse impact in terms of flood level and flood extent on the upstream and downstream of the site. Thus, there is no need to undertake post development flow attenuation.

APPENDICES

APPENDIX 1
MAPS



HARRISON GRIERSON

Legend

- Outlets
- Catchment Connection
- Cross Section

Flood depth (m)

- < 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 100
- Subcatchments
- C4 Growth Area

ASSOCIATION OF CONSULTING ENGINEERS NEW ZEALAND — ISO 9001 QUALITY ASSURED

REV	ISSUE STATUS	DATE
EDv9	DRAFT FOR INFORMATION	191212

DESIGNED:	SXG	DATE:	12/12/2019
DRAWN:	SXG	DATE:	12/12/2019
CHECKED:	MYL	DATE:	12/12/2019
APPROVED:	MYL	DATE:	12/12/2019

N

Scale: 1:7,500 (A3 Size)

0 0.05 0.1 0.2 0.3 Kilometers

C4 – MASTER PLANNING, CAMBRIDGE
Flood Risk Assessment

Post-Development 100yr ARI Flood Map
CC HIRDSv4 RCP6 (only Site)

MAP NO:

146182_00_001

esri

HARRISON GRIERSON

Legend

- Outlets
- Catchment Connection
- Flood Extent, Post-Development
- Flood Extent, Pre-Development
- Subcatchments
- C4 Growth Area

REV	ISSUE STATUS	DATE
PDv9	DRAFT FOR INFORMATION	191212

DESIGNED:	SXG	DATE:	12/12/2019
DRAWN:	SXG	DATE:	12/12/2019
CHECKED:	MYL	DATE:	12/12/2019
APPROVED:	MYL	DATE:	12/12/2019

N

Scale: 1:7,500 (A3 Size)

0 0.05 0.1 0.2 0.3 Kilometers

C4 - MASTER PLANNING, CAMBRIDGE
Flood Risk Assessment

100yr ARI Flood Extent
Post-development Vs. Pre-Development

MAP NO:

146182_00_002

esri

File Path:\\hgc-trgfp01.harrisongrierson.com\Jobs\1610\146182_01 Cambridge C4\400 Tech\460 Water Resources\02GIS\02MAPS\HG_CambridgeC4_20190930_F3_FloodExtentV9.mxd

Last saved by: SXG 2019-12-13 Last Plotted: 2015-11-27

APPENDIX 7 SOAKAGE TESTING

Mark T Mitchell Ltd

Consulting Geotechnical Engineers

1150 Victoria Street
P O Box 9123
Hamilton, New Zealand
Facsimile 07 839 3125
Telephone 07 838 3119
email: mtm@geocon.co.nz

Ref: W – 16064.6
1 November, 2019

Waipa District Council
c/- Mitchell Daysh
Planning Consultants
PO Box 1307
Hamilton 3240

Attention: Abbie Fowler

Dear Madam

Re: Supplementary Site Investigation for Stormwater Disposal Testing
Proposed C4 Growth Cell – Cambridge Road and Lamb Street, Cambridge

In accordance with your request, we have carried out a supplementary site investigation and Stormwater Disposal Testing the above referenced development area. The purpose of our studies was to determine and evaluate the subsurface conditions within the site and assess the feasibility for on-site stormwater disposal within the proposed C4 Growth Cell.

Our associate company, Geocon Geotechnical Ltd, has carried out field testing and calculations which are set out in the attached report, dated 31 October, 2019. This report is a supplement to Section 9: Stormwater Disposal within the Waipa District Council - C4 Growth Cell, Geotechnical Report dated 27 September, 2019 (Ref: W-16064.7).

Yours faithfully

Mark T Mitchell Ltd

Mark T Mitchell
Director

cc. Mike Chapman (Te Miro Water Consultants Ltd)

SUPPLEMENTARY SITE INVESTIGATION
STORMWATER DISPOSAL TESTING

WAIPA DISTRICT COUNCIL C4 GROWTH CELL
CAMBRDIGE ROAD AND LAMB STREET, LEAMINGTON, CAMBRIDGE

The following report is a supplement to Section 9: Stormwater Disposal, within the Waipa District Council C4 Growth Cell, Geotechnical Report dated 27 September, 2019 (Ref: W-16064-7).

1. Test Locations

The following report is based on site conditions as observed during site investigations carried out by our **geologists on 14 and 15 October, 2019. Testing was carried out within the Upper Terrace (Zone 1) in the locations** shown on the attached Site Plan, Drawing No. 16064-20.

The site was investigated by drilling two each, machine auger borings at four locations (eight tests) as shown on the attached Site Plan. The Bore Holes are designated Stormwater Tests A1 to D2, with the Bore Hole log presented on Fig. A-100 to -103.

The purpose of the boring and associated test was to provide guidance as to the general subsurface soil profile within the building site area. Actual ground conditions may vary across the site however, and may differ slightly from those as described below.

2. Field Procedures

The capacity of the site soils to receive concentrated stormwater flows was determined by conducting *insitu* falling head permeability testing within the pre-drilled investigation holes.

Falling Head testing was conducted in accordance with the following general procedure:

1. Pre-drill 85mm-diameter bore hole to design or test depth;
2. Ream out and scarify the bore hole using a 95mm-diameter hand auger so that the sides of the hole are not smeared;
3. Insert and push 65mm-internal diameter, open-ended and slotted PVC pipe to the base of pre-drilled test hole;
4. Pre-soak soils within the test hole by filling the PVC casing and allowing a single cycle of water drainage from the test hole;
5. Refill the test hole and monitor the rate of water level drop over time.

3. Subsurface Conditions

The near surface soils encountered within the stormwater test bore holes revealed 200mm of TOPSOIL overlying SILT (Loam) to between 0.4 to 0.8 metres depth.

The Silt was underlain by gravelly fine to coarse grained SAND to at least the base of the 1.5 to 3.0 metre deep bore holes.

Groundwater was not encountered within the bore holes during the spring site investigation.

4. Test Permeability Test Results

The results of the falling head permeability testing are presented on the attached Tables 1A to 1H with an analysis of the falling head test presented on Figs. E-100 to E-107. The test results are presented on the table below.

Stormwater Test Location	Stormwater Test Depth (Metres)	Hydraulic Conductivity (metres per second)	Hydraulic Conductivity (metres per day)
A1	1.5	2.6×10^{-5}	2.2
A2	2.8	4.5×10^{-6}	0.4
B1	1.5	2.7×10^{-5}	2.4
B2	3.0	1.4×10^{-5}	1.2
C1	1.5	1.3×10^{-5}	1.1
C2	3.0	1.3×10^{-5}	1.1
D1	1.5	2.7×10^{-5}	2.3
D2	3.0	3.3×10^{-5}	2.8

The testing was conducted as per New Zealand standard with the calculation procedure followed in general accordance with widely accepted methods following Hvorslev. The results represent the theoretical soil hydraulic conductivity or ability of that soil medium to transmit water flows under a simulated water level head.

An alternative procedure to determine design soakage rate is presented in the New Zealand Building Code Verification Method E1/VM1 (MBIE, 1992) which involves the selection of a particular gradient on the draw down curve. This procedure is discussed further by Trigger MD (2017) as it generally results in less conservative test soakage test rates and thus substantially smaller systems are designed.

5. Conclusions – Review of Test Results

The results of the testing indicate:

- Five of the six tests revealed consistent hydraulic conductivity (k) with values between 1.1 to 2.8 metres per day.
- The other test (A2 - 3.0 metre deep test) provided inconsistent results. This is likely to be on account of:
  - Heavy rainfall encountered in the days prior to testing
  - Perched water above Silt lenses which are exposed in the gully branch located south of the test site.
  - The possibility of some of the deeper sands being very dense which limited pore space availability.

The results may not be fully representative of the full capacity of the soils and further testing is to be carried out such as with a ring permeater in the base of the proposed stormwater trenches.

Prepared by:

Timothy Dunton
Engineering Geologist

Report Approved by:

Geraint Walters
Operations Manager

Geocon Geotechnical Ltd Geotechnical Engineers 1150 Victoria Street, P.O. Box 9123, Hamilton	WAIPA DISTRICT COUNCIL Stormwater Investigation for C4 Growth Cell Cambridge Road and Lamb Street, Cambridge	STORMWATER SITE PLAN	DRAWING No. 16064-20 DATE October 2019 ISSUE DATE

STORMWATER TEST A-1

SOIL DESCRIPTION

Graphic log	Soil description	Depth (metres)	Geological formation	Vane shear strength - kPa (In-situ/Remoulded)	Scala penetrometer (blows/100mm)	Piezometer / water level
	TOPSOIL.		TS			No Groundwater
	SILT with some fine to coarse sand and minor fine gravel. Moist to wet, light yellowish brown.		Loam			
	gravelly fine to coarse SAND with trace silt. Wet, light brownish grey.		Hinuera Formation			
	fine to medium gravelly fine to coarse SAND with trace silt. Wet, grey.	1	Hinuera Formation			
	Bottom of Bore Hole completed 15/10/19	2, 3				

NOTES - The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

STORMWATER TEST A-2

SOIL DESCRIPTION

Graphic log	Soil description	Depth (metres)	Geological formation	Vane shear strength - kPa (In-situ/Remoulded)	Scala penetrometer (blows/100mm)	Piezometer / water level
	TOPSOIL.		TS			No Groundwater
	SILT with some fine to coarse sand and minor fine gravel. Moist to wet, light yellowish brown.		Loam			
	silty fine to coarse SAND with fine to coarse gravel. Moist to wet, light greyish brown.		Recent Alluvium			
	fine to coarse gravelly fine to coarse SAND with trace silt. Wet, brownish grey.	1, 2	Hinuera Formation			
	Bottom of Bore Hole completed 15/10/19	3				

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064

DRILL METHOD: Machine Auger
RIG: HILUX VANE No.
DRILLER: PS

LOGGED: HZ PLOTTED: PS
DATE LOGGED: 15/10/19
CHECKED: [signature]

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

BORE HOLE LOG

STORMWATER TEST A-1 & A-2
LOCATION: refer Site Plan RL (m):
SHEET: 1 OF 1 Fig. No. A-100

STORMWATER TEST B-1

SOIL DESCRIPTION

Graphic log	Soil description	Depth (metres)	Geological formation	Vane shear strength - kPa (In-situ/Remoulded)	Scala penetrometer (blows/100mm) 1 2 3 4 5 6 7 8 9 10	Piezometer / Water level
	TOPSOIL.		TS			No Groundwater
	SILT with minor fine to medium sand. Moist, yellowish brown.		Loam			
	fine to medium gravelly fine to coarse SAND with minor silt. Moist, light greyish brown.		Recent Alluvium			
	fine to medium gravelly fine to coarse SAND with minor silt. Moist, brownish grey. Becoming fine to coarse gravelly fine to coarse SAND @ 1.4 metres.	1	Hinuera Formation			
	Bottom of Bore Hole completed 15/10/19	2, 3				

NOTES - The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

STORMWATER TEST B-2

SOIL DESCRIPTION

Graphic log	Soil description	Depth (metres)	Geological formation	Vane shear strength - kPa (In-situ/Remoulded)	Scala penetrometer (blows/100mm) 1 2 3 4 5 6 7 8 9 10	Piezometer / Water level
	TOPSOIL.		TS			No Groundwater
	SILT with minor fine to medium sand. Moist, yellowish brown.		Loam			
	silty fine to coarse SAND with some fine gravel. Wet, light greyish brown.		RA			
	fine to medium gravelly fine to coarse SAND with some silt. Wet, light greyish brown. Becoming brownish grey @ 1.4 metres. Containing trace silt @ 1.9 metres.	1, 2	Hinuera Formation			
	Bottom of Bore Hole completed 15/10/19	3				

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064

DRILL METHOD: Machine Auger
RIG: HILUX VANE No.
DRILLER: PS

LOGGED: HZ PLOTTED: PS
DATE LOGGED: 15/10/19
CHECKED: SW

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

BORE HOLE LOG

STORMWATER TEST B-1 & B-2
LOCATION: refer Site Plan RL (m):
SHEET: 1 OF 1 Fig. No. A-101

STORMWATER TEST C-1

GRAPHIC LOG	SOIL DESCRIPTION	DEPTH (metres)	GEOLOGICAL FORMATION	VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)	SCALA PENETROMETER (blows/100mm)	PIEZOMETER / WATER LEVEL
	TOPSOIL.		TS			No Groundwater
	SILT with minor fine to medium sand and trace fine gravel. Moist, yellowish brown.		Loam			
	silty fine to medium SAND with trace fine gravel. Moist, yellowish brown.		RA			
	fine to medium gravelly fine to coarse SAND. Moist, greyish brown. Becoming brownish grey @ 1.4 metres.	1	Hinuera Formation			
	Bottom of Bore Hole completed 14/10/19	2, 3				

NOTES - The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

STORMWATER TEST C-2

GRAPHIC LOG	SOIL DESCRIPTION	DEPTH (metres)	GEOLOGICAL FORMATION	VANE SHEAR STRENGTH - kPa (In-situ/Remoulded)	SCALA PENETROMETER (blows/100mm)	PIEZOMETER / WATER LEVEL
	TOPSOIL.		TS			No Groundwater
	SILT with minor fine to medium sand and trace fine gravel. Moist, yellowish brown.		Loam			
	silty fine to medium SAND with minor fine gravel. Moist, yellowish brown.		RA			
	fine to medium gravelly fine to coarse SAND with minor silt. Moist to wet, light greyish brown. Becoming wet @ 1.5 metres. " light brownish grey@ 2.0 metres.	1, 2	Hinuera Formation			
	Bottom of Bore Hole completed 14/10/19	3				

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064

DRILL METHOD: Machine Auger
RIG: HILUX VANE No.
DRILLER: PS

LOGGED: HZ PLOTTED: PS
DATE LOGGED: 14/10/19
CHECKED: SW

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

BORE HOLE LOG

STORMWATER TEST C-1 & C-2
LOCATION: refer Site Plan RL (m):
SHEET: 1 OF 1 Fig. No. A-102

STORMWATER TEST D-1

SOIL DESCRIPTION

Depth (metres)	Soil Description	Geological Formation	Piezometer / Water Level
	TOPSOIL.	TS	No Groundwater
	SILT with some fine to coarse sand. Moist, yellowish brown.	Loam	
	fine to coarse SAND with some silt and minor gravel. Moist, light greyish brown.	RA	
1	gravelly fine to medium SAND. Moist to wet, light brownish grey.	Hinuera Formation	
	Bottom of Bore Hole completed 14/10/19		
2			
3			

Columns: GRAPHIC LOG; DEPTH (metres); GEOLOGICAL FORMATION; VANE SHEAR STRENGTH - kPa (In-situ/Remoulded); SCALA PENETROMETER (blows/100mm) 1 2 3 4 5 6 7 8 9 10; PIEZOMETER / WATER LEVEL

NOTES - The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

STORMWATER TEST D-2

SOIL DESCRIPTION

Depth (metres)	Soil Description	Geological Formation	Piezometer / Water Level
	TOPSOIL.	TS	No Groundwater
	SILT with minor fine to coarse sand and trace fine gravel. Moist, yellowish brown.	Loam	
	fine to medium gravelly fine to coarse SAND with trace silt. Moist, greyish brown.	RA	
1–3	fine to medium gravelly fine to coarse SAND with trace silt. Moist, light brownish grey. Containing minor silt @ 1.8 metres. Becoming moist to wet @ 2.0 metres. " wet @ 2.6 metres	Hinuera Formation	
3	Bottom of Bore Hole completed 14/10/19		

SCALA PENETROMETER 1 2 3 4 5 6 7 8 9 10

JOB NAME: WAIPA DISTRICT COUNCIL
JOB LOCATION: Cambridge Road and Lamb Street, Cambridge
JOB NUMBER: W-16064

DRILL METHOD: Machine Auger
RIG: HILUX VANE No.
DRILLER: PS

LOGGED: HZ PLOTTED: TD
DATE LOGGED: 14/10/19
CHECKED: [signature]

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, P.O. Box 9123, Hamilton

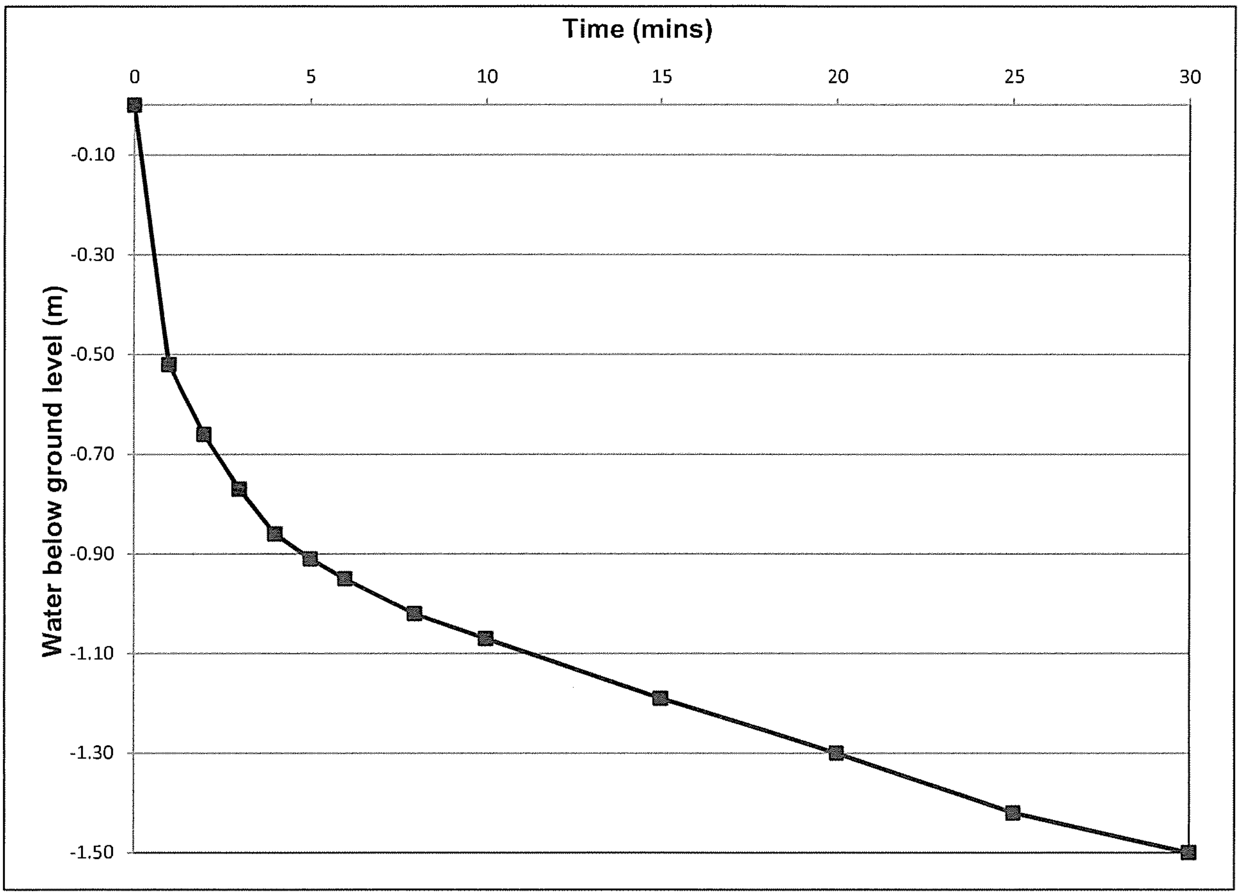
BORE HOLE LOG

STORMWATER TEST D-1 & D-2
LOCATION: refer Site Plan RL (m):
SHEET: 1 OF 1 Fig. No. A-103

FALLING HEAD SOAKAGE TEST

JOB NO. W-16064
PROJECT: WAIPA DISTRICT COUNCIL
LOCATION: C4 Growth Cell

SOAKAGE TEST A1



Time (mins)	Water Level below top of PVC (m)	Water Level Relative to Ground Level (m)	Change in Water Level (m)	Water Level head (m)
0	0.62	0.00	0.00	1.50
1	1.14	-0.52	0.52	0.98
2	1.28	-0.66	0.14	0.84
3	1.39	-0.77	0.11	0.73
4	1.48	-0.86	0.09	0.64
5	1.53	-0.91	0.05	0.59
6	1.57	-0.95	0.04	0.55
8	1.64	-1.02	0.07	0.48
10	1.69	-1.07	0.05	0.43
15	1.81	-1.19	0.12	0.31
20	1.92	-1.30	0.11	0.20
25	2.04	-1.42	0.12	0.08
30	2.12	-1.5	0.16	0.00

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, PO Box 9123, Hamilto

FALLING HEAD SOAKAGE TEST RESULTS

Figure No. E-100
DATE: October 2019
CHECKED:

Geocon Geotechnical Ltd

Geotechnical Engineers

WAIPA DISTRICT COUNCIL — W-16064

Stormwater Assessment for C4 Growth Cell — Date of test: 15 October, 2019

Field Soakage Test Data

TABLE 1A: FALLING HEAD SOAKAGE TEST RESUL STORMWATER TEST A1

Length of PVC Casing (m)	2.12
Length of PVC Above Ground (m)	0.62
Depth of Soakhole (m)	1.50
Groundwater Level (m)	0.00
Groundwater Level (height above base of Soakhole) (m)	na
Test Hole Diameter (m)	0.095

Time (mins)	Water Level below top of PVC (m)	Water Level Relative to Ground Level (m)	Change in Water Level (m)	Water Level head (m)
0.0	0.62	0.00	0.00	1.50
1.0	1.14	-0.52	0.52	0.98
2.0	1.28	-0.66	0.14	0.84
3.0	1.39	-0.77	0.11	0.73
4.0	1.48	-0.86	0.09	0.64
5.0	1.53	-0.91	0.05	0.59
6.0	1.57	-0.95	0.04	0.55
8.0	1.64	-1.02	0.07	0.48
10.0	1.69	-1.07	0.05	0.43
15.0	1.81	-1.19	0.12	0.31
20.0	1.92	-1.30	0.11	0.20
25.0	2.04	-1.42	0.12	0.08
30.0	2.12	-1.50	0.08	0.00

Geocon Geotechnical Ltd

Geotechnical Engineers

COEFFICIENT OF PERMEABILITY DERIVATION

Use Hvorslev Case 7 (from Kortegast NZGS Vol 16 Issue 1) - hole extended in uniform soil
ie. soakage occurs out the side and base of test hole (slotted) with overlying restrictive layer

PERMEABILITY CALCULATIONS **STORMWATER TEST A1**

Shape Factor F = 2 x PI x L / ln{(L/R) + [1 + (L/R)^2]^0.5} where L = soakage (sand) length (m), R = test hole radius (m)

Perm coeff. k = A / (F x (t2 - t1)) x ln h1/h2 where A = test hole flow area, h1 = initial water level, h2 = final water level, t1 = time at h1, t2 = time at h2

Soil Parameters

0.6 m impermeable materal depth

0.2 m permeable materal depth

Elapsed Time (mins)	Water Level head (m)	Av Water Level Head (m) (=H/2)	L (m)	Av. L (m)	F	k (m/sec)
0.0	1.50	1.40	0.20			
1.0	0.98	0.88	0.20	0.20	0.59	9.4E-05
2.0	0.84	0.74	0.20	0.20	0.59	3.5E-05
3.0	0.73	0.63	0.20	0.20	0.59	3.2E-05
4.0	0.64	0.54	0.20	0.20	0.59	3.1E-05
5.0	0.59	0.49	0.20	0.20	0.59	2.0E-05
6.0	0.55	0.45	0.20	0.20	0.59	1.7E-05
8.0	0.48	0.38	0.20	0.20	0.59	1.7E-05
10.0	0.43	0.33	0.20	0.20	0.59	1.4E-05
15.0	0.31	0.21	0.20	0.20	0.59	1.8E-05
20.0	0.20	0.10	0.20	0.20	0.59	3.0E-05
25.0	0.08	0.04	0.08	0.14	0.49	4.4E-05
30.0	0.00	0.00	0.00	0.04	0.33	ERR

COMPUTED ADJUSTED AVERAGE: 2.6E-05 m/sec

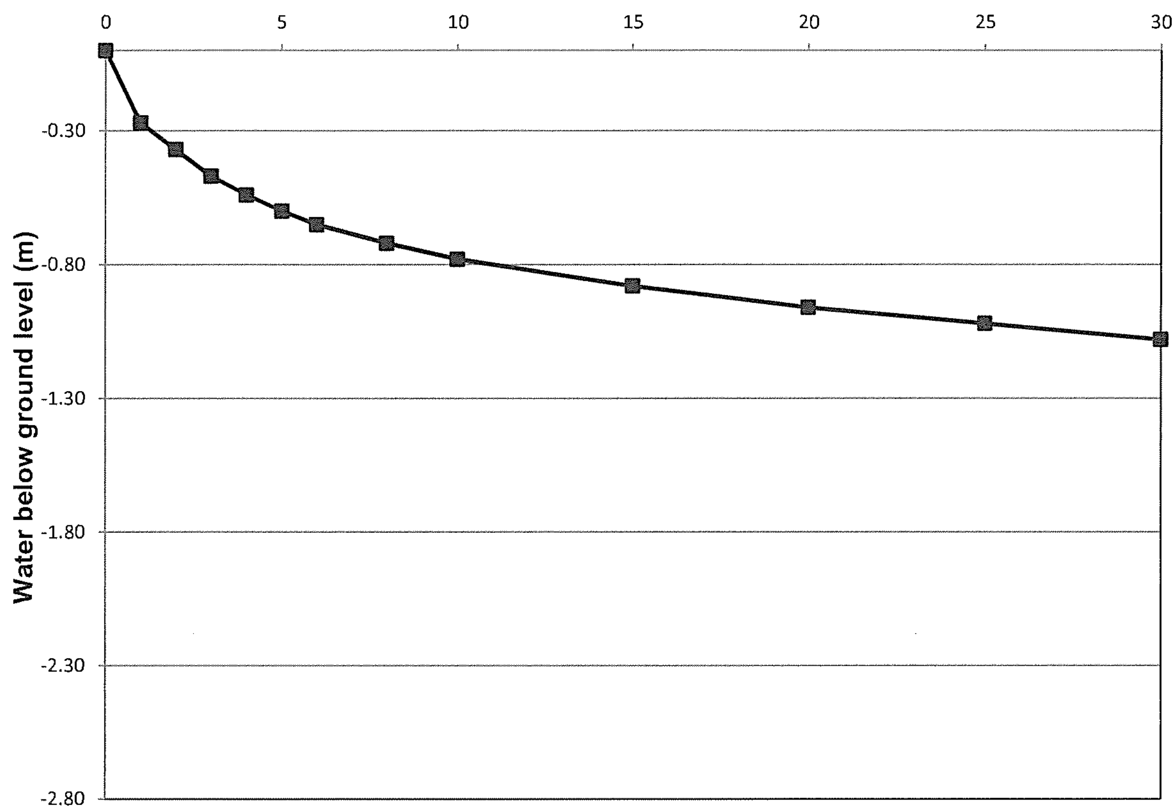
2.2 m/day

Checked: [signature]

FALLING HEAD SOAKAGE TEST

JOB NO. W-16064
PROJECT: WAIPA DISTRICT COUNCIL
LOCATION: C4 Growth Cell

SOAKAGE TEST A2



Time (mins)	Water Level below top of PVC (m)	Water Level Relative to Ground Level (m)	Change in Water Level (m)	Water Level head (m)
0	0.45	0.00	0.00	2.80
1	0.72	-0.27	0.27	2.53
2	0.82	-0.37	0.10	2.43
3	0.92	-0.47	0.10	2.33
4	0.99	-0.54	0.07	2.26
5	1.05	-0.60	0.06	2.20
6	1.10	-0.65	0.05	2.15
8	1.17	-0.72	0.07	2.08
10	1.23	-0.78	0.06	2.02
15	1.33	-0.88	0.10	1.92
20	1.41	-0.96	0.08	1.84
25	1.47	-1.02	0.06	1.78
30	1.53	-1.08	0.06	1.72

Geocon Geotechnical Lt
Geotechnical Engineers
1150 Victoria Street, PO Box 9123, Hamilto

FALLING HEAD SOAKAGE TEST RESULTS

Figure No. E-101
DATE: October 2019
CHECKED:

Geocon Geotechnical Ltd

Geotechnical Engineers

WAIPA DISTRICT COUNCIL — W-16064

Stormwater Assessment for C4 Growth Cell — Date of test: 15 October, 2019

Field Soakage Test Data

TABLE 1B: FALLING HEAD SOAKAGE TEST RESUL STORMWATER TEST A2

Length of PVC Casing (m)	3.25
Length of PVC Above Ground (m)	0.45
Depth of Soakhole (m)	2.80
Groundwater Level (m)	0.00
Groundwater Level (height above base of Soakhole) (m)	na
Test Hole Diameter (m)	0.095

Time (mins)	Water Level below top of PVC (m)	Water Level Relative to Ground Level (m)	Change in Water Level (m)	Water Level head (m)
0.0	0.45	0.00	0.00	2.80
1.0	0.72	-0.27	0.27	2.53
2.0	0.82	-0.37	0.10	2.43
3.0	0.92	-0.47	0.10	2.33
4.0	0.99	-0.54	0.07	2.26
5.0	1.05	-0.60	0.06	2.20
6.0	1.10	-0.65	0.05	2.15
8.0	1.17	-0.72	0.07	2.08
10.0	1.23	-0.78	0.06	2.02
15.0	1.33	-0.88	0.10	1.92
20.0	1.41	-0.96	0.08	1.84
25.0	1.47	-1.02	0.06	1.78
30.0	1.53	-1.08	0.06	1.72

Geocon Geotechnical Ltd

Geotechnical Engineers

COEFFICIENT OF PERMEABILITY DERIVATION

Use Hvorslev Case 7 (from Kortegast NZGS Vol 16 Issue 1) - hole extended in uniform soil
ie. soakage occurs out the side and base of test hole (slotted) with overlying restrictive layer

PERMEABILITY CALCULATIONS — STORMWATER TEST A2

Shape Factor F = 2 x PI x L / ln{(L/R) + [1 + (L/R)^2]^0.5}

where L = soakage (sand) length (m)
R = test hole radius (m)

Perm coeff. k = A / (F x (t2 - t1)) x ln h1/h2

where A = test hole flow area
h1 = initial water level
h2 = final water level
t1 = time at h1
t2 = time at h2

Soil Parameters

0.6 m impermeable materal depth
0.2 m permeable materal depth

Elapsed Time (mins)	Water Level head (m)	Av Water Level Head (m) (=H/2)	L (m)	Av. L (m)	F	k (m/sec)
0.0	2.80	2.70	0.20			
1.0	2.53	2.43	0.20	0.20	0.59	2.1E-05
2.0	2.43	2.33	0.20	0.20	0.59	8.5E-06
3.0	2.33	2.23	0.20	0.20	0.59	8.8E-06
4.0	2.26	2.16	0.20	0.20	0.59	6.4E-06
5.0	2.20	2.10	0.20	0.20	0.59	5.7E-06
6.0	2.15	2.05	0.20	0.20	0.59	4.9E-06
8.0	2.08	1.98	0.20	0.20	0.59	3.5E-06
10.0	2.02	1.92	0.20	0.20	0.59	3.1E-06
15.0	1.92	1.82	0.20	0.20	0.59	2.2E-06
20.0	1.84	1.74	0.20	0.20	0.59	1.8E-06
25.0	1.78	1.68	0.20	0.20	0.59	1.4E-06
30.0	1.72	1.62	0.20	0.20	0.59	1.5E-06

COMPUTED ADJUSTED AVERAGE: 4.5E-06 m/sec
0.4 m/day

Checked:

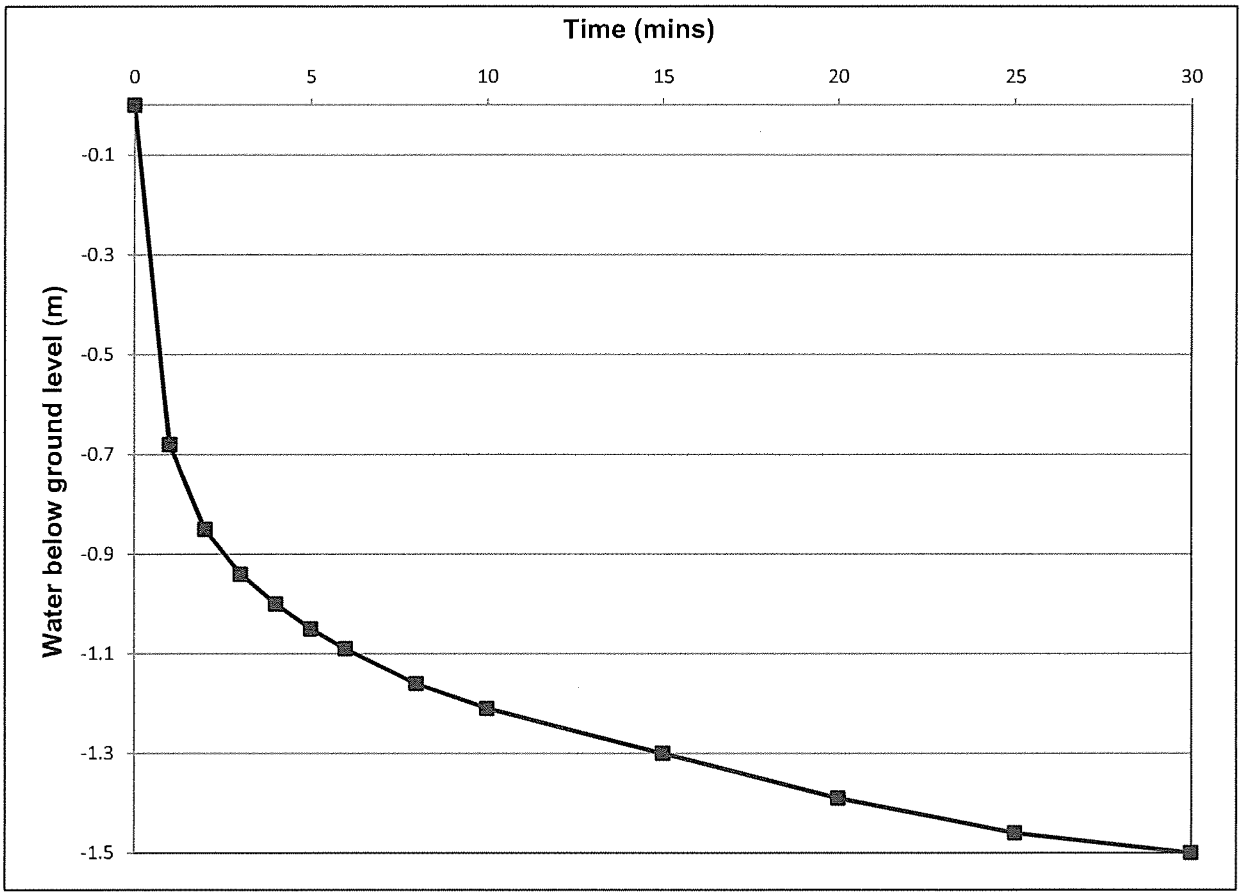
FALLING HEAD SOAKAGE TEST

JOB NO. W-16064

PROJECT: WAIPA DISTRICT COUNCIL

LOCATION: C4 Growth Cell

SOAKAGE TEST B1



Time (mins)	Water Level below top of PVC (m)	Water Level Relative to Ground Level (m)	Change in Water Level (m)	Water Level head (m)
0	0.62	0	0	1.5
1	1.3	-0.68	0.68	0.82
2	1.47	-0.85	0.17	0.65
3	1.56	-0.94	0.09	0.56
4	1.62	-1	0.06	0.5
5	1.67	-1.05	0.05	0.45
6	1.71	-1.09	0.04	0.41
8	1.78	-1.16	0.07	0.34
10	1.83	-1.21	0.05	0.29
15	1.92	-1.3	0.09	0.2
20	2.01	-1.39	0.09	0.11
25	2.08	-1.46	0.07	0.04
30	2.12	-1.5	0.04	0

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, PO Box 9123, Hamilto

FALLING HEAD SOAKAGE TEST RESULTS

Figure No. E-102
DATE: October 2019
CHECKED: [signature]

Geocon Geotechnical Ltd

Geotechnical Engineers

WAIPA DISTRICT COUNCIL — W-16064

Stormwater Assessment for C4 Growth Cell — Date of test: 15 October, 2019

Field Soakage Test Data

TABLE 1C: FALLING HEAD SOAKAGE TEST RESUL STORMWATER TEST B1

Length of PVC Casing (m)	2.12
Length of PVC Above Ground (m)	0.62
Depth of Soakhole (m)	1.50
Groundwater Level (m)	0.00
Groundwater Level (height above base of Soakhole) (m)	na
Test Hole Diameter (m)	0.095

Time (mins)	Water Level below top of PVC (m)	Water Level Relative to Ground Level (m)	Change in Water Level (m)	Water Level head (m)
0.0	0.62	0.00	0.00	1.50
1.0	1.30	-0.68	0.68	0.82
2.0	1.47	-0.85	0.17	0.65
3.0	1.56	-0.94	0.09	0.56
4.0	1.62	-1.00	0.06	0.50
5.0	1.67	-1.05	0.05	0.45
6.0	1.71	-1.09	0.04	0.41
8.0	1.78	-1.16	0.07	0.34
10.0	1.83	-1.21	0.05	0.29
15.0	1.92	-1.30	0.09	0.20
20.0	2.01	-1.39	0.09	0.11
25.0	2.08	-1.46	0.07	0.04
30.0	2.12	-1.50	0.04	0.00

Geocon Geotechnical Ltd

Geotechnical Engineers

COEFFICIENT OF PERMEABILITY DERIVATION

Use Hvorslev Case 7 (from Kortegast NZGS Vol 16 Issue 1) - hole extended in uniform soil
ie. soakage occurs out the side and base of test hole (slotted) with overlying restrictive layer

PERMEABILITY CALCULATIONS — STORMWATER TEST B1

Shape Factor F = 2 x PI x L / ln{(L/R) + [1 + (L/R)^2]^0.5}   where L = soakage (sand) length (m), R = test hole radius (m)

Perm coeff. k = A / (F x (t2 - t1)) x ln h1/h2   where A = test hole flow area, h1 = initial water level, h2 = final water level, t1 = time at h1, t2 = time at h2

Soil Parameters

0.5 m impermeable materal depth

0.2 m permeable materal depth

Elapsed Time (mins)	Water Level head (m)	Av Water Level Head (m) (=H/2)	L (m)	Av. L (m)	F	k (m/sec)
0.0	1.50	1.40	0.20			
1.0	0.82	0.72	0.20	0.20	0.59	1.3E-04
2.0	0.65	0.55	0.20	0.20	0.59	5.4E-05
3.0	0.56	0.46	0.20	0.20	0.59	3.6E-05
4.0	0.50	0.40	0.20	0.20	0.59	2.8E-05
5.0	0.45	0.35	0.20	0.20	0.59	2.7E-05
6.0	0.41	0.31	0.20	0.20	0.59	2.4E-05
8.0	0.34	0.24	0.20	0.20	0.59	2.6E-05
10.0	0.29	0.19	0.20	0.20	0.59	2.4E-05
15.0	0.20	0.10	0.20	0.20	0.59	2.6E-05
20.0	0.11	0.05	0.11	0.16	0.51	2.8E-05
25.0	0.04	0.02	0.04	0.07	0.38	6.3E-05
30.0	0.00	0.00	0.00	0.02	0.31	ERR

COMPUTED ADJUSTED AVERAGE: 2.7E-05 m/sec

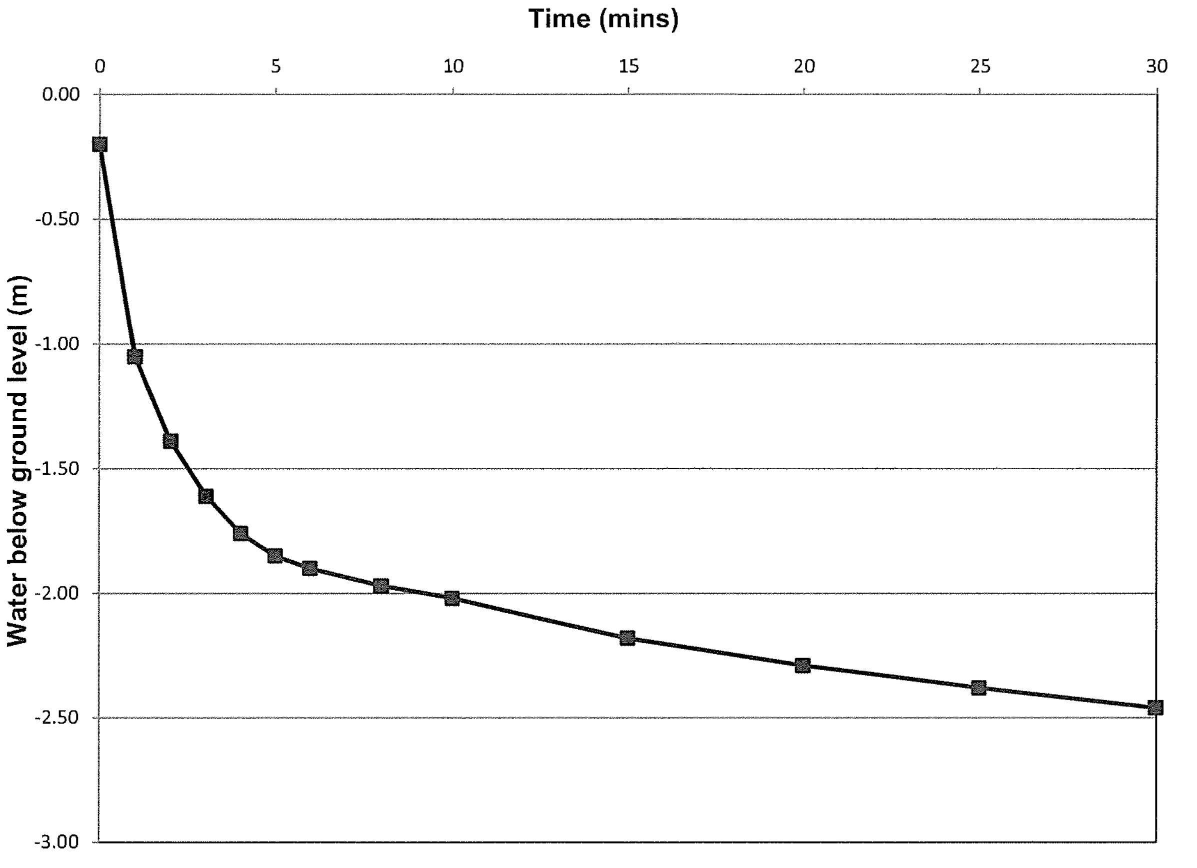
2.4 m/day

Checked: [signature]

FALLING HEAD SOAKAGE TEST

JOB NO. W-16064
PROJECT: WAIPA DISTRICT COUNCIL
LOCATION: C4 Growth Cell

SOAKAGE TEST B2



Time (mins)	Water Level below top of PVC (m)	Water Level Relative to Ground Level (m)	Change in Water Level (m)	Water Level head (m)
0	0.45	-0.20	0.00	2.80
1	1.30	-1.05	0.85	1.95
2	1.64	-1.39	0.34	1.61
3	1.86	-1.61	0.22	1.39
4	2.01	-1.76	0.15	1.24
5	2.10	-1.85	0.09	1.15
6	2.15	-1.90	0.05	1.10
8	2.22	-1.97	0.07	1.03
10	2.27	-2.02	0.07	0.98
15	2.43	-2.18	0.16	0.82
20	2.54	-2.29	0.11	0.71
25	2.63	-2.38	0.09	0.62
30	2.71	-2.46	0.08	0.54

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, PO Box 9123, Hamilton

FALLING HEAD SOAKAGE TEST RESULTS

Figure No. E-103
DATE: October 2019
CHECKED: SW

Geocon Geotechnical Ltd

Geotechnical Engineers

WAIPA DISTRICT COUNCIL — W-16064

Stormwater Assessment for C4 Growth Cell — Date of test: 15 October, 2019

Field Soakage Test Data

TABLE 1D: FALLING HEAD SOAKAGE TEST RESUL STORMWATER TEST B2

Length of PVC Casing (m)	3.25
Length of PVC Above Ground (m)	0.25
Depth of Soakhole (m)	3.00
Groundwater Level (m)	0.00
Groundwater Level (height above base of Soakhole) (m)	na
Test Hole Diameter (m)	0.095

Time (mins)	Water Level below top of PVC (m)	Water Level Relative to Ground Level (m)	Change in Water Level (m)	Water Level head (m)
0.0	0.45	-0.20	0.00	2.80
1.0	1.30	-1.05	0.85	1.95
2.0	1.64	-1.39	0.34	1.61
3.0	1.86	-1.61	0.22	1.39
4.0	2.01	-1.76	0.15	1.24
5.0	2.10	-1.85	0.09	1.15
6.0	2.15	-1.90	0.05	1.10
8.0	2.22	-1.97	0.07	1.03
10.0	2.27	-2.02	0.05	0.98
15.0	2.43	-2.18	0.16	0.82
20.0	2.54	-2.29	0.11	0.71
25.0	2.63	-2.38	0.09	0.62
30.0	2.71	-2.46	0.08	0.54

Geocon Geotechnical Ltd

Geotechnical Engineers

COEFFICIENT OF PERMEABILITY DERIVATION

Use Hvorslev Case 7 (from Kortegast NZGS Vol 16 Issue 1) - hole extended in uniform soil
ie. soakage occurs out the side and base of test hole (slotted) with overlying restrictive layer

PERMEABILITY CALCULATIONS — STORMWATER TEST B2

Shape Factor F = 2 x PI x L / ln{(L/R) + [1 + (L/R)^2]^0.5}

where L = soakage (sand) length (m)
R = test hole radius (m)

Perm coeff. k = A / F x (t2 - t1) x ln h1/h2

where A = test hole flow area
h1 = initial water level
h2 = final water level
t1 = time at h1
t2 = time at h2

Soil Parameters

0.5 m impermeable materal depth
0.2 m permeable materal depth

Elapsed Time (mins)	Water Level head (m)	Av Water Level Head (m) (=H/2)	L (m)	Av. L (m)	F	k (m/sec)
0.0	2.80	2.70	0.20			
1.0	1.95	1.85	0.20	0.20	0.59	7.6E-05
2.0	1.61	1.51	0.20	0.20	0.59	4.1E-05
3.0	1.39	1.29	0.20	0.20	0.59	3.2E-05
4.0	1.24	1.14	0.20	0.20	0.59	2.5E-05
5.0	1.15	1.05	0.20	0.20	0.59	1.7E-05
6.0	1.10	1.00	0.20	0.20	0.59	9.8E-06
8.0	1.03	0.93	0.20	0.20	0.59	7.3E-06
10.0	0.98	0.88	0.20	0.20	0.59	5.6E-06
15.0	0.82	0.72	0.20	0.20	0.59	8.1E-06
20.0	0.71	0.61	0.20	0.20	0.59	6.7E-06
25.0	0.62	0.52	0.20	0.20	0.59	6.4E-06
30.0	0.54	0.44	0.20	0.20	0.59	6.7E-06

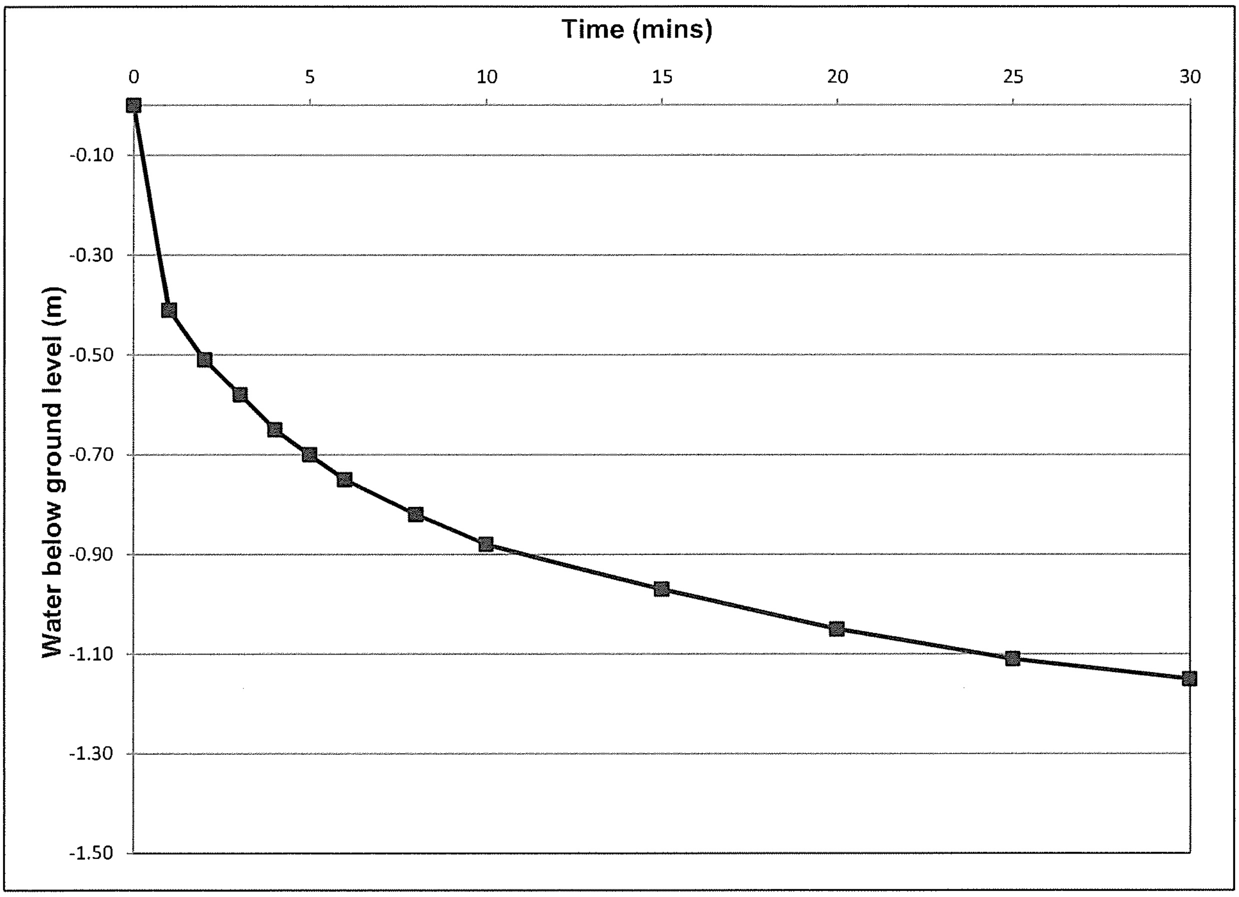
COMPUTED ADJUSTED AVERAGE: 1.4E-05 m/sec
1.2 m/day

Checked: [signature]

FALLING HEAD SOAKAGE TEST

JOB NO. W-16064
PROJECT: WAIPA DISTRICT COUNCIL
LOCATION: C4 Growth Cell

SOAKAGE TEST C1



Time (mins)	Water Level below top of PVC (m)	Water Level Relative to Ground Level (m)	Change in Water Level (m)	Water Level head (m)
0	0.62	0.00	0.00	1.50
1	1.03	-0.41	0.41	1.09
2	1.13	-0.51	0.10	0.99
3	1.20	-0.58	0.07	0.92
4	1.27	-0.65	0.07	0.85
5	1.32	-0.70	0.05	0.80
6	1.37	-0.75	0.05	0.75
8	1.44	-0.82	0.07	0.68
10	1.50	-0.88	0.06	0.62
15	1.59	-0.97	0.09	0.53
20	1.67	-1.05	0.08	0.45
25	1.73	-1.11	0.06	0.39
30	1.77	-1.15	0.04	0.35

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, PO Box 9123, Hamilton

FALLING HEAD SOAKAGE TEST RESULTS

Figure No. E-104
DATE: October 2019
CHECKED: SW

Geocon Geotechnical Ltd

Geotechnical Engineers

WAIPA DISTRICT COUNCIL — W-16064

Stormwater Assessment for C4 Growth Cell — Date of test: 14 October, 2019

Field Soakage Test Data

TABLE 1E: FALLING HEAD SOAKAGE TEST RESUL STORMWATER TEST C1

Length of PVC Casing (m)	2.12
Length of PVC Above Ground (m)	0.62
Depth of Soakhole (m)	1.50
Groundwater Level (m)	0.00
Groundwater Level (height above base of Soakhole) (m)	na
Test Hole Diameter (m)	0.095

Time (mins)	Water Level below top of PVC (m)	Water Level Relative to Ground Level (m)	Change in Water Level (m)	Water Level head (m)
0.0	0.62	0.00	0.00	1.50
1.0	1.03	-0.41	0.41	1.09
2.0	1.13	-0.51	0.10	0.99
3.0	1.20	-0.58	0.07	0.92
4.0	1.27	-0.65	0.07	0.85
5.0	1.32	-0.70	0.05	0.80
6.0	1.37	-0.75	0.05	0.75
8.0	1.44	-0.82	0.07	0.68
10.0	1.50	-0.88	0.06	0.62
15.0	1.59	-0.97	0.09	0.53
20.0	1.67	-1.05	0.08	0.45
25.0	1.73	-1.11	0.06	0.39
30.0	1.77	-1.15	0.04	0.35

Geocon Geotechnical Ltd

Geotechnical Engineers

COEFFICIENT OF PERMEABILITY DERIVATION

Use Hvorslev Case 7 (from Kortegast NZGS Vol 16 Issue 1) - hole extended in uniform soil
ie. soakage occurs out the side and base of test hole (slotted) with overlying restrictive layer

PERMEABILITY CALCULATIONS — STORMWATER TEST C1

Shape Factor F = 2 x PI x L / ln{(L/R) + [1 + (L/R)^2]^0.5}

where L = soakage (sand) length (m)
R = test hole radius (m)

Perm coeff. k = A / F x (t2 - t1) x ln h1/h2

where A = test hole flow area
h1 = initial water level
h2 = final water level
t1 = time at h1
t2 = time at h2

Soil Parameters

0.6 m impermeable materal depth
0.2 m permeable materal depth

Elapsed Time (mins)	Water Level head (m)	Av Water Level Head (m) (=H/2)	L (m)	Av. L (m)	F	k (m/sec)
0.0	1.50	1.40	0.20			
1.0	1.09	0.99	0.20	0.20	0.59	7.0E-05
2.0	0.99	0.89	0.20	0.20	0.59	2.1E-05
3.0	0.92	0.82	0.20	0.20	0.59	1.7E-05
4.0	0.85	0.75	0.20	0.20	0.59	1.8E-05
5.0	0.80	0.70	0.20	0.20	0.59	1.4E-05
6.0	0.75	0.65	0.20	0.20	0.59	1.5E-05
8.0	0.68	0.58	0.20	0.20	0.59	1.1E-05
10.0	0.62	0.52	0.20	0.20	0.59	1.1E-05
15.0	0.53	0.43	0.20	0.20	0.59	7.7E-06
20.0	0.45	0.35	0.20	0.20	0.59	8.3E-06
25.0	0.39	0.29	0.20	0.20	0.59	7.6E-06
30.0	0.35	0.25	0.20	0.20	0.59	6.0E-06

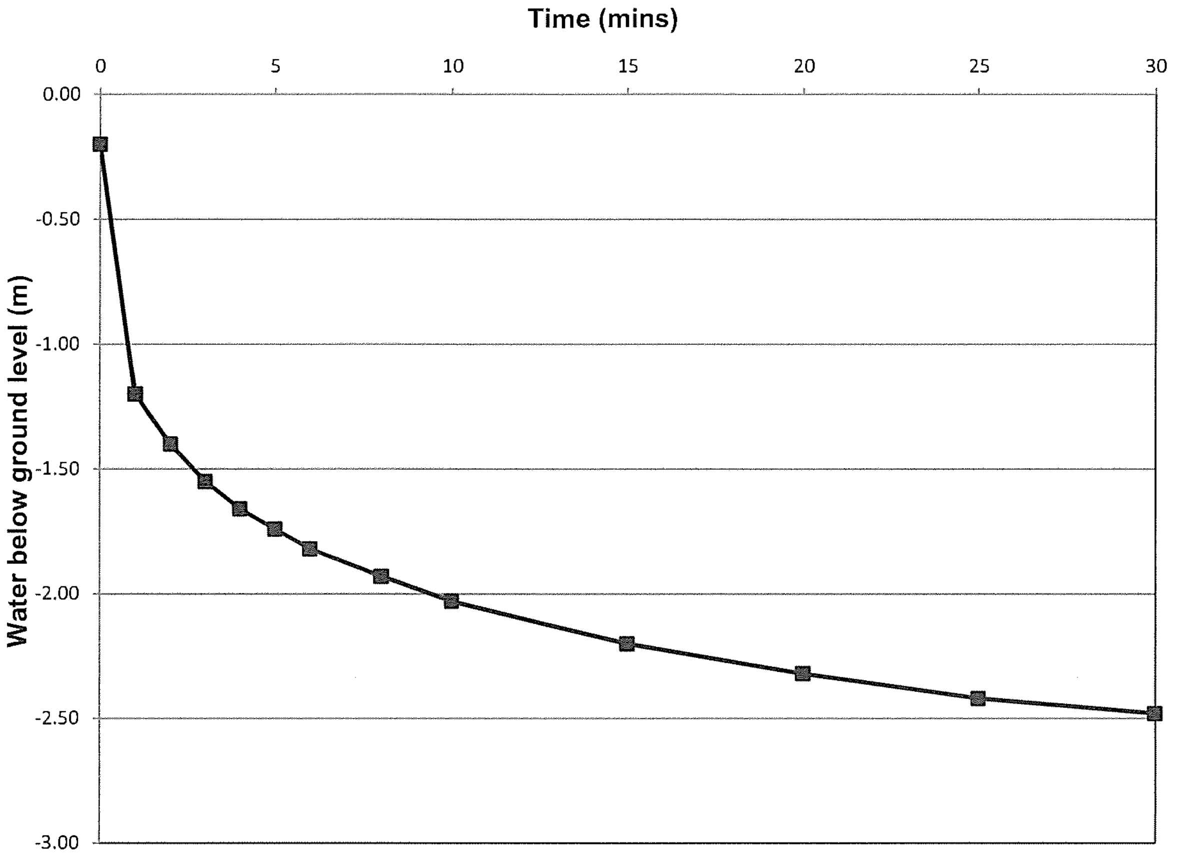
COMPUTED ADJUSTED AVERAGE: 1.3E-05 m/sec
1.1 m/day

Checked: [signature]

FALLING HEAD SOAKAGE TEST

JOB NO. W-16064
PROJECT: WAIPA DISTRICT COUNCIL
LOCATION: C4 Growth Cell

SOAKAGE TEST C2



Time (mins)	Water Level below top of PVC (m)	Water Level Relative to Ground Level (m)	Change in Water Level (m)	Water Level head (m)
0	0.45	-0.20	0.00	2.80
1	1.45	-1.20	1.00	1.80
2	1.65	-1.40	0.20	1.60
3	1.80	-1.55	0.15	1.45
4	1.91	-1.66	0.11	1.34
5	1.99	-1.74	0.08	1.26
6	2.07	-1.82	0.08	1.18
8	2.18	-1.93	0.11	1.07
10	2.28	-2.03	1.10	0.97
15	2.45	-2.20	0.17	0.80
20	2.57	-2.32	0.12	0.68
25	2.67	-2.42	0.10	0.58
30	2.73	-2.48	0.06	0.52

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, PO Box 9123, Hamilto

FALLING HEAD SOAKAGE TEST RESULTS

Figure No. E-105
DATE: October 2019
CHECKED: [signature]

Geocon Geotechnical Ltd

Geotechnical Engineers

WAIPA DISTRICT COUNCIL — W-16064

Stormwater Assessment for C4 Growth Cell — Date of test: 14 October, 2019

Field Soakage Test Data

TABLE 1F: FALLING HEAD SOAKAGE TEST RESULT STORMWATER TEST C2

Length of PVC Casing (m)	3.25
Length of PVC Above Ground (m)	0.25
Depth of Soakhole (m)	3.00
Groundwater Level (m)	0.00
Groundwater Level (height above base of Soakhole) (m)	na
Test Hole Diameter (m)	0.095

Time (mins)	Water Level below top of PVC (m)	Water Level Relative to Ground Level (m)	Change in Water Level (m)	Water Level head (m)
0.0	0.45	-0.20	0.00	2.80
1.0	1.45	-1.20	1.00	1.80
2.0	1.65	-1.40	0.20	1.60
3.0	1.80	-1.55	0.15	1.45
4.0	1.91	-1.66	0.11	1.34
5.0	1.99	-1.74	0.08	1.26
6.0	2.07	-1.82	0.08	1.18
8.0	2.18	-1.93	0.11	1.07
10.0	2.28	-2.03	0.10	0.97
15.0	2.45	-2.20	0.17	0.80
20.0	2.57	-2.32	0.12	0.68
25.0	2.67	-2.42	0.10	0.58
30.0	2.73	-2.48	0.06	0.52

Geocon Geotechnical Ltd

Geotechnical Engineers

COEFFICIENT OF PERMEABILITY DERIVATION

Use Hvorslev Case 7 (from Kortegast NZGS Vol 16 Issue 1) - hole extended in uniform soil
ie. soakage occurs out the side and base of test hole (slotted) with overlying restrictive layer

PERMEABILITY CALCULATIONS — **STORMWATER TEST C2**

Shape Factor F = 2 x PI x L / ln{(L/R) + [1 + (L/R)^2]^0.5}

where L = soakage (sand) length (m)
R = test hole radius (m)

Perm coeff. k = A / (F x (t2 - t1)) x ln (h1 / h2)

where A = test hole flow area
h1 = initial water level
h2 = final water level
t1 = time at h1
t2 = time at h2

Soil Parameters

0.7 m impermeable materal depth
0.2 m permeable materal depth

Elapsed Time (mins)	Water Level head (m)	Av Water Level Head (m) (=H/2)	L (m)	Av. L (m)	F	k (m/sec)
0.0	2.80	2.70	0.20			
1.0	1.80	1.70	0.20	0.20	0.59	9.3E-05
2.0	1.60	1.50	0.20	0.20	0.59	2.5E-05
3.0	1.45	1.35	0.20	0.20	0.59	2.1E-05
4.0	1.34	1.24	0.20	0.20	0.59	1.7E-05
5.0	1.26	1.16	0.20	0.20	0.59	1.3E-05
6.0	1.18	1.08	0.20	0.20	0.59	1.4E-05
8.0	1.07	0.97	0.20	0.20	0.59	1.1E-05
10.0	0.97	0.87	0.20	0.20	0.59	1.1E-05
15.0	0.80	0.70	0.20	0.20	0.59	8.8E-06
20.0	0.68	0.58	0.20	0.20	0.59	7.6E-06
25.0	0.58	0.48	0.20	0.20	0.59	7.6E-06
30.0	0.52	0.42	0.20	0.20	0.59	5.4E-06

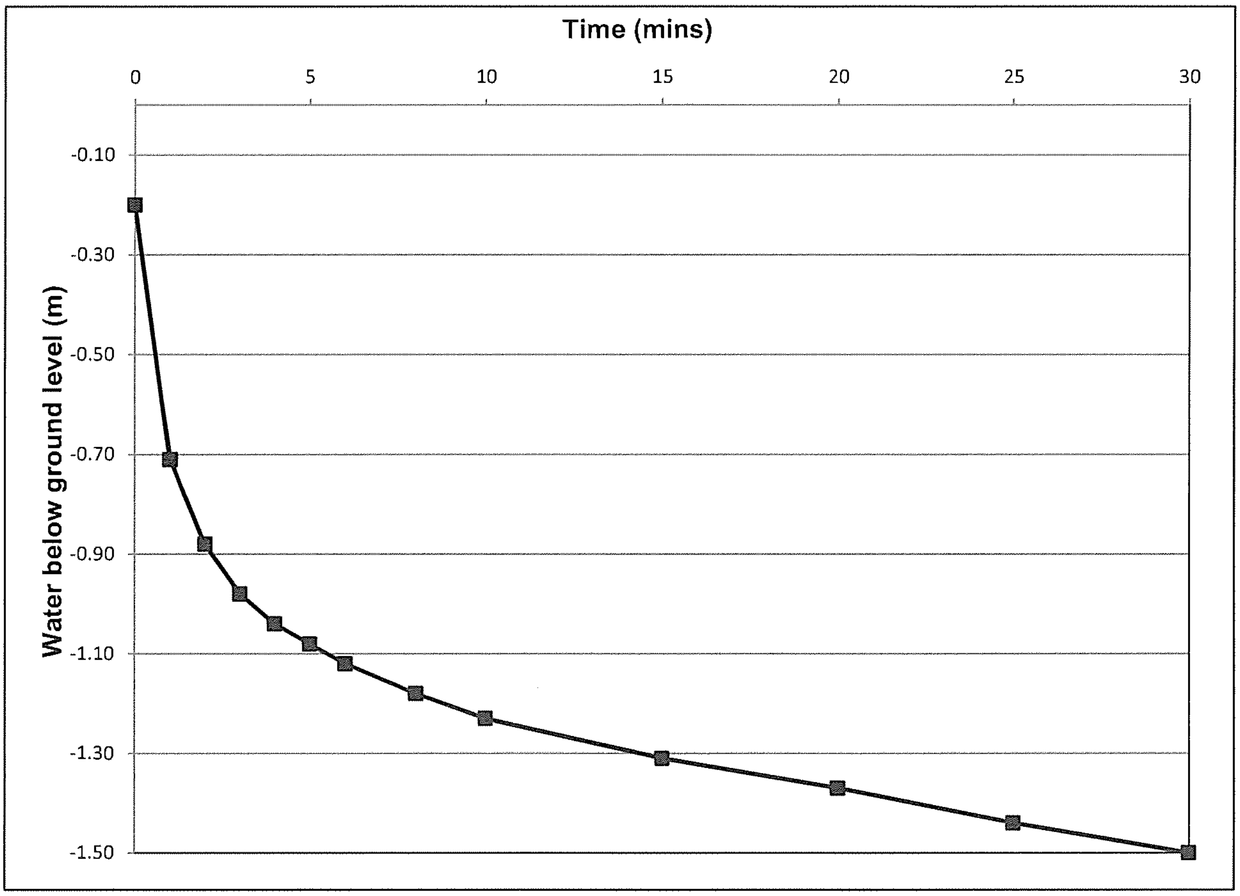
COMPUTED ADJUSTED AVERAGE: 1.3E-05 m/sec
1.1 m/day

Checked: [signature]

FALLING HEAD SOAKAGE TEST

JOB NO. W-16064
PROJECT: WAIPA DISTRICT COUNCIL
LOCATION: C4 Growth Cell

SOAKAGE TEST D1



Time (mins)	Water Level below top of PVC (m)	Water Level Relative to Ground Level (m)	Change in Water Level (m)	Water Level head (m)
0	0.82	-0.20	0.00	1.30
1	1.33	-0.71	0.51	0.79
2	1.50	-0.88	0.17	0.62
3	1.60	-0.98	0.10	0.52
4	1.66	-1.04	0.06	0.46
5	1.70	-1.08	0.04	0.42
6	1.74	-1.12	0.04	0.38
8	1.80	-1.18	0.06	0.32
10	1.85	-1.23	0.05	0.27
15	1.93	-1.31	0.08	0.19
20	1.99	-1.37	0.06	0.13
25	2.06	-1.44	0.07	0.06
30	2.12	-1.5	0.06	0.00

Geocon Geotechnical Lt
Geotechnical Engineers
1150 Victoria Street, PO Box 9123, Hamilt

FALLING HEAD SOAKAGE TEST RESULTS

Figure No. E-106
DATE: October 2019
CHECKED: [signature]

Geocon Geotechnical Ltd

Geotechnical Engineers

WAIPA DISTRICT COUNCIL — W-16064

Stormwater Assessment for C4 Growth Cell — Date of test: 14 October, 2019

Field Soakage Test Data

TABLE 1G: FALLING HEAD SOAKAGE TEST RESUL STORMWATER TEST D1

Length of PVC Casing (m)	2.12
Length of PVC Above Ground (m)	0.62
Depth of Soakhole (m)	1.50
Groundwater Level (m)	0.00
Groundwater Level (height above base of Soakhole) (m)	na
Test Hole Diameter (m)	0.095

Time (mins)	Water Level below top of PVC (m)	Water Level Relative to Ground Level (m)	Change in Water Level (m)	Water Level head (m)
0.0	0.82	-0.20	0.00	1.30
1.0	1.33	-0.71	0.51	0.79
2.0	1.50	-0.88	0.17	0.62
3.0	1.60	-0.98	0.10	0.52
4.0	1.66	-1.04	0.06	0.46
5.0	1.70	-1.08	0.04	0.42
6.0	1.74	-1.12	0.04	0.38
8.0	1.80	-1.18	0.06	0.32
10.0	1.85	-1.23	0.05	0.27
15.0	1.93	-1.31	0.08	0.19
20.0	1.99	-1.37	0.06	0.13
25.0	2.06	-1.44	0.07	0.06
30.0	2.12	-1.50	0.06	0.00

Geocon Geotechnical Ltd

Geotechnical Engineers

COEFFICIENT OF PERMEABILITY DERIVATION

Use Hvorslev Case 7 (from Kortegast NZGS Vol 16 Issue 1) - hole extended in uniform soil
ie. soakage occurs out the side and base of test hole (slotted) with overlying restrictive layer

PERMEABILITY CALCULATIONS — **STORMWATER TEST D1**

Shape Factor F = 2 x PI x L / ln{(L/R) + [1 + (L/R)^2]^0.5}

where L = soakage (sand) length (m)
R = test hole radius (m)

Perm coeff. k = A / (F x (t2 - t1)) x ln h1/h2

where A = test hole flow area
h1 = initial water level
h2 = final water level
t1 = time at h1
t2 = time at h2

Soil Parameters

0.3 m impermeable materal depth
0.2 m permeable materal depth

Elapsed Time (mins)	Water Level head (m)	Av Water Level Head (m) (=H/2)	L (m)	Av. L (m)	F	k (m/sec)
0.0	1.30	1.20	0.20			
1.0	0.79	0.69	0.20	0.20	0.59	1.1E-04
2.0	0.62	0.52	0.20	0.20	0.59	5.7E-05
3.0	0.52	0.42	0.20	0.20	0.59	4.3E-05
4.0	0.46	0.36	0.20	0.20	0.59	3.1E-05
5.0	0.42	0.32	0.20	0.20	0.59	2.4E-05
6.0	0.38	0.28	0.20	0.20	0.59	2.7E-05
8.0	0.32	0.22	0.20	0.20	0.59	2.4E-05
10.0	0.27	0.17	0.20	0.20	0.59	2.6E-05
15.0	0.19	0.10	0.19	0.20	0.58	2.4E-05
20.0	0.13	0.07	0.13	0.16	0.52	1.7E-05
25.0	0.06	0.03	0.06	0.10	0.41	4.4E-05
30.0	0.00	0.00	0.00	0.03	0.32	ERR

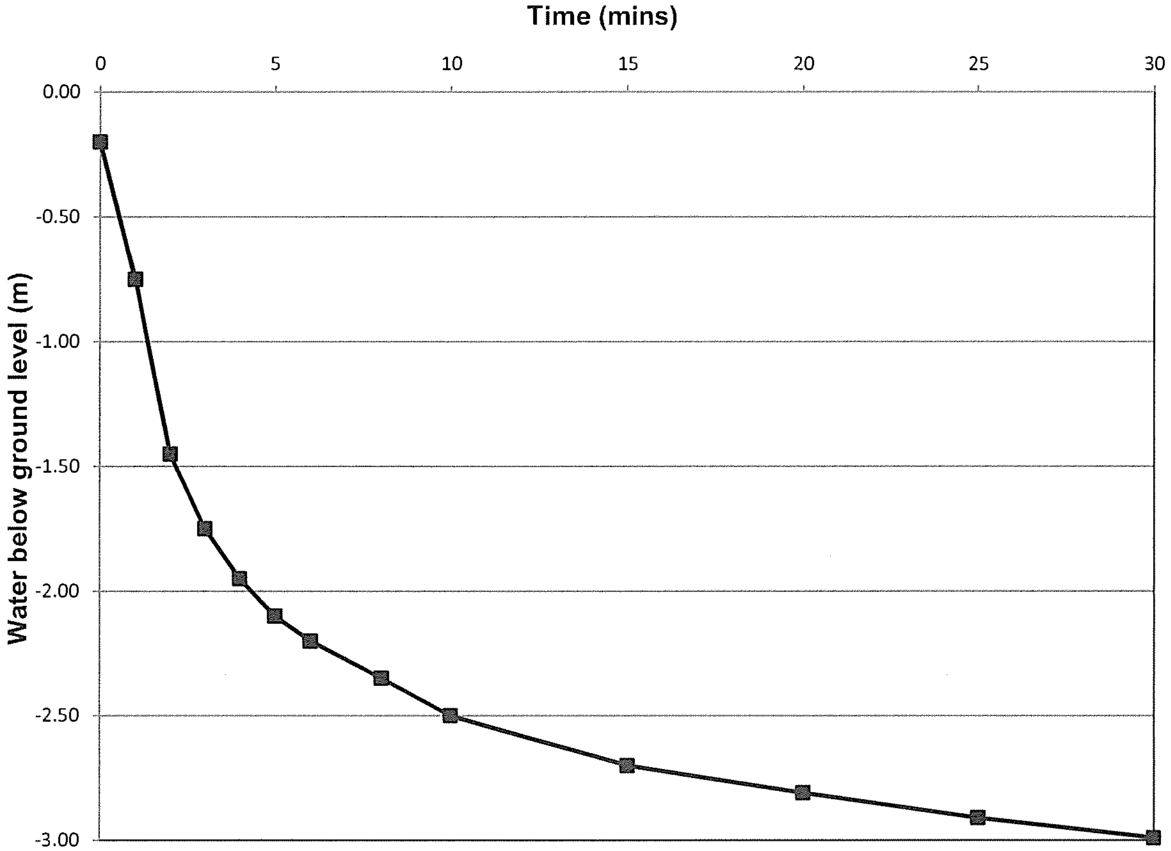
COMPUTED ADJUSTED AVERAGE: 2.7E-05 m/sec
2.3 m/day

Checked: [signature]

FALLING HEAD SOAKAGE TEST

JOB NO. W-16064
PROJECT: WAIPA DISTRICT COUNCIL
LOCATION: C4 Growth Cell

SOAKAGE TEST D2



Time (mins)	Water Level below top of PVC (m)	Water Level Relative to Ground Level (m)	Change in Water Level (m)	Water Level head (m)
0	0.45	-0.20	0.00	2.80
1	1.00	-0.75	0.55	2.25
2	1.70	-1.45	0.70	1.55
3	2.00	-1.75	0.30	1.25
4	2.20	-1.95	0.20	1.05
5	2.35	-2.10	0.15	0.90
6	2.45	-2.20	0.10	0.80
8	2.60	-2.35	0.15	0.65
10	2.75	-2.50	0.15	0.50
15	2.95	-2.70	0.20	0.30
20	3.06	-2.81	0.11	0.19
25	3.16	-2.91	0.10	0.09
30	3.24	-2.99	0.08	0.01

Geocon Geotechnical Ltd
Geotechnical Engineers
1150 Victoria Street, PO Box 9123, Hamilto

FALLING HEAD SOAKAGE TEST RESULTS

Figure No. E-107
DATE: October 2019
CHECKED: Sw

Geocon Geotechnical Ltd

Geotechnical Engineers

WAIPA DISTRICT COUNCIL — W-16064

Stormwater Assessment for C4 Growth Cell — Date of test: 14 October, 2019

Field Soakage Test Data

TABLE 1H: FALLING HEAD SOAKAGE TEST RESUL STORMWATER TEST D2

Length of PVC Casing (m)	3.25
Length of PVC Above Ground (m)	0.25
Depth of Soakhole (m)	3.00
Groundwater Level (m)	0.00
Groundwater Level (height above base of Soakhole) (m)	na
Test Hole Diameter (m)	0.095

Time (mins)	Water Level below top of PVC (m)	Water Level Relative to Ground Level (m)	Change in Water Level (m)	Water Level head (m)
0.0	0.45	-0.20	0.00	2.80
1.0	1.00	-0.75	0.55	2.25
2.0	1.70	-1.45	0.70	1.55
3.0	2.00	-1.75	0.30	1.25
4.0	2.20	-1.95	0.20	1.05
5.0	2.35	-2.10	0.15	0.90
6.0	2.45	-2.20	0.10	0.80
8.0	2.60	-2.35	0.15	0.65
10.0	2.75	-2.50	0.15	0.50
15.0	2.95	-2.70	0.20	0.30
20.0	3.06	-2.81	0.11	0.19
25.0	3.16	-2.91	0.10	0.09
30.0	3.24	-2.99	0.08	0.01

Geocon Geotechnical Ltd

Geotechnical Engineers

COEFFICIENT OF PERMEABILITY DERIVATION

Use Hvorslev Case 7 (from Kortegast NZGS Vol 16 Issue 1) - hole extended in uniform soil
ie. soakage occurs out the side and base of test hole (slotted) with overlying restrictive layer

PERMEABILITY CALCULATIONS — STORMWATER TEST D2

Shape Factor F = 2 x PI x L / ln{(L/R) + [1 + (L/R)^2]^0.5}

where L = soakage (sand) length (m)
R = test hole radius (m)

Perm coeff. k = A / (F x (t2 - t1)) x ln h1/h2

where A = test hole flow area
h1 = initial water level
h2 = final water level
t1 = time at h1
t2 = time at h2

Soil Parameters

0.6 m impermeable materal depth
0.2 m permeable materal depth

Elapsed Time (mins)	Water Level head (m)	Av Water Level Head (m) (=H/2)	L (m)	Av. L (m)	F	k (m/sec)
0.0	2.80	2.70	0.20			
1.0	2.25	2.15	0.20	0.20	0.59	4.6E-05
2.0	1.55	1.45	0.20	0.20	0.59	7.9E-05
3.0	1.25	1.15	0.20	0.20	0.59	4.7E-05
4.0	1.05	0.95	0.20	0.20	0.59	3.9E-05
5.0	0.90	0.80	0.20	0.20	0.59	3.5E-05
6.0	0.80	0.70	0.20	0.20	0.59	2.7E-05
8.0	0.65	0.55	0.20	0.20	0.59	2.4E-05
10.0	0.50	0.40	0.20	0.20	0.59	3.2E-05
15.0	0.30	0.20	0.20	0.20	0.59	2.8E-05
20.0	0.19	0.09	0.19	0.20	0.58	3.0E-05
25.0	0.09	0.04	0.09	0.14	0.49	3.6E-05
30.0	0.01	0.00	0.01	0.05	0.34	1.5E-04

COMPUTED ADJUSTED AVERAGE: 3.3E-05 m/sec
2.8 m/day

Checked: [signature]

APPENDIX 8 LID MATRIX SCORING

APPENDIX 8 SOURCE AND LIDS CONTROL CALCULATIONS

CATCHMENT 1

Catchment 1 Source Control Estimates

Catchment 1 – Proposed Layout under Integrated SW Design Principles	Quantity	Units
Residential development area (assume 85% of total residential area of lots)	9.1	ha
Road and access way area (assume roads and foot paths is 15% of total residential area)	1.6	ha
Open space/park land area	3.0	ha
Native bush area	0.0	ha
Total area	13.7	Ha
Assumed number of lots dwelling count (assume an average lot size of 600 sq.m)	151	No.
Assumed area of impervious per lot (250 sq.m with 100 sq.m for patio/driveway)	0.035	Ha
Total Impervious lot area for residential development area	5.3	Ha
Percentage lot impervious surface	58	%
Road imperious area (assume 80% of road reserve)	1.3	ha
Total impervious area for Catchment 1	6.6	ha
Total fraction impervious for Catchment 1	50	%
Catchment 1 – Comparison from Traditional Development FI	Quantity	Units
Conventional housing impervious values	50% (as per district plan)	
Number of houses if allow 600sq metre lots	151	No.
Include houses in drainage reserve area	42	No.
Include road in drainage reserve area	0.4	Ha
Total houses in conventional build	194	no.
Total impervious area if conventional build	60	%
% reduction area FI from conventional development	10	%
Site disturbance reduced from a conventional development approach		
Catchment 1 – Comparison of Disturbed Area	Quantity	Units
Proposed disturbed area	10.7	ha
Conventional disturbed area	13.7	ha
Reduction disturbed area	10.7	ha
% reduction disturbed area	20	%

On lot device sizing – 2 year ARI – 70 mm/hr

Dimensions

L	5.01	m	Area	10.02	m^2	ΣCA	245	m^2
W	2.00	m	Vol (gross)	8.62	m^3	Inf Rate	2.08E-05	m/sec
D	0.86	m	Vol (net)	8.19	m^3	Constant Outflow		l/s

Intensity and Critical Storm

Duration	i	Q	V_{runoff}	V_{inf}	Outflow	V_{stor}	Balance
	mm/hr	l/sec	m^3	m^3	m^3	m^3	m^3
10 min	72.0	5	2.9	0.1	0.0	2.8	5.4
20 min	49.0	3	4.0	0.3	0.0	3.8	4.4
30 min	39.0	3	4.8	0.4	0.0	4.4	3.8
1 hr	26.0	2	6.4	0.8	0.0	5.6	2.6
2 hrs	17.0	1	8.3	1.5	0.0	6.8	1.4
6 hrs	8.0	1	11.8	4.5	0.0	7.3	0.9
12 hrs	4.9	0	14.4	9.0	0.0	5.4	2.8
24 hrs	2.9	0	17.3	18.0	0.0	0.0	8.2
48 hrs	1.7	0	20.3	36.0	0.0	0.0	8.2

WETLAND DESIGN

Curve Number and Ia

Soil	Cover description	Curve Number	Area (ha)		Product of
classification		CN	impervious	pervious	CN * area
A	Road and Driveway	98	3.38		331
Total area (ha)			3.38	Total area (km^2)	0.0338
Weighted CN			98.0		
I_a (weighted) (mm)			0.26		
S (mm)			5		

Time of Concentration

Time of Concentration			
Catchment length along main channel (m)			700 m
pipe flow			2 m/s
Time of Concentration		t_c (minutes)	10.000

Wetland Design

Select A R I (years) or A E P (%)	WQ	EDV	Foreba y Volum e	Total (50% WQ +EDV)	Surface Area (4% of Contributing Catchment)	Width (NWL) (m)	Length (NWL) (m)	Additional 20% for batters and maintenance (sq.m)
Read 24 hour rainfall depth for that recurrence interval (mm)	24.1 67							
c*	0.69 5							
Read q* from chart	0.16 70							
Peak Flow rate (m^3/s)	0.13 6							
Runoff depth (mm)	20							
Runoff volume (V)	664	797	100	1129				
Device Area					1352			1662
Device Dimensions						20	70	

Catchment 2 Source Control Estimates

Catchment 1 – Proposed Layout under Integrated SW Design Principles	Quantity	Units
Residential development area (assume 85% of total residential area of lots)	0.6	ha
Road and access way area (assume roads and foot paths is 15% of total residential area)	0.1	ha
Open space/park land area	0.0	ha
Native bush area	0.0	ha
Total area	0.0	Ha
Assumed number of lots dwelling count (assume an average lot size of 600 sq.m)	0.8	No.
Assumed area of impervious per lot (250 sq.m with 100 sq.m for patio/driveway)	10.8	Ha
Total Impervious lot area for residential development area	0.0	Ha
Percentage lot impervious surface	40	%
Road imperious area (assume 80% of road reserve)	0.6	ha
Total impervious area for Catchment 1	0.1	ha
Total fraction impervious for Catchment 1	60	%
Catchment 1 – Comparison from Traditional Development FI	**Quantity**	**Units**
Conventional housing impervious values	50% (as per district plan)	
Number of houses if allow 600sq metre lots	11	No.
Include houses in drainage reserve area	0	No.
Include road in drainage reserve area	0	Ha
Total houses in conventional build	11	no.
Total impervious area if conventional build	60	%
% reduction area FI from conventional development	0	%
Site disturbance reduced from a conventional development approach		
Catchment 1 – Comparison of Disturbed Area	**Quantity**	**Units**
Proposed disturbed area	0.8	ha
Conventional disturbed area	0.8	ha
Reduction disturbed area	0	ha
% reduction disturbed area	0	%

On lot device sizing – 2 year ARI – 70 mm/hr

<u>Dimensions</u>

L	5.01	m	Area	6.01	m^2	ΣCA	100	m^2
W	1.20	m	Vol (gross)	2.64	m^3	Inf Rate	2.08E-05	m/sec
D	0.44	m	Vol (net)	2.51	m^3	Constant Outflow		l/s

Intensity and Critical Storm

Duration	i	Q	V_{runoff}	V_{inf}	Outflow	V_{stor}	Balance
	mm/hr	l/sec	m^3	m^3	m^3	m^3	m^3
10 min	72.0	5	2.9	0.1	0.0	2.8	5.4
20 min	49.0	3	4.0	0.3	0.0	3.8	4.4
30 min	39.0	3	4.8	0.4	0.0	4.4	3.8
1 hr	26.0	2	6.4	0.8	0.0	5.6	2.6
2 hrs	17.0	1	8.3	1.5	0.0	6.8	1.4
6 hrs	8.0	1	11.8	4.5	0.0	7.3	0.9
12 hrs	4.9	0	14.4	9.0	0.0	5.4	2.8
24 hrs	2.9	0	17.3	18.0	0.0	0.0	8.2
48 hrs	1.7	0	20.3	36.0	0.0	0.0	8.2

CATCHMENT 3:

Catchment 3 Source Control Estimates

Catchment 1 – Proposed Layout under Integrated SW Design Principles	Quantity	Units
Residential development area (assume 85% of total residential area of lots)	10.7	ha
Road and access way area (assume roads and foot paths is 15% of total residential area)	1.9	ha
Open space/park land area	1.3	ha
Native bush area	5.0	ha
Total area	18.8	Ha
Assumed number of lots dwelling count (assume an average lot size of 600 sq.m)	178	No.
Assumed area of impervious per lot (250 sq.m with 100 sq.m for patio/driveway)	0.0	Ha
Total Impervious lot area for residential development area	6.2	Ha
Percentage lot impervious surface	60	%
Road imperious area (assume 80% of road reserve)	1.5	ha
Total impervious area for Catchment 1	7.7	ha
Total fraction impervious for Catchment 1	40	%
Catchment 1 – Comparison from Traditional Development FI	**Quantity**	**Units**
Conventional housing impervious values	50% (as per district plan)	
Number of houses if allow 600sq metre lots	178	No.
Include houses in drainage reserve area	53	No.
Include road in drainage reserve area	1.68	Ha
Total houses in conventional build	231	no.
Total impervious area if conventional build	60	%
% reduction area FI from conventional development	19	%
Site disturbance reduced from a conventional development approach		

Catchment 1 – Comparison of Disturbed Area	Quantity	Units
Proposed disturbed area	18.8	ha
Conventional disturbed area	12.6	ha
Reduction disturbed area	6.3	ha
% reduction disturbed area	30	%

Catchment 3 LIDS Estimates

Onlot device sizing – 2 year ARI – 70 mm/hr

Dimensions

L	5.01	m	Area	10.02	m^2	ΣCA	350	m^2
W	2.00	m	Vol (gross)	17.03	m^3	Inf Rate	2.08E-05	m/sec
D	1.7	m	Vol (net)	16.18	m^3	Constant Outflow		l/s

Intensity and Critical Storm

Duration	i	Q	V_{runoff}	V_{inf}	Outflow	V_{stor}	Balance
	mm/hr	l/sec	m^3	m^3	m^3	m^3	m^3
10 min	72.0	7	4.2	0.1	0.0	4.1	12.1
20 min	49.0	5	5.7	0.3	0.0	5.5	10.7
30 min	39.0	4	6.8	0.4	0.0	6.4	9.7
1 hr	26.0	3	9.1	0.8	0.0	8.3	7.8
2 hrs	17.0	2	11.9	1.5	0.0	10.4	5.8
6 hrs	8.0	1	16.8	4.5	0.0	12.3	3.9
12 hrs	4.9	0	20.6	9.0	0.0	11.6	4.6
24 hrs	2.9	0	24.7	18.0	0.0	6.7	9.5
48 hrs	1.7	0	29.1	36.0	0.0	0.0	16.2

On lot device sizing – 10 year ARI – 70 mm/hr

Dimensions

L	5.01	m	Area	14.03	m^2	ΣCA	350	m^2
W	2.80	m	Vol (gross)	23.85	m^3	Inf Rate	2.08E-05	m/sec
D	1.7	m	Vol (net)	22.66	m^3	Constant Outflow		l/s

Intensity and Critical Storm

Duration	i	Q	V_{runoff}	V_{inf}	Outflow	V_{stor}	Balance
	mm/hr	l/sec	m^3	m^3	m^3	m^3	m^3
10 min	115.0	11	6.7	0.2	0.0	6.5	16.1
20 min	78.0	8	9.1	0.4	0.0	8.7	13.9
30 min	62.0	6	10.9	0.5	0.0	10.3	12.3
1 hr	41.0	4	14.4	1.1	0.0	13.3	9.4
2 hrs	26.3	3	18.4	2.1	0.0	16.3	6.4
6 hrs	12.4	1	26.0	6.3	0.0	19.7	2.9
12 hrs	7.6	1	31.9	12.6	0.0	19.3	3.3
24 hrs	4.5	0	37.8	25.2	0.0	12.6	10.1
48 hrs	2.7	0	44.5	50.4	0.0	0.0	22.7

Public device sizing – 10 year ARI (roads) – 70 mm/hr

Dimensions

L	35.75	m	Area	614.9	m^2	ΣCA	16,920	m^2
W	17.20	m	Vol (gross)	1045.33	m^3	Inf Rate	2.08E-05	m/sec
D	1.7	m	Vol (net)	993.06	m^3	Constant Outflow		l/s

Intensity and Critical Storm

Duration	i	Q	V_{runoff}	V_{inf}	Outflow	V_{stor}	Balance
	mm/hr	l/sec	m^3	m^3	m^3	m^3	m^3
10 min	115.0	541	324.3	7.7	0.0	316.6	676.4
20 min	78.0	367	439.9	15.3	0.0	424.6	568.5
30 min	62.0	291	524.5	23.0	0.0	501.5	491.6
1 hr	41.0	193	693.7	46.0	0.0	647.7	345.4
2 hrs	26.3	123	889.0	92.1	0.0	796.9	196.2
6 hrs	12.4	58	1258.8	276.3	0.0	982.6	10.5
12 hrs	7.6	36	1543.1	552.5	0.0	990.6	2.5
24 hrs	4.5	21	1827.4	1105.0	0.0	722.3	270.7
48 hrs	2.7	12	2152.2	2210.1	0.0	0.0	993.1

Notes.

- 10 year is eq, to double 2 year flow – therefore can assume lot runoff is the 2 year.
- Assume swale volume - gross

Additional Volume Required for Public System (10 year -2 year ARI)

Catchment	Additional Volume Per Lot (m^3)	Number of Lots	Additional Public Storage (m^3)
Catchment 3 (lot overflow)	6.48	178	1153

Estimate of Soakage Trenches Volume

Catchment	Swale Length (m)	Base Width (m)	Average Depth (m)	Volume (m^3)
Catchment 3	250	1.2	0.5	150

Total Volume for Public System (Roads + Lot Excess)

Catchment	Additional Volume From Lots (m^3)	Volume Required for Roads (m^3)	Swale Volume (m^3)	Additional Public Storage (m^3)
Catchment 3	1153	993	150	**1996**

Catchment 4 Source Control Estimates

Catchment 1 – Proposed Layout under Integrated SW Design Principles	Quantity	Units
Residential development area (assume 85% of total residential area of lots)	17.4	ha
Road and access way area (assume roads and foot paths is 15% of total residential area)	3.1	ha
Open space/park land area	2.8	ha
Native bush area	10.0	ha
Total area	33.2	Ha
Assumed number of lots dwelling count (assume an average lot size of 600 sq.m)	289	No.
Assumed area of impervious per lot (250 sq.m with 100 sq.m for patio/driveway)	0.035	Ha
Total Impervious lot area for residential development area	10.1	Ha
Percentage lot impervious surface	58	%
Road imperious area (assume 80% of road reserve)	2.5	ha
Total impervious area for Catchment 1	12.6	ha
Total fraction impervious for Catchment 1	38	%
Catchment 1 – Comparison from Traditional Development FI	**Quantity**	**Units**
Conventional housing impervious values	50% (as per district plan)	
Number of houses if allow 600sq metre lots	289	No.
Include houses in drainage reserve area	110	No.
Include road in drainage reserve area	3.53	Ha
Total houses in conventional build	399	no.
Total impervious area if conventional build	60	%
% reduction area FI from conventional development	22	%
Site disturbance reduced from a conventional development approach		
Catchment 1 – Comparison of Disturbed Area	**Quantity**	**Units**
Proposed disturbed area	20.4	ha
Conventional disturbed area	33.17	ha
Reduction disturbed area	12.75	ha
% reduction disturbed area	38	%

On lot device sizing – 2 year ARI – 70 mm/hr

Dimensions

L	5.01	m	Area	10.02	m^2	ΣCA	350	m^2
W	2.00	m	Vol (gross)	17.03	m^3	Inf Rate	2.08E-05	m/sec
D	1.7	m	Vol (net)	16.18	m^3	Constant Outflow		l/s

Intensity and Critical Storm

Duration	i	Q	V_{runoff}	V_{inf}	Outflow	V_{stor}	Balance
	mm/hr	l/sec	m^3	m^3	m^3	m^3	m^3
10 min	72.0	7	4.2	0.1	0.0	4.1	12.1
20 min	49.0	5	5.7	0.3	0.0	5.5	10.7
30 min	39.0	4	6.8	0.4	0.0	6.4	9.7
1 hr	26.0	3	9.1	0.8	0.0	8.3	7.8
2 hrs	17.0	2	11.9	1.5	0.0	10.4	5.8
6 hrs	8.0	1	16.8	4.5	0.0	12.3	3.9
12 hrs	4.9	0	20.6	9.0	0.0	11.6	4.6
24 hrs	2.9	0	24.7	18.0	0.0	6.7	9.5
48 hrs	1.7	0	29.1	36.0	0.0	0.0	16.2

On lot device sizing – 10 year ARI – 70 mm/hr

Dimensions

L	5.01	m	Area	14.03	m^2	ΣCA	350	m^2
W	2.80	m	Vol (gross)	23.85	m^3	Inf Rate	2.08E-05	m/sec
D	1.7	m	Vol (net)	22.66	m^3	Constant Outflow		l/s

Intensity and Critical Storm

Duration	i	Q	V_{runoff}	V_{inf}	Outflow	V_{stor}	Balance
	mm/hr	l/sec	m^3	m^3	m^3	m^3	m^3
10 min	115.0	11	6.7	0.2	0.0	6.5	16.1
20 min	78.0	8	9.1	0.4	0.0	8.7	13.9
30 min	62.0	6	10.9	0.5	0.0	10.3	12.3
1 hr	41.0	4	14.4	1.1	0.0	13.3	9.4
2 hrs	26.3	3	18.4	2.1	0.0	16.3	6.4
6 hrs	12.4	1	26.0	6.3	0.0	19.7	2.9
12 hrs	7.6	1	31.9	12.6	0.0	19.3	3.3
24 hrs	4.5	0	37.8	25.2	0.0	12.6	10.1
48 hrs	2.7	0	44.5	50.4	0.0	0.0	22.7

Public device sizing – 10 year ARI (roads) – 70 mm/hr

Dimensions

L	50.05	m	Area	1021.02	m^2	ΣCA	27,900	m^2
W	20.40	m	Vol (gross)	1735.73	m^3	Inf Rate	2.08E-05	m/sec
D	1.7	m	Vol (net)	1648.94	m^3	Constant Outflow		l/s

Intensity and Critical Storm

Duration	i	Q	V_{runoff}	V_{inf}	Outflow	V_{stor}	Balance
	mm/hr	l/sec	m^3	m^3	m^3	m^3	m^3
10 min	115.0	891	534.8	12.7	0.0	522.0	1126.9
20 min	78.0	605	725.4	25.5	0.0	699.9	949.0
30 min	62.0	481	864.9	38.2	0.0	826.7	822.3
1 hr	41.0	318	1143.9	76.5	0.0	1067.4	581.5
2 hrs	26.3	204	1465.9	152.9	0.0	1313.0	336.0
6 hrs	12.4	96	2075.8	458.7	0.0	1617.0	31.9
12 hrs	7.6	59	2544.5	917.4	0.0	1627.0	21.9
24 hrs	4.5	35	3013.2	1834.9	0.0	1178.3	470.6
48 hrs	2.7	21	3548.9	3669.8	0.0	0.0	1648.9

Document Set ID: 10476599
Version: 1, Version Date: 29/09/2020

Notes:

- 10 year is eq, to double 2 year flow – therefore can assume lot runoff is the 2 year.
- Assume swale volume - gross

Additional Volume Required for Public System (10 year -2 year ARI)

Catchment	Additional Volume Per Lot (m³)	Number of Lots	Additional Public Storage (m³)
Catchment 4 (lot overflow)	6.48	289	1872

Estimate of Soakage Trenches Volume

Catchment	Swale Length (m)	Base Width (m)	Average Depth (m)	Volume (m³)
Catchment 4	550	1.2	0.5	330

Total Volume for Public System (Roads + Lot Excess)

Catchment	Additional Volume From Lots (m³)	Volume Required for Roads (m³)	Swale Volume (m³)	Additional Public Storage (m³)
Catchment 4	1872	1648	330	**3190**

CAMBRIDGE, GROWTH CELL C4 STRUCTURE PLAN: PRELIMINARY ARCHAEOLOGICAL ASSESSMENT

Prepared for Mitchell Daysh

August 2019

By

Ellen Cameron (MSc)
Rod Clough (PhD)

Clough & Associates Ltd

321 Forest Hill Rd,
Waiatarua, Auckland 0612
Telephone: (09) 8141946
Mobile 0274 850 059
www.clough.co.nz

Contents

INTRODUCTION

Project Background

This report has been prepared to inform the C4 Growth Cell Structure Plan which is part of a broader plan to manage future growth in Cambridge. The location of Growth Cell C4 and existing properties within it are shown in Figure 1 with addresses and legal descriptions provided in Table 1. The location of the growth cell within the broader planning and development framework is shown in Figure 2. The structure plan will determine the urban form, use and manner in which infrastructure can be efficiently and cost effectively developed to facilitate residential development in Growth Cell C4. It will also include matters such as connectivity to existing roading networks/urban areas (including cycle and pedestrian linkages) and reserve provisions. Growth Cell C4 is located to the south of the Waikato River and west of Leamington.

An archaeological assessment was commissioned by Mitchell Daysh on behalf of Waipa District Council to identify any archaeological constraints within Growth Cell C4 as part of the Structure Plan process under the Resource Management Act 1991 (RMA) and to identify any potential requirements under the Heritage New Zealand Pouhere Taonga Act 2014 (HNZPTA). Recommendations are made in accordance with statutory requirements.

Methodology

The New Zealand Archaeological Association's (NZAA) site record database (ArchSite), Waipa District Plan schedules and the Heritage New Zealand Pouhere Taonga (Heritage NZ) New Zealand Heritage List/Rārangi Kōrero were searched for information on archaeological and other historic heritage sites recorded in the vicinity. Literature and archaeological reports relevant to the area were consulted (see Bibliography). Early survey plans and aerial photographs were checked and archival research was carried out to establish the history of the property.

A survey of the accessible parts of the growth cell was conducted on 25 July 2019. All of Growth Cell C4 to the south of Silverwood Lane was accessible, as were the large open paddocks to the north of the lane. The ground surface was examined for evidence of former occupation (in the form of shell midden, depressions, terracing or other unusual formations within the landscape, or indications of 19th century European settlement remains). Exposed and disturbed soils were examined where encountered for evidence of earlier modification, and an understanding of the local stratigraphy. Subsurface testing with a probe was carried out to determine whether buried archaeological deposits could be identified or establish the nature of possible archaeological features. The locations of the recorded archaeological sites were visited and photographed and site records updated.

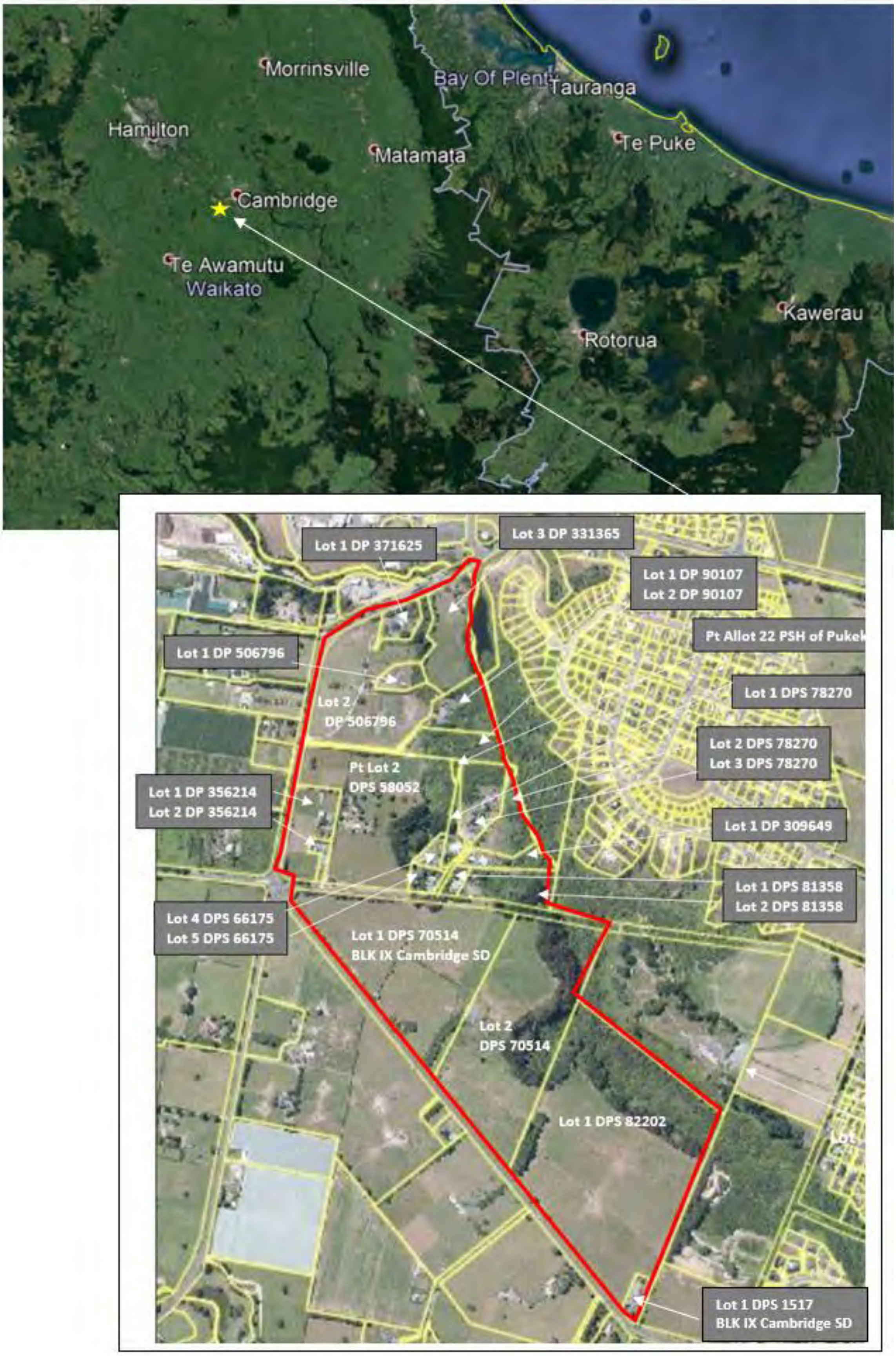


Figure 1. Upper aerial showing the regional location of Growth Cell C4 and lower showing the properties in Growth Cell C4 (source: upper GoogleEarth and lower Waikato District Intramaps)

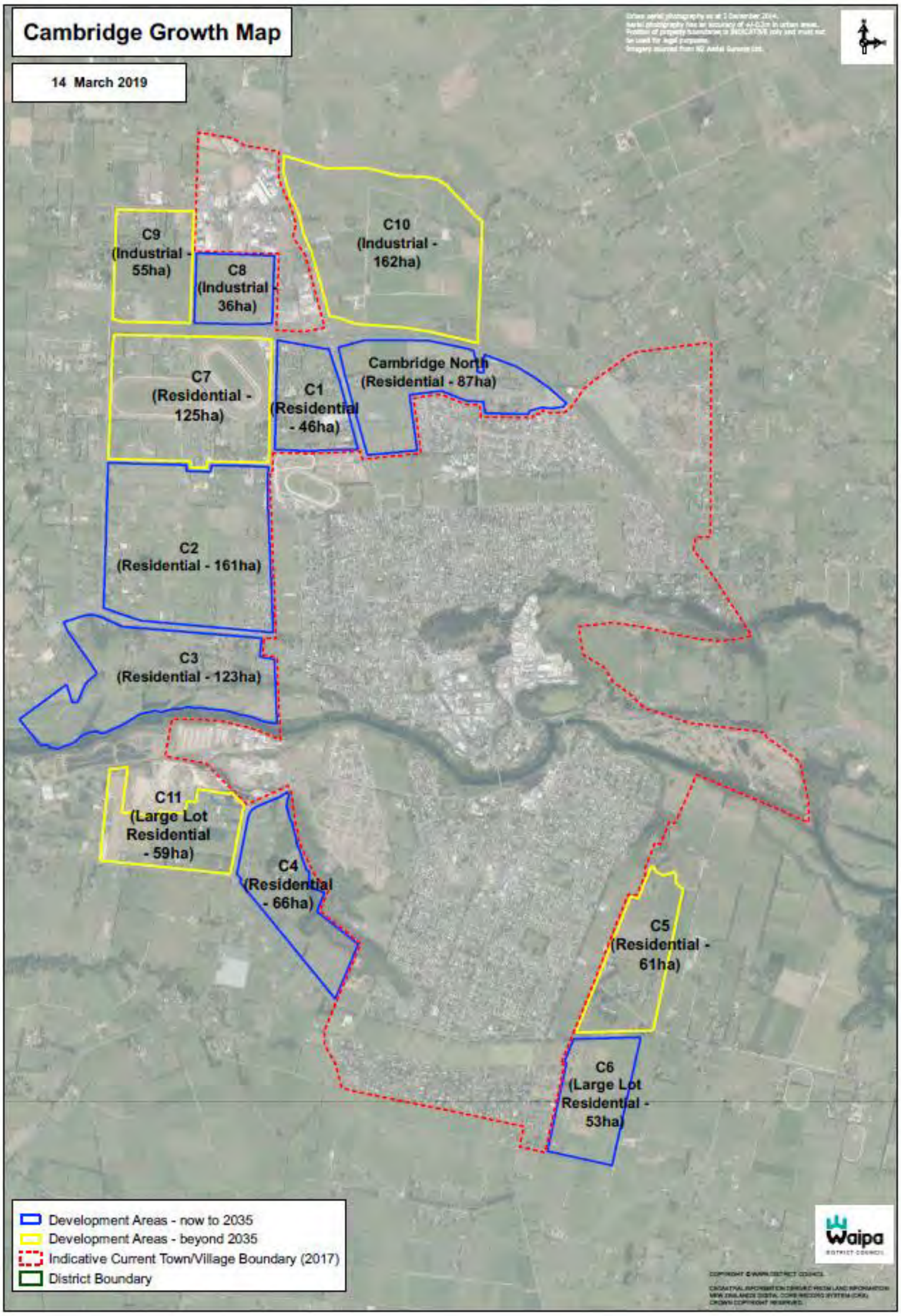


Figure 2. Cambridge growth map showing the development areas including Growth Cell C4 (Waipa District Council)

Table 1. Addresses and legal descriptions of properties within Growth Cell C4

Address	Legal Description	Area (ha)
9 Silverwood Lane	Lot 2 DP 356214	0.25
1/35 Silverwood Lane	Lot 5 DPS 66175 (1/8 SH in Lot 3 DPS 78270)	0.37
2/35 Silverwood Lane	Lot 1 DP 309649	0.71
3/35 Silverwood Lane	Lot 4 DPS 66175 BLK IX Cambridge SD (1/8 SH in Lot 3 DPS 78270)	0.30
4/35 Silverwood Lane	Lot 2 DP 309649/ Lot 3 DPS 78270	1.24
5/35 Silverwood Lane	Lot 1 DPS 78270 (1/8 SH in Lot 3 DPS 78270)	0.46
7/35 Silverwood Lane	Lot 2 DPS 78270 (1/4 SH in Lot 3 DPS 78270)	1.44
36 Silverwood Lane	Lot 2 DPS 81358	1.46
37 Silverwood Lane	Lot 1 DPS 81358	0.25
3796 Cambridge Road	Lot 1 DP 506796	0.50
3796A Cambridge Road	Lot 1 DP 371625	0.61
3838 Cambridge Road	Lot 3 DP331365	2.23
3774 Cambridge Road	Part Lot 2 DPS 58052	7.39
1/3774 Cambridge Road	Lot 1 DP 356214	1.74
3784 Cambridge Road	Lot 1 DP 90107	1.43
3794 Cambridge Road	Lot 2 DP 90107	1.37
n/a	Part Allot 22 PSH of Pukekura	0.074
37 Lamb Street	Lot 1 DPS 70514 BLK IX Cambridge SD	9.67
121 Lamb Street	Lot 1 DPS 1517 BLK IX Cambridge SD	0.40
n/a	Lot 2 DPS 70514	10.21
n/a	Lot 1 DPS 82202	17.06
3798 Cambridge Road	Lot 2 DP 506796	5.60

HISTORICAL BACKGROUND

Maori Settlement

In oral tradition the Tainui canoe, captained by chief Hoturoa made its final landfall at Kawhia some 800 years ago. The canoe had travelled around various parts of the central North Island, including the Bay of Plenty, the Coromandel, the Manukau Heads and the Hauraki Gulf, with some people leaving the voyage and settling in these areas (Te Ara Website).

Hoturoa is said to have made his base at Kawhia and over the years the Tainui people expanded inland from there. This included movement into the Waikato and Maori settlements spread throughout the region, with many concentrated along the coast to exploit the rich resources available there. Further inland, settlements were made along navigable waterways, such as the Waikato and Waipa Rivers and their tributaries, with numerous pa sites identified as well as gardening and food storage sites. Intertribal conflicts occurred periodically as a result of alliances, disputes and competition for resources.

During the early years of the 19th century contact with European traders and missionaries increased, one result being the introduction of muskets into Maori intertribal conflicts. The northern tribes were the first to arm themselves in this way and gained some advantage in battles with tribes who had not obtained such weaponry. However, by the 1830s most tribes were more or less equally equipped and were unable to sustain the long-term and large-scale warfare often referred to as 'The Musket Wars' that had occurred over the previous two decades.

The New Zealand Wars

In the years that followed, European influence increased and conflicts between Maori and the colonial government over the European demand for land became an ongoing issue, resulting in open conflict by the early 1840s. Contentious land sales, and the demands of settlers for land that was not properly secured, continued to result in conflicts and in 1845-46 these were centred in the north. However, confrontations between Maori and government forces continued with skirmishes, raids and battles taking place to the south, in the Hutt Valley and Wanganui in the late 1840s (Cowan 1955: 100-103; 143-144).

Tensions between Maori and the government continued to worsen and in 1858 resulted in the founding of the King Movement (Kingitanga) in the Waikato. This movement aimed to unite Maori under a single leader to strengthen their ability to oppose the loss of their land from the growing demands of the ever-increasing number of European settlers arriving in New Zealand (Belich 1986).

The Waikato, with its proximity to Auckland and now as the seat of the King movement, was a concern to the government and on 11 July 1863, the governor of New Zealand, Sir George Grey, issued an ultimatum to the chiefs of the Waikato, ordering that they pledge allegiance to Queen Victoria or face the consequences. Without providing adequate time for the Maori leaders to respond, on 12 July, British forces marched into the territory of the Maori King, crossing the boundary (aukati) between the Pakeha and Maori lands and marking the beginning of the Invasion of the Waikato (Belich 1986; New Zealand History Website). The Waikato campaign lasted for nine months and ended with the Maori defeat at Orakau Pa in April 1864. At this time, a new boundary (autaki) was established south of the Punui River, leaving the land to the north in the hands of the government (Cowan 1955: 408-410).

The Waikato Militia and Military Settlement

Just after the outbreak of hostilities in the Waikato, the government had devised a scheme to form militia regiments that would provide a population base for military settlements in the Waikato once the government had taken control of the area (Allen 1969:33). The settlements were intended to prevent further unrest within the Maori population by establishing a larger European presence in the area and to guard from further attacks from the Kingites living to the south of the Puniu River (Cowan 1955: 412). Many of the soldiers were recruited from the gold fields of Otago and Australia with the main incentive to join up being the provision of a one acre town allotment and a larger farm allotment (50 acres in size for the lower ranks and larger ones for the officers) to each soldier after completing three years of military service. Enlistment began in August 1863 with the men being divided into the four Waikato regiments (Allen 1969:35). The land for the settlements was to be confiscated from the Maori by the government and by mid-1864, military settlements were being planned at four locations in the Waikato at Alexandra (later renamed Pirongia), Kihikihi, Hamilton and Cambridge. The sites were chosen as defensive positions and to overlook the Waikato and Waipa Rivers. As the settlements were intended to be self-sufficient, it was also important that the sites chosen contained enough surrounding land suitable for farming. The strategic importance of the sites, in most cases, however, outweighed other factors and in the case of Cambridge, its location was ultimately decided as it guarded the head of navigation on the Waikato River (Allen 1969: 47).

The settlement at Cambridge was established in July 1864 and the site soon became the headquarters of the Third Waikato Regiment. Construction works on redoubts soon commenced. The first was the Star Redoubt which was located within the settlement at Cambridge. Pukerimu was had been used as a landing place by the British military from early 1864 saw the construction of two redoubts, one on each side of the Waikato River. The redoubts were only used for a very short period and were abandoned by the end of 1864 (Cambridge Museum Website).

Whilst the soldiers were put to tasks of building facilities, including the redoubts, surveyors were at work laying out the new settlement in one-acre town allotments and larger farm allotments in the surrounding area. The town allotments were laid out in rectangular grids situated around the two redoubts, one on each side of the Waikato River. The farm allotments were intended to spread out from the edges of the town but were planned to be kept as close to the town as possible for defensive reasons. Unfortunately, the military settlement process at Cambridge did not run particularly smoothly, as noted in the in the 29 November 1864 Edition of the *Daily Southern Cross*:

> 'Cambridge is laid out on both sides of the Horotiu River, about 30 miles above Ngaruawahia, and is the headquarters of the third Waikato Regiment. There are about 600 men up here at present. The town is laid out in one-acre allotments, and the surveyors are busy laying out the roads for the fifty-acre allotments, and yet the men of this regiment have not got any of the acre allotments given to them, although the township has been surveyed these last two months. It is not possible, therefore, for anyone to make improvements on his acre. We hear that the men of the 2nd Regiment have some of their land in potatoes and other crops, but there is nothing of the kind here.'

The town lots were eventually provided to the men, but more problems arose with the farm allotments, the main one being an abundance of swamp land. The size of the farm lot granted was dependent on the rank of the soldier, with privates receiving 50 acre lots, corporals 60 acres, sergeants 80 acres, subalterns 200 acres, 250 acres for surgeons, 300 acres for captains and 400 acres for field officers. The farm blocks were laid out in 50m units and the higher-ranking men would choose the appropriate number of blocks to make up their allotment, apart from the 60 and 80 acre farms for corporals and sergeants which were laid out separately (Allen 1969:76). Many of the lower ranking men received 50 acres of poor-quality swampy land and as many had no previous farming experience, the process of creating farms proved too difficult to manage and many sold their land as soon as their military service was finished, or in some cases they sold the land and transferred the military service to the new owner.

Information from Early Maps and Plans

Plans of the area containing Growth Cell C4 were reviewed to gain additional information on land ownership and use from the time of the establishment of the military settlement farms. The plan in Figure 3 shows the military settlement around Cambridge as it was originally laid out and as can be seen on the plan, the land in Growth Cell C4 lies to the west of a stream, which is situated in a deep gully and the irregular layout boundary was based on the topography. As can be seen in Figure 4, the land in the southern part of Growth Cell C4 was granted to William Howie (Allot 25) and the northern part to J.J. Dillon (Allot 23). William Howie was born in Scotland around 1841 and was enlisted as a substitute soldier in the Third Waikato Regiment in 1866. He farmed land at Pukerimu until the mid-1890s and passed away in 1918 and is buried at Ohinemuri. Joseph John Dillon was born around 1845 and enlisted as a private in the Third Waikato Militia in November 1863 with his profession was listed as settler/butcher (Cambridge Museum Website).

The plan in Figure 4 also contains information on two other properties in Growth Cell C4. The first is Section 25A, which lies to the southeast of Howie's and has the name John Wilson written on it. Wilson was born in 1830 in Scotland and was a major in the Third Waikato Militia. He received 400 farm acres and 2 town acres in the military settlement at Cambridge. He also acquired additional tracts of land and acted for the government in purchasing large tracts of land in the Waikato. He died at the age of 62 in 1892 (Cambridge Museum Website). The second is Section 24, which has the name W. Soutter written on it. William Soutter is listed as a member of the Third Waikato Regiment, however, no additional information was able to be gathered regarding him, although it is likely he was granted the land as a military settler

The map in Figure 4 also shows the route of a dray track that would most likely been used for the transport of goods by horse drawn wagons to and from Cambridge running through the southern part of Growth Cell C4. With regards to Section 24, the plan in Figure 5 dating from 1905 and surveyed for a Mr William Atkinson shows subdivision of this lot along with Section 25A. The plan shows the northern border of the lot as swampy and also has an annotation of 'very old ditch bank and hedge' along the western boundary line between Section 25 and Section 25A.

A later plan in Figure 6 dated 1952 shows the transfer of a small rectangular lot in the southeast corner of Growth Cell C4, namely, Lot 1 DP 1517. The date of the original subdivision has not been determined, but it can be seen on the 1905 plan in Figure 5, although this may have been added to the plan at a later date. A much more recent plan dated 1995 (Figure 7) shows the subdivision of Allotment 25 into Lot 1 and Lot 2 as it exists today (with the annotation Pleasanton Stud Ltd on Lot 1 and also on land to the southeast).

In general, the old plans show that apart from the early subdivision of the small lot in the southeast corner, the southern part of the growth cell (to the south of Silverwood Lane) has remained agricultural in nature. To the north of Silverwood Lane, plans dating from the late 20th century show the subdivision of the area at the eastern end of Silverwood Lane into residential lots, with the remainder being subdivided into large lifestyle lots (Figure 7–Figure 10).

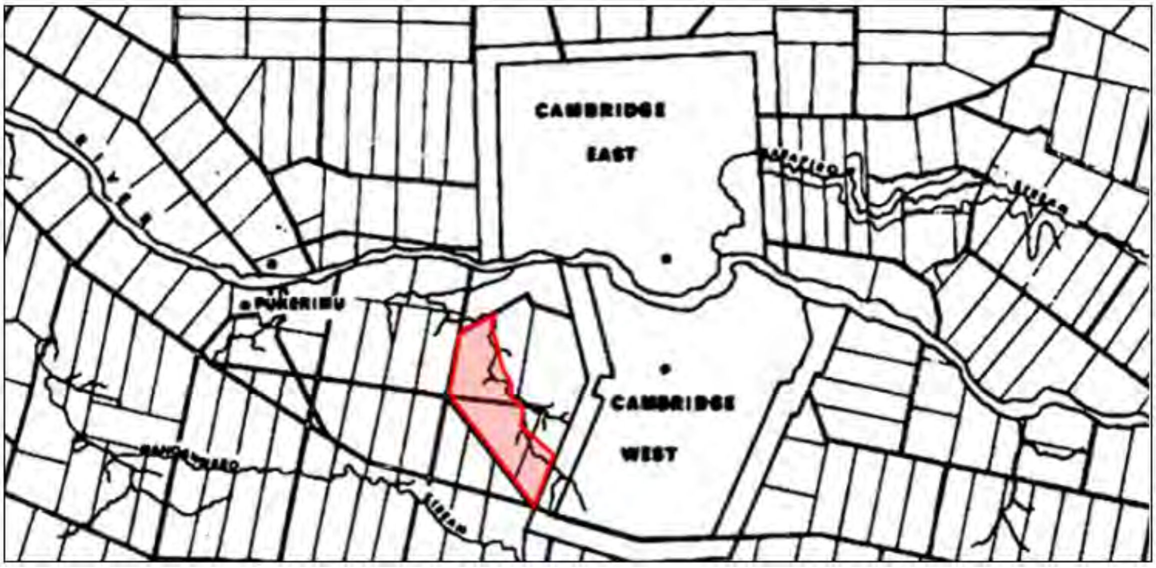


Figure 3. Plan of the militia farm allotments around Cambridge with Growth Cell C4 shaded red (source: Allen 1969)

Figure 4. Detail from HN SO 33 2 I dated late 1860s, showing the land ownership in the Growth Cell C4 (shaded red) with old dray track indicated by arrow (source: Quickmap)

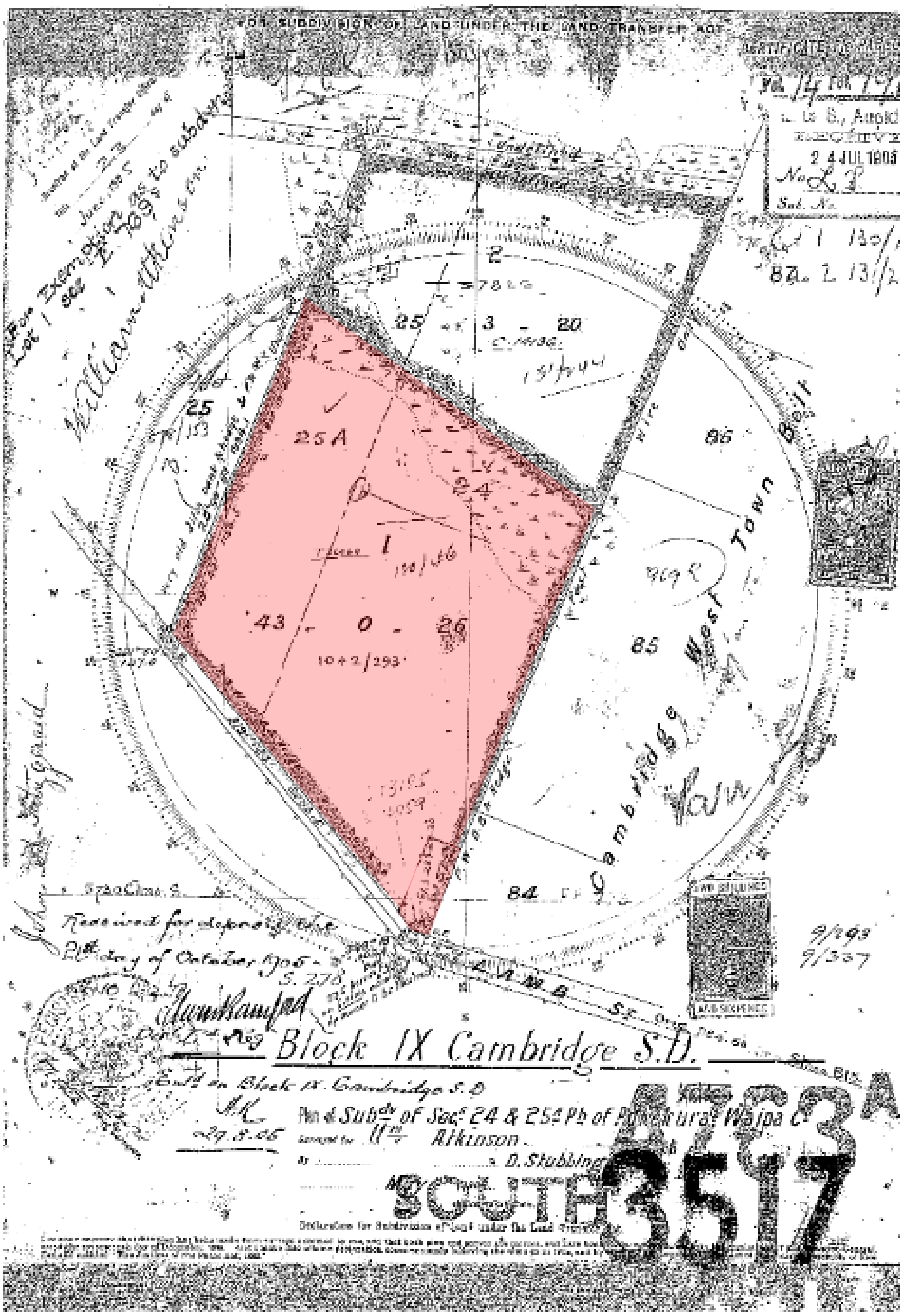


Figure 5. HN DP 3517 I dated 1905 showing the subdivision of Sec 24 and 25A, with the land in Growth Cell C4 shaded red (source: Quickmap)

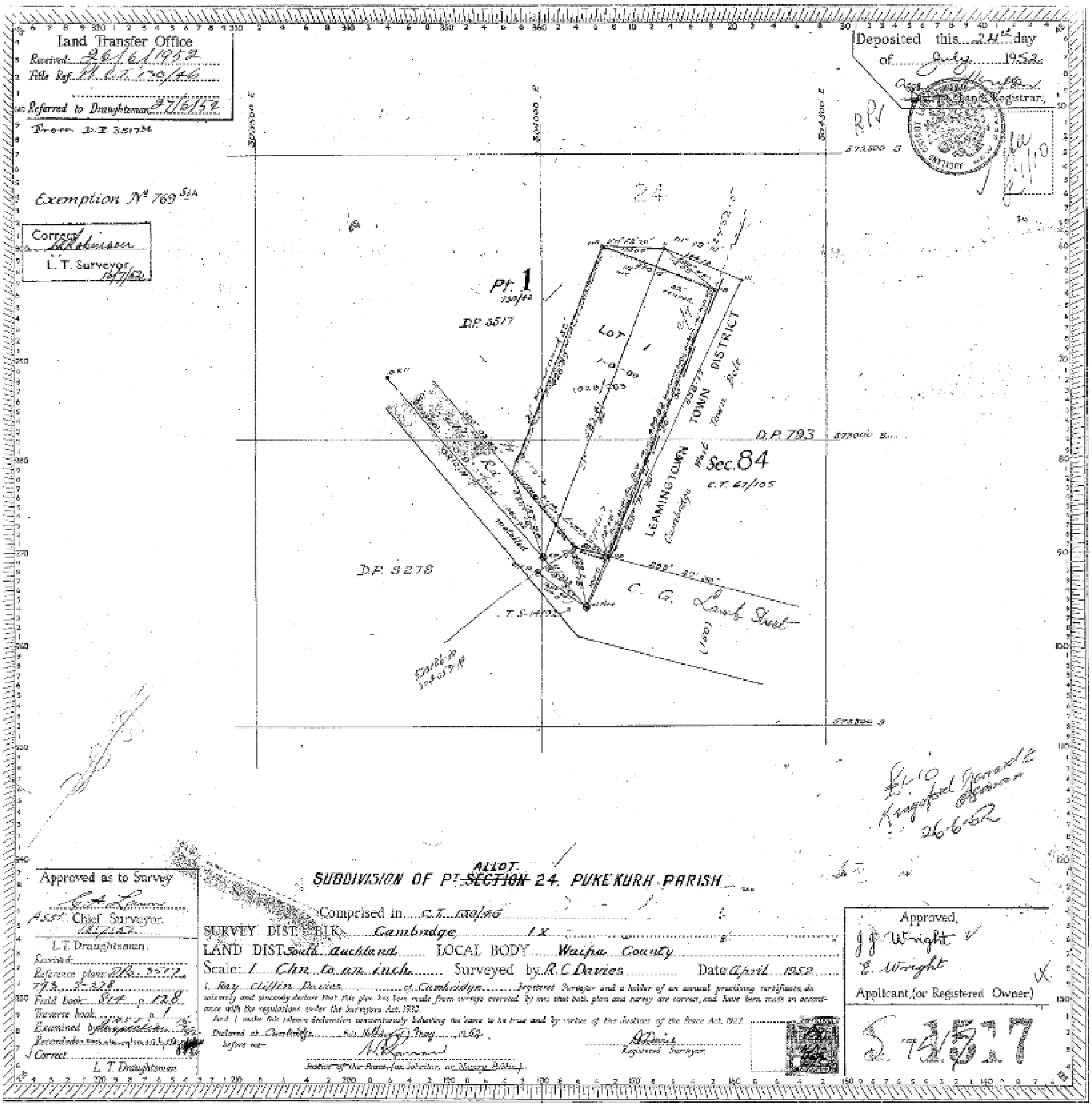


Figure 6. Land transfer plan dated 1952, showing the small rectangular lot in the southeast corner of the growth cell (source: Quickmap)

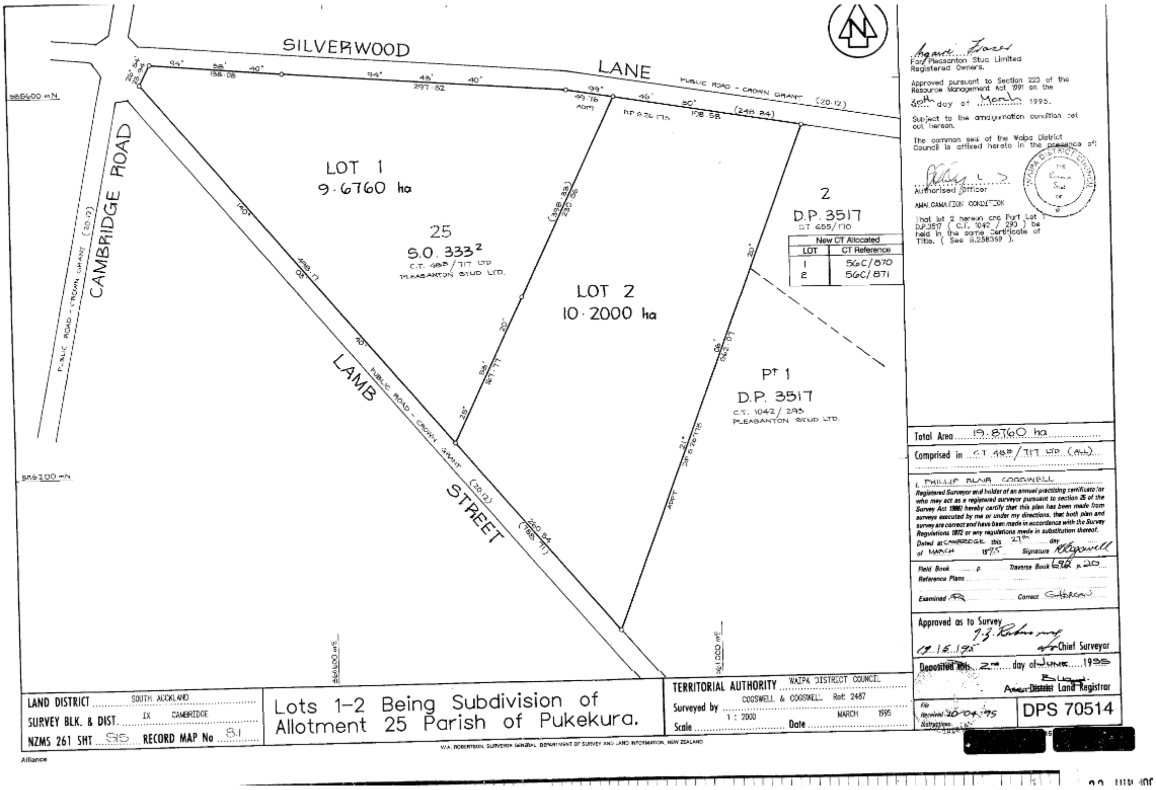


Figure 7. HN DPS 70514 dated 1995, showing the subdivision of Allotment 25 into two lots (source: Quickmap)

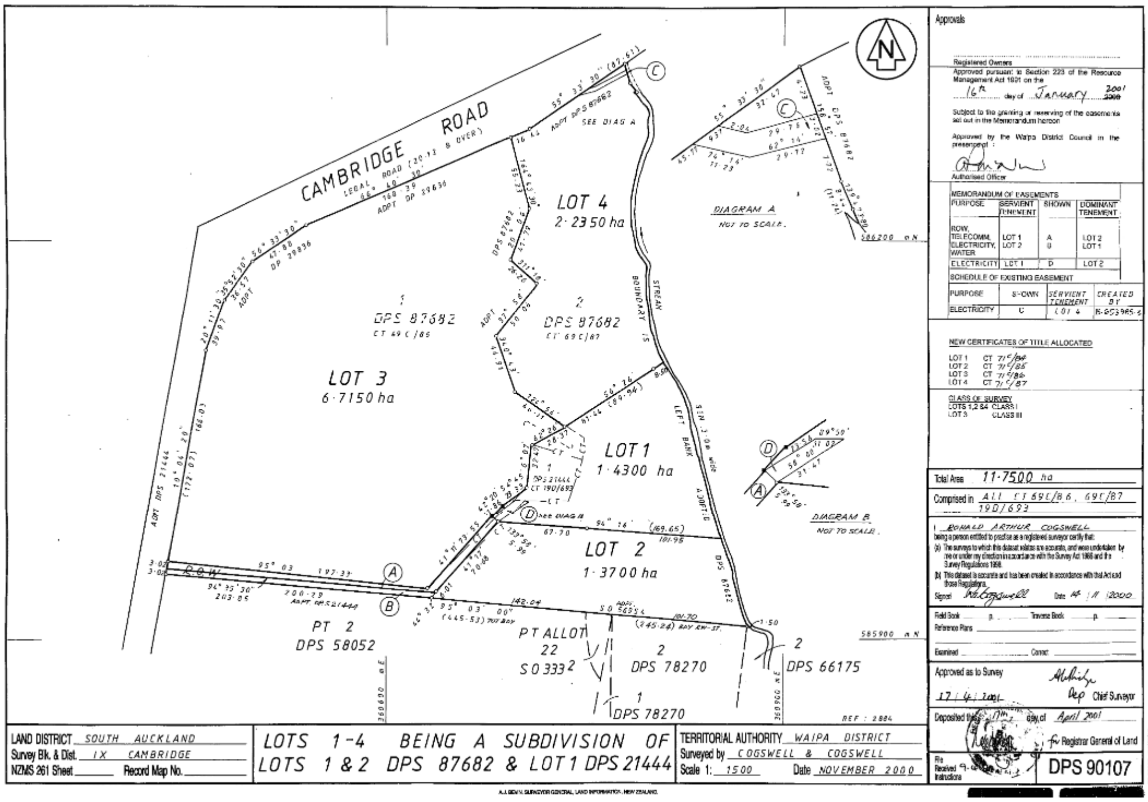


Figure 8. HN DPS 90107 dated 2000, showing the subdivision of lots in the northwest corner of the growth cell (source: Quickmap)

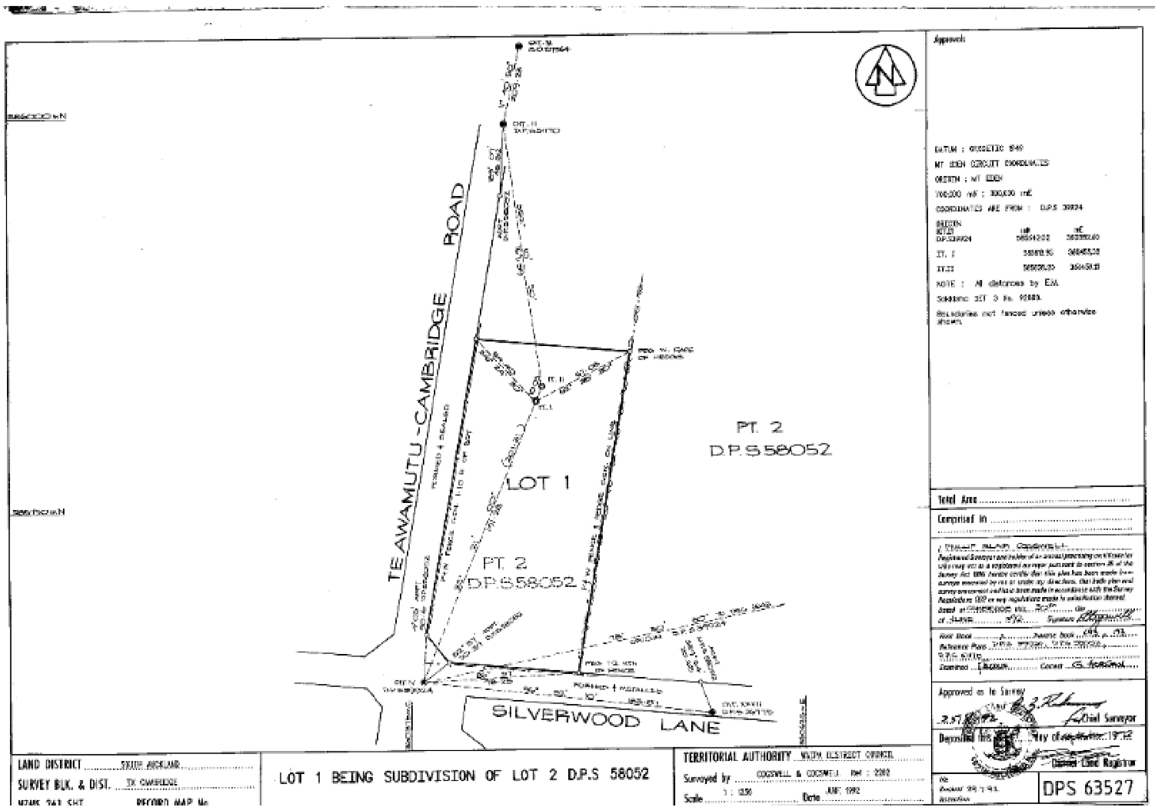


Figure 9. HN DPS 63527 dated 1992, showing the subdivision of the just to the north of Silverwood Lane at the Junction of Te Awamutu – Cambridge Road (source: Quickmap)

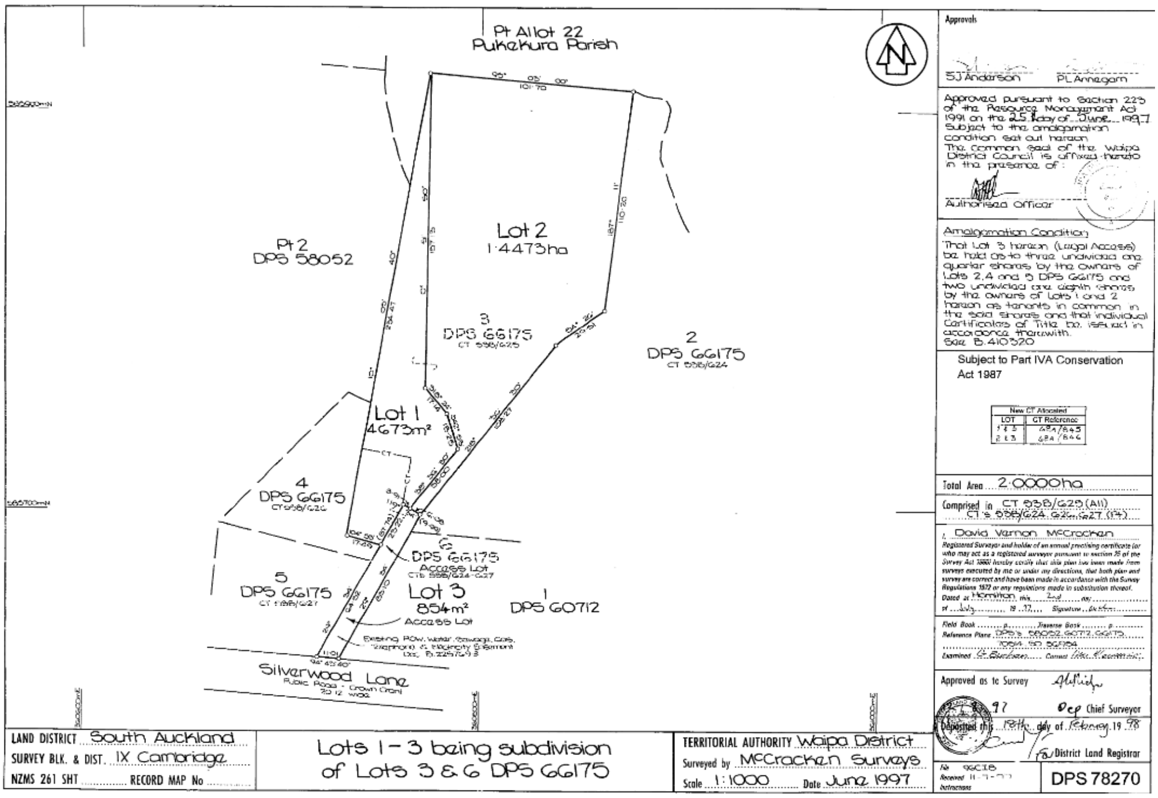


Figure 10. HN DPS 78270 dated 1997 showing the subdivision for residential lots to the north of Silverwood Lane (source: Quickmap)

ARCHAEOLOGICAL BACKGROUND

Recorded Archaeological Sites

There are six recorded archaeological sites in Growth Cell C4, all of which are associated with Maori horticulture and settlement. The locations of the sites are provided in Figure 11 and a brief description in Table 2. S15/23 is a pa site situated on an east facing headland with steep banks on the north, south and east sides. The site was described in 1973 as square in shape (45x45m) with house platforms, terraces and a ditch on west side (filled in). At that time the site was ploughed out and in grass. A house was constructed on the site c.1980 and a site visit in 2014 confirmed that most of the site has been severely damaged/ destroyed by the house construction and associated landscaping, although the ditch is believed to have survived (NZAA site record, appended).

The other five recorded archaeological sites are borrow pits and associated modified gardening soils. Borrow pits and gardening soils are common features in the archaeological landscape of the Waikato. The pits were dug to collect sands and gravels that were present below the upper soil layers. The extracted material was then added to the topsoil to modify the soil for gardening. The purpose of this was to improve soil quality (drainage, friability) for the cultivation of plants brought to New Zealand from warmer climates by Maori. Borrow pits are often found in proximity to gardening soils and it has been noted that the pits were often located near to the gardening areas (Walton and Cassels 1992: 166). Two of the sites in Growth Cell C4, S15/521 and S15/638 have been recorded to the west of the pa site (S15/23). These sites were visited in 2014 and five borrow pits were identified along with modified garden soils, as shown in Figure 12. The notes from this site visit indicated that S15/521 and S15/638 likely represent the same pre-European Maori horticultural site, although the two site references are still in use (NZAA site records, appended).

S15/637 is located further to the south and was identified from inspection of aerial photographs and has not been visited in the past. This site was originally recorded as a single borrow pit to the north of Silverwood Lane, however, more recent Lidar data would indicate that a larger number of borrow pits are present, both to the north and south of Silverwood Lane (Figure 13).The remaining two borrow pit sites in Growth Cell C4 have been recorded in paddocks to the south of Silverwood Lane. These are S15/701 and S15/702, which are described as containing 30 borrow pits each on the NZAA site records, but no additional information has been provided apart from a note that the record was intended to be updated in 2013. All of the above NZAA site records have been appended to this report for reference.

An additional 11 archaeological sites have been recorded outside of the Growth Cell C4 boundary at distances up to c.300m of that boundary. These sites will be described below to provide an overview of the general archaeological landscape setting of the project area. Ten of the sites are associated with Maori settlement and horticulture with the remaining one being the site of a historic homestead. The latter, S15/757, was the homestead of the Tucker family from the late 19th century. No surface evidence was found during a 2016 site inspection, but it is considered likely that subsurface material associated with the farm could be present (NZAA Site Record). Of the remaining 10 recorded archaeological sites, one is a pa site, S15/356. This site, which is located on a c.70 m long headland, was recorded in 1973 and it was noted the site was badly eroded at that time. The site was described as being cut off by a 60m long transverse ditch containing two terraces and numerous indentations interpreted as pits.

The nine other recorded sites are all borrow pit sites, with some containing associated modified gardening soils. Two of the sites, S15/700 and S15/703, described as containing two and five borrow pits respectively, were entered into the NZAA ArchSite database in 2013 with a note in the site record that they would be updated, but no additional information has been added. Five sites were identified on 1943 aerial photographs and have not been visited to date, these are: S15/287 (12 borrow pits), S15/520 (nine borrow pits), S15/522 (three borrow pits), S15/526 (four borrow pits) and S15/640 (a single borrow pit).

The final two sites, S15/639 and S15/641, are located c.200-300m to the east of Growth Cell C4. Both sites were originally recorded as containing a single borrow pit each from inspection of aerial photographs. Site visits have been undertaken and a total of three borrow pits have been identified at S15/639 and one borrow pit at S15/641, along with modified gardening soils. As well, material recovered from these sites has been submitted for radiocarbon dating with results indicating mid-14th century dates, which are at present some of the earliest dates recorded in the Waikato (Gumbley and Laumea 2018:16).

Archaeological Landscape

The recorded sites within and around Growth Cell C4 indicate that it was part of a broader Maori horticultural landscape located on both the northern and southern sides of the Waikato River. In general, the Waikato District contains a large number of archaeological sites, with the majority being located along the coast or in the vicinity of major waterways. The main site types that have been recorded are Pit/Terrace, Pa, Midden/Oven and Borrow Pits (Hutchinson and Simmons 2016:17). Previous research and investigations have revealed past Maori occupation with both pa sites and sites associated with Maori horticulture predominating, and with many of these sites clustered around the Waikato River. This clustering would appear to be the result of location preference, but has also been influenced by the focus of past archaeological surveys and investigations (Campbell 2012: 18-20). As noted by Campbell, there is also currently not enough available data to reconstruct the temporal progression of occupation in the wider Waikato Basin and the date of the first occupation has not been established (Campbell 2012:57). As noted above, the earliest radiocarbon dates available would suggest a date from the mid-14th century at sites located to the east of Growth Cell C4 (Gumbley and Laumea 2018). The activities associated with early occupation are thought to have been forest clearance in desirable gardening areas, as evidence has indicated that the gardens were established in areas formerly covered by primary forest, which became fern land after the gardens were abandoned (Campbell 2012:58).

Past research and investigation of Maori settlement and gardening in the general area containing Growth Cell C4, including the identification and distribution of modified gardening soils and borrow pits, has been undertaken in an in-depth desk-based study of pre-European Maori horticulture conducted as part of the archaeological assessment for the construction of the Waikato Expressway – Tamahere to Cambridge Sections (Campbell 2012[1]). The study area for that project is located to the north of the Growth Cell C4, but the findings are applicable to the wider area, including that of Growth Cell C4. One of the areas of focus for the study was a detailed analysis of soil types associated with Maori horticulture, with particular emphasis on modified soils created for gardening. The main

---

[1] As noted in the Campbell 2012 report the information on soils was gathered from the following sources: DSIR 1954, McLeod 1984 and Lowe 2010. It should be noted that the McLeod 1984 terminology is used in the current assessment report. For background information and a description of the development of soil classification, the Campbell 2012 report can be consulted.

type of soil on which pre-European gardening sites are recorded are Horotiu Sandy Loams. They are well drained soils found on the lower terraces of the Waikato River. They have been subdivided into Horotui coarse sandy loams (HS), Horotui sandy loam (H), Horotui silt loam (Hy) and (Hg) which also contains gravel (ibid.).

The soil in Growth Cell C4 is dominated by Horotiu sandy loams. An area of modified gardening soil (Tamahere) has been identified in the northern part of the growth cell in association with a number of borrow pits, just to the west of the pa site, S15/23. It is also considered likely that modified garden soils are located in other parts of the growth cell which have not been previously tested. Borrow pits have also been identified along the northern part of the growth cell (Figure 13). Although the southern part of the growth cell is not included in the area covered in Figure 13, borrow pits have been identified from inspection of old aerial photographs.

Figure 11. Plan showing the location of the recorded archaeological sites in growth Cell C4 and the surrounding area (source: NZAA Archsite Website)

Table 2. Brief description of the archaeological sites in and within 300m of Growth Cell C4. Those within Growth Cell C4 shaded in grey

NZAA #	Site Type	Description	NZTM Easting	NZTM Northing
S15/23	Pa	Roughly rectangular pa (50x50m) with transverse ditch, lateral pits and terraces. House on the site.	1815831	5802104
S15/287	Maori Horticulture	12 borrow pits (8-30 m across) identified during brief visit in 1983.	1815902	5801070
S15/356	Pa	Located on north pointing with transverse ditch, pits and terraces.	1816281	5801490
S15/520	Maori Horticulture	Nine borrow pits in an area of 310x50m. From 1943 aerial photograph SN266/835/59- not visited.	1815410	5801804
S15/521	Maori Horticulture	Five borrow pits in an area of 120x60m. From 1943 aerial photograph SN266/835/59 – not visited.	1815661	5802208
S15/522	Maori Horticulture	Three borrow pits in an area of 40x30 m. From 1943 aerial photograph SN266/835/60 – not visited	1816246	5802043
S15/526	Maori Horticulture	Four borrow pits in an area of 60x50m. From 1943 aerial photograph SN266/835/60 – not visited.	1816352	5801460
S15/637	Maori Horticulture	Single borrow pit from 1943 aerial photograph SN266/835/59- not visited.	1815686	5801845
S15/638	Maori Horticulture	Single borrow pit from 1943 aerial photograph SN266/835/59- not visited.	1815731	5802067
S15/639	Maori Horticulture	Two borrow pits and Maori modified soils- located in a new residential subdivision.	1816159	5802131
S15/640	Maori Horticulture	Single borrow pit from 1943 aerial SN266/835/60- located in a new residential subdivision.	1816408	5801829
S15/641	Maori Horticulture	Single borrow pit from 1943 aerial SN266/835/60- filled in with house constructed.	1816223	5801448
S15/700	Maori Horticulture	Two borrow pits - NZAA site record updated in 2013 but no further information provided.	1816492	5801366
S15/701	Maori Horticulture	30 borrow pits NZAA site record updated in 2013 but no further information provided.	1816264	5801020
S15/702	Maori Horticulture	30 borrow pits NZAA site record updated in 2013 but no further information provided.	1815883	5801460
S15/703	Maori Horticulture	Five borrow pits NZAA site record updated in 2013 but no further information provided.	1815429	5801146
S15/757	Historic Domestic	Tucker Homestead and farm – 19th century. Subsurface remains likely.	1816150	5802300

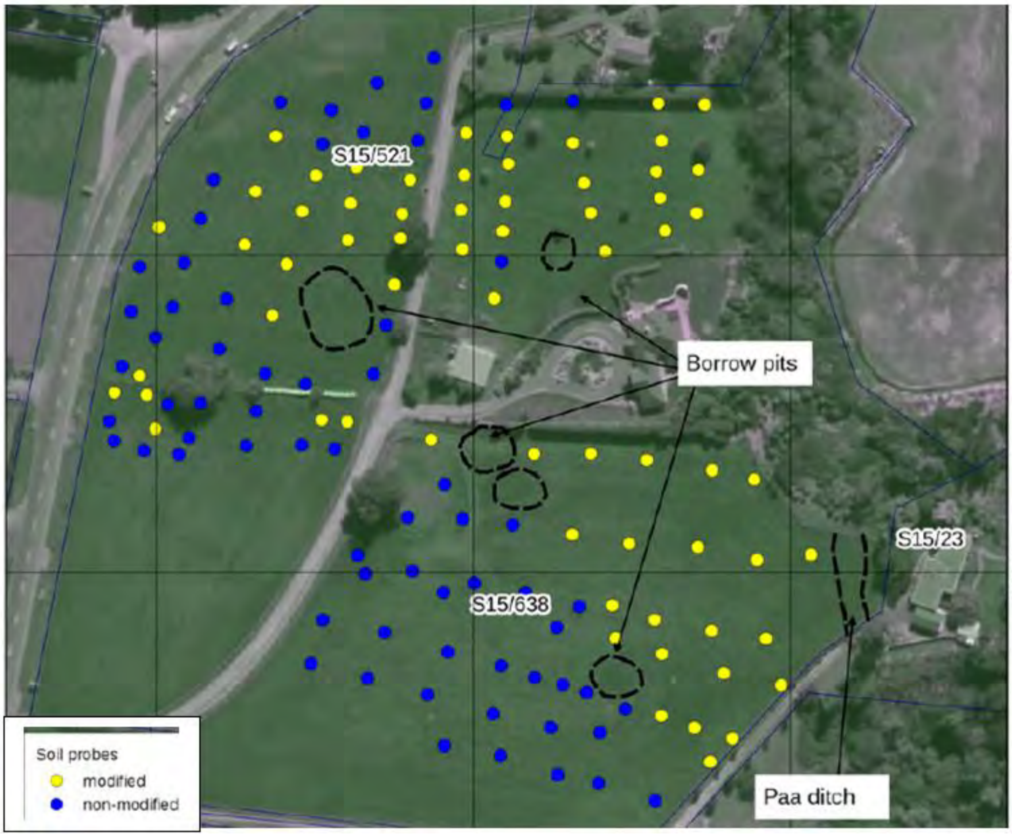


Figure 12. Aerial plan of the area containing Maori horticultural sites S15/521 and S15/638, showing locations of borrow pits and modified soil and also the pa site S15/23 with outline of surviving ditch indicated (source: NZAA Site Record)

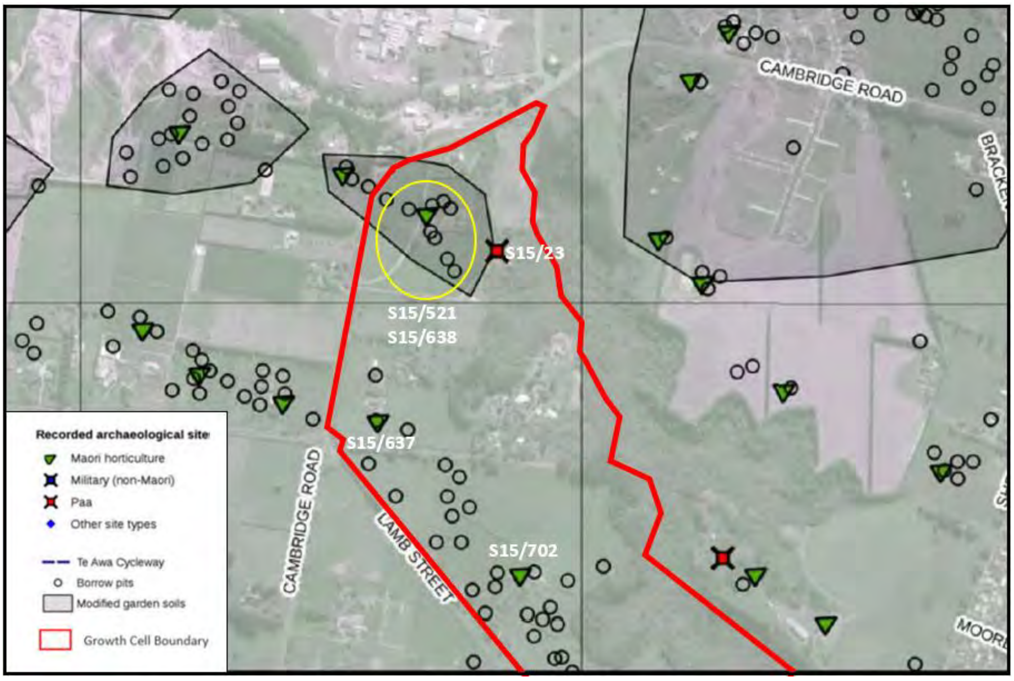


Figure 13. Aerial plan showing the location of archaeological sites and associated Maori horticultural features in the northern and central part of Growth Cell C4 (source: NZAA Site Record)

Information from Early Aerials

Aerial photographs have been reviewed in the past to identify the locations of the borrow pits in Growth Cell C4, some of which have been recorded as archaeological sites. As can be seen in the aerial photographs from 1943 in Figure 14 (northern section) and Figure 15 (southern section) depressions in the ground are clearly visible at several locations within the boundaries of Growth Cell C4 and the locations of the recorded archaeological sites are indicated in these figures. The location of a sand quarry at the eastern end of Silverwood Lane is also shown on the 1943 aerial photograph in Figure 14. The recorded pa, S15/23, is also clearly visible in the 1943 aerial, although as can be seen on the 1983 photograph in Figure 16, a house was subsequently constructed at this location.

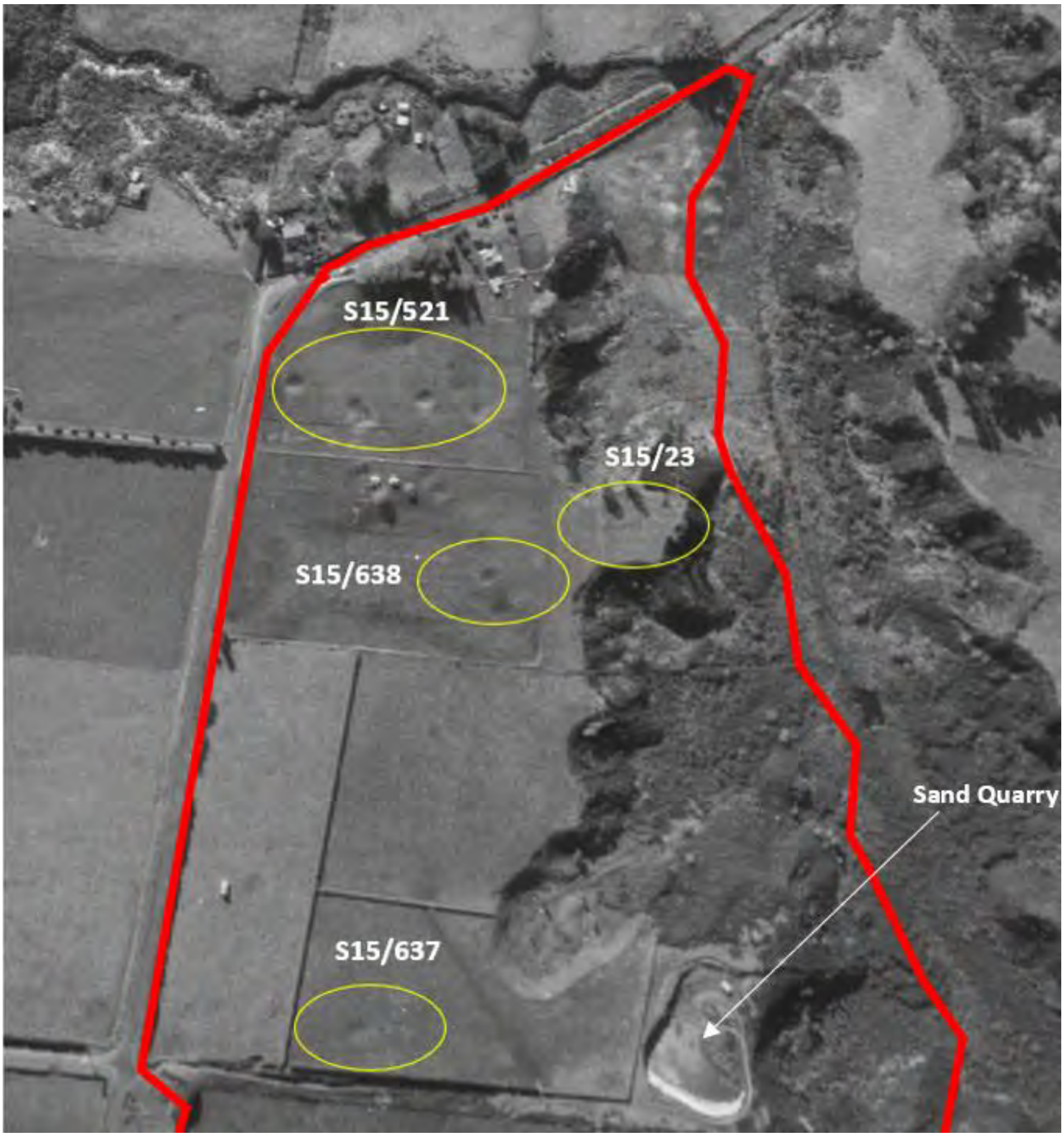


Figure 14. Aerial photograph dated 1943 (Crown 266 835 59) showing the northern part of Growth Cell C4 with archaeological sites circled in yellow and known sand quarry indicated (sourced from: http://retrolens.nz and licensed by LINZ CC-BY 3.0)

Figure 15. Aerial photograph dated 1943 (Crown 266 836 60) showing the southern part of Growth Cell C4 with the locations of the recorded archaeological sites circled in yellow (sourced from: http://retrolens.nz and licensed by LINZ CC-BY 3.0)

Figure 16. Aerial photograph dated 1983 (Crown 8178 C 16) with house construction at the location of pa site S15/23 shown in detail in upper inset (sourced from: http://retrolens.nz and licensed by LINZ CC-BY 3.0)

Physical Environment

Geology and Geomorphology

The geology of the Waipa region consists predominantly of volcanic material, including tephra. The geology of the region has been impacted by volcanic events, such as eruptions coming from the Taupo region, depositing large volumes of alluvial material (Waipa District Council 2008). Volcanic features can be found across the Waipa region, an example being Pirongia Mountain, a basaltic-andesite volcanic cone. Along with volcanic events, the region has been shaped by flooding events from the Waikato and Waipa rivers, carving out channels that can be found near the rivers.

The underlying geology of the area, including Growth Cell C4, is known as the Hinuera Formation, which is made up of volcanogenic alluvial deposits. The soil patterns on the Hinuera Formation mimic the earlier alluvial depositional activity with the more well-drained Horotiu soils found on slightly raised ancient channel and bar deposits and the lower-lying and more poorly drained soils (Te Kowhai, Ngaroto and Matangi) on ancient floodplains. The floodplains consist of silt, sand and gravel (the Hinuera Formation) deposited by migrations of the ancient Waipa and Waikato River systems over the past c.100,000 years with deposits up to 60m thick (Figure 17). These ancient alluvial deposits swept around an even older pre-existing hilly landscape, partially burying it and creating a mostly flat alluvial surface with only remnants of the older hills protruding in places (Lowe 2010). The last depositional episode was between 22,00 and 17,00 years ago and the deposits above the surface consist of numerous thin tephra layers (ibid.). Growth Cell C4 also contains an area of poorly drained soil in its central section and there is an area of Kirikiriroa soils, which are well drained steepland loams, along the eastern boundary, which contains steep sided gullies (Macleod 1992: 39-40).

Topography, Vegetation and Land use

Growth Cell C4 contains a mixture of agricultural land and large rural lifestyle blocks with the southern part (to the south of Silverwood Lane) being mostly farm paddocks, currently in use as a thoroughbred stud and formerly a dairy farm. There is also a house on the property set back from Cambridge Road.

The land to the north of Silverwood Lane has a mixture of open paddocks and lifestyle blocks. The majority of the land is relatively flat apart from the land along the eastern boundary, which slopes steeply down into a system of gullies and streams, and a low-lying section of land in the northeast corner (Figure 18). This figure also shows a number of small features in the southern and central paddocks of Growth Cell C4 which most likely represent the locations of borrow pits. As noted earlier, the land at the eastern end of Silverwood Lane was formerly used as a sand quarry. As can be seen in Figure 18, there is also a similar area to the northeast, which may also have been used as a sand quarry.

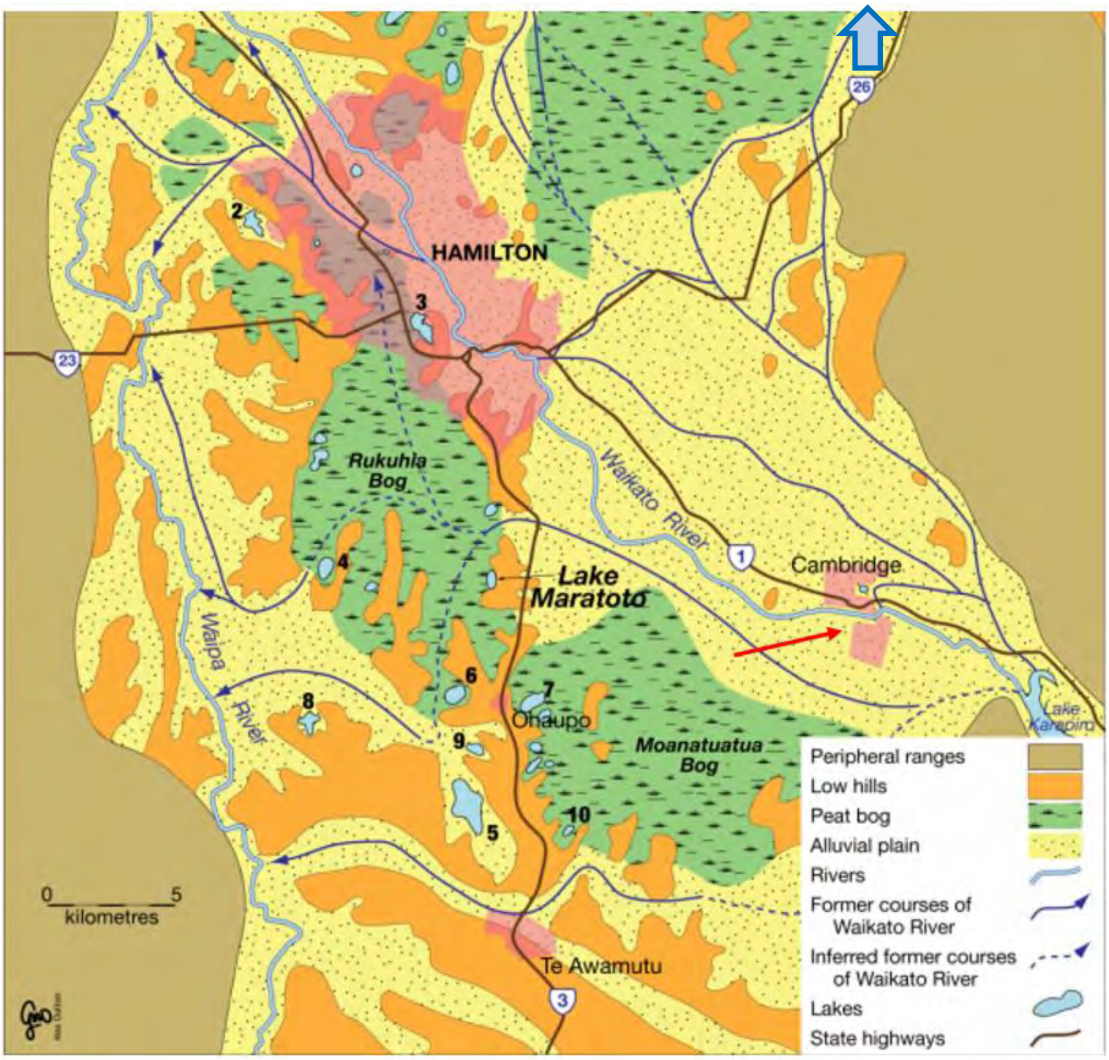


Figure 17. Map showing the modern landscape features in the central and southern part of the Hamilton Basin with approximate location of Growth Cell C4 shown by arrow (source: Lowe 2010)

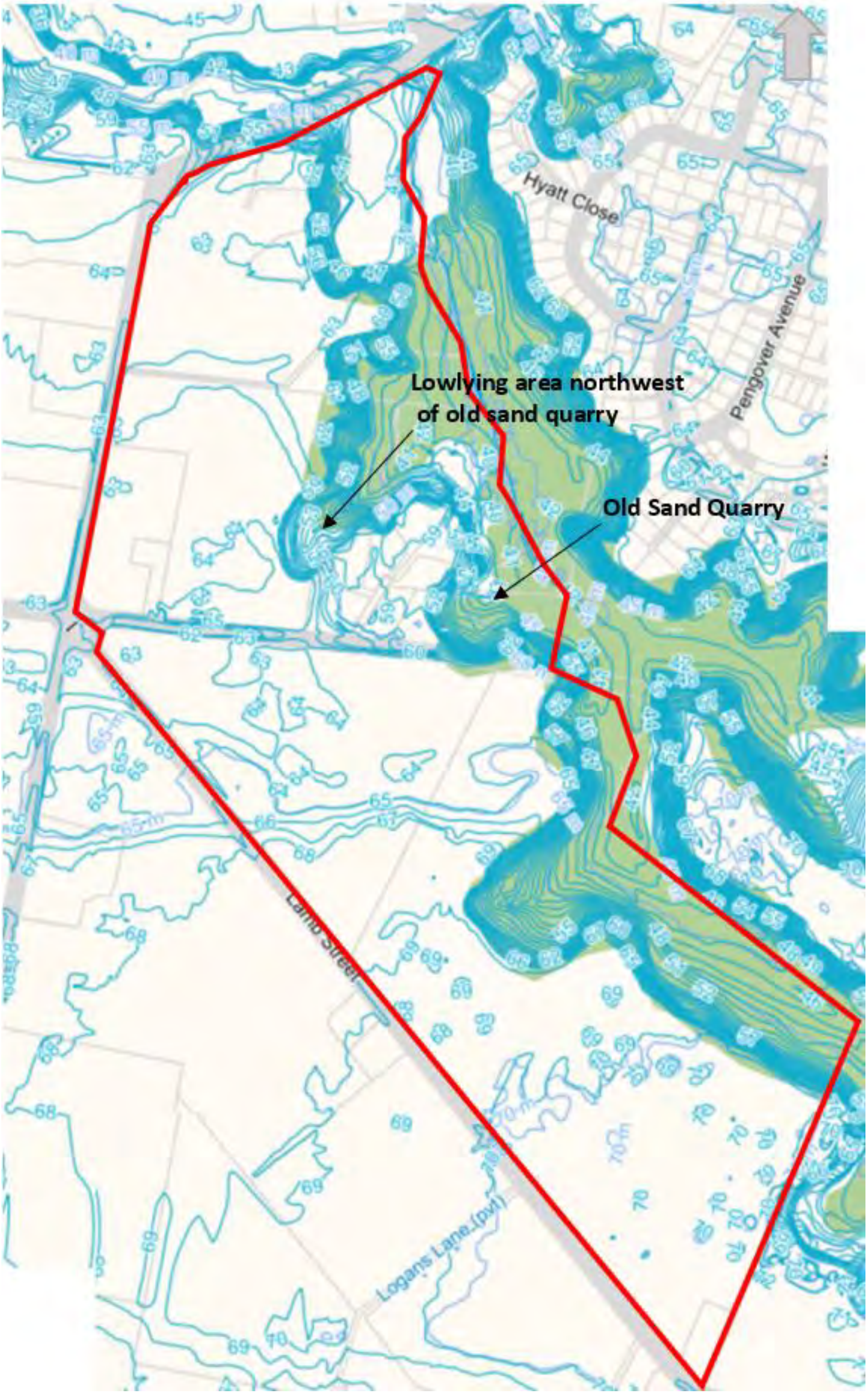


Figure 18. Map of Growth Cell C4 with contours (source: Waipa District Intramaps)

FIELD ASSESSMENT

Field Survey Results

A field survey was conducted on 25 July 2019. All of Growth Cell C4 to the south of Silverwood Lane was accessible, as were the large open paddocks to the north of the lane. As has been noted a large number of borrow pits have been identified from inspection of aerial photographs and recorded as archaeological sites. The purpose of this survey was to inspect the areas where the borrow pits have been identified and to determine if their presence could still be detected from visual inspection and probing. It should be noted that the results below are not intended to provide a comprehensive record of all of the archaeological remains that are present in the growth cell, but to indicate the current status and general condition of the archaeological sites at the current planning stage. Thirty-two previously unvisited borrow pits were able to be identified during the survey. Coordinates were taken and the locations have been plotted on the aerial plan in Figure 23 (below). The information gathered during the survey on the recorded features is provided in Table 3 and a summary of the findings for each of the archaeological sites is provided below.

S15/701

This archaeological site was previously recorded in the southernmost part of the growth cell. During the survey, the area was found to be located on fairly level grassland that had been divided into fenced paddocks and was being grazed by horses. A number of depressions were immediately noted, some with water at the base and some dry. The farm manager indicated that the horses tended to use some of the depressions for rolling in, making the bottoms of these depressions hard packed and prone to retaining water. Where the soil had not been compacted by such actions, the bases were dry. In general, waterlogging was not an issue on the property.

As noted earlier, the only information on the site record was that 30 borrow pits were present. During the survey the area was noted to have a number of very visible and large depressions and 18 were recorded as borrow pits. Smaller depressions, the origins of which could not be determined from visual inspection and probing were not recorded, but it is considered likely that after topsoil stripping evidence of more borrow pits would be revealed. In general, the pits ranged from c.8m x 10m to 20m x 30m in size, with visible depths ranging from 0.5m to over 2m. The shape of most of the depressions appeared to be roughly rectangular, although some had a more rounded appearance. In general, the land use impacts in this area are considered low with the borrow pits in a good state of preservation. A photograph is provided in Figure 19.

S15/702

This area, which lies to the north of S15/701, is dominated by grassed paddocks in use for horse grazing, but also contains a house and driveway and landscaped areas. Only six borrow pits were able to be confidently identified and recorded. Again, a number of shallow depressions were noted, but could not be positively identified as borrow pits, although it is considered likely that evidence of more borrow pits would be established after topsoil stripping.

S15/637

This site was originally identified during a review of aerial photographs and was described as a single borrow pit located to the north of Silverwood Lane (NZAA site record). More recent Lidar data has indicated a larger number of borrow pits in this area on both the north side and south side of Silverwood Lane. The area to the south of Silverwood Lane did not show any evidence of major impacts and five borrow pit features were recorded. The land to the north showed evidence of having undergone impacts from past farming activities, including earthmoving works for creation of a rubbish dump and an area of raised land along Silverwood Lane. Two borrow pits were able to be identified, but one had been used for dumping rubbish and the other was partially destroyed by previous earthworks along the border of Silverwood Lane. Again, Lidar data has indicated the presence of a larger number of features and it is considered likely that after topsoil stripping evidence of additional borrow pits may be present. Photographs are shown in Figure 20 and Figure 21.

S15/638 and S15/521

These sites were also identified from a review of aerial photographs, with S15/638 described as containing a single borrow pit and S15/521 containing five borrow pits on the NZAA site record. Again, Lidar data shows the presence of more features and a 2012 survey found evidence of five borrow pits in the general area (as can be seen in Figure 12). The area was briefly visited during the field survey to make note of its current status. The areas containing the borrow pits in 2012 were still open fields with no further development. A photograph is provided in Figure 22.

S15/23

This pa site was visited and recorded in 1973; however subsequent construction of a house and associated landscaping has severely damaged most of the site. A survey in 2012 noted that evidence of the ditch was still present. The area was visited during the survey and had been used for growing crops recently. Surface evidence of the ditch could not be seen, but it is considered likely that subsurface evidence at lower levels is still present.

Figure 19. Photograph of a borrow pit in the southern part of Growth Cell C4, previously recorded as S15/701, looking southwest

Figure 20. Photograph of a borrow pit on the southern side of Silverwood Lane, previously recorded as S15/637, looking northeast

Figure 21. Photograph of a borrow pit on the northern side of Silverwood Lane that has been damaged through rubbish dumping, previously recorded as S15/637, looking northwest

Figure 22. Photograph of a borrow pit in the northern part of the growth cell previously recorded as S15/521, looking south

Table 3. Coordinates taken for borrow pits that were identified during the field survey

NZAA #	Description	NZTM Easting	NZTM Northing
S15/637	Borrow pit c.10 x 15m and 1.5m deep. In paddock, no obvious impacts.	1815756	5801639
	Borrow pit c.10 x 15m and 1.5m deep. In paddock, no obvious impacts.	1815735	5801666
	Borrow pit c.15 x 20m and 2m deep. In paddock, no obvious impacts.	1815627	5801693
	Borrow pit c.20 x 30m and 2m deep. In paddock, no obvious impacts.	1815570	5801670
	Borrow pit c.10 x 5m and 0.5 m deep. In paddock, no obvious impacts.	1815592	5801670
	Borrow pit has been used to dump rubbish and ground has been disturbed. Original area and depth indeterminate.	1815667	5801731
	Borrow pit measuring c.5 x 10m and 0.5 m located along fence line and area has been impacted by bulldozer activity.	1815660	5801741
S15/701	Borrow pit c.20 x 10m and 1.5m deep. In paddock, no obvious impacts.	1816148	5801246
	Borrow pit c.10 x 15m and 2 m deep. In paddock, no obvious impacts.	1816170	5801208
	Borrow pit c.10 x 15 m and 0.5m deep. In paddock, no obvious impacts.	1816197	5801163

NZAA #	Description	NZTM Easting	NZTM Northing
	Borrow pit c.25 x 15m and 1.5m deep. Has been used by horses and base compacted affecting drainage, with water present.	1816217	5801172
	Borrow pit c.8 x 10m and 0.5m deep. In paddock, no obvious impacts.	1816280	5801168
	Borrow pit c.15 x 20m and 1.5m deep. In paddock, no obvious impacts.	1816280	5801112
	Borrow pit c.6 x 10m and 0.5m deep. In paddock, no obvious impacts.	1816308	5801106
	Borrow c.8 x 10m and 0.5m deep. In paddock, no obvious impacts.	1816368	5801076
	Borrow pit c.30 x 15m and 1m deep. In paddock, no obvious impacts.	1816316	5801091
	Borrow pit measuring c.8 x 10m and 0.5m deep. In paddock, no obvious impacts.	1816394	5801087
	Borrow pit c.8 x 18m and 0.2m deep. In paddock, looks to have been partially infilled.	1816387	5801063
	Borrow pit measuring c.30 x 20m and 1.5m deep. In paddock, no obvious impacts.	1816367	5801051
	Borrow pit c.30 x 20m and 1.5m deep. In paddock, no obvious impacts.	1816355	5801035
	Borrow pit c.15 x 20m and 0.5 m deep. In paddock, no obvious impacts	1816330	5800980
	Borrow pit c.10 x 20m and 1.5m deep. In paddock, no obvious impacts.	1816317	5800942
	Borrow pit c.15 x 15m and 2.5m deep. In paddock, no obvious impacts.	1816309	5800976
	Borrow pit c.10 x 15m and 2.5m deep. In paddock, no obvious impacts.	1816306	5801024
	Borrow pit c.15 x 20m and 0.5m deep. In paddock, no obvious impacts.	1816317	5800942
	Borrow pit c.10 x 10m and 0.5m deep. In paddock, no obvious impacts.	1816238	5801025
S15/702	Borrow pit c.30 x 20m and 2.5m deep. In paddock no obvious impacts.	1815952	5801221
	Borrow pit c.20 x 10m and 2m deep. Located alongside Cambridge Road and has been partially damaged from the road construction.	1815910	5801226
	Borrow pit c.15 x 25m and 1.5m deep. In paddock, no obvious impacts.	1815966	5801217
	Borrow pit c. 20 x 10m and 1m deep. In paddock, no obvious impacts.	1815997	5801225
	Borrow pit c.8 x 10m and 0.5 m deep. In paddock, no obvious impacts.	1816020	5801236
	Borrow pit measuring c.10 x 10m and 0.5m deep. In overgrown paddock near house, landscaping has taken place in general area.	1815874	5801398

Clough & Associates Ltd

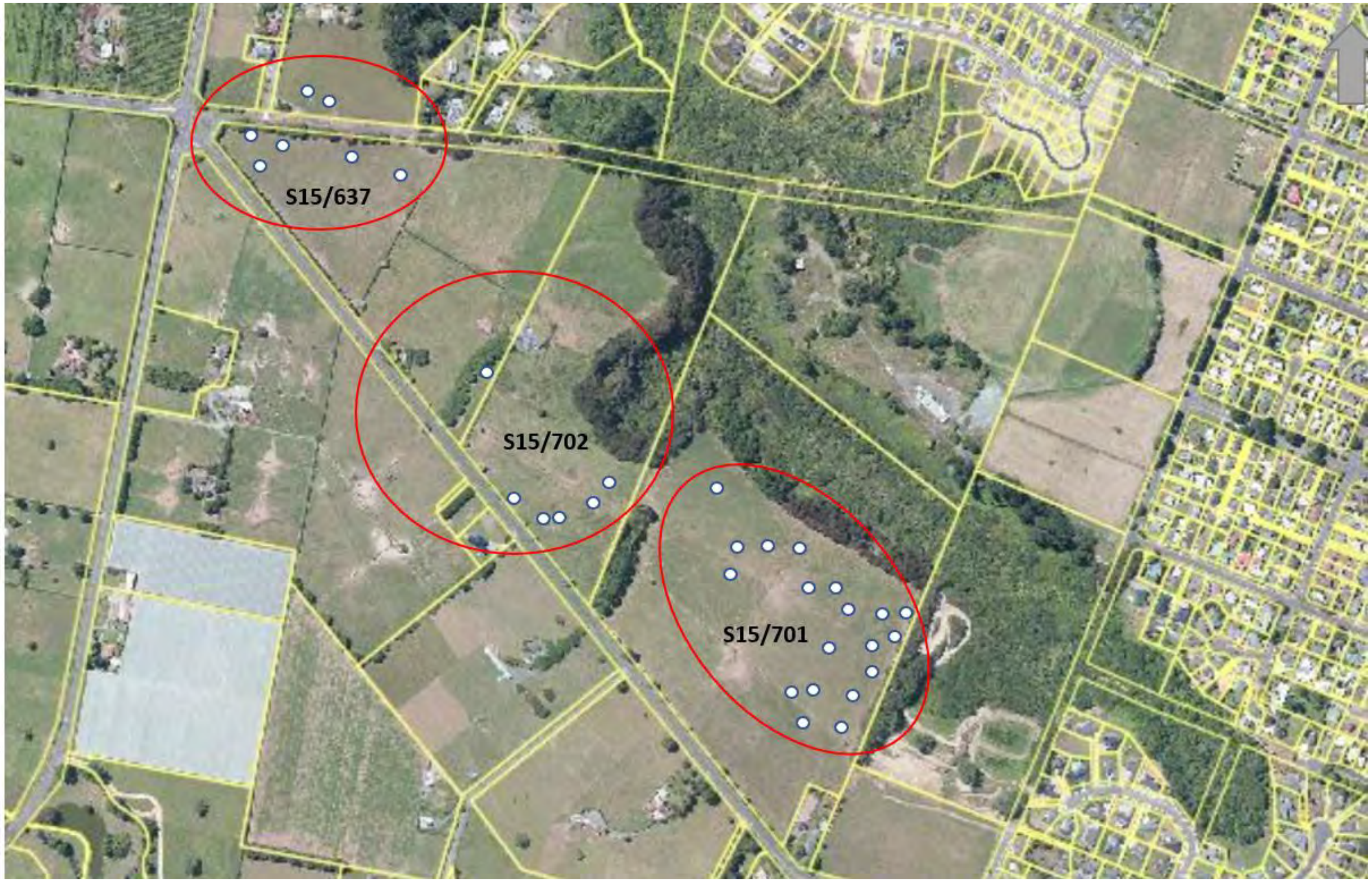


Figure 23. Aerial plan showing the locations of borrow pits identified during the field survey at S15/701, S15/702 and S15/637 (source: Waipa District Council Intramaps)

Discussion and Conclusions

Summary of Results

Six archaeological sites have been previously recorded in Growth Cell C4: S15/23, a pa site, and five borrow pit sites some with associated modified gardening soils (S15/521, S15/637, S15/638, S15/701 and S15/702). A desk-based review and a survey were undertaken as part of this preliminary assessment to gather background information and to make note of the current status and condition of the sites. The review and survey had the following results:

- Pa site S15/23 has been damaged and partially destroyed through house construction
- Sites S15/521 and S15/638, which are located to the west of the pa site, have been impacted through agricultural activities with five borrow pits and modified gardening soils identified in past surveys
- Site S15/637, originally recorded as a single borrow pit, was found to contain seven borrow pits during the survey for this assessment.
- The remaining two sites, S15/701 and S15/702, were originally recorded as containing 30 borrow pits each (from inspection of aerial photographs). During the survey a total of 25 borrow pits were able to be identified at the locations of these two sites, although it is considered likely that additional borrow pits are present and would be revealed after top-soil stripping, as surface evidence has been obscured in some cases through past agricultural activities. The condition of the inspected features ranged from poor to good, with the best preservation being in the southernmost part of the growth cell, i.e. around S15/701.

Maori Cultural Values

This is an assessment of archaeological values and does not include an assessment of Maori cultural values. Such assessments should only be made by the tangata whenua. Maori cultural concerns may encompass a wider range of values than those associated with archaeological sites.

Survey Limitations

It should be noted that archaeological survey techniques (based on visual inspection and minor sub-surface testing) cannot necessarily identify all sub-surface archaeological features, or detect wahi tapu and other sites of traditional significance to Maori, especially where these have no physical remains. All of the properties to the south of Silverwood Lane were accessible. To the north of Silverwood Lane, some of the residential properties were not accessible at the time of the survey, these included: Lots 1 &2 DP 356214, Lot 1 DP 371625, Lots 1 & 2 DP 90107, Lots 4 & 5 DPS 66175, Lots 1 & 2 DPS 81358, Lot 1 DP 309649 and Lots 1, 2 & 3 DPS 78270.

Archaeological Value and Significance

The Waikato Regional Policy Statement (RPS) identifies several criteria for evaluating the significance of historic heritage places. In addition, Heritage NZ, has provided guidelines setting out criteria that are specific to archaeological sites (condition, rarity, contextual value, information potential, amenity value and cultural associations) (Heritage NZ 2006: 9-10). Both sets of criteria have been used to assess the value and significance of archaeological sites S15/521, S15/701, S15/702, S15/637 and S15/638, which have been evaluated collectively in Table 4 and Table 5 as they are all borrow pit sites. S15/23, the pa site has been evaluated separately, with results in Table 6 and Table 7.

The archaeological value of sites relates mainly to their information potential, that is, the extent to which they can provide evidence relating to local, regional and national history using archaeological investigation techniques, and the research questions to which the site could contribute. The surviving extent, complexity and condition of sites are the main factors in their ability to provide information through archaeological investigation. For example, generally pa are more complex sites and have higher information potential than small midden (unless of early date). Archaeological value also includes contextual (heritage landscape) value. Archaeological sites may also have other historic heritage values including historical, architectural, technological, cultural, aesthetic, scientific, social, spiritual, traditional and amenity values.

Overall, the borrow pit sites are considered to have limited archaeological value based on the criteria discussed. This relates mainly to the nature of the sites, which are not complex sites and are very common in the area. As well, borrow pits have been extensively studied in previous archaeological investigations and it is not considered likely that the borrow pit sites would contribute any significant new information to the understanding of Maori horticultural practices. However, borrow pits at other archaeological sites in the area have been found to contain material suitable for carbon dating. If such material is present in the borrow pits or associated features, the archaeological value of the sites in Growth Cell C4 would be increased based on their information potential regarding dates of usage, which could provide information on how Maori settlement patterns developed over time in the Waikato, a subject which is not clearly understood at present. The occurrence of gardening soils represents another element in the archaeological landscape, but does not add significantly to the archaeological value of the sites, as gardening soils are commonly associated with borrow pits and their usage is well understood. Overall, the pa site is considered to have limited to moderate value, the latter based on the site type and the former on the fact that much of the site has been damaged or destroyed.

Table 4. Assessment of the archaeological values of sites S15/521, S15/637, S15/638, S15/701 and S15/702 (borrow pits) based on Heritage NZ criteria (Heritage NZ 2006: 9-10)

Value	Assessment
Condition	The landscape in Growth Cell C4 has undergone varying degrees of modification through historic farming practices and residential development. The best-preserved features are in the southern part of the growth cell. It is also noted that some of the borrow pit features, especially in the north, have been damaged. However, it is considered likely that even where development has damaged the upper layers, deeper archaeology and features may have survived.
Rarity	The sites are not rare as borrow pits are a very common site type in the area.
Contextual value	The borrow pits and gardening soils are associated with an archaeological landscape of Maori settlement and horticulture in the local and regional area.
Information potential	The formation and usage of borrow pits is well understood and it is not considered likely that the archaeological sites would contribute any new or significant

Value	Assessment
	information to the site type. It is, however, noted that dates of early settlement and occupation patterns in the Waikato are not well understood and the archaeological sites have the potential to contain material suitable for radiocarbon dating, which could add to the understanding of these processes.
Amenity value	The borrow pits are situated on private land and have little amenity value, although some can be seen from nearby public roads.
Cultural associations	The sites have Maori cultural association. The cultural significance of the sites is for tangata whenua to determine.
Other	No other values have been identified.

Table 5. Assessment of the heritage significance of sites S15/521, S15/637, S15/638, S15/701 and S15/702 (borrow pits) based on the Waikato Regional Policy Statement (Section 10A Table 10.1)

Archaeological Qualities	
Information	The sites have limited potential to provide new information on horticultural activities in the area and the creation and use of borrow pits is well understood
Research	The sites have limited to moderate potential to provide dating information that could add to the understanding of Maori settlement over time in the local area and along the Waikato River.
Recognition or Protection	The sites are recorded in the NZAA Site Recording Scheme and as pre-1900 archaeological sites are protected under the provisions of the HNZPT Act 2014.
Architectural Qualities	
Not applicable to these sites.	
Cultural Qualities	
Sentiment	The sites are not currently important as a focus of spiritual, political, national or other cultural sentiment. Their Maori cultural value should be determined by tangata whenua.
Identity	The sites are not currently a context for community identity or sense of place and do not provide evidence of cultural or historical continuity.
Amenity or Education	Limited, as the sites are situated on private land, although some can be seen from nearby public roads.
Historic Qualities	
Associative Value	The sites do not have any known direct association with, or relationship to, a person, group, institution, event or activity that is of historical significance to Waikato or the nation.
Historical Pattern	If appropriate material is present for dating purposes it could be used to provide information on temporal patterns of Maori settlement in the local area.
Scientific Qualities	
Information	The sites do not have any particular potential to contribute information about an historic figure, event, phase or activity.
Potential Scientific Research	The research potential of the sites is of an archaeological nature and is addressed under the first heading.
Technological Qualities	
Technical Achievement	The creation of manmade gardening soils was an innovative adaptation to a new environment and the borrow pits as part of this process have some limited technical value.

Table 6. Assessment of the heritage significance of site S15/23 (pa) based on the Waikato Regional Policy Statement (Section 10A Table 10.1)

Archaeological Qualities	
Information	The site is partially destroyed and its potential to contain any archaeological deposits or features that would make a significant contribution to the existing knowledge of Maori settlement in the area is likely to be limited.
Research	If the site does contain any intact features, including material that could be used for radiocarbon dating, this could be used to provide information on patterns of past Maori settlement in the area.
Recognition or Protection	The site is recorded in the NZAA Site Recording Scheme and is a protected archaeological site as defined in the HNZPT Act 2014.
Architectural Qualities	
Not applicable to these sites.	
Cultural Qualities	
Sentiment	The site is not currently important as a focus of spiritual, political, national or other cultural sentiment. Their Maori cultural value should be determined by tangata whenua.
Identity	The site is not currently a context for community identity or sense of place and do not provide evidence of cultural or historical continuity.
Amenity or Education	Limited, as the site is situated on private land and any evidence of the site is only visible from close up.
Historic Qualities	
Associative Value	The site does not have any known direct association with, or relationship to, a person, group, institution, event or activity that is of historical significance to Waikato or the nation.
Historical Pattern	If appropriate material is present for dating purposes it could be used to provide information on temporal patterns of Maori settlement in the local area.
Scientific Qualities	
Information	The site does not have any particular potential to contribute information about an historic figure, event, phase or activity.
Potential Scientific Research	The research potential of the site is of an archaeological nature and is addressed under the first heading.
Technological Qualities	
Technical Achievement	There is no evidence that the site shows a high degree of creative or technical achievement or is associated with scientific or technical innovations or achievements.

Table 7. **Assessment of the archaeological values of site S15/23 based on Heritage NZ criteria (Heritage NZ 2006: 9-10)**

Value	Assessment
Condition	The site has been damaged by house construction and associated landscaping and is considered mostly destroyed, although a ditch may survive.
Rarity	There are a number of pa sites in the area. It is not a rare site type.
Contextual value	The site should not be considered in isolation, as it is part of a wider archaeological landscape of sites associated with settlement around the Waikato River, a highly desirable area for Maori settlement in the past. Its contextual value lies in its contribution to the wider archaeological landscape of the area.
Information potential	This depends on both the ability of a site to provide information relating to the history of New Zealand through archaeological investigation, and on the research questions to which it could contribute. This site has suffered considerable damage from farming activities and has been partially destroyed and the information to be gained from scientific investigation will be limited by the loss of features and elements of the site. It should be noted, however, that any intact features that have survived would contribute to knowledge of Maori settlement of the area.
Amenity value	The site is on private land and currently has limited amenity value.
Cultural associations	The site has Maori cultural association. Its cultural significance is for tangata whenua to determine.
Other	No other values were identified.

Potential Effects of Future Development

Six archaeological sites are located within the boundary of Growth Cell C4 and may be affected by future development. These are S15/23, a partially destroyed pa site, and five borrow pit sites (S15/521, S15/637, S15/638, S15/70 and S15/702) with associated modified gardening soils also present. As Growth Cell C4 is proposed for residential development, it is not considered practical to avoid all impacts on the recorded archaeological sites, which are spread over a relatively large area. However, as the project is at the planning stage, consideration could be given to partial avoidance of some of the borrow pit features, which could be retained and protected in reserve areas within the future development layout, with appropriate interpretation. As the five borrow pit sites are considered to have limited archaeological value, the potential effects on the sites (or parts of sites) if they cannot be avoided during future development is considered to be minor and can be mitigated through recording of both above ground and any sub-surface remains and through collection of information (particularly through collection of material suitable for radiocarbon dating) under the provisions of the HNZPTA.

The pa site S15/23 has been seriously impacted through house construction and associated landscaping and as such the site is considered to have limited archaeological value. However, avoidance of the site should be considered in future development plans, which would allow for the preservation of any remaining features.

Based on historical research it is also considered likely that additional unrecorded subsurface archaeological sites are located within Growth Cell C4 and will be exposed during future development. The remains are expected to be associated firstly, with Maori settlement and horticulture, but possibly with early European settlement as an old dray track was identified on an 1860s plan (see Figure 24). Any unrecorded archaeological sites are not expected to be complex in nature and for sites associated with Maori settlement and horticulture they are likely to consist of additional borrow pits, modified gardening soils, midden and oven remains. As the currently recorded archaeological sites are spread throughout the growth cell, the potential for additional archaeological remains to be present is not confined to any particular area. If any sites associated with early European settlement are present, the remains would likely be associated with past agricultural use or domestic remains, such as a well and rubbish pits may also be present in the southeast corner of the growth cell, where a 1905 plan shows presence of a small subdivided lot and a 1943 aerial photograph shows the presence of buildings (location shown in Figure 24).

As this is a preliminary assessment, once layout and design have been prepared it will be necessary to determine the specific level of effects to both archaeological sites and the broader archaeological landscape and to recommend appropriate mitigation measures.

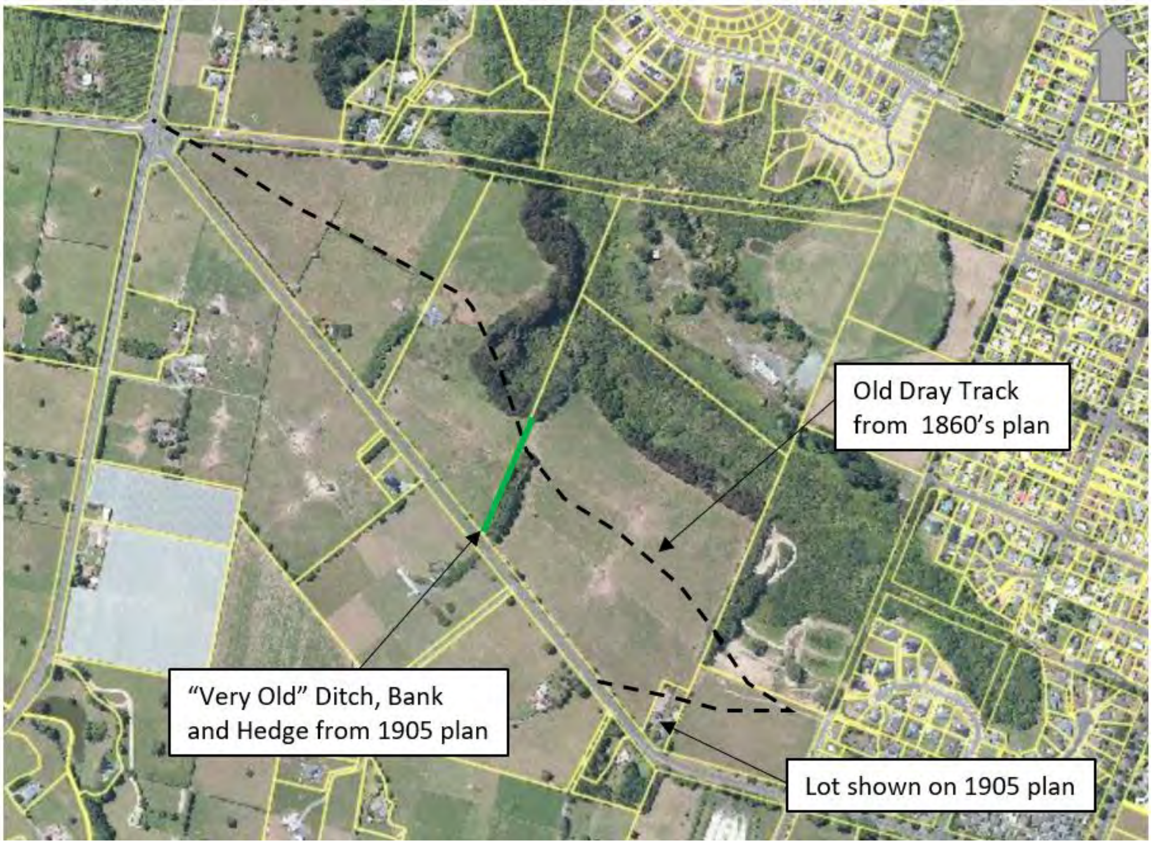


Figure 24. Aerial plan of the southern part of Growth Cell C4 showing the potential areas for containing evidence of early European settlement (source: Waipa District Intramaps)

Resource Management Act 1991 Requirements

Section 6 of the RMA recognises as matters of national importance: 'the relationship of Maori and their culture and traditions with their ancestral lands, water, sites, waahi tapu, and other taonga' (S6(e)); and 'the protection of historic heritage from inappropriate subdivision, use, and development' (S6(f)).

All persons exercising functions and powers under the RMA are required under Section 6 to recognise and provide for these matters of national importance when 'managing the use, development and protection of natural and physical resources'. There is a duty to avoid, remedy, or mitigate any adverse effects on the environment arising from an activity (S17), including historic heritage.

Historic heritage is defined (S2) as 'those natural and physical resources that contribute to an understanding and appreciation of New Zealand's history and cultures, deriving from any of the following qualities: (i) archaeological; (ii) architectural; (iii) cultural; (iv) historic; (v) scientific; (vi) technological'. Historic heritage includes: '(i) historic sites, structures, places, and areas; (ii) archaeological sites; (iii) sites of significance to Maori, including wahi tapu; (iv) surroundings associated with the natural and physical resources'.

Regional, district and local plans contain sections that help to identify, protect and manage archaeological and other heritage sites. The plans are prepared under the provisions of the RMA. The Waipa District Plan is relevant to the proposed activity.

This assessment has established that future development in Growth Cell C4 has the potential to affect six previously recorded archaeological sites (S15/23, S15/521, S15/637, S15/638, S15/701 and S15/702). There is also potential for additional unrecorded archaeological remains to be present within Growth Cell C4.

An evaluation of archaeological values of the recorded archaeological sites has been prepared and levels of effects have been predicted based on planned future development, which is proposed to be residential. Only one of the sites, S15/23 is listed in Appendix N3 on the Waipa District Plan. It should be noted however, that all archaeological sites are protected under the provisions of the Heritage New Zealand Pouhere Taonga Act (see below). Preliminary mitigation measures for the recorded sites are included in this report, but further assessment and detailed mitigation recommendations will be required once future development plans have been prepared.

Heritage New Zealand Pouhere Taonga Act 2014 Requirements

In addition to any requirements under the RMA, the HNZPTA protects all archaeological sites whether recorded or not, and they may not be damaged or destroyed unless an Authority to modify an archaeological site has been issued by Heritage NZ (Section 42).

An archaeological site is defined by the HNZPTA Section 6 as follows:

> '**archaeological site** means, subject to section 42(3)[2], –
>
> (a) any place in New Zealand, including any building or structure (or part of a building or structure) that –

[2] Under Section 42(3) an Authority is not required to permit work on a pre-1900 building unless the building is to be demolished.

(i) was associated with human activity that occurred before 1900 or is the site of the wreck of any vessel where the wreck occurred before 1900; and

(ii) provides or may provide, through investigation by archaeological methods, evidence relating to the history of New Zealand; and

(b) includes a site for which a declaration is made under section 43(1)[3]'

Authorities to modify archaeological sites can be applied for either in respect to archaeological sites within a specified area of land (Section 44(a)), or to modify a specific archaeological site where the effects will be no more than minor (Section 44(b)), or for the purpose of conducting a scientific investigation (Section 44(c)). Applications that relate to sites of Maori interest require consultation with (and in the case of scientific investigations the consent of) the appropriate iwi or hapu and are subject to the recommendations of the Maori Heritage Council of Heritage NZ. In addition, an application may be made to carry out an exploratory investigation of any site or locality under Section 56, to confirm the presence, extent and nature of a site or suspected site.

At present six archaeological sites have been identified in Growth Cell C4. Based on the findings of the background research and survey it is considered likely that other unrecorded sub-surface archaeological remains related to Maori settlement and horticulture and also possibly to early European Settlement may be present.

If modification of a pre-1900 archaeological site/s is necessary for future development, an Authority issued under the HNZPTA would be required prior to the commencement of site works. This would also apply to unrecorded archaeological sites in the growth cell.

Conclusions

This assessment has identified existing and potential heritage constraints in Growth Cell C4 in the form of six recorded archaeological sites and the potential for unrecorded archaeological sites to be present. The recorded sites consist of a pa site (S15/23) that has been modified by house construction and five borrow pit sites (S15/521, S15/637, S15/638, S15/701 and S15/702) extending over much of the growth cell. Although the full effects on archaeological values are not yet known, it is recommended that future development plans should take account recorded archaeological sites and avoid them fully or partially where possible. If avoidance is not possible, an authority issued by Heritage NZ would be required before any modification or destruction of the recorded sites (as well as any unrecorded archaeological sites) occurs as a result of future development. Mitigation measures would also be required for any impacts on recorded and unrecorded archaeological sites, which would generally be in the form of archaeological recording and investigation to recover information relating to the history of the area.

[3] Under Section 43(1) a place post-dating 1900 (including the site of a wreck that occurred after 1900) that could provide '*significant evidence relating to the historical and cultural heritage of New Zealand*' can be declared by Heritage NZ to be an archaeological site.

Clough & Associates Ltd

RECOMMENDATIONS

- Future development plans should take account of the locations of the recorded archaeological sites and ensure that they are avoided to the extent possible.
- Further assessment will be required once plans for the future development have been prepared and this report should be updated accordingly.
- If any of the recorded sites cannot be avoided, an Authority must be applied for under Section 44(a) of the HNZPTA and granted by Heritage NZ prior to the start of any works that will affect them. (*Note that this is a legal requirement*).
- The tangata whenua should be consulted regarding the potential cultural effects of future development as part of the Structure Plan process.

BIBLIOGRAPHY

Allen, P. 1969. Military Settlement in the Middle Waikato Basin. Thesis presented in partial fulfilment of the requirements for the Degree of M. Phil in Geography. University of Waikato.

Belich, J. 1986. *The New Zealand Wars and the Victorian Interpretation of Racial Conflict*. Auckland University Press, Auckland.

Campbell M. 2012. Cambridge Section of the Waikato Expressway: Archaeological Desktop Study. CFG Heritage Report to The New Zealand Transport Agency and the New Zealand Historic Places Trust.

Cowan, J. 1955. *The New Zealand Wars: A History of the Maori Campaigns and the Pioneering Period*: Volume I *(1845–64)*, sourced at http://nzetc.victoria.ac.nz/tm/scholarly/tei-Cow01NewZ-c35.html. Copyright: 2016 Victoria University of Wellington.

DSIR (New Zealand Department of Scientific and Industrial Research) 1954. General survey of the soils of North Island, New Zealand. Soil Bureau Bulletin (n.s.), 5.

Gumbley, W. and M. Laumea. 2018. Amberfield – Assessment of Archaeological Values and Effects. W Gumbley Ltd Report for Weston Lea Ltd.

Heritage NZ. 2006. Writing Archaeological Assessments. Archaeological Guidelines Series No. 2. New Zealand Historic Places Trust Pouhere Taonga (now Heritage NZ).

Hutchinson, M. and A. Simmons. 2016. Waikato District Plan Review Archaeological Heritage Project Phase I. Simmons and Associates Report prepared for Waikato District Council.

Lowe, D.J. 2010. Introduction to the landscapes and soils of the Hamilton Basin. In D.J. Lowe, V.E. Neall, M. Hedley, B. Clothier and A. Mackay. 2010. Guidebook for Pre-conference North Island, New Zealand 'Volcanoes to Oceans' field tour (27- 30 July). 19th World Soils Congress, International Union of Soil Sciences, Brisbane. *Soil and Earth Sciences Occasional Publication* No. 3, Massey University, Palmerston North, pp. 1.24-1.61.

McLeod, M. 1992. Soils of Part Northern Matamata County, North Island, New Zealand. DSIR Land Resources Hamilton, Scientific Report no. 18.

McLeod, M. 1984. Soils of the Waikato Lowlands. *Soil Bureau District Office Report*, HN 11.

Walton T. and R. Cassels. 1992. Borrow pits and made soils near Waverly, South Taranaki. *Archaeology in New Zealand* 35:160-171.

<u>Internet Sources</u>

Cambridge Museum Website accessed at : http://cambridgemuseum.org.nz

New Zealand Archaeological Association ArchSite Database, accessed at http://www.archsite.org.nz.

New Zealand Heritage List, accessed at http://www.historic.org.nz

TeAra - Rāwiri Taonui. 'Canoe traditions - Te Arawa and Tainui', Te Ara - the Encyclopedia of New Zealand, updated 22-Sep-12 accessed at http://www.TeAra.govt.nz/en/canoe-traditions/page-5

Waipa District Council (2008). Physical environment profile statement accessed at: http://www.waipadc.govt.nz/our-council/Waipa2050/DistrictGrowthStrategy/Documents/Physical%20Environment%20Profile%20Statement.pdf

<u>Old Newspaper articles accessed at</u> https://paperspast.natlib.govt.nz/newspapers

Daily Southern Cross 29 November 1864

APPENDIX A: SITE RECORD FORMS

NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

ARCHSITE archaeological site recording scheme

Site Record Form

NZAA SITE NUMBER: S15/23

SITE TYPE: Pa

SITE NAME(s):

DATE RECORDED:

SITE COORDINATES (NZTM) Easting: 1815831 **Northing:** 5802104 **Source:** On Screen

IMPERIAL SITE NUMBER: N65/43 **METRIC SITE NUMBER:** S15/23

Finding aids to the location of the site

Leamington. 300m SE of a sharp bend in Cambridge Road, on edge of stream gully.

Brief description

Roughly rectangular pa 50 x 50m, with single transverse ditch, lateral pits and terraces.

Recorded features

Ditch - transverse, Pit, Terrace

Other sites associated with this site

Printed by: ellencameron 11/05/2019

1 of 4

NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

SITE RECORD HISTORY	NZAA SITE NUMBER: S15/23

Site description

Updated: 18/07/2012 - NZTM E1815831 / N5802104 (On Screen). Location visible on Waikato Regional Council (Environment Waikato) Aerial Photographs 2002. House built on site ca. 1980. Intensive cultivation adjoining. Ditch may survive. Updated by: Coster, John (NZAA Upgrade Project, 2008-2009).

Condition of the site

Statement of condition

Current land use:

Threats:

NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

SITE RECORD INVENTORY	NZAA SITE NUMBER: S15/23

Supporting documentation held in ArchSite

AD BC AE BD AA TD

NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

SITE RECORD FORM

Map number N65
Map name Hamilton
Map edition 3rd
Grid Reference 956 330

SITE NUMBER N65/43

SITE NAME: MAORI
OTHER

SITE TYPE Pa

1. Aids to relocation of site E295600 N533000

Top of hill one mile east of Leamington - 200 yards to left of road (overlooking steep gully

2. State of site; possibility of damage or destruction

Ploughed out single unit site in grass

3. Description of site *(NOTE: This section is to be completed ONLY if no separate Site Description Form is to be prepared.)*

Square site approximately 45m x 45m. East and south sides fairly steep with small spur and possible house sites out from SE corner. North side steepish with some house terraces. West side ditch and bank pretty well filled in

4. Owner A Higgins
Address Cambridge

Tenant/Manager
Address

Attitude

Attitude

5. Methods and equipment used visit site with compass and tape

Photographs taken: ~~Yes~~/No (Describe on Photograph Record Form)
Date recorded 30 September 1973

6. Aerial photograph or mosaic No. 2173/34 x 35

Site shows: ~~Clearly~~/badly/~~not at all~~

7. Reported by NC Laurie
Address RD 9
Frankton

Date 1 May 1974

Filekeeper J.P. Elton per K. Sorby

Date 28/10/76.

Printed by: ellencameron

11/05/2019

3 of 4

NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

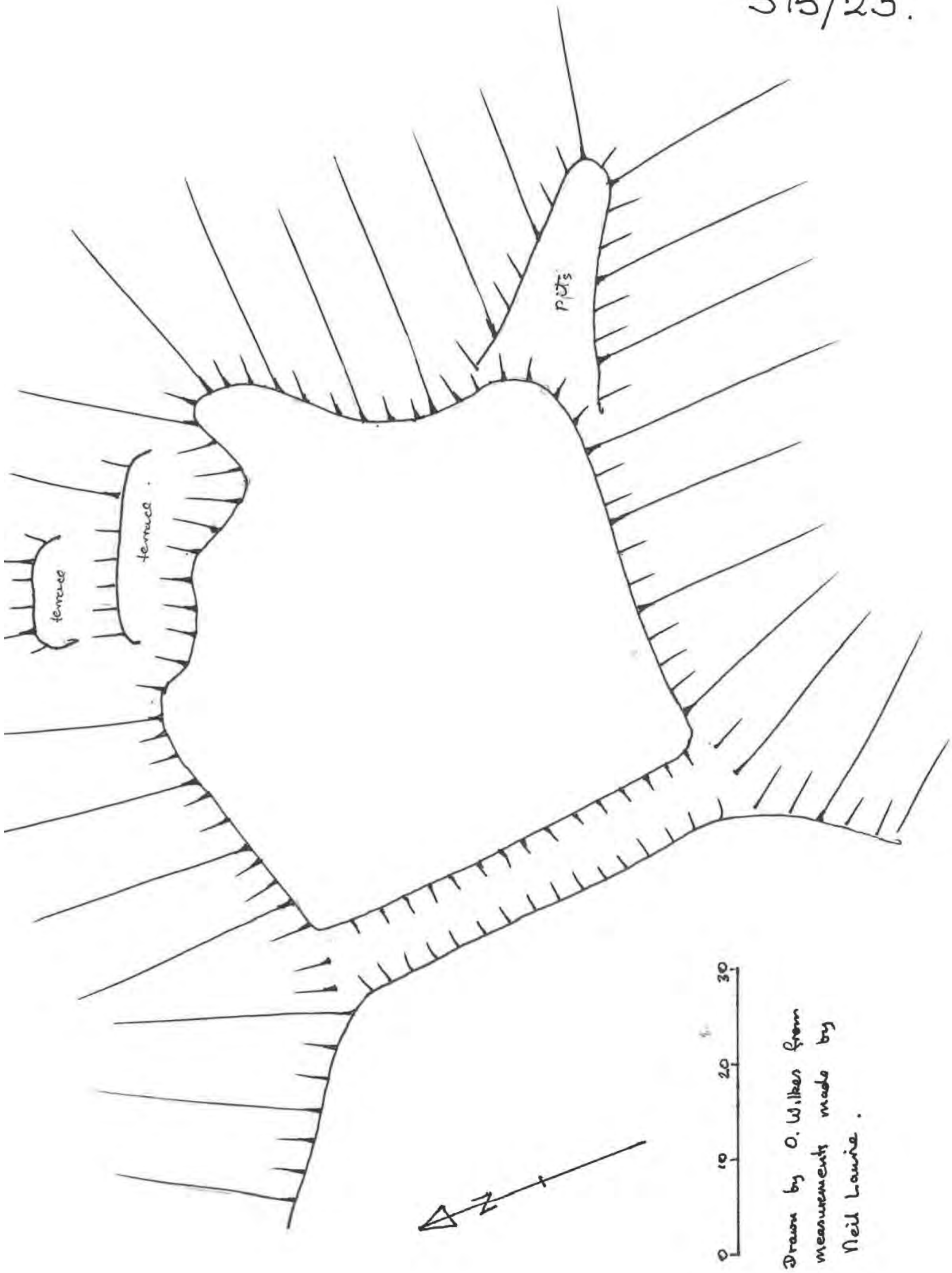
PHOTOGRAPHS AND SLIDES

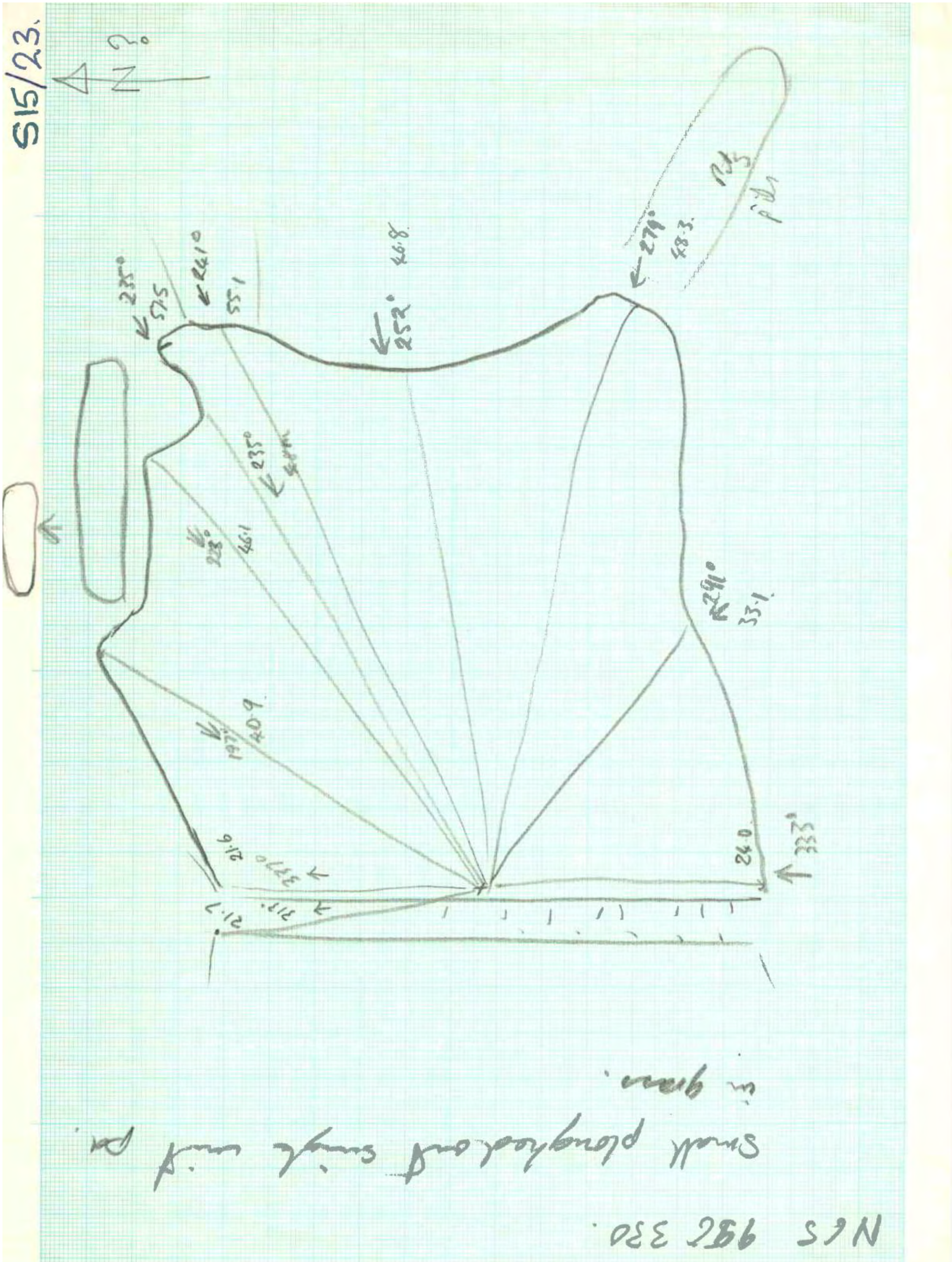
SITE NUMBER N65/43	GRID REFERENCE 956330
NZHPT COLLECTION	CENTRAL FILE AR 3158 (W.A.M. 1980)

Printed by: ellencameron 11/05/2019

4 of 4

S15/23.


pits
terrace
terrace
N
0
10
20
30
Drawn by O. Wilkes from measurements made by Neil Laurie.



NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

ARCHSITE archaeological site recording scheme

Site Record Form

NZAA SITE NUMBER: S15/521

SITE TYPE: Maori horticulture

SITE NAME(s):

DATE RECORDED: 23/03/2012

SITE COORDINATES (NZTM) Easting: 1815661 **Northing:** 5802208 **Source:** On Screen

IMPERIAL SITE NUMBER: **METRIC SITE NUMBER:**

Finding aids to the location of the site

Brief description

5 borrow pits in an area of 120 x 60 m, visible on aerial photo SN266/835/59.

Recorded features

Borrow pit

Other sites associated with this site

Printed by: ellencameron 11/05/2019

1 of 3

NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

SITE RECORD HISTORY	NZAA SITE NUMBER: S15/521

Site description

Updated: 23/03/2012 - NZTM E1815661 / N5802208 (On Screen). 5 borrow pits in an area of 120 x 60 m, visible on aerial photo SN266/835/59. Aerial photo dates from 1943. The site has not been visited and its current condition has not been ascertained. Updated by: Campbell, Matthew.

Condition of the site

Statement of condition

Current land use:

Threats:

NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

SITE RECORD INVENTORY	NZAA SITE NUMBER: S15/521

Supporting documentation held in ArchSite

Site record update: S15/521 and S15/638

14 May 2014

Site survey was carried out on 10 May 2014 by Warren Gumbley and Malcolm Hutchinson.

As well as identification of the remaining surface visible borrow pits, a survey of the soil using a 25 mm screw-type soil augur was undertaken to identify the presence of Maori modified soil (Tamahere loam).

The results indicate that S15/521 and S15/638 are aspects of the same pre-European Maori horticulture site. The immediate proximity of this horticultural site indicates an immediate association with the un-named paa S15/23.

Figure 1 is a 1943 aerial photograph showing the locations of the surface borrow pits and the soil examination locations. The yellow dots indicate the presence of Tamahere loam.

Figure 2 shows the same information overlaid on a 2012 aerial photograph.

Note: the gap in the survey in the area of the current house and curtilage in the middle of each image represents a now destroyed part of the horticulture site.

The site has been affected by rural residential subdivision, which has destroyed approximately 20-25 % of the site. The ditch of S15/23 remains while most of the rest of the paa has been badly damaged.

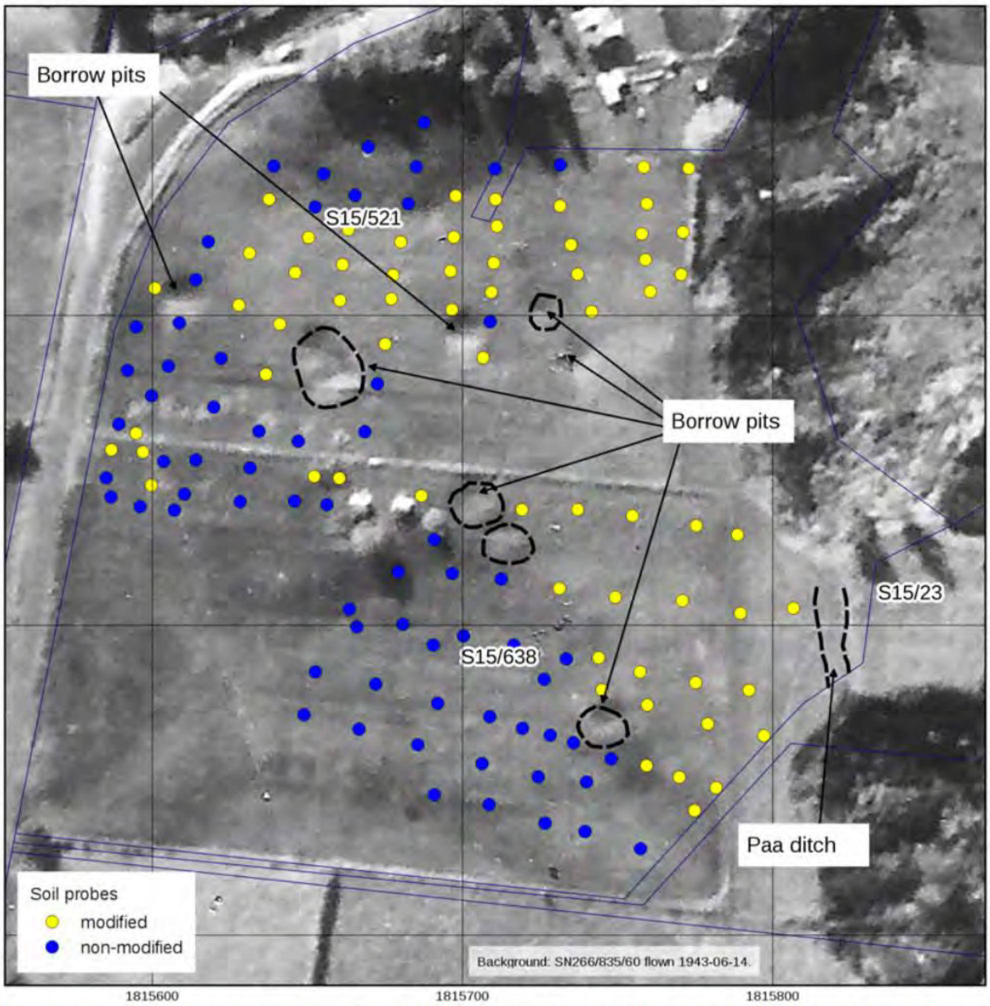


Figure 1: Aerial photograph SN 266/853/59 flown 13/9/1943. Black dashed outlines show the currently visible borrow pits. The yellow dots indicate the current extent of the Maori modified soils (Tamahere loam). Note grid-lines are at 100 m intervals; datum = NZGD 2000; projection NZTM.

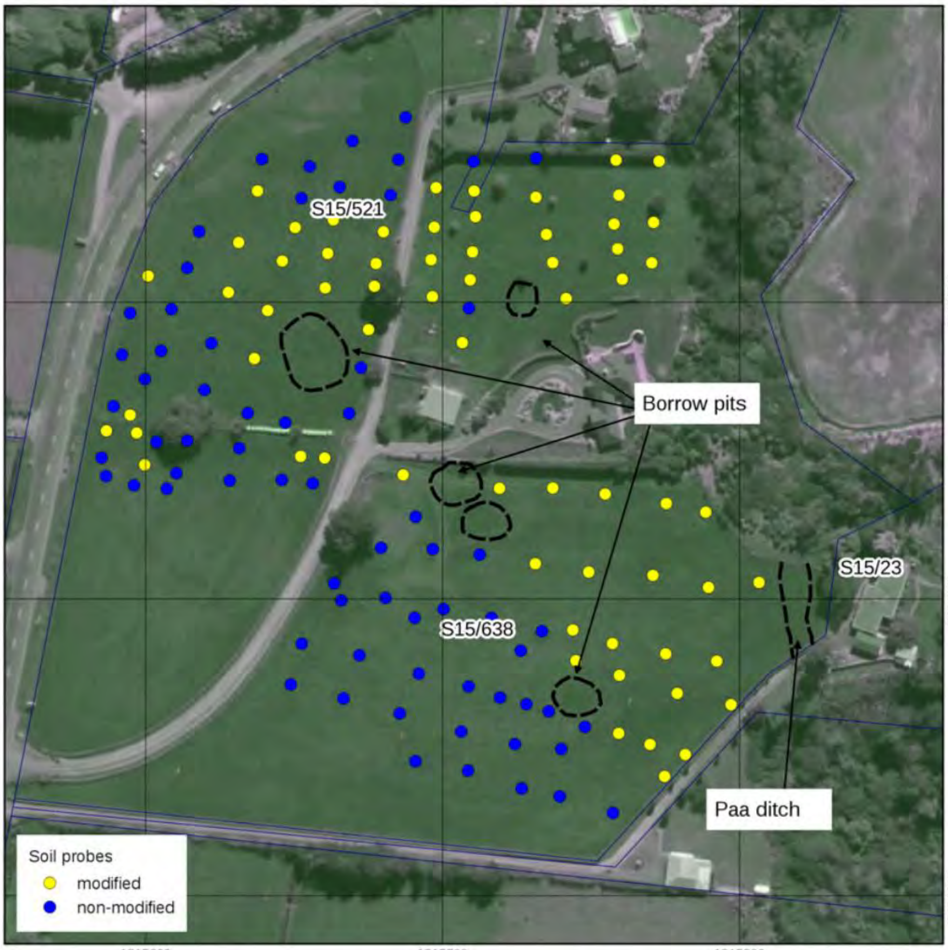


Figure 2: Site survey data overlaid on 2012 aerial photographs (WRAPS 2012 tile BD35_1005). Black dashed outlines show the currently visible borrow pits. The yellow dots indicate the current extent of the Maori modified soils (Tamahere loam). Note grid-lines are at 100 m intervals; datum = NZGD 2000; projection NZTM.

NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

ARCHSITE archaeological site recording scheme

Site Record Form

NZAA SITE NUMBER: S15/637

SITE TYPE: Maori horticulture

SITE NAME(s):

DATE RECORDED: 26/04/2012

SITE COORDINATES (NZTM) Easting: 1815686 **Northing:** 5801845 **Source:** On Screen

IMPERIAL SITE NUMBER: **METRIC SITE NUMBER:**

Finding aids to the location of the site

The site is located on the northern and southern sides of Silverwood Lane. Location of originally identified borrow pit features now has a house on it.

Brief description

Single borrow pit visible on aerial photo SN266/835/59.

Recorded features

Borrow pit

Other sites associated with this site

Printed by: ellencameron 18/08/2019

1 of 3

NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

SITE RECORD HISTORY	NZAA SITE NUMBER: S15/637

Site description

Updated 18/08/2019 (Field visit), submitted by ellencameron , visited 25/07/2019 by Cameron, Ellen
Grid reference (E1815686 / N5801845)

A site visit identified two borrow pits to the north of Silverwood Lane and five borrow pits to the south. All of the pits are located in grassed paddocks. The site visit was for a preliminary assessment and it is considered likely that additional borrow pits may be present that cannot be identified from surface evidence.

Borrow pits - Coordinates and description

South of Silverwood Lane
c. 10 x 15 m and 1.5m deep. In padddock no obvious impacts. 1815756 5801639
c. 10 x 15 m and 1.5m deep. In paddock no obvious impacts. 1815735 5801666
c. 15 x 20m and 2 m deep. In paddock no obvious impacts. 1815627 5801693
c. 20 x 30m and 2m deep. In paddock no obvious impacts. 1815570 5801670
c. 10 x 5m and .5 m deep. In paddock no obvious impacts. 1815592 5801670

North of Silverwood Lane
Has been used to dump rubbish and ground has been disturbed. Original area and depth indeterminate. 1815667 5801731
c. 5 x 10 m and .5 m located along fence line and area has been impacted by bulldozer activity. 1815660 5801741

Updated: 26/04/2012 - NZTM E1815686 / N5801845 (On Screen). Single borrow pit visible on aerial photo SN266/835/59. Aerial photo dates from 1943. The site has not been visited and its current condition has not been ascertained. Updated by: Campbell, Matthew.

Condition of the site

Updated 18/08/2019 (Field visit), submitted by ellencameron , visited 25/07/2019 by Cameron, Ellen

The site is located in paddocks and past agricultural activities have damaged the upper levels of the soil.

Statement of condition

Current land use:

Threats:

NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

SITE RECORD INVENTORY	NZAA SITE NUMBER: S15/637

Supporting documentation held in ArchSite

Printed by: ellencameron

18/08/2019

3 of 3

NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

ARCHSITE archaeological site recording scheme

Site Record Form

NZAA SITE NUMBER: S15/638

SITE TYPE: Maori horticulture

SITE NAME(s):

DATE RECORDED: 26/04/2012

SITE COORDINATES (NZTM) Easting: 1815731 **Northing:** 5802067 **Source:** On Screen

IMPERIAL SITE NUMBER: **METRIC SITE NUMBER:**

Finding aids to the location of the site

Brief description

Single borrow pit visible on aerial photo SN266/835/59.

Recorded features

Borrow pit

Other sites associated with this site

Printed by: ellencameron 11/05/2019

1 of 3

NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

SITE RECORD HISTORY	NZAA SITE NUMBER: S15/638

Site description

Updated: 26/04/2012 - NZTM E1815731 / N5802067 (On Screen). Single borrow pit visible on aerial photo SN266/835/59. Aerial photo dates from 1943. The site has not been visited and its current condition has not been ascertained. Updated by: Campbell, Matthew.

Condition of the site

Statement of condition

Current land use:

Threats:

NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

SITE RECORD INVENTORY	NZAA SITE NUMBER: S15/638

Supporting documentation held in ArchSite

Printed by: ellencameron

11/05/2019

3 of 3

Site record update: S15/521 and S15/638

14 May 2014

Site survey was carried out on 10 May 2014 by Warren Gumbley and Malcolm Hutchinson.

As well as identification of the remaining surface visible borrow pits, a survey of the soil using a 25 mm screw-type soil augur was undertaken to identify the presence of Maori modified soil (Tamahere loam).

The results indicate that S15/521 and S15/638 are aspects of the same pre-European Maori horticulture site. The immediate proximity of this horticultural site indicates an immediate association with the un-named paa S15/23.

Figure 1 is a 1943 aerial photograph showing the locations of the surface borrow pits and the soil examination locations. The yellow dots indicate the presence of Tamahere loam.

Figure 2 shows the same information overlaid on a 2012 aerial photograph.

Note: the gap in the survey in the area of the current house and curtilage in the middle of each image represents a now destroyed part of the horticulture site.

The site has been affected by rural residential subdivision, which has destroyed approximately 20-25 % of the site. The ditch of S15/23 remains while most of the rest of the paa has been badly damaged.

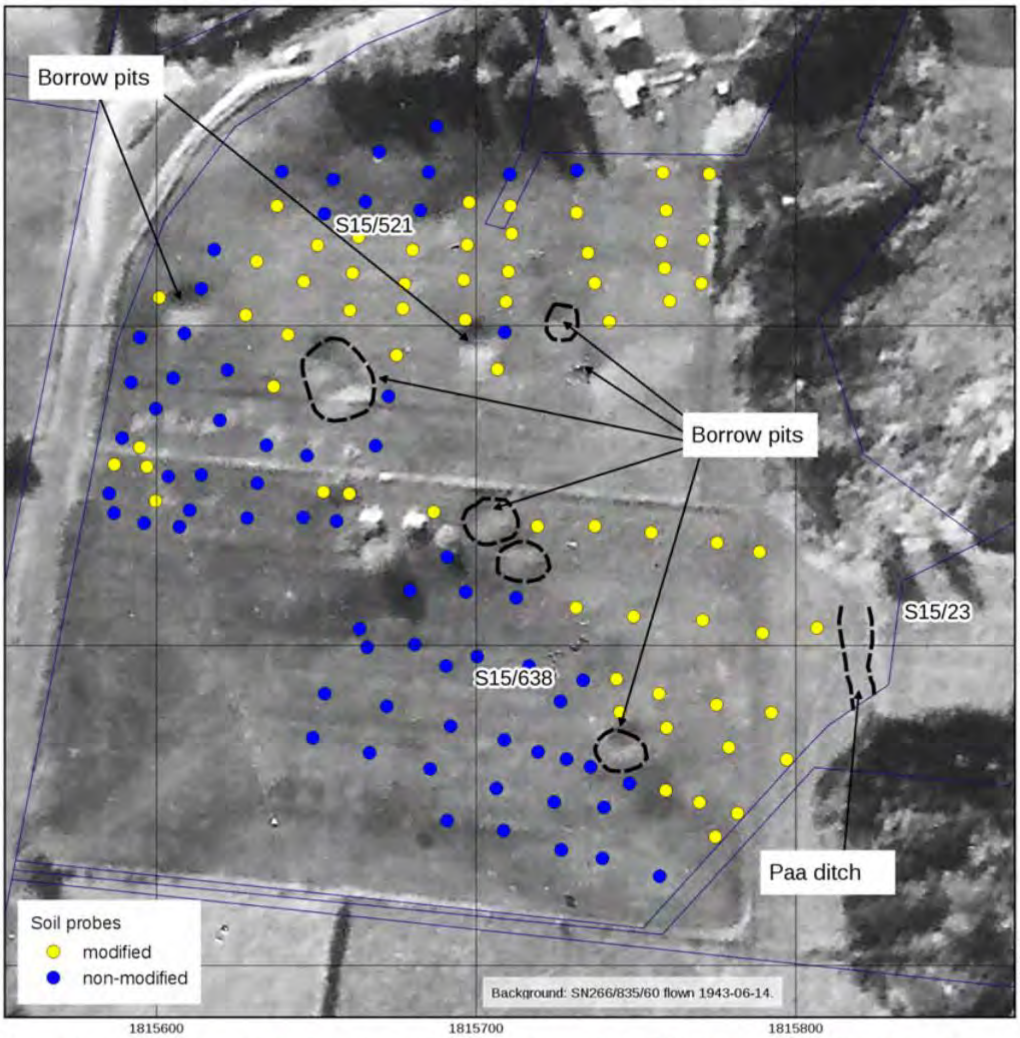


Figure 1: Aerial photograph SN 266/853/59 flown 13/9/1943. Black dashed outlines show the currently visible borrow pits. The yellow dots indicate the current extent of the Maori modified soils (Tamahere loam). Note grid-lines are at 100 m intervals; datum = NZGD 2000; projection NZTM.

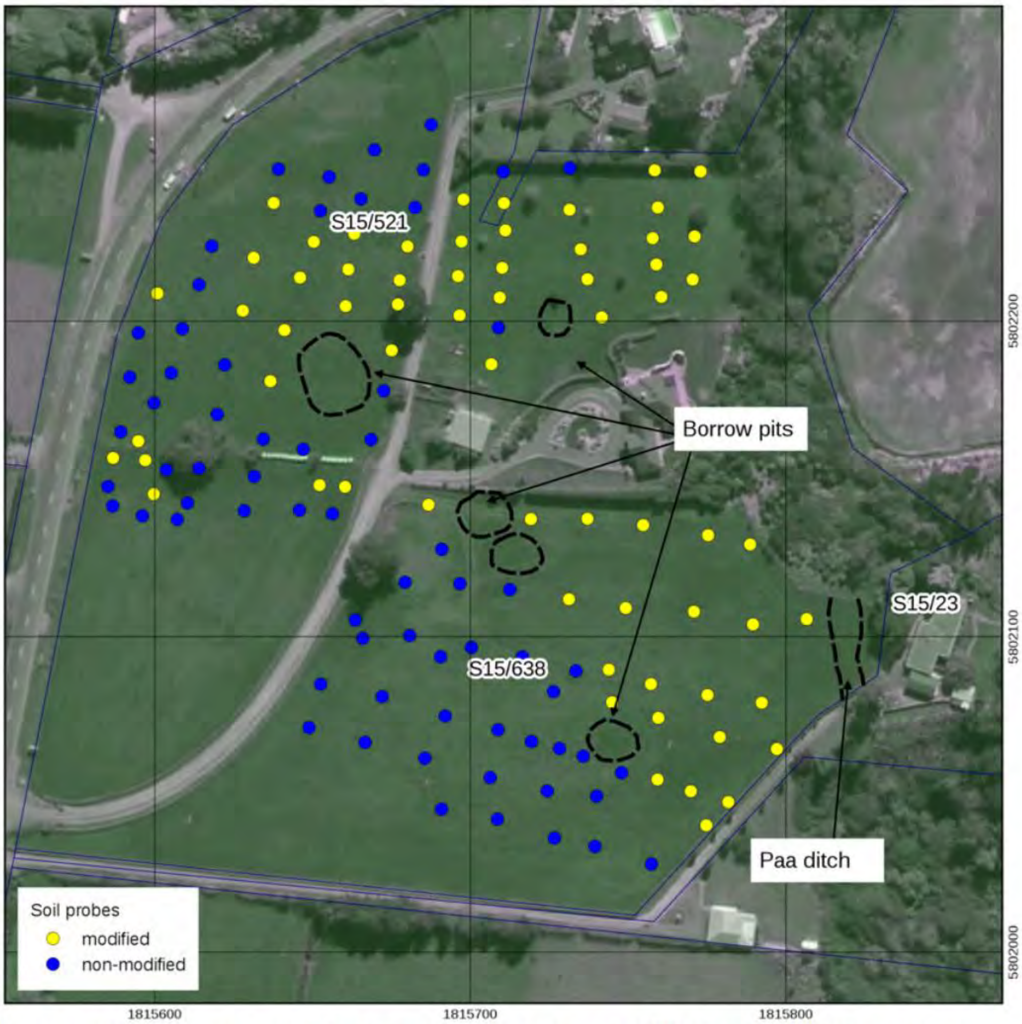


Figure 2: Site survey data overlaid on 2012 aerial photographs (WRAPS 2012 tile BD35_1005). Black dashed outlines show the currently visible borrow pits. The yellow dots indicate the current extent of the Maori modified soils (Tamahere loam). Note grid-lines are at 100 m intervals; datum = NZGD 2000; projection NZTM.

NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

ARCHSITE archaeological site recording scheme

Site Record Form

NZAA SITE NUMBER: S15/701

SITE TYPE: Maori horticulture

SITE NAME(s):

DATE RECORDED: 17/12/2013

SITE COORDINATES (NZTM) Easting: 1816264 **Northing:** 5801020 **Source:** On Screen

IMPERIAL SITE NUMBER: **METRIC SITE NUMBER:**

Finding aids to the location of the site

Brief description

30 borrow pits

Recorded features

Borrow pit, Unclassified

Other sites associated with this site

Printed by: ellencameron 11/05/2019

1 of 3

NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

SITE RECORD HISTORY	NZAA SITE NUMBER: S15/701

Site description

Updated: 17/12/2013 - to follow

Condition of the site

Statement of condition

Current land use:

Threats:

NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

SITE RECORD INVENTORY	NZAA SITE NUMBER: S15/701

Supporting documentation held in ArchSite

Printed by: ellencameron 11/05/2019

3 of 3

NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

ARCHSITE
archaeological site recording scheme

Site Record Form

NZAA SITE NUMBER: S15/702

SITE TYPE: Maori horticulture

SITE NAME(s):

DATE RECORDED: 17/12/2013

SITE COORDINATES (NZTM) Easting: 1815883 **Northing:** 5801460 **Source:** On Screen

IMPERIAL SITE NUMBER: **METRIC SITE NUMBER:**

Finding aids to the location of the site

Brief description

30 borrow pits

Recorded features

Borrow pit, Unclassified

Other sites associated with this site

Printed by: ellencameron

11/05/2019

1 of 3

NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

SITE RECORD HISTORY	NZAA SITE NUMBER: S15/702

Site description

Updated: 17/12/2013 - to follow

Condition of the site

Statement of condition

Current land use:

Threats:

NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

SITE RECORD INVENTORY	NZAA SITE NUMBER: S15/702

Supporting documentation held in ArchSite

Printed by: ellencameron

11/05/2019

3 of 3

Te Awamutu T6 Structure Plan

Context Report
Prepared for Waipa District Council
25 June 2020

Document Quality Assurance

Bibliographic reference for citation:
Boffa Miskell Limited 2020. *Te Awamutu T6 Structure Plan: Context Report*. Report prepared by Boffa Miskell Limited for Waipa District Council.

Prepared by:	Dave Moule Planner / Senior Principal Boffa Miskell Limited	
Reviewed by:	Craig Batchelar Planner / Partner Boffa Miskell Limited	
Status: Final	Revision / version: 4	Issue date: 25 June 2020

Template revision: 20140327 0000

Cover photograph: Google Maps

CONTENTS

Appendices

1.0 Introduction

1.1 Background

The Waipa District has been identified as a high growth area in the National Policy Statement on Urban Development Capacity (NPS-UDC).

The townships of Te Awamutu and Kihikihi are forecast to grow by 5,400 people by 2050. To provide for this growth, Council has set out to prepare a structure plan for the T6 growth cell, as identified in the Waipa 2050 Growth Strategy (2017), Waipa 2018-28 Long Term Plan, and Plan Change 5 to the Waipa District Plan.

The T6 growth cell is a 168ha area of land located to the west of State Highway 3 between Te Awamutu and Kihikihi.

The growth cell is currently zoned Deferred Large Lot Residential.

Specific provision for large lot residential development is identified within T6. This location is considered suitable for this land use as it expands on the existing large lot residential area on St Leger Road and provides for some growth between Te Awamutu and Kihikihi, where other land use practices may otherwise not be appropriate.

This growth cell has been identified in the Waipa District Plan as a location for “non-serviced” (water only) large lot residential development, providing an alternative form of living choice to other greenfield developments in Te Awamutu.

Plan Change 5 to the Waipa District Plan was a public plan change that was made operative on 14 March 2019 and amended the District Plan to incorporate key changes made to the updated Waipa 2050 Growth Strategy (Waipa 2050). These changes are important in taking account of revised population projections and the requirements of the NPS-UDC. The Plan Change rezoned all of the growth cells identified in the Growth Strategy zoned as “Rural” to “Deferred”.

1.2 Purpose of this report

The purpose of this report is to provide context to the design process that has informed the Structure Plan and to confirm the relevant statutory planning framework and associated procedural requirements to enable Council’s decision-making process and investment in the next phase of facilitating development within the T6 growth cell.

To ensure that development is consistent with the Council’s strategic direction as set out in Waipa 2050 and the Waipa District Plan, Council commissioned Boffa Miskell to develop a Structure Plan and to identify servicing requirements for the T6 growth cell in consultation with landowners and key stakeholders. The Final Structure Plan was endorsed an Extraordinary Council Meeting on 7 April 2020 and is attached to this report as **Appendix One.**

Design Guidelines have also been developed to support the implementation of the Structure Plan and to ensure that, as these areas are developed, the community and Council can be assured of a high level of quality and consistency for any future development. It is acknowledged that the guidelines have no statutory weight and are unlikely to be embedded into the District Plan by way of a Plan Change, however they have been developed as a guidance document for landowners and Council. The Design Guidelines are attached to this report as **Appendix Two.**

The development of the Structure Plan and Design Guidelines have been informed by background reports and technical assessments previously commissioned by Council and updated technical assessments completed by Tonkin & Taylor.

The updated technical assessments have been prepared to demonstrate that the growth cells are suitable for urban development, including consideration of three waters infrastructure, transportation, and liquefaction. The technical assessments prepared by Tonkin & Taylor are attached to this report as **Appendix Three.**

2.0 Site Context

2.1 T6 Growth Cell – Large Lot Residential

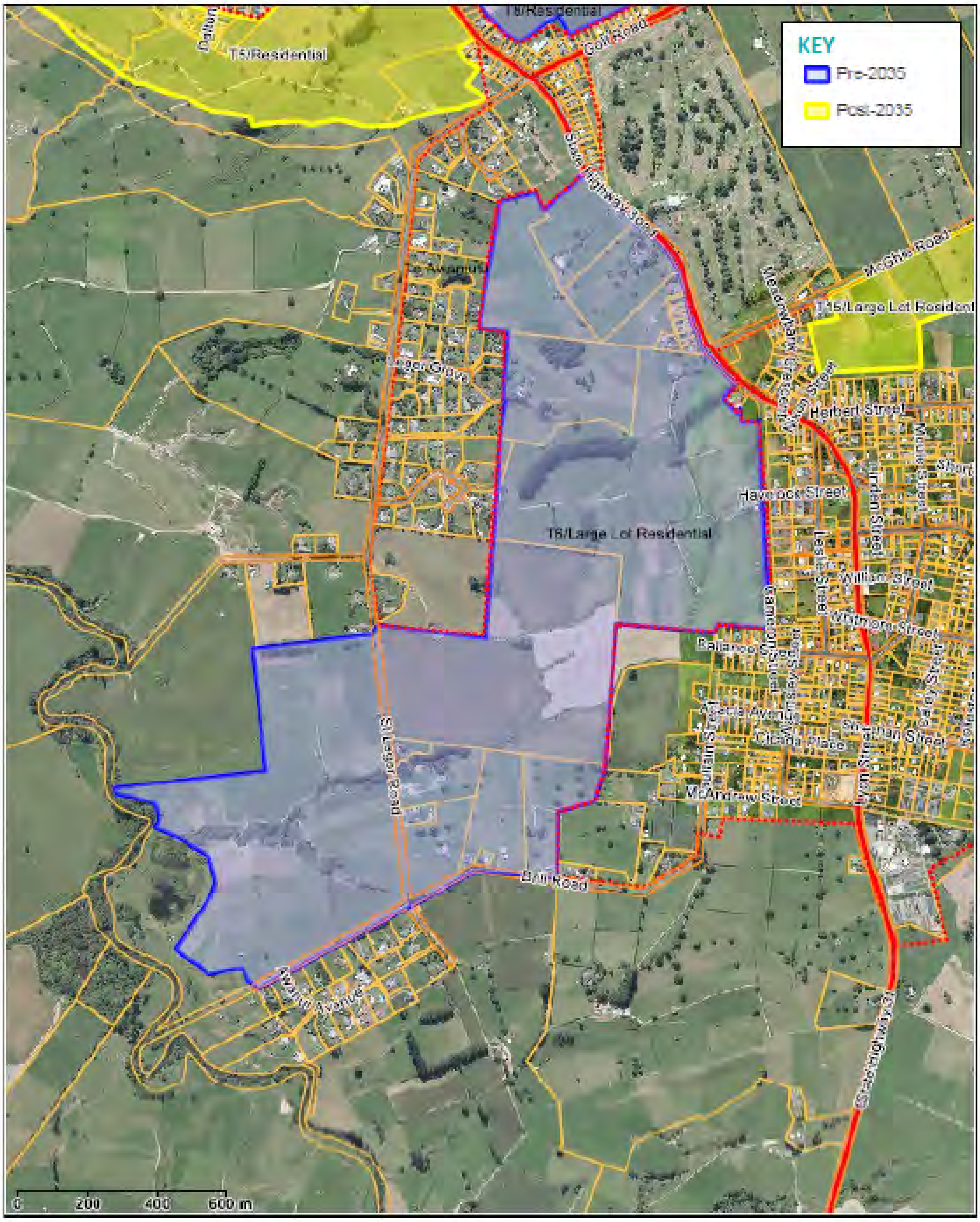


Figure 1 – T6 Large-Lot Residential Growth Cell, Te Awamutu

The T6 growth cell is predominantly characterised by rolling pasture, large mature vegetation, and large residential dwellings and spacious lots typical of the semi-rural environment on the perimeter of the Te Awamutu and Kihikihi townships. There is a large natural gully system which runs through the centre of the site and drains the surrounding farmland to the Puniu River to the south.

This area has been identified in the Waipa District Plan as suitable for Large Lot Residential development which reflects the semi-rural character of the area, lower density housing and a more rural feel than the Residential Zone. People living in this zone are generally seeking to live in a semi-rural environment, while remaining within commuting distance to urban centres.

The character of the Large Lot Residential Zone is different from urban residential and/or rural character. The elements that generally define the District's large lot residential character are:

a) Views to natural features including flat to rolling terrain, volcanic cones, and water bodies; and

b) Low density residential built form and residential land use; and

c) Generally un-serviced with a lack of urban infrastructure such as reticulated water and wastewater systems, and less services such as street lighting, footpaths, and curb and channel road edging than the Residential Zone. This character is certainly consistent with the T6 Structure Plan area.

The area has many large sections, resulting in dwellings having good separation from the road, reinforcing the semi-rural character of the area. There are a few parks and open spaces but with minimal amenities such as playgrounds and walkways. The surrounding area is primarily in pasture with several land blocks being grazed with sheep and beef, and several blocks planted in maize.

There are many mature trees within the area, with shelterbelts and trees planted along existing site boundaries and between orchards and fields. Driveways and access roads into the sites are primarily gravel and meander organically. Fences are timber post and rail, or wire, and gates are predominantly timber or galvanised steel tube.

3.0 Structure Plan Design Context

3.1 General Design Principles

The following general design principles have underpinned the development of the T6 Structure Plan:

- **Respect for existing character.** All designs should reflect a comprehensive understanding and appreciation of location and surrounding context. The natural environment is protected and enhanced to provide amenity and ecological enhancement. Important sites and landmarks are acknowledged to respect the history and culture of the area.
- **Cultural identity.** Opportunities are to be identified throughout the development of cultural interpretation and education within the landscape. Maori names and design elements will be incorporated where appropriate and in consultation with local iwi.
- **Social value.** People are the key consideration in all aspects of the design. Public safety, recreation and social values are paramount.
- **Connectivity.** Transport networks and public spaces incorporate stormwater management, and green corridors for pedestrian and ecological connections. A network of pedestrian and

cycleways through the development connects the residents to the existing town, open spaces, and playgrounds.

- **Appropriate scale.** The scale and hierarchy of roads, cycleways and walking tracks are integrated to ensure a balance of transport options and access to public transport.
- **Quality public realm.** High-quality materials and construction methods used throughout the neighbourhood in both the public and private spaces, ensure spaces will retain a sense of quality and attract residents to use the facilities.
- **Well-designed built environment.** The built form guidelines ensure that the landscape and buildings within private lots contribute to the amenity, safety, and broad context of the development. The guidelines are intended to encourage creative design outcomes, not to limit or restrict original architecture or design.

3.2 Open Space Framework

The open space framework design for the T6 Structure Plan reflects a comprehensive understanding of the existing landscape and surrounding land use context. The development will be efficient, connected and permeable, with a focus on pedestrian walkways, cycleways, reserves and green corridors.

The existing exotic and native mature trees perform many functions, including removing groundwater and reducing the requirement for stormwater attenuation; ecological functions, such as providing habitat and food for birds; retaining the rural aesthetic; shade during summer for people and animals; cutting of wind, reduction of soil erosion from storm events. Existing trees have been incorporated into the open space framework where appropriate.

The open space framework is made up of:

- Reserves
- Green Streets
- Open Spaces
- Playgrounds
- Gully system
- Vegetated Swales

The combination of these spaces allows for a green network to be created through the site, ensuring that all members of the community have access to an open space, and the natural environment.

The T6 growth cell in particular provides a unique opportunity for an extensive green corridor within the existing gully system in the southern portion of the site extended northwards along a central green boulevard.

3.3 Stormwater Management

The proposed reserves and open spaces within the T6 structure plan will provide for people's recreational interests, and the protection of landscapes, amenity, ecosystems, cultural and historical values. They also fulfil an important stormwater management function.

Stormwater is proposed to be managed through a planted gully system, vegetated swales, the St Leger Road culvert and new crossings, and potentially on lot water efficiency measures. Wherever possible retention, reuse and onsite soakage for stormwater will be provided for and managed through natural systems. Natural systems such as vegetated swales, are a low impact way of managing stormwater which are also an important amenity feature of the site.

Stormwater within the structure plan area will also be managed through the following measures:

- On lot water efficiency measures such as detention tanks may be necessary so rainfall runoff is reduced. Water will be stored for household water supply, as the development will have access to a restricted water supply. The combination of vegetated swales and on-site water efficiency measures provides a resilient design approach to stormwater and ensures the system can cope with the post- development stormwater.
- A 23m riparian planting margin has been shown on the Structure Plan to ensure that future development complies with the set back from water bodies Rule 26.4.2.1 in the Waipa District Plan. This also ensures compliance with the Waikato Regional Plan provisions (Rules 5.1.4.11-5.1.4.15 relating to accelerated erosion and earthworks within high risk erosion areas.
- Due to the position of the growth cell within the wider Puniu River catchment, peak flow control of the 2 year ARI and higher magnitude events is not recommended to avoid coincidence with the larger Puniu River flood peak.
- The St Leger Road culvert should be upgraded and new crossings appropriately designed to enable pass forwarding of post-development flood flows. Crossings and discharge points to the channel should be designed to mitigate scour and erosion within the incised gully.
- Onsite soakage will need to be tested and designed on a lot by lot basis. Especially as low soakage could be an issue in the upper areas of the growth cell.
- If on-site soakage investigations show that the post-developed water quality rainfall volume cannot be achieved through water tanks and soakage, then bio-retention devices or a suitable wetland will need to be designed.
- Vegetated swales are recommended to convey overland flow.
- Avoiding modification to existing channel corridors and an ecological survey is recommended.

3.4 Connectivity

The road connections through the T6 structure plan area will holistically integrate cars, pedestrians, cyclists, stormwater management, and ecology.

High-quality streets with tree lined berms, grassed swales, and footpaths/cycleways are proposed to provide a safe and attractive area for both vehicular and pedestrian movement.

The Structure Plan will have a 25m green boulevard / tree framed collector road through the sites which become the main spine road for vehicles, pedestrians, and cyclists. The 18m local roads accommodate pedestrian facilities on one side and the option for stormwater conveyance through a vegetated swale down the other side.

A network of shared paths and footpaths will help to connect residents to site features such as the gully system in T6, reserves, playgrounds, commercial zone, and the neighbourhood centres.

Shared paths should be a minimum of 3m wide while footpaths should be a minimum of 1.5m wide.

An integrated pedestrian and cycle network improve the wellbeing of the residents through exercise, contact with the natural environment, and social interaction.

Document Set ID: 10410947
Version: 2, Version Date: 29/06/2020

The activation of the public realm from people moving through these spaces makes them safer and more attractive to a range of users.

3.5 Built Form

The Design Guidelines in combination with the District Plan provisions for the relevant zone will ensure the height and bulk of built form is appropriate to the location and character of the site.

The scale, position and external appearance of new buildings must consider their settings and the relationships they have with nearby buildings and spaces.

Well-designed buildings will be compatible with the surrounding environment and respect privacy of neighbouring residents. They take into account the character of the area and are designed to enhance this character. The built form should also take into account site circumstances and local micro-climatic conditions, such as solar access, topography, and prevailing wind. Trees and landscaping are to be used for privacy and screening and to soften the built form.

Maximum height and site coverage controls will ensure houses relate well to the size of the lots, without being overly dominant visually. Considerate building placement ensures good relationships between neighbouring properties, roads and reserves.

The Design Guidelines provide a framework which will lead to positive outcomes for the landowners and the wider community. This encourages original design which considers the unique opportunities of the site and development areas.

3.6 Anticipated Development Yields

The Structure Plan for the T6 growth cell is anticipated to deliver a development yield of approximately 470 allotments within the 168ha total area (4 lots per hectare). This is a provisional estimate based on net developable area and takes into account the loss of land for roads and open space, in particular the gully system.

The provisional yields are relatively consistent with the capacities identified in the Waipa District Plan (Appendix S1) of 504 dwellings (where 470 are anticipated) for T6.

3.7 Growth Cell Boundary Extension

The Structure Plan for T6 includes a proposed extension to the existing growth cell boundary to encapsulate a block of land at the end of Ballance Street on the eastern side of the cell. This would include the land between the existing growth cell boundary and the Residential Zone land development accessed off the end of Acacia Avenue. This is considered to be a logical extension to incorporate an extension of Ballance Street into the growth cell and better align the growth cell with existing cadastral boundaries and the zone boundary with the adjoining Residential Zone development. The land to be included by way of the boundary extension is also zoned Deferred Large Lot Residential.

4.0 Statutory Context

4.1 Te Ture Whaimana o Te Awa o Waikato - Vision and Strategy for the Waikato River

Te Ture Whaimana o Te Awa o Waikato – the Vision and Strategy for the Waikato River arises from the Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act 2010 and the Ngati Tuwharetoa, Raukawa and Te Arawa River Iwi Waikato River Act 2010 (Upper River Act). These acts establish a co-governance regime to protect the health and wellbeing of the Waikato River for future generations. This includes the lower Waipa River to its confluence with the Puniu River.

The vision for the Waikato River is "*for a future where a healthy Waikato River sustains abundant life and prosperous communities who, in turn, are all responsible for restoring and protecting the health and wellbeing of the Waikato River, and all it embraces, for generations to come*." The Vision and Strategy also includes objectives and strategies to achieve the vision. Waipa District Council has a duty to give effect to the Vision and Strategy for the Waikato River, through the Waipa District Plan and other planning documents.

The development of the Structure Plan has taken into account the Vision and Strategy for the Waikato River. In particular, the preliminary design includes high-level stormwater management solutions to ensure that water quantity and quality effects resulting from future development are appropriately mitigated and accord with best practice. This will help inform more detailed technical assessments that will be necessary to support any subsequent resource consent applications under the District Plan and any regional stormwater discharge permits required under the Waikato Regional Plan. The objectives of Vision and Strategy for the Waikato River will need to be assessed in more detail as and when a more robust technical analysis of cumulative stormwater effects has been undertaken.

4.2 National Policy Statement on Urban Development Capacity

The NPS-UDC is intended to ensure there is sufficient land available for future housing and business needs. The NPS-UDC has identified the Hamilton area (which includes Waipa District) as a high-growth urban area.

The NPS for Urban Development Capacity requires that sufficient land for housing be available for the 'short term', 'medium term' and 'long term' (Policy PA1), and that an oversupply of land be made available (Policy PC3).

The obligations on Council are to ensure that the following is provided for each of these time periods:

- Short term (1-3 years) – development capacity must be feasible, zoned and serviced with development infrastructure. 20% over-supply against forecast is required as a 'high growth' area.
- Medium term (3-10 years) – development capacity must be feasible, zoned and either: serviced with development infrastructure, or; the funding for the development infrastructure required to service that development capacity must be identified in a Long-Term Plan required under the Local Government Act 2002. 15% over-supply against forecast is required as a 'high growth' area.

- Long term (11-30 years) – development capacity must be feasible, identified in relevant plans and strategies, and the development infrastructure required to service it must be identified in the relevant Infrastructure Strategy required under the Local Government Act 2002. 15% over-supply against forecast is required as a ‘high growth’ area.

The NPS-UDC requires councils to provide in their plans enough development capacity to ensure demand can be met, both in terms of total demand for housing and business land, and also the demand for different types, sizes and locations. Council must give effect to the NPS and this requires some changes in approach in response.

The requirements of the NPS-UDC have driven the need to review the 2009 District Growth Strategy and subsequently Plan Change 5 to incorporate key changes made to the updated Waipa 2050 Growth Strategy into the Waipa District Plan. The requirements of the NPS-UDC have been considered further in the context of the District Plan and Waipa 2050 District Growth Strategy below.

The minimum targets for sufficient, feasible development capacity for housing in the Waipa District area are outlined in Section 1.1.6 in the Waipa District Plan, in accordance with the requirements of the National Policy Statement on Urban Development Capacity (NPS-UDC) 2016, as follows:

Area	Minimum Targets (Number of dwellings)		
	Short to Medium term 1-10years (2017-2026)	Long term 11-30 years (2027-2046)	Total
Waipā District	5,700	8,200	13,900

The Structure Plan has sought to contribute to the short and medium term targets by providing capacity for the development of approximately 470 dwellings within the Waipa District.

4.3 Future Proof Sub-Regional Growth Strategy

Future Proof was formulated in 2009 and is a combined growth strategy project between five councils (Hamilton City, Waikato, Waipa and Matamata-Piako District’s and Waikato Regional Council). It establishes a strategic plan for land use, infrastructure and transportation to plan and provide for the future needs of the sub-region. The NZ Transport Agency is also involved as a major partner, recognising the importance of coordinating transportation planning with that of land use.

Future Proof has guided the development of Waikato Regional Council’s Regional Policy Statement, and the growth strategies formulated for the Waikato District, Waipa District and Hamilton City.

The Future Proof Growth Strategy was reviewed in 2017 to incorporate updated population projections, and to allow a re-consideration of some of the growth assumptions. It is also planned to narrow the scope of the Future Proof Strategy to have a stronger focus on growth management and settlement pattern implementation, in line with national policy direction.

The requirements of Future Proof have been considered further in the context of the Waikato Regional Policy Statement, District Plan and Waipa 2050 District Growth Strategy below.

4.4 Waikato Regional Policy Statement

The RPS includes a detailed policy framework for the co-ordination of growth and infrastructure and adopting the land use patterns, density targets, and development ambitions of Future Proof.

The RPS provides direction for the management of the resources of the region as a whole. Six key issues are identified, and a range of methods are proposed to address these issues. District Plans are a key method for implementing the directions within Regional Policy Statements.

The Waipa District Plan gives effect to these policy directions as they apply within the Waipa District through:

- The setting of urban limits;
- Requirements for increased urban densities in Deferred Zones and future growth areas;
- Rural land protection;
- Recognition of the significance of key infrastructure networks and sites and the need for integrated land use and infrastructure planning;
- Ecological preservation and enhancement; and
- The health and well-being of the Waikato and Waipa Rivers including the restoration and protection of the relationship of the community and the Waikato and Waipa Rivers.

The Structure Plan will provide for new urban development within Te Awamutu within the urban limits indicated on Map 6.2 (Section 6C) of the RPS and facilitate new residential (including rural-residential) development in accordance with the timing and population growth areas in Table 6-1.

Further, the Structure Plan has sought to achieve compact urban environments that support existing commercial centres, multi-modal transport options, and allow people to live, work and play within their local area. In doing so, development provisions have sought to achieve provisional net development yields which are consistent with the capacities identified in the Waipa District Plan (Appendix S1) of 504 dwellings (where 470 are anticipated) for T6. These target capacities in Appendix S1 of the District Plan give effect to the Waikato Regional Policy Statement density targets for greenfield development in Te Awamutu/Kihikihi.

The Structure Plan is consistent with the key objectives and policies of the RPS as it will bring forward the development of residential dwellings with a key growth cell in Te Awamutu in alignment with the capacity targets of the Waipa 2050 Growth Strategy and Waipa District Plan which both give effect to the overarching framework in the RPS for the co-ordination of growth and infrastructure and adoption of land use patterns, density targets, and development ambitions.

4.5 Waipa District Plan

4.5.1 Strategic Policy Framework

Section 1 of the Waipa District Plan outlines the strategic policy framework for the Plan, including key trends, future challenges, national directions, NPS-UDC, Vision and Strategy for the Waikato River, Waipa River Agreement, National Policy Statements, National Environmental Standards, Regional and Local direction, and strategic outcomes sought. It also identifies the key resource management issues for the District and associated Objectives and Policies.

One of the key objectives is to achieve a consolidated settlement pattern that is focused in and around existing settlements of the District, which is supported by policies to ensure that all future development and subdivision in the District contributes towards achieving the anticipated settlement pattern in the Future Proof Growth Strategy and Implementation Plan 2009 and the District Growth Strategy.

The Structure Plan is consistent with the key objectives and policies of the Strategic Policy Framework section in the District Plan as it will bring forward the development of residential dwellings within a key growth cell in Te Awamutu in alignment with the capacity targets of the Waipa 2050 Growth Strategy.

4.5.2 Deferred Zone

Section 14 in the District Plan identifies the relevant provisions for Deferred Zones in the District. The introduction for this section of the Plan acknowledges that in order to provide for the District's projected growth; land use in some locations will change over time to accommodate new land uses, such as new residential areas.

These Deferred Zones have an objective, policy and rule framework which generally reflects existing land use and zoning but recognises that the area is intended to change over time. It is anticipated that development in Deferred Zones will occur in a planned and integrated manner through a structure plan process.

The T6 structure plan area has been identified in the District Plan as being suitable for conversion from the current land use to a new land use and is zoned on the Planning Maps as Deferred Large Lot Residential.

As outlined earlier in this report, the Structure Plan is consistent with the key objectives and policies of the RPS as it will bring forward the development of residential dwellings within a key growth cell in Te Awamutu in alignment with the capacity targets of the Waipa 2050 Growth Strategy and Waipa District Plan which both give effect to the overarching framework in the RPS for sub-regional growth.

4.5.3 Appendix S1 – Future Growth Cells

Appendix S1 in the District Plan identifies the growth cells from the Waipa 2050 District Growth Strategy, all of which have been included within a Deferred Zone in this District Plan to indicate the intended future land use. This includes T6 as Deferred Large Lot Residential Zone.

The Appendix includes a table with information on the location and extent of each of the growth cells, and a broad timing for each of either 'anticipated now to 2035' or 'anticipated beyond 2035'. This timing for the release of each growth cell is based on growth projections within the Waipa 2050 District Growth Strategy and calculation of available land supply. The indicated timing for the release of each growth cell is intended to provide certainty to the community as to future land supply.

Details of the area and anticipated dwelling capacity within each growth cell are also included within the relevant table in the Appendix, see below:

Te Awamutu Residential Growth Cells – anticipated now to 2035

GROWTH CELL	LAND AREA	OVERVIEW AND CAPACITY
T1	37ha	▪ This is identified for residential development and has a structure plan in place. ▪ The growth cell has a dwelling capacity of approximately 444 dwellings.
T3	10ha	▪ This growth cell has been identified for residential development. ▪ The growth cell has a dwelling capacity of approximately 120 dwellings.
T6	168ha	▪ This growth cell has been identified as a location for non-serviced (water only) large lot residential development, providing an alternative form of living choice to other greenfield developments in Te Awamutu. ▪ The growth cell has a dwelling capacity of approximately 504 dwellings and due to the nature of the development and available capacity is expected to be developed over a larger time period than other growth cells.
T8	62ha	▪ This growth cell has been identified as a residential growth cell but requires a structure plan. ▪ The growth cell has a dwelling capacity of approximately 552 dwellings.
T9	11ha	▪ This residential growth cell is subject to a structure plan. ▪ The growth cell has a dwelling capacity of approximately 132 dwellings.
T10	21ha	▪ This residential growth cell is subject to a structure plan. ▪ The growth cell has a dwelling capacity of approximately 252 dwellings.
T11	47ha	▪ This growth cell has been identified as a residential growth cell. ▪ The growth cell has a dwelling capacity of approximately 432 dwellings and represents an opportunity for housing in proximity to a commercial node which provides necessary social infrastructure shopping / medical etc.
T12	11ha	▪ This growth cell is zoned for residential development. ▪ The growth cell has a dwelling capacity of approximately 132 dwellings.
T13	35ha	▪ The current Te Awamutu Racecourse is identified as a potential future residential growth cell if no longer needed for its current purpose. ▪ The growth cell has a dwelling capacity of approximately 420 dwellings.
The above growth cells make provision for 375 hectares of residential land, with a dwelling capacity of approximately 2,988 dwellings.		

Appendix S1 acknowledges that there will often be infrastructure requirements that will precede land being made available for development. Where Council intends to fund the upfront cost of this infrastructure then it will identify this through its 10 Year Plan (LTP). The 10 Year Plan is reviewed in full every 3 years. Where the infrastructure is not identified in Council's 10 Year Plan, then there may be the opportunity for the infrastructure to be privately funded, subject to a 'Developer Agreement' being in place between the private party and Council.

The Structure Plan is consistent with the future growth cell capacities identified within Appendix S1 of the District Plan

The provisional yields anticipated through the implementation of the Structure Plan are consistent with the capacities identified in the Waipa District Plan (Appendix S1) of 504 dwellings (where 470 are anticipated) for T6. This would help bring forward the development of residential dwellings within a key growth cell in Te Awamutu in alignment with the capacity targets of the Waipa 2050 Growth Strategy and Waipa District Plan which both give effect to the overarching framework in the RPS for sub-regional growth.

5.0 Conclusions

The Structure Plan contained in this report confirms the spatial intent and the Waipa District Plan outlines the procedural requirements to advance the T6 growth cell to the next stage of development.

The Structure Plan provides a level of confidence in a spatial context that the T6 growth cell can be progressed in a manner that is consistent with the Council's strategic direction as set out in Waipa 2050 Growth Strategy and the Waipa District Plan.

The Design Guidelines support the spatial intent within the Structure Plan and will assist in providing guidance for developers, the community and Council with an aim to achieve a high level of quality and consistency in the development.

The Technical Assessments contained in this report demonstrate that the growth cells are suitable for urban development, including preliminary recommendations in respect of three waters infrastructure, transportation, and liquefaction. It is important to acknowledge that these assessments are preliminary in nature and more detailed technical assessments are recommended.

Appendix 1: Final Structure Plan

Appendix 2: Final Design Guidelines

Appendix 3: Final Technical Assessments

Waipa
DISTRICT COUNCIL

DESIGN GUIDELINES

TE AWAMUTU T6 GROWTH CELL

June 2020

Boffa Miskell

Document Quality Assurance

Bibliographic reference for citation: Bo a Miskell, 2019. *Waipa Structure Plan T6 Growth Cell, Design Guidelines.* Report by Bo a Miskell Limited for Waipa District Council.		
Prepared by:	Thomas Keal Landscape Architect Bo a Miskell Ltd Brooke Foley Landscape Architect Bo a Miskell Ltd	
Reviewed by:	Morné Hugo Landscape Architect / Urban Designer Associate Partner Bo a Miskell Ltd Dave Moule Planner Senior Principal Bo a Miskell Ltd	
Status: [FINAL]	Revision / version: B	Issue date: June 2020

Disclaimer: Any variation or waiver to the guidelines will be considered unique and will not set a precedent for other variations or waivers. A variation is de ned as the approval of a practice which is considered to be consistent with the general intent of these guidelines, but may not be consistent with, or provided for by, a speci c provision. Al   nal decisions relating to the implementation of this design guide are at the discretion of the Developer & Development Controller.

File ref: Design_Guide_T6_Rev_B.indd

Contents

1. Introduction

The Waipa District has been identified as a high growth area in the National Policy Statement on Urban Development Capacity.

Te Awamutu and Kihikihi are forecast to grow by 5,400 people by 2050. To provide for this growth, a structure plan for the T6 growth cell is required, as identified in the Waipa2050 Growth Strategy (2017) and Waipa 2018-28 Long Term Plan.

The T6 growth cell is located to the west of State Highway 3 between Te Awamutu and Kihikihi, is currently zoned Deferred Large Lot Residential.

Specific provision for large lot residential development is identified within T6. This location is considered suitable for this land use as it expands on the existing large lot residential area on St Leger Road and provides for some growth between Te Awamutu and Kihikihi, where other land use practices may otherwise not be appropriate.

This growth cell has been identified as a location for non-serviced (water only) large lot residential development, providing an alternative form of living choice to other greenfield developments in Te Awamutu.

To ensure that development is consistent with the Council's strategic direction as set out in Waipa 2050, a structure plan has been developed in consultation with landowners and key stakeholders, and servicing requirements identified.

These design guidelines have been developed to support the implementation of the Structure Plan and to ensure that as the neighborhood is developed, the community and Council can be assured of a high level of quality and consistency.

This design guide is to be read in conjunction with the Waipa District Plan. In order to achieve a higher level of quality and consistency of development within the Structure Plan area, there are certain guidelines that are more onerous than the District Plan provisions. In these circumstances, it is anticipated that a design review will be undertaken as part of a development control process. The design guide has taken into account the district plan rules, but has not sought to list out every relevant provision. For the avoidance of doubt, the relevant provisions of the District Plan will prevail over these guidelines in a regulatory context and a full assessment against those provisions will need to be undertaken in parallel to any consideration of design matters in this guideline.

1.1 Purpose

This design guide is a document for future residents, designers, development partners and local authorities, clearly communicating the expectations as to how this area of land will be developed. The document guides the landscape framework, site layout, boundary treatments and built form within the T6 Structure Plan area.

This document describes the expectations that need to be met for development to proceed. It will form an integral part of quality assurance processes. It will be used as the basis for discussions with designers, local authority staff and other key stakeholders during the design and construction of the development and individual sites.

Good design comes as a result of clearly identifying the intended outcome, and the constraints and opportunities are resolved through a creative process. The guide is not meant to be prescriptive, and it should inspire imaginative and practical solutions.

1.2 Site Context

The T6 growth cell is predominantly characterised by rolling pasture, large mature vegetation, and large residential dwellings and spacious lots typical of the semi-rural environment on the perimeter of the Te Awamutu and Kihikihi townships. There is a large natural gully system which runs through the centre of the site and drains the surrounding farmland to the Puniu River to the south.

This area has been identified as suitable for Large Lot Residential development which reflects the semi-rural character of the area, which has a lower density and a more rural feel than in the Residential Zone. People living in this zone are generally seeking to live in a semi-rural environment, while remaining within commuting distance to urban centres.

The character of the Large Lot Residential Zone is different from urban residential and/or rural character. The elements that generally define the District's large lot residential character are.

» Views to natural features including flat to rolling terrain, volcanic cones, and water bodies; and

» Low density residential built form and residential land use; and

» Generally un-serviced with a lack of urban infrastructure such as reticulated water and wastewater systems, and less services such as street lighting, footpaths, and curb and channel road edging than the Residential Zone. This character is certainly consistent with the T6 Structure Plan area.

The area has many large sections, resulting in dwellings having good separation from the road, reinforcing the semi-rural character of the area. There are a few parks and open spaces but with minimal amenities such as playgrounds and walkways. The region is primarily grass paddock, with large mature exotic and native trees scattered through the landscape.

There are many mature trees within the area, with shelterbelts and trees planted linearly along existing site boundaries and between orchards and fields. Driveways and access roads into the sites are primarily gravel and meander organically. Fences are timber post and rail, or wire, and gates are predominantly timber or galvanised steel tube.

1.3 Design Principles

» **Respect for existing character.** All designs should re ect a comprehensive understanding and appreciation of location and surrounding context. The natural environment is protected and enhanced to provide amenity and ecological enhancement. Important sites and landmarks are acknowledged to respect the history and culture of the area.

» **Cultural identity.** Opportunities are to be identi ed throughout the development of cultural interpretation and education within the landscape. Maori names and design elements will be incorporated where appropriate and in consultation with local iwi.

» **Social value.** People are the key consideration in all aspects of the design. Pedestrian safety, recreation and social values are paramount.

» **Connectivity.** Transport networks and public spaces incorporate stormwater management, and green corridors, for pedestrian and ecological connections. A network of pedestrian and cycleways through the development connects the residents to the existing town, open spaces, and playgrounds.

» **Appropriate scale.** The correct scale and hierarchy of roads, cycleways and walking tracks are integrated to ensure a balance of transport options and access to public transport.

» **Quality public realm.** High-quality materials and construction methods used throughout the neighbourhood in both the public and private spaces, ensure spaces will retain a sense of quality and attract residents to use the facilities.

» **Well designed built environment.** The built form guidelines ensure that the landscape and buildings within private lots, contribute to the amenity, safety, and broad context of the development. This guide is intended to encourage creative design outcomes, not to limit or restrict original architecture or design.

2. Open space framework

The design of the T6 Growth cell re ects a comprehensive understanding of the landscape and surrounding context. The development will be efficient, connected and permeable, with a focus on pedestrian walkways, cycleways, reserves and green corridors.

The existing exotic and native mature trees perform many functions, including removing groundwater and reducing the requirement for stormwater attenuation; ecological functions, such as providing habitat and food for birds; retaining the rural aesthetic; shade during summer for people and animals; cutting of wind, reduction of soil erosion from storm events. Existing trees have been incorporated into the open space framework.

The T6 growth cell open space framework is made up of:

- » Reserves
- » Green Streets
- » Open Spaces
- » Gully System
- » Vegetated Swales

The combination of these spaces allows for a green network to be created through the site, ensuring that all members of the community has access to an open space, and natural environments.

2.1 Reserves and Stormwater management

» Reserves and open spaces provide for people's recreational interests, and the protection of landscapes, ecosystems, cultural and historical values. They also o er considerable amenity value to the community.

» Stormwater is managed through a planted gully system, vegetated swales, the St Leger road culvert and new crossings, and on lot individual water tanks. Wherever possible retention, reuse and onsite soakage for stormwater is allowed to soak into impermeable services and managed through natural systems. Natural systems such as vegetated swales, are a low impact way of managing stormwater which are also an important amenity feature of the site.

» Water tanks for each lot are required, so rainfall runo   s reduced. Water will be stored for household water supply, as the development will have access to a restricted water supply. The combination of vegetated swales and on-site water tanks makes for a resilient design approach to stormwater and ensures the system can cope with the post- development stormwater.

» All waterways will have a minimum 2m planted bu er adjacent to the water to prevent contaminants entering the water, and improve the water quality. The Main Gully system has a 23m Riparian planting margin.

» Due to the position of the growth cell within the wider Puniu River catchment, peak   ow control of the 2 year ARI and higher magnitude events is not recommended to avoid coincidence with the larger Puniu Rive   ood peak.

» The St Leger Road culvert should be upgraded and new crossings appropriately designed to enable pass forwarding of post-developmen   oo   ows. Crossings and discharge points to the channel should be designed to mitigate scour and erosion within the incised gully.

» Retention, reuse and onsite soakage of the post-development water quality volume will be required to provide stormwater treatment and erosion control. Water tanks for each lot are recommended to help meet these requirements and water supply demands.

» Onsite soakage will need to be tested and designed on a lot by lot basis. Especially as low soakage could be an issue in the upper areas of the growth cell.

» If on-site soakage investigations show that the post-developed water quality rainfall volume cannot be achieved through water tanks and soakage then bio-retention devices or a suitable wetland will need to be designed.

» Vegetated swales are recommended to convey overlan   ow.

» Avoid modi cation to existing channel corridors and an ecological survey is recommended.

2.2 Vegetation and Natural Site Features

» Where large trees over 6m tall exist on private lots, these are to be retained. Trees may be removed subject to an arboricultural assessment.

» Existing vegetation and natural features are to be protected and enhanced.

» Landscape planting is preferred over hard structures for privacy and shade.

Examples of vegetation preferred to hard structures for fencing and shade

2.3 Parks and Play-spaces

» The development could have unique and exciting playspaces to suit children of all ages and abilities.

» Playspaces could include nature-play and educational facilities, which help kids learn about the signi cance of the landscape.

» Sculptural and interpretive elements could be incorporated into the designs, which provides exposure to, and encourages interaction with New Zealand's culture and history

» Playspaces should be connected by cycleways and walkways to ensure they are accessible and utilised by residents.

Examples of nature-play opportunties

3. Roads and Streetscape

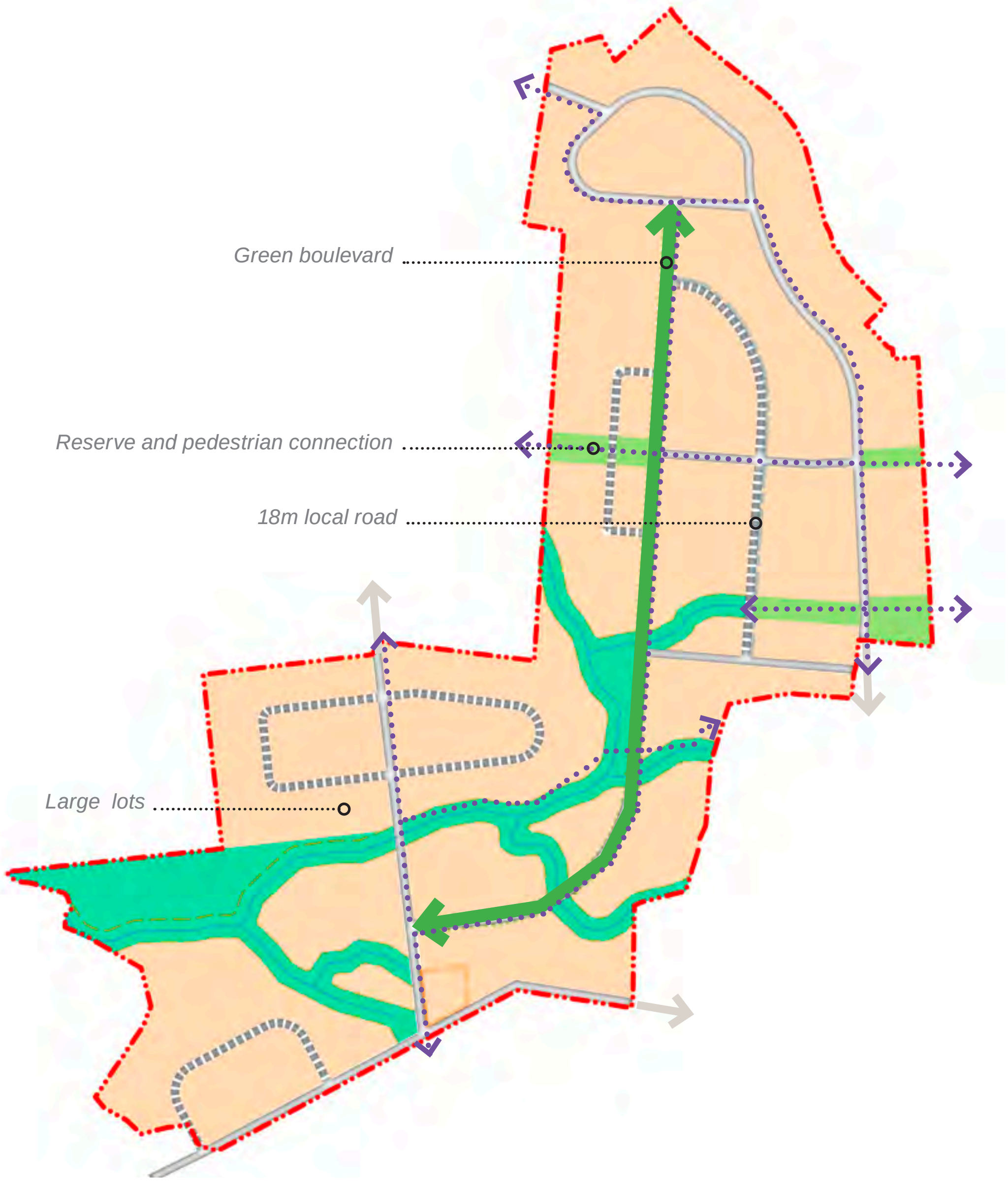
The roading connections through are considered holistically, to integrate cars, pedestrians, cyclists, stormwater management, and ecology.

High-quality streets with tree lined berms, grassed swales, and footpaths/cycleways are proposed to provide a safe and attractive area for both vehicular and pedestrian movement.

3.1 Road Hierarchy

The 25m green boulevard is a tree framed street through the site and becomes the main spine road for vehicles, pedestrians, and cyclists.

The 18m local roads accommodate pedestrian facilities on one side and the option for stormwater conveyance through a vegetated swale down the other side.



3.2 Road Typologies

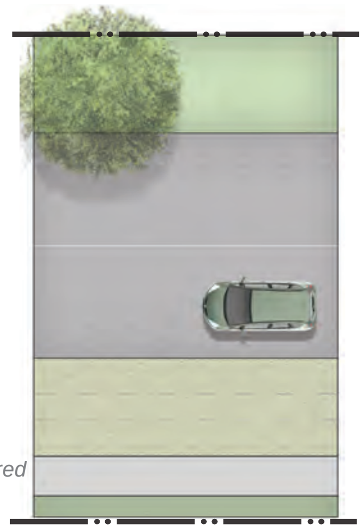
18m Local Road

Front Berm

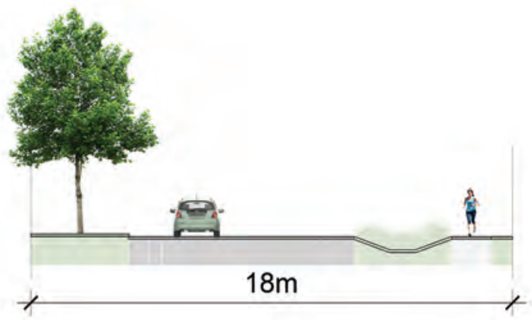
7m Carriageway

Swale

1.5m Footpath or 3.0m Shared path (refer to structure plan)



Plan



Front berm may include: Swales, recessed parking, bus stops, tree planting, street lighting

Section

25m Collector Road / Green Spine Road

1.5m Footpath

Parking

Cycle Lane

7m Carriageway

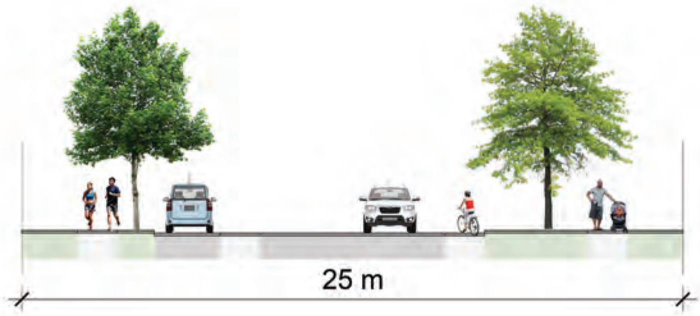
Cycle Lane

Front Berm

1.5m Footpath

Service Corridor

Plan



Front berm may include: Swales, recessed parking, bus stops, tree planting, street lighting

Section

3.3 Pedestrian and Cycle Connectivity

» A network of shared paths and footpaths will help to connect residents to site features such as the gully system, reserves, playgrounds, commercial zone, and the town centre.

» Shared paths should be a minimum of 3m wide while footpaths should be a minimum of 1.5m wide.

» An integrated pedestrian and cycle network improves the wellbeing of the residents through exercise, contact with the natural environment, and social interaction.

» The activation of the public realm from people moving through these spaces makes them safer and more attractive to a range of users.

Example image. Typical 18m street with separated 3m shared cycle path or 1.5m footpath (refer structure plan) and vegetated drainage swale.

3.4 Paving and Surface Treatments

» The use of stone paving, segmental concrete and surface treatments at key intersections, road junctions, and in the private rows is encouraged, and will assist in slowing vehicles and help to prioritise pedestrian movement

» Good quality pedestrian and cycle path materials and construction ensure they can easily be maintained to a high standard and used in all seasons.

» Permeable paving materials should be considered as an option to reduce stormwater runo nd have a low impact on the landscape.

» Using exposed aggregate concrete on walkways and cycleways is recommended to provide a higher quality surface with a more natural feel.

3.5 Site Furniture and Lighting

» The pedestrian spaces should use high-quality materials and construction methods, which ensures long life and low ongoing maintenance costs.

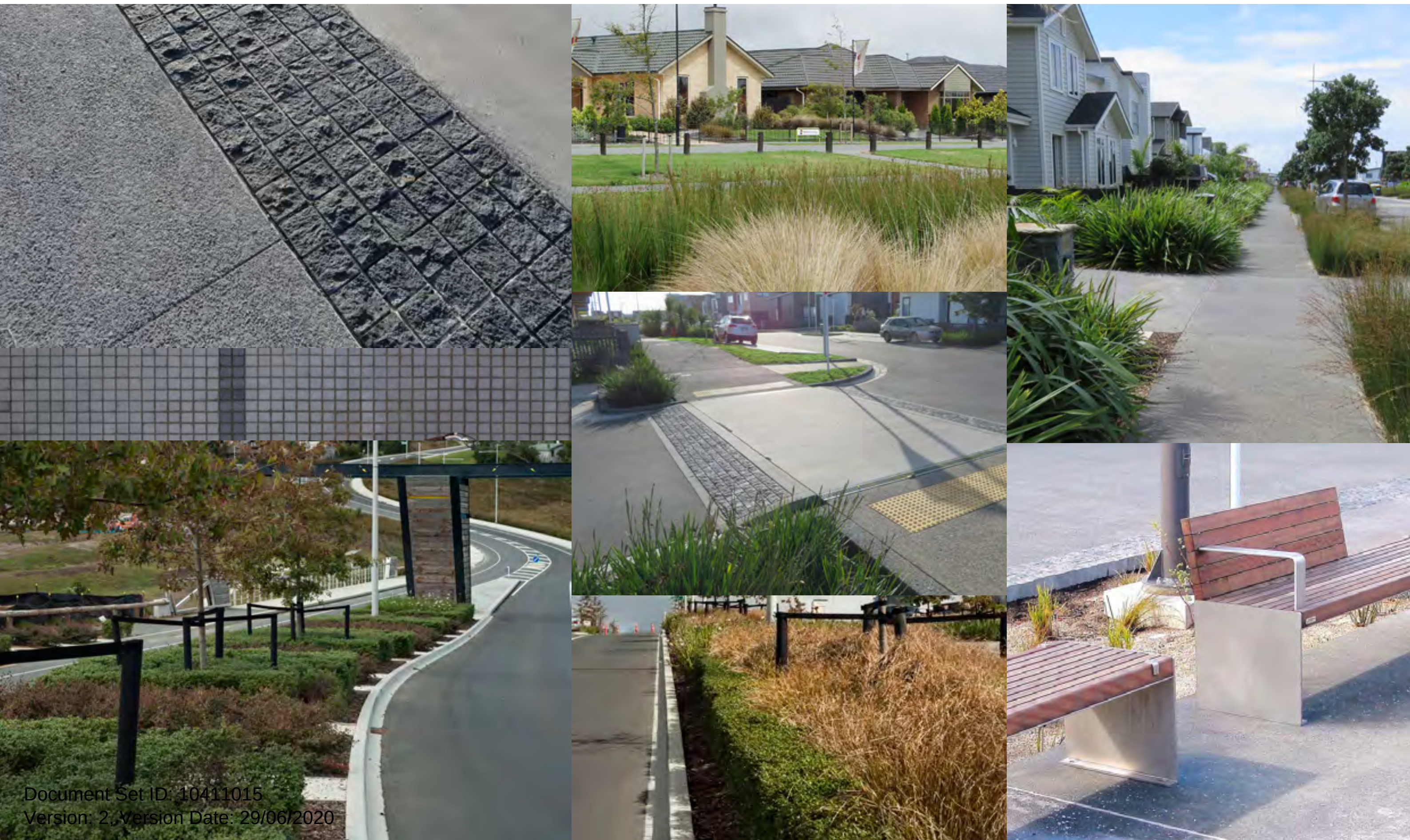
» High-quality pedestrian spaces attract people to use them, though the good design of paving, lighting and furniture.

» Site furniture should be sympathetic to its rural surroundings, the use of timber, a subtle colour palette, and simple design ensures it ties in with the rural context.

» LED Lighting with a low light spill and a warm colour tone should be used throughout for a consistent lighting e ect. Warm LED Lights are efficient and provided the appropriate light to spaces without causing any adverse e ects to people or the landscape.

» Uplighting on trees and sculptures is appropriate, so long as the spill of light does not a ect neighbouring properties or the public realm. Down lighting is preferred in outdoor living areas as there is less glare. In general, where possible the ligh tting itself should not be visible.

Example images. Public space vernacular.



4. Built Form

Good design ensures the height and bulk of built form is appropriate to the location and character of the site. The scale, position and external appearance of new buildings must consider their settings and the relationships they have with nearby buildings and spaces.

Well designed buildings are compatible with the surrounding environment and the respect the privacy of neighbouring residents. They take into account the character of the area and are designed to enhance this character. The built form should also take into account speci c site circumstances and local microclimatic conditions, such as solar access, topography, and prevailing wind. Trees and landscaping are to be used for privacy and screening and to soften the built form.

Maximum height and minimum siz oor areas will ensure houses relate well to the size of the lots, without being overly dominant visually. Considerate building placement ensures good relationships between neighbouring properties, roads and reserves.

This guide puts in place a design framework, which will lead to positive outcomes for the landowners and the wider community. This encourages original and exciting design which considers the unique opportunities of this development.

Standard district plan rules are used in combination with design recommendations to achhieve a high quality, attractive and high value design outcome for the community.

4.1 Building Placement

» The house is to be setback according to the Setback Table and Diagrams on page 13 of this document. Setbacks establish a framework for how buildings will relate to each other and the public realm. Generous setbacks ensure the relationship between the built form, and the public realm is complementary and consistent.

» The orientation of the building is to consider the sun and wind to provide the most comfort for the residents and give variation to the housing layouts.

» Well-positioned houses have enough separation from the road for usable driveways and turning areas which are in scale with the property. Where part of a garage sits in front of the house, it must adopt the architectural style or materials of the house.

4.2 Street Frontage

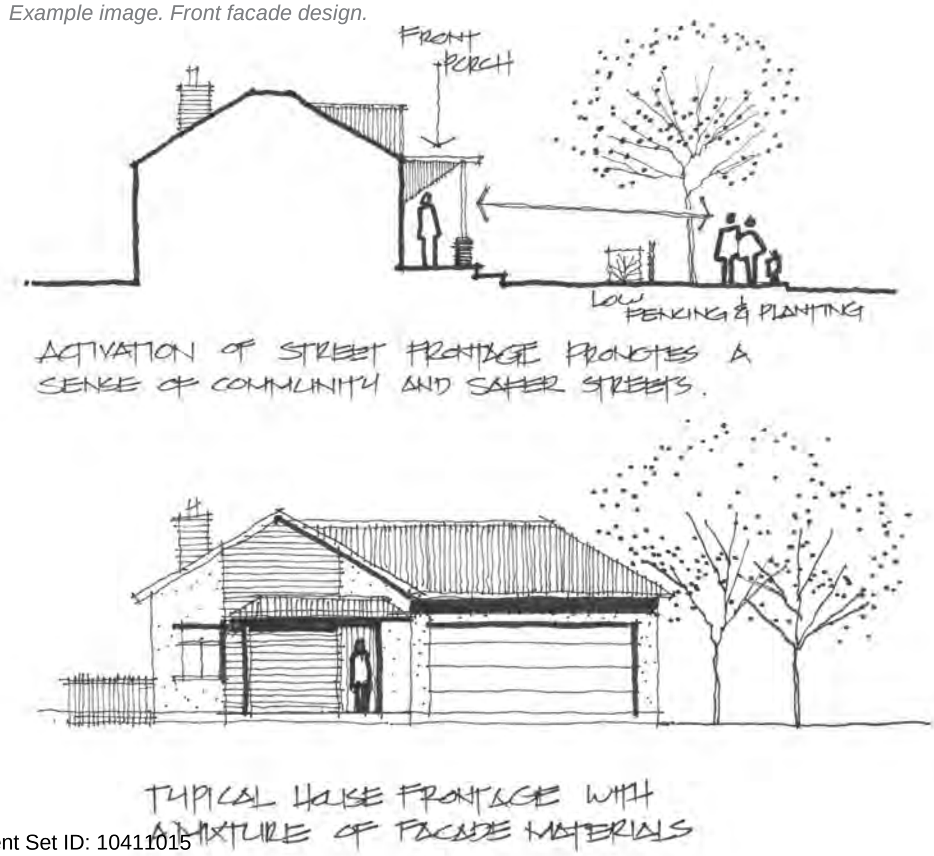
» Houses should appear to be oriented towards the street and be visible from the road. A covered entrance/outdoor space is recommended on the road frontage of the house. A welcoming front facade creates a sense of community and promotes active surveillance over the streetscape.

» The front facade should where possible incorporate two to three complimentary materials and should have variation in the form to provide interest. An attractive street frontage adds value to the neighbourhood. Relationships between the roads and the buildings are considered critical to the identity of the community, and comfort and safety of the public spaces.

» It is recommended that driveways follow the contour of the landscape to minimise earthworks or to retaining walls. Materials are to be in keeping with a rural context, and of good quality, such as asphalt, exposed aggregate concrete or metal. The design of turning circles or parking areas which are visible from the road must compliment the design of the house.

» Vehicle crossings should be constructed from exposed aggregate concrete, so a consistent high quality street / driveway interface is maintained.

Example image. Front facade design.



4.3 Building Setbacks (Large -Lot Residential (2,500m² to 5000m²)

2500m² to 5000m² Lot Building Set Backs	Meters
Road boundary setback	25
Rear boundary setback	20
Side boundary setback	10

Provided that for dwellings and detached habitable rooms where a site boundary adjoins the Rural Zone or Reserves Zone, the minimum setback from that boundary will be 20m.

*Building design, driveways and landscaping for illustrative purposes only

4.4 Boundary Treatments

» Fences between buildings on the site and any road, public walkway or reserve should be no higher than 1.2m in height if not visually permeable, or no more than 1.8m in height if visually permeable.

» Landscape planting between dwellings on the site and any public place should allow visibility between the dwelling and the public place.

» Clipped hedges are preferable to fences on front boundaries. Hedges provide a softer interface between properties and a more natural feel over long spans.

» Side and rear fences should be visually permeable. Examples include high quality pool fences and farm style fences, such as post and rail, which are sympathetic to the landscape.

» Planting should to be used to create privacy between lots, which, in addition to the public space planting framework, will improve the overall amenity for the community.

4.5 Retaining

» Retaining walls should not exceed 1.5m in height. Where retaining walls above 1.5m in height are required, stepped retaining should be used to prevent visual dominance.

» Retaining walls visible from a public viewpoint should be enhanced by plant cover using a suitable shrub, groundcover, or climber.

» Retaining walls within 2m of boundaries should be avoided where practicable.

Example image. Recommended boundary fences and walls

Timber farm style fence

Timber farm style gate

Farm style stone wall

Timber farm style formal gate

Visually permeable metal fencing

Visually permeable metal gate

4.6 Building Size, Height, Form

» The maximum height gives a consistency through the neighbourhood, and maintains a rural character. The maximum height for all houses within the T6 Growth cell is 8m.

» The maximum total building coverage on a site should be designed to comply with Rule 3.4.2.7 in the District Plan.

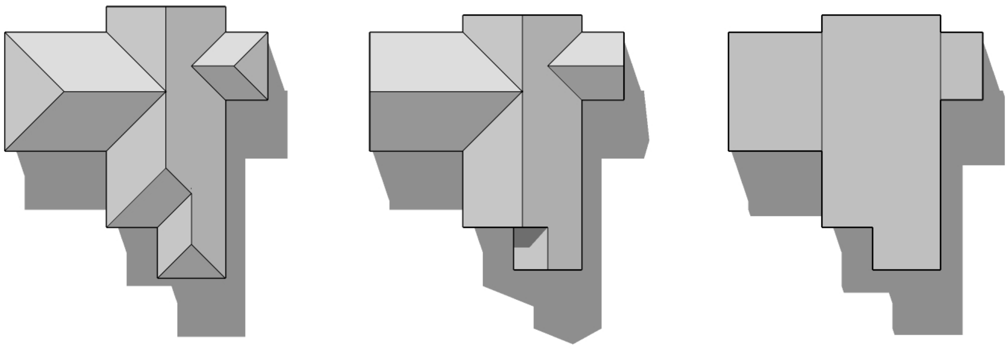
» Impermeable surface coverage on a site should be designed to comply with Rule 3.4.2.8 in the District Plan.

» The recommended roof designs are gable-end roofs, combination gable and hip roof, and monopitch roofs. Variation of roo ines adds to the interest and quality of the public realm. (see diagram below)

» Full hip roofs are not recommended.

» Design and layout of development adjoining water bodies and reserves - Within the Large Lot Residential Zone, the design and layout of development should ensure that water bodies and reserves are fronted by either the front or side façade of a dwelling in accordance with Rule 3.4.2.21 of the District Plan.

Examples of approved roof styles



Combination of roof styles *Gable end roof* *Monopitch roof*

4.7 Materials and Colours

It is recommended that:

» Houses should use natural and muted colour tones, which blend into the surrounding landscape. Bright colours and highly reflective materials should be avoided.

» Houses should be composed of two to three complementary materials. The Front facade should have a minimum of two materials. Brick cladding should not exceed 40% of any publicly visible frontage.

» Fences to be dark neutral colours.

Example images of material and colour palettes

Dark painted weatherboard and light coloured plaster

Dark painted weatherboard and cedar

Dark painted weatherboard, honed and sealed concrete block and timber

5.1 Neighbourhood Centre

The design of streets, buildings and spaces within the Neighbourhood Centre a ects the future vitality and economic potential of the area. This document is intended to provide guidance for the development of a vibrant, community-focused, and economically viable commercial centre within the growth cell.

Design guidance for the Neighbourhood Centre is not intended to be either overly complicated or prescriptive but is instead aimed at providing direction to potential future developers as to the outcomes supported by the local community and key stakeholders. These design criteria cover a wide range of matters to ensure that developments within the Centre re ect good urban design practice. A range of activities are promoted within the Centre, and pedestrian scale frontages reinforce the pedestrian focus and vibrancy of this area.

The built form of the Neighbourhood Centre should be of high quality and of an appropriate scale that is sympathetic to the unique character of the area. The architectural design should be re ective of the smaller scale of the Neighbourhood Centre, using simple and appropriate materials an nishes.

5.2 Neighbourhood Centre Character

A well-designed neighbourhood centre creates opportunities and spaces for communities to gather, interact, do business and take part in passive and sometimes active recreation activities.

The Neighbourhood Centre incorporates local service functions and small-scale retail activities that could be supported by a small community centre space and related social infrastructure, aimed at attracting residents to the centre. The Neighbourhood Centre design could incorporate shared spaces, which activate the area, by providing di erent modes of transport through the spaces.

The Neighbourhood Centre is not intended to compete with the commercial o erings within the Kihikihi township, and as such only commercial activities to service the local neighbourhood are encouraged.

Lighting throughout the centre is to be a warm colour LED for consistency with the rest of the neighbourhood streetscape.

5.3 Neighbourhood Centre Landscape

Landscaping plays an important role in supporting retail activities and providing spaces for residents to linger and enjoy social interactions with their community. The centre's landscaping should incorporate:

» High-amenity open space and quality planting

» Strong connectivity for pedestrians and cyclists.

» Appropriate use of materials to create a relaxed character wit exible spaces.

» Landscaping should be low maintenance and incorporate predominantly native trees, shrubs and groundcover species.

5.4 Neighbourhood Centre Built Form

Neighbourhood Centre built form should comply to the following requirements:

» Buildings must not exceed 14m in height and must be no more than thre oors within the Centre.

» The architecture should have a pedestrian scale, with large and welcoming doors and openings adjacent to public space. Buildings with large blank walls on th rst level are inappropriate.

» The built form is designed to allo exible use of spaces, so the character of the area can develop and adapt over time.

» Each individual retail and services tenancy should hav oor area of not more than 250m2 GFA (excluding community amenities and facilities, administration offices, and professional ces).

» All commercial building street frontage should be constructed to a 0m front lot boundary.

» All street frontages should have a minimum 3m wide continuous covered veranda to allow for weather protection.

» All commercial buildings should have a minimum 3m setback from all adjoining residential zone, reserves and public open space boundaries.

» All buildings fronting a road or reserve should have an active frontage, incorporating 70% permeable, glazed shop frontage at groun oor. Active frontages should also include wide double doorways to allow for easy pedestrian access.

» Where a site adjoins the Residential Zone, no building or stored materials should penetrate a recession plane at right angles to the Residential Zone boundary inclined inwards at an angle of 45° from 2.7m above ground level.

» Any storage or service area (including mechanical, electrical and utility equipment, refuse, and recycling activities) not enclosed within a building or where a shipping container is being used for storage, should be fully screened by landscaping or solid walls or fences not less than 1.8m in height.

» Walls and fences over 1.8m in height should be setback a minimum of 5m from the road boundary unless a landscaping strip of a minimum of 2m wide is provided on the external side of the fence.

» Walls and fences along any road or reserve should not exceed 1.6m in height, except where at least 40% of the fence is visually permeable, in which case the fence may be constructed to a maximum height of 1.8m.

The above guidelines should be read in conjunction with Section 6: Commercial Zone of the Operative Waipa District Plan.

About Boffa Miskell

Bo a Miskell is a leading New Zealand professional services consultancy with offices in Auckland, Hamilton, Tauranga, Wellington, Christchurch, Dunedin and Queenstown. We work with a wide range of local and international private and public sector clients in the areas of planning, urban design, landscape architecture, landscape planning, ecology, biosecurity, cultural heritage, graphics and mapping. Over the past four decades we have built a reputation for professionalism, innovation and excellence. During this time we have been associated with a signi cant number of projects that have shaped New Zealand's environment.

www.boffamiskell.co.nz

Auckland	Hamilton	Tauranga	Wellington	Christchurch	Queenstown	Dunedin
09 358 2526	07 960 0006	07 571 5511	04 385 9315	03 366 8891	03 441 1670	03 470 0460

REPORT

Tonkin+Taylor

Liquefaction Desktop Study

T6 and T11 Growth Cell Structure Plan

Prepared for
Boffa Miskell Ltd
Prepared by
Tonkin & Taylor Ltd
Date
August 2019
Job Number
1008305.1000.v2

Exceptional thinking together
www.tonkintaylor.co.nz

Document Set ID: 10373335
Version: 1, Version Date: 10/03/2020

Document Control

Title: Liquefaction Desktop Study, T6 and T11 Growth Cell Structure Plan					
Date	**Version**	**Description**	**Prepared by:**	**Reviewed by:**	**Authorised by:**
07/06/19	1	Draft for client review	J Brzeski	M Triggs	G Nicholson
23/08/19	2	Final	J Brzeski	M Triggs	G Nicholson

Distribution:

Boffa Miskell Ltd — 1 PDF copy

Tonkin & Taylor Ltd (FILE) — 1 PDF copy

Table of contents

1 Introduction

The Waipa district has been identified as a high growth area in the National Policy Statement on Urban Development Capacity. Te Awamutu and Kihikihi are forecast to grow by 5,400 people by 2050. To provide for this growth, structure plans for the T6 and T11 cells are required, as identified in the Waipa 2050 Growth Strategy (2017) and Waipa District Council (WDC) 2018 – 2028 Long Term Plan.

T6 cell is approximately 165 ha in size, located to the west of State Highway 3 (SH3) between Te Awamutu and Kihikihi and is currently zoned Deferred Large Lot Residential. A Plan Change to the Proposed District Plan will re-zone the land to Large Lot Residential Zone.

T11 cell is approximately 47 ha and is located to the east of central Te Awamutu and is currently zoned Rural. A Plan Change to the Proposed District Plan will re-zone the land to Residential Zone and Deferred Residential Zone.

Tonkin & Taylor Ltd (T+T) have been requested by Boffa Miskell Ltd to investigate and provide a Level A desktop liquefaction assessment for the growth cells. These assessments will support the Structure Plans for each cell and Plan Changes to the District Plan.

1.1 Scope of work

The scope of works comprises a desktop assessment of liquefaction vulnerability of the growth cells in general accordance with a Level A assessment as described in Planning and Engineering Guidance for Potentially Liquefaction-Prone Land (MBIE/MfE/EQC, 2017). A Level A assessment is further described in Section 2.4 and considers basic information about geology, groundwater and seismic hazard to assess the potential for liquefaction to occur.

The scope of this report can be summarised as:

- Collation and review of available data that is relevant to this study including:
  - Geological and geomorphic maps.
  - Ground surface elevation levels for the extent of the study area.
  - Geotechnical investigations and laboratory tests that are currently available on the New Zealand Geotechnical Database (NZGD).
  - Groundwater level information for the study extent.
- Assess the liquefaction vulnerability.
- Provide potential risk treatment options.

It should be noted that the provision of general geotechnical advice relating to the structure plans is outside the scope of the original Request for Proposal.

2 Liquefaction vulnerability assessment

2.1 Liquefaction process

It can be readily observed that dry, loose sands and silts contract in volume if shaken. However, if the loose sand is saturated, the soil's tendency to contract causes the pressure in the water between the sand grains (known as "pore water") to increase. The increase in pore water pressure causes the soil's effective grain-to-grain contact stress (known as "effective stress") to decrease. The soil softens and loses strength as this effective stress is reduced. This process is known as liquefaction.

The elevation in pore water pressure can result in the flow of water in the liquefied soil. This water can collect under a lower permeability soil layer and if this capping layer cracks, can rush to the surface bringing sediment with it. This process causes ground failure and with the removal of water and soil, a reduction in volume and hence subsidence of the ground surface.

The surface manifestation of the liquefaction process is the water, sand and silt ejecta that can be seen flowing up to two hours following an earthquake. The path for the ejecta can be a geological discontinuity or a man-made penetration, such as a fence post, which extends down to the liquefying layer to provide a preferential path for the pressurised water. The sand often forms a cone around the ejecta hole. With the dissipation of the excess pore-water pressure, the liquefied soil regains its pre-earthquake strength and stiffness.

The surface expression of liquefaction, water and sand depends on a number of characteristics of the soil and the geological profile. If there is a thick crust of non-liquefiable soil such as a clay, or sand that is too dense to liquefy during the particular level of shaking of the earthquake, then water fountains and sand ejecta may not be seen on the surface. The amount of ground surface subsidence is generally dependent on the density of the sand layers as well as how close the liquefying layers are to the surface. Ground surface subsidence increases with increasing looseness in the soil packing. The ground rarely subsides uniformly resulting in differential settlement of buildings and foundations. Figure 2.1 summarises the process of liquefaction with a schematic representation.

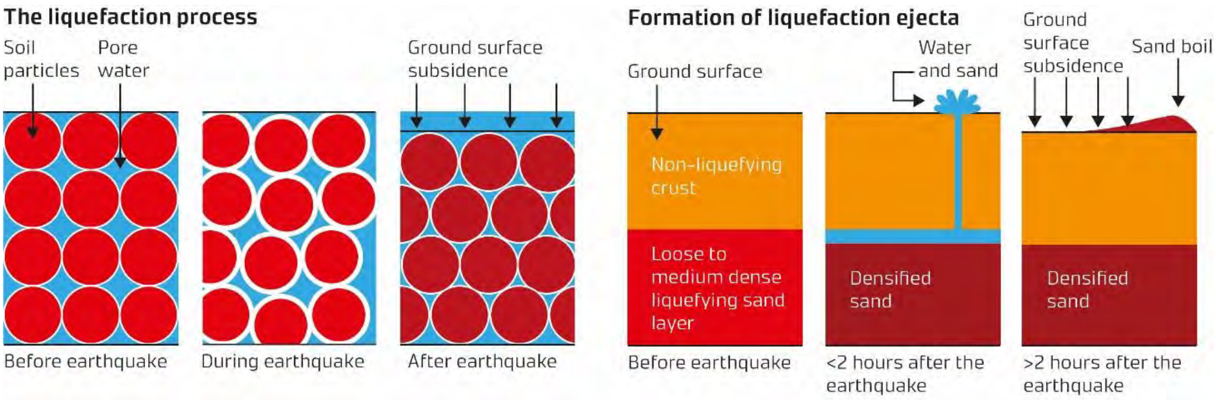


Figure 2.1: Schematic representation of the process of liquefaction and the manifestation of liquefaction ejecta.

2.2 Liquefaction susceptibility and triggering

The conditions often susceptible to liquefaction occur in geologically young sedimentary deposits such as those shown in Figure 2.2. In general terms, loose sands, some silts and in some cases gravels are most susceptible. While clays generally do not liquefy, they may still soften during an earthquake. Soil types which are susceptible to liquefaction include:

- Sands and low plasticity/non-plastic silts. (Bray & et al, 2014).
- Fine grained low to non-plastic soils with a high moisture content. (Bray & Sancio, 2006), (Boulanger & Idriss, 2006).
- Young, typically Holocene-aged (≤12,000 years old) deposits.
- Gravels can liquefy if they have a low permeability or are confined by less permeable layers.

The groundwater level in the soil is an important factor and soils with the groundwater at or near the surface are more susceptible.

Figure 2.2: Some landforms commonly susceptible to liquefaction, (MBIE/MfE/EQC, 2017).

2.3 Liquefaction consequence

Figure 2.3 presents the characteristics of liquefaction related land damage, and a summary of the likely consequences of liquefaction related damage for each category of land damage. This figure has been reproduced from (MBIE/MfE/EQC, 2017). Appendix A of the MBIE Guidance includes photos of liquefaction-induced land damage for each of these categories. These provide a useful reference for understanding the magnitude of land damage that can be expected within each category.

DEGREE OF LIQUEFACTION-INDUCED GROUND DAMAGE (example photographs)	TYPICAL CONSEQUENCES AT THE GROUND SURFACE These are examples of the type of damage that would be expected, they are not intended to be criteria for calculation
None to Minor 	– ***None to Minor*** no signs of ejected liquefied material at the ground surface[1]. – No more than minor differential settlement of the ground surface (eg undulations less than 25 mm in height). – No apparent lateral spreading ground movement (eg only hairline ground cracks). – Liquefaction causes no or only cosmetic damage to buildings and infrastructure (but damage may still occur due to other earthquake effects).
Minor to Moderate 	– ***Minor to Moderate*** quantities of ejected liquefied material at the ground surface (eg less than 25 percent of a typical residential site covered[2]); and/or – Moderate differential settlement of the ground surface (eg undulations 25–100 mm in height). – No significant lateral spreading ground movement (eg ground cracks less than 50 mm wide may be present, but pattern of cracking suggests the cause is primarily ground oscillation or settlement rather than lateral spreading). – Liquefaction causes moderate but typically repairable damage to buildings and infrastructure. Damage may be substantially less where liquefaction was addressed during design (eg enhanced foundations).
Moderate to Severe 	– Large quantities of ejected liquefied material at the ground surface (eg more than 25 percent of a typical residential site covered[2]); and/or – ***Moderate to Severe*** differential settlement of the ground surface (eg undulations more than 100 mm in height); and/or – Significant lateral spreading ground movement (eg ground cracks greater than 50 mm wide, with pattern of cracking suggesting direction of movement downslope or towards a free-face). – Liquefaction causes substantial damage and disruption to buildings and infrastructure, and repair may be difficult or uneconomic in some cases. Damage may be substantially less, and more likely to be repairable, where liquefaction was addressed during design (eg enhanced foundations and robust infrastructure detailing).

Notes:

1 An absence of ejecta at the ground surface does not necessarily mean that liquefaction has not occurred. Liquefaction may still occur at depth, potentially causing ground settlement.

2 The coverage of the site with ejected liquefied material does not in itself represent ground damage in an engineering sense, however there is a strong correlation between the volume of ejecta and the severity of differential ground settlement and foundation/infrastructure damage.

Figure 2.3: Degrees of liquefaction-induced land damage (MBIE/MfE/EQC, 2017)

The main potential consequences of liquefaction are discussed in MBIE Planning and Engineering Guidance for Potentially Liquefaction-Prone Land. Table 2.1 from these guidelines is reproduced in Table 2.1 of this report.

Table 2.1: Consequences of liquefaction, as published in Planning and engineering guidance for potentially liquefaction-prone land

Land	• Sand boils, where pressurised liquefied material is ejected to the surface (ejecta). • Ground settlement and undulation, due to consolidation and ejection of liquefied soil. • Ground cracking from lateral spreading, where the ground moves downslope or towards an unsupported face (e.g. a river channel or terrace edge).
Environment	• Discharge of sediment into waterways, impacting water quality and habitat. • Fine airborne dust from dried ejecta, impacting air quality. • Potential contamination issues from ejected soil. • Potential alteration of groundwater flow paths and formation of new springs.
Buildings	• Distortion of the structure due to differential settlement of the underlying ground, impacting the amenity and weathertightness of the building. • Loss of foundation-bearing capacity, resulting in settlement of the structure. In some cases this can result in tilting or overturning of multi-level buildings. • Stretch of the foundation due to lateral spreading, pulling the structure apart. In some cases this can result in collapse or near-collapse of buildings. • Damage to piles due to lateral ground movements, and settlement of piles due to down drag from ground settlement. • Damage to service connections due to ground and building deformations.
Infrastructure	• Damage to road, rail and port infrastructure (settlement, cracking, sinkholes, ejecta). • Damage to underground services due to ground deformation (e.g. 'three waters', power and gas networks). • Ongoing issues with sediment blocking pipes and chambers. • Uplift of buoyant buried structures (e.g. pipes, pump stations, manholes and tanks). • Damage to port facilities. • Sedimentation and 'squeezing' of waterway channels, reducing drainage capacity. • Deformation of embankments and bridge abutments (causing damage to bridge foundations and superstructure). • Settlement and cracking of flood stop banks, resulting in leakage and loss of freeboard. • Disruption of stormwater drainage and increased flooding due to ground settlement.
Economic	• Lost productivity due to damage to commercial facilities, and disruption to the utilities, transport networks and other businesses that are relied upon. • Absence of staff who are displaced due to damage to their homes or unable to travel due to transport disruption. • Cost of repairing damage.
Social	• Community disruption and displacement – initially due to damage to buildings and infrastructure, then the complex and lengthy process of repairing and rebuilding. • Potential ongoing health issues (e.g. respiratory and psychological health issues).

While the immediate effects of liquefaction relate primarily to land, building and infrastructure damage, liquefaction can also have a significant social, economic and environmental impact, refer to Section 2.4 of Planning and engineering guidance for potentially liquefaction-prone land (MBIE/MfE/EQC, 2017).

2.4 Assessment methodology

This liquefaction vulnerability assessment has been undertaken general accordance with a Level A assessment as described in Planning and engineering guidance for potentially liquefaction-prone land (MBIE/MfE/EQC, 2017). In that document a Level A assessment is described as a *Basic Desktop Assessment* which equates to an assessment of regional-scale information supported by a site walkover. For the purposes of this study, each growth cell has been classified in terms of its geomorphic zone. These zones are then assigned a liquefaction vulnerability classification as described below.

The methodology described in the Planning and engineering guidance for potentially liquefaction-prone land (MBIE/MfE/EQC, 2017) recommends categorisation of the liquefaction vulnerability of the land based on the performance criteria described in Figure 2.4 below.

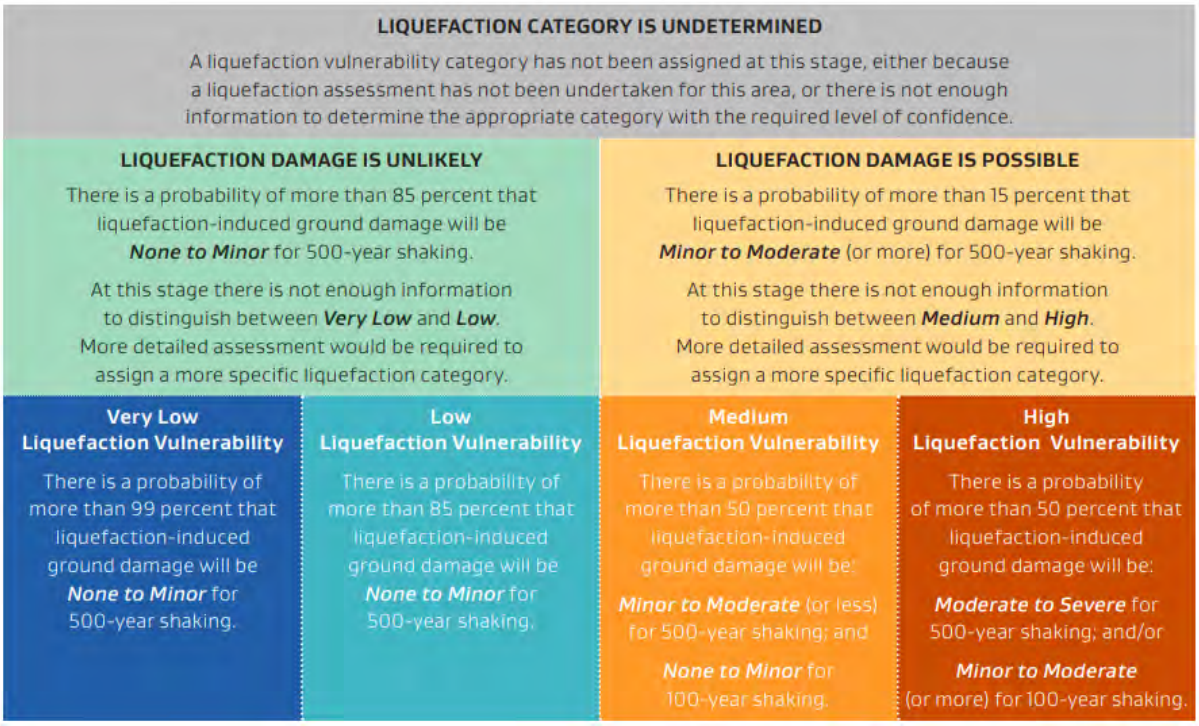


Figure 2.4: Performance criteria for determining the liquefaction vulnerability category - reproduced from Table 4.4 of MBIE/MfE/EQC (2017)

The performance criteria listed in Figure 2.4 relate the liquefaction vulnerability category to the expected liquefaction-induced land damage at a given ARI level of earthquake shaking. The assessment requires the assessor to consider the probability that a particular level of liquefaction-induced land damage will occur for a given level of shaking. In undertaking this assessment it is important to understand the following note attached to the table in the guidance document:

"The probabilities listed in this table are intended to provide a general indication of the level of confidence required to assign a particular category, rather than to be a specific numerical criteria for calculation. Conceptually, these probabilities relate to the total effect of all uncertainties in the assessment..."

That is, the guidance recommends the assessor consider the combined effect of all the uncertainties associated with the available information in the determination of the land damage category.

The general methodology applied to determine the liquefaction vulnerability category for the study area is as follows:

1. Evaluate the uncertainties associated with the mapping. This includes consideration of the resolution of mapping and the variability of soil conditions.
2. Evaluate the uncertainties associated with the groundwater level. Due to the limited amount of information about groundwater within the study area this is primarily dependent on field experience and engineering judgement and is one of the most significant sources of uncertainty in this assessment.
3. Evaluate the uncertainties associated with the determination of the seismic hazard for the study extent. Whilst current scientific understanding suggests that the Hamilton and Waipa Basin area is expected to have a relatively low level of seismic hazard compared to other regions across New Zealand, there remains considerable uncertainty regarding the likelihood and intensity of earthquake shaking that could occur. This uncertainty is especially relevant where liquefaction-susceptible soils are present but estimated design shaking intensities (e.g. PGA for 100 year ARI design event) are unlikely to be strong enough to trigger liquefaction. This means that if earthquake shaking intensity is slightly greater than assumed for design (or if design PGA values increase in future due to improved understanding of the hazard), then a step-change worsening in performance could occur. For this reason, where liquefaction-susceptible soils are present it is generally not preferable to rely exclusively on low design PGA values to assign a liquefaction vulnerability category of *Liquefaction Damage Is Unlikely, Very Low* or *Low*.
4. Based on the consideration of all of these uncertainties, assign one of the liquefaction vulnerability categories defined in Figure 2.4 to the land within the project extent.

3 Ground conditions

3.1 Geology

Te Awamutu and Kihikihi are situated on the border of the Waipa and Hamilton basins (Figure 3.1), a graben that has been progressively infilled with a complex sequence of volcanogenic alluvium and various ignimbrites and tephra since c. 2 million years ago (McCraw, 2011).

Figure 3.1: The Hamilton lowlands or Basin in the upper central North Island is bounded to the west and east by ranges and bisected by the Waikato River (McCraw, 2011).

Two distinct periods of deposition can be characterised in the Hamilton lowlands and are observed in the present day landscape as older materials (Walton Subgroup) forming the broad hills and younger materials (Primarily the Hinuera Formation of the Piako Subgroup) forming extensive plains. The Walton Subgroup and Piako Subgroup are part of the Tauranga Group. Younger Holocene sediments are also present in the Hamilton and Waipa Basin within gullies, peat bogs and along river terraces. The relationship between the geological materials is shown in Figure 3.2.

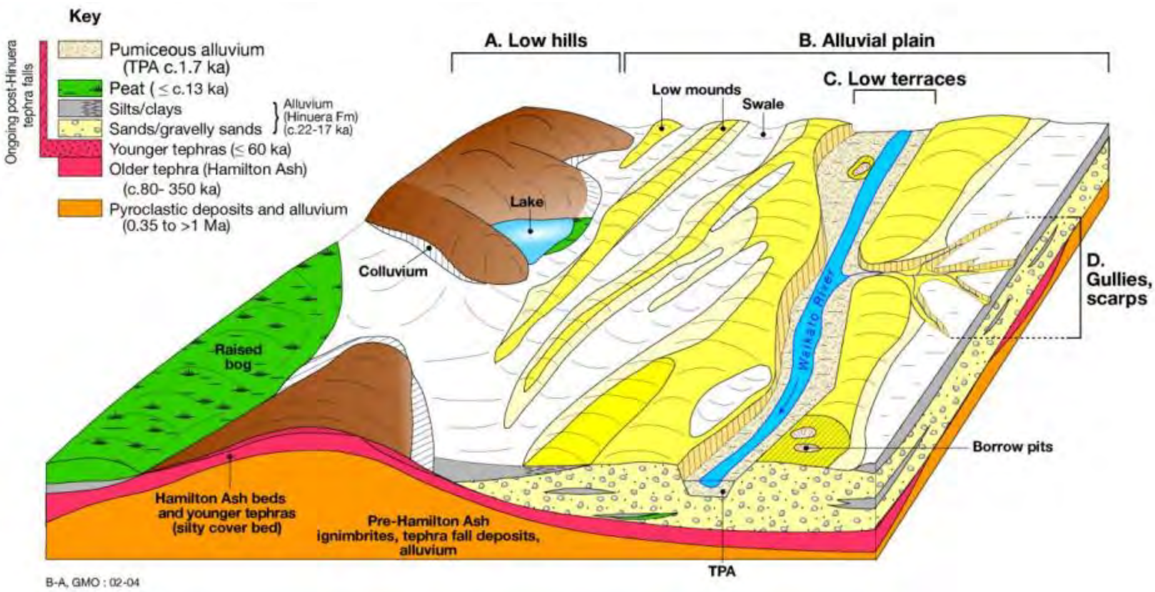


Figure 3.2: Main landscape units and geological materials, Hamilton and Waipa Basin (Lowe, 2010).

<u>Walton Subgroup</u>

The Walton Subgroup, forming the present day broad hills, comprises a sequence of ignimbrites and tephra from several sources and fine grained volcanoclastic alluvium (Edbrooke, 2005). The deposition of the Walton Subgroup beds occurred between 2 million years ago to 27,000 years ago in the Pleistocene Epoch. During later stages these materials eroded forming hills and valleys. The Walton Subgroup deposition ended upon the Oruanui Eruption (27,000 years ago).

<u>The Piako Subgroup</u>

Following the Oruanui eruption, the existing topography was infilled by the Piako Subgroup, which formed the extensive plains observed in Hamilton lowlands. The Piako Subgroup comprises interbedded coarse alluvium, pumice gravels, peat and silts deposited by braided river systems of the ancestral Waikato and Waipa Rivers. These rivers continued to deposit vast amounts of sediment into the Hamilton lowlands until climatic conditions changed c. 17,000 and the river systems entrenched into present day positions (Molloy, 1998).

Due to the nature of the depositional environment, the Piako Subgroup is highly variable both laterally and vertically. Loose sands and gravels are found in the higher energy environments and levees and finer grained sediments such as silt represent the low energy environments such as embayed channels and on the inside of river bends.

<u>Recent Holocene Sediments</u>

Subsequent to the deposition of the Hinuera Formation to form the "Hinuera Surface", a network of gullies have formed within the Hamilton and Waipa Basin. The floors of these narrow gullies are filled with young Holocene (<12,000 years old) colluvium and alluvium deposits consisting of reworked sands, silts and gravels of the Hinuera Formation and Walton Subgroup.

3.2 Faulting

The GNS New Zealand Active Fault Database identifies the Kerepehi fault as the closest active fault to the site at approximately 42km to the east. Other faults affecting the Hamilton and Waipa Basin include the inferred non-active Waipa fault and the Taupiri fault to the north proposed by (Kirk, 1991).

3.3 Site geomorphology

For the purposes of this study, the site has been divided into three geomorphic zones. These zones are presented in Figure A1 and Figure A2 in Appendix A and described in Table 3.1. The basis of the zones are the geological mapping (Edbrooke, 2005), a Digital Elevation Model (DEM) derived from LiDAR data and a site walkover undertaken in January 2019.

Table 3.1: Description of geomorphic zones adopted for the study areas

Geomorphic zone	Typical geology	Description
Low hills	Walton Subgroup	The relatively higher ground of the basin consists of low rounded hills representing the remnants of a previous ground surface. A typical sequence through this zone may consist of: Post Hamilton Ash Tephra – silt Hamilton Ash weather tephra – clay Karapiro Formation – Alluvial gravelly clay Puketoka Formation – ignimbrites
Alluvial plains	Piako Subgroup	Highly variable both vertically and laterally as the ancestral Waipa and Waikato Rivers deposited material eroded from the volcanic catchments of the central North Island. The deposits filled the low lying ground and channels and depressions within the eroded surface of the Walton Subgroup. The “Hinuera Surface” today consists of a series of low ridges, swales and flat plains sloping gently to the north. Soils comprise cross-bedded silts, sands, gravels with peat lenses also common. Sequences may exhibit a general fining upwards sequence, (McKay, Lowe, & Moon, 2017).
Gullies	Recent Holocene Deposits	Gullies are formed in the Hinuera Surface forming moderately steep slopes and terraces. Material within the gullies is recent alluvium derived from the parent materials in the basin. Uncontrolled filling is also often encountered in these zones.

3.4 Groundwater

In the absence of long term groundwater monitoring data we have undertaken a review of groundwater information for the growth cells. From experience in working within the Hamilton and Waipa Basin it is possible to draw some conclusions about the groundwater within the identified geomorphic zones (Table 3.2). However, it is not possible to assign groundwater levels in an area to the level of certainty required to refine this liquefaction assessment without long term groundwater monitoring records of sufficient density to build a reliable groundwater model.

Table 3.2: General groundwater observations for the geomorphic zones within the study area.

Geomorphic Zone	Groundwater observations
Low hills	Higher ground and often lower permeability soils leading to deeper groundwater levels relative to other geomorphic zones.
River/Gullies	Deposits in gully bases normally at or close to the median water table. River terraces generally coincident with river level. Presence of perched water normally results in the development of gullies and instability.
Alluvial plain	Relatively shallow groundwater when not controlled by localised drainage associated with river terraces, gullies and deep swales. Phreatic surfaces can be steep at slope margins depending on the underlying conditions.

3.5 Site ground conditions

The ground conditions at growth cells T6 and T11 are summarised in Table 3.3 and Table 3.4, respectively. Geomorphic zone maps are provided in Appendix A.

Table 3.3 Summary of the ground conditions at grown cell T6

Geology	Walton subgroup (eQa ~2ma to ~17 ka) Piako Subgroup (IQa – between ~128 to 12 ka) – alluvium Holocene Alluvium (Q1a) Investigations undertaken for the Haultain Street subdivision at the south eastern corner of the site indicate that the site is underlain by silts, sands and clays in this location. The geological unit was not noted, however, the descriptions are consistent with the Piako Subgroup.
Geomorphology / landforms	Low hills (Walton subgroup) Alluvial plains (Piako subgroup) Stream gullies (Recent alluvium)
Groundwater	Varied terrain including a shallow gully system that will locally control the level of the ground water. For parts of the site located away from these topographical relief features, relatively high groundwater levels could be expected. This is evidenced by the presence of shallow drain features in the growth cell. Investigations undertaken for the Haultain Street subdivision at the south eastern corner of the site indicates that groundwater levels of 1.5 m bgl are to be expected in this location. Low Hills areas likely to have relatively deep groundwater.

Table 3.4: Summary of the ground conditions at grown cell T11

Geology	Walton subgroup (eQa ~2ma to ~17 ka) Piako Subgroup (IQa – between ~128 to 12 ka) Holocene Alluvium (Q1a) No subsurface investigation are available for this growth cell. A review of aerial photography for the site has shown an area of non-engineered filling to the west of the commercial centre
Geomorphology / landforms	Low hills (Walton subgroup) Alluvial plains (Piako subgroup) Stream gullies (Recent alluvium)
Groundwater	The river and gully systems typically have the effect of lowering groundwater levels on the elevated areas of the plains. The Mangaohoi stream is located at the south of the growth cell at an RL of 43 m, local water levels are likely to be governed by this. The presence of farm drains in the centre of the site at a depth of 1.5 to 2 m suggests that groundwater may be coincident with the base of these features in this location. The alluvial plains are likely to have groundwater depths in the region of 1.5 to 3 m depending on proximity to the Mangaohoi Stream. Low Hills areas likely to have relatively deep groundwater.

4 Liquefaction assessment

4.1 Seismic site subsoil class

The seismic subsoil class in accordance with NZS 1170.5:2004 (Section 3.1.3) for the site is considered to be 'Class D – Deep Soil Sites'. This assumption is based on recent research by The University of Waikato (Jeong, 2019) which suggests that the majority of the Hamilton and Waipa Basin should be categorised as site Class D except on the basin margins. Although the growth cells are on the fringes of the study, the Waikato and Waipa Basin can be seen to extend further south.

4.2 Ground shaking hazard

The seismic hazard in terms of Peak Ground Acceleration (PGA) for the area has been assessed based on the NZTA Bridge Manual in accordance with the approach recommended in NZGS Module 1 (NZGS/MBIE, 2016).

For the purposes of this study, we have assumed that the growth cells will be used for residential development consisting of Importance Level 2 buildings with a 50 year design life. Consequently, the 25 and 500 year return periods correspond to Serviceability Limit State (SLS) and Ultimate Limit State (ULS) design events in this case.

Table 4.1 presents the return periods for earthquakes with various 'unweighted' PGAs with corresponding earthquake magnitudes.

Table 4.1: Ground seismic hazard

Event	Return period (years)	PGA (g)	Magnitude (M_{eff})
SLS	25	0.056	5.9
ULS	500	0.223	5.9

4.3 Results

Liquefaction vulnerability for the site has been assessed by geological screening with qualitative calibration and using semi-quantitative screening criteria based on age, peak ground acceleration expected, depth to groundwater and experience in undertaking quantitative assessments in these geological materials. Table 4.2 provides an outline of the general vulnerability of the geomorphic zones, their relevance to the growth cells is described in section 4.3.1 and 4.3.2 below. The following additional observations are made about the results of this assessment:

- With additional investigation and analysis it is possible that significant areas of the Low Hills geomorphology could be categorised as *Liquefaction Damage Is Unlikely*. This is due to the relatively large proportion of soils that are likely to exhibit clay like behaviour (i.e. not susceptible to liquefaction) and that it is more likely that relatively deep (i.e. deeper than 4 m) groundwater would be encountered in these areas.
- The current categorisation of *Liquefaction Damage Is Possible* for the other geomorphic zones does not preclude the later categorisation of these areas into *the Liquefaction Damage Is Unlikely* category (or *Low* or *Very Low* categories) if appropriate based on additional local investigation and analysis.

Table 4.2: Summary of liquefaction vulnerability of each geomorphic zone

Geomorphic zone	Summary of results	Liquefaction vulnerability category	Key uncertainties	Site specific information required to refine the liquefaction assessment
Low hills	The low hills generally represent areas of the Walton Subgroup. Experience in working within these materials indicates that this zone typically has lower liquefaction vulnerability than the other zones in the study area. A large proportion of the units within the Walton Subgroup exhibit clay-like behaviour, so site-specific confirmation of the presence of clay-like soil may lead to assigning a category of "*Liquefaction Damage Is Unlikely*". However, because specific groundwater depths across the area and the underlying geology are unknown a category of "*Liquefaction Category is Undetermined*" has been assigned. Groundwater likely to be deeper within this zone.	*Liquefaction Category Is Undetermined*	• Presence and thickness of soils exhibiting clay-like behaviour • Groundwater levels • Thickness and distribution of liquefiable layers • Proportion of pumiceous particles	• Confirm geological unit, i.e. Walton Subgroup • Confirm clay-like soils present • Confirm whether groundwater is present within top 4 m • Determine soil type to sufficient depth depending on the geological formation (top 4 m if Walton Subgroup or Hinuera Formation are confirmed, deeper for more vulnerable units) • Assess soil relative density if non-plastic
Stream gullies	The gully bottoms are likely to contain looser, younger material and may often have high groundwater, meaning that greater levels of damage may occur in this zone. Uncontrolled fill is a common feature of gully slopes, where this is present the risk will also increase. The presence of a free face in these locations is likely to present a lateral spreading risk. Development within this zone may is likely to require engineering assessment due to the presence of unstable slopes. The geological mapping has been undertaken at a scale that may lead to some CPTs being assigned to the incorrect geomorphic zone in the statistical analysis undertaken for this study. Confirmation of the geological unit/s present should be the first step in the assessment of liquefaction vulnerability within this area. Deposits in gully bases are normally at or close to the median water table.	*Liquefaction Damage Is Possible*	• Groundwater levels at slope margins • Geological unit • Perched water • Thickness and distribution of liquefiable layers • Proportion of pumiceous particles • Slope angles • Slope height	• Confirm whether groundwater is present within top 4 m • Determine geological unit • Determine soil type • Confirm whether uncontrolled fill is present • Assess soil relative density • Proximity to free faces • Height of free faces
Alluvial plains	The alluvial plains are highly variable in geology both laterally and vertically. Land damage of *"None to Minor"* through to *"Moderate to Severe"* are all possible within the alluvial plains, therefore it is important to have a good understanding of the underlying geology. The site may be underlain by a great thickness of liquefiable soils or may only have thin, intermittent layers of liquefiable soils interbedded with medium dense to dense gravels. A site with a high water table and the presence of non-plastic soils may require CPT investigations to determine the land damage category applicable. Groundwater is typically relatively shallow when not controlled by localised drainage associated with gullies and deep swales. Phreatic surfaces can be steep at slope margins depending on the underlying conditions.	*Liquefaction Damage Is Possible*	• Groundwater levels • Thickness and distribution of liquefiable layers • Proportion of pumiceous particles • Geomorphology	• Confirm geological unit • Confirm whether groundwater is present within top 4 m • Determine soil type to sufficient depth depending on the geological formation (top 4 m if Hinuera Formation is confirmed, deeper for more vulnerable units) • Consider proximity to slopes including swales • Determine pedological soil class • Determine what landforms are present • Assess soil relative density

4.3.1 Liquefaction vulnerability growth cell T6

Figure B1 in Appendix B shows liquefaction the vulnerability categories determined for the T6 growth cell based on the information available and the uncertainties that exist. The low hills geomorphic zone dominates the growth cell with alluvial plains forming the central low lying parts of the cell and the stream gully zone present along the existing tributaries of the Puniu River.

For the purposes of development, the current concept plan (Revision I) shows that the majority of the development is within the Low Hills geomorphic zone with the Alluvial Plains and Stream Gully zones being mostly used as green spaces.

Minimal investigations should be able to determine a classification of *Liquefaction Damage is Unlikely* in the Low Hills geomorphic zone. Experience in working with the materials of the Alluvial Plains suggests that damage could be anything from none to severe, CPT and determination of the water table will be required in the Alluvial Plains to quantify the liquefaction risk. The stream gully geomorphic group will be retained as open spaces, the potential for liquefaction at stream crossings will need to be further assessed once road layouts are confirmed.

Where development is occurring within land where a classification of *Liquefaction Damage is Possible* has been determined, consideration should be also given to the proximity to existing free faces or the construction of road swales in order to determine the potential effects of lateral spreading.

A Level C liquefaction assessment should be targeted at reducing the uncertainties in each zone based on the intended land use as outlined in Table 4.2 above. Potential mitigation approaches are presented in Section 4.5.

4.3.2 Liquefaction vulnerability growth cell T11

Figure B2 in Appendix B shows liquefaction vulnerability categories determined for the T11 growth cell based on the information available and the uncertainties that exist. Vulnerability areas follow the geomorphic assessment given in Table 4.2 above with the addition of an area of high vulnerability in the area of known non-engineered fill in the western part of the growth cell.

For the purposes of development, the current concept plan (Revision B) shows three areas of development due to the presence of a significant flood hazard in the lower lying central areas. The majority of the eastern development is situated in the Low Hills geomorphic zone fringed by the alluvial plains to the east, south and west. It is likely then that the liquefaction vulnerability and the subsequent mitigation will vary across this area. Subsequent to the completion of the geomorphological and liquefaction assessments, parts of T14 growth cell have been incorporated in to T11. It is recommended that the assessments are extended include these additional areas.

The central development is situated almost entirely on an area that has been subject to non-engineered filling in the 1960s. The presence of this fill and the likely high groundwater has led a classification of High Vulnerability in this area, however, it is likely that this material will require removal due to the presence of ground contamination and/or other geotechnical considerations. The removal of this material will not remove the liquefaction hazard completely as the level of vulnerability will be determined by the underlying soil.

The western development is situated in an area of Low Hills although this should be confirmed by site investigation during consenting.

Minimal investigations within the Low Hills geomorphic zone should determine a classification of *Liquefaction Damage is Unlikely*. Experience in working with the materials of the Alluvial Plains suggests that damage could be anything from none to severe, CPT and determination of the water table will be required in the Alluvial Plains to quantify the liquefaction risk. Development within the Stream Gullies geomorphic zone is not anticipated in this growth cell.

Where development is occurring within land where *Liquefaction Damage is Possible*, consideration should be also given to the proximity to existing free faces or the construction of road swales in order to determine the potential effects of lateral spreading.

A Level C liquefaction assessment should be targeted at reducing the uncertainties in each zone based on the intended land use as outlined in Table 4.2 above. Potential mitigation approaches are presented in Section 4.5.

4.4 Lateral spreading vulnerability

Observations from previous earthquakes demonstrate that liquefaction-induced lateral spreading can cause significant damage to buildings, infrastructure and the environment. Therefore consideration of the potential for lateral spreading should be applied when undertaking a liquefaction vulnerability assessment.

When considering the potential for lateral spreading adjacent to a free-face, the Planning and engineering guidance for potentially liquefaction-prone land (MBIE/MfE/EQC, 2017) notes that *"It is less likely (but not impossible) for lateral spreading to occur if there is no liquefied soil within a depth of 2H of the ground surface (where H is the height of the free-face)."* Zhang, Robertson, & Brachman (2004) define H as the difference in height from the toe of the embankment (frequently the invert of a river or other water surface body) to the top of the embankment for which lateral spreading is being assessed (see Figure 4.1).

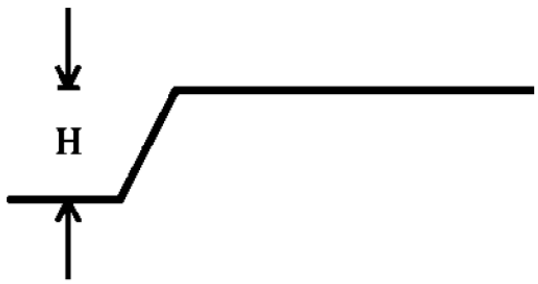


Figure 4.1: Free face height (H) as defined by Zhang et al. (2004)

However, with the information available for this study it is difficult to accurately define the free face height (H). This is primarily because it is difficult to confirm whether or not Digital Elevation Models (DEM) derived from LiDAR data are accurately estimating the elevation of the invert due to it frequently being obscured by water or vegetation.

The Planning and engineering guidance for potentially liquefaction-prone land (MBIE/MfE/EQC, 2017) recommends that particular attention should be given to land that is susceptible to liquefaction within 100 m of a free face less than 2 m high; or within 200 m of a free face greater than 2 m high. That is not to say that lateral spreading is likely to extend this far, however, the effects need to be considered to these extents.

Also, particular attention should be given to the potential for lateral spreading to occur on land within the Stream Gullies geomorphic zone. This is because of a combination of the land being categorised as *Liquefaction Damage Is Possible*, the potential for relatively shallow groundwater and there being a significant number of free faces associated with rivers and streams in this zone.

4.5 Potential risk treatment options

There are various potential options available to manage liquefaction-related risk, as summarised in Section 6 of MBIE (2017).

One potential solution is to avoid exposure to the hazard by not constructing within liquefaction-prone land. Further investigation will allow WDC to refine the liquefaction vulnerability areas and may allow uncategorised areas to be reclassified as low vulnerability.

Another potential solution is to reduce or mitigate liquefaction-related risk by reducing the likelihood of liquefaction occurring and/or reducing the consequences if liquefaction occurs. Potential foundation design and ground improvement options to mitigate the damaging effects of liquefaction are discussed in the series of guidance documents produced by MBIE for repairing and rebuilding houses affected by the Canterbury earthquakes (MBIE, 2012). Generally, the type of damage experienced may result in differential settlements, global settlements and ingress of liquefaction ejecta that could damage infrastructure and buildings. The risk of damage such as this is normally treated in one or a combination of the following ways:

- Undertake **ground improvement** so that a higher level of earthquake shaking is required to trigger liquefaction. In some cases it may be possible to change the fundamental behaviour of the ground (e.g. by physically removing or cementing susceptible soil) so that liquefaction will not occur even under the highest levels of earthquake shaking expected.
- Specify **robust foundation systems** that are able to tolerate liquefaction related land damage, such as thick reinforced foundations or stiff platforms. The importance level of the structure and the specific ground conditions at the site would inform the performance standard required for these foundation systems.
- Specify **readily repairable foundation systems** that are able to be reinstated relatively easily following liquefaction induced land damage.
- Specify the use of **lightweight building materials** for construction of buildings. Adopting lightweight cladding and roofing materials reduces the required bearing strength of the underlying soils and the severity of structural shaking imposed on the foundations. As such, lightweight building materials reduce the potential for liquefaction-induced foundation and building damage to occur.

There are various potential opportunities for Territorial Authorities to take an active role in managing liquefaction-related risk, while also facilitating development by simplifying site-specific ground investigation and foundation design requirements where appropriate. Possible examples include:

- Defining succinct geotechnical information requirements for resource and building consent applications, which focus on resolving the key uncertainties in the liquefaction assessment relevant for each geomorphic zone.
- Identifying standard foundation solutions which can be applied "off the shelf" once the liquefaction vulnerability category has been confirmed with sufficient certainty.
- Undertaking a widely-spaced grid of ground investigations and/or groundwater monitoring across the growth cells. This would provide greater certainty in the assessment of liquefaction vulnerability, and could allow some types of development to proceed relying only on the existing information without the need for site-specific investigations (where appropriate, and subject to a requirement for robust foundations).

4.6 Recommendations for further assessment

Further assessment of the liquefaction risk should be undertaken at subdivision stage in order to satisfy the requirements of s106 of the RMA. In terms of the MBIE (2017) guidance, this should consist of a Level C assessment that will provide a quantitative assessment of the liquefaction vulnerability of the growth cells that is specific to the proposed land use and tailored to the geomorphic zones. The level of uncertainty will be reduced so that a more precise liquefaction vulnerability category can be assigned and appropriate risk treatment options can be determined.

5 Works Cited

Boulanger, R. W., & Idriss, I. M. (2006). Liquefaction susceptibility criteria for silts and clays. *Journal of Geotechnical and Geoenvironmental Engineering (132 (11)*, 1412-1426.

Bray, J., & et al. (2014). Liquefaction effects on buildikngs in Central Business District of Christchurch. *Earthquake Spectra, 30*, 85-109.

Bray, J., & Sancio, R. B. (2006). Assessment of the liquefaction susceptibility of fine-graided soils. *Journal of Geotechnical and Geoenvironmental Engineering, 132 (9)*, 1165-1177.

Edbrooke, S. (2005). *Geology of the Waikato area. Institute of Geological & Nuclear Sciences 1:2500 000 geological map 4. 1 sheet + 68p.* Lower Hutt: Institute of Geological & Nuclear Sciences.

Kirk, P. A. (1991). Waipa Fault and the tectonic rotation of Hakarimata-Taupiri block. *New Zealand Geological Survey Record 43*, 81-84.

Lowe, D. J. (2010). Introduction to the landscapes and soils of the Hamilton Basin. *Guidebook for Pre-conference North Island, New Zealand „Volcanoes to Oceans‟ field tour*, 1.24-1.61.

MBIE. (2012). *Repairing and rebuilding houses affected by the Canterbury earthquakes.* MBIE.

MBIE/MfE/EQC. (2017). *Planning and engineering guidance for potentially liquefaction-prone land.*

McCraw, J. (2011). *The Wandering River.* Levin: Geoscience Society New Zealand.

McKay, A. M., Lowe, D. J., & Moon, V. G. (2017). *Evaluating soil and landscape models to predict liquefaction susceptibility in the Hinuera Formation, Hamilton Basin.*

Molloy, L. (1998). *Soils in the New Zealand Landscope: the Living Mantle.* New Zealand Soil Science Society.

NZGS/MBIE. (2016). *Guidelines for earthquake geotechnical engineering practice - Module 1: Overview of guidelines.*

Zhang, G., Robertson, P. K., & Brachman, R. (2004). Estimating Liquefaction-Induced Lateral Displacements Using the Standard Penetration Test of Cone Penetration Test. *Journal of Geotechnical and Geoenvironmental Engineering 8 (130)*, 861-871.

6 Applicability

This report has been prepared for the exclusive use of our client Boffa Miskell Ltd, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd

Report prepared by:

....

John Brzeski
Engineering Geologist

Authorised for Tonkin & Taylor Ltd by:

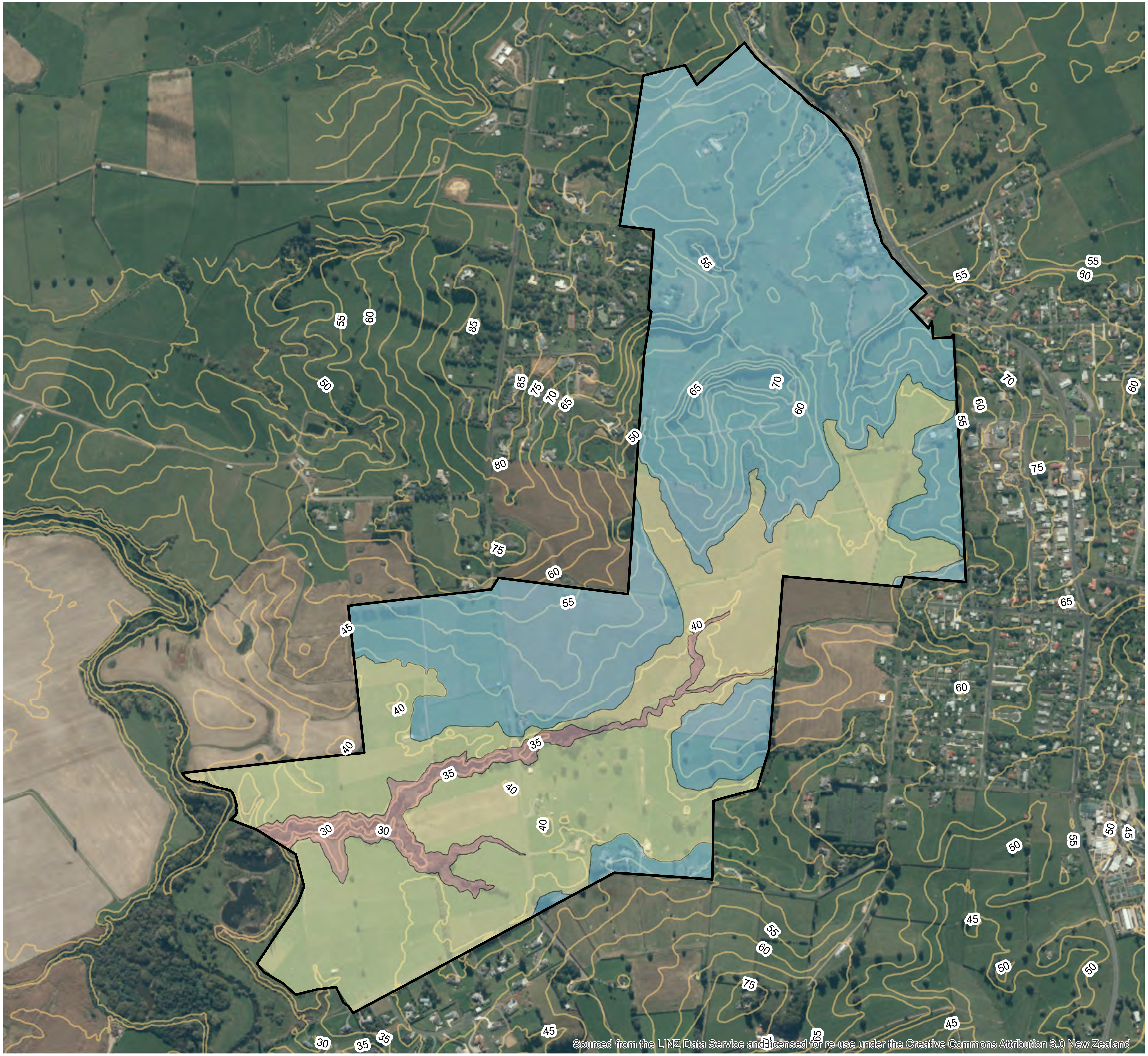
....

Glen Nicholson
Project Director

Report technically reviewed by Michael Triggs – Geotechnical Engineer

JJBR
p:\1008305\1008305.1000\issueddocuments\190823 final reports\190823.t6 t11 liquefaction study rpt.docx

Appendix A: Geomorphic Zones



LEGEND

T6 Growth cell extent

T6 Growth cell extent

T6 Geomorphic Zones

Alluvial Plains

Low Hills

Stream Gullies

N

A3 SCALE:1:9,000

0 70 140 210 280 350 Meters

Notes:
Topo map and aerial sourced from LINZ Data (Crown Copyright Reserved).
Applicability:
This figure has been prepared with respect to the particular brief given to Tonkin + Taylor.
Tonkin + Taylor do not accept responsibility for any loss or damage resulting from the use of the information and any person relying on the information does so at their own risk.
The basis of geomorphic zones are the geological mapping (Edbrooke, 2005), a Digital Elevation Model (DEM) derived from LiDAR data and a site walkover undertaken in January 2019.
This plan should be read in conjuction with accompanying growth cell structure plan report

DRAWN	JJBR	Jun.19
CHECKED	MJTT	Jun. 19
APPROVED	GGN	Aug.19

ARCFILE
T6_geomorph_map_20190116.mxd

SCALE (AT A3 SIZE)
1:9,000

PROJECT No.
1008305.1000

Tonkin+Taylor
Level 5, 711 Victoria Street, Hamilton
www.tonkintaylor.co.nz

BOFFA MISKELL
WAIPA STRUCTURE PLAN
T6 GROWTH CELL
Geomorphic Zones

Figure A1: T6 Geomorphic Zones

LEGEND

T11 Geomorphic Zones

- Alluvial Plains
- Low Hills
- Non-engineered Fill
- Stream Gullies

A3 SCALE:1:5,405

0 40 80 120 160 200 Meters

N

Notes:
Topo map and aerial sourced from LINZ Data (Crown Copyright Reserved).
Applicability:
This figure has been prepared with respect to the particular brief given to Tonkin + Taylor.
Tonkin + Taylor do not accept responsibility for any loss or damage resulting from the use of the information and any person relying on the information does so at their own risk.
The basis of geomorphic zones are the geological mapping (Edbrooke, 2005), a Digital Elevation Model (DEM) derived from LiDAR data and a site walkover undertaken in January 2019.
This plan should be read in conjuction with accompanying growth cell structure plan report

DRAWN	JJBR	Jun.19
CHECKED	MJTT	Jun. 19
APPROVED	GGN	Aug.19

ARCFILE
T11_geomorph_map_20190116.mxd

SCALE (AT A3 SIZE)
1:5,405

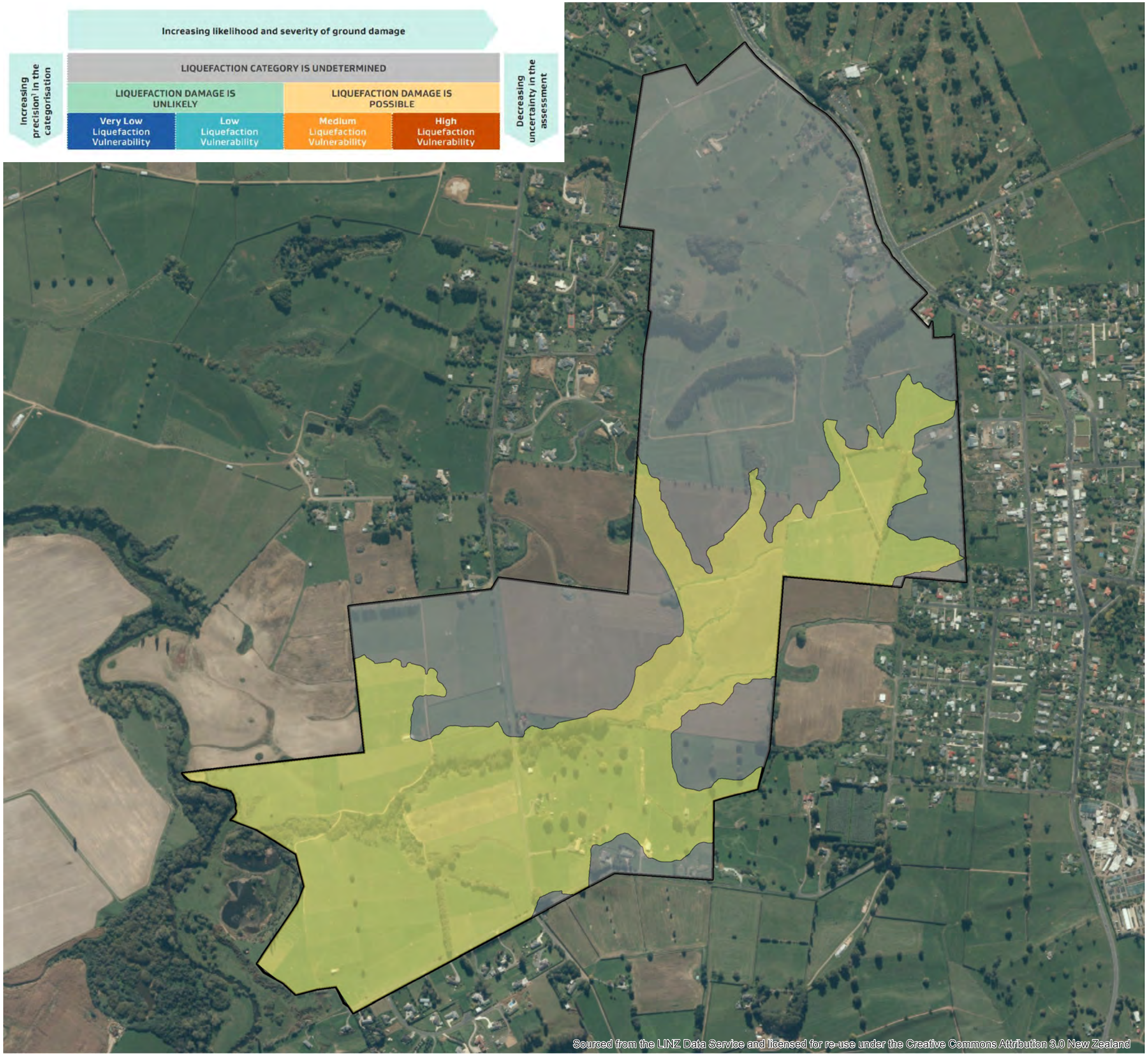
PROJECT No.
1008305.1000

Tonkin+Taylor
Level 5, 711 Victoria Street, Hamilton
www.tonkintaylor.co.nz

BOFFA MISKELL
WAIPA STRUCTURE PLAN
T11 GROWTH CELL
Geomorphic Zones

Figure A2: T11 Geomorphic Zones

Appendix B: Liquefaction Vulnerability Maps



LEGEND

T6 Growth cell extent

Liquefaction vulnerability Category

Liquefaction Category is Undetermined

Liquefaction Damage is Possible

A3 SCALE:1:9,000

0 70 140 210 280 350 Meters

N

Notes:
Topo map and aerial sourced from LINZ Data (Crown Copyright Reserved).
Applicability:
This figure has been prepared with respect to the particular brief given to Tonkin + Taylor.
Tonkin + Taylor do not accept responsibility for any loss or damage resulting from the use of the information and any person relying on the information does so at their own risk.
Liquefaction vulnerability categories determined by undertaking a Level A liquefaction assessment in line with MBIE/MfE/EQC (2017) guidelines.
This plan should be read in conjuction with accompanying growth cell structure plan report

DRAWN	JJBR	Aug.19
CHECKED	MJTT	Aug.19
APPROVED	GGN	Aug.19

ARCFILE
T6_liquefaction.mxd

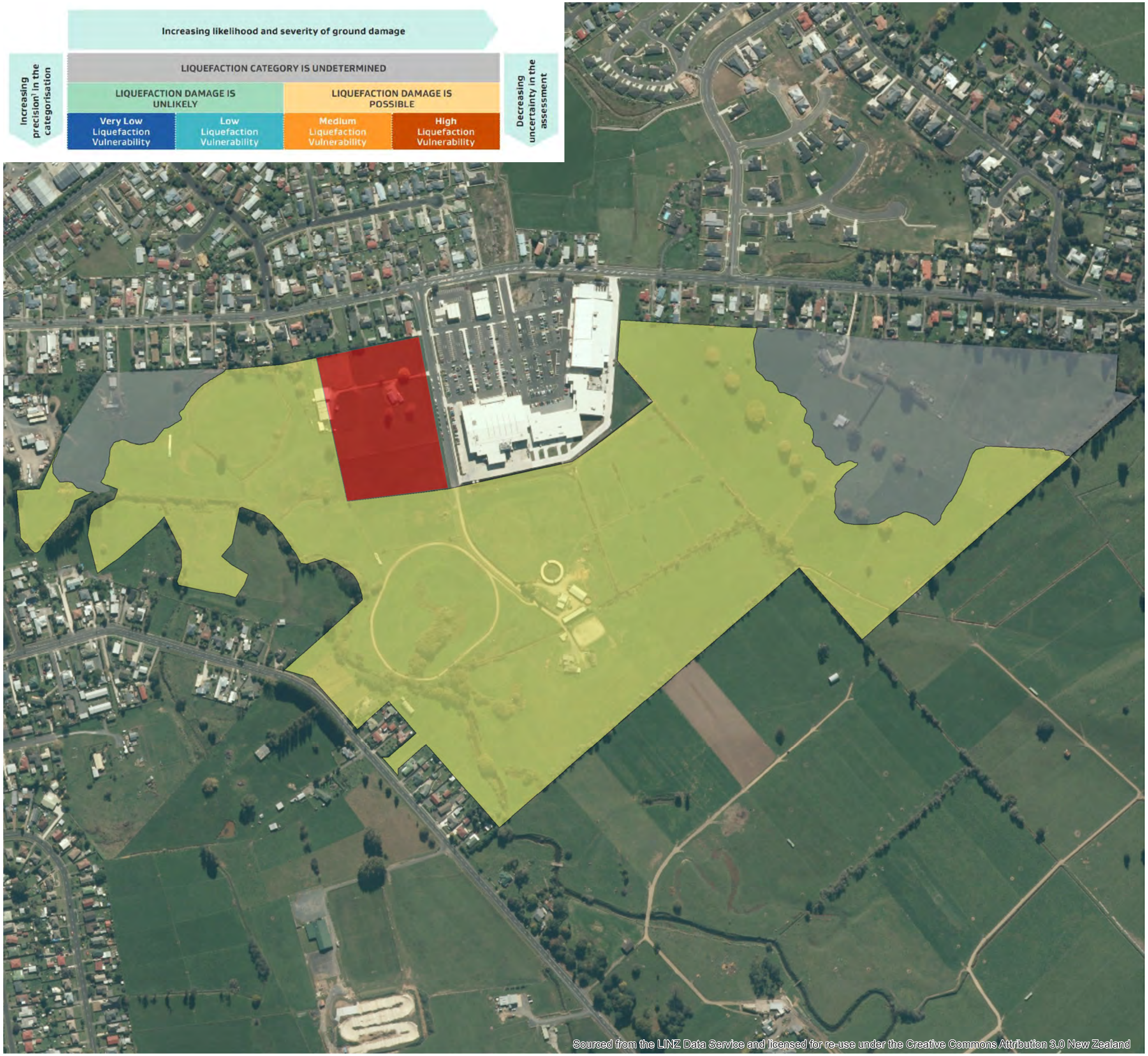
SCALE (AT A3 SIZE)
1:9,000

PROJECT No.
1008305.1000

Tonkin+Taylor
Level 5, 711 Victoria Street, Hamilton
www.tonkintaylor.co.nz

BOFFA MISKELL
WAIPA STRUCTURE PLAN
T6 GROWTH CELL
Liquefaction Vulnerability map

Figure B1: T6 Liquefaction Vulnerability Map



LEGEND

Liquefaction Vulnerability Category

- Liquefaction Category is Undetermined
- Liquefaction Damage is Possible
- High Liquefaction Vulnerability

N

A3 SCALE:1:5,000

0 40 80 120 160 200 Meters

Notes:
Topo map and aerial sourced from LINZ Data (Crown Copyright Reserved).
Applicability:
This figure has been prepared with respect to the particular brief given to Tonkin + Taylor.
Tonkin + Taylor do not accept responsibility for any loss or damage resulting from the use of the information and any person relying on the information does so at their own risk.
Liquefaction vulnerability categories determined by undertaking a Level A liquefaction assessment in line with MBIE/MfE/EQC (2017) guidelines.
This plan should be read in conjuction with accompanying growth cell structure plan report

DRAWN	JJBR	Aug.19
CHECKED	MJTT	Aug.19
APPROVED	GGN	Aug.19

ARCFILE
T11_liquefaction.mxd
SCALE (AT A3 SIZE)
1:5,000
PROJECT No.
1008305.1000

Tonkin+Taylor
Level 5, 711 Victoria Street, Hamilton
www.tonkintaylor.co.nz

BOFFA MISKELL
WAIPA STRUCTURE PLAN
T11 GROWTH CELL
Liquefaction Vulnerability map

Figure B2: T11 Liquefaction Vulnerability Map

www.tonkintaylor.co.nz

REPORT

Tonkin+Taylor

Te Awamutu T6 and T11 Structure Plans

Three waters assessment

Prepared for
Boffa Miskell Ltd
Prepared by
Tonkin & Taylor Ltd
Date
August 2019
Job Number
1008305.1000.v3

Exceptional thinking together
www.tonkintaylor.co.nz

Document Control

Title: Te Awamutu T6 and T11 Structure Plans					
Date	**Version**	**Description**	**Prepared by:**	**Reviewed by:**	**Authorised by:**
7/6/19	1	Draft three waters assessment report	J Mogridge and A Wells	S Jones and J Brzeski	G Nicholson
02/8/19	2	Draft. Updated report following Waipa DC comments	J Mogridge	S Jones and J Brzeski	
23/08/19	3	Final. Updated with high level cost estimates	J Mogridge	S Jones and J Brzeski	G Nicholson

Distribution:

Boffa Miskell Ltd	1 PDF copy
Tonkin & Taylor Ltd (FILE)	1 PDF copy

Table of contents

Executive summary

The Waipa district has been identified as a high growth area. To provide for this growth, structure plans for the T6 and T11 cells located in Kihikihi and Te Awamutu respectively are required.

Tonkin & Taylor Ltd (T+T) have been appointed by Boffa Miskell Ltd to investigate and provide technical assessments of the stormwater, wastewater and water supply requirements for the two growth cells. These assessments will support the Structure Plans for each cell and Plan Changes to the District Plan.

Existing three waters infrastructure, drainage and flood risk has been assessed as well as population demands and the required standards, criteria and best practice. The key conclusions and recommendations described in more detail within this report are as follows:

T6 growth cell

- Peak flow control of the 2 year ARI and higher magnitude events is not recommended to avoid coincidence with the larger Puniu River flood peak.
- Culvert crossings to be appropriately designed to enable pass forwarding of post-development flood flows and to mitigate scour and erosion risk.
- Retention, reuse and onsite soakage of the post-development water quality volume where possible. Water tanks for each lot are recommended and onsite soakage will need to be tested and designed on a lot by lot basis. Soakage may be limited in the higher ground areas of the cell and bio-retention devices or a suitable wetland will need to be designed if the water quality volume cannot be achieved through retention, reuse and onsite soakage.
- Vegetated swales are recommended to convey overland flow. Road berms need to be of sufficient width to accommodate swales and low impact stormwater treatment systems such as rain gardens and soakage basins if required. The sizing of such devices will be dependent on the final road layout and onsite soakage testing.
- Avoid modification to existing channel corridors and undertake an ecological survey.
- On-site wastewater treatment and discharge systems. The soil profile and soakage capacity will need to be determined on a lot by lot basis.
- Restricted Flow water supply which is likely to consist of on-site storage tanks supplemented with rainwater and/or groundwater bores or wells. Water quality needs to meet standards. It is understood that this modelling work is currently being undertaken.

T11 growth cell

- The growth cell provides a significant amount of natural floodplain storage volume and has been split into two smaller sub-cells to avoid this area and mitigate downstream effects.
- Peak flow control of the 2 year ARI and higher magnitude flood events is not recommended to avoid coincidence with the larger Mangaohoi flood peak.
- Retention, reuse and onsite soakage of the post-development water quality volume. Onsite soakage will need to be tested and designed on a lot by lot basis.
- Vegetated swales are recommended to convey overland flow. Road berms need to be of sufficient width to accommodate swales and low impact stormwater treatment systems such as rain gardens and soakage basins if required. The sizing of such devices will be dependent on the final road layout and onsite soakage testing.
- Provision of two separate wastewater reticulation systems in each of the two sub-cells to connect to the existing Te Awamutu network. Pump stations will likely be required to drain

part of, or the whole of both the sub-cells. Upgrades to the existing wastewater network are likely to be required or attenuation within T11 itself to limit peak flows.

- There are two potential connections to the existing town water supply mains.

1 Introduction

The Waipa district has been identified as a high growth area in the National Policy Statement on Urban Development Capacity. Te Awamutu and Kihikihi are forecast to grow by 5,400 people by 2050. To provide for this growth, structure plans for the T6 and T11 cells are required, as identified in the Waipa2050 Growth Strategy (2017) and Waipa District Council (WDC) 2018 – 2028 Long Term Plan (Figure 1.1).

T6 cell is approximately 165 ha in size, located to the west of State Highway 3 (SH3) between Te Awamutu and Kihikihi and is currently zoned Deferred Large Lot Residential. A Plan Change to the Proposed District Plan will re-zone the land to Large Lot Residential Zone.

T11 cell is approximately 47 ha and is located to the east of central Te Awamutu and is currently zoned Rural. A Plan Change to the Proposed District Plan will re-zone the land to Residential Zone and Deferred Residential Zone.

Tonkin & Taylor Ltd (T+T) have been requested by Boffa Miskell Ltd to investigate and provide technical assessments of the stormwater, wastewater and water supply requirements for the growth cells. These assessments will support the Structure Plans for each cell and Plan Changes to the District Plan.

The purpose of this assessment is to:

1. Identify the existing drainage, stormwater features and flood risk within, and associated with the growth cell areas.
2. Recommend high level stormwater infrastructure and management requirements for development within the growth cell areas.
3. Identify existing wastewater and water supply networks and limitations associated with the growth cell areas.
4. High level assessment of population demands and recommendations for water supply and wastewater within the growth cell areas.

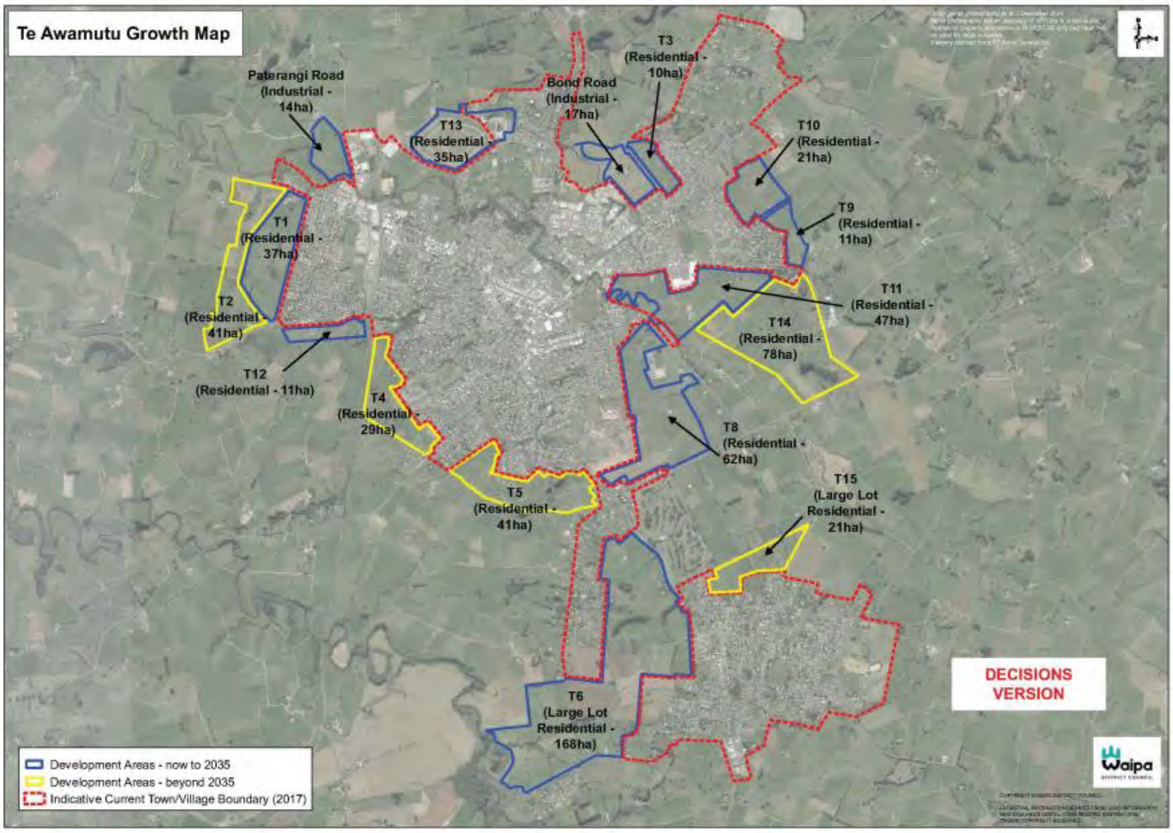


Figure 1.1: Te Awamutu growth cells (Figure from Waipa2050 Growth Strategy 2017)

2 Stormwater assessment

2.1 Catchment descriptions

2.1.1 T6 growth cell

2.1.1.1 Topography

The existing topography (2007-2008 LiDAR data) within the growth cell is shown in Figure 2.1. The growth cell contains high ground and steep slopes at the northern end. The topography slopes down to lower ground at the terraces of the Puniu River at the southern boundary, with valley side slopes on each bank of the tributary stream.

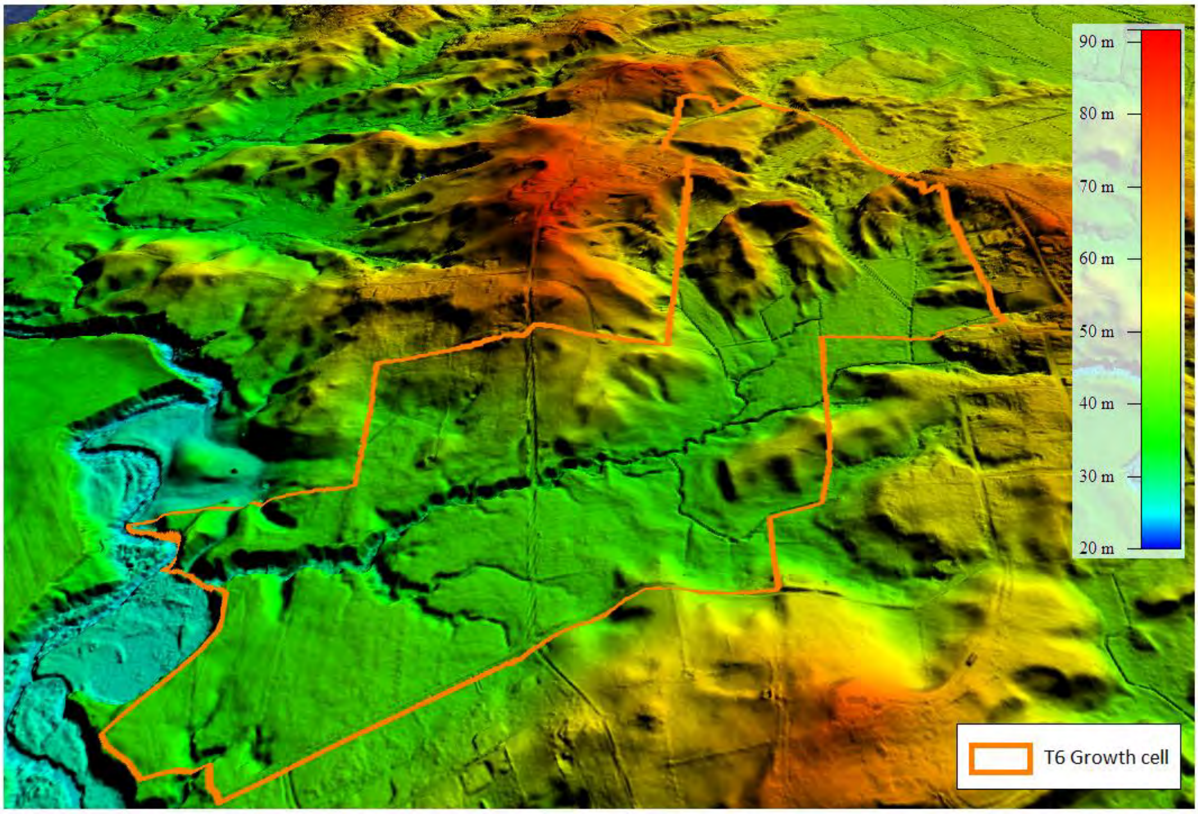


Figure 2.1: T6 growth cell existing topography (2007-2008 LiDAR)

2.1.1.2 Existing watercourses and drainage

Figure A1 in Appendix A shows the existing watercourses and drainage within and surrounding the growth cell.

The majority of runoff within the growth cell flows in a southerly direction and discharges to the Puniu River. Runoff within a 12.5 ha area at the northern end of the growth cell flows north-west to the Mangaohoi stream via a 450 mm culvert under Kihikihi Road (SH3).

There is no existing reticulated stormwater network within the growth cell itself, but stormwater pipelines discharge runoff from parts of the Kihikihi urban area to the Puniu river tributary stream that intersects the southern area of the growth cell. This tributary stream accommodates the majority of the runoff from the growth cell area and flows beneath St. Leger Road through a 1800 mm diameter culvert. The St Leger Road culvert has an upstream catchment area of approximately 203 ha. Downstream of St Leger Road the tributary stream passes through the Brill Road wetlands at the confluence with the Puniu River.

The wetlands are classified as a Significant Natural Area (SNA) and the tributary stream has a first and second order Ministry for the Environment (MfE) classification, as shown in Figure 2.2.

The direct tributary of the Puniu River that flows from east to west across the southern end of the growth cell is a second order stream and there are three first order streams that feed into this stream. The longest of these three streams flows from the north of the growth cell, near the Puniu/Mangaohoi watershed boundary, in a southerly direction. The stream exits and re-enters the growth cell near Haultain Street where there is a separate proposed subdivision development. The Waikato Regional Council (WRC) stormwater management guidelines, as described in section 2.2.1 recommends the protection of first and second order streams and the piping natural water courses is not supported.

An ecological issues and options assessment report by Kessels and Associates Ltd (2013) states that the SNA wetland may provide habitat for threatened fish species and that the Puniu River has fish habitat and spawning designations. There are no ecological freshwater fish records for the streams within the growth cell and it is therefore recommended that surveys are undertaken as part of the supporting information for the planning process.

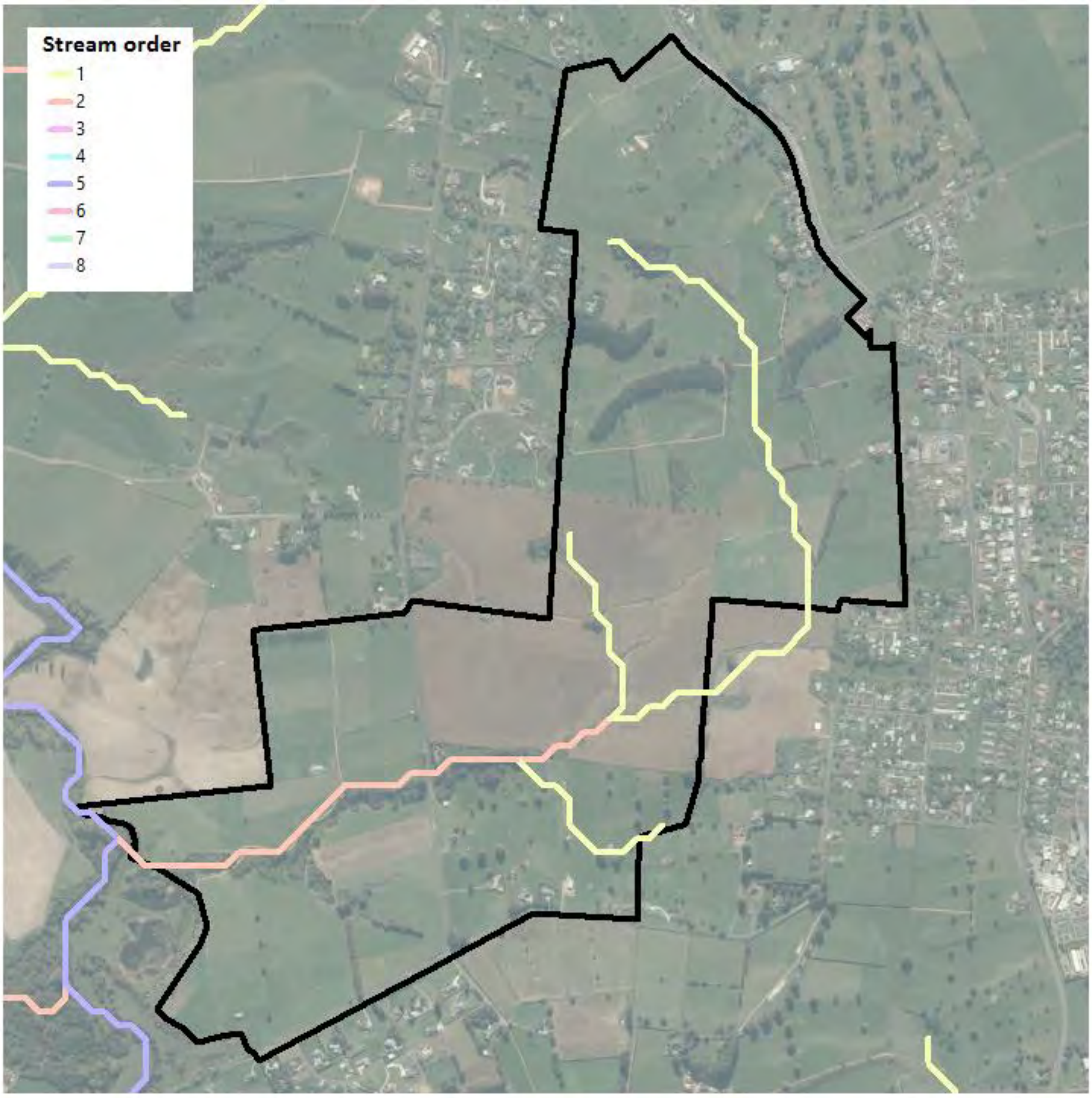


Figure 2.2: T6 growth cell MfE River environment classification

2.1.1.3 Geology

The Landcare Research Soil Permeability Map (https://soils-maps.landcareresearch.co.nz) shows that soils within the growth cell have a moderate permeability, with slow permeability within the lower valley of the Puniu tributary stream. Geological maps (refer to T6 and T11 geotechnical assessment report, Tonkin + Taylor, 2019) show that the higher elevation areas of the growth cell are underlain with clay and anecdotal records from residents suggests soakage issues in these areas. It is therefore recommended that soakage needs to be tested on a lot by lot basis.

2.1.1.4 Existing flood risk and hydrology

The WDC GIS hazards layer identifies a flood risk at the southern area of the growth cell from the Puniu River. Figure A1 in Appendix A shows the extent of this flood risk area within the growth cell. Information on the modelling that has informed this flood risk area is not provided and flood risk attributed to the tributary streams within the growth cell has yet to be identified.

The 1800 mm culvert at St Leger Road has an estimated capacity of 11.5 m^3/s at soffit level. The actual capacity of this culvert is likely to be < 11.5 m^3/s due to dense vegetation and sedimentation observed at the crossing during a recent site visit. The pre-development peak flows at the St Leger Road are shown in Table 2.1. The pre-development 100 year plus climate change peak flow exceeds the capacity of the culvert and the road is therefore susceptible to overtopping. LiDAR levels and site visit observations indicate that the road would overtop before flood levels exceed the upstream gully banks, which is only likely to occur in high magnitude flood events. The culvert is susceptible to blockage from sediment and debris which could cause flooding at higher frequency rainfall events.

Table 2.1: Pre-development peak flows at St Leger Road

Average Recurrence Interval (ARI) in years (including +2.1°C climate change)	Pre-development Peak flow rate (m^3/s)
2	2.9
10	6.3
100	13.0

2.1.2 T11 growth cell

2.1.2.1 Topography

The existing topography (2007-2008 LiDAR data) within the growth cell is shown in Figure 2.3. The eastern area of the growth cell is characterised by high ground and steep slopes whereas the southern and western areas of the growth cell are relatively flat due to the natural floodplain of the Mangaohoi stream. At present the area is largely rural grassland.

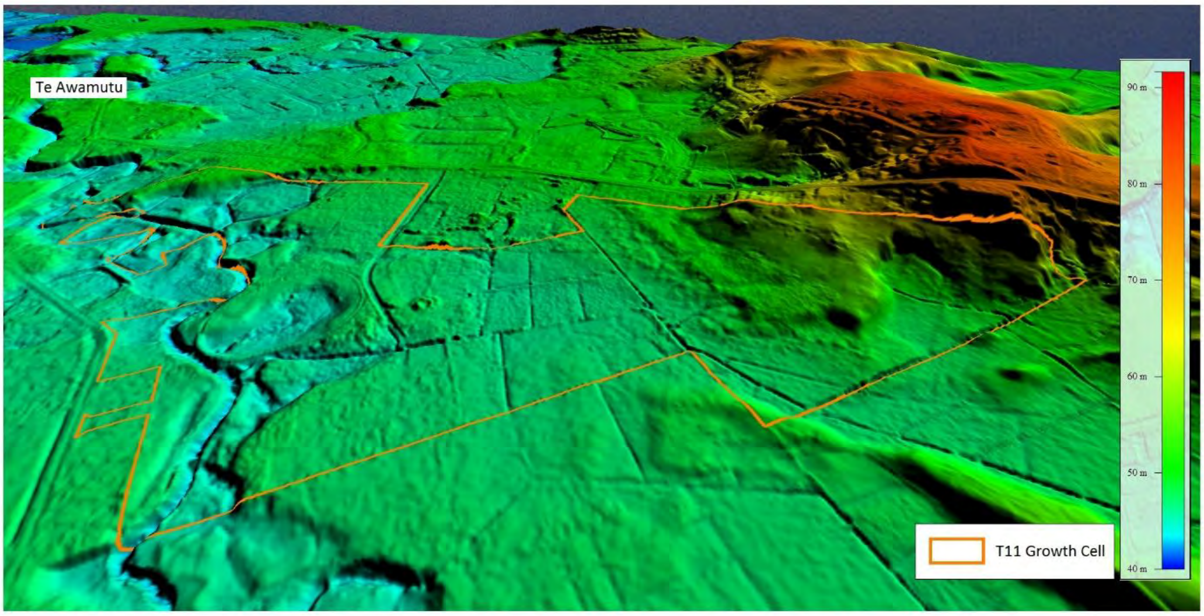


Figure 2.3: T11 growth cell existing topography (2007-2008 LiDAR)

2.1.2.2 Existing watercourses and drainage

Figure A2 in Appendix A shows the existing watercourses and drainage within and surrounding the growth cell.

The figure shows the existing overland flowpaths across the T11 growth cell (flowpaths with contributing catchment areas greater than 2000 m^2). The flowpath routes were generated using the 2007-2008 LiDAR topographical data.

Runoff within the growth cell generally flows in a southerly direction with additional flowpaths entering the cell from the east. The overland flowpaths include drainage ditches through the farmland including two culverts through the farm building area which are estimated to be approximately 0.6 m in diameter. All runoff from within and to the east of the growth cell ultimately discharges to the Mangaohoi stream, which has a large upstream catchment area of approximately 85 km^2.

Stormwater pipes discharge runoff from the 6 ha shopping complex to the North of the growth cell into the existing farm drainage ditch network. These stormwater pipes are connected to the outlet from a stormwater retention pond on the Northern side of Cambridge Road.

2.1.2.3 Geology

The Landcare Research Soil Permeability Map (https://soils-maps.landcareresearch.co.nz) shows that soils within the growth cell have a moderate permeability at higher ground, with low permeability within the natural floodplain of the Mangaohoi stream.

2.1.2.4 Existing flood risk and hydrology

The Mangaohoi stream has a large catchment area of approximately 85 km^2 upstream of the growth cell and therefore the primary flood risk is attributed to the flood hydrograph arriving from the upstream catchment rather than direct runoff from within the cell.

WSP Opus undertook a flood hazard assessment and hydraulic modelling of the stream (T8 and T11 growth cells, Te Awamutu, WSP Opus, December 2018), which has a peak modelled discharge of 98 m^3/s in the 1% AEP design event (+2.1 degrees climate change) at the T11 growth cell.

Figure A3 in Appendix A shows the maximum flood depth at the growth cell in the 1% AEP design event (+2.1 degrees climate change). A significant amount of the western and southern areas of the growth cell are inundated with over one metre flood depths, with shallower flood depths occurring in the area to the south of the shopping complex. The higher ground in the eastern area of the growth cell does not experience flooding with regards to the Mangaohoi stream.

2.2 Stormwater standards and criteria

2.2.1 Waikato Regional Council guidelines

Waikato Regional Council (WRC) released two new guideline documents in June 2018 to address stormwater management: Waikato stormwater management guideline (TR2018/01) and Waikato stormwater runoff modelling guideline (TR2018/02).

The stormwater management guidelines includes best practice low impact design approaches and devices for stormwater treatment. It also includes techniques and recommendations for minimising imperviousness and disturbance. These best practices and recommendations should be used throughout the planning and design stages of development.

Within the guideline documents there are five requirements related to peak flow control criteria:

1. Rainfall data used for all rainfall events shall have 24-hour rainfall distribution.
2. The rainfall data for the 2, 10 and 100-year ARI events should be increased for the post-development scenario to allow for predicted climate change.
3. Where there are existing downstream flooding issues, depending on the site's position in the catchment, it is recommended that the post-development peak discharge for the 100-year ARI rainfall event for a new development be limited to 80% of the pre-development peak discharge (unless there is a catchment study that demonstrates that this is not required).
4. In terms of intermediate storm control, depending on the site's position in the catchment, the 2 and 10-year ARI post-development peak discharges shall not exceed the 2 and 10-year ARI pre-development peak discharges.
5. Peak flow control is generally only recommended for projects located in the top half of catchments so as to avoid concerns over coincidence of peaks aggravating downstream flooding concerns.

Developments will need to be designed to retain (reuse or soak) the initial abstraction volume of runoff.

The guidelines include the following requirements for water quality treatment:

1. The water quality volume is the runoff volume from the 1/3 of the 2-year 24 hour rainfall event at a given location.
2. The water quality volume should be used to determine storage volumes and flow rates to size stormwater management devices.
3. In areas where the water quality event rainfall is greater than 30 mm, water quality treatment should be designed using a rainfall depth of 30 mm to determine the water quality volume. This only applies to water quality criteria. Extended detention will require design for the full, un-adjusted volume.
4. Where nutrients are a contaminant of concern, for example in contained lake catchments, a treatment train approach must be used to improve nitrogen and phosphorus removal efficiencies. This is due to the limited ability of individual stormwater management devices to achieve significant removal of nitrogen and phosphorus on their own.

The WRC guidelines recommends the protection of first and second order streams and the piping natural water courses is not supported.

2.2.2 Regional Infrastructure Technical Specification (RITS)

The Regional Infrastructure Technical Specification (RITS) includes documentation on how to design and construct stormwater infrastructure in the participating councils' areas. Section 4 of RITS sets out requirements for the design and construction of stormwater systems for land development and subdivision.

The primary objective of the stormwater system is to manage stormwater runoff to minimise flood damage and adverse effects on the environment. The stormwater system design philosophy aims to protect people, properties and ecological values by preventing or mitigating the quality and the quantity effects of stormwater on the built and natural environment.

New stormwater systems shall achieve the following minimum standards:

1. The stormwater system shall operate by gravity. Pumped systems are not acceptable due to ongoing maintenance costs.
2. The primary stormwater system shall be capable of conveying the design storm event without surcharge.
3. The secondary stormwater system shall be capable of conveying the 100 year ARI storm event within a defined path and without causing undue risk or damage to persons or property.
4. The stormwater system shall not connect or be able to overflow to the wastewater system.
5. Development shall not increase peak discharge rates for design events to the receiving waters. However an increase may be acceptable for:
   a. large events where it is demonstrated that there are no additional adverse effects, which are no more than minor, on the environment or downstream properties as a result of the increase, or
   b. Where at source mitigation is not practicable but an offset mitigation is used.
6. Development shall prevent, or minimise, any increase in discharge volumes to receiving waters to the extent reasonably practicable.
7. The stormwater system shall provide the required amount of treatment (section 4.2.3 in the RITS document).

The RITS document sets out a stormwater management disposal hierarchy to mitigate downstream flooding, scour and water quality impacts:

1. Retention of rainwater/stormwater for reuse on site.
2. Soakage techniques.
3. Treatment and detention and gradual release to a watercourse.
4. Treatment and detention and gradual release to a piped stormwater system.

The RITS guideline acknowledges that it may differ to the WRC guidelines and that the WRC document prevails.

2.3 Stormwater management approach

2.3.1 T6 growth cell

Key requirements and recommendations for the T6 growth cell described in detail within this section are as follows:

- Conveyance of the 2 year ARI and higher magnitude events to avoid coincidence with the larger Puniu River flood peak.
- Culvert crossings to be appropriately designed to enable pass forwarding of flood flows and to mitigate scour and erosion risk.
- Retention, reuse and onsite soakage of the post-development water quality volume.
- Soakage testing required as likely to be limited at higher elevations.
- Avoid modification to existing channel corridors and ecological survey recommended.

2.3.1.1 Flood and erosion risk

The Puniu River has a 500 km^2 catchment upstream of the T6 growth cell outlet/confluence. There is a gauge on the Puniu River which is approximately 5.7 km^2 downstream of the T6 growth cell outlet at Pokuru Road Bridge which recorded a maximum flow of 322 m^3/s on October 16th 1989.

Flood risk from the Puniu River is restricted to the southern area of the growth cell, however runoff from the cell will need to be managed to avoid coincidence of peaks aggravating downstream flooding concerns (see WRC peak flow control criteria point 5, section 2.2.1 in this report).

Following a rainfall event runoff directly from the growth cell is expected to discharge to the Puniu River before the flood hydrograph from the upper catchment arrives. The peak runoff discharge and volume at the growth cell outlet will be significantly lower than the Puniu flood hydrograph in both pre and post-developed scenarios.

Control of peak flows for flood events through attenuation to mitigate peak flows is therefore likely to be inappropriate within the growth cell, to avoid the risk of peak discharge coincidence at the Puniu River confluence. Pass forwarding the 2 year ARI and higher magnitude event flood flows is therefore recommended.

Whilst it is also recommended to pass forward the flood flows from the 0.14 ha of the growth cell that drains northwards to the Mangaohoi stream, this needs to be carefully managed as to not increase flood risk to the adjacent golf course and SH3 road. The 450 mm culvert under SH3 may require an upgrade to manage this appropriately.

The pre-development 100 year plus climate change flows exceed the St Leger Road culvert capacity and the culvert will therefore require an upgrade to ensure it can convey post-development flows. Upgrading the culvert will assist the recommended option of pass-forwarding of flood flows.

Crossings at the locations where the proposed 20 m collector roads cross the streams within the growth cell will need to be designed appropriately to convey the post-development flood flows to avoid flood risk to proposed lots whilst maintaining the ecological value of the corridor.

The design of the St Leger road culvert and the next road crossing upstream will also need to take into account the adjacent proposed subdivision at Haultain Street. Similarly review of the Haultain Street development should take into account the T6 channel crossings both upstream and downstream of Haultain Street.

Energy dissipaters downstream of culverts to mitigate scour are recommended as the channel is an incised gully so erosion control is required and points of discharge to the stream need to be managed so velocities do not exceed the maximum permissible values stated in the WRC guidelines.

As the channel is an MfE classified stream it should not be piped or heavily modified so that it can convey flood flows and erosion risk needs to be managed. The ecological corridor should be improved where possible and a survey is recommended to support this.

In terms of volume control for downstream erosion prevention, it is recommended that the difference between pre and post-development total volume for smaller storms up to the 2-year ARI event be retained (rainwater re-use, soakage or bio-retention) where possible. Given the size of the growth cell and that post-development impervious surfaces are limited, it is likely that the pre to post-developed 2 year ARI volume difference will be smaller than the post-developed water quality volume (1/3 of the 2 year ARI 24 hour rainfall) and erosion volume can therefore be managed through stormwater treatment.

2.3.1.1.1 High level cost estimate

A high level cost estimate to upgrade the St Leger Road culvert crossing is listed in Table 2.2. It is currently not established if these costs would fall with Waipa District Council or with the developer(s). The road may not be upgraded but the culvert would require attention regardless to reduce flood risk within the growth cell. If the road were to be upgraded then Waipa District Council may choose to levy some development contributions to the culvert upgrade.

A 2500 by 2500 mm box culvert is assumed to be required based on a high level estimate of post-development flows. The sizing requirements for the culvert and any additional culverts in T6 will need to be determined following detailed planning of the internal roading network and lots. Unit rates are based on a previous high level flood mitigation options study for Auckland Council and a 50% contingency has been added primarily due to the high level culvert size estimate and that the exact impervious surfaces upstream (number of lots and road layout) is currently unknown. St Leger road is illustrated as a 20 m collector road in the T6 structure plan revision C (Drawing number H18070_T6_001), so a high level 25 m length has been assumed for the culvert.

The cost estimate also does not include professional fees associated with the design, consenting and construction observation.

Table 2.2: High level cost estimate for St Leger road culvert upgrade

Item	**Unit cost ($)**	**Quantity**	**Cost ($M)**
Preliminary and General (15% to 30% of rough order costs)			0.1 to 0.2
2500 mm x 2500 mm, 3-4.5 m deep	10,000 per m	25 m	0.25
Extra over' for erosion protection and sediment control during works	$50,000	1	0.05
Extra over' for Traffic Management	$150,000	1	0.15
Inlet structure	$75,000	1	0.08
Outlet structure	$75,000	1	0.08
Erosion protection	200 per m^3	25 m	0.05
Surrounding planting/landscaping	$40,000	1	0.04
Total (before adding contingency)			**0.75 to 0.85**
Total (including 50% contingency)			**1.1 to 1.3**

2.3.1.2 Stormwater treatment

The direct receiving environment for the growth cell is the tributary of the Puniu River which is a natural stream and water quality treatment will be required for the post-developed water quality volume (1/3 of the 2 year ARI 24 hour rainfall) including extended detention (1/2 of the water quality volume).

Retention, reuse and onsite soakage of the water quality volume will therefore be required to provide stormwater treatment and erosion control. Impermeable surfaces should be minimised where possible using techniques and recommendations in the WRC guidelines to reduce the post-developed volume.

Water tanks for each lot in T6 are recommended so rainfall runoff is reduced and water can be stored for household water supply, as only a restricted water supply is to be provided to the growth cell (see section 3.1).

Onsite soakage will need to be tested and designed on a lot by lot basis by a suitably qualified stormwater engineer using site specific investigation data. Geological maps (refer to T6 and T11 geotechnical assessment report, Tonkin + Taylor, 2019) show that the higher elevation areas of the growth cell are underlain with clay and anecdotal records from residents suggests soakage issues in these areas. If on-site soakage investigations show that the post-developed water quality rainfall volume cannot be achieved through water tanks and soakage then bio-retention devices or suitable wetlands will need to be designed. Low lying areas of the growth cell before discharging to the existing gully and open space reserves are appropriate locations for stormwater bio-retention devices or wetlands.

Vegetated swales are recommended as appropriate devices to convey overland flows to the stream channels where required using the best practice methods in the WRC guidelines. These should be aligned adjacent to roads where possible. There are some areas of T6 which have slopes greater than 5% and therefore may require check dams in order to meet standard criteria for swale design. Road berms need to be of sufficient width to accommodate vegetated swales and low impact stormwater treatment systems such as rain gardens and soakage basins if required. Onsite soakage will need to be tested and if water quality treatment of the final road layout cannot be achieved within the berm space then a suitable wetland will need to be designed.

An allowance for swales is included in the collector road cost estimate as presented in the T+T Transportation Assessment for T6 and T11. It is assumed that the construction and design costs of other stormwater treatment devices within the growth cell will be the responsibility of the developer(s).

2.3.2 T11 growth cell

Key requirements and recommendations for the T11 growth cell described in detail within this section are as follows:

- The growth cell provides a significant amount of natural floodplain storage volume and has been split into two smaller sub-cells to avoid this area and mitigate downstream effects.
- Peak flow control of the 2 year ARI and higher magnitude flood events is not recommended to avoid coincidence with the larger Mangaohoi flood peak.
- Retention, reuse and onsite soakage of the post-development water quality volume.
- Onsite soakage will need to be tested and designed on a lot by lot basis.

2.3.2.1 Flood and erosion risk

Due to the sites position within the Mangaohoi stream catchment peak flood flow control of runoff directly from the cell in the 2 year ARI and higher magnitude events would not be appropriate, to avoid coincidence of peaks aggravating downstream flooding concerns (see WRC peak flow control criteria point 5, section 2.2.1 in this report).

Following a rainfall event runoff directly from the growth cell is expected to discharge to the Mangaohoi stream before the flood hydrograph from the upper catchment arrives. It is therefore likely to be more appropriate to pass forward flows from the growth cell with regards to flood risk.

The western and southern areas of the growth cell currently provide a significant amount of natural floodplain storage volume and it was therefore recommended that displacement of these areas without mitigation should be minimised to avoid increased flood risk downstream through the existing Te Awamutu urban area. The growth cell has therefore been split into two smaller sub-cell areas. The latest structure plan has therefore been revised to avoid the majority of these flood risk areas and minimise volume displacement, as shown in Figure 2.4.

In the 100 year ARI plus climate change flood event the flowpath across the lots in the west area will need to be managed adequately, with the most appropriate option likely to be divert the flowpath around the southern end of the lots. This flowpath will also need to provide mitigation for the displacement of the floodplain volume.

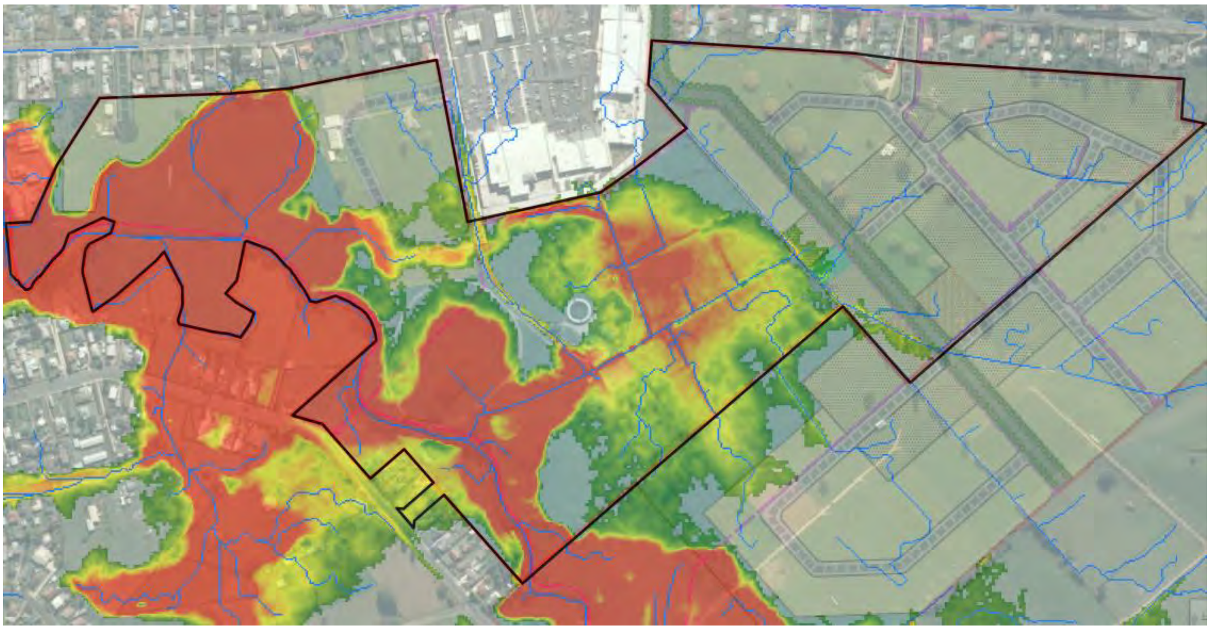


Figure 2.4: T11 flood risk map and structure plan (Draft revision J)

The existing farm buildings within the growth cell are currently within an area marked as open space/reserve. If these buildings are to remain in place then the drainage ditch and culverts through the farm will need to be managed so that the proposed lots and roading in the east of the growth cell do not increase nuisance flooding and erosion at the farm.

As the lower areas of the growth cell are on the Mangaohoi stream floodplain it is likely that discharge velocities can easily be managed to be below the maximum permissible velocities set out in the WRC guidelines. In terms of volume control for downstream erosion prevention, it is recommended that the difference between pre and post-development total volume for smaller storms up to the 2-year ARI event be retained (rainwater re-use, soakage or bio-retention) where possible. Given the size of the growth cell and that post-development impervious surfaces are limited, it is likely that the pre to post-developed 2 year ARI volume difference will be smaller than the post-developed water quality volume (1/3 of the 2 year ARI 24 hour rainfall) and erosion volume can therefore be managed through stormwater treatment.

2.3.2.2 Stormwater treatment

The direct receiving environment for the growth cell is the floodplain and the channel of the Mangaohoi stream which is a natural stream and water quality treatment will therefore be required for the post-developed water quality volume (1/3 of the 2 year ARI 24 hour rainfall) including extended detention (1/2 of the water quality volume).

Retention, reuse and onsite soakage of the stormwater water quality volume will therefore be required to provide stormwater treatment and erosion control. Impervious surfaces should be minimised where possible using techniques and recommendations in the WRC guidelines to reduce the post-developed volume.

Any onsite soakage should be tested and designed on a lot by lot basis by a suitably qualified stormwater engineer using site specific investigation data. If on-site soakage investigations show that the post-developed water quality rainfall volume cannot be achieved through soakage then bio-retention devices, stormwater attenuation tanks or a suitable wetland will need to be designed. There is ample space within the growth cell (within the areas designated as open space/reserve) for such devices.

Vegetated swales are recommended as appropriate devices to convey overland flows where required using the best practice methods in the WRC guidelines. These should be aligned adjacent to roads where possible. There are some areas of the eastern sub-cell where slopes exceed 5% and therefore may require check dams in order to meet standard criteria for swale design. Road berms need to be of sufficient width to accommodate vegetated swales and low impact stormwater treatment systems such as rain gardens and soakage basins if required. Onsite soakage will need to be tested and if water quality treatment of the final road layout cannot be achieved within the berm space then a suitable wetland will need to be designed.

An allowance for swales is included in the collector road cost estimate as presented in the T+T Transportation Assessment for T6 and T11. It is assumed that the construction and design costs of other stormwater treatment devices within the growth cell will be the responsibility of the developer(s).

3 Wastewater and water supply assessment

3.1 Existing networks and limitations

The existing wastewater and water supply networks have been investigated by examination of the WDC public GIS system and previous reports provided by WDC, where available. A description of the networks and their limitations is provided in the sections below and it should be noted that any upgrades to the existing systems to service the growth cells are not included within the technical assessment. It is assumed that WDC will incorporate any such upgrades within their 10 year plan (LTP) programme of works to address network limitations, prior to or in conjunction with the development occurring.

3.1.1 T6 growth cell

3.1.1.1 Wastewater

There are no wastewater assets within the T6 cell itself. Kihikihi to the east of the cell has a reticulated wastewater system which conveys flows via a trunk gravity main to Te Awamutu. Other residential dwellings adjacent to the cell dispose of wastewater via on-site treatment systems such as septic tanks and effluent disposal fields.

Appendix S1 - Future Growth Cells of the Waipa District Plan identifies that WDC do not intend to develop a reticulation system for T6. The large lot residential zone has an average lot size of 5000 m^2 (Part E Section 15 Rule 15.4.2.1 (n) of the District Plan) whilst the Waikato Regional Council (WRC) requirements for on-site wastewater treatment includes a minimum effective effluent disposal area of 2,500 m^2. Therefore, subject to the soakage capacity of the prevailing soil conditions, large lot residential development with on-site wastewater treatment within T6 would comply with the WRC requirements. Other interactions with groundwater, flood plains and overland flow paths would also need to be considered in the design.

3.1.1.2 Water supply

There is currently no reticulated water supply in T6 and a “trickle-feed” Restricted Flow Supply is proposed for the growth cell. Kihikihi to the east has reticulated supply from two bores and a water treatment plant and it is understood (HVC Engineers report – Three Waters Issues and Options Report – Growth Cell T6, April 2013) that the relatively new properties off St Ledger Road, north of Bruce Road (to the west of T6) have a Restricted Flow Supply (typically 2 l/min).

A Restricted Flow Supply is a small continuous flow provided by a flow restriction device and metered to each property. It is the homeowners’ responsibility to provide adequate water storage tanks or supplement supply with private bores when provided with a Restricted Flow Supply.

Appendix S1 - Future Growth Cells of the Waipa District Plan identifies that water services are proposed for T6. As T6 is located outside the defined water supply areas of Te Awamutu and Kihikihi, in accordance with WDC’s Water Supply Bylaw 2013, an on-demand supply cannot be provided and therefore a Restricted Flow Supply is the only feasible option, supplemented by private water storage tanks, rainwater tanks or bores. The RITS standard for such a supply is a provision of a minimum 1.8 m^3/day per property.

There are numerous points of potential connection to the existing water supply network in Kihikihi itself or along Kihikihi Road (SH3). The St Ledger Road restricted supply area is supplied off a 100 mm main in Kihikihi Road. No studies have been completed to date to investigate the ability to supply T6 from the existing network, water source or the optimum connection point(s). This investigation is recommended but in the interim, it is assumed that the minimum requirement of 1.8 m^3/day to each new dwelling can be accommodated by connection to the town supply. It is understood from Waipa

District council that modelling and feasibility is currently being assessed but the outcomes of this work have not yet been provided.

3.1.2 T11 growth cell

3.1.2.1 Wastewater

There are no wastewater assets within the T11 cell itself. The closest wastewater networks to T11 are the 150 mm gravity sewer in Cambridge Road bordering the north of the cell and the 375 mm gravity sewer in Park Road to the west, which serves Kihikihi.

There are a number of potential connection points to the Cambridge Road sewer. The invert levels of the existing sewer range from approximately +47 m RL at the north-western corner of the site to approximately +69 m RL at the north-eastern corner. Existing ground levels in T11 range from approximately +70 m RL at the high point in the north-eastern corner to +44 – 45 m RL at the approximate top of bank along the edge of the Mangaohoi stream boundary and extending into the site. Invert levels of the sewer in Park Road range from +43 – 45 m RL although crossing the Mangaohoi stream would be required. Development of the T11 wastewater will need to consider these levels in assessing a fully gravity system or the need to partially or fully pump flows to the public sewer.

WSP Opus were engaged by WDC to investigate the development of T11 (and cell T8 which is not covered in this assessment), using the existing wastewater hydraulic model for Te Awamutu. Their assessment looked at the capacity of the existing wastewater system to determine if the network can accept flows from the new developments. It is noted that the assessment did not include cell T14 which lies adjacent to T11 and is to be zoned Residential. T14 is to be developed beyond 2035.

The hydraulic modelling exercise (WSP Opus memo reference 3-39254.00 dated 22/6/18) concluded the following:

- The model predicts the additional dry weather flows from T11 and T8 do not have any negative impact on the downstream system. No overflow, surcharging or capacity issues were noted.
- Significant surcharging in the system is predicted during wet weather, with overflows predicted upstream of Christie Avenue Pump Station (PS), arising from the predicted under-capacity of this pump station.
- Christie Avenue PS pumping rate is impeded by the operation of Albert Park PS, albeit it was noted the model may not accurately represent this issue and the assessment may be inaccurate.
- Christie Avenue PS and Albert Park PS and/or the downstream network may require upgrading to accommodate T8 and T11 flows.
- Onsite storage and a PS within the growth cells may be an alternative option to attenuate wet weather flows within the development areas. No estimates of the storage or pump station capacities were provided.
- It was recommended that further investigation is undertaken following re-calibration of the model in early 2019, as this will provide a more accurate understanding of the interaction between the two pump stations.

It is also understood from discussions with Waipa DC that the pump station at the top of Cambridge Road currently has issues and may require an upgrade.

With these outcomes, subject to the model re-calibration exercise and further assessment, there are limitations within the existing wastewater system to receive all of the post-development flows from T11. We understand WDC have commissioned the re-calibration of the model and recommend the assessment be repeated once this exercise is complete. In the interim, it is assumed that upgrades within the existing wastewater network are required or attenuation within T11 itself to limit peak flows to manageable levels in the existing network.

3.1.2.2 Water Supply

There is currently no water supply reticulation within the T11 cell. The WDC GIS maps show a 200 mm main in Cambridge Road to the north and a 100 mm main in Park Road to the west which may provide potential connection points to the town supply.

WSP Opus were engaged by WDC to investigate the development of T11 (and cell T8), using the existing water supply hydraulic model for Te Awamutu. The modelling exercise found that the addition of T11 cell had minimal impact on the existing network and the impact can be mitigated by upgrading the capacity of pipes along Park Road (the modelled connection point) with moderate to high head loss. The modelling identified that the T11 cell water pressures would exceed 20 m, meeting the WDC minimum level of service standard.

Therefore the existing limitations to water supply to T11 appear manageable with minor upgrades in the existing network providing adequate supply flows and pressures. Further development of the water supply model has been commissioned by WDC to improve its accuracy and so the results of this analysis should be verified with the updated model, when it is available and before design of the T11 reticulation.

3.2 Population, flow and demand projections

Population projections together with associated potable water demand and wastewater flows for each of the cells are provided in the tables below. These figures have been based on the development area types and the requirements of the RITS.

Population projections, together with associated potable water demand and wastewater flows for the T6 cell are provided in Table 3.1 and for the T11 cell in Table 3.2. These figures have been based on the development area types and the requirements of the RITS or other standards as noted.

Table 3.1: T6 Population and Demands

Parameter	Value	Units
Development Type	Large Lot Residential	-
Max Development Area	168	ha
Average lot size	5000	m^2
Density	45 or not less than 2.7 persons per dwelling [1]	Pop/ha
No. of dwellings	236	
Maximum Population	637 [2]	people
Wastewater [3]		
Potable Water		
Restricted Water Supply	Not less than 1.8	m^3/day/property
Daily Demand	Not less than 425 (4.9)	m^3 (l/s)
Fire Water (SNZ PAS 4509:2008)		
Fire Water Classification	FW2	-

Parameter	Value	Units
Firefighting time (non-reticulated supply) [4]	30	mins
Min Water Storage within 90 m distance	45	m^3

1. 2.7 persons per dwelling adopted as large lot development zone
2. Needs to be confirmed. Current figure based on Concept Plan Revision J
3. On-site wastewater disposal assumed therefore no effect on WDC network
4. Restricted water supply hence on-site storage required strategically placed to be within 90 m of individual properties

Table 3.2: T11 Population and Demands

Parameter	Value	Units
Development Type	Residential Zone	-
Max Development Area	20	ha
Density	45 or not less than 2.7 persons per dwelling [1]	Pop/ha
Maximum Population	900	people
Wastewater		
Water Consumption	200	l/head/d
Infiltration	2,250	l/ha/d
Surface Water Ingress	16,500	l/ha/d
Peaking factor	3.0	-
Average Daily Flow (ADF)	5.4	l/s
Peak Daily Flow (PDF)	6.8	l/s
Peak Wet Weather Flow (PWWF)	24.9	l/s
Potable Water		
Domestic Demand	260	l/p/d
Peaking Factor	5.0	-
Average Demand	2.7	l/s
Peak Demand	13.5	l/s
Fire Water (SNZ PAS 4509:2008)		
Fire Water Classification	FW2	-
Fire flow (reticulated supply)	12.5 (within 135 m)	l/s
Supplemental fire flow	12.5 (within 270 m)	l/s
Minimum pressure head	10	m head

1. 45 pop/ha adopted

3.3 Growth cell assessments

A number of assumptions and criteria have been adopted to develop the high level, conceptual design of the wastewater and water supply systems for T6 and T11. A key assumption is that the existing networks have capacity to service the growth cells and as detailed above, this is likely to require wastewater and water supply upgrades for servicing of T11, whilst the impact of servicing T6 with a restricted water supply has not been investigated to date.

At the time of preparing this report, we understand that significant wastewater upgrades in Te Awamutu are being implemented by Council due to the connection of the Waikeria Prison wastewater flows. Future expansion in the area of T11 has been accounted for in the design of those upgrades.

3.3.1 T6 growth cell

3.3.1.1 Wastewater

The T6 growth cell will not be provided with a public wastewater system and hence is required to be serviced by on-site wastewater treatment and discharge systems. The design of such devices is covered in the Waikato Regional Plan, Section 3.5.7 Implementation Methods – Onsite Sewerage Discharges and the Auckland Regional Council 2004 On-site Wastewater Systems Design and Management Manual – Technical Publication Third Edition (TP58). TP58 states that a soil profile determination should be undertaken to determine soakage rates and the document provides guidance on how this assessment should be undertaken.

Key design criteria for such systems are listed in Table 3.3 below.

Table 3.3: T6 Key wastewater design criteria

Item	Waikato Regional Plan, Section 3.5.7 Implementation Methods – Onsite Sewerage Discharges	Comments
Effluent volume	Maximum 1,300 l/day	Averaged over any one month
Septic Tank Size	Minimum 3,000 litres	
Effective disposal area onto or into land	Minimum 2,500 m^2	

The net lot area rule within the Waipa District Plan is that large lot residential zones shall have an average area of 5,000 m^2. It is therefore assumed that each lot will be of sufficient size to have its own private on-site wastewater treatment system.

The siting of such systems on each lot must avoid interaction with streams, flood waters, overland flow paths and avoid risks of groundwater contamination. To achieve this, the Regional Plan stipulates separation distances from wastewater effluent fields and these environments.

Given that areas of the growth cell are likely to have low soakage rates, the soil profile and soakage capacity will need to be determined on a lot by lot basis in accordance with TP58 to determine the appropriate on-site wastewater treatment devices.

As the T6 growth cell will not be provided with a public wastewater system it has been assumed that the costs of the on-site wastewater treatment devices will be the responsibility of the developer(s).

3.3.1.2 Water supply

The T6 growth cell will be provided with a Restricted Flow supply rather than On Demand. Typically, large lot residential properties with a restricted water supply from the town supply have an on-site storage tank which is supplemented with rainwater and/or groundwater bores or wells. In addition to applicable criteria from Table 3.3, Table 3.4 shows the RITS water supply key criteria for Restricted Flow supplies. In accordance with SNZ PAS 4509:2008, 45 m^3 of water storage will be required, strategically placed within 90 m of properties for firefighting purposes due to the restricted flow supply.

Table 3.4: T6 key water supply design criteria

Item	RITS Requirements	Comments
Design Flow	Minimum 1.8 m^3/lot/day	Restricted Flow Supply
Supplemental flow provisions	Rainwater tanks, private bores or wells.	Restricted flow schemes do not provide firefighting capacity. Additional provisions are required.
Firefighting time (non-reticulated supply)	30 minutes	FW2 Classification
Min Water Storage within 90 m	45 m^3	

The water supply concept of service for T6 is a principal "spinal" water main supplied from the Kihikihi town supply with rider mains in secondary streets and individual metered connections to each property's tank. Connection points to the Kihikihi system are to be determined, with the 100 mm principal mains in SH3 Kihikihi Road and Ballance Street the likely options.

Water quality from all sources will need to be tested to ensure that it meets the requirements of the Ministry of Health's Drinking Water Standards for New Zealand 2005 (revised 2008) and any potential updates to these standards following proposed national reforms on potable water supply.

An investigation into the feasibility to supply T6 from the existing network on a Restricted Flow supply is also required including establishing the optimum connection point(s). It is understood from Waipa District council that modelling and feasibility is currently being assessed but the outcomes of this work have not yet been provided.

3.3.1.2.1 High level cost estimate

A high level cost estimate to provide the restricted flow supply infrastructure within the growth cell is listed in Table 3.5. The unit rates have been derived from the Cambridge C1 and C2/C3 structure plan water supply and wastewater technical assessment report (Beca, October 2017) and total pipe lengths have been estimated based on the potential road layouts illustrated in the T6 structure plan revision C (Drawing number H18070_T6_001).

A contingency of 50% has been added to the cost estimate given that the number of lots, road layout and connection points to the existing network are not confirmed. The contingency is also to allow for the high level concept design and additional extras such as air or scour valves that may be required within the network.

The cost estimate does not include provision for water tanks, bores and fire water storage as it is assumed that these will need to be provided by the developer(s). The cost estimate also does not include professional fees associated with the design, consenting and construction observation.

Table 3.5: High level cost estimate for T6 water supply infrastructure

Item	Diameter (mm)	Estimated total Length required (m)	Rate ($/unit)	Total cost ($M)
Preliminary and General (15% to 30% of rough order costs)				0.45 to 1.0
Principal spinal main	150	3,900	370	1.44
	225	0	580	0
Main (including rider)	150	0	445	0
Rider main (80% rate of 150 spinal main assumed)	63	5,800	280	1.62
Total (before contingency)				**3.5 to 4.1**
Total (including 50% contingency)				**5.25 to 6.15**

3.3.2 T11 growth cell

3.3.2.1 Wastewater

The key design criteria adopted for the concept development have been taken from the RITS and listed in Table 3.6.

Table 3.6: T11 Key wastewater design criteria

Item	RITS Requirements	Comments
Design Life		
Pipe Material and Class	PVC-U (to 225 mm)	Class SN16 RRJ DN150 – 225 Class SN10 RRJ DN100
Design Flow	Refer 5.2.4.2 of RITS and Table 3.1 above	The system must contain the peak wet weather flow without surcharge and achieve self-cleansing velocity at peak daily flow.
Minimum Grades for Self-Cleaning	Refer 5.2.4.5 of RITS	Grades vary with pipe size
Minimum velocity for self-cleaning	0.6 m/s	
Maximum velocity for PWWF	3.0 m/s	
Minimum pipe size	150DN	100DN for lateral connections
Structural design of buried pipelines	AS/NZS 2566	
Minimum cover	600 mm and AS/NZS 3725	
Layout	Within road corridor, 2 m from kerb	For residential developments
Manholes	Refer 5.2.7 of RITS Max spacing 120 m	

The concept of wastewater serving the T11 growth cell is the provision of separate reticulation systems in each of the two sub-cells that have been derived due to the flood risk across over a significant part of the overall T11 cell.

The western sub-cell topography ranges from 46 m RL on the western boundary to 48 m RL on the northern boundary and generally slopes north to south, away from Cambridge Road. The closest 150 mm diameter public sewer located on the northern boundary of the cell has an invert level of 47.43 m RL at manhole 1090325. Given the RITS key design criteria requires minimum pipe cover of 600 mm and minimum pipe sizes of 150 mm, a ground level of at least 48.18 m RL is required for gravity discharge.

Figure B1 in Appendix B shows the existing ground levels below 48.18 m RL in the western sub-cell. The figure shows that the majority of the sub-cell is below 48.18 m RL and therefore it will not be feasible to service the sub-cell with a gravity drainage system that can connect to the existing system. A pump station will be required to drain the sub-cell. The pump station location will need to be determined through design but it is noted that the sub-cell boundaries have been defined by the proximity of the 100 year flood plain and hence the siting of the pump station must consider the flood risk at the site. The area currently defined for open space/reserve within the western sub-cell is an appropriate location for siting the pump station.

The eastern sub-cell topography ranges from 47 m RL on its western boundary rising to a high point of approximately 70 m RL in the eastern corner. The site is quite steeply sloping from the high point across a significant portion of the site to an area of more gently sloping terrain on the western boundary, which is the edge of the natural floodplain of the Mangaohoi stream.

The existing 150 mm pipe downstream of manhole 1090415 at the north-west corner of the sub-cell has an invert level of 47.83 m RL. Given the RITS key design criteria requires minimum pipe cover of 600 mm and minimum pipe sizes of 150 mm, a ground level of at least 48.58 m RL is required for gravity discharge.

Figure B1 in Appendix B shows the existing ground levels below 48.58 m RL in the eastern sub-cell. The figure shows that approximately 4.8 ha of the eastern sub-cell are below 48.58 m RL at the southern and western boundaries. It will therefore not be feasible to service the areas along the western boundary of the sub-cell with a gravity drainage system that can connect to the existing system. A pump station will also be required to drain part of, or the whole of this sub-cell. The areas currently defined for open space/reserve or the commercial centre within the eastern sub-cell are appropriate locations for siting the pump station. The RITS document states that pump stations should not be proposed for less than 25 lots.

The alternative connection point to the existing network would be the sewer in Park Road. The Cambridge Road connection is closer and avoids having to cross the Mangaohoi stream. However, the invert levels of the sewer in Park Road range from +43 – 45 m and therefore gravity discharge from both the sub-cells would be more feasible.

The areas sited for pump stations should also be considered for on-site storage during wet-weather flows if the wider network is not upgraded, as recommended in the WSP Opus memo, and further investigations are recommended following re-calibration of the existing model (see section 3.1.2.1).

The ongoing modelling work by WSP Opus has identified limitations within the existing wastewater system to receive all of the post-development flows from T11 and there are reported issues with the existing pump station on Cambridge Road. Therefore subject to the model re-calibration exercise and further assessment, it is assumed that upgrades within the existing wastewater network are required or attenuation within T11 itself to limit peak flows to manageable levels in the existing network.

3.3.2.1.1 High level cost estimate

A high level cost estimate to provide the restricted flow supply infrastructure within the growth cell is listed in Table 3.7. The unit rates are inclusive of manholes and have been derived from the

Cambridge C1 and C2/C3 structure plan water supply and wastewater technical assessment report (Beca, October 2017). Total pipe lengths have been estimated based on the potential road layouts illustrated in the T11 structure plan revision J.

A contingency of 50% has been added to the cost estimate given that the number of lots, road layout and connection points to the existing network are not confirmed. The contingency is also to allow for the high level concept design and additional extras such as air or scour valves that may be required within the network. The cost estimate also does not include professional fees associated with the design, consenting and construction observation.

Table 3.7: High level cost estimate for T11 wastewater infrastructure

Item	Diameter (mm)	Estimated total Length or number required (m)	Rate ($/unit)	Total cost ($M)
Preliminary and General (15% to 30% of rough order co				**0.5 to 1.0**
Gravity main (including 1.5 to 5 m trench required)	150-225	2,400	850	2.04
	300-350	0	980	0
Riser main	150-225	2,100	370	0.78
	300	0	540	
Pump stations	150 riser main	4	150,000	0.6
	225-300 riser main	0	200,000	0
Total (before contingency)				**4.0 to 4.5**
Total (including 50% contingency)				**6.0 to 6.75**

3.3.2.2 Water supply

The key design criteria adopted for the concept development have been taken from the RITS and listed in Table 3.8 below.

Table 3.8: T11 key water supply design criteria

Item	RITS Requirements	Comments
Design Life	Minimum 100 years	
Pipe material and class	Principal mains PVC-O or PE 100 PN12.5 Rider mains PE80 PN12.5 SDR11	
Water demand	260 L/person/day	On Demand Supply
Design Flow	Water demand with peaking factor of 5	On Demand Supply
Pressure/Flow Standards	Minimum 200 kPa and 25 L/min Maximum 1000 kPa	Residual pressure at point of supply
Structural design of buried pipelines	AS/NZS 2566	
Minimum cover	750 mm in berm 900 mm in carriageway	Principal and rider mains only
Layout	Principal main on one side of road and rider main on the other. Within roadway berm, 2 m from property boundary.	Residential development
Hydrants	NZS 4509 Maximum spacing of 135 m	
Valves	Maximum spacing of 250 m	

The WDC GIS maps show a 200 mm main in Cambridge Road to the north and a 100 mm main in Park Road to the west which may provide potential connection points to the town supply. The 200 mm main in Cambridge Road is the closer to the identified sub-cells and avoids having to cross the Mangaohoi stream. However, a potential connection to Park Road has already been modelled and assessed to have a minimal impact (see section 3.1.2.2) and this connection may be more appropriate if upgrades to the network are required in conjunction with the neighbouring T8 cell.

3.3.2.2.1 High level cost estimate

A high level cost estimate to provide the restricted flow supply infrastructure within the growth cell is listed in Table 3.9. The unit rates have been derived from the Cambridge C1 and C2/C3 structure plan water supply and wastewater technical assessment report (Beca, October 2017). The total pipe lengths have been estimated based on the potential road layouts illustrated in the T11 structure plan revision J.

A contingency of 50% has been added to the cost estimate given that the number of lots, road layout and connection points to the existing network are not confirmed. The contingency is also to allow for the high level concept design and additional extras such as air or scour valves that may be required within the network. The cost estimate also does not include professional fees associated with the design, consenting and construction observation.

Table 3.9: High level cost estimate for T11 water supply infrastructure

Item	Diameter (mm)	Estimated total Length required (m)	Rate ($/unit)	Total cost ($M)
Preliminary and General (15 to 30% of rough order cost)				**0.36 to 0.73**
Principal main	150	3,400	370	1.26
	225	0	580	0
Main (including rider)	150	2,600	445	1.16
Total (before contingency)				**2.8 to 3.2**
Total (including 50% contingency)				**4.2 to 4.8**

4 Conclusions and recommendations

The T6 and T11 cells are identified for growth in the Waipa2050 Growth Strategy (2017) and Waipa District Council (WDC) 2018 – 2028 Long Term Plan.

The key conclusions and recommendations from the technical assessments of the stormwater, wastewater and water supply requirements to support the structure plans for the growth cells are as follows:

4.1 T6 growth cell

Stormwater

- Due to the position of the growth cell within the wider Puniu River catchment, peak flow control of the 2 year ARI and higher magnitude events is not recommended to avoid coincidence with the larger Puniu River flood peak.
- The St Leger Road culvert should be upgraded and new crossings appropriately designed to enable pass forwarding of post-development flood flows. Crossings and discharge points to the channel should be designed to mitigate scour and erosion within the incised gully.
- Retention, reuse and onsite soakage of the post-development water quality volume will be required to provide stormwater treatment and erosion control. Water tanks for each lot are recommended to help meet these requirements and water supply demands.
- Onsite soakage will need to be tested and designed on a lot by lot basis. Especially as low soakage could be an issue in the upper areas of the growth cell. Bio-retention devices or a suitable wetland will need to be designed if the water quality volume cannot be achieved through retention, reuse and onsite soakage.
- If on-site soakage investigations show that the post-developed water quality rainfall volume cannot be achieved through water tanks and soakage then bio-retention devices or a suitable wetland will need to be designed.
- Vegetated swales are recommended to convey overland flow. Road berms need to be of sufficient width to accommodate swales and low impact stormwater treatment systems such as rain gardens and soakage basins if required. The sizing of such devices will be dependent on the final road layout and onsite soakage testing.
- Avoid modification to existing channel corridors and an ecological survey is recommended.

Wastewater

- The growth cell will not be provided with a public wastewater system and hence is required to be serviced by on-site wastewater treatment and discharge systems.
- The design of these devices need to comply with the Waikato Regional Plan, Section 3.5.7 Implementation Methods – Onsite Sewerage Discharges and the Auckland Regional Council 2004 On-site Wastewater Systems Design and Management Manual – Technical Publication Third Edition (TP58). Given that areas of the growth cell are likely to have low soakage rates, the soil profile and soakage capacity will need to be determined on a lot by lot basis in accordance with TP58 to determine the appropriate on-site wastewater treatment devices.

Water supply

- The T6 growth cell will be provided with a Restricted Flow supply which is likely to consist of on-site storage tanks supplemented with rainwater and/or groundwater bores or wells. It is understood that modelling work is currently being undertaken to ensure feasibility.
- The restricted flow supply will need to meet the RITS key criteria.

4.2 T11 growth cell

Stormwater

- The western and southern areas of the growth cell currently provide a significant amount of natural floodplain storage volume and the growth cell has been split into two smaller sub-cells to avoid increased flood risk downstream through the existing Te Awamutu urban area.
- A flood flowpath across the lots in the western sub-cell area will need to be managed adequately, with the most appropriate option likely to be divert the flowpath around the southern end of the lots through the open space/reserve. This flowpath will also need to provide mitigation for the displacement of the floodplain volume.
- Due to the position of the growth cell within the wider Mangaohoi catchment, peak flow control of the 2 year ARI and higher magnitude flood events is not recommended to avoid coincidence with the larger Mangaohoi flood peak.
- Retention, reuse and onsite soakage of the post-development water quality volume will be required to provide stormwater treatment and erosion control.
- Onsite soakage will need to be tested and designed on a lot by lot basis. If on-site soakage investigations show that the post-developed water quality rainfall volume cannot be achieved through soakage then bio-retention devices, stormwater attenuation tanks or a suitable wetland will need to be designed.
- Vegetated swales are recommended to convey overland flow. Road berms need to be of sufficient width to accommodate swales and low impact stormwater treatment systems such as rain gardens and soakage basins if required. The sizing of such devices will be dependent on the final road layout and onsite soakage testing.

Wastewater

- The concept of wastewater serving the T11 growth cell is the provision of separate reticulation systems in each of the two sub-cells.
- It will not be feasible to service the whole of the sub-cells with gravity drainage systems to the adjacent reticulated network. Pump stations will therefore be required to drain part of, or the whole of the sub-cells unless an alternative connection at Park Road is utilised. The Park Road connection will require crossing the Mangaohoi stream.
- The reticulation systems will need to meet the RITS key design criteria.
- The ongoing modelling work by WSP Opus has identified limitations within the existing wastewater system to receive all of the post-development flows from T11 and therefore upgrades within the existing wastewater network are likely to be required or attenuation within T11 itself to limit peak flows to manageable levels in the existing network.

Water supply

- There are two potential connections to the existing town supply mains. Either at Cambridge Road to the north or Park Road to the west.
- The Cambridge Road connection is closer and avoids having to cross the Mangaohoi stream. The Park Road connection has already been assessed to have a minimal impact however and this connection could be appropriate if upgrades to the network are required in conjunction with the neighbouring T8 cell.
- The water supply network and connections will need to meet the RITS key criteria.

5 Applicability

This report has been prepared by Tonkin & Taylor Limited (T+T) for Boffa Miskell Ltd pursuant to the terms of engagement (Contract) between T+T and Boffa Miskell Ltd in relation to the T6/T11 Structure Plan project. T+T agrees this report may also be used by Waipa District Council (WDC) for the purposes set out in, or able to be reasonably inferred from, the Contract, on the basis that the aggregate liability of T+T to Boffa Miskell Ltd and WDC in respect of any such use or reliance is subject to the limitations and exclusions of liability set out in the Contract. This report may not be relied upon in other contexts or for any other purpose, or by any person other than Boffa Miskell Ltd and WDC, without T+T's prior written agreement.

Tonkin & Taylor Ltd

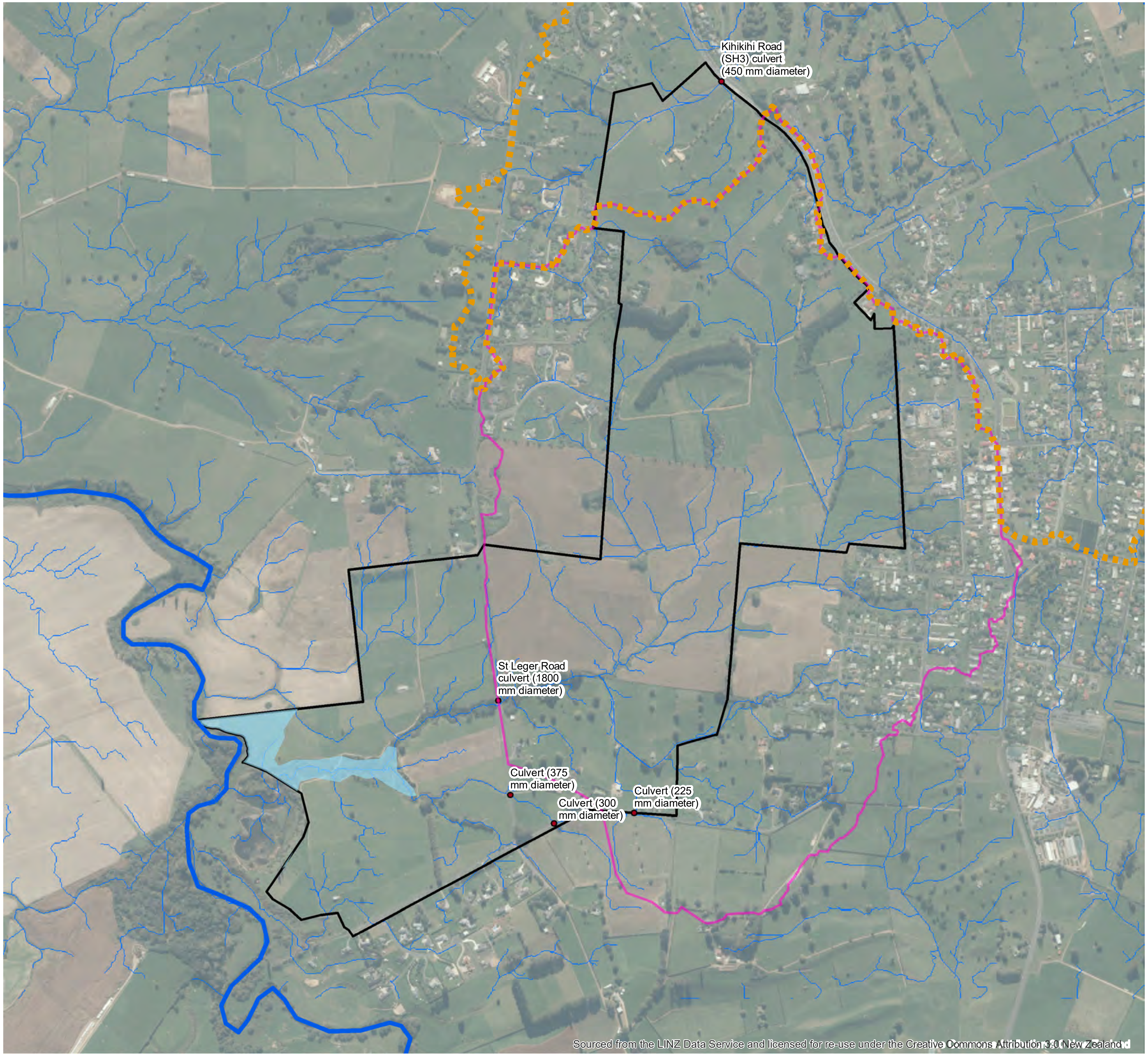
Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
....	....
James Mogridge	Glen Nicholson
Water Engineer	Project Director

Report technically reviewed by Shaun Jones – Senior Water Resources Engineer

p:\1008305\1008305.1000\issueddocuments\190823 final reports\190823.t6 t11 three waters assessment.rpt.docx

Appendix A: Stormwater Figures

- **Figure A1: T6 growth cell drainage map**
- **Figure A2: T11 growth cell drainage map**
- **Figure A3: T11 growth cell flood risk map**



LEGEND

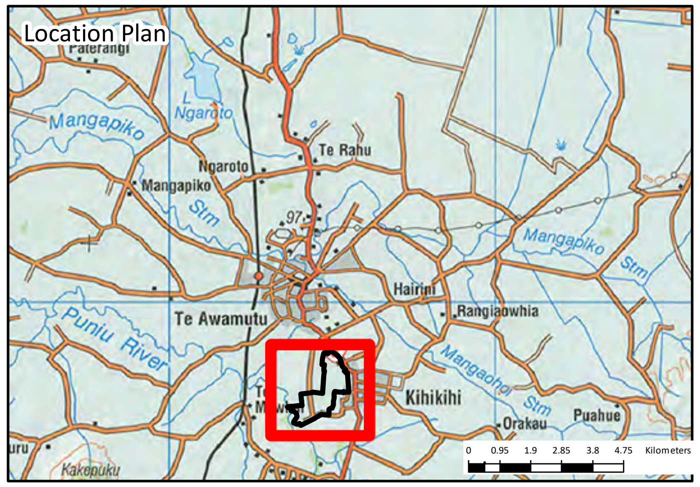
- T6 growth cell boundary
- Overland Flowpaths
- Puniu flood risk area (within T6 growth cell)
- Puniu/Mangaohoi Watershed
- T6 St Leger culvert subcatchment

A3 SCALE:1:10,000

0 80 160 240 320 400 Meters

N

Location Plan



Notes:
Topo map and aerial sourced from LINZ Data (Crown Copyright Reserved).

Applicability:
This figure has been prepared with respect to the particular brief given to Tonkin + Taylor. Tonkin + Taylor do not accept responsibility for any loss or damage resulting from the use of the information and any person relying on the information does so at their own risk.

Flowpath routes generated using the 2007-2008 LiDAR topogrpahical data

Culvert locations and sizes sourced from Howes and Vink Report (2013)

DRAWN	JMOR	May.19
CHECKED	JJBR	Aug.19
APPROVED	GGN	Aug.19

ARCFILE
FigureA1_T6_drainage_map.mxd

SCALE (AT A3 SIZE)
1:10,000

PROJECT No.
1008305.1000

Tonkin+Taylor
Level 5, 711 Victoria Street, Hamilton
www.tonkintaylor.co.nz

BOFFA MISKELL
WAIPA STRUCTURE PLAN
T6 GROWTH CELL
Drainage map

FIGURE A1

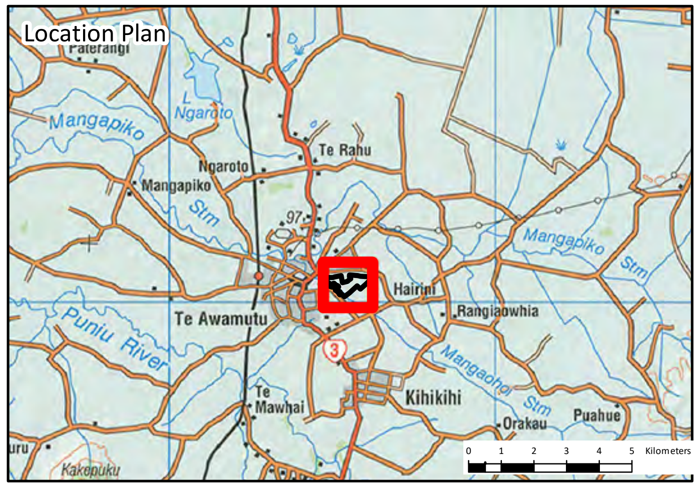
LEGEND

- T11 growth cell boundary
- Overland Flowpaths
- Stormwater pipes (within T11 Cell)

A3 SCALE:1:5,000

0 40 80 120 160 200 Meters

N



Notes:
Topo map and aerial sourced from LINZ Data (Crown Copyright Reserved).

Applicability:
This figure has been prepared with respect to the particular brief given to Tonkin + Taylor.
Tonkin + Taylor do not accept responsibility for any loss or damage resulting from the use of the information and any person relying on the information does so at their own risk.
Flowpath routes were generated using the 2007-2008 LiDAR topographical data.
Stormwater pipe locations sourced from Waipa DC GIS portal

DRAWN	JMOR	May.19
CHECKED	JJBR	Aug.19
APPROVED	GGN	Aug.19

ARCFILE
FigureA2_T11_drainage_map.mxd

SCALE (AT A3 SIZE)
1:5,000

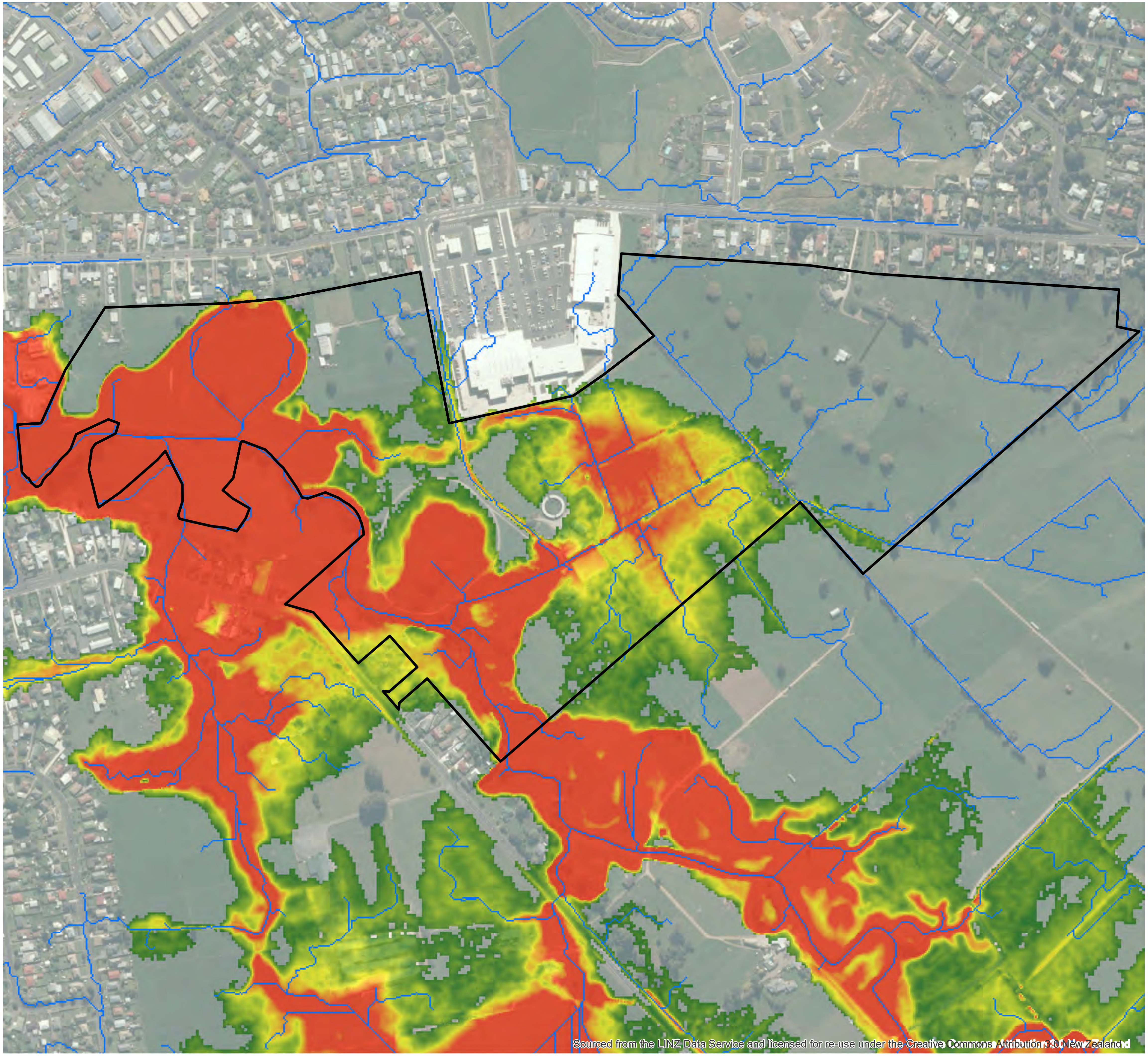
PROJECT No.
1008305.1000

Tonkin+Taylor
Level 5, 711 Victoria Street, Hamilton
www.tonkintaylor.co.nz

BOFFA MISKELL

WAIPA STRUCTURE PLAN
T11 GROWTH CELL
Drainage map

FIGURE A2



LEGEND

T11 growth cell boundary

1% AEP+CC 2118 - Max Flood Depth (m)

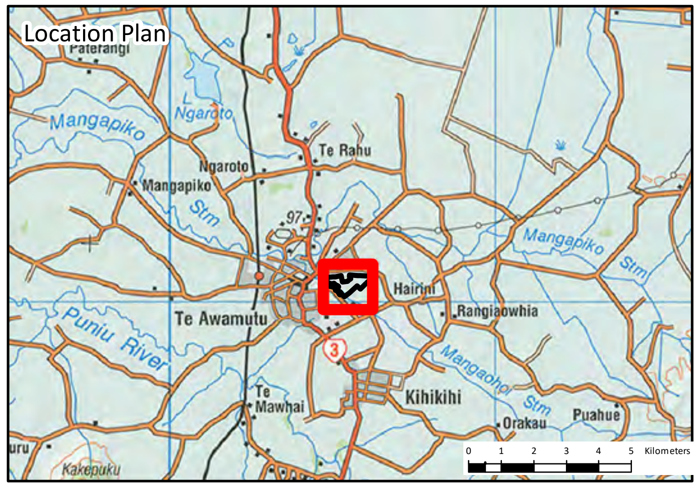
High : 1+

Low : 0

Overland Flowpaths

A3 SCALE:1:5,000

0 40 80 120 160 200 Meters



Notes:
Topo map and aerial sourced from LINZ Data (Crown Copyright Reserved).

Applicability:
This figure has been prepared with respect to the particular brief given to Tonkin + Taylor.
Tonkin + Taylor do not accept responsibility for any loss or damage resulting from the use of the information and any person relying on the information does so at their own risk.

Flood depths:
Sourced from hydraulic modelling (T8 and T11 growth cells, Te Awamutu, WSP Opus, December 2018)
Existing ground contours: 1% AEP design event (+2.1 degrees climate change)

DRAWN	JMOR	May.19
CHECKED	JJBR	Aug.19
APPROVED	GGN	Aug.19

ARCFILE
FigureA3_T11_flood_risk_map.mxd

SCALE (AT A3 SIZE)
1:5,000

PROJECT No.
1008305.1000

Tonkin+Taylor
Level 5, 711 Victoria Street, Hamilton
www.tonkintaylor.co.nz

BOFFA MISKELL
WAIPA STRUCTURE PLAN
T11 GROWTH CELL
Flood risk map

FIGURE A3

Appendix B: Wastewater Figures

- **Figure B1: T11 growth cell potential pump areas**

LEGEND

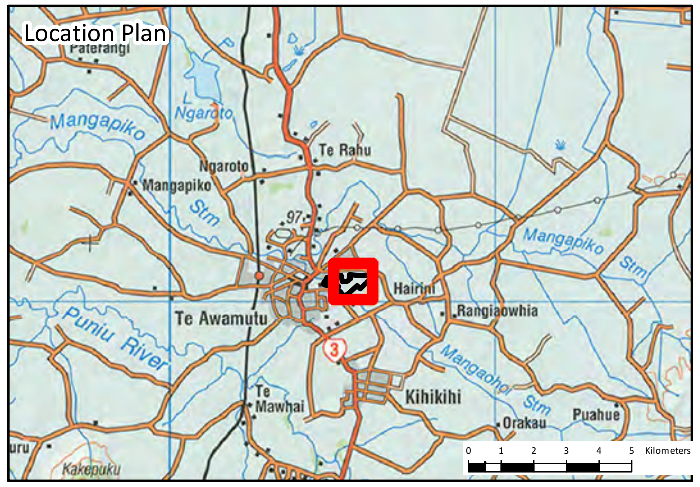
- Sub cell boundaries
- Non gravity discharge areas
- Manhole invert levels

A3 SCALE:1:4,000

0 30 60 90 120 150 Meters

N

Location Plan



Notes:
Topo map and aerial sourced from LINZ Data (Crown Copyright Reserved).

Applicability:
This figure has been prepared with respect to the particular brief given to Tonkin + Taylor.
Tonkin + Taylor do not accept responsibility for any loss or damage resulting from the use of the information and any person relying on the information does so at their own risk.

Non gravity discharge areas:
Figure shows ground levels within the growth sub-cells that are below the nearest public sewer invert level plus allowances for minimum cover (600 mm) and pipe size (150 mm). These areas are therefore likely to require pumping to connect to existing reticulated network

DRAWN	JMOR	May.19
CHECKED	JJBR	Aug.19
APPROVED	GGN	Aug.19

ARCFILE
FigureB2_T11_Wastewater_map.mxd

SCALE (AT A3 SIZE)
1:4,000

PROJECT No.
1008305.1000

Tonkin+Taylor
Level 5, 711 Victoria Street, Hamilton
www.tonkintaylor.co.nz

BOFFA MISKELL
WAIPA STRUCTURE PLAN
T11 GROWTH CELL
Wastewater map - Potential pump areas

FIGURE B1

www.tonkintaylor.co.nz

REPORT

Tonkin+Taylor

Te Awamutu T6 and T11 Structure Plans

Transportation Assessment

Prepared for
Boffa Miskell
Prepared by
Tonkin & Taylor Ltd
Date
August 2019
Job Number
1008305.1000

Exceptional thinking together
www.tonkintaylor.co.nz

Document Control

Title: Te Awamutu T6 and T11 Structure Plans					
Date	**Version**	**Description**	**Prepared by:**	**Reviewed by:**	**Authorised by:**
June 2019	1	Draft	T Broadhead	A Gregory	
August 2019	2	Draft following WDC comments	J Brzeski	A Gregory	
August 2019	3	Final	T Broadhead	A Gregory	G Nicholson

Distribution:

Boffa Miskell	1 PDF copy
Tonkin & Taylor Ltd (FILE)	1 PDF copy

Table of contents

Executive summary

Growth Cells T6 and T11, both in the Te Awamutu area of Waipa District, were assessed for both the existing and potential future statuses of the transport network.

Considerations were as follows:

- Existing nature of the roads and other transport facilities around each growth area, including safety considerations.
- Crash history for the existing roads, including a comparison against NZTA Crash Prediction Modelling.
- Likely attractors for travel, and resulting travel patterns.
- Network assessment using the principles of 'Gravity Modelling' for those travel patterns in various scenarios from Existing to a predicted 2035 2% per annum increase plus High Development of the growth areas (anticipating future sub-division).
- Intersection modelling for key locations based on the assessed trip distribution.
- A comparison of the worst case future Crash Prediction Model with the existing situation.
- Consideration of a previous Feasibility Report by Opus (T11 only).

Taking all these factors, including results of modelling exercises, into account the following conclusions and recommendations were reached.

Growth Area T6 Conclusions and Recommendations:

This report found that there may be existing deficiencies in road width on several local roads and one local arterial (Golf Road) in the rural area, and that existing crash statistics on two of these roads (Herbert Street and Whitmore Street) are in excess of what would be expected using NZTA crash prediction modelling.

The traffic modelling also revealed that normal traffic growth to 2035, without including additional demand for growth area T6, could result in the following three intersections having unacceptable waiting times:

- State Highway 3 / St Leger Road / Golf Road intersection
- State Highway 3 / Herbert Street / Nixon Street intersection
- State Highway 3 / Whitmore Street intersection

The further demand placed on the network is estimated to be 2,400 additional vehicles per day in the proposed "Low Development" scenario, or 4,800 vehicles per day in the suggested conservative "High Development" scenario (assuming future sub-division of these lots).

These additional vehicles, whilst not helping existing issues if they go unaddressed, are otherwise able to be accommodated within the assessed network even with further baseline traffic growth.

In addition, there are also a lack of pedestrian and cyclist facilities around T6 which, whilst arguably not currently a known issue, the desire of Waipa District Council to incorporate these facilities in a growth area means there could be a lack of connectivity if not addressed in the existing network.

In line with these conclusions we have prepared some recommendations for work going forward to help address existing and future concerns:

1. Existing Local Roads:
    a. The following council roads have higher than expected crash injury rates, and further investigation is required to determine why this is occurring:

- i Herbert Street
- ii Whitmore Street

b The following council roads are currently considered to have too narrow a seal width for their future purpose, and it is recommended investigation into widening and marking them is undertaken:

- i St Leger Road (some sections of)
- ii Brill Road
- iii Haultain Street
- iv McAndrew Street
- v Golf Road (rural section)
- vi McGhie Road (if desired to include as an alternative route east)

2 Pedestrian and Cyclist Facilities:

a Pedestrian and cyclist facilities around the growth area are lacking for connections to the anticipated facilities within the growth area. It is recommended that Waipa District Council review the existing facilities and programme in providing new infrastructure as the growth area is developed. The key connections to focus on for these facilities are anticipated to be:

- i St Leger Road from Brill Road to State Highway 3
- ii Ballance Street from the growth area connection to State Highway 3
- iii Leslie Street from 'Access 3' to State Highway 3

b There are currently no dedicated or shared cyclist facilities along State Highway 3. It is recommended that NZTA look into providing these in some form.

c The only existing crossing facility along State Highway 3 is in Kihikihi town centre. It is recommended that NZTA look into additional provision for pedestrian (and possibly cyclist, depending on the solution) safe crossing facilities in the residential areas to the north and south of the town centre.

3 Intersection traffic issues:

a The State Highway 3 / Golf Road / St Leger Road intersection is recommended for an immediate investigation, for potential upgrade due to existing issues with vehicles trying to exit Golf Road. This intersection is designated as the junction of the proposed Western Arterial Road with SH3 in the Integrated Transport Strategy for WDC published in 2010.

b The State Highway 3 / Herbert Street / Nixon Street intersection is recommended for an upgrade investigation should growth area T6 be approved.

c The following intersections are recommended for an upgrade investigation before 2035 whether or not growth area T6 is approved for development:

- i State Highway 3 / Whitmore Street
- ii State Highway 3 / Herbert Street / Nixon Street

Growth Area T11 Conclusions and Recommendations:

This report found that the existing injury crash rate on Cambridge Road is higher than is predicted by NZTA modelling guidelines, which should be investigated further.

The traffic modelling around the State Highway 3 intersection with Cambridge Road and Arawata Street at a high level appears to be indicating that the intersection is near if not at capacity with current traffic flows.

The further demand placed on the network is estimated to be 1,510 additional vehicles per day in the proposed “Low Development” scenario, or 3,020 vehicles per day in the suggested conservative “High Development” scenario (assuming future sub-division of these lots).

These additional vehicles, whilst not helping existing issues, are able to be accommodated within the assessed network with no measureable detriment, even with further baseline traffic growth.

In addition, there is also a lack of dedicated cyclist facilities around T11 which, whilst arguably not currently a known issue, the desire of Waipa District Council to incorporate these facilities in the growth area means there could be a break in connectivity if not addressed in the existing network.

In line with these conclusions we have prepared some recommendations for work going forward to help address existing and future concerns:

1 Pedestrian and Cyclist Facilities:
   a Cyclist facilities down Cambridge Road are lacking for connections to the anticipated facilities within the growth area, although a shared path facility exists at the State Highway roundabout with Cambridge Road. It is recommended that Waipa District Council review the existing facilities and programme in providing / extending infrastructure as the growth area is developed.
   b The only existing crossing facility along Cambridge Road is at the State Highway roundabout where there is a refuge island at the intersection. It is recommended that Waipa District Council look at a more formal facility near the supermarket, or at least another refuge island, to enable pedestrian traffic to more safely access local amenities.
2 The arrangement of Access 2 with the service lane for the shopping complex is considered to be a safety issue, and it is recommended discussions are held with the owner of that service lane to form an arrangement which is less problematic.

   It is noted that Mitre 10 does not appear to have delivery doors/facilities to the rear, so there remains the possibility of combining the two into an intersection, and providing an access off the new road.

The following points are recommendations from the Opus Feasibility Report which we believe are still relevant:

1 Undertake a more detail assessment of speed management measures for Cambridge Road.
2 Undertake a review of pedestrian and cycling connectivity.
   – Recommendations have been made in this regard, however a specific detailed review of what facilities are warranted has not been undertaken and could be useful to Waipa District Council in targeting funds.
3 Detailed assessment of how to change the right of way at Cambridge Road Access 1 to be a public road.

1 Te Awamutu: T6

1.1 Structure Plan Area

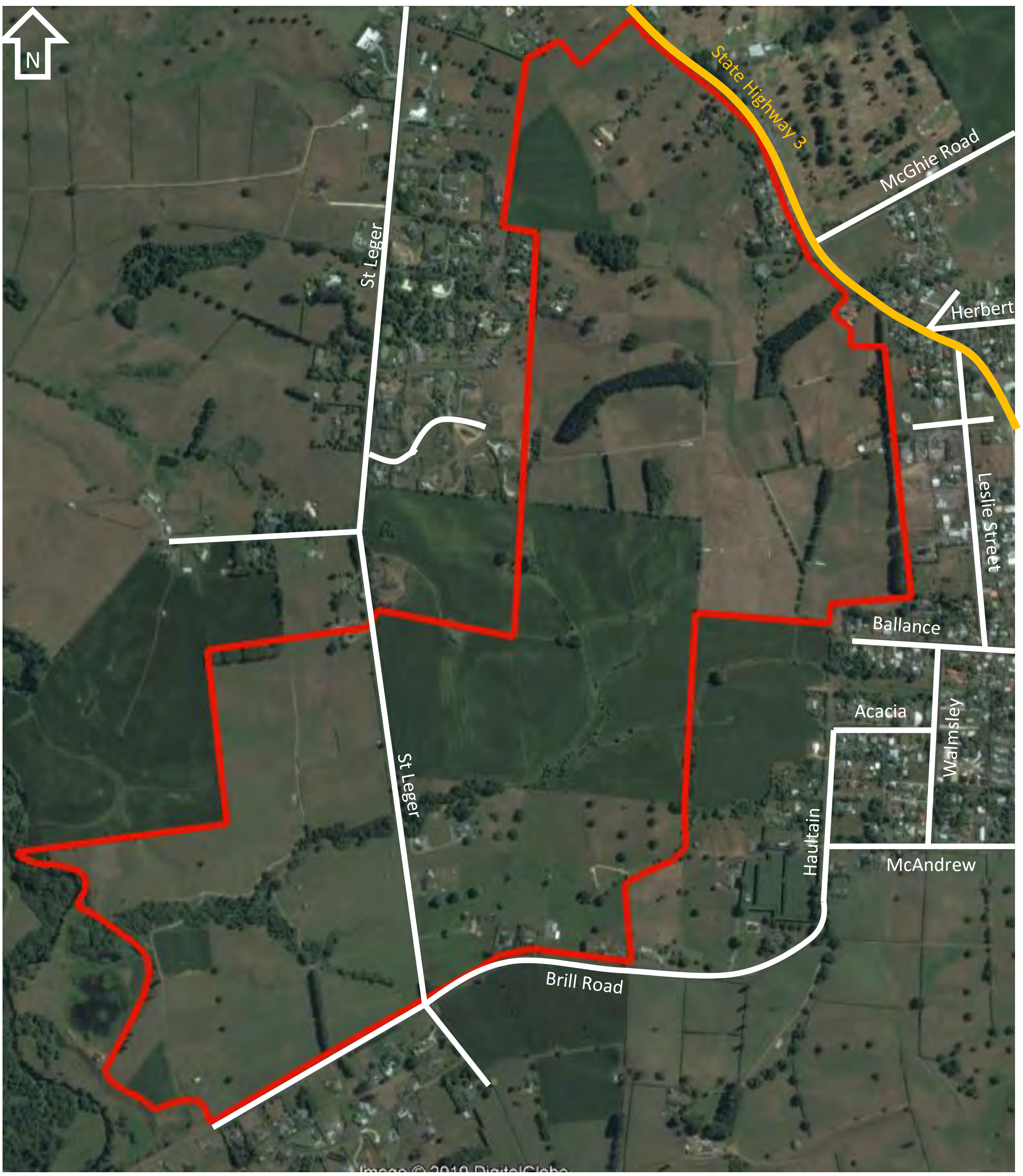


Figure 1.1: Approximate extents of T6 growth cell (image sourced from Google Earth)

The T6 growth cell lies between Kihikihi and Te Awamutu in a currently rural area zoned for future large-lot residential, immediately south of State Highway 3.

1.2 Existing Situation

1.2.1 Existing Transport Environment

With the exception of State Highway 3 to the north of the growth cell, all roads directly affected by T6 are classified as Local Roads.

There is a single narrow footpath on the northern / eastern side of the State Highway, otherwise there are no existing pedestrian or cyclist facilities on this major arterial.

Local roads surrounding the growth cell are generally consistent with a rural environment, with some residential on the Kihikihi (eastern) side.

Table 1.1: Road Details (Indicative Existing): Immediate Area

Road Name	Total Seal Width (m)	Lanes	Shoulder	Cycle Facilities	Footpaths	Posted Speed (km/hr)
St Leger Road	6.0 – 8.5	2 – Partially marked	Unmarked	None	None	80 – 100
Lawbrooke Lane	6.0	Unmarked (2 inferred)	Unmarked	None	None	80
Leger Grove	6.0	Unmarked (2 inferred)	Unmarked	None	None	80
Linehan Road	5.5	Unmarked (2 inferred)	Unmarked	None	None	80
Brill Road	5.5	2 – Partially marked	Unmarked	None	None	100
Haultain Street	4.5	2-way but effectively single lane	Unmarked	None	None	50
McAndrew Street	4.5 – 6.5	Unmarked (2 inferred)	Unmarked	None	None	50
Acacia Avenue	7.5	Unmarked (2 inferred)	Unmarked	None	1.5 m wide, northern side, full length	50
Walmsley Street	6.5 – 8.0	Unmarked (2 inferred)	Unmarked	None	1.5 m wide, western side, full length	50
Cameron Street	6.5	Unmarked (2 inferred)	Unmarked	None	None	50
Ballance Street	8.5	Unmarked (2 inferred)	Unmarked	None	1.5 m wide, northern side, full length	50
Havelock Street	4.5	2-way but effectively single lane	Unmarked	None	None	50
Leslie Street	7.5 – 8.5	Unmarked (2 inferred)	Unmarked	None	1.5 m wide, western side, 200 m long only from south	

Note: Measurements are approximate only using Google Earth.

In addition to the above the following roads, whilst not directly associated with the development (with the exception of the State Highway), will provide key links to the wider area:

Table 1.2: Road Details (Indicative Existing): Key Links

Road Name	Total Seal Width (m)	Lanes	Shoulder	Cycle Facilities	Footpaths	Posted Speed (km/hr)
State Highway 3 *Significant Road Corridor* *Major Arterial* *Regional Strategic*	15.5 – 16.5	2 + median	2, varies but generally at least 1.0 m wide	None	1.5 m wide, Northern / eastern side, full length	50 – 80
Golf Road *Major Arterial*	7.9 (town) 6.0 (rural)	2, fully marked with centreline and edgelines	1 on northern side to town boundary only, approximately 1.0 m wide	None	None	70 (town) 100 (rural)
McGhie Road *Local Road (connects SH3 to a Collector)*	4.5	2-way but effectively single lane	Unmarked	None	None	80
Herbert Street *Local Road (connects SH3 to a Collector)*	8.1	2 – Partially marked	Unmarked	None	1.5 m wide, northern side to Moule Street where it switches to southern side, ends at Oliver Street	50
Whitmore Street *Minor Arterial*	11.2 – 12.0	2, fully marked with centreline and edgelines	2, at least 2.0 m wide each	None	2 (both sides), 1.5 m wide each, full length within town	50
Church Street *Local Road (possible key link between Ballance and Whitmore)*	7.8	Unmarked (2 inferred)	Unmarked	None	1.5 m wide, southern side, full length	50

Note: Measurements are approximate only using Google Earth.

Herbert Street and, to a lesser extent, McGhie Road, provide key linkage through to Flat Road (a local Collector), and in turn feed into Golf Road, which also has its own connection to State Highway 3. Collectively these roads provide a key link to Cambridge and the rural businesses between the towns.

Whitmore Street (turning into Arapuni Road at the town boundary) provides a key link to the South Waikato towns of Putaruru and Tokoroa, as well as serving the rural areas around and to the south of Mount Maungatautari.

Church Street is a small section of road providing a second connection from State Highway 3 to Whitmore Street, however it lies directly opposite the Ballance Street intersection forming a crossroads, and would be the ideal route of many trying to travel from T6 out to the east.

These roads are not considered an exhaustive list, and there are many other local roads which provide “rat-runs” between the roads listed, however these are considered the primary, or most likely, routes for the majority of people, and certainly for those not familiar with urban Kihikihi.

1.2.2 Crash History

The NZTA Crash Analysis System (CAS) was interrogated for the period 2009 to 2018 (inclusive) to provide crash data for the roads in the immediate vicinity of the development and roads thought to be key in the distribution of traffic away from and back to the development, but only to the next major intersection or urban boundary. Full CAS outputs can be found in Appendix A.

State Highway 3 was assessed from the St Leger Road intersection to the McAndrew Street intersection (inclusive) only to account for the major intersections utilised by the new development.

While every effort was made to weed out any double-counting, it is possible that, where two roads in the assessment intersect, a crash may have been counted twice.

Table 1.3: Historical Crash Numbers with Injury by Road

Road Name	Number of Crashes	Non-injury	Minor Injury (M)	Death or Serious (DSI)	Crash Injury Rate	Years
State Highway 3	67	48	16	3	1.9	10x 2009 *(4x M; 2x DSI)* 4x 2010 *(M)* 1x 2011 *(1x M)* 4x 2012 *(1x M)* 2x 2013 *(1x M)* 3x 2014 11x 2015 *(3x M)* 14x 2016 *(1x M; 1x DSI)* 12x 2017 *(2x M)* 6x 2018 *(3x M)*
St Leger Road	3	1	1	1	0.2	1x 2010 1x 2012 1x 2015
Golf Road	12	11	1	0	0.1	2x 2009 2x 2010 2x 2011 *(1x M)* 1x 2012 3x 2015 1x 2017 1x 2018

Road Name	Number of Crashes	Non-injury	Minor Injury (M)	Death or Serious (DSI)	Crash Injury Rate	Years
McGhie Road	1	1	0	0	0	2011
Herbert Street	12	9	3	0	0.3	2x 2009 1x 2010 2x 2011 *(1x M)* 3x 2012 2x 2016 2x 2017 *(M)*
Whitmore Street	21	15	5	1	0.6	1x 2009 1x 2010 *(DSI)* 2x 2011 3x 2012 1x 2013 *(M)* 3x 2014 3x 2016 *(1x M)* 4x 2017 *(1x M)* 3x 2018 *(2x M)*
Leslie Street	3	3	0	0	0	1x 2009 1x 2012 1x 2015
Ballance Street	4	4	0	0	0	1x 2010 1x 2014 1x 2015
McAndrew Street	2	2	0	0	0	1x 2009 1x 2016
Walmsley Street	0	0	0	0	0	n/a
Acacia Street	0	0	0	0	0	n/a
Haultain Street	1	1	0	0	0.1	2009
Brill Road	0	0	0	0	0	n/a

As would be expected being a major arterial, State Highway 3 has by far the most crashes for the period, closely followed by Whitmore Street, Herbert Street and Golf Road. While this number seems high, it is less than would be expected by modelling (refer Section 1.2.3 below). This road is also noted as being a medium risk road on NZTA's KiwiRAP (Kiwi Roads Assessment Programme) report in 2012 (the most recent report) and therefore on NZTA's radar of roads that require attention.

Golf Road is a defined as a Major Arterial and Whitmore Street a Minor Arterial, therefore the crash rates on these roads appear consistent with their status.

Herbert Street is considered to be a Local Road, however the accident data suggests that it carries more traffic than normally expected or this classification and may be acting more like a collector road used as a defacto bypass of central Te Awamutu and/or as an alternative route to Cambridge and rural businesses.

If this is the case, it will have significant impact on the use of Herbert Street and its intersection with State Highway 3, over what may have been designed for, and improvement of the intersection and road corridor may be required.

1.2.3 Crash Prediction Modelling

A high-level Crash Prediction Model was assessed for the existing situation using the methods and formulae found in NZTA's Crash Estimation Compendium (2016, Updated June 2018).

For the State Highway 3 analysis, specifically the section of the State Highway from the St Leger Road / Golf Road intersection to the McAndrew Street intersection (both inclusive), the following sections were modelled independently from one another and combined in a final summation as per section 2.1.1: Methodology by site and crash type, of the Crash Estimation Compendium:

- State Highway 3 'rural' zone (i.e.: 80 km/hr) mid-block model
- State Highway 3 'urban' zone (i.e.: 50 km/hr) mid-block model
- St Leger Road / Golf Road intersection model
- Herbert Street intersection model
- Leslie Street intersection model
- Whitmore Street intersection model
- Ballance Street / Church Street intersection model
- McAndrew Street intersection model

Those Waipa District Council roads considered to be the main thoroughfares and/or distributors both currently and in the future were assessed as mid-block only as the major intersections were accounted for in the State Highway assessment, and the mid-block modelling can be said to account for minor intersections and private accesses.

Table 1.4: Crash Model Results (Existing)

Road Name	**Predicted Injury Crash Rate** (existing)	**Actual Injury Crash Rate**	**Differential: Predicted to Actual**	**Differential Rate**
State Highway 3 (includes intersections)	3.10	1.90	-1.20	-38.7%
St Leger Road	0.30	0.20	-0.10	-33.3%
Golf Road	0.10	0.10	0.00	0%
Herbert Street	0.12	0.30	+0.18	+50%
Leslie Street	0.06	0.00	-0.06	-100%
Whitmore Street	0.06	0.60	+0.54	+900%
Ballance Street	0.02	0.00	-0.02	-100%
McAndrew Street	0.02	0.00	-0.02	-100%

Most of the road corridors, including State Highway 3, are currently experiencing lower injury crash rates than the assessed prediction model estimates, with notable exceptions for Herbert Street and Whitmore Street.

The assumption regarding Herbert Street's collector road status also seems to be supported by the data, and Whitmore Street has a higher crash rate than would normally be expected, which could indicate it is in need of further detailed analysis to understand why this may be occurring.

It is important to note that, being high-level, no detailed analysis of individual crashes was undertaken; as such, it is possible that the actual injury crashes may have been assigned incorrectly.

1.2.4 Road Safety

The existing road network is that of a rural town, some is urbanised in facilities such as footpaths etc., and other areas have no footpaths or kerb and channel. Generally the local road network has some provision for pedestrians, as indicated in Table 1.1, however on the roads to the western side of State Highway 3 which will connect directly to this growth area the facilities are spotty, with some roads having partially complete paths on at least one side, and others having nothing. Dedicated cyclist facilities are none existent.

The State Highway, whilst having standard-width footpaths on both sides for most of the study length, is also lacking in dedicated cyclist facilities.

Crossing facilities beyond a drop-kerb in the footpath appear to be confined to the immediate town centre, and then a single Zebra-type crossing facility across the State Highway is the only formal arrangement.

In the crash data (refer Appendix A) there are three accidents which involve pedestrians, all associated with the State Highway; two of these resulted in vehicle to vehicle conflict due to attempts to avoid or slow down for the pedestrians in question. There are no accidents stated to involve cyclists.

One accident involved hitting a pedestrian, resulting in a minor injury, and was caused by the vehicle swerving to avoid 'another party.'

It's also important to note that these accidents were spread quite evenly over the study period, with only one non-injury crash involving a pedestrian in the last five years (in 2015).

This indicates the relative risk for pedestrians and cyclists in Kihikihi appears to be low, however it should be noted that the reason for this is unknown, for example it may be that there are very few pedestrians at all.

1.2.5 Travel Patterns

No traffic survey has been undertaken, however using best-practise and existing data from the Road Assessment and Maintenance Management database (RAMM) we can infer likely peak travel patterns.

This data was extracted from Mobileroad.org, which is populated using Road Controlling Authority (RCA) RAMM data. This data is maintained by the RCA (in this case NZTA for State Highway 3, and Waipa District Council for all other roads) for tracking and forecasting maintenance activities on their respective networks; it was noted that while the State Highway traffic data appeared to be based on recent counts, the Waipa District Council roads were all identified as estimates from 2016 and so we are unsure as to the accuracy of the data for that part of the network.

The key RAMM data used in this assessment can be found in Table 1.5 below.

Table 1.5: RAMM Data

Road Name	Average Daily Traffic (ADT) (veh/day)	Date of Count / Estimate	Heavy Vehicles (%)
Acacia Avenue	155	1/12/2016	Unknown
Ballance Street	600	1/12/2016	Unknown
Brill Road	230	1/12/2016	Unknown
Brill Road Stub	162	1/12/2016	Unknown
Church Street	1,160	1/12/2016	Unknown
Golf Road	1,580	1/12/2016	Unknown
Haultain Street	80	1/12/2016	Unknown
Havelock Street	30	1/12/2016	Unknown
Herbert Street	1,020	1/12/2016	Unknown
Leslie Street	610	1/12/2016	Unknown
McAndrew Street	250	1/12/2016	Unknown
McGhie Road	220	1/12/2016	Unknown
SH3 (Kihikihi Road) North of St Leger/Golf Int.	12,030	25/12/2017	8%
SH3 (Kihikihi Road) South of St Leger/Golf Int.	11,861	25/12/2017	11%
SH3 (Lyon Street) Herbert to Whitmore	11,861	25/12/2017	11%
SH3 (Lyon Street) Whitmore South	8,670	25/12/2017	19%
St Leger Road Brill Road to Bruce Road	355	1/12/2016	Unknown
St Leger Road Bruce Road to Linehan Road	410	1/12/2016	Unknown
St Leger Road Lawbrooke to SH3 / Golf	1,110	1/12/2016	Unknown
St Leger Road Leger Grove to Lawbrooke	920	1/12/2016	Unknown
St Leger Road Linehan Road to Leger Grove	545	1/12/2016	Unknown
St Leger Road Stub	57	1/12/2016	Unknown
Walmsley Street	130	1/12/2016	Unknown
Whitmore Street SH3 to Church	2,350	1/12/2016	Unknown
Whitmore Street East of Church	2,740	1/12/2016	Unknown

Note: All data obtained from MobileRoad.org, all 2-way traffic.

The attractors for determining travel patterns are considered to be as follows:

Table 1.6: Attractors and Type

Attractor Name	Approximate Distance from T6	Attractor Type	Attractions
Kihikihi Centre	700 m	Local Primary Attractor	• Local shops (food, postal services, etc.)
Hamilton	32 km	Primary Attractor	• Largest population centre within 0.5hrs travel • Large employment area • Large retail bases, including niche shops and large supermarkets • Recreational facilities
Te Awamutu	3 km	Secondary Attractor	• Closest large shopping area, including Supermarkets • Employment
Cambridge	23 km	Secondary Attractor	• Large shopping area, including Supermarkets • Employment
Local Rural Areas	3 km plus	Secondary Attractor	• Employment • Outdoor Recreation
Otorohanga (and South)	25 km plus	Tertiary Attractor	• Employment • Recreation

From these assumptions we can reasonably determine that the majority of traffic will travel east (Kihikihi Centre, Cambridge, and some rural areas) and north (Hamilton, Te Awamutu, and methods for getting to rural areas north, east and west), with the rest travelling south; and return from those same directions in similar proportions.

Westbound traffic moving away from this area are forced to head either north or south first as no method of direct connection in that direction exists.

1.2.6 Public Transport

State Highway 3 is currently serviced by the number 24 “Te Awamutu” bus connecting Te Awamutu and Kihikihi with Ohaupo and Hamilton City according to the “Busit.co.nz” website, and only to Kihikihi on Tuesdays and Thursdays.

No other public transport options are currently available for this area. Engagement with Waikato Regional Council is recommended to look at future public transport options in the lead up to the next LTP development in 2021.

1.2.7 Other Modes

For local trips to Kihikihi centre, and possibly Te Awamutu, it is likely cycling and walking will be used by children, the elderly, those with no access to a private vehicle, and those of a health or environmentally friendly mind-set; some of these same groups will use the bus to Te Awamutu and further to Hamilton.

Realistically, however, the majority of trips in this area are still likely to be private vehicle based regardless of the distance to travel.

1.3 Proposed Situation

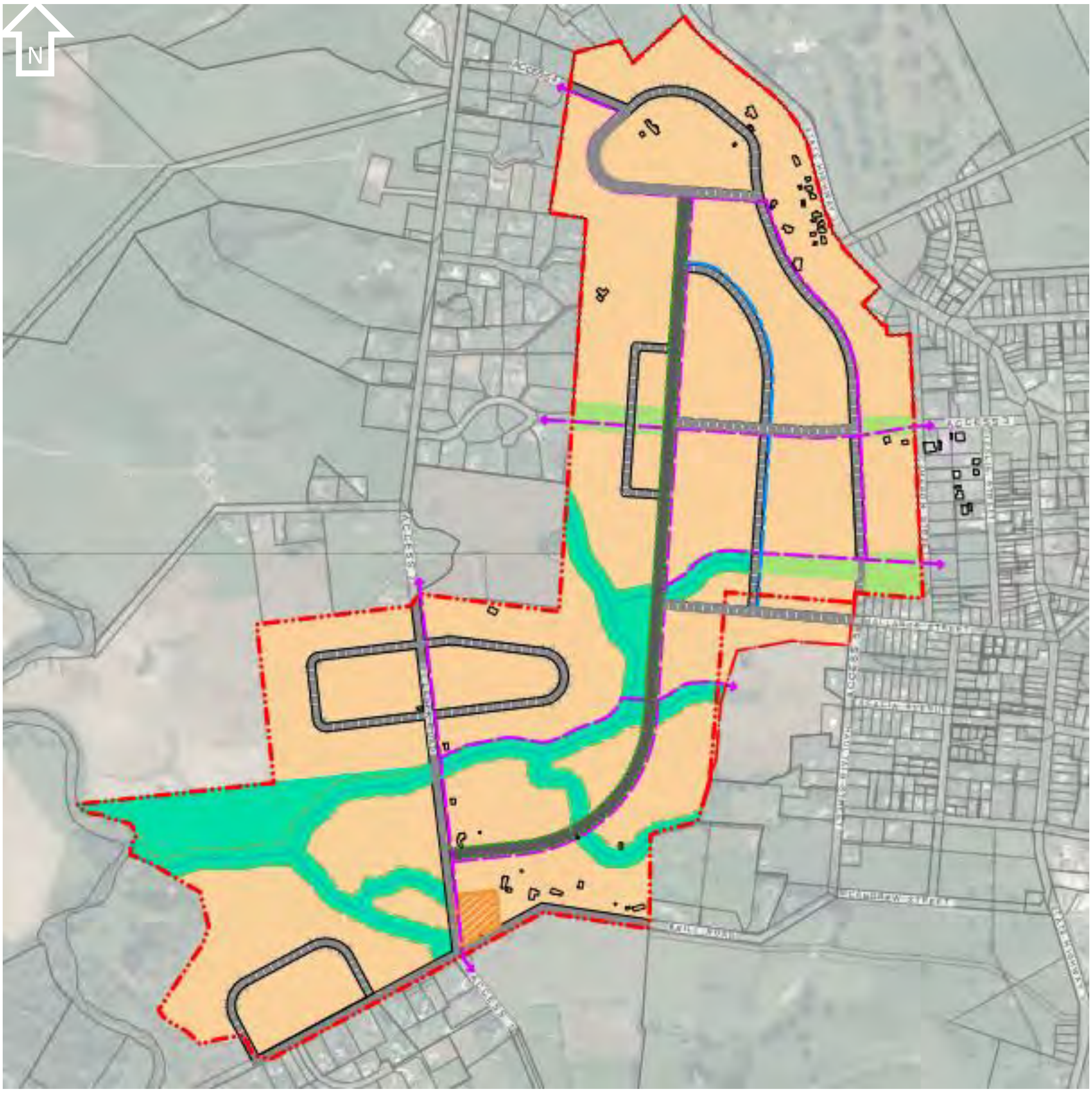


Figure 1.2: Proposed T6 Structure Plan road network

The proposed development area is intended to be a mixture of various lot sizes of residential and compact residential, ranging from 1,000 m^2, to 5,000 m^2 and over.

Based on the current Structure Plan at the time of writing, this results in an estimated lot yield of around 250-300.

1.3.1 Proposed Road Network

1.3.1.1 Overview

The proposed road network is designed to provide good connectivity both to and within the land parcel, providing good traffic amenity as well as retaining the potential for future in-fill subdivision from low density to medium density without the need for additional public roading infrastructure.

The links to the existing road network occur at two points on St Leger Road (including the intersection with Brill Road to the south), given it runs through the proposed plan area, and Ballance Street.

St Leger Road provides a good primary connection to State Highway 3 to the north for those living in the south, and parts of the central, plan area, as well as providing a reasonable local road link to State Highway 3 to the south via Brill Road and McAndrew Street.

Belle Amie Drive, leading out to St Leger Road in the northern part of the growth cell is a recently constructed road that appears to be of sufficient standard to join on to the 20 m collector road shown on the Structure Plan. It is likely that this will form the main point of entry for vehicles accessing from the north.

Ballance Street provides a good link from the centre of the plan area to Kihikihi town centre, providing an alternative link to State Highway 3 for those in the northern and central part of the plan area, saving a (comparatively) lengthy travel south.

It is anticipated that vehicles will use the Ballance Street intersection with State Highway 3 sparingly, unless they intend to use Whitmore Street to head out into the rural area, with Leslie and Walmsley Streets providing the primary north and southbound connections to the State Highway respectively.

1.3.1.2 Road Upgrades

The following roads, critical to the growth area, are currently estimated to be deficient (based on the desktop exercise) when assessed against the Waipa District Council standards (Regional Infrastructure Technical Specifications, Appendix T4: Criteria for Public and Private Roads) and may require upgrading to meet these standards:

- St Leger Road (some sections of)
- Brill Road
- Haultain Street
- McAndrew Street
- Golf Road (rural section)
- McGhie Road (if desired to include as an alternative route east)

Predominantly this relates to total seal widths, which may be exacerbated by a lack of markings, leading to drivers taking a more central position than they otherwise would do.

Upgrading the intersection of St Leger Road and Brill Road could provide a significant enhancement to safety and efficiency as the current crossroads alignment is narrow with highly constrained sight distance which is considered to be a considerable risk now, which will deteriorate in the future should traffic flows increase, although the medium term estimate is that this is unlikely given the increased ease of connectivity along other roads within the development.

We consider it necessary to undertake a review of these roads prior to the growth area coming online, in conjunction with any hierarchy changes (see below).

1.3.1.3 Road Hierarchy Changes

As part of this development, it is expected that certain local roads function, and therefore where it sits in the regional hierarchy, will change.

The table below indicates which roads are expected to change hierarchy as the development in the T6 growth area increases:

Table 1.7: Predicted Road Hierarchy Changes

Road Name	Current Zone / Hierarchy	Predicted Zone / Hierarchy
St Leger Road	Rural & Large Lot Residential / Local	Large Lot Residential / Collector
Herbert Street	Residential / Local	Residential / Collector
Ballance Street	Residential / Local	Residential / Collector
Church Street	Residential / Local	Residential / Collector

These predictions are based on a combination of function and traffic numbers, and even if T6 does not support the numbers based in this report, the roads listed are likely to function on this basis as a minimum.

If this prediction follows, then it is likely these roads will require some level of upgrade, as per the District Plan minimum standards, to function in this manner safely and efficiently. District Plan Road widths are reproduced in the table below.

Table 1.8: District Plan Residential Zone Road Widths

Class	Road Reserve Width (m)	Carriageway Width (m)	Lane Width (m)	Cycleway Width (m)	Footpath Width (m)
Collector	25	15	2 @ 3.5	Both sides @ 1.5	2 @ 1.5
Local	11	11	2 @ 3	Shared environment	2 @ 1.5

1.3.2 Proposed Alternative Mode Links

Shared pedestrian / cycle facilities have been proposed in the Structure Plan (the pink lines in Figure 1.2) which follow most of the proposed road links to the existing network, as well as providing some amenity linkage through proposed green spaces.

The majority of the roads connecting to these facilities currently have little to no pedestrian and cyclist facilities provided, and what is there is generally considered to be poorly inter-connected. We recommend that WDC consider addressing this in the next LTP by reviewing Kihikihi active mode transport facilities against the Waipa District Cycling Trails Strategic Framework to proposing projects, such as:

- Provision of shared cycle/footway path links to key destinations away from roads.
- Traffic Calming on local roads to reduce vehicle speeds and make a safer environment.
- Localised widening especially on corners to improve visibility and provide safe passing of cyclists.
- Construction of footpaths and berms wherever possible.

1.4 Modelling Assessments

1.4.1 Trip Distribution

Trip distribution has been assessed at a conceptual level using a simplified form of gravity modelling, a high-level method of determining likely travel patterns based on existing known data.

Using the attractors as a guide, at any one intersection the traffic flow in any direction currently on that road is proportionally split based on the most popular routes and likely destinations, informing the flows between, and therefore at, intersections through to the end of the study area.

The flows undergo a "balancing" exercise where the proportions turning in any one direction are gradually amended until the approximate ADT for each direction and road are arrived at.

This method is a cost effective way of estimating traffic patterns and turning flows without reliance on turning counts and origin destination surveys. The results are used to inform the indicative intersection models and give an indication as to whether intersections are currently functioning as intended, and whether they will continue to do so if more vehicles are added.

1.4.1.1 Base Year

The gravity modelling for the existing situation is based on the assumed travel patterns and traffic data identified in section 1.2.3 above.

The ADT data was pro-rated to a Base Year of 2018 using a 2% per annum average, and also to a Projected Year of 2035 using the same average; 2035 was chosen as this is the latest year this growth area is expected to be fully developed by.

These numbers were then placed into a spreadsheet-based "Wireframe Model" designed to look at the daily peaks using the following further assumptions:

- The average daily peaks will be 10% of the ADT.
- The flows on any one road are split 70/30 for direction based on the time of day and direction of attractors (i.e.: 70% AM towards attractors, 70% PM away from attractors).
- Where Heavy Traffic is 'Unknown' it will be assumed to be 1%

Turning estimates, by percentage of vehicles, were then used to try and balance the vehicles flowing into the study area with the vehicles flowing from the study area along key routes.

Using these turning estimates as a starting point, the 2035 base model was then also created.

1.4.1.2 Model Limitations

It is important to note that, no counts or observation verification was conducted at any of the key intersections and the model is entirely derived from the "most likely" routing based on the assumptions used for trip distribution.

Another issue with using ADT data over such a long section of State Highway is the "stepping" which occurs in the data between two count locations, which is difficult to reconcile within the assumptions and method mentioned above.

1.4.1.3 Development Figures

The future development of T6 has been assumed to be additional to the standard 2% traffic growth in this area; this is not strictly correct, as the traffic has to come from somewhere and this type of residential growth tends to be what supports it, however retaining this assumption does provide for a conservative model.

Two development scenarios over and above a standard 2% growth were considered:

1 Low Development: A scenario whereby the lot yield as presented in the Structure Plan was used to determine additional traffic flow.
2 High Development: A scenario whereby the lot yield was doubled when compared to that in the structure plan, to account for a worst case scenario of smaller lot types and future in-fill development.

The daily traffic per lot was assumed to be 10veh/day, with all other traffic assumptions matching that for the base models. This results in the following additional traffic figures:

1 Low Development = 2,400 veh/day
2 High Development = 4,800 veh/day

1.4.2 Intersection Modelling

The following intersections were modelled in Sidra Intersection 8.0 for levels of service, all based on the Gravity Model calculated flows and turning percentages:

- State Highway 3 / Golf Road / St Leger Road
- State Highway 3 / Herbert Street / Leslie Street / Nixon Street
- State Highway 3 / Whitmore Street / Church Street / Ballance Street
- State Highway 3 / McAndrew Street

These intersections were considered high priority intersections as they are collector roads or higher and/or currently manage or are expected to manage a significant amount of the traffic from both the existing developed areas of Kihikihi and the T6 growth area.

The Level of Service for any lane is directly related to the average delay anticipated for a vehicle in that lane, as follows:

Table 1.9: Level of Service (LoS): Sidra 8 Sign Control

Level of Service (LoS) for v/c≤1.0 (v/c>1.0 = LoS F)	**Average Delay per Vehicle** in seconds (d)
A	d ≤ 10
B	10 < d ≤ 15
C	15 < d ≤ 25
D	25 < d ≤ 35
E	35 < d ≤ 50
F	50 < d

The following assumptions, in addition to those mentioned for the Gravity Model, were used:

- No gradients are known, so all gradients for all approaches were set at 0%.
- All measurements possible were taken from aerial views on Google Earth.
- If a median was present it was assumed to act as a Right Turn Bay in lieu of an actual Right Turn Bay.
- If present, shoulders were considered ‘full’ (of parked vehicles, for example) and so not considered as additional seal width.

1.4.2.1 State Highway 3 / Golf Road / St Leger Road

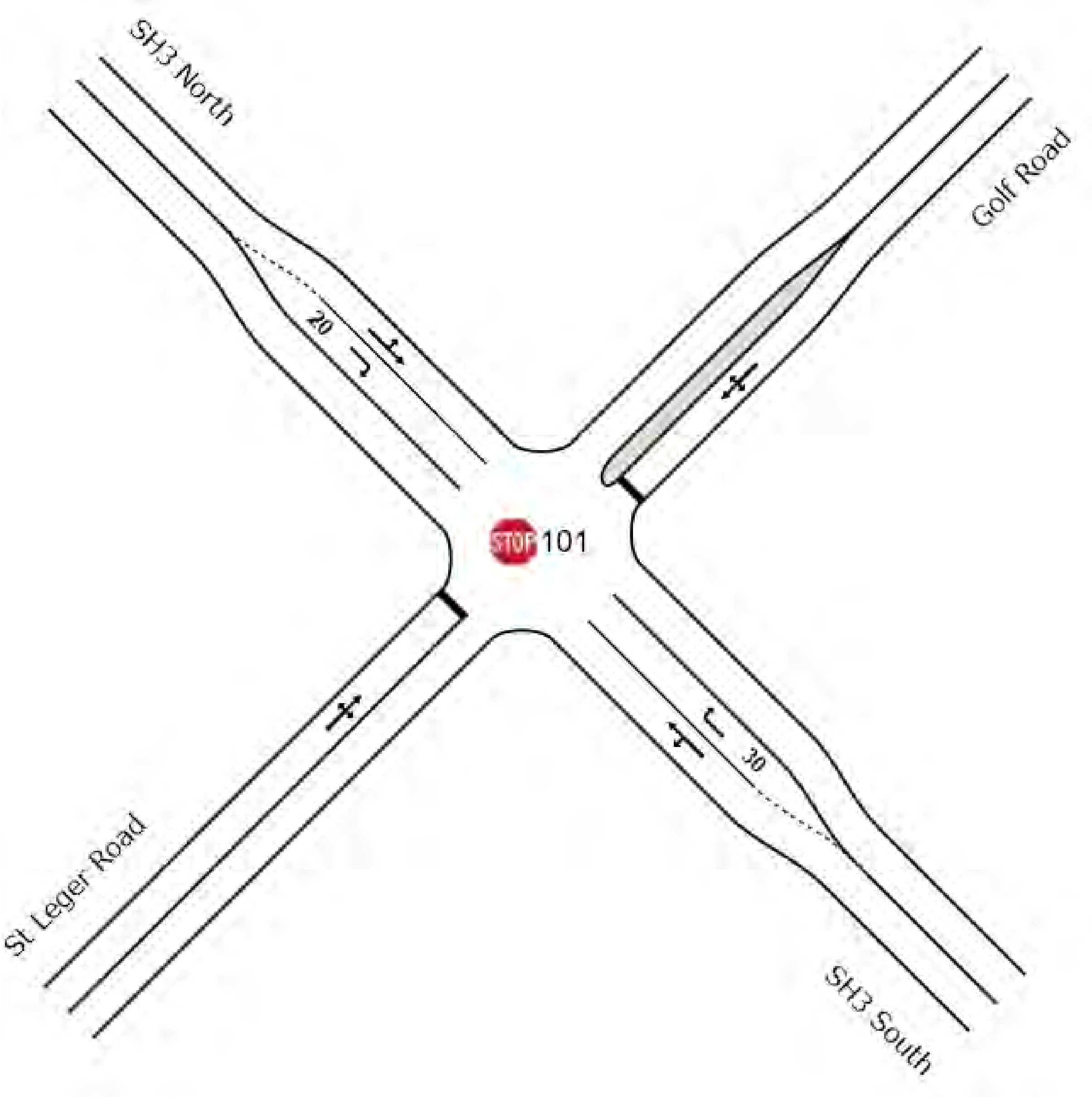


Figure 1.3: Sidra Intersection Diagram – State Highway 3 / Golf Road / St Leger Road

This intersection was modelled for the following situations:

- 2018 base year AM and PM peaks
- 2018 plus Low Development (LD) AM and PM peaks
- 2018 plus High Development (HD) AM and PM peaks
- 2035 assumed natural growth of 2%pa only, AM and PM peaks
- 2035 2% growth plus Low Development (LD), AM and PM peaks
- 2035 2% growth plus High Development (HD), AM and PM peaks

The following tables summarise the LoS findings for each leg / lane by scenario for quick reference. Summaries of the modelling reports can be found in Appendix B.

Table 1.10: AM Peaks

Scenario	SH3 North		SH3 South		Golf Road	St Leger Road
	Through Lane	Right Turn Bay	Through Lane	Right Turn Bay		
2018	A	B	A	A	F	C
2018 + LD	A	B	A	A	F	C
2018 + HD	A	B	A	A	F	C
2035	A	B	A	A	F	F
2035 + LD	A	B	A	A	F	F
2035 + HD	A	B	A	A	F	F

Table 1.11: PM Peaks

Scenario	SH3 North		SH3 South		Golf Road	St Leger Road
	Through Lane	Right Turn Bay	Through Lane	Right Turn Bay		
2018	A	A	A	B	F	C
2018 + LD	A	A	A	B	F	C
2018 + HD	A	A	A	B	F	C
2035	A	A	A	C	F	F
2035 + LD	A	A	A	C	F	F
2035 + HD	A	A	A	C	F	F

These results indicate that, for both AM and PM peaks, the existing intersection requires an upgrade with current traffic levels.

It is likely that, given Golf Road's other connections to the east, the intersection will very rarely see these levels of delay as users will re-direct to Park or Cambridge Roads to bypass any issues; however by 2035, without the added development as additional demand, St Leger Road will also be experiencing delay outside of the desired Levels of Service, with the only option for users to travel south and join the State Highway 3 traffic heading north, therefore adding to the issues with exiting a side road at this intersection, and also potentially causing problems with those within Kihikihi.

1.4.2.2 State Highway 3 / Herbert Street / Leslie Street

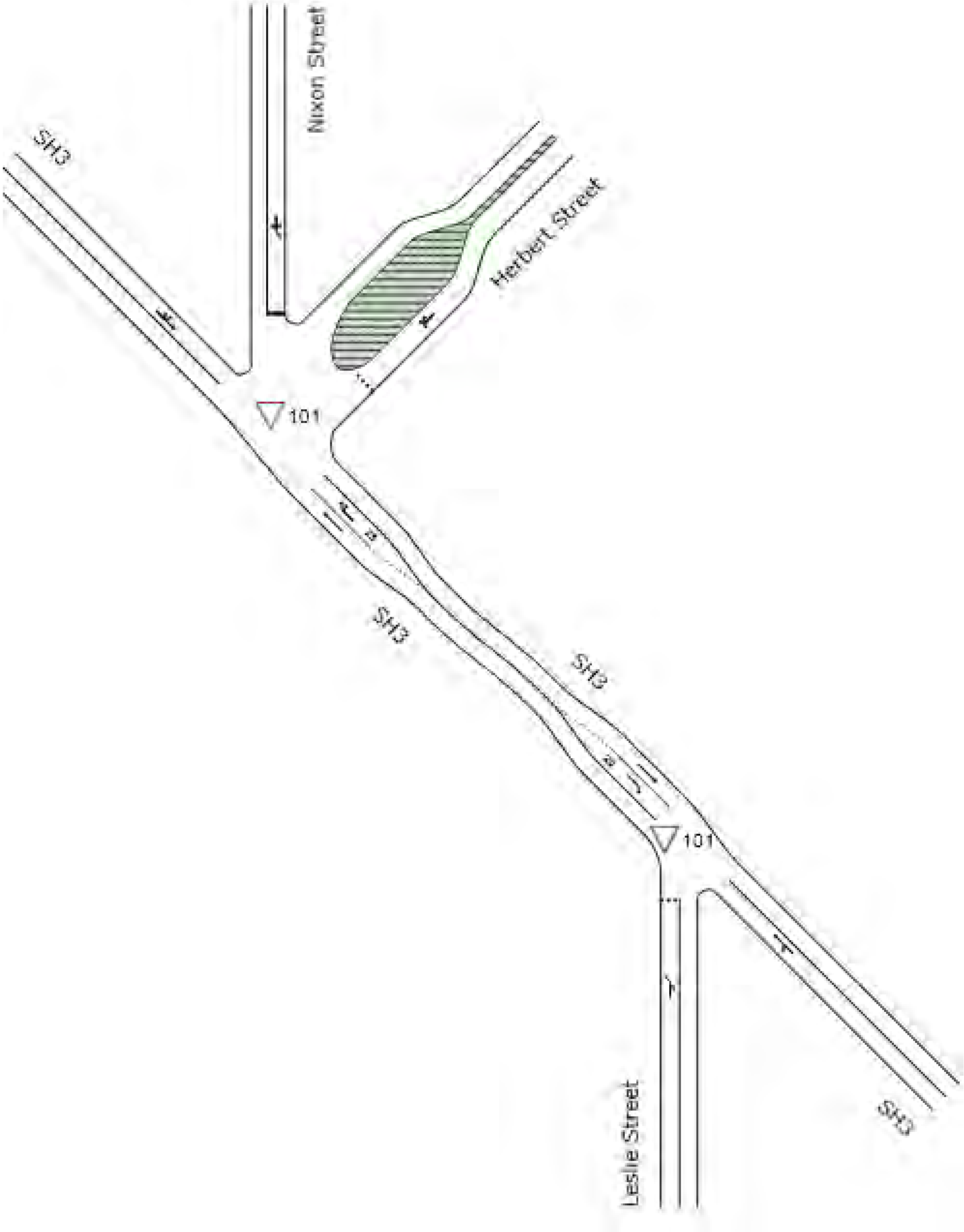


Figure 1.4: Sidra Intersection Diagram – State Highway 3 / Herbert Street / Leslie Street

This intersection was modelled for the following situations:

- 2018 base year AM and PM peaks
- 2018 plus Low Development (LD) AM and PM peaks
- 2018 plus High Development (HD) AM and PM peaks
- 2035 assumed natural growth of 2%pa only, AM and PM peaks
- 2035 2% growth plus Low Development (LD), AM and PM peaks
- 2035 2% growth plus High Development (HD), AM and PM peaks

It is important to note that this intersection is staggered, and as such has been summarised as two separate intersections, however it was analysed as one model for the purposes of this report.

The following tables summarise the LoS findings for each leg / lane by scenario for quick reference. Summaries of the modelling reports can be found in Appendix B.

Table 1.12: AM Peaks – Herbert Street

Scenario	SH3 North	SH3 South		Herbert Street	Nixon Street
		Through Lane	Right Turn Bay		
2018	A	A	A	D	C
2018 + LD	A	A	A	D	C
2018 + HD	A	A	A	E	C
2035	A	A	A	F	F
2035 + LD	A	A	A	F	F
2035 + HD	A	A	A	F	F

Table 1.13: AM Peaks – Leslie Street

Scenario	SH3 North		SH3 South	Leslie Street
	Through Lane	Right Turn Bay		
2018	A	A	A	B
2018 + LD	A	A	A	B
2018 + HD	A	A	A	B
2035	A	B	A	C
2035 + LD	A	B	A	C
2035 + HD	A	B	A	C

Table 1.14: PM Peaks – Herbert Street

Scenario	SH3 North	SH3 South		Herbert Street	Nixon Street
		Through Lane	Right Turn Bay		
2018	A	A	A	E	C
2018 + LD	A	A	A	F	D
2018 + HD	A	A	A	F	D
2035	A	A	C	F	F
2035 + LD	A	A	C	F	F
2035 + HD	A	A	C	F	F

Table 1.15: PM Peaks – Leslie Street

Scenario	SH3 North		SH3 South	Leslie Street
	Through Lane	Right Turn Bay		
2018	A	A	A	A
2018 + LD	A	A	A	A
2018 + HD	A	A	A	A
2035	A	A	A	B
2035 + LD	A	A	A	A
2035 + HD	A	A	A	A

These results indicate that the peak traffic is not currently a problem at either end of this staggered crossroads, however the PM peak becomes problematic with even low development of the T6 growth cell, and both AM and PM peaks are an issue by 2035 under a normal growth scenario.

It is likely that, given Herbert Street's other connections to the east, the intersection will rarely see these levels of delay as users will re-direct to Park or Cambridge Roads to bypass any issues, and users of Nixon Street will turn left and follow the same bypass routes if as those on Herbert; however this of course is potentially passing the problem on to other high-use intersections along the State Highway 3 corridor, which would be undesirable.

1.4.2.3 State Highway 3 / Whitmore Street / Church Street / Ballance Street

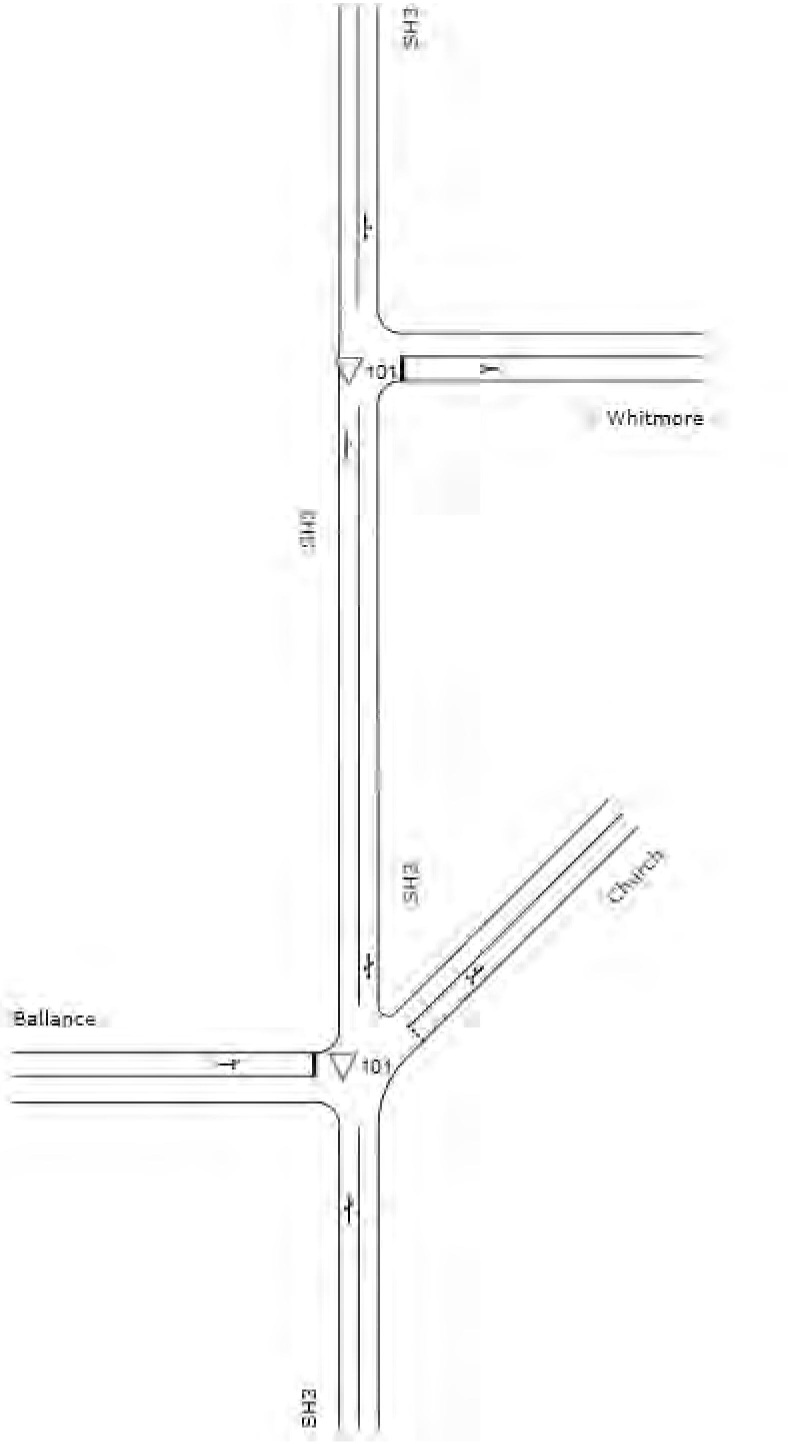


Figure 1.5: Sidra Intersection Diagram – State Highway 3 / Whitmore Street / Church Street / Ballance Street

This intersection was modelled for the following situations:

- 2018 base year AM and PM peaks
- 2018 plus Low Development (LD) AM and PM peaks
- 2018 plus High Development (HD) AM and PM peaks
- 2035 assumed natural growth of 2%pa only, AM and PM peaks

- 2035 2% growth plus Low Development (LD), AM and PM peaks
- 2035 2% growth plus High Development (HD), AM and PM peaks

It is important to note that this assessment is two intersections being treated as one due to proximity. It has been summarised as two separate intersections for clarity, however it was analysed as one model for the purposes of this report.

The following tables summarise the LoS findings for each leg / lane by scenario for quick reference. Summaries of the modelling reports can be found in Appendix B.

Table 1.16: AM Peaks – Whitmore Street

Scenario	SH3 North	SH3 South	Whitmore Street
2018	A	A	D
2018 + LD	A	A	D
2018 + HD	A	A	D
2035	A	A	F
2035 + LD	A	A	F
2035 + HD	A	A	F

Table 1.17: AM Peaks – Ballance Street

Scenario	SH3 North	SH3 South	Church Street	Ballance Street
2018	A	A	A	B
2018 + LD	A	A	A	B
2018 + HD	A	A	A	B
2035	A	A	B	B
2035 + LD	A	A	B	C
2035 + HD	A	A	B	C

Table 1.18: PM Peaks – Whitmore Street

Scenario	SH3 North	SH3 South	Whitmore Street
2018	A	A	C
2018 + LD	A	A	C
2018 + HD	A	A	D
2035	A	B	F
2035 + LD	A	B	F
2035 + HD	A	B	F

Table 1.19: PM Peaks – Ballance Street

Scenario	SH3 North	SH3 South	Church Street	Ballance Street
2018	A	A	B	B
2018 + LD	A	A	B	B
2018 + HD	A	A	B	B
2035	A	A	C	B
2035 + LD	A	A	C	B
2035 + HD	A	A	C	B

These results indicate that the peak traffic at the two intersections analysed is currently not a problem, and would still be meeting the required Levels of Service under both T6 growth scenarios.

However, by 2035 under normal a normal growth scenario, without the added development as additional demand, the Whitmore Street intersection falls below the minimum Level of Service and so may require upgrading.

1.4.2.4 State Highway 3 / McAndrew Street

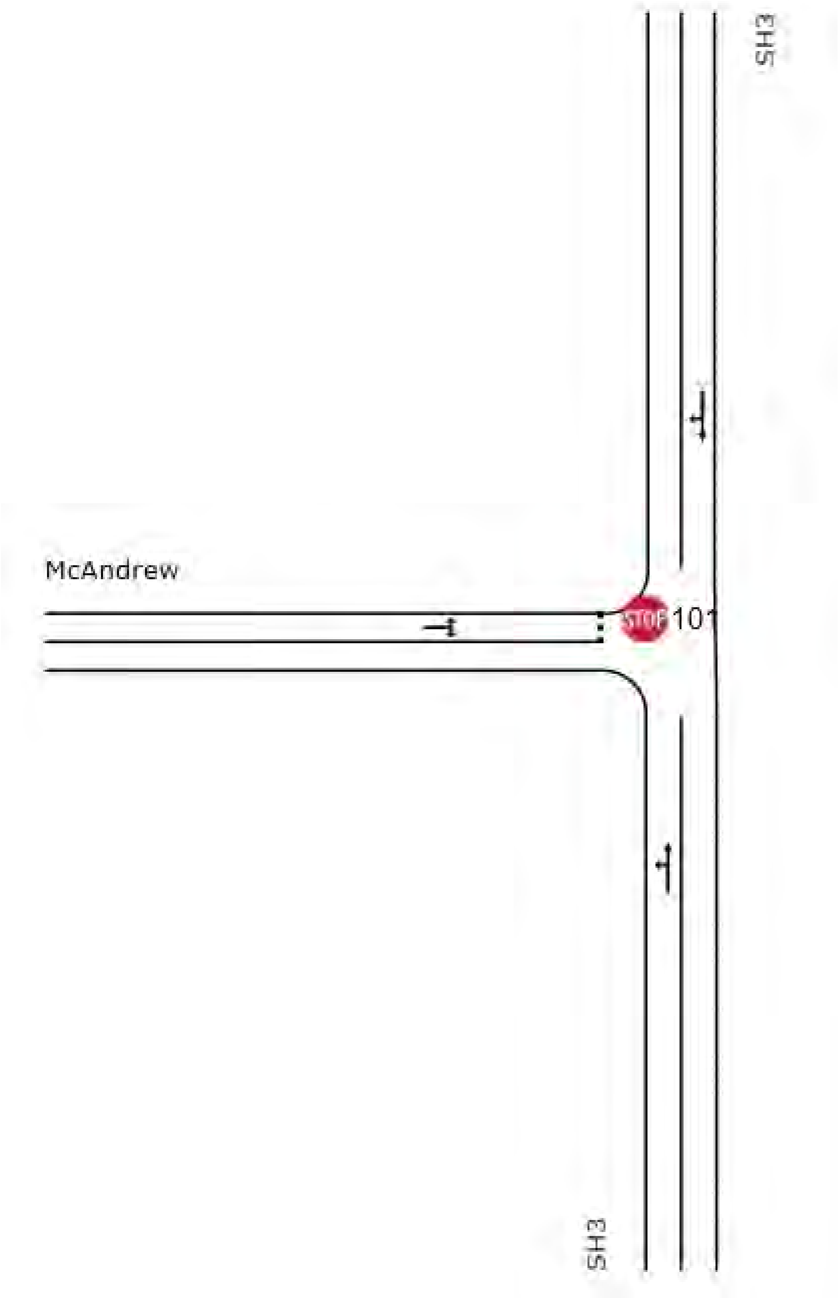


Figure 1.6: Sidra Intersection Diagram – State Highway 3 / McAndrew Street

This intersection was modelled for the following situations:

- 2018 base year AM and PM peaks
- 2018 plus Low Development (LD) AM and PM peaks
- 2018 plus High Development (HD) AM and PM peaks
- 2035 assumed natural growth of 2%pa only, AM and PM peaks
- 2035 2% growth plus Low Development (LD), AM and PM peaks
- 2035 2% growth plus High Development (HD), AM and PM peaks

The following tables summarise the LoS findings for each leg / lane by scenario for quick reference. Summaries of the modelling reports can be found in Appendix B.

Table 1.20: AM Peaks

Scenario	SH3 North	SH3 South	McAndrew Street
2018	A	A	B
2018 + LD	A	A	B
2018 + HD	A	A	B
2035	A	A	C
2035 + LD	A	A	C
2035 + HD	A	A	C

Table 1.21: PM Peaks

Scenario	SH3 North	SH3 South	McAndrew Street
2018	A	A	A
2018 + LD	A	A	A
2018 + HD	A	A	A
2035	A	A	B
2035 + LD	A	A	B
2035 + HD	A	A	B

These results indicate that the McAndrew Street intersection is both currently operating well within the Levels of Service, and continues to do so with development now and to 2035.

1.4.3 Access 4 – Belle Amie Drive

Belle Amie Drive, being positioned in the north-western section of the proposed growth area, potentially significantly alters the flow of traffic within this area as the assumptions currently assume most users want to travel north, and most of those users from the northern part of the development will therefore use the Ballance Street exit.

Access 4 would therefore draw traffic away from Ballance Street and place more traffic on the St Leger Road intersection with State Highway 3.

This would not significantly affect the modelling results, as the St Leger Road intersection is need of a more detailed investigation and more traffic would not change this, and Ballance Street (and the other assessed connections to the State Highway in this area) are expected to operate without significant problems up to the extreme case of 2035 traffic plus higher development in the growth area, which would only improve with traffic diverting away.

The connection of Access 4 to St Leger Road, therefore, is not considered a problem and could in fact reduce traffic in Kihikihi town centre if an upgrade to the State Highway 3 / St Leger Road / Golf Road intersection is implemented and works efficiently.

1.4.4 Crash Prediction Modelling

Using the additional vehicles assumed to be using the road corridors in a 2035 plus High Development worst-case scenario, as assigned in the Gravity Modelling above, the Crash Prediction Modelling was updated assuming the road corridors were not otherwise altered by the developments.

Table 1.22: Crash Model Results (Combined)

Road Name	**Predicted Injury Crash Rate** (existing)	**Predicted Injury Crash Rate** (2035 + HD)
State Highway 3 (includes intersections)	3.10	4.36
St Leger Road	0.30	0.49
Golf Road	0.10	0.13
Herbert Street	0.12	0.15
Leslie Street	0.06	0.10
Whitmore Street	0.06	0.08
Ballance Street	0.02	0.04
McAndrew Street	0.02	0.04

If the differential from Table 1.4 Crash Model Results (Existing) were applied to Herbert and Whitmore Streets, therefore assuming their current unexpected crash trends continued, they would produce a prediction of 0.23 and 0.72 crashes per year respectively.

This shows an increase in expected crashes as development increases, which is not unexpected, however with further investigation and option assessments for upgrading the various roads and intersections so they are better able to cope with expected traffic growth could help keep this increase to a minimum.

1.5 Indicative Costs

Given that the majority of road construction costs will be borne by developers, only a high-level cost estimate has been produced for the structure plan area, and only includes the following:

- Existing road sections which require upgrade to become Collectors or higher (including parts of St Leger Road and Ballance Road).
- New road infrastructure designated Collector or higher, which Waipa DC may wish to implement ahead of developer involvement.

This cost estimate is on the following basis:

- The typical cross section used was based on a “Rural and Large Lot Zone” Collector type road from the Waipa District Plan, with an allowance for a separate pedestrian and cycle shared path.
- No attempt to assess mass-balance of the structure plan area has been made, as a result a nominal earthworks quantity was assumed based on the road following existing contours with no undercutting for poor ground conditions considered.
- No Land Costs have been considered.

- No landscaping, beautification or other enhancement from the stated cross-section in the first point has been assumed (i.e.: grassed berms only).
- No minor roads are included for upgrade or construction.
- Priority intersections are standard (i.e.: no Roundabouts or Traffic Signals).
- No State Highway intersection upgrades have been included, as these are generally high cost bespoke design items, and in the case of the St Leger/Golf Road intersection is already overdue for an upgrade.
- Professional fees associated with the design, consenting and construction observation has not been included.
- Preliminary and General is assumed at 30%
- Escalation costs are not included.

The indicative estimate is $12,500,000, and is considered to be +/-50%.

1.6 Conclusion

There may be existing deficiencies in road width on several local roads including Golf Road (designated as arterial) in the rural area, and that existing crash statistics on Herbert Street and Whitmore Street are in excess of what would be expected using NZTA crash prediction modelling, suggesting that their usage is greater than current assumptions.

Modelling also suggests that normal traffic growth to 2035, without including additional demand for growth area T6, could result in the following three intersections having significant increase in delays:

- State Highway 3 / St Leger Road / Golf Road intersection
- State Highway 3 / Herbert Street / Nixon Street intersection
- State Highway 3 / Whitmore Street intersection

The additional demand placed on the network is estimated to be 2,400 vehicles per day in the proposed “Low Development” scenario, or 4,800 vehicles per day in the suggested conservative “High Development” scenario (assuming future sub-division of these lots).

These additional vehicles, whilst increasing pressure on the current network and compounding existing issues if they go unaddressed, are otherwise able to be accommodated within the assessed local roading network without significant detriment to safety and efficiency.

There is, however, insufficient pedestrian and cyclist facilities around T6 which. Whilst this is not currently a highlighted issue, the desire of Waipa District Council to incorporate these facilities in a growth area suggests there could be a lack of connectivity in the existing network.

In line with these conclusions we have made the following recommendations for work going forward to help address existing and future concerns.

1.7 Recommendations

We have prepared the below recommendations, based on the above analysis and discussion.

1 Existing Local Roads:

  a The following council roads have higher than expected crash injury rates, and further investigation is required to determine why this is occurring:

    i Herbert Street

    ii Whitmore Street

- b The following council roads are currently considered to have too narrow a seal width for their future purpose, and it is recommended investigation into widening and marking them is undertaken:
  - i St Leger Road (some sections of)
  - ii Brill Road
  - iii Haultain Street
  - iv McAndrew Street
  - v Golf Road (rural section)
  - vi McGhie Road (if desired to include as an alternative route east)

2 Pedestrian and Cyclist Facilities:

- a Pedestrian and cyclist facilities around the growth area are lacking for connections to the anticipated facilities within the growth area. It is recommended that Waipa District Council review the existing facilities and programme in providing new infrastructure as the growth area is developed. The key connections to focus on for these facilities are anticipated to be:
  - i St Leger Road from Brill Road to State Highway 3
  - ii Ballance Street from the growth area connection to State Highway 3
  - iii Leslie Street from 'Access 3' to State Highway 3
- b There are currently no dedicated or shared cyclist facilities along State Highway 3. It is recommended that NZTA look into providing these in some form.
- c The only existing crossing facility along State Highway 3 is in Kihikihi town centre. It is recommended that NZTA look into additional provision for pedestrian (and possibly cyclist, depending on the solution) safe crossing facilities in the residential areas to the north and south of the town centre.

3 Intersection traffic issues:

- a The State Highway 3 / Golf Road / St Leger Road intersection is recommended for an immediate investigation for upgrading due to possible existing issues with vehicles trying to exit Golf Road.
- b The State Highway 3 / Herbert Street / Nixon Street intersection is recommended for an upgrade investigation should growth area T6 be approved.
- c The following intersections are recommended for an upgrade investigation before 2035 whether or not growth area T6 is approved for development:
  - i State Highway 3 / Whitmore Street
  - ii State Highway 3 / Herbert Street / Nixon Street

2 Te Awamutu: T11

2.1 Structure Plan Area

Figure 2.1: Approximate extents of T11 growth cell (image sourced from Google Earth).

The T11 growth cell lies south of Cambridge Road on the eastern extents of Te Awamutu, currently rural but zoned for future residential development.

2.2 Existing Situation

2.2.1 Existing Transport Environment

The only roads bordering growth cell T11 are Cambridge Road to the north, designated a Major Arterial in the Waipa District Plan; and Park Road to the south, designated a Collector.

There are no existing cycle facilities along this length of Cambridge Road, but there is a footpath on each side.

Cambridge Road is consistent with an urban environment.

Table 2.1: Road Details (Existing)

Road Name	Total Width (m)	Lanes	Shoulder	Cycle Facilities	Footpaths	Posted Speed (km/hr)
Cambridge Road	11.0	2 (+ median for right turn bay outside supermarket)	2, min. 1.0 m wide	None	1.5 m wide, both sides, full length	50 (70 to the east of Gleneagles Drive)
Park Road	8.0	2	2, approx. 1.0 m wide	None	1.5 m wide footpath extends from north-west to edge of T11	70

Note: Measurements are approximate only using Google Earth.

Park Road in the location of the structure plan area is consistent with a more rural environment, however there is no proposal at this stage to connect any roads through, and so has been disregarded for this assessment.

2.2.2 Crash History

The NZTA Crash Analysis System (CAS) was interrogated for the period 2009 to 2018 (inclusive) to provide crash data for the roads in the immediate vicinity of the development and roads thought to be key in the distribution of traffic away from and back to the development, but only to the next major intersection or urban boundary. Full CAS outputs can be found in Appendix C.

Table 2.2: Historical Crash Numbers

Road Name	Number of Crashes	Non-injury	Minor Injury (M)	Death or Serious (DSI)	Crash Injury Rate	Years
Cambridge Road	17	9	7	1	0.8	2x 2010 1x 2011 1x 2012 2x 2013 *(1x M)* 4x 2014 *(2x M, 1x DSI)* 1x 2016 *(M)* 3x 2017 *(1x M)* 3x 2018 *(2x M)*

2.2.3 Crash Prediction Modelling

A high-level Crash Prediction Model was put together for the existing situation on Cambridge Road using the methods and formulae found in NZTA's Crash Estimation Compendium (2016, Updated June 2018).

Cambridge Road was assessed under the mid-block only formula as this modelling can be said to account for minor intersections and private accesses, which is the most common type in front of growth cell T11.

Table 2.3: Crash Model Results (Existing)

Road Name	Predicted Injury Crash Rate (existing)	Actual Injury Crash Rate	Differential: Predicted to Actual	Differential Rate
Cambridge Road	0.18	0.80	+0.62	+344%

Cambridge Road is revealed to have a higher crash rate than would normally be expected, which could indicate it is in need of more detailed analysis to understand why this may be occurring.

2.2.4 Road Safety

The existing road network connecting to Cambridge Road is urban in nature. Generally the local road network has provision for pedestrians, however Cambridge Road only has one crossing facility, being a refuge island at the State Highway intersection some 700 m west.

2.2.5 Travel Patterns

No traffic survey has been undertaken, however using best-practise and existing data from the Road Assessment and Maintenance Management database (RAMM) we can infer likely peak travel patterns.

Although not intended to be assessed as part of this work due to the proximity and options for vehicles to re-direct prior, NZTA have requested that the effects on the State Highway 3 intersection some 730 m west be considered; because of this the data for each leg of this intersection has also been retrieved (highlighted blue).

This data was extracted from Mobileroad.org, which is populated using Road Controlling Authority (RCA) RAMM data. This data is maintained by the RCA (in this case NZTA for State Highway 3, and Waipa District Council for all other roads) for tracking and forecasting maintenance activities on their respective networks; it was noted that while the State Highway traffic data appeared to be based on recent counts, the Waipa District Council roads were all identified as estimates from 2016 and so we are unsure as to the accuracy of the data for that part of the network.

The key RAMM data used in this assessment is as follows:

Table 2.4: RAMM Data

Road Name	Average Daily Traffic (ADT) (veh/day)	Date of Count / Estimate	Heavy Vehicles (%)
Cambridge Road (outside T11)	4,240	1/12/2016	0%
Arawata Street	10,020	1/12/2016	0%
Cambridge Road (at intersection)	9,300	1/12/2016	Unknown
State Highway 3 North (Ohaupo Road)	12,623	25/12/2017	6%
State Highway 3 South (Albert Park Drive)	9,331	25/12/2017	6%

Note: All data obtained from MobileRoad.org, all 2-way traffic.

The attractors for determining travel patterns are considered to be as follows:

Table 2.5: Attractors and Type

Attractor Name	Approximate Distance from T11	Attractor Type	Attractions
Te Awamutu Centre	1.2 km	Local Primary Attractor	• Closest shopping centre outside immediate area • Employment
Hamilton	30 km	Primary Attractor	• Largest population centre within 0.5hrs travel • Large employment area • Large retail bases, including niche shops and large supermarkets • Recreational facilities
Cambridge	22 km	Secondary Attractor	• Large shopping area, including Supermarkets • Employment
Local Rural Areas		Secondary Attractor	• Employment • Outdoor Recreation
Otorohanga (and South)	30 km plus	Tertiary Attractor	• Employment • Recreation

From these assumptions we can reasonably determine that the majority of traffic will travel west towards the State Highway intersection, distributing from there to Te Awamutu town centre, Hamilton and rural areas to the north and west, with the rest travelling east towards Cambridge, eastern rural areas, and as a Te Awamutu bypass route for travelling south; returning from those same directions in similar proportions.

2.2.6 Public Transport

There are no bus routes, or other method of public transport, servicing the Cambridge Road or Park Road areas according to the "Busit.co.nz" website.

2.2.7 Other Modes

For local trips to the nearby supermarket, and possibly Te Awamutu, it is likely cycling and walking will be used by children, the elderly, those without access to a private vehicle, and those of a health or environmentally friendly mind-set; some of these same groups may also use these modes in conjunction with the bus to get to Hamilton.

Realistically, however, the majority of trips in this area are still likely to be private vehicle based regardless of the distance to travel.

2.3 Feasibility Report

The Opus Transport Project Feasibility Report prepared in June 2018 for this growth area is necessarily conceptual in nature, given the broad nature of the plans for T11 at that point. It is also worth noting that some of the comments and recommendations are linked with another growth area, T8, which is outside the scope of this assessment.

Generally the current Structure Plan was developed with this concept as a basis, with the notable amendment of the reduction in size of the planned area for building construction due to flooding issues to the rear of the large-format retail development.

We have the following differences in observation to those presented in the Opus report:

- The sight distances listed as deficient for Access 2 and Access 3 appear, in our estimation, to be adequate, or at least significantly less deficient than presented, possibly due to a change in speed environment.

The following recommendations from this report are addressed as follows (as they relate to T11 only):

- <u>Reduce the number of accesses of growth cell T11 from three to two (i.e.: Remove Access 2)</u>

  This is a possibility, given the reduction in lot numbers for this growth area, however has been left in for now due to the likelihood of the growth area just south of T11 (T14) being developed more quickly than planned, and the lack of inter-connectivity with Access 1 due to the flood-prone land not being developed; these two things combined may put pressure on a single access, dependent on other road connections made as part of this further development.

  It would be preferred if some agreement could be arrived at with the owners of the service access immediately adjacent to the proposed Access 2, as we agree with the Opus conclusion that this is an undesirable arrangement even with the relatively low expected vehicle movements from the service lane.
- <u>Undertake traffic capacity assessment/ traffic modelling at the following intersections:</u>
  - Cambridge Rd/Albert Park Dr/Arawata St/Ohaupo Rd
  - Park Rd/Albert Park Dr
  - Vaile St/Sloane St/Albert Park Dr

  The impact on the Cambridge Road-State Highway 3-Arawata Street intersection is discussed in the Modelling Assessment section below, the other two intersections appear to be more aligned with the T8 growth area and are not considered significantly affected by this proposal.
- <u>Traffic modelling at each of the proposed access locations to assist with intersection layouts</u>

  This has been conducted and is presented in the Modelling Assessment section below.
- <u>Undertake more detail assessment of speed management measures for Cambridge Road</u>

  This has not been considered as part of this assessment, and is considered to be future work to be conducted when the effects of all growth areas impacting Cambridge Road can be aggregated.
- <u>Undertake a review of pedestrian and cycling connectivity</u>

  Recommendations are made in this regard at the end of this assessment, however a specific detailed review of these facilities has not yet been undertaken.
- <u>Undertake a more detail assessment of internal road network, including midblock cross sections and intersection form</u>

  This work has been conducted in conjunction with Boffa Miskell and is presented elsewhere.
- <u>Detail assessment how to change the right of way at Cambridge Access 1 to be a public road</u>

  This is deemed to be a landowner negotiation and legal issue, not covered by this report.

2.4 Proposed Situation

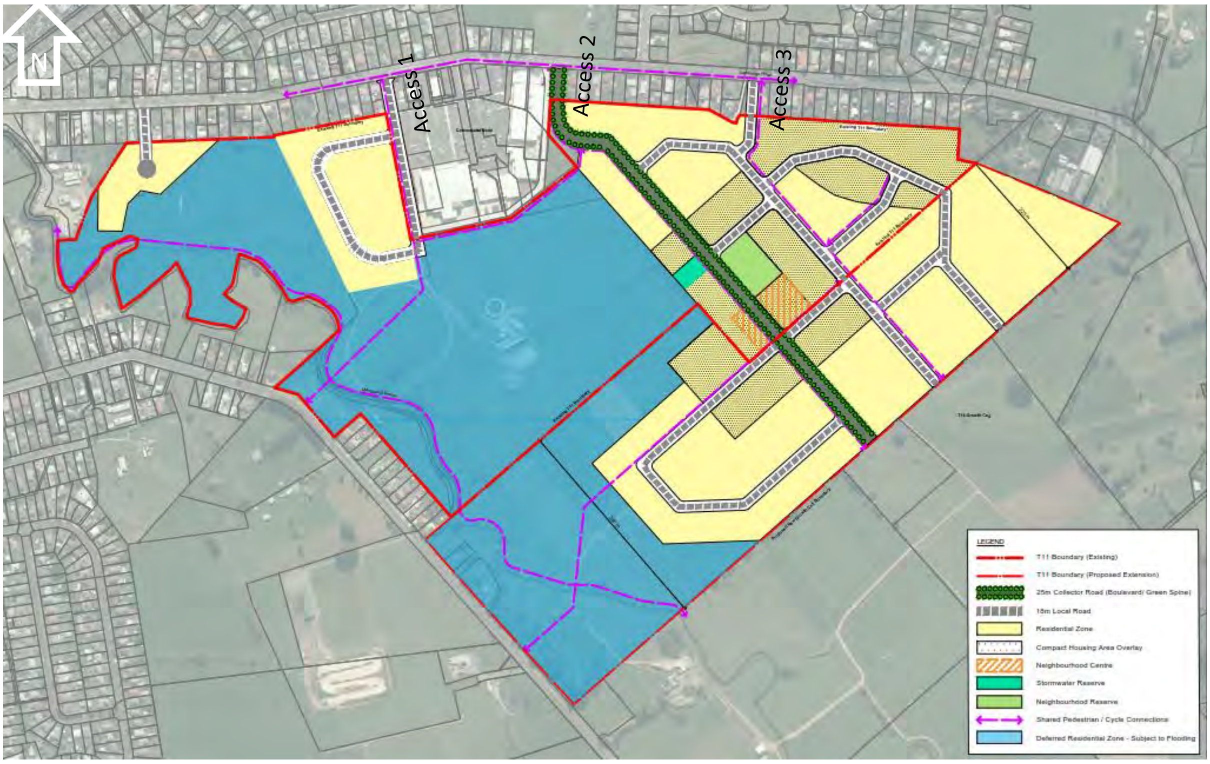


Figure 2.2: Proposed T11 Structure Plan road network

The proposed development area is intended to be a mixture of low and medium density urban residential.

Based on the current Structure Plan at the time of writing, which includes further land to the south-east, this results in an estimated lot yield of around 350. This was a late addition and so is not reflected in the modelling below, however experience suggests that this addition is not significant and the intersections will still be able to cope with this additional development area, though the models should be updated to be sure.

2.4.1 Proposed Road Network

The proposed road network is designed to provide good connectivity to Cambridge Road, as well as future connectivity to the T14 growth area, which also lies between Cambridge and Park road, but to the south of T11.

A significant section of this growth area has had to be left undeveloped due to potential flooding issues, which has also significantly affected how the roads will be laid out.

Because of this restriction, there is a small section to the west which is intended to have its own dedicated access to Cambridge Road down an existing access to the supermarket; the rest of the development, and eventually parts of T14, will share two further exit points to the east of the supermarket.

Once onto Cambridge Road, there are several local road options to help bypass the perceived main routes, however these all lead to either no exit roads or back to Cambridge Road to the east, so is considered to only really be useful for those with destinations along these roads rather than as true alternative or bypass routes that significant numbers will utilise.

2.4.2 Proposed Alternative Mode Links

Shared pedestrian / cycle facilities have been proposed in the Structure Plan which follow most of the proposed road links to the existing network, as well as providing some amenity linkage through proposed green spaces to Park Road.

Unfortunately, Cambridge and Park roads are both lacking in dedicated cyclist, or shared, facilities, and only Cambridge Road is fully serviced with pedestrian facilities in the immediate area of T11.

2.5 Modelling Assessments

2.5.1 Trip Distribution

Trip distribution has been assessed at a conceptual level using a simplified form of gravity modelling, a high-level method of determining likely travel patterns based on existing known data.

Using the attractors as a guide, at any one intersection the traffic flow in any direction currently on that road is proportionally split based on the most popular routes and likely destinations, informing the flows between, and therefore at, intersections through to the end of the study area.

The flows undergo a "balancing" exercise where the proportions turning in any one direction are gradually amended until the approximate ADT for each direction and road are arrived at.

This method is a cost effective way of estimating traffic patterns and turning flows without reliance on turning counts and origin destination surveys. The results are used to inform the indicative intersection models and give an indication as to whether intersections are currently functioning as intended, and whether they will continue to do so if more vehicles are added.

2.5.1.1 Modelling Basis

Given the relative simplicity of the internal road network and proposed connections, no specific gravity model has been produced for T11; the interaction with future growth cells will change this, and a holistic model of some kind will need to be considered prior to those areas coming on-line.

The following assumptions were used in calculating flows for intersection modelling:

- The ADT data was pro-rated to a Base Year of 2018 using a 2% per annum average.
- A Projected Year of 2035 using a 2% per annum average was also used; 2035 was chosen as this is the latest year this growth area is expected to be fully developed by.
- The average daily peaks will be 10% of the ADT.
- The flows on any one road are split 70/30 for direction based on the time of day and direction of attractors (i.e.: 70% AM towards attractors, 70% PM away from attractors).
- Where Heavy Traffic is 'Unknown' it will be assumed to be 1%.

2.5.1.2 Model Limitations

It is important to note that, due to cost constraints, no observation verification was conducted at any of the existing intersections and the model is entirely founded on the "most likely" routing based on attractor assumptions and anecdotal evidence.

2.5.1.3 Development Figures

The future development of T11 has been assumed to be additional to the standard 2% traffic growth in this area; this is not strictly correct, as the traffic has to come from somewhere and this type of residential growth tends to be what supports it, however retaining this assumption does provide for a conservative model.

Two development scenarios over and above a standard 2% growth were considered:

1. Low Development: A scenario whereby the lot yield as presented in the Structure Plan was used to determine additional traffic flow.
2. High Development: A scenario whereby the lot yield was doubled when compared to that in the structure plan, to account for a worst case scenario of smaller lot types and future in-fill development.

The daily traffic per lot was assumed to be 10veh/day, with all other traffic assumptions as per those in section 2.5.1.1 above.

2.5.2 Intersection Modelling

The following intersections were modelled in Sidra Intersection 8.0 for levels of service, all based on the logic stated in section 2.5.1 above:

- Access 1 / Cambridge Road
- Access 2 / Cambridge Road
- Access 3 / Cambridge Road
- Gleneagles Drive / Cambridge Road

The Level of Service for any lane is directly related to the average delay anticipated for a vehicle in that lane, as follows:

Table 2.6: Level of Service (LoS): Sidra 8 Sign Control

Level of Service (LoS) for v/c≤1.0 (v/c>1.0 = LoS F)	Average Delay per Vehicle in seconds (d)
A	d ≤ 10
B	10 < d ≤ 15
C	15 < d ≤ 25
D	25 < d ≤ 35
E	35 < d ≤ 50
F	50 < d

The following assumptions, in addition to those mentioned for the Gravity Model, were used:

- No gradients are known, so all gradients for all approaches were set at 0%.
- All measurements possible were taken from aerial views on Google Earth.
- If a median was present it was assumed to act as a Right Turn Bay in lieu of an actual Right Turn Bay.
- If present, shoulders were considered ‘full’ (of parked vehicles for example) and so not considered as additional seal width.

2.5.2.1 Access 1 / Cambridge Road

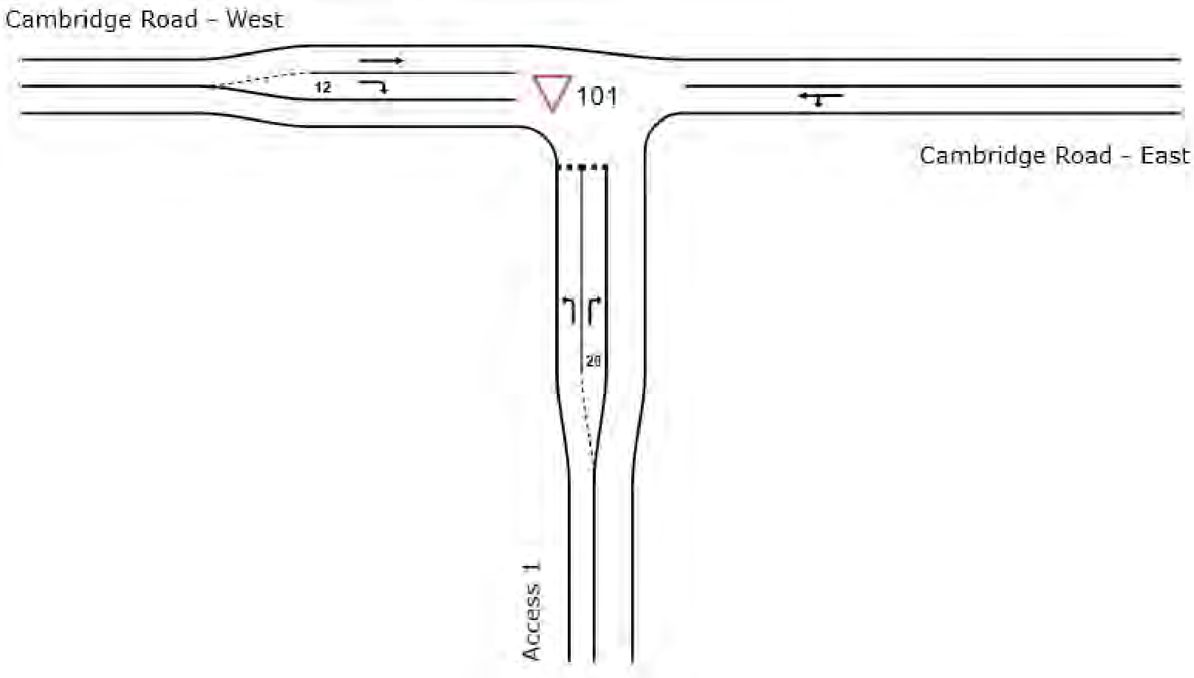


Figure 2.3: Sidra Intersection Diagram – Access 1

This intersection was modelled for the following situations:

- 2018 plus Low Development (LD) AM and PM peaks.
- 2035 2% growth plus High Development (HD), AM and PM peaks.

This intersections is too new to have existing traffic flow data as of the inception of this growth area, and existing traffic appears to be restricted to delivery traffic and a relatively small proportion of the carpark, so no base years for 2018 and 2035 were modelled. To account for the 'existing traffic' a peak movement of 10 vehicles (or 100 veh/day, equivalent to 10 houses) was added to the calculated figures for this part of the development.

Initially only the current proposed situation, and the forecast extreme situation indicated above were modelled to check the extreme ends of the development impact; given the results, no further modelling was deemed to be necessary.

The following tables summarise the LoS findings for each leg / lane by scenario for quick reference. Summaries of the modelling reports can be found in Appendix D.

Table 2.7: AM Peaks

Scenario	Cambridge Road West		Cambridge Road East	Access 1
	Through Lane	Right Turn Bay		
2018 + LD				
2035 + HD				

Table 2.8: PM Peaks

Scenario	Cambridge Road West		Cambridge Road East	Access 1
	Through Lane	Right Turn Bay		
2018 + LD				
2035 + HD				

The results indicate that the intersection should operate well during peak hours at all levels of development to 2035.

2.5.2.2 Access 2 / Cambridge Road

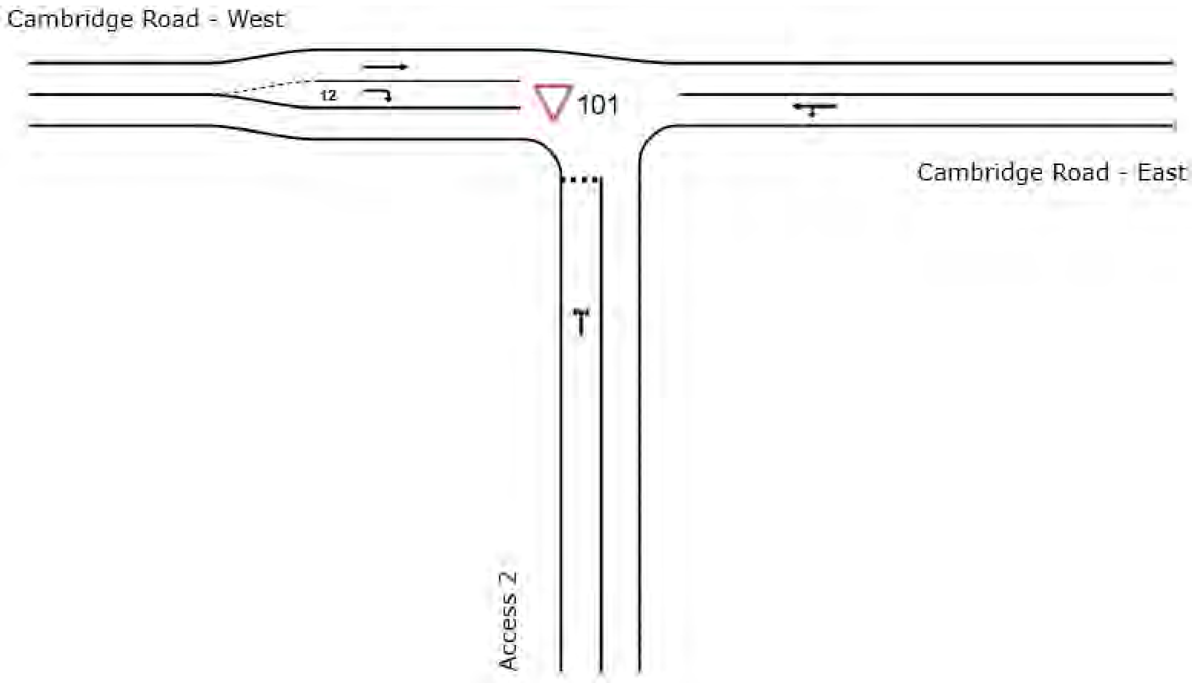


Figure 2.4: Sidra Intersection Diagram – Access 2

This intersection was modelled for the following situations:

- 2018 plus Low Development (LD) AM and PM peaks.
- 2035 2% growth plus High Development (HD), AM and PM peaks.

This intersection is brand new as of the inception of this growth area, so no base years for 2018 and 2035 were modelled.

Initially only the current proposed situation, and the forecast extreme situation indicated above were modelled to check the extreme ends of the development impact; given the results, no further modelling was deemed to be necessary.

The following tables summarise the LoS findings for each leg / lane by scenario for quick reference. Summaries of the modelling reports can be found in Appendix D.

Table 2.9: AM Peaks

Scenario	Cambridge Road West		Cambridge Road East	Access 2
	Through Lane	Right Turn Bay		
2018 + LD				
2035 + HD				

Table 2.10: PM Peaks

Scenario	Cambridge Road West		Cambridge Road East	Access 2
	Through Lane	Right Turn Bay		
2018 + LD				
2035 + HD				

The results indicate that the intersection should operate well during peak hours at all levels of development to 2035.

2.5.2.3 Access 3 / Cambridge Road

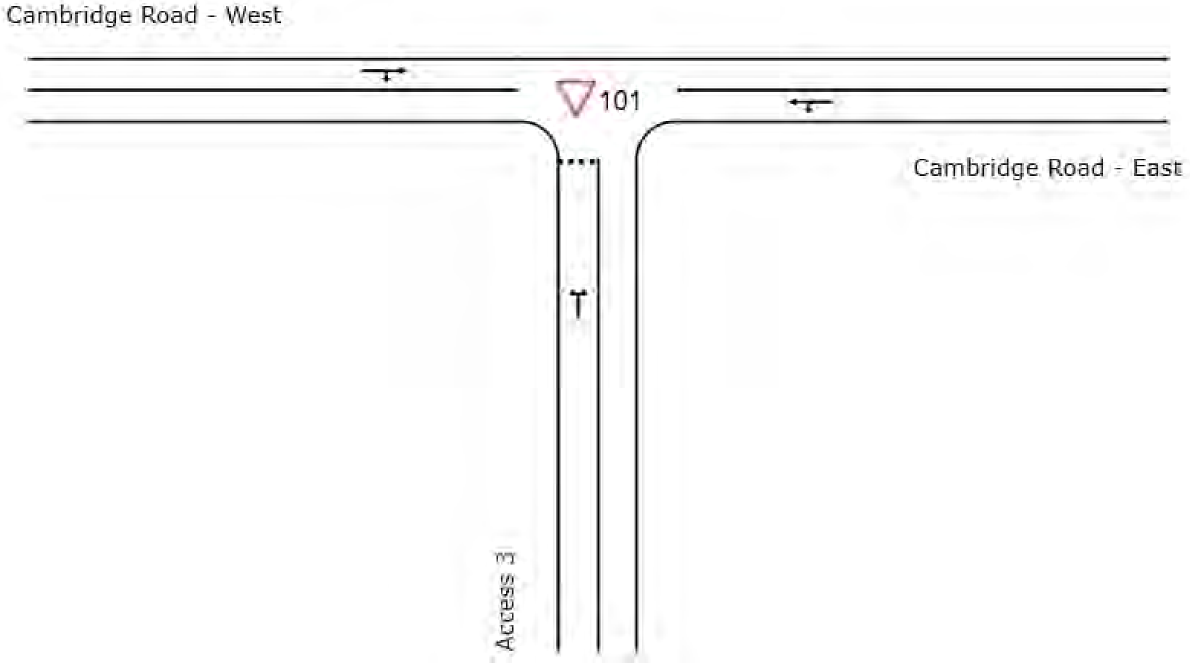


Figure 2.5: Sidra Intersection Diagram – Access 3

This intersection was modelled for the following situations:

- 2018 plus Low Development (LD) AM and PM peaks.
- 2035 2% growth plus High Development (HD), AM and PM peaks.

This intersection is brand new as of the inception of this growth area, so no base years for 2018 and 2035 were modelled.

Initially only the current proposed situation, and the forecast extreme situation indicated above were modelled to check the extreme ends of the development impact; given the results, no further modelling was deemed to be necessary.

The following tables summarise the LoS findings for each leg / lane by scenario for quick reference. Summaries of the modelling reports can be found in Appendix D.

Table 2.11: AM Peaks

Scenario	Cambridge Road West		Cambridge Road East	Access 3
	Through Lane	Right Turn Bay		
2018 + LD				
2035 + HD				

Table 2.12: PM Peaks

Scenario	Cambridge Road West		Cambridge Road East	Access 3
	Through Lane	Right Turn Bay		
2018 + LD				
2035 + HD				

The results indicate that the intersection should operate well during peak hours at all levels of development to 2035.

2.5.2.4 Gleneagles Drive / Cambridge Road

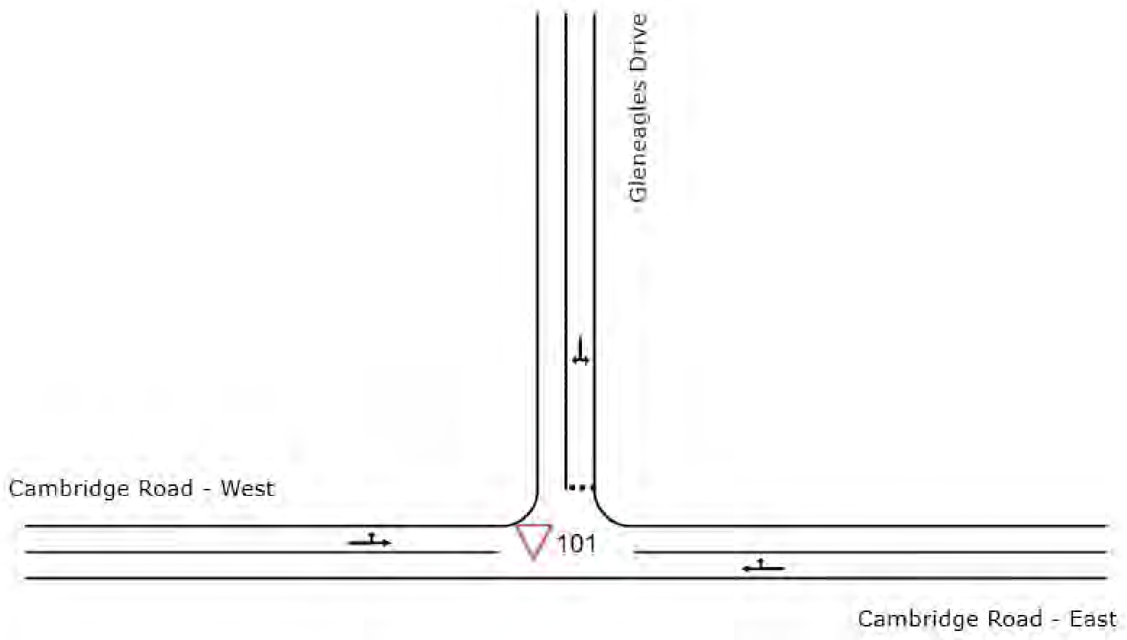


Figure 2.6: Sidra Intersection Diagram – Gleneagles Drive

This intersection was modelled for the following situations:

- 2018 plus Low Development (LD) AM and PM peaks.
- 2035 2% growth plus High Development (HD), AM and PM peaks.

This intersection was modelled for the same situations as the three Accesses so that a Network model (see next section) could be built to check that the close proximity of this and the three other intersections wasn't having a detrimental effect on the operation of Cambridge Road.

Initially only the current proposed situation and the forecast extreme situation indicated above were modelled to check the extreme ends of the development impact; given the results, no further modelling was deemed to be necessary.

The following tables summarise the LoS findings for each leg / lane by scenario for quick reference. Summaries of the modelling reports can be found in Appendix D.

Table 2.13: AM Peaks

Scenario	Cambridge Road West	Cambridge Road East		Gleneagles Drive
		Through Lane	Right Turn Bay	
2018 + LD				
2035 + HD				

Table 2.14: PM Peaks

Scenario	Cambridge Road West	Cambridge Road East		Gleneagles Drive
		Through Lane	Right Turn Bay	
2018 + LD				
2035 + HD				

The results indicate that the intersection should operate well during peak hours at all levels of development to 2035.

2.5.2.5 Network Assessment

These four intersections were then put together in network models to check the LoS "in-situ" as close as can be done.

The results were as per the individual intersection models with no obvious changes; below are the network diagrams for the 2035 2% growth plus High Development AM and PM:

Figure 2.7: Cambridge Road Network Model – 2035 2% growth plus HD, AM

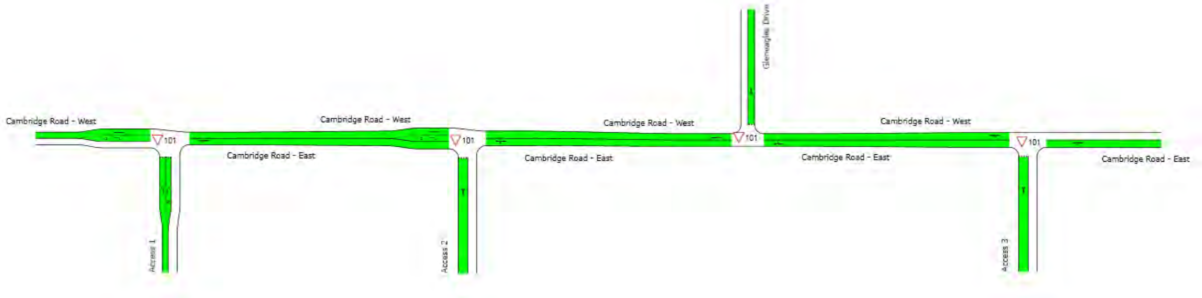


Figure 2.8: Cambridge Road Network Model – 2035 2% growth plus HD, PM

2.5.2.6 State Highway 3 Considerations

NZTA have requested the impacts on the State Highway 3 intersection with Cambridge Road and Arawata Street be considered as part of this assessment.

It is noted that this intersection is over 700 m to the west of the nearest exit from the proposed growth area, however the arrangement of the local roads are not conducive to traffic being able to bypass this intersection if they wish to travel to Te Awamutu town centre, or north to Hamilton.

The existing two-way traffic through the intersection was over 40,000 veh/day as at the last State Highway count; this growth area proposes to add some 1,510 veh/day (two-way), with the potential to increase to 3020 veh/day (two-way) if infill development is catered for.

This amounts to an increase of less than 4% initially, with the potential for an increase of up to 7.5% in the future, not accounting for other increases in State Highway traffic over that time.

A high-level assessment was conducted as to the capacity of the intersection based on the same assumptions used for the Gravity and Intersection modelling above, and it appears that the intersection may be close to capacity with existing traffic volumes at peak times, with very little change in waiting times once the additional flows are added. This is considered to be a small increase on the demands already placed on the intersection, however further investigation by NZTA may be warranted given the apparent existing issues with capacity. It is recommended that a full traffic survey and modelling exercise is undertaken to determine actual use and capacity thresholds at the roundabout.

CAS data was also retrieved on this intersection, and in the ten years to the end of 2018 there were 36 crashes associated with this intersection, with 3 injury crashes (two minor injury crashes and one severe).

This is an injury crash rate of 0.3, which is considered better than would be expected by the prediction models used by NZTA, and so the safety risks are considered minimal.

2.5.3 Crash Prediction Modelling

Using the additional vehicles assumed to be using the Cambridge Road corridor in a 2035 plus High Development worst-case scenario, as assigned in the Gravity Modelling above, the Crash Prediction Modelling was updated assuming the road corridor was not otherwise altered by the developments.

Table 2.15: Crash Model Results (Combined)

Road Name	**Predicted Injury Crash Rate** (existing)	**Predicted Injury Crash Rate** (2035 + HD)
Cambridge Road	0.18	0.35

This shows an increase in expected injury crashes as development increases, which is not unexpected given the additional volume of traffic on Cambridge Road in addition to the new flows from the development, however the movement is from approximately one injury crash every 5 years to approximately one injury crash every 3 years on average, which is still considered reasonable for a Major Arterial road.

However, if the injury crash differential rate from Table 2.3 is applied, therefore assuming the current unexpected crash trend continues, this would result in a new predicted injury crash rate of 1.19, or more than one per year on average, which could be considered less acceptable.

2.6 Indicative Costs

Given that the majority of road construction costs will be borne by developers, only a high-level cost estimate has been produced for the structure plan area, and only includes new road infrastructure designated Collector or higher, which Waipa DC may wish to implement ahead of developer involvement.

This cost estimate is on the following basis:

- The typical cross section used was based on a “Rural and Large Lot Zone” Collector type road from the Waipa District Plan, with an allowance for a separate pedestrian and cycle shared path.
- No attempt to assess mass-balance of the structure plan area has been made, as a result a nominal earthworks quantity was assumed based on the road following existing contours with no undercutting for poor ground conditions considered.
- No Land Costs have been considered.
- No landscaping, beautification or other enhancement from the stated cross-section in the first point has been assumed (i.e.: grassed berms only).
- No minor roads are included for upgrade or construction.
- Priority intersections are standard (i.e.: no Roundabouts or Traffic Signals).
- Professional fees associated with the design, consenting and construction observation has not been included.
- Preliminary and General is assumed at 30%
- Escalation costs are not included.

The indicative estimate is $3,200,000, and is considered to be +/-50%.

2.7 Conclusion

The existing injury crash rate on Cambridge Road is higher than is predicted by NZTA modelling guidelines, which should be investigated further.

The State Highway 3 intersection with Cambridge Road and Arawata Street high level assessment suggests the intersection is near or at capacity with current traffic flows.

The further demand placed on the network is estimated to be 1,510 additional vehicles per day in the proposed “Low Development” scenario, or 3,020 vehicles per day in the suggested conservative “High Development” scenario (assuming future sub-division of these lots).

These additional vehicles, are able to be accommodated within the assessed network with no measureable detriment to safety or efficiency, even with further baseline traffic growth.

Dedicated cyclist facilities around T11 appear to be insufficient which, whilst arguably not currently a known issue, the desire of Waipa District Council to incorporate these facilities in the growth area means there could be a break in connectivity if not addressed in the existing network.

In line with these conclusions we have prepared some recommendations for work going forward to help address existing and future concerns.

2.8 Recommendations

We have prepared recommendations, based on the above analysis and discussion.

1 Pedestrian and Cyclist Facilities:
   a Cyclist facilities down Cambridge Road are lacking for connections to the anticipated facilities within the growth area, although a shared path facility exists at the State Highway roundabout with Cambridge Road. It is recommended that Waipa District Council review the existing facilities and programme in providing / extending infrastructure as the growth area is developed.
   b The only existing crossing facility along Cambridge Road is at the State Highway roundabout where there is a refuge island at the intersection. It is recommended that Waipa District Council look at a more formal facility near the supermarket, or at least another refuge island, to enable pedestrian traffic to more safely access local amenities.

2 The arrangement of Access 2 with the service lane for the shopping complex is considered to be a safety issue, and it is recommended discussions are held with the owner of that service lane to form an arrangement which is less problematic.

   It is noted that there doesn’t appear to be any delivery doors at the rear of the Mitre 10, so there remains the possibility of combining the two into an intersection, and providing an access off the new road.

3 The structure plan models should be updated to reflect the late change to the lot yield to ensure the intersections with Cambridge Road are not adversely affected, although experience suggest they will not be.

The following points are recommendations from the Opus Feasibility Report which we believe are still relevant:

1 Undertake a more detail assessment of speed management measures for Cambridge Road

2 Undertake a review of pedestrian and cycling connectivity
   – Recommendations have been made in this regard, however a specific detailed review of what facilities are warranted has not been undertaken and could be useful to Waipa District Council in targeting funds.

3 Detailed assessment of how to change the right of way at Cambridge Road Access 1 to be a public road.

3 Applicability

This report has been prepared by Tonkin & Taylor Limited (T+T) for Boffa Miskell Ltd pursuant to the terms of engagement (Contract) between T+T and Boffa Miskell Ltd in relation to the T6/T11 Structure Plan project. T+T agrees this report may also be used by Waipa District Council (WDC) for the purposes set out in, or able to be reasonably inferred from, the Contract, on the basis that the aggregate liability of T+T to Boffa Miskell Ltd and WDC in respect of any such use or reliance is subject to the limitations and exclusions of liability set out in the Contract. This report may not be relied upon in other contexts or for any other purpose, or by any person other than Boffa Miskell Ltd and WDC, without T+T's prior written agreement.

Tonkin & Taylor Ltd

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
....	....
Timothy Broadhead	Glen Nicholson
Civil Engineer	Project Director

Reviewed by:

....

Alan Gregory

Principal Transport Planner

TIBR
p:\1008305\1008305.1000\issueddocuments\190823 final reports\190823.T6 T11 Transportation Assessment.rpt.docx

Appendix A: T6 CAS Outputs

CAS outputs for the following roads included:

- **Ballance Street**
- **Golf Road**
- **Haultain Street**
- **Herbert Street**
- **Leslie Street**
- **McAndrew Street**
- **McGhie Road**
- **State Highway 3**
- **St Leger Road**
- **Walmsley Street**
- **Whitmore Street**

Untitled query

Saved sites

Leslie Street

Crash year

2009 — 2019

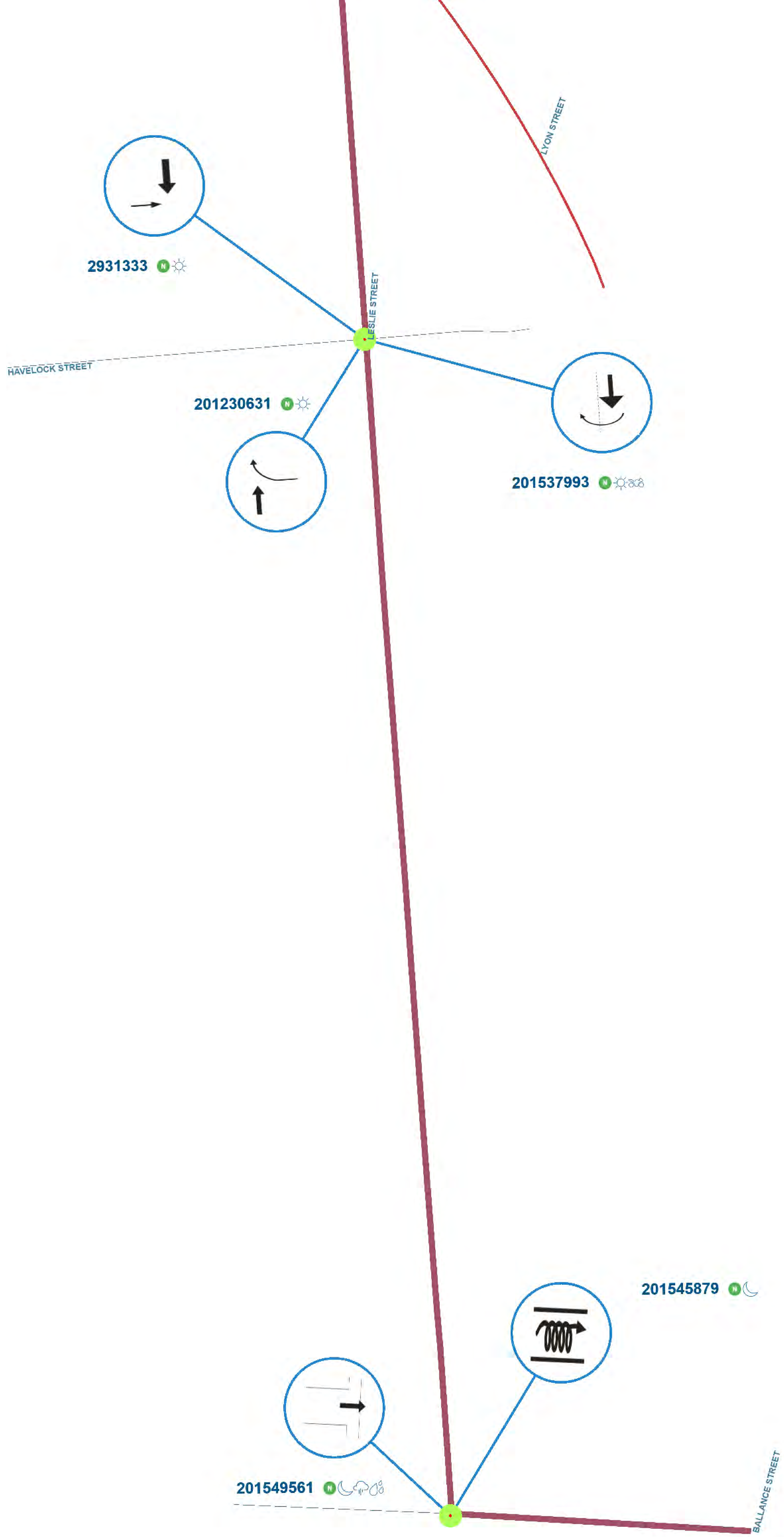
Plain English report

5 results from your query.

1-5 of 5

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
BALLANCE ST		I	LESLIE ST	201545879	18/09/2015	Fri	22:23	Car/Wagon1 EDB on BALLANCE ST lost control but did not leave the road, Car/Wagon1 hit fences	CAR/WAGON1, alcohol suspected, speed on straight	Dry	Dark	Fine	T Junction	Give way	0	0	0
BALLANCE ST		I	LESLIE ST	201549561	24/10/2015	Sat	03:00	Car/Wagon1 SDB on BALLANCE ST missed intersection or end of road, Car/Wagon1 hit fences	CAR/WAGON1, alcohol test above limit or test refused, lost control under braking, speed entering corner/curve, ENV: slippery road due to rain	Wet	Dark	Light rain	T Junction	Give way	0	0	0
LESLIE ST	0m			2931333	05/02/2009	Thu	12:10	Car/Wagon1 SDB on LESLIE ST hit Car/Wagon2 crossing at right angle from right, Car/Wagon1 hit kerbing	CAR/WAGON2, did not check/notice another party from other dirn	Dry	Bright sun	Fine	Crossroads	Nil	0	0	0
LESLIE ST	0m			201230631	20/03/2012	Tue		Car/Wagon1 NDB on LESLIE ST hit Car/Wagon2 merging from the right	CAR/WAGON2, other failed to give way	Dry	Bright sun	Fine	Crossroads	Nil	0	0	0
LESLIE ST	160m	S	SH 3	201537993	19/06/2015	Fri	14:48	Motorcycle1 SDB on LESLIE ST hit Car/Wagon2 U-turning from same direction of travel	CAR/WAGON2, did not check/notice another party behind	Dry	Bright sun	Fine	Nil (Default)	Nil	0	0	0

1-5 of 5


LYON STREET
2931333
LESLIE STREET
HAVELOCK STREET
201230631
201537993
201545879
201549561
BALLANCE STREET

NZ TRANSPORT AGENCY WAKA KOTAHI CAS

Untitled query

Saved sites

McAndrew Street

Crash year

2009 — 2019

Plain English report

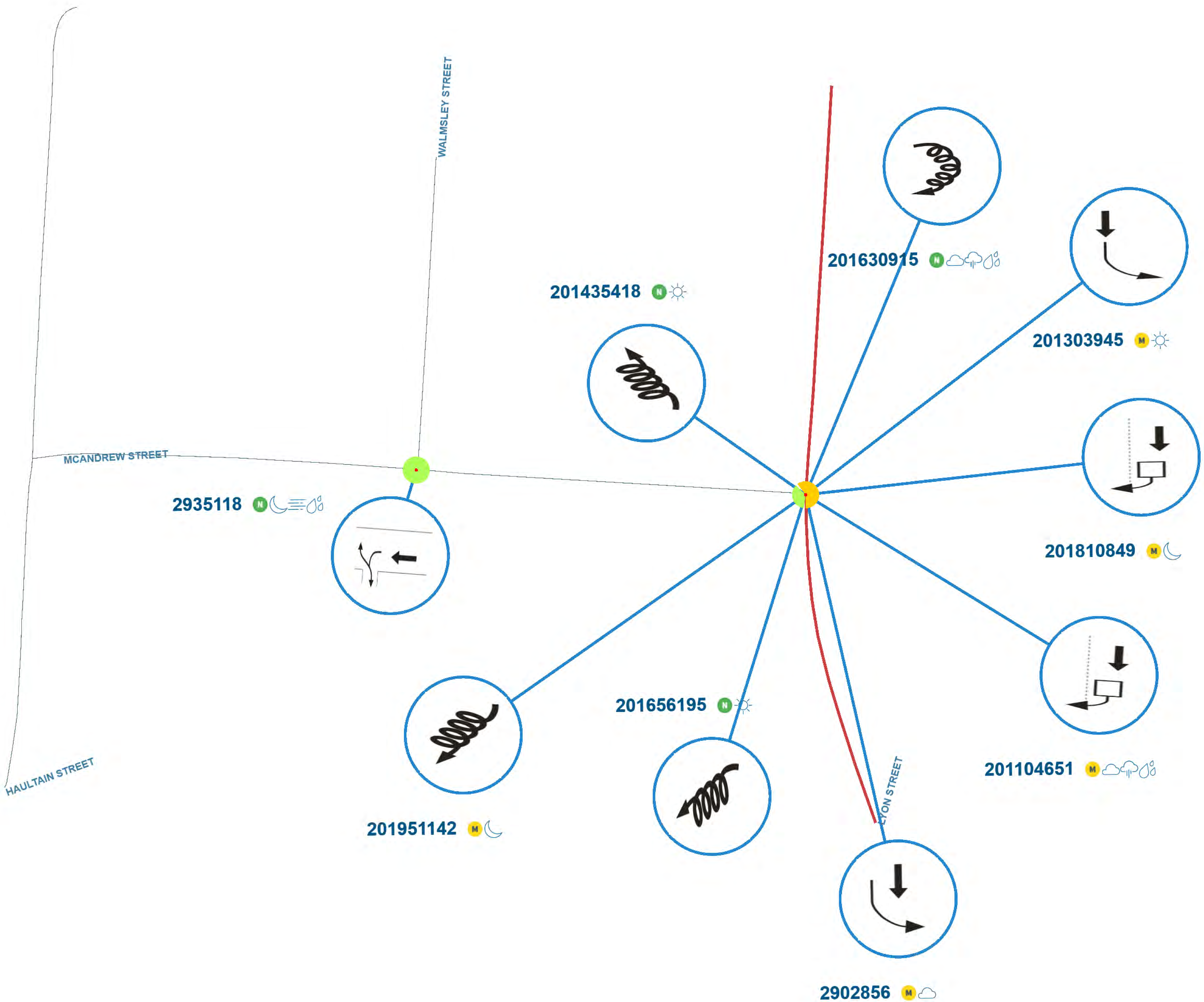
9 results from your query.

1-9 of 9

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
LYON STREET		I	MCANDREW STREET	201951142	17/02/2019	Sun	02:00	Car/Wagon1 SDB on LYON STREET, KIHIKIHI, WAIPA lost control; went off road to right	CAR/WAGON1, alcohol test above limit or test refused, interferred with driver, too far right	Dry	Dark	Fine	T Junction	Give way	0	0	1
MCANDREW ST	10m	S	SH 3	201656195	25/12/2016	Sun	19:46	Car/Wagon1 NDB on State Highway 3 lost control; went off road to left, Car/Wagon1 hit fences	CAR/WAGON1, alcohol test above limit or test refused, too far left	Dry	Bright sun	Fine	T Junction	Give way	0	0	0
MCANDREW ST	20m	W	WALMSLEY ST	2935118	22/05/2009	Fri	20:58	Car/Wagon1 WDB on MCANDREW ST hit SUV2 doing driveway manoeuvre	CAR/WAGON1, alcohol test above limit or test refused SUV2, failed to give way entering roadway from driveway, misjudged intentions of another party, ENV: entering or leaving private house / farm	Wet	Dark	Mist or Fog	Driveway	Nil	0	0	0
SH 3		I	MCANDREW ST	201435418	02/05/2014	Fri	13:05	Other1 NDB on SH 3 lost control; went off road to left, Other1 hit fences	OTHER1, too far left	Dry	Bright sun	Fine	T Junction	Give way	0	0	0
SH 3		I	MCANDREW ST	201630915	02/01/2016	Sat	11:35	Car/Wagon1 SDB on SH 3 lost control turning right, Car/Wagon1 hit fences	CAR/WAGON1, inappropriate speed for road conditions, lost control under braking, ENV: slippery road due to rain	Wet	Overcast	Light rain	T Junction	Nil	0	0	0
SH 3		I	MCANDREW ST	2902856	24/04/2009	Fri	14:25	Car/Wagon1 SDB on SH 3 sideswiped by Truck2 SDB on SH 3 turning left	CAR/WAGON1, failed to notice indication of vehicle in front, overtaking on left without due care, ENV: entering or leaving other commercial	Dry	Overcast	Fine	Driveway	Give way	0	0	1

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
SH 3		I	MCANDREW ST	201104651	06/11/2011	Sun	12:20	Car/Wagon1 SDB on SH 3 hit rear of Car/Wagon2 SDB on SH 3 turning right from centre line	CAR/WAGON1, attention diverted by passengers, failed to notice car slowing, stopping/stationary, ENV: slippery road due to rain	Wet	Overcast	Light rain	T Junction	Give way	0	0	2
SH 3	5m	S	MCANDREW ST	201303945	06/09/2013	Fri	15:20	Car/Wagon1 SDB on SH 3 hit rear of left turning Car/Wagon2 SDB on SH 3	CAR/WAGON1, attn diverted by scenery/persons outside vehicle, failed to notice indication of vehicle in front, ENV: entering or leaving private house / farm	Dry	Bright sun	Fine	Driveway	Give way	0	0	1
SH 3		I	MCANDREW ST	201810849	21/01/2018	Sun	21:05	Car/Wagon1 SDB on Lyon Street hit rear of Car/Wagon2 SDB on Lyon Street turning right from centre line	CAR/WAGON1, alcohol test below limit, misjudged another vehicle CAR/WAGON2, alcohol test below limit	Dry	Dark	Fine	T Junction	Give way	0	0	1

1-9 of 9


WALMSLEY STREET
MCANDREW STREET
HAULTAIN STREET
LYON STREET
201630915
201435418
201303945
2935118
201810849
201656195
201104651
201951142
2902856

Untitled query

Saved sites

McGhie Road

Crash year

2009 — 2019

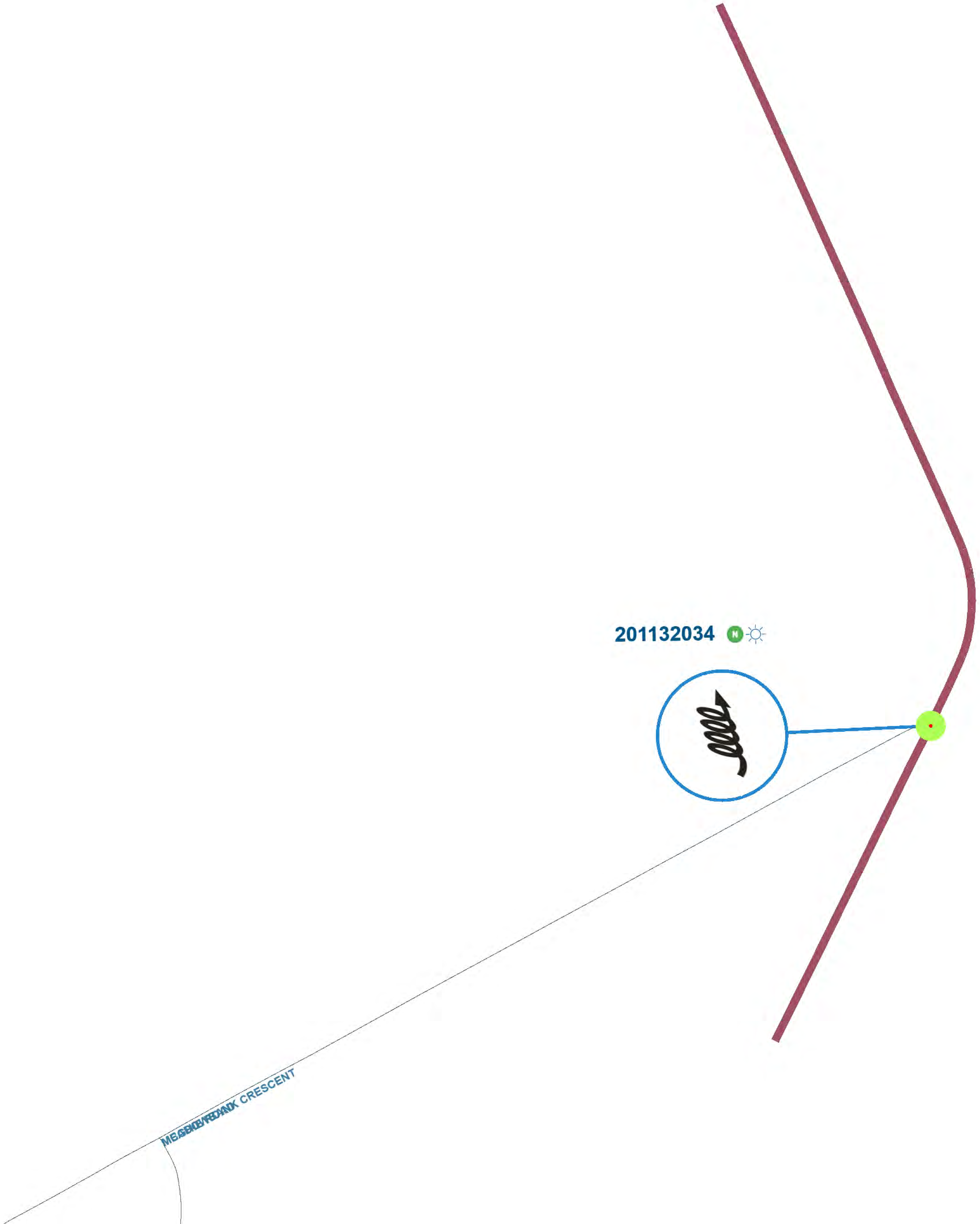
Plain English report

1 results from your query.

1-1 of 1

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
FLAT ROAD	20m	S	MCGHIE ROAD	201132034	19/03/2011	Sat	15:56	Car/Wagon1 NDB on FLAT ROAD lost control; went off road to left	CAR/WAGON1, attention diverted by food, cigarettes, beverages, speed at temporary speed limit, too far left	Dry	Bright sun	Fine	Nil (Default)	Unknown	0	0	0

1-1 of 1


201132034
CRESCENT

Untitled query

Crash year

2009 — 2019

Saved sites

SH3 - St Leger to McAndrew

Plain English report

69 results from your query.

Showing 20 100 results at once.

1-69 of 69

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
LYON STREET		I	MCANDREW STREET	201951142	17/02/2019	Sun	02:00	Car/Wagon1 SDB on LYON STREET, KIHIKIHI, WAIPA lost control; went off road to right	CAR/WAGON1, alcohol test above limit or test refused, interferred with driver, too far right	Dry	Dark	Fine	T Junction	Give way	0	0	1
003-0016		I	SHEEHAN ST	201950632	30/01/2019	Wed	23:45	Car/Wagon1 SDB on Lyon Street, Kihikihi lost control turning left; went off road to left, Car/Wagon1 hit cliffs	CAR/WAGON1, alcohol suspected, lost control when turning, speed entering corner/curve	Dry	Dark	Fine	T Junction	Nil	0	0	1
GOLF ROAD		I	SH 3	2931945	13/03/2009	Fri	14:30	Truck1 NDB on GOLF ROAD lost control turning right	TRUCK1, lost control when turning, speed entering corner/curve	Dry	Overcast	Fine	Crossroads	Stop	0	0	0
HERBERT ST		I	SH 3	2939001	05/08/2009	Wed	17:17	Car/Wagon1 SDB on HERBERT ST lost control turning left, Car/Wagon1 hit fences	CAR/WAGON1, speed entering corner/curve	Dry	Bright sun	Fine	T Junction	Give way	0	0	0
MCANDREW ST	10m	S	SH 3	201656195	25/12/2016	Sun	19:46	Car/Wagon1 NDB on State Highway 3 lost control; went off road to left, Car/Wagon1 hit fences	CAR/WAGON1, alcohol test above limit or test refused, too far left	Dry	Bright sun	Fine	T Junction	Give way	0	0	0
SH 3	40m	S	BALLANCE ST	201653711	17/11/2016	Thu	15:10	Car/Wagon1 SDB on State highway changing lanes/overtaking to right hit SUV2	CAR/WAGON1, did not check/notice another party from other dirn	Dry	Overcast	Fine	Nil (Default)	Unknown	0	0	0
SH 3		I	BALLANCE ST	201744193	05/07/2017	Wed	13:50	Van1 NDB on SH 3 hit rear of Van2 NDB on SH 3 turning right from centre line	VAN1, swerved to avoid pedestrian	Dry	Bright sun	Null	T Junction	Give way	0	0	0
SH 3		I	BALLANCE ST	201530499	26/01/2015	Mon	21:25	Car/Wagon1 NDB on SH 3 lost control turning left, Car/Wagon1 hit fences	CAR/WAGON1, speed entering corner/curve, wrong pedal/foot slipped	Dry	Dark	Fine	T Junction	Stop	0	0	0

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
SH 3	60m	S	CHURCH ST	201005983	21/12/2010	Tue	08:24	Car/Wagon1 SDB on SH 3 hit rear of Car/Wagon2 SDB on SH 3 turning right from centre line	CAR/WAGON1, failed to notice car slowing, stopping/stationary, ENV: entering or leaving other commercial	Dry	Overcast	Fine	Driveway	Nil	0	0	1
SH 3	100m	S	CHURCH ST	201752046	05/10/2017	Thu	17:30	Truck1 NDB on Sh 3 kihikihi hit obstruction, Truck1 hit poles	TRUCK1, misjudged own vehicle	Dry	Bright sun	Fine	Nil (Default)	Unknown	0	0	0
SH 3	15m	S	CHURCH ST	201040752	02/10/2010	Sat	15:00	Car/Wagon1 SDB on SH 3 hit Van2 U-turning from same direction of travel	VAN2, did not check/notice another party behind	Dry	Bright sun	Fine	Nil (Default)	Unknown	0	0	0
SH 3	70m	N	GALLOWAY ST	201235953	03/08/2012	Fri	16:00	Car/Wagon1 SDB on SH 3 lost control; went off road to left, Car/Wagon1 hit fences, kerbing	CAR/WAGON1, medical illness (not sudden)	Dry	Bright sun	Fine	Nil (Default)	Unknown	0	0	0
SH 3	10m	S	GALLOWAY ST	201516715	26/08/2015	Wed	17:00	Car/Wagon1 SDB on SH 3 hit Pedestrian2 (Age 35)	CAR/WAGON1, lost control avoiding another party, swerved to avoid vehicle	Dry	Twilight	Fine	T Junction	Give way	0	0	1
SH 3	20m	S	GALLOWAY ST	201655874	22/11/2016	Tue	09:30	Car/Wagon1 NDB on Lyon street hit turning Car/Wagon2	CAR/WAGON2, did not check/notice another party from other dirn, failed to give way entering roadway from driveway	Dry	Bright sun	Fine	Driveway	Nil	0	0	0
SH 3		I	GALLOWAY ST	201549085	11/10/2015	Sun	15:30	Car/Wagon1 SDB on SH 3 lost control; went off road to right	CAR/WAGON1, fatigue due to lack of sleep, medical illness (not sudden), too far left	Dry	Bright sun	Fine	T Junction	Give way	0	0	0
SH 3	50m	S	GALLOWAY ST	2931485	04/03/2009	Wed	10:40	Car/Wagon1 NDB on SH 3 hit rear end of Car/Wagon2 stop/slow for PEDESTRIAN	CAR/WAGON1, failed to notice car slowing, stopping/stationary, other attention diverted	Dry	Bright sun	Fine	Nil (Default)	Unknown	0	0	0
SH 3		I	GALLOWAY ST	201752686	13/10/2017	Fri	15:35	Car/Wagon1 NDB on Lyon st hit Van2 merging from the right	VAN2, did not check/notice another party from other dirn, failed to give way at priority traffic control	Dry	Overcast	Fine	T Junction	Give way	0	0	0
SH 3	50m	S	GALLOWAY ST	201203965	24/08/2012	Fri	08:30	Car/Wagon1 NDB on SH 3 hit rear end of Car/Wagon2 stop/slow for PEDESTRIAN	CAR/WAGON1, attention diverted by passengers, failed to notice car slowing, stopping/stationary	Dry	Bright sun	Fine	Nil (Default)	Unknown	0	0	1
SH 3	120m	N	GALLOWAY ST	201657073	29/12/2016	Thu	18:44	Truck1 NDB on Lyon street hit Car/Wagon2 manoeuvring	CAR/WAGON2, emotionally upset/road rage, too far right	Dry	Bright sun	Fine	Nil (Default)	Unknown	0	0	0
SH 3	90m	S	GALLOWAY ST	201646597	02/08/2016	Tue	19:40	parked Van1 NDB on SH 3 ran away, Van1 hit parked vehicle	VAN1, parking brake failed/defective	Dry	Dark	Fine	Nil (Default)	Unknown	0	0	0
SH 3	60m	N	GALLOWAY ST	201737274	20/04/2017	Thu	16:00	parked Truck1 NDB on Lyon street ran away, Truck1 hit fences	TRUCK1, other brakes	Dry	Bright sun	Fine	Nil (Default)	Unknown	0	0	0
SH 3		I	GOLF ROAD	201513311	15/05/2015	Fri	09:30	Van1 NDB on SH 3 hit Car/Wagon2 turning right onto AXROAD from the left	CAR/WAGON2, did not check/notice another party from other dirn, failed to give way at priority traffic control	Wet	Overcast	Heavy rain	Crossroads	Stop	0	0	1

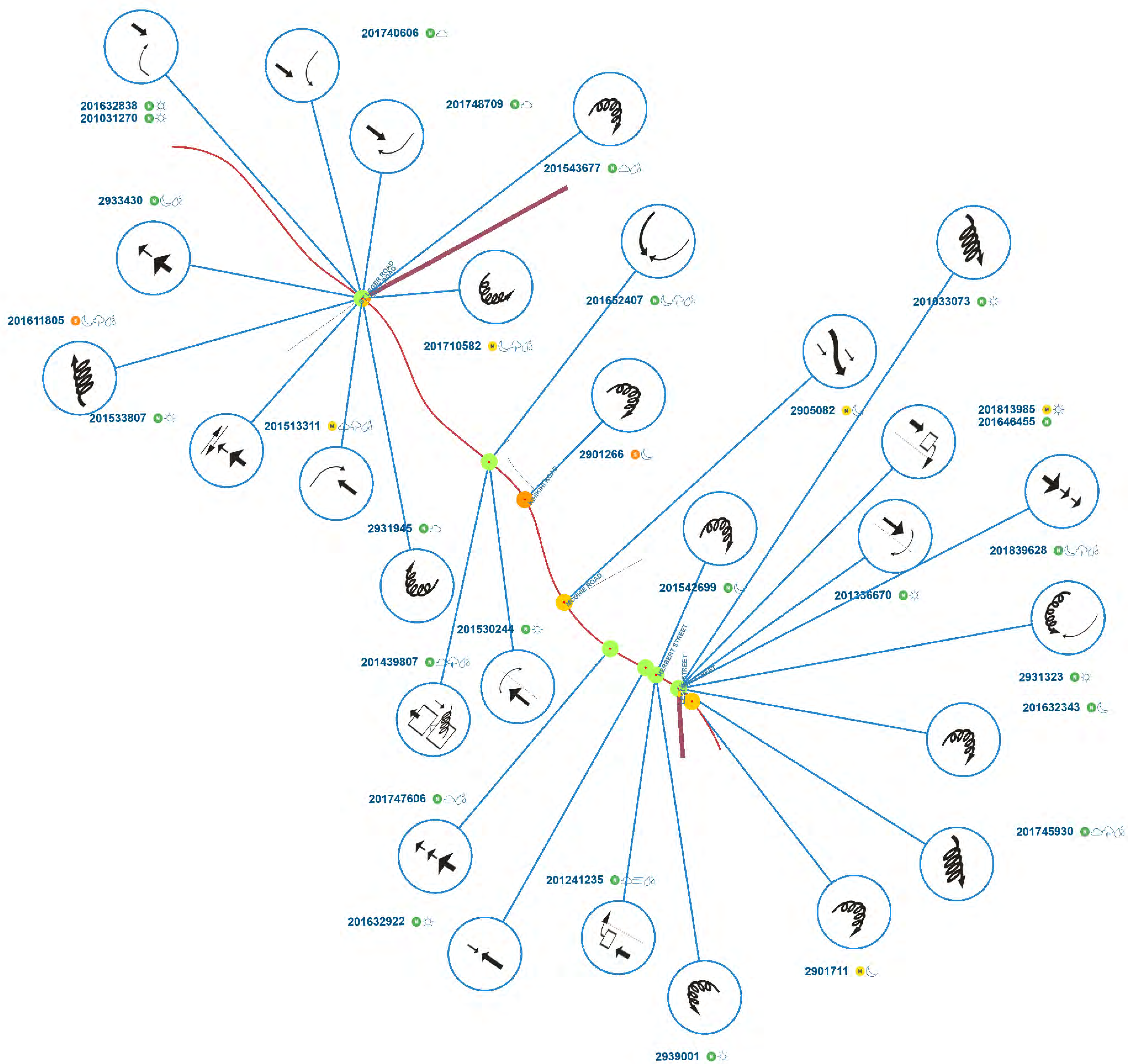
Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
SH 3	400m	S	GOLF ROAD	201530244	21/01/2015	Wed	11:07	Car/Wagon1 NDB on SH 3 hit Car/Wagon2 U-turning from same direction of travel	CAR/WAGON2, attention diverted fiding intersection, house, etc, did not check/notice another party behind	Dry	Bright sun	Fine	Nil (Default)	Unknown	0	0	0
SH 3		I	GOLF ROAD	201031270	10/03/2010	Wed	15:08	Other2 turning right hit by oncoming Van1 SDB on SH 3	OTHER2, didnt look/notice other party - visibility obstruc, failed to give way turning to non-turning traffic, overseas/migrant driver fail to adjust to nz roads	Dry	Bright sun	Fine	Crossroads	Stop	0	0	0
SH 3		I	GOLF ROAD	201533807	04/04/2015	Sat	13:00	Car/Wagon1 WDB on SH 3 hit rear end of Car/Wagon2 stop/slow for cross traffic	CAR/WAGON1, following too closely	Dry	Bright sun	Fine	Crossroads	Stop	0	0	0
SH 3	250m	S	GOLF ROAD	201543677	18/07/2015	Sat	14:45	SUV1 SDB on SH 3 lost control turning right, SUV1 hit trees	SUV1, lost control when turning, other attention diverted	Wet	Overcast	Fine	Nil (Default)	Unknown	0	0	0
SH 3		I	GOLF ROAD	201632838	28/01/2016	Thu	09:40	Car/Wagon2 turning right hit by oncoming Van1 SDB on SH 3	CAR/WAGON2, did not check/notice another party from other dirn, failed to give way turning to non-turning traffic	Dry	Bright sun	Fine	Crossroads	Stop	0	0	0
SH 3	330m	S	GOLF ROAD	201652407	12/11/2016	Sat	03:15	Car/Wagon1 SDB on SH 3 swinging wide hit Truck2 head on, Car/Wagon1 hit ditches	CAR/WAGON1, wrong way in one way street, motorway or roundabou TRUCK2, swerved to avoid vehicle, ENV: heavy rain	Wet	Dark	Heavy rain	Nil (Default)	Unknown	0	0	0
SH 3	90m	S	GOLF ROAD	201710582	03/02/2017	Fri	03:58	Car/Wagon1 SDB on Sh 3 otorohanga lost control turning left, Car/Wagon1 hit embankments	CAR/WAGON1, lost control when turning	Wet	Dark	Light rain	Nil (Default)	Unknown	0	0	1
SH 3		I	GOLF ROAD	201740606	02/06/2017	Fri	14:50	SUV1 EDB on Kihikihi Road hit Car/Wagon2 merging from the left	CAR/WAGON2, failed to give way at priority traffic control, other inexperience	Dry	Overcast	Fine	Crossroads	Stop	0	0	0
SH 3	200m	S	GOLF ROAD	201611805	01/03/2016	Tue	03:30	SUV1 NDB on SH 3 lost control; went off road to right	SUV1, fatige due to long day (working/recreation), fatigue due to lack of sleep	Wet	Dark	Light rain	Nil (Default)	Unknown	0	1	0
SH 3		I	GOLF ROAD	201748709	07/09/2017	Thu	14:45	Car/Wagon1 EDB on State highway 3 hit Van2 turning right onto AXROAD from the left	VAN2, did not check/notice another party from other dirn, failed to give way at priority traffic control	Dry	Overcast	Fine	Crossroads	Stop	0	0	0
SH 3	50m	N	HAVELOCK ST	201445661	01/10/2014	Wed	21:50	Car/Wagon1 SDB on SH 3 lost control turning right, Car/Wagon1 hit other	CAR/WAGON1, other fatigue	Dry	Dark	Fine	Nil (Default)	Unknown	0	0	0
SH 3	5m	S	HAVELOCK ST	2901756	02/02/2009	Mon	14:48	Car/Wagon1 NDB on SH 3 swinging wide hit Truck2 head on	CAR/WAGON1, lost control when turning	Dry	Bright sun	Fine	T Junction	Give way	0	1	0
SH 3	30m	S	HAVELOCK ST	201831252	13/01/2018	Sat	22:15	Car/Wagon1 NDB on Lyon st hit obstruction, Car/Wagon1 hit animals	CAR/WAGON1, alcohol test below limit, ENV: household pet rushed out or playing	Dry	Dark	Fine	Nil (Default)	Unknown	0	0	0

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
SH 3		I	HERBERT ST	201542699	12/07/2015	Sun	22:00	Car/Wagon1 SDB on SH 3 lost control turning right, Car/Wagon1 hit other	CAR/WAGON1, fatigue due to lack of sleep, lost control when turning	Dry	Dark	Fine	T Junction	Give way	0	0	0
SH 3		I	HERBERT ST	201241235	28/12/2012	Fri	13:41	Car/Wagon1 NDB on SH 3 hit rear of Car/Wagon2 NDB on SH 3 turning right from centre line	CAR/WAGON1, failed to notice indication of vehicle in front, other attention diverted, ENV: fog or mist	Wet	Overcast	Mist or Fog	T Junction	Give way	0	0	0
SH 3	50m	S	HERBERT ST	201336670	06/08/2013	Tue	15:02	Car/Wagon1 SDB on SH 3 hit Car/Wagon2 U-turning from same direction of travel	CAR/WAGON2, did not check/notice another party behind	Dry	Bright sun	Fine	Nil (Default)	Unknown	0	0	0
SH 3		I	LESLIE ST	201646455	12/08/2016	Fri	08:30	SUV1 EDB on SH 3 hit rear of Car/Wagon2 EDB on SH 3 turning right from centre line	SUV1, failed to notice car slowing, stopping/stationary	Null	Unknown	Null	T Junction	Give way	0	0	0
SH 3	20m	W	LESLIE ST	201839628	11/05/2018	Fri	17:45	SUV1 SDB on LYON STREET, KIHIKIHI, WAIPA hit rear end of Car/Wagon2 stop/slow for queue	SUV1, alcohol test below limit, failed to notice car slowing, stopping/stationary VAN3, alcohol test below limit	Wet	Dark	Light rain	T Junction	Give way	0	0	0
SH 3		I	LESLIE ST	201632343	17/01/2016	Sun	22:47	SUV1 EDB on SH 3 lost control turning right, SUV1 hit trees	SUV1, fatige due to long day (working/recreation), new driver/under instruction, too far left	Dry	Dark	Fine	T Junction	Nil	0	0	0
SH 3	100m	E	LESLIE ST	201735845	07/04/2017	Fri	08:26	Car/Wagon1 SDB on Lyon St hit rear of left turning Van2 SDB on Lyon St , Van2 hit houses	CAR/WAGON1, failed to notice car slowing, stopping/stationary, other attention diverted	Dry	Bright sun	Fine	Driveway	Nil	0	0	0
SH 3		I	LESLIE ST	201813985	14/05/2018	Mon	10:16	Van1 EDB on LYON STREET, KIHIKIHI, WAIPA hit rear of Car/Wagon2 EDB on LYON STREET, KIHIKIHI, WAIPA turning right from centre line	CAR/WAGON2, alcohol test below limit VAN1, alcohol test below limit, failed to notice car slowing, stopping/stationary	Dry	Bright sun	Fine	T Junction	Give way	0	0	1
SH 3	50m	S	LESLIE ST	2901711	20/02/2009	Fri	00:15	Car/Wagon1 SDB on SH 3 lost control turning right, Car/Wagon1 hit street furniture, other	CAR/WAGON1, other fatigue	Dry	Dark	Fine	Nil (Default)	Unknown	0	0	1
SH 3	10m	N	LESLIE ST	2931323	30/01/2009	Fri	16:30	SUV1 SDB on SH 3 lost control on curve and hit Truck2 head on	SUV1, lost control when turning, other fatigue	Dry	Bright sun	Fine	T Junction	Nil	0	0	0
SH 3	30m	S	LESLIE ST	201033073	13/03/2010	Sat	07:36	SUV1 SDB on SH 3 lost control; went off road to right, SUV1 hit trees	SUV1, sudden illness	Dry	Bright sun	Fine	Nil (Default)	Unknown	0	0	0
SH 3	30m	S	MCANDREW ST	201610570	01/01/2016	Fri	17:08	Car/Wagon1 NDB on SH 3 lost control turning right, Car/Wagon1 hit fences	CAR/WAGON1, fatigue due to lack of sleep, too far left	Wet	Overcast	Light rain	Nil (Default)	Unknown	0	0	1
SH 3		I	MCANDREW ST	201435418	02/05/2014	Fri	13:05	Other1 NDB on SH 3 lost control; went off road to left, Other1 hit fences	OTHER1, too far left	Dry	Bright sun	Fine	T Junction	Give way	0	0	0

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
SH 3		I	MCANDREW ST	201630915	02/01/2016	Sat	11:35	Car/Wagon1 SDB on SH 3 lost control turning right, Car/Wagon1 hit fences	CAR/WAGON1, inappropriate speed for road conditions, lost control under braking, ENV: slippery road due to rain	Wet	Overcast	Light rain	T Junction	Nil	0	0	0
SH 3		I	MCANDREW ST	201104651	06/11/2011	Sun	12:20	Car/Wagon1 SDB on SH 3 hit rear of Car/Wagon2 SDB on SH 3 turning right from centre line	CAR/WAGON1, attention diverted by passengers, failed to notice car slowing, stopping/stationary, ENV: slippery road due to rain	Wet	Overcast	Light rain	T Junction	Give way	0	0	2
SH 3		I	MCANDREW ST	2902856	24/04/2009	Fri	14:25	Car/Wagon1 SDB on SH 3 sideswiped by Truck2 SDB on SH 3 turning left	CAR/WAGON1, failed to notice indication of vehicle in front, overtaking on left without due care, ENV: entering or leaving other commercial	Dry	Overcast	Fine	Driveway	Give way	0	0	1
SH 3	20m	S	MCANDREW ST	201516710	21/09/2015	Mon	12:39	Van1 NDB on SH 3 lost control; went off road to left	VAN1, other fatigue, too far left	Dry	Overcast	Fine	T Junction	Give way	0	0	1
SH 3	90m	N	MCANDREW ST	201551169	18/11/2015	Wed	10:22	Truck1 SDB on SH 3 sideswiped by Car/Wagon2 SDB on SH 3 turning left	TRUCK1, misjudged intentions of another party CAR/WAGON2, attention diverted by passengers, failed to signal in time	Dry	Overcast	Fine	Driveway	Nil	0	0	0
SH 3	5m	S	MCANDREW ST	201303945	06/09/2013	Fri	15:20	Car/Wagon1 SDB on SH 3 hit rear of left turning Car/Wagon2 SDB on SH 3	CAR/WAGON1, attn diverted by scenery/persons outside vehicle, failed to notice indication of vehicle in front, ENV: entering or leaving private house / farm	Dry	Bright sun	Fine	Driveway	Give way	0	0	1
SH 3		I	MCANDREW ST	201810849	21/01/2018	Sun	21:05	Car/Wagon1 SDB on Lyon Street hit rear of Car/Wagon2 SDB on Lyon Street turning right from centre line	CAR/WAGON1, alcohol test below limit, misjudged another vehicle CAR/WAGON2, alcohol test below limit	Dry	Dark	Fine	T Junction	Give way	0	0	1
SH 3	60m	S	MCANDREW ST	201812253	24/03/2018	Sat	15:30	Car/Wagon1 NDB on Lyon street lost control; went off road to left, Car/Wagon1 hit poles	CAR/WAGON1, alcohol test below limit, lost control - road conditions, ENV: heavy rain	Wet	Overcast	Heavy rain	Nil (Default)	Unknown	0	0	1
SH 3	410m	N	MCGHIE ROAD	201439807	30/06/2014	Mon	14:56	load or trailer from Van1 NDB on SH 3 hit VEHB, Van1 hit kerbing	VAN1, inadequate tow coupling, load not well secured or load moved, lost control when turning, ENV: heavy rain	Wet	Overcast	Heavy rain	Nil (Default)	Unknown	0	0	0
SH 3	280m	N	MCGHIE ROAD	2901266	09/01/2009	Fri	22:27	Car/Wagon1 SDB on SH 3 lost control turning right, Car/Wagon1 hit fences, trees	CAR/WAGON1, alcohol test above limit or test refused, lost control when turning	Dry	Dark	Fine	Nil (Default)	Unknown	0	1	2
SH 3	60m	S	MCGHIE ROAD	2905082	14/11/2009	Sat	22:00	Car/Wagon1 SDB on SH 3 changing lanes/overtaking to right hit Car/Wagon2	CAR/WAGON1, did not check/notice another party behind	Dry	Dark	Fine	Nil (Default)	Nil	0	0	1
SH 3	30m	W	NIXON ST	201632922	09/02/2016	Tue	19:00	Car/Wagon1 WDB on SH 3 hit Van2 headon on straight	VAN2, alcohol test below limit CAR/WAGON1, alcohol test below limit, fatigue due to lack of sleep, too far right	Dry	Bright sun	Fine	Nil (Default)	Unknown	0	0	0

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
SH 3	130m	W	NIXON ST	201747606	08/08/2017	Tue	10:50	Car/Wagon1 NDB on Kihikihi road hit rear end of Van2 stop/slow for queue	CAR/WAGON1, failed to notice car slowing, stopping/stationary	Wet	Overcast	Fine	Nil (Default)	Unknown	0	0	0
SH 3	50m	E	NIXON ST	201745930	18/07/2017	Tue	13:06	Car/Wagon1 EDB on Herbert st lost control; went off road to right, Car/Wagon1 hit fences, poles	CAR/WAGON1, lost control when turning	Wet	Overcast	Light rain	Nil (Default)	Unknown	0	0	0
SH 3	60m	S	SHEEHAN ST	201847529	31/08/2018	Fri	00:29	Van1 SDB on LYON STREET, KIHIKIHI, WAIPA lost control while overtaking	VAN1, drugs suspected, other lost control, overtaking in the face of oncoming traffic, speed on straight	Wet	Dark	Light rain	Nil (Default)	Unknown	0	0	0
SH 3	15m	N	ST LEGER ROAD	2933430	08/04/2009	Wed	18:30	Car/Wagon1 NDB on SH 3 hit rear end of Car/Wagon2 stopped/moving slowly	CAR/WAGON1, other visibility limited CAR/WAGON2, following too closely, suddenly braked CAR/WAGON3, attention diverted fiding intersection, house, etc, ENV: visibility limited by crest or dip	Wet	Dark	Fine	Nil (Default)	Unknown	0	0	0
SH 3	40m	N	WHITMORE ST	201232618	22/05/2012	Tue	07:55	Truck1 SDB on SH 3 hit Car/Wagon2 manoeuvring, Truck1 hit parked vehicle	TRUCK1, misjudged own vehicle	Dry	Bright sun	Fine	Nil (Default)	Unknown	0	0	0
SH 3		I	WHITMORE ST	201552292	19/10/2015	Mon	19:06	Car/Wagon1 SDB on SH 3 lost control turning left, Car/Wagon1 hit fences	CAR/WAGON1, lost control when turning, new driver/under instruction, speed entering corner/curve	Dry	Bright sun	Fine	T Junction	Stop	0	0	0
SH 3		I	WHITMORE ST	201713430	02/05/2017	Tue	14:45	Car/Wagon1 SDB on Lyon hit rear of left turning Car/Wagon2 SDB on Lyon	CAR/WAGON1, wrong pedal/foot slipped	Dry	Bright sun	Fine	T Junction	Stop	0	0	2
SH 3		I	WHITMORE ST	201738969	19/04/2017	Wed	19:30	Car/Wagon1 NDB on Statehighway Three hit Car/Wagon2 merging from the right	CAR/WAGON2, did not stop at stop sign	Dry	Dark	Fine	T Junction	Stop	0	0	0
SH 3		I	WHITMORE ST	201633688	26/02/2016	Fri	15:30	Van1 SDB on SH 3 hit SUV2 turning right onto AXROAD from the left	SUV2, did not check/notice another party from other dirn, failed to give way at priority traffic control	Dry	Bright sun	Fine	T Junction	Stop	0	0	0

1-69 of 69


201740606
201632838
201031270
201748709
201543677
2933430
201611805
201710582
201652407
201033073
201533807
201513311
2905082
201813985
201646455
2901266
KIHIKIHI ROAD
2931945
201839628
MCGHIE ROAD
201542699
201336670
HERBERT STREET
201530244
201439807
2931323
201632343
201747606
201745930
201241235
201632922
2901711
2939001

Untitled query

Saved sites

St Leger Road

Crash year

2009 — 2019

Plain English report

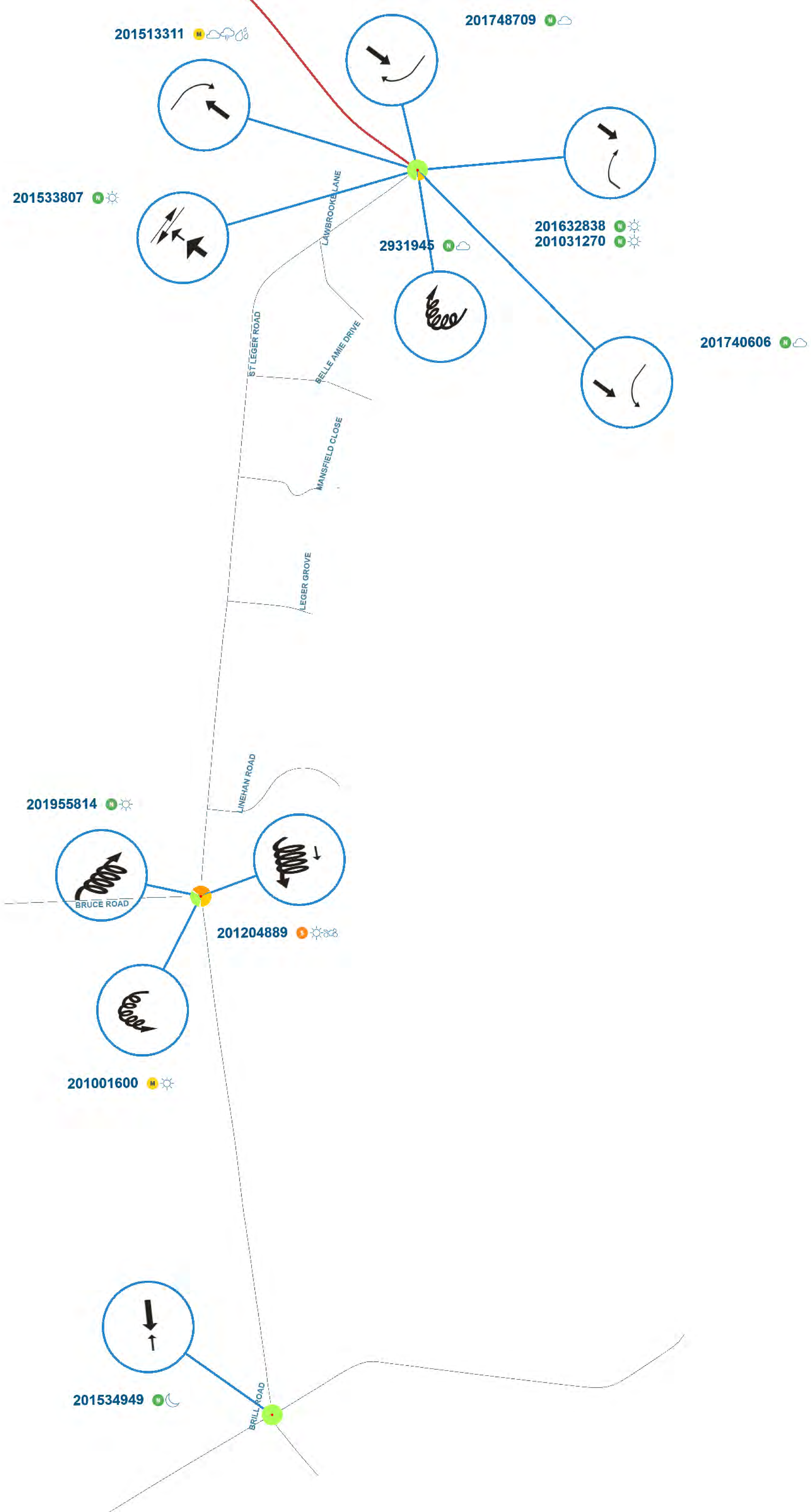
11 results from your query.

1-11 of 11

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
GOLF ROAD		I	SH 3	2931945	13/03/2009	Fri	14:30	Truck1 NDB on GOLF ROAD lost control turning right	TRUCK1, lost control when turning, speed entering corner/curve	Dry	Overcast	Fine	Crossroads	Stop	0	0	0
SH 3		I	GOLF ROAD	201748709	07/09/2017	Thu	14:45	Car/Wagon1 EDB on State highway 3 hit Van2 turning right onto AXROAD from the left	VAN2, did not check/notice another party from other dirn, failed to give way at priority traffic control	Dry	Overcast	Fine	Crossroads	Stop	0	0	0
SH 3		I	GOLF ROAD	201740606	02/06/2017	Fri	14:50	SUV1 EDB on Kihikihi Road hit Car/Wagon2 merging from the left	CAR/WAGON2, failed to give way at priority traffic control, other inexperience	Dry	Overcast	Fine	Crossroads	Stop	0	0	0
SH 3		I	GOLF ROAD	201513311	15/05/2015	Fri	09:30	Van1 NDB on SH 3 hit Car/Wagon2 turning right onto AXROAD from the left	CAR/WAGON2, did not check/notice another party from other dirn, failed to give way at priority traffic control	Wet	Overcast	Heavy rain	Crossroads	Stop	0	0	1
SH 3		I	GOLF ROAD	201031270	10/03/2010	Wed	15:08	Other2 turning right hit by oncoming Van1 SDB on SH 3	OTHER2, didnt look/notice other party - visibility obstruc, failed to give way turning to non-turning traffic, overseas/migrant driver fail to adjust to nz roads	Dry	Bright sun	Fine	Crossroads	Stop	0	0	0
SH 3		I	GOLF ROAD	201533807	04/04/2015	Sat	13:00	Car/Wagon1 WDB on SH 3 hit rear end of Car/Wagon2 stop/slow for cross traffic	CAR/WAGON1, following too closely	Dry	Bright sun	Fine	Crossroads	Stop	0	0	0
SH 3		I	GOLF ROAD	201632838	28/01/2016	Thu	09:40	Car/Wagon2 turning right hit by oncoming Van1 SDB on SH 3	CAR/WAGON2, did not check/notice another party from other dirn, failed to give way turning to non-turning traffic	Dry	Bright sun	Fine	Crossroads	Stop	0	0	0

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
ST LEGER RD	70m	N	BRUCE ROAD	201955814	09/02/2019	Sat	19:57	Car/Wagon1 NDB on ST LEGER ROAD lost control; went off road to right, Car/Wagon1 hit cliffs	CAR/WAGON1, alcohol test below limit, lost control avoiding another party, swerved to avoid animal, ENV: loose material on seal	Dry	Bright sun	Fine	Nil (Default)	Unknown	0	0	0
ST LEGER ROAD	100m	N	BRILL ROAD	201534949	22/02/2015	Sun	00:05	Car/Wagon1 SDB on ST LEGER ROAD hit Car/Wagon2 headon on straight	CAR/WAGON1, headlights fail suddenly, inadequate/no headlights, too far left	Dry	Dark	Fine	Nil (Default)	Nil	0	0	0
ST LEGER ROAD	90m	S	BRUCE ROAD	201204889	16/11/2012	Fri	18:07	Motorcycle1 SDB on ST LEGER ROAD lost control while overtaking	MOTORCYCLE1, lost control - road conditions, ENV: loose material on seal	Dry	Bright sun	Fine	Nil (Default)	Unknown	0	1	0
ST LEGER ROAD	150m	S	BRUCE ROAD	201001600	05/02/2010	Fri	20:00	Car/Wagon1 SDB on ST LEGER ROAD lost control turning left, Car/Wagon1 hit cliffs	CAR/WAGON1, alcohol test above limit or test refused, attention diverted by passengers, lost control when turning	Dry	Bright sun	Fine	Nil (Default)	Nil	0	0	1

1-11 of 11


201513311
201748709
201533807
LAWBROOKE LANE
201632838
201031270
2931945
201740606
ST LEGER ROAD
BELLE AMIE DRIVE
MANSFIELD CLOSE
LEGER GROVE
LINEHAN ROAD
201955814
BRUCE ROAD
201204889
201001600
201534949
BRILL ROAD

Untitled query

Saved sites

Walmsley Street

Crash year

2009 — 2019

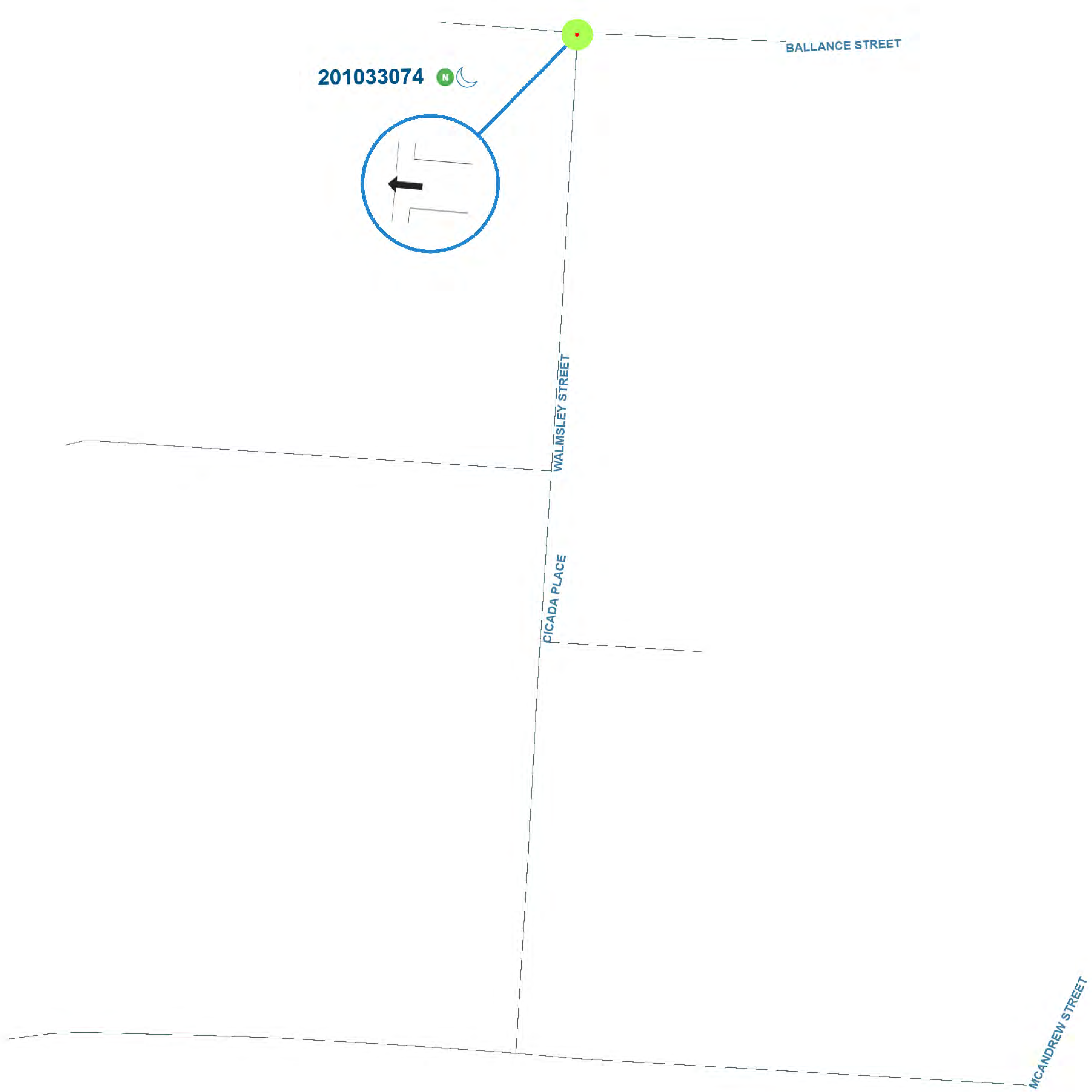
Plain English report

1 results from your query.

1-1 of 1

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
BALLANCE ST		I	WALMSLEY ST	201033074	13/03/2010	Sat	03:55	Car/Wagon1 NDB on BALLANCE ST missed intersection or end of road, Car/Wagon1 hit houses	CAR/WAGON1, alcohol test above limit or test refused, other fatigue	Dry	Dark	Fine	T Junction	Give way	0	0	0

1-1 of 1


201033074
N
BALLANCE STREET
WALMSLEY STREET
CICADA PLACE
MCANDREW STREET

Untitled query

Crash year

2009 — 2019

Saved sites

Whitmore Street

Plain English report

25 results from your query.

Showing 20 100 results at once.

1-25 of 25

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
ARAPUNI ROAD	160m	W	KIMBERLEY ROAD	201742178	19/06/2017	Mon	02:45	Car/Wagon1 EDB on Arapuni Rd lost control turning right, Car/Wagon1 hit fences, ditches	CAR/WAGON1, alcohol test below limit, other fatigue, other lost control	Dry	Dark	Fine	Nil (Default)	Unknown	0	0	0
ARAPUNI ROAD	170m	W	KIMBERLEY ROAD	201810980	31/01/2018	Wed	18:36	Van1 WDB on Arapuni road lost control turning right, Van1 hit trees	VAN1, alcohol test below limit, drugs suspected, fatigue due to lack of sleep, too far left	Dry	Bright sun	Fine	Nil (Default)	Unknown	0	0	1
ARAPUNI ROAD	320m	E	WHITMORE ST	201043693	26/11/2010	Fri	18:54	Car/Wagon1 WDB on ARAPUNI ROAD lost control turning right, Car/Wagon1 hit ditches	CAR/WAGON1, lost control under braking	Wet	Overcast	Heavy rain	Nil (Default)	Nil	0	0	0
CHURCH ST		I	WHITMORE ST	201818251	06/10/2018	Sat	09:00	Car/Wagon1 NDB on CHURCH STREET, KIHIKIHI, WAIPA hit Van2 crossing at right angle from right	VAN2, alcohol test below limit CAR/WAGON1, alcohol test below limit, failed to give way at priority traffic control, overseas/migrant driver fail to adjust to nz roads	Dry	Bright sun	Fine	Crossroads	Give way	0	0	3
MOULE ST		I	WHITMORE ST	201239395	06/10/2012	Sat		Car/Wagon1 EDB on MOULE ST lost control turning left, Car/Wagon1 hit parked vehicle, traffic sign	CAR/WAGON1, alcohol test above limit or test refused, lost control when turning, speed entering corner/curve	Wet	Overcast	Light rain	T Junction	Give way	0	0	0
ROLLESTON ST		I	WHITMORE ST	201000109	31/07/2010	Sat	19:02	Car/Wagon1 WDB on ROLLESTON ST hit Car/Wagon2 crossing at right angle from right, Car/Wagon1 hit fences	CAR/WAGON2, alcohol test above limit or test refused, failed to give way at priority traffic control, failed to notice control, speed approaching a traffic control	Dry	Dark	Fine	Crossroads	Give way	2	3	1
ROLLESTON ST		I	WHITMORE ST	201614399	25/05/2016	Wed	11:42	SUV1 WDB on ROLLESTON ST hit Car/Wagon2 crossing at right angle from right	CAR/WAGON2, failed to give way at priority traffic control, overseas/migrant driver fail to adjust to nz roads	Wet	Overcast	Light rain	Crossroads	Give way	0	0	1

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
WHITMORE ST	40m	W	CAREY ST	201648246	05/09/2016	Mon	17:10	parked Car/Wagon1 EDB on Whitmore street, kihikihi ran away, Car/Wagon1 hit poles	CAR/WAGON1, parking brake not fully applied	Wet	Overcast	Fine	Nil (Default)	Unknown	0	0	0
WHITMORE ST	50m	E	CAREY ST	201734936	31/01/2017	Tue	16:59	Car/Wagon1 EDB on Whitmore st sideswiped by Van2 EDB on Whitmore st turning left	CAR/WAGON1, misjudged intentions of another party	Dry	Bright sun	Fine	Driveway	Nil	0	0	0
WHITMORE ST		I	CHURCH ST	2930474	15/01/2009	Thu	15:53	Car/Wagon1 NDB on WHITMORE ST hit SUV2 crossing at right angle from right	CAR/WAGON1, didnt look/notice other party - visibility obstruc, failed to give way at priority traffic control, ENV: visibility limited by parked vehicle	Dry	Bright sun	Fine	Crossroads	Give way	0	0	0
WHITMORE ST		I	CHURCH ST	201230037	16/01/2012	Mon	14:20	Car/Wagon1 WDB on WHITMORE ST hit Motorcycle2 turning right onto AXROAD from the left	MOTORCYCLE2, did not check/notice another party from other dirn, failed to give way at priority traffic control, failed to notice control	Dry	Bright sun	Fine	Crossroads	Give way	0	0	0
WHITMORE ST		I	CHURCH ST	201845827	03/08/2018	Fri	18:00	Van1 EDB on WHITMORE STREET, KIHIKIHI, WAIPA hit Car/Wagon2 merging from the right	CAR/WAGON2, alcohol test below limit, did not check/notice another party from other dirn, failed to give way turning to non-turning traffic VAN1, alcohol test below limit	Dry	Dark	Fine	Crossroads	Give way	0	0	0
WHITMORE ST		I	CHURCH ST	201437937	17/06/2014	Tue	14:40	SUV1 EDB on WHITMORE ST hit Car/Wagon2 crossing at right angle from right	CAR/WAGON2, failed to give way at priority traffic control, other attention diverted, other inattentive	Dry	Overcast	Fine	Crossroads	Give way	0	0	0
WHITMORE ST		I	CHURCH ST	201136569	18/07/2011	Mon	09:00	Van1 EDB on WHITMORE ST hit Car/Wagon2 merging from the right	CAR/WAGON2, failed to give way at priority traffic control, ENV: dazzling sun	Dry	Bright sun	Fine	Crossroads	Give way	0	0	0
WHITMORE ST	50m	W	CHURCH ST	201954029	13/01/2019	Sun	17:15	Car/Wagon1 EDB on WHITMORE STREET, KIHIKIHI, WAIPA lost control; went off road to right, Car/Wagon1 hit fences	CAR/WAGON1, alcohol test below limit, other lost control	Wet	Overcast	Fine	Nil (Default)	Unknown	0	0	0
WHITMORE ST	90m	W	DICK ST	201436016	31/03/2014	Mon	09:47	Bus1 EDB on WHITMORE ST hit Truck2 U-turning from same direction of travel	TRUCK2, did not check/notice another party behind	Dry	Bright sun	Fine	Nil (Default)	Nil	0	0	0
WHITMORE ST	50m	S	OLIVER ST	201638078	14/05/2016	Sat	05:53	Car/Wagon1 SDB on WHITMORE ST lost control; went off road to left, Car/Wagon1 hit poles	CAR/WAGON1, fatigue due to lack of sleep	Wet	Dark	Light rain	Nil (Default)	Unknown	0	0	0
WHITMORE ST		I	OLIVER ST	201744665	28/04/2017	Fri	16:30	Car/Wagon2 turning right hit by oncoming Car/Wagon1 WDB on Arapuni rd, Car/Wagon1 hit traffic sign	CAR/WAGON2, attention diverted by cell phone, attention diverted by passengers, emotionally upset/road rage	Dry	Bright sun	Fine	Crossroads	Give way	0	0	0

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
WHITMORE ST	150m	E	OLIVER ST	201430721	15/01/2014	Wed	18:00	Car/Wagon1 EDB on WHITMORE ST hit Car/Wagon2 headon on straight	CAR/WAGON1, too far right	Dry	Bright sun	Fine	Nil (Default)	Nil	0	0	0
WHITMORE ST		I	ROLLESTON ST	201138254	21/10/2011	Fri	19:10	Van1 WDB on WHITMORE ST hit Car/Wagon2 crossing at right angle from right	CAR/WAGON2, alcohol test above limit or test refused, did not check/notice another party from other dirn, failed to give way at priority traffic control	Dry	Twilight	Fine	Crossroads	Give way	0	0	0
WHITMORE ST		I	ROLLESTON ST	201711676	14/03/2017	Tue	14:13	Car/Wagon1 EDB on Whitmore hit Car/Wagon2 crossing at right angle from right	CAR/WAGON2, failed to give way at priority traffic control, overseas/migrant driver fail to adjust to nz roads	Dry	Bright sun	Fine	Crossroads	Give way	0	0	2
WHITMORE ST		I	ROLLESTON ST	201742808	17/04/2017	Mon	14:15	Van1 EDB on Whitmore street hit Car/Wagon2 turning right onto AXROAD from the left	CAR/WAGON2, did not check/notice another party from other dirn	Dry	Overcast	Fine	Crossroads	Give way	0	0	0
WHITMORE ST		I	ROLLESTON ST	201818956	14/10/2018	Sun	12:39	Van1 EDB on WHITMORE STREET, KIHIKIHI, WAIPA hit Car/Wagon2 crossing at right angle from right	VAN1, alcohol test below limit CAR/WAGON2, alcohol test below limit, did not check/notice another party from other dirn, failed to give way at priority traffic control CAR/WAGON3, alcohol test below limit	Dry	Bright sun	Fine	Crossroads	Give way	0	0	1
WHITMORE ST	15m	E	SH 3 LYON	201304411	07/09/2013	Sat	12:10	Van1 EDB on WHITMORE ST hit obstruction, Van1 hit stationary vehicle	VAN1, emotionally upset/road rage, intentional collision CAR/WAGON2, emotionally upset/road rage	Dry	Bright sun	Fine	Nil (Default)	Unknown	0	0	2
WHITMORE ST	10m	S	WHITAKER ST	201230962	12/04/2012	Thu	12:45	Car/Wagon1 WDB on WHITMORE ST lost control; went off road to right, Car/Wagon1 hit poles	CAR/WAGON1, sudden illness, ENV: heavy rain	Wet	Overcast	Heavy rain	Crossroads	Give way	0	0	0

1-25 of 25

Untitled query

Saved sites

Ballance Street

Crash year

2009 — 2019

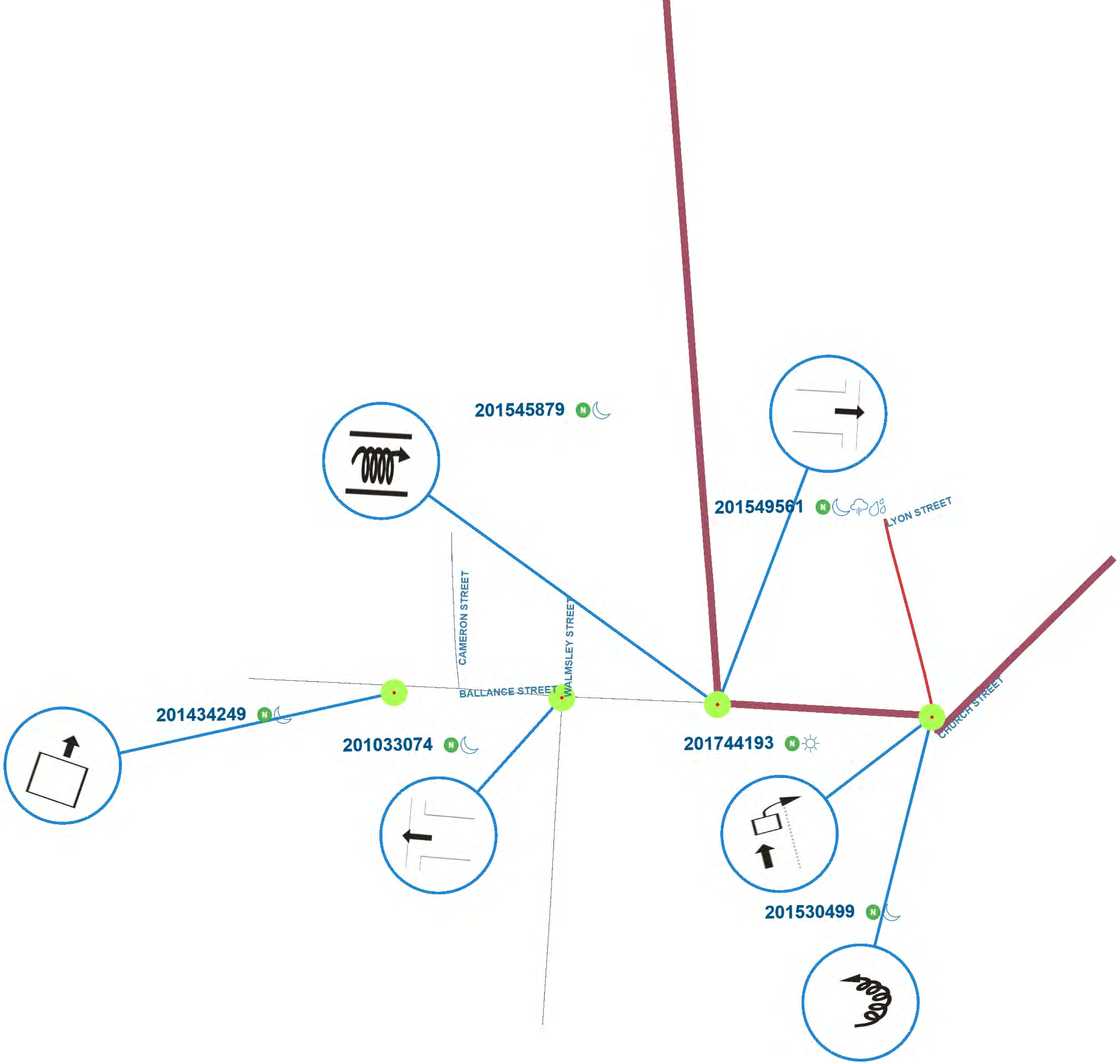
Plain English report

6 results from your query.

1-6 of 6

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
BALLANCE ST		I	LESLIE ST	201545879	18/09/2015	Fri	22:23	Car/Wagon1 EDB on BALLANCE ST lost control but did not leave the road, Car/Wagon1 hit fences	CAR/WAGON1, alcohol suspected, speed on straight	Dry	Dark	Fine	T Junction	Give way	0	0	0
BALLANCE ST		I	LESLIE ST	201549561	24/10/2015	Sat	03:00	Car/Wagon1 SDB on BALLANCE ST missed intersection or end of road, Car/Wagon1 hit fences	CAR/WAGON1, alcohol test above limit or test refused, lost control under braking, speed entering corner/curve, ENV: slippery road due to rain	Wet	Dark	Light rain	T Junction	Give way	0	0	0
BALLANCE ST		I	WALMSLEY ST	201033074	13/03/2010	Sat	03:55	Car/Wagon1 NDB on BALLANCE ST missed intersection or end of road, Car/Wagon1 hit houses	CAR/WAGON1, alcohol test above limit or test refused, other fatigue	Dry	Dark	Fine	T Junction	Give way	0	0	0
BALLANCE ST	100m	W	WALMSLEY ST	201434249	04/02/2014	Tue	22:43	parked Car/Wagon1 EDB on BALLANCE ST ran away, Car/Wagon1 hit houses	CAR/WAGON1, other attention diverted, parking brake not fully applied, ENV: entering or leaving private house / farm	Dry	Dark	Fine	Driveway	Unknown	0	0	0
SH 3		I	BALLANCE ST	201744193	05/07/2017	Wed	13:50	Van1 NDB on SH 3 hit rear of Van2 NDB on SH 3 turning right from centre line	VAN1, swerved to avoid pedestrian	Dry	Bright sun	Null	T Junction	Give way	0	0	0
SH 3		I	BALLANCE ST	201530499	26/01/2015	Mon	21:25	Car/Wagon1 NDB on SH 3 lost control turning left, Car/Wagon1 hit fences	CAR/WAGON1, speed entering corner/curve, wrong pedal/foot slipped	Dry	Dark	Fine	T Junction	Stop	0	0	0

1-6 of 6


201545879
201549561
LYON STREET
CAMERON STREET
WALMSLEY STREET
BALLANCE STREET
CHURCH STREET
201434249
201033074
201744193
201530499

Untitled query

Saved sites

Golf Road

Crash year

2009 — 2019

Plain English report

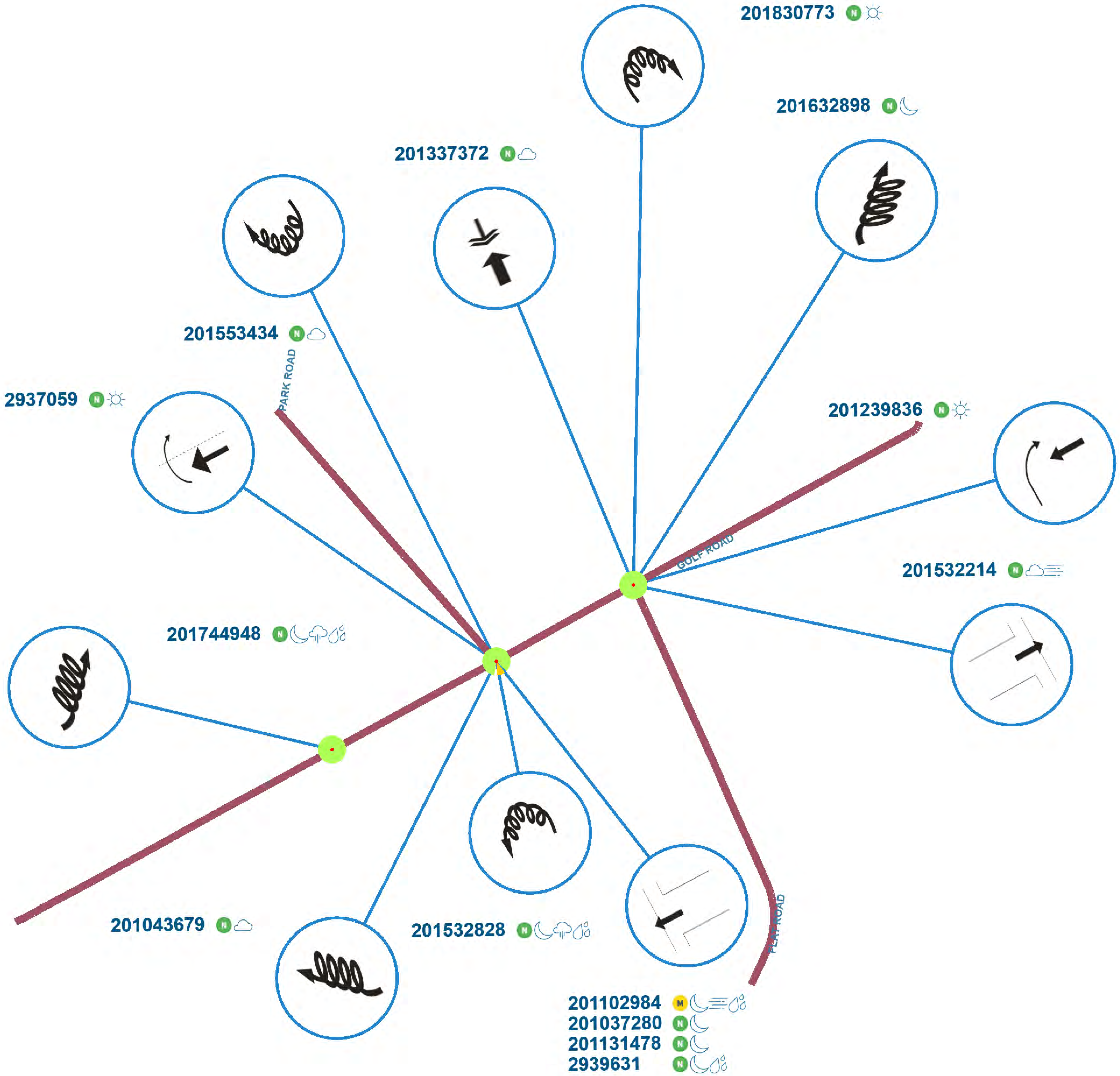
14 results from your query.

1-14 of 14

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
FLAT ROAD		I	GOLF ROAD	201632898	03/02/2016	Wed	21:51	Car/Wagon1 NDB on FLAT ROAD lost control; went off road to right, Car/Wagon1 hit fences, traffic islands	CAR/WAGON1, alcohol test above limit or test refused, other lost control, too far right	Dry	Dark	Fine	T Junction	Give way	0	0	0
FLAT ROAD		I	GOLF ROAD	201337372	27/08/2013	Tue	15:00	Van1 NDB on FLAT ROAD hit Car/Wagon2 reversing along road	CAR/WAGON2, did not check/notice another party behind	Dry	Overcast	Fine	T Junction	Give way	0	0	0
GOLF ROAD		I	FLAT ROAD	201239836	03/10/2012	Wed	17:30	Car/Wagon1 WDB on GOLF ROAD hit Car/Wagon2 turning right onto AXROAD from the left	CAR/WAGON2, did not check/notice another party from other dirn, failed to give way at priority traffic control	Dry	Bright sun	Fine	T Junction	Give way	0	0	0
GOLF ROAD		I	FLAT ROAD	201830773	05/01/2018	Fri	18:00	Car/Wagon1 EDB on Golf rd lost control turning right, Car/Wagon1 hit guide/guard rails	CAR/WAGON1, alcohol test below limit, lost control when turning, too far left, ENV: loose material on seal	Dry	Bright sun	Fine	T Junction	Give way	0	0	0
GOLF ROAD		I	FLAT ROAD	201532214	18/02/2015	Wed	06:32	Car/Wagon1 NDB on GOLF ROAD missed intersection or end of road, Car/Wagon1 hit fences, poles, traffic sign	CAR/WAGON1, failed to notice control, other lost control, speed on straight, ENV: fog or mist	Dry	Overcast	Mist or Fog	T Junction	Stop	0	0	0
GOLF ROAD		I	PARK ROAD	201131478	14/03/2011	Mon	22:40	SUV1 SDB on GOLF ROAD missed intersection or end of road, SUV1 hit fences, traffic sign, ditches, other	SUV1, lost control under braking, speed on straight	Dry	Dark	Fine	T Junction	Give way	0	0	0
GOLF ROAD		I	PARK ROAD	201037280	18/07/2010	Sun	03:45	SUV1 SDB on GOLF ROAD missed intersection or end of road	SUV1, alcohol test above limit or test refused	Dry	Dark	Fine	T Junction	Give way	0	0	0
GOLF ROAD	50m	W	PARK ROAD	201043679	13/12/2010	Mon	19:18	Car/Wagon1 WDB on GOLF ROAD lost control; went off road to right, Car/Wagon1 hit ditches	CAR/WAGON1, lost control - road conditions, ENV: loose material on seal	Dry	Overcast	Fine	Nil (Default)	Nil	0	0	0

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
GOLF ROAD	440m	W	PARK ROAD	201744948	20/07/2017	Thu	19:40	Car/Wagon1 EDB on Golf lost control; went off road to left, Car/Wagon1 hit ditches	CAR/WAGON1, alcohol test below limit, new driver/under instruction, too far left	Wet	Dark	Heavy rain	Nil (Default)	Unknown	0	0	0
GOLF ROAD		I	PARK ROAD	2939631	11/07/2009	Sat	19:10	Car/Wagon1 SDB on GOLF ROAD missed intersection or end of road, Car/Wagon1 hit fences	CAR/WAGON1, alcohol test above limit or test refused, failed to notice control	Wet	Dark	Fine	T Junction	Give way	0	0	0
GOLF ROAD	50m	W	PARK ROAD	2937059	01/06/2009	Mon	13:15	Car/Wagon1 WDB on GOLF ROAD hit SUV2 U-turning from same direction of travel, Car/Wagon1 hit fences	SUV2, did not check/notice another party behind	Dry	Bright sun	Fine	Nil (Default)	Unknown	0	0	0
GOLF ROAD		I	PARK ROAD	201532828	07/03/2015	Sat	20:39	Car/Wagon1 SDB on GOLF ROAD lost control turning left, Car/Wagon1 hit street furniture, ditches	CAR/WAGON1, lost control when turning, new driver/under instruction, wheelspins/wheelies/doughnuts/drifting	Wet	Dark	Heavy rain	T Junction	Give way	0	0	0
PARK ROAD		I	GOLF ROAD	201102984	06/06/2011	Mon	21:54	Car/Wagon1 SDB on PARK ROAD missed intersection or end of road, Car/Wagon1 hit fences, traffic islands, traffic sign, trees	CAR/WAGON1, attention diverted by cell phone, failed to notice control, worn tread on tyre, ENV: fog or mist	Wet	Dark	Mist or Fog	T Junction	Give way	0	0	1
PARK ROAD		I	GOLF ROAD	201553434	24/12/2015	Thu	11:13	Car/Wagon1 SDB on PARK ROAD lost control turning right	CAR/WAGON1, load interferes with driver, towed vehicle or trailer too heavy or incompatible	Dry	Overcast	Fine	T Junction	Give way	0	0	0

1-14 of 14



201830773 N
201632898 N
201337372 N
201553434 N
PARK ROAD
2937059 N
201239836 N
GOLF ROAD
201532214 N
201744948 N
201043679 N
201532828 N
201102984 M
201037280 N
201131478 N
2939631 N

Untitled query

Saved sites

Haultain Street

Crash year

2009 — 2019

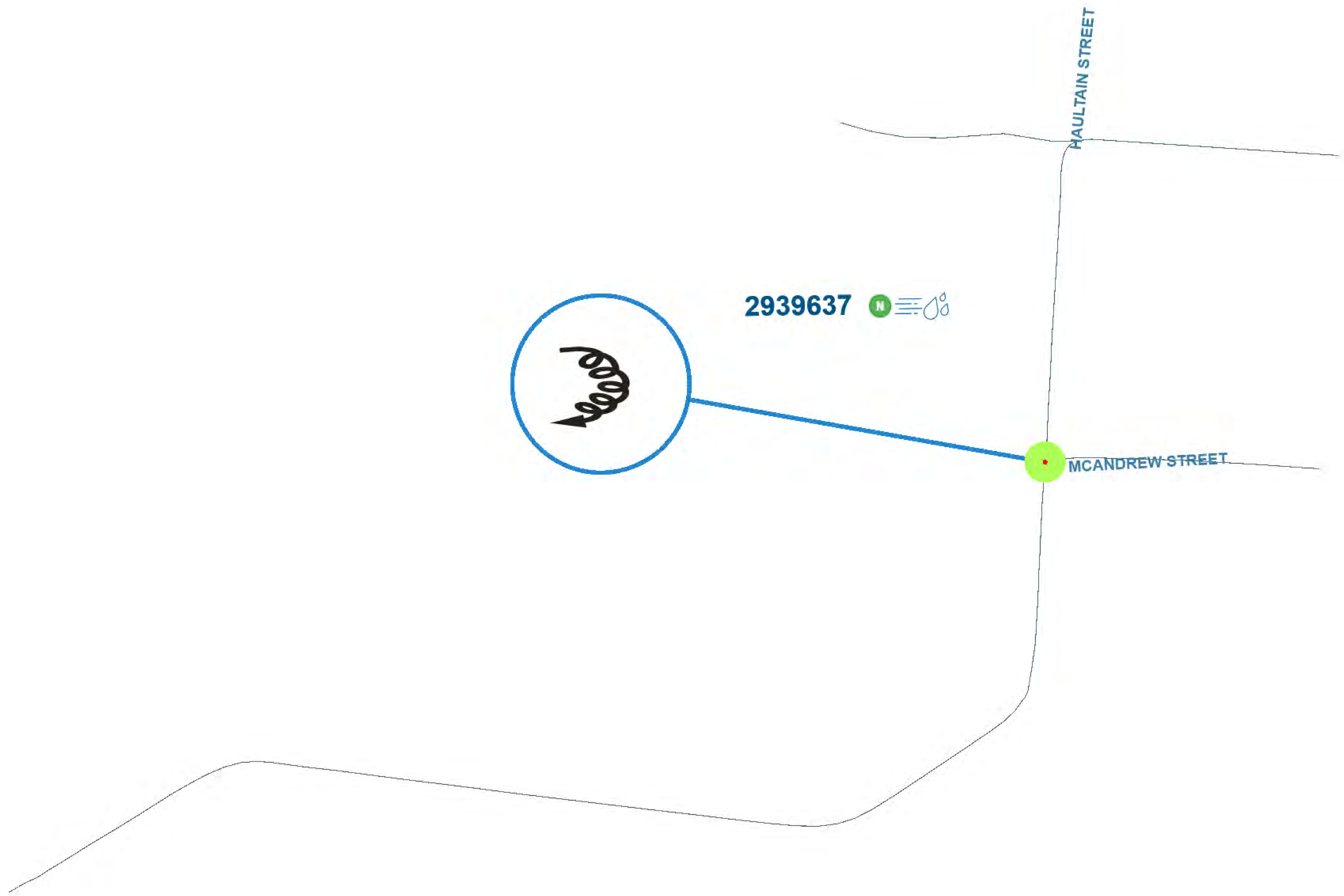
Plain English report

1 results from your query.

1-1 of 1

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
HAULTAIN ST		I	MCANDREW ST	2939637	30/07/2009	Thu	19:00	Car/Wagon1 WDB on HAULTAIN ST lost control turning right, Car/Wagon1 hit fences	CAR/WAGON1, lost control when turning, new driver/under instruction, speed entering corner/curve	Wet	Twilight	Mist or Fog	T Junction	Nil	0	0	0

1-1 of 1


2939637
HAULTAIN STREET
MCANDREW STREET

Untitled query

Saved sites

Herbert Street

Crash year

2009 — 2019

Plain English report

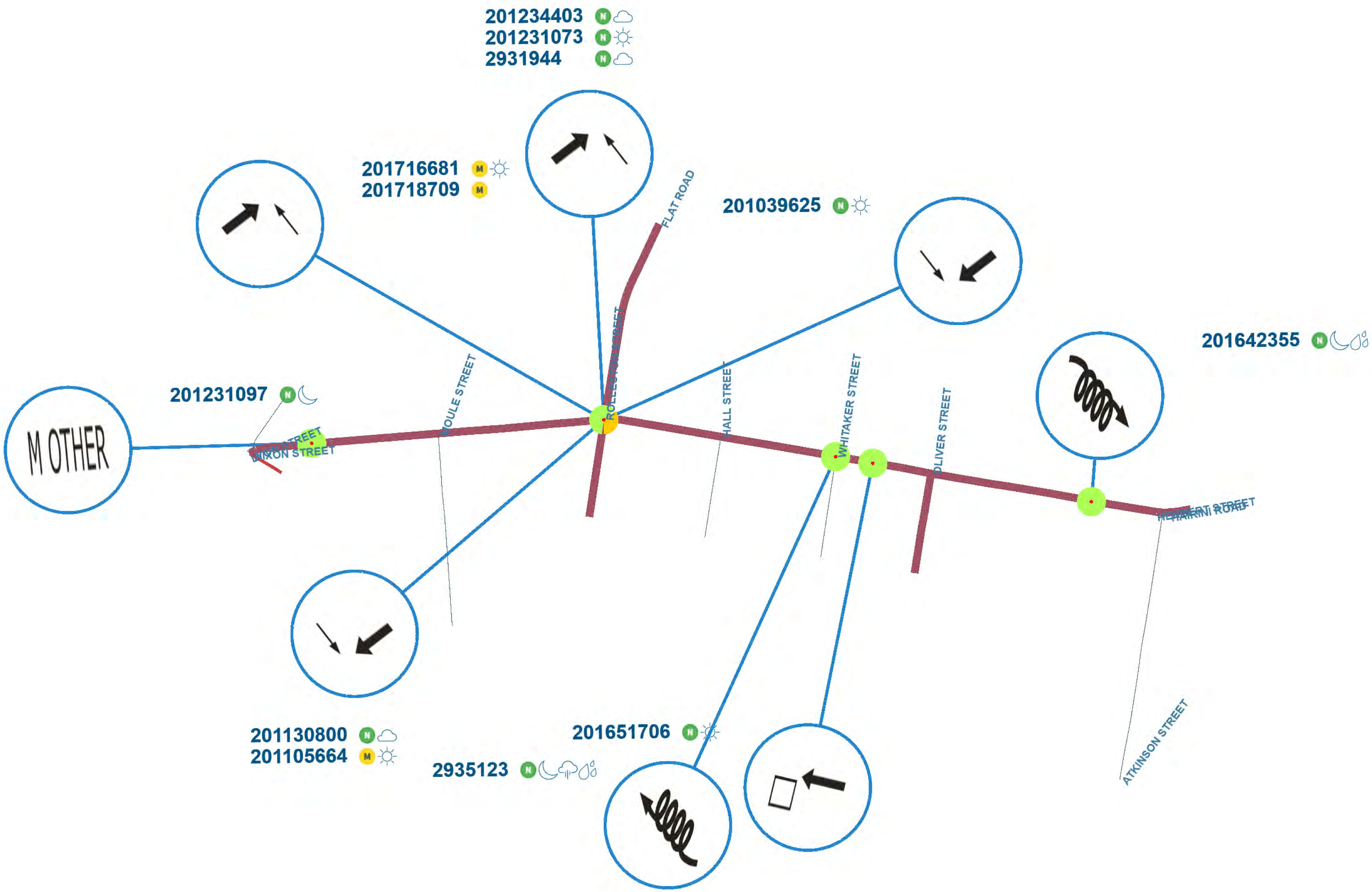
12 results from your query.

1-12 of 12

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
FLAT ROAD		I	HERBERT ST	2931944	14/03/2009	Sat	18:10	Truck1 NDB on FLAT ROAD hit Car/Wagon2 crossing at right angle from right	TRUCK1, did not check/notice another party from other dirn, failed to give way at priority traffic control	Dry	Overcast	Fine	Crossroads	Stop	0	0	0
FLAT ROAD		I	HERBERT ST	201105664	23/12/2011	Fri	12:27	Car/Wagon1 SDB on FLAT ROAD hit Car/Wagon2 crossing at right angle from right	CAR/WAGON2, did not check/notice another party from other dirn, failed to give way at priority traffic control	Dry	Bright sun	Fine	Crossroads	Stop	0	0	1
FLAT ROAD		I	HERBERT ST	201716681	24/07/2017	Mon	12:56	Car/Wagon1 EDB on Rolleston road hit Car/Wagon2 crossing at right angle from right	CAR/WAGON1, did not check/notice another party from other dirn, failed to give way at priority traffic control	Dry	Bright sun	Fine	Crossroads	Stop	0	0	1
HERBERT ST	140m	W	ATKINSON ST	201642355	22/06/2016	Wed	17:45	Car/Wagon1 EDB on HERBERT ST lost control; went off road to right, Car/Wagon1 hit poles	CAR/WAGON1, other lost control, other vehicle controls	Wet	Dark	Fine	Nil (Default)	Unknown	0	0	0
HERBERT ST		I	FLAT ROAD	201130800	03/02/2011	Thu	07:55	Car/Wagon1 SDB on HERBERT ST hit Car/Wagon2 crossing at right angle from right , Car/Wagon2 hit stationary vehicle	CAR/WAGON1, did not check/notice another party from other dirn, failed to give way at priority traffic control	Dry	Overcast	Fine	Crossroads	Stop	0	0	0
HERBERT ST		I	ROLLESTON ST	201231073	26/04/2012	Thu	15:50	Car/Wagon1 NDB on HERBERT ST hit Car/Wagon2 crossing at right angle from right	CAR/WAGON2, did not check/notice another party from other dirn, failed to give way at priority traffic control	Dry	Bright sun	Fine	Crossroads	Stop	0	0	0
HERBERT ST	120m	W	SH 3	201231097	03/04/2012	Tue	01:36	Car/Wagon1 EDB on HERBERT ST hit Car/Wagon2 manoeuvring, Car/Wagon1 hit stationary vehicle	CAR/WAGON1, evading enforcement, intentional collision	Dry	Dark	Fine	Nil (Default)	Unknown	0	0	0

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
HERBERT ST	25m	W	WHITAKER ST	2935123	14/05/2009	Thu	19:30	Car/Wagon1 WDB on HERBERT ST lost control; went off road to right, Car/Wagon1 hit fences	CAR/WAGON1, alcohol test above limit or test refused	Wet	Dark	Light rain	Nil (Default)	Nil	0	0	0
HERBERT ST	70m	E	WHITAKER ST	201651706	04/11/2016	Fri	12:55	Car/Wagon1 WDB on Herbert Road hit parked veh, Car/Wagon1 hit parked vehicle	CAR/WAGON1, too far left, wrong pedal/foot slipped	Dry	Bright sun	Fine	Nil (Default)	Unknown	0	0	0
ROLLESTON ST		I	HERBERT ST	201039625	01/09/2010	Wed	17:00	SUV1 WDB on ROLLESTON ST hit Car/Wagon2 crossing at right angle from right	CAR/WAGON2, attention diverted by passengers, failed to give way at priority traffic control, other visibility limited, ENV: other visibility limited	Dry	Bright sun	Fine	Crossroads	Stop	0	0	0
ROLLESTON ST		I	HERBERT ST	201234403	12/07/2012	Thu	08:00	Car/Wagon1 NDB on ROLLESTON ST hit Car/Wagon2 crossing at right angle from right	CAR/WAGON2, did not check/notice another party from other dirn, failed to give way at priority traffic control	Dry	Overcast	Fine	Crossroads	Stop	0	0	0
ROLLESTON ST		I	HERBERT ST	201718709	21/10/2017	Sat	07:32	Car/Wagon1 EDB on Herbert street, kihikihi hit Car/Wagon2 crossing at right angle from right	CAR/WAGON1, did not stop at stop sign, failed to give way at priority traffic control, speed entering corner/curve	Dry	Twilight	Fine	Crossroads	Stop	0	0	1

1-12 of 12



Document Set ID: 10373344
Version: 1, Version Date: 10/03/2020

Appendix B: T6 Modelling Reports

Modelling outputs for the following intersections included:

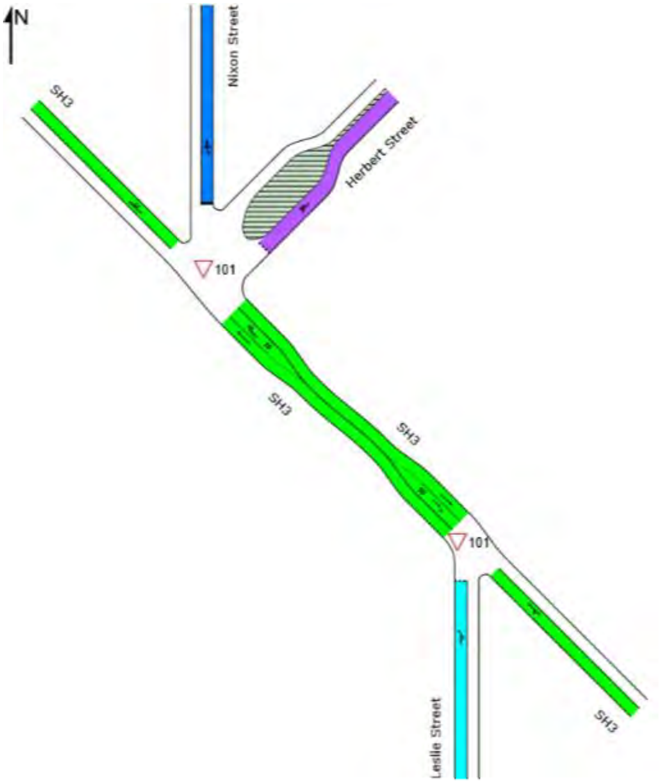
- **State Highway 3 / Golf Road / St Leger Road**
- **State Highway 3 / Herbert Street / Leslie Street / Nixon Street**
- **State Highway 3 / Whitmore Street / Church Street / Ballance Street**
- **State Highway 3 / McAndrew Street**

LANE LEVEL OF SERVICE

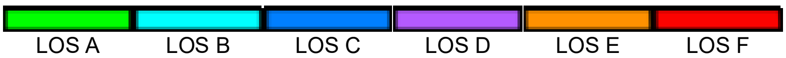
Lane Level of Service for Network Sites

Network: N101 [2018_Existing_AM]

New Network
Network Category: (None)



Colour code based on Level of Service



Delay model settings are specified for individual Sites forming the Network.

Organisation: TONKIN & TAYLOR | Processed: Tuesday, 4 June 2019 10:17:24 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Herbert SH3 Int & Leslie SH3 Int.sip8

NETWORK SUMMARY

Network: N101 [2018_Existing_AM]

New Network
Network Category: (None)

Network Performance - Hourly Values			
Performance Measure	**Vehicles**	**Per Unit Distance**	**Persons**
Network Level of Service (LOS)	LOS B		
Travel Time Index	8.67		
Speed Efficiency	0.88		
Congestion Coefficient	1.14		
Travel Speed (Average)	52.8 km/h		52.8 km/h
Travel Distance (Total)	1330.2 veh-km/h		1596.3 pers-km/h
Travel Time (Total)	25.2 veh-h/h		30.2 pers-h/h
Desired Speed	60.0 km/h		
Demand Flows (Total for all Sites)	2452 veh/h		2942 pers/h
Arrival Flows (Total for all Sites)	2452 veh/h		2942 pers/h
Demand Flows (Entry Total)	1259 veh/h		
Midblock Inflows (Total)	7 veh/h		
Midblock Outflows (Total)	-1 veh/h		
Percent Heavy Vehicles (Demand)	10.2 %		
Percent Heavy Vehicles (Arrival)	10.2 %		
Degree of Saturation	0.433		
Control Delay (Total)	0.66 veh-h/h		0.80 pers-h/h
Control Delay (Average)	1.0 sec		1.0 sec
Control Delay (Worst Lane)	32.2 sec		
Control Delay (Worst Movement)	46.1 sec		46.1 sec
Geometric Delay (Average)	0.4 sec		
Stop-Line Delay (Average)	0.6 sec		
Queue Storage Ratio (Worst Lane)	0.00		
Total Effective Stops	146 veh/h		175 pers/h
Effective Stop Rate	0.06	0.11 per km	0.06
Proportion Queued	0.04		0.04
Performance Index	29.0		29.0
Cost (Total)	628.37 $/h	0.47 $/km	628.37 $/h
Fuel Consumption (Total)	115.6 L/h	86.9 mL/km	
Fuel Economy	8.7 L/100km		
Carbon Dioxide (Total)	278.8 kg/h	209.6 g/km	
Hydrocarbons (Total)	0.019 kg/h	0.015 g/km	
Carbon Monoxide (Total)	0.262 kg/h	0.197 g/km	
NOx (Total)	0.724 kg/h	0.545 g/km	

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: Standard Left.

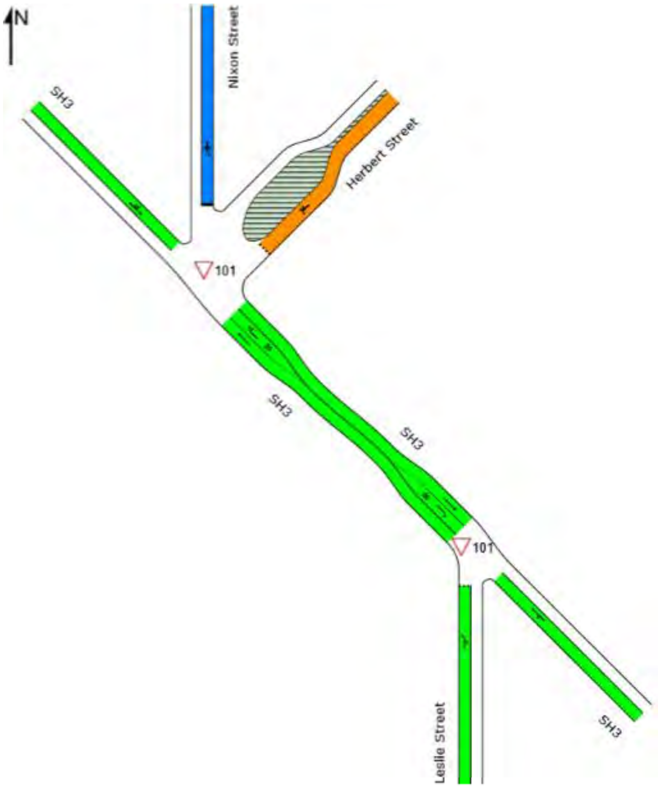
Network Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total for all Sites)	1,176,758 veh/y	1,412,110 pers/y
Delay	319 veh-h/y	383 pers-h/y
Effective Stops	69,844 veh/y	83,813 pers/y
Travel Distance	638,505 veh-km/y	766,206 pers-km/y
Travel Time	12,091 veh-h/y	14,509 pers-h/y
Cost	301,617 $/y	301,617 $/y
Fuel Consumption	55,503 L/y	
Carbon Dioxide	133,811 kg/y	
Hydrocarbons	9 kg/y	
Carbon Monoxide	126 kg/y	
NOx	348 kg/y	

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N101 [2018_Existing_PM]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A	LOS B	LOS C	LOS D	LOS E	LOS F

Delay model settings are specified for individual Sites forming the Network.

Organisation: TONKIN & TAYLOR | Processed: Tuesday, 4 June 2019 10:17:27 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Herbert SH3 Int & Leslie SH3 Int.sip8

NETWORK SUMMARY

Network: N101 [2018_Existing_PM]

New Network
Network Category: (None)

Network Performance - Hourly Values			
Performance Measure	**Vehicles**	**Per Unit Distance**	**Persons**
Network Level of Service (LOS)	LOS B		
Travel Time Index	8.47		
Speed Efficiency	0.86		
Congestion Coefficient	1.16		
Travel Speed (Average)	51.8 km/h		51.8 km/h
Travel Distance (Total)	1350.9 veh-km/h		1621.1 pers-km/h
Travel Time (Total)	26.1 veh-h/h		31.3 pers-h/h
Desired Speed	60.0 km/h		
Demand Flows (Total for all Sites)	2445 veh/h		2934 pers/h
Arrival Flows (Total for all Sites)	2445 veh/h		2934 pers/h
Demand Flows (Entry Total)	1284 veh/h		
Midblock Inflows (Total)	1 veh/h		
Midblock Outflows (Total)	-2 veh/h		
Percent Heavy Vehicles (Demand)	10.3 %		
Percent Heavy Vehicles (Arrival)	10.3 %		
Degree of Saturation	0.561		
Control Delay (Total)	1.18 veh-h/h		1.42 pers-h/h
Control Delay (Average)	1.7 sec		1.7 sec
Control Delay (Worst Lane)	46.8 sec		
Control Delay (Worst Movement)	51.6 sec		51.6 sec
Geometric Delay (Average)	0.3 sec		
Stop-Line Delay (Average)	1.4 sec		
Queue Storage Ratio (Worst Lane)	0.01		
Total Effective Stops	140 veh/h		168 pers/h
Effective Stop Rate	0.06	0.10 per km	0.06
Proportion Queued	0.04		0.04
Performance Index	32.5		32.5
Cost (Total)	685.94 $/h	0.51 $/km	685.94 $/h
Fuel Consumption (Total)	118.8 L/h	88.0 mL/km	
Fuel Economy	8.8 L/100km		
Carbon Dioxide (Total)	286.3 kg/h	211.9 g/km	
Hydrocarbons (Total)	0.020 kg/h	0.015 g/km	
Carbon Monoxide (Total)	0.270 kg/h	0.200 g/km	
NOx (Total)	0.740 kg/h	0.548 g/km	

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: Standard Left.

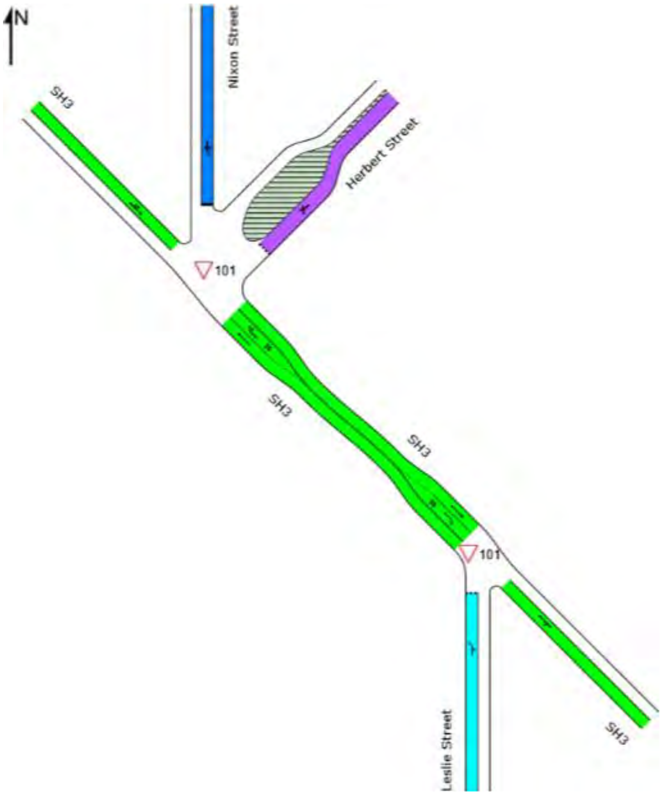
Network Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total for all Sites)	1,173,726 veh/y	1,408,472 pers/y
Delay	568 veh-h/y	682 pers-h/y
Effective Stops	67,213 veh/y	80,655 pers/y
Travel Distance	648,445 veh-km/y	778,134 pers-km/y
Travel Time	12,528 veh-h/y	15,034 pers-h/y
Cost	329,252 $/y	329,252 $/y
Fuel Consumption	57,032 L/y	
Carbon Dioxide	137,430 kg/y	
Hydrocarbons	10 kg/y	
Carbon Monoxide	130 kg/y	
NOx	355 kg/y	

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N101 [2018_Low Dev_AM]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A LOS B LOS C LOS D LOS E LOS F

Delay model settings are specified for individual Sites forming the Network.

Organisation: TONKIN & TAYLOR | Processed: Tuesday, 4 June 2019 10:17:29 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Herbert SH3 Int & Leslie SH3 Int.sip8

NETWORK SUMMARY

Network: N101 [2018_Low Dev_AM]

New Network
Network Category: (None)

Network Performance - Hourly Values						
Performance Measure	**Vehicles**		**Per Unit Distance**		**Persons**	
Network Level of Service (LOS)	LOS B					
Travel Time Index	8.65					
Speed Efficiency	0.88					
Congestion Coefficient	1.14					
Travel Speed (Average)	52.7	km/h			52.7	km/h
Travel Distance (Total)	1370.0	veh-km/h			1644.0	pers-km/h
Travel Time (Total)	26.0	veh-h/h			31.2	pers-h/h
Desired Speed	60.0	km/h				
Demand Flows (Total for all Sites)	2525	veh/h			3030	pers/h
Arrival Flows (Total for all Sites)	2525	veh/h			3030	pers/h
Demand Flows (Entry Total)	1289	veh/h				
Midblock Inflows (Total)	20	veh/h				
Midblock Outflows (Total)	0	veh/h				
Percent Heavy Vehicles (Demand)	10.2	%				
Percent Heavy Vehicles (Arrival)	10.2	%				
Degree of Saturation	0.441					
Control Delay (Total)	0.74	veh-h/h			0.88	pers-h/h
Control Delay (Average)	1.0	sec			1.0	sec
Control Delay (Worst Lane)	34.4	sec				
Control Delay (Worst Movement)	49.8	sec			49.8	sec
Geometric Delay (Average)	0.4	sec				
Stop-Line Delay (Average)	0.7	sec				
Queue Storage Ratio (Worst Lane)	0.00					
Total Effective Stops	158	veh/h			190	pers/h
Effective Stop Rate	0.06		0.12	per km	0.06	
Proportion Queued	0.04				0.04	
Performance Index	30.1				30.1	
Cost (Total)	647.16	$/h	0.47	$/km	647.16	$/h
Fuel Consumption (Total)	119.2	L/h	87.0	mL/km		
Fuel Economy	8.7	L/100km				
Carbon Dioxide (Total)	287.3	kg/h	209.7	g/km		
Hydrocarbons (Total)	0.020	kg/h	0.015	g/km		
Carbon Monoxide (Total)	0.270	kg/h	0.197	g/km		
NOx (Total)	0.745	kg/h	0.543	g/km		

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: Standard Left.

Network Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total for all Sites)	1,212,126	veh/y	1,454,552	pers/y
Delay	353	veh-h/y	424	pers-h/y
Effective Stops	75,808	veh/y	90,969	pers/y
Travel Distance	657,587	veh-km/y	789,105	pers-km/y
Travel Time	12,473	veh-h/y	14,968	pers-h/y
Cost	310,636	$/y	310,636	$/y
Fuel Consumption	57,197	L/y		
Carbon Dioxide	137,897	kg/y		
Hydrocarbons	10	kg/y		
Carbon Monoxide	130	kg/y		
NOx	357	kg/y		

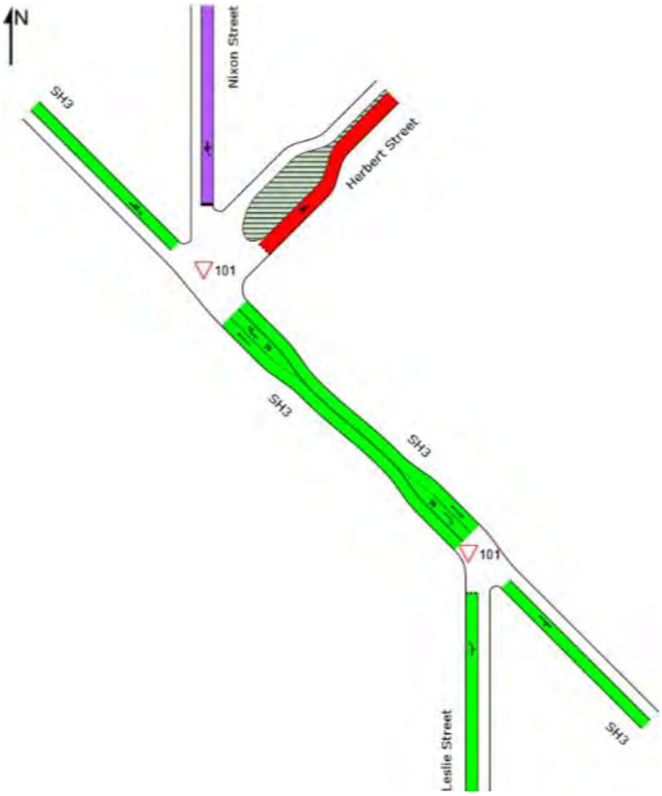
Organisation: TONKIN & TAYLOR | Processed: Tuesday, 4 June 2019 10:17:29 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Herbert SH3 Int & Leslie SH3 Int.sip8

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N101 [2018_Low Dev_PM]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A	LOS B	LOS C	LOS D	LOS E	LOS F

Delay model settings are specified for individual Sites forming the Network.

Organisation: TONKIN & TAYLOR | Processed: Tuesday, 4 June 2019 10:17:31 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Herbert SH3 Int & Leslie SH3 Int.sip8

NETWORK SUMMARY

Network: N101 [2018_Low Dev_PM]

New Network
Network Category: (None)

Network Performance - Hourly Values			
Performance Measure	**Vehicles**	**Per Unit Distance**	**Persons**
Network Level of Service (LOS)	LOS B		
Travel Time Index	8.36		
Speed Efficiency	0.85		
Congestion Coefficient	1.17		
Travel Speed (Average)	51.2 km/h		51.2 km/h
Travel Distance (Total)	1393.7 veh-km/h		1672.4 pers-km/h
Travel Time (Total)	27.2 veh-h/h		32.7 pers-h/h
Desired Speed	60.0 km/h		
Demand Flows (Total for all Sites)	2520 veh/h		3024 pers/h
Arrival Flows (Total for all Sites)	2520 veh/h		3024 pers/h
Demand Flows (Entry Total)	1322 veh/h		
Midblock Inflows (Total)	7 veh/h		
Midblock Outflows (Total)	-2 veh/h		
Percent Heavy Vehicles (Demand)	10.3 %		
Percent Heavy Vehicles (Arrival)	10.3 %		
Degree of Saturation	0.661		
Control Delay (Total)	1.53 veh-h/h		1.84 pers-h/h
Control Delay (Average)	2.2 sec		2.2 sec
Control Delay (Worst Lane)	56.4 sec		
Control Delay (Worst Movement)	62.7 sec		62.7 sec
Geometric Delay (Average)	0.4 sec		
Stop-Line Delay (Average)	1.8 sec		
Queue Storage Ratio (Worst Lane)	0.02		
Total Effective Stops	158 veh/h		189 pers/h
Effective Stop Rate	0.06	0.11 per km	0.06
Proportion Queued	0.04		0.04
Performance Index	35.2		35.2
Cost (Total)	717.83 $/h	0.52 $/km	717.83 $/h
Fuel Consumption (Total)	122.9 L/h	88.2 mL/km	
Fuel Economy	8.8 L/100km		
Carbon Dioxide (Total)	296.2 kg/h	212.5 g/km	
Hydrocarbons (Total)	0.021 kg/h	0.015 g/km	
Carbon Monoxide (Total)	0.279 kg/h	0.200 g/km	
NOx (Total)	0.761 kg/h	0.546 g/km	

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: Standard Left.

Network Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total for all Sites)	1,209,600 veh/y	1,451,520 pers/y
Delay	734 veh-h/y	881 pers-h/y
Effective Stops	75,636 veh/y	90,763 pers/y
Travel Distance	668,970 veh-km/y	802,764 pers-km/y
Travel Time	13,078 veh-h/y	15,693 pers-h/y
Cost	344,559 $/y	344,559 $/y
Fuel Consumption	59,006 L/y	
Carbon Dioxide	142,170 kg/y	
Hydrocarbons	10 kg/y	
Carbon Monoxide	134 kg/y	
NOx	365 kg/y	

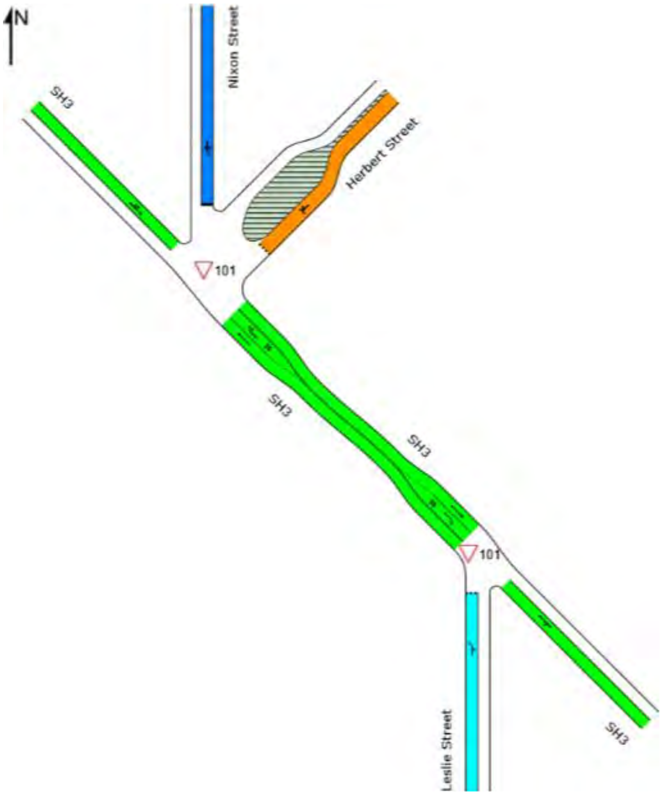
Organisation: TONKIN & TAYLOR | Processed: Tuesday, 4 June 2019 10:17:31 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Herbert SH3 Int & Leslie SH3 Int.sip8

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N101 [2018_Hi Dev_AM]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A	LOS B	LOS C	LOS D	LOS E	LOS F

Delay model settings are specified for individual Sites forming the Network.

Organisation: TONKIN & TAYLOR | Processed: Tuesday, 4 June 2019 10:17:33 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Herbert SH3 Int & Leslie SH3 Int.sip8

NETWORK SUMMARY

Network: N101 [2018_Hi Dev_AM]

New Network
Network Category: (None)

Network Performance - Hourly Values			
Performance Measure	**Vehicles**	**Per Unit Distance**	**Persons**
Network Level of Service (LOS)	LOS B		
Travel Time Index	8.61		
Speed Efficiency	0.88		
Congestion Coefficient	1.14		
Travel Speed (Average)	52.5 km/h		52.5 km/h
Travel Distance (Total)	1390.1 veh-km/h		1668.1 pers-km/h
Travel Time (Total)	26.5 veh-h/h		31.8 pers-h/h
Desired Speed	60.0 km/h		
Demand Flows (Total for all Sites)	2562 veh/h		3075 pers/h
Arrival Flows (Total for all Sites)	2562 veh/h		3075 pers/h
Demand Flows (Entry Total)	1307 veh/h		
Midblock Inflows (Total)	24 veh/h		
Midblock Outflows (Total)	-2 veh/h		
Percent Heavy Vehicles (Demand)	10.1 %		
Percent Heavy Vehicles (Arrival)	10.1 %		
Degree of Saturation	0.447		
Control Delay (Total)	0.81 veh-h/h		0.98 pers-h/h
Control Delay (Average)	1.1 sec		1.1 sec
Control Delay (Worst Lane)	38.9 sec		
Control Delay (Worst Movement)	55.2 sec		55.2 sec
Geometric Delay (Average)	0.4 sec		
Stop-Line Delay (Average)	0.8 sec		
Queue Storage Ratio (Worst Lane)	0.01		
Total Effective Stops	167 veh/h		200 pers/h
Effective Stop Rate	0.07	0.12 per km	0.07
Proportion Queued	0.05		0.05
Performance Index	31.0		31.0
Cost (Total)	659.12 $/h	0.47 $/km	659.12 $/h
Fuel Consumption (Total)	121.0 L/h	87.0 mL/km	
Fuel Economy	8.7 L/100km		
Carbon Dioxide (Total)	291.6 kg/h	209.8 g/km	
Hydrocarbons (Total)	0.020 kg/h	0.015 g/km	
Carbon Monoxide (Total)	0.274 kg/h	0.197 g/km	
NOx (Total)	0.754 kg/h	0.542 g/km	

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: Standard Left.

Network Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total for all Sites)	1,229,811 veh/y	1,475,773 pers/y
Delay	391 veh-h/y	469 pers-h/y
Effective Stops	80,086 veh/y	96,104 pers/y
Travel Distance	667,257 veh-km/y	800,708 pers-km/y
Travel Time	12,708 veh-h/y	15,250 pers-h/y
Cost	316,376 $/y	316,376 $/y
Fuel Consumption	58,060 L/y	
Carbon Dioxide	139,976 kg/y	
Hydrocarbons	10 kg/y	
Carbon Monoxide	131 kg/y	
NOx	362 kg/y	

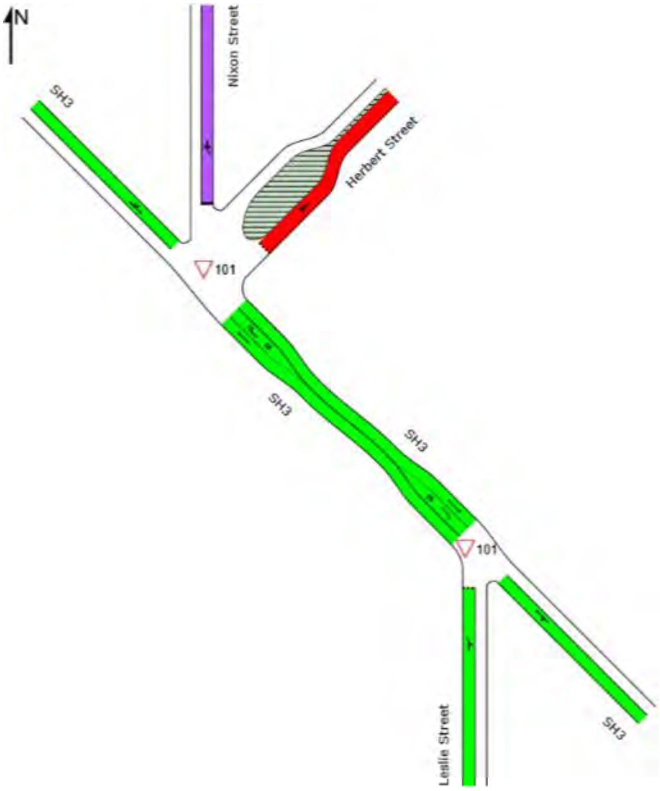
Organisation: TONKIN & TAYLOR | Processed: Tuesday, 4 June 2019 10:17:33 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Herbert SH3 Int & Leslie SH3 Int.sip8

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N101 [2018_Hi Dev_PM]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A	LOS B	LOS C	LOS D	LOS E	LOS F

Delay model settings are specified for individual Sites forming the Network.

NETWORK SUMMARY

Network: N101 [2018_Hi Dev_PM]

New Network
Network Category: (None)

Network Performance - Hourly Values						
Performance Measure	**Vehicles**		**Per Unit Distance**		**Persons**	
Network Level of Service (LOS)	LOS B					
Travel Time Index	8.30					
Speed Efficiency	0.85					
Congestion Coefficient	1.18					
Travel Speed (Average)	50.8	km/h			50.8	km/h
Travel Distance (Total)	1422.1	veh-km/h			1706.5	pers-km/h
Travel Time (Total)	28.0	veh-h/h			33.6	pers-h/h
Desired Speed	60.0	km/h				
Demand Flows (Total for all Sites)	2573	veh/h			3087	pers/h
Arrival Flows (Total for all Sites)	2573	veh/h			3087	pers/h
Demand Flows (Entry Total)	1348	veh/h				
Midblock Inflows (Total)	9	veh/h				
Midblock Outflows (Total)	-3	veh/h				
Percent Heavy Vehicles (Demand)	10.3	%				
Percent Heavy Vehicles (Arrival)	10.3	%				
Degree of Saturation	0.711					
Control Delay (Total)	1.75	veh-h/h			2.10	pers-h/h
Control Delay (Average)	2.5	sec			2.5	sec
Control Delay (Worst Lane)	65.4	sec				
Control Delay (Worst Movement)	72.3	sec			72.3	sec
Geometric Delay (Average)	0.4	sec				
Stop-Line Delay (Average)	2.1	sec				
Queue Storage Ratio (Worst Lane)	0.02					
Total Effective Stops	163	veh/h			196	pers/h
Effective Stop Rate	0.06		0.11	per km	0.06	
Proportion Queued	0.04				0.04	
Performance Index	36.7				36.7	
Cost (Total)	738.53	$/h	0.52	$/km	738.53	$/h
Fuel Consumption (Total)	125.6	L/h	88.4	mL/km		
Fuel Economy	8.8	L/100km				
Carbon Dioxide (Total)	302.7	kg/h	212.9	g/km		
Hydrocarbons (Total)	0.021	kg/h	0.015	g/km		
Carbon Monoxide (Total)	0.285	kg/h	0.200	g/km		
NOx (Total)	0.777	kg/h	0.546	g/km		

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: Standard Left.

Network Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total for all Sites)	1,234,863	veh/y	1,481,836	pers/y
Delay	840	veh-h/y	1,008	pers-h/y
Effective Stops	78,208	veh/y	93,850	pers/y
Travel Distance	682,611	veh-km/y	819,134	pers-km/y
Travel Time	13,437	veh-h/y	16,124	pers-h/y
Cost	354,496	$/y	354,496	$/y
Fuel Consumption	60,310	L/y		
Carbon Dioxide	145,311	kg/y		
Hydrocarbons	10	kg/y		
Carbon Monoxide	137	kg/y		
NOx	373	kg/y		

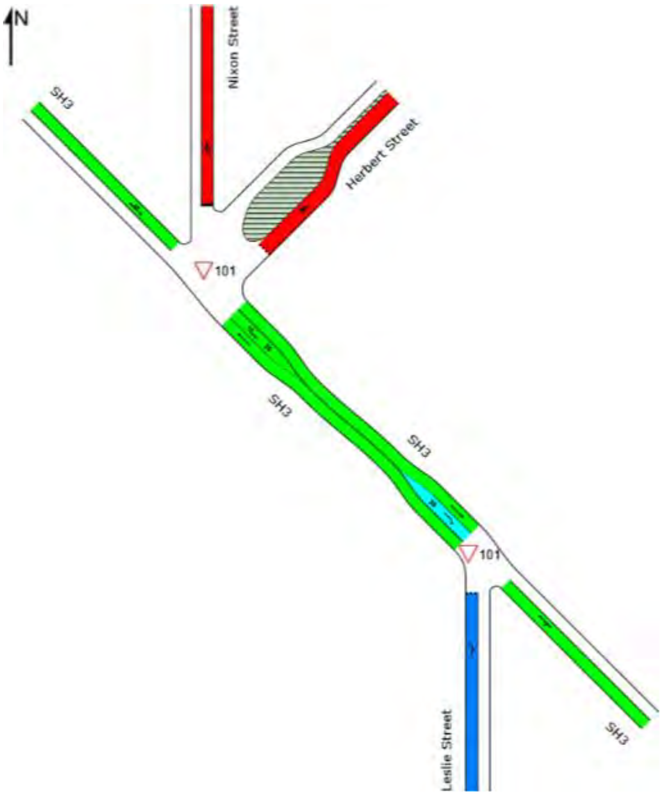
Organisation: TONKIN & TAYLOR | Processed: Tuesday, 4 June 2019 10:17:36 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Herbert SH3 Int & Leslie SH3 Int.sip8

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N101 [2035_No Dev_AM]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A	LOS B	LOS C	LOS D	LOS E	LOS F

Delay model settings are specified for individual Sites forming the Network.

NETWORK SUMMARY

Network: N101 [2035_No Dev_AM]

New Network
Network Category: (None)

Network Performance - Hourly Values			
Performance Measure	**Vehicles**	**Per Unit Distance**	**Persons**
Network Level of Service (LOS)	LOS C		
Travel Time Index	7.70		
Speed Efficiency	0.79		
Congestion Coefficient	1.26		
Travel Speed (Average)	47.6 km/h		47.6 km/h
Travel Distance (Total)	1792.2 veh-km/h		2150.7 pers-km/h
Travel Time (Total)	37.7 veh-h/h		45.2 pers-h/h
Desired Speed	60.0 km/h		
Demand Flows (Total for all Sites)	3304 veh/h		3965 pers/h
Arrival Flows (Total for all Sites)	3304 veh/h		3965 pers/h
Demand Flows (Entry Total)	1684 veh/h		
Midblock Inflows (Total)	31 veh/h		
Midblock Outflows (Total)	-1 veh/h		
Percent Heavy Vehicles (Demand)	10.2 %		
Percent Heavy Vehicles (Arrival)	10.2 %		
Degree of Saturation	1.052		
Control Delay (Total)	4.57 veh-h/h		5.48 pers-h/h
Control Delay (Average)	5.0 sec		5.0 sec
Control Delay (Worst Lane)	301.0 sec		
Control Delay (Worst Movement)	318.4 sec		318.4 sec
Geometric Delay (Average)	0.3 sec		
Stop-Line Delay (Average)	4.6 sec		
Queue Storage Ratio (Worst Lane)	0.04		
Total Effective Stops	231 veh/h		277 pers/h
Effective Stop Rate	0.07	0.13 per km	0.07
Proportion Queued	0.05		0.05
Performance Index	56.7		56.7
Cost (Total)	970.62 $/h	0.54 $/km	970.62 $/h
Fuel Consumption (Total)	160.4 L/h	89.5 mL/km	
Fuel Economy	9.0 L/100km		
Carbon Dioxide (Total)	386.6 kg/h	215.7 g/km	
Hydrocarbons (Total)	0.028 kg/h	0.015 g/km	
Carbon Monoxide (Total)	0.360 kg/h	0.201 g/km	
NOx (Total)	0.982 kg/h	0.548 g/km	

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: Standard Left.

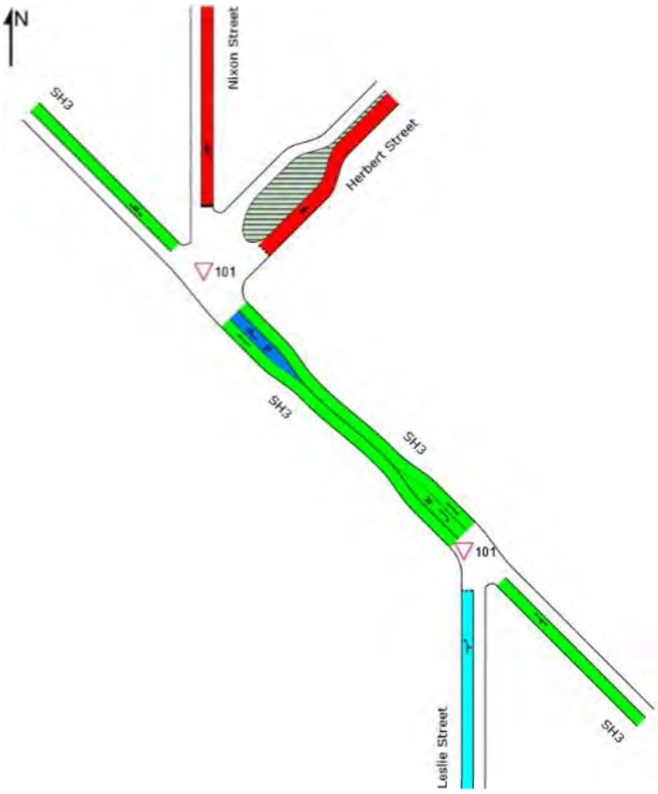
Network Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total for all Sites)	1,586,021 veh/y	1,903,225 pers/y
Delay	2,194 veh-h/y	2,633 pers-h/y
Effective Stops	110,813 veh/y	132,975 pers/y
Travel Distance	860,279 veh-km/y	1,032,335 pers-km/y
Travel Time	18,078 veh-h/y	21,693 pers-h/y
Cost	465,897 $/y	465,897 $/y
Fuel Consumption	77,014 L/y	
Carbon Dioxide	185,571 kg/y	
Hydrocarbons	13 kg/y	
Carbon Monoxide	173 kg/y	
NOx	471 kg/y	

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N101 [2035_No Dev_PM]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A	LOS B	LOS C	LOS D	LOS E	LOS F

Delay model settings are specified for individual Sites forming the Network.

NETWORK SUMMARY

Network: N101 [2035_No Dev_PM]

New Network
Network Category: (None)

Network Performance - Hourly Values			
Performance Measure	**Vehicles**	**Per Unit Distance**	**Persons**
Network Level of Service (LOS)	LOS E		
Travel Time Index	2.72		
Speed Efficiency	0.35		
Congestion Coefficient	2.90		
Travel Speed (Average)	20.7 km/h		20.7 km/h
Travel Distance (Total)	1818.7 veh-km/h		2182.5 pers-km/h
Travel Time (Total)	87.8 veh-h/h		105.4 pers-h/h
Desired Speed	60.0 km/h		
Demand Flows (Total for all Sites)	3297 veh/h		3956 pers/h
Arrival Flows (Total for all Sites)	3287 veh/h		3944 pers/h
Demand Flows (Entry Total)	1722 veh/h		
Midblock Inflows (Total)	20 veh/h		
Midblock Outflows (Total)	0 veh/h		
Percent Heavy Vehicles (Demand)	10.3 %		
Percent Heavy Vehicles (Arrival)	10.3 %		
Degree of Saturation	2.862		
Control Delay (Total)	52.40 veh-h/h		62.88 pers-h/h
Control Delay (Average)	57.4 sec		57.4 sec
Control Delay (Worst Lane)	1760.3 sec		
Control Delay (Worst Movement)	1765.9 sec		1765.9 sec
Geometric Delay (Average)	0.3 sec		
Stop-Line Delay (Average)	57.1 sec		
Queue Storage Ratio (Worst Lane)	0.29		
Total Effective Stops	369 veh/h		443 pers/h
Effective Stop Rate	0.11	0.20 per km	0.11
Proportion Queued	0.04		0.04
Performance Index	212.8		212.8
Cost (Total)	2718.08 $/h	1.49 $/km	2718.08 $/h
Fuel Consumption (Total)	224.3 L/h	123.3 mL/km	
Fuel Economy	12.3 L/100km		
Carbon Dioxide (Total)	536.8 kg/h	295.1 g/km	
Hydrocarbons (Total)	0.046 kg/h	0.026 g/km	
Carbon Monoxide (Total)	0.461 kg/h	0.253 g/km	
NOx (Total)	1.039 kg/h	0.572 g/km	

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: Standard Left.

Network Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total for all Sites)	1,582,484 veh/y	1,898,981 pers/y
Delay	25,152 veh-h/y	30,182 pers-h/y
Effective Stops	177,350 veh/y	212,820 pers/y
Travel Distance	872,996 veh-km/y	1,047,596 pers-km/y
Travel Time	42,163 veh-h/y	50,595 pers-h/y
Cost	1,304,680 $/y	1,304,680 $/y
Fuel Consumption	107,643 L/y	
Carbon Dioxide	257,663 kg/y	
Hydrocarbons	22 kg/y	
Carbon Monoxide	221 kg/y	
NOx	499 kg/y	

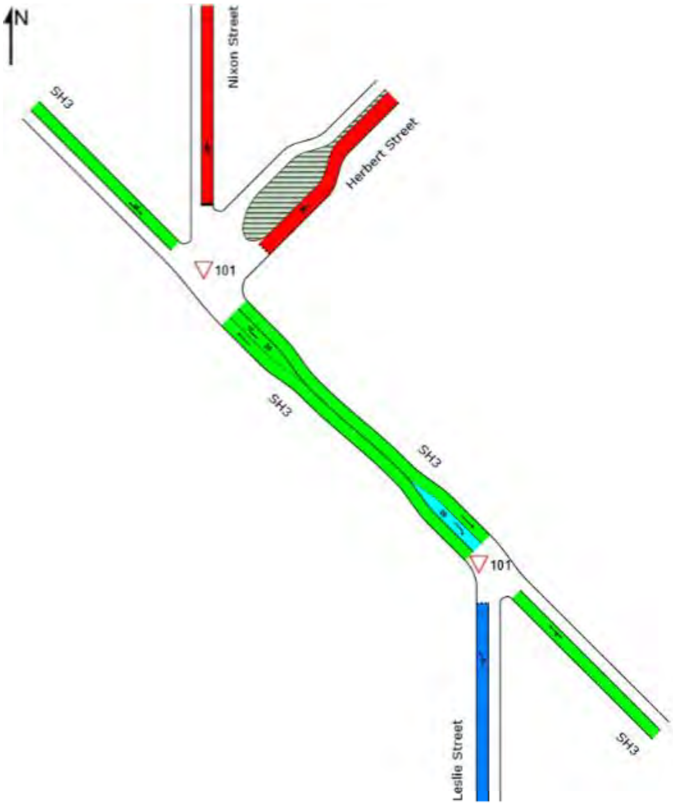
Organisation: TONKIN & TAYLOR | Processed: Tuesday, 4 June 2019 10:17:40 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Herbert SH3 Int & Leslie SH3 Int.sip8

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N101 [2035_Low Dev_AM]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A	LOS B	LOS C	LOS D	LOS E	LOS F

Delay model settings are specified for individual Sites forming the Network.

NETWORK SUMMARY

Network: N101 [2035_Low Dev_AM]

New Network
Network Category: (None)

Network Performance - Hourly Values						
Performance Measure	**Vehicles**		**Per Unit Distance**		**Persons**	
Network Level of Service (LOS)	LOS C					
Travel Time Index	7.39					
Speed Efficiency	0.76					
Congestion Coefficient	1.31					
Travel Speed (Average)	45.9	km/h			45.9	km/h
Travel Distance (Total)	1806.5	veh-km/h			2167.8	pers-km/h
Travel Time (Total)	39.4	veh-h/h			47.2	pers-h/h
Desired Speed	60.0	km/h				
Demand Flows (Total for all Sites)	3331	veh/h			3997	pers/h
Arrival Flows (Total for all Sites)	3329	veh/h			3995	pers/h
Demand Flows (Entry Total)	1708	veh/h				
Midblock Inflows (Total)	12	veh/h				
Midblock Outflows (Total)	-3	veh/h				
Percent Heavy Vehicles (Demand)	10.2	%				
Percent Heavy Vehicles (Arrival)	10.2	%				
Degree of Saturation	1.179					
Control Delay (Total)	5.84	veh-h/h			7.00	pers-h/h
Control Delay (Average)	6.3	sec			6.3	sec
Control Delay (Worst Lane)	392.5	sec				
Control Delay (Worst Movement)	409.7	sec			409.7	sec
Geometric Delay (Average)	0.4	sec				
Stop-Line Delay (Average)	5.9	sec				
Queue Storage Ratio (Worst Lane)	0.05					
Total Effective Stops	251	veh/h			301	pers/h
Effective Stop Rate	0.08		0.14	per km	0.08	
Proportion Queued	0.05				0.05	
Performance Index	64.7				64.7	
Cost (Total)	1028.07	$/h	0.57	$/km	1028.07	$/h
Fuel Consumption (Total)	163.3	L/h	90.4	mL/km		
Fuel Economy	9.0	L/100km				
Carbon Dioxide (Total)	393.4	kg/h	217.7	g/km		
Hydrocarbons (Total)	0.028	kg/h	0.016	g/km		
Carbon Monoxide (Total)	0.365	kg/h	0.202	g/km		
NOx (Total)	0.988	kg/h	0.547	g/km		

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: Standard Left.

Network Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total for all Sites)	1,598,653	veh/y	1,918,383	pers/y
Delay	2,802	veh-h/y	3,362	pers-h/y
Effective Stops	120,599	veh/y	144,718	pers/y
Travel Distance	867,138	veh-km/y	1,040,566	pers-km/y
Travel Time	18,894	veh-h/y	22,672	pers-h/y
Cost	493,474	$/y	493,474	$/y
Fuel Consumption	78,386	L/y		
Carbon Dioxide	188,808	kg/y		
Hydrocarbons	14	kg/y		
Carbon Monoxide	175	kg/y		
NOx	474	kg/y		

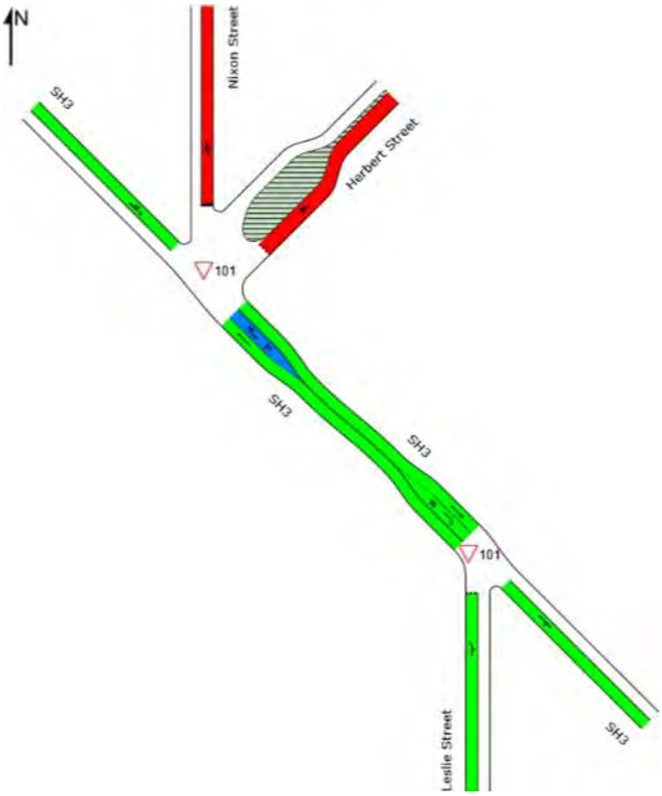
Organisation: TONKIN & TAYLOR | Processed: Tuesday, 4 June 2019 10:17:42 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Herbert SH3 Int & Leslie SH3 Int.sip8

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N101 [2035_Low Dev_PM]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A LOS B LOS C LOS D LOS E LOS F

Delay model settings are specified for individual Sites forming the Network.

Organisation: TONKIN & TAYLOR | Processed: Tuesday, 4 June 2019 10:17:45 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Herbert SH3 Int & Leslie SH3 Int.sip8

NETWORK SUMMARY

Network: N101 [2035_Low Dev_PM]

New Network
Network Category: (None)

Network Performance - Hourly Values						
Performance Measure	Vehicles		Per Unit Distance		Persons	
Network Level of Service (LOS)	LOS F					
Travel Time Index	2.16					
Speed Efficiency	0.29					
Congestion Coefficient	3.40					
Travel Speed (Average)	17.6	km/h			17.6	km/h
Travel Distance (Total)	1857.0	veh-km/h			2228.5	pers-km/h
Travel Time (Total)	105.3	veh-h/h			126.3	pers-h/h
Desired Speed	60.0	km/h				
Demand Flows (Total for all Sites)	3368	veh/h			4042	pers/h
Arrival Flows (Total for all Sites)	3357	veh/h			4029	pers/h
Demand Flows (Entry Total)	1765	veh/h				
Midblock Inflows (Total)	11	veh/h				
Midblock Outflows (Total)	-3	veh/h				
Percent Heavy Vehicles (Demand)	10.3	%				
Percent Heavy Vehicles (Arrival)	10.3	%				
Degree of Saturation	3.464					
Control Delay (Total)	68.54	veh-h/h			82.24	pers-h/h
Control Delay (Average)	73.5	sec			73.5	sec
Control Delay (Worst Lane)	2305.2	sec				
Control Delay (Worst Movement)	2310.6	sec			2310.6	sec
Geometric Delay (Average)	0.3	sec				
Stop-Line Delay (Average)	73.2	sec				
Queue Storage Ratio (Worst Lane)	0.32					
Total Effective Stops	357	veh/h			429	pers/h
Effective Stop Rate	0.11		0.19	per km	0.11	
Proportion Queued	0.04				0.04	
Performance Index	242.8				242.8	
Cost (Total)	3306.27	$/h	1.78	$/km	3306.27	$/h
Fuel Consumption (Total)	247.7	L/h	133.4	mL/km		
Fuel Economy	13.3	L/100km				
Carbon Dioxide (Total)	592.2	kg/h	318.9	g/km		
Hydrocarbons (Total)	0.053	kg/h	0.029	g/km		
Carbon Monoxide (Total)	0.499	kg/h	0.269	g/km		
NOx (Total)	1.073	kg/h	0.578	g/km		

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: Standard Left.

Network Performance - Annual Values				
Performance Measure	Vehicles		Persons	
Demand Flows (Total for all Sites)	1,616,842	veh/y	1,940,211	pers/y
Delay	32,898	veh-h/y	39,478	pers-h/y
Effective Stops	171,544	veh/y	205,852	pers/y
Travel Distance	891,380	veh-km/y	1,069,656	pers-km/y
Travel Time	50,526	veh-h/y	60,631	pers-h/y
Cost	1,587,009	$/y	1,587,009	$/y
Fuel Consumption	118,901	L/y		
Carbon Dioxide	284,235	kg/y		
Hydrocarbons	25	kg/y		
Carbon Monoxide	239	kg/y		
NOx	515	kg/y		

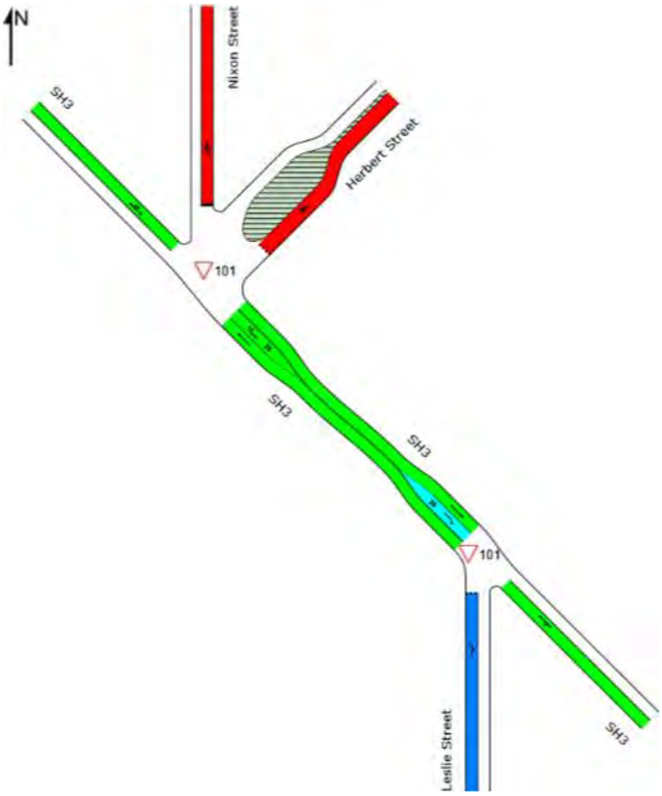
Organisation: TONKIN & TAYLOR | Processed: Tuesday, 4 June 2019 10:17:45 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Herbert SH3 Int & Leslie SH3 Int.sip8

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N101 [2035_Hi Dev_AM]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A	LOS B	LOS C	LOS D	LOS E	LOS F

Delay model settings are specified for individual Sites forming the Network.

Organisation: TONKIN & TAYLOR | Processed: Tuesday, 4 June 2019 10:17:47 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Herbert SH3 Int & Leslie SH3 Int.sip8

NETWORK SUMMARY

Network: N101 [2035_Hi Dev_AM]

New Network
Network Category: (None)

Network Performance - Hourly Values			
Performance Measure	**Vehicles**	**Per Unit Distance**	**Persons**
Network Level of Service (LOS)	LOS C		
Travel Time Index	7.02		
Speed Efficiency	0.73		
Congestion Coefficient	1.37		
Travel Speed (Average)	43.9 km/h		43.9 km/h
Travel Distance (Total)	1837.5 veh-km/h		2205.0 pers-km/h
Travel Time (Total)	41.9 veh-h/h		50.2 pers-h/h
Desired Speed	60.0 km/h		
Demand Flows (Total for all Sites)	3388 veh/h		4066 pers/h
Arrival Flows (Total for all Sites)	3387 veh/h		4064 pers/h
Demand Flows (Entry Total)	1733 veh/h		
Midblock Inflows (Total)	23 veh/h		
Midblock Outflows (Total)	-3 veh/h		
Percent Heavy Vehicles (Demand)	10.2 %		
Percent Heavy Vehicles (Arrival)	10.2 %		
Degree of Saturation	1.342		
Control Delay (Total)	7.60 veh-h/h		9.12 pers-h/h
Control Delay (Average)	8.1 sec		8.1 sec
Control Delay (Worst Lane)	523.3 sec		
Control Delay (Worst Movement)	540.2 sec		540.2 sec
Geometric Delay (Average)	0.4 sec		
Stop-Line Delay (Average)	7.7 sec		
Queue Storage Ratio (Worst Lane)	0.07		
Total Effective Stops	270 veh/h		325 pers/h
Effective Stop Rate	0.08	0.15 per km	0.08
Proportion Queued	0.05		0.05
Performance Index	74.4		74.4
Cost (Total)	1106.60 $/h	0.60 $/km	1106.60 $/h
Fuel Consumption (Total)	168.3 L/h	91.6 mL/km	
Fuel Economy	9.2 L/100km		
Carbon Dioxide (Total)	405.4 kg/h	220.6 g/km	
Hydrocarbons (Total)	0.029 kg/h	0.016 g/km	
Carbon Monoxide (Total)	0.375 kg/h	0.204 g/km	
NOx (Total)	1.005 kg/h	0.547 g/km	

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: Standard Left.

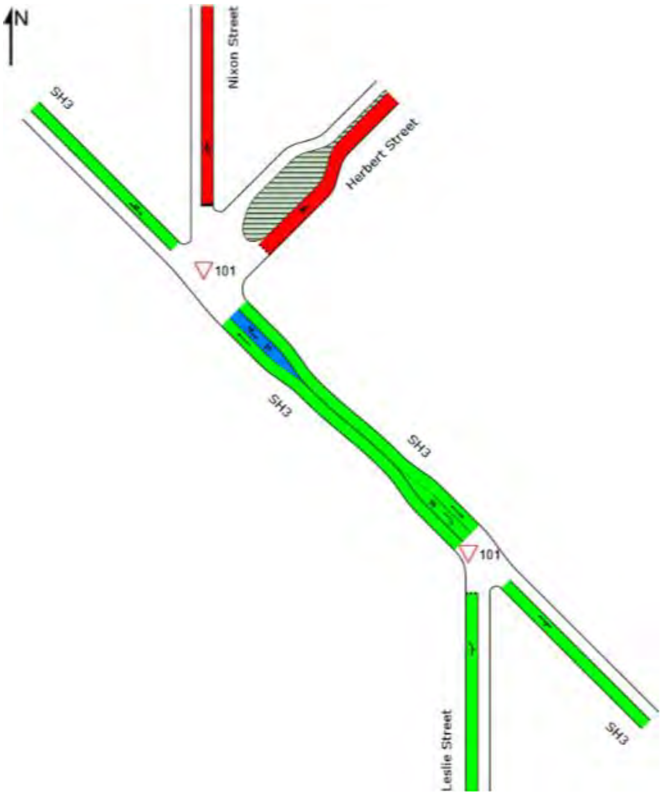
Network Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total for all Sites)	1,626,442 veh/y	1,951,731 pers/y
Delay	3,648 veh-h/y	4,378 pers-h/y
Effective Stops	129,835 veh/y	155,803 pers/y
Travel Distance	882,016 veh-km/y	1,058,419 pers-km/y
Travel Time	20,097 veh-h/y	24,116 pers-h/y
Cost	531,166 $/y	531,166 $/y
Fuel Consumption	80,800 L/y	
Carbon Dioxide	194,571 kg/y	
Hydrocarbons	14 kg/y	
Carbon Monoxide	180 kg/y	
NOx	482 kg/y	

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N101 [2035_Hi Dev_PM]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A LOS B LOS C LOS D LOS E LOS F

Delay model settings are specified for individual Sites forming the Network.

NETWORK SUMMARY

Network: N101 [2035_Hi Dev_PM]

New Network
Network Category: (None)

Network Performance - Hourly Values			
Performance Measure	**Vehicles**	**Per Unit Distance**	**Persons**
Network Level of Service (LOS)	LOS F		
Travel Time Index	2.03		
Speed Efficiency	0.28		
Congestion Coefficient	3.54		
Travel Speed (Average)	16.9 km/h		16.9 km/h
Travel Distance (Total)	1875.2 veh-km/h		2250.3 pers-km/h
Travel Time (Total)	110.7 veh-h/h		132.9 pers-h/h
Desired Speed	60.0 km/h		
Demand Flows (Total for all Sites)	3402 veh/h		4083 pers/h
Arrival Flows (Total for all Sites)	3391 veh/h		4069 pers/h
Demand Flows (Entry Total)	1783 veh/h		
Midblock Inflows (Total)	9 veh/h		
Midblock Outflows (Total)	-2 veh/h		
Percent Heavy Vehicles (Demand)	10.3 %		
Percent Heavy Vehicles (Arrival)	10.3 %		
Degree of Saturation	3.649		
Control Delay (Total)	73.49 veh-h/h		88.19 pers-h/h
Control Delay (Average)	78.0 sec		78.0 sec
Control Delay (Worst Lane)	2471.9 sec		
Control Delay (Worst Movement)	2477.4 sec		2477.4 sec
Geometric Delay (Average)	0.3 sec		
Stop-Line Delay (Average)	77.7 sec		
Queue Storage Ratio (Worst Lane)	0.33		
Total Effective Stops	358 veh/h		429 pers/h
Effective Stop Rate	0.11	0.19 per km	0.11
Proportion Queued	0.04		0.04
Performance Index	251.5		251.5
Cost (Total)	3489.16 $/h	1.86 $/km	3489.16 $/h
Fuel Consumption (Total)	255.5 L/h	136.2 mL/km	
Fuel Economy	13.6 L/100km		
Carbon Dioxide (Total)	610.5 kg/h	325.5 g/km	
Hydrocarbons (Total)	0.055 kg/h	0.029 g/km	
Carbon Monoxide (Total)	0.512 kg/h	0.273 g/km	
NOx (Total)	1.085 kg/h	0.579 g/km	

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: Standard Left.

Network Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total for all Sites)	1,633,011 veh/y	1,959,613 pers/y
Delay	35,275 veh-h/y	42,330 pers-h/y
Effective Stops	171,678 veh/y	206,014 pers/y
Travel Distance	900,115 veh-km/y	1,080,138 pers-km/y
Travel Time	53,144 veh-h/y	63,773 pers-h/y
Cost	1,674,799 $/y	1,674,799 $/y
Fuel Consumption	122,619 L/y	
Carbon Dioxide	293,023 kg/y	
Hydrocarbons	27 kg/y	
Carbon Monoxide	246 kg/y	
NOx	521 kg/y	

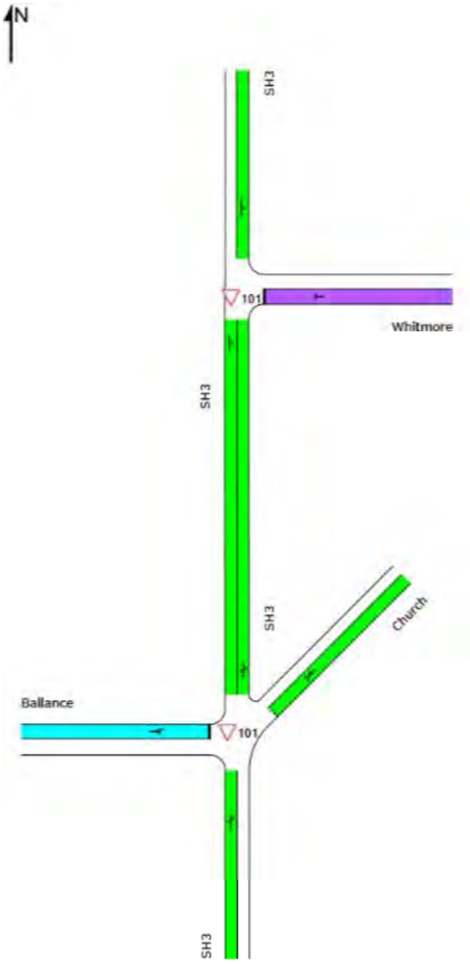
Organisation: TONKIN & TAYLOR | Processed: Tuesday, 4 June 2019 10:17:49 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Herbert SH3 Int & Leslie SH3 Int.sip8

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N101 [2018_Existing_AM]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A LOS B LOS C LOS D LOS E LOS F

Delay model settings are specified for individual Sites forming the Network.

Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 11:42:53 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Ballance SH3 Church Int & Whitmore SH3 Int.sip8

NETWORK SUMMARY

Network: N101 [2018_Existing_AM]

New Network
Network Category: (None)

Network Performance - Hourly Values			
Performance Measure	**Vehicles**	**Per Unit Distance**	**Persons**
Network Level of Service (LOS)	LOS A[3]		
Travel Time Index	11.02		
Speed Efficiency	1.09		
Congestion Coefficient	0.92		
Travel Speed (Average)	54.6 km/h		54.6 km/h
Travel Distance (Total)	1282.4 veh-km/h		1538.9 pers-km/h
Travel Time (Total)	23.5 veh-h/h		28.2 pers-h/h
Desired Speed	50.0 km/h		
Demand Flows (Total for all Sites)	2295 veh/h		2754 pers/h
Arrival Flows (Total for all Sites)	2295 veh/h		2754 pers/h
Demand Flows (Entry Total)	1292 veh/h		
Midblock Inflows (Total)	5 veh/h		
Midblock Outflows (Total)	-4 veh/h		
Percent Heavy Vehicles (Demand)	9.1 %		
Percent Heavy Vehicles (Arrival)	9.1 %		
Degree of Saturation	0.611		
Control Delay (Total)	1.95 veh-h/h		2.34 pers-h/h
Control Delay (Average)	3.1 sec		3.1 sec
Control Delay (Worst Lane)	26.2 sec		
Control Delay (Worst Movement)	26.3 sec		26.3 sec
Geometric Delay (Average)	1.2 sec		
Stop-Line Delay (Average)	1.8 sec		
Queue Storage Ratio (Worst Lane)	0.06		
Total Effective Stops	375 veh/h		450 pers/h
Effective Stop Rate	0.16	0.29 per km	0.16
Proportion Queued	0.15		0.15
Performance Index	33.7		33.7
Cost (Total)	660.43 $/h	0.52 $/km	660.43 $/h
Fuel Consumption (Total)	119.5 L/h	93.2 mL/km	
Fuel Economy	9.3 L/100km		
Carbon Dioxide (Total)	286.8 kg/h	223.7 g/km	
Hydrocarbons (Total)	0.022 kg/h	0.017 g/km	
Carbon Monoxide (Total)	0.307 kg/h	0.239 g/km	
NOx (Total)	0.704 kg/h	0.549 g/km	

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: New Zealand.

3 Calculated Average Speed exceeds the specified Desired Speed.

Network Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total for all Sites)	1,101,474 veh/y	1,321,768 pers/y
Delay	937 veh-h/y	1,124 pers-h/y
Effective Stops	179,885 veh/y	215,863 pers/y
Travel Distance	615,543 veh-km/y	738,652 pers-km/y
Travel Time	11,275 veh-h/y	13,530 pers-h/y
Cost	317,008 $/y	317,008 $/y
Fuel Consumption	57,353 L/y	
Carbon Dioxide	137,678 kg/y	
Hydrocarbons	11 kg/y	
Carbon Monoxide	147 kg/y	

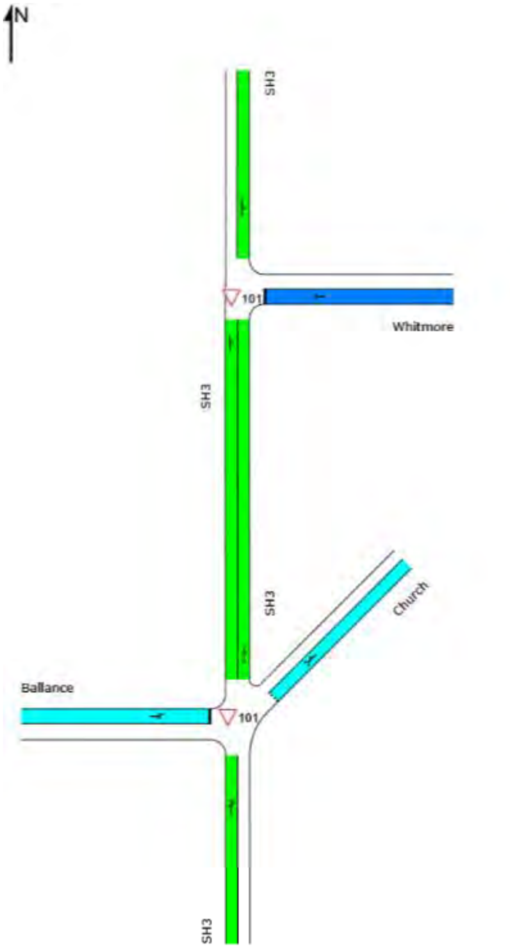
NOx	338 kg/y

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N101 [2018_Existing_PM]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A | LOS B | LOS C | LOS D | LOS E | LOS F

Delay model settings are specified for individual Sites forming the Network.

Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 11:42:56 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Ballance SH3 Church Int & Whitmore SH3 Int.sip8

NETWORK SUMMARY

Network: N101 [2018_Existing_PM]

New Network
Network Category: (None)

Network Performance - Hourly Values						
Performance Measure	**Vehicles**		**Per Unit Distance**		**Persons**	
Network Level of Service (LOS)	LOS A[3]					
Travel Time Index	11.20					
Speed Efficiency	1.11					
Congestion Coefficient	0.90					
Travel Speed (Average)	55.4	km/h			55.4	km/h
Travel Distance (Total)	1291.2	veh-km/h			1549.4	pers-km/h
Travel Time (Total)	23.3	veh-h/h			28.0	pers-h/h
Desired Speed	50.0	km/h				
Demand Flows (Total for all Sites)	2302	veh/h			2763	pers/h
Arrival Flows (Total for all Sites)	2302	veh/h			2763	pers/h
Demand Flows (Entry Total)	1301	veh/h				
Midblock Inflows (Total)	9	veh/h				
Midblock Outflows (Total)	-9	veh/h				
Percent Heavy Vehicles (Demand)	9.1	%				
Percent Heavy Vehicles (Arrival)	9.1	%				
Degree of Saturation	0.466					
Control Delay (Total)	1.54	veh-h/h			1.85	pers-h/h
Control Delay (Average)	2.4	sec			2.4	sec
Control Delay (Worst Lane)	23.4	sec				
Control Delay (Worst Movement)	23.5	sec			23.5	sec
Geometric Delay (Average)	1.2	sec				
Stop-Line Delay (Average)	1.3	sec				
Queue Storage Ratio (Worst Lane)	0.03					
Total Effective Stops	328	veh/h			394	pers/h
Effective Stop Rate	0.14		0.25	per km	0.14	
Proportion Queued	0.13				0.13	
Performance Index	31.1				31.1	
Cost (Total)	669.99	$/h	0.52	$/km	669.99	$/h
Fuel Consumption (Total)	120.4	L/h	93.2	mL/km		
Fuel Economy	9.3	L/100km				
Carbon Dioxide (Total)	288.9	kg/h	223.8	g/km		
Hydrocarbons (Total)	0.022	kg/h	0.017	g/km		
Carbon Monoxide (Total)	0.309	kg/h	0.239	g/km		
NOx (Total)	0.717	kg/h	0.555	g/km		

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: New Zealand.

3 Calculated Average Speed exceeds the specified Desired Speed.

Network Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total for all Sites)	1,105,011	veh/y	1,326,013	pers/y
Delay	740	veh-h/y	888	pers-h/y
Effective Stops	157,557	veh/y	189,069	pers/y
Travel Distance	619,760	veh-km/y	743,712	pers-km/y
Travel Time	11,187	veh-h/y	13,424	pers-h/y
Cost	321,596	$/y	321,596	$/y
Fuel Consumption	57,781	L/y		
Carbon Dioxide	138,676	kg/y		
Hydrocarbons	11	kg/y		
Carbon Monoxide	148	kg/y		

NOx	344 kg/y

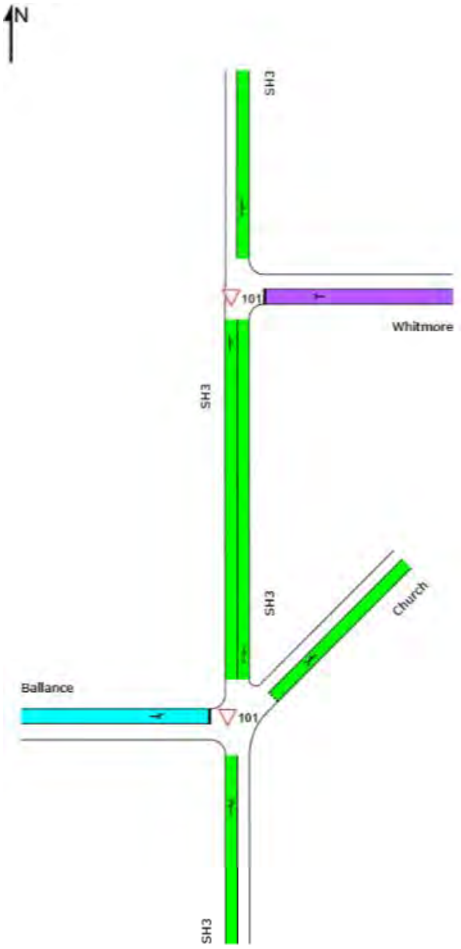
Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 11:42:56 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Ballance SH3 Church Int & Whitmore SH3 Int.sip8

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N101 [2018_Low Dev_AM]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A	LOS B	LOS C	LOS D	LOS E	LOS F

Delay model settings are specified for individual Sites forming the Network.

Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 11:42:58 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Ballance SH3 Church Int & Whitmore SH3 Int.sip8

NETWORK SUMMARY

Network: N101 [2018_Low Dev_AM]

New Network
Network Category: (None)

Network Performance - Hourly Values			
Performance Measure	**Vehicles**	**Per Unit Distance**	**Persons**
Network Level of Service (LOS)	LOS A[3]		
Travel Time Index	11.00		
Speed Efficiency	1.09		
Congestion Coefficient	0.92		
Travel Speed (Average)	54.5 km/h		54.5 km/h
Travel Distance (Total)	1300.2 veh-km/h		1560.2 pers-km/h
Travel Time (Total)	23.9 veh-h/h		28.6 pers-h/h
Desired Speed	50.0 km/h		
Demand Flows (Total for all Sites)	2325 veh/h		2790 pers/h
Arrival Flows (Total for all Sites)	2325 veh/h		2790 pers/h
Demand Flows (Entry Total)	1307 veh/h		
Midblock Inflows (Total)	6 veh/h		
Midblock Outflows (Total)	-4 veh/h		
Percent Heavy Vehicles (Demand)	9.1 %		
Percent Heavy Vehicles (Arrival)	9.1 %		
Degree of Saturation	0.629		
Control Delay (Total)	2.03 veh-h/h		2.44 pers-h/h
Control Delay (Average)	3.1 sec		3.1 sec
Control Delay (Worst Lane)	27.3 sec		
Control Delay (Worst Movement)	27.4 sec		27.4 sec
Geometric Delay (Average)	1.2 sec		
Stop-Line Delay (Average)	1.9 sec		
Queue Storage Ratio (Worst Lane)	0.07		
Total Effective Stops	381 veh/h		457 pers/h
Effective Stop Rate	0.16	0.29 per km	0.16
Proportion Queued	0.16		0.16
Performance Index	34.4		34.4
Cost (Total)	671.47 $/h	0.52 $/km	671.47 $/h
Fuel Consumption (Total)	121.2 L/h	93.2 mL/km	
Fuel Economy	9.3 L/100km		
Carbon Dioxide (Total)	291.0 kg/h	223.8 g/km	
Hydrocarbons (Total)	0.022 kg/h	0.017 g/km	
Carbon Monoxide (Total)	0.311 kg/h	0.239 g/km	
NOx (Total)	0.714 kg/h	0.549 g/km	

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: New Zealand.

3 Calculated Average Speed exceeds the specified Desired Speed.

Network Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total for all Sites)	1,116,126 veh/y	1,339,352 pers/y
Delay	976 veh-h/y	1,171 pers-h/y
Effective Stops	182,730 veh/y	219,276 pers/y
Travel Distance	624,079 veh-km/y	748,894 pers-km/y
Travel Time	11,455 veh-h/y	13,745 pers-h/y
Cost	322,304 $/y	322,304 $/y
Fuel Consumption	58,194 L/y	
Carbon Dioxide	139,699 kg/y	
Hydrocarbons	11 kg/y	
Carbon Monoxide	149 kg/y	

NOx	343 kg/y

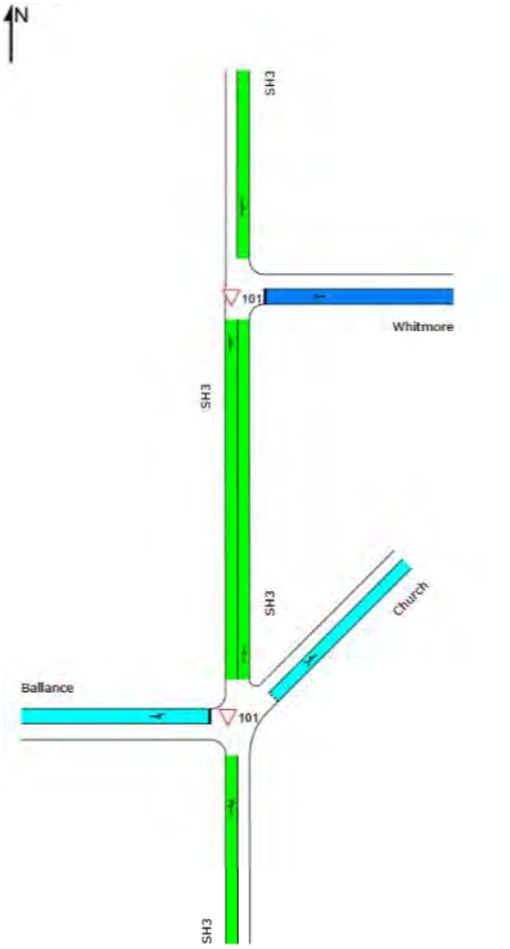
Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 11:42:58 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Ballance SH3 Church Int & Whitmore SH3 Int.sip8

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N101 [2018_Low Dev_PM]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A	LOS B	LOS C	LOS D	LOS E	LOS F

Delay model settings are specified for individual Sites forming the Network.

Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 11:43:00 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Ballance SH3 Church Int & Whitmore SH3 Int.sip8

NETWORK SUMMARY

Network: N101 [2018_Low Dev_PM]

New Network
Network Category: (None)

Network Performance - Hourly Values			
Performance Measure	**Vehicles**	**Per Unit Distance**	**Persons**
Network Level of Service (LOS)	LOS A[3]		
Travel Time Index	11.18		
Speed Efficiency	1.11		
Congestion Coefficient	0.90		
Travel Speed (Average)	55.3 km/h		55.3 km/h
Travel Distance (Total)	1317.9 veh-km/h		1581.5 pers-km/h
Travel Time (Total)	23.8 veh-h/h		28.6 pers-h/h
Desired Speed	50.0 km/h		
Demand Flows (Total for all Sites)	2351 veh/h		2821 pers/h
Arrival Flows (Total for all Sites)	2351 veh/h		2821 pers/h
Demand Flows (Entry Total)	1327 veh/h		
Midblock Inflows (Total)	6 veh/h		
Midblock Outflows (Total)	-9 veh/h		
Percent Heavy Vehicles (Demand)	9.1 %		
Percent Heavy Vehicles (Arrival)	9.1 %		
Degree of Saturation	0.476		
Control Delay (Total)	1.61 veh-h/h		1.94 pers-h/h
Control Delay (Average)	2.5 sec		2.5 sec
Control Delay (Worst Lane)	24.6 sec		
Control Delay (Worst Movement)	24.8 sec		24.8 sec
Geometric Delay (Average)	1.1 sec		
Stop-Line Delay (Average)	1.3 sec		
Queue Storage Ratio (Worst Lane)	0.03		
Total Effective Stops	332 veh/h		399 pers/h
Effective Stop Rate	0.14	0.25 per km	0.14
Proportion Queued	0.13		0.13
Performance Index	32.0		32.0
Cost (Total)	685.98 $/h	0.52 $/km	685.98 $/h
Fuel Consumption (Total)	123.0 L/h	93.4 mL/km	
Fuel Economy	9.3 L/100km		
Carbon Dioxide (Total)	295.3 kg/h	224.1 g/km	
Hydrocarbons (Total)	0.023 kg/h	0.017 g/km	
Carbon Monoxide (Total)	0.315 kg/h	0.239 g/km	
NOx (Total)	0.736 kg/h	0.558 g/km	

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: New Zealand.

3 Calculated Average Speed exceeds the specified Desired Speed.

Network Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total for all Sites)	1,128,253 veh/y	1,353,903 pers/y
Delay	774 veh-h/y	929 pers-h/y
Effective Stops	159,483 veh/y	191,380 pers/y
Travel Distance	632,602 veh-km/y	759,122 pers-km/y
Travel Time	11,435 veh-h/y	13,722 pers-h/y
Cost	329,268 $/y	329,268 $/y
Fuel Consumption	59,063 L/y	
Carbon Dioxide	141,760 kg/y	
Hydrocarbons	11 kg/y	
Carbon Monoxide	151 kg/y	

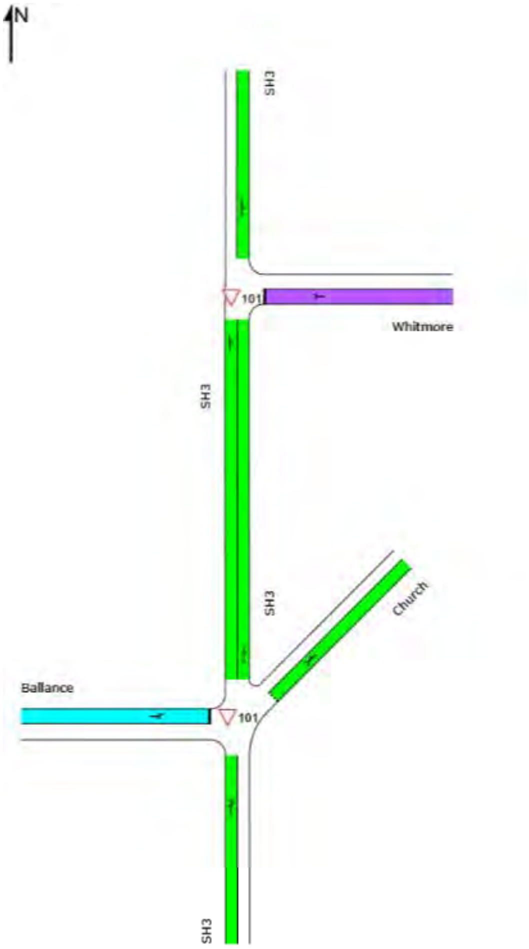
NOx	353 kg/y

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N101 [2018_Hi Dev_AM]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A	LOS B	LOS C	LOS D	LOS E	LOS F

Delay model settings are specified for individual Sites forming the Network.

Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 11:43:02 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Ballance SH3 Church Int & Whitmore SH3 Int.sip8

NETWORK SUMMARY

Network: N101 [2018_Hi Dev_AM]

New Network
Network Category: (None)

Network Performance - Hourly Values			
Performance Measure	Vehicles	Per Unit Distance	Persons
Network Level of Service (LOS)	LOS A[3]		
Travel Time Index	10.96		
Speed Efficiency	1.09		
Congestion Coefficient	0.92		
Travel Speed (Average)	54.3 km/h		54.3 km/h
Travel Distance (Total)	1319.0 veh-km/h		1582.8 pers-km/h
Travel Time (Total)	24.3 veh-h/h		29.1 pers-h/h
Desired Speed	50.0 km/h		
Demand Flows (Total for all Sites)	2357 veh/h		2828 pers/h
Arrival Flows (Total for all Sites)	2357 veh/h		2828 pers/h
Demand Flows (Entry Total)	1323 veh/h		
Midblock Inflows (Total)	15 veh/h		
Midblock Outflows (Total)	-4 veh/h		
Percent Heavy Vehicles (Demand)	9.1 %		
Percent Heavy Vehicles (Arrival)	9.1 %		
Degree of Saturation	0.649		
Control Delay (Total)	2.14 veh-h/h		2.57 pers-h/h
Control Delay (Average)	3.3 sec		3.3 sec
Control Delay (Worst Lane)	28.5 sec		
Control Delay (Worst Movement)	28.7 sec		28.7 sec
Geometric Delay (Average)	1.3 sec		
Stop-Line Delay (Average)	2.0 sec		
Queue Storage Ratio (Worst Lane)	0.07		
Total Effective Stops	392 veh/h		470 pers/h
Effective Stop Rate	0.17	0.30 per km	0.17
Proportion Queued	0.16		0.16
Performance Index	35.4		35.4
Cost (Total)	684.91 $/h	0.52 $/km	684.91 $/h
Fuel Consumption (Total)	123.3 L/h	93.5 mL/km	
Fuel Economy	9.3 L/100km		
Carbon Dioxide (Total)	296.0 kg/h	224.4 g/km	
Hydrocarbons (Total)	0.023 kg/h	0.017 g/km	
Carbon Monoxide (Total)	0.316 kg/h	0.240 g/km	
NOx (Total)	0.726 kg/h	0.550 g/km	

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: New Zealand.

3 Calculated Average Speed exceeds the specified Desired Speed.

Network Performance - Annual Values		
Performance Measure	Vehicles	Persons
Demand Flows (Total for all Sites)	1,131,284 veh/y	1,357,541 pers/y
Delay	1,030 veh-h/y	1,235 pers-h/y
Effective Stops	188,048 veh/y	225,658 pers/y
Travel Distance	633,113 veh-km/y	759,736 pers-km/y
Travel Time	11,659 veh-h/y	13,990 pers-h/y
Cost	328,755 $/y	328,755 $/y
Fuel Consumption	59,190 L/y	
Carbon Dioxide	142,081 kg/y	
Hydrocarbons	11 kg/y	
Carbon Monoxide	152 kg/y	

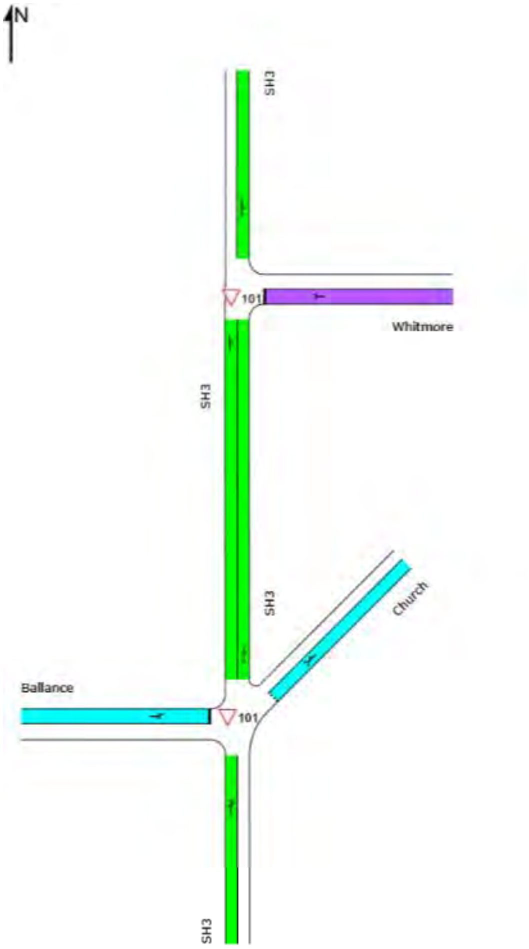
NOx	348 kg/y

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N101 [2018_Hi Dev_PM]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A LOS B LOS C LOS D LOS E LOS F

Delay model settings are specified for individual Sites forming the Network.

Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 11:43:05 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Ballance SH3 Church Int & Whitmore SH3 Int.sip8

NETWORK SUMMARY

Network: N101 [2018_Hi Dev_PM]

New Network
Network Category: (None)

Network Performance - Hourly Values			
Performance Measure	**Vehicles**	**Per Unit Distance**	**Persons**
Network Level of Service (LOS)	LOS A[3]		
Travel Time Index	11.17		
Speed Efficiency	1.11		
Congestion Coefficient	0.90		
Travel Speed (Average)	55.3 km/h		55.3 km/h
Travel Distance (Total)	1345.5 veh-km/h		1614.5 pers-km/h
Travel Time (Total)	24.3 veh-h/h		29.2 pers-h/h
Desired Speed	50.0 km/h		
Demand Flows (Total for all Sites)	2398 veh/h		2877 pers/h
Arrival Flows (Total for all Sites)	2398 veh/h		2877 pers/h
Demand Flows (Entry Total)	1353 veh/h		
Midblock Inflows (Total)	5 veh/h		
Midblock Outflows (Total)	-9 veh/h		
Percent Heavy Vehicles (Demand)	9.2 %		
Percent Heavy Vehicles (Arrival)	9.2 %		
Degree of Saturation	0.487		
Control Delay (Total)	1.68 veh-h/h		2.01 pers-h/h
Control Delay (Average)	2.5 sec		2.5 sec
Control Delay (Worst Lane)	26.0 sec		
Control Delay (Worst Movement)	26.1 sec		26.1 sec
Geometric Delay (Average)	1.1 sec		
Stop-Line Delay (Average)	1.4 sec		
Queue Storage Ratio (Worst Lane)	0.03		
Total Effective Stops	335 veh/h		402 pers/h
Effective Stop Rate	0.14	0.25 per km	0.14
Proportion Queued	0.13		0.13
Performance Index	32.9		32.9
Cost (Total)	700.41 $/h	0.52 $/km	700.41 $/h
Fuel Consumption (Total)	125.6 L/h	93.3 mL/km	
Fuel Economy	9.3 L/100km		
Carbon Dioxide (Total)	301.4 kg/h	224.0 g/km	
Hydrocarbons (Total)	0.023 kg/h	0.017 g/km	
Carbon Monoxide (Total)	0.322 kg/h	0.239 g/km	
NOx (Total)	0.752 kg/h	0.559 g/km	

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: New Zealand.

3 Calculated Average Speed exceeds the specified Desired Speed.

Network Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total for all Sites)	1,150,990 veh/y	1,381,187 pers/y
Delay	805 veh-h/y	966 pers-h/y
Effective Stops	160,996 veh/y	193,195 pers/y
Travel Distance	645,816 veh-km/y	774,980 pers-km/y
Travel Time	11,685 veh-h/y	14,022 pers-h/y
Cost	336,195 $/y	336,195 $/y
Fuel Consumption	60,267 L/y	
Carbon Dioxide	144,661 kg/y	
Hydrocarbons	11 kg/y	
Carbon Monoxide	155 kg/y	

NOx	361 kg/y

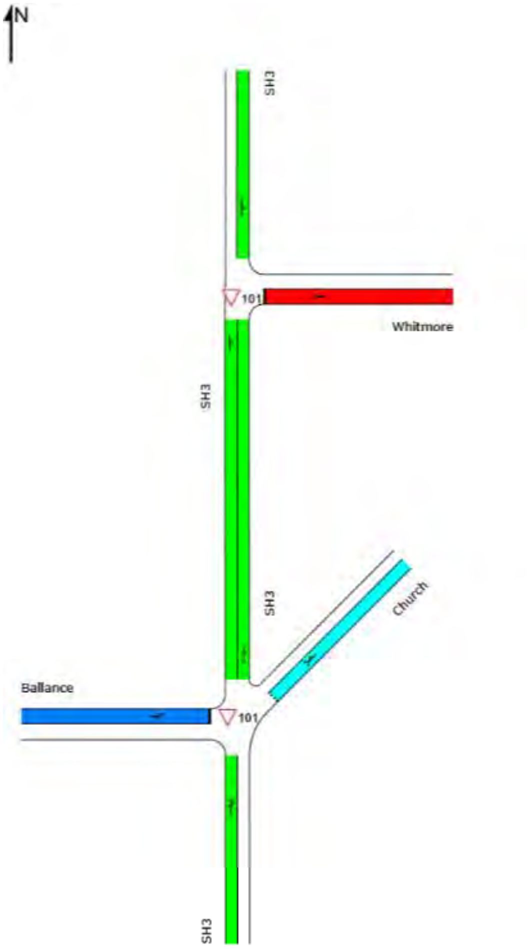
Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 11:43:05 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Ballance SH3 Church Int & Whitmore SH3 Int.sip8

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N101 [2035_No Dev_AM]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A	LOS B	LOS C	LOS D	LOS E	LOS F

Delay model settings are specified for individual Sites forming the Network.

Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 11:43:07 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Ballance SH3 Church Int & Whitmore SH3 Int.sip8

NETWORK SUMMARY

Network: N101 [2035_No Dev_AM]

New Network
Network Category: (None)

Network Performance - Hourly Values						
Performance Measure	Vehicles		Per Unit Distance		Persons	
Network Level of Service (LOS)	LOS E					
Travel Time Index	3.71					
Speed Efficiency	0.43					
Congestion Coefficient	2.30					
Travel Speed (Average)	21.7	km/h			21.7	km/h
Travel Distance (Total)	1716.6	veh-km/h			2059.9	pers-km/h
Travel Time (Total)	79.1	veh-h/h			94.9	pers-h/h
Desired Speed	50.0	km/h				
Demand Flows (Total for all Sites)	3074	veh/h			3688	pers/h
Arrival Flows (Total for all Sites)	3073	veh/h			3687	pers/h
Demand Flows (Entry Total)	1729	veh/h				
Midblock Inflows (Total)	7	veh/h				
Midblock Outflows (Total)	-6	veh/h				
Percent Heavy Vehicles (Demand)	9.1	%				
Percent Heavy Vehicles (Arrival)	9.1	%				
Degree of Saturation	1.782					
Control Delay (Total)	49.51	veh-h/h			59.41	pers-h/h
Control Delay (Average)	58.0	sec			58.0	sec
Control Delay (Worst Lane)	742.4	sec				
Control Delay (Worst Movement)	742.5	sec			742.5	sec
Geometric Delay (Average)	1.2	sec				
Stop-Line Delay (Average)	56.8	sec				
Queue Storage Ratio (Worst Lane)	1.59					
Total Effective Stops	1260	veh/h			1512	pers/h
Effective Stop Rate	0.41		0.73	per km	0.41	
Proportion Queued	0.20				0.20	
Performance Index	206.5				206.5	
Cost (Total)	2533.61	$/h	1.48	$/km	2533.61	$/h
Fuel Consumption (Total)	223.4	L/h	130.1	mL/km		
Fuel Economy	13.0	L/100km				
Carbon Dioxide (Total)	533.3	kg/h	310.7	g/km		
Hydrocarbons (Total)	0.048	kg/h	0.028	g/km		
Carbon Monoxide (Total)	0.509	kg/h	0.297	g/km		
NOx (Total)	1.030	kg/h	0.600	g/km		

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: New Zealand.

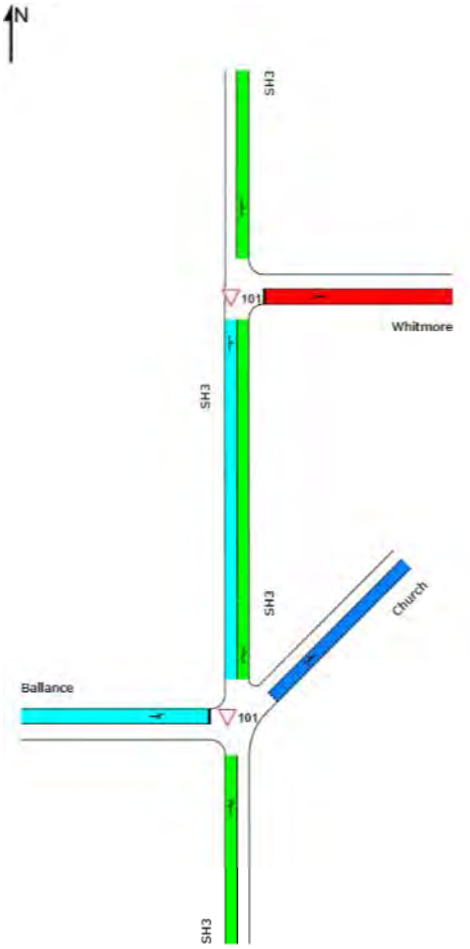
Network Performance - Annual Values				
Performance Measure	Vehicles		Persons	
Demand Flows (Total for all Sites)	1,475,369	veh/y	1,770,442	pers/y
Delay	23,765	veh-h/y	28,518	pers-h/y
Effective Stops	604,869	veh/y	725,842	pers/y
Travel Distance	823,948	veh-km/y	988,737	pers-km/y
Travel Time	37,979	veh-h/y	45,575	pers-h/y
Cost	1,216,134	$/y	1,216,134	$/y
Fuel Consumption	107,227	L/y		
Carbon Dioxide	256,004	kg/y		
Hydrocarbons	23	kg/y		
Carbon Monoxide	244	kg/y		
NOx	494	kg/y		

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N101 [2035_No Dev_PM]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A	LOS B	LOS C	LOS D	LOS E	LOS F

Delay model settings are specified for individual Sites forming the Network.

Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 11:43:10 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Ballance SH3 Church Int & Whitmore SH3 Int.sip8

NETWORK SUMMARY

Network: N101 [2035_No Dev_PM]

New Network
Network Category: (None)

Network Performance - Hourly Values						
Performance Measure	**Vehicles**		**Per Unit Distance**		**Persons**	
Network Level of Service (LOS)	LOS A					
Travel Time Index	8.97					
Speed Efficiency	0.91					
Congestion Coefficient	1.10					
Travel Speed (Average)	45.3	km/h			45.3	km/h
Travel Distance (Total)	1729.5	veh-km/h			2075.5	pers-km/h
Travel Time (Total)	38.1	veh-h/h			45.8	pers-h/h
Desired Speed	50.0	km/h				
Demand Flows (Total for all Sites)	3084	veh/h			3701	pers/h
Arrival Flows (Total for all Sites)	3084	veh/h			3701	pers/h
Demand Flows (Entry Total)	1743	veh/h				
Midblock Inflows (Total)	11	veh/h				
Midblock Outflows (Total)	-12	veh/h				
Percent Heavy Vehicles (Demand)	9.1	%				
Percent Heavy Vehicles (Arrival)	9.1	%				
Degree of Saturation	1.121					
Control Delay (Total)	8.90	veh-h/h			10.68	pers-h/h
Control Delay (Average)	10.4	sec			10.4	sec
Control Delay (Worst Lane)	214.2	sec				
Control Delay (Worst Movement)	214.4	sec			214.4	sec
Geometric Delay (Average)	1.2	sec				
Stop-Line Delay (Average)	9.2	sec				
Queue Storage Ratio (Worst Lane)	0.28					
Total Effective Stops	552	veh/h			662	pers/h
Effective Stop Rate	0.18		0.32	per km	0.18	
Proportion Queued	0.19				0.19	
Performance Index	73.5				73.5	
Cost (Total)	1160.57	$/h	0.67	$/km	1160.57	$/h
Fuel Consumption (Total)	175.7	L/h	101.6	mL/km		
Fuel Economy	10.2	L/100km				
Carbon Dioxide (Total)	421.2	kg/h	243.6	g/km		
Hydrocarbons (Total)	0.034	kg/h	0.019	g/km		
Carbon Monoxide (Total)	0.439	kg/h	0.254	g/km		
NOx (Total)	1.041	kg/h	0.602	g/km		

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: New Zealand.

Network Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total for all Sites)	1,480,421	veh/y	1,776,505	pers/y
Delay	4,272	veh-h/y	5,127	pers-h/y
Effective Stops	264,730	veh/y	317,675	pers/y
Travel Distance	830,180	veh-km/y	996,216	pers-km/y
Travel Time	18,307	veh-h/y	21,968	pers-h/y
Cost	557,074	$/y	557,074	$/y
Fuel Consumption	84,349	L/y		
Carbon Dioxide	202,194	kg/y		
Hydrocarbons	16	kg/y		
Carbon Monoxide	211	kg/y		
NOx	499	kg/y		

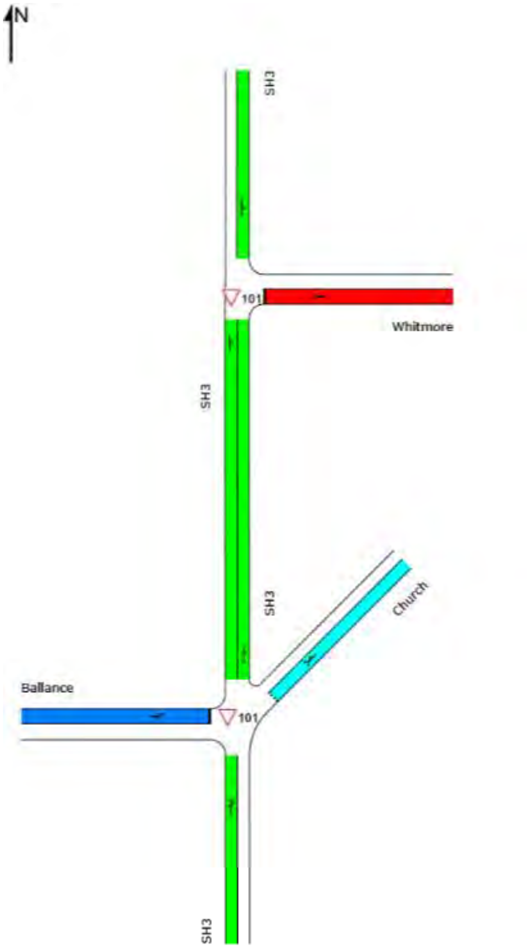
Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 11:43:10 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Ballance SH3 Church Int & Whitmore SH3 Int.sip8

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N101 [2035_Low Dev_AM]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A	LOS B	LOS C	LOS D	LOS E	LOS F

Delay model settings are specified for individual Sites forming the Network.

Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 11:43:12 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Ballance SH3 Church Int & Whitmore SH3 Int.sip8

NETWORK SUMMARY

Network: N101 [2035_Low Dev_AM]

New Network
Network Category: (None)

Network Performance - Hourly Values			
Performance Measure	**Vehicles**	**Per Unit Distance**	**Persons**
Network Level of Service (LOS)	LOS E		
Travel Time Index	3.50		
Speed Efficiency	0.41		
Congestion Coefficient	2.41		
Travel Speed (Average)	20.7 km/h		20.7 km/h
Travel Distance (Total)	1733.4 veh-km/h		2080.1 pers-km/h
Travel Time (Total)	83.6 veh-h/h		100.3 pers-h/h
Desired Speed	50.0 km/h		
Demand Flows (Total for all Sites)	3104 veh/h		3725 pers/h
Arrival Flows (Total for all Sites)	3103 veh/h		3724 pers/h
Demand Flows (Entry Total)	1745 veh/h		
Midblock Inflows (Total)	7 veh/h		
Midblock Outflows (Total)	-6 veh/h		
Percent Heavy Vehicles (Demand)	9.1 %		
Percent Heavy Vehicles (Arrival)	9.1 %		
Degree of Saturation	1.852		
Control Delay (Total)	53.64 veh-h/h		64.37 pers-h/h
Control Delay (Average)	62.2 sec		62.2 sec
Control Delay (Worst Lane)	805.3 sec		
Control Delay (Worst Movement)	805.4 sec		805.4 sec
Geometric Delay (Average)	1.2 sec		
Stop-Line Delay (Average)	61.0 sec		
Queue Storage Ratio (Worst Lane)	1.67		
Total Effective Stops	1274 veh/h		1528 pers/h
Effective Stop Rate	0.41	0.73 per km	0.41
Proportion Queued	0.20		0.20
Performance Index	216.4		216.4
Cost (Total)	2685.57 $/h	1.55 $/km	2685.57 $/h
Fuel Consumption (Total)	230.2 L/h	132.8 mL/km	
Fuel Economy	13.3 L/100km		
Carbon Dioxide (Total)	549.5 kg/h	317.0 g/km	
Hydrocarbons (Total)	0.050 kg/h	0.029 g/km	
Carbon Monoxide (Total)	0.521 kg/h	0.301 g/km	
NOx (Total)	1.045 kg/h	0.603 g/km	

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: New Zealand.

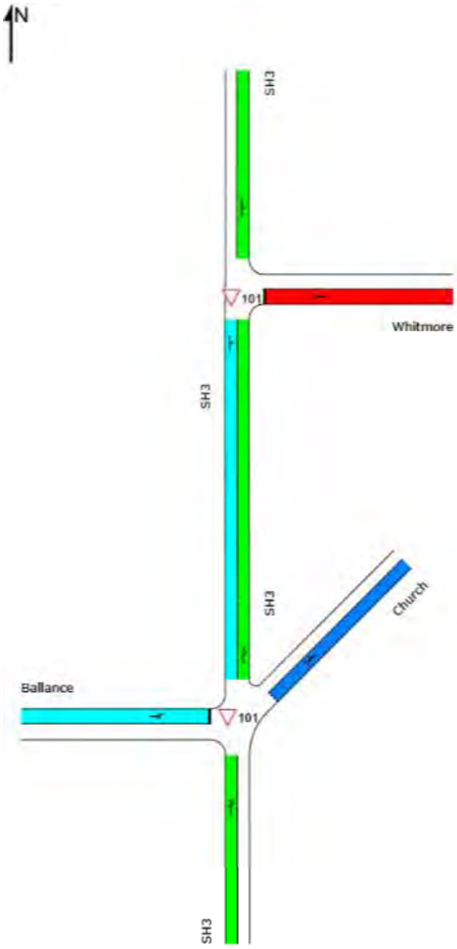
Network Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total for all Sites)	1,490,021 veh/y	1,788,025 pers/y
Delay	25,746 veh-h/y	30,896 pers-h/y
Effective Stops	611,349 veh/y	733,619 pers/y
Travel Distance	832,031 veh-km/y	998,438 pers-km/y
Travel Time	40,129 veh-h/y	48,155 pers-h/y
Cost	1,289,075 $/y	1,289,075 $/y
Fuel Consumption	110,508 L/y	
Carbon Dioxide	263,764 kg/y	
Hydrocarbons	24 kg/y	
Carbon Monoxide	250 kg/y	
NOx	501 kg/y	

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N101 [2035_Low Dev_PM]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A	LOS B	LOS C	LOS D	LOS E	LOS F

Delay model settings are specified for individual Sites forming the Network.

Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 11:43:14 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Ballance SH3 Church Int & Whitmore SH3 Int.sip8

NETWORK SUMMARY

Network: N101 [2035_Low Dev_PM]

New Network
Network Category: (None)

Network Performance - Hourly Values			
Performance Measure	Vehicles	Per Unit Distance	Persons
Network Level of Service (LOS)	LOS B		
Travel Time Index	8.42		
Speed Efficiency	0.86		
Congestion Coefficient	1.17		
Travel Speed (Average)	42.9 km/h		42.9 km/h
Travel Distance (Total)	1757.4 veh-km/h		2108.9 pers-km/h
Travel Time (Total)	41.0 veh-h/h		49.1 pers-h/h
Desired Speed	50.0 km/h		
Demand Flows (Total for all Sites)	3134 veh/h		3760 pers/h
Arrival Flows (Total for all Sites)	3134 veh/h		3760 pers/h
Demand Flows (Entry Total)	1769 veh/h		
Midblock Inflows (Total)	10 veh/h		
Midblock Outflows (Total)	-12 veh/h		
Percent Heavy Vehicles (Demand)	9.1 %		
Percent Heavy Vehicles (Arrival)	9.1 %		
Degree of Saturation	1.211		
Control Delay (Total)	11.16 veh-h/h		13.39 pers-h/h
Control Delay (Average)	12.8 sec		12.8 sec
Control Delay (Worst Lane)	283.7 sec		
Control Delay (Worst Movement)	283.9 sec		283.9 sec
Geometric Delay (Average)	1.1 sec		
Stop-Line Delay (Average)	11.7 sec		
Queue Storage Ratio (Worst Lane)	0.37		
Total Effective Stops	581 veh/h		697 pers/h
Effective Stop Rate	0.19	0.33 per km	0.19
Proportion Queued	0.19		0.19
Performance Index	83.8		83.8
Cost (Total)	1256.28 $/h	0.71 $/km	1256.28 $/h
Fuel Consumption (Total)	181.7 L/h	103.4 mL/km	
Fuel Economy	10.3 L/100km		
Carbon Dioxide (Total)	435.4 kg/h	247.7 g/km	
Hydrocarbons (Total)	0.035 kg/h	0.020 g/km	
Carbon Monoxide (Total)	0.452 kg/h	0.257 g/km	
NOx (Total)	1.066 kg/h	0.606 g/km	

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: New Zealand.

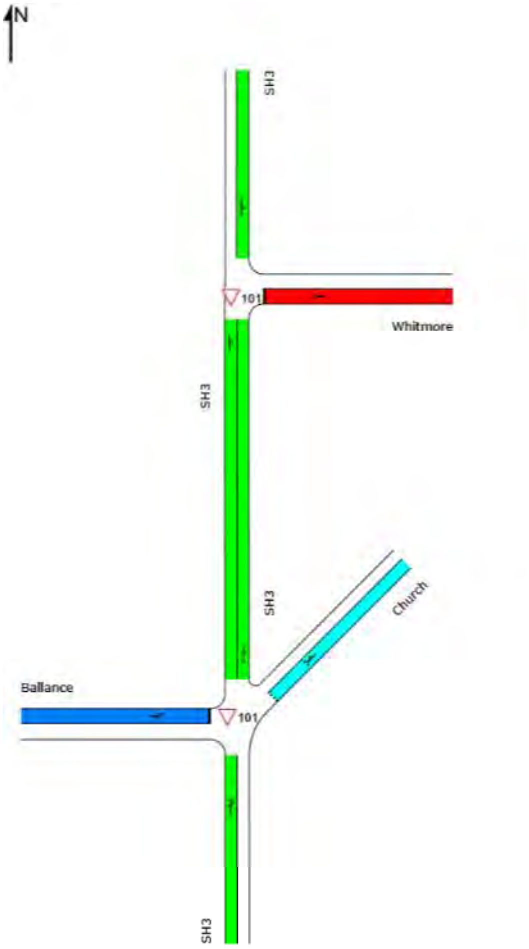
Network Performance - Annual Values		
Performance Measure	Vehicles	Persons
Demand Flows (Total for all Sites)	1,504,169 veh/y	1,805,002 pers/y
Delay	5,356 veh-h/y	6,427 pers-h/y
Effective Stops	278,724 veh/y	334,469 pers/y
Travel Distance	843,568 veh-km/y	1,012,281 pers-km/y
Travel Time	19,658 veh-h/y	23,590 pers-h/y
Cost	603,016 $/y	603,016 $/y
Fuel Consumption	87,205 L/y	
Carbon Dioxide	208,989 kg/y	
Hydrocarbons	17 kg/y	
Carbon Monoxide	217 kg/y	
NOx	511 kg/y	

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N101 [2035_Hi Dev_AM]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A	LOS B	LOS C	LOS D	LOS E	LOS F

Delay model settings are specified for individual Sites forming the Network.

Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 11:43:16 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Ballance SH3 Church Int & Whitmore SH3 Int.sip8

NETWORK SUMMARY

Network: N101 [2035_Hi Dev_AM]

New Network
Network Category: (None)

Network Performance - Hourly Values			
Performance Measure	**Vehicles**	**Per Unit Distance**	**Persons**
Network Level of Service (LOS)	LOS E		
Travel Time Index	3.25		
Speed Efficiency	0.39		
Congestion Coefficient	2.54		
Travel Speed (Average)	19.6 km/h		19.6 km/h
Travel Distance (Total)	1752.6 veh-km/h		2103.2 pers-km/h
Travel Time (Total)	89.2 veh-h/h		107.0 pers-h/h
Desired Speed	50.0 km/h		
Demand Flows (Total for all Sites)	3139 veh/h		3767 pers/h
Arrival Flows (Total for all Sites)	3138 veh/h		3766 pers/h
Demand Flows (Entry Total)	1764 veh/h		
Midblock Inflows (Total)	6 veh/h		
Midblock Outflows (Total)	-6 veh/h		
Percent Heavy Vehicles (Demand)	9.1 %		
Percent Heavy Vehicles (Arrival)	9.1 %		
Degree of Saturation	1.940		
Control Delay (Total)	58.83 veh-h/h		70.60 pers-h/h
Control Delay (Average)	67.5 sec		67.5 sec
Control Delay (Worst Lane)	884.2 sec		
Control Delay (Worst Movement)	884.4 sec		884.4 sec
Geometric Delay (Average)	1.3 sec		
Stop-Line Delay (Average)	66.2 sec		
Queue Storage Ratio (Worst Lane)	1.75		
Total Effective Stops	1288 veh/h		1546 pers/h
Effective Stop Rate	0.41	0.74 per km	0.41
Proportion Queued	0.20		0.20
Performance Index	228.5		228.5
Cost (Total)	2877.36 $/h	1.64 $/km	2877.36 $/h
Fuel Consumption (Total)	238.9 L/h	136.3 mL/km	
Fuel Economy	13.6 L/100km		
Carbon Dioxide (Total)	570.0 kg/h	325.2 g/km	
Hydrocarbons (Total)	0.053 kg/h	0.030 g/km	
Carbon Monoxide (Total)	0.537 kg/h	0.306 g/km	
NOx (Total)	1.064 kg/h	0.607 g/km	

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: New Zealand.

Network Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total for all Sites)	1,506,695 veh/y	1,808,034 pers/y
Delay	28,240 veh-h/y	33,888 pers-h/y
Effective Stops	618,479 veh/y	742,175 pers/y
Travel Distance	841,266 veh-km/y	1,009,519 pers-km/y
Travel Time	42,820 veh-h/y	51,383 pers-h/y
Cost	1,381,131 $/y	1,381,131 $/y
Fuel Consumption	114,667 L/y	
Carbon Dioxide	273,593 kg/y	
Hydrocarbons	25 kg/y	
Carbon Monoxide	258 kg/y	
NOx	511 kg/y	

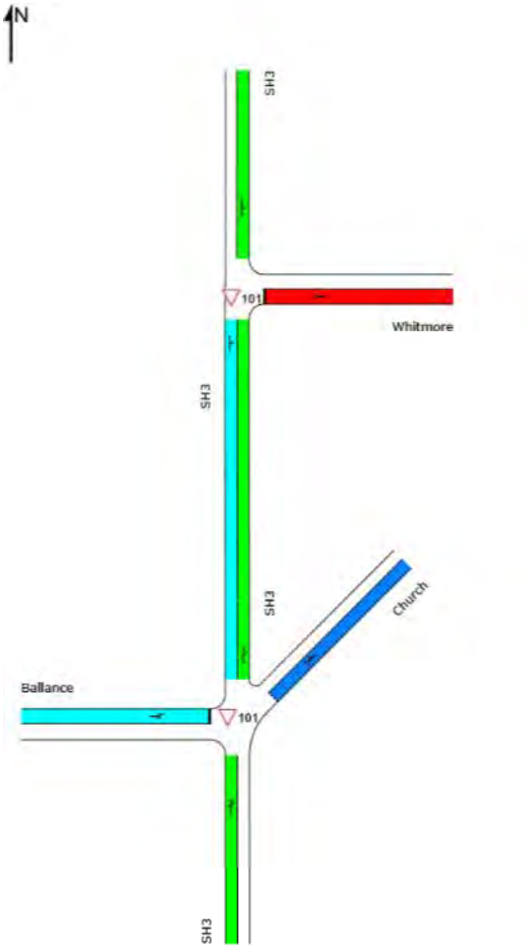
Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 11:43:16 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Ballance SH3 Church Int & Whitmore SH3 Int.sip8

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N101 [2035_Hi Dev_PM]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A	LOS B	LOS C	LOS D	LOS E	LOS F

Delay model settings are specified for individual Sites forming the Network.

Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 11:43:18 AM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_Ballance SH3 Church Int & Whitmore SH3 Int.sip8

NETWORK SUMMARY

Network: N101 [2035_Hi Dev_PM]

New Network
Network Category: (None)

Network Performance - Hourly Values						
Performance Measure	Vehicles		Per Unit Distance		Persons	
Network Level of Service (LOS)	LOS C					
Travel Time Index	7.70					
Speed Efficiency	0.79					
Congestion Coefficient	1.26					
Travel Speed (Average)	39.6	km/h			39.6	km/h
Travel Distance (Total)	1786.3	veh-km/h			2143.6	pers-km/h
Travel Time (Total)	45.1	veh-h/h			54.1	pers-h/h
Desired Speed	50.0	km/h				
Demand Flows (Total for all Sites)	3186	veh/h			3824	pers/h
Arrival Flows (Total for all Sites)	3186	veh/h			3823	pers/h
Demand Flows (Entry Total)	1801	veh/h				
Midblock Inflows (Total)	3	veh/h				
Midblock Outflows (Total)	-13	veh/h				
Percent Heavy Vehicles (Demand)	9.1	%				
Percent Heavy Vehicles (Arrival)	9.1	%				
Degree of Saturation	1.342					
Control Delay (Total)	14.67	veh-h/h			17.60	pers-h/h
Control Delay (Average)	16.6	sec			16.6	sec
Control Delay (Worst Lane)	393.2	sec				
Control Delay (Worst Movement)	393.5	sec			393.5	sec
Geometric Delay (Average)	1.1	sec				
Stop-Line Delay (Average)	15.4	sec				
Queue Storage Ratio (Worst Lane)	0.49					
Total Effective Stops	620	veh/h			744	pers/h
Effective Stop Rate	0.19		0.35	per km	0.19	
Proportion Queued	0.24				0.24	
Performance Index	100.8				100.8	
Cost (Total)	1420.00	$/h	0.79	$/km	1420.00	$/h
Fuel Consumption (Total)	194.3	L/h	108.8	mL/km		
Fuel Economy	10.9	L/100km				
Carbon Dioxide (Total)	465.5	kg/h	260.6	g/km		
Hydrocarbons (Total)	0.038	kg/h	0.021	g/km		
Carbon Monoxide (Total)	0.476	kg/h	0.266	g/km		
NOx (Total)	1.156	kg/h	0.647	g/km		

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: New Zealand.

Network Performance - Annual Values				
Performance Measure	Vehicles		Persons	
Demand Flows (Total for all Sites)	1,529,432	veh/y	1,835,318	pers/y
Delay	7,041	veh-h/y	8,449	pers-h/y
Effective Stops	297,633	veh/y	357,160	pers/y
Travel Distance	857,434	veh-km/y	1,028,921	pers-km/y
Travel Time	21,637	veh-h/y	25,964	pers-h/y
Cost	681,599	$/y	681,599	$/y
Fuel Consumption	93,283	L/y		
Carbon Dioxide	223,421	kg/y		
Hydrocarbons	18	kg/y		
Carbon Monoxide	229	kg/y		
NOx	555	kg/y		

INTERSECTION SUMMARY

Site: 101 [2018_Existing_AM]

New Site
Site Category: (None)
Stop (Two-Way)

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	59.6 km/h	59.6 km/h
Travel Distance (Total)	1019.7 veh-km/h	1223.6 pers-km/h
Travel Time (Total)	17.1 veh-h/h	20.5 pers-h/h
Demand Flows (Total)	1009 veh/h	1211 pers/h
Percent Heavy Vehicles (Demand)	10.7 %	
Degree of Saturation	0.354	
Practical Spare Capacity	176.6 %	
Effective Intersection Capacity	2849 veh/h	
Control Delay (Total)	0.10 veh-h/h	0.12 pers-h/h
Control Delay (Average)	0.3 sec	0.3 sec
Control Delay (Worst Lane)	10.6 sec	
Control Delay (Worst Movement)	12.8 sec	12.8 sec
Geometric Delay (Average)	0.2 sec	
Stop-Line Delay (Average)	0.2 sec	
Idling Time (Average)	0.1 sec	
Intersection Level of Service (LOS)	NA	
95% Back of Queue - Vehicles (Worst Lane)	0.1 veh	
95% Back of Queue - Distance (Worst Lane)	1.0 m	
Queue Storage Ratio (Worst Lane)	0.00	
Total Effective Stops	22 veh/h	27 pers/h
Effective Stop Rate	0.02	0.02
Proportion Queued	0.02	0.02
Performance Index	17.5	17.5
Cost (Total)	396.54 $/h	396.54 $/h
Fuel Consumption (Total)	84.1 L/h	
Carbon Dioxide (Total)	203.3 kg/h	
Hydrocarbons (Total)	0.014 kg/h	
Carbon Monoxide (Total)	0.219 kg/h	
NOx (Total)	0.549 kg/h	

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Site Model Variability Index (Iterations 3 to N): 0.0 %

Number of Iterations: 3 (Maximum: 10)

Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 70.4% 1.1% 0.0%

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	484,547 veh/y	581,457 pers/y
Delay	46 veh-h/y	56 pers-h/y
Effective Stops	10,789 veh/y	12,947 pers/y
Travel Distance	489,437 veh-km/y	587,325 pers-km/y
Travel Time	8,216 veh-h/y	9,860 pers-h/y
Cost	190,338 $/y	190,338 $/y
Fuel Consumption	40,365 L/y	
Carbon Dioxide	97,596 kg/y	
Hydrocarbons	7 kg/y	
Carbon Monoxide	105 kg/y	
NOx	263 kg/y	

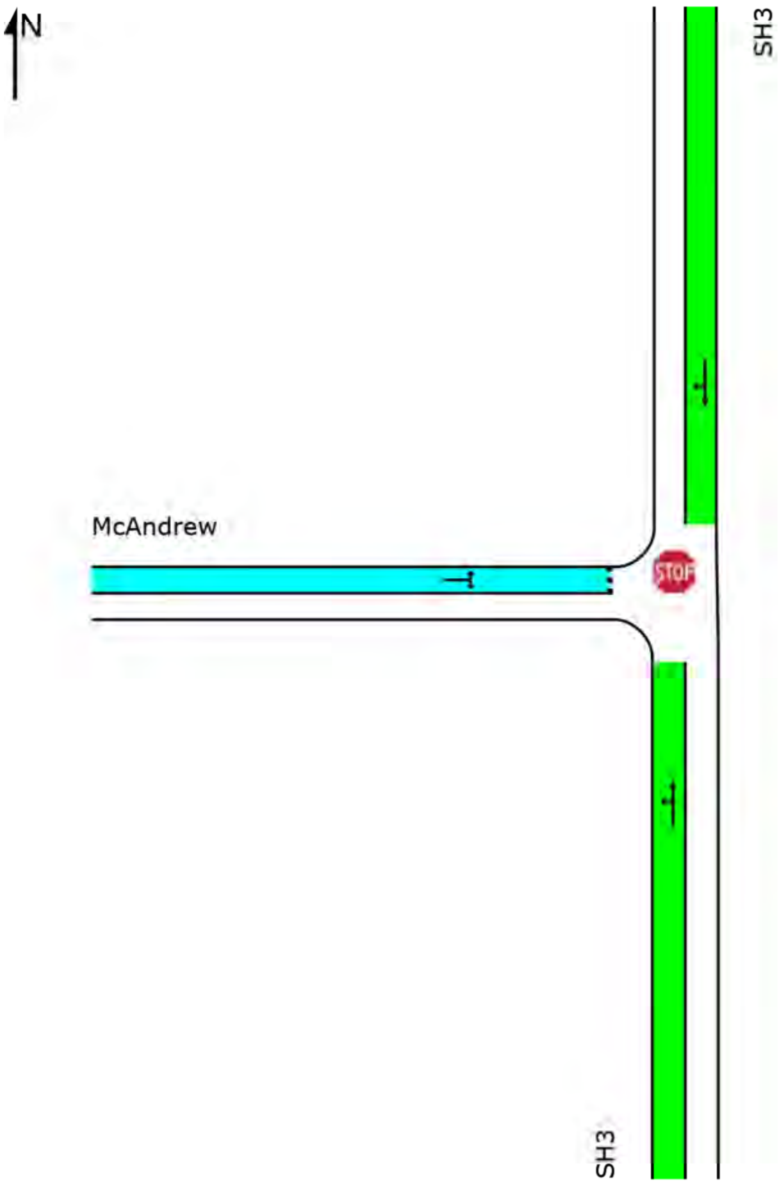
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [2018_Existing_AM]

New Site
Site Category: (None)
Stop (Two-Way)

	Approaches			Intersection
	South	North	West	
LOS	NA	NA	B	NA



Colour code based on Level of Service

LOS A LOS B LOS C LOS D LOS E LOS F

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

INTERSECTION SUMMARY

Site: 101 [2018_Existing_PM]

New Site
Site Category: (None)
Stop (Two-Way)

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	59.5 km/h	59.5 km/h
Travel Distance (Total)	1013.3 veh-km/h	1215.9 pers-km/h
Travel Time (Total)	17.0 veh-h/h	20.4 pers-h/h
Demand Flows (Total)	1003 veh/h	1204 pers/h
Percent Heavy Vehicles (Demand)	10.6 %	
Degree of Saturation	0.400	
Practical Spare Capacity	145.1 %	
Effective Intersection Capacity	2509 veh/h	
Control Delay (Total)	0.09 veh-h/h	0.11 pers-h/h
Control Delay (Average)	0.3 sec	0.3 sec
Control Delay (Worst Lane)	9.6 sec	
Control Delay (Worst Movement)	12.8 sec	12.8 sec
Geometric Delay (Average)	0.2 sec	
Stop-Line Delay (Average)	0.1 sec	
Idling Time (Average)	0.0 sec	
Intersection Level of Service (LOS)	NA	
95% Back of Queue - Vehicles (Worst Lane)	0.3 veh	
95% Back of Queue - Distance (Worst Lane)	2.2 m	
Queue Storage Ratio (Worst Lane)	0.00	
Total Effective Stops	23 veh/h	28 pers/h
Effective Stop Rate	0.02	0.02
Proportion Queued	0.03	0.03
Performance Index	17.6	17.6
Cost (Total)	399.56 $/h	399.56 $/h
Fuel Consumption (Total)	84.6 L/h	
Carbon Dioxide (Total)	204.5 kg/h	
Hydrocarbons (Total)	0.015 kg/h	
Carbon Monoxide (Total)	0.220 kg/h	
NOx (Total)	0.556 kg/h	

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 3 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 68.0% 1.1% 0.0%

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	481,516 veh/y	577,819 pers/y
Delay	43 veh-h/y	52 pers-h/y
Effective Stops	11,062 veh/y	13,275 pers/y
Travel Distance	486,366 veh-km/y	583,639 pers-km/y
Travel Time	8,168 veh-h/y	9,802 pers-h/y
Cost	191,790 $/y	191,790 $/y
Fuel Consumption	40,618 L/y	
Carbon Dioxide	98,175 kg/y	
Hydrocarbons	7 kg/y	
Carbon Monoxide	106 kg/y	
NOx	267 kg/y	

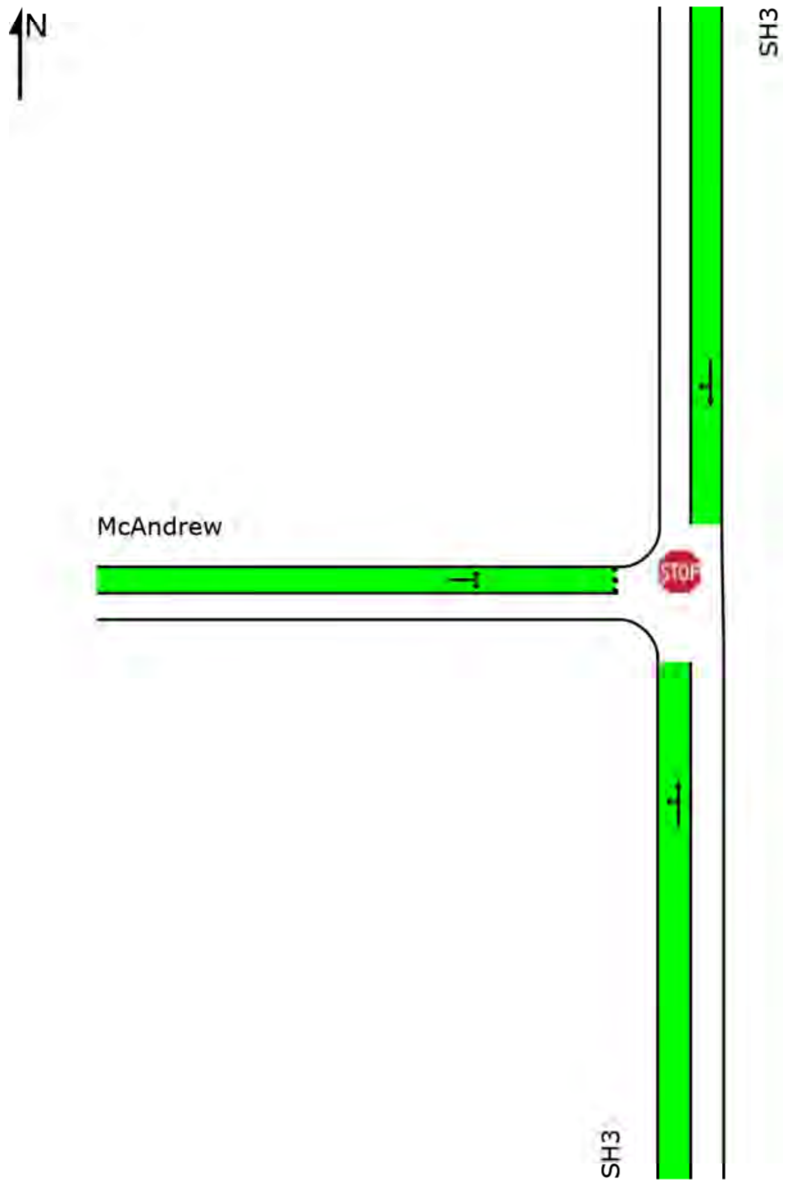
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [2018_Existing_PM]

New Site
Site Category: (None)
Stop (Two-Way)

	Approaches			Intersection
	South	North	West	
LOS	NA	NA	A	NA



Colour code based on Level of Service

LOS A LOS B LOS C LOS D LOS E LOS F

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

INTERSECTION SUMMARY

Site: 101 [2018_Low Dev_AM]

New Site
Site Category: (None)
Stop (Two-Way)

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	59.5 km/h	59.5 km/h
Travel Distance (Total)	1032.4 veh-km/h	1238.9 pers-km/h
Travel Time (Total)	17.3 veh-h/h	20.8 pers-h/h
Demand Flows (Total)	1022 veh/h	1227 pers/h
Percent Heavy Vehicles (Demand)	10.7 %	
Degree of Saturation	0.355	
Practical Spare Capacity	175.7 %	
Effective Intersection Capacity	2875 veh/h	
Control Delay (Total)	0.11 veh-h/h	0.13 pers-h/h
Control Delay (Average)	0.4 sec	0.4 sec
Control Delay (Worst Lane)	10.5 sec	
Control Delay (Worst Movement)	13.0 sec	13.0 sec
Geometric Delay (Average)	0.2 sec	
Stop-Line Delay (Average)	0.2 sec	
Idling Time (Average)	0.1 sec	
Intersection Level of Service (LOS)	NA	
95% Back of Queue - Vehicles (Worst Lane)	0.2 veh	
95% Back of Queue - Distance (Worst Lane)	1.2 m	
Queue Storage Ratio (Worst Lane)	0.00	
Total Effective Stops	26 veh/h	31 pers/h
Effective Stop Rate	0.03	0.03
Proportion Queued	0.02	0.02
Performance Index	17.8	17.8
Cost (Total)	402.28 $/h	402.28 $/h
Fuel Consumption (Total)	85.2 L/h	
Carbon Dioxide (Total)	205.9 kg/h	
Hydrocarbons (Total)	0.015 kg/h	
Carbon Monoxide (Total)	0.222 kg/h	
NOx (Total)	0.554 kg/h	

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 3 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 70.0% 1.1% 0.0%

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	490,611 veh/y	588,733 pers/y
Delay	52 veh-h/y	63 pers-h/y
Effective Stops	12,441 veh/y	14,930 pers/y
Travel Distance	495,570 veh-km/y	594,683 pers-km/y
Travel Time	8,326 veh-h/y	9,991 pers-h/y
Cost	193,096 $/y	193,096 $/y
Fuel Consumption	40,880 L/y	
Carbon Dioxide	98,831 kg/y	
Hydrocarbons	7 kg/y	
Carbon Monoxide	106 kg/y	
NOx	266 kg/y	

Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 4:39:12 PM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_McAndrew SH3 Int.sip8

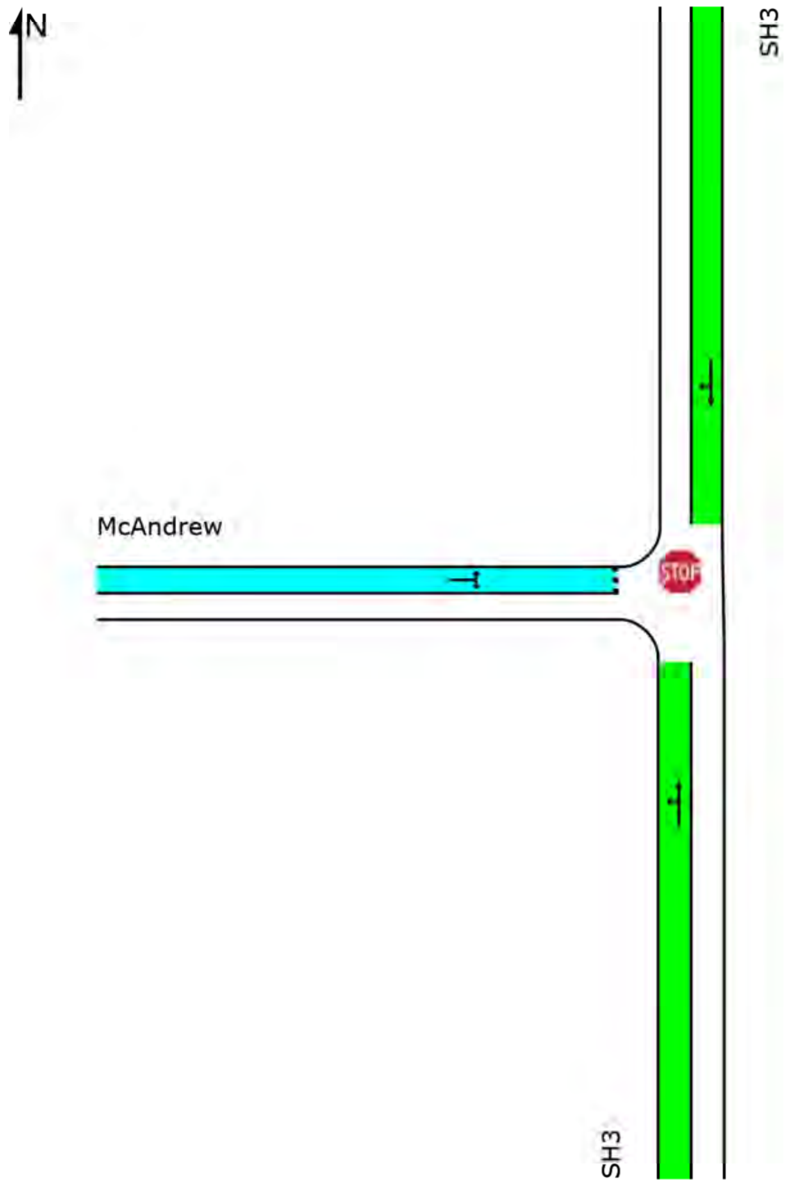
LANE LEVEL OF SERVICE

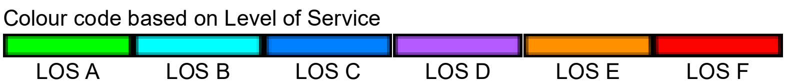
Lane Level of Service

Site: 101 [2018_Low Dev_AM]

New Site
Site Category: (None)
Stop (Two-Way)

	Approaches			Intersection
	South	North	West	
LOS	NA	NA	B	NA





Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 4:39:12 PM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_McAndrew SH3 Int.sip8

INTERSECTION SUMMARY

Site: 101 [2018_Low Dev_PM]

New Site
Site Category: (None)
Stop (Two-Way)

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	59.5 km/h	59.5 km/h
Travel Distance (Total)	1034.6 veh-km/h	1241.5 pers-km/h
Travel Time (Total)	17.4 veh-h/h	20.9 pers-h/h
Demand Flows (Total)	1024 veh/h	1229 pers/h
Percent Heavy Vehicles (Demand)	10.6 %	
Degree of Saturation	0.408	
Practical Spare Capacity	140.2 %	
Effective Intersection Capacity	2511 veh/h	
Control Delay (Total)	0.10 veh-h/h	0.12 pers-h/h
Control Delay (Average)	0.4 sec	0.4 sec
Control Delay (Worst Lane)	8.7 sec	
Control Delay (Worst Movement)	13.2 sec	13.2 sec
Geometric Delay (Average)	0.2 sec	
Stop-Line Delay (Average)	0.1 sec	
Idling Time (Average)	0.0 sec	
Intersection Level of Service (LOS)	NA	
95% Back of Queue - Vehicles (Worst Lane)	0.3 veh	
95% Back of Queue - Distance (Worst Lane)	2.3 m	
Queue Storage Ratio (Worst Lane)	0.00	
Total Effective Stops	26 veh/h	31 pers/h
Effective Stop Rate	0.03	0.03
Proportion Queued	0.03	0.03
Performance Index	18.0	18.0
Cost (Total)	408.65 $/h	408.65 $/h
Fuel Consumption (Total)	86.4 L/h	
Carbon Dioxide (Total)	208.8 kg/h	
Hydrocarbons (Total)	0.015 kg/h	
Carbon Monoxide (Total)	0.225 kg/h	
NOx (Total)	0.565 kg/h	

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Site Model Variability Index (Iterations 3 to N): 0.0 %

Number of Iterations: 3 (Maximum: 10)

Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 61.8% 1.1% 0.0%

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	491,621 veh/y	589,945 pers/y
Delay	48 veh-h/y	58 pers-h/y
Effective Stops	12,541 veh/y	15,049 pers/y
Travel Distance	496,587 veh-km/y	595,905 pers-km/y
Travel Time	8,345 veh-h/y	10,014 pers-h/y
Cost	196,150 $/y	196,150 $/y
Fuel Consumption	41,476 L/y	
Carbon Dioxide	100,239 kg/y	
Hydrocarbons	7 kg/y	
Carbon Monoxide	108 kg/y	
NOx	271 kg/y	

Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 4:40:10 PM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_McAndrew SH3 Int.sip8

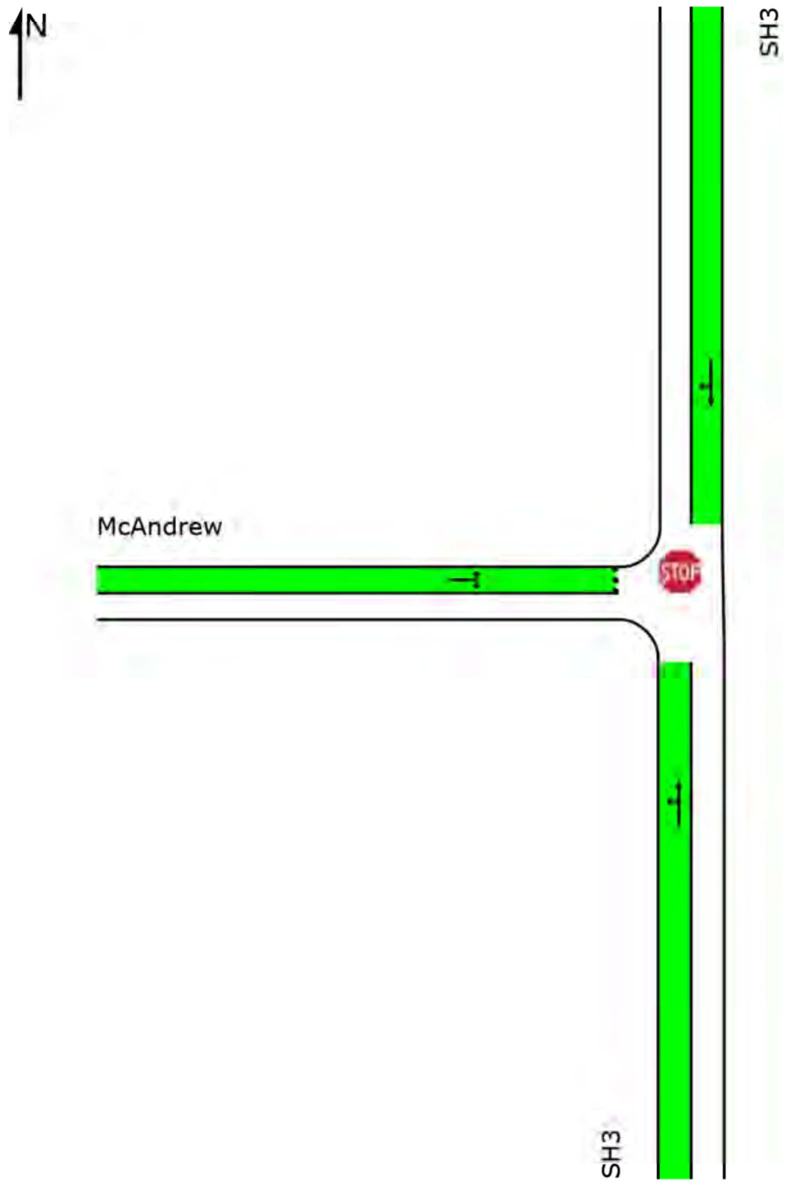
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [2018_Low Dev_PM]

New Site
Site Category: (None)
Stop (Two-Way)

	Approaches			Intersection
	South	North	West	
LOS	NA	NA	A	NA



Colour code based on Level of Service

LOS A LOS B LOS C LOS D LOS E LOS F

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

INTERSECTION SUMMARY

Site: 101 [2018_Hi Dev_AM]

New Site
Site Category: (None)
Stop (Two-Way)

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	59.5 km/h	59.5 km/h
Travel Distance (Total)	1044.1 veh-km/h	1253.0 pers-km/h
Travel Time (Total)	17.6 veh-h/h	21.1 pers-h/h
Demand Flows (Total)	1034 veh/h	1240 pers/h
Percent Heavy Vehicles (Demand)	10.6 %	
Degree of Saturation	0.356	
Practical Spare Capacity	175.2 %	
Effective Intersection Capacity	2903 veh/h	
Control Delay (Total)	0.13 veh-h/h	0.15 pers-h/h
Control Delay (Average)	0.4 sec	0.4 sec
Control Delay (Worst Lane)	10.7 sec	
Control Delay (Worst Movement)	13.1 sec	13.1 sec
Geometric Delay (Average)	0.2 sec	
Stop-Line Delay (Average)	0.2 sec	
Idling Time (Average)	0.1 sec	
Intersection Level of Service (LOS)	NA	
95% Back of Queue - Vehicles (Worst Lane)	0.2 veh	
95% Back of Queue - Distance (Worst Lane)	1.4 m	
Queue Storage Ratio (Worst Lane)	0.00	
Total Effective Stops	30 veh/h	36 pers/h
Effective Stop Rate	0.03	0.03
Proportion Queued	0.03	0.03
Performance Index	18.1	18.1
Cost (Total)	408.35 $/h	408.35 $/h
Fuel Consumption (Total)	86.3 L/h	
Carbon Dioxide (Total)	208.5 kg/h	
Hydrocarbons (Total)	0.015 kg/h	
Carbon Monoxide (Total)	0.224 kg/h	
NOx (Total)	0.560 kg/h	

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Site Model Variability Index (Iterations 3 to N): 0.0 %

Number of Iterations: 3 (Maximum: 10)

Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 70.5% 1.4% 0.0%

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	496,168 veh/y	595,402 pers/y
Delay	61 veh-h/y	74 pers-h/y
Effective Stops	14,518 veh/y	17,422 pers/y
Travel Distance	501,189 veh-km/y	601,426 pers-km/y
Travel Time	8,430 veh-h/y	10,116 pers-h/y
Cost	196,009 $/y	196,009 $/y
Fuel Consumption	41,401 L/y	
Carbon Dioxide	100,077 kg/y	
Hydrocarbons	7 kg/y	
Carbon Monoxide	108 kg/y	
NOx	269 kg/y	

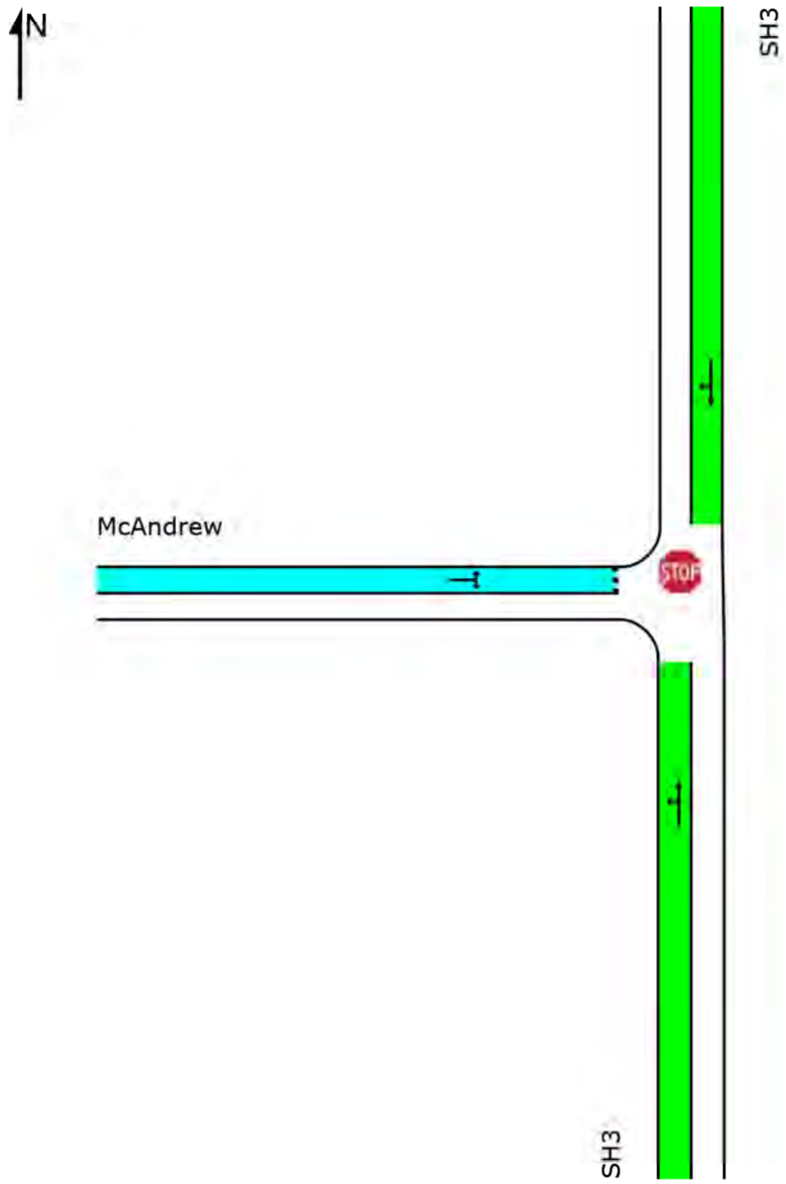
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [2018_Hi Dev_AM]

New Site
Site Category: (None)
Stop (Two-Way)

	Approaches			Intersection
	South	North	West	
LOS	NA	NA	B	NA



Colour code based on Level of Service

LOS A LOS B LOS C LOS D LOS E LOS F

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Document Set ID: 10373344
Version: 1, Version Date: 10/03/2020

INTERSECTION SUMMARY

Site: 101 [2018_Hi Dev_PM]

New Site
Site Category: (None)
Stop (Two-Way)

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	59.5 km/h	59.5 km/h
Travel Distance (Total)	1056.9 veh-km/h	1268.3 pers-km/h
Travel Time (Total)	17.8 veh-h/h	21.3 pers-h/h
Demand Flows (Total)	1046 veh/h	1256 pers/h
Percent Heavy Vehicles (Demand)	10.6 %	
Degree of Saturation	0.417	
Practical Spare Capacity	135.1 %	
Effective Intersection Capacity	2510 veh/h	
Control Delay (Total)	0.11 veh-h/h	0.14 pers-h/h
Control Delay (Average)	0.4 sec	0.4 sec
Control Delay (Worst Lane)	9.1 sec	
Control Delay (Worst Movement)	13.6 sec	13.6 sec
Geometric Delay (Average)	0.2 sec	
Stop-Line Delay (Average)	0.1 sec	
Idling Time (Average)	0.0 sec	
Intersection Level of Service (LOS)	NA	
95% Back of Queue - Vehicles (Worst Lane)	0.3 veh	
95% Back of Queue - Distance (Worst Lane)	2.5 m	
Queue Storage Ratio (Worst Lane)	0.00	
Total Effective Stops	29 veh/h	35 pers/h
Effective Stop Rate	0.03	0.03
Proportion Queued	0.04	0.04
Performance Index	18.5	18.5
Cost (Total)	418.40 $/h	418.40 $/h
Fuel Consumption (Total)	88.4 L/h	
Carbon Dioxide (Total)	213.5 kg/h	
Hydrocarbons (Total)	0.015 kg/h	
Carbon Monoxide (Total)	0.230 kg/h	
NOx (Total)	0.577 kg/h	

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 3 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 64.7% 1.1% 0.0%

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	502,232 veh/y	602,678 pers/y
Delay	54 veh-h/y	65 pers-h/y
Effective Stops	13,886 veh/y	16,663 pers/y
Travel Distance	507,310 veh-km/y	608,772 pers-km/y
Travel Time	8,531 veh-h/y	10,237 pers-h/y
Cost	200,834 $/y	200,834 $/y
Fuel Consumption	42,409 L/y	
Carbon Dioxide	102,483 kg/y	
Hydrocarbons	7 kg/y	
Carbon Monoxide	110 kg/y	
NOx	277 kg/y	

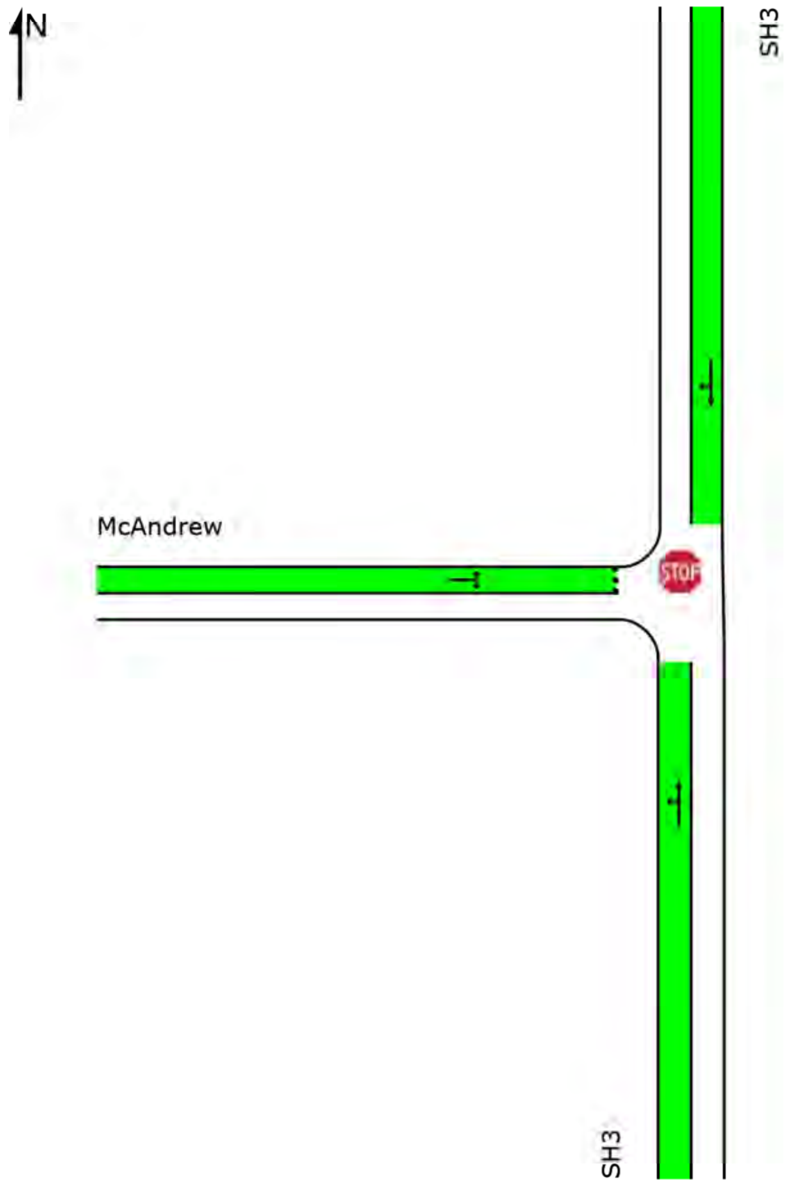
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [2018_Hi Dev_PM]

New Site
Site Category: (None)
Stop (Two-Way)

	Approaches			Intersection
	South	North	West	
LOS	NA	NA	A	NA



Colour code based on Level of Service

LOS A LOS B LOS C LOS D LOS E LOS F

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 4:43:48 PM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_McAndrew SH3 Int.sip8

INTERSECTION SUMMARY

Site: 101 [2035_No Dev_AM]

New Site
Site Category: (None)
Stop (Two-Way)

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	59.4 km/h	59.4 km/h
Travel Distance (Total)	1365.2 veh-km/h	1638.3 pers-km/h
Travel Time (Total)	23.0 veh-h/h	27.6 pers-h/h
Demand Flows (Total)	1352 veh/h	1622 pers/h
Percent Heavy Vehicles (Demand)	10.7 %	
Degree of Saturation	0.475	
Practical Spare Capacity	106.3 %	
Effective Intersection Capacity	2845 veh/h	
Control Delay (Total)	0.20 veh-h/h	0.24 pers-h/h
Control Delay (Average)	0.5 sec	0.5 sec
Control Delay (Worst Lane)	15.9 sec	
Control Delay (Worst Movement)	21.5 sec	21.5 sec
Geometric Delay (Average)	0.2 sec	
Stop-Line Delay (Average)	0.4 sec	
Idling Time (Average)	0.2 sec	
Intersection Level of Service (LOS)	NA	
95% Back of Queue - Vehicles (Worst Lane)	0.3 veh	
95% Back of Queue - Distance (Worst Lane)	2.1 m	
Queue Storage Ratio (Worst Lane)	0.00	
Total Effective Stops	33 veh/h	40 pers/h
Effective Stop Rate	0.02	0.02
Proportion Queued	0.03	0.03
Performance Index	23.8	23.8
Cost (Total)	534.40 $/h	534.40 $/h
Fuel Consumption (Total)	112.9 L/h	
Carbon Dioxide (Total)	273.0 kg/h	
Hydrocarbons (Total)	0.019 kg/h	
Carbon Monoxide (Total)	0.293 kg/h	
NOx (Total)	0.738 kg/h	

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 3 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 83.0% 2.1% 0.0%

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	648,758 veh/y	778,510 pers/y
Delay	96 veh-h/y	116 pers-h/y
Effective Stops	15,901 veh/y	19,081 pers/y
Travel Distance	655,304 veh-km/y	786,365 pers-km/y
Travel Time	11,039 veh-h/y	13,246 pers-h/y
Cost	256,514 $/y	256,514 $/y
Fuel Consumption	54,198 L/y	
Carbon Dioxide	131,037 kg/y	
Hydrocarbons	9 kg/y	
Carbon Monoxide	141 kg/y	
NOx	354 kg/y	

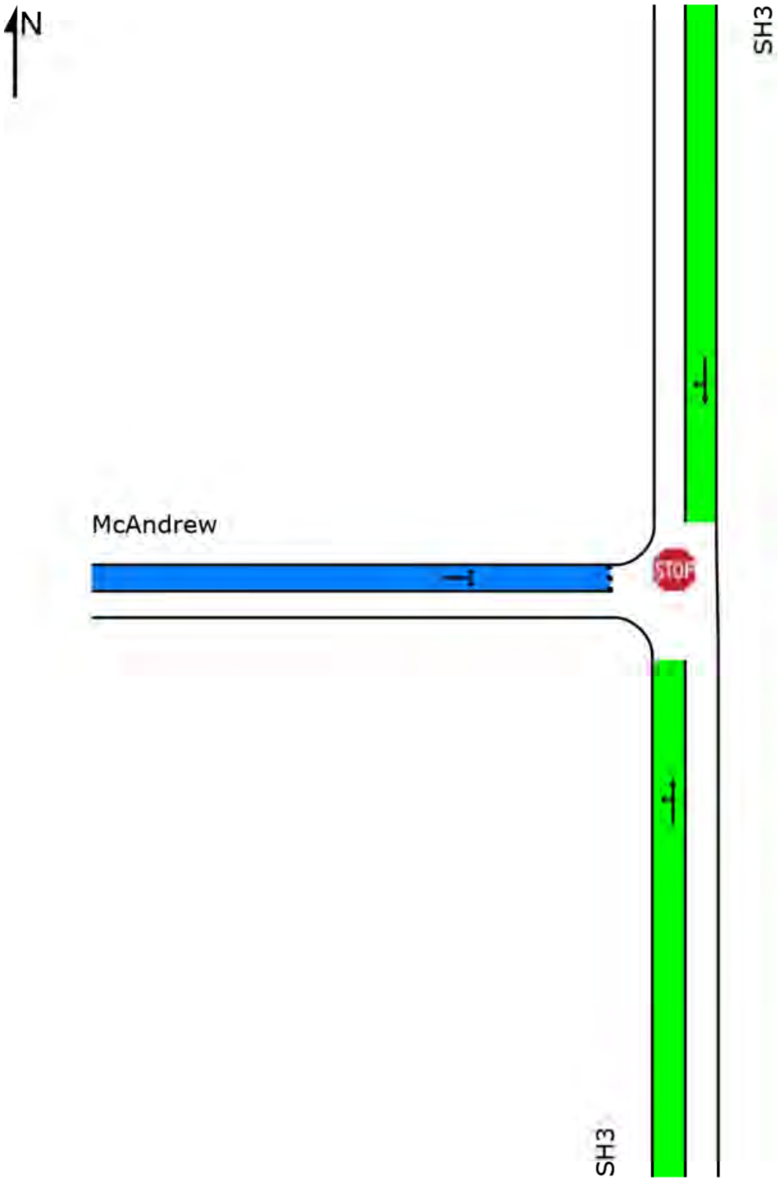
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [2035_No Dev_AM]

New Site
Site Category: (None)
Stop (Two-Way)

	Approaches			Intersection
	South	North	West	
LOS	NA	NA	C	NA



Colour code based on Level of Service

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

INTERSECTION SUMMARY

Site: 101 [2035_No Dev_PM]

New Site
Site Category: (None)
Stop (Two-Way)

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	59.4 km/h	59.4 km/h
Travel Distance (Total)	1359.9 veh-km/h	1631.9 pers-km/h
Travel Time (Total)	22.9 veh-h/h	27.5 pers-h/h
Demand Flows (Total)	1346 veh/h	1616 pers/h
Percent Heavy Vehicles (Demand)	10.6 %	
Degree of Saturation	0.538	
Practical Spare Capacity	82.0 %	
Effective Intersection Capacity	2500 veh/h	
Control Delay (Total)	0.18 veh-h/h	0.22 pers-h/h
Control Delay (Average)	0.5 sec	0.5 sec
Control Delay (Worst Lane)	11.9 sec	
Control Delay (Worst Movement)	22.2 sec	22.2 sec
Geometric Delay (Average)	0.2 sec	
Stop-Line Delay (Average)	0.3 sec	
Idling Time (Average)	0.0 sec	
Intersection Level of Service (LOS)	NA	
95% Back of Queue - Vehicles (Worst Lane)	0.7 veh	
95% Back of Queue - Distance (Worst Lane)	5.2 m	
Queue Storage Ratio (Worst Lane)	0.00	
Total Effective Stops	34 veh/h	41 pers/h
Effective Stop Rate	0.03	0.03
Proportion Queued	0.05	0.05
Performance Index	24.2	24.2
Cost (Total)	541.83 $/h	541.83 $/h
Fuel Consumption (Total)	114.4 L/h	
Carbon Dioxide (Total)	276.5 kg/h	
Hydrocarbons (Total)	0.020 kg/h	
Carbon Monoxide (Total)	0.297 kg/h	
NOx (Total)	0.754 kg/h	

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 3 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 76.7% 1.5% 0.0%

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	646,232 veh/y	775,478 pers/y
Delay	87 veh-h/y	104 pers-h/y
Effective Stops	16,485 veh/y	19,781 pers/y
Travel Distance	652,757 veh-km/y	783,308 pers-km/y
Travel Time	10,987 veh-h/y	13,184 pers-h/y
Cost	260,080 $/y	260,080 $/y
Fuel Consumption	54,924 L/y	
Carbon Dioxide	132,728 kg/y	
Hydrocarbons	10 kg/y	
Carbon Monoxide	143 kg/y	
NOx	362 kg/y	

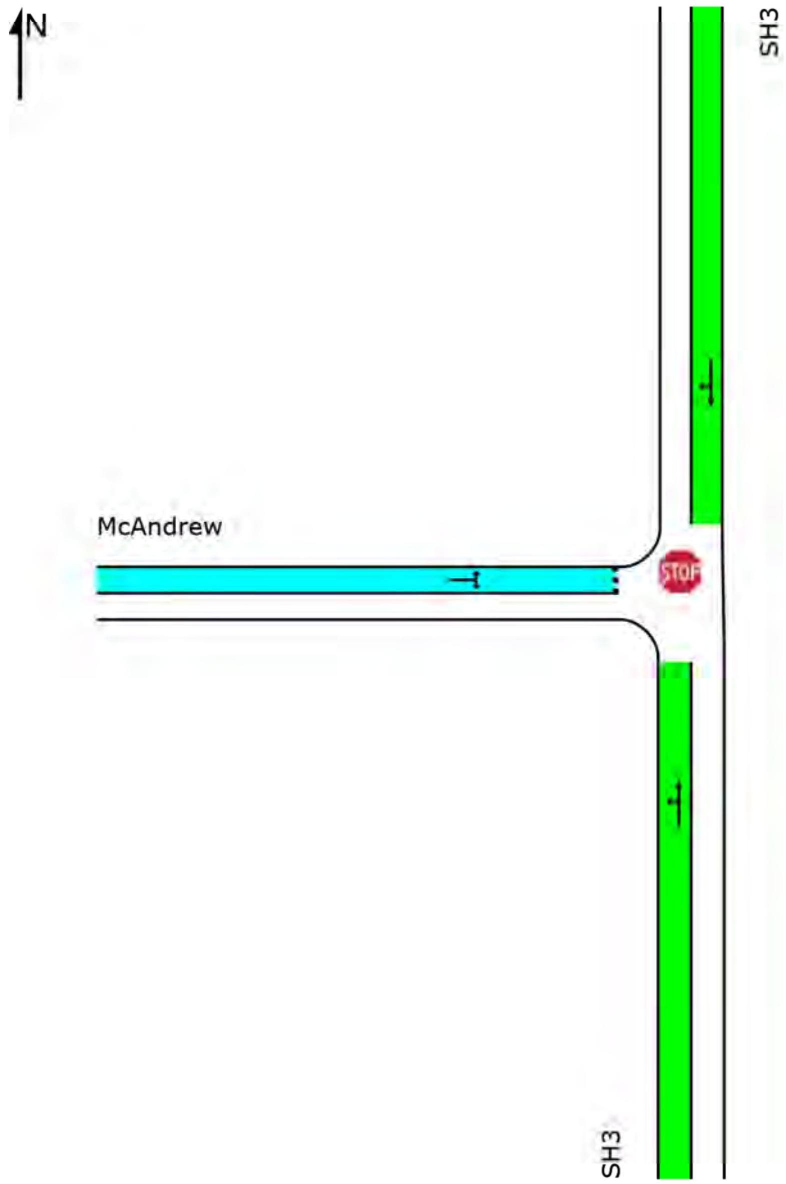
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [2035_No Dev_PM]

New Site
Site Category: (None)
Stop (Two-Way)

	Approaches			Intersection
	South	North	West	
LOS	NA	NA	B	NA



Colour code based on Level of Service

LOS A LOS B LOS C LOS D LOS E LOS F

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

INTERSECTION SUMMARY

Site: 101 [2035_Low Dev_AM]

New Site
Site Category: (None)
Stop (Two-Way)

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	59.3 km/h	59.3 km/h
Travel Distance (Total)	1378.0 veh-km/h	1653.6 pers-km/h
Travel Time (Total)	23.2 veh-h/h	27.9 pers-h/h
Demand Flows (Total)	1364 veh/h	1637 pers/h
Percent Heavy Vehicles (Demand)	10.7 %	
Degree of Saturation	0.476	
Practical Spare Capacity	106.0 %	
Effective Intersection Capacity	2868 veh/h	
Control Delay (Total)	0.22 veh-h/h	0.27 pers-h/h
Control Delay (Average)	0.6 sec	0.6 sec
Control Delay (Worst Lane)	16.2 sec	
Control Delay (Worst Movement)	21.9 sec	21.9 sec
Geometric Delay (Average)	0.2 sec	
Stop-Line Delay (Average)	0.4 sec	
Idling Time (Average)	0.2 sec	
Intersection Level of Service (LOS)	NA	
95% Back of Queue - Vehicles (Worst Lane)	0.3 veh	
95% Back of Queue - Distance (Worst Lane)	2.5 m	
Queue Storage Ratio (Worst Lane)	0.00	
Total Effective Stops	37 veh/h	44 pers/h
Effective Stop Rate	0.03	0.03
Proportion Queued	0.03	0.03
Performance Index	24.2	24.2
Cost (Total)	540.49 $/h	540.49 $/h
Fuel Consumption (Total)	114.0 L/h	
Carbon Dioxide (Total)	275.6 kg/h	
Hydrocarbons (Total)	0.020 kg/h	
Carbon Monoxide (Total)	0.296 kg/h	
NOx (Total)	0.744 kg/h	

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Site Model Variability Index (Iterations 3 to N): 0.0 %

Number of Iterations: 3 (Maximum: 10)

Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 83.3% 2.1% 0.0%

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	654,821 veh/y	785,785 pers/y
Delay	107 veh-h/y	128 pers-h/y
Effective Stops	17,787 veh/y	21,345 pers/y
Travel Distance	661,434 veh-km/y	793,721 pers-km/y
Travel Time	11,152 veh-h/y	13,383 pers-h/y
Cost	259,433 $/y	259,433 $/y
Fuel Consumption	54,721 L/y	
Carbon Dioxide	132,291 kg/y	
Hydrocarbons	9 kg/y	
Carbon Monoxide	142 kg/y	
NOx	357 kg/y	

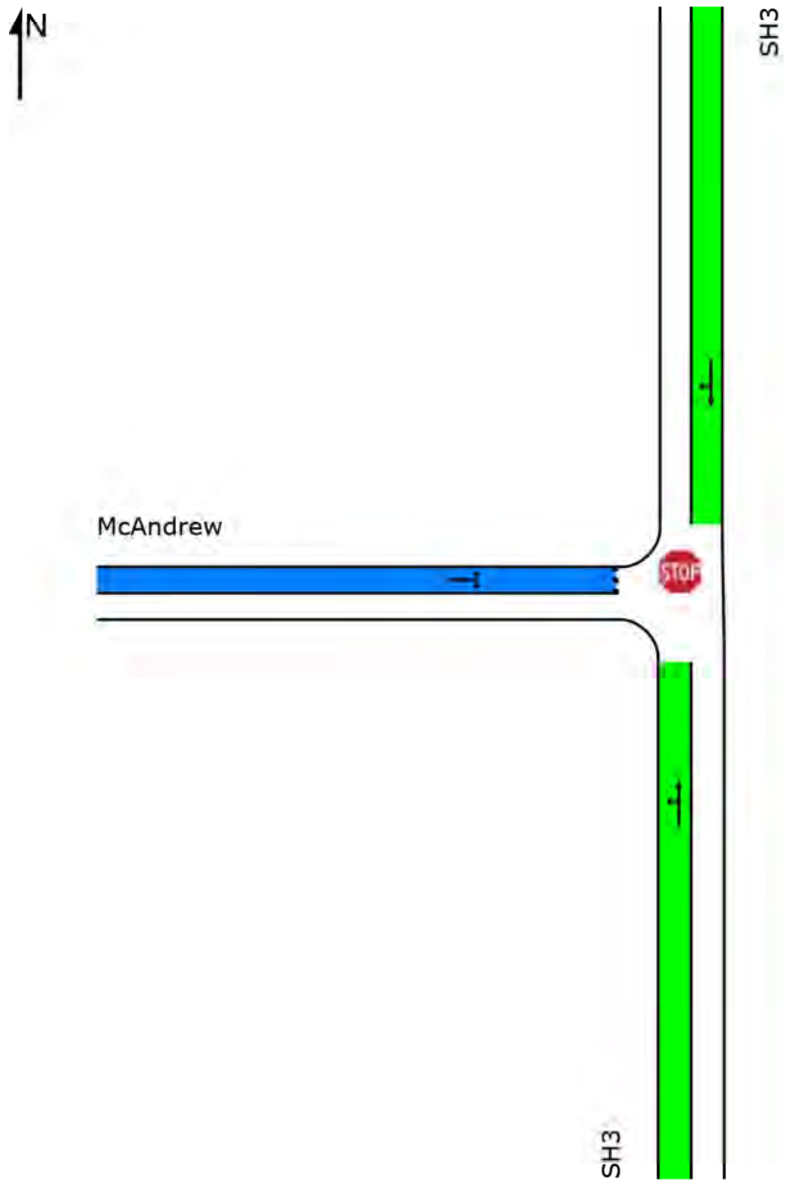
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [2035_Low Dev_AM]

New Site
Site Category: (None)
Stop (Two-Way)

	Approaches			Intersection
	South	North	West	
LOS	NA	NA	C	NA



Colour code based on Level of Service

LOS A LOS B LOS C LOS D LOS E LOS F

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 4:44:58 PM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_McAndrew SH3 Int.sip8

INTERSECTION SUMMARY

Site: 101 [2035_Low Dev_PM]

New Site
Site Category: (None)
Stop (Two-Way)

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	59.4 km/h	59.4 km/h
Travel Distance (Total)	1380.1 veh-km/h	1656.1 pers-km/h
Travel Time (Total)	23.2 veh-h/h	27.9 pers-h/h
Demand Flows (Total)	1366 veh/h	1640 pers/h
Percent Heavy Vehicles (Demand)	10.6 %	
Degree of Saturation	0.547	
Practical Spare Capacity	79.3 %	
Effective Intersection Capacity	2499 veh/h	
Control Delay (Total)	0.19 veh-h/h	0.23 pers-h/h
Control Delay (Average)	0.5 sec	0.5 sec
Control Delay (Worst Lane)	13.0 sec	
Control Delay (Worst Movement)	23.2 sec	23.2 sec
Geometric Delay (Average)	0.2 sec	
Stop-Line Delay (Average)	0.3 sec	
Idling Time (Average)	0.1 sec	
Intersection Level of Service (LOS)	NA	
95% Back of Queue - Vehicles (Worst Lane)	0.7 veh	
95% Back of Queue - Distance (Worst Lane)	5.3 m	
Queue Storage Ratio (Worst Lane)	0.00	
Total Effective Stops	35 veh/h	42 pers/h
Effective Stop Rate	0.03	0.03
Proportion Queued	0.05	0.05
Performance Index	24.6	24.6
Cost (Total)	550.26 $/h	550.26 $/h
Fuel Consumption (Total)	116.1 L/h	
Carbon Dioxide (Total)	280.7 kg/h	
Hydrocarbons (Total)	0.020 kg/h	
Carbon Monoxide (Total)	0.301 kg/h	
NOx (Total)	0.765 kg/h	

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 3 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 79.2% 1.5% 0.0%

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	655,832 veh/y	786,998 pers/y
Delay	92 veh-h/y	110 pers-h/y
Effective Stops	16,975 veh/y	20,370 pers/y
Travel Distance	662,452 veh-km/y	794,943 pers-km/y
Travel Time	11,154 veh-h/y	13,385 pers-h/y
Cost	264,123 $/y	264,123 $/y
Fuel Consumption	55,752 L/y	
Carbon Dioxide	134,728 kg/y	
Hydrocarbons	10 kg/y	
Carbon Monoxide	145 kg/y	
NOx	367 kg/y	

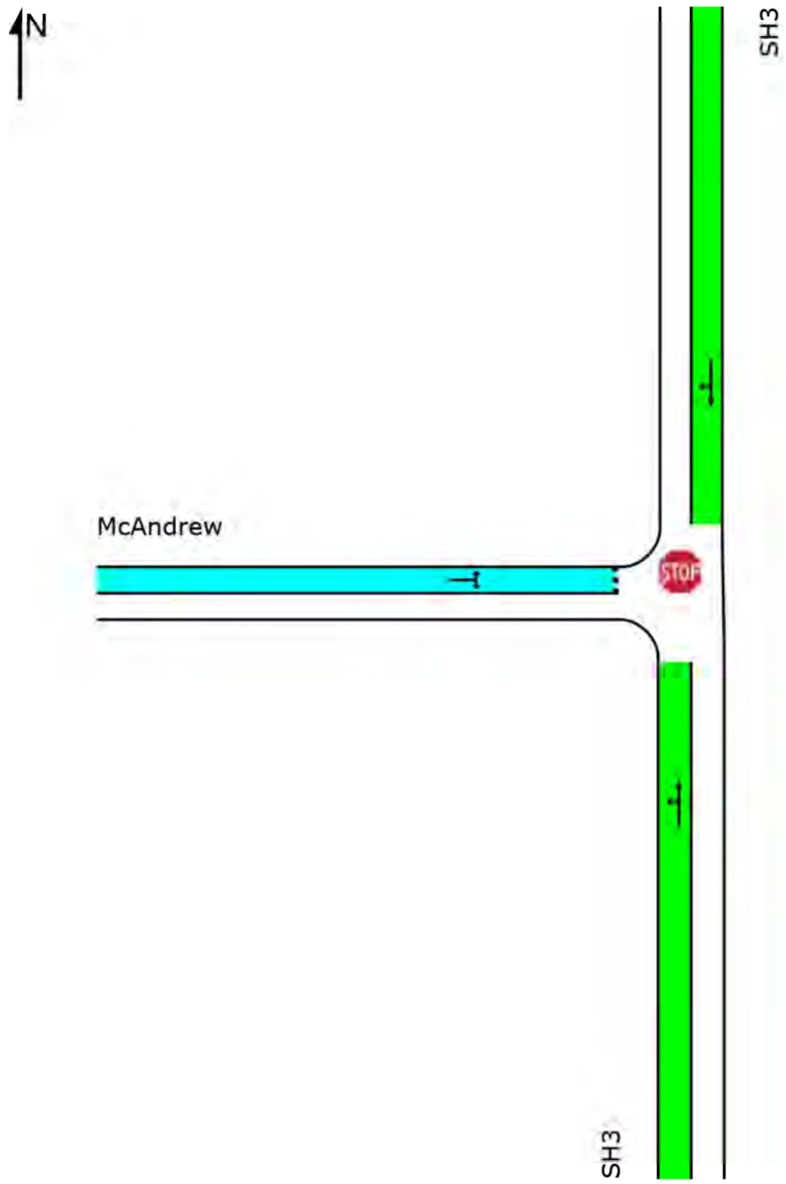
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [2035_Low Dev_PM]

New Site
Site Category: (None)
Stop (Two-Way)

	Approaches			Intersection
	South	North	West	
LOS	NA	NA	B	NA



Colour code based on Level of Service

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

INTERSECTION SUMMARY

Site: 101 [2035_Hi Dev_AM]

New Site
Site Category: (None)
Stop (Two-Way)

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	59.2 km/h	59.2 km/h
Travel Distance (Total)	1390.8 veh-km/h	1668.9 pers-km/h
Travel Time (Total)	23.5 veh-h/h	28.2 pers-h/h
Demand Flows (Total)	1377 veh/h	1652 pers/h
Percent Heavy Vehicles (Demand)	10.6 %	
Degree of Saturation	0.477	
Practical Spare Capacity	105.5 %	
Effective Intersection Capacity	2888 veh/h	
Control Delay (Total)	0.25 veh-h/h	0.30 pers-h/h
Control Delay (Average)	0.7 sec	0.7 sec
Control Delay (Worst Lane)	16.1 sec	
Control Delay (Worst Movement)	22.3 sec	22.3 sec
Geometric Delay (Average)	0.2 sec	
Stop-Line Delay (Average)	0.5 sec	
Idling Time (Average)	0.3 sec	
Intersection Level of Service (LOS)	NA	
95% Back of Queue - Vehicles (Worst Lane)	0.4 veh	
95% Back of Queue - Distance (Worst Lane)	2.7 m	
Queue Storage Ratio (Worst Lane)	0.00	
Total Effective Stops	42 veh/h	50 pers/h
Effective Stop Rate	0.03	0.03
Proportion Queued	0.03	0.03
Performance Index	24.6	24.6
Cost (Total)	547.62 $/h	547.62 $/h
Fuel Consumption (Total)	115.3 L/h	
Carbon Dioxide (Total)	278.6 kg/h	
Hydrocarbons (Total)	0.020 kg/h	
Carbon Monoxide (Total)	0.299 kg/h	
NOx (Total)	0.750 kg/h	

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 3 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 83.2% 2.6% 0.0%

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	660,884 veh/y	793,061 pers/y
Delay	121 veh-h/y	145 pers-h/y
Effective Stops	19,980 veh/y	23,976 pers/y
Travel Distance	667,566 veh-km/y	801,080 pers-km/y
Travel Time	11,270 veh-h/y	13,524 pers-h/y
Cost	262,857 $/y	262,857 $/y
Fuel Consumption	55,321 L/y	
Carbon Dioxide	133,726 kg/y	
Hydrocarbons	10 kg/y	
Carbon Monoxide	144 kg/y	
NOx	360 kg/y	

Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_McAndrew SH3 Int.sip8

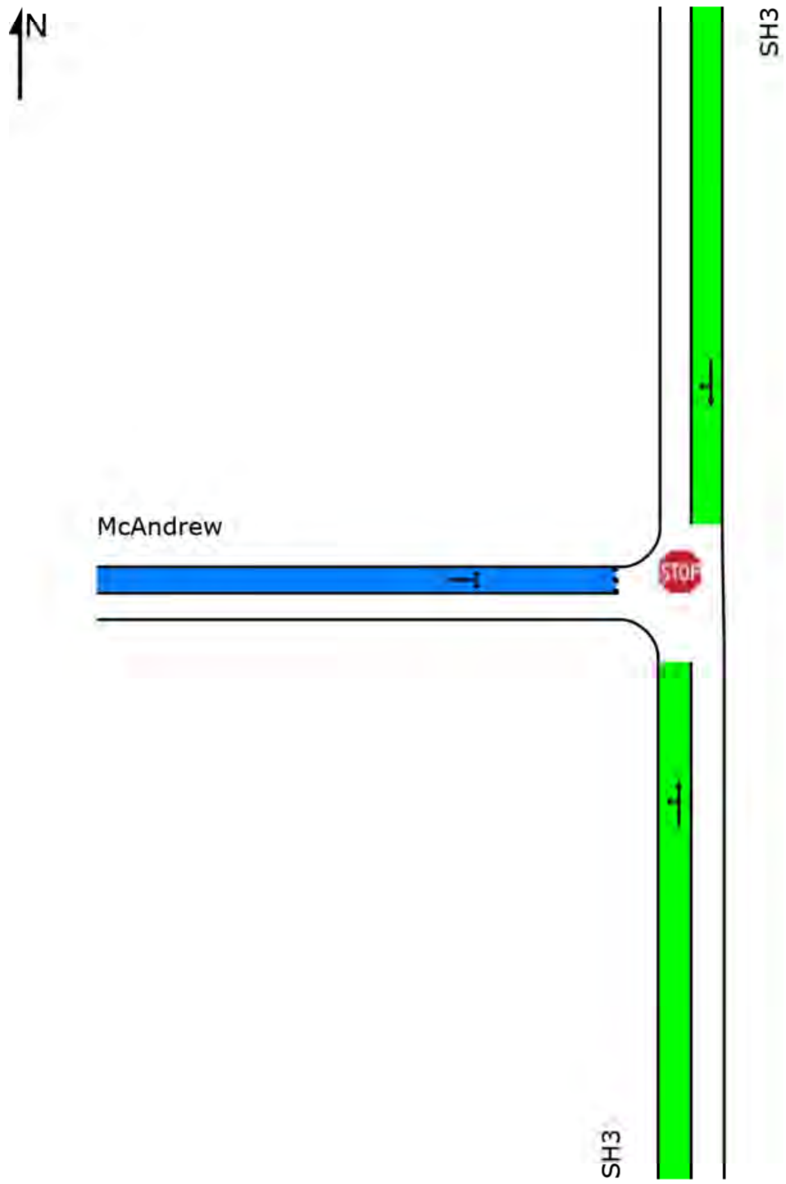
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [2035_Hi Dev_AM]

New Site
Site Category: (None)
Stop (Two-Way)

	Approaches			Intersection
	South	North	West	
LOS	NA	NA	C	NA



Colour code based on Level of Service

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 4:47:34 PM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_McAndrew SH3 Int.sip8

INTERSECTION SUMMARY

Site: 101 [2035_Hi Dev_PM]

New Site
Site Category: (None)
Stop (Two-Way)

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	59.3 km/h	59.3 km/h
Travel Distance (Total)	1400.3 veh-km/h	1680.4 pers-km/h
Travel Time (Total)	23.6 veh-h/h	28.3 pers-h/h
Demand Flows (Total)	1386 veh/h	1664 pers/h
Percent Heavy Vehicles (Demand)	10.6 %	
Degree of Saturation	0.555	
Practical Spare Capacity	76.5 %	
Effective Intersection Capacity	2497 veh/h	
Control Delay (Total)	0.21 veh-h/h	0.25 pers-h/h
Control Delay (Average)	0.5 sec	0.5 sec
Control Delay (Worst Lane)	14.5 sec	
Control Delay (Worst Movement)	24.1 sec	24.1 sec
Geometric Delay (Average)	0.2 sec	
Stop-Line Delay (Average)	0.3 sec	
Idling Time (Average)	0.1 sec	
Intersection Level of Service (LOS)	NA	
95% Back of Queue - Vehicles (Worst Lane)	0.7 veh	
95% Back of Queue - Distance (Worst Lane)	5.7 m	
Queue Storage Ratio (Worst Lane)	0.00	
Total Effective Stops	38 veh/h	46 pers/h
Effective Stop Rate	0.03	0.03
Proportion Queued	0.05	0.05
Performance Index	25.1	25.1
Cost (Total)	559.70 $/h	559.70 $/h
Fuel Consumption (Total)	118.0 L/h	
Carbon Dioxide (Total)	285.1 kg/h	
Hydrocarbons (Total)	0.020 kg/h	
Carbon Monoxide (Total)	0.306 kg/h	
NOx (Total)	0.776 kg/h	

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Site Model Variability Index (Iterations 3 to N): 0.0 %

Number of Iterations: 3 (Maximum: 10)

Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 82.2% 1.6% 0.0%

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	665,432 veh/y	798,518 pers/y
Delay	101 veh-h/y	122 pers-h/y
Effective Stops	18,443 veh/y	22,132 pers/y
Travel Distance	672,155 veh-km/y	806,585 pers-km/y
Travel Time	11,326 veh-h/y	13,591 pers-h/y
Cost	268,655 $/y	268,655 $/y
Fuel Consumption	56,631 L/y	
Carbon Dioxide	136,842 kg/y	
Hydrocarbons	10 kg/y	
Carbon Monoxide	147 kg/y	
NOx	373 kg/y	

Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 4:48:55 PM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_McAndrew SH3 Int.sip8

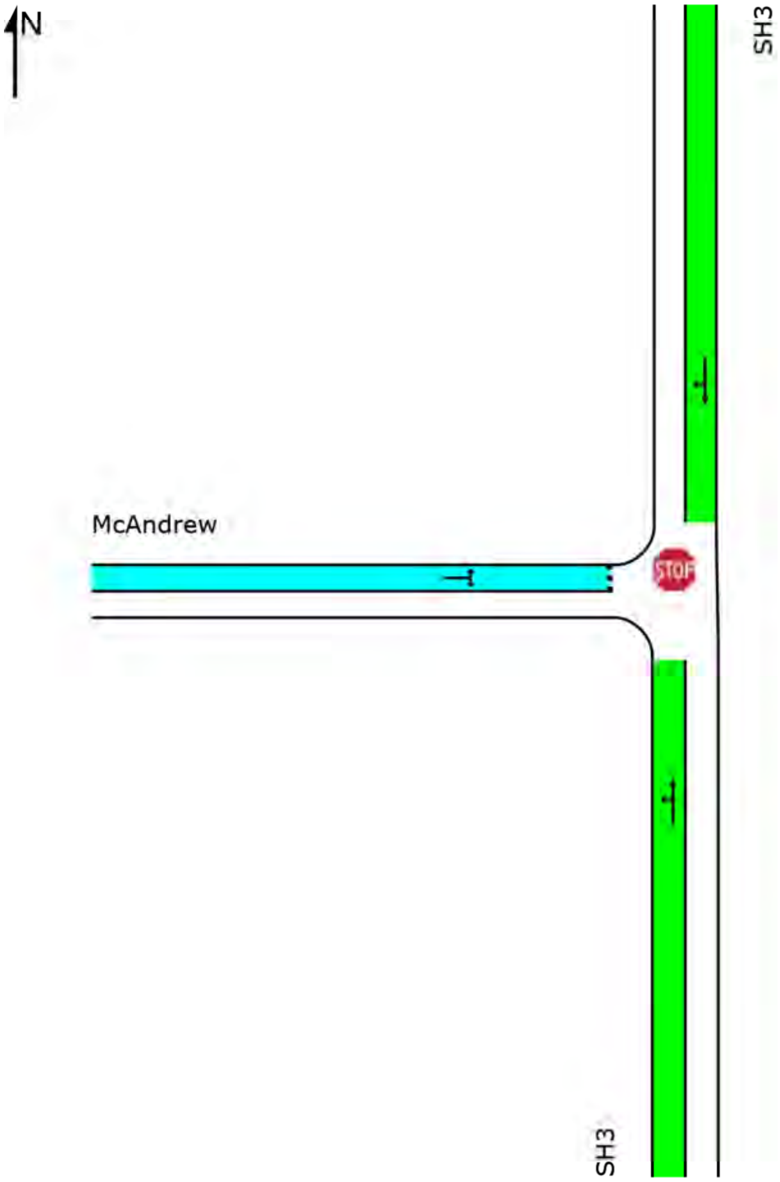
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [2035_Hi Dev_PM]

New Site
Site Category: (None)
Stop (Two-Way)

	Approaches			Intersection
	South	North	West	
LOS	NA	NA	B	NA



Colour code based on Level of Service

LOS A LOS B LOS C LOS D LOS E LOS F

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Organisation: TONKIN & TAYLOR | Processed: Friday, 24 May 2019 4:48:55 PM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T6_McAndrew SH3 Int.sip8

Appendix C: T11 CAS Outputs

CAS outputs for the following roads included:

- **Cambridge Road**

Also included as reference for the high-level assessment of State Highway 3:

- **State Highway 3 / Cambridge Road / Arawata Street intersection**

Untitled query

Saved sites

Cambridge Road

Crash year

2009 — 2019

Plain English report

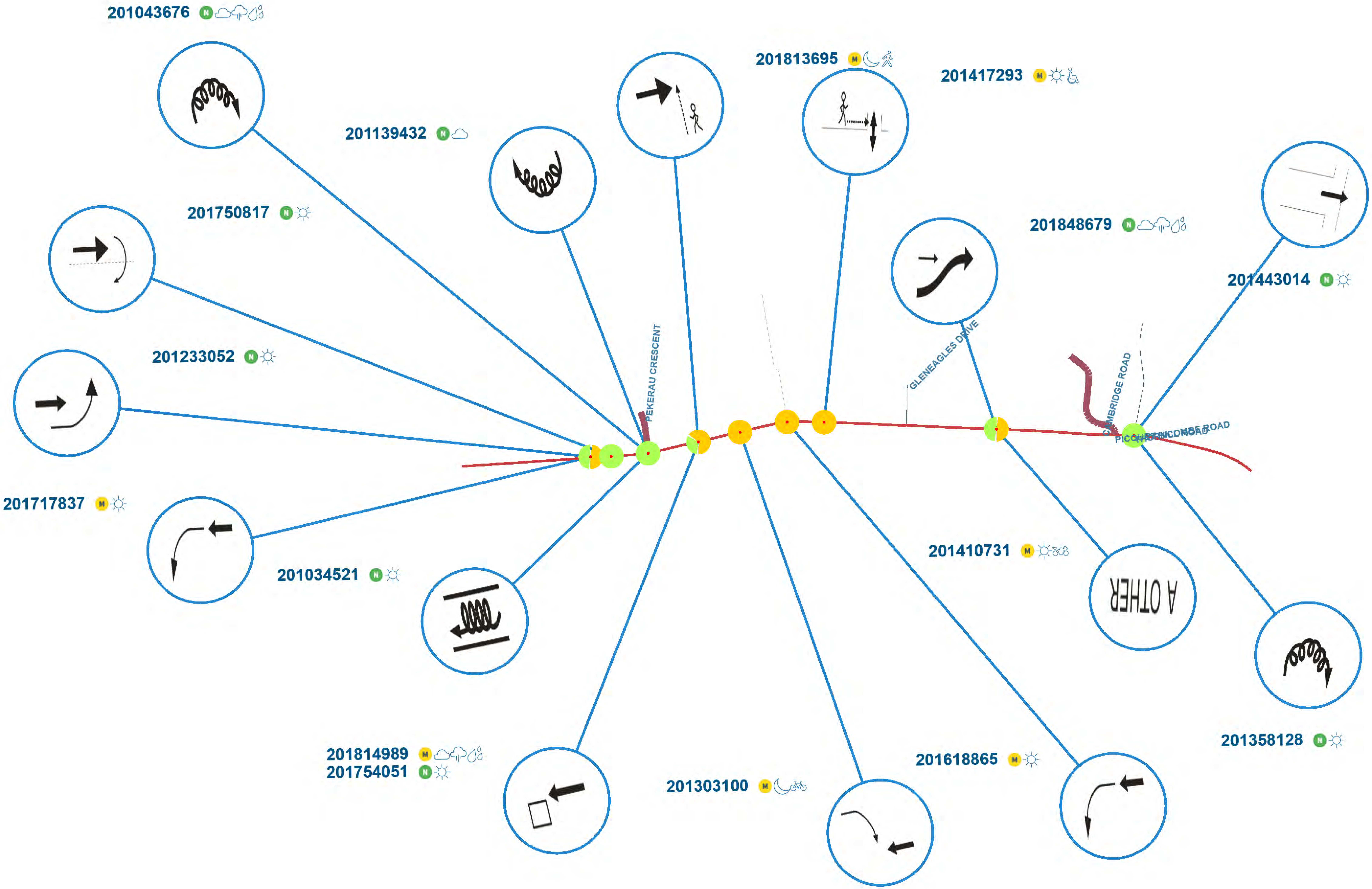
17 results from your query.

1-17 of 17

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
CAMBRIDGE ROAD	200m	E	GLENEAGLES DRIVE	201410731	22/03/2014	Sat	15:58	Car/Wagon1 WDB on CAMBRIDGE ROAD overtaking Motorcycle2	MOTORCYCLE2, misjudged another vehicle, other overtaking CAR/WAGON1, misjudged another vehicle, other overtaking	Dry	Bright sun	Fine	Nil (Default)	Nil	0	0	1
CAMBRIDGE ROAD	200m	W	GLENEAGLES DRIVE	201417293	04/11/2014	Tue	16:20	Car/Wagon1 entering/leaving driveway hit Wheeled pedestrian (wheelchairs, mobility scooters, etc)&CR;&LF;2 (Age 83) walking on footpath	CAR/WAGON1, did not check/notice another party behind, other visibility limited, WHEELED PEDESTRIAN (WHEELCHAIRS, MOBILITY SCOOTERS2, other did not see or look for other party, ENV: entering or leaving private house / farm, visibility limited by hedge or fence	Dry	Bright sun	Fine	Driveway	Unknown	0	0	1
CAMBRIDGE ROAD	210m	E	GLENEAGLES DRIVE	201848679	04/09/2018	Tue	17:42	Car/Wagon1 EDB on CAMBRIDGE ROAD changing lanes to left hit Car/Wagon2	CAR/WAGON1, alcohol suspected, cut in after overtaking, emotionally upset/road rage	Wet	Overcast	Light rain	Nil (Default)	Unknown	0	0	0
CAMBRIDGE ROAD	300m	W	GLENEAGLES DRIVE	201618865	17/12/2016	Sat	16:10	Car/Wagon1 WDB on Cambridge hit rear of left turning Car/Wagon2 WDB on Cambridge	CAR/WAGON1, following too closely	Dry	Bright sun	Fine	Driveway	Nil	0	0	1
CAMBRIDGE ROAD	400m	W	MCLARNON ROAD	201043676	14/12/2010	Tue	18:45	Car/Wagon1 NDB on CAMBRIDGE ROAD lost control turning right, Car/Wagon1 hit fences	CAR/WAGON1, lost control when turning, speed entering corner/curve, ENV: heavy rain, slippery road due to rain	Wet	Overcast	Heavy rain	Nil (Default)	Nil	0	0	0
CAMBRIDGE ROAD	140m	W	PEKERAU CRESCENT	201233052	01/06/2012	Fri	12:05	Car/Wagon1 EDB on CAMBRIDGE ROAD sideswiped by Car/Wagon2 EDB on CAMBRIDGE ROAD turning left	CAR/WAGON2, turned from incorrect position on road CAR/WAGON1, misjudged intentions of another party, ENV: entering or leaving private house / farm	Dry	Bright sun	Fine	Driveway	Unknown	0	0	0
CAMBRIDGE ROAD	220m	E	PEKERAU CRESCENT	201303100	13/06/2013	Thu	05:57	Car/Wagon2 turning right hit by oncoming Cycle1 WDB on CAMBRIDGE ROAD	CAR/WAGON2, did not check/notice another party from other dirn, failed to give way turning to non-turning traffic, ENV: entering or leaving shopping complex	Dry	Dark	Fine	Driveway	Unknown	0	0	2

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
CAMBRIDGE ROAD	90m	W	PEKERAU CRESCENT	201750817	30/09/2017	Sat	11:45	Van1 EDB on Cambridge Rd Te Awamutu hit Van2 U-turning from same direction of travel	VAN2, blind spot, did not check/notice another party behind	Dry	Bright sun	Fine	Nil (Default)	Unknown	0	0	0
CAMBRIDGE ROAD	120m	E	PEKERAU CRESCENT	201813695	19/04/2018	Thu	18:25	Car/Wagon1 EDB on Cambridge Rd hit Pedestrian2 (Age 65) crossing road from right side	CAR/WAGON1, alcohol test below limit, did not check/notice another party from other dirn, failed to see another party wearing dark clothing, ENV: street lighting inadequate	Dry	Dark	Fine	Nil (Default)	Unknown	0	0	1
CAMBRIDGE ROAD	25m	E	PEKERAU CRESCENT	201034521	02/05/2010	Sun	10:11	Car/Wagon1 WDB on CAMBRIDGE ROAD lost control but did not leave the road	CAR/WAGON1, puncture or blowout	Dry	Bright sun	Fine	Nil (Default)	Nil	0	0	0
CAMBRIDGE ROAD		I	PEKERAU CRESCENT	201139432	28/12/2011	Wed	15:20	Truck1 WDB on CAMBRIDGE ROAD lost control turning right, Truck1 hit kerbing, poles	TRUCK1, attention diverted by other traffic, lost control when turning	Dry	Overcast	Fine	T Junction	Stop	0	0	0
CAMBRIDGE ROAD	140m	W	PEKERAU CRESCENT	201717837	29/09/2017	Fri	16:20	Car/Wagon1 WDB on Cambridge rd hit rear of left turning Van2 WDB on Cambridge rd	CAR/WAGON1, following too closely, other attention diverted	Dry	Bright sun	Fine	Driveway	Nil	0	0	1
CAMBRIDGE ROAD	120m	E	PEKERAU CRESCENT	201754051	02/11/2017	Thu	12:15	SUV1 WDB on Cambridge hit parked veh, SUV1 hit parked vehicle	SUV1, attention diverted by food, cigarettes, beverages, too far left	Dry	Bright sun	Fine	Nil (Default)	Unknown	0	0	0
CAMBRIDGE ROAD	100m	E	PEKERAU CRESCENT	201814989	12/06/2018	Tue	14:30	Car/Wagon1 WDB on Cambridge Road hit parked veh, Car/Wagon1 hit parked vehicle	CAR/WAGON1, alcohol test below limit, too far left	Wet	Overcast	Light rain	Nil (Default)	Unknown	0	0	1
CAMBRIDGE ROAD	110m	W	PICQUET HILL ROAD	201418710	23/12/2014	Tue	07:42	Car/Wagon1 WDB on CAMBRIDGE ROAD lost control on straight and hit SUV2 head on, Car/Wagon1 hit fences	CAR/WAGON1, fatigue due to lack of sleep, other inattentive, other lost control	Dry	Bright sun	Fine	Nil (Default)	Unknown	0	1	1
CAMBRIDGE ROAD		I	THORNCOMBE ROAD	201358128	16/11/2013	Sat	17:35	Car/Wagon1 SDB on CAMBRIDGE ROAD lost control turning right, Car/Wagon1 hit parked vehicle	CAR/WAGON1, alcohol test above limit or test refused, wheelspins/wheelies/doughnuts/drifting	Dry	Bright sun	Fine	T Junction	Give way	0	0	0
CAMBRIDGE ROAD		I	THORNCOMBE ROAD	201443014	14/08/2014	Thu	15:14	Car/Wagon1 SDB on CAMBRIDGE ROAD missed intersection or end of road	CAR/WAGON1, alcohol test above limit or test refused, did not stop at stop sign, new driver/under instruction, other lost control	Dry	Bright sun	Fine	T Junction	Stop	0	0	0

1-17 of 17


201043676 N
201139432 N
201813695 M
201417293 M
201750817 N
201848679 N
201443014 N
201233052 N
PEKERAU CRESCENT
GLENEAGLES DRIVE
CAMBRIDGE ROAD
201717837 M
201034521 N
201410731 M
201814989 M
201754051 N
201303100 M
201618865 M
201358128 N

NZ TRANSPORT AGENCY WAKA KOTAHI CAS

Untitled query

Crash year

2009 — 2019

Saved sites

SH3 RAB Te Awamutu

Plain English report

38 results from your query.

Showing 20 100 results at once.

1-38 of 38

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
003-0016		I	ARAWATA ST	201897617	24/07/2018	Tue	16:10	Car/Wagon1 DIRN on 003-0016 sideswiped by Unknown2 DIRN on 003-0016 turning left	UNKNOWN2, turned right from incorrect lane	Dry	Bright sun	Fine	Roundabout	Give way	0	0	0
003-0016		I	CAMBRIDGE ROAD	201895902	22/11/2018	Thu	17:00	Car/Wagon1 NDB on 003-0016 overtaking SUV2	CAR/WAGON1, too far left	Dry	Overcast	Fine	Roundabout	Give way	0	0	0
ARAWATA ST		I	SH 3	201239396	19/10/2012	Fri	07:05	Van1 NDB on ARAWATA ST hit Van2 crossing at right angle from right	VAN1, did not check/notice another party from other dirn, failed to give way at priority traffic control, ENV: slippery road due to rain	Wet	Bright sun	Light rain	Roundabout	Give way	0	0	0
ARAWATA ST		I	SH 3	201736211	07/04/2017	Fri	07:00	Car/Wagon1 NDB on ARAWATA ST hit rear end of Car/Wagon2 stop/slow for cross traffic	CAR/WAGON1, following too closely CAR/WAGON2, suddenly braked	Dry	Twilight	Null	Roundabout	Give way	0	0	0
ARAWATA ST		I	SH 3	201138354	03/11/2011	Thu	15:30	Car/Wagon1 EDB on ARAWATA ST sideswiped by SUV2 EDB on ARAWATA ST turning left	SUV2, turned right from incorrect lane	Dry	Bright sun	Fine	Roundabout	Give way	0	0	0
ARAWATA ST		I	SH 3	201139354	28/12/2011	Wed	10:10	Van1 EDB on ARAWATA ST sideswiped by Car/Wagon2 EDB on ARAWATA ST turning left	CAR/WAGON2, turned right from incorrect lane	Dry	Overcast	Fine	Roundabout	Give way	0	0	0
ARAWATA ST		I	SH 3	201440078	04/07/2014	Fri	16:55	Car/Wagon1 NDB on ARAWATA ST hit Car/Wagon2 crossing at right angle from right	CAR/WAGON1, failed to give way at priority traffic control	Dry	Bright sun	Fine	Roundabout	Give way	0	0	0
ARAWATA ST		I	SH 3	201652520	15/09/2016	Thu	18:45	Car/Wagon1 NDB on ARAWATA ST hit Car/Wagon2 crossing at right angle from right	CAR/WAGON1, failed to give way at priority traffic control	Wet	Dark	Fine	Roundabout	Give way	0	0	0

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
BOND ROAD		I	OHAUPO ROAD	201637035	28/04/2016	Thu	11:00	Truck1 and Truck2 both SDB on BOND ROAD and turning; collided	TRUCK1, alcohol test below limit, too far left TRUCK2, alcohol test below limit	Dry	Bright sun	Fine	T Junction	Give way	0	0	0
BOND ROAD		I	SH 3	201837764	07/04/2018	Sat	12:30	Car/Wagon2 turning right hit by oncoming Car/Wagon1 SDB on Ohaupo	CAR/WAGON1, other wrong lane or position CAR/WAGON2, failed to give way when waved through by other dri	Dry	Bright sun	Fine	T Junction	Give way	0	0	0
BOND ROAD		I	SH 3	201233687	21/06/2012	Thu	16:30	Truck1 and Van2 both SDB on BOND ROAD and turning; collided	TRUCK1, blind spot VAN2, failed to notice indication of vehicle in front	Dry	Bright sun	Fine	T Junction	Give way	0	0	0
CAMBRIDGE ROAD		I	OHAUPO ROAD	201631734	21/01/2016	Thu	00:00	Car/Wagon1 EDB on CAMBRIDGE ROAD changing lanes to left hit Car/Wagon2	CAR/WAGON1, alcohol test below limit, did not check/notice another party from other dirn, other inattentive, overtaking on left without due care CAR/WAGON2, alcohol test below limit	Dry	Bright sun	Fine	Roundabout	Give way	0	0	0
CAMBRIDGE ROAD		I	SH 3	201836605	03/04/2018	Tue	18:15	Van1 SDB on CAMBRIDGE ROAD hit Car/Wagon2 merging from the left	CAR/WAGON2, failed to give way at priority traffic control	Dry	Bright sun	Fine	Roundabout	Give way	0	0	0
CAMBRIDGE ROAD		I	SH 3	201836607	27/02/2018	Tue	16:00	Car/Wagon1 SDB on CAMBRIDGE ROAD sideswiped by Van2 SDB on CAMBRIDGE ROAD turning left	VAN2, failed to give way at priority traffic control	Dry	Twilight	Fine	Roundabout	Give way	0	0	0
CAMBRIDGE ROAD		I	SH 3	201040618	24/09/2010	Fri	19:00	Car/Wagon1 SDB on CAMBRIDGE ROAD hit Car/Wagon2 merging from the left	CAR/WAGON2, alcohol suspected, failed to give way at priority traffic control	Dry	Dark	Fine	Roundabout	Give way	0	0	0
CAMBRIDGE ROAD		I	SH 3	201356469	01/11/2013	Fri	08:13	Car/Wagon1 NDB on CAMBRIDGE ROAD hit Motorcycle2 crossing at right angle from right	CAR/WAGON1, alcohol test above limit or test refused, did not check/notice another party from other dirn, failed to give way at priority traffic control	Dry	Overcast	Fine	Roundabout	Give way	0	0	0
CAMBRIDGE ROAD		I	SH 3	201435253	21/03/2014	Fri	16:06	Van1 SDB on CAMBRIDGE ROAD hit Car/Wagon2 merging from the right	CAR/WAGON2, failed to give way at priority traffic control	Dry	Bright sun	Fine	Roundabout	Give way	0	0	0
CAMBRIDGE ROAD		I	SH 3 ALBERT PARK	201138015	05/10/2011	Wed	21:15	Car/Wagon1 WDB on CAMBRIDGE ROAD hit Car/Wagon2 turning right onto AXROAD from the left	CAR/WAGON2, failed to give way at priority traffic control, misjudged intentions of another party	Wet	Dark	Fine	Roundabout	Give way	0	0	0
CAMBRIDGE ROAD		I	SH 3 ALBERT PARK DRIVE	201547700	24/09/2015	Thu	09:47	Car/Wagon1 WDB on CAMBRIDGE ROAD hit Car/Wagon2 crossing at right angle from right	CAR/WAGON2, attn diverted by scenery/persons outside vehicle	Dry	Overcast	Fine	Roundabout	Give way	0	0	0
ROGERS PLACE	50m	E	BOND ROAD	201640974	26/05/2016	Thu	14:36	Car/Wagon1 WDB on ROGERS PLACE hit Car/Wagon2 turning into angle park	CAR/WAGON2, did not check/notice another party behind	Dry	Bright sun	Null	Nil (Default)	Unknown	0	0	0

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
ROGERS PLACE	60m	W	TE RAHU ROAD	201746939	04/08/2017	Fri	11:30	Car/Wagon1 NDB on Rogers place hit VEHB manoeuvring, Car/Wagon1 hit houses	CAR/WAGON1, wrong pedal/foot slipped	Dry	Overcast	Fine	Nil (Default)	Unknown	0	0	0
SH 3		I	ARAWATA ST	201833163	02/02/2018	Fri	11:50	Car/Wagon1 SDB on SH 3 hit rear end of Car/Wagon2 stopped/moving slowly	CAR/WAGON1, following too closely	Dry	Bright sun	Fine	Roundabout	Give way	0	0	0
SH 3		I	ARAWATA ST	201302009	13/03/2013	Wed	20:19	Car/Wagon1 EDB on SH 3 lost control turning right, Car/Wagon1 hit traffic islands, parked vehicle, stationary vehicle	CAR/WAGON1, alcohol test above limit or test refused, driver over-reacted, lost control when turning, speed entering corner/curve	Dry	Dark	Fine	Roundabout	Give way	0	1	1
SH 3		I	ARAWATA ST	201339127	30/09/2013	Mon	18:20	Car/Wagon1 EDB on SH 3 hit SUV2 crossing at right angle from right	CAR/WAGON1, failed to give way at priority traffic control, failed to notice control	Wet	Overcast	Light rain	Roundabout	Give way	0	0	0
SH 3		I	ARAWATA ST	201642318	29/06/2016	Wed	11:52	Car/Wagon1 SDB on SH 3 hit Car/Wagon2 crossing at right angle from right	CAR/WAGON2, alcohol test below limit CAR/WAGON1, alcohol test below limit, did not check/notice another party from other dirn, failed to give way at priority traffic control	Wet	Overcast	Heavy rain	Roundabout	Give way	0	0	0
SH 3		I	ARAWATA ST	201752650	10/10/2017	Tue	13:15	Car/Wagon1 SDB on SH 3 changing lanes to left hit Car/Wagon2	CAR/WAGON1, following too closely	Dry	Bright sun	Fine	Roundabout	Give way	0	0	0
SH 3		I	ARAWATA ST	201440072	04/07/2014	Fri	14:00	Car/Wagon1 NDB on SH 3 hit rear of Car/Wagon2 NDB on SH 3 turning right from left side	CAR/WAGON1, travelled straight ahead from turning lane or flus	Dry	Bright sun	Fine	Roundabout	Give way	0	0	0
SH 3		I	ARAWATA ST	201039448	08/09/2010	Wed	08:00	Car/Wagon1 WDB on SH 3 overtaking hit Car/Wagon2 WDB on SH 3 turning right	CAR/WAGON2, turned right from incorrect lane	Dry	Overcast	Fine	Roundabout	Give way	0	0	0
SH 3		I	ARAWATA ST	201201043	19/01/2012	Thu	22:17	Motorcycle2 turning right hit by oncoming SUV1 NDB on SH 3	SUV1, failed to give way at priority traffic control, misjudged intentions of another party	Dry	Dark	Fine	Roundabout	Give way	0	0	1
SH 3		I	ARAWATA ST	201039388	03/09/2010	Fri	08:30	Car/Wagon1 SDB on SH 3 hit Car/Wagon2 merging from the left	CAR/WAGON1, failed to give way at priority traffic control	Dry	Overcast	Fine	Roundabout	Give way	0	0	0
SH 3		I	ARAWATA ST	201848911	25/09/2018	Tue	16:20	Car/Wagon1 NDB on ARAWATA STREET, TE AWAMUTU, WAIPA sideswiped by Van2 NDB on ARAWATA STREET, TE AWAMUTU, WAIPA turning left	VAN2, alcohol test below limit, other wrong lane or position CAR/WAGON1, alcohol test below limit	Dry	Bright sun	Fine	Roundabout	Give way	0	0	0
SH 3	5m	S	BOND ROAD	2936728	16/05/2009	Sat	09:34	SUV1 SDB on SH 3 hit rear end of Car/Wagon2 stop/slow for queue	SUV1, failed to notice car slowing, stopping/stationary, following too closely, ENV: slippery road due to rain	Wet	Overcast	Light rain	T Junction	Give way	0	0	0

Crash road	Distance	Direction	Side road	ID	Date	Day of week	Time	Description of events	Crash factors	Surface condition	Natural light	Weather	Junction	Control	Crash count fatal	Crash count severe	Crash count minor
SH 3		I	BOND ROAD	201519543	23/12/2015	Wed	14:40	Car/Wagon2 turning right hit by oncoming SUV1 SDB on SH 3	CAR/WAGON2, didnt look/notice other party - visibility obstruc, failed to give way turning to non-turning traffic SUV1, failed to give way when waved through by other dri	Dry	Bright sun	Null	T Junction	Give way	0	0	1
SH 3		I	CAMBRIDGE ROAD	201335938	08/08/2013	Thu	14:00	Car/Wagon1 SDB on SH 3 hit Car/Wagon2 merging from the left	CAR/WAGON1, failed to give way at priority traffic control, other inattentive	Dry	Overcast	Fine	Roundabout	Give way	0	0	0
SH 3		I	CAMBRIDGE ROAD	201530394	06/01/2015	Tue	08:00	Van1 EDB on SH 3 sideswiped by Car/Wagon2 EDB on SH 3 turning left	VAN1, other inattentive, turned right from incorrect lane	Dry	Bright sun	Fine	Roundabout	Give way	0	0	0
SH 3		I	CAMBRIDGE ROAD	201650354	26/09/2016	Mon	15:40	Car/Wagon1 SDB on SH 3 sideswiped by Car/Wagon2 SDB on SH 3 turning left	CAR/WAGON1, travelled straight ahead from turning lane or flus	Dry	Overcast	Fine	Roundabout	Give way	0	0	0
SH 3		I	CAMBRIDGE ROAD	201652816	18/11/2016	Fri	14:45	Van1 EDB on Ohaupo Road sideswiped by Car/Wagon2 EDB on Ohaupo Road turning left	CAR/WAGON2, turned right from incorrect lane	Dry	Bright sun	Fine	Roundabout	Nil	0	0	0
SH 3		I	SH 3	201739448	15/05/2017	Mon	14:50	Car/Wagon1 EDB on Ohaupo road sideswiped by Car/Wagon2 EDB on Ohaupo road turning left	CAR/WAGON2, did not check/notice another party behind, non-compliance with regulatory device with sign or, turned right from incorrect lane	Dry	Overcast	Fine	Roundabout	Give way	0	0	0

1-38 of 38

Appendix D: T11 Modelling Reports

Modelling outputs for the following intersections included:

- **Proposed Access 1**
- **Proposed Access 2**
- **Proposed Access 3**
- **Gleneagles Road**

Also included as reference for the high-level assessment of State Highway 3:

- **State Highway 3 / Cambridge Road / Arawata Street intersectio**

INTERSECTION SUMMARY

▽ Site: 101 [2018_Low Dev_Access 1_AM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

Intersection Performance - Hourly Values

Performance Measure	Vehicles		Persons	
Travel Speed (Average)	49.5	km/h	49.5	km/h
Travel Distance (Total)	521.7	veh-km/h	626.1	pers-km/h
Travel Time (Total)	10.5	veh-h/h	12.7	pers-h/h
Demand Flows (Total)	518	veh/h	621	pers/h
Percent Heavy Vehicles (Demand)	1.0	%		
Degree of Saturation	0.173			
Practical Spare Capacity	466.9	%		
Effective Intersection Capacity	2996	veh/h		
Control Delay (Total)	0.09	veh-h/h	0.11	pers-h/h
Control Delay (Average)	0.6	sec	0.6	sec
Control Delay (Worst Lane)	7.7	sec		
Control Delay (Worst Movement)	7.7	sec	7.7	sec
Geometric Delay (Average)	0.5	sec		
Stop-Line Delay (Average)	0.2	sec		
Idling Time (Average)	0.0	sec		
Intersection Level of Service (LOS)	NA			
95% Back of Queue - Vehicles (Worst Lane)	0.1	veh		
95% Back of Queue - Distance (Worst Lane)	0.6	m		
Queue Storage Ratio (Worst Lane)	0.00			
Total Effective Stops	31	veh/h	37	pers/h
Effective Stop Rate	0.06		0.06	
Proportion Queued	0.04		0.04	
Performance Index	10.8		10.8	
Cost (Total)	165.94	$/h	165.94	$/h
Fuel Consumption (Total)	32.3	L/h		
Carbon Dioxide (Total)	76.3	kg/h		
Hydrocarbons (Total)	0.005	kg/h		
Carbon Monoxide (Total)	0.059	kg/h		
NOx (Total)	0.040	kg/h		

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 1.2 %
Number of Iterations: 4 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 28.0% 1.6% 0.8%

Intersection Performance - Annual Values

Performance Measure	Vehicles		Persons	
Demand Flows (Total)	248,590	veh/y	298,307	pers/y
Delay	44	veh-h/y	52	pers-h/y
Effective Stops	14,679	veh/y	17,614	pers/y
Travel Distance	250,434	veh-km/y	300,521	pers-km/y
Travel Time	5,062	veh-h/y	6,075	pers-h/y
Cost	79,650	$/y	79,650	$/y
Fuel Consumption	15,521	L/y		
Carbon Dioxide	36,617	kg/y		
Hydrocarbons	2	kg/y		
Carbon Monoxide	28	kg/y		
NOx	19	kg/y		

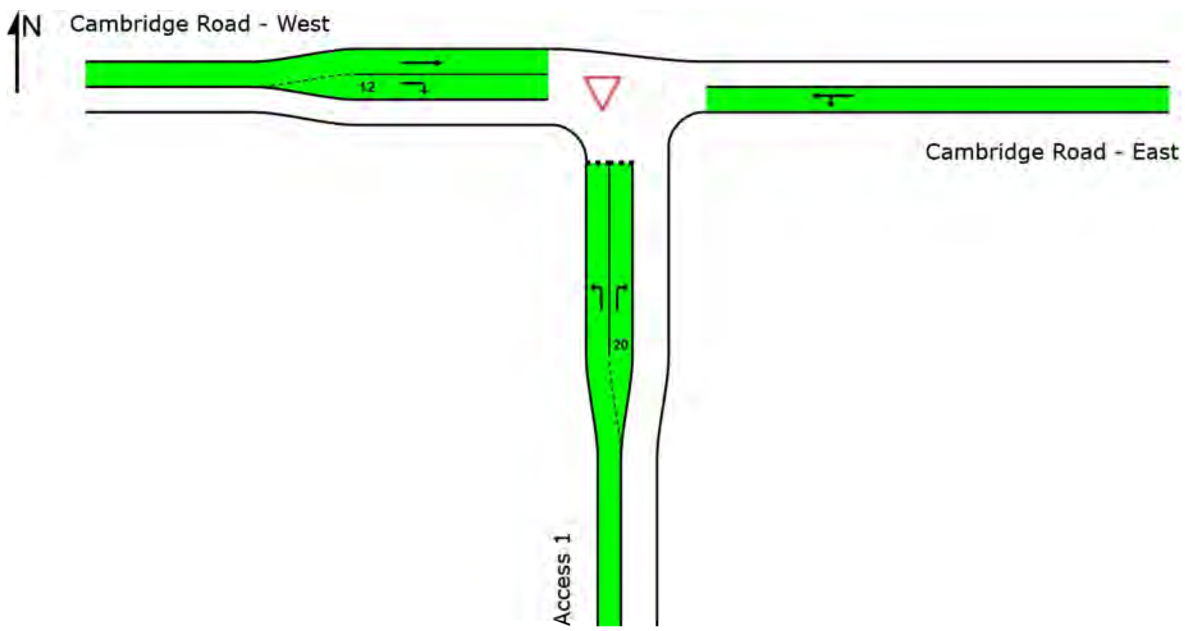
LANE LEVEL OF SERVICE

Lane Level of Service

▽ Site: 101 [2018_Low Dev_Access 1_AM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	South	East	West	
LOS	A	NA	NA	NA



Colour code based on Level of Service

LOS A LOS B LOS C LOS D LOS E LOS F

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

INTERSECTION SUMMARY

▽ Site: 101 [2018_Low Dev_Access 1_PM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	49.5 km/h	49.5 km/h
Travel Distance (Total)	521.7 veh-km/h	626.1 pers-km/h
Travel Time (Total)	10.5 veh-h/h	12.6 pers-h/h
Demand Flows (Total)	518 veh/h	621 pers/h
Percent Heavy Vehicles (Demand)	1.0 %	
Degree of Saturation	0.172	
Practical Spare Capacity	471.0 %	
Effective Intersection Capacity	3017 veh/h	
Control Delay (Total)	0.08 veh-h/h	0.09 pers-h/h
Control Delay (Average)	0.5 sec	0.5 sec
Control Delay (Worst Lane)	7.8 sec	
Control Delay (Worst Movement)	7.8 sec	7.8 sec
Geometric Delay (Average)	0.5 sec	
Stop-Line Delay (Average)	0.1 sec	
Idling Time (Average)	0.0 sec	
Intersection Level of Service (LOS)	NA	
95% Back of Queue - Vehicles (Worst Lane)	0.1 veh	
95% Back of Queue - Distance (Worst Lane)	0.5 m	
Queue Storage Ratio (Worst Lane)	0.00	
Total Effective Stops	28 veh/h	34 pers/h
Effective Stop Rate	0.05	0.05
Proportion Queued	0.02	0.02
Performance Index	10.8	10.8
Cost (Total)	217.50 $/h	217.50 $/h
Fuel Consumption (Total)	32.3 L/h	
Carbon Dioxide (Total)	76.1 kg/h	
Hydrocarbons (Total)	0.005 kg/h	
Carbon Monoxide (Total)	0.059 kg/h	
NOx (Total)	0.040 kg/h	

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Site Model Variability Index (Iterations 3 to N): 0.6 %

Number of Iterations: 3 (Maximum: 10)

Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 63.7% 13.7% 0.6%

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	248,590 veh/y	298,307 pers/y
Delay	38 veh-h/y	45 pers-h/y
Effective Stops	13,465 veh/y	16,158 pers/y
Travel Distance	250,428 veh-km/y	300,513 pers-km/y
Travel Time	5,057 veh-h/y	6,068 pers-h/y
Cost	104,400 $/y	104,400 $/y
Fuel Consumption	15,503 L/y	
Carbon Dioxide	36,544 kg/y	
Hydrocarbons	2 kg/y	
Carbon Monoxide	28 kg/y	
NOx	19 kg/y	

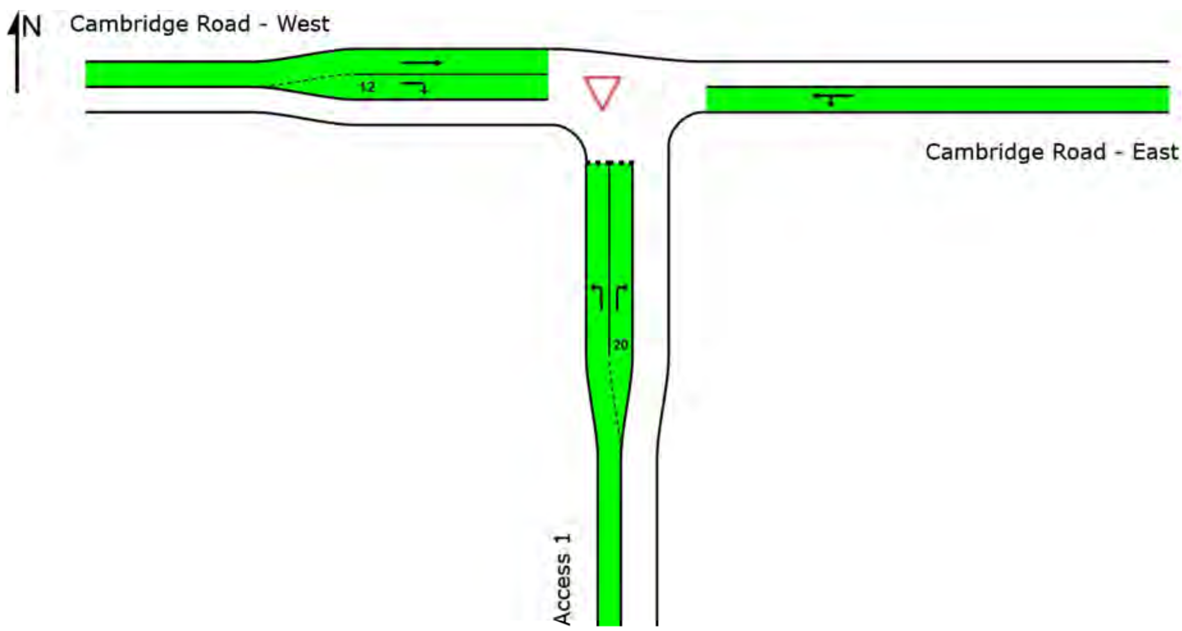
LANE LEVEL OF SERVICE

Lane Level of Service

▽ Site: 101 [2018_Low Dev_Access 1_PM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	South	East	West	
LOS	A	NA	NA	NA



Colour code based on Level of Service

LOS A LOS B LOS C LOS D LOS E LOS F

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

INTERSECTION SUMMARY

▽ Site: 101 [2035_Hi Dev_Access 1_AM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	49.3 km/h	49.3 km/h
Travel Distance (Total)	720.9 veh-km/h	865.1 pers-km/h
Travel Time (Total)	14.6 veh-h/h	17.6 pers-h/h
Demand Flows (Total)	719 veh/h	863 pers/h
Percent Heavy Vehicles (Demand)	1.0 %	
Degree of Saturation	0.233	
Practical Spare Capacity	320.4 %	
Effective Intersection Capacity	3084 veh/h	
Control Delay (Total)	0.18 veh-h/h	0.22 pers-h/h
Control Delay (Average)	0.9 sec	0.9 sec
Control Delay (Worst Lane)	9.6 sec	
Control Delay (Worst Movement)	9.6 sec	9.6 sec
Geometric Delay (Average)	0.6 sec	
Stop-Line Delay (Average)	0.3 sec	
Idling Time (Average)	0.1 sec	
Intersection Level of Service (LOS)	NA	
95% Back of Queue - Vehicles (Worst Lane)	0.2 veh	
95% Back of Queue - Distance (Worst Lane)	1.2 m	
Queue Storage Ratio (Worst Lane)	0.00	
Total Effective Stops	61 veh/h	73 pers/h
Effective Stop Rate	0.09	0.09
Proportion Queued	0.06	0.06
Performance Index	15.2	15.2
Cost (Total)	233.25 $/h	233.25 $/h
Fuel Consumption (Total)	45.1 L/h	
Carbon Dioxide (Total)	106.5 kg/h	
Hydrocarbons (Total)	0.006 kg/h	
Carbon Monoxide (Total)	0.082 kg/h	
NOx (Total)	0.057 kg/h	

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 1.7 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 3.0% 1.5% 0.7%

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	345,095 veh/y	414,114 pers/y
Delay	88 veh-h/y	106 pers-h/y
Effective Stops	29,348 veh/y	35,217 pers/y
Travel Distance	346,050 veh-km/y	415,260 pers-km/y
Travel Time	7,025 veh-h/y	8,431 pers-h/y
Cost	111,961 $/y	111,961 $/y
Fuel Consumption	21,672 L/y	
Carbon Dioxide	51,126 kg/y	
Hydrocarbons	3 kg/y	
Carbon Monoxide	39 kg/y	
NOx	27 kg/y	

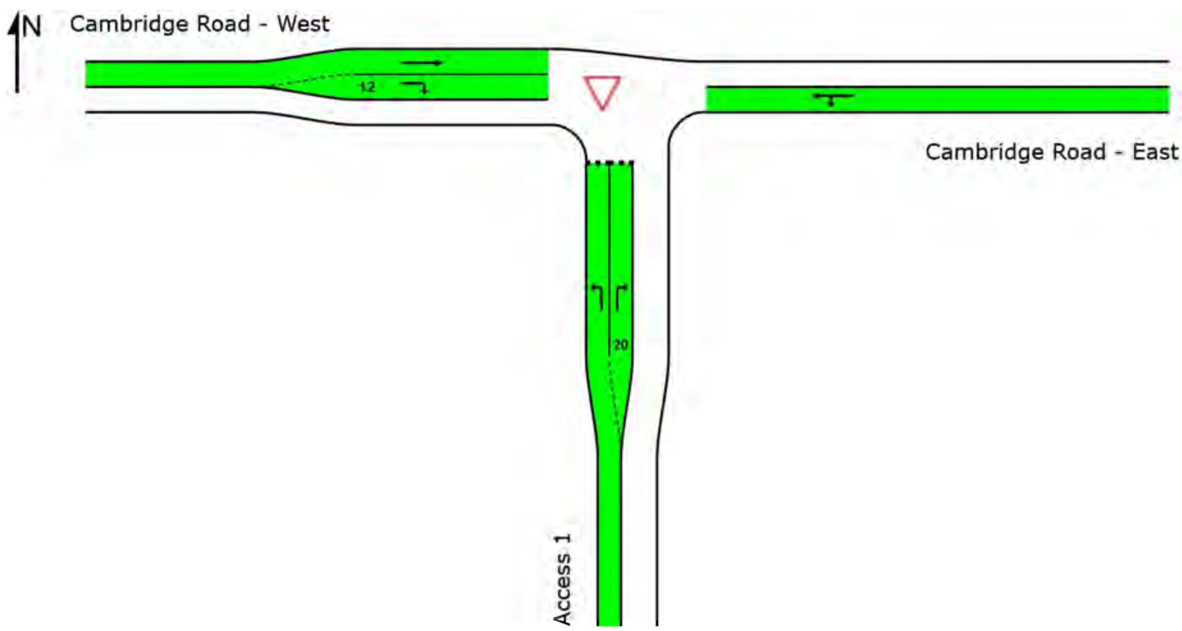
LANE LEVEL OF SERVICE

Lane Level of Service

▽ Site: 101 [2035_Hi Dev_Access 1_AM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	South	East	West	
LOS	A	NA	NA	NA



Colour code based on Level of Service

LOS A | LOS B | LOS C | LOS D | LOS E | LOS F

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Organisation: TONKIN & TAYLOR | Processed: Friday, 31 May 2019 1:42:57 PM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T11_Cambridge Rd.sip8

INTERSECTION SUMMARY

▽ Site: 101 [2035_Hi Dev_Access 1_PM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	49.3 km/h	49.3 km/h
Travel Distance (Total)	720.9 veh-km/h	865.1 pers-km/h
Travel Time (Total)	14.6 veh-h/h	17.5 pers-h/h
Demand Flows (Total)	719 veh/h	863 pers/h
Percent Heavy Vehicles (Demand)	1.0 %	
Degree of Saturation	0.230	
Practical Spare Capacity	326.4 %	
Effective Intersection Capacity	3128 veh/h	
Control Delay (Total)	0.15 veh-h/h	0.18 pers-h/h
Control Delay (Average)	0.8 sec	0.8 sec
Control Delay (Worst Lane)	9.8 sec	
Control Delay (Worst Movement)	9.8 sec	9.8 sec
Geometric Delay (Average)	0.6 sec	
Stop-Line Delay (Average)	0.1 sec	
Idling Time (Average)	0.0 sec	
Intersection Level of Service (LOS)	NA	
95% Back of Queue - Vehicles (Worst Lane)	0.1 veh	
95% Back of Queue - Distance (Worst Lane)	1.0 m	
Queue Storage Ratio (Worst Lane)	0.00	
Total Effective Stops	53 veh/h	63 pers/h
Effective Stop Rate	0.07	0.07
Proportion Queued	0.04	0.04
Performance Index	15.1	15.1
Cost (Total)	303.70 $/h	303.70 $/h
Fuel Consumption (Total)	45.1 L/h	
Carbon Dioxide (Total)	106.2 kg/h	
Hydrocarbons (Total)	0.006 kg/h	
Carbon Monoxide (Total)	0.082 kg/h	
NOx (Total)	0.056 kg/h	

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 0.9 %
Number of Iterations: 4 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 18.2% 1.2% 0.6%

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	345,095 veh/y	414,114 pers/y
Delay	73 veh-h/y	87 pers-h/y
Effective Stops	25,317 veh/y	30,380 pers/y
Travel Distance	346,036 veh-km/y	415,243 pers-km/y
Travel Time	7,012 veh-h/y	8,415 pers-h/y
Cost	145,777 $/y	145,777 $/y
Fuel Consumption	21,633 L/y	
Carbon Dioxide	50,993 kg/y	
Hydrocarbons	3 kg/y	
Carbon Monoxide	39 kg/y	
NOx	27 kg/y	

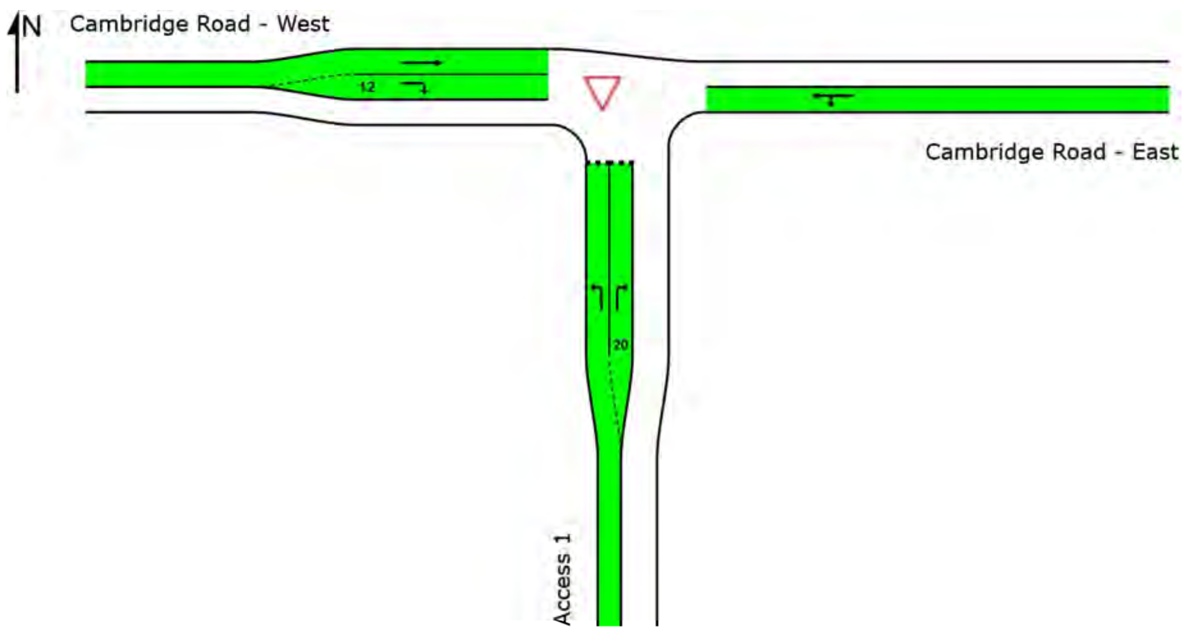
LANE LEVEL OF SERVICE

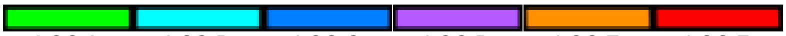
Lane Level of Service

▽ Site: 101 [2035_Hi Dev_Access 1_PM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	South	East	West	
LOS	A	NA	NA	NA





Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

INTERSECTION SUMMARY

Site: 101 [2018_Low Dev_Access 2_AM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	49.3 km/h	49.3 km/h
Travel Distance (Total)	210.1 veh-km/h	252.2 pers-km/h
Travel Time (Total)	4.3 veh-h/h	5.1 pers-h/h
Demand Flows (Total)	496 veh/h	595 pers/h
Percent Heavy Vehicles (Demand)	1.0 %	
Degree of Saturation	0.168	
Practical Spare Capacity	483.8 %	
Effective Intersection Capacity	2954 veh/h	
Control Delay (Total)	0.05 veh-h/h	0.06 pers-h/h
Control Delay (Average)	0.4 sec	0.4 sec
Control Delay (Worst Lane)	6.2 sec	
Control Delay (Worst Movement)	7.7 sec	7.7 sec
Geometric Delay (Average)	0.3 sec	
Stop-Line Delay (Average)	0.1 sec	
Idling Time (Average)	0.0 sec	
Intersection Level of Service (LOS)	NA	
95% Back of Queue - Vehicles (Worst Lane)	0.1 veh	
95% Back of Queue - Distance (Worst Lane)	0.6 m	
Queue Storage Ratio (Worst Lane)	0.00	
Total Effective Stops	18 veh/h	21 pers/h
Effective Stop Rate	0.04	0.04
Proportion Queued	0.02	0.02
Performance Index	4.5	4.5
Cost (Total)	71.45 $/h	71.45 $/h
Fuel Consumption (Total)	13.2 L/h	
Carbon Dioxide (Total)	31.2 kg/h	
Hydrocarbons (Total)	0.002 kg/h	
Carbon Monoxide (Total)	0.024 kg/h	
NOx (Total)	0.017 kg/h	

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 0.9 %
Number of Iterations: 3 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 49.9% 27.9% 0.9%

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	237,979 veh/y	285,575 pers/y
Delay	25 veh-h/y	30 pers-h/y
Effective Stops	8,569 veh/y	10,283 pers/y
Travel Distance	100,865 veh-km/y	121,037 pers-km/y
Travel Time	2,047 veh-h/y	2,457 pers-h/y
Cost	34,296 $/y	34,296 $/y
Fuel Consumption	6,341 L/y	
Carbon Dioxide	14,956 kg/y	
Hydrocarbons	1 kg/y	
Carbon Monoxide	12 kg/y	
NOx	8 kg/y	

Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T11_Cambridge Rd.sip8

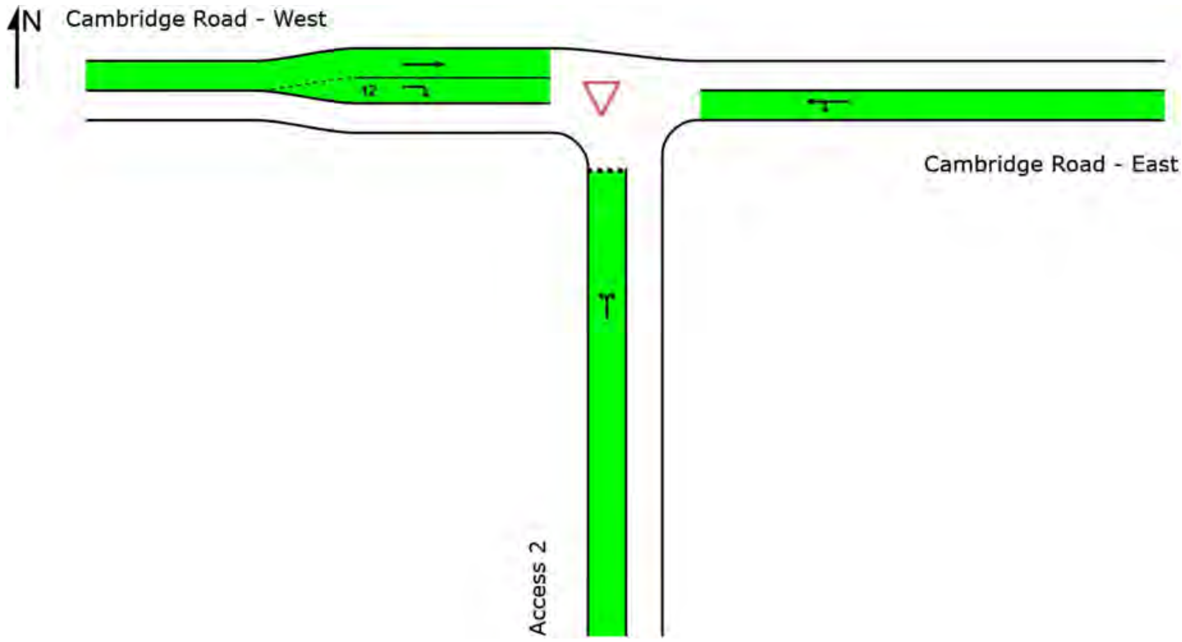
LANE LEVEL OF SERVICE

Lane Level of Service

▽ Site: 101 [2018_Low Dev_Access 2_AM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	South	East	West	
LOS	A	NA	NA	NA



Colour code based on Level of Service

LOS A LOS B LOS C LOS D LOS E LOS F

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Organisation: TONKIN & TAYLOR | Processed: Friday, 31 May 2019 1:42:53 PM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T11_Cambridge Rd.sip8

INTERSECTION SUMMARY

▽ Site: 101 [2018_Low Dev_Access 2_PM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

Intersection Performance - Hourly Values				
Performance Measure	Vehicles		Persons	
Travel Speed (Average)	49.3	km/h	49.3	km/h
Travel Distance (Total)	210.1	veh-km/h	252.1	pers-km/h
Travel Time (Total)	4.3	veh-h/h	5.1	pers-h/h
Demand Flows (Total)	496	veh/h	595	pers/h
Percent Heavy Vehicles (Demand)	1.0	%		
Degree of Saturation	0.167			
Practical Spare Capacity	487.5	%		
Effective Intersection Capacity	2972	veh/h		
Control Delay (Total)	0.05	veh-h/h	0.06	pers-h/h
Control Delay (Average)	0.3	sec	0.3	sec
Control Delay (Worst Lane)	5.9	sec		
Control Delay (Worst Movement)	7.7	sec	7.7	sec
Geometric Delay (Average)	0.3	sec		
Stop-Line Delay (Average)	0.0	sec		
Idling Time (Average)	0.0	sec		
Intersection Level of Service (LOS)	NA			
95% Back of Queue - Vehicles (Worst Lane)	0.0	veh		
95% Back of Queue - Distance (Worst Lane)	0.3	m		
Queue Storage Ratio (Worst Lane)	0.00			
Total Effective Stops	16	veh/h	20	pers/h
Effective Stop Rate	0.03		0.03	
Proportion Queued	0.01		0.01	
Performance Index	4.4		4.4	
Cost (Total)	87.53	$/h	87.53	$/h
Fuel Consumption (Total)	13.2	L/h		
Carbon Dioxide (Total)	31.1	kg/h		
Hydrocarbons (Total)	0.002	kg/h		
Carbon Monoxide (Total)	0.024	kg/h		
NOx (Total)	0.017	kg/h		

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 0.4 %
Number of Iterations: 3 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 47.1% 13.3% 0.4%

Intersection Performance - Annual Values				
Performance Measure	Vehicles		Persons	
Demand Flows (Total)	237,979	veh/y	285,575	pers/y
Delay	22	veh-h/y	27	pers-h/y
Effective Stops	7,859	veh/y	9,430	pers/y
Travel Distance	100,855	veh-km/y	121,026	pers-km/y
Travel Time	2,045	veh-h/y	2,454	pers-h/y
Cost	42,012	$/y	42,012	$/y
Fuel Consumption	6,331	L/y		
Carbon Dioxide	14,924	kg/y		
Hydrocarbons	1	kg/y		
Carbon Monoxide	12	kg/y		
NOx	8	kg/y		

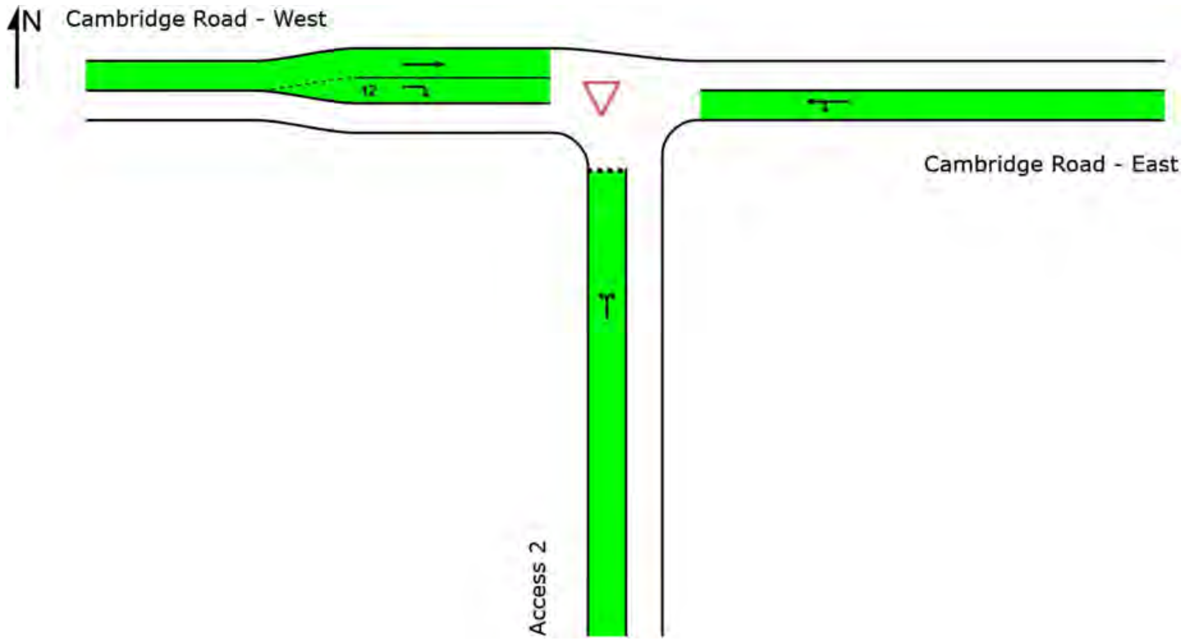
LANE LEVEL OF SERVICE

Lane Level of Service

▽ Site: 101 [2018_Low Dev_Access 2_PM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	South	East	West	
LOS	A	NA	NA	NA



Colour code based on Level of Service

LOS A | LOS B | LOS C | LOS D | LOS E | LOS F

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

INTERSECTION SUMMARY

Site: 101 [2035_Hi Dev_Access 2_AM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	48.8 km/h	48.8 km/h
Travel Distance (Total)	291.0 veh-km/h	349.2 pers-km/h
Travel Time (Total)	6.0 veh-h/h	7.2 pers-h/h
Demand Flows (Total)	685 veh/h	822 pers/h
Percent Heavy Vehicles (Demand)	1.0 %	
Degree of Saturation	0.225	
Practical Spare Capacity	334.7 %	
Effective Intersection Capacity	3040 veh/h	
Control Delay (Total)	0.12 veh-h/h	0.14 pers-h/h
Control Delay (Average)	0.6 sec	0.6 sec
Control Delay (Worst Lane)	7.3 sec	
Control Delay (Worst Movement)	9.7 sec	9.7 sec
Geometric Delay (Average)	0.4 sec	
Stop-Line Delay (Average)	0.2 sec	
Idling Time (Average)	0.0 sec	
Intersection Level of Service (LOS)	NA	
95% Back of Queue - Vehicles (Worst Lane)	0.2 veh	
95% Back of Queue - Distance (Worst Lane)	1.4 m	
Queue Storage Ratio (Worst Lane)	0.00	
Total Effective Stops	40 veh/h	48 pers/h
Effective Stop Rate	0.06	0.06
Proportion Queued	0.04	0.04
Performance Index	6.5	6.5
Cost (Total)	102.47 $/h	102.47 $/h
Fuel Consumption (Total)	18.7 L/h	
Carbon Dioxide (Total)	44.1 kg/h	
Hydrocarbons (Total)	0.003 kg/h	
Carbon Monoxide (Total)	0.034 kg/h	
NOx (Total)	0.024 kg/h	

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 1.2 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 2.1% 1.0% 0.5%

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	328,926 veh/y	394,712 pers/y
Delay	58 veh-h/y	69 pers-h/y
Effective Stops	19,276 veh/y	23,132 pers/y
Travel Distance	139,664 veh-km/y	167,596 pers-km/y
Travel Time	2,860 veh-h/y	3,432 pers-h/y
Cost	49,185 $/y	49,185 $/y
Fuel Consumption	8,972 L/y	
Carbon Dioxide	21,161 kg/y	
Hydrocarbons	1 kg/y	
Carbon Monoxide	16 kg/y	
NOx	12 kg/y	

Organisation: TONKIN & TAYLOR | Processed: Friday, 31 May 2019 1:42:57 PM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T11_Cambridge Rd.sip8

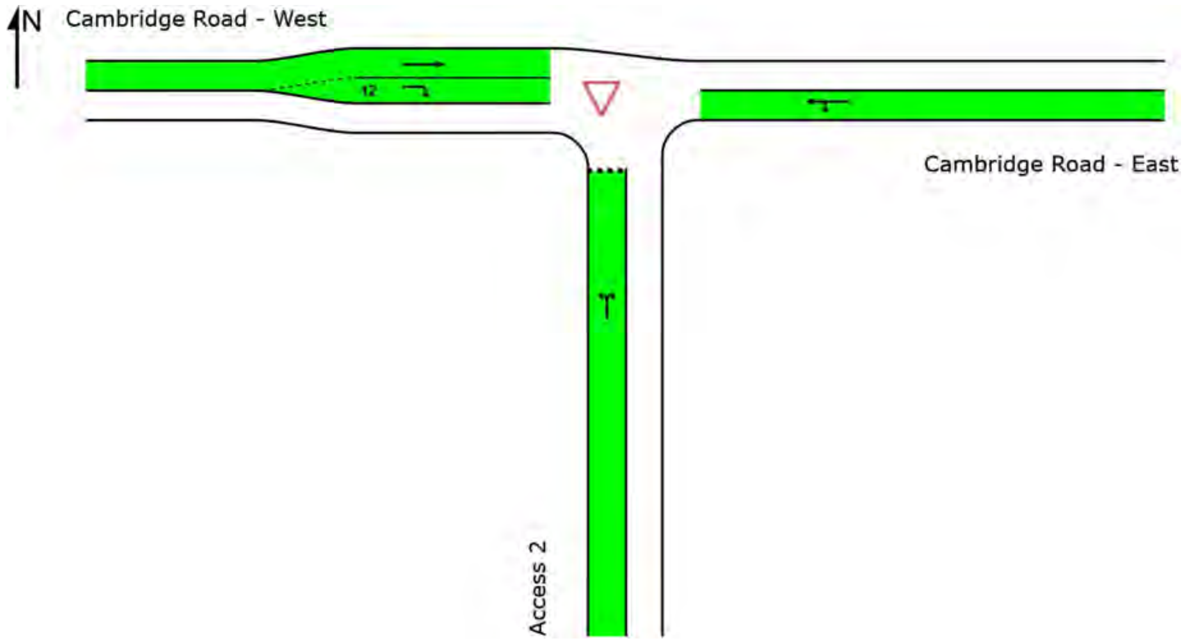
LANE LEVEL OF SERVICE

Lane Level of Service

▽ Site: 101 [2035_Hi Dev_Access 2_AM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	South	East	West	
LOS	A	NA	NA	NA



Colour code based on Level of Service

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Organisation: TONKIN & TAYLOR | Processed: Friday, 31 May 2019 1:42:57 PM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T11_Cambridge Rd.sip8

INTERSECTION SUMMARY

Site: 101 [2035_Hi Dev_Access 2_PM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	49.0 km/h	49.0 km/h
Travel Distance (Total)	290.9 veh-km/h	349.1 pers-km/h
Travel Time (Total)	5.9 veh-h/h	7.1 pers-h/h
Demand Flows (Total)	685 veh/h	822 pers/h
Percent Heavy Vehicles (Demand)	1.0 %	
Degree of Saturation	0.224	
Practical Spare Capacity	336.8 %	
Effective Intersection Capacity	3054 veh/h	
Control Delay (Total)	0.10 veh-h/h	0.12 pers-h/h
Control Delay (Average)	0.5 sec	0.5 sec
Control Delay (Worst Lane)	6.4 sec	
Control Delay (Worst Movement)	9.7 sec	9.7 sec
Geometric Delay (Average)	0.4 sec	
Stop-Line Delay (Average)	0.1 sec	
Idling Time (Average)	0.0 sec	
Intersection Level of Service (LOS)	NA	
95% Back of Queue - Vehicles (Worst Lane)	0.1 veh	
95% Back of Queue - Distance (Worst Lane)	0.6 m	
Queue Storage Ratio (Worst Lane)	0.00	
Total Effective Stops	34 veh/h	41 pers/h
Effective Stop Rate	0.05	0.05
Proportion Queued	0.02	0.02
Performance Index	6.3	6.3
Cost (Total)	123.57 $/h	123.57 $/h
Fuel Consumption (Total)	18.6 L/h	
Carbon Dioxide (Total)	43.9 kg/h	
Hydrocarbons (Total)	0.003 kg/h	
Carbon Monoxide (Total)	0.034 kg/h	
NOx (Total)	0.024 kg/h	

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 0.8 %
Number of Iterations: 3 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 52.1% 17.7% 0.8%

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	328,926 veh/y	394,712 pers/y
Delay	46 veh-h/y	56 pers-h/y
Effective Stops	16,214 veh/y	19,457 pers/y
Travel Distance	139,651 veh-km/y	167,582 pers-km/y
Travel Time	2,850 veh-h/y	3,421 pers-h/y
Cost	59,315 $/y	59,315 $/y
Fuel Consumption	8,942 L/y	
Carbon Dioxide	21,080 kg/y	
Hydrocarbons	1 kg/y	
Carbon Monoxide	16 kg/y	
NOx	12 kg/y	

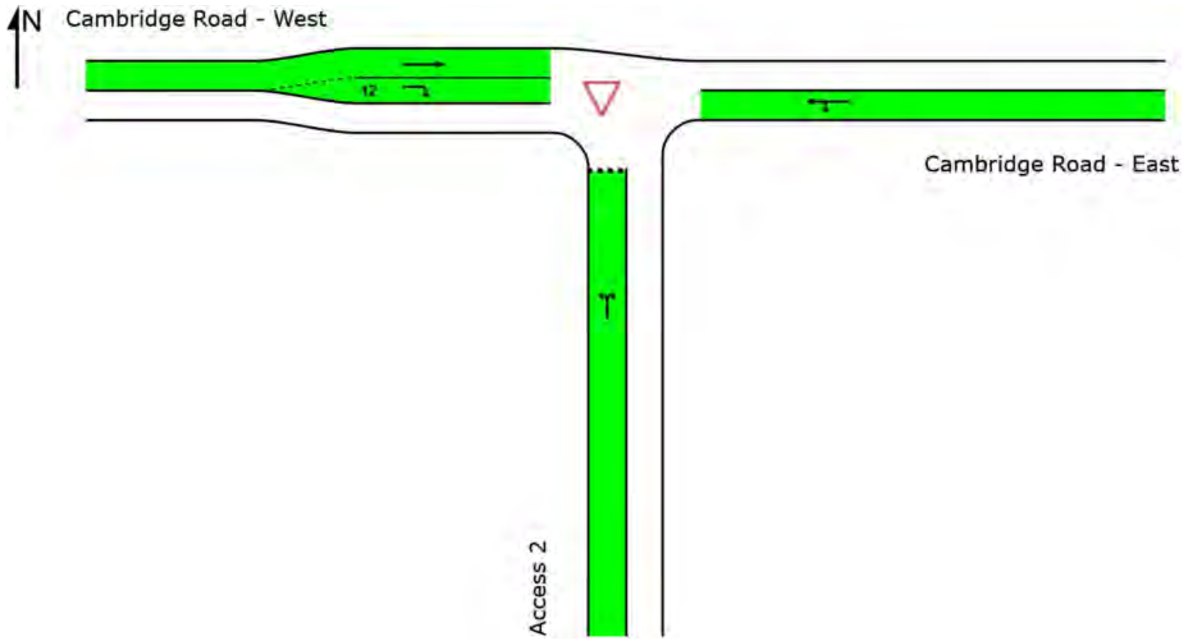
LANE LEVEL OF SERVICE

Lane Level of Service

▽ Site: 101 [2035_Hi Dev_Access 2_PM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	South	East	West	
LOS	A	NA	NA	NA



Colour code based on Level of Service

LOS A LOS B LOS C LOS D LOS E LOS F

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Organisation: TONKIN & TAYLOR | Processed: Friday, 31 May 2019 1:42:58 PM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T11_Cambridge Rd.sip8

INTERSECTION SUMMARY

Site: 101 [2018_Low Dev_Access 3_AM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	48.3 km/h	48.3 km/h
Travel Distance (Total)	259.4 veh-km/h	311.3 pers-km/h
Travel Time (Total)	5.4 veh-h/h	6.4 pers-h/h
Demand Flows (Total)	548 veh/h	658 pers/h
Percent Heavy Vehicles (Demand)	1.0 %	
Degree of Saturation	0.170	
Practical Spare Capacity	476.1 %	
Effective Intersection Capacity	3224 veh/h	
Control Delay (Total)	0.15 veh-h/h	0.18 pers-h/h
Control Delay (Average)	1.0 sec	1.0 sec
Control Delay (Worst Lane)	6.0 sec	
Control Delay (Worst Movement)	6.7 sec	6.7 sec
Geometric Delay (Average)	0.7 sec	
Stop-Line Delay (Average)	0.3 sec	
Idling Time (Average)	0.0 sec	
Intersection Level of Service (LOS)	NA	
95% Back of Queue - Vehicles (Worst Lane)	0.2 veh	
95% Back of Queue - Distance (Worst Lane)	1.4 m	
Queue Storage Ratio (Worst Lane)	0.00	
Total Effective Stops	50 veh/h	60 pers/h
Effective Stop Rate	0.09	0.09
Proportion Queued	0.08	0.08
Performance Index	6.2	6.2
Cost (Total)	113.30 $/h	113.30 $/h
Fuel Consumption (Total)	17.5 L/h	
Carbon Dioxide (Total)	41.2 kg/h	
Hydrocarbons (Total)	0.003 kg/h	
Carbon Monoxide (Total)	0.032 kg/h	
NOx (Total)	0.024 kg/h	

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 3 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 46.5% 5.3% 0.0%

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	263,242 veh/y	315,891 pers/y
Delay	70 veh-h/y	84 pers-h/y
Effective Stops	23,864 veh/y	28,637 pers/y
Travel Distance	124,532 veh-km/y	149,439 pers-km/y
Travel Time	2,576 veh-h/y	3,091 pers-h/y
Cost	54,385 $/y	54,385 $/y
Fuel Consumption	8,385 L/y	
Carbon Dioxide	19,765 kg/y	
Hydrocarbons	1 kg/y	
Carbon Monoxide	16 kg/y	
NOx	11 kg/y	

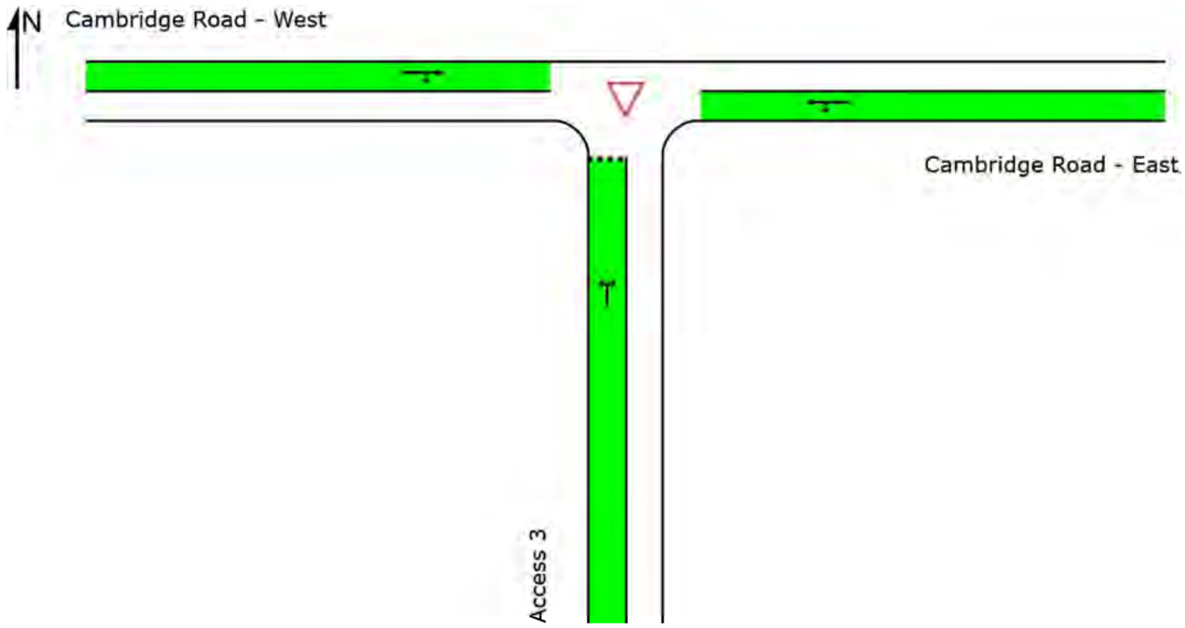
LANE LEVEL OF SERVICE

Lane Level of Service

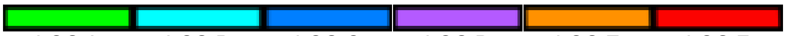
▽ Site: 101 [2018_Low Dev_Access 3_AM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	South	East	West	
LOS	A	NA	NA	NA



Colour code based on Level of Service



Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Organisation: TONKIN & TAYLOR | Processed: Saturday, 8 June 2019 6:13:52 PM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T11_Cambridge Rd.sip8

INTERSECTION SUMMARY

▽ Site: 101 [2018_Low Dev_Access 3_PM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

Intersection Performance - Hourly Values

Performance Measure	Vehicles		Persons	
Travel Speed (Average)	48.4	km/h	48.4	km/h
Travel Distance (Total)	259.4	veh-km/h	311.3	pers-km/h
Travel Time (Total)	5.4	veh-h/h	6.4	pers-h/h
Demand Flows (Total)	548	veh/h	658	pers/h
Percent Heavy Vehicles (Demand)	1.0	%		
Degree of Saturation	0.193			
Practical Spare Capacity	406.6	%		
Effective Intersection Capacity	2835	veh/h		
Control Delay (Total)	0.13	veh-h/h	0.16	pers-h/h
Control Delay (Average)	0.8	sec	0.8	sec
Control Delay (Worst Lane)	5.5	sec		
Control Delay (Worst Movement)	6.8	sec	6.8	sec
Geometric Delay (Average)	0.7	sec		
Stop-Line Delay (Average)	0.1	sec		
Idling Time (Average)	0.0	sec		
Intersection Level of Service (LOS)	NA			
95% Back of Queue - Vehicles (Worst Lane)	0.3	veh		
95% Back of Queue - Distance (Worst Lane)	2.2	m		
Queue Storage Ratio (Worst Lane)	0.01			
Total Effective Stops	46	veh/h	55	pers/h
Effective Stop Rate	0.08		0.08	
Proportion Queued	0.06		0.06	
Performance Index	6.2		6.2	
Cost (Total)	100.27	$/h	100.27	$/h
Fuel Consumption (Total)	17.6	L/h		
Carbon Dioxide (Total)	41.5	kg/h		
Hydrocarbons (Total)	0.003	kg/h		
Carbon Monoxide (Total)	0.033	kg/h		
NOx (Total)	0.024	kg/h		

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 3 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 41.0% 2.7% 0.0%

Intersection Performance - Annual Values

Performance Measure	Vehicles		Persons	
Demand Flows (Total)	263,242	veh/y	315,891	pers/y
Delay	62	veh-h/y	74	pers-h/y
Effective Stops	22,104	veh/y	26,525	pers/y
Travel Distance	124,514	veh-km/y	149,417	pers-km/y
Travel Time	2,572	veh-h/y	3,087	pers-h/y
Cost	48,130	$/y	48,130	$/y
Fuel Consumption	8,443	L/y		
Carbon Dioxide	19,911	kg/y		
Hydrocarbons	1	kg/y		
Carbon Monoxide	16	kg/y		
NOx	12	kg/y		

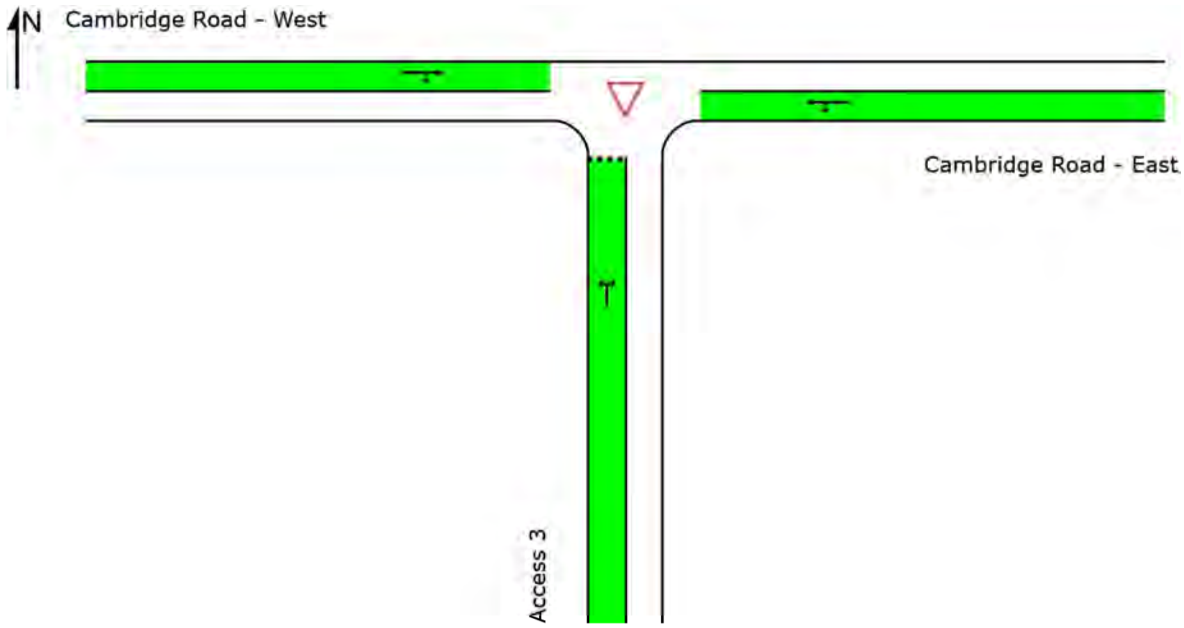
LANE LEVEL OF SERVICE

Lane Level of Service

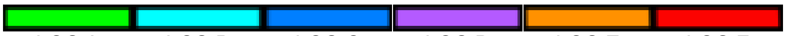
▽ Site: 101 [2018_Low Dev_Access 3_PM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	South	East	West	
LOS	A	NA	NA	NA



Colour code based on Level of Service



Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Organisation: TONKIN & TAYLOR | Processed: Saturday, 8 June 2019 6:13:52 PM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T11_Cambridge Rd.sip8

INTERSECTION SUMMARY

▽ Site: 101 [2035_Hi Dev_Access 3_AM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	47.5	km/h	47.5	km/h
Travel Distance (Total)	371.2	veh-km/h	445.5	pers-km/h
Travel Time (Total)	7.8	veh-h/h	9.4	pers-h/h
Demand Flows (Total)	791	veh/h	949	pers/h
Percent Heavy Vehicles (Demand)	1.0	%		
Degree of Saturation	0.231			
Practical Spare Capacity	325.1	%		
Effective Intersection Capacity	3429	veh/h		
Control Delay (Total)	0.34	veh-h/h	0.41	pers-h/h
Control Delay (Average)	1.5	sec	1.5	sec
Control Delay (Worst Lane)	6.9	sec		
Control Delay (Worst Movement)	8.2	sec	8.2	sec
Geometric Delay (Average)	1.0	sec		
Stop-Line Delay (Average)	0.6	sec		
Idling Time (Average)	0.1	sec		
Intersection Level of Service (LOS)	NA			
95% Back of Queue - Vehicles (Worst Lane)	0.5	veh		
95% Back of Queue - Distance (Worst Lane)	3.4	m		
Queue Storage Ratio (Worst Lane)	0.01			
Total Effective Stops	112	veh/h	134	pers/h
Effective Stop Rate	0.14		0.14	
Proportion Queued	0.13		0.13	
Performance Index	9.7		9.7	
Cost (Total)	171.05	$/h	171.05	$/h
Fuel Consumption (Total)	26.3	L/h		
Carbon Dioxide (Total)	61.9	kg/h		
Hydrocarbons (Total)	0.004	kg/h		
Carbon Monoxide (Total)	0.049	kg/h		
NOx (Total)	0.037	kg/h		

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 3 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 54.4% 10.2% 0.0%

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	379,453	veh/y	455,343	pers/y
Delay	162	veh-h/y	195	pers-h/y
Effective Stops	53,537	veh/y	64,245	pers/y
Travel Distance	178,181	veh-km/y	213,817	pers-km/y
Travel Time	3,750	veh-h/y	4,500	pers-h/y
Cost	82,103	$/y	82,103	$/y
Fuel Consumption	12,600	L/y		
Carbon Dioxide	29,699	kg/y		
Hydrocarbons	2	kg/y		
Carbon Monoxide	24	kg/y		
NOx	18	kg/y		

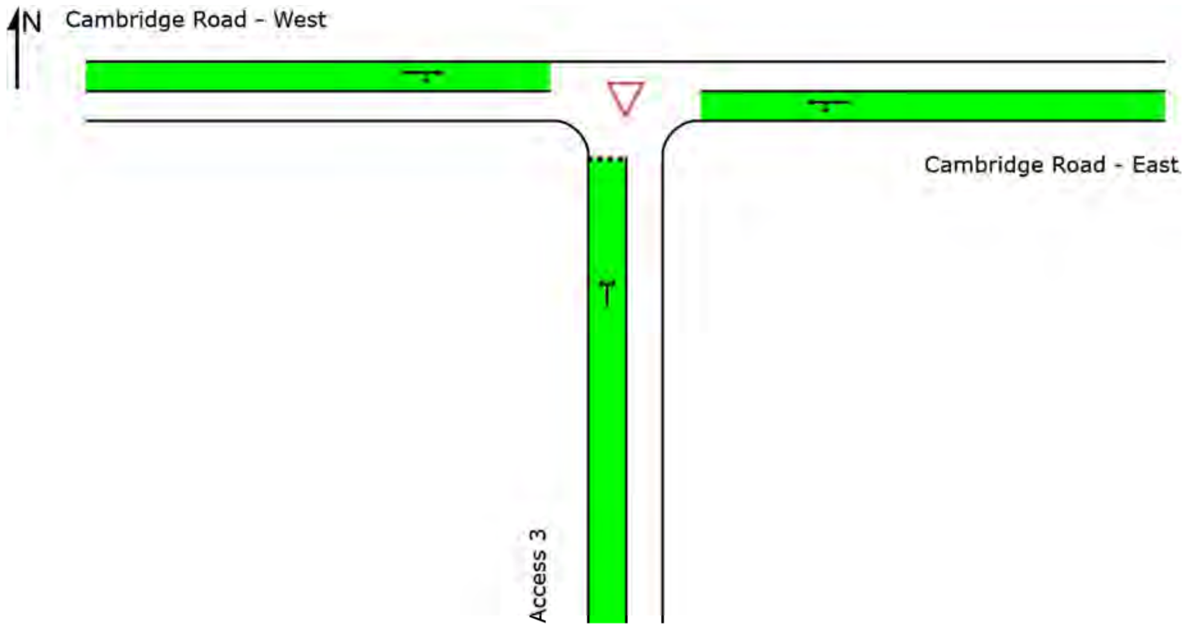
LANE LEVEL OF SERVICE

Lane Level of Service

▽ Site: 101 [2035_Hi Dev_Access 3_AM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	South	East	West	
LOS	A	NA	NA	NA



Colour code based on Level of Service

LOS A LOS B LOS C LOS D LOS E LOS F

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

INTERSECTION SUMMARY

▽ Site: 101 [2035_Hi Dev_Access 3_PM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	47.6	km/h	47.6	km/h
Travel Distance (Total)	371.1	veh-km/h	445.4	pers-km/h
Travel Time (Total)	7.8	veh-h/h	9.4	pers-h/h
Demand Flows (Total)	791	veh/h	949	pers/h
Percent Heavy Vehicles (Demand)	1.0	%		
Degree of Saturation	0.281			
Practical Spare Capacity	249.3	%		
Effective Intersection Capacity	2817	veh/h		
Control Delay (Total)	0.29	veh-h/h	0.34	pers-h/h
Control Delay (Average)	1.3	sec	1.3	sec
Control Delay (Worst Lane)	6.1	sec		
Control Delay (Worst Movement)	8.5	sec	8.5	sec
Geometric Delay (Average)	1.0	sec		
Stop-Line Delay (Average)	0.3	sec		
Idling Time (Average)	0.0	sec		
Intersection Level of Service (LOS)	NA			
95% Back of Queue - Vehicles (Worst Lane)	0.7	veh		
95% Back of Queue - Distance (Worst Lane)	5.1	m		
Queue Storage Ratio (Worst Lane)	0.01			
Total Effective Stops	95	veh/h	114	pers/h
Effective Stop Rate	0.12		0.12	
Proportion Queued	0.11		0.11	
Performance Index	9.7		9.7	
Cost (Total)	154.73	$/h	154.73	$/h
Fuel Consumption (Total)	26.6	L/h		
Carbon Dioxide (Total)	62.7	kg/h		
Hydrocarbons (Total)	0.004	kg/h		
Carbon Monoxide (Total)	0.050	kg/h		
NOx (Total)	0.039	kg/h		

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 3 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 48.8% 5.0% 0.0%

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	379,453	veh/y	455,343	pers/y
Delay	138	veh-h/y	166	pers-h/y
Effective Stops	45,569	veh/y	54,683	pers/y
Travel Distance	178,144	veh-km/y	213,772	pers-km/y
Travel Time	3,741	veh-h/y	4,489	pers-h/y
Cost	74,272	$/y	74,272	$/y
Fuel Consumption	12,771	L/y		
Carbon Dioxide	30,113	kg/y		
Hydrocarbons	2	kg/y		
Carbon Monoxide	24	kg/y		
NOx	19	kg/y		

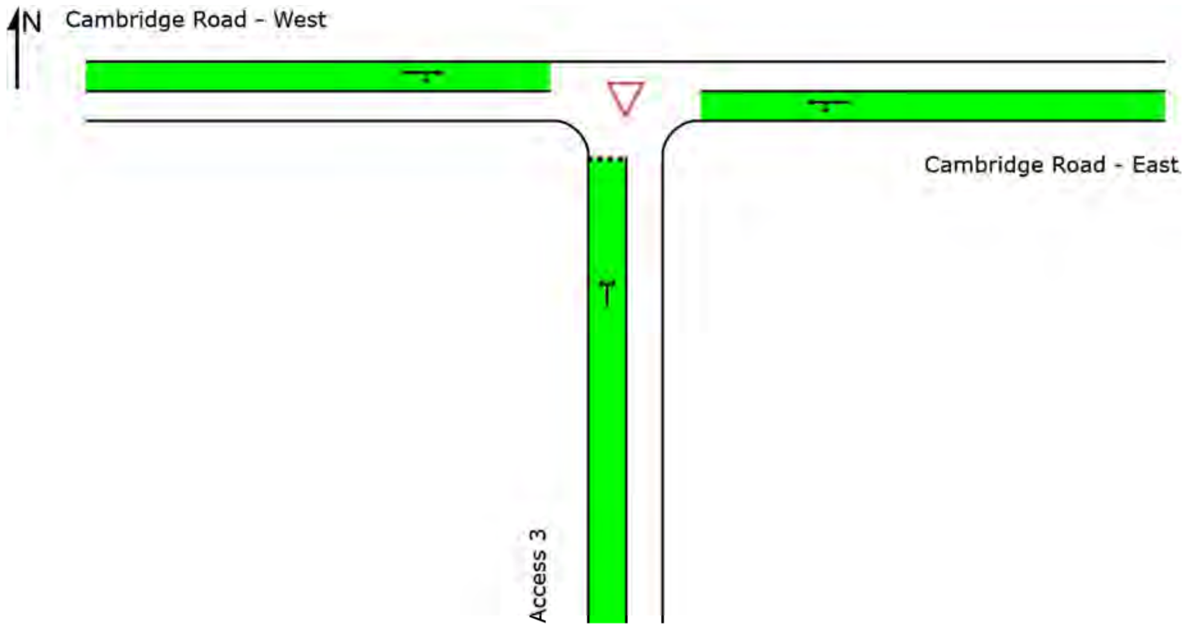
LANE LEVEL OF SERVICE

Lane Level of Service

▽ Site: 101 [2035_Hi Dev_Access 3_PM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	South	East	West	
LOS	A	NA	NA	NA



Colour code based on Level of Service

LOS A | LOS B | LOS C | LOS D | LOS E | LOS F

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Organisation: TONKIN & TAYLOR | Processed: Saturday, 8 June 2019 6:13:57 PM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T11_Cambridge Rd.sip8

INTERSECTION SUMMARY

▽ Site: 101 [2018_Low Dev_Gleneagles_AM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	49.0 km/h	49.0 km/h
Travel Distance (Total)	155.1 veh-km/h	186.1 pers-km/h
Travel Time (Total)	3.2 veh-h/h	3.8 pers-h/h
Demand Flows (Total)	496 veh/h	595 pers/h
Percent Heavy Vehicles (Demand)	0.9 %	
Degree of Saturation	0.173	
Practical Spare Capacity	467.7 %	
Effective Intersection Capacity	2872 veh/h	
Control Delay (Total)	0.05 veh-h/h	0.06 pers-h/h
Control Delay (Average)	0.4 sec	0.4 sec
Control Delay (Worst Lane)	6.1 sec	
Control Delay (Worst Movement)	6.5 sec	6.5 sec
Geometric Delay (Average)	0.3 sec	
Stop-Line Delay (Average)	0.1 sec	
Idling Time (Average)	0.0 sec	
Intersection Level of Service (LOS)	NA	
95% Back of Queue - Vehicles (Worst Lane)	0.1 veh	
95% Back of Queue - Distance (Worst Lane)	0.5 m	
Queue Storage Ratio (Worst Lane)	0.00	
Total Effective Stops	18 veh/h	22 pers/h
Effective Stop Rate	0.04	0.04
Proportion Queued	0.02	0.02
Performance Index	3.3	3.3
Cost (Total)	62.41 $/h	62.41 $/h
Fuel Consumption (Total)	9.9 L/h	
Carbon Dioxide (Total)	23.3 kg/h	
Hydrocarbons (Total)	0.001 kg/h	
Carbon Monoxide (Total)	0.018 kg/h	
NOx (Total)	0.011 kg/h	

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 2 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 0.0% 49.4% 0.2%

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	237,979 veh/y	285,575 pers/y
Delay	24 veh-h/y	29 pers-h/y
Effective Stops	8,714 veh/y	10,456 pers/y
Travel Distance	74,445 veh-km/y	89,334 pers-km/y
Travel Time	1,519 veh-h/y	1,823 pers-h/y
Cost	29,958 $/y	29,958 $/y
Fuel Consumption	4,741 L/y	
Carbon Dioxide	11,176 kg/y	
Hydrocarbons	1 kg/y	
Carbon Monoxide	9 kg/y	
NOx	5 kg/y	

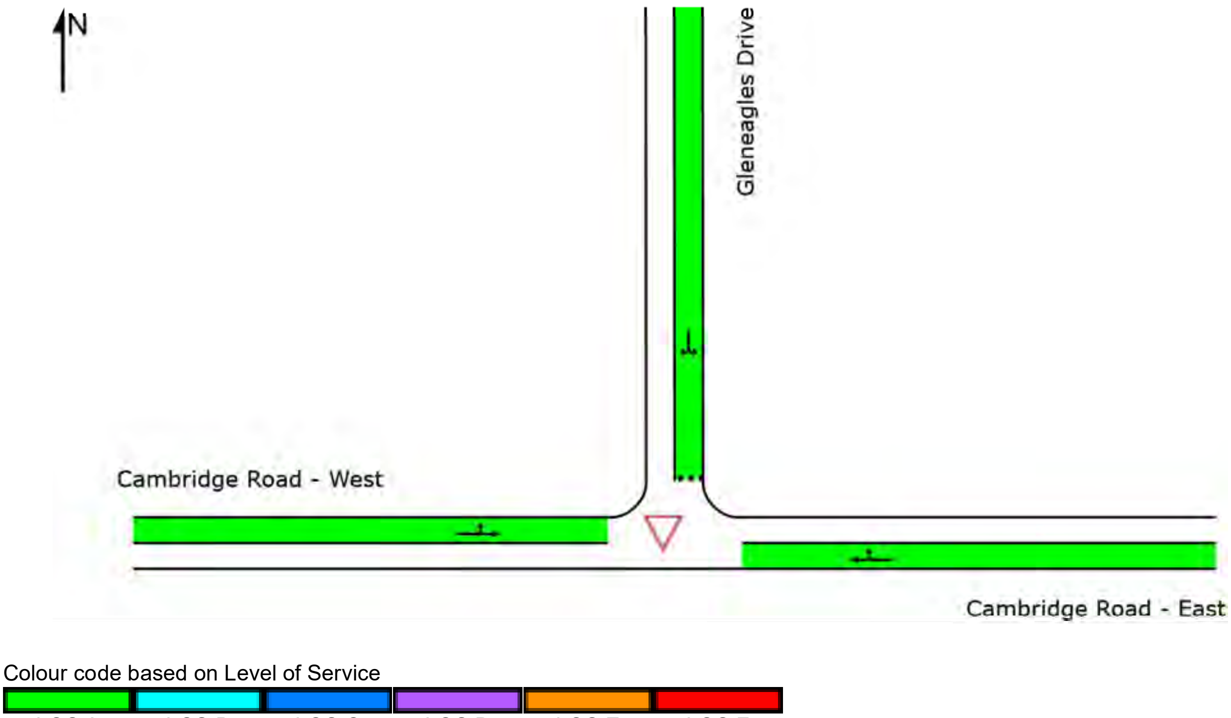
LANE LEVEL OF SERVICE

Lane Level of Service

▽ Site: 101 [2018_Low Dev_Gleneagles_AM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	East	North	West	
LOS	NA	A	NA	NA



Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Organisation: TONKIN & TAYLOR | Processed: Saturday, 8 June 2019 6:13:49 PM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T11_Cambridge Rd.sip8

INTERSECTION SUMMARY

▽ Site: 101 [2018_Low Dev_Gleneagles_PM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	49.1 km/h	49.1 km/h
Travel Distance (Total)	155.1 veh-km/h	186.2 pers-km/h
Travel Time (Total)	3.2 veh-h/h	3.8 pers-h/h
Demand Flows (Total)	496 veh/h	595 pers/h
Percent Heavy Vehicles (Demand)	0.9 %	
Degree of Saturation	0.175	
Practical Spare Capacity	460.9 %	
Effective Intersection Capacity	2838 veh/h	
Control Delay (Total)	0.05 veh-h/h	0.06 pers-h/h
Control Delay (Average)	0.3 sec	0.3 sec
Control Delay (Worst Lane)	6.0 sec	
Control Delay (Worst Movement)	6.5 sec	6.5 sec
Geometric Delay (Average)	0.3 sec	
Stop-Line Delay (Average)	0.0 sec	
Idling Time (Average)	0.0 sec	
Intersection Level of Service (LOS)	NA	
95% Back of Queue - Vehicles (Worst Lane)	0.0 veh	
95% Back of Queue - Distance (Worst Lane)	0.3 m	
Queue Storage Ratio (Worst Lane)	0.00	
Total Effective Stops	18 veh/h	21 pers/h
Effective Stop Rate	0.04	0.04
Proportion Queued	0.01	0.01
Performance Index	3.3	3.3
Cost (Total)	62.11 $/h	62.11 $/h
Fuel Consumption (Total)	9.9 L/h	
Carbon Dioxide (Total)	23.3 kg/h	
Hydrocarbons (Total)	0.001 kg/h	
Carbon Monoxide (Total)	0.018 kg/h	
NOx (Total)	0.011 kg/h	

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 2 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 0.0% 48.5% 0.4%

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	237,979 veh/y	285,575 pers/y
Delay	22 veh-h/y	27 pers-h/y
Effective Stops	8,431 veh/y	10,117 pers/y
Travel Distance	74,462 veh-km/y	89,355 pers-km/y
Travel Time	1,517 veh-h/y	1,821 pers-h/y
Cost	29,811 $/y	29,811 $/y
Fuel Consumption	4,754 L/y	
Carbon Dioxide	11,206 kg/y	
Hydrocarbons	1 kg/y	
Carbon Monoxide	9 kg/y	
NOx	6 kg/y	

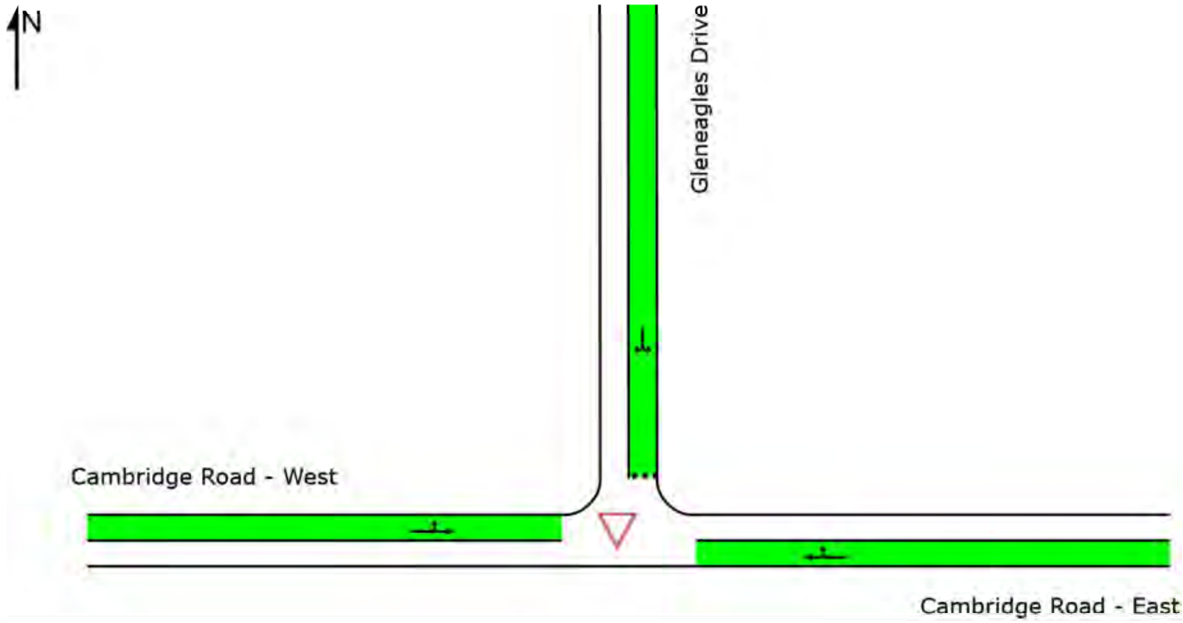
LANE LEVEL OF SERVICE

Lane Level of Service

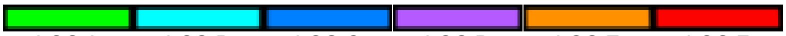
▽ Site: 101 [2018_Low Dev_Gleneagles_PM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	East	North	West	
LOS	NA	A	NA	NA



Colour code based on Level of Service



Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

INTERSECTION SUMMARY

Site: 101 [2035_Hi Dev_Gleneagles_AM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	48.9 km/h	48.9 km/h
Travel Distance (Total)	208.5 veh-km/h	250.2 pers-km/h
Travel Time (Total)	4.3 veh-h/h	5.1 pers-h/h
Demand Flows (Total)	666 veh/h	800 pers/h
Percent Heavy Vehicles (Demand)	0.9 %	
Degree of Saturation	0.231	
Practical Spare Capacity	323.5 %	
Effective Intersection Capacity	2880 veh/h	
Control Delay (Total)	0.08 veh-h/h	0.09 pers-h/h
Control Delay (Average)	0.4 sec	0.4 sec
Control Delay (Worst Lane)	6.8 sec	
Control Delay (Worst Movement)	7.6 sec	7.6 sec
Geometric Delay (Average)	0.3 sec	
Stop-Line Delay (Average)	0.1 sec	
Idling Time (Average)	0.0 sec	
Intersection Level of Service (LOS)	NA	
95% Back of Queue - Vehicles (Worst Lane)	0.1 veh	
95% Back of Queue - Distance (Worst Lane)	0.9 m	
Queue Storage Ratio (Worst Lane)	0.00	
Total Effective Stops	27 veh/h	32 pers/h
Effective Stop Rate	0.04	0.04
Proportion Queued	0.02	0.02
Performance Index	4.5	4.5
Cost (Total)	84.41 $/h	84.41 $/h
Fuel Consumption (Total)	13.3 L/h	
Carbon Dioxide (Total)	31.4 kg/h	
Hydrocarbons (Total)	0.002 kg/h	
Carbon Monoxide (Total)	0.024 kg/h	
NOx (Total)	0.015 kg/h	

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 2 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 0.0% 56.3% 0.3%

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	319,832 veh/y	383,798 pers/y
Delay	37 veh-h/y	45 pers-h/y
Effective Stops	12,835 veh/y	15,402 pers/y
Travel Distance	100,099 veh-km/y	120,119 pers-km/y
Travel Time	2,047 veh-h/y	2,457 pers-h/y
Cost	40,519 $/y	40,519 $/y
Fuel Consumption	6,402 L/y	
Carbon Dioxide	15,089 kg/y	
Hydrocarbons	1 kg/y	
Carbon Monoxide	12 kg/y	
NOx	7 kg/y	

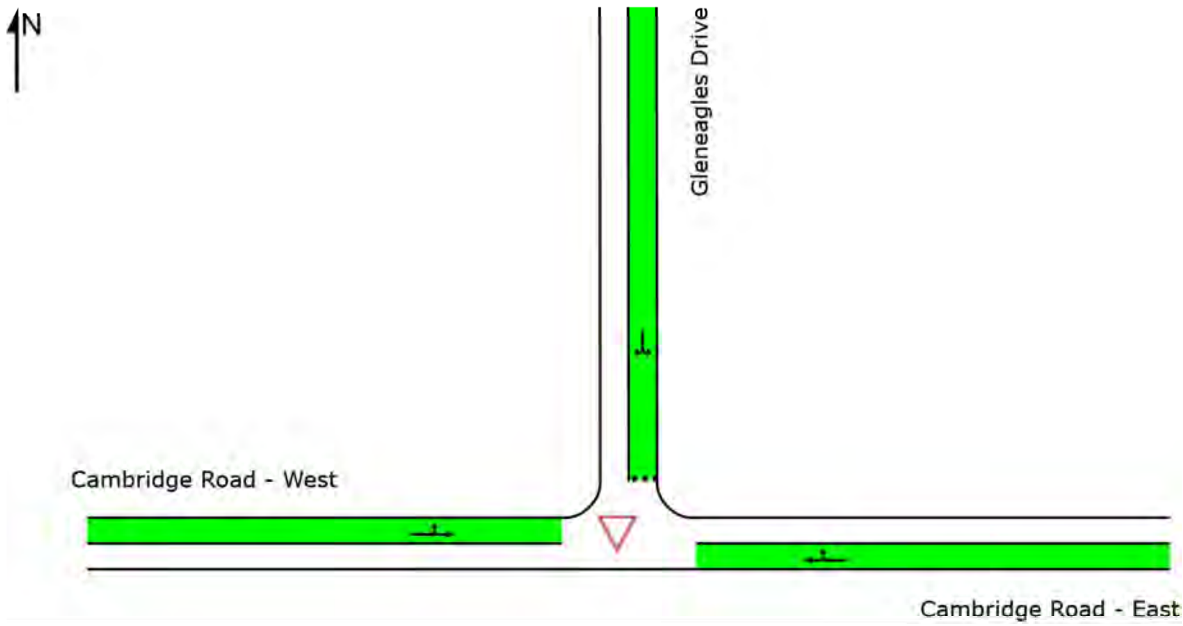
LANE LEVEL OF SERVICE

Lane Level of Service

▽ Site: 101 [2035_Hi Dev_Gleneagles_AM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	East	North	West	
LOS	NA	A	NA	NA



Colour code based on Level of Service

LOS A LOS B LOS C LOS D LOS E LOS F

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

INTERSECTION SUMMARY

▽ Site: 101 [2035_Hi Dev_Gleneagles_PM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	48.9	km/h	48.9	km/h
Travel Distance (Total)	208.6	veh-km/h	250.3	pers-km/h
Travel Time (Total)	4.3	veh-h/h	5.1	pers-h/h
Demand Flows (Total)	666	veh/h	800	pers/h
Percent Heavy Vehicles (Demand)	0.9	%		
Degree of Saturation	0.240			
Practical Spare Capacity	308.3	%		
Effective Intersection Capacity	2776	veh/h		
Control Delay (Total)	0.08	veh-h/h	0.10	pers-h/h
Control Delay (Average)	0.4	sec	0.4	sec
Control Delay (Worst Lane)	7.1	sec		
Control Delay (Worst Movement)	7.6	sec	7.6	sec
Geometric Delay (Average)	0.3	sec		
Stop-Line Delay (Average)	0.1	sec		
Idling Time (Average)	0.0	sec		
Intersection Level of Service (LOS)	NA			
95% Back of Queue - Vehicles (Worst Lane)	0.1	veh		
95% Back of Queue - Distance (Worst Lane)	0.7	m		
Queue Storage Ratio (Worst Lane)	0.00			
Total Effective Stops	26	veh/h	31	pers/h
Effective Stop Rate	0.04		0.04	
Proportion Queued	0.03		0.03	
Performance Index	4.6		4.6	
Cost (Total)	79.08	$/h	79.08	$/h
Fuel Consumption (Total)	13.5	L/h		
Carbon Dioxide (Total)	31.8	kg/h		
Hydrocarbons (Total)	0.002	kg/h		
Carbon Monoxide (Total)	0.025	kg/h		
NOx (Total)	0.016	kg/h		

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Site Model Variability Index (Iterations 3 to N): 0.0 %

Number of Iterations: 3 (Maximum: 10)

Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 59.0% 3.2% 0.0%

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	319,832	veh/y	383,798	pers/y
Delay	38	veh-h/y	46	pers-h/y
Effective Stops	12,480	veh/y	14,976	pers/y
Travel Distance	100,117	veh-km/y	120,140	pers-km/y
Travel Time	2,048	veh-h/y	2,458	pers-h/y
Cost	37,961	$/y	37,961	$/y
Fuel Consumption	6,471	L/y		
Carbon Dioxide	15,255	kg/y		
Hydrocarbons	1	kg/y		
Carbon Monoxide	12	kg/y		
NOx	8	kg/y		

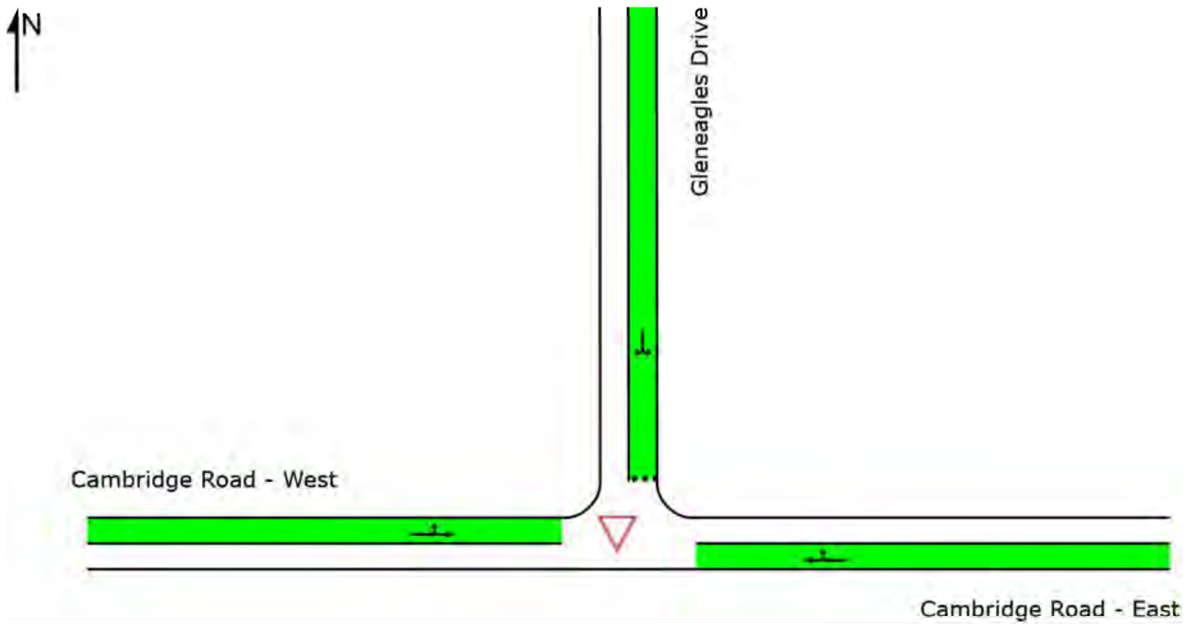
LANE LEVEL OF SERVICE

Lane Level of Service

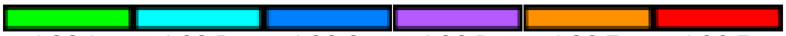
▽ Site: 101 [2035_Hi Dev_Gleneagles_PM]

New Site
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	East	North	West	
LOS	NA	A	NA	NA



Colour code based on Level of Service



Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

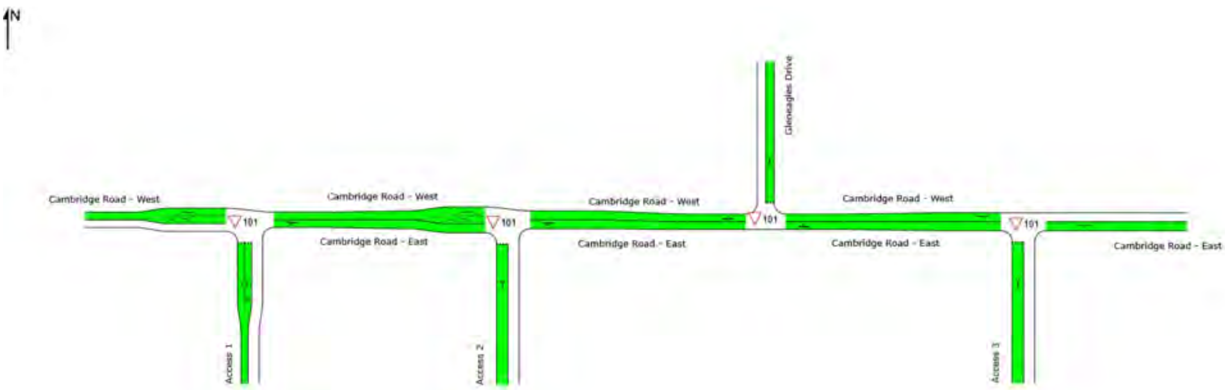
Organisation: TONKIN & TAYLOR | Processed: Saturday, 8 June 2019 6:13:55 PM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T11_Cambridge Rd.sip8

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N101 [2018_Low Dev]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A LOS B LOS C LOS D LOS E LOS F

Delay model settings are specified for individual Sites forming the Network.

Organisation: TONKIN & TAYLOR | Processed: Saturday, 8 June 2019 6:17:29 PM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T11_Cambridge Rd.sip8

NETWORK SUMMARY

Network: N101 [2018_Low Dev]

New Network
Network Category: (None)

Network Performance - Hourly Values			
Performance Measure	**Vehicles**	**Per Unit Distance**	**Persons**
Network Level of Service (LOS)	LOS A		
Travel Time Index	9.64		
Speed Efficiency	0.97		
Congestion Coefficient	1.03		
Travel Speed (Average)	48.4 km/h		48.4 km/h
Travel Distance (Total)	1196.6 veh-km/h		1435.9 pers-km/h
Travel Time (Total)	24.7 veh-h/h		29.7 pers-h/h
Desired Speed	50.0 km/h		
Demand Flows (Total for all Sites)	2861 veh/h		3433 pers/h
Arrival Flows (Total for all Sites)	2861 veh/h		3433 pers/h
Demand Flows (Entry Total)	918 veh/h		
Midblock Inflows (Total)	26 veh/h		
Midblock Outflows (Total)	-126 veh/h		
Percent Heavy Vehicles (Demand)	1.0 %		
Percent Heavy Vehicles (Arrival)	1.0 %		
Degree of Saturation	0.233		
Control Delay (Total)	0.72 veh-h/h		0.86 pers-h/h
Control Delay (Average)	0.9 sec		0.9 sec
Control Delay (Worst Lane)	9.6 sec		
Control Delay (Worst Movement)	9.7 sec		9.7 sec
Geometric Delay (Average)	0.6 sec		
Stop-Line Delay (Average)	0.3 sec		
Queue Storage Ratio (Worst Lane)	0.01		
Total Effective Stops	240 veh/h		287 pers/h
Effective Stop Rate	0.08	0.20 per km	0.08
Proportion Queued	0.07		0.07
Performance Index	28.1		28.1
Cost (Total)	566.08 $/h	0.47 $/km	566.08 $/h
Fuel Consumption (Total)	79.7 L/h	66.6 mL/km	
Fuel Economy	6.7 L/100km		
Carbon Dioxide (Total)	187.9 kg/h	157.0 g/km	
Hydrocarbons (Total)	0.012 kg/h	0.010 g/km	
Carbon Monoxide (Total)	0.147 kg/h	0.123 g/km	
NOx (Total)	0.106 kg/h	0.088 g/km	

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: New Zealand.

Network Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total for all Sites)	1,373,305 veh/y	1,647,966 pers/y
Delay	346 veh-h/y	415 pers-h/y
Effective Stops	114,997 veh/y	137,996 pers/y
Travel Distance	574,369 veh-km/y	689,243 pers-km/y
Travel Time	11,867 veh-h/y	14,240 pers-h/y
Cost	271,717 $/y	271,717 $/y
Fuel Consumption	38,270 L/y	
Carbon Dioxide	90,184 kg/y	
Hydrocarbons	6 kg/y	
Carbon Monoxide	71 kg/y	
NOx	51 kg/y	

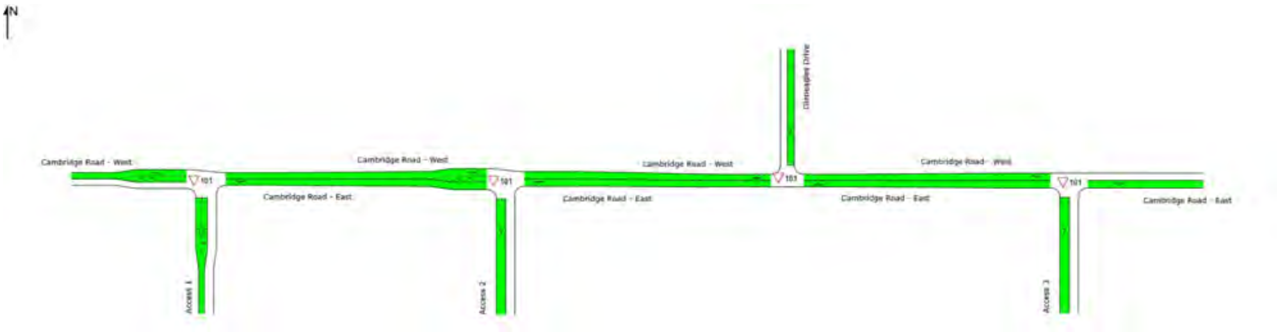
Organisation: TONKIN & TAYLOR | Processed: Saturday, 8 June 2019 6:17:29 PM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T11_Cambridge Rd.sip8

LANE LEVEL OF SERVICE

Lane Level of Service for Network Sites

Network: N102 [2035_Hi Dev]

New Network
Network Category: (None)



Colour code based on Level of Service

LOS A LOS B LOS C LOS D LOS E LOS F

Delay model settings are specified for individual Sites forming the Network.

NETWORK SUMMARY

Network: N102 [2035_Hi Dev]

New Network
Network Category: (None)

Network Performance - Hourly Values			
Performance Measure	**Vehicles**	**Per Unit Distance**	**Persons**
Network Level of Service (LOS)	LOS A		
Travel Time Index	9.67		
Speed Efficiency	0.97		
Congestion Coefficient	1.03		
Travel Speed (Average)	48.5 km/h		48.5 km/h
Travel Distance (Total)	1215.8 veh-km/h		1459.0 pers-km/h
Travel Time (Total)	25.1 veh-h/h		30.1 pers-h/h
Desired Speed	50.0 km/h		
Demand Flows (Total for all Sites)	2861 veh/h		3433 pers/h
Arrival Flows (Total for all Sites)	2861 veh/h		3433 pers/h
Demand Flows (Entry Total)	818 veh/h		
Midblock Inflows (Total)	126 veh/h		
Midblock Outflows (Total)	-26 veh/h		
Percent Heavy Vehicles (Demand)	1.0 %		
Percent Heavy Vehicles (Arrival)	1.0 %		
Degree of Saturation	0.281		
Control Delay (Total)	0.62 veh-h/h		0.74 pers-h/h
Control Delay (Average)	0.8 sec		0.8 sec
Control Delay (Worst Lane)	9.8 sec		
Control Delay (Worst Movement)	9.8 sec		9.8 sec
Geometric Delay (Average)	0.6 sec		
Stop-Line Delay (Average)	0.2 sec		
Queue Storage Ratio (Worst Lane)	0.01		
Total Effective Stops	207 veh/h		249 pers/h
Effective Stop Rate	0.07	0.17 per km	0.07
Proportion Queued	0.05		0.05
Performance Index	28.1		28.1
Cost (Total)	637.21 $/h	0.52 $/km	637.21 $/h
Fuel Consumption (Total)	81.2 L/h	66.8 mL/km	
Fuel Economy	6.7 L/100km		
Carbon Dioxide (Total)	191.4 kg/h	157.4 g/km	
Hydrocarbons (Total)	0.012 kg/h	0.010 g/km	
Carbon Monoxide (Total)	0.150 kg/h	0.123 g/km	
NOx (Total)	0.108 kg/h	0.089 g/km	

Network Model Variability Index (Iterations 3 to N): 0.0 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation or Queue Storage Ratios for the last three Network Iterations: 0.0% 0.0% 0.0%
Network Level of Service (LOS) Method: SIDRA Speed Efficiency.
Software Setup used: New Zealand.

Network Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total for all Sites)	1,373,305 veh/y	1,647,966 pers/y
Delay	295 veh-h/y	354 pers-h/y
Effective Stops	99,580 veh/y	119,496 pers/y
Travel Distance	583,599 veh-km/y	700,319 pers-km/y
Travel Time	12,033 veh-h/y	14,440 pers-h/y
Cost	305,861 $/y	305,861 $/y
Fuel Consumption	38,995 L/y	
Carbon Dioxide	91,857 kg/y	
Hydrocarbons	6 kg/y	
Carbon Monoxide	72 kg/y	
NOx	52 kg/y	

Organisation: TONKIN & TAYLOR | Processed: Saturday, 8 June 2019 6:17:33 PM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T11_Cambridge Rd.sip8

INTERSECTION SUMMARY

Site: 101 [2018_No Dev_Hi-Lvl Peak]

New Site
Site Category: (None)
Roundabout

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	13.3 km/h	13.3 km/h
Travel Distance (Total)	3725.0 veh-km/h	4470.0 pers-km/h
Travel Time (Total)	279.5 veh-h/h	335.3 pers-h/h
Demand Flows (Total)	4342 veh/h	5211 pers/h
Percent Heavy Vehicles (Demand)	6.8 %	
Degree of Saturation	1.325	
Practical Spare Capacity	-35.8 %	
Effective Intersection Capacity	3278 veh/h	
Control Delay (Total)	207.26 veh-h/h	248.71 pers-h/h
Control Delay (Average)	171.8 sec	171.8 sec
Control Delay (Worst Lane)	317.0 sec	
Control Delay (Worst Movement)	318.7 sec	318.7 sec
Geometric Delay (Average)	3.7 sec	
Stop-Line Delay (Average)	168.1 sec	
Idling Time (Average)	118.6 sec	
Intersection Level of Service (LOS)	LOS F	
95% Back of Queue - Vehicles (Worst Lane)	170.3 veh	
95% Back of Queue - Distance (Worst Lane)	1304.9 m	
Queue Storage Ratio (Worst Lane)	1.12	
Total Effective Stops	18868 veh/h	22642 pers/h
Effective Stop Rate	4.35	4.35
Proportion Queued	0.98	0.98
Performance Index	1072.3	1072.3
Cost (Total)	8081.36 $/h	8081.36 $/h
Fuel Consumption (Total)	762.2 L/h	
Carbon Dioxide (Total)	1813.9 kg/h	
Hydrocarbons (Total)	0.206 kg/h	
Carbon Monoxide (Total)	1.661 kg/h	
NOx (Total)	4.169 kg/h	

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 4.7 %
Number of Iterations: 7 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 1.9% 1.0% 0.5%

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	2,084,211 veh/y	2,501,053 pers/y
Delay	99,484 veh-h/y	119,381 pers-h/y
Effective Stops	9,056,741 veh/y	10,868,090 pers/y
Travel Distance	1,787,985 veh-km/y	2,145,582 pers-km/y
Travel Time	134,139 veh-h/y	160,967 pers-h/y
Cost	3,879,052 $/y	3,879,052 $/y
Fuel Consumption	365,868 L/y	
Carbon Dioxide	870,655 kg/y	
Hydrocarbons	99 kg/y	
Carbon Monoxide	798 kg/y	
NOx	2,001 kg/y	

Organisation: TONKIN & TAYLOR | Processed: Friday, 7 June 2019 1:09:51 PM
Project: \\ttgroup.local\corporate\Hamilton\Projects\1008305\1008305.1000\WorkingMaterial\Traffic\Modelling\SIDRA\T11_SH3 RAB.sip8

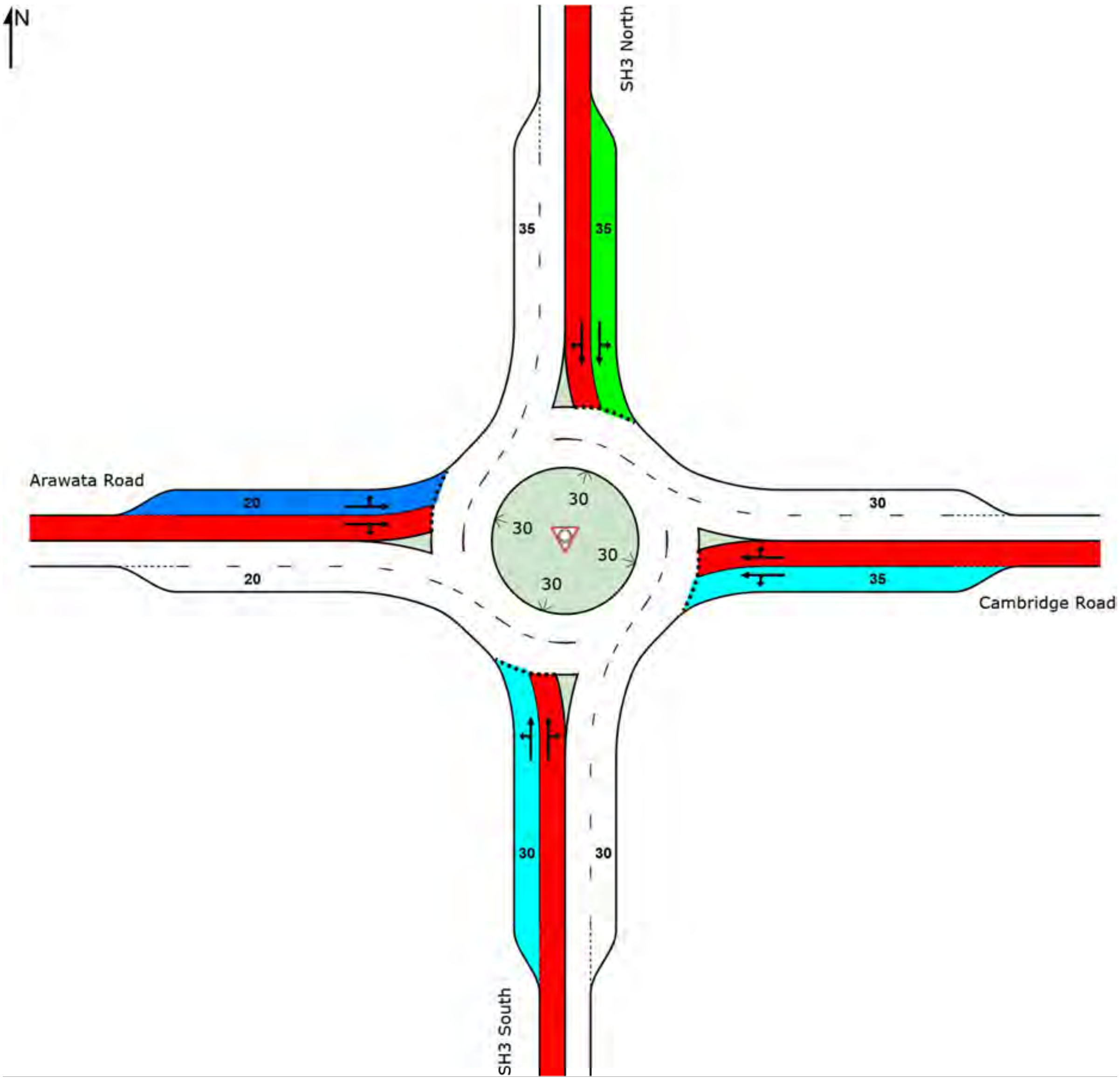
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [2018_No Dev_Hi-Lvl Peak]

New Site
Site Category: (None)
Roundabout

	Approaches				Intersection
	South	East	North	West	
LOS	F	F	F	F	F



Colour code based on Level of Service

LOS A LOS B LOS C LOS D LOS E LOS F

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
Roundabout Level of Service Method: SIDRA Roundabout LOS
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

INTERSECTION SUMMARY

Site: 101 [2018_Low Dev_Hi-Lvl Peak]

New Site
Site Category: (None)
Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	11.2	km/h	11.2	km/h
Travel Distance (Total)	3888.4	veh-km/h	4666.1	pers-km/h
Travel Time (Total)	348.7	veh-h/h	418.5	pers-h/h
Demand Flows (Total)	4505	veh/h	5406	pers/h
Percent Heavy Vehicles (Demand)	6.6	%		
Degree of Saturation	1.558			
Practical Spare Capacity	-45.4	%		
Effective Intersection Capacity	2892	veh/h		
Control Delay (Total)	273.09	veh-h/h	327.71	pers-h/h
Control Delay (Average)	218.2	sec	218.2	sec
Control Delay (Worst Lane)	521.4	sec		
Control Delay (Worst Movement)	523.0	sec	523.0	sec
Geometric Delay (Average)	3.8	sec		
Stop-Line Delay (Average)	214.4	sec		
Idling Time (Average)	157.9	sec		
Intersection Level of Service (LOS)	LOS F			
95% Back of Queue - Vehicles (Worst Lane)	218.8	veh		
95% Back of Queue - Distance (Worst Lane)	1557.6	m		
Queue Storage Ratio (Worst Lane)	1.25			
Total Effective Stops	21908	veh/h	26290	pers/h
Effective Stop Rate	4.86		4.86	
Proportion Queued	0.98		0.98	
Performance Index	1301.6		1301.6	
Cost (Total)	9971.07	$/h	9971.07	$/h
Fuel Consumption (Total)	871.0	L/h		
Carbon Dioxide (Total)	2070.2	kg/h		
Hydrocarbons (Total)	0.238	kg/h		
Carbon Monoxide (Total)	1.851	kg/h		
NOx (Total)	4.339	kg/h		

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 3.9 %
Number of Iterations: 10 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 1.0% 1.1% 0.8%

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	2,162,526	veh/y	2,595,032	pers/y
Delay	131,083	veh-h/y	157,300	pers-h/y
Effective Stops	10,516,060	veh/y	12,619,270	pers/y
Travel Distance	1,866,426	veh-km/y	2,239,711	pers-km/y
Travel Time	167,380	veh-h/y	200,856	pers-h/y
Cost	4,786,112	$/y	4,786,112	$/y
Fuel Consumption	418,100	L/y		
Carbon Dioxide	993,702	kg/y		
Hydrocarbons	114	kg/y		
Carbon Monoxide	889	kg/y		
NOx	2,082	kg/y		

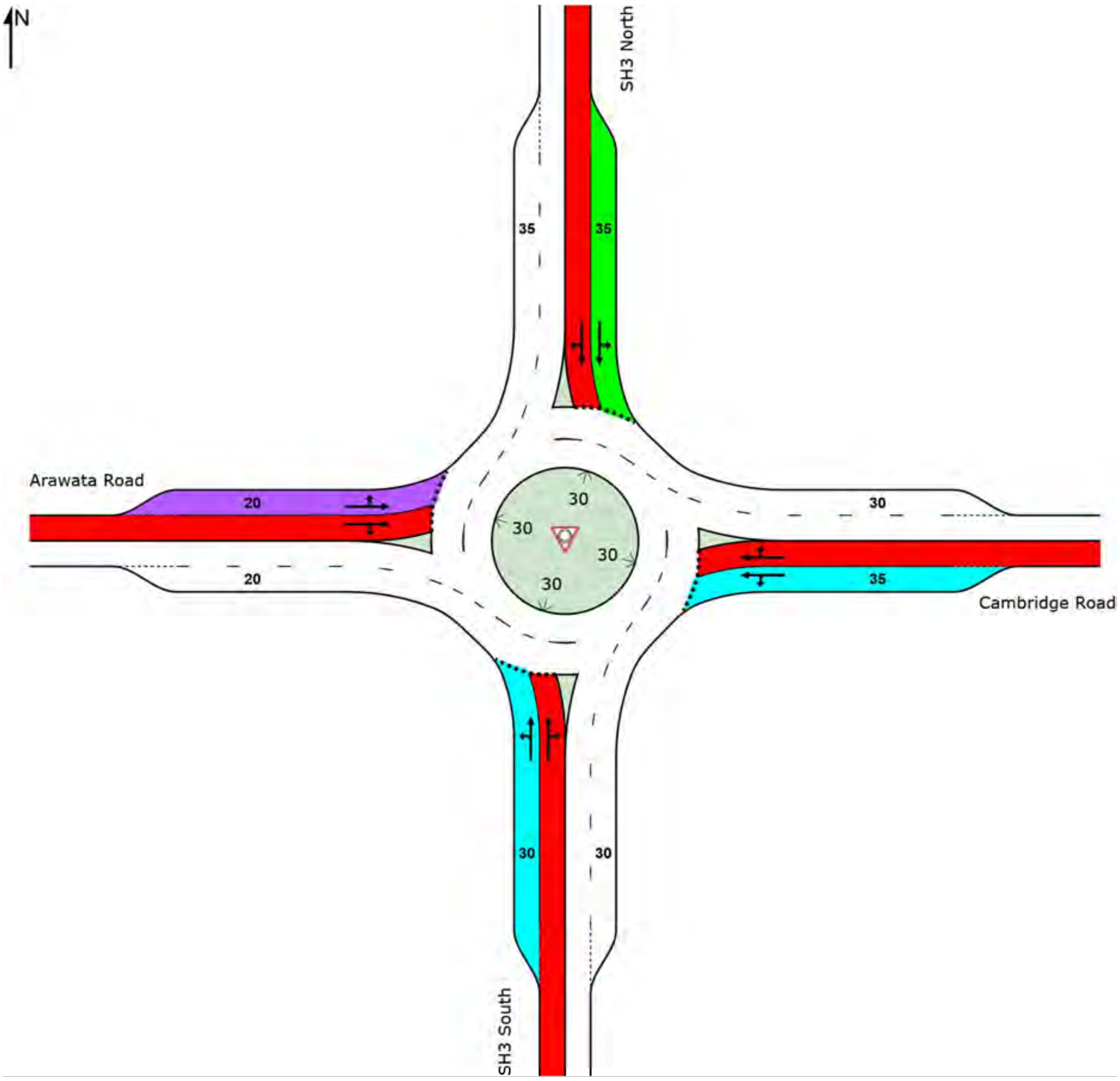
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [2018_Low Dev_Hi-Lvl Peak]

New Site
Site Category: (None)
Roundabout

	Approaches				Intersection
	South	East	North	West	
LOS	F	F	F	F	F



Colour code based on Level of Service

LOS A LOS B LOS C LOS D LOS E LOS F

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
Roundabout Level of Service Method: SIDRA Roundabout LOS
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

www.tonkintaylor.co.nz

Te Awamutu T11 Structure Plan

Context Report
Prepared for Waipa District Council
25 June 2020

Document Quality Assurance

Bibliographic reference for citation: Boffa Miskell Limited 2020. *Te Awamutu T11 Structure Plan: Context Report*. Report prepared by Boffa Miskell Limited for Waipa District Council.		
Prepared by:	Dave Moule Planner / Senior Principal Boffa Miskell Limited	
Reviewed by:	Craig Batchelar Planner / Partner Boffa Miskell Limited	
Status: Final	Revision / version: 3	Issue date: 25 June 2020
Use and Reliance This report has been prepared by Boffa Miskell Limited on the specific instructions of our Client. It is solely for our Client's use for the purpose for which it is intended in accordance with the agreed scope of work. Boffa Miskell does not accept any liability or responsibility in relation to the use of this report contrary to the above, or to any person other than the Client. Any use or reliance by a third party is at that party's own risk. Where information has been supplied by the Client or obtained from other external sources, it has been assumed that it is accurate, without independent verification, unless otherwise indicated. No liability or responsibility is accepted by Boffa Miskell Limited for any errors or omissions to the extent that they arise from inaccurate information provided by the Client or any external source.		

Template revision: 20140327 0000

Cover photograph: Google Maps

CONTENTS

Appendices

Document Set ID: 10411036

Version: 2, Version Date: 29/06/2020

1.0 Introduction

1.1 Background

The Waipa District has been identified as a high growth area in the National Policy Statement on Urban Development Capacity (NPS-UDC).

The townships of Te Awamutu and Kihikihi are forecast to grow by 5,400 people by 2050. To provide for this growth, Council has set out to prepare a structure plan for the T11 growth cell, as identified in the Waipa 2050 Growth Strategy (2017), Waipa 2018-28 Long Term Plan, and Plan Change 5 to the Waipa District Plan.

The T11 growth cell is a 47ha area of land located on the eastern side of Te Awamutu to the south of the Cambridge Road commercial node. The growth cell has been identified as a residential growth cell with a capacity of approximately 432 dwellings. This location is suitable for this land use as it expands on the existing residential area on Cambridge Road and provides for some growth in close proximity to the Cambridge Road commercial node.

The growth cell is currently zoned Deferred Residential.

Plan Change 5 to the Waipa District Plan was a public plan change that was made operative on 14 March 2019 and amended the District Plan to incorporate key changes made to the updated Waipa 2050 Growth Strategy (Waipa 2050). These changes are important in taking account of revised population projections and the requirements of the NPS-UDC. The Plan Change rezoned all of the growth cells identified in the Growth Strategy zoned as "Rural" to "Deferred".

1.2 Purpose of this report

The purpose of this report is to provide context to the design process that has informed the Structure Plan and to confirm the relevant statutory planning framework and associated procedural requirements to enable Council's decision-making process and investment in the next phase of facilitating development within the T11 growth cell.

To ensure that development is consistent with the Council's strategic direction as set out in Waipa 2050 and the Waipa District Plan, Council has commissioned Boffa Miskell to develop a Structure Plan and to identify servicing requirements for the T11 growth cell in consultation with landowners and key stakeholders. The Final Structure Plan was endorsed at an Extraordinary Council Meeting on 7 April 2020 and is attached to this report as **Appendix One.**

Design Guidelines have also been developed to support the implementation of the Structure Plan and to ensure that, as these areas are developed, the community and Council can be assured of a high level of quality and consistency for any future development. It is acknowledged that the guidelines have no statutory weight and are unlikely to be embedded into the District Plan by way of a Plan Change, however they have been developed as a guidance document for landowners and Council. The Design Guidelines are attached to this report as **Appendix Two.**

The development of the Structure Plan and Design Guidelines have been informed by background reports and technical assessments previously commissioned by Council and updated technical assessments completed by Tonkin & Taylor.

The updated technical assessments have been prepared to demonstrate that the growth cells are suitable for urban development, including consideration of three waters infrastructure, transportation, and liquefaction. The technical assessments prepared by Tonkin & Taylor are attached to this report as **Appendix Three.**

2.0 Site Context

2.1 T11 Growth Cell - Residential

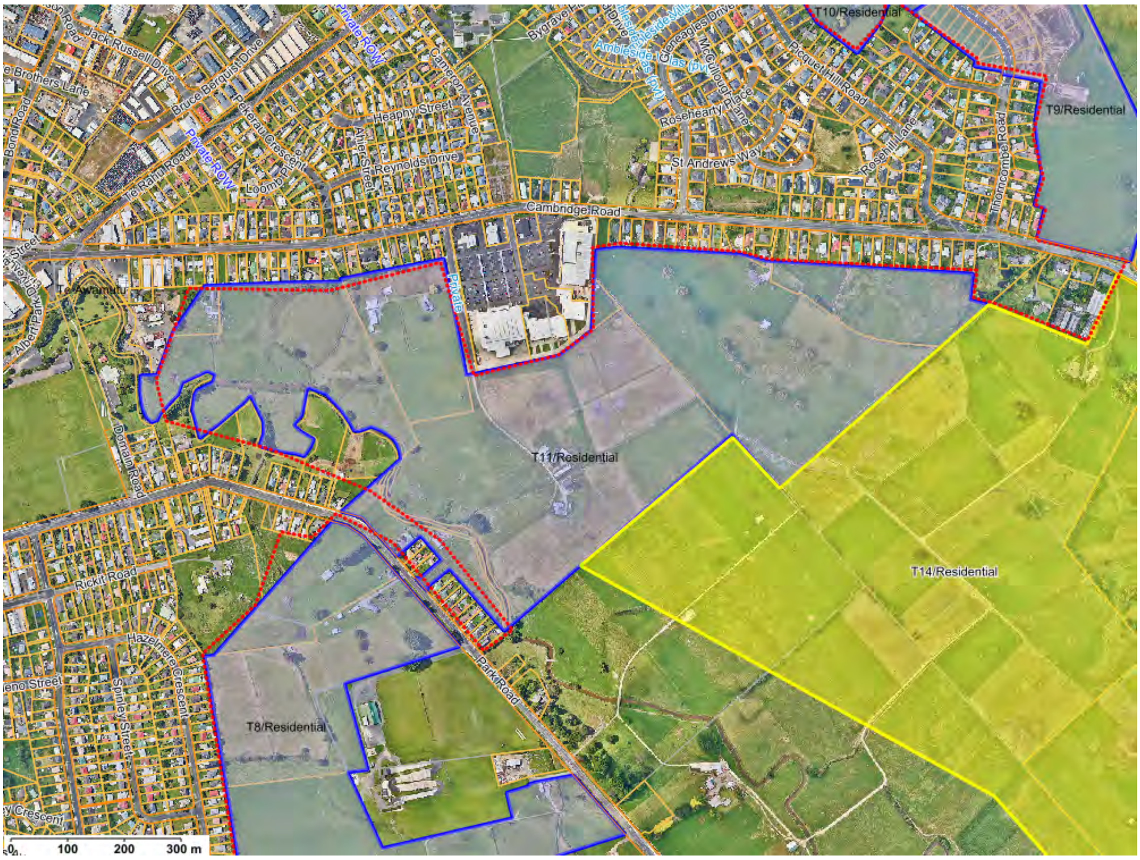


Figure 1 – T11 Residential Growth Cell, Te Awamutu

The T11 growth cell is predominantly characterised by rural farming and cropping blocks, large mature vegetation, with a limited number of residential dwellings. The topography generally slopes to the south and the land drains to the Mangaohoi Stream which runs along the southern boundary of the growth cell.

There are significant flooding constraints within this growth cell associated with the Mangaohoi Stream, which has resulted in a large portion of the cell being deemed unsuitable for development.

Providing for changing housing demands while maintaining existing character and amenity expectations will be challenging. The Town Concept Plan 2010 prepared for Te Awamutu provides guidance on how these competing demands can be managed. The Town Concept Plan recognises that a change in the current density and form of residential development will need to occur if future housing demands are to be met in a sustainable manner.

It is important that the distinguishing characteristics of this particular place are maintained, including reflecting the existing semi-rural character, retaining existing mature trees where suitable and ensuring appropriate boundary setbacks for buildings.

The deferred residential zone status of the land makes future provision for more sustainable forms of living. Sustainable forms of living are required in order to manage resources that have a limited supply (such as land) as well as to reduce the overall ‘footprint’ on the environment. In the Residential Zone this outcome is to be achieved by providing for appropriate infill development, and compact housing development options (including semi-detached dwellings, duplexes, terrace housing or low-rise apartments).

Any development options of this nature on the site will be required to be comprehensively designed, coordinated with infrastructure provision, take into account key elements of character, and address effects on neighbouring properties. Sustainable living is also supported through rules that require dwellings to be positioned for passive solar gain and by ensuring enough open space is provided on site for a range of activities such as recreation activity, pedestrian and cycle connectivity, and amenity outcomes.

3.0 Structure Plan Design Context

3.1 General Design Principles

The following general design principles have underpinned the development of the T11 Structure Plan:

- **Respect for existing character.** All designs should reflect a comprehensive understanding and appreciation of location and surrounding context. The natural environment is protected and enhanced to provide amenity and ecological enhancement. Important sites and landmarks are acknowledged to respect the history and culture of the area.
- **Cultural identity.** Opportunities are to be identified throughout the development of cultural interpretation and education within the landscape. Maori names and design elements will be incorporated where appropriate and in consultation with local iwi.
- **Social value.** People are the key consideration in all aspects of the design. Public safety, recreation and social values are paramount.
- **Connectivity.** Transport networks and public spaces incorporate stormwater management, and green corridors for pedestrian and ecological connections. A network of pedestrian and cycleways through the development connects the residents to the existing town, open spaces, and playgrounds.
- **Appropriate scale.** The scale and hierarchy of roads, cycleways and walking tracks are integrated to ensure a balance of transport options and access to public transport.
- **Quality public realm.** High-quality materials and construction methods used throughout the neighbourhood in both the public and private spaces, ensure spaces will retain a sense of quality and attract residents to use the facilities.
- **Well-designed built environment.** The built form guidelines ensure that the landscape and buildings within private lots contribute to the amenity, safety, and broad context of the development. The guidelines are intended to encourage creative design outcomes, not to limit or restrict original architecture or design.

3.2 Open Space Framework

The open space framework design for the T11 Structure Plan reflects a comprehensive understanding of the existing landscape and surrounding land use context. The development will be efficient, connected and permeable, with a focus on pedestrian walkways, cycleways, reserves and green corridors.

The existing exotic and native mature trees perform many functions, including removing groundwater and reducing the requirement for stormwater attenuation; ecological functions, such as providing habitat and food for birds; retaining the rural aesthetic; shade during summer for people and animals; cutting of wind, reduction of soil erosion from storm events. Existing trees have been incorporated into the open space framework where possible.

The open space framework is made up of:

- Reserves
- Green Streets
- Open Spaces
- Playgrounds
- Vegetated Swales

The combination of these spaces allows for a green network to be created through the site, ensuring that all members of the community have access to an open space, and the natural environment.

3.3 Stormwater Management

The proposed reserves and open spaces within the T11 structure plan will provide for people's recreational interests, and the protection of landscapes, amenity, ecosystems, cultural and historical values. They also fulfil an important stormwater management function.

There are significant flood risks that have been identified within this growth cell associated with the Mangaohoi Stream. This has resulted in a large portion of the growth cell being deemed unsuitable for development.

The stormwater management approach for those developable areas of the growth cell can be summarised as follows:

- Wherever possible retention, reuse and onsite soakage for stormwater is allowed to soak into impermeable services and managed through natural systems. Natural systems such as vegetated swales, are a low impact way of managing stormwater which are also an important amenity feature of the site.
- The western and southern areas of the growth cell currently provide a significant amount of natural floodplain storage volume and the growth cell has been split into two smaller sub-cells to avoid increased flood risk downstream through the existing Te Awamutu urban area.
- A flood flowpath across the lots in the western sub-cell area will need to be managed adequately, with the most appropriate option likely to be divert the flowpath around the southern end of the lots through the open space/reserve. This flowpath will also need to provide mitigation for the displacement of the floodplain volume.
- Due to the position of the growth cell within the wider Mangaohoi catchment, peak flow control of the 2 year ARI and higher magnitude flood events is not recommended to avoid coincidence with the larger Mangaohoi flood peak.
- Retention, reuse and onsite soakage of the post-development water quality volume will be required to provide stormwater treatment and erosion control.

- Onsite soakage will need to be tested and designed on a lot by lot basis. If on-site soakage investigations show that the post-developed water quality rainfall volume cannot be achieved through water tanks and soakage, then bio-retention devices or a suitable wetland will need to be designed.
- Vegetated swales are recommended to convey overland flow.
- The compact housing area overlay is in close proximity to public open space. This is a best practice approach, where higher density residential environments are offset with easy access to usable open space networks.

3.4 Connectivity

The road connections through the T11 structure plan area will holistically integrate cars, pedestrians, cyclists, stormwater management, and ecology.

High-quality streets with tree lined berms, grassed swales, and footpaths/cycleways are proposed to provide a safe and attractive area for both vehicular and pedestrian movement.

The Structure Plan will have a 25m green boulevard / tree framed collector road through the sites which become the main spine road for vehicles, pedestrians, and cyclists. The 18m local roads accommodate pedestrian facilities on one side and the option for stormwater conveyance through a vegetated swale down the other side.

A network of shared paths and footpaths will help to connect residents to site features such as reserves, playgrounds, commercial zone, and the neighbourhood centres.

Shared paths should be a minimum of 3m wide while footpaths should be a minimum of 1.5m wide.

An integrated pedestrian and cycle network improve the wellbeing of the residents through exercise, contact with the natural environment, and social interaction.

The activation of the public realm from people moving through these spaces makes them safer and more attractive to a range of users.

3.5 Built Form

The Design Guidelines in combination with the District Plan provisions for the relevant zone will ensure the height and bulk of built form is appropriate to the location and character of the site.

The scale, position and external appearance of new buildings must consider their settings and the relationships they have with nearby buildings and spaces.

Well-designed buildings will be compatible with the surrounding environment and respect privacy of neighbouring residents. They take into account the character of the area and are designed to enhance this character. The built form should also take into account site circumstances and local micro-climatic conditions, such as solar access, topography, and prevailing wind. Trees and landscaping are to be used for privacy and screening and to soften the built form.

Maximum height and site coverage controls will ensure houses relate well to the size of the lots, without being overly dominant visually. Considerate building placement ensures good relationships between neighbouring properties, roads and reserves.

The Design Guidelines provide a framework which will lead to positive outcomes for the landowners and the wider community. This encourages original design which considers the unique opportunities of the site and development areas.

3.6 Anticipated Development Yields

The Structure Plan for the T11 growth cell is anticipated to deliver a development yield of approximately 380 allotments (approximately 10 lots per hectare). This is a provisional estimate based on net developable area and takes into account the loss of land used for roads and open space. As already outlined, a large portion of the growth cell has been identified as vulnerable to flood risks and has been excluded from the developable areas of the structure plan.

The provisional yields are relatively consistent with the capacities identified in the Waipa District Plan (Appendix S1) of 432 dwellings (where 380 are anticipated) for T11.

3.7 Growth Cell Boundary Extension

The Structure Plan for T11 includes a proposed extension into the adjoining growth cell to the south-east, being the T14 growth cell. This extension is ultimately at the request of the landowners who have progressed some concept design for development on their landholdings within T11 and T14. This is considered to be a logical extension to incorporate an extension of the key road connections between the growth cells and better align the growth cell boundaries with existing cadastral boundaries within T14. The land to be included by way of the boundary extension is also zoned Deferred Residential.

4.0 Statutory Context

4.1 Te Ture Whaimana o Te Awa o Waikato - Vision and Strategy for the Waikato River

Te Ture Whaimana o Te Awa o Waikato – the Vision and Strategy for the Waikato River arises from the Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act 2010 and the Ngati Tuwharetoa, Raukawa and Te Arawa River Iwi Waikato River Act 2010 (Upper River Act). These acts establish a co-governance regime to protect the health and wellbeing of the Waikato River for future generations. This includes the lower Waipa River to its confluence with the Puniu River.

The vision for the Waikato River is "*for a future where a healthy Waikato River sustains abundant life and prosperous communities who, in turn, are all responsible for restoring and protecting the health and wellbeing of the Waikato River, and all it embraces, for generations to come*." The Vision and Strategy also includes objectives and strategies to achieve the vision. Waipa District Council has a duty to give effect to the Vision and Strategy for the Waikato River, through the Waipa District Plan and other planning documents.

The development of the Structure Plan has taken into account the Vision and Strategy for the Waikato River. In particular, the preliminary design includes high-level stormwater management solutions to ensure that water quantity and quality effects resulting from future development are appropriately mitigated and accord with best practice. This will help inform more detailed technical assessments that will be necessary to support any subsequent resource consent applications under the District Plan and any regional stormwater discharge permits required under the Waikato Regional Plan. The objectives of Vision and Strategy for the Waikato River will need to be assessed in more detail as and when a more robust technical analysis of cumulative stormwater effects has been undertaken.

4.2 National Policy Statement on Urban Development Capacity

The NPS-UDC is intended to ensure there is sufficient land available for future housing and business needs. The NPS-UDC has identified the Hamilton area (which includes Waipa District) as a high-growth urban area.

The NPS for Urban Development Capacity requires that sufficient land for housing be available for the 'short term', 'medium term' and 'long term' (Policy PA1), and that an oversupply of land be made available (Policy PC3).

The obligations on Council are to ensure that the following is provided for each of these time periods:

- Short term (1-3 years) – development capacity must be feasible, zoned and serviced with development infrastructure. 20% over-supply against forecast is required as a 'high growth' area.
- Medium term (3-10 years) – development capacity must be feasible, zoned and either: serviced with development infrastructure, or; the funding for the development infrastructure required to service that development capacity must be identified in a Long-Term Plan required under the Local Government Act 2002. 15% over-supply against forecast is required as a 'high growth' area.
- Long term (11-30 years) – development capacity must be feasible, identified in relevant plans and strategies, and the development infrastructure required to service it must be identified in the relevant Infrastructure Strategy required under the Local Government Act 2002. 15% over-supply against forecast is required as a 'high growth' area.

The NPS-UDC requires councils to provide in their plans enough development capacity to ensure demand can be met, both in terms of total demand for housing and business land, and also the demand for different types, sizes and locations. Council must give effect to the NPS and this requires some changes in approach in response.

The requirements of the NPS-UDC have driven the need to review the 2009 District Growth Strategy and subsequently Plan Change 5 to incorporate key changes made to the updated Waipa 2050 Growth Strategy into the Waipa District Plan. The requirements of the NPS-UDC have been considered further in the context of the District Plan and Waipa 2050 District Growth Strategy below.

The minimum targets for sufficient, feasible development capacity for housing in the Waipa District area are outlined in Section 1.1.6 in the Waipa District Plan, in accordance with the requirements of the National Policy Statement on Urban Development Capacity (NPS-UDC) 2016, as follows:

Area	Minimum Targets (Number of dwellings)		
	Short to Medium term 1-10years (2017-2026)	Long term 11-30 years (2027-2046)	Total
Waipā District	5,700	8,200	13,900

The Structure Plan has sought to contribute to the short and medium term targets by providing capacity for the development of approximately 380 dwellings within the Waipa District.

4.3 Future Proof Sub-Regional Growth Strategy

Future Proof was formulated in 2009 and is a combined growth strategy project between five councils (Hamilton City, Waikato, Waipa and Matamata-Piako District's and Waikato Regional Council). It establishes a strategic plan for land use, infrastructure and transportation to plan and provide for the future needs of the sub-region. The NZ Transport Agency is also involved as a major partner, recognising the importance of coordinating transportation planning with that of land use.

Future Proof has guided the development of Waikato Regional Council's Regional Policy Statement, and the growth strategies formulated for the Waikato District, Waipa District and Hamilton City.

The Future Proof Growth Strategy was reviewed in 2017 to incorporate updated population projections, and to allow a re-consideration of some of the growth assumptions. It is also planned to narrow the scope of the Future Proof Strategy to have a stronger focus on growth management and settlement pattern implementation, in line with national policy direction.

The requirements of Future Proof have been considered further in the context of the Waikato Regional Policy Statement, District Plan and Waipa 2050 District Growth Strategy below.

4.4 Waikato Regional Policy Statement

The RPS includes a detailed policy framework for the co-ordination of growth and infrastructure and adopting the land use patterns, density targets, and development ambitions of Future Proof.

The RPS provides direction for the management of the resources of the region as a whole. Six key issues are identified, and a range of methods are proposed to address these issues. District Plans are a key method for implementing the directions within Regional Policy Statements.

The Waipa District Plan gives effect to these policy directions as they apply within the Waipa District through:

- The setting of urban limits;
- Requirements for increased urban densities in Deferred Zones and future growth areas;
- Rural land protection;
- Recognition of the significance of key infrastructure networks and sites and the need for integrated land use and infrastructure planning;
- Ecological preservation and enhancement; and
- The health and well-being of the Waikato and Waipa Rivers including the restoration and protection of the relationship of the community and the Waikato and Waipa Rivers.

The Structure Plan will provide for new urban development within Te Awamutu within the urban limits indicated on Map 6.2 (Section 6C) of the RPS and facilitate new residential (including rural-residential) development in accordance with the timing and population growth areas in Table 6-1.

Further, the Structure Plan has sought to achieve compact urban environments that support existing commercial centres, multi-modal transport options, and allow people to live, work and play within their local area. In doing so, development provisions have sought to achieve provisional net development yields which are consistent with the capacities identified in the

Waipa District Plan (Appendix S1) of 432 dwellings (where 380 are anticipated) for T11. These target capacities in Appendix S1 of the District Plan give effect to the Waikato Regional Policy Statement density targets for greenfield development in Te Awamutu/Kihikihi.

The Structure Plan is consistent with the key objectives and policies of the RPS as it will bring forward the development of residential dwellings with a key growth cell in Te Awamutu in alignment with the capacity targets of the Waipa 2050 Growth Strategy and Waipa District Plan which both give effect to the overarching framework in the RPS for the co-ordination of growth and infrastructure and adoption of land use patterns, density targets, and development ambitions.

4.5 Waipa District Plan

4.5.1 Strategic Policy Framework

Section 1 of the Waipa District Plan outlines the strategic policy framework for the Plan, including key trends, future challenges, national directions, NPS-UDC, Vision and Strategy for the Waikato River, Waipa River Agreement, National Policy Statements, National Environmental Standards, Regional and Local direction, and strategic outcomes sought. It also identifies the key resource management issues for the District and associated Objectives and Policies.

One of the key objectives is to achieve a consolidated settlement pattern that is focused in and around existing settlements of the District, which is supported by policies to ensure that all future development and subdivision in the District contributes towards achieving the anticipated settlement pattern in the Future Proof Growth Strategy and Implementation Plan 2009 and the District Growth Strategy.

The Structure Plan is consistent with the key objectives and policies of the Strategic Policy Framework section in the District Plan as it will bring forward the development of residential dwellings within a key growth cell in Te Awamutu in alignment with the capacity targets of the Waipa 2050 Growth Strategy.

4.5.2 Deferred Zone

Section 14 in the District Plan identifies the relevant provisions for Deferred Zones in the District. The introduction for this section of the Plan acknowledges that in order to provide for the District’s projected growth; land use in some locations will change over time to accommodate new land uses, such as new residential areas.

These Deferred Zones have an objective, policy and rule framework which generally reflects existing land use and zoning but recognises that the area is intended to change over time. It is anticipated that development in Deferred Zones will occur in a planned and integrated manner through a structure plan process.

The T11 structure plan area has been identified in the District Plan as being suitable for conversion from the current land use to a new land use and is zoned on the Planning Maps as Deferred Residential.

As outlined earlier in this report, the Structure Plan is consistent with the key objectives and policies of the RPS as it will bring forward the development of residential dwellings within a key growth cell in Te Awamutu in alignment with the capacity targets of the Waipa 2050 Growth

Strategy and Waipa District Plan which both give effect to the overarching framework in the RPS for sub-regional growth.

4.5.3 Appendix S1 – Future Growth Cells

Appendix S1 in the District Plan identifies the growth cells from the Waipa 2050 District Growth Strategy, all of which have been included within a Deferred Zone in this District Plan to indicate the intended future land use. This includes T11 as Deferred Residential Zone.

The Appendix includes a table with information on the location and extent of each of the growth cells, and a broad timing for each of either 'anticipated now to 2035' or 'anticipated beyond 2035'. This timing for the release of each growth cell is based on growth projections within the Waipa 2050 District Growth Strategy and calculation of available land supply. The indicated timing for the release of each growth cell is intended to provide certainty to the community as to future land supply.

Details of the area and anticipated dwelling capacity within each growth cell are also included within the relevant table in the Appendix, see below:

Te Awamutu Residential Growth Cells – anticipated now to 2035

GROWTH CELL	LAND AREA	OVERVIEW AND CAPACITY
T1	37ha	▪ This is identified for residential development and has a structure plan in place. ▪ The growth cell has a dwelling capacity of approximately 444 dwellings.
T3	10ha	▪ This growth cell has been identified for residential development. ▪ The growth cell has a dwelling capacity of approximately 120 dwellings.
T6	168ha	▪ This growth cell has been identified as a location for non-serviced (water only) large lot residential development, providing an alternative form of living choice to other greenfield developments in Te Awamutu. ▪ The growth cell has a dwelling capacity of approximately 504 dwellings and due to the nature of the development and available capacity is expected to be developed over a larger time period than other growth cells.
T8	62ha	▪ This growth cell has been identified as a residential growth cell but requires a structure plan. ▪ The growth cell has a dwelling capacity of approximately 552 dwellings.
T9	11ha	▪ This residential growth cell is subject to a structure plan. ▪ The growth cell has a dwelling capacity of approximately 132 dwellings.
T10	21ha	▪ This residential growth cell is subject to a structure plan. ▪ The growth cell has a dwelling capacity of approximately 252 dwellings.
T11	47ha	▪ This growth cell has been identified as a residential growth cell. ▪ The growth cell has a dwelling capacity of approximately 432 dwellings and represents an opportunity for housing in proximity to a commercial node which provides necessary social infrastructure shopping / medical etc.
T12	11ha	▪ This growth cell is zoned for residential development. ▪ The growth cell has a dwelling capacity of approximately 132 dwellings.
T13	35ha	▪ The current Te Awamutu Racecourse is identified as a potential future residential growth cell if no longer needed for its current purpose. ▪ The growth cell has a dwelling capacity of approximately 420 dwellings.
The above growth cells make provision for 375 hectares of residential land, with a dwelling capacity of approximately 2,988 dwellings.		

Appendix S1 acknowledges that there will often be infrastructure requirements that will precede land being made available for development. Where Council intends to fund the upfront cost of this infrastructure then it will identify this through its 10 Year Plan (LTP). The 10 Year Plan is reviewed in full every 3 years. Where the infrastructure is not identified in Council's 10 Year Plan, then there may be the opportunity for the infrastructure to be privately funded, subject to a 'Developer Agreement' being in place between the private party and Council.

The Structure Plan is consistent with the future growth cell capacities identified within Appendix S1 of the District Plan

The provisional yields anticipated through the implementation of the Structure Plan are consistent with the capacities identified in the Waipa District Plan (Appendix S1) of 432 dwellings (where 380 are anticipated) for T11. This would help bring forward the development of residential dwellings within a key growth cell in Te Awamutu in alignment with the capacity targets of the Waipa 2050 Growth Strategy and Waipa District Plan which both give effect to the overarching framework in the RPS for sub-regional growth.

5.0 Conclusions

The Structure Plan contained in this report confirms the spatial intent and the Waipa District Plan outlines the procedural requirements to advance the T11 growth cell to the next stage of development.

The Structure Plan provides a level of confidence in a spatial context that the T11 growth cell can be progressed in a manner that is consistent with the Council's strategic direction as set out in Waipa 2050 Growth Strategy and the Waipa District Plan.

The Design Guidelines support the spatial intent within the Structure Plan and will assist in providing guidance for developers, the community and Council with an aim to achieve a high level of quality and consistency in the development.

The Technical Assessments contained in this report demonstrate that the growth cells are suitable for urban development, including preliminary recommendations in respect of three waters infrastructure, transportation, and liquefaction. It is important to acknowledge that these assessments are preliminary in nature and more detailed technical assessments are recommended.

Appendix 1: Final Structure Plan

Appendix 2: Final Design Guidelines

Appendix 3: Final Technical Assessments

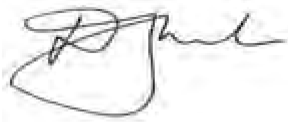
Waipa
DISTRICT COUNCIL

DESIGN GUIDELINES

TE AWAMUTU T11 GROWTH CELL

25 June 2020

Document Quality Assurance

Bibliographic reference for citation: Bo a Miskell, 2019. *Waipa Structure Plan T11 Growth Cell, Design Guidelines.* Report by Bo a Miskell Limited for Waipa District Council.		
Prepared by:	Thomas Keal Landscape Architect Bo a Miskell Ltd Brooke Foley Landscape Architect Bo a Miskell Ltd	 
Reviewed by:	Morné Hugo Landscape Architect / Urban Designer Associate Partner Bo a Miskell Ltd Dave Moule Planner Senior Principal Bo a Miskell Ltd	 
Status: [FINAL]	Revision / version: B	Issue date: June 2020

Disclaimer: Any variation or waiver to the guidelines will be considered unique and will not set a precedent for other variations or waivers. A variation is de ned as the approval of a practice which is considered to be consistent with the general intent of these guidelines, but may not be consistent with, or provided for by, a speci c provision. Al   nal decisions relating to the implementation of this design guide are at the discretion of the Developer & Development Controller.

File ref: Design_Guide_T11_Rev_B.indd

Contents

1. Introduction

The Waipa District has been identified as a high growth area in the National Policy Statement on Urban Development Capacity.

Te Awamutu is forecast to grow by 5,400 people by 2050. To provide for this growth, a structure plan for the T11 growth cell is required, as identified in the Waipa 2050 Growth Strategy (2017), Plan Change 5 – Waipa Growth Strategy, and Waipa 2018-28 Long Term Plan.

The T11 growth cell is a 47ha area of land located on the eastern side of Te Awamutu to the south of the Cambridge Road commercial node. The growth cell has been identified as a residential growth cell with a dwelling capacity of approximately 380 dwellings and represents an opportunity for housing in proximity to a commercial node which provides necessary social infrastructure shopping / medical services.

The growth cell is currently zoned Deferred Residential.

Specific provision for residential development is identified within T11. This location is considered suitable for this land use as it expands on the existing residential area on Cambridge Road and provides for some growth in close proximity to the Cambridge Road commercial node.

To ensure that development is consistent with the Council's strategic direction as set out in Waipa 2050, a structure plan has been developed in consultation with landowners and key stakeholders, and servicing requirements identified.

These design guidelines have been developed to support the implementation of the Structure Plan and to ensure that as the neighborhood is developed, the community and Council can be assured of a high level of quality and consistency.

This design guide is to be read in conjunction with the Waipa District Plan. In order to achieve a higher level of quality and consistency of development within the Structure Plan area, there are certain guidelines that are more onerous than the District Plan provisions. In these circumstances, it is anticipated that a design review will be undertaken as part of a development control process. The design guide has taken into account the district plan rules, but has not sought to list out every relevant provision. For the avoidance of doubt, the relevant provisions of the District Plan will prevail over these guidelines in a regulatory context and a full assessment against those provisions will need to be undertaken in parallel to any consideration of design matters in this guideline

1.1 Purpose

This design guide is a document for future residents, designers, development partners and local authorities, clearly communicating the expectations as to how this area of land will be developed. The document guides the landscape framework, site layout, boundary treatments and built form within the T11 Structure Plan area.

This document describes the expectations that need to be met for development to proceed. It will form an integral part of quality assurance processes. It will be used as the basis for discussions with designers, local authority sta nd other key stakeholders during the design and construction of the development and individual sites.

Good design comes as a result of clearly identifying the intended outcome, and the constraints and opportunities are resolved through a creative process. The guide is not meant to be prescriptive, and it should inspire imaginative and practical solutions.

1.2 Site Context

The T11 growth cell is predominantly characterised by rural farming and cropping blocks, large mature vegetation, with a limited number of residential dwellings. The topography generally slopes to the south and the land drains to the Mangaohoi Stream which runs along the southern boundary of the growth cell. There are signi can ooding constraints within this growth cell associated with the Mangaohoi Stream.

Providing for changing housing demands while maintaining existing character and amenity expectations will be challenging. The Town Concept Plan 2010 prepared for Te Awamutu provides guidance on how these competing demands can be managed. It is acknowledged that a change in the current density and form of residential development will need to occur if future housing demands are to be met in a sustainable manner.

It is important that the distinguishing characteristics of this particular place are maintained, including re ecting the existing semi-rural character, and ensuring appropriate boundary setback rules maintain this character.

The deferred residential zone status of the land makes future provision for more sustainable forms of living. Sustainable forms of living are required in order to manage resources that have a limited supply (such as land) as well as to reduce the overall ‘footprint’ on the environment. In the Residential Zone this outcome is achieved by providing for appropriate in ll development, and compact housing development options (such as may include semi-detached dwellings, duplexes, terrace housing or low rise apartments).

Any development options of this nature on the site will be required to be comprehensively designed, coordinated with infrastructure provision, take into account key elements of character, and address e ects on neighbouring properties. Sustainable living is also supported through rules that require dwellings to be positioned for passive solar gain and by ensuring enough open space is provided on site for a range of activities such as recreation activity, pedestrian and cycle connectivity, and amenity outcomes.

1.2 Design Principles

» **Respect for existing character.** All designs should re ect a comprehensive understanding and appreciation of location and surrounding context. The natural environment is protected and enhanced to provide amenity and ecological enhancement. Important sites and landmarks are acknowledged to respect the history and culture of the area.

» **Cultural identity.** Opportunities are to be identi ed throughout the development of cultural interpretation and education within the landscape. Maori names and design elements will be incorporated where appropriate and in consultation with local iwi.

» **Social value.** People are the key consideration in all aspects of the design. Pedestrian safety, recreation and social values are paramount.

» **Connectivity.** Transport networks and public spaces incorporate stormwater management, and green corridors, for pedestrian and ecological connections. A network of pedestrian and cycleways through the development connects the residents to the existing town, open spaces, and playgrounds.

» **Appropriate scale.** The correct scale and hierarchy of roads, cycleways and walking tracks are integrated to ensure a balance of transport options and access to public transport.

» **Quality public realm.** High-quality materials and construction methods used throughout the neighbourhood in both the public and private spaces, ensure spaces will retain a sense of quality and attract residents to use the facilities.

» **Well designed built environment.** The built form guidelines ensure that the landscape and buildings within private lots, contribute to the amenity, safety, and broad context of the development. This guide is intended to encourage creative design outcomes, not to limit or restrict original architecture or design.

2. Open space framework

The design of the T11 Growth cell re ects a comprehensive understanding of the landscape and surrounding context. The development will be efficient, connected and permeable, with a focus on pedestrian walkways, cycleways, reserves and green corridors.

The existing exotic and native mature trees perform many functions, including removing groundwater and reducing the requirement for stormwater attenuation; ecological functions, such as providing habitat and food for birds; retaining the rural aesthetic; shade during summer for people and animals; cutting of wind, reduction of soil erosion from storm events. Existing trees have been incorporated into the open space framework.

The T11 growth cell open space framework is made up of:

- Reserves
- Green Streets
- Open Spaces
- Vegetated Swales

The combination of these spaces allows for a green network to be created through the site, ensuring that all members of the community has access to an open space, and natural environments.

2.1 Reserves and Stormwater management

» Reserves and open spaces provide for people’s recreational interests, and the protection of landscapes, ecosystems, cultural and historical values. They also o er considerable amenity value to the community.

» The compact residential area is located in close proximity to public open space. This is a best practice approach, where higher density residential environments are o set with easy access to usable open space networks.

» Wherever possible retention, reuse and onsite soakage for stormwater is allowed to soak into impermeable services and managed through natural systems. Natural systems such as vegetated swales, are a low impact way of managing stormwater which are also an important amenity feature of the site.

» All waterways will have a minimum 2m planted bu er adjacent to the water to prevent contaminants entering the water, and improve the water quality.

» The western and southern areas of the growth cell currently provide a signi cant amount of natura oodplain storage volume and the growth cell has been split into two smaller sub-cells to avoid increase ood risk downstream through the existing Te Awamutu urban area.

» oo owpath across the lots in the western sub-cell area will need to be managed adequately, with the most appropriate option likely to be divert th owpath around the southern end of the lots through the open space/reserve. Thi owpath will also need to provide mitigation for the displacement of th oodplain volume.

» Due to the position of the growth cell within the wider Mangaohoi catchment, peak ow control of the 2 year ARI and higher magnitud ood events is not recommended to avoid coincidence with the larger Mangaoho ood peak.

» Retention, reuse and onsite soakage of the post-development water quality volume will be required to provide stormwater treatment and erosion control. Water tanks for each lot are recommended to help meet these requirements and reduce potable demand.

» Onsite soakage will need to be tested and designed on a lot by lot basis. If on-site soakage investigations show that the post-developed water quality rainfall volume cannot be achieved through water tanks and soakage then bio-retention devices or a suitable wetland will need to be designed.

» Vegetated swales are recommended to convey overlan ow.

2.2 Vegetation and Natural Site Features

» Existing vegetation and natural features are to be protected and enhanced.

» Landscape planting is preferred over hard structures for privacy and shade.

Examples of vegetation preferred to hard structures for fencing and shade



2.3 Parks and Play-spaces

» The development could incorporate unique and exciting playspaces to suit children of all ages and abilities.

» Playspaces could include nature-play and educational facilities, which help kids learn about the signi cance of the landscape.

» Sculptural and interpretive elements can be incorporated into the designs, which provides exposure to, and encourages interaction with New Zealand's culture and history.

» Reserve spaces should be connected by cycleways and walkways to ensure they are accessible and utilised by residents.

Examples of nature-play opportunties


3. Roads and Streetscape

The roading connections are considered holistically, to integrate cars, pedestrians, cyclists, stormwater management, and ecology.

High-quality streets with tree lined berms, grassed swales, and footpaths/cycleways are proposed to provide a safe and attractive area for both vehicular and pedestrian movement.

3.1 Road Hierarchy

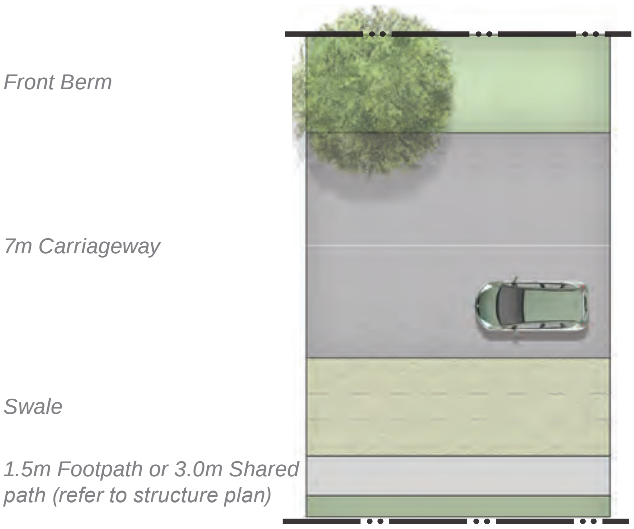
A 25m green boulevard / tree framed collector road through the sites which become the main spine road for vehicles, pedestrians, and cyclists

The 18m local roads accommodate pedestrian facilities on one side and the option for stormwater conveyance through a vegetated swale down the other side.

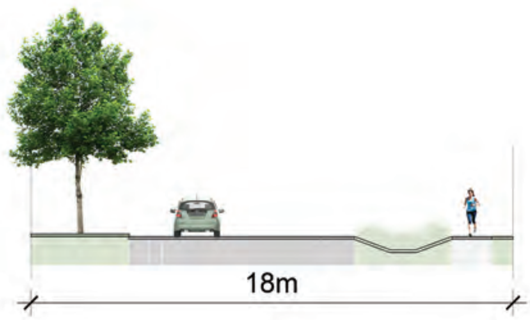
Document Set ID: 10411038
Version: 2, Version Date: 29/06/2020

3.2 Road Typologies

18m Local Road



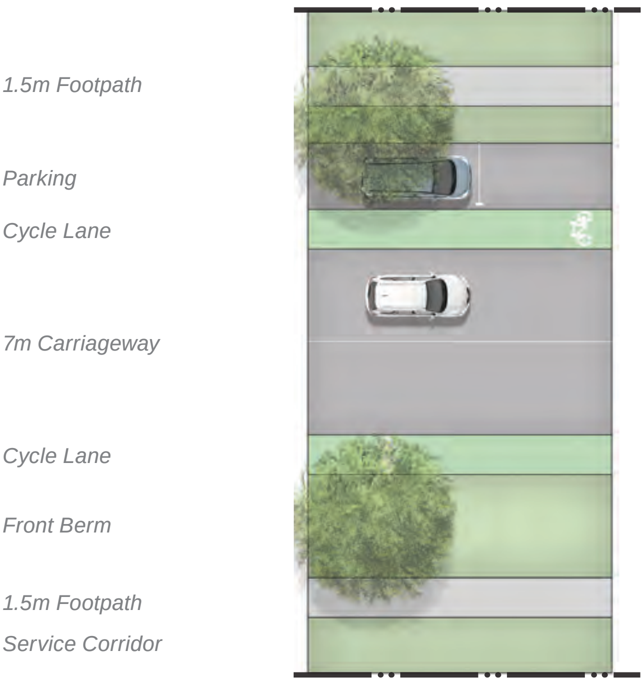
Plan



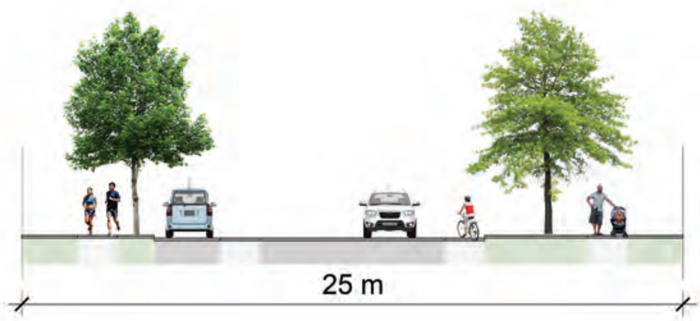
Front berm may include: Swales, recessed parking, bus stops, tree planting, street lighting

Section

25m Collector Road / Green Spine Road



Plan



Front berm may include: Swales, recessed parking, bus stops, tree planting, street lighting

Section

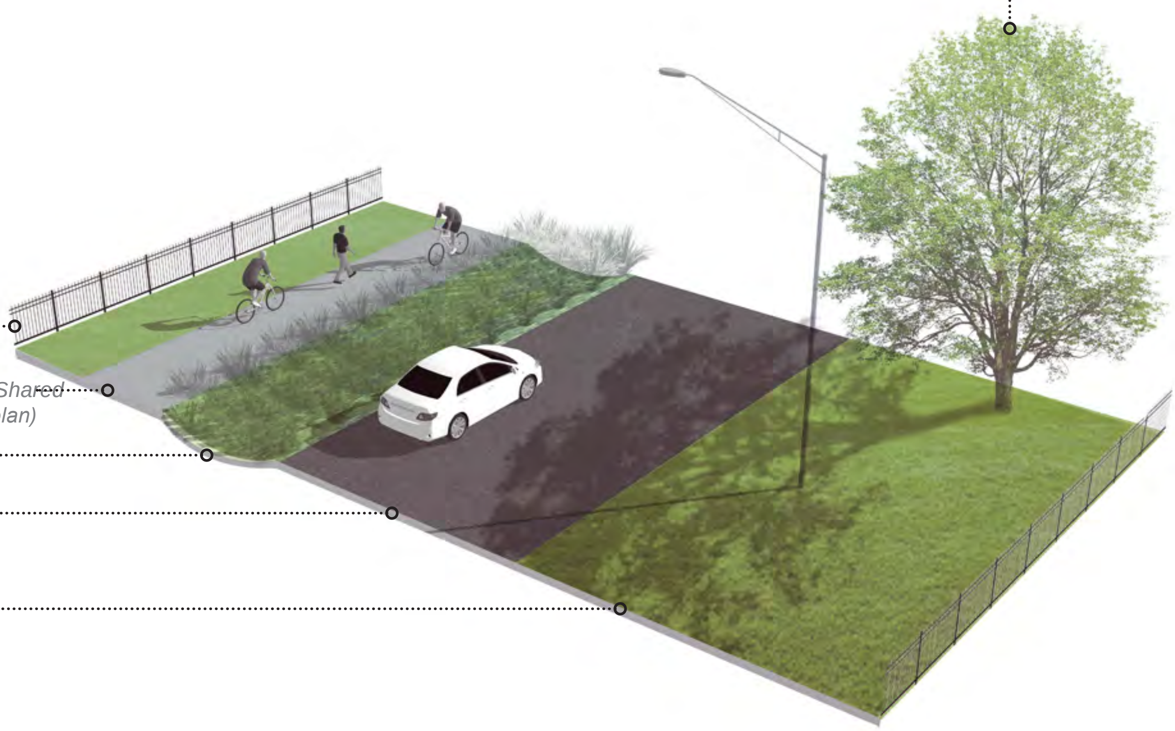
3.3 Pedestrian and Cycle Connectivity

» A network of shared paths and footpaths will help to connect residents to site features such as the gully system, reserves, playgrounds, commercial zone, and the town centre.

» Shared paths should be a minimum of 3m wide while footpaths should be a minimum of 1.5m wide.

» An integrated pedestrian and cycle network improves the wellbeing of the residents through exercise, contact with the natural environment, and social interaction.

» The activation of the public realm from people moving through these spaces makes them safer and more attractive to a range of users.



Example image. Typical 18m street with separated 3m shared cycle path or 1.5m footpath (refer structure plan) and vegetated drainage swale.

3.4 Paving and Surface Treatments

» The use of stone paving, segmental concrete and surface treatments at key intersections, road junctions, and in the private rows is encouraged, and will assist in slowing vehicles and help to prioritise pedestrian movement

» Good quality pedestrian and cycle path materials and construction ensure they can easily be maintained to a high standard and used in all seasons.

» Permeable paving materials should be considered as an option to reduce stormwater runo   nd have a low impact on the landscape.

» Using exposed aggregate concrete on walkways and cycleways is recommended to provide a higher quality surface with a more natural feel.

3.5 Site Furniture and Lighting

» The pedestrian spaces should use high-quality materials and construction methods, which ensures long life and low ongoing maintenance costs.

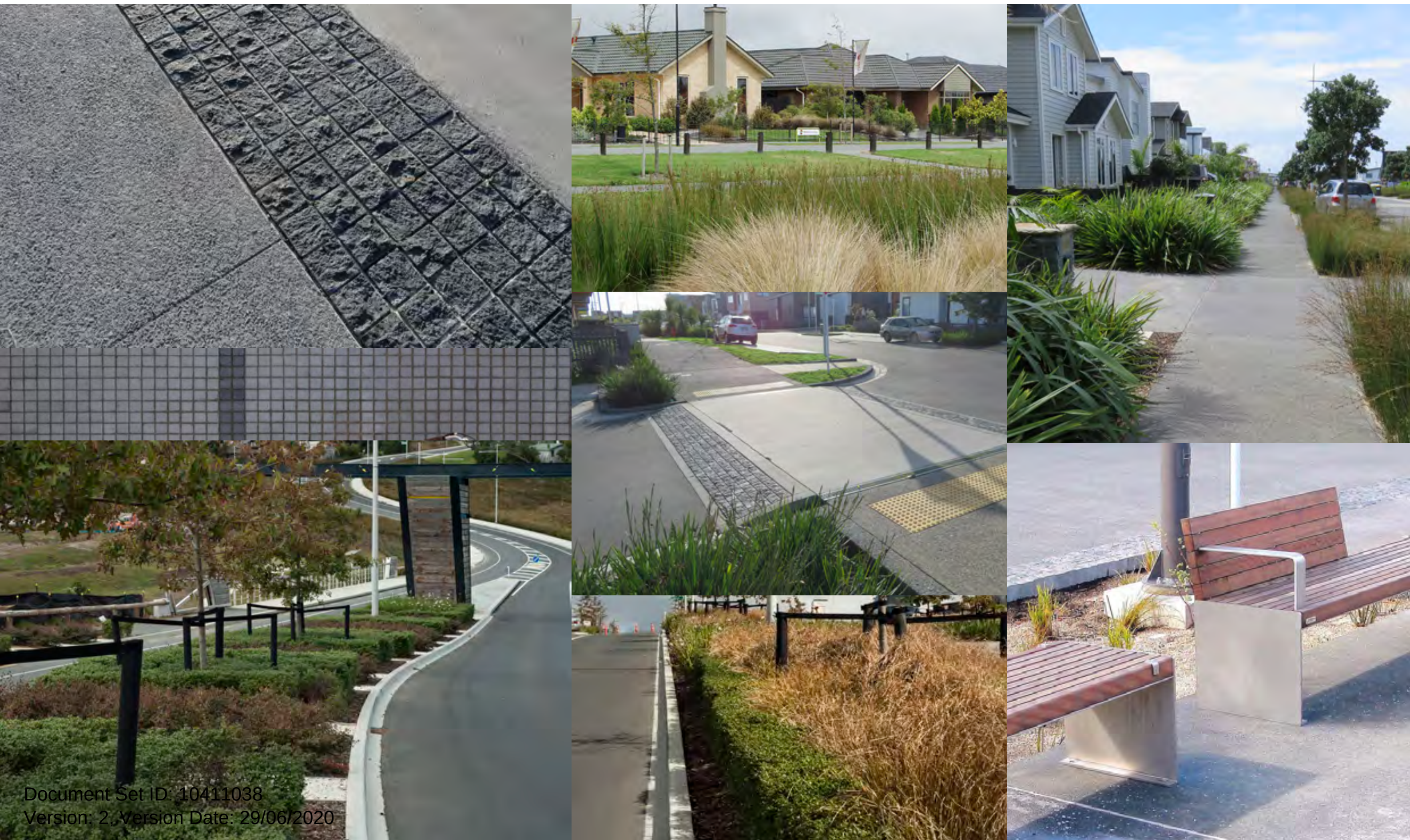
» High-quality pedestrian spaces attract people to use them, though the good design of paving, lighting and furniture.

» Site furniture should be sympathetic to its rural surroundings, the use of timber, a subtle colour palette, and simple design ensures it ties in with the rural context.

» LED Lighting with a low light spill and a warm colour tone should be used throughout for a consistent lighting e ect. Warm LED Lights are efficient and provided the appropriate light to spaces without causing any adverse e ects to people or the landscape.

» Uplighting on trees and sculptures is appropriate, so long as the spill of light does not a ect neighbouring properties or the public realm. Down lighting is preferred in outdoor living areas as there is less glare. In general, where possible the ligh   tting itself should not be visible.

Example images. Public space vernacular.



4. Built Form

Good design ensures the height and bulk of built form is appropriate to the location and character of the site. The scale, position and external appearance of new buildings must consider their settings and the relationships they have with nearby buildings and spaces.

Well designed buildings are compatible with the surrounding environment and the respect the privacy of neighbouring residents. They take into account the character of the area and are designed to enhance this character. The built form should also take into account speci c site circumstances and local microclimatic conditions, such as solar access, topography, and prevailing wind. Trees and landscaping are to be used for privacy and screening and to soften the built form.

Maximum height and minimum siz oor areas will ensure houses relate well to the size of the lots, without being overly dominant visually. Considerate building placement ensures good relationships between neighbouring properties, roads and reserves.

This guide puts in place a design framework, which will lead to positive outcomes for the landowners and the wider community. This encourages original and exciting design which considers the unique opportunities of this development.

Standard district plan rules are used in combination with design recommendations to achhieve a high quality, attractive and high value design outcome for the community.

4.1 Building Placement

» The house is to be setback according to the Setback Table and Diagrams on page 13 of this document. Setbacks establish a framework for how buildings will relate to each other and the public realm. Generous setbacks ensure the relationship between the built form, and the public realm is complementary and consistent.

» The design of the building is to consider the sun and wind to provide the most comfort for the residents and give variation to the housing layouts.

» Well-positioned houses have enough separation from the road for o   treet parking. The garage must be recessed from the house frontage.

4.2 Street Frontage

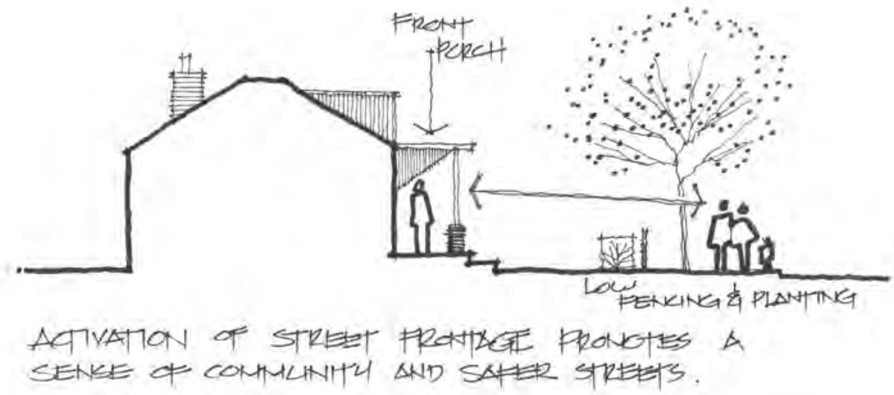
» Houses should appear to be oriented towards the street and be visible from the road. A covered entrance/outdoor space is recommended on the road frontage of the house. A welcoming front facade creates a sense of community and promotes active surveillance over the streetscape.

» The front facade should incorporate two to three complimentary materials and should have variation in the form to provide interest. An attractive street frontage adds value to the neighbourhood. Relationships between the roads and the buildings are considered critical to the identity of the community, and comfort and safety of the public spaces.

» Driveway materials should be of good quality, such as asphalt or exposed aggregate concrete. Parking areas which are visible from the road must compliment the design of the house.

» Vehicle crossings should be constructed from exposed aggregate concrete, so a consistent high quality street / driveway interface is maintained.

Example image. Front facade design.



4.3 Building Setbacks Residential Zone - 500 to 1,000m² Lots

500 - 1,00m² Lot Building Set Backs	Meters
State Highways	15
Front boundary setback	10
Rear boundary setback	3
Side boundary setback	3

Provided that for dwellings and detached habitable rooms where a site boundary adjoins the Rural Zone or Reserves Zone, the minimum setback from that boundary will be 4m

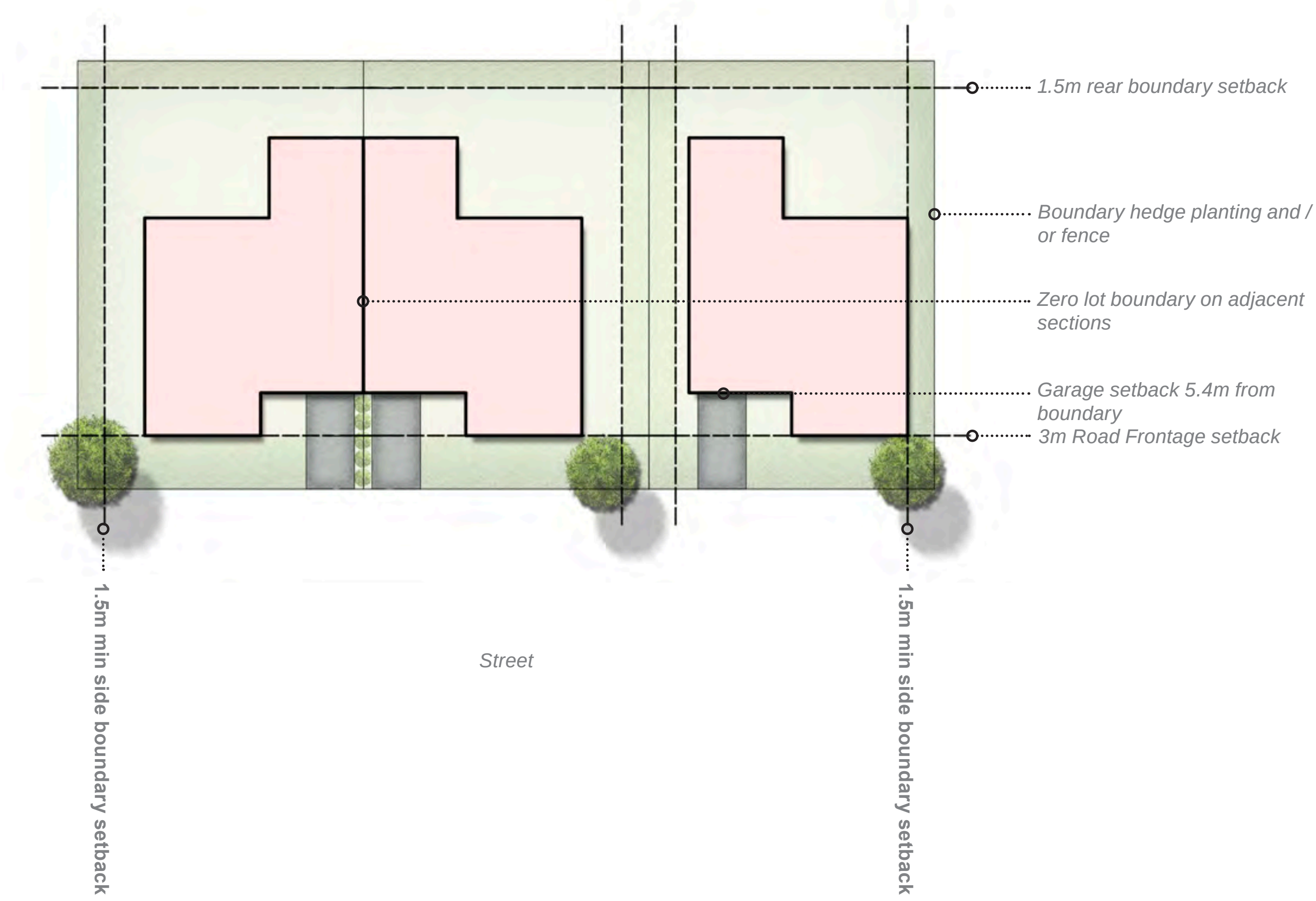
*Building design, driveways and landscaping for illustrative purposes only

Building Setbacks Compact Residential Overlay

Lot Building Set Backs	Meters
Front boundary setback	3
Rear boundary setback	1.5
Side boundary setback	1.5
Garage setback	5.4

Adjacent lots may have one zero lot boundary to allow for duplex house design.

Provided that for dwellings and detached habitable rooms where a site boundary adjoins the Rural Zone or Reserves Zone, the minimum setback from that boundary will be 3m.



*Building design, driveways and landscaping for illustrative purposes only

4.4 Boundary Treatments

» Fences between buildings on the site and any road, public walkway or reserve should be no higher than 1.2m in height if not visually permeable, or no more than 1.8m in height if visually permeable.

» The same style of fence on the front boundary must continue along the side boundaries until parallel with the house.

» Utility areas are to be screened from public view with high quality screens and gates.

» Landscape planting between dwellings on the site and any public place should allow visibility between the dwelling and the public place.

» Clipped hedges are preferable to fences on front boundaries. Hedges provide a softer interface between properties and a more natural feel over long spans.

» Planting should be used to create privacy between lots, which, in addition to the public space planting framework, will improve the overall amenity for the community.

4.5 Retaining

» Retaining walls should not exceed 1.5m in height. Where retaining walls above 1.5m in height are required, stepped retaining should be used to prevent visual dominance.

» Retaining walls visible from a public viewpoint should be enhanced by plant cover using a suitable shrub, groundcover, or climber.

Example images. Approved boundary fences and walls

High quality 1.8m timber fence

High quality 1.8m timber fence

High quality 1.2m pool style fence

High quality 1.2m timber fence

Visually permeable metal fencing

Privacy screen and metal gate

4.6 Building Size, Height, Form

» The maximum height gives a consistency through the neighbourhood, and maintains a rural character. The maximum height for all houses within the T11 Growth cell is 8m.

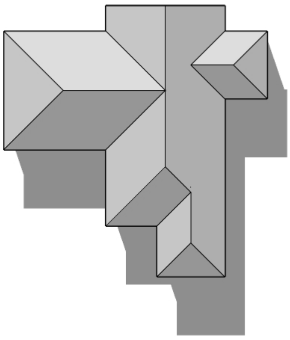
» Site coverage should not exceed 40% of the net area of the site where no garage or carport has been provided the maximum site coverage shall be reduced by 20m2, provided that this rule does not apply to the compact housing overlay area (refer to Rule 2.4.2.43 in the District Plan)

» Each site should be grassed, planted in trees and/or shrubs or otherwise landscaped in a manner that retains a minimum of 40% of the gross site area in permeable surfaces. For the avoidance of doubt Rule 2.4.2.43 shall apply to the compact housing overlay area.

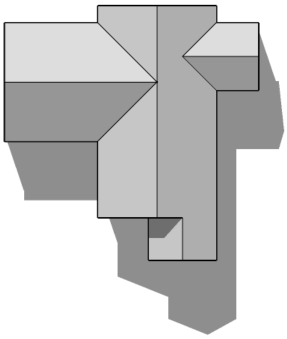
» The recommended roof designs are gable-end roofs, combination gable and hip roof, and monopitch roofs. Variation of roo ines adds to the interest and quality of the public realm. (see diagram below)

» Full hip roofs are not recommended.

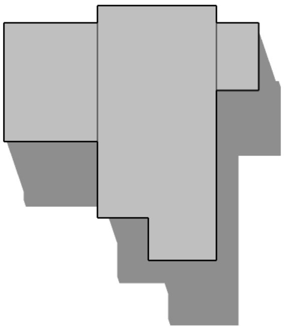
Examples of approved roof styles



Combination of roof styles



Gable end roof



Monopitch roof

4.7 Materials and Colour

It is recommended that:

» Houses should use natural and muted colour tones, which blend into the surrounding landscape. Bright colours and highly re ective materials should be avoided.

» Houses should be composed of two to three complementary materials. The Front facade should have a minimum of two materials. Brick cladding should not exceed 40% of any publicly visible frontage.

» Fences to be dark neutral colours.

Example images of material and colour palettes

Dark painted weatherboard and light coloured plaster

Dark painted weatherboard and cedar

Dark painted weatherboard, honed and sealed concrete block and timber

5.1 Neighbourhood Centre

The design of streets, buildings and spaces within the Neighbourhood Centre a ects the future vitality and economic potential of the area. This document is intended to provide guidance for the development of a vibrant, community-focused, and economically viable commercial centre within the growth cell.

Design guidance for the Neighbourhood Centre is not intended to be either overly complicated or prescriptive but is instead aimed at providing direction to potential future developers as to the outcomes supported by the local community and key stakeholders. These design criteria cover a wide range of matters to ensure that developments within the Centre re ect good urban design practice. A range of activities are promoted within the Centre, and pedestrian scale frontages reinforce the pedestrian focus and vibrancy of this area.

The built form of the Neighbourhood Centre should be of high quality and of an appropriate scale that is sympathetic to the unique character of the area. The architectural design should be re ective of the smaller scale of the Neighbourhood Centre, using simple and appropriate materials an   nishes.

5.2 Neighbourhood Centre Character

A well-designed neighbourhood centre creates opportunities and spaces for communities to gather, interact, do business and take part in passive and sometimes active recreation activities.

The Neighbourhood Centre incorporates local service functions and small-scale retail activities that could be supported by a small community centre space and related social infrastructure, aimed at attracting residents to the centre. The Neighbourhood Centre design could incorporate shared spaces, which activate the area, by providing di erent modes of transport through the spaces.

Lighting throughout the centre is to be a warm colour LED for consistency with the rest of the neighbourhood streetscape.

5.3 Neighbourhood Centre Landscape

Landscaping plays an important role in supporting retail activities and providing spaces for residents to linger and enjoy social interactions with their community. The Centre's landscaping should incorporate:

» High-amenity open space and quality planting

» Strong connectivity for pedestrians and cyclists.

» Appropriate use of materials to create a relaxed character wit   exible spaces.

» Landscaping should be low maintenance and incorporate predominantly native trees, shrubs and groundcover species.

5.4 Neighbourhood Centre Built Form

Neighbourhood Centre built form shall comply to the following requirements:

» Building heights would be limited to 14m in height within the Neighbourhood Centre.

» The architecture is to have a pedestrian scale, with large and welcoming doors and openings adjacent to public space. Buildings with large blank walls on th rst level are inappropriate.

» The built form is designed to allo exible use of spaces, so the character of the area can develop and adapt over time.

» Each individual retail and services tenancy should hav oor area of not more than 250m2 GFA (excluding community amenities and facilities, administration offices, and professional ces).

» All commercial building street frontage should be constructed to a 0m front lot boundary.

» All street frontages should have a minimum 3m wide continuous covered veranda to allow for weather protection.

» All commercial buildings should have a minimum 3m setback from all adjoining residential zone, reserves and public open space boundaries.

» All buildings fronting a road or reserve should have an active frontage, incorporating 70% permeable, glazed shop frontage at groun oor. Active frontages should also include wide double doorways to allow for easy pedestrian access.

» Where a site adjoins the Residential Zone, no building or stored materials should penetrate a recession plane at right angles to the Residential Zone boundary inclined inwards at an angle of 45° from 2.7m above ground level.

» Any storage or service area (including mechanical, electrical and utility equipment, refuse, and recycling activities) not enclosed within a building or where a shipping container is being used for storage, should be fully screened by landscaping or solid walls or fences not less than 1.8m in height.

» Walls and fences over 1.8m in height should be setback a minimum of 5m from the road boundary unless a landscaping strip of a minimum of 2m wide is provided on the external side of the fence.

» Walls and fences along any road or reserve should not exceed 1.6m in height, except where at least 40% of the fence is visually permeable, in which case the fence may be constructed to a maximum height of 1.8m.

The above guidelines should be read in conjunction with Section 6: Commercial Zone of the Operative Waipa District Plan.

About Boffa Miskell

Bo a Miskell is a leading New Zealand professional services consultancy with offices in Auckland, Hamilton, Tauranga, Wellington, Christchurch, Dunedin and Queenstown. We work with a wide range of local and international private and public sector clients in the areas of planning, urban design, landscape architecture, landscape planning, ecology, biosecurity, cultural heritage, graphics and mapping. Over the past four decades we have built a reputation for professionalism, innovation and excellence. During this time we have been associated with a signi cant number of projects that have shaped New Zealand's environment.

www.boffamiskell.co.nz

Auckland	Hamilton	Tauranga	Wellington	Christchurch	Queenstown	Dunedin
09 358 2526	07 960 0006	07 571 5511	04 385 9315	03 366 8891	03 441 1670	03 470 0460