3. RECOMMENDED STRATEGY

3.1 Urban growth needs

The main objective of this project is to identify suitable land to replace areas earlier identified to accommodate urban growth, distinguishing between land for residential activities and employment land.

Figure 3-1 indicates which of the original growth areas need replacing. These include as a result of the identified liquefaction risk:

- → E1 (residential): 38.6ha
- → E2-remainder (residential): 7.5ha
- → SE (residential): 28.9ha
- → E2 (employment): 85ha

Due to various other reasons:

- → W2 (residential): 21ha
- → Taylor Pass area (residential): up to 12ha

RESIDENTIAL GROWTH NEEDS

The table in **Figure 3-1** provides an overview of the total residential growth needs that should be accommodated amounting to **1434 dwellings**.

Growth Area	Area (ha)	# dwelling units
E1	38.6	540*
E2-remainder	7.5	75**
SE	28.9	405*
W2 (Colonial Vineyard)	21	294*
Taylor Pass area	12	120**
Total	**108ha**	**1,434 dwellings**

*based on 14 units / ha
**based on 10 units / ha

ABOVE FIG. 3-1: The residential growth needs that should be replaced through this project.

It should be noted that these figures are based on:

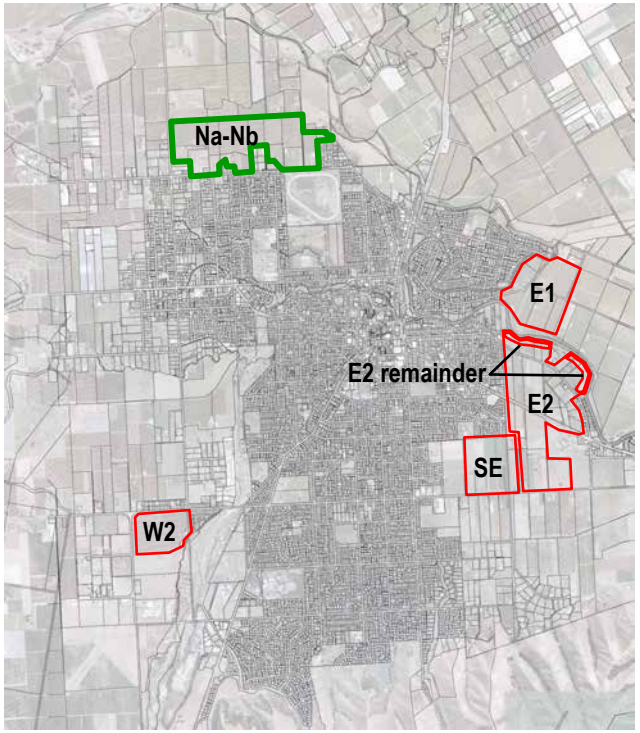
- → The growth projections used during the process that led to the original growth strategy. During that process a higher growth scenario was assumed than is currently used by the Assets and Services Group within MDC.
- → The same average household size (2.4 people / dwelling) across the residential growth areas.
- → An average density of 14 dwellings / ha as identified for most of the areas in the original growth strategy. The density of 10 dwellings / ha in the Taylor Pass area is based on actual development outcomes.
- → The same figures for the infill (already residentially zoned land within urban Blenheim) and intensification (adding one or more units to already developed lots) potential as those used during the original growth strategy process. This excludes the zoned land in the Taylor Pass area set aside for the establishment of a school.
- → A supply that was 15% higher than the forecast demand was identified in the original growth strategy, allowing for development inefficiencies and contingency.

EMPLOYMENT GROWTH NEEDS

Employment area E2 indicated in **Figure 3-2** amounts to **85 hectares**.

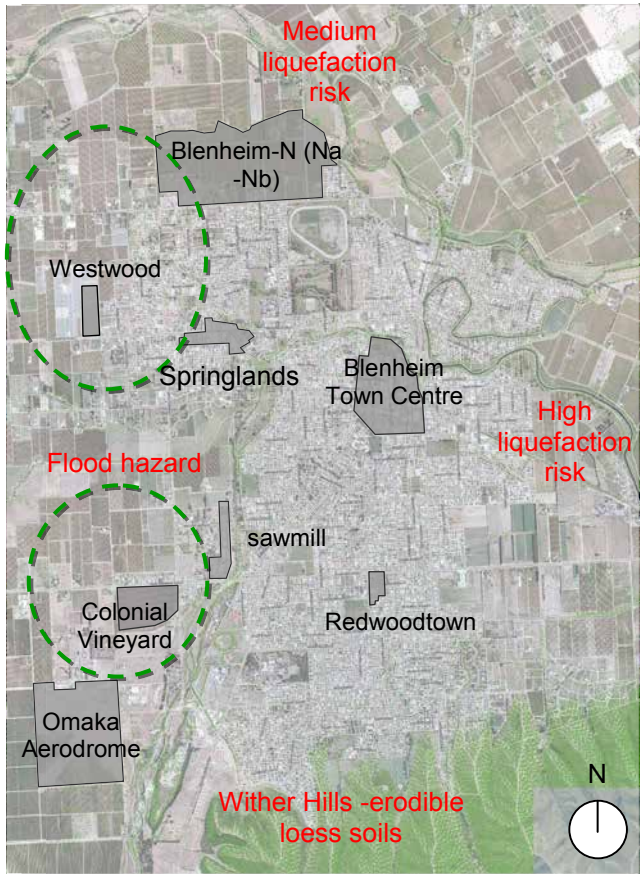
It should be noted that:

- → This is a gross figure that included an extensive area set aside for storm water.
- → The original growth strategy identified employment land needs ranging between 69 and 120 hectares, including further development at Riverlands.
- → Some remnant of E2 might be pursued privately, possibly reducing the balance to be replaced.
- → Riverlands is in the process of being extended as per the original growth strategy. The target of 85ha employment land is in addition to this.

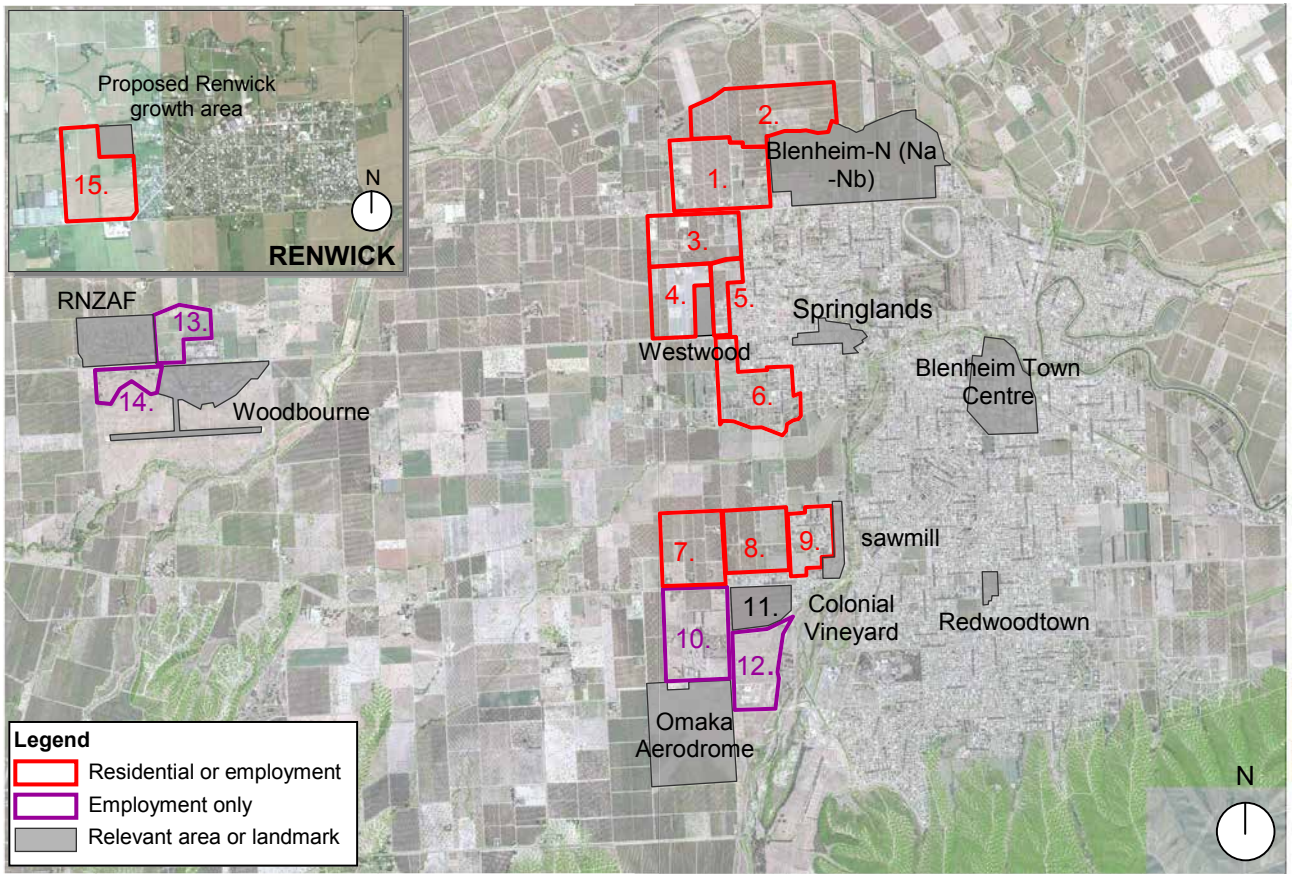


ABOVE FIG. 3-2: The growth areas in the original Growth Strategy. Residential areas E1, E2-remainder, SE and W2, and employment area E2 need replacing.

- → The intention for the employment areas include light-industrial activities, rather than offices (which are more suitably located in town centres and mixed-use areas) and heavy industry (which is more appropriately located in Riverlands and possibly other designated areas within the District).



ABOVE FIG. 3-3: The two broad growth directions considered, after north, east, south and mid-west were discarded for various reasons



ABOVE FIG. 3-4: Growth options considered

3.2 Growth options considered

The two main aims of the project included identifying Greenfield locations able to accommodate:

- → Approximately 1,434 dwellings
- → Approximately 85 hectares of employment land

This is based on the same population projections, the same density and household size assumptions, and the same amount of infill / intensification, as the original growth strategy.

BROAD GROWTH DIRECTIONS CONSIDERED

During the scoping session at the outset of the project it was identified that Greenfield land surrounding Blenheim is highly constrained in the following ways (refer to **Figure 3-3**):

- → East: High liquefaction risk
- → North: Medium liquefaction risk
- → South: Wither Hills -erodible loess soils
- → Mid-West: Flood hazard in Yelverton Stream and Doctors Creek areas

It was therefore concluded that it is likely that only to the northwest and to the southwest of Blenheim viable options may exist.

ASSESSMENT METHODOLOGY

North- and south-western areas were further analysed during the early stages of the project. To help focus the preferences of different disciplines and to prioritise strategic thinking, a series of conceptual growth options were developed prior to the workshop. These were based on 'growth pockets', areas identified on the basis of where logical urban growth could occur in a manner that complemented existing patterns of development. **Figure 3 -4** on the previous page shows the areas in the north- and southwest that were assessed for their opportunities to accommodate urban growth. The following should be noted:

- → A distinction was made between areas suitable for either residential or employment growth, and areas suitable for employment growth only.
- → The areas identified for 'Deferred Township Residential' and 'Deferred Rural Residential' in Renwick were included in order to assess the scenario to relieve some of the residential growth pressure on Blenheim and instead accommodate more growth in Renwick.
- → Two possible employment areas on land near the Woodbourne Airport that may become available in the future were included for consideration. It was argued that development on these lands would take advantage of both the airport and proximity to SH6.

During the workshop the following relevant technical discipline groups were represented:

- → Flooding and storm water - the management of streams, rivers and storm water, both related to existing urban areas as well as possible new areas;
- → Strategic planning - aligning with the Council's higher level planning and resource management strategies;
- → Wastewater infrastructure - waste water reticulation for existing and possible new urban areas;
- → Water supply - water supply to existing and possible new urban areas;
- → Geotech - the usability of the land from a land stability (including pertaining to liquefaction risk) perspective.

Growth Area #	Flooding and storm	Strategic Planning	Waste water	Water supply	Geotech	Ground water	Open space	Transport	Community
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11	Colonial Vineyard subject to final decision								
12									
13									
14									
15	Renwick's growth disconnected from Blenheim's growth								

Key: Employment; Residential area; *Least constrained*; *Constrained*; *Most constrained*

ABOVE FIG. 3-5: Growth areas assessment from single discipline perspective

- → Ground water - the impact that urban development could have on the springs and ground water level;
- → Open space and recreation - the provision of public open space and recreational options for both existing and future residents;
- → Transport - existing and possible new roads and streets, as well as bus routes, and cycling and walking opportunities; and
- → Community infrastructure - existing and possible community facilities such as halls and schools, as well as accessibility and security issues.

Each of these groups representing one technical discipline undertook an assessment of these growth areas. Each group used a simple three-category 'traffic light' ranking system of 'least constrained' (green), 'constrained' (orange), and 'most constrained' (red) for urban growth from their position, where appropriate conditional on other pre-requisite factors that would need to be available were growth to occur. This analysis led to a comprehensive overview of the individual technical discipline's high-level preferences for the urban growth directions for Blenheim (**Figure 3-5**, previous page). The exercise provided a useful basis to readily compare many different possible growth pockets on a large number of themes or interests.

In addition to the assessment of the individual growth areas, the broader growth direction, i.e. north-west versus south-west was also discussed.

The analysis described above identified that:

- → There were a number of contrasts between groups.
- → No one growth area was considered ideal from the perspectives of all relevant technical disciplines. All growth options are constrained. However, the mix of constraints varies.
- → In most cases constraints can be overcome by expenditure.
- → Some growth areas 'scored' better on a larger number of themes than other.
- → The aim should therefore be to identify the least constrained while also identifying the growth areas that can give most benefit to the existing community.

Although giving a strong indication, this assessment technique was by no means designed to provide a mathematical answer to the question where urban growth should or should not occur by simply adding up the number of green, orange and red grading. 'Red' could in some cases mean 'fatally flawed' and in other cases 'technically solvable at a price'. Neither was it aimed to help the workshop 'pick winners'; one or more technical disciplines that should perhaps be given preference over others. Instead the outcomes of this assessment were subjected to an integrated discussion in order to exchange views among the representatives of the different technical disciplines and come to a common conclusion. Contrasts between groups were, once highlighted, able to be worked through. Discussion also identified possible measures associated with development of growth area which would make growth in that particular area more acceptable.

The technical considerations informing the grading are included in **Section 6** of this report.

3.3 Preferred growth areas

KEY WORKSHOP OUTCOMES

Workshop-based analysis identified the following outcomes, which were endorsed during an informal Councillor briefing at the conclusion of the workshop:

- → It was decided to consider Blenheim's growth disconnected from Renwick's and therefore exclude Area 15 from the assessment.
- → Analysis identified that the northwest is marginally more preferred for residential development than the south-west. The reasons behind this include:
  - It is better connected to the township and public amenities including schools and open space.
  - It is not affected by potential Omaka reverse sensitivity or noise effects.
  - It is not affected by potential Flight Timbers Sawmill reverse sensitivity or adverse environmental effects.
  - Based on information available during the assessment, the land between Old and Middle Renwick Roads is less constrained from a geotechnical perspective.
  - Growth in the area will support the Springlands and Westwood retail and other facilities.
  - Clustering growth and combining it with Growth Area Blenheim-N (which is likely to develop to at least some extent) gives the best chance for new amenities, e.g. storm water, mains improvements, bus services etc.
- → Based on this notion, liquefaction testing in Areas 1, 3, 4, 5 and 6 was commissioned by the Council and commenced in October 2012. Results are due in February 2013.
- → Colonial Vineyard (Growth Area 11) was excluded from assessment as a residential area at the time, pending the commissioners' decision. Area 8 was identified as a suitable back-up option for Colonial Vineyard. After the commissioners' decision to decline the application for Private Plan Change 59, Area 8 was included in this strategy.
- → Areas 11, 12 and 14 were identified as preferred employment areas, with Areas 10 and 13 as back-ups.

THE WESTERN BOUNDARIES OF THE PREFERRED GROWTH AREAS

Capacity tests have identified that the preferred residential growth areas would have sufficient capacity to provide for the growth needs (refer to the discussion in **Section 3.4**). In addition to not growing further to the west than necessary to meet the growth needs, the main reasons behind the proposed definition of the western boundaries of these areas include the following:

Area 1

- → Boundary set at Blicks Lane in response to consultation feedback received from property owners to the west of Blicks Lane.

Areas 3 and 4

- → Development on both sides of Rene Street to optimally utilise this street which could form a crucial north-south connection between Old and Middle Renwick Roads.
- → To incorporate properties which have already become urbanised to some degree.
- → To align the western boundary of Area 4 with the western boundary of Area 3.

Area 5

- → Not applicable - Area 5 is located between the existing urban area around Rose Street / Adams Lane to the east and Westwood to the west.

Area 6

- → Boundary to include the properties off Severne Street (western side) to not stretch this area, which in many respects is not ideal, further west than strictly necessary to control infrastructure aspects of developments currently underway on an ad-hoc basis; and the large-lot development on the western side of Severne Street (already underway) functions as transition between urban and rural.

Areas 8, 11 and 12

- → *Refer to the discussion on Areas 7 and 10 below*.

THE LESS-PREFERRED GROWTH AREAS

Detailed discussions on the opportunities and challenges of the preferred growth areas are included in **Section 4** (Residential Areas) and **Section 5** (Employment Areas). The key reasons for <u>not</u> selecting the less-preferred areas include the following:

Area 2 (considered for residential development)

- → Based on the information available it could be assumed that the liquefaction risk for Area 2 is the greatest of the growth areas considered.
- → Area 2 is relatively disconnected from the rest of the town. Access to this growth area would have to fully rely on Thomsons Ford Road, unless appropriate and direct connections are provided via the Blenheim-North Area and / or recommended Area 1. This would however be unlikely to have the required capacity.
- → The transmission lines would form a major negative impact on a coherent and efficient development structure of Area 2, whilst in Area 1 this may be more easily overcome by good planning and design.
- → Area 2 is located further away from the Springlands centre, schools, the town centre, public open spaces, and service infrastructure than the preferred residential growth areas in the north-west.

Area 7 (considered for residential development)

- → Based on the information available it could be assumed that the liquefaction risk for the northern part of Area 7 is greater than many of the preferred areas.
- → The degree of isolation from the rest of Blenheim is greater than in Area 8, which is considered as a major disadvantage.
- → Development of Area 7, in addition to Area 8, would contribute significant additional loads to the waste water system. Further upgrades to the downstream reticulation may be required.

Area 9 (considered for residential and / or employment development)

- → Area 9 is currently zoned rural-residential and partly developed accordingly.
- → There are reverse sensitivity issues arising from the residential land use currently existing on the site and the non-residential uses in its immediate proximity.
- → The current zoning is regarded the best way to manage this situation until there is more clarity regarding the long-term future of the non-residential activities in the area, most notably Flight Timbers Sawmill.

Area 10 (considered for employment development)

- → Area 10 is further removed and slightly more disconnected from the town than preferred Areas 11 and 12, which could be made accessible for commuters through extension of the walkway / cycleway along the Taylor River corridor, in addition to road access.
- → Area 10 is more constrained in its current land uses than Areas 11 and 12.
- → Area 10 is proposed as a back-up area in case there is not enough capacity in the preferred areas.

Area 13 (considered for employment development)

- → Development of Area 13 is dependent on the site owner's vision, which is unclear at this stage.
- → Area 13 is proposed as a back-up area in case there is not enough capacity in the preferred areas.

3.4 Preferred overall growth strategy

The assessment described in broad terms on the previous page has resulted in the 'composite picture' in **Figure 3-7**.

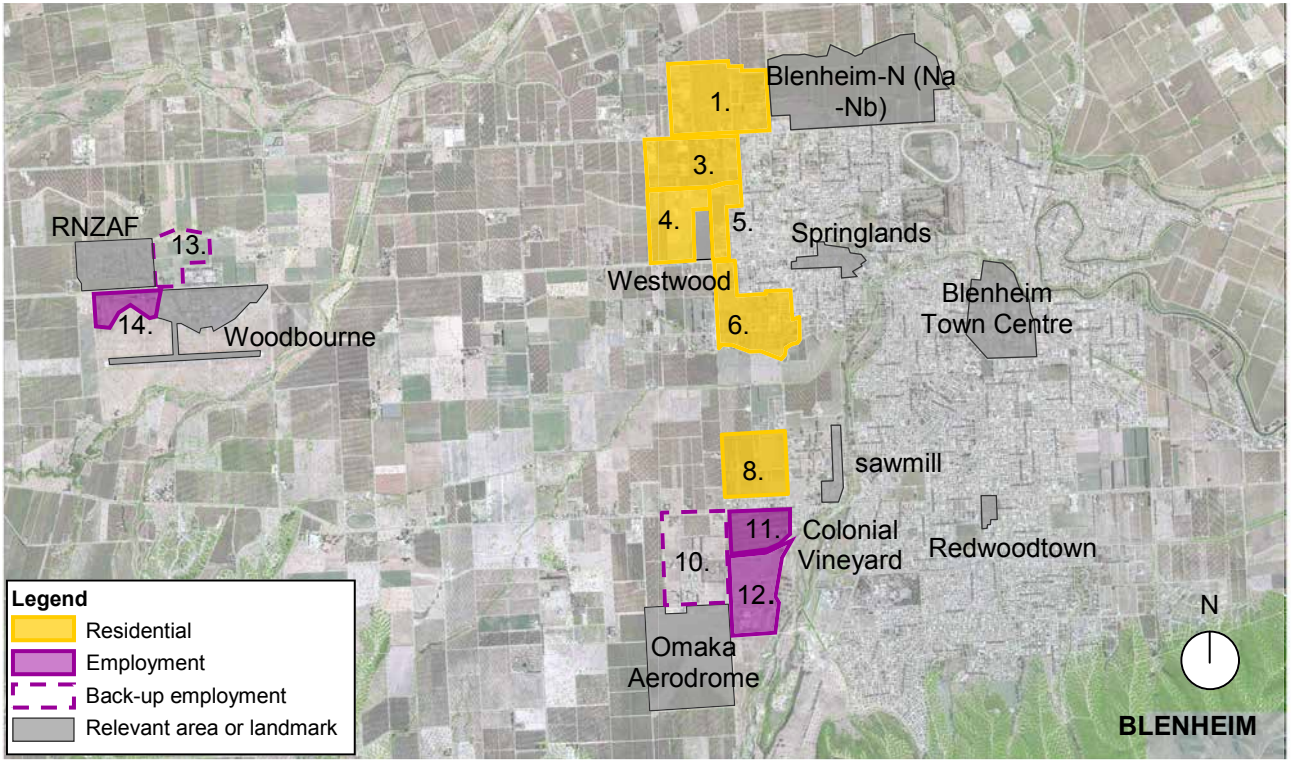
RESIDENTIAL DEVELOPMENT

The table in **Figure 3-6** shows how the expected total dwelling yield exceeds the number of dwellings targeted by 5.6% (1,515 vs. 1,434). The figures in this table should be understood against the backdrop of the following:

- → This a conservative estimate based on conceptual sketches for each of the areas, only for the purposes of this strategy.
- → All proposed areas are constrained by existing dwellings and most consist of multiple properties, leading to development inefficiencies, which have been part of the yield estimate. Removal of existing dwellings and a high degree of coordination between properties may lead to a higher yield.
- → Almost all areas would include a significant component of large-lot residential development to form an appropriate interface between residential and rural land. In some cases proposed landscape buffers and no-build zones have led to a further reduction of the estimated yield.
- → Developing at an average density of 10 dwellings per hectare would lead to a total yield of 1,649 dwellings, 9% higher than estimated, and 15% higher than the target.
- → Developing at an average density of 14 dwellings per hectare, as assumed and recommended for the (less constrained) growth areas in the original strategy, would lead to a total yield of 2,309 dwellings, 52% higher than estimated, and 61% higher than the target.
- → Landowners may develop at a higher density than assumed realistic in this report. Using the land more efficiently would delay the need for more residentially zoned land beyond the horizon of this strategy.

Growth Area	Area gross (ha)	Developable area (ha)	# Dwelling units
Area 1	52.1	43.7	370
Area 3	36.3	31.6	355
Area 4	25.2	25.2	220
Area 5	15.9	12.0	95
Area 6	38.7	21.7	130
Area 8	33.4	30.7	345
Total	**201.6ha**	**164.9ha**	**1,515 dwellings**

ABOVE FIG. 3-6: Expected dwelling yield for each of the proposed Residential Growth Areas



ABOVE FIG. 3-7: Recommended growth strategy

Assumptions and considerations

The residential component of the preferred overall strategy is based on the following key assumptions and considerations:

- → It is assumed that Blenheim-N (Na and Nb) will be developed at least to some extent.
- → It is assumed that Areas 5 and 6 will likely continue to intensify further, despite (partial) rural zoning. These areas should be regulated in order for the Council to achieve integral and coherent outcomes.

- → High-level capacity tests identified that Areas 5 and 6 together would yield approximately 225 dwellings, requiring approximately 1209 dwellings in other areas.
- → A cluster of 1209 dwellings can be leveraged. 'Pepper potting' will lead to an inefficient outcome requiring duplication of amenities and additional cost.
- → At the same time, the assessment identified that Areas 1, 3 and 4 are considered as relatively unconstrained from many technical perspectives and could logically follow the development of Blenheim-N.
- → High-level capacity tests identified that these areas together would yield approximately 945 dwellings.
- → The remaining approximately 264 dwellings can be accommodated in Area 8, which from a dwelling number as well as infrastructure capacity point of view can replace Growth Area W2 (Colonial Vineyard).

The opportunities and challenges for Areas 1, 3, 4, 5, 6 and 8, as well as illustrative concepts for the proposed residential development in these areas are described and presented in **Section 4**. It is recommended that for future subdivision in any of the areas a Structure Plan for the entire growth area is required. The illustrative concept plans could serve as preliminary structure plans. The design of the main structuring elements in the plans for Areas 3, 4 and 5 should be coordinated.

The preferred sequence of development is presented in **Section 3.5**.

EMPLOYMENT LAND DEVELOPMENT

Figure 3-7 also depicts the recommended distribution of employment land. Proposed for development are Area 12, additionally suggested are Areas 11 and 14. The table in **Figure 3-8** indicates the areas of each of these lands. This is based on the following key considerations and assumptions:

- → The combined capacity of the proposed areas is lower than the target of 85ha. However, the proposed areas may be developed more efficiently than the earlier proposed Area E2, where a large component of land was set aside for storm water measures.
- → Development on the Corlett Block (Area 12) would capitalise on opportunities that exist in conjunction with Omaka aerodrome and the surrounding aviation cluster. Consultation has indicated that the landowners' aspirations are in line with this.
- → A logical progression from employment development on the Corlett Block would be to also include Colonial Vineyard (Area 11). A response to this recommendation has not yet been received from the landowner, although a recent application by the landowner included employment uses on the southern half, as a way forward in response to concerns relative to air noise from Omaka.
- → The former golf course at Woodbourne (Area 14) may become available in the near future. Key advantages include the proximity of the airport and the presence of SH6 between Blenheim and Renwick. No feedback has yet been received from the land owners.

Growth Area	Area (ha)
Area 11 (formerly W2): Colonial Vineyard	21.7
Area 12: Corlett Block	31.1
Area 14: former golf course adjacent to Woodbourne airport	15.3
Total	**68.1ha**

ABOVE FIG. 3-8: Land areas of each of the proposed Employment Growth Areas

- → Some remnant of E2 (Alabama Road area) might be pursued privately. This may reduce the balance that is to be replaced.

Recommendations

- → Alongside the landowners, explore further the opportunities that exist for the Corlett Block.
- → Approach the owners of Colonial Vineyard and the former golf course at Woodbourne on the idea to develop employment uses on these lands.
- → Reserve Area 10 (west of Aerodrome Road) and Area 13 (north of SH6 at Woodbourne) as possible back-up employment areas.
- → Consult with the local development community regarding the suitability of the proposed locations.
- → Monitor the demand for employment land into the future and release land as necessary.

The opportunities and challenges for Areas 11, 12 and 14 are described and presented in **Section 5**. It is recommended that for future subdivision in any of the areas a Structure Plan for the entire growth area is required. The main structuring elements in the plans for Areas 11 and 12 should be designed in coordination.

The preferred sequence of development is presented in **Section 3.6**.

3.5 Staging and prioritisation of residential development

Figure 3-9 indicates the preferred staging of residential growth (conditional upon liquefaction testing) combined with a prioritisation of key planning-related implementation actions.

STAGING

The preferred staging of residential development is informed by the outcomes of the technical assessment of the growth areas. Key considerations include the following:

- → Residential subdivision in Area 5 is already taking place, despite the (partly) rural zoning.
- → Development in Blenheim-N was identified in the original growth strategy and structure planning is currently underway, but halted due to the liquefaction testing.
- → Area 8 can be readily developed.
- → Development in Area 1 ideally follows after Blenheim-N is completed; Area 3 follows Area 1; and Area 4 follows Area 3.
- → Residential subdivision in Area 6 is already taking place, despite the (partly) rural zoning.

Due to individual landowners' aspirations and many other factors, development exactly according to these steps cannot realistically be expected. However this preferred staging influences the actions to be taken to implement the strategy.

PRIORITISATION OF ACTIONS

Liquefaction testing (process already started) should be carried out as a matter of highest priority. This will provide the required certainty for adoption of this strategy and reflecting this into the zoning of the land. Other key planning actions could be divided in *High*, *Medium* and *Low* priority actions:

- → Identified as *High* priority actions are those that enable the development of areas positioned early in the staging. Additionally, the zoning of Area 6 is considered High priority so that the Council is able to positively influence the outcomes, particular from an infrastructure perspective.
- → Identified as *Medium* priority actions are those that enable the development of areas positioned later in the staging.
- → Identified as *Low* priority actions are those that enable the development of areas positioned last in the staging.

Preferred staging		Key action required (in addition to liquefaction testing)	Priority
1	Continued residential subdivision in Area 5 from south to north.	Acknowledge development of Area 5 by means of Residential zoning.	High
	Residential development in Blenheim-N from east to west.	Apply Residential zoning.	High
2	Residential development of Area 8 from east to west.	Apply Residential zoning.	Medium
	Residential development in Area 1 from east to west.	Apply Residential zoning.	Medium
3	Residential development in Area 3 from north-east to south-west.	Apply Residential zoning.	Low
4	Residential development in Area 4 from east to west.	Apply Residential zoning.	Low
5	Continued residential subdivision in Area 6 from north-east to south -west.	Formalise recent and future developments in Area 6 in the form of zoning in order to achieve coherent and consistent outcomes, particularly relative to infrastructure.	High

ABOVE FIG. 3-9: Preferred staging of residential development and prioritisation of required planning-related actions

3.6 Staging and prioritisation of employment land development

Figure 3-10 indicates the preferred staging of employment land development combined with a prioritisation of key planning-related implementation actions.

STAGING OF EMPLOYMENT LAND DEVELOPMENT

Key considerations pertaining to the preferred staging of employment land development include the following:

- → The landowners of Area 12 seem to be willing to commence development.
- → Area 12 is furthest away from any existing sewer and water reticulation and would therefore be expensive to service for sewerage if it were developed ahead of Area 11. Recognising the additional cost of a long run of unused sewer before it gets to Area 12, this area should be given priority given its proximity to the existing aviation activities and willing landowners.
- → The land of Area 11 is available for urban development. Landowners have indicated aspirations to develop the southern half of the property for employment activities. Landowner consultation on the recommendations made in this report has yet to take place.
- → Development of Area 11 could take place simultaneously with, and independently of, Area 12.
- → Area 14 is Crown owned and part of the Treaty settlement process. It is unknown whether this land is readily available for urban development. Landowner consultation on the recommendations made in this report has yet to take place.
- → If development of Area 14 were to go ahead, it could take place simultaneously with, and independently of, other proposed areas.

Due to differing landowners' aspirations and many other factors, development exactly according to these steps cannot realistically be expected. However this preferred staging influences the actions to be taken to implement the strategy.

PRIORITISATION OF ACTIONS

Key planning actions could be divided in *High*, *Medium* and *Low* priority actions:

- → Identified as *High* priority actions are those that enable the development of areas positioned early in the staging. Additionally, urgent informal consultation with the landowners of Areas 11 and 14 should take place.
- → Identified as *Medium* priority action is the proposed Industrial zoning of Area 11, following informal consultation.
- → Identified as *Low* priority action is the proposed Industrial zoning of Area 14, following informal consultation.

Preferred staging		Key action required	Priority
1	Employment land development in Area 12 from south to north.	Apply zoning to allow for commercial activity.	High
2	Employment land development in Area 11.	Engage in consultation with the landowner.	High
		Apply zoning to allow for commercial activity.	Medium
3	Employment land development in Area 14.	Engage in consultation with the landowner.	High
		Apply zoning to allow for commercial activity.	Low

ABOVE FIG. 3-10: Preferred staging of employment land development and prioritisation of required planning-related actions

4. RESIDENTIAL GROWTH AREAS

4.1 Residential Area 1

OPPORTUNITIES FOR AREA 1

Technical analysis has indicated the following key opportunities associated with residential development in this area:

- → The area is located within reasonable proximity to schools, kindergarten and shopping.
- → One or more public open spaces would provide linkage in the public open space network.
- → Urban development of the area has already commenced to some extent and some landowners have indicated support for further development.
- → There are no flooding issues in this area.
- → The area is bounded by public roads on three sides.
- → Extending water and waste water infrastructure to the area would be possible, but would preferably follow after development of Blenheim-N.
- → There are no groundwater quality issues.

CHALLENGES FOR AREA 1

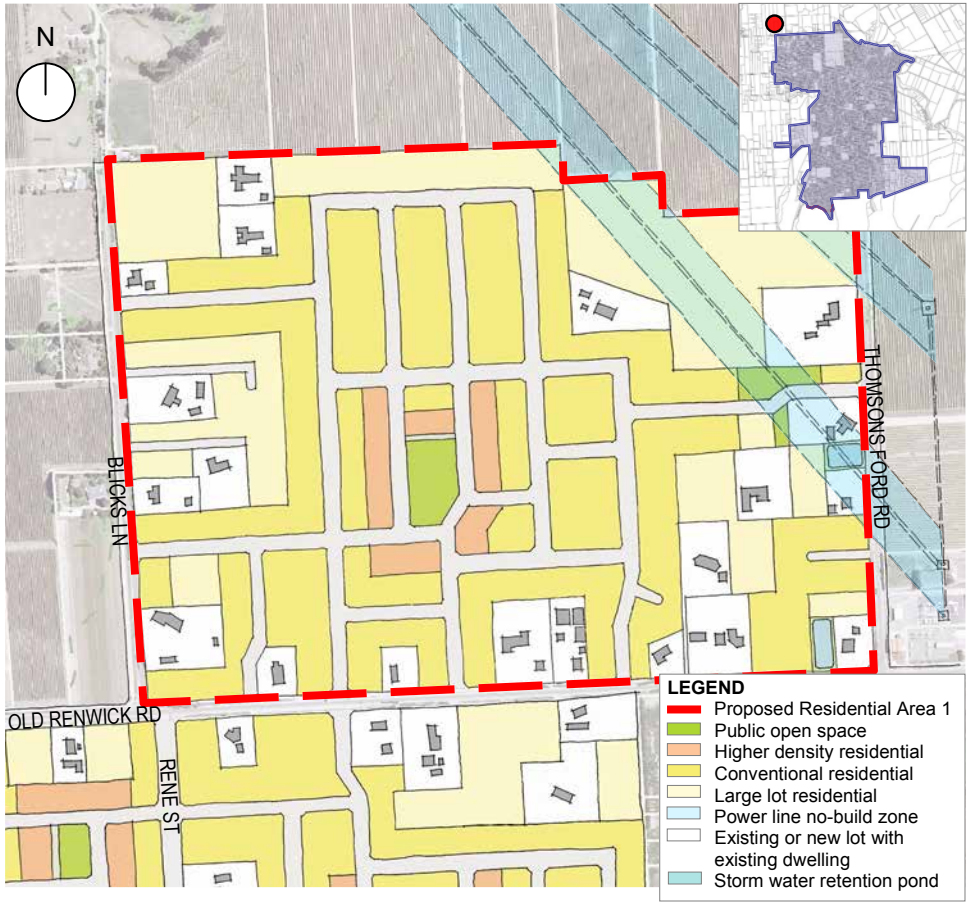
Technical analysis has indicated the following key challenges associated with urban development in this area:

- → The probability of liquefaction risk is thought to be low (particularly in western parts), but is to be tested.
- → Access to schools would require crossing Old Renwick Road.
- → The area is already subdivided and consists of multiple land ownerships.
- → The area contains several existing dwellings and businesses that may not be compatible with conventional residential activities in close proximity.
- → The area is adjacent to rural activities, leading to reverse sensitivity concerns.
- → Transmission power lines inhibit intensive development in the north-eastern corner of the site.
- → Storm water infrastructure encounters similar issues as in Blenheim-N and measures are slightly more costly than in Blenheim-N.
- → A high number of heavy vehicles use Old Renwick Road.
- → Development will lead to an increase in traffic at Murphys and Middle Renwick Roads.
- → Development would necessitate a reduction of the speed limit and therefore the efficiency of Old Renwick Road, which may create capacity problems at SH1.

PERFORMANCE CRITERIA FOR AREA 1

Figure 4-1 illustrates a possible development layout for this area. The following performance criteria could be derived from this illustrative concept in order to capitalise on opportunities and respond to challenges associated with development of the area:

- → Allowance should be made for the retention of the transmission power lines in the north-eastern corner of the site. This could be done by positioning streets, open space, and / or large lots with no-build zones within the 64m wide corridor.
- → Street connections to Blicks Lane (2), Thomsons Ford Road (1) and Old Renwick Road (4) should be established.
- → The layout should be suitable for a future bus service through the area.
- → Existing dwellings could be integrated within the development layout.
- → Two storm water retention / infiltration ponds are likely to be required on the eastern edge of the area, adjacent to existing drains.



ABOVE FIG. 4-1: Illustrative concept for proposed Residential Area 1, used to identify the likely lot yield of the area (not to scale).

- → Lots located immediately on Old Renwick Road should be accessed from side streets where possible.
- → Although development coordinated between properties is preferred, most properties could be developed independently.
- → A buffer in the form of landscaping or larger lots with building setbacks on the interface between urban and rural should be established.
- → One or more public open spaces should be provided within the area.
- → A design test has identified that the yield for the developable portion of Area 1 (43.7ha) could be approximately 370 dwellings.

4.2 Residential Area 3

OPPORTUNITIES FOR AREA 3

Technical analysis has indicated the following key opportunities associated with residential development in this area:

- → The area is located within reasonable proximity to schools, kindergarten and shopping.
- → Nearby public open spaces and educational facilities could be made accessible via local connections.
- → The area is bounded by Old Renwick Road, and Rene Street bisects the area.
- → There are no flooding issues in this area.
- → Extending water and waste water infrastructure to the area would be possible, but would preferably follow after development of Blenheim-N.
- → There are no groundwater quality issues.

CHALLENGES FOR AREA 3

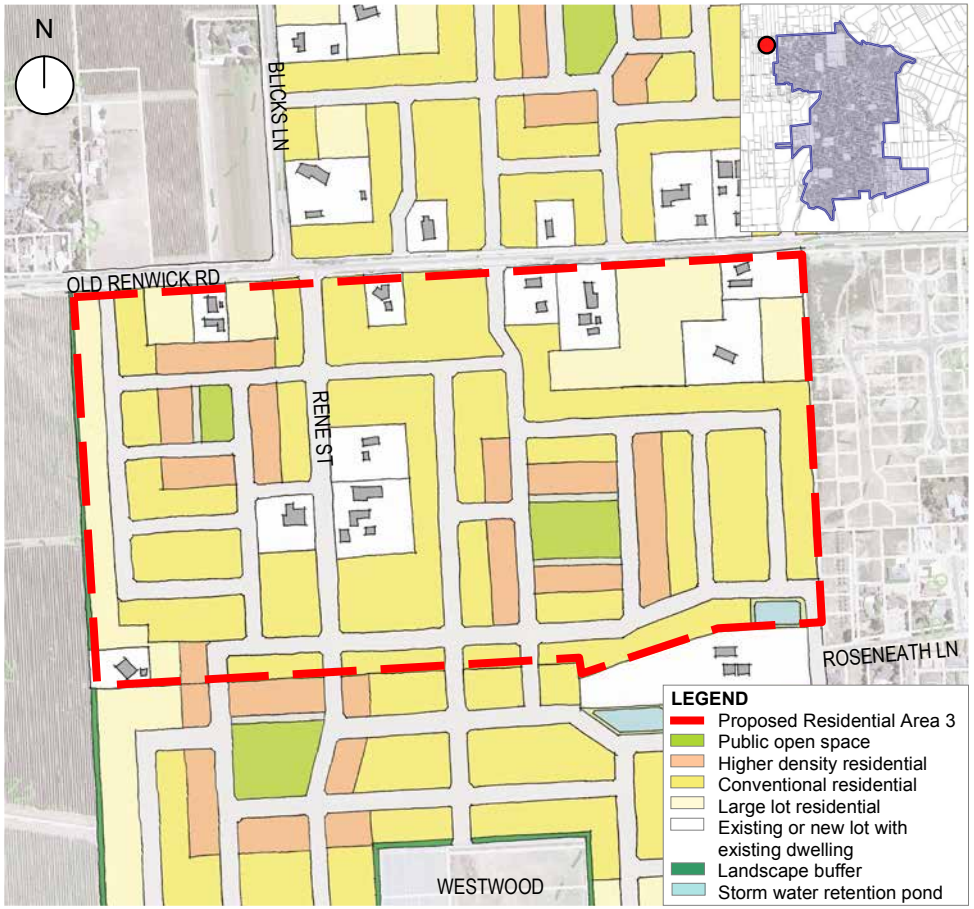
Technical analysis has indicated the following key challenges associated with urban development in this area:

- → The probability of liquefaction is un-quantified and is to be tested.
- → The area contains several existing dwellings and businesses that may not be compatible with conventional residential activities in close proximity.
- → The area is adjacent to rural activities, leading to reverse sensitivity concerns.
- → The neighbouring Westwood site may cause adverse effects.
- → Without crucial local connections, access to and from the area would fully rely on Old Renwick Road.
- → A high number of heavy vehicles use Old Renwick Road.
- → Development will lead to an increase in traffic at Murphys and Middle Renwick Roads.
- → Development would necessitate a reduction of the speed limit and therefore the efficiency of Old Renwick Road, which may create capacity problems at SH1.

PERFORMANCE CRITERIA FOR AREA 3

Figure 4-2 illustrates a possible development layout for this area. The following performance criteria could be derived from this illustrative concept in order to capitalise on opportunities and respond to challenges associated with development of the area:

- → Street connections to Old Renwick Road (2), Rene Street (3 to the west; 2 to the east), Roseneath Lane (1, possibly pedestrian-only), and proposed Growth Area 4 (4) should be established.
- → The layout should be suitable for a future bus service through the area.
- → Lots located immediately on Old Renwick Road should be accessed from side streets where possible.
- → Existing dwellings could be integrated within the development layout. The rural-residential properties in the northwest of the area should be surrounded by larger lots.
- → Although development coordinated between properties is preferred, most properties could be developed independently.
- → A buffer in the form of landscaping or larger lots with building setbacks on the interface between urban and rural should be established.



ABOVE FIG. 4-2: Illustrative concept for proposed Residential Area 3, used to identify the likely lot yield of the area (not to scale).

- → A storm water retention / infiltration pond is likely to be required on the eastern edge of the area, adjacent to existing drains.
- → One or more public open spaces should be provided. There is a particular need for playgrounds within the area.
- → A design test has identified that the yield for the developable portion of Area 3 (31.6ha) could be approximately 355 dwellings.

4.3 Residential Area 4

OPPORTUNITIES FOR AREA 4

Technical analysis has indicated the following key opportunities associated with residential development in this area:

- → The area is located within reasonable proximity to schools, kindergarten and shopping.
- → There are only a limited number of property owners in the area and all seem willing to develop.
- → The newly formed Westwood Road could function as one of the connections into the area.
- → There are no flooding issues in this area.
- → Storm water storage with soakage to the ground may be feasible.
- → Extending water supply and waste water infrastructure to the area would be possible, but should follow after development of proposed Areas 3 and 5.

CHALLENGES FOR AREA 4

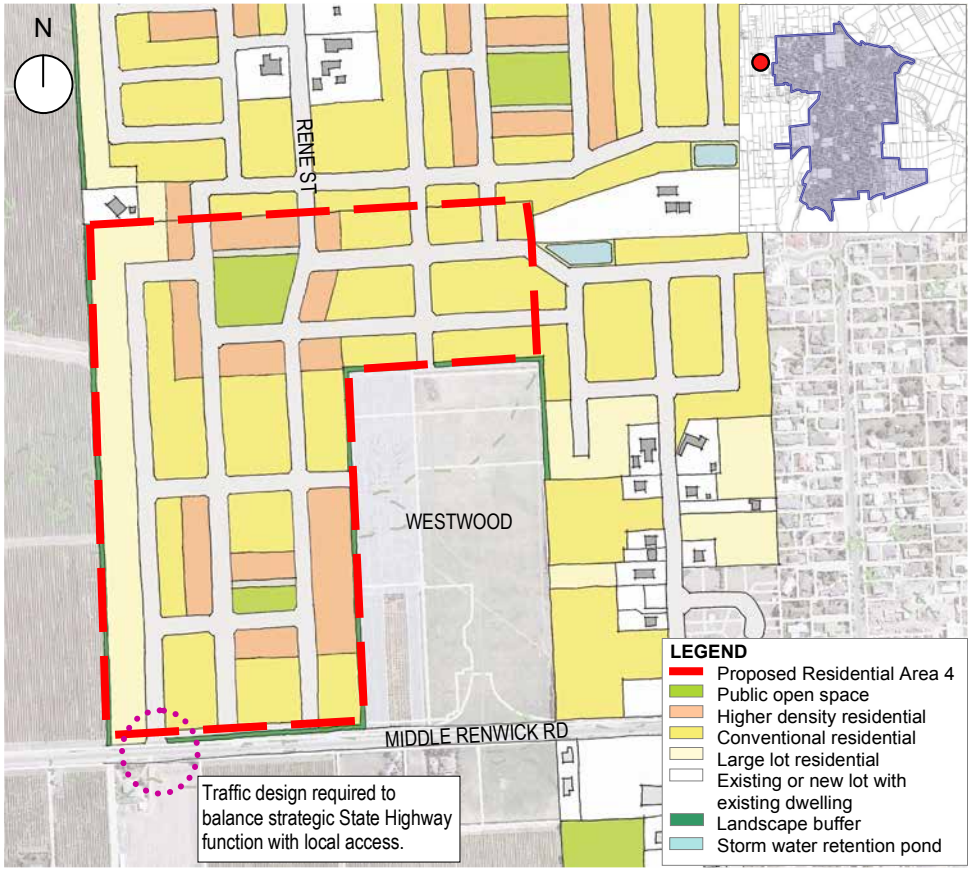
Technical analysis has indicated the following key challenges associated with urban development in this area:

- → The probability of liquefaction is un-quantified and is to be tested.
- → The area is adjacent to rural activities, leading to reverse sensitivity concerns.
- → The existing industrial activities in the area need to be relocated and may cause reverse effects before relocation.
- → The activities on the Westwood site may cause adverse effects for residential activities on the site.
- → Westwood functions as a barrier for local traffic and pedestrians to access nearby areas, without using SH6. Without crucial local connections, access to and from the area would fully rely on SH6.
- → SH 6 may generate traffic noise.
- → Storm water solutions for this area may not be easy.
- → Ground water in the area is important as a source for public water supply. It will be necessary to have controls in place to limit the impacts to the groundwater network during development.

PERFORMANCE CRITERIA FOR AREA 4

Figure 4-3 illustrates a possible development layout for this area. The following performance criteria could be derived from this illustrative concept in order to capitalise on opportunities and respond to challenges associated with development of the area:

- → Development would need to comply with groundwater protection requirements.
- → Street connections to Middle Renwick Road (1), Rene Street (1, through proposed Growth Area 3), proposed Growth Area 3 (3) should be established. If these connections cannot be established this site will become a very isolated large 'cul-de-sac' off SH6.
- → Careful traffic design is required for the proposed street connection with Middle Renwick Road in order to achieve the appropriate balance between access to the area and the strategic function of the State Highway
- → The layout should be suitable for a future bus service through the area.
- → Lots located immediately on Middle Renwick Road should be accessed from side streets where possible.



ABOVE FIG. 4-3: Illustrative concept for proposed Residential Area 4, used to identify the likely lot yield of the area (not to scale).

- → A buffer in the form of landscaping or larger lots with building setbacks on the interface between urban and rural and between residential and the neighbouring Westwood site should be established.
- → A storm water retention / infiltration pond is likely to be required on the eastern edge of the area, adjacent to existing drains.
- → One or more public open spaces should be provided. There is a particular need for playgrounds within the area.
- → A design test has identified that the yield for the developable portion of Area 4 (25.2ha) could be approximately 220 dwellings.

4.4 Residential Area 5

OPPORTUNITIES FOR AREA 5

Technical analysis has indicated the following key opportunities associated with residential development in this area:

- → The area is located within reasonable proximity to schools, kindergarten and shopping.
- → Nearby public open spaces and educational facilities could be made accessible via local connections.
- → Development in the area is already taking place, despite the rural zoning and most landowners seem willing to develop.
- → Water supply can be facilitated without extensive upgrades.
- → The wastewater infrastructure for this area would be available.
- → Provision of storm water solutions for this part of northwest Blenheim have been thoroughly investigated. A major pipeline to discharge SW further down Murphys Creek has been constructed and no problem is envisaged for connecting pipelines.
- → There are no flooding issues in this area.

CHALLENGES FOR AREA 5

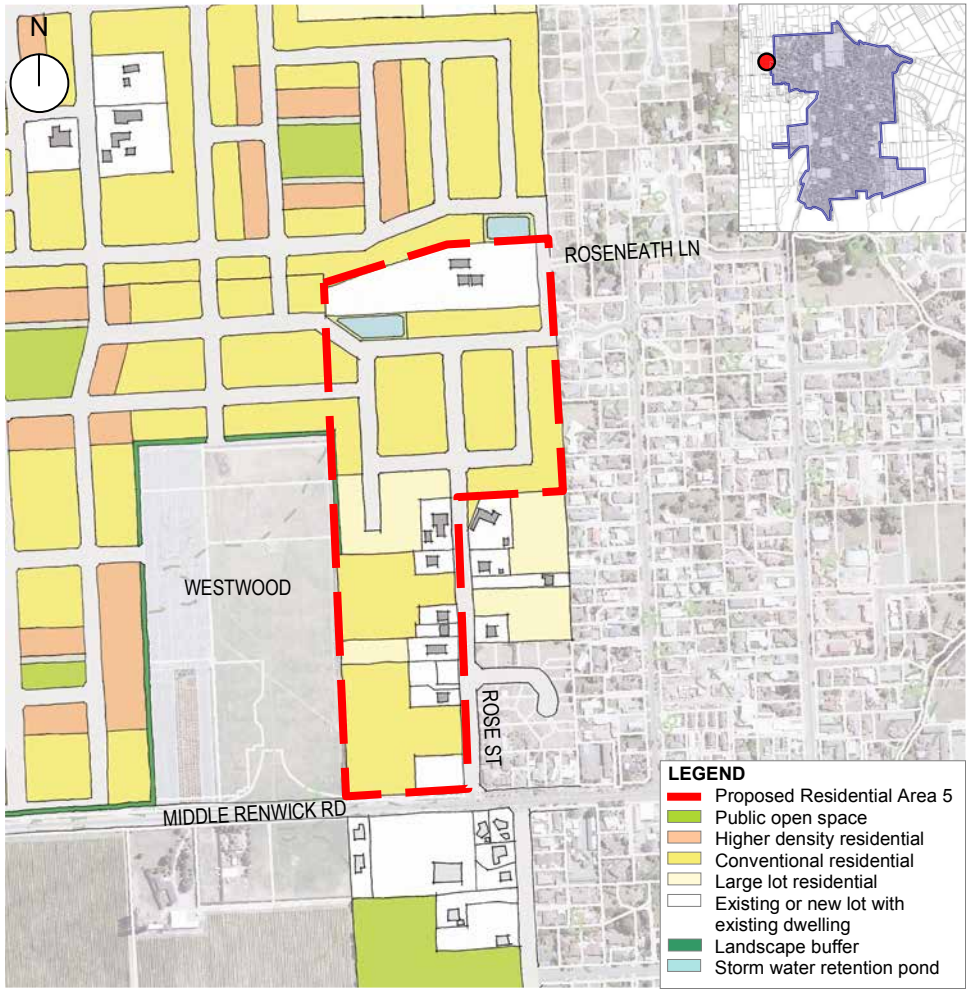
Technical analysis has indicated the following key challenges associated with urban development in this area:

- → The probability of liquefaction is thought to be low, but is to be tested.
- → The activities on the Westwood site may cause adverse effects for residential activities on the site.
- → Without crucial local connections, access to and from the area would fully rely on SH6.
- → SH 6 may generate traffic noise.
- → Ground water in the area is important as a source for public water supply. It will be necessary to have controls in place to limit the impacts to the groundwater network during development.

PERFORMANCE CRITERIA FOR AREA 5

Figure 4-4 illustrates a possible development layout for this area. The following performance criteria could be derived from this illustrative concept in order to capitalise on opportunities and respond to challenges associated with development of the area:

- → Development would need to comply with groundwater protection requirements.
- → Street connections to Middle Renwick Road (1), Roseneath Lane (1, possibly pedestrian-only), proposed Growth Area 4 (2) should be established. If these connections cannot be established this site will become a very isolated large 'cul-de-sac' off SH6.
- → The layout should be suitable for a future bus service through the area.
- → A buffer in the form of landscaping between residential and the neighbouring Westwood site should be established.
- → A design test has identified that the yield for the developable portion of Area 5 (12ha) could be approximately 95 dwellings.



ABOVE FIG. 4-4: Illustrative concept for proposed Residential Area 5, used to identify the likely lot yield of the area (not to scale).

4.5 Residential Area 6

OPPORTUNITIES FOR AREA 6

Technical analysis has indicated the following key opportunities associated with residential development in this area:

- → The area is located within reasonable proximity to schools, kindergarten and shopping.
- → There are several local recreational opportunities, including Sheps Park.
- → Zoning would acknowledge the status quo and the unavoidable further development of the area, and would provide an opportunity to take greater control of integrated infrastructure solutions.
- → Development in the area is already taking place and many landowners seem willing to develop.
- → The need for a storm water pump station is unlikely.
- → Water supply can be facilitated without extensive upgrades.
- → The wastewater infrastructure for this area is already accounted for. A grinder pump system is required, due to the high water table.
- → The two properties immediately to the south of the Yelverton Stream (the southern boundary of Area 6) should be investigated for their potential to be subdivided in very large lots, with a key benefit for the Council would be the acquisition of an esplanade reserve along Yelverton Stream for maintenance purposes.

CHALLENGES FOR AREA 6

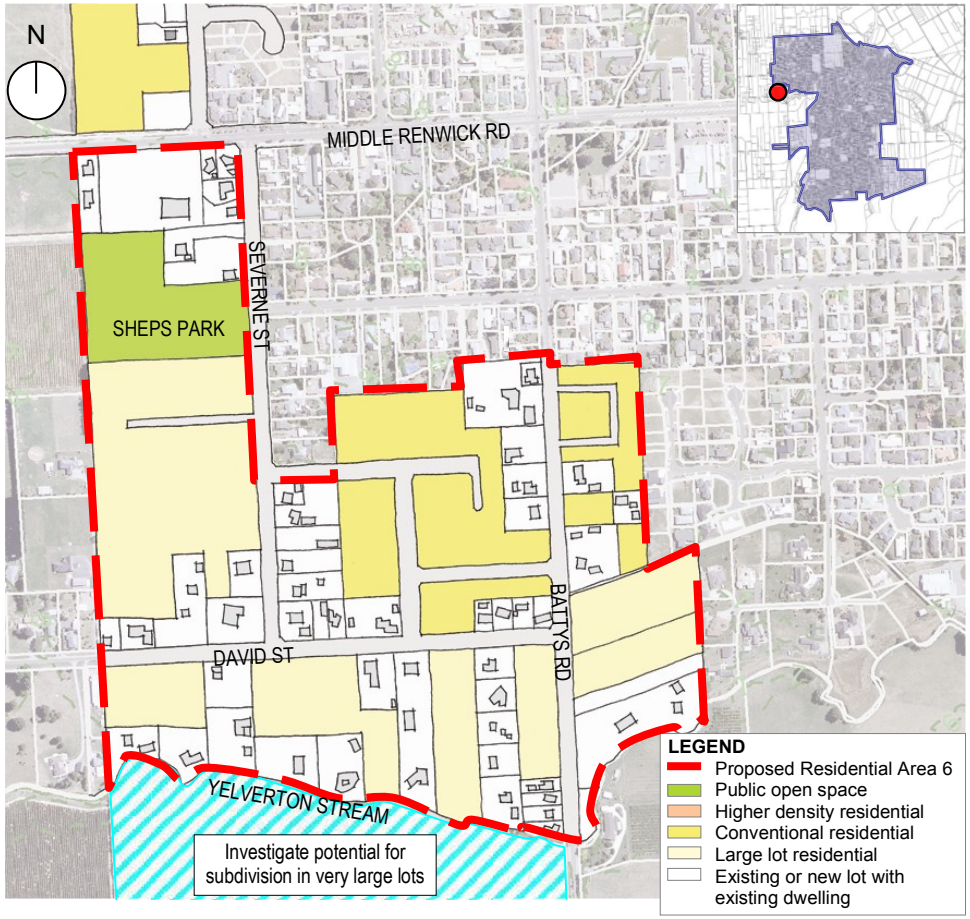
Technical analysis has indicated the following key challenges associated with urban development in this area:

- → The probability of liquefaction is variable and is to be tested.
- → Crossing of the State Highway is required to access schools.
- → There are multiple landowners and many already developed properties, likely resulting in an even more fragmented and potentially incoherent outcome.
- → The upgrade of David Street, and particularly the bridge on this street, is required.
- → The area is prone to flood hazard.
- → The upgrade of the Old Fairhall / Yelverton channel and of the Yelverton to Doctors Creek channel is required.
- → Ground water in the area is important as a source for public water supply. It will be necessary to have controls in place to limit the impacts to the groundwater network during development.

PERFORMANCE CRITERIA FOR AREA 6

Figure 4-5 illustrates a possible development layout for this area. The following performance criteria could be derived from this illustrative concept in order to capitalise on opportunities and respond to challenges associated with development of the area:

- → Development would need to comply with groundwater protection requirements.
- → In response to the existing semi-developed situation the development of larger lots on the southern and western edges of the area are recommended, while there is more scope for conventional residential lot sizes in the eastern part. Larger lots would also form a suitable transition and buffer between residential and rural to the west and south of this area.
- → The conventional density area should incorporate additional street connections to Severne Street, David Street and Battys Road.
- → A design test has identified that the yield for the developable portion of Area 6 (21.7ha) could be approximately 130 dwellings.



ABOVE FIG. 4-5: Illustrative concept for proposed Residential Area 6, used to identify the likely lot yield of the area (not to scale).

4.6 Residential Area 8

OPPORTUNITIES FOR AREA 8

Technical analysis has indicated the following key opportunities associated with residential development in this area:

- → The area exists of a very limited number of properties, all with landowners willing to develop.
- → The site can easily connect to Battys and New Renwick Roads.
- → Increase in traffic on New Renwick and Alabama Roads resulting from development can be accommodated without upgrades.
- → There are no flooding issues in this area and storm water can be easily discharged.
- → Trunk water and wastewater services are available at the boundary of this area.
- → There are no groundwater quality issues.

CHALLENGES FOR AREA 8

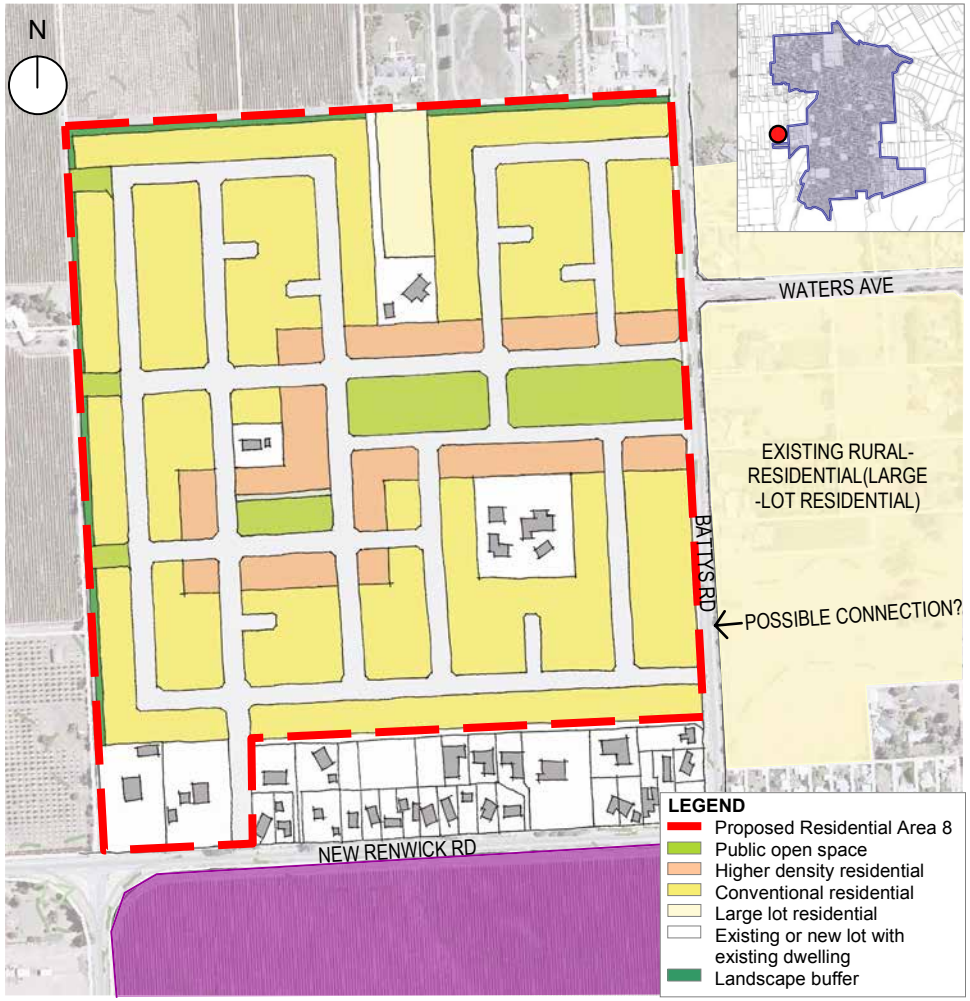
Technical analysis has indicated the following key challenges associated with urban development in this area:

- → The location of the historical swamp land is undefined and requires testing to determine the potential for liquefaction.
- → The area is disconnected from the existing urban area with its commercial, recreational and community facilities. Battys Road forms the most significant barrier.
- → Flight Timbers Sawmill may cause some adverse effects for residential activities in this area.
- → The area is adjacent to rural activities, leading to reverse sensitivity concerns.
- → Upgrade of the Battys - Middle Renwick Road intersection may be required.
- → No feedback has been received from the landowners to the south of Area 8.

PERFORMANCE CRITERIA FOR AREA 8

Figure 4-6 illustrates a possible development layout for this area. The following performance criteria could be derived from this illustrative concept in order to capitalise on opportunities and respond to challenges associated with development of the area:

- → Street connections to Battys Road (4) and New Renwick Road (1) should be established.
- → The layout should be suitable for a future bus service through the area.
- → Opportunities to improve connections through the land to the east of the site (Burleigh Park and beyond, the recreational corridor along the Taylor River) should be explored with the landowners.
- → Generous public open space should be incorporated in order to provide on-site recreational amenities within walking distance from all dwellings.
- → Reservations for future connections to the west should be incorporated.
- → A design test has identified that the yield for the developable portion Area 8 (30.7ha) could be approximately 345 dwellings.



ABOVE FIG. 4-6: Illustrative concept for proposed Residential Area 8, used to identify the likely lot yield of the area (not to scale).

5. EMPLOYMENT GROWTH AREAS

5.1 Employment Area 11

OPPORTUNITIES FOR AREA 11

Technical analysis has indicated the following key opportunities associated with employment land development in this area:

- → The capacity of the area is approximately 21.7ha (refer to **Figure 5-1**).
- → Light-industrial development could take place in conjunction with development of the adjacent Corlett Block (Area 12), for which the owners have a similar type of development in mind, in line with the recommendations of this strategy.
- → A proposal by the owners included a light-industrial development on the southern half of the property.
- → The area could be made accessible for commuter cyclists via the Taylor River corridor.
- → The area is surrounded by formed public roads on three sides.
- → There are no flooding issues in this area and storm water can be easily discharged.
- → There are no groundwater quality issues.

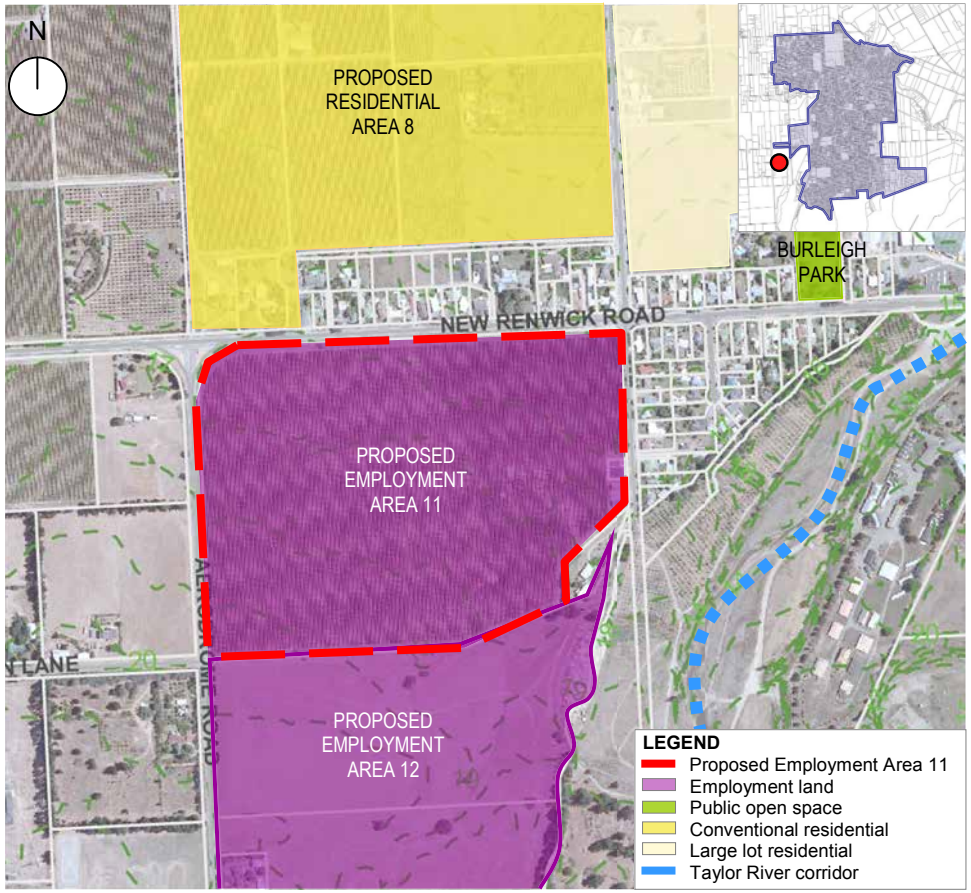
CHALLENGES FOR AREA 11

Technical analysis has indicated the following key challenges associated with urban development in this area:

- → Area 11 has been subject to a request from the owner to change the zoning of the land to enable it to be used for residential purposes. This request was declined by the Council in mid 2012, primarily because of the potential for reverse sensitivity issues associated with the operation of Omaka Airfield (which is located in close proximity to the site). The decision to decline the request has been appealed to the Environment Court and this appeal may be determined following a Court hearing in 2013. It is acknowledged that the decision of the Court has the potential to influence the future use of part or all of the site. However, the appeal process does not detract from the suitability of the site for employment purposes and for this reason it has been included within the strategy.
- → The location of the historical swamp land is undefined and requires testing to determine the potential for liquefaction and the potential for lateral spreading.
- → There are some 'sensitive' land uses located in the area, such as the Omaka Marae and the Omaka Aviation Heritage Centre.
- → The number of access and connection points onto New Renwick Road is limited.
- → The Battys - New Renwick Road intersection would need upgrading.
- → Water supply to the area is limited, especially for fire-fighting capacity.
- → The capacity of the waste water system may limit opportunities for the types of industries generating large amounts of waste water.

PERFORMANCE CRITERIA FOR AREA 11

The following performance criteria apply in order to capitalise on opportunities and respond to challenges associated with development of the area:



ABOVE FIG. 5-1: The location of Employment Area 11, Colonial Vineyard (not to scale).

- → Development should be compatible (including visual impact and other effects) with the current activities in the area that are likely to remain.
- → The development should incorporate walking and cycling connections with the recreational network within the Taylor River corridor.
- → Storm water to be discharged into the Taylor River should be appropriately managed.

5.2 Employment Area 12

OPPORTUNITIES FOR AREA 12

Technical analysis has indicated the following key opportunities associated with employment land development in this area:

- → The capacity of the area is approximately 31.1ha (refer to **Figure 5-2**).
- → The property owners are willing to develop light-industrial and other employment activities compatible with the aviation cluster of Omaka.
- → The area could be made accessible for commuter cyclists via the Taylor River corridor.
- → There are no flooding issues in this area and storm water can be easily discharged.
- → There are no groundwater quality issues.

CHALLENGES FOR AREA 12

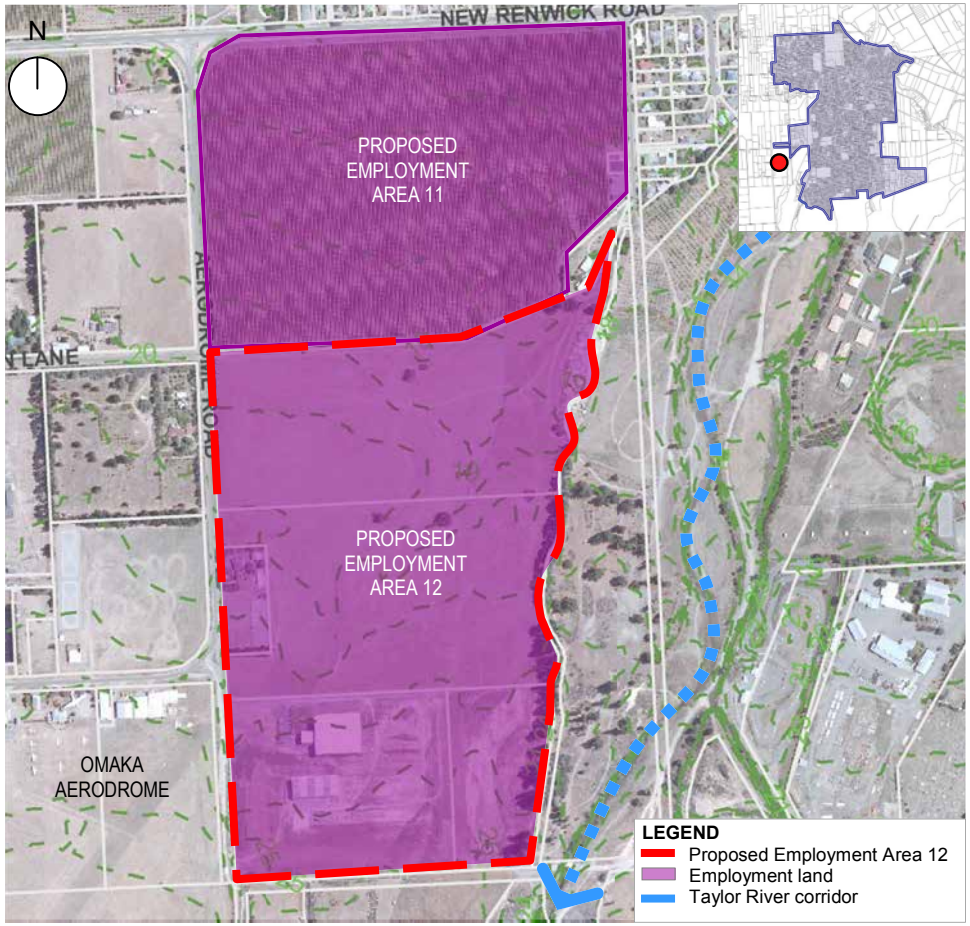
Technical analysis has indicated the following key challenges associated with urban development in this area:

- → The probability of liquefaction is thought to be low, but investigation would be required, including any possible lateral spread.
- → There are some 'sensitive' land uses located in the area, such as the Omaka Marae and the tourist attractions associated with the Omaka Aviation Heritage Centre.
- → The Battys - New Renwick Road intersection would need upgrading.
- → Water supply to the area is limited.
- → The capacity of the waste water system is limited.

PERFORMANCE CRITERIA FOR AREA 12

The following performance criteria apply in order to capitalise on opportunities and respond to challenges associated with development of the area:

- → Development should be compatible (including visual impact and other effects) with the current activities in the area that are likely to remain.
- → The development should incorporate walking and cycling connections with the recreational network within the Taylor River corridor.
- → Storm water to be discharged into the Taylor River should be appropriately managed.



ABOVE FIG. 5-2: The location of Employment Area 12, Corlett Block (not to scale).

5.3 Employment Area 14

OPPORTUNITIES FOR AREA 14

Technical analysis has indicated the following key opportunities associated with employment land development in this area:

- → The capacity of the area is approximately 15.3ha (refer to **Figure 5-3**).
- → It is likely that the land becomes available for development.
- → There is sufficient capacity available in the waste water system for the development of this area.
- → The probability of liquefaction risk is very low. Testing is not required.
- → There are no groundwater quality issues.

CHALLENGES FOR AREA 14

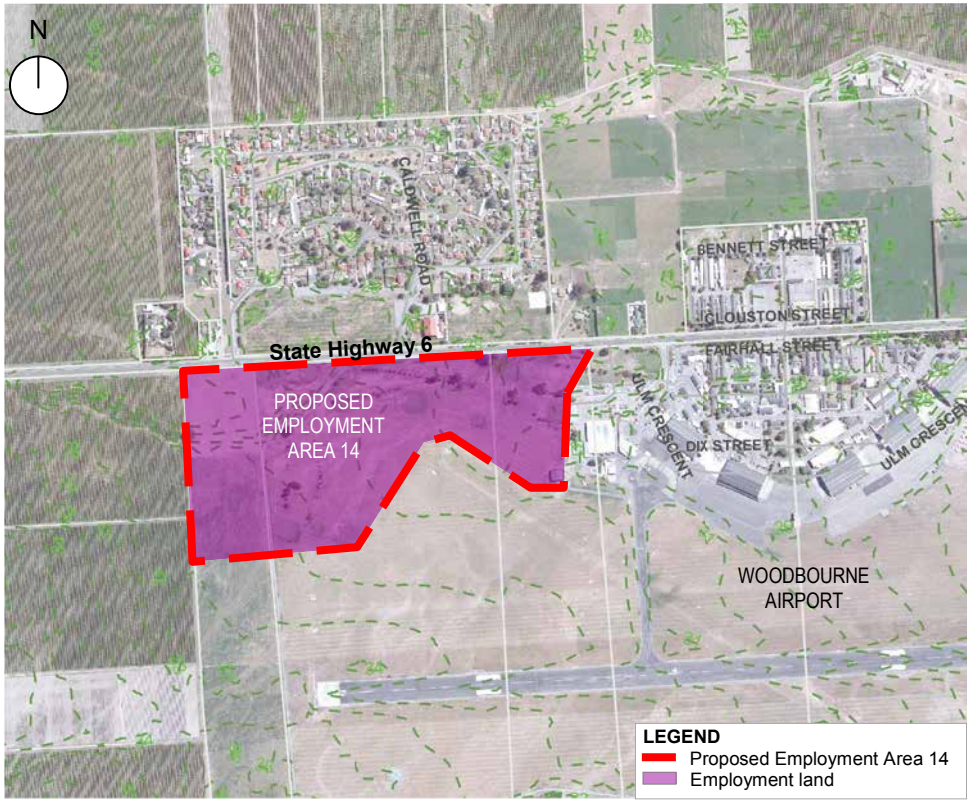
Technical analysis has indicated the following key challenges associated with urban development in this area:

- → The land is crown owned and is part of the Treaty settlement process.
- → An indication of whether development of the land for employment activities is supported has not been received from the landowner.
- → One or more points of access from SH6 will impact on the efficiency of the State Highway.
- → Commuter access would largely be car -based.
- → There are problems relating to storm water infiltration into the local waste water system, either within the network operated and maintained by Base Woodbourne or the trunk main along the State Highway.
- → A new well or a new trunk main is required in order to create sufficient capacity in the water supply to the area.
- → Storm water discharge is not easy, due to the levels of the land. An expensive pump station is required, unless soakage to the ground is a feasible option.

PERFORMANCE CRITERIA FOR AREA 14

The following performance criteria apply in order to capitalise on opportunities and respond to challenges associated with development of the area:

- → The layout should be designed in conjunction with Marlborough Roads in order to manage the possible impacts on the efficiency of SH6.
- → Providing access to the site by alternative means of transport, such as cycling or bus transport should be explored.



ABOVE FIG. 5-3: The location of Employment Area 14 (not to scale).

6. TECHNICAL CONSIDERATIONS

6.1 Community facilities

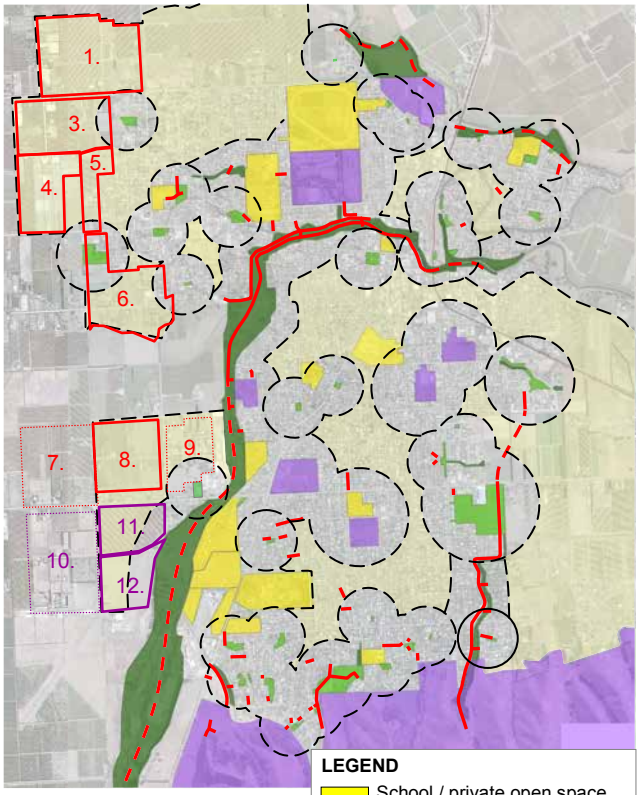
Key considerations pertaining to community and social aspects of the strategy include the following:

- → Analysis of the population growth figures indicates that the strongest growth will take place in the 65+ years category. Growth planning should respond to this notion and the growth areas should cater for this age group.
- → The capacity of social and medical services, such as police, GPs, dentist, hospital etc. is generally sufficient to accommodate Blenheim's projected growth.
- → The production of a coherent Structure Plan should be a requirement for all proposed growth areas in order to ensure optimal community outcomes. This includes design that, among other things, promotes safety, walking, cycling and social interaction, and provides accessible public open space for each site.
- → The layout for each growth area should be designed in such a way that public transport connections within the areas and between the areas and major destinations (the town centre, hospital and employment areas) could be established. The requirement for public transport increases with the distance from the Blenheim Town Centre.
- → Proposed Areas 1, 3, 4, 5, and 6 are located within reasonable proximity to Springlands School, Kindergarten, the Springlands Shopping Centre and services for the elderly. Accessibility of these facilities and services should be improved, and additional facilities are likely required if the proposed growth areas are developed.
- → The capacity of Fairhall School could be insufficient in the case of extensive residential development in the southwest.
- → Woodbourne would be unsuitable to accommodate residential growth due to its isolated location relative to facilities and services.
- → Renwick's facilities are not sufficient to accommodate significantly more residential growth than is projected for the town itself.

6.2 Open space and recreation

Key considerations pertaining to open space and recreational aspects of the strategy include the following:

- → Some of the proposed areas have the potential to fill 'holes' in the public open space network (refer to **Figure 6-1**). Connectivity from existing residential areas is crucial as public open space in the proposed growth area provides for the recreational needs of the surrounding existing community, as well as for the residents of the development area.
- → The areas located in proximity to the Taylor River corridor have an advantage from a recreational point of view.
- → A highly walkable street system should be a key consideration in the design for the growth areas.
- → All proposed residential growth areas need one or more public open spaces; many areas need a playground.
- → Areas 7 and 8 are isolated from recreational activities, as Battys Road and Flight Timbers Sawmill provide barriers to direct access to the Taylor River corridor.
- → The need to cross arterial roads to access public open space should be minimised.



ABOVE FIG. 6-1: Public and private open space assessment, with areas outside a 5 to 10 minute walk of significant open space are indicated in light yellow (adapted drawing from the original strategy).

6.3 Strategic planning issues

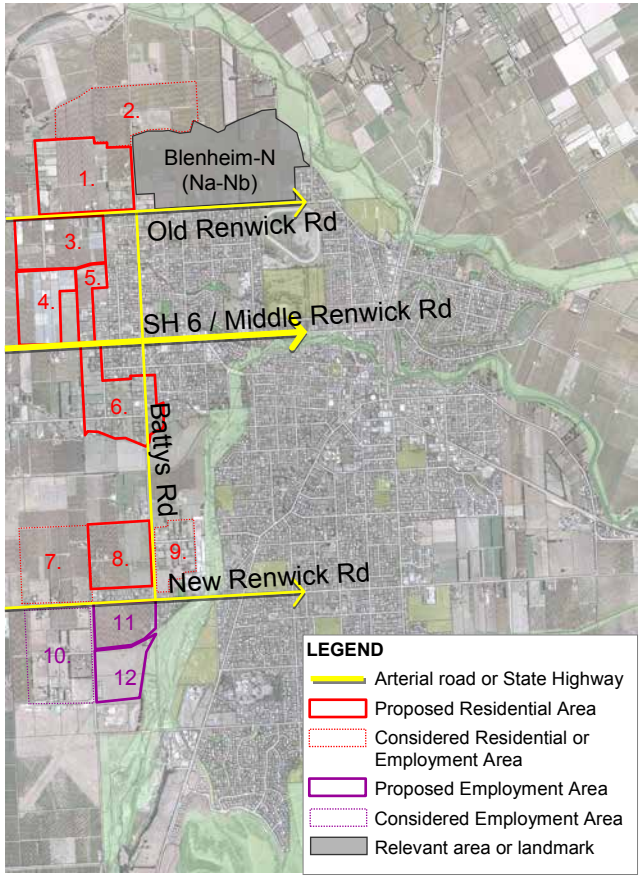
Key considerations pertaining to the Council's planning policy include the following:

- → The land to the west of the town consists of valuable soils for agricultural production. Development in all proposed areas would use land with versatile soils, with the areas north of State Highway 6 being in the most valuable Class 1 area.
- → Residential development in the North-west would benefit from the Springlands Town Centre, which is proposed to be rezoned to mixed-use, and from the Westwood retail facilities. However, Westwood could also result in negative effects for the growth areas in close proximity to it. This could include traffic congestion, noise and odours.
- → Reverse sensitivity issues could arise from development on the edge of the town, where rural production activities are immediately bordering onto proposed residential areas. This interface should be well-managed. The same applies to areas near Flight Timbers Sawmill.
- → There is also the risk of reverse sensitivity related to the interface between existing residential areas and the proposed employment growth areas.
- → Resistance (due to loss of rural outlook) from residents currently located on the edge of the town could be an issue.
- → The transmission lines in the Thomsons Ford Road area should be integrated in the design of the growth areas north of Old Renwick Road. No-build zones of 32m on either side of both lines should be maintained. Relocation of the lines cannot realistically be expected.

6.4 Traffic and transport

Key considerations pertaining to traffic- and transport-related aspects of the strategy include the following:

- → Development of the areas located on Old Renwick Road would impact on the efficiency of the road and, vice versa, the road would impact on the residential amenity of the areas, creating severance and producing traffic noise.
- → The areas located on SH6 (refer to **Figure 6-2**) would be constrained in their access, particularly immediately west of Westwood.
- → The areas located on SH6 would experience traffic noise.
- → Development to the west of Blenheim would necessitate the increase of the capacity of Battys Road intersections on both ends.
- → Opportunities to create connections between the considered growth areas and the existing urban area in addition to arterial roads are limited. Local connections should be established within all proposed growth areas and between all growth areas in order to minimise dependence on arterial roads (refer to **Figure 6-2**) and maximise opportunities for alternative modes of transport.
- → Keeping the town as compact as possible would increase the opportunities for a viable public transport system.



ABOVE FIG. 6-2: Main arterial roads and State Highway 6 interfacing with the proposed and considered growth areas.

6.5 Flooding and storm water

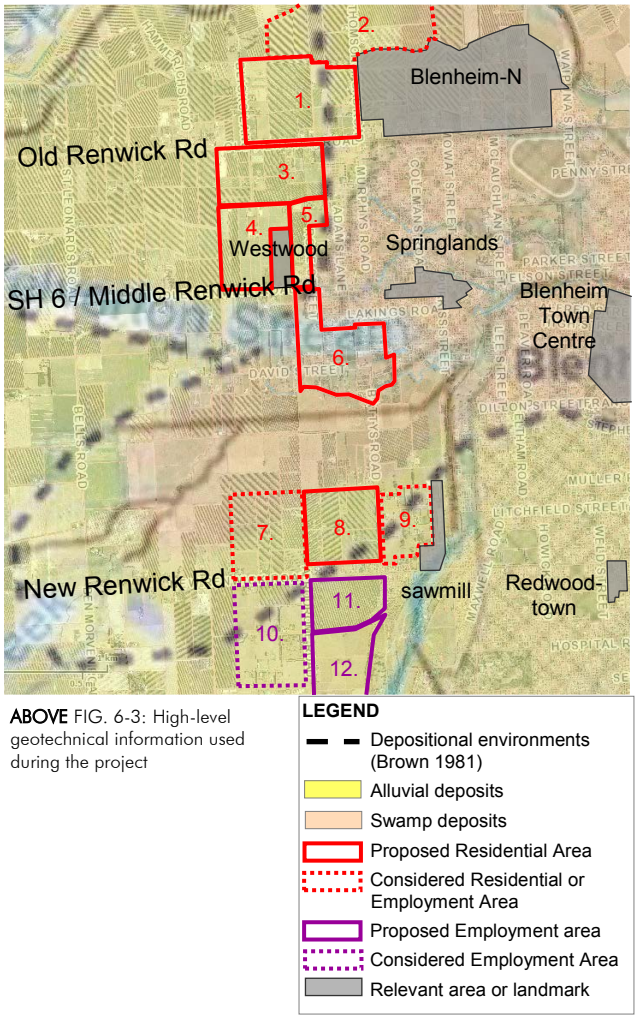
Key considerations pertaining to flooding and storm water aspects of the strategy include the following:

- → Known flooding areas are excluded from consideration. An exception to this is Area 6 (David / Severne Street), where there is some flood hazard.
- → The preferences from a storm water perspective for the proposed areas are mostly a matter of cost differences, based on high-level analysis and assumptions.
- → Most of the considered growth areas require storm water piping and some require one or more pump stations or pump station upgrades.
- → Storm water soakage to the ground or storage becomes more feasible the further west one goes. Detailed investigations are required to confirm this.
- → Several crucial drainage corridors are and will remain located on land in private ownership. It is important to gain some form of control over these.

6.6 Geotechnical issues

Key considerations pertaining to geotechnical aspects of the strategy include the following:

- → Proposed Area 6, and not-proposed Areas 2 and 7 (northern part only) are considered medium liquefaction risk. All other areas are considered lower liquefaction risk, based on high-level information currently available (refer to **Figure 6-3**).
- → All recommended areas north of New Renwick Road will require liquefaction testing.
- → Parts of Growth Area E2 (identified for employment uses in the original growth strategy) might be pursued privately for light industry. This area is considered high liquefaction risk.

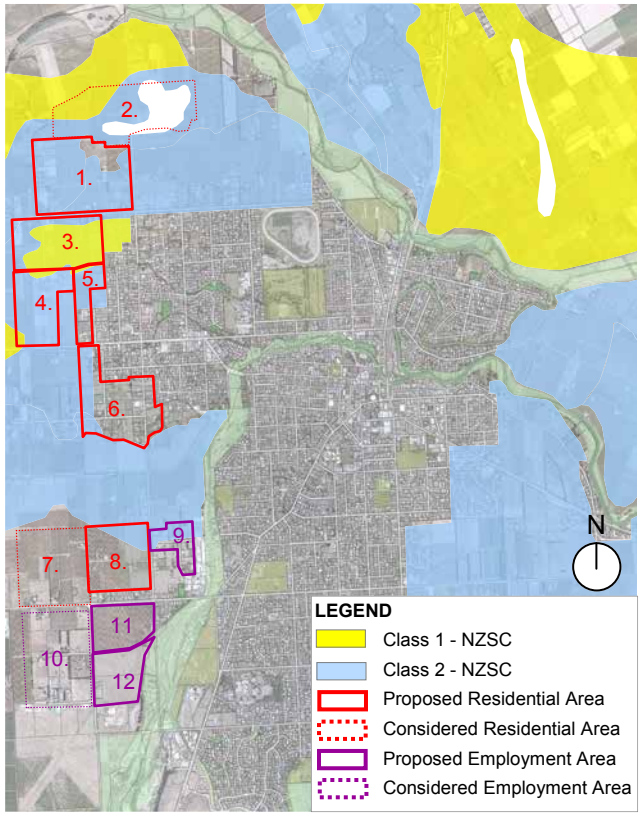


ABOVE FIG. 6-3: High-level geotechnical information used during the project

6.7 Soils

Key considerations pertaining to soils include the following:

- → Blenheim is almost entirely surrounded by outstanding versatile soils with high potential for agricultural production (refer to **Figure 6-4**). Any expansion of Blenheim will encroach on these soils. An exception to this is the South-western area around Burleigh.
- → Potential soil contamination has not been considered as part of the assessment during the project. Soil contamination in any of the proposed growth areas should be investigated prior to development.



ABOVE FIG. 6-4: Soil classification (adapted drawing from original growth strategy)

6.8 Groundwater

Key considerations pertaining to groundwater include the following:

- → Development of proposed areas located in and around Springlands (Areas 3, 4, 5 and 6) should be conditional on Resource Management Plan requirements that are aimed at the protection of the aquifer. These requirements should manage:
  - Effects of urban development on stream flows; and
  - Groundwater contamination.
- → The impact of either residential or employment development on groundwater flows should be further investigated.
- → The impact of possible new wells required for the proposed area located in Woodbourne (Area 14) on the groundwater table should still be investigated.

6.9 Water supply

Key considerations pertaining to water supply include the following:

- → Contiguous and sequential development (working from the town outward) would be preferred.
- → Areas 1 and 3 should follow after Na-Nb, Areas 4, 5, 6 and 8 can be accommodated more readily.
- → The quality of the Springlands groundwater should be maintained by an Aquifer Protection Zone in the Resource Management Plan. Impacts on the groundwater have the potential to affect the Wairau Aquifer as it contributes to and is a major source for Blenheim's water supply.
- → Upgrades to water mains are required for all considered growth areas.
- → The capacity of water supply for fire fighting purposes in proposed employment areas has to be increased to meet current fire fighting regulations.
- → Additional water supply required for urban development at Woodbourne would possibly necessitate new wells or main extensions.

6.10 Wastewater infrastructure

Key considerations pertaining to wastewater infrastructure include the following:

- → Wastewater reticulation is available to serve the proposed Blenheim growth areas. However, upgrades to the existing infrastructure will be required to manage the increased flows. The extent of the future upgrades will depend on a number of inter-related factors, e.g. the growth in wastewater flows, management of inflow and infiltration of storm water into the wastewater network, future regulatory conditions, etc. Hydraulic modelling is being undertaken to maximise the currently available capacity and assist in the development of efficient solutions to meet the requirements in future circumstances.
- → Areas 2, 7, 10, 13 and14 have not been included in the modelling calculations.
- → Development of all growth pockets will require on-site reticulation and extension of mains to connect to the existing network.
- → A high groundwater table can lead to infiltration to the wastewater infrastructure. A system based on grinder pumps is required in Area 6 and possibly other specific locations. Grinder pump units maybe required for areas of low density (rural-residential) housing to facilitate the connection of long service lines.

Appendix 4

Marlborough District Council

Blenheim Urban Growth Study Stage 2

Geotechnical Evaluation

Interpretive Report

Marlborough District Council

Blenheim Urban Growth Study

Stage 2

Geotechnical Evaluation

Interpretive Report

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Contents

1 Introduction

Marlborough District Council is developing a strategy for the urban growth and development of Blenheim. The Council has identified a number of potential urban growth areas that lie on the periphery of the city. Opus International Consultants Ltd (Opus) has been commissioned by the Council to carry out a geotechnical evaluation of the proposed growth areas.

Geotechnical investigations and assessment of proposed growth areas to the north, east and southeast of the city were previously carried out in early 2012 (Opus, 2011; 2012a). The investigations showed the areas to the east and southeast are underlain by significant thicknesses (> 15 m) of loose materials which are susceptible to liquefaction. Consequently, these areas would be prone to damage in earthquakes or alternatively require considerable cost and resources to develop with appropriate mitigation measures.

The geotechnical appraisal of the ground conditions and suitability of the land for development recommended that land which is more stable to earthquake hazards be developed (Opus, 2012b). The Council therefore identified 6 new areas to the northwest, west and southwest of the city for possible urban growth, and engaged Opus to carry out investigations in the new areas to assess the geotechnical issues there, particularly relating to the hazard posed by liquefaction. The site investigations were carried out during September to December 2012 (Opus, 2013).

This report presents a characterisation of the ground conditions and geotechnical hazards in the proposed new urban growth areas, and makes recommendations for land use planning taking into account the earthquake hazards.

2 Site Description

The proposed urban growth areas are located on the outskirts of Blenheim's urban area, to the north (area Na:Nb), northwest (areas 1, 3 to 6) and southwest (area 8). The locations of the growth areas are shown on Figure 1. The sites are situated on predominantly flat to gently undulating alluvial plains, and the land is predominantly under agricultural use with some rural-residential developments. Several streams and drains cross the sites, flowing from west to east.

The NZMS 260 map grid reference of the area under investigation is BR28 775 050.

3 Geological Setting

3.1 Geology

The geology of the Marlborough Area has been mapped at 1:25,000 scale by the New Zealand Geological Survey (NZGS, 1981) and at 1:250,000 scale by the Institute of Geological and Nuclear Sciences (IGNS, 2000).

The mapping shows the Blenheim area to be underlain by Holocene age marine/estuarine silts and sands of the Dillons Point Formation and alluvial gravels and sands of the Rapaura Formation (see Figure 2). Southern Fan Deposits were deposited by the Taylor River to the southwest of Blenheim, contemporaneous with deposition of Rapaura Formation gravels in the Wairau Valley.

These strata are underlain by older, clay-bound alluvial gravels of the Speargrass Formation (NZGS, 1981; Landcare Research, 1995; MCRWB, 1987; Davidson and Wilson, 2011).

3.2 Active Faults

The plate boundary between the Pacific and Australian plates passes through Marlborough, and consequently this region is an area of high seismicity. Relative plate motion between the tectonic plates is accommodated across a zone of active strike slip faults (the Marlborough Fault System), which links the Alpine fault transform plate boundary to the south with the westward-directed Hikurangi subduction margin to the north. The Marlborough Fault System comprises four principal strike-slip faults and a number of smaller faults. Those within 15 km of the site are summarised in Table 1 and discussed below.

Table 1 Active fault summary table

Fault	Characteristic Event Magnitude	Recurrence Interval (years)	Distance from site (km)	Direction
Wairau Fault	7.1 – 7.6	1,150 – 1,400	0.4	Northwest
Vernon Fault	?	3,000 – 4,000	8	Southeast
Awatere Fault	7.5	820 – 950	14	Southeast

Source: Benson et al. (2001); Clark et al. (2011); Geotech Consulting Ltd (2003a, 2003b, 2005); Mason et al. (2006a, 2006b); Zachariasen et al. (2006).

The Wairau Fault is the closest principal active fault to the site, lying approximately 400 m northwest of Area 1. The fault is capable of rupturing in earthquakes of characteristic magnitude 7.1 to 7.6, and horizontal surface displacements of 5 to 7 m with an average return period of 1150 to 1400 years (Geotech Consulting, 2003a, 2003b, 2005; Zachariasen *et al.*, 2006).

Two secondary faults (the Tempello and Fairhall faults) have been inferred from stratigraphic cross-cutting relationships between boreholes in south western Blenheim (Davidson and Wilson, 2011). The activity of these faults is not well defined, as they do not form obvious traces on the ground surface. The Fairhall Fault is indicated to lie within approximately 100 m of the northwestern corner of Area 8 (see Figure 2). This fault appears to displace the base of the Winterholme Formation, which suggests possible activity in the last 75,000 to 130,000 years. The Tempello Fault lies approximately 1.5 km to the south of Area 8. This fault appears to displace the base of Speargrass Formation strata, which suggests possible activity in the last 13,000 years.

As the Tempello and Fairhall faults do not have well defined traces it is likely that they have not ruptured in the last ~9000 years and 75,000 years, respectively (i.e. since the formation of the Dillon's Point and Winterholme formations). These faults are not recorded on GNS' Active Faults Database and given the long duration since the most recent activity the hazard posed by these features is likely to be very low to low. However, no detailed studies of the location, rates and magnitude of displacement of these faults have been carried out, and therefore the hazard posed by these faults cannot be quantified without further investigation.

4 Ground Conditions

4.1 Site Investigations

Geotechnical site investigations have been carried out across the study area to provide information to better characterise the ground conditions and assess the geotechnical issues, particularly relating to the hazard posed by liquefaction. The investigations were scoped and carried out in accordance with the guidelines provided by the former Department of Building and Housing (now the Ministry of Business, Innovation and Employment) for geotechnical investigations of land in Canterbury (MBIE, 2012).

The investigations were carried out between October and December 2012, and comprised the following:

- Twenty seven boreholes, to depths of 10 m to 20 m, with in situ Standard Penetration Tests carried out at 1 m depth intervals.
- Twenty five static Piezo-Cone Penetration Tests (CPTu), to depths of between 1 m and 7.44 m, with further penetration retarded by dense gravels.
- Laboratory testing of samples recovered from the boreholes.

The results of the investigations are provided in the site investigation report (Opus, 2013).

4.2 Ground Conditions

The area under investigation is located on flat to gently undulating terrace surfaces, which are underlain by young (Holocene and late Pleistocene age) interbedded alluvial and swamp deposits. Information on the ground conditions in the Blenheim area is provided by the 2013 site investigations (Opus, 2013) and factual information available from previous investigations in the wider Blenheim area (Geotech Consulting, 2004; Nelson Consulting Engineers, 2007; CH2M Beca, 2008; Opus, 2012a; MDC borehole database).

These investigations show the surficial soil layers in the local area to consist of interbedded gravels, sands and silts of the Rapaura and shallow Speargrass formations, which interfinger with estuarine silts and sands of the Dillons Point Formation to the east of the study area.

The Rapaura Formation deposits consist of loose sands and soft clayey silts underlain by dense to very dense alluvial gravels, with a sandy matrix and some interbedded sand layers.

Speargrass Formation deposits have been mapped to the southwest of Blenheim, and were encountered in the exploratory holes at Area 8. These strata consist of loose sands and soft silty clays overlying dense to very dense clayey gravels and hard silts and clays.

A summary of the soils encountered is provided below in Table 2.

Table 2 Generalised soil profiles at the growth areas

Growth Areas	Depth Range	Lithology
Na:Nb	0 – 4 m	Very loose to medium dense sand, silty sand and silt, and firm to hard sandy clay
	1 – 5 m	Medium dense to very dense silty sand and sandy gravel
	5 m +	Medium dense to very dense sandy gravel and gravelly sand with occasional silt and sand layers
1 – 4	0 – 4 m	Soft to hard silt, clayey silt, and sandy silt
	1 – 6 m	Loose to very dense silty sand and sandy gravel
	4 m +	Dense to very dense sandy gravel and gravelly sand
5, 6 and 8	0 – 10 m	Very soft to hard silt, clayey silt and silty clay
	1 – 8 m	Medium dense to very dense sandy silt, silty sand and sandy gravel
	10 m +	Dense to very dense sandy gravel, clayey gravel and gravelly sand

4.3 Groundwater Conditions

The groundwater levels recorded during the site investigations ranged from 1 m to 3 m depth below ground level in Areas 1 to 6 and Na:Nb, and 2 m to 7.1 m depth in Area 8. This is consistent with longer term static groundwater levels recorded in the wider Blenheim area, which show that the groundwater table lies approximately 2 m to 5 m below ground level in the development areas (Davidson and Wilson, 2011).

5 Geotechnical Hazards

5.1 Consolidation Settlement

Compressible soft clays and silts can consolidate over time if subjected to loads such as that from a building. Consolidation of founding soils can lead to settlement of the building and consequently damage to the structure. Investigations showed the upper 2 to 4 m of soil in all areas contained clay or silt. In particular, Areas 6 and 8 have significant thicknesses (< 10 m) of potentially compressible soils which could pose a hazard to future development, as special measures may be required such as preloading of the site or deep foundations.

5.2 Slope Failure

The slope failure hazard at the site is very low due to the flat, low-lying topography of the land. Areas in close proximity to river banks will be susceptible to slumping or erosion in flood events or lateral spreading of the banks as a possible consequence of earthquake-induced liquefaction. The issues related to liquefaction hazard at the site are described in Section 5.5.

5.3 Fault Rupture

The closest active fault to the study areas is the Wairau Fault. This fault has a distinct trace over much of its length, except for the lower Wairau Valley where the trace is intermittent and subdued. The fault is inferred from available geological evidence to lie approximately 300 m to 400 m from Area 1 at its closest point (Geotech Consulting, 2003a; IGNS, 2000). Rupture of this fault is expected to result in 3.4 m to 7 m of lateral displacement of the ground surface at the fault trace (Geotech Consulting Ltd, 2003b, 2005; Zachariasen *et al.*, 2006).

The proximity of the fault to Area 1 and the uncertainty of the fault's position suggests fault rupture could pose a hazard to this development area. The land use planning issues from permanent ground damage associated with fault rupture are discussed in Section 6.4.

5.4 Ground Shaking

Blenheim's principal earthquake hazard derives from the close proximity of the active Wairau Fault and Awatere Fault. Geotech Consulting (2003a, 2003b) conclude there is a moderate to high likelihood of a surface rupturing earthquake on the Wairau Fault in the next 50 - 100 years. The average return period of the Wairau and Awatere Faults is between 350 and 950 years (Robertson and Smith, 2004). Other principal active faults in the region include the Clarence, Kekerengu, Elliot, Jordon and Hope faults. All of these faults are capable of producing large magnitude (>M7) earthquakes (Stirling *et al.*, 2002), and Robertson and Smith (2004) state that collectively an earthquake on any one of these faults has an average recurrence interval of less than 50 years. Ground shaking is therefore a significant hazard to the Blenheim area.

5.5 Liquefaction

5.5.1 Definition

Liquefaction will occur when saturated loose to medium dense fine grained granular materials and silt are subjected to ground shaking. Liquefaction can cause sand boils, subsidence, lateral

spreading and flow slides. Damage from such deformation can include floatation of buried structures, fissuring of the ground, subsidence of large areas, differential subsidence, and foundation failure caused by loss of support as the liquefied soil substantially loses its shear strength.

5.5.2 Analysis

The liquefaction potential of soils was determined using LiquefyPro, version 5.8h (CivilTech Software, 2010). This software uses cyclic liquefaction evaluation methods to determine whether liquefaction is likely in a particular earthquake event and estimate the resulting ground subsidence. The modified Robertson method (Robertson and Wride, 1997) and modified Stark and Olsen methods (Stark and Olsen, 1995) were used to assess liquefaction with CPT and SPT results respectively. The method proposed by Ishihara and Yoshimine (1992) was used to estimate the resulting ground subsidence.

The design horizontal peak ground acceleration (PGA) has been derived in accordance with the New Zealand Earthquake Loading Standard, NZS 1170.5: 2004 (Standards New Zealand, 2004).

The derivation of the design horizontal PGA is shown as follows.

Design PGA,

$$C_0 g = C_h(T = 0) Z R_u N(T, D) g$$

Where :

C_o	=	design ground acceleration coefficient
g	=	acceleration due to gravity
C_h (T=0)	=	spectral shape factor for Site Class D at period T = 0
	=	1.12
Z	=	hazard factor
	=	0.33
R_u	=	return period factor
	=	1.0 (for a 500 year return period event)
	=	1.3 (for a 1000 year return period event)
	=	1.8 (for a 2500 year return period event)
N (T, D)	=	near-fault factor
	=	1.0

Therefore,

Design horizontal PGA for a 500-year return period event = 0.37g

Design horizontal PGA for a 1000-year return period event = 0.48g

Design horizontal PGA for a 2500-year return period event = 0.67g

The characteristic magnitude used in the liquefaction assessment was assumed to be M_W = 7.5 for all return period events considered, which reflects the magnitude weighting for the calculation of the PGAs and is consistent with the characteristic magnitude of earthquake sources in the region.

5.5.3 Results

The approximate thicknesses of soil layers assessed to liquefy at each area are shown in the cross sections provided in Appendix A. Typically there was only a slight difference in the thicknesses of layers assessed to liquefy in 1/500, 1/1000 and 1/2500 year return period events. This is because most soil layers susceptible to liquefaction have a low density such that they are likely to liquefy in earthquakes with a PGA less than that from a 1/500 year return period level.

The liquefaction analyses showed the shallow silt and sand layers above the gravels as liquefiable for all return period events considered. Site investigations show this layer to be typically 2 m to 4 m thick, and the groundwater to be between 1.3 m to 2.1 m depth. The underlying Rapaura Formation gravels and sands are typically dense to very dense, and do not exhibit liquefaction potential apart from occasional thin layers of loose sand.

The potential for liquefaction induced ground damage will be strongly influenced by the groundwater table depth. As described above in Section 4.3, the regional groundwater table in the Blenheim area lies approximately 2 m below ground level. If the groundwater table is lower, the thickness of liquefiable material beneath the water table is reduced and the potential ground damage effects will be smaller.

5.5.4 Liquefaction Induced Ground Damage

Liquefaction induced ground damage causes most damage to the built environment including lifelines, and needs to be considered in the assessment of liquefaction hazards (Brabhaharan, 1994 and 2010). Therefore the potential for ground damage from liquefaction has been considered for the urban growth areas under consideration.

Ground Subsidence

Subsidence is the vertical downward displacement of the ground, which happens without any vertical load being applied to the ground. Liquefaction leads to subsidence as a result of the liquefied soil settling to a slightly denser state and ejection of sand with water to the surface.

Widespread ground subsidence can cause areas to become more prone to flooding. Localised differential subsidence can lead to cracking and damage to structures, and affect the functionality of services, particularly gravity sewers and storm water systems.

The magnitude of expected liquefaction induced ground subsidence in each area, excluding the areas that are prone to lateral spreading, is tabulated in Table 3.

Table 3 Estimated ground subsidence due to liquefaction

Return period event	Estimated subsidence (mm) by area						
	Na:Nb	1	3	4	5	6	8
1 / 500	0 – 50	0 – 65	0 – 65	0 – 50	0 – 25	0 – 25	0 – 25
1 / 1,000	0 – 50	0 – 65	0 – 65	0 – 55	0 – 25	0 – 45	0 – 25
1 / 2,500	0 – 50	0 – 65	0 – 65	0 – 60	0 – 25	0 – 65	0 – 25

Lateral Spreading

Lateral spreading occurs predominantly in the vicinity of free surfaces such as water courses where the liquefied soil can laterally displace towards the water course, but can also occur when there is slope along which the liquefied ground can displace. This can lead to large displacements of the ground from hundreds of millimetres to a few metres.

Lateral spreading can extend to 200 m or more from water courses but is typically more severe nearer the river. In some situations it has extended 300 m to 500 m due to block sliding. This may be mainly in areas where the land can spread in more than one direction due to bends or loops in the water course. Experience from the 2010 Darfield and 2011 Christchurch earthquakes shows the ground damage due to lateral spreading reduces at a distance greater than 130 m from a river or stream. Figure 3 shows the study areas and the proximity to nearby rivers and streams. The extent of lateral spreading is a function of both the depth of the stream or channel and the depth of the liquefiable soils.

The estimates of ground subsidence given in Table 3 do not take into account the subsidence effects of lateral spreading.

Area Na:Nb

Liquefaction in this area may lead to lateral spreading of the land towards nearby streams and drains although the effects are likely to be limited given the relatively thin deposits of liquefiable material. The effects of lateral spreading are likely to be most significant at the eastern end of this area, where the land is underlain by thicker deposits of liquefiable material and where watercourses run in close proximity to the northeastern and southern boundaries (Opawa River and Caseys Creek, respectively).

Areas 1 to 5

Liquefaction in these areas is not considered likely to cause significant lateral spreading given the thin deposits of liquefiable material and the flat terrain with only minor watercourses (shallow farm drains).

Area 6

Lateral spreading is likely to be a significant issue in Area 6, particularly along the southern boundary where up to 7.5 m of soft silt and clay soils are present adjacent to Old Fairhall Stream. Other watercourses such as Murphys Creek and Camerons Creek cross this area and may also present a lateral spreading risk, however these watercourses are shallower with only thin liquefiable deposits and so the potential ground damage is likely to be less significant.

Area 8

Lateral spreading is not considered to be a significant issue in Area 8, because of the flat ground with no significant watercourses in the vicinity.

6 Land Use Planning for Geotechnical and Earthquake Hazards

6.1 Strategic Planning Timeframe

The timeframe used for planning and design depends on two factors:

(1) The importance level of the development

(2) The life of the development.

A life of 50 years is traditionally assumed for normal buildings, and 100 years for infrastructure. For normal buildings of Importance Level 2 (NZS 1170.0), a 500 year return period earthquake hazard is used for ultimate state design, which gives about 10% probability of the event occurring over the 50 year life assumed for typical buildings. For higher value infrastructure, a life of 100 years is often assumed, with a 1,000 or 2,500 year return period earthquake is used for ultimate state design, depending on its importance, giving probabilities of 10% and 4% respectively, see Table 4.

Table 4 Probability of event for planning and design

Return period event	Probability of event in life			
	Building life 50 years	Infrastructure Life 100 years	Urban Growth Life 200 years	Urban Growth Life 500 years
1 / 500	10%	-	-	-
1 / 1,000	-	10%	-	-
1 / 2,500	-	4%	-	-
1 / 2,000	-	-	10%	-
1 / 5,000	-	-	4%	10%

Areas of urban expansion will have a mix of normal buildings and higher value and importance level infrastructure. Although individual buildings or infrastructure may be renewed from time to time, the areas once developed will remain in use for a long time. An area developed could potentially be in use in perpetuity, unless and until there is some major environmental or social change that leads to abandonment of the area. Therefore, a longer "life" is appropriate for zoning areas for urban growth, a "life" of at least 200 years or 500 years or more may be appropriate.

For considering urban growth, retaining a similar probability of 10%, consideration of events with a return period of 5,000 years may be appropriate for land use planning for hazard events which can have a destructive effect on the built environment. This would limit the probability of such destructive events over a 500 year "life" to 10%.

Such an approach may be appropriate for example when zoning for buildings in an active fault zone. This may also be prudent for land prone to very high landslide hazards or extensive lateral spreading from liquefaction. This is on the basis that these hazards can have a destructive effect on the built environment exposed to the hazard.

For the areas investigated for urban growth in Blenheim, the ground shaking associated with earthquakes with a return period of less than 500 years is assessed to be sufficient to cause extensive liquefaction (and lateral spreading in vulnerable areas) of the liquefaction susceptible loose soils present. There is only limited additional liquefaction in larger earthquake events with a longer return period. Therefore, in this instance, the length of the strategic planning period for the liquefaction hazards is not significant.

6.2 Poor Foundation Conditions

The thickness of soft and compressible silt and clay deposits present are generally less than 2 m deep, and locally up to 4 m deep. The geotechnical hazards due to poor ground conditions leading to poor foundation conditions and consolidation settlement (referred to in Section 5.1) can be addressed during construction by simple traditional foundation measures. Such measures may include preloading, undercut and replacement or the use of short piles founded below these soft layers.

6.3 Slope Stability

Slope failure is not a significant hazard and does not need special measures other than avoiding building on land very close to the banks of water courses.

6.4 Fault Rupture

The Ministry for the Environment published guidelines on planning for development of land on, or near, active faults in 2003 (MfE, 2003). In these guidelines, the surface rupture hazard of an active fault is characterised by the location/complexity of surface rupture of the fault, and the activity of the fault, as measured by its average recurrence interval of surface rupture.

The Wairau Fault is a Class I active fault under the MfE guidelines, as it has an average recurrence interval of less than 2000 years (Table 1). As described in Section 5.3, this fault has an intermittent and subdued trace in the lower Wairau Valley. Geotech Consulting (2003)and IGNS (2000) have inferred the location of the fault in the lower Wairau Valley from available geological evidence. This mapping shows the fault to lie approximately 300 m to 400 m from Area 1 at its closest point (see Figure 2).

The distance of the Wairau Fault from the study areas and the uncertainty of the fault's position suggests fault rupture could pose a risk to the northwestern part of Area 1. Potential ground damage in Area 1 will be controlled by the amount of surface rupture displacement and the width of the zone over which this displacement is accommodated. The nature of surface rupture at the northeastern end of the Wairau Fault is likely to be distributed, given the subdued nature of the fault trace, and therefore ground damage is likely to be relatively minor.

Experience of the Greendale Fault rupture during the Darfield Earthquake shows ground damage can be sustained from fault rupture that does not form an obvious fault trace (Villamor *et al.*, 2012), which has important implications for land use planning and resilient infrastructure design.

Ground damage resulting from the rupture of the Greendale Fault comprised discrete shears and localised bulges, but predominantly horizontal dextral flexure. This deformation occurred over a zone up to 300 m wide. About a dozen buildings, mainly single-storey houses and farm sheds, were affected by rupture of the fault, but none collapsed, largely because most of the buildings were

relatively flexible and resilient timber-framed structures and also because of the distributed nature of the deformation. Houses with only lightly-reinforced concrete slab foundations suffered moderate to severe structural and non-structural damage, whereas houses with robust concrete slab or shallow pile foundations performed more favourably (Van Dissen *et al.*, 2011).

Given the proximity of the Class I Wairau Fault to Area 1, the potential for fault rupture in the northwestern part of that area should be considered as part of any land re-zoning process. We recommend fault avoidance zones be developed for the Wairau Fault, and building control measures be incorporated into the land use policy to ensure any new structures are tolerant to potential ground deformation resulting from fault rupture.

6.5 Ground Shaking

Buildings are designed to withstand earthquake ground shaking, which is derived for each area of New Zealand. Therefore existing design standards cover the design of structures in these areas of Blenheim, and no special measures are considered to be required to be considered as part of land use planning.

6.6 Liquefaction

6.6.1 Ground Subsidence

There is potential for shallow liquefaction in much of the areas under consideration for urban growth land use re-zoning. Our assessment shows that the ground subsidence from the limited liquefaction is generally expected to be small, that is up to about 70 mm. Differential subsidence across a building footprint will be smaller, say less than 40 mm.

One approach will be to exclude these areas from being zoned for development, which could exclude much of the areas in the vicinity of Blenheim.

An alternate pragmatic approach could be to allow development in these areas (except areas that are subject to lateral spreading as discussed below), but put in place plan rules to ensure that the development takes into consideration this low consequential subsidence from liquefaction. For example building foundations may be designed to protect the building from damage due to such limited subsidence, by using short piles up to 5 m depth, or use of foundations that are tolerant to limited subsidence and can be easily repaired after any event. Using the principle resilience, a suitable approach will be to limit damage and / or build in a manner that any damage can be quickly and economically repaired and building reinstated.

Services should also be designed with the potential for subsidence in mind, such as using flexible connections along pipelines that tolerate some ground deformation.

6.6.2 Liquefaction-Induced Ground Damage

The development areas under consideration in northern, western and southwestern Blenheim are underlain by alluvial gravel soils with only thin deposits of loose sand and silt layers overlying the gravels. Liquefaction of these sands and silts can occur in modest earthquake events which are used for design of normal buildings.

Land susceptible to liquefaction and lateral spreading is prone to significant risks in earthquake events. Therefore, it would be prudent to not zone for intensive development the areas susceptible

to lateral spreading, such as the northeastern part of Area Na:Nb and the southern part of Area 6. These areas subject to liquefaction and lateral spreading can be used for less intensive land uses such as parks and gardens or agriculture. This could be achieved by appropriate zoning of the land through district planning measures. Brabhaharan (2013) suggests approaches at three levels that can be considered to avoid lateral spreading hazards depending on the land use and the nature and extent of the hazard.

- Land Use Zoning – extensive hazardous areas can be avoided by zoning the land prone to those hazards for less intensive land use such as rural farming or parks.
- Town planning or Subdivision Planning – District Plan rules can stipulate that smaller extents of severe hazards, perhaps localised liquefaction lateral spreading or slope hazard from nearby hillside, can be mitigated by making use of these areas within a township or sub-division for open areas with no building or car parking. A good example is the use of river flood prone areas in the Hutt City for car parking and mobile markets.
- Micro-siting – stipulate and encourage development to avoid areas of high hazard by micro-siting buildings in safer parts of land parcels, with more hazard prone areas used for open space or parking.

Given the limited nature of some of the areas of lateral spreading from liquefaction in the context of the wider area, some of the measures could be to stipulate areas prone to lateral spreading such as near the rivers as areas of high hazard where development is excluded, but the areas can be used for less intensive land use.

The liquefaction hazard is generally low in the remaining areas. There is the potential for shallow liquefaction to occur, but this is not considered significant enough to preclude development of these areas. However, we recommend that measures be put in place through planning policy and development controls to ensure foundations for new developments can tolerate deflections imposed by liquefaction-induced ground subsidence.

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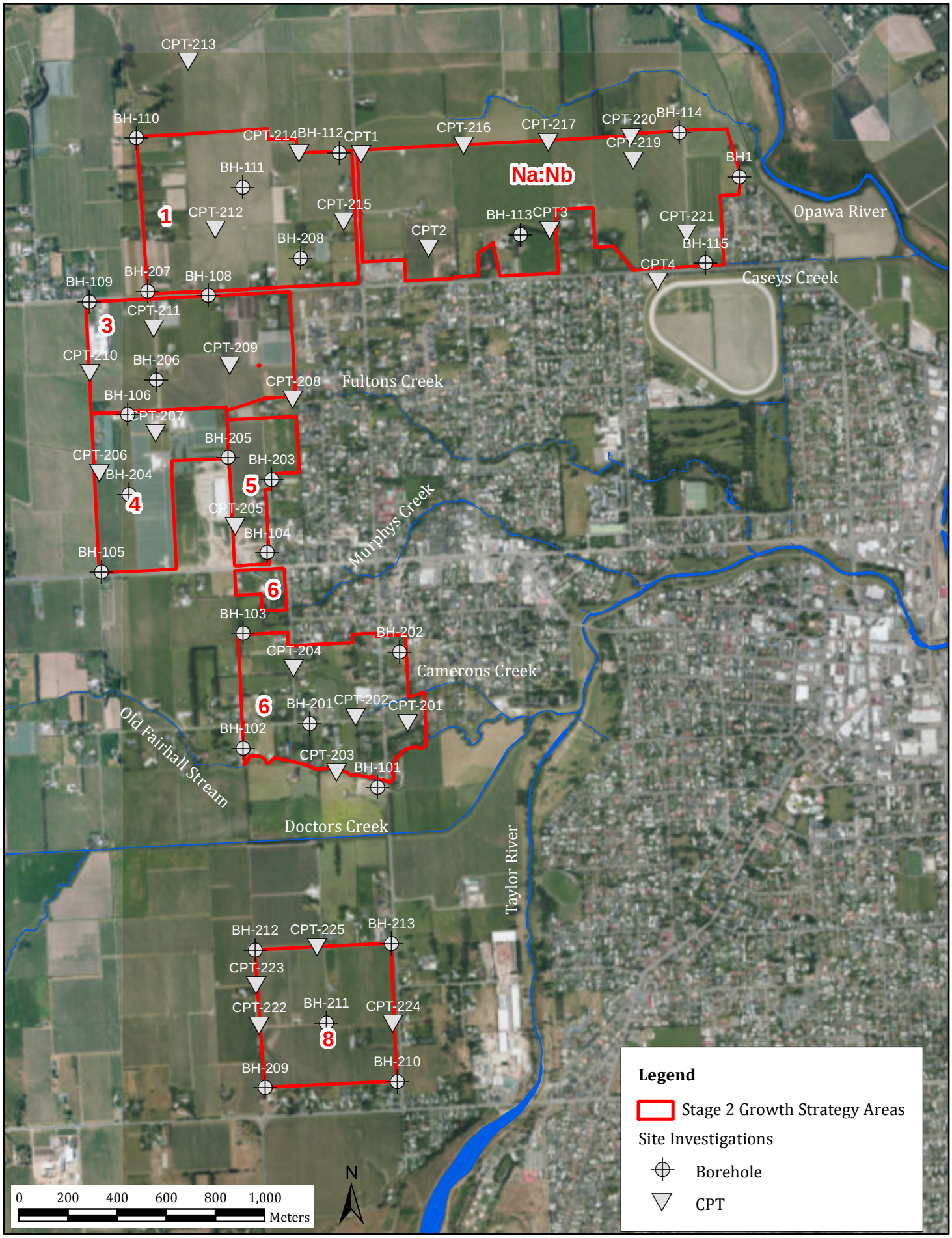
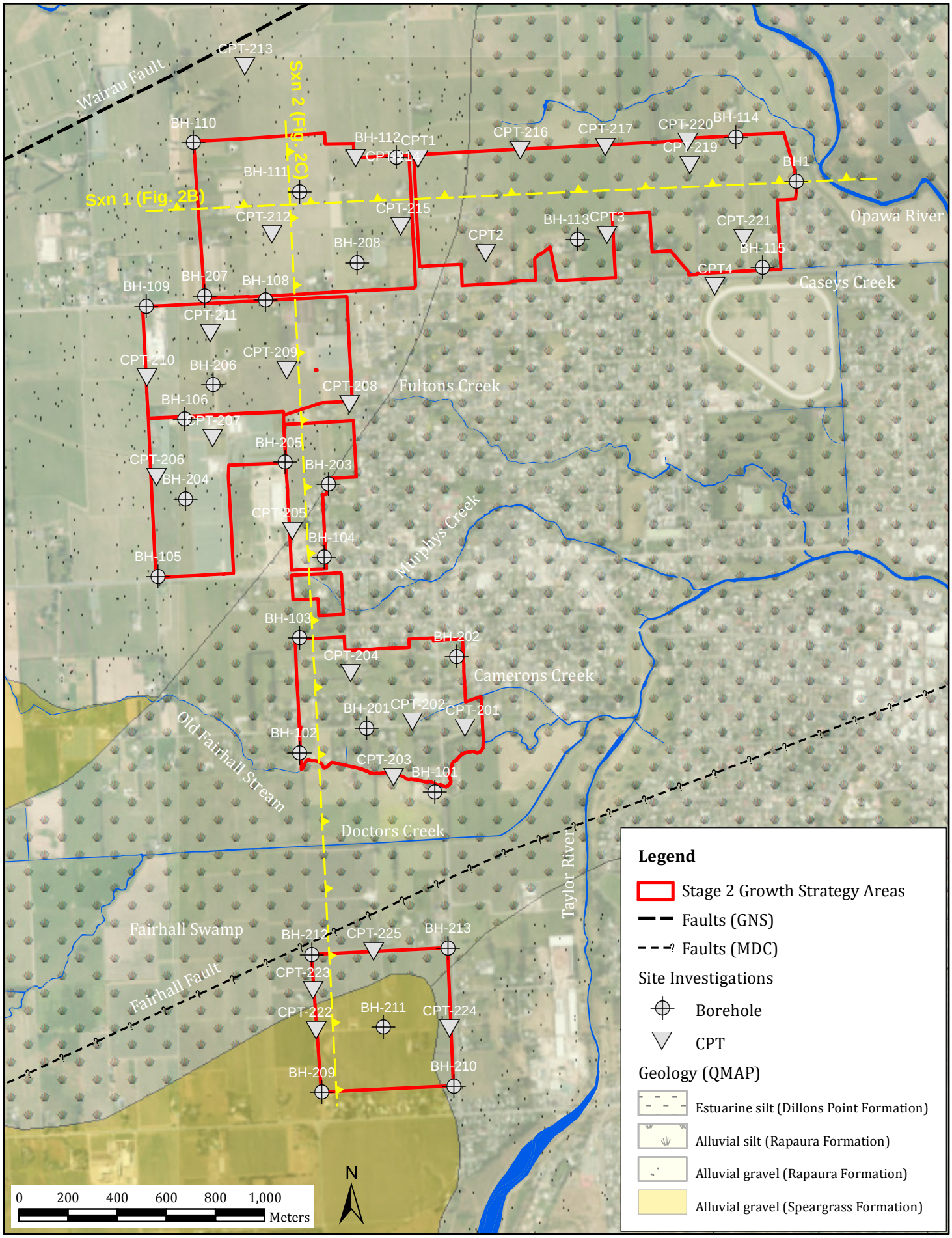
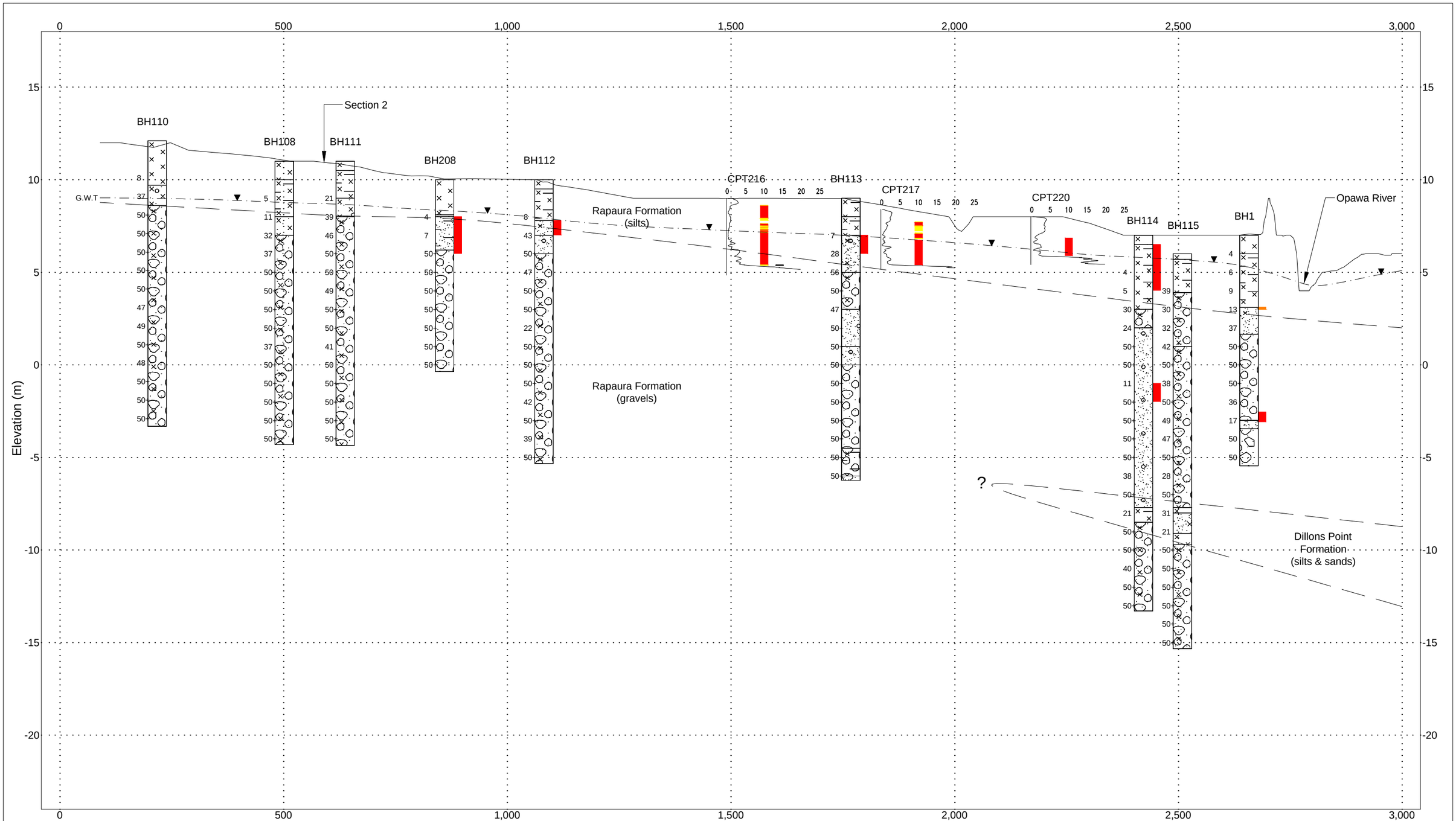
Figures



Prepared For:	Prepared By:	Title: Site location map			
MARLBOROUGH DISTRICT COUNCIL	OPUS	Project: Blenheim Urban Growth Study Stage 2			
		Scale: 1:20,000	Date: Feb 2013	Project No: 5C2128.01	Figure: 1



Prepared For:	Prepared By:	Title:			
MARLBOROUGH DISTRICT COUNCIL	OPUS	Geological map & cross section locations			
		Project: Blenheim Urban Growth Study Stage 2			
		Scale: 1:20,000	Date: Feb 2013	Project No: 5C2128.01	Figure: 2A



Prepared for:

MARLBOROUGH DISTRICT COUNCIL

Prepared by:

OPUS

Legend:

Lithological Graphics

- SILT
- SAND
- Sandy SILT some Gravel rounded/subrounded gravel
- Clayey SILT
- Sandy GRAVEL
- Gravelly sandy SILT angular/subangular
- Silty SAND
- Sandy SILT
- Gravelly SAND
- Sandy GRAVEL
- Sandy Silty GRAVEL
- Silt with some Clay
- Formation Boundary
- Ground Water Table

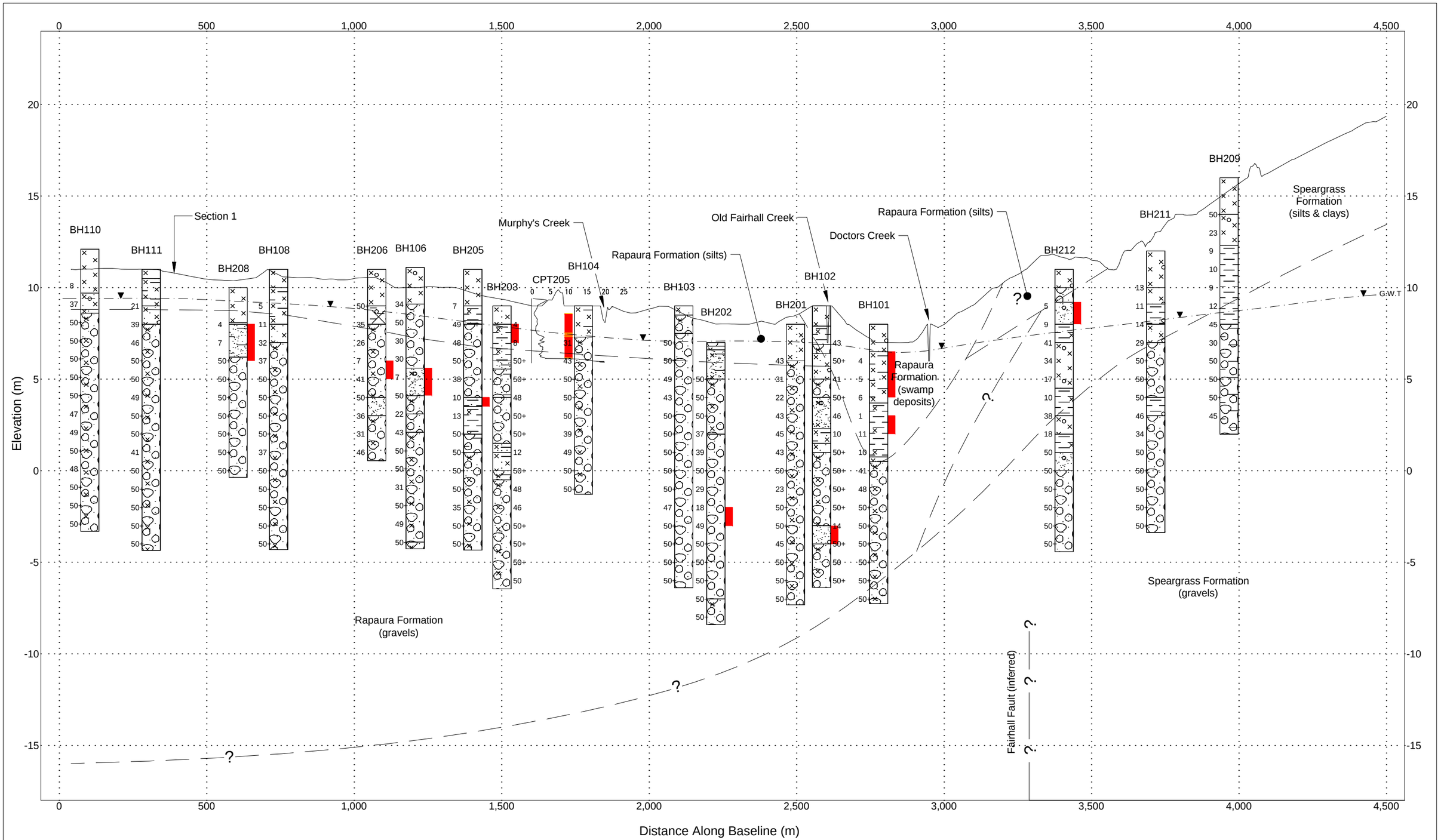
Return Period Event Liquefaction

- 1500 yr
- 1/1000 yr
- 1/2500 yr

Title: Figure 2B Cross Section 1

Project: Blenheim Urban Growth Study Stage 2

Vertical Scale:	Date:	Project:
1:200 (A3)	22/02/2013	5C2128.01



Prepared for:

MARLBOROUGH DISTRICT COUNCIL

Prepared by:

OPUS

Legend:

Lithological Graphics

- Silt with some Gravel. Rounded / subrounded gravel
- Sandy Silty GRAVEL
- Silty SAND some gravel rounded/subrounded gravel
- Clayey SILT
- Silt
- Clayey Silt with some sand
- Silty CLAY
- Silty GRAVEL
- SAND with some Gravel. Rounded / subrounded gravel
- Clayey SILT some gravel some sand angular/subangular
- Gravelly sandy SILT angular/subangular
- Silt with some Sand

- Formation Boundary
- Ground Water Table

Return Period Event Liquefaction

- 1500 yr
- 1/1000 yr
- 1/2500 yr

Title: Figure 2C Cross Section 2

Project: Blenheim Urban Growth Study Stage 2

Vertical Scale:	Date:	Project:
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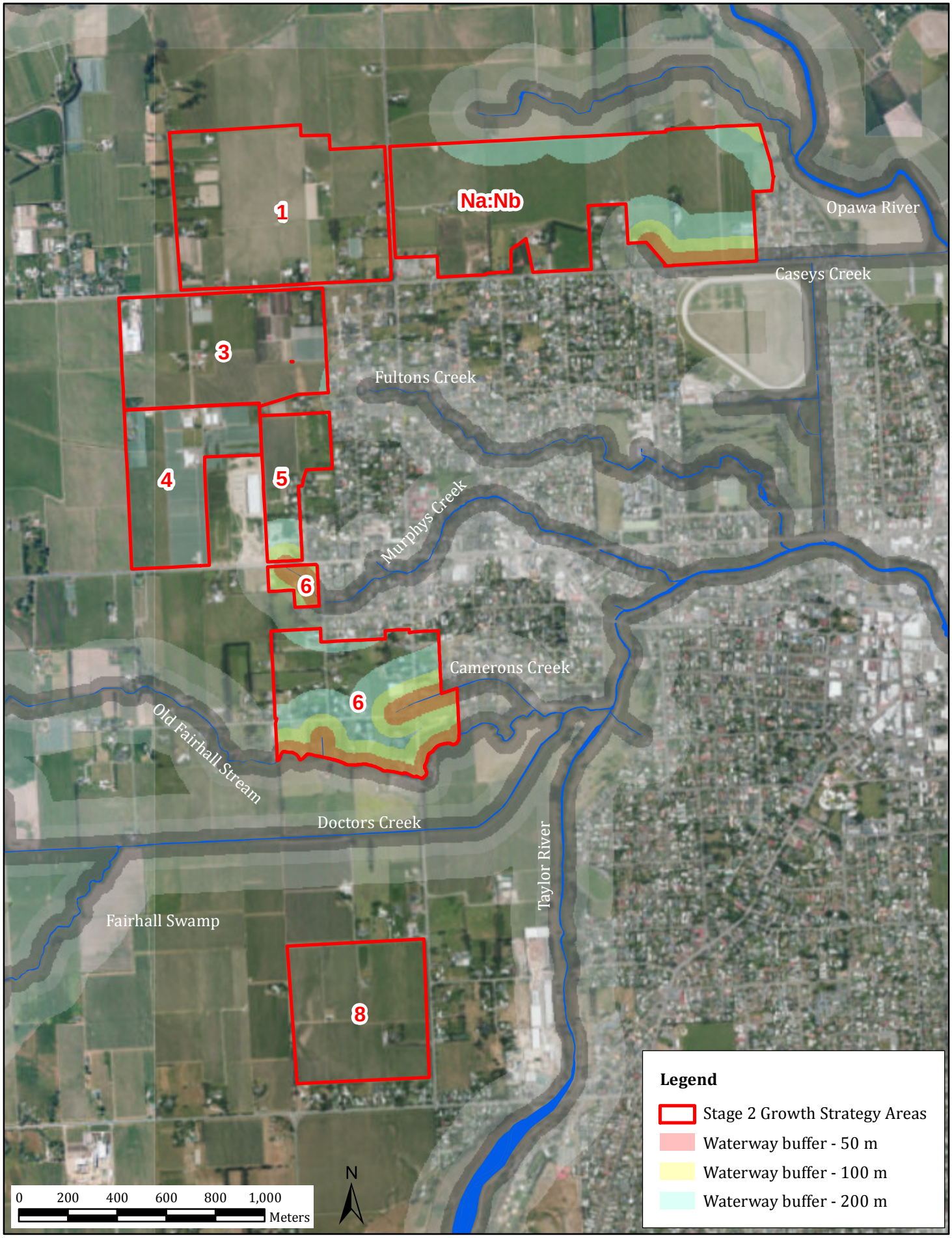

Prepared For: MARLBOROUGH DISTRICT COUNCIL	*Prepared By:* OPUS	*Title:* Site areas and proximity of waterways	
		Project: Blenheim Urban Growth Study Stage 2	
		Scale: 1:20,000	*Date:* Feb 2013
		Project No: 5C2128.01	*Figure:* 3