TRAFFIC ENGINEERING AND PLANNING

REGIONAL CYCLE NETWORK DISCUSSION DOCUMENT

Prepared for

Environment Canterbury

ViaStrada Ltd

March 2009

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Glossary

Assessment criteria	The variables used to assess the utility of the candidate network for cycling, specifically motor vehicle traffic volume, heavy vehicle traffic volume, carriageway width and bridge characteristics.
Candidate network	A collection of regionally significant routes considered to have the potential to be chosen for the regional cycling network.
Element	An individual road segment with no intersections characterised by homogenous RAMM data.
Key destination	A regionally significant location to which the regional cycle network should give access.
Node	A junction of two or more routes or a key destination on the candidate network.
Proposed network	A subset of the candidate network proposed to be the regional cycle network. Consists of primary elements required to properly service the key destinations supplemented by supporting elements considered to be useful but not critical to the network. Developed through desktop analysis and presented to a series of stakeholder workshops for refinement.
RAMM data	Road asset and maintenance data held by either local councils or NZTA.
Regional cycle network	A collection of roads that gives cycle access to key destinations in the Canterbury region identified by ECan as the regional cycle network.
Route	A collection of sections of a cycle network running between two key destinations
Section	A group of elements running between two adjacent nodes along the candidate network

Executive Summary

This discussion document outlines the desktop analysis undertaken to identify a regional cycle network for Canterbury. Its purpose is to provide background for a series of workshops to refine the methodology for selecting a regional cycle network.

The need for a regional cycle network has been identified in previous Environment Canterbury studies and strategies and it is anticipated that it will support national targets presented in the New Zealand Transport Strategy and Government Policy Statement on Transport.

The key regional destinations to be serviced by the regional cycle network were identified and a candidate network of road elements considered to have potential to form the regional cycle network was selected from the region's entire road network. The elements of the candidate network were grouped into sections between nodes to aid the analysis process.

The desktop analysis identified motor traffic volume, volume of heavy vehicles, carriageway width and bridges as key, quantifiable criteria that affect the utility of a road for cycling. Bands of varying utility for cycling were identified for each of these criteria based on standards, guidelines, engineering judgement and the distribution of the actual provision of the candidate network road sections. The bridge criterion was the most complex as it combined the motor vehicle volumes, heavy vehicle volumes, carriageway width and bridge length for individual bridge elements and then aggregated to give a score for each section in the candidate network.

The overall utility of each section was then obtained using a weighted sum of the individual criteria. The weightings for each criterion were based on judgements made as engineers and cyclists and subjected to sensitivity testing. It was concluded that volume of motor traffic has twice as much effect on the utility of a road for cycling as volume of heavy traffic or carriageway width (at lower volumes narrower roads have less effect as vehicles overtaking cyclists are more likely to be able to cross the centreline) and that the bridge score should have a weighting of 0.5.

Based on the overall utility of the candidate network sections and the requirement of servicing the key destinations a proposed regional cycle network was selected. This consisted of primary elements required to properly service the key destinations supplemented by supporting elements considered to be useful but not critical to the network.

The majority of the proposed cycle network coincided with the regional freight and / or state highway networks. While it would be beneficial to keep the cycle network separate from these other networks, it is not possible to achieve this given the road network and key destination locations.

The next stage of this project is to discuss the proposed regional cycle network and supporting network at a series of stakeholder workshops in north, central and south Canterbury. The stakeholder workshops will aim to refine the methodology and supplement the desktop analysis with local knowledge.

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1 Introduction

ViaStrada Ltd has been engaged by Environment Canterbury (ECan) to assist with the development of a regional cycle network within the framework of "Cycling in Canterbury: Strategy for the development of a regional network of cycle routes." The cycle network will play a critical role in encouraging cycling at a regional level and assisting the Canterbury region in achieving recent targets set in the New Zealand Transport Strategy and Government Policy Statement on Transport. The relevant targets from these documents are listed below:

- Halve per capita greenhouse gas emissions from domestic transport by 2040 (NZTS);
- Increase walking, cycling and other active modes to 30 percent of total trips in urban areas by 2040 (NZTS); and
- Increase the number of walking and cycling trips by one percent per year though to 2015 (GPS).

The cycle network will also assist ECan, territorial local authorities and the New Zealand Transport Agency (NZTA) in prioritising funds for cycling by identifying the areas where resources should be focused.

This work continues on from the 2006 Traffix Ltd (now ViaStrada) report which presented a methodology for route assessment based on Road Asset Maintenance Management (RAMM) data and site visits; this in turn was based on the ECan (2005) investigations into the development of a regional cycle network map.

This discussion document outlines the methodology of the desktop study used in identifying the proposed regional cycle network. The next step of the project is to present the proposed network to a series of stakeholder workshops (in north, central and south Canterbury) to refine the methodology and finalise the network by supplementing the desktop findings with local knowledge.

2 Methodology

2.1 Initial considerations

The methodology presented by Traffix formed the basis for the methodology of this project. The ECan 2005 report "Development of a Regional Cycle Network Map" and the Transit (and Beca) October 2007 report "Cycle Pinch Points in Rural Environments" were also reviewed and incorporated.

Various sources of data were available for the analysis of routes on state highways. State Highway Information Sheets and the New Zealand Transport Agency's (NZTA) road camera footage in particular were investigated as potential sources of data. However, it was decided that the state highway and non-state highway roads should be analysed according to the same methodology and therefore RAMM was used as the main source of information, with the data specific to state highways used as a supplement where available.

It was anticipated that an approximate financial cost for rectifying each possible route (or constructing new off-road routes) to achieve desired minimum standards would be calculated. The rectification costs of alternative routes could then be used to select the routes that would form the regional cycle network. It was intended that the Beca (2007) report on pinch points would provide a useful source of possible treatments and approximate costs.

However, when the “rectification cost” approach was investigated further, it was determined that some characteristics important to cycle routes could not be easily assigned a monetary value for rectification. For example, it may be possible to determine which roads in the network do not provide the minimum cycle lane widths recommended in the New Zealand Supplement to Austroads Guide to Traffic Engineering Practice (GTEP) Part 14: Bicycles and an approximate monetary rate of upgrading roads to meet the recommended widths. It would not, however, be easy to define a threshold volume of motor vehicles above which cycling on the same road should not be recommended and a method (let alone an associated monetary rate) of reducing traffic volumes to reach this threshold.

Thus it was decided that each criterion would be assessed according to a scale (ranging from desirable to undesirable) and grouped into bands of differing utility to cyclists. Each route was assessed according to the severities of the different criteria, with the effects of different weightings for the criteria explored by sensitivity testing.

2.2 Selection of key destinations

The required coverage of the regional cycle network was defined according to the locations that it was considered necessary (or desirable) to service. These locations were named “key destinations” and were selected on the basis of being important urban centres, tourist destinations or strategic locations near the regional boundary. The key destinations are illustrated in Figure 1 and listed in Table 1.

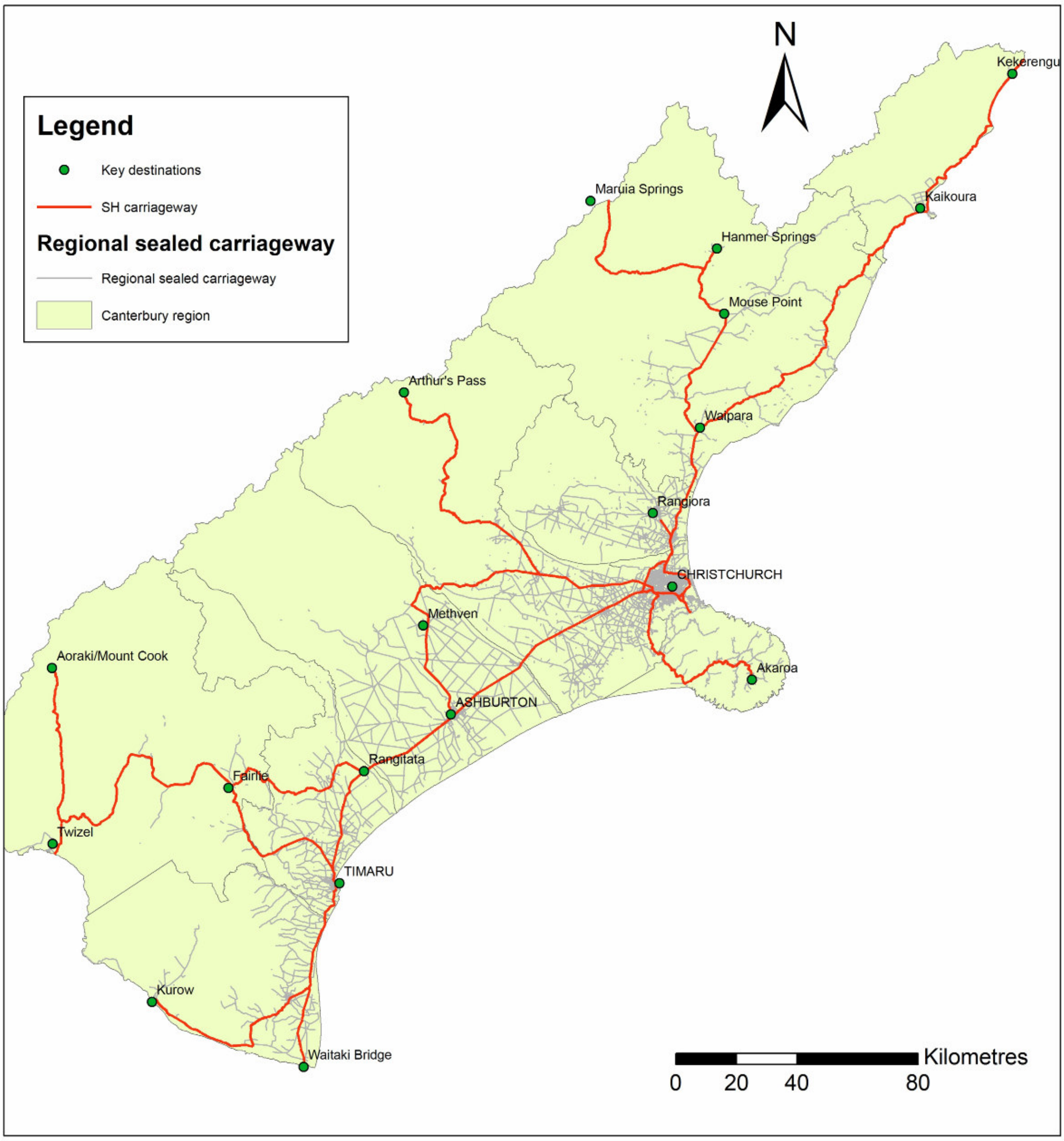

Figure 1: Key regional destinations

Table 1: Key regional destinations

Destination	Reason for inclusion
1. Akaroa	Tourist destination
2. Aoraki / Mount Cook	Tourist destination
3. Arthurs Pass	Regional boundary / tourist destination
4. Ashburton	Urban centre
5. Christchurch	Urban centre
6. Fairlie	Key junction
7. Hanmer Springs	Tourist destination
8. Kaikoura	Urban centre
9. Kekerengu	Regional boundary
10. Kurow	Regional boundary
11. Maruia Springs	Tourist destination
12. Methven	Tourist destination
13. Mouse Point	Key junction
14. Rangiora	Urban centre
15. Rangitata	Key junction
16. Timaru	Urban centre
17. Twizel	Tourist destination
18. Waipara	Key junction
19. Waitaki Bridge	Regional boundary

2.3 Selection of candidate network

The roads considered to have potential as regional cycle routes were selected as the "candidate network," as illustrated in Figure 2. It was anticipated that the regional cycle network would be selected from within this candidate network.

The candidate network is not defined through major urban areas (Christchurch, Rangiora and Timaru) where several route options exist. In these locations it is the responsibility of the local road controlling authorities to develop their urban networks and ensure they enable coherent linkages between the various regional network links. The methodology used to analyse the candidate network and then select the proposed network would not be appropriate for roads in urban areas as factors such as intersection density and traffic signal phasing and coordination become more important than the criteria used in rural cycle route analysis.

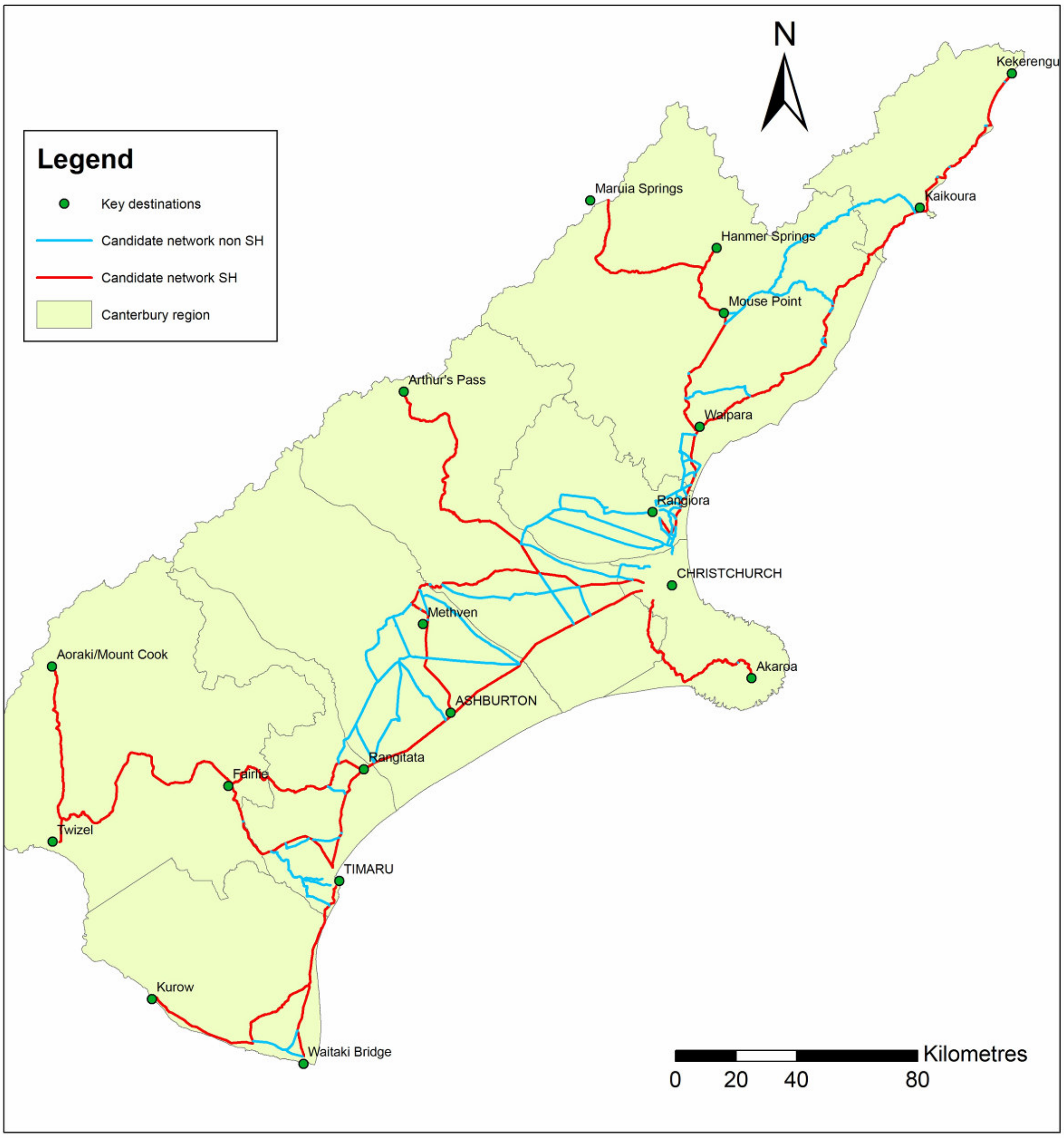

Figure 2: Candidate regional cycling network

2.4 Selection of assessment criteria

The assessment criteria for choosing between various route options within the candidate network were selected according to the factors considered important to regional cycling and within the limitations and abilities of the data available.

Several potential criteria for auditing route deficiency were identified in the 2006 Traffix report; these are presented in Appendix 1. From discussions with ECan staff it was confirmed that the criteria selected for analysis should be quantifiable to allow comparisons between different routes and different deficiencies along the same route. As detailed previously, it was decided that the most appropriate way of quantifying and comparing the criteria would be to define a scale for each of the criteria and group them according to varying levels of utility.

Based on the desired criteria and the data available it was determined that the options between routes should be assessed according to:

- Motor vehicle traffic volumes
- Heavy vehicle traffic volumes
- Average carriageway width
- Characteristics of bridges (pinch points)

The length of alternative routes was also considered as an assessment criterion. However, it was considered that cyclists willing to make long trips within the region are generally willing to travel long distances and will favour other qualities, such as safety and aesthetics over route length. Thus route length was not included as a criterion.

The "hilliness" of a route was also identified as a possible assessment criterion and proxy measures for hilliness, such as the average absolute gradient or the standard deviation of altitude were considered. However, the exact effect of hilliness of a road on the utility for cycling was unclear. While some cyclists may prefer to avoid extremely hilly routes, it is known that some longer-distance cyclists prefer varied terrain and may seek out hillier routes. Cyclists are known to use routes such as State Highway 74 to Arthur's Pass and State Highway 75 to Akaroa, even though these routes are particularly hilly.

It was also considered that flat sections, particularly in the Canterbury region, are often straight and provide less interest for cyclists. Therefore a relationship between hilliness and utility for cycling would not be linear (as flat and extremely steep routes might be of lower utility than moderately hilly routes) and would be largely dependant on the personal tastes and preferences of individual cyclists. Thus, for the development of the suggested network, hilliness has been omitted as a criterion. Appendix 2 further outlines the investigations made into hilliness as an assessment criterion.

2.5 Data processing

The GIS data obtained from RAMM required considerable processing and manipulation to achieve a format compatible with the required computations. This included the aggregation of the candidate network into sections between each node in the network with weighted averages (based on length) of the criteria.

2.6 Definition of criteria utility bands

A ranking system was developed for each of the criteria and the data grouped into bands. The definition of the bands was aimed at distinguishing between the varying degrees of provision of a certain criterion from unacceptable to best practice. This was to allow the total utility of each route option to be assigned a score based on its performance with respect to the different criteria.

The most important consideration in this method was to set the bands for each criterion to ensure suitable comparison between the criteria. The bands were developed by considering desirable levels of provision, distributions of the existing roads and sensitivity testing to determine the most appropriate groupings.

The bands were organised so that a higher value represented a higher utility for cycling.

2.6.1 Motor vehicle traffic volumes

The NZ Supplement to Austroads GTEP suggests that, for an 85th percentile motor vehicle speed of 100 km/h (the speed limit of most roads in the candidate network) only off-road cycle paths are appropriate, regardless of the traffic volume. The premise of the regional cycle network project is that the majority of the network will consist of unmarked road shoulders or on-road cycle lanes, as it would not be feasible to provide a complete off-road regional network. Thus the volume guide presented in the supplement was not used to define the different levels of provision with respect to motor traffic volumes.

As there is no relevant guidance regarding the relationship between motor traffic volumes and cycling utility, the volume bands were based on the distribution of average volumes present in the candidate network. The bands were spaced so that a reasonably flat distribution was obtained (thus maximising the likelihood of contrast between any two given elements in the candidate network). The distribution of the chosen bands, along with the volume-based utility for each of the candidate network sections is detailed in Figure 3. Thresholds between the bands occur at 500, 1,000, 2,000 and 5,000 vehicles per day (vpd).

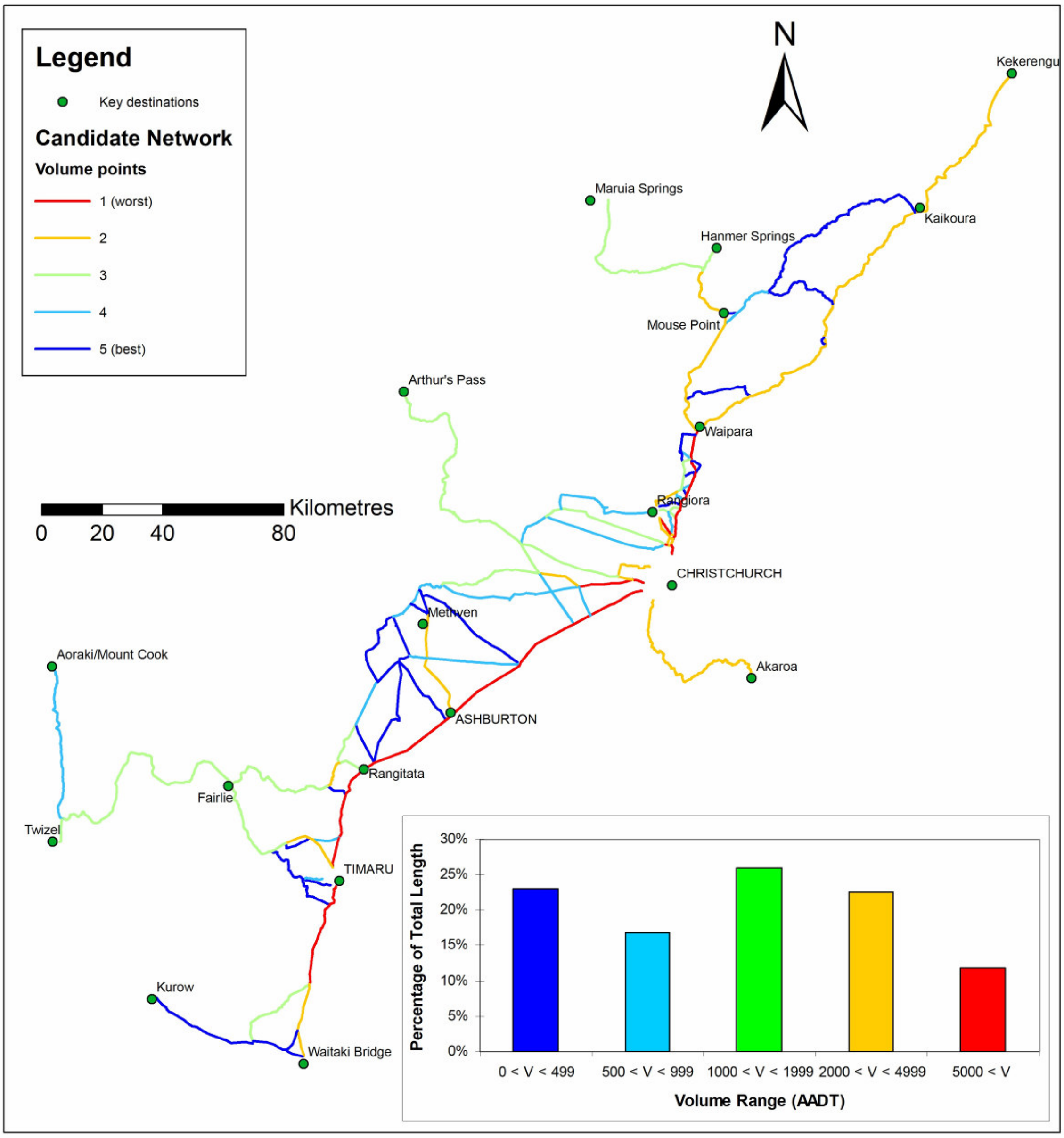

Figure 3: Motor traffic volume criterion bands and distribution

2.6.2 Heavy vehicle traffic volume

Heavy vehicles have different effects on the utility to cyclists than cars due to their size and thus the heavy vehicle traffic volume was considered as a separate criterion. It was considered that the absolute volume of heavy vehicles, rather than the percentage of heavy vehicles, would be the most appropriate measure of the effects of heavy vehicles on cycling utility. This measure is consistent with the use of the motor traffic volume criterion and gives an indication of the likely exposure of cyclists to heavy vehicles. The distribution of the chosen bands, along with the utility for each of the candidate network sections is detailed in Figure 4. Thresholds between the bands occur at 40, 100, 200 and 400 vehicles per day (vpd).

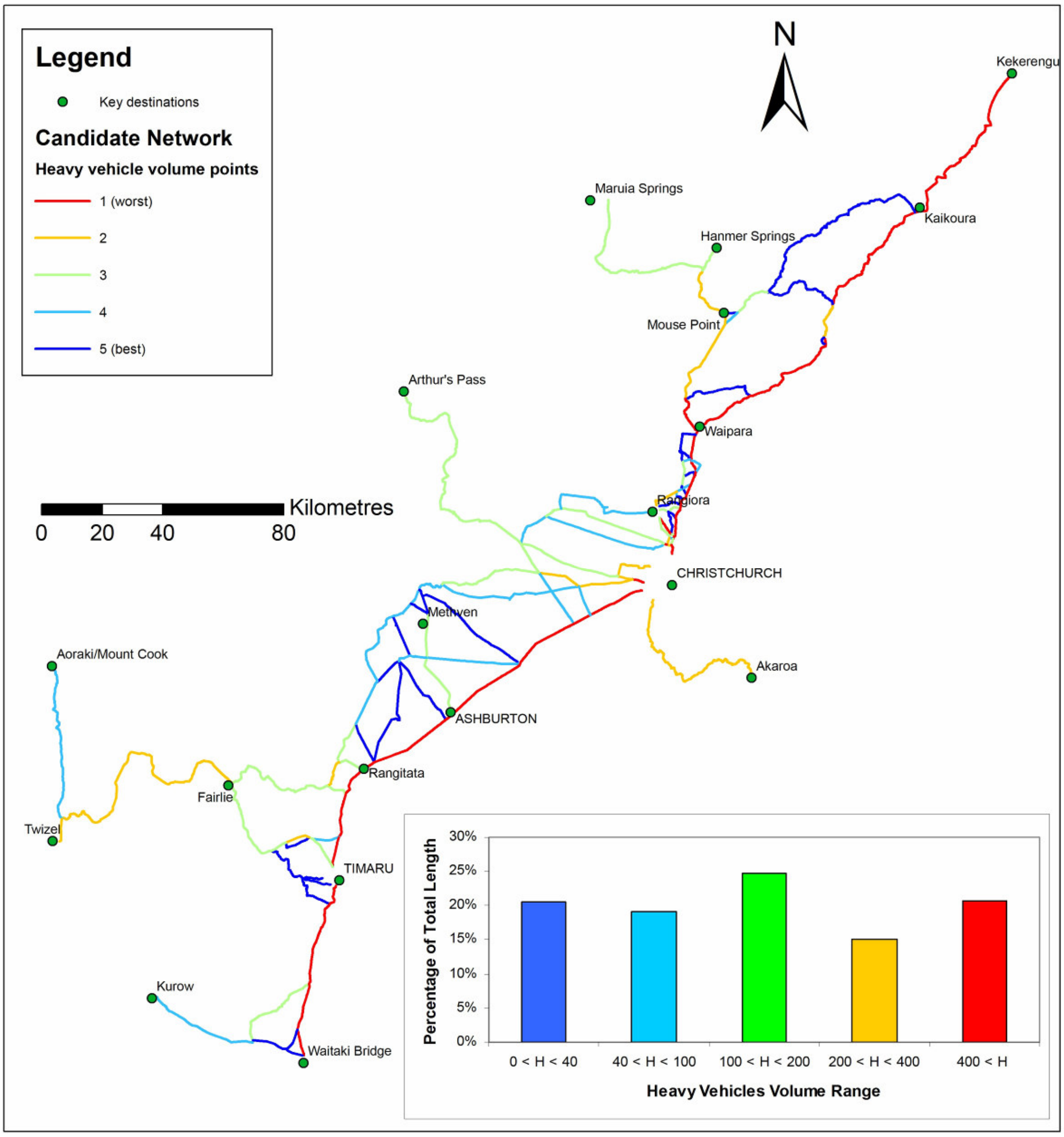

Figure 4: Heavy vehicle traffic volume criterion bands and distribution

2.6.3 Carriageway width

As RAMM databases do not include comprehensive cycle lane and sealed shoulder widths, the total carriageway width was used to represent the total width available to provide for all road users. As noted above, most roads in the candidate network have 100 km/h speed limits. The NZ Supplement states the desirable minimum width for a cycle lane or sealed shoulder in a 100 km/h speed environment is 2.5 m; the acceptable range is 2.0 – 2.5 m. It was assumed that a motor vehicle traffic lane width of 3.5 m is necessary for cyclists to feel comfortable cycling next to motor vehicles at this speed, and that an adequate shoulder must also be present. The carriageway width bands detailed in Figure 5 were chosen. Thresholds between the bands occur at 7 m, 8 m, 9 m and 10.5 m

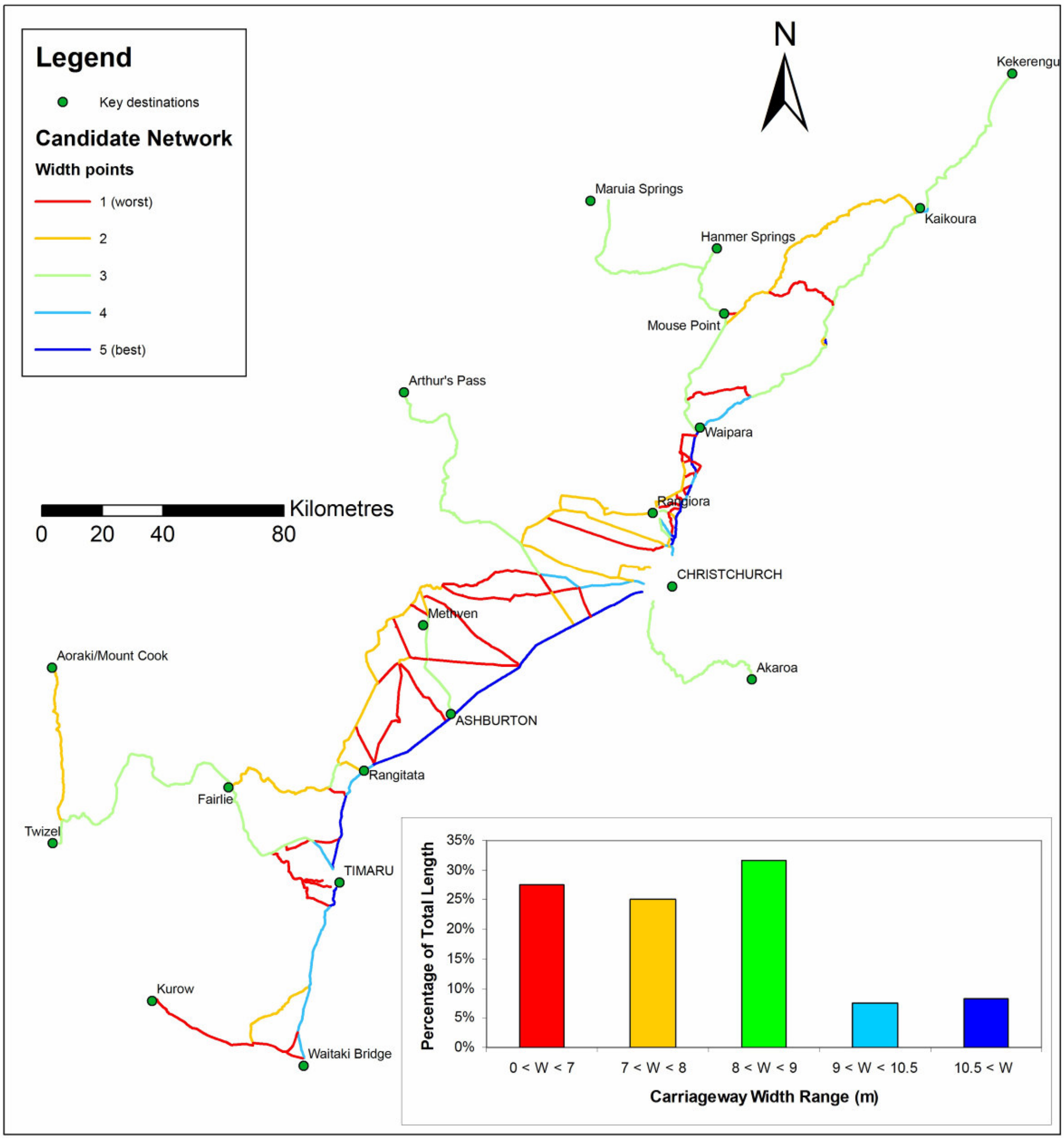

Figure 5: Carriageway width criterion bands and distribution

2.6.4 Bridges

Although it was not possible to identify all types of pinch points with the RAMM data, it was anticipated that bridges could be assessed. Bridges are a significant type of pinch point due to their boundary restrictions which increase the risk and consequence of conflicts between cyclists and motor vehicles. As cyclists and motorists on a bridge cannot deviate from the road they have few options other than braking for remedial action when faced with impending collision. Motorists overtaking cyclists may cross the centre line to give cyclists more space, so long as there are no approaching motor vehicles.

Through analysis of known bridge locations, it was found that not all bridges were correctly classified as bridges in RAMM. GIS was used to search for elements with widths less than 80 percent of the widths of both adjacent elements. The 80 percent threshold was established by assessing the characteristics of several known bridges and their approaches. This method did not identify bridges where one or both approaches had a similar width to the bridge itself. The RAMM bridge data were therefore combined with the pinch points identified by the GIS analysis and checked further against known bridge locations. It was assumed that by using both sets of bridge data the majority of bridges were correctly identified. It was found that the route to Arthur's Pass (in Selwyn District) does not correctly identify several bridges; this was found to be due to the RAMM data which had a high degree of data aggregation and therefore grouped bridges with adjacent elements as single elements. The problems (of bridges not being identified in RAMM) with this route were not of particular concern, given that it was the only option for reaching the Arthur's Pass key destination and therefore would be included in the suggested network regardless of its bridge attributes.

It was considered that the presence of a bridge on a section of the candidate network is not enough to predict the effect of bridges on cyclists' utility. Nor is there any one defining feature of a bridge that can be used to develop the criterion bands. It was considered that the factors of motor vehicle traffic volumes, heavy vehicle volumes, bridge width and bridge length all affect the utility of a bridge for cycling. Thus the bridge scoring system was developed differently to the band system used for the other criteria.

The utility for cycling of a bridge increases with increasing carriageway width and decreases with increasing motor vehicle traffic volume, heavy vehicle traffic volume and bridge length. Thus Equation 1 was used to calculate the bridge score assigned to a section where a higher bridge score represents a lower utility.

Equation 1: Bridge score

$$B = 6.1 - \sum_{N} \sqrt{\frac{VHL}{W}} \times 10^{-3}$$

Where: B = the bridge score for a section of road with *N* bridges

V = the average annual daily motor traffic volume on the bridge

H = the average annual daily heavy traffic volume on the bridge

L = the length of the bridge in metres

W = the width of the bridge in metres

The square root was applied to ensure the dimensions of the bridge score were the same as that of the volume based criteria bands (vehicles per day) and to give a smoother distribution among the various bridges on the candidate network. The coefficient (10^{-3}) was applied to make the bridge score of the same order of magnitude as the other criteria values.

The main part of the equation (i.e. the term inside the square root) was calculated for individual bridge elements and then the score for the section was obtained by summing the values for the individual bridge elements within that section. The majority of sections had no bridges, 18 had one bridge and 7 had more than one bridge.

The main part of the equation was subtracted from the constant (6.1) to ensure that a lower score represented a lower utility and therefore a lower risk to cyclists and that sections without any bridges had a higher bridge utility score than those with bridges. The constant represented the highest possible value for the main part of the equation.

The section of State Highway 1 which contains the Rakaia River bridge (approximately halfway between Christchurch and Ashburton) obtained a score of 0, by far the lowest utility bridge score; the other sections in the network had scores ranging from 0.3 to 6.1, as illustrated in the distribution shown in Figure 6.

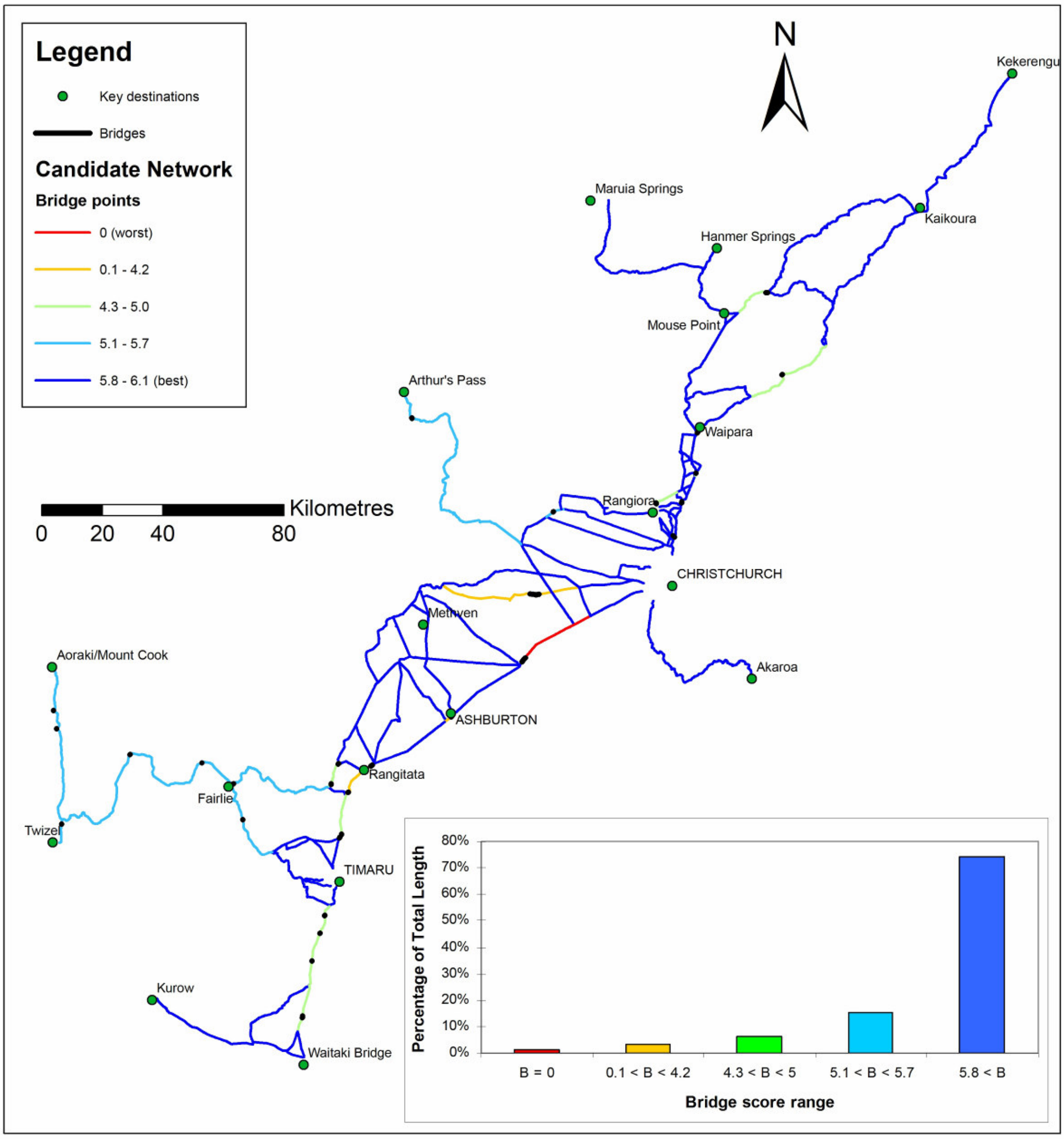

Figure 6: Bridge criterion scores and distribution

2.7 Definition of utility function

A "utility function" that combined the various assessment criteria was developed according to engineering judgement and sensitivity testing.

It was assumed that traffic volume has a greater impact on utility for cycling than available width as lower volume roads allow more opportunity for vehicles overtaking cyclists to cross the centreline and provide cyclists with enough width without coming into conflict with oncoming vehicles. The interaction between cyclists and motor vehicles is also much less frequent, as opposed to higher volume roads where cyclists are exposed to passing motor vehicles which, even if adequate width is provided, can decrease the feeling of safety and enjoyment and therefore utility for cycling.

Sensitivity testing was performed by developing a series of utility functions giving different weights to the five criteria and comparing the outputs according to knowledge of various known route options and engineering judgement regarding which sections should have the lowest utilities and the relative importance of the criteria. The chosen utility function is defined in Equation 2:

Equation 2: Utility function

$$U = 2V + W + H + 0.5B$$

Where: U = the utility of a section of the candidate network

V = the average annual daily motor vehicle volume of the section

W = the width (in metres) of the section

H = the average annual daily heavy vehicle volume of the section

B = the bridge score of the section

The utility function was applied to each of the sections in the candidate network and is illustrated in Figure 7. The strategic freight network is also illustrated in Figure 7 as the selection of the proposed regional cycle network was required to take into account the location of the strategic freight network.

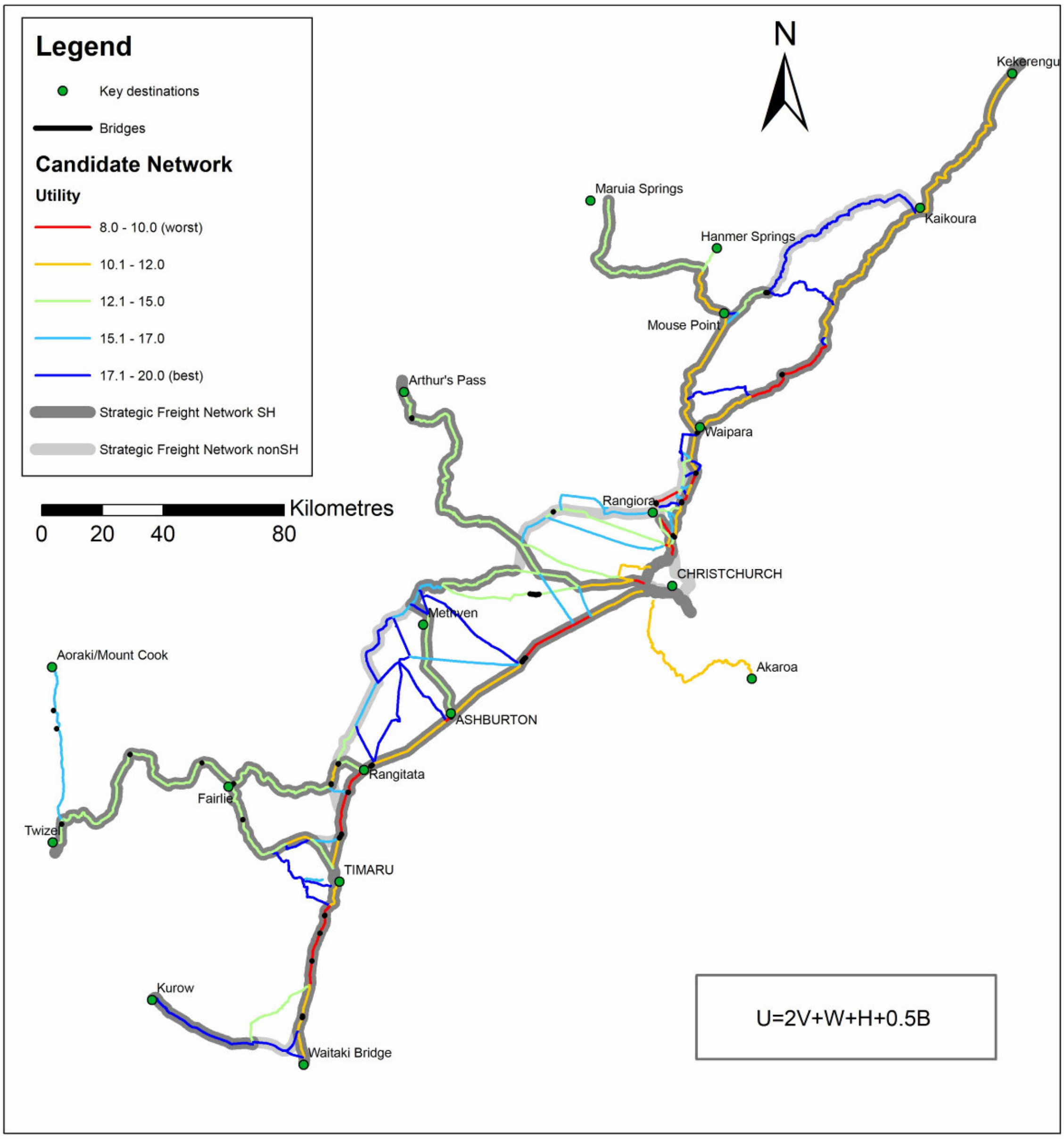

Figure 7: Candidate network with chosen utility function

2.8 Selection of proposed network

The proposed regional cycle network was chosen from the candidate network based on the most appropriate route options according to the utility of each section and ensuring appropriate linkage between each of the key destinations. The proposed network consists of primary and supporting sections. The supporting sections were identified as regionally important routes for cycling that are useful but not critical to the completeness of the network and therefore should not be prioritised over the primary regional cycle network sections. The primary sections can service the key destinations but are enhanced by the addition of the supporting sections

Where possible, the routes selected for the proposed network were those with the highest utility for cycling. However, adequate servicing of the key destinations required selection of some of the routes identified as having low utility for cycling. For example, State Highway 1 (SH 1) between Christchurch and Waitaki was selected, regardless of its low utility, because it services several of the key destinations and is a known desire line. SH 1 between Waipara and Kaikoura was selected to be part of the supporting network because, although it doesn't service any key destinations not serviced by the alternate route via Mouse Point, it is also a known desire line.

Many possible routes between key destinations comprised multiple sections, often with different utility values, however none of the routes involved severe changes in the utility between adjacent sections. While the utilities of different sections were not aggregated, it was simple enough to gauge the relative utilities of various route options by visual inspection.

The utilities of the candidate network elements were used firstly to aid in route selection. Now that the proposed and supporting networks have been identified the utilities should be used to identify areas requiring treatment and prioritise which areas to treat first.

The proposed regional cycle network is detailed in Figure 8.

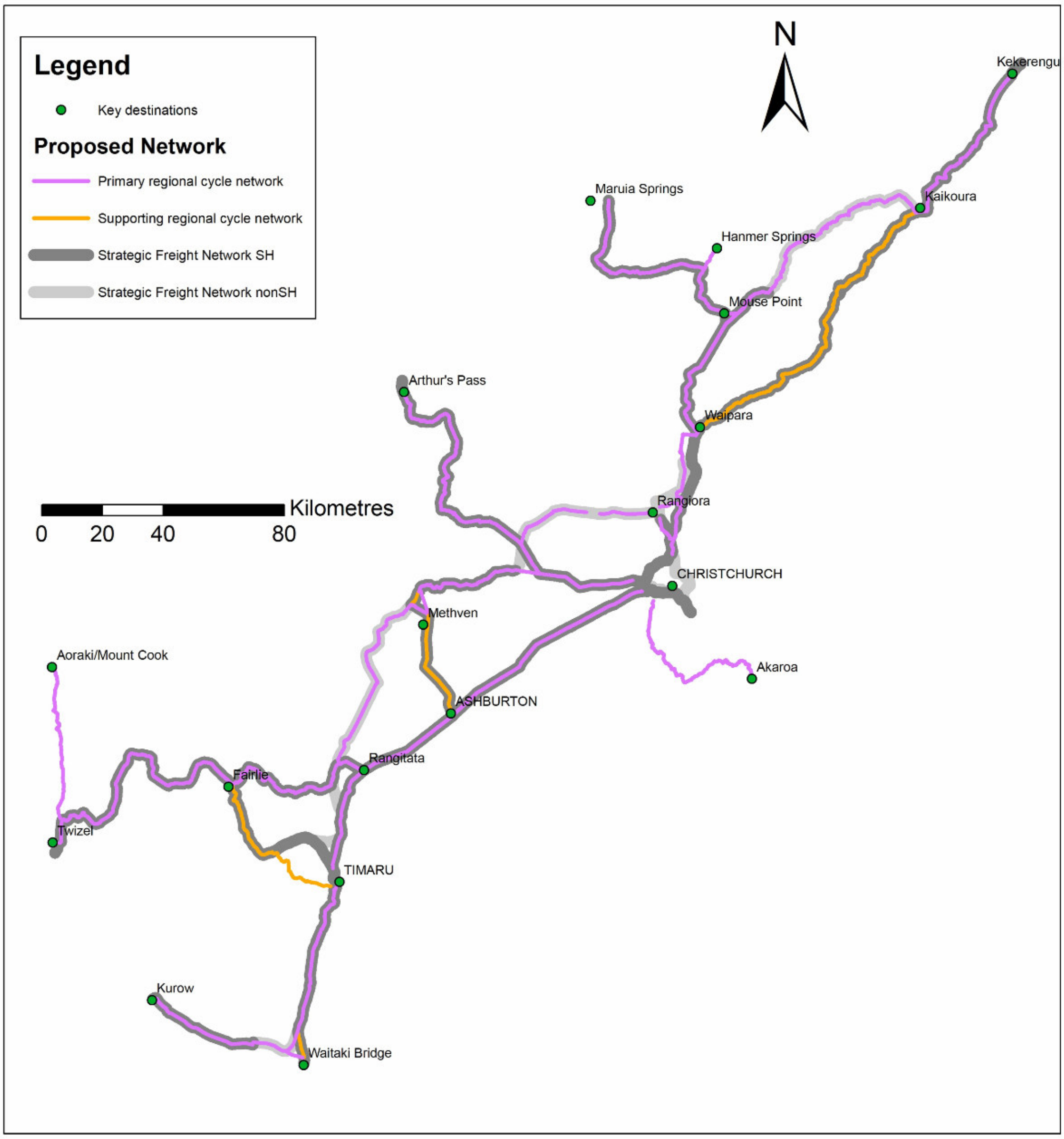

Figure 8: Proposed regional cycle network

The location of the strategic freight network was also taken into consideration when selecting the proposed network and is included in Figure 8. Policy 1.2.10 of the

Canterbury Regional Land Transport Strategy 2008-2018 (RLTS) states that territorial authorities and NZTA should *"seek to provide physically separated cycling facilities on the strategic freight network and busy arterial roads where demand warrants and these do not greatly disadvantage cyclists in relation to distance and desired routes."* The strategic freight network encompasses the bulk of the region's most important roads and services many of the key destinations.

The distribution of roads in the primary and supporting networks that coincide with the regional freight and state highway networks according to road length is shown in Figure 9. It can be seen that the majority of roads in both the primary and supporting regional cycle networks coincide with both the regional freight and state highway networks.

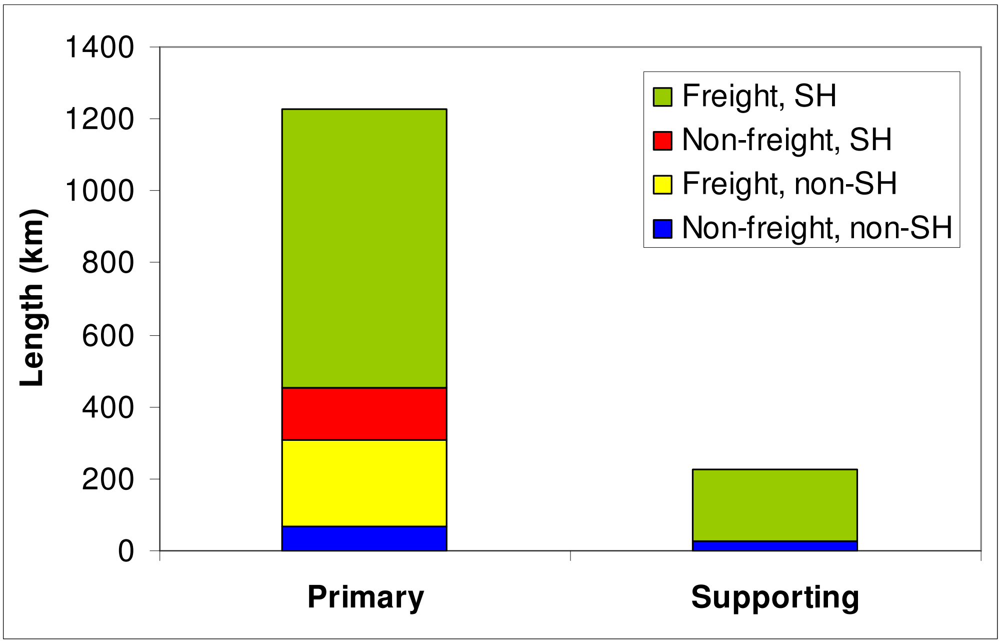

Figure 9: Attributes of proposed network

It makes sense that the key destinations for freight are similar to those for cycling, as both are developed to service the people living in or visiting an area. This is why the majority of the proposed regional cycle network coincides with the strategic freight network. It would be ideal to have two separate networks for freight and cycling but it is not possible to do this given the location of the freight network, the existing road network and the key destinations for cycling.

Few physically separated cycling facilities currently exist on the regional freight network. The provision of physically separated cycle facilities, in line with Policy 1.2.10 of the RLTS, would be a very time and resource intensive exercise. Intermediate solutions, such as road widening in strategic areas and pinch point reduction would be beneficial and would be the most cost-effective way of achieving a regional cycle network in the short to medium term.

3 Conclusions

This discussion paper has outlined a methodology employed to develop a proposed regional cycle network for Canterbury, which consists of primary routes supplemented by a supporting network of alternative routes. The cycle network was developed by assessing the utility of various routes according to traffic volume, width and bridge characteristics and selecting a network considered to most appropriately service the region's key destinations.

The location of Canterbury's strategic freight network was also taken into consideration. Due to the similarity between objectives of the freight and cycle networks and the characteristics of the region's road network, the majority of the proposed cycle network coincided with the freight network and also the state highway network.

The next step of this process is to present the proposed regional cycle network to a series of stakeholder workshops (in north, central and south Canterbury) to refine the methodology and add local knowledge and qualitative assessments to the selection of the network sections.

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Appendix 1: Deficiency criteria from Traffix (2006)

Criteria	RAMM	Site visit
The width of the outside traffic lane and the width of a (sealed) shoulder.	X	X
The traffic volume and the proportion heavy vehicles.	X	
The traffic speed and the set speed limit.	X	X
The carriageway surface (coarseness of chip or whether the road is unsealed).	X	
The route length and the length of various network elements.	X	
The road surface from inspection (maintenance and detritus removal).		X
The number of stops required (i.e. does the route have priority or not).		X
The horizontal road alignment (as a proxy for driver forward-visibility).		X
The vertical road alignment (i.e. how physically challenging is a route, and as a proxy for driver forward-visibility).		X
The attractiveness of a route (e.g. scenery, tourist icons along the route).		X
The availability of supplies and amenities.		X
Other observations from a site visit not yet listed.		X

Appendix 2: Hilliness criterion investigations

As mentioned in Section 2.4, the possibility and appropriateness of including a measure of hilliness as an assessment criterion was considered. Hilliness is a term used to express the vertical variability of a stretch of road but does not have a standard definition or method of measurement, thus several different ways of approximating the hilliness of a route were investigated.

The most appropriate hilliness measure that would be easy to understand and compute was considered to be the average absolute gradient (or slope). The standard deviation of altitude of points along a route was also considered as a measure but it was determined that this would not provide any more information than the average gradient measure and may not be as widely understood.

The gradient of points 100 m along each route was calculated from digital elevation models and averaged for each route. The absolute gradient was used to avoid the possibility of uphill and downhill gradients effectively cancelling each other out. This meant that uphill slopes and downhill slopes were classified in the same way but was considered acceptable, given that whether a slope is uphill or downhill depends only on the direction of travel and, for most regional routes, equal volumes of cyclists would travel in each direction. Thus a higher value of average absolute gradient represents a higher degree of hilliness.

Figure 10 shows the network classified according to a linear utility function for hilliness. However, it is considered that the hilliness function should not actually be linear as many cyclists would prefer slightly hilly routes or even very hilly routes over flat ones.

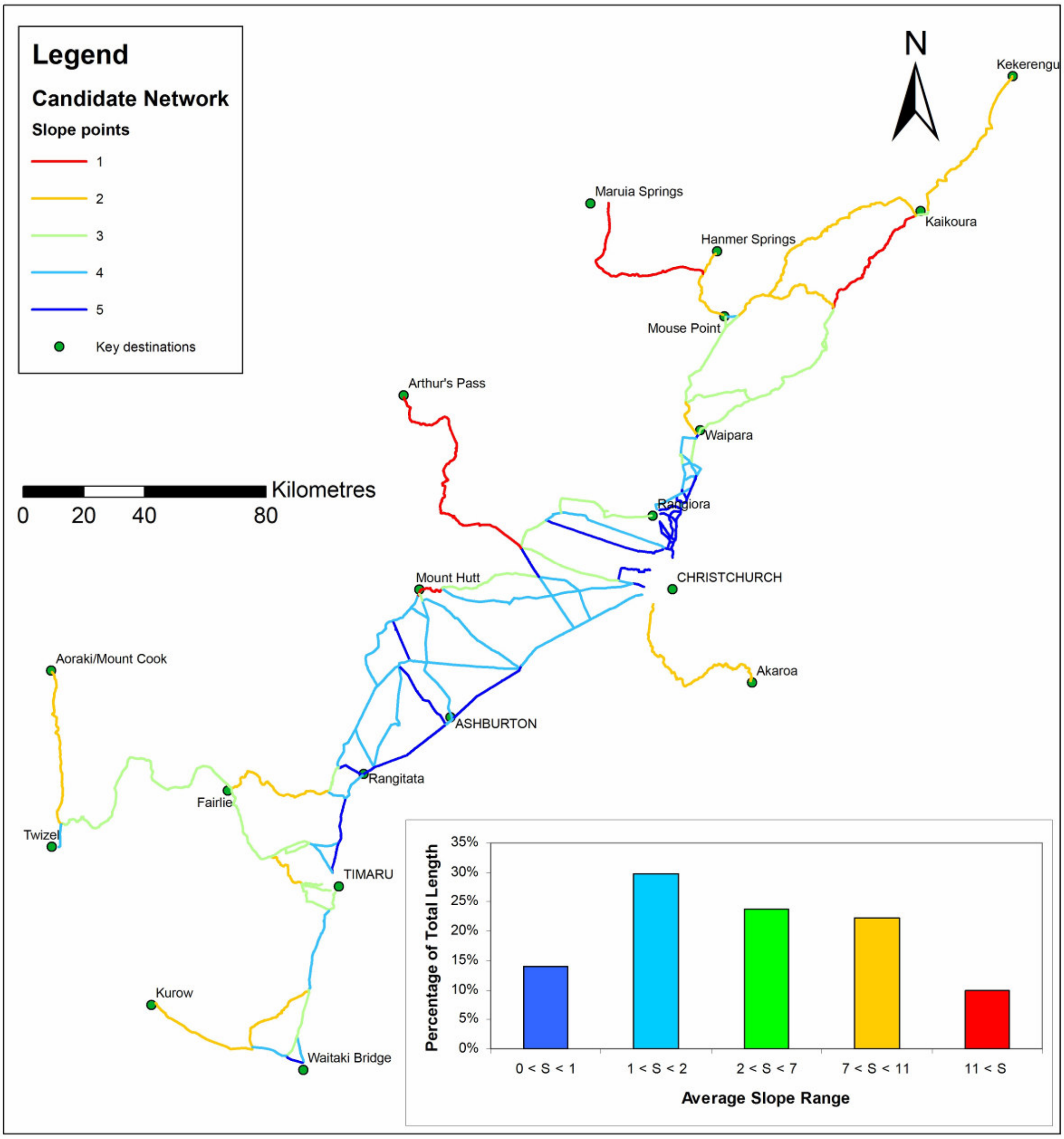

Figure 10: Potential hilliness criterion distribution