Cycling demand analysis

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Abstract

This report explores the data collection, analysis methods and results of a Wellington City Council cycling survey carried out between March and June 2014. Using latent class logit modelling, collected data is analysed to determine the trade-offs and cycleway features that most influence the decision to cycle in Wellington. In addition, the potential demand for the proposed Island Bay to city cycleway is assessed using this model, including prompted indications of cycling frequency. The results indicate excellent demand potential when the features of the cycleway are tailored to the needs of the population – who are overwhelmingly safety-conscious.

About the authors

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Tom Pettit is a Wellington City Council researcher who is co-funded by the City Council and the Resilient Urban Futures programme led by the New Zealand Centre for Sustainable Cities, University of Otago Wellington. The Resilient Urban Futures programme is funded by a grant from the Ministry of Business, Innovation and Employment.

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Introduction

This research, conducted between March and June 2014, investigates how providing different types of cycling infrastructure (lanes or other safety improvements) is likely to affect the numbers of people choosing to cycle in Wellington City, New Zealand. The research objectives were to:

- assess the relative importance of different attributes of cycling infrastructure for current and potential cyclists, such as route directness, slope, and route type
- assess the demand for cycling infrastructure improvement among current and potential cyclists
- assess the potential increase in cycling given the hypothetical construction of cycling routes in Wellington City, particularly the Island Bay to city cycle route.

Executive summary

Wellington City Council has been evaluating options to create a cycleway between Island Bay and the CBD as a demonstration project for the 20-route cycleway network it is proposing to eventually make the city more cycle-friendly, less congested, and perhaps most importantly, safer for all road users. A variety of information is required to determine what cycling infrastructure is most appropriate – ranging from possible engineering solutions to community desires.

The Council also wanted to assess the potential demand on this route and what barriers there may be to achieving that potential. To assess what infrastructure should be built, demand projections were produced for 11 potential options (some proposed by the community and some proposed by engineers). This report details the methodology used to produce those numbers, as well as the results.

The research showed:

1. Cycleways which physically separate people on bikes from other road users and potential risks (moving cars, pedestrians and the doors of parked cars) will encourage more people to consider cycling than either shared spaces or cycle lanes that are created by simply painting a line or lines on the road. The effect of this is substantial, with physical separation doubling potential growth. This effect is relevant broadly across the city – both for the specific routes in Island Bay and as further cycle routes are investigated.

2. There is a strong preference for routes that are relatively flat and direct (or at the very least not too hilly). This is because most people who say they would consider cycling aren't just looking at commuting by bike to get exercise – a safe route that is convenient for any purpose is desirable.

3. If an ideal route is chosen, cycling numbers nearly triple. Even more growth is possible if just a few of the people who don't own bikes were to buy or be provided with one.

4. The chief barriers to cycling in Wellington City are a lack of safe cycle infrastructure and concern about drivers. Nearly 50 percent (including residents who do not cycle) either said they would

consider cycling if drivers were more considerate, or that the fear of motorists driving unsafely put them off cycling.

5. Across the city, 76 percent of the population over age 18 would consider cycling in some circumstances if safe, separated infrastructure was provided – whether for recreation, errands or commuting.

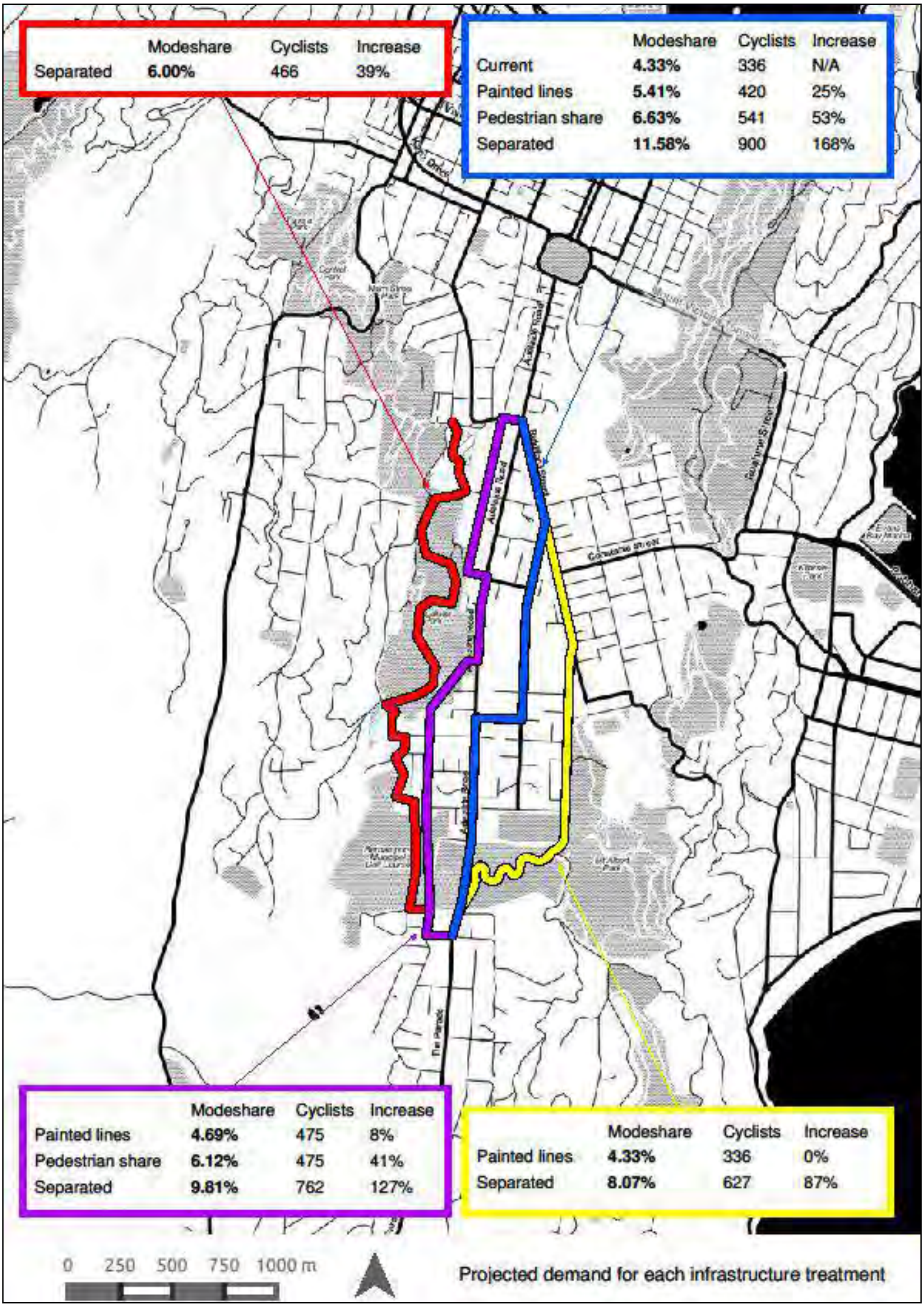
6. Significant support is noted for cycle infrastructure – more than 75 percent support the development of cycleways, including many non-cyclists. However, that strong support is dependent on what trade-offs are proposed. Removing parking on one side of the road, making more streets one-way and using Town Belt space is very well supported. That said, the research shows most people would oppose removing parking on both sides of the road.

7. Specifically in Island Bay, about 60 percent of cycleway area residents would cycle on the road for any purpose during a given year (up from 39 percent today) – and as many as 11.5 percent of trips would be made by bike (up from around 4.5 percent) – if good quality cycling infrastructure was provided on a convenient route.

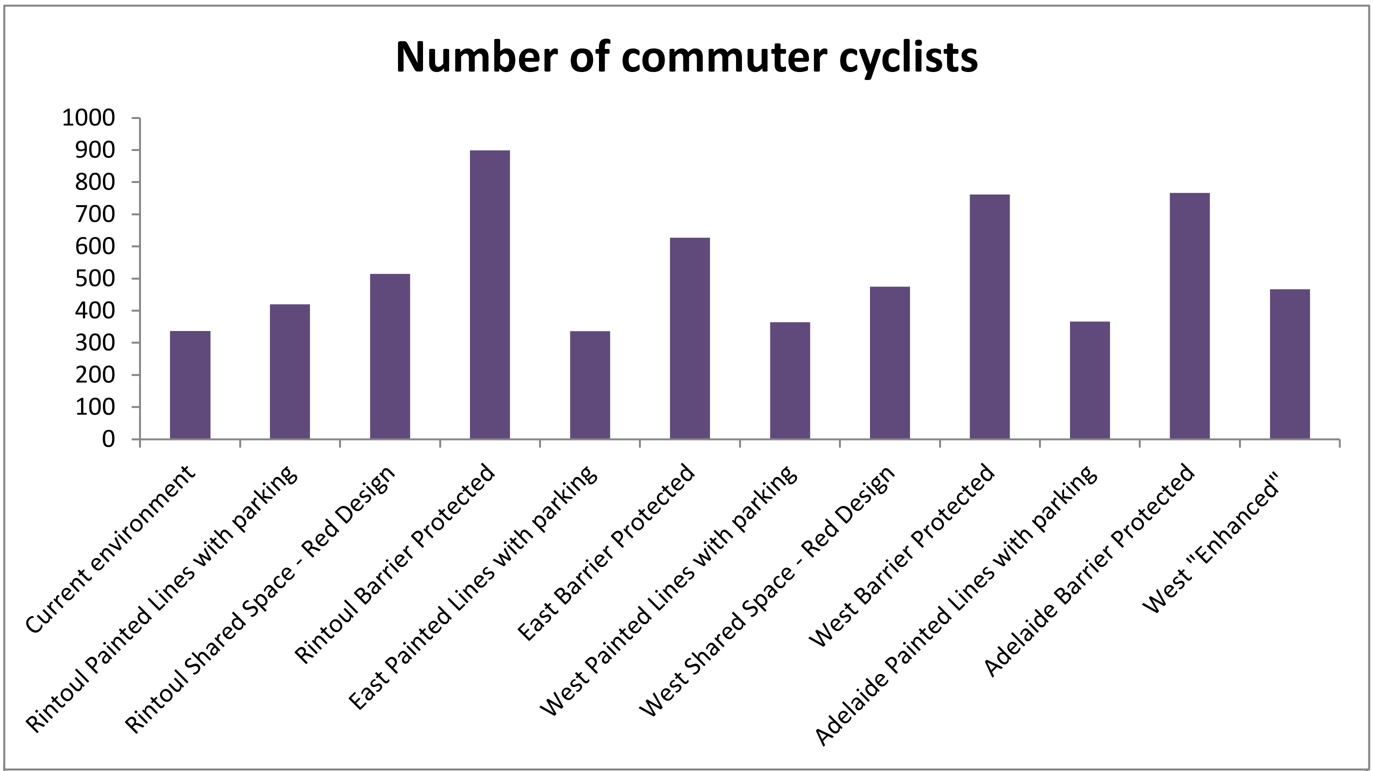
8. Significant opportunity exists for programmes that provide bicycles for those who wish to cycle but do not own one – innovative ideas along the lines of those recently proposed in Sweden, where free bikes are provided for six months, and France, where people are paid to cycle to work, present intriguing options. These programmes could be very successful at increasing cycling. However, it is important to note that these programmes would likely only make a significant impact once cycleways have been built.

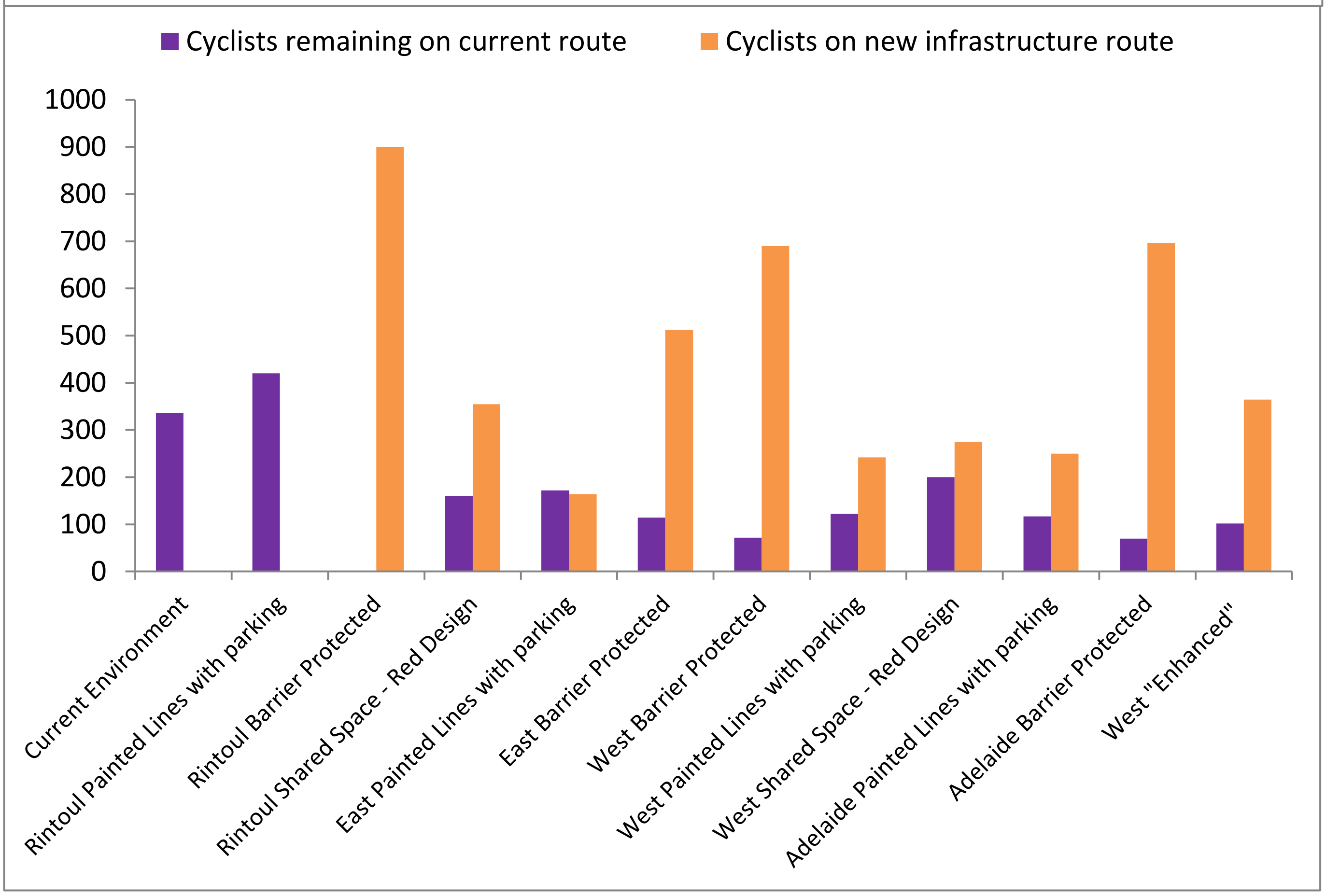
For suburbs south of Berhampore –

map of routes with number of commuter cyclists

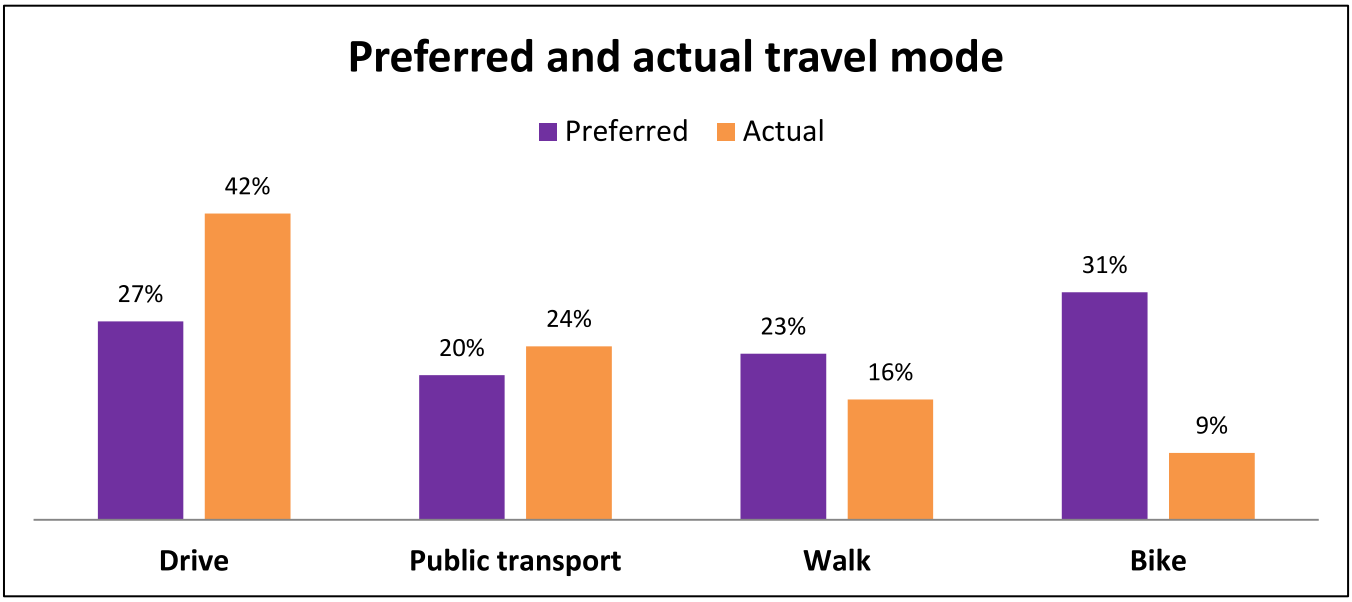


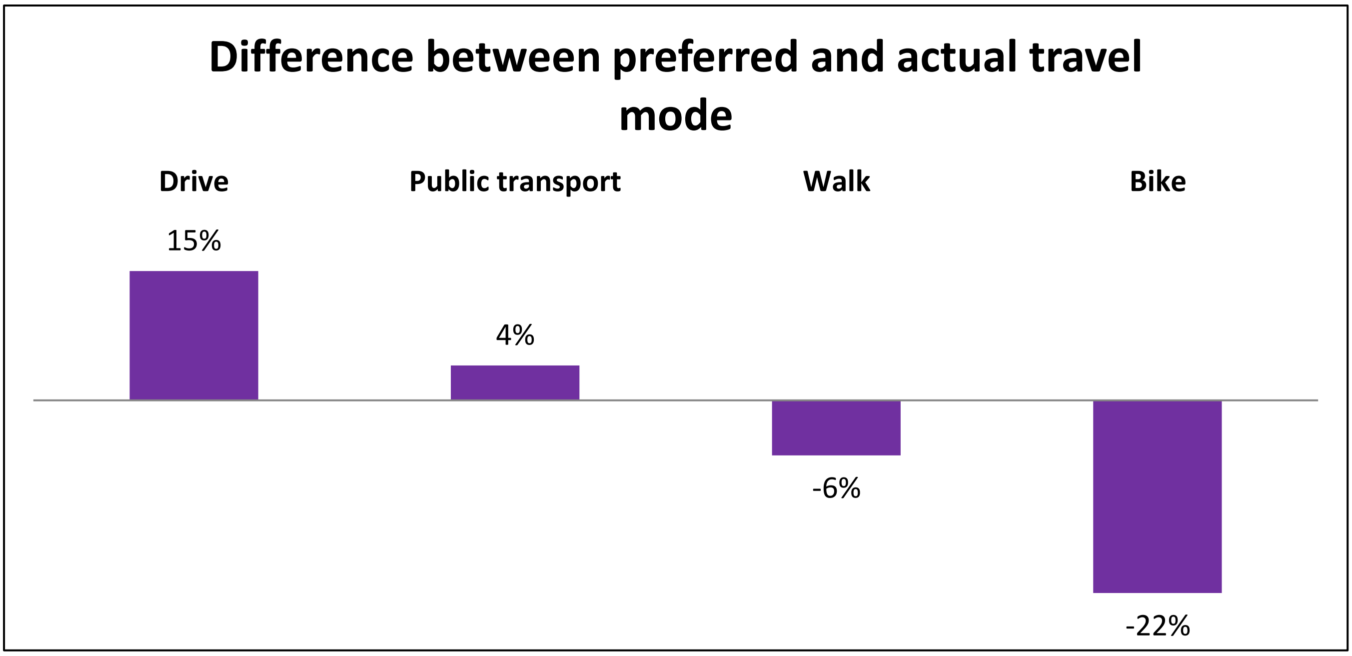
For suburbs south of Berhampore – charts of number of commuter cyclists





Travel modes among all respondents





*Positive values indicate more individuals taking that mode than would prefer to. Negative values indicate fewer people than would like to take that mode are able to. For example, 22 percent of the city's population would like to bike, but currently use another method to get to work for one reason or another.

Survey distribution

A web-based survey, consisting of a stated choice experiment and general questions regarding attitudes towards cycling, was distributed to Wellington residents between April and May 2014. The survey was distributed using a two-stage design method; the first stage was distributed to an email list of 850 people, while the second stage was distributed to an email list of 800. The two-stage design method allowed preliminary results from the first stage to be completed at an earlier date, and also allowed the results from the first stage of the survey to be used to refine the design of the second stage of the survey.

We received a total of 358 completed responses for stage one, a response rate of 40 percent. Relative to the population of Wellington City, the sample over-represented high-income groups, females and those over the age of 35, and under-represented males, low and medium income groups and those under the age of 35. The sample was weighted to correct these imbalances as much as possible by using sampling weights. However, the imbalances could not be completely corrected due to a shortage of low-income males in the sample group. The demographics of the Wellington City population were obtained from the 2013 Census. The age, gender and income profiles of the unweighted sample, the weighted sample, and Wellington City are shown in figures 1-3.

Figure 1: Gender distribution

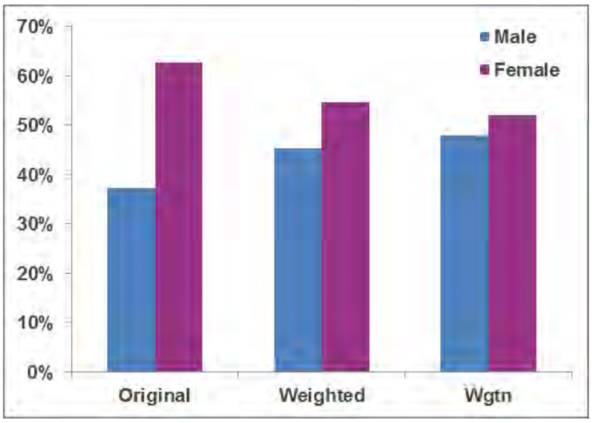


Figure 2: Individual (not household) income distribution

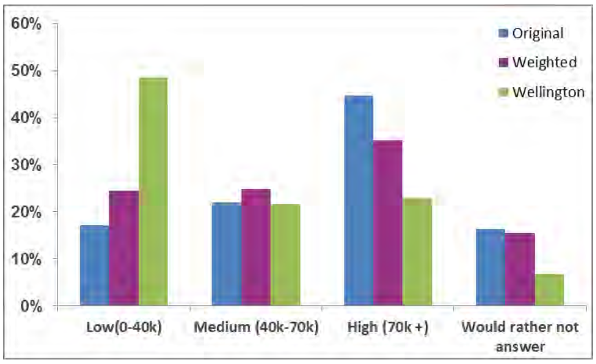
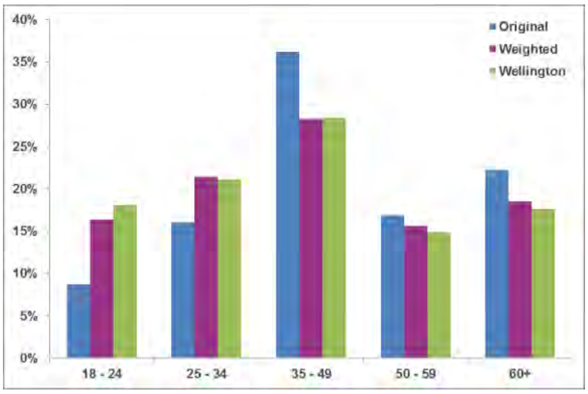


Figure 3: Age distribution



Stage two of the survey was completed by 245 people, a response rate of 30 percent. Similar weighting has been conducted on the second stage data, but the data has only been recently collected. As a result, these responses are excluded from this analysis *except* for the level of support expressed by residents along the route for cycling infrastructure improvement and/or compromises to be made to make space for such infrastructure. Additionally, the demand calculations are verified by running the second stage through the model, but the second stage does not inform the class information. The survey is available to any member of the public at: http://tinyurl.com/WellyCycleStudy. Responses from the general public will not be used.

About Our Capital Views panel

The Council has a research panel of more than 900 people called Our Capital Views, established in 2013, which was used for stage one of the survey. Our Capital Views' main purpose is to provide responses to the Residents' Monitoring Survey, which tracks Council performance in a variety of areas on an annual basis. The Council requires a high response rate and high degree of confidence in responses, so it established Our Capital Views to address this need.

The panel is designed to be demographically representative of the city in terms of age, gender and where people live (by electoral ward). Survey samples are not necessarily representative but results are weighted to match the above demographics according to Census figures. The majority of the Council's research panel members were recruited using a third party research firm. Ongoing recruitment is conducted to fill gaps in the demographic representation.

The key characteristic of Our Capital Views is that, unlike other panels, both internal and external to Wellington City Council, none of the panel members were self-selected.

Research methods

Latent class multinomial logit modelling was the method used to estimate the relative importance of different attributes of cycling infrastructure for current and potential cyclists; the demand for cycling infrastructure improvement among current and potential cyclists; and the potential increase in cycling given the hypothetical construction of cycling routes in Wellington City. Latent class analysis is a type of multinomial logit modelling that allows for the identification of market segments as a means of accounting for the heterogeneity of preferences across the population. Unlike other methods, it is not dependent upon a pre-defined specification of preferences. Instead, class membership and class profiles are determined by respondents' choices and/or behaviour, and may also include other individual level characteristics such as demographics (Greene & Hensher, 2003; Louviere, Hensher, & Swait, 2000). In latent class analysis, class membership is not assumed to be known and is instead treated as probabilistic (Walker & Li, 2007).

Latent class analysis may be based either on data collected in a stated-choice experiment or from observed real-world behaviour. A stated-choice experiment is the preferred method when the research subject is one that is not widespread in the current marketplace, as the method excels in evaluating products that do not yet exist in the market.

A stated-choice experiment consists of hypothetical choices, with varying attributes, that the respondent is asked to choose between. Constructing a stated-choice experiment involves selecting the attributes which are the most salient to influencing choice behaviour and are, to the greatest extent possible, mutually exclusive, exhaustive and finite in number (Louviere et al., 2000). However, these priorities must also be weighed against the cognitive burden placed on respondents; the complexity and length of the survey must be minimised to ensure people are prepared to participate and provide accurate responses.

In the current study, respondents were asked to choose between two hypothetical cycle routes, or a third option, 'Would not cycle or would use another route'. Cycle routes varied according to five attributes: facility type, road type, slope, the presence of on-street parking and directness (expressed in minutes). These attributes were chosen as they are likely to be the most influential in the choice to cycle, and are aspects of a cycle route that organisations like the Council can factor in when they plan and construct new cycleways. The levels for each of the attributes are shown in Table 1.

Table 1: Attributes used in choice experiment

Time	Slope	Facility Type	Parking	Road
12 minutes	Flat	None	Barrier Protected	Quiet / Residental Road
15 minutes	A Few Gentle Hills	Painted Lines	No Parking	Not busy / Local Road
18 minutes	Short Steep Sections	Barrier Protected	On-street Parking	Busy / Arterial
25 minutes	Long or Very Steep Sections	Fully Segregated		Very Busy / Main Arterial

Each respondent was asked to answer 12 choice questions. The experiment design was created using the efficient design method (Rose & Bliemer, 2009). Efficient design methods use previous knowledge about the values of attributes to design more efficient choice questions, and so are able to decrease sample size requirements and/or increase the reliability of parameter estimates. Prior information about the values of attributes was obtained from a pilot distribution of the survey completed by Wellington City Council employees. For the second stage, the prior information was derived from analysis of first-stage respondents. The D-error criterion was used to determine choice tasks, as it is considered the most appropriate criterion when designing a stated choice experiment that will be used to model market segmentation (Kessels, Goos, & Vandebroek, 2006; Rose & Bliemer, 2009).

Each choice was accompanied by a pictorial and written description. The picture accompanying each choice varied according to facility type, parking and road type, while all other elements of the picture were kept constant.

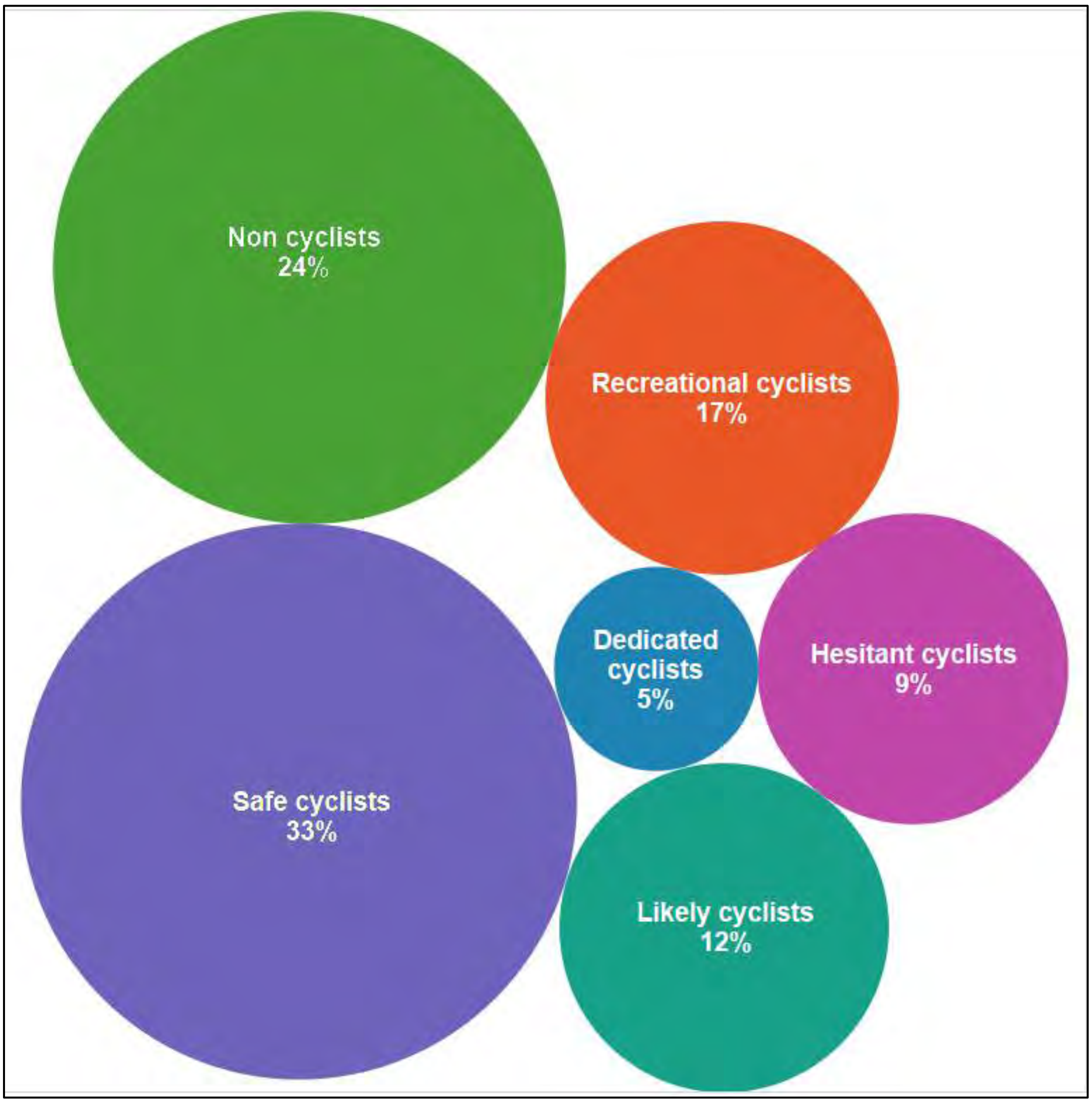
Figure 4: Example of a stated choice task

	A	B
		
Travel time	12 minutes	15 minutes
Slope	Flat	Flat
Cycleway type	Barrier protected	Fully separated
Road type	Busy / arterial	Busy / arterial

Results

The responses from the stated choice experiment were used to construct a latent class multinomial logit model of cycling preferences among Wellington residents. A six-class, latent class model was identified as the best model, as measured by the normalised BIC (Bayesian Information Criterion) (Nylund, Asparouhov, & Muthén, 2007). Figure 5 shows the relative size of each class. A summary of the preferences and demographic characteristics of each class follows.

Figure 5: Size of modelled classes



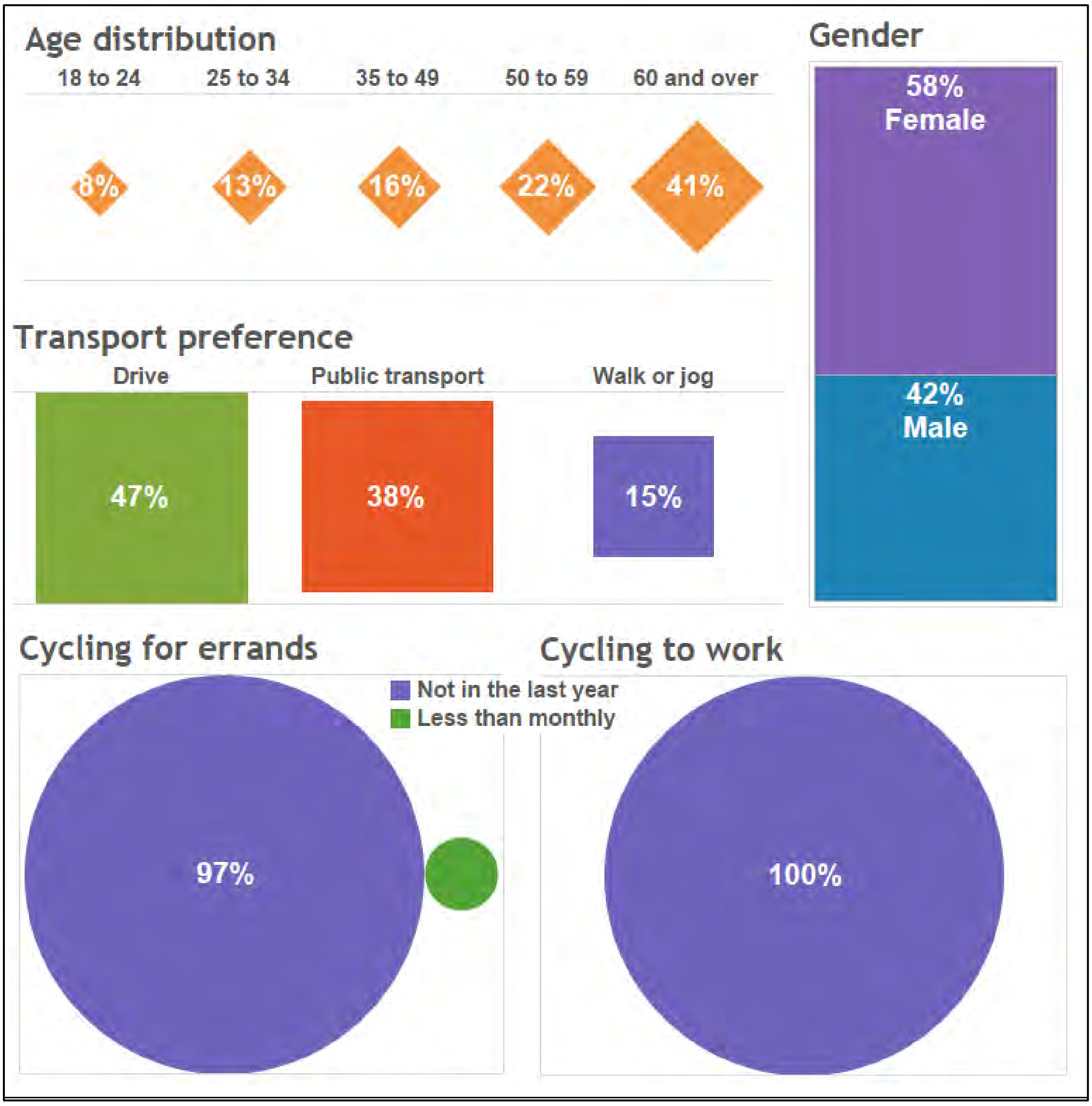
About each class

Non-cyclists

Non-cyclists represented 24 percent of the weighted sample. This is the only group that is highly unlikely to ever consider cycling, regardless of what infrastructure improvements are made. Ninety-seven percent of the group has not cycled in the past year for any purpose, and only 2.2 percent of the class would consider cycling more often if cycling infrastructure was improved.

Compared with the whole sample, non-cyclists are more likely to be over the age of 50 and prefer to commute to work by public transport or private vehicle.

Figure 6: Characteristics of non-cyclists



Hesitant cyclists

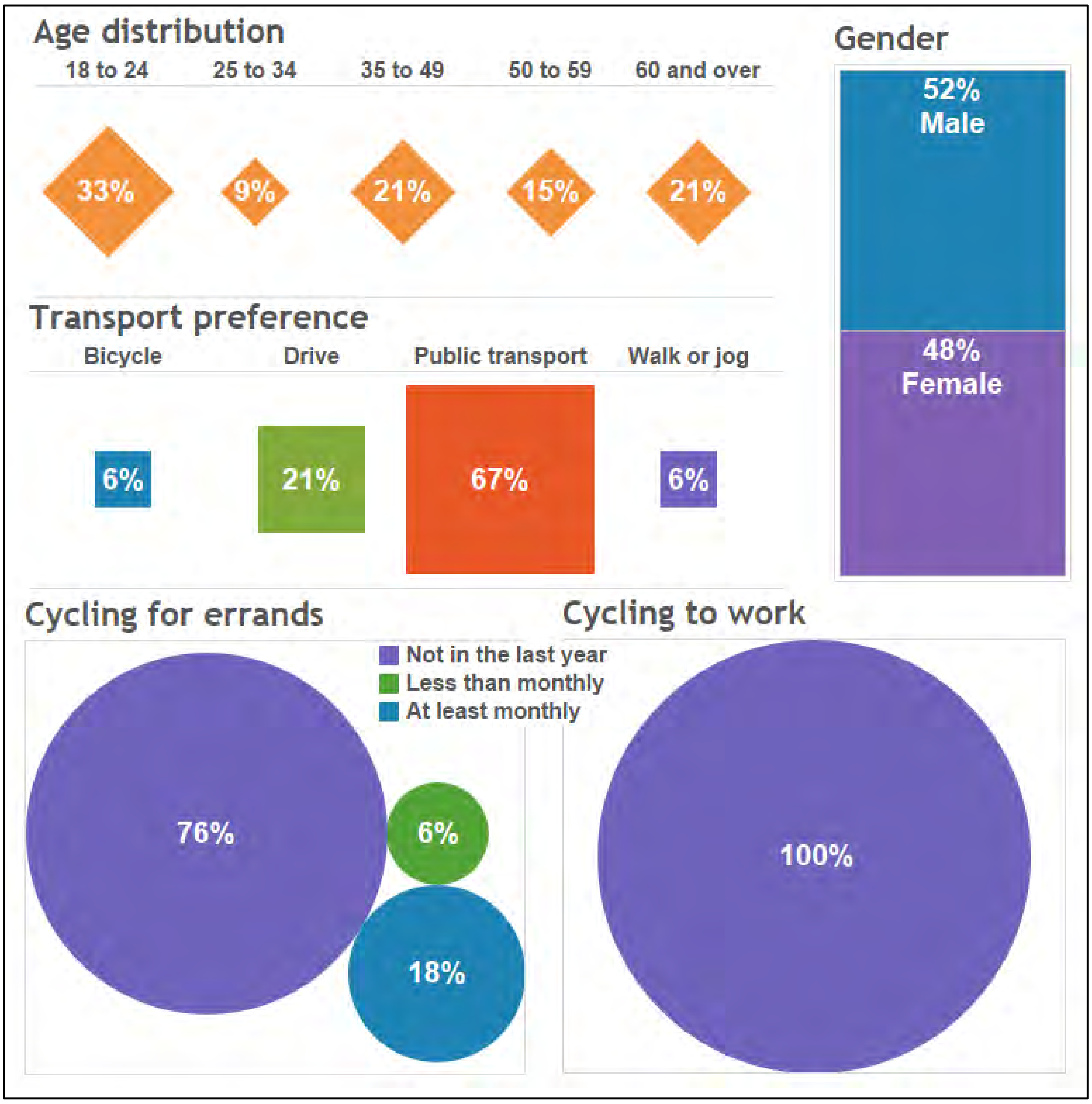
Hesitant cyclists represented 9 percent of the weighted sample. Hesitant cyclists are very unlikely to cycle under current cycling conditions; 25.4 percent have cycled for errands in the past year but none (0 percent) have cycled for commuting purposes. They are much more likely to cycle under ideal cycling conditions; 62 percent would cycle at least once a year under ideal conditions[1]. However, even under ideal conditions, they would still be unlikely to cycle on a weekly basis or for commuting purposes.

For hesitant cyclists, slope is by far the most important aspect of a cycle route, and members of the group will be very unlikely to cycle if the route has either short or long steep sections. The next most important elements are directness and road type. Facility type and parking have little to no importance for this group.

Compared with the general population, hesitant cyclists are more likely to be either under 25 or over 50 and to prefer to commute to work using public transport or private vehicle.

[1] Ideal cycling conditions were defined as: flat, fully segregated from traffic, and the shortest possible on-road route between two points.

Figure 7: Characteristics of hesitant cyclists



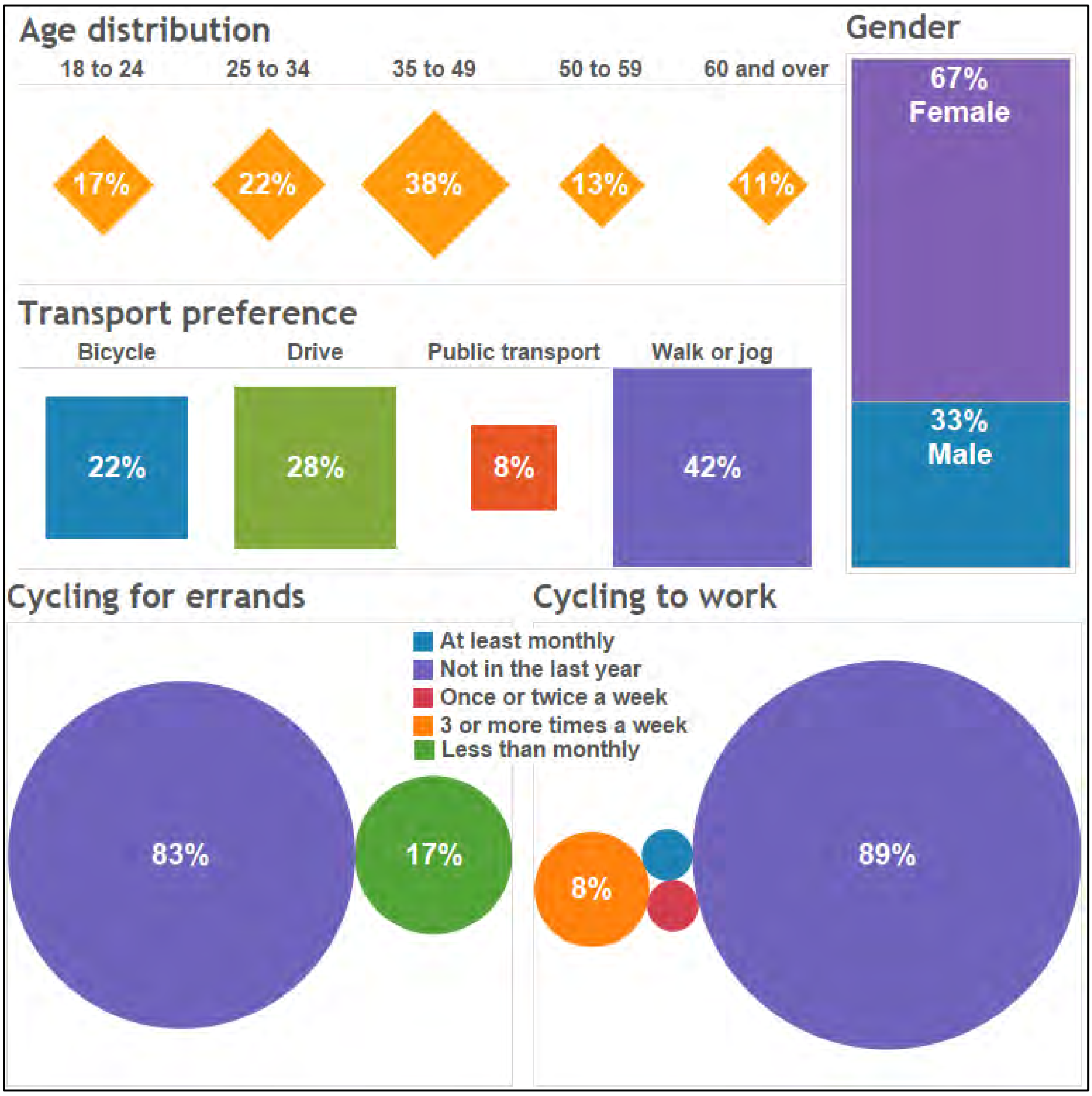
Recreational cyclists

Recreational cyclists represented 17 percent of the weighted sample. They are much more likely to cycle for recreational rather than transport purposes; in the past year 11.4 percent have cycled for commuting purposes and 37.4 percent have cycled on-road for recreation. Providing cycling infrastructure has a very strong influence on recreational cyclists' choice to cycle; although less than half currently cycle, 96 percent say they would cycle under ideal conditions. Although almost all would cycle under ideal conditions, they would cycle less often than certain other groups.

For recreational cyclists, slope is the most important cycleway element. Flat or gentle hills are preferred and the group will be unlikely to cycle if there are long or very steep sections. The next most important element is facility type, with barrier-separated and fully segregated lanes being viewed positively, painted lines neutrally, and no facility very negatively. Parking and time are relatively unimportant to this group.

Compared with the general population, recreational cyclists are more likely to be between the ages of 25 and 49, female and prefer to commute to work on foot or by private vehicle.

Figure 8: Characteristics of recreational cyclists



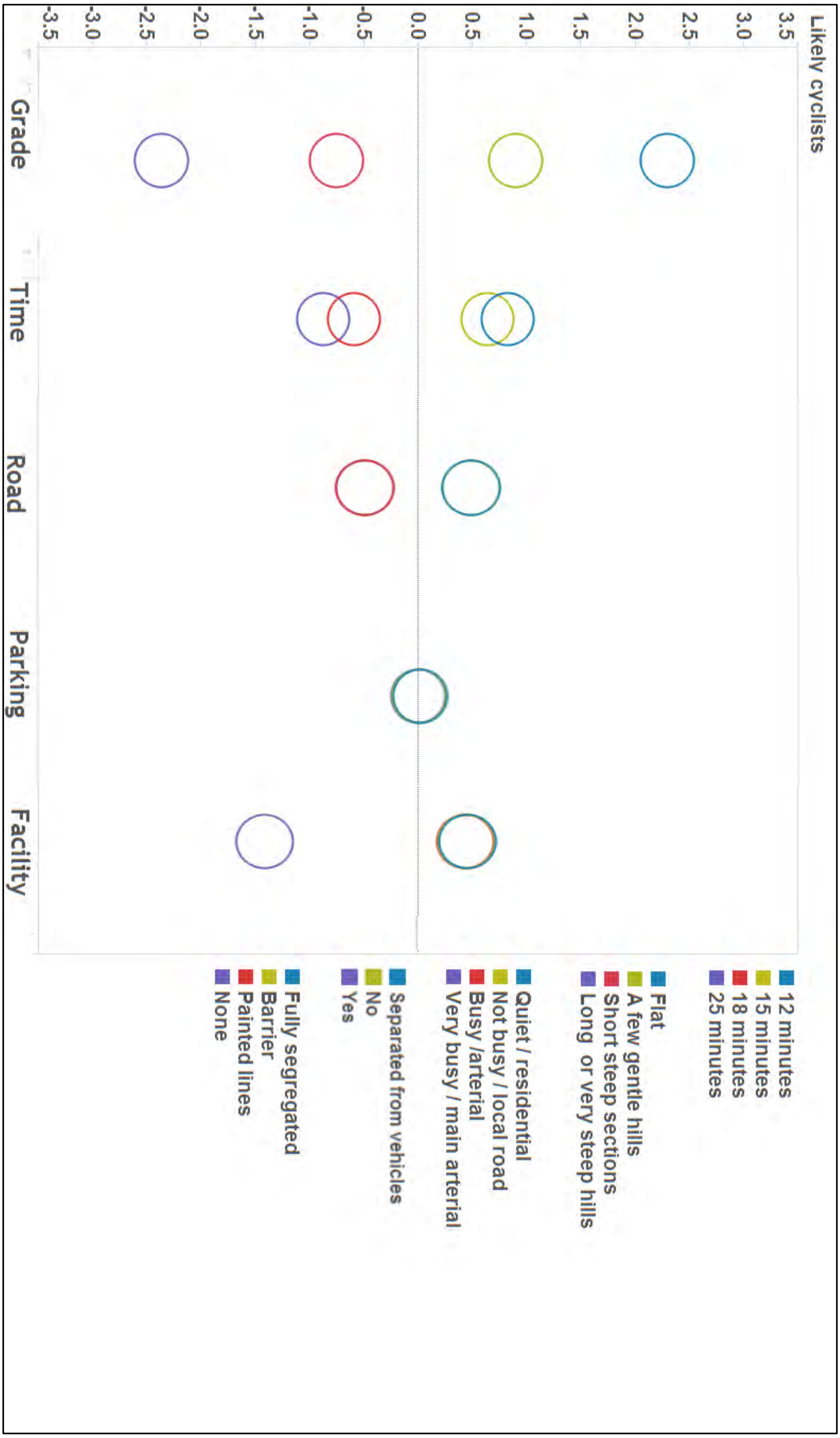
Likely cyclists

Likely cyclists represented 12 percent of the weighted sample. Likely cyclists are people who are likely to cycle under current cycling conditions provided they have access to a working bicycle; 24.4 percent have cycled for errands in the past year and 28.5 percent have cycled for commuting purposes in the past year. However, a larger percentage of the group would cycle, and many would cycle more often, if infrastructure was improved. They are more likely to cycle for transport rather than for recreation; only 18.2 percent have cycled on-road for recreation, while 29 percent have cycled for commuting purposes in the past year. For this group, lack of access to a working bicycle is also a key barrier to cycling; 34.5 percent would cycle more often if they had access to a working bicycle.

For likely cyclists, slope is the single most important factor when choosing a cycle route, followed by road type and directness. With regards to slope, flat and gentle hills are preferred, while short steep sections are viewed negatively and long or very steep sections are viewed even more negatively. Painted lines, barrier-separated and fully segregated lanes are viewed positively, while 'no facility' is viewed negatively. With regards to time, 12 minutes is preferred followed by 15 minutes, while 18 minutes is viewed negatively and 25 minutes is viewed very negatively. Road type is relatively unimportant in the choice of cycle routes, although residential and local roads are preferred over busy or very busy roads.

The following page details the preferences of likely cyclists in relation to certain attributes of a cycle route according to the five factors we assess – grade, travel time, road type, parking, and facility. Aspects are assessed based on their relative utility within the model. These aspects are also included for safe and dedicated cyclists, and they are considered the "target" population most likely to cycle. Strongly positive attributes indicate a strong preference for that feature, while strongly negative ones indicate the potential that the particular feature is a barrier for that type of cyclist.

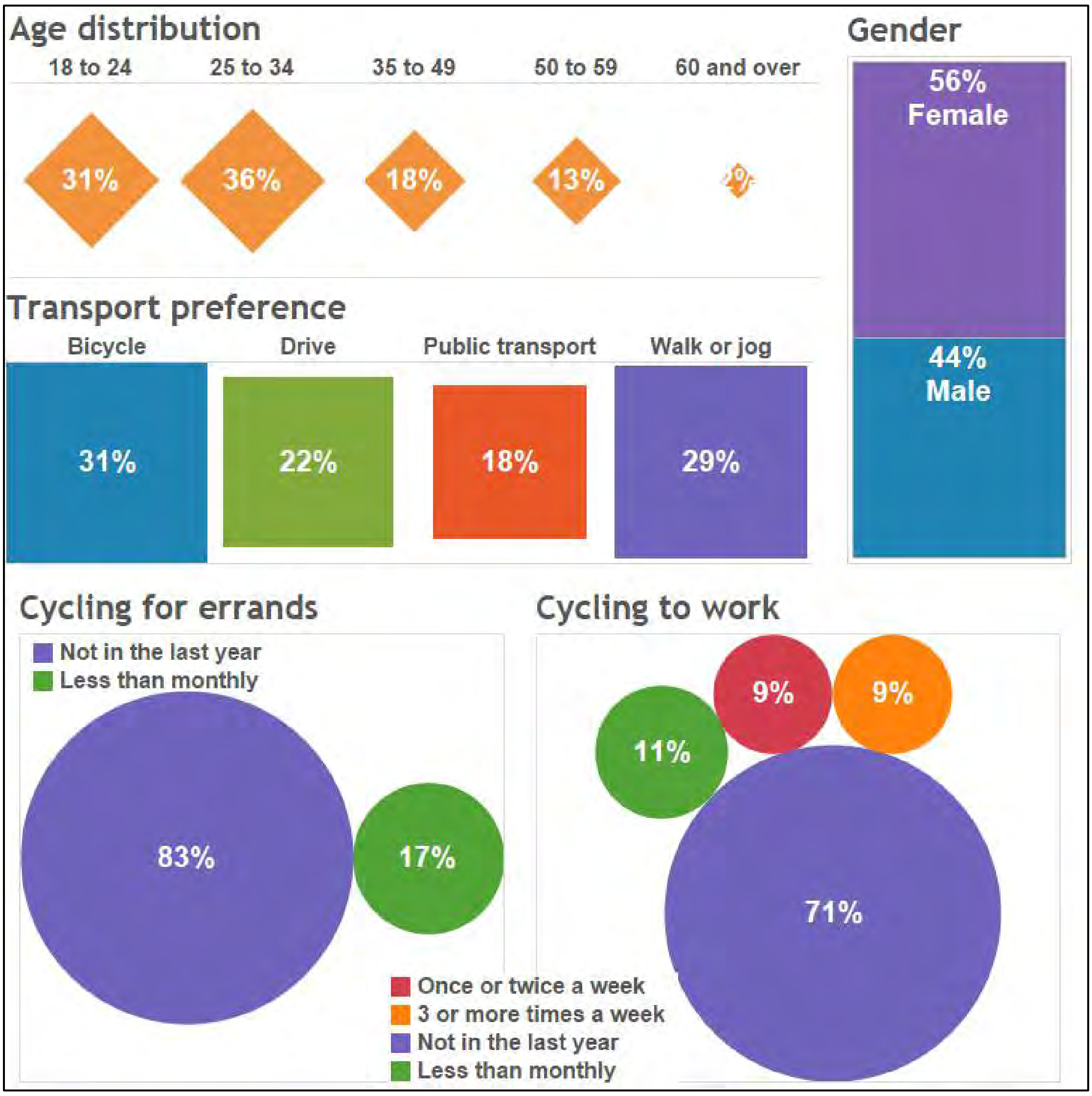
Figure 9: Importance of route attributes to likely cyclists



While cycling infrastructure would modestly increase the percentage of the likely cyclists group who cycle, it has great potential to increase how frequently the cyclists in the group choose to bike. Ninety-one percent would cycle under current conditions and 99 percent would cycle under ideal cycling conditions. If cycling infrastructure was improved, 76.5 percent of likely cyclists would cycle more often, with many cyclists moving from riding less than monthly or monthly, to weekly.

Compared to the general population, likely cyclists are more likely to be 18 to 34 and prefer to commute to work by bike or on foot.

Figure 10: Characteristics of likely cyclists

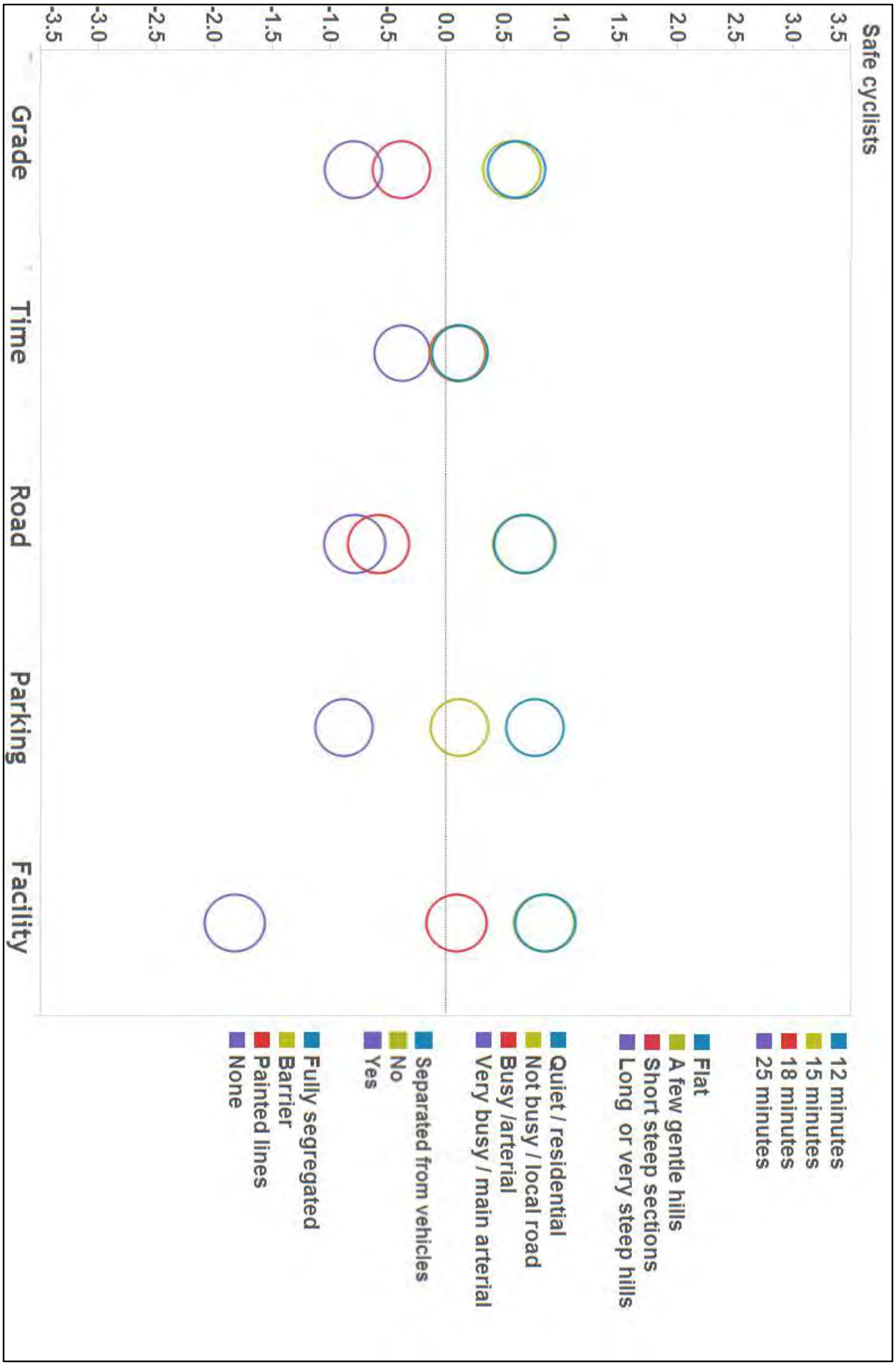


Safe cyclists

Safe cyclists were the single largest group in this study, representing 33 percent of the weighted sample. They also represent the largest portion of individuals who will likely start cycling if cycling infrastructure improvements are made. As a group, they are strongly oriented towards cycling and already have substantially higher levels of cycling than the general population. In the past year, 40.1 percent have cycled for commuting purposes and 56.8 percent have cycled on-road for recreation. However, as a group they would prefer to cycle more often than they do currently. Only 56 percent would cycle under current conditions, while all of them (100 percent) say they would cycle under ideal conditions. Additionally, cycling infrastructure improvements would also encourage current cyclists in the group to cycle more frequently with many current cyclists moving from riding less than monthly or monthly, to weekly.

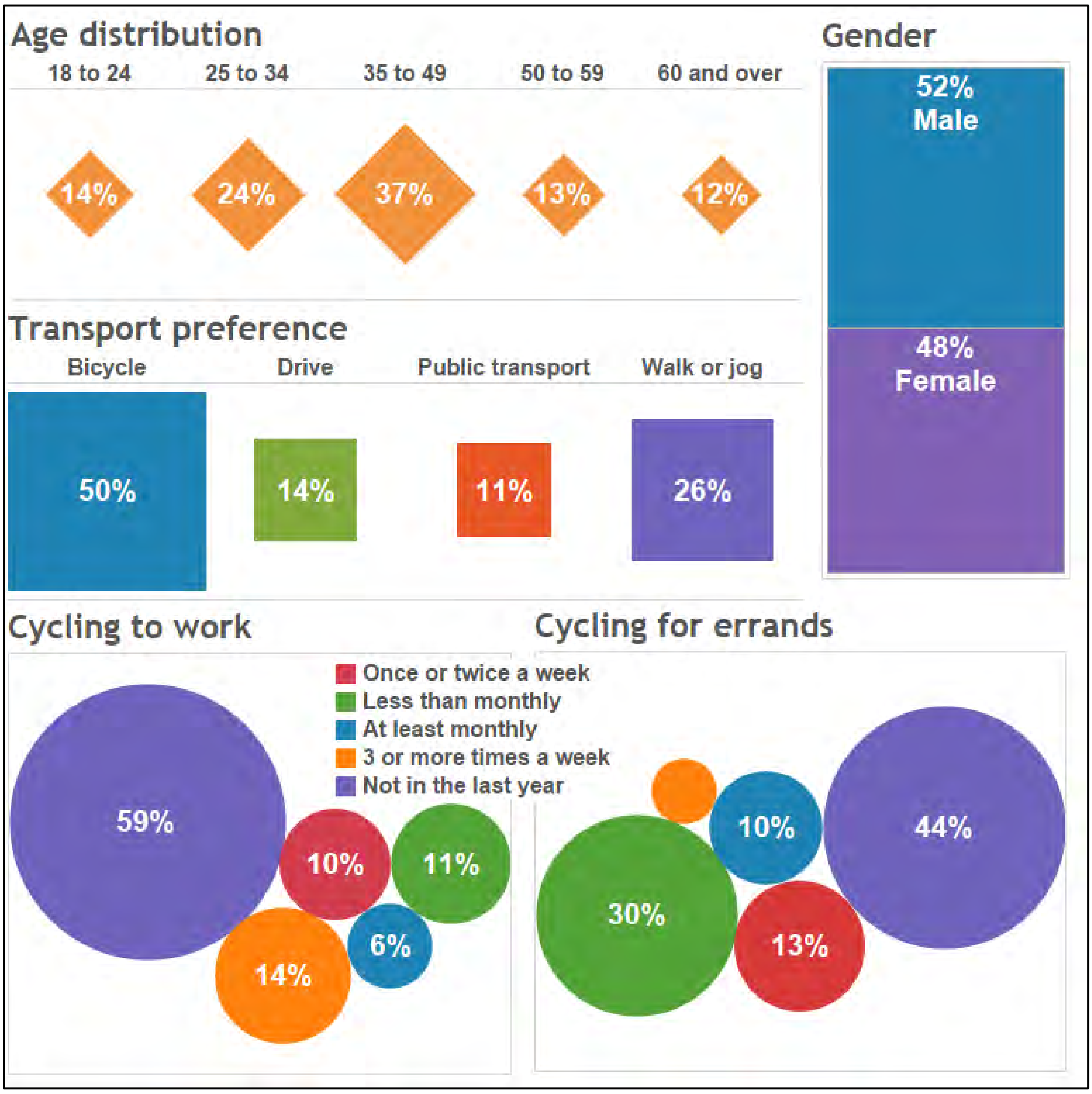
When choosing a cycling route, safety-related factors are the most important for this group. The type of cycling facility is the single most important consideration, followed by the presence of on-street parking. Both barrier-separated and fully segregated lanes are viewed very positively, while painted lines are viewed slightly positively. Having 'no facility' is viewed very negatively and significantly reduces the likelihood of members of the group choosing to cycle. With regards to road type, quiet and not busy roads are preferred, while busy roads are viewed negatively and very busy roads even more so. With regards to slope, flat and gentle hills are preferred, while short steep sections are viewed negatively and long or very steep sections are viewed even more negatively. For safe cyclists, route directness is relatively unimportant; 12-minute, 15-minute, and 18-minute routes were all viewed equally positively, while 25-minute routes are viewed slightly negatively. When considering all cycle route attributes, the group is highly likely to choose the route that provides the highest level of segregation from traffic and parking.

Figure 11: Importance of route attributes to safe cyclists



Compared with the general population, safe cyclists are more likely to be between 25 and 49, female and prefer to walk or bike to work.

Figure 12: Characteristics of safe cyclists



Dedicated cyclists

Dedicated cyclists represented 5 percent of the weighted sample. They are dedicated to cycling regardless of circumstances; all of them (100 percent) would cycle under current conditions. Lack of access to a working bicycle is the main barrier with 34 percent saying they would cycle more often if they had access to a working bicycle.

When choosing a cycle route, directness is the single most important factor for this group. Unlike other groups, cycling infrastructure will not increase the likelihood they would cycle more often. This means new cycleways would not increase cycling rates for this group, as it is very unlikely that they could be encouraged to cycle more often. Dedicated cyclists will always cycle if there is a direct route available, regardless of other factors. They have a slight preference for cycleway infrastructure and view fully segregated lanes, barrier-separated lanes and painted lines equally positively while viewing ‘no facility’ negatively. With regards to road type, quiet and not busy roads are preferred, while busy roads are viewed negatively and very busy roads even more so. With regards to slope, flat and gentle hills are preferred, while short steep sections are viewed negatively and long or very steep sections are viewed even more negatively. Compared with the general population, dedicated cyclists are more likely to be male, much more likely to be between 25 and 49, and prefer to commute by bike.

Figure 13: Importance of route attributes to dedicated cyclists

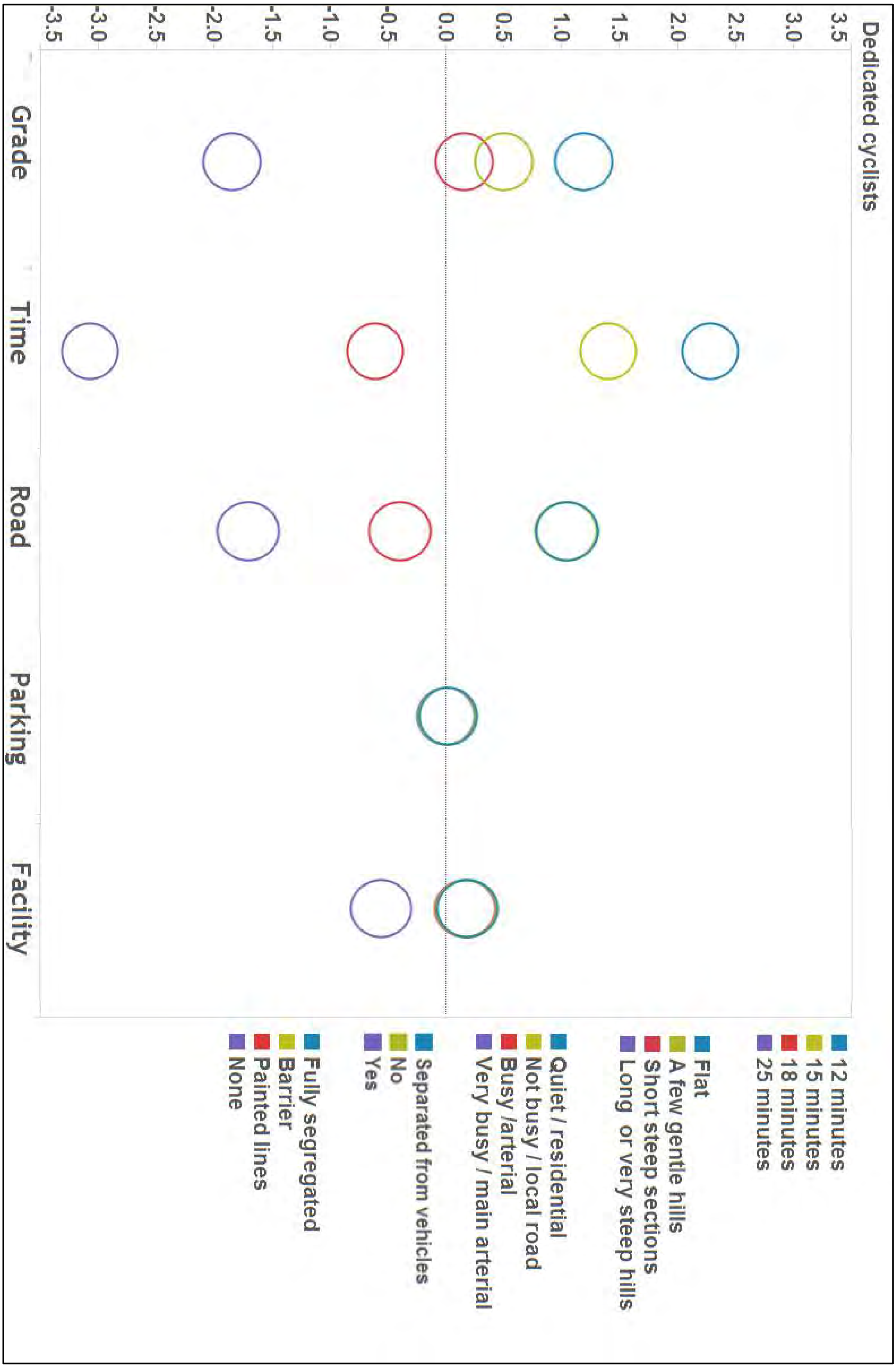
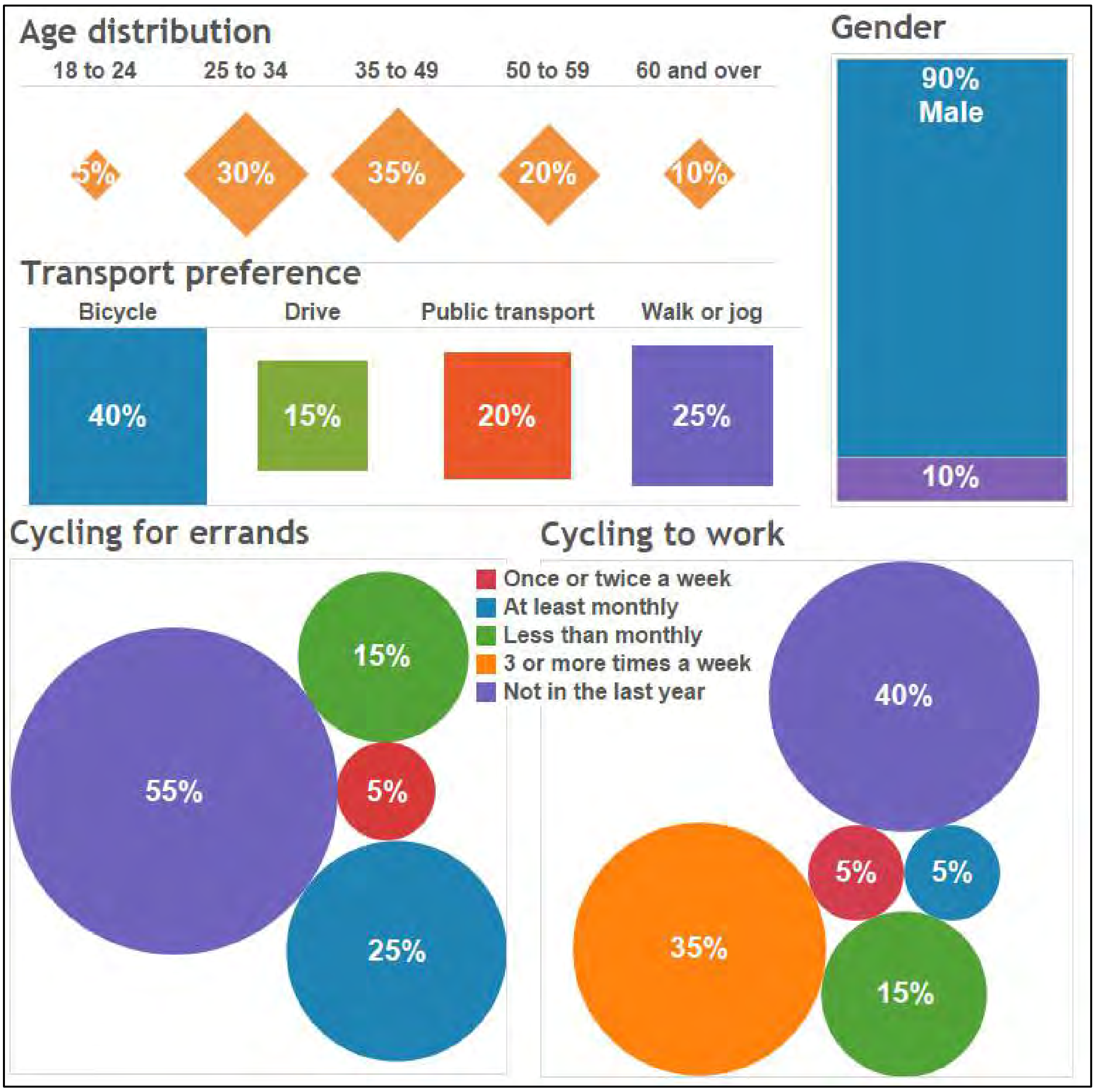


Figure 14: Characteristics of dedicated cyclists



Modelling hypothetical scenarios

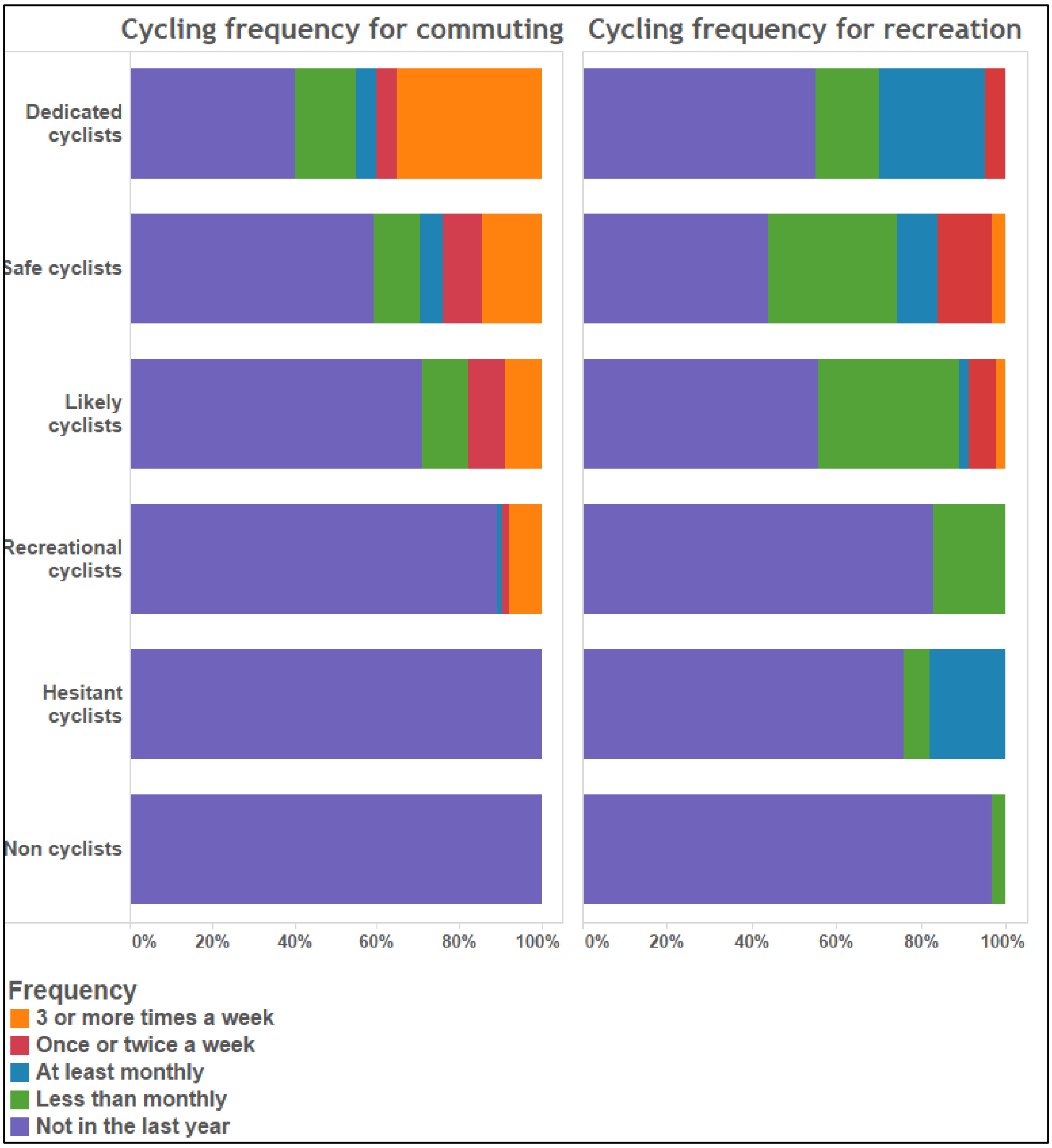
The latent class model was used to model cycling behaviour under 12 cycling route scenarios. One represented the current cycling conditions from Island Bay to central Wellington, while 11 others represented the hypothetical construction of different types of cycling infrastructure improvements along the same corridor. In each of these 11 scenarios, there was a choice of three options: a cycle infrastructure improvement, the current cycle infrastructure, or would not use cycle route.

Trip frequency analysis

To convert yearly modelled cycling behaviour into daily mode share, it is necessary to determine how frequently new cyclists would cycle. Both the percentage of individuals cycling, and the frequency of cycle trips among active cyclists, vary depending on the type of infrastructure provided. Though it is possible to calculate how frequently new cyclists would cycle on a per-class basis, it is a less robust measure than across the entire sample due to the limited number of new cyclists within each class. Due to this limitation, the percentage of individuals cycling in a given year is produced on a per-class basis, and projected cycling frequency across the sample is used to generate projected daily mode share.

An interesting insight from the trip frequency analysis is that people are much more likely to cycle more frequently to get to or from work than for recreational purposes as shown in Figure 15. However, across the sample, the frequency may be similar because of the larger cohort of recreational cyclists. Our analysis focuses on commuter cycling trips due to their higher frequency per individual.

Figure 15: Cycling frequency for commuting and recreation



The frequency of cycling trips was determined by two separate questions: self-reported past cycling for commute purposes early on in the survey; and later in the survey, projected future cycling for commute purposes dependent on certain infrastructure improvements being made. These two measures were markedly different in that reporting of past behaviour exceeded projected future use, even in cases where infrastructure was improved. We attribute this anomalous reporting to the fact that projected future behaviour was a visually prompted question It was after the section of the survey where individuals were shown examples of the different ways cycling infrastructure could be improved. This dichotomy was incorporated into the survey design to test whether visually prompted or unprompted research methods yield more accurate results in different scenarios.

Part and parcel of answering this question is evaluating which answers are inaccurate – the reported past behaviour or projected future behaviour. Due to these discrepancies in self reporting, it is necessary to evaluate whether the reported existing behaviour was higher than should be due to being an unprompted survey question; or if future behaviour was underestimated based on known issues with projecting the frequency of personal behaviour.

First, we estimate the proportion of individuals who would cycle using on-road routes for any purpose on any given day based on self-reported frequencies. We focus on workdays as mode share for weekends will largely be unpredictable due to the higher variability in recreational cycling. We estimate the following trip frequencies:

Table 2: Estimated trip frequencies

Self-reported frequency	**Percentage of days cycled**	**Rationale for percentage of days cycled**
Less than monthly	2%	5 days cycled per year
At least monthly	5%	1 day cycled per month
Once or twice a week	25%	4-8 days cycled per month
Three or more times a week	80%	12-16 days cycled per month

These adjustments were then applied to the percentage of individuals in each category for existing behaviour, projected behaviour given each type of infrastructure improvement, and “new” cyclists generated by infrastructure investment. The total trips taken on a given day is then generated by adding the totals of these values, and dividing by the total number of cyclists.

To assess whether the reported behaviour or future-projected behaviour yielded a more accurate assessment of cycling rates in the current environment, cycling mode share (calculated from reported behaviour and future-projected behaviour) were both compared to cycle mode share in the 2013 Census with allowances made that the Census only tracks journey-to-work mode share. Along the route in question, the current reported behaviour indicates a daily mode share of between 9 percent and 11 percent, while the future-projected behaviour indicates a daily mode share of between 5 percent and 6.5 percent based on the current cycling environment. The

Census currently indicates a mode share of 6 percent for the study area. From this validation exercise, it is clear that the future-projected behaviour, due to its nature as a prompted question, is more accurate.

We attribute this over-reporting of existing cycling behaviour to several interconnected issues:

1. It is well known that survey respondents are more adept at assessing their overall behaviour (eg whether or not they cycled in the past year) rather than the frequency at which they engage in such behaviour due to the conservatism or regressive bias. (This bias means high frequencies are under-reported and low frequencies are over-reported.)
2. We speculate that because cycling may be seen as socially desirable, the interviewee wishes to appear pleasing to the interviewer. Over-reporting may occur prior to prompting due to the misconception that the survey may be a cursory gauge of support.
3. We also speculate that after going through a rigorous analytical choice process, survey respondents are better prepared to effectively and accurately report their own cycling behaviour given varying levels of infrastructure provision.
4. Finally, we speculate that given the high prominence of cycling in the media of late, it is possible that some respondents who support cycling initially thought it might be a good idea to overstate how much they actually cycle to help "support" the idea of cycling. However, as they progressed through the intensive survey, they realised that honest answers are more helpful .

Whatever the case, two conclusions are drawn from this analysis. Firstly, unprompted methods that do not take into consideration the multiple factors that influence the choice to cycle are not a valid and accurate method for assessing demand for cycling infrastructure. Secondly, we must adjust the reported cycling behaviour for the purposes of our final analysis to better match the future-projected cycling behaviour due to its greater accuracy.

To make this adjustment, we reduced the number of reported trip frequencies among the unprompted answers by locating any respondent who indicated a higher frequency in current behaviour than in future scenarios with improved infrastructure (as our latent class analysis indicates that any infrastructure is better than no infrastructure). We then adjusted these individuals' reported behaviour to their projected behaviour for the purposes of trip-frequency analysis.

Another plausible explanation for this over-reporting is that it may be due to dedicated cyclists choosing to interpret the later questions as how many additional trips will be generated by infrastructure, rather than overall use. To test this hypothesis, our analysis identified 47 individuals who over-reported their current cycling behaviour. One individual met the criteria – a dedicated cyclist reporting additional rather than total trips. The remaining 46 were clearly identified as individuals who would not commute by bike to any substantial degree regardless of infrastructure improvements. Interestingly, this implies that their over-reporting may be due to a combination of social desirability bias *and* a desire to influence political decisions. In either case, the initial hypothesis that over-reporting was the source of this discrepancy is rigorously validated.

The following table includes the final trip frequencies for different types of cycling infrastructure. Note, though, this is only relative to the facility as other factors are handled by the five-factor logit modelling process:

Table 3: Daily cycling rates given infrastructure type

Environment	**% of cyclists taking trips on a given work day**	**% of bicycle-owning population that has cycled to work in a given year**
No infrastructure	22%	15%
Painted lines	20%	31%
Barrier-separated lane	39%	42%

It's interesting to note that the percentage of cyclists taking a trip on a given work day, when painted lines are provided, actually decreases when compared with the percentage using the same route with no cycling infrastructure. This is because the number of overall cyclists increases substantially, while the overall frequency profile of those cyclists lowers the average frequency of cycling behaviour. This is a result of the noted trend where cyclists enter the cycling population and largely remain in the "less than monthly" or "at least monthly" categories. The barrier-separated lane, in contrast, sees an increase in both cycling frequency and number of cyclists.

To then generate the mode share for a given cycleway route option, the total number of cyclists in a given year is modelled. Those who report that they would cycle but who do not own a working bicycle are removed. This is to ensure that the model does not substantially overestimate cycling rates. However, it is plausible that infrastructure improvements could encourage many who do not currently own bicycles to purchase or rent bicycles. If this is the case, the model would likely underestimate the number of people cycling each year. To reach daily use, the modelled values are multiplied by the frequencies above.

Finally, to achieve the mode shares along this single route, origin-destination pairs where both origin and destination lie along the route (eg live on the route and work in either the southern suburbs or CBD) are calculated. Sixty-six percent those who live on the route also work along the route. To account for this, only 66 percent of additional trips predicted for a given suburb are considered to actually appear. We apply this same factor to non-work trips inferring that the arterial cycleway will be used for many of the on-road cycling trips that people make to do errands (high frequency) and for recreation (low frequency).

Validation

Validation of this methodology is undertaken on two levels: cycling rates on a yearly basis and cycling rates on a daily basis.

Firstly, the modelled cycling behaviour across a given year is validated against the number of respondents who have reported cycling in the past year. The over-reporting of cycle frequency noted in the trip-frequency analysis, on consideration, is viewed not to influence the net overall cycling behaviour. Over-reporting is likely to influence the reported frequency, due to the conservatism and regressive bias, rather than the reported engagement in the activity due to the long time span of analysis (one year). Thirty-nine percent of individuals reported some on-road cycling behaviour in the last year in the most recent sample, which is a few years old, while the model in fact projects that 42 percent of people will engage in some on-road cycling. In this first, broader, sense the model is validated to a high level of precision: the model proves to be highly accurate in predicting the percentage of people who will cycle in a given year.

Secondly, it is necessary to validate the daily mode shares projected for an individual route to assess the accuracy of the mode share assessment on a per-route basis. The modelled cycling mode share projected in the current cycling environment needs to be validated against actual cycle use along the route. As self-reported trip-frequency data is noted to be variable and needing adjustment, we must validate it against the 2013 Census data of cycling frequency. We establish this for two separate stages of infrastructure development along the Island Bay to city route:

- The stage one and two infrastructure improvements from Newtown to the CBD
- The stage three and four infrastructure improvements from Island Bay to Newtown.

All assessments are compared to the existing reported journey-to-work mode shares in the Census. It is key to note that these assessments compare mode share for all on-road purposes to mode share for work purposes. As a result, we expected the mode share to be slightly lower than Census figures, given that higher frequencies are noted for work commuting use. This lower mode share across the day is borne out by past analysis of the New Zealand Household Travel Survey compared to Census data for the region. That analysis indicated that total mode share across the day for cycling across Wellington Region is 1 percent less than mode share for journey to work purposes (State of Cycling 2001–2012, Greater Wellington Regional Council, 2012). We expect this difference to remain so the model is expected to fall 1 percent below 2013 Census figures.

For stage one and two improvements, the modelled mode share in the current environment of 5.19 percent falls about 1.2 percent short of the 6.4 percent seen in the 2013 Census when Newtown, Berhampore and Melrose are aggregated as the stage one and two suburbs. The stage three and four modelled mode share of 4.33 percent falls about 1.2 percent short of the 5.5 percent seen in the 2013 Census when Island Bay, Houghton Bay, Owhiro Bay and Southgate are aggregated as the stage three and four suburbs. Both of these validation measures indicated are within 3 percent of expected figures.

The expected slightly lower mode share indicates this model is a promising predictor of cycling behaviour both at the full route and sub-route levels when the stages are aggregated based on their similarity as assessed by the five-factor model developed in this research.

For application purposes, it is also advantageous that the model tends to underestimate rather than overestimate cycling demand as reported by the Census. It is undesirable for reports to overestimate the demand a given investment will inspire. As a result, these lower numbers are viewed as both valid and fit-for-purpose for assessing cycling demand in Wellington City.

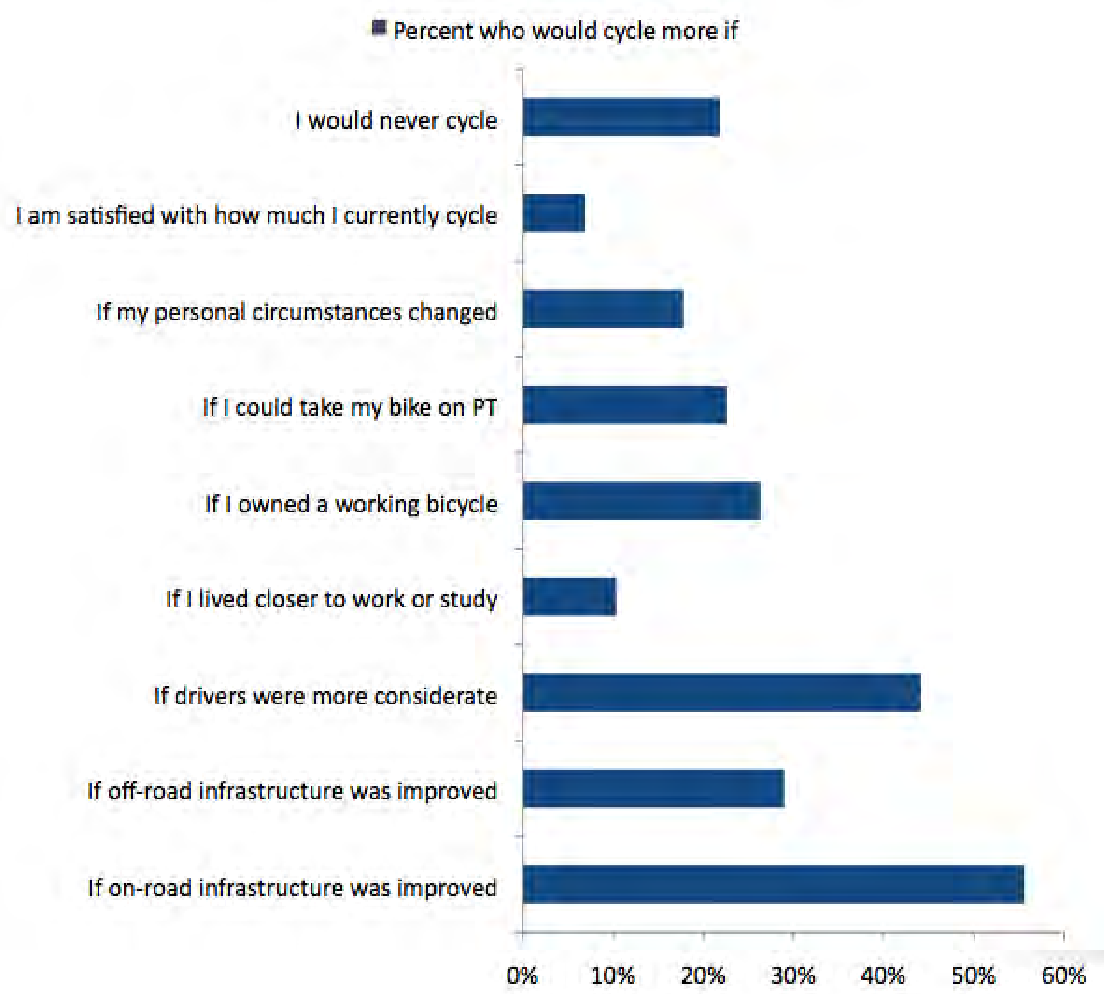
Application

This method can be applied on a route-by-route basis to different areas of Wellington City. It can also be applied across the whole city if a theoretical cycling network (including route options) is developed and provided. The method is best suited to analysing the different potentials of different route options and ways these routes could be improved. It is undesirable to apply this method to assess the different ways parts of a route could be developed (eg The Parade in Island Bay), as they do not align with the length-of-trip journey types modelled. However, assessing longer routes or the broader network is an appropriate application of this methodology.

To provide proximate mode shares for journey-to-work travel, the increases projected on a percentage basis for all-day mode shares are applied to the existing mode shares for journey to work.

Results – Decision to cycle and route choice influences

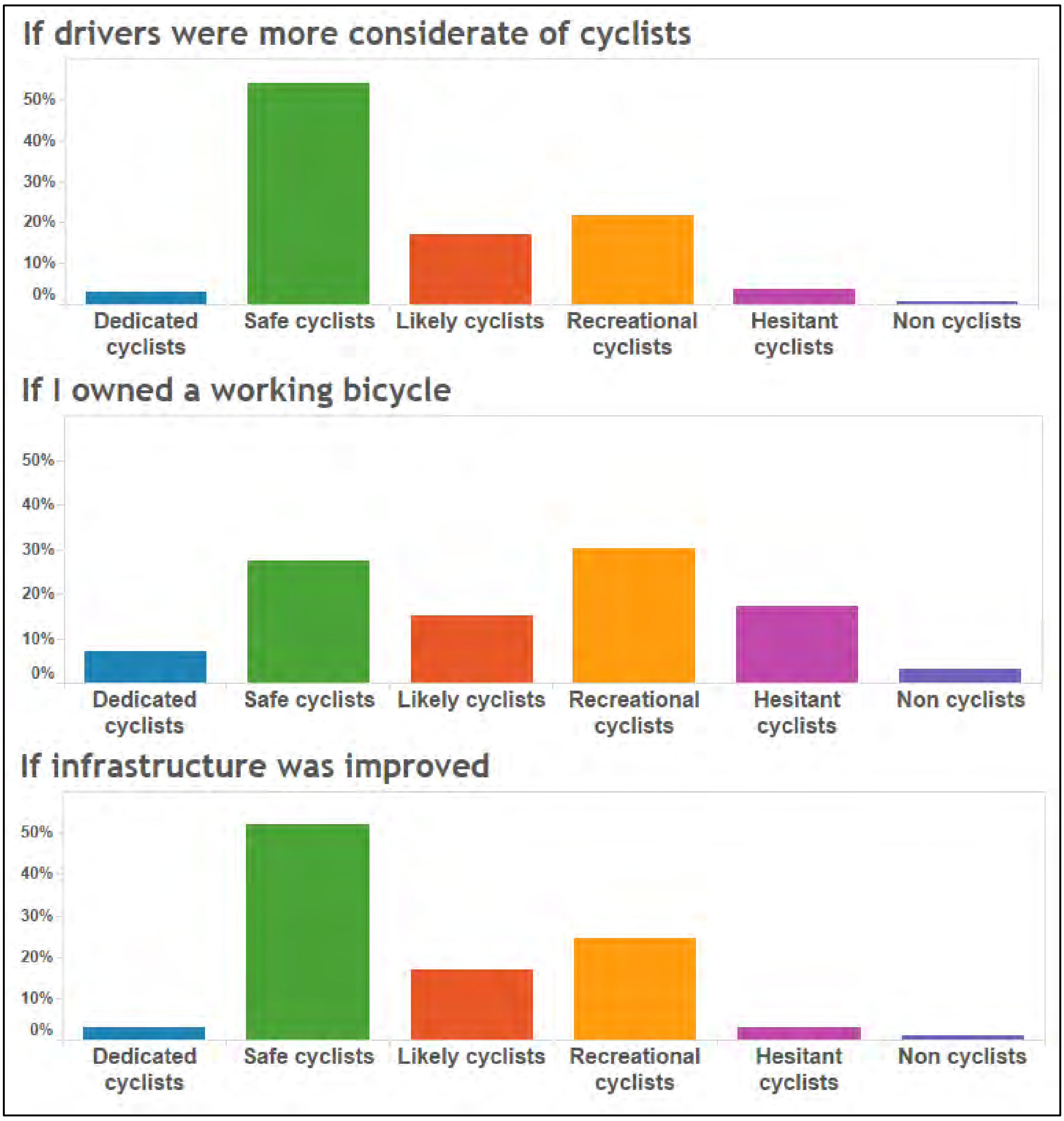
Figure 16: Influences on decision to cycle



Respondents were asked to indicate which of a series of characteristics were most important to how often they cycle. From this it is evident that on-road infrastructure improvements and more considerate drivers are the key influencers of cycling behaviour. More than 55 percent of the sample (the cycling cohort amounts to 76 percent of the sample, so that is 72 percent of all cyclists) indicates that on-road infrastructure improvements will inspire them to cycle more frequently. Forty-four percent of the sample indicated that more considerate drivers would also influence them to cycle more often.

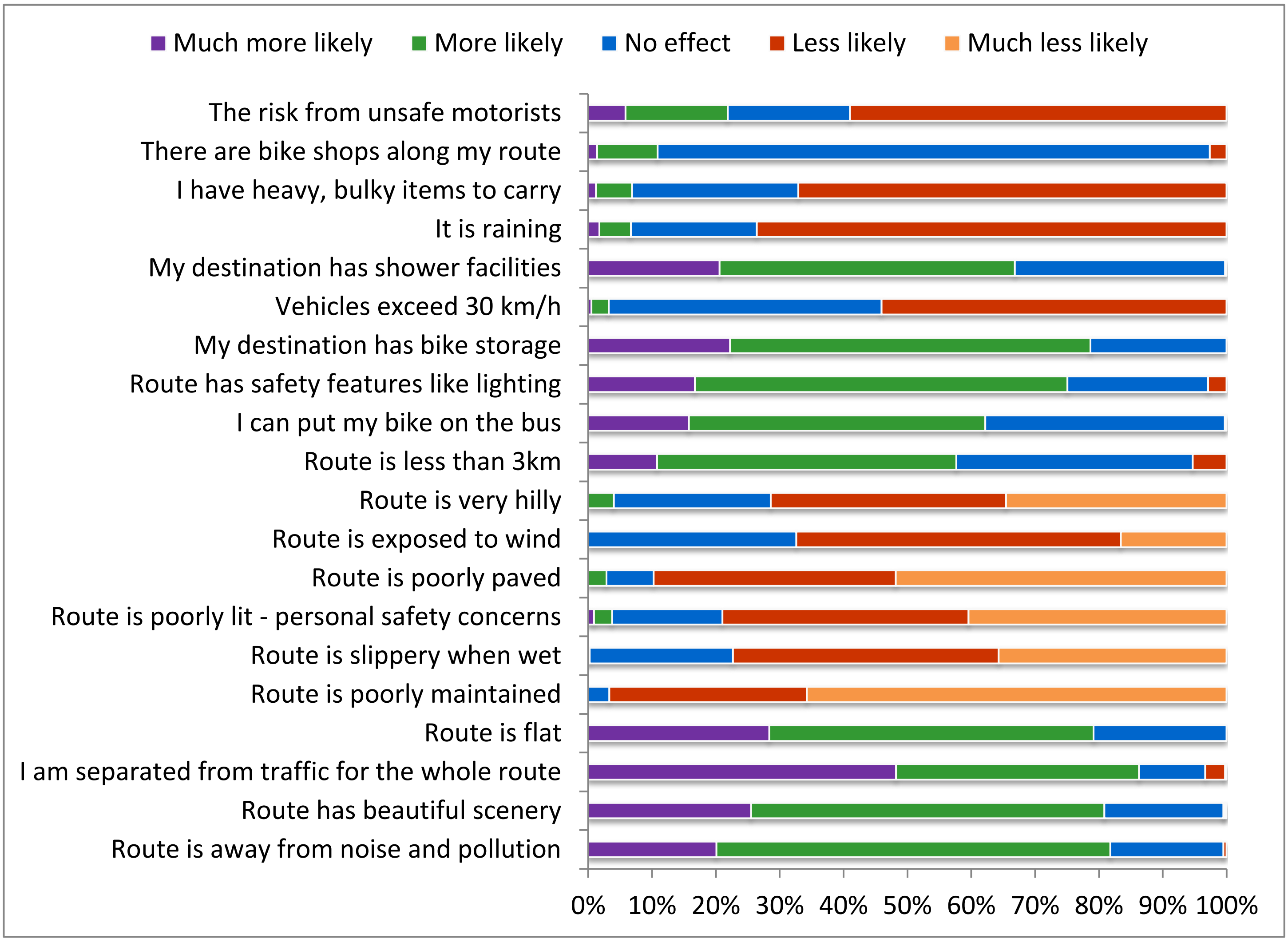
Barriers do differ across classes, as shown in the figure below:

Figure 17: Barriers across classes



The other factors that influence the choice to cycle are off-road infrastructure improvements like mountain biking tracks, owning a working bicycle, being able to take a bicycle on public transport and personal circumstances changing. Further, it shows that 21 percent of people would never cycle at this stage.

Figure 18: Route influences on decision to cycle



Positive influences

Quite a few factors were tested in more depth to find out what aspects of those things had the most influence on how likely people were to cycle. The most important issues across the sample of cyclists are separation from traffic for the entire distance and a flat route, both of which are currently unavailable in the Wellington. This is followed by the route having beautiful scenery and being away from noise and pollution. Equally important were shower and changing facilities at the destination, secure bicycle storage and poor weather/night safety features such as good lighting. Again, these are factors that may not be available at this time.

Barriers to cycling

The most notable barriers to cycling are poorly designed or maintained roads (debris or a poor surface). This is followed by the risk from motorists driving unsafely and an assortment of other barriers such as: poor lighting, a route that is slippery when wet, whether or not it is raining, and the need to transport bulky items.

Results – Guide to routes modelled

The modelling of the two separate parts of the cycleway (from Island Bay to Newtown and from Newtown to the CBD) evaluates three scenarios for each of the following three routes that are based on routes proposed for the Council by Red Design for stage three of the proposed Island Bay to city cycleway (through Berhampore/Newtown):

1. A centre route that runs down Adelaide Road and uses Rintoul Street to get to Newtown. This route is the most direct and flattest, but due to the arterial nature of parts of it, as well as the parking, it is also the most likely to benefit from cycling facility improvements. It differs slightly from the Red Design route in that it does not divert behind Wakefield Park – instead running down Adelaide Road. This route is also analysed as shared space.
2. A western route that runs around Wakefield Park, along Stanley Street, reconnects with Adelaide Road at Macalister Park and then moves onto Hanson Street. This route is largely flat, has better scenery, quieter roads and is relatively direct. This route is also analysed as shared space.
3. An eastern route that ascends up to Martin Luckie Park from the Parade, then descends to Riddiford Street and goes through Newtown shopping centre. This route goes through the shops, which is advantageous, but it is quite hilly and indirect for Island Bay, Southgate and Owhiro bay users. Also, the busy nature of Riddiford Street makes it challenging to install anything other than painted lines.
4. A community-proposed Western Enhanced Route that would keep primarily to Town Belt space from Island Bay to John Street.

Figure 19 shows three of the routes (excluding the Enhanced Route) that are evaluated through Newtown. Figure 20 shows the four separate stages of infrastructure for the Island Bay to City cycleway. Stages one and two are not analysed because the selected routes there are dependent on the Board of Inquiry decision on the Basin Reserve flyover and the design work required to create a bus rapid transit route to Wellington Hospital.

Figure 19: Newtown routes analysed

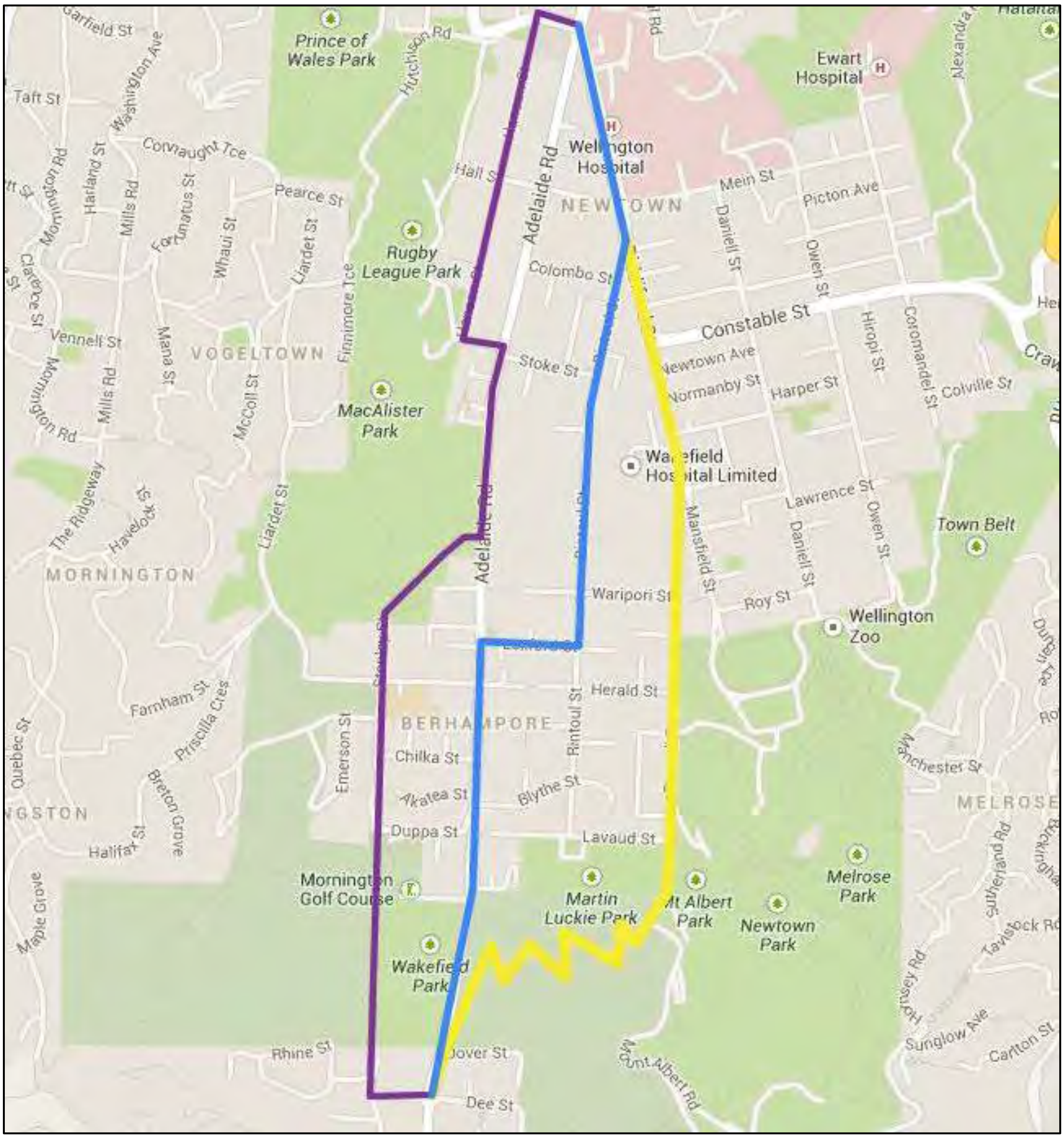
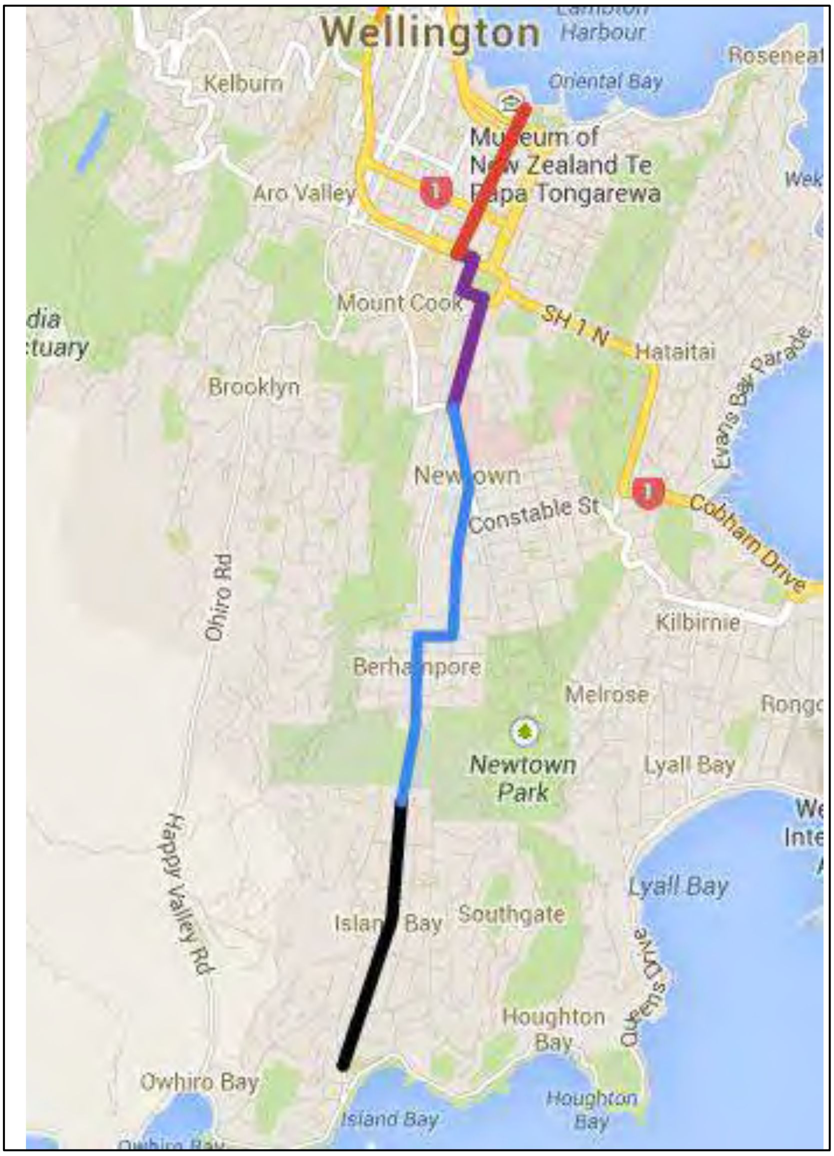


Figure 20: Stages 1(Red) - 4(Black)



For suburbs that would primarily use Stage 2 or closer infrastructure, the options are evaluated as being the most direct, least hilly route – and thus vary only based on type for this analysis. This is simply due to the lack of information about the infrastructure treatments in these areas at this time.

These options are evaluated for each stage, and are then evaluated for two types of infrastructure treatments: barrier-separated cycle lanes and painted cycle lanes with parking retained. These are modelled against the current most direct option, which indicates how many would use the new infrastructure, and how many would continue to use the existing most direct route.

Results – Cycling participation throughout the year

Table 4 - Cycling across the year

Island Bay to City Cycleway	
Routes	**Percentage of population cycling for any reason (Annual)**
Newtown, Berhampore, Melrose	
Current Environment	69%
Barrier Protected	81%
Painted Lines with parking	79%
Island Bay, Owhiro Bay, Southgate, Houghton Bay	
Current Environment	42%
Centre Route	
Centre Painted Lines with parking	57%
Centre Barrier Protected	60%
Centre Shared Space - Red Design	49%
East Route	
East Painted Lines with parking	42%
East Barrier Protected	47%
West Route	
West Barrier Protected	55%
West Painted Lines with parking	57%
West Shared Space - Red Design	44%
Adelaide Route	
Adelaide None with parking	42%
Adelaide Painted Lines with parking	47%
Adelaide Barrier Protected	55%
West Enhanced Route	
West "Enhanced"	45%

From this table we can get an understanding of the percentage of the population who would at some point during the year give cycling a try on the road (it excludes some mountain bikers who would only use off-road tracks). It isn't necessarily instructive as to what would show up on the streets, as it gives no indication of the frequency of cycling, but it is useful to know that as much as 60 percent of the population in Island Bay and its surrounds could be convinced to cycle by appropriately designed infrastructure.

Table 5: Daily mode share

Island Bay to City Cycleway					
Routes	**Percentage using route**	**Mode share (all day)**	**Number of cyclists (Journey to work)**	**% increase in cycling**	**% decrease in mixing with traffic**
Newtown, Berhampore, Melrose					
Current Environment		5.19%	453	0%	0%
Uses current route	100%				
Barrier Protected		11.76%	928	105%	100%
Uses barrier route	100%				
Painted Lines with parking		5.74%	500	10%	0%
Uses painted route	100%				
Island Bay, Owhiro Bay, Southgate, Houghton Bay					
Current Environment		4.33%	336	0%	0%
Uses current route	100%				
Centre Route					
Centre Painted Lines with parking		5.41%	420	25%	0%
Uses current route	100%				
Centre Barrier Protected		11.58%	900	168%	100%
Uses barrier route	100%				
Centre Shared Space - Red Design		6.62%	514	53%	52%
Uses shared space	69%		354		
Uses current route	31%		160		
East Route					
East Painted Lines with parking		4.33%	336	0%	0%
Uses painted route	49%		164		
Uses current route	51%		172		
East Barrier Protected		8.07%	627	87%	66%
Uses barrier route	82%		512		
Uses current route	18%		115		
West Route					
West Barrier Protected		9.81%	762	127%	79%
Uses barrier route	91%		690		
Uses current route	9%		72		
West Painted Lines with parking		4.69%	364	8%	0%
Uses painted route	67%		242		
Uses current route	33%		122		
West Shared Space - Red Design		6.12%	475	41%	40%
Uses shared space	58%		275		
Uses current route	42%		200		
Adelaide Route					
Adelaide None with parking		4.33%	336	0%	0%
Uses Adelaide route	35%		117		
Uses current route	65%		219		
Adelaide Painted Lines with parking		4.72%	367	9%	0%
Uses painted route	68%		250		
Uses current route	32%		117		
Adelaide Barrier Protected		9.86%	766	128%	79%
Uses barrier route	91%		697		
Uses current route	9%		69		
West Enhanced Route					
West "Enhanced"		6.00%	466	39%	70%
Uses barrier route	78%		364		
Uses current route	22%		102		

When taking into account frequency, a variety of options offer improvement over the existing status quo for both stages one and two (Newtown, Melrose, Berhampore) and stages one to four (Island Bay, Owhiro Bay, Houghton Bay, Strathmore). Barrier-protected routes stand out as an extremely effective way to increase mode share – and thus visible cycling and the "safety in numbers" crash-reduction effect – particularly when the most direct route is used. If selected instead of barrier infrastructure, painted cycle lanes offer the opportunity to boost cycling with the caveat that many dedicated cyclists will remain on the existing unimproved route if the painted lanes are not on the most direct and convenient route.

Results – Mode share with additional bike purchases

Table 6: Daily mode share with bike purchase at varying levels (speculative only)

Island Bay to City Cycleway				
Routes	Mode share (all day)	Bicycles purchased: 25% more	Bicycles purchased: 50% more	Bicycles purchased: 75% more
Newtown, Berhampore, Melrose				
Current Environment	5.19%	6.49%	7.79%	9.09%
Barrier Protected	11.76%	14.70%	17.64%	20.58%
Painted Lines with parking	5.74%	7.17%	8.61%	10.04%
Island Bay, Owhiro Bay, Southgate, Houghton Bay				
Current Environment	4.33%	5.41%	6.49%	7.57%
Centre Route				
Centre Painted Lines with parking	5.41%	6.76%	8.11%	9.47%
Centre Barrier Protected	11.58%	14.48%	17.37%	20.27%
Centre Shared Space - Red Design	6.62%	8.28%	9.94%	11.59%
East Route				
East Painted Lines with parking	4.33%	5.41%	6.49%	7.57%
East Barrier Protected	8.07%	10.09%	12.11%	14.12%
West Route				
West Barrier Protected	9.81%	12.26%	14.72%	17.17%
West Painted Lines with parking	4.69%	5.86%	7.03%	8.21%
West Shared Space - Red Design	6.12%	7.65%	9.18%	10.71%
Adelaide Route				
Adelaide None with parking	4.33%	5.41%	6.49%	7.57%
Adelaide Painted Lines with parking	4.72%	5.90%	7.08%	8.26%
Adelaide Barrier Protected	9.86%	12.33%	14.80%	17.26%
West Enhanced Route				
West "Enhanced"	6.00%	7.51%	9.01%	10.51%

The Opus peer review raised concerns that by excluding those who would purchase a bicycle if safer cycling infrastructure was installed, the potential growth in cyclists was being underestimated. However, the Opus team also agreed that predicting how many individuals would buy bicycles as a result of the newly available infrastructure was currently not possible due to a lack of research in this area. As a result, we provide on a purely speculative basis what mode shares would be among our cohort if certain percentages of individuals who do not own cycles then purchased them. We view these as unlikely – except perhaps at the 25 percent level which would take time to realise – and believe the modelled (without bike purchases) mode share as the most likely.

However, with promotional programmes like those recently seen in Europe where bicycles are provided for low weekly rates or individuals are paid to cycle to work and provided bicycles to do so, there is potential to further increase the numbers cycling. The main issue with this is that many who already cycle would likely sign up for such a programme if it existed. Some exploration is warranted to discern how bicycles could more effectively be provided to those who currently don't have access to one.

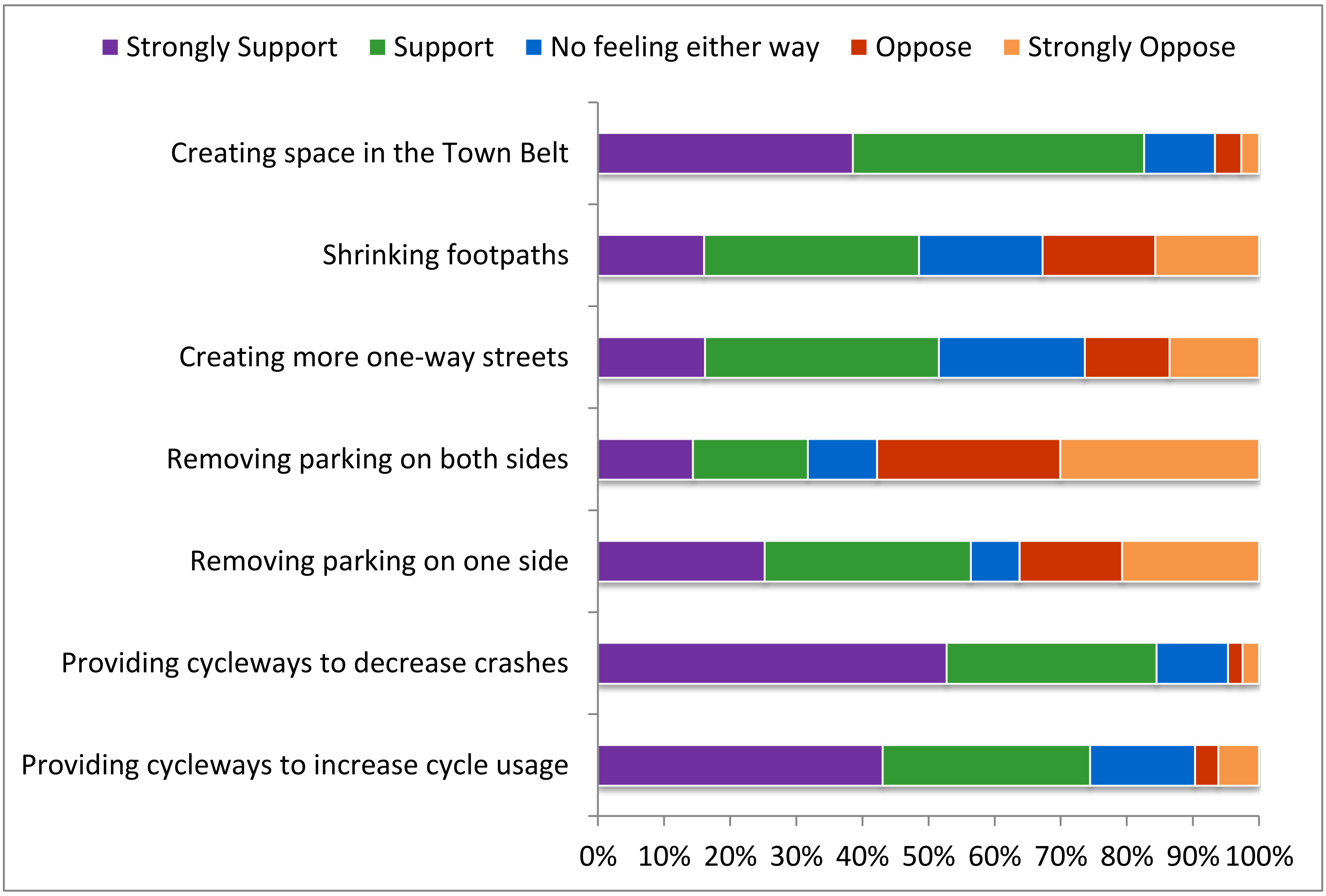
Results – Stage two respondents

The responses from the second stage of the survey were acquired too late to incorporate them into the full analysis of this report. However, we assessed the response from this completely different group of people, recruited in a different way, and modelled their yearly use using the same methods that were applied to the first stage respondents, which are analysed in this document. The expanded set concurs with the smaller sample, with the single meaningful change that the dedicated cyclist cohort was spread through other classes – split by caring about safety versus caring about time – and the other five classes were further validated. This likely stems from the small "dedicated cyclist" cohort in the first stage sample, which meant the definition of that class was slightly less than complete. This adds further confidence to the findings in this report as the sample is expanded from 358 to 603.

Results – levels of support and preferred mode

Across the city

Figure 21: Levels of support across the city



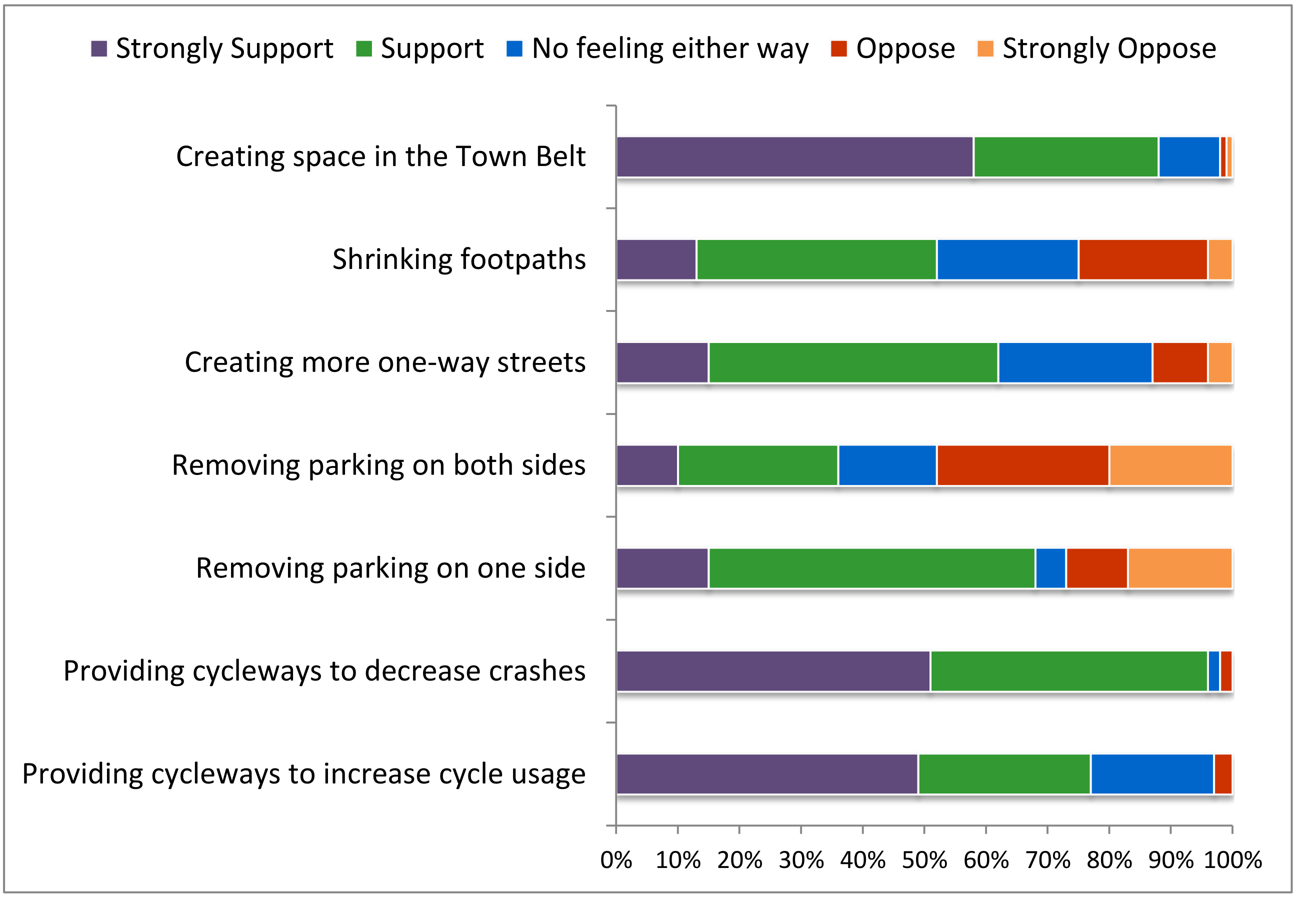
Respondents were asked to express levels of support for providing cycleways for two reasons: to reduce crashes and to increase cycle use. They are then asked about various methods of achieving installing cycleways ranging from removing parking to using Town Belt land. They were asked to indicate how they felt about each using a scale that ranged from strongly support to strongly oppose.

It is clear from the responses that there is overwhelming support for reducing cycling crashes and increasing cycle use by providing better cycling infrastructure – with support over 75 percent for both. There is also unquestioned support for providing space for such infrastructure in parks and Town Belt areas. The most meaningful point of opposition is that 55 percent of city residents are unwilling to tolerate the removal of parking on both sides of a street to make way for a cycleway.

Where there isn't sufficient road width, removing one side of parking or making some streets one-way may be the best of a suite of options to make more room for cycleways – as around 60 percent of residents support each. Shrinking footpaths has similar levels of support, but added legal issues relating to accessibility.

Along the Island Bay to city route

Figure 22: Level of support along the Island Bay to city route



Interestingly, along the route where the infrastructure is proposed, even more support is noted – with 75 percent supporting cycleways to increase use and 90+ percent supporting cycleways to decrease crashes. Additionally, the support level for removing parking on one side of the street increases. The results show that parking is an issue where there is little middle ground. Most people express whether they support or oppose removing parking to make space for cycleways – and there is a roughly 25 percent swing in support and opposition between removing one side of parking versus removing two. Removing one side of parking is about equally as popular as removing both sides is unpopular.

Preferred mode

Figure 23: Preferred versus actual travel mode

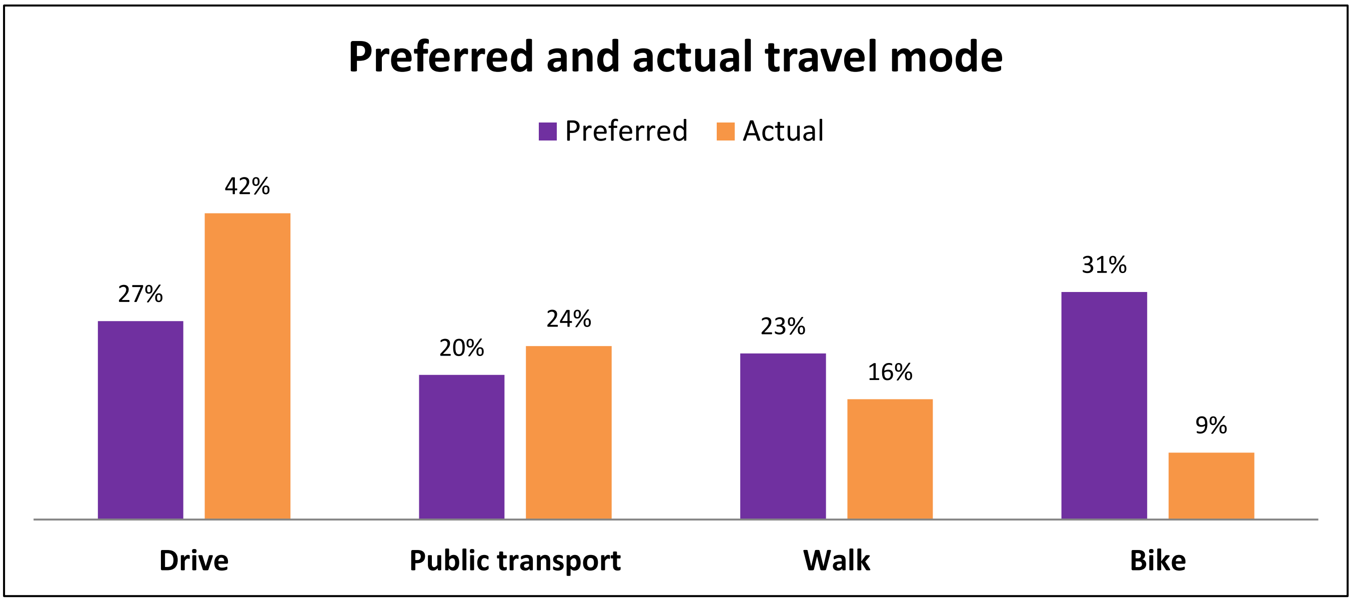
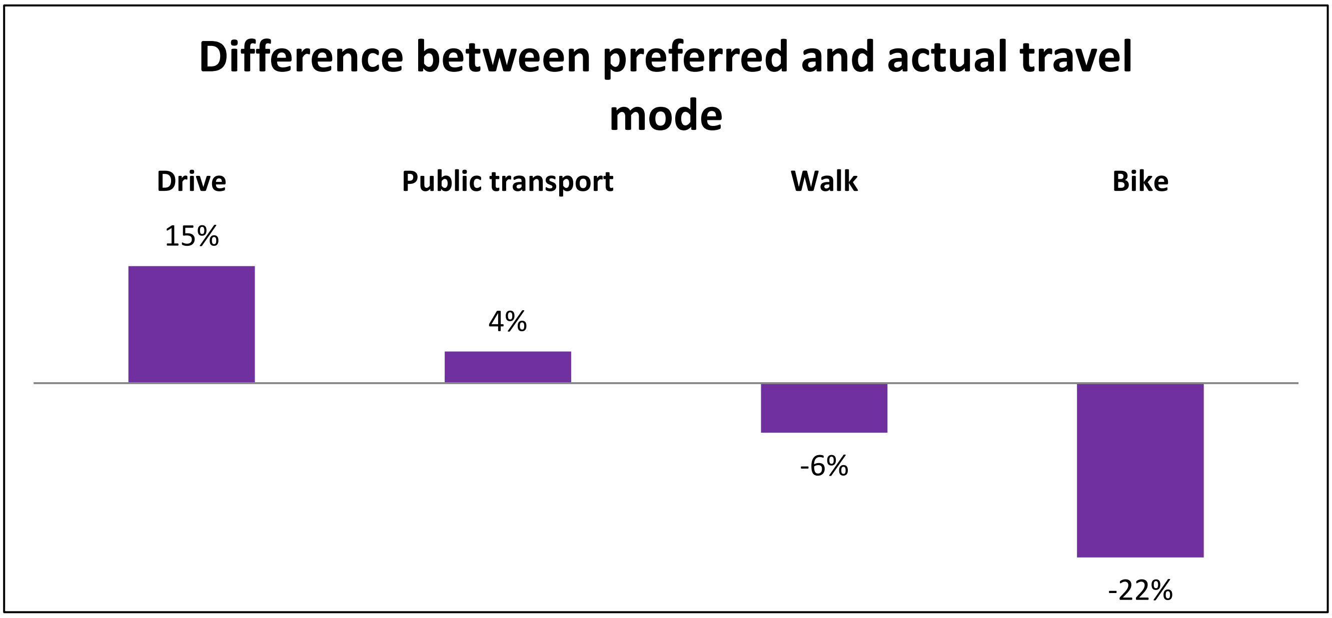


Figure 24: Difference between preferred and actual mode



A notable difference exists between preferred and actual travel mode. The largest gap is for cyclists. Twenty-two percent of people across the sample would like to cycle to work but are not able to. Additionally, 15 percent drive to work when they would prefer to use another mode. Public transport is the only mode that has a roughly equal percentage of people who say it is their preferred mode for their journey and also travel that way.

Confidence in findings

The cultural shift towards cycling (as seen in the near-doubling of cycling in Wellington City since the last Census despite little to no cycling investment) is not accounted for in this study. The potential to inspire an additional cohort to purchase bicycles by improving cycling infrastructure (among the 50 percent of Wellingtonians who do not own one) is also not accounted for. Both are almost certain to contribute meaningfully to growth in cycling in the future, but are challenging to assess. These projections are generated based on a snapshot at this point in time, so it likely underestimates the potential growth in cycling that will be generated. This means mode shares may end up being much higher than projected in this study due to these two factors. This research focused only on cyclists who are "sure things" – certain to appear if infrastructure is built – and excludes those possible future cyclists whose behaviour is harder to predict.

Aside from this, the degree of confidence in the findings is high. Given the large 603-person sample, the level of sophistication of the analysis, and the clear preference for active modes over other travel modes expressed by large segments of the population, this is an excellent indication of what cycling behaviour could be expected if investment is made in new cycleways. Keep in mind that it is an excellent indication of what cycling behaviour is certain to appear – not the total potential for cycling.

This report should be viewed as a conservative estimate of what cycling behaviour could be induced by such investments, as at each stage we have endeavoured to choose the most conservative estimate possible.

Peer review

The methodology for this report has been peer reviewed by a statistician, urban scientist, as well as the Research Manager, Behavioural Sciences from Opus International Consultants. The full report has also been peer reviewed at multiple stages by several members of the Wellington City Council research team.

Discussion

The results indicate two points of interest that should be considered. Relating to infrastructure choice, it is clear that both painted lines and barrier infrastructure will substantially increase the numbers of people cycling. Barrier-separated infrastructure is the best way to get more people cycling more often, however it depends what we most want to achieve – more people cycling, people cycling more frequently or both.

Perhaps the defining difference aside from frequency is that painted lines do not effectively convince existing cyclists to use alternative routes. In cases where the route is indirect, painted lines see 50 percent or more of the cyclists remaining on the most direct route. On the other hand, when barriers are installed, more cyclists choose to use the improved route, even when they are not the most direct route.

The Wellington research verifies international research that shows the most important issue to non-cyclists, when making the decision to cycle or not, is safety. The separation from vehicles is much more effective at getting more people cycling than painted roadways, particularly when you consider how often people choose to cycle. They are noticeably more willing to cycle often on separated cycleways than on shared roads regardless of whether there are painted lines or not.

The research shows projects that will reduce crashes involving cyclists and other road users are the ones most likely to be supported by the public. Similar levels of public support are likely for projects that will increase the numbers of people cycling. Combining these, it implies that a barrier-separated route – as direct as reasonable – is the most effective choice to achieve these dual goals.

However, it's also very important to consider the trade-offs people are most willing to tolerate. The survey indicates a majority of the people along the Island Bay to city route – and in fact across the city – are willing to sacrifice parking on one side of the street, but oppose removing parking on both sides. Additional one-way streets may be a way to make room for improved cycling infrastructure if used judiciously. Most people were also not averse to the idea of creating cycleways that use Town Belt land.

Given the near universal support for better cycling infrastructure and difficult choices and trade-offs required to provide them, there will be challenges. As part of reaching a compromise to achieve the Council's aim to make the city more cycle friendly, the support for cycleway construction will need to be carefully considered along with the levels of support and opposition for what needs to be done to achieve this goal.

It is important to note that the demand predictions made in this research may take several years to occur, particularly if the infrastructure is rolled out in stages. The indications that the route needs to be separated for the full distance lead us to conclude that, given the cycleway to Island Bay is likely to be constructed from the southern end rather than the CBD, the latent demand noted in this report will take time to be realised.

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