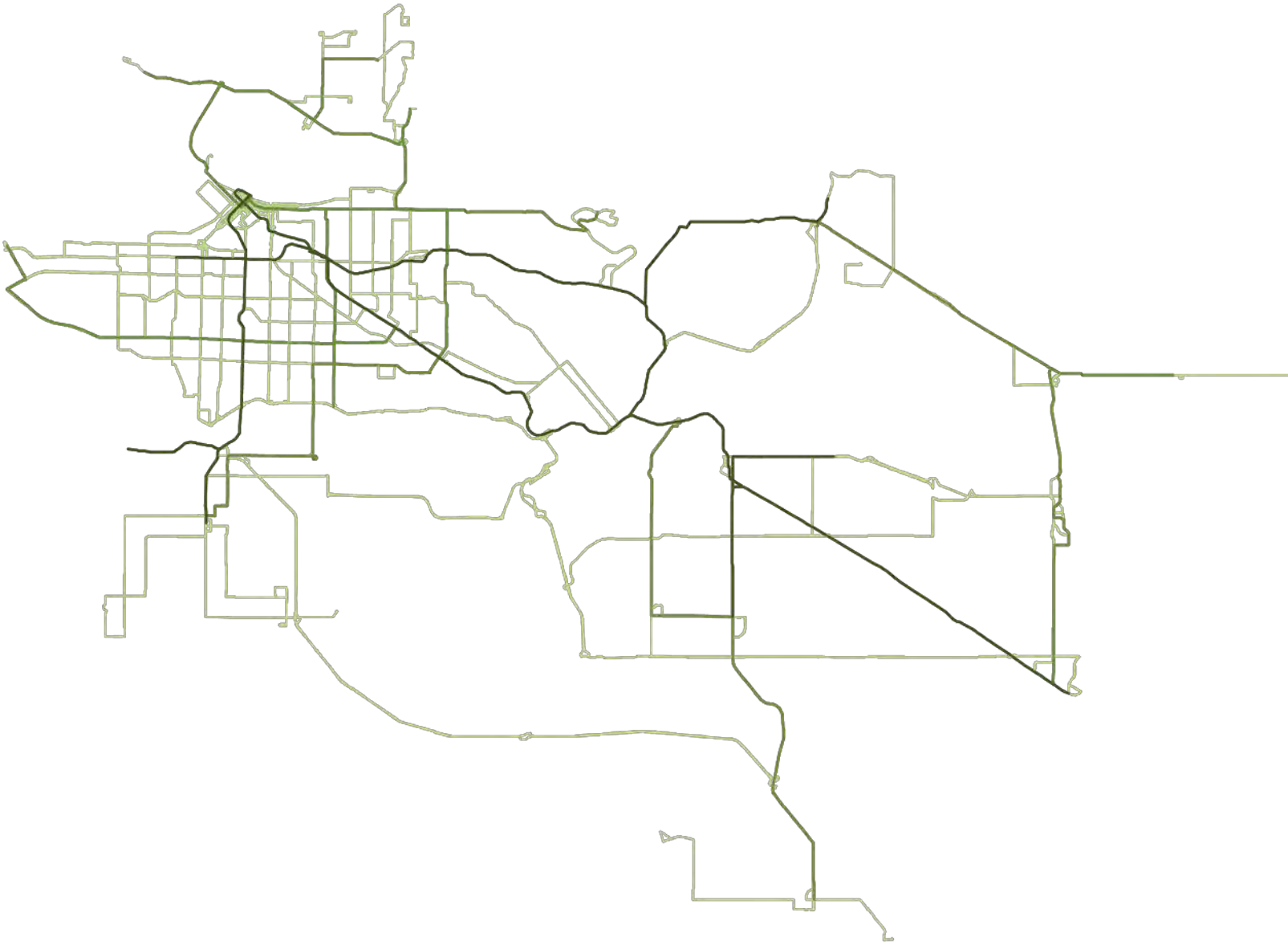
Accessing the Frequent Transit Network

Impacts of the Mayors' Plan



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Transportation Planning & Analysis

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Introduction

Frequency is an essential element for making public transportation appealing. In order for transit to be seen as a viable alternative to private automotive travel, it must be a reliable, consistent travel choice. Users must be able to operate around their own schedule, not their bus'. TransLink's Frequent Transit Network (FTN) is Metro Vancouver's strategy for offering this level of transit service. The FTN operates seven days a week with 15 minute or better wait times for all stops along the designated corridors. In doing so, TransLink aims to provide "convenient, reliable, easy-to-use services," an essential element if the region is to meet its goals of having 50% of its mode share be comprised of walking, cycling, or transit (TransLink, 2012). With rapid population growth throughout the region, TransLink must now provide this level of service at an even greater scale, using the same budget that has stagnated since 2010.

This spring, residents of Metro Vancouver will vote on whether to adopt a new 0.5% regional sales tax in order to fund public transit improvements over the next decade. In support of their proposal, the regional Mayor's Council has argued that investment in public transit will alleviate road congestion, improve air quality, encourage healthier lifestyles, and provide for more equitable mobility throughout the region. Although the majority of Metro Vancouver residents rely on private automobiles, there are large segments of the population who either cannot afford or are unable to drive (ie. elderly, low-income populations, students, and recent immigrants). For these residents, accessibility to quality public transit serve can have significant impact on quality of life. The Mayors' Plan looks to extensively expand the frequent transit network, in order to meet the growing need for transit use in areas welcoming large numbers of new residents and businesses.

This project looks to examine the impacts of the Mayor's Plan on two dimensions of accessibility. First, this study will assess what percentage of the population is able to access the Frequent Transit Network (FTN) as a result of the proposed improvements. Second, the project will quantify how improved levels of service will impact travel times between municipal centres and special generators throughout the region. The two scenarios are defined as the current scenario without the Mayors' Plan improvements and the proposed scenario with the implementation of the Mayors' Plan. An analysis of the level of accessibility and mobility will then be carried out for each of the scenarios to determine the final results and recommendations.

Background

To achieve Metro Vancouver's sustainable transportation targets, an investment to expand transit in the region is necessary. This transit investment will ensure that the region will have a

healthy, prosperous and green future (City of Vancouver 2015). To address these growing concerns about the need to expand transit, the Mayor's Council, representing twenty-three municipalities in the Metro Vancouver region, has developed a common regional vision for the transportation system. The vision has local governments working together to protect the regional economy, environment, and their residents' public health and quality of life through implementing a $7.5 billion investment in our transportation system over the next twenty years. To carry out the Mayors' Plan, a 0.5% increase in sales tax has been proposed to raise $250 million in funding per year. Residents across the region have an opportunity to vote in the Vancouver transit plebiscite to determine whether the region supports this funding mechanism for a large amount of transportation investments. If this measure were to pass, transportation improvements would include a 25% increase of bus service to the region in the form of 159 new buses and 200 kilometers of new B-Line service, 2,700 kilometers of bikeways, an LRT in Surrey and The Langleys, an expansion of the Millennium Line to Arbutus along the Broadway Corridor and a new Pattullo Bridge. The plan's results are projected to lower commute times by 20-30 minutes per day by reducing congestion by 20% (Better Transit & Transportation Coalition, 2015).

Problem Statement

This report examines how the Mayors' Plan will impact region on two dimensions of accessibility: the percentage of the regional population that will be able to access the FTN and the impact on travel times between municipal centres and special generators as a result of the proposed improvements. The analysis will focus on the proposed transportation improvements and their effects in Metro Vancouver for the next twenty years. There will be two scenarios defined: the current scenario without the implementation of the Mayors' Plan improvements and the proposed scenario with the implementation of the Mayors' Plan improvements. The Mayors' Plan is a $7.5 billion investment over the next 12 years to serve our region's transportation future. With the one million new residents expected to enter the region during this time, the cost of not investing in transportation for residents is anticipated to be even higher. The impacts of the Mayors' Plan will be analyzed through determining the accessibility and mobility (travel time) improvements gained and monetizing the resulting mode shift and benefits. These benefits will be weighed against the costs to analyze the costs and benefits of the Mayors' Plan transportation investments.

Policy Basis: The Regional Transportation Strategy

TransLink's Regional Transportation Strategy, Transport 2040, has a vision to create and sustain a transportation system that meets the needs of residents, businesses and goods movers in a way that protects the environmental, social and economic goals of the region. The goals of the Regional Transportation Strategy are to:

1. Aggressively reduce greenhouse gas emissions from transportation;
2. Ensure most trips are made by walking, cycling and transit;
3. Ensure that the majority of jobs and housing in the region are located along the FTN;
4. Ensure that traveling is safe, secure and accessible for everyone;
5. Efficiently move goods through effective management of the transportation system to ensure economic growth in the region; and,
6. Ensure that funding for TransLink is stable, sufficient, appropriate and influences transportation choices (TransLink, 2008).

Accessibility to the FTN and sustainable transportation options for all are the integral objectives of TransLink's Transport 2040 plan and are also the principles for the Mayors' Plan. In addition, ensuring an adequate and steady funding source would be realized by the proposed 0.5% increase in sales tax for implementation of the transportation improvements outlined in the Mayors' Plan. If passed, these projects would be major steps towards realising the goals established in Transport 2040.

Metro Vancouver Growth Projections

Over the next thirty years, Metro Vancouver's population is projected to increase by more than one million people and six hundred thousand jobs (Metro Vancouver 2011):

	2011	2041
People	**2.3 Million**	**3.4 Million**
Jobs	**1.2 Million**	**1.8 Million**

Table 1: Population and Employment Projections for 2011 and 2041 in Metro Vancouver

More people and jobs in the region will result in more transportation trips by all modes. Without a significant transit expansion in the region, the roads will become much more congested. The regional population is growing by 2 per cent per year, with TransLink's transportation costs rising about 7 per cent annually. TransLink hit peak bus capacity in 2010, and is now facing declining service hours annually without investment in transit improvements (Price 2015). In addition, total per capita annual expenses has been surpassing per capita revenue, due to an expanding transit and road network, which comes with increased operating costs (TransLink 2013).

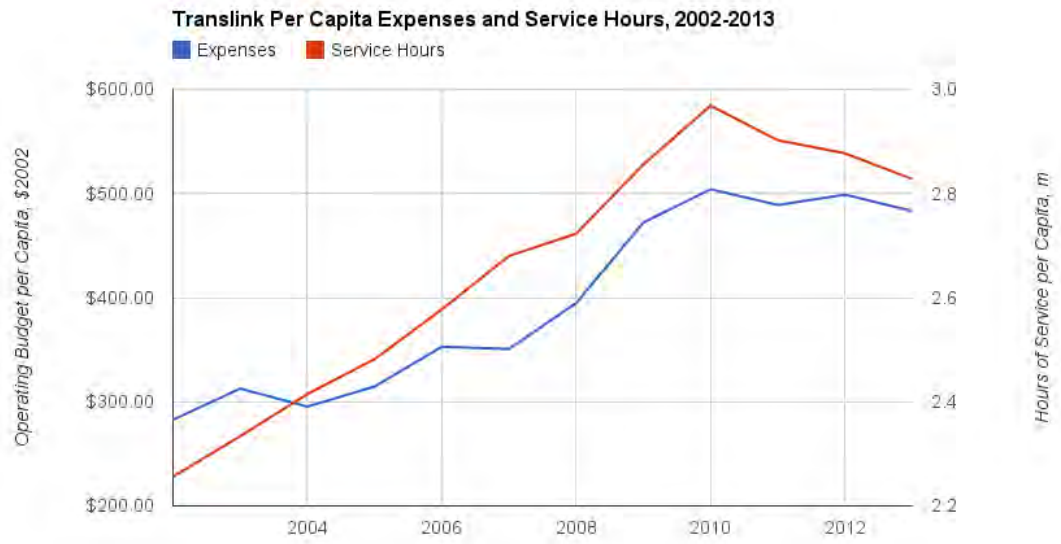

Figure 1: TransLink Per Capita Expenses and Service Hour Comparison

To mitigate future road congestion problems, TransLink requires the necessary funding to expand its transit network and serve the future mobility needs of the region. This is justifiable, as future growth in Metro Vancouver is projected to grow along rapid transit corridors (Translink, 2012):

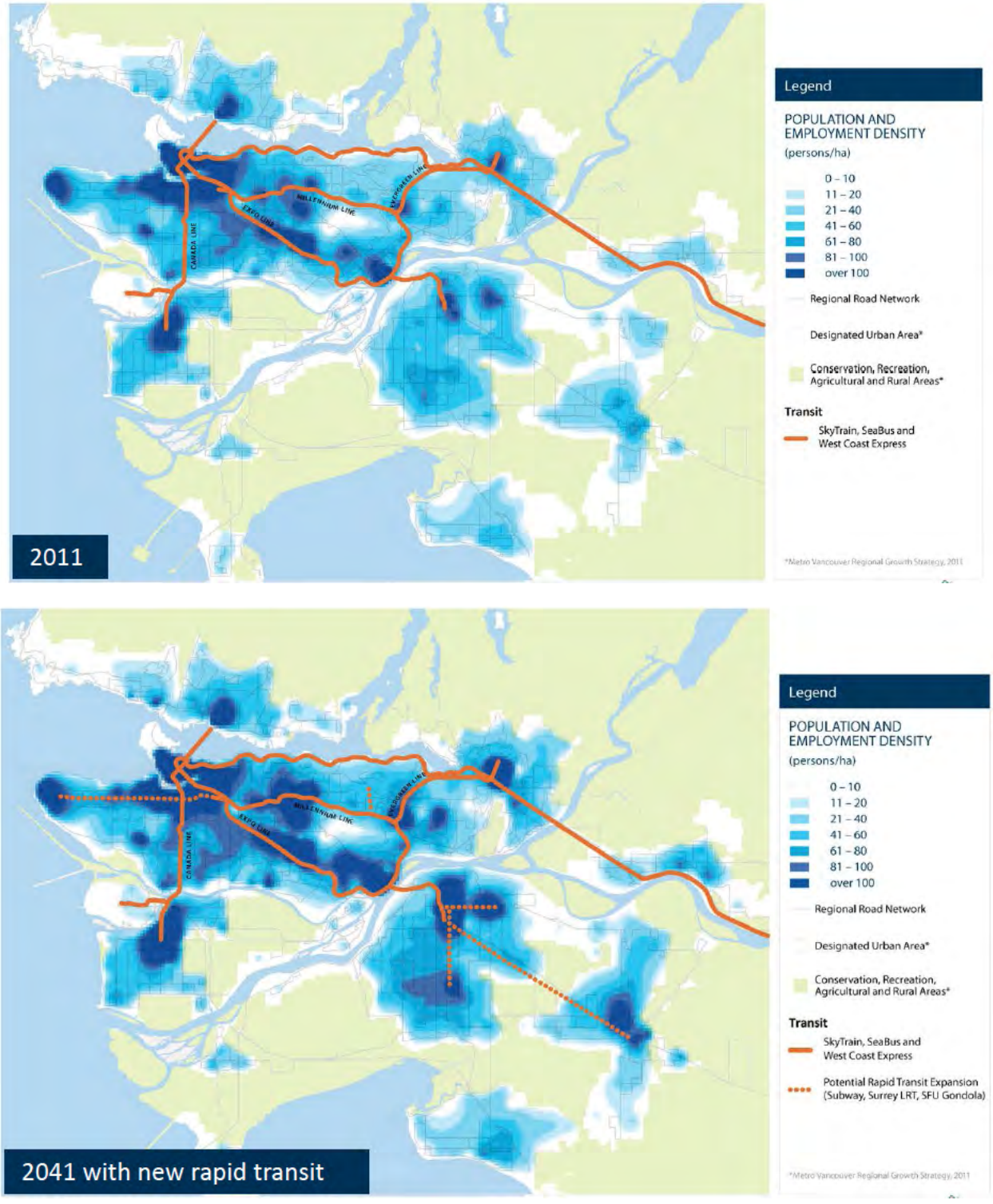

Figure 2+3: Population and Employment Growth Projections

These maps show a combined population and employment density over-layed with the existing and proposed rapid transit investments. In Metro Vancouver, most high density development has been along rapid transit lines, giving people sustainable transportation options. The population projections for 2041 with the new rapid transit overlay shows that rapid transit expansion will serve new growth, ensuring future populations will be able to get around safely and efficiently, preserving natural environment and preventing gridlock. The Province of British Columbia has ambitious targets for Metro Vancouver, with a goal to significantly increase transit ridership by 2030:

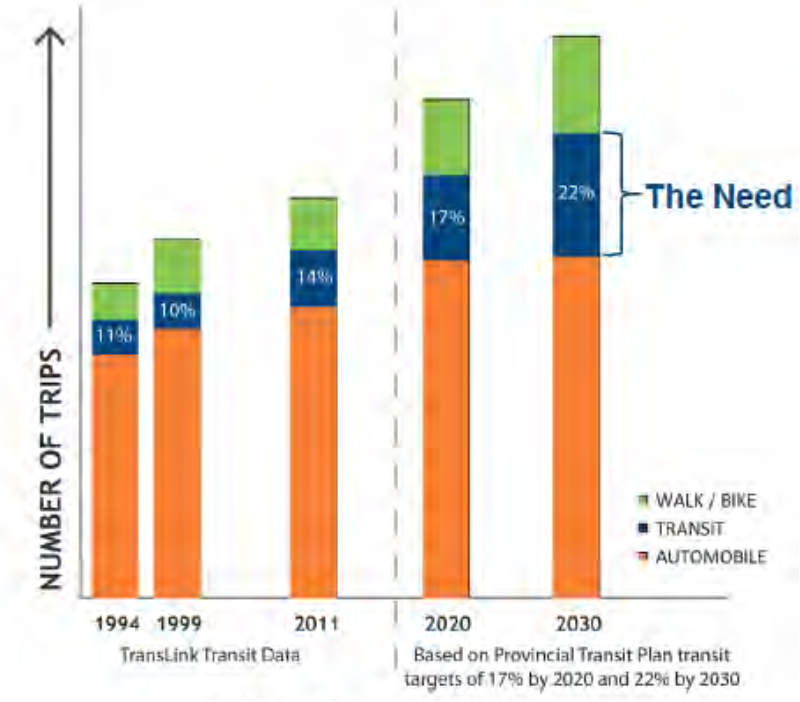

Figure 4: Metro Vancouver Mode Share Targets

Metro Vancouver Context

Metro Vancouver has one of highest rates of transit ridership per capita in North America, but in order for the entire Metro Vancouver Region to hold similar success rates, as outlined in Transport 2040, the current networks will need to be expanded. The following figures examine transit use and automobile travel in the GVRD. As can be expected, transit ridership is strongly correlated with areas of high transit accessibility, and a negative correlation can be seen when comparing drivers and transit accessibility. With projects in several auto-dominant areas, like Surrey and Coquitlam, the Mayors' Plan's expanded network will look to increase the transit ridership in several key areas where it is currently lacking.

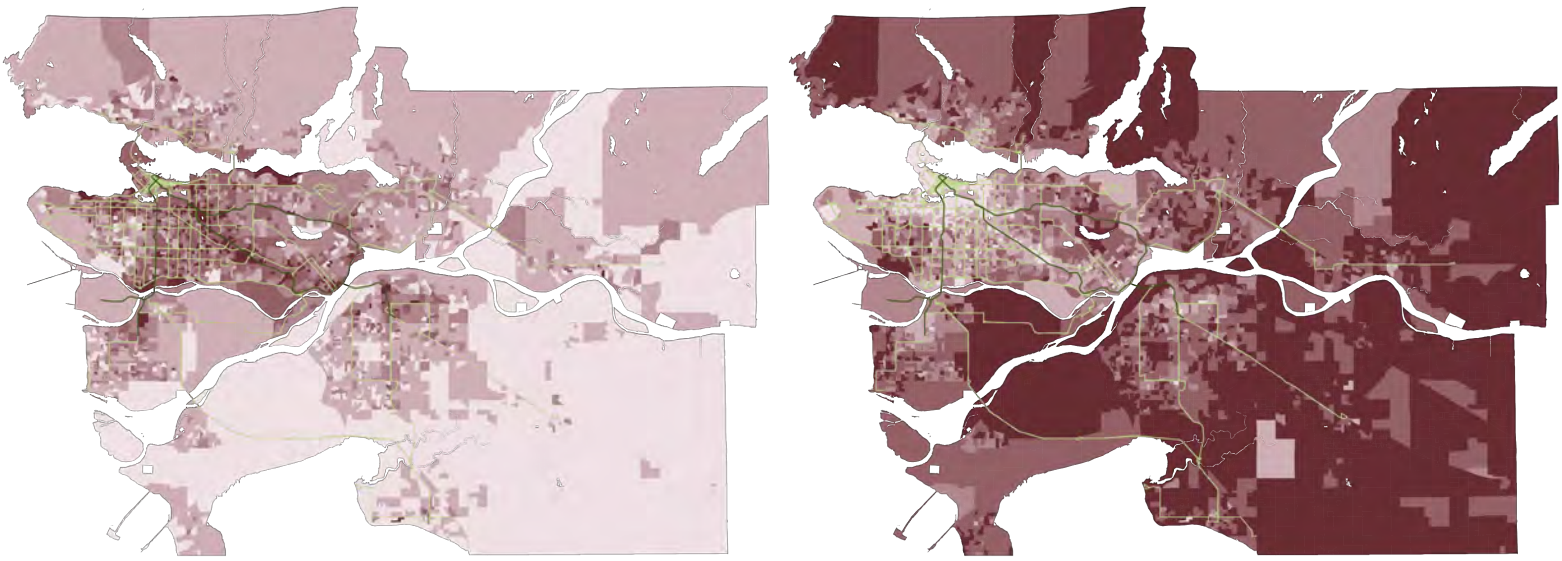

Figure 5: Metro Vancouver Transit Mode Share / Automobile Mode Share

Low-income residents are often much more reliant on public transportation. When mode share for Metro Vancouver is broken down by income it can be seen that public transportation is a much more important form of transit for lower-income residents (TransLink, 2011, p.27). As seen in the figure on the next page, low-income groups reside predominantly within urban centers where public transportation is more abundant. When one overlays the current TransLink Frequent Transit Network, it becomes quite apparent that residents who are bound by the limitations of public transportation are at a distinct disadvantage. Their ability to find and compete for work is significantly hindered by where they can access by public transportation. The Mayors' Plan looks to rectify this issue by expanding the areas that can be reached via public transport, and increase the amount of off peak service hours to serve those who do not work during traditional working hours.

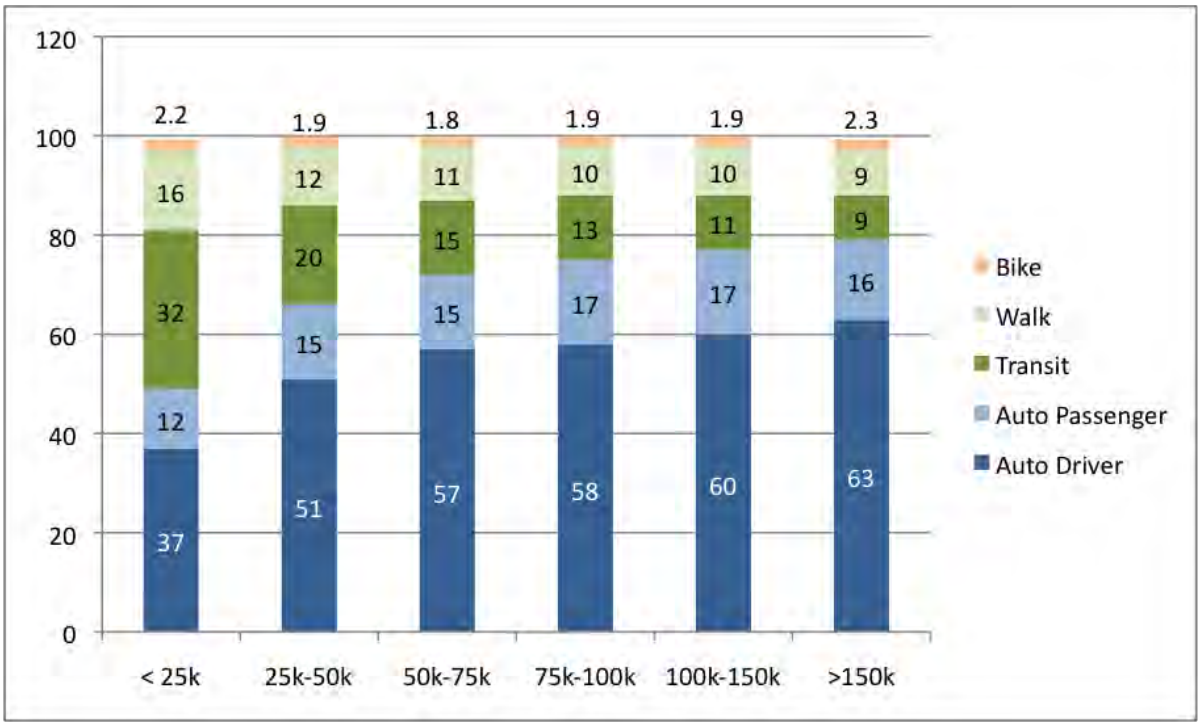

Figure 6: Metro Vancouver Mode Choice by Household Income

The need to provide better transit services becomes even more apparent when looking at the poverty statistics of the region. Using Statistics Canada's Low-Income Median- After Tax (LIM-AT) rating, it can be seen that Metro Vancouver's 2011 poverty rate (15.7%) is noticeably higher than both the British Columbia's provincial average (15.3%) and the Canadian national average (12.6%) (Statistics Canada, 2013). Within this notable segment of the region's population are several different demographics including: fixed income residents (seniors and students), low-wage earners, and no wage earners; of which, immigrants and racialized groups make up a disproportionate share. As of 2010, immigrants who had been residing in Vancouver between 1 and 5 years had a low-income rate of 35.6%, and immigrants who had been residing in Vancouver between 5 and 10 years still had a low-income rate of 33.1% (Statistics Canada, 2014). Together, these two immigrant groups made up 13.4% of the 2010 population, and 20.8% of the population if one includes immigrants who have been in the city for 15 years (Statistics Canada).

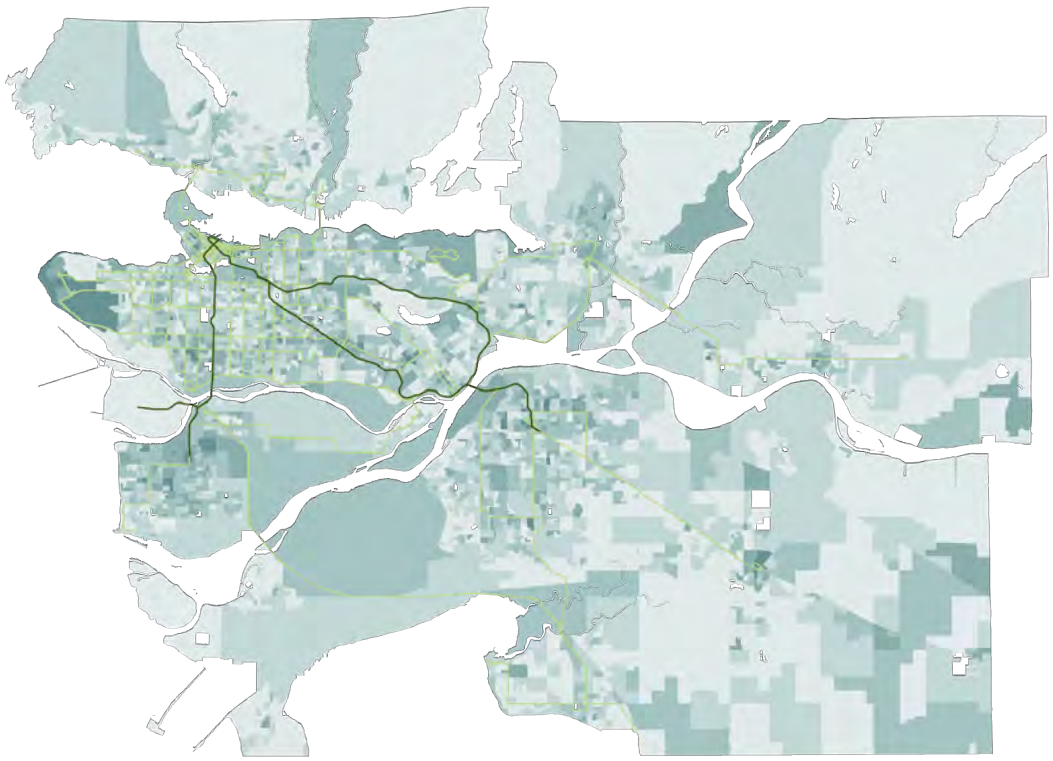

Figure 7: Metro Vancouver LIM-AT Income Ratings

Establishing transit in areas where it can easily be accessed on foot is an integral part of its success. In order to entice the number of riders Transport 2040 calls for, transit networks will need to be easily accessible by foot. As seen on the next page, the region's FTN is directly correlated to the region's most walkable environments, according to the Health and Community Design Lab's Walkability Index rating for the metro region. Expanding the FTN in and around these walkable environments will be essential in the region meeting its transportation objectives. While having walkable environments is key for transit success, the proposed transit investments will also develop more walkable communities. As previously noted, the growth strategies for the region focused along existing and proposed transit corridors which will add to the amount of walkable areas in the region, especially in areas like Surrey. In doing so, these investments will not only encourage more people to make the switch to public transportation, but also promote active transportation opportunities.

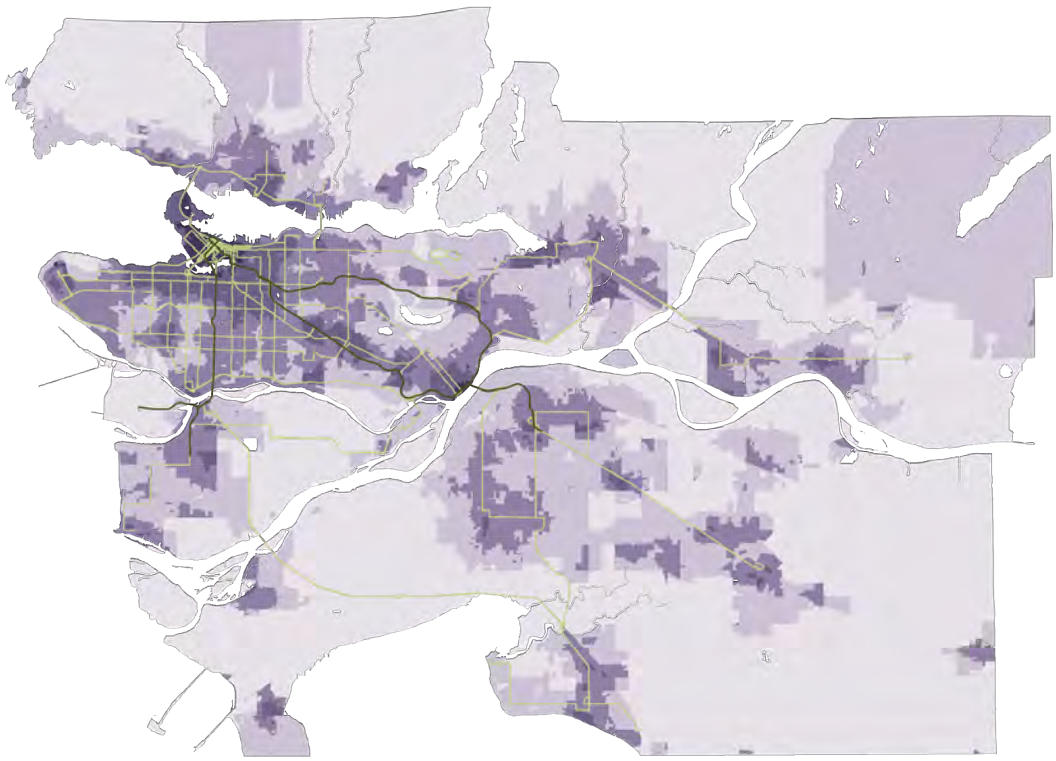

Figure 8: Metro Vancouver Walkability Index

Scenarios for Analysis

The current scenario is defined in detail in the Metro Vancouver context above. The proposed scenario is a long-term 12 year vision of Metro Vancouver's future with the transportation investments proposed by the Mayors' Council implemented throughout the region. In 2027, the proposed transportation projects will be completed and operational. The accessibility and mobility levels before and after the transportation improvements are compared for this analysis. Throughout the analysis, the relative improvements are quantified to +justify the potential accessibility and mobility benefits of implementing the proposed transportation projects. The costs associated with the proposed scenario is a 0.5% increase in sales tax to raise $250 million in funding per year, while the costs associated with the current scenario is currently nil. However, in the future a do-nothing scenario will result in increased congestion throughout the region increasing travel time and costs for all residents. A study by HDR found that by 2030, the improved transportation options due to the Mayor's Plan will save the average household $360 per year and $1,100 per year by 2045 even after the 0.5% increase in sales tax (TransLink, 2015).

Methodology

Dimension One: Accessibility of FTN

Accessibility: Population Within Range of the FTN

To model the accessibility of the FTN, a map of bus stops (Translink, 2010) and bus frequencies (Translink, 2014) was combined with a street network (DMTI Spatial, 2010) to form a multi-modal network dataset. Rather than make assumptions about the maximum distance residents are willing to walk to different types of services- i.e. rapid transit, frequent local, or frequent express- we elected to combine walking and waiting times. This reflects the intention of the FTN, which combines routes based on frequency rather than technology. Walking times to and wait times at bus stops were combined using a 5 km/h assumed walking speed and average wait times equal to half of the headway between buses. Where multiple routes ran along a given street, their combined frequency was divided in half to give the average waiting time. Once service area polygons were drawn for each bus stop, they were overlaid on dissemination blocks from the 2011 Census (Statistics Canada, 2013). The population within accessible range of the current and future frequent transit networks were then estimated. In order to test the effects of combining frequency with walking distance, a separate model considering only pedestrian travel times was constructed. An addition model which excluded the rail projects in the Mayors' Plan was also included from the purposes of cost benefit analysis.

There are a number of important conceptual limitations to this method. First and foremost, it assumes that pedestrians are constrained to the street network and ignores the possibility of shortcuts on pathways, through buildings, or across parking lots and open spaces. This network analysis also does not consider pedestrian signal timings, and assumes that pedestrians may cross the street at any point. Our approach of combining waiting and walking time avoids the need for a priori assumptions about the willingness to walk to specific types of services, but does make the assumption that each type of service is equally useful for residents and that they will value walking and waiting time equally. Further, the method used to find combined headways assumes that buses are perfectly distributed to give the lowest possible average waiting time. It is also assumes that the arrival of users at bus stops is randomly distributed, and that passengers do not time their arrivals to be within a few minutes of the scheduled departure. Estimating the population within range of the FTN required the assumption that populations were evenly distributed within dissemination blocks. This limitation is

more pressing in outer areas where dissemination blocks cover larger geographic areas, but the majority of residents may be concentrated in a specific subarea.

Another major category of limitations involves how predictions are made about future conditions. With regards to the bus network, the documents associated with the Mayor's Plan do not include detailed routing information, or an exhaustive list of routes which will receive frequency improvements. In the absence of these details, we elected for a conservative approach. On the fifteen routes identified for intensified FTN service in the Mayor's Plan, a modest increase in frequency was assumed (Mayor's Council, 2014, A-50). The fifteen new routes were assumed to follow the minimum FTN standard of 15 minute headways. There is also the issue of bus stop placement, which remains unchanged in the model of the future network, even though the conversion of local routes to express service means that many stops will be consolidated. No prediction was made in the future model about the magnitude and spatial distribution of population growth, and how that might affect the level of access to the FTN. The street network also remains unchanged in the future model, though considerable changes are being made in rapidly growing areas like Surrey and Langley.

Accessibility: Projected Mode Share

To estimate the potential mode shift resulting from changes in transit accessibility, the network buffers were overlaid with census data on commute mode share from the 2011 NHS. An average transit mode share for dissemination areas within each time interval of the FTN was then found, as shown in Table 2. The resulting estimate of all-day transit mode share for each municipality is compared to the actual mode share from the 2011 Trip Diary in Figure 9. The average error for central areas was roughly 2%, but larger discrepancies exist in the outer suburbs. This is likely due to the incomplete network and lack of destinations and employment along the FTN in lower density areas.

Time Interval	Average Transit Mode Share
0 to 5 min	25%
5 min to 10 min	22%
10 min to 15 min	16%
15 min to 20 min	14%
20 min +	9%

Table 2: Average Mode Share by Time to FTN

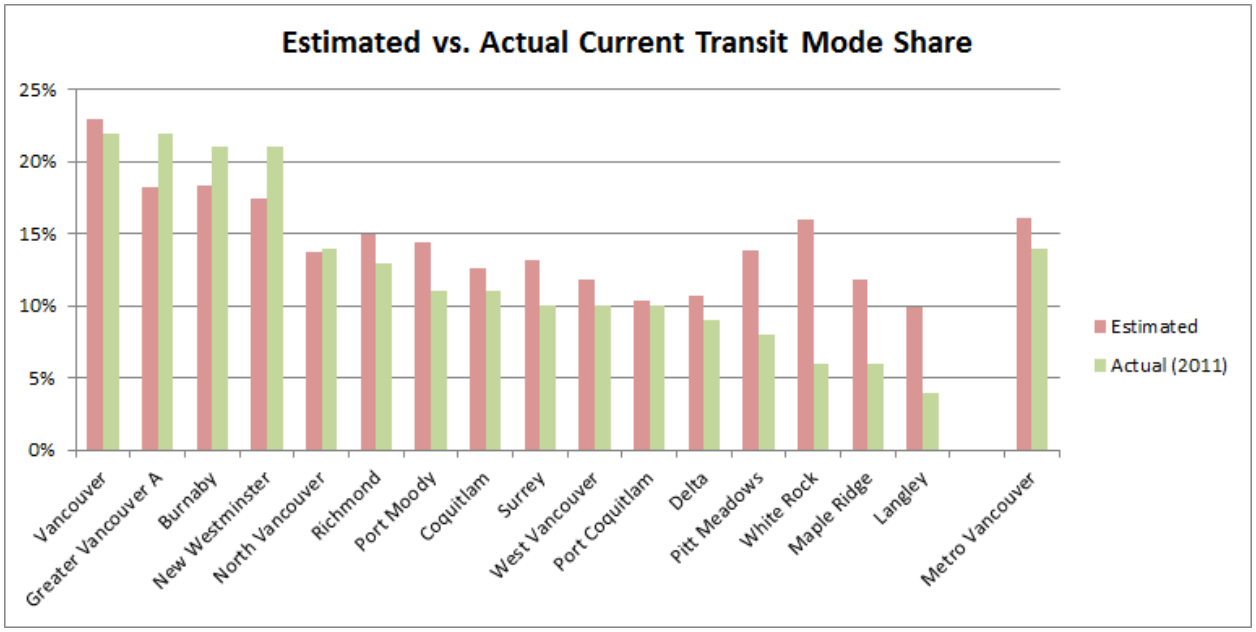

Figure 9: Estimated vs. Observed Mode Share By Municipality

Dimension Two: Mobility between Regional Centres

To perform a mobility analysis for the region, special generators and frequent hubs of activity such as CBDs were used as origins and destinations. These locations were chosen to provide a representative sample of potential time savings between subregions in Metro Vancouver. Two time periods were studied: arriving at 8:00 am and leaving at noon on a Tuesday. Tuesday was chosen as a base workday because it is not likely to have large fluctuations due to proximity to the weekend.

Mobility: Current Scenario

To establish a baseline for comparison, current conditions are approximated using Google Maps' direction functions. The destinations and origins are input, the routes are chosen by using the shortest time to travel, and arrivals are reasonably before 8:00 am and 12:00 pm. Figure 9 shows an example of the use of Google Maps to generate current travel times.

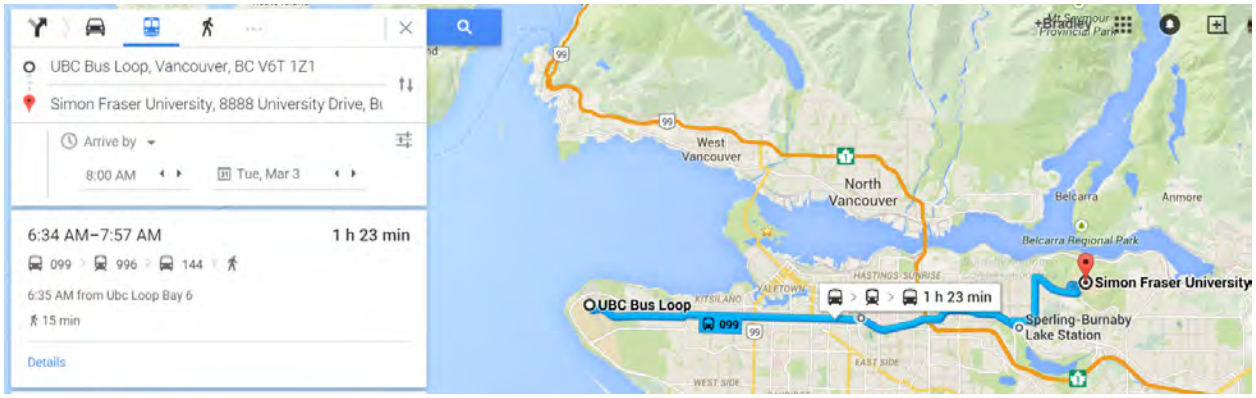

Figure 9: Current travel time from UBC to SFU

The process is continued for each origin to each destination until all transit times for the current mobility scenario are compiled. Google Maps is a good data source because of the high quality and quantity of real-time information available.

Mobility: Proposed Scenario

Using the Mayors' Plan for the proposed scenario, transit travel times are approximated based on proposed expanded B-Line service, SkyTrain service, and LRT service. The calculations were based on wait-time assumptions and speed approximations to find new travel times for the proposed scenario.

The analysis was performed by assuming two parameters of different transit modes: headway and speed. Increases in frequency implies less waiting time for transit service, which also reduces the door-to-door time for the trip. In order to establish the headway for the new B-Line routes proposed in the Mayors' Plan, the frequency of both the AM Peak and midday of the current 99 B-Line was referenced. When calculating the time to travel, the wait time was equivalent to the average headway between units, which was simplified to half of the headway. This average was a standard time used to assume all of the transit modes in order to standardize the travel times for ease of comparison. It also represents the expected value of the time spent waiting between transit modes.

The speed of each transit mode was approximated by examining similar existing lines for their speed. The time for travel can therefore be approximated through the use of Google Maps to obtain the distance travelled by a future transit mode. Any walking time associated between arriving at a local access point for each transit mode was also considered using Google Maps' anticipated walking time to reach any special generator. The calculation can therefore be summarized in the following summation equation:

$$Travel\ Time = \sum_{i=1}^{n} (\frac{headway_i}{2} + travel\ time_i) + walk\ time$$

Where n is equivalent to the number of transit modes, headway is the headway between units on the i'th transit mode, travel time is the duration to travel from one local access point on the i'th transit mode to another local access point, and walk time is added for any trips that require additional walking to leave or reach a special generator. In summary, in one trip, the total travel time was the sum of each transit mode's corresponding wait time, approximated as the average headway, as each transit mode's travel time and as any walk time necessary.

The proposed Broadway Line is an extension of the Millennium Line, and, as such, the travel time was approximated using the reported Millennium Line skytrain schedule. The travel time for the whole line was taken using Translink's trip planning schedule and found to be 27 minutes. Google Maps was used to measure the distance of the entire Millennium Line, reported as 20.8 km. Finally, the average speed of the Millennium Line was listed as 46.2 km/h. The Broadway Skytrain distance was measured from Google Maps to be 5.49 km, and using the average speed, the time to travel the entire Broadway Line was found to be 7.1 minutes. Translink's trip planning schedule as a data source is dependable, but is not very precise. The lack of precision is considered to be negligible for the purposes of the analysis. It is recommended that the analysis be repeated with the updated average speed for the Broadway Line once it is finalized to provide a more accurate estimate of travel time. The same process was repeated for the B-Line routes in the proposed using the current 99 travel time as the basis for approximation. Since there no data was available for each new B-Line's speed and frequency, the assumptions should be updated with accurate data when available.

The proposed Surrey-Langley Line's data was obtained from the City of Surrey website, where the distance was reported as 17 km and the time to travel was 22 minutes. This data source was considered dependable and imprecise, but acceptable for the purposes of this approximation. The analysis is recommended to be recalculated when the travel time is confirmed.

The total annual cost benefits resulting from the proposed Mayors' Plan were calculated using the following formula for both the AM Peak and midday times.

$$Total\ Annual\ Costs = \#\ of\ trips * time\ savings/day * value\ for\ time$$

In order to determine the number of transit trips generated per day from each origin, each region's individual city populations was found using BCStats. These individual city populations were then converted into a percentage to display the portion of the region's population it represents. Following that, the percentage was multiplied by number of "Daily Trips to Sub-Regions", found below, and percentage of transit mode share from the "Weekday Mode Share to Sub-Regions" table shown in the figure below, to finally determine the number of transit trips generated per day.

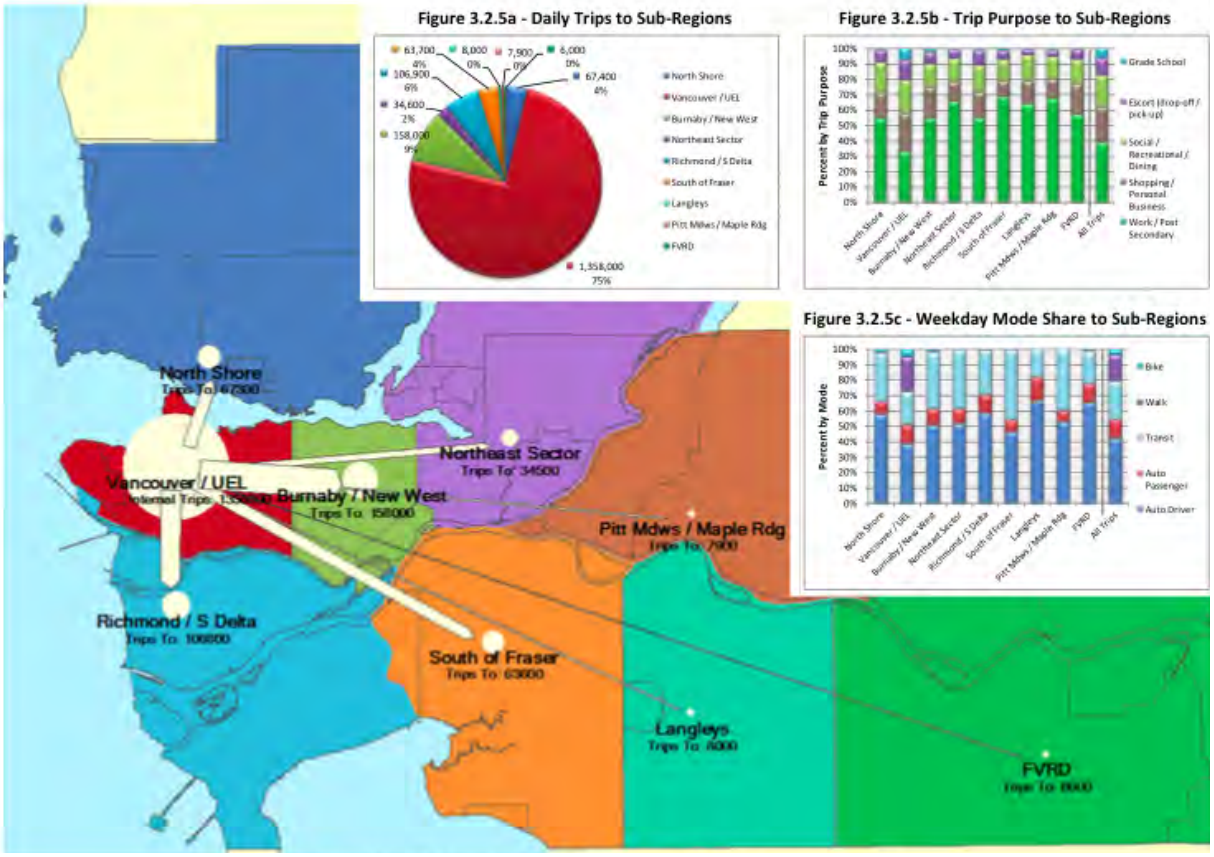

Figure 10: TransLink 2011 Trip Diary Inter-Subregional Travel Example

It was estimated that the average Vancouver resident values their time at $10/hour, resulting in a $0.17/minute rate. By using this value for time, number of trips per day, and time savings as calculated above, the total annual costs were determined.

Analyzing the Impacts of the Mayors' Plan

Dimension One: Accessibility of FTN

Accessibility: Population Within Range of the FTN

The population living within 15 minutes of an FTN service will increase considerably, from 55% of the current population to two-thirds in 2030. A breakdown of new residents within accessible range by municipality is given in Table 3 below. In the Northeast, Port Coquitlam will see an 35% increase in FTN accessibility through improved frequency on the 188 and replacement of the 701 with a B-Line on Lougheed Highway. The higher frequencies on this B-Line will also lead to an 18% higher portion of Pitt Meadows and Maple Ridge residents within accessible range. South of the Fraser River, just over half of Surrey residents will be in accessible range of the FTN, compared to about a third today. The portion of Langley residents within range will nearly triple with the introduction of LRT on Fraser Highway and a B-Line on 200th, but will remain far below the regional average at 23%. Given the currently very high level of transit accessibility within Vancouver proper, the changes following the implementation of the Mayors' Plan are negligible.

Municipality	New Residents Within 15min	Change
Port Coquitlam	19,707	35.0%
Richmond	54,033	28.4%
North Vancouver	31,356	23.6%
Pitt Meadows	3,339	18.8%
Maple Ridge	13,742	18.1%
Surrey	78,735	16.8%
Langley	19,245	14.9%
White Rock	2,126	11.0%
Delta	10,426	10.4%
New Westminster	5,673	8.6%
West Vancouver	2,821	6.6%
Burnaby	12,877	5.8%
Greater Vancouver A	543	4.2%
Coquitlam	1,437	1.1%
Vancouver	1,769	0.3%
Port Moody	-5,206	-15.8%
Metro Vancouver	**252,700**	**10.9%**

Table 3: New Residents Within 15min of the FTN During AM Peak

Future transit investments will not have positive impacts on accessibility in all municipalities however. The number of Port Moody residents within walking distance of frequent transit will decrease with the introduction of the Evergreen Skytrain extension and the discontinuation of the 97 B-Line. Also significant is the finding that virtually all the City of Vancouver residents will be within 15 minutes of a bus during the morning rush hour following the introduction of the Mayor's Plan. It is important to note the method used to calculate combined frequencies on streets with multiple bus routes assumes that buses are perfectly distributed in time, and, as such, might bias results towards inner-city areas where multiple routes follow the same street more often.

The increases in population within accessible range of frequent transit are stated in terms of capital cost in Table 4 below. This table highlights the high capital costs for rail as compared to buses, as the bus only scenario provides higher levels of accessibility for a fraction of the capital costs. These high costs per new resident within accessible range for rail projects could be offset by improvements to mobility as well as societal benefits such as emission reductions and improved public health.

	AM Peak	Midday	AM (Bus Only)	AM (Walking Only)
New Residents within 15min	252,700	215,057	257,635	409,177
Capital Cost per Resident	$23,728	$27,881	$563	$14,654

Table 4: Cost per New Resident Within Accessible Range of the FTN

Accessibility: Projected Mode Share

Regarding potential mode shift, it is predicted that the the Mayors' Plan would increase transit mode by 1.6% region-wide by 2027. The predicted mode shift per municipality is shown in Figure 10 and Table 5 below. The largest shift towards transit use is predicted to occur in Port Coquitlam, although future mode share will only reach the current regional average. Large shifts also occur in Richmond and North Vancouver where the geographic coverage of the FTN is greatly expanded. As expected, the mode shift in the City of Vancouver is very small. In the Northeast Sector, the mode shift is negligible in Coquitlam and significantly negative in Port Moody. The Mayors' Council has not published an estimate for transit mode share, although the sustainable mode share (transit, walking, and cycling) is predicted to increase by 5.7% (Mayors' Council, 2014, p.C7).

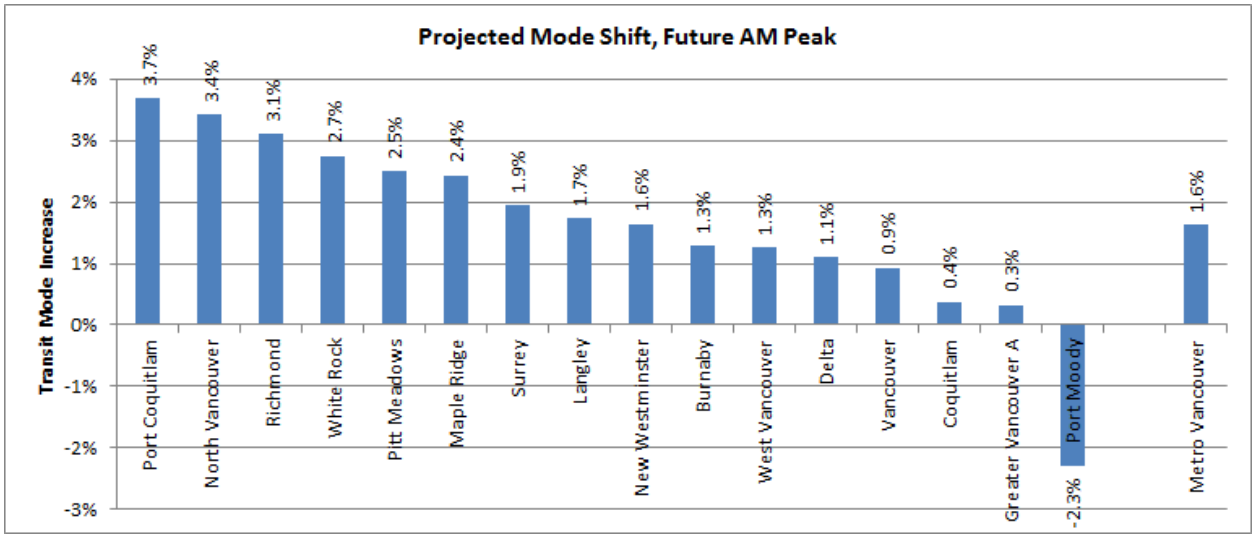

Figure 11: Projected Mode Shift in AM Peak, By Municipality

Estimated Mode Share	Current	Future	Change
Vancouver	23%	24%	0.9%
Burnaby	18%	20%	1.3%
Greater Vancouver A	18%	19%	0.3%
New Westminster	17%	19%	1.6%
White Rock	16%	19%	2.7%
Richmond	15%	18%	3.1%
Port Moody	14%	12%	-2.3%
Pitt Meadows	14%	16%	2.5%
North Vancouver	14%	17%	3.4%
Surrey	13%	15%	1.9%
Coquitlam	13%	13%	0.4%
West Vancouver	12%	13%	1.3%
Maple Ridge	12%	14%	2.4%
Delta	11%	12%	1.1%
Port Coquitlam	10%	14%	3.7%
Langley	10%	12%	1.7%
Metro Vancouver	**16%**	**18%**	**1.6%**

Table 5: Estimated Change in Transit Mode Share

Dimension Two: Mobility Between Subregions

The results of analysis for the current and proposed scenario are presented in this section through a summary table, with raw data and further bar charts in Appendix A. The Burrard St. Station

bar chart is detailed below for further analysis. Since the downtown central business district is such a vital hub of both commuters and other users of the FTN, Burrard St. Station was chosen as one of the special generators for comparison. The travel time for the current scenario is shown in blue bar charts, and the time to travel for the proposed scenario is shown in the below graph in red.

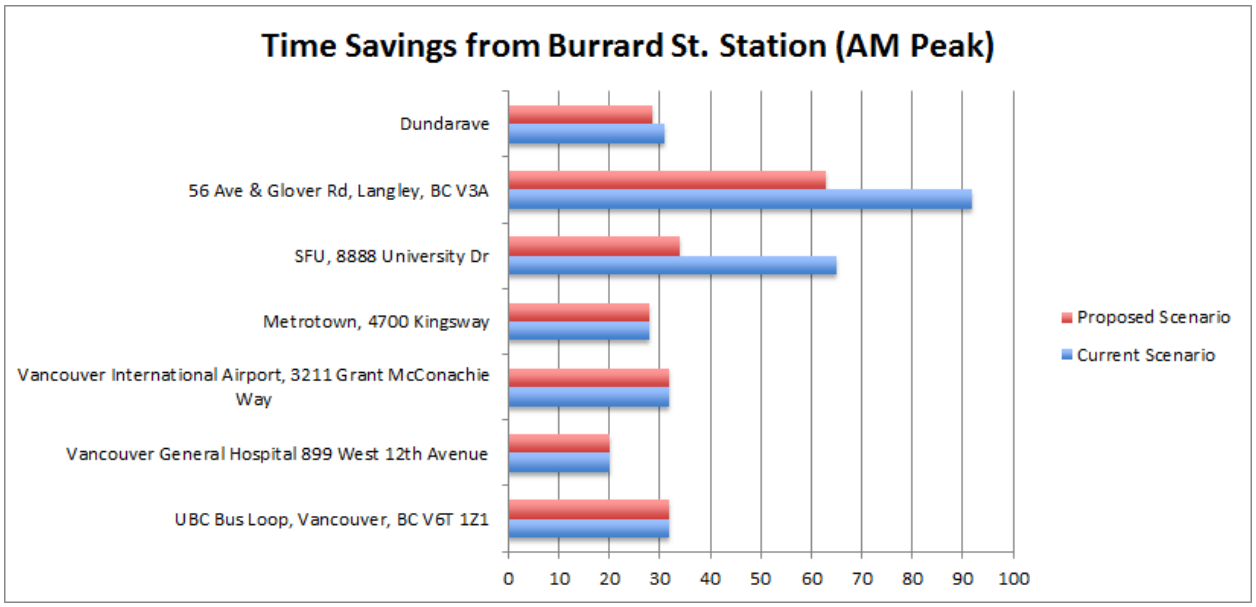

Figure 12: Travel times for AM from Burrard St. Station

The largest improvements in travel time are found in the travel to Langley, and to SFU. The Langley travel time improvement is mostly attributed to the installation of the new Surrey-Langley Line. The time is calculated as follows.

$$Burrard\ to\ Langley = walk + \frac{Frequency_{Expo\ Line}}{2} + Time_{Expo\ Line} + \frac{Frequency_{LRT}}{2} + Time_{LRT}$$

$$Burrard\ to\ Langley = 3\ min + \frac{3\ min}{2} + 35\ min + \frac{3\ min}{2} + 22\ min = 63\ min$$

The travel time along the Expo Line is conservatively assumed as remaining the same as the current scenario. The speed is likely to improve in the proposed scenario due to the fact that funding will be allocated to purchase Skytrain fleet and increase the frequency of car arrivals. The improvement in travel time from Burrard Station to SFU illustrates the potential improvements from newly installed B-Lines. By providing a more direct path with improved service via a new B-Line from downtown to SFU along Hastings Street, the travel time in the proposed scenario can be reduced by nearly half an hour from 65 minutes currently to 34 minutes.

$$Burrard\ to\ SFU = \frac{Distance_{Hastings}}{Avg\ Speed} = \frac{14.4km}{0.43\frac{km}{min}} = 33.86\ min$$

The average speed of the B-Line is approximated by using the current 99's travel time and distance, and is calculated to be 0.43 km/min, which is equivalent to 25.8 kph. Given the congestion and frequent stops for traffic lights and bus stops, the average speed is reasonable. The trips from Burrard St. Station to Metrotown, YVR, VGH, and UBC are not affected by transit infrastructure improvements in the proposed scenario. Since the trips from Burrard St. are part of the FTN system, and the assumption that the service along the skytrains will remain the same, the best travel time is not anticipated to be affected by the proposed scenario. The travel time matrix, summarizing all the travel times between special generators, and additional bar graphs are located in Appendix B.

Origin	AM % Reduction	PM % Reduction	Overall % Reduction
UBC Bus Loop	15.60%	12.17%	13.88%
Burrard St. Station	13.50%	10.01%	11.76%
Vancouver General Hospital	21.27%	20.27%	20.77%
YVR	10.46%	8.89%	9.67%
Metrotown	16.40%	12.98%	14.69%
SFU	22.95%	20.85%	21.90%
Langley Centre	19.43%	11.74%	15.59%
Dundarave	16.77%	10.74%	13.76%
Central City Shopping Centre	29.54%	23.52%	26.53%
Coquitlam Station	14.91%	32.04%	23.48%
Haney Place Transit Exchange	9.36%	8.99%	9.18%
Total	**17.05%**	**13.46%**	**15.25%**

Table 6: Travel Time Matrix

Overall, the trend shows a reduction in travel time for the region in general, with SFU, Surrey, Coquitlam, and VGH receiving the most benefit from the proposed scenario. With all of the locations being served by FTN systems in the future, the travel times are expected to decrease.

Economic Analysis

The total economic benefits were calculated based on the time savings from each sub region and expanded to the entire population. The dollar value of annual time savings for the year 2027 are summarized in the table below.

Benefit Value from Time Savings - Sub Region	
North Shore	$2,620,266
Vancouver / UEL	$26,492,766
Burnaby / New West	$1,130,968
Northeast Sector	$1,645,065
Richmond / S Delta	$956,546
South of Fraser	$9,954,090
Langleys	$1,483,735
Pitt Meadows / Maple Ridge	$1,351,478
Total	**$45,634,915**

Table 7: Economic Benefits of Time Savings

Trips generated from Vancouver are the largest contribution of time benefit due to the large number of trips generated from Vancouver as an origin. Since it is a common destination-origin, the large benefit evaluation is reasonable.

It is worth noting that the benefit evaluation is conservative and does not comprehensively estimate the value obtained from many other sources and considerations. The evaluation does not consider intra-subregion travel trips such as from Vancouver to another destination in Vancouver. These trips make up a large portion of common trips, and time savings estimated from these would increase the value of the Mayor's plan. In addition, the times chosen only approximate the am peak trips and the 12pm trips. If all times of the day are considered, more time savings can be accounted for and included in the estimate. Psychological effects such as the removal of barriers to travel can lead to further benefits for businesses. If travel to businesses and restaurants is faster and more convenient, people are more likely to decide to travel to spend money, leading to increased revenue for businesses. Businesses can also benefit due to increased foot traffic if located in proximity to a local access point for the FTN. It can also be noted that the health benefits associated with using transit, such as walking from destinations to the FTN, can have a direct influence on riders' health and correspondingly decrease the load on the public health system.

Recommendations

The proposed Mayors' Plan offers a wide array of potential benefits, from tangible time savings to harder to quantify environmental and health benefits. While the Plan offers numerous savings and positive externalities, further savings could be achieved by examining the light rail investments in Surrey and Langley. As seen in Appendix A's "Projected Transit Mode Shift, By Municipality" and the previously stated cost per FTN access population examinations, investments in B-Line services would not only increase bus frequency, but dramatically reduce the cost per capita as well. Between the high cost of the rail construction, and the larger population of residents who would be able to access the FTN in under 15 minutes, cost per capita could drop from upwards of $22k to $580. WIth these savings in mind, it is recommended that the Mayors' Plan forego the LRT projects in Surrey and Langley until necessary population densities exist to warrant light or heavy rail investments. Further, the Mayors' Plan should consider alternatives to rail, such as expanded investments in B-Line services, in order to increase the amount of potential users and destinations that can be easily accessed along the FTN.

Additionally, FTN transit stops should be reviewed and assessed on their walking and waiting times. As seen through the first half of this study, combining these two times can result in a metric that can more accurately conveys true travel time. These results can be used to assess what current bus stops are necessary and what stops might be able to be removed in order to increase bus speed and overall frequency. Removing bus stops is always a contentious issue, but gains in frequency and speed might offset the increased walking times and lead to a more efficient, holistic network.

Conclusions

As the region looks to welcome a million new residents to the region over the next 25 years, transportation investments will be essential in ensuring that residents maintain the ability to access reliable, affordable, and efficient modes of transportation. The Mayors' Plan looks to lay the foundation for establishing this type accessible and reliable transportation system. Through this study, it can be seen that the Mayors' Plan will offer 66% of Metro Vancouver residents access to the FTN and an average reduction of transit travel times by over 15%. This increase in both access and mobility will be an essential element in making transit an appealing option for current and future residents alike. For transit to be successful at influencing mode shift, a necessary component of the region's growth strategy, it needs to be convenient, frequent and accessible for all. The outlined transportation improvements in the Mayors' Plan will strengthen the region as it grows and provide the infrastructure necessary to achieve the region's transportation objectives.

In conjunction with the potential time savings and increased access and mobility, the Mayors' Plan will also produce several key positive externalities that will help the region achieve many of its health, development and, environmental goals. The health implications stand to be one of the largest money saving benefits of the Plan. As a greater population of commuters begin to engage in more physical activity through walking and cycling to a transit stop, the healthcare costs associated with sedentary lifestyles will begin to decrease. The proposed transit investments will also assist in the region's growth strategy. By developing along the newly built rail and bus corridors, Metro Vancouver will grow in a manner that will be more conducive to walking, cycling, and transit, while also reducing the need to use an automobile for daily trips. Furthermore, these investments, and the associated positive externalities, will help the region realize its larger environmental goals. Promoting shorter, less auto-dependent travel choices will be vital in assuring Metro Vancouver remains a vibrant and ecologically stable environment. Through these numerous associated benefits, it can be seen that the Mayors' Plan is not only an integral part of improving the region's transportation system, but an important step in achieving Metro Vancouver's larger development strategies and environmental initiatives.

Future Work

The results of this study could be furthered through several additional considerations including:

Incorporate Sidewalks and Pedestrian Shortcuts

The current model places pedestrians along the street network, which does not simulate the free moving nature users have in the actual urban environment. Including sidewalks and known pedestrian shortcuts (cutting across parking lots, going through buildings, and using off-road trails) will create a more accurate depiction of actual pedestrian circulation. These additions will be difficult to know in entirety, but those that are added to the current model will help to create a more accurate measurement for how long it takes users to arrive at a FTN stop. Through alterations pedestrian walking times will be reduced, resulting in a wider FTN access area.

Include More Destinations & Trip Start Times

For the second half of the project, 11 trip generators were utilized to assess the change in travel times. In order to establish a more holistic and thorough view of how travel times would change throughout the region, more generators would need to be added. Potential additions include: regional town centres, municipal town centres, large employers, and civic centres. Additionally, more

trip start times need to be added in order to understand how trip times vary throughout the day with the addition of the Mayors' Plan. To establish a more comprehensive view on how travel times will be altered throughout the day, travel times must be measured during the PM Peak and evening periods.

Expand the Scope of the Project to Include Cycling

The current studies only assess how the Mayors' Plan impacts walking and transit, but could also be expanded to bicycle infrastructure as well. The proposed improvements call for an additional 2,700 km of bikeways, which could noticeably improve bikeable access to the FTN. By adding cycling to the model, the area accessible to the FTN could, again, be further expanded.

Lessons Learned

Tradeoffs Between Accessibility & Mobility

The concept of the tradeoffs between accessibility and mobility were known prior to the results project, but the difficulty of promoting both features within one system did not become truly apparent until we began modeling the changes to the FTN. An important example that highlighted how accessibility can sometimes be sacrificed for increased mobility was the replacement of the 97 B-Line route for the new Evergreen line. While the Evergreen line is the main reason for a majority of the travel time reductions in the Northeast subregion, it is also the reason why access is lost in parts of Port Moody after the Mayors' Plan is implemented. This example demonstrates the need to thoroughly evaluate the costs and benefits associated with projects that look to increase regional mobility. Although many users will benefit from the increased speeds and frequencies, some other users may lose the network access they had previously.

Difficult to Monetize the Benefits of Mode Shift and Time Savings

Another difficulty that developed into a learning experience was the monetization of both mode shift and time savings. While calculating the time savings was fairly straightforward, it became difficult to extrapolate the costs over the entire length of the project due to the limited information provided in the Mayors' Plan. Since the Plan was hastily assembled many important details, such as implementation timelines for specific projects and financing strategies, were not included. Because of this large, ill informed assumptions would have been required to draw any sort of holistic conclusions. Likewise, stop locations of future FTN stations were not given in full, making it challenging to fully estimate which areas would be receiving the largest accessibility gains. Finally, mode shift could not be analyzed from a benefit cost standpoint without knowing all of the potential costs and savings at both a personal and societal level.

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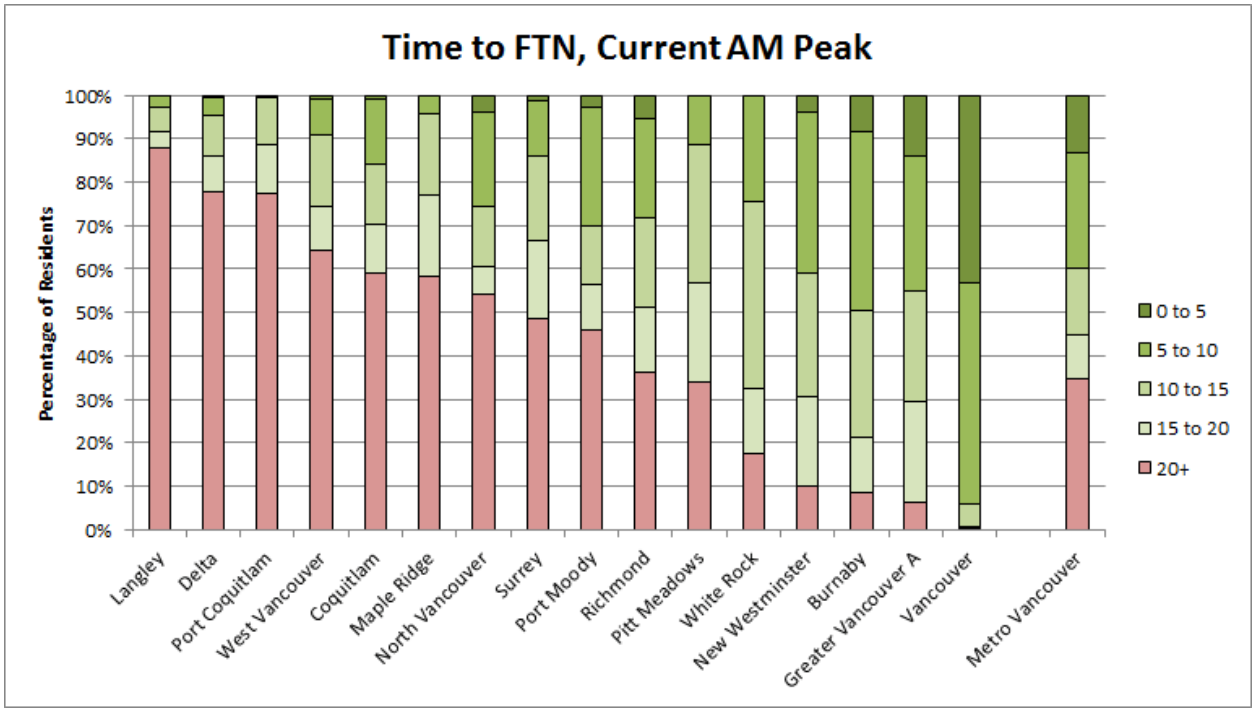
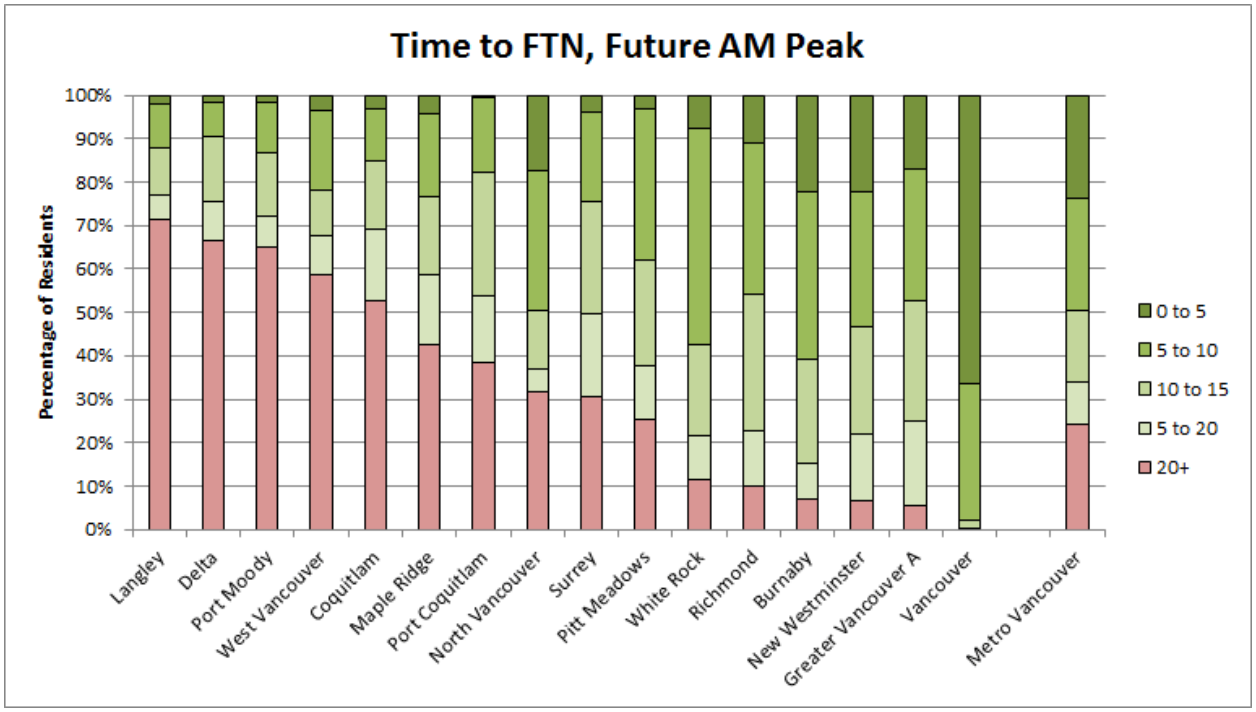
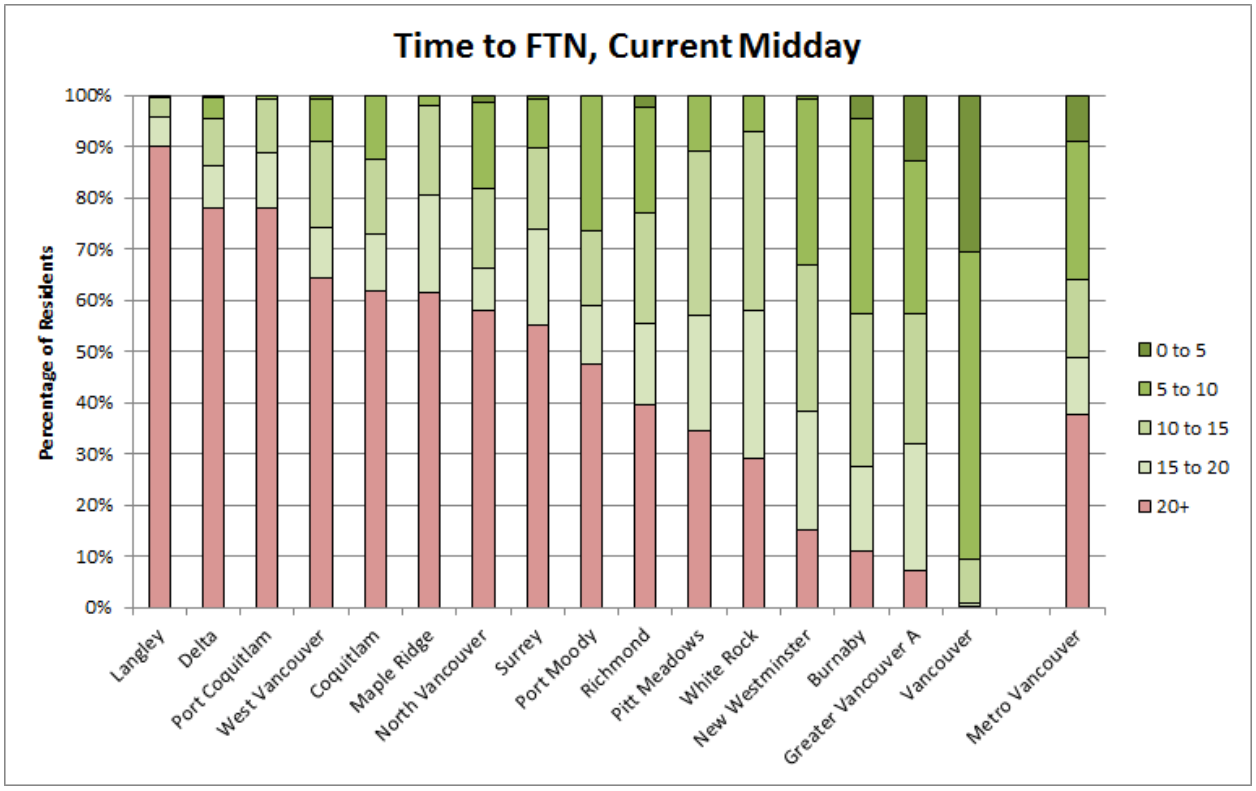
Appendix A

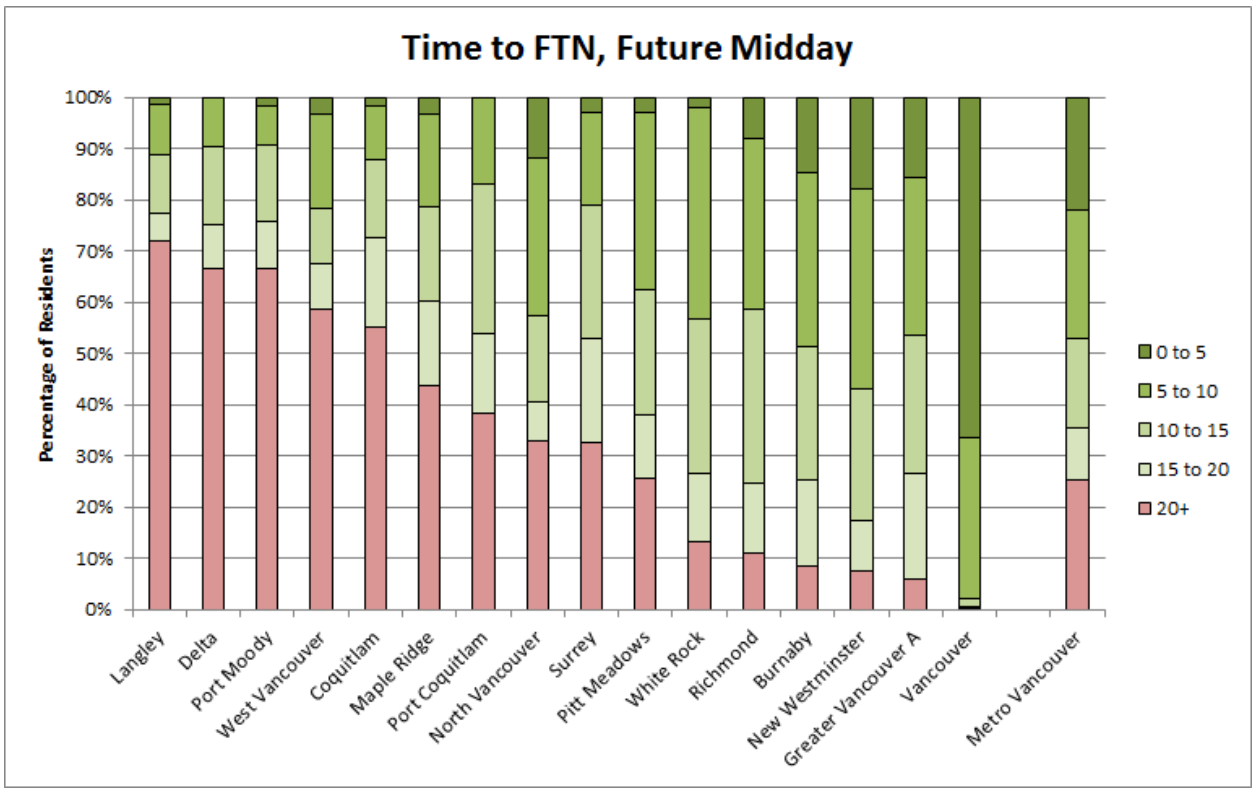
Distribution of Residents by Time to the FTN, AM Peak



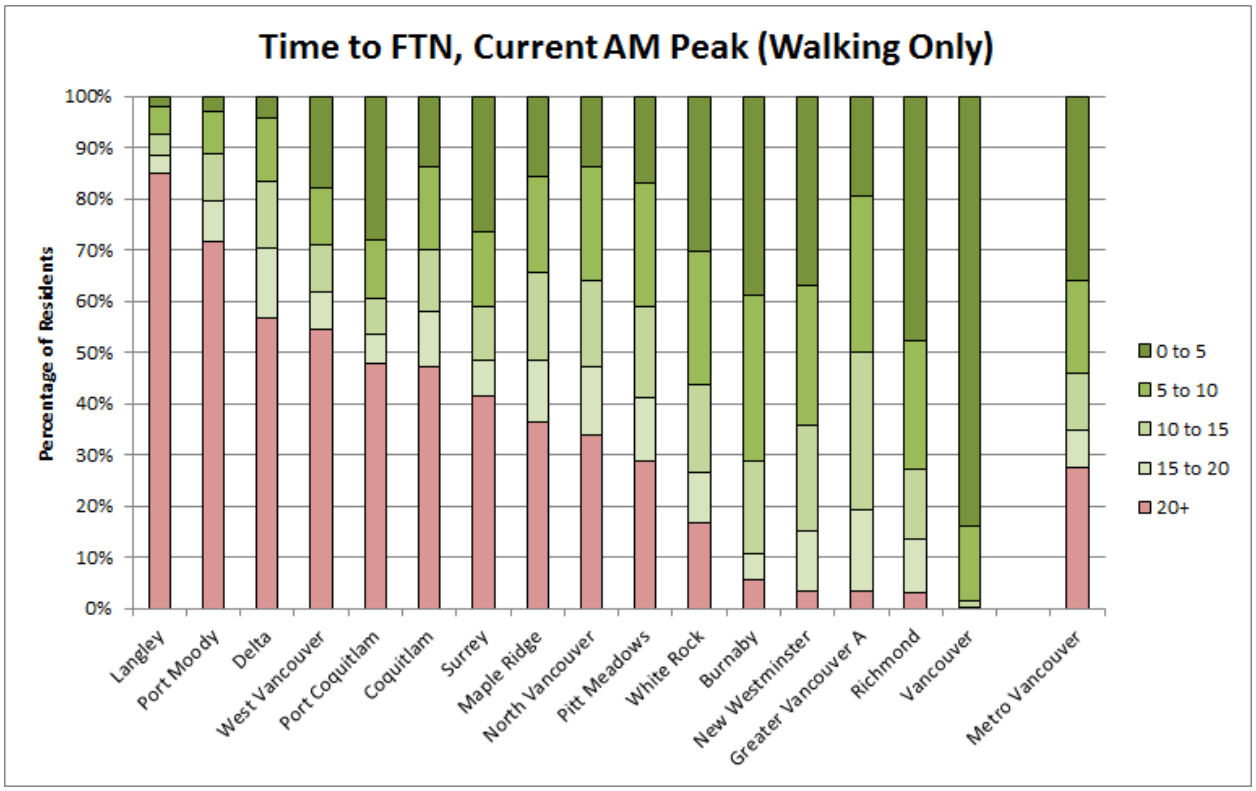


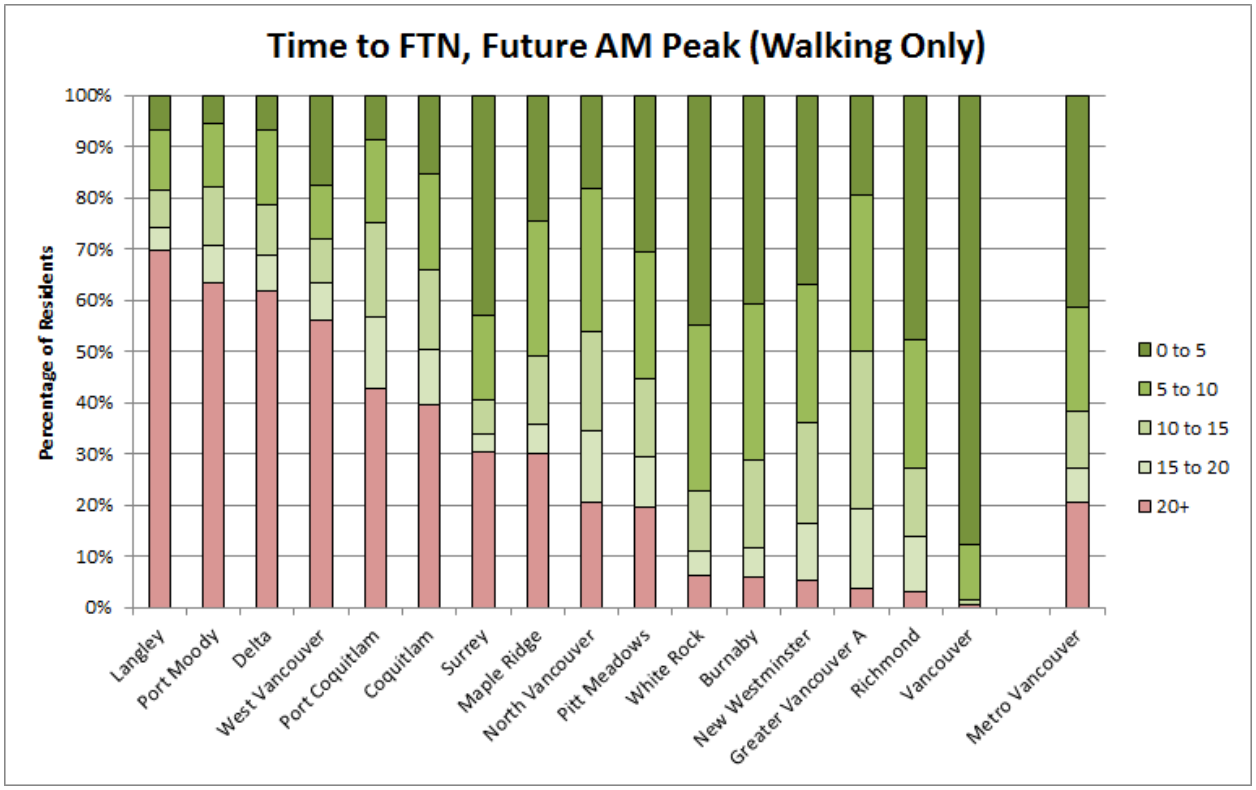
Distribution of Residents by Time to the FTN, Midday



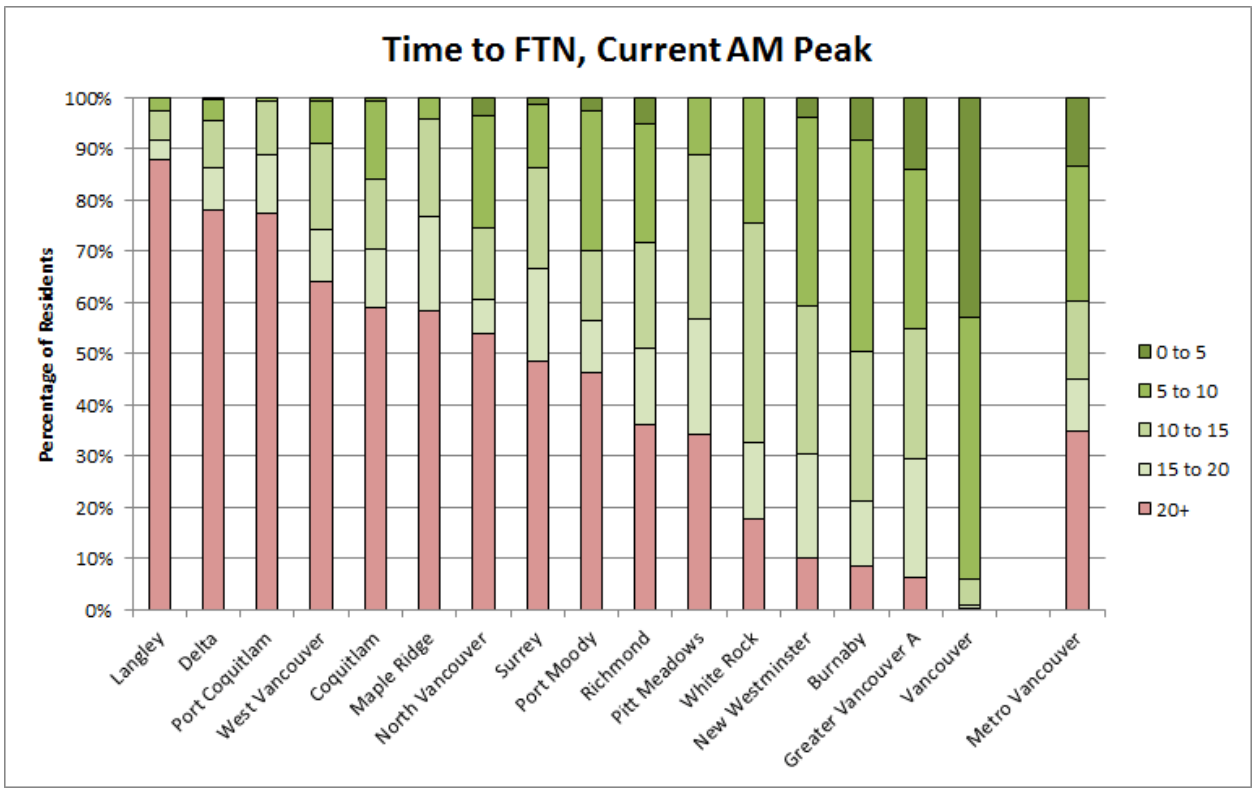


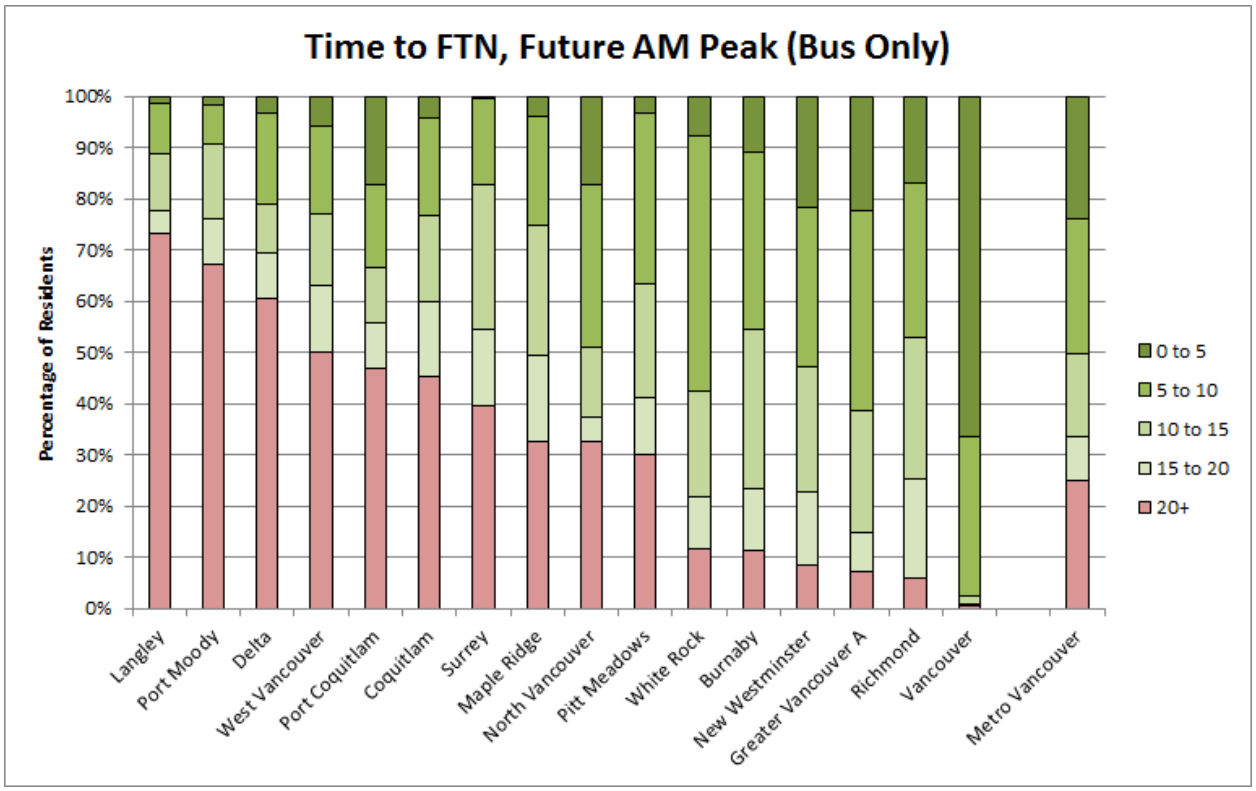
Distribution of Residents by Time to the FTN, AM Peak (Walking Only)



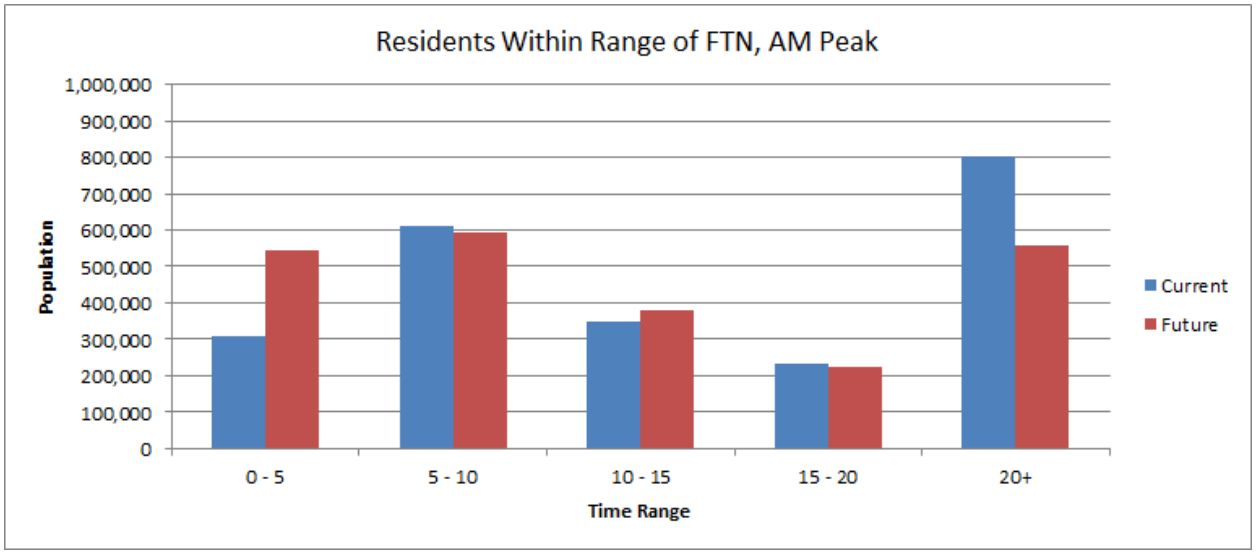


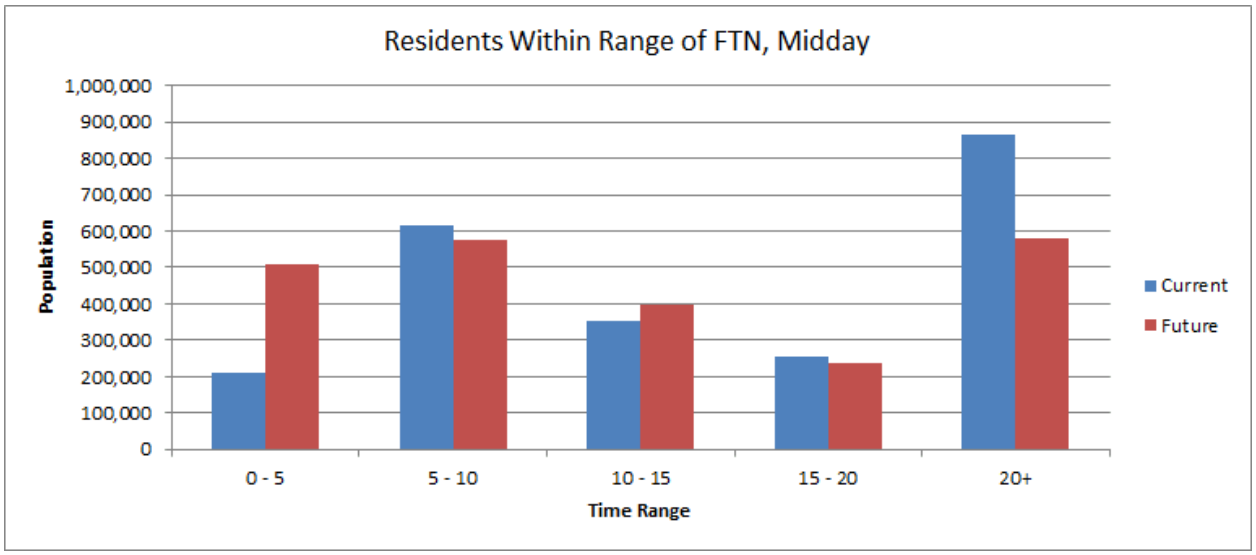
Distribution of Residents by Time to the FTN, AM Peak (Bus Only)

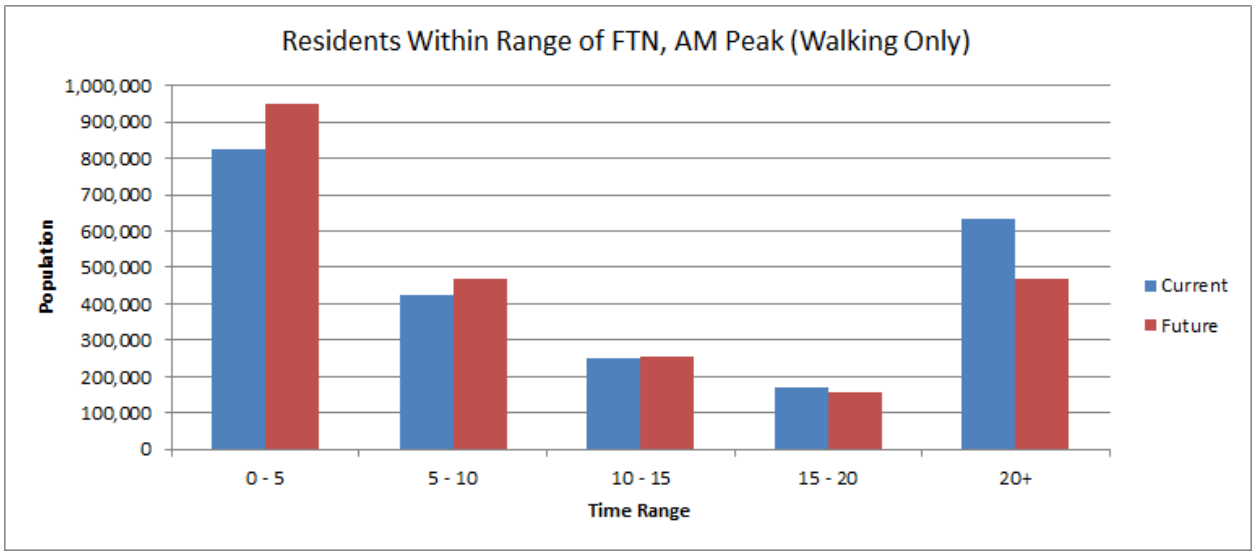




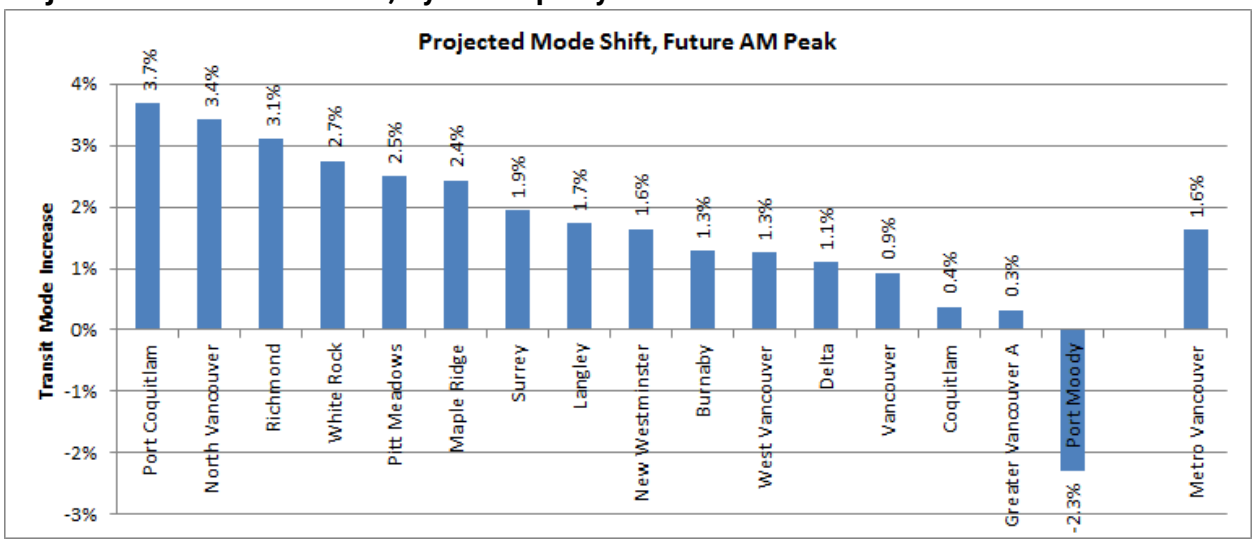
Number of Residents Within Range of the FTN, Current and Future

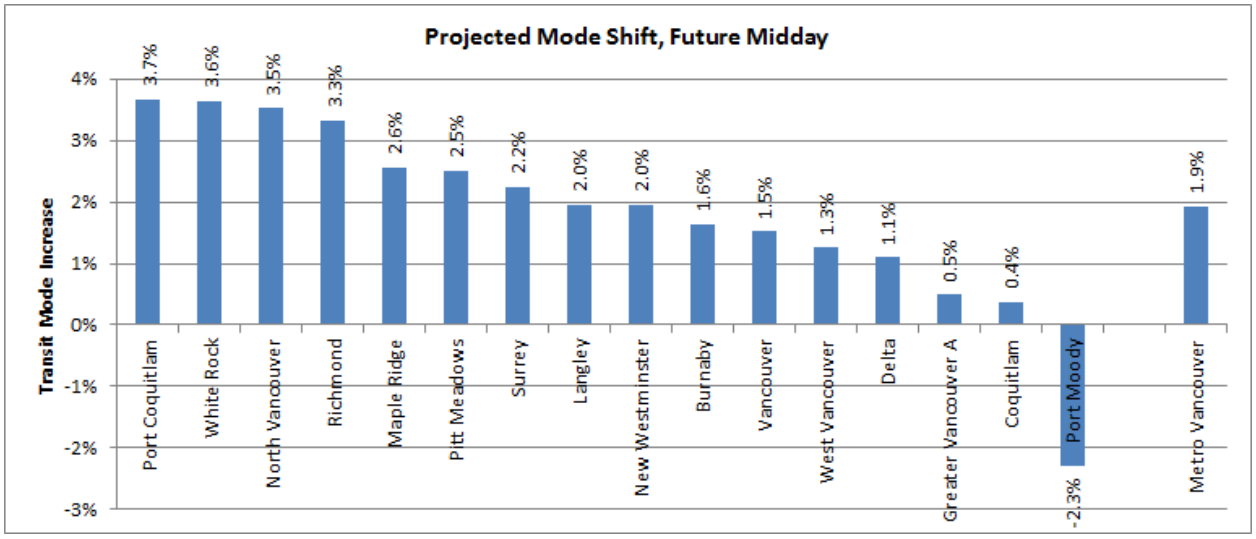


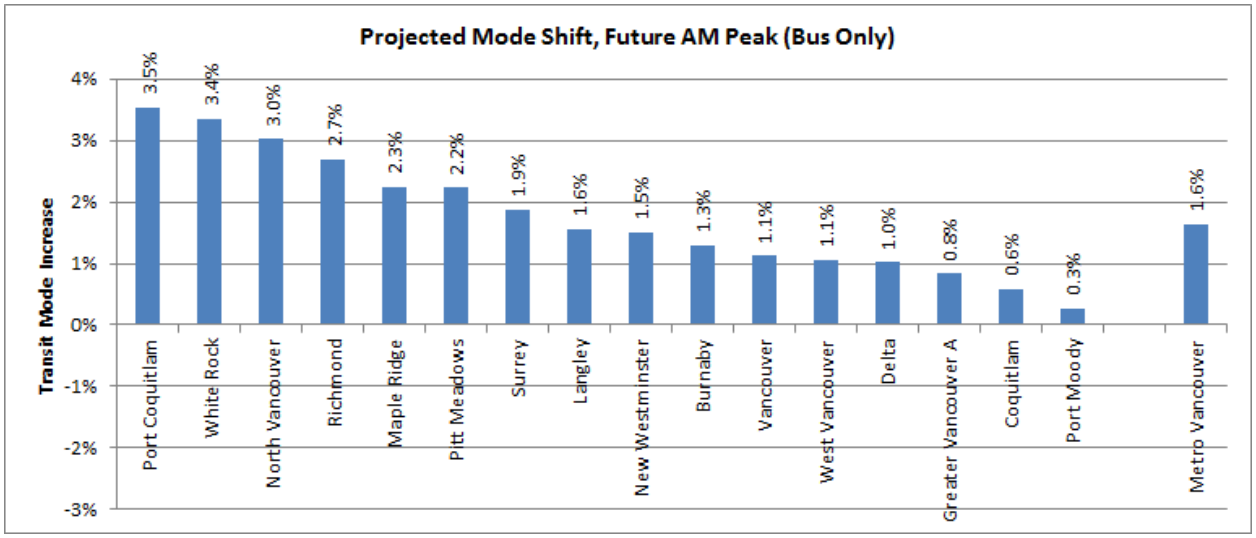




Projected Transit Mode Shift, By Municipality







Projected Transit Mode Share, By Municipality

Municipality	Current			Future			
	AM	Midday	Walk Only	AM Peak	Midday	Walk Only	Bus Only
Vancouver	22.9%	22.3%	24.4%	23.9%	23.9%	24.5%	23.8%
Richmond	15.0%	14.4%	16.7%	18.1%	17.7%	21.5%	18.1%
North Vancouver	13.7%	12.9%	15.8%	17.2%	16.5%	18.7%	17.1%
Surrey	13.1%	12.4%	15.9%	15.1%	14.7%	17.6%	15.0%
White Rock	15.9%	13.8%	21.4%	18.7%	17.5%	21.4%	18.6%
Maple Ridge	11.8%	11.4%	15.7%	14.2%	14.0%	15.5%	14.1%
New Westminster	17.5%	16.5%	20.5%	19.1%	18.5%	20.4%	19.0%
Burnaby	18.4%	17.6%	21.0%	19.7%	19.2%	21.0%	19.7%
Coquitlam	12.6%	12.2%	14.7%	13.0%	12.6%	14.5%	13.7%
Delta	10.7%	10.7%	11.6%	11.8%	11.8%	13.0%	11.7%
Langley	9.9%	9.6%	10.5%	11.7%	11.6%	12.4%	11.5%
Pitt Meadows	13.8%	13.8%	18.9%	16.3%	16.3%	18.7%	16.1%
West Vancouver	11.9%	11.9%	14.3%	13.1%	13.1%	14.1%	12.9%
Port Coquitlam	10.4%	10.4%	12.9%	14.1%	14.0%	17.6%	13.9%
Port Moody	14.5%	14.0%	16.2%	12.2%	11.8%	12.7%	15.0%
Greater Vancouver A	18.2%	18.0%	19.0%	18.6%	18.5%	19.0%	18.5%
Metro Vancouver	**16.1%**	**15.5%**	**18.2%**	**17.7%**	**17.4%**	**19.3%**	**17.7%**

Appendix B

Origins / Destinations Map & Address Table

Addresses Applied In Google Maps	
UBC Bus Loop, Vancouver, BC V6T 1Z1	Central City Shopping Centre, 10153 King George Blvd
Burrard St. Station, 635 Burrard Street	SFU, 8888 University Dr
Vancouver General Hospital 899 West 12th Avenue	Vancouver International Airport, 3211 Grant McConachie Way
Haney Place Transit Exchange, Haney Place, Maple Ridge, BC	56 Ave & Glover Rd, Langley, BC V3A
Coquitlam Station, Barnet Highway, Coquitlam, BC	Dundarave, West Vancouver, BC V7V Dundarave
Metrotown, 4700 Kingsway	

Origin	UBC									
Destinations	Burrard	VGH	YVR	Metrotown	Surrey Centre	SFU	Langley Centre	Dundarave	Coquitlam Station	Haney Exchange
Transit AM before	32	29	55	50	73	90	117	64	91	119
Transit 12 before	29	30	53	62	84	90	113	75	93	127
Transit AM after	32	24	50.35	41	65	69.626	90	58	59.63	105
Transit 12 after	29	28	53	42	69	73.626	108	79	62.63	108
Time saved AM	**0**	**5**	**4.65**	**9**	**8**	**20.374**	**27**	**6**	**31.37**	**14**
Time saved PM	**0**	**2**	**0**	**20**	**15**	**16.374**	**5**	**-4**	**30.37**	**19**

Origin	Burrard									
Destinations	UBC	VGH	YVR	Metrotown	Surrey Centre	SFU	Langley Centre	Dundarave	Coquitlam Station	Haney Exchange
Transit AM before	32	20	32	28	36.5	65	92	45	54	88
Transit 12 before	35	20	32	28	38	73	86	39	64	92
Transit AM after	32	20	32	28	36.5	34	63	28.56	44.5	86.5
Transit 12 after	35	20	32	28	38	40	71	35.07	47.5	90.5
Time saved AM	**0**	**0**	**0**	**0**	**0**	**31**	**29**	**16.44**	**9.5**	**1.5**
Time saved PM	**0**	**0**	**0**	**0**	**0**	**33**	**15**	**3.93**	**16.5**	**1.5**

Origin	VGH									
Destinations	UBC	Burrard	YVR	Metrotown	Surrey Centre	SFU	Langley Centre	Dundarave	Coquitlam Station	Haney Exchange
Transit AM before	27	19	27	33	55	67	91	52	72	95
Transit 12 before	30	19	27	37	61	72	91	50	78	102
Transit AM after	24	19	27	20	34	49	66	48.56	36.89	81.4
Transit 12 after	28	19	27	22	36	49	73	55.07	36.89	81.4
Time saved AM	**3**	**0**	**0**	**13**	**21**	**18**	**25**	**3.44**	**35.11**	**13.6**
Time saved PM	**2**	**0**	**0**	**15**	**25**	**23**	**18**	**-5.07**	**41.11**	**20.6**

Origin	YVR									
Destinations	UBC	VGH	Burrard	Metrotown	Surrey Centre	SFU	Langley Centre	Dundarave	Coquitlam Station	Haney Exchange
Transit AM before	55	27	33	47	69	81	107	61	87	119
Transit 12 before	59	27	33	48	78	95	101	73	80	122
Transit AM after	50.35	27	33	44	55	68	101	60.56	57.7	103.1
Transit 12 after	57.35	27	33	48	65	75	101	67.07	59.2	104.6
Time saved AM	**4.65**	**0**	**0**	**3**	**14**	**13**	**6**	**0.44**	**29.3**	**15.9**
Time saved PM	**1.65**	**0**	**0**	**0**	**13**	**20**	**0**	**5.93**	**20.8**	**17.4**

Origin	Metrotown									
Destinations	UBC	VGH	YVR	Burrard	Surrey Centre	SFU	Langley Centre	Dundarave	Coquitlam Station	Haney Exchange
Transit AM before	51	30	52	28	20.5	53	74	59	48	72
Transit 12 before	62	33	57	28	22	55	65	58	47	76
Transit AM after	41	20	49	28	20.5	31	58	44.56	39.5	72
Transit 12 after	42	22	54	28	22	37	64	51.07	41	76
Time saved AM	**10**	**10**	**3**	**0**	**0**	**22**	**16**	**14.44**	**8.5**	**0**
Time saved PM	**20**	**11**	**3**	**0**	**0**	**18**	**1**	**6.93**	**6**	**0**

Origin	Surrey Centre									
Destinations	UBC	VGH	YVR	Metrotown	Burrard	SFU	Langley Centre	Dundarave	Coquitlam Station	Haney Exchange
Transit AM before	74	53	71	28	54	59	47	82	55	77
Transit 12 before	79	56	81	28	53	67	35	81	55	91
Transit AM after	65	36.5	36.5	20.5	36.5	42	27	65	42	55
Transit 12 after	69	38	38	22	38	50	27	70.07	45	84
Time saved AM	**9**	**16.5**	**34.5**	**7.5**	**17.5**	**17**	**20**	25.93	**13**	**22**
Time saved PM	**10**	**18**	**43**	**6**	**15**	**17**	**8**	**10.93**	**10**	**7**

Origin	SFU									
Destinations	UBC	VGH	YVR	Metrotown	Surrey Centre	Burrard	Langley Centre	Dundarave	Coquitlam Station	Haney Exchange
Transit AM before	87	67	88	59	42	65	97	82	39	88
Transit 12 before	91	66	94	55	50	76	96	104	40	91
Transit AM after	69.626	49	68	31	42	38	91	62.56	29	74.4
Transit 12 after	73.626	49	75	37	50	46	92	75.07	30.5	76.9
Time saved AM	**17.374**	**18**	**20**	**28**	**0**	**27**	**6**	**19.44**	**10**	**13.6**
Time saved PM	**17.374**	**17**	**19**	**18**	**0**	**30**	**4**	**28.93**	**9.5**	**14.1**

Origin	Langley Centre									
Destinations	UBC	VGH	YVR	Metrotown	Surrey Centre	Burrard	SFU	Dundarave	Coquitlam Station	Haney Exchange
Transit AM before	105	95	105	76	53	87	100	109	58	51
Transit 12 before	129	101	112	67	37	76	93	128	71	53
Transit AM after	90	66	101	58	27	63	91	87.06	52	48
Transit 12 after	108	73	111	64	27	71	92	101.57	66	50
Time saved AM	**15**	**29**	**4**	**18**	**26**	**24**	**9**	**21.94**	**6**	**3**
Time saved PM	**21**	**28**	**1**	**3**	**10**	**5**	**1**	**26.43**	**5**	**3**

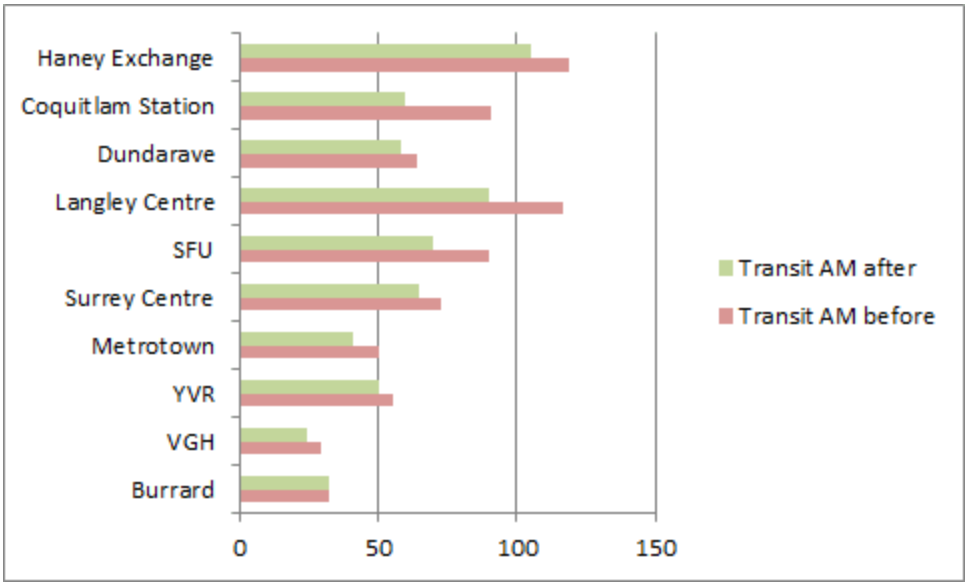
Origin	Dundarave									
Destinations	UBC	VGH	YVR	Metrotown	Surrey Centre	Burrard	SFU	Langley Centre	Coquitlam Station	Haney Exchange
Transit AM before	58	58	66	57	81	31	94	120	98	109
Transit 12 before	79	50	73	59	77	38	111	114	104	137
Transit AM after	58	48.56	60.56	44.56	65	28.56	62.56	87.06	73	101
Transit 12 after	79	55.07	67.07	51.07	71	35.07	75.07	101.57	82	115
Time saved AM	**0**	**9.44**	**5.44**	**12.44**	**16**	**2.44**	**31.44**	**32.94**	**25**	**8**
Time saved PM	**0**	**-5.07**	**5.93**	**7.93**	**6**	**2.93**	**35.93**	**12.43**	**22**	**22**

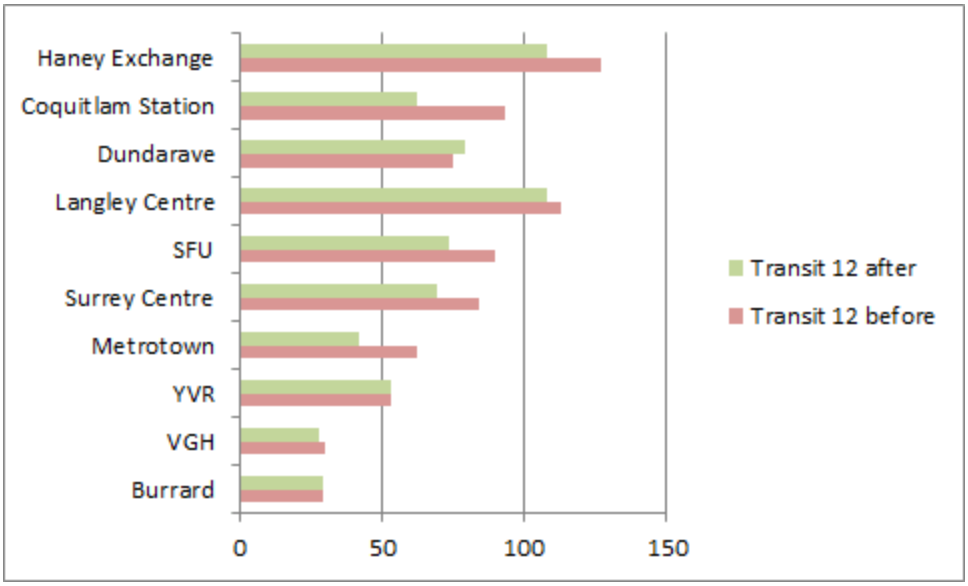
Origin	Coquitlam Station									
Destinations	UBC	Burrard	VGH	YVR	Metrotown	Surrey Centre	SFU	Langley Centre	Dundarave	Haney Exchange
Transit AM before	71	42	57	78	50	43	39	58	87	35
Transit 12 before	101	63	76	91	53	47	40	71	100	40
Transit AM after	59.63	44.5	36.89	57.7	39.5	42	29	52	71	35
Transit 12 after	62.63	47.5	36.89	59.2	41		30.5	66	82	40
Time saved AM	**11.37**	**-2.5**	**20.11**	**20.3**	**10.5**	**1**	**10**	**6**	**16**	**0**
Time saved PM	**38.37**	**15.5**	**39.11**	**31.8**	**12**	**47**	**9.5**	**5**	**18**	**0**

Origin	Haney Place Transit Exchange									
Destinations	UBC	Burrard	VGH	YVR	Metrotown	Surrey Centre	SFU	Langley Centre	Dundarave	Coquitlam Station
Transit AM before	119	77	109	109	88	60	88	51	109	49
Transit 12 before	127	92	98	122	78	90	85	53	137	45
Transit AM after	105	77	81.4	103.1	72	55	78	48	101	49
Transit 12 after	108	90.5	81.4	104.6	76	84	75.5	50	115	45
Time saved AM	**14**	**0**	**27.6**	**5.9**	**16**	**5**	**10**	**3**	**8**	**0**
Time saved PM	**19**	**1.5**	**16.6**	**17.4**	**2**	**6**	**9.5**	**3**	**22**	**0**

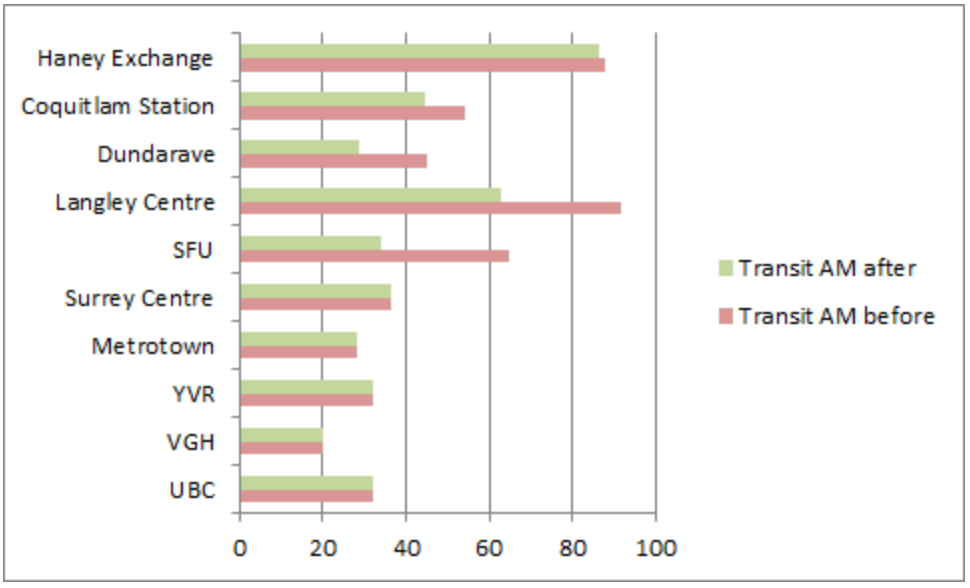
Travel Time Graphs

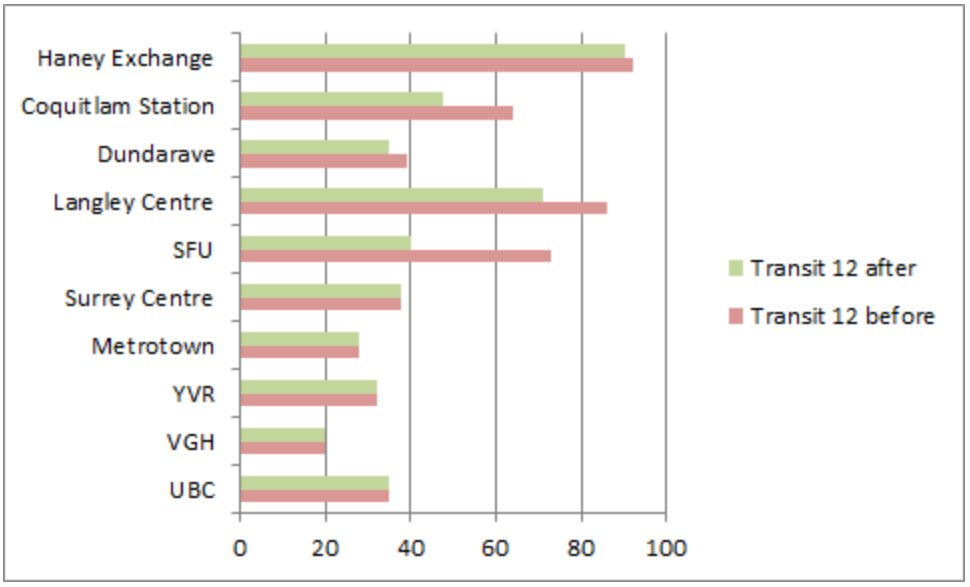
UBC Bus Loop (To Destinations in Minutes)



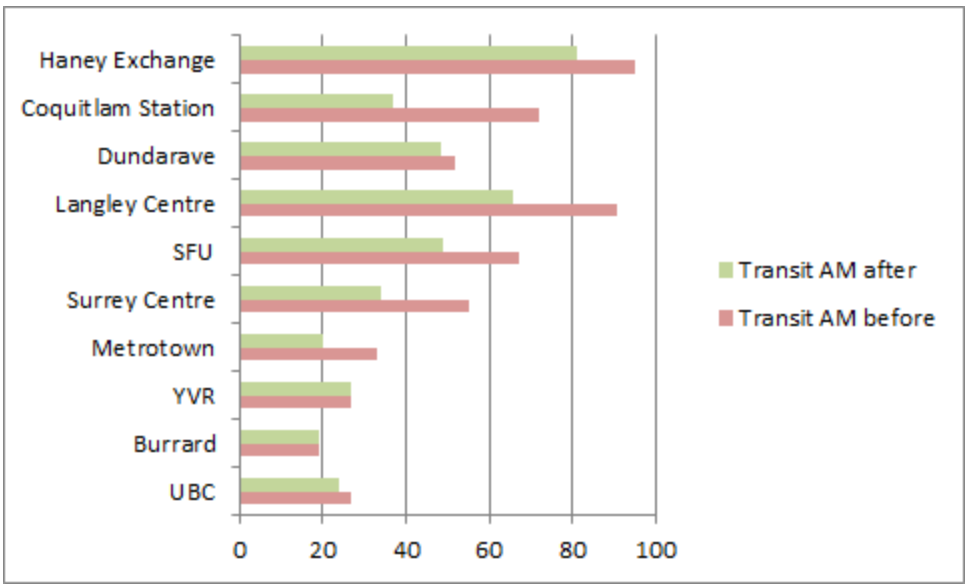


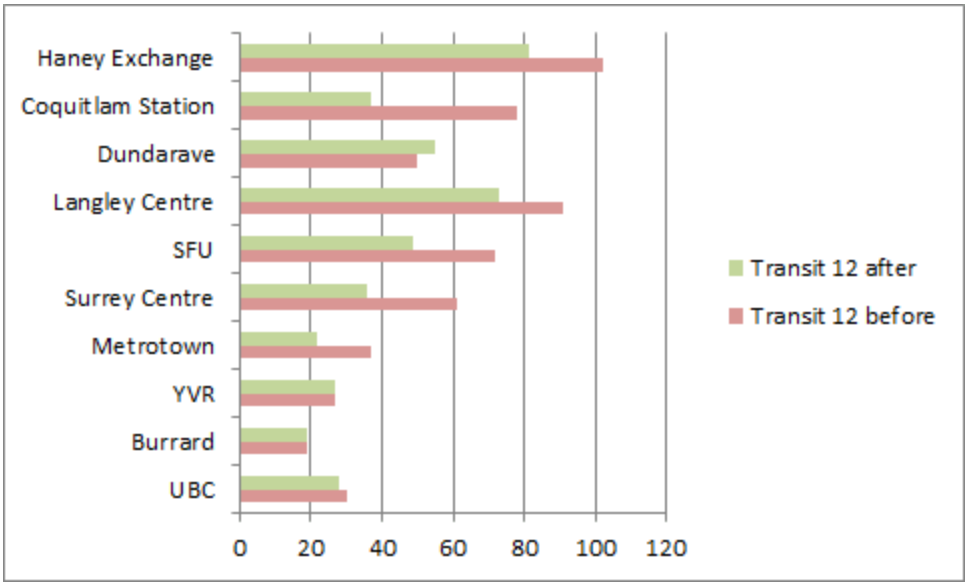
Burrard Station (To Destinations in Minutes)



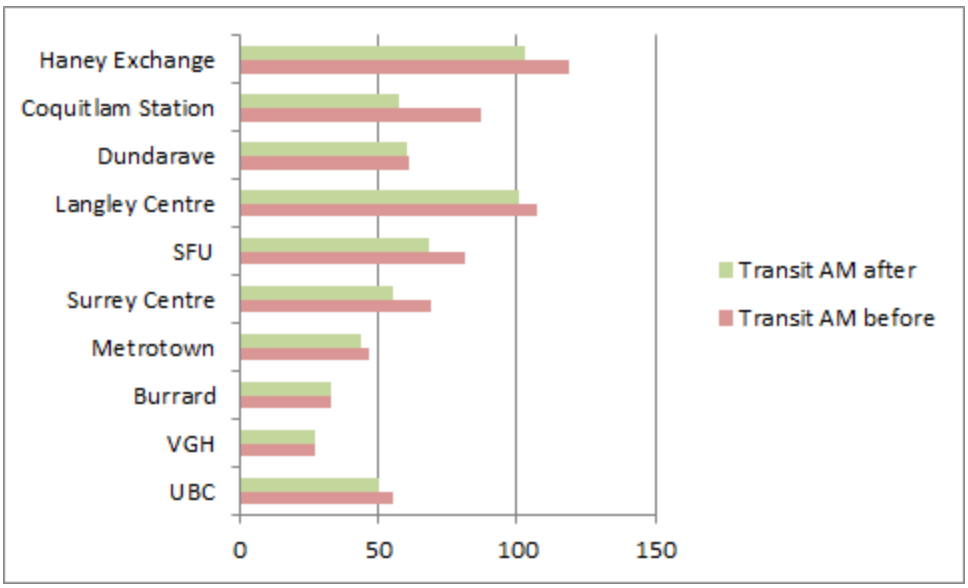


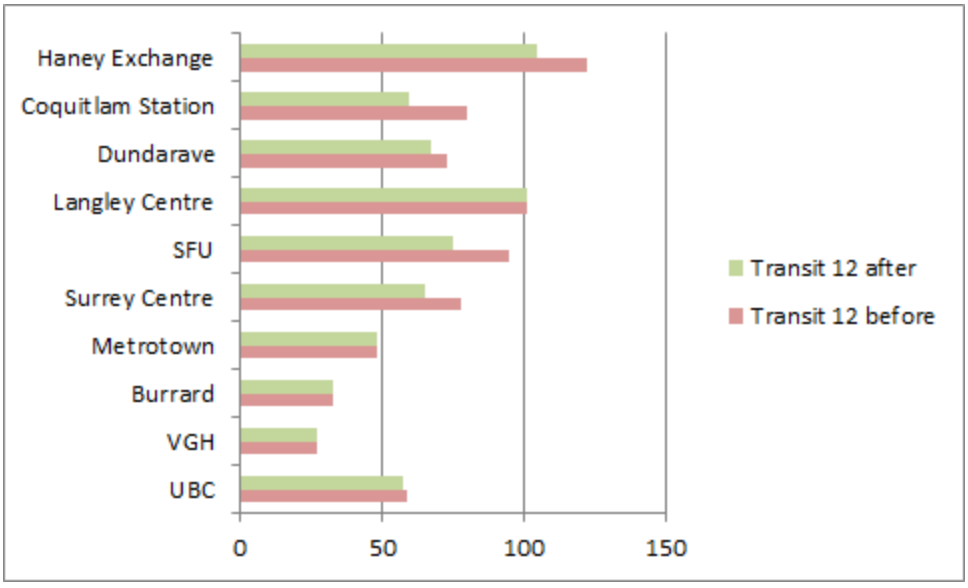
Vancouver General Hospital (To Destinations in Minutes)



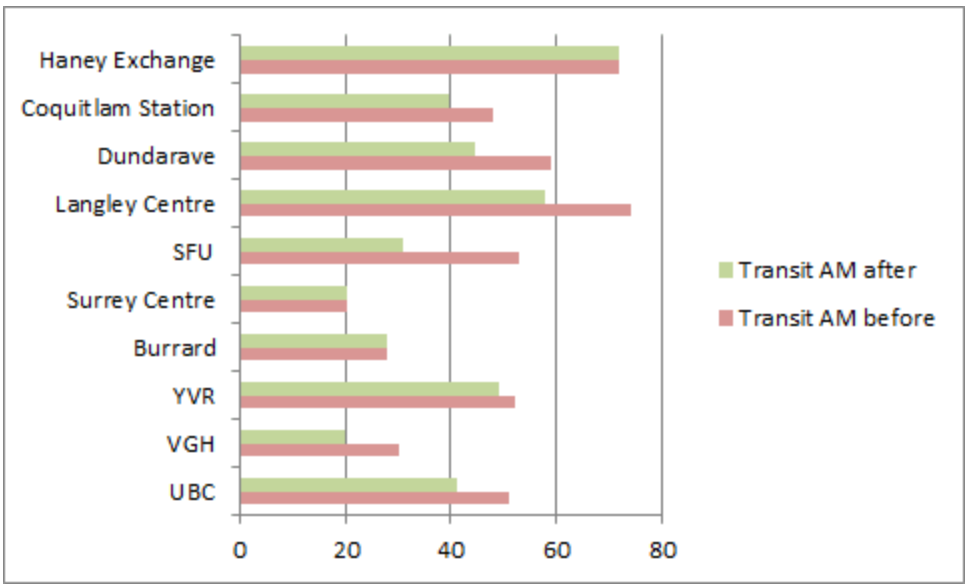


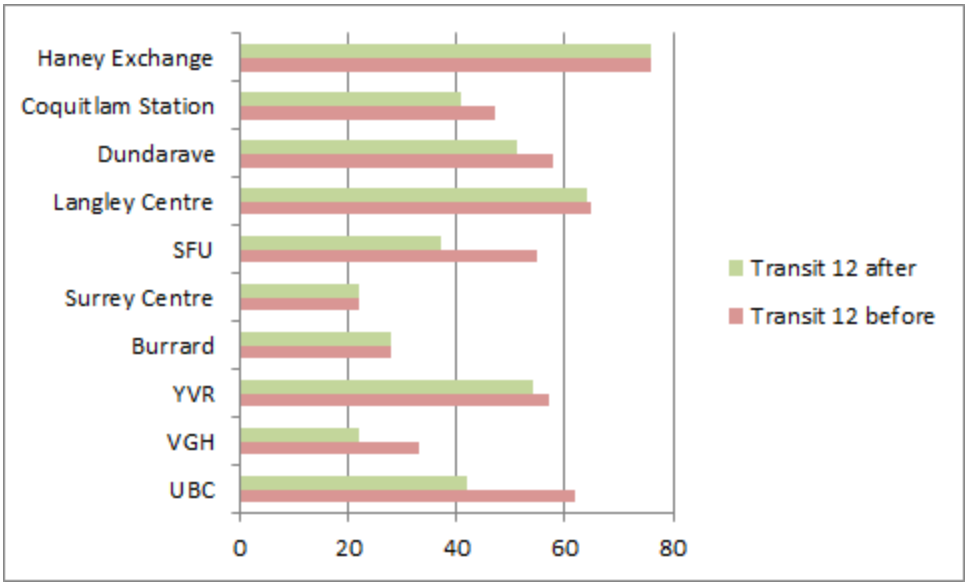
Vancouver International Airport (To Destinations in Minutes)



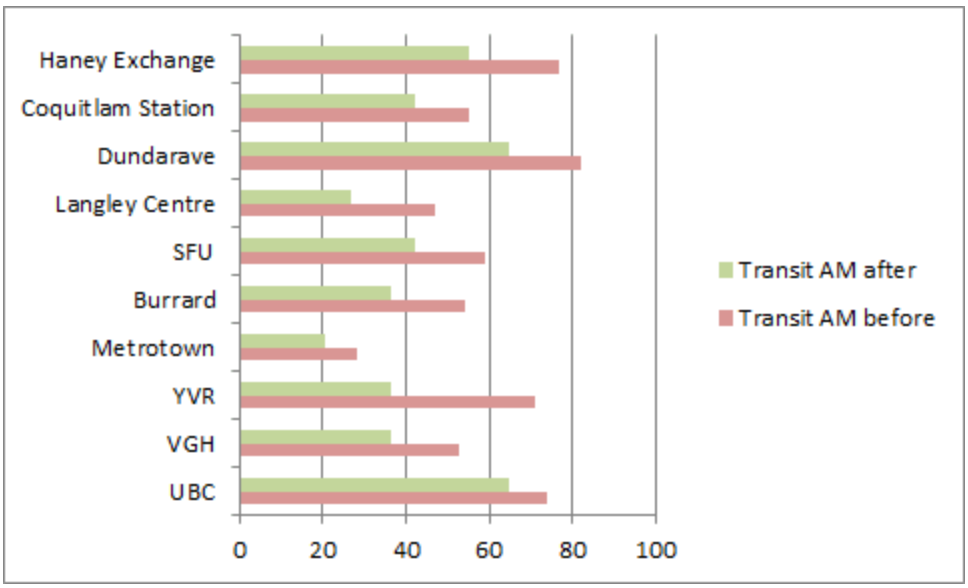


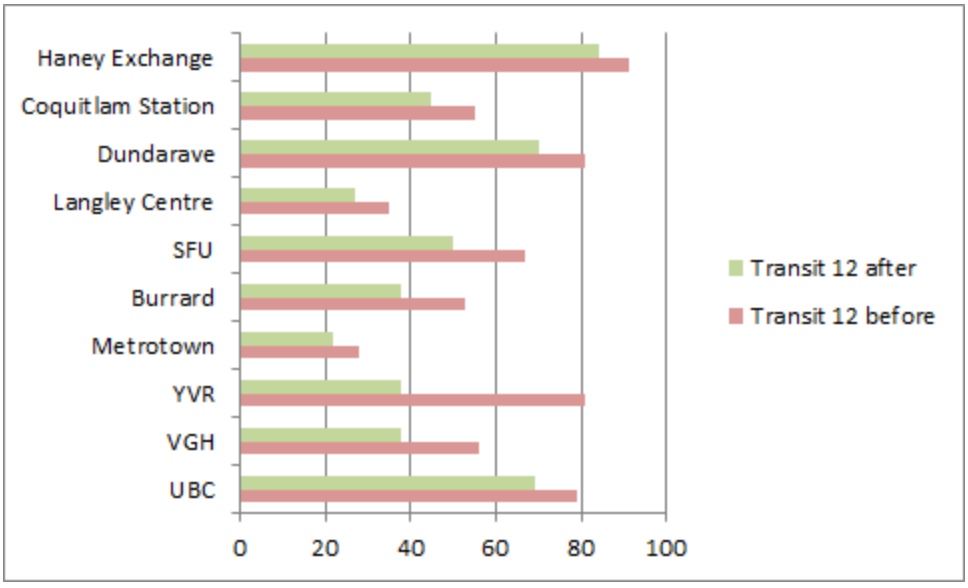
Metrotown (To Destinations in Minutes)



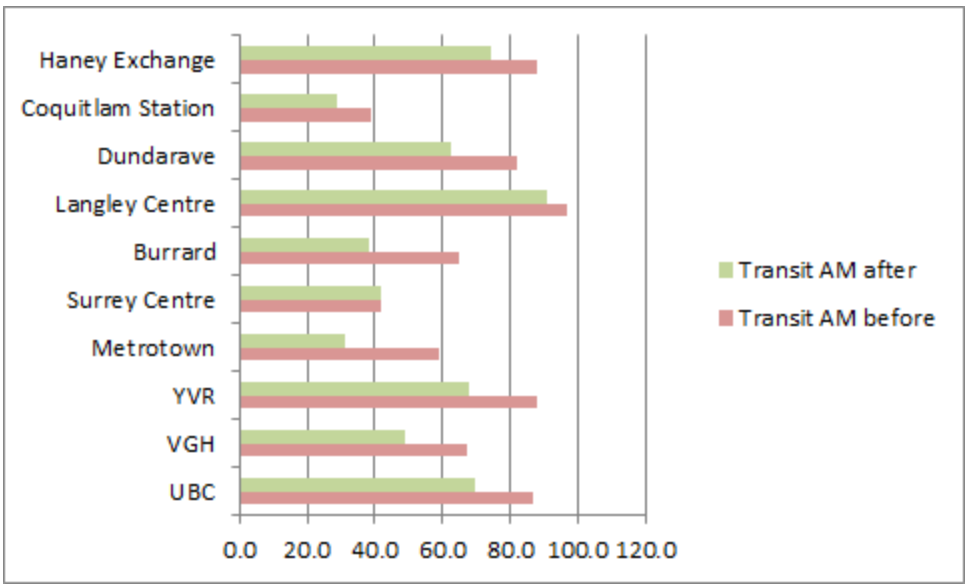


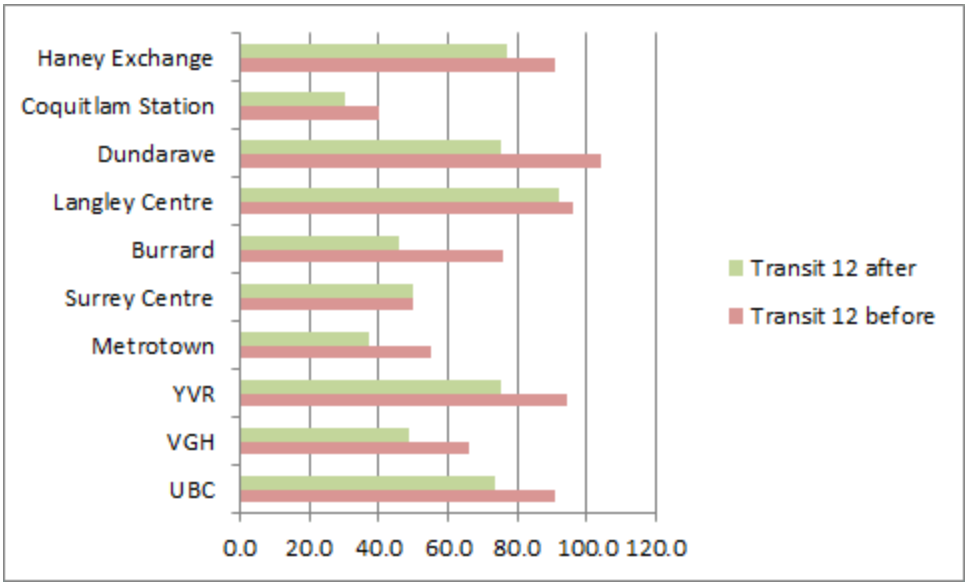
Central City Shopping Centre (To Destinations in Minutes)



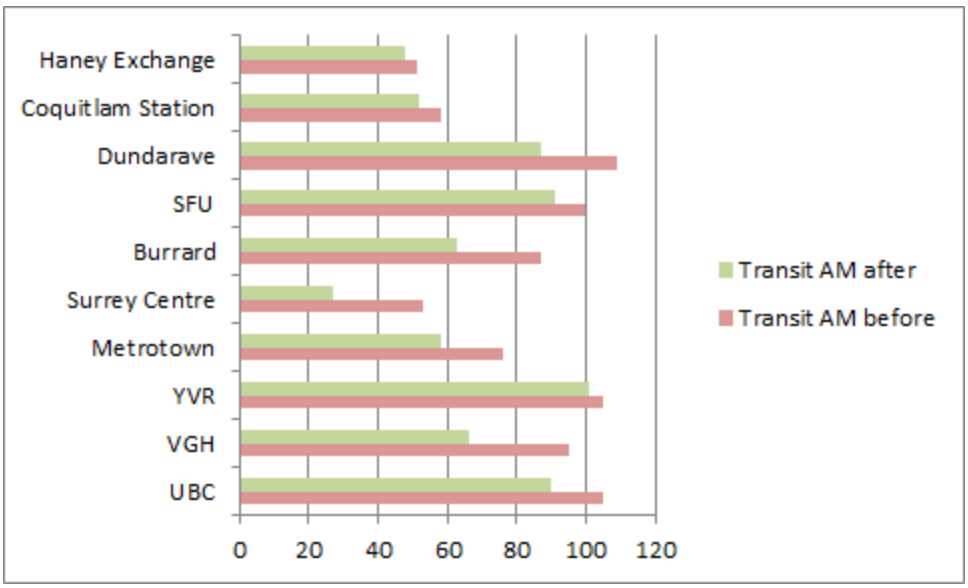


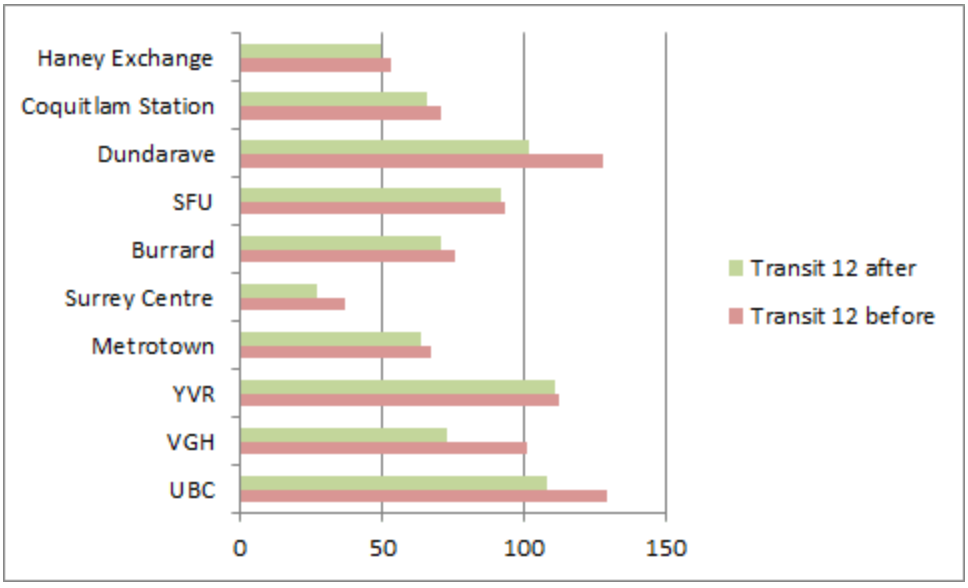
Simon Fraser University (To Destinations in Minutes)



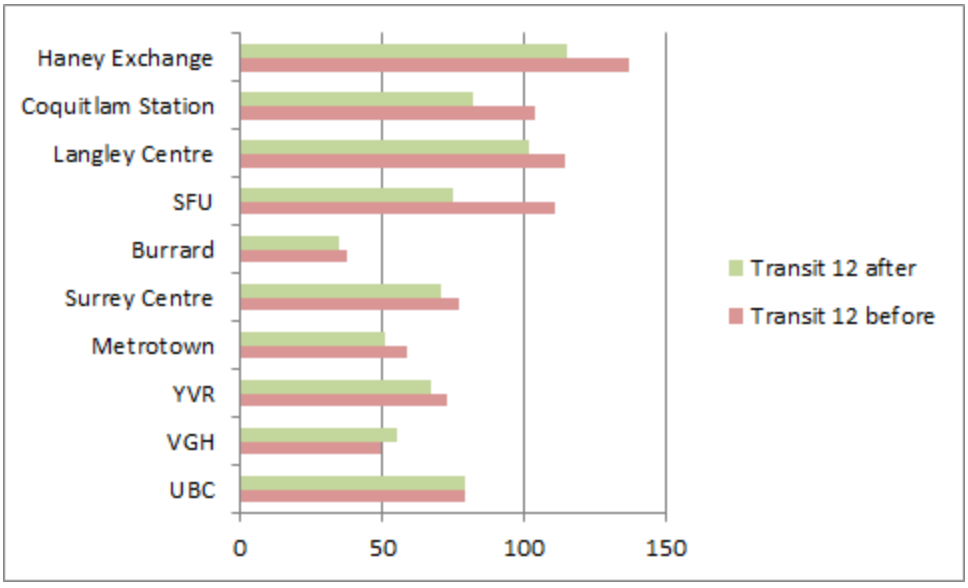


Langley Centre (To Destinations in Minutes)

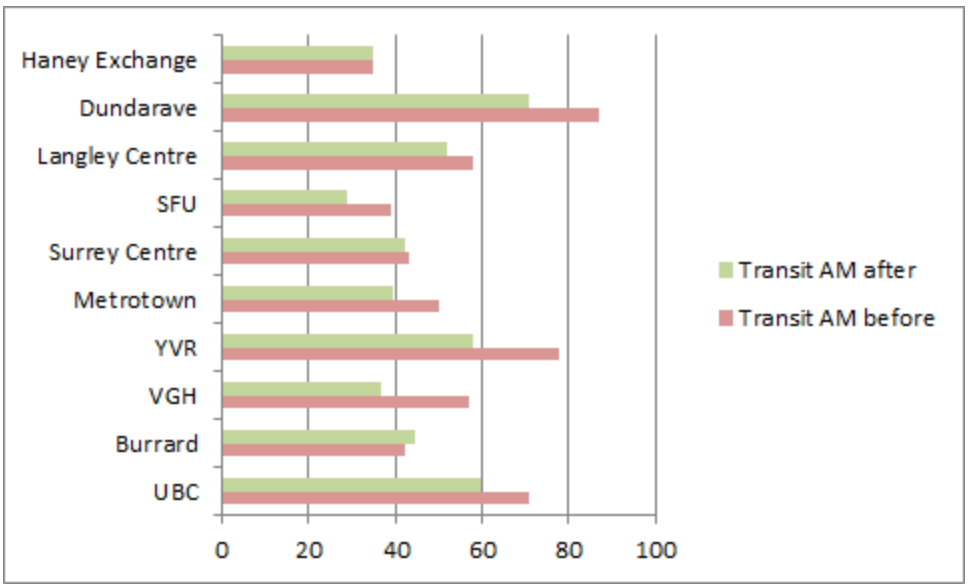


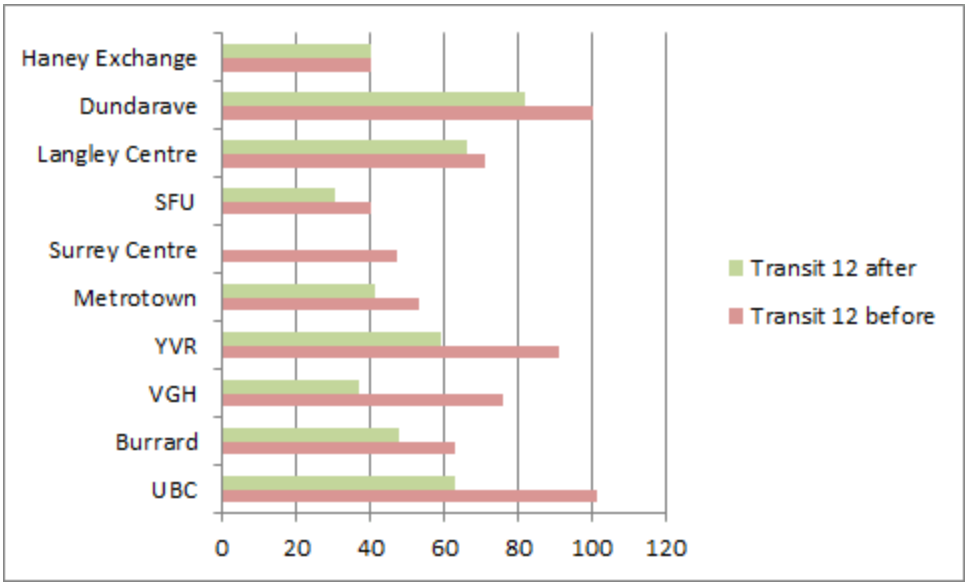


Dundarave (To Destinations in Minutes)



Coquitlam Station (To Destinations in Minutes)





Haney Place Transit Exchange (To Destinations in Minutes)