SURREY RAPID TRANSIT ALTERNATIVES ANALYSIS PHASE 2 EVALUATION

FINAL EVALUATION REPORT

AUGUST, 2012

In association with Hatch Mott Macdonald, Golder Associates, A. Steadman, and Coriolis

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EXECUTIVE SUMMARY

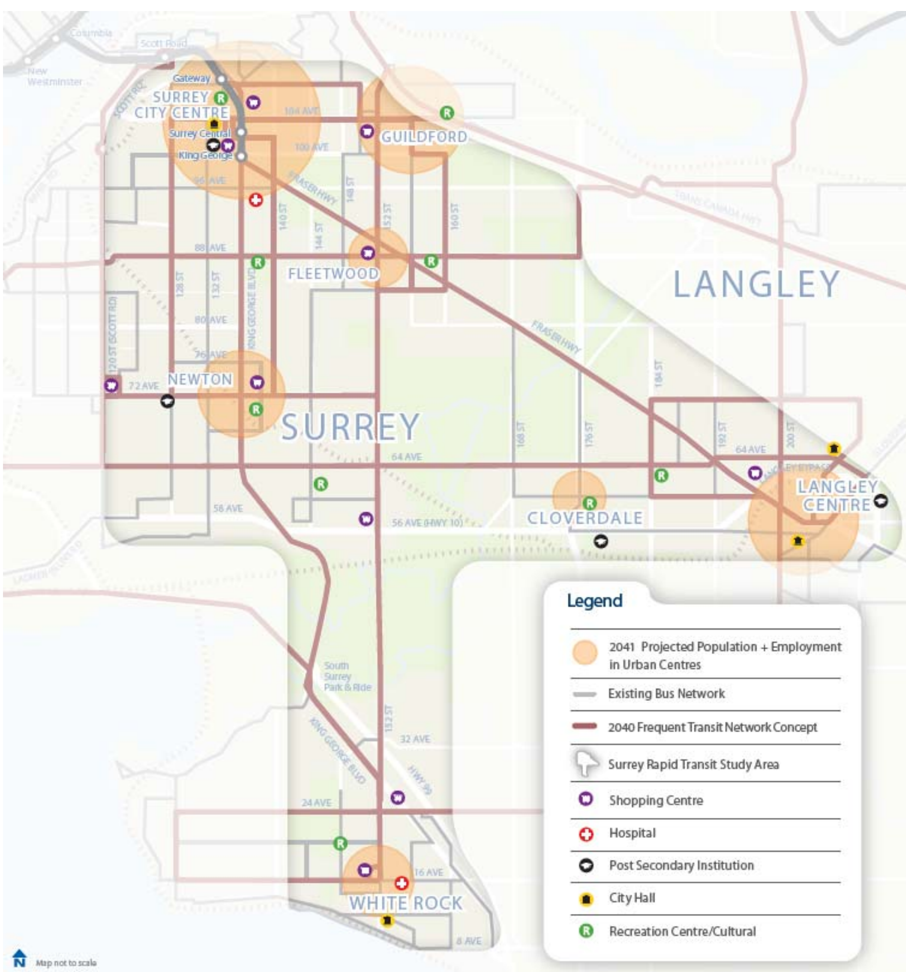
E1. Introduction

TransLink and the BC Ministry of Transportation and Infrastructure (MoTI) sponsored a multi-phase study to evaluate alternatives for rapid transit in Surrey and surrounding communities. The Cities of Surrey and Langley, and Metro Vancouver were partners in the study. The Corporation of Delta, the City of White Rock, and the Township of Langley were also involved in the process at key milestones.

Since the 1990s regional plans have identified expansion of rapid transit in Surrey as a priority to help shape future travel and growth there. Surrey and the South of the Fraser area are home to an already significant and growing portion of the region's population and employment. Surrey alone is expected to accommodate more than a quarter of Metro Vancouver's residential growth over the next 30 years. Surrey Metro Centre is also poised to become a 'second downtown' for the region, with large scale residential, commercial and institutional growth expected, including SFU Surrey and a relocated Surrey City Hall. Transit usage is increasing across Surrey's communities, but remains well below the regional average at 8% of all trips.

In December 2009, IBI Group was retained to examine a range of rapid transit technology and alignment alternatives to respond to these conditions. The study area, shown in **Exhibit E.1**, extends along King George Boulevard, Fraser Highway and 104 Avenue through most of Surrey. It encompasses the communities of Surrey Centre, Newton, Guildford, Fleetwood, Cloverdale/Clayton, South Surrey/White Rock, and Langley Centre, as well as significant agricultural lands within its almost 300 square kilometres.

Exhibit E.1 – Surrey Rapid Transit - Study Area



EXECUTIVE SUMMARY

The Surrey Rapid Transit Study is being undertaken in three phases and IBI Group has led the technical work of the first two phases.

- Phase 1 - Shortlist Identification: technology and alignment alternatives are identified and screened in order to arrive at a shortlist of alternatives for further development in Phase 2.
- Phase 2 - Alternatives Development and Evaluation: shortlisted alternatives are further developed and evaluated to support a decision on a preferred alternative.
- Phase 3 - Design Development: after selection of a preferred alternative, further design development and costing is undertaken. Phase 3 will establish a budget, timeline and phasing for the project and provide the basis for project definition, securing funding and procurement.

The study has involved stakeholder and public consultation at each step and this has informed the study process and outcomes.

E2. Evaluation Process and Alternatives Considered

The study undertook a review of the current and expected conditions in the study area, and with stakeholder and public input synthesized project objectives in order to ensure that the rapid transit solutions identified and evaluated address the underlying needs and issues.

Project Objectives

1. Meet, shift and help shape travel demand through better transit service;
2. Shape future land use in keeping with regional and municipal plans, including the growth of Surrey Metro Centre and other urban centres; and
3. Help achieve ambitious mode share and emissions targets.

An evaluation framework was developed based on these objectives to assess the rapid transit alternatives. The study employed a Multiple Account Evaluation (MAE) approach, which provides a qualitative and quantitative evaluation across a wide range of factors or “accounts” to identify the benefits and impacts of each alternative in a structured format.

The Surrey Rapid Transit Study MAE framework consists of seven accounts: transportation, financial, environment, urban development, economic development, social/community, and deliverability. Within each account more specific objectives and a set of qualitative and quantitative evaluation criteria and measures were developed. **Exhibit E.2** summarizes the accounts, objectives and criteria employed with the evaluation.

Three rapid transit technologies were considered (BRT, LRT and RRT), described in **Exhibit E.3**.

A long list of thousands of possible alternatives was screened to a shortlist according to the evaluation framework above. The shortlist was confirmed through public consultation and thirteen alternatives were advanced for more detailed study (see **Exhibit E.4**). Design concepts and a multiple account evaluation were developed for each alternative and these were brought forward for public consultation. Based on the input received and further technical work, the designs and evaluations were refined and the final results documented in this report.

EXECUTIVE SUMMARY

All alternatives were evaluated against a Business As Usual (BAU) scenario as a point of reference. The BAU scenario assumes that the study area would continue to be served by buses consistent with TransLink's South of Fraser Area Transit Plan vision, with service increases consistent with past trends and forecast population and employment growth, but without rapid transit investment. A neutral rating means that an alternative would perform no better or worse than "business as usual". These assessments have been summarized on a five point scale, represented as follows:

Worse ← **BAU** → **Better**

1 2 3 4 5

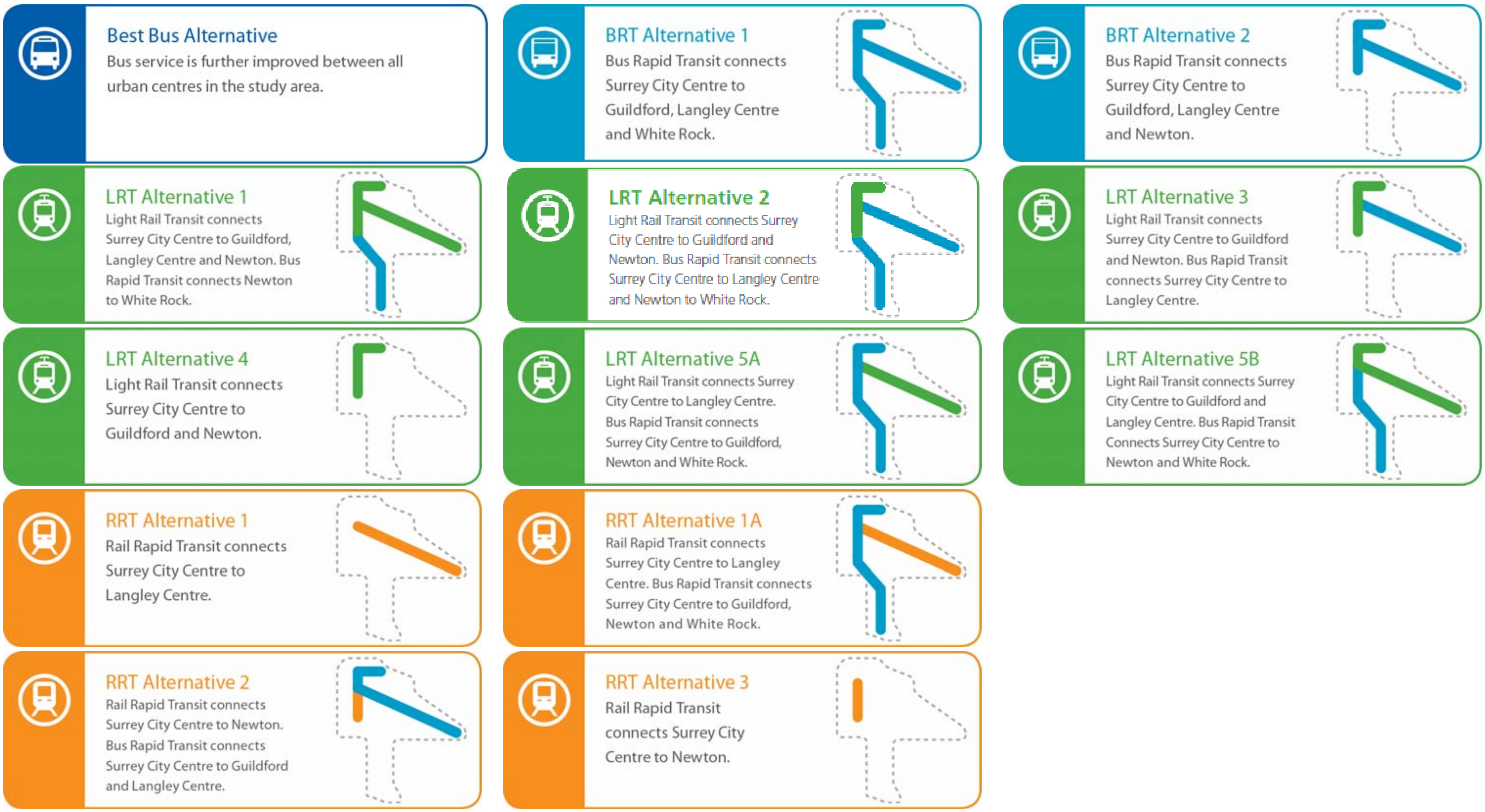
Exhibit E.2 – Evaluation Framework (Accounts and Criteria)

Accounts	*Account-Level Objectives*	Criteria Considered
Transportation	*Rapid transit is fast, frequent, reliable and attractive to all users, and integrated with the regional transit system and with active modes.* *Rapid transit and the supporting transit network meet current and future travel demand efficiently for multiple destinations, increasing transit mode shares and reducing vehicle kilometres travelled (VKT).*	Transit User Effects, Non-Transit User Effects, Transit Network/ System Access, Reliability, Capacity and Expandability, Integration with Active Modes, Transit Mode Share
Financial	*Rapid transit and the supporting transit network are cost-effective in meeting travel demands and shaping land use in multiple corridors*	Capital Cost, Operating Cost, Cost Effectiveness
Environment	*Rapid transit service contributes towards achieving emission reduction targets by positively affecting travel choices.* *Rapid transit is sensitive to natural resources, protected lands, food-producing lands and watercourses.*	Emissions Reductions, Noise and Vibration, Biodiversity, Water Environment, Effect on Parks and Open Space, Effect on Agricultural Resources
Urban Development	*Rapid transit is supported by land use planning that promotes density and diversity of uses, integration of the station areas and by high quality urban design.* *Rapid transit supports city shaping by encouraging municipalities to focus appropriate levels of development around stations.*	Land Use Integration, Land Use Intensification Potential, Property Requirements, Urban Design
Economic Development	*Rapid transit supports economic development.* *Rapid transit is compatible with economic needs, including goods movement.*	Construction Effects, Tax Revenue Effects, Goods Movement
Social and Community	*Rapid transit is safe, accessible and secure.* *Rapid transit and the supporting transit network provide benefits to and do not disproportionately impact disadvantaged groups.*	Operational Safety, Personal Security, Community Connectivity, Low Income Population Served, Heritage and Archaeology
Deliverability	*The rapid transit service is constructible and operable, and avoids 'show-stopper' constraints.* *The rapid transit service allows phasing flexibility and is scalable.* *The rapid transit service is affordable, and supported at all levels of government*	Constructability, Potential for Phasing, Time Required to Deliver, Acceptability, Affordability

Exhibit E.3 – Rapid Transit Technologies Considered

Technology	Typical Characteristics	Assumptions in this Study
Bus Rapid Transit 	• High-frequency, medium-capacity service; • High-quality stop infrastructure, with off-vehicle ticketing facilities and multiple-door, level boarding; • Uses rubber-tire, low-floor articulated buses that can run on diesel, compressed natural gas or electricity; • Operates in the street in reserved lanes or on street-level dedicated rights-of-way separated from other traffic; • Runs on the surface, but can also be underground or elevated; • Uses signal priority at intersections and serves moderately-spaced stations at key destinations to improve journey times; and • Can typically move 2,000 to 3,000 people per hour in each direction.	• Low-floor articulated bus using modern, clean diesel propulsion, carries up to 100 people; • Driver operated; • Frequency in peak: 2 to 5 minutes, carrying up to 3,000 per hour in each direction; • Alignment: mostly in segregated median lanes, with sections of side running, operation in mixed traffic, and one new bridge; • Signal priority at intersections; and • Street-level stations every 800 to 1600 metres, with shelters, seating, ticket vending, security cameras, real time information and wayfinding.
Light Rail Transit 	• High-frequency, high-capacity service; • High-quality stop infrastructure, with off-vehicle ticketing facilities and multiple-door, level boarding; • Uses driver-operated, electrically-powered rail vehicles; • Operates in the street in reserved lanes or on street-level dedicated rights of way separated from other traffic • Runs on the surface, but can also be underground or elevated; • Has variants that include diesel light rail and tram-train; and • Can typically move up to 6,000 to 10,000 people per hour in each direction.	• Low-floor electrically powered rail, carries up to 240 people in two-car sets; • Driver operated; • Frequency in peak: 3 to 5 minutes, carrying up to 4,800 per hour in each direction; • Alignment: mostly in segregated median lanes, with sections of side running, and one new bridge; • Signal priority at intersections; and • Street-level stations every 800 to 1600 metres, with shelters, seating, ticket vending, security cameras, real time information and wayfinding.
Rail Rapid Transit 	• High-frequency, high-capacity service; • High-quality stop infrastructure with off-vehicle ticketing facilities and multiple-door, level boarding; • Comes in a variety of types, for example, the region's SkyTrain systems are automated, driverless systems powered by electricity, while Toronto and New York subways and London Underground systems typically use drivers; • Typically operates completely separated from traffic, usually in a tunnel / trench, elevated structure, or fenced off at surface level; and • Can typically move 10,000 to 25,000 people per hour in each direction.	• Electrically powered SkyTrain technology, carries up to 650 people in five-car sets; • Automated operation, centrally controlled; • Frequency in peak: 2.3 or 4.6 minutes, carrying up to 17,000 per hour in each direction; • Alignment: elevated above street; and • Elevated stations every 800 to 1600 metres, with station building accessed by stairs / elevators / escalators; includes seating, ticket vending, security cameras, real time information and wayfinding.

Exhibit E.4 – Surrey Rapid Transit Study Alternatives – Schematic Maps



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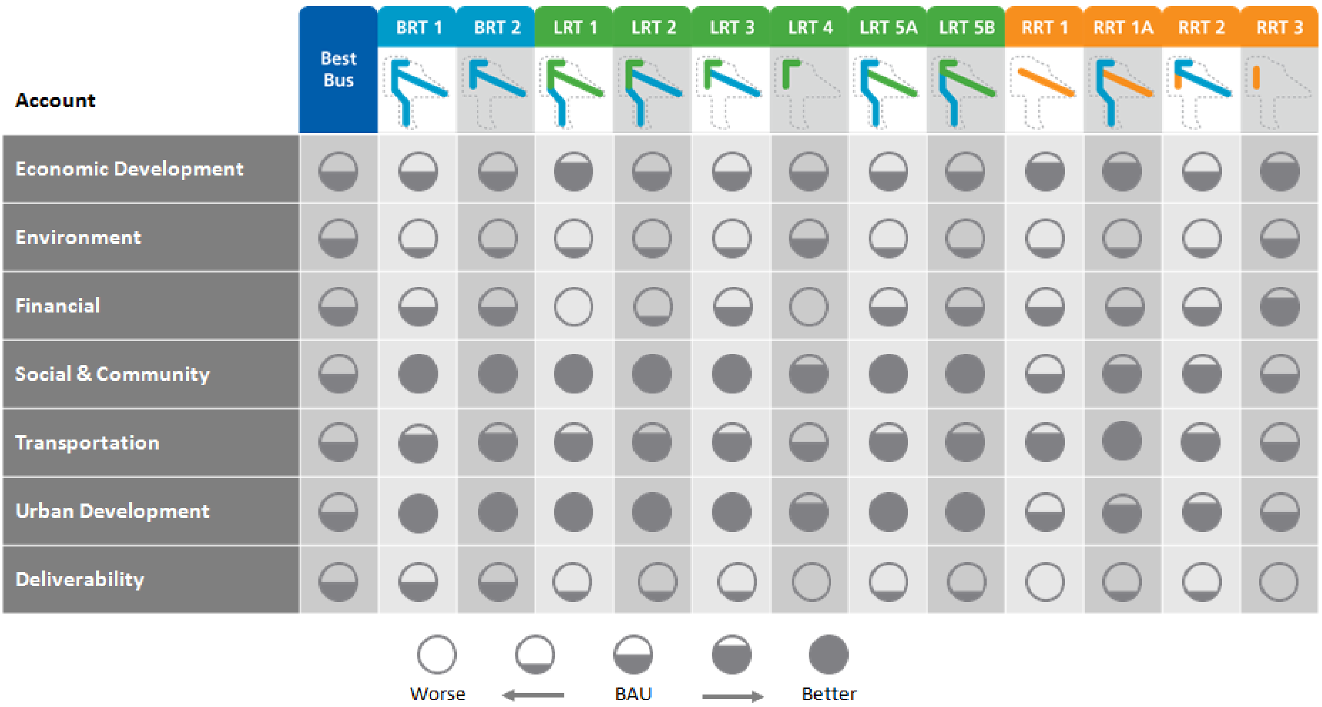
E3. Evaluation Results

The performance of each alternative within each account is summarized in **Exhibit E.5** followed by an account by account description of the findings for each account.

Exhibit E.5 – Multiple Account Evaluation Summary for Phase 2 Alternatives



Transportation

The Transportation account measures the benefits and impacts to transportation network users. All alternatives would provide transportation benefits, with RRT 1A having the greatest transit user benefits due to fast, transfer-free travel times to Fraser Highway. Best Bus, LRT 4 and RRT 3 do not provide rapid transit on Fraser Highway and generate the least transit user benefits. Alternatives without rapid transit on Fraser Hwy or King George Blvd would not meet long term demand. BRT (combined with local bus service) would provide sufficient capacity on all three corridors, but would be nearing the limits by 2041 on Fraser Highway. Alternatives with LRT or RRT on Fraser Highway would provide expandability on this busy corridor. BRT and LRT alternatives require some reductions in travel lanes which somewhat increase congestion levels and travel times for non-transit users. All alternatives increase transit mode share, but at a regional scale the impact would be small.

Financial

The Financial account considers capital and operating costs, as well as cost-effectiveness. Capital costs for rapid transit alternatives range from $770 million (BRT 2) to $2.2 billion (RRT 1A), with the Best Bus capital cost at $290 million. With the exception of Best Bus, over the lifecycle, operating costs for all alternatives are small in relation to capital costs. Operating costs range from an additional $9 million per year (RRT 3) to $58 million (Best Bus). Generally the alternatives with the greatest extent have the highest operating costs as they require more vehicles and drivers. The BRT and RRT-based alternatives were most cost-effective overall in achieving the project objectives due to greater relative benefits (RRT) or lower costs (BRT). LRT 1 and LRT 4 performed the worst in this account, due to higher costs and minimal benefits, respectively.

Environment

The Environment account considers a range of criteria including regional vehicle emissions, noise and emissions, and potential for impact on biodiversity, fish bearing watercourses, parks and open space, and agricultural resources. All alternatives reduce air emissions from automobiles, but also increase emissions due to construction and/or increases in bus service. At a regional scale, emissions impacts are small relative to regional totals. Construction of rapid transit alternatives carries some risk of environmental impacts that would require mitigation. All alternatives travel through urban areas and on road rights-of-way; potential impacts on ecological resources are modest. The alternatives passing through the Agricultural Land Reserve and over Nicomekl and Serpentine rivers are viewed as having greater potential for impacts. All rapid transit alternatives produce noise and vibration, with RRT having the most potential impact.

Urban Development

The urban development account considers the benefits and impacts on local land uses and the urban environment. All rapid transit alternatives generate improvements in urban development, though for RRT alternatives those benefits are balanced by negative urban design impacts. All rapid transit alternatives have the potential to intensify land use around stations with the greater extent alternatives accessing the most development capacity. All alternatives attract similar amounts of development demand (14 to 19 million square feet of high density development through 2041) with most of this development forecast around existing stations in Surrey Centre and expected to occur under the BAU scenario. The BRT and LRT alternatives will improve urban design through widening of sidewalks and/or increases to boulevards. Elevated RRT alternatives have negative visual impacts due to their large guideway structures. All rapid transit alternatives require property to construct; LRT 4 and RRT 3 are shortest and require fewest properties.

Economic Development

The economic development account addresses the economic benefits generated by construction activity, impact on tax revenues as well as goods movement. All alternatives generate positive impacts associated with construction and tax revenue effects, however for most alternatives these are balanced by negative goods movement impacts. The construction of rapid transit is expected to generate benefits associated with employment and increases in GDP. The capital intensive alternatives have the greatest construction and tax revenue benefits (LRT 1, RRT 1, RRT 1A). There are some impacts to goods movement for the street level alternatives due to localized lane reductions and mid-block turn restrictions; similar mid-block restrictions would apply to the RRT alternatives due to guideway columns and sightlines.

Social / Community

The social and community account addresses a wide range of social and community benefits and impacts, including operational safety, personal security, community connectivity, service to low-income households, and heritage and archaeological impacts. All rapid transit alternatives would improve operational safety and perceived security and they all would increase access for low-income populations. Alternatives with the greatest extent would provide the greatest safety and access benefits. Street-level stations and driver-operated vehicles are perceived as most secure, and therefore BRT and LRT alternatives rated higher than RRT alternatives on perceived security. All alternatives would remove some minor vehicular crossings, having a negative impact on community connectivity, though they do maintain pedestrian and cyclist crossings and increase pedestrian refuges. No impacts to heritage or archaeological sites have been identified.

Deliverability

The deliverability account considers potential issues associated with implementing the alternative, including the ease and speed with which it can be constructed, potential for phasing, public acceptability, and affordability. All alternatives are deliverable subject to funding, based on analysis to date. Larger LRT and RRT alternatives are more complex to construct, with greater utility conflicts. All alternatives require a similar length of time to deliver (4 to 7 years). Best Bus and BRT have the most potential for phasing, while single-route rail alternatives have the least potential. Market research indicates that the most significant factor in public acceptability is the extent of coverage, with rapid transit alternatives that would serve all three corridors being deemed most acceptable relative to Business as Usual. There is a wide range in capital and lifecycle costs; affordability of alternatives cannot be assessed through this study as the sources and other uses of funds at a regional scale have not been identified.

Sensitivity Tests

A range of sensitivity tests were undertaken to assess the robustness of the above evaluation results to variations in land use, transportation model assumptions, emissions assumptions and financial inputs. While the specific results from the sensitivity tests varied from the base evaluation, the relative performance of the alternatives remained generally consistent. The tests identified the following risks and opportunities for further consideration in a later phase:

- BRT on Fraser Hwy would not have the capacity to meet forecast 2041 peak demand on that corridor in the event of : (1) accelerated population and employment growth in the study area over that forecast in the Regional Growth Strategy; and/or (2) lower levels of connecting bus service growth than called for in the South of Fraser Area Transit Plan;
- Emerging bus propulsion technologies have potential to reduce GHG emissions at low lifecycle costs for alternatives containing BRT.
- Optimization of connecting local bus service, through development of a detailed transit integration plan, has potential to achieve operating cost savings for all of the alternatives.

E4. Key Findings and Conclusions

Based on this evaluation and considering the primary project objectives identified for the study area, the following conclusions can be drawn:

Capacity to Meet Demand

By 2041, rapid transit will be required to serve demand on Fraser Hwy and King George Blvd. Conventional bus service can continue to meet demand on 104 Ave through 2041. BRT and local bus service combined provide sufficient capacity to meet forecast demand (2041) on all three corridors. On Fraser Hwy, BRT is forecast to be at capacity in 2041, with uncertain ability to expand further[1]. LRT and RRT meet forecast demand on Fraser Hwy (2041) and provide the opportunity for expansion.

[1] The use of high capacity bi-articulated buses for BRT has not been evaluated in this phase of the study. Further analysis will take place in a later study phase to identify the specific vehicle requirements for the preferred alternative.

EXECUTIVE SUMMARY

Shape Land Use

All of the rapid transit alternatives support additional development demand in rapid transit station areas, consistent with the regional growth strategy and local plans. The rapid transit alternatives with the greatest extent provide connectivity between the six largest of the seven urban centres in the study area, and are expected to attract the most station area development. Over the next thirty years 47 million square feet of multifamily and office development is forecast for the entire study area, of which 14.2 million square feet is anticipated to take place around the existing SkyTrain stations in Surrey. The additional station area development attracted by rapid transit ranges from 1 to 5.2 million square feet by 2041. Additional land use and demand management measures may increase the share of development drawn to station areas, but these were not evaluated in the study.

Shift Trips and Achieve Mode Share and Emissions Targets

All alternatives increase transit trips and mode share, and do so in similar amounts when considered at the scale of the region. Within the study area, alternatives with RRT increase transit trips and mode share the most. On King George Boulevard, alternatives with transfer-free service between Surrey Centre and South Surrey attract more new transit trips than those with a transfer at Newton. For all the alternatives, the number of new transit trips is small relative to the number of trips shifted from bus to rapid transit, and to the total number of transit trips in the region. Therefore, at a regional scale, and when considered in isolation, they all have a similar and limited impact on regional and sub-regional mode share and greenhouse gas emissions. None of these supply-side interventions would achieve mode share or emission targets, consistent with findings elsewhere in the region. Demand-side measures, such as road pricing, tolling, higher parking rates or gas prices, may complement rapid transit expansion to further increase transit mode share, but were not evaluated in depth in the study.

Exhibit E.6 summarizes selective quantitative measures for the Phase 2 alternatives, relative to the original project objectives. The “Business as Usual” case is presented for comparison. It also indicates the capital cost for construction and the net present value of costs (capital and operating costs and fare revenue, discounted at 6% to 2010).

Exhibit E.6 – Summary of Selected Measures

Measure		Business As Usual	Best Bus	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5a	LRT 5b	RRT 1	RRT 1a	RRT 2	RRT 3
Capacity to Meet Demand															
2041 Forecast Peak Load (passengers per hour per direction)	Fraser Hwy	1,700*	3,000	4,300	4,350	4,300	4,300	4,350	1,700*	4,250	4,350	6,800	6,600	4,300	1,700*
	KGB	1,700*	3,350	3,900	3,300	3,450	3,450	3,300	3,450	3,900	3,900	1,700*	3,650	5,250	5,250
	104 Ave	1,150	1,250	2,000	2,000	1,800	1,800	1,800	1,850	2,000	1,800	1,000	1,850	1,950	1,100
Assumed Capacity ** (passengers per hour per direction)	Fraser Hwy	1,700	4,000	4,700	4,700	6,500	4,700	4,700	1,700	6,500	6,500	10,200	10,200	4,700	1,700
	KGB	1,700	4,000	4,700	4,700	6,500	6,500	6,500	6,500	4,700	4,700	1,700	4,700	18,700	18,700
	104 Ave	1,700	4,000	4,700	4,700	6,500	6,500	6,500	6,500	4,700	6,500	1,700	4,700	4,700	1,700
Transit Trips and Mode Share															
Surrey Rapid Transit Daily Ridership (2041)		-	-	180,000	149,000	166,000	169,000	152,000	65,000	178,000	180,000	115,000	202,000	200,000	81,000
New Regional Daily Transit Trips (Weekday Average, 2020-2049)		-	11,500	13,500	11,500	12,000	12,500	12,000	4,000	12,500	13,500	17,000	24,500	17,500	8,000
Reduction in Vehicle Kilometres Travelled (millions km, to 2041) ***		-	1,200	1,500	1,200	1,300	1,400	1,300	500	1,400	1,500	1,500	2,400	1,700	800
2041 Transit Peak Hour Mode Share	(Regional / Study Area, %)	16.4 / 14.5	16.5 / 14.9	16.5 / 15.1	16.5 / 15.0	16.5 / 15.0	16.5 / 15.0	16.5 / 15.0	16.4 / 14.7	16.5 / 15.1	16.5 / 15.1	16.5 / 15.2	16.6 / 15.5	16.5 / 15.3	16.4 / 14.2
Air Emissions															
CO2 Net Reduction, Life Cycle (tonnes)			-524,000	-250,000	-141,000	-38,000	-174,000	-68.000	30,000	-114,000	-102,000	66,000	-50,000	-56,000	54,000
Land Use															
Station Area Redevelopment Demand (square feet millions, to 2041) ****		14.2	14.2	19.4	18.2	19.4	19.4	18.2	16.0	19.4	19.4	17.0	19.4	18.5	15.4
Costs															
Capital Costs ($ millions)		-	290	900	770	2,180	1,510	1,370	910	1,680	1,930	1,800	2,220	1,540	920
Net Present Value of Lifecycle Costs ($ millions)		-	530	820	640	1,630	1,180	1,030	640	1,280	1,460	1,260	1,670	1,150	630

* Peak Load for "Business as Usual" (and alternatives with the same level of service as BAU) is forecast to be above capacity and therefore is shown here at capacity.

** The assumed capacity is the level of capacity used for the purposes of evaluation and costing, and the numbers here include supporting bus service and rapid transit. The capacity of LRT is assumed to be 4,800 passengers per hour per direction (pphpd) and can be expanded to 10,000 pphpd or more subject to further analysis. RRT capacity is assumed to be 8,500 pphpd can be expanded to 26,000 pphpd.

*** For context, without Surrey Rapid Transit there are projected to be 800 Billion Vehicle Kilometres Travelled in the region over the same 30-year period.

**** For context, over the same 30-year period, 47 million square ft of total office and high density multifamily residential development demand is expected in the entire study area.

E5. Tradeoffs between Alternatives

It is worth highlighting the following tradeoffs and considerations further to those identified relative to the project objectives.

Speed, Reliability, and Frequency

BRT and LRT provide similar improvements in speed and reliability, particularly on Fraser Hwy. RRT on Fraser Hwy provides the greatest speed and reliability improvements for those travelling on that corridor, associated with grade segregation of the Expo Line SkyTrain extension and avoiding the requirement to transfer at Surrey Central / King George for those travelling to or from the existing SkyTrain system.

On King George Boulevard, improvements in speed and reliability depend on whether or not there is a transfer required to reach White Rock. Direct BRT service between Surrey Central and White Rock (included in BRT 1, LRT 5A, LRT 5B and RRT 1A) provides the greatest overall speed improvements over local bus. LRT/BRT combinations with a transfer in Newton (LRT 1 and LRT 2) also have speed improvements over local bus, but overall are slower than the single BRT service over the length of the corridor.

All alternatives provide high frequencies of service. For example, on Fraser Hwy during the 2041 peak hour, RRT provides service every 4-5 minutes, LRT every 3 minutes, and BRT every 2 minutes to provide sufficient capacity to meet forecasted demand. These frequencies would be higher than needed if the population and employment growth in the study area was less than the forecast in the RGS.

Urban Design

BRT and LRT provide the greatest potential to improve urban design. RRT on Fraser Hwy or King George Blvd would introduce an elevated guideway and stations, and have a negative visual impact on the corridor.

Timing and Phasing

All alternatives can be constructed in phases, with differences based on technology and extent, which would spread out the capital requirements over a longer period of time. Best Bus and BRT alternatives have the greatest potential for phasing, including the ability to begin operating service and generating benefits independent from the construction of the rapid transit guideway. BRT infrastructure can be planned and designed for future conversion to LRT or RRT, at increased costs and with impacts to users during the conversion. Phasing plans have not been developed or evaluated through this study.

Affordability

There is a large range in capital and lifecycle costs for the alternatives. The capital costs of the alternatives range from $290 million for Best Bus to over $2.2 billion for RRT 1A. An assessment of affordability can only be made by considering regional investment needs relative to available funding. Such an assessment cannot be done within an alternatives analysis focused on the assessment of an individual subregion.

E6. Next Steps

The results of this evaluation will help to inform the selection of a preferred alternative. The selection of an alternative will take place within a regional context, to allow the consideration of funding availability for this project and other regional transportation investment needs.

Once a preferred alternative has been identified, Phase 3 will advance the planning and design of that alternative, and carry out further public consultation to aid in design development. The technical scope would include more detailed design of the alignments and intersection layouts, station locations, station area planning and urban design, transit service integration, and environmental study and identification of any mitigation measures.

1. INTRODUCTION AND OVERVIEW

This Final Evaluation report reviews the Phase 2 Evaluation of Alternatives in the Surrey Rapid Transit Alternatives Analysis (SRTAA). The purpose of Phase 2 was to assess a set of rapid transit alternatives against the project objectives, based on application of a technical evaluation framework, and drawing upon project partner and public input.

1.1 Introduction

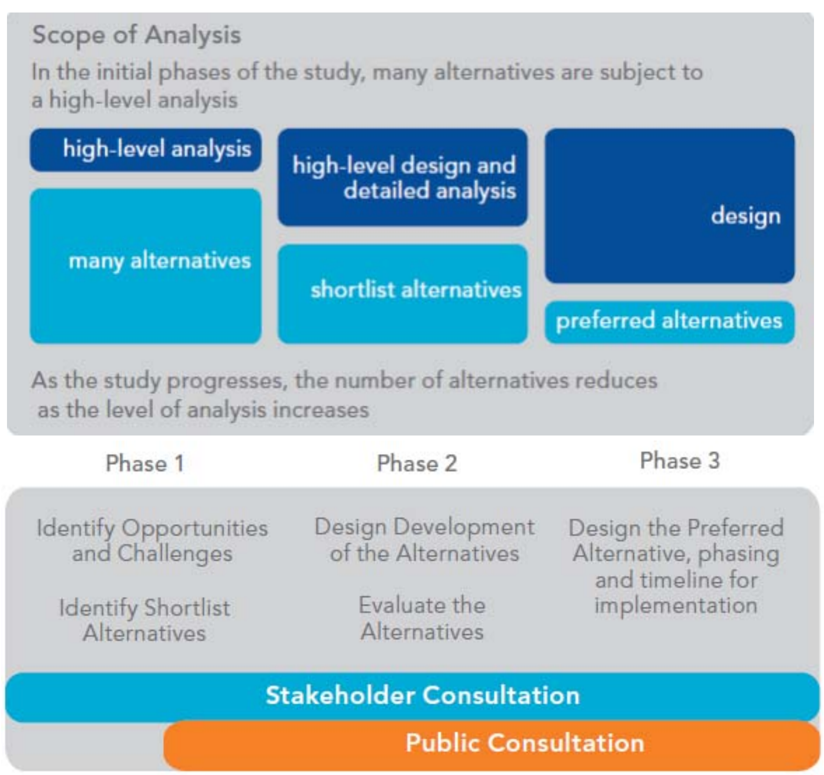
The SRTAA was sponsored by TransLink and the BC Ministry of Transportation and Infrastructure (MoTI). Study partners include the Cities of Surrey and Langley, and Metro Vancouver. The Corporation of Delta, the City of White Rock, and the Township of Langley were also involved in the process at key milestones.

The purpose of the SRTAA study was to:

- Identify and evaluate a range of rapid transit technology and alignment alternatives on several corridors; and
- Support the selection of a preferred network rapid transit alternative for 2041.

The project development process involves three phases of technical study, with an increasing level of detail in each phase as the number of alternatives decreases. In each phase, stakeholder and public consultation provide input into the development and evaluation of transit alternatives. This process is illustrated by **Exhibit 1.1**. The SRTAA included Phases 1 and 2, with Phase 3 to follow.

Exhibit 1.1 – Surrey Rapid Transit - Study Process



Phase 1 of the study identified opportunities and challenges to be addressed by rapid transit, through a context review and development of project objectives. Phase 1 also identified thousands of potential network alternatives, and through two initial rounds of Multiple Account Evaluation (MAE) screening, defined a shortlist of ten rapid transit alternatives to be evaluated in greater detail in Phase 2.

Phase 2 developed the set of rapid transit alternatives in more detail and evaluated them against the project objectives. The evaluation was based on application of a technical MAE framework, partner agency comments, and public consultation on the process and preliminary results. The Phase 2 rapid transit alternatives were compared against a projected future condition called Business As Usual (BAU), which continues growth of the transportation network and includes trend growth of conventional bus services and a future road network based on projects that are under construction, planned or projected. BAU does not include any new rapid transit within the study area.

The alternatives included a Best Bus (BB) alternative that enhances conventional bus service beyond the BAU, and rapid transit alternatives comprised of Bus Rapid Transit (BRT), Light Rail Transit (LRT) and Rail Rapid Transit (RRT) elements overlaid on the future background transportation networks.

After the initial design assumptions and preliminary evaluation results were presented to the public for their input, design refinements were made to improve the performance of several of the alternatives. Also, three new alternatives were generated to combine high performing components from the initial short list. The final Phase 2 evaluation focused on the refined short list of thirteen Phase 2 alternatives. The outcomes from Phase 2 include observations from the evaluation results, and a set of key findings.

Phase 3 will occur after the identification of a preferred alternative. It will further the design of the preferred alternative, including identifying phasing, the timeline for implementation, and determining project costs and funding.

The rest of this report outlines the major findings and outcomes of Phase 1 and describes the Phase 2 alternatives, evaluation results, and the key findings of the study.

Phase 1 of the SRTAA resulted in the confirmation of ten 'short list' alternatives that were carried into Phase 2. In Phase 2, three additional alternatives were generated based on preliminary findings, partner and public input. During the Alternatives Development, the thirteen alternatives were developed in further detail (conceptual design and definition of operating assumptions) sufficient to carry out a detailed evaluation. This Final Evaluation report incorporates additional analysis and concludes with the SRTAA Phase 2 key findings.

The next Phase (3) will continue to resolve design issues, optimize layouts and stations, refine the supporting bus network, and carry out further investigations as needed to advance the preferred alternative towards implementation.

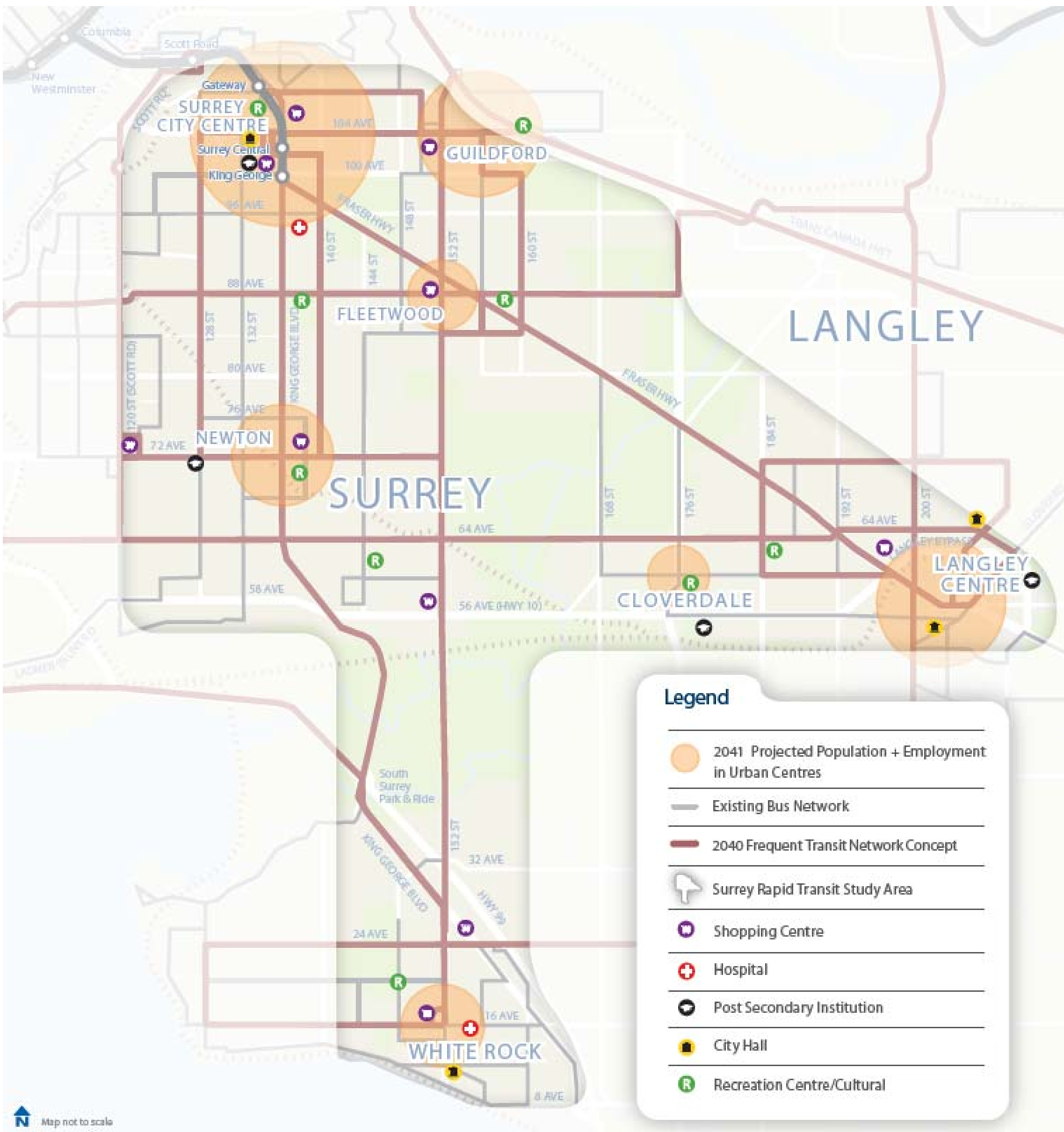
1.2 Phase 1 Overview

This section describes the study area, the context for rapid transit planning, project objectives, evaluation process and framework, rapid transit technologies and the key findings and outcomes of Phase 1.

1.2.1 Study Area

Exhibit 1.2 illustrates the study area for the SRTAA, showing the seven urban centres and the major elements of the transit and road networks within and around the study area. The study area includes both urbanized and rural areas, with portions of the Agricultural Land Reserve separating the northwest corner of the study area from the south and the east. The study area is large (298 square kilometres), with major destinations spread throughout and at significant distances from each other. For example, Langley Centre is 17 km from Surrey Central Station and White Rock Centre is 19 km away. Surrey Metro Centre, Newton and South Surrey / White Rock line up on a north-south axis. Surrey Metro Centre[2] and Guildford line up east-west. Fleetwood, Cloverdale/Clayton and Langley Centre are diagonally arrayed along Fraser Highway from Surrey Metro Centre.

Exhibit 1.2 – Surrey Rapid Transit - Study Area



[2] The City of Surrey refers to this area as 'Surrey City Centre', while Metro Vancouver refers to it as 'Surrey Metro Centre' .

1.2.2 Context for Rapid Transit Planning

Much of the expected population and employment growth in the Lower Mainland will take place in Surrey and surrounding communities over the period through 2041. Between 2006 and 2041, the study area population is forecast to grow 70% to nearly 750,000 residents and local employment is forecast to grow by 78% to 290,000 jobs[3]. This growth introduces many challenges and opportunities. This study was undertaken to start planning now for the expected rapid transit needs over the next thirty years.

Future travel demand in the study area will grow in conjunction with the projected population and employment increases. Within the study area, there are two major concentrations of travel demand: between Newton, Surrey Metro Centre and Guildford; and between Surrey Metro Centre, Fleetwood, Cloverdale/Clayton and Langley Centre. Currently, 40% of commute trips remain within the study area, but this is projected to increase towards 60% by 2041.

In 2008, TransLink developed the South of Fraser Area Transit Plan (SOFATP) after two years of consultation with local stakeholders and the public. The plan laid out a long-term transit vision for the area, and identified near-term transit service priorities. The vision included rapid transit corridors and an expanded grid of frequent local transit routes across the study area.

Transport 2040 (TransLink) and the Provincial Transit Plan (MoTI) both set out ambitious targets for shifting travel patterns and mode choice across the region. The TransLink plan called for 50% of future travel to be by transit and active modes, with the other 50% by car. Today (2008) in the study area, 8% of weekday travel is by transit, 8% by active modes, and 84% by car. The Provincial Transit Plan includes regional transit market share targets of 17% in 2020 and 22% in 2030, while the Provincial Climate Action Plan sets out aggressive greenhouse gas emission reduction targets province-wide.

At the local level, the City of Surrey is updating its Official Community Plan (OCP) and its City Centre Plan, where a second regional downtown is envisioned. The City of Langley adopted its OCP in 2006, and has built on that work through development of its Downtown Master Plan. These planning efforts anticipate major growth within the study area, and seek to shape land uses to create vibrant and sustainable communities.

1.2.3 Project Objectives

Based on the context review, stakeholder consultation, and input from project partners, three overarching project objectives were identified:

1. Meet, shift and help shape travel demand through better transit service;
2. Shape future land use in keeping with regional and municipal plans, including the growth of Surrey Metro Centre and other urban centres; and
3. Help achieve ambitious mode share and emissions targets.

1.2.4 Phase 1 Alternatives Definition and Evaluation

In Phase 1, thousands of potential network alternatives were identified, following one or multiple routes using public rights of way, and combinations of one or more of the three rapid transit technologies: Bus Rapid Transit (BRT), Light Rail Transit (LRT), and Rail Rapid Transit (RRT,

[3] These figures reflect the Regional Growth Strategy, Metro Vancouver.

known as SkyTrain in Metro Vancouver). These alternatives underwent pre-screening and screening evaluations using a MAE framework, in order to assess which alternatives would best meet the project objectives. (The MAE framework is described in the following section.) By definition, all rapid transit alternatives had to be fast, frequent and reliable.

The high level evaluation found that the alternatives should:

- Connect directly to Surrey Metro Centre and other high-growth centres;
- Connect major activity centres and areas of high population and employment;
- Connect these areas with direct routes, using higher capacity technology in higher growth areas; and
- Take into account environmentally sensitive, agricultural and industrial lands.

1.2.5 Multiple Account Evaluation Framework

The MAE framework was developed to compare the Phase 1 and 2 alternatives against a future benchmark scenario 'Business As Usual' (BAU) in a structured manner, and was used to determine how well each of the alternatives met the project objectives, across a broad range of considerations. The results of the alternatives analysis will inform the selection of a preferred alternative after Phase 2 of the study is completed.

The initial Phase 1 framework was developed with input from project partners and stakeholders at an April 2010 workshop. With additional input from the project partners, the MAE framework was refined early in Phase 2, to provide guidance on the conceptual design of the rapid transit alternatives and the evaluation activity. It includes specific qualitative and quantitative criteria and measures in seven accounts: transportation, financial, environment, urban development, social/community, economic development, and deliverability. (This framework is discussed in more detail in Section 2).

1.2.6 Rapid Transit Technologies

The Phase 1 and 2 rapid transit alternatives included three different rapid transit technologies, by combining one or more of them along with the background bus network, to create future transit network alternatives for the study area. **Exhibit 1.3** (next page) outlines the typical characteristics of Bus Rapid Transit (BRT), Light Rail Transit (LRT), and Rail Rapid Transit (RRT), including the range of assumptions used in the design and evaluation of alternatives in the SRTAA.

1.2.7 Phase 1 Findings and Public Consultation

The Phase 1 MAE compared alternatives with different geographic extents and combinations of rapid transit technologies. From several thousand initial alternatives, ten alternatives were selected as the best performing representatives for detailed study. The short list alternatives included BRT, LRT, LRT / BRT hybrids, RRT, RRT / BRT hybrids, and Best Bus, and ranged in extent from small to large, in order to enable detailed evaluation of the tradeoffs between different types of alternatives in Phase 2.

The project objectives and recommended short list were presented to the public in October 2010 for their input, and 84% agreed with the set of project objectives. A majority (73%) agreed that the short list of ten alternatives was complete and appropriate for detailed study. Consequently, the set of ten alternatives was advanced to Phase 2 for detailed evaluation. Sections 2 through 5 of this report document the Phase 2 alternatives and the multiple account evaluation of the final set of alternatives.

Exhibit 1.3 – Rapid Transit Technologies

Technology	Typical Characteristics	Assumptions in this Study
Bus Rapid Transit 	• High-frequency, medium-capacity service; • High-quality stop infrastructure, with off-vehicle ticketing facilities and multiple-door, level boarding; • Uses rubber-tire, low-floor articulated buses that can run on diesel, compressed natural gas or electricity; • Operates in the street in reserved lanes or on street-level dedicated rights-of-way separated from other traffic; • Runs on the surface, but can also be underground or elevated; • Uses signal priority at intersections and serves moderately-spaced stations at key destinations to improve journey times; and • Can typically move 2,000 to 3,000 people per hour in each direction.	• Low-floor articulated bus using modern, clean diesel propulsion, carries up to 100 people; • Driver operated; • Frequency in peak: 2 to 5 minutes, carrying up to 3,000 per hour in each direction; • Alignment: mostly in segregated median lanes, with sections of side running, operation in mixed traffic, and one new bridge; • Signal priority at intersections; and • Street-level stations every 800 to 1600 metres, with shelters, seating, ticket vending, security cameras, real time information and wayfinding.
Light Rail Transit 	• High-frequency, high-capacity service; • High-quality stop infrastructure, with off-vehicle ticketing facilities and multiple-door, level boarding; • Uses driver-operated, electrically-powered rail vehicles; • Operates in the street in reserved lanes or on street-level dedicated rights of way separated from other traffic • Runs on the surface, but can also be underground or elevated; • Has variants that include diesel light rail and tram-train; and • Can typically move up to 6,000 to 10,000 people per hour in each direction.	• Low-floor electrically powered rail, carries up to 240 people in two-car sets; • Driver operated; • Frequency in peak: 3 to 5 minutes, carrying up to 4,800 per hour in each direction; • Alignment: mostly in segregated median lanes, with sections of side running, and one new bridge; • Signal priority at intersections; and • Street-level stations every 800 to 1600 metres, with shelters, seating, ticket vending, security cameras, real time information and wayfinding.
Rail Rapid Transit 	• High-frequency, high-capacity service; • High-quality stop infrastructure with off-vehicle ticketing facilities and multiple-door, level boarding; • Comes in a variety of types, for example, the region's SkyTrain systems are automated, driverless systems powered by electricity, while Toronto and New York subways and London Underground systems typically use drivers; • Typically operates completely separated from traffic, usually in a tunnel / trench, elevated structure, or fenced off at surface level; and • Can typically move 10,000 to 25,000 people per hour in each direction.	• Electrically powered SkyTrain technology, carries up to 650 people in five-car sets; • Automated operation, centrally controlled; • Frequency in peak: 2.3 or 4.6 minutes, carrying up to 17,000 per hour in each direction; • Alignment: elevated above street; and • Elevated stations every 800 to 1600 metres, with station building accessed by stairs / elevators / escalators; includes seating, ticket vending, security cameras, real time information and wayfinding.

1.3 Report Structure

This report documents key assumptions about the design and operations of the Phase 2 alternatives, and presents the evaluation results.

Therefore, the rest of the report includes the following materials:

- **Section 2: Methodology and Evaluation Inputs**. This chapter identifies the inputs into the evaluation process, including the evaluation framework, the definition of the Business As Usual (BAU) scenario, the development of the rapid transit alternatives and best bus alternative, and the major characteristics of those alternatives.
- **Section 3: Multiple Account Evaluation**. This chapter provides an explanation of the evaluation approach and results. It presents this information for each of the completed accounts and criteria for each alternative.
- **Section 4: Sensitivity Tests**. This chapter outlines the series of sensitivity tests undertaken on land use, transportation, modelling and financial assumptions, which were used to assess the robustness of the base evaluation.
- **Section 5: Study Key Findings**. This chapter discusses the main observations for the study area and each of the corridors, and reviews how well the alternatives meet the study objectives.
- **Appendices**. Where the evaluation inputs and results are too voluminous to include in the main report, additional detail has been organized into supporting appendices.

Rapid Transit Concept Designs

Additional technical material is included in **Appendix 1 (Design Principles)**. This appendix describes the Bus Rapid Transit (BRT), Light Rail Transit (LRT), and SkyTrain (RRT) conceptual design assumptions for the rapid transit alternatives. These assumptions include the alignment, typical cross sections, intersections assumptions, typical vehicle dimensions, and station locations and amenities. The assumptions underwent several rounds of detailed review with project partners (spring and summer 2011), and high-level review during the spring 2011 public consultation. These design principles were applied to develop refined Concept Designs (Fall 2011), which were used to evaluate the potential costs, benefits and impacts of the Phase 2 alternatives.

2. METHODOLOGY AND EVALUATION INPUTS

The evaluation of the Phase 2 alternatives applied a technical evaluation framework to the initial conceptual design of the alternatives, and drew upon refined assumptions about the design and operations of the thirteen alternatives.

This section of the Final Evaluation Report outlines the Phase 2 process used to develop and evaluate the alternatives, and provides an overview of the design and operating assumptions for the alternatives.

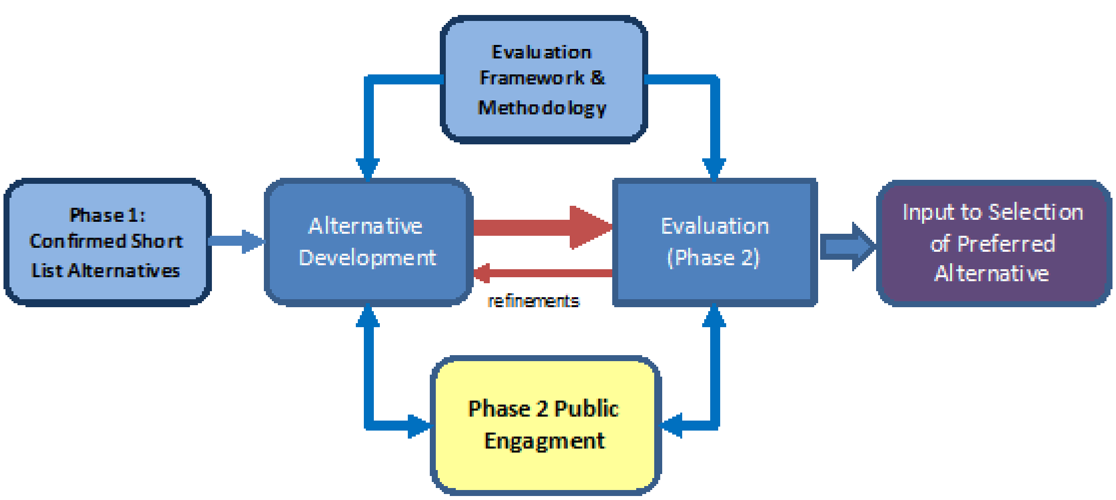
2.1 Overview

The Phase 2 process involved several stages of alternatives development and evaluation, outlined here to provide context for the work described in the remainder of this report:

- **Short List Alternatives, identified in Phase 1**. These were confirmed as the Phase 2 Alternatives with the Technical and Steering Committees, representing the project partners;
- **Alternatives Development**. In this activity, the study identified alternatives for evaluation, prepared conceptual design assumptions, conceptual plans and profiles, refined the bus network assumptions and road network assumptions, and prepared the inputs needed for evaluation of the alternatives;
- **Evaluation of Phase 2 Alternatives**. The project study carried out a preliminary Multiple Account Evaluation (MAE), as an input to the public engagement program. Subsequently, the design assumptions for the set of Phase 2 alternatives were refined, and the MAE was completely updated. In addition, sensitivity tests were carried out on several of the input assumptions. The key findings from the Phase 2 evaluation will support the decision-making process for the selection of a preferred alternative after the culmination of the study; and
- **Phase 2 Public Affairs Program**. The main elements of the initial conceptual design and preliminary evaluation were presented to the public to help solicit input on the design assumptions and completeness of the evaluation of the alternatives.

Exhibit 2.1 illustrates this overall process schematically.

Exhibit 2.1 – Overview of Phase 2

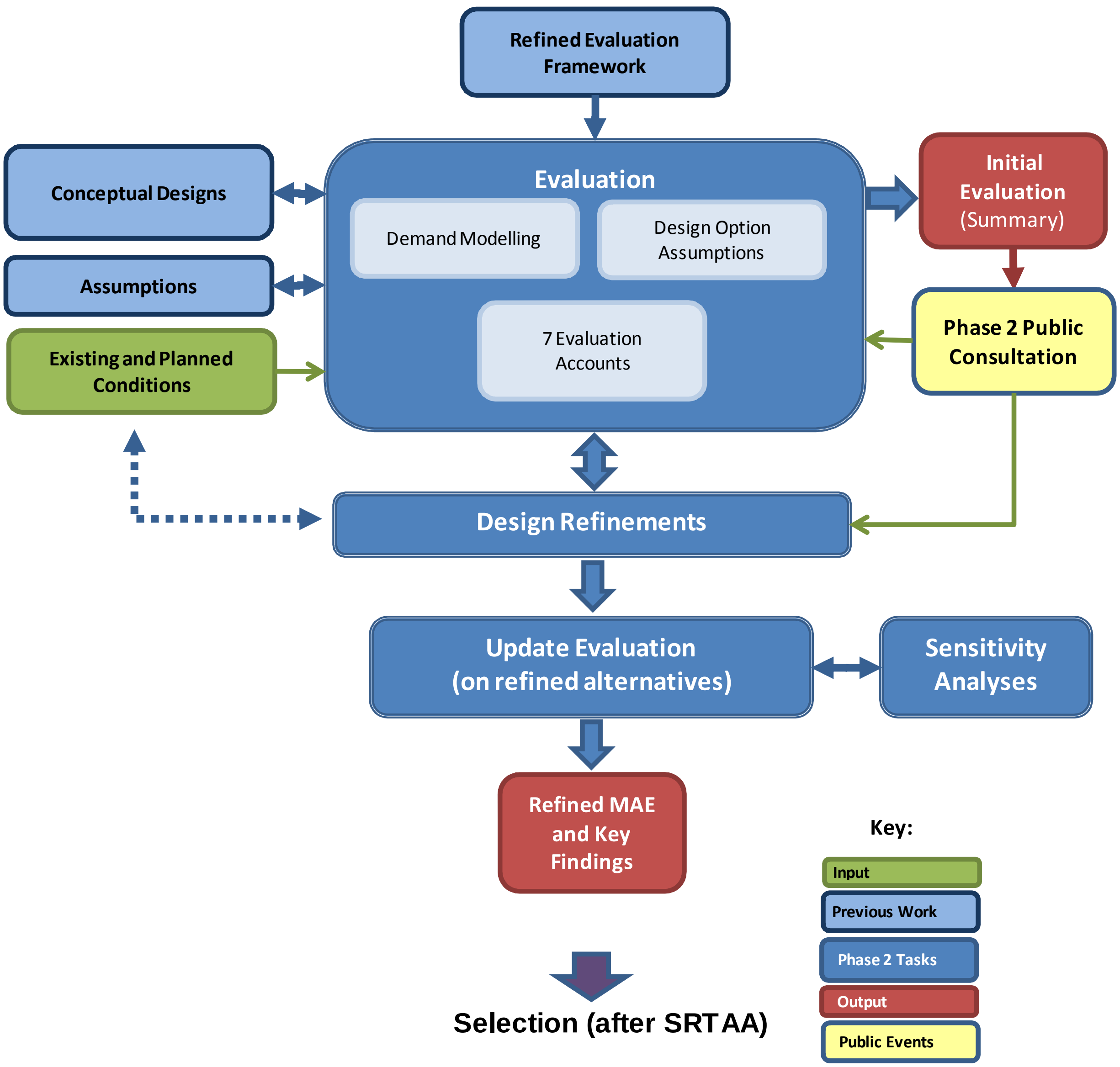


2.2 Phase 2 Evaluation Inputs and Results

The major inputs to the evaluation of alternatives in Phase 2 included the evaluation framework, conceptual design of alternatives, and evaluation assumptions. After the evaluation process was completed for the initial/preliminary evaluation, the results were shared with project partners. The feedback from that process and from the project team guided a series of design refinements and sensitivity tests, which were incorporated into Final Evaluation Report.

Exhibit 2.2 illustrates the evaluation inputs and outputs schematically.

Exhibit 2.2 – Phase 2 Evaluation Inputs and Results



The first of the inputs to this process was the **Evaluation Framework**, which is described in Section 2.3. The framework defined the evaluation accounts, criteria and measures, and by implication, the level of detail required in the design of the alternatives and the supporting evaluation assumptions.

The **Conceptual Design** of the rapid transit alternatives provided an indication of the alignment, station locations, allocation of street space and right of way limits associated with each of the alternatives and forms the basis for the evaluation of the alternatives. The process used to develop the designs is outlined in Section 2.5.

Supporting Assumptions for the purpose of the evaluation included:

- Transit Operations, including the Business As Usual (BAU) network (Section 2.4), Rapid Transit Service Plans (Section 2.8), and definition of the Best Bus Alternative.
- Typical Values (consistent with other rapid transit studies), such as unit costs for capital and operating components, real inflation, financial discount rate, and GHG emission rates.

Existing and Planned Conditions defined the context for the conceptual design and for the evaluation. The types of information included:

- Planned developments and transportation improvements along the rapid transit routes based on information provided by project partners;
- The projected road network configuration in 2021/2041, as most recently revised by the City of Surrey in August 2011;
- Specific study area constraints (e.g. environmental) defined in municipal GIS data sets; and
- The projected land use (Metro Vancouver Regional Growth Strategy, June 2010 with August 2011 update) in 2021/2041, and current parcel data (provided by the cities).

Exhibit 2.2 breaks up the evaluation into four related components.

Transportation **Demand Modelling** was used as an evaluation tool throughout the process, including the assessment of the BAU, several design options, the thirteen alternatives, and several sensitivity tests.

The **Design Option Assumptions** were developed to simplify the evaluation and the presentation of results. At the conclusion of Phase 1, there were several different route options still under consideration between some of the urban centres, which would mean some alternatives could have had up to 24 associated variations. An initial mini-MAE was used to compare these design options, and select the options to assess during the evaluation. (The other options remain open to later consideration, should new information arise that could improve their performance as rapid transit routes.) The design option selection process is described in **Section 2.6**.

The MAE assessment using the seven **Evaluation Accounts** applied the evaluation framework to the Phase 2 alternatives (using the assumed design options) to produce qualitative and quantitative measures of the performance of the alternatives. An assessment rating was then applied for each criterion on the basis of the evaluation results. The review of the evaluation methodologies, assumptions, results, and criteria ratings was interactive and drew upon input and information provided by the project partners.

The **Design Refinement** step investigated suggestions from the partner agencies and Phase 2 public consultation program in spring 2011. Based on a technical review of the refinement options that were identified, several were incorporated into the final set of alternatives, and three new alternatives added to the evaluation. This is outlined in **Section 2.7**.

(Initial assumptions were presented to the public in the Phase 2 consultation process in 2011. Based on the public and partner input and technical review, the designs and operations were refined to improve the performance of the alternatives within the evaluation accounts. The recommended design refinements are documented in **Appendix 2D**).

As noted above, the Phase 2 Evaluation was based on projected future land use and transportation networks, and on design and operating assumptions for the transit alternatives. These assumptions represented a 'base' (most likely) future, around which there are degrees of uncertainty. Therefore, after the refined evaluation of the alternatives was completed, **Sensitivity Tests** were carried out on several of the land use, transit service, regional modelling and financial assumptions, to determine the robustness of the base evaluation, and help identify any risks or opportunities associated with the alternatives. This process and its findings are described in **Section 4**.

2.3 Evaluation Framework

The purpose of the evaluation was to compare the Best Bus and rapid transit alternatives against a baseline (BAU) to inform the identification of key findings and support the selection of a preferred alternative after study completion. The evaluation was guided by several principles:

- Evaluation results were related directly to the attributes of each alternative (conceptual design, service operating assumptions, and results from other related accounts);
- Other assumptions were consistent across the evaluations (e.g. land use, background transit and road networks, transportation model assumptions);
- The sensitivity tests carried out after the base evaluation (the full MAE of all of the alternatives) considered the effect of alternate input assumptions.

A MAE framework was used to structure an assessment of how well each alternative met the project objectives, across a broad range of considerations. With input from the project partners, the MAE framework was refined early in the Conceptual Designs activity, to provide guidance to the conceptual design of alternatives and the evaluation activity. It includes specific qualitative and quantitative criteria and measures in seven accounts:

- Transportation;
- Financial;
- Environment;
- Urban Development;
- Economic Development;
- Social / Community; and
- Deliverability.

The criteria and related project objectives for each of the accounts are identified in **Exhibit 2.3**. The complete matrix of accounts, criteria and measures is provided in **Appendix 2A**.

Exhibit 2.3 – Evaluation Framework (Accounts and Criteria)

Accounts	*Account-Level Objectives*	Criteria Considered
Transportation	*Rapid transit is fast, frequent, reliable and attractive to all users, and integrated with the regional transit system and with active modes.* *Rapid transit and the supporting transit network meet current and future travel demand efficiently for multiple destinations, increasing transit mode shares and reducing vehicle kilometres travelled (VKT).*	Transit User Effects, Non-Transit User Effects, Transit Network/ System Access, Reliability, Capacity and Expandability, Integration with Active Modes, Transit Mode Share
Financial	*Rapid transit and the supporting transit network are cost-effective in meeting travel demands and shaping land use in multiple corridors*	Capital Cost, Operating Cost, Cost Effectiveness
Environment	*Rapid transit service contributes towards achieving emission reduction targets by positively affecting travel choices.* *Rapid transit is sensitive to natural resources, protected lands, food-producing lands and watercourses.*	Emissions Reductions, Noise and Vibration, Biodiversity, Water Environment, Effect on Parks and Open Space, Effect on Agricultural Resources
Urban Development	*Rapid transit is supported by land use planning that promotes density and diversity of uses, integration of the station areas and by high quality urban design.* *Rapid transit supports city shaping by encouraging municipalities to focus appropriate levels of development around stations.*	Land Use Integration, Land Use Intensification Potential, Property Requirements, Urban Design
Economic Development	*Rapid transit supports economic development.* *Rapid transit is compatible with economic needs, including goods movement.*	Construction Effects, Tax Revenue Effects, Goods Movement
Social and Community	*Rapid transit is safe, accessible and secure.* *Rapid transit and the supporting transit network provide benefits to and do not disproportionately impact disadvantaged groups.*	Operational Safety, Personal Security, Community Connectivity, Low Income Population Served, Heritage and Archaeology
Deliverability	*The rapid transit service is constructible and operable, and avoids 'show-stopper' constraints.* *The rapid transit service allows phasing flexibility and is scalable.* *The rapid transit service is affordable, and supported at all levels of government*	Constructability, Potential for Phasing, Time Required to Deliver, Acceptability, Affordability

These evaluation accounts were organized alphabetically (except for Deliverability, placed last) for the public consultation process and that same order was used for the study website.

2.4 BAU Assumptions

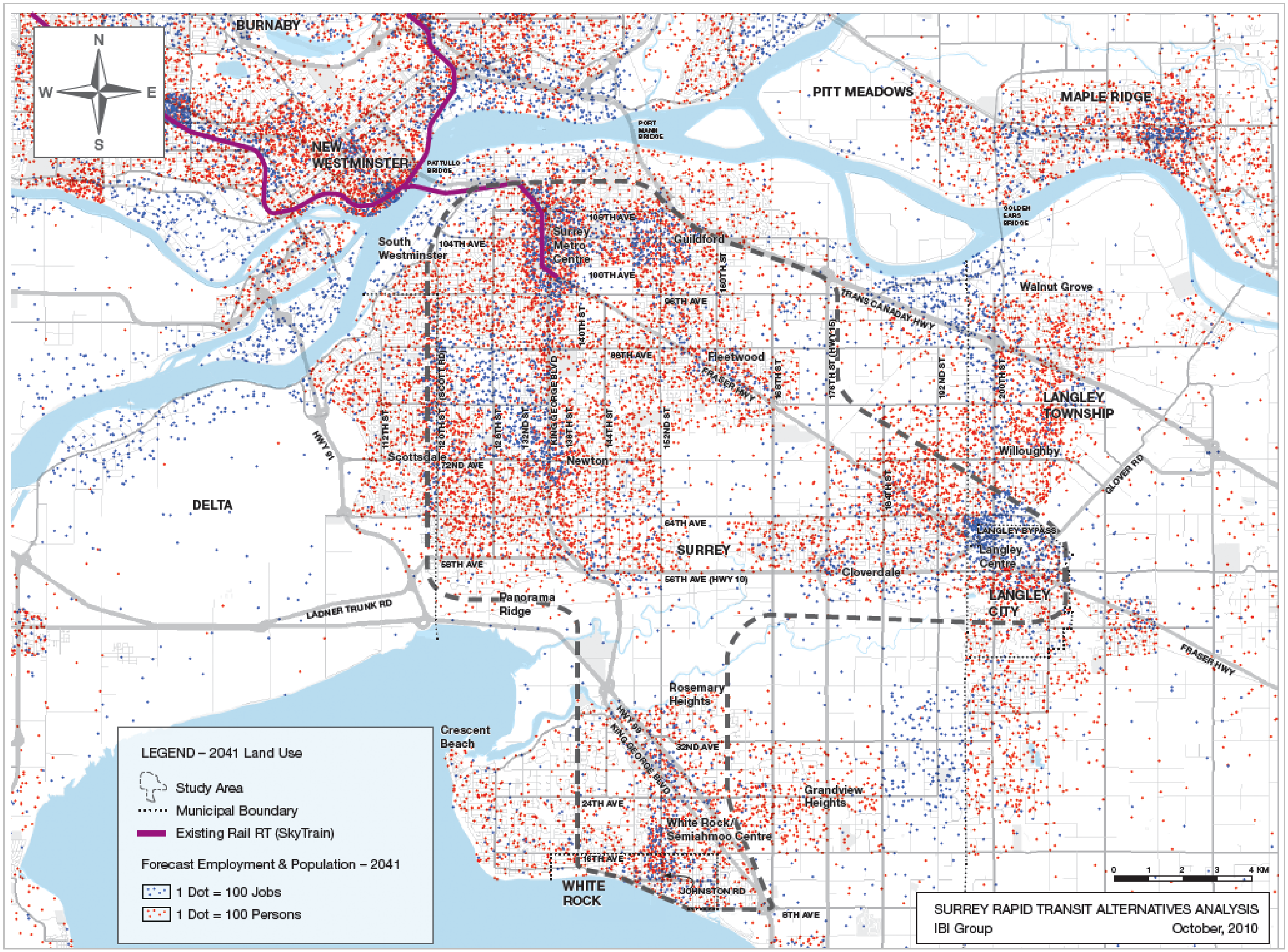
The Business As Usual (BAU) scenario was used as the benchmark for evaluation of the thirteen Phase 2 alternatives, and was defined for the 2021 and 2041 horizon years. The main components of the BAU included the land use projections, the transit network, and the road network.

2.4.1 Land Use

The land use assumptions for 2021 and 2041 were established at the municipal level by Metro Vancouver in the Regional Growth Strategy (RGS). The finer-grained distribution to neighbourhoods and traffic zones was prepared through an iterative, collaborative process by each municipality and Metro Vancouver, based on regional and local policies. For the SRTAA, the land use assumptions used were the RGS – June 2010 (with an August 2011 update to account for certain post-secondary students). These assumptions included substantial increases in population and employment within the study area through to 2041, with significant increases in most of the regional urban centres (particularly Surrey Metro Centre, Langley Centre, Guildford, and Newton) and along major travel corridors (e.g., in the Clayton and North Cloverdale areas adjacent to Fraser Highway). The projected distribution of residents and jobs in 2041 is depicted using a dot density map on **Exhibit 2.4.** Additional land use information, including the projections used in the analysis, is contained in **Appendix 2B**.

The Phase 2 alternatives were selected specifically to connect Surrey Metro Centre and the other fast-growing urban centres, thereby serving the areas with higher population and employment densities in the study area.

Exhibit 2.4 – Map of Land Use Densities, 2041



2.4.2 Transit Network

The BAU transit network was based on the future transit network vision identified in TransLink's 2007 South of Fraser Area Transit Plan (SOFATP). The types of service in the SOFATP vision included rapid bus, limited stop bus, frequent transit network (FTN) and other local bus services, and community shuttles. The BAU assumed a substantial increase in transit service hours over the present day (2010), based on past service growth trends and extrapolating based on projected study area population and employment growth. The BAU assumed a restructuring of routes (grid), additional services, increased frequency in the FTN corridors, and very frequent service on key corridors.

Exhibit 2.5 depicts the assumed coverage of service for the 2041 BAU transit network. The assumed bus routes, headways and types of buses on each route are documented for both 2021 and 2041 in **Appendix 2B**. The 2041 peak headway assumptions ranged from 3 to 7 minutes on the FTN routes, and 6 to 15 minutes on other routes. Off-peak service would be less frequent. Most buses were assumed to be standard 12-metre buses, with the exception of routes on higher-demand corridors (e.g. Fraser Highway, King George Blvd, and 104 Avenue) where 18-metre buses were assumed.

The SOFATP vision identified potential future rapid transit on several of the study corridors, including Fraser Highway, King George Boulevard, and 104th Avenue. The SOFATP vision also included rapid bus services on Highways 1 and 99 with the routes continuing along city streets to logical termini including White Rock Centre and Langley Exchange. These rapid buses on Highways 1 and 99 are included within the BAU.

2.4.3 Road Network

The 2021 and 2041 road network assumptions were developed by starting with the known conditions in 2008, and then adding in projects that were under construction, planned, or projected (by the Cities, based on street funding and allocation to higher-demand locations) in the study area. The 2021 network was developed with input from TransLink, MoTI, and the Cities of Surrey and Langley, and primarily included the following additions:

- Highway 1/Port Mann Bridge project;
- Golden Ears Bridge and approach roads (replaced the Albion Ferry in 2009);
- South Fraser Perimeter Road and connecting streets;
- Pattullo Bridge widening/replacement;
- Planned arterial additions and widening on the Major Road Network in North Delta and Langley Township;
- Roberts Bank Rail Corridor improvements, including grade separations;
- Completion of several widening projects already underway in 2008, namely Highway 10, King George Boulevard between Highways 10 and 99, and Fraser Highway; and
- Elements of the City of Surrey's 10-year servicing plan (except those recently deferred by Council decisions).

The 2041 network was a projection of likely road conditions with significant input from City of Surrey staff, based on locations where development may trigger future widening and arterial extensions; many of these were in the eastern and southern part of the City of Surrey, but also included completion of several east-west arterials between Scott Road and 152 Street. **Exhibit 2.6** illustrates the assumed changes to the road network between 2008 and 2041 in the study area and surroundings.

Exhibit 2.5 – Map of BAU Transit Network

(Based on Transport 2040 and the
South of Fraser Area Transit Plan Vision)

LEGEND – Business As Usual Concept (2041)

- Study Area
- Municipal Boundary
- City and Town Centres
- Existing Rail RT (Sky Train)
- Rapid Bus
- Frequent Transit Network
- Local Bus
- Neighbourhood Bus
- Existing Local Network
- Railway

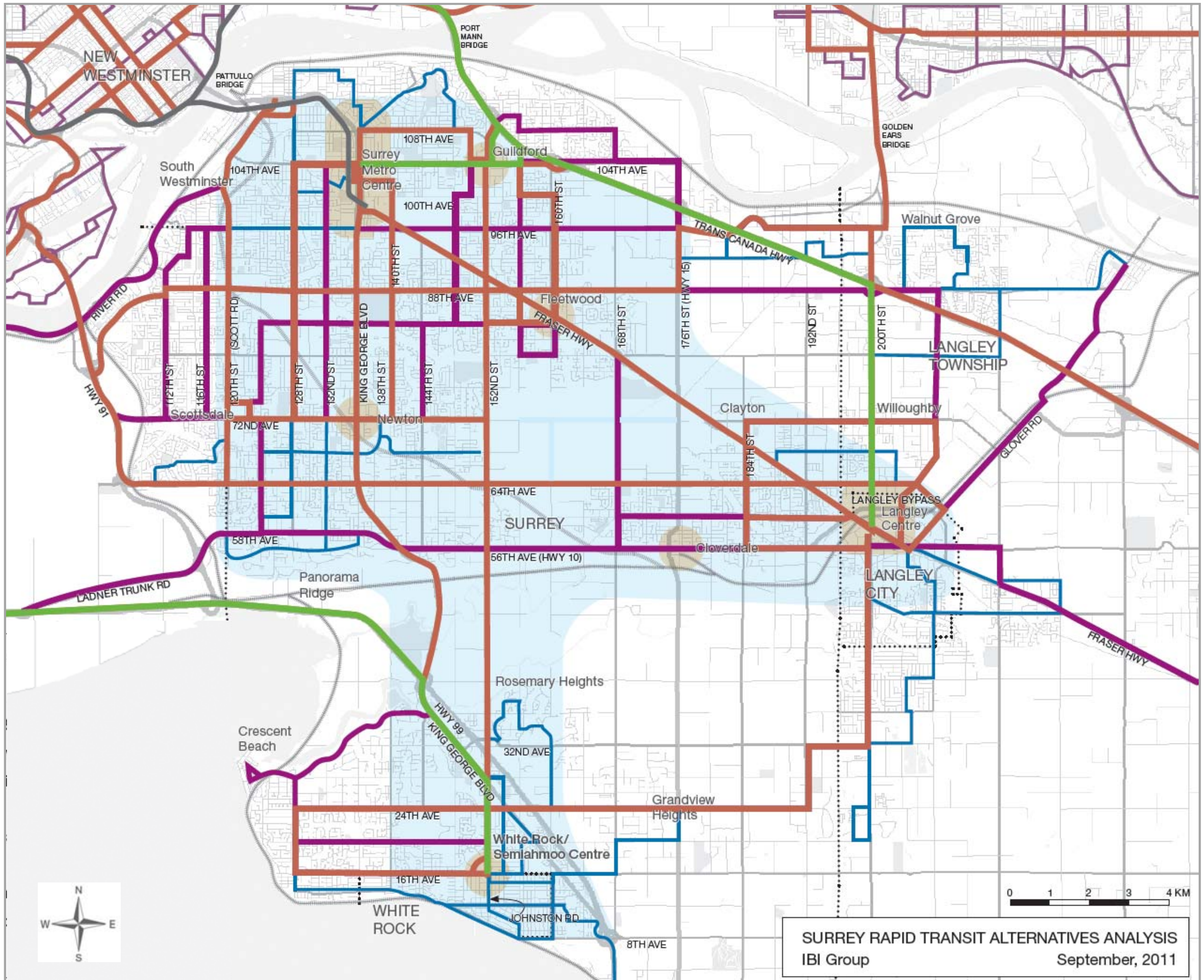


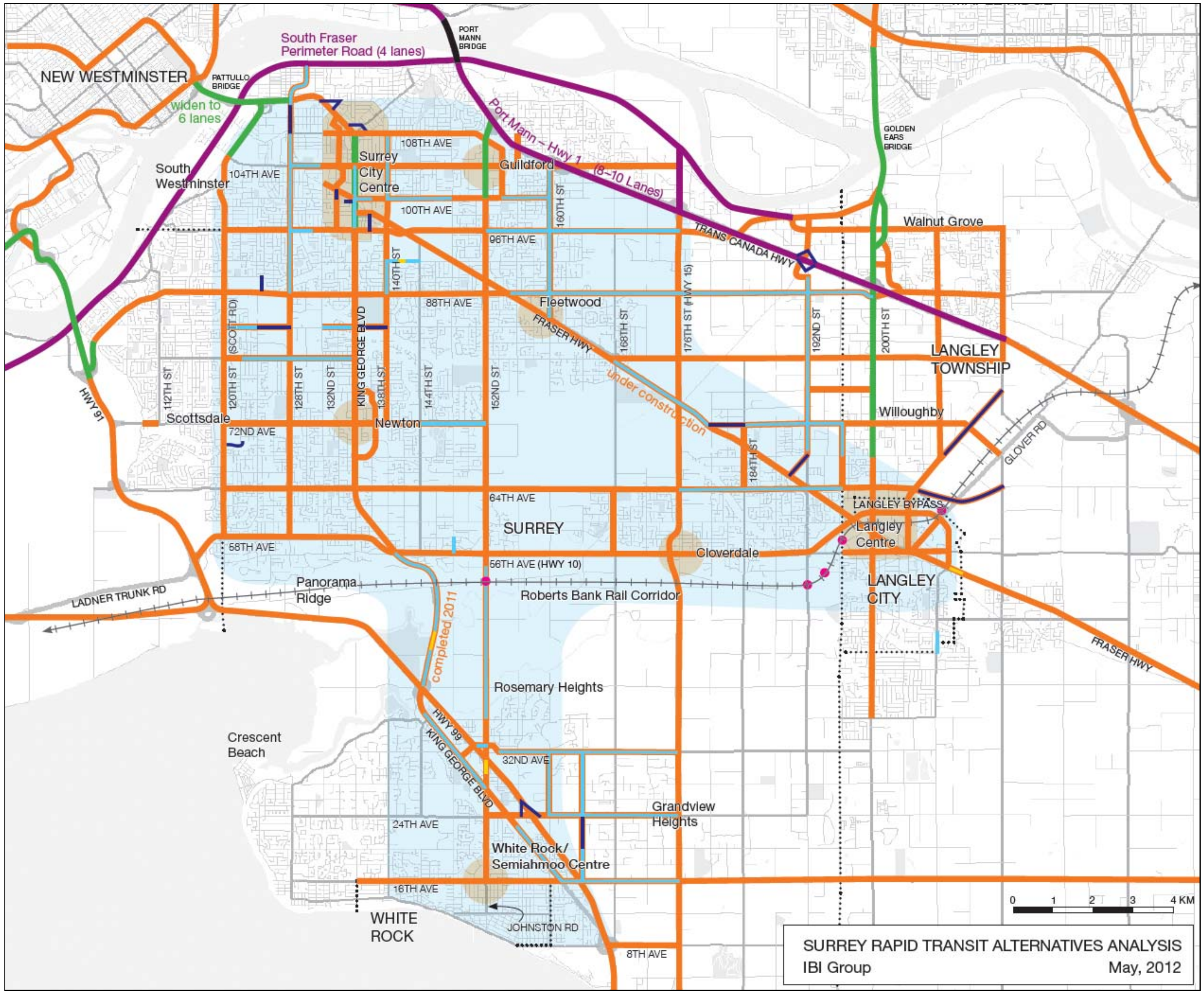
Exhibit 2.6 – Map of BAU Road Network

(Streets and highways as defined by TransLink, MoTI, Surrey, Langley, for 2041)

LEGEND – BAU Road Network (2041)

- Study Area
- Municipal Boundary
- City and Town Centres
- Gateway Program
- Roberts Bank Rail Corridor Program
- 6 Lane Highway / Street
- 4 Lane Highway / Street
- New City Streets (2011–2041)
- Bridges
- City Street Widening (2010–2041)

Note: All other arterials and collectors assumed to be 2 through lanes.



2.5 Phase 2 - Development of Alternatives

The development of the initial ten alternatives included an iterative process to design the BRT, LRT and RRT alternatives in conceptual detail, based on aerial photography and alignment information (e.g. GIS mapping) provided by the local municipalities. To supplement this, the transit operating assumptions were developed for the BAU (refer to Section 2.4), the Best Bus alternative, and the rapid transit alternatives.

2.5.1 Rapid Transit Alternatives – Conceptual Design

In Phase 2, each alternative was developed in sufficient detail to address the requirements set out in the Phase 2 Evaluation Framework. In the case of the BRT, LRT and RRT alternatives, conceptual designs were prepared to show the layout of the system, including the horizontal alignment in the street, vertical alignment (street level, elevated or tunnel), assumed intersection layouts (signals and lanes), types of cross section (number of lanes and space allocation), right of way limits, and station locations (in relation to adjacent intersections). Details are documented in **Appendix 1**.

The process to develop the conceptual designs is described below. The first step was to identify design principles to guide the preparation of conceptual plans and profiles. These principles were reviewed with the project partners, and included an approach to overall design, to cross sections, and to station locations:

Rapid Transit Parameters

- The technologies were designed in a manner consistent with other rapid transit studies (UBC Line Study [for BRT, LRT, and RRT] and the Expo Line Upgrade Strategy [for RRT]).
- Maximum grades, minimum curves, clearances for each technology were based on industry standards.
- RRT was assumed to be grade separated (since the routes follow arterial streets), with column size and spacing based on typical standards.
- BRT and LRT were assumed to run at grade; the width of the dedicated transit lanes and clearance from other traffic is based on typical standards.
- Station footprints (for each technology) included the typical size and general layout for platforms.

Cross Section Considerations

- Rapid transit was placed in the street median, except where advantages to side running were identified by the project team or partners.
- To fit rapid transit into the street, where necessary, the approach minimized property takes by narrowing traffic/parking lanes, boulevards, or sidewalks down from the ideal width but maintained minimum safe standards.
- The evaluation of property takes was based on existing property lines for the public ROW (including existing and funded construction).
- At bridge structures, the approach was to fit the rapid transit within the available space. If it was not feasible, widening or replacing bridges was assumed in order to provide sufficient space for rapid transit and the rest of the street.
- In selecting the alignment for rapid transit, major parallel utilities were avoided; otherwise the relocation/protection of utilities was assumed.

Station Locations

- Same station locations were assumed for each rapid transit technology on a given route.
- Spacing was assumed as ~ 800 m to 1600 m, at crossing arterials with transit routes and/or major activity centres.
- No stations were planned inside the floodplains where few residents or jobs exist.
- Minor differences in layout may exist due to fit of technologies within certain locations (but they are still located within same block).

As an input to design, information gathering meetings were held with the project partners to identify some of the known projects that were either planned or under construction, so that where possible these could be accounted for in the design. These included the ongoing widening of Fraser Highway, the 10-year servicing plan for Surrey, longer-term planning for several transit exchanges in the study area, land use plans and road layouts for Surrey Central Transit Village and Newton Town Centre, and the Downtown Master Plan in Langley.

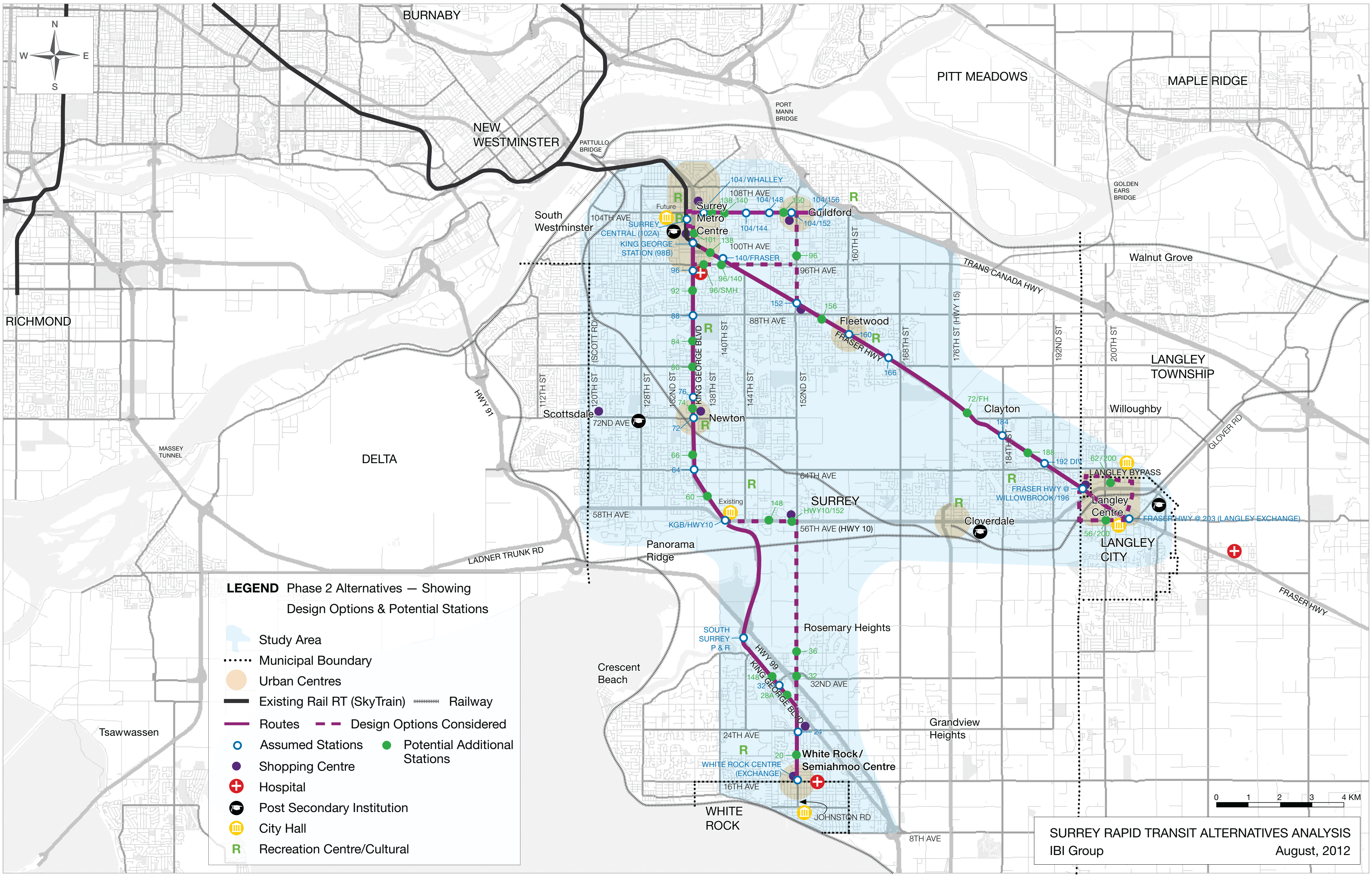
Conceptual Designs were prepared for the rapid transit components that made up the set of Phase 2 alternatives. As noted previously, the design principles – including assumptions for each technology, typical dimensions and cross sections – are documented in **Appendix 1**. The conceptual designs also included:

- Conceptual plans (1:1000 scale), indicating the alignment, station locations, type of cross section assumed and right of way limits, based on recent aerial photos; and
- Conceptual profiles in locations with grades and/or overhead clearance issues to note.

The Conceptual Designs were developed collaboratively with project partners, inclusive of the planning and engineering staff. A first iteration was developed and refined in a series of internal workshops (February 2011) to explain the purpose and review process, conduct an initial walk-through of the design principles, cross sections and plans, and obtain initial feedback from transportation and planning staff in the Cities of Surrey and Langley. At these meetings project partners identified issues and provided comments that were then incorporated into a second iteration of designs (April 2011), which were input to an initial evaluation of the alternatives. The initial conceptual design assumptions and evaluation results were presented to the partners and public, and comments gathered to help refine the alternatives. The comments received from the project partner reviews, and public input in May and June 2011 on the initial design assumptions, informed the development of the Fall 2011 Conceptual Designs. These designs served as the basis of the Phase 2 evaluation, and also document issues for further consideration in Phase 3.

The resulting alignments and assumed station locations are illustrated on the overview map of the rapid transit alternatives, **Exhibit 2.7**. The map also indicates other alignments considered (Section 2.6) and potential stations for consideration in Phase 3 suggested by the project partners. The final set of Phase 2 alternatives was developed from these alignments and stations.

Exhibit 2.7 - Overview Map of Alignments with Design Options and Potential Stations



2.5.2 Transit Service Definition

Each of the alternatives required definition of the background transit service assumptions. These were developed in consultation with TransLink staff, reviewed with the project partners and endorsed for use in the evaluation.

The BAU network for Phase 2 (described in Section 2.4) formed the foundation for each of the alternatives. The BAU network was a refinement of the assumptions from Phase 1, and considered the routes and service levels outlined in the SOFATP, population and employment projections in the study area, and the known road network conditions (to 2008) and projects under construction, planned, or projected (by the province, Metro Vancouver, or the Cities).

Initial rapid transit service plan assumptions were developed for the BRT, LRT and RRT operations, and then the connecting and overlapping BAU transit routes were reviewed to determine where minor modifications could be made to ensure high-quality connections. The Best Bus alternative was developed by 1) overlaying additional B-Line and Express services on the corridors where BRT, LRT or RRT were included in the other alternatives, and 2) increasing the frequency of local services on parallel routes and one cross study area route. The Best Bus alternative is described in further detail in Section 2.8.

The assumed transit operations under BAU and Best Bus are described in detail in **Appendix 2B**.

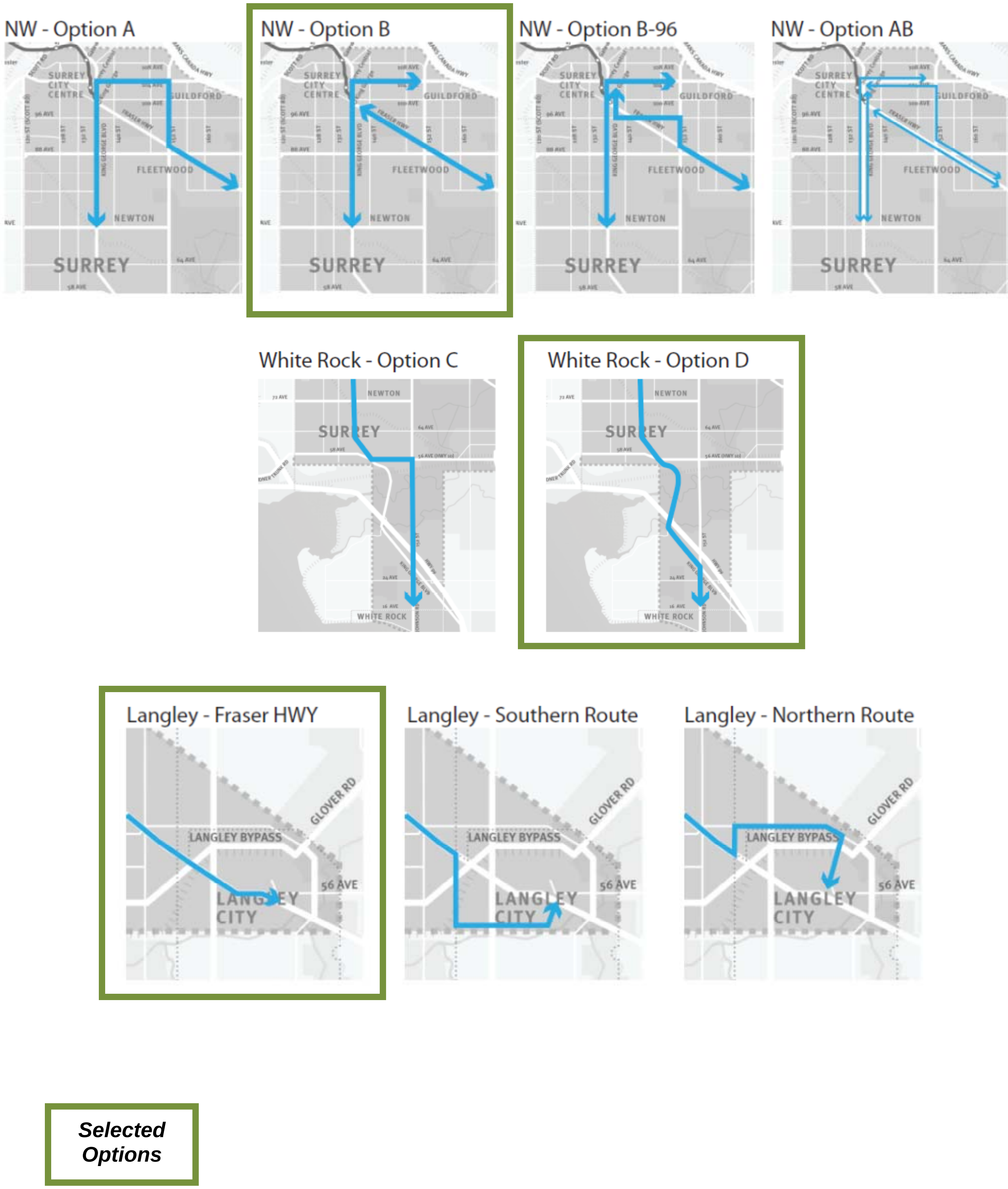
2.6 Selection of Design Options

Many of the segments between urban centres included design options: alternate routes and sets of stations connecting the centres together. Multiple design options for some alternatives were carried into Phase 2 as a result of the short listing process at the end of Phase 1. For the purpose of the Phase 2 evaluation, one set of design options was selected to represent the assumed alignment of each alternative, and simplify the evaluation of alternatives. To support the selection of better performing design options, an evaluation was undertaken. These design options are illustrated on **Exhibit 2.8**, and included alternate routes between the urban centres in the study area:

- Several different options were assessed to connect Surrey Metro/City Centre to Fleetwood. One was along 152nd Street and 104th Avenue (in north Surrey) via Guildford (Option A), and another was along Fraser Highway towards Surrey Metro/City Centre (Option B). In addition, there was a variation to the Fraser Highway option using 96th Avenue (Option B-96), and a combination option (Option AB) that split service and used both 152nd Street and Fraser Highway.
- There were two design options for the route between Newton and White Rock Centre. The first of these (Option C) followed Highway 10 east and then 152nd Street south; the other (Option D) stayed on King George Boulevard until joining 152 Street.
- There were also three different Langley design options applicable only to BRT. The first of these was a continuous route along Fraser Highway until the general vicinity of the Langley transit exchange. Two other options to the north and south of this, which would take advantage of existing or planned grade separations over the Roberts Bank rail corridor, were also considered.

The selection of the assumed design option was informed by a mini-MAE process. It included initial quantitative and qualitative assessments of the potential benefits and impacts of the options, using the same accounts and criteria documented in Section 2.3. The design option mini-evaluation drew upon engineering conceptual designs, land use assumptions, GIS data on potential environmental effects, and demand modelling where different configurations of BRT Alternative 1 were used to estimate ridership and traffic impacts.

Exhibit 2.8 – Assumed Design Options for Evaluation



The design option mini MAE (**Appendix 2C**) resulted in the following recommended alignments, which were found to generate the most benefits with the lowest costs and impacts:

- Between Fleetwood and Surrey Metro Centre, service would be via Fraser Highway (Option B), with service between Surrey Metro Centre and Guildford provided by 104th Avenue.
- From Newton to South Surrey, the assumed alignment for the evaluation would follow King George Boulevard from Newton, across the Agricultural Land Reserve (Option D), down to the intersection with 152nd Street which it would then follow to White Rock Centre.
- Within Langley, the Fraser Highway option would be assumed.

These alignment options were assumed for the Phase 2 evaluation as agreed with project partners. The assumed alignment options were carried forward and included in the Conceptual Designs (Fall 2011). Where deemed appropriate, the other design options – which were not carried forward for further consideration in Phase 2 – may be revisited in Phase 3.

2.7 Public Consultation and Design Refinements

During winter and spring 2011, initial conceptual designs and a preliminary evaluation of the Phase 2 alternatives were prepared and reviewed with project partners. These preliminary results provided a foundation for the final set of alternatives.

The public consultation process for the Phase 2 initial designs and preliminary evaluation was conducted in May to June, 2011. Members of the public were asked to comment on the initial design assumptions and the completeness of the preliminary evaluation. There was broad agreement with most of the initial design assumptions and the scope of the evaluation. Comments and questionnaire responses from the public workshops and online suggested some design modifications such as station locations, service coverage, and specific alignment assumptions.

Based on the review of the preliminary evaluation results and key comments from the public consultation program, the project team and partners identified potential changes to the design and operating assumptions of the rapid transit alternatives. The purpose was to identify design refinements that could improve the performance of the alternatives.

The design refinement analyses (carried out in summer 2011) tested changes to the operations and design of the rapid transit alternatives, with the objectives of increasing ridership, matching service capacity more closely to peak loads, reducing costs and impacts, and/or improving the cost-effectiveness of the alternatives. **Appendix 2D** outlines the input received, the outcomes of the design refinement tests, and the recommended changes from the initial alternatives to arrive at the thirteen documented in this report.

Based on the technical results, it was agreed with the project partners that the design and operating assumptions would be modified in the following ways:

- BRT along King George Blvd / 152 St was assumed to operate in mixed traffic in South Surrey (south of Highway 10);
- Alternatives on 104th Avenue were extended to 156 Street;
- One station location along King George Blvd was modified (from 80 Ave. To 76 Ave.);
- Rapid transit service levels were optimized. This included adjusting frequency (decrease RRT on Fraser Highway, and increase BRT on all corridors), and adjusting the service structure (providing BRT on 104th Avenue with Hwy 1 Rapid Bus routes);

- The number of alternatives was increased to thirteen. Three new alternatives (LRT 5A, LRT 5B, and RRT 1A) were generated in response to the preliminary evaluation results. The objective was to combine higher-capacity RRT and LRT elements on Fraser Highway with medium-capacity BRT on King George Blvd;
- It was agreed to defer further review of other potential changes, such as number and location of stations, potential park and ride lots, and other design details, to Phase 3 of the project.

In parallel with the investigation of design refinements, the travel demand model underwent several updates, which were incorporated into the final evaluation of alternatives. These refinements included: revised land use to account for post-secondary students at private institutions (updated by Metro Vancouver); the revised road network depicted in Exhibit 2.6 (City of Surrey); and fine-tuning of the model based on peer review (commissioned by the City of Surrey).

The next section describes the final set of Phase 2 Alternatives developed through this design refinement process.

2.8 Refined Alternatives for Evaluation

Twelve rapid transit alternatives and a Best Bus alternative underwent the evaluation. The performance of each alternative was compared against the BAU (described in Section 2.4), which includes bus service growth consistent with the SOFATP based on past trends and projected population and employment growth. The BAU excluded rapid transit investment in the study area in order to evaluate the effects of the alternatives. The operating and design assumptions for each of the transit technologies are described below, followed by descriptions of the associated individual alternatives.

2.8.1 Best Bus Alternative

Operating Assumptions

The Best Bus alternative is a low capital cost alternative that increases bus services along the main travel corridors and parallel routes, above and beyond what is provided under BAU, including B-Line and express bus services, building on the SOFATP. It seeks to determine how well future demand can be met through improvements to conventional bus service without rapid transit infrastructure investment.

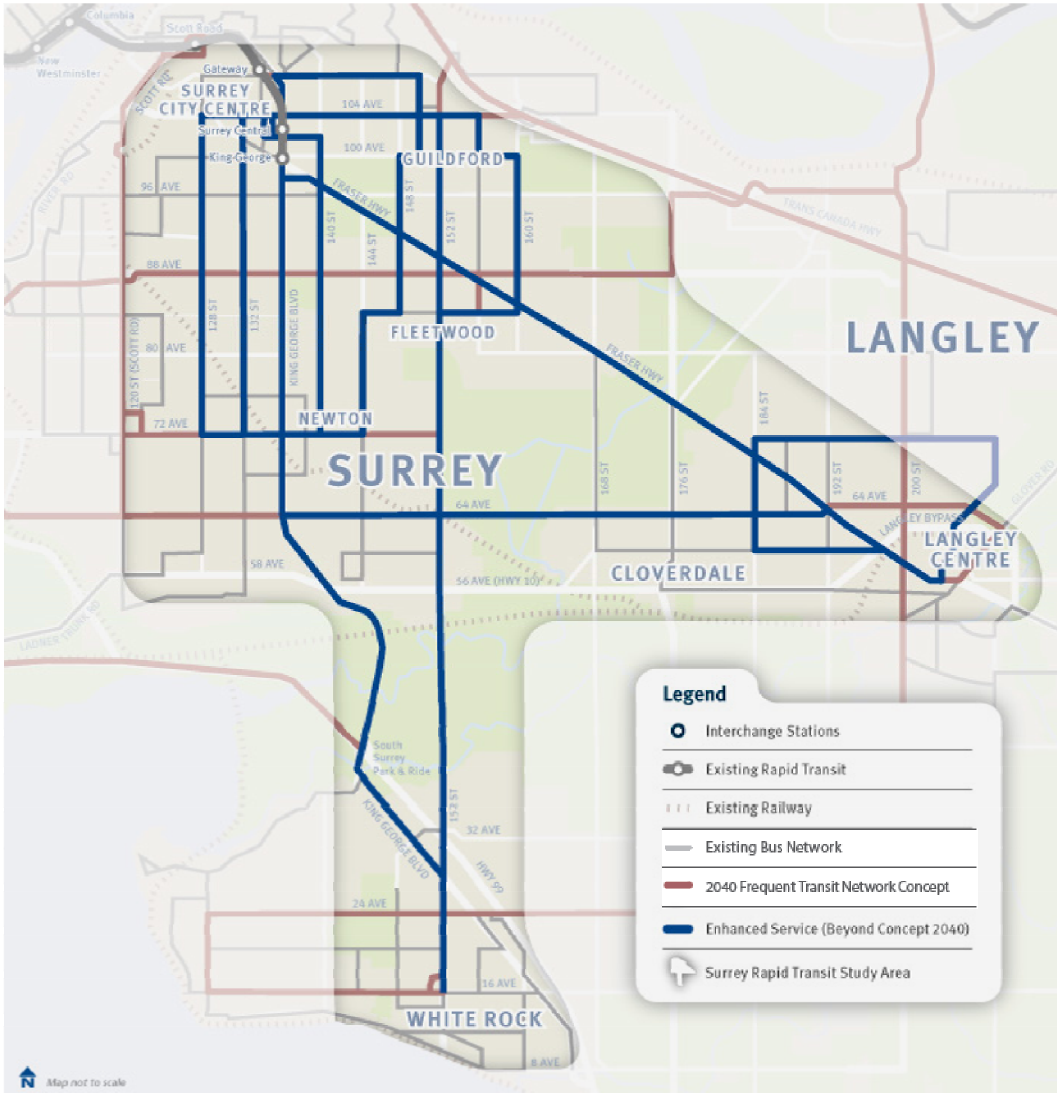
Exhibit 2.9 shows the extent of the Best Bus alternative within the study area. The routes with enhanced service on the map represent corridors with additional local, B-Line and/or express bus services added, on top of the baseline transit service expansion assumed in the BAU.

Design Assumptions

Enhancements were assumed to include more frequent service, new routes including B-Lines and express buses (focused on Fraser Hwy, King George Blvd, and 104 Avenue), new vehicles, and low cost infrastructure improvements including transit signal priority at busier signals along Fraser Highway, 104th Avenue, King George Boulevard and 152nd Street. Bus lanes were assumed on King George Blvd between King George Station and 96th Avenue, where two of the six traffic lanes would be converted to peak period bus lanes.

The Best Bus alternative is described in more detail, including service headways, in **Appendix 2B**.

Exhibit 2.9 – Best Bus



2.8.2 Surface Rapid Transit – BRT and LRT Alternatives

Operating Assumptions

Headways

BRT is assumed to operate on 3 minute (Fraser Highway) to 4 minute (King George Blvd and 104 Avenue) headways during peak periods in 2021 and at 2 minute headways in 2041. In LRT Alternatives 1 and 2, the BRT service south of Newton would match the LRT headways to allow for convenient transfers.

LRT is assumed to operate on 5 minute headways during peak periods in 2021 and at 3 minute peak period headways in 2041.

Intersections

It has been assumed that BRT and LRT alternatives include priority[4] at intersections for rapid transit to ensure it is fast and reliable. As a result, two types of intersections would exist:

- Full movement intersections: all major intersections along the rapid transit routes, with no restrictions to left turns. (Major intersections include arterials and collectors, and any streets providing the only access into neighbourhoods.)
- Right-in/right-out movements would be allowed at minor intersections, but no crossing of the transit lanes by general traffic.

City of Surrey plans a 4-lane road through Green Timbers Urban Forest, accommodating the growth of traffic volumes along Fraser Highway and providing safety for all road users. Planning for rapid transit through Green Timbers Urban Forest assumes that BRT and LRT share the planned general purpose traffic lanes, minimizing additional tree or vegetation loss. A shared right of way somewhat reduces rapid transit reliability and speed and vehicle traffic capacity through this segment. Transit priority (provided by queue jump lanes and signals) at intersections approaching and within Green Timbers will help to allow safe and efficient rapid transit operations through the area. This approach would allow rapid transit vehicles to enter the shared lanes ahead of other traffic.

BRT is also assumed to share the general purpose traffic lanes on King George Blvd and 152 Street south of Highway 10. Transit priority queue jump lanes would be provided at Highway 10 and approaching the traffic signals at South Surrey Park and Ride.

Design Assumptions

The design philosophy applied to the conceptual designs has two basic premises. The first premise is to minimize property and potential environmental impacts along each alignment, and the second is to provide high-quality rapid transit by maximizing the segregation from other traffic wherever possible. These design principles were confirmed with the project partners in fall of 2010, and were carried into the design of the rapid transit alignments and stations.

BRT and LRT will operate almost entirely within the centre of the street, except where advantages to side running are identified by the project team or partners. Centre-running allows for greater segregation of the rapid transit operation from other traffic, side streets, driveways, parking, and cyclists, in order to make LRT or BRT operations faster and more reliable. Therefore, over 98% of the initial design incorporates centre-running lanes.

It is assumed that both BRT and LRT will operate in semi-exclusive segregated medians. The BRT lanes will be separated from other traffic, except at signalized intersections where other traffic can cross the alignment. At this stage of design, the BRT right of way is 7.0 metres wide and separated from parallel lanes of general-purpose traffic by a 1.2-m safety clearance zone on both sides. The LRT median would be physically separated from other traffic, except at signalized intersections. At this stage of design, the LRT right of way is 6.8 metres wide and separated from parallel lanes of general purpose traffic by a safety clearance zone (1.2m on both sides, in addition to the 6.8m). The safety clearance zone would include an angled raised curb to deter road users from driving onto or over the BRT or LRT alignment. Emergency vehicles will be able to mount the curb and use the alignment to cross or bypass other traffic.

Generally, it has been assumed for LRT and BRT alternatives that there will be two lanes of rapid transit running down the centre of the roadway and two lanes of vehicular traffic on each side of the rapid transit line. An exception to this would be along 104 Avenue between Surrey Centre,

[4] Signal priority for BRT and LRT was assumed at a conceptual level, where several seconds of green time are added for the BRT or LRT based on vehicle detection, constrained by minimum time settings for cross traffic and pedestrians.

Guildford, and 156 Street where there is only one lane of directional traffic on each side due to space restrictions.

The alternatives are assumed to be elevated when crossing the Roberts Bank Rail Corridor heading to Langley Centre, while BRT and LRT alternatives crossing through Green Timbers Urban Forest or operating south of Highway 10 on King George Boulevard will share a lane with vehicular traffic.

Rapid transit stations are located alongside the transit alignment, generally in the centre of arterial streets. The platforms are typically placed on the opposite sides of major intersections for the two directions of travel in order to facilitate pedestrian access as well as to assist in minimizing delays to general-purpose traffic. The platforms are 3 metres wide (minimum) to provide room for accessible boarding and station amenities, and 40 metres long so that up to two articulated buses or one LRT train could stop alongside. Platforms at termini, including Surrey Central Station, would be longer to allow for operations and storage of vehicles laying over.

The same number of stations was assumed in Phase 2 for each rapid transit technology along a given route, for purposes of comparability between alternatives; this will be examined in further detail in a later phase of the project. The stations are located at or near major crossing arterials with transit routes or major activity centres, resulting in a spacing of approximately 800 to 1600 metres.

Exhibit 2.10 illustrates examples of typical vehicles, alignment and stations for BRT and LRT.

Exhibit 2.10 – BRT and LRT – Typical Vehicles, Alignment and Stations

Artist rendering of 104 Avenue and 144 Street

Artist rendering of King George Boulevard and 96 Avenue

Source: C-Tran, Vancouver, WA

2.8.3 BRT Alternatives

There are two BRT alternatives.

BRT Alternative 1 connects Surrey City Centre and the existing rapid transit network to key urban centres with three rapid transit services:

- BRT from Surrey City Centre to White Rock (along King George Boulevard and 152 Street) through Newton, operating in shared lanes with other traffic south of Highway 10;
- BRT from Surrey City Centre to Guildford (along 104 Avenue) and Hwy 1, provided by two routes that continue as Highway 1 rapid bus. One route continues from 152 Street to Coquitlam, and the other from 156 Street to Walnut Grove; and
- BRT from Langley Centre to Surrey City Centre (along Fraser Highway and King George Boulevard) through Fleetwood.

This alternative operates primarily at street-level, with a bridge where it crosses the Roberts Bank Rail Corridor in Langley. This alternative adds nearly 31 km of BRT infrastructure (segregated running way exclusively for BRT, mostly in the median) within the study area including 25 stations, two of which offer intermodal transfers onto the existing SkyTrain network at Surrey Central and King George Stations. (The extent of service shown on the map is 40 km, including 9 km operating in shared lanes south of Highway 10.) **Exhibit 2.11** shows the extent of this alternative within the study area.

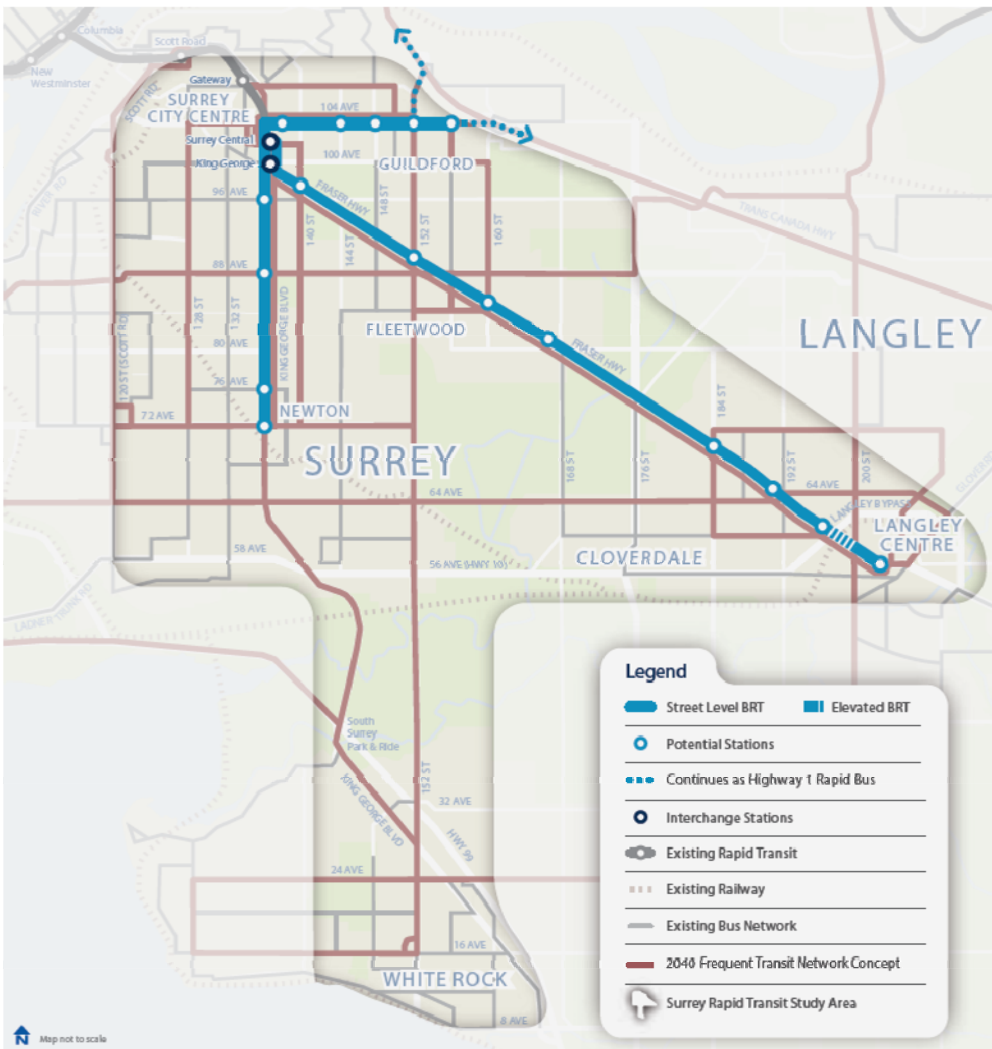
Exhibit 2.11 – BRT Alternative 1

BRT Alternative 2 connects Surrey City Centre and the existing rapid transit network to key urban centres with three rapid transit services:

- BRT from Surrey City Centre to Newton (along King George Boulevard); and
- BRT from Surrey City Centre to Guildford (along 104 Avenue) and Hwy 1, provided by two routes that continue as Highway 1 rapid bus. One route continues from 152 Street to Coquitlam, and the other from 156 Street to Walnut Grove; and
- BRT from Langley Centre to Surrey City Centre (along Fraser Highway and King George Boulevard) through Fleetwood.

This alternative operates primarily at street-level, running on a bridge where it crosses the Roberts Bank Rail Corridor in Langley. Approximately 27 km of BRT infrastructure is provided under this alternative including 19 stations, two of which offer intermodal transfers onto the existing SkyTrain network at Surrey Central and King George Stations. **Exhibit 2.12** shows the extent of this alternative within the study area.

Exhibit 2.12 – BRT Alternative 2



2.8.4 LRT Alternatives

There are six LRT alternatives.

LRT Alternative 1 combines LRT and BRT services. It connects Surrey City Centre and the existing rapid transit network to key urban centres with three rapid transit services:

- LRT from Guildford to Newton (along 104 Avenue and King George Boulevard) through Surrey City Centre
- LRT from Langley Centre to Surrey City Centre (along Fraser Highway and King George Boulevard) through Fleetwood, and
- BRT from Newton to White Rock (along King George Boulevard and 152 Street), operating in shared lanes with other traffic south of Highway 10.

This alternative operates primarily at street-level, with a bridge where it crosses the Roberts Bank Rail Corridor in Langley. This alternative has nearly 27 km of LRT and 4 km of BRT infrastructure. It is comprised of 19 LRT stations including three interchange stations of Surrey Central, King George and Newton Centre. The Newton Centre transit interchange allows passengers to transfer onto the BRT service with 6 additional BRT stations. **Exhibit 2.13** shows the extent of this alternative within the study area.

Exhibit 2.13 – LRT Alternative 1

LRT Alternative 2 combines LRT and BRT. It connects Surrey City Centre and the existing rapid transit network to key urban centres with three rapid transit services:

- LRT from Guildford to Newton (along 104 Avenue and King George Boulevard) through Surrey City Centre
- BRT from Langley Centre to Surrey City Centre (along Fraser Highway and King George Boulevard) through Fleetwood, and
- BRT from Newton to White Rock (along King George Boulevard and 152 Street), operating in shared lanes with other traffic south of Highway 10.

This alternative operates primarily at street-level, with a bridge where it crosses the Roberts Bank Rail Corridor in Langley. The LRT 2 Alternative includes approximately 11 km of LRT and 20 km of BRT infrastructure. Interchange stations at Surrey Central and King George link BRT and LRT to the existing SkyTrain network while the interchange station at Newton Centre connects the LRT line with the BRT line to White Rock. There are 11 LRT stations (including interchanges with BRT) and an additional 14 BRT stations. **Exhibit 2.14** shows the extent of this alternative within the study area.

Exhibit 2.14 – LRT Alternative 2

LRT Alternative 3 combines LRT and BRT. It connects Surrey City Centre and the existing rapid transit network to key urban centres with two rapid transit services:

- LRT from Guildford to Newton (along 104 Avenue and King George Boulevard) through Surrey City Centre, and
- BRT from Langley Centre to Surrey City Centre (along Fraser Highway and King George Boulevard) through Fleetwood.

This alternative operates primarily at street-level, with a bridge where it crosses the Roberts Bank Rail Corridor in Langley. The LRT 3 Alternative includes 11 km of LRT and nearly 16 km of BRT. Interchange stations at Surrey Central and King George link LRT and BRT to the existing SkyTrain network. There are 11 LRT stations (including two interchanges with BRT) and an additional 8 BRT stations. **Exhibit 2.15** shows the extent of this alternative within the study area.

Exhibit 2.15 – LRT Alternative 3

LRT Alternative 4 connects Surrey City Centre and the existing rapid transit network to key urban centres with a single rapid transit service:

- LRT from Guildford to Newton (along 104 Avenue and King George Boulevard) through Surrey City Centre.

This alternative operates entirely at street-level. This alternative consists of nearly 11 km of LRT including 11 stations, two of which offer intermodal transfers onto the existing SkyTrain network at Surrey Central and King George Stations.. **Exhibit 2.16** shows the extent of this alternative within the study area.

Exhibit 2.16 – LRT Alternative 4

LRT Alternative 5A connects Surrey City Centre and the existing rapid transit network to key urban centres with three rapid transit services:

- LRT from Langley Centre to Surrey City Centre (along Fraser Highway and King George Boulevard) through Fleetwood, and
- BRT from Surrey City Centre to Guildford (along 104 Avenue) and Hwy 1, provided by two routes that continue as Highway 1 rapid bus. One route continues from 152 Street to Coquitlam, and the other from 156 Street to Walnut Grove; and
- BRT from Surrey City Centre to White Rock (along King George Boulevard and 152 Street) through Newton, operating in shared lanes with other traffic south of Highway 10.

This alternative operates primarily at street-level, with a bridge where it crosses the Roberts Bank Rail Corridor in Langley. This alternative consists of 17 km of LRT infrastructure (some of which is shared with BRT), and an additional 14 km of BRT infrastructure. It serves 10 LRT stations (including two interchanges with BRT) and 15 BRT stations. **Exhibit 2.17** shows the extent of this alternative within the study area.

Exhibit 2.17 – LRT Alternative 5A

LRT Alternative 5B connects Surrey City Centre and the existing rapid transit network to key urban centres with two rapid transit services:

- LRT from Guildford to Langley Centre (along 104 Avenue, King George Boulevard and Fraser Highway) through Surrey City Centre and Fleetwood; and
- BRT from Surrey City Centre to White Rock (along King George Boulevard and 152 Street) through Newton, operating in shared lanes with other traffic south of Highway 10.

This alternative operates primarily at street-level, with a bridge where it crosses the Roberts Bank Rail Corridor in Langley. Over 21 km of LRT is added including 15 LRT stations (including two interchanges with BRT). An additional 9 km of BRT infrastructure (King George Station to Highway 10) and 10 BRT stations are also included. **Exhibit 2.18** shows the extent of this alternative within the study area.

Exhibit 2.18 – LRT Alternative 5B

2.8.5 Elevated Rapid Transit - RRT Alternatives

Operating Assumptions

Rail Rapid Transit (RRT) is assumed to have peak hour headways of 2.3 minutes north of King George Station in both 2021 and 2041, representing the planned level of RRT (SkyTrain) service on the Expo Line during peak hours. For extensions along Fraser Highway, the service is assumed to operate every 4.6 minutes (i.e. half the trains from Waterfront turn back at King George), while along King George Blvd the extension is shorter and is assumed to operate every 2.3 minutes. RRT only makes stops at stations, since it is completely segregated from traffic.

While RRT would be elevated above the street, its guideway columns would also require restriction of vehicular traffic to right in/right out at minor intersections along its alignment.

Design Assumptions

Rail Rapid Transit is typically located above the centre of arterial streets, except where advantages to side running are identified by the project team or partners. This allows the support columns to be placed in the street median, thereby reducing potential property impacts. RRT must be separated from other traffic, either elevated, in a tunnel, or at grade with a barrier completely separating it from other traffic. At this stage of design, elevated RRT columns are assumed to be 1.6 metres wide and separated from parallel lanes of general-purpose traffic. The columns would typically be placed within a 3.6-metre wide median, which creates a safety clearance for other traffic.

Exhibit 2.19 – RRT – Typical Vehicles, Alignment and Stations

Artist rendering of King George Boulevard and 96 Avenue

Exhibit 2.19 illustrates typical SkyTrain vehicles, elevated alignment and stations.

Side running and off-street running were assumed in special circumstances, including the extensions beyond King George Station to the east (before joining Fraser Highway) or south (before joining King George Boulevard), and along sections of Fraser Highway in the City of Langley that currently lack a central median. Along the Fraser Highway in the Agricultural Land Reserve, conceptual designs have assumed that the elevated RRT track and columns are located on the side of the roadway rather than running down the median.

RRT stations are assumed to be similar in scale and layout to the existing Millennium Line, which has platforms for each direction of travel outside the tracks, and a mezzanine level below the platform and above the street so that passengers can access both platforms after entering the station. The platforms are assumed to be approximately 85 metres long.

The same number of station locations is assumed for each rapid transit technology along a given route, so that the evaluation can focus primarily on the technology differences within the alternatives. As with BRT and LRT, the RRT stations are located at or near major crossing arterials with transit routes or major activity centres, resulting in a spacing of approximately 800 to 1600 metres. As noted earlier, the number of stations in each corridor was held constant for comparability, and may be studied further in a later project phase.

2.8.6 RRT Alternatives

There are four RRT (SkyTrain) alternatives.

RRT Alternative 1 extends the existing Expo Line to key urban centres with a single rapid transit service:

- RRT extends beyond King George Station (along Fraser Highway) to Langley Centre via Fleetwood.

This alternative operates on an elevated guideway above the street. Almost 16 km of RRT infrastructure is added along Fraser Highway with eight new SkyTrain stations connecting to the existing station at King George. **Exhibit 2.20** shows the extent of this alternative within the study area.

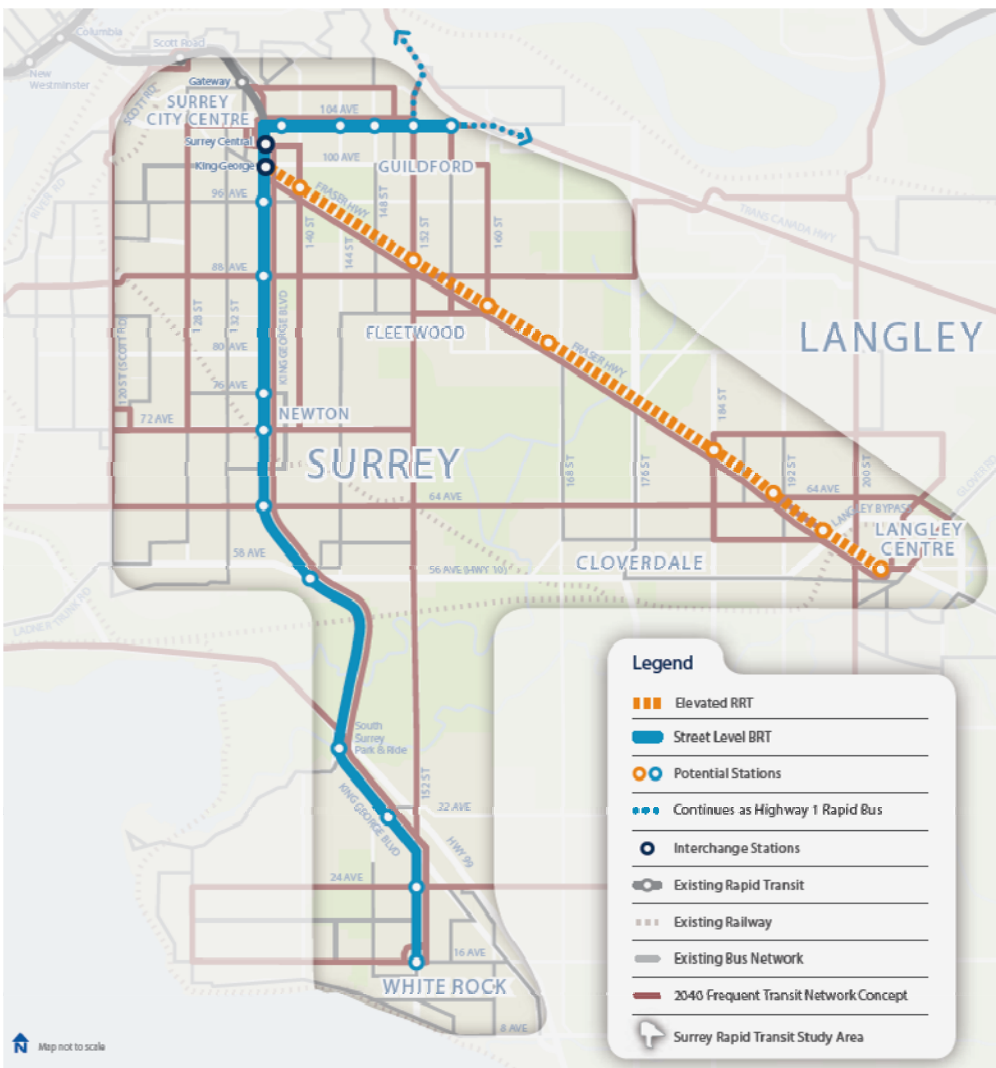
Exhibit 2.20 – RRT Alternative 1

RRT Alternative 1A connects Surrey City Centre and the existing rapid transit network to key urban centres with three rapid transit services:

- RRT extends beyond King George Station (along Fraser Highway) to Langley Centre via Fleetwood;
- BRT from Surrey City Centre to Guildford (along 104 Avenue) and Hwy 1, provided by two routes that continue as Highway 1 rapid bus. One route continues from 152 Street to Coquitlam, and the other from 156 Street to Walnut Grove; and
- BRT from Surrey City Centre to White Rock (along King George Boulevard and 152 Street) through Newton, operating in shared lanes with other traffic south of Highway 10.

The RRT element of this alternative operates on an elevated guideway above the street, while the BRT component is entirely street-level. Almost 16km of RRT infrastructure is added along Fraser Highway with eight new SkyTrain stations connecting to the existing station at King George. It also includes nearly 15 km of BRT infrastructure (between Guildford and Highway 10), and serves 17 BRT stations, two of which interchange with RRT. **Exhibit 2.21** shows the extent of this alternative within the study area.

Exhibit 2.21 – RRT Alternative 1A



RRT Alternative 2 combines RRT and BRT. It connects Surrey City Centre and the existing rapid transit network to key urban centres with three rapid transit services:

- RRT extends the existing Expo Line south from King George Station (along King George Boulevard) to Newton;
- BRT from Langley Centre to Surrey City Centre (along Fraser Highway and King George Boulevard) through Fleetwood; and
- BRT from Surrey City Centre to Guildford (along 104 Avenue) and Hwy 1, provided by two routes that continue as Highway 1 rapid bus. One route continues from 152 Street to Coquitlam and the other from 156 Street to Walnut Grove.

The RRT component of this alternative operates on an elevated guideway above the street. BRT operates primarily at street-level, with a bridge where it crosses the Roberts Bank Rail Corridor in Langley. Nearly 6 km of RRT infrastructure is added in this alternative with four new SkyTrain stations connecting into the existing King George Station. Almost 22 km of BRT is added including 15 BRT stations. **Exhibit 2.22** shows the extent of this alternative within the study area.

Exhibit 2.22 – RRT Alternative 2

RRT Alternative 3 extends the existing Expo Line with a single rapid transit service:

- RRT extends beyond King George Station (along King George Boulevard) to Newton.

This alternative operates on an elevated guideway above the street. Nearly 6 km of new RRT infrastructure is added in this alternative with four new stations connecting to the existing SkyTrain at King George Station. **Exhibit 2.23** shows the route followed by this alternative within the study area.

Exhibit 2.23 – RRT Alternative 3

3. MULTIPLE ACCOUNT EVALUATION

Each of the thirteen alternatives underwent an MAE based on the design (and operating) assumptions in Section 2. The evaluation was carried out using the following types of planning tools to prepare quantitative and qualitative assessments:

- Transportation demand forecasting models and inputs including service characteristics, future land use assumptions, and the transit and road networks;
- Financial models, based on comparable rapid transit projects;
- Real estate forecasting; and
- Physical assessment of potential impacts based on the alternative designs, industry best practice, and information about the existing and planned conditions in the study area, including environmental, property and transportation data.

The performance of each alternative was compared against the BAU scenario over the period of construction plus thirty years of operations, to understand the long-term benefits and impacts of each alternative. For the purpose of demand modelling, the assessment compared the alternatives against the BAU in 2021 and 2041, years for which land use forecasts are available. The following sections document the evaluation results for the refined alternatives, which incorporated input gathered from the community consultation process, from the project partners, and from a technical assessment to identify design refinements that would enhance the alternatives.

Evaluation Scoring

The evaluation results within each of the accounts and criteria included both quantitative and qualitative findings. To help interpret the significance of these findings, these results were summarized using evaluation scoring, representing how each alternative performed relative to BAU. The scores help to differentiate between alternatives, but do not necessarily infer that an alternative is “good” or “bad”. Using the individual results as a guide, the thirteen alternatives were rated on a five-point scale for each criterion.

Worse	←	BAU	→	Better
1	2	3	4	5

In this scale, scores of “5” or “4” indicated that the alternative performed “better” than BAU. Because the results for the individual alternatives sometimes displayed significant variation, the “5” and “4” scoring was used to differentiate between the alternatives, with the “5” score given to alternatives that clearly out-performed both the BAU and other alternatives. At the other end of the scale, scores of “1” or “2” were given where the alternative performed “worse” than BAU. A score of “3” meant that the alternative’s performance was similar to BAU.

Within nearly all criteria, the alternatives tended to fall on one side of the scoring range. Where the criterion reflected benefits, the scores for the alternatives ranged from “better” to “similar to BAU.” Where the criterion reflected negative impacts, the scoring ranged from “similar to BAU” to “worse.”

Evaluation Accounts

This section is organized according to the seven evaluation accounts (presented in the order of the MAE framework):

- Transportation
- Financial
- Environment
- Urban Development
- Economic Development
- Social and Community
- Deliverability

The following sections provide an overview of these accounts, the individual criteria and measures within them, the key inputs and assumptions used in the assessments, and a brief discussion of the results and evaluation ratings. **Appendix 2A** describes the evaluation accounts, criteria, and measures, and specific assumptions used in the evaluation.

Please Note: The evaluation was based on the set of criteria and measures discussed in Section 2 and Appendix 2A, and confirmed by the project partners in 2010. Other criteria and measures may also be of interest, but were not included in the Phase 2 analysis because they were not related to project objectives, could not be assessed based on conceptual designs, or would not differentiate the alternatives. In later phases of project development, additional measures may be evaluated against specific design aspects, such as station layouts, vehicle size and configuration, transit priority measures, etc.

3.1 Transportation Account

Brief Overview

The transportation account evaluates the performance of the alternatives against the following project objectives:

- *Rapid transit is fast, frequent, reliable and attractive to all users.*
- *Rapid transit and the supporting transit network meet current and future travel demand efficiently for multiple destinations, increasing transit mode shares and reducing vehicle kilometres travelled (VKT)*
- *Rapid transit service is integrated with the regional and local transit system, and*
- *Walking and cycling modes are integrated with the rapid transit service*.

The transportation account measures the benefits and impacts to users of the regional transportation network, including transit users, car drivers and passengers, pedestrians and cyclists. The assessment is built on assumptions about the future transportation networks during the thirty-year operating period, with forecasts for 2021 and 2041 highlighted.

The relative benefits and impacts in terms of travel times, number of boardings, and mode share are based on outputs of the travel demand model, which produces forecasts for the BAU and each of the Phase 2 alternatives. (The demand model is described in **Appendix 2B**.) The accessibility of the system, in terms of number of people living or working in station areas, is a function of the assumed stations and future land use projections. The reliability, capacity and expandability of the system are a function of the design of each alternative and operating assumptions and characteristics associated with each technology. Integration with other modes is related both to existing and planned cycling/pedestrian conditions, and the design assumptions of the alternatives.

The transportation criteria include:

3.1.1. Transit User Effects

3.1.2. Non-Transit User Effects

3.1.3. Transit Network/System Access

3.1.4. Reliability

3.1.5. Capacity and Expandability

3.1.6. Integration with Active Modes

3.1.7. Transit Mode Share

The evaluation approach, assumptions and results are described for each of these criteria on the following pages. Details of the transportation account analysis are located in **Appendix 3A**.

3.1.1 Transit User Effects

Approach

The transit user effects criterion assesses travel time savings for each alternative and forecasts how many people would use the transit system. The related measures included: transit travel time between major origins and destinations, travel time savings, and total transit boardings and passenger km.

Travel Times on Rapid Transit and Best Bus

Travel times between major origins and destinations in the study area were estimated based on the design assumptions for each of the alternatives, and their resulting effects on travel time. The following key assumptions were made:

- BRT and LRT operate at street level in segregated medians (on tires or on tracks), and due to other traffic being segregated, the BRT/LRT vehicles can operate up to the posted speed limit. BRT/LRT operations through Green Timbers Urban Forest and south of Highway 10 on King George Blvd / 152 St, where there is transit priority but the lanes are shared with other traffic, were assumed to be approximately 10 km/h slower.
- BRT and LRT vehicles would have to stop at intersections when the traffic signal indication is red. The travel time impact of traffic signals includes deceleration, wait time, and then acceleration after the signal turns green. If the BRT/LRT vehicle encounters a green signal, it proceeds through at full speed. The travel time effects of signals are a probability-weighted average of the red-signal and green-signal conditions encountered.
- Transit priority systems would detect the oncoming BRT or LRT vehicles, and if needed (and when possible), additional green time would be added to help BRT/LRT encounter fewer red signals. In this way, transit priority increases the average transit speed through the intersection.
- Acceleration and deceleration rates were based on industry typical values. LRT is electrically powered and able to accelerate and decelerate more efficiently than BRT, giving it a marginal travel time advantage.
- RRT is entirely segregated from traffic and can operate up to a maximum speed of 80 km/h, based on the performance specifications of the Expo Line.

- All three technologies are assumed to stop at each rapid transit station, and dwell for 20 seconds. (This value was based on observations of dwell times at current RRT and B-Line stops in Greater Vancouver).
- For transit trips, passengers will have an initial wait time averaging half the service headway. For 2041, the assumed headways were 2 minutes for BRT, 3 minutes for LRT (and Newton-White Rock BRT in LRT 1 and LRT 2), 4.6 minutes for RRT to Langley, and 2.3 minutes for RRT to Newton.
- B-Line services included in Best Bus would operate at speeds midway between BRT and the local bus. This accounts for both the effects of time saved by the limited-stop service pattern (assuming the same stops and dwell time as BRT), and the delays caused by operating in mixed traffic, similar to local buses.
- Local buses included in the BAU and each alternative are assumed to operate at similar speeds to auto traffic, with additional time spent at bus stops.
- Any transfers required between different modes (BRT, LRT, RRT, B-Line, connecting local bus) or different routes add time equal to half the service headway of the second route.

Based on the assumptions noted above, **Exhibit 3.1** summarizes the transit travel times (including in-vehicle, wait and transfer times) between Surrey Central Station and the other urban centres in the study area, for the BAU and each of the alternatives. Each of the alternatives provides travel times that are as good as, if not substantially faster than, the BAU.

Transit Boardings, Ridership and Travel Time Savings

The other measures in this criterion were estimated from travel demand forecasting output, which used the assumed designs, operating plans and travel times for the alternatives as input.

Exhibit 3.2 includes the average transit boardings within the study area, based on the boarding activity on all transit routes – existing and any new rapid transit, express/rapid bus, and local services – within the study area boundaries. The exhibit also indicates the rapid transit ridership in 2041 for each alternative (and more detail is included in Exhibit 3.3). The regional transit passenger-kilometres were estimated from the demand model's transit assignment for each alternative, and then the increment relative to BAU estimated.

The estimated travel time savings in 2021 and 2041 are also included on Exhibit 3.2. Travel time savings were extracted from the travel demand model for two types of transit riders: (1) 'existing' transit users common to the BAU scenario and the alternative, many of whom save time due to the faster travel speed and more frequent service provided by rapid transit; and (2) new transit riders that switch travel modes to save travel time. The person-minutes of time saved during the AM peak hour were converted to annual travel time saving, assuming 5100 peak hours equivalent to one year of ridership. (This factor was estimated from 2009 passenger counts for the local bus routes on King George Blvd and Fraser Highway).

Exhibit 3.1 - Travel Time Competitiveness

Total Transit Time (2021)

		BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Surrey Central	Newton	26	21	16	16	15	15	15	15	16	16	25	16	10	10
Surrey Central	White Rock	55	47	38	41	39	39	47	47	38	38	54	38	42	42
Surrey Central	Guildford	17	14	11	11	10	10	10	10	11	10	17	11	11	17
Surrey Central	Fleetwood	21	18	14	14	14	14	14	21	14	14	10	10	14	21
Surrey Central	Cloverdale	44	40	36	36	36	36	36	43	36	36	32	32	36	43
Surrey Central	Langley Centre	51	40	30	30	30	30	30	49	30	30	22	22	30	49
Factored Average		34	28	22	23	22	22	23	29	22	22	26	20	21	27

Total Transit Time (2041)

		BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Surrey Central	Newton	27	20	15	15	14	14	14	14	15	15	25	15	10	10
Surrey Central	White Rock	59	46	37	40	38	38	46	46	37	37	54	37	42	42
Surrey Central	Guildford	17	13	10	10	9	9	9	9	10	9	17	10	10	17
Surrey Central	Fleetwood	23	17	14	14	13	14	14	21	13	13	10	10	14	21
Surrey Central	Cloverdale	46	39	36	36	35	36	36	43	35	35	32	32	36	43
Surrey Central	Langley Centre	54	39	30	30	29	30	30	49	29	29	22	22	30	49
Factored Average		36	27	21	22	21	21	23	28	21	21	26	19	21	27

Times include in-vehicle, wait, and transfers; all unweighted in these tables. (For demand modelling, waiting and transfer times are perceived as longer)
Factor for average times based on peak passenger loads (for BAU) in each travel corridor.

Exhibit 3.2 - Transit User Effects, including Travel Time Savings

Alternatives	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Transit Boardings in Study Area														
2021 Study Area Daily Transit Boardings	406,000	449,000	458,000	451,000	442,000	448,000	446,000	414,000	453,000	447,000	422,000	446,000	463,000	421,000
2041 Study Area Daily Transit Boardings	642,000	692,000	755,000	739,000	740,000	743,000	732,000	669,000	753,000	745,000	684,000	735,000	753,000	670,000
Thirty-Year Incremental Boardings, Millions		485	916	786	757	796	722	197	877	807	323	741	917	234
Surrey Rapid Transit Ridership														
Daily (on new RT services), 2041			180,000	149,000	166,000	169,000	152,000	65,000	178,000	180,000	115,000	202,000	200,000	81,000
New Regional Transit Trips - Life Cycle Average														
Average Weekday (2020-2049)		11,500	13,500	11,500	12,000	12,500	12,000	4,000	12,500	13,500	17,000	24,500	17,500	8,000
Transit Passenger-km (Regional)														
2021 Regional Transit Network Pass-km/AM Pk	1,530,000	1,540,000	1,550,000	1,540,000	1,550,000	1,540,000	1,550,000	1,530,000	1,540,000	1,540,000	1,570,000	1,580,000	1,560,000	1,550,000
2041 Regional Transit Network Pass-km/AM Pk	2,110,000	2,130,000	2,150,000	2,140,000	2,140,000	2,140,000	2,140,000	2,120,000	2,140,000	2,150,000	2,170,000	2,180,000	2,160,000	2,140,000
Thirty-Year Incremental Pass-km, Millions		1800	3960	3260	3540	3300	3370	330	3690	3840	7830	9260	5820	2910
Transit Travel Time Savings, Millions of Passenger-Hours														
Regional Unadjusted Annual TTS - Hours, 2021 (Unco.)		2.5	2.8	2.6	2.2	2.5	2.5	0.3	2.5	2.5	6.2	7.4	4.6	2.2
Regional Unadjusted Annual TTS - Hours, 2041 (Unco.)		2.8	5.7	5.2	5.2	4.9	5.0	0.7	5.7	6.1	9.1	11.4	8.0	3.6
Adjusted for Capacity Constraints	constrained													
Adj2021 - Existing and New Transit		2.5	2.4	2.2	2.2	2.2	2.2	0.3	2.5	2.5	6.2	7.4	4.2	2.2
Adj2041 - Existing and New Transit		2.8	5.2	4.6	5.2	4.4	4.4	0.7	5.7	6.1	9.1	11.4	7.4	3.6
Pass-Up Time Savings (BAU V/C>1 on FH, KGB)														
2021 (Annual)		1.0	1.0	1.0	1.0	1.0	1.0	0.3	1.0	1.0	0.7	1.0	1.0	0.3
2041 (Annual)		0.5	1.2	0.5	0.5	0.5	0.5	0.0	1.2	1.2	0.5	1.2	1.2	0.7
Total Transit Travel Time Savings (Reflects Pass-Up Relief from BAU, and Capacity Constraints)														
2021 (Annual Hours), Millions		**3.5**	**3.4**	**3.2**	**3.2**	**3.2**	**3.2**	**0.6**	**3.5**	**3.5**	**6.9**	**8.4**	**5.2**	**2.5**
2041 (Annual Hours), Millions		**3.3**	**6.5**	**5.1**	**5.7**	**4.9**	**4.9**	**0.7**	**7.0**	**7.3**	**9.6**	**12.6**	**8.6**	**4.3**
Thirty Year Total (Undiscounted), Mill.		**101**	**159**	**131**	**143**	**127**	**127**	**20**	**169**	**175**	**258**	**331**	**219**	**108**
Travel Time Benefit (minutes) per Rapid Transit Rider, 2041			**6.3**	**6.0**	**6.1**	**5.1**	**5.7**	**1.9**	**6.9**	**7.2**	**14.8**	**11.0**	**7.6**	**9.4**
Evaluation Rating (5 Better > 3 BAU > 1 Worse)		**4**	**4**	**4**	**4**	**4**	**4**	**3**	**4**	**4**	**5**	**5**	**4**	**4**

Two post-model adjustments were made to the estimated travel time savings to reflect factors not captured by the model, because it is not capacity-constrained. First, the assessment of demand versus capacity (see Section 3.1.5) indicated that the peak point demand on corridors with BRT would be met using a combination of BRT and local buses. The travel time savings for those passengers were constrained to the percentage able to board BRT rather than local buses. The second adjustment was made to reflect pass-up benefits relative to BAU. The model does not estimate pass-up delays for local bus passengers, and in BAU, the demand for local transit on Fraser Highway and King George Blvd was greater than capacity. It was conservatively estimated that the ‘excess’ BAU local bus riders would each experience delay of at least one local bus headway. This time would be saved by transit passengers in one or both corridors depending on the coverage of the alternative. (Refer to Appendix 3A for additional detail.)

An average travel time benefit per passenger was estimated based on the total travel time savings, divided by the number of rapid transit boardings.

For the purpose of comparing how transit passengers use the system on different alternatives, an assessment of the weekday transit boarding activity by mode and corridor was prepared from the AM peak hour estimates for each of the groups of transit routes in the demand model output. The results for 2021 and 2041 are presented in **Exhibit 3.3**, which indicates that boarding activity on the background bus network and existing SkyTrain stations make up a very significant proportion of the total in the study area, even for the more extensive rapid transit alternatives.

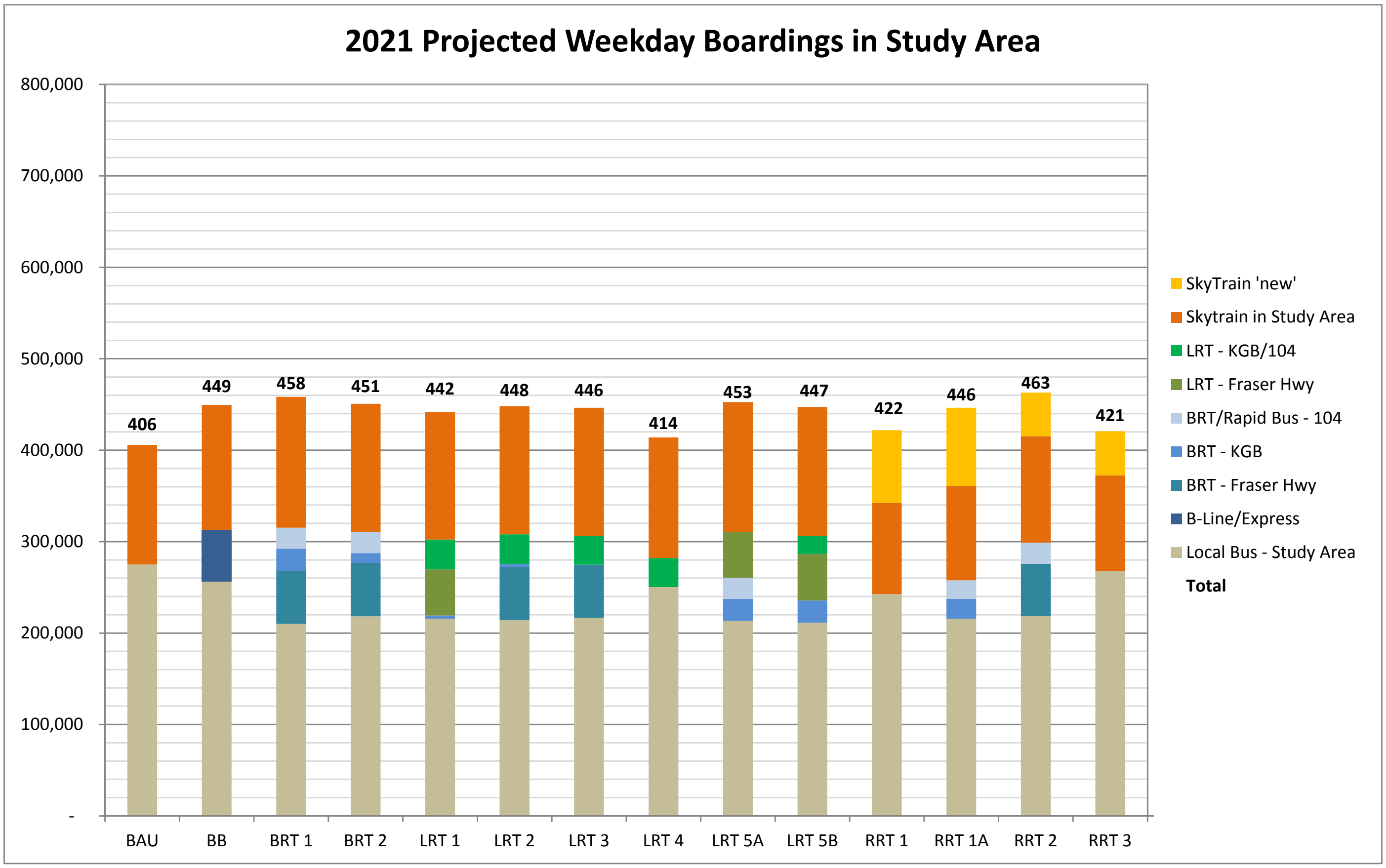
Results

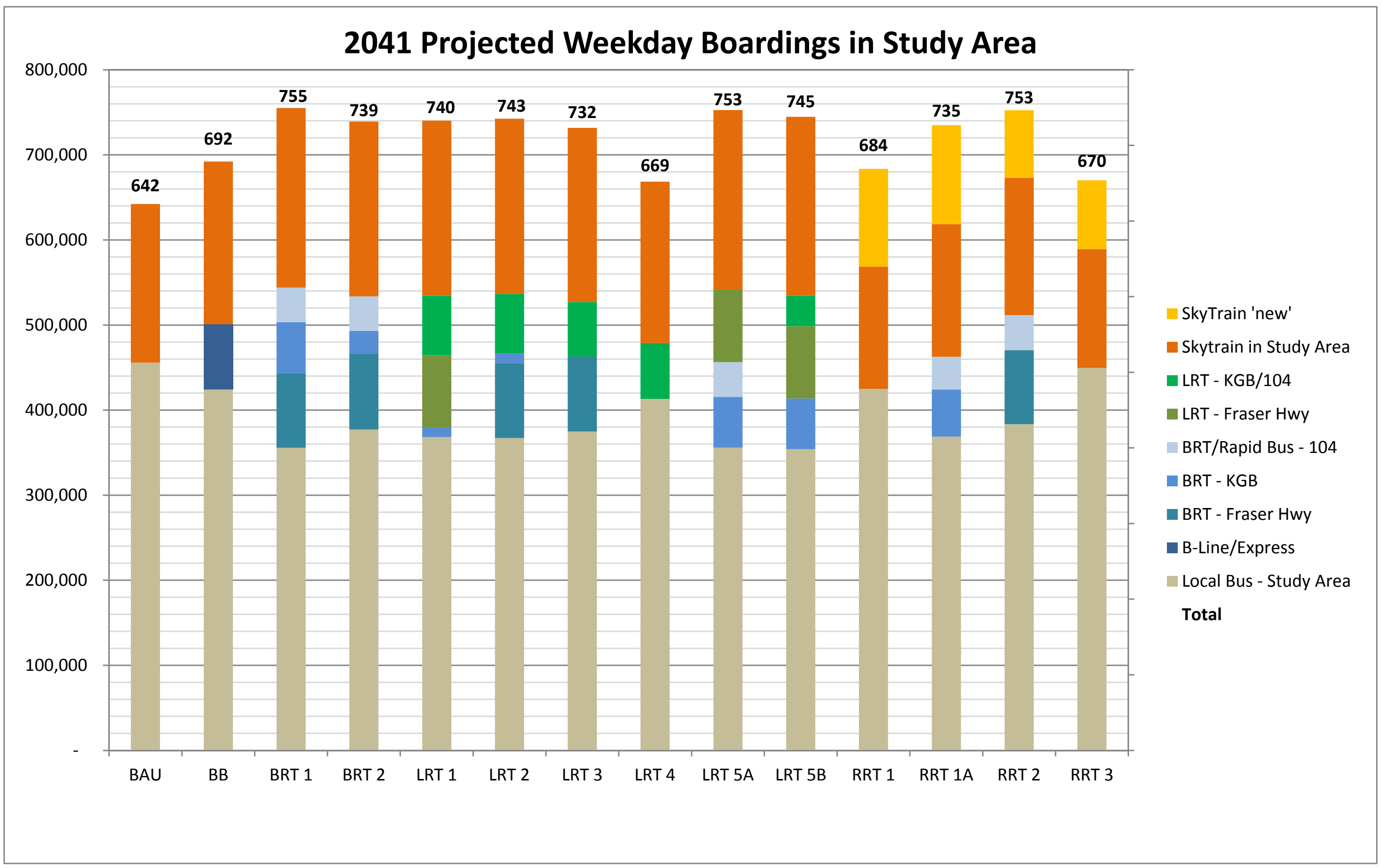
All of the alternatives would improve transit travel times and demonstrate significant growth in overall boardings in the study area between 2021 and 2041, consistent with population and employment in the South of the Fraser area. Generally, the largest and fastest alternatives would provide the largest improvements in travel time, have more boardings on rapid transit, and/or larger increases in transit passenger-km. However, the overall transit boardings within the study area did not vary between alternatives as significantly as the travel time savings.

All RRT alternatives are extensions of the existing Expo Line, providing a transfer-free service out of Surrey into New Westminster, Burnaby and Vancouver. As a result, they would provide large travel time savings (as shown in Exhibits 3.1 and 3.2), especially for longer trips between the rest of the study area, Surrey Metro Centre, and areas north of the Fraser.

RRT 1 and RRT 1A have the fastest service over a long corridor, providing significant travel time savings focused on Fraser Highway. RRT 1 would not have as many riders as the more extensive BRT and LRT alternatives, but those riding it would save a lot of time per passenger. RRT 1A has the greatest time savings because it combines the savings of RRT 1 along the Fraser Highway with BRT-based benefits on King George Blvd and 104th Avenue. RRT 2 would have the highest boardings of all thirteen alternatives in 2021, and second-highest in 2041, as well as large overall travel time savings. RRT 2 combines frequent RRT service on King George Blvd with BRT on Fraser Highway and 104th Avenue. RRT 3 would have relatively few additional boardings due to its small extent, but would provide travel time savings along King George Boulevard. Consequently, all four RRT alternatives rated as better than BAU, with scores of “5” for RRT 1 and RRT 1A, and “4” for RRT 2 and RRT 3.

Exhibit 3.3 - Transit Boardings in Study Area, by Mode





All street-level alternatives (BRT and LRT) would provide similarly high levels of boardings and travel time savings, with the exception of LRT 4. LRT alternatives would provide slightly greater travel time savings than BRT alternatives of the same extent due to the faster acceleration and marginally faster travel times between stations. The only exception was between White Rock and Surrey Centre, where BRT provides the greatest travel time savings by offering a continuous, transfer-free trip; this applied to BRT 1, LRT 5A, and LRT 5B. The BRT and LRT alternatives all performed better than BAU and were assessed a score of “4,” with the exception of LRT 4 which offers relatively little travel time savings and was assessed a rating of “3” (similar to BAU).

Best Bus had similar numbers of transit boardings and travel time savings as the BRT alternatives, and so was assessed as better than BAU and rated a score of “4”.

3.1.2 Non-Transit User Effects

Approach

Non-transit user effects assesses auto travel time changes, traffic impacts, and changes in operating costs and collision costs resulting from changes in car use. These are all derived from the demand model forecasts, which are influenced by the assumed road network capacity for each alternative (described in Appendix 2B[5]), and the estimated mode shift from auto usage to transit.

Auto travel time savings are based on the total travel times across the regional road network in the BAU scenario versus the total travel time for each of the alternatives. The estimated travel times per person trip are a function of vehicle trip time savings and the average auto occupancy of 1.2 embedded in the model. The expansion factor from AM peak hour to annual time savings is 5100 (this was derived from the region-wide expansion factor). The average saving in minutes per regional auto trip was also calculated.

The estimated auto trips and auto travel time savings are summarized in **Exhibit 3.4**. The time savings reflect both decreased automobile use due to a mode shift towards transit, as well as localised increases in congestion, or diversion to alternate routes, where lane capacity was reduced to fit rapid transit. (This typically happened along 104th Avenue and on King George Boulevard in Surrey Metro Centre for the BRT and LRT alternatives).

When comparing 2021 and 2041 results in the exhibit, it should be noted that the reductions in vehicle kilometres travelled (VKT) are related to the introduction of transit service as well as an overall increase in auto travel. BRT service is more frequent in 2041 than 2021, and the VKT reduction increases approximately 30% to 40%. LRT service frequency improves more in a relative sense (from 5 minutes to 3 minutes) and so the VKT reductions for LRT tend to increase more, approximately doubling for LRT 1 and LRT 4. LRT 2, LRT 3, LRT 5A and LRT 5B combine LRT and BRT and so their VKT reductions follow a trend in between. RRT headways do not change from 2021 to 2041, so the VKT reductions are similar in both years for RRT 1 and RRT 3. RRT 1A and RRT 2 combine RRT with BRT, and so increase from 2021 to 2041.

A sampling of traffic volumes and speeds indicates the local effect of capacity changes to the streets for each alternative, as shown by **Exhibit 3.5**.

[5] The alternatives have the same road capacity as BAU, except where design assumptions reduced the number of lanes. Depending on the alternative, this included 104 Avenue east of City Parkway, King George Blvd from 102 to 96 Ave, and Fraser Highway between 200 Street and 203 Street.

Exhibit 3.4 - Auto Trips and Travel Time Savings

Alternatives	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
2021														
Regional Total Auto Trips (Person)	567,900	567,100	567,200	567,200	567,300	567,200	567,200	567,600	567,300	567,300	566,900	566,600	566,900	567,400
Regional Total Auto Trips (Vehicle)	385,700	385,200	385,300	385,300	385,400	385,300	385,300	385,600	385,300	385,300	385,100	384,900	385,100	385,400
Study Area Total Auto Trips (Person)	63,900	63,400	63,500	63,500	63,600	63,500	63,500	63,700	63,600	63,500	63,600	63,300	63,400	63,700
Regional Existing users auto travel time savings (person-min) (AM Peak)	-	(7,000)	(8,100)	(8,000)	(3,700)	(7,100)	(9,000)	(8,200)	(9,100)	(4,600)	14,200	8,100	(3,900)	4,300
Annual TTS - Hours	**-**	**(590,000)**	**(690,000)**	**(680,000)**	**(310,000)**	**(600,000)**	**(770,000)**	**(690,000)**	**(780,000)**	**(390,000)**	**1,210,000**	**680,000**	**(330,000)**	**370,000**
Average TTS (minutes) per regional auto trip (road user)	-	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	0.04	0.02	(0.01)	0.01
Average trip distance (km), AM Peak	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1
Regional Total Veh-Km (AM Peak)	4,677,500	4,669,800	4,669,700	4,670,800	4,672,900	4,670,800	4,670,000	4,675,600	4,670,500	4,671,800	4,667,100	4,664,000	4,667,200	4,672,600
Regional Net Reduction, 2021 AM Peak	-	7,700	7,800	6,700	4,600	6,700	7,500	2,000	7,000	5,700	10,400	13,600	10,300	5,000
Regional 2021 Annual Reduction, VKT (Millions)	**-**	**39.2**	**39.9**	**34.1**	**23.5**	**34.1**	**38.5**	**10.0**	**35.6**	**29.0**	**52.9**	**69.2**	**52.6**	**25.3**
2041														
Regional Total Auto Trips (Person)	645,400	644,500	644,200	644,300	644,300	644,200	644,300	644,900	644,300	644,100	644,300	643,500	643,900	644,800
Regional Total Auto Trips (Vehicle)	447,100	446,500	446,300	446,400	446,400	446,400	446,500	446,800	446,400	446,300	446,400	445,900	446,100	446,700
Study Area Total Auto Trips (Person)	71,500	70,900	70,900	70,900	70,900	70,900	70,900	71,200	70,900	70,800	71,100	70,700	70,800	71,300
Regional Existing Users Auto Travel Time Savings (person-min)	-	(7,100)	2,700	(1,000)	(3,200)	(2,000)	(1,000)	(10,300)	3,200	1,100	32,500	26,000	10,500	8,200
Annual TTS - Hours	**-**	**(600,000)**	**230,000**	**(90,000)**	**(270,000)**	**(170,000)**	**(80,000)**	**(880,000)**	**270,000**	**90,000**	**2,760,000**	**2,210,000**	**900,000**	**700,000**
Average TTS (minutes) per regional auto trip (road user)	-	(0.02)	0.01	(0.00)	(0.01)	(0.00)	(0.00)	(0.02)	0.01	0.00	0.07	0.06	0.02	0.02
Average trip distance (km), AM Peak	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4
Regional Total Veh-Km (AM Peak)	5,545,300	5,537,800	5,534,400	5,536,400	5,534,100	5,534,700	5,536,100	5,541,000	5,535,200	5,533,200	5,536,200	5,528,500	5,533,500	5,540,300
Regional Net Reduction, 2041 AM Peak	-	7,500	10,900	8,900	11,200	10,600	9,100	4,300	10,100	12,100	9,100	16,800	11,800	5,000
Regional 2041 Annual Reduction, VKT (Millions)	**-**	**38.1**	**55.4**	**45.3**	**56.9**	**54.2**	**46.6**	**21.7**	**51.5**	**61.5**	**46.5**	**85.6**	**60.3**	**25.6**

Exhibit 3.5– Traffic Volume Diversions and Average Speeds

2021 Traffic Projections		BAU		Best Bus		BRT 1		BRT 2		LRT 1		LRT 2		LRT 3		LRT 4		LRT 5A		LRT 5B		RRT 1		RRT 1A		RRT 2		RRT 3	
		Auto Vol	Speed	Auto Vol	Speed	Auto Vol	Speed	Auto Vol	Speed	Auto Vol	Speed	Auto Vol	Speed	Auto Vol	Speed	Auto Vol	Speed	Auto Vol	Speed	Auto Vol	Speed	Auto Vol	Speed	Auto Vol	Speed	Auto Vol	Speed	Auto Vol	Speed
104 Ave From 140 St to 143 St	EB	840	60	810	60	480	60	480	60	460	60	460	60	460	60	440	60	480	60	460	60	840	60	470	60	480	60	840	60
	WB	1,250	40	1,210	40	680	30	680	30	670	30	660	30	660	30	660	30	680	30	670	30	1,230	40	670	30	680	30	1,240	40
KGB From Fraser HWY to 96 Ave	SB	1,500	60	1,300	50	1,230	50	1,220	50	1,220	50	1,220	50	1,220	50	1,210	50	1,230	50	1,220	50	1,500	60	1,220	50	1,230	50	1,330	50
	NB	1,670	50	1,380	50	1,270	50	1,270	50	1,270	50	1,270	50	1,270	50	1,230	50	1,270	50	1,260	50	1,680	50	1,240	50	1,270	50	1,320	50
KGB From 88 Ave to 84 Ave	SB	1,580	30	1,510	30	1,560	30	1,590	30	1,560	30	1,560	30	1,560	30	1,590	30	1,580	30	1,550	30	1,580	30	1,580	30	1,560	30	1,560	30
	NB	1,450	50	1,350	50	1,420	50	1,420	50	1,420	50	1,420	50	1,430	50	1,430	50	1,430	50	1,420	50	1,440	50	1,420	50	1,410	50	1,420	50
KGB From 64 Ave to 60 Ave	SB	1,810	50	1,760	50	1,810	50	1,810	50	1,810	50	1,810	50	1,810	50	1,810	50	1,810	50	1,810	50	1,810	50	1,810	50	1,810	50	1,800	50
	NB	1,760	60	1,710	50	1,750	60	1,770	60	1,760	60	1,760	60	1,760	60	1,760	60	1,760	60	1,750	60	1,760	60	1,750	60	1,760	60	1,760	60
KGB South of Hwy 10	SB	1,400	70	1,380	70	1,390	70	1,400	70	1,390	70	1,400	70	1,400	70	1,390	70	1,390	70	1,390	70	1,390	70	1,380	70	1,400	70	1,390	70
	NB	1,910	70	1,870	60	1,880	70	1,910	70	1,890	70	1,890	70	1,900	70	1,910	70	1,880	70	1,880	70	1,900	70	1,880	70	1,900	70	1,900	70
152 St From 24 Ave to 20 Ave	SB	660	50	630	50	650	50	650	50	650	50	650	50	660	50	650	50	640	50	650	50	660	50	650	50	660	50	660	50
	NB	960	40	910	40	940	40	960	40	940	40	930	40	960	40	960	40	930	40	930	40	950	40	930	40	960	40	950	40
Fraser HWY From 144 St to 148 St	EB	910	60	720	50	750	50	750	50	750	50	750	50	750	50	920	60	750	50	750	50	900	60	920	60	750	50	910	60
	WB	1,460	60	1,220	50	1,270	50	1,270	50	1,270	50	1,270	50	1,270	50	1,450	60	1,270	50	1,270	50	1,390	60	1,370	60	1,260	50	1,450	60
Fraser HWY From 164 St to 168 St	EB	1,650	40	1,590	40	1,670	40	1,670	40	1,670	40	1,670	40	1,670	40	1,680	40	1,670	40	1,670	40	1,640	40	1,670	40	1,670	40	1,650	40
	WB	1,530	50	1,470	50	1,530	50	1,540	50	1,540	50	1,530	50	1,540	50	1,550	50	1,530	50	1,530	50	1,500	50	1,530	50	1,530	50	1,520	50
Fraser HWY From Harvie Rd to 72 Ave	EB	1,720	70	1,660	70	1,710	70	1,710	70	1,710	70	1,710	70	1,710	70	1,720	70	1,710	70	1,710	70	1,710	70	1,710	70	1,710	70	1,720	70
	WB	1,890	70	1,830	70	1,870	70	1,870	70	1,870	70	1,870	70	1,870	70	1,900	70	1,870	70	1,870	70	1,840	70	1,840	70	1,870	70	1,890	70
Fraser HWY From 192 St/64 Ave to 196 St	EB	1,290	50	1,200	40	1,270	50	1,270	50	1,270	50	1,270	50	1,270	50	1,290	50	1,270	50	1,270	50	1,270	50	1,270	50	1,270	50	1,290	50
	WB	980	60	920	60	970	60	970	60	970	60	970	60	970	60	980	60	970	60	970	60	960	60	970	60	970	60	970	60

2041 Traffic Projections		BAU		Best Bus		BRT 1		BRT 2		LRT 1		LRT 2		LRT 3		LRT 4		LRT 5A		LRT 5B		RRT 1		RRT 1A		RRT 2		RRT 3	
		Auto Vol	Speed	Auto Vol	Speed	Auto Vol	Speed	Auto Vol	Speed	Auto Vol	Speed	Auto Vol	Speed	Auto Vol	Speed	Auto Vol	Speed	Auto Vol	Speed	Auto Vol	Speed	Auto Vol	Speed	Auto Vol	Speed	Auto Vol	Speed	Auto Vol	Speed
104 Ave From 140 St to 143 St	EB	1,000	60	940	60	550	60	550	60	510	60	510	60	510	60	500	60	540	60	510	60	1,000	60	540	60	550	60	1,000	60
	WB	1,310	35	1,210	35	680	32	680	32	640	32	640	32	640	32	640	32	670	33	640	32	1,280	36	670	33	670	33	1,300	35
KGB From Fraser HWY to 96 Ave	SB	1,620	54	1,420	43	1,350	44	1,330	44	1,350	44	1,350	44	1,340	44	1,330	45	1,350	44	1,350	44	1,640	53	1,350	44	1,340	44	1,380	42
	NB	1,810	49	1,510	39	1,420	40	1,420	40	1,410	40	1,410	40	1,410	40	1,390	41	1,410	40	1,420	40	1,810	49	1,410	40	1,420	40	1,440	39
KGB From 88 Ave to 84 Ave	SB	1,370	39	1,270	37	1,330	40	1,350	40	1,340	40	1,340	40	1,340	40	1,340	40	1,340	40	1,340	40	1,370	39	1,350	40	1,330	40	1,350	39
	NB	1,570	44	1,470	43	1,560	45	1,550	45	1,550	45	1,550	45	1,560	45	1,560	45	1,550	45	1,550	45	1,570	44	1,550	45	1,550	45	1,550	45
KGB From 64 Ave to 60 Ave	SB	1,960	49	1,880	47	1,960	49	1,960	49	1,960	49	1,960	49	1,960	49	1,970	49	1,960	49	1,970	48	1,960	49	1,960	49	1,950	49	1,950	49
	NB	2,060	45	1,960	44	2,010	47	2,050	45	2,040	46	2,020	46	2,040	46	2,040	46	2,020	46	2,020	47	2,040	46	2,000	47	2,040	46	2,050	45
KGB South of Hwy 10	SB	1,690	67	1,650	66	1,670	66	1,690	67	1,680	67	1,680	67	1,690	67	1,690	67	1,680	66	1,680	66	1,680	67	1,670	66	1,690	67	1,670	67
	NB	2,340	60	2,250	60	2,260	60	2,330	60	2,290	60	2,290	60	2,340	60	2,340	60	2,260	60	2,260	60	2,330	61	2,260	60	2,330	60	2,330	60
152 St From 24 Ave to 20 Ave	SB	750	47	690	47	700	47	760	47	720	47	720	47	760	47	750	47	700	47	700	47	760	47	700	47	760	47	760	47
	NB	1,050	41	980	39	980	40	1,050	41	1,010	40	1,010	40	1,050	41	1,050	41	980	40	980	40	1,050	41	980	40	1,050	41	1,050	41
Fraser HWY From 144 St to 148 St	EB	1,040	53	890	46	910	47	920	47	910	47	920	47	910	47	1,070	52	920	47	910	47	1,030	53	1,060	52	920	47	1,040	53
	WB	1,760	59	1,580	49	1,600	49	1,600	49	1,600	49	1,600	49	1,600	49	1,760	59	1,590	49	1,600	49	1,700	59	1,700	59	1,590	49	1,750	59
Fraser HWY From 164 St to 168 St	EB	1,850	36	1,760	35	1,860	35	1,860	35	1,860	35	1,860	35	1,860	35	1,870	35	1,860	35	1,860	35	1,840	36	1,860	35	1,860	35	1,850	36
	WB	1,720	41	1,630	40	1,690	41	1,690	41	1,690	41	1,690	41	1,690	41	1,710	41	1,690	42	1,690	41	1,690	42	1,680	42	1,690	41	1,710	41
Fraser HWY From Harvie Rd to 72 Ave	EB	2,150	63	2,060	63	2,120	63	2,130	63	2,130	63	2,130	63	2,130	63	2,140	63	2,120	63	2,120	63	2,130	63	2,120	63	2,130	63	2,140	63
	WB	2,160	63	2,070	63	2,150	63	2,150	63	2,150	63	2,150	63	2,150	63	2,160	63	2,150	63	2,140	63	2,140	63	2,140	63	2,140	63	2,160	63
Fraser HWY From 192 St/64 Ave to 196 St	EB	1,320	44	1,210	41	1,300	44	1,300	44	1,300	44	1,300	44	1,300	44	1,320	44	1,300	44	1,300	44	1,300	44	1,300	44	1,300	44	1,310	44
	WB	1,230	55	1,160	53	1,210	56	1,210	55	1,210	55	1,210	55	1,210	56	1,220	55	1,210	55	1,210	55	1,200	56	1,200	56	1,210	56	1,220	55

The net reductions in VKT estimated by the model were also expanded to annual estimates of auto usage reductions. Due to the decrease in private vehicle use relative to BAU, each alternative has an incremental savings in auto operating costs and auto collision costs. These were estimated based on an average operating cost of \$0.16 per kilometre and an allocation of \$0.12/km in auto collision cost reductions (see Appendix 2B for further details on the evaluation parameters). These results are summarized in **Exhibit 3.6**.

Results

The overall results of the assessment for this criterion are indicated on **Exhibit 3.7**.

All alternatives would improve non-transit user operating costs and reduce collisions due to a reduction in the number of vehicle kilometres travelled. Street-level alternatives (BRT and LRT) would have some negative impacts on travel times for non-transit users due to a reduction in travel lanes in some locations. Generally the largest traffic impacts would be within the urban core in the northwest of the study area. All street-level alternatives would serve the urban core, and so alternatives with the greatest extent would have only marginally more overall impacts.

Street-level alternatives (BRT and LRT) require some lane reductions, causing minor impacts on non-transit users; however, these alternatives would also cause reductions in car trips, decreasing the incidence of collisions and generating other benefits. Overall, street-level alternatives have both impacts and benefits and are assessed as similar (overall) to BAU and scored “3” on this criterion. The only exception was LRT 4, which would have the same negative traffic delay impacts but with few of the benefits because it would attract few trips from cars to transit. As a result, LRT 4 was assessed as worse (score of “2”).

Fully elevated RRT would have the greatest benefits for non-transit users, because it would improve travel times somewhat for non-transit users and would also reduce auto operating costs and collisions by taking cars off the road. In keeping with these findings, RRT 1, RRT 1A and RRT 3 were assessed as better than BAU (score of “4”). RRT 2 was assessed a score of “3” because most of its extent is BRT technology, with the RRT benefits on King George Blvd offset by traffic delays on Fraser Hwy and 104th Avenue.

Exhibit 3.6 - VKT Reductions, Auto Operating and Collision Cost Savings

Alternatives	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Annual Auto Operating Costs - Savings														
2021 Annual Reduction, VKT - Millions		**39.2**	**39.9**	**34.1**	**23.5**	**34.1**	**38.5**	**10**	**35.6**	**29**	**52.9**	**69.2**	**52.6**	**25.3**
2021 Annual Op. Cost Savings ($0.16/km) - Millions		$ 6.3	$ 6.4	$ 5.5	$ 3.8	$ 5.5	$ 6.2	$ 1.6	$ 5.7	$ 4.6	$ 8.5	$ 11.1	$ 8.4	$ 4.0
2041 Annual Reduction, VKT - Millions		**38.1**	**55.4**	**45.3**	**56.9**	**54.2**	**46.6**	**21.7**	**51.5**	**61.5**	**46.5**	**85.6**	**60.3**	**25.6**
2041 Annual Op. Cost Savings ($0.16/km) - Millions		$ 6.1	$ 8.9	$ 7.2	$ 9.1	$ 8.7	$ 7.5	$ 3.5	$ 8.2	$ 9.8	$ 7.4	$ 13.7	$ 9.6	$ 4.1
Annual Auto Collision Reduction Cost Savings														
2021 Annual Reduction, VKT - Millions		**39.2**	**39.9**	**34.1**	**23.5**	**34.1**	**38.5**	**10**	**35.6**	**29**	**52.9**	**69.2**	**52.6**	**25.3**
2021 Annual Collision Cost Savings ($0.12/km) - Millions		$ 4.7	$ 4.8	$ 4.1	$ 2.8	$ 4.1	$ 4.6	$ 1.2	$ 4.3	$ 3.5	$ 6.3	$ 8.3	$ 6.3	$ 3.0
2041 Annual Reduction, VKT - Millions		**38.1**	**55.4**	**45.3**	**56.9**	**54.2**	**46.6**	**21.7**	**51.5**	**61.5**	**46.5**	**85.6**	**60.3**	**25.6**
2041 Annual Collision Cost Savings ($0.12/km) - Millions		$ 4.6	$ 6.6	$ 5.4	$ 6.8	$ 6.5	$ 5.6	$ 2.6	$ 6.2	$ 7.4	$ 5.6	$ 10.3	$ 7.2	$ 3.1

Exhibit 3.7 - Summary - Non-Transit User Effects

Alternatives	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Auto Travel Time Savings (2020-2049), hours, Millions	0	(17.9)	(3.7)	(9.5)	(8.6)	(10.0)	(10.3)	(24.2)	(4.0)	(2.8)	65.0	48.7	12.9	17.2
VKT Reduction (2020-2049), km, Millions	0	1,160	1,490	1,240	1,340	1,400	1,310	520	1,370	1,490	1,470	2,390	1,720	760
Evaluation Rating (5 Better > 3 BAU > 1 Worse)		3	3	3	3	3	3	2	3	3	4	4	3	4

3.1.3 Transit Network/System Access

Approach

Transit network/system access compares how many people are served by the rapid transit stations in each alternative, and how accessible those stations are to enter. Measures included:

- How many people live or work within an easy walking distance (400 to 800 metres) of the assumed set of stations, based on the projected population and employment for the transportation analysis zones around the stations in 2021 and 2041 (Regional Growth Strategy, June 2011). The estimates were prepared using GIS software and are based on the proportions of each zone falling within 400 m or 800 m of the station.

- The accessibility of the rapid transit stations in each alternative was evaluated qualitatively, based on the types of station and access points provided.

The results of the accessibility analysis are presented in **Exhibit 3.8**.

Results

All alternatives will be universally accessible and provide improved access to the system, ranging from connecting 127,000 people and jobs (in 2041) for RRT 3 to 384,000 people and jobs for BRT 1, LRT 1, LRT 2, LRT 5A, LRT 5B, and RRT 1A. Generally, alternatives with a larger extent would serve more future population and employment by a larger number of stations.

The accessibility of the individual stations was assessed qualitatively, based on the number of at-grade or elevated stations in each alternative. Street-level alternatives (BRT and LRT) would provide somewhat easier access due to at-grade stations, whereas elevated RRT stations may have somewhat longer access times due to platforms above the street that must be accessed by stairs, escalators or elevators. This assessment is also presented in **Exhibit 3.8**.

The combined results of the two measures were used to assess the scores for each alternative, with the number of people served showing greater variation between alternatives and therefore serving as the key differentiator.

The more extensive alternatives with at-grade (or mostly at-grade) stations rated as better than BAU with a score of “5”; these included BRT 1, BRT 2, LRT 1, LRT 2, LRT 3, LRT 5A, LRT 5B, RRT 1A and RRT 2. The other rapid transit alternatives (LRT 4, RRT 1 and RRT 3) would also provide rapid transit service to more people, and rated a score of “4.” By definition, Best Bus would not add any rapid transit stations beyond what is in BAU, and so rated a score of “3” (same as BAU).

Exhibit 3.8 - Transit Network/System Accessibility

Alternatives	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
People Served by Additional Rapid Transit Stations													
400 M Buffer													
Pop 2021	-	58,000	46,000	58,000	58,000	46,000	29,000	46,000	46,000	21,000	46,000	46,000	16,000
Emp 2021	-	39,000	33,000	39,000	39,000	33,000	22,000	33,000	33,000	14,000	33,000	33,000	15,000
Pop 2041	-	84,000	69,000	84,000	84,000	69,000	46,000	69,000	69,000	29,000	69,000	69,000	28,000
Emp 2041	-	51,000	44,000	51,000	51,000	44,000	30,000	44,000	44,000	18,000	44,000	44,000	19,000
800 M Buffer													
Pop 2021	-	183,000	144,000	183,000	183,000	144,000	86,000	183,000	183,000	74,000	183,000	144,000	52,000
Emp 2021	-	101,000	83,000	101,000	101,000	83,000	53,000	101,000	101,000	43,000	101,000	83,000	35,000
Pop 2041	-	248,000	198,000	248,000	248,000	198,000	125,000	248,000	248,000	99,000	248,000	198,000	80,000
Emp 2041	-	136,000	115,000	136,000	136,000	115,000	74,000	136,000	136,000	57,000	136,000	115,000	47,000
People In 2041		*384,000*	*313,000*	*384,000*	*384,000*	*313,000*	*199,000*	*384,000*	*384,000*	*156,000*	*384,000*	*313,000*	*127,000*
Station Accessibility													
Station Types	**BB**	**BRT 1**	**BRT 2**	**LRT 1**	**LRT 2**	**LRT 3**	**LRT 4**	**LRT 5A**	**LRT 5B**	**RRT 1**	**RRT 1A**	**RRT 2**	**RRT 3**
Elevated													
Existing	4	4	4	4	4	4	4	4	4	4	4	4	4
New										8	8	4	4
At-Grade													
Off-Street		1	1	1	1	1		1	1			1	
Curb-Side		4		4	4			4	4		4		
Transit in Median + 2 GP		7	7	7	7	7	6	7	7		6	7	
Transit in Median + 4 GP		13	11	13	13	11	5	13	13		7	7	
Total New Stations	**0**	**25**	**19**	**25**	**25**	**19**	**11**	**25**	**25**	**8**	**25**	**19**	**4**
Evaluation Rating (5 Better > 3 BAU > 1 Worse)	**3**	**5**	**5**	**5**	**5**	**5**	**4**	**5**	**5**	**4**	**5**	**5**	**4**

3.1.4 Reliability

Approach

Reliability examines whether the travel times are likely to be consistent, measured by looking at the level of separation transit receives from other traffic. The qualitative assessment was based on several quantitative indices:

- The number of signals encountered along the route(s), since these introduce some variability into travel times. This applies only to BRT/LRT, since elevated RRT alignments will span the signalized intersections.
- The amount of route that is grade-separated (elevated);
- The length of surface running that is segregated versus shared lanes; and
- The overall amount of transit service in the three corridors (Fraser Hwy, King George Blvd, and 104 Avenue) that is segregated or separated from traffic.

The results of the assessment are presented in **Exhibit 3.9**.

Results

All of the rapid transit alternatives would be primarily in their own right of way to improve reliability of the transit service. The alternatives with the greatest extent (BRT 1, LRT 1, LRT 2, LRT 5A, LRT 5B, and RRT 1A) would provide the reliability improvements to the most people and the greatest number of journeys. Of these, RRT 1A is also fully elevated along Fraser Highway and therefore rates highest, with a score of “5.” RRT 2 includes a portion of elevated RRT along King George Boulevard, which does not interact with traffic at intersections as do street-level alternatives. As a result, it was considered more reliable than other alternatives of the same extent, and also rates “5”. While RRT 3 is not as extensive, it is fully grade separated and rates “4”.

All but one of the surface rapid transit alternatives rated “4” since they would improve reliability on the northern half of King George Blvd, Fraser Highway, and 104th Avenue (approximately 27 to 30 km of segregated routes). LRT 4 has relatively short extent (11 km) compared to the other street-level alternatives, and was rated a “3”. Best Bus also rated “3” (similar to BAU) since it would operate in mixed traffic with some signal priority, and was more similar to BAU than the rapid transit alternatives.

3.1.5 Capacity and Expandability

Approach

Capacity and expandability examines the planned corridor capacities on Fraser Highway, King George Boulevard and 104 Avenue, and examines how well it meets forecast demand, as well as how easily the system capacity can be increased as demand grows. The results are based on the assumed Phase 2 service plans, and the following approach and assumptions:

- The peak loading points were taken from each of the bus and rapid transit routes along the study corridors (Fraser Highway, King George Blvd, and 104th Ave) for travel in the AM peak. Peak loads include the passengers on local buses and rapid transit. (Detailed load plots are included in Appendix 3A.)

Exhibit 3.9 – Reliability (of Transit Service)

Alternatives	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
No. Of Signals Along Route	67	67	67	55	67	67	55	24	67	67	26	67	55	13
No. of Signals Encountered	**67**	**67**	**67**	**55**	**67**	**67**	**55**	**24**	**67**	**67**	**0**	**41**	**42**	**0**
Extent of Route(s) - km			39.6	26.8	39.6	39.6	26.8	10.8	39.6	39.6	15.8	39.4	27.1	5.6
Density of Encountered Signals (per km)	1.7	1.7	1.7	2.1	1.7	1.7	2.1	2.2	1.7	1.7	0.0	1.0	1.5	0.0
Elevated Route (km)		0	0.8	0.8	0.8	0.8	0.8	0	0.8	0.8	15.8	15.8	6.4	5.6
RRT Elevated											15.8	15.8	5.6	5.6
BRT/LRT Elevated over RBRC			0.8	0.8	0.8	0.8	0.8		0.8	0.8			0.8	
Shared Lanes (km) per direction			**10.0**	**1.1**	**10.0**	**10.0**	**1.1**	**0.0**	**10.0**	**10.0**	**0.0**	**8.9**	**1.1**	**0.0**
BRT in South Surrey (Hwy 10-White Rock)			8.9		8.9	8.9			8.9	8.9		8.9		
BRT/LRT section through Green Timbers with queue jumps and 60 % shared lanes			1.9	1.9	1.9	1.9	1.9		1.9	1.9			1.9	
Segrated At Grade (km)		1.2	28.7	24.8	28.7	28.7	24.8	10.8	28.7	28.7	0.0	14.7	19.6	0.0
% Elevated			2%	3%	2%	2%	3%	0%	2%	2%	100%	40%	24%	100%
% Shared lanes			25%	4%	25%	25%	4%	0%	25%	25%	0%	23%	4%	0%
% Segregated At Grade			73%	93%	73%	73%	93%	100%	73%	73%	0%	37%	72%	0%
Total Distance Separated/Segregated from Traffic	**0.0**	**1.2**	**29.6**	**25.7**	**29.6**	**29.6**	**25.7**	**10.8**	**29.6**	**29.6**	**15.8**	**30.5**	**26.0**	**5.6**
Evaluation Rating		**3**	**4**	**4**	**4**	**4**	**4**	**3**	**4**	**4**	**4**	**5**	**5**	**4**

- The planned capacity is the number of vehicles per hour assumed in the service plan, multiplied by the unit capacity of each vehicle (refer also to Appendix 2B):
  - On the higher-demand corridors in the study area, buses were assumed to be articulated, with peak capacity of ~100 at the peak point. This applied to local routes and to Best Bus B-Line services.
  - BRT was assumed to be articulated buses with average capacity of 100 passengers (seated plus standing).
  - LRT was assumed to be coupled articulated vehicles with a total capacity of 240.
  - RRT was assumed to operate as 5-car sets, with total capacity of 650 passengers (130 per car).
- The combined corridor capacity is the sum of planned rapid transit and local service capacities in the same corridor.
- Theoretical capacity estimates the limit of how much service could be introduced by increasing frequency or lengthening vehicles (and stations), building on the assumed conceptual designs and operating assumptions.

As input to the assessment, **Exhibits 3.10** to **3.12** illustrate the peak passenger volumes from the demand forecasts, and compares these with the planned capacity for each corridor. Key observations in each corridor are included on the exhibits. Of most significance, it was found that BAU service levels would be insufficient to meet demand at the peak load points on Fraser Highway and King George Boulevard. (This finding fed back into the estimates of travel time savings under Transit User Benefits.)

Exhibit 3.13 summarizes the assessment for this criterion.

Results

All of the rapid transit alternatives (BRT, LRT and RRT) would provide increased transit capacity and help to ease passenger crowding relative to BAU, on one or more corridors. BAU was projected to be deficient in capacity on Fraser Highway and King George Boulevard.

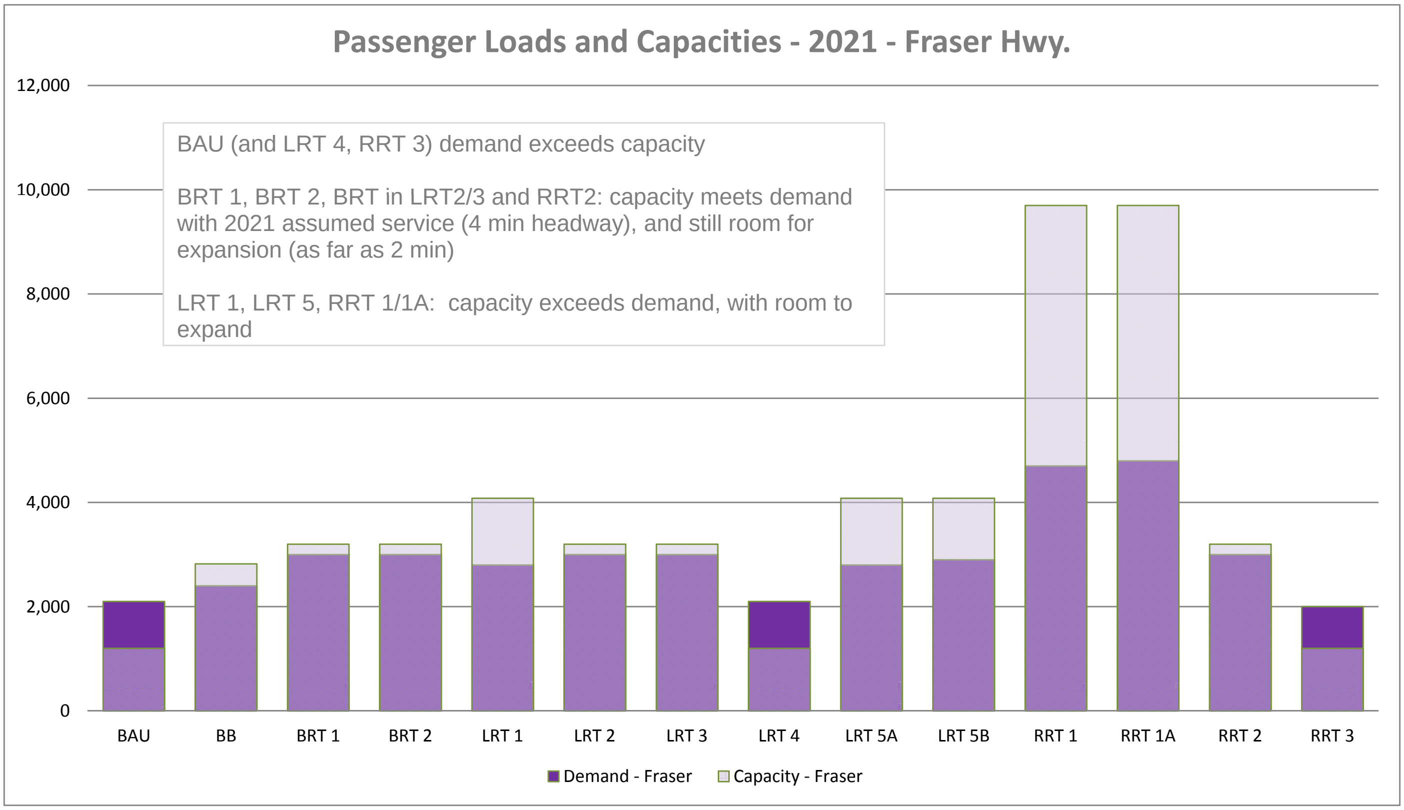
On Fraser Highway, BRT in combination with local bus would meet peak corridor demand, but with limited ability to increase capacity beyond 2041. (To achieve headways lower than 2 minutes, transit priority and thus speeds for BRT would be compromised, or the system design would have to be expanded using even larger vehicles[6] or widened to provide passing lanes.) In addition, at the peak load point, not all passengers would be able to board BRT vehicles and would have to ride the frequent local bus instead. (Most of the BRT route would operate within capacity – the peak loads were forecast to occur between the 3rd and 2nd last stops in the peak direction).

On King George Boulevard, BRT combined with local bus would meet peak demand, and there would be modest additional capacity remaining in 2041 to address additional demand.

LRT and RRT would provide sufficient capacity and room to expand (beyond 2041) on both Fraser Highway and King George Boulevard. RRT would provide capacity far in excess of peak demand on King George Boulevard.

[6] The use of high capacity bi-articulated buses for BRT has not been evaluated in this phase of the study. Further analysis will take place in a later study phase to identify the specific vehicle requirements for the preferred alternative.

Exhibit 3.10 - Peak Passenger Loads and Corridor Capacity - Fraser Highway



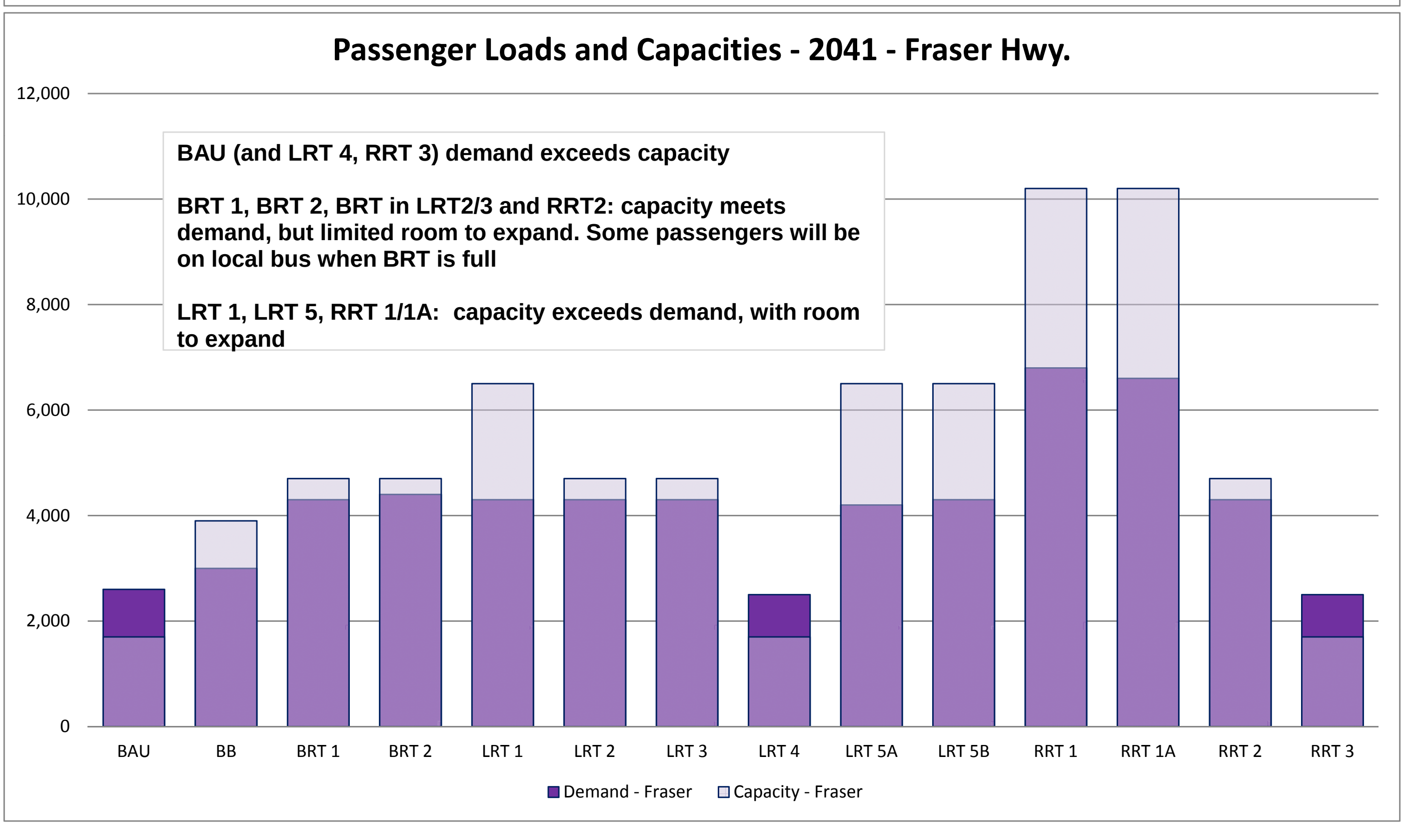
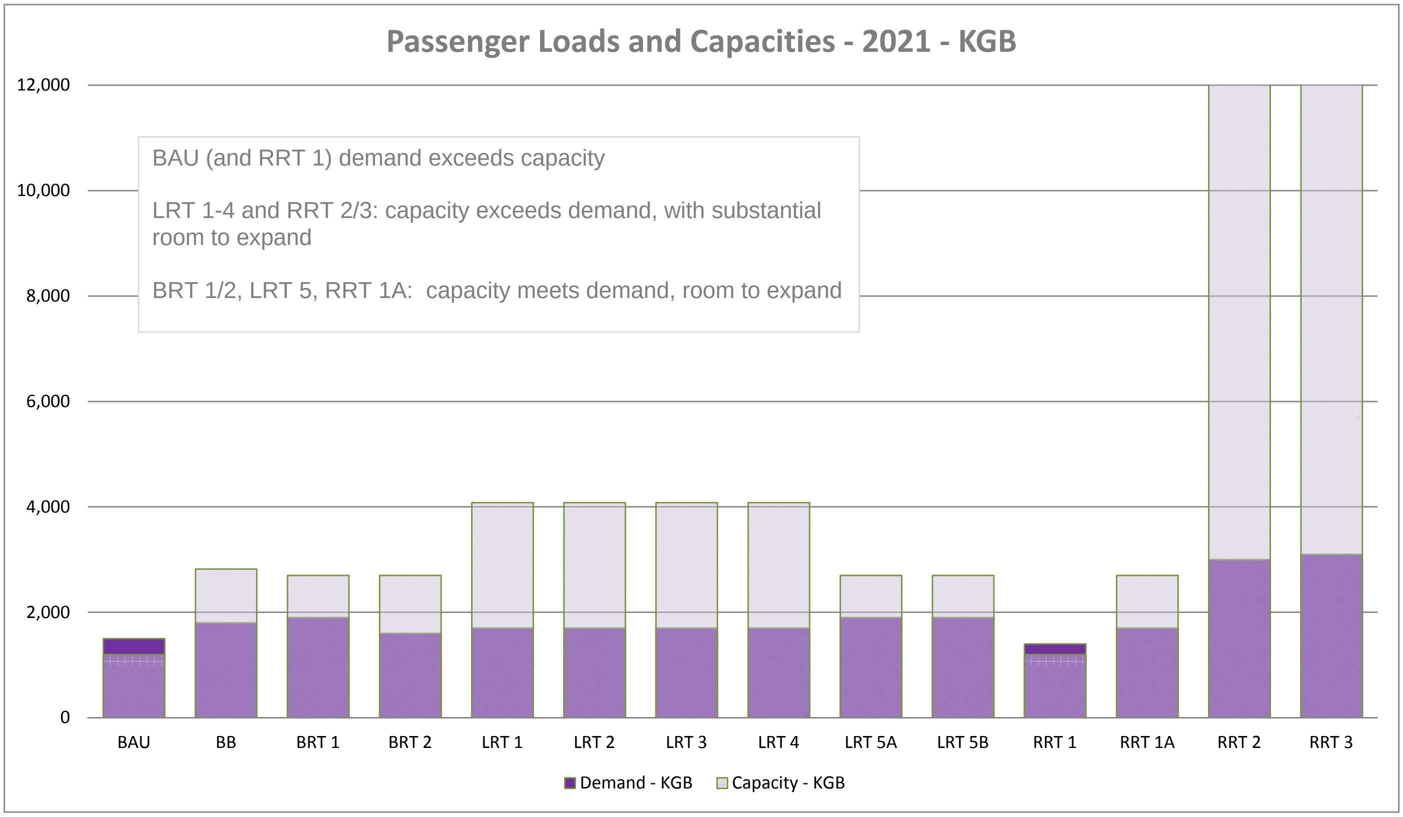


Exhibit 3.11 - Peak Passenger Loads -and Corridor Capacity - King George Blvd.



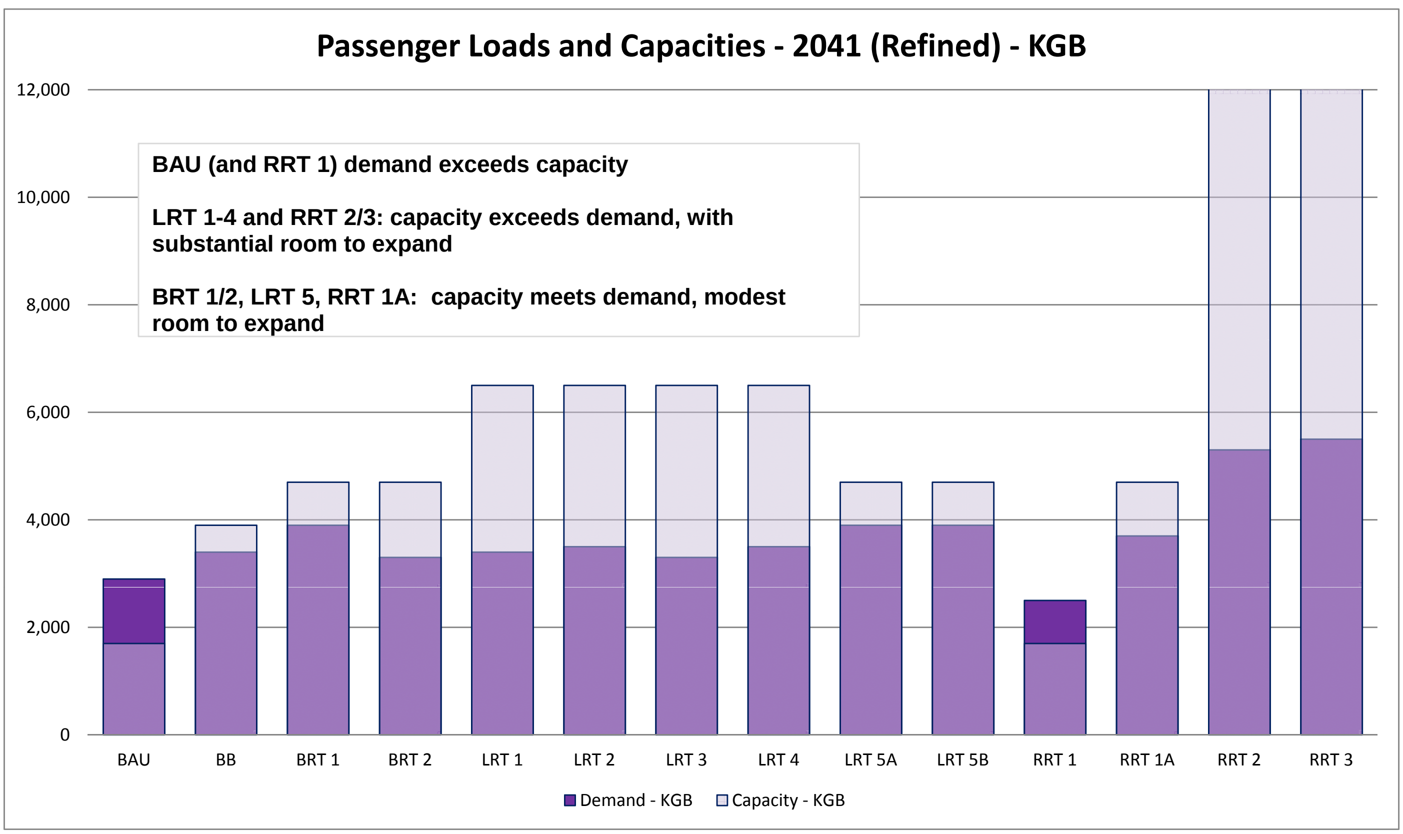
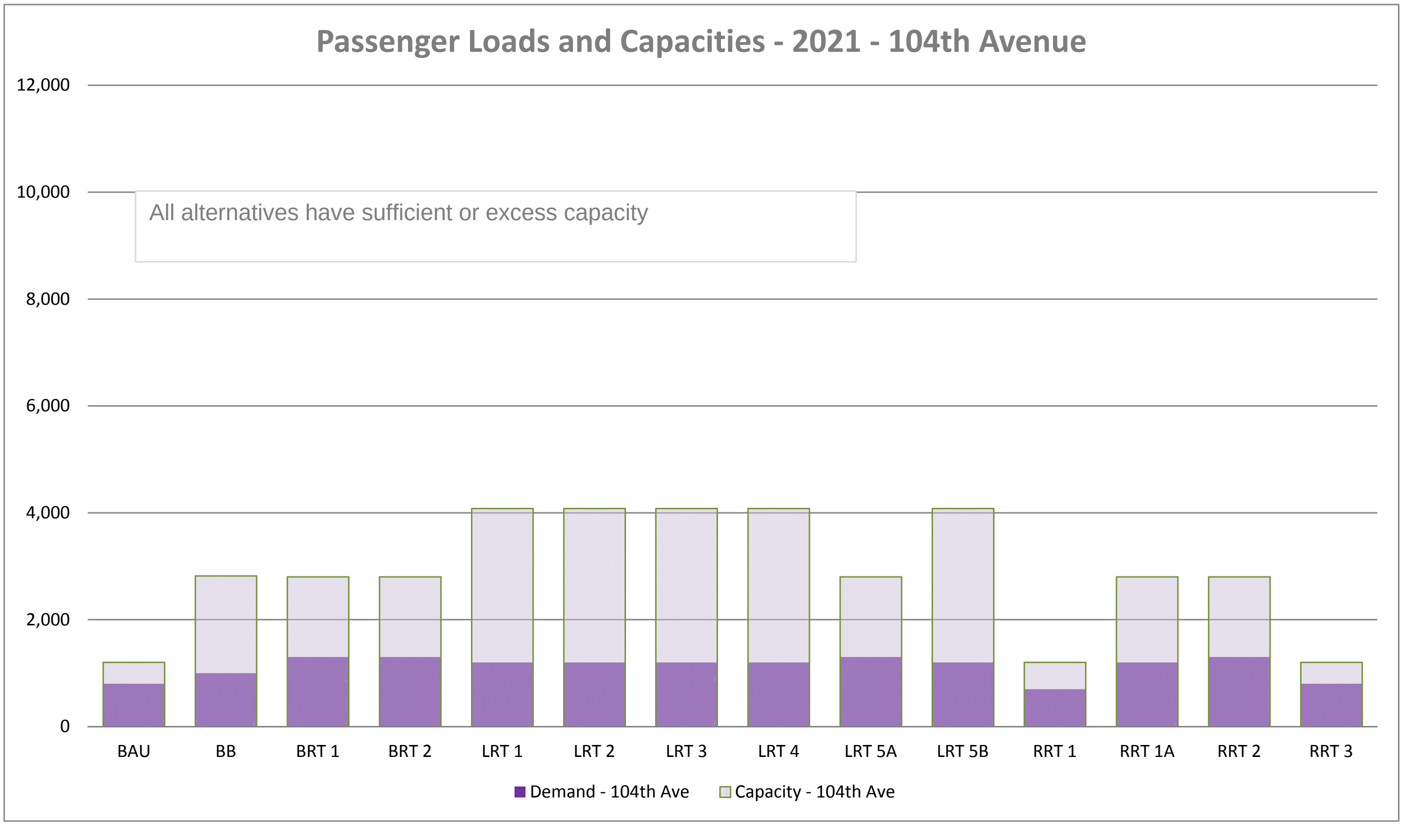


Exhibit 3.12 - Peak Passenger Loads and Corridor Capacity - 104th Avenue



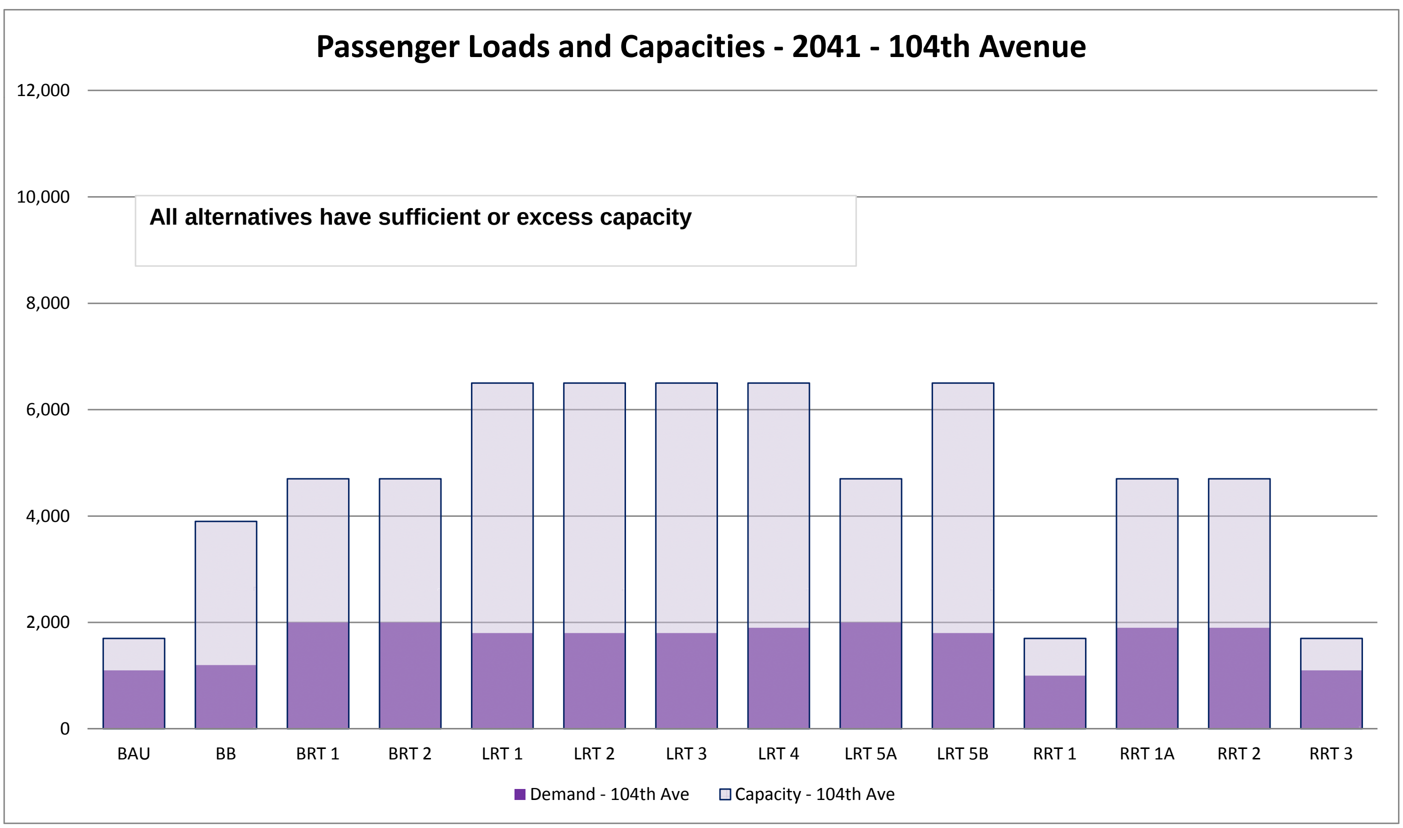


Exhibit 3.13 - Capacity and Expandability Summary

Alternatives	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Planned Total Capacity (Rapid Transit + Bus, Based on Assumed Headways) *(People Per Hour, Per direction)*														
2021 - Assumed Transit Capacity														
King George Boulevard	1,200	2,820	2,700	2,700	4,080	4,080	4,080	4,080	2,700	2,700	1,200	2,700	18,200	18,200
104th Avenue	1,200	2,820	2,800	2,800	4,080	4,080	4,080	4,080	2,800	4,080	1,200	2,800	2,800	1,200
Fraser Highway	1,200	2,820	3,200	3,200	4,080	3,200	3,200	1,200	4,080	4,080	9,700	9,700	3,200	1,200
2041 - Assumed Transit Capacity														
King George Boulevard	1,700	3,900	4,700	4,700	6,500	6,500	6,500	6,500	4,700	4,700	1,700	4,700	18,700	18,700
104th Avenue	1,700	3,900	4,700	4,700	6,500	6,500	6,500	6,500	4,700	6,500	1,700	4,700	4,700	1,700
Fraser Highway	1,700	3,900	4,700	4,700	6,500	4,700	4,700	1,700	6,500	6,500	10,200	10,200	4,700	1,700
Peak Load Point, Passengers														
2021 - Total Peak Load														
King George Boulevard	1,500	1,800	1,900	1,600	1,700	1,700	1,700	1,700	1,900	1,900	1,400	1,700	3,000	3,100
104th Avenue	800	1,000	1,300	1,300	1,200	1,200	1,200	1,200	1,300	1,200	700	1,200	1,300	800
Fraser Highway	2,100	2,400	3,000	3,000	2,800	3,000	3,000	2,100	2,800	2,900	4,700	4,800	3,000	2,000
2041 - Total Peak Load														
King George Boulevard	2,900	3,400	3,900	3,300	3,400	3,500	3,300	3,500	3,900	3,900	2,500	3,700	5,300	5,500
104th Avenue	1,100	1,200	2,000	2,000	1,800	1,800	1,800	1,900	2,000	1,800	1,000	1,900	1,900	1,100
Fraser Highway	2,600	3,000	4,300	4,400	4,300	4,300	4,300	2,500	4,200	4,300	6,800	6,600	4,300	2,500
Peak Load Point, V/C, in Corridor (Combined Bus + Rapid Transit)							**Key:**	Over Capacity			Lightly Used			
2021														
King George Boulevard	1.3	0.6	0.7	0.6	0.4	0.4	0.4	0.4	0.7	0.7	1.2	0.6	**0.2**	**0.2**
104th Avenue	0.7	0.4	0.5	0.5	0.3	0.3	0.3	0.3	0.5	0.3	0.6	0.4	0.5	0.7
Fraser Highway	1.8	0.9	0.9	0.9	0.7	0.9	0.9	1.8	0.7	0.7	0.5	0.5	0.9	1.7
2041														
King George Boulevard	1.7	0.9	0.8	0.7	0.5	0.5	0.5	0.5	0.8	0.8	1.5	0.8	0.3	0.3
104th Avenue	0.7	0.3	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.3	0.6	0.4	0.4	0.6
Fraser Highway	1.5	0.8	0.9	0.9	0.7	0.9	0.9	1.5	0.6	0.7	0.7	0.6	0.9	1.5
Theoretical Total Capacity (Rapid Transit + Bus) *(People Per Hour, Per direction)*														
King George Boulevard	2,000	5,000	5,000	5,000	16,400	16,400	16,400	16,400	5,000	5,000	2,000	5,000	27,400	27,400
104th Avenue	2,000	5,000	5,000	5,000	16,400	16,400	16,400	16,400	5,000	16,400	2,000	5,000	5,000	2,000
Fraser Highway	2,000	5,000	5,000	5,000	16,400	5,000	5,000	2,000	16,400	16,400	27,400	27,400	5,000	2,000
Evaluation Rating		4	4	4	5	4	4	3	5	5	3	5	4	3

On 104th Avenue, BAU would provide sufficient capacity to meet future peak demand (2041). BRT and LRT would provide additional capacity on that corridor, with. LRT providing capacity far in excess of peak demand.

The alternatives are rated according to how well their capacity would meet demand, and whether they have additional room to expand. Neither LRT 4 nor RRT 3 would address the capacity shortfall on Fraser Highway, and therefore rated scores of “3” for not meeting demand. Likewise, RRT 1 would not address the capacity needs on King George Boulevard, and also rated a “3”.

LRT 1, LRT 5A, LRT 5B and RRT 1A would all meet peak demand on Fraser Highway, King George Boulevard and 104th Avenue, and provide additional capacity and/or expandability beyond 2041. These alternatives were rated “5” because they addressed this criterion better than all other alternatives.

BRT 1, BRT 2, LRT 2, LRT 3 and RRT 2 would all meet future demand, but with more limited expandability because they assume BRT on the highest demand corridor of Fraser Highway. For this reason, they rated a score of “4”. Best Bus would also provide a modest capacity increase to each of the corridors – and attract less peak point demand – and therefore rated a score of “4” (better than BAU).

3.1.6 Integration with Active Modes

Approach

Integration with active modes assesses the pedestrian and cyclist experience for passengers accessing rapid transit, based on the quality of the walking and cycling networks around proposed stations. The following quantitative indicators were considered to assess the qualitative factors related to cycling and pedestrian integration, based on an aggregation from the station areas (800 metres radius) included within each alternative:

- Street pattern, as suggested by the number of intersections (within 800 metres) near the station locations.
- Streetlight density (indicating how well lit the areas are around stations).
- Sidewalk density (the amount of walking infrastructure).
- Bicycle routes.
- Cross section width of sidewalks and cycling facilities.

Each of these indicators was determined for the station areas along the alternatives, and an average score derived for each alternative based on cycling and pedestrian amenities at the stations served. These scores were normalized with an index score of “1” assigned to the highest value, and each other score being relative. The overall index of station area cycling/pedestrian amenities was taken into consideration along with the number of new rapid transit boardings on each alternative (which provides an indication of the exposure of passengers to these potential access modes to rapid transit). The results of the assessment are indicated on **Exhibit 3.14**.

Exhibit 3.14 – Integration with Active Modes

Alternatives	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Indices (Qualitative Comparison Between Collective Station Areas)														
Pattern (Grid Completeness)			0.91	0.91	0.91	0.91	0.91	0.84	0.91	0.91	1.00	0.91	0.91	0.84
Streetlight Density			0.86	0.89	0.86	0.86	0.89	1.00	0.86	0.86	0.79	0.86	0.89	0.96
Sidewalk Density			0.88	0.92	0.88	0.88	0.92	1.00	0.88	0.88	0.88	0.88	0.92	1.00
Bike Network			0.88	0.88	0.88	0.88	0.88	1.00	0.88	0.88	0.88	0.88	0.88	1.00
Cross Section of Bike Facilities			0.75	0.63	0.75	0.75	0.63	1.00	0.75	0.75	0.00	0.49	0.63	1.00
Composite Index - Quality of Active Modes in Station Areas			0.87	0.88	0.87	0.87	0.88	0.95	0.87	0.87	0.82	0.85	0.88	0.94
Exposure of Passengers to Active Mode Opportunities														
Added RT Boardings, 2041 AM Peak			14,000	11,500	12,300	12,500	11,300	4,600	13,800	13,600	4,900	12,100	12,100	2,400
Quality Index × Transit Use			12,200	10,100	10,700	10,900	9,900	4,400	12,000	11,800	4,000	10,300	10,600	2,300
Active Modes Integration Index	0	0	1.00	0.83	0.88	0.89	0.81	0.36	0.98	0.97	0.33	0.84	0.87	0.19
Evaluation Rating **(5 Better > 3 BAU > 1 Worse)**		**3**	**5**	**5**	**5**	**5**	**5**	**4**	**5**	**5**	**4**	**5**	**5**	**4**

Results

All stations are in locations with existing or planned future active transportation networks, though the quality of those networks varies by station. The strongest concentrations of good cycling connections and walking environment are found within designated urban centres and in the northwest part of the study area (Surrey Metro Centre, Guildford, Newton, and Fleetwood).

All alternatives will increase the number of passengers accessing the transit system on foot or by bicycle. The largest extent alternatives with the greatest number of riders would provide the most benefits to passengers accessing the stations on foot or by bicycle, and the greatest opportunities to increase integration between transit and active modes.

Most of the rapid transit alternatives rated better than BAU, with a score of "5" due to their extent and the quality of cycling and pedestrian and cycling networks in the station areas. LRT 4, RRT 1 and RRT 3 are more limited in scale, with fewer stations and rapid transit boardings, and rated "4," which is still better than BAU. By definition, Best Bus would not provide additional opportunity beyond BAU for active modes integration with rapid transit, since both would connect to the existing SkyTrain stations in the study area, and it rates a score of "3."

3.1.7 Transit Mode Share

Transit mode share measures the shifting of trips from private automobiles to transit, within the study area, and the Greater Vancouver region. The results are taken from the trip tables of the demand forecasting model, and include travel within, to and from the study area. The results of the transit mode share assessment are summarized in **Exhibit 3.15**.

Results

All alternatives would generate increases in transit mode share because of increased overall transit service frequency and speeds; however, the change in mode share resulting from the alternatives was not significant relative to "Business As Usual" which increased from ~8% of peak hour trips today (within, to and from the study area) to 11.5% in 2021 and 14.5% in 2041. This change was caused by increased densities in the study area as growth occurs, and expansion of background transit service (as assumed in the BAU networks). Given the substantial population and employment growth expected in the study area, it is a challenge to maintain mode share given the expected growth in overall trips.

Regionally, the peak hour transit mode shares ranged from 14.4% to 14.5% in 2021, compared to 14.3% for BAU. In 2041, the range for the alternatives was 16.4% to 16.6%, compared to 16.4% for BAU. The regional increases caused by the alternatives are relatively modest. Due to the narrow range in transit mode share results across the alternatives and BAU, all were scored "3" (similar to BAU).

There were some variations in mode share within the study area, with certain alternatives having more noticeable benefits in smaller sub-areas. **Exhibit 3.16** illustrates the variation, with Surrey Metro Centre having the highest transit usage, followed by Newton. The range of mode shares from across the alternatives is formatted to highlight any higher-performing alternatives for each sub-area, and generally the fastest travel times (usually RRT or LRT) provided into each sub-area resulted in the highest mode shares. A reference map of the eleven sub-areas accompanies the mode share chart. In 2041, the overall study area mode share was 14.5% for BAU, and increased to 14.7% to 15.5% for the set of alternatives. Additional details on 2021 and 2041 mode share are included in Appendix 3A.

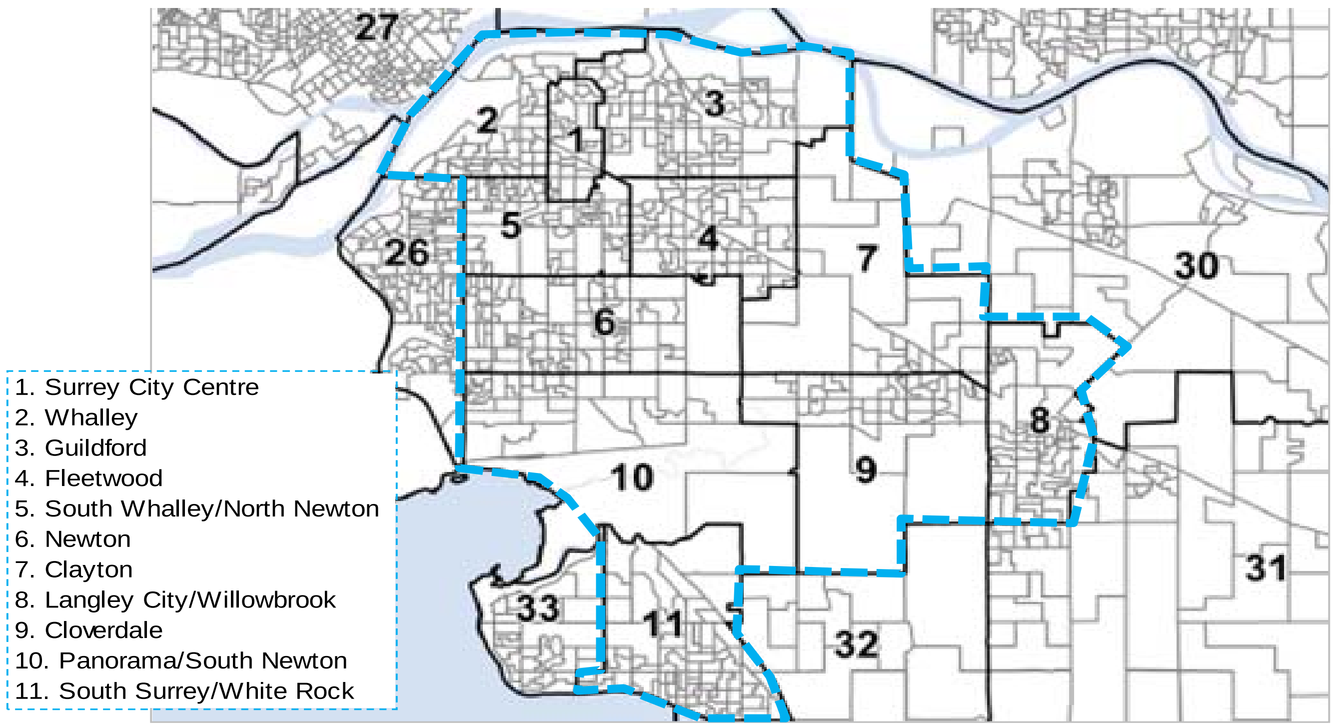
Exhibit 3.15 - Transit Mode Shares in 2021/2041

Alternatives	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
2021 Transit Mode Shares														
2021 Total Trips (Person)	817,510	817,490	817,460	817,460	817,460	817,450	817,460	817,510	817,460	817,450	817,370	817,340	817,410	817,470
2021 Total Transit Trips (Person)	117,200	117,970	117,800	117,720	117,670	117,760	117,770	117,370	117,710	117,680	118,220	118,440	118,080	117,710
2021 Regional Transit Mode Share	**14.34%**	**14.43%**	**14.41%**	**14.40%**	**14.39%**	**14.41%**	**14.41%**	**14.36%**	**14.40%**	**14.40%**	**14.46%**	**14.49%**	**14.45%**	**14.40%**
Increase in Reg. Transit Mode Share		**0.09%**	**0.07%**	**0.06%**	**0.06%**	**0.07%**	**0.07%**	**0.02%**	**0.06%**	**0.06%**	**0.13%**	**0.15%**	**0.11%**	**0.06%**
2021 Transit Mode Share within Study Area (1-11)	9.0%	9.5%	9.3%	9.2%	9.2%	9.3%	9.3%	9.1%	9.2%	9.3%	9.2%	9.4%	9.3%	9.1%
2021 Transit Mode Share Leaving Study Area	16.9%	17.1%	17.3%	17.3%	17.2%	17.3%	17.3%	16.9%	17.3%	17.2%	18.1%	18.3%	17.8%	17.4%
2021 Transit Mode Share Entering Study Area	10.5%	10.7%	10.8%	10.8%	10.7%	10.7%	10.7%	10.6%	10.8%	10.7%	10.9%	11.2%	11.1%	10.8%
2021 Transit Mode Share To/From/Within	11.5%	11.9%	11.9%	11.8%	11.8%	11.8%	11.8%	11.6%	11.8%	11.8%	12.1%	12.3%	12.1%	11.8%
2041 Transit Mode Shares														
2041 Total Trips (Person) - Regional	950,650	950,600	950,530	950,540	950,550	950,530	950,540	950,640	950,510	950,530	950,410	950,380	950,460	950,570
2041 Total Transit Trips (Person) - Regional	155,620	156,390	156,730	156,560	156,640	156,630	156,570	155,940	156,650	156,810	156,840	157,500	156,990	156,180
2041 Regional Transit Mode Share	**16.37%**	**16.45%**	**16.49%**	**16.47%**	**16.48%**	**16.48%**	**16.47%**	**16.40%**	**16.48%**	**16.50%**	**16.50%**	**16.57%**	**16.52%**	**16.43%**
Increase in Reg. Transit Mode Share		**0.08%**	**0.12%**	**0.10%**	**0.11%**	**0.11%**	**0.10%**	**0.03%**	**0.11%**	**0.13%**	**0.13%**	**0.20%**	**0.15%**	**0.06%**
2041 Transit Mode Share within Study Area (1-11)	12.0%	12.5%	12.5%	12.5%	12.5%	12.5%	12.5%	12.2%	12.5%	12.6%	12.3%	12.6%	12.5%	12.1%
2041 Transit Mode Share Leaving Study Area	19.4%	19.6%	20.1%	20.0%	20.0%	20.0%	20.0%	19.5%	20.1%	20.1%	20.7%	21.0%	20.5%	20.0%
2041 Transit Mode Share Entering Study Area	13.8%	14.1%	14.3%	14.2%	14.2%	14.2%	14.1%	14.0%	14.3%	14.2%	14.2%	14.7%	14.6%	14.1%
2041 Transit Mode Share To/From/Within	14.5%	14.9%	15.1%	15.0%	15.0%	15.0%	15.0%	14.7%	15.1%	15.1%	15.2%	15.5%	15.3%	14.8%
Source: Rapid Transit Planning Model, results Sep. to Nov. 2011														
Evaluation Rating (5 Better > 3 BAU > 1 Worse)		**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**

Exhibit 3.16 - Transit Mode Shares for Study Sub-Areas

2041	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Study Area	**14.5%**	**14.9%**	**15.1%**	**15.0%**	**15.0%**	**15.0%**	**15.0%**	**14.7%**	**15.1%**	**15.1%**	**15.2%**	**15.5%**	**15.3%**	**14.8%**
1. Surrey Metro Centre	25.1%	25.9%	26.6%	26.5%	26.5%	26.5%	26.5%	25.8%	26.6%	26.7%	26.0%	26.9%	26.8%	25.7%
2. Other Whalley	11.4%	11.6%	11.8%	11.7%	11.7%	11.7%	11.7%	11.6%	11.8%	11.8%	11.8%	12.0%	11.8%	11.5%
3. Guildford	13.8%	14.4%	14.5%	14.5%	14.6%	14.6%	14.6%	14.4%	14.5%	14.6%	14.0%	14.6%	14.5%	13.8%
4. Fleetwood	11.7%	12.2%	12.4%	12.4%	12.3%	12.4%	12.4%	11.8%	12.3%	12.4%	12.9%	13.2%	12.4%	11.8%
5. North Newton	14.6%	15.0%	14.8%	14.8%	14.8%	14.8%	14.8%	14.7%	14.8%	14.8%	14.7%	14.9%	14.9%	14.7%
6. Newton	16.1%	16.7%	16.5%	16.4%	16.5%	16.5%	16.4%	16.4%	16.5%	16.5%	16.2%	16.5%	17.1%	17.0%
7. Clayton/N. Cloverdale	11.7%	12.1%	12.9%	12.9%	12.9%	12.9%	12.9%	11.6%	13.1%	13.1%	13.6%	13.8%	12.9%	11.7%
8. Langley Centre	12.0%	12.2%	12.7%	12.7%	12.7%	12.7%	12.7%	12.0%	12.6%	12.6%	13.5%	13.7%	12.7%	12.0%
9. Cloverdale	9.8%	10.2%	10.4%	10.4%	10.4%	10.4%	10.4%	9.8%	10.4%	10.4%	10.9%	11.1%	10.4%	9.9%
10. Panorama/S. Newton	12.0%	12.3%	12.2%	12.0%	12.1%	12.1%	12.0%	12.0%	12.2%	12.2%	12.0%	12.2%	12.4%	12.3%
11. South Surrey/WR	11.5%	11.7%	11.8%	11.5%	11.6%	11.6%	11.5%	11.5%	11.7%	11.8%	11.5%	11.7%	11.7%	11.8%

Reference Map of Sub-Areas

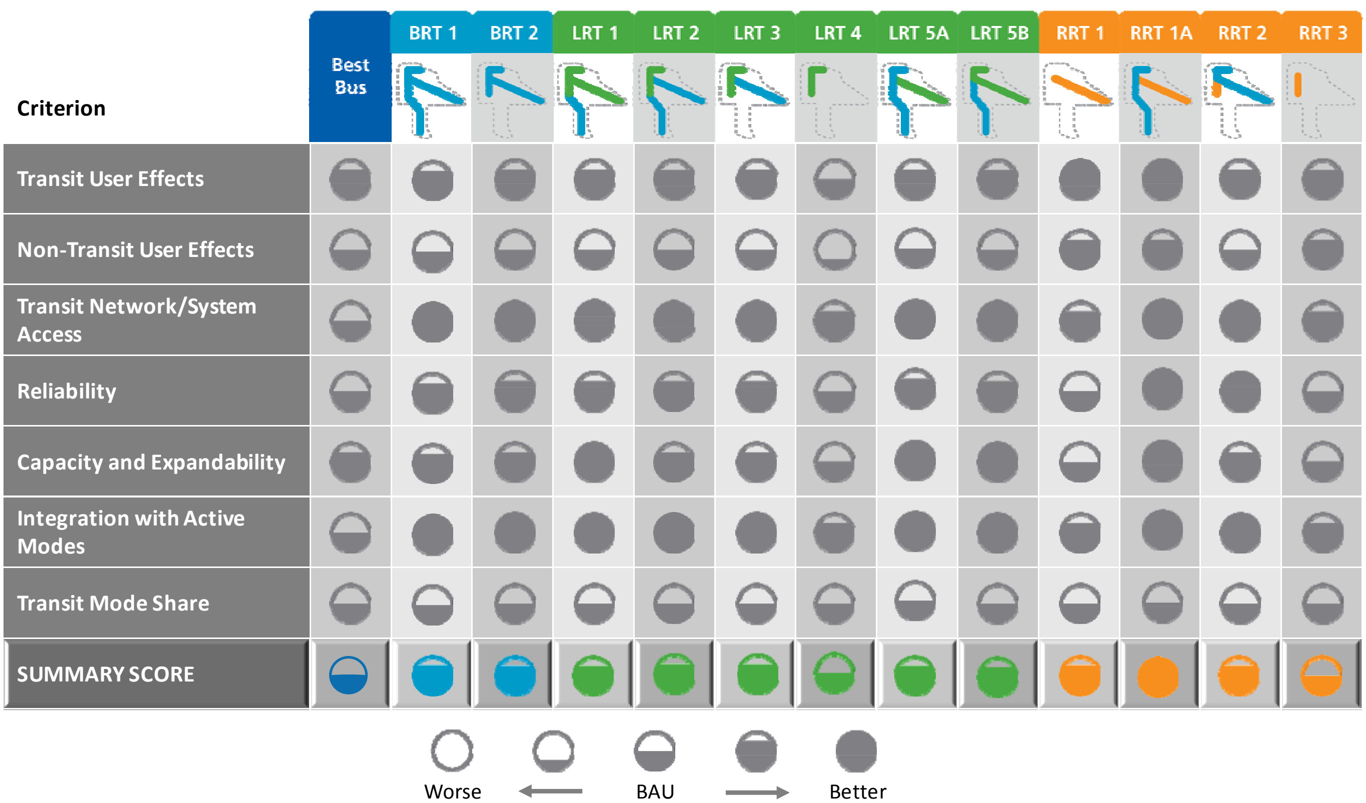


3.1.8 Transportation Account Key Points

The evaluation ratings for each of the criteria, and an overall summary rating for the account are indicated on **Exhibit 3.17**. These were the highlights of the transportation assessment:

- All alternatives would provide transportation benefits. RRT 1A would have the greatest transit user benefits due to fast, transfer-free travel times to Fraser Highway. Best Bus, LRT 4 and RRT 3 do not provide rapid transit on Fraser Highway and generate the least transit user benefits.
- BRT and LRT alternatives require some reductions in travel lanes which increase congestion levels and travel times for non-transit users.
- Alternatives without rapid transit on Fraser Hwy and King George Blvd would not meet long term demand.
- BRT plus local bus would provide sufficient combined capacity on all three corridors, but would be nearing the limits by 2041 on Fraser Highway. This capacity would be sufficient on King George Blvd and 104 Avenue.
- Alternatives with LRT/RRT on Fraser Highway would provide expandability on this busy corridor.
- All alternatives increase transit mode share, but at a regional scale the impact would not be significant.

Exhibit 3.17 – Transportation Account Ratings Summary



3.2 Financial Account

Brief Overview

The financial account evaluates the performance of the alternatives against the following objective:

- *Rapid transit and the supporting transit network are cost-effective in meeting travel demands and shaping land use in multiple corridors.*

The financial account brings together many of the monetary pieces of the evaluation, including benefits and impacts for transit users, other road users and the transit agency. The assessment looked at total capital cost, operating cost and measures of cost-effectiveness over the assessment period, which includes several years of construction followed by thirty years of operations.

The capital and operating costs are dependent on the design and operating assumptions (in Section 2) that were confirmed with the project partners. The cost-effectiveness measures combine the capital and operating costs together with outputs from the transportation and urban development accounts (which are described in Sections 3.1 and 3.4).

The financial criteria include:

3.2.1. Capital Costs

3.2.2. Operating Costs

3.2.3. Cost-Effectiveness

These are described in detail in the following pages. Further detailed financial analyses of capital cost, operating cost, and net present value are contained within **Appendix 3B.**

3.2.1 Capital Costs

Approach

Capital cost includes the cost of construction, property purchases required to build and operate the alternative, utility relocations, transit vehicle fleet, and operations and maintenance centre capital costs.

The costs were developed on the basis of the conceptual designs, and included the following categories of cost components:

Alignment/Guideway

- At-grade dedicated transit lanes for BRT and LRT, and the elevated structures carrying RRT (and a short segment of BRT and LRT) above city streets.
- Street widening and reconstruction including traffic lanes, cycling lanes, boulevards and sidewalks.
- Widening and replacement of bridges over several rivers and creeks, to accommodate BRT or LRT segments.
- Allowance for relocation or protection of underground utilities, for relocation of minor overhead utilities, and for RRT, the raising of hydro towers.

Transit-Specific Systems and Infrastructure

- Transit priority system for BRT and LRT.
- Tracks, power, signals and communications system for LRT.
- Tracks, power, and communications/control system for RRT.

Stations

- At grade platforms with passenger shelter, typically in the centre of the street and in each direction of travel, for BRT and LRT.
- Two-level elevated stations above the street for RRT.
- Allowances for rapid transit station amenities, including passenger information, fare vending, security cameras, etc.

Vehicles

- BRT, LRT and RRT vehicle requirements are based on the assumed operating plans, including the travel times along the planned routes (see Appendix 2B), and the frequency of service.
- The vehicle fleet requirement was based on the end-to-end travel times, and schedule recovery of 3 minutes or 10% (at the end of the route). In addition to the vehicles operating the peak service, 15% spares were assumed for each type of vehicle.
- There is an initial set of rapid transit vehicles required in 2021, and then increments after 10 and 20 years for the additional service required by 2041 (for routes with increases).
- Incremental costs for study area bus transit services are calculated using the same approach. This applied primarily to Best Bus where additional vehicles are needed to increase frequencies on existing routes, and add B-Lines and express routes.

Operations & Maintenance Centre (OMC) – Facility and Property

- The OMC for BRT vehicles does not strictly have to be connected to the BRT alignment, and could be part of a larger transit centre providing maintenance to more than one type of bus in the South of Fraser area. For this reason, incremental costs to provide space for BRT vehicles were included as an average cost allowance of $400,000 per bus, based on recent TransLink experience with transit centre construction. (Also see Appendix 2B.)
- The Best Bus alternative used the same assumptions as BRT for the OMC cost for additional buses.
- The OMC for RRT vehicles must be located somewhere on the SkyTrain network. On the basis of recent analysis done for TransLink through the Expo Line Upgrade Strategy, an average OMC cost of $650,000 per RRT car was assumed.
- Cost estimates for the LRT OMC were based on a typical facility and average footprint for the estimated number of LRT vehicles in the fleet. A larger fleet was assumed for LRT 1, which has 2 LRT routes, and a smaller fleet for LRT 2/3/4/5A/5B. Sampling of over one dozen representative sites (adjacent to or very near the alignment) made up of commercial and industrial properties was used to develop average costs for the OMC facility and property.

Property Costs (for the Alignment and Stations)

- These costs include the dollar value of the property requirements from the evaluation in the Urban Development account (Section 3.4.3). Any parcels identified as full takes (due to impacts on buildings, access or substantial decrease in parking supply) are based on the assessed values in the municipal parcel data, plus a 20% relocation/displacement cost.

Some full takes included land that could likely be assembled and resold after construction, and this resale value – without contingency – was offset against the other ROW costs.

- Partial takes (strips of land from the edge of properties) were compiled from the change in right of way limits (projected with rapid transit versus existing) and an average land value based on a sampling of parcel values along the alignment(s). This value ranged from $420 to $500 per square metre.

Implementation Costs and Design/Cost Contingencies

- On top of the subtotal for construction and vehicle costs, the following implementation costs were applied: Design 5%; and Project and Construction Management 29%.
- Design and Cost Contingencies to allow for unknown and undefined cost items, and possible fluctuations in costs, have an allowance of 31 %.
- For property, a cost contingency of 20% was applied on top of the property plus the relocation costs.

Real Inflation

- In addition to the base capital costs, which are the sum of all items above, real inflation was also determined. Real inflation is the projected increase in vehicle and procurement costs in excess of the Consumer Price Index (the specific values are in Appendix 2A), between the 2010 base year and the assumed dates of procurement/construction.

The main inputs to the capital costs (alignments, stations and transit vehicles) are summarized in **Exhibit 3.18** for each of the alternatives.

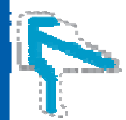
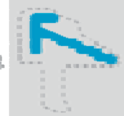
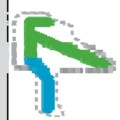
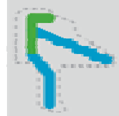
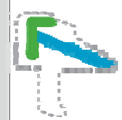
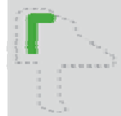
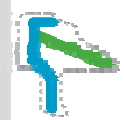
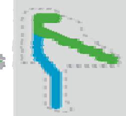
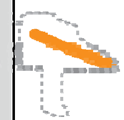
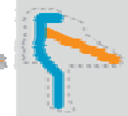
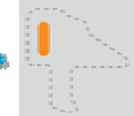
The capital cost estimates are summarized in **Exhibit 3.19**, which breaks down the construction, vehicle/OMC (initial and incremental), property costs, and real inflation, and also indicates the average cost per kilometre of each alternative.

Results

Capital cost reflects the incremental cost over BAU, and ranged from $290 million for the Best Bus alternative to $2.2 billion for RRT 1A. Generally, the most expensive alternatives were those that have the greatest extent and included rail (RRT 1A, LRT 1, LRT 5B, RRT 1, LRT 5A and RRT 2) because they require the most infrastructure and land. Some specifics:

- RRT alternatives would have the highest average cost per kilometre due to the elevated guideway and track construction and more substantial stations. These alternatives rate “worse than BAU”, with scores of “1” for RRT 1, RRT 1A and RRT 2, and “2” for RRT 3 on the five-point scale.
- LRT alternatives are at street-level and would cost less than elevated RRT alternatives, but would be more expensive than the BRT alternatives due to higher costs associated with tracks, overhead power and vehicles. LRT 1, LRT 2, LRT 5A and LRT 5B rated a score of “1” while LRT 3 and LRT 4 rated a score of “2.”
- BRT alternatives would be the least expensive of the rapid transit alternatives due to simpler infrastructure and vehicles. Since this is still higher capital costs than BAU, both alternatives rated “worse than BAU” with a score of “2.”
- Best Bus Alternative costs include vehicles; however, little infrastructure would be required and therefore it had the lowest capital cost. Because its capital cost did not vary significantly from BAU, the Best Bus Alternative was assessed a score of “3”.

Exhibit 3.18 - Major Inputs to Capital Costs (Alignment, Stations and Vehicles)

BAU and Phase 2 Alternatives	BAU	Best Bus	BRT 1 	BRT 2 	LRT 1 	LRT 2 	LRT 3 	LRT 4 	LRT 5A 	LRT 5B 	RRT 1 	RRT 1A 	RRT 2 	RRT 3 
Elements Include:														
SOFATP Bus Services	Yes	Enhanced	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Enh. B-Line/Express		Yes												
Additional Rapid Transit			Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Extent of System (km)														
BRT (segregated lanes)			30.7	26.8	3.9	19.9	16		13.6	9.2		14.7	21.5	
LRT					26.8	10.8	10.8	10.8	17.1	21.5				
RRT extension											15.8	15.8	5.6	5.6
Total Length, New Infrastructure			30.7	26.8	30.7	30.7	26.8	10.8	30.7	30.7	15.8	30.5	27.1	5.6
BRT operating in mixed traffic			8.9		8.9	8.9			8.9	8.9		8.9		
Total extent of new service			**39.6**	**26.8**	**39.6**	**39.6**	**26.8**	**10.8**	**39.6**	**39.6**	**15.8**	**39.4**	**27.1**	**5.6**
Stations (New)														
Number of BRT Stations			25	19	6	14	8		15	10		17	15	
Number of LRT Stations					19	11	11	11	10	15				
Number of new RRT stations											8	8	4	4
New Stations, All Types			**25**	**19**	**25**	**25**	**19**	**11**	**25**	**25**	**8**	**25**	**19**	**4**
Vehicles by 2041														
Additional Buses		131												
BRT			97	66	23	60	37	0	60	51	0	60	46	0
LRT			0	0	45	21	21	21	24	33	0	0	0	0
RRT (see note)			0	0	0	0	0	0	0	0	50	50	45	45
Additional Vehicles, All Types		**131**	**97**	**66**	**68**	**81**	**58**	**21**	**84**	**84**	**50**	**110**	**91**	**45**

Note: RRT trains are 5 vehicles per consist. 50 vehicles = 10 trains, etc.

Exhibit 3.19 - Capital Costs Summary ($ 2010, millions)

Alternative	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Segments (Construction Costs)*													
Surrey Centre - Newton (KGB)		$ 65	$ 65	$ 301	$ 301	$ 301	$ 301	$ 137	$ 137		$ 65	$ 583	$ 583
Newton-White Rock (KGB)		$ 59		$ 59	$ 59			$ 59	$ 59		$ 59		
Surrey Centre - Guildford (104)		$ 99	$ 99	$ 256	$ 256	$ 256	$ 256	$ 99	$ 256		$ 99	$ 99	
King George to Langley (FH)		$ 301	$ 301	$ 746	$ 295	$ 295		$ 746	$ 746	$ 1,356	$ 1,356	$ 301	
Alignment and Stations - Subtotal	$ -	$ 524	$ 465	$ 1,361	$ 911	$ 852	$ 556	$ 1,040	$ 1,197	$ 1,356	$ 1,579	$ 983	$ 583
Bus Costs, + OMC Allocation	*$ 223*												
BRT Costs, + OMC Allocation		*$ 116*	*$ 84*	*$ 30*	*$ 82*	*$ 53*		*$ 63*	*$ 53*		*$ 63*	*$ 63*	
LRT Costs + OMC Estimates				*$ 307*	*$ 146*	*$ 146*	*$ 146*	*$ 169*	*$ 223*				
RRT Costs + OMC Allocation										*$ 261*	*$ 261*	*$ 235*	*$ 235*
Initial Vehicles and Related OMC Costs	$ 223	$ 116	$ 84	$ 337	$ 228	$ 199	$ 146	$ 233	$ 276	$ 261	$ 324	$ 298	$ 235
Capital Cost - Alignment and Initial Vehicle Fleet	$ 223	$ 640	$ 549	$ 1,698	$ 1,139	$ 1,050	$ 702	$ 1,273	$ 1,473	$ 1,616	$ 1,903	$ 1,281	$ 818
Expansion Bus Costs + OMC Allocation	*$ 38*												
Expansion BRT Costs + OMC Allocation		*$ 89*	*$ 55*	*$ 19*	*$ 44*	*$ 25*		*$ 63*	*$ 55*		*$ 63*	*$ 34*	
Expansion LRT Costs + OMC Estimates				*$ 177*	*$ 83*	*$ 83*	*$ 83*	*$ 94*	*$ 136*				
Expansion Vehicles and Related OMC Costs**	$ 38	$ 89	$ 55	$ 196	$ 127	$ 108	$ 83	$ 156	$ 189	$ -	$ 63	$ 34	$ -
Total Cost, Infrastructure and Vehicles	$ 260	$ 729	$ 604	$ 1,894	$ 1,266	$ 1,159	$ 786	$ 1,429	$ 1,662	$ 1,616	$ 1,966	$ 1,315	$ 818
Property Costs for Alignment and Stations (Order of Magnitude)													
Alignment/Station-related ROW Costs		$ 88	$ 87	$ 91	$ 88	$ 87	$ 51	$ 91	$ 91	$ 24	$ 75	$ 82	$ 16
Relocation and Contingency Costs		$ 39	$ 38	$ 40	$ 39	$ 38	$ 22	$ 40	$ 40	$ 11	$ 33	$ 36	$ 7
Gross Price of ROW with relocation and contingency		$ 127	$ 125	$ 131	$ 127	$ 125	$ 74	$ 131	$ 131	$ 35	$ 109	$ 118	$ 23
Resale value of land not needed during operations		$ 34	$ 34	$ 34	$ 34	$ 34	$ 27	$ 34	$ 34	$ 6	$ 34	$ 29	$ 5
Net ROW Costs		$ 93	$ 91	$ 97	$ 93	$ 91	$ 47	$ 97	$ 97	$ 29	$ 75	$ 89	$ 18
Base Cost of Construction, Property and Vehicles	$ 260	822	695	1990	1359	1250	832	1526	1760	1645	2041	1403	835
Real Inflation (Inflation over Consumer Price Index)***	$ 30	$ 81	$ 72	$ 187	$ 146	$ 125	$ 82	$ 153	$ 171	$ 153	$ 176	$ 139	$ 82
Total Capital Cost (Year of Expenditure)	**$ 290**	**$ 900**	**$ 770**	**$ 2,180**	**$ 1,510**	**$ 1,370**	**$ 910**	**$ 1,680**	**$ 1,930**	**$ 1,800**	**$ 2,220**	**$ 1,540**	**$ 920**
Total Extent of New Services		39.6	26.8	39.6	39.6	26.8	10.8	39.6	39.6	15.8	39.4	27.1	5.60
Total Extent of New Infrastructure		30.7	26.8	30.7	30.7	26.8	10.8	30.7	30.7	15.8	30.5	27.1	5.60
Gross Average, Millions per km of infrastructure		**$ 29**	**$ 29**	**$ 71**	**$ 49**	**$ 51**	**$ 84**	**$ 55**	**$ 63**	**$ 114**	**$ 73**	**$ 57**	**$ 164**
Evaluation Rating	3	2	2	1	1	1	2	1	1	1	1	1	2

** Primary rapid transit mode(s) in segment are indicated by shading* BRT LRT BRT/LRT RRT

*** Expansion of fleet assumed 10 and 20 years after opening year, to increase frequency of BRT and/or LRT. RRT frequency is not assumed to change.*

**** Inflation between base year (2010) and assumed year of expenditure (years of construction and procurement)*

3.2.2 Operating Costs

Approach

Operating cost accounts for the total cost of operating and maintaining rapid transit services, as well as the incremental savings or costs that result from changes to the bus network. Operating cost is calculated specifically for 2021 and 2041 service levels and then projected over the 30-year assessment period. The costs are assessed on the basis of the following measures:

- Rapid Transit Vehicle Operations: driver wages and benefits/admin based on vehicle-hours, maintenance and fuel/power based on vehicle-km.
- Rapid Transit Infrastructure Maintenance (per km of extent, by technology).
- Cost factors based on TransLink recent values, and on North American peer review.
- Average operating costs are calculated from three factors:
    - $/ service (revenue) hour - Operator wages and overall administration. Operator wages are lowest for RRT because operations are centralized and partially automated, whereas BRT and LRT require on-board drivers. Administration costs have been assumed to be equal for all technologies and are based on a per service hour calculation, using the average of CMBC and BCRTC costs.
    - $/service (revenue) km - Vehicle fuel/power and vehicle maintenance are most closely associated with the extent of service provided, measured in car-km. Multipliers for fuel/power and maintenance are applied to account for the number of cars per vehicle (1 for the articulated BRT vehicles, 1 for the articulated LRT vehicles, and 5 for the cars in a SkyTrain/RRT consist).
    - $/track or lane-km - infrastructure maintenance of alignment and stations is more closely related to system extent (track km) than service intensity (service km).
- The net difference in conventional bus service, measured in service-hours and service-km, based on changes to connecting BAU bus routes.
- Operating costs factored from peak hour to annual, based on typical variations in headways by time period and weekday/weekend.

Exhibit 3.20 summarizes the average operating costs used in this assessment.

Exhibit 3.20 – Assumed Rapid Transit Operating Costs

Technology	Items	Unit	Average Costs	Multiplier**, for units/train
BRT	Operator* Wages, Admin.	/hr	**$67.42**	1
	Fuel/Power, Maintenance	/service km	**$1.67**	**1**
	Non-vehicle maintenance	/track or lane km	**$19,380**	1
LRT	Operator* Wages, Admin.	/hr	**$67.42**	1
	Fuel/Power, Maintenance	/service km	**$2.00**	1
	Non-vehicle maintenance	/track or lane km	**$102,097**	1
RRT	Operations* Wages, Admin.	/hr	**$35.33**	1
	Fuel/Power, Maintenance	/service km	**$0.75**	**5**
	Non-vehicle maintenance	/track or lane km	**$245,310**	1

** Operations wages include operators for BRT/LRT, roving station attendants (RRT), and control room/communications and other operating personnel.*
*** Multiplier for fuel/power and maintenance only, used to go from veh-km to car-km*

Results

The estimated operating costs are presented in **Exhibit 3.21**.

Operating cost is incremental to the costs associated with operating the BAU transit network, which by 2041 approximately doubles compared to existing bus service levels in the study area. Based on initial bus service plans, there are no assumed savings from reducing conventional bus service because each alternative assumes all background local bus service from the BAU is retained. As a result, incremental operating costs range from an additional $9 million per year for RRT 3 to $58 million per year for the Best Bus alternative. Best Bus alternative would have the highest operating cost as it includes increased bus service on the most kilometres of route, requiring the most vehicles and drivers.

Of the rapid transit alternatives, those with the greatest extent would have the highest operating costs, as they required more vehicles and drivers and have more infrastructure to maintain. There was some variation in operating costs between the larger extent alternatives, due to different unit costs and frequency of service for each technology and corridor. LRT and RRT alternatives are rail-based and tend to have higher costs associated with track and power system maintenance. BRT alternatives tend to have highest costs associated with vehicle operations due to the additional driver costs compared to an automated RRT system, and the need to operate more frequently than LRT to provide a similar level of capacity.

Overall, RRT 1A had the highest costs besides BB, followed closely by BRT 1, LRT 5B, LRT 5A, LRT2 and LRT 1.

A score of “1” (worse than BAU) was assigned to the highest operating cost alternative, Best Bus, as well as the larger extent rapid transit alternatives (BRT 1, LRT 1, LRT 2, LRT 5A, LRT 5B, RRT 1A). The two lowest cost alternatives, RRT 3 and LRT 4, were assessed a score “3” (similar to BAU). The other rapid transit alternatives (BRT 2, LRT 3, RRT 1, and RRT 2) had operating costs between these extremes and scored “2”.

Exhibit 3.21 – Operating Costs Summary

Alternatives				BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
2021 Near-Term				**Bus****												
BRT	Service	Veh-hrs		361,500	242,400	178,300	60,900	166,400	105,500	-	136,900	111,100	-	136,900	131,300	-
		Service Bus-km		9,957,000	6,457,000	4,551,000	1,519,000	4,749,000	3,230,000	-	3,227,000	2,859,000	-	3,227,000	3,598,000	-
	Extent	Lanes-km (count each lane)			61.4	53.6	7.8	39.8	32.0	-	27.2	18.4	-	29.4	43.0	-
LRT	Service	Veh-hrs			-	-	120,800	57,400	57,400	57,400	63,400	86,900	-	-	-	-
		Service LRT Car-km			-	-	3,310,000	1,281,000	1,281,000	1,281,000	2,029,000	2,551,000	-	-	-	-
	Extent	Track-km (count each track)			-	-	53.6	21.6	21.6	21.6	34.2	43.0	-	-	-	-
RRT	Service	Veh-hrs			-	-	-	-	-	-	-	-	48,300	48,300	36,600	36,600
		Service RRT Car-km			-	-	-	-	-	-	-	-	11,265,000	11,265,000	6,700,000	6,700,000
	Extent	Track-km (count each track)			-	-	-	-	-	-	-	-	31.6	31.6	11.2	11.2
Time-based Subtotal			millions, 2010$	$ 24.4	$ 16.3	$ 12.0	$ 12.3	$ 15.1	$ 11.0	$ 3.9	$ 13.5	$ 13.4	$ 1.7	$ 10.9	$ 10.2	$ 1.3
Distance-based Subtotal			millions, 2010$	$ 16.6	$ 10.8	$ 7.6	$ 9.2	$ 10.5	$ 8.0	$ 2.6	$ 9.5	$ 9.9	$ 8.4	$ 13.8	$ 11.0	$ 5.0
Extent-based (Non-Vehicle Maint.)			millions, 2010$	$ -	$ 1.2	$ 1.0	$ 5.6	$ 3.0	$ 2.8	$ 2.2	$ 4.0	$ 4.8	$ 7.8	$ 8.3	$ 3.6	$ 2.8
		2021 Annual Op.&Mtce.		**$ 41.0**	**$ 28.3**	**$ 20.7**	**$ 27.0**	**$ 28.6**	**$ 21.8**	**$ 8.6**	**$ 27.0**	**$ 28.0**	**$ 17.9**	**$ 33.1**	**$ 24.8**	**$ 9.1**
2041 Horizon				**Bus****												
BRT	Service	Veh-hrs		479,500	403,800	284,100	94,800	255,900	161,100	-	242,700	202,000	-	242,700	201,800	-
		Service Bus-km		15,305,000	10,844,000	7,371,000	2,387,000	7,397,000	5,010,000	-	5,834,000	5,210,000	-	5,834,000	5,634,000	-
	Extent	Lanes-km (count each lane)			61.4	53.6	7.8	39.8	32.0	-	27.2	18.4	-	29.4	43.0	-
LRT	Service	Veh-hrs			-	-	184,500	87,200	87,200	87,200	97,300	132,400	-	-	-	-
		Service LRT Car-km			-	-	5,202,000	2,014,000	2,014,000	2,014,000	3,188,000	4,009,000	-	-	-	-
	Extent	Track-km (count each track)			-	-	53.6	21.6	21.6	21.6	34.2	43.0	-	-	-	-
RRT	Service	Veh-hrs			-	-	-	-	-	-	-	-	48,300	48,300	36,600	36,600
		Service RRT Car-km			-	-	-	-	-	-	-	-	11,265,000	11,265,000	6,700,000	6,700,000
	Extent	Track-km (count each track)			-	-	-	-	-	-	-	-	31.6	31.6	11.2	11.2
Time-based Subtotal			millions, 2010$	$ 32.3	$ 27.2	$ 19.2	$ 18.8	$ 23.1	$ 16.7	$ 5.9	$ 22.9	$ 22.6	$ 1.7	$ 18.1	$ 14.9	$ 1.3
Distance-based Subtotal			millions, 2010$	$ 25.6	$ 18.1	$ 12.3	$ 14.4	$ 16.4	$ 12.4	$ 4.0	$ 16.1	$ 16.7	$ 8.4	$ 18.2	$ 14.4	$ 5.0
Extent-based (Non-Vehicle Maint.)			millions, 2010$	$ -	$ 1.2	$ 1.0	$ 5.6	$ 3.0	$ 2.8	$ 2.2	$ 4.0	$ 4.8	$ 7.8	$ 8.3	$ 3.6	$ 2.8
		2041 Annual Op.&Mtce.		**$ 57.9**	**$ 46.6**	**$ 32.5**	**$ 38.9**	**$ 42.5**	**$ 32.0**	**$ 12.1**	**$ 43.1**	**$ 44.0**	**$ 17.9**	**$ 44.6**	**$ 32.9**	**$ 9.1**
NPV of Operating Costs (6% Discount to 2010)				**$ 398**	**$ 300**	**$ 214**	**$ 265**	**$ 286**	**$ 216**	**$ 83**	**$ 281**	**$ 289**	**$ 146**	**$ 313**	**$ 233**	**$ 74**
Evaluation Ratings				**1**	**1**	**2**	**1**	**1**	**2**	**3**	**1**	**1**	**2**	**1**	**2**	**3**

*** Operating and maintenance costs shown here are Net of BAU costs for planned SOFATP bus services.**

**** Incremental service on BB provided with articulated and standard conventional bus.**

3.2.3 Cost-Effectiveness

Approach

Cost-effectiveness assesses the quantifiable transportation and land use benefits of the alternative relative to the Net Present Value (NPV) of the costs. Further details of the NPV of costs and benefits are included in Appendix 3B.

NPV of Costs

The first step in determining cost-effectiveness was to carry out a life cycle analysis of the net costs, including the construction period and thirty years of operations. Inputs to this analysis included the following capital and operating costs:

- Costs during the construction period of 4 to 7 years, prior to opening year. The costs were distributed over this period according to typical cash flows, with the bulk of the costs in the middle years until the penultimate year, when much of the construction is finished and testing and vehicle procurement are completed.
- Any additional vehicles to increase service frequency from 2021 to 2041 were assumed to be purchased 10 and 20 years into the 30-year operations period.
- Since vehicles have a shorter life-cycle than the guideway, the original vehicles will require renewal and refurbishment over the 30 year operating period. It is assumed that there will be technological improvements during this time period that extend the life of the vehicles. These costs are included in the life cycle analysis.
- Real inflation (increases in costs expected to exceed the background trend for the Consumer Price Index) was also applied to future capital costs. The real inflation assumptions (from 0 to 3% per year) were consistent with other rapid transit studies.
- The annual costs explicitly estimated for 2021 and 2041 were fed into the cash flow model, and real inflation was applied to those annual costs. Net operating costs for the rest of the 30-year period were then interpolated and extrapolated.
- Incremental fare revenues were deducted from operating costs. This revenue was estimated by the travel demand model, based on new transit trips, the average transit fare, and annualized from the AM peak hour. Annual revenue was calculated for 2021/2041 and then interpolated/extrapolated to cover the 30-year operating period. A ramp-up factor (90%, 95%) was applied to the initial years to represent a transition period for passengers to switch from past travel patterns.
- All values are expressed in 2010 dollars, plus real inflation.
- The NPV was calculated by discounting the cash flows at 6% per year back to 2010.

The main elements of the NPV (capital costs, operating costs, and new fare revenues) are identified in **Exhibit 3.22**.

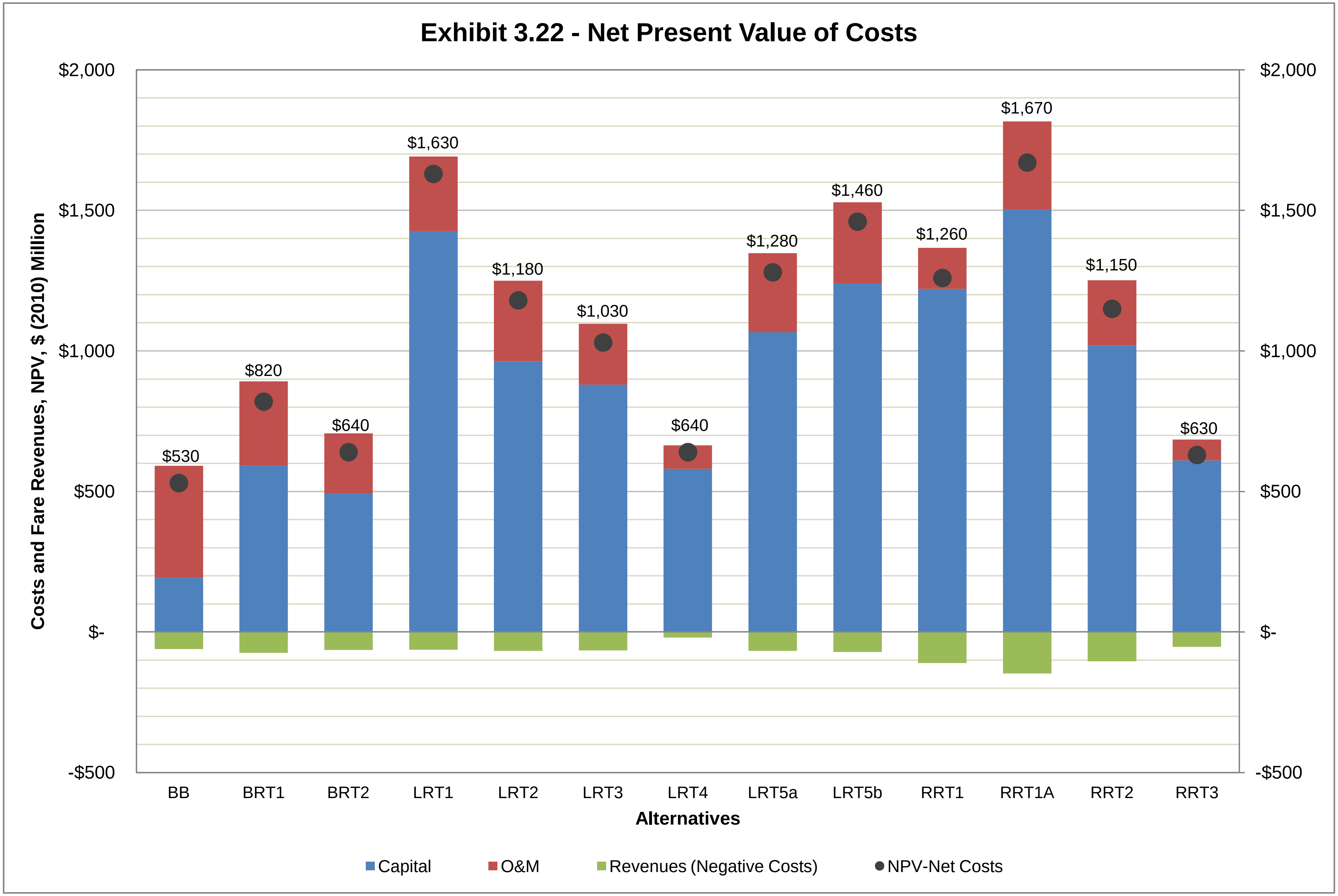


Exhibit 3.22 - Net Present Value of Costs
$2,000
$1,500
$1,000
$500
$-
-$500
Costs and Fare Revenues, NPV, $ (2010) Million
$530
$820
$640
$1,630
$1,180
$1,030
$640
$1,280
$1,460
$1,260
$1,670
$1,150
$630
BB
BRT1
BRT2
LRT1
LRT2
LRT3
LRT4
LRT5a
LRT5b
RRT1
RRT1A
RRT2
RRT3
Alternatives
Capital
O&M
Revenues (Negative Costs)
NPV-Net Costs

NPV of Benefits

The following benefits were monetized and then converted to a Net Present Value ($2010, 6% discount) using the same approach as used for the costs:

- Travel time savings (net of transit users and non-transit users), adjusted for transit capacity constraints and including local bus pass-up savings relative to BAU. The savings in hours are converted to monetary benefits using the value of time;
- Other travel benefits included reliability improvements and quality of service benefits for passengers on the rapid transit system. These are economic benefits that have been expressed in travel time equivalents for the purpose of the evaluation.
  - The reliability benefit is related to the increased certainty of transit travel times for existing transit passengers that switch to rapid transit, which is segregated from other traffic. This benefit is related to reducing the additional time that passengers have to allow for travel because of local bus schedule fluctuations. It was assessed as a 15% overlay on the estimated travel time savings for existing passengers. It was not assessed for new users because they switch from unscheduled modes (auto, walk, cycle).
  - The quality benefit is the perceived improvement in transit service due to the rapid transit experience, amenities and ride quality of the station and vehicles, and was valued once per trip consistent with other rapid transit studies.
- Auto operating cost and collision cost savings were derived from VKT reductions (estimated in the transportation account); and
- Air emissions savings, from the environment account. Any increases in air emissions, for example during construction, were evaluated as negative savings.

Cost-Effectiveness

The Benefit/Cost (B/C) Ratio was estimated based on NPV of the above net costs and net benefits.

To gain an understanding of the average cost of transportation (e.g. time savings, new riders) and land use intensification benefits, the total costs were divided by transportation, environment and land use outputs. The resulting measures of cost-effectiveness were:

- Average cost per added transit trip in 2021 and 2041. The capital costs were converted to an annual average over the life cycle, and this value was added to the operating costs net of new fare revenues to derive 2021 and 2041 total annualized costs. These values were then divided by the estimated number of additional regional transit trips (determined in the transportation account);
- Cost per additional transit passenger-km (annualized cost divided by incremental regional transit passenger-km in 2041);
- Average cost per hour saved, based on the travel time benefits (annualized costs divided by savings in person-hours);
- For air emissions, the life cycle costs (NPV of costs) were divided by life cycle net change in GHG emissions (from the environment account); and
- Cost per land use intensification [NPV_{costs}/square feet of development] (from urban development account).

The calculations of cost-effectiveness are summarized in **Exhibit 3.23**.

Exhibit 3.23 - Cost-Effectiveness

Alternative	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
(Net) Present Value, at 6% Discount to 2010:														
PV of Capital Costs		$ 193	$ 592	$ 493	$ 1,426	$ 963	$ 880	$ 581	$ 1,066	$ 1,240	$ 1,221	$ 1,503	$ 1,019	$ 610
PV of Operating Costs		$ 398	$ 300	$ 214	$ 265	$ 286	$ 216	$ 83	$ 281	$ 289	$ 146	$ 313	$ 233	$ 74
PV of Fare Revenues ('negative' cost)		-$ 61	-$ 74	-$ 64	-$ 63	-$ 67	-$ 66	-$ 20	-$ 67	-$ 71	-$ 111	-$ 148	-$ 104	-$ 53
NPV of Costs*, Millions		$ 530	$ 820	$ 640	$ 1,630	$ 1,180	$ 1,030	$ 640	$ 1,280	$ 1,460	$ 1,260	$ 1,670	$ 1,150	$ 630
PV of Travel Time Savings		$ 383	$ 684	$ 539	$ 589	$ 527	$ 517	-$ 20	$ 703	$ 738	$ 1,421	$ 1,662	$ 1,018	$ 545
PV of Other Travel Benefits		$ -	$ 278	$ 234	$ 439	$ 318	$ 304	$ 156	$ 392	$ 431	$ 419	$ 566	$ 443	$ 254
PV of Auto Operating Cost Savings		$ 50	$ 61	$ 51	$ 51	$ 56	$ 55	$ 20	$ 56	$ 57	$ 64	$ 107	$ 73	$ 33
PV of Collision Cost Savings		$ 37	$ 46	$ 38	$ 38	$ 42	$ 41	$ 15	$ 42	$ 43	$ 48	$ 81	$ 54	$ 25
PV of GHG emission reductions		$ 3	$ 1	$ 1	$ 1	$ 1	$ 1	$ 0	$ 1	$ 1	$ 1	$ 1	$ 1	$ 0
NPV, Benefits**, Millions		$ 470	$ 1,070	$ 860	$ 1,120	$ 940	$ 920	$ 170	$ 1,190	$ 1,270	$ 1,950	$ 2,420	$ 1,590	$ 860
Total NPV		**-$ 60**	**$ 250**	**$ 220**	**-$ 510**	**-$ 240**	**-$ 110**	**-$ 470**	**-$ 90**	**-$ 190**	**$ 690**	**$ 750**	**$ 440**	**$ 230**
Benefit/Cost Ratio		**0.89**	**1.30**	**1.34**	**0.69**	**0.80**	**0.89**	**0.27**	**0.93**	**0.87**	**1.55**	**1.45**	**1.38**	**1.37**
Average Costs														
Average Annual Costs (Undiscounted Annualized Capital Costs plus Operating Cost in future year of operations)														
Annualized Capital Cost		$ 24	$ 61	$ 52	$ 154	$ 105	$ 95	$ 64	$ 117	$ 135	$ 118	$ 146	$ 103	$ 61
2021 Net Operating Cost (Op.Cost -Revenue)		$ 34	$ 22	$ 15	$ 22	$ 23	$ 16	$ 7	$ 22	$ 23	$ 6	$ 19	$ 15	$ 3
2021 Total Annualized Cost ($M)		**$ 58**	**$ 83**	**$ 67**	**$ 176**	**$ 128**	**$ 111**	**$ 71**	**$ 139**	**$ 158**	**$ 124**	**$ 165**	**$ 118**	**$ 64**
2041 Net Operating Cost (Op.Cost -Revenue)		$ 51	$ 35	$ 22	$ 28	$ 32	$ 22	$ 9	$ 32	$ 31	$ 3	$ 23	$ 17	$ 2
2041 Total Annualized Cost ($M)		**$ 75**	**$ 96**	**$ 74**	**$ 182**	**$ 137**	**$ 117**	**$ 73**	**$ 149**	**$ 166**	**$ 121**	**$ 169**	**$ 120**	**$ 63**
Transit Passenger Activity														
Additional Transit Trips (Increase in Regional Transit Trips relative to BAU, Estimated Annual Value)														
2021 Additional Transit Trips (Millions)		3.9	3.0	2.6	2.4	2.8	2.9	0.8	2.6	2.5	5.2	6.6	4.5	2.6
Avg. Cost Per Added Transit Passenger, 2021		**$ 15**	**$ 27**	**$ 25**	**$ 74**	**$ 45**	**$ 39**	**$ 85**	**$ 54**	**$ 64**	**$ 24**	**$ 25**	**$ 26**	**$ 25**
2041 Additional Transit Trips (Millions)		3.9	5.7	4.8	5.2	5.1	4.8	1.6	5.2	6.1	6.2	9.6	7.0	2.9
Avg. Cost Per Added Transit Passenger, 2041		**$ 19**	**$ 17**	**$ 15**	**$ 35**	**$ 27**	**$ 24**	**$ 44**	**$ 28**	**$ 27**	**$ 19**	**$ 18**	**$ 17**	**$ 22**
Additional Transit Pass-km (relative to BAU, Estimated Annual Value)														
2041 Additional Transit Pass-km (Millions)		57.6	159.6	128.5	140.3	138.2	131.1	13.8	153.0	164.7	289.7	351.9	227.0	107.1
Avg. Cost Per Added Transit Pass-km, 2041		**$ 1.30**	**$ 0.60**	**$ 0.58**	**$ 1.29**	**$ 0.99**	**$ 0.89**	**$ 5.27**	**$ 0.97**	**$ 1.01**	**$ 0.42**	**$ 0.48**	**$ 0.53**	**$ 0.59**
Travel Time Benefits														
Person-Hours Saved (Decrease in person-hours for transit and auto trips relative to BAU, Estimated Annual Value)														
2021 Travel Time Saved (Hours, Millions)		2.9	2.8	2.5	2.9	2.6	2.4	(0.1)	2.7	3.1	8.1	9.1	4.8	2.8
Avg. Cost Per Hour Saved, 2021		**$ 20**	**$ 30**	**$ 27**	**$ 60**	**$ 50**	**$ 46**	**n/a**	**$ 52**	**$ 52**	**$ 15**	**$ 18**	**$ 24**	**$ 23**
2041 Travel Time Saved (Hours, Millions)		2.7	6.7	5.0	5.4	4.7	4.8	(0.2)	7.2	7.4	12.4	14.8	9.5	5.0
Avg. Cost Per Hour Saved, 2041		**$ 28**	**$ 14**	**$ 15**	**$ 33**	**$ 29**	**$ 24**	**n/a**	**$ 21**	**$ 22**	**$ 10**	**$ 11**	**$ 13**	**$ 13**
Life Cycle Average Costs (NPV Costs divided by Types of Benefits)														
Air Emission Benefits														
GHG Tonnes Reduced, 30 Years		- 519,000	- 237,000	- 130,000	- 25,000	- 160,000	- 56,000	33,000	- 103,000	- 89,000	68,000	- 8,000	- 40,000	59,000
* Some reductions are negative														
Cost per tonne GHG Reduction*		n/a	n/a	n/a	n/a	n/a	n/a	$ 19,400	n/a	n/a	$ 18,500	n/a	n/a	$ 10,700
Land Use Benefits														
Land Use Intensification (LUI), sf at Stations		14,200,000	19,400,000	18,200,000	19,400,000	19,400,000	18,200,000	16,000,000	19,400,000	19,400,000	17,200,000	19,400,000	18,500,000	15,400,000
Cost Per Square Foot (LUI)		$ 37	$ 42	$ 35	$ 84	$ 61	$ 57	$ 40	$ 66	$ 75	$ 73	$ 86	$ 62	$ 41
Evaluation Rating		3	4	4	1	2	3	1	3	3	4	4	4	4

Results

The cost-effectiveness ratings reflect how well each alternative balanced the combined capital and operating costs against transportation and land use benefits. Generally, the most cost-effective alternatives were those with low to medium costs, and high to medium benefits. Best Bus alternative represented the average costs for a non-rapid transit solution, and was used as the pivot for assessing the other alternatives. It was therefore rated “3.”

The BRT alternatives were rated “4” (better) because of their relatively high benefits and lower costs, (B/C ratios of ~1.3) on both the transportation and land use measures.

LRT 3, LRT 5A and LRT 5B had similar or slightly higher costs per transportation or land use benefit, when compared to Best Bus. The B/C ratios of each ranged from 0.87 to 0.93. These alternatives were rated “3” since their performance was closest to BB. LRT 1 had the highest costs per land use benefit, the second highest costs per transportation benefit. LRT 4 had a poor B/C ratio of 0.27 because it registered few net transportation benefits. These alternatives were rated “1” because they performed markedly worse than the other alternatives within this criterion. LRT 2 performed worse than LRT 3 and better than LRT 1, and so rated a “2”.

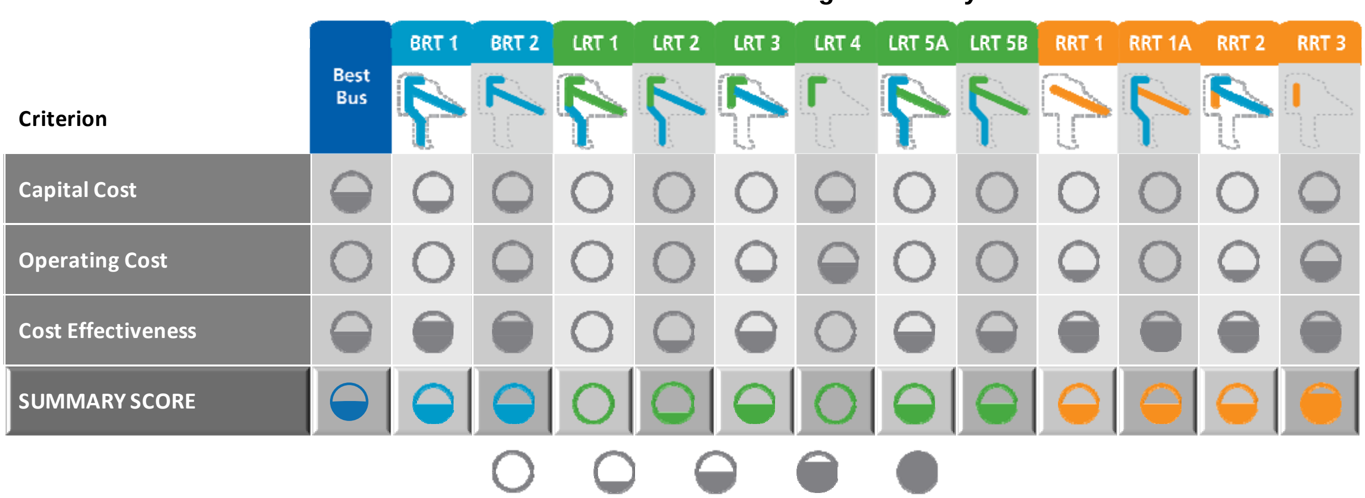
The RRT alternatives had the highest B/C ratios (~1.4 to 1.5), performing well in transportation cost-effectiveness, but only moderately well against land use cost-effectiveness. For these reasons, the RRT alternatives were also rated “4” (better).

3.2.4 Financial Account Key Points

The evaluation ratings for each of the criteria, and an overall summary rating for the account are indicated on **Exhibit 3.24**. These were the highlights of the financial assessment:

- Capital costs for rapid transit alternatives range from $770 M to $2.2 B, with the Best Bus capital cost at $290 million.
- Operating costs range from an additional $9 M per year (RRT 3) to $58 M (Best Bus). Generally the alternatives with the greatest extent have the highest operating costs as they require more vehicles and drivers.
- Cost–effectiveness scores reflect a range of transportation and land use cost-effectiveness measures relative to continued investment in buses. The RRT and BRT alternatives performed best in this criterion due to greater relative benefits (RRT) or lower costs (BRT).

Exhibit 3.24 –Financial Account Ratings Summary



3.3 Environment Account

Brief Overview

The environment account evaluates the performance of the alternatives against the following project objectives:

- *Rapid transit service contributes towards achieving emission reduction targets and objectives by positively affecting travel choices; and*
- *Rapid transit is sensitive to natural resources, protected lands, food-producing lands and watercourses*.

The environment account assesses the impact of the construction and operation of the rapid transit alternatives on the natural and anthropogenic environments. The study area is a mixture of urbanized areas and protected and undeveloped natural areas. As a result, the environment account includes measures that explore the interaction between these areas, such as emissions reductions, effects on biodiversity, and on the water environment. Environmental measures that are almost exclusively related to the anthropogenic environment include noise and vibration, the effect on parks and open space, and on agricultural resources.

The environmental criteria include:

3.3.1. Emissions Reductions

3.3.2. Noise and Vibration

3.3.3. Biodiversity

3.3.4. Water Environment

3.3.5. Effect on Parks and Open Spaces

3.3.6. Effect on Agricultural Resources

The evaluation approach, assumptions and results are described for each of these criteria on the following pages. Supporting details for the environment analysis are located in **Appendix 3C**.

3.3.1 Emission Reductions

Approach

The emissions reductions measures include changes in greenhouse gas (GHG) emissions and criteria air contaminants (CAC) resulting from construction, shifting trips from cars to transit as well as shifting to transit powered by electricity (LRT, RRT) rather than fossil fuels.

This study examines the regional increases and decreases of GHGs and CACs - Carbon Dioxide (CO_2), Carbon Oxide (CO), Nitrous Oxide (NOx), Sulphur Oxide (SOx), volatile organic emissions (VO), and particulate matter (PM) – from the construction of the alternatives plus thirty years of operation. The emissions reductions measures include:

- Change in tonnes of net CO_2.
- Change in tonnes of net CAC emissions (by contaminant).

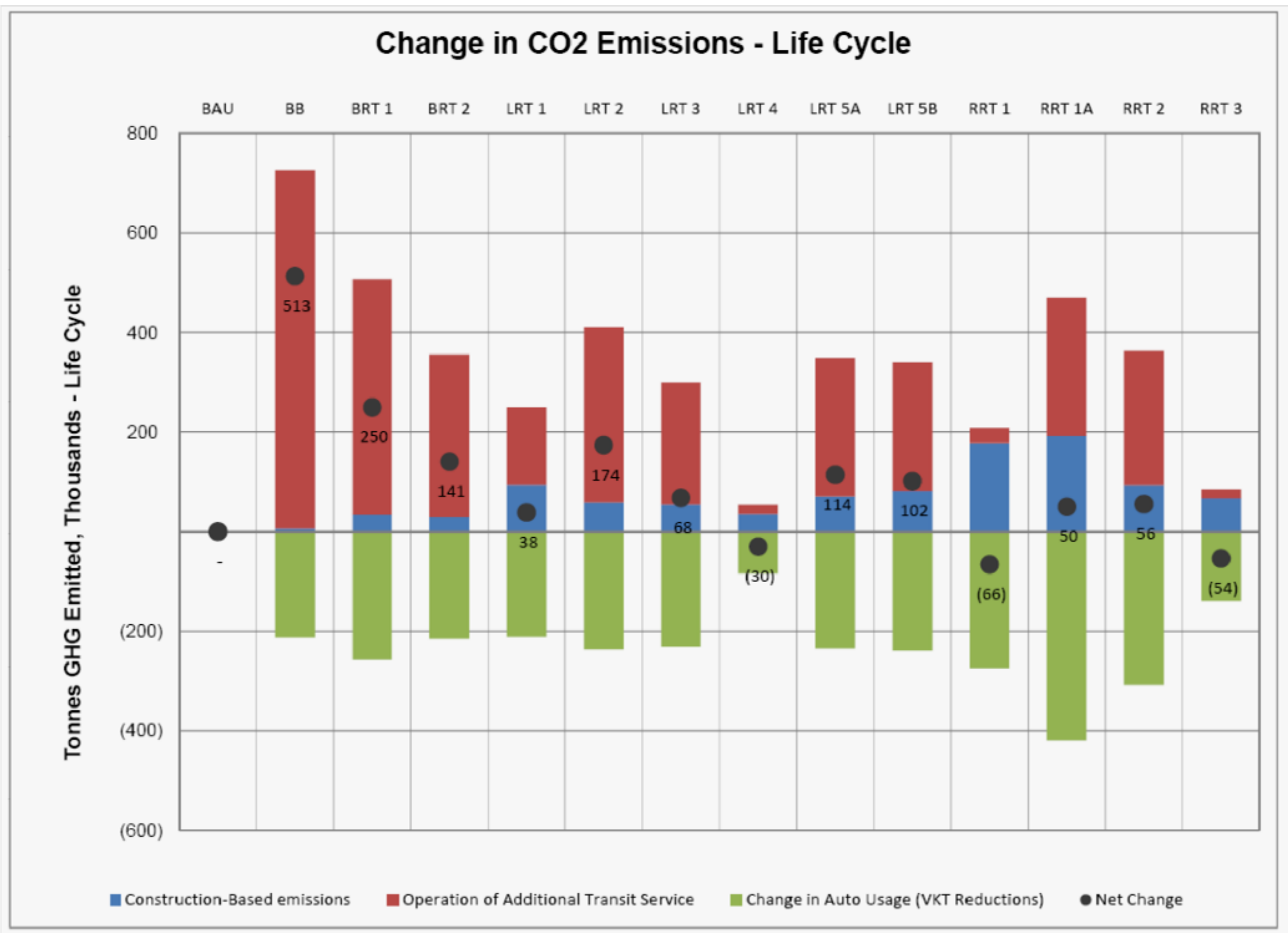
The emissions rates (by vehicle type) were provided by Metro Vancouver, based on emissions monitoring for the Greater Vancouver region. Future emissions rates are projected based on expected turnover of vehicle fleets, with aging vehicles replaced by current and emerging technologies. The detailed results of the emissions reductions are presented in **Exhibit 3.25**. The emissions rates are included in Appendix 2A, and details of the calculation are in Appendix 3C.

Results

All of the alternatives produce GHG emissions during construction, with the exception of Best Bus as it uses the existing infrastructure. Exhibit 3.25 illustrates that RRT and LRT alternatives would produce more GHG emissions during construction than the BRT alternatives, because there are more infrastructure components that need to be built to support the technologies.

There is an inverse relationship between construction related GHG emissions and operation GHG emissions. Alternatives using a high proportion of buses (Best Bus, BRT 1, BRT 2, LRT 2, LRT 3, LRT 5A, LRT 5B, RRT 1A and RRT 2) increase net GHG and CAC emissions because decreases in vehicle travel are offset by increases in emissions associated with bus operations. Alternatives that are primarily powered by electricity (LRT 4, RRT 1 and RRT 3) decrease future emissions by reducing vehicle traffic and have low emissions associated with rapid transit operations.

Exhibit 3.25 – Estimated Changes in CO2 Emissions during Construction and Operation

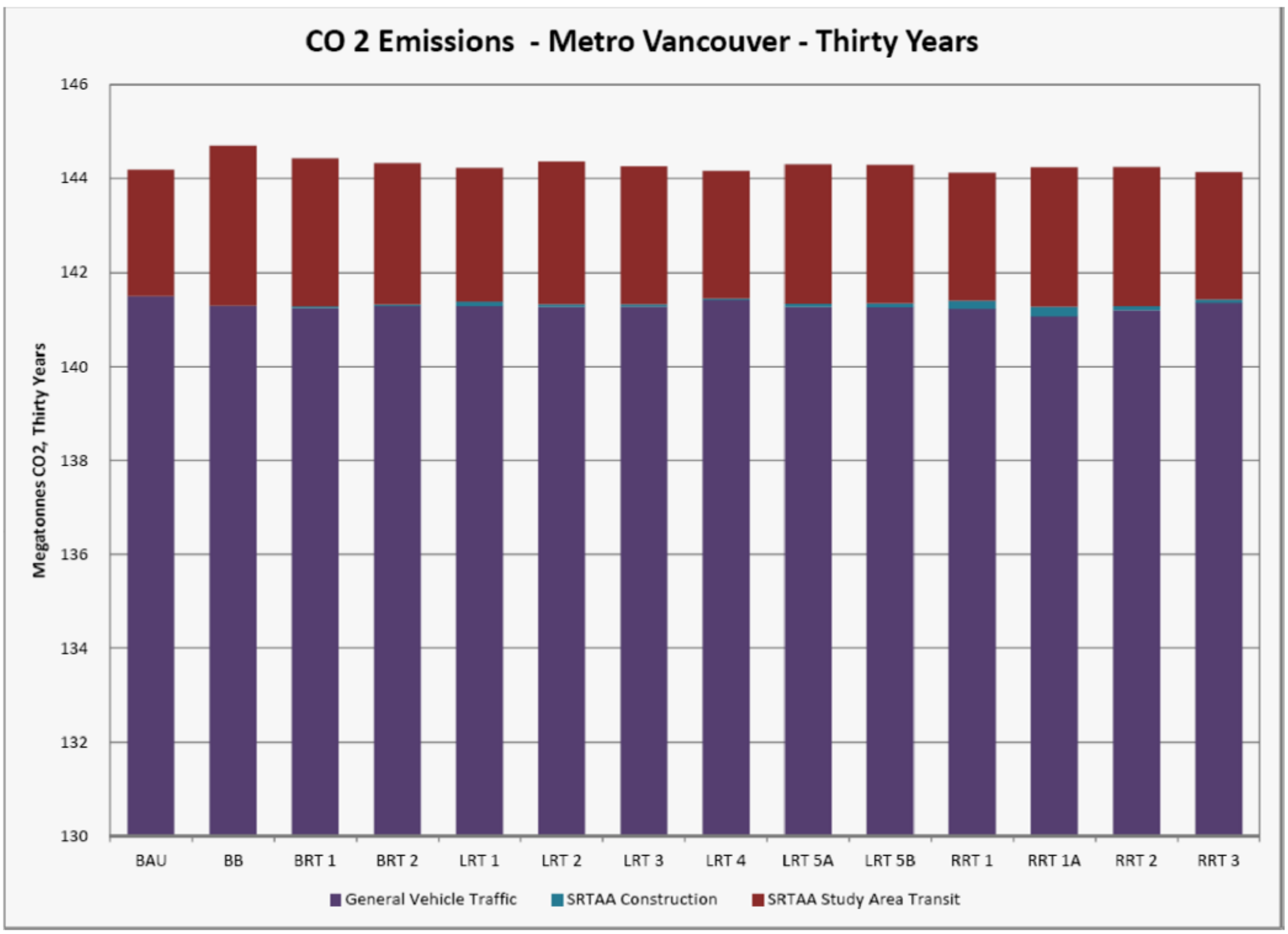


There was a net increase in CO_2 emissions projected for most of the alternatives during operation; this is reflected in **Exhibit 3.25.** The alternatives with the most limited routes would produce the lowest operational emissions: LRT 4, RRT 1, and RRT 3. All of the LRT and RRT alternatives would use electricity generated from hydroelectric power, as opposed to BRT alternatives which were assumed to use 'clean' diesel. LRT and RRT alternatives that include BRT segments would have less CO_2 efficiency savings.

Alternatives BRT 1, BRT 2, LRT 1, LRT 2, LRT 3, LRT 5A and LRT 5B are forecast to be almost equal in their ability to induce drivers to switch to transit use. The more extensive the route, the more drivers would be likely to switch modes and reduce the VKT by automobile. The RRT alternatives are forecast to be the most effective at reducing VKT in the region.

Over the next 30 years the Metro Vancouver region will generate significant CO_2 emissions, as displayed in **Exhibit 3.26**. Transit within the SRTAA study area will contribute a very small amount to the total vehicle emissions of the region. Approximately 2% of the study area's emissions will be attributable to transit.

Exhibit 3.26 – Total CO2 Emissions in Metro Vancouver



CACs would be lower across the RRT and LRT alternatives, and higher across the BRT alternatives as displayed in **Exhibit 3.27**. As the BRT alternatives exclusively use diesel they release more CACs than the LRT and RRT alternative which use electricity and diesel.

Overall, each of the alternatives was rated similar to BAU, with an assessed score of “3.” The changes in emissions directly from the transportation alternatives amounted to an impact of 0.4% or less, compared to BAU at the regional scale.

3.3.2 Noise and Vibration

Approach

The noise and vibration criterion is a qualitative assessment of the impacts of the rapid transit system during construction and operation on the surrounding area. The noise and vibration measure was assessed qualitatively for each alternative, relative to the future ambient traffic noise (including BAU levels of bus service and forecast automobile and truck volumes) along each corridor. The noise and vibration measures include:

- Noise during operation.
- Vibration during operation.
- Noise and vibration during construction.

The three measures were assessed based on industry experience with these rapid transit modes, and the extent of operations based on the designs of the alternatives. The results of the noise and vibration assessment are presented in **Exhibit 3.28**.

Results

During operation the BRT and LRT alternatives would produce minor noise effects relative to background traffic, since BRT and LRT were assumed to operate mostly in the street median. Noise would most likely be experienced by building users where streets have been widened because the background traffic would be closer to the buildings. RRT alternatives would produce intermittent noise along the guideway.

The vibration impacts of the alternatives increase in scale from the BRT alternatives, which have the least intense ground vibration, to LRT alternatives which have more intense vibrations originating from rail on track slabs, to RRT alternatives which have the most intense vibrations originating from the vehicles on the guideways.

During construction, all of the alternatives would produce noise and vibration impacts. For BRT and LRT alternatives, the noise and vibration would be produced by lane and roadway reconstruction during the installation of the segregated median. For RRT alternatives, the noise and vibration would be produced by guideway and localized roadway reconstruction. This noise and vibration would be experienced in the local area. Alternatives with limited geographic coverage would produce less noise and vibration than similar alternatives of greater extents.

Overall, most of the rapid transit alternatives were rated worse than BAU since they would increase noise and/or vibrations. All of the BRT, LRT and one of the RRT alternatives, due to its limited extent (RRT 3), were rated “2”. The other three RRT alternatives have a greater SkyTrain/RRT extent and BRT extent (RRT 1A and RRT 2) and were rated as worse than BAU with scores of “1”. Best Bus was assessed as similar to BAU (score of “3”) since its impact would be limited to increased numbers of transit buses on the main travel corridors.

Exhibit 3.27 – GHG (CO_2) and CAC Emissions

Alternative	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
CO_2 Emissions (tonnes)													
Construction CO2 emissions	6,000	33,800	29,400	93,900	59,200	55,000	35,400	71,000	82,300	178,300	191,900	93,000	67,600
Operation Period CO_2 Emissions - Transit Over Thirty Year Period	730,200	473,100	326,000	155,600	351,000	244,200	18,900	277,700	258,200	29,700	277,500	270,100	17,700
Operation Period CO2 Emission Reductions from Autos - Transit Over Thirty Year Period	(212,200)	(257,100)	(214,800)	(211,100)	(236,400)	(231,000)	(84,100)	(234,600)	(239,000)	(273,900)	(419,200)	(307,500)	(139,300)
Net CO_2 Emissions from Project	524,000	249,800	140,700	38,400	173,800	68,300	(29,800)	114,100	101,600	(65,800)	50,200	55,600	(53,900)
Metro Vancouver Emissions Total (tonnes, Millions)	144.3	144.0	143.9	143.8	143.9	143.8	143.7	143.9	143.8	143.7	143.8	143.8	143.7
Percent Change in Metro Vancouver Emissions over 30 years from BAU	0.4%	0.2%	0.1%	0.0%	0.1%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%
CAC Emissions (tonnes)													
Net CO Emissions	(6,900)	(9,500)	(8,000)	(8,900)	(9,100)	(8,600)	(3,500)	(9,000)	(9,800)	(10,100)	(15,900)	(11,400)	(5,200)
Net HN3/HC Emissions	60	(10)	(20)	(60)	(30)	(40)	(30)	(40)	(50)	(90)	(100)	(60)	(50)
Net NoX Emissions	3,400	2,000	1,300	200	1,300	800	(100)	900	800	(400)	700	900	(200)
Net PM Emissions	220	130	90	10	90	50	(10)	60	50	(20)	40	60	(10)
Net PM10 Emissions	220	130	90	10	90	50	(10)	60	50	(20)	40	60	(10)
Net PM2.5 Emissions	230	150	100	30	100	70	0	70	60	(10)	60	70	(10)
Net SoX Emissions	230	150	100	30	100	70	0	70	60	(10)	60	70	(10)
Net VO Emissions	230	150	100	30	100	70	0	70	60	(10)	60	70	(10)
Evaluation Rating	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**

Exhibit 3.28 – Noise and Vibration - Potential Effects

Issue/Extent	BB	BRT1	BRT2	LRT1	LRT2	LRT3	LRT4	LRT 5a	LRT 5b	RRT1	RRT 1a	RRT2	RRT3
Noise Sources (Operations)	- BB will have more buses than BAU	- Traffic closer to buildings where streets are widened - Fairly minor noise effects from BRT	- Traffic closer to buildings where streets are widened - Fairly minor noise effects from BRT	- Traffic closer to buildings where street is spot-widened - Fairly minor noise effects from LRT and BRT	-Traffic closer to buildings where street is spot-widened - Fairly minor noise effects from LRT and BRT	-Traffic closer to buildings where street is spot-widened - Fairly minor noise effects from LRT and BRT	-Traffic closer to buildings where street is spot-widened - Fairly minor noise effects from LRT	Traffic closer to buildings where streets are widened and spot-widened Fairly minor noise effects from LRT and BRT	Traffic closer to buildings where streets are widened and spot-widened Fairly minor noise effects from LRT and BRT	- SkyTrain vehicle noise on guideway - Public address system	- SkyTrain vehicle noise on guideway - Public address system - Traffic closer to buildings where streets are widened (for BRT portion) - More minor noise effects from BRT	- SkyTrain vehicle noise on guideway - Public address system - Traffic closer to buildings where streets are widened (for BRT portion) - More minor noise effects from BRT	- SkyTrain vehicle noise on guideway - Public address system
Vibration (Operations)	- Little to no change from background traffic and buses	- From traffic (large trucks) and BRT vehicles - Less intense ground vibrations than rail, but more airborne - Location in middle of street limits the effects	- From traffic (large trucks) and BRT vehicles - Less intense ground vibrations than rail, but more airborne - Location in middle of street limits the effects	- From traffic (large trucks) and LRT vehicles, also BRT vehicles - LRT may have more intense ground vibrations than bus - Location in middle of street limits the effects	- From traffic (large trucks) and LRT vehicles, also BRT vehicles - LRT may have more intense ground vibrations than bus - Location in middle of street limits the effects	- From traffic (large trucks) and LRT vehicles, also BRT vehicles - LRT may have more intense ground vibrations than bus - Location in middle of street limits the effects	- From traffic (large trucks) and LRT vehicles - LRT may have more intense ground vibrations than bus - Location in middle of street limits the effects	- From traffic (large trucks) and LRT vehicles, also BRT vehicles - LRT may have more intense ground vibrations than bus - Location in middle of street limits the effects	- From traffic (large trucks) and LRT vehicles, also BRT vehicles - LRT may have more intense ground vibrations than bus - Location in middle of street limits the effects	- Vibrations from vehicles on guideways	- Vibrations from vehicles on guideways - From traffic (large trucks) and BRT vehicles- Location in middle of street limits the effects	- Vibrations from vehicles on guideways - From traffic (large trucks) and BRT vehicles- Location in middle of street limits the effects	- Vibrations from vehicles on guideways
BRT (km)		29.6	25.7	3.9	18.8	14.9		12.5	8.1		14.7	20.4	
BRT operating in mixed traffic		10.0	1.1	8.9	10.0	1.1		10.0	10.0		8.9	1.1	
LRT (km)				26.8	10.8	10.8	10.8	17.1	21.5				
RRT (km)										15.8	15.8	5.6	5.6
Total Extent		**39.6**	**26.8**	**39.6**	**39.6**	**26.8**	**10.8**	**39.6**	**39.6**	**15.8**	**39.4**	**27.1**	**5.6**
Impact of Extent	Broad coverage but no construction, so negligible effects	Greater effects than BRT 2, but less than LRT 1	Less extent than BRT 1	Noise, vibration exposure greatest of LRT alternatives due to significant extent Most vibration	Similar extent to LRT 1 but more BRT and less LRT, so vibrations would be far lower	Less extent than LRT 2	Least extent of LRT alternatives	LRT component will produce noise and vibrations; the majority of the alternative will produce similar impact as BRT 1	Similar impact as LRT 1 and BRT 1	Noise, vibration exposure greater than RRT 2 or 3 due to the extent	Noise, vibration exposure greatest of RRT alternatives due to extent and people in catchment; additional noise attributed to BRT component Most noise	Greater impact than RRT 3 due to additional BRT component, but overall less than RRT1	Least extent of RRT alternatives
Evaluation Rating	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**2**

3.3.3 Biodiversity

Approach

The biodiversity criterion examines the potential for impacts that may require mitigation based on proximity to the conceptual alignments of the rapid transit alternatives. Potentially sensitive features within the rapid transit system footprint (the full width of the street with rapid transit) were identified, as well as within a 100 metre buffer of the alignment. The biodiversity assessment was based on the following quantitative measures:

- Terrestrial habitat
  - Hectares of overlap with terrestrial hubs of ecological significance in the footprint or within a 100 m buffer.
  - Hectares of overlap with corridors of ecological significance in the footprint, or within a 100 m buffer.
- Listed species
  - Number of sensitive species (bird) nesting sites within 100 metres.
  - Red and blue listed species (designated by Ministry of Environment as endangered or of special concern) sightings within the 100 metre buffer.
- Arboricultural
  - Number of important trees (trees of historic or representative importance, as defined by the local municipalities, to distinguish from typical landscaping trees) within the 100 metre buffer.

A high-level assessment of the biodiversity measures was carried out by querying GIS data on environmental constraints. The source GIS data for the study area was provided by the Cities and Provincial Ministries[7], and supplemented by site visits. The results of the biodiversity assessment are presented in **Exhibit 3.29**.

Results

Overall there would be limited potential for impacts to biodiversity throughout the study area as all of the alternatives travel through urban areas, along existing road rights of way, and using existing traffic lanes through some of the sensitive areas (i.e. South Surrey floodplains).

The alternatives that traverse the Agricultural Land Reserve (ALR) along Fraser Highway (BRT 1, BRT 2, LRT 1, LRT 2, LRT 3, LRT 5A, LRT 5B, RRT 1, RRT 1A and RRT 2) would create increased risk of potential impacts to habitat and fish bearing streams.

Road realignment and widening of the right of way at select locations would be required to accommodate each of the alternatives. The realignment and right of way reconfiguration could result in the removal or relocation of some of the landscaping street trees planted throughout the study area.

The alternatives with the most limited extent were rated as “3” (LRT 4 and RRT 3). All other alternatives were rated as “2” as they have larger extents and would be adjacent to habitat areas along Fraser Highway.

[7] City of Surrey, City of Langley, and GeoBC environmental layer data sets were obtained and updated through 2011.

Exhibit 3.29 - Biodiversity - Potential Effects

Potential Overlap/Proximity to Alternatives				**BB**	**BRT1**	**BRT2**	**LRT1**	**LRT2**	**LRT3**	**LRT4**	**LRT 5a**	**LRT 5b**	**RRT1**	**RRT 1a**	**RRT2**	**RRT3**
Within Footprint																
Terrestrial habitat		- Significant			4.28	4.28	3.82	4.28	4.28	0.00	3.82	3.82	3.06	3.06	4.28	0.00
	Terrestrial hubs of ecological	- Moderate	ha		0.18	0.18	0.21	0.21	0.21	0.21	0.18	0.18	0.00	0.00	0.01	0.01
	significance overlap	- Slight			0.23	0.19	0.17	0.17	0.13	0.11	0.22	0.15	0.00	0.00	0.18	0.09
		- Significant			1.20	0.00	1.20	1.20	0.00	0.00	1.20	1.20	0.00	1.20	0.00	0.00
	Corridors of ecological	- Moderate	ha		6.45	4.21	6.31	6.50	4.26	1.79	6.26	6.27	2.09	2.49	5.01	2.13
	significance overlap	- Slight			1.37	1.37	1.41	1.42	1.42	1.00	1.36	1.41	0.37	0.00	1.34	0.26
Listed species	Sensitive species nesting sites		No.		2	2	2	2	2	0	2	2	2	2	2	0
	Red and Blue-listed species sightings		No.		1	1	1	1	1	0	1	1	1	1	1	0
Arboricultural	Important trees		No.		0	0	0	0	0	0	0	0	0	0	0	0
Within 100 m Buffer																
Terrestrial habitat		- Significant			16.74	16.74	16.77	16.74	16.74	0.00	16.77	16.77	16.71	16.71	16.74	0.00
	Terrestrial hubs of ecological	- Moderate	ha		6.84	3.39	6.86	6.86	3.41	3.18	6.48	6.86	0.23	0.48	3.30	2.10
	significance overlap	- Slight			2.81	0.82	2.84	2.73	0.81	0.56	2.85	2.84	0.17	1.61	0.74	0.49
		- Significant			2.49	0.00	2.49	2.49	0.00	0.00	2.49	2.49	0.00	2.49	0.00	0.00
	Corridors of ecological	- Moderate	ha		28.15	12.36	28.12	28.12	12.36	5.39	28.12	28.12	7.43	17.83	14.80	6.51
	significance overlap	- Slight			5.51	4.49	5.42	5.50	4.48	2.69	5.42	5.42	1.73	0.07	4.50	0.49
Listed species	Sensitive species nesting sites		No.		6	2	6	6	2	0	6	6	2	6	2	0
	Red and Blue-listed species sightings		No.		3	2	3	3	2	1	3	3	1	1	2	1
Arboricultural	Important trees		No.		35	0	35	35	0	0	35	35	0	35	0	0
Evaluation Rating				**3**	**2**	**2**	**2**	**2**	**2**	**3**	**2**	**2**	**2**	**2**	**2**	**3**

3.3.4 Water Environment

Approach

Water environment assesses the potential impact of the rapid transit system on aquatic resources during construction and operation, including surface run-off. The water environment assessment measures are:

- Kilometres of overlap between fish bearing watercourses and the alignment of the rapid transit alternatives.
- Number of groundwater wells affected by the alternatives.

The water environment measure was assessed using GIS source data from the Cities and Provincial Ministries. The results of the water environment assessment are presented in **Exhibit 3.30**.

Results

Alternatives that did not extend beyond the urban core in the northwest of the study area (LRT 4 and RRT 3) would have the lowest impact on fish bearing watercourses. All other alternatives would have potential for some modest impact on fish bearing watercourses along the Fraser Highway as it crosses the floodplains and over the Serpentine River.

A maximum of single groundwater well would be directly impacted by the alternatives with LRT along Fraser Hwy (LRT 1, LRT 5A, and LRT 5B). The remaining alternatives did not impact any wells.

Overall most of the alternatives rated worse “2” regarding overlap with the fish bearing watercourses and the number of wells impacted as they pose some modest risk to the water environment that would need to be addressed through the Phase 3 design phase. There were two alternatives, LRT 4 and RRT 3 that were rated as “3.” These alternatives are located in largely developed areas along road alignments that do not impact fish bearing watercourses or wells.

3.3.5 Effect on Parks and Open Space

Approach

Parks and open space assesses the impact of proposed rapid transit alternatives on recreational trails and parks and open spaces within the rapid transit system footprint.

The effect on parks and open spaces measures include:

- Kilometers of overlap of recreational trails and the rapid transit system.
- Kilometers of overlap of greenway areas and the rapid transit system.
- Hectares of overlap of parks and open space and the rapid transit system.

GIS source data from the Cities and Provincial Ministries was used to assess the effects on local, regional, and provincial parks and open space. The results of the parks and open space assessment are presented in **Exhibit 3.31**.

Exhibit 3.30 – Effects on Water Environment

Potential Overlap/Proximity to Alternatives			BB	BRT1	BRT2	LRT1	LRT2	LRT3	LRT4	LRT 5a	LRT 5b	RRT1	RRT 1a	RRT2	RRT3
Within Footprint (Right of Way Limits after Construction)															
Aquatic	Fish bearing watercourse overlap	km		0.98	0.98	0.82	0.98	0.98	0.05	0.82	0.82	2.10	2.05	0.97	0.03
Groundwater	Wells	No.		0	0	1	0	0	0	1	1	0	0	0	0
Evaluation Rating			3	2	2	2	2	2	3	2	2	2	2	2	3

Exhibit 3.31 Effects on Parks and Open Space

Potential Overlap/Proximity to Alternatives			BB	BRT1	BRT2	LRT1	LRT2	LRT3	LRT4	LRT 5a	LRT 5b	RRT1	RRT 1a	RRT2	RRT3
Within Footprint (Right of Way Limits after Construction)															
Parks and Public Open Spaces															
	Greenway area overlap	km		16.2	12.6	14.7	12.6	12.6	1.2	14.7	14.7	9.4	11.7	13.0	0.8
	Trails overlap	km		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Parks and Natural Area overlap	ha		0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.1	0.0
Evaluation Rating			3	3	3	3	3	3	3	3	3	3	3	3	3

Exhibit 3.32 – Effects on Agricultural Resources

Potential Overlap/Proximity to Alternatives			BB	BRT1	BRT2	LRT1	LRT2	LRT3	LRT4	LRT 5a	LRT 5b	RRT1	RRT 1a	RRT2	RRT3
Within Footprint (Right of Way Limits after Construction)															
	Agricultural Land Reserve overlap	ha		6.40	6.40	5.17	6.40	6.40	0.00	5.17	5.17	5.25	5.25	6.40	0.00
Evaluation Rating			3	2	2	2	2	2	3	2	2	2	2	2	3

Results

There are limited parks and open space areas abutting the alternatives that would be impacted. The total impacts range from 0.01 - 0.07 hectares, of which the primary impacts would be on the fringes of Bear Creek Park.

Existing greenways that are adjacent to the alternatives would be impacted by any required road widening. However, the greenways are incorporated in the assumed conceptual designs and will be replaced, resulting in no net loss of the greenways.

Alternatives that traverse Green Timbers Urban Forest along Fraser Highway (BRT 1, BRT 2, LRT 1, LRT 2, LRT 3, LRT 5A, LRT 5B, RRT 1, RRT 1A, RRT 2) are assumed to fit within the City of Surrey's planned widening of Fraser Highway to a four-lane road. As a result, all rapid transit alternatives are assessed as having no net impact on the park.

Overall there would be limited impacts to parks and open space, as all of the alternatives are assumed to be located within existing road rights of way. Consequently all of the alternatives have been rated similar to BAU – "3".

3.3.6 Effect on Agricultural Resources

Approach

The agricultural resources criterion examines the impact of the rapid transit alternatives on lands designated as Agricultural Land Reserve (ALR). The ALR is a provincial zone in which agriculture is recognized as the priority use. A comparative review of ALR lands in the study area and the rapid transit alternatives was conducted. This review comprised reviewing the ALR land mapping at the parcel layer and the conceptual design of proposed rapid transit alternatives.

The effect on agricultural resources measure is:

- Hectares of overlap of Agricultural Land Reserve (ALR) land and the rapid transit system. (The overlap area includes the existing roadway passing through the ALR, not just the extent of any potential widening to construct rapid transit.)

The results of this assessment are presented in **Exhibit 3.32**.

Results:

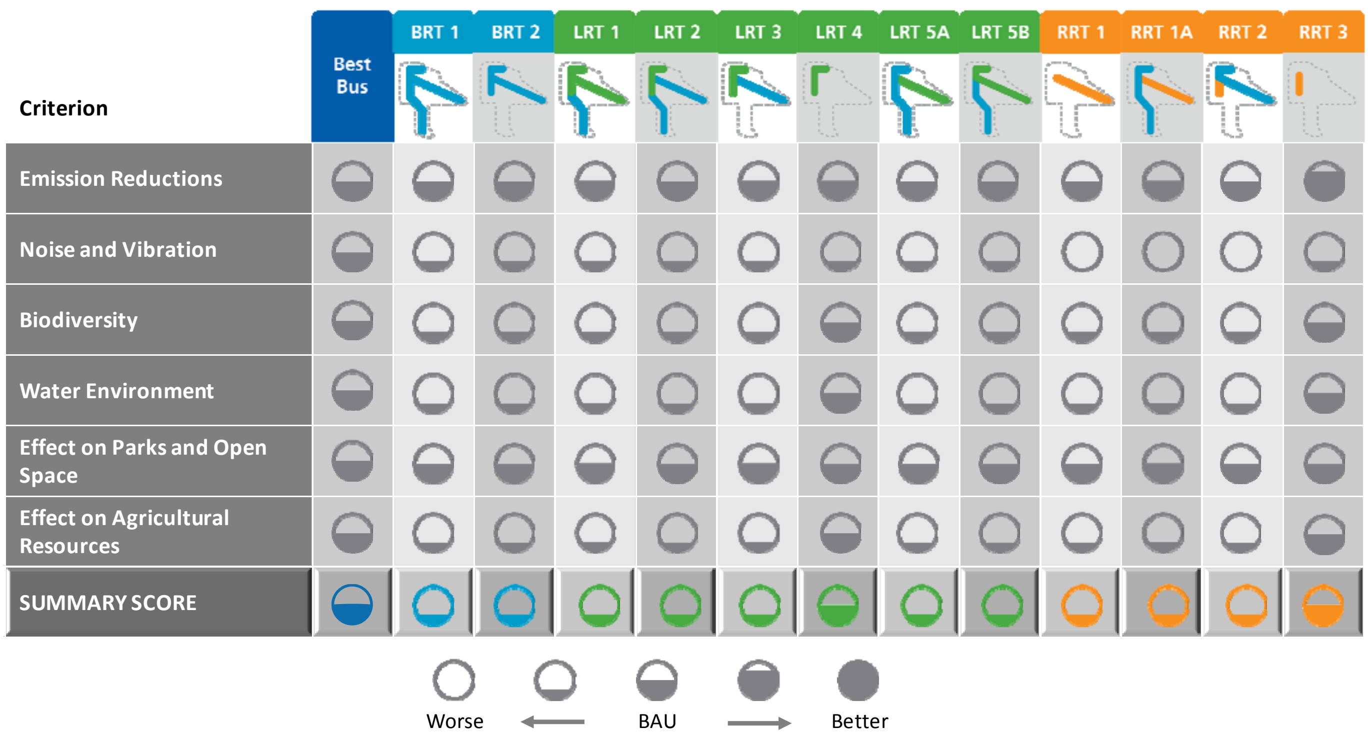
Overall there would be limited impacts to agricultural resources throughout the study area as all of the alternatives travel through urban areas, along existing road rights of way, and in general purpose lanes through the ALR. The alternatives that operate exclusively in urban areas (Best Bus, LRT 4 and RRT 3) have no impact on ALR lands and have been rated as "3". However, alternatives that traverse the ALR (BRT 1, BRT 2, LRT 1, LRT 2, LRT 3, LRT 5A, LRT 5B, RRT 1, RRT 1A and RRT 2) would have minor potential impacts and have been rated "2".

3.3.7 Environment Account Key Points

The evaluation ratings for each of the criteria, and an overall summary rating for the account are indicated on **Exhibit 3.33**. These were the highlights of the environment assessment:

- At a regional scale, emissions impacts were not significant. All alternatives reduce air emissions from automobiles, but also increase emissions due to construction and/or reliance on buses.
- Construction of rapid transit alternatives carries some risk of environmental impacts that would require mitigation. All alternatives travel through urban areas and on road ROW; potential impacts on biodiversity, water resources, parks and open space and agricultural land are modest. The alternatives passing over Nicomekl and Serpentine rivers are viewed as having greater potential for impacts.
- All rapid transit alternatives produce noise and vibration, with RRT having the most potential impact (due to noise).

Exhibit 3.33 – Environment Account Ratings Summary



3.4 Urban Development Account

Brief Overview

The urban development account evaluates the performance of the alternatives against the following project objectives:

- *Rapid transit is supported by land use planning that promotes density and diversity of uses, as outlined in regional and local land use plans.*
- *Rapid transit supports city shaping by encouraging municipalities to focus development at urban centres and at other nodes along frequent transit development corridors.*
- *Rapid transit is supported by integration of the station areas and surrounding neighbourhoods through community land use plans that incorporate transit-oriented development guidelines and high quality urban design,.*
- *Rapid transit encourages appropriate levels of development around stations*.

The urban development account considers the benefits and impacts on local land uses and the urban environment, including how alternatives connect to key activity centres, the likelihood of development near stations, the impacts on properties along the alignment and urban design potential.

The urban development criteria include:

3.4.1. Land use integration

3.4.2. Land use intensification potential

3.4.3. Property requirements

3.4.4. Urban design

These are described in detail in the following pages. Further details of the urban development analysis are documented in **Appendix 3D**.

3.4.1 Land Use Integration

Approach

Land use integration assesses how each alternative connects the designated urban centres and major activity centres within the study area. The land use integration measures are:

- Number of designated urban centres
- Number of existing/future activity centres.
- Integration with existing/future activity centres.

The land use integration measures were evaluated on the basis of the conceptual designs. All rapid transit alternatives connect to a number of designated urban centres[8] and activity centres, including shopping centres, civic centres, hospitals, recreational facilities and post secondary institutions. The activity centres within 400m of a rapid transit station were counted and the alternatives rated based on the number of activity centres within 400m of a rapid transit station.

[8] Urban centres are intended to be the region's primary focal points for concentrated growth and transit service. They are intended as priority locations for employment and services, higher density housing, commercial, cultural, entertainment, institutional and mixed uses. (Metro Vancouver 2040 Regional Growth Strategy)

The integration with existing/future activity centres was measured by calculating the average distance from each activity centre to the transit station and comparing the results across each rapid transit alternative. The results of the land use integration assessment are presented in **Exhibit 3.34**.

Results

The alternatives with the greatest extent would connect to the most existing urban centres and existing and future activity centres (BRT 1, BRT 2, LRT 1, LRT 2, LRT 3, LRT 5A, LRT 5B, and RRT 2). The alternatives with the least extent (RRT 1, LRT 4 and RRT 3) would serve fewer existing/future activity centres. Best Bus did not improve the connection of urban centres and major activity centres to rapid transit, relative to BAU.

The majority of the rapid transit alternatives rated as better with a score of "5" since most would connect five or six of the urban centres in the study area. LRT 4, RRT 1 and RRT 3 would connect fewer urban centres and activity centres, but still rated better than BAU with a score of "4." Best Bus would not extend rapid transit and therefore rated "3" (same as BAU).

3.4.2 Land Use Intensification Potential

Approach

Land use intensification potential examines the likelihood of development within a 400-metre buffer around station areas based on established rates of development, known development sites and local land use and development policy (adopted or anticipated). The land use intensification potential measures are:

- Access to redevelopment opportunities (capacity in station areas); and
- Land use intensification potential (demand attracted to station areas by 2041).

Access to redevelopment opportunities was evaluated based on theoretical residual development capacity and the likeliness of sites to be redeveloped. Using parcel level data submitted by project partners, the analysis comprised a review of existing and planned conditions that considered vacant parcels, existing developments, and developments that are planned or under construction. The theoretical capacity of each site (in a 400-metre buffer from the assumed station areas) was measured as the OCP/NCP (or anticipated plan) density minus the existing land use. It was assumed that sites did not qualify as redevelopment candidates if the potential value (built out FAR) did not exceed the existing value in the assessment data by more than 50%. The 50% threshold was assumed to be sufficient incentive to redevelop a property. Other sites excluded from the stock of development candidates included publicly owned buildings, buildings under strata ownership, and recent construction of significant value (new high-cost buildings are less likely to redevelop in under thirty years).

To estimate the land use intensification potential, a market analysis was conducted to provide a forecast projection of the long-term demand for high-density office and residential development in the study area. This total demand was held constant between alternatives, with the amount locating in station areas being variable across alternatives. Based on land use projections (including RGS) of population and employment, estimates were made of how much apartment and multi-storey office development would occur in the study area. This BAU demand was allocated to the urban centres according to recent trends and future land use projections. The BAU assumed that since Surrey Metro Centre is already served by existing RRT, has reasonable road access, a concentration of amenities (such as the library and new city hall), and the highest planned densities, it would attract a high proportion of high-density development.

Exhibit 3.34 – Land Use Integration Assessment

	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Urban Centres Directly Served by RT	1	6	5	6	6	5	3	6	6	3	6	5	2
Large Activity Centres													
Number of activity centres within 400m including commercial/office with 500+ emp		**24**	**22**	**24**	**24**	**22**	**13**	**24**	**24**	**16**	**24**	**22**	**9**
Integration with existing/future major activity centres (m)													
Distance from stations (average)		140	143	140	140	143	156	140	140	123	140	143	172
Medium and Large Activity Centres													
Number of activity centres within 400m including commercial/office with 300+ emp		**33**	**29**	**33**	**33**	**29**	**19**	**33**	**33**	**19**	**33**	**29**	**13**
Integration with existing/future major activity centres (m)													
Distance from stations (average)		157	148	157	157	148	153	157	157	141	157	148	159
Evaluation Rating	**3**	**5**	**5**	**5**	**5**	**5**	**4**	**5**	**5**	**4**	**5**	**5**	**4**

For the rapid transit alternatives, the proportion of development that could be expected to locate within 400 metres of transit stations was calculated based on recent real estate data for municipalities that already have RRT in Metro Vancouver. The real estate analysis indicated that rapid transit helps to concentrate the high-density market. The allocation to each subarea differed from the BAU, where the added accessibility provided by rapid transit would shift some of the development market between the subareas. Much of the demand would still be in Surrey Metro Centre, but the rest would concentrate around new stations in other urban centres.

The results of the land use intensification assessment are presented in **Exhibits 3.35 and 3.36**. The methodology and results are discussed in more detail in Appendix 3D.

Results

The range of redevelopment opportunities at stations depended in part on the extent of the alternatives. For the most extensive alternatives, nearly 60 million square feet of build-out capacity was identified for parcels that were considered redevelopment candidates in the next thirty years. There was a concentration of redevelopment opportunities around the existing stations in Surrey Metro Centre, 18 million square feet, because the densities included in the City Centre Plan are higher than typical of most of the City of Surrey. These stations in Surrey Metro Centre were included in the BAU and all of the alternatives. Approximately 40 million square feet of capacity was identified within 400 metres of stations in the remainder of the study area. (There is also substantial additional capacity between the stations along the corridors, as well as throughout the study area, though this was not assessed in detail as part of this study; the total available capacity far exceeded estimated demand).

All rapid transit alternatives would connect to additional development capacity (the amount of office and high density residential development that could theoretically be built based on current, planned and emerging municipal zoning, planned densities and anticipated policies). All of the alternatives would have sufficient development capacity around proposed stations to accommodate forecast demand, based on existing land use and current and emerging municipal plans. Therefore, demand would not be constrained by the supply of land.

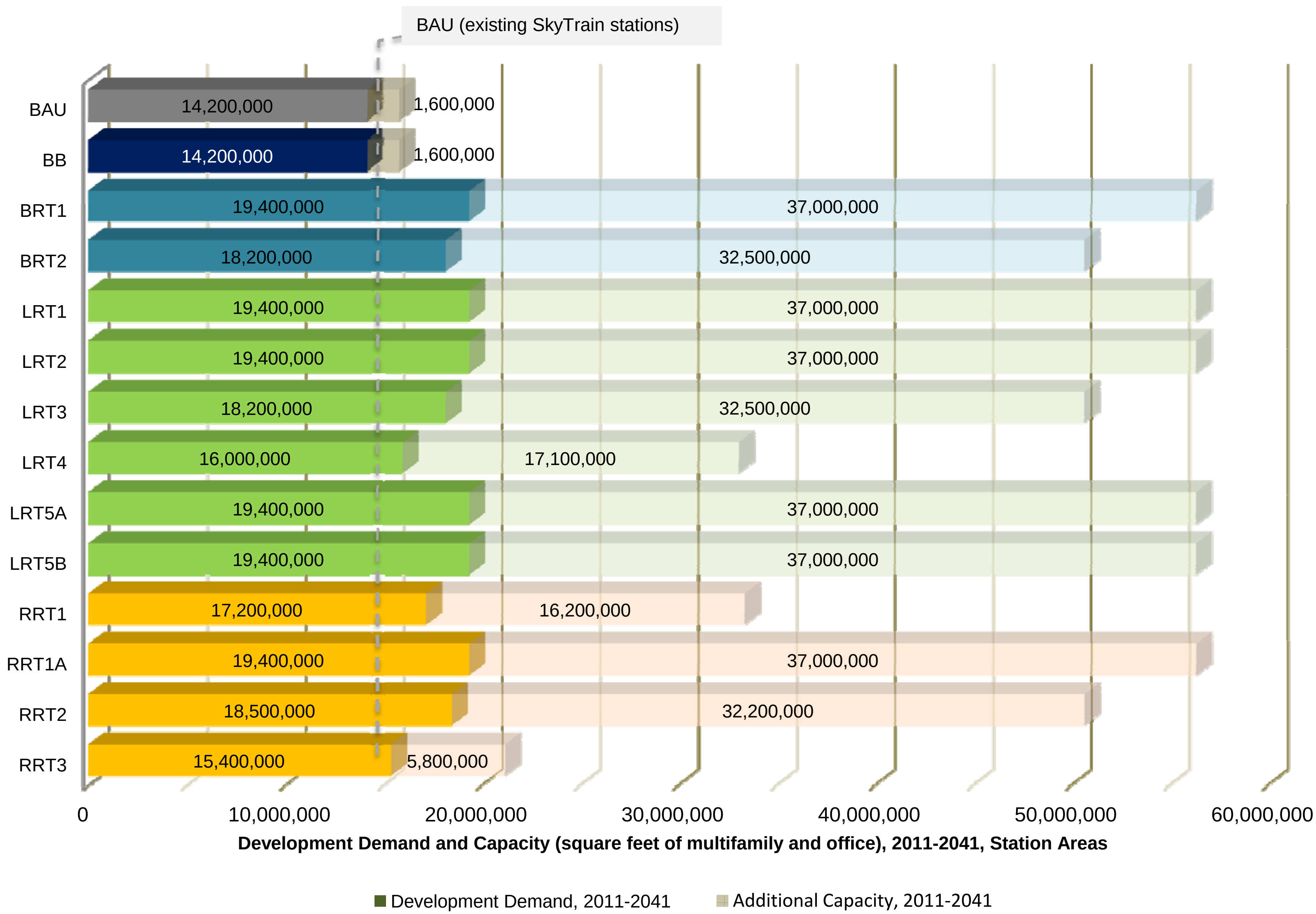
The alternatives are also forecast to intensify development demand around station areas. The amount of land use intensification potential depends on the size of the market for apartments and multi-storey offices. Much of the new development in the study area over the next 30 years is forecast to be low to medium density ground-oriented development, including single family homes, townhouses and office parks. The overall high-density development forecast for the study area for the next thirty years has a range of 45 to 50 million square feet. The greatest concentration of higher density residential and office development over the 30 year period is forecast to be in Surrey Metro Centre around existing SkyTrain stations. This is consistent with the RGS and with Surrey's City Centre Plan, where significant additional density is permitted on most sites around the rapid transit stations and arterial corridors (i.e. King George Blvd and 104 Avenue).

The alternatives were forecast to support 14.2 million to 19.5 million square feet of high-density development in station areas, with Best Bus at the low end (not adding any stations to those in BAU), and the most extensive alternatives supporting 19.5 million square feet. (For context, 1 million sq ft of development is equivalent to approximately four 25-storey towers, or twelve large 4-storey apartments.) It should be noted that the forecast assumes 40% of all high-density development would occur within 400 metres of station areas; this is a fairly significant concentration given that the station areas make up less than 5% of the total land in the study area.

Exhibit 3.35 – Land Use Intensification Potential - Access to Redevelopment Opportunities and Demand in Station Areas

	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5a	LRT 5b	RRT 1	RRT 1a	RRT 2	RRT 3
Access to Revelopment Capacity														
Total redevelopment candidates (within 30 years) in station areas	**145**	**145**	**885**	**765**	**885**	**885**	**765**	**530**	**885**	**885**	**380**	**885**	**765**	**270**
Total number of properties within 400 m of station areas	300	300	4400	3500	4400	4400	3500	1900	4400	4400	1900	4400	3500	950
Percentage of properties which are pre-2041 redevt candidates	48%	48%	20%	22%	20%	20%	22%	28%	20%	20%	20%	20%	22%	28%
Total redevelopment parcel area (sq.ft)	**3,100,000**	**3,100,000**	**28,300,000**	**24,200,000**	**28,300,000**	**28,300,000**	**24,200,000**	**12,100,000**	**28,300,000**	**28,300,000**	**15,300,000**	**28,300,000**	**24,200,000**	**6,100,000**
Total Area within 400m of Stations (sq.ft)	10,800,000	10,800,000	135,000,000	102,600,000	135,000,000	135,000,000	102,600,000	59,400,000	135,000,000	135,000,000	54,000,000	135,000,000	102,600,000	32,400,000
Percentage of parcel area within redevelpment candidates by 2041	29%	29%	21%	24%	21%	21%	24%	20%	21%	21%	28%	21%	24%	19%
Total redevelopment capacity at stations (sq.ft)	**15,800,000**	**15,800,000**	**56,400,000**	**50,700,000**	**56,400,000**	**56,400,000**	**50,700,000**	**33,100,000**	**56,400,000**	**56,400,000**	**33,400,000**	**56,400,000**	**50,700,000**	**21,200,000**
Capacity at existing stations in Surrey Centre	15,800,000	15,800,000	15,800,000	15,800,000	15,800,000	15,800,000	15,800,000	15,800,000	15,800,000	15,800,000	15,800,000	15,800,000	15,800,000	15,800,000
Total new redevelopment capacity at other stations (sq.ft)	-	-	40,600,000	34,900,000	40,600,000	40,600,000	34,900,000	17,300,000	40,600,000	40,600,000	17,600,000	40,600,000	34,900,000	5,400,000
Land Use Intensification (Demand) in Station Areas														
Square Feet of Development within 400 m, through 2041														
Estimated Office Demand	1,580,000	1,580,000	2,060,000	1,980,000	2,060,000	2,060,000	1,980,000	1,840,000	2,060,000	2,060,000	1,940,000	2,060,000	1,980,000	1,760,000
Estimated Apartment Demand	12,660,000	12,660,000	17,310,000	16,210,000	17,310,000	17,310,000	16,210,000	14,190,000	17,310,000	17,310,000	15,290,000	17,310,000	16,490,000	13,670,000
Total Land Use Intensification	**14,200,000**	**14,200,000**	**19,400,000**	**18,200,000**	**19,400,000**	**19,400,000**	**18,200,000**	**16,000,000**	**19,400,000**	**19,400,000**	**17,200,000**	**19,400,000**	**18,500,000**	**15,400,000**
Net from BAU	-	-	5,200,000	4,000,000	5,200,000	5,200,000	4,000,000	1,800,000	5,200,000	5,200,000	3,000,000	5,200,000	4,300,000	1,200,000
Evaluation Rating	**n/a**	3	4	4	4	4	4	4	4	4	4	4	4	3

Exhibit 3.36 – Land Use Intensification Potential: 30-Year Station Area Development Demand and Additional Capacity



All of the rapid transit alternatives would provide increased opportunities for land use intensification around stations, with greater extent alternatives accessing the most development capacity. However, since most development over the next 30 years was already forecast to continue concentrating around existing stations, then most of the rapid transit alternatives were rated as better than BAU with a score of “4.” Due to its small extent (connecting only Surrey Metro Centre and Newton), RRT 3 was assessed as having only minor impacts to land use intensification, and scored “3” since the resulting land use would be similar to BAU. Best Bus would have limited ability to shape land use and also rated a score of “3.

3.4.3 Property Requirements

Approach

The property requirements criterion assesses the impact on private or commercial properties in order to build and operate the system. The property requirements measures include:

- Number of impacted properties by type during operation.
- Number of impacted properties by type during construction.
- Property effects/risks in regionally significant areas.

While precise property requirements will not be known until more detailed design is undertaken, the scale of the impact has been identified here and included in the cost estimates for each alternative. No specific locations for an OMC were identified in this assessment, but costs were developed for the financial account, based on representative sites of sufficient size along potential LRT routes.

The measures were calculated on the basis of conceptual engineering designs of each alternative. The impacted properties by type were summed based on whether they are required for the construction period or during operation of the transit facility. (Portions of some parcels required for construction can be re-assembled and redeveloped, and would no longer be required by the project during the operating period).

Key assumptions for the identification of property effects included:

- Right-of-way effects of adjacent projects, such as the Roberts Bank Rail Corridor grade separations, and City plans for changes to various cross streets throughout the study area, were not counted as rapid transit related. Only net additional property strictly related to fitting rapid transit was counted;
- Property requirements are based on where the proposed roadway design infringed on buildings and parking lots. If the projected property line would pass through part of a building, then the whole parcel was assumed to be required. Also, if the projected property line would remove more than 20% of the on-site parking supply or completely cut off access to the site, then the whole parcel was assumed to be affected; and
- Slivers of land were treated as partial property takes.

The assessment of property requirements is summarized in **Exhibit 3.37**. Additional details, including the number of properties by corridor, are discussed in Appendix 3D.

Results

Property impacts are required for all alternatives, with the exception of Best Bus. However, as the alternatives are largely within existing public rights of way and designed to minimize impact, the overall effect is expected to be limited.

Exhibit 3.37 – Property Requirements

		BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5a	LRT 5b	RRT 1	RRT 1A	RRT 2	RRT 3
Full takes														
Number of impacted properties by type during construction	residential	-	2	2	2	2	2	1	2	2	2	3	8	7
	commercial	-	34	34	34	34	34	15	34	34	17	32	31	0
	comprehensive development	-	1	1	1	1	1	1	1	1	0	1	5	4
	other	-	1	1	1	1	1	1	1	1	0	1	1	0
	total	**-**	**38**	**38**	**38**	**38**	**38**	**18**	**38**	**38**	**19**	**37**	**45**	**11**
Number of impacted properties by type during operation	no resale potential	-	3	3	3	3	3	0	3	3	2	2	10	7
	unlikely resale potential	-	11	11	11	11	11	2	11	11	8	10	11	1
	Resale potential after construction	-	24	24	24	24	24	16	24	24	9	25	24	3
	No/Unlikely Resale													
	residential	-	0	0	0	0	0	0	0	0	1	1	7	7
	commercial	-	13	13	13	13	13	1	13	13	9	10	13	0
	comprehensive development	-	1	1	1	1	1	1	1	1	0	1	1	1
	other	-	0	0	0	0	0	0	0	0	0	0	0	0
	Total retained during operations	-	14	14	14	14	14	2	14	14	10	12	21	8
Partial takes - parcels affected		**-**	**398**	**370**	**398**	**398**	**370**	**220**	**398**	**398**	**101**	**349**	**311**	**38**
Evaluation Rating		**3**	**2**	**2**	**2**	**2**	**2**	**3**	**2**	**2**	**2**	**2**	**2**	**3**

The alternatives limited to the urban core areas (LRT 4 and RRT 3) would have minor property impacts as they affect relatively few properties. Alternatives with greater extents would impact more properties, with the effects spread along the alignments of the alternatives.

There was a large variation between the alternatives in the number of properties (mostly commercial) that may be impacted across the study area - between 40 and 400 potential land takes. However, the majority of impacts would be limited to those resulting from road widening, which may not require more than one metre of frontage, without impacting buildings or significantly reducing parking. The alternatives with greatest extent generate the most potential impacts because they require more road widening.

The alternatives with the most limited extent (LRT 4 and RRT 3) rated a score of "3" (similar to BAU). Best Bus would have almost no impacts, and also rated a "3." All other rapid transit alternatives rated a score of "2" because they would have greater property requirements, which is worse than BAU.

3.4.4 Urban Design

Approach

The urban design criterion assesses changes to the urban environment, including the introduction of visual barriers, changes to the streetscape, and pedestrian facilities, through the introduction of the rapid transit alternatives in the study area. The urban design measures are:

- Pedestrian experience.
- Placemaking potential.

The pedestrian experience was calculated by comparing the measurements of existing and proposed sidewalk widths, buffer distance of pedestrians from adjacent traffic and the scale of the street based on crossing distances.

The placemaking potential was calculated by determining which stations had opportunities to improve the local character by implementing improvements to the land made available from the construction and operation of rapid transit. The properties required in the immediate vicinity of stations provide the best opportunities to create a sense of place through improvements to the public realm. The results of the urban design assessment are presented in **Exhibit 3.38**.

Results

All of the alternatives would improve the pedestrian environment due to street reconstruction. The reconstruction could result in overall improvements to the pedestrian environment through widening of sidewalks and/or increases to boulevard widths. These improvements to the pedestrian realm would buffer pedestrians from vehicular traffic as well as reduce the crossing distances for pedestrians at some intersections.

Generally, the elevated guideway of the RRT alternatives would have a negative visual impact on the urban realm. RRT only alternatives (RRT 1 and RRT 3) have more negative visual impacts. The RRT alternatives that operate with BRT (RRT 1A and RRT 2) have negative visual impacts, but also provide positive pedestrian benefits due to street reconstruction required for BRT, and so their overall impact would not be as negative as RRT 1 or RRT 3. LRT overhead wires have some modest visual impact relative to BAU but are considered minor relative to the impact of introducing elevated guideway structures.

Exhibit 3.38 – Urban Design - Potential Effects

Alternatives	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Pedestrian Experience													
Average sidewalk width - existing		1.9	2.0	1.9	1.9	2.0	2.2	1.9	1.9	1.8	2.0	2.0	2.0
Average sidewalk width - proposed		2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Difference proposed to existing sidewalk widths		0.1	0.0	0.1	0.1	0.0	-0.2	0.1	0.1	0.2	0.0	0.0	0.0
Average buffer from adjacent traffic - existing		0.6	0.5	0.6	0.6	0.5	0.3	0.6	0.6	0.8	0.5	0.5	0.0
Average buffer from adjacent traffic - proposed		1.8	1.8	1.3	1.4	1.3	1.1	1.8	1.3	1.4	1.8	1.7	1.6
Average difference proposed to existing		1.3	1.3	0.8	0.9	0.8	0.8	1.2	0.8	0.6	1.3	1.2	1.6
Average scale of street based on crossing distances - existing		23.6	23.1	23.5	23.5	23.1	24.9	23.5	23.5	21.7	23.6	23.1	27.8
Average scale of street based on crossing distances - proposed		25.0	25.0	25.0	24.4	24.3	26.0	25.5	24.9	21.8	24.6	24.0	21.0
Average difference proposed to existing		-1.3	-2.0	-1.6	-0.9	-1.2	-1.1	-2.1	-1.4	-0.1	-0.9	-0.9	6.8
Comments		refuge added	refuge added	refuge added	refuge added	refuge added	refuge added	refuge added	refuge added	refuge added	refuge added	refuge added	refuge added
Placemaking Potential													
Number of stations with opportunities		4	4	5	5	5	2	4	4	3	4	5	1
Size of Opportunities(# of properties)		6	6	7	7	7	3	6	6	5	6	7	3
Visual Impacts													
Visual Enhancements (plantings around stations)		yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Extent of Route(s) - km	0	30.7	26.8	30.7	30.7	26.8	10.8	30.7	30.7	15.8	30.5	27.1	5.6
Extent of additional overhead wires	0	0.0	0.0	26.8	10.8	10.8	10.8	17.1	21.5	0.0	0.0	0.0	0.0
Extent of elevated Route (km)	0	0.8	0.8	0.8	0.8	0.8	0.0	0.8	0.8	15.8	15.8	6.4	5.6
Evaluation Rating	3	5	5	5	5	5	4	5	5	2	3	3	2

All alternatives, other than Best Bus, create opportunities at stations to enhance the surrounding character and amenities. Larger extent alternatives generate the most placemaking potential by making available more land around stations.

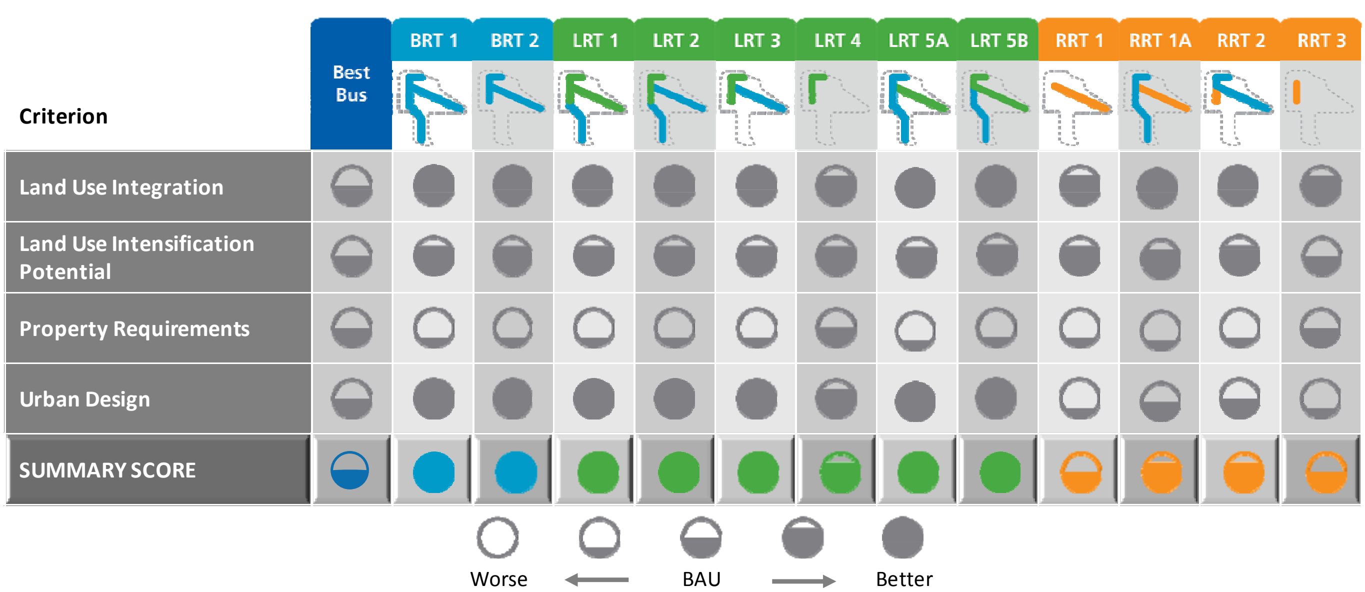
In summary, the more extensive BRT and LRT alternatives all rated as better with scores of “5” due to improvements in the pedestrian experience and placemaking potential. Due to its small extent LRT 4 was scored a “4.” RRT 1 and RRT 3 are exclusively SkyTrain with negative visual impacts, and rated as worse than BAU, with scores of “2.” RRT 1A and RRT 2 combine BRT and RRT elements with their associated urban design benefits and impacts, resulting in a net effect similar to BAU - “3”. Best Bus would not make any significant physical changes from BAU, so also rated a score of “3.”

3.4.5 Urban Development Account Key Points

The evaluation ratings for each of the criteria, and an overall summary rating for the account are indicated on **Exhibit 3.39**. These were the highlights of the urban development assessment:

- All rapid transit alternatives have the potential to intensify land use around stations with the greater extent alternatives accessing the most development capacity. All alternatives generate similar amounts of development demand (14 to 19 million square feet of high density development through 2041) with most of this development forecast around existing stations in Surrey Centre. The development around existing stations is in common with BAU.
- The BRT and LRT alternatives will improve urban design through widening of sidewalks and/or increases to boulevards. Elevated RRT alternatives have negative visual impacts due to their large guideway structures.
- All rapid transit alternatives require property to construct; LRT 4 and RRT 3 are shortest and require fewest properties.
- Overall, all rapid transit alternatives generate improvements in urban development. However, for RRT alternatives those benefits are balanced by negative urban design impacts.

Exhibit 3.39 – Urban Development Account Ratings Summary



3.5 Economic Development Account

Brief Overview

The economic development account evaluates the performance of the alternatives against the following project objectives:

- *Rapid transit supports economic development by improving transit access to urban centres and employment concentrations, and*
- *Rapid transit is compatible with the economic needs of the region, including goods movement.*

The economic development account measures the economic benefits and impacts of the rapid transit system, including the direct employment created by construction and any related increases in gross domestic product (GDP). It also assesses changes in tax revenues from income tax and fuel tax sources (but does not include changes in property taxes and other local taxes). The broader economic development effects of operating the system were not assessed at this stage of analysis, but may be included in a later phase of work as part of Business Case development. This account also assesses the impacts of implementing the alternatives on goods movement routes and access to local commercial, industrial and agricultural areas.

The economic development criteria include:

3.5.1. Construction Effects

3.5.2. Tax Revenue Effects

3.5.3. Goods Movement

The evaluation approach, assumptions and results are described for each of these criteria on the following pages.

3.5.1 Construction Effects

Approach

Construction effects are assessed according to the employment opportunities created through construction of the system. The assessment was based on benchmark values in the construction industry to ensure consistency with other rapid transit and construction projects in the region. Measures include:

- Employment (from construction) in person-years.
- Added Gross Domestic Product (GDP).

The main inputs to the assessment are the quantities for major construction materials (m^3 of concrete, tonnes of steel, and tonnes of asphalt) and the overall capital cost for the construction elements (all costs except vehicles and right of way). These major cost drivers were estimated based on typical unit amounts of each material for the types of construction for the BRT, LRT, RRT and Best Bus alternatives. The results were used in conjunction with economic multipliers from the British Columbia Input Output Model (BCIOM) to estimate construction-related employment (in person-years) and additional Gross Domestic Product (GDP) in 2010 dollars. The results of this assessment are shown on **Exhibit 3.40**.

Exhibit 3.40 – Economic Outputs from Construction

Alternatives	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Input: Materials - Order of Magnitude Estimate													
Concrete (m3)	8,200	34,000	29,000	127,000	73,000	69,000	48,000	92,000	109,000	248,000	261,000	120,000	94,000
Steel (t)	400	8,100	8,100	33,000	19,000	18,000	13,000	23,000	28,000	79,000	81,000	37,000	30,000
Asphalt (t)	31,000	285,000	245,000	171,000	237,000	198,000	55,000	215,000	196,000	17,000	158,000	201,000	7,000
Estimates include Alignment, Station, OMC materials													
Costs excluding property and real inflation (Millions, $2010)	$ 260	$ 730	$ 605	$ 1,895	$ 1,265	$ 1,160	$ 785	$ 1,430	$ 1,660	$ 1,615	$ 1,965	$ 1,315	$ 820
Estimated Outputs													
Employment (pers-yr)	780	6,400	5,100	14,700	10,200	9,300	6,700	11,500	13,200	16,000	19,100	12,100	7,700
Added GDP ($2010, Millions)	50	440	360	1,140	750	680	470	840	980	1,070	1,240	840	560
Evaluation Rating	3	4	4	5	4	4	4	4	4	5	5	4	4

Results

The exhibit includes the calculated outputs and the assessment ratings.

Generally, the alternatives with the largest extent would take longer to build, require more materials (especially concrete and steel) and have higher capital costs, and consequently output greater direct employment opportunities (labour required to supply and construct the alternatives) and GDP (money into the economy). LRT 1, RRT 1 and RRT 1A had the greatest construction effects, and rated as better than BAU with scores of “5”. All other rapid transit alternatives had intermediate outputs from construction, and rated as better with scores of “4”. The Best Bus Alternative would not require extensive construction and is similar to BAU, rating a score of “3”.

There may also be operating effects associated with ongoing employment generated by the alternatives. In general, it can be inferred that there are economic benefits attributable to better transportation infrastructure. These benefits could include direct benefits to users such as decreased transportation costs and increased productivity (reduction in commuting). Also, the general public may experience an increase in property values, the municipalities may benefit from additional property taxes, and the region may benefit from increased competitiveness. This was not assessed at this stage in the study.

3.5.2 Tax Revenue Effects

The tax revenue effects criterion assesses the direct increase in income tax (from construction employment) and sales taxes (from construction materials), and also estimates reductions in fuel tax revenues as a result of shifting trips from cars to transit. The specific measures for tax revenue effects included:

- Net federal/provincial taxes during construction.
- Net present value (NPV) of fuel tax reductions during operations.
- Net life cycle effects on federal and provincial taxes (sum of the previous two).

This assessment includes federal and provincial tax revenue effects only. The effects on property taxes and other local tax revenues were not estimated at this stage.

The following inputs and assumptions were used to estimate construction-related taxes:

- Income Tax on Construction Income. The estimated employment in person-years from the Construction Effects criterion was used as an input. To estimate net income taxes for this additional employment, average earnings of $35 per hour ($70,000 per person-year) and approximate income tax rate of 30% were assumed.
- Construction Materials Taxes. Taxes on construction materials assumed that approximately 20% of the capital cost (excluding property) fell into this category. A sales tax rate of 12% was applied to the materials portion of the capital costs.

The impacts on fuel tax revenues relied on outcomes from the travel demand model, and the following process was applied:

- The net change in VKT was taken from the transportation analyses for 2021 and 2041. The resulting reduction in fuel consumption was estimated assuming an average 10 kilometres per litre of fuel.
- The reduction in fuel taxes collected for 2021 and 2041 was estimated using the current tax rate of 27.95 cents per litre (BC Ministry of Finance). The NPV of fuel taxes for the thirty year operating period interpolated from those values and assumed a 6% discount rate.

The results of the tax revenue assessments (including the net results) are presented in **Exhibit 3.41**.

Results

Generally, the alternatives with the greatest construction effects would generate more employment and therefore would result in more income taxes and sales taxes on materials. The reduction in fuel taxes was an order of magnitude less than the income/construction/supplier taxes related to construction. LRT 1, RRT 1 and RRT 1A were rated as better (with a score of “5”), and all other rapid transit alternatives received a score of “4” to reflect their intermediate level of benefits.

3.5.3 Goods Movement

Approach

The goods movement criterion assesses the impact of rapid transit on how goods can move in the study area, focusing on the travel conditions on goods movement routes in the study area, and physical access to industrial and agricultural areas. Other vehicular access impacts are considered in the Social/Community account under community connectivity.

The qualitative assessment considered several quantitative factors related to goods movement, including:

- The number of intersections closed due to the design of the system.
- Driveway access closures to left turns, including industrial and agricultural accesses.
- Lane-kilometres of capacity remaining along goods movement routes. The assessment focused on King George Boulevard, 104th Avenue, 152nd Street, and Fraser Highway – the routes followed by one or more of the alternatives.
- The relative impacts of lane reallocation was assessed, based on average speeds on the goods movement routes.

The results for each of these factors, and the overall assessment, are summarized in **Exhibit 3.42**.

Results

All alternatives are compatible with goods movement and overall impacts were considered minimal, so the assessment considered the relative degree of impacts between alternatives.

Generally, alternatives with street-level alignments (BRT and LRT alternatives, and the BRT segments of RRT 1A, and RRT 2) would remove some lane capacity along parts of King George Boulevard, 104th Avenue, 152nd Street, and a short segment of Fraser Highway in the City of Langley. The areas with assumed lane reductions are projected to experience reduced average traffic speeds, with the reduced lane capacity partially offset by lower traffic volumes. While all alternatives maintain existing signalized intersections, the closure of the street median requires that non-signalized intersections become right-in/right-out. The surface alternatives would also close mid-block left turning movements across the corridors into a modest number of commercial sites, industrial properties and agricultural areas, affecting servicing and deliveries.

Street-level alternatives with the largest extent (BRT 1, LRT 1, LRT 2, LRT 5A, and LRT 5B) would have the greatest potential impact on travel conditions on goods movement routes. These alternatives rated as worse than BAU and in this relative assessment were assigned a score of “2.”

Exhibit 3.41 - Tax Revenue Effects

Alternatives	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Costs excluding property (Millions, $2010)	$ 260	$ 730	$ 605	$ 1,895	$ 1,265	$ 1,160	$ 785	$ 1,430	$ 1,660	$ 1,615	$ 1,965	$ 1,315	$ 820
Net Federal/Provinical taxes during construction													
Employment	16	130	110	310	210	200	140	240	280	340	400	250	160
Construction and Suppliers	6	20	10	50	30	30	20	30	40	40	50	30	20
Federal/Provincial Construction Taxes (Millions)	$ 22	$ 150	$ 120	$ 360	$ 240	$ 230	$ 160	$ 270	$ 320	$ 380	$ 450	$ 280	$ 180
Net fuel taxes during operations													
Input: Annual Vehicle Km Travel Reductions													
VKT Reduction, 2021, Millions	39.2	39.9	34.1	23.5	34.1	38.5	10.0	35.6	29.0	52.9	69.2	52.6	25.3
VKT Reduction, 2041, Millions	38.1	55.4	45.3	56.9	54.2	46.6	21.7	51.5	61.5	46.5	85.6	60.3	25.6
Fuel tax (Dedicated+Provincial) reductions													
Fuel Tax Reduction, 2021	1,096,000	1,115,000	953,000	657,000	953,000	1,076,000	280,000	995,000	811,000	1,479,000	1,934,000	1,470,000	707,000
Fuel Tax Reduction, 2041	1,065,000	1,548,000	1,266,000	1,590,000	1,515,000	1,302,000	607,000	1,439,000	1,719,000	1,300,000	2,393,000	1,685,000	716,000
NPV, 6% Discounted Over 30 Years	$ 8,800,000	$ 10,700,000	$ 9,000,000	$ 8,900,000	$ 9,900,000	$ 9,600,000	$ 3,500,000	$ 9,800,000	$ 10,100,000	$ 11,400,000	$ 17,500,000	$ 12,800,000	$ 5,800,000
NPV, net Federal/Provincial taxes ($Millions)	**$ 13**	**$ 139**	**$ 111**	**$ 351**	**$ 230**	**$ 220**	**$ 157**	**$ 260**	**$ 310**	**$ 369**	**$ 433**	**$ 267**	**$ 174**
Evaluation Rating	**3**	**4**	**4**	**5**	**4**	**4**	**4**	**4**	**4**	**5**	**5**	**4**	**4**

Exhibit 3.42 - Goods Movement Effects

Alternatives	**BAU**	**BB**	**BRT 1**	**BRT 2**	**LRT 1**	**LRT 2**	**LRT 3**	**LRT 4**	**LRT 5A**	**LRT 5B**	**RRT 1**	**RRT 1A**	**RRT 2**	**RRT 3**
No. Of Intersections on Alignment	113	113	113	92	113	113	92	43	92	92	39	113	92	22
No. Of Intersection Converted (right-in/right-out only)	0	0	31	30	31	31	30	18	30	30	18	31	30	7
Closed by median for LRT/BRT (for segregation)	0	0	31	30	31	31	30	18	30	30		13	23	
Closed by median for RRT (because of traffic sight lines)											18	18	7	7
Total Intersections Remaining Open (on KGB + 104 Av + Fraser Hwy + 152 in South Surrey)	113	113	82	83	82	82	83	95	83	83	95	82	83	106
Left Turn Driveway Access Closures	0	0	11	11	11	11	11	3	11	11	8	11	11	1
Goods Movement Route Effects														
Lane-km reallocated from routes	0.0	2.4	12.7	12.7	12.7	12.7	12.7	11.2	12.7	12.7	0.8	12.0	11.2	1.3
Total Lane-Km remaining (includes RT alignments only)	172	170	159	159	159	159	159	161	159	159	171	160	161	171
Impact of Lane Reallocation (Average Speeds, 2041 AM Peak Hour)														
KGB, 96 to Fraser Hwy	51.3	41.7	41.6	41.9	41.8	41.9	42.0	42.8	41.9	41.9	51.2	51.2	41.7	40.5
104th Avenue at 140th	45.8	45.7	44.6	44.6	44.6	44.6	44.4	44.2	44.8	44.8	46.7	44.6	44.9	46.0
152 Street, 24th to 20th	43.8	42.3	42.6	43.6	42.8	42.9	43.7	43.7	42.5	42.5	43.7	42.6	43.7	43.7
Evaluation Rating		**3**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**3**

BRT 2 and LRT 3 would avoid any impacts between Newton and White Rock, resulting in somewhat fewer overall impacts, but maintained a score of “2”. While LRT 4 has a very small extent, it would overlap two significant goods movement routes (104th Avenue and King George Blvd in the City Centre), and so was also rated a score of “2”.

Elevated RRT places columns in the street median, and therefore would also require closing minor intersections (because sight lines would be blocked by the guideway columns if minor intersections were kept open). Changes to goods movement lane capacity for the RRT would be limited to King George Blvd just south of King George Station (on RRT 2 and RRT 3), and to Fraser Highway just east of 200th Street. Average speeds on the goods movement routes are forecast to be reduced slightly in these areas, but overall the RRT segments would result in small speed increases on goods movement routes, where lane capacity was retained and traffic volumes decreased. RRT alternatives would, however, have some impacts on mid-block left-turning movements across the corridors due to the location of guideway columns in the roadway median.

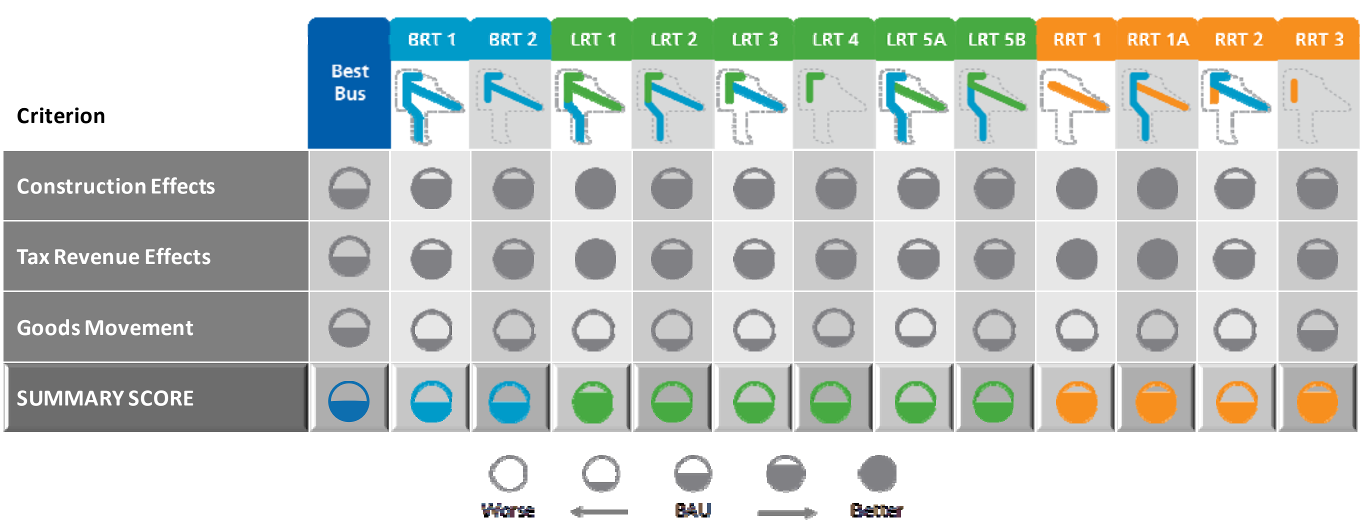
RRT 1 and RRT 1A were rated worse than BAU (“2”) due to the closure of minor intersections and driveway accesses. RRT 2 was also rated a “2”, primarily due to its BRT segments along 104th Avenue and Fraser Highway. RRT 3 was rated similar to BAU (score of “3”) because its impacts on intersections would be modest due to its shorter extent, and overall the alternative would result in faster speeds on goods movement routes.

3.5.4 Economic Development Account Key Points

The evaluation ratings for each of the criteria, and an overall summary rating for the account are indicated on **Exhibit 3.43**. These were the highlights of the economic development assessment:

- The construction of rapid transit is expected to generate benefits associated with employment and increases in GDP;
- The capital intensive alternatives have higher construction and tax revenue benefits and perform better (LRT 1, RRT 1, RRT 1A)
- There are some impacts to goods movement for the street−level alternatives due to localized lane reductions and mid - block turn closures, and to a lesser degree for the SkyTrain alternatives due to the placement of guideway columns.
- Overall, the positive impacts associated construction and tax revenue effects are balanced by the negative goods movement impacts for most alternatives.

Exhibit 3.43 – Economic Development Account Ratings Summary



3.6 Social / Community Account

Brief Overview

The social / community account evaluates the performance of the alternatives against the following project objectives:

- *Rapid transit and the supporting transit network provide benefits to and do not disproportionately impact disadvantaged groups; and*
- *Rapid transit is safe, accessible and secure.*

The social/community account measures the social /community benefits and impacts of the rapid transit system, including the operational safety, personal security, and community connectivity. It also assesses the ability of the rapid transit system to service low income populations. Finally, it reviews interaction of the rapid transit system with known heritage and archaeological sites.

The social / community criteria include:

3.6.1. Operational Safety

3.6.2. Personal Security

3.6.3. Community Connectivity

3.6.4. Low Income Population Served

3.6.5. Heritage and Archaeology

3.6.1 Operational Safety

Approach

The operational safety criterion assesses the relative operating safety of the alternatives, including the safety of rapid transit operations on the road or guideway. The measures include:

- Kilometres of elevated routes.
- Kilometres of segregated at grade routes.

This measure was assessed qualitatively using the operating plan of each alternative and considered risks based on available precedent data. The detailed results are contained in **Exhibit 3.44.**

Results

All of the rapid transit alternatives would improve operational safety. The BRT and LRT alternatives would provide an improvement over mixed-traffic operations because they would be separated from traffic. The street level alternatives with the greatest extent (BRT 1, BRT 2, LRT 1, LRT 2, LRT 3 LRT5A, LRT 5B) would provide the most opportunities to improve operational safety since they provide a more extensive separation of operations from traffic, and consequently scored “5”. (Differences between the surface rapid transit technologies were not assessed in detail in Phase 2; tradeoffs would include number and type of transit/traffic conflicts, safety attributes of each technology, and other operational details. In either case, moving more passengers in a segregated running way rather than mixed traffic enhances safety.)

Exhibit 3.44 - Operational Safety

	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Extent of Route(s) - km		**39.6**	**26.8**	**39.6**	**39.6**	**26.8**	**10.8**	**39.6**	**39.6**	**15.8**	**39.4**	**27.1**	**5.6**
Elevated Route (km)		0.8	0.8	0.8	0.8	0.8	0.0	0.8	0.8	15.8	15.8	6.4	5.6
Shared Lanes (km)		10.5	2.0	10.5	10.5	2.0	0.0	10.5	10.5	0.0	8.5	2.0	0.0
Segrated At Grade (km)	1.2	28.3	24.0	28.3	28.3	24.0	10.8	28.3	28.3	0.0	15.1	18.7	0.0
No. of Intersections at-grade	n/a	64	52	64	64	52	21	64	64	0	33	39	0
At-grade intersections per km of route		1.6	1.9	1.6	1.6	1.9	1.9	1.6	1.6	0.0	0.8	1.4	0.0
% Elevated		2%	3%	2%	2%	3%	0%	2%	2%	100%	40%	24%	100%
% Shared Running		27%	7%	27%	27%	7%	0%	27%	27%	0%	22%	7%	0%
% Segregated At Grade		71%	89%	71%	71%	89%	100%	71%	71%	0%	38%	69%	0%
Evaluation Rating	3	5	5	5	5	5	4	5	5	4	5	5	4

The RRT segments would provide the greatest improvements in operational safety per kilometre because they are fully grade-separated, which removes opportunities for conflict with other transportation modes. As with the street level alternatives, the RRT alternatives with the greatest extent (RRT 1A and RRT 2) would provide the most overall operational safety improvements. The Best Bus alternative would have limited changes to infrastructure from BAU, and therefore was assessed a score of “3”.

3.6.2 Personal Security

Approach

The personal security criterion assesses the relative impacts on perception of personal security at transit stations and onboard rapid transit vehicles. The personal security measures include:

- Number of elevated stations.
- Number of at-grade stations.

A qualitative assessment of personal security was conducted that considered the presence (or absence) of staff on board, staff at stations, safety amenities (CCTV, Help Point, real-time information), and the proximity to the street. The personal security assessment is contained in **Exhibit 3.45**.

Results

All alternatives were considered safe and further station and vehicle design development has the potential to mitigate perceived safety risks. The street level BRT and LRT alternatives would maintain the same level of perceived safety as Best Bus and BAU, “3”, as the at-grade stops and stations are visible from the street, and all vehicles would have a driver onboard.

During less busy parts of the day and evening, more isolated stations are perceived as less safe by passengers. Therefore, all the RRT alternatives, on the RRT technology portion of the route, have a negative impact on perceived personal security and are rated “2” because station platforms are elevated and not visible from the street and do not have a driver onboard the vehicle.

Exhibit 3.45 – Personal Security

Station Type	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Elevated													
Existing	4	4	4	4	4	4	4	4	4	4	4	4	4
New										8	8	4	4
At-Grade													
Off-Street		1	1	1	1	1		1	1		0	1	
4-Lane		7	7	7	7	7	6	7	7		6	7	
6-Lane		13	11	13	13	11	5	13	13		7	7	
Evaluation Rating	3	3	3	3	3	3	3	3	3	2	2	2	2

3.6.3 Community Connectivity

Approach

The community connectivity criterion examines the impact on connectivity within the study area as a result of changing pedestrian and vehicular crossings, or the creation of a physical barrier. The community connectivity measures include:

- Existing pedestrian crosswalks (number).
- Planned pedestrian crosswalks (number).
- Existing cycling crossings (marked crossings).
- Planned cycling crossings (number).
- Vehicle crossing points:
    - Signalized intersections
    - Mid-block crossings (existing)
    - Mid-block becoming right-in/right-out (because of rapid transit design).
- Total number of projected crossing points, across all modes.
- Psychological impact of visual barrier across the community.

The community connectivity measure was assessed on the basis of the conceptual design and setting. As a proxy measure for connectivity the number of cross traffic locations, including vehicles, pedestrians and cyclists were considered. The community connectivity assessment results are presented in **Exhibit 3.46.**

Results

All of the alternatives would have minimal impact on pedestrian and cyclist crossings. Existing pedestrian and cyclist crossings would be maintained for all of the alternatives.

Street-level improvements would result in a net improvement in the pedestrian and cycling environment with the addition or widening of pedestrian refuges and improved crossings. With the removal of some vehicular crossings, there would be a negative impact on vehicular connectivity. The more extensive alternatives would have greater potential positive impacts on pedestrian and cycling connectivity and negative impacts on vehicular connectivity. The street level alternatives included both positive and negative impacts, and so overall were rated the same as BAU (score of “3”).

The RRT alternatives were ranked lower, “2”, due to the visual impacts they would induce, and their lack of the positive bicycle and pedestrian impacts of the street-level alternatives.

Exhibit 3.46 – Community Connectivity

	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT5B	RRT 1	RRT 1A	RRT 2	RRT 3
Number of existing pedestrian crosswalks (on Fraser, KGB, 104, 152)	123	123	123	123	123	123	123	123	123	123	123	123	123	123
Expected pedestrian crosswalks	123	123	123	123	123	123	123	123	123	123	123	123	123	123
Anticipated crossing improvements for surface alternatives			1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2		1-2	1-2	
Existing cycling crossings (on routes/common use)	66	66	66	66	66	66	66	66	66	66	66	66	66	66
Expected cycling crossings (on routes/common use)	64	64	57	62	57	55	60	65	57	57	64	64	60	64
Reduction - affects unmarked common use crossings	2	2	9	4	9	11	6	1	9	9	2	2	6	2
Relocation of unmarked crossings to nearby signals (safety enhancement)	n/a	n/a	yes	yes	yes	yes	yes	yes	yes	yes	n/a	n/a	yes	n/a
Vehicle Crossing Points (original) *Intersections/Driveway*	113	113	113	113	113	113	113	113	113	113	113	113	113	113
Intersections Becoming Right-In/Right Out	0	0	31	30	31	31	30	18	30	30	18	31	30	7
Total Crossing Points Remaining	113	113	82	83	82	82	83	95	83	83	95	82	83	106
Barrier (Visual)	no	no	no	no	no	no	no	no	no	no	Yes, Fraser Highway	Partial: Fraser Highway	Partial: KGB	Yes, KGB
Total expected number of crossing pointss	300	300	262	268	262	260	266	283	263	263	282	269	266	293
Evaluation Rating		**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**2**

3.6.4 Low Income Population Served

Approach

Low income population served examines how well the alternatives connect low-income and transit-dependent social groups/communities to jobs and public services based on land use and census data for the area around each station. The low income population served measure was analyzed based on the station locations and the number of low income individuals within the vicinity. The travel time from place of residence to employment was considered for areas with low-income concentrations. The low income population served measures include:

- Total number of households within 800 metres of stations, with an annual income less than $30,000.
- Ratings of travel times from Surrey Central to the town centres within the study area.

Exhibits 3.47 and **3.48** show the results of the analysis.

Results

Across the study area there is an uneven distribution of number of households with annual incomes less than $30,000, as indicated by **Exhibit 3.47.**

Exhibit 3.47 – Map of Low Income Concentrations in Study Area

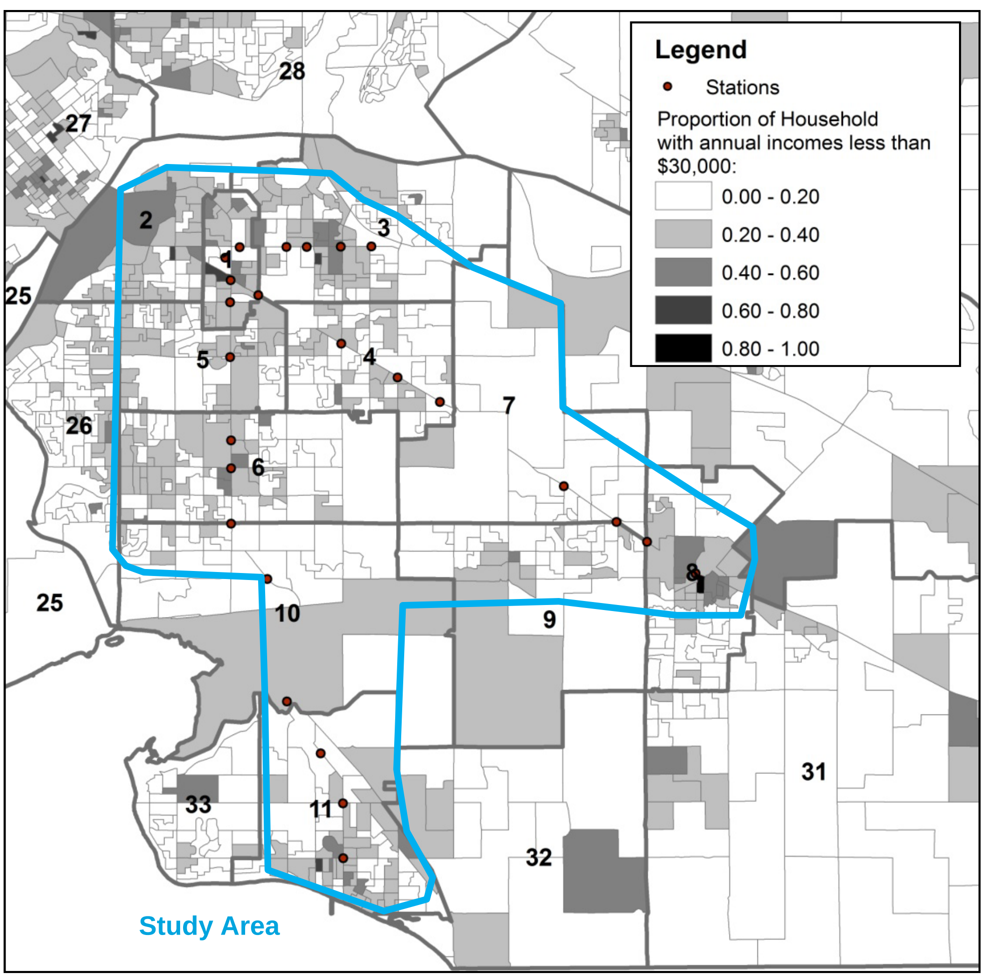


Exhibit 3.48 – Low Income Population Served

	BB	BRT 1	BRT2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5A	RRT 1	RRT 1A	RRT 2	RRT 3
800M Buffer from Transit Stations													
Private households reporting income in 2005		45,817	33,647	45,817	45,817	33,647	20,034	45,817	45,817	17,350	45,817	33,647	11,300
Under 10K		2,404	1,944	2,404	2,404	1,944	1,293	2,404	2,404	932	2,404	1,944	773
Between 10K-20K		5,106	3,844	5,106	5,106	3,844	2,459	5,106	5,106	1,984	5,106	3,844	1,458
Between 20K-30K		5,162	3,747	5,162	5,162	3,747	2,412	5,162	5,162	1,765	5,162	3,747	1,196
Total HH under 30K		12,672	9,535	12,672	12,672	9,535	6,164	12,672	12,672	4,681	12,672	9,535	3,427
Evaluation Rating	4	5	5	5	5	5	4	5	5	4	5	5	3

Depending on the alternative, approximately 28% to 32% of the private households within 800m of stations reported household incomes less than $30,000 in 2005. The greatest concentrations of low-income households in the study area were around Surrey City Centre and along 104th Avenue.

Generally, all of the alternatives would provide positive benefits to low-income households concentrated around Surrey City Centre. The alternatives with the greatest extent (BRT 1, BRT 2, LRT 1, LRT 2, LRT 3, LRT 5A, LRT 5B, RRT 1A and RRT 2) would provide the greatest benefit and are rated a “5”. The remaining alternatives (LRT 4, RRT 1, and RRT 3) would improve access to many concentrations of jobs and services within the study area, but have a more limited extent.

3.6.5 Heritage and Archaeology

Approach

The heritage and archaeology criterion assesses the potential for impacts of the rapid transit alternatives on known sites of heritage or archaeological importance. GIS data[9] was used to identify potential impacts where sites overlap the right of way limits of the alignment based on the conceptual design. The heritage and archaeology measures include:

- Number of heritage sites within the footprint.
- Number of archaeological sites within the footprint.

The detailed results of the heritage and archaeological measure are contained in **Exhibit 3.49**.

Results

All of the alternatives were rated similar to BAU, scoring “3”, in terms of the heritage and cultural impacts. There are no archaeological sites potentially impacted by the rapid transit system as most of the alignments run along existing roads and rights of way. There was one heritage site (an historic store along Fraser Highway) on property adjacent to several of the alternatives, but the heritage feature itself is set well back from the street and would not be directly affected.

Exhibit 3.49 – Heritage and Archaeology Impacts

Exhibit 3.49 – Heritage and Archaeology Assessment

		BB	BRT1	BRT2	LRT1	LRT2	LRT3	LRT4	LRT 5a	LRT 5b	RRT1	RRT 1a	RRT2	RRT3
Within Footprint														
Heritage*	Sites	-	1	1	1	1	1	-	1	1	-	-	1	-
Archaeological	Sites	-	-	-	-	-	-	-	-	-	-	-	-	-
Evaluation Rating		3	3	3	3	3	3	3	3	3	3	3	3	3

*Heritage site is parking lot in front of heritage building overlapping part of the project footprint.

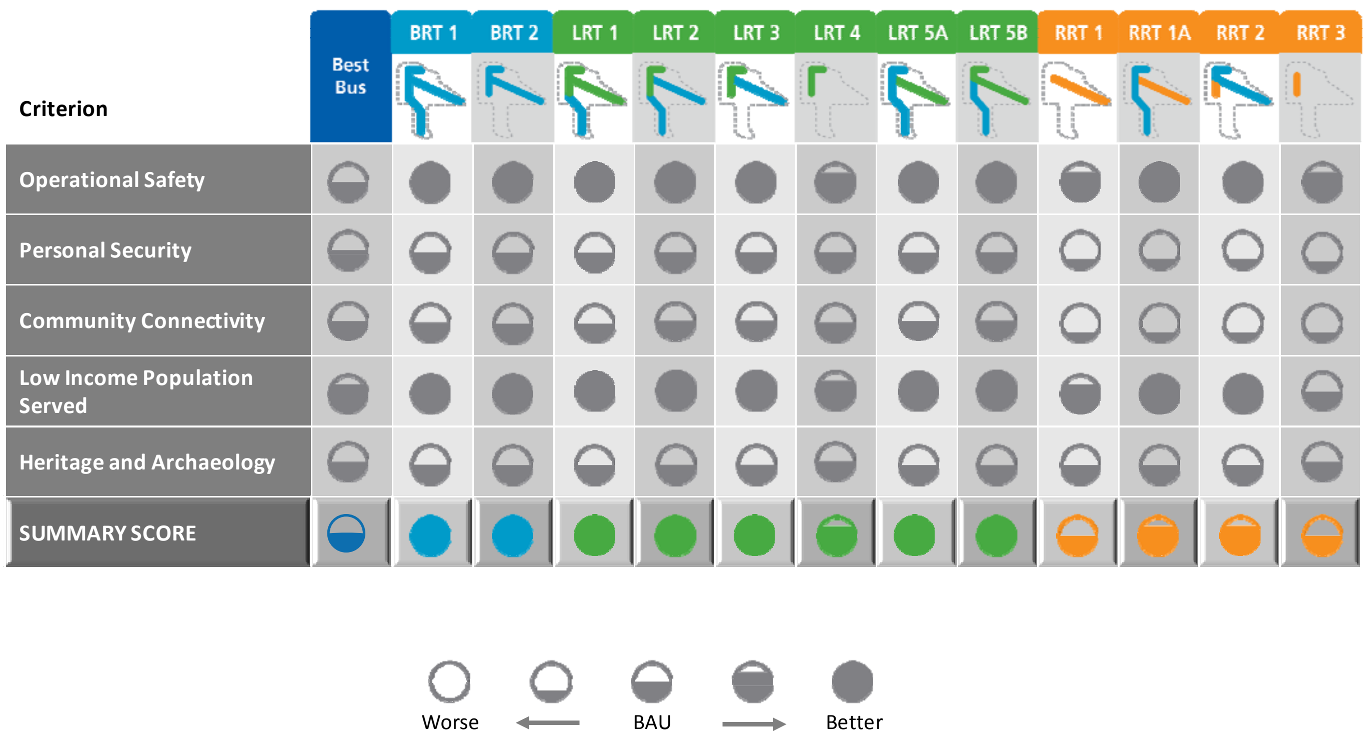
[9] City of Surrey, City of Langley, GeoBC, BC Conservation Centre, and BC Archaeology Branch data sets were obtained and updated through 2011.

3.6.6 Social/Community Account Key Points

The evaluation ratings for each of the criteria, and an overall summary rating for the account are indicated on **Exhibit 3.50**. These were the highlights of the social/community assessment:

- All Rapid Transit alternatives improve operational safety and perceived security and increase access for low income populations Alternatives with the greatest extent provide the greatest benefits.
- Street-level stations and driver-operated vehicles are perceived as most secure and therefore RRT alternatives did not rate as highly as BRT or LRT on perceived security.
- All alternatives remove some minor vehicular crossings having a negative impact on community connectivity, though they do maintain pedestrian and cyclist crossings and increase pedestrian refuges.

Exhibit 3.50 – Social/Community Account Ratings Summary



3.7 Deliverability Account

Brief Overview

The deliverability account assesses the performance of the alternatives against the following objectives:

- *The rapid transit service is constructible and operable, and avoids 'show-stopper' constraints;*
- *The rapid transit service allows phasing flexibility and is scalable;*
- *The rapid transit service is supported at all levels of government,; and*
- *Rapid transit is compatible with local, regional and provincial transportation, environmental and land use targets and objectives.*

The deliverability account broadly considers potential risks associated with delivering or implementing the alternative such as technical or engineering challenges in building the system, the likely construction impacts, the level of public and stakeholder acceptance, as well as the funding requirements to build and operate the alternative. This account also assesses the time to deliver an alternative and potential phasing of implementation. (Compatibility with targets and objectives is discussed in Section 5.)

The deliverability criteria include:

3.7.1. Constructability

3.7.2. Time Required to Deliver

3.7.3. Potential for Phasing

3.7.4. Acceptability

3.7.5. Affordability

The evaluation approach, assumptions and results are described for each of these criteria on the following pages. **Appendix 3E** includes further detail of the assessments carried out in support of the Deliverability account.

3.7.1 Constructability

Approach

Constructability assesses potential design and construction challenges or risks to construct the system, such as engineering, geotechnical, environmental, contamination, or archaeological constraints. A qualitative assessment was conducted on the basis of the designs, taking into account several measures related to design constraints, including:

- Utilities (underground and overhead).
- Available street space.
- Geotechnical conditions.
- Pre-existing contamination.
- Environmental and other constraints that may constrain construction.

Input included GIS mapping of the study area, online mapping data for both cities, comments provided by municipal planning and engineering staff on the initial conceptual designs, and typical practices for construction of each technology. Geotechnical and contaminated site reviews were also conducted of the study alignments to determine if there were any special conditions that could affect design or construction. **Exhibit 3.51** summarizes the assessment of constructability for the thirteen alternatives.

Results

Generally, all alternatives are constructible and no major engineering difficulties have been identified. However, constructing the rapid transit alternatives presents a range of possible challenges, including utility relocations, rebuilding of structures and potential environment impacts (which sometimes trigger environmental mitigation and/or permitting processes) from crossing agricultural lands, streams/creeks or floodplains. There are no substantial risks of disturbing pre-existing contaminated sites expected for any alternatives as they are assumed to be built largely within existing road rights of way; however, it is likely that some contamination may be encountered during construction, with greater potential in areas with street widening, former gas stations and industrial sites.

RRT alternatives would have the greatest impact on existing overhead hydro corridors that cross the alignment due to the elevated guideway, which would require relocation or raising of hydro lines. LRT alternatives pose lesser construction risks at crossings of hydro corridors, but may face some power supply interference. All street-level alternatives have potential impacts on utility relocations, but this impact is considered greater for LRT than BRT. LRT requires tracks and it is advisable to relocate and protect any utilities located beneath and parallel to the alignment to reduce potential utility maintenance issues during the operating period.

All alternatives that cross the floodplain – especially the portion within the ALR – carry an environmental risk, because of potential environmental impacts that could require additional study in later phases of project development. The implementation risk related to environmental impacts is that additional studies, definition of mitigations, and permitting processes may be triggered, which typically increase the complexity and duration of the project. Crossing the floodplain also poses geotechnical challenges due to poor soils, which requires pre-loading of embankments where widening of the streets is required (for BRT or LRT alternatives), and deep piles to support the columns for elevated structures (for RRT).

Overall, the most extensive LRT alternatives (LRT 1, LRT 2, LRT 5A, and LRT 5B) were rated as worse than BAU with a “1” score, due to their combination of hydro corridor, utility and floodplain/ALR impacts. RRT 1 and RRT 1A were also assessed a score of “1” due to their hydro and ALR-related challenges. LRT 3, LRT 4 and RRT 3 would have the same types of challenges, but less extensively, and so would be worse than BAU but with an intermediate score of “2”. BRT alternatives were also rated as “2”.

Unlike the other alternatives, the Best Bus Alternative would not involve construction of significant infrastructure and therefore it has been assessed as similar to BAU (score of “3”).

Exhibit 3.51 – Constructability of Alternatives

Alts.	Main Issue Areas for Constructability	Eval. Rating
Best Bus	• Limited construction in field (signal improvements, bus stops)	3
BRT 1	• In-ground utility relocations, but less critical than LRT, BRT can divert • ALR/floodplain issues (poor soils, environmental constraints) on Fraser Hwy • In-street construction of BRT within Surrey Metro Centre and on 104 Avenue (physically constrained areas)	2
BRT 2	• In-ground utility relocations, but less critical than LRT, BRT can divert • ALR/floodplain issues (poor soils, environmental constraints) on Fraser Hwy • In-street construction of BRT within Surrey Metro Centre and on 104 Avenue (physically constrained areas)	2
LRT 1	• ALR/floodplain issues (poor soils, environmental constraints) on Fraser Hwy • Extensive utility relocations required (LRT on Fraser Hwy, King George Blvd, 104th); • In-street construction of LRT within Surrey Metro Centre and on 104 Avenue (physically constrained areas)	1
LRT 2	• ALR/floodplain issues(poor soils, environmental constraints) on Fraser Hwy • Extensive utility relocations required (especially LRT on King George Blvd, 104th) • In-street construction of LRT within Surrey Metro Centre and on 104 Avenue (physically constrained areas); segment around Surrey Central would also have BRT terminus	1
LRT 3	• ALR/floodplain issues(poor soils, environmental constraints) on Fraser Hwy • Extensive utility relocations required (especially LRT on King George Blvd, 104th) • In-street construction of LRT within Surrey Metro Centre and on 104 Avenue (physically constrained areas); segment around Surrey Central would also have BRT terminus	1
LRT 4	• No ALR/floodplain issues • Extensive utility relocations required (LRT on KGB, 104th); shortest of LRT alternatives • In-street construction of LRT within Surrey Metro Centre and on 104 Avenue (physically constrained areas)	2
LRT 5A	• ALR/floodplain issues(poor soils, environmental constraints) on Fraser Hwy • Extensive utility relocations required (especially LRT on Fraser Highway) • In-street construction of LRT within Surrey Metro Centre (physically constrained areas); segment around Surrey Central would also have BRT terminus	1
LRT 5B	• ALR/floodplain issues(poor soils, environmental constraints) on Fraser Hwy • Extensive utility relocations required (especially LRT on Fraser Highway) • In-street construction of LRT within Surrey Metro Centre and on 104 Avenue (physically constrained areas); segment around Surrey Central would also have BRT terminus	1
RRT 1	• Fraser Highway corridor affected by high-voltage hydro • ALR/floodplain issues(poor soils, environmental constraints) on Fraser Hwy • Utility relocations localized and potentially able to be designed around • Fewest construction impacts within Surrey Metro Centre	1
RRT 1A	• Fraser Highway corridor affected by high-voltage hydro • ALR/floodplain issues(poor soils, environmental constraints) on Fraser Hwy • Utility relocations localized and potentially able to be designed around (RRT portion); utility relocations on BRT segments less critical than LRT	1
RRT 2	• King George Blvd corridor affected by high-voltage hydro (2 locations) • ALR/floodplain issues on Fraser Hwy • Utility relocations localized and potentially able to be designed around (RRT portion); utility relocations on BRT segments less critical than LRT	2
RRT 3	• King George Blvd corridor affected by high-voltage hydro (2 locations) • No ALR issues • Utility relocations localized and potentially able to be designed around • Few construction impacts within Surrey Metro Centre	2

3.7.2 Time Required to Deliver

Approach

Time required to deliver assesses the time required to complete the planning, design and construction of the system, once a preferred alternative has been selected and funding identified. The assessment broadly considers the extent and technology, and precedents for the design, permitting, construction and testing/commissioning phases of implementation. The implementation timing includes preliminary engineering, environmental assessment, environmental permitting and land acquisition, tender document preparation and procurement process, design and construction. It assumes no funding or procedural delays and no significant unanticipated risks. **Exhibit 3.52** includes the assessment of time required.

Results

All rapid transit alternatives have substantial construction requirements and are all estimated to require between four and seven years of project implementation. The alternatives with greater extent and multiple technologies are likely to take somewhat longer to implement due to multiple procurement processes, and more materials and labour being required on the larger projects. Other factors in the timing would include environmental permitting, which could affect all alternatives, for example, involving segments along Fraser Highway through the floodplain. All rapid transit alternatives are rated worse than BAU with a score of “2” since the range of time to deliver is clearly more than building no rapid transit, but none of the alternatives stand out significantly compared to the others. Best Bus has no major construction required and therefore time to deliver is similar to BAU, and it has been rated a score of “3”.

3.7.3 Potential for Phasing

Approach

The potential for phasing criterion assesses the ease of implementing the complete alternative in phases, such as starting with a smaller initial system or converting the system from a lower capacity technology. The assessment considers technology, ability to operate initial segments, and operations and maintenance centre (OMC) and terminus requirements. It also identifies whether design changes would have to be made if technology were converted on part of the alignment. The summary of results is presented in **Exhibit 3.52**.

Results

In summary, all alternatives can be phased, but there are differences by technology and extent. Best Bus has the most phasing potential, since bus routes can be introduced relatively independently and incrementally once orders for fleets are placed. Some incremental depot capacity would be required beyond BAU.

BRT alternatives also have strong potential for phasing because of the flexibility of operations, potential to commence operation and ability to build and then operate segregated busways in segments. It is also possible to introduce bus service improvements in mixed lanes and later upgrade to BRT. As a result, BRT alternatives are also assessed as equally flexible as BAU (score of “3”).

Exhibit 3.52 – Time Required to Deliver/Potential for Phasing

Alternative	Time to Deliver	Eval. Rating	Potential for Phasing	Eval. Rating
Best Bus	Bus procurement and implementation of transit priority, should be as fast as BAU	3	Flexibility to introduce bus routes; easiest to phase	3
BRT 1	To deliver rapid transit, 4-7 years. BRT potentially in lower half of range, depending on design and construction challenges. • Potential for more rapid implementation as less fixed infrastructure required for BRT	2	• BRT provides potential for phased implementation (nearly as flexible as Best Bus or BAU); • Sections of network could be developed and built incrementally; and • Independent of OMC location.	3
BRT 2	• BRT 2 same or shorter time to deliver than BRT 1, due to shorter extent	2	Same comments as BRT 1	3
LRT 1	To deliver rapid transit, 4-7 years. LRT potentially in middle/upper half of range, depending on design and construction challenges. • Generally LRT options may require the longest to construct per unit length: - Street construction more involved than BRT due to greater need for utility relocations - Also requires rail infrastructure to be installed and tested (e.g. tracks, signals, power, comm) • LRT 1 likely longest time to construct of LRT, due to extent	2	• Because there are three corridors, LRT 1 offers potential to choose which LRT to start with (provided it has the OMC); • BRT elements could be phased separately from LRT; and • BRT could be used as a precursor to LRT recognizing challenge of serving BRT passengers during transition to LRT	2
LRT 2	• LRT 2 potentially faster than LRT 1, LRT 5A due to greater proportion of BRT	2	• More BRT elements (KGB south of Newton, plus Fraser Hwy) than LRT 1, and these could be phased separately from LRT	2
LRT 3	• LRT 3 potentially faster than LRT 1 due to greater proportion of BRT, and faster than LRT 2 due to shorter extent	2	Same comment as LRT 2	2
LRT 4	• LRT 4 potentially faster than other LRT alternatives due to shortest extent, avoidance of floodplains	2	• Only two choices for corridor, and system would be undersized if not all built at once; less flexible than most alternatives, little choice in corridors	1
LRT 5A	• LRT 5A potentially faster than LRT 1 due to greater proportion of BRT, but slower than LRT 2	2	Same comment as LRT 2	2
LRT 5B	• LRT 5B potentially faster than LRT 1 due to greater proportion of BRT, likely more time to construct than 5A due to higher amount of LRT	2	• Several choices for initial LRT segment, (provided first corridor has the OMC); • BRT element on KGB could be phased separately from LRT	2
RRT 1	To deliver rapid transit, 4-7 years. RRT potentially in middle/upper half of range, depending on design and construction challenges. • RRT may be quicker to construct per unit length than LRT: - Once the guideway has been constructed, work can continue on top with less delay related to GP traffic alongside the construction - Construction in Surrey Metro Centre limited to east of King George Station. - Significantly reduced utility relocation. • RRT 1 passes through floodplain on Fraser Highway	2	• Low for RRT elements themselves since RRT 1 extends from one logical place; • Technically possible to phase King George to Fleetwood, then later Fleetwood to Langley. This would be an expensive solution and would have mobilization issues.	1
RRT 1A	• RRT 1A has RRT through floodplain on Fraser; also includes BRT construction on 104, through Surrey Central, and on KGB	2	• Possible to phase BRT elements, and each route independently. Same as RRT 1 re: RRT segment	2
RRT 2	• RRT 2 has RRT south of KGS, and also includes BRT construction on 104, through Surrey Central, and on Fraser Hwy	2	• Low for RRT element since it extends from one logical place; • Possible to phase BRT elements, and each route independently.	2
RRT 3	• RRT 3 has RRT south of KGS, and likely shorter time to construct than other RRT alts due to avoidance of floodplains	2	• Low - the RRT element extends from one logical place, with no realistic option to built in shorter segments	1

LRT alternatives have some phasing potential, but less than BRT alternatives because of the integrated nature of LRT systems and requirement for an operations and maintenance centre location that is alongside the initial route. Conversion from BRT or bus to LRT is feasible; however, in the case of a BRT-to-LRT conversion, closure of BRT would impact transit riders during the construction of LRT. LRT 1, LRT 2, LRT 3, LRT 5A, and LRT 5B have been assessed as worse (less flexible) than BAU, with a score of “2”. LRT 4 is shorter and has less phasing potential than the LRT alternatives that cover greater distances, and was assessed a score of “1”.

RRT has the least phasing potential because of construction staging and mobilization requirements. The only logical starting point is King George Station, since RRT would involve an extension to the existing Expo Line. While it would be possible to extent the alignment to Fleetwood first, and then to Langley, there are no logical locations for an interim terminus station or transit exchange in Fleetwood, and re-mobilizing to extend to Langley would complicate construction and add to overall project costs . RRT 1A and RRT 2 have greater phasing potential (score of “2”) than RRT 1 and RRT 3 (scores of “1”) because they include portions of BRT that could be introduced with some flexibility.

3.7.4 Acceptability

Approach

The acceptability criterion measures the community support for each alternative, as indicated by the public. This criterion was assessed using market research conducted in early 2012. The online “TransLink Listens” panel members, from within the study area and region-wide, were invited to undertake an online survey about the Phase 2 evaluation and alternatives. The survey included general questions about: importance of investing in rapid transit; relative importance of evaluation factors in making decisions about rapid transit; and demographic information.

More specific to this criterion, participants were asked to indicate relative preferences among the technologies and the rapid transit elements that comprise the alternatives. Summary information about the design and operation of the rapid transit technologies (BRT, LRT and RRT) was provided to help inform the participants before they rated the options. There was also a question about which combination of corridors (Fraser Highway, King George Boulevard, and 104 Avenue) should be served. Within each corridor, the sets of rapid transit elements that comprised the alternatives were presented, including the coverage, mix of technologies, travel times, costs, and impacts to the street as assessed in Phase 2. Participants were asked to rate the different options for each corridor, including expanded bus service and rapid transit.

The market research survey methodology and detailed results are documented in Appendix 3E.

The qualitative ratings were converted into numerical scores on a scale of “1” (very unacceptable) to “5” (very acceptable). Average acceptability scores were then derived for each combination of corridors, and the transit options within each corridor. To assess the acceptability of the alternatives, the results from the corridor combination and corridor options that applied to each alternative were blended together. **Exhibit 3.53** shows the derivation of acceptability scores and ratings from the survey.

Exhibit 3.53 – Acceptability of Alternatives

Alternatives	BAU	Best Bus	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Reference Schematic														
	Numbers = Average Scores from Public Market Research Survey (Higher means more acceptable, 3 = neutral)													
Combination of Corridors														
Corridors	No RT	No RT	All 3	All 3	All 3	All 3	All 3	KGB & 104	All 3	All 3	Fraser only	All 3	All 3	KGB only
Average Score for Response	2.5	2.5	4.3	4.3	4.3	4.3	4.3	3.6	4.3	4.3	3.3	4.3	4.3	3.2
King George Boulevard														
Option (Technology/Extent)	Bus	Bus	BRT White Rock	BRT Newton	LRT and BRT	LRT and BRT	LRT Newton	LRT Newton	BRT White Rock	BRT White Rock	Bus	BRT White Rock	RRT Newton	RRT Newton
Average Score for Option	2.7	2.7	3.5	2.9	3.7	3.7	3.1	3.1	3.5	3.5	2.7	3.5	3	3
Fraser Highway														
Option (Technology)	Bus	Bus	BRT	BRT	LRT	BRT	BRT	Bus	LRT	LRT	RRT	RRT	BRT	Bus
Average Score for Option	2.5	2.5	3.4	3.4	3.5	3.4	3.4	2.5	3.5	3.5	3.5	3.5	3.4	2.5
104 Avenue														
Option (Technology)	Bus	Bus	BRT	BRT	LRT	LRT	LRT	LRT	BRT	LRT	Bus	BRT	BRT	Bus
Average Score for Option	3.3	3.3	3.4	3.4	3.2	3.2	3.2	3.2	3.4	3.2	3.3	3.4	3.4	3.3
Average Score for Alternative														
Corridor and Options	2.67	2.67	3.87	3.77	3.88	3.87	3.77	3.27	3.88	3.85	3.23	3.88	3.78	3.07
Score Relative to BAU	**1.0**	**1.0**	**1.5**	**1.4**	**1.5**	**1.5**	**1.4**	**1.2**	**1.5**	**1.4**	**1.2**	**1.5**	**1.4**	**1.2**
Evaluation Rating (5 Better > 3 BAU > 1 Worse)	**3**	**3**	**5**	**5**	**5**	**5**	**5**	**4**	**5**	**5**	**4**	**5**	**5**	**4**

Source: "TransLink Listens - Surrey Rapid Transit" Market Research Survey, conducted Feb. 9 to 21, 2012

Results

All rapid transit alternatives were rated as more acceptable than BAU, with the more extensive alternatives rating the highest (score of "5") and the alternatives serving fewer than three corridors (LRT 4, RRT 1, RRT 3) receiving an intermediate score of "4". Best Bus was rated the same as BAU.

These results were a reflection of the findings from each of the questions:

- The most highly rated combination of corridors was "all three";
- On King George Blvd, the LRT/BRT and BRT to White Rock options were highest rated;
- On Fraser Highway, there was little difference in acceptability between rapid transit technologies, and continuing to serve the corridor with buses (BAU and Best Bus) rated lower; and
- On 104 Avenue, there was minimal overall difference in acceptability between BRT, LRT or continuing to serve the corridor with buses (BAU and Best Bus).

3.7.5 Affordability

Approach

Affordability is equally defined by the cost of the project and the ability to fund the project. Cost calculations (NPV) are noted in **Exhibit 3.54**. However, assessing the ability to fund this project is beyond the scope of this study. Consequently, the affordability of the alternatives was not assessed.

Exhibit 3.48 shows the Net Present Value of the full costs to build and operate each of the alternatives, including incremental capital costs, renewal costs, incremental operating costs and farebox revenues over the evaluation period. These are expressed in 2010 dollars, with future cash flows discounted at 6 % per annum. These values were derived as part of the Financial Account assessment, as explained in Section 3.2.

Results

Generally, the rail-based alternatives with the greatest extent (LRT 1, LRT 2, LRT 3, LRT 5A, LRT 5B, RRT 1, RRT 1A and RRT 2) would have the highest overall costs due to the higher capital costs of these projects. The lower cost alternatives would include BB, BRT 1, BRT 2, LRT 4 and RRT 3.

As noted, since assessing the ability to fund this project is beyond the scope of this study, an affordability rating was not assessed.

Exhibit 3.54 – Net Present Value of Alternative Costs

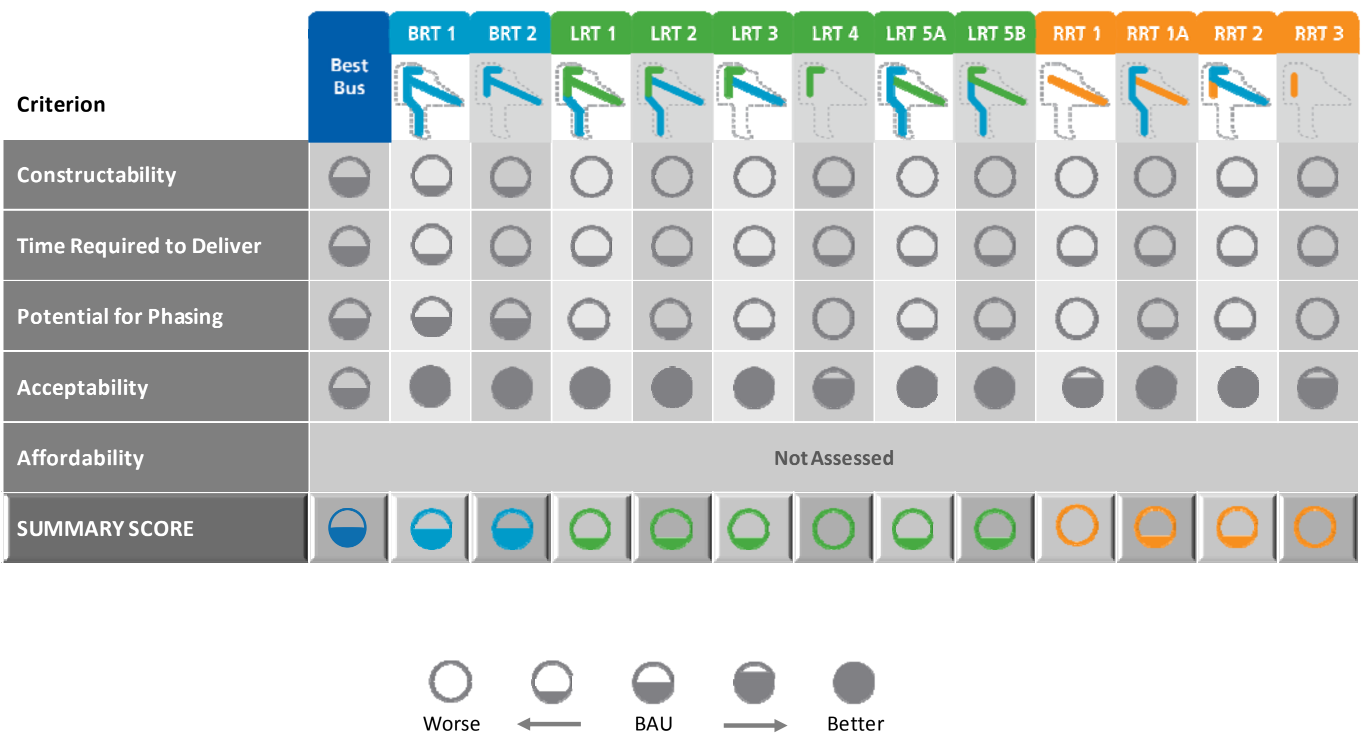
Alternative	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Net Present Value of Costs ($M 2010)	530	820	640	1,630	1,180	1,030	640	1,280	1,460	1,260	1,670	1,150	630
Evaluation Rating	Not Assessed												

3.7.6 Account Summary

The evaluation ratings for each of the criteria, and an overall summary rating for the account are indicated on **Exhibit 3.55**. These were the highlights of the deliverability assessment:

- All alternatives are deliverable subject to funding, based on analysis to date. Since funding will be assessed within a regional context, affordability was not rated for Phase 2.
- Larger LRT and RRT alternatives are more complex to construct.
- All rapid transit alternatives require a similar length of time to deliver (4 to 7 years)
- Best Bus would have the most potential for phasing, and then BRT, while single-route rail alternatives have the least potential.
- The public rated the alternatives serving all three corridors as most acceptable, and the most extensive service in each corridor was most highly favoured. The choice of technologies produced different reactions from individuals, but to the overall public each was similarly acceptable, and all were preferred to Best Bus or BAU.

Exhibit 3.55 – Deliverability Account Evaluation Summary



3.8 Summary of Account-Level Findings

Exhibits 3.56 to 3.62 present the ratings for each evaluation account, based on the results in Sections 3.1 to 3.7. In addition to ratings for each of the criteria, summary scores for each alternative were assigned within each account. While no weighting was applied to the criteria, an emphasis was placed on the criteria that helped to differentiate between the alternatives.

In most of the accounts, the summary ratings tend to be 'better' or 'worse' than BAU depending on whether benefits or impacts/challenges are the focus of the account. Alternatives that performed similar to BAU (e.g. minimal benefits or impacts under certain criteria) were rated in the middle of the range. The exception is the summary rating for the financial account, because the criteria showed a wide range of relative performance, with some alternatives rating better and some rating worse. The exhibits use a graphical representation of the five-point rating scale, ranging from "5" for better to "1" for worse. Performing similarly to BAU was rated a "3"; ratings of "4" and "2" represented intermediate better and worse assessments, respectively.

Transportation

The transportation account measures the benefits and impacts to transportation network users. The results are presented in **Exhibit 3.56**.

All alternatives provide transportation benefits. The fastest and largest extent alternative (RRT 1A) would perform best in this account, providing fast, transfer-free travel times along Fraser Highway, resulting in the highest transportation benefits to users and non-users. Best Bus, LRT 4 and RRT 3 would provide the fewest transit user benefits compared with the other alternatives. BRT and LRT alternatives require some reductions in general travel lanes which increase congestion levels and travel times for non-transit users.

BRT would provide sufficient capacity on all three corridors, but would be nearing the limits during peak hours (volume / capacity ratio of 1.0) by 2041 on Fraser Highway. Alternatives without rapid transit on Fraser Hwy or King George Blvd (LRT 4, RRT 1, and RRT 3) would not meet long term demand. Alternatives with LRT or RRT on Fraser Highway would provide expandability on this busy corridor, whereas BRT would be close to capacity on that corridor. All alternatives increase transit mode share, but at a regional scale the impact is small. In 2041, the regional mode share was 16.4% for BAU, and ranged from 16.4% to 16.6% for the alternatives.

Financial

The financial account measures capital and operating costs, as well as cost-effectiveness, and its assessment results are presented on **Exhibit 3.57.**

Capital costs for rapid transit alternatives would range from $770 million to $2.2 billion, with the Best Bus capital cost at $290 million. With the exception of Best Bus, over the lifecycle, operating costs for all alternatives are small in relation to capital costs. Operating costs range from an additional $9 M per year (RRT 3) to $58 M (Best Bus) by 2041. Generally, the alternatives with the greatest extent would have the highest operating costs as they would require more vehicles and drivers. Cost-effectiveness scores reflect a range of transportation and land use cost-effectiveness measures relative to enhanced investment in buses (BB). The RRT and BRT alternatives were most cost-effective in achieving the project objectives due to relatively greater benefits (RRT) or lower costs (BRT). LRT 1 and LRT 4 performed the worst in this account, due to higher costs and minimal benefits, respectively. Overall scores in this account are differentiated by the cost-effectiveness of the alternatives.

Exhibit 3.56 – Evaluation Ratings – Transportation Account

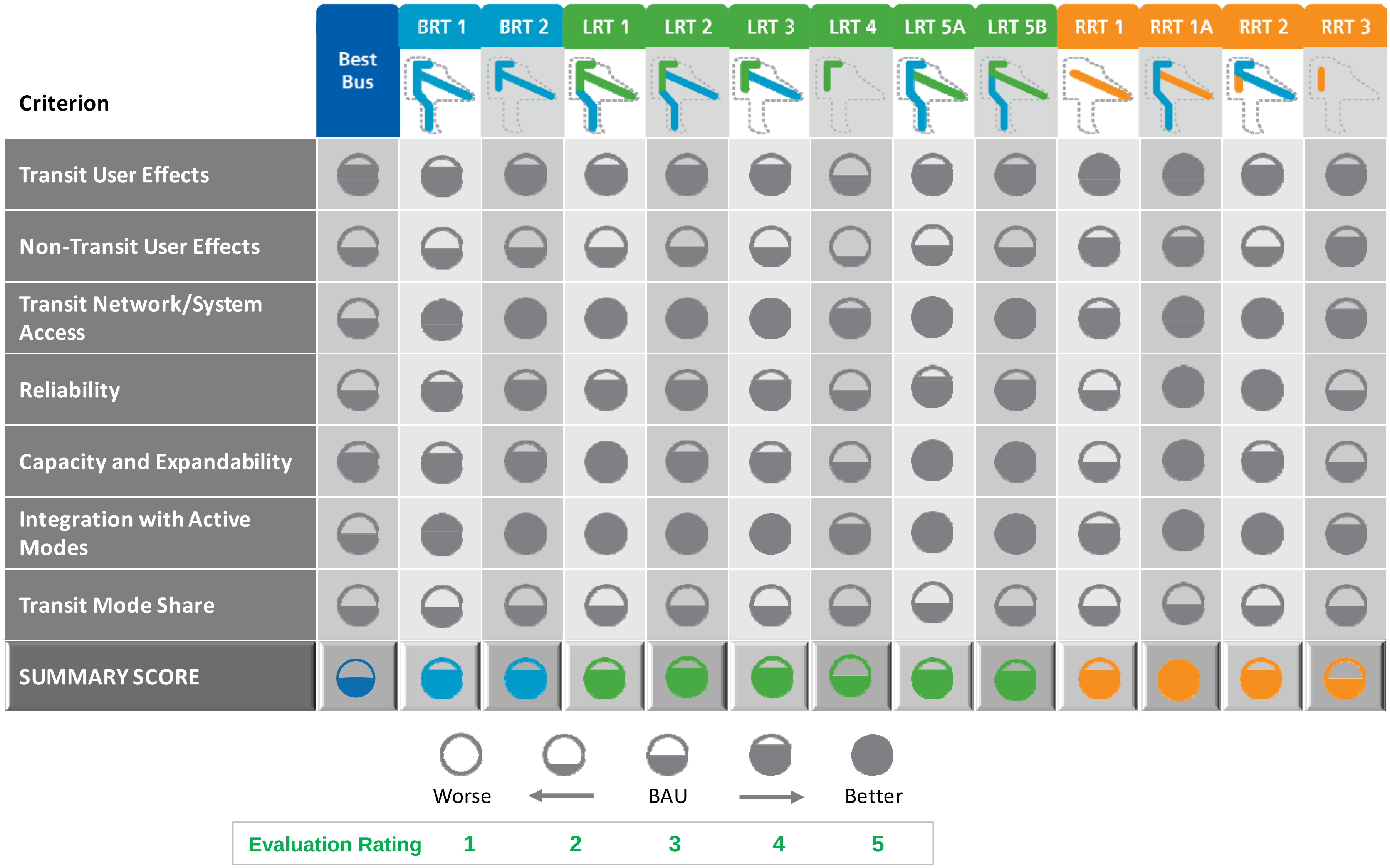


Exhibit 3.57 – Evaluation Ratings – Financial Account

Criterion	Best Bus	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Capital Cost	◑	◔	◔	○	○	○	◔	○	○	○	○	○	◔
Operating Cost	○	○	◔	○	○	◔	◑	○	○	◔	○	◔	◑
Cost Effectiveness	◑	◕	◕	○	◔	◑	○	◑	◑	◕	◕	◕	◕
SUMMARY SCORE	◑	◑	◑	○	◔	◑	○	◑	◑	◑	◑	◑	◕

○ Worse ← ◔ ◑ BAU ◕ → ● Better

Environment

The environment account considers a range of environmental measures including air emissions reductions, noise and vibration, as well as impacts on biodiversity, water environment, parks and open space, greenways, and agricultural resources. Environmental assessment results are presented on **Exhibit 3.58.** Most of the alternatives would have modest potential for environmental impacts, since construction would be involved to implement them. The three alternatives with the least extent – Best Bus, LRT 4 and RRT 3 - were assessed as having the fewest potential impacts.

At a regional scale, estimated emissions impacts would not be significant. All alternatives would reduce harmful air emissions from automobiles, but also increase emissions due to construction and/or reliance on buses. This account does not measure all the long-term environmental benefits of rapid transit, as many of those benefits relate to optimizing land use and travel patterns, which is assessed in part in the Urban Development account.

Construction of rapid transit alternatives would carry some limited risk of environmental impacts requiring mitigation. All alternatives travel through urban areas and on road ROW; potential impacts on biodiversity, water resources, parks and open space and agricultural land are therefore modest. The more extensive alternatives passing through the Agricultural Land Reserve (ALR) and over the Nicomekl and Serpentine rivers are viewed as having greater potential impact. All rapid transit alternatives would produce noise and vibration, with RRT having the most potential impact.

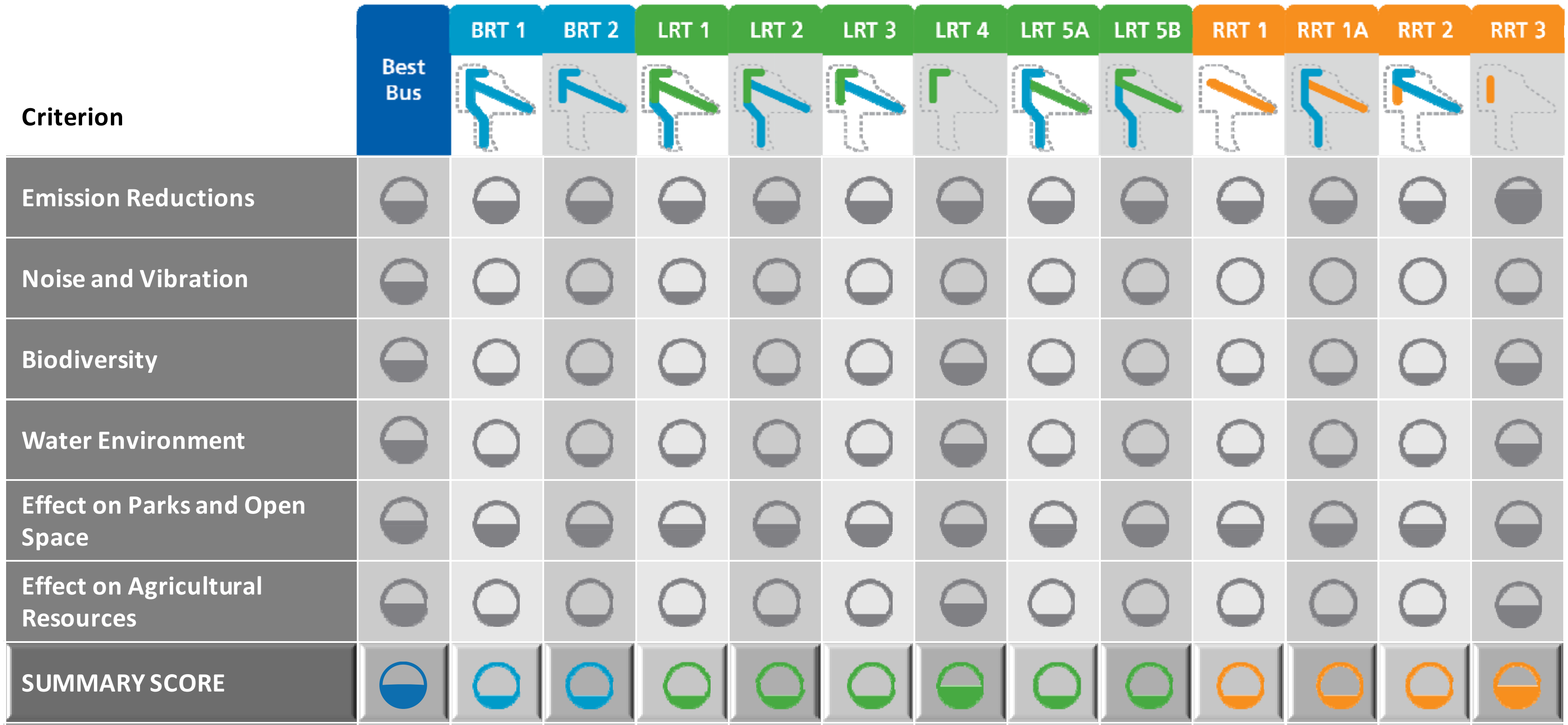
Urban Development

The urban development account considers the benefits and impacts on local land uses and the urban environment. Its assessment results are presented in **Exhibit 3.59.**

All rapid transit alternatives have the potential to intensify land use around stations with the greater extent alternatives accessing the most development capacity. All alternatives generate similar amounts of development demand because much of the apartment and office development in the next thirty years is forecast to continue around existing stations in Surrey City Centre. The potential for land use intensification is dependent on the overall size of the market for higher density residential and commercial development. This market will either concentrate in Surrey City Centre or spread itself across a larger number of rapid transit stations. However, alternatives with the greatest extent (and therefore more station areas) are forecast to attract more development.

Overall, all rapid transit alternatives would generate improvements in urban development. However for RRT 1 and RRT 3, those benefits would be balanced by negative urban design impacts associated with the RRT elevated guideway. RRT 1A and RRT 2 would have greater benefits than impacts due to the BRT component and their larger extents. Urban design would be improved with surface rapid transit, because there are opportunities to widen sidewalks and boulevards during street reconstruction for BRT or LRT. Elevated RRT alternatives would have negative visual impacts due to their large guideway structures. All rapid transit alternatives would require property to construct; LRT 4 and RRT 3 are shortest and would require fewest properties. All surface alternatives provide urban development benefits; however, the more limited scale of LRT 4 minimizes its potential benefits.

Exhibit 3.58 – Evaluation Ratings – Environment Account



Evaluation Rating	1	2	3	4	5

Exhibit 3.59 – Evaluation Ratings – Urban Development Account

Criterion	Best Bus	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Land Use Integration	◑	●	●	●	●	●	◕	●	●	◕	●	●	◕
Land Use Intensification Potential	◑	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◕	◑
Property Requirements	◑	◔	◔	◔	◔	◔	◑	◔	◔	◔	◔	◔	◑
Urban Design	◑	●	●	●	●	●	◕	●	●	◔	◑	◑	◔
SUMMARY SCORE	◑	●	●	●	●	●	◕	●	●	◑	◕	◕	◑

○ Worse ◔ ← ◑ BAU → ◕ ● Better

Economic Development

The Economic Development account addresses the economic benefits generated by construction activity, impact on tax revenues as well as goods movement. Its assessment results are presented on **Exhibit 3.60.**

The construction of rapid transit is expected to generate benefits associated with employment and increases in GDP. The more capital intensive alternatives would have higher construction and tax revenue benefits and perform better (LRT 1, RRT 1, RRT 1A) in those criteria. There are some impacts to goods movement for the street level alternatives due to localized lane reductions and mid-block turn restrictions; similar mid-block restrictions would apply to the RRT alternatives due to guideway columns and sightlines.

Overall, the positive impacts associated with construction and tax revenue effects would be balanced by the negative goods movement impacts for most alternatives. The three alternatives with greater construction and tax revenue effects (LRT 1, RRT 1, RRT 1A) and the alternative with the least goods movements impacts (RRT 3) were all assessed as performing better than BAU.

Social / Community

The Social and Community account addresses a wide range of social and community benefits and impacts, including operational safety, personal security, community connectivity, service to low-income households, and heritage and archaeological impacts. Its results are summarized on **Exhibit 3.61**.

All rapid transit alternatives would improve operational safety and perceived security and they all would increase access for low income populations. Alternatives with the greatest extent would provide the greatest safety and access benefits. Street-level stations and driver-operated vehicles are perceived as most secure, and therefore BRT and LRT rated higher than RRT alternatives on perceived security. All alternatives would remove some minor vehicular crossings, having a negative impact on community connectivity, though they do maintain pedestrian and cyclist crossings and increase pedestrian refuges. RRT has less benefit to pedestrian connectivity and also creates a visual barrier through the community. No impacts to heritage or archaeological sites have been identified.

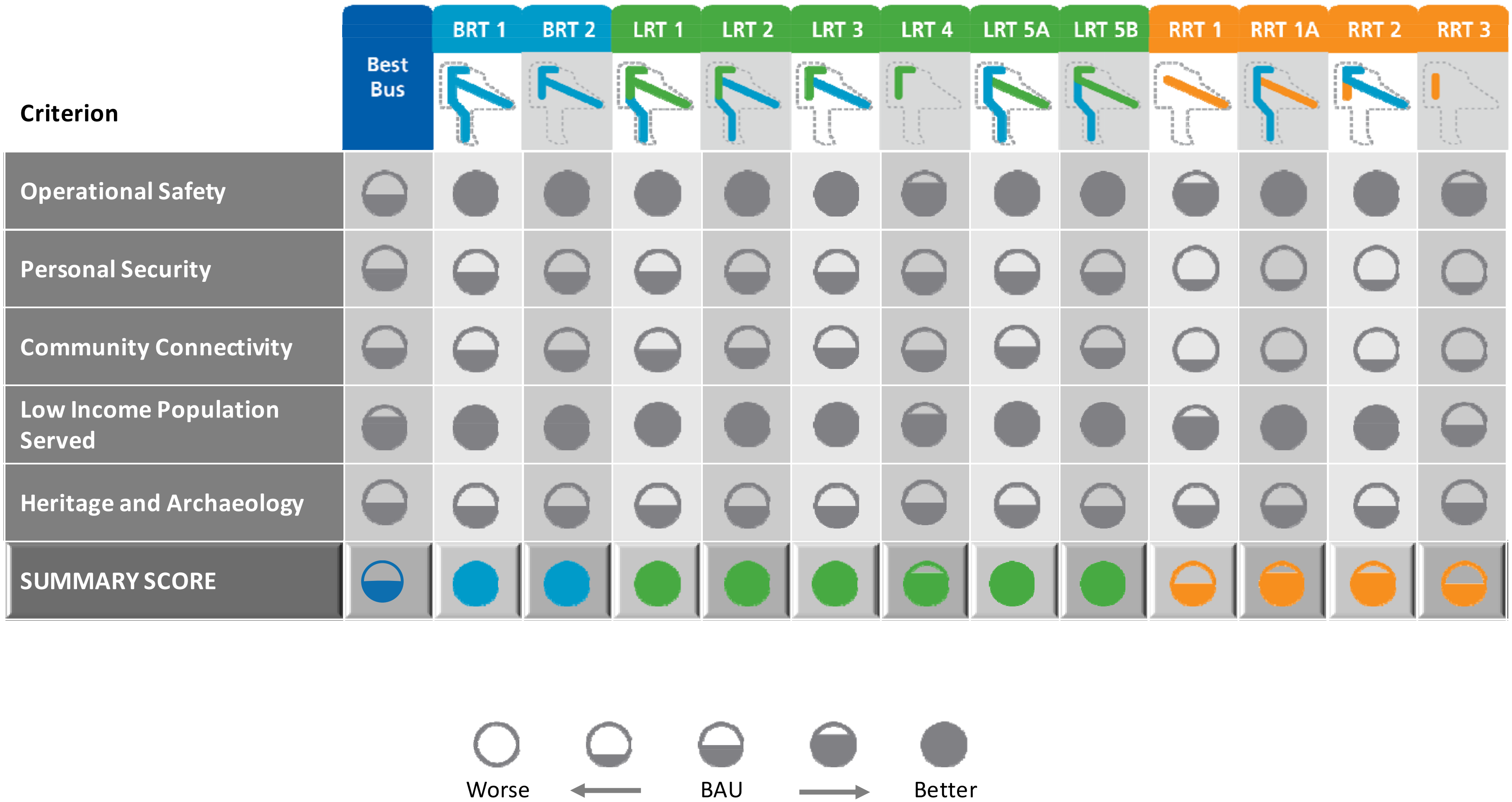
With the exception of LRT 4, the street-level BRT and LRT alternatives performed best in this account. RRT elements would have greater benefits to operational safety, but have a negative perception for personal security, and would provide little improvement to community connectivity. RRT 1A and RRT 2 combine RRT and BRT elements, resulting in net benefits in this account.

Exhibit 3.60 – Evaluation Ratings – Economic Development Account

Criterion	Best Bus	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Construction Effects	3	4	4	5	4	4	4	4	4	5	5	4	4
Tax Revenue Effects	3	4	4	5	4	4	4	4	4	5	5	4	4
Goods Movement	3	2	2	2	2	2	2	2	2	2	2	2	3
SUMMARY SCORE	3	3	3	4	3	3	3	3	3	4	4	3	4

Evaluation Rating	1	2	3	4	5
	Worse	←	BAU	→	Better

Exhibit 3.61 – Evaluation Ratings – Social and Community Account



Deliverability

The deliverability account considers potential issues associated with implementing the alternative, including the ease and speed with which it can be constructed, potential for phasing, public acceptability, and affordability. Its assessment results are presented in **Exhibit 3.62.**

All alternatives are deliverable subject to funding, based on analysis to date. Larger LRT and RRT alternatives would be more complex to construct, with greater utility conflicts. All alternatives would require a similar length of time to deliver (4 to 7 years). Best Bus and BRT have the most potential for phasing, while single-route rail alternatives have the least potential. Market research indicates that the most significant factor in public acceptability was the extent of coverage, with alternatives that would serve all three corridors deemed the most acceptable relative to BAU. There is a wide range of capital and lifecycle costs; affordability was not rated because the capacity to fund the construction and operation of the alternatives was unknown, and beyond the scope of the current study.

Summary of Account-Level Scores

Exhibit 3.63 summarizes the account-level ratings from the individual evaluations, to help highlight the key differences between alternatives. The order of the accounts is alphabetical, with deliverability last – this was the order used in public consultation.

The differences in ratings relate both to the extent of the alternatives and the characteristics of each of the technologies. In general, the alternatives with greater benefits, as highlighted by the economic development, social and community, transportation and urban development results, also have greater potential for costs and impacts, as identified in the environment, financial, and deliverability accounts.

Exhibit 3.62 – Evaluation Ratings – Deliverability Account

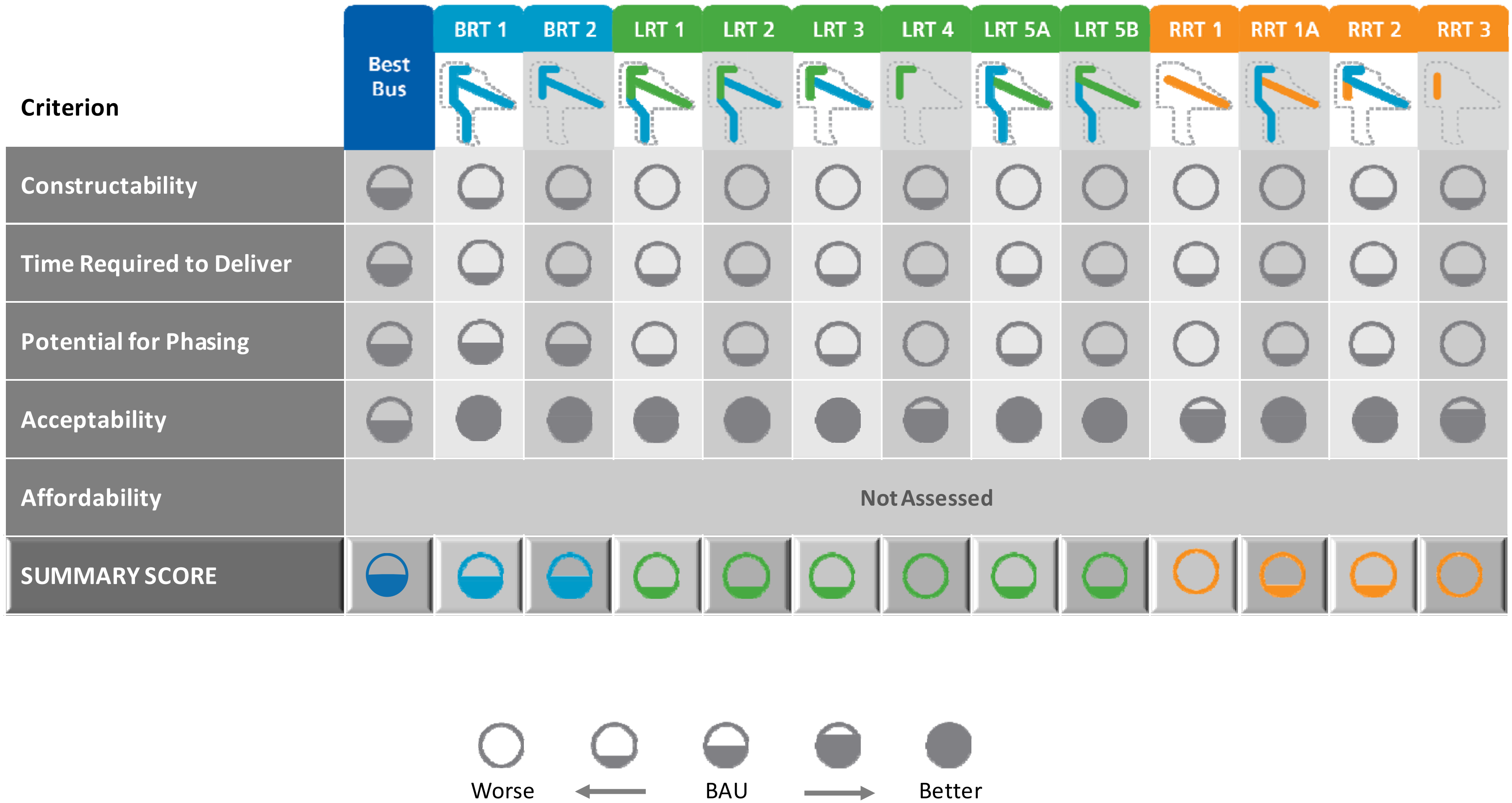
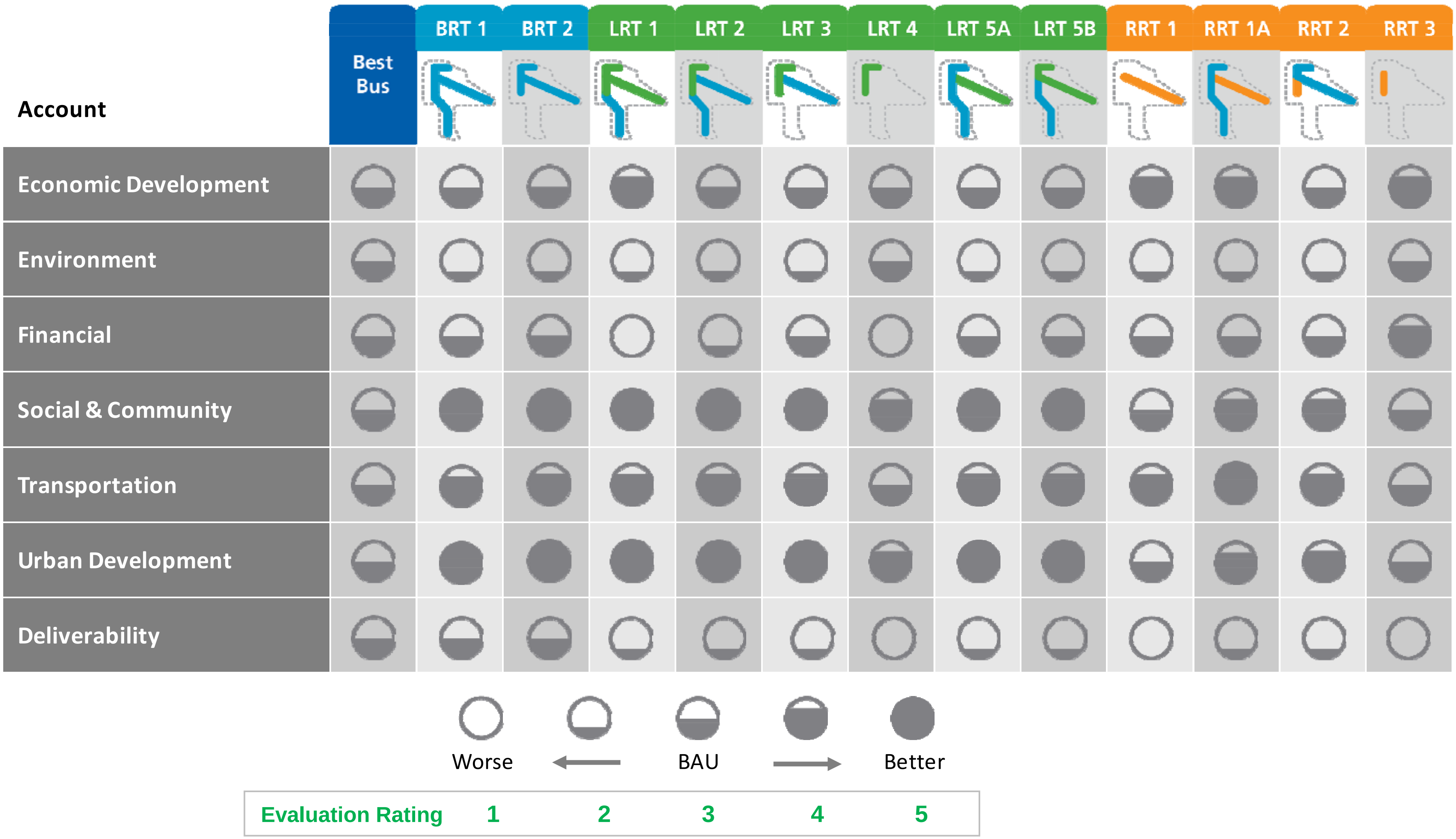


Exhibit 3.63 – Summary Ratings – All Accounts



4. SENSITIVITY TEST RESULTS

The objective of the Phase 2 evaluation was to undertake a sufficiently detailed level of analysis to identify and compare the key differences between the alternatives. The results of the alternatives analysis will inform the selection of a preferred alternative by the project sponsors. The MAE summarized in Section 3 forms the cornerstone for this comparison of alternatives, and was based on projected future land use and transportation networks, and on design and operating assumptions for the transit alternatives. These assumptions represented a 'base' (most likely) future, around which there are degrees of uncertainty. **Sensitivity Tests** were carried out on several of the land use, transit service, regional modelling and financial assumptions, to test the robustness of the results and highlight the extent to which variations in input assumptions to the evaluation affected the relative performance of the alternatives. The results from Section 3 formed the "base case" evaluation against which the sensitivity tests were compared.

This section provides a summary of the sensitivity tests that were carried out, the key results, and the implications of the tests for the evaluation of alternatives. **Appendix 4** includes further details on the sensitivity tests.

4.1 Scope of Tests

Exhibit 4.1 summarizes the series of modelling-based sensitivity tests conducted for the SRTAA.

Exhibit 4.1 – Sensitivity Test Scenarios (Modelling-Based)

Test	Alternatives	Description
Land Use Assumptions (Growth/Distribution)		
Base (2041)	**BAU, BRT 1, LRT 5A, RRT 1**	Regional Growth Strategy (MV) + Study area road network (CoS)
High Growth		Advance population/employment forecast 10 years
Low Growth		Slow down forecast by 10 years
Base Prime		Modified distribution (City of Surrey allocation of growth)
Transportation Assumptions (Rapid and Local Transit)		
Base (2041)	**BAU, BRT 1, LRT 5A, RRT 1**	Transit service growth according to South of Fraser Area Transit Plan, full vision to 2041 (3.5% annual increase)
Lower Background Transit Growth		Slower transit service growth, according to trend, allocated by population increase (2.5% annual increase)
Lower Background Transit + High Growth Land Use	**BRT 1**	Accelerated land use growth plus lower background transit growth
Transit Signal Priority	**BRT 1, LRT 5A**	Reduced availability of transit priority for surface rapid transit
Regional Modelling Assumptions		
Base (2041)	**BAU, BRT 1, LRT 5A, RRT 1**	Phase 2 RTPM08 (Rapid Transit Projects Model).
TDM (Demand Management)		150% increase (above inflation) in auto-related costs (operating cost, parking etc.)
Reduced Transfer Penalties	**BAU, BRT 1/2, LRT 1/5A, RRT 1**	Attractiveness of transfers to/from rapid transit increased by 40% at major interchange points

The land use, transit and regional modelling tests investigated how different inputs to the regional forecasting model affected travel demand, capacity and mode share. The relative sensitivity of the results to changes in the future study area conditions (and model assumptions) becomes important over the long term, because the inputs (future land use, future transportation networks) were also projections subject to some uncertainty.

For efficiency, the modelling-based tests focused on BAU and a set of representative alternatives (BRT 1, LRT 5A, RRT 1) to provide an indication of the impacts of different assumptions. These particular alternatives were selected because they included each of the three technologies, and within each technology, these alternatives had higher preliminary ridership and peak passenger loads in each of the corridors. Therefore, these selections were felt to have good potential to demonstrate the impacts of different assumptions.

Exhibit 4.2 summarizes the financial sensitivity tests conducted for the SRTAA.

Exhibit 4.2 – Sensitivity Test Scenarios (Financial)

Test	Alternatives	Description
Financial Tests		
Base	**All: BB, BRT, LRT, RRT**	6% discount rate, all alternatives start operating in 2020
Discount Rate		Test of 3% and 10% discount rates
Implementation Timing		Alts. enter service different years (2017 to 2021), depending on complexity and size
Capital Cost Risk	**BRT 1, LRT 5A, RRT 1**	Assume higher costs for grading/ piling in poor soils, floodplains
Local Bus Integration		Off-model financial analysis, reduce frequency of local bus service sharing the corridor with rapid transit
BRT Technology		Off model financial and emissions analysis of different potential BRT fuel/power technologies

The financial sensitivity tests focused on inputs to certain financial analyses, including risks that may reduce performance and opportunities that may improve it. These tests were carried out to determine if alternatives that performed similarly in the "base case" evaluation had variable sensitivity to factors such as capital costs, operating costs, the discount rate in the financial evaluation, or air emissions rates for BRT vehicles.

4.2 Results

The sensitivity test results varied quantitatively from the base evaluation in Section 3, as would be expected with different inputs. However, the outcomes from the modelling-based and financial tests all trended the same way (with the exception of Best Bus under one financial scenario); therefore, the relative performance of the alternatives remained the same, and the resulting evaluation ratings would be the same. Certain test scenarios helped identify design risks (where demand would exceed capacity under the conditions of the test), and others identified future opportunities to optimize the design and investigate potential risks in later phases of project development

Exhibits 4.3 and 4.4 summarize the key findings from the individual tests. These outcomes are discussed over the following pages. The results demonstrated that the design capacity of the alternatives could become an issue in a limited number of scenarios where higher peak demands would not be fully met by the planned system.

Exhibit 4.3 – Results: Summary of Sensitivity Analyses (Modelling-Based)

Study Area Transit Mode Share, Ability of Planned Capacity to Meet Peak Corridor Demand

Category	**Land Use**				**Transportation**				**Regional Modelling**		
Test	**Base**	**High Growth**	**Low Growth**	**Base Prime**	**Base**	**Lower Back-ground Transit**	**Lower Transit/ High Growth**	**Reduced Transit Priority***	**Base**	**Travel Demand Mgmt. (TDM)**	**Reduced Transfer Penalties**
Description	2041 Regional Growth Strategy	Growth 10 yrs earlier (add 10 yrs growth to 2041)	Growth 10 yrs later (2031 values in 2041)	Allocation to urban centres modified; e.g. more growth by 2041 on 104 Avenue	South of Fraser ATP: 3.5% annual service increase to 2041	Slower 2.5% annual service increase to 2041	Slower 2.5% annual bus service increase; and 10 years added to 2041 land use	reduced probability of encountering green signal (TSP benefit)	2041 Regional Growth Strategy, Transport 2040 Network	Increase auto operating, parking costs 150%	Reduce transfer time at rapid transit exchanges by 40%
BAU	14.5% Fraser Hwy, KGB over capacity	15.5% Fraser Hwy, KGB over capacity	13.7% Fraser Hwy, KGB over capacity	14.6% Fraser Hwy, KGB over capacity	14.5% Fraser Hwy, KGB over capacity	13.1% Fraser Hwy, KGB over capacity	NA	14.5% (no TSP assumed in BAU)	14.5% Fraser Hwy, KGB over capacity	18.7% Fraser, KGB over capacity	14.5% KGB over capacity
BRT 1	15.1%, all corridors within capacity	16.1% Fraser Hwy at/over capacity	14.2% all corridors within capacity	15.2% all corridors within capacity	15.1% all corridors within capacity	13.8%, Fraser over capacity and KGB near capacity	Transit trips exceed capacity on Fraser Hwy, KGB	15.1% 3% decrease in travel time saved	15.1% all corridors within capacity	19.3% all corridors within capacity	5% to 10% peak volume increase, within capacity
LRT 5A	15.1% all corridors within capacity	16.1% all corridors within capacity	14.2% all corridors within capacity	15.2% all corridors within capacity	15.1% all corridors within capacity	13.8% KGB demand near capacity	NA	15.1% 4% decrease in travel time saved	15.1% all corridors within capacity	19.3% all corridors within capacity	5% to 10% peak volume increase, within capacity
RRT 1	15.2%, KGB over capacity (as in BAU)	16.1% KGB over capacity (as in BAU	14.2% KGB over capacity (as in BAU	15.2% KGB over capacity (as in BAU	15.2% KGB over capacity (as in BAU)	13.8% KGB over capacity (as in BAU)	NA	No change	15.2% KGB over capacity (as in BAU)	19.4% KGB over capacity (as in BAU)	5% to 10% peak volume increase, KGB over capacity (as in BAU)

*Financial impact of reduced transit priority was also assessed: BCR reduces in line with decreased travel time savings (-3% for BRT, -4% for LRT)

Exhibit 4.4 – Summary of Financial Sensitivity Analysis Results

(Impact of Tests on Benefit-Cost Ratio)

Test	**Base**	**Discount Rate**	**Implement-ation Timing**	**Capital Cost Risk**	**Local Bus Integration**	**BRT Power Technology**
Description	6% discount rate, 2020 opening year, clean diesel for BRT	3%, 10%	Opening years between 2017 and 2021	Floodplain cost risk due to poor soils	Increase local bus headway to match demand (and not exceed FTN guideline of 15 min)	Hybrid, Battery, Fuel Cell options instead of clean diesel
BAU		N/A	N/A	N/A	N/A	N/A
BB	BCR 0.89	BCR 0.94 - 0.82	BCR 0.90 (small increase)	N/A	N/A	N/A
BRT 1	BCR 1.30	BCR 1.79 - 0.87	BCR 1.28 (small decrease)	Potential 2.6% cost increase, BCR 1.28	Potential $90m NPV saving; BCR 1.47	Fuel cell lowest GHG, highest cost
LRT 5A	BCR 0.93	BCR 1.34 - 0.59	BCR 0.89 (small decrease)	Potential 1.6% cost increase; BCR 0.92	Potential $170m NPV saving; BCR 1.07	Hybrid-electric diesel and battery have small cost increase, lower GHG
RRT 1	BCR 1.55	BCR 2.45 - 0.93	BCR 1.50 (small decrease)	Potential 3.1% cost increase; BCR 1.51	*See note.*	

Note: Local bus integration test was also carried out for LRT 1 and RRT 1A. For LRT 1, potential savings were $220 million, and BCR increase from 0.69 to 0.78. For RRT 1A, savings of $170 million and BCR increase from 1.45 to 1.60.

4.2.1 Land Use Growth/Distribution Scenarios

Overall, variations in the land use assumptions produced little change in the performance of the alternatives relative to each other. Demand increased and decreased consistently across the alternatives. In the high growth test, Fraser Highway showed a potential capacity risk for BRT. Low growth produced reductions in peak loads, particularly on Fraser Highway, which meant some technologies had more spare capacity. The base prime test did not produce significant overall differences, but did demonstrate some trade-off in allocation of peak loads, with more on 104 Avenue and less on Fraser Highway and King George Blvd.

Several key observations with respect to peak loads were noted by corridor:

- On Fraser Hwy, BRT combined with local bus service was slightly over capacity in the High Growth scenario, but provided sufficient corridor capacity to meet forecast peak demand in all other scenarios; BAU service would not meet corridor peak demand under any scenario.
- On King George Blvd, BRT combined with local bus service would meet forecast peak demand in all scenarios; BAU service would not meet corridor peak demand under any scenario;
- On 104 Ave, peak demand was below corridor capacity for all alternatives tested, including, the BAU service level , in all scenarios.

4.2.2 Rapid and Local Transit Scenarios

Overall, the transit tests underscore the sensitivity of mode share and peak demand results to the assumed level of background transit. For the lower growth background transit scenario, there was a significant drop in study area transit mode share relative to the base scenario, but similar or slightly higher peak point passenger loads on the rapid transit corridors. The forecast peak loads exceeded BRT capacity under certain circumstances.

On Fraser Highway, forecast peak demand exceeded BRT plus local bus capacity if lower levels of background transit service were provided, and particularly if lower levels of background transit service growth were combined with higher land use growth. On King George Blvd, BRT would also be over capacity if lower levels of background transit service growth were provided while higher land use growth was achieved. On 104 Avenue, BAU levels of service would meet the forecast demand in all scenarios.

Where reduced transit priority was tested for surface alternatives, the differences in passenger demand were modest, but life cycle costs increased and travel time benefits decreased due to slower and less reliable BRT/LRT operation. This would result in a reduction in BCR of 3% to 4% for BRT or LRT alternatives.

4.2.3 Modelling Scenarios

Large increases in auto operating costs reflected in the TDM test are forecast to have the largest upward effects on mode share (converging towards 20% transit mode share in both the study area and region), but a much smaller effect on peak loads. On Fraser Highway and King George Blvd, BRT combined with local bus meets the 2041 forecast demand under both the TDM and reduced transfer penalty scenarios. For the TDM scenario, the peak load matched the BRT plus local bus capacity on Fraser Highway. On 104 Avenue, BAU meets the forecast demand in both scenarios.

Through the TDM test, trip patterns change regionally and within the study area as people respond to higher costs by taking shorter trips, which is part of the reason transit mode share increases. Some of the peak passenger load points move to new locations compared to the base evaluation because of the differences in origin-destination patterns. Consequently, peak loads are generally a little higher than in the base scenario (but not as significant an increase as the mode share), but there are also some small reductions. However, along the Fraser Highway corridor capacity becomes a risk with BRT service as it is at capacity during the peak under this scenario.

With reduced transfer penalties, no additional capacity risks were apparent beyond those in the base scenario.

4.2.4 Financial Tests – Summary of Findings

Overall, the financial tests had little effect on the comparative performance of the alternatives. Several promising topics were identified for possible consideration in the next phase of the study. The main findings from the sensitivity tests on the financial assumptions are as follows:

- ***Discount Rate***. The Benefit-Cost Ratios for the alternatives tended to converge with higher discount rates, with little change in relative performance. Lower discount rates made the BCR increase, due mostly to higher net present value of long-term benefits. Best Bus showed the least sensitivity due to most of its costs being annual operations and maintenance.
- ***Implementation Timing.*** Assuming earlier opening years for less complex alternatives reduced their BCR. Costs and benefits are both discounted less if the life cycle is earlier,

but benefits have less opportunity to grow. The results did not affect the comparison between alternatives.

- ***Capital Cost Risks***. Construction costs through the floodplains and high water table areas of Langley are subject to ground conditions (due to poor soils), but the potential increase would be only 3-4% of the base evaluation capital costs. Since most alternatives carry this risk, there was no change in comparative performance.
- ***Local Bus Integration/Optimization***. There is potential to reduce local bus service relative to BAU to better match demand in all of the alternatives. This would reduce projected present value of costs and would increase the BCR, with the greater reductions to LRT and RRT alternatives, and greater relative benefit (BCR improvement) to lower cost alternatives.
- ***BRT Technology.*** Alternative BRT fuel/power source technologies could reduce GHG emissions with potentially modest impacts on lifecycle costs, though there is a high degree of uncertainty as to performance of the alternative rapid transit vehicles. Emission reduction was not a differentiator between alternatives in the base evaluation or in this test.

The financial tests supported the findings of the base evaluation, and also provided initial insights into several areas where costs may increase or decrease due to local conditions. It also uncovered design decisions to be made in subsequent phases of this study regarding the alternatives and connecting transit networks.

4.3 Implications of Sensitivity Test Outcomes

In summary, the sensitivity tests investigated the performance of the alternatives when land use, transit, modelling assumptions and financial inputs were varied from those used in the base evaluation. While the specific results from the tests varied from the base evaluation, the relative performance of the alternatives remained consistent with the ratings in Section 3.8 (except for the financial performance of BB, which was less sensitive than other alternatives). The tests did identify some design risks and avenues for further development of the alternatives in a later phase, as discussed below.

The model-based tests considered variations to land use and transportation inputs, and broad modelling assumptions. The key outcomes of the tests included the following:

- Rapid transit fleet size and operating assumptions in the base evaluation were robust, with respect to the land use and transportation variables and provided sufficient capacity, except for BRT in certain scenarios.
- The tests confirmed the importance of rapid transit on Fraser Highway and King George Boulevard in order to provide adequate transit capacity, since BAU service levels had insufficient capacity to meet future demand projections.
- Mode share and peak load results were sensitive to South of Fraser background bus network assumptions (especially on Fraser Highway). The results were also sensitive to population and employment growth assumptions, with the greatest effect (both positive and negative) on Fraser Highway because the base demand was close to BRT capacity.
- BRT would meet forecast long term demand on Fraser Highway in most scenarios, with 3 exceptions (high population/employment growth, lower background transit growth, and lower background transit growth combined with high population/employment growth). BRT would meet forecast long term demand on King George Boulevard in all but one scenario (lower background transit growth combined with high population/employment growth). BAU would meet forecast long term demand on 104 Ave in all scenarios.

Variations in the financial assumptions did not affect the relative financial performance of the alternatives (for example, the cost-effectiveness changed but the better performing alternatives remained the same). The results of the tests suggested that further investigation into two topics would be warranted in the next phase of the study, to optimize the design of any alternative carried forward from this study. Potential opportunities for future study include:

- Emerging bus propulsion technologies have potential to reduce GHG emissions at low lifecycle costs for alternatives containing BRT.
- Optimization of connecting local bus service, through development of a detailed transit integration plan, has potential to achieve operating cost savings for all of the alternatives.

The outcomes of the sensitivity tests, both overall and within each corridor, were taken into consideration in the study key findings.

5. STUDY KEY FINDINGS

The Surrey Rapid Transit study developed and evaluated a range of possible solutions for the study area, to inform the selection of a preferred rapid transit solution for Surrey and surrounding communities. At the outset, the study identified the primary project objectives to be addressed by rapid transit in the study area as follows:

1. Meet, shift and help shape travel demand through improved transit service quality.

2. Shape future land use in keeping with the Regional Growth Strategy and municipal plans.

3. Help achieve mode share and emissions targets.

A long list of rapid transit technology and alignment alternatives was narrowed in Phase 1 of the study to a short list of alternatives focusing on Fraser Highway, King George Blvd and 104 Ave. This short list was confirmed through public consultation and then developed and evaluated in more detail through a Multiple Account Evaluation.

Initial designs and evaluation results were brought to the public in spring / summer 2011 and, based on public input and further technical study, the design and operating assumptions were refined (as described in Section 2) and the evaluation updated, with the results presented in Sections 3 and 4.

5.1 Meeting Project Objectives

Considering the primary project objectives identified for the study area, the following conclusions can be drawn as to the appropriateness of each technology (Best Bus, BRT, LRT, and RRT) to the study area and to three primary corridors.

Capacity to Meet Demand

By 2041, rapid transit will be required to serve demand on Fraser Hwy and King George Blvd. Conventional bus service can continue to meet demand on 104 Ave through 2041. BRT and local bus service combined provide sufficient capacity to meet forecast peak demand (2041) on all three corridors. On Fraser Hwy, BRT is forecast to be at capacity in 2041, with uncertain ability to expand further[10]. LRT and RRT meet forecast demand on Fraser Hwy (2041) and provide the opportunity for expansion.

Shape Land Use

All of the rapid transit alternatives support additional development demand in rapid transit station areas, consistent with the regional growth strategy and local plans. The rapid transit alternatives with the greatest extent provide connectivity between the six largest of the seven urban centres in the study area, and are expected to attract the most station area development. Over the next thirty years 47 million square feet of multifamily and office development is forecast for the entire study area, of which 14.2 million square feet is anticipated to take place around the existing SkyTrain stations in Surrey. The additional station area development attracted by rapid transit alternatives ranges from 1 to 5.2 million square feet by 2041. Additional land use and demand management measures may increase the share of development drawn to station areas, but these were not evaluated in the study.

[10] The use of high capacity bi-articulated buses for BRT has not been evaluated in this phase of the study. Further analysis will take place in a later study phase to identify the specific vehicle requirements for the preferred alternative.

Shift Trips and Achieve Mode Share and Emissions Targets

All alternatives increase transit trips and mode share, and do so in similar amounts when considered at the scale of the region. Within the study area, alternatives with RRT increase transit trips and mode share the most. On King George Boulevard, alternatives with transfer-free service between Surrey Centre and South Surrey attract more new transit trips than those that require a transfer at Newton. For all the alternatives, the number of new transit trips is small relative to the number of trips shifted from bus to rapid transit, and to the total number of transit trips in the region. Therefore, at a regional scale, and when considered in isolation, they all have a similar and small impact on regional and sub-regional mode share and greenhouse gas emissions. None of these supply-side interventions would achieve mode share or emission targets, consistent with findings elsewhere in the region. Demand-side measures, such as road pricing, tolling, higher parking rates or gas prices, may complement rapid transit expansion to further increase transit mode share, but were not evaluated in-depth in the study.

5.2 Tradeoffs between Alternatives

Exhibit 5.1 summarizes quantitative measures for the Phase 2 alternatives, relative to the original project objectives of meeting demand, shifting travel and meeting mode share targets, and shaping land use. The “Business as Usual” case is presented for comparison. It also indicates the capital cost for construction and the net present value of costs (capital and operating costs and fare revenue, discounted at 6% to 2010).

The following sections outline several tradeoffs between the Phase 2 alternatives, further to those identified relative to the proeject objectives.

Capacity

The forecast demand for rapid transit is sensitive to the growth in population and employment and the level of service of the connecting bus network. All but three of the alternatives have the capacity to meet peak demand (2041) under the base conditions assumed for the study; neither LRT 4 nor RRT 3 would meet peak demand on Fraser Highway, and RRT 1 would not meet peak demand on King George Blvd.

BRT provides sufficient capacity to meet forecast peak demand (through 2041), but uncertain ability to expand beyond the assumed capacity. By 2041, with BRT on Fraser Highway (which applies to BRT 1, BRT 2, LRT 2, LRT 3, and RRT 2) forecast peak demand would take up most of the corridor’s available capacity. It would be over capacity if population and employment growth in the study area were greater than forecast, or if growth in the supporting bus network were slower than called for in the South of Fraser Area Transit Plan. It could also be over capacity if demand-side measures were put in place to draw more demand to transit; these measures were not evaluated in detail through this study. LRT and RRT both provide additional capacity to meet this greater demand and could be expanded further. They would provide capacity in excess of what would be required if population and employment growth in the study area were less than forecast.

(Continues after exhibit)

Exhibit 5.1 – Comparison of Alternatives – Meeting Demand, Transit Trips/Mode Share, Land Use and Costs

Measure		Business As Usual	Best Bus	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5a	LRT 5b	RRT 1	RRT 1a	RRT 2	RRT 3
Capacity to Meet Demand															
2041 Forecast Peak Load (passengers per hour per direction)	Fraser Hwy	1,700*	3,000	4,300	4,350	4,300	4,300	4,350	1,700*	4,250	4,350	6,800	6,600	4,300	1,700*
	KGB	1,700*	3,350	3,900	3,300	3,450	3,450	3,300	3,450	3,900	3,900	1,700*	3,650	5,250	5,250
	104 Ave	1,150	1,250	2,000	2,000	1,800	1,800	1,800	1,850	2,000	1,800	1,000	1,850	1,950	1,100
Assumed Capacity ** (passengers per hour per direction)	Fraser Hwy	1,700	4,000	4,700	4,700	6,500	4,700	4,700	1,700	6,500	6,500	10,200	10,200	4,700	1,700
	KGB	1,700	4,000	4,700	4,700	6,500	6,500	6,500	6,500	4,700	4,700	1,700	4,700	18,700	18,700
	104 Ave	1,700	4,000	4,700	4,700	6,500	6,500	6,500	6,500	4,700	6,500	1,700	4,700	4,700	1,700
Transit Trips and Mode Share															
Surrey Rapid Transit Daily Ridership (2041)		-	-	180,000	149,000	166,000	169,000	152,000	65,000	178,000	180,000	115,000	202,000	200,000	81,000
New Regional Daily Transit Trips (Weekday Average, 2020-2049)		-	11,500	13,500	11,500	12,000	12,500	12,000	4,000	12,500	13,500	17,000	24,500	17,500	8,000
Reduction in Vehicle Kilometres Travelled (millions km, to 2041) ***		-	1,200	1,500	1,200	1,300	1,400	1,300	500	1,400	1,500	1,500	2,400	1,700	800
2041 Transit Peak Hour Mode Share	(Regional / Study Area, %)	16.4 / 14.5	16.5 / 14.9	16.5 / 15.1	16.5 / 15.0	16.5 / 15.0	16.5 / 15.0	16.5 / 15.0	16.4 / 14.7	16.5 / 15.1	16.5 / 15.1	16.5 / 15.2	16.6 / 15.5	16.5 / 15.3	16.4 / 14.2
Air Emissions															
CO2 Net Reduction, Life Cycle (tonnes)			-524,000	-250,000	-141,000	-38,000	-174,000	-68.000	30,000	-114,000	-102,000	66,000	-50,000	-56,000	54,000
Land Use															
Station Area Redevelopment Demand (square feet millions, to 2041) ****		14.2	14.2	19.4	18.2	19.4	19.4	18.2	16.0	19.4	19.4	17.0	19.4	18.5	15.4
Costs															
Capital Costs ($ millions)		-	290	900	770	2,180	1,510	1,370	910	1,680	1,930	1,800	2,220	1,540	920
Net Present Value of Lifecycle Costs ($ millions)		-	530	820	640	1,630	1,180	1,030	640	1,280	1,460	1,260	1,670	1,150	630

* Peak Load for "Business as Usual" (and alternatives with the same level of service as BAU) is forecast to be above capacity and therefore is shown here at capacity.

** The assumed capacity is the level of capacity used for the purposes of evaluation and costing, and the numbers here include supporting bus service and rapid transit. The capacity of LRT is assumed to be 4,800 passengers per hour per direction (pphpd) and can be expanded to 10,000 pphpd or more subject to further analysis. RRT capacity is assumed to be 8,500 pphpd can be expanded to 26,000 pphpd.

*** For context, without Surrey Rapid Transit there are projected to be 800 Billion Vehicle Kilometres Travelled in the region over the same 30-year period.

**** For context, over the same 30-year period, 47 million square ft of total office and high density multifamily residential development demand is expected in the entire study area.

Speed, Reliability, and Frequency

BRT and LRT provide similar improvements in speed and reliability, particularly on Fraser Hwy, with a respective 23% and 26% reduction in travel time between Surrey Centre and Langley Centre relative to local bus service. RRT on Fraser Hwy provides the greatest speed and reliability improvements for those travelling on that corridor, associated with grade segregation of the Expo Line SkyTrain extension and avoiding the requirement to transfer at Surrey Central / King George stations for those travelling to or from the existing SkyTrain system. RRT on Fraser Highway provides a 46% reduction in travel time between Surrey Centre and Langley Centre.

On King George Boulevard, improvements in speed and reliability depend on whether or not there is a transfer required to reach White Rock. Direct BRT service between Surrey Central and White Rock (BRT 1, LRT 5A, LRT 5B and RRT 1A) provides the greatest overall speed improvements over local bus. LRT/BRT combinations with a transfer in Newton (LRT 1 and LRT 2) also have speed improvements over local bus, but overall are somewhat slower than the single BRT service over the length of the corridor. Alternatives providing service south of Newton operate in mixed traffic south of Highway 10 and due to the travel pattern variation (i.e. traffic changing lanes, differential travel speeds, and braking) their reliability is impacted.

All alternatives provide high frequencies of service. For example, on Fraser Hwy during the 2041 peak hour, RRT provides service every 4-5 minutes, LRT every 3 minutes, and BRT every 2 minutes to provide sufficient capacity to meet forecasted peak demand. These frequencies would be higher than needed if the population and employment growth in the study area was significantly less than the forecast in the Regional Growth Strategy.

Urban Design

BRT and LRT provide the greatest potential to improve urban design. RRT on Fraser Hwy or King George Blvd would introduce an elevated guideway and stations, and have a negative visual impact on the corridor.

Timing and Phasing

All alternatives can be constructed in phases, with differences based on technology and extent, which would spread out the capital requirements over a longer period of time. Best Bus and BRT alternatives have the greatest potential for phasing, including the ability to begin operating service and generating benefits independent from the construction of the rapid transit guideway. BRT infrastructure can be planned and designed for future conversion to LRT or RRT, at increased costs and with impacts to users during the conversion. Phasing plans have not been developed or evaluated through this study.

Affordability

There is a large range in capital and lifecycle costs for the alternatives. The capital costs of the alternatives range from $290 million for Best Bus to over $2.2 billion for RRT 1A. An assessment of affordability can only be made by considering regional investment needs relative to available funding. Such an assessment cannot be done within an alternatives analysis focused on the assessment of a single subregion.

Performance of Alternatives

Exhibit 5.2 compares the relative performance of BAU and the thirteen alternatives in terms of meeting demand, transportation and land use benefits, and financial performance.

Exhibit 5.2 – Comparative Summary of Alternatives

Alternative	Overall Performance
BAU	Does not provide sufficient future capacity or support land use objectives beyond existing stations.
Best Bus	Meets demand in all three corridors but has capacity risks beyond 2041. Provides few transportation and land use benefits at similar lifecycle cost to BRT 2.
BRT 1	Meets demand in all three corridors but has capacity risks on Fraser Highway by 2041. Provides fairly high transportation and land use benefits, at lower cost than most other rapid transit alternatives.
BRT 2	Meets demand in all three corridors but has capacity risks on Fraser Highway by 2041. Provides lower transportation benefits than BRT 1 due to transfer required at Newton, but also at lower cost.
LRT 1	Meets demand in all three corridors and provides expandability on Fraser Highway. Provides transportation benefits and land use benefits similar to BRT 1, but at second highest cost of the alternatives.
LRT 2	Meets demand in all three corridors but has capacity risks on Fraser Highway by 2041. Provides transportation benefits and land use benefits lower than BRT 1, but at higher cost.
LRT 3	Meets demand in all three corridors but has capacity risks on Fraser Highway by 2041. Provides transportation benefits and land use benefits similar to BRT 2, but at higher cost.
LRT 4	Does not meet demand on Fraser Highway, and so is not a feasible long-term solution. Due to its shorter length, it provides few transportation benefits, resulting in the lowest cost-effectiveness.
LRT 5a	Meets demand in all three corridors and provides expandability on Fraser Highway. Provides fairly high transportation and land use benefits at medium-high cost
LRT 5b	Meets demand in all three corridors and provides expandability on Fraser Highway. Provides similar benefits to LRT 5a at higher cost.
RRT 1	Does not meet demand on King George Blvd, and so is not a feasible long-term solution. Provides high transportation benefits but only in Fraser Highway corridor.
RRT 1a	Meets demand in all three corridors. Provides highest transportation and land use benefits at highest cost of the alternatives.
RRT 2	Meets demand in all three corridors, with excess provided on King George Blvd, but has capacity risks on Fraser Hwy by 2041. Provides higher transportation benefits than similar-extent BRT 2, but at higher costs.
RRT 3	Does not meet demand on Fraser Highway, and so is not a feasible long-term solution.

5.3 Next Steps

The results of this evaluation will help to inform the selection of a preferred alternative. The selection of an alternative will take place within a regional context, to allow the consideration of funding availability for this project and other regional transportation investment needs.

Once a preferred alternative has been identified, Phase 3 will advance the planning and design of that alternative, and carry out further public consultation to aid in design development. The technical scope would include more detailed design of the alignments and intersection layouts, station locations, station area planning and urban design, transit service integration, and environmental study and identification of any mitigation measures.

Surrey Rapid Transit Alternatives Analysis

Phase 2 Evaluation

APPENDIX 1 – DESIGN PRINCIPLES

August, 2012

APPENDIX 1 – DESIGN PRINCIPLES

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APPENDIX 1 – DESIGN PRINCIPLES

This appendix contains information on the design principles applied to develop conceptual designs in support of the final Phase 2 Evaluation. The design principles relate to three technologies:

- Bus Rapid Transit (BRT);
- Light Rail Transit (LRT); and
- Rail Rapid Transit (RRT, also known as SkyTrain).

The material in this appendix includes:

- Introduction;
- Design Principles for BRT, LRT and RRT;
- Typical Cross Sections for Streets with Rapid Transit;
- Key Plans of Design Assumptions; and
- Renderings illustrating the typical stations and alignment features for BRT, LRT and RRT.

1. INTRODUCTION

There were twelve Phase 2 Rapid Transit Alternatives, which came from Phase 1 of the SRTAA, and from a Design Refinement process in Phase 2. This appendix presents the design principles separately for BRT, LRT and RRT (focusing on alignments and stations) that can be assembled to make up alternatives. There was a thirteenth Phase 2 alternative, Best Bus, which does not involve new rapid transit, and therefore it is not the subject of this Appendix.

1.1 PURPOSE OF CONCEPTUAL DESIGNS

Phase 2 involved developing conceptual designs for the alternatives and carrying out analysis of this set of alternatives, based on a Multiple Account Evaluation (MAE). The Phase 2 evaluation framework included seven accounts with quantitative and qualitative criteria, which were informed directly by the conceptual designs and the transit operating assumptions for each alternative. The evaluation framework was refined at the beginning of Phase 2 with the project partners, to guide the preliminary evaluation. The intent of the evaluation is to inform the selection of a Preferred Alternative for the study area, after completion of the study. This required completing an initial evaluation, receiving public input on the design assumptions and initial findings, refining the conceptual designs, carrying out sensitivity tests and then completing the evaluation.

Therefore, the conceptual design process for Phase 2 of the study is to develop conceptual engineering designs for the rapid transit alternatives to a sufficient level of detail to:

1. Confirm the feasibility of the rapid transit alternatives; and

2. Support the MAE evaluation process for the alternatives under consideration.

The reader should be aware that Phase 2 will support the identification of a Preferred Alternative for the SRTAA study area. Phase 3 of the project will develop the design of the Preferred Alternative in more detail, including further examination of alignment, cross-section, station location, and urban design options, as well as project phasing.

Given the requirements of Phase 2, the level of design detail is sufficient to provide input to the evaluation process. The contents include:

- Key plans of the overall geographic scope of each of the three technologies;
- Typical sections for each technology, showing how the rapid transit system could fit into arterial streets;

Conceptual designs finalised in the Fall of 2011 provided the basis for the Phase 2 evaluation. They were refined from earlier designs, based on partner review and comment, and public input received in June and July 2011.

2. BRT DESIGN PRINCIPLES

The design philosophy applied to these conceptual designs had two basic premises. The first was to minimize property and potential environmental impacts along each alignment, and the second was to provide high-quality rapid transit by maximizing the segregation from other traffic wherever possible. These design principles were discussed with the project partners in fall of 2010, and were carried into the design of the rapid transit alignments and stations.

2.1 BRT ALIGNMENT

Most of the conceptual alignments assumed that Bus Rapid Transit is almost entirely located within the centre of arterial streets, except where advantages to side running were identified by the project team or partners. This allows for greater segregation of the rapid transit operation from other traffic, side streets, driveways, parking, and cyclists, all of which could make BRT operations slower and less reliable. Therefore, over 80% of the design featured centre-running BRT lanes.

BRT is assumed to operate in semi-exclusive median bus lanes, used only by rapid transit vehicles. These lanes would be separated from other traffic, except at signalized intersections. At this stage of design, the BRT right of way is 7.0 metres wide and separated from parallel lanes of general purpose traffic by a safety clearance zone (assumed to be 0.6 m on both sides, in addition to the 7m). This zone would include an angled raised curb to deter road users from driving onto or over the BRT alignment. Emergency vehicles will be able to mount the curb and use the alignment to cross or bypass other traffic.

The cross-section design is based on existing property lines for public ROW (existing conditions + funded construction), and therefore much of the design is centred on the current median. However, in some areas, it was understood that the ultimate cross-section may shift the centre-line of the street to one side from the current state, and where practical this was accounted for.

Exhibit 2.1 – Example of BRTway Eugene, Oregon

One of the key objectives in accommodating rapid transit in the corridors under consideration was to minimize property impacts whilst seeking to ensure that an effective and efficient rapid transit service can be delivered. In order to achieve this, three types of cross-sections were developed. These included:

- An 'Unconstrained' cross-section, which is based on existing partner agency design standards and best practice;
- A 'Constrained' cross-section which reduces the width of traffic/parking lanes, boulevards, cycling lanes and/or sidewalks. This design was assumed in locations where the unconstrained cross-section could not be accommodated without significant adverse impacts.
- An additional 'Further Constrained' cross-section was developed which further reduces the widths of the safety clearance zone, traffic/parking lanes, boulevards, cycling lanes and/or sidewalks. This option was developed for possible use in Phase 3 but is not included in this appendix.

Exhibits 6.1 through 6.4 illustrate these typical sections for 2-lane and 4-lane configurations of arterial streets. Exhibits 7.1 and 7.2 illustrate where these typical sections were applied in the Phase 2 conceptual designs, and show the location of signalized and restricted movement intersections along the alignment. To address constraints through Green Timbers Urban Forest, the assumed section features queue jump lanes at approaches to intersections, and then shared lanes through the constrained part of the alignment; this approach is illustrated on Exhibit 8.4.

At bridges, the available width was compared to the typical rapid transit section to see if BRT could fit on existing structures. If this was not feasible, then widening or construction of new bridges was assumed in the concept design. Other potential design constraints include major utilities, and major parallel utilities (running continuously under the BRT alignment) which will be avoided where possible through design process. Otherwise, utility conflicts will be addressed through relocation or protection-in-place.

2.2 BRT STATIONS

In this design, BRT stations are located alongside the BRT alignment, generally in the centre of arterial streets. The platforms are typically placed on the opposite sides of major intersections for the two directions of travel in order to facilitate pedestrian access as well as to assist in minimizing delays to general purpose traffic. Design features at the stations could include: shelters, seating, ticket machines, passenger information, real-time service information, safety systems, and wayfinding to connecting transit. The platforms are 3 metres wide to provide room for accessible boarding and station amenities, and 40 metres long, so that up to two articulated buses could stop alongside simultaneously. Some platforms at termini are 57 metres in length, 3 metres width sidewalk platforms to allow for accessible boarding and station amenities.

The same number of station locations is assumed for each rapid transit technology along a given route, so that the evaluation can focus first on the technology differences within the alternatives. The number and location of stations will be reviewed and refined as appropriate in Phase 3 in order to evaluate costs and other benefits. There are minor differences in the layout of the stations for each technology because of how the infrastructure fits in the right-of-way. Additional stations may be identified for consideration in Phase 3, but these were not included in the Phase 2 Evaluation. Exhibit 7.3 shows an assumed set of stations for the Phase 2 Evaluation, and several other candidate station locations for possible later consideration.

The stations are located at or near major crossing arterials with transit routes or major activity centres, resulting in a spacing of approximately every 800 to 1600 metres. In addition, no stations are assumed inside the floodplains where there are few residents or jobs to serve. The stop spacing is longer than conventional bus transit services to be compatible with higher-speed rapid transit operations. Adding stations sometimes improves local access, but slows down the overall rapid transit system and increases costs for stations, right of way, and rapid transit vehicles. Because of the complex tradeoffs, station optimization will continue into Phase 3.

Exhibit 2.2 -- Example of BRT Station Eugene, Oregon

Exhibit 8.1 illustrates a conceptual BRT station, as seen from three different perspectives.

2.3 BRT HIGH-LEVEL DESIGN ASSUMPTIONS

Design Element	Design Principle	Comments
Vehicle	Length: 18 metres Width: 2.5 metres	Generic vehicle parameters were developed based upon a selection of current modern vehicles that are likely to be offered during procurement.
Alignment	Two way running width of 7 metres, widening through curves. Running at grade. Central running.	7 metres excludes the required safety clearance zone (approx 0.6 m each side, or more) for the vehicles.
Segregation	The design philosophy was to maximize segregation along the alignments while seeking to minimize property take and environmental impacts. Reallocation of road space for the exclusive use of the BRT system where this is achievable (mountable curbs separating the BRT from other traffic).	
Priority	The design philosophy was to maximize priority at key intersections while seeking to minimize any adverse impacts on general traffic. Automatic Vehicle Location System (AVLS) employed to provide Traffic Signal Priority (TSP) through signaled intersections.	AVLS and TSP will help facilitate *reduced* journey times and greater journey time reliability.
Stations	Length: 40 metres Width: 3 metres, side platform The majority of stations will feature eastbound and westbound platforms staggered across intersections.	Length to accommodate two vehicles stopped at the station. Some termini stations 57m platforms.
Station Infrastructure	Dedicated stop infrastructure elements to include: • Shelters; • Seating; • Ticket machines; • Passenger Information; • Real Time Service Information; and • Branding.	
Roadway	The design will seek to minimize cross corridor traffic impacts, though most minor intersections will need to be converted to right-in right-out to provide greater lengths of segregated running. Four lanes of general traffic were maintained on both King George Boulevard and Fraser Highway in line with ROW availability and desired cross-section provided by the City of Surrey.	

3. LRT DESIGN PRINCIPLES

The design philosophy applied to these conceptual designs had two basic premises. The first was to minimize property and potential environmental impacts along each alignment, and the second was to provide high-quality rapid transit by maximizing the segregation from other traffic wherever possible. These design principles were discussed with the project partners in fall of 2010, and were carried into the design of the rapid transit alignments and stations.

3.1 LRT ALIGNMENT

Most of the conceptual alignments assumed that Light Rail Transit is almost entirely located within the centre of arterial streets, except where advantages to side running were identified by the project team or partners. This allows for greater segregation of the rapid transit operation from other traffic, side streets, driveways, parking, and cyclists, all of which could make LRT operations slower and less reliable. Therefore, over 98% of the design features centre-running LRT lanes.

LRT is assumed to operate in a semi-exclusive segregated median. This median would be physically separated from other traffic, except at signalized intersections. At this stage of design, the LRT right of way is 6.8 metres wide and separated from parallel lanes of general purpose traffic by a safety clearance zone (assumed to be 1.2m on both sides, in addition to the 6.8m). This zone would include an angled raised curb to deter road users from driving onto or over the LRT alignment. Emergency vehicles will be able to mount the curb and use the alignment to cross or bypass other traffic.

The cross-section design is based on existing property lines for public ROW (existing conditions + funded construction), and therefore much of the design is centred on the current median. However, in some areas, it was understood that the ultimate cross-section may shift the centre-line of the street to one side from the current state, and where practical this was accounted for.

Exhibit 3.1 -- Example of LRT Alignment in Centre of Street (Portland, Oregon)

One of the key objectives in accommodating rapid transit in corridors under consideration was to minimize property impacts while seeking to ensure that an effective and efficient rapid transit service can be delivered. In order to achieve this, three types of cross-sections were developed. These included:

- An 'Unconstrained' cross-section, which is based on existing partner agency design standards and industry best practice;
- A 'Constrained' cross-section which reduces the width of traffic/parking lanes, boulevards, cycling lanes and/or sidewalks. This design was assumed in locations where the unconstrained cross-section could not be accommodated without significant adverse impacts.
- An additional 'Further Constrained' cross-section was developed which further reduces the widths of the safety clearance zone, traffic/parking lanes, boulevards, cycling lanes and/or sidewalks. This option was developed for possible use in Phase 3 and was not used in this appendix.

Exhibits 6.5 through 6.8 illustrate these typical sections for 2-lane and 4-lane configurations of arterial streets. Exhibits 7.4 and 7.6 illustrate where these typical sections were applied in the Phase 2 designs, and show the location of signalized and restricted movement intersections along the alignment. To address constraints through Green Timbers Urban Forest, the assumed section features queue jump lanes at approaches to intersections, as illustrated on Exhibit 8.4.

At bridges, the available width was compared to the typical rapid transit section to see if LRT could fit on existing structures. If this was not feasible, or if the bridge structure appeared unsuitable for supporting LRT, then widening or construction of new bridges was assumed for the conceptual design. Other potential design constraints include major utilities, and major parallel utilities (running continuously under the LRT alignment) will be avoided where possible through design. Otherwise, utility conflicts will be addressed through relocation or protection-in-place.

3.2 LRT STATIONS

In this design, LRT stations are located alongside the LRT alignment, generally in the centre of arterial streets. The platforms are typically placed on the opposite sides of major intersections for the two directions of travel in order to facilitate pedestrian access as well as to assist in minimising delays to general purpose traffic. Design features at the stations could include: shelters, seating, ticket machines, passenger information, real-time service information, safety systems, and wayfinding to connecting transit. The side platforms are 3 metres wide (minimum), to provide room for accessible boarding and station amenities, and a minimum of 40 metres long, so that an articulated LRT (length up to 40 m) can stop alongside. The platforms at termini are 4.5 metres (minimum) centre platforms to allow for accessible boarding and station amenities.

The same number of station locations is assumed for each rapid transit technology along a given route, so that the evaluation can focus first on the technology differences within the alternatives. The number and location of stations will be reviewed and refined as appropriate in Phase 3 in order to evaluate costs and other benefits. There are minor differences in the layout of the stations for each technology because of how the infrastructure fits in the right-of-way. Additional stations may be identified for consideration in Phase 3, but these were not included in the Phase 2 Evaluation. Exhibit 7.6 shows the assumed set of stations for the Phase 2 Evaluation, and several other candidate station locations for possible consideration in later phases.

The stations are located at or near major crossing arterials with transit routes or major activity centres, resulting in a spacing of approximately every 800 to 1600 metres. In addition, no stations are assumed inside the floodplains where there are few residents or jobs to serve. The stop spacing is longer than conventional bus transit services to be compatible with higher-speed rapid transit operations. Adding stations sometimes improves local access, but slows down the overall rapid transit system and increases costs for stations, right of way, and rapid transit vehicles. Because of the complex tradeoffs, station optimization will continue into Phase 3.

Exhibit 3.2 -- Example of LRT Station (Seattle, Washington)

Exhibit 8.2 illustrates a conceptual LRT station, as seen from three different perspectives.

3.3 LRT HIGH-LEVEL DESIGN ASSUMPTIONS

Design Element	Design Principle	Comments
Vehicle	Length: up to 40 metres Width: 2.65 metres	Generic vehicle parameters were developed based upon a selection of current modern vehicles that are likely to be offered during procurement.
Alignment	Two-way running width of 6.8 metres (excluding safety clearance zone), widening through curves. Running at grade. Central running.	Running width includes allowance for Overhead Line Equipment (OLE) support poles.
Segregation	The design philosophy was to maximize segregation along the alignments while seeking to minimize property take and environmental impacts. Reallocation of road space for the exclusive use of the LRT system where this is achievable (mountable curbs separating the LRT from other traffic).	
Priority	The design philosophy was to maximize	AVLS and TSP priority will help

Design Element	Design Principle	Comments
	priority at key intersections while seeking to minimize any adverse impacts on general traffic. Automatic Vehicle Location System (AVLS) employed to provide Traffic Signal Priority (TSP) through signaled intersections.	facilitate *reduced* journey times and greater journey time reliability.
Stations	Length: 40 metres (standard), 80 metres at termini Width: 3 metres (minimum), side platform. 4.5m (minimum), centre platforms at termini and specific locations The majority of stations will feature far-side platforms staggered across intersections.	There is room within the conceptual layouts to extend platforms to 45 m in the event of longer LRT vehicles. Length to accommodate two vehicles stopped at the station.
Station Infrastructure	Dedicated infrastructure elements to include: • Shelters; • Seating; • Ticket machines; • Passenger Information; • Real Time Service Information; and • Branding.	
Roadway	The design will seek to minimize cross corridor traffic impacts, though most minor intersections will need to be converted to right-in right-out to provide greater lengths of segregated running. Four lanes of general traffic were maintained on both King George Boulevard and Fraser Highway in line with ROW availability and desired cross-section provided by the City of Surrey.	

4. RRT DESIGN PRINCIPLES

The design philosophy applied to these conceptual designs had two basic premises. The first was to minimize property and potential environmental impacts along each alignment, and the second was to provide high-quality rapid transit by maximizing the segregation from other traffic wherever possible. These design principles were discussed with the project partners in fall of 2010, and were carried into the design of the rapid transit alignments and stations.

4.1 RRT ALIGNMENT

Most of the conceptual alignments assumed Rail Rapid Transit is elevated above the centre of arterial streets, except where advantages to side running were identified by the project team or partners. This allows the support columns to be placed in the street median, thereby reducing potential property impacts. Side running and off-street running were assumed in special circumstances, including the extensions beyond King George Station to the east (before joining

Fraser Highway) or south (before joining King George Boulevard), and along sections of Fraser Highway in the City of Langley that currently lack a central median.

RRT must be separated from other traffic, either elevated, or at grade with a barrier completely separating it from other traffic. At this stage of design, elevated RRT columns are assumed to be 1.6 metres wide and separated from parallel lanes of general purpose traffic. The columns would typically be placed within a 3.6-metre wide median, which creates a safety clearance for other traffic. Off-street, the column would be set back from the street curb for safety and visibility reasons.

The cross-section design is based on existing property lines for public ROW (existing conditions + funded construction), and therefore much of the design is centred on the current median. However, in some areas, it was understood that the ultimate cross-section may shift the centre-line of the street to one side from the current state, and where practical this was accounted for.

One of the key objectives in accommodating rapid transit in corridors under consideration was to minimize property impacts while seeking to ensure that an effective and efficient rapid transit service can be delivered. In order to achieve this, two types of cross-sections were developed:

- An ‘Unconstrained’ cross-section which is based on existing partner design standards and industry best practice; and
- A ‘Constrained’ cross-section which reduces the width of traffic/parking lanes, boulevards, cycling lanes and/or sidewalks which was used in locations where the unconstrained cross-section could not be accommodated without significant adverse impacts.

Exhibits 6.9 and 6.10 illustrate the typical sections for 4-lane configurations of arterial streets, with elevated RRT. Exhibit 7.7 illustrates where these were applied to the Phase 2 design, and Exhibit 7.8 shows the assumed intersection configurations along the alignments.

Exhibit 4.1 -- Example of RRT Alignment (Surrey)

Existing bridges are assumed not to be able to support RRT, and support columns would be placed away from existing (or planned) bridges. Other potential design constraints include major utilities, and major parallel utilities (running continuously under the RRT alignment) will be avoided where possible through design. Otherwise, utility conflicts will be addressed through relocation or protection-in-place.

4.2 RRT STATIONS

In this design, RRT stations are assumed to be similar in scale and layout to the existing Millennium Line, which has platforms for each direction of travel outside the tracks, and a mezzanine level below the platform and above the street so that passengers can access both platforms after entering the station. Design features at the stations could include: seating, ticket machines and fare gates, passenger information, real-time service information, security and safety systems, and wayfinding to connecting transit. The stations are assumed to be approximately 85 metres long.

The same number of station locations is assumed for each rapid transit technology along a given route, so that the evaluation can focus first on the technology differences within the alternatives. There are minor differences in the layout of the stations for each technology because of how the infrastructure fits in the right-of-way. Additional stations may be identified for consideration in Phase 3, but these were not included in the Phase 2 Evaluation. Exhibit 7.9 shows the assumed set of stations for the Phase 2 Evaluation, and several other candidate station locations for consideration in later phases.

The stations are located at or near major crossing arterials with transit routes or major activity centres, resulting in a spacing of approximately every 800 to 1600 metres. In addition, no stations are assumed inside the floodplains where there are few residents or jobs to serve. The stop spacing is longer than conventional bus transit services to be compatible with higher-speed rapid transit operations. Adding stations sometimes improves local access, but slows down the overall rapid transit system and increases costs for stations, right of way, and rapid transit vehicles. Because of the complex tradeoffs, station optimization will continue into Phase 3.

Exhibit 4.2 -- Example of RRT Station (Brentwood)

Exhibit 8.3 illustrates a conceptual RRT station, as seen from three different perspectives.

4.3 RRT HIGH-LEVEL DESIGN ASSUMPTIONS

Design Element	Design Principle	Comments
Vehicle	Length: up to 80 metres Width: 2.65 metres	Designed to allow for up to 5-car SkyTrain consists.
Alignment	Centre running above street median; or side-running elevated next to street	Placement relative to the street is context-dependent.
Segregation	100% segregated, automatically controlled from a central location	Consistent with the design of the Expo SkyTrain line.
Stations	Length: 85 metres Width: 5 metre (minimum) platforms, each side of the running way.	
Station Infrastructure	Elevated stations to include a mezzanine between street level and platforms. Dedicated infrastructure elements to include: • Entrances; • Mezzanine/Concourse; • Ticketing equipment; • Fare gates; • Elevators, escalators and stairs; • Seating; • Passenger Information; • Real Time Service Information; • Safety features (CCTV, Help Points, fire equipment); • Emergency exits; and • Branding.	
Other Infrastructure	Dedicated infrastructure elements related to RRT include-traction power substations.	
Roadway	The design will seek to minimize roadway impacts during and following construction.	

5. CONNECTING BUS SERVICE

Each rapid transit alternative will include an enhanced connecting future bus transit network. This network will be consistent with the service levels in the South of Fraser Area Transit Plan (SOFATP) vision through 2041. This "Business As Usual" network assumes increases in transit service commensurate with population and employment growth in the study area. In Phase 2, this background network is integrated with each of the rapid transit alternatives to provide convenient connections and coverage of the study area. . Limited modifications to local services were assumed (where these duplicate the same routes as rapid transit) to ensure comparability between the alternatives. Optimization of the study area transit network will occur in Phase 3 for the Preferred Alternative.

The rapid transit alignments connect to five transit exchanges in the study area, and the Phase 2 designs were based on the best current (end of 2010) information on plans to upgrade each of the transit exchanges in the future. The designs were developed to be compatible with approved plans. Additional work will be required in Phase 3 to develop integrated rapid transit station/exchange plans for the preferred alternative.

6. TYPICAL CROSS SECTIONS

6.1 BRT TYPICAL CROSS SECTIONS

Exhibit 6.1 -- Typical 4 Lane BRT Cross Section with Unconstrained Parameters

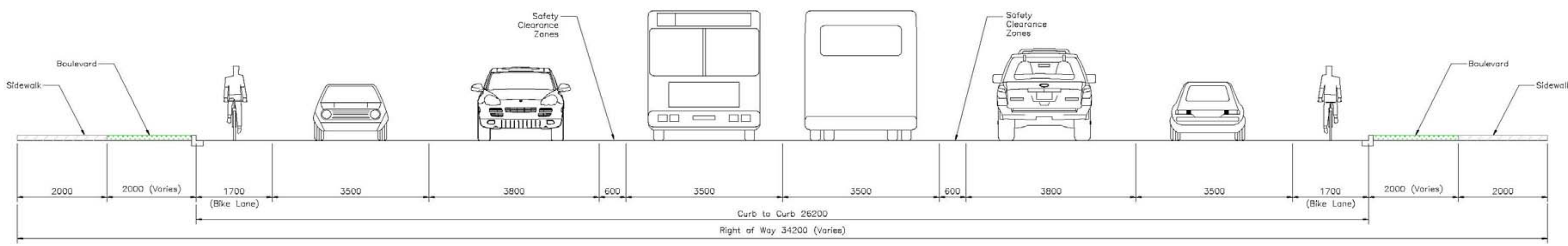


Exhibit 6.2 --Typical 4 Lane BRT Cross Section with Constrained Parameters

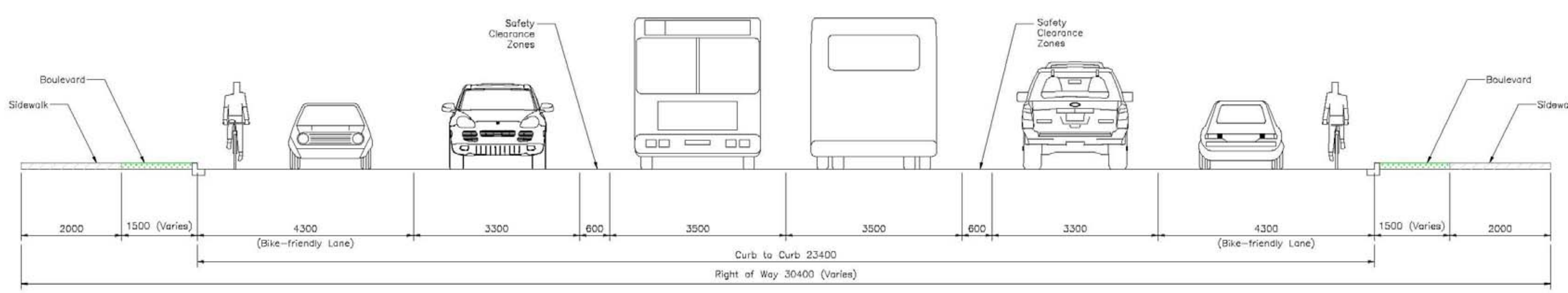
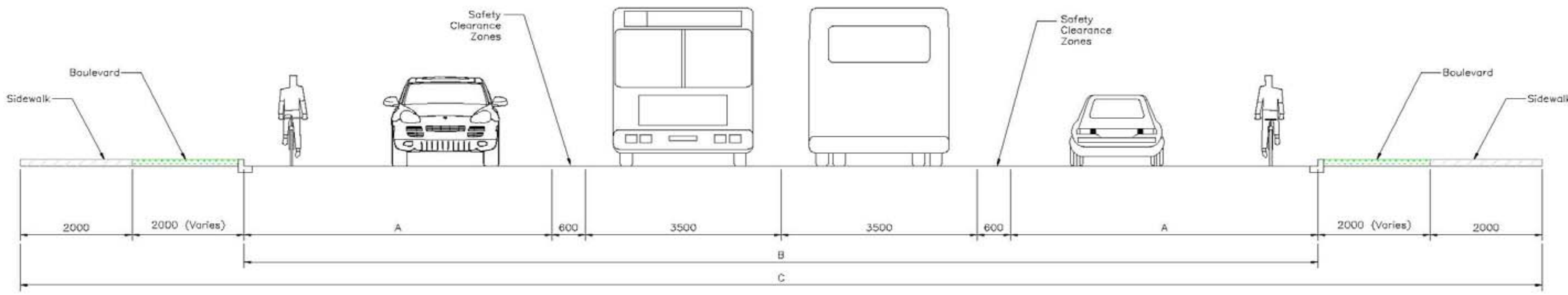
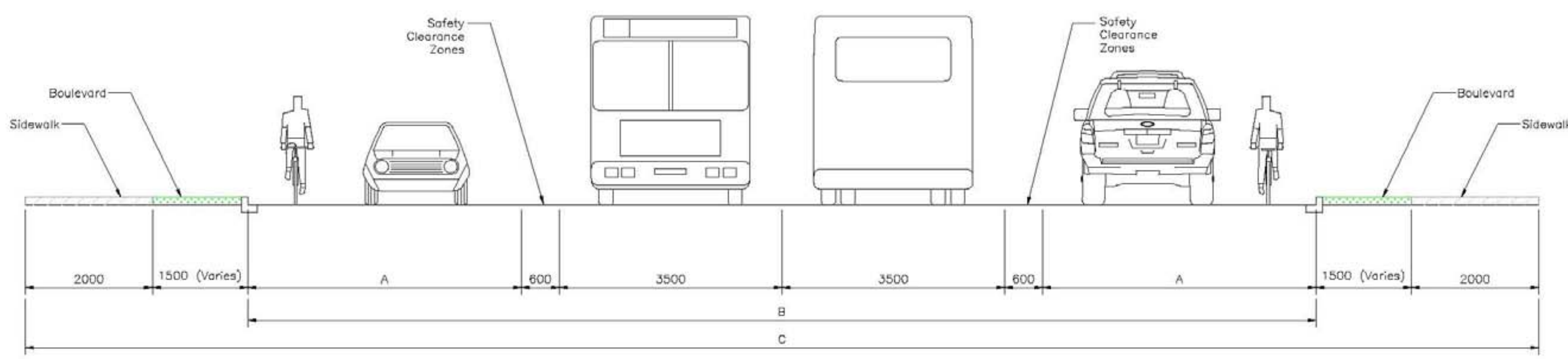


Exhibit 6.3 -- Typical 2 Lane BRT Cross Section with Unconstrained Parameters



Desirable Min.	A	B	C
With cyclist provision	5.5m	19.2m	27.2m
Without cyclist provision	3.8m	15.8m	23.8m

Exhibit 6.4 -- Typical 2 Lane BRT Cross Section with Constrained Parameters



Absolute Min.	A	B	C
With cyclist provision	4.3m	16.8m	23.8m
Without cyclist provision	3.8m	15.8m	22.8m

6.2 LRT TYPICAL CROSS SECTIONS

Exhibit 6.5 -- Typical 4 Lane LRT Cross Section with Unconstrained Parameters

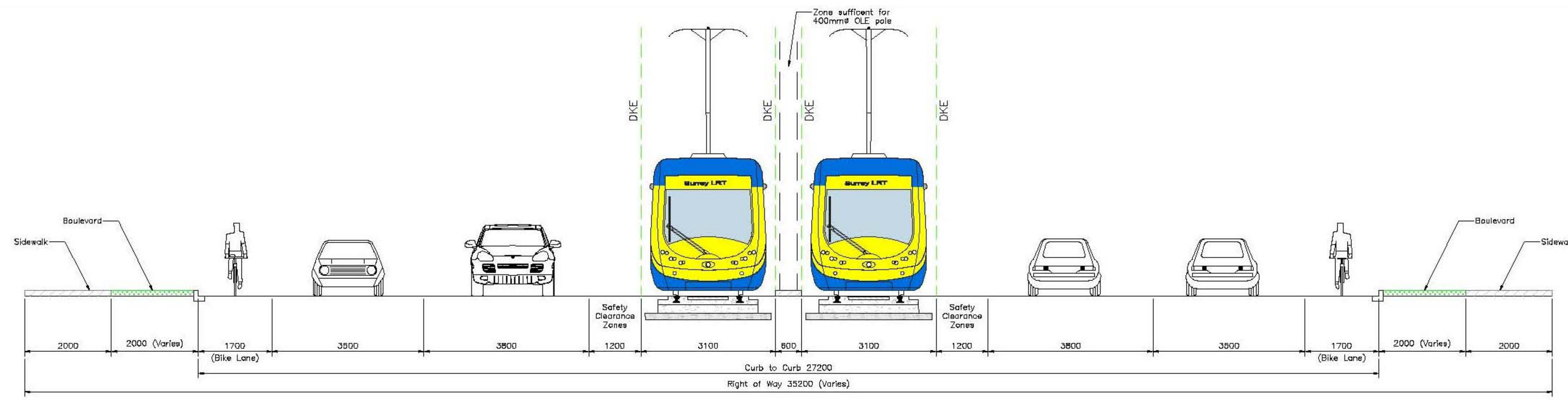


Exhibit 6.6 -- Typical 4 Lane LRT Cross Section with Constrained Parameters

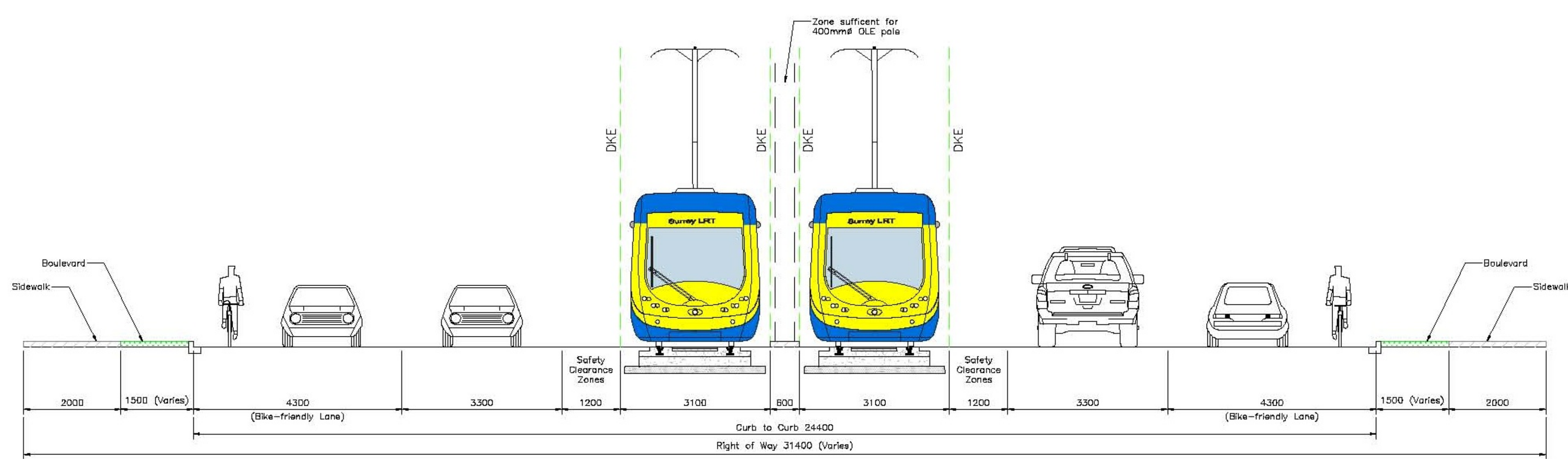
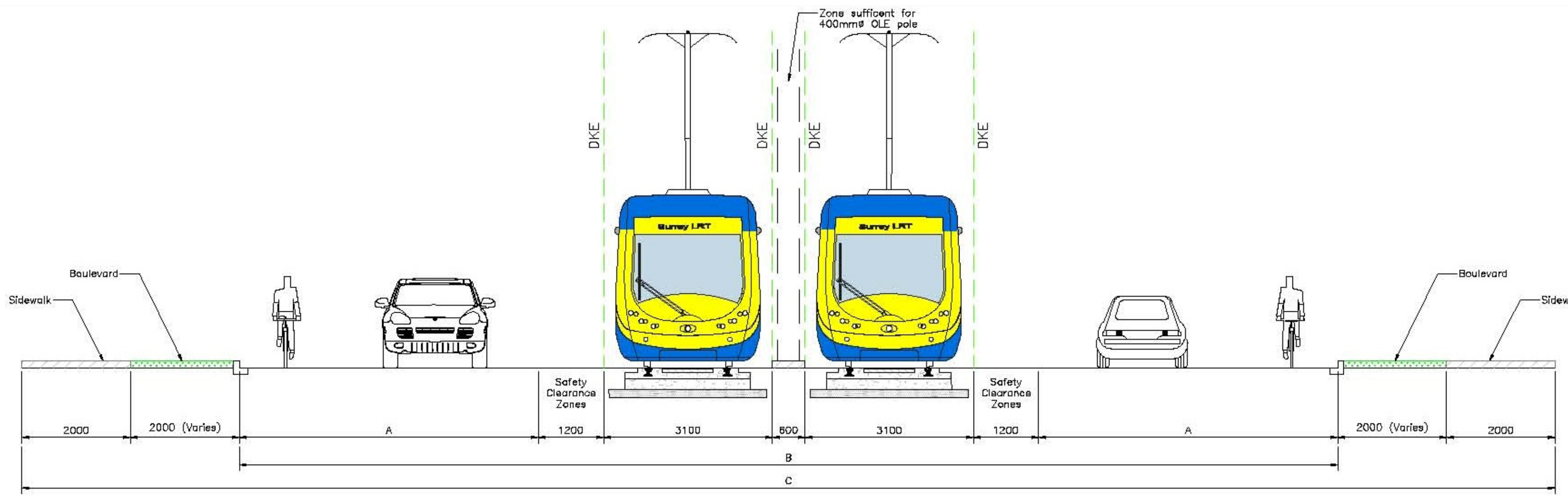
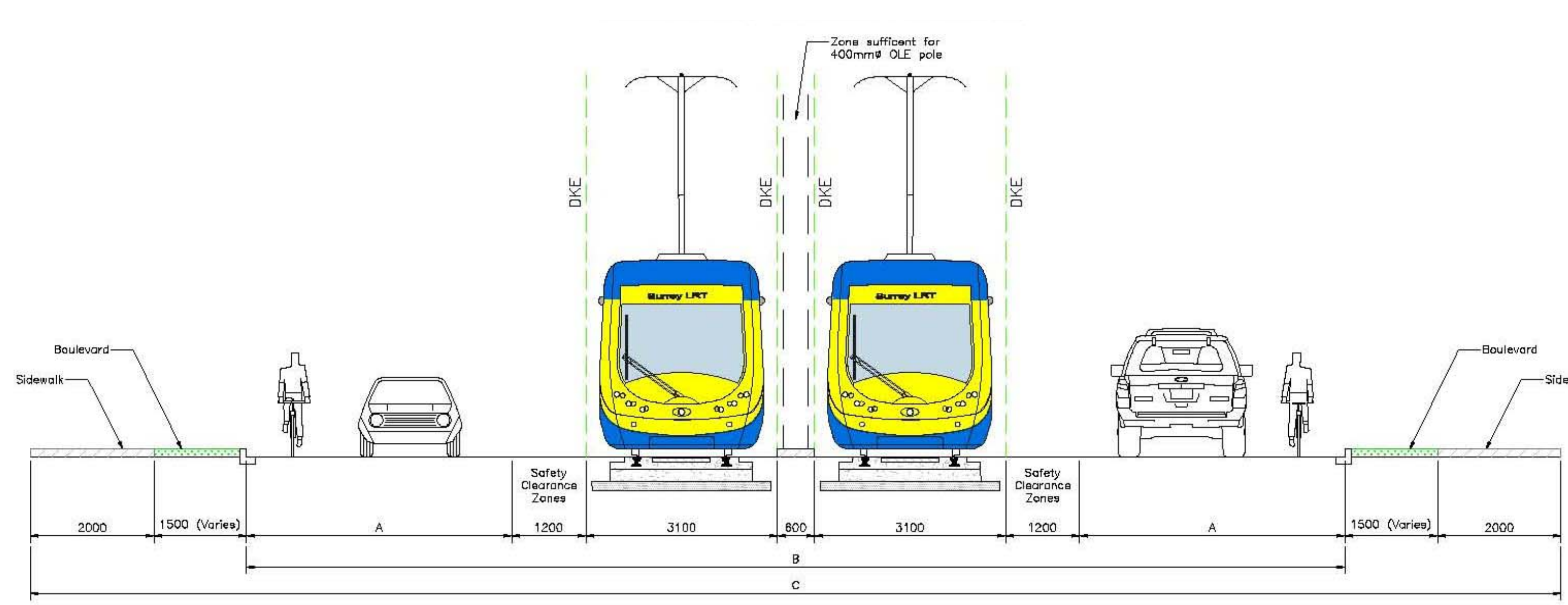


Exhibit 6.7 -- Typical 2 Lane LRT Cross Section with Unconstrained Parameters



Desirable Min.	A	B	C
With cyclist provision	5.5m	20.2m	28.2m
Without cyclist provision	3.8m	16.8m	24.8m

Exhibit 6.8 -- Typical 2 Lane LRT Cross Section with Constrained Parameters



Absolute Min.	A	B	C
With cyclist provision	4.3m	17.8m	24.8m
Without cyclist provision	3.8m	16.8m	23.8m

6.3 RRT TYPICAL CROSS SECTIONS

Exhibit 6.9 -- Typical 4 Lane RRT Cross Section with Unconstrained Parameters

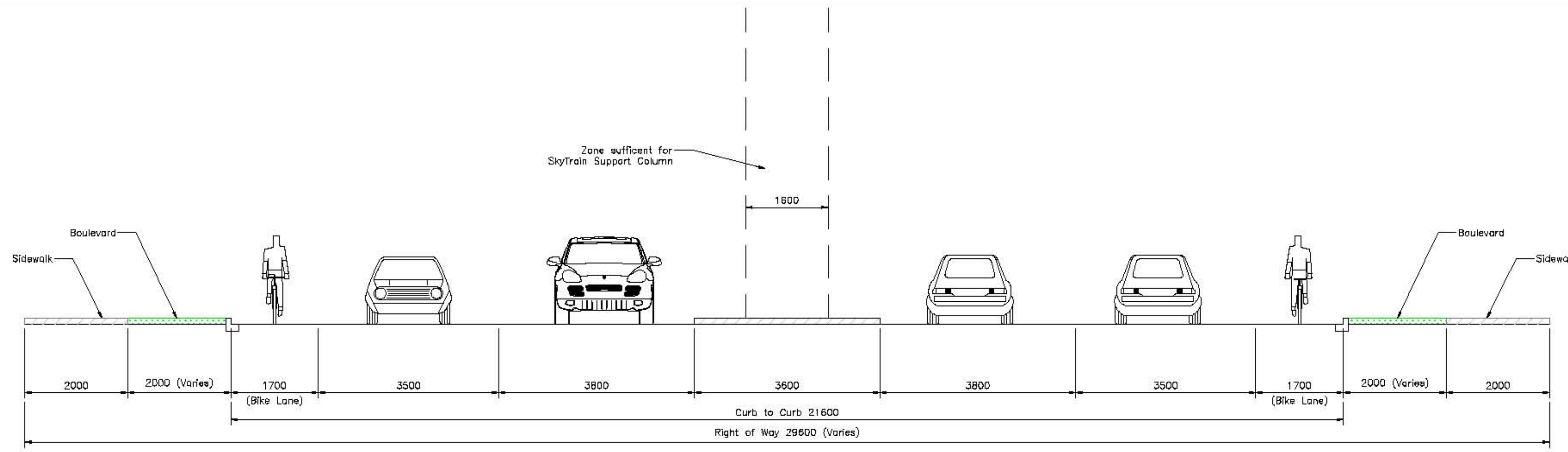
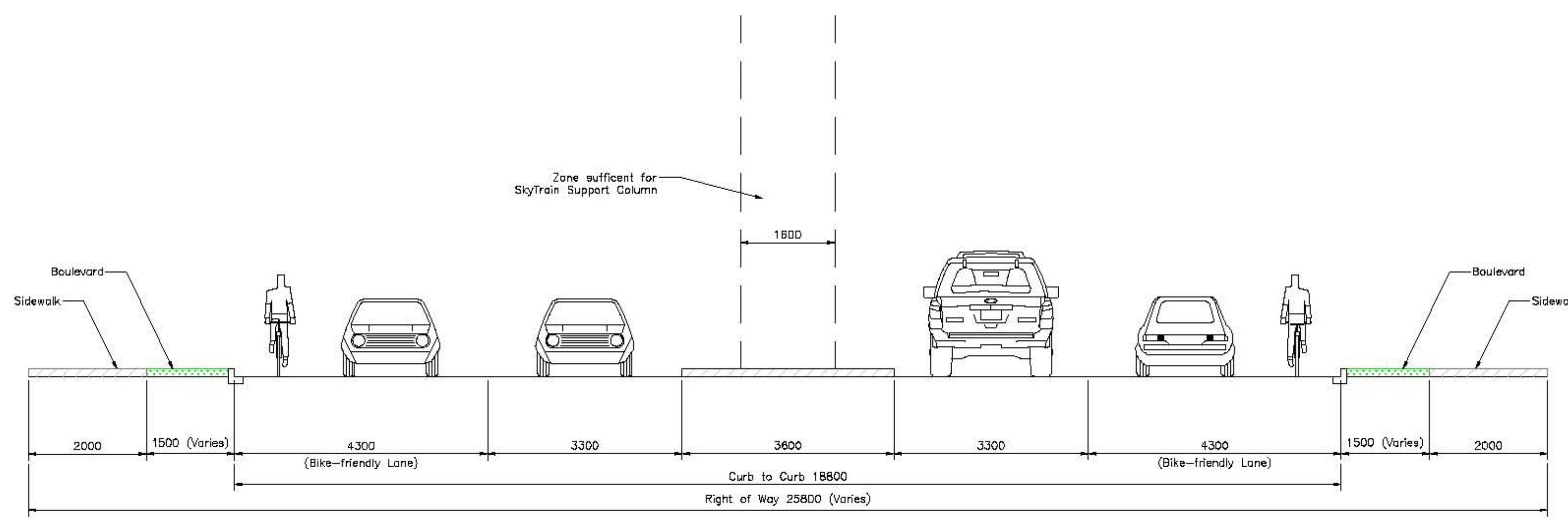


Exhibit 6.10 -- Typical 4 Lane RRT Cross Section with Constrained Parameters



7. KEY PLANS: ALIGNMENT, INTERSECTION STATUS AND STATION LOCATIONS

7.1 BRT KEY PLANS

Exhibit 7.1 -- BRT Key Plan - Typical Cross Section Locations

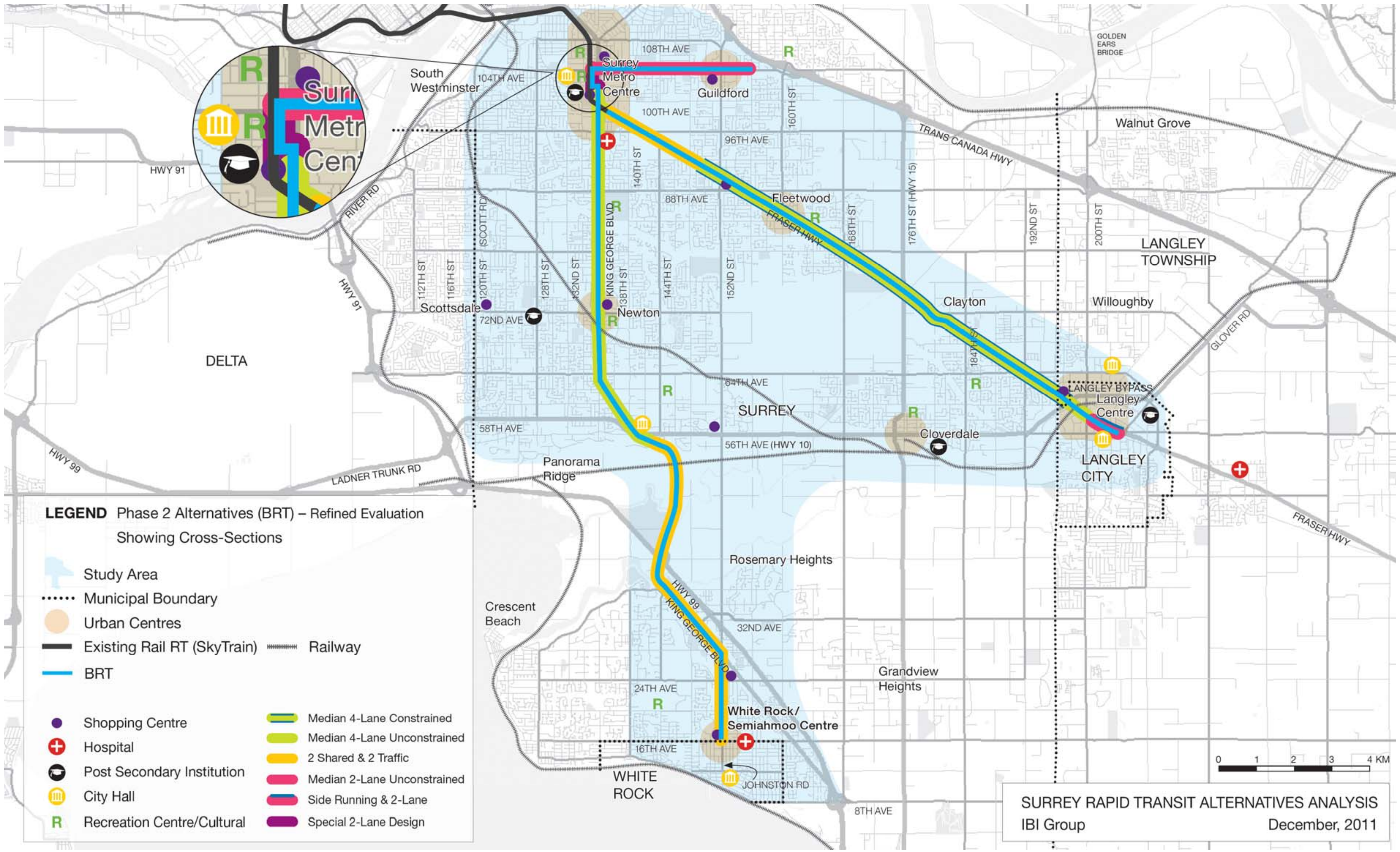


Exhibit 7.2 -- BRT Key Plan – Intersection Status

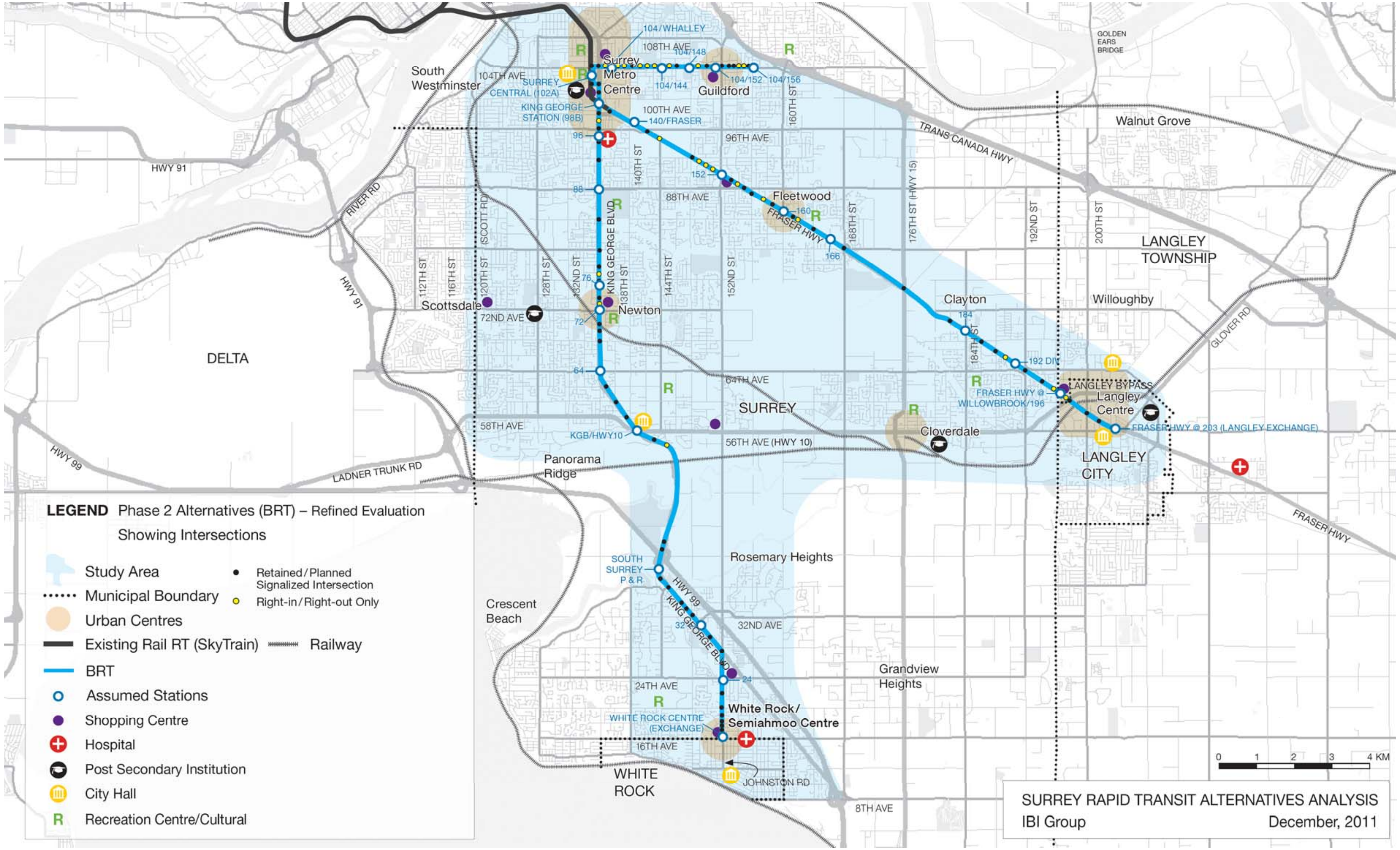


Exhibit 7.3 -- BRT Key Plan - Assumed Station Locations

7.2 LRT KEY PLANS

Exhibit 7.4 -- LRT Key Plan – Typical Cross Section Locations

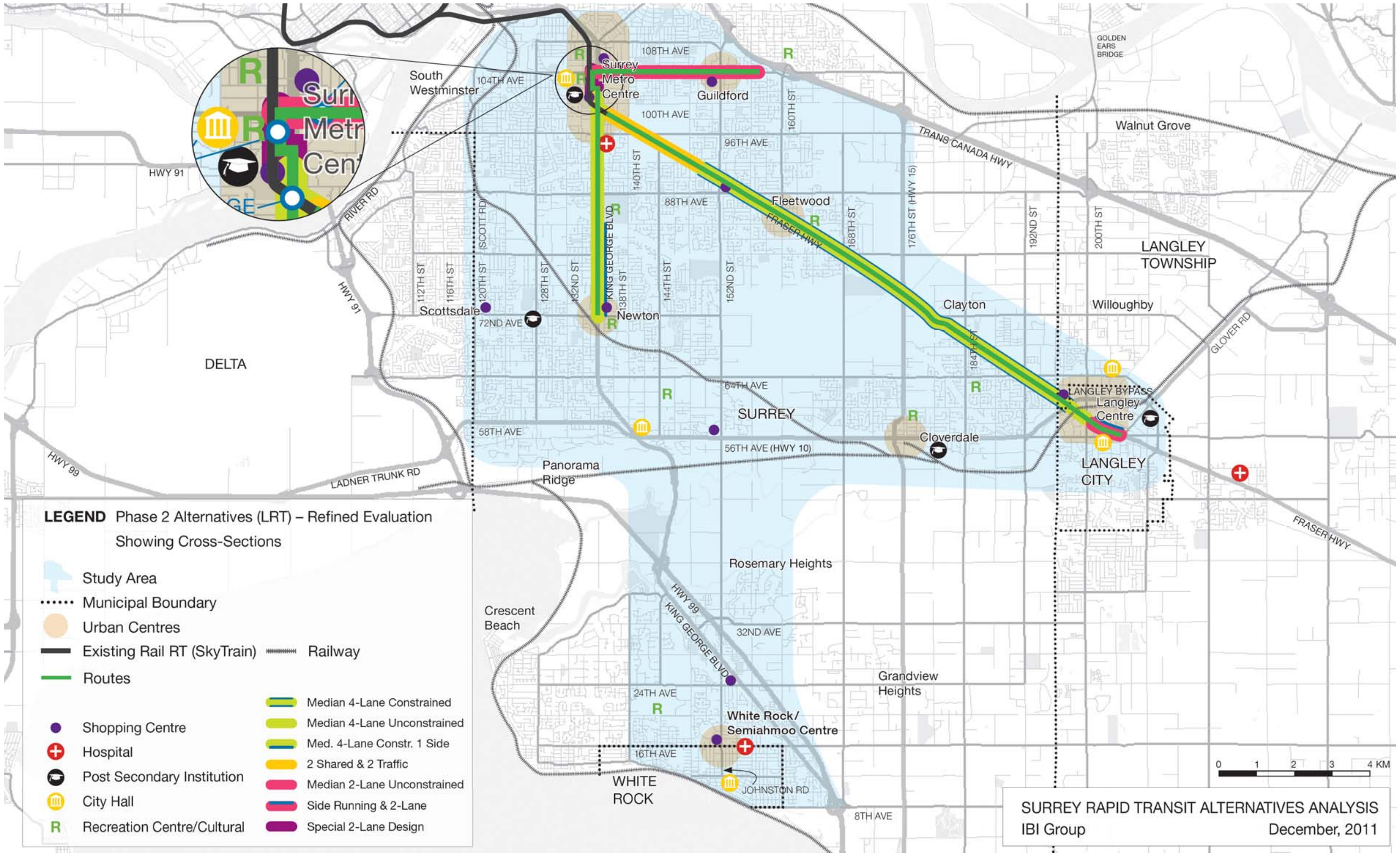


Exhibit 7.5 -- LRT Key Plan – Intersection Status

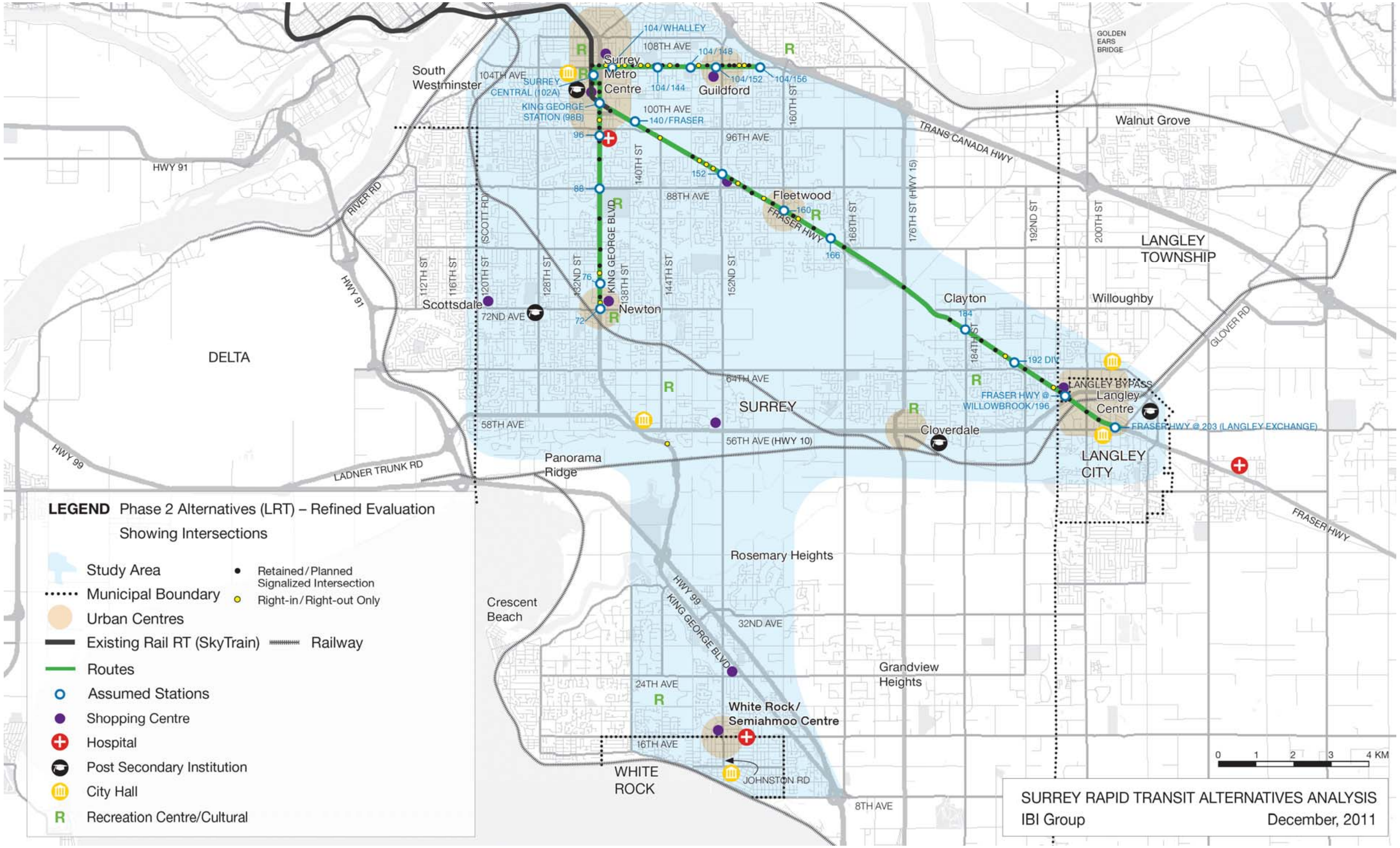
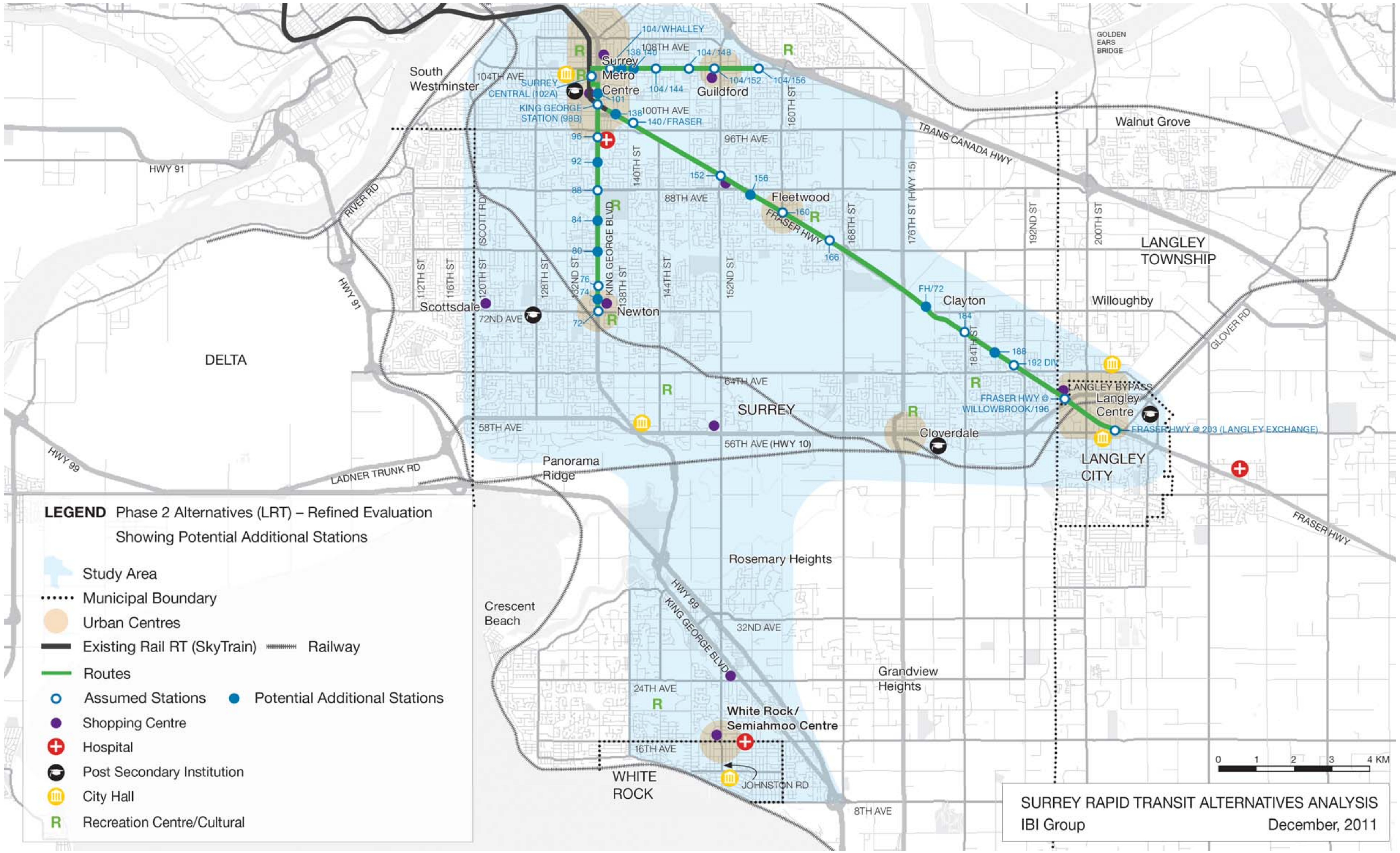


Exhibit 7.6 -- LRT Key Plan – Assumed Station Locations



7.3 RRT KEY PLANS

Exhibit 7.7 -- RRT Key Plan - Typical Cross Section Locations

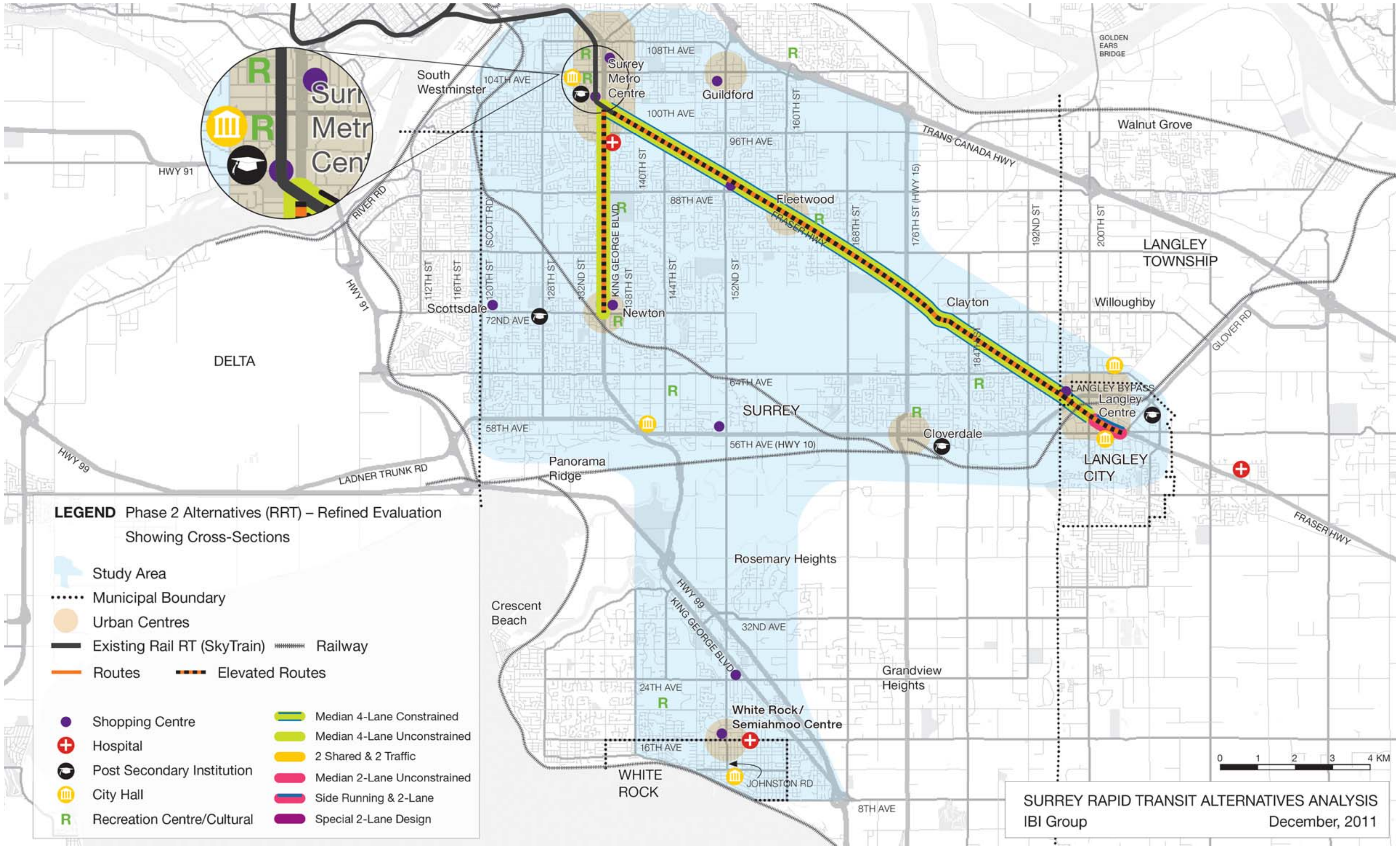


Exhibit 7.8 -- RRT Key Plan – Intersection Status

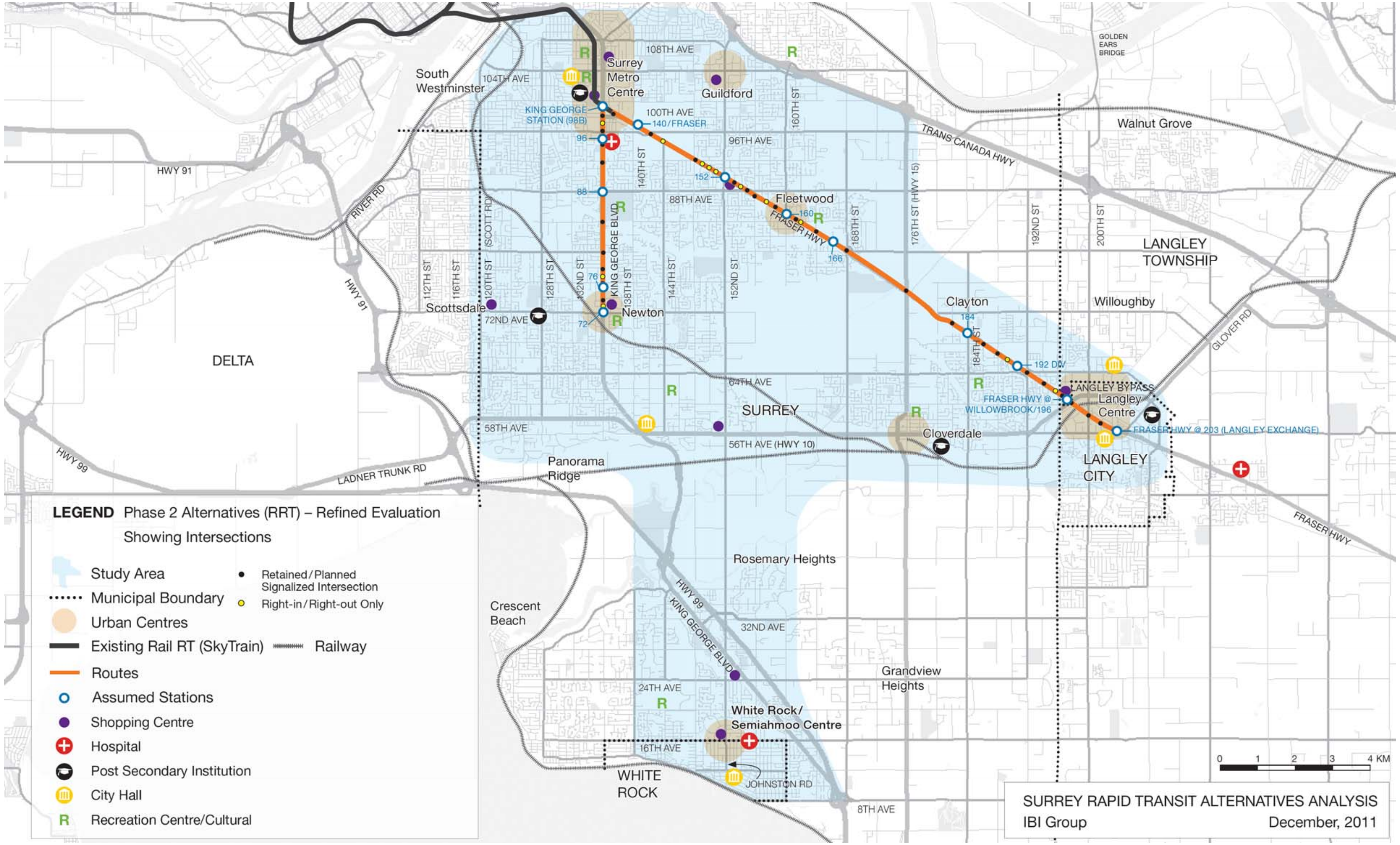
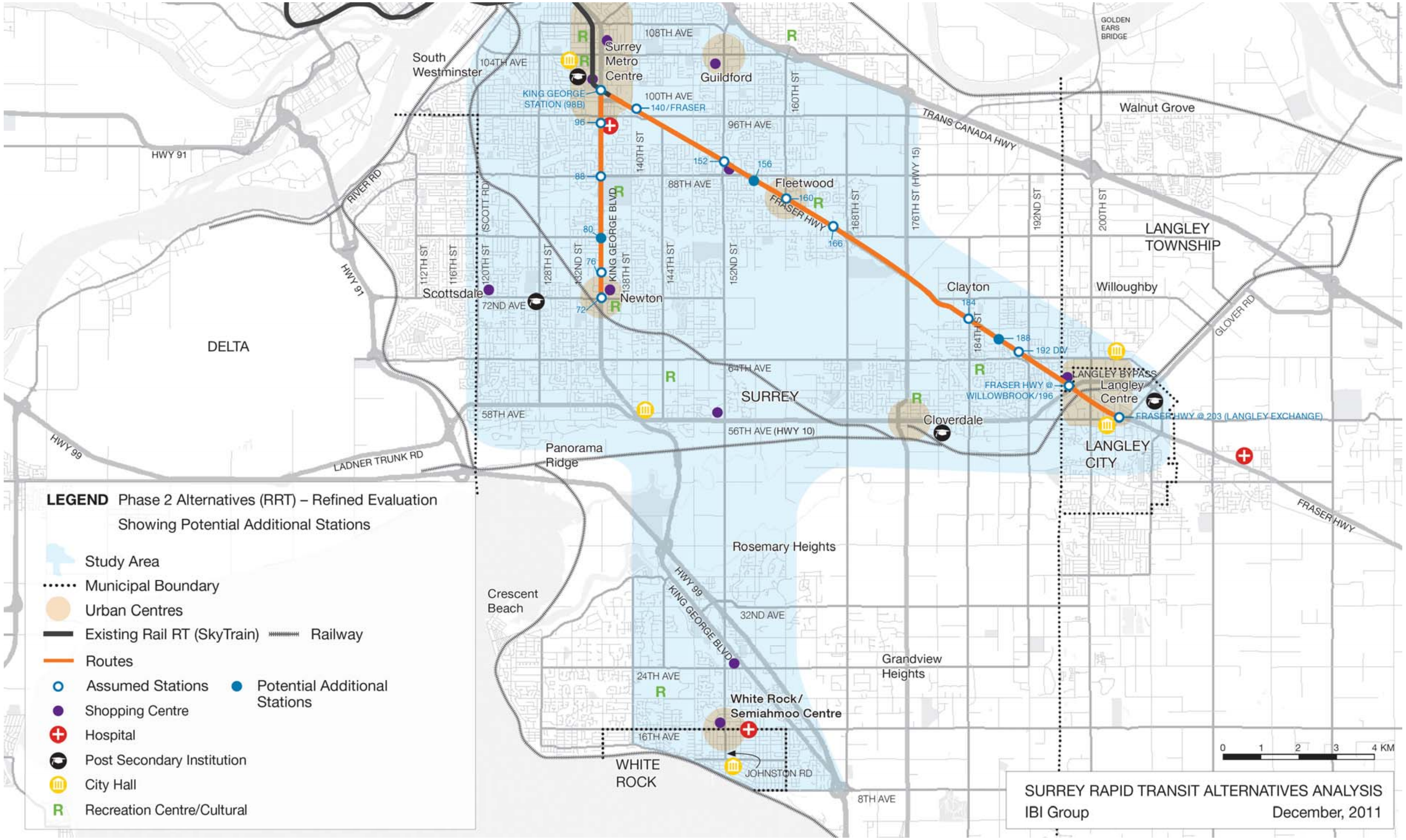


Exhibit 7.9 -- RRT Key Plan – Assumed Station Locations



8. RENDERINGS

Exhibit 8.1 -- Aerial and Street Level Views Of BRT

Exhibit 8.2 -- Aerial and Street Level Views Of LRT

Exhibit 8.3 -- Aerial and Street Level Views Of RRT

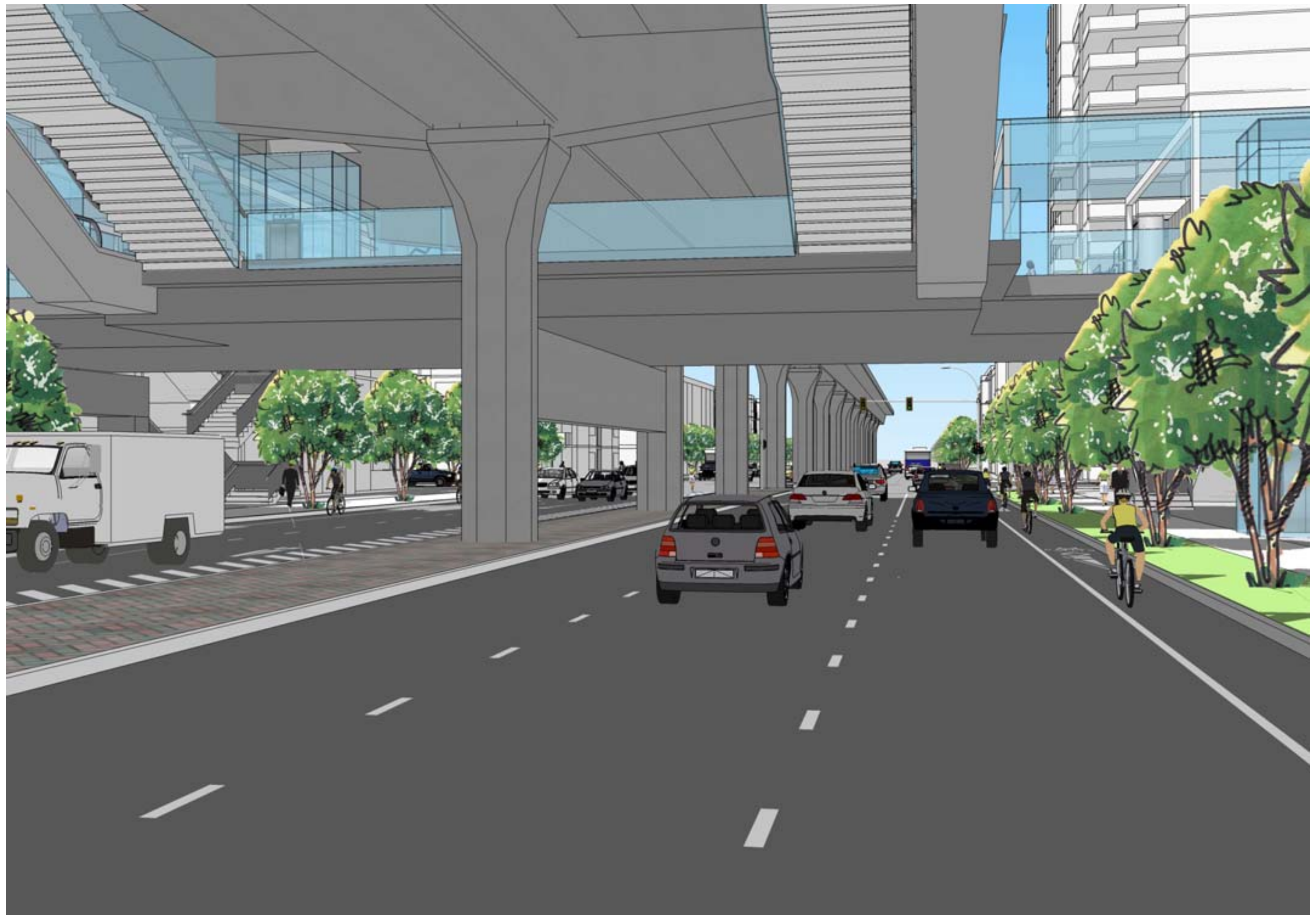
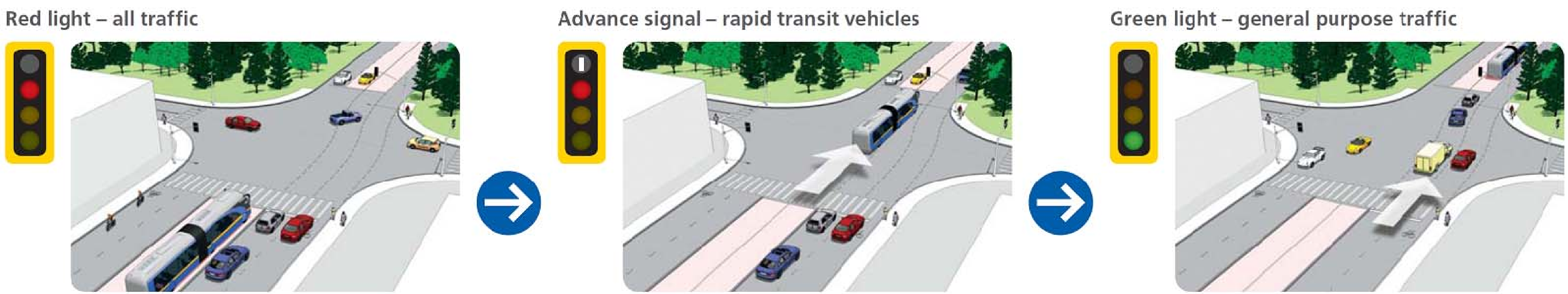


Exhibit 8.4 -- Rapid Transit Priority into Green Timbers



TRANSLINK

BRITISH COLUMBIA

Surrey Rapid Transit Alternatives Analysis

Phase 2 Evaluation

APPENDIX 2 – EVALUATION INPUTS

2A. EVALUATION FRAMEWORK

2B. TRAVEL DEMAND MODEL AND TRANSIT EVALUATION ASSUMPTIONS

2C. SELECTION OF DESIGN OPTIONS

2D. REFINEMENT OF ALTERNATIVES

August 2012

IBI GROUP

Appendix 2A – Evaluation Framework

Exhibits

Appendix 2B – Travel Demand Model and Transit Evaluation Assumptions

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Appendix 2C – Selection of Design Options

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Appendix 2D – Refinement of Alternatives

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APPENDIX 2A – EVALUATION FRAMEWORK

Overview

The Phase 2 evaluation of the thirteen alternatives required several key inputs, including:

- Refined Evaluation Framework, as confirmed by the study team in 2010;
- Existing and Planned Conditions, to establish a basis for design of the alternatives and a benchmark against which to evaluate the alternatives;
- Conceptual Designs including refinements, documented in Design Workbook v.3; and
- Transit input assumptions, documented in Appendix 2B.

This appendix documents:

- Refined Phase 2 Evaluation Framework; and
- Phase 2 Evaluation Assumptions (excluding transit service assumptions documented further in App 2B and sensitivity assumptions documented in App 4).

The refined framework was updated in 2010, and the methodologies and assumptions for the individual accounts, measures and criteria were confirmed in March, April and October 2011.

Exhibit 2A.1 lists the elements of the evaluation framework, while **Exhibit 2A.2** lists the quantitative assumptions and data sources for each criterion.

Exhibit 2A.1 -- Refined Evaluation Framework for the SRTAA - Phase 2, with Data Inputs

Account	Criteria	Measures		
		Phase 2 Detailed Measures	**Inputs from Project**	**Other Data, Assumptions Used**
Transportation	1. Transit User Effects	>Transit travel time savings >Total ridership, boardings and passenger km >Travel time competitiveness by transit (several origins, destinations)	RTPM08 (model) outputs RT + transit operating plans Capacity constraints (#5)	VoT
	2. Non- Transit User Effects	>Journey travel time (dis)benefits for road users >Vehicle operating costs changes >Street closings and turn restrictions, diverted traffic and parking >Changes in vehicle collisions	RTPM08 (model) outputs Design drawings	Background vehicle collision and auto operating costs
	3. Transit Network/ System Access	>Catchment analysis of population, employment around rapid transit stops (at 400 m and 800 m radii) > Urban centres served by rapid transit >Qualitative assessment of station access	Confirmed station locations (for GIS analysis purposes) RT + transit operating plans	RGS (using June 2010)
	4. Reliability	>Qualitative assessment of network based on type and length of route segregated and intersection priority	Design drawings Transit operations	
	5. Capacity and Expandability	>Corridor-by-corridor peak load utilization rates (ridership divided by capacity) > Assessment of optimization (within capacity without oversupplying) >Ability to increase system capacity (beyond assumed vehicle size, headways)	RT operating plan RTPM08 (model) outputs Design evaluation	Transit vehicle capacity and loading standards
	6. Integration with Active Modes	>Qualitative assessment of the connectivity by the pedestrian and cycle network(s), based on several quantitative sub-measures (catchment area cycle/walk characteristics without and with alternative)	Confirmed cross sections (design), stations Results of #1 and 7, design/ integration assumptions	Existing + committed cycling and pedestrian networks in station areas
	7. Transit Mode Share	>Transit mode share (regional, and using 11 super-zones)	RTPM08 (model) outputs	

Account	Criteria	Measures		
		Phase 2 Detailed Measures	**Inputs from Project**	**Other Data, Assumptions Used**
Financial	8. Capital Cost	>Full capital cost (including alignment construction, vehicles, support facilities, property/urban realm improvements, impact mitigations, contingencies and inflation) plus vehicle and infrastructure renewal	Design drawings quantities, construction method assumptions Quantities of property (#20)	Unit costs for capital Property values from parcel data
	9. Operating Cost	>Net operating cost of the transit network (rapid transit plus net difference in study area bus routes from the BAU benchmark)	RT travel times Transit network vehicle service hours Vehicle headways for alternatives	Cost components for RT operation Average costs for bus operations Traffic signal locations and cycle times
	10. Cost-Effectiveness	>Benefit/Cost ratio (including NPV) >Cost per hour of travel saved >Cost per new transit trip >Cost per new transit pass-km > Cost per tonne of GHG emission reductions >Incremental land use benefits (SF of intensification) per $ life cycle costs	Cost inputs from #8,9 Benefits from #1, 2, 5, 7, 11, 20	Real Inflation Rate, Discount Rate Timing of Costs, Benefits (including ramp-up) Values of non-monetary benefits for NPV and B/C ratio Average Asset lives for Cost-Effectiveness
Environment	11. Air Emissions	>Reduction in VKT (modelled) >Reduction in net greenhouse gas (GHG) emissions during life cycle (construction and operations) >Reduction in net criteria air contaminants (CAC) emissions	RTPM08 (model) outputs (#2) Material quantities for construction period	Emission rates from construction and transportation sources
	12. Noise and Vibration	>Qualitative assessments for construction and for operations	Design drawings	Geotechnical conditions, adjacent land use types
	13. Biodiversity	>Qualitative assessment, based on extent and degree >Vegetation & Wetlands > Wildlife & Wildlife Habitat > Forest Resources > Listed species	Design drawing layer (footprint versus constraints)	Constraints mapping from municipalities, provincial agencies

Account	Criteria	Measures		
		Phase 2 Detailed Measures	**Inputs from Project**	**Other Data, Assumptions Used**
Environment	14. Water Environment	> Aquatic Resources	Design drawing layer (footprint versus constraints)	Constraints mapping from municipalities, provincial agencies
	15. Effect on Parks and Open Spaces	>Total hectares of parks or public open space lost/gained	Design drawing layer (footprint versus constraints)	Constraints mapping from municipalities, provincial agencies
	16. Effect on Agricultural Resources	>Total hectares impacted, lost/gained, in ALR	Design drawing layer (footprint versus constraints)	Constraints mapping from municipalities, provincial agencies
Urban Development	17. Land Use Integration	> Number of existing/future activity centres within walking distance of stations >Integration with existing/future major activity centres proximate to stations (including distance, centre size, type of activity in the centre etc.)	Confirmed station locations for analysis	Activity centre sizes (from parcel data) Pedestrian access to activity centres (from mapping) Other facility information
	18. Urban Design	> Effect of rapid transit infrastructure on the urban realm – quantitative assessment of pedestrian crossing distances, buffer from traffic, sidewalk width > Qualitative assessment of visual impact > Place making potential	Confirmed cross sections (design), stations – in conceptual designs ROW impacts and resale potential at/near station areas – in conceptual designs	Existing/planned and committed pedestrian facilities (mostly known)
	19. Land Use Intensification Potential (Flexibility to Change)	>Access to (re)development opportunities (SF of additional developable capacity in station areas) >Land use intensification potential (SF of development by community and alternative)	Confirmed station locations for analysis Real estate market analysis >> Travel times to/between stations, approximate ridership (RTPM08 model results, from #1)	Regional Growth Strategy projections. (June 2010) Existing assessment information for properties within 400 metres of each proposed station, to compare the ratio of assessed land value to improvements value. Planned/under construction developments by land use type, i.e. multi-family residential projects and office projects Market impact of introducing rapid transit (previous cases – CMHC data)

Account	Criteria	Measures		
		Phase 2 Detailed Measures	**Inputs from Project**	**Other Data, Assumptions Used**
Urban Development	20. Property Requirements	>Number of impacted properties by type during construction, and impacted properties during construction – full takes > Area of partial takes (slivers) > Property effects/risks to regionally significant areas	Design drawing layer (indicating footprint, minimum ROW impacts)	Existing parcel data, assessment values Layouts and ROW limits, committed transportation improvements along alignments
Economic Development	21. Construction Effects	>Incremental employment, income and GDP	Results of #8 (costs)	Employment rate from construction $
	22. Tax Revenue Effects	>Effects on provincial and federal taxes during construction and operations	Results of #8,9 (costs) Fuel usage effects (#2)	Applicable taxes
	23. Goods Movement	>Qualitative assessment on the impacts to goods movement/goods routes in the corridor including identification of alternatives, based on quantifiable indices (e.g. lane-km of removed/ added goods movement routes, number of removed/added access points to industrial areas and agricultural areas)	Design drawings – assumed lanes, intersection layouts and driveway access	Goods movement routes
Social, Community	24. Low Income Population Served	>Comparative accessibility (quantified) of jobs and public services from low income areas	RT + transit operating assumptions, travel times	Low income areas (GIS analysis of Census Data)
	25. Operational Safety	>Qualitative assessment of the operating plan of each option (potential risks based on extent and type of operating environment)	RT + transit operating assumptions	Operational safety data from precedents
	26. Personal Security	>Qualitative assessment of perceived personal security, including security and CPTED measures	Design feature assumptions	Perceived safety data researched by UBC Study
	27. Community Cohesion	>Number of cross traffic locations for pedestrians, cyclists and vehicles, including restricted and enhanced locations >Qualitative assessment on the effects on communities (visual intrusion/ improvement, community severance/ cohesion)	Design drawings Illustrations (samples)	Existing, planned/ committed conditions
	28. Heritage and Archaeology	>Number (and type) of heritage properties impacted >Identification of any known archaeological sites/resources impacted	Design drawing layer (footprint versus constraints)	Constraints mapping from municipalities, provincial agencies

Account	Criteria	Measures		
		Phase 2 Detailed Measures	**Inputs from Project**	**Other Data, Assumptions Used**
Deliverability	29. Constructability	>Detailed qualitative assessment of design and construction challenges >Surface Geology/ Soils/ Topography > Environmental risks	Design drawings Assumed construction methods	> Geotechnical conditions > Environmental constraints > Local constraints to construction (e.g. utilities, special conditions, access routes to adjacent properties)
	30. Potential for Phasing	>Feasibility of phasing the implementation of the alternative > Incremental costs of phasing option(s) > Feasibility to convert technology as part of phasing	Design drawings	Best practice for phasing and technology conversion
	31. Time Required to Deliver	Qualitative comparison of implementation schedule	Results of #32, #8	Precedents for speed of construction
	32. Acceptability	Qualitative support for agreement with alternatives, based on technologies, alignments, and combination of corridors.	Phase 2 Market Research Survey	
	33. Affordability	>NPV of life-cycle capital and operating costs >Ability to fund – not assessed	Results of #8, 9, 22, 23, 24, 25	

Exhibit 2A.2 -- Phase 2 Evaluation Assumptions

Transportation Account

For Demand Modelling and GIS Analysis

- Land Use Projections for 2021/2041 - Regional Growth Strategy (rev. May/July 2011)
- Background Road Networks - see Appendix 2B
- Background Transit – see Appendix 2B
- Service Plans – as defined in Evaluation Report and Appendix 2B

1. Transit User Effects

- Travel times were estimated based on corridor conditions, technology parameters, probability of stopping at signals (for BRT, LRT), and 20 seconds of dwell per station (all technologies)
- Annualization factor (from AM Peak model output) for ridership derived from passenger counts on existing routes # 321 and # 502 – also see Appendix 2B
- Value of Time (VoT) – for valuation of travel time savings – 2010 base used ($15.03 in 2021; $19.07 in 2041)

Value of Time growth	Base	1.2% p/a		
	Price base	2007	2021	2041
Value of Time ($/hr)	**2007**	$12.17	$14.38	$18.26
	2010	$12.72	$15.03	$19.07

2. Non- Transit User Effects

- Annualization factor of 5100 for vehicles applied, developed by UBC Line study from screenline counts
- Background vehicle collision and auto operating costs

	Price base	Per veh km	Fatal	Non-fatal	Property
Average collision cost ($)	**2004**	$0.11	$6,410,000	$110,000	$5,035
	2010	$0.12	$7,137,535	$122,485	$5,606.47

Auto Op Costs increase	Base	0%	p/a		
	Price base	2008	2021	2041	
Auto Operating Costs ($/km)	2008	$0.16			
	2010	$0.16	$0.16	$0.16	

5. Capacity and Expandability

- Transit vehicle capacity limits:
  - BRT = 100 per vehicle
  - LRT = 240 per vehicle
  - RRT = 650 per five-car train
- Discussion of vehicle capacity is in Appendix 2B

Financial Account

8. Capital Cost

- Unit costs for capital (construction and vehicles)– same as UBC Line Study
- Capital Costs based on conceptual designs from Fall 2011 (refer to Appendix 1)
- Vehicle quantities based on:
  - Running time in corridors is based on distance, speeds, probability of stopping for traffic signals
  - Round trip is two-way travel time plus layover of 3 minutes or 10%, whichever is greater
  - Vehicle quantity is round trip divided by headway, then rounded up to next whole value
  - Spares of 15% assumed for fleet sizing
- Operations and Maintenance Centre
  - BRT – allowance of $400,000 per bus
  - LRT – typical site based on fleet sizes, facility based on typical features, land cost based on average of sample locations in study area
  - RRT – allowance of $650,000 per RRT car
- Property values – see also Appendix 3D
  - Assessed Value (in parcel data) for full takes
  - Partial Takes – Average Assessed value of land (approx. $420 to $500/square metre) x area of partial takes
  - 15% added for displacement/relocation costs

9. Operating Cost

- Operations – refer to Appendix 2B for transit assumptions
- Annual Operations – routes #321/502:
  - Headways for representative future rapid transit routes developed for early AM, midday, PM peak, evening, weekend based on existing ratios of peak/off-peak service on routes #321/#502 and on Expo Line SkyTrain
  - Annual factors derived from annual service hours divided by AM peak service hours (for rapid transit)

- Parametric cost factors, developed by UBC Line Study with TransLink and CMBC
  - For service-km, multiply RRT by 5 (five cars per train)

Costs $ (2010)	Basis	BRT (D)	LRT	RRT	Bus (D)
Vehicle Operations- wages	/hr	$53.15	$53.15	$21.06	$53.15
Vehicle Operations- fuel/power	/service km	$0.71	$0.20	$0.22	$0.71
Vehicle Maintenance	/service km	$0.96	$1.80	$0.52	$0.96
Administration	/hr	$14.27	$14.27	$14.27	$14.27
Distance-based Subtotal	/service km	$1.67	$2.00	$0.75	$1.67
Time-based Subtotal	/hr	$67.42	$67.42	$35.33	$67.42
Extent-based (Non-Vehicle Maintenance)	/track or lane km	$19,380	$102,097	$245,310	$0

BRT (D) = Diesel BRT

10. Cost-Effectiveness

- Financial Cash Flow Inputs – same as UBC Line for consistency
- Opening Year is 2020 with construction period ending in 2019 for each alternative, and operations from 2020-2049
- As indicated below, real inflation on construction costs included in cash flow analysis

Evaluation period (years)	30	plus construction period
Appraisal end year	2049	
Evaluation year	2041	
Price base year	2010	
Discount rate 6%	6%	

Cost increases (real p/a)		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	after 2019
	Goods and services	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Construction	1.0%	1.0%	3.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	0.0%

Real terms cost increases applied

Rapid transit capital costs	Construction
Bus capital costs relative to BAU	Construction
Renewal and mid-life refurbishment costs relative to BAU	Construction
Ongoing fixed asset maintenance	Goods and services
Operating costs - additional costs over BAU	Goods and services
Operating costs - cost savings due to reductions	Goods and services

Environment Account

General

- Environmental Constraints Mapping from Provincial Ministries, GeoBC, City of Langley, City of Surrey (current as of September, 2011)

11. Emission Reductions

- Emission rates from construction and transportation sources

- *Construction - CO_2*

% cement in concrete		30%	
tonnes concrete per m3		2.4	
Emissions (kg of carbon per…)			
cement	tonne	777	http://www.mineralproducts.org/documents/MPA_SD_Report_2009.pdf
concrete	tonne	233	
concrete	m3	559	
steel reinforcement	tonne	464	
steel	tonne	464	http://www.corusconstruction.com/en/sustainability/carbon_and_steel/
asphalt	tonne	34	http://www.mineralproducts.org/documents/MPA_SD_Report_2009.pdf

- *Transportation Sources – During Operating Period - CO_2 and Criteria Air Contaminants(Source: Metro Vancouver)*

			2007	2021	2041
GHG Emissions (g/km)	Bus	Base	1920	1823	1827
	BRT (D)		1920	1823	1827
	BRT (T)		62	59	59
	LRT		202	191	192
	RRT		93	88	88
	Auto	Base	287	201	164
CAC Emissions (g/km)	CO	Bus	2.6	2.6	2.6
		BRT (D)	2.6	2.6	2.6
		BRT (T)	0	0	0
		LRT	0	0	0
		RRT	0	0	0
		Auto	9.8	7.1	6.7

HN3/HC	Bus	0.32	0.32	0.32
	BRT (D)	0.32	0.32	0.32
	BRT (T)	0	0	0
	LRT	0	0	0
	RRT	0	0	0
	Auto	0.061	0.062	0.062
Nox	Bus	9.2	9.2	9.2
	BRT (D)	9.2	9.2	9.2
	BRT (T)	0	0	0
	LRT	0	0	0
	RRT	0	0	0
	Auto	0.63	0.28	0.21
PM	Bus	0.6	0.6	0.6
	BRT (D)	0.6	0.6	0.6
	BRT (T)	0	0	0
	LRT	0	0	0
	RRT	0	0	0
	Auto	0.017	0.016	0.015
PM10	Bus	0.6	0.6	0.6
	BRT (D)	0.6	0.6	0.6
	BRT (T)	0	0	0
	LRT	0	0	0
	RRT	0	0	0
	Auto	0.017	0.016	0.015
PM2.5	Bus	0.6	0.6	0.6
	BRT (D)	0.6	0.6	0.6
	BRT (T)	0	0	0
	LRT	0	0	0
	RRT	0	0	0
	Auto	0.008	0.007	0.007
Sox	Bus	0.6	0.6	0.6
	BRT (D)	0.6	0.6	0.6
	BRT (T)	0	0	0
	LRT	0	0	0
	RRT	0	0	0
	Auto	0.008	0.007	0.007
VO	Bus	0.6	0.6	0.6
	BRT (D)	0.6	0.6	0.6
	BRT (T)	0	0	0
	LRT	0	0	0
	RRT	0	0	0
	Auto	0.008	0.007	0.007

Average Cost of CO2	Base	$25	per tonne

Urban Development Account

19. Land Use Intensification Potential

- Regional Growth Strategy projections. (July 2011 update to 2010)
- Existing parcel information for properties within 400 metres of each proposed station, City of Surrey, City of Langley (current as of September 2011)
- Planned/under construction developments, City of Surrey, City of Langley (current as of September 2011)

Other Assumptions – also see Appendix 3D for discussion

- Station Area buffer of 400 metres used
- Capacity in station areas based on:
  - Official Community Plan, Neighbourhood Community Plan, or proposed density for areas with plans pending (values provided by City planning staff)
  - Parcels with institutional uses (e.g. school) not assumed to be development candidates
  - Parcels with significant recent construction (improvements are less than 10 years old) not assumed to be development candidates
  - Parcels where potential value of development does not exceed existing value by 50% are unlikely to redevelop
- Demand based on:
  - Recent trends in development distribution in study area (by neighbourhood)
  - Projected growth in population (used RGS and BC Stats to benchmark values)
  - Projected growth in employment (used RGS and Surrey Employment Study to benchmark values)
  - Percentage of growth in station areas based on development distribution during 1990s/2000s around Expo Line and Millennium Line

20. Property Requirements

- Existing parcel data, assessment values

Other Assumptions

- Right of way needed for earlier projects such as Roberts Bank Rail Corridor grade separations, are assumed to be done by others
- If the projected ROW line passes through a building, the whole parcel is required
- If the projected ROW eliminates more than 20% of parking, then the whole parcel is required
- Other takes are partial takes
- Resale of land is possible where full takes have significant residual area left beyond the new right of way line. This resale is assumed to take place once the project starts operation

Economic Development Account

21. Construction Effects

- Employment rate from construction $ is based on multipliers from the British Columbia Input/Output Model
- Gross Domestic Product (GDP) output is based on multipliers from the British Columbia Input/Output Model
- Based on "2004 BRITISH COLUMBIA PROVINCIAL ECONOMIC MULTIPLIERS"

22. Tax Revenue Effects

- Income tax is based on years of employment at average salary + benefits of $70,000
- Income tax rate is assumed 30%
- 20% of capital cost excluding vehicles is assumed to be materials
- Sales tax of 12% applied to material cost estimate
- Fuel usage change based on 10 km travelled per litre fuel
- Tax rate for fuel is 27.95 cents per litre (BC Ministry of Finance) in Metro Vancouver

23. Goods Movement

- Goods movement routes (City of Surrey Truck Routes Map, 2010)

Social/Community Account

24. Low Income Population Served

- 2006 Census Data at the Dissemination Area geography used to determine number and percentage of households within threshold
- 'Low Income' threshold assumed to be $30,000 (rounded to nearest $10,000 because income data is counts of households by $10,000 increments)

28. Heritage and Archaeology

- City of Surrey, City of Langley, GeoBC, BC Conservation Centre, and BC Archaeology Branch data sets were obtained and updated through 2011

Deliverability Account

No quantitative assumptions outside of conceptual designs.

Affordability based on Net Present Value of costs versus funding. Not assessed in Phase 2.

APPENDIX 2B – TRAVEL DEMAND MODEL AND TRANSIT EVALUATION ASSUMPTIONS

Overview

The Phase 2 evaluation required several key inputs, including:

- Refined Evaluation Framework, as confirmed by the study team in 2010 (refer to Appendix 2A);
- Existing and planned conditions, to establish a basis for design of the alternatives and a benchmark against which to evaluate the alternatives;
- Conceptual designs including refinements, documented in Appendix 1; and
- Transit evaluation input assumptions, for demand modelling and for off-model calculations.

This appendix provides details on the **travel demand model** and the **transit evaluation inputs**, which define assumed future transit operations for 2021 and 2041, including the future baseline (called Business As Usual), the Rapid Transit Alternatives, and the Best Bus Alternative. Most of these inputs were coded into the regional travel demand model as part of the Phase 2 evaluation.

The transit evaluation assumptions are complementary to the conceptual designs. These transit evaluation inputs were prepared by the consulting team with input from TransLink and the project partners. The transit assumptions were initially developed for a preliminary evaluation, and then subsequently updated as part of a design refinement process. This memo documents the final Phase 2 evaluation assumptions.

This appendix is divided into the following topic areas:

- Regional Travel Demand Model Background and Assumptions;
- Business As Usual (BAU);
- Best Bus Alternative;
- Rapid transit operating assumptions;
- Transit Integration with rapid transit; and
- Off-model transit evaluation inputs.

These evaluation inputs characterize the structure of the transit network, including the rapid transit operations, bus routes, and the frequency, size and type of vehicles on each type of service. These initial inputs influence several evaluation criteria including the capital costs (for vehicles and infrastructure), operating costs (for transit service), and the transportation and environmental benefits of the alternatives, including transit boardings, travel time savings, passenger loads, mode share, and reductions in air emissions.

1. REGIONAL TRAVEL DEMAND MODEL BACKGROUND AND ASSUMPTIONS

1.1 BACKGROUND

The Rapid Transit Projects Model 2008 (RTPM08) was developed as an analytical tool for the UBC Rapid Transit Line, Rapid Transit Strategic Network Review and Surrey Rapid Transit Alternatives Analysis.

RTPM08 is a four-stage EMME multi-modal forecasting model representing the Metro Vancouver region and largely based on the Metro Vancouver Model (MVM). It is an AM peak hour (7:30-8:30) model calibrated to 2008 trip diary and regional screenline data. It is used to forecast 2021 and 2041 travel demand. Future year population and employment forecasts are driven by the Regional Growth Strategy (RGS) as provided by Metro Vancouver and approved by all municipalities.

The model represents the road and transit networks of the Metro Vancouver region for 2008 based and the 2021/2041 forecast years, and model outputs include ridership, mode share, travel time savings, decongestion benefits and vehicle kilometres which have provided the basis for the Phase 2 evaluation calculations.

1.2 ASSUMPTIONS

Land Use

Metro Vancouver's Regional Growth Strategy population and employment forecasts were applied (2021 forecasts were updated in May 2011; 2041 in July 2011). Exhibit 2B.1 summarizes this data.

Exhibit 2B.1 -- Regional Growth Strategy Forecasts (May/July 2011)

Geographic Area	**Population**		**Employment**	
	2021	**2041**	**2021**	**2041**
West Vancouver	55,991	65,485	25,508	30,096
North Vancouver	153,926	182,017	67,000	80,000
CBD	108,662	128,930	182,729	201,634
Rest of Vancouver/UEL	579,462	631,714	276,268	301,799
Burnaby/New Westminster	356,193	450,777	206,098	250,006
North East Sector	286,272	368,757	110,820	144,477
Richmond	226,682	280,579	154,007	180,325
Delta South	53,562	57,686	49,883	58,481
Delta North/Surrey	541,913	680,766	196,092	256,850
Surrey South/White Rock	118,430	156,229	45,097	61,097
Pitt Meadows/Maple Ridge	117,128	156,061	42,201	57,297
Langley	176,882	242,237	93,415	128,175
Fraser Valley North	64,602	81,252	25,412	32,577
Fraser Valley South	276,511	341,709	133,462	157,770
TOTAL	**3,116,216**	**3,824,199**	**1,607,992**	**1,940,584**

Model Input Assumptions

Exhibit 2B.2 provides an outline of the economic model input assumptions.

Exhibit 2B.2 -- Model Inputs

Parameter	2008	2021	2041
Vehicle Operating Cost – Car	$0.16/km		
Vehicle Operating Cost – LGV	$0.24/km		
Vehicle Operating Cost – HGV	$0.56/km		
Transit Fares (average)	$1.68 for 1 zone $2.27 for 2 zones $2.76 for 3 zones WCE: $5.95-$11.05		
Parking Costs	$0.43-$4.48		
Toll Costs – Car	-	$2.50	$2.50
Toll Costs – LGV	-	$5.00	$5.00
Toll Costs – HGV	-	$7.50	$7.50
Average Hourly Income ($ per hour)	$20.90	$23.71	$30.09
Value of Time ($ per hour)	$10.45	$11.86	$15.04
Value of Time – LGV ($ per hour)	$29.55	$33.52	$42.55
Value of Time – HGV ($ per hour)	$41.90	$47.62	$60.61

The key macroeconomic assumption underlying the RTPM's forecast year is real growth in GDP per capita (i.e. without the effect of inflation). Observed annual GDP per capita growth rate of -1.70% for British Columbia has been applied for the base year (2008) to represent effects of the economic slowdown, based on the GDP statistics available from the Government of British Columbia. However a longer term annual growth rate of 1.20% has been adopted for the years beyond 2008. This was derived from historical BC GDP statistics over the past 10 years (1999 – 2008) and 2009-2010 GDP forecasts prepared by the Conference Board of Canada, together with Metro Vancouver population forecasts.

These growth rates have been applied to update the base year hourly incomes and VOTs to the forecast year values. The other costs (vehicle operating costs, transit fares, parking costs and toll costs) are assumed constant in real terms over the years.

There are also a number of model parameters. These are included in Exhibit 2B.3 below.

Exhibit 2B.3 -- Model Parameters

Parameter	Description	Value
Interchange Penalty	Time in minutes applied to any transferring transit trip	4
Wait Factor	Factor applied to wait time	2.25
Walk Factor	Factor applied to walk time	1.75
Reliability	Mode specific factor applied to wait time to reflect service reliability	Bus=1.2 LRT=1.1 BRT=1.1 RRT=0.8 WCE=0.8

Expansion Factors

Factors were estimated to expand AM peak hour model outputs to daily and annual estimates based on vehicle screenlines (Translink 2008 Regional Screenline Survey) for the auto factors, and transit ridership (2009 APC Data for transit) patterns on the Fraser Highway and King George Blvd local bus services for the transit factors.

Exhibit 2B.4 -- Expansion Factors

	Hourly to Daily	Daily to Annual	Hourly to Annual
Auto	15	340	5100
Transit	15	330	5000[1]

Model data between 2021 and 2041 forecast years was estimated based on straight line interpolation, and growth after 2041 was assumed to follow the same trend line to the end of the appraisal period.

1.3 MODEL NETWORK ADJUSTMENTS

A number of updates were carried out to refine the RTPM08 Business As Usual (BAU), a future baseline scenario against which the alternatives were compared. These included:

- Transit network assumptions (including travel time functions);
- Road network assumptions;
- Parking cost assumptions.

Transit Network Assumptions

The model was coded with the BAU transit service, which represents a substantial increase in transit service from 2010. At the regional level, the BAU includes the existing rapid transit system operating at greater frequency, plus the Evergreen Line, and increases to frequency and coverage of bus services throughout the region. In the SRTAA study area, the resulting bus network is a more complete grid of services and greater frequencies. The assumed growth in service was consistent with the South of Fraser Area Transit Plan (SOFATP) long-term vision projected through 2041, with increases commensurate with population and employment growth.

The draft BAU that was applied during the SRTAA Phase 1 evaluation, using the refined Metro Vancouver Model, was incorporated in the RTPM08 in Phase 2. For the purpose of modelling the BAU in Phase 2, the model assumptions for the study area were reviewed in more detail to confirm compatibility with SOFATP and other relevant service plans. Modifications were required to the model coding to accurately represent the assumed BAU service plan, and eliminate some unintended duplication of transit services. The assumed service plan is described and tabulated in Section 2 of this appendix.

Updates to Transit Travel Time Functions

Travel time functions are applied within RTPM08 to estimate the travel speeds for buses, based on bus route itinerary. The functions reflect that buses are typically subject to similar congestion to auto traffic (the variable timau = auto travel time on a network link) on the same road, plus additional bus stop dwell time (estimated as an average time per unit of distance). This additional

[1] Local transit boardings on 104 Avenue, King George Blvd and Fraser Highway were expanded using the 5000 factor, based on APC data for routes 320, 321 and 502. Other transit routes in the study area carry a smaller proportion of ridership outside the peak, and therefore a lower expansion factor of 3300 was applied to bus boardings on other routes. For regional and study area statistics where the changes would result from rapid transit, the 5000 factor was used.

bus stop dwell time is higher in more densely developed areas because heavier bus stop activity results in longer dwell times and/or stops are more closely spaced. This is reflected in the series of functions in Exhibit 2B.5.

For the purpose of the SRTAA BAU, travel time functions in Surrey Metro Centre and Langley Centre were modified to reflect increasing development density and changes to urban form. As these regional town centres intensify, the speed of transit service usually slows because of busier bus stops with more passenger activity, as well as traffic congestion. Adjusting the functions brings Surrey Metro Centre and Langley Centre in line with other regional centres in the future model runs.

The application of travel time functions is outlined in Exhibits 2B.5. Exhibits 2B.6 and 2B.7 illustrate the revised transit travel time functions around Surrey Metro Centre and Langley Centre, with traffic zones are highlighted pink on the maps.

Exhibit 2B.5 -- Transit Time Functions used in SRTAA Phase 2

Bus Services	Application in RTPM08	Transit Time Functions	Additional Changes for SRTAA Phase 2
Downtown Vancouver	Vancouver CBD Area	ft1 = timau + 3.0 * length	
Densely Served Town Centres	Burnaby Metrotown (TZ 4330-4350), Richmond Centre (TZ 6310-6350), New Westminster downtown (TZ 4740 - 4770 & 4800), Coquitlam Centre (TZ 5380-5390) and North Vancouver Lonsdale Quay (TZ 1230-1250), and Vancouver Broadway Area (TZ 3080-3200).	ft2 = timau + 1.8 * length	Surrey Metro Centre (TZ 7160, 7170, 7180, 7200, 7210, 7222, 7250, 7270, 7280) Langley Centre (TZ 8300, 8311, 8312, 8321, 8332)
Urban	Route sections in the remaining urban areas and medium to high density suburban areas.	ft3 = timau + 1.0 * length	
Arterial	Buses operating in limited stop mode (boarding or alighting only) in mixed traffic on urban and suburban arterial streets.	ft4 = timau + 0.5 * length	
Express	Buses operating on the freeway or in express mode on arterial streets that do not allow boardings or alightings for long segments of the route.	ft5 = timau * 1.5	Travel times in the model for Highway 1 Rapid Buses were confirmed against specific service plans.

Exhibit 2B.6 -- Surrey Metro Centre Revised TTF

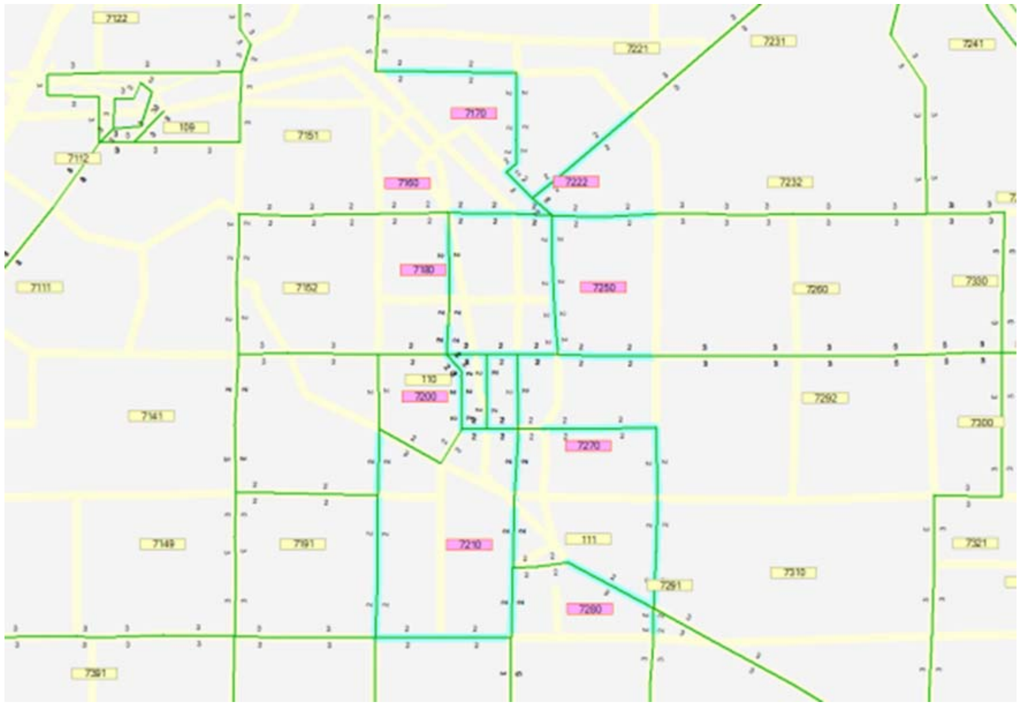
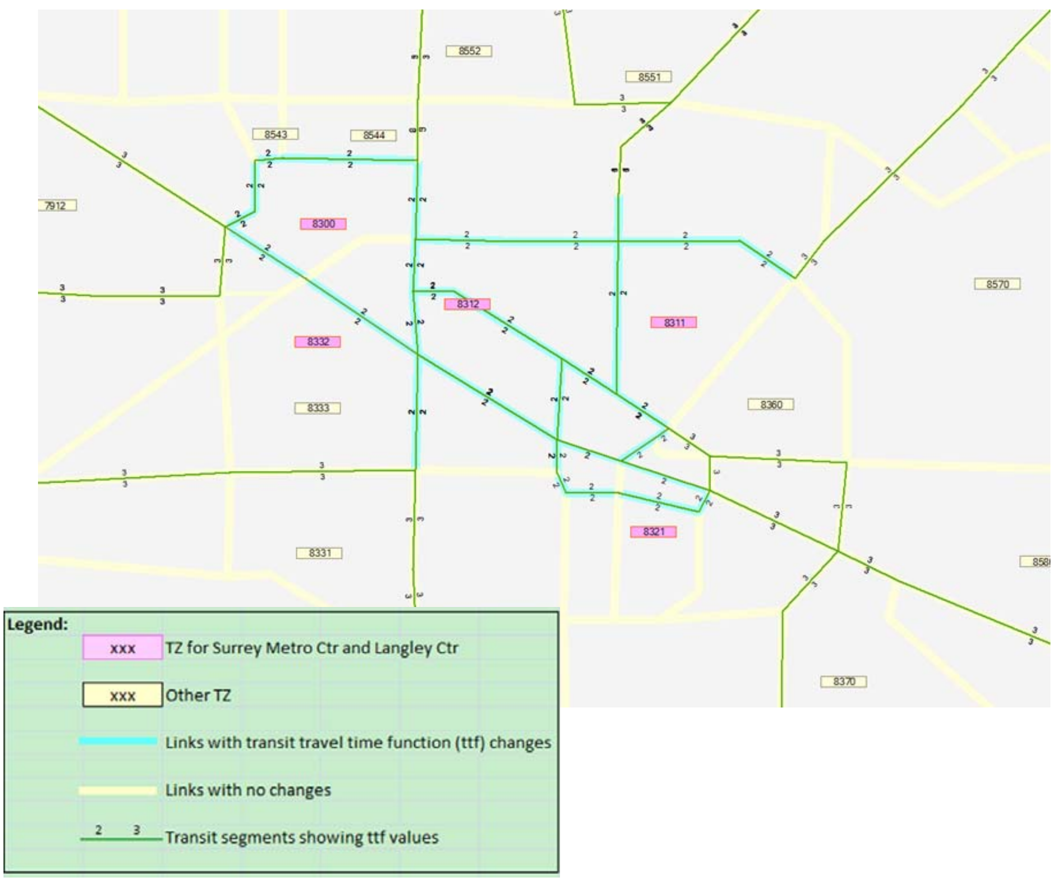


Exhibit 2B.7 -- Langley Centre Revised TTF

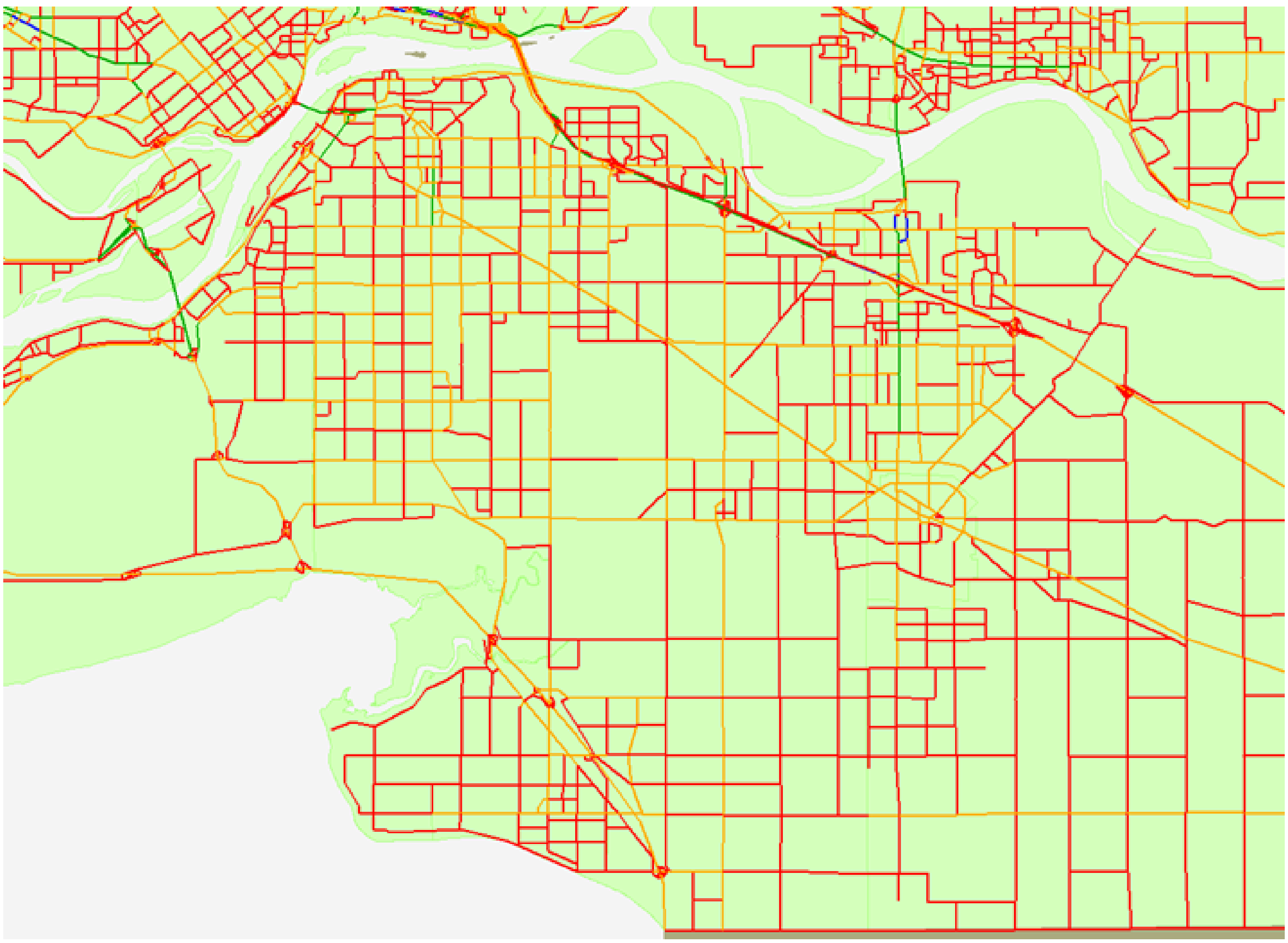


Road Network Assumptions

The future road network for 2041 includes all existing and planned road facilities in the study area. The planned facilities include projects currently under construction (such as the Gateway Program, widening of Fraser Highway between Fleetwood and Langley) and near-term programs such as the Roberts Bank Rail Corridor (including grade separations) and Surrey's 10-Year Servicing Plan.

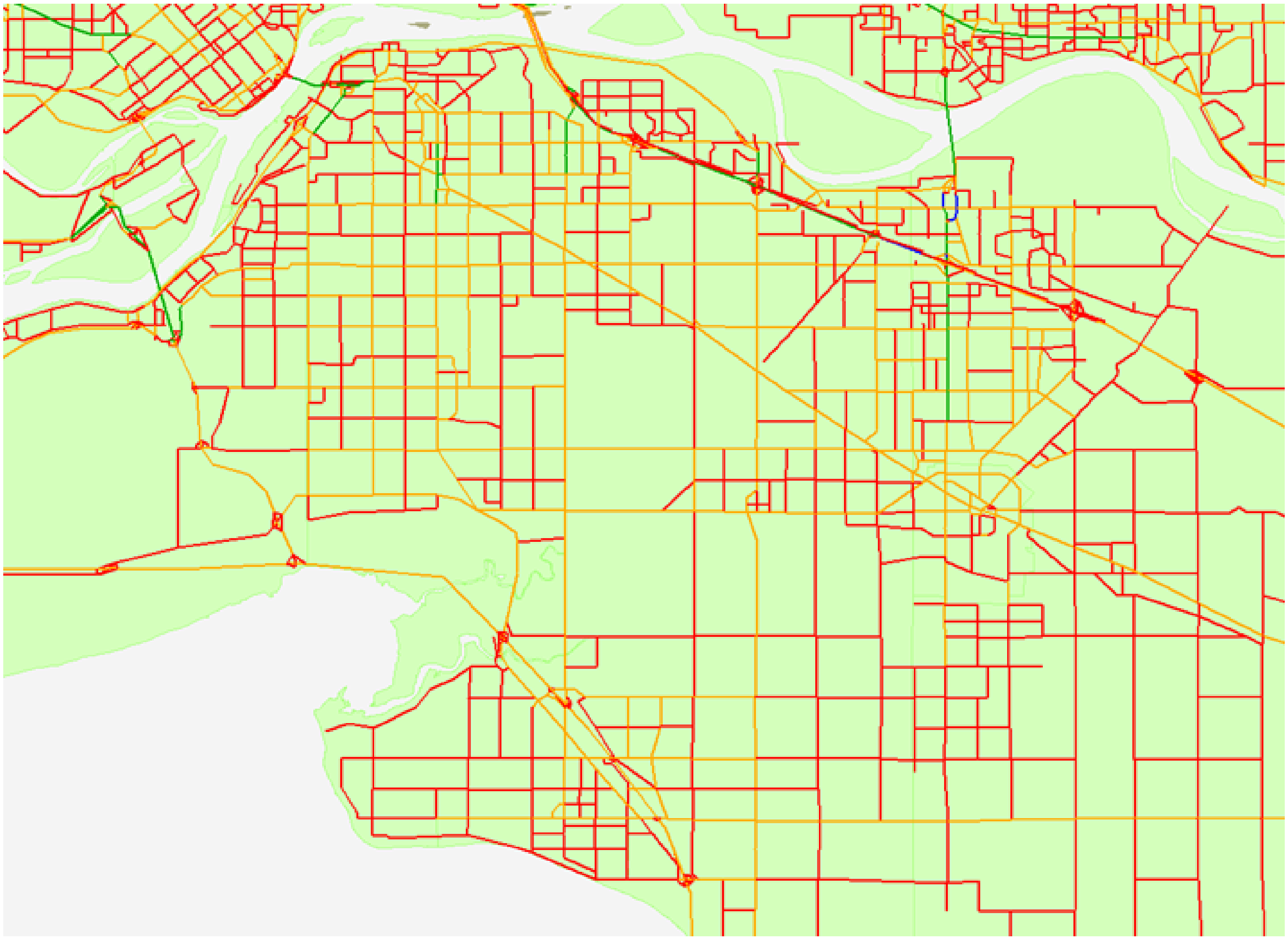
Specific to the study area, City of Surrey reviewed projected population and employment and in August, 2011 updated future road widening assumptions to reflect a funding-constrained built-out arterial network. Some narrower (2-lane) arterials were assumed to be widened, and gaps in the arterial network were projected to be filled by 2041 (the figures reflect City of Surrey revisions from August 2011). Exhibits 2B.8 and 2B.9 below show the updated road network lane capacity assumptions for 2021 and 2041. The colours indicate lanes per direction. Highway 1 includes separate traffic lanes and HOV lanes in each direction, and overall will have 4-6 lanes per direction west of 216 Street.

Exhibit 2B.8 -- 2021 Surrey Road Network



(legend: red-1 lane; orange-2 lanes; green-3 lanes; blue-4 lanes)

Exhibit 2B.9 -- 2041 Surrey Road Network

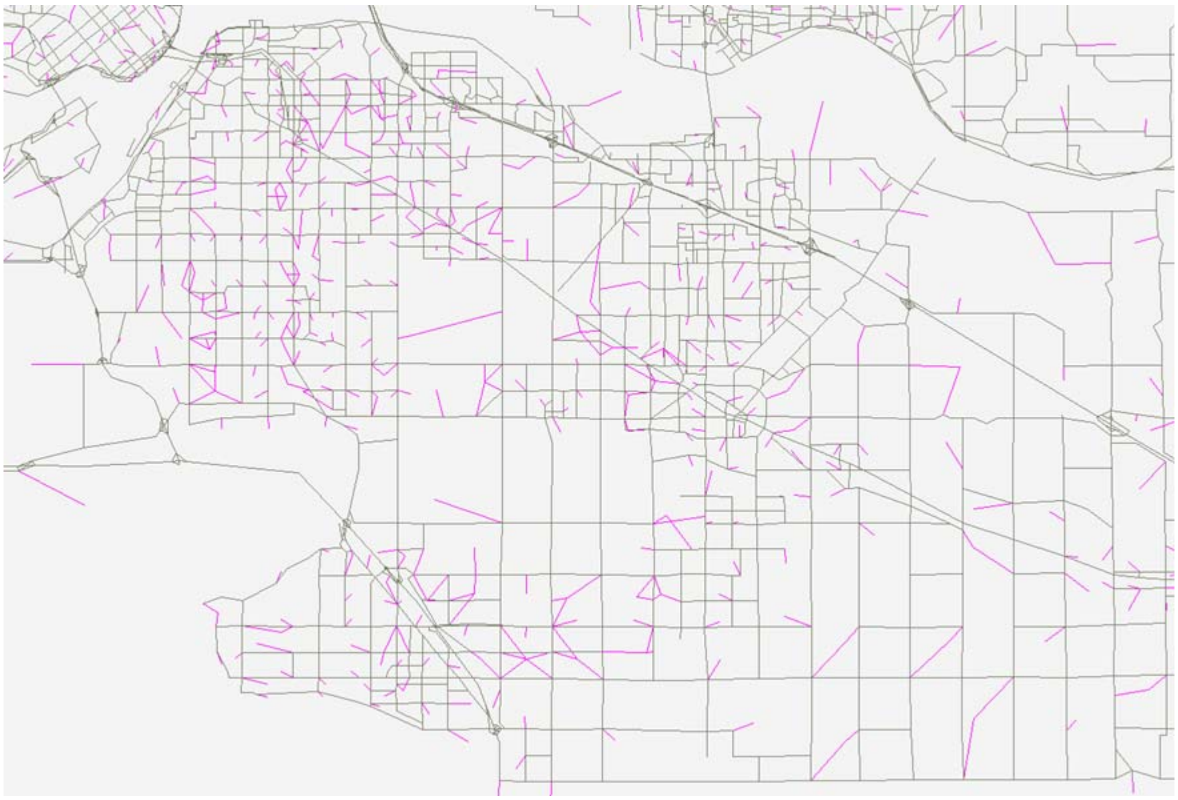


(legend: red-1 lane; orange-2 lanes; green-3 lanes; blue-4 lanes)

Zone Centroids / Connectors

The City of Surrey reviewed the model's zone boundaries and centroid locations in May 2010, and provided a set of modified zone centroid connectors. The intent was to improve the model's representation of the proximity of land uses to different arterial corridors, from each transportation analysis zone (TAZ) within the City of Surrey. This set of refinements was used in the SRTAA Phase 1 modelling and these modified connectors were carried forward into the RTPM08 used in Phase 2. Exhibit 2B.10 illustrates the zone connectors in the study area and surroundings.

Exhibit 2B.10 -- 2041 Surrey Zone Connectors



(legend: grey-streets; pink-connectors)

Parking Cost Assumptions

To calibrate the RTPM08, parking cost input was developed for a set of intermediate-sized geographic superzones across Metro Vancouver using the 2008 trip diary data. AM peak period parking costs were derived from monthly costs divided by 20 weekdays per month, and then half the daily cost assigned to the AM and PM peaks. To ensure sufficient data points, the parking cost parameters were derived at the superzone level where sufficient survey data samples were available. This resulted in equivalent "half day" parking costs ranging between $0.43 and $4.48. These parking parameters were used in the model calibration process for 2008.

The parking cost parameters derived for much of the SRTAA study area reflected recent parking price conditions, where substantial free parking resulted in fairly low average parking costs in Surrey and Langley.

Due to recent changes in direction on parking supply and management, the City of Surrey is implementing a program to install parking meters and pay stations in additional areas. Given the forecast changes to land use in most of the SRTAA urban centres, by 2041 the densities are more likely to resemble parts of Vancouver and Burnaby served by rapid transit. Therefore, the following approach was taken to generate parameters that reflect parking policies and pricing consistent with greater densification in the Cities of Surrey and Langley:

- Surrey Metro Centre is projected to be the region's "second downtown" and parking rates (not accounting for inflation) will resemble the mixed residential and commercial portions of downtown Vancouver. An average was taken of the Vancouver CBD parking parameters, and this average was assumed for Surrey Metro Centre in 2041;
- The parking parameters for Metrotown, Edmonds, Joyce-Collingwood and Edmonds were averaged, and this value was assumed for the other urban centres in the study area for 2041; and
- 2021 parking parameters (when the baseline is run for 2021) were interpolated between the 2008 trip diary and the proposed 2041 values.

Exhibit 2B.11 below summarizes the RTPM08 and refined model parking parameters for the study area.

Exhibit 2B.11 -- SRTAA Parking Cost assumptions

Urban Centre	TAZ	AM Peak (Trip Diary) Parking Cost	Refined 2041 Parking Cost	Refined 2021 Parking Cost (Interpolated)
Surrey Centre	7160, 7180, 7200, 7210, 7250, 7270, 7280	$0.75	$1.80	$1.35
	7221, 7222	$1.10	$1.80	$1.35
	7452, 7484	$1.34	$1.80	$1.35
Guildford	7300, 7330, 7340, 7350	$1.01	$1.40	$1.07
Fleetwood	7763, 7774, 7786, 7793	$0.76	$1.40	$1.40
Cloverdale	7922, 7932	$0.80	$1.40	$1.07
Newton	7472, 7501, 7502, 7602, 7604, 7652, 7654, 7655	$1.36	$1.40	$1.36
White Rock	8072, 8084	$0.79	$1.40	$1.16
	8212, 8213, 8222	$0.86	$1.40	$1.16
Langley	8300, 8331, 8332, 8333, 8311, 8312, 8321, 8360, 8543, 8544, 8551, 8552	$1.25	$1.40	$1.25
	8580, 8602	$0.52	$1.40	$1.07

2. BUSINESS AS USUAL (BAU)

The Business As Usual alternative forms the future baseline against which the Phase 2 alternatives are measured. It includes the updated road networks described above, and the updated transit networks. This section of the appendix outlines the full set of transit services that are included in the BAU (and also carried forward into the other alternatives).

SRTAA Study Area Transit Network

The BAU transit network is based on the future transit network vision from the recent South of Fraser Area Transit Plan (SOFATP). Exhibit 2B.12 is a map of the transit network in the original SOFATP Vision.

The transit network in the BAU has most of the SOFATP Vision elements, except for the conceptual rapid transit connections, which are featured instead in the Phase 2 alternatives. In lieu of rapid transit, the BAU includes a benchmark level of local services against which the Rapid Transit and Best Bus Alternatives can be evaluated.

The transit plan vision for 2031 was extrapolated to 2041 and interpolated to 2021, the two horizon years in the SRTAA evaluation. The same general structure of transit routes is assumed in both of these years except in a few places where roads are not assumed to be completed by 2021. The main difference is that service frequency is higher in 2041 in keeping with the population and employment growth of the study area, which would drive demand upwards. This increase in service results in several additional routes meeting the threshold qualifications for the FTN by 2041.

The SOFATP vision included future rapid transit on several of the study routes, including King George Boulevard, 104th Avenue and Fraser Highway, which was one of the foundations for carrying out this present study. For the purpose of making comparisons with rapid transit, the future base line excludes rapid transit on the routes that are being evaluated. To provide transit connectivity in the BAU on routes where rapid transit is included in the other alternatives, local bus services on King George Boulevard, 104th Avenue, and Fraser Highway have been increased for this study. For 2021, 5-minute peak local headways have been designated, and it was assumed these would increase to 3 minutes by 2041.

The SOFATP vision also included Rapid Bus services on Highways 1 and 99 with the routes continuing along city streets to logical termini including White Rock Centre, Guildford, Surrey Central and Langley Exchange. These Rapid Buses on Highways 1 and 99 are retained within the BAU. The operation of these routes was assumed to match service plans drafted by TransLink especially for these services.

Therefore, the basic elements assumed for the BAU transit network in the study area include:

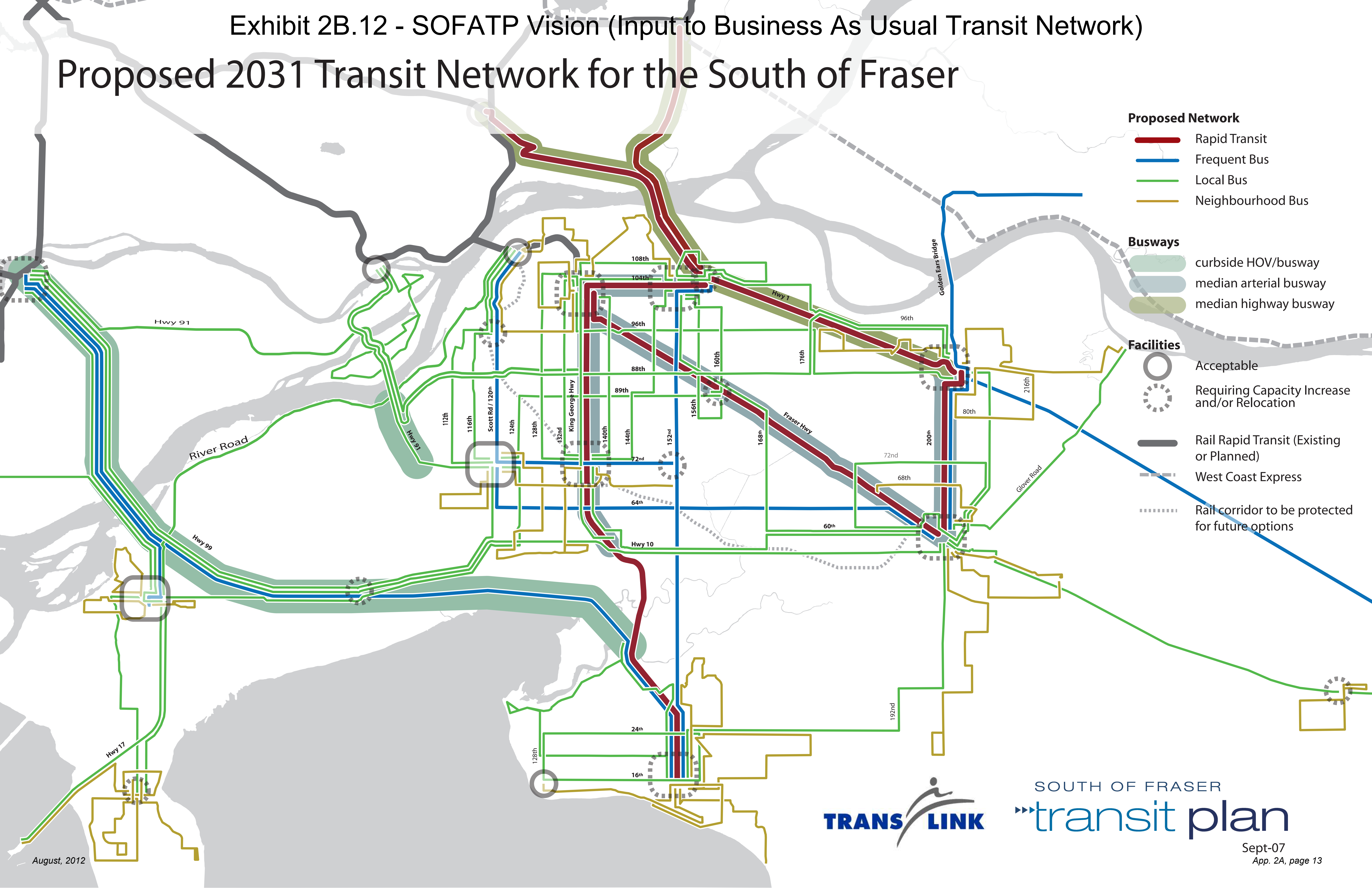
- SkyTrain service to the existing stations in Surrey (Scott Road, Gateway, Surrey Central and King George), at increased frequency and capacity. Plans to upgrade the Expo Line will permit 5-car trains to serve the study area up to 24 times per hour, resulting in an average 2.3 minute headway during peak hours;
- A system of frequent bus and local bus routes will provide grid coverage in Surrey and Langley. The frequency and coverage of services would represent a significant increase over 2010.
- High-frequency local bus services were assumed on King George Boulevard, Fraser Highway, 104th Avenue and 152nd Street (south of King George Blvd). Peak period headways of 5 minutes or less were assumed by 2041.

- Other corridors within the study area were also assumed to have frequent local service that meets the Frequent Transit Network (FTN) definition of 15-minute or better service for most of the day.
- Community shuttles will provide circulator services through neighbourhoods, to complement the basic grid; and
- Rapid bus service will operate into and through the study area via Highways 1 and 99, and connecting arterial streets.

The assumed Business As Usual network structure used in the Phase 2 evaluation is shown on Exhibit 2B.13, including which routes will meet the FTN threshold. Exhibit 2B.14 provides a headway summary for all the BAU routes within the study area, showing the service assumptions for 2021 and 2041.

Exhibit 2B.12 - SOFATP Vision (Input to Business As Usual Transit Network)

Proposed 2031 Transit Network for the South of Fraser



August, 2012

Exhibit 2B.13 -- Business As Usual (BAU) Transit Network

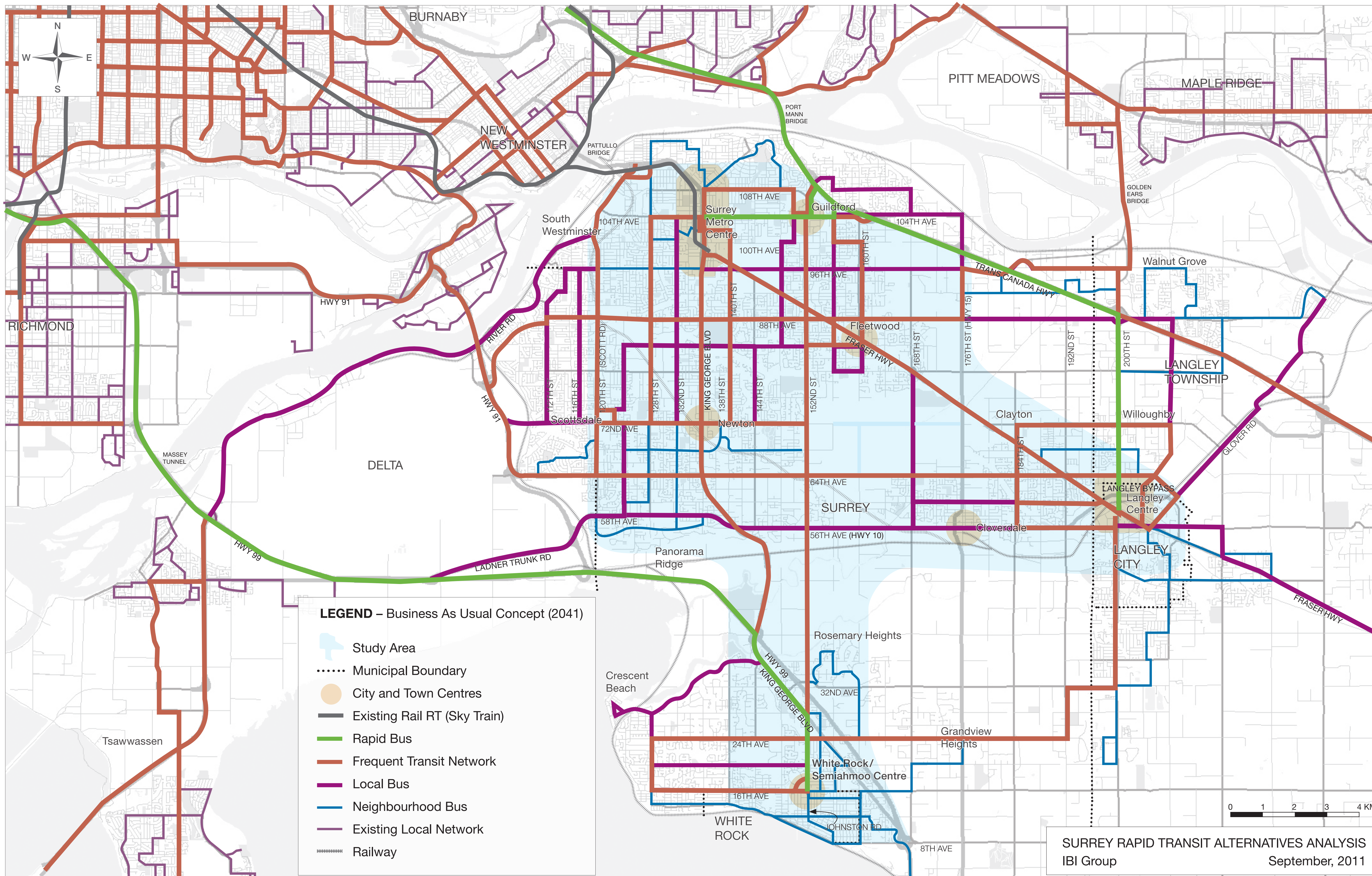


Exhibit 2B-14 -- Business As Usual (BAU) Transit Service Headways

TRANSIT LINES

line	veh type	length (km)	Description	What Street(s) in Study Area?	Overlap with Phase 2 Rapid Transit coverage	Comments for Business As Usual - Benchmark	BAU Phase 2 (2041)	BAU Phase 2 (2021)
Frequent, Local and Community Bus Services								
F-Ai	Std. Bus	20.27	LangleyCtrMapleRidge	200 st	Mostly outside study area/connecting route		6.5	12
F-Ao	Std. Bus	20.95	LangleyCtrMapleRidge	200 st	Mostly outside study area/connecting route		6.5	12
F-Bi	Std. Bus	19.18	White Rock/Guildford	152 St	Overlaps on 152 from FH to 104th ave; 56th to White Rock		6.5	10
F-Bo	Std. Bus	19.18	Guildford/White Rock	152 St	Overlaps on 152 from FH to 104th ave; 56th to White Rock		6.5	10
F-C1i	Artic.	14.93	72nd Ave/Scott Rd	72 ave west	Connecting route		4.5	6
F-C1o	Artic.	14.93	Scott Rd/72nd Ave	72 ave west	Connecting route		4.5	6
F-Di	Hwy Coach	37.61	WhiteRock/Bridgeport	KGB south of Hwy 99, 152nd south	South Surrey P&R to White Rock Centre/bus to Richmond		3	4
F-Do	Hwy Coach	36.62	Bridgeport/WhiteRock	KGB south of Hwy 99, 152nd south	South Surrey P&R to White Rock Centre/bus from Richmond		3	4
F-Ei	Std. Bus	19.59	Langley\Scottsdale	64th ave	Connecting route		6.5	15
F-Eo	Std. Bus	19.59	Scottsdale\Langley	64th ave	Connecting route		6.5	15
F-Fi	Hwy Coach	33.35	Abbot/Hwy 1/200th		outside study area		6.5	15
F-Fo	Hwy Coach	35.37	Hwy 1/200th/Abbot		outside study area		6.5	15
F-Gi	Hwy Coach	15.97	Ladner/Bridgeport		outside study area		6.5	8
F-Go	Hwy Coach	15.32	Bridgeport/Ladner		outside study area		6.5	8
L-A	Artic.	36.64	Surrey Central - Langley Centre (Local Service)	Fraser HWY	Fraser Highway (local route)	Increase frequency to replace R-A	3.5	5
L-A2i	Std. Bus	33.03	Walnut Grove\22nd St	88th ave/Hwy 15/96th	Connecting route	on FTN, use tighter headway	9	13
L-A2o	Std. Bus	33.09	22nd St\Walnut Grove	88th ave/Hwy 15/96th	Connecting route		9	13
L-AAi	Std. Bus	9.58	Tsawwassen-Ladner		outside study area		9	10
L-AAo	Std. Bus	9.58	Tsawwassen-Ladner		outside study area		9	10
L-B	Std. Bus	12.84	22 St Sta\Annacis		outside study area		7	10
L-BBi	Std. Bus	14.76	Walnut Gro\Guildford	104th/Hwy 15/96 Avenue	Mostly outside study area/connecting route		9	12
L-BBo	Std. Bus	14.33	Guildford\Walnut Gro	104th/Hwy 15/96 Avenue	Mostly outside study area/connecting route		9	12
L-C	Artic.	19.05	200th St: Langley - Walnut Grove (Local Service)		outside study area		13.5	15
L-C1i	Shuttle	9.15	Scottsdale-Fleetwood	84th ave	Connecting route (in Fleetwood)		13.5	30
L-C1o	Shuttle	9.15	Scottsdale-Fleetwood	84th ave	Connecting route (in Fleetwood)		13.5	30
L-C2i	Hwy Coach	31.23	Bridgeport-SurreyCen	88th ave, KGB	on KGB, between 88th & Surrey Central		13.5	20
L-C2o	Hwy Coach	29.98	Bridgeport-SurreyCen	88th ave, KGB	on KGB, between 88th & Surrey Central		13.5	20
L-C3	Std. Bus	36.38	Ladner - Scottsdale (Hwy10/124)		outside study area		13.5	20
L-CCi	Std. Bus	20.09	Sry Ctrl - Walnut G	88th, Hwy 15, 96th ave, KGB	on KGB, north of 96th; on 96th, KGB to 152		13.5	30
L-CCo	Std. Bus	20.09	Sry Ctrl - Walnut G	88th, Hwy 15, 96th ave, KGB	on KGB, north of 96th; on 96th, KGB to 152		13.5	30
L-DDi	Std. Bus	5.11	Fleetwood-Guildford	156th st	Connecting route		13.5	15
L-DDo	Std. Bus	5.11	Fleetwood-Guildford	156th st	Connecting route		13.5	15
L-Di	Std. Bus	41.52	Langley\Bridgeport	HWY 10	Connecting route		13.5	20
L-Do	Std. Bus	42.14	Bridgeport\Langley	HWY 10	Connecting route		13.5	20
L-EEi	Artic.	22.7	Surrey Muni C\Guildf	KGB (Hwy 10 to 104), 104 ave	Local Bus on KGB and on 104	Extend (to White Rock Ctr), increase frequency to replace R-B	3.5	5
L-EEo	Artic.	22.7	Guildf\Surrey Muni C	KGB (Hwy 10 to 104), 104 ave	Local Bus on KGB and on 104	As above	3.5	5
L-Ei	Hwy Coach	28.5	Scottsdale\Bridgepor		outside study area		5.5	10
L-Eo	Hwy Coach	28.77	Bridgepor\Scottsdale		outside study area		5.5	10
L-FFi	Std. Bus	26.88	Tswwassen Hts\Bridge		outside study area		7	8
L-FFo	Std. Bus	28.43	Bridge\Tswwassen Hts		outside study area		7	8
L-Fi	Std. Bus	17.49	Langley\White Rock	200 st, 24th ave	Connects via Grandview Heights		13.5	15
L-Fo	Std. Bus	17.49	White Rock\Langley	200 st, 24th ave	Connects via Grandview Heights		13.5	15
L-GGi	Std. Bus	13.07	Abbotsford\Aldergrov		outside study area		13.5	20
L-GGo	Std. Bus	13.07	Aldergrov\Abbotsford		outside study area		13.5	20
L-Gi	Std. Bus	12.95	White Rock	24th, 16th Avenues	Connecting route		9	15
L-Go	Std. Bus	12.95	White Rock	24th, 16th Avenues	Connecting route		9	15
L-Hi	Std. Bus	8.92	Langley\Walnut Grove	204th, 208th	Mostly outside study area/connecting route		13.5	15
L-Ho	Std. Bus	8.92	Walnut Grove\Langley	204th, 208th	Mostly outside study area/connecting route		13.5	15
L-I1i	Std. Bus	16.53	Clayton\Willoughby	72 Ave E, 184th, 60th, FH, 204th	Connecting route	on FTN, add service to balance other changes	11	20
L-I1o	Std. Bus	16.53	Willoughby\Clayton	72 Ave E, 184th, 60th, FH, 204th	Connecting route	As above	11	20
L-Ji	Std. Bus	18.52	Langley168\Guildford	60th ave, 168st, Fraser HWY, 152nd	Local Bus, overlaps on parts of Fraser Hwy/152		13.5	15
L-Jo	Std. Bus	18.52	Guildford\Langley168	60th ave, 168st, Fraser HWY, 152nd	Local Bus, overlaps on parts of Fraser Hwy/152		13.5	15
L-Ki	Std. Bus	17.92	Langley\Newton	60th ave, HWY 10, KGB	Connecting route		13.5	20
L-Ko	Std. Bus	17.92	Newton\Langley	60th ave, HWY 10, KGB	Connecting route		13.5	20
L-Li	Std. Bus	16.08	Aldergrove\Langley	Fraser HWY (east of Langley)	Mostly outside study area/connecting route		13.5	15
L-Lo	Std. Bus	15.51	Langley\Aldergrove	Fraser HWY (east of Langley)	Mostly outside study area/connecting route		13.5	15
L-Mi	Std. Bus	8.14	Newton Exch\Surrey C	132nd st	Connecting route		9	15
L-Mo	Std. Bus	8.14	Surrey C\Newton Exch	132nd st	Connecting route		9	15

Exhibit 2B-14 -- Business As Usual (BAU) Transit Service Headways

TRANSIT LINES line	veh type	length (km)	Description	What Street(s) in Study Area?	Overlap with Phase 2 Rapid Transit coverage	Comments for Business As Usual - Benchmark	BAU Phase 2 (2041)	BAU Phase 2 (2021)
L-N1i	Std. Bus	9.42	Newton Exch\Surrey C	128th	Connecting route		9	15
L-N1o	Std. Bus	9.42	Surrey C\Newton Exch	128th	Connecting route		9	15
L-O	Std. Bus	6.84	Guildford - Fraser Heights (104/108)	104th/152 St/108th	Mostly outside study area/connecting route		9	10
L-Qi	Std. Bus	13.66	Scottsdale-22ndStati		Mostly outside study area		9	10
L-Qo	Std. Bus	13.94	Scottsdale-22ndStati		Mostly outside study area		9	10
L-R1i	Std. Bus	9.72	Newton-Guildford	72nd st, 144th ave, 84th st, 148th ave	Connecting route		13.5	15
L-R1o	Std. Bus	9.72	Newton-Guildford	72nd st, 144th ave, 84th st, 148th ave	Connecting route		13.5	15
L-Si	Std. Bus	8.35	Newton Exch\Surrey C	140th st	Connecting route		9	15
L-So	Std. Bus	8.35	Surrey C\Newton Exch	140th st	Connecting route		9	15
L-Ti	Std. Bus	5.67	Fleetwood\Guildford	160th, 100th	Connecting route		10.5	15
L-To	Std. Bus	5.67	Guildford\Fleetwood	160th, 100th	Connecting route		10.5	15
L-U1i	Std. Bus	6.45	Guildford\Surrey Ctr	108th ave	Connecting route		9	12
L-U1o	Std. Bus	5.43	Surrey Ctr Stn\Guild	108th ave	Connecting route		9	12
L-V1i	Std. Bus	13.11	Scottsdale\Scott 112		Mostly outside study area		9	12
L-V1o	Std. Bus	13.11	Scott 112\Scottsdale		Mostly outside study area		9	12
L-Wi	Std. Bus	11.53	Scottsdale\Scott 116		Mostly outside study area		9	20
L-Wo	Std. Bus	11.53	Scott 116\Scottsdale		Mostly outside study area		9	20
L-Xi	Std. Bus	22.07	Ladner-ScottRdStatio		Mostly outside study area		10.5	12
L-Xo	Std. Bus	22.38	Ladner-ScottRdStatio		Mostly outside study area		10.5	12
L-Y2i	Std. Bus	20.73	WhiteRock-CrescentBe	152, 32, KGB, Crescent, 128, 20th Ave	Overlaps 152, part of KGB south of Hwy 99	local service on 152 south of S.Surrey P&R	9	15
L-Y2o	Std. Bus	20.88	WhiteRock-CrescentBe	152, 32, KGB, Crescent, 128, 20th Ave	Overlaps 152, part of KGB south of Hwy 99	+ local service to Crescent Beach	9	15
L-Zi	Artic	28.24	Ferries-Bridgeport		outside study area		13.5	30
L-Zo	Artic	27.26	Ferries-Bridgeport		outside study area		13.5	30
N-A1	Std. Bus	15.1	Aldergrove - Gloucester		outside study area		13.5	20
N-C10	Std. Bus	5.98	South Ladner (44/45/47/Ladner Trunk)		outside study area		9	10
N-C11	Std. Bus	3.64	East Ladner (Ladner Trunk/Holly Park)		outside study area		13.5	20
N-C12i	Shuttle	3.92	Tsawsn Hts\S Delta		outside study area		9	10
N-C12o	Shuttle	3.92	S Delta\Tsawsn Hts		outside study area		9	10
N-C13i	Shuttle	3.91	Boundary Bay\S Delta		outside study area		13.5	20
N-C13o	Shuttle	3.91	S Delta\Boundary Bay		outside study area		13.5	20
N-C14i	Shuttle	7.12	Ferry Term\Tsawsn TC		outside study area		13.5	30
N-C14o	Shuttle	7.12	Tsawsn TC\Ferry Term		outside study area		13.5	30
N-C15i	Shuttle	7.68	S Delta\Engl Bluff		outside study area		9	10
N-C15o	Shuttle	7.68	Engl Bluff\S Delta		outside study area		9	10
N-C16i	Shuttle	3.89	Beach Grov\Tsawsn TC		outside study area		13.5	15
N-C16o	Shuttle	3.89	Tsawsn TC\Beach Grov		outside study area		13.5	15
N-C17	Shuttle	5.1	Aldergrove		outside study area		13.5	20
N-C18	Std. Bus	31.7	Scottsdale - Newton (128/New McLellan/132)	132 St/128 St	Connecting route		13.5	20
N-C19	Std. Bus	10.94	Scott Rd Stn - Surrey Central (Bridgeview/Bolivar Heights)	KGB (Surrey Centre + Scott Road)	Connecting route		13.5	20
N-C20	Std. Bus	16.38	Surrey Central - Guildford (Grosvenor Rd)	104th/Whalley/Grosvenor/148 St/104th	Connecting route		13.5	15
N-C21i	Shuttle	6.26	W Whalley\Surrey Cen	University Dr/100/128/108th	Connecting route		13.5	20
N-C21o	Shuttle	6.26	Surrey Cen\W Whalley	University Dr/100/128/108th	Connecting route		13.5	20
N-C22	Std. Bus	16.44	Langley - Fort Langley (Langley Bypass/Glover)	Langley Bypass, Glover (NE of Langley)	Mostly outside study area/connecting route		13.5	15
N-C23	Shuttle	6.21	Yorkson-WalnutGrove		outside study area		13.5	20
N-C24	Std. Bus	12.12	Walnut Grove - Fort Langley (96/Walnut Grove/88)		outside study area		13.5	20
N-C25i	Std. Bus	8.14	Walnut Gr\Port Kells		outside study area		13.5	15
N-C25o	Std. Bus	8.14	Port Kells\Walnut Gr		outside study area		13.5	15
N-C26	Std. Bus	22.28	Fernridge - Langley (200/206/204/Grade/208)	200th, others (south of Langley Ctr)	Mostly outside study area/connecting route		13.5	30
N-C27i	Shuttle	8.67	Langley-Murrayville	203, others (e. of Langley Ctr)	Mostly outside study area/connecting route		13.5	20
N-C27o	Shuttle	8.67	Langley-Murrayville	203, others (e. of Langley Ctr)	Mostly outside study area/connecting route		13.5	20
N-C28	Shuttle	5.42	Langley-LangleyHospi	Logan, others (e. of Langley Ctr)	Mostly outside study area/connecting route		13.5	20
N-C29i	Shuttle	9.56	Clayton-Langley	68th (in Clayton)	Connecting route		13.5	20
N-C29o	Shuttle	9.56	Clayton-Langley	68th (in Clayton)	Connecting route		13.5	20
N-C2i	Shuttle	5.51	Scottsdale-Newton	68th (in Newton)	Connecting route		13.5	30
N-C2o	Shuttle	5.51	Scottsdale-Newton	68th (in Newton)	Connecting route		13.5	30
N-C30i	Shuttle	8.02	Surrey Cen\Scott Rd	KGB/96th/Scott Rd	on KGB 96th to Surrey Central		13.5	20
N-C30o	Shuttle	8.54	Scott Rd\Surrey Cen	KGB/96th/Scott Rd	on KGB 96th to Surrey Central		13.5	20

Exhibit 2B-14 -- Business As Usual (BAU) Transit Service Headways

TRANSIT LINES

line	veh type	length (km)	Description	What Street(s) in Study Area?	Overlap with Phase 2 Rapid Transit coverage	Comments for Business As Usual - Benchmark	BAU Phase 2 (2041)	BAU Phase 2 (2021)
N-C31	Shuttle	9.07	Scottsdale\SunshHill	Scott Road, others (w. of study area)	Mostly outside study area/connecting route		13.5	20
N-C4i	Shuttle	4.84	WhiteRock-MorganCree	152nd	Overlap on 152nd south of hwy 99		13.5	15
N-C4o	Shuttle	4.84	WhiteRock-MorganCree	152nd	Overlap on 152nd south of hwy 99		13.5	15
N-C5	Std. Bus	16.98	Ocean Park - White Rock (Marine)	Marine	Connecting route		13.5	15
N-C6 EB	Std. Bus	7.47	White Rock (Johnson/Marine/Stayte)	Johnson, others (south of study area)	Connecting route		13.5	15
N-C6 WB	Std. Bus	7.47	White Rock (Johnson/Marine/Stayte)	Johnson, others (south of study area)	Connecting route		13.5	20
N-C7i	Shuttle	14.23	Grandview Heights	24th, 16th Avenues	Mostly outside study area/connecting route	on FTN, add service to balance other changes	11	15
N-C7o	Shuttle	14.23	Grandview Heights	24th, 16th Avenues	Mostly outside study area/connecting route	As above	11	15
N-C8i	Shuttle	6.48	Border-WhiteRock	Johnson (south of W.R.C./16th)	Mostly outside study area/connecting route		13.5	60
N-C8o	Shuttle	6.45	Border-WhiteRock	Johnson (south of W.R.C./16th)	Mostly outside study area/connecting route		13.5	60
N-C9	Std. Bus	5.91	North Ladner (Ladner Trunk/Ferry/57)		outside study area		9	12
Rapid Bus on Highway 1								
Rap-Srry	Artic	48.38	Walnut Grove/Surrey Central Stn	HWY 1, 104th	Limited stops: Guildford, Surrey Central. Terminate at Guildford for applicable RT alternatives	Frequency per Hwy 1 Rapid Bus plan	4	7.5
R-C2i	Artic	20.88	Walnut Gr/Lougheed	HWY 1	Mostly outside study area/connecting route	Frequency per Hwy 1 Rapid Bus plan (RB-LH)	2.5	5
R-C2o	Artic	21.25	Lougheed/Walnut Gr	HWY 1	Mostly outside study area/connecting route	Frequency per Hwy 1 Rapid Bus plan (RB-LH)	2.5	5
R-Ci	Artic	7.76	LangCtr/Hwy 1/200th	200 st	Mostly outside study area/connecting route		3.5	5
R-Co	Artic	7.75	Hwy 1/200th/LangCtr	200 st	Mostly outside study area/connecting route		3.5	5
R-Di	Artic	11.86	Hwy 1 @ 156th/CoqCtr	HWY 1, 152 St	Mostly outside study area/connecting route	Frequency per Hwy 1 Rapid Bus plan (RB-Coq)	4	7.5
R-Do	Artic	11.74	CoqCtr/Hwy 1 @ 156th	HWY 1, 152 St	Mostly outside study area/connecting route	Frequency per Hwy 1 Rapid Bus plan (RB-Coq)	4	7.5
Rapid Bus proxies for Phase 2 alternatives, not applicable to BAU								
R-Ai	Artic	17.56	Langley/Surrey Ctr R	Fraser HWY	Proxy for rapid transit in study area	N/A, add frequency on route L-A	0	0
R-Ao	Artic	17.56	Surrey Ctr/Langley R	Fraser HWY	Proxy for rapid transit in study area	N/A, add frequency on route L-A	0	0
R-Bi	Artic	23.88	White Rock/Guildford	KGB, 104 ave	Proxy for rapid transit in study area	N/A, add frequency on route L-EE	0	0
R-Bo	Artic	23.88	Guildford/White Rock	KGB, 104 ave	Proxy for rapid transit in study area	N/A, add frequency on route L-EE	0	0
Duplicate Routes removed from RTPM for Phase 2								
509-RB	Artic		212 St/Walnut Grove	HWY 1, 104th	Same as Rap-Srry	Duplicate Route >> Remove	0	0
LF-B	Std. Bus	38.36	White Rock - Guildford (152)	152 st	Same as F-B	Duplicate Route >> Remove	0	0
LF-C1	Std. Bus	29.86	72nd - Scott Road (72/Scott)	72 ave west	Same as F-C1	Duplicate Route >> Remove	0	0
LF-E	Hwy Coach	57.27	Scottsdale - Langley (64)	64th ave	Same route as F-E	Duplicate Route >> Remove	0	0
LL-A2	Std. Bus	66.12	22nd St Stn - Walnut Grove (Hwy 91/8	88th ave/Hwy 15/96th	Same as L-A2	Duplicate Route >> Remove	0	0
L-A0	Std. Bus	22.48	Langley Centre - Coquitlam Station	200 St/Hwy 7		Not consistent with SOFATP >> Remove	0	0
Rap-Coq	Artic	22.48	Guildford/Coquitlam Ctr	HWY 1, 152 St	Same as R-D	Duplicate Route >> Remove	0	0
Rap-LH	Artic	41.18	Walnut Grove/Lougheed Stn	HWY 1	Same as R-C2	Duplicate Route >> Remove	0	0

3. BEST BUS ALTERNATIVE

The Best Bus Alternative (BB) is a non-rapid transit alternative where new transit routes and a series of headway enhancements are layered on top of the BAU along key study corridors.

The Best Bus Alternative was assumed to have the following components:

- BAU bus network forms the background for the BB, with other services added to it.
- B-Line services. These have the same stopping patterns as rapid transit on King George Boulevard/104th Avenue, Fraser Highway and 64th Avenue. The routes included:
    - King George Boulevard/104th Avenue (Guildford/Surrey Central/Newton/ White Rock Centre);
    - Fraser Highway (Surrey Central/Fleetwood/Langley Centre); and
    - 64th Avenue (Newton/North Cloverdale/Langley Centre).
- Super B-Line "express" services making one stop per urban centre:
    - King George Boulevard (White Rock Centre/ Newton – KGB/72nd Ave/ Surrey Central Station);
    - 152nd Street (White Rock Centre / Guildford Exchange non-stop); and
    - Fraser Highway (Langley Centre / Fleetwood – 160th Street/ Surrey Central).
- Headway enhancements would see an increase in frequency of 20 to 30% over BAU on several parallel local services. These include:
    - North/south streets on each side of King George Boulevard such as 128th St., 132nd St., 140th St., 114th/148th St. and 152nd St.
    - Local service would also be enhanced on 60th Avenue and 72nd Avenue in the Clayton / Cloverdale / Langley area.

These enhanced services are illustrated in Exhibit 2B.15. Exhibit 2B.16 includes the headway assumptions for the Best Bus Alternative transit services.

Transit Priority for Best Bus

- To facilitate the operation of the Best Bus Alternative, signal priority was assumed for the B-Line and express services similar to LRT and BRT. The effectiveness of transit priority for B-Lines would be less than LRT/BRT, because of operation in mixed traffic.
- Lane conversion for bus operations would have the greatest potential on wider street segments. The City of Surrey agreed that bus lane conversion without reducing traffic lanes below two per direction could be assumed. The one area where this is feasible with minimal construction is on King George Boulevard, north of 96th Avenue as far as 102nd Avenue, and this was assumed for Best Bus.
- Queue jumps were assumed at several existing busy locations. The City of Surrey has recently implemented one at King George Boulevard and 96th Street. In addition, queue jumps were assumed through the Green Timbers segment of Fraser Highway, and several other locations were designated by the City of Surrey as an output from their review of transit priority potential within the City of Surrey.
- The net outcome is that the B-Line services in the Best Bus Alternative had assumed schedule speeds approximately midway between local bus and BRT.

Best Bus Road Modifications

Transit priority measures were assumed to be in place for the B-Line and Super B-Line services, with several associated changes to modeled road capacity:

- Conversion of King George Boulevard between 102nd Avenue and 96th Avenue from 3 lanes per direction, to 2 lanes plus bus lanes, during peak periods.
- Changes to Volume Delay Functions (see Section 4.1 for a more detailed discussion) on Fraser Highway from Whalley Boulevard to 148th Street. These changes were the same applied for BRT and LRT segments due to the same queue jump and lane-sharing approach for transit operations.

Exhibit 2B.15 -- Best Bus (BB) Alternative: Map

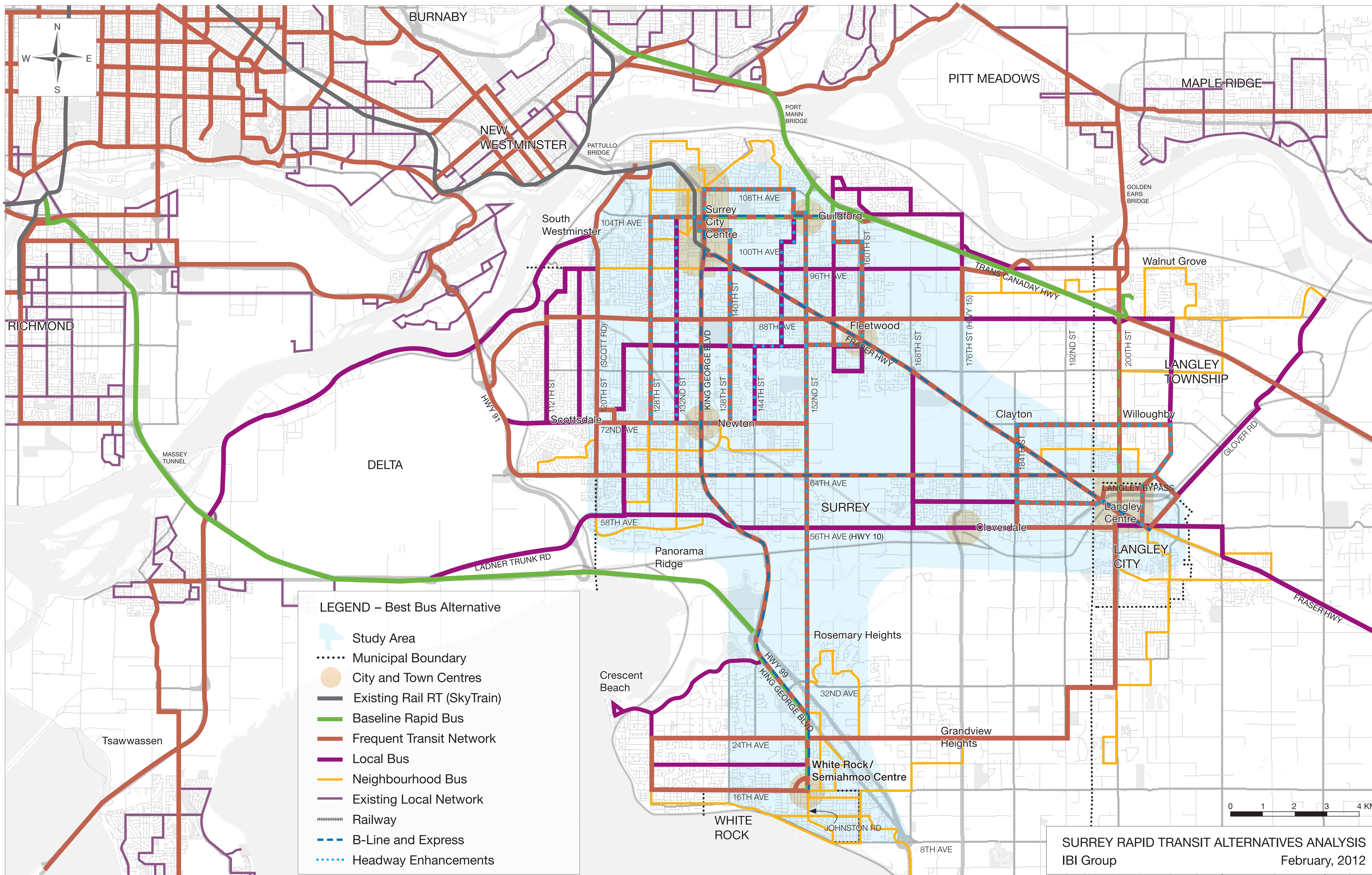


Exhibit 2B.16 -- Transit Route Headways - Best Bus Alternative

TRANSIT LINES			BAU	BAU	Best Bus (BB) Alternative		
			Phase 2	Phase 2	2041	2021	Notes
line	Description	What Street(s) in Study Area?	(2041)	(2021)	Hdwy	Hdwy	(Changes on parallel routes)
F-Ai	LangleyCtrMapleRidge	200 st	6.5	12	6.5	12	
F-Ao	LangleyCtrMapleRidge	200 st	6.5	12	6.5	12	
F-Bi	White Rock/Guildford	152 St	6.5	10	**5**	**8**	parallel additional local service
F-Bo	Guildford/White Rock	152 St	6.5	10	**5**	**8**	parallel additional local service
F-C1i	72nd Ave/Scott Rd	72 ave west	4.5	6	4.5	6	
F-C1o	Scott Rd/72nd Ave	72 ave west	4.5	6	4.5	6	
F-Di	WhiteRock/Bridgeport	KGB south of Hwy 99, 152nd south	3	4	3	4	
F-Do	Bridgeport/WhiteRock	KGB south of Hwy 99, 152nd south	3	4	3	4	
F-Ei	Langley\Scottsdale	64th ave	6.5	15	6.5	15	
F-Eo	Scottsdale\Langley	64th ave	6.5	15	6.5	15	
F-Fi	Abbot/Hwy 1/200th		6.5	15	6.5	15	
F-Fo	Hwy 1/200th/Abbot		6.5	15	6.5	15	
F-Gi	Ladner/Bridgeport		6.5	8	6.5	8	
F-Go	Bridgeport/Ladner		6.5	8	6.5	8	
L-A	Surrey Central - Langley Centre (Local Servic	Fraser HWY	3.5	5	3.5	5	same as BAU, see additional B-Line
L-A2i	Walnut Grove\22nd St	88th ave/Hwy 15/96th	9	13	9	13	
L-A2o	22nd St\Walnut Grove	88th ave/Hwy 15/96th	9	13	9	13	
L-AAi	Tsawwassen-Ladner		9	10	9	10	
L-AAo	Tsawwassen-Ladner		9	10	9	10	
L-B	22 St Sta\Annacis		7	10	7	10	
L-BBi	Walnut Gro\Guildford	104th/Hwy 15/96 Avenue	9	12	9	12	
L-BBo	Guildford\Walnut Gro	104th/Hwy 15/96 Avenue	9	12	9	12	
L-C	200th St: Langley - Walnut Grove (Local Service)		13.5	15	13.5	15	
L-C1i	Scottsdale-Fleetwood	84th ave	13.5	30	13.5	30	
L-C1o	Scottsdale-Fleetwood	84th ave	13.5	30	13.5	30	
L-C2i	Bridgeport-SurreyCen	88th ave, KGB	13.5	20	13.5	20	
L-C2o	Bridgeport-SurreyCen	88th ave, KGB	13.5	20	13.5	20	
L-C3	Ladner - Scottsdale (Hwy10/124)		13.5	20	13.5	20	
L-CCi	Sry Ctrl - Walnut G	88th, Hwy 15, 96th ave, KGB	13.5	30	13.5	30	
L-CCo	Sry Ctrl - Walnut G	88th, Hwy 15, 96th ave, KGB	13.5	30	13.5	30	
L-DDi	Fleetwood-Guildford	156th st	13.5	15	13.5	15	
L-DDo	Fleetwood-Guildford	156th st	13.5	15	13.5	15	
L-Di	Langley\Bridgeport	HWY 10	13.5	20	13.5	20	
L-Do	Bridgeport\Langley	HWY 10	13.5	20	13.5	20	
L-EEi	Surrey Muni C\Guildf	KGB (Hwy 10 to 104), 104 ave	3.5	5	3.5	5	same as BAU, see additional B-Line
L-EEo	Guildf\Surrey Muni C	KGB (Hwy 10 to 104), 104 ave	3.5	5	3.5	5	same as BAU, see additional B-Line
L-Ei	Scottsdale\Bridgepor		5.5	10	5.5	10	
L-Eo	Bridgepor\Scottsdale		5.5	10	5.5	10	
L-FFi	Tswwassen Hts\Bridge		7	8	7	8	
L-FFo	Bridge\Tswwassen Hts		7	8	7	8	
L-Fi	Langley\White Rock	200 st, 24th ave	13.5	15	13.5	15	
L-Fo	White Rock\Langley	200 st, 24th ave	13.5	15	13.5	15	
L-GGi	Abbotsford\Aldergrov		13.5	20	13.5	20	
L-GGo	Aldergrov\Abbotsford		13.5	20	13.5	20	
L-Gi	White Rock	24th, 16th Avenues	9	15	9	15	
L-Go	White Rock	24th, 16th Avenues	9	15	9	15	
L-Hi	Langley\Walnut Grove	204th, 208th	13.5	15	13.5	15	
L-Ho	Walnut Grove\Langley	204th, 208th	13.5	15	13.5	15	
L-I1i	Clayton\Willoughby	72 Ave E, 184th, 60th, FH, 204th	11	20	**9**	**15**	parallel additional local service
L-I1o	Willoughby\Clayton	72 Ave E, 184th, 60th, FH, 204th	11	20	**9**	**15**	parallel additional local service
L-Ji	Langley168\Guildford	60th ave, 168st, Fraser HWY, 152nd	13.5	15	13.5	15	
L-Jo	Guildford\Langley168	60th ave, 168st, Fraser HWY, 152nd	13.5	15	13.5	15	
L-Ki	Langley\Newton	60th ave, HWY 10, KGB	13.5	20	13.5	20	
L-Ko	Newton\Langley	60th ave, HWY 10, KGB	13.5	20	13.5	20	
L-Li	Aldergrove\Langley	Fraser HWY (east of Langley)	13.5	15	13.5	15	
L-Lo	Langley\Aldergrove	Fraser HWY (east of Langley)	13.5	15	13.5	15	
L-Mi	Newton Exch\Surrey C	132nd st	9	15	**7.5**	**12**	parallel additional local service
L-Mo	Surrey C\Newton Exch	132nd st	9	15	**7.5**	**12**	parallel additional local service
L-N1i	Newton Exch\Surrey C	128th	9	15	**7.5**	**12**	parallel additional local service
L-N1o	Surrey C\Newton Exch	128th	9	15	**7.5**	**12**	parallel additional local service
L-O	Guildford - Fraser Heights (104/108)	104th/152 St/108th	9	10	9	10	
L-Qi	Scottsdale-22ndStati	72 Ave. w. of Scott Road	9	10	9	10	
L-Qo	Scottsdale-22ndStati	72 Ave. w. of Scott Road	9	10	9	10	
L-R1i	Newton-Guildford	72nd st, 144th ave, 84th st, 148th ave	13.5	15	**12**	**12**	parallel additional local service
L-R1o	Newton-Guildford	72nd st, 144th ave, 84th st, 148th ave	13.5	15	**12**	**12**	parallel additional local service
L-Si	Newton Exch\Surrey C	140th st	9	15	**7.5**	**12**	parallel additional local service
L-So	Surrey C\Newton Exch	140th st	9	15	**7.5**	**12**	parallel additional local service
L-Ti	Fleetwood\Guildford	160th, 100th	10.5	15	**9**	**12**	parallel additional local service
L-To	Guildford\Fleetwood	160th, 100th	10.5	15	**9**	**12**	parallel additional local service
L-U1i	Guildford\Surrey Ctr	108th ave	9	12	**7.5**	**10**	parallel additional local service
L-U1o	Surrey Ctr Stn\Guild	108th ave	9	12	**7.5**	**10**	parallel additional local service
L-V1i	Scottsdale\Scott 112		9	12	9	12	
L-V1o	Scott 112\Scottsdale		9	12	9	12	
L-Wi	Scottsdale\Scott 116		9	20	9	20	
L-Wo	Scott 116\Scottsdale		9	20	9	20	
L-Xi	Ladner-ScottRdStatio		10.5	12	10.5	12	
L-Xo	Ladner-ScottRdStatio		10.5	12	10.5	12	
L-Y2i	WhiteRock-CrescentBe	152, 32, KGB, Crescent, 128, 20th Ave	9	15	9	15	
L-Y2o	WhiteRock-CrescentBe	152, 32, KGB, Crescent, 128, 20th Ave	9	15	9	15	
L-Zi	Ferries-Bridgeport		13.5	30	13.5	30	

Exhibit 2B.16 -- Transit Route Headways - Best Bus Alternative

TRANSIT LINES			BAU	BAU	Best Bus (BB) Alternative		
			Phase 2	Phase 2	2041	2021	Notes
line	Description	What Street(s) in Study Area?	(2041)	(2021)	Hdwy	Hdwy	(Changes on parallel routes)
L-Zo	Ferries-Bridgeport		13.5	30	13.5	30	
N-A1	Aldergrove - Gloucester		13.5	20	13.5	20	
N-C10	South Ladner (44/45/47/Ladner Trunk)		9	10	9	10	
N-C11	East Ladner (Ladner Trunk/Holly Park)		13.5	20	13.5	20	
N-C12i	Tsawsn Hts\S Delta		9	10	9	10	
N-C12o	S Delta\Tsawsn Hts		9	10	9	10	
N-C13i	Boundary Bay\S Delta		13.5	20	13.5	20	
N-C13o	S Delta\Boundary Bay		13.5	20	13.5	20	
N-C14i	Ferry Term\Tsawsn TC		13.5	30	13.5	30	
N-C14o	Tsawsn TC\Ferry Term		13.5	30	13.5	30	
N-C15i	S Delta\Engl Bluff		9	10	9	10	
N-C15o	Engl Bluff\S Delta		9	10	9	10	
N-C16i	Beach Grov\Tsawsn TC		13.5	15	13.5	15	
N-C16o	Tsawsn TC\Beach Grov		13.5	15	13.5	15	
N-C17	Aldergrove		13.5	20	13.5	20	
N-C18	Scottsdale - Newton (128/New McLellan/13	132 St/128 St	13.5	20	13.5	20	
N-C19	Scott Rd Stn - Surrey Central (Bridgeview/Bo	KGB (Surrey Centre + Scott Road)	13.5	20	13.5	20	
N-C20	Surrey Central - Guildford (Grosvenor Rd)	104th/Whalley/Grosvenor/148 St/104th	13.5	15	13.5	15	
N-C21i	W Whalley\Surrey Cen	University Dr/100/128/108th	13.5	20	13.5	20	
N-C21o	Surrey Cen\W Whalley	University Dr/100/128/108th	13.5	20	13.5	20	
N-C22	Langley - Fort Langley (Langley Bypass/Glov	Langley Bypass, Glover (NE of Langley)	13.5	15	13.5	15	
N-C23	Yorkson-WalnutGrove		13.5	20	13.5	20	
N-C24	Walnut Grove - Fort Langley (96/Walnut Grove/88)		13.5	20	13.5	20	
N-C25i	Walnut Gr\Port Kells		13.5	15	13.5	15	
N-C25o	Port Kells\Walnut Gr		13.5	15	13.5	15	
N-C26	Fernridge - Langley (200/206/204/Grade/20	200th, others (south of Langley Ctr)	13.5	30	13.5	30	
N-C27i	Langley-Murrayville	203, others (e. of Langley Ctr)	13.5	20	13.5	20	
N-C27o	Langley-Murrayville	203, others (e. of Langley Ctr)	13.5	20	13.5	20	
N-C28	Langley-LangleyHospi	Logan, others (e. of Langley Ctr)	13.5	20	13.5	20	
N-C29i	Clayton-Langley	68th (in Clayton)	13.5	20	13.5	20	
N-C29o	Clayton-Langley	68th (in Clayton)	13.5	20	13.5	20	
N-C2i	Scottsdale-Newton	68th (in Newton)	13.5	30	13.5	30	
N-C2o	Scottsdale-Newton	68th (in Newton)	13.5	30	13.5	30	
N-C30i	Surrey Cen\Scott Rd	KGB/96th/Scott Rd	13.5	20	13.5	20	
N-C30o	Scott Rd\Surrey Cen	KGB/96th/Scott Rd	13.5	20	13.5	20	
N-C31	Scottsdale\SunshHill	Scott Road, others (w. of study area)	13.5	20	13.5	20	
N-C4i	WhiteRock-MorganCree	152nd	13.5	15	13.5	15	
N-C4o	WhiteRock-MorganCree	152nd	13.5	15	13.5	15	
N-C5	Ocean Park - White Rock (Marine)	Marine	13.5	15	13.5	15	
N-C6 EB	White Rock (Johnson/Marine/Stayte)	Johnson, others (south of study area)	13.5	15	13.5	15	
N-C6 WB	White Rock (Johnson/Marine/Stayte)	Johnson, others (south of study area)	13.5	20	13.5	20	
N-C7i	Grandview Heights	24th, 16th Avenues	11	15	11	15	
N-C7o	Grandview Heights	24th, 16th Avenues	11	15	11	15	
N-C8i	Border-WhiteRock	Johnson (south of W.R.C./16th)	13.5	60	13.5	60	
N-C8o	Border-WhiteRock	Johnson (south of W.R.C./16th)	13.5	60	13.5	60	
N-C9	North Ladner (Ladner Trunk/Ferry/57)		9	12	9	12	
R-Ai	Langley/Surrey Ctr R	Fraser HWY	0	0	0	0	
R-Ao	Surrey Ctr/Langley R	Fraser HWY	0	0	0	0	
R-Bi	White Rock/Guildford	KGB, 104 ave	0	0	0	0	
R-Bo	Guildford/White Rock	KGB, 104 ave	0	0	0	0	
Rap-Srry	Walnut Grove/Surrey Central Stn	HWY 1, 104th	4	7.5	4	7.5	
R-C2i	Walnut Gr/Lougheed	HWY 1	2.5	5	2.5	5	
R-C2o	Lougheed/Walnut Gr	HWY 1	2.5	5	2.5	5	
R-Ci	LangCtr/Hwy 1/200th	200 st	3.5	5	3.5	5	
R-Co	Hwy 1/200th/LangCtr	200 st	3.5	5	3.5	5	
R-Di	Hwy 1 @ 156th/CoqCtr	HWY 1, 152 St	4	7.5	4	7.5	
R-Do	CoqCtr/Hwy 1 @ 156th	HWY 1, 152 St	4	7.5	4	7.5	
B-Line A	Langley Centre-Surrey Central Stn	via Fraser			3.5	5	B-Line, unique to Best Bus
B-Line B	Guildford-Surrey Ctrl - White Rock Ctr	via 104, KGB, 152 (South Surrey)			3.5	5	B-Line, unique to Best Bus
B-Line C	Langley Centre-Newton Exchange	via Fraser, 64th Avenue			3.5	5	B-Line, unique to Best Bus
Super-B A	Langley-Fleetwood-Surrey Central				8	10	super-limited, unique to Best Bus
Super-B B	White Rock-Newton-Surrey Central				8	10	super-limited, unique to Best Bus
Super-B D	White Rock - Guildford Direct				8	10	super-limited, unique to Best Bus

4. RAPID TRANSIT OPERATING ASSUMPTIONS

The rapid transit alternatives consist of Bus Rapid Transit (BRT), Light Rail Transit (LRT) and Rail Rapid Transit (RRT) technologies. Several of the LRT- and RRT-based alternatives also include BRT services. For the evaluation, the following broad assumptions were made:

- All bus network headways from the BAU remained the same across all rapid transit alternatives unless otherwise indicated.
- The alignments for rapid transit assumed the design options selected in April 2011, as documented in **Appendix 2C**.

4.1 ROAD NETWORK ASSUMPTIONS FOR RAPID TRANSIT

For street running options (LRT and BRT), the future road network is based on the BAU, with adjustments made to specific road segments for the evaluation where, due to the available street cross section and right of way constraints, reductions in street capacity are assumed. Much of the alignment of BRT/LRT is unaffected as provision was made for the addition of more traffic lanes or rapid transit through setbacks and generous medians.

However the following roadway segments would be affected by BRT or LRT:

- King George Boulevard from 96th Ave to 102nd Ave would be reduced from 3 lanes to 2 per direction;
- 104th Avenue between City Parkway and 156th would be reduced from 2 lanes to 1 lane per direction;
- Fraser Highway from 200th Street to 203/204 would be reduced from 2 lanes to 1 lane per direction; and
- Fraser Highway from 148th Street to Whalley Boulevard, volume-delay functions (described below) were modified to reflect reduced auto speed.

For RRT, the number of lanes on Fraser Highway from 200th to 203/204, and King George Blvd between Fraser Highway and 96th Avenue, was modified the same way as BRT or LRT, because placement of the guideway would require street narrowing to minimize property impacts

VDF Changes

For alternatives (BRT 1, BRT 2, LRT 1, LRT 2, LRT 3, LRT5A/5B and RRT 2) with street-running components along Fraser Highway, the Phase 2 designs assumed sharing of lanes on Fraser Highway by rapid transit vehicles and general purpose traffic through Green Timbers Forest. Rapid transit vehicles would use queue jumps on the approaches and at intersections within this segment, and receive high levels of priority over other traffic. The combined effect of waiting for rapid transit vehicles at signals and sharing capacity along the roadway would introduce some delay to other vehicles.

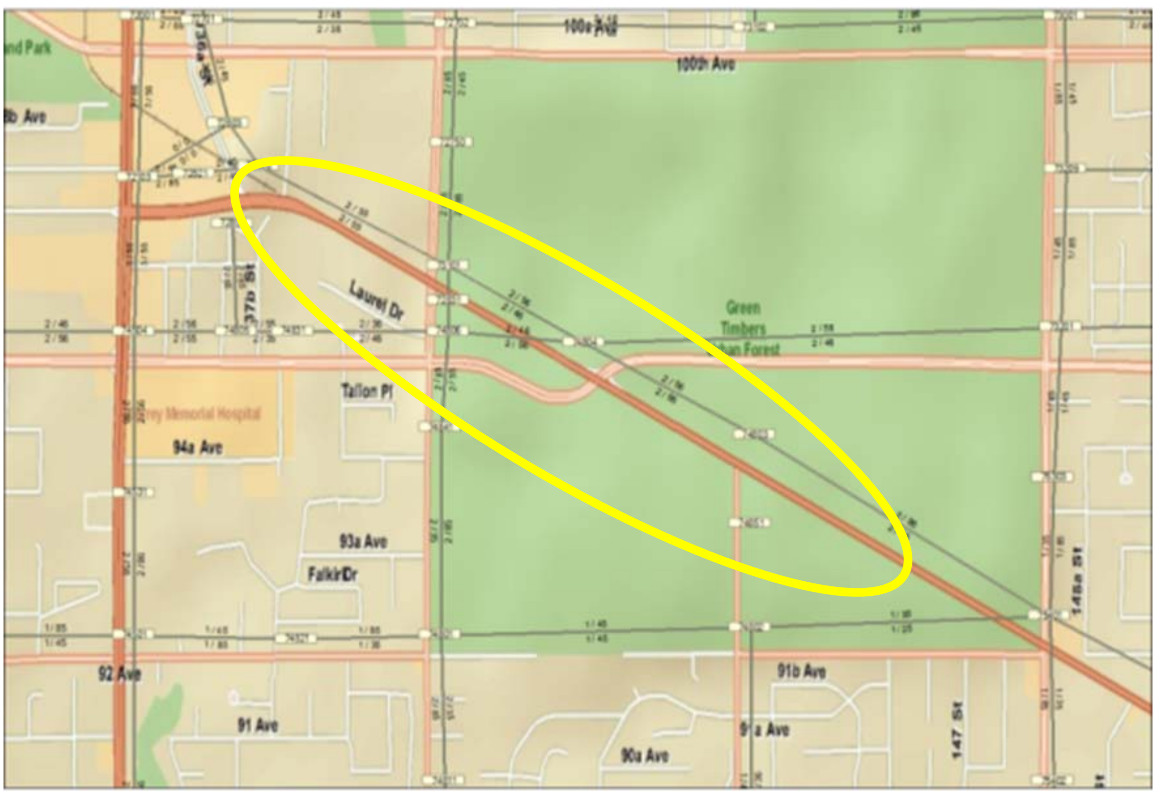
Therefore, Volume Delay Functions (vdf) on Fraser Highway between 148th Street and Whalley Boulevard were modified to reflect the reduced auto speed to provide special transit priority for selected LRT/BRT segments. These VDF functions estimate the travel time of traffic based on maximum speeds and the effects of congestion on the average speeds, in order to produce realistic representations of travel time on the street network.

The total amount of model delay added by the vdf modification over the selected links was approximately 49 seconds per direction. In practice, queue jumps can introduce up to 15 seconds of delay per signal, or 45 seconds, so the model adjustment was felt to be a good representation of the effect. The links highlighted in yellow on Exhibit 2B.18 and listed on Exhibit 2B.17 contain modified vdf.

Exhibit 2B.17 -- Vdf Changes and Estimated Delay Increases

Links		Estimated Increased Delay with new VDF
i- node	**j-node**	**(sec)**
73101	74804	12.3
74804	73101	12.3
74803	74804	15.3
74804	74803	15.3
72802	73101	10.1
73101	72802	10.1
74803	75401	10.9
75401	74803	10.9
Total		**97.2 sec**

Exhibit 2B.18 -- Links with VDF Changes



4.2 BRT ALTERNATIVES

Design Option Selection Using BRT 1

BRT 1 extends through all the urban centres in the study area with the exception of Cloverdale. Several design options (different routes) between Newton and South Surrey/White Rock, between Fleetwood and Guildford and/or Surrey Central; and within Langley Centre were initially considered. Early in Phase 2, the project team conducted a comparative mini-evaluation of the design options (different alignments between urban centres) based on variations of BRT1. The evaluation and selection of design options is documented in **Appendix 2C**.

The selected design options included the following alignments:

- Within Langley, the Fraser Highway option was assumed.
- North of Fleetwood, the connection to Surrey Metro Centre was via Fraser Highway with service between Surrey Metro Centre and Guildford provided by 104th Avenue.
- From Newton to South Surrey, the assumed alignment for the evaluation followed King George Boulevard from Newton, across the ALR, down to the intersection of King George and 152nd which it then followed to White Rock Centre.

These were assumed for all applicable BRT, LRT and RRT alternatives in the subsequent Phase 2 evaluation, including demand modeling.

Phase 2 BRT Alternatives

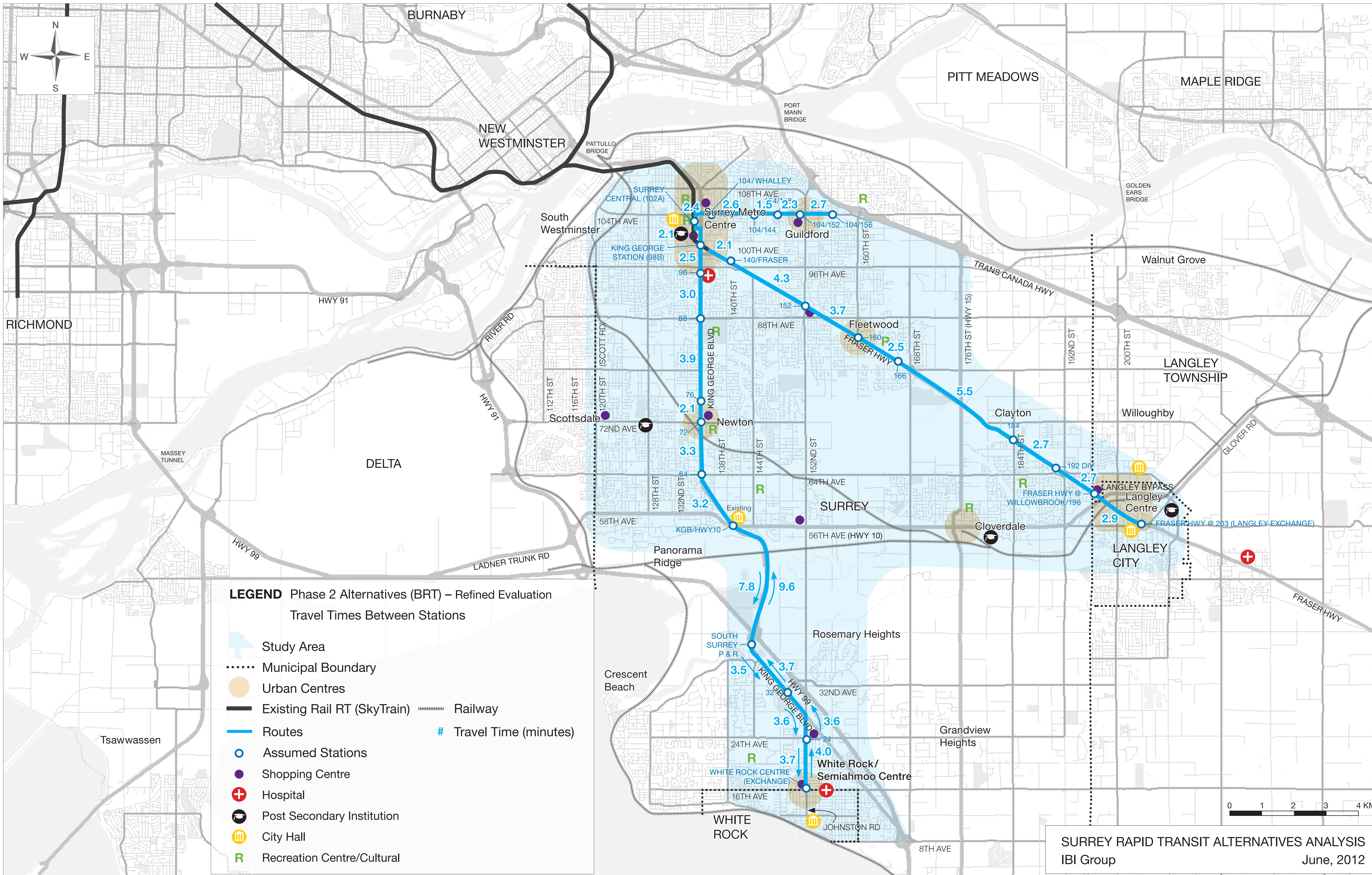
BRT is assumed to operate every 3 minutes on Fraser Highway and every 4 minutes on King George Blvd in 2021 (and increase to every 2 minutes by 2041), except when connecting to LRT at Newton Exchange, in which case the Newton-White Rock service would operate at LRT frequencies (5 minutes and 3 minutes in 2021 and 2041). BRT will operate primarily in its own segregated lanes on arterial streets. BRT makes stops at stations and at any traffic signals that it encounters. The maximum speed is usually the same as the posted speed available to traffic and the segregated lane helps BRT to maintain a higher speed than local buses. The transit priority system available to BRT would reduce the number of red light signals encountered by the vehicle (by approximately 10-15%), which increases the overall scheduled speed of the BRT.

Exhibit 2B.19 -- Final Phase 2 BRT Alternatives

Option	Description of Route	Headway 2021 / 2041 (min)
BRT 1	Surrey Central – White Rock	4/2
	Langley Centre – Surrey Central Station	3/2
	Surrey Central – Guildford (two Rapid Bus routes)	3.8/2 combined (7.5/4 each)
BRT 2	Surrey Central – White Rock	4/2
	Langley Centre – Surrey Central Station	3/2
	Surrey Central – Guildford (two Rapid Bus routes)	3.8/2 combined (7.5/4 each)

Exhibit 2B.20 illustrates the assumed BRT stations and the estimated travel times (including dwell at stations) between each pair of stations. These travel times were coded into the model for each alternative, depending on the mix of technologies making up each alternative. The estimated times were the same in each direction except for BRT in South Surrey, because the design assumed running in mixed traffic, which had effects on achievable bus speeds.

Exhibit 2B.20 -- Travel Times between Stations: BRT



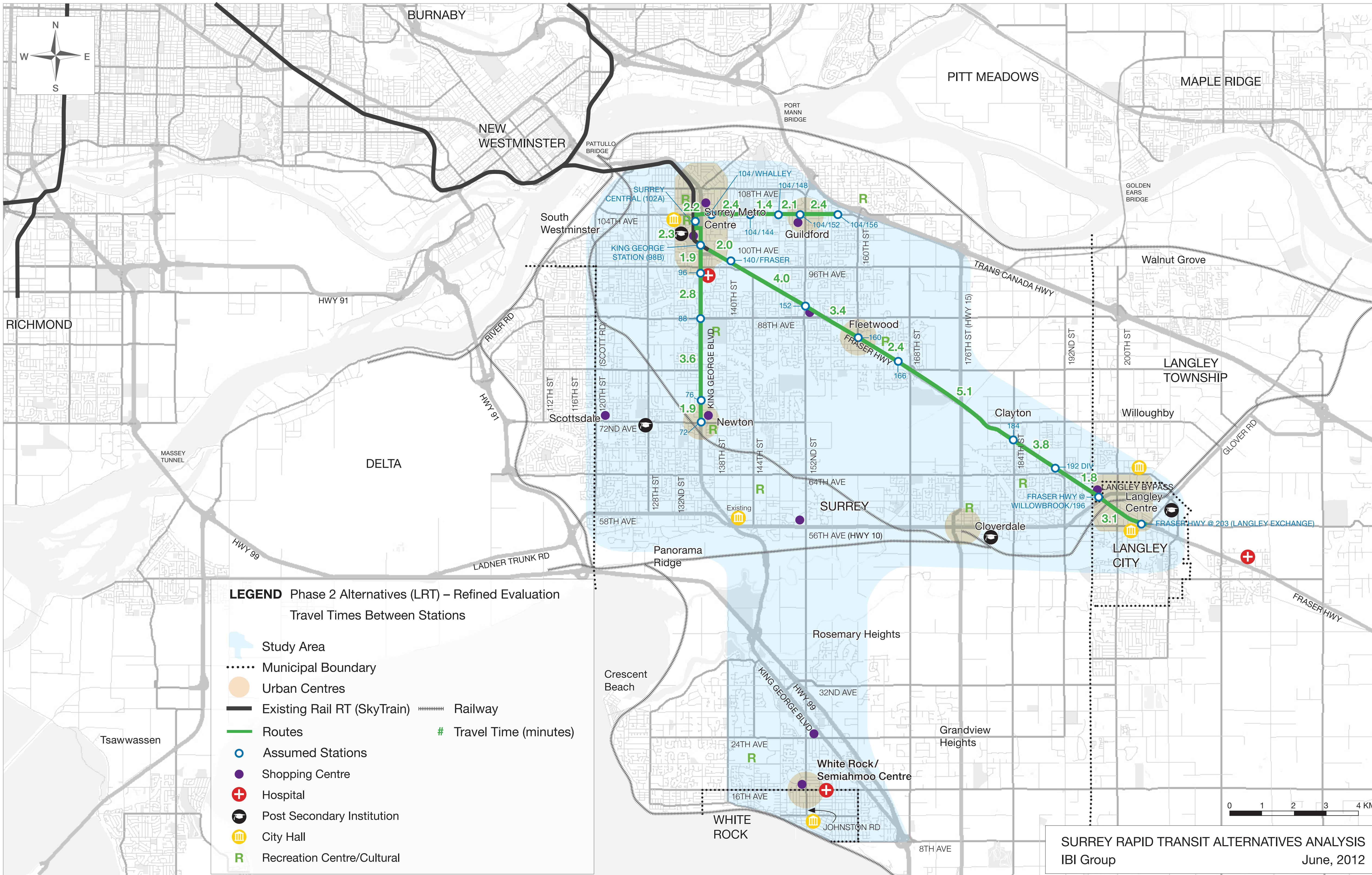
4.3 PHASE 2 LRT ALTERNATIVES

LRT alternatives assume the same alignments as BRT, and some of the segments of the LRT alternatives are served with BRT. LRT is initially assumed to operate every 5 minutes in 2021 (and every 3 minutes by 2041). Exhibit 2B.21 summarizes the LRT alternatives for Phase 2.

Exhibit 2B.21 -- LRT Alternatives

Option	Description of Route	Technology	Headway 2021 / 2041 (min)
LRT 1	Surrey Central Station - Langley	LRT	5/3
	Guildford - Newton	LRT	5/3
	Newton - White Rock	BRT	5/3
LRT 2	Surrey Central Station - Langley	BRT	3/2
	Guildford - Newton	LRT	5/3
	Newton - White Rock	BRT	5/3
LRT 3	Guildford - Newton	LRT	5/3
	Surrey Central Station - Langley	BRT	3/2
LRT 4	Guildford - Newton	LRT	5/3
LRT5A	Surrey Central – Langley	LRT	5/3
	Surrey Central – White Rock	BRT	4/2
	Surrey Central – Guildford (two Rapid Bus routes)	BRT	3.8/2 combined (7.5/4 each)
LRT5B	Guildford – Surrey Central – Langley Centre	LRT	5/3
	Surrey Central – White Rock	BRT	4/2

Exhibit 2B.22 illustrates the assumed LRT stations and the estimated travel times (including dwell at stations) between each pair of stations. LRT operations would be similar to BRT, stopping at stations and traffic signals, and governed by the posted speed limits on the street. While the LRT top speed would be similar to BRT, its acceleration performance is better so in-vehicle LRT travel times on the same route are 5-10% faster. (For the segments of LRT alternatives served by BRT, the BRT travel times on Exhibit 2B.20 applied.)



BURNABY
NEW WESTMINSTER
PITT MEADOWS
MAPLE RIDGE
RICHMOND
DELTA
SURREY
LANGLEY TOWNSHIP
LANGLEY CITY
WHITE ROCK
South Westminster
Scottsdale
Newton
Guildford
Fleetwood
Clayton
Cloverdale
Willoughby
Walnut Grove
Panorama Ridge
Rosemary Heights
Grandview Heights
Crescent Beach
Tsawwassen
White Rock/ Semiahmoo Centre
Surrey Metro Centre
Langley Centre
PORT MANN BRIDGE
PATTULLO BRIDGE
GOLDEN EARS BRIDGE
MASSEY TUNNEL
SURREY CENTRAL (102A)
104/WHALLEY
104/148
104/144
104/152
104/156
KING GEORGE STATION (98B)
140/FRASER
FRASER HWY @ WILLOWBROOK/196
FRASER HWY @ 203 (LANGLEY EXCHANGE)
LANGLEY BYPASS
192 DIV
TRANS CANADA HWY
FRASER HWY
KING GEORGE BLVD
HWY 91
HWY 99
RIVER RD
LADNER TRUNK RD
GLOVER RD
56TH AVE (HWY 10)
176TH ST (HWY 15)
LEGEND Phase 2 Alternatives (LRT) – Refined Evaluation
Travel Times Between Stations
Study Area
Municipal Boundary
Urban Centres
Existing Rail RT (SkyTrain)
Railway
Routes
Travel Time (minutes)
Assumed Stations
Shopping Centre
Hospital
Post Secondary Institution
City Hall
Recreation Centre/Cultural
0 1 2 3 4 KM
SURREY RAPID TRANSIT ALTERNATIVES ANALYSIS
IBI Group June, 2012

4.4 PHASE 2 RRT ALTERNATIVES

The RRT, or SkyTrain, alternatives extend from King George Station to Langley Exchange or Newton Exchange, with same stop locations as BRT and LRT along Fraser Highway and King George Boulevard, but with higher travel speeds, and different (more minimal) impacts on the road network.

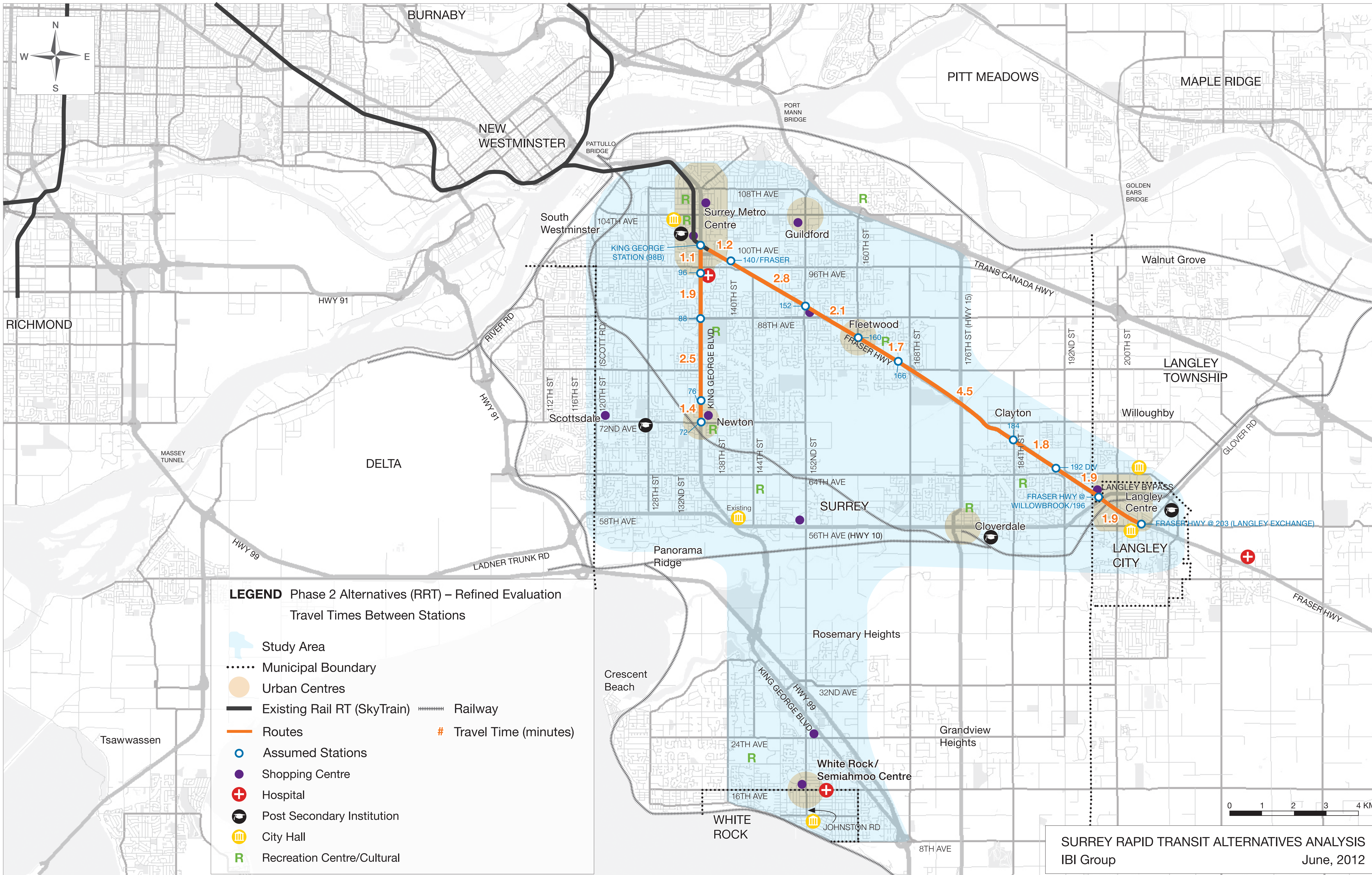
RRT is initially assumed to operate every 2.3 minutes for extensions from King George to Newton, based on the capacity and operating plan identified in the Expo Line Upgrade Strategy. For the longer extension to Langley Centre, the service is assumed to continue operating every 2.3 minutes north of King George Station, with every second train continuing to Langley (and thus providing 4.6-minute headways). Since RRT is completely segregated, it does not encounter any traffic signals and only stops at stations, resulting in an overall schedule speed 25-35% faster than LRT.

Exhibit 2B.23 summarizes the RRT alternatives, and two of these include BRT segments. Exhibit 2B.24 summarizes the RRT travel times between stations. (For the segments of RRT alternatives served by BRT, the BRT travel times on Exhibit 2B.20 applied.)

Exhibit 2B.23 -- RRT Alternatives

Option	Description of Route	Technology	Headway 2021 / 2041 (min)
RRT 1	King George - Langley Centre	RRT	4.6/4.6
RRT1A	King George – Langley Centre	RRT	4.6/4.6
	Surrey Central – White Rock	BRT	4/2
	Surrey Central – Guildford (two Rapid Bus routes)	BRT	3.8/2 combined (7.5/4 each)
RRT 2	King George - Newton	RRT	2.3/2.3
	Surrey Central – Guildford (two Rapid Bus routes)	BRT	3.8/2 combined (7.5/4 each)
	Surrey Central - Langley Centre	BRT	3/2
RRT 3	King George - Newton	RRT	2.3/2.3

Exhibit 2B.24 -- Travel Times between Stations: RRT



5. TRANSIT INTEGRATION WITH RAPID TRANSIT

The integration of rapid transit and buses includes ensuring that local services connect to rapid transit (in the demand model assumptions) and developing a strategy for how services should overlap with the rapid transit network.

It was found when reviewing the structure of the BAU bus network that nearly all planned routes would already connect to the assumed rapid transit stations. In a small number of cases, minor deviations are assumed from the planned east/west routes on 88th and 64th Avenues to connect to the rapid transit stations in the general vicinity of those two crossing streets.

The service levels on the local routes overlapped by rapid transit were retained from the 2021 and 2041 BAU headways in the Phase 2 evaluation; no reduction in frequency was assumed. This applied to the frequent local routes assumed to operate on Fraser Highway from Langley to Surrey Central and on King George Blvd/104 between White Rock and Guildford. Likewise, other transit routes that briefly overlapped the rapid transit corridor also retained consistent headways with the BAU. This approach allowed for consistency across alternatives, and meant that the evaluation results would be exclusively due to the rapid transit service (and any directly related road capacity changes as noted earlier).

Due to the limitations of RTPM08, and the nature of transit trips in the corridors, initial tests of conceptual reductions in local transit service produced spurious results. The approach where local service headways were held constant was confirmed with the study team for use in Phase 2.

Recent experience with the Canada Line and local #15 bus service on Cambie Street suggested that local service could in fact be reduced modestly. Since the opening of the Canada Line, the current local bus along Cambie Street now operates every 12 minutes, a modest reduction from the previous frequency to account for the shifting of demand from the local bus to the rapid transit network. Therefore, Appendix 4 documents a sensitivity test showing the potential impacts of reduced levels of local service on operating costs for several representative SRTAA Phase 2 alternatives. Transit service integration should be revisited in Phase 3, for further analysis and refinement.

Exhibit 2B.25 is a summary of the headways assumed for rapid transit services in each of the alternatives, including Rapid Bus providing the BRT service on 104 Avenue. All SOF local bus services are assumed to keep the same headways as BAU, for the Phase 2 evaluation. (Refined service integration planning will be carried out in a later phase of project development.)

Exhibit 2B.25 – Transit Service Assumptions and Integration – Phase 2 Alternatives

Alternative Name	**BAU**	**BB**	**BRT 1**	**BRT 2**	**LRT 1**	**LRT 2**	**LRT 3**	**LRT 4**	**LRT 5A**	**LRT 5B**	**RRT 1**	**RRT 1A**	**RRT 2**	**RRT 3**
Services Included, By Corridor, 2021 Headways ** Local Bus is in all corridors, in all alternatives*														
Fraser Highway	*Local Bus**	*Local + B-Line + Express*	BRT 3 min	BRT 3 min	LRT 5 min	BRT 3 min	BRT 3 min	*Local Bus*	LRT 5 min	LRT 5 min	RRT 4.6 min	RRT 4.6 min	BRT 3 min	*Local Bus*
104th Avenue	*Local Bus**	*Local + B-Line + Express*	Rapid Bus 3.75 min	Rapid Bus 3.75 min	LRT 5 min	LRT 5 min	LRT 5 min	LRT 5 min	Rapid Bus 3.75 min	LRT 5 min	*Local Bus*	Rapid Bus 3.75 min	Rapid Bus 3.75 min	*Local Bus*
King George (n. of Newton)	*Local Bus**	*Local + B-Line + Express*	BRT 4 min	BRT 4 min	LRT 5 min	LRT 5 min	LRT 5 min	LRT 5 min	BRT 4 min	BRT 4 min	*Local Bus*	BRT 4 min	RRT 2.3 min	RRT 2.3 min
King George (s. of Newton)	*Local Bus**	*Local + B-Line + Express*	BRT 4 min - shared lanes	*Local Bus*	BRT 5 min - shared lanes	BRT 5 min - shared lanes	*Local Bus*	*Local Bus*	BRT 4 min - shared lanes	BRT 4 min - shared lanes	*Local Bus*	BRT 4 min - shared lanes	*Local Bus*	*Local Bus*
Rest of Study Area	*Local Bus, Shuttles, Rapid Bus*	*Local Bus**, Shuttles, Rapid Bus*	*Local Bus, Shuttles, Rapid Bus*	*Local Bus, Shuttles, Rapid Bus*	*Local Bus, Shuttles, Rapid Bus*	*Local Bus, Shuttles, Rapid Bus*	*Local Bus, Shuttles, Rapid Bus*	*Local Bus, Shuttles, Rapid Bus*	*Local Bus, Shuttles, Rapid Bus*	*Local Bus, Shuttles, Rapid Bus*	*Local Bus, Shuttles, Rapid Bus*	*Local Bus, Shuttles, Rapid Bus*	*Local Bus, Shuttles, Rapid Bus*	*Local Bus, Shuttles, Rapid Bus*

Alternative Name	**BAU**	**BB**	**BRT 1**	**BRT 2**	**LRT 1**	**LRT 2**	**LRT 3**	**LRT 4**	**LRT 5A**	**LRT 5B**	**RRT 1**	**RRT 1A**	**RRT 2**	**RRT 3**
Services Included, By Corridor, 2041 Headways ** Local Bus is in all corridors, in all alternatives*														
Fraser Highway	*Local Bus**	*Local + B-Line + Express*	BRT 2 min	BRT 2 min	LRT 3 min	BRT 2 min	BRT 2 min	*Local Bus*	LRT 3 min	LRT 3 min	RRT 4.6 min	RRT 4.6 min	BRT 2 min	*Local Bus*
104th Avenue	*Local Bus**	*Local + B-Line + Express*	Rapid Bus 2 min	Rapid Bus 2 min	LRT 3 min	LRT 3 min	LRT 3 min	LRT 3 min	Rapid Bus 2 min	LRT 3 min	*Local Bus*	Rapid Bus 2 min	Rapid Bus 2 min	*Local Bus*
King George (n. of Newton)	*Local Bus**	*Local + B-Line + Express*	BRT 2 min	BRT 2 min	LRT 3 min	LRT 3 min	LRT 3 min	LRT 3 min	BRT 2 min	BRT 2 min	*Local Bus*	BRT 2 min	RRT 2.3 min	RRT 2.3 min
King George (s. of Newton)	*Local Bus**	*Local + B-Line + Express*	BRT 2 min - shared lanes	*Local Bus*	BRT 3 min - shared lanes	BRT 3 min - shared lanes	*Local Bus*	*Local Bus*	BRT 2 min - shared lanes	BRT 2 min - shared lanes	*Local Bus*	BRT 2 min - shared lanes	*Local Bus*	*Local Bus*
Rest of Study Area	*Local Bus, Shuttles, Rapid Bus*	*Local Bus**, Shuttles, Rapid Bus*	*Local Bus, Shuttles, Rapid Bus*	*Local Bus, Shuttles, Rapid Bus*	*Local Bus, Shuttles, Rapid Bus*	*Local Bus, Shuttles, Rapid Bus*	*Local Bus, Shuttles, Rapid Bus*	*Local Bus, Shuttles, Rapid Bus*	*Local Bus, Shuttles, Rapid Bus*	*Local Bus, Shuttles, Rapid Bus*	*Local Bus, Shuttles, Rapid Bus*	*Local Bus, Shuttles, Rapid Bus*	*Local Bus, Shuttles, Rapid Bus*	*Local Bus, Shuttles, Rapid Bus*

Notes:

* All alternatives include BAU services (SkyTrain to King George Station, Rapid Bus on Hwys. 1/99, increased FTN/local bus service)
Local buses are assumed to connect to nearby RT stops, if BAU route was within 500 m of the station.
** Best Bus includes further increased local bus frequencies parallel to KGB, 104 Ave and Fraser Highway.
*** Rapid Bus integration on 104 Avenue (applies to BRT 1, BRT 2, LRT 5A, RRT 1A, RRT 2) has RB from Surrey Central providing the BRT service, with buses then continuing via to Coquitlam (via 152 Street) or Walnut Grove (via 156 Street)

6. OFF-MODEL TRANSIT EVALUATION INPUTS

The off-model transit evaluation inputs included vehicle capacity assumptions and Operations and Maintenance Centre assumptions, to support calculations for the transportation and financial evaluation accounts.

6.1 CORRIDOR TRANSIT CAPACITY ASSUMPTIONS

The assessment of several evaluation measures drew upon the estimated transit capacity for each corridor. The transit capacity developed for this study is a function of service frequency and vehicle capacity, added across each of the transit services within a study corridor. The frequency of transit services for the BAU and all thirteen alternatives was described in detail in preceding sections of this appendix. This section describes the vehicle capacities and calculation of peak capacity.

For the Phase 2 evaluation, the following capacities were assumed:

- BRT – 100 passengers per articulated (~18m x 2.5 m) bus. (Bi-articulated buses were not considered at this stage, but would have a greater capacity);
- LRT – 240 passengers per coupled pair of LRT vehicles (average size of coupled vehicle is 40 m x 2.65 m);
- RRT (SkyTrain) – 130 passengers per unit, or 650 passengers per 5-car train (5-car train length is approximately 80 metres);
- Standard conventional bus (12 metres) – 70 passengers; and
- Articulated bus (18 metres) – 100 passengers.

Capacities for rapid transit vehicles in TransLink's recent rapid transit studies (UBC Line, Expo Upgrade Strategy, SRTAA) have consistently assumed a vehicle capacity of seats + standees @ 4/m^2. This is consistent with North American standards and state of the art practice for typical vehicle capacities[2]. Higher standee densities are observed in other locations but there is insufficient evidence to support their use locally. The figure of 4 passengers/m^2 of usable floor space is also consistent with local experience on the SkyTrain[3] and the 99 B-Line[4]. All rapid transit vehicles assumed in this study are low-floor and/or level-boarding, with an interior layout and seating configuration specifically designed for high-capacity transit operations.

The peak hour capacity of each service was calculated based on the peak capacities per vehicle, and the assumed number of vehicles per hour. The total combined transit capacity of each corridor was the sum of all rapid transit and local service services within each corridor. For BAU, Best Bus, and any applicable rapid transit alternatives, the high-frequency local services and B-Lines were assumed to operate using articulated buses, with a capacity of approximately 100 passengers per bus.

These assumptions were used in the assessment of capacity and expandability, and were also considered when calculating the capacity-constrained travel time benefits in the Transportation Account.

[2] TCRP Transit Capacity and Quality of Service Manual shows articulated bus capacity of 100-120, with 100 being "service" capacity and 120 being "crush" capacity.
[3] BCRTC conducts annual observations of passenger loads on SkyTrain.
[4] Passenger count data showed maximum average hourly loads of 97 on routes served by articulated buses, derived from 188 trip samples on the WB 99 B-Line between 8 and 9 am in 2011. This equates to a standee density of 4.11 per m^2 (54 seats + 10.45 m^2 of usable floor area). As this was based on an hourly average, many trips were actually exceeding 100 passengers.

6.2 OPERATIONS AND MAINTENANCE CENTRE (OMC) REQUIREMENTS

Each of the rapid transit technologies will require vehicle storage and maintenance for the operational fleet, which varies by alternative. The treatment of these is different for each transit technology:

- For BRT, the OMC (or transit centre) can be shared with other transit services, and does not need to be connected directly to the BRT running way. Ideally, the BRT OMC/transit centre should be located near the alignment to minimize deadheading costs. Based on recent cost estimates for the provision of a new transit centre in Metro Vancouver, the typical cost to accommodate one articulated BRT vehicle is in the order of $400,000. This includes the land and average facility costs per bus.
- For RRT/SkyTrain, a new OMC facility or extra yard capacity would need to be added, somewhere on the existing and planned SkyTrain network consisting of the Expo, Millennium and Evergreen lines. Based on recent experience with OMC costs for the Canada Line and estimates from the Expo Line Upgrade Strategy, the allocation for each SkyTrain car is estimated to be approximately $650,000 in costs to add the storage capacity and facilities. For a 5-car train, the average OMC cost would thus be $3.5 million per train.
- For LRT, the OMC would be unique to the Surrey LRT fleet and therefore would need to be adjacent to (or within one city block of) the initial LRT route. For LRT 1, the OMC could be anywhere suitable between Newton, Guildford and Langley. For LRT 2/3/4, the OMC would be limited to a location between Newton and Guildford. For LRT 5A, the location would have to be between the City Centre and Langley, whereas for LRT 5B, Guildford would also be applicable.
- The LRT OMC would include the maintenance and control facility buildings, the storage tracks for the LRT, a buffer outside the site, and the lead track connecting the yard to the main LRT line. The storage tracks and maintenance area would have to accommodate the initial fleet based on the 5-minute assumed service headway plus a set of spare vehicles, and also be able to expand to accommodate the 2041 LRT fleet based on the shorter 3-minute headway. The site for LRT 1 would likely be in the order of 3.5 to 4 hectares whereas the requirement for LRT 2/3/4 would likely be in the order of 2.5 to 3 hectares. LRT 5A and 5B would require approximately 3 to 4 hectares.
- The costs estimated for the LRT OMC included the facility and property based on an average land value from several sample locations of sufficient size. The total facility plus property costs varied from $ 60 million to $ 80 million. This averages out to $ 750,000 to $ 1 million per LRT unit, or $1.5 to $2.0 Million in OMC costs per 2-car LRT train.

These OMC cost estimates fed into the Financial Account. Where applicable, potential OMC site locations and costs would be reviewed in further detail in a later phase.

APPENDIX 2C – SELECTION OF DESIGN OPTIONS

Overview

This appendix documents the evaluation and selection of design options for the Phase 2 alternatives. The purpose of the mini- evaluation was to select which design options would be assumed to represent the alternatives when preliminary results were presented during public consultation in May and June 2011. The same assumptions were carried forward into the final Phase 2 evaluation completed in 2011/2012.

Summary of Results

The result of the design option mini-evaluation, which used qualitative and available quantitative measures, had the following recommendations:

- Within Langley, the Fraser Highway option was assumed for BRT and already was being assumed for LRT and RRT.
- North of Fleetwood the connection to Surrey Metro Centre and to Guildford was via Fraser Highway with service between Surrey Metro Centre and Guildford provided by 104th Avenue. This was known as Option B.
- From Newton to South Surrey the assumed alignment for the evaluation followed King George Boulevard from Newton, across the ALR, down to the intersection of King George and 152nd which it then followed to White Rock Centre. This was known as Option D.

These options were assumed for the Phase 2 evaluation as agreed with representatives of the City of Surrey, City of Langley and Metro Vancouver. The other options will remain in the technical documentation for further consideration during a later phase.

The rest of this appendix provides additional background on the design options and the min-evaluation findings.

1. DESIGN OPTIONS

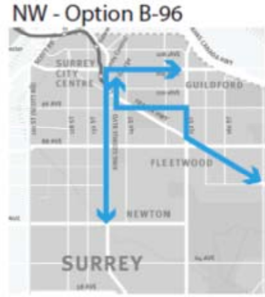
Multiple design options were carried into Phase 2 as a result of the short listing process at the end of Phase 1. These design options included alternate routes between the urban centres in the study area:

- Several different options were assessed north of Fleetwood. One was along 152nd Street (in north Surrey) towards Guildford, and another was along Fraser Highway towards Surrey Metro/City Centre. These were called Options A and B, respectively. In addition, there was a variation to the Fraser Highway option using 96th Avenue, and a combination option (AB) that split service and used both 152nd Street and Fraser Highway.

NW - Option A

NW - Option B

NW - Option B-96



NW - Option AB

- There were two design options for the route between Newton and White Rock Centre. The first of these (Option C) followed 152nd Street between Highway 10 and Highway 99 whereas the other (Option D) stayed on King George Boulevard for most of the trip from Newton to White Rock Centre.

- There were also three different Langley design options applicable only to BRT. The first of these is a continuous route along Fraser Highway until reaching the general vicinity of the Langley transit exchange. Two other options to the north and south of this, which would take advantage of existing or planned grade separations over the Roberts Bank rail corridor, were also under consideration.

For the purpose of the Phase 2 evaluation, one set of design options was assumed to represent the basic alignment of each alternative. This made the designs and evaluation results easier to understand for the study team, decision makers and members of the public. The other options will be retained for consideration during a later phase.

2. EVALUATION PROCESS

The process to establish which options were assumed used BRT Alternative 1 as the basis for making relative comparisons, because BRT 1 was the most extensive of the alternatives and included all of the design options. The travel demand model was set up with each of the BRT 1 design options to assess how the different routes and stations would affect transportation performance, including transit ridership and traffic impacts. The assessment also considered other high level factors including the comments provided during the design review with the project partners and other significant impacts and constraints, using the seven evaluation accounts as an organizing tool.

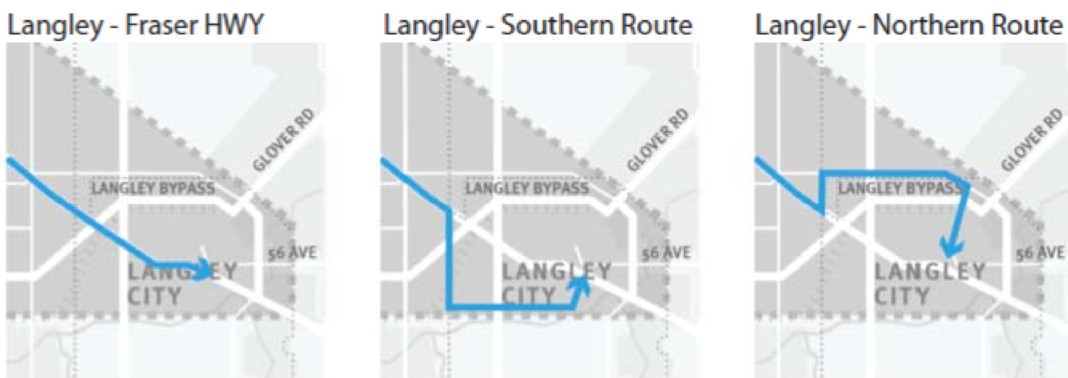
The recommendations from the initial mini-evaluation were presented to the project partners in April 2011, and subsequently the recommendations were confirmed as suitable assumptions for the evaluation. It should be recognized that the other design options may be revisited in a subsequent phase of the study, if applicable to the alternatives being refined and evaluated at that time.

The following sections describe the mini-evaluation findings for the Langley, South Surrey, and Fleetwood/Guildford/Surrey Metro Centre options.

The evaluation of these options, using the multiple account evaluation framework criteria, is attached to this appendix. It includes the results of the initial evaluation of the options within each segment, including descriptions of the options, the length of the connections, the number of stations, and then an assessment of the financial, transportation, environmental, urban development, economic development, social community, and deliverability performance based on the information available at the time on these options. The summary mini-evaluation is attached as **Exhibit 2C.1** to this appendix.

3. LANGLEY DESIGN OPTIONS

Three design options were evaluated for the segment from Fraser Highway at 196th Street to the assumed location for a future Langley transit exchange. For the purpose of this study, the intersection of Fraser Highway and 203rd Street is being assumed as the terminus point because it falls within the general vicinity of the existing transit exchange and is central to the downtown core of the City of Langley.



The Fraser Highway option would follow Fraser Highway 196th Street to 203rd and would include a viaduct over the Roberts Bank rail corridor and Langley Bypass, return to grade just before 200th Street and then continue down Fraser Highway to the terminus of the line. Because this option includes a new structure to cross over the railway, two other options were considered that would follow existing and planned bridges.

The Langley/Southern option would use the planned 196th Street overpass to cross over the Roberts Bank rail corridor and then turn east on 56th Avenue and follow that to 203rd Street, to reach the same terminus point. The third option, the Langley/Northern, would follow Willowbrook Drive and 62nd Avenue and then use the 204th / 203rd Street overpass to cross over the Roberts Bank rail corridor and access the assumed terminus at 203rd and Fraser Highway.

The relative performance of the three options was as follows:

Financial Account

- Within the Financial Account, the Langley/Southern option was assessed to have the lowest potential cost, even though the alignment of the Langley/Southern option is 2.7 km vs. 1.8km for the most direct Langley/Fraser option. The Southern option features 2 km of surface construction and 0.7 km of lane sharing on the planned 196th bridge. This results in a considerably lower capital cost than the new BRT viaduct that is included in the Langley/Fraser option. The capital cost of the Northern option falls between the other two.

While it features the same concept of sharing a lane on an existing bridge, the amount of surface construction is longer than the Southern option.

- An advantage that the Langley/Fraser option has is its fastest journey time, which allows the operations to reduce the fleet requirement by one bus during both the peak and off-peak periods. This reduction in the number of buses required to maintain the same headway, produces a savings of nearly $1M per year in operating and maintenance costs.
- The overall difference between the three alternatives is not particularly high in the overall scale of the Surrey rapid transit alternatives, with a range on the life cycle net present value of only $10M - $20M between the high and low range. The higher operating costs of the Southern and Northern options go some way to making up the difference in the capital cost in terms of the overall life cycle net present value.

Transportation Account

- Within the Transportation Account, the Fraser option performed the best and the other two were assessed to have medium performance. The Fraser option would be most attractive to riders because of its directness and speed, with a travel time of only 29 minutes from Langley to Surrey Central if operated as a BRT. The other two options being longer would have travel times of 31 to 32 minutes.
- Another of the advantages of the Fraser option is that the capacity reduction to the road network would be the least of the three with only lane reductions on the least busy part of Fraser Highway, east of 200th Street. Because of the viaduct, the two busiest intersections along this segment of Fraser Highway are not actually crossed at grade by the BRT alignment. Similarly, the Fraser option also has the fewest restrictions in terms of street closings and turning movements.
- Because the stations are assumed to be in the same location for all three alternatives, with one near Willowbrook Mall and the other at the transit exchange, there were no differences in the initial assumptions between the future population and employment and several of the other criteria related to stations.
- The reliability of the Fraser option was assessed to be the greatest because it would be completely in a segregated running way and have full priority, whereas both of the others would have mixed operation on the existing bridges.

Environmental Account

- The Environmental Account was not determined to be a differentiator between the three Langley alternatives.
- The Fraser option would have the highest air emissions during construction because of the use of concrete and other materials to produce the viaduct but it would have the lowest air emissions during the operating period because of the more direct service and the greater potential with the faster travel time to attract additional riders and therefore reduce vehicle emissions in the Langley city area.
- The potential for noise was assessed to be the least for the Fraser Highway option because the land use is mainly businesses along the Fraser Highway, and all three alignments include an elevated section (either new or an existing bridge) where noise produced by the transit vehicles would have greater effect. Each of the other two alternatives would have somewhat more exposure to potential noise and vibration partly because the length is longer, and in the case of the Southern option, because there are homes that back onto 56th Avenue where traffic pushed closer to the homes by the spot widening of the street could have noise or vibration impacts.

Urban Development Account

- The Fraser Highway option was assessed to be neutral under Urban Development because it has the greater potential to integrate with public realm concepts on Fraser Highway and widen sidewalks and boulevards, while introducing a new elevated structure, which has a negative visual effect. The other two alternatives would likely result in reduction in boulevard space in order to accommodate the median transit within the existing streets, and so have a worse rating.

Economic Development

- The Fraser Highway option was assessed to be the best performer under Economic Development because it has fairly minor impacts on the least busy section of Fraser Highway and preserves most of the accesses to industrial sites because of the viaduct over the Roberts Bank rail corridor. Each of the other two alternatives requires some lane capacity to be shared on goods movement routes and there would be some reduction in industrial accesses. The Northern option was assessed to have the poorest performance under Economic Development because of reductions in capacity along Willowbrook Drive, an access to the regional mall.

Social/Community Account

- Within the Social Community Account, the main differentiator was that the Southern option would have the poorest performance because of likely reductions in the number of pedestrian and cyclist crossing opportunities along 56th Avenue, which has residential developments on both sides.
- The Northern option would have a reduction in crossing opportunities around Willowbrook Mall, however this is an auto-oriented segment of the street, so it was rated medium.
- The Fraser Highway option could potentially increase community cohesion because it adds a new path above the RBRC corridor, connecting the two sides, and was rated ‘better.’

Deliverability Assessment

- Under the Deliverability assessment, all three of the options were considered to have a medium performance, each of them with some minor challenges ranging from the construction of the viaduct to the lane conversion of the existing streets and planned bridges. While the construction of the viaduct in the Fraser Highway option may be the greatest of the constructability challenges, it is likely that the Northern and Southern options would have greater community resistance because of the loss of road space and crossing locations.

The recommended assumption for the design within Langley was the Fraser Highway option due to its overall better performance in this initial mini-evaluation. Those factors where this option was not the most promising, including costs and visual impact, would still be fairly neutral against the LRT and RRT alternatives (both along Fraser Highway) into the City of Langley. The City of Langley staff agreed with the overall assessment of these design options and with the recommendation to use the Fraser Highway option as the assumption for BRT alignments in the City of Langley for the evaluation.

4. DESIGN OPTIONS WITHIN SOUTH SURREY

The design options in South Surrey include:

- Option C which operates on King George Boulevard, Highway 10 and 152nd Street from Newton to White Rock Centre; and
- Option D which follows King George Boulevard through South Surrey and then 152nd Street to White Rock.

The segment of King George Boulevard between Highway 10 and its intersection with 152nd is included in Option D, and runs for 7.2km and has three stations. In Option C, this connection follows the alternate route via Highway 10 and 152 Street, which is 8.2km and also features three stations.

White Rock - Option C

White Rock - Option D

These are the highlights of the assessment of the two options against the evaluation framework:

Financial Account

- Both of the options were assessed to have a medium performance in the Financial Account.
- Option C could potentially have initially lower average costs per kilometre, because of the shorter extent of bridge construction. Initial cost estimates indicated that in fact Options C and D were similar, with the higher average costs of Option D offset by the longer length of C. In addition, while not included in the cost estimates, the anticipated mitigation of traffic impacts by widening 152nd Street would probably make this a more expensive capital cost option once the initial evaluation was refined.
- Option D features four bridges instead of three and a greater degree of bridge construction and shorter amount of surface construction. It was assumed that this may have a marginally higher capital cost but the design also includes retention of four traffic lanes on King George Blvd, and therefore no additional mitigation is expected to be required for traffic impacts.
- Option D was also assessed to have a lower operating cost due to the shorter route and resulting saving of one less bus to provide the same frequency of service over the course of the year.

Transportation Account

- Within the Transportation Account, Option D was a better performer than Option C.
- The number of transit boardings along the both options in the AM peak was assessed to be similar, both overall in the network from White Rock to Langley and in terms of the local boardings.
- The journey time on transit was assessed to be lower on the more direct King George Boulevard route (D) than it was on the 152nd and Highway 10 option (C).
- Fewer impacts were expected with King George Boulevard option for non-transit users because the number of traffic lanes was retained in the design assumption for King George Boulevard, whereas there was a lane reduction on 152nd Street in the initial design. An assessment of the average speeds showed that each of the roadway links would slow by approximately 10km per hour due to increased congestion.
- Option C had a slightly higher population and employment within the station catchments whereas in Option D, one of the stations was the South Surrey Park & Ride. Option D had similar ridership to Option C because of the effect of the park & ride to capture passengers from a larger area around the station.
- The reliability of both options would be similar but Option C is likely to require some mitigation of agricultural access issues which might compromise the segregated right of way. This would result in reduced reliability relative to Option D.

Environmental Account

- Both of these options were assessed to have a relatively poor performance against the Environmental account due to the potential risks against several criteria.
- Both options fare poorly against the biodiversity criterion because both options pass through rural sections and river crossings.
- Option D (King George Boulevard) has closer proximity to Mud Bay (and a row of heritage trees along the west side of King George Boulevard), and therefore a greater potential for impacts to habitat.
- Option C (152nd St) has a greater potential for partial takings from the agricultural land reserve due to a narrower right of way along the existing street.
- This combination of factors resulted in the same relative rating for these two options.

Urban Development Account

- Both of these design options were assessed to have a medium performance under Urban Development.
- Both of them would have neutral performance against urban design, particularly because there are significant rural segments along both of these alignments. Property requirements are likely to be higher for Option C due to narrower public right of way (and would increase with mitigation of traffic impacts), whereas the potential for development is somewhat lower along Option D due to the South Surrey Park & Ride.

Economic Development Account

- Option C was assessed to have a poor performance against Economic Development relative to a medium assessment for Option D. Option C has an assumption of reducing the number of lanes on a goods movement route and it also would impede farm accesses along 152nd Street.

Social/Community Account

- Neither option would produce many changes in community cohesion nor in visual impacts; therefore, both rated a medium performance in this account.

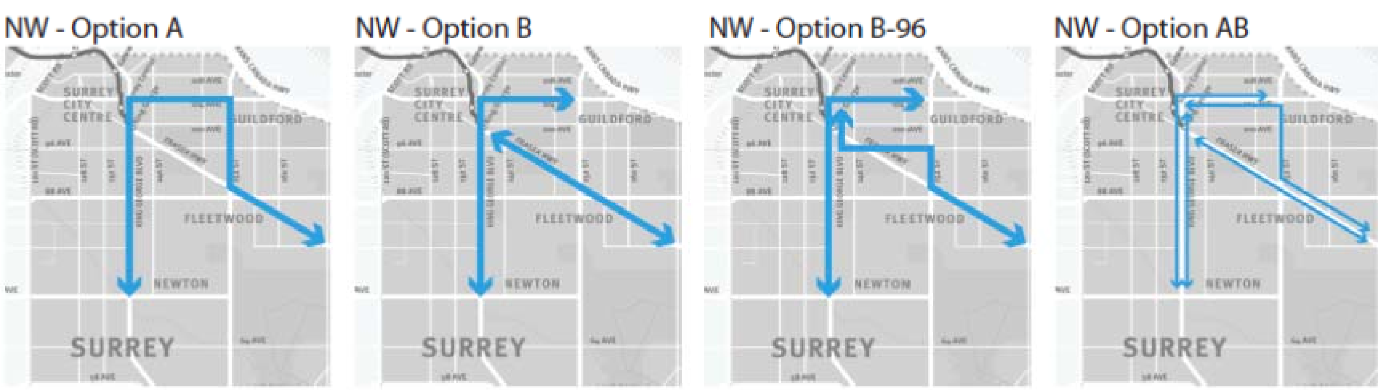
Deliverability Account

- Both options were assessed to have medium deliverability. Each of them have challenges with crossing through the agricultural land reserve, bridge crossing areas, and with the lane conversion and widening both in the vicinity of bridges and in the ALR. It was also felt that there was some potential for resistance to the project if reducing GP lanes on 152nd Street was required there could also be local concerns expressed over habitat areas and trees along King George Boulevard.

Option D was recommended as the assumed alignment for the evaluation. It should be noted that Option C may have a slightly lower capital cost because of the initial design options although it would have a higher operating cost. However, the likely effect of mitigating traffic impacts would be to refine the design, widen the street and then this would trigger a higher capital cost, more environmental effects, and more property impacts. The City of Surrey agreed with this recommendation for Option D to be used as the assumption for the evaluation.

5. OPTIONS BETWEEN FLEETWOOD AND GUILDFORD TO SURREY METRO CENTRE

Four different design options were evaluated for the connection from Fleetwood to Surrey Central station: Options A, B, B-96, and AB. The design options either pass through the Green Timbers urban forest or through Guildford. The segment between 104th Avenue and City Parkway to the Surrey Central station is common to all design options and is 3.5km long. Therefore, the focus of the evaluation was on the differences between these options on 152nd Street, Fraser Highway and 96th Avenue.



Option A runs along 152nd Street and Fraser Highway connecting Fleetwood to Surrey Metro Centre, and is a total length of 6.45 km long (2.95km & 3.5km along 104 Avenue). In Option A, the section along 104th Avenue is assumed to be part of a continuous service to Fleetwood and Langley Centre, whereas in Options B and B-96, the service from Guildford to Surrey Metro Centre is part of a separate route.

Option B operates along Fraser Highway and is slightly longer than Option A, at 8.25km. With the common section on 104 Avenue, only 4.75km of the route would be on Fraser Highway from Fleetwood to Surrey Metro Centre. Similarly, Option B-96, which uses 96th Avenue (instead of Fraser Highway) would be slightly longer again at 9.7km, 6.2km of which is the connection from Fleetwood to Surrey Metro Centre. One last option, which is denoted as AB, would connect to both Guildford and Surrey Metro Centre using 152nd Street and Fraser Highway, with service alternating between the two. This was assessed to determine if there was any ridership benefit in splitting service and going to both locations with every second bus from Langley.

The performance of these options against the evaluation accounts was as follows:

Financial Account

- Option B on Fraser Highway was assessed as having the lowest capital cost because it includes the least amount of new surface construction. Its design assumes shared lanes with priority operations along Fraser Highway through the Green Timbers urban forest. This short distance of new construction relative to all of the alternatives, results in it having the least potential cost.
- Option A was assessed as having the potentially lowest operating cost. Although the route from Langley to Surrey Central Station is longer than Options B and B-96, the common section on 104th Avenue is included in all of the options. The overall network being served is shortest for Option A (6.45 km versus 8.25 or 9.7 km) and requires the fewest vehicles to serve it.
- Neither option B nor B-96 offered any advantages to operating costs due to the length of the alignments being served. Option AB includes all of the routes and its operating costs would be the average of Options A and B.

Transportation Account

- Option B on Fraser Highway performed the best under the Transportation account based on the highest number of transit boardings along the BRT 1 system, including 2,100 boardings along the segment included in Option B. This proved to be the most attractive of the options both to local riders and along the rest of the routes because of its very competitive travel time from Langley to Surrey Central Station of 29 minutes.
- In contrast, the poorest performer in this account, Option A, had the lowest number of riders and the highest travel time between Langley and Surrey Central Station. The single advantage of Option A was the provision of more direct service from Langley to Guildford. But, the demand modelling demonstrated that from Langley to Guildford there was less demand than a direct route into Surrey Central instead.
- Option A was assessed as having the most significant impacts on non-transit users, with congestion and delays on 152nd Street having the greatest impact due to the lane reductions assumed in order to construct the alternative. These delays would spill over to some extent on the shorter segments of 152nd Street on the B96 option and would also be incurred on the AB option.
- Option B has the fewest local street impacts because the Green Timbers urban forest has relatively few streets running through it.
- Most of the other criteria performed similarly between the options with the exception of reliability. Option B had better reliability due to the queue jump operation through the Green Timbers urban forest, instead of a fully segregated running way along its entire alignment. This impact was included in the assessment of its travel time. Nevertheless, it had the highest ridership of these four options through this segment of the study area.

Environmental Account

- Three of the four options were assessed as having medium performance under the Environmental Account, with the combined option AB having the poorest performance due to its greater extent, which would produce more impacts during construction and an exposure to more locations in terms of noise and vibration, potential biodiversity impacts, water resources, and parks and public open spaces.

- Option A had the least potential for impacts against several of the environmental criteria including biodiversity, water resources, and parks and public open spaces; however, due to its lower ridership, it would not have as big of a benefit during the operating period in the reduction of air emissions from private automobiles relative to the benefits assessed for Option B.

Urban Development Account

- Three of the four options were assessed a high performance under Urban Development because they connect many of the most significant activity centres within the study area with high concentrations of population, employment and redevelopment capacity. Option AB was considered to have only a medium performance under these criteria, because it does have the greatest exposure to property requirements with it having the longest alignment out of the four options.

Economic Development Account

- Option B was assessed as being the best performer under Economic Development because it would have the least impacts on goods movement routes, with no reduction in lanes on Fraser Highway. Option AB was assessed as having the poorest performance because of its greater exposure to goods movement routes on Fraser Highway and on 152nd Street. The other two options were assessed as having medium pact on economic development.

Social/Community Account

- Three of the four options were assessed as having a medium impact on Social Community factors, when all criteria are taken into account. Option AB
- Options A and B-96 were assessed as having fairly modest benefits or neutral effects on community cohesion, due to all signals being retained (which permits pedestrians and cyclists to cross) but some intermediate streets being closed to left turns which makes it somewhat harder to navigate between neighbourhoods. Option B has the least effect on left turns and therefore a positive effect on cohesion. Option AB would perform the poorest because of its larger exposure to the community.
- All of the options would see a benefit to safety due to moving transit passengers from mixed traffic into segregated lanes. Option B does feature a mixed traffic section through Green Timbers, so its effect would be least.

Deliverability Account

- Under Deliverability, three of the four options were assessed as having a medium rating with the combined option of AB combining the challenges from both of those options and therefore being assessed the poorest. The biggest challenges on Option A are the construction on 152nd Street as well as the common challenge of constructing on 104th Avenue, whereas in Option B the greatest challenge would be construction on Fraser Highway within Green Timbers. While the public might anticipate some potential of biodiversity impacts within Green Timbers, the design of Option B is being developed to limit or eliminate those impacts by staying within the planned road cross-section of four lanes.

Option B (Fraser Highway) was the recommended assumption for the design option, because its overall cost and transportation benefits were the most favourable within the scope of this mini evaluation. The other options are not recommended at this time because they appear to have lower potential ridership and higher potential costs relative to Option B.

Exhibit 2C.1 - Mini-MAE for SRTAA Phase 2 Preliminary Design Options

Account/Criterion/ Measure	Langley Fraser Option	Langley Southern Option	Langley Northern Option
Description	Fraser Highway, from 196th to 203rd, including viaduct over RBRC and Langley Bypass	196th Street overpass (planned) and 56th Avenue to 203rd/Fraser Hwy	Willowbrook Drive, 62nd Avenue and 204th/203rd overpass
Length of connection(s) being compared	1.8 km	2.7 km	3.0 km
Number of Stations	2	2	2
Financial	Medium Cost	Least Cost	Medium Cost
Capital Cost Considerations	0.875 km of new BRT viaduct + 0.925 km of surface construction ~ $90-95 million	2.00 km of surface construction + 0.70 of sharing a lane on planned bridge $65-70 million	2.35 km of surface construction + 0.65 of sharing a lane on existing bridge $75-80 million
Operating Cost Considerations	Fastest journey time reduces fleet requirement by 1 bus both peak and off-peak Savings of nearly $1 million per year O&M relative to other options	Additional round trip time requires one more bus to achieve same headway as Fraser route	Additional round trip time requires one more bus to achieve same headway as Fraser route
Life Cycle NPV	$90-95 million	$75-80 million	$85-90 million
Transportation	Best	Medium	Medium
Ridership Effects	Most attractive to riders because of directness, speed	Less attractive (initially) But potential to add station on 56th and increase local ridership	Least attractive (initially) But potential to add station on 62nd and increase ridership
Journey Times on Transit (BRT 1)	29 minutes Langley to Surrey Central (5 min in Langley)	31 minutes Langley to Surrey Central (7 min in Langley)	32 minutes Langley to Surrey Central (8 min in Langley)
Travel Time Effects for Non-Transit	Capacity reduction on least busy part of Fraser Highway. Because of viaduct, only 2 busy intersections crossed	Capacity reduction on 196th, 56th Several moderately busy intersections Local neighbourhood access reduced	Capacity reduction on 196th/ Willowbrook/ 62nd and sharing lanes on 204th Several busy intersections
Street Closings and Turn Restrictions	Least restrictions – primarily around 196A	Local street accesses off 196th, 56th except at signals	Some accesses to malls, commercial properties limited to right-in, right-out
Future Population, Employment in Station Catchments	12,700 (2041) Same stations assumed	12,700 (2041) Same stations assumed	12,700 (2041) Same stations assumed
Reliability (Segregation and Transit Priority)	Segregated running way and full priority	Segregated running way and full priority, except mixed operation on 196th Street bridge over Roberts Bank	Segregated running way and full priority, except mixed operation on 204th Street bridge over Roberts Bank
Capacity Optimization and peak v/c	Not an issue for these options	Not an issue for these options	Not an issue for these options
Integration with Active Modes – Major Differentiators	Neutral with same stations.	Neutral with same stations	Neutral with same stations
Environmental	Medium	Medium	Medium
Air Emissions – Key Factors	Highest during construction because of viaduct, lowest during operations	Lowest during construction, medium during operations	Medium during construction, highest during operations
Noise/Vibration - Potential	Businesses along Fraser Hwy (some fairly distant from street) Noise on elevated structure	Businesses along 196th St, homes backing onto 56th Avenue (some distant from street) Noise of operation over 196th Street Bridge	Businesses along Willowbrook, 62nd, 204th (some fairly distant from street) Noise of operation over 204th Street Bridge
Biodiversity	Neutral	Neutral	Neutral
Water Resources	Neutral	Neutral	Neutral
Parks, Public Open Spaces	Neutral	Neutral	Neutral
Agricultural Resources	Not applicable	Not applicable	Not applicable
Urban Development	Best	Medium	Medium
Activity Centres	Same centres	Same centres, but marginally less accessible to Willowbrook Mall	Same centres, but potentially best orientation to Willowbrook Mall
Urban Design Factors	Potential to integrate with public realm concepts on Fraser Highway and increase pedestrian facilities	Some reduction in boulevard space along 56th	Potential need for widening of 62nd may reduce boulevard space
Land Use Potential – Qualitative Comparison	Same station areas assumed	Same station areas assumed	Same station areas assumed
Property Requirements	Limited to station areas and spot widening at surface intersections	Limited to station areas and spot widening at surface intersections	Station areas, spot widening at surface intersections, and potentially 62nd Avenue
Economic Development	Best	Medium	Poorest
Goods Movement Routes	Minor impact on less busy section of Fraser Highway	Lane capacity shared on 196th Street	Reduction in capacity along Willowbrook Drive
Changes to Industrial Access	Accesses mostly preserved by viaduct over RBRC	Some reduction along 196th Street	Possible reductions along 62nd Avenue
Social/Community	Medium	Poorest	Medium
Community Cohesion - Relative	Least impact on ability to cross route; potential improvement near Langley Exchange area	Reductions in minor street crossing opportunities along 56th Avenue (residential on both sides), and to a lesser	Reductions in crossing opportunities around Willowbrook Mall (but this is an auto-oriented segment to begin with)

Exhibit 2C.1 - Mini-MAE for SRTAA Phase 2 Preliminary Design Options

Account/Criterion/ Measure	Langley Fraser Option	Langley Southern Option	Langley Northern Option
Description	Fraser Highway, from 196th to 203rd, including viaduct over RBRC and Langley Bypass	196th Street overpass (planned) and 56th Avenue to 203rd/Fraser Hwy	Willowbrook Drive, 62nd Avenue and 204th/203rd overpass
		extent on 196th Street	
Visual Changes	New viaduct over RBRC (but area is industrial)	Minimal (bridge already planned)	Minimal (bridge already exists)
Deliverability	Medium	Medium	Medium
Constructability – Design/ Construction Challenges	Construction of viaduct over railway	Lane conversion on existing streets, planned bridge	Lane conversion on existing streets and bridge
Environmental Risks	None identified at this level of detail	None identified at this level of detail	None identified at this level of detail
Acceptability – Potential Differentiators for Public	Most similar BRT option to structures already required for RRT, LRT	May be some community resistance to loss of road space, crossing locations	May be some resistance to reduction in mall accesses, constrained road (62nd)
Design Option Assumption for Purpose of Phase 2 Evaluation	Recommended Assumption. Factors where this option is not the most promising (costs, visual impact) will be fairly neutral against LRT, RRT	Lower capital cost and potential to modify design assumptions may make this option more promising (either later in Phase 2 or Phase 3)	Least promising at this stage. May have some future merit if transit exchange or redevelopment of land near mall was planned

Exhibit 2C.1 - Mini-MAE for SRTAA Phase 2 Preliminary Design Options

Account/Criterion/ Measure	Option C (152nd)	Option D (KGB)
Description	KGB/Hwy 10 to KGB/152nd Street, via Hwy 10 then 152nd Street	KGB/Hwy 10 to KGB/152nd Street, via King George Boulevard
Length of connection(s) being compared	8.20 km	7.20 km
Number of Stations	3	3
Financial	Medium	Medium
Capital Cost Considerations	3 bridges to widen/replace (total length ~0.25 km) + 0.65 km lane conversion from planned bridge + 7.3 km surface construction Initial cost lower per kilometre, but similar overall capital cost Anticipated mitigation of traffic impacts by widening 152nd Street would make this more expensive	4 bridges to widen/replace (total length ~0.3 km) + 0.40 km lane conversion from existing bridge + 6.5 km surface construction Initial assumption of widening to retain lanes and longer bridge structures means higher cost per km, but similar cost overall
Operating Cost Considerations	Operating cost will be higher as headways decrease post-2021, due to one extra bus required to serve the longer route and resulting longer round trip time	Operating cost will be lower as headways decrease post-2021, due to one less bus required to serve round trip time Savings of nearly $1 million per year O&M relative to Option C.
Transportation	Medium	Best
Transit Boardings along route – AM Peak (preliminary estimates)	5,300 of which 750 board south of Newton Marginally more local riders, but somewhat fewer riders from rest of route coming into the area	5,350 of which 700 board south of Newton Serves South Surrey P& R, and BRT alignment (on KGB) can also be used by Highway 99 Rapid bus
Journey Times on Transit (BRT 1)	38 minutes (White Rock Centre to Surrey Central Station) 13 minutes from Hwy 10/KGB to KGB/152	36 minutes (White Rock Centre to Surrey Central Station) 11 minutes from Hwy 10/KGB to KGB/152
Travel Time Effects for Non-Transit	Greater diversion and slowing of traffic due to initial assumption of lane reduction on 152nd Street (average speed slows from 60-70 kph to 50-60)	Less impact, because number of lanes is easier to retain with reallocation/rebuilding along KGB
Street Closings and Turn Restrictions	Relatively low number because of rural segment, but larger number of local streets (than Option D) to be converted to right-in/right-out	Relatively low number because of rural segment
Future Population, Employment in Station Catchments	7,200 within 400 m (2041) Difference is reflected in marginally higher AM peak boardings	6,000 within 400 m (2041) South Surrey P& R has little adjacent development
Reliability (Segregation and Transit Priority)	Segregated running way and full priority, except at bridge over RBRC. Probable need to mitigate agricultural access issues could compromise segregated ROW.	Segregated running way and full priority, except at bridge over RBRC
Capacity Optimization	Loading nearly the same	Loading nearly the same
Integration with Active Modes – Major Differentiators	Multi-use pathway parallel to parts of 152nd in Rosemary Heights	Some trails and parks off King George Boulevard
Environmental	Poor	Poor
Air Emissions – Key Factors	Similar amount of construction impact and transportation emissions benefit	Similar amount of construction impact and transportation emissions benefit
Noise/Vibration - Potential	Relatively low with mix of rural and urban; more residences along this route	Relatively low with mix of rural and urban; more businesses along this route
Biodiversity	Rural sections and river areas	Rural sections and river areas More proximate to Mud Bay, may be more bird habitat in vicinity; Heritage trees along west side of King George Boulevard.
Water Resources	Two significant river crossings (same for both options)	Two significant river crossings (same for both options)
Parks, Public Open Spaces	Similar types of potential impact, but no major parks along option	Similar types of potential impact, but no major parks along option
Agricultural Resources	Greater potential for partial takings through ALR. Right of way is narrower. Any further widening would make these impacts even greater along 152nd	Some potential for small partial takings through ALR
Urban Development	Medium	Medium
Activity Centres	Includes activity nodes at 152/Hwy 10, and 152/32 Ave	Includes activity node at KGB/32 and South Surrey P&R
Urban Design Factors	Neutral. Some buffer areas between street and residential may be made narrower. Sidewalks, trails still accommodated fairly well in urban sections. May be constrained on short section of Hwy 10 with retaining wall.	Neutral. Some buffer areas between street and residential may be made narrower. Sidewalks, trails still accommodated fairly well in urban sections. May be constrained on short section of KGB with retaining wall.
Land Use Potential – Qualitative Comparison	Theoretically more long-term potential because of 152/Hwy 10, but has already built out	Limited potential at South Surrey P&R because of Highway 99, Nicomekl River
Property Requirements	Likely to be higher if 152 Street requires widening to mitigate traffic impacts; property impact around 152/KGB common to both options	Minimal requirements beyond ROW except property impact around 152/KGB common to both options

Exhibit 2C.1 - Mini-MAE for SRTAA Phase 2 Preliminary Design Options

Account/Criterion/ Measure	Option C (152nd)	Option D (KGB)
Description	KGB/Hwy 10 to KGB/152nd Street, via Hwy 10 then 152nd Street	KGB/Hwy 10 to KGB/152nd Street, via King George Boulevard
Economic Development	Poor	Medium
Goods Movement Routes	Initial assumption is lane reduction on goods movement route	Major goods movement route, but lanes are retained
Changes to Industrial or Agricultural Access	Safety barrier for BRT likely to impede farm accesses	Safety barrier for BRT likely to impede farm accesses, but fewer locations than on 152nd Street
Social/Community	Medium	Medium
Community Cohesion - Relative	Route is already a high-speed arterial, so changes are minimal	Route is already a high-speed arterial, so changes are minimal
Visual Changes	Minimal	Minimal
Deliverability	Medium	Medium
Constructability – Design/ Construction Challenges	Construction along 152nd Street – either lane conversion (initial assumption) or widening. Complicated by presence of several bridges (RBRC, Serpentine, Nicomekl, Hwy 99)	Construction along KGB – additional widening or lane conversion. Complicated by presence of several bridges (RBRC, Serpentine, Nicomekl, Hwy 99)
Environmental Risks	ALR and bridge crossing areas	ALR (less than Option C), proximity to Mud Bay affecting bridges, plus potential concerns over heritage trees
Acceptability – Potential Differentiators for Public	Greatest potential for resistance will be initial assumption of taking lane from 152 Street.	May be local concerns expressed over habitat areas, trees along KGB
Design Option Assumption for Purpose of Phase 2 Evaluation	Initial assumptions have same capital cost, but higher operating cost. Likely effect of traffic impacts would be to refine design and widen street, making potential costs, impacts of this route higher.	Recommended as assumed alignment.

Exhibit 2C.1 - Mini-MAE for SRTAA Phase 2 Preliminary Design Options

Account/Criterion/ Measure	Option A (152 St)	Option B (Fraser Hwy)	Option B-96 (96 Ave)	Option AB (152 St & Fraser Hwy)
Description	Fleetwood to Surrey Metro Centre via 152nd Street and 104th Avenue, through Guildford	Fleetwood to Surrey Metro Centre via Fraser Highway and King George Blvd (Guildford to SC connected by 104th)	Fleetwood to Surrey Metro Centre via 96th Ave and King George Blvd (Guildford to SC connected by 104th)	Both connections served, via 152nd/104th and Fraser Highway
Length of connection(s) being compared	6.45 km SMC-GF-FW (2.95 FW-GF plus 3.5 km GF-SMC)	8.25 km (4.75 km FW-SMC plus 3.5 km GF-SMC)	9.70 km (6.20 km FW-SMC plus 3.5 km GF-SMC)	11.20 km (6.45 + 4.75)
Number of Stations	8 (including SCS and KGS)	8 (including KGS and SCS)	8 (including KGS and SCS)	9 (including KGS and SCS)
Financial	Medium Cost	Least Cost	Higher Cost	Higher Cost
Capital Cost Considerations (4.5 km of construction on 104th and City Parkway/ KGB common to all options)	Common section + 2.95 km of new surface construction on 152nd Street	Common section + 1.95 km of new surface construction, and 1.85 km of shared/priority operation on Fraser Highway	Common section + 4.8 km of new construction on 96th Avenue and 152nd Street	Common section + 4.9 km of new construction on Fraser Highway and 152nd Street; plus 1.85 km of shared/priority operation
Operating Cost Considerations	Potentially lowest operating cost due to shortest network (section on 152nd Street takes 6 minutes versus 9 minutes on Fraser Highway, 104th segment is common to all network options)	Moderate operating cost	Highest operating cost (1-2 more buses needed than Option B)	Moderate operating cost
Transportation	Worse	Best	Medium	Medium
Transit Boardings along route – AM Peak (preliminary estimates)	4,200 of which 1,700 along Option A segment Least attractive to riders, especially rest of route (due to travel times)	5,300 of which 2,100 along Option B Most attractive to riders locally and along rest of route	5,000 of which 2,000 along Option B-96	4,700 of which 1,900 along Options A+B
Journey Times on Transit (BRT 1) Guildford-SCS 9 min, common to all	Langley – Surrey Central Station: 35 minutes Langley-Guildford service more direct (but less demand for this)	Langley – Surrey Central Station: 29 minutes	Langley – Surrey Central Station: 32 minutes	Lowest travel times from Options A and B (but some longer wait times because of split routes)
Travel Time Effects for Non-Transit (impacts to 104 Avenue common to all options)	Impacts on 104th + Congestion and delays on 152nd Street due to lane reduction (average speed slows from 35-50 kph to 25-40)	Impacts on 104th + Slight delay to Fraser Highway GP traffic to provide transit priority (average speed slows from 45-60 kph to 40-55)	Impacts on 104th + Congestion and delays on part of 152nd Street due to lane reduction, minor impacts on 96th Ave.	Impacts on 104th + Congestion on 152nd, delays on Fraser highway
Street Closings and Turn Restrictions	Local streets become right-on/ right-out along 152nd	Local street impacts in isolated parts of Fraser highway (fewest local streets)	Local streets become right-on/ right-out along part of 152nd and on 96th	Same as A and B
Future Population and Employment in Station Catchments (48,000 on common segments from Guildford to King George Station)	Common segment + 6,900	Common segment + 8,200	Common segment + 12,700 (station at 96th/SMH overlaps most of 96th/KGB catchment on north-south route)	Common segment + 11,900
Reliability (Segregation and Transit Priority)	Segregated running way and full priority	Segregated running way and full priority, except mixed operation with queue jump from 140th to 148th	Segregated running way and full priority	Segregated running way and full priority, except mixed operation with queue jump on Fraser Highway from 140th to 148th
Capacity Optimization	Forces all riders through single peak load point	Separate routes to Guildford and Langley provide more flexibility	Separate routes to Guildford and Langley provide more flexibility	Separate routes to Guildford and Langley provide more flexibility
Integration with Active Modes – Major Differentiators	Crossed by off-street trail south of 96th Street	Runs through Green Timbers (GTUF) and connects to Surrey Parkway	Crossed by off-street trail south of 96th Street, runs through part of Urban Forest	Runs through GTUF and connects to Surrey Parkway
Environmental	Medium	Medium	Medium	Worse
Air Emissions – Key Factors	Second least during construction, but highest during operations because of least ridership	Least during construction, least during operations because of greater ridership	Medium during construction, second lowest during operations	Highest during construction, medium during operations
Noise/Vibration – Potential (Homes, businesses on 104th Avenue common to all options)	Homes and businesses along both parts of the route: 152nd and 104th	Potentially sensitive site at Surrey Outpatient at FH/140th Lowest number of homes exposed	Homes and businesses along 152nd (less than Option A) and 104th All networks include exposure to Surrey Memorial along KGB; this option increases that exposure along 96th	Exposure to more locations but at lower frequency
Biodiversity	Least potential for impacts	Potential disruption to row of trees in Green Timbers Forest (but will be limited)	Potential disruption to row of trees in Green Timbers Forest. Heritage value on 96th higher than FH. (If existing median can be converted for BRT, then tree impacts should be limited)	Potential disruption to row of trees in Green Timbers Forest (but will be limited)

Exhibit 2C.1 - Mini-MAE for SRTAA Phase 2 Preliminary Design Options

Account/Criterion/ Measure	Option A (152 St)	Option B (Fraser Hwy)	Option B-96 (96 Ave)	Option AB (152 St & Fraser Hwy)
Description	Fleetwood to Surrey Metro Centre via 152nd Street and 104th Avenue, through Guildford	Fleetwood to Surrey Metro Centre via Fraser Highway and King George Blvd (Guildford to SC connected by 104th)	Fleetwood to Surrey Metro Centre via 96th Ave and King George Blvd (Guildford to SC connected by 104th)	Both connections served, via 152nd/104th and Fraser Highway
Water Resources	Least potential for impacts	Additional creek crossing between Whalley Blvd, 140th	Additional creek crossing between Whalley Blvd, 140th	Additional creek crossing between Whalley Blvd, 140th
Parks, Public Open Spaces	Least potential for impacts	Does not require ROW from park, but could impact trees in ROW	Unlikely to require ROW from park	Does not require ROW from park, but could impact trees in ROW
Agricultural Resources	Not applicable	Not applicable	Not applicable	Not applicable
Urban Development	Good	Good	Good	Medium
Activity Centres	Fleetwood, Guildford Mall, Surrey City Centre	Fleetwood, Guildford Mall, Surrey City Centre Surrey Memorial Out Patient Facility & RCMP E Division	Fleetwood, Guildford Mall, Surrey City Centre Surrey Memorial Hospital (on this specific route and part of all networks)	Fleetwood, Guildford Mall, Surrey City Centre Surrey Memorial Out Patient Facility
Urban Design Factors (Effects on 104th Avenue common to all)	Sidewalks maintained on 152	Sidewalks maintained where present (none within Green Timbers, and limited room to add new)	Sidewalks maintained where present.	Sidewalks maintained where present. Limited room to add new sidewalks though Green Timbers
Land Use Potential – Qualitative Comparison	Most stations common to all options, except 152/96 – appears to be fairly limited potential	Most stations common to all options, except FH/140 – somewhat constrained by Green Timbers	Most stations common to all options	Most stations common to all options
Property Requirements	Limited, but potential need to widen 152nd Street to address traffic could create greatest need	Limited, some requirements along FH near 152nd Street	Limited, but potential need to widen 152nd Street (south of ~95th) to address traffic could create moderate need; some spot widening along 96th	Limited, some requirements along FH near 152nd Street, and potential for significant takes on 152nd as noted under Option A
Economic Development	Medium	Best	Medium	Poorest
Goods Movement Routes	Lanes reduced on 152nd Street	Lane sharing on Fraser Highway through Green Timbers	Lanes reduced on portion of 152nd Street south of ~95th	Lanes reduced on 152nd Street; and Lane sharing on Fraser Highway through Green Timbers
Changes to Industrial or Agricultural Access	Neutral	Neutral	Neutral	Neutral
Social/Community	Medium	Medium	Medium	Poorest
Community Cohesion - Relative	Pedestrian, cyclist improvements at signalized crossings Some local vehicle access/ crossing location reductions at minor (unsignalized) streets along 152nd	Pedestrian, cyclist improvements at signalized crossings Some local access reductions/crossings lost along FH, but only outside Green Timbers	Pedestrian, cyclist improvements at signalized crossings Some local access reductions along 96th, 152nd	Pedestrian, cyclist improvements at signalized crossings Same local access reductions on 152nd , FH (most exposure)
Safety	Segregated except at intersections, so better than regular bus	Segregated except at intersections, and mixed operation through Green Timb.	Segregated except at intersections, so better than regular bus	Segregated except at intersections, so better than regular bus
Visual Changes	BRT lanes in street	BRT or shared lanes in street	BRT lanes in street	BRT or shared lanes in street, most exposure
Deliverability	Medium	Medium	Medium	Poorest
Constructability – Design/ Construction Challenges (104th Avenue is common to all)	Construction on 152nd Street	Construction on Fraser highway, especially within Green Timbers	Construction on 96th near hospital, within Green Timbers, and also construction along 152nd Street	Challenges of both Options A and B
Environmental Risks	No major items known at this time	Biodiversity impacts within Green Timbers (but design is trying to limit)	Biodiversity impacts within Green Timbers (but design is trying to limit)	Risks of A and B
Acceptability – Potential Differentiators for Public	Traffic impacts on 152nd Street	Resistance to widening of Fraser Highway (although baseline is a 4-lane road)	Resistance to construction through Green Timbers	Potential resistance to issues caused by A and B
Design Option Assumption for Purpose of Phase 2Evaluation	Not recommended at this time because of lower ridership, potential for costs and impacts on 152nd to escalate.	Recommended Assumption. Overall costs and transportation benefits look most promising initially.	Can be a backup design option to B.	Not recommended. Higher costs and impacts not justified by medium ridership.

APPENDIX 2D – REFINEMENT OF ALTERNATIVES

Overview

This appendix describes the refinement and finalization of the Phase 2 rapid transit alternative designs. The initial stages of Phase 2 involved the development of initial designs and a preliminary evaluation of the transit alternatives. These were presented for public comment and project partner review in spring 2011, and based on the feedback, the alternatives were modified and new alternatives generated. The end result was the set of thirteen alternatives documented in the main evaluation report.

This appendix provides a summary of the design refinement inputs, process, and the resulting changes to the alternatives. The intent of the design refinements was to improve the performance of the alternatives and make use of the latest inputs to the evaluation. This appendix includes the following sections:

- Design Refinement and Evaluation Update Process
- Design Refinement Inputs;
- Recommendations from Design Refinement Testing; and
- Summary: Changes to Alternatives.

1. DESIGN REFINEMENT AND EVALUATION UPDATE PROCESS

During winter and spring 2011, initial conceptual designs and a preliminary evaluation of the ten initial Phase 2 alternatives (that had advanced from Phase 1) were prepared and reviewed with project partners. These preliminary results provided an initial foundation for the current set of alternatives and the evaluation documented in the evaluation report.

The public consultation process for the Phase 2 initial designs and preliminary evaluation was conducted in May and June, 2011. Members of the public were asked to comment on the initial design assumptions and the completeness of the preliminary evaluation. There was broad agreement with most of the initial design assumptions and the scope of the evaluation. Comments and questionnaire responses from the public workshops and website suggested design modifications such as station locations, service coverage, and specific alignment assumptions.

Based on review of the preliminary evaluation results and key outcomes from the Phase 2 public consultation program, the project team and partners identified potential changes to the design and operating assumptions of the rapid transit alternatives. The purpose was to identify design refinements that could improve the performance of the alternatives. (Refer to Section 2 of this appendix for an outline of the input from the public and project partners.)

The design refinement analyses (carried out in summer 2011) tested operations and design refinements with the objectives of increasing ridership, matching service capacity more closely with projected peak loads, reducing costs and impacts, and/or improving the cost-effectiveness of the alternatives. The technical analyses included demand model tests of the key design and service modifications, including changes to headways, stations, and extent. This was informed by initial technical work, including preparation of model inputs (travel times, stations, and service frequencies), sketch planning of proposed design modifications (e.g. 104th Avenue east towards Highway 1), and order of magnitude estimates of the cost increases/decreases of each change. (Section 3 of this appendix describes the technical recommendations.)

Following review with the project partners, the conceptual designs for the refinements to the alternatives were prepared. Land use, transportation, environmental and other data were compiled for new segments in sufficient detail to support the MAE.

The Multiple Account Evaluation was updated for all thirteen alternatives. This was to account for design refinements, 'new' alternatives, and refinements to the Business As Usual (BAU) road network and land use assumptions. The Phase 2 Evaluation Report documents the updated MAE and the sensitivity tests on the evaluation.

2. DESIGN REFINEMENT INPUTS

A series of potential design refinements was investigated based on input from members of the public, as well as the project team and partners, informed by review of the preliminary evaluation results.

2.1 INPUT FROM THE PUBLIC

The public consultation workshops and online materials provided opportunity to gather comments on the design assumptions and preliminary evaluation. The comments received during the workshop sessions and on the questionnaires were reviewed to determine whether any potential changes to the initial alternatives should be investigated. The key questions asked of the public included:

- *Should we add, move or remove any of the station locations?*
- *Should we change the alignment for all or part of the alternatives?*
- *Please indicate your priorities for how road space should be shared among uses.*
- *Please indicate your level of agreement with giving rapid transit priority at intersections.*
- *Please indicate your level of agreement with the results of the preliminary evaluation.*

The following high-level observations were made from the public comments. (Details of the public consultation process and results are included in *Surrey Rapid Transit Study - Report on June 2011 Public Consultation.*)

Station Locations

Most respondents (63%) agreed with or provided no comment on the initial set of station locations. A total of 37% suggested changes to stations (22% wanted to add a station; 6% suggested removing one; and 9% suggested changing locations).

No specific suggestions regarding station locations were shared by more than a few respondents. By corridor, the suggestions were distributed as follows:

- 20 comments on King George Blvd/152nd;
- 16 comments on Fraser Hwy; and
- 13 comments on 104th Ave.

Alignment

Most respondents (67%) agreed with or provided no comment on the initial alignment assumptions.

No specific suggestions regarding alignment were shared by more than a few respondents. By corridor, the suggestions were distributed as follows:

- 18 comments on King George Blvd/152nd;
- 9 comments on Fraser Hwy;
- 13 comments on 104th Ave;
- 42 comments on other routes/corridors (that were outside the study area or already evaluated earlier in the study, in Phase 1); and

- 30 comments and suggestions were specific to horizontal (position within the street) & vertical alignment (street level, elevated, or below grade) assumptions.

Road Space Allocation (Alignment Design)

In descending order, these were the priorities placed by the public on street elements:

a. Rapid transit platforms
b. Traffic lanes
c. Sidewalks
d. Bike lanes
e. Left turn bays
f. Boulevard plantings.

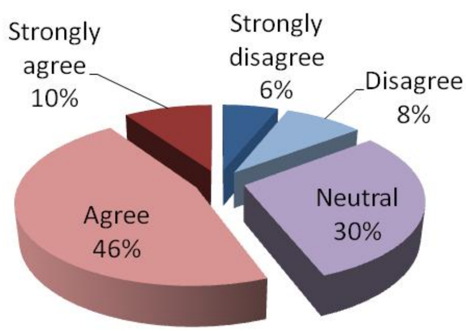
There were 30 comments on various topics regarding the road space assumptions, and most respondents did not comment on the assumptions made in the initial designs.

Priority at Intersections

Most respondents (67%) agreed or strongly agreed with the assumptions of physical and traffic signal priority for rapid transit. There were 37 specific comments on various topics regarding transit priority, and given the high level of agreement, most respondents did not comment on the initial design assumptions.

Preliminary Evaluation

More than half of the respondents (56%) agreed or strongly agreed with the preliminary evaluation scores and technical findings, while a smaller number (14%) disagreed with certain aspects:



There was a wide range of individual comments with very few focusing on any particular evaluation issues. Where there was disagreement, it often related to results that would change if the design assumptions were modified, or with how the evaluation was rated qualitatively.

The comments from the public were taken into consideration, along with the suggestions of the project team and partners, when investigating possible design refinement in July and August 2011, and carrying out sensitivity tests in October/November 2011.

2.2 INPUT FROM THE PROJECT TEAM AND PARTNERS

The project team and partners developed a list of potential design refinements for the rapid transit alternatives based on the public consultation program, and on the results of the preliminary analyses. In broad terms, suggestions that would affect the rapid transit alternatives design or operations included the following:

Station Locations

- Moving certain stations in each of the main corridors;
- Reducing or increasing the number of stations;
- Considering park and ride lots;

Alignment

- Creating new alternatives with LRT on Fraser Highway, with BRT on the other corridors;
- Extending the alignment on 104th Avenue towards Highway 1;
- Reconsidering centre running versus side running (to be revisited in Phase 3).

Sharing of Road Space

- Consider the merits of stopping King George Boulevard service at Highway 10 and/or using shared instead of dedicated lanes south of Highway 10;

General Operating Assumptions

- Increasing BRT frequency to address passenger demands;
- Modifying LRT and RRT frequency to 'right-size' the system.

3. RECOMMENDATIONS FROM DESIGN REFINEMENT TESTING

This section documents the agreed recommendations regarding the optimization of rapid transit alternatives for the SRTAA, based on analysis of a series of potential design refinements. The design refinement analyses (summer 2011) tested changes to the operations and design of the rapid transit alternatives, with the objective of increasing ridership, matching service capacity more closely to projected peak loads, and/or improving the cost-effectiveness of the alternatives.

3.1 DESIGN REFINEMENT TEST RESULTS

Design refinement testing was carried out – for the 2041 horizon year -- on modified rapid transit operating assumptions and service and capacity optimization options. **Exhibit 2D.1** identifies the individual design refinement tests carried out, and which ones resulted in recommended modifications to the alternatives.

Exhibit 2D.1 - Summary of Design Refinement Tests

Topic		ID #	Test	Alternatives Used	Results	Recommended?
1	**Modified Operating Assumptions (for Alternatives)**					
1.1	Service and Capacity Optimization	9A	RRT every 4.6 min beyond King George	RRT1, RRT2, RRT3	Ridership/Travel Time Savings Drop; Costs Decrease; Improved V/C	Yes - on RRT 1 No - on RRT 2, RRT 3
		9B	BRT more frequent (1.5 minutes without TSP)	BRT1	Ridership Increase; Large Cost Increase; V/C improves on Fraser	No
			BRT more frequent (2 minutes)	BRT1, LRT2	Ridership Increase; Cost Increase; V/C improves	Yes - on BRT elements except So. Surrey
		9C	King George / 104th – LRT every 7.5 min for 2041	LRT2	Ridership Decrease; Cost Decrease; V/C worse	No
		9D	BRT - Split service south of Hwy 10, every 2nd bus continues (e.g. 3 min to north/6 min to south)	BRT1, LRT2	Ridership Decrease; Cost Decrease	No - See 11B instead
1.2	Service Refinements	10A	BRT & LRT - Extend to Hwy 10 (on KGB)	BRT2, LRT3	Ridership Increase; Large Cost Increase	No - but can reconsider in Phase 3
		10B	BRT & LRT - Extend toward Hwy 1 (on 104th)	BRT2, LRT3	Ridership/Travel Time Savings Increase; Cost Increase	Yes
		10C	BRT – Interline with Hwy 1 Rapid Bus routes	BRT1	Ridership Increase; Small Cost Increase	Yes - any BRT routes on 104th
1.3	Infrastructure Refinements	11A	BRT White Rock to Guildford & LRT Surrey Central to Langley Centre	New "LRT 5"	Relative to LRT 2, has similar costs and ridership; better V/C	Yes
		11B	BRT - Provide service to White Rock via shared running	BRT1	Small ridership decrease; large cost decrease; environmental, property impacts reduced	Yes
2	**Modified Design Assumptions**					
2.1	Station Locations	14A	Modified Base – relocate stops (remove 104/148, shift KGB/80 to 76)	BRT1, LRT2, LRT5	Ridership decrease; cost decrease. Move from 80th to 76th: riders increase	Partly - move station from KGB/80 to 76; retain station at 104/148
		14C	Additional stations (KGB/76 and FH/188)	BRT1, LRT2	Small ridership decrease; small cost increase	Not FH/188 - but can reconsider in Phase 3
		14D	Reduced Stations for RRT (consolidate Clayton stops to 188th instead of 184th, 192nd)	RRT1	Ridership increase; cost decrease.	Yes, but defer until Phase 3
2.2	Park and Ride	15A/B	At 104th and 156, at KGB and Hwy 10 (test extensions with and without P&R, see 10A/B)	BRT2	Addition of park and ride increases ridership; increases costs	No P&R assumed in Phase 2, but could reconsider in Phase 3 (esp. 104/156 if terminus)

3.2 ADDITIONAL ALTERNATIVES

Three additional alternatives were generated for the final Phase 2 evaluation, in light of the forecast demand in the different study corridors. Fraser Highway emerged as the highest demand corridor in the future, and BAU service levels had proven to be insufficient to meet demand on King George Blvd. Therefore, alternatives that combined higher capacity on Fraser Highway with moderate capacity on King George Blvd were identified for the final evaluation.

Exhibits 2D.2 through 2D.4 illustrate the three newly defined alternatives, LRT 5A, LRT 5B and RRT 1A. These were generated by combining elements from the other alternatives:

- LRT 5A includes LRT on Fraser Highway and into Surrey Central Station, with BRT on King George Blvd and 104th. LRT 5A (and LRT 5B) combine the BRT elements from BRT 1 that met demand on King George Blvd, with higher-capacity LRT on Fraser Highway. Other BRT and LRT alternatives already included LRT on King George Blvd and BRT on Fraser Highway.

- LRT 5B has LRT on 104th Avenue as well as on Fraser Highway, and has BRT between Surrey Central Station and White Rock.

- RRT 1A has RRT extended along Fraser Highway, plus BRT on King George Blvd and 104 Avenue. RRT 1A includes the RRT on Fraser Highway from RRT 1, which was performing well on Fraser Highway but lacked service on King George Blvd, and therefore would not meet future demand. RRT 1A assumes exactly the same BRT and rapid bus on King George Blvd and 104 Avenue included in BRT 1 (and LRT 5A.)

Exhibit 2D.2 – New Alternative – LRT 5A

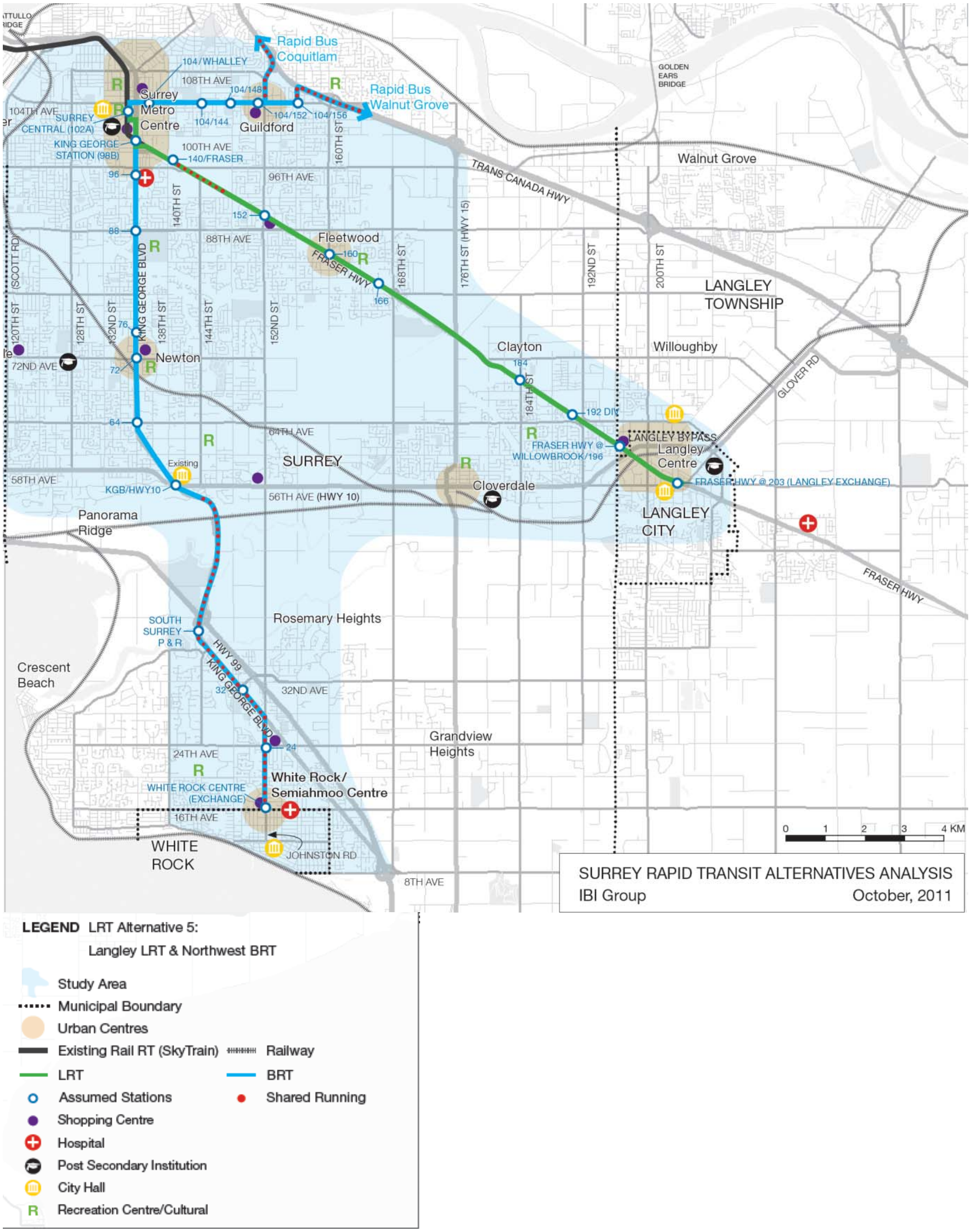


Exhibit 2D.3 – New Alternative – LRT 5B

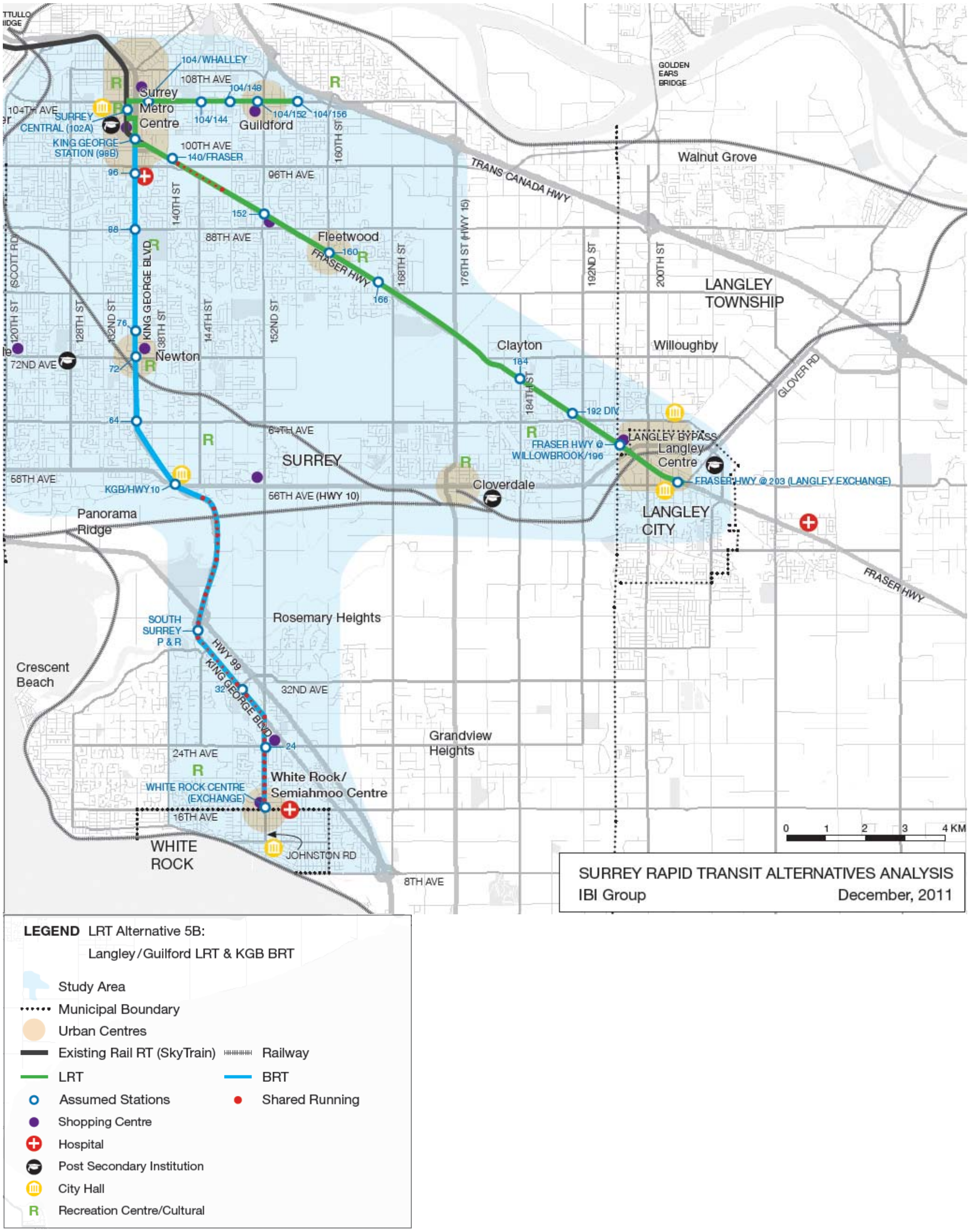
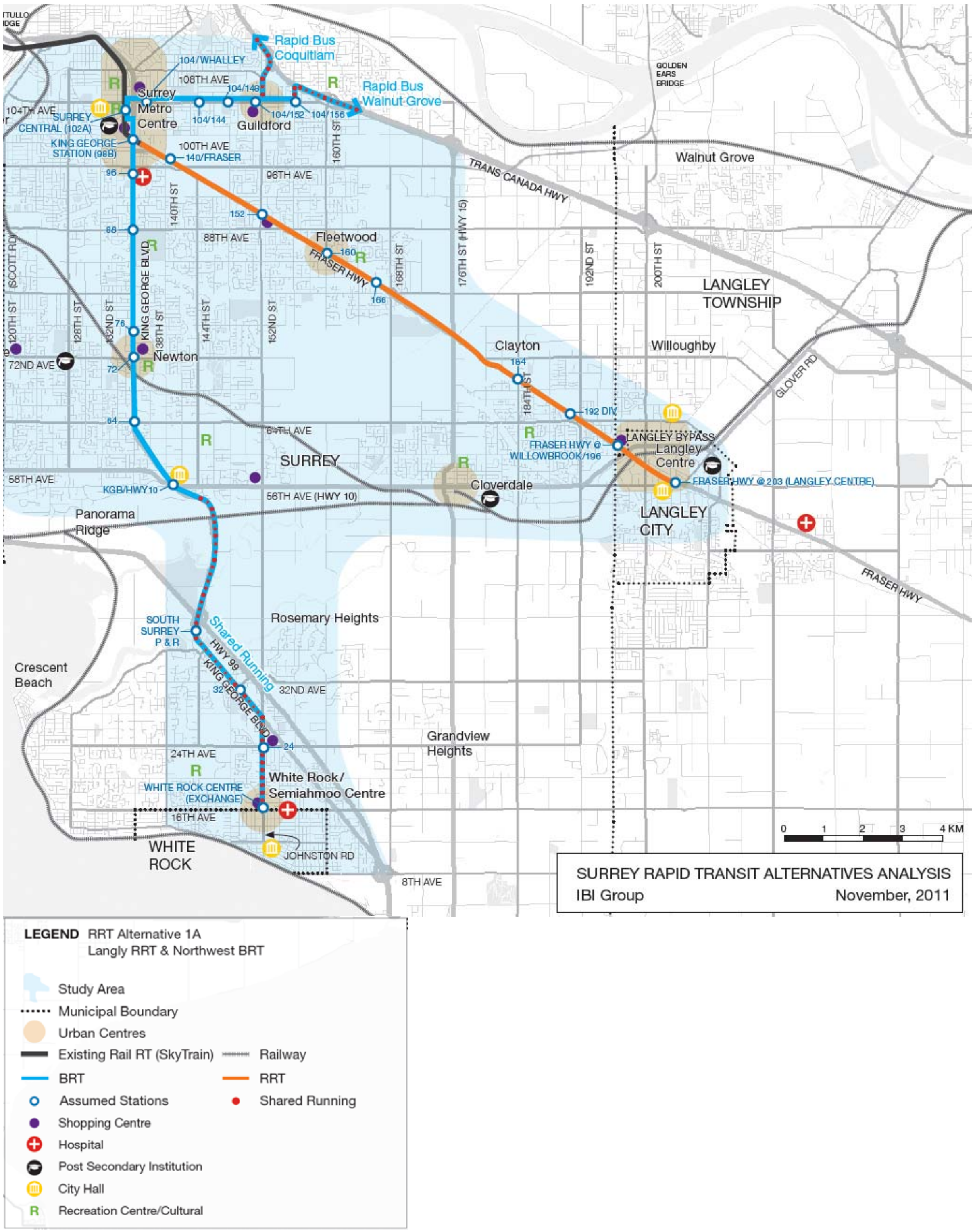


Exhibit 2D.4 – New Alternative – RRT 1A



4. SUMMARY: REFINED SET OF ALTERNATIVES

For reference, **Exhibit 2D.5** lists the individual alternatives and identifies the design and operating modifications that were recommended by the team and agreed with the project partners. This provides a broad summary of the proposed changes and new alternatives.

Exhibit 2D.6 is a map of the design refinements applied to the alternatives, illustrated using BRT 1. These modifications included:

- Shared running starting just south of Highway 10 (instead of dedicated lanes). This applies to each alternative with BRT south of Newton;
- Moving a station from King George Blvd/80th to 76th (which applies to BRT, LRT or RRT, and only RRT 1 is unaffected by this change); and
- Extending BRT infrastructure along 104th Avenue to 156th Street (which applies to BRT 1, BRT 2, LRT 5A, RRT 1A and RRT 2). As indicated by the map, BRT service along 104th would be provided by two overlapping rapid bus routes continuing from Highway 1:
  - Surrey Central – 104th Avenue to 152nd Street – Hwy 1 towards Coquitlam.
  - Surrey Central – 104th Avenue to 156th Street – Highway 1 to Walnut Grove.

Exhibit 2D.7 summarizes the 2041 assumed service plan for each of the alternatives, by corridor. Changes from the original service plan are highlighted, with some changes pushing the operating requirements (and costs) upward, and others (highlighted and outlined) resulting in savings. The optimization of rapid transit service levels included adjusting frequency and service structure:

- Fraser Highway. BRT more frequent (2 /3 minutes in 2041 /2021), and RRT every 4.6 /4.6 east of King George (was 2.3/2.3)
- King George Boulevard. BRT every 2 /4 minutes for Surrey Central to Newton on King George Blvd. BRT remains at every 3 /5 minutes for Newton to White Rock Centre, if connecting to LRT. Service south of Hwy. 10 on BRT was switched to running in shared instead of dedicated lanes.
- 104th Avenue. LRT extended to 156th. BRT service separated from King George Blvd route, and provided by two Rapid Bus routes (as noted above), with combined headway of 2 /3.75 minutes between Surrey Central and 152nd Street.

Exhibit 2D.5 - Design Refinement Recommendations - Application to Alternatives

	Modified Operating Assumptions (for Alternatives)		Recommended?	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	New LRT 5A	New LRT 5B	RRT 1	New RRT 1A	RRT 2	RRT 3
1.1	Service and Capacity Optimization	RRT every 4.6 min beyond King George	Yes - on RRT 1 No - on RRT 2, 3									4.6 min KGS to LC	4.6 min KGS to LC		
		BRT more frequent (1.5 minutes without TSP)	No												
		BRT more frequent (2 minutes)	Yes - on BRT elements except So. Surrey	2 min headways	2 min headways		2 min BRT on Fraser	2 min BRT on Fraser		2 min BRT on KGB	2 min BRT on KGB		2 min BRT on KGB	2 min BRT	
		King George / 104th – LRT every 7.5 min for 2041	No												
		BRT - Split service south of Hwy 10, every 2nd bus continues (e.g. 3 min to north/6 min to south)	No - See 11B instead												
1.2	Service Refinements	BRT & LRT - Extend to Hwy 10 (on KGB)	No. Can revisit in Phase 3.												
		BRT & LRT - Extend toward Hwy 1 (on 104th)	Yes	BRT to 104/156	BRT to 104/156	LRT to 104/156	LRT to 104/156	LRT to 104/156	LRT to 104/156	BRT to 104/156	*LRT to 104/156*		BRT to 104/156	BRT to 104/156	
		BRT – Interline with Hwy 1 Rapid Bus (RB) routes	Yes - any BRT routes on 104th	RB on 104th	RB on 104th					RB on 104th			RB on 104th	RB on 104th	
1.3	Infrastructure Refinements	BRT White Rock to Guildford & LRT Surrey Central to Langley Centre	Yes							Yes - New Alt.	*Modified from LRT 5A*				
		BRT - Provide service to White Rock via shared running	Yes	Shared lanes So. of Hwy 10		Shared lanes So. of Hwy 10	Shared lanes So. of Hwy 10			Shared lanes So. of Hwy 10	Shared lanes So. of Hwy 10		Shared lanes So. of Hwy 10		
2	**Modified Design Assumptions**														
2.1	Station Locations	Modified Base – relocate stops (remove 104/148, shift KGB/80 to 76)	Partly - move station from KGB/80 to 76; retain station at 104/148	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes
		Additional stations (KGB/76 and FH/188)	Not FH/188, but can reconsider in Ph 3												
		Reduced Stations for RRT (consolidate Clayton stops to 188th instead of 184th, 192nd)	Yes, but defer until Phase 3												
2.2	Park and Ride	At 104th and 156, at KGB and Hwy 10 (test extensions with and without P&R, see 10A/B)	No P&R, but could reconsider in Ph. 3	No P&R assumed	No P&R assumed	No P&R assumed	No P&R assumed	No P&R assumed	No P&R assumed	No P&R assumed	No P&R assumed	No P&R assumed	No P&R assumed	No P&R assumed	No P&R assumed

Exhibit 2D.6 – Design Refinements (Map)

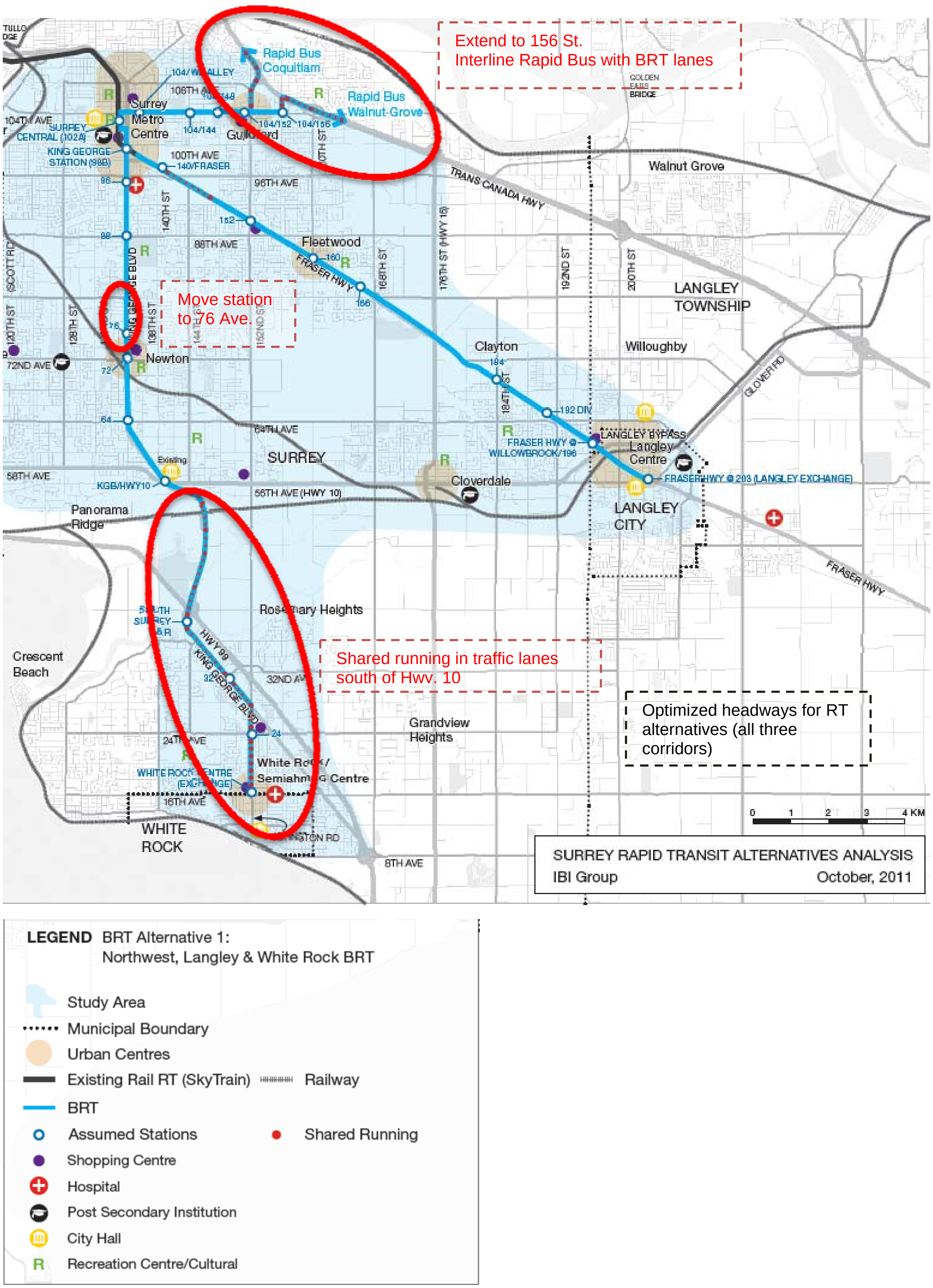
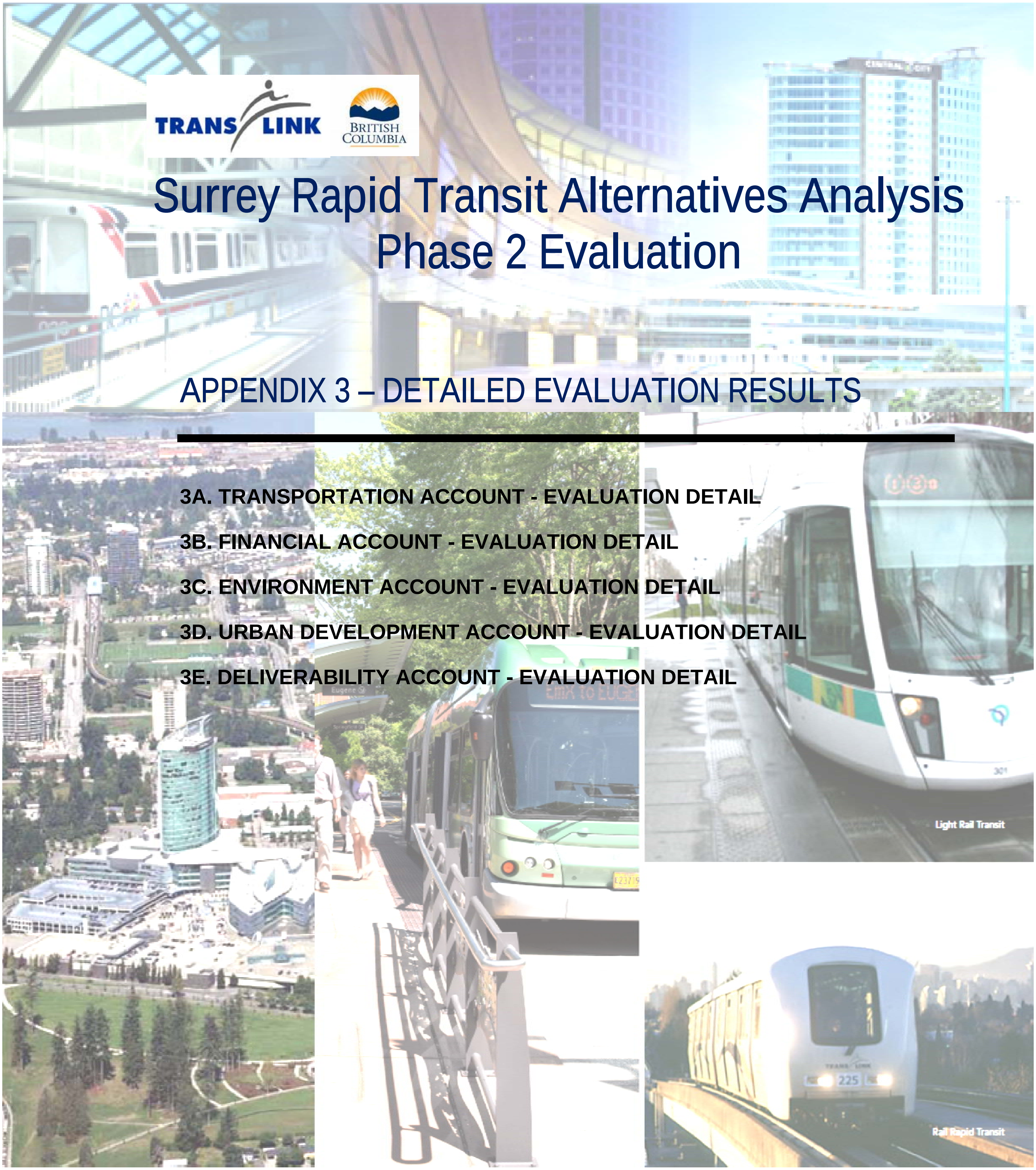


Exhibit 2D.7 – Rapid Transit Service Plans for 2041, Refined versus Preliminary

Alternative Name	**BAU**	**BB**	**BRT 1**	**BRT 2**	**LRT 1**	**LRT 2**	**LRT 3**	**LRT 4**	**LRT 5A**	**LRT 5B**	**RRT 1**	**RRT 1A**	**RRT 2**	**RRT 3**
Original/Refined Alternative	Refined	Refined	Refined	Refined	Refined	Refined	Refined	Refined	**New**	**New**	Refined	**New**	Refined	Refined
Services Included, By Corridor, 2041 Headways														
** Local Bus is in all corridors, in all alternatives*														
Fraser Highway	*Local Bus**	*Local + B-Line + Express*	BRT 2 min	BRT 2 min	LRT 3 min	BRT 2 min	BRT 2 min	*Local Bus*	LRT 3 min	LRT 3 min	RRT 4.6 min	RRT 4.6 min	BRT 2 min	*Local Bus*
104th Avenue (extended to 156)	*Local Bus**	*Local + B-Line + Express*	Rapid Bus 2 min	Rapid Bus 2 min	LRT 3 min	LRT 3 min	LRT 3 min	LRT 3 min	Rapid Bus 2 min	LRT 3 min	*Local Bus*	Rapid Bus 2 min	Rapid Bus 2 min	*Local Bus*
King George (n. of Newton)	*Local Bus**	*Local + B-Line + Express*	BRT 2 min	BRT 2 min	LRT 3 min	LRT 3 min	LRT 3 min	LRT 3 min	BRT 2 min	BRT 2 min	*Local Bus*	BRT 2 min	RRT 2.3 min	RRT 2.3 min
King George (s. of Newton)	*Local Bus**	*Local + B-Line + Express*	BRT 2 min - shared lanes	*Local Bus*	BRT 3 min - shared lanes	BRT 3 min - shared lanes	*Local Bus*	*Local Bus*	BRT 2 min - shared lanes	BRT 2 min - shared lanes	*Local Bus*	BRT 2 min - shared lanes	*Local Bus*	*Local Bus*

Alternative Name	**BAU**	**BB**	**BRT 1**	**BRT 2**	**LRT 1**	**LRT 2**	**LRT 3**	**LRT 4**	**LRT 5A**	**LRT 5B**	**RRT 1**	**RRT 1A**	**RRT 2**	**RRT 3**
Original/Refined Alternative	Original	Original	Original	Original	Original	Original	Original	Original	n/a	n/a	Original	n/a	Original	Original
Services Included, By Corridor, 2041 Headways														
** Local Bus is in all corridors, in all alternatives*														
Fraser Highway	*Local Bus**	*Local + B-Line + Express*	BRT 3 min	BRT 3 min	LRT 3 min	BRT 3 min	BRT 3 min	*Local Bus*	-	-	RRT 2.3 min		BRT 3 min	*Local Bus*
104th Avenue	*Local Bus**	*Local + B-Line + Express*	BRT 3 min	BRT 3 min	LRT 3 min	LRT 3 min	LRT 3 min	LRT 3 min	-	-	*Local Bus*		BRT 3 min	*Local Bus*
King George (n. of Newton)	*Local Bus**	*Local + B-Line + Express*	BRT 3 min	BRT 3 min	LRT 3 min	LRT 3 min	LRT 3 min	LRT 3 min	-	-	*Local Bus*		RRT 2.3 min	RRT 2.3 min
King George (s. of Newton)	*Local Bus**	*Local + B-Line + Express*	BRT 3 min	*Local Bus*	BRT 3 min	BRT 3 min	*Local Bus*	*Local Bus*	-	-	*Local Bus*		*Local Bus*	*Local Bus*

Note: Highlighted cells show changes relative to preliminary assumptions.



Surrey Rapid Transit Alternatives Analysis
Phase 2 Evaluation

APPENDIX 3 – DETAILED EVALUATION RESULTS

3A. TRANSPORTATION ACCOUNT - EVALUATION DETAIL

3B. FINANCIAL ACCOUNT - EVALUATION DETAIL

3C. ENVIRONMENT ACCOUNT - EVALUATION DETAIL

3D. URBAN DEVELOPMENT ACCOUNT - EVALUATION DETAIL

3E. DELIVERABILITY ACCOUNT - EVALUATION DETAIL

August 2012

Appendix 3A – TRANSPORTATION ACCOUNT: EVALUATION DETAIL

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Exhibits

Appendix 3B – FINANCIAL ACCOUNT: EVALUATION DETAIL

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APPENDIX 3C – ENVIRONMENT ACCOUNT EVALUATION DETAIL

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Appendix 3D – URBAN DEVELOPMENT ACCOUNT: EVALUATION DETAIL

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APPENDIX 3E – DELIVERABILITY ACCOUNT EVALUATION DETAILS

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APPENDIX 3A – TRANSPORTATION ACCOUNT EVALUATION DETAILS

This appendix contains additional background information from the final Phase 2 Evaluation of Alternatives, with materials related to the following transportation criteria:

- Transit User Benefits
- Capacity and Expandability
- Transit Mode Share

The approach and results for each of the transportation account criteria appear in the Evaluation Report; this appendix focuses on additional details to support the main set of results. This appendix also summarizes key outputs from the regional travel demand model that were used to derive the performance measures for the transportation account.

1. TRAVEL DEMAND MODEL OUTPUTS

Exhibits 3A.1 and 3A.2 present the regional travel statistics estimated by the model for each alternative for 2021 and 2041. Many of the transportation account results are derived from these values[1].

Exhibit 3A.1 – 2021 Regional Statistics (AM Peak Hour)

Alternative	Auto Trips (Person)	Transit Trips (Person)	Walk/Cycle Trips	Transit Pass KM	Transit Hours	Auto Vehicle KM
BAU	567,881	117,204	132,430	1,529,400	49,000	4,677,522
Best Bus	567,090	117,968	132,428	1,541,900	49,400	4,669,835
BRT1	567,171	117,802	132,487	1,546,600	49,200	4,669,694
BRT 2	567,242	117,720	132,496	1,544,500	49,100	4,670,829
LRT 1	567,318	117,668	132,477	1,545,500	49,100	4,672,921
LRT 2	567,210	117,762	132,481	1,542,100	49,000	4,670,828
LRT 3	567,199	117,767	132,496	1,545,500	49,100	4,669,973
LRT 4	567,623	117,367	132,522	1,530,700	49,000	4,675,556
LRT 5A	567,252	117,710	132,500	1,544,000	49,100	4,670,533
LRT 5B	567,292	117,685	132,475	1,542,900	49,000	4,671,846
RRT1	566,921	118,216	132,230	1,571,500	49,300	4,667,148
RRT1A	566,589	118,439	132,315	1,576,300	49,400	4,663,963
RRT2	566,895	118,077	132,433	1,557,100	49,200	4,667,205
RRT3	567,416	117,708	132,345	1,545,200	49,100	4,672,560

[1] Results in 3A.1 and 3A.2 are presented as is, because the increments of each alternative relative to BAU measure the effects. Rounding is carried out on the results derived from this model output,

Exhibit 3A.2 – 2041 Regional Statistics (AM Peak Hour)

Alternative	Auto Trips (Person)	Transit Trips (Person)	Walk/Cycle Trips	Transit Pass KM	Transit Hours	Auto Vehicle KM
BAU	645,382	155,621	149,646	2,114,400	69,100	5,545,285
Best Bus	644,549	156,386	149,666	2,125,700	69,300	5,537,806
BRT1	644,184	156,733	149,617	2,145,700	69,200	5,534,414
BRT 2	644,324	156,562	149,657	2,139,600	69,100	5,536,402
LRT 1	644,251	156,639	149,659	2,141,900	68,900	5,534,127
LRT 2	644,248	156,630	149,657	2,141,500	69,100	5,534,661
LRT 3	644,321	156,568	149,654	2,140,100	69,000	5,536,140
LRT 4	644,949	155,944	149,745	2,117,100	69,000	5,541,021
LRT 5A	644,274	156,650	149,588	2,144,400	69,100	5,535,183
LRT 5B	644,088	156,813	149,630	2,146,700	69,100	5,533,222
RRT1	644,260	156,839	149,316	2,171,200	69,100	5,536,173
RRT1A	643,480	157,502	149,395	2,183,400	69,400	5,528,501
RRT2	643,948	156,991	149,521	2,158,900	69,100	5,533,454
RRT3	644,831	156,182	149,560	2,135,400	69,000	5,540,271

2. TRANSIT USER BENEFITS

Transit user benefit measures included transit boardings, passenger-km, and travel time benefits.

Exhibit 3A.3 summarizes transit boardings and passenger-km. The exhibit shows the estimated daily boardings (2021, 2041) on transit in the study area, including local bus and rapid transit. These were estimated from the AM peak based on the ratio observed in 2009-10 on several Fraser Highway, King George Blvd and 104 Avenue bus routes. (These values are the basis of the charts in the evaluation report.)

The second part of the exhibit includes the forecast AM peak boardings, passenger-km and passenger-hours from the model's output of transit statistics. This output was used to estimate the incremental transit passenger-km.

Exhibit 3A.4 includes the travel time savings estimated by the demand model, for the AM peak. The study area and regional values are both indicated. Because many trips using the transit system within the study area start or end outside it, the regional travel time savings are higher. The unadjusted travel time savings for each alternative are based on the regional AM peak value directly from the demand model, expanded to annual hours. The demand model is not capacity constrained, and therefore adjustments were made to the estimated travel time savings to account for certain factors such as capacity constraints, and pass-up relief for existing local bus users.

Where the model allows transit lines to operate over capacity, travel time savings are output for passengers that would actually use the local bus instead of the new rapid transit. Where this occurred, the travel time savings relative to BAU were capped by the percentage of passengers actually able to fit into the rapid transit system (between 85% and 100%, depending on the alternative).

The BAU travel times do not include pass-up effects (because the local buses can operate above capacity in the model), and on Fraser Highway and King George Blvd the local buses were forecast to have insufficient capacity to handle peak demands. Any alternatives that relieve the local transit capacity issues therefore provide an additional benefit, and so this benefit was estimated for each applicable case. The pass-up benefit is a function of the number of extra passengers on the local buses in BAU, and the local bus service headways, in both 2021 and 2041. If an alternative serves either or both corridors, and the new corridor volume/capacity ratio is less than 1.0, then the BAU pass-up delays have been offset, and this additional benefit applies.

Other travel benefits of the alternatives, including schedule reliability and quality of service, were considered in the cost-benefit life cycle analysis but not included in the pure travel time benefits in Exhibit 3A.4. (Refer to Section 3.2 of the Evaluation Report or Appendix 3B for discussion of the other benefits).

Exhibit 3A.3 - Transit Boardings and Passenger-Kilometres

	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Estimated Daily Transit Boardings														
Local Bus - Study Area	334,000	318,000	269,000	277,000	274,000	273,000	275,000	308,000	272,000	276,000	305,000	277,000	279,000	329,000
B-Line/Express	-	56,000	-	-	-	-	-	-	-	-	-	-	-	-
BRT - Fraser Hwy	-	-	58,000	59,000	-	58,000	58,000	-	-	-	-	-	57,000	-
BRT - KGB	-	-	24,000	11,000	3,000	3,000	-	-	24,000	24,000	-	22,000	-	-
Rapid Bus	-	-	23,000	23,000	-	-	-	-	23,000	-	-	20,000	23,000	-
LRT - Fraser Hwy	-	-	-	-	50,000	-	-	-	50,000	51,000	-	-	-	-
LRT - KGB/104	-	-	-	-	33,000	33,000	31,000	32,000	-	19,000	-	-	-	-
Skytrain in Study Area	131,000	137,000	143,000	141,000	139,000	140,000	140,000	132,000	142,000	141,000	100,000	103,000	116,000	105,000
SkyTrain 'new'	-	-	-	-	-	-	-	-	-	-	80,000	86,000	48,000	48,000
2021 Study Area	465,000	511,000	517,000	511,000	499,000	507,000	504,000	472,000	511,000	511,000	485,000	508,000	523,000	482,000
Local Bus - Study Area	559,000	545,000	460,000	480,000	473,000	471,000	479,000	515,000	460,000	473,000	534,000	476,000	488,000	554,000
B-Line/Express	-	77,000	-	-	-	-	-	-	-	-	-	-	-	-
BRT - Fraser Hwy	-	-	87,000	89,000	-	88,000	88,000	-	-	-	-	-	87,000	-
BRT - KGB	-	-	60,000	27,000	11,000	11,000	-	-	60,000	60,000	-	55,000	-	-
Rapid Bus	-	-	41,000	40,000	-	-	-	-	41,000	-	-	39,000	41,000	-
LRT - Fraser Hwy	-	-	-	-	85,000	-	-	-	85,000	85,000	-	-	-	-
LRT - KGB/104	-	-	-	-	70,000	70,000	64,000	65,000	-	36,000	-	-	-	-
Skytrain in Study Area	186,000	191,000	211,000	206,000	206,000	206,000	205,000	190,000	211,000	210,000	144,000	156,000	161,000	139,000
SkyTrain 'new'	-	-	-	-	-	-	-	-	-	-	115,000	116,000	79,000	81,000
2041 Study Area	745,000	813,000	859,000	842,000	845,000	846,000	836,000	770,000	857,000	864,000	793,000	842,000	856,000	774,000
Transit Statistics for Region (AM Peak Hour)														
2021 AM Pk Brdg	232,300	234,800	234,200	234,200	234,500	233,800	234,100	232,600	233,800	233,900	232,400	233,000	234,500	233,200
2021 Pass-km	**1,529,400**	**1,541,900**	**1,546,600**	**1,544,500**	**1,545,500**	**1,542,100**	**1,545,500**	**1,530,700**	**1,544,000**	**1,542,900**	**1,571,500**	**1,576,300**	**1,557,100**	**1,545,200**
2021 Pass-hrs	49,000	49,400	49,200	49,100	49,100	49,000	49,100	49,000	49,100	49,000	49,300	49,400	49,200	49,100
2041 AM Pk Brdg	320,100	322,900	324,600	324,000	325,000	324,900	324,500	321,700	324,200	325,000	321,000	322,800	324,500	321,100
2041 Pass-km	**2,114,400**	**2,125,700**	**2,145,700**	**2,139,600**	**2,141,900**	**2,141,500**	**2,140,100**	**2,117,100**	**2,144,400**	**2,146,700**	**2,171,200**	**2,183,400**	**2,158,900**	**2,135,400**
2041 Pass-hrs	69,100	69,300	69,200	69,100	68,900	69,100	69,000	69,000	69,100	69,100	69,100	69,400	69,100	69,000
30-Year Additional Transit Pass-Km, Millions		1,800	3,960	3,260	3,540	3,300	3,370	330	3,690	3,840	7,830	9,260	5,820	2,910

Source: Derived from SRTAA output from RTPM08.

Exhibit 3A.4 - Transit User Effects, including Travel Time Savings

		BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
2021															
Average Journey Time															
Study Area	Existing users transit time savings (person-min)	-	12,162	8,078	7,256	6,657	8,107	7,933	1,580	6,685	7,637	9,878	13,421	10,525	3,990
	New users transit time savings (person-min)	-	1,260	1,049	967	808	1,053	1,042	193	826	1,083	2,059	2,815	1,482	459
Regional	Existing users transit time savings (person-min)	-	27,761	28,987	26,823	23,966	26,219	26,580	3,601	26,381	26,244	59,361	71,295	48,072	23,132
	New users transit time savings (person-min)	-	1,995	3,360	3,139	2,255	2,904	2,879	318	2,660	2,582	13,355	16,174	5,784	2,638
	Total Transit Time Savings (per-min) - AM Peak Hr		29,756	32,347	29,962	26,221	29,123	29,458	3,919	29,041	28,827	72,715	87,469	53,856	25,770
	% from 'existing' users		**93%**	**90%**	**90%**	**91%**	**90%**	**90%**	**92%**	**91%**	**91%**	**82%**	**82%**	**89%**	**90%**
	Unadjusted Annual TTS - Hours, 2021		*2,530,000*	*2,750,000*	*2,550,000*	*2,230,000*	*2,480,000*	*2,500,000*	*330,000*	*2,470,000*	*2,450,000*	*6,180,000*	*7,430,000*	*4,580,000*	*2,190,000*
	Capacity Constrained (Max RT V/C=1)		2,530,000	2,440,000	2,210,000	2,230,000	2,170,000	2,170,000	330,000	2,470,000	2,450,000	6,180,000	7,430,000	4,170,000	2,190,000
	Adjusted for reliability benefit of segregation from traffic		*2,530,000*	*2,770,000*	*2,510,000*	*2,540,000*	*2,460,000*	*2,460,000*	*380,000*	*2,810,000*	*2,780,000*	*6,940,000*	*8,340,000*	*4,730,000*	*2,480,000*
	Pass-Up Relief Time Savings (Relief of BAU V/C>1 on FH, KGB)		*1,000,000*	*1,000,000*	*960,000*	*1,000,000*	*1,000,000*	*1,000,000*	*260,000*	*1,000,000*	*1,000,000*	*740,000*	*1,000,000*	*1,000,000*	*260,000*
	Adjusted Transit Travel Time Savings, 2021 (Capacity-Constrained, Benefits for Pass-Up Relief and Reliability Added)		**3,530,000**	**3,770,000**	**3,470,000**	**3,540,000**	**3,460,000**	**3,460,000**	**640,000**	**3,810,000**	**3,780,000**	**7,680,000**	**9,340,000**	**5,730,000**	**2,740,000**
2041															
Average Journey Time															
Study Area	Existing Users Transit Time Savings (person-min)		14,234	17,382	15,281	16,515	16,951	16,445	4,529	17,580	18,911	15,293	23,058	18,741	5,685
	New Users Transit Time Savings (person-min)		922	2,652	2,374	2,495	2,534	2,498	519	2,761	3,251	3,331	4,841	2,842	582
Regional	Existing Users Transit Time Savings (person-min)	-	31,177	59,649	52,997	54,387	50,517	51,718	7,217	59,416	63,771	86,896	108,826	83,762	38,367
	New Users Transit Time Savings (person-min)	-	1,582	7,921	7,921	6,754	6,760	6,661	941	8,116	8,027	20,356	25,400	10,633	3,821
	Total Transit Time Savings (per-min) - AM Peak Hr		32,758	67,569	60,918	61,141	57,277	58,378	8,158	67,532	71,798	107,252	134,226	94,396	42,188
	% from 'existing' users		**95%**	**88%**	**87%**	**89%**	**88%**	**89%**	**88%**	**88%**	**89%**	**81%**	**81%**	**89%**	**91%**
	Unadjusted Annual TTS - Hours, 2041		*2,780,000*	*5,740,000*	*5,180,000*	*5,200,000*	*4,870,000*	*4,960,000*	*690,000*	*5,740,000*	*6,100,000*	*9,120,000*	*11,410,000*	*8,020,000*	*3,590,000*
	Capacity Constrained (Max RT V/C=1)		2,780,000	5,240,000	4,580,000	5,200,000	4,370,000	4,380,000	690,000	5,740,000	6,100,000	9,120,000	11,410,000	7,390,000	3,590,000
	Adjusted for reliability benefit of segregation from traffic		*2,780,000*	*5,930,000*	*5,180,000*	*5,890,000*	*4,950,000*	*4,960,000*	*780,000*	*6,500,000*	*6,910,000*	*10,230,000*	*12,800,000*	*8,370,000*	*4,080,000*
	Pass-Up Relief Time Savings (Relief of BAU V/C>1 on FH, KGB)		*510,000*	*1,220,000*	*510,000*	*510,000*	*510,000*	*510,000*	*-*	*1,220,000*	*1,220,000*	*510,000*	*1,220,000*	*1,220,000*	*720,000*
	Adjusted Transit Travel Time Savings, 2041 (Capacity-Constrained, Benefits for Pass-Up Relief and Reliability Added)		**3,290,000**	**7,150,000**	**5,690,000**	**6,400,000**	**5,460,000**	**5,470,000**	**780,000**	**7,720,000**	**8,130,000**	**10,740,000**	**14,020,000**	**9,590,000**	**4,800,000**

3. CAPACITY AND EXPANDABILITY

Capacity was assessed against peak point demand, and was one of the considerations when the alternatives designs were refined after the preliminary evaluation. The peak load points were determined by considering the passenger demand profiles of the transit system and the individual rapid transit and parallel local services.

3.1 TRANSIT PASSENGER FLOWS

The figures on the following pages (Exhibits 3A.5 to 3A.18) provide an indication of the peak direction peak hour transit volumes along the key study area corridors at peak load points. The locations shown include 104 Avenue at King George Blvd, Fraser Highway at Whalley Boulevard, King George Blvd at Fraser Highway, and the Skybridge over the Fraser River. These values represent EMME model outputs and are unconstrained to capacity. (The values include only passengers on rapid transit and major local bus services along the corridors. For comparability with Exhibits 3A.19 to 3A.31, other transit routes incidental to these peak points were not included in the peak loads or capacity).

Exhibit 3A.5 -- 2041 AM Peak Hour Transit Flows– BAU

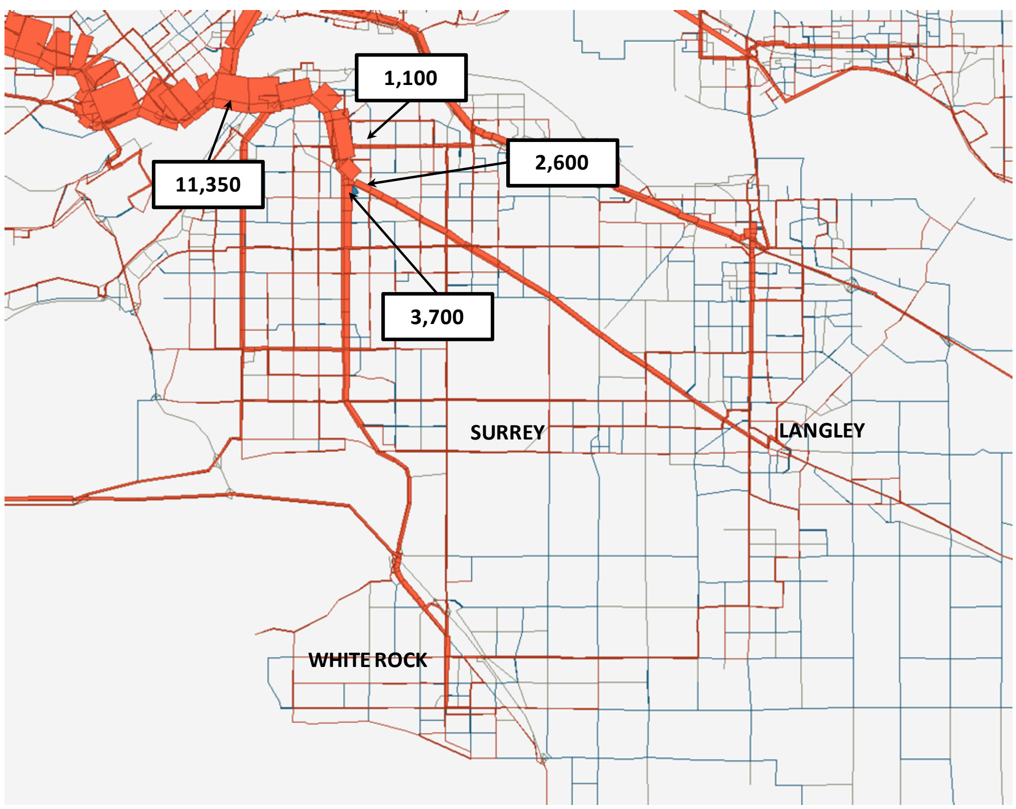


Exhibit 3A.6 -- 2041 AM Peak Hour Transit Flows– Best Bus

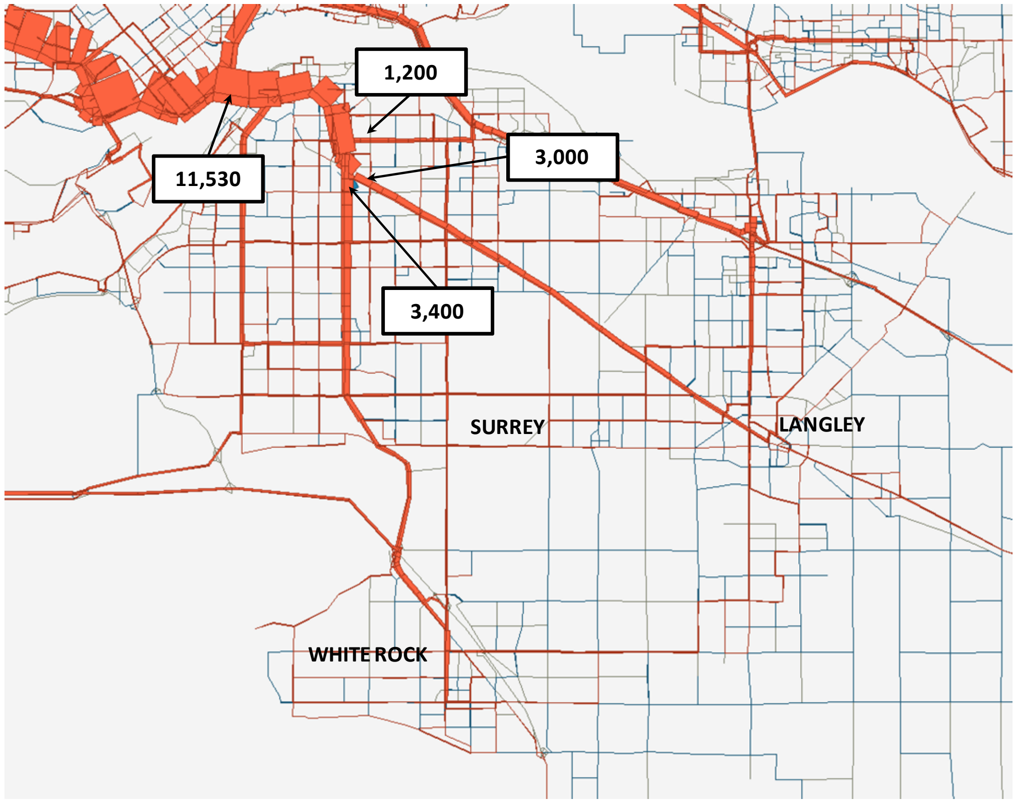


Exhibit 3A.7 -- 2041 AM Peak Hour Transit Flows– BRT1

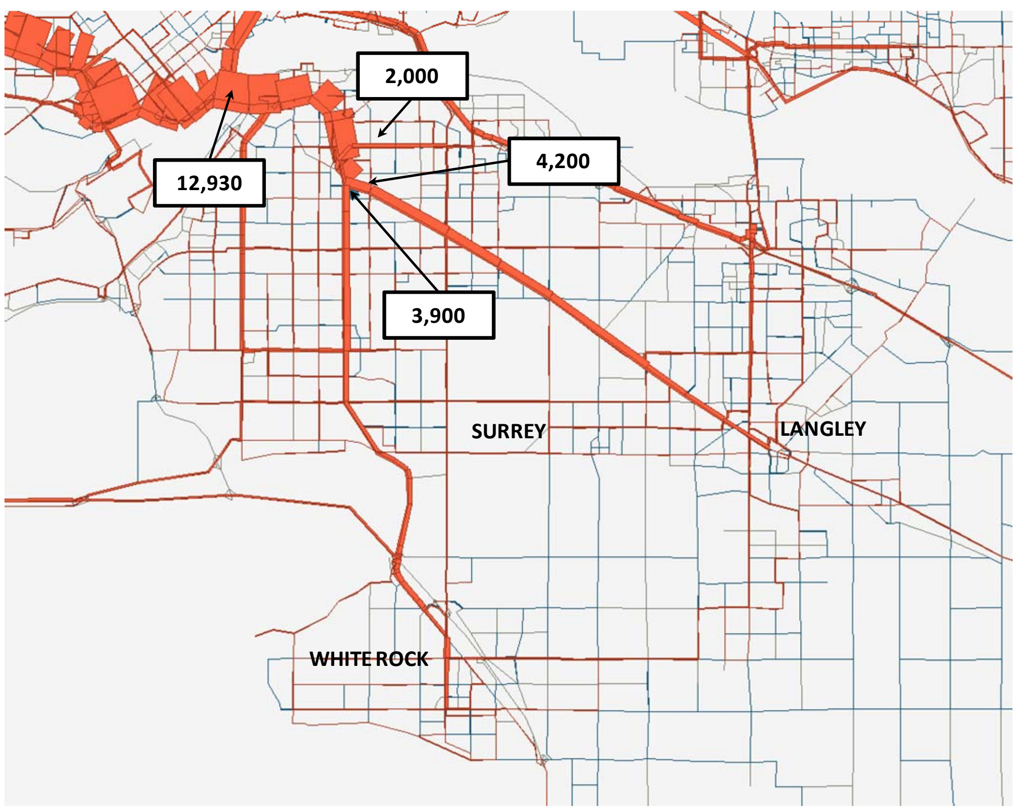


Exhibit 3A.8 -- 2041 AM Peak Hour Transit Flows– BRT2

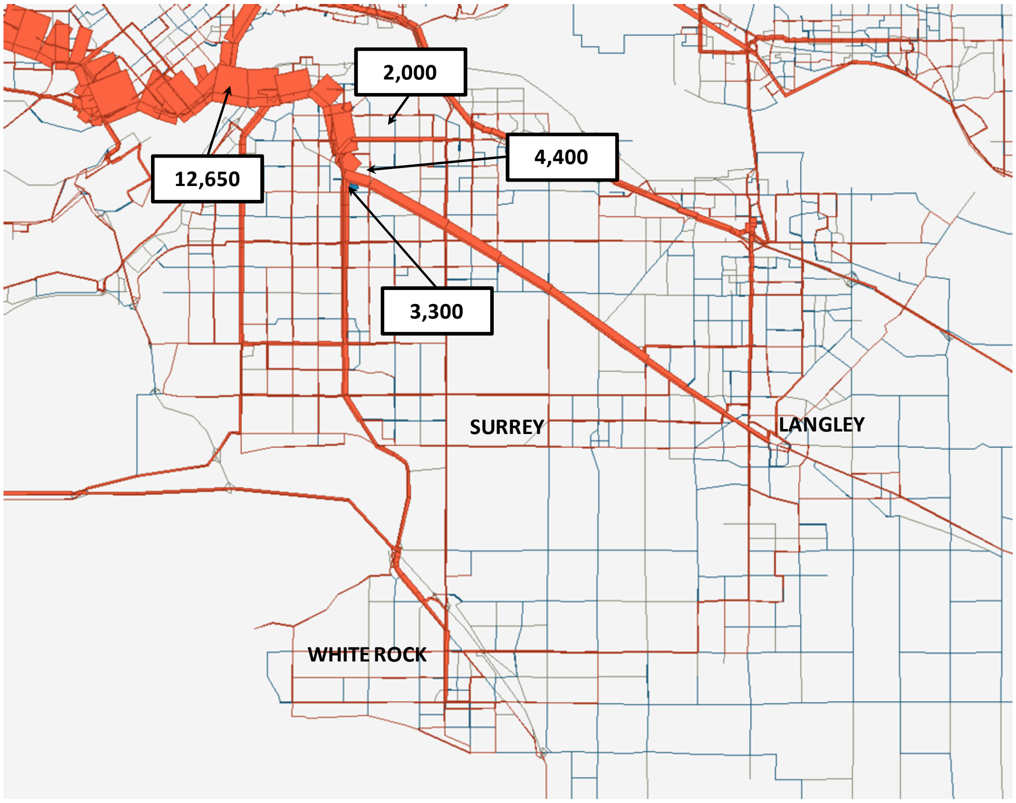


Exhibit 3A.9 -- 2041 AM Peak Hour Transit Flows– LRT1

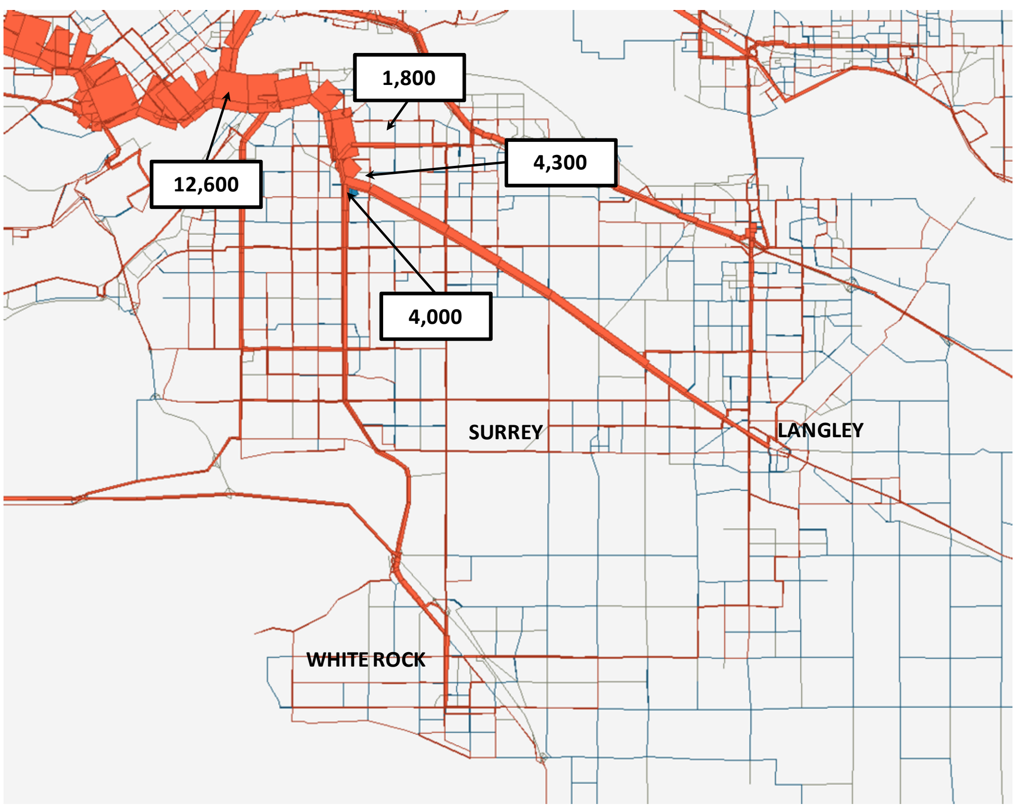


Exhibit 3A.10 -- 2041 AM Peak Hour Transit Flows– LRT2

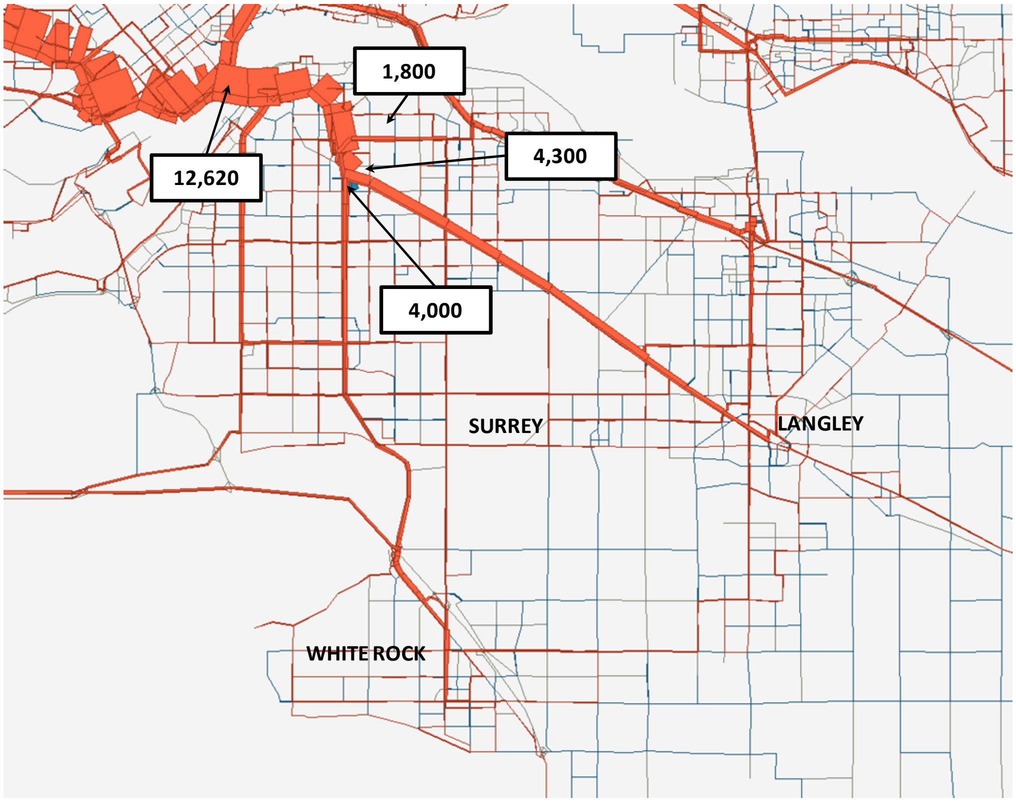


Exhibit 3A.11 -- 2041 AM Peak Hour Transit Flows– LRT3

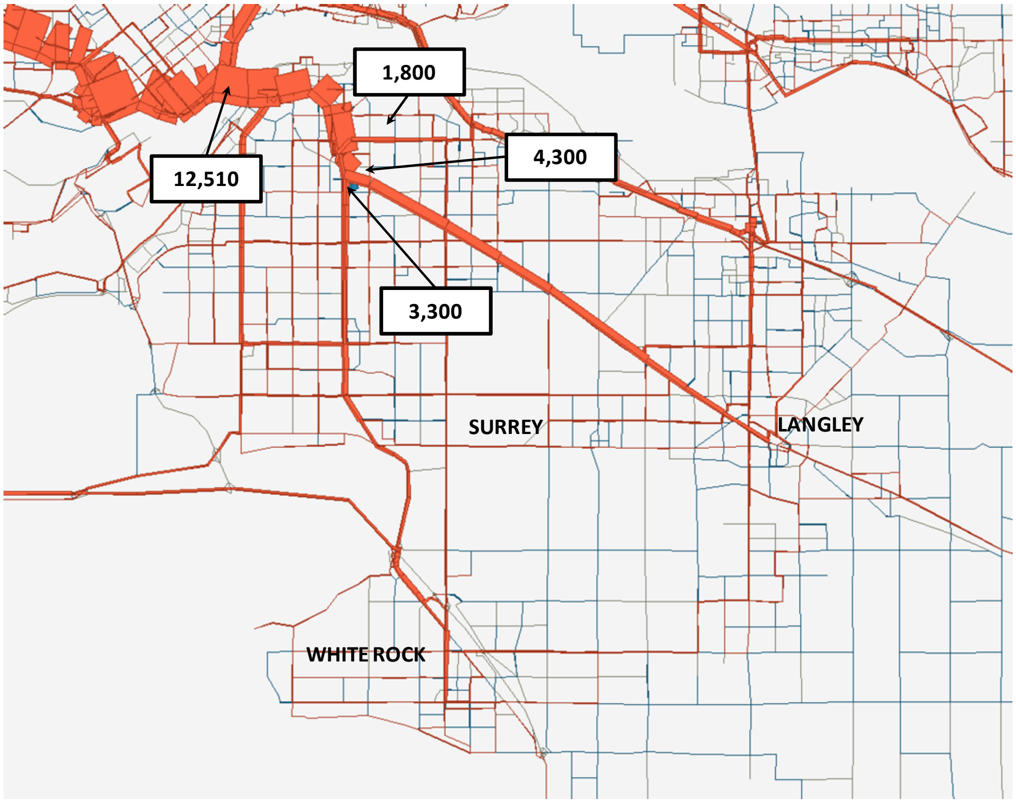


Exhibit 3A.12 -- 2041 AM Peak Hour Transit Flows– LRT4

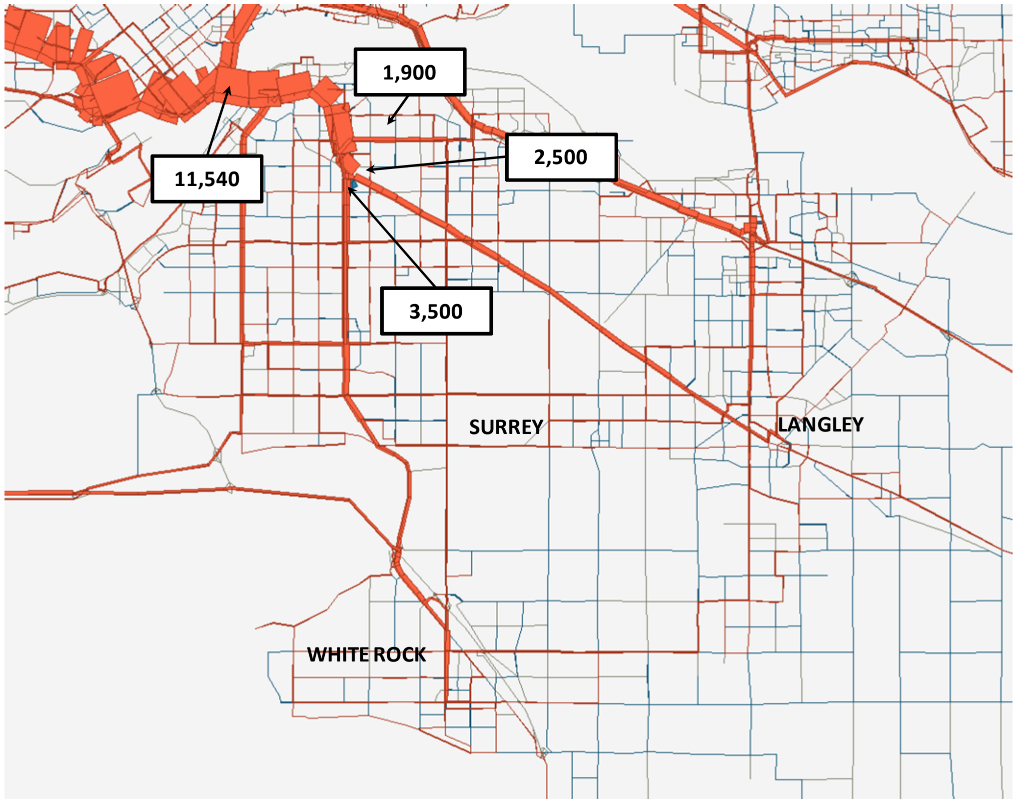


Exhibit 3A.13 -- 2041 AM Peak Hour Transit Flows– LRT5A

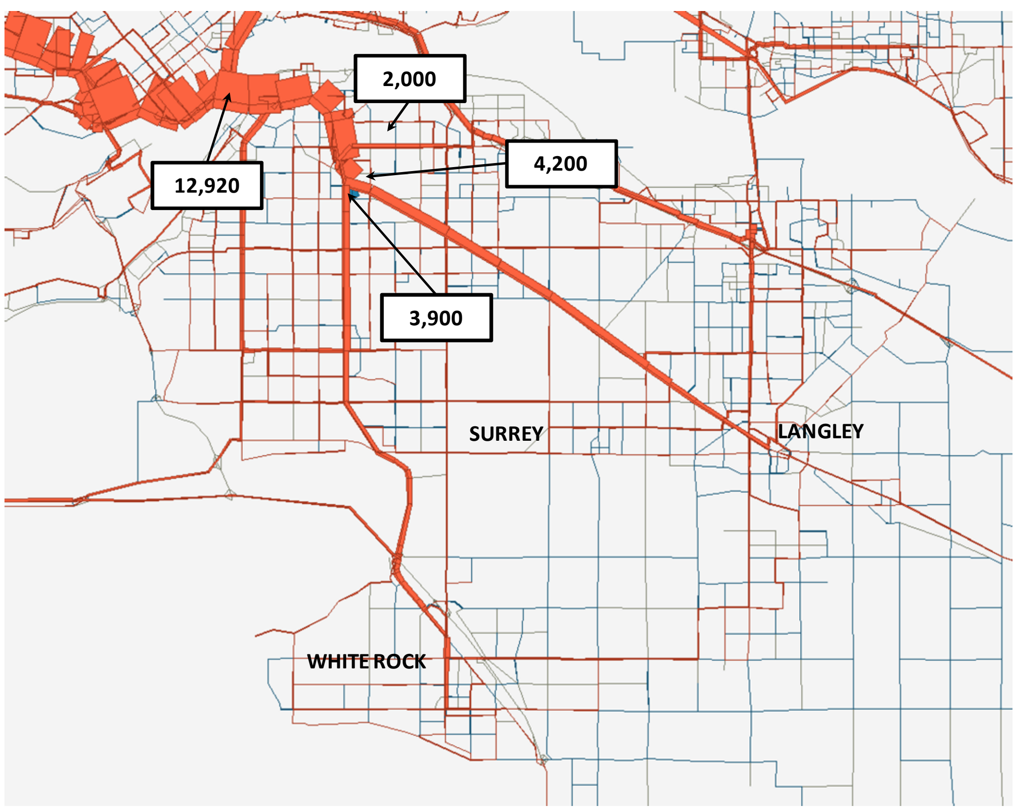


Exhibit 3A.14 -- 2041 AM Peak Hour Transit Flows– LRT5B

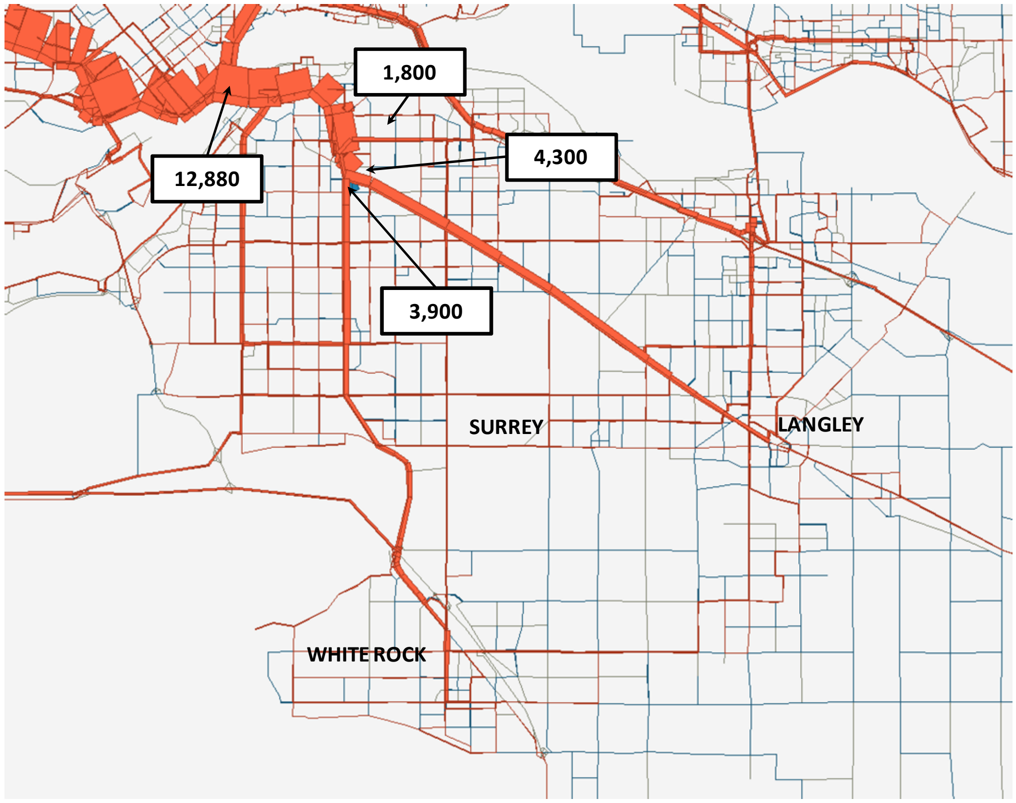


Exhibit 3A.15 -- 2041 AM Peak Hour Transit Flows– RRT1

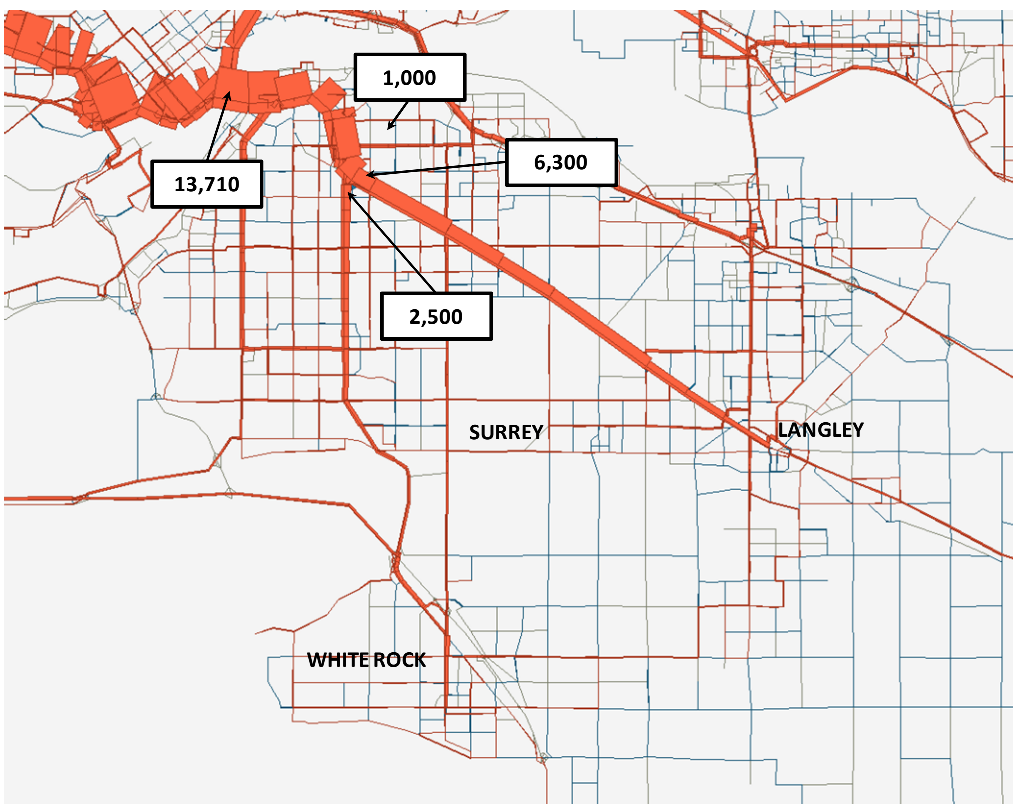


Exhibit 3A.16 -- 2041 AM Peak Hour Transit Flows– RRT1A

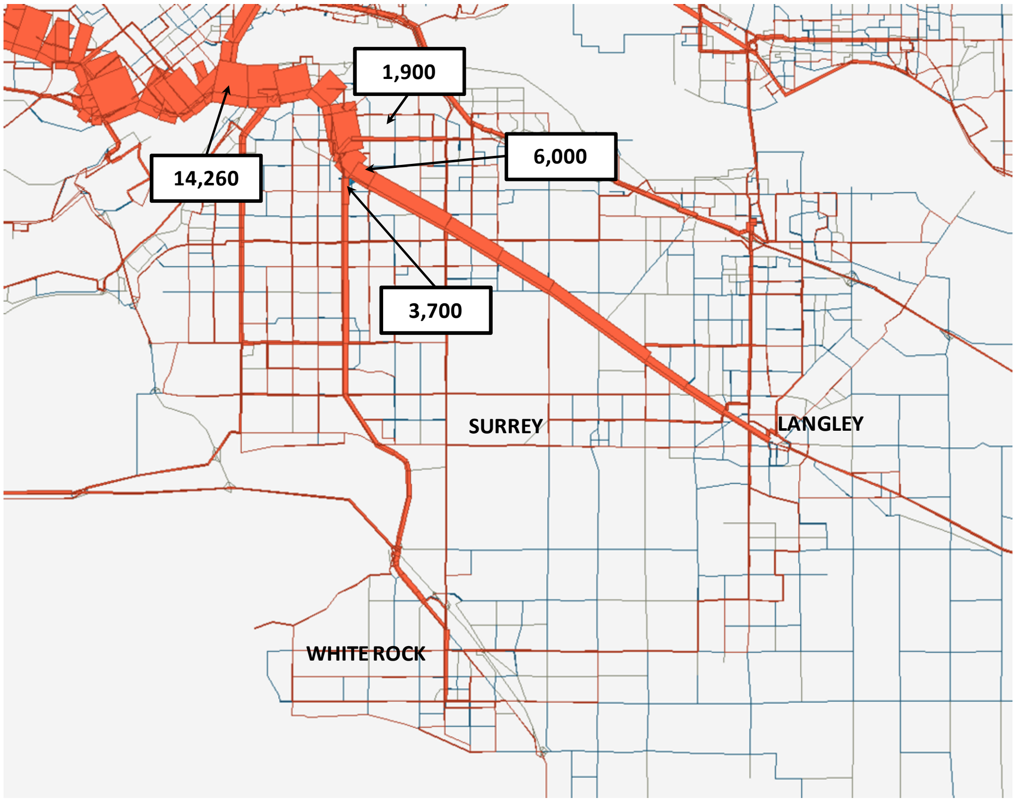


Exhibit 3A.17 -- 2041 AM Peak Hour Transit Flows– RRT2

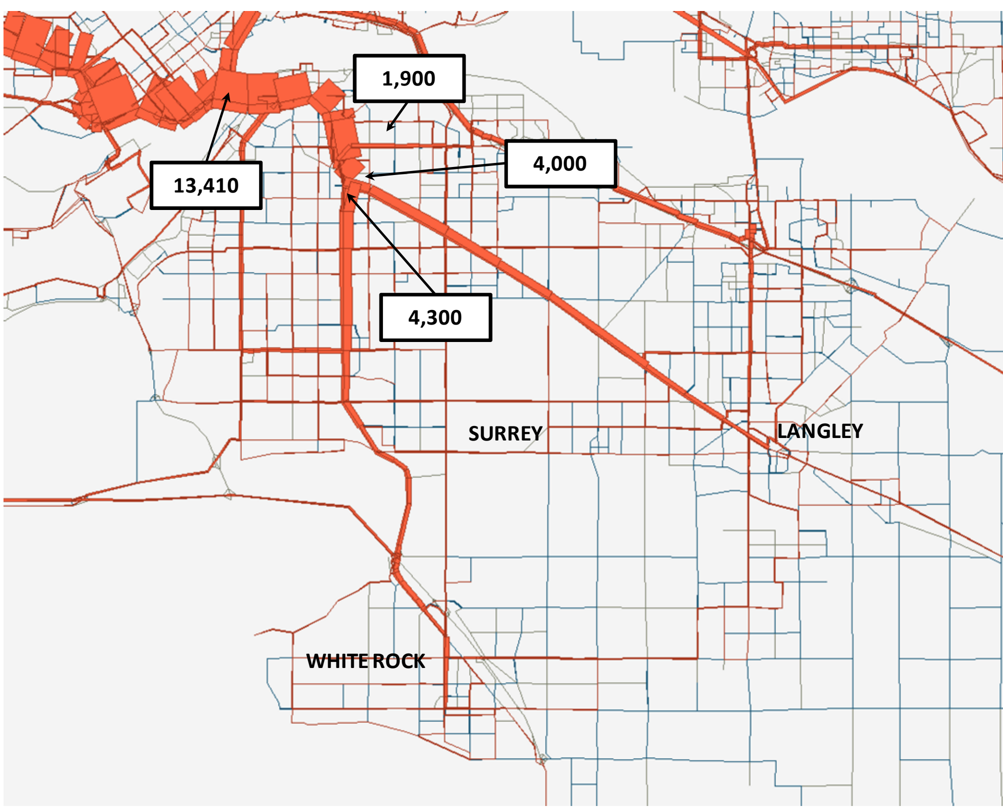
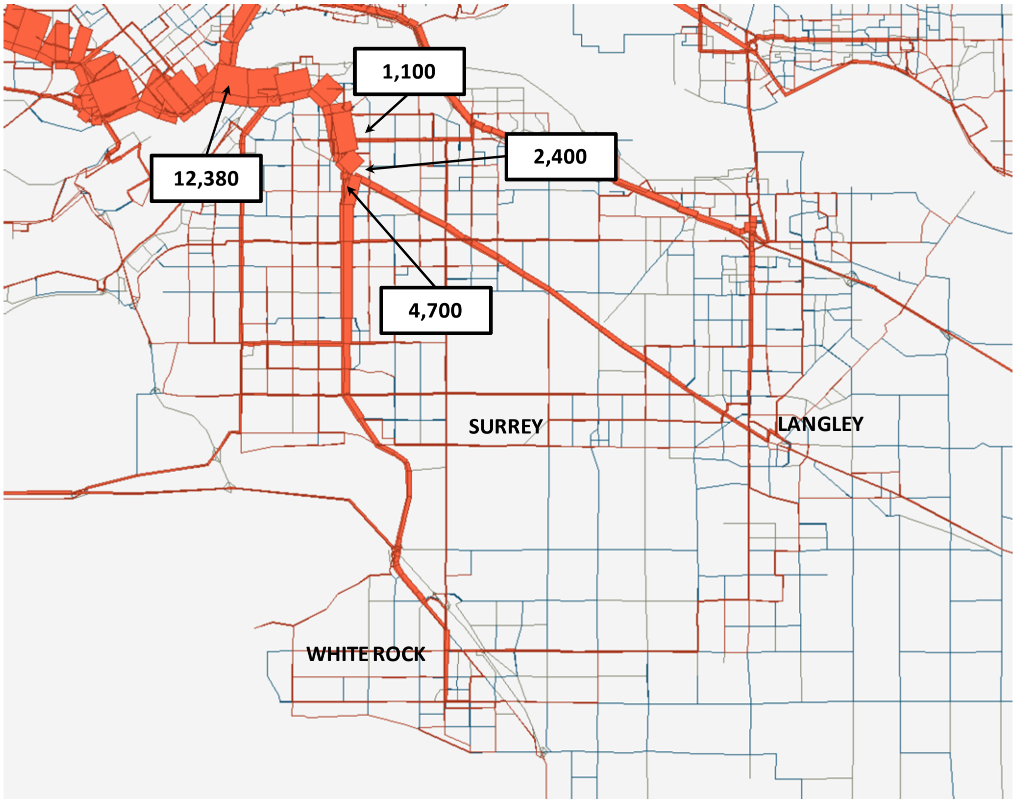


Exhibit 3A.18 -- 2041 AM Peak Hour Transit Flows– RRT3

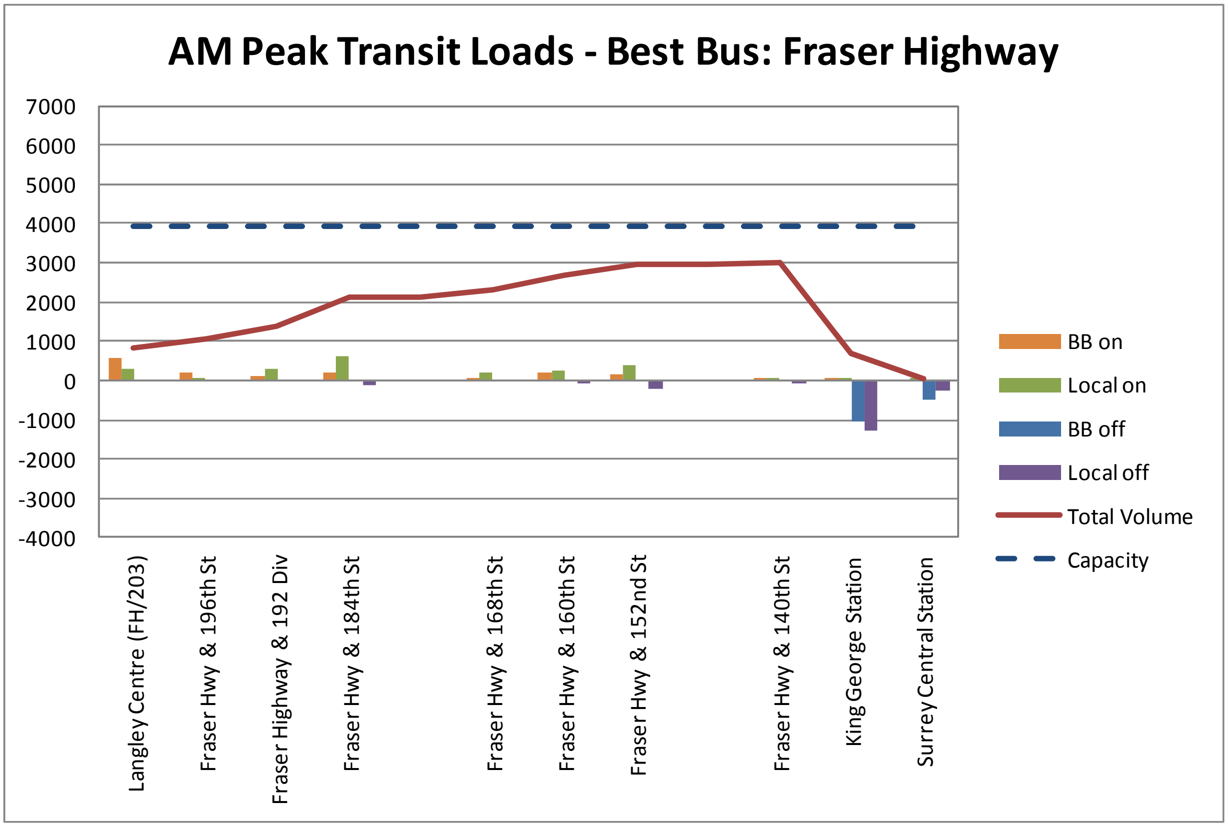


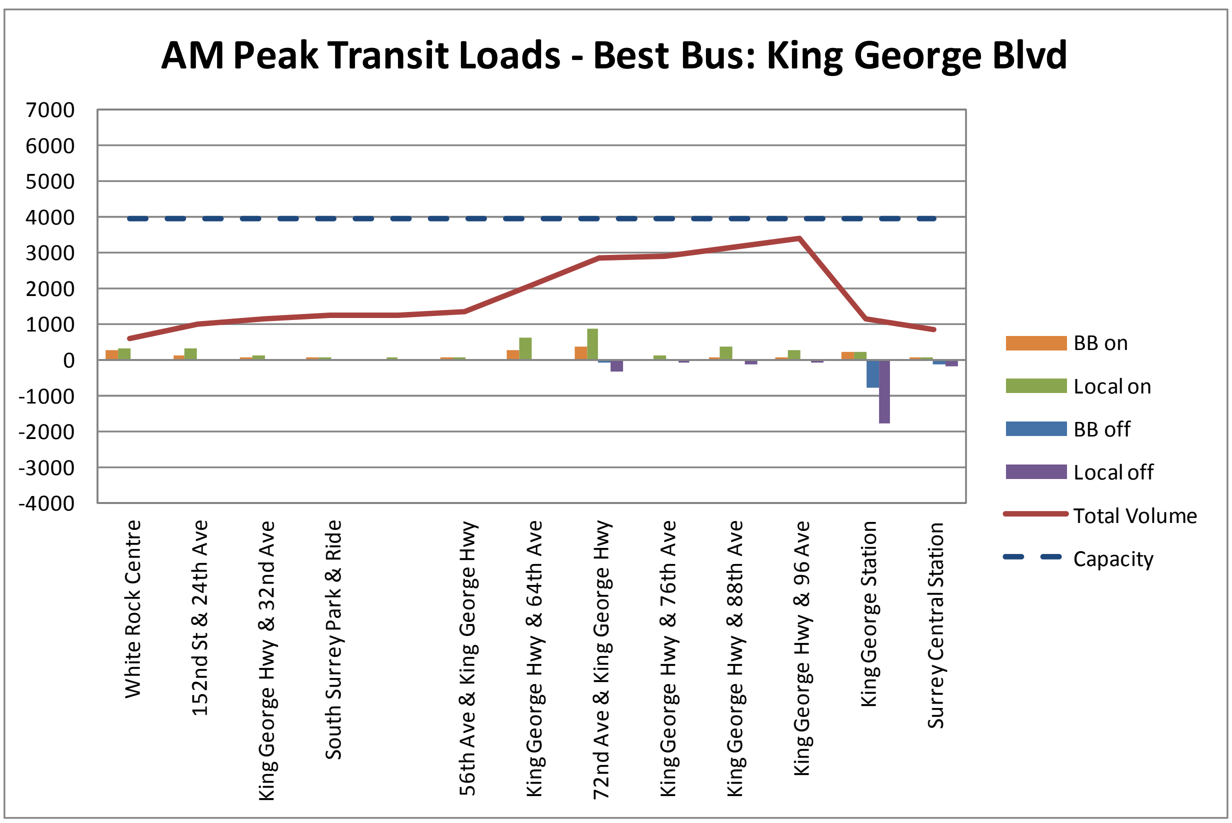
3.2 TRANSIT PASSENGER BOARDINGS, LOADS AND CORRIDOR CAPACITY

Exhibits 3A.19 to 3A.31 illustrate the peak passenger loads for each alternative, for each of the corridors (Fraser Highway, King George Boulevard and/or 104 Avenue) where rapid transit is part of the alternative. The demand plots include the rapid transit boarding and alighting activity, and the main local transit services (the local route between Langley and Surrey Central on Fraser Highway, and the local route between White Rock, Surrey Central and Guildford on King George Blvd and 104 Avenue). For Best Bus, the plots include B-Line, Super B-Line and local buses.

Note that the demand is often well below capacity at the beginnings of the routes, and only approaches capacity near the end of the line (e.g. just before King George or Surrey Central Station).

Exhibit 3A.19 – 2041 AM Peak Transit Loads– Best Bus





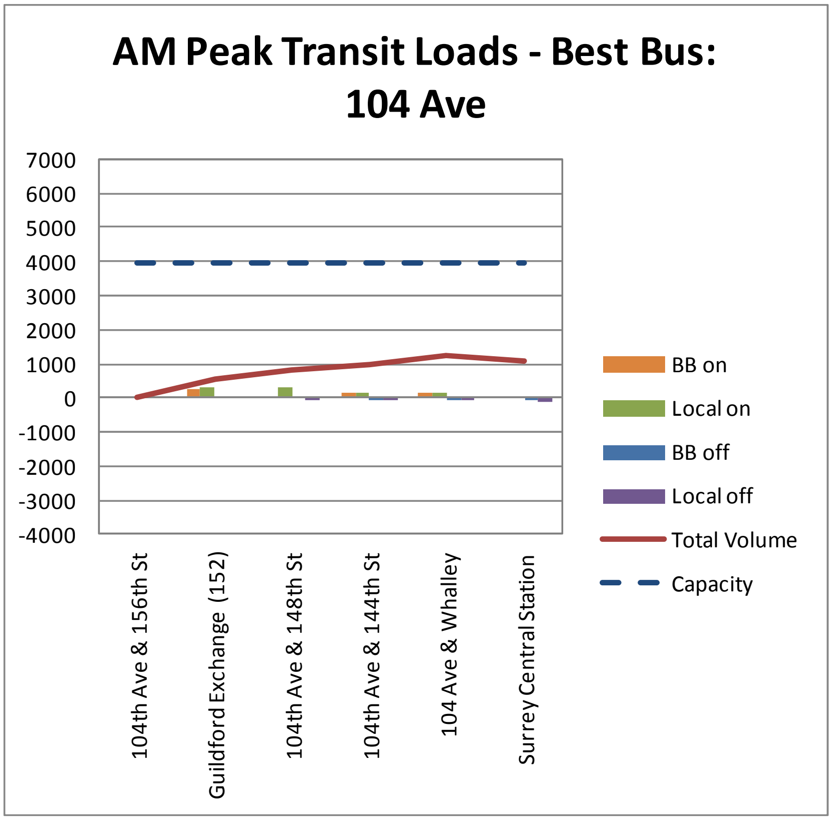
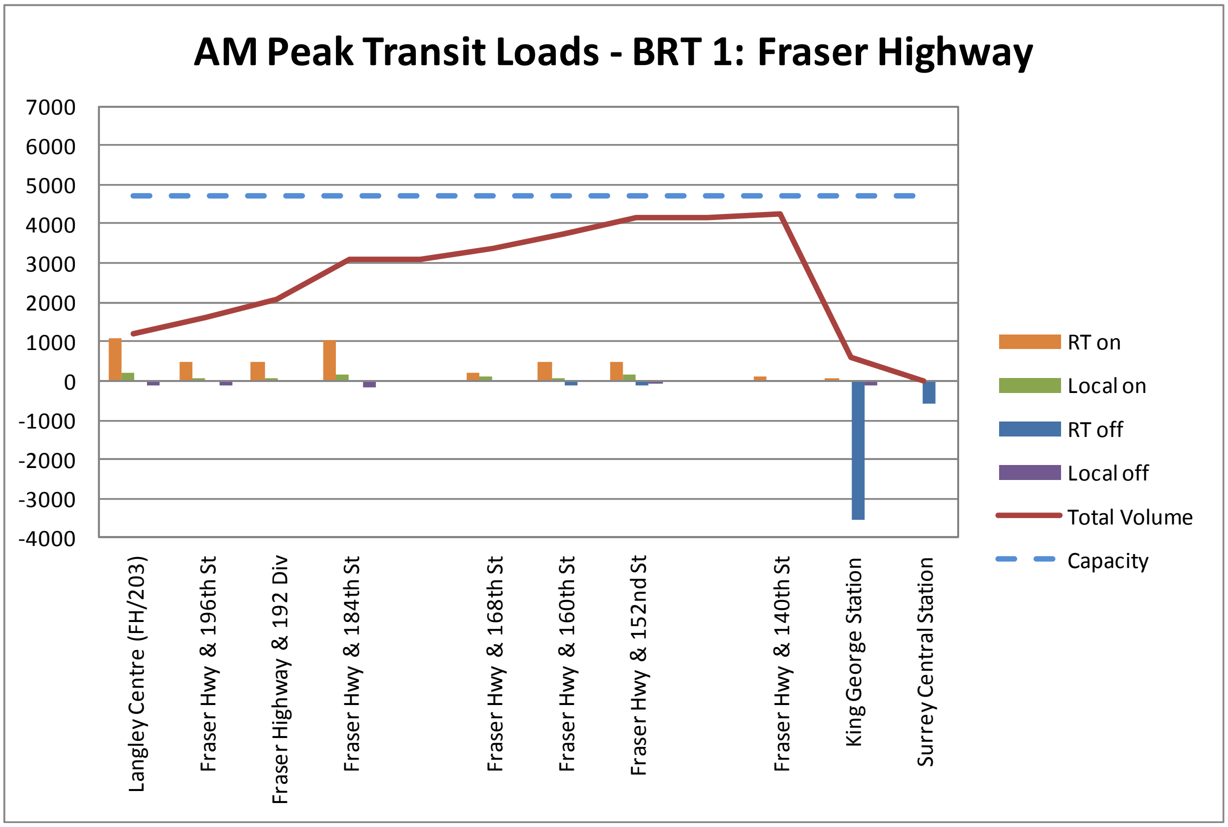
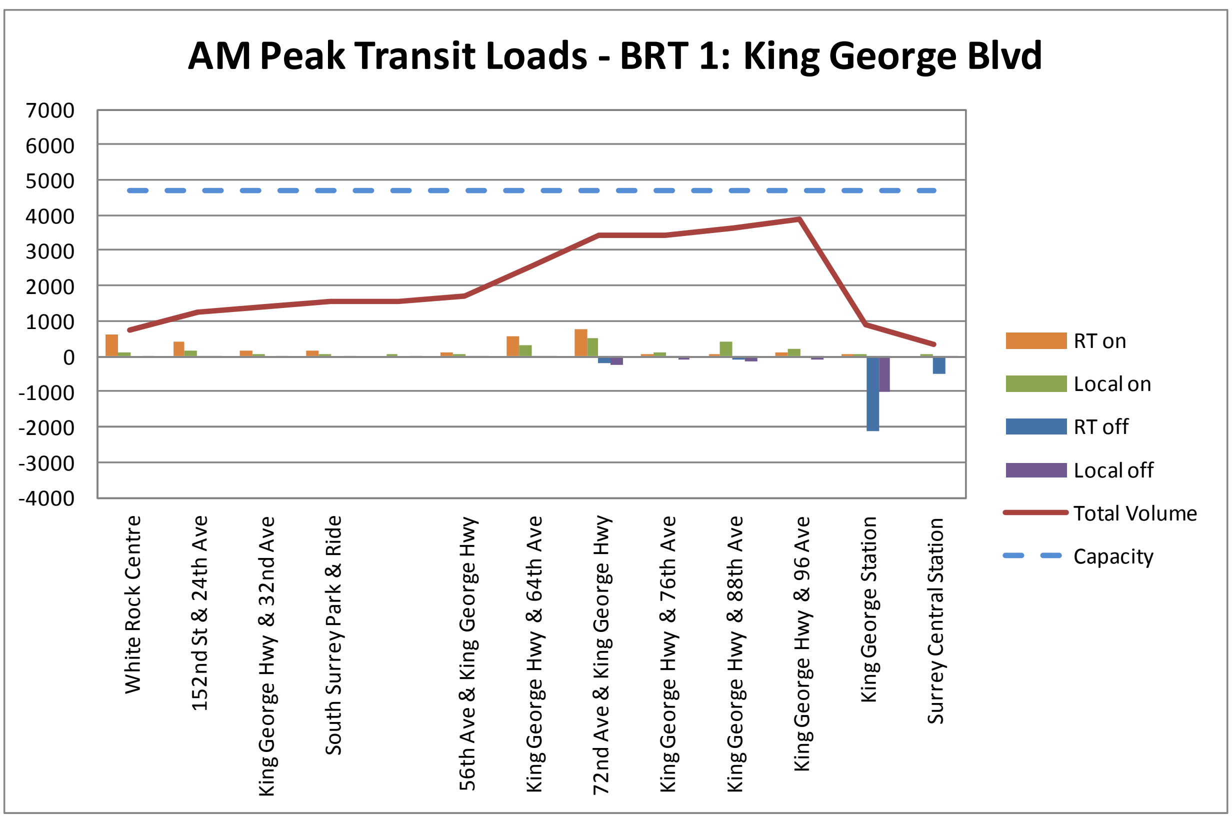

AM Peak Transit Loads - Best Bus: 104 Ave
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
104th Ave & 156th St
Guildford Exchange (152)
104th Ave & 148th St
104th Ave & 144th St
104 Ave & Whalley
Surrey Central Station
BB on
Local on
BB off
Local off
Total Volume
Capacity

Exhibit 3A.20 - 2041 AM Peak Transit Loads – BRT 1





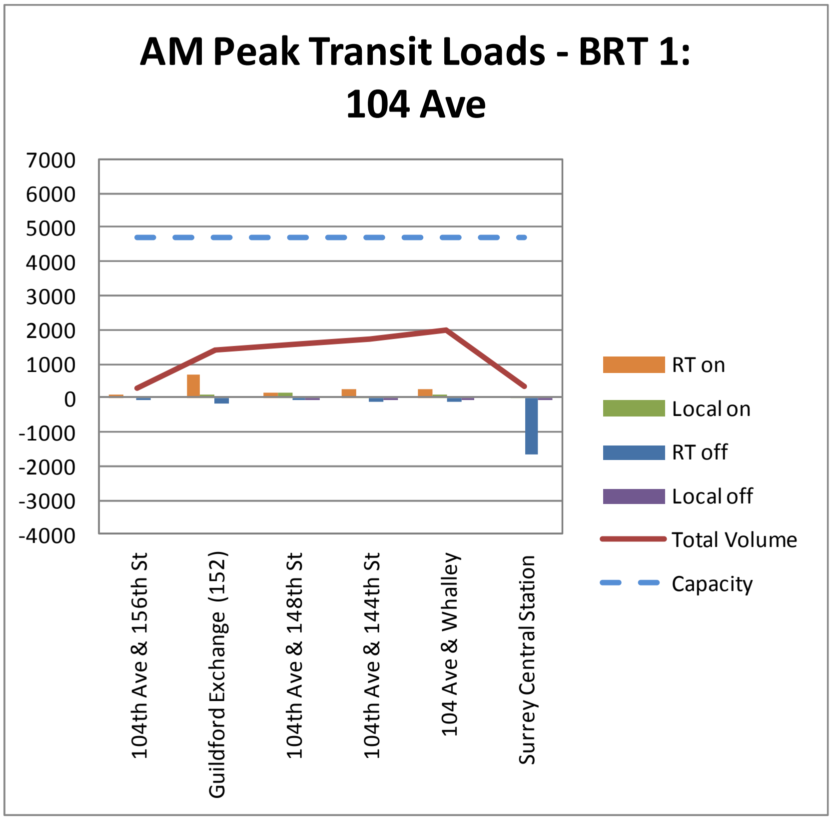
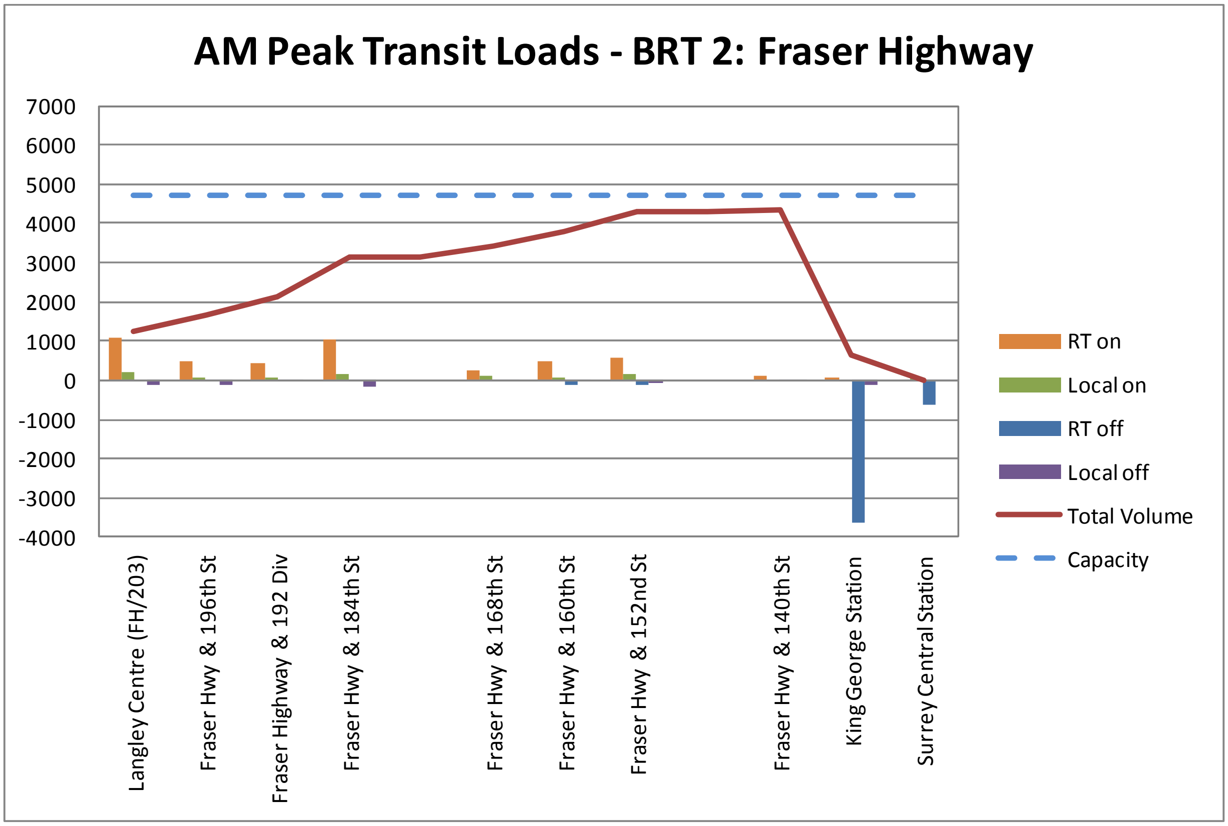
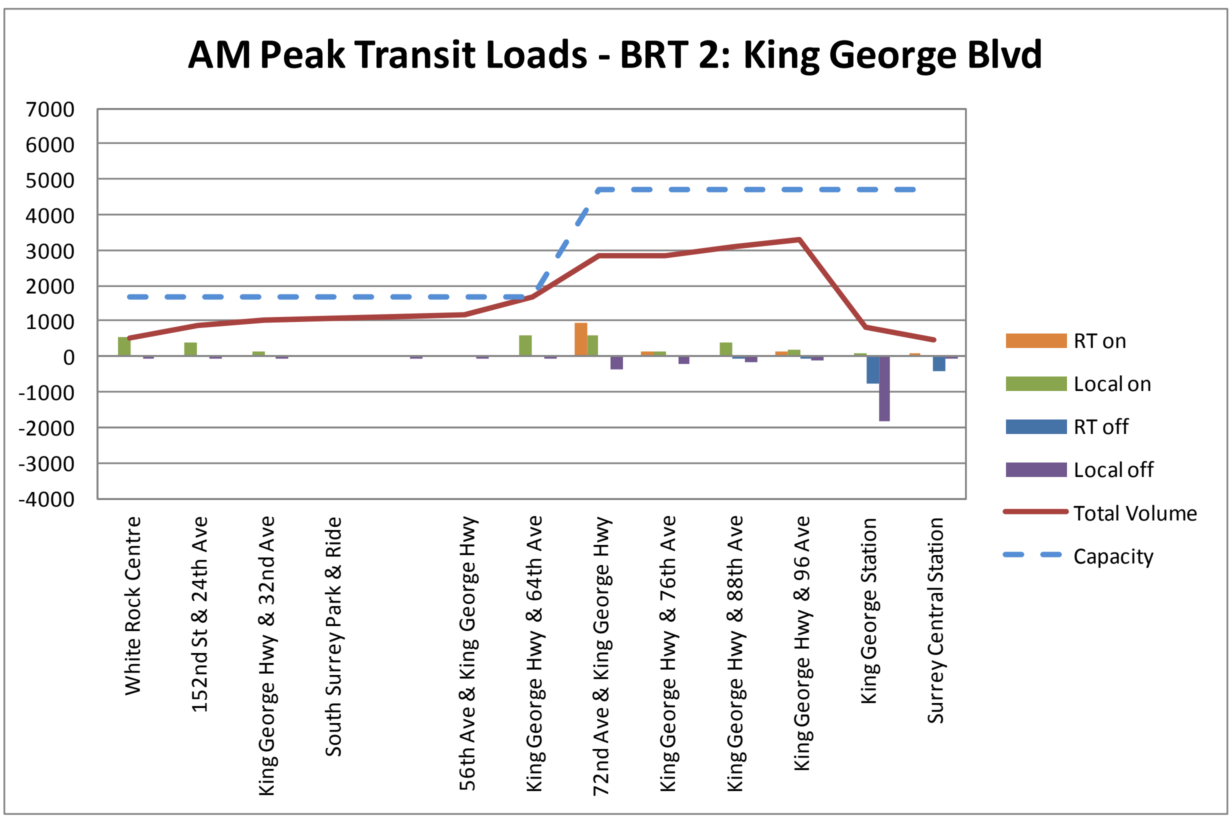

AM Peak Transit Loads - BRT 1:
104 Ave
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
104th Ave & 156th St
Guildford Exchange (152)
104th Ave & 148th St
104th Ave & 144th St
104 Ave & Whalley
Surrey Central Station
RT on
Local on
RT off
Local off
Total Volume
Capacity

Exhibit 3A.21 - 2041 AM Peak Transit Loads – BRT 2





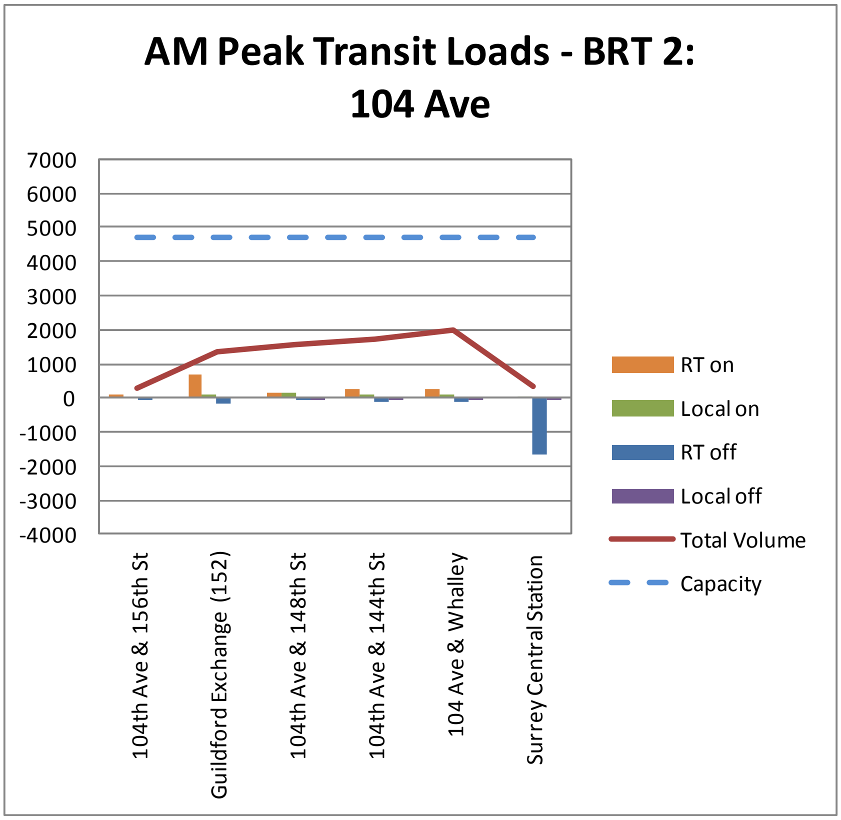
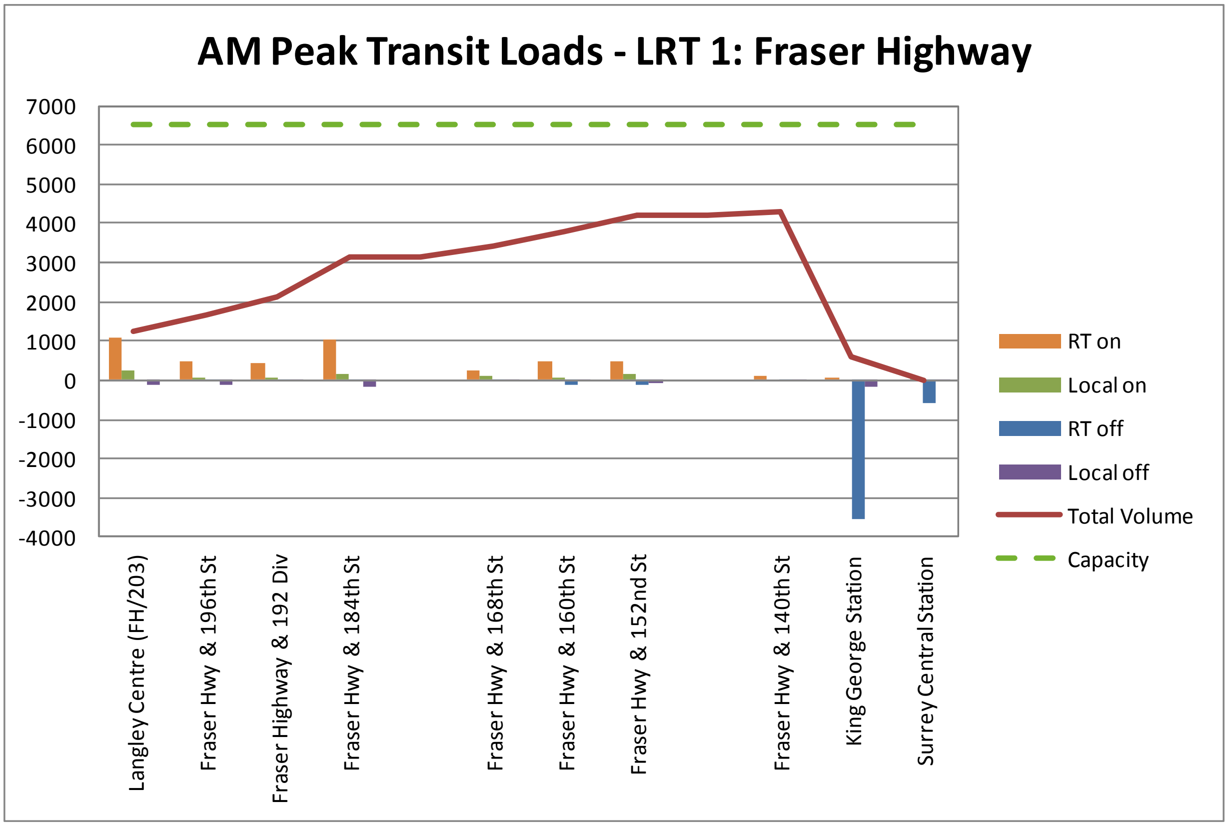
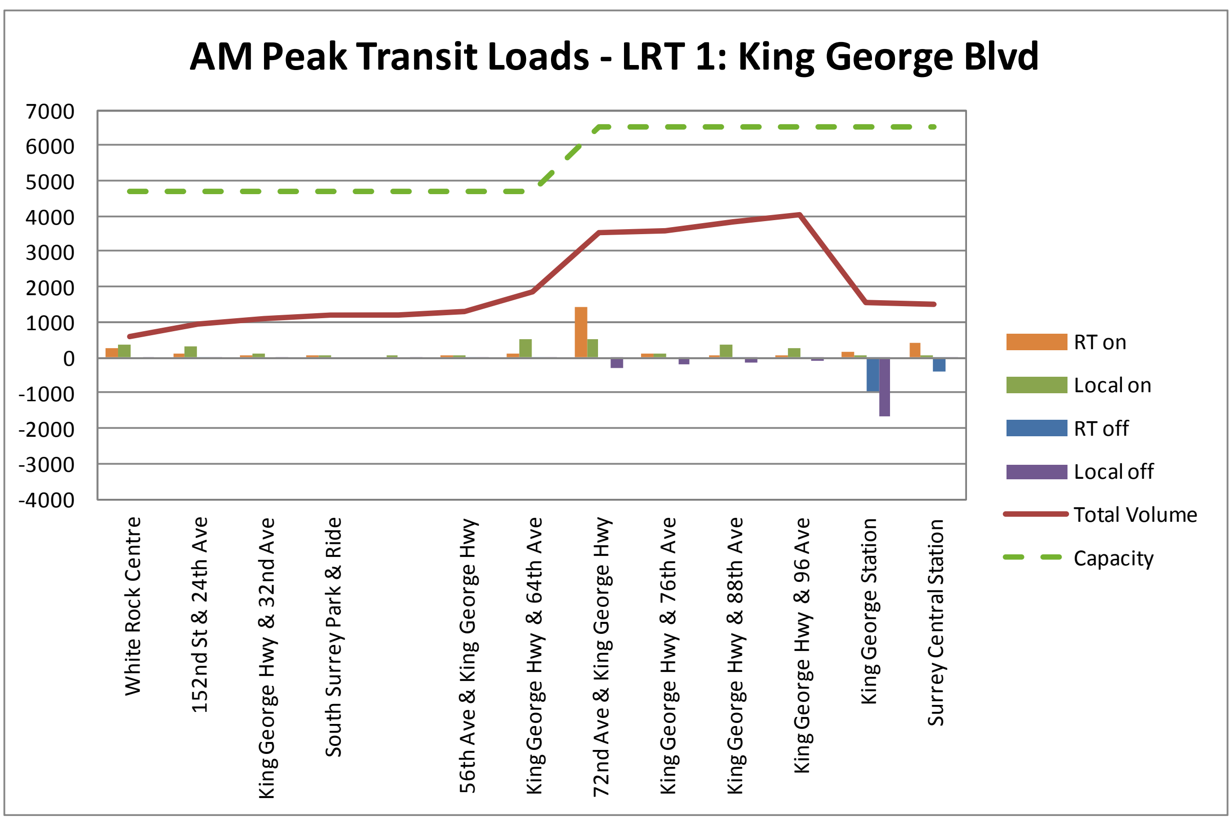

AM Peak Transit Loads - BRT 2: 104 Ave
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
104th Ave & 156th St
Guildford Exchange (152)
104th Ave & 148th St
104th Ave & 144th St
104 Ave & Whalley
Surrey Central Station
RT on
Local on
RT off
Local off
Total Volume
Capacity

Exhibit 3A.22 - 2041 AM Peak Transit Loads – LRT 1





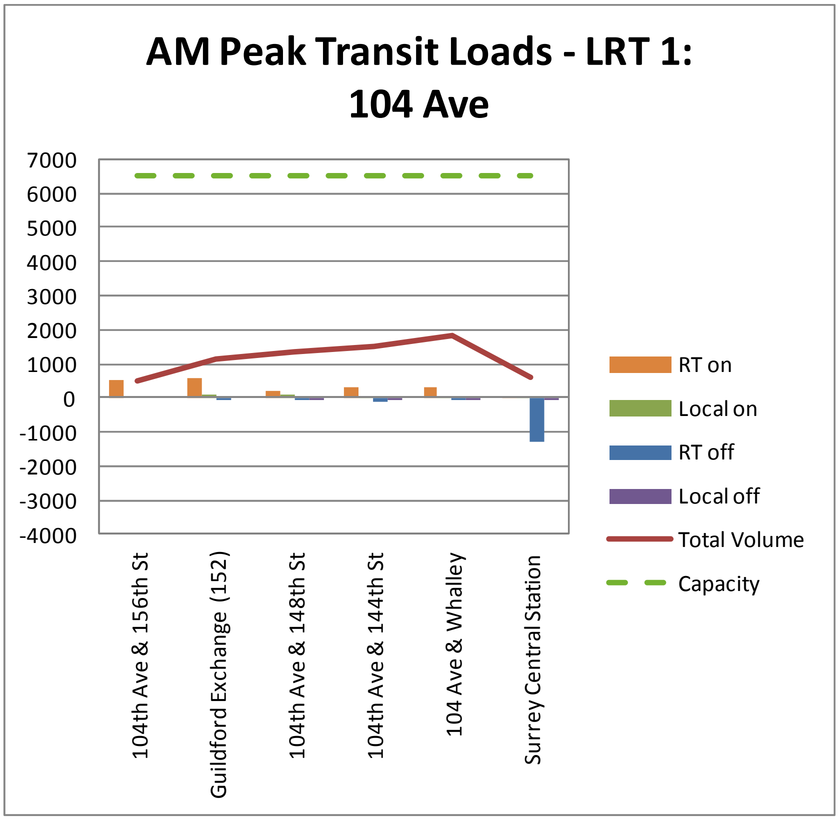
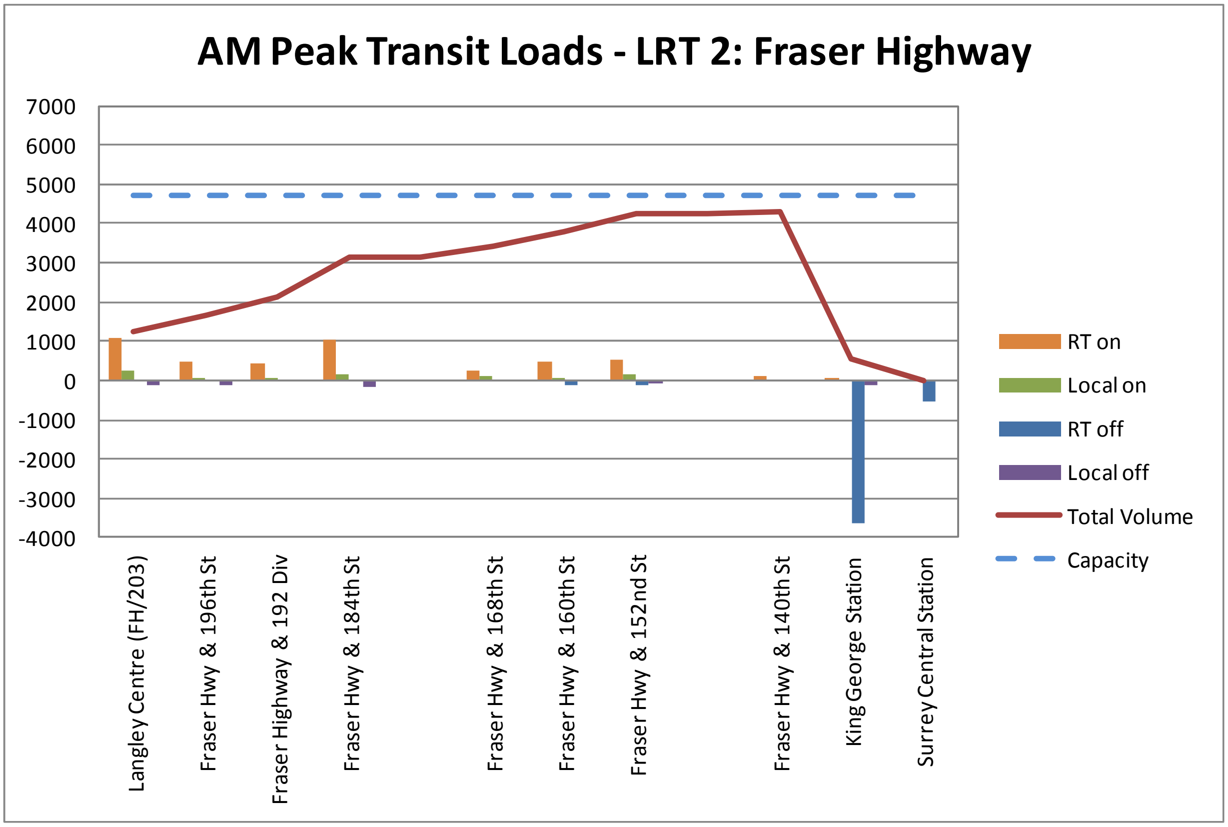
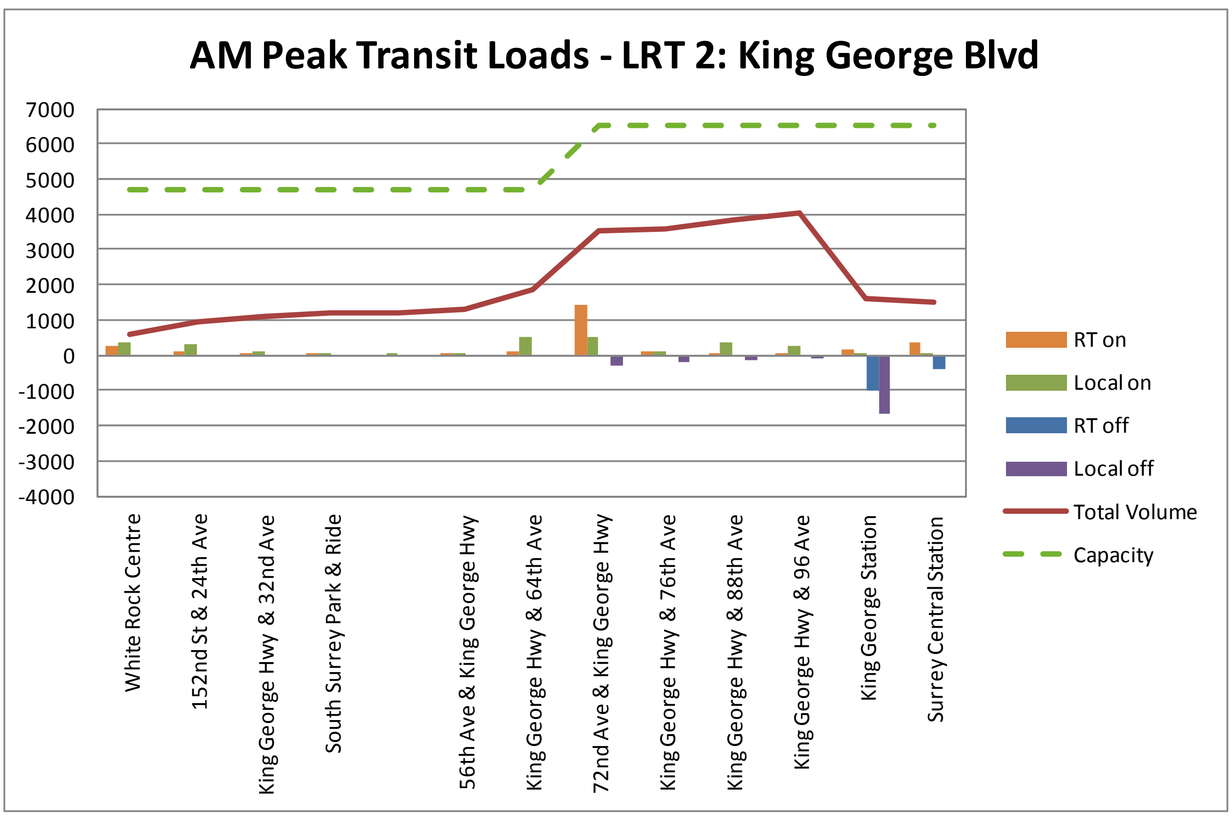

AM Peak Transit Loads - LRT 1:
104 Ave
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
104th Ave & 156th St
Guildford Exchange (152)
104th Ave & 148th St
104th Ave & 144th St
104 Ave & Whalley
Surrey Central Station
RT on
Local on
RT off
Local off
Total Volume
Capacity

Exhibit 3A.23 - 2041 AM Peak Transit Loads – LRT 2





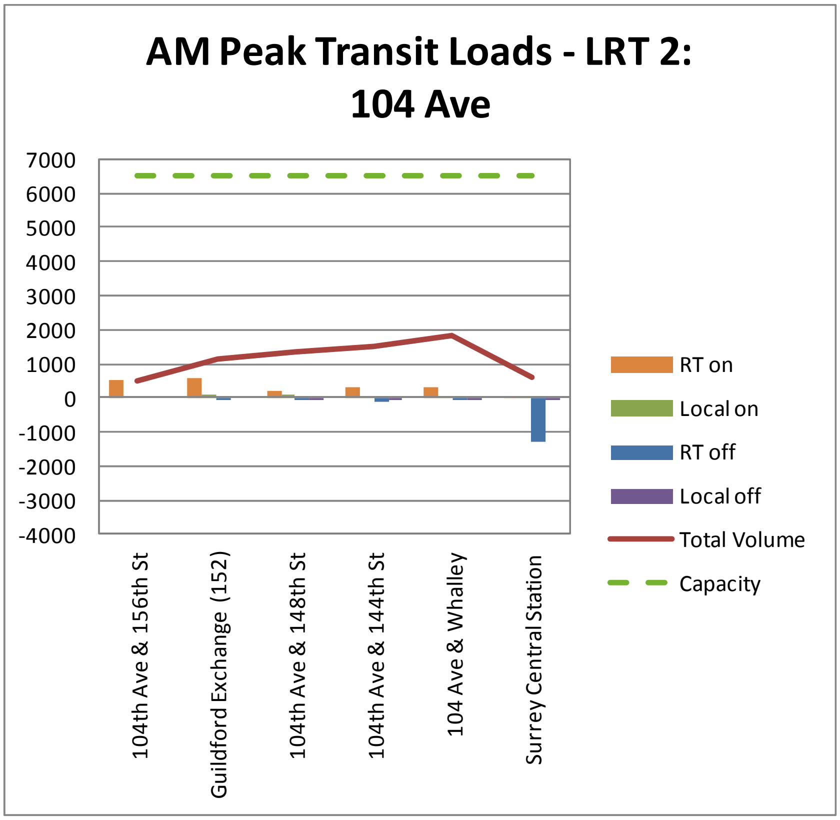
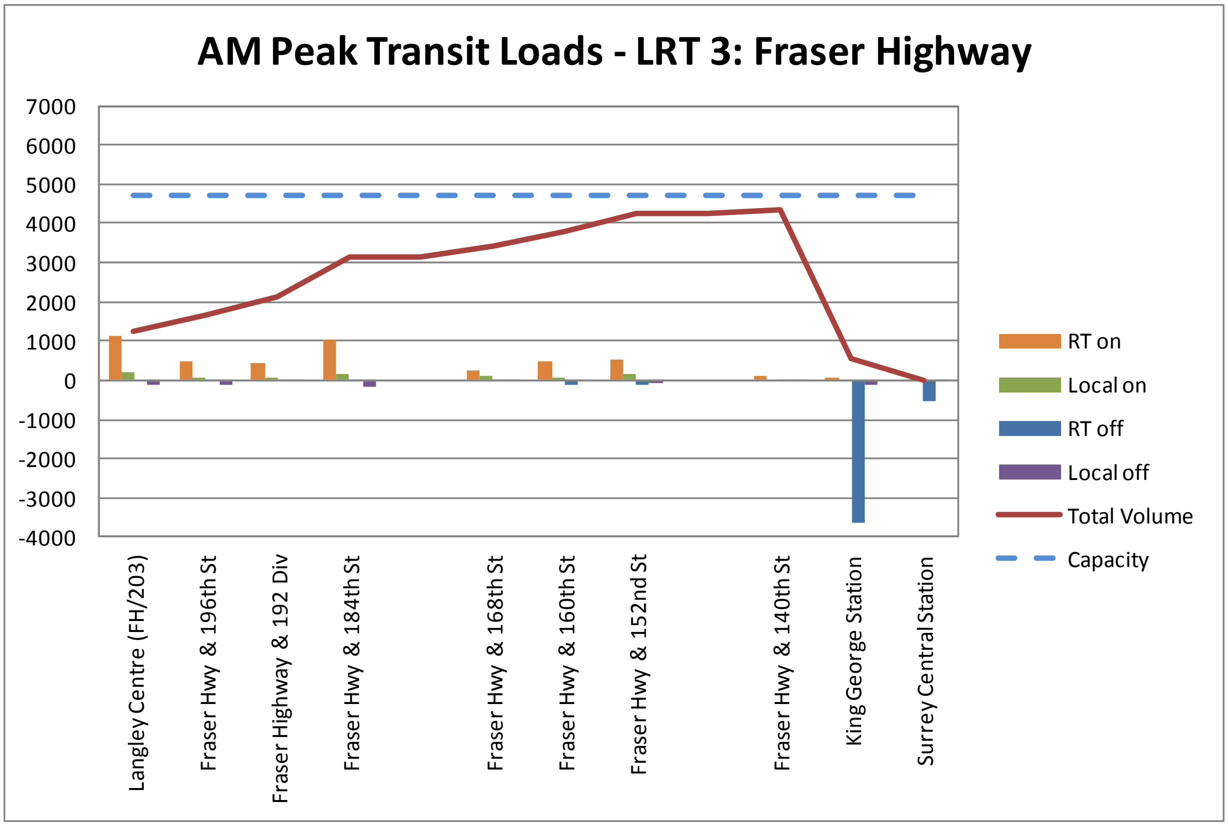
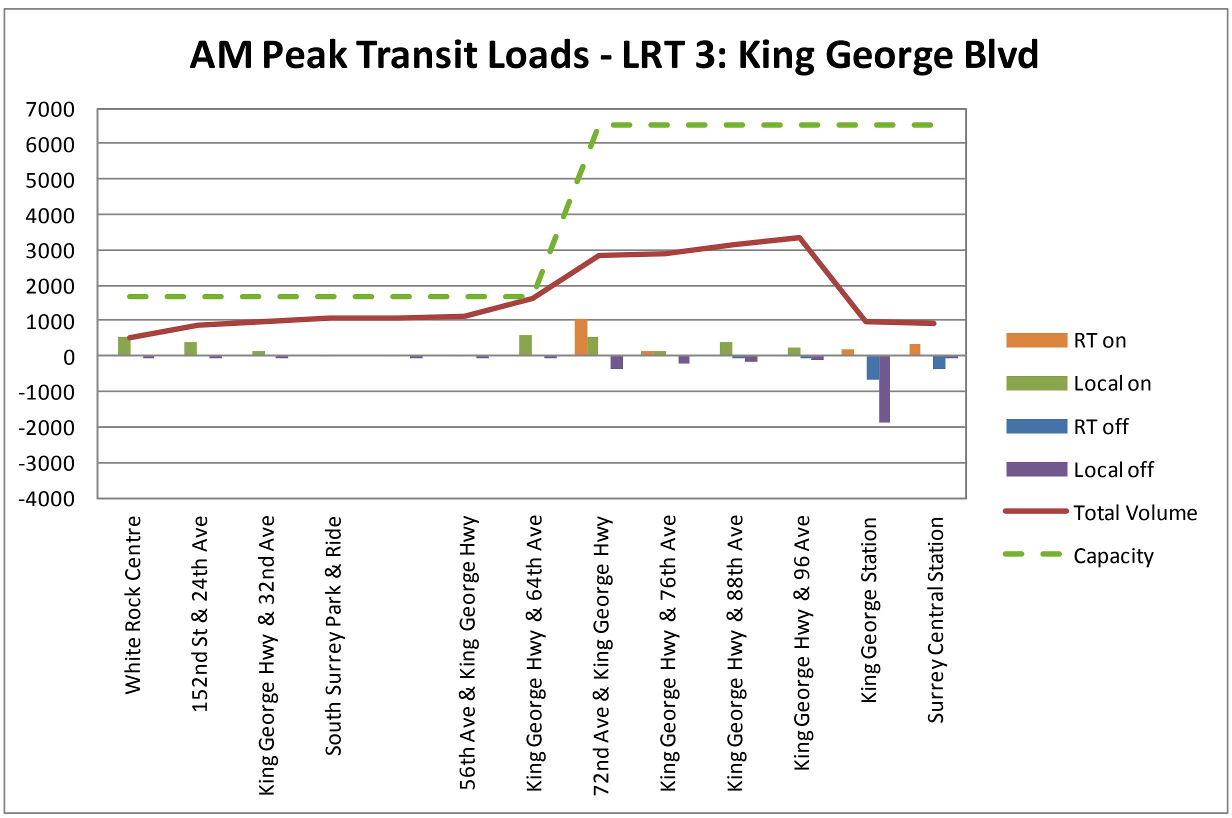

AM Peak Transit Loads - LRT 2:
104 Ave
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
104th Ave & 156th St
Guildford Exchange (152)
104th Ave & 148th St
104th Ave & 144th St
104 Ave & Whalley
Surrey Central Station
RT on
Local on
RT off
Local off
Total Volume
Capacity

Exhibit 3A.24 - 2041 AM Peak Transit Loads – LRT 3





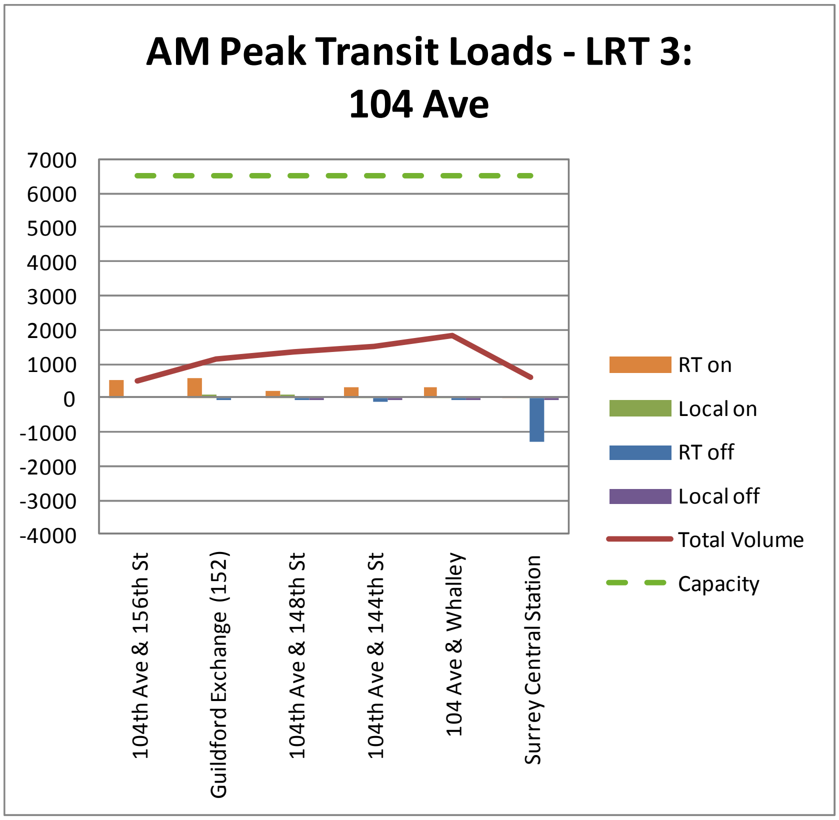
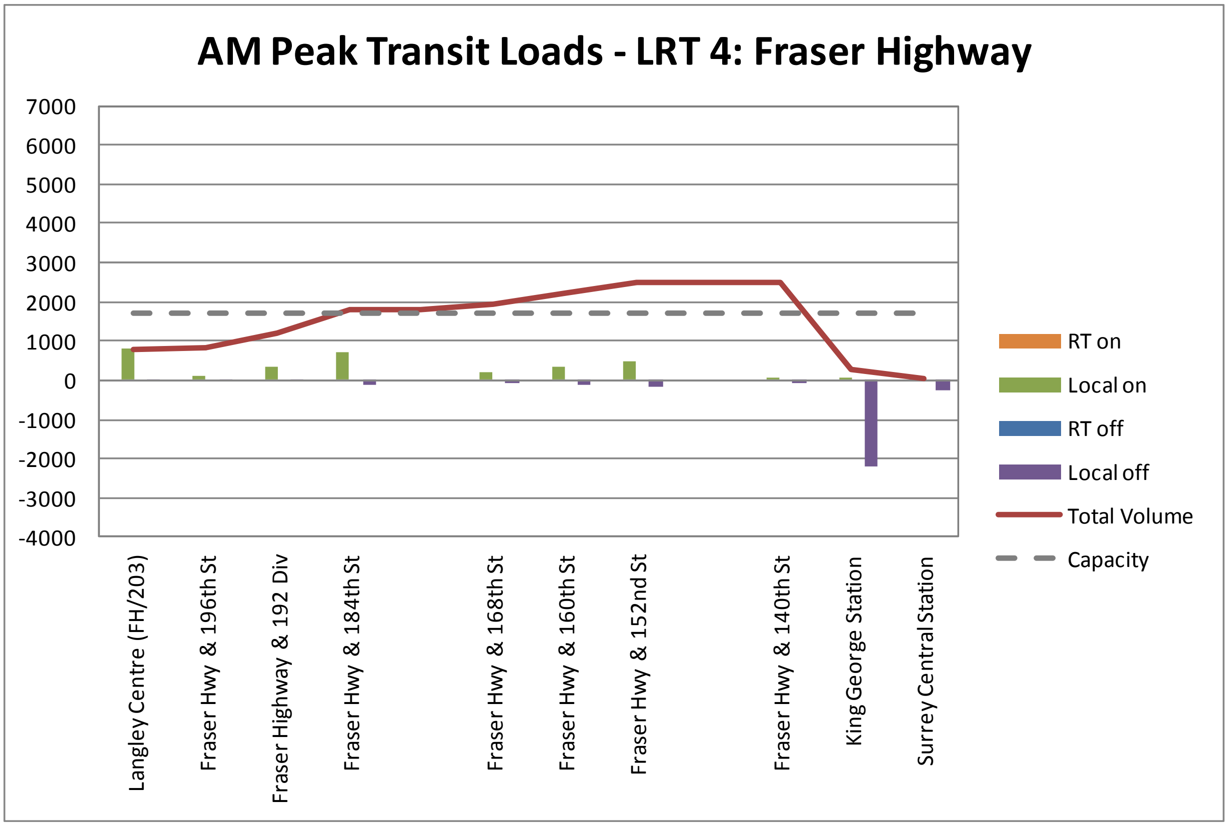
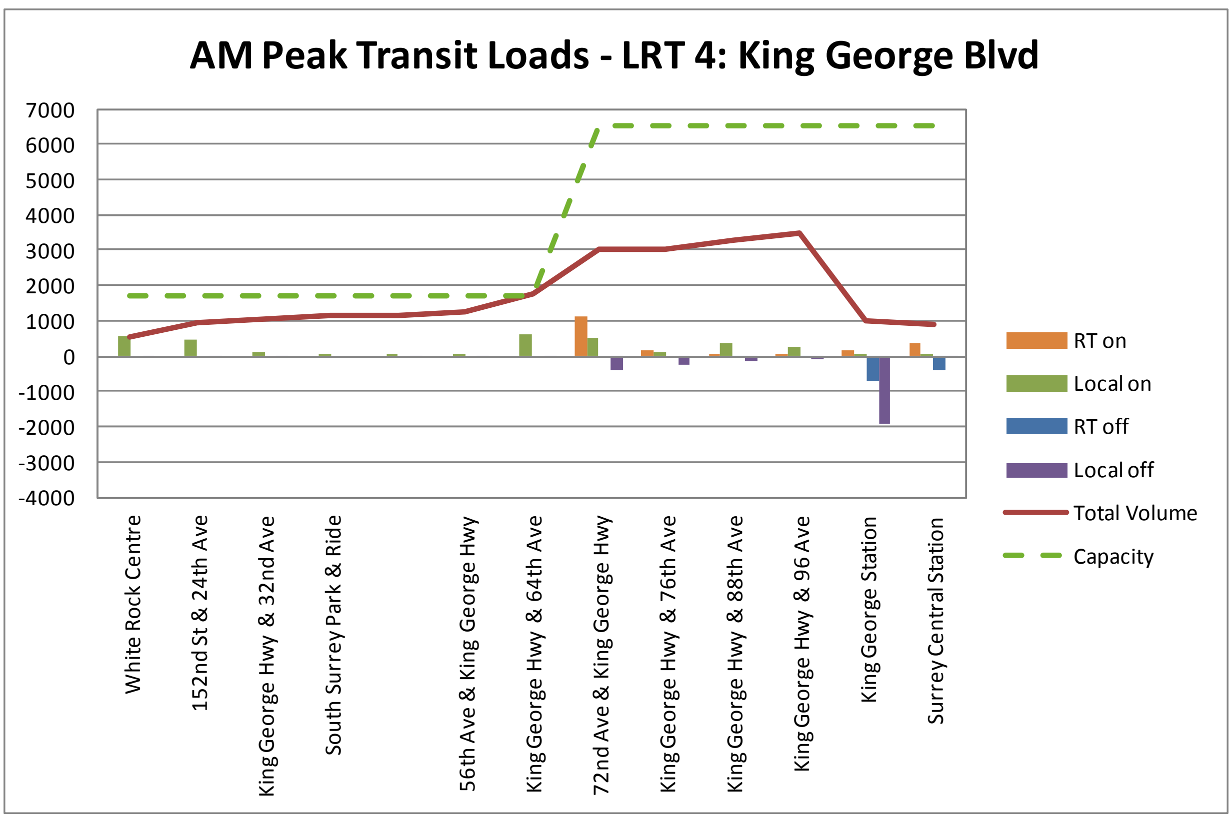

AM Peak Transit Loads - LRT 3: 104 Ave
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
104th Ave & 156th St
Guildford Exchange (152)
104th Ave & 148th St
104th Ave & 144th St
104 Ave & Whalley
Surrey Central Station
RT on
Local on
RT off
Local off
Total Volume
Capacity

Exhibit 3A.25 - 2041 AM Peak Transit Loads – LRT 4





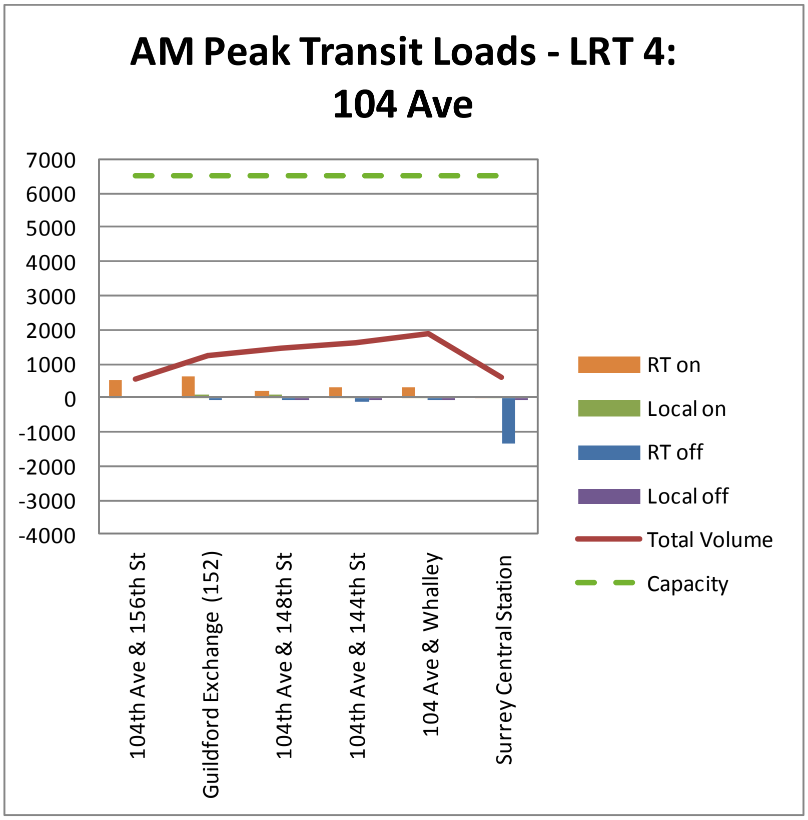
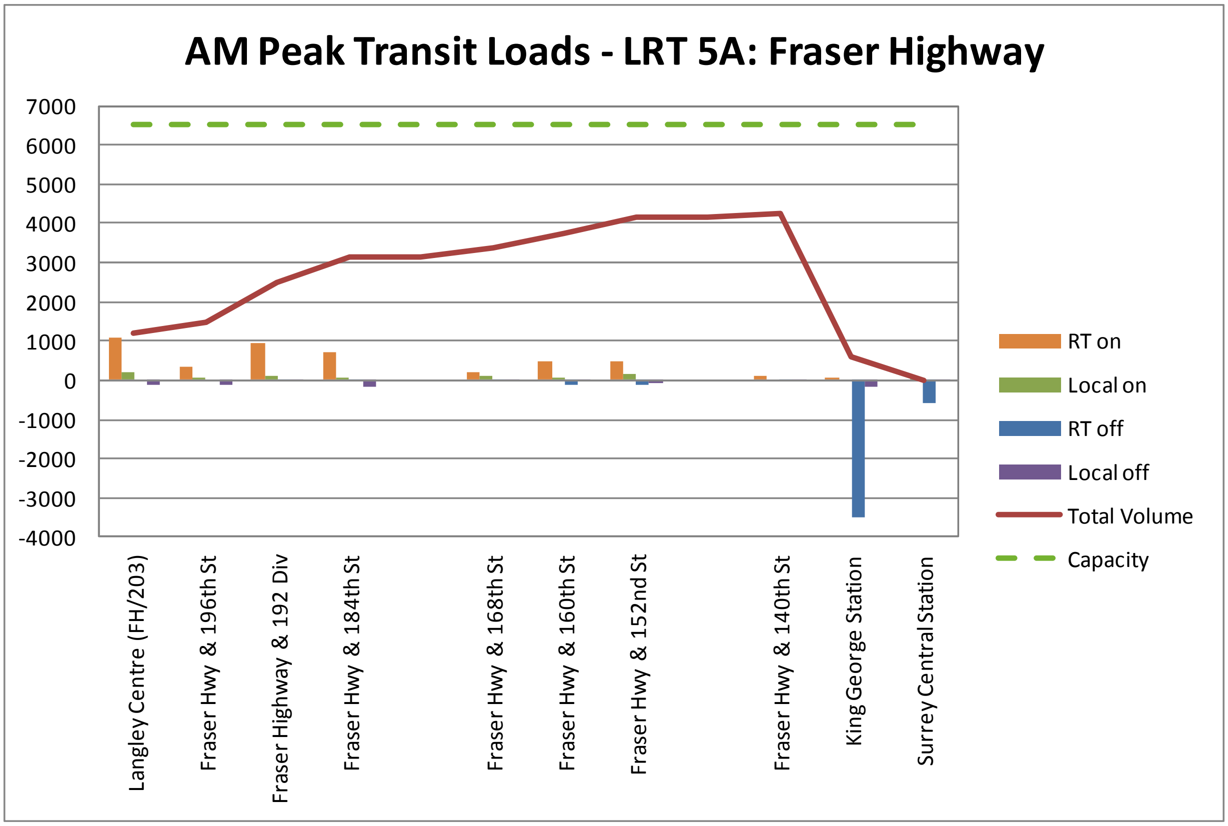
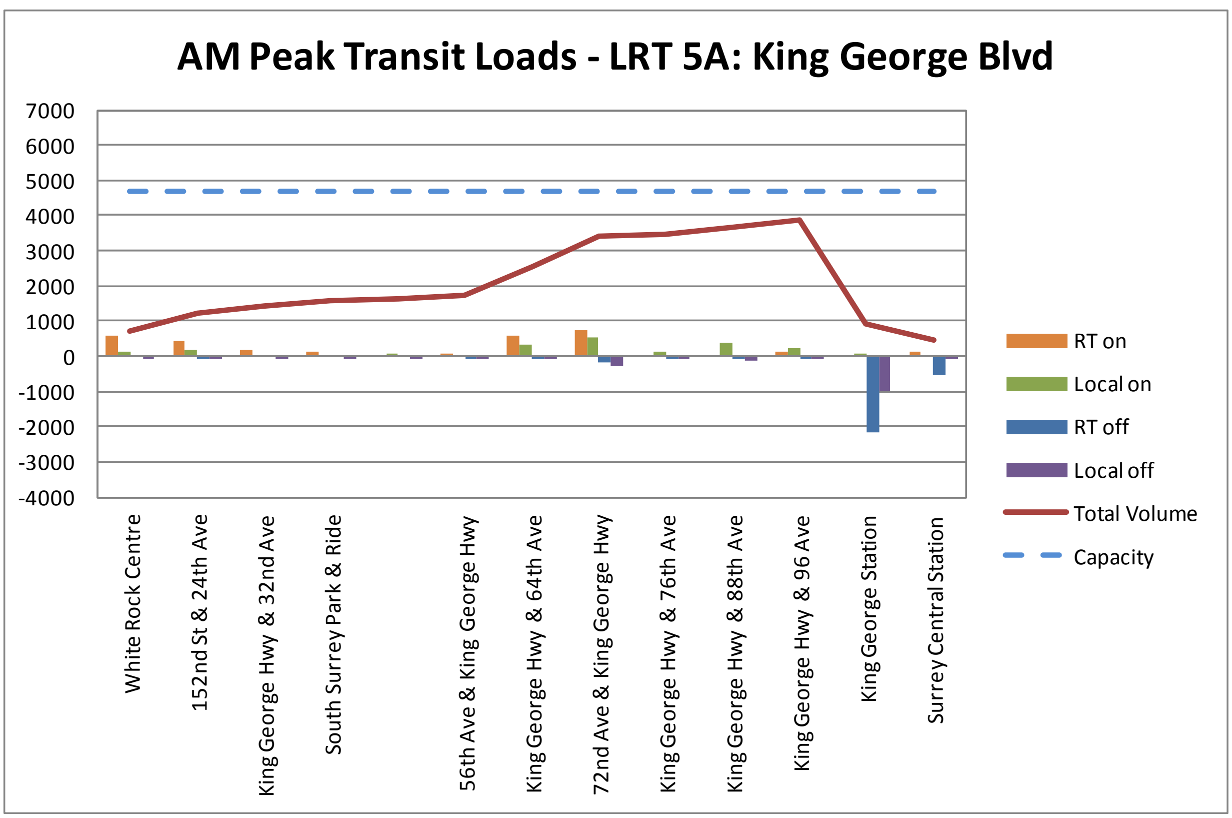

AM Peak Transit Loads - LRT 4:
104 Ave
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
104th Ave & 156th St
Guildford Exchange (152)
104th Ave & 148th St
104th Ave & 144th St
104 Ave & Whalley
Surrey Central Station
RT on
Local on
RT off
Local off
Total Volume
Capacity

Exhibit 3A.26 - 2041 AM Peak Transit Loads – LRT 5A





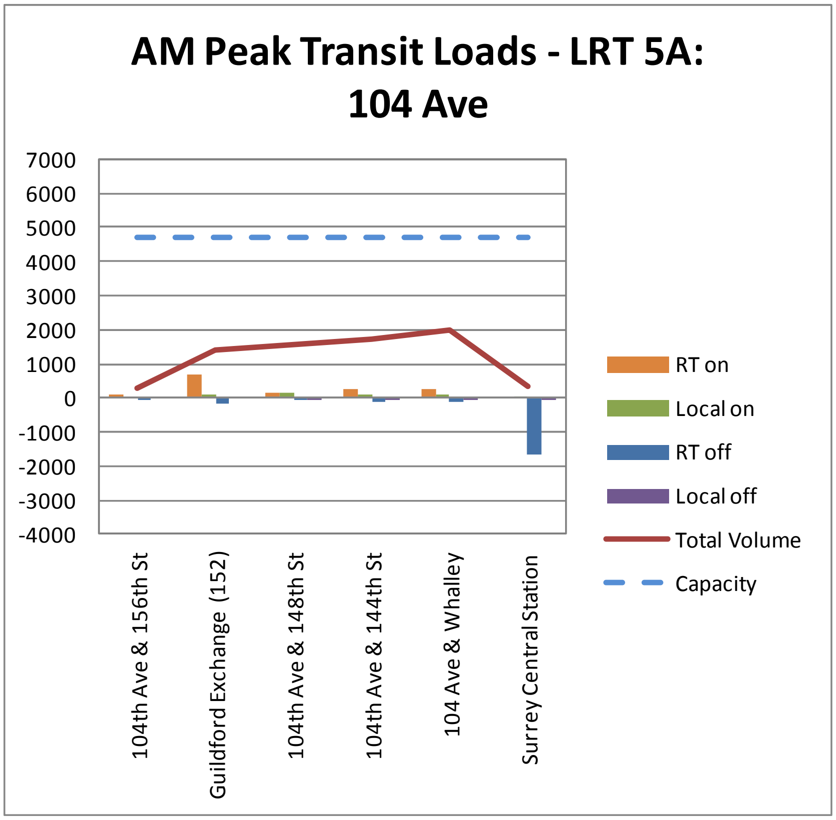
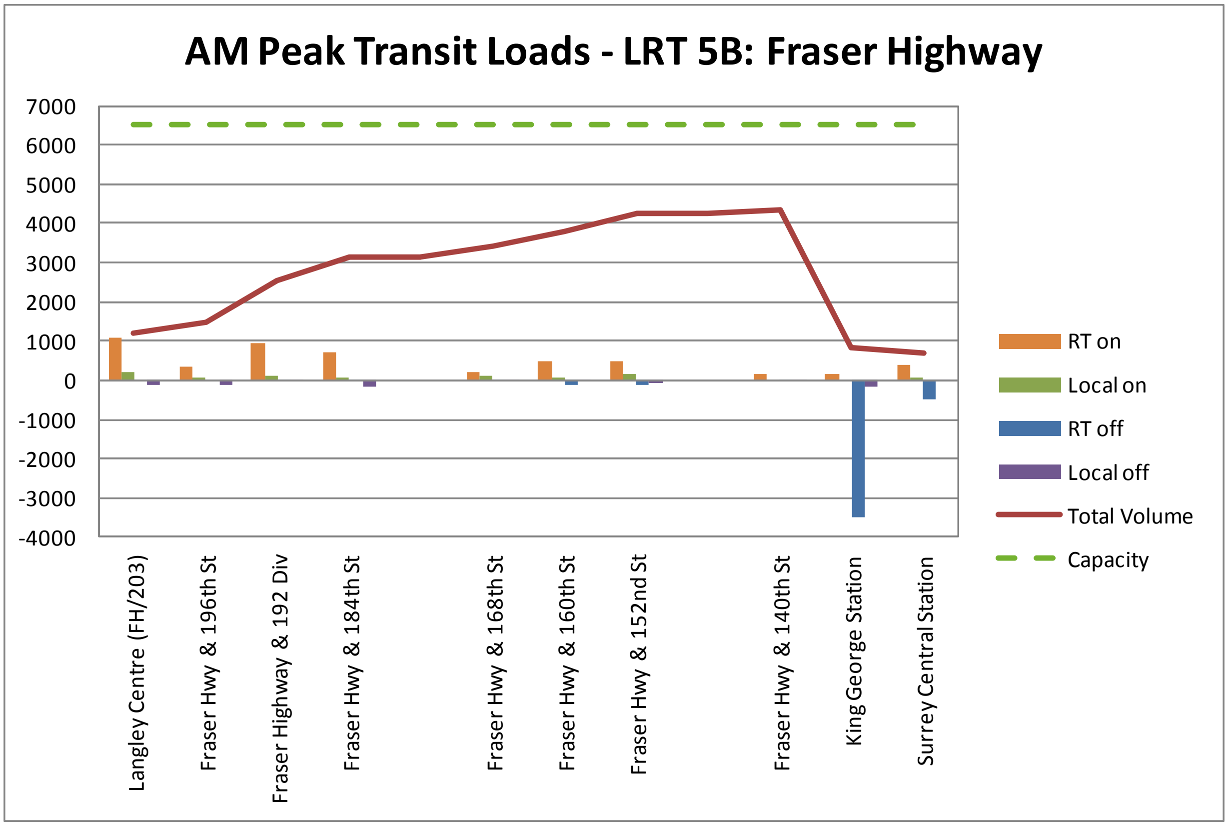
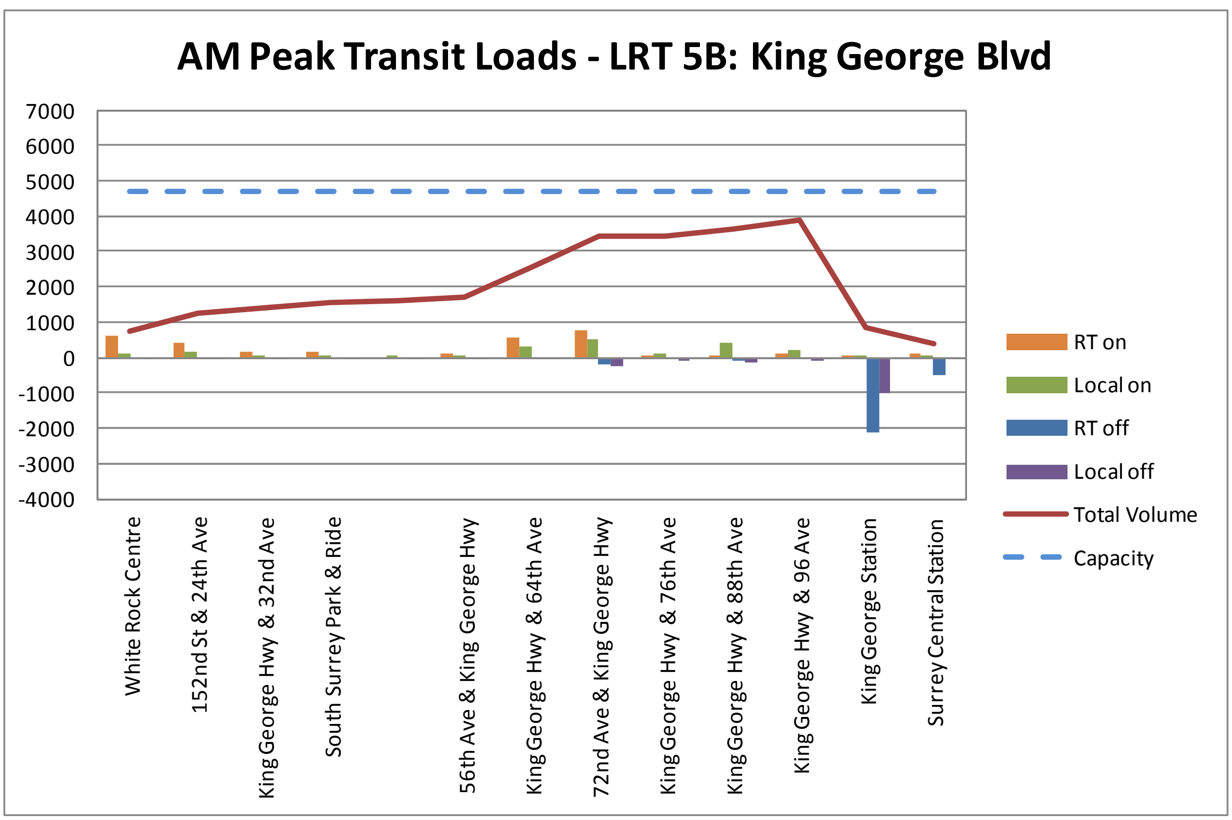

AM Peak Transit Loads - LRT 5A:
104 Ave
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
104th Ave & 156th St
Guildford Exchange (152)
104th Ave & 148th St
104th Ave & 144th St
104 Ave & Whalley
Surrey Central Station
RT on
Local on
RT off
Local off
Total Volume
Capacity

Exhibit 3A.27 - 2041 AM Peak Transit Loads – LRT 5B





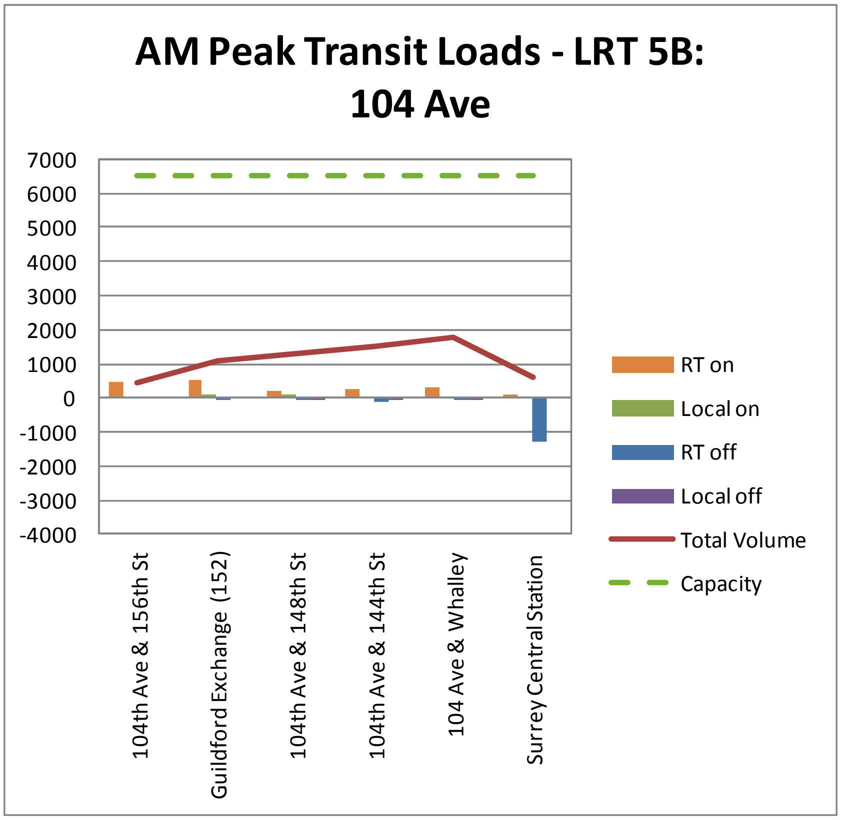
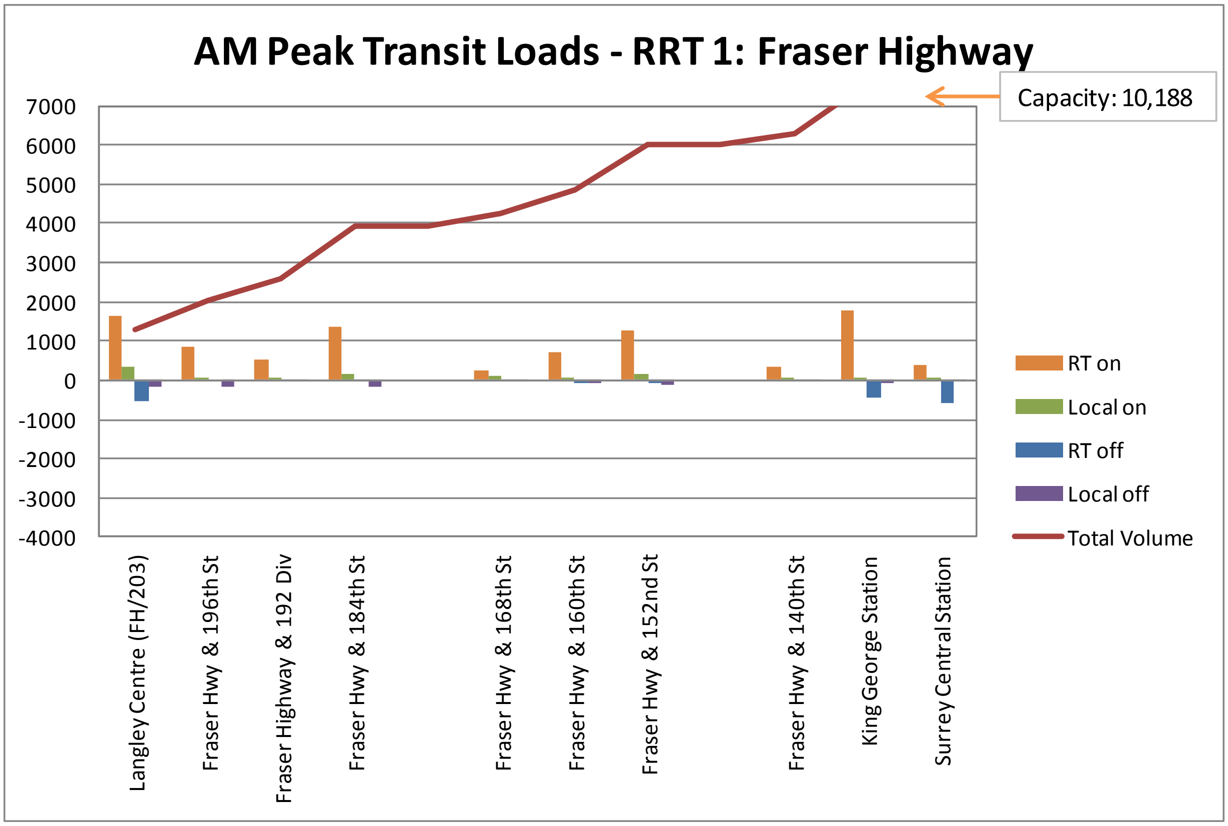
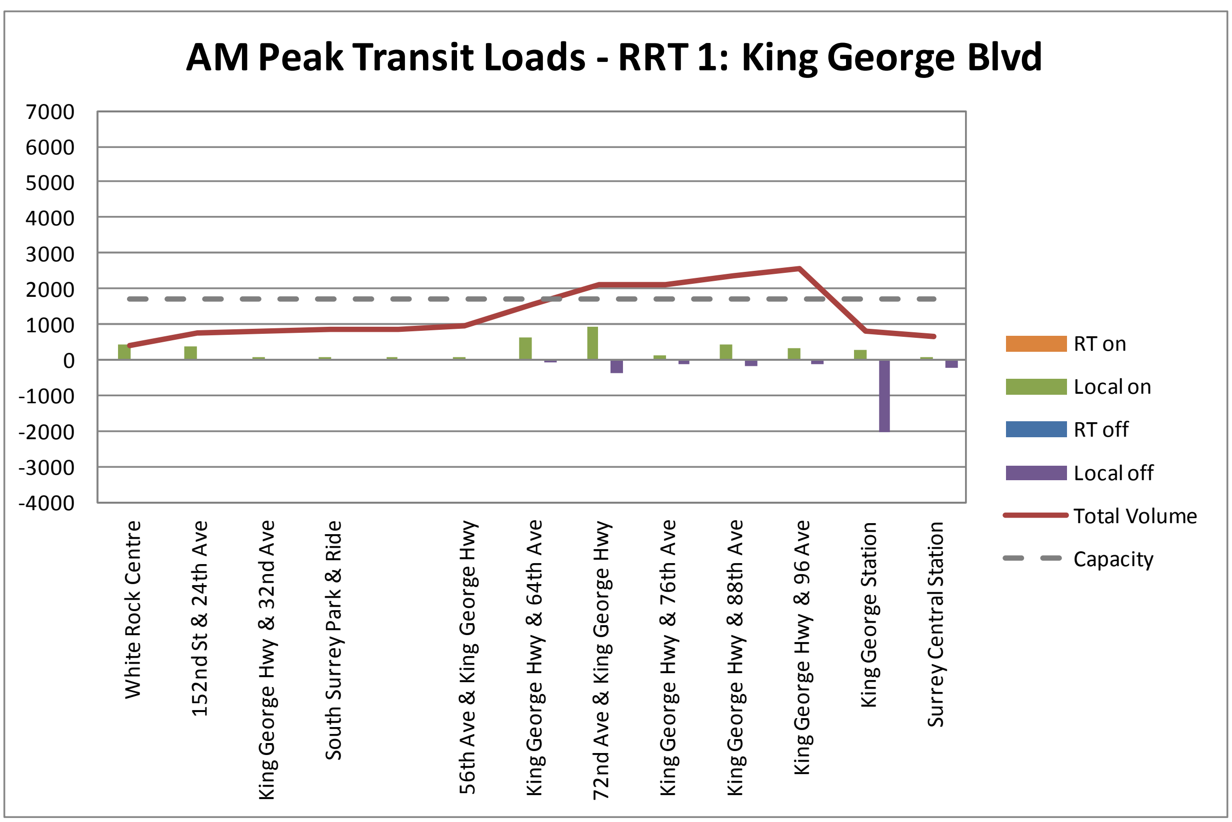

AM Peak Transit Loads - LRT 5B: 104 Ave
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
104th Ave & 156th St
Guildford Exchange (152)
104th Ave & 148th St
104th Ave & 144th St
104 Ave & Whalley
Surrey Central Station
RT on
Local on
RT off
Local off
Total Volume
Capacity

Exhibit 3A.28 - 2041 AM Peak Transit Loads –RRT 1





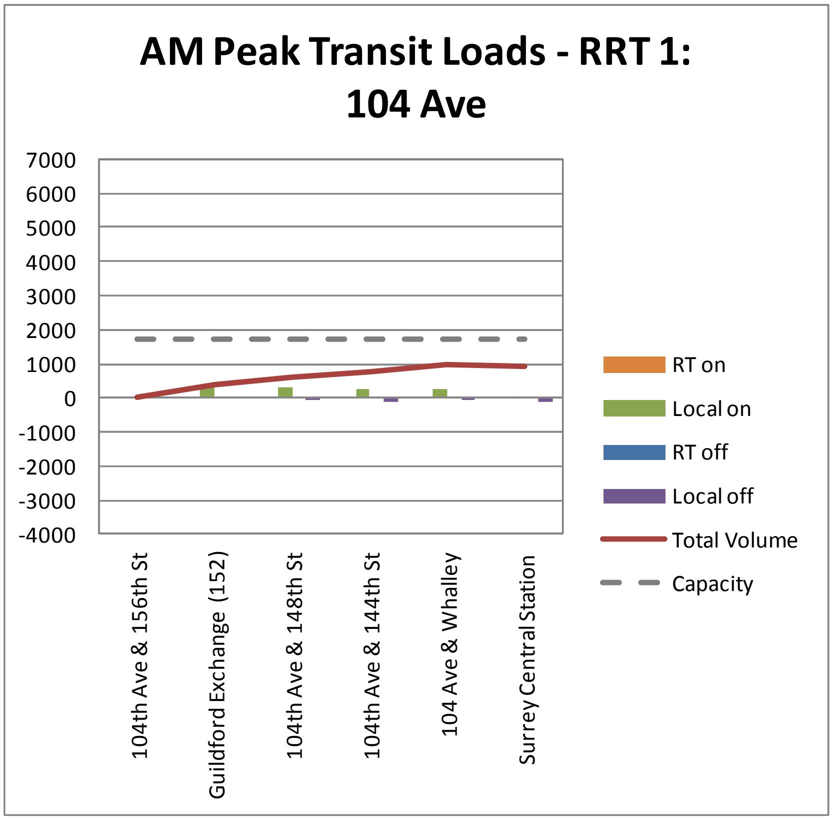
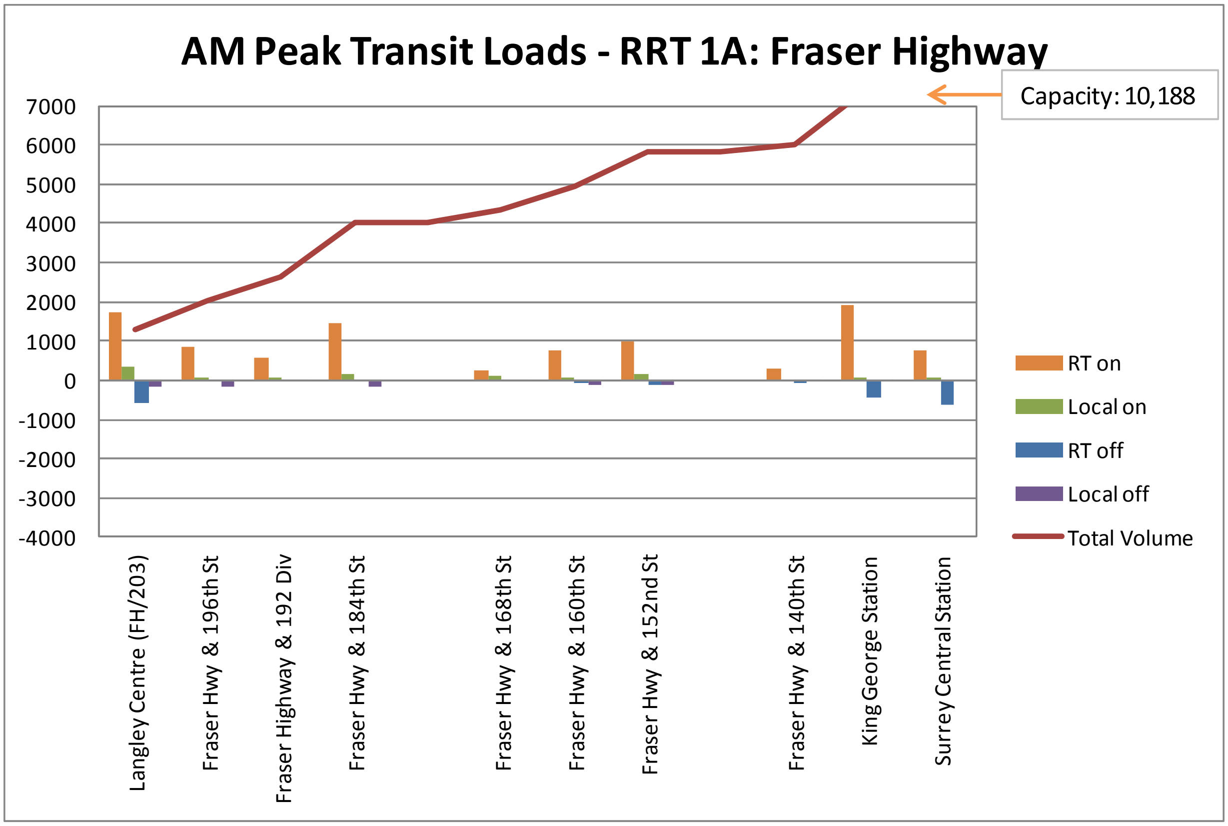
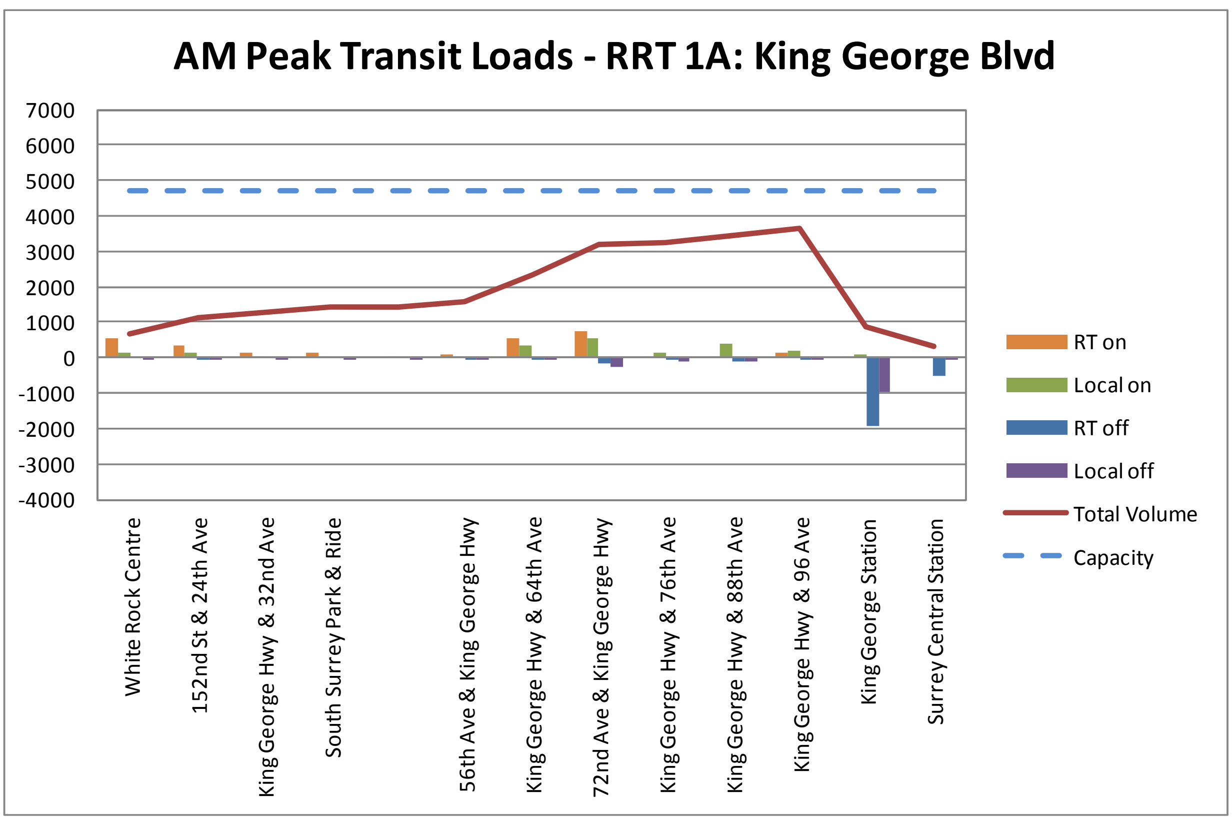

AM Peak Transit Loads - RRT 1:
104 Ave
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
104th Ave & 156th St
Guildford Exchange (152)
104th Ave & 148th St
104th Ave & 144th St
104 Ave & Whalley
Surrey Central Station
RT on
Local on
RT off
Local off
Total Volume
Capacity

Exhibit 3A.29 - 2041 AM Peak Transit Loads – RRT 1A





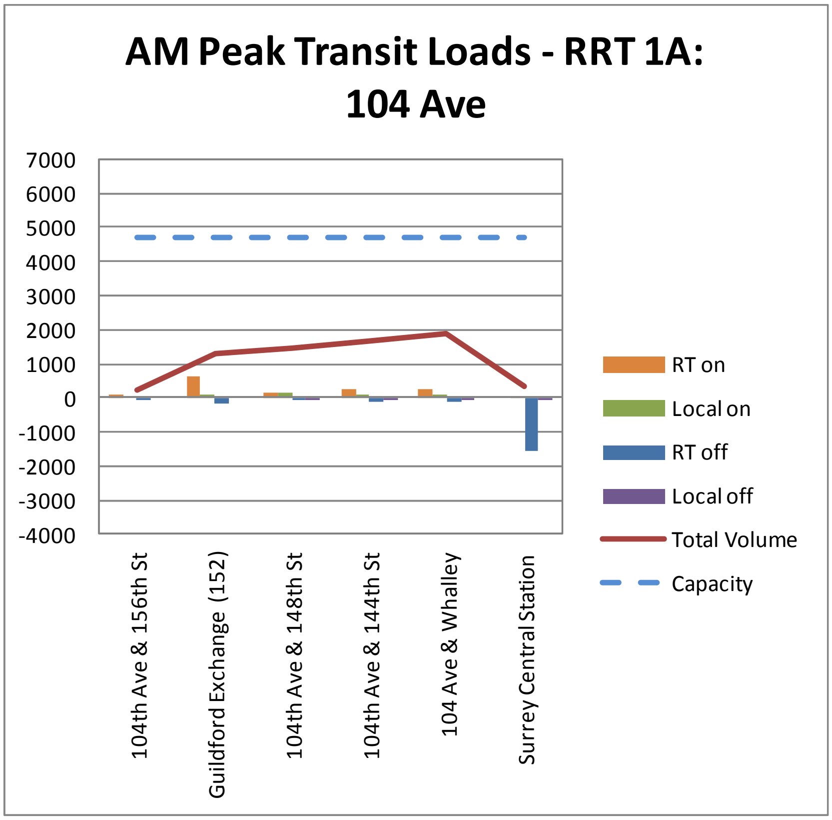
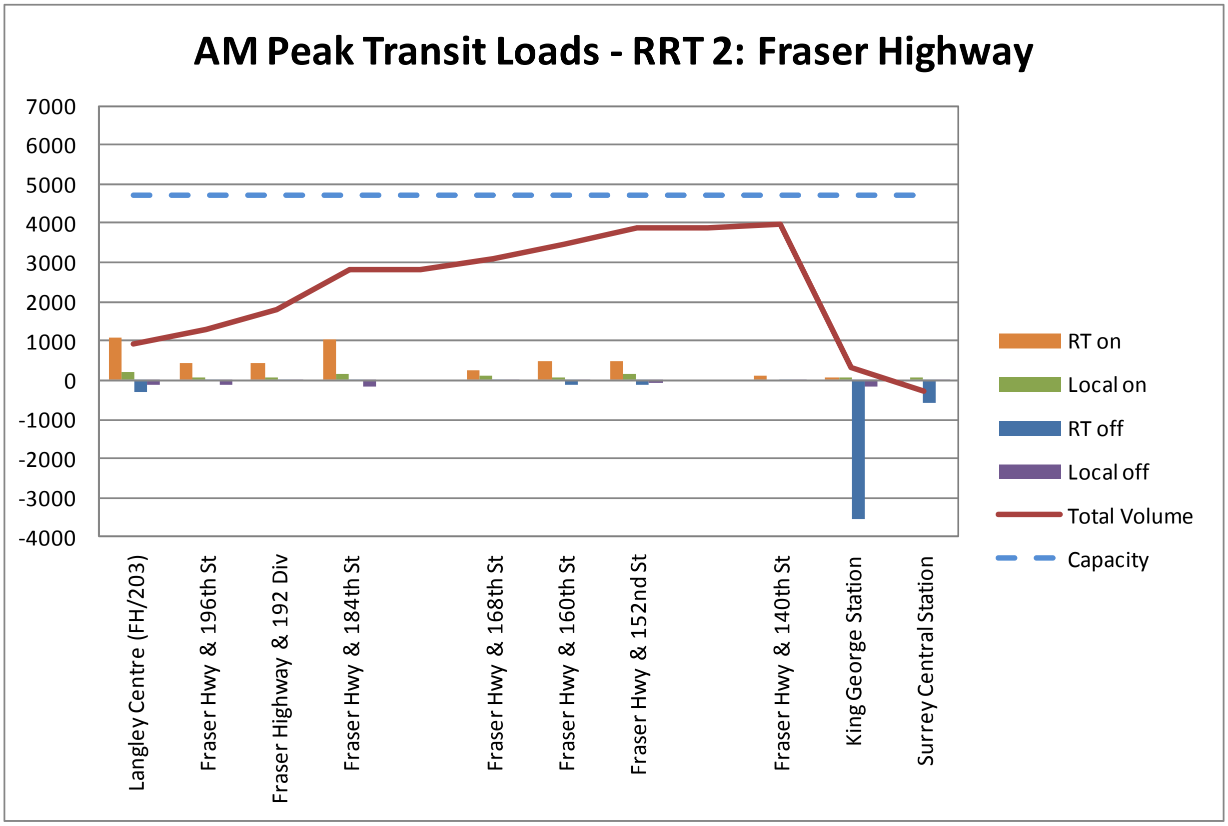
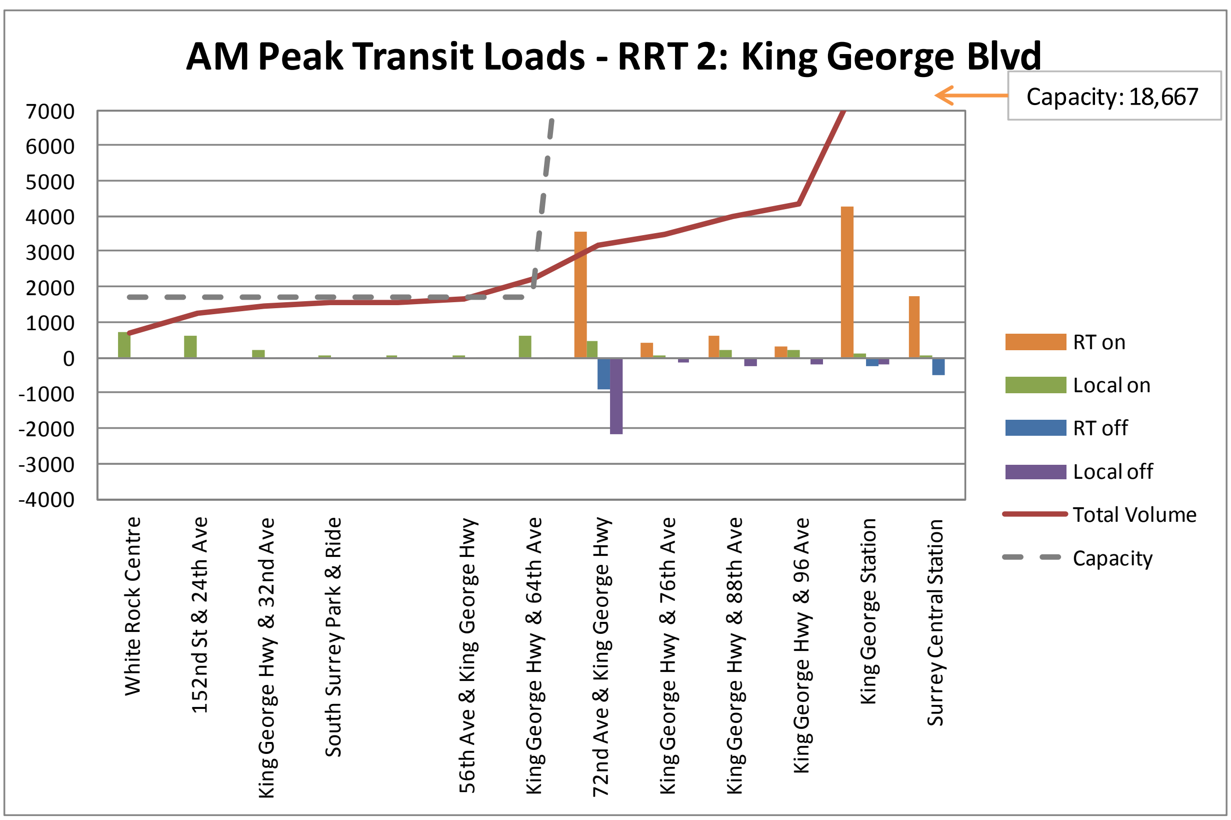

AM Peak Transit Loads - RRT 1A: 104 Ave
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
104th Ave & 156th St
Guildford Exchange (152)
104th Ave & 148th St
104th Ave & 144th St
104 Ave & Whalley
Surrey Central Station
RT on
Local on
RT off
Local off
Total Volume
Capacity

Exhibit 3A.30 - 2041 AM Peak Transit Loads – RRT 2





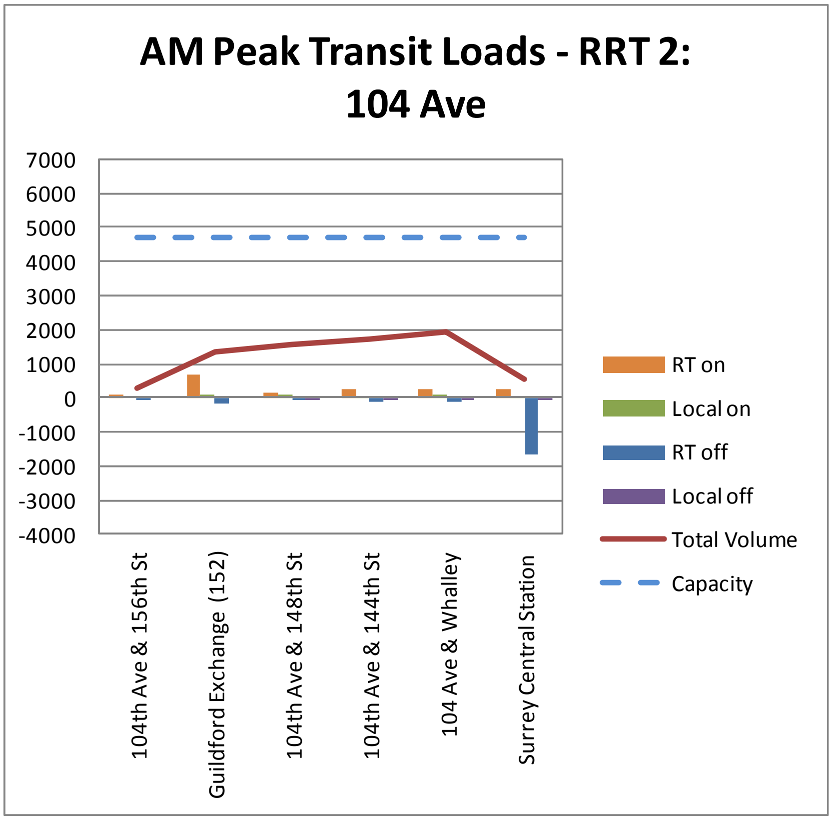
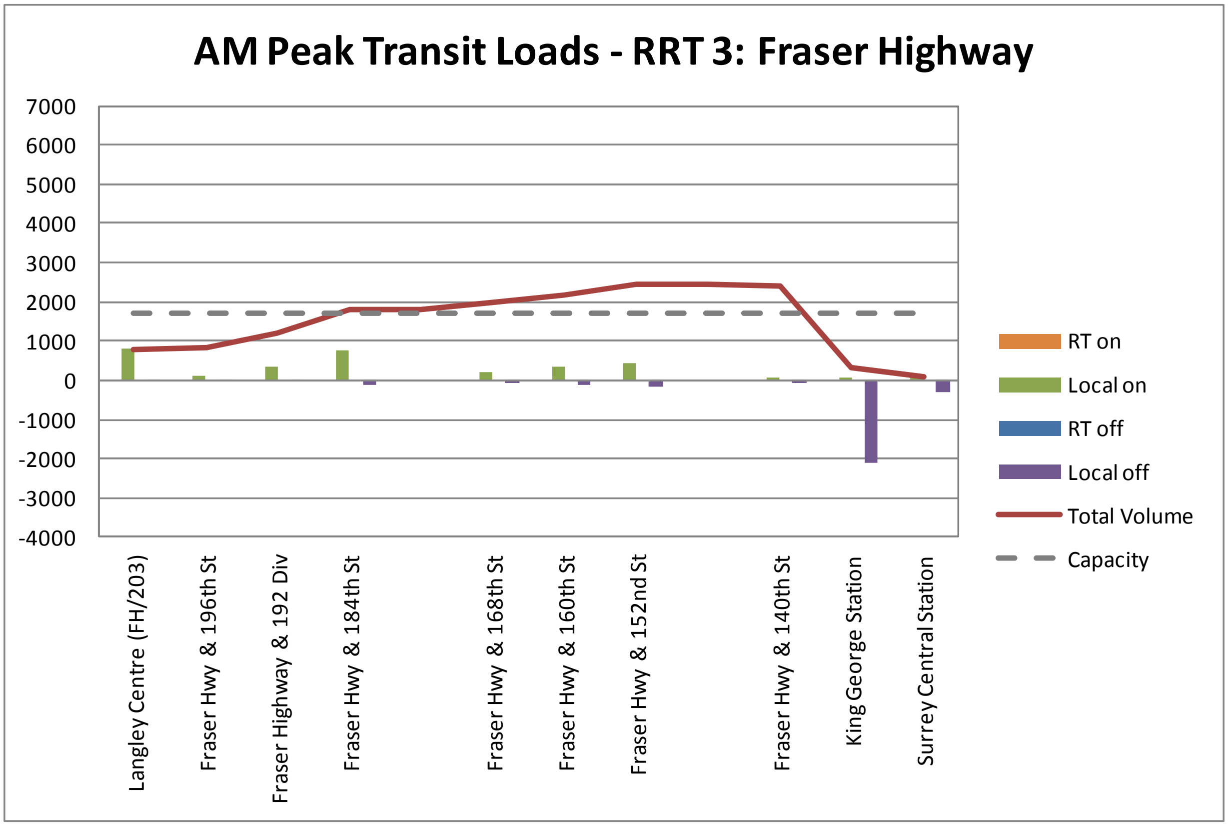
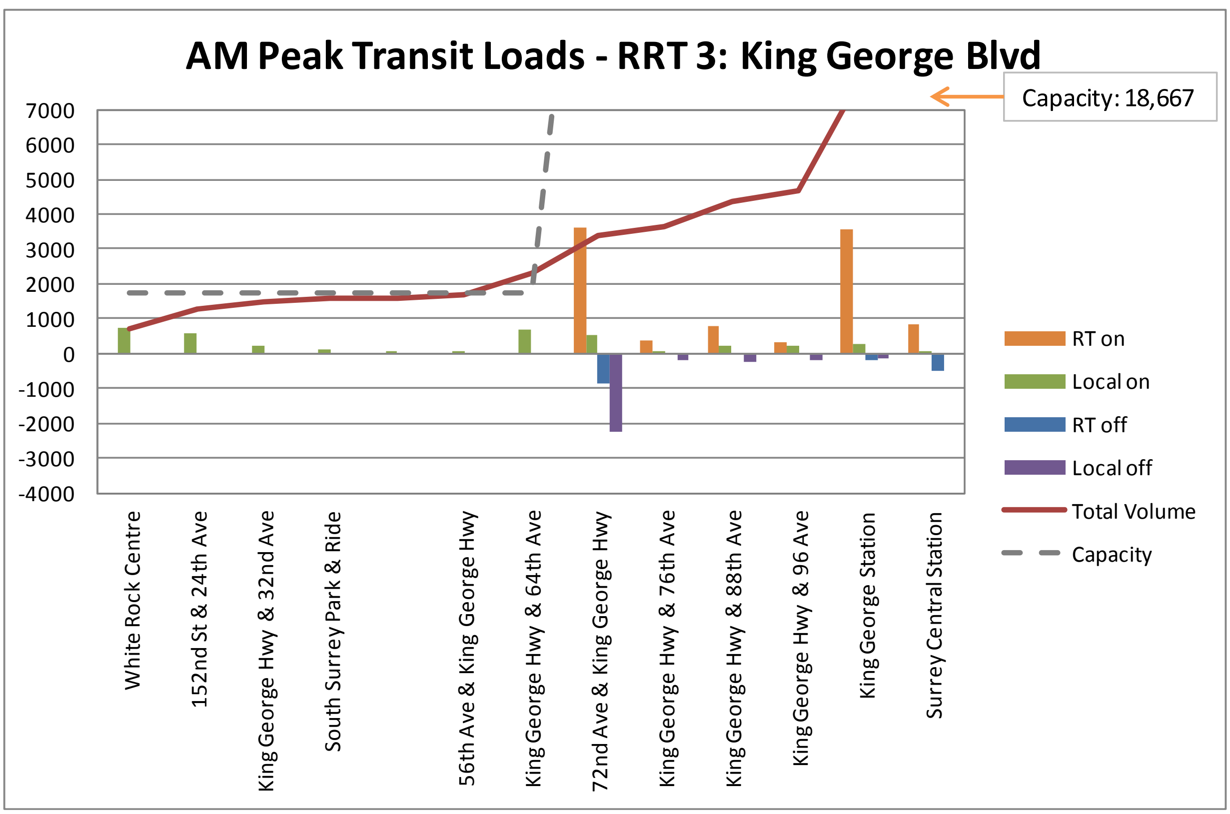
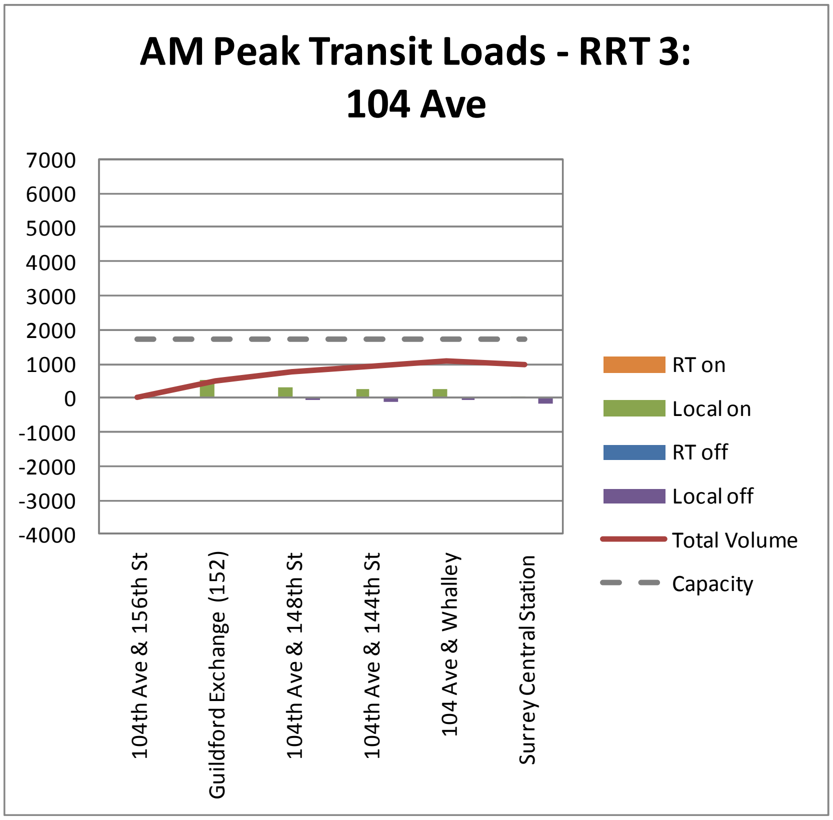

AM Peak Transit Loads - RRT 2:
104 Ave
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
104th Ave & 156th St
Guildford Exchange (152)
104th Ave & 148th St
104th Ave & 144th St
104 Ave & Whalley
Surrey Central Station
RT on
Local on
RT off
Local off
Total Volume
Capacity

Exhibit 3A.31 - 2041 AM Peak Transit Loads – RRT 3






AM Peak Transit Loads - RRT 3: 104 Ave
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
104th Ave & 156th St
Guildford Exchange (152)
104th Ave & 148th St
104th Ave & 144th St
104 Ave & Whalley
Surrey Central Station
RT on
Local on
RT off
Local off
Total Volume
Capacity

3.3 TRANSIT CAPACITY VERSUS PEAK DEMAND

The capacity of each alternative was assessed against the peak point demand in the peak direction. **Exhibit 3A.32** shows the calculation of capacity, peak point demand, and the volume-to-capacity ratio for each alternative.

The first portion of the exhibit shows the estimated corridor capacity, including the rapid transit and the principal local bus services running between Langley and Surrey Central (on Fraser Highway), and between White Rock, Surrey Central and Guildford (on King George Blvd and 104). The number of transit vehicles is multiplied by the average capacity for each technology type, and the result is added to the background local transit capacity in each corridor. These capacity figures include sitting (number of seats) and standing passengers (4 per square meter of assumed standing space) on the transit vehicles passing a single point, in one direction. (refer to Appendix 2B)

The second part of the exhibit shows the peak passenger loads forecast by the model, comprised of local transit and rapid transit riders. The AM peak maximum load points tended to be on King George Boulevard NB and Fraser Highway WB approaching King George Station, and on 104 Avenue WB approaching Surrey Central. (refer to Exhibit 3A.19-31)

The peak load point v/c ratio compares the total transit riders with the total capacity provided. Cells are highlighted where demand is close to capacity. (As indicated in Section 2, this was a factor in assessing travel time benefits.)

The exhibits indicate the demand versus capacity of the rapid transit lines and of the total transit service in the corridor. In some cases, the model assumed additional passengers on rapid transit where the available capacity was on the local transit routes; this was accounted for when assessing travel time benefits. Where the peak load point exceeds the rapid transit capacity in the model output, the passengers were assumed to use the local system instead. The peak load was only an issue for two to three stations before King George Station (as illustrated by the load plots in Exhibits 3A.19 to 3A.31), and it would be logical for passengers to use the first transit service to arrive at the station, whether it was local bus or rapid transit.

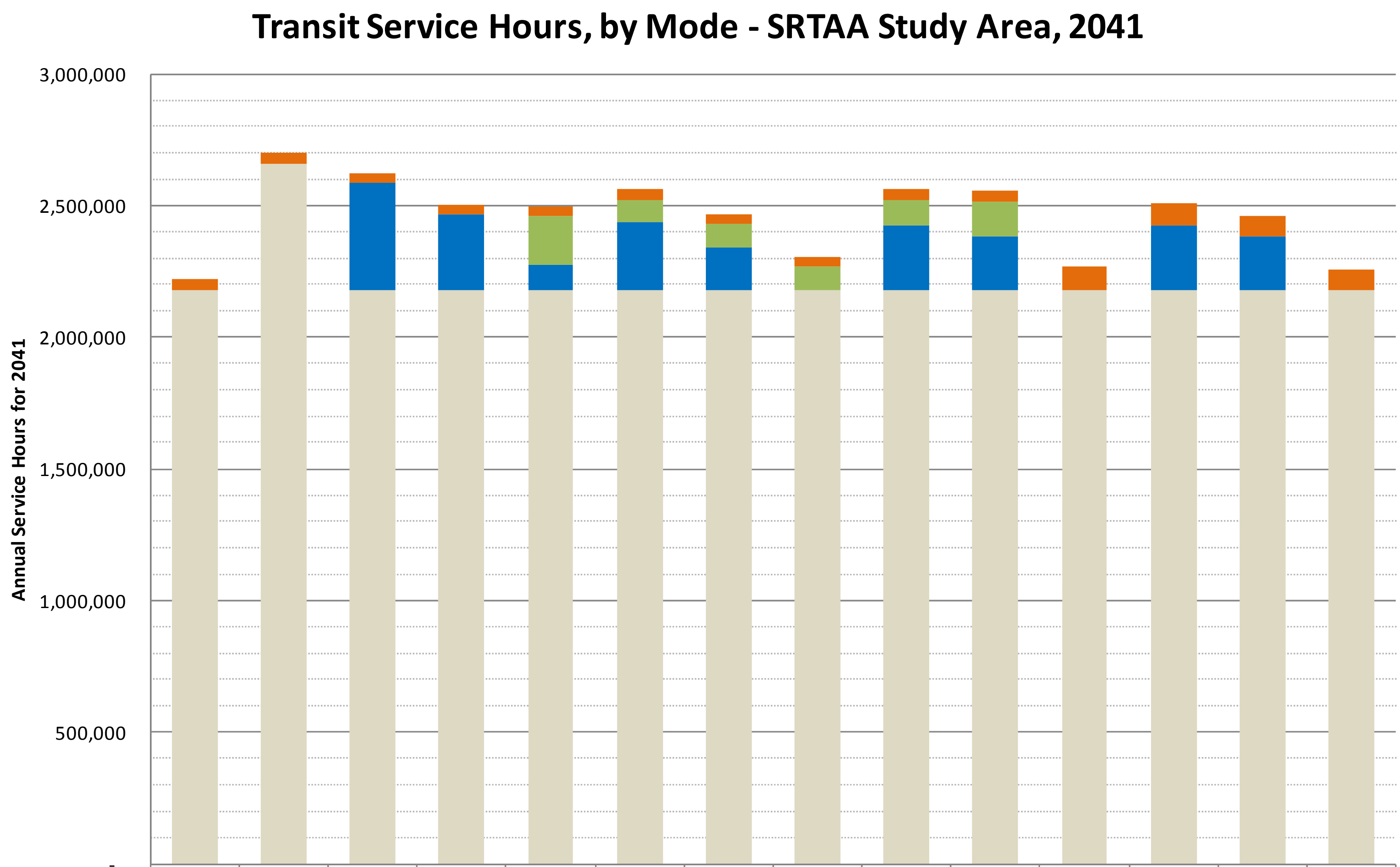
Caution should be exercised in interpreting the route level-forecasts as the RTPM08 model used is generally not considered a reliable tool to allocate demand between local and rapid transit services sharing a single corridor. This is one reason corridor totals have been used throughout the study.

Exhibits 3A.33 and 3A.34 illustrate the total amount of study area transit service per alternative, in annual service hours, and in total person-capacity added to the system. The annual service hours use expansion factors for the main corridors (Fraser Highway, King George Boulevard, and 104th Avenue) derived from the rapid transit service plans (refer to Appendix 2B). The rest of the study area service hours are based on lower factors, taken from the ratio of AM peak to annual service provided in the study area in 2009-10.

Exhibit 3A.32 -- Transit Capacity and Peak Point Passenger Loads on Phase 2 Alternatives

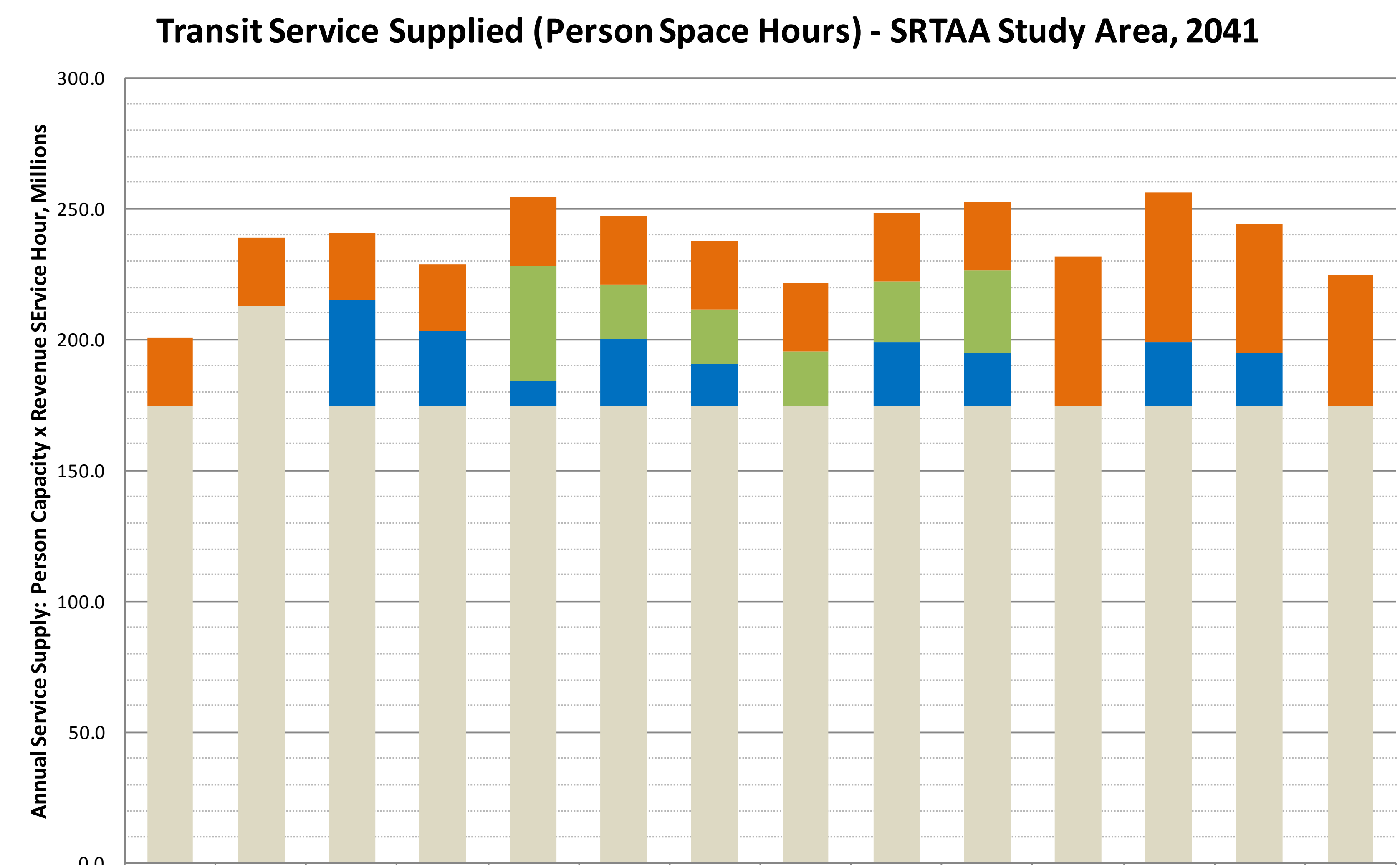
	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
	Planned Total Capacity (Rapid Transit + Bus, Based on Assumed Headways)										*(People Per Hour, Per direction)*			
2021 - Assumed Transit Capacity														
King George Boulevard	1,200	2,800	2,700	2,700	4,100	4,100	4,100	4,100	2,700	2,700	1,200	2,700	18,200	18,200
104th Avenue	1,200	2,800	2,800	2,800	4,100	4,100	4,100	4,100	2,800	4,100	1,200	2,800	2,800	1,200
Fraser Highway	1,200	2,800	3,200	3,200	4,100	3,200	3,200	1,200	4,100	4,100	9,700	9,700	3,200	1,200
2041 - Assumed Transit Capacity														
King George Boulevard	1,700	3,900	4,700	4,700	6,500	6,500	6,500	6,500	4,700	4,700	1,700	4,700	18,700	18,700
104th Avenue	1,700	3,900	4,700	4,700	6,500	6,500	6,500	6,500	4,700	6,500	1,700	4,700	4,700	1,700
Fraser Highway	1,700	3,900	4,700	4,700	6,500	4,700	4,700	1,700	6,500	6,500	10,200	10,200	4,700	1,700
Peak Load Point, Passengers														
2021 AM Peak Hour														
Fraser Highway (Local)	2,100	1,200	200	200	300	200	200	2,100	300	300	100	0	200	2,000
Fraser Highway (Rapid Transit)	0	1,200	2,800	2,800	2,600	2,800	2,800	-	2,500	2,600	4,600	4,800	2,800	-
Fraser Highway (Total)	**2,100**	**2,400**	**3,000**	**3,000**	**2,800**	**3,000**	**3,000**	**2,100**	**2,800**	**2,900**	**4,700**	**4,800**	**3,000**	**2,000**
King George Boulevard (Local)	1,500	1,100	900	1,200	1,100	1,100	1,200	1,200	900	900	1,400	900	200	300
King George Boulevard (Rapid Transit)	0	700	900	400	500	500	500	500	1,000	1,000	-	800	2,800	2,900
King George Boulevard (Total)	**1,500**	**1,800**	**1,900**	**1,600**	**1,700**	**1,700**	**1,700**	**1,700**	**1,900**	**1,900**	**1,400**	**1,700**	**3,000**	**3,100**
104th Avenue (Local)	800	700	300	300	200	200	200	200	300	200	700	300	300	800
104th Avenue (Rapid Transit)	0	300	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	-	900	1,000	-
104th Avenue (Total)	**800**	**1,000**	**1,300**	**1,300**	**1,200**	**1,200**	**1,200**	**1,200**	**1,300**	**1,200**	**700**	**1,200**	**1,300**	**800**
2041 AM Peak Hour														
Fraser Highway (Local)	2,600	1,500	200	200	200	200	200	2,500	200	200	100	0	200	2,500
Fraser Highway (Rapid Transit)	0	1,500	4,100	4,200	4,100	4,200	4,200	-	4,100	4,200	6,700	6,600	4,100	-
Fraser Highway (Total)	**2,600**	**3,000**	**4,300**	**4,400**	**4,300**	**4,300**	**4,300**	**2,500**	**4,200**	**4,300**	**6,800**	**6,600**	**4,300**	**2,500**
King George Boulevard (Local)	2,900	2,300	1,300	2,200	1,900	1,900	2,100	2,100	1,300	1,300	2,500	1,300	400	500
King George Boulevard (Rapid Transit)	0	1,100	2,600	1,100	1,600	1,600	1,200	1,300	2,600	2,600	-	2,400	4,800	5,000
King George Boulevard (Total)	**2,900**	**3,400**	**3,900**	**3,300**	**3,400**	**3,500**	**3,300**	**3,500**	**3,900**	**3,900**	**2,500**	**3,700**	**5,300**	**5,500**
104th Avenue (Local)	1,100	800	300	300	100	100	100	100	300	200	1000	300	300	1,100
104th Avenue (Rapid Transit)	0	500	1,600	1,600	1,700	1,700	1,700	1,700	1,600	1,600	-	1,500	1,600	-
104th Avenue (Total)	**1,100**	**1,200**	**2,000**	**2,000**	**1,800**	**1,800**	**1,800**	**1,900**	**2,000**	**1,800**	**1,000**	**1,900**	**1,900**	**1,100**
Peak Load Point, V/C, in Corridor (Combined Bus + Rapid Transit)														
2021														
Fraser Highway	1.7	0.9	0.9	0.9	0.7	0.9	0.9	1.7	0.7	0.7	0.5	0.5	0.9	1.7
King George Boulevard	1.3	0.6	0.7	0.6	0.4	0.4	0.4	0.4	0.7	0.7	1.1	0.6	0.2	0.2
104th Avenue	0.6	0.3	0.5	0.5	0.3	0.3	0.3	0.3	0.5	0.3	0.6	0.4	0.5	0.6
2041														
Fraser Highway	1.5	0.8	0.9	0.9	0.7	0.9	0.9	1.5	0.6	0.7	0.7	0.7	0.9	1.5
King George Boulevard	1.7	0.9	0.8	0.7	0.5	0.5	0.5	0.5	0.8	0.8	1.5	0.8	0.3	0.3
104th Avenue	0.7	0.3	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.3	0.6	0.4	0.4	0.6

Exhibit 3A.33 – Annual Study Area Transit Service, 2041



	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
RRT	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	88,300	88,300	76,600	76,600
LRT		-	-	-	184,500	87,200	87,200	87,200	97,300	132,400	-	-	-	-
BRT		-	403,800	284,100	94,800	255,900	161,100	-	242,700	202,000	-	242,700	201,800	-
Bus	2,180,000	2,660,200	2,180,000	2,180,000	2,180,000	2,180,000	2,180,000	2,180,000	2,180,000	2,180,000	2,180,000	2,180,000	2,180,000	2,180,000

Exhibit 3A.34 – Annual Study Area Transit Capacity, 2041



	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
RRT	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	57.4	57.4	49.8	49.8
LRT	0.0	0.0	0.0	0.0	44.3	20.9	20.9	20.9	23.4	31.8	0.0	0.0	0.0	0.0
BRT	0.0	0.0	40.4	28.4	9.5	25.6	16.1	0.0	24.3	20.2	0.0	24.3	20.2	0.0
Bus	174.4	212.8	174.4	174.4	174.4	174.4	174.4	174.4	174.4	174.4	174.4	174.4	174.4	174.4

4. TRANSIT MODE SHARE

Exhibit 3A.36 shows the estimated person trips, transit trips, and transit mode share for the region and for the study area in the 2021 AM peak. The study area value includes trips entirely within the study area, plus those entering and leaving. The transit mode share for trips entering and leaving is actually higher, due in part to the level of service offered by rapid transit versus parallel streets.

Exhibit 3A.37 shows the estimated trips and transit mode splits for 2041, with additional details by sub-area, and for a set of trips between origins and destinations inside the study area (e.g. Surrey Metro Centre to each of the other centres, and several representative trips between other study area urban centres). The mode split results on the second page of the exhibit have been highlighted to show where the greatest improvement in mode share occurs and this is most prominent for Clayton, Langley Centre, Cloverdale, and Fleetwood, trips between Surrey Metro Centre and those locations, and trips between Guildford and Langley. The following reference map indicates the eleven subareas used in the mode share reporting.

Exhibit 3A.35 – Map of Study Area Subareas for Demand Model Output

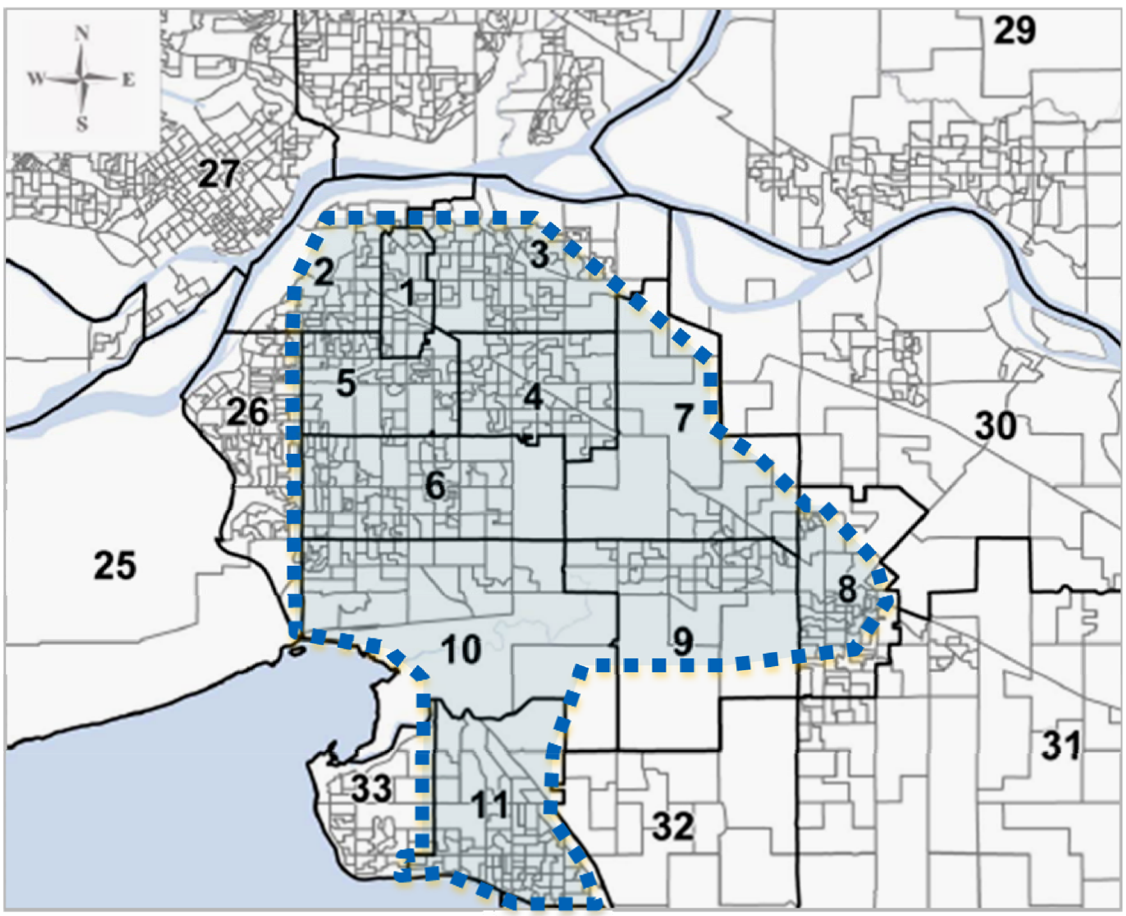


Exhibit 3A.36 - Transit Mode Share, 2021

		BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
2021	Total Trips (Person)	817,500	817,500	817,500	817,500	817,500	817,500	817,500	817,500	817,500	817,500	817,400	817,300	817,400	817,500
2021	Total Transit Trips (Person)	117,200	118,000	117,800	117,700	117,700	117,800	117,800	117,400	117,700	117,700	118,200	118,400	118,100	117,700
2021	Regional Transit Mode Share	14.34%	14.43%	14.41%	14.40%	14.39%	14.41%	14.41%	14.36%	14.40%	14.40%	14.46%	14.49%	14.45%	14.40%
Person Trips in 2021															
2021	Person Trips Within Study Area (1-11)	91,780	91,760	91,740	91,740	91,770	91,770	91,760	91,810	91,750	91,780	91,580	91,580	91,630	91,650
	Person Trips Leaving Study Area	50,530	50,580	50,610	50,610	50,580	50,590	50,590	50,510	50,600	50,570	50,830	50,850	50,760	50,700
	Person Trips Entering Study Area	38,780	38,800	38,820	38,820	38,790	38,790	38,790	38,750	38,810	38,780	38,980	38,980	38,930	38,910
Transit Trips and Mode Share in 2021															
2021	Transit Trips within Study Area (1-11)	8,240	8,730	8,500	8,480	8,470	8,520	8,510	8,330	8,460	8,510	8,470	8,610	8,540	8,320
	Transit Trips Leaving Study Area	8,520	8,670	8,780	8,750	8,710	8,750	8,750	8,550	8,740	8,720	9,210	9,310	9,030	8,820
	Transit Trips Entering Study Area	4,060	4,160	4,200	4,190	4,140	4,150	4,150	4,100	4,190	4,150	4,250	4,360	4,330	4,220
2021	Transit Mode Share within Study Area (1-11)	9.0%	9.5%	9.3%	9.2%	9.2%	9.3%	9.3%	9.1%	9.2%	9.3%	9.2%	9.4%	9.3%	9.1%
Transit	Transit Mode Share Leaving Study Area	16.9%	17.1%	17.3%	17.3%	17.2%	17.3%	17.3%	16.9%	17.3%	17.2%	18.1%	18.3%	17.8%	17.4%
Mode Share	Transit Mode Share Entering Study Area	10.5%	10.7%	10.8%	10.8%	10.7%	10.7%	10.7%	10.6%	10.8%	10.7%	10.9%	11.2%	11.1%	10.8%
	Transit Mode Share To/From/Within	***11.5%***	***11.9%***	***11.9%***	***11.8%***	***11.8%***	***11.8%***	***11.8%***	***11.6%***	***11.8%***	***11.8%***	***12.1%***	***12.3%***	***12.1%***	***11.8%***

Exhibit 3A.37 - Transit Mode Share, 2041 (1/2)

		BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
2041	Total Trips (Person) - Regional	950,600	950,600	950,500	950,500	950,500	950,500	950,500	950,600	950,500	950,500	950,400	950,400	950,500	950,600
2041	Total Transit Trips (Person) - Regional	155,620	156,390	156,730	156,560	156,640	156,630	156,570	155,940	156,650	156,810	156,840	157,500	156,990	156,180
2041	Regional Transit Mode Share	16.37%	16.45%	16.49%	16.47%	16.48%	16.48%	16.47%	16.40%	16.48%	16.50%	16.50%	16.57%	16.52%	16.43%
Person Trips in 2041															
2041	Person Trips Within Study Area (1-11)	106,180	106,150	106,100	106,120	106,150	106,150	106,150	106,240	106,100	106,140	105,880	105,880	105,930	105,980
	Person Trips Leaving Study Area	62,060	62,120	62,220	62,190	62,160	62,170	62,160	62,010	62,220	62,180	62,500	62,530	62,430	62,320
	Person Trips Entering Study Area	51,310	51,340	51,380	51,370	51,330	51,340	51,340	51,250	51,380	51,350	51,600	51,600	51,550	51,500
													-		
2041	Person Trips to/from/within zone 1 (SMC)	32,010	31,990	31,990	31,980	31,980	31,980	31,980	31,980	31,990	31,990	32,040	32,020	32,000	32,020
Person	Person Trips to/from/within zone 2 (other Whalley)	15,390	15,390	15,390	15,390	15,390	15,390	15,390	15,390	15,390	15,390	15,400	15,390	15,390	15,390
Trips	Person Trips to/from/within zone 3 (GF)	33,080	33,080	33,080	33,070	33,070	33,070	33,070	33,060	33,080	33,070	33,120	33,100	33,080	33,080
(AM Peak)	Person Trips to/from/within zone 4 (FW)	22,160	22,140	22,160	22,160	22,160	22,160	22,160	22,140	22,160	22,160	22,220	22,210	22,170	22,160
	Person Trips to/from/within zone 5 (north Newton)	24,380	24,370	24,380	24,380	24,380	24,380	24,380	24,370	24,380	24,380	24,390	24,390	24,390	24,390
	Person Trips to/from/within zone 6 (NT)	42,840	42,830	42,870	42,860	42,860	42,870	42,860	42,850	42,870	42,870	42,860	42,880	42,950	42,940
	Person Trips to/from/within zone 7 (Clayton)	21,630	21,630	21,660	21,660	21,660	21,660	21,660	21,630	21,660	21,660	21,700	21,700	21,660	21,630
	Person Trips to/from/within zone 8 (LC)	30,020	30,030	30,080	30,080	30,080	30,080	30,080	30,010	30,080	30,080	30,160	30,170	30,080	30,020
	Person Trips to/from/within zone 9 (CD)	16,660	16,660	16,680	16,680	16,680	16,680	16,680	16,660	16,680	16,680	16,700	16,700	16,680	16,670
	Person Trips to/from/within zone 10 (Panorama)	22,160	22,150	22,170	22,160	22,160	22,160	22,160	22,160	22,170	22,170	22,170	22,170	22,180	22,180
	Person Trips to/from/within zone 11 (SS/WR)	26,350	26,350	26,360	26,350	26,350	26,350	26,350	26,340	26,360	26,360	26,360	26,360	26,370	26,370
			-										-		
2041	Tot. Pers. Trips, SMC (1) to/from NT (6)	2,660	2,660	2,690	2,680	2,690	2,690	2,690	2,690	2,690	2,690	2,660	2,690	2,700	2,690
Person	Tot. Pers. Trips, SMC (1) to/from SS/WR (11)	470	460	470	470	470	470	470	470	470	470	470	470	470	470
Trips	Tot. Pers. Trips, SMC (1) to/from GF (3)	4,060	4,070	4,020	4,020	4,030	4,030	4,040	4,040	4,020	4,030	4,050	4,010	4,020	4,050
(AM Peak)	Tot. Pers. Trips, SMC (1) to/from FW (4)	1,690	1,650	1,650	1,650	1,650	1,650	1,650	1,660	1,650	1,650	1,710	1,690	1,650	1,680
	Tot. Pers. Trips, SMC (1) to/from CD (9)	410	410	420	420	420	420	420	410	420	430	440	440	420	420
	Tot. Pers. Trips, SMC (1) to/from LC (8)	440	440	460	460	470	460	460	430	460	470	500	490	460	440
	Tot. Pers. Trips, Guildford (3) – Fleetwood (4)	3,240	3,240	3,260	3,260	3,270	3,260	3,270	3,270	3,260	3,270	3,230	3,260	3,260	3,240
	Tot. Pers. Trips, Guildford (3) – Newton (6)	1,960	1,950	1,960	1,960	1,970	1,970	1,970	1,970	1,960	1,960	1,960	1,960	1,960	1,950
	Tot. Pers. Trips, Guildford (3) – Langley Centre (8)	650	650	650	650	650	650	650	630	650	650	660	660	650	650
	Tot. Pers. Trips, Guildford (3) – South Surrey (11)	390	390	390	390	390	390	390	390	390	390	390	390	390	390
	Tot. Pers. Trips, Fleetwood (4) – Newton (6)	2,170	2,180	2,170	2,170	2,170	2,170	2,170	2,170	2,170	2,170	2,160	2,160	2,170	2,170
	Tot. Pers. Trips, Newton (6) – Langley Centre (8)	820	820	820	820	820	820	820	820	820	820	820	820	810	810
	Tot. Pers. Trips, Newton (6) – South Surrey (11)	1,150	1,130	1,140	1,150	1,140	1,140	1,140	1,140	1,140	1,140	1,150	1,140	1,130	1,130

Transit Trips in 2041		BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
2041	Transit Trips within Study Area (1-11)	12,750	13,280	13,280	13,220	13,280	13,300	13,280	12,960	13,280	13,360	13,060	13,350	13,230	12,810
	Transit Trips Leaving Study Area	12,030	12,180	12,490	12,430	12,420	12,420	12,410	12,090	12,480	12,480	12,930	13,120	12,810	12,470
	Transit Trips Entering Study Area	7,070	7,210	7,350	7,320	7,270	7,270	7,260	7,170	7,360	7,290	7,350	7,570	7,500	7,270
			-										-		
2041	Transit Trips to/from/within zone 1 (SMC)	8,050	8,290	8,520	8,470	8,480	8,480	8,470	8,270	8,520	8,540	8,320	8,600	8,570	8,220
Transit	Transit Trips to/from/within zone 2 (other Whalley)	1,760	1,790	1,810	1,810	1,810	1,810	1,800	1,780	1,810	1,810	1,820	1,850	1,820	1,780
Trips	Transit Trips to/from/within zone 3 (GF)	4,570	4,770	4,790	4,790	4,810	4,820	4,820	4,760	4,780	4,820	4,650	4,830	4,790	4,560
(AM Peak)	Transit Trips to/from/within zone 4 (FW)	2,600	2,700	2,740	2,740	2,720	2,740	2,740	2,600	2,730	2,740	2,860	2,930	2,750	2,620
	Transit Trips to/from/within zone 5 (north Newton)	3,550	3,660	3,610	3,600	3,600	3,600	3,600	3,570	3,610	3,610	3,590	3,640	3,630	3,590
	Transit Trips to/from/within zone 6 (NT)	6,920	7,140	7,070	7,030	7,060	7,060	7,040	7,020	7,070	7,070	6,950	7,090	7,340	7,290
	Transit Trips to/from/within zone 7 (Clayton)	2,520	2,620	2,800	2,800	2,790	2,790	2,790	2,520	2,830	2,840	2,950	3,000	2,790	2,520
	Transit Trips to/from/within zone 8 (LC)	3,600	3,670	3,810	3,810	3,820	3,820	3,820	3,600	3,790	3,800	4,080	4,130	3,810	3,590
	Transit Trips to/from/within zone 9 (CD)	1,630	1,700	1,740	1,730	1,730	1,730	1,730	1,630	1,740	1,740	1,820	1,850	1,740	1,650
	Transit Trips to/from/within zone 10 (Panorama)	2,650	2,720	2,700	2,670	2,670	2,670	2,670	2,660	2,700	2,700	2,660	2,710	2,740	2,740
	Transit Trips to/from/within zone 11 (SS/WR)	3,040	3,090	3,100	3,030	3,050	3,050	3,030	3,030	3,100	3,100	3,040	3,100	3,100	3,110
			-	-	-	-	-	-	-			-	-	-	-
2041	Transit Trips SMC (1) to/from NT (6)	650	690	710	700	700	700	700	700	710	710	650	710	740	740
Transit	Transit Trips SMC (1) to/from SS/WR (11)	120	130	150	130	130	130	130	130	150	150	130	150	130	130
Trips	Transit Trips SMC (1) to/from GF (3)	740	790	790	790	810	820	820	810	780	810	740	780	780	740
(AM Peak)	Transit Trips SMC (1) to/from FW (4)	340	360	380	380	370	380	380	340	370	380	380	390	380	340
	Transit Trips SMC (1) to/from CD (9)	90	110	130	130	130	130	130	100	130	130	140	150	130	100
	Transit Trips SMC (1) to/from LC (8)	120	140	180	180	180	180	180	120	180	180	210	210	180	120
	Transit Trips Guildford (3) – Fleetwood (4)	330	350	330	330	330	330	330	330	330	340	330	330	330	330
	Transit Trips Guildford (3) – Newton (6)	290	310	290	290	310	310	310	310	290	290	290	290	290	290
	Transit Trips Guildford (3) – Langley Centre (8)	90	90	100	100	100	100	100	80	100	110	110	120	100	90
	Transit Trips Guildford (3) – South Surrey (11)	60	70	60	60	60	60	60	60	60	60	60	60	60	60
	Transit Trips Fleetwood (4) – Newton (6)	220	230	230	220	220	220	220	220	220	220	220	220	230	220
	Transit Trips Newton (6) – Langley Centre (8)	120	130	120	120	120	120	120	120	120	120	130	130	120	120
	Transit Trips Newton (6) – South Surrey (11)	180	190	190	180	190	190	180	180	190	190	180	190	180	180

Exhibit 3A.37 - Transit Mode Share, 2041 (2/2)

		BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
2041	Transit Mode Share within Study Area (1-11)	12.0%	12.5%	12.5%	12.5%	12.5%	12.5%	12.5%	12.2%	12.5%	12.6%	12.3%	12.6%	12.5%	12.1%
Transit	Transit Mode Share Leaving Study Area	19.4%	19.6%	20.1%	20.0%	20.0%	20.0%	20.0%	19.5%	20.1%	20.1%	20.7%	21.0%	20.5%	20.0%
Mode Share	Transit Mode Share Entering Study Area	13.8%	14.0%	14.3%	14.2%	14.2%	14.2%	14.1%	14.0%	14.3%	14.2%	14.2%	14.7%	14.5%	14.1%
	Transit Mode Share To/From/Within	**14.51%**	**14.88%**	**15.08%**	**15.01%**	**15.01%**	**15.02%**	**15.00%**	**14.68%**	**15.08%**	**15.08%**	**15.16%**	**15.47%**	**15.25%**	**14.81%**
	Transit Mode Share to/from/within zone 1 (SMC)	25.1%	25.9%	26.6%	26.5%	26.5%	26.5%	26.5%	25.9%	26.6%	26.7%	26.0%	26.9%	26.8%	25.7%
	Transit Mode Share to/from/within zone 2 (other Whalley)	11.4%	11.6%	11.8%	11.8%	11.8%	11.8%	11.7%	11.6%	11.8%	11.8%	11.8%	12.0%	11.8%	11.6%
	Transit Mode Share to/from/within zone 3 (GF)	13.8%	14.4%	14.5%	14.5%	14.5%	14.6%	14.6%	14.4%	14.4%	14.6%	14.0%	14.6%	14.5%	13.8%
	Transit Mode Share to/from/within zone 4 (FW)	11.7%	12.2%	12.4%	12.4%	12.3%	12.4%	12.4%	11.7%	12.3%	12.4%	12.9%	13.2%	12.4%	11.8%
	Transit Mode Share to/from/within zone 5 (north Newton)	14.6%	15.0%	14.8%	14.8%	14.8%	14.8%	14.8%	14.6%	14.8%	14.8%	14.7%	14.9%	14.9%	14.7%
	Transit Mode Share to/from/within zone 6 (NT)	16.2%	16.7%	16.5%	16.4%	16.5%	16.5%	16.4%	16.4%	16.5%	16.5%	16.2%	16.5%	17.1%	17.0%
	Transit Mode Share to/from/within zone 7 (Clayton)	11.7%	12.1%	12.9%	12.9%	12.9%	12.9%	12.9%	11.7%	13.1%	13.1%	13.6%	13.8%	12.9%	11.7%
	Transit Mode Share to/from/within zone 8 (LC)	12.0%	12.2%	12.7%	12.7%	12.7%	12.7%	12.7%	12.0%	12.6%	12.6%	13.5%	13.7%	12.7%	12.0%
	Transit Mode Share to/from/within zone 9 (CD)	9.8%	10.2%	10.4%	10.4%	10.4%	10.4%	10.4%	9.8%	10.4%	10.4%	10.9%	11.1%	10.4%	9.9%
	Transit Mode Share to/from/within zone 10 (Panorama)	12.0%	12.3%	12.2%	12.0%	12.0%	12.0%	12.0%	12.0%	12.2%	12.2%	12.0%	12.2%	12.4%	12.4%
	Transit Mode Share to/from/within zone 11 (SS/WR)	11.5%	11.7%	11.8%	11.5%	11.6%	11.6%	11.5%	11.5%	11.8%	11.8%	11.5%	11.8%	11.8%	11.8%
2041	Transit Trips SMC (1) to/from NT (6)	24.4%	25.9%	26.4%	26.1%	26.0%	26.0%	26.0%	26.0%	26.4%	26.4%	24.4%	26.4%	27.4%	27.5%
Transit	Transit Trips SMC (1) to/from SS/WR (11)	25.5%	28.3%	31.9%	27.7%	27.7%	27.7%	27.7%	27.7%	31.9%	31.9%	27.7%	31.9%	27.7%	27.7%
Trips	Transit Trips SMC (1) to/from GF (3)	18.2%	19.4%	19.7%	19.7%	20.1%	20.3%	20.3%	20.0%	19.4%	20.1%	18.3%	19.5%	19.4%	18.3%
(AM Peak)	Transit Trips SMC (1) to/from FW (4)	20.1%	21.8%	23.0%	23.0%	22.4%	23.0%	23.0%	20.5%	22.4%	23.0%	22.2%	23.1%	23.0%	20.2%
	Transit Trips SMC (1) to/from CD (9)	22.0%	26.8%	31.0%	31.0%	31.0%	31.0%	31.0%	24.4%	31.0%	30.2%	31.8%	34.1%	31.0%	23.8%
	Transit Trips SMC (1) to/from LC (8)	27.3%	31.8%	39.1%	39.1%	38.3%	39.1%	39.1%	27.9%	39.1%	38.3%	42.0%	42.9%	39.1%	27.3%
	Transit Trips Guildford (3) – Fleetwood (4)	10.2%	10.8%	10.1%	10.1%	10.1%	10.1%	10.1%	10.1%	10.1%	10.4%	10.2%	10.1%	10.1%	10.2%
	Transit Trips Guildford (3) – Newton (6)	14.8%	15.9%	14.8%	14.8%	15.7%	15.7%	15.7%	15.7%	14.8%	14.8%	14.8%	14.8%	14.8%	14.9%
	Transit Trips Guildford (3) – Langley Centre (8)	13.8%	13.8%	15.4%	15.4%	15.4%	15.4%	15.4%	12.7%	15.4%	16.9%	16.7%	18.2%	15.4%	13.8%
	Transit Trips Guildford (3) – South Surrey (11)	15.4%	17.9%	15.4%	15.4%	15.4%	15.4%	15.4%	15.4%	15.4%	15.4%	15.4%	15.4%	15.4%	15.4%
	Transit Trips Fleetwood (4) – Newton (6)	10.1%	10.6%	10.6%	10.1%	10.1%	10.1%	10.1%	10.1%	10.1%	10.1%	10.2%	10.2%	10.6%	10.1%
	Transit Trips Newton (6) – Langley Centre (8)	14.6%	15.9%	14.6%	14.6%	14.6%	14.6%	14.6%	14.6%	14.6%	14.6%	15.9%	15.9%	14.8%	14.8%
	Transit Trips Newton (6) – South Surrey (11)	15.7%	16.8%	16.7%	15.7%	16.7%	16.7%	15.8%	15.8%	16.7%	16.7%	15.7%	16.7%	15.9%	15.9%
Other Modes		**BAU**	**BB**	**BRT 1**	**BRT 2**	**LRT 1**	**LRT 2**	**LRT 3**	**LRT 4**	**LRT 5A**	**LRT 5B**	**RRT 1**	**RRT 1A**	**RRT 2**	**RRT 3**
2041	Auto Person Trips within Study Area (1-11)	71,498	70,922	70,868	70,923	70,895	70,874	70,894	71,223	70,877	70,823	71,076	70,691	70,807	71,303
	Auto Person Trips Leaving Study Area	47,986	47,903	47,696	47,729	47,702	47,705	47,714	47,880	47,702	47,672	47,540	47,377	47,585	47,807
	Auto Person Trips Entering Study Area	42,035	41,919	41,830	41,846	41,863	41,865	41,878	41,874	41,823	41,854	42,057	41,840	41,844	42,028
	Auto Mode Share To/From/Within	**73.6%**	**73.2%**	**73.0%**	**73.1%**	**73.1%**	**73.0%**	**73.1%**	**73.3%**	**73.0%**	**73.0%**	**73.0%**	**72.7%**	**72.9%**	**73.3%**
2041	Walk/Cycle Trips within Study Area (1-11)	21,927	21,947	21,951	21,972	21,978	21,973	21,973	22,056	21,948	21,958	21,744	21,836	21,902	21,865
	Walk/Cycle Trips Leaving Study Area	2,041	2,041	2,036	2,036	2,036	2,036	2,036	2,041	2,036	2,035	2,031	2,030	2,036	2,041
	Walk/Cycle Trips Entering Study Area	2,202	2,203	2,201	2,201	2,201	2,201	2,201	2,203	2,201	2,200	2,198	2,198	2,203	2,204
	Walk/Cycle Mode Share To/From/Within	**11.9%**	**11.9%**	**11.9%**	**11.9%**	**11.9%**	**11.9%**	**11.9%**	**12.0%**	**11.9%**	**11.9%**	**11.8%**	**11.8%**	**11.9%**	**11.9%**

APPENDIX 3B – FINANCIAL ACCOUNT EVALUATION

This appendix contains additional background information on three topics of the Phase 2 Evaluation:

1. Capital Cost Estimates
2. Operating Cost Estimates
3. Cost-Effectiveness.

This material documents assumptions and more detailed calculations that were carried out.

1. CAPITAL COSTS

The material related to capital costs includes an overall summary (**Exhibit 3B.1**) that shows the construction costs by geographic segment, plus the property requirement estimates and the fleet expansion costs for each of the alternatives.

The construction costs were developed for each alternative on the basis of conceptual designs.. The unit costs for construction, vehicles and contingencies were based on precedent projects, and consistent with other TransLink-led studies (including the UBC Line study).

2. OPERATING COSTS

Operating costs are estimated on the basis of an operating plan for each rapid transit route from one urban centre to another, with each alternative then built up from the constituent routes. The exception was Best Bus, where the incremental peak hour requirements for bus service relative to BAU were then annualized.

The assumed set of rapid transit routes, including distance and estimated end-to-end travel time, are included in **Exhibit 3B.2**. For each route, the vehicle requirement was estimated based on round trip travel time, schedule recovery, and a spares ratio. The peak hour operations, expressed as vehicle-hours and vehicle-kilometres, were also calculated. The annualized operations, and the extents of the routes, were the inputs to the calculation of annual operating costs for 2021 and 2041.

The assumed pattern of operations for the rapid transit routes at different times of day was considered when developing annual estimates of service. Early morning, midday, evening, and weekend headways were assumed to step down in frequency from the peak period, in a similar way to the existing SkyTrain service on the Expo and Millennium Lines. The net effect was that a typical year of rapid transit service was equivalent to approximately 4,900 to 5,300 “AM peak hours”, in terms of vehicle service hours and vehicle kilometres. The rapid transit annual expansion factors were also applied to the B-Lines and Super B-Lines in the Best Bus Alternative.

The total amounts of rapid transit service and extent were compiled for each alternative from its constituent routes. For example, BRT 1 includes the BRT service from Surrey Central to Langley, plus Surrey Central to White Rock, plus the incremental rapid bus service added to 104 Avenue.

The derivation of annual costs was explained in the main evaluation report; this involved multiplying the number of vehicle-hours, vehicle-km and extent of the system by average costs for each parameter. Several of the Phase 2 alternatives include more than one service, and sometimes more than one technology, and so the individual routes were aggregated for each alternative. This calculation is shown on **Exhibit 3B.3**.

Exhibit 3B.1 - Phase 2 Alternatives - Capital Costs Summary ($ 2010, millions)

Alternative	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Segments (Construction Costs)*													
Surrey Centre - Newton (KGB)		$ 65	$ 65	$ 301	$ 301	$ 301	$ 301	$ 137	$ 137		$ 65	$ 583	$ 583
Newton-White Rock (KGB)		$ 59		$ 59	$ 59			$ 59	$ 59		$ 59		
Surrey Centre - Guildford (104)		$ 99	$ 99	$ 256	$ 256	$ 256	$ 256	$ 99	$ 256		$ 99	$ 99	
King George to Langley (FH)		$ 301	$ 301	$ 746	$ 295	$ 295		$ 746	$ 746	$ 1,356	$ 1,356	$ 301	
Alignment and Stations - Subtotal	$ -	$ 524	$ 465	$ 1,361	$ 911	$ 852	$ 556	$ 1,040	$ 1,197	$ 1,356	$ 1,579	$ 983	$ 583
Bus Costs, + OMC Allocation	*$ 223*												
BRT Costs, + OMC Allocation		*$ 116*	*$ 84*	*$ 30*	*$ 82*	*$ 53*		*$ 63*	*$ 53*		*$ 63*	*$ 63*	
LRT Costs + OMC Estimates				*$ 307*	*$ 146*	*$ 146*	*$ 146*	*$ 169*	*$ 223*				
RRT Costs + OMC Allocation										*$ 261*	*$ 261*	*$ 235*	*$ 235*
Initial Vehicles and Related OMC Costs	$ 223	$ 116	$ 84	$ 337	$ 228	$ 199	$ 146	$ 233	$ 276	$ 261	$ 324	$ 298	$ 235
Capital Cost - Alignment and Initial Vehicle Fleet	$ 223	$ 640	$ 549	$ 1,698	$ 1,139	$ 1,050	$ 702	$ 1,273	$ 1,473	$ 1,616	$ 1,903	$ 1,281	$ 818
Expansion Bus Costs + OMC Allocation	*$ 38*												
Expansion BRT Costs + OMC Allocation		*$ 89*	*$ 55*	*$ 19*	*$ 44*	*$ 25*		*$ 63*	*$ 55*		*$ 63*	*$ 34*	
Expansion LRT Costs + OMC Estimates				*$ 177*	*$ 83*	*$ 83*	*$ 83*	*$ 94*	*$ 136*				
Expansion Vehicles and Related OMC Costs**	$ 38	$ 89	$ 55	$ 196	$ 127	$ 108	$ 83	$ 156	$ 189	$ -	$ 63	$ 34	$ -
Total Cost, Infrastructure and Vehicles	$ 260	$ 729	$ 604	$ 1,894	$ 1,266	$ 1,159	$ 786	$ 1,429	$ 1,662	$ 1,616	$ 1,966	$ 1,315	$ 818
Property Costs for Alignment and Stations (Order of Magnitude)													
Alignment/Station-related ROW Costs		$ 88	$ 87	$ 91	$ 88	$ 87	$ 51	$ 91	$ 91	$ 24	$ 75	$ 82	$ 16
Relocation and Contingency Costs		$ 39	$ 38	$ 40	$ 39	$ 38	$ 22	$ 40	$ 40	$ 11	$ 33	$ 36	$ 7
Gross Price of ROW with relocation and contingency		$ 127	$ 125	$ 131	$ 127	$ 125	$ 74	$ 131	$ 131	$ 35	$ 109	$ 118	$ 23
Resale value of land not needed during operations		$ 34	$ 34	$ 34	$ 34	$ 34	$ 27	$ 34	$ 34	$ 6	$ 34	$ 29	$ 5
Net ROW Costs		$ 93	$ 91	$ 97	$ 93	$ 91	$ 47	$ 97	$ 97	$ 29	$ 75	$ 89	$ 18
Base Cost of Construction, Property and Vehicles	$ 260	822	695	1990	1359	1250	832	1526	1760	1645	2041	1403	835
Real Inflation (Inflation over Consumer Price Index)***	$ 30	$ 81	$ 72	$ 187	$ 146	$ 125	$ 82	$ 153	$ 171	$ 153	$ 176	$ 139	$ 82
Total Capital Cost (Year of Expenditure)	**$ 290**	**$ 900**	**$ 770**	**$ 2,180**	**$ 1,510**	**$ 1,370**	**$ 910**	**$ 1,680**	**$ 1,930**	**$ 1,800**	**$ 2,220**	**$ 1,540**	**$ 920**
Total Extent of New Services		39.6	26.8	39.6	39.6	26.8	10.8	39.6	39.6	15.8	39.4	27.1	5.60
Total Extent of New Infrastructure		30.7	26.8	30.7	30.7	26.8	10.8	30.7	30.7	15.8	30.5	27.1	5.60
Gross Average, Millions per km of infrastructure		**$ 29**	**$ 29**	**$ 71**	**$ 49**	**$ 51**	**$ 84**	**$ 55**	**$ 63**	**$ 114**	**$ 73**	**$ 57**	**$ 164**
Evaluation Rating	**3**	**2**	**2**	**1**	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**2**

** Primary rapid transit mode(s) in segment are indicated by shading* BRT LRT BRT/LRT RRT

*** Expansion of fleet assumed 10 and 20 years after opening year, to increase frequency of BRT and/or LRT. RRT frequency is not assumed to change.*

**** Inflation between base year (2010) and assumed year of expenditure (years of construction and procurement)*

Exhibit 3B.2 -- Phase 2 Rapid Transit Routes - Operations and Vehicle Fleet

Technology	Start of Route	End of Route	Corridor	Distance (km)	Trav. Time (minutes)	Recovery (peak)	Peak TT+Rec (minutes)	2-way T+R	Peak 2021 Headway	Peak 2021 Units	Pk + Spare 2021	Vehicles per Consist	2021 Vehicles	Peak 2041 Headway	Peak 2041 Units	Pk + Spare 2041	Vehicles per Consist	2041 Vehicles
												BRT bus						
BRT	Langley Centre	Surrey City Centre	Fraser Hwy	17.1	28.9	3	31.9	63.8	3	22	25	1	25	2	32	37	1	37
(New)	Surrey City Ctr.	White Rock Centre	King George	19.2	39.9	4	43.9	87.8	4	22	25	1	25	2	44	51	1	51
	Surrey City Ctr.	Newton	King George	6.4	13.6	3	16.6	33.2	4	9	10	1	10	2	17	20	1	20
	Newton	White Rock Centre	D. King George	12.8	26.3	3	29.3	58.6	5	12	14	1	14	3	20	23	1	23
	Guildford (156)	Surrey City Centre	104 (Rapid Bus)	4.4	11.5	3	14.5	29	7.5	4	5	1	5	4	8	9	1	9
										Incremental Headway (Rapid Bus on BRT Infrastructure)								
												LRT coupled pair						
LRT	Langley Centre	Surrey City Centre	Fraser Hwy	17.1	27.2	3	30.2	60.4	5	13	15	1	15	3	21	24	1	24
	Langley Centre	Guildford (156)	Fraser/104th	21.5	38.4	3.8	42.2	84.4	5	17	20	1	20	3	29	33	1	33
(New)	Guildford (156)	Newton	King George	10.8	22.9	3	25.9	51.8	5	11	13	1	13	3	18	21	1	21
												RRT units						
RRT	King George Stn	Langley Centre	Fraser Hwy	15.8	17.9	3	20.9	38.8	4.6	9	10	5	50	4.6	9	10	5	50
(Extensions)	King George Stn	Newton	King George	5.6	6.9	3	9.9	16.8	2.3	8	9	5	45	2.3	8	9	5	45

** Recovery applies only to one end of RRT extension*

Assumptions:

Recovery is minimum of 3 minutes; for longer services, use 10% to account to potential variability in arrival time at end of route.
Recovery only applies to one end of the SkyTrain line, since this is an extension of an existing route.
Spare ratio for all types of vehicle = 15%
Initial vehicles are to serve assumed 2021 service pattern, with peak period dictating fleet size.
Additional 2030/2040 vehicles are broken out separately, because cost for fleet expansion happen later in the life cycle.

Rapid Transit Operations and Applicable Alternatives

							2021 Operations			2041 Operations			Applicable Alternatives		
Technology	Start of Route	End of Route	Option/Corridor	Distance (km)	Trav. Time (minutes)	Recovery (peak)	2021 Vehicles	2021 Veh-hrs	2021 Veh-km	2041 Vehicles	2041 Veh-hrs	2041 Veh-km	BRT	LRT	RRT
BRT	Langley Centre	Surrey City Centre	Fraser Hwy	17.1	28.9	3	25	105,500	3,230,000	37	161,100	5,010,000	1, 2	2, 3	2
(New)	Surrey City Ctr.	White Rock Centre	King George	19.2	39.9	4	25	111,100	2,859,000	51	202,000	5,210,000	1	5A, 5B	1A
	Surrey City Ctr.	Newton	King George	6.4	13.6	3	10	47,000	953,000	20	82,300	1,737,000	2		
	Newton	White Rock Centre	D. King George	12.8	26.3	3	14	60,900	1,519,000	23	94,800	2,387,000		1, 2	
	Guildford (156)	Surrey City Centre	104 (Rapid Bus)	4.4	11.5	3	5	25,800	368,000	9	40,700	624,000	1, 2	5A	1A, 2
LRT	Langley Centre	Surrey City Centre	Fraser Hwy	17.1	27.2	3	15	63,400	2,029,000	24	97,300	3,188,000		1, 5A	
	Langley Centre	Guildford (156)	Fraser/104th	21.5	38.4	3.8	20	86,900	2,551,000	33	132,400	4,009,000		5B	
(New)	Guildford (156)	Newton	King George	10.8	22.9	3	13	57,400	1,281,000	21	87,200	2,014,000		1, 2, 3, 4	
RRT	King George Stn	Langley Centre	Fraser Hwy	15.8	17.9	3	50	48,300	2,253,000	50	48,300	2,253,000			1, 1A
(Extensions	King George Stn	Newton	King George	5.6	6.9	3	45	36,600	1,340,000	45	36,600	1,340,000			2, 3

Exhibit 3B.3 -- Rapid Transit Alternatives - Calculation of Operating Costs

2021 Initial

				BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3			mutiplier for units/train
BRT	Service	Veh-hrs		242,400	178,300	60,900	166,400	105,500	-	136,900	111,100	-	136,900	131,300	-	/hr	$ 67.42	
		Service Bus-km		6,457,000	4,551,000	1,519,000	4,749,000	3,230,000	-	3,227,000	2,859,000	-	3,227,000	3,598,000	-	/service km	$ 1.67	1.00
	Extent	Lanes-km (count each lane)		61.40	53.60	7.80	39.80	32.00	-	27.20	18.40	-	29.40	43.00	-	/track or lane km	$ 19,380	
LRT	Service	Veh-hrs		-	-	120,800	57,400	57,400	57,400	63,400	86,900	-		-	-	/hr	$ 67.42	
		Service LRT Car-km		-	-	3,310,000	1,281,000	1,281,000	1,281,000	2,029,000	2,551,000	-		-	-	/service km	$ 2.00	1.00
	Extent	Track-km (count each track)		-	-	53.60	21.60	21.60	21.60	34.20	43.00	-		-	-	/track or lane km	$ 102,097	
RRT	Service	Veh-hrs		-	-	-	-	-	-	-	-	48,300	48,300	36,600	36,600	/hr	$ 35.33	
		Service RRT Car-km		-	-	-	-	-	-	-	-	11,265,000	11,265,000	6,700,000	6,700,000	/service km	$ 0.75	5.00
	Extent	Track-km (count each track)		-	-	-	-	-	-	-	-	31.60	31.60	11.20	11.20	/track or lane km	$ 245,310	
Time-based Subtotal			millions, 2010$	$ 16.3	$ 12.0	$ 12.3	$ 15.1	$ 11.0	$ 3.9	$ 13.5	$ 13.4	$ 1.7	$ 10.9	$ 10.1	$ 1.3			
Distance-based Subtotal			millions, 2010$	$ 10.8	$ 7.6	$ 9.2	$ 10.5	$ 8.0	$ 2.6	$ 9.5	$ 9.9	$ 8.4	$ 13.8	$ 11.0	$ 5.0			
Extent-based (Non-Vehicle Maintenance)			millions, 2010$	$ 1.2	$ 1.0	$ 5.6	$ 3.0	$ 2.8	$ 2.2	$ 4.0	$ 4.7	$ 7.8	$ 8.3	$ 3.6	$ 2.7			
		2021 Annual		$ 28.3	$ 20.7	$ 27.0	$ 28.6	$ 21.8	$ 8.6	$ 27.0	$ 28.0	$ 17.9	$ 33.1	$ 24.7	$ 9.0			

2041 Horizon

				BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3			mutiplier for units/train
BRT	Service	Veh-hrs		403,800	284,100	94,800	255,900	161,100	-	242,700	202,000	-	242,700	201,800	-	/hr	$ 67.42	
		Service Bus-km		10,844,000	7,371,000	2,387,000	7,397,000	5,010,000	-	5,834,000	5,210,000	-	5,834,000	5,634,000	-	/service km	$ 1.67	1.00
	Extent	Lanes-km (count each lane)		61.40	53.60	7.80	39.80	32.00	-	27.20	18.40	-	29.40	43.00	-	/track or lane km	$ 19,380	
LRT	Service	Veh-hrs		-	-	184,500	87,200	87,200	87,200	97,300	132,400	-	-	-	-	/hr	$ 67.42	
		Service LRT Car-km		-	-	5,202,000	2,014,000	2,014,000	2,014,000	3,188,000	4,009,000	-	-	-	-	/service km	$ 2.00	1.00
	Extent	Track-km (count each track)		-	-	53.60	21.60	21.60	21.60	34.20	43.00	-	-	-	-	/track or lane km	$ 102,097	
RRT	Service	Veh-hrs		-	-	-	-	-	-	-	-	48,300	48,300	36,600	36,600	/hr	$ 35.33	
		Service RRT Car-km		-	-	-	-	-	-	-	-	11,265,000	11,265,000	6,700,000	6,700,000	/service km	$ 0.75	5.00
	Extent	Track-km (count each track)		-	-	-	-	-	-	-	-	31.60	31.60	11.20	11.20	/track or lane km	$ 245,310	
Time-based Subtotal			millions, 2010$	$ 27.2	$ 19.2	$ 18.8	$ 23.1	$ 16.7	$ 5.9	$ 22.9	$ 22.5	$ 1.7	$ 18.1	$ 14.9	$ 1.3			
Distance-based Subtotal			millions, 2010$	$ 18.1	$ 12.3	$ 14.4	$ 16.4	$ 12.4	$ 4.0	$ 16.1	$ 16.7	$ 8.4	$ 18.2	$ 14.4	$ 5.0			
Extent-based (Non-Vehicle Maintenance)			millions, 2010$	$ 1.2	$ 1.0	$ 5.6	$ 3.0	$ 2.8	$ 2.2	$ 4.0	$ 4.7	$ 7.8	$ 8.3	$ 3.6	$ 2.7			
		2041 Annual		$ 46.5	$ 32.5	$ 38.9	$ 42.5	$ 32.0	$ 12.1	$ 43.1	$ 44.0	$ 17.9	$ 44.6	$ 32.9	$ 9.0			

Note: Best Bus incremental costs are estimated from addition of bus service beyond BAU levels.

			2021	2041
Best Bus	Service	Veh-hrs	361,500	479,500
		Service Bus-km	9,957,000	15,305,000
Time-based Subtotal		millions, 2010$	$ 24.4	$ 32.3
Distance-based Subtotal		millions, 2010$	$ 16.6	$ 25.6
		Annual	$ 41.0	$ 57.9

3. COST-EFFECTIVENESS

This section of the appendix includes supplementary information on the life cycle cost analysis for each alternative, and the resulting cost-effectiveness calculations.

3.1 LIFE CYCLE COST ANALYSIS

The first step in determining cost-effectiveness was to perform a life-cycle analysis of costs. The net project costs included construction-period costs, including design, construction, right of way, vehicle procurement, and the testing and commissioning of the system. After opening year, costs included operating costs and vehicle fleet costs (for expansion, renewal and replacement). Revenues during the operating period included re-sale of any excess right-of-way and incremental farebox revenues from additional transit passengers.

These costs (including real inflation on construction costs) were laid out year-by-year for the construction period plus 30-year life cycle, and then discounted back to 2010 to produce the Net Present Value (NPV) of costs. **Exhibit 3B.4** charts the annual costs associated with BRT 1 as an example. The costs include the initial construction, followed by a stream of annual operating costs. At several times during the life cycle, there are small jumps in the cost in years when the vehicle fleet is expanded or renewed.

3.2 LIFE CYCLE BENEFIT ANALYSIS

The NPV calculation was repeated for benefits (the values are taken from the transportation account), including quantified transportation (travel time savings, other travel benefits, auto operating cost reductions and collision cost savings) and air emissions (monetized value of CO_2 reductions) benefits. **Exhibit 3B.5** charts the annual benefits associated with BRT 1 as an example. The annual benefits start in the first year of operation, and due to study area growth, the benefits increase each year.

The benefits were calculated in the following manner:

- Travel time savings (net of transit users and non-transit users) were derived from the model. To account for the model not being capacity constrained, two adjustments were made.
    - Where rapid transit capacity was exceeded by demand, only the percentage of passengers fitting on rapid transit was assumed to accrue travel time benefits. This capped the BRT-related travel time savings in BRT 1, BRT 2, LRT 2, LRT 3, LRT 5A, LRT 5B, RRT 1A and RRT 2.
    - Time spent by passengers on BAU local buses is underestimated by the model, because there would be local bus pass-ups in the BAU. Where the rapid transit alternatives relieved BAU pass-ups, then it was assumed the “excess” BAU passengers would save one headway each.
- Other travel benefits included reliability improvements and quality of service benefits for passengers on the rapid transit system. These are economic benefits that have been expressed in travel time equivalents for the purpose of the evaluation.
    - The reliability benefit is related to the increased certainty of transit travel times for existing transit passengers that switch to rapid transit, which is segregated from other traffic. This benefit is related to reducing the additional time that passengers have to allow for travel because of local bus schedule fluctuations. It was assessed as a 15% overlay on the estimated travel time savings for existing passengers. It was not assessed for new users because they switch from unscheduled modes (auto, walk, cycle).

    - The quality benefit is the perceived improvement in transit service due to the rapid transit experience, amenities and ride quality of the station and vehicles, and was valued once per trip consistent with other rapid transit studies. Two minutes were assumed for BRT passengers, and four minutes for LRT or RRT passengers.

- Auto operating cost and collision cost savings were derived from VKT reductions (estimated in the transportation account); and
- Air emissions savings (from the environment account), were valued at $25 per tonne of CO_2. Any increases in air emissions, for example during construction, were evaluated as negative savings.

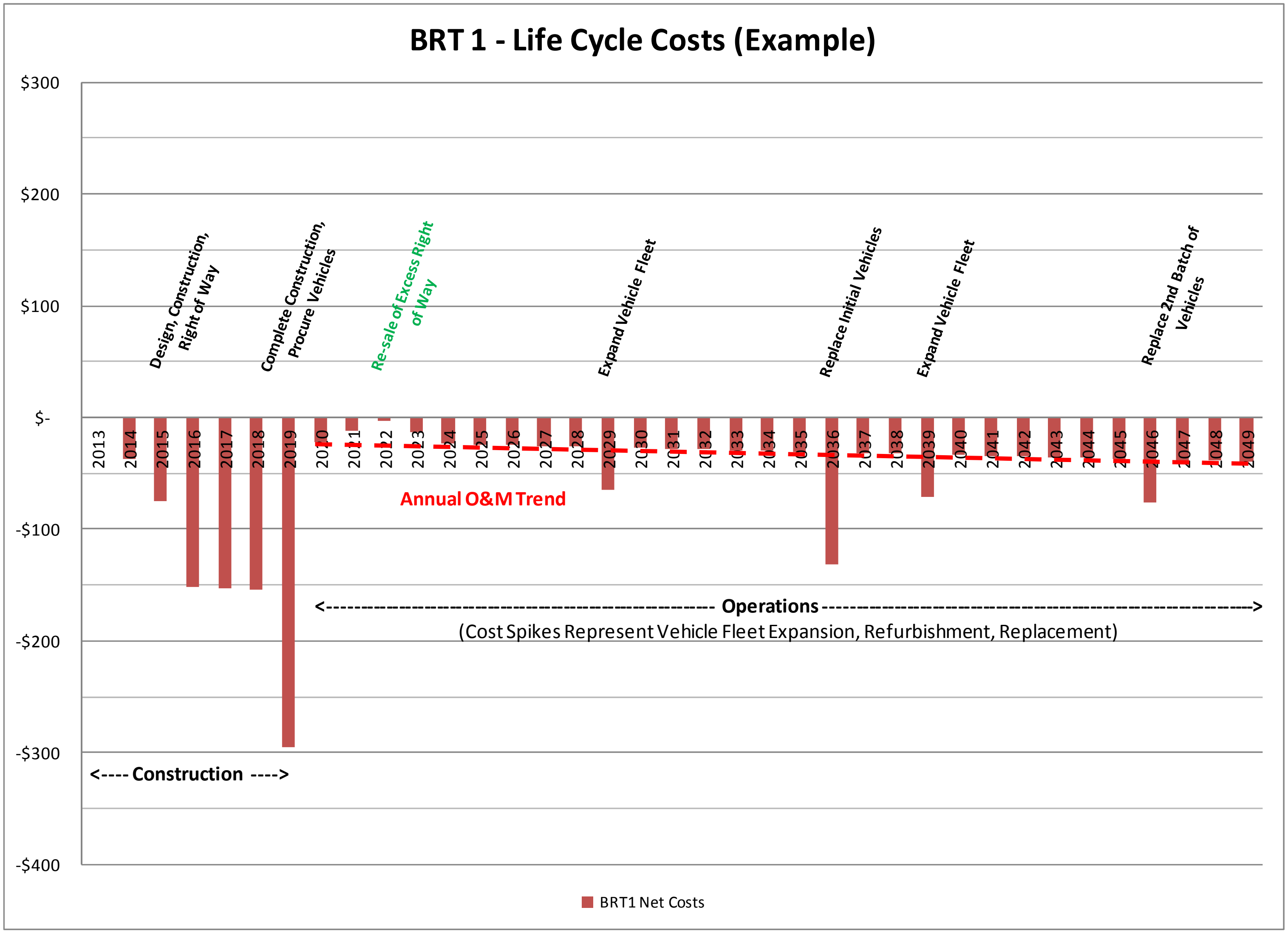
Exhibit 3B.6 illustrates the travel time, reliability and quality transportation benefits graphically, in terms of person-hours over the life cycle. These benefit categories were all converted to time equivalents before applying the value of time.

Exhibit 3B.7 plots the net present value of the different components of benefits, including the travel time savings, other transportation benefits, auto operating cost/collision savings, and value of air emissions changes. The total net present value of all benefits is labelled on the plots.

3.3 CASH FLOW CHARTS

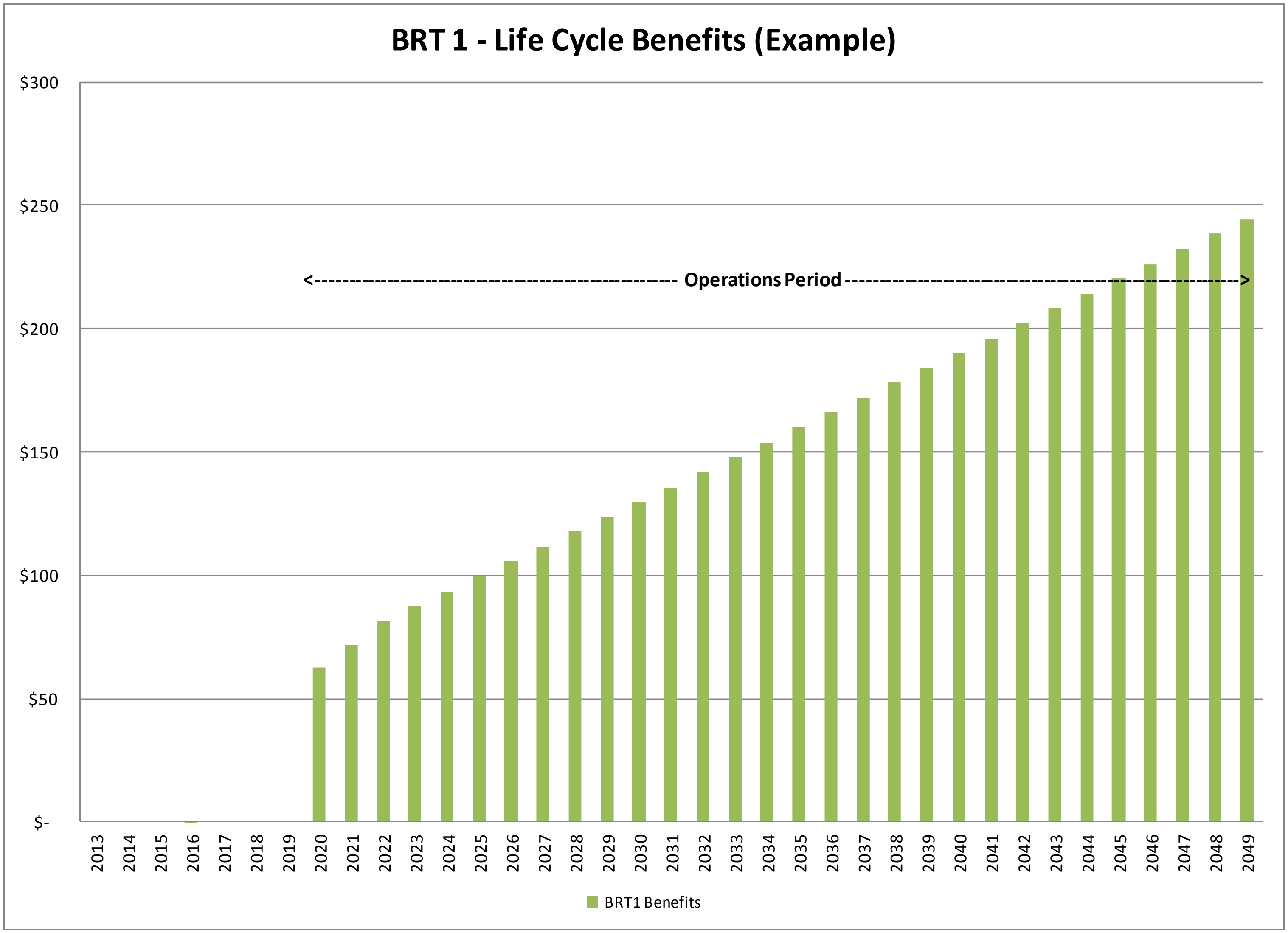
Annual cash flow charts **(Exhibits 3B.8 to 3B.20)** were prepared for each alternative, indicating the capital and operating costs, and the monetized benefits. The charts also indicate the net benefits minus costs, which improves over the life cycle since most of the costs are up front and the benefits follow later. The cumulative NPV is a summation of the discounted costs and benefits from the start of construction through to that specific year in the life cycle, and the final life cycle NPV is indicated against the last year of appraisal (2049). Positive results indicated that the discounted benefits amounted to a greater amount than discounted costs for an alternative; in other words, the Benefit-Cost Ratio (BCR) was greater than 1.0.

Exhibit 3B.4 – Life Cycle Cash Flow for Project Costs – BRT 1 Example



(Values in Millions, $2010)

Exhibit 3B.5 – Life Cycle Cash Flow for Project Benefits – BRT 1 Example



(Values in Millions, $2010)

Exhibit 3B.6 – Travel Time Savings, Reliability and Quality Benefits of Alternatives

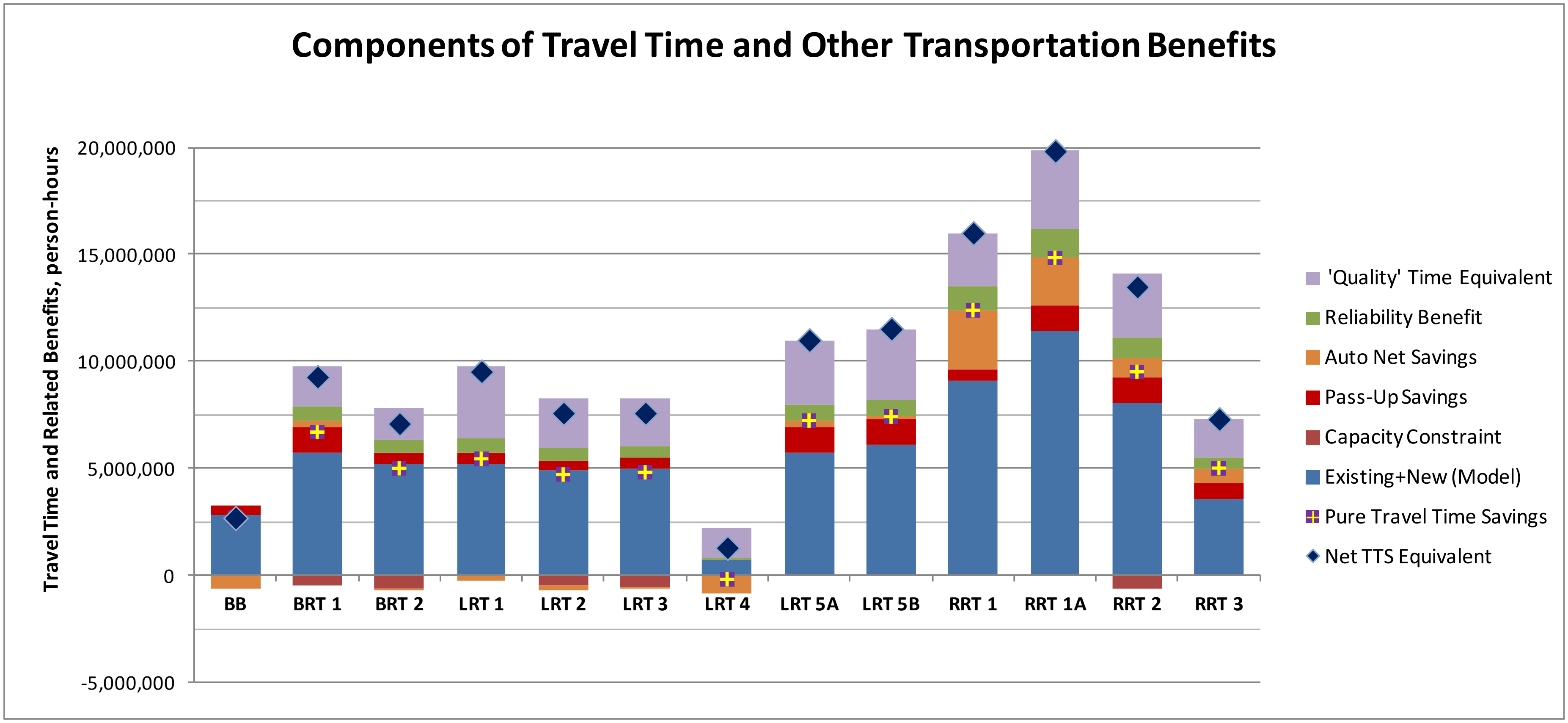


Exhibit 3B.7 – Net Present Value of Benefits (by Major Components)

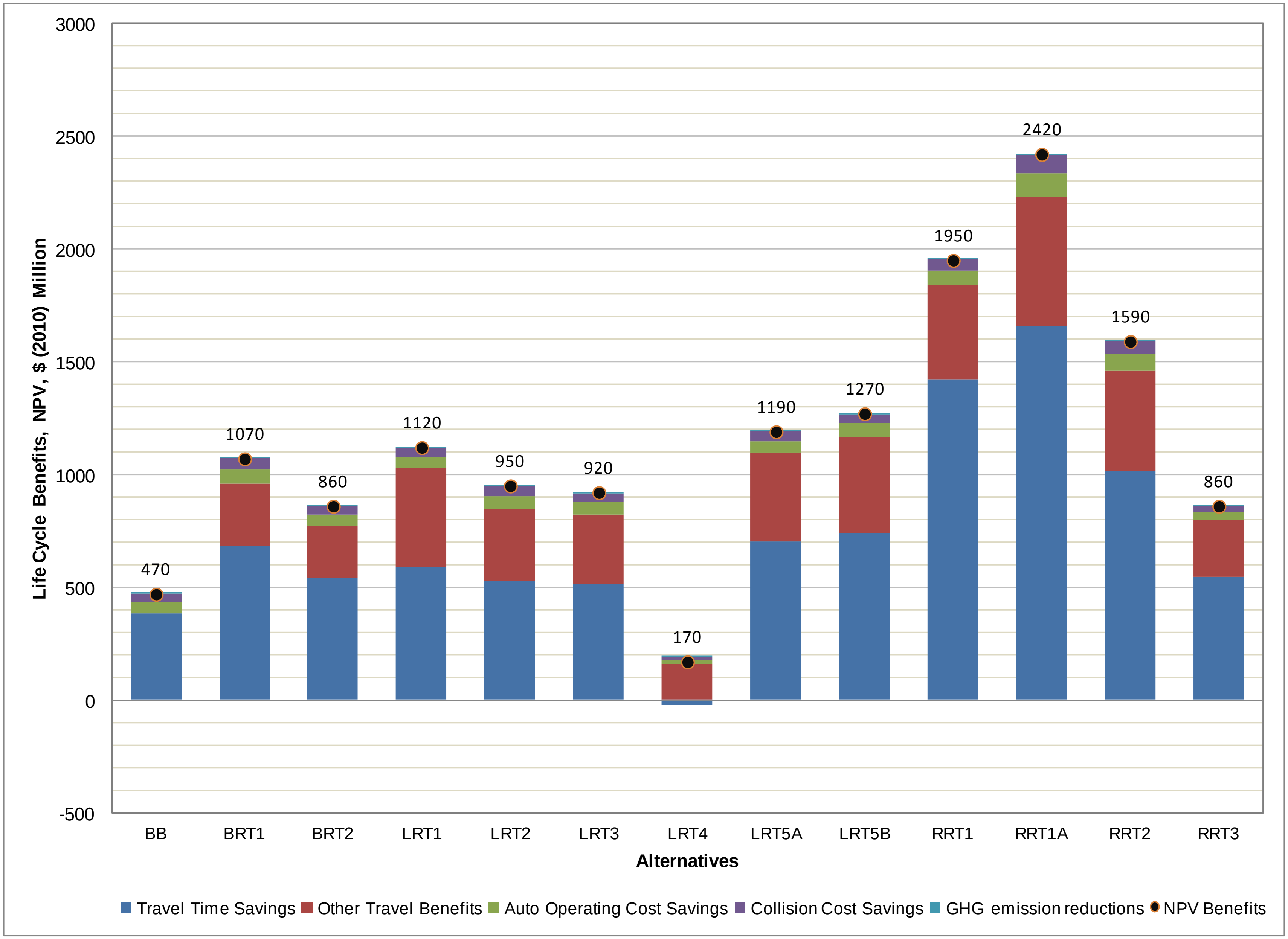
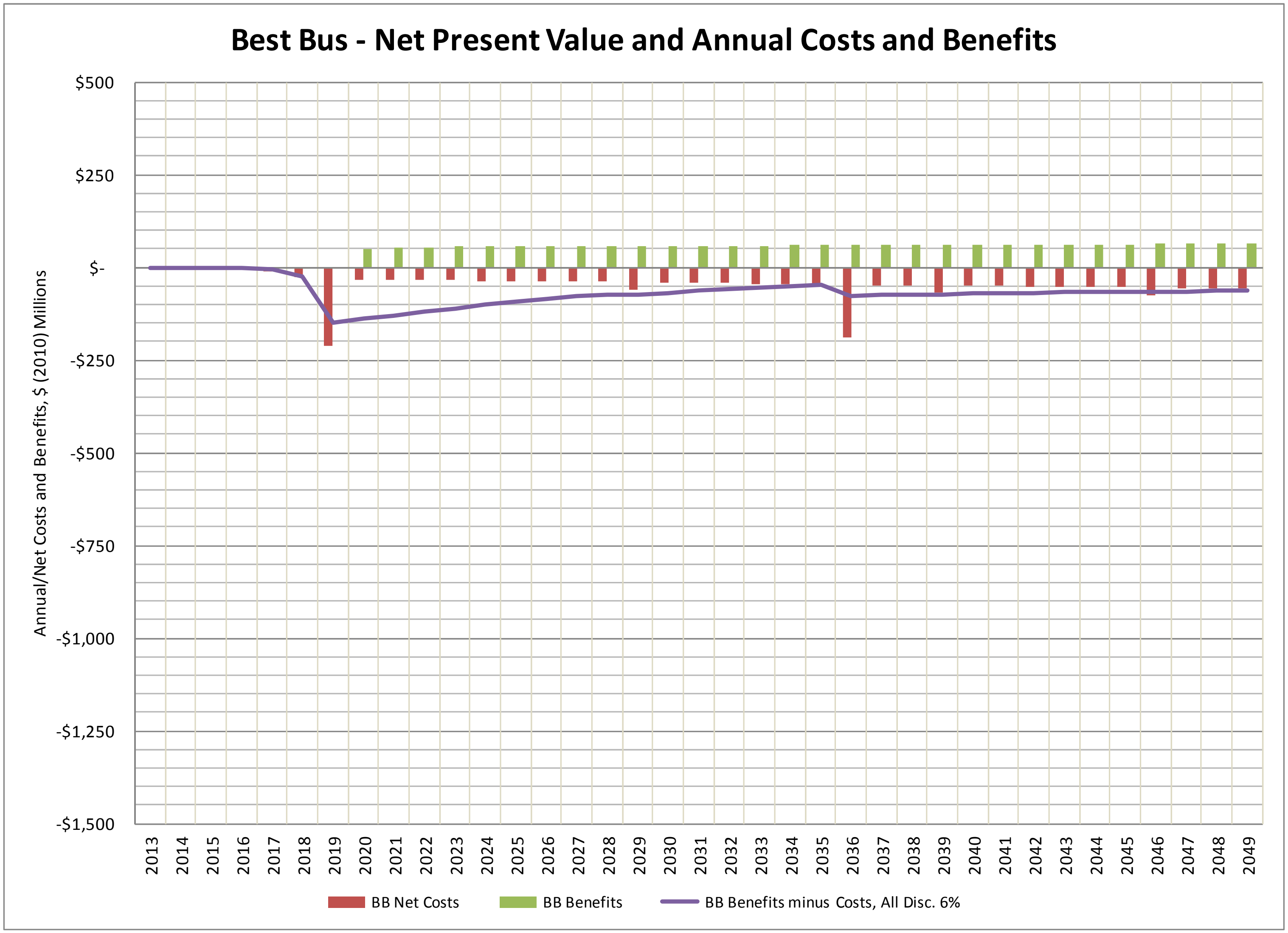
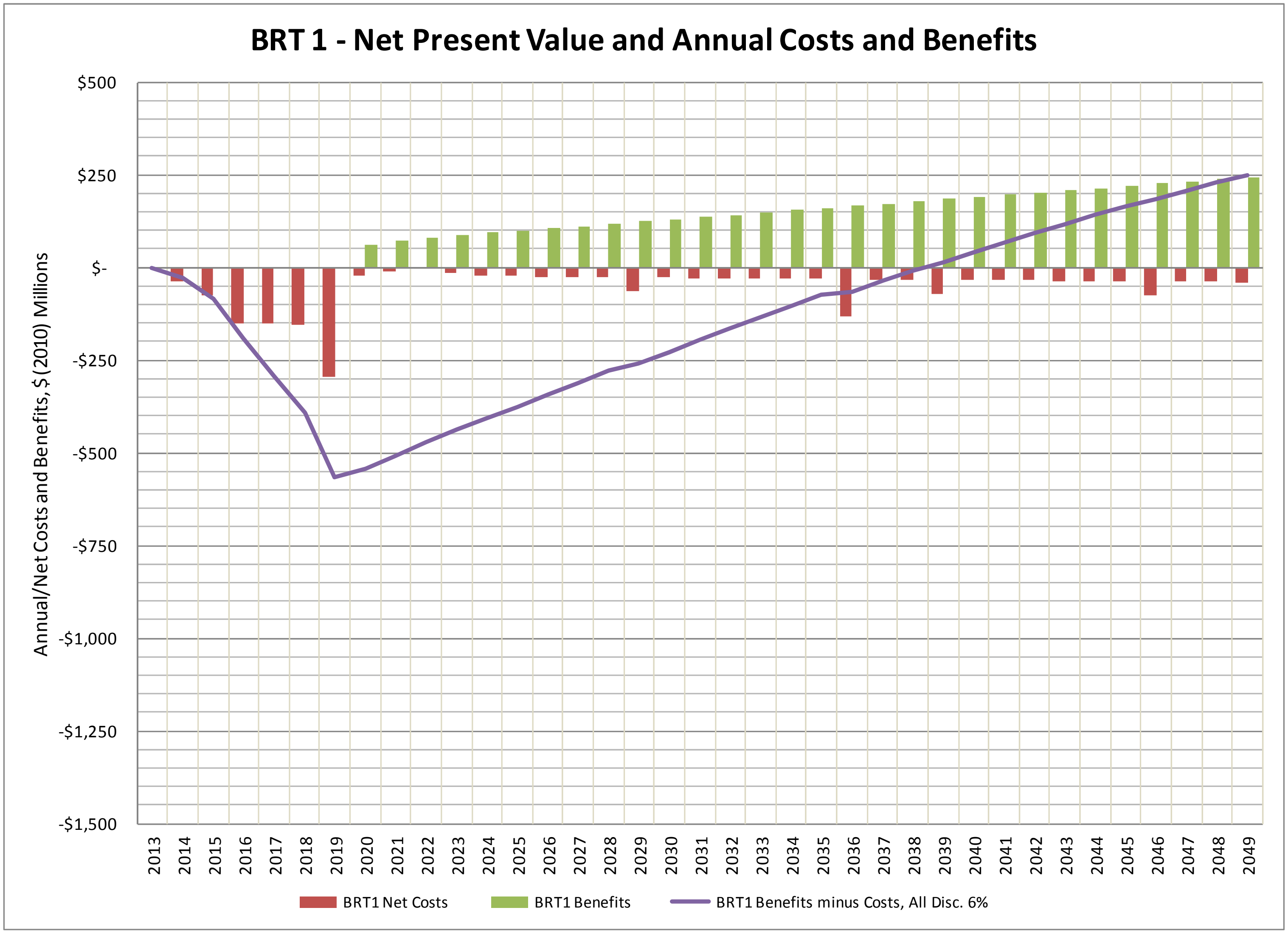


Exhibit 3B.8 – Life Cycle Costs, Benefits and Net Present Value – Best Bus



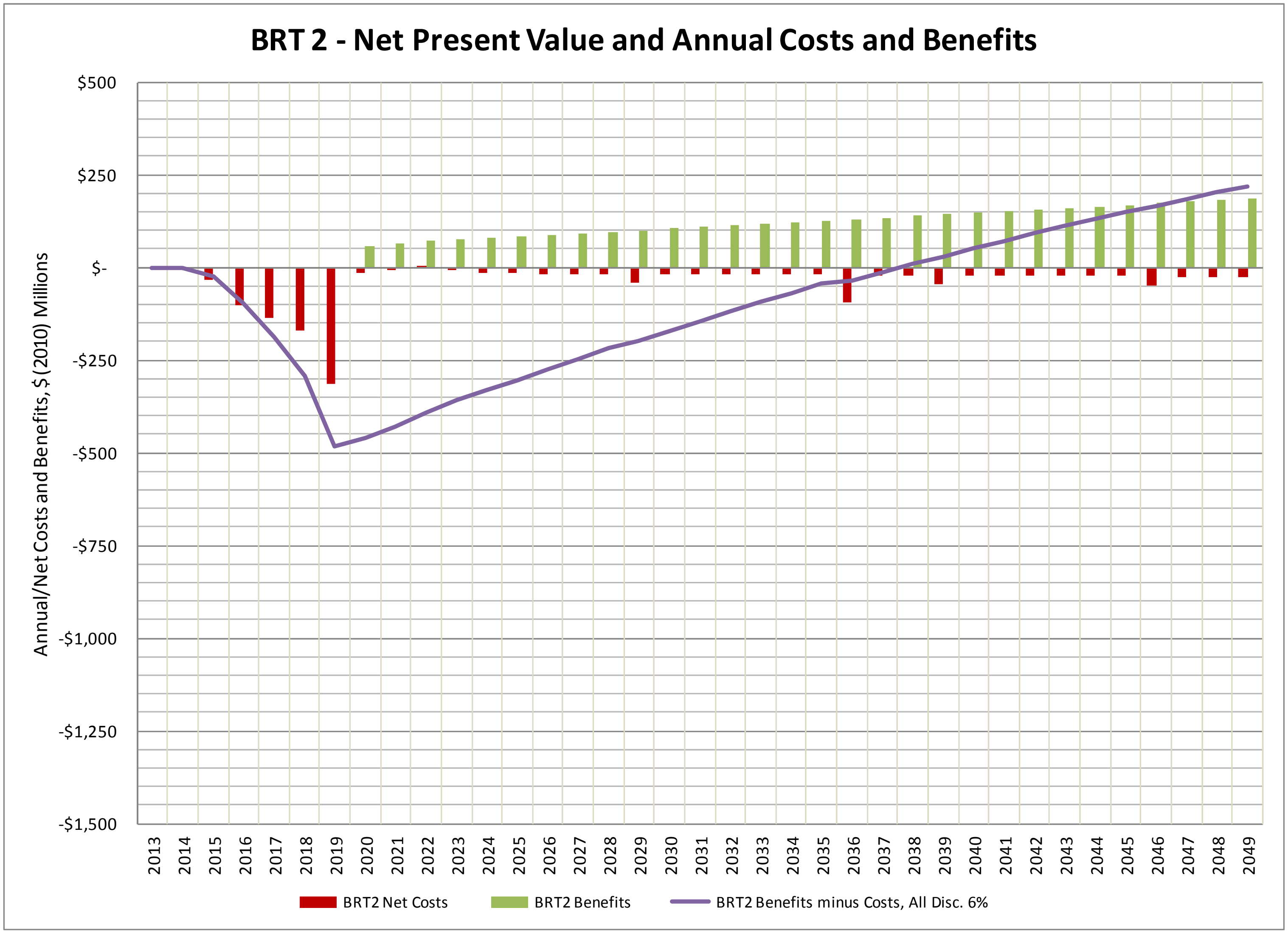
(Values in Millions, $2010)

Exhibit 3B.9 – Life Cycle Costs, Benefits and Net Present Value – BRT 1



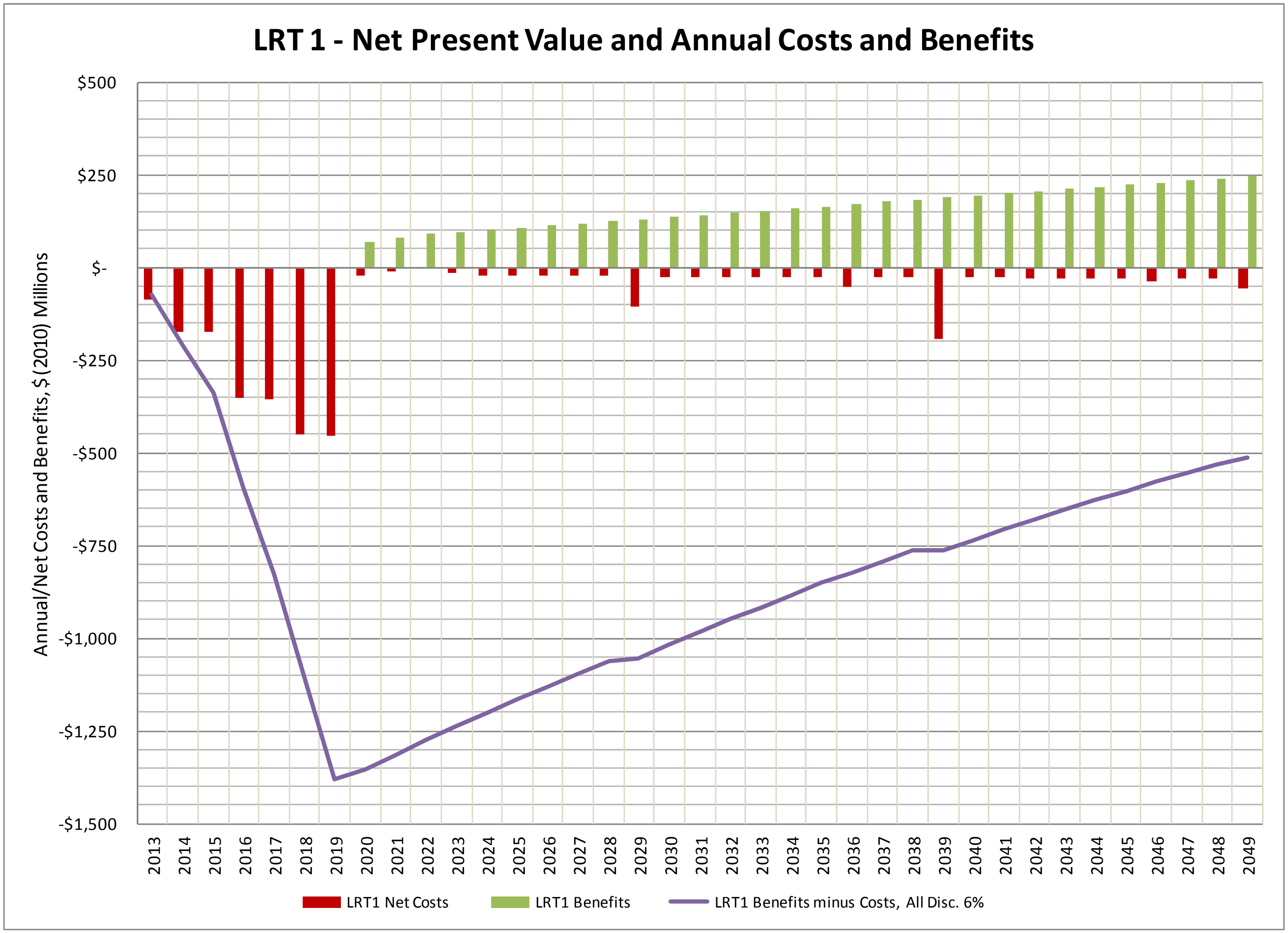
(Values in Millions, $2010)

Exhibit 3B.10 – Life Cycle Costs, Benefits and Net Present Value – BRT 2



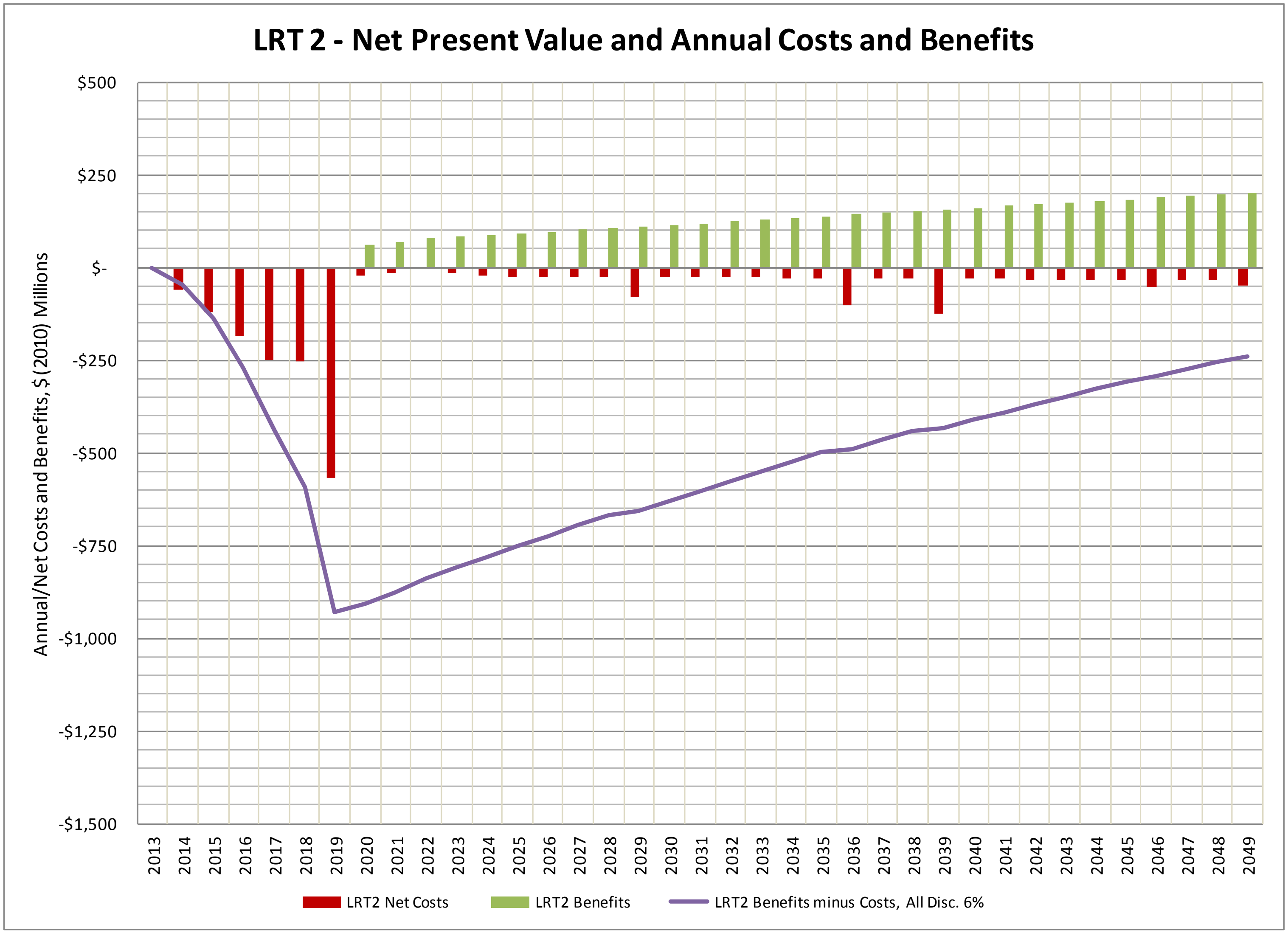
(Values in Millions, $2010)

Exhibit 3B.11 – Life Cycle Costs, Benefits and Net Present Value – LRT 1



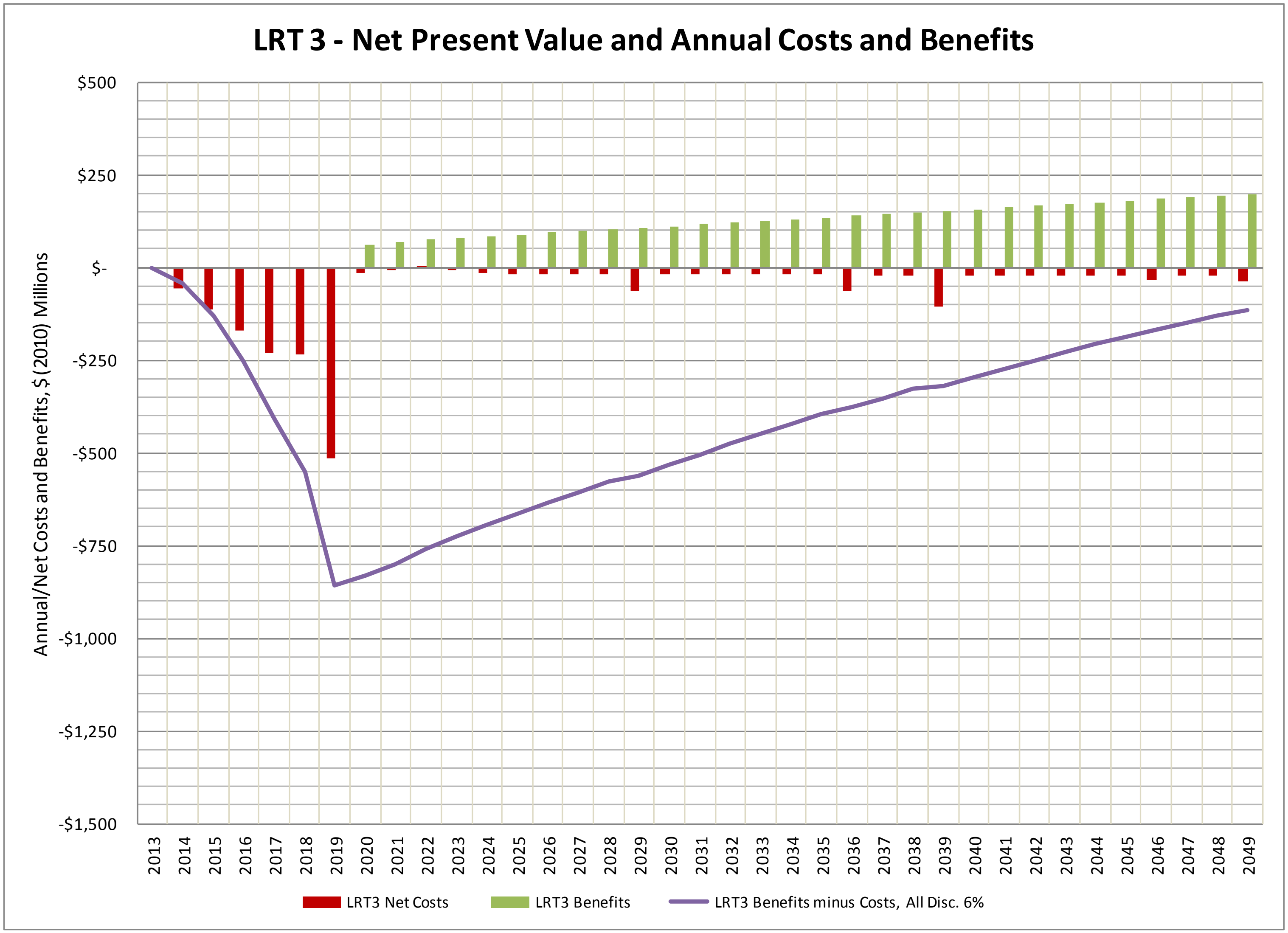
(Values in Millions, $2010)

Exhibit 3B.12 – Life Cycle Costs, Benefits and Net Present Value – LRT 2



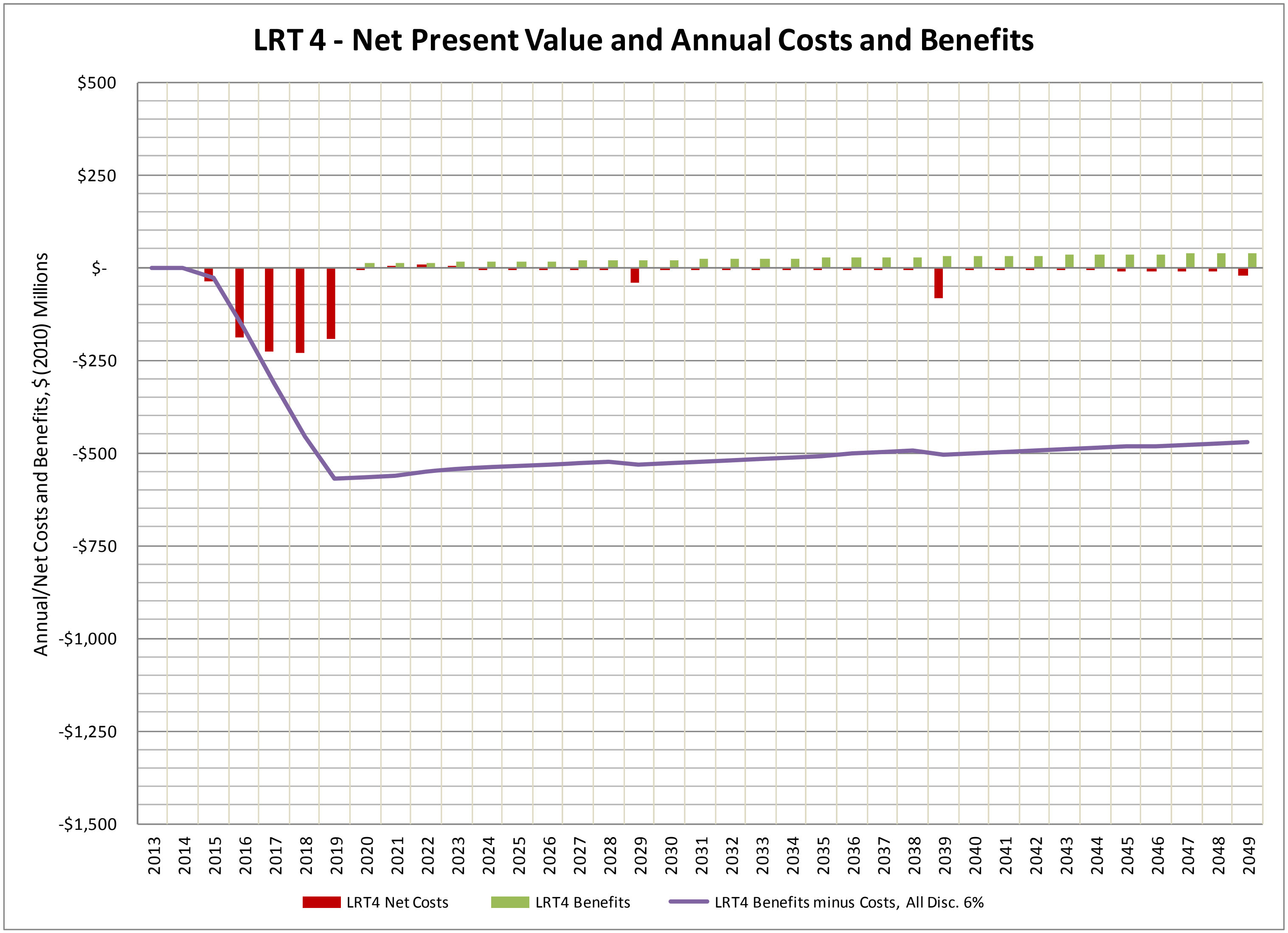
(Values in Millions, $2010)

Exhibit 3B.13 – Life Cycle Costs, Benefits and Net Present Value – LRT 3



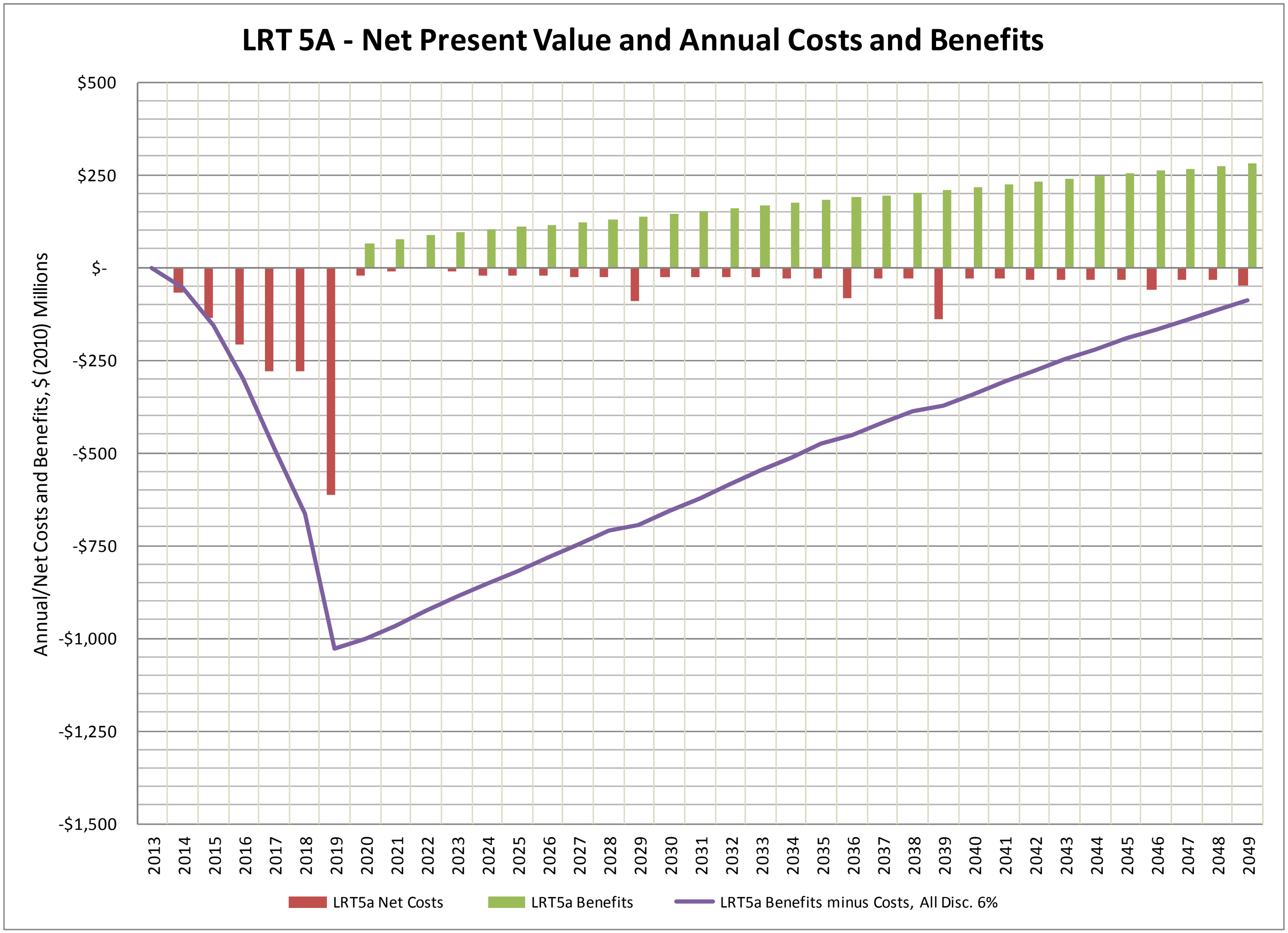
(Values in Millions, $2010)

Exhibit 3B.14 – Life Cycle Costs, Benefits and Net Present Value – LRT 4



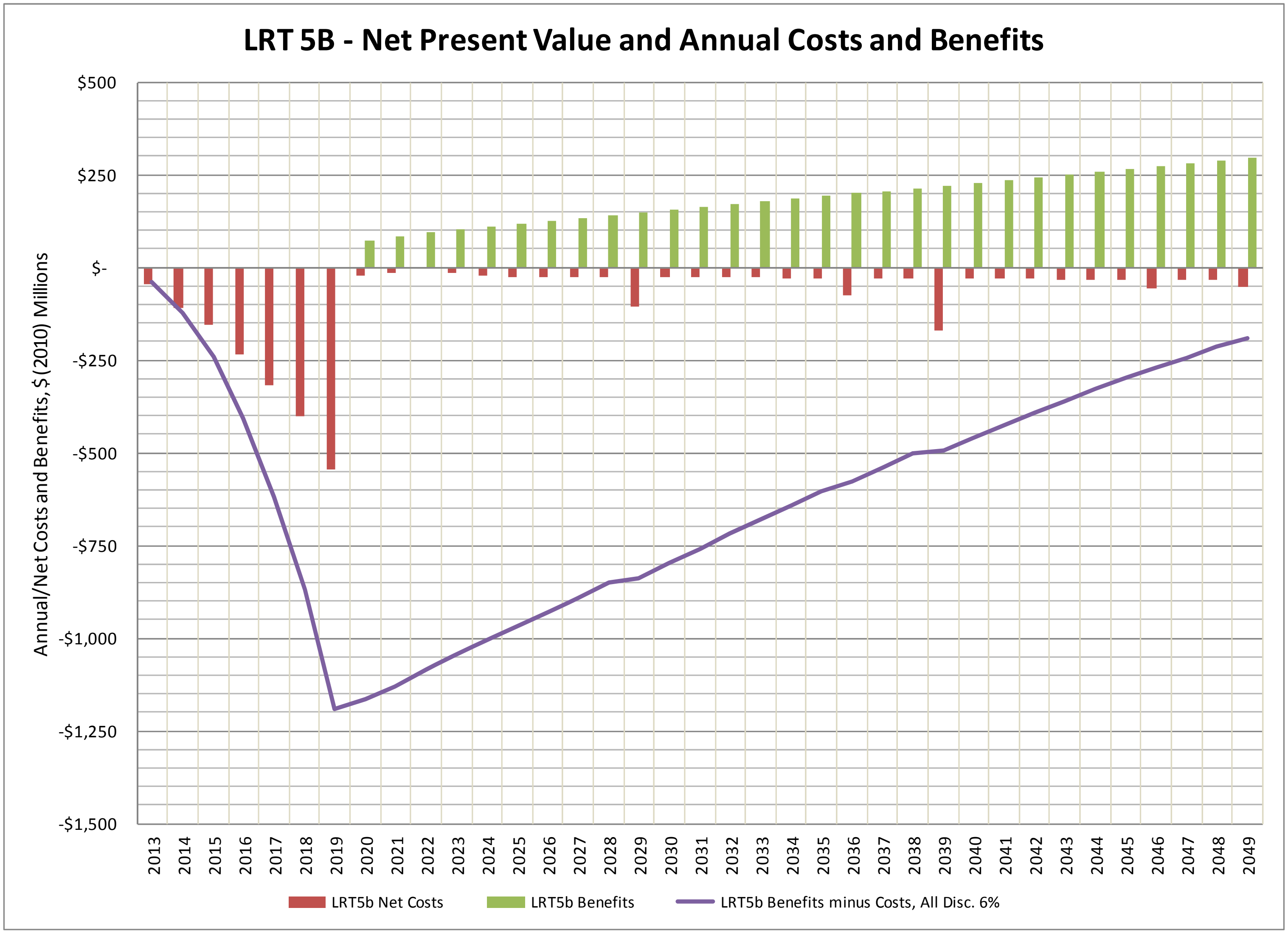
(Values in Millions, $2010)

Exhibit 3B.15 – Life Cycle Costs, Benefits and Net Present Value – LRT 5A



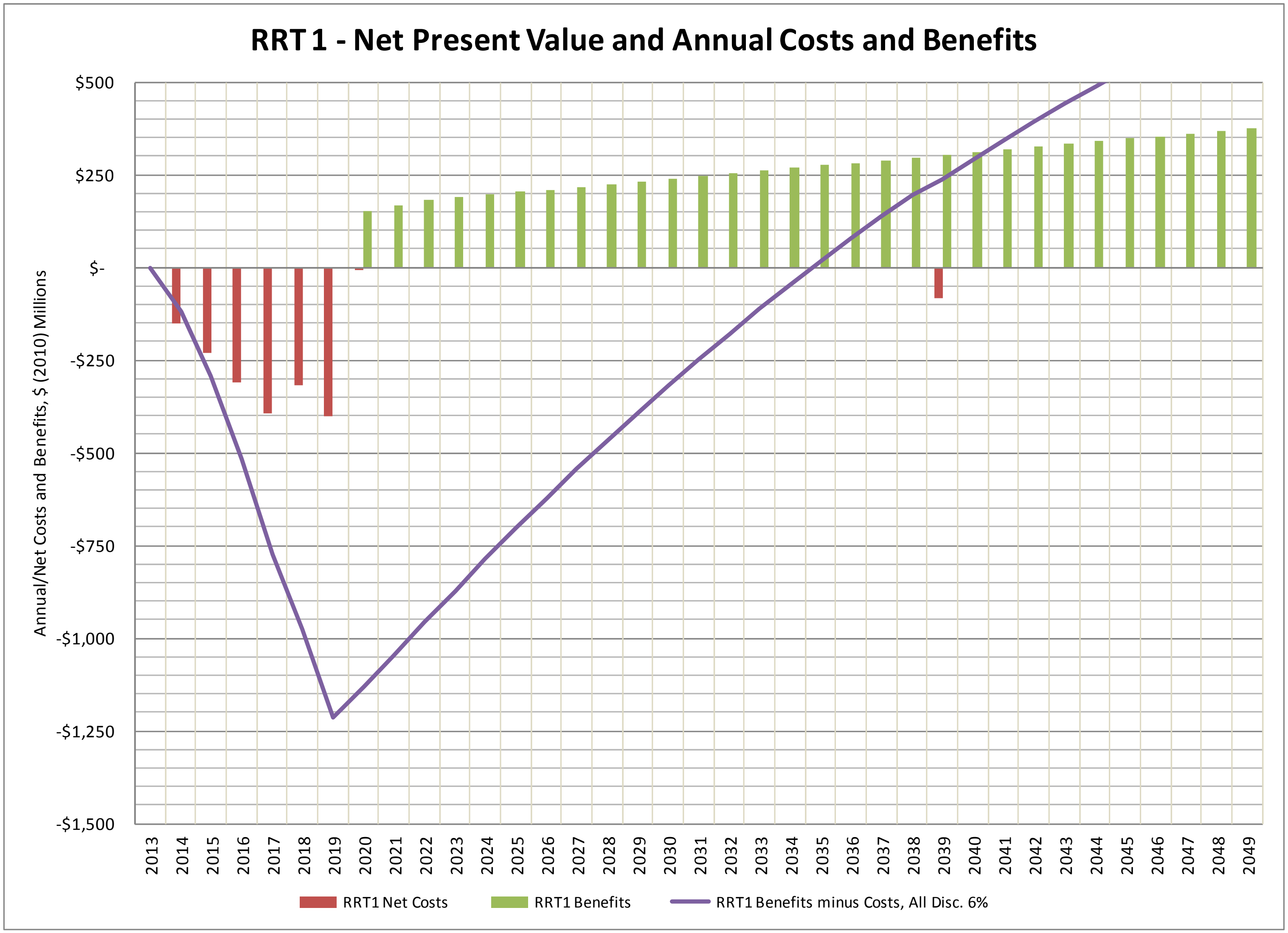
(Values in Millions, $2010)

Exhibit 3B.16 – Life Cycle Costs, Benefits and Net Present Value – LRT 5B



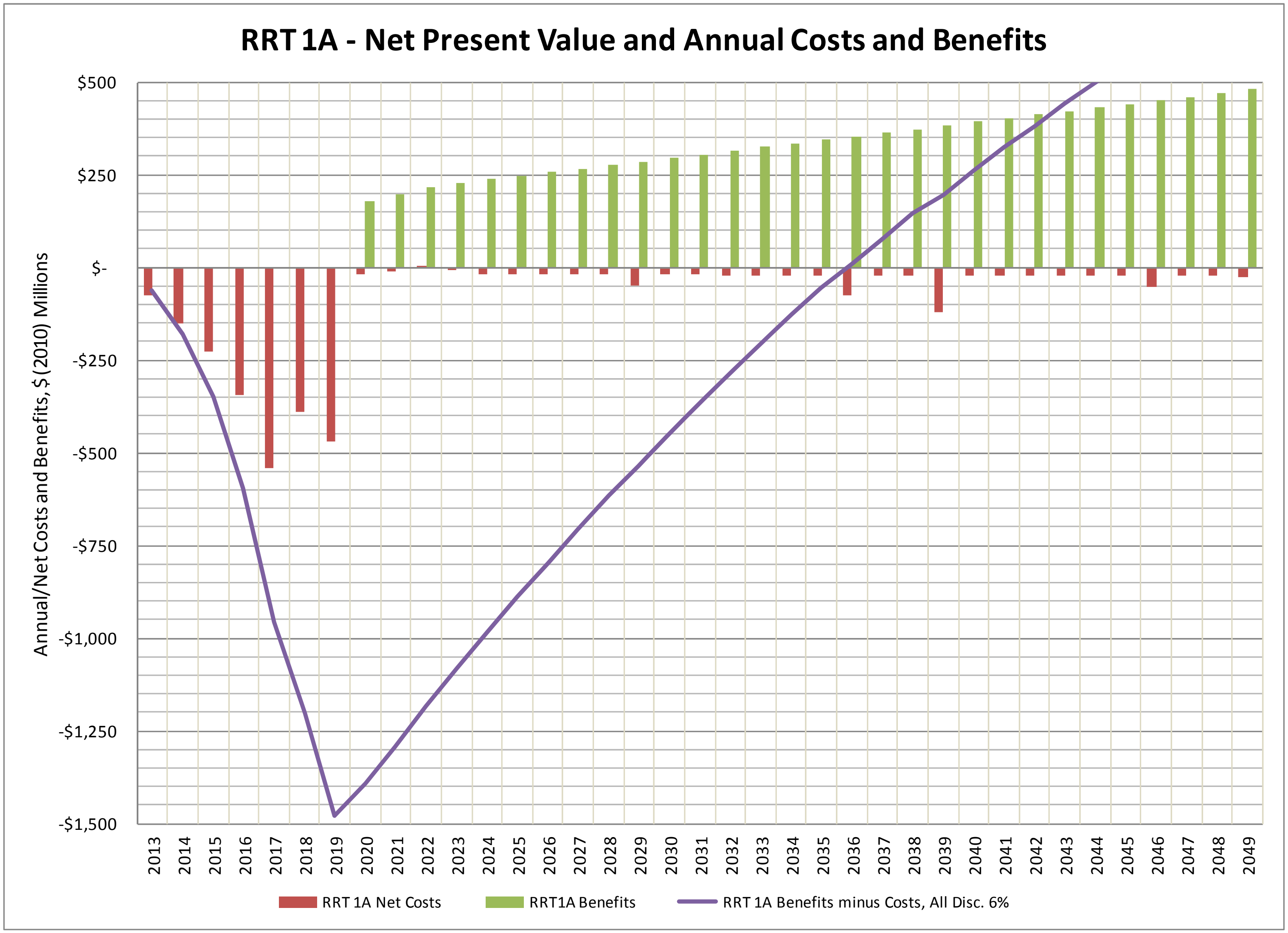
(Values in Millions, $2010)

Exhibit 3B.17 – Life Cycle Costs, Benefits and Net Present Value – RRT 1



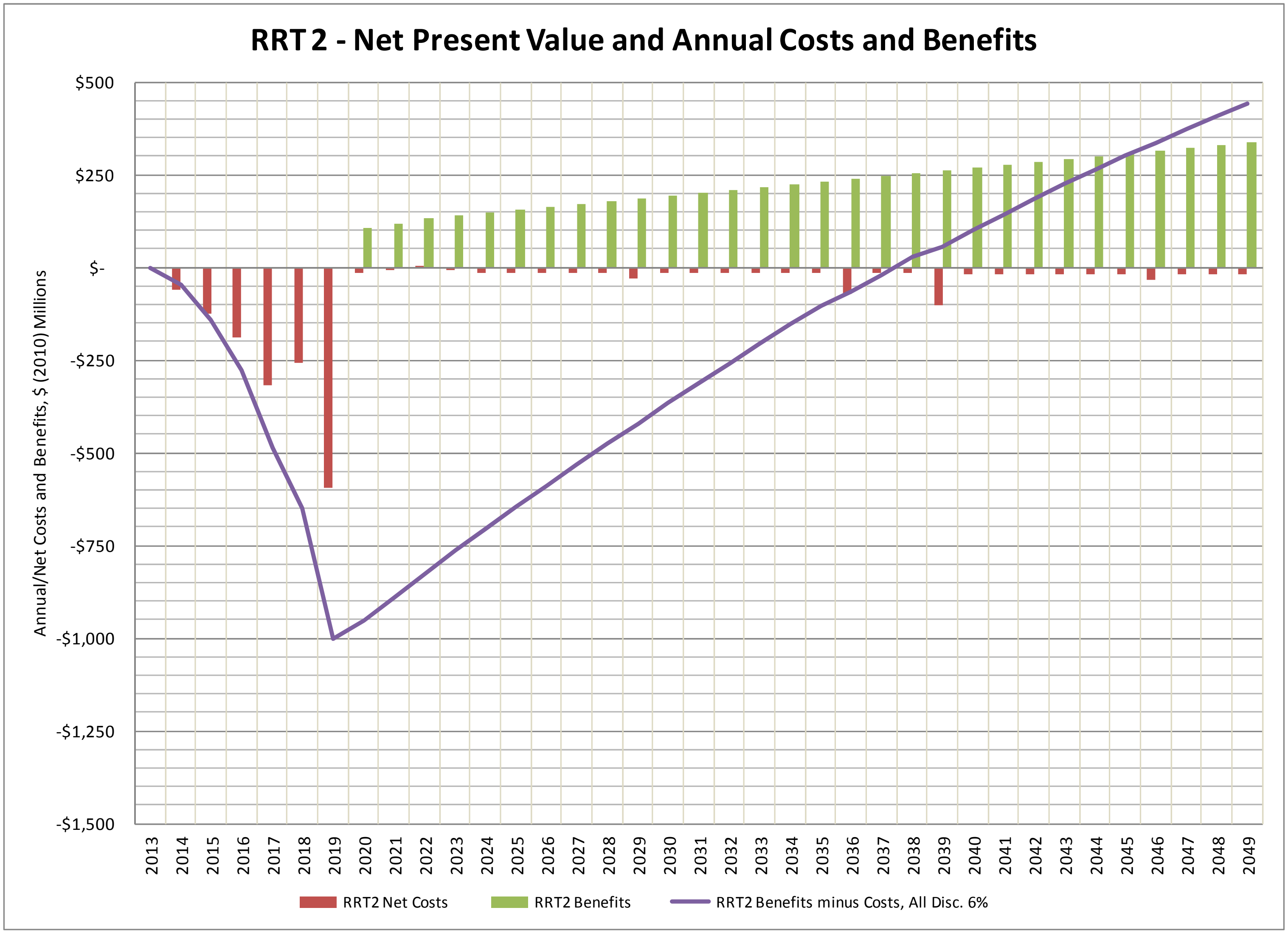
(Values in Millions, $2010)

Exhibit 3B.18 – Life Cycle Costs, Benefits and Net Present Value – RRT 1A



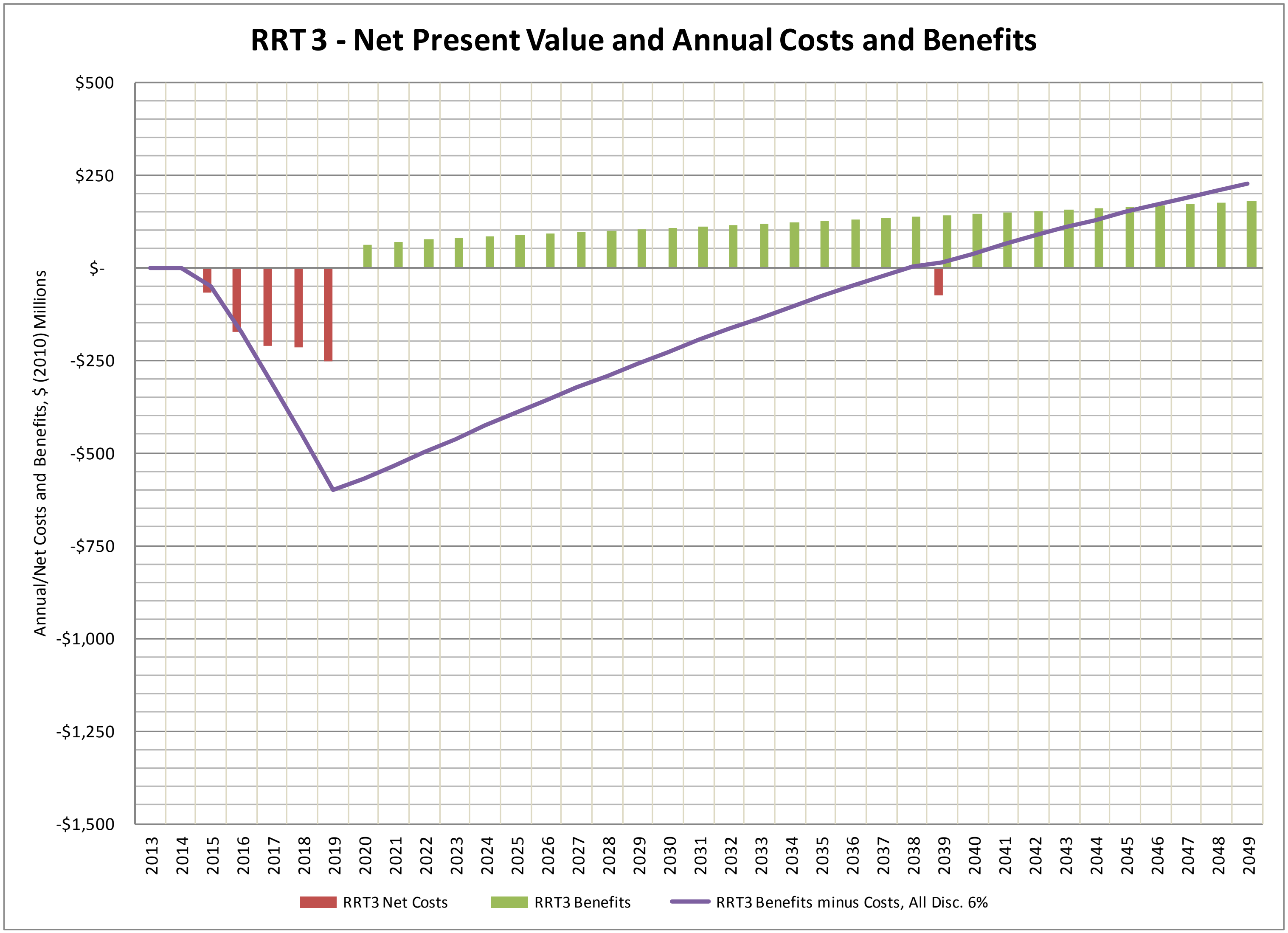
(Values in Millions, $2010)

Exhibit 3B.19 – Life Cycle Costs, Benefits and Net Present Value – RRT 2



(Values in Millions, $2010)

Exhibit 3B.20 – Life Cycle Costs, Benefits and Net Present Value – RRT 3



(Values in Millions, $2010)

3.3 COST-EFFECTIVENESS MEASURES

To gain an understanding of the average cost of transportation benefits (e.g. time savings, new riders) and land use intensification benefits, the total costs were divided by transportation, environment and land use outputs.

The resulting measures of cost-effectiveness were based on annualized costs (transportation benefits) or Net Present Value of costs (air emissions and land use benefits), as noted below:

- Average (annualized) cost per added transit trip in 2021 and 2041.
  - The capital costs were converted to an *annual average* over the life cycle, and this value was added to the operating costs net of new fare revenues to derive 2021 and 2041 *total annualized costs*. The annual average is calculated by taking the capital cost and converting it to an annuity (using the 6% rate) over the asset life of the alternative[1]. The average asset life for each alternative is based on the construction, vehicle and property components. The asset lives for vehicles are shorter, in-street construction asset lives are moderate length, and structures and property have the longest assumed asset lives. The average asset life was determine for each alternative based on the proportion of costs by category; BB had the shortest life since most of its costs would be vehicles; the RRT alternatives had long asset lives due to structures making up much of the costs. The capital costs were annualized at 6% over the asset life for each alternative, as shown on the exhibit;
  - The annualized capital costs were added to the 2021 and 2041 annual operating costs to produce the total annualized cost for each of those years;
  - The resulting annualized costs (operating + capital) for 2021 and 2041 were then divided by the estimated number of additional regional transit trips (determined in the transportation account);
- Cost per additional transit passenger-km (annualized cost divided by incremental regional transit passenger-km in 2041); and
- Average cost per hour saved, based on the travel time benefits (annualized costs divided by savings in person-hours);
- For air emissions, the life cycle costs (NPV of costs) were divided by life cycle net change in GHG (from the environment account);
- Cost per land use intensification (NPV of costs/square feet of station area development).

The calculations of cost-effectiveness, including the derivation of annualized costs, are summarized in **Exhibit 3B.21**. The exhibit also shows the Net Present Value of the costs and benefits (which were illustrated over the preceding pages), and the resulting Benefit/Cost Ratio.

[1] The US Federal Transit Administration uses this measure to compare proposed transit projects. This approach "un-discounts" the capital costs into a time stream, with varying asset lives for the different components (e.g. property, vehicles of different types, paving, stations, etc.) of the project, and the implementation costs allocated to the direct cost categories.

Exhibit 3B.21 - Cost-Effectiveness (including Net Present Value, Benefit Cost Ratio, and Annualized Costs)

Alternative	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Net Present Value, at 6% Discount to 2010:														
PV of Capital Costs		$ 193	$ 592	$ 493	$ 1,426	$ 963	$ 880	$ 581	$ 1,066	$ 1,240	$ 1,221	$ 1,503	$ 1,019	$ 610
PV of Operating Costs		$ 398	$ 300	$ 214	$ 265	$ 286	$ 216	$ 83	$ 281	$ 289	$ 146	$ 313	$ 233	$ 74
PV of Fare Revenues ('negative' cost)		-$ 61	-$ 74	-$ 64	-$ 63	-$ 67	-$ 66	-$ 20	-$ 67	-$ 71	-$ 111	-$ 148	-$ 104	-$ 53
NPV of Costs*, Millions		$ 530	$ 820	$ 640	$ 1,630	$ 1,180	$ 1,030	$ 640	$ 1,280	$ 1,460	$ 1,260	$ 1,670	$ 1,150	$ 630
PV of Travel Time Savings		$ 383	$ 684	$ 539	$ 589	$ 527	$ 517	-$ 20	$ 703	$ 738	$ 1,421	$ 1,662	$ 1,018	$ 545
PV of Other Travel Benefits		$ -	$ 278	$ 234	$ 439	$ 318	$ 304	$ 156	$ 392	$ 431	$ 419	$ 566	$ 443	$ 254
PV of Auto Operating Cost Savings		$ 50	$ 61	$ 51	$ 51	$ 56	$ 55	$ 20	$ 56	$ 57	$ 64	$ 107	$ 73	$ 33
PV of Collision Cost Savings		$ 37	$ 46	$ 38	$ 38	$ 42	$ 41	$ 15	$ 42	$ 43	$ 48	$ 81	$ 54	$ 25
PV of GHG emission reductions		$ 3	$ 1	$ 1	$ 1	$ 1	$ 1	$ 0	$ 1	$ 1	$ 1	$ 1	$ 1	$ 0
NPV, Benefits**, Millions		$ 470	$ 1,070	$ 860	$ 1,120	$ 940	$ 920	$ 170	$ 1,190	$ 1,270	$ 1,950	$ 2,420	$ 1,590	$ 860
Total NPV		**-$ 60**	**$ 250**	**$ 220**	**-$ 510**	**-$ 240**	**-$ 110**	**-$ 470**	**-$ 90**	**-$ 190**	**$ 690**	**$ 750**	**$ 440**	**$ 230**
Benefit/Cost Ratio		**0.89**	**1.30**	**1.34**	**0.69**	**0.80**	**0.89**	**0.27**	**0.93**	**0.87**	**1.55**	**1.45**	**1.38**	**1.37**

* Capital including initial construction and vehicle purchases, renewals/refurbishment, O&M, partially offset by net fare revenues
** Travel time savings, auto operating and collision costs, value of net change in GHG emissions

Average Costs

Average Annual Costs (Undiscounted Annualized Capital Costs plus Operating Cost in future year of operations)

Alternative	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Capital Cost (Undiscounted)		*$290*	*$900*	*$770*	*$2,180*	*$1,510*	*$1,370*	*$910*	*$1,680*	*$1,930*	*$1,800*	*$2,220*	*$1,540*	*$920*
Average Asset Life (Construction, Vehicles, Property)		*25*	*48*	*51*	*41*	*43*	*44*	*42*	*43*	*42*	*61*	*59*	*54*	*57*
Annualization Factor (6% over asset life of components)		*0.084*	*0.068*	*0.067*	*0.070*	*0.070*	*0.069*	*0.070*	*0.070*	*0.070*	*0.066*	*0.066*	*0.067*	*0.066*
Annualized Capital + Renewals Cost		$ 24	$ 61	$ 52	$ 154	$ 105	$ 95	$ 64	$ 117	$ 135	$ 118	$ 146	$ 103	$ 61
2021 Net Operating Cost (Op.Cost -Revenue)		$ 34	$ 22	$ 15	$ 22	$ 23	$ 16	$ 7	$ 22	$ 23	$ 6	$ 19	$ 15	$ 3
2021 Total Annualized Cost ($M)		**$ 58**	**$ 83**	**$ 67**	**$ 176**	**$ 128**	**$ 111**	**$ 71**	**$ 139**	**$ 158**	**$ 124**	**$ 165**	**$ 118**	**$ 64**
2041 Net Operating Cost (Op.Cost -Revenue)		$ 51	$ 35	$ 22	$ 28	$ 32	$ 22	$ 9	$ 32	$ 31	$ 3	$ 23	$ 17	$ 2
2041 Total Annualized Cost ($M)		**$ 75**	**$ 96**	**$ 74**	**$ 182**	**$ 137**	**$ 117**	**$ 73**	**$ 149**	**$ 166**	**$ 121**	**$ 169**	**$ 120**	**$ 63**

Transit Passenger Activity

Additional Transit Trips (Increase in Regional Transit Trips relative to BAU, Estimated Annual Value)

Alternative	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
2021 Additional Transit Trips (Millions)		3.9	3.0	2.6	2.4	2.8	2.9	0.8	2.6	2.5	5.2	6.6	4.5	2.6
Avg. Cost Per Added Transit Passenger, 2021		**$ 15**	**$ 27**	**$ 25**	**$ 74**	**$ 45**	**$ 39**	**$ 85**	**$ 54**	**$ 64**	**$ 24**	**$ 25**	**$ 26**	**$ 25**
2041 Additional Transit Trips (Millions)		3.9	5.7	4.8	5.2	5.1	4.8	1.6	5.2	6.1	6.2	9.6	7.0	2.9
Avg. Cost Per Added Transit Passenger, 2041		**$ 19**	**$ 17**	**$ 15**	**$ 35**	**$ 27**	**$ 24**	**$ 44**	**$ 28**	**$ 27**	**$ 19**	**$ 18**	**$ 17**	**$ 22**

Additional Transit Pass-km (relative to BAU, Estimated Annual Value)

Alternative	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
2041 Additional Transit Pass-km (Millions)		57.6	159.6	128.5	140.3	138.2	131.1	13.8	153.0	164.7	289.7	351.9	227.0	107.1
Avg. Cost Per Added Transit Pass-km, 2041		**$ 1.30**	**$ 0.60**	**$ 0.58**	**$ 1.29**	**$ 0.99**	**$ 0.89**	**$ 5.27**	**$ 0.97**	**$ 1.01**	**$ 0.42**	**$ 0.48**	**$ 0.53**	**$ 0.59**

Travel Time Benefits

Person-Hours Saved (Decrease in person-hours for transit and auto trips relative to BAU, Estimated Annual Value)

Alternative	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
2021 Travel Time Saved (Hours, Millions)		2.9	2.8	2.5	2.9	2.6	2.4	(0.1)	2.7	3.1	8.1	9.1	4.8	2.8
Avg. Cost Per Hour Saved, 2021		**$ 20**	**$ 30**	**$ 27**	**$ 60**	**$ 50**	**$ 46**	**n/a**	**$ 52**	**$ 52**	**$ 15**	**$ 18**	**$ 24**	**$ 23**
2041 Travel Time Saved (Hours, Millions)		2.7	6.7	5.0	5.4	4.7	4.8	(0.2)	7.2	7.4	12.4	14.8	9.5	5.0
Avg. Cost Per Hour Saved, 2041		**$ 28**	**$ 14**	**$ 15**	**$ 33**	**$ 29**	**$ 24**	**n/a**	**$ 21**	**$ 22**	**$ 10**	**$ 11**	**$ 13**	**$ 13**

Life Cycle Average Costs (NPV Costs divided by Types of Benefits)

Air Emission Benefits

Alternative	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
GHG Tonnes Reduced, 30 Years		- 519,000	- 237,000	- 130,000	- 25,000	- 160,000	- 56,000	33,000	- 103,000	- 89,000	68,000	- 8,000	- 40,000	59,000
* Some reductions are negative														
Cost per tonne GHG Reduction*		n/a	n/a	n/a	n/a	n/a	n/a	$ 19,400	n/a	n/a	$ 18,500	n/a	n/a	$ 10,700

Land Use Benefits

Alternative	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Land Use Intensification (LUI), sf at Stations		14,200,000	19,400,000	18,200,000	19,400,000	19,400,000	18,200,000	16,000,000	19,400,000	19,400,000	17,200,000	19,400,000	18,500,000	15,400,000
Cost Per Square Foot (LUI)		**$ 37**	**$ 42**	**$ 35**	**$ 84**	**$ 61**	**$ 57**	**$ 40**	**$ 66**	**$ 75**	**$ 73**	**$ 86**	**$ 62**	**$ 41**

APPENDIX 3C – ENVIRONMENT ACCOUNT EVALUATION DETAIL

Overview

This appendix includes the following supporting information related to the evaluation:

- Air Emissions Supporting Calculations are included on Exhibits 3C1. to 3C.3;
- Biodiversity - Maps of Potential Impact Areas (Exhibit 3C.4);
- Water Resources - Map of Potential Impact Areas (Exhibit 3C.5); and
- Agricultural Resources - Map of Potential Impact Areas (Exhibit 3C.6).

Results and evaluation ratings for the individual alternatives are presented in the Evaluation Report.

Exhibit 3C.1 - Environment Account Evaluation - Air Emissions Supporting Calculations

Air Emissions		BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
CO2 Emissions															
Material Inputs to Construction		unit rates CO2 (kg per)													
Concrete (m3)		559	8200	34,000	29,000	127,000	73,000	69,000	48,000	92,000	109,000	248,000	261,000	120,000	94,000
Steel (t)		464	400	8,100	8,100	33,000	19,000	18,000	13,000	23,000	28,000	79,000	81,000	37,000	30,000
Asphalt (t)		34	31000	285,000	245,000	171,000	237,000	198,000	55,000	215,000	196,000	17,000	158,000	201,000	7,000
Subtotal - Emissions for Material Production (kg)			5,823,400	32,454,400	28,299,400	92,119,000	57,681,000	53,655,000	34,734,000	69,410,000	80,587,000	175,866,000	188,855,000	91,082,000	66,704,000
Transportation of Construction Materials															
Tonnes of Materials			51,080	374,700	322,700	508,800	431,200	381,600	183,200	458,800	485,600	691,200	865,400	526,000	262,600
Truckloads (assumed 30 t capacity)			1,703	12,490	10,757	16,960	14,373	12,720	6,107	15,293	16,187	23,040	28,847	17,533	8,753
Delivery Distance (assume 100 km round trip)			*170,000*	*1,249,000*	*1,076,000*	*1,696,000*	*1,437,000*	*1,272,000*	*611,000*	*1,529,000*	*1,619,000*	*2,304,000*	*2,885,000*	*1,753,000*	*875,000*
Diesel HGV (emissions per UTEC tool)		1.0692	182,000	1,335,000	1,150,000	1,813,000	1,536,000	1,360,000	653,000	1,635,000	1,731,000	2,463,000	3,085,000	1,874,000	936,000
Construction CO2 emissions	tonnes		6,005	33,789	29,449	93,932	59,217	55,015	35,387	71,045	82,318	178,329	191,940	92,956	67,640
Operation Period - Transit VKT (Annual)															
2021 Bus + BRT		39,460,000	50,470,711	45,917,000	44,011,000	40,979,000	44,209,000	42,690,000	39,460,000	42,687,000	42,319,000	39,460,000	42,687,000	43,058,000	39,460,000
2021 LRT		-	-	-	-	6,620,000	2,562,000	2,562,000	2,562,000	4,058,000	5,102,000	-	-	-	-
2021 RRT		8,000,000	8,000,000	8,000,000	8,000,000	8,000,000	8,000,000	8,000,000	8,000,000	8,000,000	8,000,000	19,265,000	19,265,000	14,700,000	14,700,000
2031 Bus + BRT		48,860,000	62,017,855	57,510,500	54,821,000	50,813,000	54,933,000	52,980,000	48,860,000	53,390,500	52,894,500	48,860,000	53,390,500	53,476,000	48,860,000
2031 LRT		-	-	-	-	8,512,000	3,295,000	3,295,000	3,295,000	5,217,000	6,560,000	-	-	-	-
2031 RRT		8,000,000	8,000,000	8,000,000	8,000,000	8,000,000	8,000,000	8,000,000	8,000,000	8,000,000	8,000,000	19,265,000	19,265,000	14,700,000	14,700,000
2041 Bus + BRT		58,260,000	73,565,000	69,104,000	65,631,000	60,647,000	65,657,000	63,270,000	58,260,000	64,094,000	63,470,000	58,260,000	64,094,000	63,894,000	58,260,000
2041 LRT		-	-	-	-	10,404,000	4,028,000	4,028,000	4,028,000	6,376,000	8,018,000	-	-	-	-
2041 RRT		8,000,000	8,000,000	8,000,000	8,000,000	8,000,000	8,000,000	8,000,000	8,000,000	8,000,000	8,000,000	19,265,000	19,265,000	14,700,000	14,700,000
Operation Period CO2 Emissions - Transit	g/km														
2021 Transit Emissions	1823	72,640	92,712	84,411	80,936	76,673	81,786	79,017	73,129	79,297	78,826	73,631	79,514	79,788	73,229
2031 Transit Emissions	191	89,776	113,763	105,546	100,643	94,962	101,476	97,916	90,405	99,031	98,384	90,767	99,026	98,780	90,365
2041 Transit Emissions	88	106,912	134,813	126,681	120,349	113,251	121,166	116,815	107,681	118,765	117,941	107,903	118,539	117,772	107,502
Over Thirty Year Period	tonnes	2,693,273	3,412,877	3,166,369	3,019,280	2,848,857	3,044,286	2,937,477	2,712,154	2,970,940	2,951,509	2,723,013	2,970,786	2,963,410	2,710,961
Incremental CO2 Emissions - Transit	1-10		20,073	11,771	8,296	4,034	9,147	6,378	489	6,658	6,186	991	6,874	7,149	590
	11-20		23,987	15,770	10,867	5,186	11,700	8,140	629	9,256	8,608	991	9,250	9,005	590
(Annual)	21-30		27,901	19,769	13,437	6,339	14,254	9,903	769	11,853	11,029	991	11,627	10,860	590
Over Thirty Year Period	tonnes		719,603	473,096	326,007	155,583	351,013	244,203	18,880	277,666	258,236	29,740	277,513	270,137	17,688
2021															
Regional Total Veh-Km		4,677,522	4,669,835	4,669,694	4,670,829	4,672,921	4,670,828	4,669,973	4,675,556	4,670,533	4,671,846	4,667,148	4,663,963	4,667,205	4,672,560
Net Reduction, 2021 AM Peak			7,688	7,828	6,694	4,601	6,694	7,549	1,966	6,990	5,677	10,374	13,560	10,317	4,962
2021 Annual VKT		23,855,400,000	23,816,200,000	23,815,400,000	23,821,200,000	23,831,900,000	23,821,200,000	23,816,900,000	23,845,300,000	23,819,700,000	23,826,400,000	23,802,500,000	23,786,200,000	23,802,700,000	23,830,100,000
2041															
Regional Total Veh-Km		5,545,285	5,537,806	5,534,414	5,536,402	5,534,127	5,534,661	5,536,140	5,541,021	5,535,183	5,533,222	5,536,173	5,528,501	5,533,454	5,540,271
Net Reduction, 2041 AM Peak			7,479	10,871	8,883	11,158	10,624	9,145	4,264	10,103	12,063	9,112	16,784	11,831	5,014
2041 Annual VKT		28,281,000,000	28,242,800,000	28,225,500,000	28,235,600,000	28,224,000,000	28,226,800,000	28,234,300,000	28,259,200,000	28,229,400,000	28,219,400,000	28,234,500,000	28,195,400,000	28,220,600,000	28,255,400,000
Annualization Factor, Vehicle Travel															
5100		*798*	*Billion in 30 Years*	*796*						*796*			*795*		
				-1.49						*-1.37*			*-2.38*		
Incremental CO2 Emissions - Autos	1-10		(7,879)	(8,040)	(6,874)	(4,724)	(6,874)	(7,739)	(2,030)	(7,176)	(5,829)	(10,633)	(13,909)	(10,593)	(5,085)
	11-20		(7,072)	(8,571)	(7,160)	(7,036)	(7,882)	(7,699)	(2,803)	(7,819)	(7,966)	(9,129)	(13,974)	(10,249)	(4,642)
(Annual)	21-30		(6,265)	(9,102)	(7,446)	(9,348)	(8,889)	(7,659)	(3,575)	(8,462)	(10,102)	(7,626)	(14,038)	(9,906)	(4,198)
Over Thirty Year Period	tonnes		(212,160)	(257,130)	(214,797)	(211,073)	(236,445)	(230,959)	(84,080)	(234,572)	(238,971)	(273,884)	(419,214)	(307,474)	(139,256)
Operation Period CO2 Emissions from Autos															
201 g/km in 2021	tonnes	4,794,935	4,787,056	4,786,895	4,788,061	4,790,212	4,788,061	4,787,197	4,792,905	4,787,760	4,789,106	4,784,303	4,781,026	4,784,343	4,789,850
2031 (Average)		4,716,510	4,709,438	4,707,939	4,709,350	4,709,474	4,708,628	4,708,811	4,713,707	4,708,691	4,708,544	4,707,380	4,702,536	4,706,261	4,711,868
164 g/km in 2041	tonnes	4,638,084	4,631,819	4,628,982	4,630,638	4,628,736	4,629,195	4,630,425	4,634,509	4,629,622	4,627,982	4,630,458	4,624,046	4,628,178	4,633,886
Over Thirty Year Period	tonnes	**141,495,291**	141,283,131	141,238,161	141,280,494	141,284,219	141,258,846	141,264,332	141,411,212	141,260,720	141,256,320	141,221,408	141,076,077	141,187,817	141,356,036
Regional Co2 Emissions		144,188,564	144,702,013	144,438,320	144,329,224	144,227,007	144,362,349	144,256,823	144,158,752	144,302,704	144,290,147	144,122,750	144,238,803	144,244,183	144,134,637
Net CO2 Emissions Reduction		0	(513,000)	(250,000)	(141,000)	(38,000)	(174,000)	(68,000)	30,000	(114,000)	(102,000)	66,000	(50,000)	(56,000)	54,000

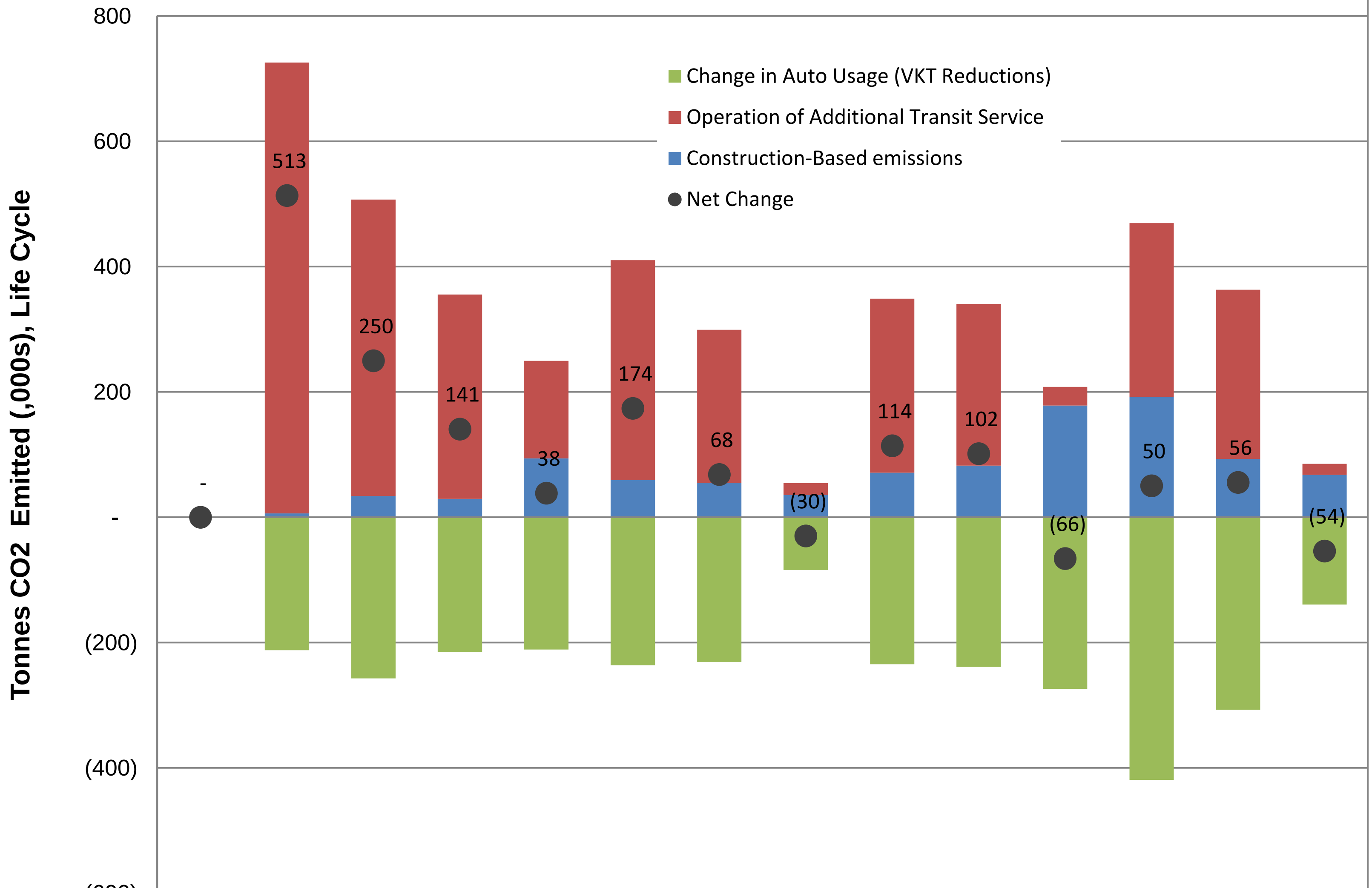
CO2 Emissions - Summary

Net Changes to CO2 Emissions, thousands of tonnes	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Construction-Based emissions	-	6	34	29	94	59	55	35	71	82	178	192	93	68
Operation of Additional Transit Service	-	720	473	326	156	351	244	19	278	258	30	278	270	18
Change in Auto Usage (VKT Reductions)	-	(212)	(257)	(215)	(211)	(236)	(231)	(84)	(235)	(239)	(274)	(419)	(308)	(139)
Net Change	-	513	250	141	38	174	68	(30)	114	102	(66)	50	56	(54)
Regional Co2 Emissions														
CO2 - Megatonnes over 30 years														
General Vehicle Traffic	141	141	141	141	141	141	141	141	141	141	141	141	141	141
SRTAA Construction	-	0.01	0.03	0.03	0.09	0.06	0.06	0.04	0.07	0.08	0.18	0.19	0.09	0.07
SRTAA Study Area Transit	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Total	144.19	144.70	144.44	144.33	144.23	144.36	144.26	144.16	144.30	144.29	144.12	144.24	144.24	144.13

Exhibit 3C.1 (2/2) - Environment Account Evaluation - Air Emissions Supporting Calculations

CAC Emissions		BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Input *Additions:*															
VKT - Transit (Operating Period)	Bus		394,735,660	259,515,000	178,830,000	58,590,000	182,190,000	123,600,000	-	135,915,000	121,035,000	-	135,915,000	138,480,000	-
	LRT					255,360,000	98,850,000	98,850,000	98,850,000	156,510,000	196,800,000	-	-	-	-
	RRT											337,950,000	337,950,000	201,000,000	201,000,000
Reduction:															
VKT - Autos (Operating Period)	Autos		1,155,650,000	1,483,750,000	1,230,200,000	1,322,900,000	1,394,850,000	1,304,850,000	516,450,000	1,362,150,000	1,471,250,000	1,468,600,000	2,379,400,000	1,720,450,000	764,550,000
CO Emissions	g/v-km		tonnes												
Bus and BRT Diesel	2.6		1,026	675	465	152	474	321	-	353	315	-	353	360	-
LRT	0		-	-	-	-	-	-	-	-	-	-	-	-	-
RRT	0		-	-	-	-	-	-	-	-	-	-	-	-	-
Autos (average rate over 30 years)	6.85		(7,916)	(10,164)	(8,427)	(9,062)	(9,555)	(8,938)	(3,538)	(9,331)	(10,078)	(10,060)	(16,299)	(11,785)	(5,237)
Net CO Emissions	tonnes		(6,890)	(9,489)	(7,962)	(8,910)	(9,081)	(8,617)	(3,538)	(8,977)	(9,763)	(10,060)	(15,946)	(11,425)	(5,237)
HN3/HC Emissions	g/v-km		tonnes												
Bus and BRT Diesel	0.32		126	83	57	19	58	40	-	43	39	-	43	44	-
LRT	0		-	-	-	-	-	-	-	-	-	-	-	-	-
RRT	0		-	-	-	-	-	-	-	-	-	-	-	-	-
Autos (average rate over 30 years)	0.062		(72)	(92)	(76)	(82)	(86)	(81)	(32)	(84)	(91)	(91)	(148)	(107)	(47)
Net HN3/HC Emissions	tonnes		55	(9)	(19)	(63)	(28)	(41)	(32)	(41)	(52)	(91)	(104)	(62)	(47)
NoX Emissions	g/v-km		tonnes												
Bus and BRT Diesel	9.2		3,632	2,388	1,645	539	1,676	1,137	-	1,250	1,114	-	1,250	1,274	-
LRT	0		-	-	-	-	-	-	-	-	-	-	-	-	-
RRT	0		-	-	-	-	-	-	-	-	-	-	-	-	-
Autos (average rate over 30 years)	0.24		(277)	(356)	(295)	(317)	(335)	(313)	(124)	(327)	(353)	(352)	(571)	(413)	(183)
Net NoX Emissions	tonnes		3,354	2,031	1,350	222	1,341	824	(124)	924	760	(352)	679	861	(183)
PM Emissions	g/v-km		tonnes												
Bus and BRT Diesel	0.6		237	156	107	35	109	74	-	82	73	-	82	83	-
LRT	0		-	-	-	-	-	-	-	-	-	-	-	-	-
RRT	0		-	-	-	-	-	-	-	-	-	-	-	-	-
Autos (average rate over 30 years)	0.0155		(18)	(23)	(19)	(21)	(22)	(20)	(8)	(21)	(23)	(23)	(37)	(27)	(12)
Net PM Emissions	tonnes		219	133	88	15	88	54	(8)	60	50	(23)	45	56	(12)
PM10 Emissions	g/v-km		tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes
Bus and BRT Diesel	0.6		237	156	107	35	109	74	-	82	73	-	82	83	-
LRT	0		-	-	-	-	-	-	-	-	-	-	-	-	-
RRT	0		-	-	-	-	-	-	-	-	-	-	-	-	-
Autos (average rate over 30 years)	0.0155		(18)	(23)	(19)	(21)	(22)	(20)	(8)	(21)	(23)	(23)	(37)	(27)	(12)
Net PM10 Emissions	tonnes		219	133	88	15	88	54	(8)	60	50	(23)	45	56	(12)
PM2.5 Emissions	g/v-km		tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes
Bus and BRT Diesel	0.6		237	156	107	35	109	74	-	82	73	-	82	83	-
LRT	0		-	-	-	-	-	-	-	-	-	-	-	-	-
RRT	0		-	-	-	-	-	-	-	-	-	-	-	-	-
Autos (average rate over 30 years)	0.007		(8)	(10)	(9)	(9)	(10)	(9)	(4)	(10)	(10)	(10)	(17)	(12)	(5)
Net PM2.5 Emissions	tonnes		229	145	99	26	100	65	(4)	72	62	(10)	65	71	(5)
SoX Emissions	g/v-km		tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes
Bus and BRT Diesel	0.6		237	156	107	35	109	74	-	82	73	-	82	83	-
LRT	0		-	-	-	-	-	-	-	-	-	-	-	-	-
RRT	0		-	-	-	-	-	-	-	-	-	-	-	-	-
Autos (average rate over 30 years)	0.007		(8)	(10)	(9)	(9)	(10)	(9)	(4)	(10)	(10)	(10)	(17)	(12)	(5)
Net SoX Emissions	tonnes		229	145	99	26	100	65	(4)	72	62	(10)	65	71	(5)
VO Emissions	g/v-km		tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes
Bus and BRT Diesel	0.6		237	156	107	35	109	74	-	82	73	-	82	83	-
LRT	0		-	-	-	-	-	-	-	-	-	-	-	-	-
RRT	0		-	-	-	-	-	-	-	-	-	-	-	-	-
Autos (average rate over 30 years)	0.007		(8)	(10)	(9)	(9)	(10)	(9)	(4)	(10)	(10)	(10)	(17)	(12)	(5)
Net VO Emissions	tonnes		229	145	99	26	100	65	(4)	72	62	(10)	65	71	(5)

Exhibit 3C.2 -- Change in GHG Emissions, Construction Plus 30 Years



	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Change in Auto Usage (VKT Reductions)	-	(212)	(257)	(215)	(211)	(236)	(231)	(84)	(235)	(239)	(274)	(419)	(308)	(139)
Operation of Additional Transit Service	-	720	473	326	156	351	244	19	278	258	30	278	270	18
Construction-Based emissions	-	6	34	29	94	59	55	35	71	82	178	192	93	68
Net Change	-	513	250	141	38	174	68	(30)	114	102	(66)	50	56	(54)

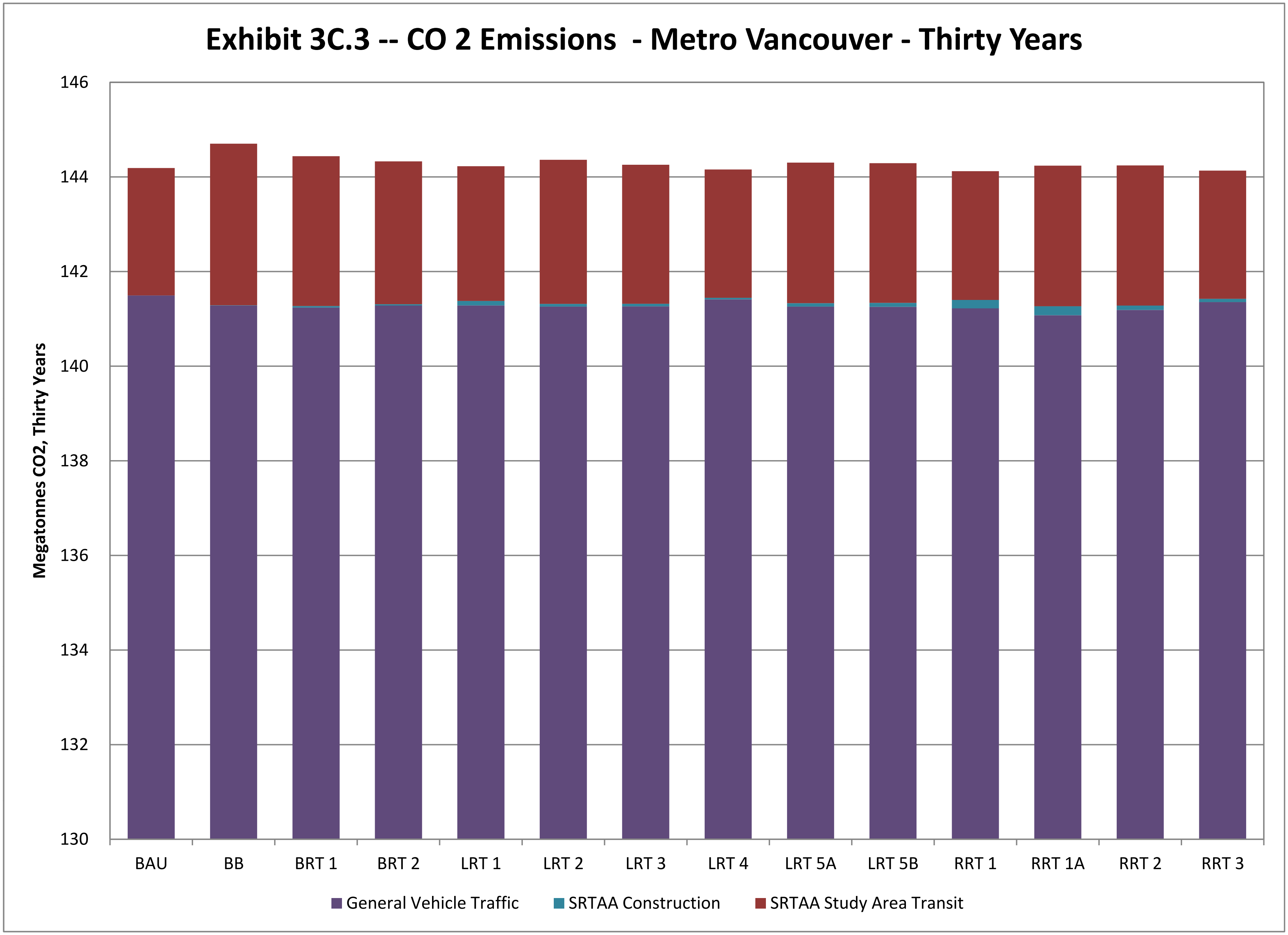
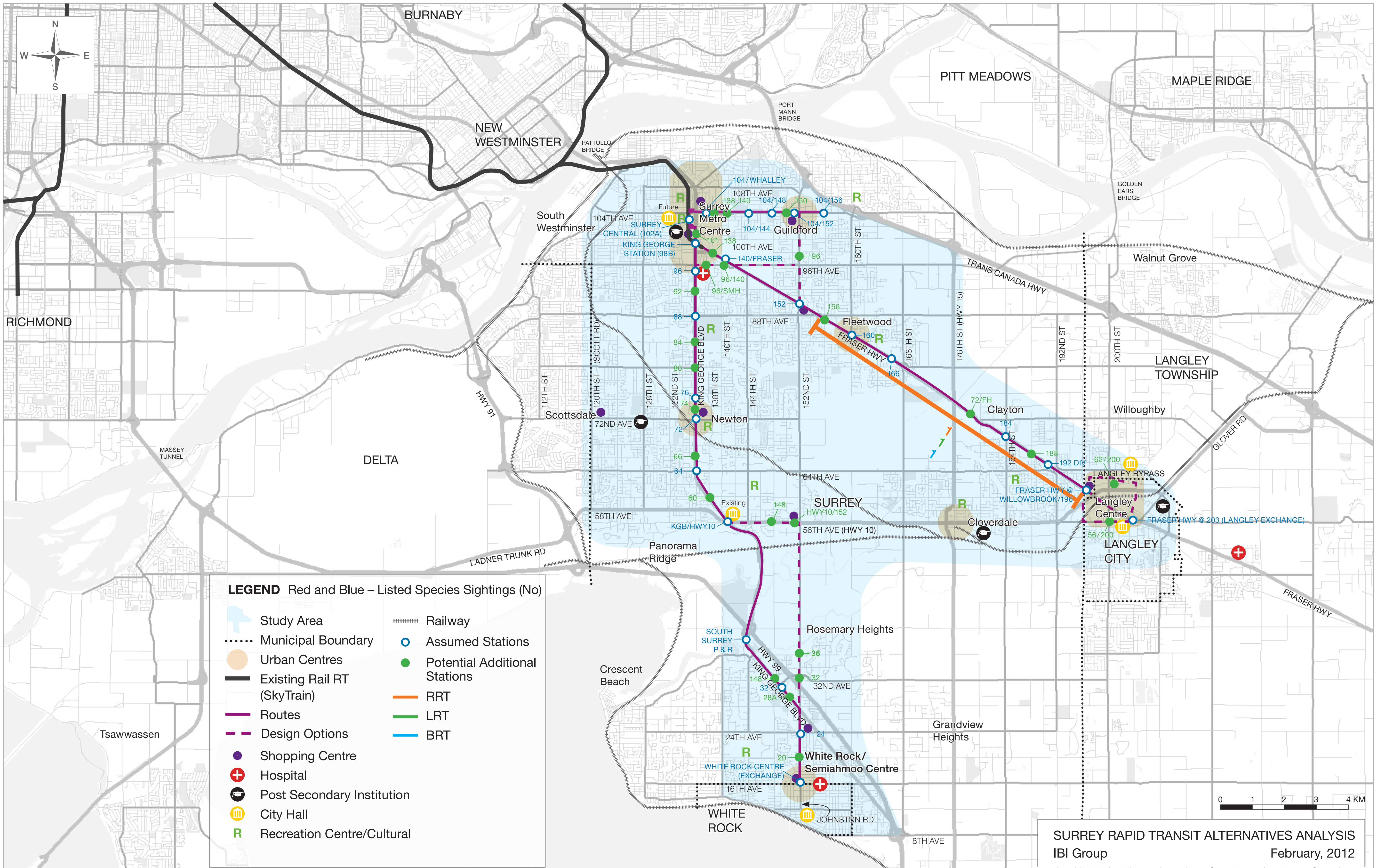
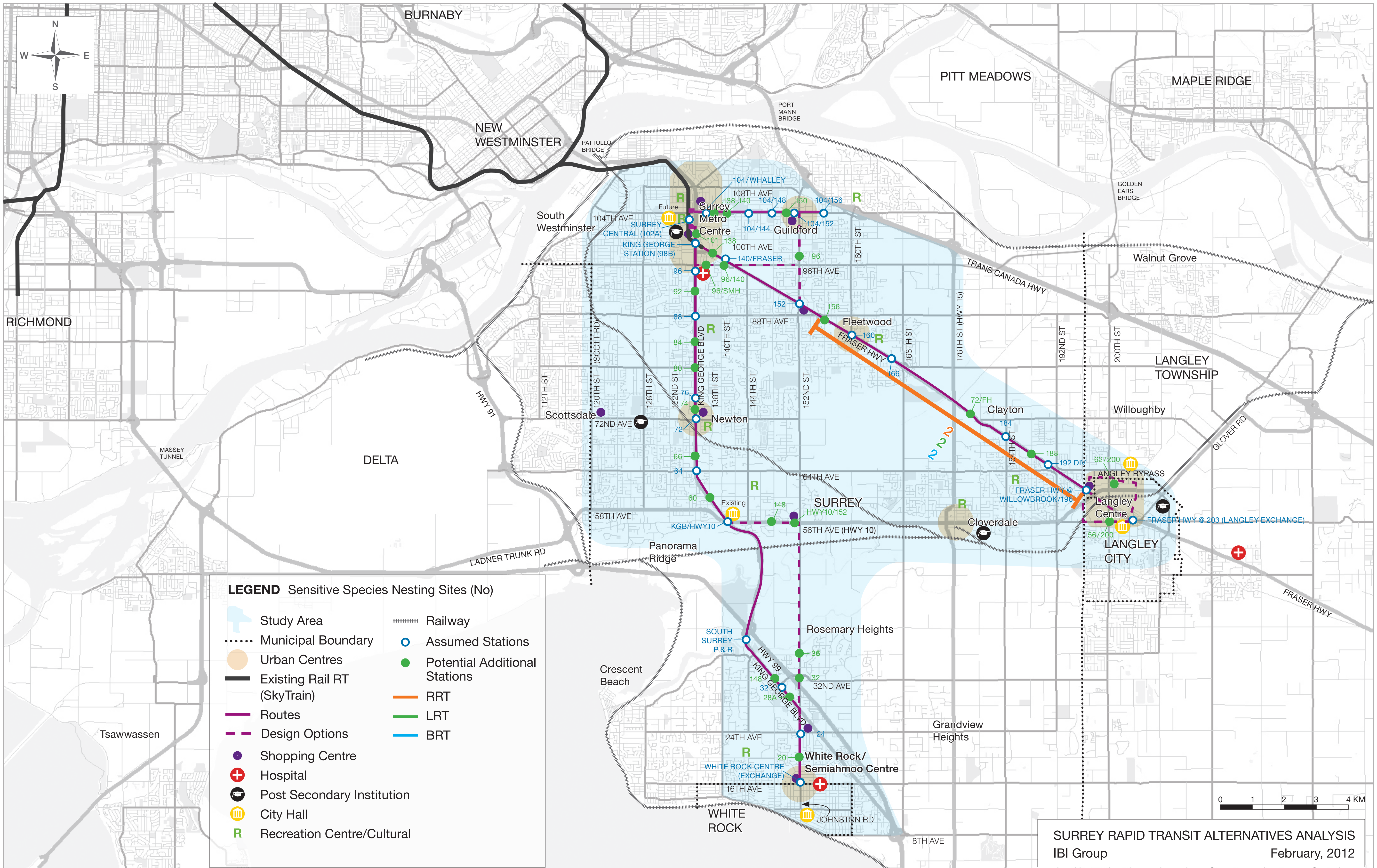


Exhibit 3C.3 -- CO 2 Emissions - Metro Vancouver - Thirty Years
Megatonnes CO2, Thirty Years
146
144
142
140
138
136
134
132
130
BAU
BB
BRT 1
BRT 2
LRT 1
LRT 2
LRT 3
LRT 4
LRT 5A
LRT 5B
RRT 1
RRT 1A
RRT 2
RRT 3
General Vehicle Traffic
SRTAA Construction
SRTAA Study Area Transit

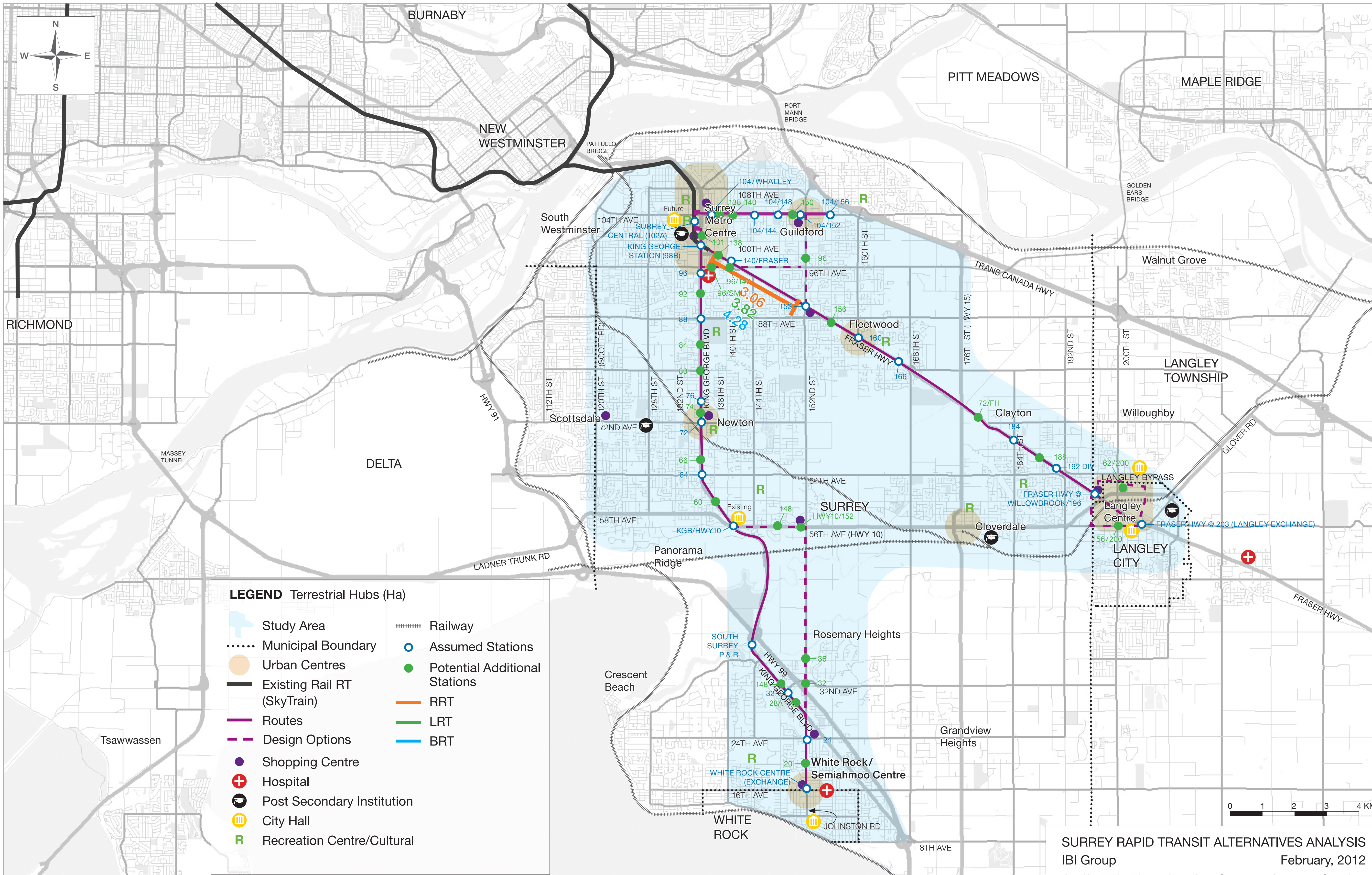
Appendix 3C.4 - Biodiversity - Potential Overlap/Impacts within 100 metre Buffer of Alignment (Map 1 of 3)



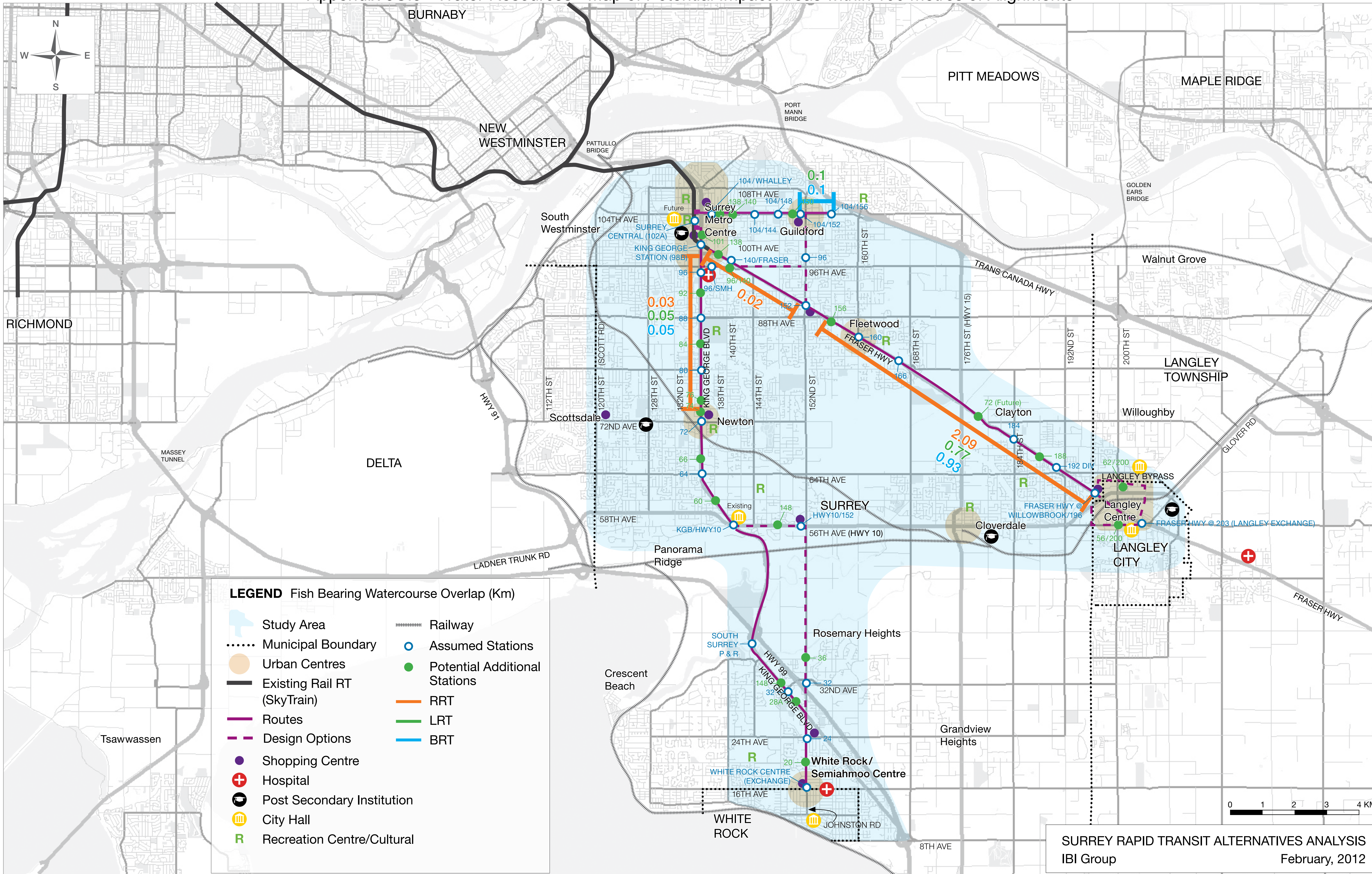
Appendix 3C.4 - Biodiversity - Potential Overlap/Impacts within 100 metre Buffer of Alignment (Map 2 of 3)



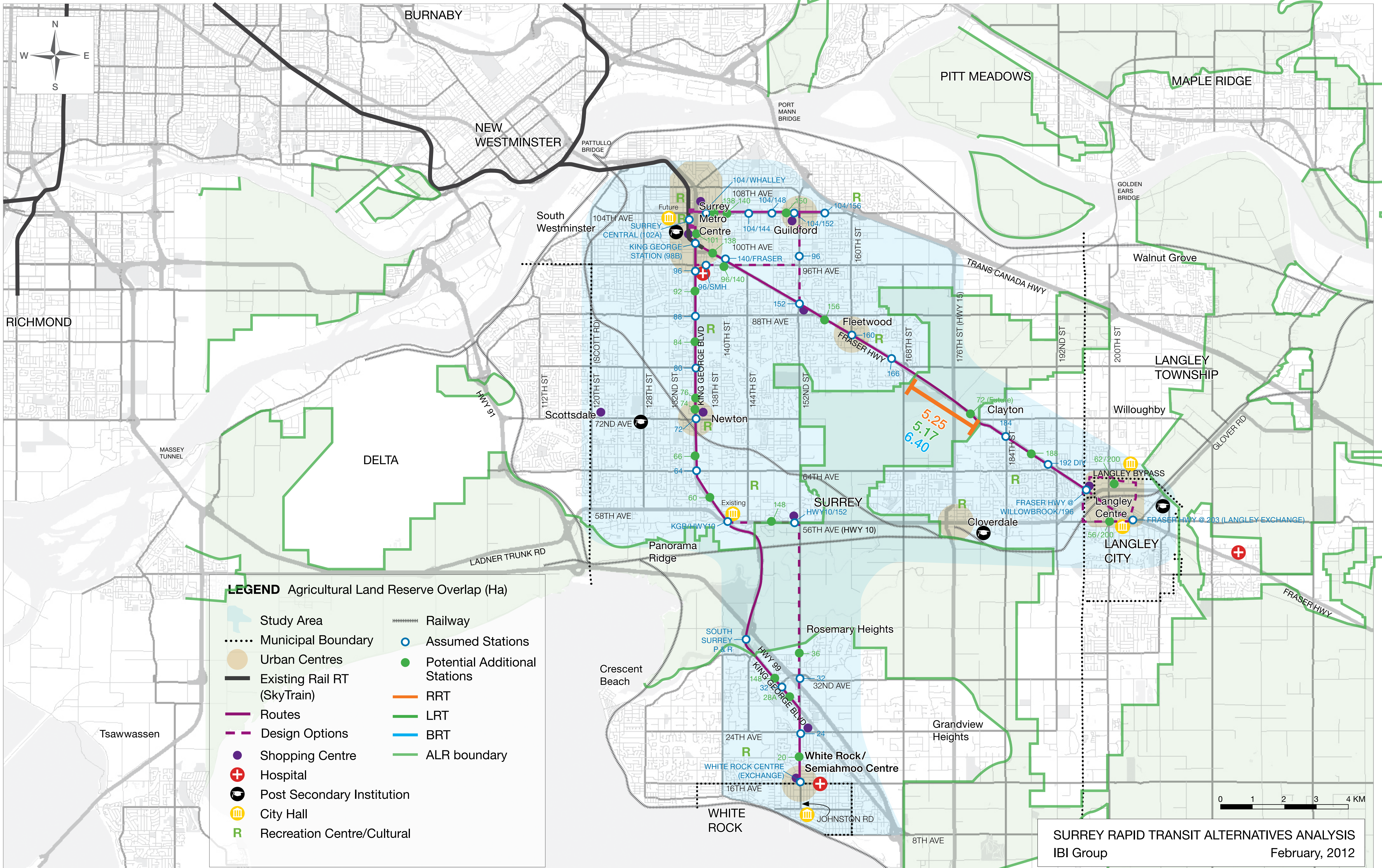
Appendix 3C.4 - Biodiversity - Potential Overlap/Impacts within 100 metre Buffer of Alignment (Map 3 of 3)



Appendix 3C.5 - Water Resources - Map of Potential Impact Areas within 100 metres of Alignments



Appendix 3C.6 - Agricultural Resources - Map of Potential Impact Areas within 100 metres of Alignments



APPENDIX 3D – URBAN DEVELOPMENT ACCOUNT EVALUATION

OVERVIEW

The urban development account considers the benefits and impacts on local land uses and the urban environment, including how alternatives connect to key activity centres, the likelihood of development near stations, the impacts on properties along the alignment and urban design potential. The urban development criteria include: land use integration; land use intensification potential, property requirements, and urban design.

This appendix includes supporting information for the following Urban Development criteria:

- Land Use Intensification Potential (Sections 1 to 7); and
- Property Requirements (Section 8).

Results and evaluation ratings for all of the Urban Development criteria are presented in the Evaluation Report.

1. LAND USE INTENSIFICATION POTENTIAL - OVERVIEW

This appendix provides details on the analysis of **land use intensification potential,** which projected future demand for high density residential and office development along the rapid transit alternatives in Surrey and the City of Langley (the study area). In parallel with the market assessment of demand, the development capacity in station areas was estimated with input from the Cities. The capacity assessment was carried out to determine if any constraints to demand would arise that could influence future development patterns. Taken together, the demand and capacity informed the assessment of land use intensification potential for each alternative.

The methods employed were developed for this study with input and data sets from project partners in 2011, and the method and results were reviewed and confirmed as sound by an external expert outside the project team in April 2012.

1.1 OBJECTIVES OF THE LAND USE ANALYSIS

Land use intensification potential examines the likelihood of development around station areas based on established rates of development, known development sites and local policy. The land use intensification potential measures are:

- Access to redevelopment opportunities (capacity in station areas), which was evaluated based on theoretical residual development capacity and the likeliness of parcels in stations areas to be redeveloped.
- Land use intensification potential (demand attracted to station areas), which was evaluated based on the future study area demand for apartment (medium to high rise) and office (non business park) development, and the potential effects of rapid transit on the distribution of future demand.

Therefore, the land use analysis included:

- A ballpark forecast of the development potential around station locations for each alternative. The development potential measured demand for apartment units and office space;
- An estimate of development capacity around stations;
- Comparison of forecasts with the base case, or Business As Usual (BAU).

1.2 FACTORS INFLUENCING AMOUNT AND LOCATION OF DEVELOPMENT

There are many factors that influence where development occurs within a community. These factors relate to the demand for the development by type (i.e. apartments or offices), suitability of the location for development, provision in policy documents to support development, cost to develop the land, accessibility of the development by different modes of transportation, and connectivity to other types of land uses.

The following factors will affect the amount and location of development in the study area:

- Overall demand for different uses.
- Land use policy and capacity to accommodate additional development.
- Financial viability of development.
- Relative cost of locations to buyers/users.
- Number and quality of competing locations.
- Availability and quality of transit.
- Accessibility of location by other transportation modes.
- Availability of services, facilities and amenities.
- Proximity of employment opportunities.
- For businesses, proximity of other businesses and accessibility for employees.

The analysis for the Multiple Account Evaluation (MAE) focuses on variations between alternatives in the “availability and quality of transit;” however, the other factors were also considered in the analysis.

1.3 SCOPE OF ANALYSIS

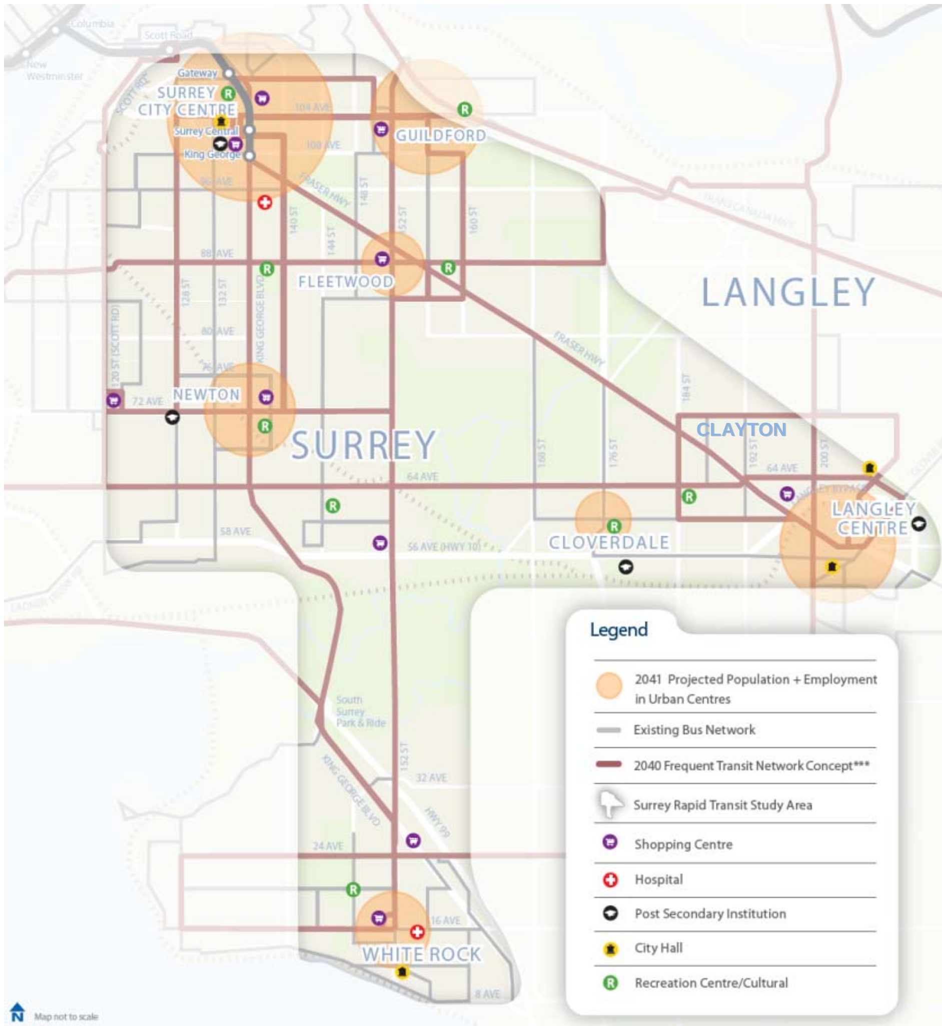
The demand projections cover the period from 2011 to 2041, and focus on the demand for apartment (low-rise to high-rise) and office development (other than business parks) as these will be the main private sector uses near transit stations. Local-serving retail development[1] would also occur, typically in the lower floor(s) of the same buildings, and the pattern would mirror the residential and office markets. The capacity estimates were developed for the same set of stations.

The study area includes most of the City of Surrey and the City of Langley, and is shown in Exhibit 3D.1. For the analysis, demand was projected for the following sub-areas within the two cities:

- Surrey City Centre;
- Guildford;
- Newton;
- Fleetwood;
- Cloverdale / Clayton;
- South Surrey; and
- Langley Centre.

[1] Larger retail developments such as shopping centres were considered in another criterion: Land Use Integration.

Exhibit 3D.1 – Study Area and Sub-Areas for Land Use Analysis



1.4 ANALYSIS ASSUMPTIONS

The land use analysis was guided by five key assumptions. These assumptions were derived by the study team and included:

1. Analyses were carried out for the refined set of alternatives defined in fall 2011.

2. Development capacity was based on cities' existing plans (Official Community Plans, Neighbourhood Community Plans) and staff-projected land use policies (for areas where the planning processes were/are not yet complete but the expected policies can be projected). Access to redevelopment capacity is described in detail in Section 4.

3. New rapid transit was assumed to be operating in 2021. The timing of rapid transit implementation would influence when development patterns would start to shift in response to the project.

4. Total study area (combined City of Surrey and City of Langley) market demand for each alternative was held constant with the future baseline:

   - The baseline forecasts consider the population and household projections for the study area (City of Surrey and City of Langley) that are contained in the Metro Vancouver Regional Growth Strategy (RGS), but do not rely on the RGS projections as the sole basis for the urban development demand forecasts. The RGS projections were compared to other indicators of potential demand (such as the historic growth and distribution of population, employment and development in the study area) to determine a realistic long term forecast of demand in the study area. The other indicators did not differ greatly from the RGS.
   - Development patterns will change (by alternative) in response to the relative accessibility of different communities, and the other factors noted in Section 1.2. This is represented as shifts in demand between the subareas and concentration of demand into the station areas.
   - This is consistent with the approach employed throughout the study. Other accounts in the Phase 2 evaluation (such as transportation, which depends on travel demand forecasts) also held the base case assumptions fixed. TransLink and BCMoT's mandates do not include prescribing land use policy to the municipalities or Metro Vancouver.
   - Possible variations in total study area demand from incorporating shifts from adjacent areas would be modest. While it is possible that some alternatives may draw some demand from adjacent areas without rapid transit, these locations (Delta, Township of Langley) have a lower order of magnitude demand for apartments and office buildings, and the other development influence factors, including price, would limit the attraction of that development into the study area.

5. Analysis focused on the parcels within 400m of station locations, the area of greatest influence of the station, where higher density development would be most desirable. An 800m radius is considered the limit of the walking distance to the station, and some development would also occur between 400m and 800m. However, it would trend in the same direction as the more focused 400m catchment, and there would be some overlap where stations are closer than 1600 m; therefore the 400 m catchment was felt to be a better differentiator[2].

1.5 ANALYSIS APPROACH

The forecast of demand for apartment units and office space near the transit stations in each rapid transit alternative was completed in a series of steps:

1. Future long term demand was estimated for apartment units in the entire study area, between 2011 and 2041, using the following approach (refer also to Section 2.1):

   - Examine available forecasts of population and household growth in the study area (i.e., RGS, BC Stats projections).
   - Examine the historic pace of population growth, residential development and apartment development in the study area and recent trends.
   - Examine trends in the share of total residential development in the study area by housing type (apartment, attached, single family).
   - Examine the remaining capacity for single family development in the study area. As the capacity to accommodate single family development declines, there could be a shift toward higher density forms of housing. There could also be redistribution of demand to other areas if this capacity was reached, but none of the subareas were forecast to reach capacity.

[2] In addition, the assessment of development capacity in Section 4 found that there was sufficient space within 400 m and therefore posed no capacity constraint that might have affected the forecasts.

2. Long term (2011-2041) demand for office space in the study area was estimated (refer also to section 2.2) using the following approach:
   - Examine the historic pace of office development, growth in occupied office space, and recent trends in the region and in the study area.
   - Examine the historic share of regional office growth captured by the study area.
   - Examine the total pace of office development and growth in occupied office space in the study area.
   - Evaluate factors that could influence the future demand for office space in the study area.
3. The based case distribution was estimated of future study area apartment and office demand that would go to each apartment and office growth subarea (in the absence of any change in the rapid transit system in the study area). This is documented in Section 3, and took into account:
   - Historic trends in the geographic distribution of development by subarea.
   - Existing development proposals.
   - The approximate capacity for high density urban development in each subarea.
4. For each rapid transit alternative being considered, its effect on the distribution of apartment and office demand by subarea was estimated (see Section 5), taking into account:
   - The impact on travel times by transit from each subarea to Surrey City Centre and other employment areas.
   - Any change in the accessibility of other subareas that are competing for a share of the study area's high density development.
   - The marketability of competing locations.
   - Other factors.
5. For each alternative, the share of apartment and office development in each subarea that could be attracted to station locations was estimated (see Section 6), taking into account:
   - The capacity for additional high density development at the proposed station locations in each alternative (see Section 4).
   - The number and marketability of other high density locations that are not served by rapid transit that would also be competing for a share of the market.
   - Recent trends in the share of the high density market captured by existing transit station locations in other parts of Metro Vancouver.
6. The station area demand forecasts were aggregated for each rapid transit alternative to estimate the amount of high density urban development that could occur near stations for each alternative.

2. PROJECTED APARTMENT AND OFFICE DEMAND IN THE STUDY AREA

This section summarizes the analysis and projections of apartment and office demand in the study area. It is divided into two parts:

1. Forecast total long term apartment demand in the study area.
2. Forecast total long term office demand in the study area.

Based on historic trends in urban development and the role of Surrey and Langley in the regional residential and office markets, most of the high density urban development in the study area will be apartment floorspace. Office space will account for a much smaller (though still significant) share of high density urban development. Therefore, the analysis and forecast of apartment demand in the study area is more detailed than the office demand forecast.

Uncertainties exist in these demand projections due to several factors that could influence demand for development, including long-term economic cycles, consumer preferences, energy prices, etc. The projections combine data on existing trends and the most recent land use/socioeconomic projections, which are a reflection of current regional and municipal policy.

2.1 APARTMENT DEMAND

2.1.1 Historic Population Growth

Exhibit 3D.2 shows total population in the study area and in Metro Vancouver between 2001 and 2010. The table shows the estimated population for each year, the share of regional population, and recent growth rates.

Exhibit 3D.2 – Existing and Historic Population

	2001	2006	2010	Share of 2010 Regional Population	Avg. Annual Growth Rate 2001 to 2010	Share of Regional Growth 2001 to 2010
City of Surrey	369,000	412,700	462,300	19.5%	2.5%	33.1%
City of Langley	25,200	24,900	25,900	1.1%	0.3%	0.2%
Subtotal	394,200	437,600	488,200	20.6%	2.4%	33.4%
Remainder of Metro Vancouver	1,698,700	1,761,500	1,886,400	79.4%	1.2%	66.6%
Total Metro Vancouver	2,092,900	2,199,100	2,374,600	100.0%	1.4%	100.0%

Source: BC Stats

As shown, the study area accounts for about 20% of total regional population as of 2010. Between 2001 and 2010, the study area accounted for about 33% of total regional population growth. Most of this growth was concentrated in Surrey, with the City of Langley accounting for a small share.

The average population growth rate in the study area was about 2.4% per year between 2001 and 2010. The growth rate in the remainder of Metro Vancouver over the same time period was 1.2% per year.

2.1.2 Historic Development Trends by Structure Type

Exhibits 3D.3.1 to 3D.3.3 summarize trends in the total number of housing starts in the study area from 1994 to 2010 by municipality and by structure type.

Exhibit 3D.3.1 – Historic Housing Starts - Surrey

	Average Units Per Year Surrey				Share of Total Units			
	1994 to 1999	2000 to 2005	2006 to 2010	2000 to 2010	1994 to 1999	2000 to 2005	2006 to 2010	2000 to 2010
Single Detached	1,350	1,740	1,680	1,710	52%	59%	40%	49%
Row + Semi	590	930	1,110	1,010	23%	32%	26%	29%
Apartment	630	270	1,450	810	25%	9%	34%	23%
Surrey Total	2,575	2,930	4,240	3,530	100%	100%	100%	100%

Source: CMHC "Housing Now" (Year End Editions), 1994-2010

Exhibit 3D.3.2 – Historic Housing Starts - City of Langley

	Average Units Per Year City of Langley				Share of Total Units			
	1994 to 1999	2000 to 2005	2006 to 2010	2000 to 2010	1994 to 1999	2000 to 2005	2006 to 2010	2000 to 2010
Single Detached	5	3	5	4	2%	5%	2%	3%
Row + Semi	11	22	7	15	5%	30%	4%	12%
Apartment	186	48	173	105	92%	65%	94%	84%
City of Langley Total	202	74	185	124	100%	100%	100%	100%

Source: CMHC "Housing Now" (Year End Editions), 1994-2010

Exhibit 3D.3.3 – Historic Housing Starts - Study Area

	Average Units Per Year Study Area				Share of Total Units			
	1994 to 1999	2000 to 2005	2006 to 2010	2000 to 2010	1994 to 1999	2000 to 2005	2006 to 2010	2000 to 2010
Single Detached	1,355	1,740	1,685	1,715	49%	58%	38%	47%
Row + Semi	600	950	1,115	1,025	22%	32%	25%	28%
Apartment	820	315	1,625	915	29%	11%	37%	25%
Study Area Total	2,7775	3,010	4,428	3,653	100%	100%	100%	100%

Source: CMHC "Housing Now" (Year End Editions), 1994-2010

The notable points to be taken from this data include:

- Total annual average housing starts in the study area have been increasing over the past 15 years or so.
- Between 2000 and 2010, total housing starts in the study area averaged about 3,600 units per year. Starts were higher from 2006 to 2010, at about 4,400 units per year.
- Apartment units have been accounting for an increasing share of total study area housing starts in recent years. Between 2000 and 2010 apartment units accounted for about 25% of study area housing starts. Between 2006 and 2010, apartment units accounted for about 37% of total housing starts in the study area.
- Apartment unit starts in the study area averaged about 900 units per year between 2000 and 2010. This increased to about 1600 units per year between 2006 and 2010. Surrey accounted for about 90% of the apartment unit starts in the study area during this time period.

2.1.3 Projected Population and Household Growth

2.1.3.1 Indicators of Future Study Area Population Growth

Three indicators of potential population growth in the study area were examined:

1. Historic population growth rates in the study area. Between 2001 and 2010:
   - The City of Surrey's population grew at an average rate of about 2.5% per year.
   - The City of Langley's population grew at an average rate of about 0.3% per year.

2. The municipal population projections used in the Metro Vancouver Regional Growth Strategy:

   - According to the RGS, the City of Surrey's population is expected to grow from about 413,000 in 2006 to about 740,000 in 2041, or at an average rate of about 1.7% per year. This is lower than the City's actual growth rate between 2001 and 2010 of about 2.5% per year.
   - The City of Langley's population is expected to grow from about 24,900 in 2006 to about 38,000 in 2041, or at an average rate of about 1.2% per year. This is higher than the City's actual growth rate between 2001 and 2010 of about 0.3% per year.
   - The study area's population is expected to grow from about 437,900 in 2006 to about 778,000 in 2041, or at an average rate of about 1.6% per year. This is lower than the study area's actual growth rate between 2001 and 2010 of about 2.4% per year.

3. BC Stats population projections:

   - BC Stats projects long term population growth for Local Health Areas (LHAs). The LHA boundaries represent one or more municipalities and are slightly larger than the study area boundaries, therefore the rate of growth implied by the projections was carried into the analysis, not the absolute numbers. The LHA for Langley, includes the City and the Township. Because the Township (outside the study area) accounts for about 80% of the LHA population, the LHA projection for Langley was not used.
   - According to the BC Stats, the population of the LHA comprised of the City is Surrey and White Rock is expected to grow from about 490,114 in 2011 to about 736,647 in 2036, or at an average rate of about 1.6% per year. This is lower than the City's growth rate between 2001 and 2010 of about 2.5% per year, but consistent with the long term RGS forecast.
   - The growth rates in the RGS and BC Stats projections are fairly consistent for the City of Surrey. Both assume the rate of growth in Surrey will slow over the long term, which is consistent with expectations for a lower rate of population in the overall Metro Vancouver region. Therefore, the approach used the BC Stats and the RGS population projections as a basis for forecasting population growth in the City of Surrey.
   - BC Stats does not provide a population projection for the City of Langley. The RGS projections imply a significant increase in population growth in the City of Langley (similar to the overall Metro Vancouver average). This is reasonable because rapid transit could be extended to Langley, the rate of apartment development in the City has been increasing in recent years, and the City recently allowed increases in the permitted density in its apartment districts (which should help improve the financial viability of apartment development in the City). Therefore, the approach used the RGS projection as a basis for forecasting population growth in the City of Langley.

The growth rates in both municipalities decline over the forecast period as indicated by the BC Stats and RGS projections. The annual growth rates used in the analysis follow in **Exhibit 3D.4**.

Exhibit 3D.4 – Projected Annual Population Growth Rates by Municipality

	2010 to 2021	2021 to 2031	2031 to 2041
City of Surrey	2.0%	1.5%	1.2%
City of Langley	1.7%	0.9%	0.8%

2.1.3.2 Population and Household Projection Used in Analysis

The population projection used in the housing demand forecast is shown in **Exhibit 3D.5**.

Exhibit 3D.5 – Projected Population by Municipality

Projected Population	2010	2021	2031	2041
City of Surrey	462,345	574,900	677,200	772,100
City of Langley	25,860	31,100	34,400	37,500
Total	488,200	606,000	711,600	809,600

The projected 2041 study area population is about 809,000. For comparison, the projected 2041 population in the RGS for the study area is about 778,000, which is very similar given the 30 year time frame for the projection.

Long term housing demand will be fairly consistent with long term household growth. Therefore, the estimates use the population projection plus projections about average household size to estimate future household growth in Surrey and the City of Langley. The average household size assumptions are based on BC Stats projections. **Exhibits 3D.6.1 and 3D.6.2** summarize the household growth projections for the study area.

Exhibit 3D.6.1 – Projected Household Growth in Surrey

City of Surrey	2010	2021	2031	2041
Projected Population	462,300	574,900	677,200	772,100
Assumed Average Household Size	2.97	2.91	2.87	2.83
Projected Households	155,690	197,315	236,140	272,830
Cumulative Household Growth	0	41,625	80,450	117,140

Exhibit 3D.6.2 – Projected Household Growth in the City of Langley

City of Langley	2010	2021	2031	2041
Projected Population	25,860	31,125	34,350	37,497
Assumed Average Household Size[1]	2.23	2.21	2.19	2.22
Projected Households	11,590	14,105	15,705	16,875
Cumulative Household Growth	0	2,515	4,115	5,285

2.1.4 Factors Affecting Future Apartment Demand

Between 2000 and 2010, apartment units accounted for about 23% of all housing starts in Surrey and about 84% of all starts in the City of Langley. More recently (2006 to 2010), apartments accounted for 34% of total housing starts in Surrey and over 90% in the City of Langley.

Going forward, apartment units will likely account for a higher share of housing demand in the study area (Surrey in particular), because of the following:

- Increasing average age of residents (older age groups are more likely to live in apartments).

- Declining average number of people per household (in Surrey).
- Increasing single family house prices (which will shift some potential buyers from detached housing into apartment units).
- Increasing apartment prices in the core of the region (which will shift some apartment demand to Surrey, Langley and other comparatively more affordable locations).
- Decreasing supply of vacant single family land in Surrey and other areas, which will decrease the share of new residential development that is comprised of single detached units.
- Increasing road congestion, which will draw apartment demand into locations that are served by rapid transit.

The current analysis projects that apartment units will account for about 40% of total housing demand in Surrey between 2010 and 2041. This proportion will likely start near 30% to 35%, and increase to between 45% and 50% over the 30-year time frame. As a comparison, apartment units typically account for about 60% to 80% of housing starts in the municipalities nearer the core of the region that have limited land available for single family housing development, such as Richmond, Burnaby and New Westminster. Because Surrey has substantial capacity for additional single family and townhouse development, apartment units will make up a smaller share of total housing starts over the forecast period.

The current analysis assumes that apartment starts will continue to account for between 80% and 90% of all housing starts in the City of Langley.

2.1.5 Projected Study Area Apartment Demand

Between 2000 and 2010, apartment demand averaged about 900 units per year in the study area. More recently (2006 to 2010), apartment demand averaged 1600 units per year.

Based on the household growth projections and anticipated share of total housing demand that will be comprised of apartment units, as described earlier, future apartment demand by municipality has been projected. **Exhibits 3D.7.1 and 3D.7.2** summarize the apartment demand forecasts by municipality.

Exhibit 3D.7.1 – Projected Apartment Demand in the City of Surrey

Surrey	2010 to 2021	2021 to 2031	2031 to 2041	2010 to 2041
Annual Housing Demand	3,784	3,882	3,669	3,779
Apartment Share	35%	40%	45%	40%
Annual Apartment Unit Demand	1,325	1,550	1,650	1,500

Exhibit 3D.7.2 – Projected Apartment Demand in the City of Langley

City of Langley	2010 to 2021	2021 to 2031	2031 to 2041	2010 to 2041
Annual Housing Demand	229	160	117	170
Apartment Share	85%	85%	85%	85%
Annual Apartment Unit Demand	200	140	100	145

Overall, the analysis anticipates apartment demand in the study area will average about 1600 to 1700 units per year between 2011 and 2041 as shown in **Exhibit 3D.7.3**

Exhibit 3D.7.3 – Projected Apartment Demand in the Study Area

Projected Apartment Demand (Annual Average)	2011 to 2021	2021 to 2031	2031 to 2041	2011 to 2041	Total Units 2011 to 2041
City of Langley	200	140	100	147	4,395
Surrey	1,325	1,550	1,650	1,508	45,250
Total	1,525	1,690	1,750	1,655	49,645

2.2 PROJECTED OFFICE DEMAND IN THE STUDY AREA

2.2.1 Regional and Study Area Office Demand Trends

Total office development in Metro Vancouver is estimated to have averaged 1.0 to 1.1 million square feet (sf) per year between 1998 and 2010. In recent years, growth has been slower (due to the downturn in the economy in late 2008).

Over the past decade, the study area captured a significant share of the office space growth in Metro Vancouver region. Total office development averaged approximately 150,000 sf. per year in the study area between 2000 and 2010, or roughly 15% of regional office development over this time period. The study area captured a share of the regional demand for office space in urban centres (such as Surrey City Centre, Metrotown, Downtown Vancouver) as well as a share of the regional demand for office space in business parks.

Much of the study area's historic office growth can be attributed to office projects that involved major government tenants or government investments (such as ICBC’s investment in Surrey Central). Without continued government investment, it may be difficult for the study area to continue to achieve this pace of development. The demand for office space in the region, and more specifically the share attributed to the study area, are subject to the same long-term economic and policy uncertainties cited for the apartment projections.

2.2.2 Factors Affecting Future Office Demand in the Study Area

Four key factors were considered to affect the total demand for office space in the study area over the long term, including:

1. Population growth in the study area. The study area is expected to continue to capture a high share of regional population growth. As an increasing share of the region's population resides south of the Fraser River, the study area should become an increasingly popular office location for two reasons:
   - The growing population creates demand for locally oriented office users (such as medical, dental, realty, insurance, and financial service businesses).
   - The growing labour pool south of the Fraser River will likely attract businesses to the study area.
2. Total Metro Vancouver office demand:
   - Over the past decade, office demand in Metro Vancouver has averaged more than 1.0 million sq.ft. per year. In recent years, total regional demand has been lower. For example, between 2005 and 2010, regional office demand averaged between 400,000 and 500,000 sq.ft. per year.

- Some of the study area's office growth will be internally generated by growth in the local population and employment base (local oriented office demand). However, a portion will likely be attributable to firms that have considerable locational flexibility. If overall regional office demand from this portion of the market declines, then total office demand in the study area could decline. However, long term regional office demand is assumed to increase from recent levels.

3. The number of competing urban office locations in the region.

- Part of the study area (specifically, Surrey City Centre) has been served by rapid transit since the early 1990's so it has been able to attract office tenants that are interested in high density office space in a transit oriented location. This has helped attract office demand to Surrey.
- With the construction of the Canada Line and the planned construction of the Evergreen Line, the number of existing (or potential) high density office nodes that are served by rapid transit in the region is increasing. The study area will need to compete with a number of additional high density transit-served office locations (such as Richmond, Marine Gateway, Oakridge, Coquitlam Town Centre) over time. This could have a downward influence on the study area's share of regional office demand.

4. The level of office demand generated by public sector tenants. Historically, the study area (Surrey City Centre) has benefitted from an influx of public sector office users and investment by government agencies. Demand from public sector office users will likely be required to sustain the historic rate of office demand in the study area.

The outlook for office demand in the study area is based on the following:

- Notwithstanding the recent decline in overall regional office demand, this study projects that regional office demand will increase closer to the historic average (about 1.0 million sq.ft. per year) over the long term.
- The study area has captured a 15% share of the region's office market over the past decade or so. Continued strong growth in the study area's population (and employment) base will have a positive influence on the share of regional office demand captured by the study area.
- There will be an increasing number of rapid transit-served office locations in the region over time (on the Canada Line and Evergreen Line). This will have a downward influence on the share of regional office demand captured by the study area.

On balance, one would expect the historic rate of office demand to be a reasonable basis for projecting future lease of build space in the study area.

2.2.3 Projected Study Area Office Demand

Exhibit 3D.8 summarizes the estimated long term demand for new office space in the study area by time period, based on the discussion above.

Exhibit 3D.8 – Projected Office Demand in the Study Area

Projected Annual Average Floorspace Demand (sq.ft.)	2011 to 2021	2021 to 2031	2031 to 2041	2011 to 2041
Lower Demand Forecast	125,000	125,000	125,000	125,000
Higher Demand Forecast	150,000	150,000	150,000	150,000

Overall, the forecast anticipates that office floorspace demand in the study area will average between 125,000 sq.ft. and 150,000 sq.ft. per year from 2011 to 2041. The higher end of this forecast assumes that government agencies and crown corporations continue to lease or build space in Surrey City Centre (or other parts of the study area).

Given the narrow range in the study area office forecasts, the balance of the analysis focused on a single forecast estimate. The office demand projections in the remainder of this analysis use the higher demand forecast, which is consistent with historic office growth in the study area.

2.3 SUMMARY OF OVERALL STUDY AREA DEMAND FORECASTS

Exhibits 3D.9 and 3D.10 summarize the study area demand projections used in the analysis.

Exhibit 3D.9 – Projected Apartment Demand in the Study Area

Location	Projected Apartment Demand (Annual Average) – Units			Cumulative
	2011 to 2021	2021 to 2031	2031 to 2041	2011 to 2041
City of Langley	200	140	100	4,400
Surrey	1,325	1,550	1,650	45,250
Total Units	**1,525**	**1,690**	**1,750**	**49,650**
Approximate S.F.*	**1.3M**	**1.4M**	**1.5M**	**42.2M**

* Apartment units assumed to include 850 s.f. (average) of gross space.

Exhibit 3D.10 – Projected Office Demand in the Study Area

Projected Annual Average Floorspace Demand (sq.ft.)	2011 to 2021	2021 to 2031	2031 to 2041	Cumulative 2011 to 2041
Total Study Area	150,000	150,000	150,000	4.5M

3. ESTIMATED BASE CASE DEMAND BY SUBAREA

For each rapid transit alternative, the geographic distribution of apartment and office development was estimated by neighbourhood or subarea. The projections were prepared using the seven subareas (defined in Section 1) that include all of the apartment and office locations in the study area.

The geographic distribution of high density urban development in the study area will be influenced by the rapid transit network and technology that is selected. This section summarizes the base case projection which assumes that rapid transit is not extended in the study area. The estimated impact of each rapid transit alternative on the geographic distribution of development is summarized in Sections 5 to 7.

To help estimate the distribution of demand by subarea in the base case, two indicators were examined:

- Historic study area development by subarea.
- The geographic distribution of proposed development in the study area.

3.1 HISTORIC TRENDS

As one input to the projections, indicators were reviewed of the historic share of apartment and office development captured by each subarea, including:

- CHMC apartment starts data from 1994 to 2010.
- Data compiled on the number of apartment units at projects in the study area that marketed between 2004 and early 2011.
- Data compiled on the amount of floorspace built at new office projects in the study area between 1990 and 2010.

3.1.1 Apartment Units

Exhibits 3D.11 and 3D.12 summarize the apartment analysis. These exhibits show that:

- Surrey City Centre has accounted for about 35% to 40% of total apartment development in the study area over the past decade or so. This share has been increasing over time.
- Fleetwood has accounted for very little apartment development over the past decade.
- The remaining apartment development has been spread fairly evenly between the other five locations, ranging from roughly 8% (Guildford) to 19% (Cloverdale/Clayton) over the past decade.

Exhibit 3D.11 – Study Area Apartment Starts by Subarea -- Share of Apartment Units

Location	1994 to 1999	2000 to 2005	2006 to 2010	1994 to 2010	2000 to 2010
City Centre/Whalley	13%	24%	36%	27%	34%
Guildford	18%	23%	5%	11%	8%
Newton and Fleetwood	30%	7%	11%	17%	10%
Cloverdale/Clayton	4%	8%	21%	14%	19%
South Surrey	13%	22%	16%	16%	17%
City of Langley	23%	15%	11%	15%	12%
Total	100%	100%	100%	100%	100%

Source: Source: CMHC "Housing Now" (Year End Editions), 1994-2010

Exhibit 3D.12 – Projects Marketing in the Study Area by Subarea (Proportion of Units)

Share of Apartment Units by Location	2004 to 2011
City Centre/Whalley	40%
Guildford	7%
Fleetwood	1%
Newton	7%
Cloverdale/Clayton	13%
South Surrey	20%
City of Langley	13%
Total	100%

Source: Coriolis and MPC Intelligence

3.1.2 Office Floorspace

Exhibit 3D.13 summarizes the analysis of the geographic distribution of new office floorspace by subarea over the past 20 years or so.

Exhibit 3D.13 – New Office Floorspace by Subarea

Subarea	**1990 to 1999**	**2000 to 2010**	**1990 to 2010**
City Centre	33%	47%	41%
Guildford	16%	3%	8%
Fleetwood	2%	0%	1%
Newton/Panorama	34%	25%	29%
Cloverdale	1%	0%	0%
South Surrey	4%	16%	11%
Total Surrey	90%	90%	90%
City of Langley + Willowbrook	10%	10%	10%
Total Study Area	**100%**	**100%**	**100%**

Source: Coriolis

Exhibit 3D.13 shows that Surrey City Centre has accounted for approximately half of all office development in the study area, over the past decade. The City Centre's share of study area office development has been increasing. Newton (which includes Panorama) also captured a relatively high share (25%) of study area office development over the past decade or so. However, most of this has been at business park office projects, not in higher density commercial locations.

3.2 PROPOSED PROJECTS

Information on all proposed apartment projects in the study area was obtained, to evaluate the distribution of proposed projects by subarea. In total over 11,800 units are proposed projects (or about 3 to 4 years of supply at historic rates of demand).

Exhibit 3D.14 – Proposed Apartment Projects (share of units) by Subarea

Share of Apartment Units by Location	Proposals
City Centre/Whalley	55%
Guildford	14%
Fleetwood	0%
Newton	5%
Cloverdale/Clayton	7%
South Surrey	15%
City of Langley	4%
Total	100%

Source: Surrey and City of Langley

This exhibit shows that Surrey City Centre accounts for over half of all planned apartment units in the study area. Guildford and South Surrey also account for a fairly large share (about 15% each) of proposed apartment units.

At the time of the analysis (2011), there were very few office projects in the application process, therefore the distribution of proposed office floorspace was not analyzed.

3.3 BASE CASE DEMAND PROJECTION BY SUBAREA

Drawing on the historic trend and information about proposed projects, apartment and office demand was projected by subarea, assuming rapid transit is not extended in the study area.

3.3.1 Apartment Units

Exhibit 3D.15 shows the projected share of future apartment demand by subarea in the absence of an extension of the rapid transit network.

Exhibit 3D.15 – Base Case Projected Apartment Share by Subarea

Share of Apartment Demand by Location	2011 to 2021	2021 to 2031	2031 to 2041
City Centre/Whalley	50.0%	50.0%	50.0%
Guildford	8.0%	8.0%	8.0%
Fleetwood	1.0%	1.0%	1.0%
Newton	7.0%	7.0%	7.0%
Cloverdale/Clayton	10.0%	10.0%	10.0%
South Surrey	15.0%	15.0%	15.0%
City of Langley	9.0%	9.0%	9.0%
Total	100.0%	100.0%	100.0%

This would result in total unit demand[3] as shown in **Exhibit 3D.16**.

Exhibit 3D.16 – Base Case Projected Apartment Units by Subarea (Annual Average)

Projected Annual Apartment Demand	2011 to 2021	2021 to 2031	2031 to 2041	2011 to 2041	Total Units 2011 to 2041
City Centre/Whalley	763	845	875	827	24,800
Guildford	122	135	140	132	3,970
Fleetwood	15	17	17	17	500
Newton	107	118	122	116	3,480
Cloverdale/Clayton	153	169	175	165	4,960
South Surrey	229	254	262	248	7,450
City of Langley	137	152	157	149	4,470
Total	1,525	1,690	1,750	1,655	49,650

Based on the station area redevelopment capacity estimates that were completed (see Section 4 below) and on a review of other available information about total existing capacity by subarea, each of the subareas should be able to accommodate the projected unit demand for the base case[4].

3.3.2 Office Floorspace

Exhibit 3D.17 shows the projected shares of future office demand by subarea[5] in the absence of an extension of the rapid transit network. This would result in total floorspace demand as shown in **Exhibit 3D.18**. These projections represent the base case, or Business As Usual (BAU) scenario in the evaluation.

Exhibit 3D.17 – Base Case Projected Office Share by Subarea

Share of Office Demand by Location	2011 to 2021	2021 to 2031	2031 to 2041
City Centre/Whalley	50.0%	50.0%	50.0%
Guildford	5.0%	5.0%	5.0%
Fleetwood	1.0%	1.0%	1.0%
Newton (including Panorama)	25.0%	25.0%	25.0%
Cloverdale/Clayton	1.0%	1.0%	1.0%
South Surrey	10.0%	10.0%	10.0%
City of Langley + Willowbrook	8.0%	8.0%	8.0%
Total	100.0%	100.0%	100.0%

[3] The unit demand projections for 2011-2021, 2021-2031, etc. are precise calculations based on the assumed market share figures outlined in Exhibit D3.I5. These projections were only developed to estimate the cumulative total in the right column, which is carried forward into the rest of the forecasts. The annual volumes are subject to some uncertainty and the figures shown represent the midpoints of a range of possible outcomes.
[4] The development capacity estimates in Section 4 only apply to sites within 400 metres of an existing or potential station location. Therefore, these estimates understate the potential development capacity.
[5] The 25% share to Newton (including Panorama) assumes that this subarea continues to have business park land available for development.

Exhibit 3D.18 – Base Case Projected Office Floorspace (sq.ft.) by Subarea (Annual Average)

Projected Annual Office Demand	2011 to 2021	2021 to 2031	2031 to 2041	2011 to 2041	Total Floorspace 2011 to 2041
City Centre/ Whalley	75,000	75,000	75,000	75,000	2,250,000
Guildford	7,500	7,500	7,500	7,500	225,000
Fleetwood	1,500	1,500	1,500	1,500	45,000
Newton (including Panorama)	37,500	37,500	37,500	37,500	1,125,000
Cloverdale/Clayton	1,500	1,500	1,500	1,500	45,000
South Surrey	15,000	15,000	15,000	15,000	450,000
City of Langley + Willowbrook	12,000	12,000	12,000	12,000	360,000
Total	150,000	150,000	150,000	150,000	4,500,000

4. URBAN DEVELOPMENT CAPACITY AT STATION LOCATIONS

One factor that could influence the amount of urban development that occurs near station locations in each rapid transit alternative is the amount of development (or redevelopment) capacity available near existing and potential station locations. If there is limited ability to accommodate new development (or redevelopment of existing older properties is not financially viable), then development near stations will be constrained.

The amount of development capacity at each station location was estimated as one input to the long term projections of apartment and office development near station locations in each alternative. The total capacity at the stations served by each alternative produces the measure: Access to Redevelopment Opportunities.

4.1 APPROACH

The development capacity within a 400 metre radius of existing and potential rapid transit station locations was estimated, consistent with the evaluation of development market potential. This radius represents approximately a 5-minute walking distance, the zone of greatest influence for Transit Oriented Development.

Most properties near existing proposed station locations have existing improvements. The existing improvements (structures situated in the parcel of land, e.g. homes, office buildings, stores, ancillary buildings) often have significant value. In order for redevelopment of a site to be financially attractive, the land value supported by the uses, densities, and form of development permitted for redevelopment (under existing zoning, OCP, NCP or staff-projected NCP) must equal (or exceed) the property value supported by the existing use. If the existing use supports a higher value, then there will not be a financial incentive for private developers to acquire the site, demolish the existing building and build a new project.

Therefore, the approach compared indicators of the property value of the sites under existing use with the estimated land value supported by redevelopment to determine if redevelopment generates increased value and is, therefore, financially viable. Sites that are financially viable for redevelopment are identified as potential redevelopment candidates. The estimate of redevelopment capacity at station locations included the following main steps:

1. The consulting team and municipalities developed a database identifying the parcels within 400 metres of each station, including the following data:
   - Parcel area.
   - Total existing building area.

- Allowable FSR (Floor Space Ratio) under current zoning.
- Potential FSR under existing OCP, NCP or emerging policy.
- Assessed value, including total, land, and improvements.

The resulting database included over 5000 properties.

2. Using the data, the potential maximum development capacity was estimated for each parcel within a 400 metre radius of a station location (i.e., FSR x parcel area).
3. Based on a detailed review of land values for different types of development sites in the study area, the ‘ballpark’ market value was estimated for each property in the database as a redevelopment site (i.e. the land value of each site).
4. Two tests were applied to determine whether a property was a likely redevelopment candidate:
   - Compare the estimated land value of each site (as a redevelopment site) with its existing assessed value. If the estimated land value exceeded the assessed value by 50% or more, the property was identified as being financially viable for (re)development. The 50% buffer was included as rough allowance to cover the costs that a developer could face during rezoning and redevelopment (such as assembly costs, rezoning costs, rezoning risk, holding costs during approvals). Based on experience, if the increase in value exceeds these costs, then there is financial incentive for redevelopment.
   - Sites where the assessed improvements value accounted for less than 5% of the total assessed value. Based on local experience, this threshold identifies properties where the existing built improvements make very little contribution to overall property value, suggesting that the site is (or will be in the near future) a candidate for redevelopment.

   If a property met either one of these two tests, it was identified as a potential redevelopment candidate. All other properties were assumed to be more valuable under their existing use than as a redevelopment site, so these properties were assumed to not be redevelopment candidates.

5. Any sites that had physical barriers (e.g. high voltage transmission lines) to redevelopment, or were used for public purposes (e.g. parks, hospitals, recreation centres), were removed from the list of potential redevelopment candidates.
6. All of the permitted floorspace at the sites identified as development candidates was summed for each station location to estimate the redevelopment capacity in that station area.
7. The floorspace capacity at all of the stations in each rapid transit alternative was summed to estimate the redevelopment capacity at station locations in each alternative.

Exhibit 3D.19 illustrates one example of this process, where the parcels around a station (King George Blvd at 64 Avenue) were identified and the analysis undertaken to identify redevelopment candidates according to the above criteria. The proposed densities (Floor Space Ratio – FSR) for the candidate parcels make up the estimated development capacity within 400 meters of the station. The Exhibit 3D.19 illustrates the identification of parcels by type, with utilities, schools, parks and federal lands removed from consideration. Any parcels that met the development value threshold and other criteria in the steps above are highlighted in the second illustration. Parcels where the proposed land use exceeds the current density, and are not strata-owned or recently constructed, accounted for most of the candidate parcels.

Exhibit 3D.20 shows the results of this process for each of the alternatives, noting how many parcels fall within station areas, and how many are likely redevelopment candidates within 30 years. The results are expressed as totals and percentages of number of parcels and land area.

Exhibit 3D.19 – Identification of Development Candidate Parcels and Station Area Capacity

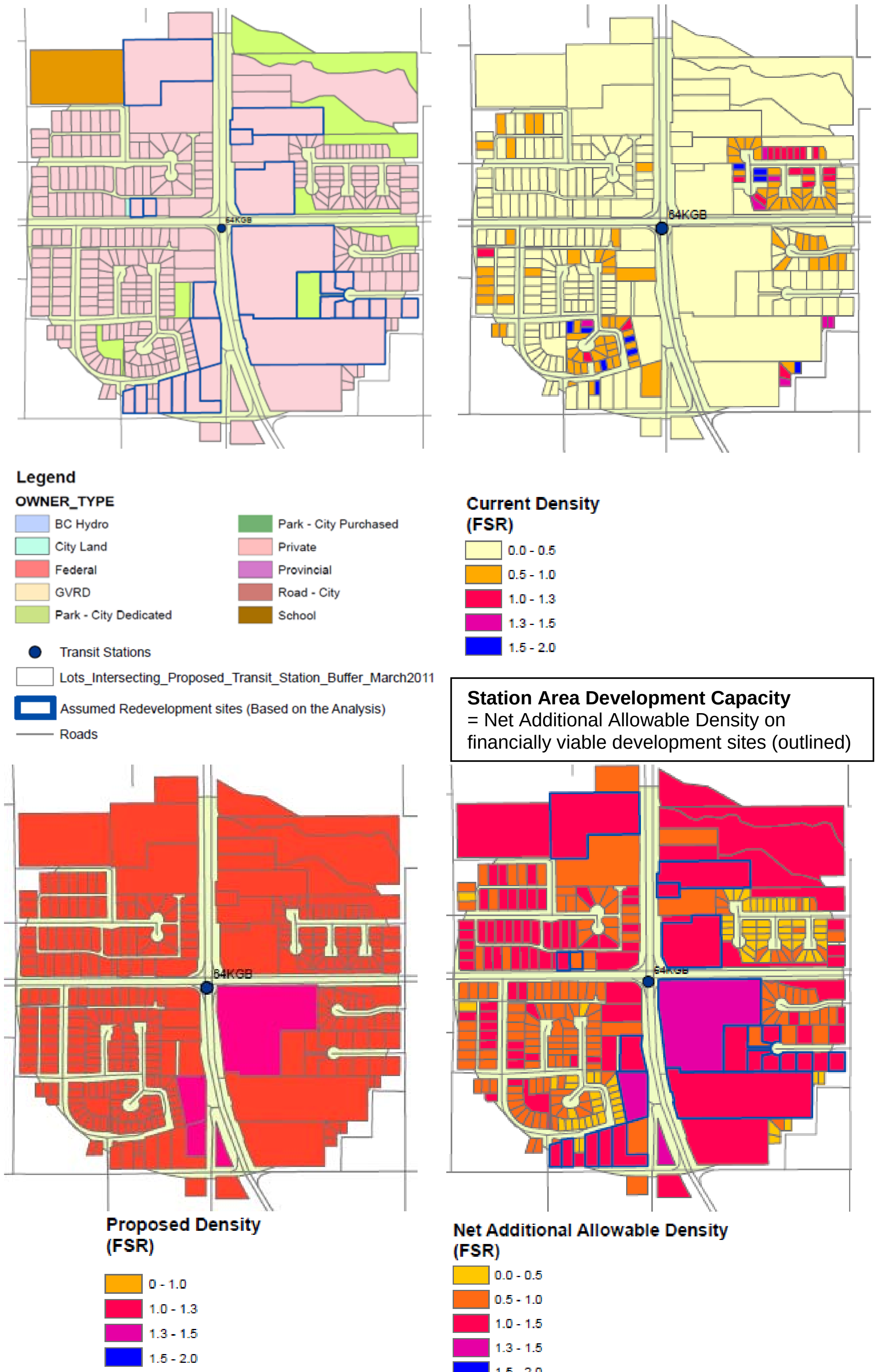


Exhibit 3D.20 – Estimate of Redevelopment Candidate Parcels, Area and Capacity

	BAU	BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5a	LRT 5b	RRT 1	RRT 1a	RRT 2	RRT 3
Access to Revelopment Capacity														
Total redevelopment candidates (within 30 years) in station areas	**145**	**145**	**885**	**765**	**885**	**885**	**765**	**530**	**885**	**885**	**380**	**885**	**765**	**270**
Total number of properties within 400 m of station areas	300	300	4400	3500	4400	4400	3500	1900	4400	4400	1900	4400	3500	950
Percentage of properties which are pre-2041 redevt candidates	48%	48%	20%	22%	20%	20%	22%	28%	20%	20%	20%	20%	22%	28%
Total redevelopment parcel area (sq.ft)	**3,100,000**	**3,100,000**	**28,300,000**	**24,200,000**	**28,300,000**	**28,300,000**	**24,200,000**	**12,100,000**	**28,300,000**	**28,300,000**	**15,300,000**	**28,300,000**	**24,200,000**	**6,100,000**
Total Area within 400m of Stations (sq.ft)	10,800,000	10,800,000	135,000,000	102,600,000	135,000,000	135,000,000	102,600,000	59,400,000	135,000,000	135,000,000	54,000,000	135,000,000	102,600,000	32,400,000
Percentage of parcel area within redevelpment candidates by 2041	29%	29%	21%	24%	21%	21%	24%	20%	21%	21%	28%	21%	24%	19%
Total redevelopment capacity at stations (sq.ft)	**15,800,000**	**15,800,000**	**56,400,000**	**50,700,000**	**56,400,000**	**56,400,000**	**50,700,000**	**33,100,000**	**56,400,000**	**56,400,000**	**33,400,000**	**56,400,000**	**50,700,000**	**21,200,000**
Capacity at existing stations in Surrey Centre	15,800,000	15,800,000	15,800,000	15,800,000	15,800,000	15,800,000	15,800,000	15,800,000	15,800,000	15,800,000	15,800,000	15,800,000	15,800,000	15,800,000
Total new redevelopment capacity at other stations (sq.ft)	-	-	40,600,000	34,900,000	40,600,000	40,600,000	34,900,000	17,300,000	40,600,000	40,600,000	17,600,000	40,600,000	34,900,000	5,400,000

4.2 RESULTS

The following exhibit summarizes the estimated redevelopment capacity (total gross floorspace) at station locations for each of the different rapid transit alternatives.

Exhibit 3D.21 – Summary - Redevelopment Capacity in Station Areas by Alternative

Rapid Transit Alternative	Total redevelopment capacity at stations (sq.ft)	Capacity at existing stations in Surrey City Centre (sq.ft.)	Total new redevelopment capacity at stations (sq.ft)
BAU	15,800,000	15,800,000	-
BB	15,800,000	15,800,000	-
BRT 1	56,400,000	15,800,000	40,600,000
BRT 2	50,700,000	15,800,000	34,900,000
LRT 1	56,400,000	15,800,000	40,600,000
LRT 2	56,400,000	15,800,000	40,600,000
LRT 3	50,700,000	15,800,000	34,900,000
LRT 4	33,100,000	15,800,000	17,300,000
LRT 5A	56,400,000	15,800,000	40,600,000
LRT 5B	56,400,000	15,800,000	40,600,000
RRT 1	33,400,000	15,800,000	17,600,000
RRT 1A	56,400,000	15,800,000	40,600,000
RRT 2	50,700,000	15,800,000	34,900,000
RRT 3	21,200,000	15,800,000	5,400,000

5. FACTORS INFLUENCING THE GEOGRAPHIC DISTRIBUTION OF DEVELOPMENT BY SUBAREA WITH RAPID TRANSIT

The geographic distribution of high density urban development in the study area would be influenced by the rapid transit alternative that is implemented. This section summarizes the factors that were considered to help estimate the share of high density urban development in the study area that could be attracted by each subarea under each of the different rapid transit alternatives.

5.1 TIMING OF RAPID TRANSIT

The projections assume that the rapid transit system would enter service by about 2020. Therefore, the projections assume that the geographic distribution of development would not be significantly influenced by rapid transit until 2021 or so. It is possible this is conservative as the distribution of development could be impacted slightly in advance of completion of any new rapid transit network (i.e., possibly upon start of construction of the system).

5.2 MARKETABILITY OF SUBAREA

Historically, some subareas in the study area have captured high shares of apartment and/or office development while others have not. For example, Surrey City Centre has captured a very large share of the study area's office development and apartment development over the past decade or more.

Rapid transit can help reinforce a location as a strong apartment or office location. However, if a location is not currently marketable for office or apartment use, the introduction of rapid transit would not necessarily increase its market share of future apartment and/or office development. The market share projections consider the overall marketability of each subarea as well as the benefits of rapid transit.

In each alternative, any increase in the share of development that is captured by a subarea must result in a decreased market share in another subarea within a study area. Even if study area demand varied between alternatives to account for shifts from adjacent areas, the competition for development would still largely be between subareas in Surrey and Langley. Neighbouring locations outside the study area are more focused on single family residential and business park office development, which are not the focus of these projections and would contribute fairly little to the overall estimates.

The subarea with the greatest risk of declining study area market share is Surrey City Centre as it is currently the only subarea served by rapid transit in the study area. If other subareas are served with rapid transit, they could capture increased market share. However, it should be noted that Surrey City Centre is evolving into the primary high density residential and office location in Surrey and is the focus of most of the proposed high density development in the study area. In addition, it will continue to be served by rapid transit in all alternatives and will provide the most convenient connection by transit to other urban centres located north of the Fraser River as well as a convenient connection to other centres served by rapid transit in the study area. Therefore, the analysis considers that any reduction in Surrey City Centre's market share would be moderate.

5.3 NUMBER OF COMPETING LOCATIONS

The share of apartment and office development that is captured by each subarea and each station location would depend on its marketability in comparison to other competing locations in the study area (particular other locations served by rapid transit). In alternatives where a small number of new locations are served by rapid transit, those locations could experience a significant increase in market share (assuming they are marketable locations for apartment and/or office development). In alternatives with a large number of new locations served by transit, the change in each location's market share would be more modest.

5.4 ACCESSIBILITY BY RAPID TRANSIT

The extension of rapid transit in the study area would significantly reduce transit travel times from new locations served by rapid transit to Surrey City Centre and to other regional employment nodes. This improved accessibility for transit users is based on the specific designs of the alternatives and their travel times within the corridors studied. Consequently, accessibility is not premised solely on the rapid transit technology, but is reflective of the speed, frequency and competitiveness of the alternatives within the corridor.

Travel time estimates between subareas were estimated for the transportation account for each alternative, and these were an input here. The specific operating assumptions in the Phase 2 evaluation are reflected in the travel times. Reduced transit travel times to Surrey City Centre would improve the marketability of a subarea and were considered to have an upward influence on the share of study area apartment and office development attracted by that subarea (although as noted in Section 5.6, changes in market share in most alternatives would likely be modest).

There would be very little difference in overall travel times between BRT and LRT (LRT was estimated to run marginally faster but operate less frequently in the Phase 2 evaluation), and little difference in the quality of the vehicles, stations and running way. Therefore, no difference was forecast between these technologies in terms of impacts on the geographic distribution of urban development. The Best Bus Alternative was not considered to have a significant effect on the distribution of development (relative to the base case) due to its lack of infrastructure. SkyTrain would offer higher speeds and faster travel times (relative to LRT/BRT in the Phase 2 analysis), and therefore SkyTrain alternatives were considered to have a larger impact on the marketability of areas served by SkyTrain, particularly on the distribution of office development.

5.5 CAPACITY TO ACCOMMODATE ADDITIONAL DEVELOPMENT AT STATIONS

The capacity to accommodate additional apartment and office development along each route alternative could influence the amount of development that occurs within each subarea. The development capacity at station locations along each alternative was estimated, as described in Section 4. The station area development capacity estimates (coupled with available information from each municipality about overall development capacity) were used as a guideline on the maximum amount of development that could occur within subareas and at stations within each alternative. The analysis found that none of the alternatives were constrained by a lack of development capacity.

5.6 IMPLICATIONS FOR PROJECTIONS BY SUBAREA WITH RAPID TRANSIT

The main implications of these factors on the market share that would be captured by each subarea in the rapid transit alternatives are as follows:

1. The extension of rapid transit to additional subareas would allow those newly served subareas to attract a higher share of development due to improved accessibility. Increased market share would come primarily from locations already served by rapid transit (Surrey City Centre) and from other nearby subareas that are not served by rapid transit.
2. Surrey City Centre will continue to capture a high share of study area apartment and office development even if rapid transit is extended to other locations. Surrey City Centre is evolving into the primary high density residential, office, institutional and cultural location in Surrey and is the focus of most of the proposed high density development in the study area. In addition, it will continue to be served by rapid transit in any alternative and will provide the most convenient connection by transit to urban centres located north of the Fraser River as well as a convenient connection to centres served by rapid transit within the study area. Therefore, the expectation is that any reduction in Surrey City Centre's market share would be low to moderate.
3. In most alternatives, the change in market share between subareas would be modest as most alternatives improve the accessibility of multiple subareas in the study area. Smaller extent rapid transit services can have a greater localized impact in shifting demand to the subareas being served, (e.g. if only Newton were connected to new rapid transit , then the shift in development patterns would focus on Newton and Surrey City Centre). This could occur provided the subarea is marketable to office and/or apartment development. If rapid transit were extended to a large number of subareas, the impact, while larger overall, is spread across multiple subareas so the impact on any single subarea might be modest.
4. Alternatives that include SkyTrain create the most significant improvement in travel times and service to new subareas. Therefore, these alternatives have the potential to create the most significant shifts in market share between study area subareas.
5. For most alternatives, significant changes in the geographic distribution of office development are not expected[6]. It was considered that Surrey City Centre will continue to be the preferred office location because it is connected by SkyTrain to the other major office locations in the region.
6. Changes in the market share captured by any subarea would primarily occur after 2020, following the completion of any rapid transit extension.

[6] Some locations will likely see higher office demand than indicated due to the introduction of rapid transit because they could draw office demand that would otherwise go to locations outside of the study area in the base case forecast. However, for the analysis, it was assumed that total study area demand remains constant in all alternatives. A location such as Guildford might draw some demand from the Carvolth area of the Township of Langley, although this would be limited by other factors, such as relative price points for development. The potential for additional demand to be drawn in was not explicitly assessed because it would not differentiate the alternatives any more than the forecasts that were prepared.

Exhibit 3D.22 summarizes the resulting shares of study area high-density development by subarea, as assessed for the base case and each of the rapid transit alternatives.

Exhibit 3D.22 – Effects of Rapid Transit on Distribution of High-Density Development

Apartments	2011-2021	During Operating Period												
Share by Subarea	All	Base Case	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Surrey City Centre & Whalley	50%	50%	44%	44%	44%	44%	44%	45%	44%	44%	45%	45%	51%	52%
Guildford	8%	8%	10%	10%	10%	10%	10%	12%	10%	10%	5%	6%	6%	5%
Fleetwood	1%	1%	3%	3%	3%	3%	3%	1%	3%	3%	5%	4%	1%	1%
Newton	7%	7%	9%	9%	9%	9%	9%	9%	9%	9%	4%	5%	8%	9%
Cloverdale/Clayton	10%	10%	10%	10%	10%	10%	10%	9%	10%	10%	14%	13%	10%	9%
South Surrey	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
Langley Centre	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	12%	12%	9%	9%
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Office (non business park)	2011-2021	During Operating Period												
Share by Subarea	All	Base Case	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Surrey City Centre & Whalley	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	40%	40%	50%	50%
Guildford	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	4%	4%	5%	5%
Fleetwood	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	6%	6%	1%	1%
Newton	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	15%	15%	25%	25%
Cloverdale/Clayton	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	6%	6%	1%	1%
South Surrey	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Langley Centre	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	19%	19%	8%	8%
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Key: Lower than Base | Higher than Base

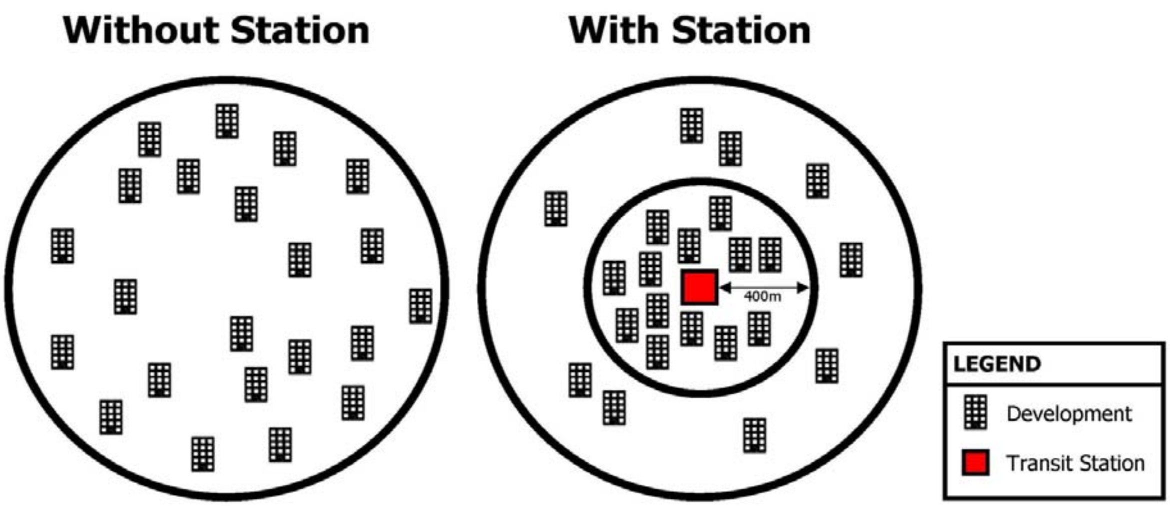
Note: For purpose of Phase 2 comparative evaluation only. Market shares for 2011-2021 based on recent trends and subject to change.

6. ESTIMATING THE SHARE OF DEVELOPMENT AT TRANSIT STATION LOCATIONS

The projections include an estimate of the share of new apartment and office development that could go to sites within a 400 metre radius of a potential new rapid transit station. **Exhibit 3D.23** shows the conceptual effect of rapid transit stations on distribution of development. The development concentrates around the transit station to take advantage of the higher degree of accessibility (and often, supportive land use policies) that encourage transit-oriented rather than dispersed auto-oriented patterns. The analyses in this section assumed a continuation of current policies as reflected in the RGS and municipal plans. Additional policies could potentially enhance the effects of rapid transit on transit-oriented development, and elaborating on these policies could be carried out in later phases of the project.

This section outlines the factors that were considered to estimate the share in the collective station areas along the rapid transit alternatives.

Exhibit 3D.23 – Development Pattern Effect of Rapid Transit Station



6.1 DEVELOPMENT CAPACITY AT STATION LOCATIONS

One factor that could influence the amount of urban development that occurs near station locations in each rapid transit alternative is the amount of development (or redevelopment) capacity available near existing and potential station locations. If there is limited ability to accommodate new development, or redevelopment of existing older properties is not financially viable, then development near stations would be constrained. As indicated in Section 4, there is substantial capacity available near each of the station locations, sufficient for more than 30 years of growth.

The demand projections for each alternative assume future development at the station location cannot exceed the station area development capacity estimates for each alternative. If the estimated floorspace demand at station locations exceeded the estimated redevelopment capacity, then the estimated share of development captured by station locations would have been capped. However, this was not required in any alternative because capacity was not forecast to be exceeded.

6.2 COMPETING LOCATIONS

The share of development attracted to station locations within any specific subarea, would depend on the number and marketability of other (outside of a 400 metre radius of a station) competing apartment and office locations within the subarea.

Subareas with strong apartment and office locations that are outside the station areas are assumed to see lower shares of development at the station locations. For example, in the Cloverdale/Clayton subarea, Clayton is served by rapid transit in some of the alternatives but Cloverdale is not. However, Cloverdale is a marketable and established apartment node with significant apartment development capacity. Therefore, it is assumed that Cloverdale will continue to attract a high share of the apartment development in this subarea, creating a downward influence on the share of development that could be captured by stations (in Clayton) in this subarea.

6.3 HISTORIC SHARE OF DEVELOPMENT AT METRO VANCOUVER TRANSIT STATIONS

A detailed analysis was completed of the historic amount and share of apartment development within a 400 metre radius of existing rapid transit stations in Metro Vancouver (Surrey, Burnaby, New Westminster, Vancouver and Richmond). The analysis focused on apartment construction because historic data on apartment construction by address was available and could therefore be compared to 400 m station areas around SkyTrain stations. The office space analysis focused on the share around the SkyTrain stations in Surrey. The main findings of this analysis follow.

1. In the municipalities that are served by rapid transit, about 27% of all new apartment development occurred within 400 metres of rapid transit station between 2004 and March 2011.
2. The share of apartment development near stations varies by municipality, as follows:
   a) In Burnaby, about 35% of units were within 400 metres of transit stations. A high share was located close to stations because:
      - Rapid transit stations are located in most of the major apartment growth areas in Burnaby.
      - Land use policies in Burnaby permit high density apartment development near stations.
      - Apartment development is financially attractive in Burnaby.
      - Development sites are available near stations.

   b) In New Westminster, about 51% of units were within 400 metres of transit stations. A high share was located close to stations because:
      - Land use policies in New Westminster permit high density apartment development near stations.
      - Apartment development is financially attractive in New Westminster.
      - Development sites are available near stations.

   c) In Surrey, about 27% of units were within 400 metres of transit stations. A moderate share was close to stations because Surrey has several apartment growth areas and rapid transit only serves one of these growth areas (City Centre). Within the City Centre a very high share (63%) of units were within 400 metres of a station.
   d) The share of office space development near the existing SkyTrain stations in Surrey was compared to the overall office market in Surrey City Centre/Whalley. For the City Centre stations, it was found that approximately 70% of the office development was within 400 m of the stations, compared to 63% of the apartment demand.

e) In Richmond, about 26% of units were within 400 metres of transit stations. A moderate share was close to stations because Richmond includes some significant apartment growth areas that are located away from rapid transit stations.

f) In Vancouver, excluding downtown due to its unique circumstances and distorting effect on results, about 11% of units were within 400 metres of transit stations. This share of units built near stations (outside of Downtown) in Vancouver was lower than the other municipalities that were examined because:

- There are limited apartment redevelopment opportunities (under existing zoning) near existing stations in East Vancouver.
- There are several growth areas that are not served by rapid transit (such as Kitsilano, Dunbar, parts of Kingsway, South Main Street, Fraser Street, Hastings Street, and the new River District) which attract significant shares of Vancouver's apartment development.
- The recent approval of the Cambie Corridor Plan (which permits increased density at certain Canada Line stations) can be expected to help increase the share of new apartment development near stations in Vancouver.

3. Some specific subareas have seen higher shares of new apartment development within 400 metres of a station. For example, in North Burnaby (which includes Brentwood Town Centre) the share was between 50% and 55% and in Surrey City Centre the share was between 60% and 65%. This occurred where areas were well-served by the street/highway network and the rapid transit system, and were locations where the municipality encouraged redevelopment.

6.4 IMPLICATIONS FOR ESTIMATED SHARE OF DEMAND CAPTURED BY TRANSIT STATION LOCATIONS IN EACH SUBAREA

The share of development that can be expected to occur near transit stations will vary by municipality based on a variety of factors, including:

a) The extent and coverage of the rapid transit network in the municipality.

b) The relative marketability of subareas served by rapid transit, based on factors such as accessibility to other transportation modes, public amenities, types of development, etc.

c) Municipal land use planning policy, such as:

- Whether or not individual municipalities have identified station locations for high density apartment development.
- The number and marketability of other growth areas in a municipality that are not served by rapid transit.

d) The availability of development sites near stations.

e) The financial viability of development near transit station locations. Redevelopment to higher densities may not be financially attractive in some station locations if the station area lands are already improved with valuable buildings.

The main findings from the evaluation of the share of share of apartment and office development that could occur at station locations in each subarea are as follows:

1. Generally, rapid transit stations can be expected to capture between 25% and 50% of office and high density residential demand within a subarea. In some cases, the share could be higher if there are few competing locations within the subarea.

2. Stations in Surrey City Centre will likely capture a very high share (60% to 70%) of this subarea's apartment and office demand. This is consistent with the historic trend in the City Centre and there is substantial remaining development capacity near stations in the City Centre.
3. Stations in Guildford will capture a high share (50%) of this subarea's apartment and office demand. There are relatively few apartment and office locations in Guildford that would be outside of the station areas so a high share could be expected to go to the station locations.
4. Stations in Fleetwood will capture a high share (50%) of this subarea's apartment and office demand. There are relatively few apartment and office locations in Fleetwood that would be outside of the station areas so a high share could be expected to go to the station locations.
5. Stations in Newton will capture a lower share (25%) of apartment and office demand because there are opportunities for a significant amount of apartment and office development in Newton outside of the station locations (e.g., Scott Road, 72nd Avenue, Southeast Newton). In addition, office space in this subarea tends to either be focused at business parks (not near potential stations) or is local-oriented (i.e., medical, realty, insurance, financial) space which has a tendency to disperse throughout the subarea.
6. Stations in the Cloverdale/Clayton subarea will capture a lower share (25%) of apartment and office demand because there are opportunities for a significant amount of apartment and office development in Cloverdale and there are no rapid transit stations in Cloverdale in any of the alternatives.
7. Stations in the South Surrey subarea will capture a lower share (25%) of apartment and office demand because there are opportunities for a significant amount of apartment and office development in South Surrey outside of the station locations (e.g., Rosemary Heights, Grandview Heights, future NCP areas). In addition, office space in this subarea tends to either be focused at business parks (not near potential stations) or is local-oriented (i.e., medical, realty, insurance, financial) space which has a tendency to disperse throughout the subarea.
8. Stations in the City of Langley will capture a high share (50%) of this subarea's apartment and office demand. There are relatively few apartment and office locations in the City of Langley that would be outside of the station areas so a high share could be expected to go to the station locations.

7. SUMMARY OF LAND USE INTENSIFICATION PROJECTIONS

Drawing on the approach, assumptions, research and analysis outlined in Sections 1 to 6, a projection of the future amount and geographic distribution of apartment and office development in the study area was completed for the base case (BAU) and each of the 12 rapid transit alternatives (BRT, LRT and RRT) being considered. Best Bus (BB) was assumed to have the same result as BAU since it does not add rapid transit to the study area.

Each projection started with the base case study area and subarea demand projection outlined in Sections 2 and 3. The estimated share of development that would go to each subarea in each alternative was based on the change in the marketability and competitiveness (see Sections 5 and 6) of each subarea due to the change in the rapid transit network in the study area. The share of development that occurs within a 400 metre radius of station locations was guided by the findings outlined in Section 6.4.

Exhibit 3D.24 summarizes the overall results of the land use intensification potential analysis in millions of square feet of capacity and development demand, by alternative. For reference, 1 million square feet of development is equivalent to approximately four 25-storey towers or twelve large 4-storey apartments. Over the same 30 year period, 47 million square feet of total office and high density multifamily residential development demand is expected in the entire study area. Details are on the following pages.

Exhibit 3D.24 – Projected Development Capacity and Intensification in Station Areas, 2011-2041

Measures	BAU	Best Bus	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Development Capacity in Station Areas (Mill. SF)	16	16	56	51	56	56	51	33	56	56	33	56	51	22
Potential Development Intensification (Mill. SF)	14.2	14.2	19.4	18.2	19.4	19.4	18.2	16.0	19.4	19.4	17.2	19.4	18.5	15.4

7.1 PROJECTED SHARES OF SUBAREA AND STATION LOCATION DEMAND

Exhibit 3D.25 summarizes the projected shares of subarea and station location apartment and office demand from 2011 to 2041. There is a range in each subarea's market share as the assumed share changes for different rapid transit alternatives.

Exhibit 3D.25 – Projected Shares of Subarea and Station Location Demand

Subarea	Share of Study Area Apartment Demand	Share of Subarea Apartment Demand to Station Locations	Share of Study Area Office Demand	Share of Subarea Office Demand to Station Locations
Surrey City Centre	44% to 52%	60%	40% to 50%	70%
Guildford	5% to 12%	50%	4% to 5%	50%
Fleetwood	1% to 5%	50%	1% to 6%	50%
Newton	4% to 9%	25%	15% to 25%	25%
Cloverdale/Clayton	9% to 15%	25%	1% to 6%	25%
South Surrey	15%	25%	10%	25%
City of Langley	9% to 12%	50%	8% to 19%	50%

7.2 PROJECTED DEMAND AT STATION LOCATIONS BY RAPID TRANSIT ALTERNATIVE

Exhibit 3D.26 summarizes the projected apartment demand from 2011 to 2041 at station locations for each rapid transit alternative. Projections assume an average gross apartment unit size of 850 sq.ft.

Exhibit 3D.26 – Projected Apartment Demand at Station Locations 2011 to 2041 by Alternative

Alternative	Study Area Apartment Demand, 2011 to 2041	Apartment Units at Station Locations (400 metres or less)	Assumed Gross Apartment Floorspace at Stations Locations (sq.ft.)	Share of Study Area Apartment Demand to Station Locations
BAU (and BB)	49,650	14,900	12.66M	30%
BRT1	49,650	20,350	17.31M	41%
BRT2	49,650	19,050	16.21M	38%
LRT1	49,650	20,350	17.31M	41%
LRT2	49,650	20,350	17.31M	41%
LRT3	49,650	19,050	16.21M	38%
LRT4	49,650	16,700	14.19M	34%
LRT5A	49,650	20,350	17.31M	41%
LRT5B	49,650	20,350	17.31M	41%
RRT1	49,650	18,000	15.29M	36%
RRT1A	49,650	20,500	17.41M	41%
RRT2	49,650	19,400	16.49M	39%
RRT3	49,650	16,100	13.67M	32%

The projected share of apartment development captured by station locations varies from about 30% (BAU) to 41%. These shares fall within the actual shares of historic (1994 to 2011) apartment development experienced at transit station locations in Burnaby, New Westminster and Richmond.

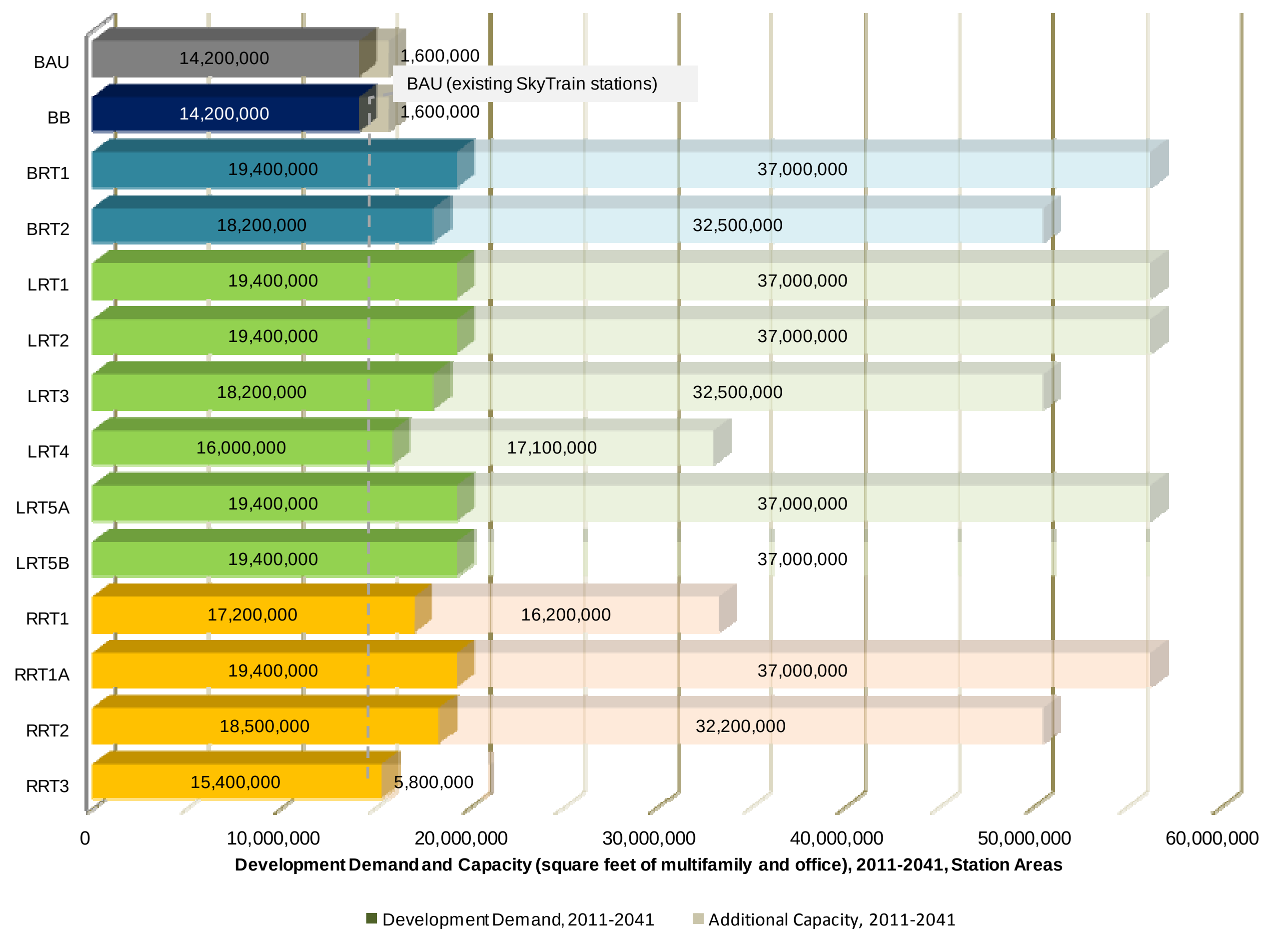
Exhibit 3D.27 summarizes the projected office demand from 2011 to 2041 at station locations for each rapid transit alternative.

Exhibit 3D.27 – Projected Office Demand at Station Locations 2011 to 2041 by Alternative

Alternative	Total Office Floorspace Demand 2011 to 2041 (square feet)		
	Study Area Office Demand (square feet)	Office Floorspace Demand at Station Locations (400 metres or less)	Share of Study Area Office Demand to Station Locations
BAU (and BB)	4,500,000	1,575,000	35%
BRT1	4,500,000	2,055,000	46%
BRT2	4,500,000	1,980,000	44%
LRT1	4,500,000	2,055,000	46%
LRT2	4,500,000	2,055,000	46%
LRT3	4,500,000	1,980,000	44%
LRT4	4,500,000	1,837,500	41%
LRT5A	4,500,000	2,055,000	46%
LRT5B	4,500,000	2,055,000	46%
RRT1	4,500,000	1,941,000	43%
RRT1A	4,500,000	1,941,000	43%
RRT2	4,500,000	1,980,000	44%
RRT3	4,500,000	1,762,500	39%

Exhibit 3D.28 plots the total area (sf) of development demand and capacity within 400 metres of stations for the Business As Usual scenario and all thirteen Phase 2 alternatives. The BAU and BB attract development to the existing SkyTrain stations in Surrey City Centre, while other alternatives open up significant additional capacity and attract additional demand relative to BAU.

Exhibit 3D.28 – Projected Development Demand and Capacity in Station Areas



8. PROPERTY REQUIREMENTS TO CONSTRUCT AND OPERATE ALTERNATIVES

Another of the criteria within the Urban Development Account was **Property Requirements**. This included counting the number of impacted properties, and adding up the area, during construction and operation. The methodology and results are summarized in the following sections.

8.1 METHOD OF ANALYSIS

The measures were evaluated on the basis of the refined conceptual designs using the estimated footprints of the rapid transit alternatives. The project footprint includes the rapid transit infrastructure plus any associated street modifications, and defines the new proposed Right of Way (ROW) limits. Projected ROW limits beyond existing public property lines (as of 2011) and temporary additional property requirements were included in the assessment.

It was understood that property requirements could change from the Phase 2 evaluation by the time an alternative is implemented, because future road projects and developments may address some needs or introduce new constraints. Since these uncertainties exist, known ROW limits were used as the basis for evaluating property effects.

Key Assumptions

The following assumptions were made when identifying property requirements:

- ROW requirements from other/adjacent projects were not counted. Only property related to fitting rapid transit was included. For example, proposals for new streets around the future Newton Exchange were identified, however only the incremental right of way between the planned limits of the Newton Exchange project and the ultimate requirements for rapid transit were attributed to the alternatives. (The same principle applied in several areas, such as 196th Street/Fraser Highway where the Roberts Bank Combo Project was underway in 2012, and street widening underway in 2011 along parts of Fraser Highway and King George Boulevard.)
- Parcels were identified as full takes if the buildings, parking or access were compromised. Where the projected property line would pass through part of a building, would remove more than 20% of on-site parking supply, or would completely cut off access to the site, then the whole parcel was assumed to be affected.
- Slivers of land and modest impacts to parking spaces were treated as partial property takes. Near transit stations, impacts of up to 30% were treated as partial; otherwise the threshold was approximately 15%. These partial takes are required for the construction and operation periods.

The assessment was carried out for each technology along each applicable alignment since the footprints varied between the conceptual designs for each technology. The impacts for each alternative were an aggregation of the applicable property requirements identified in each segment of the alternative.

8.2 PROPERTY REQUIREMENTS – PHASE 2 RESULTS

The property requirements assessment results are included on the following pages.

Exhibit 3D.29 is a summary map indicating the number and location of full and partial takes required in each segment. The requirements for surface rapid transit (BRT and LRT) would be essentially the same other than the area of partial takes (in square metres) due to the similarity of cross section. RRT would have fewer takes overall but in some areas there are more full takes, because the curvature of the alignment and large stations can have localized impacts to property.

Exhibit 3D.29 – Property Requirements – Map of Locations

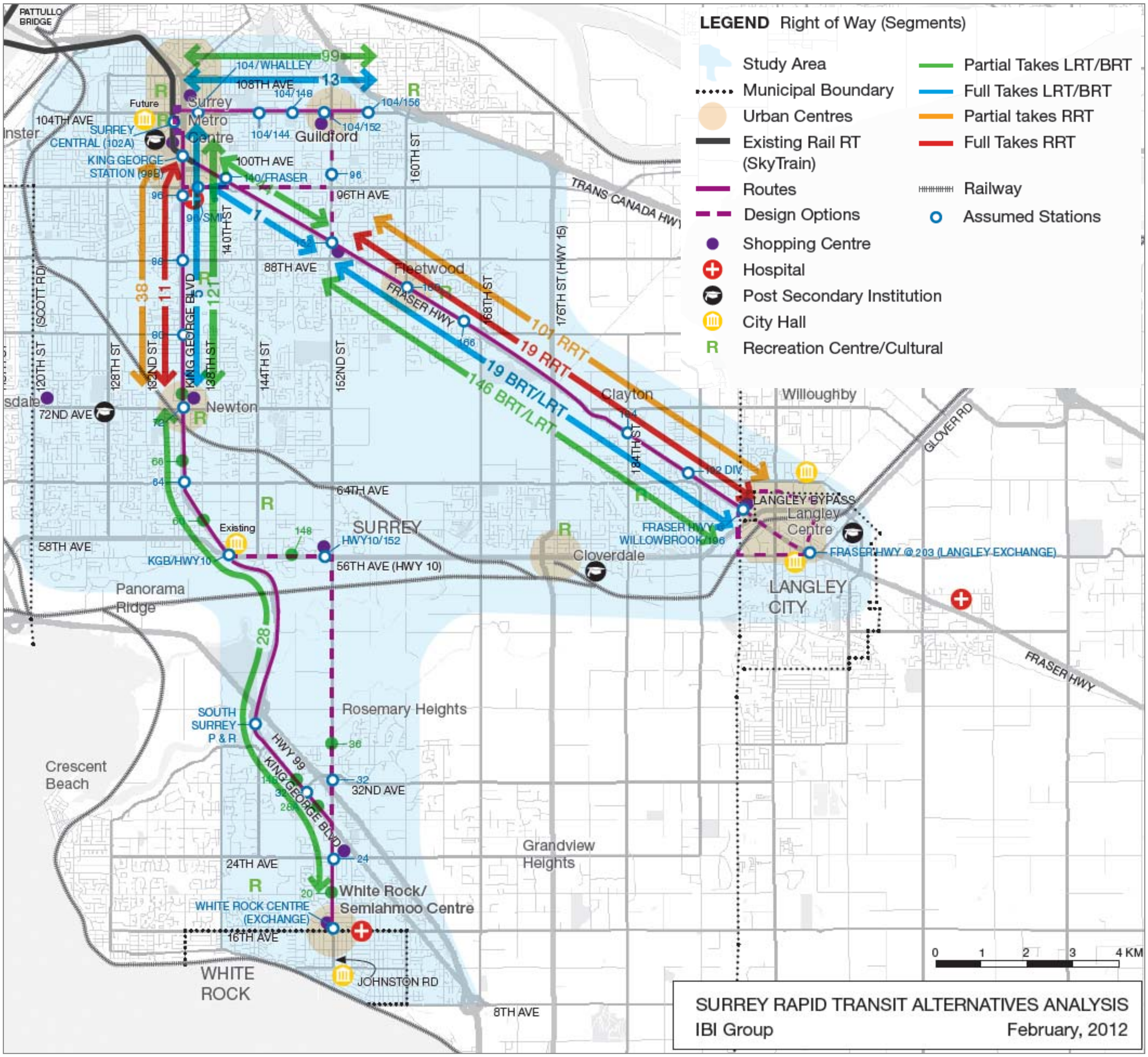


Exhibit 3D.30 tabulates the property requirements assessment based on the map locations, and by types of properties. These results are shown for each alternative; please note that RRT 1A and RRT 2 actually combine BRT with SkyTrain, so the overall requirements are a mix of both types from the map.

Exhibit 3D.30 – Property Requirements – Number of Full Takes and Area of Partial Takes, by Alternative

		BB	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5a	LRT 5b	RRT 1	RRT 1A	RRT 2	RRT 3
Full takes														
Number of impacted properties by type during construction	residential	-	2	2	2	2	2	1	2	2	2	3	8	7
	commercial	-	34	34	34	34	34	15	34	34	17	32	31	0
	comprehensive development	-	1	1	1	1	1	1	1	1	0	1	5	4
	other	-	1	1	1	1	1	1	1	1	0	1	1	0
	total	**-**	**38**	**38**	**38**	**38**	**38**	**18**	**38**	**38**	**19**	**37**	**45**	**11**
Number of impacted properties by type during operation	no resale potential	-	3	3	3	3	3	0	3	3	2	2	10	7
	unlikely resale potential	-	11	11	11	11	11	2	11	11	8	10	11	1
	Resale potential after construction	-	24	24	24	24	24	16	24	24	9	25	24	3
	No/Unlikely Resale													
	residential	-	0	0	0	0	0	0	0	0	1	1	7	7
	commercial	-	13	13	13	13	13	1	13	13	9	10	13	0
	comprehensive development	-	1	1	1	1	1	1	1	1	0	1	1	1
	other	-	0	0	0	0	0	0	0	0	0	0	0	0
	Total retained during operations	-	14	14	14	14	14	2	14	14	10	12	21	8
Partial takes - parcels affected		**-**	**398**	**370**	**398**	**398**	**370**	**220**	**398**	**398**	**101**	**349**	**311**	**38**
Evaluation Rating		**3**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**3**
Full Takes														
(for alignment)	BRT/LRT on 104th		13	13	13	13	13	13	13	13		13	13	
(OMC for vehicles	BRT/LRT, SCS to Newton		5	5	5	5	5	5	5	5		5	1	
not included)	BRT/LRT, Newton-White Rock		0		0	0			0	0		0		
	BRT/LRT, KGS-Fleetwood		1	1	1	1	1		1	1			1	
	BRT/LRT, Fleetwood-Langley		19	19	19	19	19		19	19			19	
	RRT, SCS to Newton												11	11
	RRT, Fleetwood-Langley										19	19		
	Sum - Full Takes	**0**	**38**	**38**	**38**	**38**	**38**	**18**	**38**	**38**	**19**	**37**	**45**	**11**
Partial Takes														
(slivers of fronting	BRT/LRT on 104th		99	99	99	99	99	99	99	99		99	99	
parcels, typically ~100 s.m.)	BRT/LRT, SCS to Newton		121	121	121	121	121	121	121	121		121	24	
	BRT/LRT, Newton-White Rock		28		28	28			28	28		28		
	BRT/LRT, KGS-Fleetwood		4	4	4	4	4		4	4			4	
	BRT/LRT, Fleetwood-Langley		146	146	146	146	146		146	146			146	
	RRT, SCS to Newton												38	38
	RRT, Fleetwood-Langley										101	101		
	Sum - Full Takes	**0**	**398**	**370**	**398**	**398**	**370**	**220**	**398**	**398**	**101**	**349**	**311**	**38**

APPENDIX 3E – DELIVERABILITY ACCOUNT EVALUATION DETAILS

This appendix contains additional background information on the Phase 2 Evaluation. The materials are related to four of the five criteria[1] from the Deliverability Account:

- Constructability;
- Time Required to Deliver;
- Potential for Phasing; and
- Acceptability.

A summary of the evaluation findings and ratings is included in Section 3 of the main **Phase 2 Evaluation Report** .

1. CONSTRUCTABILITY

Constructability assesses potential design and construction challenges or risks to construct the system, such as engineering, geotechnical, environmental, contamination, or archaeological constraints. A qualitative assessment was conducted on the basis of the designs, taking into account several factors to produce a comparative rating of the Phase 2 alternatives:

- Scope of Construction (technology and corridors);
- Utilities;
- Available street space;
- Existing property contamination;
- Design challenges and construction impacts;
- Effects on existing structures;
- Geotechnical suitability for construction (additional discussion follows in Section 1.1); and
- Potential for complex environmental review and challenges.

Input included GIS mapping of the study area, online mapping data for both cities, comments provided by municipal planning and engineering staff on the initial conceptual designs, and typical practices for construction of each technology.

Exhibit 3E.1 presents a comparative evaluation of these factors for the rapid transit alternatives. The overall rating and distinguishing factors are summarized in the bottom rows of the exhibit.

1.1 GEOTECHNICAL DESIGN INPUT TO PHASE 2 ALTERNATIVES

A geotechnical review was prepared in support of the conceptual designs and the evaluation of the Phase 2 Alternatives. The analysis covered the alignments of the Phase 2 alternatives, as well as the design options that underwent the mini-MAE early in Phase 2 (refer to Appendix 2C for a complete discussion of the options and evaluation).

The review included key observations about the type of construction likely to be required for each technology along each corridor, for the different soil conditions in the study area. It should be recognized that this review was based on previous knowledge of the study area from past and recent construction, and represents the most likely conditions to be found if rapid transit construction were undertaken. The specific ground conditions that would be encountered (e.g. soil layers, water content, resulting strength) can be highly variable, and this uncertainty is expressed in this initial assessment. In later phases of project development, more detailed analysis and testing would be undertaken to support related aspects of design.

[1] The affordability criterion was not assessed a rating in Phase 2, because the ability to fund projects requires evaluation in a regional context looking at packages of projects and revenue sources.

Exhibit 3E.1 – Constructability Assessment for Rapid Transit Alternatives

Constructability Factors	**BRT 1**	**BRT 2**
Scope of Construction	BRT: Langley Centre to Surrey Central Station BRT: Highway 10 to Surrey Central Station; BRT (stations only): south of Highway 10 to White Rock BRT: 104/156 to Surrey Central Station	BRT: Langley Centre to Surrey Central Station BRT: Newton to Surrey Central Station BRT: 104/156 to Surrey Central Station
Utilities	• Assume relocation or protection of in-ground utilities; access for maintenance will be less problematic, because there is more flexibility to divert BRT services temporarily during utility maintenance; and • BRT not electrically powered, so limited/no conflicts with Hydro corridors crossing ROW.	• Assume relocation or protection of in-ground utilities; access for maintenance will be less problematic, because there is more flexibility to divert BRT services temporarily during utility maintenance; and • BRT not electrically powered, so limited/no conflicts with Hydro corridors crossing ROW.
Available Street Space During Construction	• Widening of the existing road cross section will be required to deliver segregated BRT; however, much of this widening is within the existing ROW boundary lines. Land take required at many major intersections for station platforms and/or left turn lanes outside the BRT alignment. • Localized land take outside ROW boundary required to deliver segregated BRT in some tight locations; • Reduction in capacity for GP traffic on 104th Avenue, during and after construction. • Widening of Fraser Hwy through Green Timbers by City of Surrey assumed as base case for evaluation; Any widening of Fraser Hwy through Green Timbers to facilitate BRT service (using queue jumps and shared lanes) will be within the City of Surrey ROW limits for a proposed 4-lane street.	• Widening of the existing road cross section will be required to deliver segregated BRT; however, much of this widening is within the existing ROW boundary lines. Land take required at many major intersections for station platforms and/or left turn lanes outside the BRT alignment. • Localized land take outside ROW boundary required to deliver segregated BRT in some tight locations; • Reduction in capacity for GP traffic on 104th Avenue, during and after construction. • Widening of Fraser Hwy through Green Timbers by City of Surrey assumed as base case for evaluation; Any widening of Fraser Hwy through Green Timbers to facilitate BRT service (using queue jumps and shared lanes) will be within the City of Surrey ROW limits for a proposed 4-lane street. • BRT 2 has marginally less construction impact on the existing road network than BRT 1 (no changes south of Newton to Highway 10 for BRT 2)
Existing Property Contamination	• No substantial risks of disturbing pre-existing contaminated sites since assumed to be built within existing road rights of way. Potential minor impacts: gas stations, older buildings with asbestos	• No substantial risks of disturbing pre-existing contaminated sites since assumed to be built within existing road rights of way. Potential minor impacts: gas stations, older buildings with asbestos
Design Challenges and Construction Impacts	• Significant new structure required over Roberts Bank Rail Corridor in Langley; • Disruption to Surrey Metro Centre during BRT and street construction.	• Significant new structure required over Roberts Bank Rail Corridor in Langley; • Disruption to Surrey Metro Centre during BRT and street construction.
Structures	• BRT 1 affects six existing structures (five others on alignment in South Surrey avoided with refined design)	• BRT 2 affects six existing structures
Geotechnical suitability/impact on construction	• Construction -- widening of overall street with rapid transit -- across poor soils of floodplain (Fraser Hwy) of the alignment. • Construction -- deep piles for bridge over RBRC in Langley	• Construction -- widening of overall street with rapid transit -- across poor soils of floodplain (Fraser Hwy) of the alignment. • Construction -- deep piles for bridge over RBRC in Langley
Potential for Complex Environmental Reviews/Challenges to Implementation	• Watercourse crossings including Serpentine and several creeks; and • Construction within Green Timbers and ALR (although impacts may be quite limited, they will require study and mitigation could prove challenging).	• Watercourse crossings including Serpentine and several creeks; and • Construction within Green Timbers and ALR (although impacts may be quite limited, they will require study and mitigation could prove challenging).
Rating versus BAU	**2**	**2**
Distinguishing Issues for Constructability	• In-ground utility relocations, but less critical than LRT, BRT can divert • ALR/floodplain issues (poor soils, environmental constraints) on Fraser Hwy • In-street construction of BRT within Surrey Metro Centre and on 104 Avenue (physically constrained areas)	• In-ground utility relocations, but less critical than LRT, BRT can divert • ALR/floodplain issues (poor soils, environmental constraints) on Fraser Hwy • In-street construction of BRT within Surrey Metro Centre and on 104 Avenue (physically constrained areas)

Constructability Factors	**LRT 1**	**LRT 2**
Scope of Construction	LRT: Langley Centre to Surrey Central Station LRT: Newton to Surrey Central Station; BRT: Highway 10 to Newton; BRT (stations only): south of Highway 10 to White Rock LRT: 104/156 to Surrey Central Station	BRT: Langley Centre to King George Station LRT: Newton to Surrey Central Station; BRT: Highway 10 to Newton; BRT (stations only): south of Highway 10 to White Rock LRT: 104/156 to Surrey Central Station
Utilities	• Extensive relocation of existing in-ground utilities required for LRT segments given fixed rail infrastructure and need for overhead power distribution system; Stray current protection and electromagnetic field issues to be accounted for in design of track structure. • Potential minor conflicts (related to electromagnetic fields from power currents) for LRT segments with overhead Hydro corridors crossing routes. LRT 1 is LRT at all four overhead hydro locations.	• Extensive relocation of existing in-ground utilities required for LRT segments given fixed rail infrastructure and need for overhead power distribution system; Stray current protection and electromagnetic field issues to be accounted for in design of track structure. BRT segments would have less significant utility relocation requirements. • Potential minor conflicts (related to electromagnetic fields from power currents) for LRT segments with overhead Hydro corridors crossing routes. Three overhead crossings of LRT and one of BRT (which has few issues).
Available Street Space During Construction	• Widening of the existing road cross section will be required to deliver segregated LRT (and widening for BRT from Newton to Highway 10); however, much of this widening is within the existing ROW boundary lines. Land take required at many major intersections for station platforms and/or left turn lanes outside the LRT and BRT alignments. • Localized land take outside ROW boundary required to deliver segregated LRT/BRT in some tight locations; • Reduction in capacity for GP traffic on 104th Avenue, during and after construction. • Widening of Fraser Hwy through Green Timbers by City of Surrey assumed as base case for evaluation; Any widening of Fraser Hwy through Green Timbers to facilitate LRT service (using queue jumps and shared lanes) will be within the City of Surrey ROW limits for a proposed 4-lane street.	• Widening of the existing road cross section will be required to deliver segregated LRT (and widening for BRT on Fraser Hwy, and KGB from Newton to Highway 10); however, much of this widening is within the existing ROW boundary lines. Land take required at many major intersections for station platforms and/or left turn lanes outside the LRT and BRT alignments. • Localized land take outside ROW boundary required to deliver segregated LRT/BRT in some tight locations; • Reduction in capacity for GP traffic on 104th Avenue, during and after construction. • Widening of Fraser Hwy through Green Timbers by City of Surrey assumed as base case for evaluation; Any widening of Fraser Hwy through Green Timbers to facilitate BRT service (using queue jumps and shared lanes) will be within the City of Surrey ROW limits for a proposed 4-lane street.
Existing Property Contamination	• No substantial risks of disturbing pre-existing contaminated sites since assumed to be built within existing road rights of way. Potential minor impacts: gas stations, older buildings with asbestos	• No substantial risks of disturbing pre-existing contaminated sites since assumed to be built within existing road rights of way. Potential minor impacts: gas stations, older buildings with asbestos
Design Challenges and Construction Impacts	• Significant structure required over Roberts Bank Rail Corridor in Langley; • Disruption to Surrey Metro Centre during construction would be worse than for BRT given the additional infrastructure requirements; and • Greater impact than BRT to traffic and local businesses during construction, due to complexity (guideway plus train system construction) • Potential gradient challenges on Fraser Hwy (vehicle selection limitations if slope is too steep)	• Significant structure required over Roberts Bank Rail Corridor in Langley; • Disruption to Surrey Metro Centre during construction would be worse than for BRT given the additional infrastructure requirements; and • Greater impact than BRT to traffic and local businesses during construction, due to complexity (guideway plus train system construction)
Structures	• LRT 1 affects six existing structures	• LRT 2 affects six existing structures
Geotechnical suitability/impact on construction	• Construction -- widening of overall street with rapid transit -- across poor soils of floodplain (Fraser Hwy) of the alignment. • Construction -- deep piles for bridge over RBRC in Langley	• Construction -- widening of overall street with rapid transit -- across poor soils of floodplain (Fraser Hwy) of the alignment. • Construction -- deep piles for bridge over RBRC in Langley
Potential for Complex Environmental Reviews/Challenges to Implementation	• Watercourse crossings including Serpentine and several creeks; and • Construction within Green Timbers and ALR (although impacts may be quite limited, they will require study and mitigation could prove challenging).	• Watercourse crossings including Serpentine and several creeks; and • Construction within Green Timbers and ALR (although impacts may be quite limited, they will require study and mitigation could prove challenging).
Rating versus BAU	**1**	**1**
Distinguishing Issues for Constructability	• ALR/floodplain issues (poor soils, environmental constraints) on Fraser Hwy • Extensive utility relocations required (LRT on Fraser Hwy, KGB, 104th); LRT 1 is most extensive LRT • In-street construction of LRT within Surrey Metro Centre and on 104 Avenue (physically constrained areas)	• ALR/floodplain issues(poor soils, environmental constraints) on Fraser Hwy • Extensive utility relocations required (especially LRT on KGB, 104th) • In-street construction of LRT within Surrey Metro Centre and on 104 Avenue (physically constrained areas); segment around Surrey Central would also have BRT terminus

Constructability Factors	**LRT 3**	**LRT 4**
Scope of Construction	BRT: Langley Centre to King George Station LRT: Newton to Surrey Central Station LRT: 104/156 to Surrey Central Station	LRT: Newton to Surrey Central Station LRT: 104/156 to Surrey Central Station
Utilities	• Extensive relocation of existing in-ground utilities required for LRT segments given fixed rail infrastructure and need for overhead power distribution system; Stray current protection and electromagnetic field issues to be accounted for in design of track structure. BRT segments would have less significant utility relocation requirements. • Potential minor conflicts (related to electromagnetic fields from power currents) for LRT segments with overhead Hydro corridors crossing routes. Three overhead crossings of LRT for LRT 3.	• Extensive relocation of existing in-ground utilities required for LRT segments given fixed rail infrastructure and need for overhead power distribution system; Stray current protection and electromagnetic field issues to be accounted for in design of track structure. LRT 4 has shortest extent and therefore fewest conflicts of LRT alternatives. • Potential minor conflicts (related to electromagnetic fields from power currents) for LRT segments with overhead Hydro corridors crossing routes. Three overhead crossings of LRT for LRT 4.
Available Street Space During Construction	• Widening of the existing road cross section will be required to deliver segregated LRT (and widening for BRT on Fraser Hwy); however, much of this widening is within the existing ROW boundary lines. Land take required at many major intersections for station platforms and/or left turn lanes outside the LRT and BRT alignments. • Localized land take outside ROW boundary required to deliver segregated LRT/BRT in some tight locations; • Reduction in capacity for GP traffic on 104th Avenue, during and after construction. • Widening of Fraser Hwy through Green Timbers by City of Surrey assumed as base case for evaluation; Any widening of Fraser Hwy through Green Timbers to facilitate BRT service (using queue jumps and shared lanes) will be within the City of Surrey ROW limits for a proposed 4-lane street. • LRT 3 has marginally less construction impact on the existing road network than LRT 1 or 2 (LRT 3 has no changes between Newton and Highway 10)	• Widening of the existing road cross section will be required to deliver segregated LRT; however, much of this widening is within the existing ROW boundary lines. Land take required at many major intersections for station platforms and/or left turn lanes outside the LRT and BRT alignments. • Localized land take outside ROW boundary required to deliver segregated LRT/BRT in some tight locations; • Reduction in capacity for GP traffic on 104th Avenue, during and after construction. • LRT 4 has the least construction impact of the LRT alternatives due to its short extent.
Existing Property Contamination	• No substantial risks of disturbing pre-existing contaminated sites since assumed to be built within existing road rights of way. Potential minor impacts: gas stations, older buildings with asbestos	• No substantial risks of disturbing pre-existing contaminated sites since assumed to be built within existing road rights of way. Potential minor impacts: gas stations, older buildings with asbestos
Design Challenges and Construction Impacts	• Significant structure required over Roberts Bank Rail Corridor in Langley; • Disruption to Surrey Metro Centre during construction would be worse than for BRT given the additional infrastructure requirements; and • Greater impact than BRT to traffic and local businesses during construction, due to complexity (guideway plus train system construction)	• Disruption to Surrey Metro Centre during construction would be worse than for BRT given the additional infrastructure requirements; and • Greater impact than BRT to traffic and local businesses during construction, due to complexity (guideway plus train system construction)
Structures	• LRT 3 affects six existing structures	• LRT4 affects four existing structures
Geotechnical suitability/impact on construction	• Construction of BRT portion -- widening of overall street with rapid transit -- across poor soils of floodplain (Fraser Hwy) of the alignment. • Construction -- deep piles for bridge over RBRC in Langley	• Soils are relatively good condition along KGB in NW part of the study area.
Potential for Complex Environmental Reviews/Challenges to Implementation	• Watercourse crossings including Serpentine and several creeks; and • Construction within Green Timbers and ALR (although impacts may be quite limited, they will require study and mitigation could prove challenging).	• Watercourse crossings including several creeks
Rating versus BAU	1	2
Distinguishing Issues for Constructability	• ALR/floodplain issues(poor soils, environmental constraints) on Fraser Hwy • Extensive utility relocations required (especially LRT on KGB, 104th) • In-street construction of LRT within Surrey Metro Centre and on 104 Avenue (physically constrained areas); segment around Surrey Central would also have BRT terminus	• No ALR/floodplain issues • Extensive utility relocations required (especially LRT on KGB, 104th); shortest of LRT alternatives • In-street construction of LRT within Surrey Metro Centre and on 104 Avenue (physically constrained areas)

Constructability Factors	LRT 5A	LRT 5B
Scope of Construction	LRT: Langley Centre to Surrey Central Station BRT: Highway 10 to Surrey Central Station; BRT (stations only): south of Highway 10 to White Rock BRT: 104/156 to Surrey Central Station	LRT: Langley Centre to Surrey Central Station BRT: Highway 10 to Surrey Central Station; BRT (stations only): south of Highway 10 to White Rock LRT: 104/156 to Surrey Central Station
Utilities	• Extensive relocation of existing in-ground utilities required for LRT segments given fixed rail infrastructure and need for overhead power distribution system; Stray current protection and electromagnetic field issues to be accounted for in design of track structure. BRT segments would have less significant utility relocation requirements. • Potential minor conflicts (related to electromagnetic fields from power currents) for LRT segments with overhead Hydro corridors crossing routes. One overhead crossing of LRT on LRT 5A.	• Extensive relocation of existing in-ground utilities required for LRT segments given fixed rail infrastructure and need for overhead power distribution system; Stray current protection and electromagnetic field issues to be accounted for in design of track structure. BRT segments would have less significant utility relocation requirements. • Potential minor conflicts (related to electromagnetic fields from power currents) for LRT segments with overhead Hydro corridors crossing routes. Two overhead crossings of LRT on LRT 5B.
Available Street Space During Construction	• Widening of the existing road cross section will be required to deliver segregated LRT (and widening for BRT from Highway 10 to King George Station, and Surrey Central to 104/156); however, much of this widening is within the existing ROW boundary lines. Land take required at many major intersections for station platforms and/or left turn lanes outside the LRT and BRT alignments. • Localized land take outside ROW boundary required to deliver segregated LRT/BRT in some tight locations; • Reduction in capacity for GP traffic on 104th Avenue, during and after construction. • Widening of Fraser Hwy through Green Timbers by City of Surrey assumed as base case for evaluation; Any widening of Fraser Hwy through Green Timbers to facilitate LRT service (using queue jumps and shared lanes) will be within the City of Surrey ROW limits for a proposed 4-lane street.	• Widening of the existing road cross section will be required to deliver segregated LRT (and widening for BRT from Highway 10 to King George Station); however, much of this widening is within the existing ROW boundary lines. Land take required at many major intersections for station platforms and/or left turn lanes outside the LRT and BRT alignments. • Localized land take outside ROW boundary required to deliver segregated LRT/BRT in some tight locations; • Reduction in capacity for GP traffic on 104th Avenue, during and after construction. • Widening of Fraser Hwy through Green Timbers by City of Surrey assumed as base case for evaluation; Any widening of Fraser Hwy through Green Timbers to facilitate LRT service (using queue jumps and shared lanes) will be within the City of Surrey ROW limits for a proposed 4-lane street.
Existing Property Contamination	• No substantial risks of disturbing pre-existing contaminated sites since assumed to be built within existing road rights of way. Potential minor impacts: gas stations, older buildings with asbestos	• No substantial risks of disturbing pre-existing contaminated sites since assumed to be built within existing road rights of way. Potential minor impacts: gas stations, older buildings with asbestos
Design Challenges and Construction Impacts	• Significant structure required over Roberts Bank Rail Corridor in Langley; • Disruption to Surrey Metro Centre during construction would be worse than for BRT given the additional infrastructure requirements; and • Greater impact than BRT to traffic and local businesses during construction, due to complexity (guideway plus train system construction) • Potential gradient challenges on Fraser Hwy (vehicle selection limitations if slope is too steep)	• Significant structure required over Roberts Bank Rail Corridor in Langley; • Disruption to Surrey Metro Centre during construction would be worse than for BRT given the additional infrastructure requirements; and • Greater impact than BRT to traffic and local businesses during construction, due to complexity (guideway plus train system construction) • Potential gradient challenges on Fraser Hwy (vehicle selection limitations if slope is too steep)
Structures	• LRT 5A affects six existing structures	• LRT 5B affects six existing structures
Geotechnical suitability/impact on construction	• Construction -- widening of overall street with rapid transit -- across poor soils of floodplain (Fraser Hwy) of the alignment. • Construction -- deep piles for bridge over RBRC in Langley	• Construction -- widening of overall street with rapid transit -- across poor soils of floodplain (Fraser Hwy) of the alignment. • Construction -- deep piles for bridge over RBRC in Langley
Potential for Complex Environmental Reviews/Challenges to Implementation	• Watercourse crossings including Serpentine and several creeks; and • Construction within Green Timbers and ALR (although impacts may be quite limited, they will require study and mitigation could prove challenging).	• Watercourse crossings including Serpentine and several creeks; and • Construction within Green Timbers and ALR (although impacts may be quite limited, they will require study and mitigation could prove challenging).
Rating versus BAU	**1**	**1**
Distinguishing Issues for Constructability	• ALR/floodplain issues(poor soils, environmental constraints) on Fraser Hwy • Extensive utility relocations required (especially LRT on Fraser Highway) • In-street construction of LRT within Surrey Metro Centre (physically constrained areas); segment around Surrey Central would also have BRT terminus	• ALR/floodplain issues(poor soils, environmental constraints) on Fraser Hwy • Extensive utility relocations required (especially LRT on Fraser Highway) • In-street construction of LRT within Surrey Metro Centre and on 104 Avenue (physically constrained areas); segment around Surrey Central would also have BRT terminus

Constructability Factors	RRT 1	RRT 1A
Scope of Construction	RRT: Langley Centre to King George Station	RRT: Langley Centre to King George Station BRT: Highway 10 to Surrey Central Station; BRT (stations only): south of Highway 10 to White Rock BRT: 104/156 to Surrey Central Station
Utilities	• Given the elevated nature of the RRT, impacts on buried utilities will be localized (column placements and stations) • Conflict with existing overhead Hydro corridors due to physical clearances and potential electromagnetic interference due to power supply. RRT 1 crosses one Hydro corridor.	• Given the elevated nature of the RRT, impacts on buried utilities will be localized (column placements and stations); for BRT segments, assume relocation or protection of in-ground utilities; access for maintenance will have flexibility to divert BRT services temporarily during utility maintenance; • Conflict with existing overhead Hydro corridors due to physical clearances and potential electromagnetic interference due to power supply. RRT 1 crosses one Hydro corridor.
Available Street Space During Construction	• RRT technology has least impact on existing road space, with limited widening of ROW required except at stations; and • RRT 1 would have little impact on Surrey Metro Centre because construction would extend east from King George Station • Widening of Fraser Hwy through Green Timbers by City of Surrey assumed as base case for evaluation; placement of RRT columns will be within the City of Surrey ROW limits for a proposed 4-lane street.	• RRT technology has least impact on existing road space except at stations; BRT segments of RRT 1A would have impacts on KGB, 104 Avenue and Surrey Metro Centre. • Widening of the existing road cross section will be required to deliver segregated BRT (from Highway 10 through Surrey Metro Centre to 104/156); however, much of this widening is within the existing ROW boundary lines. Land take required at many major intersections for station platforms and/or left turn lanes outside the BRT alignments. • Localized land take outside ROW boundary required to deliver segregated RRT/BRT in some tight locations; • Reduction in capacity for GP traffic on 104th Avenue, during and after construction. • Widening of Fraser Hwy through Green Timbers by City of Surrey assumed as base case for evaluation; placement of RRT columns will be within the City of Surrey ROW limits for a proposed 4-lane street.
Existing Property Contamination	• No substantial risks of disturbing pre-existing contaminated sites since assumed to be built within existing road rights of way. Potential minor impacts: gas stations, older buildings with asbestos	• No substantial risks of disturbing pre-existing contaminated sites since assumed to be built within existing road rights of way. Potential minor impacts: gas stations, older buildings with asbestos
Design Challenges and Construction Impacts	•Limited potential for conflicts with development site at existing KGB Station. • Potential gradient challenges on Fraser Hwy.	•Limited potential for conflicts with development site at existing KGB Station. • Potential gradient challenges on Fraser Hwy.
Structures	• RRT 1 affects two structures	• RRT 1A affects six structures (four affected by BRT, two others will have RRT alongside)
Geotechnical suitability/impact on construction	• Construction -- deep piles to support guideway including bridge over RBRC in Langley -- into poor soils of floodplain(along Fraser Hwy).	• Construction -- deep piles to support guideway including bridge over RBRC in Langley -- into poor soils of floodplain(along Fraser Hwy).
Potential for Complex Environmental Reviews/Challenges to Implementation	• Watercourse crossings including Serpentine and several creeks; and • Construction within Green Timbers and ALR (although impacts may be quite limited, they will require study and mitigation could prove challenging).	• Watercourse crossings including Serpentine and several creeks; and • Construction within Green Timbers and ALR (although impacts may be quite limited, they will require study and mitigation could prove challenging).
Rating versus BAU	**1**	**1**
Distinguishing Issues for Constructability	• Fraser Highway corridor affected by high-voltage hydro • ALR/floodplain issues(poor soils, environmental constraints) on Fraser Hwy • Utility relocations localized and potentially able to be designed around • Fewest construction impacts within Surrey Metro Centre	• Fraser Highway corridor affected by high-voltage hydro • ALR/floodplain issues(poor soils, environmental constraints) on Fraser Hwy • Utility relocations localized and potentially able to be designed around (RRT portion); utility relocations on BRT segments less critical than LRT

Constructability Factors	**RRT 2**	**RRT 3**
Scope of Construction	BRT: Langley Centre to King George Station RRT: Newton to King George Station BRT: 104/156 to Surrey Central Station	RRT: Newton to King George Station
Utilities	• Given the elevated nature of the RRT, impacts on buried utilities will be localized (column placements and stations); for BRT segments, assume relocation or protection of in-ground utilities; access for maintenance will have flexibility to divert BRT services temporarily during utility maintenance; • Conflict with existing overhead Hydro corridors due to physical clearances and potential electromagnetic interference due to power supply. RRT 2 crosses two Hydro corridors.	• Given the elevated nature of the RRT, impacts on buried utilities will be localized (column placements and stations); • Conflict with existing overhead Hydro corridors due to physical clearances and potential electromagnetic interference due to power supply. RRT 3 crosses two Hydro corridors.
Available Street Space During Construction	• RRT technology has least impact on existing road space except at stations; BRT segments of RRT 2 would have impacts on Fraser Hwy, 104 Avenue and Surrey Metro Centre. • Widening of the existing road cross section will be required to deliver segregated BRT (from Langley Centre via Fraser Hwy through Surrey Metro Centre to 104/156); however, much of this widening is within the existing ROW boundary lines. Land take required at many major intersections for station platforms and/or left turn lanes outside the BRT alignments. • Localized land take outside ROW boundary required to deliver segregated RRT/BRT in some tight locations; • Reduction in capacity for GP traffic on 104th Avenue, during and after construction. • Widening of Fraser Hwy through Green Timbers by City of Surrey assumed as base case for evaluation; Any widening of Fraser Hwy through Green Timbers to facilitate BRT service (using queue jumps and shared lanes) will be within the City of Surrey ROW limits for a proposed 4-lane street.	• RRT technology has least impact on existing road space, with limited widening of ROW required except at stations; and • RRT 3 would have minor impact on Surrey Metro Centre, since construction would proceed east and then south from King George Station.
Existing Property Contamination	• No substantial risks of disturbing pre-existing contaminated sites since assumed to be built within existing road rights of way. Potential minor impacts: gas stations, older buildings with asbestos	• No substantial risks of disturbing pre-existing contaminated sites since assumed to be built within existing road rights of way. Potential minor impacts: gas stations, older buildings with asbestos
Design Challenges and Construction Impacts	• Keeping King George Station operating during construction requires the alignment to head eastward, then southwest back to KBG. The assumed conceptual alignment passes through a potential development site and the edge of an existing neighbourhood that may also redevelop. Coordination would be required with other projects to determine the final alignment.	• Keeping King George Station operating during construction requires the alignment to head eastward, then southwest back to KBG. The assumed conceptual alignment passes through a potential development site and the edge of an existing neighbourhood that may also redevelop. Coordination would be required with other projects to determine the final alignment.
Structures	• RRT2 affects six structures (five affected by BRT segments, one will have RRT alongside)	• RRT3 affects one structure
Geotechnical suitability/impact on construction	• Construction -- widening of overall street with rapid transit -- across poor soils of floodplain on one leg (Fraser Hwy) of the alignment. • Construction -- deep piles for bridge over RBRC in Langley • For RRT, soils are relatively good condition along KGB in NW part of study area.	• Soils are relatively good condition along KGB in NW part of the study area.
Potential for Complex Environmental Reviews/Challenges to Implementation	• Watercourse crossings including Serpentine and several creeks; and • Construction of BRT within Green Timbers and ALR (although impacts may be quite limited, they will require study and mitigation could prove challenging).	• Watercourse crossings including several creeks.
Rating versus BAU	**2**	**2**
Distinguishing Issues for Constructability	• KGB corridor affected by high-voltage hydro (2 locations) • ALR/floodplain issues on Fraser Hwy • Utility relocations localized and potentially able to be designed around (RRT portion); utility relocations on BRT segments less critical than LRT	• KGB corridor affected by high-voltage hydro (2 locations) • No ALR issues • Utility relocations localized and potentially able to be designed around • Few construction impacts within Surrey Metro Centre

1.1.1 Surrey City Centre to Guildford, Fleetwood and Newton (BRT, LRT or RRT)

All of the alternatives running between Surrey City Centre, Guildford, Fleetwood and Newton extend through areas which are generally underlain by competent foundation strata at relatively shallow depth. There would be little if any differentiation between alternatives from a geotechnical perspective. The surficial materials range from sandy raised beach sediments to stoney clay, which are typically less than 5 m in thickness; these are generally underlain by more competent till-like deposits.

BRT/LRT: In general, no special ground treatment is expected to be required for grade-supported systems or road widening to accommodate the new infrastructure. However, there may be local exceptions where localized poorly drained depressions or watercourses exist.

RRT: Elevated guideways for a SkyTrain system can be supported either on shallow foundations, or more likely on drilled caissons typically 10 to 15 m in depth to limit the foundation size and impacts.

1.1.2 Newton to White Rock (BRT)

Some geotechnical challenges are anticipated within, and at the margins of, the low-lying segments of these alignments, although they should be relatively easy to address for BRT technology.

The floodplains of the Nicomekl and Serpentine Rivers are characterized by low-lying, poorly-drained topography and underlying deep weak and compressible soils. The subsurface stratigraphy in this area comprises a deep sequence of weak and compressible marine silts and clays, with zones of organic soils (peat and organic silt). Although liquefiable sandy soils are not expected to be common in these areas, some deformation and/or damage to the roadway/bridge infrastructure should be anticipated under seismic loading conditions. The upland margins are generally underlain by competent marine and glacial soils at relatively shallow depth which are, in turn, underlain by interglacial glaciofluvial and marine Quadra Sediments.

BRT (where new alignment construction is assumed): If road widening were required between the Nicomekl and Serpentine Rivers, preloading would be required to widen the road in this segment. However, the refined design for BRT sharing lanes south of Highway 10 assumes only limited spot widening to accommodate BRT stations around the South Surrey Park and Ride intersection.

1.1.3 Fleetwood to Langley (SkyTrain, LRT or BRT)

BRT/LRT: Some geotechnical challenges would be anticipated within the low-lying segments of this alignment, particularly between about 170th St. and 179th St. if road widening or bridge construction is required for LRT or BRT. Given the ongoing widening of Fraser Hwy. in this area, it is possible that further widening (outside the new road limits) may not be required for LRT or BRT options; the rapid transit alignments may be placed between the lanes of traffic. Although liquefiable sandy soils are not expected to be common in these areas, some deformation and/or damage to the roadway/bridge infrastructure should be anticipated under seismic loading conditions.

The remaining higher ground segments are expected to generally be underlain by more competent soils which would place few geotechnical constraints on either BRT or LRT construction. Widening in the Langley area may also involve preloading, although possibly not if grade changes are minimal.

The proposed bridge over Langley Bypass and the Roberts Bank Rail Corridor for the LRT and BRT options will require long piles for support (likely in excess of 40 m).

RRT: Foundations for a Skytrain guideway will require piled support, likely in excess of 50 m in the low-lying areas between about 170th St. and 179th St., in excess of 40 m in the Langley terminus area, and somewhat shallower in other areas.

(Note: due to the higher degree of uncertainty for soil conditions and therefore the design requirements for this segment, a sensitivity test on the financial impacts of deeper foundations for each technology was carried out, and this is included in Appendix 4.)

1.1.4 Summary of Design Issues/Approaches

Exhibit 3E.2 summarizes the main findings from the geotechnical assessment and relates them to the individual Phase 2 alternatives. These findings informed the overall assessment of constructability.

Exhibit 3E.2 -- Geotechnical Assessment - Summary

General Area	Surrey City Centre to Guildford, Fleetwood or Newton		Newton to White Rock	Fleetwood to Langley	
Type of Support	BRT/LRT – no special treatment except at watercourses	RRT – shallow foundations or drilled caissons	BRT – refined design avoids widening (and therefore pre-loading) in floodplain	BRT/LRT – preloading in floodplain if any widening required; deep piles for bridge in Langley	RRT – deep piles in floodplain and Langley terminus area, shorter piles elsewhere
BRT 1	✓		✓	✓	
BRT 2	✓			✓	
LRT 1	✓		✓	✓	
LRT 2	✓		✓	✓	
LRT 3	✓			✓	
LRT 4	✓				
LRT 5A	✓		✓	✓	
LRT 5B	✓		✓	✓	
RRT 1		✓			✓
RRT 1A	✓	✓	✓		✓
RRT 2	✓	✓		✓	
RRT 3		✓			

✓ **=** geotechnical assessment applies to alternative. Blank cell = does not apply.

2. TIME REQUIRED TO DELIVER AND POTENTIAL FOR PHASING

Time required to deliver assesses the time required to complete the planning, design and construction of the system, once a preferred alternative has been selected and funding identified. The assessment broadly considers the extent and technology, and precedents for the design, permitting, construction and testing/commissioning phases of implementation. The implementation timing includes preliminary engineering, environmental assessment, environmental permitting and land acquisition, tender document preparation and procurement process, design and construction.

The potential for phasing criterion assesses the ease of implementing the complete alternative in phases, such as starting with a smaller initial system or converting the system from a lower capacity technology. The assessment considers technology, ability to operate initial segments, and operations and maintenance centre (OMC) and terminus requirements. It also identifies whether design changes would have to be made if technology were converted on part of the alignment.

Exhibit 3E.3 presents a comparative evaluation of these two criteria for the rapid transit alternatives.

3. ACCEPTABILITY

The acceptability criterion measures the community support for each alternative, as indicated by the public. This criterion was assessed using Phase 2 market research conducted in early 2012. The online “TransLink Listens” panel members, from within the study area and region-wide, were invited by e-mail to undertake an online survey about the Phase 2 evaluation and alternatives. The survey included general questions about: importance of investing in rapid transit; relative importance of evaluation factors in making decisions about rapid transit; and demographic information.

More specific to this criterion, participants were also asked to indicate relative preferences among the technologies and the rapid transit elements that comprise the alternatives. Summary information about the design and operation of the rapid transit technologies (BRT, LRT and RRT) was provided to help inform the participants before they rated the options. There was also a question about which combination of corridors (Fraser Highway, King George Boulevard, and 104 Avenue) should be served. Within each corridor, the sets of rapid transit elements that comprised the alternatives were presented, including the coverage, mix of technologies, travel times, costs, and impacts to the street assessed in Phase 2. Participants were asked to rate the different options for each corridor, including expanded bus service and rapid transit.

The qualitative ratings from the survey were converted into numerical scores on a scale of “1” (very unacceptable) to “5” (very acceptable). Average acceptability scores were then derived for each combination of corridors, and the transit options within each corridor. To assess the acceptability of the alternatives relative to BAU, the results from the corridor combination and corridor options that applied to each alternative were blended together and normalized relative to the rating for BAU. **Exhibit 3E.4** shows the derivation of acceptability scores and ratings

The detailed market research survey methodology and results are documented in: *Surrey Rapid Transit Study Draft Report* (prepared for TransLink by NRG Research Group). This report on market research is attached to this appendix, after the summary exhibit.

Exhibit 3E.3 – Assessment of Time Required to Deliver and Potential for Phasing

	BRT 1	BRT 2	LRT 1	LRT 2
Time Required to Deliver	To deliver rapid transit, 4-7 years. BRT potentially in lower half of range, depending on design and construction challenges. • Potential for more rapid implementation as less fixed infrastructure required for BRT; and • Construction staging important as there will be impacts on existing traffic during construction.	To deliver rapid transit, 4-7 years. BRT potentially in lower half of range, depending on design and construction challenges. • Potential for more rapid implementation as less fixed infrastructure required for BRT; and • Construction staging important as there will be impacts on existing traffic during construction.	To deliver rapid transit, 4-7 years. LRT potentially in upper half of range, depending on design and construction challenges. • Generally LRT options may require the longest to construct per unit length: o Street construction more involved than BRT due to greater need for utility relocations/protection o Also requires rail infrastructure to be installed and tested (e.g. tracks, signals, power, communications)	To deliver rapid transit, 4-7 years. LRT potentially in middle/upper half of range, depending on design and construction challenges. • Generally LRT options may require the longest to construct per unit length: o Street construction more involved than BRT due to greater need for utility relocations/protection o Also requires rail infrastructure to be installed and tested (e.g. tracks, signals, power, communications) • LRT 2 potentially faster than LRT 1 due to greater proportion of BRT
Rating versus BAU	**2**	**2**	**2**	**2**
Potential for Phasing	• BRT provides the greatest potential for phased implementation (nearly as flexible as Best Bus or BAU); • Sections of network could be developed and built incrementally; and • BRT staging not required to link directly to the location of a new OMC facility.	• BRT provides the greatest potential for phased implementation(nearly as flexible as Best Bus or BAU) ; • Sections of network could be developed and built incrementally; and • BRT staging not required to link directly to the location of a new OMC facility.	• Will highly depend on the location of the proposed OMC facility; • Because there are three corridors, LRT 1 offers potential to choose which LRT to start with (provided it has the OMC); • BRT elements could be phased separately from LRT; and • Technically BRT could be used as a precursor to LRT recognizing challenge of serving BRT passengers during transition to LRT	• Will highly depend on the location of the proposed OMC facility; • Because there are two corridors, LRT 3 offers some potential to choose which LRT to start with (provided it has the OMC); • More BRT elements (KGB south of Newton, plus Fraser Hwy) than LRT 1, and these could be phased separately from LRT; and • Technically BRT could be used as a precursor to LRT recognizing challenge of serving BRT passengers during transition to LRT
Rating versus BAU	**3**	**3**	**2**	**2**

	LRT 3	LRT 4	LRT 5A	LRT 5B
Time Required to Deliver	To deliver rapid transit, 4-7 years. LRT potentially in middle/upper half of range, depending on design and construction challenges. • Generally LRT options may require the longest to construct per unit length: o Street construction more involved than BRT due to greater need for utility relocations/protection o Also requires rail infrastructure to be installed and tested (e.g. tracks, signals, power, communications) • LRT 3 potentially faster than LRT 1 due to greater proportion of BRT, and faster than LRT 2 due to shorter extent	To deliver rapid transit, 4-7 years. LRT potentially in middle/upper half of range, depending on design and construction challenges. • Generally LRT options may require the longest to construct per unit length: o Street construction more involved than BRT due to greater need for utility relocations/protection o Also requires rail infrastructure to be installed and tested (e.g. tracks, signals, power, communications) • LRT 4 potentially faster than other LRT alternatives due to shorter extent	To deliver rapid transit, 4-7 years. LRT potentially in upper half of range, depending on design and construction challenges. • Generally LRT options may require the longest to construct per unit length: o Street construction more involved than BRT due to greater need for utility relocations/protection o Also requires rail infrastructure to be installed and tested (e.g. tracks, signals, power, communications) • LRT 5A potentially faster than LRT 1 due to greater proportion of BRT	To deliver rapid transit, 4-7 years. LRT potentially in upper half of range, depending on design and construction challenges. • Generally LRT options may require the longest to construct per unit length: o Street construction more involved than BRT due to greater need for utility relocations/protection o Also requires rail infrastructure to be installed and tested (e.g. tracks, signals, power, communications) • LRT 5B potentially faster than LRT 1 due to greater proportion of BRT, may be slightly more time to construct than 5B due to higher amount of LRT
Rating versus BAU	**2**	**2**	**2**	**2**
Potential for Phasing	• Will highly depend on the location of the proposed OMC facility; • Because there are two corridors, LRT 3 offers some potential to choose which LRT to start with (provided it has the OMC); • More BRT elements (KGB south of Newton, plus Fraser Hwy) than LRT 1, and these could be phased separately from LRT; and • Technically BRT could be used as a precursor to LRT recognizing challenge of serving BRT passengers during transition to LRT	• Will highly depend on the location of the proposed OMC facility; • Only two choices for corridor, and system would be undersized if not all built at once; less flexible than most alternatives, little choice in corridors • Technically BRT could be used as a precursor to LRT recognizing challenge of serving BRT passengers during transition to LRT	• Will highly depend on the location of the proposed OMC facility; • Technically possible to open Surrey Central-Fleetwood then Fleetwood-Langley as system is being completed (provided first segment has the OMC); • More BRT elements (KGB and 104th) than LRT 1, and these could be phased separately from LRT; and • Technically BRT could be used as a precursor to LRT recognizing challenge of serving BRT passengers during transition to LRT	• Will highly depend on the location of the proposed OMC facility; • Two choices for initial LRT corridor, and also technically possible to open Surrey Central-Fleetwood then Fleetwood-Langley as system is being completed (provided first corridor has the OMC); • BRT element on KGB could be phased separately from LRT; and • Technically BRT could be used as a precursor to LRT recognizing challenge of serving BRT passengers during transition to LRT
Rating versus BAU	**2**	**1**	**2**	**2**

	RRT 1	RRT 1A	RRT 2	RRT 3
Time Required to Deliver	To deliver rapid transit, 4-7 years. RRT potentially in middle/upper half of range, depending on design and construction challenges. • Scale of RRT makes it quicker to construct than LRT, due to: o Method of construction o Length of Route o Once the guideway has been constructed, work can continue on top with less delay related to GP traffic alongside the construction o Construction in Surrey Metro Centre limited to east of King George Station. • Significantly reduced utility relocation program.	To deliver rapid transit, 4-7 years. RRT potentially in middle/upper half of range, depending on design and construction challenges. • Scale of RRT makes it quicker to construct than LRT, due to: o Method of construction o Length of Route o Once the guideway has been constructed, work can continue on top with less delay related to GP traffic alongside the construction o Construction in Surrey Metro Centre limited to east of King George Station. • Significantly reduced utility relocation program. RRT 1A also includes BRT construction on 104, through Surrey Central, and on KGB	To deliver rapid transit, 4-7 years. RRT potentially in middle/upper half of range, depending on design and construction challenges. • Scale of RRT makes it quicker to construct than LRT, due to: o Method of construction o Length of Route o Once the guideway has been constructed, work can continue on top with less delay related to GP traffic alongside the construction o Construction in Surrey Metro Centre limited to south of King George Station. • Significantly reduced utility relocation program. RRT 2 also includes BRT construction on 104, through Surrey Central, and on Fraser Hwy	To deliver rapid transit, 4-7 years. RRT potentially in middle/upper half of range, depending on design and construction challenges. • Scale of RRT makes it quicker to construct than LRT, due to: o Method of construction o Length of Route o Once the guideway has been constructed, work can continue on top with less delay related to GP traffic alongside the construction o Construction in Surrey Metro Centre limited to south of King George Station. • Significantly reduced utility relocation program.
Rating versus BAU	**2**	**2**	**2**	**2**
Potential for Phasing	• Low for RRT elements themselves since it extends from one logical place; • Technically possible to phase King George to Fleetwood, then later Fleetwood to Langley. This would be an expensive solution and would have mobilization issues; and • Potential to phase opening to Fleetwood as construction continues along the route.	• Possible to phase BRT elements. • Low for RRT elements themselves since it extends from one logical place; • Technically possible to phase King George to Fleetwood, then later Fleetwood to Langley. This would be an expensive solution and would have mobilization issues; and • Potential to phase opening to Fleetwood as construction moves along the route.	• Low for RRT element since it extends from one logical place; • Possible to phase BRT elements.	• Low - the RRT element extends from one logical place; • Only a single extension with no realistic option to built in shorter segments.
Rating versus BAU	**1**	**2**	**2**	**1**

Exhibit 3E.4 – Acceptability Scoring for Alternatives

Alternatives	BAU	Best Bus	BRT 1	BRT 2	LRT 1	LRT 2	LRT 3	LRT 4	LRT 5A	LRT 5B	RRT 1	RRT 1A	RRT 2	RRT 3
Reference Schematic														
	Numbers = Average Scores from Public Market Research Survey (Higher means more acceptable, 3 = neutral)													
Combination of Corridors														
Corridors	No RT	No RT	All 3	All 3	All 3	All 3	All 3	KGB & 104	All 3	All 3	Fraser only	All 3	All 3	KGB only
Average Score for Response	2.5	2.5	4.3	4.3	4.3	4.3	4.3	3.6	4.3	4.3	3.3	4.3	4.3	3.2
King George Boulevard														
Option (Technology/Extent)	Bus	Bus	BRT White Rock	BRT Newton	LRT and BRT	LRT and BRT	LRT Newton	LRT Newton	BRT White Rock	BRT White Rock	Bus	BRT White Rock	RRT Newton	RRT Newton
Average Score for Option	2.7	2.7	3.5	2.9	3.7	3.7	3.1	3.1	3.5	3.5	2.7	3.5	3	3
Fraser Highway														
Option (Technology)	Bus	Bus	BRT	BRT	LRT	BRT	BRT	Bus	LRT	LRT	RRT	RRT	BRT	Bus
Average Score for Option	2.5	2.5	3.4	3.4	3.5	3.4	3.4	2.5	3.5	3.5	3.5	3.5	3.4	2.5
104 Avenue														
Option (Technology)	Bus	Bus	BRT	BRT	LRT	LRT	LRT	LRT	BRT	LRT	Bus	BRT	BRT	Bus
Average Score for Option	3.3	3.3	3.4	3.4	3.2	3.2	3.2	3.2	3.4	3.2	3.3	3.4	3.4	3.3
Average Score for Alternative														
Corridor and Options	2.67	2.67	3.87	3.77	3.88	3.87	3.77	3.27	3.88	3.85	3.23	3.88	3.78	3.07
Score Relative to BAU	**1.0**	**1.0**	**1.5**	**1.4**	**1.5**	**1.5**	**1.4**	**1.2**	**1.5**	**1.4**	**1.2**	**1.5**	**1.4**	**1.2**
Evaluation Rating (5 Better > 3 BAU > 1 Worse)	**3**	**3**	**5**	**5**	**5**	**5**	**5**	**4**	**5**	**5**	**4**	**5**	**5**	**4**

Source: "TransLink Listens - Surrey Rapid Transit" Market Research Survey, conducted Feb. 9 to 21, 2012

Attachment: "Surrey Rapid Transit Study Draft Report" (Market Research)

Surrey Rapid Transit Study
Draft Report

February 2012 – DRAFT 3

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Background

- TransLink conducted a survey with residents of the Metro Vancouver region to better understand their opinions about potential rapid transit expansion within the Surrey Rapid Transit Study Area.
- The specific research objectives were as follows:
  - Profile the awareness and familiarity of the Surrey Rapid Transit Study among Metro Vancouver residents, and profile travel within the study area and familiarity with the existing transit in the area.
  - Gauge Metro Vancouver residents' overall support of the Surrey Rapid Transit Study, in terms of importance for Metro Vancouver, the Surrey area, and personally.
  - Determine study area residents' and users' reactions to three possible rapid transit technologies (BRT, LRT, and SkyTrain) that may be used for rapid transit expansion in the study area.
  - Assess residents' and users' level of acceptance for different combinations of corridor options for rapid transit expansion in the study area.
  - Understand residents' and users' level of acceptance of rapid transit expansion options for each of the three separate corridors of interest (King George Boulevard, Fraser Highway, and 104th Avenue).
- The survey was conducted using the *TransLink Listens** online panel from February 8th through February 21st, 2012. The results were weighted to reflect the known age, gender, region, and main transportation mode parameters of the Metro Vancouver region.**

*The TransLink Listens panel includes a disproportionately high representation of transit users, that with weighting by age, gender, municipality and main mode to duplicate Census and other data, may not adjust for attitudinal differences. TransLink Listens panelists are more critical overall of all transportation services, giving lower ratings than ongoing telephone tracking research. When parallel studies using the same questionnaire are run on the panel and on an independent research supplier's telephone survey, results parallel each other in terms of order of priority or support or opposition, but TransLink Listens' panelists results tend to be more positive or more negative, even with weighting, because of their deeper engagement with transit and transportation.
** Known from a combination of census data and prior demographic studies.

Surrey Rapid Transit Study Awareness and Area Familiarity Profile

- As of the time of the fielding of this survey, awareness of the Surrey Rapid Transit Study is quite low among Metro Vancouver panelists. Including those who say they were not aware of the study before completing the survey, 70% of residents are not at all familiar with the study and another 12% are not very familiar. Only 1% are very familiar with the study, with 9% being somewhat familiar. That said, there has been press coverage in March about rapid transit expansion in the Surrey area, so awareness may be slightly higher as of the time of this report.
- Generally speaking, most Metro Vancouver panelists say that investing in rapid transit for Surrey and the surrounding communities is very important both to Surrey and the surrounding communities (81%) and for the entire Metro Vancouver region (51%). Personal importance of investing in rapid transit for Surrey and the surrounding communities is much lower, with 16% considering it very important (though residents of the study area are understandably more likely to rate this expansion as personally important).
- More than one-half (56%) of Metro Vancouver panelists have travelled to the Surrey Rapid Transit Study area within the past six months. However, only about one-third in all consider that they are very familiar (6%) or somewhat familiar (29%) with existing transit service in the Surrey Rapid Transit Study area.

Factors to Consider in Rapid Transit Expansion in Study Area

- Respondents were presented with some of the factors that TransLink considers when evaluating rapid transit projects. Of the sixteen factors presented, all are considered either *very or somewhat important* by at least one-half of those who live in or travel to the Surrey Rapid Transit Study area.
- Of all the factors, four factors come out on top in terms of importance (based on the percentage who rate each as *very important*):
  - Reliability: Whether the system offers consistent travel times and is there when you need it
  - Integration with the regional transit network: How well the system integrates with the existing rapid transit network
  - Speed: Whether the system offers fast, competitive travel times
  - Capacity and expandability: Whether the system has the capacity to meet initial demand and can be easily upgraded or expanded as demand grows
- Another four factors settle out as the least crucial (based on the percentage who rate each as *very important*), though still somewhat important overall:
  - Timing: How quickly the system can be implemented once funding is attained
  - Urban development: The amount and type of residential and commercial development that the system helps to generate
  - Economic development potential: The economic benefits of building and operating the system (e.g., job creation, effects on goods movement and GDP, etc.)
  - Potential for phasing: The ease of implementing the system in phases, such as starting with a smaller initial system

Overall Reactions to Rapid Transit Technology Options in Study Area

- Respondents who either reside or had travelled to the study area in the past six months were presented with three different technologies which could be used for rapid transit expansion within the study area. These three options are as follows, in order of acceptability:

Light Rail Transit (LRT): A driver-operated, electrically-powered rail technology that typically operates at street level. LRT can run as frequently as every 2 minutes. LRT travels at an average speed of 30 kilometers per hour. LRT operates primarily in the centre of the street. It is in its own right-of-way, separated from other traffic by a curb with signal priority at intersections.

Rail Rapid Transit (SkyTrain): An automated, driverless rail technology that is powered by electricity. SkyTrain can run as frequently as every 2 minutes. SkyTrain travels at an average speed of 40 kilometers per hour. SkyTrain typically operates in a tunnel or on an elevated track; in the case of this study, it is assumed to operate on an elevated track above the centre of the street.

Bus Rapid Transit (BRT): A driver-operated, low-floor articulated bus technology that typically operates at street level. BRT can run as frequently as every 2 minutes. BRT travels at an average speed of 30 kilometers per hour. BRT vehicles would run on modern, clean diesel fuel. BRT operates primarily in the centre of the street. It is in its own right-of-way, separated from other traffic by a curb with signal priority at intersections.

- Each of the three technology options is rated as acceptable by the majority of participants who live or travel in the study area, and each option is seen as having unique positives and negatives. Specific reactions to each of the three alternative technologies are described on the following slides.

Reactions to Rapid Transit Technology Options – Light Rail Transit (LRT)

- Light Rail Transit (LRT) technology is considered *very or somewhat acceptable* by 81% and considered *very or somewhat unacceptable* by 10%.
- Reasons for considering this technology acceptable include affordability (13%) and the positive impact on the look and feel of the street (10%). Another 8% mention that LRT technology works well in other cities, and 7% mention a positive environmental impact as a reason for considering LRT technology acceptable.
- Those who consider this technology unacceptable believe that it will have a negative impact on street traffic (29%). Many also express concerns about affordability (17%), while speed (6%) and personal safety and security (6%) are also reasons for considering LRT technology unacceptable.

Reactions to Rapid Transit Technology Options – Rail Rapid Transit (SkyTrain)

- Rail Rapid Transit (SkyTrain) technology is considered *very or somewhat acceptable* by 75% and considered *very or somewhat unacceptable* by 19%.
- Those who consider this technology acceptable are likely to mention speed (18%) as a positive factor. Another 17% say they find SkyTrain technology acceptable because it currently operates effectively in other parts of Metro Vancouver.
- On the other hand, the cost of implementing the SkyTrain technology is a major factor against the technology for nearly one-half (48%) of those who find it unacceptable. Urban design impacts (13%) and cost effectiveness or "bang for the buck" (10%) are other factors cited for why SkyTrain technology is unacceptable.

Reactions to Rapid Transit Technology Options – Bus Rapid Transit (BRT)

- Bus Rapid Transit (BRT) technology is considered *very or somewhat acceptable* by 62% and considered *very or somewhat unacceptable* by 25%.
- Reasons for finding this technology acceptable include affordability (16%) and quick timing to put in place (7%). The type of fuel used is given as a reason by 7% of panelists. Since the proposed fuel type is viewed as a negative trait of the technology it is mentioned by those who find BRT *somewhat acceptable* as opposed to *very acceptable*.
- Reasons for finding this technology unacceptable include the impact on street traffic (27%). Some are also concerned about unattractiveness or noise of a BRT system (15%), while 14% have a concern with the use of fuel (as opposed to electricity), and 13% are worried about the slower speed than other alternatives.

Reactions to Specific Rapid Transit Expansion Options – Corridors of Interest

- Panelists were presented with five different options for how to expand rapid transit on a combination of three different corridors: King George Boulevard, Fraser Highway, and 104th Avenue.
- Those who live in or travel to the Surrey Rapid Transit Study area are most in favour of a rapid transit plan that would provide coverage of all three of the corridors discussed (as opposed to focusing on one or two corridors). Notably, rapid transit on all three corridors is rated as the most acceptable (with 79% rating this option as very or somewhat acceptable), whereas improvements to bus service in lieu of rapid transit is rated as the least acceptable (only 29% rate this option as very or somewhat acceptable).
- Other options considered at least somewhat acceptable include rapid transit on King George Boulevard and 104th Avenue (61% rate this option as very or somewhat acceptable), rapid transit on Fraser Highway only (51% rate this option as very or somewhat acceptable), and rapid transit on King George Boulevard only (46% rate this option as very or somewhat acceptable).
- As might be expected, municipality of residence is tied to the acceptability of various corridor options. Panelists from Langley City and Langley Township, for instance, rate "Fraser Highway corridor only" as more acceptable than those in other municipalities within the study area; conversely, those in Surrey, North Delta, and particularly White Rock find "King George Boulevard corridor only" more acceptable than those in other municipalities.

Reactions to Potential Rapid Transit Options – King George Boulevard Corridor

- Looking at the King George Boulevard corridor, the options providing coverage all the way to South Surrey/White Rock are much more acceptable than options which truncate at Newton. Of the six options presented for the King George Boulevard corridor, a combination of LRT between Surrey Central and Newton and BRT between Newton and South Surrey/White Rock is given the most strongly acceptable ratings (61% very or somewhat acceptable), followed by BRT between Surrey City Centre, Newton, and South Surrey/White Rock (55% very or somewhat acceptable).
- The least acceptably-rated option is improving bus services along the corridor instead of rapid transit (34% very or somewhat acceptable). Other options offering service between Surrey Central and Newton only are moderately acceptable (44% very or somewhat acceptable for SkyTrain; 45% for LRT; and 36% for BRT) compared with options extending to South Surrey/White Rock.
- SkyTrain is the most polarizing of the options presented for the King George Boulevard; transit users and younger panelists tend to be more likely to find SkyTrain acceptable (due in large part to speed and reliability), whereas older panelists and SOV users steer away from SkyTrain in large part due to cost implications.
- When panelists are asked to pick the most acceptable option from among the items in the list, the LRT/BRT combination option once again comes out on top (with 42% selecting this option as the most acceptable). Not surprisingly, the option to forgo rapid transit also fares worst when panelists choose the least acceptable options (with 46% selecting this option).
- Not surprisingly, residents of sub-areas along the corridor are more in favour of options that more fully service their areas. Those in South Surrey/White Rock, as well as those in Newton, are more likely to select options that extend as far as White Rock as the most acceptable or highest-rated options.

Reactions to Potential Rapid Transit Options – Fraser Highway Corridor

- Of the four options presented for the Fraser Highway corridor between Surrey Central and Langley City Centre, SkyTrain and LRT receive nearly identical overall acceptability ratings (57% very or somewhat acceptable for LRT; 56% very or somewhat acceptable for SkyTrain). However, based on the percentage who rate each alternative as "very acceptable, SkyTrain has the most strongly acceptable ratings (39% very acceptable, compared with 24% for LRT). BRT is also seen as an acceptable option for this corridor, with 53% rating this option as very or somewhat acceptable.
- The least acceptably-rated option for the Fraser Highway Corridor is improving bus services along the corridor instead of expanding rapid transit (29% very or somewhat acceptable).
- When asked to choose the most acceptable option, panelists are most likely to choose SkyTrain (with 39% selecting this option as the most acceptable). That said, nearly three in ten panelists select SkyTrain as the least acceptable option, indicating that support for this alternative is far from universal.
- Not surprisingly, the option for no rapid transit is most commonly chosen as the least acceptable alternative (54%).
- Those in the Langley City Centre sub-area, albeit on a small sample size, are actually more likely to choose LRT as the most acceptable option (47%) compared with those in Surrey Centre/Whalley who are more likely to choose SkyTrain as the most acceptable option (56%).

Reactions to Potential Rapid Transit Options – 104th Avenue Corridor

- Opinions are much more divided regarding the 104th Avenue corridor. Of the three options presented for the 104th Avenue corridor, there are no clear indications for the most or least acceptable options.
- Notably, while the option to use improved bus services (such as B-Line) instead of rapid transit has low acceptability for the other corridors, it is considered a moderately acceptable alternative for the 104th Avenue corridor. However, it is important to note that improved bus service is a polarizing option which is also rated as unacceptable by one-third (34%) of panelists.
- BRT has a slightly higher overall acceptability rating (53% very or somewhat acceptable) than the two alternatives, specifically no rapid transit (49% very or somewhat acceptable) and LRT (47% very or somewhat acceptable). That said, the option for no rapid transit garners more "very acceptable" ratings (32%, compared with 24% each for BRT and LRT).
- Interestingly, when asked to choose the most and least acceptable options for the corridor, the polarizing "no rapid transit" option tops each list (38% select this as most acceptable and 48% choose this as least acceptable). Of the three options, only BRT is selected more frequently as the most acceptable option (29%) than as the least acceptable (13%).
- Further muddying the picture is the lack of clear differences between regions or study sub-areas in acceptability ratings or chosen preferences. Communities along the corridor, such as Surrey City Centre and Guildford, do not generally show different preferences than those in the general population. One finding that may be surprising is that those in Surrey are slightly more likely to choose no rapid transit as the most acceptable option (54%) compared with other municipalities in the study area.

Method

Data Collection & Weighting

Participants

- TransLink Listens panelists were invited to complete a survey titled “How acceptable are these rapid transit alternatives for Surrey and surrounding communities?” A soft launch involving 400 panelists was conducted on February 8, 2012. The full launch started on February 14; an additional 4657 panelists were invited to complete the survey at that time. The survey was open until 11:59pm on February 21.
- One reminder email was sent on February 19, to increase the response rate.
- Out of 5057 panelists who were invited to participate, 2054 started the survey – a click-through rate of 40.6%. Of the 2054 who started the survey, 349 did not reach the end of the survey, and a further 50 were disqualified from the study for residing outside of Metro Vancouver (including Abbotsford and Mission). Another panelist requested that his responses be removed from the datafile. A total of 1654 reached the end of the survey (a completion rate of 32.7%), of which 1034 were asked the entire questionnaire and 620 were asked only the screener and demographic questions.
- Of the 1034 who completed the entire survey, 459 surveys were completed by South of Fraser residents (including those living in Surrey, Richmond, Delta, White Rock, and Langley). Vancouver residents accounted for 292 completed surveys, while 145 surveys were completed by residents of Burnaby and New Westminster. The Northeast region (including Anmore, Port Coquitlam, Port Moody, Coquitlam, Pitt Meadows, and Maple Ridge) had 101 completed surveys, and the remaining 37 were completed by residents of the North Shore.
- The data in this study were weighed to more closely represent the age, gender, municipality and main transportation mode of Metro Vancouver residents. The weighting methodology is described on the following two slides.

Weighting the data occurs in two steps, based on the RIM weighting process:

Step 1: Calculating Sex-Age by Region weights

- Using 2006 Canada Census data, the appropriate proportions of Sex (male and female) and Age (16-34, 35-54, 55+) groups by region are determined for Vancouver, Burnaby/ New Westminster, South of Fraser, Northeast, and North Shore.
- This results in a 6 (Sex-Age groups) by 5 (Regions) matrix of proportions that sum to 1.00 (a sample row for Vancouver is shown below).
- The obtained proportions for those same matrix cells are then calculated based on the survey results.
- By dividing the obtained proportions into the parameter proportions, weights for each group are obtained. Each case is up- or down-weighted in accordance with its under- or over-representation in the sample.

	M 16 - 34	M 35 - 54	M 55+	F 16 - 34	F 35 - 54	F 55+
Vancouver (Parameter)	0.049	0.054	0.037	0.051	0.055	0.043
Vancouver (Obtained)	0.061	0.079	0.077	0.035	0.056	0.051
Vancouver (Weight)	0.80	0.68	0.48	1.45	0.99	0.84

Step 2: Correcting for Main Mode of Transportation after applying the first weights.

- Parameters for Main Mode are obtained using the results of a 2008 TransLink Metro Vancouver telephone survey, with responses broken out by region.
- Using these parameters, weighting factors are calculated for each mode.
- The original weights are then multiplied by the Main Mode weighting factor to obtain the final weights (a sample row for Vancouver is shown below).
- The second weights slightly offset the initial corrections, but because of the over-representation of transit users on *TransLink Listens*, and the under-representation of vehicle users, particularly those whose main mode is to drive alone (SOV), it is an important correction to make when extrapolating to the population of Metro Vancouver.

	SOV	Rideshare	Transit	Other
Vancouver (Parameter)	0.107	0.031	0.105	0.047
Vancouver (Obtained)	0.068	0.022	0.204	0.065
Vancouver (Weight)	1.58	1.37	0.51	0.72

Results

Surrey Rapid Transit Study Awareness, Opinion, and Familiarity Profiles

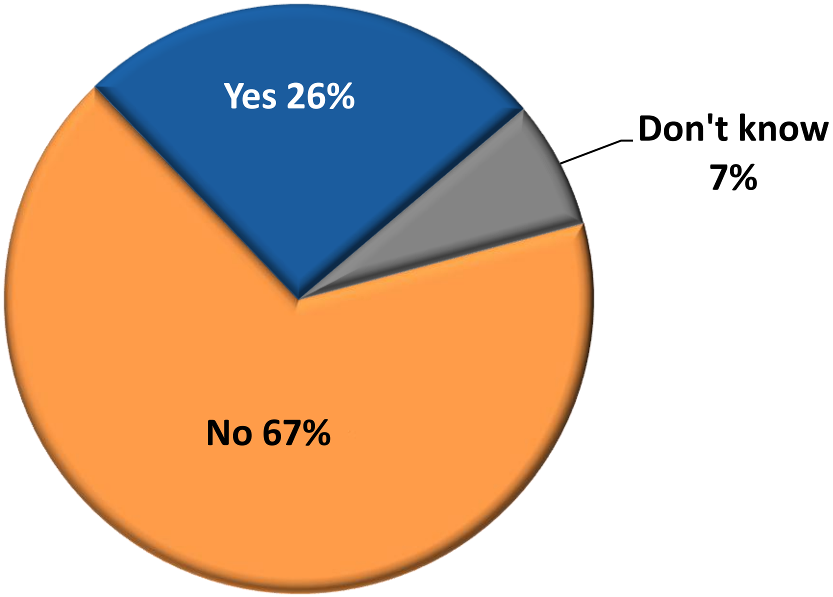
Note: In some cases, the summary statistics (e.g., the total percent acceptable) when compared to the sum of the individual percentages of the *very* and the *somewhat* may not appear to have been added correctly (i.e., off by +/- 1 percentage point) . However, these differences are due to rounding and the percentages shown are correct.

Surrey Rapid Transit Study Awareness and Area Familiarity Profiles

- All respondents were first asked which of the Metro Vancouver municipalities they live in. Those living outside of Metro Vancouver were disqualified from completing the survey; those residing in Metro Vancouver were asked whether they were aware of the Surrey Rapid Transit Study, and if so, how familiar they are with the study.
- Respondents were then shown a map of the study area and informed of the purpose of the Surrey Rapid Transit Study. Following this, the respondents were asked how important investing in rapid transit for Surrey and the surrounding communities is for the overall Metro Vancouver region, for Surrey and the surrounding communities, and for the respondent personally.
- Respondents were also asked whether they have travelled to the Surrey Rapid Transit Study area within the past six months, as well as how familiar they are with existing transit service in the Surrey Rapid Transit Study area.
- Those who either reside in the Surrey Rapid Transit Study area (i.e., Surrey, North Delta, Langley City, Langley Township, and White Rock) or who have travelled to the Surrey Rapid Transit Study area within the past six months went on to complete the full survey. Those who did not either live in or travel to the Surrey Rapid Transit Study area were asked a short series of demographic questions and thanked for their time.

Awareness of Surrey Rapid Transit Study

S2. Before today, were you aware of the Surrey Rapid Transit Study? (n=1,654)



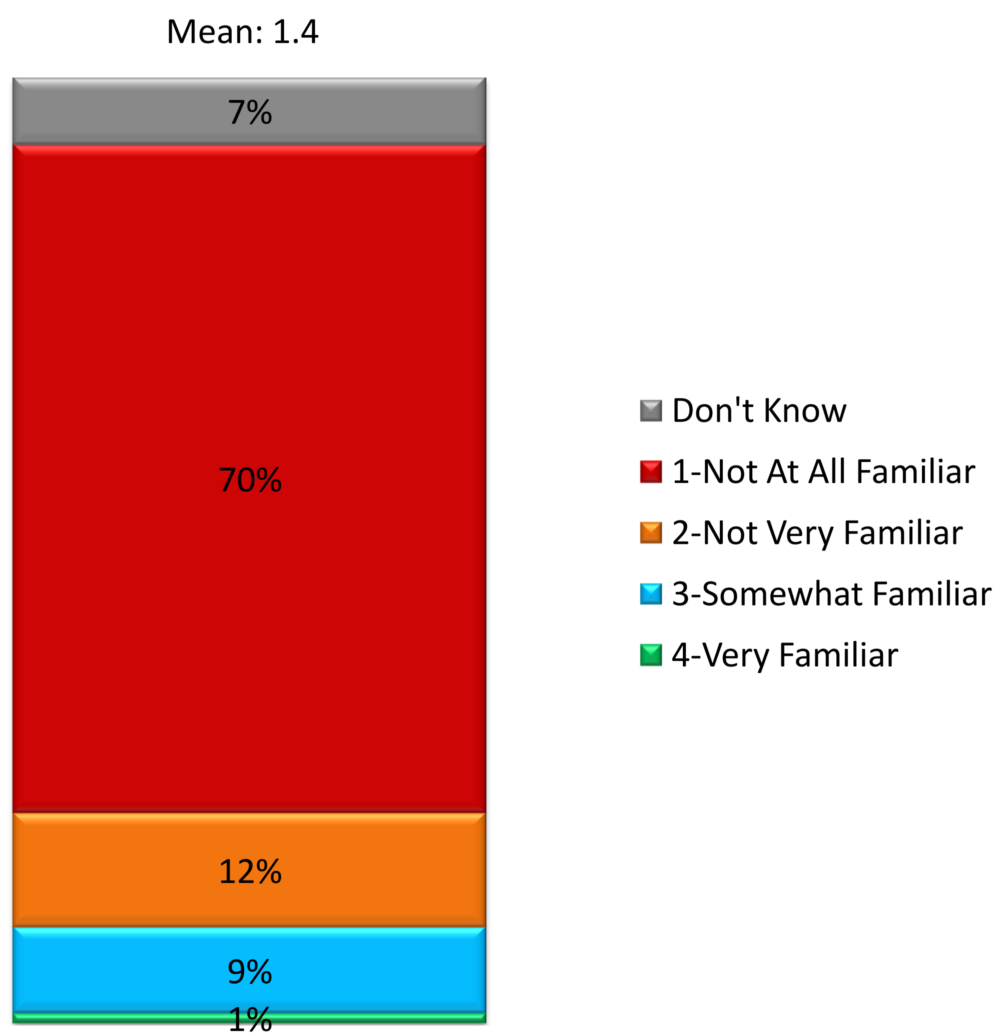
- Of the 1,654 people asked (including residents of any municipality within the Metro Vancouver region), 26% were previously aware of the Surrey Rapid Transit Study.
- Not surprisingly, those living in the South of the Fraser region (32%) and particularly those in the city of Surrey (40%) are more likely than those in other municipalities to be aware of the Surrey Rapid Transit Study.
- As well, those whose main mode of transportation is transit (31%) are more likely than their counterparts to be aware of the study, and males are more likely than females to be aware of the study (29% versus 21%).

Base: All Participants

Familiarity with Surrey Rapid Transit Study

- The majority of Metro Vancouver residents (70%) are not at all familiar with the Surrey Rapid Transit Study, while 12% say they are not very familiar with the study, 9% are somewhat familiar, and 1% are very familiar with the study.
- As with overall awareness of the study, those in the South of Fraser (15% very or somewhat familiar) and particularly in Surrey (23%) are more familiar with the study than those in other areas.
- Again mirroring overall awareness, those who take transit as their main mode are more familiar with the study than those who take other modes of transportation (17% of transit users are very or somewhat familiar). Notably, those familiar with transit in the study area are also more familiar with the study (19% very or somewhat familiar).

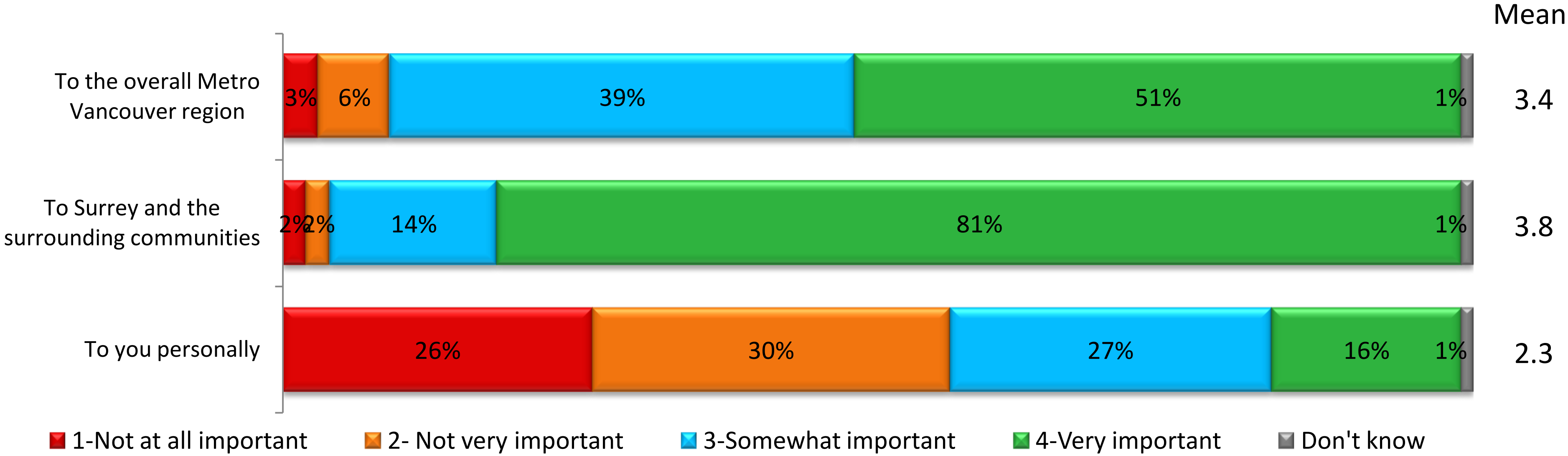
S3. How familiar are you with the Surrey Rapid Transit Study? (n=1,654)



Base: All Participants

Importance of Investing in Rapid Transit for Surrey and Area

S4. Based on what you have read, seen or heard, how important would you say investing in rapid transit for Surrey and the surrounding communities is... ? (n=1,654)

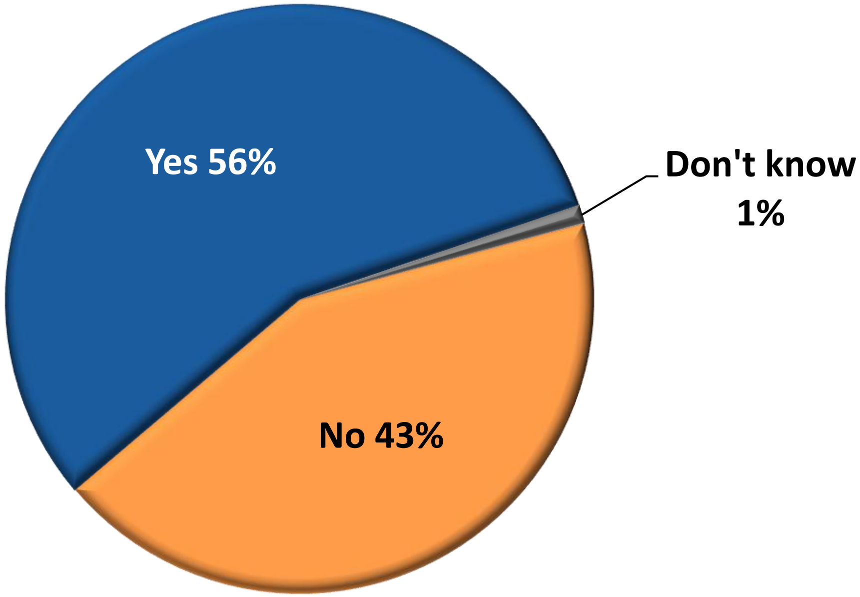


- One-half (51%) of Metro Vancouver residents say that investing in rapid transit for Surrey and the surrounding communities is very important to the overall Metro Vancouver region, and eight in ten say that it is very important to Surrey and the surrounding communities.
- That said, only 16% of Metro Vancouver residents say that investing in rapid transit for Surrey and the surrounding communities is very important to them personally.
- Those who consider rapid transit expansion important to any one of these three groups are also likely to consider the study important to the other groups. Interestingly, current transit users are no more likely to consider the study important to Metro Vancouver or Surrey and area than those who use other modes, but they are more likely to consider rapid transit expansion personally important than their counterparts. Those living within the study area, not surprisingly, are more likely than those in other regions to consider rapid transit expansion personally important.

Base: All Participants

Travel to Surrey Rapid Transit Study Area

S5. Have you travelled to the Surrey Rapid Transit Study area in the past six months? (n=1,654)



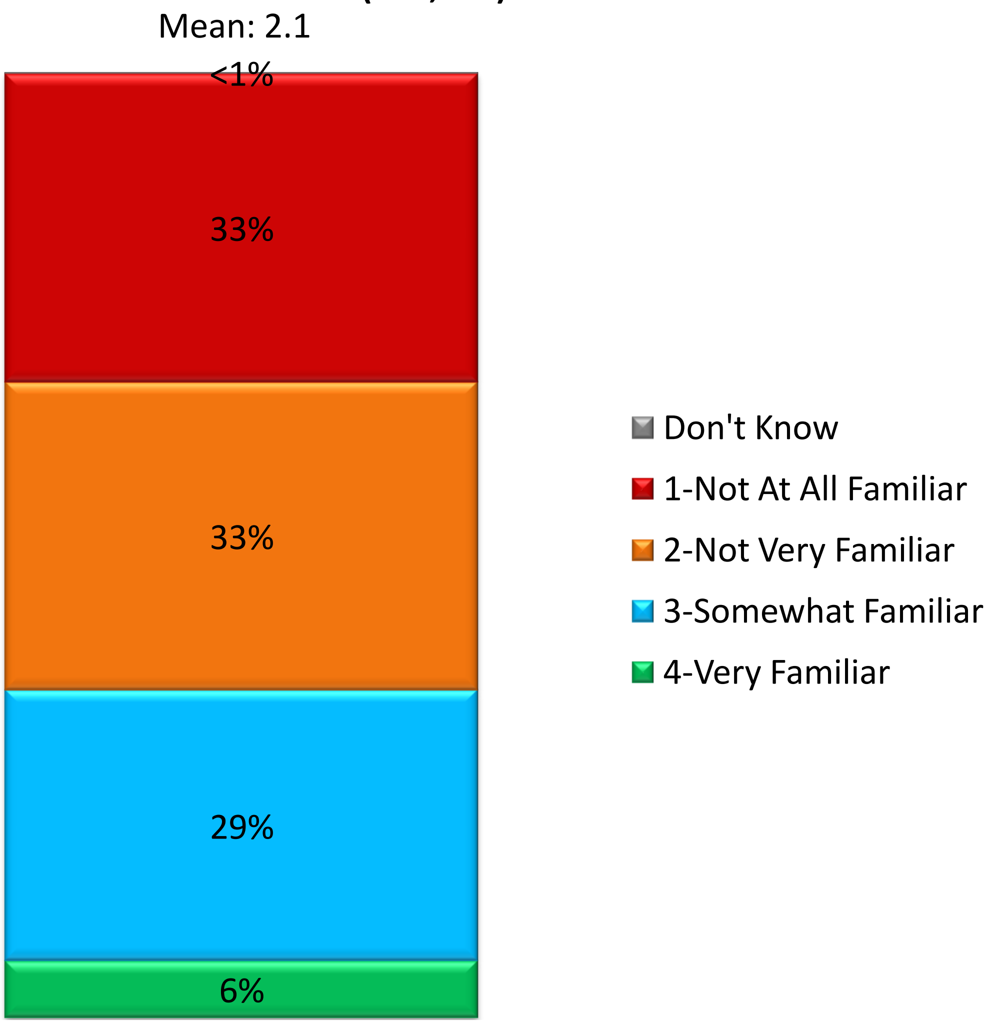
- More than one-half (56%) of all Metro Vancouver residents who participated have travelled to the Surrey Rapid Transit Study area within the past six months.
- As might be expected, those living South of the Fraser are the most likely to have travelled within the study area (73%), though many of those in Burnaby/ New Westminster (69%) have also travelled to the region within the past six months.
- Males (64%) and those whose main mode of transportation is other than a private vehicle or transit (66%) are more likely than their counterparts to have travelled within the study area.

Base: All Participants

Familiarity with Existing Transit Service

- While 6% of Metro Vancouver residents say they are very familiar and 29% are somewhat familiar with the existing transit service in the Surrey Rapid Transit Study area, one-third (33%) each say they are either not very familiar or not at all familiar with transit service in the area.
- Once again, those living South of the Fraser (60% very or somewhat familiar) or in Burnaby/ New Westminster (43%) are more likely than those in other regions to be familiar with existing transit service in the study area. As well, those whose main mode of transportation is transit (43%) and those aged 16-34 (43%) – a group that tends to have a high proportion of transit users – are particularly likely to be familiar with existing transit service in the study area.

S6. How familiar would you say you are with the existing transit service in the Surrey Rapid Transit Study Area? (n=1,654)



Base: All Participants

Results

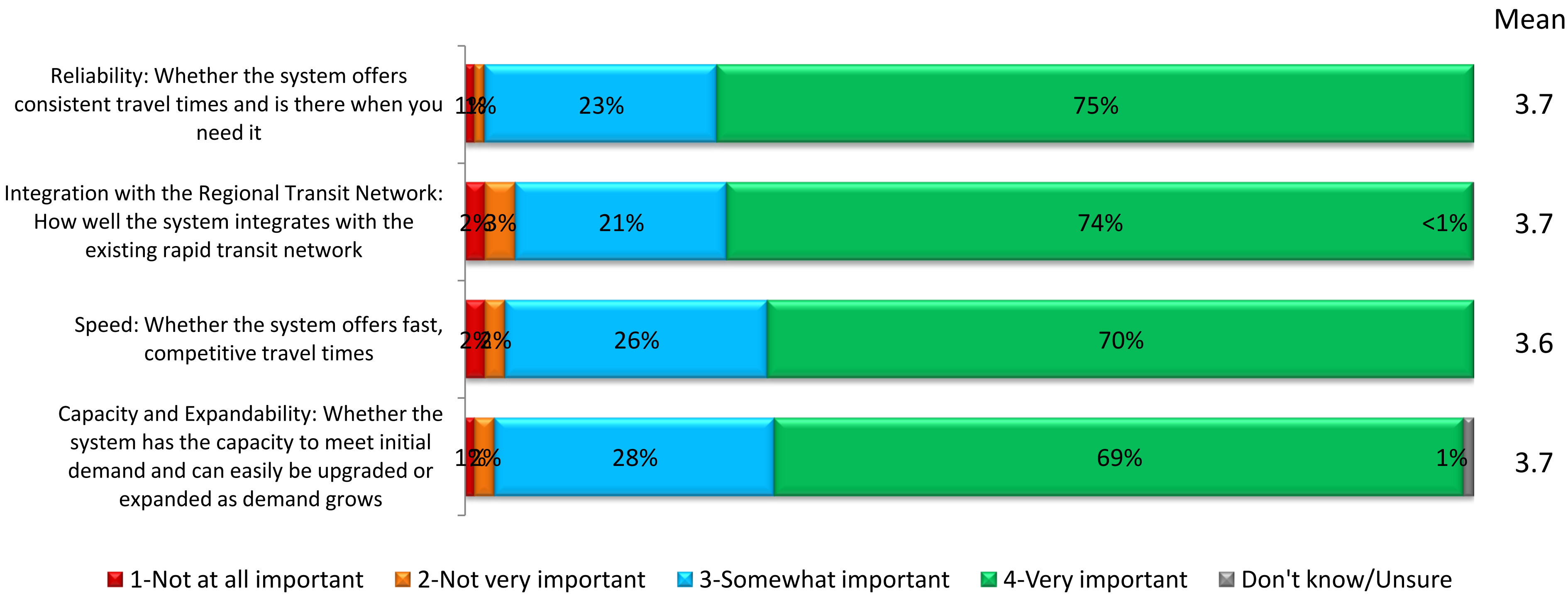
Factors to Consider in Rapid Transit Expansion in Study Area

Factors to Consider in Rapid Transit Expansion in Study Area

- All those who either reside in or have travelled to the Surrey Rapid Transit Study area in the past six months were asked to rate the importance of each of a number of factors that TransLink considers when planning rapid transit projects. These factors include:
  - Speed
  - Reliability
  - Capacity and Expandability
  - Extent of Rapid Transit Coverage
  - Cost Effectiveness
  - Affordability for the Region
  - Economic Development Potential
  - Environmental Impacts
  - Safety and Personal Security
  - Urban Development Effects
  - Timing
  - Potential for Phasing
  - Ridership Attracted
  - Impacts on Street Traffic
  - Urban Design Impacts
  - Integration with the Regional Transit Network

Importance of Factors Considered in Making Rapid Transit Decisions

Q1. There are a range of factors that TransLink considers when planning rapid transit projects. How important is each factor to you in making decisions about rapid transit in the Surrey Rapid Transit Study area? (n=1,034)



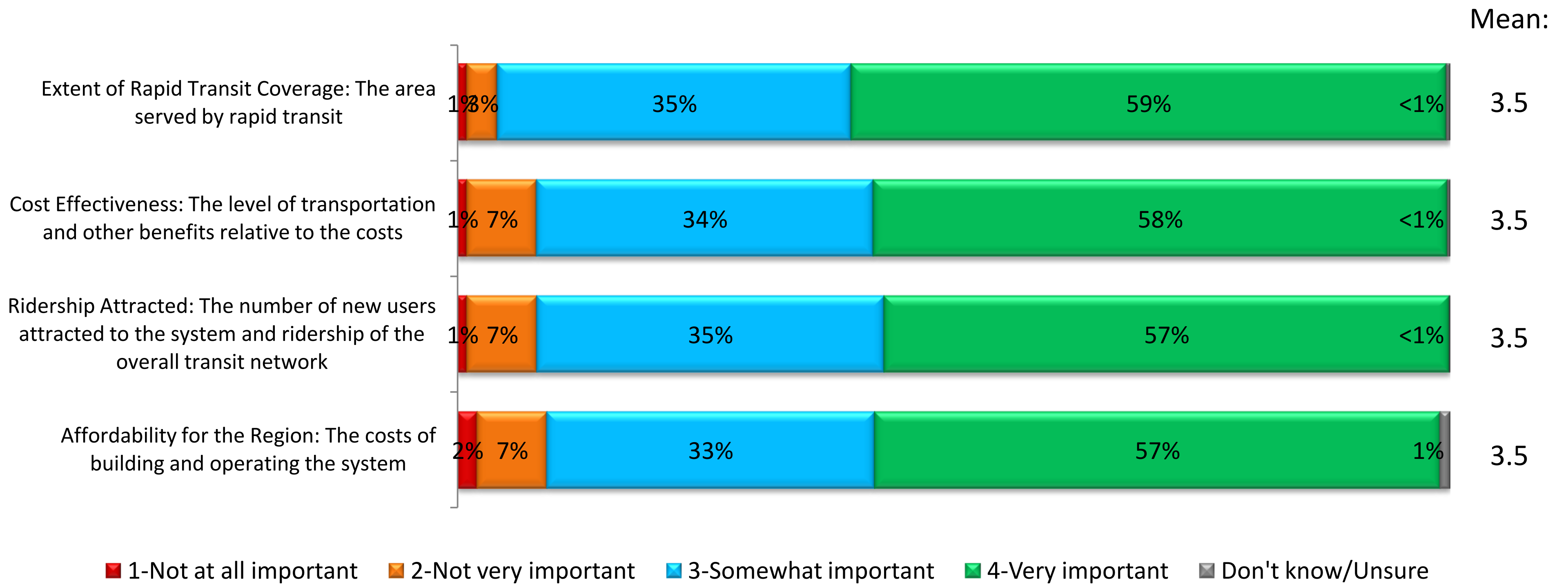
- The most important factor to consider, rated very important by three-quarters of those who live or travel in the Surrey Rapid Transit Study area, is reliability. Integration with the regional transit system is also of great importance (74% rate it as very important), followed closely by speed (70%) and capacity and expandability (69%).
- As a general rule, those who consider rapid transit expansion in Surrey and surrounding communities the most important, often including those living in or near the study area, also tend to rate the importance of each factor higher than people who do not consider rapid transit expansion in the area to be as important.

enrg RESEARCH GROUP

Base: All who reside in or travel to Surrey Rapid Transit Study area

Importance of Factors Considered in Making Rapid Transit Decisions

Q1. There are a range of factors that TransLink considers when planning rapid transit projects. How important is each factor to you in making decisions about rapid transit in the Surrey Rapid Transit Study area? (n=1,034)

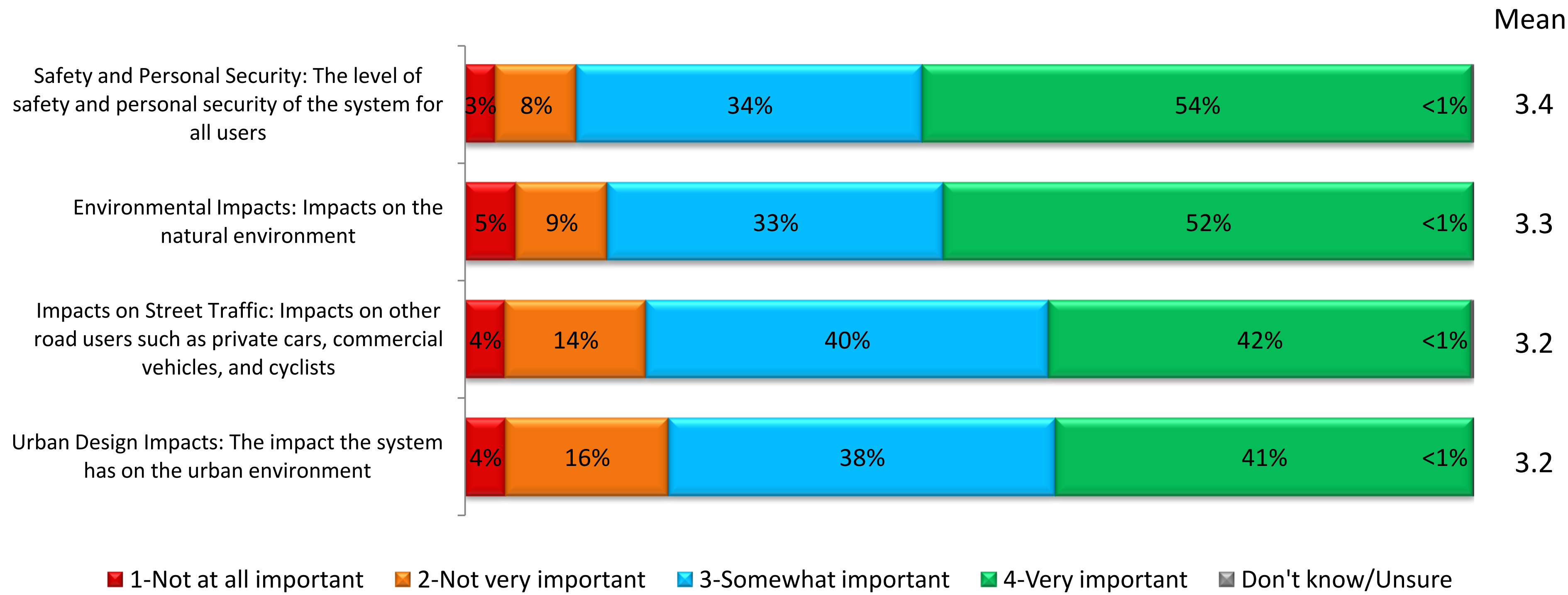


- Other important factors to consider include extent of rapid transit coverage (59% rate it as very important), followed closely by cost effectiveness (58%), ridership attracted (57%), and affordability for the region (57%).

Base: All who reside in or travel to Surrey Rapid Transit Study area

Importance of Factors Considered in Making Rapid Transit Decisions

Q1. There are a range of factors that TransLink considers when planning rapid transit projects. How important is each factor to you in making decisions about rapid transit in the Surrey Rapid Transit Study area? (n=1,034)

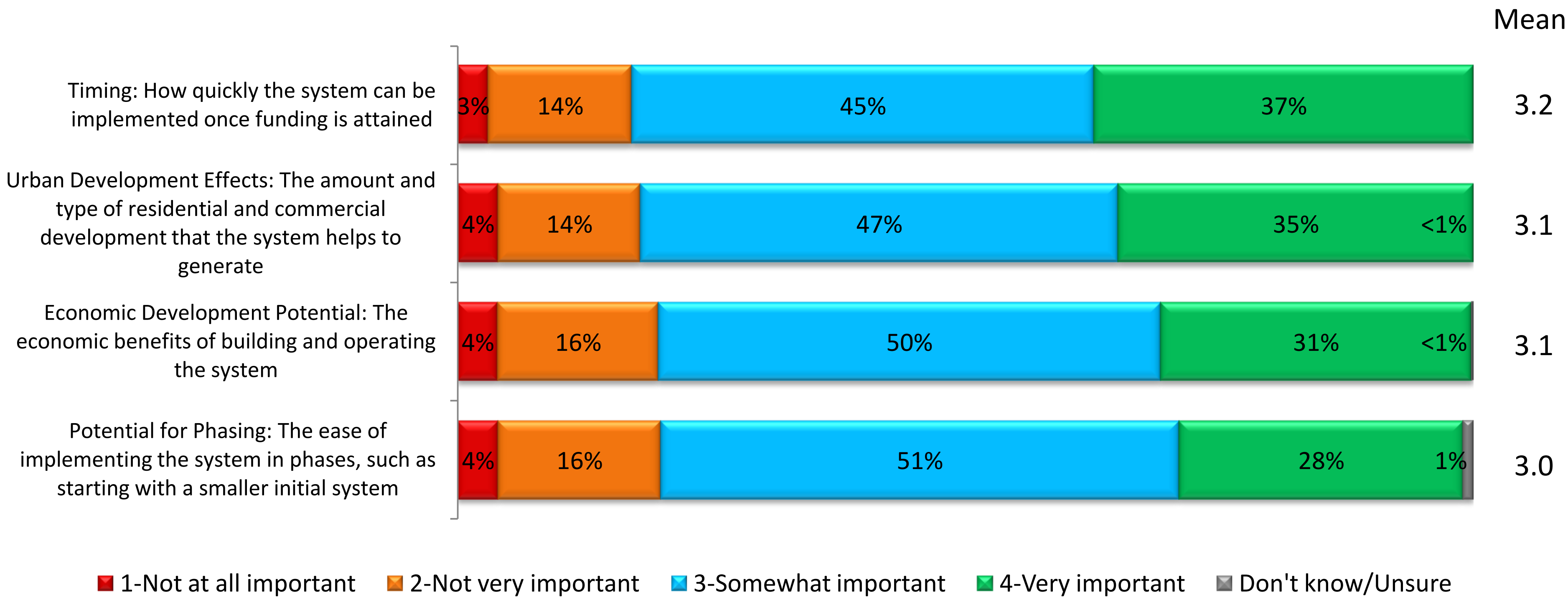


- More than one-half of those residing in or travelling to the study area consider safety and personal security (54%) and environmental impacts (52%) to be very important. Four in ten also consider impacts on street traffic (42%) and urban design impacts (41%) to be very important.

Base: All who reside in or travel to Surrey Rapid Transit Study area

Importance of Factors Considered in Making Rapid Transit Decisions

Q1. There are a range of factors that TransLink considers when planning rapid transit projects. How important is each factor to you in making decisions about rapid transit in the Surrey Rapid Transit Study area? (n=1,034)



- Rounding out the list of factors to consider when planning rapid transit projects are timing (37% rate it as very important), urban development effects (35%), economic development potential (31%), and the potential for phasing (28%).

enrg RESEARCH GROUP

Base: All who reside in or travel to Surrey Rapid Transit Study area

Results

Overall Reactions to Rapid Transit Technology Options in Study Area

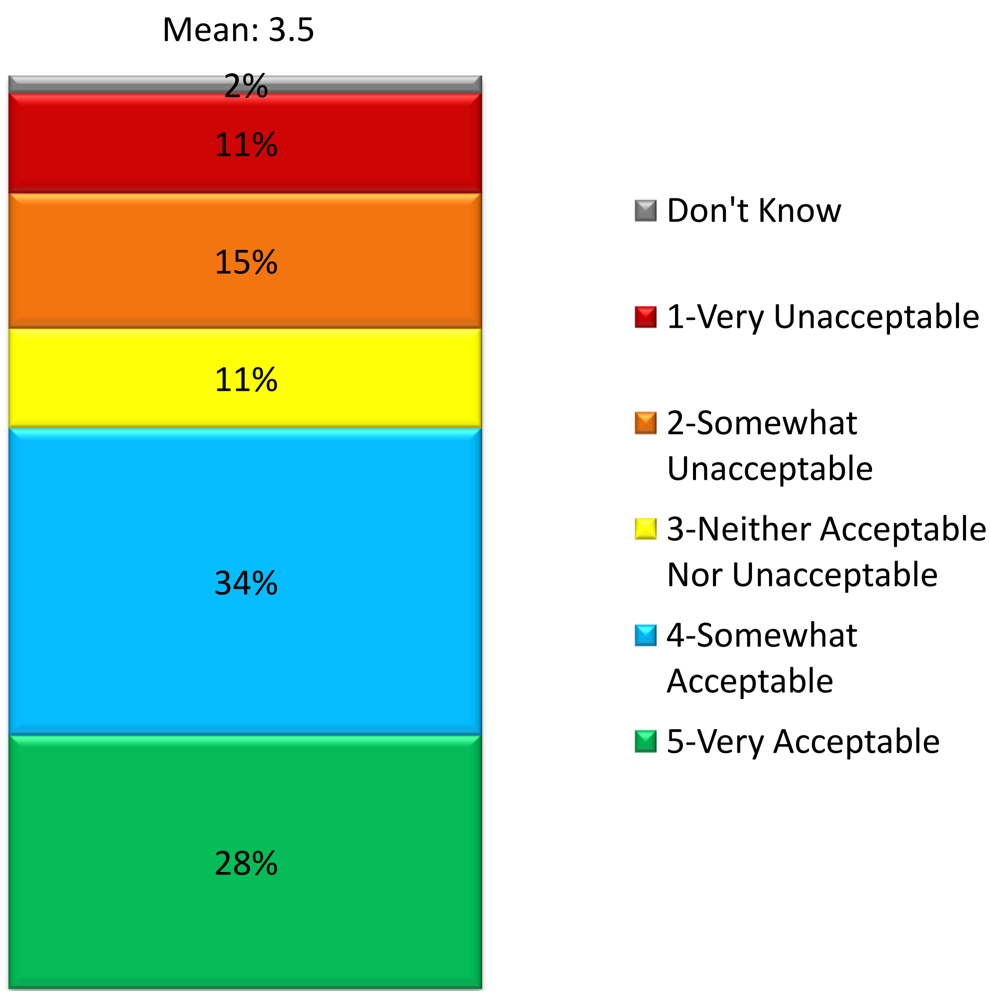
Overall Reactions to Rapid Transit Technology Options in Study Area

- All those who either reside in or have travelled to the Surrey Rapid Transit Study area in the past six months were asked to rate the acceptability of three different rapid transit technologies being considered for the Surrey Rapid Transit Study. Respondents were given a description of each of the options, including information on technology, alignment, and station type. These rapid transit technologies are:
  - Bus Rapid Transit (BRT) – a driver-operated, low-floor articulated bus technology that typically operates at street level.
  - Light Rail Transit (LRT) – a driver-operated, electrically-powered rail technology that typically operates at street level.
  - Rail Rapid Transit (SkyTrain) – an automated, driverless rail technology that is powered by electricity.
- Those who rated each rapid transit technology option as either *somewhat or very* acceptable or *somewhat or very* unacceptable were asked to provide reasons for these ratings.

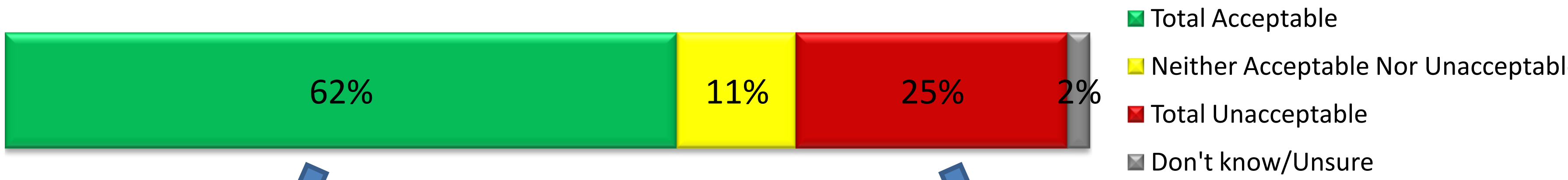
Acceptability of BRT Technology

- Though the lowest-rated of the three technologies described, BRT technology is still rated as somewhat or very acceptable by more than six in ten (28% very acceptable, and 34% somewhat acceptable).
- One in ten (11%) say that BRT technology is very unacceptable, and 15% say that it is somewhat unacceptable.
- Those under 35 years of age (36%) and males (29%) are more likely than their counterparts to find BRT unacceptable.
- There are few differences by region when it comes to the acceptability of BRT technology; that said, those in the Guildford sub-area are slightly more in favour of BRT than those in other study-sub areas (82% very or somewhat acceptable).
- As well, there are very few notable differences between groups based on familiarity with the study or the study area, or the importance placed on rapid transit expansion within the study area.

Q2a. Based on the information provided, how acceptable is BRT technology as one of the technologies considered for the Surrey Rapid Transit Study area? (n=1,034)



Base: All who reside in or travel to Surrey Rapid Transit Study area



Q2b. Why is the BRT Technology (somewhat/very) acceptable to you?	Total (n=632)
Affordability for the region (positive)	16%
Timing/ Quick to put in place (positive)	7%
Environmental impact/ Type of fuel used (negative)	7%
Impacts on street traffic (negative)	6%
Reliability (positive)	6%
Urban design impacts/ Improve look & feel of the street (positive)	5%
Extent of rapid transit coverage (positive)	5%
Impacts on street traffic (positive)	5%

Q2b. Why is the BRT Technology (somewhat/very) unacceptable to you?	Total (n=269)
Impacts on street traffic (negative)	27%
Urban design impacts/ Unattractive/ Noisy (negative)	15%
Environmental impact/ Type of fuel used (negative)	14%
Speed (negative)	13%
Capacity & expandability (negative)	7%
Difficult to use (negative)	6%
Reliability (negative)	5%

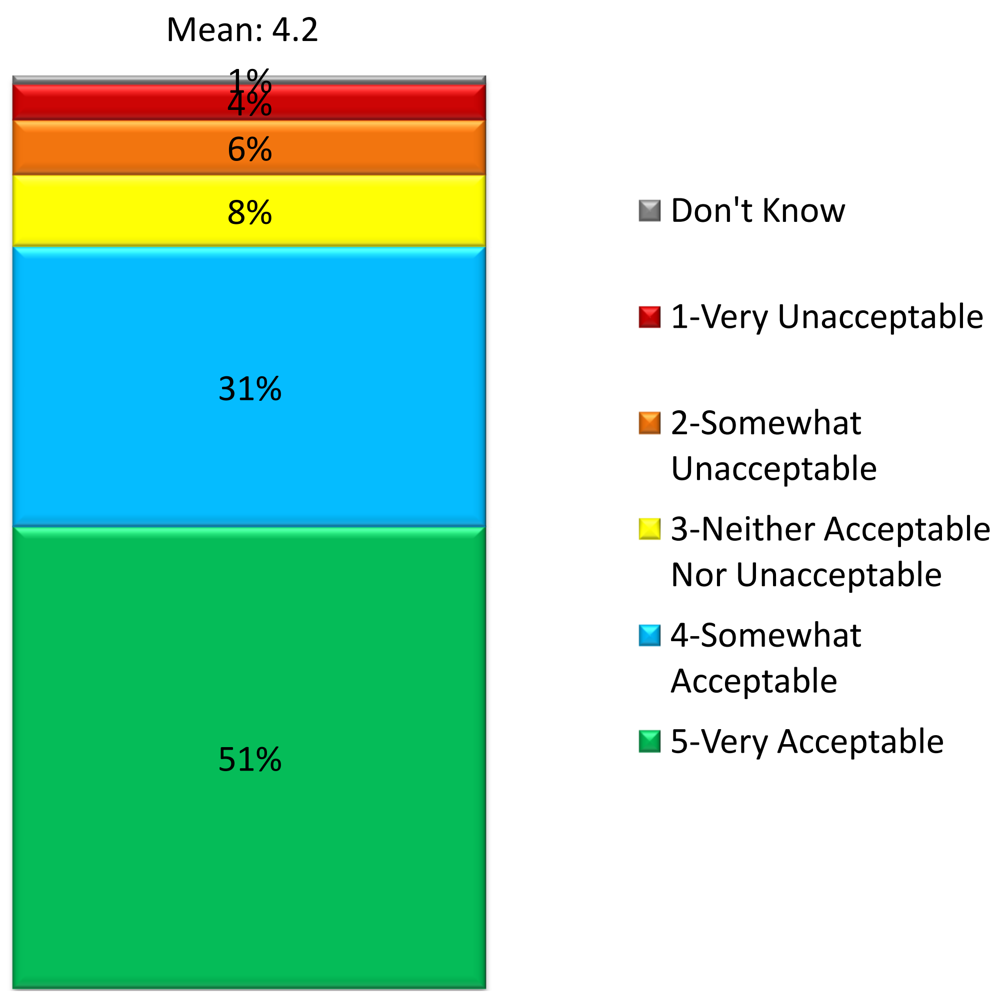
- Those who say that BRT technology is acceptable are most likely to point to its affordability as a strong feature (16%). Other reasons for supporting BRT technology include that it is quick to put in place (7%) and the type of fuel used (7%).
- Of those who find BRT technology unacceptable, more than one-quarter (27%) say that they are concerned about the impact on street traffic. Another 15% mention urban design impacts (unattractiveness or noise), 14% have a concern with the type of fuel used, and 13% indicate that it is slower than other alternatives.

Base: All who reside in or travel to Surrey Rapid Transit Study area
NOTE: Only responses mentioned by 5% or more are shown

Acceptability of LRT Technology

- The top-rated of the three technology options, LRT is considered very or somewhat acceptable by eight in ten of those who live in or travel to the Surrey Rapid Transit Study area. One-half (51%) rate LRT technology as very acceptable, and another three in ten (31%) consider it somewhat acceptable.
- Only one in ten consider LRT technology to be unacceptable (4% very unacceptable, and 6% somewhat unacceptable).
- As with BRT technology, there are few differences by region in terms of the acceptability of LRT technology. Those in the Northeast region (90%) are more likely than those in other regions (especially Burnaby/New Westminster and North Shore) to rate LRT as very or somewhat acceptable.
- There are very few notable differences between groups based on familiarity with the study or the study area. However, there is a significant difference between those who rate rapid transit expansion as important (83% very or somewhat acceptable) versus unimportant (67%) to Metro Vancouver. This is even more pronounced for those who rate rapid transit expansion as important (83%) versus unimportant (34%) to Surrey and the surrounding communities.

Q3a. Based on the information provided, how acceptable is LRT technology as one of the technologies considered for the Surrey Rapid Transit Study area? (n=1,034)



Base: All who reside in or travel to Surrey Rapid Transit Study area

Comments on LRT Technology

Q3b. Why is the LRT Technology (somewhat/very) acceptable to you?	Total (n=821)
Affordability for the region (positive)	13%
Urban design impacts/ Improves look & feel of the street (positive)	10%
Works well in other cities (positive)	8%
Environmental impact (positive)	7%
Speed (positive)	6%
Reliability (positive)	5%
Impacts on street traffic (negative)	5%

Q3b. Why is the LRT Technology (somewhat/very) unacceptable to you?	Total (n=126)
Impacts on street traffic (negative)	29%
Affordability for the region (negative)	17%
Speed (negative)	6%
Safety & personal security (negative)	6%

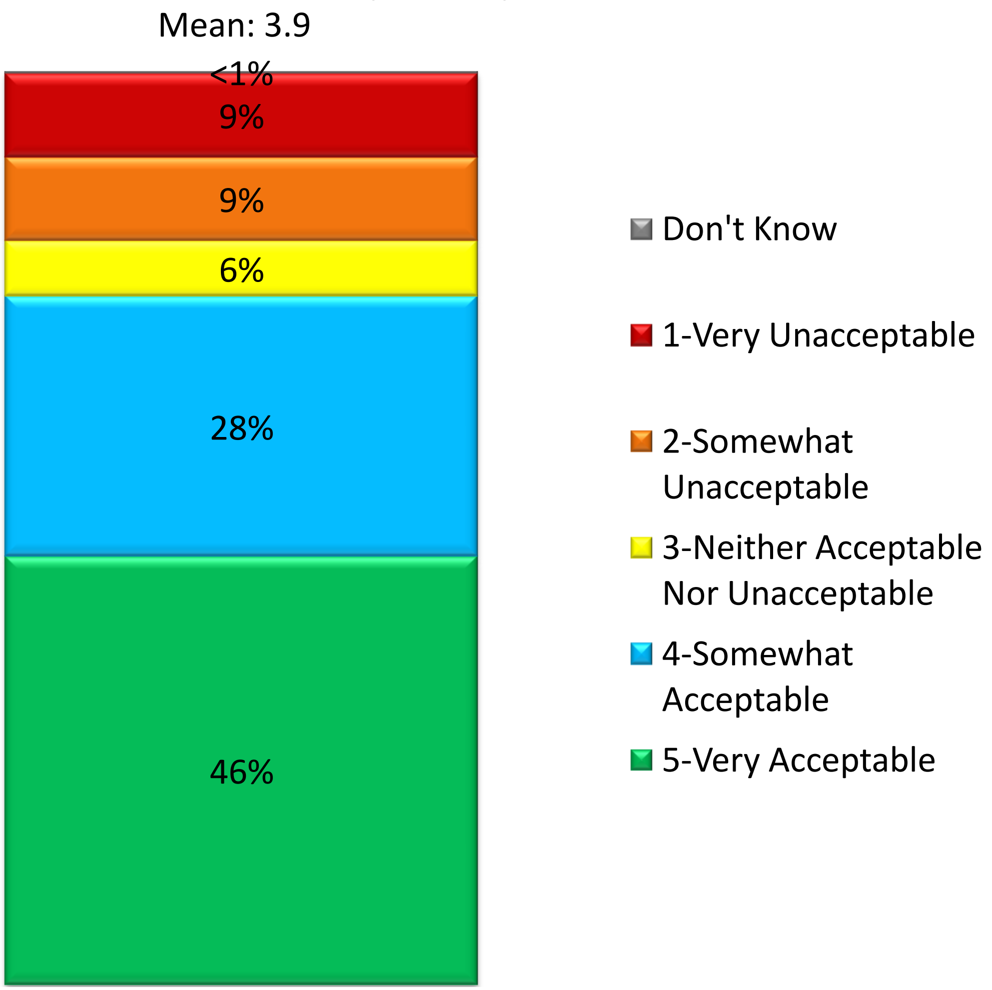
- Those who find LRT technology acceptable are most likely mention its affordability (13%) as a point in its favour. Other reasons for supporting LRT technology include improving the look and feel of the street (10%), that it works well in other cities (8%), and that it has a positive environmental impact (7%).
- Of those who find LRT technology unacceptable, nearly three in ten (29%) say that they are concerned about the impact on street traffic. Another 17% mention concerns about affordability, while 6% each mention speed and safety & personal security concerns.

Base: All who reside in or travel to Surrey Rapid Transit Study area
NOTE: Only responses mentioned by 5% or more are shown

Acceptability of SkyTrain Technology

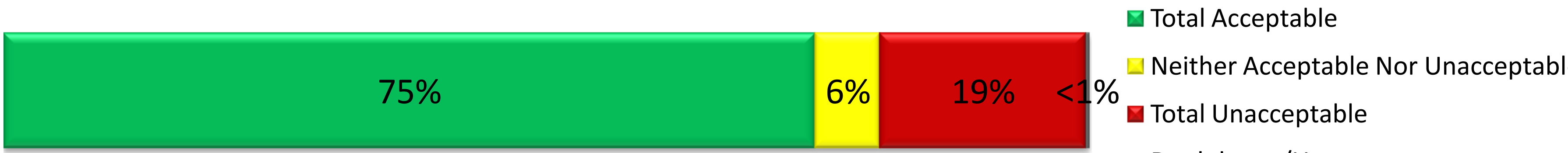
- Three-quarters of those who reside in or travel to the Surrey Rapid Transit Study area consider SkyTrain technology to be acceptable (46% very acceptable, and 28% somewhat acceptable).
- Nine percent each consider SkyTrain technology to be very or somewhat unacceptable.
- Those under 35 years of age are more likely than their older counterparts to find SkyTrain technology acceptable (87% compared with 67% of those 55+).
- There are notable differences by region in the acceptability of SkyTrain technology. Those in Burnaby/New Westminster (93%) are more likely than those in any other region to rate the technology as very or somewhat acceptable, while those in the Northeast are more hesitant (58% acceptable). Within the study area, though on small sample sizes, Surrey Central/Whalley (79%) and Fleetwood/Cloverdale (76%) show the strongest support for this technology.
- There are very few notable differences between groups based on familiarity with the study or the study area. However, there is a significant difference between those who rate rapid transit expansion as important (77% very or somewhat acceptable) versus unimportant (59%) to Metro Vancouver.

Q4a. Based on the information provided, how acceptable is SkyTrain technology as one of the technologies considered for the Surrey Rapid Transit Study area? (n=1,034)



Base: All who reside in or travel to Surrey Rapid Transit Study area

Comments on SkyTrain Technology



Q4b. Why is the SkyTrain Technology (somewhat/very) acceptable to you?	Total (n=790)
Speed (positive)	18%
Operates effectively in other parts of Metro Vancouver (positive)	17%
Affordability for the region (negative)	14%
Integration with the regional transit network (positive)	9%
Impacts on street traffic (positive)	8%
Reliability (positive)	5%

Q4b. Why is the SkyTrain Technology (somewhat/very) unacceptable to you?	Total (n=176)
Affordability for the region (negative)	48%
Urban design impacts/ Unattractive/ Noisy (negative)	13%
Cost effectiveness/ Least bang for the buck (negative)	10%
Safety & personal security (negative)	6%
Timing/ Slow to put in place (negative)	6%

- Those who support using SkyTrain technology are most likely to mention speed (18%) as a reason for finding SkyTrain acceptable. Seventeen percent say that SkyTrain currently operates effectively in other parts of Metro Vancouver, while 14% make a negative comment about affordability.
- Of those who find SkyTrain technology unacceptable, nearly one-half (48%) say that the cost of implementing the system is a factor against SkyTrain technology. Urban design impacts (13%) and modest "bang for the buck" (10%) are other commonly mentioned concerns about SkyTrain technology.

Base: All who reside in or travel to Surrey Rapid Transit Study area
NOTE: Only responses mentioned by 5% or more are shown

Results

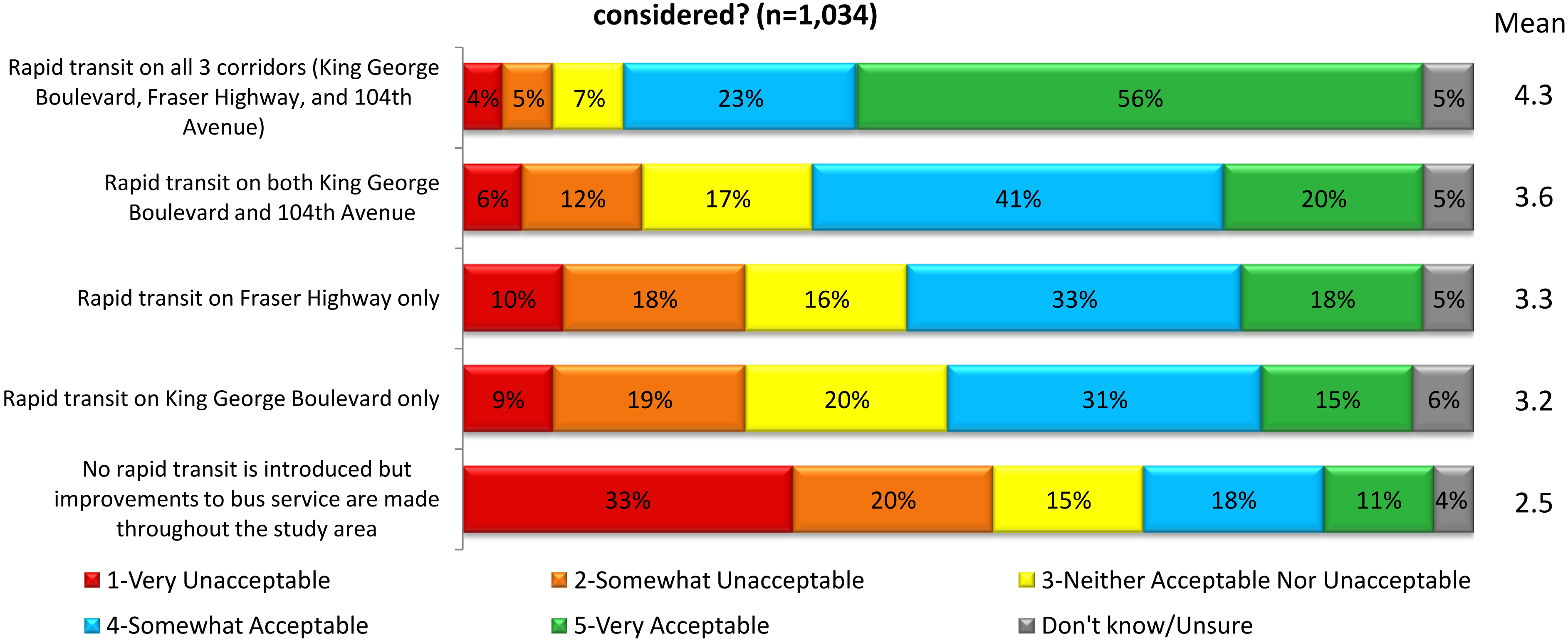
Reactions to Specific Rapid Transit Expansion Options

Reactions to Specific Rapid Transit Expansion Options

- All those who either reside in or have travelled to the Surrey Rapid Transit Study area in the past six months were asked to rate the acceptability of various corridor combinations involving the King George Boulevard, Fraser Highway, and 104th Avenue Corridors.
- Following this, respondents were shown a table summarizing the travel times, capital costs, new boardings, and impact on existing road capacity for the alternatives being considered for each corridor. They were then asked about the acceptability of those specific alternatives for each of the corridors being considered for the study based on the information provided in the table for that corridor.
- After rating the acceptability of each alternative for a given corridor, respondents were asked to choose the *most* acceptable and *least* acceptable option for that corridor. Finally, respondents were asked to provide reasons why they chose their most and least acceptable options.

Acceptability of Corridor Options Being Considered

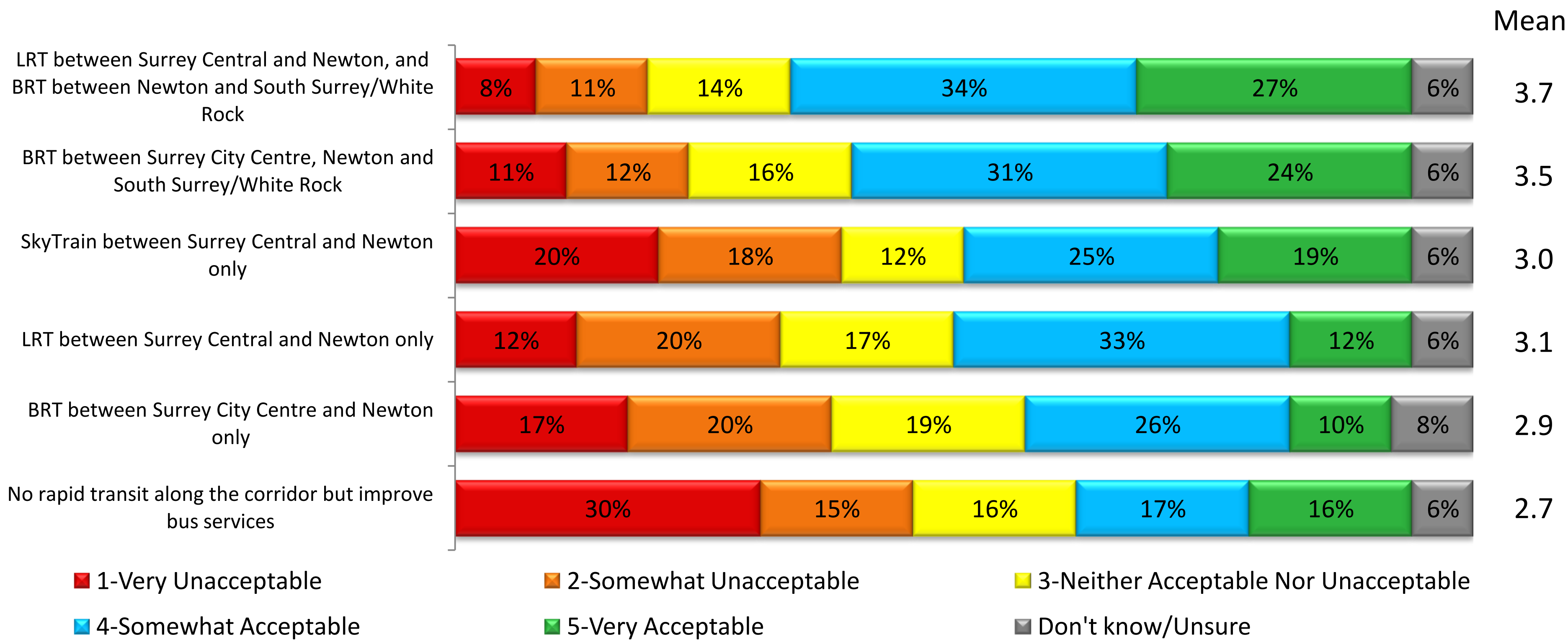
Q5. Now, based on the information provided about each of the three transportation corridors, how acceptable to you is each of the following corridor options that are being considered? (n=1,034)



- In general, those residing in or travelling to the study area are in favour of rapid transit being considered for all three corridors of interest (56% find this idea very acceptable, and another 23% find the idea somewhat acceptable). The least acceptable option is not to introduce rapid transit to any of the three corridors, but rather to make improvements to bus service throughout the study area (11% find the idea very acceptable, and 18% find it somewhat acceptable; on the other hand, 33% find it very unacceptable).
- Those aged 16-34 are particularly likely to support rapid transit on all three corridors (85% find this option very or somewhat acceptable), as are transit users (85%).
- Those in Langley City and Township rate expansion on only the Fraser Highway corridor more acceptable than those in Surrey, North Delta, or White Rock. Those in Surrey, North Delta, and particularly White Rock are more likely to consider the option to expand only the King George Boulevard acceptable than those in Langley City or Township.

Base: All who reside in or travel to Surrey Rapid Transit Study area

Q6. How acceptable to you is each of the alternatives for the King George Boulevard Corridor? (n=1,034)

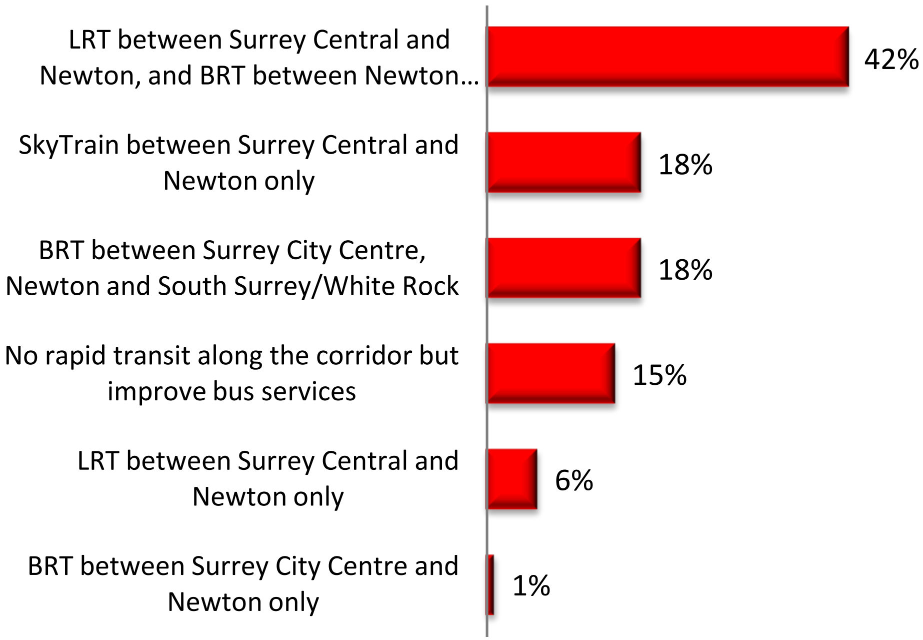


- Of the six options presented for the King George Boulevard corridor, the split LRT/BRT option connecting Surrey Central with Newton and South Surrey/White Rock is deemed the most acceptable (27% very and 34% somewhat). On the other hand, the least acceptable option is not introducing any rapid transit along the corridor (16% very acceptable, and 17% somewhat). The SkyTrain option garners the most divided reactions of all of the alternatives.
- Those aged 16-34 (70%) and transit users (64%) are particularly likely to find the split LRT/BRT option very or somewhat acceptable.
- Not surprisingly, residents of various study sub-areas are likely to rate options providing service to their area as more acceptable. For instance, those in South Surrey/White Rock are particularly likely to rate the LRT/BRT option (67%) and the BRT extending from Surrey City Centre through to South Surrey/White Rock (76%) as very or somewhat acceptable.

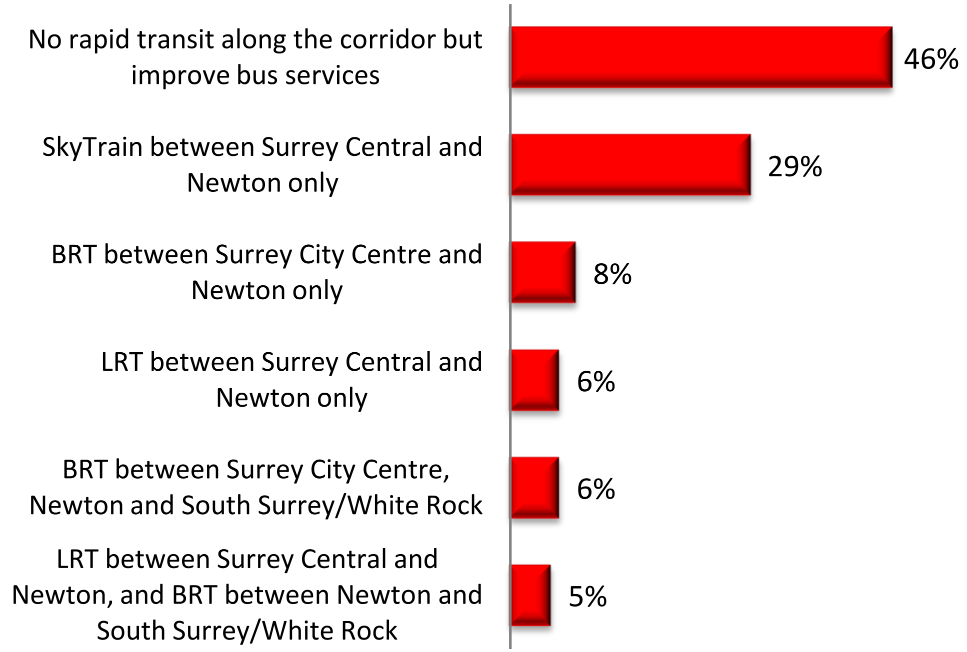
Base: All who reside in or travel to Surrey Rapid Transit Study area

Most/Least Acceptable Alternatives for King George Boulevard Corridor

Q7a. Which of the alternatives is the most acceptable to you? (n=1,034)



Q7a. Which of the alternatives is the least acceptable to you? (n=1,034)



- As with acceptability ratings, the split LRT/BRT option connecting Surrey Central with Newton and South Surrey/White Rock is considered the most acceptable (with 42% choosing this as the most acceptable option of the six presented).
- The option to improve bus services instead of adding rapid transit is considered the least acceptable alternative by 46%.
- Women (49%) and those whose main mode of transportation is rideshare (47%) are among the most likely to support the LRT/BRT option. Those who typically travel by SOV are more likely than those who use rideshare or transit to consider the SkyTrain option least acceptable (33%, compared with 23% and 24% respectively).
- Residents of the South of Fraser (44%) and Northeast (49%) are among the most likely to select the LRT/BRT option as most acceptable; those in White Rock (61%) are also particularly in favour of this option (though on a small sample size).

BRT between Surrey Central and Newton

Q7b. Why is BRT between Surrey Central and Newton only the most acceptable alternative for the King George Boulevard Corridor?	Total (n=19*)
Affordability for the region (positive)	46%
Cost effectiveness/ Bang for the buck (positive)	12%
Potential for phasing/ Easy to do in stages (positive)	9%
Ridership attracted (positive)	9%
Environmental impact (positive)	6%

Q7c. Why is BRT between Surrey Central and Newton only the least acceptable alternative for the King George Boulevard Corridor?	Total (n=89)
Extent of rapid transit coverage (negative)	12%
Dislike buses (negative)	11%
Ridership attracted (negative)	10%
Impacts on street traffic (negative)	9%
Speed (negative)	7%
Cost effectiveness/ Least bang for the buck (negative)	5%
Capacity & expandability (negative)	5%

- BRT between Surrey Central and Newton is selected as the most acceptable by 1% and the least acceptable by 8%; 91% do not consider this option to be the most or the least acceptable.
- Reasons for supporting this option include affordability (46%) and cost effectiveness (12%). Reasons for not supporting this option include the limited extent of rapid transit coverage (12%) and a general dislike of buses (11%).

Base: All who reside in or travel to Surrey Rapid Transit Study area
NOTE: Only responses mentioned by 5% or more are shown
*Caution: small sample size

BRT between Surrey Central, Newton, and South Surrey/White Rock

Q7b. Why is BRT between Surrey Central, Newton, and South Surrey/White Rock the most acceptable alternative for the King George Boulevard Corridor?	Total (n=207)
Cost effectiveness/ Bang for the buck (positive)	36%
Ridership attracted (positive)	22%
Extent of rapid transit coverage (positive)	20%
It covers White Rock (positive)	15%
Affordability for the region (positive)	15%
Speed (positive)	12%
Fewer transfers required (positive)	10%
Timing/ Quick to put in place (positive)	7%

Q7c. Why is BRT between Surrey Central, Newton, and South Surrey/White Rock the least acceptable alternative for the King George Boulevard Corridor?	Total (n=52)
Speed (negative)	17%
Timing/ Slow to put in place (negative)	14%
Ridership attracted (negative)	8%
Environmental impact/ Type of fuel used (negative)	7%
Impacts on street traffic (negative)	7%
Cost effectiveness/ Least bang for the buck (negative)	5%
Affordability for the region (negative)	5%

- BRT between Surrey Central, Newton, and South Surrey/White Rock is selected as the most acceptable by 18% and the least acceptable by 6%; 76% do not consider this option to be the most or the least acceptable.
- Reasons for supporting this option include cost effectiveness (36%), ridership attracted (22%), and the extent of rapid transit coverage (20%, with another 15% specifically mentioning the coverage of White Rock). Reasons for not supporting this option include the lower speed of BRT compared with SkyTrain (17%) and a perceived slowness to be put in place (14%).

Base: All who reside in or travel to Surrey Rapid Transit Study area
NOTE: Only responses mentioned by 5% or more are shown

LRT between Surrey Central and Newton

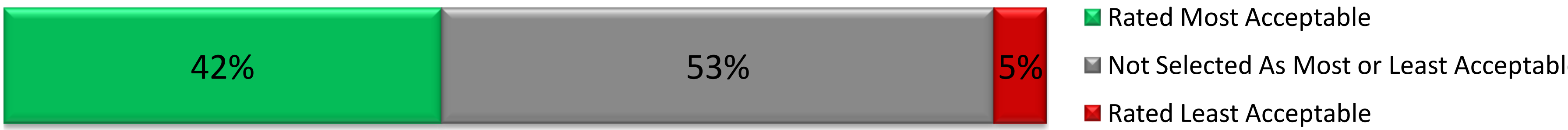
Q7b. Why is LRT, between Surrey Central and Newton only, the most acceptable alternative for the King George Boulevard Corridor?	Total (n=39*)
Impacts on street traffic (positive)	28%
Affordability for the region (positive)	26%
Cost effectiveness/ Bang for the buck (positive)	22%
Speed (positive)	16%
Reliability (positive)	13%
Ridership attracted (positive)	6%
Environmental impact (positive)	5%

Q7c. Why is LRT, between Surrey Central and Newton only, the least acceptable alternative for the King George Boulevard Corridor?	Total (n=80)
Extent of rapid transit coverage (negative)	29%
Affordability for the region (negative)	28%
Cost effectiveness/ Least bang for the buck (negative)	17%
Speed (negative)	7%
Ridership attracted (negative)	7%
Impacts on street traffic (negative)	5%
Potential for phasing/ Difficult to do in phases (negative)	5%

- LRT between Surrey Central and Newton is selected as the most acceptable by 6% and the least acceptable by 6%; 88% do not consider this option to be the most or the least acceptable.
- Reasons for supporting this option include impacts on street traffic (28%) and affordability (26%). Reasons for not supporting this option include the limited extent of rapid transit coverage (29%) and affordability (28%).

Base: All who reside in or travel to Surrey Rapid Transit Study area
NOTE: Only responses mentioned by 5% or more are shown
*Caution: small sample size

LRT between Surrey Central and Newton, & BRT to South Surrey/White Rock



Q7b. Why is LRT between Surrey Central and Newton, and BRT between Newton and South Surrey/White Rock the most acceptable alternative for the King George Boulevard Corridor?	Total (n=414)
Extent of rapid transit coverage (positive)	18%
Cost effectiveness/ Bang for the buck (positive)	17%
Affordability for the region (positive)	16%
Ridership attracted (positive)	10%
Speed (positive)	10%
Capacity & expandability (positive)	8%
Impacts on street traffic (positive)	7%
Reliability (positive)	5%

Q7c. Why is LRT between Surrey Central and Newton, and BRT between Newton and South Surrey/White Rock the least acceptable alternative for the King George Boulevard Corridor?	Total (n=62)
Affordability for the region (negative)	37%
Cost effectiveness/ Least bang for the buck (negative)	19%
Involves extra transfers (negative)	16%
Speed (negative)	11%
Ridership attracted (negative)	7%
Impacts on street traffic (negative)	6%
Urban design impacts/ Unattractive/ Noisy (negative)	6%

- LRT between Surrey Central and Newton along with BRT from Newton to South Surrey/White Rock is selected as the most acceptable by 42% and the least acceptable by 5%; 53% do not consider this option to be the most or the least acceptable.
- Reasons for supporting this option include the extent of rapid transit coverage (18%), and cost effectiveness (17%), and affordability (16%). Reasons for not supporting this option include affordability (37%), cost effectiveness (19%), and the need for additional transfers (16%).

Base: All who reside in or travel to Surrey Rapid Transit Study area
NOTE: Only responses mentioned by 5% or more are shown

SkyTrain between Surrey Central and Newton

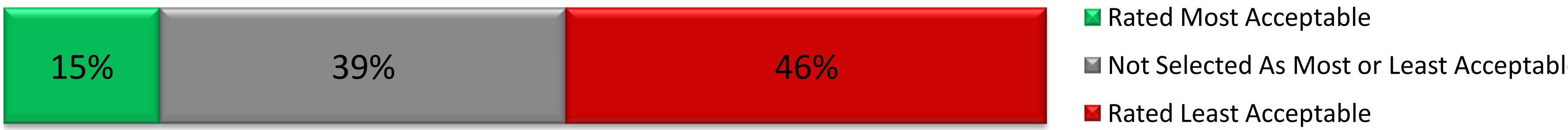
Q7b. Why is SkyTrain between Surrey Central and Newton only the most acceptable alternative for the King George Boulevard Corridor?	Total (n=221)
Ridership attracted (positive)	32%
Impacts on street traffic (positive)	16%
Speed (positive)	15%
Capacity & expandability (positive)	15%
Integration with the regional transit network (positive)	12%
Reliability (positive)	6%
Environmental impact (positive)	6%
Extent of rapid transit coverage (positive)	6%
Cost effectiveness/ Bang for the buck (positive)	6%
Urban design impacts/ Improve look & feel of the street (positive)	5%

Q7c. Why is SkyTrain between Surrey Central and Newton only the least acceptable alternative for the King George Boulevard Corridor?	Total (n=283)
Affordability for the region (negative)	55%
Cost effectiveness/ Least bang for the buck (negative)	19%
Extent of rapid transit coverage (negative)	12%
Timing/ Slow to put in place (negative)	6%

- SkyTrain between Surrey Central and Newton is selected as the most acceptable by 18% and the least acceptable by 29%; 53% do not consider this option to be the most or the least acceptable.
- Reasons for supporting this option include ridership attracted (32%), impacts on street traffic (16%), speed (15%), and capacity & expandability (15%). Reasons for not supporting this option include the affordability (55%) and a cost effectiveness (19%).

Base: All who reside in or travel to Surrey Rapid Transit Study area
NOTE: Only responses mentioned by 5% or more are shown

No Rapid Transit Along King George Boulevard Corridor



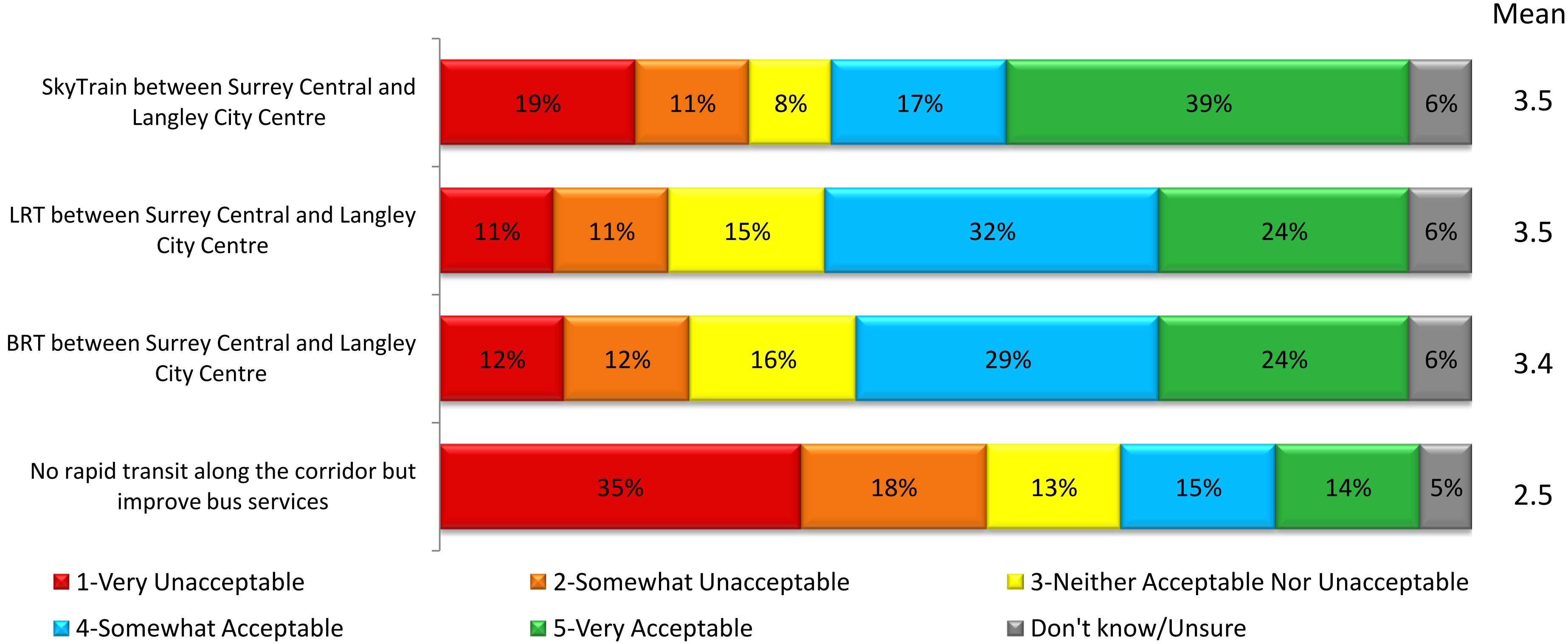
Q7b. Why is no rapid transit along the corridor, but improve bus services with B-Line and Express Buses and transit priority measures the most acceptable alternative for the King George Boulevard Corridor?	Total (n=133)
Cost effectiveness/ Bang for the buck (positive)	38%
Affordability for the region (positive)	26%
Ridership attracted (positive)	10%
Integration with the regional transit network (positive)	7%
Impacts on street traffic (positive)	5%

Q7c. Why is no rapid transit along the corridor, but improve bus services with B-Line and Express Buses and transit priority measures the least acceptable alternative for the King George Boulevard Corridor?	Total (n=467)
Impacts on street traffic (negative)	37%
Speed (negative)	12%
Reliability (negative)	12%
Ridership attracted (negative)	9%
Capacity & expandability (negative)	8%
Potential for phasing/ Difficult to do in stages (negative)	6%
Affordability for the region (negative)	5%

- No rapid transit along the corridor is selected as the most acceptable by 15% and the least acceptable by 46%; 39% do not consider this option to be the most or the least acceptable.
- Reasons for supporting this option include cost effectiveness (38%) and affordability (26%). Reasons for not supporting this option include impact on street traffic (37%), speed (12%), and reliability (12%).

Base: All who reside in or travel to Surrey Rapid Transit Study area
NOTE: Only responses mentioned by 5% or more are shown

Q8. How acceptable to you is each of the alternatives for the Fraser Highway Corridor? (n=1,034)

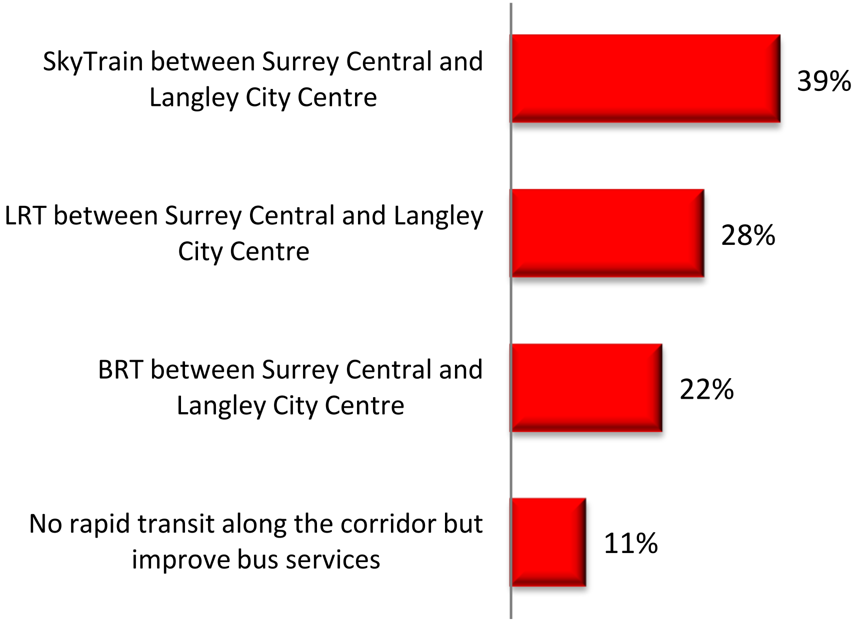


- Among the alternatives for the Fraser Highway Corridor, SkyTrain between Surrey Central and Langley City Centre garners the highest acceptability ratings (39% very acceptable and 17% somewhat acceptable), while no rapid transit along the corridor has the lowest acceptability ratings (14% very and 15% somewhat).
- Those under 35 years of age (71%) and transit users (63%) are among the most likely to support the SkyTrain option for the Fraser Highway corridor.
- Not surprisingly, residents of study sub-areas most impacted by the Fraser Highway Corridor are less likely to rate no rapid transit as being acceptable than other areas (for instance, 3% rate this option very or somewhat acceptable in the Langley City Centre sub-area, compared with 29% overall).

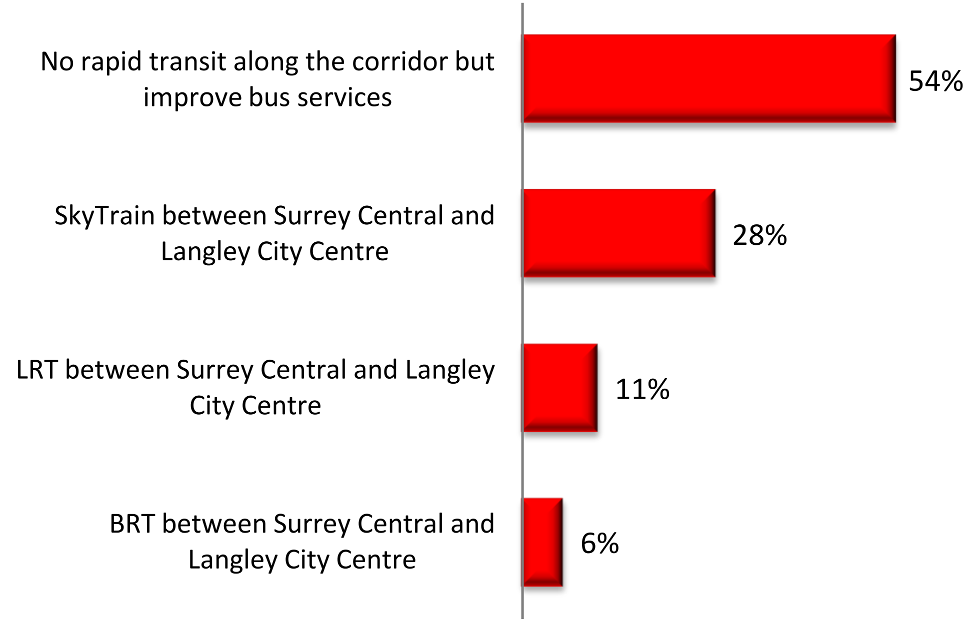
Base: All who reside in or travel to Surrey Rapid Transit Study area

Most/Least Acceptable Alternatives for Fraser Highway Corridor

Q9a. Which of the alternatives is the most acceptable to you? (n=1,034)



Q9a. Which of the alternatives is the least acceptable to you? (n=1,034)



- As with acceptability ratings, SkyTrain connecting Surrey Central with Langley City Centre is considered the most acceptable (with 39% choosing this as the most acceptable option of the four presented).
- The option to improve bus services instead of adding rapid transit is considered the least acceptable alternative by 54%.
- Those under 35 years of age are particularly likely to choose the SkyTrain option as the most acceptable (49%) and “no rapid transit” option as the least acceptable (68%).
- Residents of the Northeast (23%) are notably the least likely among all regions to choose Skytrain as the most acceptable. Those in Surrey City Centre/Whalley, on the other hand, are particularly in favour of this option (56% acceptable, though on a small sample size). Those in the Langley City Centre sub-area are more likely to choose LRT as the most acceptable option (47%, again on a small sample size).

Base: All who reside in or travel to Surrey Rapid Transit Study area

BRT between Surrey Central and Langley City Centre

Q9b. Why is BRT between Surrey Central and Langley City Centre the most acceptable alternative for the Fraser Highway Corridor?	Total (n=210)
Affordability for the region (positive)	42%
Cost effectiveness/ Bang for the buck (positive)	39%
Ridership attracted (positive)	23%
Speed (positive)	21%
Capacity & expandability (positive)	7%
Reliability (positive)	5%

Q9c. Why is BRT between Surrey Central and Langley City Centre the least acceptable alternative for the Fraser Highway Corridor?	Total (n=66)
Impacts on street traffic (negative)	26%
Urban design impacts/ Unattractive/ Noisy (negative)	15%
Affordability for the region (negative)	14%
Speed (negative)	10%
Ridership attracted (negative)	9%
Extent of rapid transit coverage (negative)	5%

- BRT between Surrey Central and Langley City Centre is selected as the most acceptable by 22% and the least acceptable by 6%; 72% do not consider this option to be the most or the least acceptable.
- Reasons for supporting this option include affordability (42%) and cost effectiveness (39%). Reasons for not supporting this option include the impact on street traffic (26%) and urban design impacts such as unattractiveness and noise (15%).

Base: All who reside in or travel to Surrey Rapid Transit Study area
NOTE: Only responses mentioned by 5% or more are shown

LRT between Surrey Central and Langley City Centre

Q9b. Why is LRT between Surrey Central and Langley City Centre the most acceptable alternative for the Fraser Highway Corridor?	Total (n=254)
Cost effectiveness/ Bang for the buck (positive)	26%
Ridership attracted (positive)	16%
Speed (positive)	15%
Impacts on street traffic (positive)	14%
Urban design impacts/ Improve look & feel of the street (positive)	11%
Affordability for the region (positive)	11%
Capacity and expandability (positive)	10%
Extent of rapid transit coverage (positive)	7%
Reliability (positive)	7%

Q9c. Why is LRT between Surrey Central and Langley City Centre the least acceptable alternative for the Fraser Highway Corridor?	Total (n=110)
Affordability for the region (negative)	35%
Ridership attracted (negative)	21%
Cost effectiveness/ Least bang for the buck (negative)	20%
Speed (negative)	18%
Impacts on street traffic (negative)	6%
Extent of rapid transit coverage (negative)	6%
Urban design impacts/ Unattractive/ Noisy (negative)	5%

- LRT between Surrey Central and Langley City Centre is selected as the most acceptable by 28% and the least acceptable by 11%; 61% do not consider this option to be the most or the least acceptable.
- Reasons for supporting this option include cost effectiveness (26%), ridership attracted (16%), and speed (15%). Reasons for not supporting this option include affordability (35%), ridership attracted (21%), and cost effectiveness (20%).

Base: All who reside in or travel to Surrey Rapid Transit Study area
NOTE: Only responses mentioned by 5% or more are shown

SkyTrain between Surrey Central and Langley City Centre

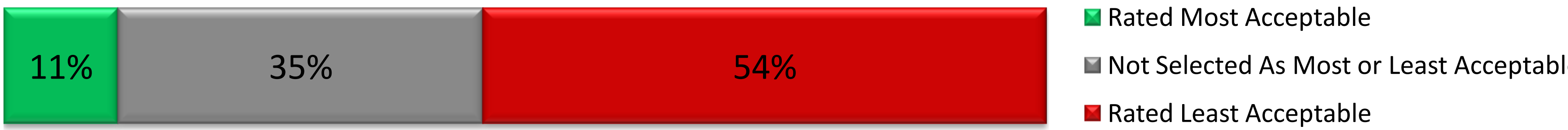
Q9b. Why is SkyTrain between Surrey Central and Langley City Centre the most acceptable alternative for the Fraser Highway Corridor?	Total (n=469)
Speed (positive)	36%
Ridership attracted (positive)	27%
Impacts on street traffic (positive)	19%
Integration with the regional transit network (positive)	14%
Extent of rapid transit coverage (positive)	12%
Urban design impacts/ Improve look & feel of street (positive)	12%
Capacity & expandability (positive)	11%
Reliability (positive)	7%
Cost effectiveness/ Bang for the buck (positive)	6%

Q9c. Why is SkyTrain between Surrey Central and Langley City Centre the least acceptable alternative for the Fraser Highway Corridor?	Total (n=255)
Affordability for the region (negative)	62%
Cost effectiveness/ Least bang for the buck (negative)	24%
Capacity & expandability (negative)	11%
Urban design impacts/ Unattractive/ Noisy (negative)	9%
Ridership attracted (negative)	8%
Extent of rapid transit coverage (negative)	6%

- SkyTrain between Surrey Central and Langley City Centre is selected as the most acceptable by 39% and the least acceptable by 28%; 33% do not consider this option to be the most or the least acceptable.
- Reasons for supporting this option include speed (36%) and ridership attracted (27%). Reasons for not supporting this option centre on affordability (62%) and cost effectiveness (24%).

Base: All who reside in or travel to Surrey Rapid Transit Study area
NOTE: Only responses mentioned by 5% or more are shown

No Rapid Transit Along Fraser Highway Corridor



Q9b. Why is no rapid transit along the corridor, but improve bus services with B-Line and Express Buses and transit priority measures the most acceptable alternative for the Fraser Highway Corridor?	Total (n=100)
Cost effectiveness/ Bang for the buck (positive)	36%
Affordability for the region (positive)	33%
Capacity & expandability (positive)	13%
Extent of rapid transit coverage (positive)	10%
Economic development potential/ Job creation (positive)	8%
Urban design impacts/ Improve look & feel of the street (positive)	8%

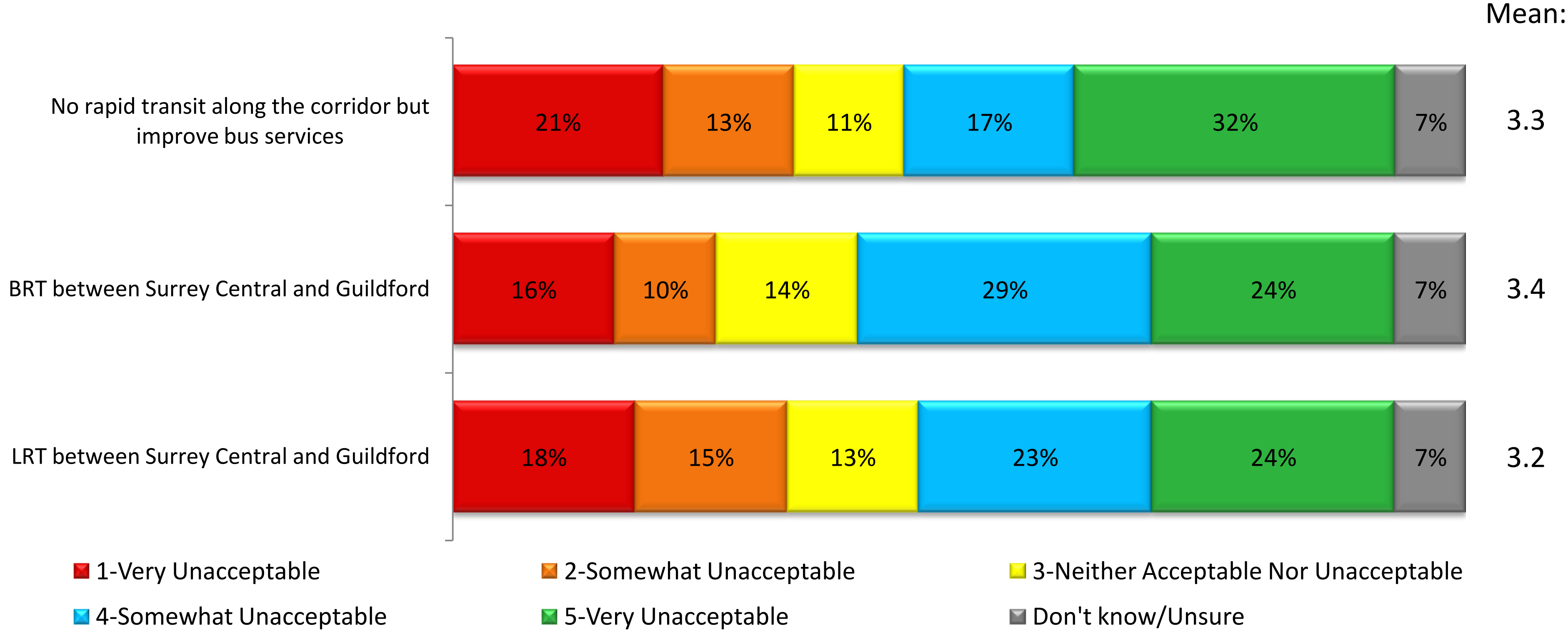
Q9c. Why is no rapid transit along the corridor, but improve bus services with B-Line and Express Buses and transit priority measures the least acceptable alternative for the Fraser Highway Corridor?	Total (n=602)
Impacts on street traffic (negative)	29%
Speed (negative)	15%
Extent of rapid transit coverage (negative)	12%
Capacity & expandability (negative)	10%
Ridership attracted (negative)	9%
Reliability (negative)	6%

- No rapid transit in the Fraser Highway corridor is selected as the most acceptable by 11% and the least acceptable by 54%; 35% do not consider this option to be the most or the least acceptable.
- Reasons for supporting this option include cost effectiveness (36%) and affordability (33%). Reasons for not supporting this option include impacts on street traffic (29%), speed (15%), and poor extent of rapid transit coverage (12%).

Base: All who reside in or travel to Surrey Rapid Transit Study area
NOTE: Only responses mentioned by 5% or more are shown

Acceptability of Alternatives for 104th Avenue Corridor

Q10. How acceptable to you is each of the alternatives for the 104th Avenue Corridor? (n=1,034)



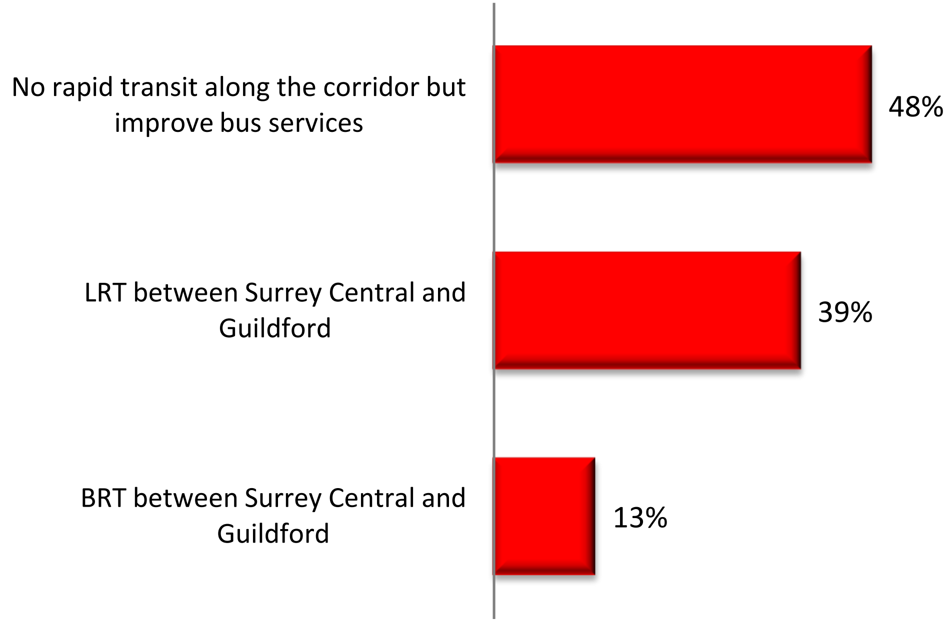
- Unlike in the other two corridors, the option that garners the most "very acceptable" ratings is no rapid transit along the corridor (32% very acceptable). That said, there is no clear winner in this corridor, as the total acceptability scores are quite similar for the three options presented.
- Users of transit as their main mode of transportation are more likely to find the BRT (59%) and LRT (52%) options very or somewhat acceptable than are users of other transportation modes.
- There are few differences in acceptability ratings by region or sub-area. Those in Surrey (60%) are slightly more likely than those in other municipalities to rate no rapid transit expansion as acceptable. Meanwhile, those in Guildford (56%) and South Surrey/White Rock (52%) are slightly more likely than other sub-areas to rate BRT as acceptable.

Base: All who reside in or travel to Surrey Rapid Transit Study area

Most/Least Acceptable Alternatives for 104th Avenue Corridor

Q11a. Which of the alternatives is the most acceptable to you? (n=1,033)

Q11a. Which of the alternatives is the least acceptable to you? (n=1,033)



- Interestingly, the polarizing "no rapid transit" option for the 104th Avenue corridor is both the most and the least acceptable of the three alternatives presented; more people choose this option as the least acceptable than as the most acceptable.
- Of the three options, only BRT has a net positive "acceptable" score, with 29% choosing this as the most acceptable and 13% choosing it as the least acceptable.
- Those 55 years of age and older are slightly more likely than their younger counterparts to choose "no rapid transit" as the most acceptable alternative.
- There are again few differences in most and least acceptable choices by region or sub-area. Those in Surrey are slightly more likely than those in other municipalities to choose no rapid transit as the most acceptable option (54%), whereas those in North Delta are more likely to choose BRT as the most acceptable alternative (45%).

Base: All who reside in or travel to Surrey Rapid Transit Study area

BRT between Surrey Central and Guildford

Q11b. Why is BRT between Surrey Central and Guildford the most acceptable alternative for the 104th Avenue Corridor?	Total (n=290)
Cost effectiveness/ Bang for the buck (positive)	40%
Ridership attracted (positive)	24%
Affordability for the region (positive)	11%
Extent of rapid transit coverage (positive)	11%
Timing/ Quick to put in place (positive)	10%
Speed (positive)	8%
Impacts on street traffic (positive)	7%

Q11c. Why is BRT between Surrey Central and Guildford the least acceptable alternative for the 104th Avenue Corridor?	Total (n=132)
Impacts on street traffic (negative)	24%
Affordability for the region (negative)	16%
Cost effectiveness/ Least bang for the buck (negative)	8%
Extent of rapid transit coverage (negative)	7%
Urban design impacts/ Unattractive/ Noisy (negative)	5%

- BRT between Surrey Central and Guildford is selected as the most acceptable by 29% and the least acceptable by 13%; 58% do not consider this option to be the most or the least acceptable.
- Reasons for supporting this option include cost effectiveness (40%) and ridership attracted (24%). Reasons for not supporting this option include the impact on street traffic (24%) and affordability (16%).

Base: All who reside in or travel to Surrey Rapid Transit Study area
NOTE: Only responses mentioned by 5% or more are shown

LRT between Surrey Central and Guildford

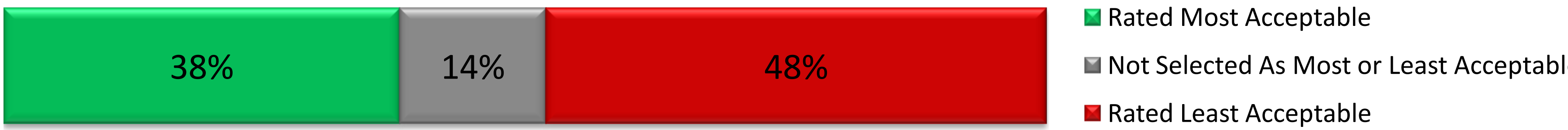
Q11b. Why is LRT between Surrey Central and Guildford the most acceptable alternative for the 104th Avenue Corridor?	Total (n=358)
Speed (positive)	16%
Capacity & expandability (positive)	9%
Reliability (positive)	9%
Extent of rapid transit coverage (positive)	8%
Impacts on street traffic (positive)	8%
Environmental impact (positive)	7%
Cost effectiveness/ Bang for the buck (positive)	7%
Ridership attracted (positive)	7%
Affordability for the region (positive)	5%

Q11c. Why is LRT between Surrey Central and Guildford the least acceptable alternative for the 104th Avenue Corridor?	Total (n=413)
Affordability for the region (negative)	43%
Cost effectiveness/ Least bang for the buck (negative)	25%
Impacts on street traffic (negative)	19%
Extent of rapid transit coverage (negative)	16%
Urban design impacts/ Unattractive/ Noisy (negative)	6%

- LRT between Surrey Central and Guildford is selected as the most acceptable by 33% and the least acceptable by 39%; 28% do not consider this option to be the most or the least acceptable.
- Reasons for supporting this option include speed (16%), capacity & expandability (9%), and reliability (9%). Reasons for not supporting this option include affordability (43%) and cost effectiveness (25%).

Base: All who reside in or travel to Surrey Rapid Transit Study area
NOTE: Only responses mentioned by 5% or more are shown

No Rapid Transit Along 104th Avenue Corridor



Q11b. Why is no rapid transit along the corridor, but improve bus services with B-Line and Express Buses and transit priority measures the most acceptable alternative for the 104th Avenue Corridor?	Total (n=385)
Impacts on street traffic (positive)	24%
Cost effectiveness/ Bang for the buck (positive)	24%
Extent of rapid transit coverage (positive)	23%
Affordability for the region (positive)	18%
Urban design impacts/ Improve look & feel of the street (positive)	6%
Capacity & expandability (positive)	5%

Q11c. Why is no rapid transit along the corridor, but improve bus services with B-Line and Express Buses and transit priority measures the least acceptable alternative for the 104th Avenue Corridor?	Total (n=488)
Impacts on street traffic (negative)	17%
Capacity & expandability (negative)	12%
Ridership attracted (negative)	8%
Speed (negative)	7%
Reliability (negative)	6%

- No rapid transit between Surrey Central and Guildford is selected as the most acceptable by 38% and the least acceptable by 48%; 14% do not consider this option to be the most or the least acceptable.
- Reasons for supporting this option include impacts on street traffic (24%), cost effectiveness (24%), and extent of rapid transit coverage (23%). Reasons for not supporting this option include the impact on street traffic (17%) and capacity & expandability (12%).

Base: All who reside in or travel to Surrey Rapid Transit Study area
NOTE: Only responses mentioned by 5% or more are shown

Appendix
Demographics

In which of the following areas do you live?	Unweighted Completes* (n=1034) %	Weighted Completes* (n=956) %	Unweighted All Cases** (n=1654) %	Weighted All Cases** (n=1654) %
South of Fraser	**44**	**26**	**32**	**18**
Delta – South Delta (includes Ladner and Tsawwassen)	2	2	3	2
Delta – North Delta	3	1	2	1
Langley City	2	1	1	<1
Langley Township	7	5	4	3
Richmond	4	3	5	4
Surrey	23	12	14	7
White Rock	4	2	2	1
Burnaby/ New Westminster	**14**	**27**	**14**	**23**
Burnaby	9	16	9	14
New Westminster	5	11	5	9
Vancouver	**28**	**20**	**36**	**25**

*Completes: Live within study area, or have travelled to area in past 6 months

**All Cases: Completes plus those who have not travelled to area within past 6 months and reside outside of the study area

In which of the following areas do you live?	Unweighted Completes* (n=1034) %	Weighted Completes* (n=956) %	Unweighted All Cases** (n=1654) %	Weighted All Cases** (n=1654) %
North Shore	**4**	**10**	**7**	**16**
Bowen Island	0	0	<1	<1
Lions Bay	<1	<1	<1	<1
North Vancouver – City	1	3	2	4
North Vancouver – District	2	5	4	9
West Vancouver	1	1	1	2
Northeast	**10**	**17**	**11**	**18**
Anmore/Belcarra	<1	<1	<1	<1
Coquitlam	4	7	4	7
Maple Ridge	2	3	3	5
Pitt Meadows	<1	<1	1	1
Port Coquitlam	1	4	2	3
Port Moody	1	2	1	2

*Completes: Live within study area, or have travelled to area in past 6 months

**All Cases: Completes plus those who have not travelled to area within past 6 months and reside outside of the study area

Do you have access to a car, van, or truck for your own use on a regular basis?	Unweighted Completes* (n=1034) %	Weighted Completes* (n=956) %	Unweighted All Cases** (n=1654) %	Weighted All Cases** (n=1654) %
Yes	74	84	72	82
No	25	16	28	18
Don't know	<1	<1	<1	<1

What mode of transportation do you use most often to travel to work, school or your other frequent trips in Metro Vancouver?	Unweighted Completes* (n=1034) %	Weighted Completes* (n=956) %	Unweighted All Cases** (n=1654) %	Weighted All Cases** (n=1654) %
SOV	29	25	28	27
Rideshare	12	25	12	28
Transit	50	18	50	18
Walk/ Cycle/ Other	10	31	10	27

*Completes: Live within study area, or have travelled to area in past 6 months

**All Cases: Completes plus those who have not travelled to area within past 6 months and reside outside of the study area

Appendix – Demographics

Age/ Gender	Unweighted Completes* (n=1034) %	Weighted Completes* (n=956) %	Unweighted All Cases** (n=1654) %	Weighted All Cases** (n=1654) %
M 16-34	17	14	14	11
M 35-54	23	28	22	25
M 55+	24	25	22	24
F 16-34	8	5	9	7
F 35-54	17	16	18	19
F 55+	11	12	14	15

*Completes: Live within study area, or have travelled to area in past 6 months

**All Cases: Completes plus those who have not travelled to area within past 6 months and reside outside of the study area

Appendix – Demographics

What is your present employment status?	Unweighted Completes* (n=1034) %	Weighted Completes* (n=956) %	Unweighted All Cases** (n=1654) %	Weighted All Cases** (n=1654) %
Employed full time (30 or more hours per week)	59	60	58	57
Employed part time (less than 30 hours per week)	12	9	12	11
Student	6	4	6	4
Retired	17	19	18	20
Not employed	3	4	4	5
Homemaker	2	3	2	4

Which of the following best describes your total household income before taxes for 2010?	Unweighted Completes* (n=1034) %	Weighted Completes* (n=956) %	Unweighted All Cases** (n=1654) %	Weighted All Cases** (n=1654) %
Under $35,000	16	13	17	14
$35,000 to under $65,000	21	21	21	21
$65,000 to under $95,000	19	20	19	20
$95,000 or over	23	27	23	25
Don't know/ Refused	21	19	21	21

*Completes: Live within study area, or have travelled to area in past 6 months

**All Cases: Completes plus those who have not travelled to area within past 6 months and reside outside of the study area

Appendix

Survey

Surrey Rapid Transit Study Acceptability Questionnaire
Final Draft February 14, 2012

FIELD DATES: Soft launch, February 8; full launch February 9; close on Feb 21st

REMINDERS: reminder Feb 19th.

SAMPLE: All panelists living in Metro Vancouver.

E-MAIL INVITATION

Subject: How acceptable are these rapid transit alternatives for Surrey and surrounding communities?

Dear [INSERT PANELIST NAME],

TransLink and the Province of British Columbia have partnered with the cities of Surrey and Langley to conduct a multi-phase study evaluating a number of rapid transit alternatives for the area and we would like your feedback on the subject.

Click here to start the survey

This survey will take about 15 minutes on average.

Please click the link below to complete this survey by February 21, 2012.

If you cannot click on the link above, copy and paste the following link into a new browser.

[%LINK%]

Thank you,

TransLink Listens

TransLink
1600 - 4720 Kingsway
Burnaby, BC V5H 4N2

1

[QUESTIONNAIRE]

[Screening Questions]
Thank you for agreeing to participate in the survey.

S1. To begin, in which of the following areas do you live?
[SINGLE RESPONSE]

1. Anmore/Belcarra
2. Burnaby
3. Bowen Island
4. Coquitlam
5. Delta—North Delta
6. Delta—South Delta (Ladner/Tsawwassen)
7. Langley—City
8. Langley—Township
9. Lions Bay
10. Maple Ridge
11. New Westminster
12. North Vancouver –City
13. North Vancouver—District
14. Pitt Meadows
15. Port Coquitlam
16. Port Moody
17. Richmond
18. Surrey
19. Vancouver
20. West Vancouver
21. White Rock
22. Outside of Metro Vancouver (not in above list) [GO TO THANK AND TERMINATE]

[Thank and Terminate if S1=22]
Thank you, but this survey is intended for Metro Vancouver residents.

2

[NEW SCREEN]
S2. Over the next 30 years, Metro Vancouver's population is estimated to grow by one million people. Much of this growth will happen in Surrey and the surrounding communities. This population growth will affect many aspects of peoples' lives, including how they get around the area.

TransLink and the Province of British Columbia have partnered with the cities of Surrey and Langley to conduct a multi-phase study evaluating a number of rapid transit alternatives for the area.

Before today, were you aware of the Surrey Rapid Transit Study?

1. Yes
2. No
3. Don't know/Unsure.

[NEW SCREEN]
[ASK IF S2=1; OTHERWISE SKIP TO S4] [IN DATA PROCESSING IMPUTE S2=2 AS "NOT AT ALL FAMILIAR" AND S2=3 AS "DON'T KNOW/UNSURE"]
S3. How familiar are you with Surrey Rapid Transit Study? Would you say you are...?
Please choose one response.

1. Very familiar
2. Somewhat familiar
3. Not very familiar
4. Not at all familiar
5. Don't know

[NEW SCREEN]
S4. As mentioned earlier, the purpose of the Surrey Rapid Transit Study is to look at a wide range of rapid transit alternatives to serve most of Surrey (including the areas of Surrey City Centre, Newton, Guildford, Fleetwood, South Surrey and Cloverdale) as well as portions of the City of Langley, the Township of Langley, North Delta and White Rock. The study area is based on the regional rapid transit expansion priorities identified in previous plans and focuses on linking the corridors of 104th Avenue, King George Boulevard and the Fraser Highway to the existing rapid transit system.

Click here to see the map of the study area. [LINK TO SAME MAP AS S5]

Based on what you have read, seen or heard, how important would you say investing in rapid transit for Surrey and the surrounding communities is ...

Please choose one response per row.

	Very important	Somewhat important	Not very important	Not at all important	Don't know/Unsure
To the overall Metro Vancouver region					
To Surrey and the surrounding communities					
To you personally					

3

[NEW SCREEN]
S5. Have you travelled to the Surrey Rapid Transit Study area in the past six months? [SHOW STUDY AREA MAP BELOW QUESTION]

1. Yes
2. No
3. Don't know

[INSERT STUDY AREA MAP]

4

S6. How familiar would you say you are with the existing transit service in the Surrey Rapid Transit Study Area? Would you say you are…?

Please choose one response.

1. Very familiar
2. Somewhat familiar
3. Not very familiar
4. Not at all familiar
5. Don't know

[Main Questionnaire—asked of panelists who have either travelled to the study area in the past 6 months or they reside in the areas.]

[ASK IF S5=1, OR ((S5=2 OR 3) AND (S1=5, 7, 8, 18, 21)); OTHERWISE SKIP TO DEMOGRAPHICS.]
[NEW SCREEN]
Q1. There are a range of factors that TransLink considers when planning rapid transit projects and some of these are listed below. How important is each factor to you in making decisions about rapid transit in the Surrey Rapid Transit Study area?

[RANDOMIZE ORDER OF FACTOR LIST]

FACTOR	Very important	Somewhat important	Not very important	Not at all important	Don't know/ Unsure
Speed: Whether the system offers fast, competitive travel times.					
Reliability: Whether the system offers consistent travel times and is there when you need it.					
Capacity & Expandability: Whether the system has the capacity to meet initial demand and can easily be upgraded or expanded as demand grows.					
Extent of Rapid Transit Coverage: The area served by rapid transit.					
Cost Effectiveness: The level of transportation and other benefits relative to the costs.					
Affordability for the Region: The costs of building and operating the system.					
Economic Development Potential: The economic benefits of building and operating the system (e.g., job creation, effects on goods movement and GDP, etc.)					
Environmental Impacts: Impacts on the natural environment. (e.g., air emissions, effects on waterways, agricultural land, etc.)					
Safety & Personal Security: The level of safety and personal security of the system for all users.					
Urban Development Effects: The amount and type of residential and commercial development that the system helps to generate.					
Timing: How quickly the system can be implemented once funding is attained.					
Potential for Phasing: The ease of implementing the system in phases, such as starting with a smaller initial system.					
Ridership Attracted: The number of new users attracted to the system and ridership of the overall transit network.					
Impacts on Street Traffic: Impacts on other road users, such as private cars, commercial vehicles and cyclists.					
Urban Design Impacts: The impact the system has on the urban environment such as the look and feel of the street, the amount of sidewalk space and the design of station locations.					
Integration with the Regional Transit Network: How well the system integrates with the existing rapid transit network.					

[NEW SCREEN]

There are three rapid transit technologies being considered for the Surrey Rapid Transit Study: Bus Rapid Transit (BRT), Light Rail Transit (LRT) and Rail Rapid Transit (SkyTrain).

We want to know whether each technology is acceptable to you.

Next we will give you a brief explanation of each of the three technologies, and then ask you a few questions about each one.

[RANDOMIZE Q2A, Q3A, AND Q4A]

[NEW SCREEN]

Q2a. Bus Rapid Transit (BRT)

Technology
BRT is a driver-operated, low-floor articulated bus technology that typically operates at street-level.

BRT can run as frequently as every 2 minutes (similar to Light Rail Transit and SkyTrain)

BRT travels at an average speed of 30 kilometres per hour (similar to Light Rail Transit) but slower than SkyTrain's 40 km/h).

BRT vehicles would run on modern, clean diesel fuel.

Alignment
BRT operates primarily in the centre of the street. It is in its own right-of-way, separated from other traffic by a curb with signal priority at intersections.

Artist rendering of 104 Avenue and 144 Street

Station Type
BRT stations are typically located within the street and connect to both sides of the street with pedestrian crossings. Stations are sheltered and typically feature ticket vending machines, closed circuit TV for security, seating, real-time information and wayfinding.

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Based on the information above, how acceptable is BRT technology as one of the technologies considered for the Surrey Rapid Transit Study area?

1. Very Acceptable
2. Somewhat Acceptable
3. Neither Acceptable nor Unacceptable
4. Somewhat Unacceptable
5. Very Unacceptable
6. Don't know/Unsure

[ASK IF Q2A=1, 2, 4 or 5]
[NEW SCREEN]
Q2b. Why is the BRT technology [INSERT RESPONSE FROM Q2A] to you?
Please explain fully.
[OPEN-END]

[NEW SCREEN]
Q3a. Light Rail Transit (LRT)

Technology
LRT is a driver-operated, electrically-powered rail technology that typically operates at street-level.

LRT can run as frequently as every 2 minutes (similar to Bus Rapid Transit and SkyTrain)

LRT travels at an average speed of 30 kilometres per hour (similar to Bus Rapid Transit, but slower than SkyTrain's 40 km/h).

Alignment
LRT operates primarily in the centre of the street. It is in its own right-of-way, separated from other traffic by a curb with signal priority at intersections.

Artist rendering of King George Boulevard and 96 Avenue

Station Type
LRT stations are typically located within the street and connect to both sides of the street with pedestrian crossings. Stations are sheltered and typically feature ticket vending machines, closed circuit TV for security, seating, real-time information and wayfinding.

8

Based on the information above, how acceptable is LRT technology as one of the technologies considered for the Surrey Rapid Transit Study area?

1. Very Acceptable
2. Somewhat Acceptable
3. Neither Acceptable nor Unacceptable
4. Somewhat Unacceptable
5. Very Unacceptable
6. Don't know/Unsure

[ASK IF Q3A=1, 2, 4 or 5]
[NEW SCREEN]
Q3b. Why is the LRT technology [INSERT RESPONSE FROM Q3A] to you?
Please explain fully.
[OPEN-END]

[NEW SCREEN]

Q4a. Rail Rapid Transit (SkyTrain)

Technology
SkyTrain is an automated, driverless rail technology that is powered by electricity.

SkyTrain can run as frequently as every 2 minutes (similar to Bus Rapid Transit and Light Rail Transit).

SkyTrain travels at an average speed of 40 kilometres per hour (compared to 30 km/h for Bus Rapid Transit and Light Rail Transit).

Alignment
SkyTrain typically operates in a tunnel or on an elevated track. Surface level operation is possible; however, automated systems must be fully segregated and protected by fencing. In the case of the Surrey Rapid Transit Study, SkyTrain is assumed to operate on an elevated track above the centre of the street.

Artist rendering of King George Boulevard and 96 Avenue

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Station Type
SkyTrain stations are elevated above the roadway and accessed by elevators, escalators and stairs. Stations feature ticket vending machines and faregates, closed circuit TV for security, seating, real-time information and wayfinding.

Based on the information above, how acceptable is SkyTrain technology as one of the technologies considered for the Surrey Rapid Transit Study area?

1. Very Acceptable
2. Somewhat Acceptable
3. Neither Acceptable nor Unacceptable
4. Somewhat Unacceptable
5. Very Unacceptable
6. Don't know/Unsure

[ASK IF Q4A=1, 2, 4 or 5]
[NEW SCREEN]
Q4b. Why is the SkyTrain technology [INSERT RESPONSE FROM Q4A] to you?
Please explain fully.
[OPEN-END]

10

[Acceptability of Rapid Transit Corridors]
[NEW SCREEN]
Q5intro. The Surrey Rapid Transit Study project team has identified three key transportation corridors where rapid transit could be implemented to connect Surrey City Centre, and the existing rapid transit system, with the surrounding communities of Guildford, Fleetwood, Langley, Newton and White Rock.

The map below shows the three corridors, which are:

King George Boulevard: This corridor connects Surrey City Centre with the growing town centres of Newton and White Rock as well as key destinations such as Surrey Memorial Hospital, Surrey Arts Centre, Newton Recreation Centre, the South Surrey Park & Ride, and Semiahmoo Shopping Centre. At 19.5 km, this is the longest corridor being considered. The option of running rapid transit only as far as Newton (6.5 km) is also being considered.

104th Avenue: This corridor connects Surrey City Centre with the growing town centre of Guildford as well as key destinations such as Guildford Town Centre Mall, the Guildford Recreation Centre and Public Library, and connections with future Highway 1 Rapid Bus service. At 4.5 km, this is the shortest corridor being considered. Since there is little available space along this corridor, introducing rapid transit would reduce the existing road capacity by one lane in each direction.

Fraser Highway: This corridor connects Surrey City Centre with the growing town centre of Fleetwood and Langley City Centre as well as key destinations such as the Surrey Sports and Leisure Centre, Willowbrook Mall, and connections to other communities in the Fraser Valley. At 17 km, this is the 2nd longest corridor being considered.
[INSERT MAP HIGHLIGHTING 3 CORRIDORS]

[NEW SCREEN]

Q5. Now, based on the information provided about each of the three transportation corridors, how acceptable to you is each of the following corridor options that are being considered. Please focus only on the corridor options and not the rapid transit technology that may be used on a particular corridor.

Click here [LINK TO Q5INTRO MAP] to see the map of the corridors again.

[RANDOMIZE ORDER OF CORRIDOR OPTIONS WITHIN TABLE]

Traffic Corridor Options	Very Acceptable	Somewhat Acceptable	Neither Acceptable nor Unacceptable	Somewhat Unacceptable	Very Unacceptable	Don't Know/ Unsure
Rapid transit on King George Boulevard only						
Rapid transit on Fraser Highway only						
Rapid transit on both King George Boulevard and 104th Avenue						
Rapid transit on all 3 corridors, King George Boulevard, Fraser Highway, and 104th Ave.						
No rapid transit is introduced but improvements to bus service are made throughout the study area including B-Line service, Express Bus service and transit priority measures.						

[NEW SCREEN]
Q6INTRO. Next, for each of the 3 transportation corridors we've been discussing we will present you with a list of potential rapid transit alternatives and ask how acceptable each alternative is to you.

We'll start with the King George Boulevard corridor, which connects Surrey City Centre to Newton and then to South Surrey/White Rock via 152nd street (see the map below). Because there is available space along this corridor to replace lanes, introducing rapid transit will not have an impact on road capacity. Between Highway 10 and White Rock the service would operate in mixed traffic (not in its own right-of-way) with signal priority at intersections.

[MAP OF HIGHLIGHTED CORRIDOR WITH STOP LOCATIONS]

[NEW SCREEN][RANDOMIZE ORDER OF ALTERNATIVES IN BOTH THE SUMMARY INFORMATION TABLE AND THE RESPONSE TABLE. MATCH ORDER IN 2ND TABLE TO ORDER IN 1ST TABLE]

Q6. The first table below provides information to help you evaluate the alternatives and includes:

- The travel time, in minutes, between key destinations;
- The capital cost (i.e., cost to build the line including stations, vehicles);
- The number of new transit boardings generated by the alternative over a 30-year period;
- The impact, if any, the rapid transit line will have on the existing road space.

Once you have read each of the King George Boulevard corridor alternatives, rate each alternative in the 2nd table below.
Click here [LINK TO KING GEORGE BLVD MAP FROM Q6INTRO] to see the King George Boulevard map again (opens in a new window).

Alternatives for King George Boulevard Corridor	Travel Times (mins): Surrey City Centre to Newton	Travel Times (mins): Surrey City Centre to White Rock	Capital Cost* ($Millions, 2010)	New Boardings over 30-year Study Period (Millions)	Impact on Existing Road Capacity
BRT between Surrey City Centre and Newton only	15	41	130	50	Some turning restrictions
BRT between Surrey City Centre, Newton and South Surrey/White Rock	15	38	290	140	Some turning restrictions
LRT between Surrey Central and Newton only	14	46	480	130	Some turning restrictions
LRT between Surrey Central and Newton, and BRT between Newton and South Surrey/White Rock	14	39	590	170	Some turning restrictions
SkyTrain between Surrey Central and Newton only	10	42	880	560	None
No rapid transit along the corridor, but improve bus services with B-Line, Express Buses and transit priority measures	20	46	up to 130	190	None

- * Operating costs also vary but the difference among alternatives is small compared to capital costs.

How acceptable to you is each of the alternatives for the King George Boulevard corridor?

Alternatives for King George Boulevard Corridor	Very Acceptable	Somewhat Acceptable	Neither Acceptable nor Unacceptable	Somewhat Unacceptable	Very Unacceptable	Don't Know/ Unsure
BRT between Surrey City Centre and Newton only						
BRT between Surrey City Centre, Newton and South Surrey/White Rock						
LRT between Surrey Central and Newton only						
LRT between Surrey Central and Newton, and BRT between Newton and South Surrey/White Rock						
SkyTrain between Surrey Central and Newton only						
No rapid transit along the corridor, but improve bus services with B-Line, Express Buses and transit priority measures						

[NEW SCREEN]

Q7a. Below is the same list of rapid transit alternatives for the King George Boulevard corridor that we've been discussing, which one in the list is the most acceptable and which one is the least acceptable to you?

Please choose only one option per column.

[RANDOMIZE ORDER]

List of Alternatives for King George Boulevard Corridor	Most Acceptable	Least Acceptable
BRT between Surrey Central and Newton only		
BRT between Surrey Central, Newton and South Surrey White Rock		
LRT between Surrey Central and Newton only		
LRT between Surrey Central and Newton, and BRT between Newton and South Surrey White Rock		
SkyTrain between Surrey Central and Newton only		
No rapid transit along the corridor, but improve bus services with B-Line and Express Buses and transit priority measures		

[NEW SCREEN]

Q7b. Why is [INSERT MOST ACCEPTABLE FROM Q7A] the most acceptable alternative for the King George Boulevard corridor?

Q7c. Why is [INSERT LEAST ACCEPTABLE FROM Q7A] the least acceptable alternative for the King George Boulevard corridor?

[NEW SCREEN]

Q8intro. The next set of alternatives is for the Fraser Highway corridor which connects Surrey Central to Langley City Centre via the communities of Fleetwood and Clayton (see the map below). Because there is available space along this corridor to replace lanes, introducing rapid transit will not have an impact on road capacity.

[MAP OF HIGHLIGHTED CORRIDOR WITH STOP LOCATIONS]

[NEW SCREEN]
[RANDOMIZE ORDER OF ALTERNATIVES IN BOTH THE SUMMARY INFORMATION TABLE AND THE RESPONSE TABLE. MATCH ORDER IN 2ND TABLE TO ORDER IN 1ST TABLE]

Q8. There are four alternatives for the Fraser Highway Corridor.

Once you have read each of the Fraser Highway Corridor alternatives, rate each alternative in the 2nd table below.
Click here [LINK TO FRASER HIGHWAY CORRIDOR MAP FROM Q8INTRO] to see the Fraser Highway Corridor map again (opens in a new window).

Alternatives for the Fraser Highway Corridor	Travel Time (mins) Surrey City Centre to Langley Centre	Capital Cost* ($Millions, 2010)	New Boardings over 30-year Study Period (Millions)	Impact on Existing Road Capacity
BRT between Surrey Central and Langley City Centre	30	480	360	Some turning restrictions
LRT between Surrey Central and Langley City Centre	29	1,080	320	Some turning restrictions
SkyTrain between Surrey Central and Langley City Centre	21	1,660	650	None
No rapid transit along the corridor, but improve bus services with B-Line and Express Buses and transit priority measures	39	up to 110	80	None

* Operating costs also vary but the difference among alternatives is small compared to capital costs.

How acceptable to you is each of the alternatives for the Fraser Highway corridor?

Alternatives for the Fraser Highway Corridor	Very Acceptable	Somewhat Acceptable	Neither Acceptable nor Unacceptable	Somewhat Unacceptable	Very Unacceptable	Don't Know/ Unsure
BRT between Surrey Central and Langley City Centre						
LRT between Surrey Central and Langley City Centre						
SkyTrain between Surrey Central and Langley City Centre						
No rapid transit along the corridor, but improve bus services with B-Line and Express Buses and transit priority measures						

[NEW SCREEN]
Q9a. Below is the list of rapid transit alternatives for the Fraser Highway corridor that we've been discussing, which one in the list is the most acceptable and which one is the least acceptable to you?

Please choose only one option per column.
[RANDOMIZE ORDER]

List of Alternatives for Fraser Highway Corridor	Most Acceptable	Least Acceptable
BRT between Surrey Central and Langley City Centre		
LRT between Surrey Central and Langley City Centre		
SkyTrain between Surrey Central and Langley City Centre		
No rapid transit along the corridor, but improve bus services with B-Line and Express Buses and transit priority measures		

[NEW SCREEN]
Q9b. Why is [INSERT MOST ACCEPTABLE FROM Q9A] the most acceptable alternative for the Fraser Highway corridor?

Q9c. Why is [INSERT LEAST ACCEPTABLE FROM Q9A] the least acceptable alternative for the Fraser Highway corridor?

[NEW SCREEN]

The next set of alternatives is for the 104th Avenue corridor which connects Surrey Central to Guildford (156th Avenue—see map below). Since there is little available space along this corridor, introducing rapid transit will reduce existing road capacity by one lane in each direction.

[MAP OF HIGHLIGHTED CORRIDOR W STOP LOCATIONS]

[NEW SCREEN][RANDOMIZE ORDER OF Q10 AND MATCH ORDER OF ROWS IN TABLE]

Q10. There are three alternatives for the 104th Avenue Corridor.

Once you have read each of the 104th Avenue Corridor alternatives, rate each alternative in the 2nd table.

Click here [LINK TO 104TH AVE CORRIDOR MAP FROM Q10INTRO] to see the 104th Avenue Corridor map again (opens in a new window).

Alternatives for 104th Ave Corridor	Travel Time (mins) Surrey City Centre to Guildford	Capital Cost* ($Millions, 2010)	New Boardings over 30-year Study Period (Millions)	Impact on Existing Road Capacity
BRT between Surrey Central and Guildford	10	150	140	Some turning restrictions; Road reduced by one lane in each direction
LRT between Surrey Central and Guildford	9	370	100	Some turning restrictions; Road reduced by one lane in each direction
No rapid transit along the corridor, but improve bus services with B-Line and Express Buses and transit priority measures	13	up to 23	40	None

* Operating costs also vary but the difference among alternatives is small compared to capital costs

How acceptable to you is each of the alternatives for the 104th Avenue corridor?

Alternatives for 104th Ave Corridor	Very Acceptable	Somewhat Acceptable	Neither Acceptable nor Unacceptable	Somewhat Unacceptable	Very Unacceptable	Don't Know/ Unsure
BRT between Surrey Central and Guildford						
LRT between Surrey Central and Guildford						
No rapid transit along the corridor, but improve bus services with B-Line and Express Buses and transit priority measures						

[NEW SCREEN]

Q11a. Below is the list of rapid transit alternatives for the 104th Avenue corridor that we've been discussing, which one in the list is the most acceptable and which one is the least acceptable to you?

Please choose only one option per column.

[RANDOMIZE ORDER]

List of Alternatives for 104th Avenue Corridor	Most Acceptable	Least Acceptable
BRT between Surrey Central and Guildford		
LRT between Surrey Central and Guildford		
No rapid transit along the corridor, but improve bus services with B-Line and Express Buses and transit priority measures		

[NEW SCREEN]

Q11b. Why is [INSERT MOST ACCEPTABLE FROM Q11A] the most acceptable alternative for 104th Avenue corridor?

Q11c. Why is [INSERT LEAST ACCEPTABLE FROM Q11A] the least acceptable alternative for the 104th Avenue corridor?

[DEMOGRAPHICS]

[NEW SCREEN]

Finally we have a few questions about you that will help us properly categorize your responses.

D1. Do you have access to a car, van, or truck for your own use on a regular basis?

Yes
No
Don't Know

[ASK ALL – NEED FOR WEIGHTING PURPOSES] [NEW SCREEN]

D2. What mode of transportation do you use most often to travel to work, school or your other frequent trips in Metro Vancouver? [If you use more than one mode on the same trip, choose the mode that takes you the greatest distance]

Car/truck – driven alone
Car/truck – more than one person/carpool or vanpool (vehicle with driver and one or more passenger)
Bicycle
Walk
Transit (Bus, SeaBus, SkyTrain, West Coast Express, HandyDART)
Motorcycle, scooter
Other (*please specify*)

[NEW SCREEN]

D3. What is your present employment status?

Employed full-time (30 or more hours per week)
Employed part-time (less than 30 hours per week)
Student
Not employed
Homemaker
Retired

[NEW SCREEN]
D4. Which of the following best describes your total household income before taxes for 2010?

Under $15,000
$15,000 to under $25,000
$25,000 to under $35,000
$35,000 to under $45,000
$45,000 to under $55,000
$55,000 to under $65,000
$65,000 to under $75,000
$75,000 to under $85,000
$85,000 to under $95,000
$95,000 or over
Don't Know
Prefer not to say

[NEW SCREEN]

QSOFT. [SOFT LAUNCH ONLY – first 100] Was there anything about the questionnaire that you found confusing or difficult to answer? If yes, please provide a detailed explanation, if not click NEXT to continue? [OPEN END – NOT REQUIRED]

QFEEDBACK. Just before we finish:

Is there anything else you would like to share with us on any of the topics covered in this survey? [OPEN END – NOT REQUIRED]

[Closing Screen]
Those are all our questions today, thank you for participating!
Your responses have been recorded. You may now close this window.

Sincerely,
TransLink Listens

DEMOGRAPHIC VARIABLES TO IMPORT FROM PANELIST'S PROFILING QUESTIONNAIRE

- Age
- Gender
- Full postal code.

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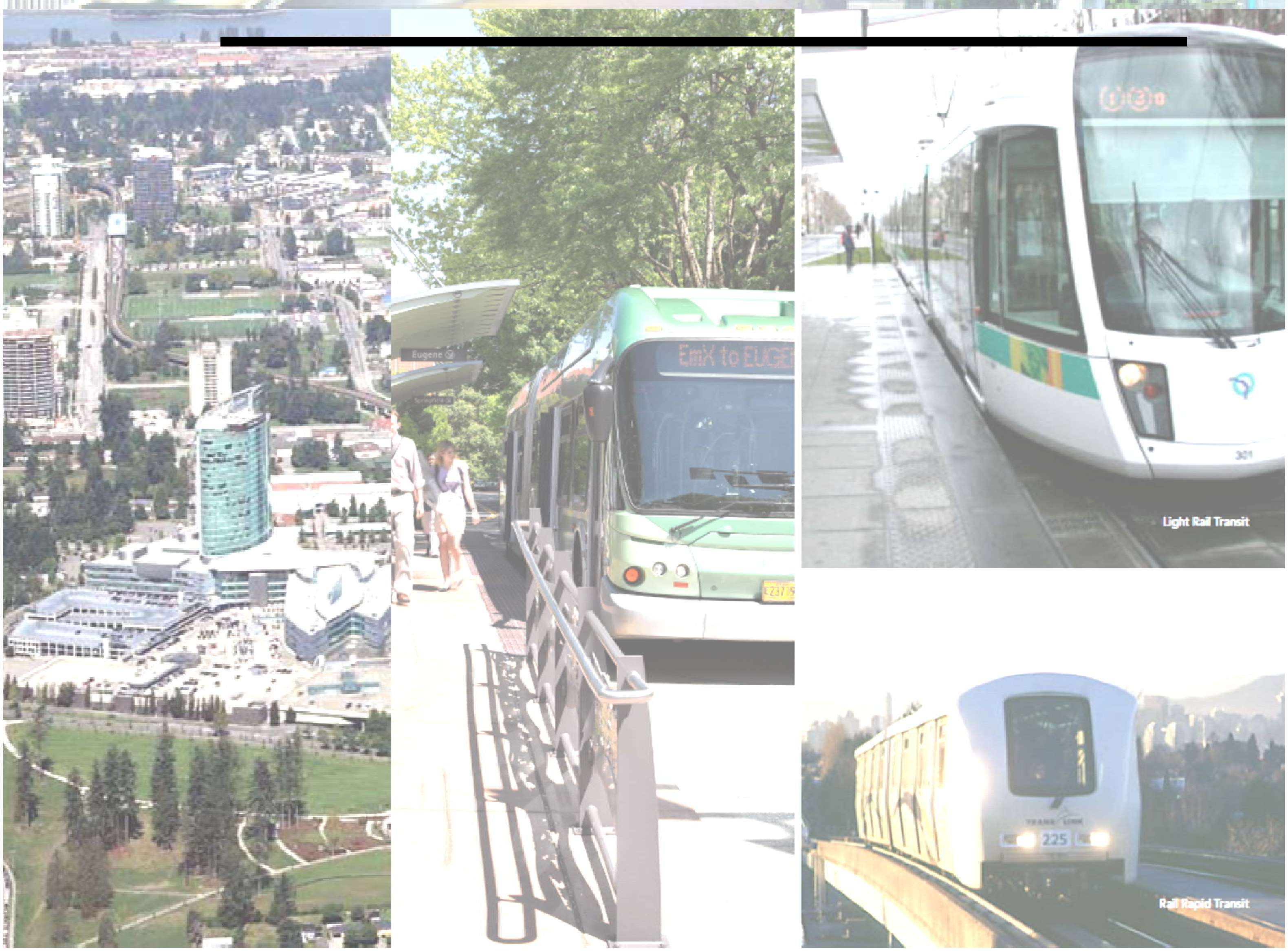
Surrey Rapid Transit Alternatives Analysis

Phase 2 Evaluation

APPENDIX 4 – SENSITIVITY TESTS



August, 2012

IBI GROUP

APPENDIX 4 – SENSITIVITY TESTS

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Exhibits

APPENDIX 4 – SENSITIVITY TESTS

This appendix contains additional information on the four categories of sensitivity tests carried out on the final Phase 2 Evaluation:

- Land use assumptions;
- Transportation assumptions (local and rapid transit);
- Regional modelling assumptions; and
- Financial analysis assumptions.

This material documents assumptions and more detailed results; a summary of these was included in **Section 4** of the **Evaluation Report**.

1. SCOPE OF SENSITIVITY TESTS

The objective of the Phase 2 evaluation was to undertake a sufficiently detailed level of analysis and highlight the key differences between the alternatives. The MAE summarized in Section 3 of the Evaluation Report forms the cornerstone for this comparison of alternatives. The purpose of sensitivity testing was to highlight the extent to which variations in input assumptions to the evaluation affected the relative performance of the alternatives. Broadly, the four categories of inputs tested were land use, transportation, modelling and financial assumptions. The results from Section 3 formed the “base case” for the sensitivity tests.

Exhibit 4.1 summarizes the series of modelling-based sensitivity tests conducted for the SRTAA.

Exhibit 4.1 – Sensitivity Test Scenarios (Modelling-Based)

Test	Alternatives	Description
Land Use Assumptions		
Base (2041)	**BAU, BRT 1, LRT 5A, RRT 1**	Regional Growth Strategy (MV) + Study area road network (CoS)
High Growth		Advance population/employment forecast 10 years
Low Growth		Slow down forecast by 10 years
Base Prime		Modified distribution (City of Surrey allocation of growth)
Transportation Assumptions		
Base (2041)	**BAU, BRT 1, LRT 5A, RRT 1**	Transit service growth according to South of Fraser Area Transit Plan, full vision to 2041 (3.5% annual increase)
Lower Background Transit Growth		Slower transit service growth, according to trend, allocated by population increase (2.5% annual increase)
Lower Background Transit + High Growth Land Use	**BRT 1**	Accelerated land use growth plus lower background transit
Transit Signal Priority	**BRT 1, LRT 5A**	Reduced availability of transit priority for surface rapid transit
Regional Modelling Assumptions		
Base (2041)	**BAU, BRT 1, LRT 5A, RRT 1**	Phase 2 RTPM08 (Rapid Transit Projects Model)
TDM (Demand Management)		150% increase (above inflation) in auto-related costs (operating cost, parking etc.)
Reduced Transfer Penalties	**BAU, BRT 1/2, LRT 1/5A, RRT 1**	Attractiveness of transfers to/from rapid transit increased by 40% at major interchange points

The land use, transportation and demand modelling tests investigated how different inputs to the regional forecasting model affected mode share, demand and capacity. The mode shares were compared to the base case for each test to indicate whether the overall benefits/attractiveness of the alternatives would increase or decrease. The changes to assumed capacity and resulting travel demand helped determine if the alternatives would have design capacity risks under different scenarios.The relative sensitivity of the results to changes in the future study area conditions (and model assumptions) becomes important over the long term, because the inputs (future land use, future transportation networks, and future travel behaviour) were also projections subject to some uncertainty. The results demonstrated that the planned design capacity of the alternatives would still meet higher demands for most scenarios, but for some cases there would be capacity risks.

For efficiency, the modelling-based tests focused on a set of representative alternatives (BRT 1, LRT 5A, RRT 1) to provide an indication of the impacts of different assumptions. These particular alternatives were selected because they included each of the three technologies, and within each technology, these alternatives had higher preliminary ridership and peak passenger loads in each of the corridors. Therefore, these selections were felt to have good potential to demonstrate the impacts of different assumptions. (For some tests, additional alternatives were also considered to verify the impacts.)

Exhibit 4.2 summarizes the financial sensitivity tests conducted for the SRTAA.

Exhibit 4.2 – Sensitivity Test Scenarios (Financial)

Test	Alternatives	Description
Financial Tests		
Base	**All: BB, BRT, LRT, RRT**	6% discount rate, all alternatives start operating in 2020
Discount Rate		Test of 3% and 10% discount rates
Implementation Timing		Alts. enter service different years (2017 to 2021), depending on complexity and size
Capital Cost Risk	**BRT 1, LRT 5A, RRT 1**	Assume higher costs for grading/ piling in poor soils
Local Bus Integration		Off-model: assume higher % of passengers on RT, reduce frequency of local bus that follows RT route
BRT Technology		Effects of different BRT fuel/power systems on costs, emissions

The financial sensitivity tests focused on inputs to certain financial analyses, including risks that may reduce performance and opportunities that may improve it. These tests were carried out to determine if alternatives that performed similarly in the “base case” evaluation had variable sensitivity to factors such as capital costs, operating costs, the discount rate in the financial evaluation, or air emissions rates for transit vehicles.

This section provides a summary of the sensitivity tests that were carried out, the key results, and the implications of the tests for the evaluation of alternatives. Appendix 4 includes a discussion of all of the sensitivity tests that were carried out.

2. LAND USE ASSUMPTIONS

The intent of the land use sensitivity tests was to determine the influence of the land use assumptions on the long term performance of the rapid transit alternatives. The sensitivity tests of the different land use assumptions focused on the 2041 horizon year for a representative subset of the alternatives (BAU and one alternative for each technology), using forecasts from the Rapid Transit Planning Model (RTPM08) and the same methodologies outlined in Section 3.2 (Transportation Account) of the Evaluation Report.

2.1 LAND USE GROWTH/DISTRIBUTION SCENARIOS

The land use growth and distribution scenarios compared in this section are outlined in **Exhibit 4.3**, which shows the types of tests and the representative alternatives against which they were applied. The model-based tests focused on 2041 and considered four alternative growth scenarios which were developed through the collaboration of Metro Vancouver (MV) and the City of Surrey (CoS), specifically for the purpose of this study. The land use growth scenarios include base growth which assumes that the current growth rate will continue (as set out in the RGS), a low growth (slowing RGS forecast by ten years), a high growth (accelerating the RGS forecast by ten years), and a redistribution of base growth (aka base prime), The City of Surrey proposed that under the base prime land use scenario there would be a redistribution of the growth within the city with greater growth concentrated near the proposed station areas, predominantly along 104 Avenue and King George Boulevard. The intent of the land use sensitivity tests is to provide a refined understanding of the influence of the scenarios on mode shares and transit demand within the study area.

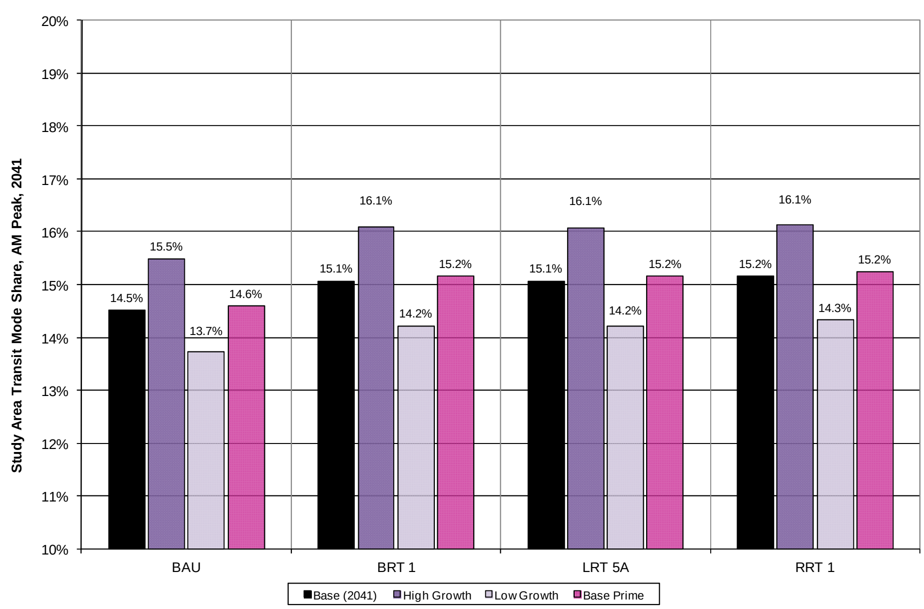
Exhibit 4.3 – Land Use Growth Rate and Distribution Test Scenarios

Scenario	BAU	BRT 1	LRT 5A	RRT 1	Assumption
Base (2041)	✓	✓	✓	✓	Regional Growth Strategy (MV) + Study area road network (CoS)
High Growth	✓	✓	✓	✓	Advance forecast 10 years
Low Growth	✓	✓	✓	✓	Slow down forecast by 10 years
Base Prime	✓	✓	✓	✓	Modified distribution (CoS)

2.2 MODE SHARES

The land use scenarios were tested against the transit mode shares for the study area to gauge the future modal split. **Exhibit 4.4** shows the transit mode shares for the study area in 2041 for the base, high growth, low growth, and modified distribution ("base prime"). The high growth scenario resulted in transit mode share being 0.9% to 1.0% higher than the base for the BAU and each rapid transit alternative, with slower growth producing 0.8% to 0.9% lower transit mode shares. The "base prime" reallocated future density between different parts of the study area, resulting in marginally more transit trips than the base scenario.

Exhibit 4.4 – Transit Mode Shares Under Different Land Use Scenarios



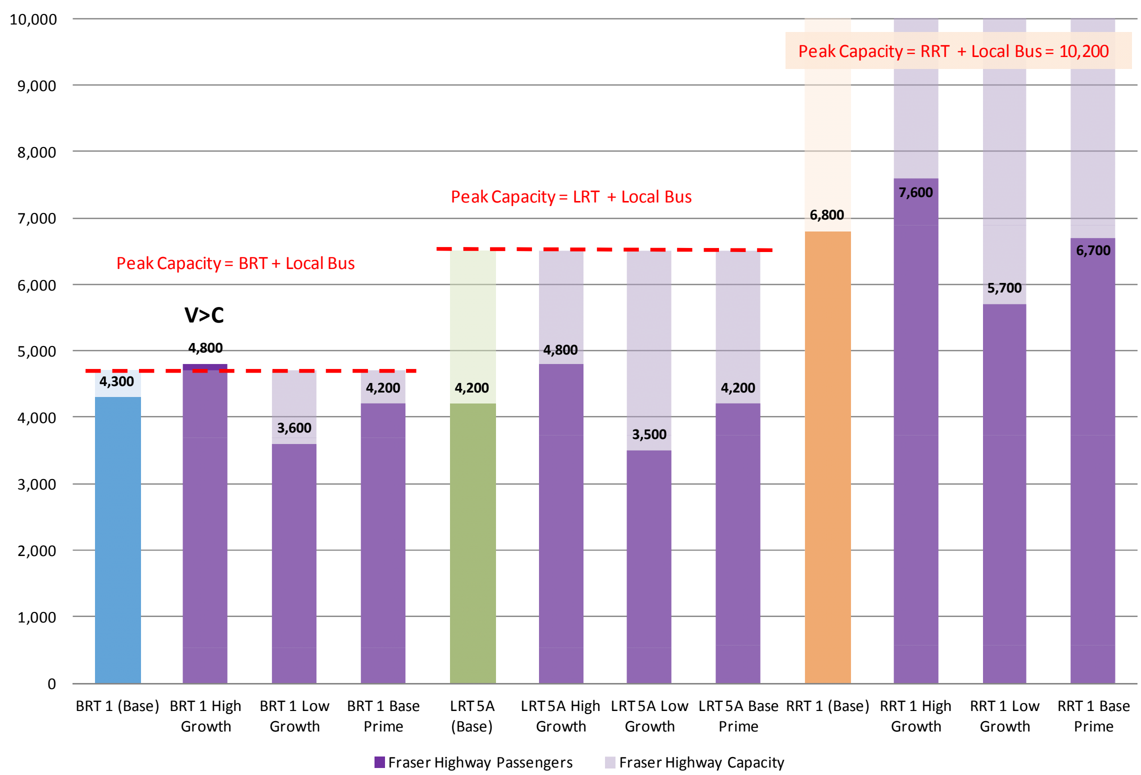
2.3 CAPACITY AND DEMAND

The land use scenarios were tested to determine the capacity and demand of the peak passenger loads. **Exhibits 4.5 to 4.7** illustrate the sensitivity of peak passenger loads on each of the main study corridors (Fraser Highway, King George Boulevard and 104 Avenue).

Each of the bars shows the forecast 2041 demand (dark shading) against the capacity (lighter shading) provided during the peak hour. The red dashed lines also indicate the total transit capacity provided during the peak hour, for reference. Each group of bars starts with the base scenario, colour-coded according to technology (blue for BRT service, green for LRT service, orange for RRT, and grey where service is provided only by conventional buses). The other bars within each group show how the three alternatives vary under each scenario. The peak loads vary between alternatives because each technology and network configuration provided different travel times though each corridor.

As shown in **Exhibit 4.5**, peak loads on Fraser Highway increase on BRT, LRT and RRT under the high growth scenario, whereas the peak loads are lower than the base in low growth and base prime. As indicated, the peak passenger volume exceeds capacity (V>C) on BRT in the high growth scenario.

Exhibit 4.5 – Fraser Highway Peak Passenger Loads – Sensitivity to Land Use (2041)



In **Exhibit 4.6**, the peak loads on King George Boulevard follow the same pattern as on Fraser Highway, but the BRT capacity is only approached and not exceeded by demand in the high growth scenario. For alternative RRT 1, the service on King George Blvd consists of the same local bus service as in BAU, and the demand exceeds capacity under all four scenarios.

Peak loads in all of the scenarios are within the capacity provided on 104 Avenue, even in the case of BAU, as indicated on Exhibit 4.7.

Exhibit 4.6 – King George Boulevard Peak Passenger Loads – Sensitivity to Land Use (2041)

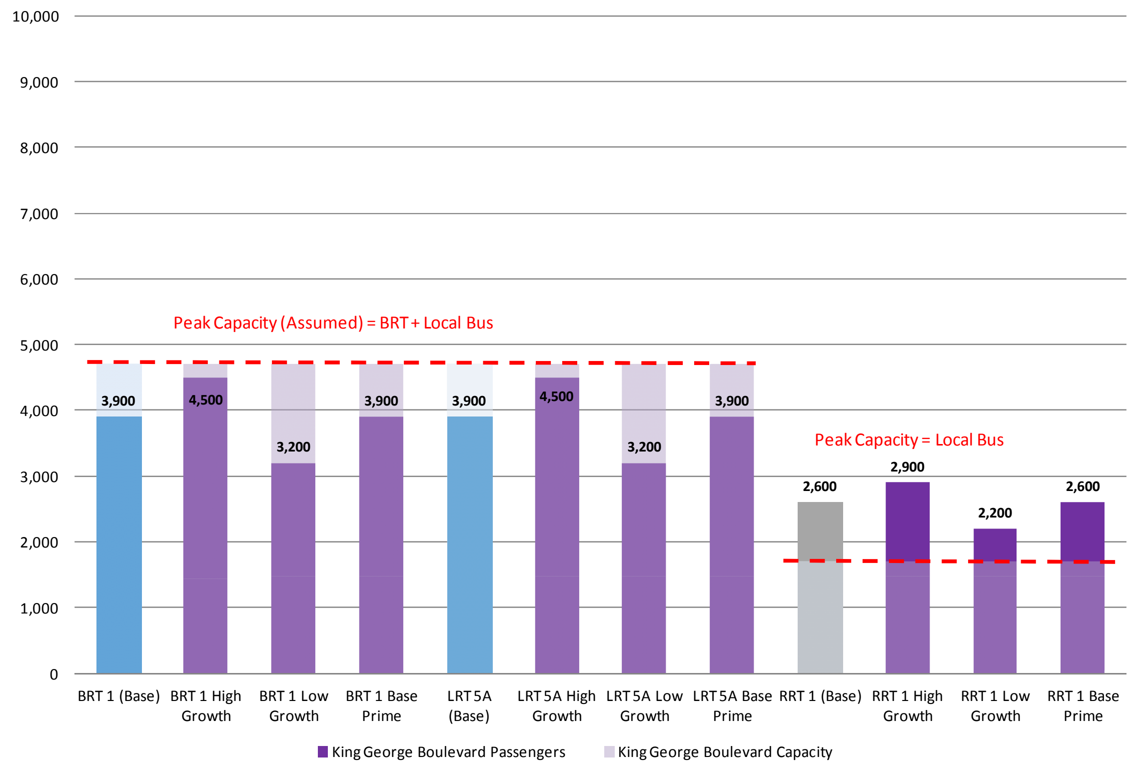
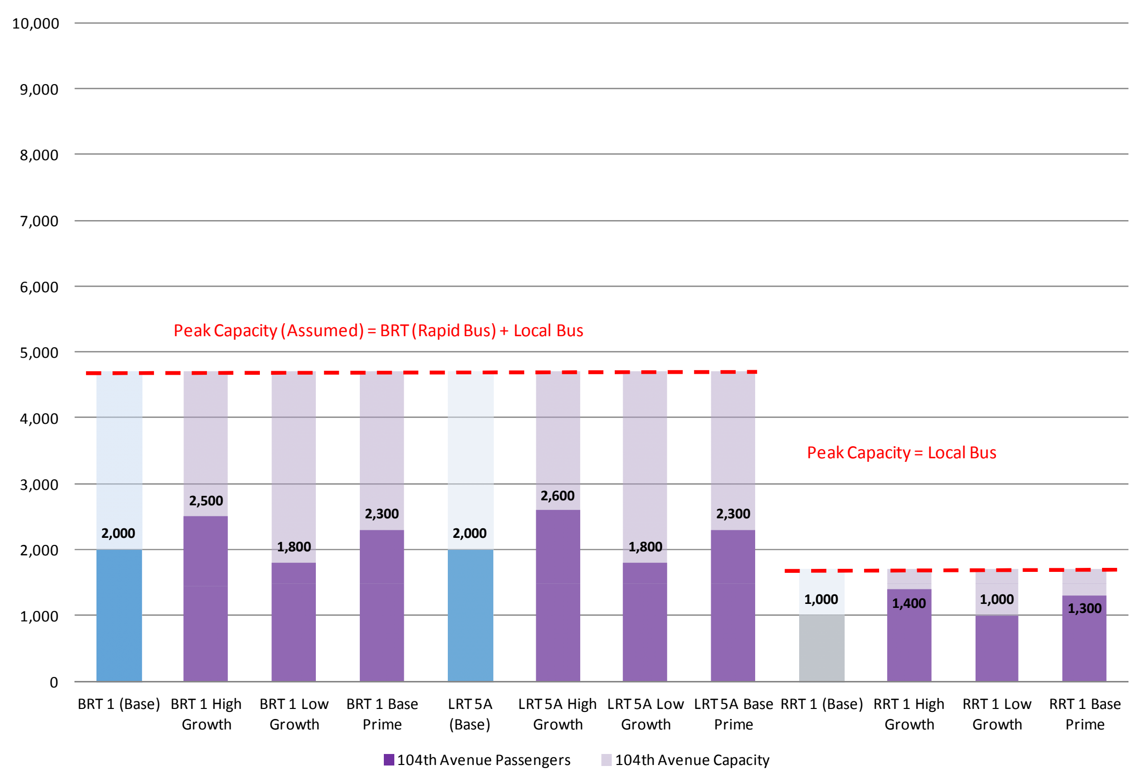


Exhibit 4.7 – 104th Avenue Peak Passenger Loads – Sensitivity to Land Use (2041)



2.4 FINDINGS – TESTS OF LAND USE

Overall, variations in the land use assumptions produced little change in the performance of the alternatives relative to each other. Demand increased and decreased consistently across the alternatives. In the high growth test, Fraser Highway showed a potential capacity risk for BRT. Low growth produced reductions in peak loads, particularly on Fraser Highway, which meant some technologies had more spare capacity. The base prime test did not produce significant overall differences, but did demonstrate some trade-off in allocation of peak loads, with more on 104 Avenue and less on Fraser Highway and King George Blvd.

Several interesting observations can be noted by corridor:

- On Fraser Hwy, BRT was slightly over capacity in the High Growth scenario, but all other alternatives were below corridor capacity;
- On King George Blvd, BRT (plus local transit) would meet forecast demand in all scenarios, while the BAU service included in RRT1 would not meet demand under any scenario;
- On 104 Ave, all volumes were below corridor capacity, and the BAU service level (in RRT 1) meets the forecast demand in all scenarios.

3. TRANSPORTATION ASSUMPTIONS

The intent of the transportation tests was to determine the influence of the transportation assumptions on the long term performance of the rapid transit alternatives (mode share and demand). The sensitivity tests of the different transportation assumptions focused on the 2041 horizon year for a representative subset of the alternatives (BAU and one alternative for each technology), using forecasts from the Rapid Transit Planning Model (RTPM08) and the same methodologies outlined in Section 3.2 (Transportation Account) of the Evaluation Report.

The following analyses consider transit mode share and the demand implications related to the level of investment in providing area-wide local transit service, and with the level of transit priority achievable at corridor intersections.

3.1 RAPID AND LOCAL TRANSIT SCENARIOS

Exhibit 4.8 identifies the scenarios and transit alternatives for this category of sensitivity tests. The base scenario assumes a growth in background bus service levels based on regional trends and forecast population and employment projections for the study area. The background bus network was based on the South of Fraser Area Transit Plan vision extrapolated until 2041. This was equivalent to a 3.5% annual growth rate in the study area. The lower growth background transit scenario assumes a slower service growth trend of 2.5% per year. The lower background transit + high growth land use scenario assumes an accelerated land use growth in conjunction with the lower growth in transit service, to ‘stress’ the rapid transit demand. The transit signal priority scenario assumes reduced availability of transit priority for surface rapid transit, with a reduction of the benefit to surface rapid transit relative to normal traffic signals assumed in the base (see Section 3.4).

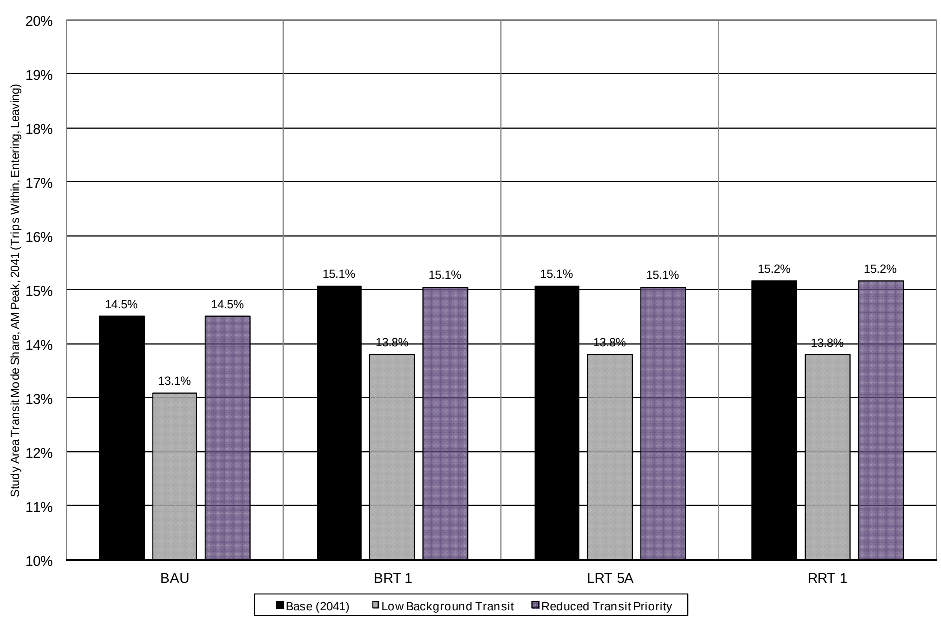
Exhibit 4.8 – Rapid and Local Transit Test Scenarios

Scenario	BAU	BRT 1	LRT5A	RRT 1	Assumption
Base (2041)	✓	✓	✓	✓	Transit service growth according to South of Fraser Area Transit Plan, full vision to 2041 (3.5% annual increase)
Lower Background Transit Growth	✓	✓	✓	✓	Slower transit service growth, according to trend, allocated by population increase (2.5% annual increase)
Lower Background Transit + High Growth Land Use		✓			Accelerated land use growth plus lower background transit growth
Transit Signal Priority	n/a	✓	✓	n/a	Reduced availability of transit priority for surface rapid transit

3.2 MODE SHARES

Exhibit 4.9 shows the transit mode shares for the study area in 2041 for the base, lower background transit, and reduced transit signal priority scenarios. As expected, lower levels of background transit across the study area in the model produce lower transit mode share results, with each alternative 1.3% to 1.4% lower than the base. Reduced transit signal priority only affected transit mode share to a small degree, with reductions well under 0.1% and therefore not visible on the graph.

Exhibit 4.9 – Transit Mode Shares in Study Area under Different Transit Service Scenarios



3.3 DEMAND/CAPACITY

Exhibit 4.10 illustrates the risks associated with different levels of background transit service on the performance of rapid transit on Fraser Highway. The total transit capacity would be less for the low background transit scenario because the parallel local bus service in the corridor (and throughout the study area) was reduced for this test. Interestingly, while overall transit ridership was lower (i.e. fewer trips in **Exhibit 4.9**), the demand in the rapid transit corridor stayed constant or increased slightly for BRT and LRT, while for RRT it decreased slightly. It appears that BRT and LRT would both attract more passengers if there was less parallel transit service. For RRT, the peak load decreased, because many of its passengers would be connecting via other transit services. For BRT, the increased peak loads under lower transit and lower transit + high growth pushed demand above the available capacity on Fraser Hwy by 2041.

Similar patterns are observed in **Exhibit 4.11**, which shows the same comparisons of 2041 peak passenger loads and capacity for King George Boulevard. Again, the lower transit + high growth scenario resulted in an increased demand above the assumed capacity of BRT combined with local bus service by 2041. The forecast peak load for RRT 1 exceeded the capacity in the base case and tests because the alternative included only local bus on King George Blvd.

In the case of Fraser Highway and King George Blvd, the reduction in transit priority reduced the speed of BRT and LRT, which produced a small decrease in the forecast peak loads (~100pphpd) relative to the base. No changes were apparent on 104 Ave.

Exhibit 4.10 – Fraser Highway Peak Passenger Loads – Sensitivity to Transit Assumptions (2041)

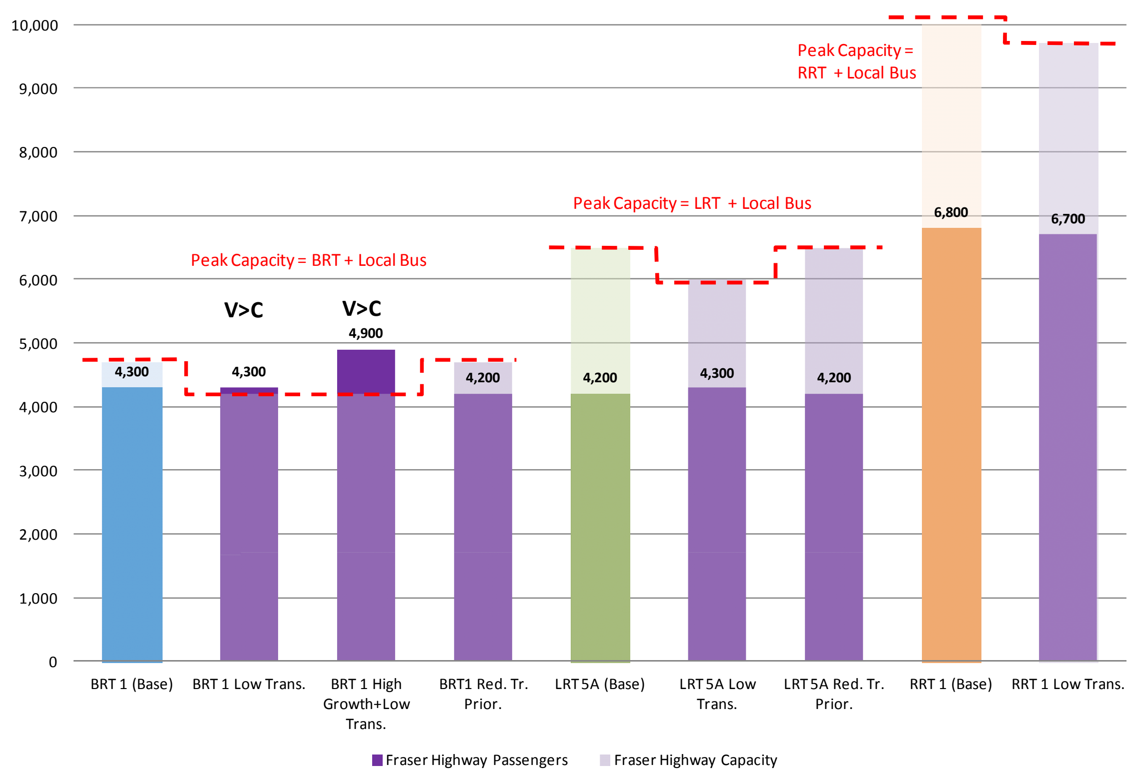


Exhibit 4.11 – King George Boulevard Peak Passenger Loads – Sensitivity to Transit Assumptions (2041)

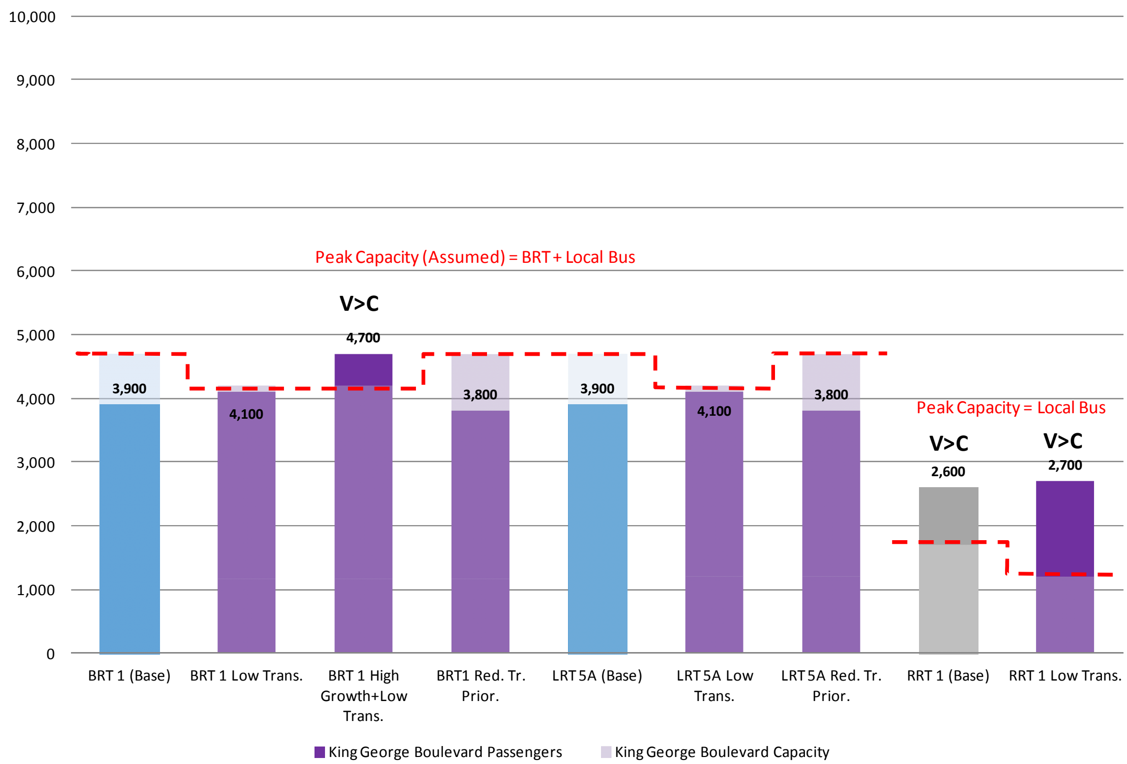
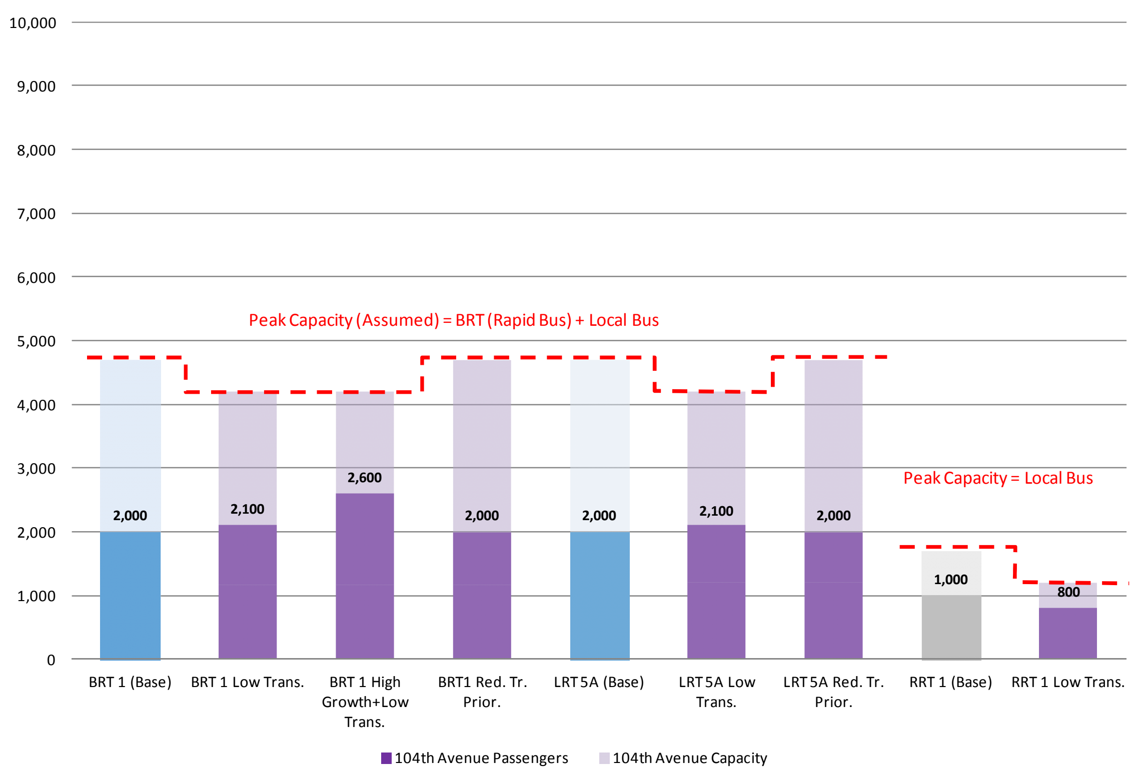


Exhibit 4.12 shows the same comparisons of 2041 peak passenger loads and capacity for 104 Avenue. In this case, the passenger loads would also increase in this corridor if there was less local study area transit service, but the peak loads would be well within the assumed capacity.

Exhibit 4.12 – 104th Avenue Peak Passenger Loads – Sensitivity to Transit Assumptions (2041)



3.4 EFFECTS OF REDUCED TRANSIT SIGNAL PRIORITY

For surface rapid transit alternatives (BRT and LRT) reduced transit priority would result if there were situations where, for various reasons (e.g. high cross street traffic, complex turning movements, pedestrian crossing time constraints), it was not possible to provide the level of transit priority assumed in the base evaluation. For Fraser Highway, King George Boulevard and 104 Avenue, the resulting BRT and LRT travel times would be 3% to 5% slower if transit vehicles received priority less often. The effects of different levels of priority were assumed to be as follows:

- In the BAU, transit would arrive at green 48% of the time at major intersections, and 65% of the time at minor intersections;
- In the base Phase 2 evaluation, BRT and LRT with transit priority would arrive during a green signal 60% of the time at major intersections, and 69% at minor (the improvement at minor signals is limited by minimum time requirements for pedestrians and cross traffic);
- In the sensitivity test, it was assumed that corridor constraints might limit the overall benefits, and the typical green signal percentages would be 54% and 67% respectively.

To provide the same frequency of service, the future BRT and LRT fleets would need to be marginally larger, resulting in higher capital and operating costs. In addition, slower operating times would reduce the travel time benefits for transit passengers, due to fewer riders and slower travel times. (There would be a small increase in auto usage and auto travel times, further reducing benefits.)

Exhibit 4.13 summarizes the key effects of reduced rapid transit priority on the financial performance of BRT 1 and LRT 5A, representing the surface rapid transit alternatives. With transit priority reduced, the NPV of costs would increase by $6 million, benefits would decrease by $22 million, and the BCR would reduce by 0.03 for BRT 1. With LRT 5A, the costs would increase by $7 million, benefits would decrease by $46 million, and the BCR would reduce by 0.04.

Exhibit 4.13 –Sensitivity of Financial Performance to Level of Transit Priority

Alternative	Scenario	NPV of Costs ($2010)	NPV Benefits ($2010)	Benefit-Cost Ratio
BRT 1	Base	$818 M	$1,067 M	1.30
	Reduced Transit Priority	$824 M	$1,045 M	1.27
	Difference	***+ $6 Million***	***-$22 Million***	***-0.03***
LRT 5A	Base	$1,280	$1,191 M	0.93
	Reduced Transit Priority	$1,287	$1,145 M	0.89
	Difference	***+$7 Million***	***-$46 Million***	***-0.04***

3.5 FINDINGS – TESTS OF TRANSPORTATION ASSUMPTIONS

Overall, the transit tests underscore the sensitivity of mode share and peak demand results to the assumed level of background transit. For the low background transit scenario, there was a significant drop in study area transit mode shares relative to the base scenario, but similar or slightly higher peak point passenger loads on BRT or LRT. The loads exceeded BRT capacity under certain circumstances.

On Fraser Highway, demand exceeded BRT plus local bus capacity if lower levels of background transit service were provided, and particularly if lower levels of background transit service were combined with higher than forecast land use growth. On King George Blvd, BRT would also be over capacity if lower levels of background transit were provided while higher land use growth was achieved. On 104 Avenue, BAU levels of service would meet the forecast demand in all scenarios.

Where only reduced transit priority was assumed, the differences in passenger demand were modest, but there are risks with increasing life cycle costs and reducing travel time benefits, with a reduction in BCR of 3% to 4% for BRT or LRT.

4. REGIONAL MODELLING ASSUMPTIONS

The following analyses consider the demand and capacity risks related to broader policy decisions such as implementation of transportation demand management strategies to making alternative modes more competitive relative to private automobiles, and more convenient transfers between transit modes. These tests were carried out by modifying underlying modelling assumptions, and result in mode share, peak load passenger volumes and other travel patterns in the forecast results.

4.1 MODELING SCENARIOS

Exhibit 4.14 identifies the scenarios and rapid transit alternatives for this category of sensitivity tests. The base scenario assumed the inputs from the Phase 2 RTPM08. The Transportation Demand Management (TDM) scenario assumed an increase in vehicle operating costs and parking charges as a proxy for regional demand management measures. The reduced transit penalties scenario utilized the RTPM08 which was calibrated to the existing regional travel patterns with a base transfer penalty of four minutes between transit modes to reflect the disbenefit of transferring. To test the impact of potential for improved passenger experience at higher quality transit interchange facilities, transfer penalties at primary interchange stations where rapid transit is collocated with major bus exchanges were halved by two minutes. The premise for the reduced transfer 'penalties' is that access and layout improvements could be made in the future to increase the convenience and reduce transfer times at key passenger facilities.

The reduced transfer penalties were applied for connections to/from BRT, LRT and RRT, at the existing SkyTrain stations in the study area, and at any transit exchanges connected to rapid transit within the alternatives. Locations included (where applicable): Surrey Central, King George, Newton Exchange, Guildford Exchange, and Langley Centre (the stations at both 196 Street and Downtown Langley).

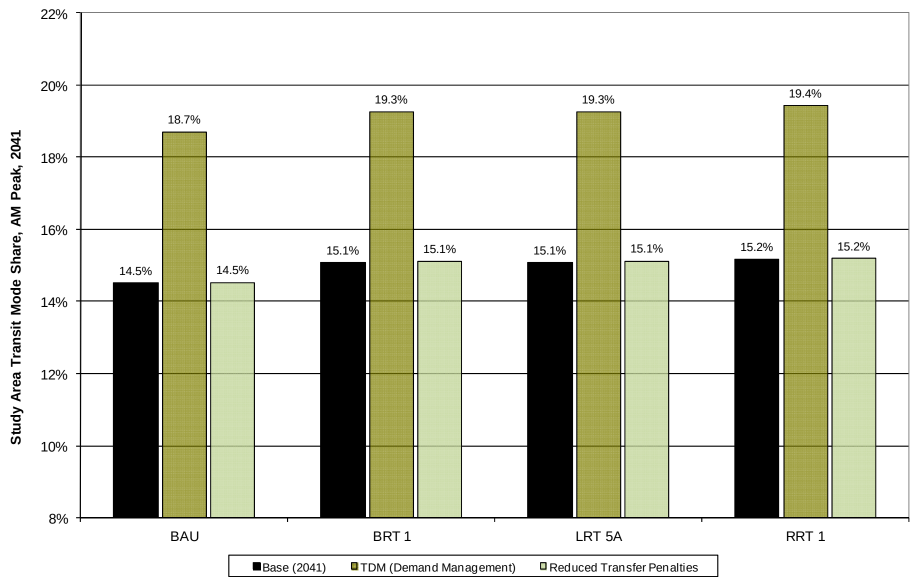
Exhibit 4.14 – Regional Modelling Test Scenarios

Scenario	BAU	BRT 1	LRT5A	RRT 1	Assumption
Base (2041)	✓	✓	✓	✓	Phase 2 RTPM08
TDM (Transportation Demand Management)	✓	✓	✓	✓	150% increase (above inflation) in auto-related costs (operating cost, parking etc.)
Reduced Transfer Penalties	✓	✓ + **BRT2**	✓ + **LRT 1**	✓	Attractiveness of transfers to/from rapid transit increased by 40% at major interchange points

4.2 MODE SHARES

Exhibit 4.15 shows the transit mode shares for the study area in 2041 for the base, TDM, and reduced transfer penalty scenarios.

Exhibit 4.15 – Transit Mode Shares for Different Regional Modelling Assumptions



The reduced transfer penalties produced near-imperceptible gains in the overall number of transit trips because perceived travel time was reduced if transfers at major terminals were made faster and/or more convenient. While this impact on mode share was small, the effect of TDM was large, with estimated mode shares increasing to approximately 19% under the test conditions (refer to Section 4.3 for a discussion of the TDM test).

4.3 TRANSPORTATION DEMAND MANAGEMENT

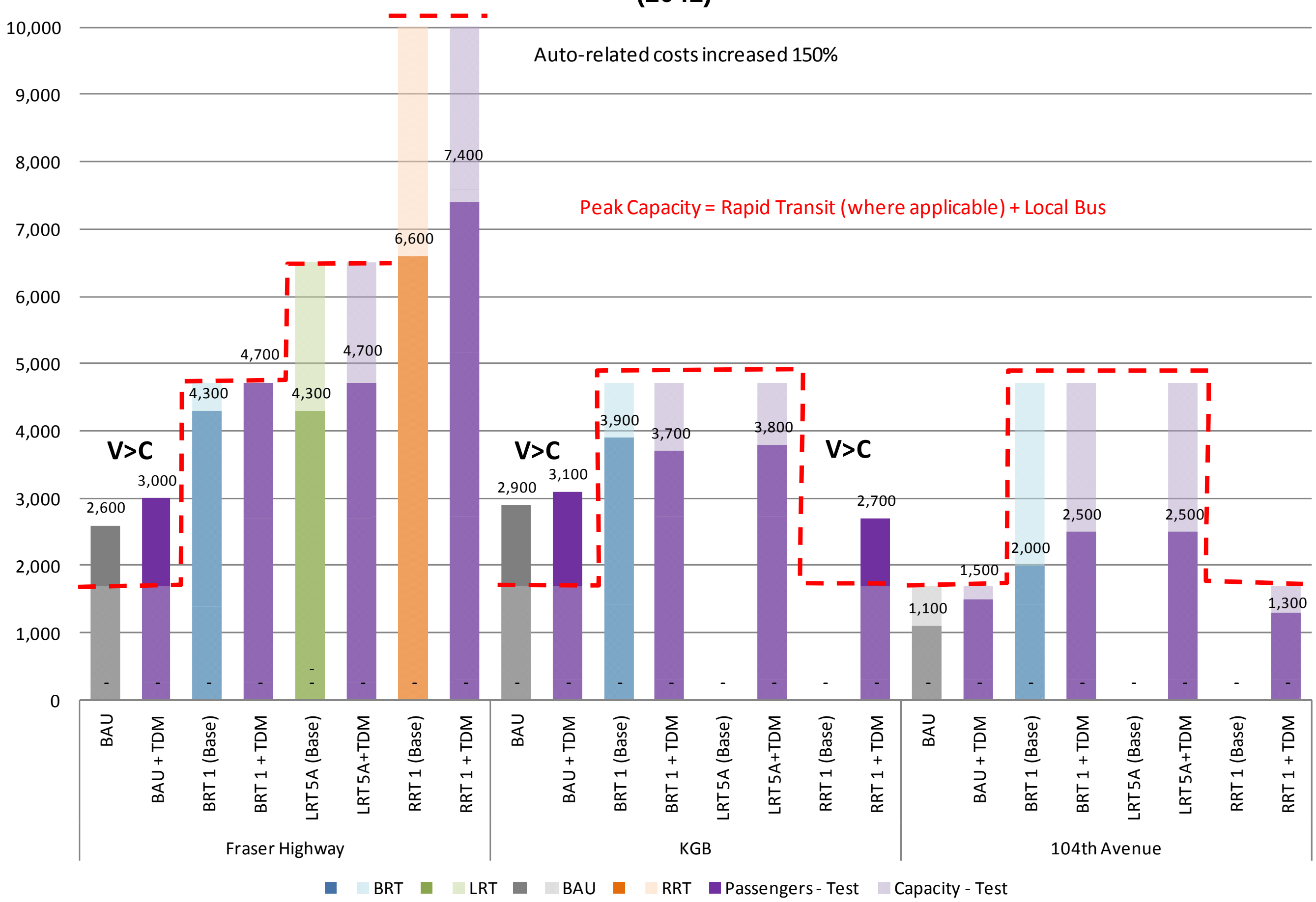
None of the base evaluation results for mode share indicated that the rapid transit alternatives in isolation would meet regional or Provincial targets. This was not unexpected as the region has diverse travel patterns and relatively low levels of traffic congestion on most facilities. The purpose of the TDM test was to understand the impacts on ridership if the targets were met using changes in transportation policy. The TDM test utilized the RTPM08 model with increased vehicle operating costs and parking charges as a proxy for some form of demand management program. Previous modelling experience has demonstrated that the RTPM08 model requires a substantial increase in vehicle operating costs and parking charges (~150%) to produce significant shifts in travel patterns and mode shares. Since the model has not been calibrated to accurately predict the large-scaled changes due to TDM, this model input of 150% should not be interpreted as a required value to reach regional targets.

The TDM assumptions increase auto travel costs and the model responds by adjusting origin-destination patterns and regional trips shorten on average by 30%. As a result of these shorter trips, other modes of transportation become more tenable (transit, walking, and cycling) and the more costly auto-dominated travel patterns become less attractive. As indicated in Exhibit 4.15, the regional mode share values for transit increase with TDM, from about 14.5% in the base evaluation to about 18.7% in this scenario. The study area value starts to converge on the regional result in this case, because of the broad implications of the TDM scenario.

Exhibit 4.16 summarizes the effects of TDM on peak passenger loads in each of the main corridors. Peak passenger loads increase with TDM, but not as much as the increase in mode share, because the change in travel patterns is forecast to lead to fewer longer trips.

In both the Fraser Highway and King George Blvd corridors, the base BAU would provide insufficient capacity to meet future demand, and in the TDM scenario the shortfall would become worse. With BRT on Fraser Highway, demand would match the maximum transit capacity by 2041. BRT would be able to meet demand on King George Blvd in all cases (and the peak load decreases due to travel patterns shifting). At a minimum the BAU alternative would be sufficient to meet demand on 104 Avenue.

Exhibit 4.16 – Peak Passenger Loads – Sensitivity to TDM (Automobile Cost) Assumptions (2041)



4.4 REDUCED TRANSFER PENALTIES

The tests on reduced transfer penalties produced varied effects on peak passenger loads, due to the specific locations where reduced transfer times were assumed.

Exhibit 4.17 shows peak passenger loads increasing on Fraser Highway with reduced penalties for alternatives BRT 1, BRT 2, LRT 5A and LRT 1 due to the increased attractiveness of transfers at Langley Centre, King George Station, and Surrey Central Station. In the case of either BRT alternative, the peak loads resulting from reduced transfer penalties are close to capacity at the peak point.

Exhibit 4.17 – Fraser Highway Peak Passenger Loads – Sensitivity to Reduced Transfer Penalties (2041)

The RRT result on Fraser Highway with lower transfer penalties was different: the peak load decreased on the new portion of the RRT. While the improved transfer in Langley Centre did attract more passengers, the new RRT segment southeast of King George Station had lower peak loads. Fewer passengers were boarding at stops in Fleetwood (where transfer penalties were the same as the base) because they were attracted instead by competing routes making now faster transfers at King George or Surrey Central stations. North of Surrey Central station on the existing Expo Line, the passenger loads were higher for RRT 1 with reduced transfer penalties than in the base case, as would be expected.

Exhibit 4.18 illustrates the effects of reduced transfer penalties on King George Boulevard. Due to more convenient transfers in Newton and King George Station, the peak passenger loads increase on all alternatives. The peak loads remain highest for BRT 1 and LRT 5A, which provide continuous service from South Surrey. BRT 2 and LRT 1 see greatest relative increase in peak loads on King George Boulevard (~10%, whereas BRT saw a 5% increase), however those alternatives still have a lower peak load on the corridor than alternatives with continuous service (BRT 1, LRT 5A).

Exhibit 4.19 illustrates the effects of reduced transfer penalties on 104 Avenue. In all cases, the reduced transfer penalties at Guildford Exchange and at Surrey Central produce a 10% increase in peak loads. In all cases, BAU would provide sufficient capacity to meet demand.

Exhibit 4.18 – King George Boulevard Peak Passenger Loads – Sensitivity to Reduced Transfer Penalties (2041)

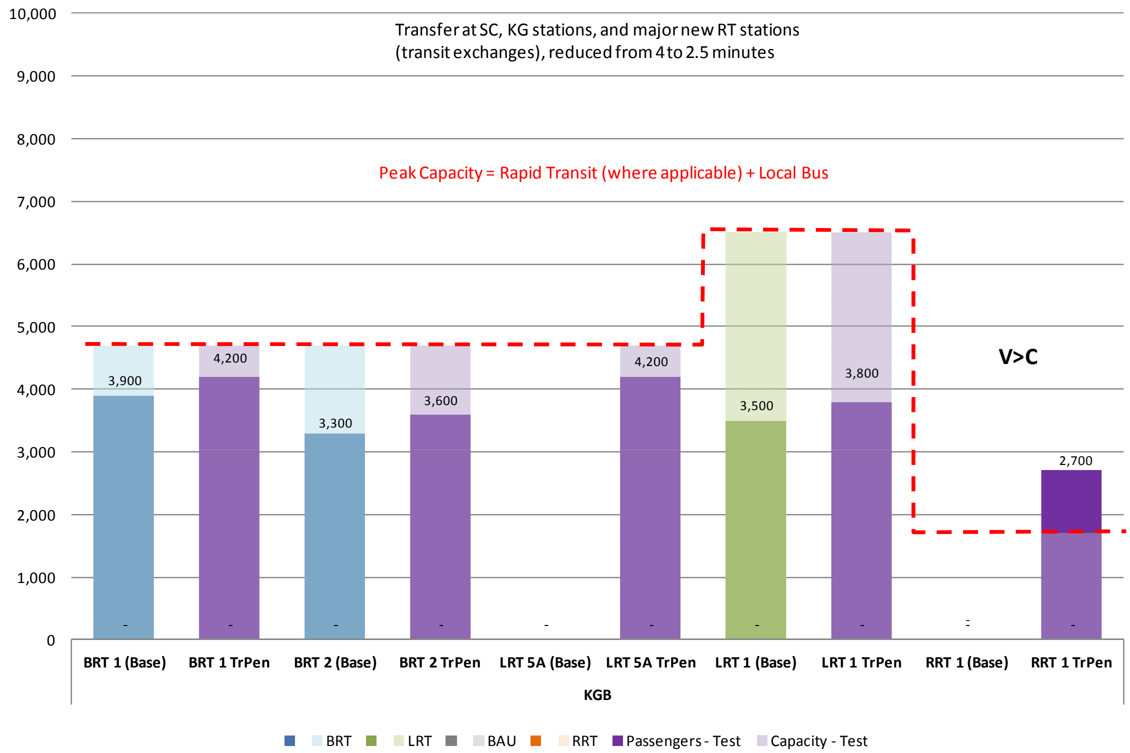
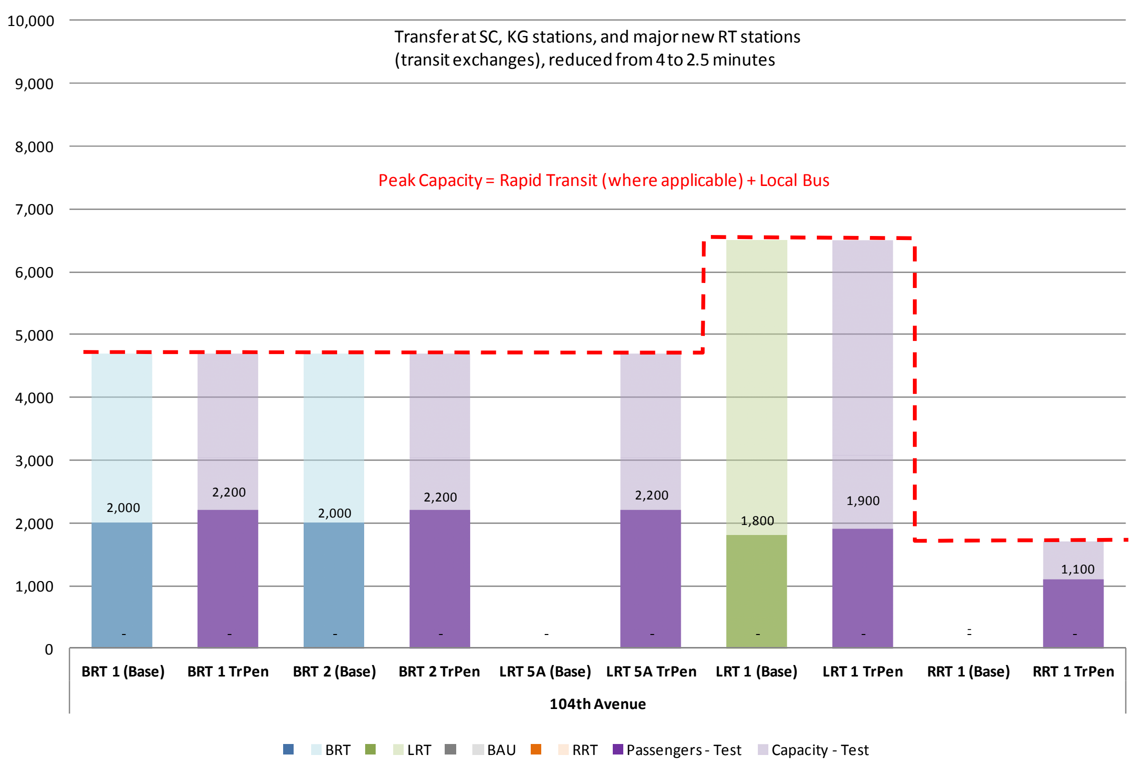


Exhibit 4.19 – 104th Avenue Peak Passenger Loads – Sensitivity to Reduced Transfer Penalties (2041)



4.5 SUMMARY FINDINGS – TESTS OF REGIONAL MODELLING ASSUMPTIONS

Large increases in auto operating costs reflected in the TDM test are forecast to have the largest effects on mode share (converging towards 20% transit mode share in both the study area and region), but a much smaller effect on peak loads. On Fraser Highway and King George Blvd, BRT plus local bus meets the 2041 forecast demand for both scenarios. For the TDM scenario, the peak load matched the BRT plus local bus capacity on Fraser Highway resulting in transit service in the corridor being at capacity. On 104 Avenue, BAU meets the forecast demand in both scenarios.

With the TDM test, trip patterns change regionally and within the study area, which is part of the reason transit mode share increases. Some of the peak passenger load points move to new locations compared to the base evaluation because of the differences in origin-destination patterns. Consequently, peak loads are generally a little higher than the base (but not as significant an increase as the mode share), but there are also some small reductions. However, along the Fraser Highway corridor capacity becomes a risk with BRT service .

With reduced transfer penalties, Fraser Highway continues to have capacity risks with BRT service, but no additional capacity risks were apparent, and the modelling results showed that some transit passengers have choices between transit routes that are influenced by a combination of travel time and transfer convenience.

5. FINANCIAL ANALYSIS ASSUMPTIONS

The tests carried out on the financial analysis assumptions highlight several risks and opportunities related to the costs and cost-effectiveness of the alternatives. The analyses use the methodologies outlined in Section 3.1 (Financial Account), with specific inputs changed for each scenario.

5.1 OVERVIEW

Exhibit 4.20 provides an outline of the financial analysis tests carried out. Some tests were applied to all of the alternatives since the travel demand model was not required.

Exhibit 4.20 – Financial Analysis Assumptions Tested

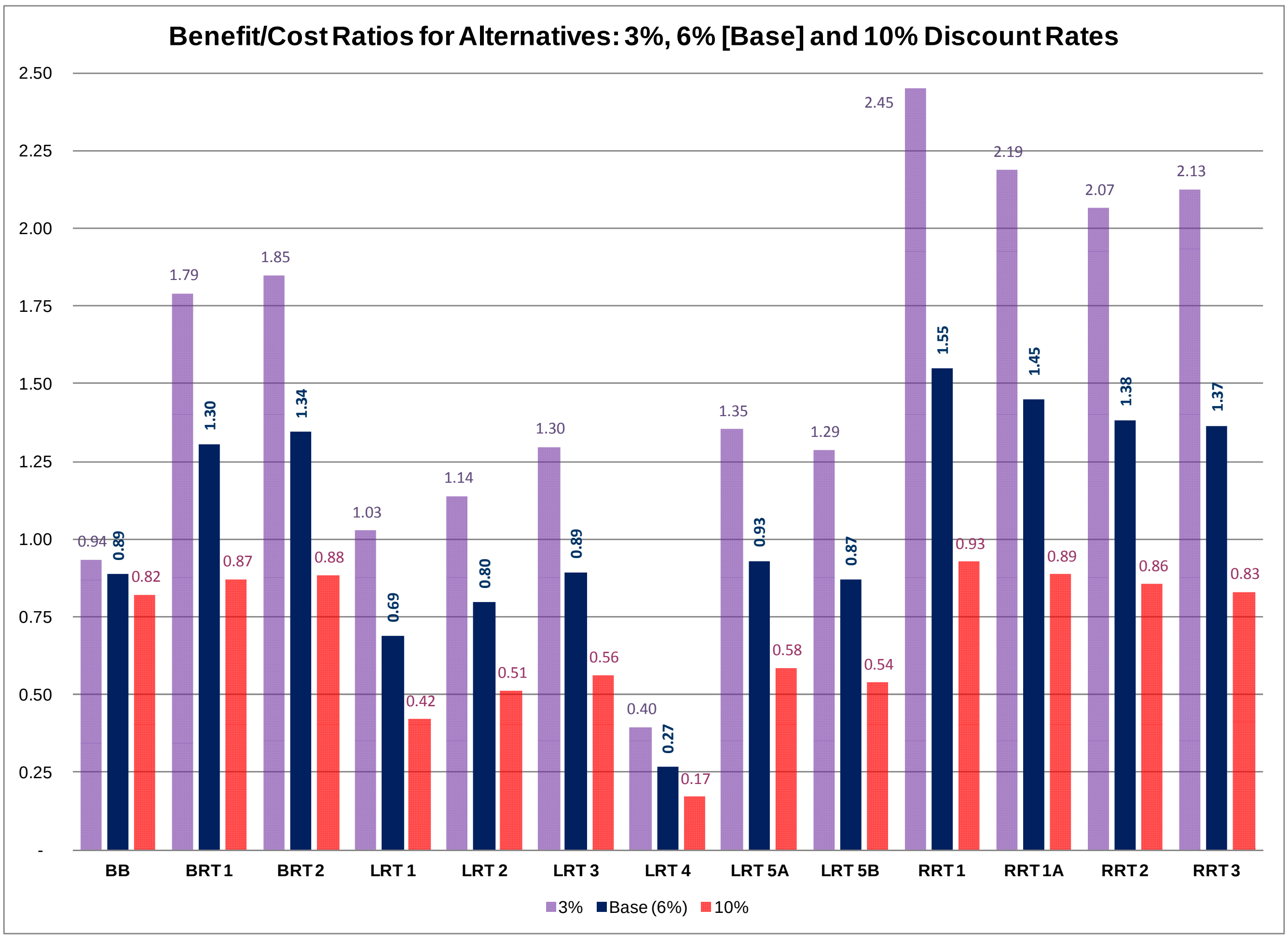
Scenario	BB	BRT	LRT	RRT	Assumption
Base (2041)	✓	✓	✓	✓	6% discount rate, all alternatives start operating in 2020
Discount Rate	✓	✓	✓	✓	Test of 3% and 10% discount rates
Implementation Timing	✓	✓	✓	✓	Alts. enter service different years (2017 to 2021), depending on complexity and size
Capital Cost Risk	n/a	BRT 1	LRT 5A	RRT 1	Assume higher costs for grading/ piling in poor soils e.g. through floodplains
Local Bus Integration		BRT 1	LRT 1, 5A	RRT 1A	Off-model financial analysis: reduced frequency of local bus service sharing the corridor with rapid transit
BRT Technology	n/a	BRT 1	LRT 5A	RRT 1	Off model financial and emissions analysis of different potential BRT fuel/power technologies

5.2 DISCOUNT RATES

In this financial test, the cash flows for both the costs (capital including vehicle renewals, plus operating and maintenance, minus net new fare revenue) and the monetized benefits (travel time savings, reliability and quality travel benefits, auto-related costs, GHG reduction credits) are converted to Net Present Value using a range of discount rates. The base evaluation used 6% as the discount rate, which is used by the Province of British Columbia for decision-making purposes, and is also commonly used across the North American public transit industry. Bracketing this, the Canadian Federal rate of 10% and the UK standard rate of 3% have also been tested. Higher discount rates tend to focus on shorter-term costs and benefits, while lower discount rates make a greater allowance for the longer term.

Exhibit 4.21 illustrates the Benefit-Cost Ratios that result from the use of the 3%, 6% and 10% rates for each of the alternatives. In this study, the discount rate assumption has a big effect on the benefits stream (especially travel time savings) because of the population and employment growth of the study area over a 30-year period. The rapid transit alternatives all show similar sensitivity to the discount rates, with no shift in their relative performance. The higher capital cost alternative showed the greatest range in changes to the BCR. Best Bus was an exception, showing little sensitivity to discount rates, because most of its costs are related to annual operations, as are its benefits; consequently, the alternatives that performed similar to BB at 6% did worse at 10% and better at 3%.

Exhibit 4.21 – Impact of Different Discount Rates on Benefit/Cost Ratios



5.3 IMPLEMENTATION TIMING

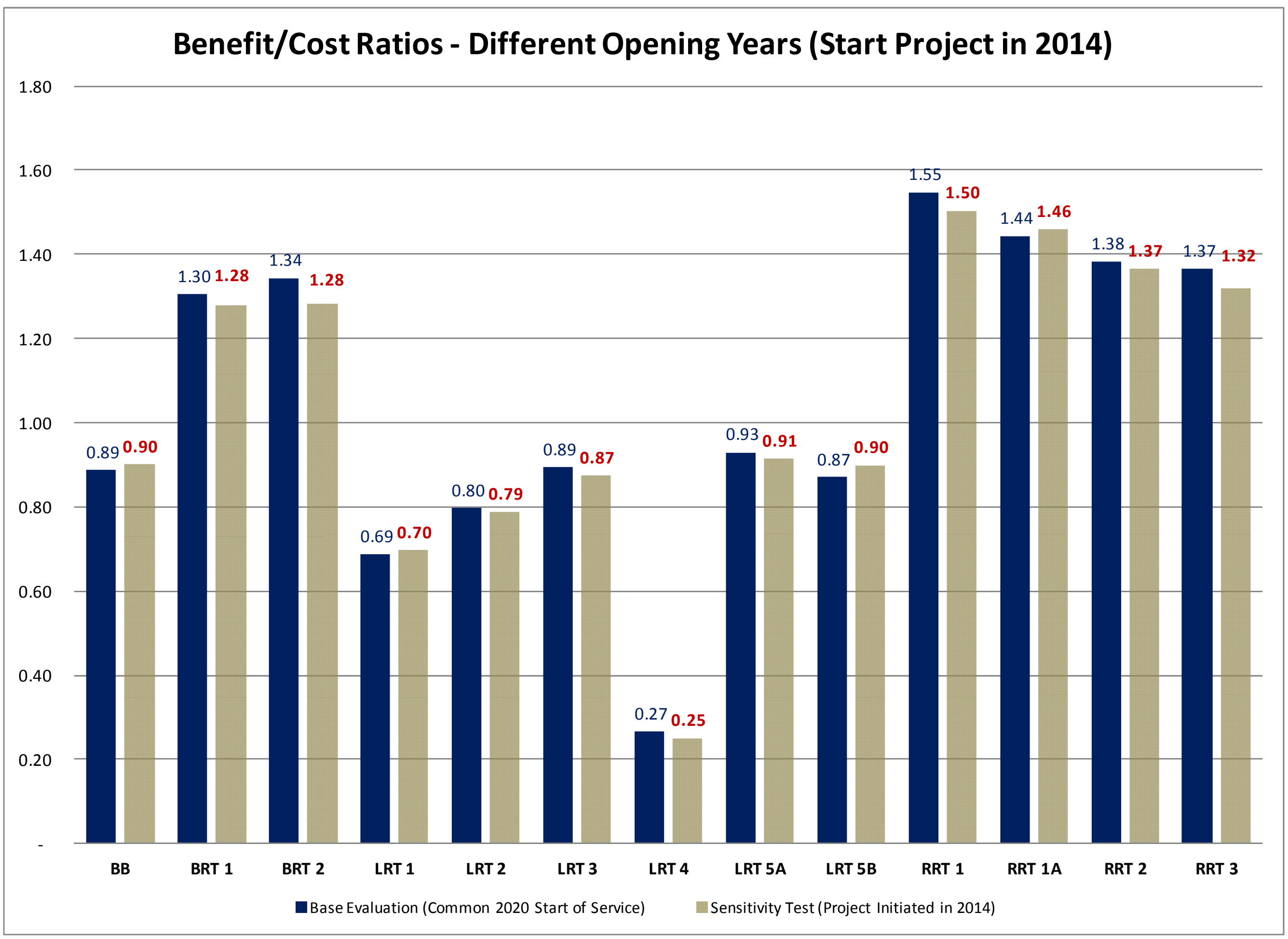
In this financial test, the cash flows for the costs and benefits have been modified to reflect different implementation timing. In the base evaluation, all of the alternatives are assumed to have the same 2020 to 2049 life cycle, with construction and vehicle procurement taking place through to 2019.

For this test, it is assumed that implementation starts in 2014, with final design, construction and procurement taking 2 to 6 years, with less complex alternatives commencing operations sooner. The following timetables were assumed:

- Implementation 2014-2016, operating 2017 to 2046: Best Bus (BB);
- Implementation 2014-2018, operating 2019 to 2048: BRT 2, LRT 4, and RRT 3;
- Implementation 2014-2019, operating 2020 to 2049: BRT 1, LRT 2, LRT 3, LRT 5A, RRT 1, and RRT 2;
- Implementation 2014-2020, operating 2021 to 2050: LRT 1, LRT 5B, and RRT 1A.

Exhibit 4.22 illustrates the Benefit-Cost Ratios that result from the modified implementation timing for all the alternatives. Alternatives with an earlier opening year (smaller, less costly alternatives) produce marginally lower B/C ratios because the thirty-year life cycle starts and ends sooner, and the larger benefits were later in the life cycle. Larger alternatives would start service one year later, resulting in higher BCR.

Exhibit 4.22 – Impact of Different Project Opening Years on Benefit/Cost Ratios



5.4 CAPITAL COST RISKS

The base cost estimates were developed based on conceptual designs, taking into account site visits and constructability issues review comprised of transit engineering, geotechnical, and environmental topics. Based on these reviews and on anecdotal evidence regarding construction of foundations, the alignment along Fraser Highway through the Serpentine floodplain may have higher potential for risk due to ground conditions (poor soils) that could require atypical treatments to support the rapid transit alignments. There is also an area of poor soils, coinciding with a high water table, in Langley Centre.

In the base evaluation, BRT and LRT construction in the floodplain assumed pre-loading of the same type as used for road construction, I with the transit alignment between the two directions of traffic and reinforced by the roadway. RRT construction assumed piles for column support in the soft ground, and part of the RRT alignment was offset from Fraser Highway.

This test assesses the relative impacts on overall project costs if the excavation and/or piling costs were to double because ground settlement was worse than expected. Within the floodplain (a distance of approximately 2.6 km along Fraser Highway), the impact would be:

- BRT/LRT capital cost increment of $15 million for the ALR (more excavation or mini-piles)
- RRT capital cost increment of $34 million more for deeper piles in the ALR.

In the City of Langley, the cost increments would be similar for all three technologies for the 700-metre bridge portion over the railway, and the remaining 1 km would vary at the same 1:2 ratio as in the ALR for street-level versus elevated construction.

- BRT/LRT capital cost increment of $15 million (deeper piles for the bridge and mini-piles for the rest of the segment); and
- RRT capital cost increment of $22 million more for deeper piles in Langley.

Exhibit 4.23 summarizes the net effects of these increases on the NPV of costs, and the BCR. Because of the unknowns regarding piling to support elevated columns, RRT 1 has the greatest risk, but this amount is only 3.5% higher than the base.

Exhibit 4.23 –Capital Cost Risks related to Construction in Poor Soils

Alternative	Scenario	NPV of Costs ($2010)	Benefit-Cost Ratio
BRT 1	Base	$818 M	1.30
	High Costs in Poor Soils	$840 M	1.28
	Difference	***+ $22 Million***	***-0.02***
LRT 5A	Base	$1,280	0.93
	High Costs in Poor Soils	$1,301	0.92
	Difference	***+$21 Million***	***-0.01***
RRT 1	Base	$1,256	1.55
	High Costs in Poor Soils	$1,298	1.51
	Difference	***+$42 Million***	***-0.04***

5.5 LOCAL BUS INTEGRATION/OPTIMIZATION

The purpose of the local bus integration test was to investigate potential cost savings from reducing future local bus service levels in the main study corridors (Fraser Highway, King George Boulevard and 104 Avenue). The test considered resizing the amount of local service on these corridors to match the estimated demand for transit in 2021 and 2041.

The base evaluation assumed 3.5 minute headways (in 2041) for the local bus routes on all three corridors, the same as BAU. However, the forecast future peak demand was lower on most corridors than the total combined capacity that would be available on rapid transit and local bus service. As a result, there would be potential opportunity to reduce the service levels provided by local buses to reduce costs.

Local Bus Frequency Modification

For the purpose of this test, the rapid transit headways were kept the same as in the base evaluation, and the frequency of the two local transit routes that follow the rapid transit were trimmed back so that total demand in 2041 would still be met in each corridor.

Exhibit 4.24 shows the resulting modified capacities in 2041 for each corridor, for several alternatives: BRT 1, LRT 1, LRT 5A, and RRT 1A. The objective of adjusting the local transit service was to estimate potential future capital and operating cost reductions due to lower service frequencies, which would require fewer transit buses and operators than the base evaluation assumptions. At the same time, capacity still needed to meet passenger demand, and remain within policy thresholds for frequent service. (Local service on 104th was the same route as King George Blvd, and so the demand on King George Blvd was the governing factor).

Exhibit 4.24 – Peak Capacity versus Passenger Demand with Local Bus Service Modified

Transit Corridors	BRT 1 (Base)	BRT 1 Mod. Local	LRT 1 (Base)	LRT 1 Mod. Local	LRT 5A (Base)	LRT 5A Mod. Local	RRT 1A (Base)	RRT 1A Mod. Local
King George Boulevard Passengers	3900	3900	3450	3450	3900	3900	3650	3650
Rapid Transit	BRT 2min	BRT 2min	LRT 3min	LRT 3min	BRT 2min	BRT 2min	BRT 2min	BRT 2min
Local Bus Headway	3.5 min	7.5 min	3.5 min	15 min	3.5 min	7.5 min	3.5 min	7.5 min
King George Boulevard Capacity	4710	3800	6510	5200	4710	3800	4710	3800
104th Avenue Passengers	2000	2000	1800	1800	1950	1950	1850	1850
Rapid Transit	BRT 2min	BRT 2min	LRT 3min	LRT 3min	BRT 2min	BRT 2min	BRT 2min	BRT 2min
Local Bus Headway	3.5 min	7.5 min	3.5 min	15 min	3.5 min	7.5 min	3.5 min	7.5 min
104th Avenue Capacity	4710	3800	6510	5200	4710	3800	4710	3800
Fraser Highway Passengers	4250	4250	4300	4300	4250	4250	6600	6600
Rapid Transit	BRT 2min	BRT 2min	LRT 3min	LRT 3min	LRT 3min	LRT 3min	RRT 4.6min	RRT 4.6min
Local Bus Headway	3.5 min	5 min	3.5 min	15 min	3.5 min	15 min	3.5 min	15 min
Fraser Highway Capacity	4710	4200	6510	5200	6510	5200	10190	8900

The local bus service modifications in the test included:

- For corridors with RRT or LRT, the rapid transit capacity alone exceeded total corridor demand. Therefore, the assumed frequency of local bus was reduced from 3.5 minutes to a Frequent Transit Network policy threshold of every 15 minutes;
- For corridors with BRT, part of the local bus service was required to meet corridor demand, and the reductions were more modest:
    - On Fraser Highway, it was found for 2041 that a frequency of approximately 5 minutes matched total capacity more closely to demand (instead of 3.5 minutes);
    - On King George Boulevard and 104 Avenue, approximately 7.5 minutes local service (instead of 3.5) would more closely match demand in 2041.

For this test, the same changes were also applied for 2021: local bus service was reduced from 5 minutes to 15 minutes for RRT and LRT, and reduced from 5 minutes to 7.5 minutes on King George Blvd/104.

Financial Outcome of Local Bus Frequency Reduction

The reductions in service frequency result in reduced operating costs, and also offset the capital costs for buses. The key points of the financial analysis included:

- For BRT 1, reductions of 8 and 29 peak period buses, respectively, in 2021 and 2041. This results in capital cost reductions of $15 million before opening year (8 fewer local buses to meet 2021 service levels), and $39 million less cost for additional buses (21 fewer future buses) to expand service to 2031/2041 levels.
- For BRT 1, the annual O&M reductions were estimated at $4 million and $13 million per year. (Other years would be interpolated/extrapolated from these values.)
- LRT 1 would have reductions to 15 minutes on all three corridors, and therefore the largest savings in buses (31 in 2021, 52 by 2041). The resulting capital savings were $58 million for initial buses and $39 million for additional buses. O&M reductions from the case were estimated at $16 million and $24 million per year.
- LRT 5A would have the more modest BRT-related reductions on King George Blvd/104 and the higher LRT-related reductions on Fraser Highway. The result was a savings in peak buses of 22 in 2021 and 43 in 2041. The resulting capital savings were $41 million for initial buses and $39 million for additional buses. O&M reductions from the case were estimated at $11 million and $20 million per year.
- RRT 1A would have the same local bus cost reductions as LRT 5A, because the local bus frequency for LRT or RRT on Fraser Highway would be the same, and both alternatives feature BRT service on King George Blvd and 104 Avenue.
- With local transit operating less frequently, the result would be lower travel time benefits for some passengers; these were not considered through this test.

Exhibit 4.25 summarizes the potential financial benefits of optimizing local transit service that operates in the rapid transit corridors. In each case, operating the local buses at somewhat lower frequency once rapid transit is in place produced a cost offset relative to the base evaluation, where local headways were unchanged. The Benefit-Cost Ratios of each alternative improve, with greater sensitivity if both corridors are affected, and the alternative has lower capital costs in the base evaluation.

Exhibit 4.25 – Potential Financial Impact of Local Bus Service Modifications

Alternative	Scenario	NPV of Costs ($2010)	Benefit-Cost Ratio
BRT 1	Base	$818 M	1.30
	Optimized Local Transit	$724 M	1.47
	Difference	***- $94 Million***	***+0.17***
LRT 1	Base	$1,628	0.69
	Optimized Local Transit	$1,404	0.78
	Difference	***-$224 Million***	***+0.09***
LRT 5A	Base	$1,280	0.93
	Optimized Local Transit	$1,105	1.07
	Difference	***-$175 Million***	***+0.14***
RRT 1A	Base	$1,668	1.45
	Optimized Local Transit	$1,493	1.60
	Difference	***-$175 Million***	***+0.15***

These cost savings are estimated relative to assumed future bus service levels, around which there is uncertainty, and the values are intended as an order-of-magnitude estimate based on current plans. Further analysis will be required in a later project phase to identify optimal bus service levels.

5.6 BRT TECHNOLOGY

The base evaluation of air emissions shows that most alternatives have a benefit in reducing GHG emissions by reducing automobile usage, but for alternatives with a large BRT component, the amount of bus service being added contributed to increases in emissions that offset much of the savings. Part of the reason for this is the assumed GHG emission rates for bus and BRT in the base evaluation are nearly the same from 2008 in 2021 and 2041; whereas private vehicle emission rates are assumed to drop significantly compared to 2008. The result is the BRT component of alternatives produced an increase in GHG while the benefits of VKT reduction became less significant over time.

The emission rates for transit buses were very conservative because better technologies are still emerging. This test considers several different fuel/power sources for BRT vehicles that could produce lower emissions than clean diesel power, as assumed in the base evaluation:

- Hybrid electric/diesel;
- Electric battery; and
- Hybrid electric-fuel cells.

Diesel buses are the most common technology and are used worldwide, including in Greater Vancouver. Hybrid electric-diesel buses are starting to gain market share in North America and are likely to form a larger part of future transit vehicle purchases. Electric battery and fuel cell vehicles are less common and generally focused on special transit systems and smaller operations. To date there is little practical knowledge of these technologies in high-capacity heavy usage applications.

Exhibit 4.26 summarizes broad indicators relevant to this analysis for this range of vehicle types, including capital costs, operating and fuel costs, and the typical reductions in GHG emissions, all expressed relative to diesel buses. These values are based on 2010-2011 research for Transport Canada (Transportation Emissions Calculator, by IBI Group) and recent reports published by the Transit Cooperative Research program (TCRP) in the United States.

Exhibit 4.26 – Relative Costs and Emissions for Alternative Fuel/Power BRT Vehicles

Vehicle Types	Capital Cost Effect	Op. Cost (/hr)	Fuel & Maint'ce (per km)	GHG Emissions*
Base (Diesel)	100%	100%	100%	100%
Hybrid Elec-Diesel	130%	100%	105%	75%
Electric Battery	115% + 10 year life	100%	60%	60% (typical for No.Amer., depends on electricity supply source**)
Hybrid Elec-Fuel Cell	200 to 300%	100%	140%	16%

*Including fuel production and transportation — Derived from TCRP Rpt. 146

** Hydro power in BC produces relatively low GHG per unit of energy

As indicated in Exhibit 4.26, the different BRT vehicle types would have higher capital costs than diesel, the same per-hour operating cost , and generally higher maintenance and fuel costs. However, based on the evidence to date, average fuel and maintenance costs for electric buses are lower per kilometre, largely due to fuel cost savings. There is some uncertainty due to developing technologies not in wide usage yet (such as electric battery and fuel cell), and the limited number of vehicles is possibly a factor in the comparative costs in the exhibit.

Also, the GHG emissions per unit of local energy will vary depending on the power source for electricity. Electrical power in British Columbia is hydro-based, with the emissions largely related to constructing and maintaining the power facilities, not directly to power production. Therefore, emissions in BC for these bus types may be even lower than estimated.

Exhibit 4.27 shows the potential impact of different technologies on the net GHG emissions of the alternatives. With construction-related and private vehicle emissions held constant within each alternative, the differences shown relate to the BRT vehicle emissions, which would decline for each type of fuel. No change applied to RRT 1 since it does not feature any BRT service.

Exhibit 4.27 – Impact of BRT Vehicle Technology on Net Life Cycle GHG Emissions

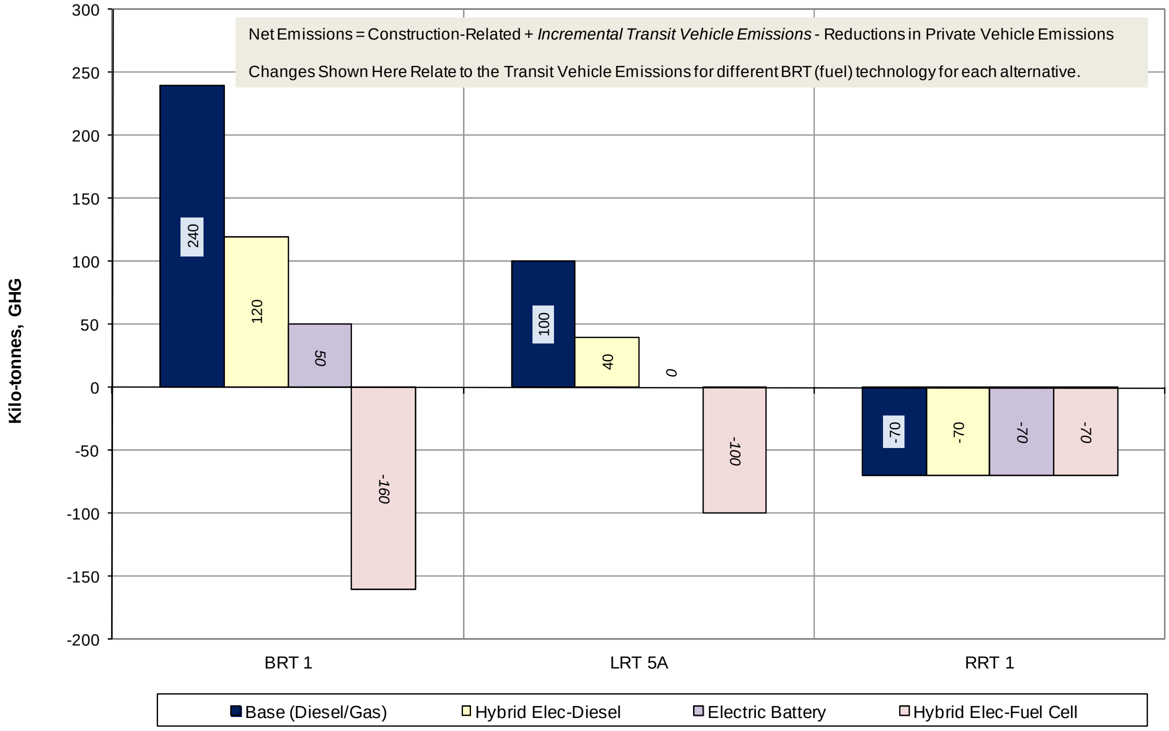
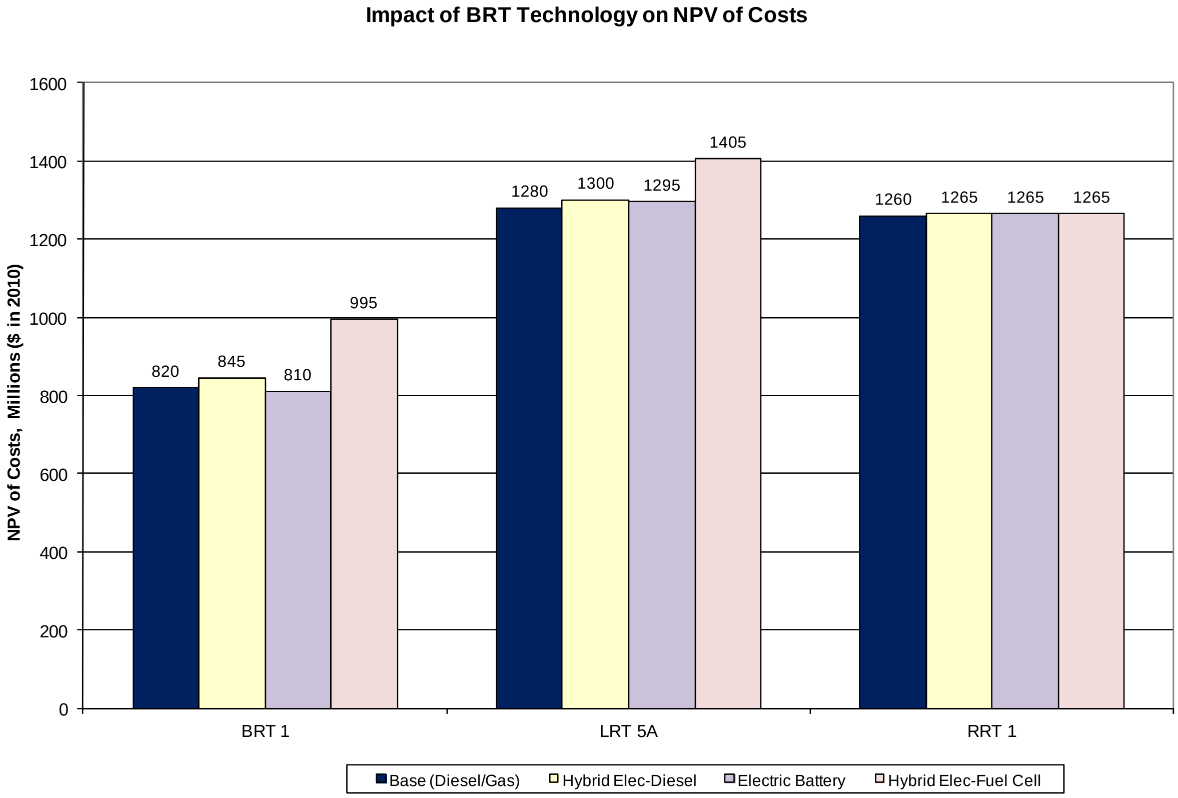


Exhibit 4.28 summarizes the estimated Net Present Value of life cycle costs (6% discount to 2010) for BRT 1, LRT 5A and RRT 1, assuming each of the different fuel/power sources for BRT. As before, RRT 1 shows no change because this sensitivity test considers only BRT vehicles. With the exception of fuel cells, which are the most uncertain at this time, the NPV of costs would increase modestly for the alternate bus types.

Coupled with the potential to reduce GHG emissions, further consideration of these developing technologies appears to be warranted in a later phase of this study.

Exhibit 4.28 – Impact of BRT Vehicle Technology on NPV of Costs



5.7 FINANCIAL TESTS – SUMMARY OF FINDINGS

Overall, the financial tests had little effect on the comparative performance of the alternatives. Several promising topics were identified for possible consideration in the next phase of the study. The main findings from the sensitivity tests on the financial assumptions are as follows:

- ***Discount Rate***. The Benefit-Cost Ratios for the alternatives tended to converge with higher discount rates, little change in relative performance. Lower discount rates made the BCR increase, due mostly to higher present values of long-term benefits. Best Bus showed the least sensitivity due to most of its costs being annual operations and maintenance.
- ***Implementation Timing.*** Assuming earlier opening years for less complex alternatives reduced their BCR. Costs and benefits are both discounted less if the life cycle is earlier, but benefits have less opportunity to grow. The results did not affect the comparison between alternatives.
- ***Capital Cost Risks***. Construction costs through the floodplains and high water table areas of Langley are subject to risk due to the ground conditions (due to poor soils), but the potential increase would be only 3-4% of the base evaluation capital costs. Since most alternatives carry this risk, there was no change in comparative performance.
- ***Local Bus Integration/Optimization***. There is potential to reduce local bus service relative to BAU to better match demand in all of the alternatives. This would reduce the Present Value of costs and would increase the BCR, with the greater NPV reductions to LRT and RRT alternatives, and greater relative benefit (BCR improvement) to lower cost alternatives.

- ***BRT Technology.*** Alternative BRT fuel/power source technologies could reduce GHG emissions with potentially modest impacts on lifecycle costs, though there is a high degree of uncertainty as to performance of the alternative rapid transit vehicles. Emission reduction was not a differentiator between alternatives in the base evaluation or in this test.

The financial tests supported the findings of the base evaluation, and also provided initial insights into several areas where costs may increase or decrease due to local conditions. It also uncovered design decisions to be made in subsequent phases of this study regarding the alternatives and connecting transit networks.

6. IMPLICATIONS OF SENSITIVITY TEST OUTCOMES

In summary, the sensitivity tests investigated the performance of the alternatives when land use, transportation, model assumptions and financial inputs were varied from those used in the base evaluation. While the specific results from the tests varied from the base evaluation, the relative performance of the alternatives remained consistent with the ratings in the Evaluation Report (except for the financial performance of BB, which was less sensitive than other alternatives). The tests did identify some design risks and avenues for further development of the alternatives in a later phase, as discussed below.

The model-based tests considered variations to land use and transportation inputs, and broad modeling assumptions. **Exhibit 4.29** summarizes the test results. The key outcomes of the tests included the following:

- Rapid transit fleet size and operating assumptions in the base evaluation were robust, with respect to the land use and transportation variables and provided sufficient capacity, except for BRT in certain scenarios.
- The tests confirmed the importance of rapid transit on Fraser Highway and King George Boulevard in order to provide adequate transit capacity, since BAU service levels had insufficient capacity to meet future demand projections.
- Mode share and peak load results were sensitive to South of Fraser background bus network assumptions (especially on Fraser Highway). The results were also sensitive to population and employment growth assumptions, with the greatest effect (+/-) on Fraser Highway because the base demand was close to BRT capacity.
- BRT would meet forecast long term demand on Fraser Highway in most scenarios, with 3 exceptions (high population/employment growth, low background transit, and low background transit + high growth). BRT would meet forecast long term demand on King George Boulevard in all but 1 scenario (low background transit + high growth). BAU would meet forecast long term demand on 104 Ave in all scenarios.

Variations in the financial assumptions did not affect the relative financial performance of the alternatives (Best Bus was relatively insensitive so some of the LRT results that were close to its BCR sometimes went higher or lower; otherwise, the cost-effectiveness changed but the better performing alternatives remained the same). The results of the tests, as summarized on **Exhibit 4.30**, suggested that further investigation into two topics would be warranted in the next phase of the study, to optimize the design of any alternative carried forward from this study. Areas of further study include:

- Reviewing the potential to improve GHG emissions based on alternative BRT fuel/power source technologies.
- Taking advantage of the potential to achieve operating cost savings based on optimized local bus service, through development of a detailed bus integration plan.

The outcomes of the sensitivity tests, both overall and within each corridor, were taken into consideration in the study findings.

Exhibit 4.29 – Results: Summary of Sensitivity Analyses (Modelling-Based)

(Study Area Transit Mode Share, Ability of Planned Capacity to Meet Peak Corridor Demand)

Category	**Land Use**				**Transportation**				**Regional Modelling**		
Test	**Base**	**High Growth**	**Low Growth**	**Base Prime**	**Base**	**Lower Back-ground Transit**	**Lower Transit/ High Growth**	**Reduced Transit Priority***	**Base**	**Travel Demand Mgmt. (TDM)**	**Reduced Transfer Penalties**
Description	2041 Regional Growth Strategy	Growth 10 yrs earlier (add 10 yrs growth to 2041)	Growth 10 yrs later (2031 values in 2041)	Allocation to urban centres modified; e.g. more growth by 2041 on 104 Avenue	South of Fraser ATP: 3.5% annual service increase to 2041	Slower 2.5% annual service increase to 2041	Slower 2.5% annual bus service increase; and 10 years added to 2041 land use	reduced probability of encountering green signal (TSP benefit)	2041 Regional Growth Strategy, Transport 2040 Network	Increase auto operating, parking costs 150%	Reduce transfer time at rapid transit exchanges by 40%
BAU	14.5% Fraser Hwy, KGB over capacity	15.5% Fraser Hwy, KGB over capacity	13.7% Fraser Hwy, KGB over capacity	14.6% Fraser Hwy, KGB over capacity	14.5% Fraser Hwy, KGB over capacity	13.1% Fraser Hwy, KGB over capacity	NA	14.5% (no TSP assumed in BAU)	14.5% Fraser Hwy, KGB over capacity	18.7% Fraser, KGB over capacity	14.5% KGB over capacity
BRT 1	15.1%, all corridors within capacity	16.1% Fraser Hwy at/over capacity	14.2% all corridors within capacity	15.2% all corridors within capacity	15.1% all corridors within capacity	13.8%, Fraser over capacity and KGB near capacity	Transit trips exceed capacity on Fraser Hwy, KGB	15.1% 3% decrease in travel time saved	15.1% all corridors within capacity	19.3% all corridors within capacity	5% to 10% peak volume increase, within capacity
LRT 5A	15.1% all corridors within capacity	16.1% all corridors within capacity	14.2% all corridors within capacity	15.2% all corridors within capacity	15.1% all corridors within capacity	13.8% KGB demand near capacity	NA	15.1% 4% decrease in travel time saved	15.1% all corridors within capacity	19.3% all corridors within capacity	5% to 10% peak volume increase, within capacity
RRT 1	15.2%, KGB over capacity (as in BAU)	16.1% KGB over capacity (as in BAU	14.2% KGB over capacity (as in BAU	15.2% KGB over capacity (as in BAU	15.2% KGB over capacity (as in BAU)	13.8% KGB over capacity (as in BAU)	NA	No change	15.2% KGB over capacity (as in BAU)	19.4% KGB over capacity (as in BAU)	5% to 10% peak volume increase, KGB over capacity (as in BAU)

*Financial impact of reduced transit priority was also assessed: BCR reduces in line with decreased travel time savings (-3% for BRT, -4% for LRT)

Exhibit 4.30 – Summary of Financial Sensitivity Analysis Results

(Impact of Tests on Benefit-Cost Ratio)

Test	Base	Discount Rate	Implementation Timing	Capital Cost Risk	Local Bus Integration	BRT Power Technology
Description	6% discount rate, 2020 opening year, clean diesel for BRT	3%, 10%	Opening years between 2017 and 2021	Floodplain cost risk due to poor soils	Increase local bus headway to match demand (and not exceed FTN guideline of15 minutes)	Hybrid, Battery, Fuel Cell options instead of clean diesel
BAU		N/A	N/A	N/A	N/A	N/A
BB	BCR 0.89	BCR 0.94 - 0.82	BCR 0.90 (small increase)	N/A	N/A	N/A
BRT 1	BCR 1.30	BCR 1.79 - 0.87	BCR 1.28 (small decrease)	Potential 2.6% cost increase BCR 1.28	Potential $90m NPV saving BCR 1.47	Fuel cell lowest GHG, highest cost Hybrid-electric diesel and battery have small cost increase, lower GHG
LRT 5A	BCR 0.93	BCR 1.35 - 0.58	BCR 0.92 (small decrease)	Potential 1.6% cost increase BCR 0.92	Potential $170m NPV saving BCR 1.07	
RRT 1	BCR 1.55	BCR 2.45 - 0.93	BCR 1.50 (small decrease)	Potential 3.1% cost increase BCR 1.51	*See note.*	

Note: Local bus integration test was also carried out for LRT 1 and RRT 1A. For LRT 1, potential savings were $220 million, and BCR increase from 0.69 to 0.78. For RRT 1A, savings of $170 million and BCR increase from 1.45 to 1.60.