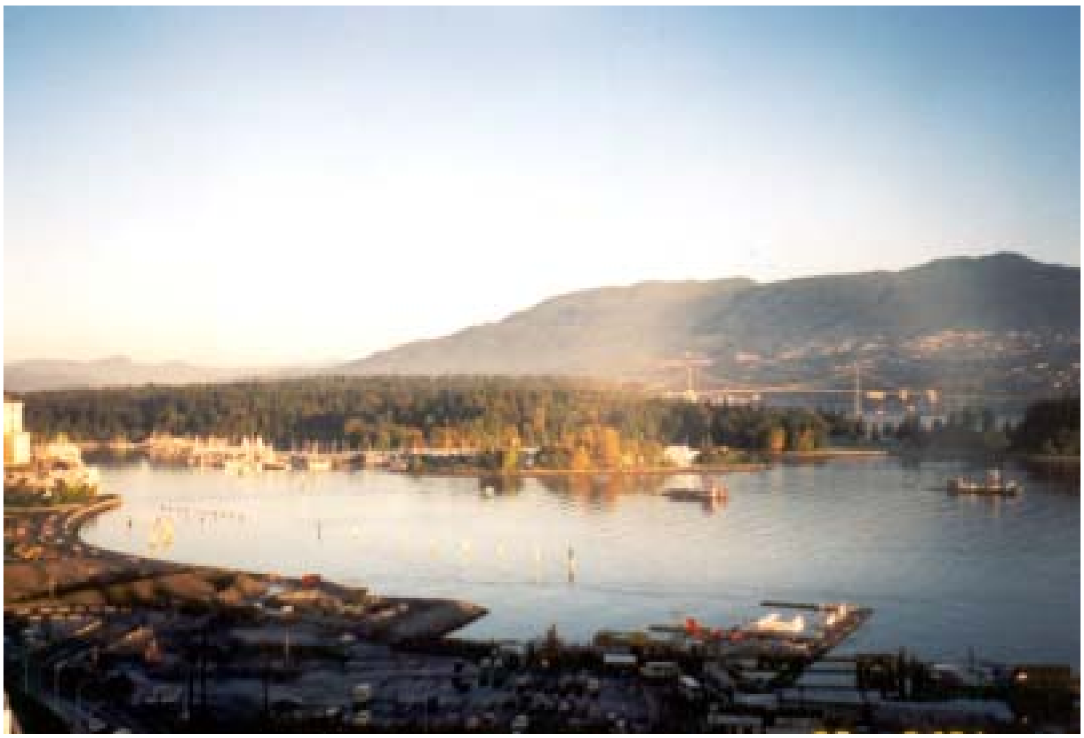
HIGHER SPEED PASSENGER RAIL

VANCOUVER TO WHISTLER



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Higher Speed Passenger Rail

Vancouver to Whistler

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Executive Summary

This report set out to examine the potential for establishing Higher Speed passenger rail service between downtown Vancouver and Whistler, what the order-of-magnitude costs for building and operating such a service and finally what level of ridership would be needed to bring a Return on Investment of 15%, after tax.

Four Options were examined, each one an incremental improvement over the previous Option. The final Option 4 is one that was to provide a competitive running time to the automobile in this corridor and one that could provide a schedule running time of close to 1 hour and 30 minutes.

Three different types of equipment were simulated in the corridor. RDC's which are the current passenger rail rolling stock used by BC Rail are about 50 years old and is considered outdated by today's standards but was simulated to give a comparison to the rest of the considerations. Bi-Level cars like those used by West Coast Express are a modern version of the high capacity commuter car most commonly used in North America. The Acela is a new compliant passenger train that has the capability to tilt through curves and by so doing achieves a higher corridor speed than the RDC or the Bi-level trains.

Terminal stations considered where the Creekside station in Whistler and either the Waterfront or Pacific Central Stations in Vancouver, depending on the option assessed. Intermediate station vary slightly with each option but in most cases include a second stop in Vancouver, North Vancouver, Horseshoe Bay, Lions Bay, Porteau Cove/Furry Creek and Squamish.

The obvious barrier to a competitive running time in the corridor is the presence of Burrard Inlet and the rugged nature of the countryside between North Vancouver and Whistler. Options 1 and 2 utilize existing tracks of BC Rail, CN Rail, BNSF and in the case of Option 2 the CP. Neither of these two Options can provide a competitive schedule time as they offer a total trip time in the neighbourhood of 3 hours and 15 minutes.

Option 3, which utilizes a 4.3 mile tunnel between North Vancouver and Vancouver reduces the total trip time to 2 hours and 7 minutes from Waterfront Station, when tilting equipment is utilized. This Option, because of its station stop in North Vancouver and at Waterfront and Pacific Central in Vancouver is quite competitive for the long distance trip users but not with the commuter in the Squamish to Vancouver portion of the corridor.

Option 4 contemplates a 10.1 mile tunnel commencing just south of Pacific Central Station, with subway type stations at Pacific Central and Waterfront, and the northern tunnel portal is just south of the existing tunnel leading to Horseshoe Bay. Between Horseshoe Bay and Whistler there are a further 15.2 miles of tunnels required plus track

straightening of a further 4.4 miles. With 4 intermediate stops and using tilting trains Option 4 will have a total trip time of 1 hour and 41 minutes from Waterfront Station. However, if trains were allowed to operate express from Waterfront Station to Whistler the total trip time is reduced to 1 hour and 33 minutes or an average speed of 47 miles per hour. Option 4 is a competitive service in the corridor for both commuters and tourists.

It is the opinion of this report that to achieve a total trip time of about 1 hour, between the two terminal stations, requires the average speed to increase to around 74 mph with only one intermediate stop at Squamish. This would result in between 60% and 80% of the total distance being in a tunnel and would not be acceptable to the patrons of the service resulting in very poor ridership. The capital cost would increase to well over $2 billion.

To determine the magnitude of investment that should be made to improve the rail service in this corridor requires a top quality ridership and revenue forecasting study to be undertaken by a qualified firm using this report as a guide in the type of service that can be offered. When this information is obtained it will then be appropriate for the public sector to consider what kind of Public/Private/Partnership arrangement might be achievable to upgrade the rail passenger service in the Vancouver to Whistler corridor.

I Background

The BC Ministry of Transportation and Highways, early in 2001, released a study titled "Highway 99 North Corridor Transportation Study" that reviewed demand-based scenarios and options in the Sea-to-Sky corridor from Vancouver to Whistler and further north.

One of the options considered was the passenger rail potential in the corridor. Three potentially viable levels of rail investment, each with different performances and costs, were examined. Following government department reviews the "median investment" level of package improvements was selected as the most likely to provide a cost-effective option, and hence suitable for further analysis.

The Medium Rail Investment Scenario focuses on increasing passenger capacity in the corridor through substantially expanded passenger rail service. Expansion would be concentrated on relieving peak period travel demand for both commuter and recreational traffic.

The rail service would be substantially increased with the use of 100 bi-level passenger cars, each seating approximately 150 passengers (similar to West Coast Express trains), operating in up to 10 train sets. Five return trains per day to Squamish and/or Whistler would be provided. Four of these trains would operate in the peak period travel demand and one in mid-day, with the schedule and service configuration depending on the day of week and season. One train per day would run past Whistler to Lillooet, replacing the Caribou Prospector service now in operation.

This scenario also required investment in rail infrastructure including the installation of a Central Train Control (CTC) system, track protection in rock-slide prone areas and in road/rail level crossing improvements. No major investment to reduce the travel time by train (currently 2 hours and 35 minutes) from North Vancouver to Whistler was considered. For the purposes of this Higher Speed Passenger Rail study the Medium Rail Investment Scenario will be referred to as the "Improved Rail Option".

Major constituents in the corridor have requested that the rail option be given further consideration and have specifically asked that "High Speed" passenger rail service be assessed. They are interested to understand what would be required to provide a frequent passenger rail service that is competitive in travel time, with the automobile, from downtown Vancouver to Whistler or in fact be substantially shorter.

II Scope of Services

To be competitive with the automobile it will be necessary to assess technologies and infrastructure that can make the trip from downtown Vancouver (Waterfront Station) to Whistler, including intermediate stops, in about 1 hour and 30 minutes. This is considered a “Higher Speed” scenario whereas a “High Speed” scenario is one where train speeds exceed 125 mph. It will also be necessary to consider how passenger trains are to get from BC Rail’s North Vancouver Station to Vancouver.

The client wishes the consultant to examine the feasibility of providing a “Higher Speed” passenger rail service from downtown Vancouver to Whistler and the order-of-magnitude of capital and operating costs to firstly build the rail corridor and secondly to operate the passenger rail service.

Operating Options

The Consultants will assess the following passenger rail options:

1. The Improved Rail Option with its southern terminus for passenger rail being extended via existing trackage over the Second Narrows Railway Bridge to the Pacific Central passenger rail station of VIA Rail;
2. The Improved Rail Option with its southern terminus for passenger rail being extended via existing trackage over the Second Narrows Railway Bridge to the Waterfront Commuter Rail station of West Coast Express;
3. The Improved Rail Option with a new direct cross-harbour tunnel connecting between the North Shore and both Waterfront Station and Pacific Central Station;
4. A Higher-Speed Rail Option with speeds up to 130 km/h (80 mph) between Whistler and downtown Vancouver, with potential stops at both Waterfront Station and Pacific Central Station. The consultant will use its judgement and expertise to choose a practical alignment to meet the given design criteria.

Only one alignment per Option is to be included in each assessment and each Option will need to include the following elements and parameters:

- In addition to the terminus stations in Vancouver and Whistler there should be stops in Squamish, Porteau Cove/Furry Creek, Lions Bay, Horseshoe Bay and North Vancouver;
- Reasonable ability for Amtrak passenger rail service from the Canada/USA border to run directly through to Whistler;
- Ability to accommodate freight trains connecting between North Vancouver and downtown Vancouver using grades of no greater than 1.5%; a comparison alternative showing the impact of using 2% maximum grade; ventilation requirements for all tunnels will be considered to accommodate diesel power.

- maximum grade for Squamish to Whistler to be 1.5%;
- Preliminary order-of-magnitude capital cost estimate for each option (no environmental, geotechnical, land acquisition issues to be considered)
- Preliminary order-of-magnitude operating cost estimate for a passenger rail service of 5 return trips per day for each option;
- An estimate for each option of the number of passengers required to return a 15% Internal Rate of Return based on operating costs only.

III Methodology

The approach taken for this high level evaluation of the four passenger service options included the following basic steps:

- Determine train running time using TPC modeling (Train Performance Calculator)
- Adjust track alignment, as necessary, to achieve run time objectives
- Develop service design to determine required number of train sets to provide the targeted 5 departures per day each way, in addition to crewing requirements.
- Develop order-of-magnitude capital and operating cost estimates
- Determine minimum ridership to achieve threshold return on investment targets

In order to complete this pre-feasibility study, within the given time and budget constraints, every effort to make best use of available data was made. Pertinent data on track characteristics, rolling stock performance and operating and capital costs was obtained from railways, suppliers, and from previous studies.

The approach used for each given operating scenario was comprised of the following basic steps:

- Identify the route and intermediate stations
- Obtain right-of-way specifications including: grades; curves; elevations; timetable speeds; track standards; location of tunnels and bridges
- Identify suitable passenger equipment type to be evaluated.
- Develop new track speeds, as necessary, in accordance with rolling stock performance specifications

With the above information, TPC's were run for each of the four options. The TPC model is commonly used in the railway industry to predict train performance on a given route based on a set of operating characteristics for the train including weight, power, adhesion, braking and fuel consumption factors. All track characteristics, as noted above, as well the location of station stops, are also factored into the model calculations.

In all scenarios, most practical use was made of existing rail infrastructure and alignment in order to minimize capital investment. Track realignment and tunneling was considered only as necessary to achieve the stated running time objectives for Options 3 and 4.

In the absence of specific performance criteria for rolling stock options, adjustments were made to existing TPC data files of comparable equipment to provide a reasonable representation of expected train performance.

A standard operating allowance of 5% was added to TPC minimum run times to account for normal railway operating inefficiencies and opposing train meets. Allowance for dwell time of 2 minutes per intermediate station was added. It has been assumed that the proposed enhanced passenger service would be given priority over conflicting freight traffic for mainline movements. A detailed line capacity study of the future freight and passenger traffic mix on the proposed routes will need to be done in the next stage of project development. This should be done to ensure there is sufficient track capacity in place to ensure adequate performance of all affected traffic.

For each scenario, TPC's were run for a number of rolling stock options. However, operating cost estimates were only developed for those options determined to be practical for further consideration.

Train Service Scenarios - Analysis Summary

Scenario	Equipment	Consist	Run Time	Costing
Option 1	RDC	10 units	X	
	WCE (Bi-level)	2 units; 10 cars	X	X
	Tilting Body	2 units; 10 cars	X	
Option 2	RDC	10 units	X	
	WCE (Bi-level)	2 units; 10 cars	X	X
	Tilting Body	2 units; 10 cars	X	
Option 3	RDC	10 units	X	
	WCE (Bi-level)	2 units; 10 cars	X	X
	Tilting Body	2 units; 10 cars	X	X
Option 4	Tilting Body	2 units; 10 cars	X	X

Only diesel powered options were considered for the proposed service in consideration of the prohibitive cost to install the required catenary and power distribution system to support equipment electrification. In addition, the stated requirement to enable standard diesel-electric powered AMTRAK trains to operate over the same routes necessitated that all tunnel systems be designed to meet the ventilation requirements of diesel-electric locomotives. Hence, the tunnels were designed and cost estimated accordingly.

Alternative alignments and tunnel options were designed and analysed only with regards to their impact on running time performance and cost. Factors such as geotechnical conditions, land availability & acquisition costs, environmental constraints and remediation costs were not factored into consideration at this stage of project development.

It was initially considered that any new cross-harbour tunnels would be shared between freight and passenger use. However it was later decided by the client and consultant to limit the operation to passenger service only, since the gradients required to accommodate freight train service imposed insurmountable constraints on the necessary length, costs and ventilating requirements for the cross-harbour tunnels. Hence the initial requirement to respect a maximum ruling grade in the tunnel to 1.5% or 2.0 % was subsequently eased.

IV Passenger Rail Equipment

The following three equipment options were considered in the study. In all options, train consists were comprised of 10 passenger cars.

RDC:

RDC equipment is currently in service on the BC Rail line between North Vancouver and Whistler. RDC's are self-propelled, diesel powered units with a top speed of approximately 90 mph. This type of equipment is now considered technically obsolete and is being phased out of service throughout North America. However, running times have been provided for comparison with other more appropriate modern equipment options.

Bi-Level:

The passenger equipment now utilized for the West Coast Express commuter service was also selected for performance evaluation. This high capacity rolling stock could be modified to be suitable for both commuter as well as recreational use. Recreational passengers will require suitable stowage compartments for ski equipment as well as regular luggage. When drawn by two 3000 HP locomotives this equipment can operate up to 100 mph and can operate in a push-pull manner negating the need to wye the equipment at either terminal points (Vancouver or Whistler).

Tilting Body:

This high speed equipment alternative represents the highest performance option for consideration in the study. The equipment, modeled after the Acela design, produced by Bombardier, represents the latest generation in tilting body rolling stock. Its automatic sensors and modified suspension allow the equipment to bank, or lean, to the inside of curves to allow the train to safely and comfortably negotiate curves at higher than normal speeds. It should be noted that the ability of this equipment to negotiate reverse curves with little or no tangent track between them was not evaluated. If proceeding with this equipment option the manufacturer will have to confirm the equipment capabilities in this condition. The top speed of this equipment is rated at 150 mph and can also operate in a push-pull manner.

V Rail Service Options Analysis

The following summarizes the attributes of the four service options. See Appendix I for schematics of the planned route for each option in the Greater Vancouver area. In the case of Options 3 and 4 profiles may also be found.

<u>Option 1:</u>

Route:
- Pacific Central Station on CN/BNSF to Willingdon Junction
- Willingdon Junction on CN over Second Narrows Bridge to BC Rail North Vancouver
- BC Rail Squamish Subdivision to Whistler

Stations:
- Pacific Central Station; North Vancouver; Horseshoe Bay; Lions Bay; Porteau Cove/Furry Creek; Squamish; Whistler

Alignment:
- Present alignment with following exception:
  - new single track connection required at Willingdon Junction

Rolling Stock: RDC; Bi-Level; Tilting Body

<u>Option 2:</u>

Route:
- Waterfront Station (WCE) on CP to Heatley Diamond
- Heatley on BNSF to Willingdon Junction
- Willingdon Junction on CN over Second Narrows Bridge to BC Rail North Vancouver
- BC Rail Squamish Subdivision to Whistler

Stations:
- Waterfront Station; North Vancouver; Horseshoe Bay; Lions Bay; Porteau Cove/Furry Creek; Squamish; Whistler

Alignment:
- Present alignment with following exceptions:
  - two new single track connections required; Heatley Diamond and Willingdon Jct.

Rolling Stock: RDC; Bi-Level; Tilting Body

<u>Option 3:</u>

Route:
- Pacific Central Station to Waterfront Station (underground)

- Waterfront Station through cross-harbour tunnel to BC Rail North Vancouver (Mile 2.8) Squamish Subdivision
- BC Rail Mile 2.8 Squamish Subdivision to Whistler

Stations: - Pacific Central Station; Waterfront Station; North Vancouver; Horseshoe Bay; Lions Bay; Porteau Cove/Furry Creek; Squamish; Whistler

Alignment: - Present alignment with following exceptions:

- new underground connection between Pacific Central and Waterfront Stations
- new tunnel under Vancouver Harbour connecting Waterfront Station to BC Rail Mile 2.8 in North Vancouver.
  Total tunnel length: 4.3 miles

Rolling Stock: RDC; Bi-Level; Tilting Body

<u>Option 4:</u>

Route: - Pacific Central Station to Waterfront Station (underground)
- Waterfront Station through cross-harbour tunnel to BC Rail Mile 10.58
- BC Rail Mile 10.58 Squamish Subdivision to Whistler

Stations: - Pacific Central Station; Waterfront Station; Horseshoe Bay; Lions Bay; Porteau Cove/Furry Creek; Squamish; Whistler

Alignment: - Present alignment with following exceptions:

- new underground connection between Pacific Central and Waterfront Stations
- new tunnel under Burrard Inlet connecting Waterfront Station to BC Rail Mile 10.58 Squamish Subdivision South of existing Horseshoe Bay tunnel.
  Total cross-harbour tunnel length: 10.1 miles
- 11 new tunnels (15.2 miles) and 5 sections of curve straightening (4.4 miles) between Horseshoe Bay and Whistler (see Exhibit A and Appendix II for details)

Rolling Stock: Tilting Body

In general, the TPC modeling was based on new, calculated track speeds which considers train velocity, track characteristics (incl. degree of curvature and curve super-elevation standards) and equipment capabilities (inches of unbalance tolerance). Present posted timetable speeds on BC Rail were considered too restrictive in consideration of the higher speeds required to enhance passenger service. Posted speeds were used only along the track segments between downtown Vancouver and BC Rail Mile 2.8 given the operating constraints of this heavily utilized freight and passenger corridor.

BC Rail engineering standards prescribe maximum installed super-elevation of 4.5 inches. Industry standards typically use 5.5 inches. Typical passenger equipment is permitted to run at 3 inches unbalanced. For TPC purposes, RDC and bi-level trains were simulated based on 7.5 inches of equivalent super-elevation (4.5" + 3"). Modern tilting body equipment is permitted to operate at 7 inches unbalanced. Therefore simulations for this equipment were based on 12.5 inches of equivalent super-elevation (5.5" + 7") to assess the maximum performance capabilities of this equipment. To achieve this capability would require investment in the track structure to increase the super-elevation to the stated standard. Furthermore, to properly support the intended upgrade in passenger service, it is recommended for all scenarios, that an initial program be undertaken to improve the general condition and durability of track structures and components.

It should be noted that on BC Rail, government regulations prescribe that locomotive drawn passenger equipment be restricted to freight speed. However, for the purposes of establishing future operating speeds, in recognition of operating practices elsewhere in North America, simulation speeds were set based on equipment capabilities and not constrained by current imposed limitations.

Run Time Results

The TPC run times in each direction for each option are summarized in Exhibit B. Note that there is minimal difference in performance between RDC and bi-level cars since their power-to-weight ratios and curve performance are comparable. Also, there is little difference between northbound and southbound train performance times

The one way run times for conventional, non-tilting equipment on the present right-of-way ranges between 3 hours 10 minutes and 3 hours 17 minutes in Options 1 and 2.

The introduction, in Option 3, of a new cross-harbour tunnel to North Vancouver effectively reduces, the overall run time, as expected, by about 45 minutes for most equipment types.

The high performance characteristics of the tilting body equipment provides an approximate 17 minute time advantage over conventional equipment over the same alignment. To achieve this time performance, however, requires increasing the super-elevation of curves on the BC Rail mainline by one inch – which would conform with accepted industry standards. With tilting equipment, Option 3 run time, from Waterfront Station to Whistler, can be reduced to 2 hour and 7 minutes, including the specified five intermediate station stops. This compares with the current schedule from BC Rail's North Vancouver Station of 2 hours and 35 minutes, using RDC equipment.

For Option 4, the aim was to maximize train performance by selecting a track alignment that optimized the use of existing rail infrastructure while reducing or eliminating heavily curved segments by tunneling or curve straightening. Only the high performance tilting body equipment type was considered for this option. Constraints such as proximity of highways, settlements, environmentally sensitive waterways and heavy canyon topography were given high level consideration in this process. These factors led to the Burrard Inlet tunnel being extended to Mile 10.58, BC Rail Squamish Subdivision, thus eliminating the very slow conditions from North Vancouver to the Horseshoe Bay area.

The result was a one way run time for tilting equipment of 1 hour 41 minutes, from Waterfront Station to Whistler, including the required four intermediate station stops. An “express service” operating without stops would have a run time of 1 hour 33 minutes. These times are in the range considered to be competitive with the highway option and meeting the requirements of this study.

With further investigation and analysis there is potential for additional minor reductions in run time. Such improvements would, of course, require additional capital investment. Significant running time improvements beyond a few minutes are not considered practical given the major investment required for additional tunneling, the constraints imposed by the difficult terrain and the need to serve several intermediate stations.

It should be noted that the cross-harbour tunnels specified for Options 3 and 4 would each be major engineering projects on their own. At 10.1 miles in length, the tunnel in Option 4 would rank amongst the world’s longest railway tunnels, most of which are not required to accommodate diesel motive powered trains. It was necessary to plan the connection between the two downtown stations to be underground in order to provide a reasonable tunnel grade (max. 2.5%) for passenger equipment and to respect known navigational clearance requirements in the harbour. The tunnel connection also facilitates rapid access from downtown to the North Shore in both options. Both downtown stations will be underground or ‘subway-type’ stations accessible from street level through the existing station buildings.

The cross-harbour tunnel concept design provides for two adjoining ‘tubes’ formed in pre-cast concrete sections. One tube will accommodate the single track mainline and the second will serve as a ventilation duct and as a service/emergency access way. Where clearances permit, the concrete sections would be laid under water in a trench on the harbour floor to limit costly tunneling. The ventilation systems for these tunnels will need to be highly sophisticated and would be very costly.

Given the scale and complexity of these harbour tunnels, ventilation systems and underground stations, it is anticipated that the construction period would require 5 to 8 years to design and build.

VI System Support Facilities

The following are the design parameters assumed in developing the estimated cost of support facilities:

<u>Signals & Communication</u>

- Upgrade of BCR train control system to CTC centralized dispatch capability including applicable modifications to BN, CN, CP systems.
- Replacement of uninsulated steel ties

<u>Crossing Protection</u>

- Upgrade of level crossing protection systems to meet required safety standards
- No provision for pedestrian underpasses

<u>Rock Fall Protection</u>

- Provision for rock slide sheds; catchment structures, rock stabilization programs

<u>Maintenance Facilities</u>

- Layover facilities at Whistler (Mons) including wayside power, siding and crew hostel
- Other facilities assumed to be provided by maintenance contractor and cost included in contracted rates.

<u>Stations</u>

- New or upgraded stations at Pacific Central Station; Waterfront Station; North Vancouver; Horseshoe Bay; Lions Bay; Porteau Cove/Furry Creek; Squamish; Whistler including structures, platforms, parking lots, utilities

- At smaller intermediate stops station structures will be shelters only (North Vancouver; Horseshoe Bay; Lions Bay; Porteau Cove/Furry Creek)

<u>Ticketing System</u>

- Automated ticketing system at all station stops

VII Rail Option Costing

Capital Costs

Exhibit C summarizes the order-of-magnitude capital cost investment required for each of the operating options. For Options 1 and 2 the total capital cost estimate for infrastructure (signals & communications, track & roadway, stations and other facilities) is approximately $128 million to $134 million.

Given the slower trip times for Options 1 & 2, three sets of train rolling stock are considered necessary at a cost $133 million, bringing the total order-of-magnitude capital cost of Options 1 & 2 to $262.5 million and $266.5 million respectively.

The significant difference for Option 3 is the cost of the 4.3 mile cross-harbour tunnel estimated to be $360 million. However, due to the shorter scheduled running time between Whistler and Vancouver it is believed that only two sets of train rolling stock is necessary. The estimated cost of rolling stock varies from Bi-Levels at $88.7 million to Tilting at $116.9 million.

The Total order-of-magnitude capital cost of Option 3 is $615.3 million using Bi-Levels and $643.6 million using Tilting trains.

Option 4 introduces the costs of the 10.1 mile cross-harbour tunnel plus 15.2 miles of additional tunnels and 4.4 miles of track straightening between Horseshoe Bay and Whistler. Estimated infrastructure costs are $1,314 million.

Only Tilting trains were considered at $116.9 million bringing the total estimated order-of-magnitude cost of Option 4 to $1,431 million.

Operating Costs

Exhibit D summarizes the order-of-magnitude operating costs for each of the four scenarios and lists the “Elements of Cost” that were considered in this analysis.

The “Summary of Operating Costs” table indicates that Option 2, using Bi-Level rolling stock is the most expensive at $32.3 million per year while Option 3 using Bi-Level rolling stock is the least expensive at $26.1 million per year.

VIII Return on Investment Analysis

To undertake a Return on Investment (ROI) analysis required the consultant to make some further assumptions on ridership, trip lengths, trip purpose and trip fare cost.

Following consultation with the client it was determined that a reasonable assessment of these assumptions was, and is shown in Exhibit D titled "Vancouver Whistler Preliminary Fare Structure and Ridership Projections".

In the table titled "Summary of Operating Costs", in Exhibit D, the four options are shown and what ridership per train, using the above-noted "Preliminary Fare Structure and Ridership Projections", is necessary to achieve the ROI target of 15%, after tax, for three alternatives:

(a) Total Operating Costs without including rolling stock and infrastructure capital costs

(b) Total Operating Costs including the cost of rolling stock but excluding all infrastructure capital costs

(c) Total Operating Costs including both costs of rolling stock and all infrastructure

The results can be summarized by stating that for alternatives (a) and (b) the lowest per train ridership required to achieve the target ROI is Option 4. However, in alternative (c) Option 4 becomes the highest per train ridership to reach the target ROI at 805 passengers.

IX Conclusions and Recommendations

This report has considered graduated investments from the Medium Rail Investment Strategy developed previously by the Provincial Government. Common to the four Options that have been evaluated is the need to invest in Signals & Communications, Track & Roadway improvements and in other facilities such as Stations, Crew quarters, and in passenger rail rolling stock. The following table lists the key schedule times, in hours (h) and minutes (‘), for the four Options evaluated. With the exception of Option 1 Vancouver means the Waterfront WCE Station. In Option 1 Vancouver is the Pacific Central VIA Rail Station.

	Option 1			Option 2			Option 3			Option 4
		MRT			M RT			MRT		MRT
	RDC	Bi-L	Tilting	RDC	Bi-L	Tilting	RDC	Bi-L	Tilting	Tilting
Vancouver-North Vancouver	42'	42'	42'	48'	48'	48'	2'	2'	2'	NA
Vancouver-Horseshoe Bay*	1h 11'	1h 11'	1h 7'	1h 17'	1h 17'	1h 13'	27'	27'	24'	13'
Horseshoe Bay - Squamish*	56'	55'	48'	56'	55'	48'	56'	55'	48'	39'
Squamish - Whistler*	51'	51'	45'	51'	51'	45'	51'	51'	45'	40'
Vancouver - Squamish**	2h 15'	2h 14'	2h 3'	2h 21'	2h 20'	2h 9'	1h 29'	1h 28'	1h 18'	57'
Vancouver - Whistler**	3h 11'	3h 10'	2h 52'	3h 17'	3h 16'	2h 58'	2h 25'	2h 24'	2h 7'	1h 41'
Vancouver - Whistler Express**										1h 33'

Notes: MRT is Minimum Run Time
* indicates 2 minutes (2') has been added for each intermediate station stop
** indicates that a 5% Operating Factor has been added to the MRT

Options 1 and 2 require an investment of $262.5 and $266.5 million respectively but they result in a trip time from Vancouver to Whistler of about 3 hours and 15 minutes which is not attractive to passengers, particularly if they are regular commuters. A major source of the lengthy trip time is the 40 minutes approximately to go from Vancouver to North Vancouver via the Second Narrows Railway bridge and it must be remembered that this is the absolute minimum running time and will frequently be subjected to delays.

Option 3 introduces the cross-harbour tunnel from North Vancouver to Vancouver’s Waterfront WCE Station and reduces the trip time for this crossing to about 2 minutes compared to 48 minutes in Option 2. Total trip time from Vancouver’s Waterfront Station to Whistler is estimated to be 2 hours and 24 minutes with Bi-Level equipment and 2 hours and 7 minutes with Tilting equipment. This Option is still not expected to be attractive to the regular commuter who has the option of driving, particularly those in the Vancouver to Squamish section. This Option requires an investment of between $615.3 million using Bi-Levels and $643.6 million using Tilting equipment.

Option 4 tries to achieve a trip time that is competitive with the automobile and with extensive tunneling and track straightening a trip time of 1 hour and 41 minutes has been achieved (average train speed is 42 mph) from Waterfront Station. If trains were able to operate express between Waterfront Station and Whistler without the four intermediate stops the trip time would be 1 hour and 33 minutes (average train speed is 47 mph). This is a very competitive trip time when compared with similar trips by automobile. This Option requires an investment of about $1,430 million

Option 4 has approximately 26 miles of the total trip length from Vancouver (Pacific Central Station) to Whistler in tunnels. This represents about 33% of the total trip length. While travelling, this much, in tunnel may not be a concern of regular commuters it will be a concern by tourists that they are not able to see more of the countryside. This could lead to discontent over the higher price paid by tourists for the same trip as commuters and result in a lowering of this market segment ridership.

The following Table summarizes the Capital and Operating Costs of the four Options.

	Costs Expressed in Millions				
	Option 1	**Option 2**	**Option 3**		**Option 4**
Cost Items	**Bi-L**	**Bi-L**	**Bi-L**	**Tilt**	**Tilting**
Fleet Cost	133.05	133.05	88.70	116.93	116.93
Infrastructure Cost	129.40	133.45	526.63	526.63	1313.97
Total Capital Cost	**262.45**	**266.50**	**615.33**	**643.56**	**1430.89**
Annual Train Operating Cost	**30.78**	**32.31**	**26.12**	**27.85**	**27.88**

To achieve a reduced travel time of 1 hour between Vancouver and Whistler requires average train speeds of around 74 mph and if achievable would require extensively more tunneling to the point that you could well be in tunnel between 60% and 80% of the trip time. In addition it would be necessary to reduce the number of intermediate stops with Squamish being the only one. The capital cost to achieve this result would most certainly exceed $2 billion in total.

If Options 3 and 4 are considered for potential investment it is necessary for the client to determine whether just direct operating costs are to be considered for a ROI or are some or all capital costs to be included in the assessment. If all operating and capital costs are to be considered in the analysis it would appear that to reach the target 15% after tax ROI it will be necessary to carry an average of 655 passengers per train in Option 3 and 805 passengers per train in Option 4.

This report recommends that a detailed ridership and revenue forecast study be undertaken by the client, using the Options outlined in this report (particularly Options 3 and 4), in order to make an informed decision on which if any of the Options in this report should be further pursued in more detail.

The results of the detailed Ridership and Revenue Forecast study, along with this Higher Speed Passenger Rail study would provide critical input to the discussion required to determine what Public involvement may be necessary and what form a Public/Private/Partnership arrangement could take.

Exhibits

Exhibit A

Track Changes
BC Rail, Squamish Subdivision
Mile 11.0 to Mile 77.4 (Mons)

New Tunnels and Curve Straightening
BC Rail, Squamish Subdivision

Begin Tunnel = bt End Tunnel = et	Old MP	Tunnel & cut & fill footage	New MP	Tunnel Length Mi.	Curve straighten cut & fill
#1 bt	14.5				
et	14.94	1,508	14.79	0.29	
#2 bt	19.99		19.84		
	20.06				
	20.2				
	20.29				
	20.5				
	20.9				
et	21.2	4,022	20.60	0.76	
#3 bt	21.5		20.90		
et	25.8	18,939	24.48	3.59	
#4 bt	28.6		27.28		
et	30.1	7,542	28.71	1.43	
#5 b curve str	30.38		28.99		
e curve str	31	3,017	29.28		0.57
#6 bt	31.56		29.84		
et	36.2	16,760	33.02	3.17	
#7 b curve str	36.4		33.22		
e curve str	37	2,849	33.76		0.54
#8 bt	51.5		48.26		
et	52.5	4,860	49.18	0.92	
#9 bt	52.65		49.33		
et	53.43	4,190	50.12	0.79	
#10 bt	53.62		50.31		
et	54.7	5,196	51.30	0.98	
#11 bt	54.75		51.35		
et	55.44	3,184	51.95	0.60	
#12 bt	56		52.51		
et	58.15	9,888	54.38	1.87	
#13 b curve str	60.4		56.63		
e curve str	61.6	5,698	57.71		1.08
#14 b cut & fill	63.2		59.31		
e cut & fill	64.62	5,698	60.39		1.08
#15 b cut & fill	69.69		65.46		
e cut & fill	71	5,698	66.54		1.08

#16 bt	73.1		68.64			
et	74.1	4,022	69.40		0.76	
				Total		Total
		103,071			**15.17**	**4.35**
		19.52			Total of all mods.	
					19.52	

Exhibit B

Train Performance Calculations (TPC)

Run Times by Service Option

Exhibit C

Order-of-Magnitude

Capital Costs

Exhibit D

Order-of-Magnitude Operating Costs

Elements of Cost

Preliminary Fare Structure and Ridership Projections

Summary of Operating Costs

Appendices

Appendix I

Vicinity of Vancouver

Four Option Plans

Tunnel Profiles Options 3 & 4

Appendix II

Track Revision Plans

Horseshoe Bay to Whistler