McElhanney

March 12, 2004
Our File: 2111-01954-0

Ministry of Transportation
Sea-To-Sky Highway Improvement Project
PO box 10426, Pacific Centre
1120 – 777 Dunsmuir Street
Vancouver BC V7Y 1K3

Attention: Brian Stone, P.Eng.
Project Director, West Vancouver

Dear Brian:

Sea-to-Sky Project Section 1 - Multiple Account Evaluation

This letter report summarizes the Multiple Account Evaluation (MAE) of four design options developed for consultation with public and stakeholders for the Horseshoe Bay to Sunset Beach segment of the STS Project.

Background

The Ministry of Transportation is undertaking improvements to the Sea-to-Sky Highway between Horseshoe Bay and Whistler to improve its safety and reliability. Section 1 is located within the District of West Vancouver, between Horseshoe Bay and Sunset Beach. This 7 km section of highway will be designed with goals consistent with the overall project. Four options have been developed and each option addresses project goals and community concerns to varying degrees. McElhanney Consulting Services Ltd. (McElhanney) has conducted a Multiple Account Evaluation (MAE) of the four options.

Overall Project Goals

The primary goals for the Sea-to-Sky Highway Improvement Project are to:

- Achieve safety improvements;
- Achieve reliability improvements;
- Achieve capacity improvements;
- Complete the project by late 2009;
- Manage traffic flows during construction to minimize disruption and maximize predictability; and
- Remain within the project budget of $600 million.

13160 - 88th Ave
Surrey BC
Canada V3W 3K3
Tel 604 596 0391
Fax 604 596 8853

Design Options

The four design options are briefly described below:

Option A – 2 Northbound Lanes Upslope

- 2 northbound lanes use a new route constructed upslope from the existing highway
- 2 southbound lanes, with improvements, use the existing Highway 99 route

Option B – 4 Upslope Lanes

- 4 new lanes use a new route constructed upslope from the existing Highway 99 corridor
- The existing Highway 99 serves local traffic

Option C – Northbound Tunnel

- 2 northbound lanes use a new route through a 1 km to 1.4 km tunnel.
- 2 southbound lanes, with improvements, use the existing Highway 99 route

Option D – 2-Way, 2 Lane Tunnel

- A new 2-way, 2 lane tunnel, one lane northbound and one lane southbound partially serves Hwy 99 traffic
- The existing Highway 99 with improvements serves local traffic and overflow Highway 99 through traffic

These four design options are measured against the existing condition, base case option (do-nothing). Options A, B, C, and D are presented to the public and stakeholders for comments and input during February 2004.

MAE

Purpose

The purpose of the Multiple Account Evaluation is as follows:

- To provide an evaluation tool for decision-makers; and
- To facilitate a fair and standardized comparison process of transportation options.

MAE Accounts

Multiple Account Evaluation (MAE) involves estimating the outcome or impact in each of a number of accounts for each option. These accounts represent areas of importance to facility users and decision makers. The Ministry of Transportation typically applies five standard accounts in MAE:

- Financial
- Customer Service
- Environmental
- Social/Community
- Economic Development

Within each standard account, there are mandatory and project specific indicators. For this project, the accounts and indicators used are summarized in **Table 1**.

Table 1: MAE Accounts and Indicators Description

Account / Indicator	Measurement	Description
Financial Account		
• Capital Costs	Quantitative	The present value of capital costs (less salvage values) for the proposed project, including planning, design, property acquisition and construction costs.
• Increase in Periodic Rehabilitation Costs	Quantitative	The present value of rehabilitation costs with the improvement minus the present value of rehabilitation costs without the improvement, including pavement resurfacing and bridge rehabilitation.

• Increase in Operating Costs	Quantitative	The present value of average annual operating costs with the improvement minus the present value of average annual operating costs without the improvement.
Customer Service Account		
• Value of Travel Time Savings	Quantitative	The present value of travel time costs without the improvement minus the present value of travel time costs with the improvement.
• Value of Safety Savings	Quantitative	The present value of accident costs without the improvement minus the present value of accident costs with the improvement.
• Savings in Vehicle Operating Costs	Quantitative	The present value of vehicle operating costs without the improvement minus the present value of vehicle operating costs with the improvement.
• Net Present Value	Economic Indicator	The present value of road user benefits minus the present value of agency costs.
• Gross Benefit-Cost Ratio	Economic Indicator	The present value of road user benefits divided by the present value of agency costs.
Environmental Account		
• Environmentally Sensitive Areas	Quantitative	Area impacted and degree of impact to environmental areas of concern including endangered animals or plant communities, wetlands, and forest.
• Fisheries and Water Quality	Quantitative/ Qualitative	Potential impact to fish and aquatic resource and water quality.
• Air Quality	Quantitative/ Qualitative	Assess how the changes in roadway alignment can impact air quality.
Social/Community Account		
• Property Takings	Quantitative	The area of private and municipal developable and un-developable properties being impacted.
• Noise	Quantitative/ Qualitative	During and after construction.
• Park and Recreation Impacts	Quantitative	Number (or area) of parks or other recreational facilities impacted.
• Cultural and Heritage	Qualitative	Impact to cultural and heritage areas.

• Aesthetic (Visual) Impacts	Qualitative	Relative visual impact of each option.
• Local Connectivity	Qualitative	Degree of impact to local accesses and connections.
• Community Severance	Qualitative	Fragmentation of the community. Severance of residences and community facilities.
Economic Development Account		
• Network Connectivity (Goods)	Qualitative	Relative contribution of each option to: the completeness of roads connectivity between major activity centres in the multi-modal network and for goods movement.
• Local/Regional Businesses	Qualitative	The economic impacts to existing businesses.
• Economic Development	Qualitative	The potential for new economic development opportunities.

Source: BC MoT/BCFA MicroBENCOST Guidebook

MAE Assumptions

Financial Parameters

The financial parameter used in this analysis included a social discount rate of 6% and an inflation rate of 2% (based on the average consumer price index variation in British Columbia in the last 10 years). All benefits and costs are modeled for 25 years. Economic indicators are based on the calculated NPV and B/C ratio.

Capital Cost

Capital costs are derived from the Elemental Parametric cost estimation method, developed by Ernest Wolski, where each option is broken down into segments that provide full project costs for each element of the design. The estimates have been prepared to the functional design level using 2004 dollars with a 20% contingency.

Basic cost components included in each estimates are:

- Planning stage and preliminary design;
- Hydro and Tel relocations;
- Detailed design engineering for Geotechnical, grade, structural and paving;

- Construction supervision, quality assurance and surveying;
- Grade Construction including clearing and grubbing, excavation, rock bolting, wire mesh protection, rock smooth wall, offsite disposal of surplus material, pavement structure, drainage, detours, hydro seeding, and environmental mitigation and monitoring;
- Structural construction including retaining walls, bridges and tunnels;
- Paving construction including machine paving asphalt;
- Operational construction including lighting, guard rail, pavement markings and signing;
- Project management costs; and
- Property acquisition land costs including management and indirect costs.

Rehabilitation Cost

Rehabilitation costs are calculated from the following:

- Roadway rehabilitation cost is based on MicroBENCOST Guidebook ($60,000 / 2 Lane-km) for hot mix resurfacing with 15 years between resurfacings. Adjusted for inflation at 2%/year.
- Salvage Value = Resurfacing Cost x (1-N/10), where N = number of years remaining to end of planning period (25 years).
- Assume Base Case Resurface in Year 5 and Year 20 with Salvage Value of 5 years, for a 25-year planning period.
- Assume all other options resurface in Year 15; N = 10; therefore, Salvage Value = 0, for a 25-year planning period.
- Structural rehabilitation cost is based on 10% of replacement value of the bridge, incurred in year 25.

Annual Operating and Maintenance Costs

Annual operating and maintenance cost are calculated from the following:

- Roadway Operating and Maintenance (O/M) cost based on MicroBENCOST Guidebook 1998 O/M cost - adjusted for 2004. In 1998, O/M cost is $24,500/2-lane-mile and $33,100/4-lane-mile. This cost covers the maintenance and repair of the highway and bridge infrastructure, such as surface, drainage, winter, roadside, traffic, structure, and emergency maintenance.

- Tunnel Operating and Maintenance cost based on information provided by Mr. Mano Walia, P.Eng., per email March 26, 2003 to Mr. Rob Bedard, MCSL. Tunnel O/M cost includes lighting, ventilation, portal heating, signal lights, pressure washing, and fan and battery generating units. The O/M costs for the one-way and two-way tunnel options are summarized below:

Tunnel Operating and Maintenance Costs

Tunnel Option	Operating Cost ($/yr)	Maintenance Cost ($/yr)	Total ($/yr)
2-Lane, 1-way Tunnel, 1 km Long	$70,000	$50,000	$120,000
2-Lane, 2-way Tunnel, 1 km Long	$120,000	$50,000	$170,000

- Tunnel Options assumed no control room. All control and monitoring to be done from a remote control centre. A point duty wrecker is assumed to be required for Option D – 2-Way, 2-Lane Tunnel.
- Bridge O/M cost is assumed to be $\$4/m^2$.

Travel Time Cost

Travel time costs for each of the Options are based on the driving distance and the mean speed. The driving distance for all options was selected from the curve section at Eagle Creek (approximately 600 meters east of Nelson Creek bridge) to the south, to Ansell Place Interchange to the north. The mean speed for each of the options was determined as follows:

- 70 km/h for the "do-nothing" scenario and the residual road alignments for Options B and D based on the following:
    - Between Nelson Creek and Marine Drive, the speed was calculated based on the average of the posted speed limit in both directions.
    - For the section between Marine Drive and Ansell Place, the mean speed was determined based on driving observations conducted by MCSL in 2002. The overall observed speed was 70 km/h, which is lower than the posted speed limit of 80 km/h due to the numerous curves along this section.
- 80 km/h: Design speed for the options featuring continuous four-lane sections (Options A, B, and C).

- 74 km km/h for Option D based on the average mean speed obtained from the TWOPAS98 simulation software. This speed corresponds to the average for the section between Eagle Creek and Ansell Place interchange.

The economic evaluation assumed a vehicle occupancy of 2.3 persons[1] per non-truck vehicle, and 1 person per vehicle for trucks.

The hourly rate for travel time cost was based on the Ministry of Transportation's MicroBENCOST Guidelines. For cars and RV users, the travel time cost is $11 per person per hour, while truck user is $31 per person per hour (2004 dollars in both cases).

Traffic Split Assumption

For Option B, the analysis assumed a traffic split of 90/10 between new alignments and residual old alignments. For Option D, an initial traffic split of 80/20 was used for the first 20 years to maintain a Level of Service better than E (near congestion). As the level of service in the 2-lane 2-way tunnel reaches a LOS E in year 21 (year 2024), a traffic split of 70/30 was used.

Accident Cost

The number of accidents was estimated based on collision prediction models with each of the options prepared by Dr. Paul de Leur, P.Eng. and Dr. Traek Sayed, P.Eng. These models provided the annual expected collisions broken down into fatalities, injuries, and property damage only (PDO). The safety performance results are attached in Appendix A for reference. Based on this information, McElhanney calculated the present value of the cost of accidents associated with each option. Collision costs (2004 dollars) were based on MoT guidelines as follows:

- Fatal: $4,170,000 / incident
- Injury: $97,000 / incident
- PDO: $6,000 / incident

[1] Sea to Sky TDM Study, Final Report 2003, TSi, which reported that "overall, the average auto occupancy is estimated at 2.3."

Vehicle Operating Cost

Vehicle operating costs were determined based on the models outlined in the Ministry of Transportation's "The Economic Appraisal of Highway Investment, Guidebook", published in 1992. This guidebook contains vehicle operating cost models for four types of vehicles. According to these models, the operating costs, expressed in dollars per kilometer, are basically functions of the vertical alignment (average grade) and the travel speed.

Since these models were developed in 1992, the estimated costs were adjusted to represent 2004 dollars.

Environmental Accounts

Environmental evaluations were conducted by the contracted project consultants for each area of specialization. The documents prepared are included in Appendix B for reference:

- Environmental - prepared by Robertson Environmental Services Ltd.;
- Air Quality - prepared by Levelton Engineering Ltd.;
- Noise - prepared by Wakefield Acoustics Ltd.;
- Aquatic Habitat Values/Issues – prepared by Coast River Environmental Services Ltd.; and
- Recreational Issues – prepared by Confluence Environmental Consulting.

MAE Results

Table 2 summarizes the MAE results based on a 25-year planning period, using an annual traffic growth rate of 2.3%, and an average vehicle occupancy rate of 2.3. Highlights of the MAE results are:

- The options range in cost between $115 M (Option A) and $170 M (Option D).
- Rehabilitation cost is approximately the same for each option between $500,000 and $700,000.
- The annual operating and maintenance cost (O/M) ranges from $2 M (Option A) to $9.7 M (Option D). All the tunnel options have higher O/M costs.

Sea to Sky Project
Highway 99 - Section 1
Horseshoe Bay to Sunset Beach

Table 2: MAE Results

Multiple Account Evaluation

MAE ACCOUNT	OPTION 1	A	B	C	D
	Base Case (Do-Nothing)	2- NB Lanes Upslope	4 Upslope Lanes	NB Tunnel	2-Way, 2-Lane Tunnel
FINANCIAL ($ millions)		$ millions 2004			
Capital Cost (PV)		$115.0	$130.0	$140.0	$170.0
Rehabilitation Costs (PV)	$0.6	$0.5	$0.7	$0.6	$0.7
Operating and Maintenance Cost (PV)	$1.9	$2.1	$3.2	$4.5	$9.7
Incremental Cost		$115.1	$131.3	$142.6	$177.9
CUSTOMER SERVICE		$ millions 2004			
Travel Time Cost (PV)	$227.3	$187.7	$186.7	$179.4	$171.7
Accident Cost (PV)	$80.3	$38.7	$22.9	$30.4	$37.8
Vehicle Operating Cost (PV)	$192.9	$184.2	$187.3	$174.5	$159.1
Incremental Benefit		$89.8	$103.5	$116.1	$131.8
NPV		($25.3)	($27.8)	($26.5)	($46.1)
B/C Ratio		0.78	0.79	0.81	0.74
ENVIRONMENTAL					
Terrestrial					
a) Blue-listed plant communities	-	1.47 ha	1.57 ha	2.03 ha	1.64 ha
b) Arbutus (Eagle Ridge)	-	2.19 ha	1.41 ha	0.47 ha	0.05 ha
c) Swamp	-	0.43 ha	0.68 ha	0 ha	0.11 ha
d) Common vegetation	-	10.19 ha	13.5 ha	9.79 ha	10.07 ha
Fisheries and Water Quality					
a) Nelson Creek	-	no change	no change	one 2-lane bridge	two 2-lane bridges
b) Larsen Creek	-	2 lane bridge creek crossing. Non-fish bearing at crossing.	4 lane bridge creek crossing. Non-fish bearing at crossing.	60 m crossing upper catchment. Non-fish bearing at crossing.	60 m crossing upper catchment. Non-fish bearing at crossing.
Air Quality					
	no change	vehicles have higher emissions on steeper grade, alignments further away from population, neutral effect	vehicles have higher emissions on steeper grade, alignments further away from population, neutral effect	no change	higher ambient concentrations near tunnel portals over shorter distance, lower ambient concentrations along original alignments, neutral to negative impact
SOCIAL / COMMUNITY					
Property					
Developable Land (less than 3:1 slope)	-	3.81 ha	5.43 ha	4.38 ha	3.46 ha
Un-Developable Land	-	12.27 ha	20.78 ha	16.15 ha	15.91 ha
Noise					
	Noise levels will increase gradually with traffic volume.	Impacts will be negligible except for slightly positive effect in Horseshoe Bay	Impacts will be negligible except for slight positive effect in Eagle Ridge & Horseshoe Bay	Impacts will generally be slightly positive	Potential minor to moderate impacts at Nelson Creek otherwise negligible or positive
Recreation					
	Trailhead staging areas and recreation through-access is uncertain over long term due to private land	400 m of trail adjustment and 1 pedestrian crossing needed; partially mitigatable	400 m of trail adjustment and 2 pedestrian crossings needed; partially mitigatable	100 m of trail adjustment and 1 pedestrian crossing needed; mitigatable (favourable)	1 pedestrian crossing needed at north portal; difficult to mitigate change to trail at south portal
Aesthetic (Visual)	●	◉	◉	◉	◉
Local Connectivity	◉	◉	○	◉	◉
Community Severance	○	○	○	○	○
ECONOMIC DEVELOPMENT					
Network Connectivity	●	◉	○	◉	◉
Local / Regional Business	◉	○	◉	○	○
Economic Development	●	◉	○	◉	◉

KEY	
○	Good/Favourable
◉	Fair/Neutral
●	Poor/Unfavourable

NOTES

1) PV = Present Value
2) NPV = Net Present Value
3) Larsen Creek Impact will be mitigated by adding 15 ha to catchment with flume.
4) 25 years design horizon (2004 to 2028)
5) Traffic Growth Rate at 2.3 %
6) 90/10 Split on Options B
7) Traffic Split for Option D:
   80/20 from year 1 to year 20
   70/30 after year 20
8) Vehicle Occupancy Rate = 2.3

- Options A and D have the lowest and highest incremental financial cost at $115 M and $178 M, respectively.
- Options A and B have similar travel time cost at $188 M and $187 M respectively. The lowest travel time cost option is Option D at $172 M.
- Accident cost is the highest for Options A and D, both at approximately $38 M. The lowest accident cost option is Option B at $23 M.
- Vehicle operating cost is the highest for Option B at $187 M. The lowest vehicle operating cost option is also Option D at $159 M.
- Options A and D have the lowest and highest incremental benefits at $90 M and $132 M, respectively.
- All options have negative Net Present Value (NPV); that is, incremental cost exceeds incremental benefits. Option D has the highest negative NPV at -$46 M due to the high incremental cost, and Option A has the least negative NPV at -$25 M due to the lower incremental cost. Options B and C have a negative NPV of -$28 M and -$27 M respectively.
- Similarly, all options have a benefit cost ratio (B/C) less than 1 due to the high incremental costs associated with each of the options. Option C has the highest B/C ratio of 0.81, while Option D has the lowest B/C ratio of 0.74. The other two options, A and B, have similar B/C ratios at 0.78 and 0.79, respectively.
- The environmental evaluation did not find any environmental issues or constraints considered so significant that any option is likely to be considered unacceptable by the responsible agency. Mitigation measures are expected to be in place with each option.
- Air quality impacts will be negligible for all options.
- Noise impacts will be negligible or slightly positive for all options.
- Mitigations will be required to improve recreational trails. Option C is most favorable for the recreation account.
- All the options with the exception of the base case will improve network connectivity and enhance economic development in the region.

Not reflected in the standard MAE Accounts are the amounts of new highway infrastructure achieved on the corridor consistent with the ultimate northbound extension of the existing highway. By this measure, Options B is the only option that will provide four lane extensions of the highway, while Options A, C and D are various two lane compromises that postpone the construction of a full four lane cross section. These

three options utilize the existing Highway 99 alignment that cannot achieve the design speed of 80 km/hr.

Summary

The Multiple Account Evaluation (MAE) described herein evaluated the four design options against the Do-Nothing Scenario. The purpose of the MAE is to provide an evaluation tool for decision-makers, and to facilitate a fair and standardized comparison process of transportation options. Five standard accounts are used in MAE:

- Financial
- Customer Service
- Environmental
- Social/Community
- Economic Development

Highlights of the MAE results are as follows:

- Although Option D provides the best incremental benefit, it has the worst NPV (-$46 M) and lowest B/C ratio (0.74) due to the high incremental cost ($178 M).
- None of the options achieve B/C ratio greater than 1. Options A, B, C, and D have B/C ratio of 0.78, 0.79, 0.81, and 0.74 respectively.
- Options A, B, and C have similar NPV and B/C ratios. As such, within these options, there is a largely linear relationship between investment level and benefit level.
- Option B is a relatively low investment option given that it could meet the 4-lane 80 km/hr design speed project objectives, and provides similar B/C ratio to the other three options.
- The environmental evaluations did not find any environmental issues or constraints considered so significant that any option is likely to be considered unacceptable by the responsible agency.

In closing, we trust the above analysis will provide a tool for the decision makers in selecting a preferred option. Should you have any questions, please do not hesitate to contact me.

Yours very truly,

McELHANNEY CONSULTING SERVICES LTD.

- Original Signed-

Denny Leung, P.Eng.
Sr. Transportation Engineer
Vancouver Region Engineering
email: dleung@mcelhanney.com
DL:jjf
Enclosure

Appendices:

Appendix A: Safety Performance Results
Appendix B: Environmental Evaluation Documents:
- Environmental – prepared by Robertson Environmental Services Ltd.;
- Air Quality – prepared by Levelton Engineering Ltd.;
- Noise – prepared by Wakefield Acoustics Ltd.;
- Aquatic Habitat Values/Issues – prepared by Coast River Environmental Services Ltd.; and
- Recreational Issues – prepared by Confluence Environmental Consulting.

APPENDIX A

SAFETY PERFORMANCE RESULTS

Sea to Sky Highway: Section 1 Improvement Options Safety Performance Results

Safety Performance Results
(Based on a 2.3% Traffic Growth Rate)

Improvement Options	Estimated Safety Performance (Collisions / year)							
	2004				2028			
	FAT	INJ	PDO	TOTAL	FAT	INJ	PDO	TOTAL
A	0.25	7.72	9.90	17.86	0.42	12.69	16.27	29.37
B 90/10 Traffic Split	0.107	6.155	8.943	15.205	0.178	10.255	14.900	25.333
C	0.18	6.73	9.19	16.10	0.30	11.05	15.08	26.43
D 80/20 Traffic Split	0.235	7.832	10.526	18.594	0.390	12.968	17.426	30.784
70/30 Traffic Split	0.256	8.401	11.253	19.911	0.424	13.896	18.611	32.931

Description of Options:

Option A: Split grade option, with new alignment for northbound traffic and existing route (with improvements) for southbound traffic.

Option B: New four-lane alignment option, with new four-lane highway, 2 lanes northbound and 2 lanes southbound.

Option C: Couplet option with a short tunnel for northbound traffic and existing route (with improvements) for southbound traffic.

Option D: Two-way operation option, with a short two-way, two-lane tunnel and the existing route also serving as a two-way operation. This option includes various traffic split scenarios from a 80-20 traffic split to a 70-30 traffic split.

APPENDIX B

ENVIRONMENTAL EVALUATION DOCUMENTS:

- Environmental – prepared by Robertson Environmental Services Ltd;
- Air Quality – prepared by Levelton Engineering Ltd;
- Noise – prepared by Wakefield Acoustics Ltd;
- Aquatic Habitat Values/Issues – prepared by Coast River Environmental Services Ltd.; and
- Recreational Issues – prepared by Confluence Environmental Consulting.

ROBERTSON ENVIRONMENTAL SERVICES
1525 - 200th Street, Langley, BC V2Z 1W5 • Voice: (604) 530-1080 • Fax: (604) 530-9800
email: res@quik.com

MEMORANDUM

To: Isobel Doyle, Par Terre — January 28, 2004
Angela Buckingham, Ministry of Transportation — Revised February 21, 2004

From: Anré McIntosh and Ian Robertson — 02-08

Re: Review of proposed options for WP 1 alignment at Horseshoe Bay

In the text below, we outline the environmental implications of the four proposed alignment options: A (E-1), B (E-2), C (C-1), D outlined in the January 20, 2004 and February 09, 2004 McElhanney maps. In completing this review, we have compared each of the proposed options with our resource and ecosystem mapping to determine the potential impacts to vegetation and wildlife resources of this area.

In this revised memo, we have taken into consideration discussions with the design engineers on February 03, 2004. In particular we have assessed the 4 options assuming that:

1. Mitigation will be applied to preserve the function of the upper Larsen Creek swamp for options C and D if it is found that there will be an impact to the hydrological function of the swamp (e.g bridge at north portal, moving the north portal out of the swamp, moving tunnel facilities out of the swamp).
2. A bridge will be used to cross Larsen Creek with either of the overland routes (A or B).
3. Mitigation will be applied to options A and B to ensure encroachment into the western edge of the Larsen Creek swamp will not negatively impact the swamp function.
4. MoT has committed to compensate for the loss of red and blue listed habitats and dry arbutus habitats through protection elsewhere.

General

In general, we do not believe there are any insurmountable vegetation or wildlife issues with any of the options presented. That said, the WP 1 options affect to differing degrees the blue-listed plant communities, a sensitive ecosystem, a swamp, and common vegetation. The area of each habitat type estimated to be impacted by each option is summarised in Table 1.

Our assessment is largely driven by vegetation and ecosystem characteristics.

Table 1. Summary of losses by habitat for 4 options proposed within the WP1 alignment.

Habitat	Option			
	A- split grade	B- 4-lanes up slope	C- couplet north bound	D- 2-way 2-lane tunnel
Blue-listed habitat	1.47 ha	1.57 ha	2.03 ha	1.64 ha
Eagle Ridge bluffs	2.19 ha	1.41 ha	0.47 ha	0.05 ha
Swamp habitat*	0.43 ha	0.68 ha	0 ha	0.11 ha
Common vegetation	10.19 ha	13.5 ha	9.79 ha	10.07 ha

* these numbers are pre-mitigation

Option A Split Grade

This option will have the greatest impact to the Eagle Ridge bluffs in terms of absolute area (2.19 ha), but as these losses are concentrated along the edge of the bluffs their potential impact is less than if this loss occurred within the bluff habitat as with Option B. Other losses associated with this option are: 1.47 ha of blue-listed habitat, 0.43 ha of swamp habitat and 10.19 ha of common vegetation.

Of primary concern with this option is the loss of dry arbutus and rock bluff habitat on the Eagle Ridge bluffs. The Ministry of Sustainable Resource Management (MSRM) has classified the rock/woodland complex at Eagleridge Bluffs as a sensitive ecosystem. The area is a complex of open woodland and rock outcrops, with dry Arbutus – Douglas-fir forests occupying the rock gullies between outcrop ridges. These ecosystems are unique in being the driest and most nutrient poor (in terms of nutrient storage) of those found in the area. As a consequence, they support plant species specific to these conditions, some of which are regionally rare as documented in our report. Close proximity to the ocean appears to add another unique element to these rock outcrops. The greatest impact from this option will be the reduction of core habitat as the "edge" of the existing arbutus/rock bluff habitat is moved inward.

Blue-listed communities in polygons 445 and 698 (Resource Map 1) will be impacted. Most of the loss will occur in polygon 445 (1.41 ha). Blue-listed species or plant communities are considered to be vulnerable in British Columbia, and are of special concern because of characteristics that make them particularly sensitive to human activities or natural events (MSRM 2002). Blue-listed species and communities are considered at risk of becoming extirpated, endangered or extinct.

We have assumed that any effects arising from the location of the highway immediately adjacent to the western side of the swamp along Larsen Creek will be mitigated as required to avoid altering the swamp function, particularly effects from altered hydrology and water quality.

That said, the swamp habitat occurs in the lowland depression adjacent to Larsen Creek, (polygons 693 and 696 Resource Map 1). It supports one of the largest extents of deciduous (big leaf maple and alder) dominated forests, plus conifers (with a small component of Sitka spruce) documented along the Sea-to-Sky corridor South of Squamish. Much of this area is composed of rich forests, where gaps in the canopy are common and allow for the development of lush herb and shrub layers. These layers in turn provide high value forage for a variety of mammals (black-tailed deer, black bear) and birds (woodpeckers, owls).

Option B 4-Lanes up-slope

This option has the greatest impacts on vegetation in terms of hectares (17.16). It will also result in the bisection of the dry arbutus habitat on the Eagle Ridge Bluffs resulting in the loss of 1.41 ha of internal habitat, the loss 1.57 ha of blue-listed habitat (all in polygon 445), 0.68 ha of swamp habitat and 13.5 ha of common vegetation.

This option would also abut the western side of the swamp along Larsen Creek. Our assessment assumes mitigation would be employed to avoid impacting the swamp function, as in Option A. To repeat what was stated above (for Option A) and in our earlier reports, the vegetation attributes of this area are considerable.

Option C Couplet-Northbound Tunnel

This option has potential impacts associated with the connector road to Horseshoe Bay, and the north end tunnel portal. Habitat losses associated with this option are: 2.03 ha of blue-listed habitat, 0.47 ha of dry arbutus habitat on the Eagle Ridge Bluffs and 9.79 ha of common vegetation.

The connector to Horseshoe Bay will run through the blue-listed habitat at the south western end of polygon 698 (Resource Map 1) resulting in an estimated loss of 0.61 ha of blue-listed habitat (the remaining 1.41 ha of blue-listed habitat will be lost in polygon 445).

The portal at the north end of the tunnel emerges within polygon 693, whose habitat attributes were discussed above. As with our consideration of the other options, we assume potential impacts on the swamp (upper Larsen Creek lowlands) would be mitigated as required to avoid altering the swamp function, particularly effects from altered hydrology and water quality. The difference with the tunnel options is their greater distance from these wet lowlands.

ROBERTSON ENVIRONMENTAL SERVICES
1525 - 200th Street, Langley, BC V2Z 1W5 • Voice: (604) 530-1080 • Fax: (604) 530-9800
email: res@quik.com

Option D- 2-way, 2-lane tunnel

Impacts with this option will occur in blue-listed forests (1.64 ha), swamp habitat (0.11 ha), arbutus habitat (0.05 ha) and common vegetation (10.07 ha).

Impacts to blue-listed habitat will occur only in polygon 445 (Resource map 2: 1.64 ha); the portion of polygon 698 impacted does not contain the blue-listed community.

Impacts to the swamp habitat are similar to those discussed under Option C above.

Arbutus habitat lost under this option is along the base of polygon 404. Impacts are anticipated to be minimal due to the location of the loss along the edge of the polygon.

André McIntosh
Ian Robertson

c.c. Marni Fedoruk

LEVELTON
Engineering Solutions

Memo

Levelton Engineering Ltd.

150 - 12791 Clarke Place
Richmond, B.C.
Canada V6V 2H9

Tel: 604 278-1411
Fax: 604 278-1042
E-Mail: aschutte@levelton.com

To	Isobel Doyle, Angela Buckingham	**CC**	
From	Alex Schutte, B. Sc.		
Project number	402-1011	**Contract Number:**	099LM1031
Date	14 February, 2004		

Amended - Work Package 1 Options Recap

Message

Based on our meeting on February 3rd, and discussion regarding the various options, attached is a revised examination of the options to assess how the changes in alignment could impact air quality. Option C does not represent a significant change in alignment. Therefore assuming the same traffic volumes as the original air quality assessment, the change in air quality is expected to be neutral.

For the Options A and B, the lanes would be moved further away from the current south bound lanes and existing residences in Horseshoe Bay. In terms of ambient concentrations of pollutants, maximum predicted modelled concentrations would be lower than in the air quality assessment for that alignment. However, concentrations may be higher than what were predicted in the areas further east of the highway in the original assessment (due to the highway being closer to that area). The grades over which vehicles will be traveling are steeper than the original assessment. Vehicles may 'work' harder (causing more emissions) than if they were traveling over the existing alignments. Overall, these changes in the alignment would be expected to have a neutral impact, with some differences in the spatial distribution of pollutants.

Option D shows a tunnel with both north and southbound lanes. Assuming that the tunnel would be ventilated in each direction, maximum predicted ambient concentrations would increase at the south exit/entrance of the tunnel(s) due to the southbound traffic compared with the original assessment. There would be lower concentrations predicted for the existing alignments of the highway, due to reduced traffic on those alignments, thus providing some benefit to residences in that area. Based on these assumptions and changes for this option, the impact on air quality is expected to be slightly negative in direction but still well below applicable ambient guidelines.

Alternatively, assuming that Option D would be ventilated only in the north direction, maximum predicted ambient concentrations would increase at the north exit/entrance of the tunnel(s). Assuming the same traffic volumes, a conservative worst-case impact would be that the maximum predicted concentrations at the north end of the tunnel would double. This is assumed since twice the amount of emissions from vehicles would occur in the vicinity of that location. The maximum predicted concentrations are presented in Table 1. The maximum predicted concentrations plus background are below the applicable ambient guidelines for each pollutant except NO_2. The annual average concentration of NO_2 is 60.1$\mu g/m^3$ which is at the ambient guideline.

For this option, although the impact would be negative in direction, it is anticipated that if this scenario is modelled, that all concentrations would be actually be below the applicable guidelines, given that it is a conservative assumption that concentrations would be double.

If you have any questions, or would like us to provide further details, please do not hesitate to contact me via e-mail at aschutte@levelton.com or directly at 604-207-5134.

Yours truly,
LEVELTON ENGINEERING LTD.

per: Alex Schutte, B. Sc., CCEP
Environment and Energy Division

Table 1 Maximum predicted concentrations in PA 1 for Baseline and Improved StS with North/South Tunnels ventilated in one direction.

Pollutant	Averaging Period	Back-ground[(1)] ($\mu g/m^3$)	2000 Baseline ($\mu g/m^3$)	2010 Improved with Tunnel ($\mu g/m^3$)	2025 Improved with Tunnel ($\mu g/m^3$)	Background plus 2025 with Tunnel ($\mu g/m^3$)	Ambient Guideline ($\mu g/m^3$)
SO_2	1-hour	37	3.8	3.6	6.4	43.4	450
	24-hour	22.6	1.17	0.76	1.5	24.1	160
	Annual	6.8	0.79	0.32	0.58	7.4	25
VOC	1-hour	n/a	126.3	276.2	362.6	n/a	n/a
	24-hour	n/a	51.5	101.6	133.6	n/a	n/a
	Annual	n/a	26.4	25.2	33.0	n/a	n/a
NO_X	1-hour	n/a	164.1	380.8	441.6	n/a	n/a
	24-hour	n/a	66.9	140.4	163.0	n/a	n/a
	Annual	n/a	34.4	34.6	40.2	n/a	n/a
NO_2 [(2)]	1-hour	74	116.4	138.0	144.1	218.1	400
	24-hour	58	66.9	114.0	116.3	174.3	200
	Annual	20	28.4	34.6	40.2	**60.2**	60
PM_{10}	24-hour	36	1.3	4.2	7.0	44.0	50
	Annual	15	0.9	1.2	2.0	17.0	50
$PM_{2.5}$	24-hour	12	0.9	2.0	3.8	15.8	30
	Annual	6.1	0.6	0.8	1.2	7.3	30
CO	1-hour	1000	655.9	1553.0	2111.8	3111.8	14300
	8-hour	750	1129.9	2609.4	3548.0	4298.0	5500
NH_3	1-hour	n/a	1.4	4.0	5.0	n/a	n/a

[1] Based on maximum 98th percentile concentration of StS ambient stations
[2] NOx converted to NO_2 using the Ozone Limiting Method (0.1*concentration + 100$\mu g/m^3$)

STS WP1 MAE – Noise

Wakefield Acoustics Ltd.

February 6, 2004

Within the WP1 MAE spreadsheet, under the Do-Nothing Option, it is noted that average traffic noise levels in the area of interest would be expected to increase gradually with growing Highway 99 traffic volumes. If a compounded annual traffic growth rate of 2% is assumed for Highway 99, the associated increase in average traffic noise level over a decade would be 0.9 dB. If a 3% annual growth rate is assumed, the noise effect would grow to 1.3 dB per decade.

A substantial portion of this growth is projected to occur even under the Do-Nothing Option, i.e., without the STS Improvement Project.

Except in the case of Option D, the two-way 2 lane tunnel, the proposed realignments of Highway 99 would create negligible community noise impacts or slight positive impacts (i.e., reduced noise exposures). Under Option D, after emerging from the tunnel, the southbound lanes would pass beneath the existing Highway 99 and encroach upon the residential area to the south of the highway near Nelson Creek. This encroachment could result in minor to moderate traffic noise impacts at the very closest residences.

COAST RIVER ENVIRONMENTAL SERVICES LTD

Review of WP 1 Alignment Options –Aquatic Habitat Values/Issues
Coast River Environmental Services – March 6, 2004 (rev)

Option A: 2 northbound lanes upslope (Split Grade)

Upper Larsen Creek wetland

- The split grade should avoid fill placement in the upper Larsen Creek wetland area to minimize the risk of potential negative effects on the hydrological function of Larsen Creek's headwater area (present design shows some potential for overlap).

Larsen Creek

- There would be a new bridge crossing of Larsen Creek, with >1.5 km of a 2-lane highway footprint crossing through the Larsen Creek watershed. We note that the bridge is proposed as a clear-span structure with minimum 15-meter setbacks from top of bank to the bridge abutments. As proposed, the structure is of minor concern to downstream fish/fish habitat values in Larsen Creek. Storm water runoff from the new highway footprint within the watershed can be managed to minimize the risk to water quality impacts on Larsen Creek.

Option B: 4-Lanes Upslope

Upper Larsen Creek wetland

- As with the 2-lane split grade option, the highway footprint should avoid the upper Larsen Creek wetland as much as possible to reduce any risk of potential negative effects on the hydrological function of Larsen Creek's headwater area (present design shows a slightly larger area of potential overlap along northern boundary of Larsen Creek's upper wetland than the 2-lane split grade option does).

Larsen Creek

- As with the 2-lane split grade option, the new highway footprint has the potential to affect water quality in the watercourse. Features such as biofiltration swales and/or infiltration areas can be used to mitigate this risk.
- The extent of impervious highway surface will be approximately 2x greater than for the 2-lane split grade option.

Option C: 2-lane northbound tunnel

Nelson Creek

- Important fish-bearing stream.
- New 2 lane bridge proposed upstream of the existing highway bridge. South portal of tunnel will be located above the west bank of the stream. Bridge will be a clear-span, with only minor impacts on riparian vegetation anticipated. Bridge piers shown on the conceptual general arrangement drawings for the bridge are setback more than 15 m from the stream channel. The crossing structure will also be high over the creek and, therefore, only minor shading effects are expected. Given that the southern tunnel portal is directly above the Nelson Creek Ravine, specific design features have been incorporated into the design to protect water quality in the Nelson Creek watershed.

1672 West 75th Avenue, Vancouver, British Columbia, Canada V6P 6G2 Tel 604 264 7522 Fax 604 264 9152

These measures include management of silt, blast-rock, construction wastewater runoff, groundwater drainage intercepted by the tunnel, and potential contaminants that could result from spills or accidents. The preliminary design concept to treat construction wastewater and operations runoff includes storm piping through an oil/silt separator followed by infiltration through a subsurface granular filter/soak-a-way system.

Upper Larsen Creek wetland

- This wetland is located near the headwaters of Larsen Creek and provides an important hydrological function within the Larsen Creek watershed, contributing water flows and food/nutrient supply for the benefit of downstream fish-bearing habitats (downstream of Highway 99, at the Horseshoe Bay Overhead Structure). These downstream fish-bearing habitats are characterized by critical low flows in the summer, therefore maintaining natural hydrological function of this wetland in the headwaters of this watershed is critical. This wetland also provides habitat for amphibians. The north tunnel portal appears to surface upslope from the wetland.
- It is anticipated that the location the north portal, as shown on the design drawings, will avoid direct impacts to the wetland. Through-drainage mitigation may be required near the tunnel portal to preserve the hydrological function of the upper Larsen Creek watershed. The precise location of the north portal is understood to be somewhat flexible in order to address these concerns.

Larsen Creek

- Larsen Creek is non-fish bearing from its wetland headwater area downstream to the existing highway 99. This upstream section of the watercourse does, however, provide critical water quality, streamflow, and food and nutrients to downstream fish populations. Therefore these functions will need to be preserved.
- The required northbound access ramp from Horseshoe Bay runs close to Larsen Creek near the existing Highway 99 and could pose some risk of sediment input into this watercourse.

Option D: 2-lane, 2-way tunnel

Nelson Creek

- Two new crossings over Nelson Creek are required to service the 2-way traffic; a single south portal will be constructed on the north side of the creek. The structures would be clear span and would result in some impact to riparian vegetation in the Nelson Creek Ravine. As with option C, special design considerations will be required to prevent water quality impacts from tunnel construction and operations. These will be essentially identical as those constructed for Option C.

Upper Larsen Creek wetland

- As noted for the northbound tunnel option (Option C), the location of the north portal shown on the design appears to be located up-gradient from the wetland area. However, through-drainage mitigation may be required to prevent impact to hydrological function in the upper Larsen Creek watershed.

Aquatic Effects of Alignment Options

In summary, all options carry with them good opportunities to mitigate impacts to Larsen Creek mainstem and its upper watershed wetland area. Upslope and split grade options (options A & B) avoid potential impacts to Nelson Creek.

CONFLUENCE
Environmental Consulting

MEMO

To: Isobel Doyle
From: Ethan Askey
Date: February 11, 2004 (subsequently revised)
Re: Multiple Account Evaluation (MAE) of design options, Work Package 1

Following is some background information on the four different alignment and design options in the vicinity of Horseshoe Bay (at Locations PA1-1 and PA1-2 in the Upland Recreation Assessment report), presented to provide context for the revised MAE table sent with this memo.

Note that the base-case (do nothing) scenario represents a valued recreation amenity, in that currently there are vehicle-accessible trailhead staging areas and a forested trail system that is for the most part well removed from the traffic movement and noise of Highways 1 and 99. However, trailhead parking and trail continuity over the long term may be subject to change or restrictions associated with the future development of private land in the vicinity.

The "direct" effects made reference to below include direct encroachment on trails by the proposed new lanes, and unbuffered traffic noise, exhaust etc. The "indirect" effects include possible vegetation removal (clearing and grubbing) that physically affects the trail, and any additional traffic noise, exhaust etc. that affects the recreational experience despite being mitigated by the greater distance and/or vegetation buffer between the new lanes and the trail.

Option A: 2 northbound lanes upslope

- 650 m of trail directly and indirectly affected by highway
- 400 m of trail need re-routing (i.e re-built more or less along roadway post-construction)
- 1 highway crossing of trail (at Larsen Creek)
- *Favourable*: Nelson Canyon Park and trail system at south end remain unaffected
- *Unfavourable*: a heavily used section of Baden-Powell Trail would be affected by construction and operation of northbound lanes, in both the short-term and long-term
- *Mitigation*: 1) bridge over Larsen Creek and trail adjustments can be made to provide continued access for local pedestrian use, but the "recreation experience" would be affected by the proximity to the new 2-lanes and by traffic noise; 2) additional trailhead parking area constructed approx.100 m north of the wetland feature for northbound traffic may provide alternate, more secure long-term trail access for hikers traversing the North Shore mountains.

Option B: 4 upslope lanes

- 650 m of trail directly affected by highway
- 400 m of trail need re-routing (i.e re-built more or less along roadway post-construction)
- 2 highway crossings of trail, near Eagle Ridge Drive and at Larsen Creek

- *Favourable*: Nelson Canyon Park and trail system at south end remain unaffected
- *Unfavourable*: a heavily used section of Baden-Powell Trail would be affected by construction and operation of a new section of 4-lane highway, in short-term and long-term
- *Mitigation*: 1) trail over/underpasses in two locations and trail adjustments can provide for continued access for local pedestrian use, but the "recreation experience" would be affected by the proximity to 4 lanes of traffic and the traffic noise; 2) additional trailhead parking area constructed approx.100 m north of the wetland feature for northbound traffic may provide alternate, more secure long-term trail access for hikers traversing the North Shore mountains.

Option C: 2-lane northbound tunnel

- 350 m of Baden-Powell trail may be directly and/or indirectly affected by construction and operation of 1-lane on-ramp/connector from Marine Dr.
- 100+ m of trail need re-routing (i.e. re-built where there is encroachment, and re-routed to follow on-ramp underpass route to east side of northbound lanes)
- 2 highway crossings of trail
- *Favourable*: 1) tunnel avoids encroachment and disturbance for most of the trail system; and 2) this particular option may best facilitate the construction and use of additional trailhead parking on east side of highway at northbound on-ramp underpass from Marine Dr.
- *Unfavourable*: trail system would be affected by construction disturbance and increased traffic noise in the 2 locations near/under highway, in short-term and long-term
- *Mitigation*: 1) trail underpasses in two locations and trail adjustments can provide for continued access for local pedestrian use, but the "recreation experience" would be affected by the proximity to 2 lanes of traffic and the traffic noise; 2) additional trailhead parking area constructed approx.100 m north of the wetland feature for northbound traffic may provide alternate, more secure long-term trail access for hikers traversing the North Shore mountains.

Option D: 2 –lane, 2-way tunnel

- Approx. 300 m of Trans Canda Trail (near south portal) and 100 m of Baden-Powell Trail (near north portal) may be directly and indirectly affected by construction and operation of tunnel portals and 4-lanes of highway
- 200 m of trail may need re-routing at north portal if a pedestrian underpass is constructed
- 2 highway crossings of trail (near south and north portals of tunnel), and encroachment on trail access route at southbound on-ramp to Highway 1
- *Favourable*: tunnel avoids encroachment and disturbance for most of the Baden-Powell Trail
- *Unfavourable*: 1) a short section of the Trans Canada Trail at Nelson Canyon Park will need to be re-routed as a result of the 2 new bridge crossings of Nelson Cr. and the south tunnel portal approach; 2) the northbound off-ramp will require property taking at Nelson Canyon Park; 3) the southbound on-ramp will affect parking and the Trans Canada Trail on the south side of the Upper Levels Highway
- *Mitigation*: 1) trail underpasses in two locations would provide for continued access for local pedestrian use, but the "recreation experience" would be affected by the proximity to 4 lanes of traffic and the traffic noise; 2) note that available design information suggests the trail system impacts at the south portal of the tunnel will be difficult to mitigate.