Ministry of Transportation and Highways
Province of British Columbia

BRITISH COLUMBIA

Highway 1 (North Vancouver to Surrey) Monitoring and Evaluation Program

Phase II HOV Evaluation & TMP Baseline

IBI GROUP

FINAL REPORT

March 31st, 2000

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List of Acronyms

AID	Automatic Incident Detection
AVO	Average Vehicle Occupancy
FSP	Freeway Service Patrols
GP	General Purpose
HAS	Highway Accident System (MoTH)
HOV	High Occupancy Vehicles
ICBC	Insurance Corporation of British Columbia
MOE	Measure(s) of Effectiveness
MoTH	B.C. Ministry of Transportation & Highways
MVA	Motor vehicle Accident
Phase I	Prior to the start of the construction of the HOV lanes in October 1997
Phase II	Subsequent to the opening of the HOV lanes on October 28, 1998
Phase III	After HOV and FSP improvements
SOV	Single Occupant Vehicle
TAS	Traffic Accident System (ICBC)
TCH	Trans Canada Highway
TMP	Traffic Management Program

List of Definitions

AM Peak Hour	7:00 AM to 8:00 AM
AM Peak Period	6:00 AM to 9:00 AM
Mid-day Peak Hour	12:00 PM to 1:00 PM
Mid-day Peak Period	11:00 AM to 1:00 PM
PM Peak Hour	4:00 PM to 5:00 PM
PM Peak Period	3:00 PM to 6:00 PM (to 6:30 or 7:00 PM for some analysis)

Mainline	Trans Canada Highway / Highway 1 (TCH)
Study Corridor	Mainline & Parallel Routes (North: Lougheed Highway, etc., South: Canada Way, Pattullo Bridge, etc.)
HOV-FSP Section	Mainline, Grandview Highway (Vancouver/Burnaby border) to Lougheed Highway (Cape Horn) Interchange at west end of Port Mann Bridge (Surrey/Coquitlam border), i.e. Highway 1 in Burnaby-Coquitlam
Study Section	Mainline, Lynn Valley Road in North Vancouver to Highway 15 (176 Street) in Surrey

Screenline 1	Centre Screenline (TCH, Lougheed Highway at Gaglardi, Canada Way at 10th Avenue)
Screenline 2	King Edward Screenline (TCH, Lougheed Highway at King Edward)
Screenline 3	Fraser River Screenline (Port Mann Bridge, Pattullo Bridge)
Screenline 4	Second Narrows Bridge
Screenline 5	East Screenline (Lougheed Highway, Mary Hill Bypass)

Exhibit ES-1– Study Section

KEY FINDINGS *(Highway 1 HOV-FSP Section "Before/After" Comparison)*

1. Person throughput in the central portion of the HOV section has increased by approximately 40% (or 4500 persons) in the morning (6:00 AM to 9:00 AM) westbound peak direction, and 72% (or 6700 persons) in the evening (3:00 PM to 6:00 PM) peak direction.
2. Overall traffic volumes in the central portion of the HOV section have increased by approximately 55% in the peak hour directions, and about 15% in the off-peak hour directions.
3. HOV lane peak hour volumes are about 1100 vph east of Kensington Avenue in the AM westbound peak direction, and about 1250 vph east of Sprott Street in the PM eastbound peak direction.
4. Average Vehicle Occupancy (AVO) in the central portion of Highway 1 has increased about 5% to 6% in both peak period directions.
5. The overall peak direction High Occupancy Vehicle (HOV) versus Single Occupant Vehicle (SOV) split is between 25% to 30% HOV and 70% to 75% SOV.
6. Average Vehicle Occupancy on TCH at the Port Mann Bridge has increased approximately 3.3 to 6.2%, while the Pattullo Bridge AVOs have decreased approximately 2.5 to 3.6%.
7. Travel time savings are about 20 minutes (64%) for HOV, and 12 minutes (36%) for GP traffic in the afternoon eastbound peak hour direction; as well as 7 minutes (44%) for HOV, and 2 minutes (11%) for GP traffic in the morning westbound peak hour direction.
8. HOV lane travel time reliability has increased by 24% in the morning westbound peak hour direction, and 13% in the afternoon eastbound peak hour direction.
9. In the peak hour direction, "Per Lane Efficiency" has increased 31% in the morning and 106% in the afternoon.
10. Levels of Service (LOS) for the GP lanes have improved generally from LOS F to E and D.
11. HOV rule compliance is 85-95%.
12. FSP deal with approximately 300 incidents per month (10 per day).
13. A reduction in average incident time duration of approximately 50% compared to Phase I, and 43% compared to locations without FSP is observed.
14. The total annual cost of delay due to incidents in the FSP section has decreased about 40%, from $46 Million before to $28 Million after the HOV and FSP improvement projects.
15. Potential capacity, currently lost due to incident impacts (to be regained by TMP) is between 10% to 15% in the peak periods, which at a 1.4% growth rate could defer infrastructure expenditures by as much as 10 years.

16. ICBC crash claims have decreased about 25%, and the cost of claims has decreased about 48% or about $4.6 Million, after HOV and FSP improvements.

17. Almost all of the Stakeholder respondents, especially the RCMP, find the FSP to be a clear asset in incident response and clearance.

18. The Highway 1 Motorist Surveys taken after HOV-FSP implementation indicate that:

- About 28% of the HOV are new carpools, while 72% were already carpooling.
- About 60% of the HOV were previously on the TCH, while 40% switched from the parallel routes.
- About 17% of the HOV were new carpools formed by SOV on the TCH, while 11% were new carpools formed by SOV from the parallel routes; and, about 43% of the HOV were old carpools already on the TCH, while 29% were old carpools formerly on the parallel routes.
- About 93% of the SOV were already on the TCH, while 7% switched from the parallel routes.
- Approximately 52% of motorists often see the FSP vehicles responding to incidents.
- Approximately 10% of all respondents have been helped by, or know someone who has been helped by the FSP.
- Approximately 89% of HOV and 74% of SOV motorists believe that the designated number of occupants for the HOV lanes should be 2 or more persons (existing rule).
- Approximately 30% of the SOV said they would be encouraged to become HOV users if their hours of work permitted it, while 20% require a "good rideshare opportunity" to become HOV users.
- More than 85% of HOV and 70% of SOV motorists are satisfied with the HOV and FSP operations.

RECOMMENDATIONS

It is recommended that:

1. ICBC look at continuing the FSP initiative, and together with BCTFA/MoTH consider expediting the evolution of FSP into the proposed TMP coordinated Roadside Assistance/Emergency Service Patrols.

2. The ICBC Crash Claims Contravention project team consider following up the use of the Highway 1 HOV-FSP section as a prototype for calibrating MV104 trend data and for "piloting" the transition to the proposed new and more comprehensive "consolidated" Police MV104/ICBC claims database.

3. Consideration be given to extension of the HOV lanes along the TCH corridor, through the Cassiar Tunnel and possibly over the Second Narrows Bridge, as well as across the Port Mann Bridge, in order to extend the advantages, generate new carpools, and maximize the use of available capacity.

4. The safety analysis of the HOV-FSP section be updated using a complete sample of data from Police, ICBC, and MoTH databases (when the 1999 data is available). Also, additional pre-TMP accident data should be collected using the FSP as an additional source of incident data collection within the HOV portion of the Highway 1.

5. Further accident data analysis and research of experience in other jurisdictions be conducted to estimate more accurately the relative impact of the accident increasing/reducing factors involved in the TCH-HOV-TMP project.

6. Consideration be given to periodic monitoring of the HOV lanes to determine if the improved travel time and trip time reliability, safety and satisfaction incentives are maintained, and to measure the effectiveness of future improvements.

7. A follow-up (Phase III) of this study and report be included as part of the TMP "pilot" project.

8. The scope and timing of the TMP pilot project deployment be coordinated closely with other improvements along the corridor, such that a few fundamental data surveys are made as part of each project.

INTRODUCTION

Improving traffic management measures by encouraging higher occupant modes of travel through High Occupancy Vehicle (HOV) facilities, and through the deployment of Intelligent Transportation System (ITS) applications, represent two ways of efficiently accommodating increasing travel demands on existing highways.

The Ministry of Transportation and Highways (MoTH) has several major projects underway, targeted at improving person travel accessibility, encouraging more efficient usage of roadway infrastructure, improving travel safety, and improving air quality.

1. **HOV Project:** a BCTFA-funded $62 million widening of the Trans Canada Highway (TCH) from 4 to 6 lanes to provide 2 HOV lanes, over a distance of 16 km from Grandview Highway in Burnaby to Lougheed Highway (Cape Horn) Interchange in Coquitlam. The HOV Project on Highway 1 opened October 28, 1998, and included the following physical components:

   - Six laning with provision of median HOV lanes;
   - Various ramp improvements,
   - Additional lighting;
   - Continuous median barrier;
   - Wider median shoulders where possible.

2. **FSP Project:** an ICBC-funded ($1.6 million over 3 years) deployment of Freeway Service Patrols (FSP) started on January 4, 1999 as a forerunner or "precursor" to the proposed TMP coordinated Roadside Assistance/Emergency Service Patrols. This service is designed to assist motorists by detecting, responding to, and clearing, traffic incidents more quickly. The service includes a tow truck and a push truck with appropriate equipment, as well as a temporary Traffic Management Centre (trailer with radio and CCTV), to provide the following services:

   - CCTV monitoring for quick detection and response;
   - Tow or push disabled vehicles:
   - Provide jump starts, gas, water, and minor repairs:
   - Remove debris and clean up spills;
   - Transport motorists and pedestrians from the Freeway;
   - Provide temporary traffic control;
   - Record or log all incidents.

3. **TMP Pilot Project:** a BCTFA-funded $25 million initiative, over 4 years, as the first phase of a long-range plan aimed at managing traffic congestion, encouraging more efficient use of roadway infrastructure, improving travel safety, and improving air quality along a 34 km stretch of Highway 1. Subject to further review and clarification, this pilot program includes the section of Highway 1, between Lynn Valley Road in North Vancouver and 160 Street in Surrey, and will include the application of ITS technologies with interagency coordination. The TMP

demonstration "pilot" project will deploy two key transportation user service applications on Highway 1, i.e. Incident Management and Traveler Information. The current project scope involves interagency coordination through a Traffic Management Centre to manage the following components:

- Fibre optic communications backbone,
- Coordinated Roadside Assistance/Emergency Service Patrols,
- Digital cameras and automatic incident detection systems;
- Toll-free motorist cell-phone incident reporting system;
- Changeable message signs and other traffic information/control devices;
- Internet and Radio/TV traffic information programming;
- Supporting hardware and software systems, etc.

4. **Other Related Projects (not part of Phase II Study)**: include the following recently completed or proposed near-term future projects:

- Lougheed westbound on-ramp near Coleman Avenue (with ramp signal control) - opened Dec. 15, 1999;
- Lougheed westbound on-ramp at Cape Horn I/C - closed Dec. 15, 1999;
- Mary Hill Bypass westbound on-ramp at Cape Horn I/C - proposed;
- Port Mann Bridge 5-laning and HOV lane extension - proposed.

The HOV, FSP, and TMP initiatives are intended to increase the operational lifecycle of this critical urban section of the TCH corridor by optimizing person throughput, providing Incident Management and Traveler Information services, thus reducing delays, improving safety, and minimizing impacts to the environment.

As part of its program evaluation mandate, MoTH retained IBI Group in August of 1997 (prior to the construction of the HOV lanes) to develop and implement Phase I of a staged monitoring and evaluation methodology for evaluating the incremental benefits of the HOV lanes and the TMP pilot project as it unfolds.

IBI Group carried out the first phase of that program which included the collection and analysis of related traffic data to establish a “before” baseline prior to implementation of the HOV and TMP projects. Data for the Phase I “before” study was collected in September/October 1997.

Two years later (one year after the opening of the HOV lanes October 28, 1999), IBI Group carried out Phase II of the TCH Monitoring and Evaluation Program data collection. This report presents the analyses and findings of this Phase II “after” study. In addition to the evaluation of the HOV lanes, this report evaluates and documents the benefits of the ICBC-funded FSP deployment starting January 4, 1999. Also, the Phase II study is intended to provide a secondary baseline for measuring the benefits of further evolution of the FSP and the initiation of other TMP components described above.

STUDY COST AND OBJECTIVES

The overall BCTFA-funded "Before/After" (Phase I & II) TCH-HOV Evaluation & TMP Baseline study cost approximately $1/2 Million, but over ¾ of that is reusable survey data, such as traffic counts, travel times, vehicle occupancy, incident frequency, etc.

This Phase II report reveals that HOV and FSP objectives have been achieved, and that MOEs and baselines for the TMP are reliable. The report also reveals more general and aggregate improvements resulting from the array of improvements along the Highway 1 sections between North Vancouver and Surrey. Attributing these benefits to specific improvements is however difficult because the contributing factors are so numerous and overlapping.

The HOV-FSP Section covers the 16 km of TCH between Grandview Highway and Cape Horn, while the TMP section lies within the 34 km stretch of the TCH between the Lynn Valley Road overpass in North Vancouver and 160 Street overpass in Surrey. The Study Section (Lynn Valley Road to 176 Street) is shown in ES-1 (at the beginning of this Executive Summary). The Study Corridor includes parallel arterial roadways that provide alternate routes for Highway 1 traffic in these sections.

The primary objectives of the Phase II Monitoring and Evaluation Program were defined as follows:

- ✓ Review HOV and TMP Measures of Effectiveness (MOEs) identified in Phase I and confirm the application of the developed methodology for a quantitative evaluation of the MOEs for both "before" and "after" surveys.
- ✓ Coordinate and conduct data collection activities for the "after" HOV conditions, the "after" FSP conditions, and the "before" TMP conditions.
- ✓ Analyze all the data collected and compare before and after statistics to document HOV and FSP/CCTV benefits, and any background changes affecting the TMP second baseline travel patterns.

HOV MONITORING & EVALUATION

By providing higher travel speed and lower travel time variability, the HOV facility is expected to encourage a modal shift to higher occupancy vehicles, resulting in an increase in the person carrying throughput of the highway, optimization of travel speeds, more reliable travel times and a reduction in energy consumption and vehicle emissions due to reduced delays and congestion.

In order to evaluate these expected benefits, eight objectives were defined:

1. Increase Person Movement Throughput;
2. Provide Travel Time Savings;
3. Improve Trip Travel Time Reliability;
4. Increase Per-Lane Efficiency;
5. Minimize Negative Impacts on General Purpose (GP) Lanes;
6. Maintain Safety;
7. Obtain Compliance
8. Acquire Public and Stakeholder Acceptance & Satisfaction

For each of these objectives, measures of effectiveness (MOEs) were defined. These MOEs dictated the traffic data requirements to measure the degree of achievement of each of the objectives. The evaluation relative to each of the objectives is described below.

HOV Objective 1: Increase Person Movement Throughput

The new HOV lanes have significantly increased the person movement throughput along the HOV section of TCH and its parallel routes during the peak periods. The key MOEs for measuring increases in person throughput are before and after Average Vehicle Occupancy comparisons, and before and after comparisons of HOV market share.

Overall traffic volumes in the central portion of the HOV section have increased by approximately 55% in the peak hour directions, and about 15% in the off-peak hour directions.

Average Vehicle Occupancy (AVO)

Peak direction AVOs have increased by approximately 2.5% to 4.4% along the Centre screenline (TCH, Lougheed Highway, and Canada Way) near the Gaglardi interchange, and between 5.3% and 9.4% across the King Edward Screenline (TCH and Lougheed Highway) near Brunette. Increases in AVO across the screenlines have been significant on the TCH, without significant decreases on the parallel routes, confirming that the HOV lanes have induced the generation of new carpools. Exhibit ES-2 provides a summary of before and after AVOs.

Exhibit ES-2 - Before & After AVO Changes by Screenline

WESTBOUND AM PEAK PERIOD	September 1997 AVO	September 1999 AVO	% Difference
Centre Screenline: Lougheed, TCH, Canada Way (West of King Edward)	1.14	1.19	+4.4%
King Edward Screenline: Lougheed, TCH (east of **Brunette**)	1.13	1.19	+5.3 %
Fraser River Screenline: Pattullo Bridge, Port Mann Bridge	1.16	1.19	+2.6%
Second Narrows Screenline: Second Narrows Bridge only	1.11	1.13	+ 1.9%

EASTBOUND PM PEAK PERIOD	September 1997 AVO	September 1999 AVO	% Difference
Centre Screenline: Lougheed, TCH, Canada Way (West of King Edward)	1.24	1.27	+ 2.4 %
King Edward Screenline: Lougheed, TCH (east of **Brunette**)	1.17	1.28	+9.4%
Fraser River Screenline: Pattullo Bridge, Port Mann Bridge	1.20	1.23	+2.5 %
Second Narrows Screenline: Second Narrows Bridge only	1.20	1.23	+2.9 %

Some diversions in existing HOVs have been observed across the Fraser River screenline (Pattullo Bridge and Port Mann Bridge), where the TCH/Port Mann Bridge AVOs have increased significantly (approximately 3.3 to 6.2%), while the Pattullo Bridge AVOs have decreased significantly (approximately 2.5 to 3.6%).

Person Throughput

In general AVOs are the best measure of person throughput because they are normalized by the before and after number of vehicles. Raw person throughput data can also be used to measure the degree to which this objective is achieved, but are not as reliable since traffic volume variations can significantly sway results. Using the AVOs and the available short count data collected during September of 1997 and 1999, changes in person throughput along Highway 1 near Gaglardi interchange (central and representative portion of the HOV section) are summarized in Exhibit ES-3.

Exhibit ES-3 - Before & After Person Throughput at the Central Portion of the HOV Section

Highway at Gaglardi Interchange (Central Portion of HOV Section)			
Peak Period / Direction Person Throughput	**Before**	**After**	**% Change**
AM Period (6:00 –9:00) **Westbound**	11,200	15,700	40%
PM Period (3:00- 6:00) **Eastbound**	9,200	15,900	72%

Review of the person volume data indicates that total person movement throughput along the Highway 1 HOV Section has increased by approximately 40% in the AM westbound peak direction, and 72% in the PM eastbound peak direction. When interpreted with the overall AVO increase observations across all screenlines, it can be confirmed that the increase in person throughput is due to an increase in higher occupant modes, and not just an increase in traffic volumes. The increase in person throughput beyond normal growth can be accounted for by attraction of SOVs and HOVs from parallel routes (such as Lougheed Highway and Canada Way / Pattullo Bridge), and by satisfaction of latent demand (where more people are able to make the trip they want when they want, etc).

HOV Market Share

Significant increases in HOV market share have been observed primarily in the peak direction. Specifically, the percentage of people in the HOVs has increased between 9% and 12% across the King Edward screenline, 2% to 4% across the Centre screenline, and 3% to 5% across the Fraser River screenline during the AM and PM peak directions. Exhibit ES-4 provides a tabulation of before and after HOV market share percentages.

Exhibit ES-4 - Before & After HOV Market Share Changes by Screenline

WESTBOUND AM PEAK PERIOD	% of People in HOVs		% Difference
	September 1997	September 1999	
Centre Screenline: Lougheed, TCH, Canada Way (near **Gaglardi**)	27 %	29 %	+2%
King Edward Screenline: Lougheed, TCH (east of **Brunette**)	20 %	29 %	+9%
Fraser River Screenline: Pattullo Bridge, Port Mann Bridge	25 %	30 %	+5%
Second Narrows Screenline: Second Narrows Bridge only	17 %	21 %	+4%

EASTBOUND PM PEAK PERIOD	% of People in HOVs		% Difference
	September 1997	September 1999	
Centre Screenline: Lougheed, TCH, Canada Way (near **Gaglardi**)	34 %	38 %	+4%
King Edward Screenline: Lougheed, TCH (east of **Brunette**)	27 %	39 %	+12%
Fraser River Screenline: Pattullo Bridge, Port Mann Bridge	31 %	34 %	+3%
Second Narrows Screenline: Second Narrows Bridge only	29 %	33 %	+4%

HOV Objective 2: Provide Travel Time Savings

The new HOV lanes provide significant travel time savings to HOVs relative to Phase I conditions prior to the construction of the HOV lanes, and relative to adjacent current GP traffic (Phase II). In the AM peak period westbound, HOVs save 7.3 minutes compared to travel times in Phase I, and 5.6 minutes compared to the GP traffic currently in the lanes next to them. In the PM peak period eastbound, HOVs save 20.3 minutes compared to travel times in Phase I, and 8.7 minutes compared to the GP traffic currently next to them. All of the savings were found to be statistically significant at the 95% level.

Exhibit ES-5 provides a tabulation of travel time comparisons travel times along the HOV/FSP corridor parallel routes. It can be observed that the Highway 1 travel times are consistently lower than the parallel routes, predominantly due to the arterial nature of those routes. It is interesting to note that the parallel route travel times are lower in the peak direction, than in the off-peak, illustrating the benefits of signal coordination.

Exhibit ES-5 - HOV/FSP Corridor Phase II Travel Time and Speed Comparison

HIGHWAY 1 vs NORTHERN PARALLEL ROUTE	Distance (km)	EASTBOUND				WESTBOUND			
		AM		PM		AM		PM	
		Travel Time (min)	Speed (km/hr)	Travel Time (min)	Speed (km/hr)	Travel Time (min)	Speed (km/hr)	Travel Time (min)	Speed (km/hr)
Highway 1	16.2	11.7	83	22.0	44	16.1	60	13.1	73
Northern Route	15.8	18.8	51	24.6	39	31.9	30	28.4	33

Note: Highway 1 - Boundary Road to Cape Horn
Norhthern Route - Boundary Road to United Blvd

HIGHWAY 1 vs SOUTHERN PARALLEL ROUTE	Distance (km)	EASTBOUND				WESTBOUND			
		AM		PM		AM		PM	
		Travel Time (min)	Speed (km/hr)	Travel Time (min)	Speed (km/hr)	Travel Time (min)	Speed (km/hr)	Travel Time (min)	Speed (km/hr)
Highway 1	22.6	16.6	81	27.9	48	27.2	49	19.4	69
Southern Route	22.3	31.4	43	44.0	30	45.2	30	44.0	30

Note: Highway 1 - Boundary Road to 104 Ave / 160 Street
Southern Route - Boundary Road to 104 Ave / 160 Street

HOV Objective 3: Improve Trip Time Reliability

Variances in average speeds along the HOV lanes were also observed to be significantly lower when compared to Phase I variances, and when compared to current GP variances in average speed. In the westbound AM peak direction, HOV trip time reliability has increased by 27% and 24% relative to previous (Phase I) conditions, and current (Phase II) GP conditions, respectively. In the eastbound PM peak direction, HOV trip time reliability has increased by 13% and 17% relative to Phase I conditions, and current GP conditions, respectively. All of the differences were found to be statistically significant at the 95% level.

HOV Objective 4: Increase Per Lane Efficiency

An increase in the efficiency of the HOV section has been observed, as measured by increased person throughput and increased operating speeds (averaged for all three lanes). In the peak directions, the per lane efficiency has increased by 31% for the westbound AM peak period, and an astounding 106% for the PM peak period eastbound, clearly showing the efficiency improvements when capacity is utilized to its potential with higher occupant modes of travel.

HOV Objective 5: Minimize Negative Impacts on GP Lanes

The new HOV lanes have not adversely affected the GP lane operations, as measured in terms of average GP speeds and levels of service. Average GP speeds have increased in all periods and directions as a result of the additional capacity and the absorption of existing HOVs by the new lanes. Although not an objective to improve conditions for GP traffic, some of the GP travel times savings were also observed to be statistically significant. LOS were also observed to improve for the GP lanes, increasing from LOS F to E and D in the peak directions.

HOV Objective 6: Maintain Safety

The assessment of safety impacts to the HOV/FSP section was based on comparisons of crash claims data, as obtained from ICBC's claims database, for the periods before, during and after construction of the HOV lanes. It was initially intended to use MoTH's Highway Accident System (HAS) which is based on the ICBC's Traffic Accident System (TAS) and Police MV104 accident database; however, this data was not available at the time of this project.

Comparisons of the claims data indicate a noticeable increase in the number of accident related claims during the construction period, but a dramatic decrease in the frequency of claims and total associated claim costs after the construction of the HOV facility and the FSP service. Specifically, when compared to the total number of annualized claims prior to construction of the HOV lanes, claims increased by 22% during construction, but decreased (from the pre-construction phase) by 25% in the year subsequent to the HOV and FSP operations. In terms of cost of claims, the costs increased by approximately $400,000 during construction of the HOV lanes, but decreased by $ 4.6 million from before construction, expressed on an annual basis.

Although claims data is not a comprehensive source of safety data, the general reduction in accident claims tentatively confirms that safety has been maintained along the Highway 1 HOV and FSP section since the construction of the HOV lanes and deployment of the FSP.

HOV Objective 7: Obtain Compliance

HOV lane compliance rates were observed to be satisfactory in all periods and directions, ranging between 90 to 95%, except near the east terminus of the eastbound HOV lanes where AM compliance rates of 85% were observed. The proximity of the measurements to the terminus of the lanes suggests that during peak conditions, GP traffic may enter the HOV lanes close to its terminus. Nevertheless, most agencies including MoTH target a minimum compliance rate of 85%. The TCH HOV lanes clearly achieve this.

Comparison of 2+ HOV compliance data six months after the HOV lanes opened, versus one year after, indicates consistency in the results, with compliance rates increasing between 6 to 11% near the Gaglardi interchange, and decreasing by 3 to 8% near the Cape Horn terminus of the HOV lanes

Analysis of all HOV-related offences (including 2+ non-compliance) since the opening of the lanes indicates that the frequency of offences has not increased or decreased. However, the allocation of enforcement resources has been optimized by starting out with higher levels of enhanced enforcement and accordingly reducing the effort to the required amount of enforcement to maintain standards.

HOV Objective 8: Acquire Public Acceptance and Satisfaction

Information, observation, and opinion seeking surveys were distributed to TCH motorists, as well as to a selected sample of stakeholders, to document acceptance and satisfaction with the HOV lanes. Based on responses from approximately 566 motorists on Highway 1 (with an appropriate 30% to 70% HOV and SOV split), public acceptance and satisfaction was observed to be very high (stakeholders even higher).

Exhibit ES-6 below summarizes the critical attributes of the full sample of HOV respondents, broken down by whether they are newly formed or existing, and whether they were already on the TCH or switched from parallel routes.

Exhibit ES-6 - Existing & New HOVs versus TCH & Route Switching HOVs

TCH Sample of HOV Users	Already on Highway 1	Switched from Parallel Routes	Totals
Existing HOVs (i.e. already carpooling prior to HOV lanes)	43%	29%	72%
New HOVs (i.e. carpooling after HOV lanes)	17%	11%	28%
Totals	60%	40%	100%

Of the sample of all HOV users, the surveys indicate that:

- About 28% of the are new carpools, while 72% were already carpooling.
- About 60% of were already on the TCH, while 40% switched from the parallel routes.
- About 17% of the HOVs were new carpools formed by SOVs on the TCH, while 11% were new carpools formed by SOVs on the parallel routes.
- About 43% of the HOVs were carpools already existing on the TCH, while 29% were carpools already on the parallel routes.

Results were consistent irrespective of the respondents' mode of travel and confirm that for most of the acceptance and satisfaction accounts used (relating to HOV benefits and safety), more than 70% of SOVs and 85% of HOVs are satisfied. Also, approximately 89% of HOV and 74% of SOV motorists believe that the designated number of occupants for the HOV lanes should be 2 or more persons (existing rule).

Primary issues raised by the respondents related to HOV expansion and improvements across the Port Mann Bridge, as well as the need for additional enforcement. Only 23% of the SOVs indicated a desire to limit the HOV lanes to peak periods only.

SUMMARY OF HOV BENEFITS

All of the HOV project objectives have been achieved, with expected benefits attained:

1. Person movement throughput has increased significantly through the formation of new carpools, as opposed to merely diversion of existing HOV traffic from other parallel facilities
2. HOVs experience significant travel time savings in both peak periods and directions
3. Trip times are significantly more reliable for HOV traffic
4. Per lane efficiency during the peak directions has significantly increased due to the movement of more persons at optimum average speeds
5. GP lanes have not been adversely affected but operate better now due to the added capacity
6. Safety has not been compromised, with the total frequency and cost of claims decreasing
7. Compliance is above the desired 85% minimum for all directions and time periods
8. More than 70% of the SOVs and 85% of the HOVs view the HOV lanes as a benefit to their transportation system and are satisfied with its benefits.

TMP MONITORING & EVALUATION

The TMP is intended to increase the efficiency and operational lifecycle of this critical urban section of the Highway 1 corridor by providing Incident Management and Traveler Information services, and thus improving vehicle throughput, reducing delays due to incidents, and reducing accidents.

Similar to the HOV evaluation, a set of objectives was defined to evaluate the benefits expected from the TMP as well as interim benefits associated with the FSP. The objectives identified were:

1. Reduce/Manage Recurrent Congestion
2. Reduce/Manage Non-Recurrent Congestion
3. Improve Safety
4. Optimize Efficient Use of Capacity
5. Acquire Public Acceptance & Satisfaction

Using the MOE's and data requirements identified for the TMP evaluation objectives, a second baseline of data were collected and analyzed for the TMP to reflect pre-and post-HOV conditions. Where applicable, the FSP benefits were evaluated as part of the TMP objectives of reduced non-recurrent congestion and improved safety. Relevant before and after comparisons were made in an attempt to differentiate the changes due to HOV, FSP and TMP,

TMP Objective 1: Reduce/Manage Recurrent Congestion

Recurrent congestion is due to regular, daily high levels of traffic relative to capacity, which regularly create traffic congestion and delays. The primary MOE for measuring the reduction in recurring congestion is average speeds and travel times along the entire length of the Study section. Exhibit ES-7 below tabulates before and after travel time estimates, providing a breakdown by the key study sections. Differences between Phase I and II travel times within the North Vancouver and Surrey sections were observed to be negligible; this was expected since no major improvements were implemented in these sections since Phase I. The results do indicate an “end to end” (Lynn Valley Road to 176 Street) travel time saving of 13.8 minutes for the eastbound PM peak period, confirming that the benefits of the HOV and FSP improvements are significant and extend well beyond the boundaries of the HOV / FSP section.

Exhibit ES-7- Before and After Comparisons of Study Section Travel Times

Travel Time Comparisons (Minutes)	AM Peak Direction (WB)			PM Peak Direction (EB)		
	Before	After	Savings	Before	After	Savings
North Vancouver & Vancouver Section: Lynn Valley to Grandview Highway	15.7	17.1	**-1.4**	8.7	8.2	**0.5**
Vancouver Coquitlam HOV & FSP Section	16.7	14.9	**1.8**	32	20.3	**11.7**
Coquitlam & Surrey Section: Cape Horn to 176 Street	8.2	7.4	**0.8**	8.8	7.2	**1.6**
Lynn Valley to 176 Street Total Study Section	**40.6**	**39.4**	**1.2**	**49.5**	**35.7**	**13.8**

This second baseline of travel time data for evaluating the TMP complements the Phase I baseline well, is statistically reliable, and will permit separating the effects of the HOV and “precursor” FSP improvements from other forthcoming TMP improvements. Phase III “after” evaluation of TMP should reflect more significant savings along this length of the Study section due to improved traffic management and traveler information services. Collection of Phase III travel time data will be more efficient, if volume and speed data are extractable from an Automatic Incident Detection (AID) system.

TMP Objective 2: Reduce/Manage Non-Recurrent Congestion

Non-recurrent congestion results from random traffic incidents, such as accidents and stalls, which reduce available capacity by blocking lanes and/or shoulders and therefore delay the flow of traffic.

Non-recurrent congestion can be reduced and managed by reducing the overall duration of incidents, by detecting, responding, and clearing incidents faster. The primary MOE for this objective is reduced incident durations. A supporting MOE, which is a function of incident duration, is reduced delay due to incident blockages.

A substantial database of incident data (such as type, location, time, direction, response time, lane blockages, and clearance times) was logged during Phase I and Phase II using the FSP traffic management centre, temporary CCTV installed specifically for this project, and the North Shore maintenance contractor. This data has been used to evaluate the FSP, in terms of this objective of managing and reducing non-recurrent congestion. Comparisons are made between Phase I incident data capturing the no FSP scenario, the Phase II data capturing the with FSP scenario for the HOV-FSP section, and the Phase II data without FSP scenario using data from other sections of the Study corridor. The data has also been used to establish a post-HOV and pre-TMP baseline of data for the TMP.

Incident Duration

A comparison of the Phase I and II incident duration data is provided in Exhibit ES-6 below.

Exhibit ES-8 - Incident Duration Comparisons

Incident Data Source	Coverage Area	Average Response Time (min)	Average Clearance Time (min)	Average Incident Duration (min)
Phase I (Visual Observations)	HOV/FSP Section	23.0	19.0	41.0
Phase II FSP Data Logs	HOV/FSP Section	7.1	13.8	21.0
Phase II CCTV & Video-taping	North Vancouver Section Surrey Section	23.7 3.4	38.9 13.4	61.5 14.8
	Average of Both Sections	10.3	22.0	29.3
Phase II North Shore Contractor	First Avenue to 2nd Narrows	19.7		19.7

Specific conclusions drawn include:

- **FSP Evaluation:** The FSP currently respond to approximately 300 incidents per month. In the HOV and FSP section of the corridor, the average incident duration has been reduced by approximately 50%, from 41 minutes to 21 minutes. This reduction is the result of a reduction in response times from 23 minutes down to 7 minutes, and a reduction in average incident clearance time from 19 minutes to 14 minutes, clearly reflecting the benefits of CCTV monitoring and FSP incident response, and clearance.

- **TMP Baseline:** Along the North Vancouver and Surrey sections of the study corridor where maintenance contractor service vehicles are present, but without FSP/CCTV, the average incident duration is 30 minutes. In both cases, the incident duration is comprised of approximately one-third response time and two-third clearance time. Along the HOV and FSP section of the corridor, the average duration of incidents is 21 minutes with FSP (Phase II), and 41 minutes without FSP (Phase I).

Delay Due to Incident Lane & Shoulder Blockage

The incident data were also used to estimate delays and costs resulting from lane and shoulder blockages. It is observed that incidents involving lane blockages comprised 18% of all incidents at an annualized user cost of $13.5 million, while the remaining 82% of incidents resulting in shoulder blockages cost users over $14.7 million. It was further determined that the average frequency and duration of lane and shoulder blockages, during the peak directions, results in a 15% reduction in capacity.

Incident user cost estimates were also used to further demonstrate FSP benefits. Linear regression techniques were used to determine a relationship between average incident duration and the cost of delays due to incidents. It was estimated that the reduction in incident durations from 41 minutes to 21 minutes translates to an approximate $ 18 million dollar reduction in user costs attributable to incident delays.

TMP Objective 3: Improve Safety

Safety analysis of the TCH was limited to the analysis presented under the HOV safety objective. This analysis identified a significant decrease in the frequency of accident claims and associated costs since the opening of the HOV lanes.

Exhibit ES-9- Percent Difference in Claim Frequency by Project Phase

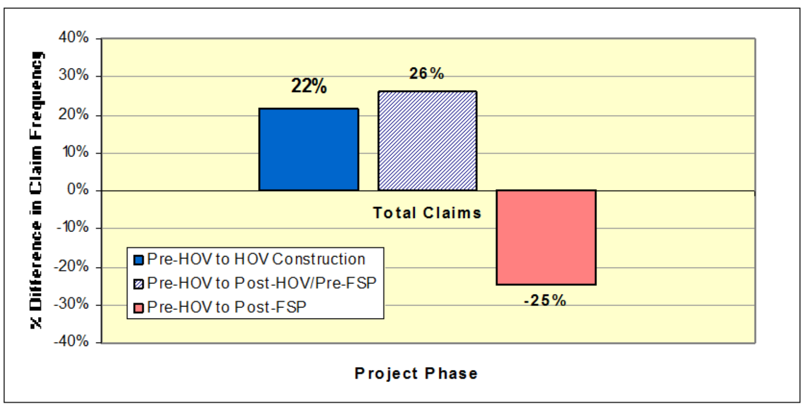


Exhibit ES-9 provides a summary of the increase and decrease in accident claim frequencies when comparing pre HOV lane conditions to post HOV and pre-FSP, and post-HOV and FSP conditions. An approximate 25% reduction in crashes is observed when comparing the safety performance of the Highway 1 study section before and after the HOV and FSP improvement projects.

Preliminary analysis by MoTH, of raw MV104 accident data obtained from the Police, indicates a 10% reduction in crashes when comparing the safety performance of the Highway 1 study section before and after the HOV and FSP improvement projects. However, temporary enhanced Police enforcement (paid by BCTFA) may have led to an increase in MV104 reporting after the HOV-FSP improvements (this following a few years of decreased reporting starting in 1996). The MV104 accident reports generally make up 25% to 30% of the ICBC claims data on crashes.

A portion of the above 10% to 25% crash reduction benefits may be attributable to improved incident response, management, and clearance by the FSP, but is difficult to separate from potential safety benefits of other improvements along the HOV and FSP segment. Exhibit ES-10 below provides a tabulated summary of potential safety impacts associated with changes in the HOV and FSP segment of Highway 1.

Exhibit ES-10 - Safety Impact Contributing Factors

Contributing Factors	Potential Safety Impact
Fsp	✓ Positive
Continuous lighting	✓ Positive
Traffic growth	✕ Negative
Addition of Capacity through six Laning of Highway 1	✓ Positive
Continuous median barrier	✓ Positive
Provision of 3 meter left shoulder where possible	✓ Positive
Less stop and go	✓ Positive
HOV versus GP Speed Differential with weaving	✕ Negative
Additional lane ends and merge conflicts	✕ Negative

Prior to implementation, it was estimated that the ICBC Freeway Service Patrols and *4444 incident reporting system (CCTV detection was used instead of *4444) would improve safety by clearing incidents more quickly, and thereby reduce accidents by 5 – 12% (TMP Business Plan, by Delcan, 1995; and ICBC Review of Systems for Freeways, by Hamilton Associates, 1997). Although the 25% reduction in collision claims made to ICBC since the construction of the HOV lanes and the deployment of the FSP cannot be broken down, it does tentatively confirm that the safety benefits of recent improvements along the HOV and FSP sections of Highway 1 are substantial and may equal or exceed earlier estimates.

TMP Objective 4: Efficient Use of Capacity

This objective is intended to demonstrate that the utilization of capacity between the mainline and the parallel routes is optimized, especially during non-recurrent (incident) congestion when traffic may divert to adjacent routes with spare capacity. The MOE proposed for this objective is total person throughput across key screenlines which reflect diversion impacts, such as across TCH, Lougheed Highway and Canada Way near the Gaglardi interchange. Baseline throughput data has been collected, for future comparisons after the deployment of the TMP pilot project.

TMP Objective 5: Public Acceptance and Satisfaction

At this point, prior to the deployment of the TMP pilot project service applications, the public acceptance and satisfaction questions were limited to FSP and general questions on the impacts and benefits of responding to and clearing incidents faster. Survey results were based on a large sample of TCH users and a smaller sample of transportation agencies stakeholders. Approximately 60% of TCH users, and 90% of the stakeholders often see the FSP respond to traffic incidents and agree that clearing incidents quickly minimizes congestion and leads to secondary benefits like improved air quality and lower fuel consumption. Almost all of the stakeholder respondents, especially the RCMP, find the FSP to be a clear asset in incident response and clearance.

All of the fundamental traffic data elements required to support the evaluation of the TMP pilot project have been collected for pre and post-HOV conditions consistent with the recommended study methodology and evaluation methodologies used for other similar evaluations. The following results have been derived during this secondary baseline of the TMP pilot project evaluation:

SUMMARY OF PHASE II TMP BASELINE & FSP BENEFITS

- ✓ Statistically reliable travel time data has been collected to complement the same data collected in Phase I for the evaluation of reductions in recurrent congestion delays. Marginal differences were observed between Phase I and II, except in the PM peak eastbound direction where significant travel time savings were observed (13.8 minutes) primarily due to the benefits associated with the HOV and FSP sections.
- ✓ The database of incident data has been expanded to include over 800 incidents. A reduction in average incident duration times of approximately 50% on sections patrolled by the FSP compared to Phase I, Total user cost of delay due to incident lane blockages has been reduced from $46M to $28M per year due to the FSP and overall improved operations with the HOV lanes. Potential capacity to be gained with TMP is between 10% to 15%, which at a 1.4% annual growth rate, could defer infrastructure expenditures by 10 years.
- ✓ All collision data, available at the time of the study, was collected for establishing a second post-HOV and pre-TMP baseline for measuring improved safety. Claims data from ICBC was used to compare frequency of accidents before, during, and after construction of the HOV lanes, and after deployment of the FSP. The accident analysis indicated substantial crash claims reductions as a result of the HOV and FSP implementation programs.
- ✓ Average speed, volume and occupancy data have been used to establish baseline throughput estimates across the west screenline of TCH, Canada Way, and Lougheed Highway at Gaglardi for throughput comparisons with the post TMP data.
- ✓ Public acceptance and satisfaction with the FSP is high, with approximately 60% of the respondents aware of the FSP, and the benefits of short incident duration times due to improved traffic management.

1 INTRODUCTION

The purpose of this report is to summarize the methodology, analyses, and results of Phase II of the Trans Canada Highway (TCH) monitoring and evaluation program. This three phase program began in August of 1997 (prior to the construction of the HOV lanes) to develop a staged monitoring and evaluation methodology for evaluating the incremental benefits of the High Occupancy Vehicle (HOV) lanes opened on October 28, 1999, and the Traffic Management Program (TMP) pilot project as it unfolds.

The Phase I Study was completed in March of 1998 and established a "before" baseline representing conditions prior to implementation of the HOV and TMP projects. Data for the Phase I study was collected in September/October 1997.

In September of 1999, approximately one year after the opening of the HOV lanes, data collection for this Phase II Study began. This report presents the analyses and findings of the Phase II study which includes the evaluation of the HOV lanes, and establishes a second baseline for the TMP to represent post-HOV conditions.

1.1 PHASE II STUDY COST AND OBJECTIVES

The overall BCTFA-funded "Before/After" (Phase I & II) TCH-HOV Evaluation & TMP Baseline study cost approximately $1/2 Million, but over ¾ of that is reusable survey data, such as traffic counts, travel times, vehicle occupancy, incident frequency, etc.

The HOV-FSP Section covers the 16 km of TCH between Grandview Highway and Cape Horn, while the TMP section lies within the 34 km stretch of the TCH between the Lynn Valley Road overpass in North Vancouver and 176 Street overpass in Surrey. The Study section is shown in Exhibit 1.1.1. The Study Corridor includes parallel arterial roadways that provide alternate routes for Highway 1 traffic in these sections.

The primary objectives of the Phase II Monitoring and Evaluation Program were defined as follows:

- ✓ Review HOV and TMP Measures of Effectiveness (MOEs) identified in Phase I and confirm the application of the developed methodology for a quantitative evaluation of the MOEs for both "before" and "after" surveys.
- ✓ Coordinate and conduct data collection activities for the "after" HOV conditions, the "after" FSP conditions, and the "before" TMP conditions.
- ✓ Analyze all the data collected and compare before and after statistics to document HOV and FSP/CCTV benefits, and any background changes affecting the TMP secondary baseline travel patterns.

Exhibit 1.1.1 - Study Section

In meeting these objectives, the Phase II study included a comprehensive data collection program (see Appendices bound separately) comprising the following surveys tabulated in Exhibit 1.1.2:

Exhibit 1.1.2 - Phase II Data Collection Tasks

Description
Data Collection - Trans Canada Highway
24 Hour Mechanical Counts
Travel Time/Speed/Delay Survey
Trip Reliability Surveys
Vehicle Classification and Occupancy Counts
Incident Logging & Observation
Data Collection - Network/Parallel routes
24 Hour Mechanical Counts
Intersection Counts
Vehicle Classification and Occupancy Counts
Travel Time Survey
Motorists & Stakeholders Survey
Motorist Survey
Stakeholder Survey
Queue Length Survey

The Phase I and II data collection programs were generally identical, except:

- mainline travel time surveys were doubled to cover both HOV and GP lanes;
- small sample parallel route travel time surveys were added;
- motorist and stakeholder observation and opinion surveys were conducted.

Both the Phase I and II data collection programs were carried out during the same time period, i.e. late August to early October of 1997 and 1999 respectively.

2 HOV MONITORING & EVALUATION

The benefits of HOV facilities are realized by a shift to higher-occupancy vehicles, such as carpools, vanpools and buses, resulting in an increase in vehicle occupancy and person carrying throughput of the highway corridor, an increase in average travel speeds on the less congested HOV lanes, more reliable trip travel times, and a reduction in energy consumption and vehicle emissions.

Recognizing these potential benefits, the Province of British Columbia has invested in a $62 million HOV project – spanning a 16 kilometre stretch of the Trans-Canada Highway between the Cape Horn and Grandview interchanges. The highway has been widened from 4 lanes to six lanes, with the new lane in each direction reserved for 2+ car pools, van pools, buses and motorcycles on a 24 hour basis. Construction of the project began in October of 1997, and the facility was open for public use on October 28, 1998.

In August of 1997, prior to the construction of the HOV lanes, IBI Group developed a monitoring and evaluation framework to evaluate the (then proposed) Highway 1 HOV lanes, as well as the future TMP relative to the expected benefits. The evaluation framework was structured around the definition of clear and concise "objectives" and associated Measures of Effectiveness (MOEs) to measure the extent to which they are achieved.

This framework reflected previous work by MoTH, and by other agencies for similar evaluations. Specifically, MoTH's draft *HOV Operations Implementation Manual* for the Trans Canada Highway HOV facility was used as a reference for the objectives and the measures of effectiveness, along with other literature and research including the Texas Transportation Institute document entitled An Assessment of High Occupancy Vehicle Facilities in North America. The evaluation objectives are:

1. Increase Person Movement Throughput;
2. Provide Travel Time Savings;
3. Improve Trip Travel Time Reliability;
4. Increase Per-Lane Efficiency;
5. Minimize Negative Impacts on General Purpose (GP) Lanes;
6. Maintain Safety;
9. Obtain Compliance
10. Acquire Public and Stakeholder Acceptance & Satisfaction

The data collection program for the Phase I evaluation framework began at the end of August and finished in October of 1997, forming a pre-HOV baseline. In September/October of 1999, the complimentary collection of Phase II post-HOV data supporting the above objectives and their MOEs was completed. Motorist and Stakeholder opinion surveys were carried out in December, 1999.

The following sections describe the Phase II data collected, followed by a "before" and "after" comparison of the data supporting each MOE. Each of the objectives identified for evaluation is discussed in the following sub-sections:

- **Description of Objective;**
- **Measures of Effectiveness (MOEs);**
- **Data Requirements;**
- **Phase II Data;**
- **Before & After Evaluation;**
- **Recommendations For Future Phases.**

As indicated, each of the objectives is described independently, relative to the MOEs identified and their associated data requirements. Where applicable, additional context is provided by comparing the results from one objective to another to demonstrate the consistency in achieving HOV objectives. These objectives and analysis are also discussed in context of impacts to the parallel routes.

Traffic Volumes

As broader basis for data comparison, Exhibit 2.1 presents traffic volumes along the Study Section for the peak hour (7:00 to 8:00 AM and 4:00 to 5:00 PM), before and after introduction of the HOV lanes. Overall traffic volumes in the central portion of the HOV section have increased by approximately 55% in the peak hour directions, and about 15% in the off-peak hour directions. This is expected since capacity has been increased. Comparatively, traffic volumes in the off-peak directions and North Vancouver and Surrey Sections have increased between 2 to 20%

Exhibit 2.1 - Before & After Peak Hour Traffic Volumes

COMBINED	WEST BOUND								EAST BOUND							
HIGHWAY SEGMENT	# of Lanes		AM-PEAK HR.			PM-PEAK HR.			# of Lanes		AM-PEAK HR.			PM-PEAK HR.		
EAST OF	Before	After	Before	After	% Diff	Before	After	% Diff	Before	After	Before	After	% Diff	Before	After	% Diff
104	2	2	n/a	3355	-	n/a	3731	-	2	2	2980	2774	-7%	3480	3398	-2%
152	2	2	2680	2920	9%	2740	2871	5%	2	2	2480	2494	1%	2545	2716	7%
Cape Horn	2	2	3690	4176	13%	3905	4008	3%	2	2	3755	3900	4%	3875	3949	2%
Brunette	2	3	3060	3740	22%	2400	2462	3%	2	3	n/a	3933	-	2970	4239	43%
Stormont	2	3	n/a	4254	-	n/a	3011	-	2	3	3080	3411	11%	2358	3938	67%
Deer Lake	2	3	2520	4730	88%	2625	3608	37%	2	3	3180	3212	1%	2490	4623	86%
Sprott	2	3	3410	4950	45%	2440	3946	62%	2	3	3495	3246	-7%	2875	4690	63%
Willingdon	2	3	3905	5294	36%	3820	4297	12%	2	3	3830	4085	7%	3140	4986	59%
Grandview	2	3	3840	4336	13%	3950	3642	-8%	2	3	4220	4459	6%	3360	4754	42%
Boundary	2	2	2700	3527	31%	2870	3361	17%	2	2	3090	3013	-2%	2505	3109	24%
1st Ave	2	2	3170	4011	27%	3470	3979	15%	2	2	3810	3784	-1%	3070	3639	19%
Cassiar	2	2	2980	3372	13%	3660	3111	-15%	2	2	3985	4183	5%	3385	3990	18%
McGill	2	2	2420	2739	13%	3230	2651	-18%	2	2	3715	3858	4%	2860	3268	14%
2nd Narrows	3	3	3780	4124	9%	5260	5585	6%	3	3	5515	5910	7%	4615	5057	10%
Fern	2	2	n/a	2338	-	3930	3893	-1%	2	2	n/a	2612	-	n/a	1811	-
Lynn Valley	2	2	2135	2254	6%	2970	3107	5%	2	2	2410	2667	11%	2270	2943	30%

The following sections present the "before" and "after" evaluation of each of the eight objectives of the HOV project. The exhibits that demonstrate the results of each evaluation are presented following the description of each objective.

NOTE:

Details of the traffic volume, occupancy, and travel time data are included in many of the exhibits throughout this report, as well as in the separately bound Appendices which also include 24 hour graphs of traffic volume data at key stations along the TCH.

Digital traffic volume data, at 15 minute increments, is also available on MoTH's Traffic Information Management System (TIMS).

2.1 OBJECTIVE 1: INCREASE PERSON MOVEMENT THROUGHPUT

2.1.1 Description of Objective

The focus of this objective is to increase the movement throughput of a congested roadway in terms of the number of people, rather than the number of vehicles. This objective is achieved when the Average Vehicle Occupancy (AVO) level of a roadway increases. It is desirable that this increase result from a modal shift from single occupant vehicles to carpools, vanpools and public transit as a result of the improved travel times in the HOV facility, and not the result of attraction/diversion of existing HOVs from adjacent lanes or routes.

2.1.2 MOEs

Specific MOEs which were selected to evaluate the achievement of this objective are:

- increase in average vehicle occupancy;
- increase in the number of vanpools and carpools;
- increase in bus ridership.
  No current Coast Mountain BusLink (formerly BC Transit) service on Highway 1.

2.1.3 Data Requirements

In order to measure the MOEs identified above, the “before” and “after” data collection included:

- vehicle counts;
- vehicle occupancy counts;
- vehicle classifications (vanpool, carpool, buses, motorcycles).

These MOEs were measured on all roadways in the corridor, including Highway 1 and the parallel routes on Canada Way and Lougheed Highway, in order to distinguish between induced HOV usage on TCH, and diverted HOVs from parallel routes.

2.1.4 Phase II Data

All of the data requirements for the MOEs identified above have been obtained through the vehicle occupancy and classification count surveys (documented in Appendix A-2). This information has been compiled and analyzed to establish the post-HOV conditions for each MOE.

2.1.4.1 Vehicle Occupancy Data

The details of the collected occupancy data are summarized in the following exhibits:

- Exhibit 2.1.1 presents the weekday peak period AVOs, for the AM, Mid-day, and PM peak periods, at all 4 stations along the mainline.

- Exhibit 2.1.2 presents the weekday peak period AVOs, for the AM, Mid-day, and PM peak periods, at the stations within the HOV section and include breakdown of the characteristics by lane type (i.e. GP versus HOV);

- Exhibit 2.1.3 and 2.1.4 present the above referenced data for the weekend (Sunday) conditions. Sundays were chosen to represent the weekend conditions to provide a non-business baseline and account for social and recreational trips.

Weekday vehicle occupancies are observed to be lowest during the AM period which comprises largely work trips, highest during the mid-day period which comprises the least proportion of work trips, and between the two extremes for the PM period which comprises a combination of work and non-work trips. Weekend occupancies are much higher than average, as they comprise mostly social / recreational trips.

Exhibits 2.1.1 to 2.1.4 also include a breakdown of the percentages of carpools, vanpools, and buses.

2.1.4.2 Vehicle Classification Data

The following exhibits provide a further breakdown by vehicle classification (i.e. cars, trucks, motorcycles, buses, and taxis):

- Exhibit 2.1.5 presents the weekday peak period vehicle classification data, for the AM, Mid-day, and PM peak period, at all 4 stations along the mainline (corridor averages are provided in the table below);

- Exhibit 2.1.6 presents the weekday peak period vehicle classification data, for the AM, Mid-day, and PM peak period, at the stations within the HOV section and include breakdown of the characteristics by lane type (i.e. GP versus HOV);

- Exhibits 2.1.7 and to 2.1.8 present the above referenced data for the weekend (Sunday) conditions

Generally, cars comprise approximately 90% of the traffic stream on Highway 1, followed by approximately 4 to 8% trucks, with motorcycles, bicycles (Second Narrows Bridge only), buses, and taxis comprising less than 1% each. Truck traffic tends to be relatively constant throughout the day, but represents a higher proportion of total vehicles during the mid-day as a result of the lower number of car trips. The volume of truck traffic along individual parallel routes may be lower than on the mainline, but the proportion of trucks to cars is higher.

Exhibit 2.1.1 - Mainline Vehicle Occupancies - Combined Lanes - Weekday Peak Period

EASTBOUND

Location	1 Occupant		2 Occupants		3 Occupants		4+ Occupants		Van Pools		Bus Occupants		Taxi Occupants		Total Occupants	**Vehicle Occupancy**
Second Narrows Bridge																
AM Peak Period	12182	90.5%	1099	8.2%	71	0.5%	16	0	0	0.0%	1460	9.0%	87	0.5%	16204	1.10
Noon Peak Period	5601	81.0%	1147	16.6%	82	1.2%	38	0.5%	0	0.0%	374	4.3%	41	0.5%	8708	1.21
PM Peak Period	11416	79.3%	2480	17.2%	264	1.8%	111	0.8%	0	0.0%	1239	6.5%	119	0.6%	18970	1.23
Gaglardi																
AM Peak Period	6917	85.9%	919	11.4%	140	1.7%	36	0	1	0.0%	688	6.9%	13	0.1%	10026	1.16
Noon Peak Period	4919	77.1%	1179	18.5%	204	3.2%	55	0.9%	0	0.0%	166	2.0%	27	0.3%	8302	1.28
PM Peak Period	9677	74.1%	2776	21.3%	462	3.5%	108	0.8%	7	0.1%	117	0.7%	17	0.1%	17223	1.31
Cape Horn																
AM Peak Period	7334	87.8%	783	9.4%	111	1.3%	91	0	4	0.0%	85	0.9%	8	0.1%	9714	1.16
Noon Peak Period	5093	77.7%	1158	17.7%	182	2.8%	99	1.5%	0	0.0%	48	0.6%	15	0.2%	8414	1.28
PM Peak Period	9102	75.6%	2445	20.3%	327	2.7%	137	1.1%	10	0.1%	19	0.1%	6	0.0%	15606	1.30
Port Mann Bridge																
AM Peak Period	7952	87.2%	984	10.8%	109	1.2%	49	0	1	0.0%	426	3.9%	9	0.1%	10884	1.15
Noon Peak Period	4912	77.1%	1273	20.0%	117	1.8%	60	0.9%	0	0.0%	165	2.0%	10	0.1%	8224	1.27
PM Peak Period	8947	77.7%	2183	19.0%	257	2.2%	102	0.9%	9	0.1%	65	0.4%	14	0.1%	14625	1.27

WESTBOUND

Location	1 Occupant		2 Occupants		3 Occupants		4+ Occupants		Van Pools		Bus Occupants		Taxi Occupants		Total Occupants	**Vehicle Occupancy**
Second Narrows Bridge																
AM Peak Period	8589	87.4%	1050	10.7%	69	0.7%	30	0	1	0.0%	666	5.7%	85	0.7%	11773	1.13
Noon Peak Period	4995	79.0%	1087	17.2%	123	1.9%	62	1.0%	0	0.0%	167	2.1%	70	0.9%	8023	1.24
PM Peak Period	11141	82.4%	1961	14.5%	228	1.7%	89	0.7%	1	0.0%	983	5.7%	114	0.7%	17206	1.20
Gaglardi																
AM Peak Period	7984	79.2%	1825	18.1%	227	2.3%	26	0	6	0.1%	136	1.1%	9	0.1%	12600	1.24
Noon Peak Period	4841	77.6%	1164	18.7%	177	2.8%	43	0.7%	0	0.0%	64	0.8%	13	0.2%	7949	1.26
PM Peak Period	7865	79.4%	1725	17.4%	204	2.1%	70	0.7%	0	0.0%	1202	9.0%	18	0.1%	13427	1.24
Cape Horn																
AM Peak Period	7077	80.3%	1553	17.6%	144	1.6%	34	0	1	0.0%	87	0.8%	2	0.0%	10846	1.22
Noon Peak Period	4411	74.0%	1383	23.2%	90	1.5%	57	1.0%	0	0.0%	24	0.3%	20	0.3%	7719	1.29
PM Peak Period	5138	71.8%	1719	24.0%	166	2.3%	93	1.3%	0	0.0%	1057	10.0%	20	0.2%	10523	1.33
Port Mann Bridge																
AM Peak Period	7286	82.8%	1322	15.0%	137	1.6%	41	0	8	0.1%	241	2.2%	1	0.0%	10795	1.20
Noon Peak Period	4589	76.7%	1199	20.0%	134	2.2%	46	0.8%	0	0.0%	55	0.7%	17	0.2%	7645	1.27
PM Peak Period	8808	77.7%	2049	18.1%	302	2.7%	139	1.2%	7	0.1%	1077	6.9%	15	0.1%	15502	1.27

Note:
Single Occupant Vehicles include Cars, Trucks, Motorcycles, and Bicycles
Occupancy %s = Number of Vehicles in each Occupancy Category/Total number of Vehicles
Bus Occupancy %s = Number of Bus Occupants/Total Number of Occupants
Vehicle Occupancy = Total Occupants/Total Vehicles (excluding Buses and Taxis)

Exhibit 2.1.2 - Mainline Vehicle Occupancies - GP vs HOV Lanes - Weekday Peak Period

EASTBOUND

GP Lanes Combined	1 Occupant		2 Occupants		3 Occupants		4+ Occupants		Van Pools		Bus Occupants		Taxi Occupants		Total Occupants	**Vehicle Occupancy**
Gaglardi																
AM Peak Period	6852	94.3%	353	4.9%	30	0.4%	14	0.2%	0	0.0%	207	2.6%	5	0.1%	7916	1.06
Noon Peak Period	4885	88.3%	535	9.7%	63	1.1%	31	0.6%	0	0.0%	50	0.8%	21	0.3%	6339	1.14
PM Peak Period	9460	95.2%	393	4.0%	53	0.5%	21	0.2%	0	0.0%	13	0.1%	2	0.0%	10504	1.06
Cape Horn																
AM Peak Period	7173	94.3%	374	4.9%	30	0.4%	10	0.1%	4	0.1%	73	0.9%	3	0.0%	8151	1.06
Noon Peak Period	5022	87.1%	652	11.3%	50	0.9%	24	0.4%	0	0.0%	44	0.7%	13	0.2%	6629	1.14
PM Peak Period	8833	91.9%	685	7.1%	64	0.7%	23	0.2%	0	0.0%	11	0.1%	1	0.0%	10499	1.09

HOV Lane	1 Occupant		2 Occupants		3 Occupants		4+ Occupants		Van Pools		Bus Occupants		Taxi Occupants		Total Occupants	**Vehicle Occupancy**
Gaglardi																
AM Peak Period	65	8.2%	566	71.8%	110	14.0%	22	2.8%	1	0.1%	481	22.8%	8	0.4%	2110	2.12
Noon Peak Period	51	5.9%	644	74.4%	141	16.3%	24	2.8%	0	0.0%	116	5.9%	6	0.3%	1980	2.16
PM Peak Period	217	7.0%	2383	76.4%	409	13.1%	87	2.8%	7	0.2%	104	1.5%	15	0.2%	6719	2.13
Cape Horn																
AM Peak Period	161	21.5%	409	54.7%	81	10.8%	81	10.8%	0	0.0%	12	0.8%	5	0.3%	1563	2.11
Noon Peak Period	71	9.0%	506	64.1%	132	16.7%	75	9.5%	0	0.0%	4	0.2%	2	0.1%	1785	2.27
PM Peak Period	269	11.1%	1760	72.5%	263	10.8%	114	4.7%	10	0.4%	8	0.2%	5	0.1%	5107	2.11

WESTBOUND

GP Lanes Combined	1 Occupant		2 Occupants		3 Occupants		4+ Occupants		Van Pools		Bus Occupants		Taxi Occupants		Total Occupants	**Vehicle Occupancy**
Gaglardi																
AM Peak Period	7773	98.5%	108	1.4%	8	0.1%	4	0.1%	1	0.0%	0	0.0%	0	0.0%	8035	1.02
Noon Peak Period	4767	88.1%	544	10.1%	61	1.1%	32	0.6%	0	0.0%	2	0.0%	10	0.2%	6178	1.14
PM Peak Period	7767	89.0%	802	9.2%	90	1.0%	50	0.6%	0	0.0%	455	4.4%	8	0.1%	10304	1.13
Cape Horn																
AM Peak Period	6931	94.6%	354	4.8%	28	0.4%	15	0.2%	1	0.0%	1	0.0%	0	0.0%	7790	1.06
Noon Peak Period	4330	85.6%	619	12.2%	55	1.1%	42	0.8%	0	0.0%	24	0.4%	6	0.1%	5931	1.17
PM Peak Period	5083	83.5%	833	13.7%	102	1.7%	56	0.9%	0	0.0%	55	0.7%	6	0.1%	7340	1.20

HOV Lane	1 Occupant		2 Occupants		3 Occupants		4+ Occupants		Van Pools		Bus Occupants		Taxi Occupants		Total Occupants	**Vehicle Occupancy**
Gaglardi																
AM Peak Period	211	9.6%	1717	78.5%	219	10.0%	22	1.0%	5	0.2%	136	3.0%	9	0.2%	4565	2.03
Noon Peak Period	74	8.9%	620	75.0%	116	14.0%	11	1.3%	0	0.0%	62	3.5%	3	0.2%	1771	2.08
PM Peak Period	98	8.3%	923	78.4%	114	9.7%	20	1.7%	0	0.0%	747	23.9%	10	0.3%	3123	2.05
Cape Horn																
AM Peak Period	146	9.8%	1199	80.6%	116	7.8%	19	1.3%	0	0.0%	86	2.8%	2	0.1%	3056	2.01
Noon Peak Period	81	9.0%	764	84.6%	35	3.9%	15	1.7%	0	0.0%	0	0.0%	14	0.8%	1788	1.98
PM Peak Period	55	5.1%	886	82.9%	64	6.0%	37	3.5%	0	0.0%	1002	31.5%	14	0.4%	3183	2.08

Exhibit 2.1.3 - Mainline Vehicle Occupancies - Combined Lanes - Sunday Peak Period

EASTBOUND

	1 Occupant		2 Occupants		3 Occupants		4+ Occupants		Van Pools		Bus Occupants		Taxi Occupants		Total Occupants	**Vehicle Occupancy**
Second Narrows Bridge																
AM Peak Period	2008	78.9%	444	17.5%	44	1.7%	16	0	0	0.0%	29	0.9%	40	1.3%	3161	1.23
Noon Peak Period	3573	51.4%	2693	38.8%	391	5.6%	248	3.6%	2	0.0%	410	3.5%	44	0.4%	11590	1.61
PM Peak Period	5234	49.5%	4170	39.4%	688	6.5%	422	4.0%	0	0.0%	688	3.8%	56	0.3%	18070	1.65
Gaglardi																
AM Peak Period	1934	67.2%	709	24.6%	141	4.9%	62	0	3	0.1%	482	10.6%	12	0.3%	4535	1.42
Noon Peak Period	3455	49.9%	2711	39.1%	496	7.2%	246	3.6%	1	0.0%	38	0.3%	22	0.2%	11415	1.64
PM Peak Period	5975	47.2%	4942	39.0%	1189	9.4%	527	4.2%	1	0.0%	210	1.0%	29	0.1%	21779	1.70
Cape Horn																
AM Peak Period	2165	68.9%	797	25.4%	104	3.3%	46	0	0	0.0%	323	7.0%	10	0.2%	4588	1.37
Noon Peak Period	3351	50.1%	2638	39.4%	420	6.3%	268	4.0%	1	0.0%	161	1.4%	14	0.1%	11140	1.64
PM Peak Period	5320	47.3%	4483	39.9%	822	7.3%	591	5.3%	2	0.0%	155	0.8%	27	0.1%	19310	1.71
Port Mann Bridge																
AM Peak Period	2532	76.6%	618	18.7%	95	2.9%	34	0	0	0.0%	87	2.0%	6	0.1%	4282	1.28
Noon Peak Period	3449	49.8%	2800	40.5%	420	6.1%	240	3.5%	0	0.0%	171	1.5%	11	0.1%	11451	1.63
PM Peak Period	5056	49.2%	4092	39.8%	693	6.7%	421	4.1%	0	0.0%	122	0.7%	15	0.1%	17140	1.66

WESTBOUND

	1 Occupant		2 Occupants		3 Occupants		4+ Occupants		Van Pools		Bus Occupants		Taxi Occupants		Total Occupants	**Vehicle Occupancy**
Second Narrows Bridge																
AM Peak Period	1964	66.7%	740	25.1%	117	4.0%	77	0	0	0.0%	40	1.0%	50	1.2%	4193	1.42
Noon Peak Period	3143	45.1%	2961	42.5%	494	7.1%	351	5.0%	0	0.0%	119	1.0%	30	0.2%	12100	1.72
PM Peak Period	5002	45.5%	4562	41.5%	853	7.8%	530	4.8%	2	0.0%	471	2.4%	62	0.3%	19350	1.72
Gaglardi																
AM Peak Period	2480	68.3%	895	24.6%	176	4.8%	68	0	0	0.0%	37	0.7%	8	0.2%	5115	1.40
Noon Peak Period	3290	45.2%	2953	40.6%	653	9.0%	356	4.9%	0	0.0%	267	2.1%	20	0.2%	12866	1.73
PM Peak Period	4500	44.0%	4332	42.4%	894	8.7%	467	4.6%	2	0.0%	904	4.9%	4	0.0%	18634	1.74
Cape Horn																
AM Peak Period	2295	68.7%	790	23.7%	142	4.3%	91	0	6	0.2%	47	1.0%	10	0.2%	4758	1.41
Noon Peak Period	3116	48.9%	2494	39.2%	489	7.7%	248	3.9%	0	0.0%	222	2.1%	30	0.3%	10815	1.66
PM Peak Period	4178	42.5%	4148	42.2%	983	10.0%	480	4.9%	0	0.0%	638	3.5%	4	0.0%	17985	1.77
Port Mann Bridge																
AM Peak Period	2024	69.5%	655	22.5%	132	4.5%	85	0	1	0.0%	12	0.3%	4	0.1%	4092	1.41
Noon Peak Period	3073	47.5%	2902	44.9%	0	0.0%	468	7.2%	0	0.0%	199	1.8%	16	0.1%	10964	1.67
PM Peak Period	3784	39.3%	4242	44.1%	724	7.5%	843	8.8%	0	0.0%	412	2.3%	7	0.0%	18231	1.86

Note:
Single Occupant Vehicles include Cars, Trucks, Motorcycles, and Bicycles
Occupancy %s = Number of Vehicles in each Occupancy Category/Total number of Vehicles
Bus Occupancy %s = Number of Bus Occupants/Total Number of Occupants
Vehicle Occupancy = Total Occupants/Total Vehicles (excluding Buses and Taxis)

Exhibit 2.1.4 - Mainline Vehicle Occupancies - GP vs HOV Lanes - Sunday Peak Period

EASTBOUND

GP Lanes Combined											Bus		Taxi		Total	**Vehicle**
	1 Occupant		2 Occupants		3 Occupants		4+ Occupants		Van Pools		Occupants		Occupants		Occupants	**Occupancy**
Gaglardi																
AM Peak Period	1889	76.9%	443	18.0%	70	2.9%	33	1.3%	3	0.1%	238	7.0%	11	0.3%	3384	1.29
Noon Peak Period	3257	65.2%	1394	27.9%	201	4.0%	131	2.6%	1	0.0%	35	0.5%	12	0.2%	7225	1.44
PM Peak Period	5648	65.5%	2339	27.1%	380	4.4%	243	2.8%	1	0.0%	96	0.8%	12	0.1%	12552	1.45
Cape Horn																
AM Peak Period	2119	78.2%	527	19.4%	35	1.3%	16	0.6%	0	0.0%	89	2.6%	7	0.2%	3438	1.24
Noon Peak Period	3175	64.8%	1374	28.0%	172	3.5%	171	3.5%	0	0.0%	51	0.7%	9	0.1%	7183	1.46
PM Peak Period	5082	62.5%	2336	28.7%	356	4.4%	348	4.3%	0	0.0%	90	0.7%	13	0.1%	12317	1.50

HOV Lane											Bus		Taxi		Total	**Vehicle**
	1 Occupant		2 Occupants		3 Occupants		4+ Occupants		Van Pools		Occupants		Occupants		Occupants	**Occupancy**
Gaglardi																
AM Peak Period	45	10.6%	266	62.9%	71	16.8%	29	6.9%	0	0.0%	244	21.2%	1	0.1%	1151	2.20
Noon Peak Period	198	10.2%	1317	68.1%	295	15.3%	115	5.9%	0	0.0%	3	0.1%	10	0.2%	4190	2.17
PM Peak Period	327	8.1%	2603	64.4%	809	20.0%	284	7.0%	0	0.0%	114	1.2%	17	0.2%	9227	2.26
Cape Horn																
AM Peak Period	46	10.7%	270	62.8%	69	16.0%	30	7.0%	0	0.0%	234	20.3%	3	0.3%	1150	2.20
Noon Peak Period	176	9.8%	1264	70.6%	248	13.8%	97	5.4%	1	0.1%	110	2.8%	5	0.1%	3957	2.15
PM Peak Period	238	7.7%	2147	69.0%	466	15.0%	243	7.8%	2	0.1%	65	0.9%	14	0.2%	6993	2.23

WESTBOUND

GP Lanes Combined											Bus		Taxi		Total	**Vehicle**
	1 Occupant		2 Occupants		3 Occupants		4+ Occupants		Van Pools		Occupants		Occupants		Occupants	**Occupancy**
Gaglardi																
AM Peak Period	2442	78.3%	563	18.1%	68	2.2%	36	1.2%	0	0.0%	4	0.1%	6	0.2%	3926	1.26
Noon Peak Period	3213	61.4%	1604	30.6%	216	4.1%	192	3.7%	0	0.0%	85	1.1%	12	0.2%	7934	1.50
PM Peak Period	4361	59.4%	2377	32.4%	334	4.5%	261	3.6%	0	0.0%	172	1.5%	2	0.0%	11335	1.52
Cape Horn																
AM Peak Period	2257	78.5%	501	17.4%	63	2.2%	44	1.5%	0	0.0%	44	1.2%	7	0.2%	3675	1.26
Noon Peak Period	2986	63.7%	1345	28.7%	197	4.2%	146	3.1%	0	0.0%	131	1.9%	15	0.2%	6997	1.47
PM Peak Period	3938	57.0%	2196	31.8%	479	6.9%	288	4.2%	0	0.0%	193	1.7%	4	0.0%	11116	1.58

HOV Lane											Bus		Taxi		Total	**Vehicle**
	1 Occupant		2 Occupants		3 Occupants		4+ Occupants		Van Pools		Occupants		Occupants		Occupants	**Occupancy**
Gaglardi																
AM Peak Period	38	7.4%	332	64.3%	108	20.9%	32	6.2%	0	0.0%	33	2.8%	2	0.2%	1189	2.26
Noon Peak Period	77	3.8%	1349	66.2%	437	21.5%	164	8.1%	0	0.0%	182	3.7%	8	0.2%	4932	2.34
PM Peak Period	139	4.8%	1955	67.7%	560	19.4%	206	7.1%	2	0.1%	732	10.0%	2	0.0%	7299	2.29
Cape Horn																
AM Peak Period	38	8.2%	289	62.3%	79	17.0%	47	10.1%	6	1.3%	3	0.3%	3	0.3%	1083	2.35
Noon Peak Period	130	7.7%	1149	68.3%	292	17.3%	102	6.1%	0	0.0%	91	2.4%	15	0.4%	3818	2.22
PM Peak Period	240	8.3%	1952	67.1%	504	17.3%	192	6.6%	0	0.0%	445	6.5%	0	0.0%	6869	2.22

Exhibit 2.1.5 - Mainline Vehicle Classification - Combined Lanes - Weekday Peak Period

EASTBOUND

	Cars		Trucks		Motorcycles		Bicycles		Buses		Taxi		Total Vehicles	
Second Narrows Bridge														
AM Peak Period	12907	95.9%	389	2.9%	63	0.5%	9	0.1%	42	0.3%	51	0.4%	13461	100%
Noon Peak Period	6291	91.0%	540	7.8%	33	0.5%	4	0.1%	16	0.2%	27	0.4%	6911	100%
PM Peak Period	13542	94.0%	588	4.1%	110	0.8%	31	0.2%	66	0.5%	65	0.5%	14402	100%
Gaglardi														
AM Peak Period	7603	94.4%	371	4.6%	39	0.5%	0	0.0%	29	0.4%	12	0.1%	8054	100%
Noon Peak Period	5738	89.9%	615	9.6%	4	0.1%	0	0.0%	5	0.1%	18	0.3%	6380	100%
PM Peak Period	12340	94.5%	587	4.5%	103	0.8%	0	0.0%	10	0.1%	13	0.1%	13053	100%
Cape Horn														
AM Peak Period	7384	88.4%	907	10.9%	32	0.4%	0	0.0%	23	0.3%	7	0.1%	8353	100%
Noon Peak Period	5512	84.1%	1002	15.3%	18	0.3%	0	0.0%	9	0.1%	12	0.2%	6553	100%
PM Peak Period	11125	92.4%	809	6.7%	87	0.7%	0	0.0%	10	0.1%	5	0.0%	12036	100%
Port Mann Bridge														
AM Peak Period	8190	89.8%	862	9.5%	43	0.5%	0	0.0%	17	0.2%	7	0.1%	9119	100%
Noon Peak Period	5394	84.6%	938	14.7%	30	0.5%	0	0.0%	6	0.1%	6	0.1%	6374	100%
PM Peak Period	10575	91.8%	838	7.3%	85	0.7%	0	0.0%	8	0.1%	11	0.1%	11517	100%

WESTBOUND

	Cars		Trucks		Motorcycles		Bicycles		Buses		Taxi		Total Vehicles	
Second Narrows Bridge														
AM Peak Period	9033	91.9%	581	5.9%	66	0.7%	59	0.6%	51	0.5%	40	0.4%	9830	100%
Noon Peak Period	5653	89.4%	572	9.0%	31	0.5%	11	0.2%	16	0.3%	39	0.6%	6322	100%
PM Peak Period	12863	95.1%	358	2.6%	122	0.9%	77	0.6%	33	0.2%	67	0.5%	13520	100%
Gaglardi														
AM Peak Period	9419	93.4%	589	5.8%	60	0.6%	0	0.0%	9	0.1%	5	0.0%	10082	100%
Noon Peak Period	5577	89.4%	610	9.8%	38	0.6%	0	0.0%	6	0.1%	8	0.1%	6239	100%
PM Peak Period	9367	94.5%	426	4.3%	71	0.7%	0	0.0%	32	0.3%	11	0.1%	9907	100%
Cape Horn														
AM Peak Period	8108	91.9%	655	7.4%	46	0.5%	0	0.0%	8	0.1%	1	0.0%	8818	100%
Noon Peak Period	5141	86.3%	759	12.7%	41	0.7%	0	0.0%	5	0.1%	14	0.2%	5960	100%
PM Peak Period	6650	92.9%	422	5.9%	44	0.6%	0	0.0%	27	0.4%	12	0.2%	7155	100%
Port Mann Bridge														
AM Peak Period	8073	91.7%	681	7.7%	40	0.5%	0	0.0%	7	0.1%	1	0.0%	8802	100%
Noon Peak Period	5150	86.1%	782	13.1%	36	0.6%	0	0.0%	7	0.1%	9	0.2%	5984	100%
PM Peak Period	10535	92.9%	706	6.2%	64	0.6%	0	0.0%	29	0.3%	9	0.1%	11343	100%

Exhibit 2.1.6 - Mainline Vehicle Classification - GP vs HOV Lanes - Weekday Peak Period

EASTBOUND

GP Lanes Combined	Cars		Trucks		Motorcycles		Bicycles		Buses		Taxi		Total Vehicles	
Gaglardi														
AM Peak Period	6881	94.7%	362	5.0%	6	0.1%	0	0.0%	12	0.2%	5	0.1%	7266	100%
Noon Peak Period	4907	88.7%	603	10.9%	4	0.1%	0	0.0%	2	0.0%	15	0.3%	5531	100%
PM Peak Period	9388	94.5%	531	5.3%	8	0.1%	0	0.0%	4	0.0%	2	0.0%	9933	100%
Cape Horn														
AM Peak Period	6692	88.0%	896	11.8%	3	0.0%	0	0.0%	11	0.1%	3	0.0%	7605	100%
Noon Peak Period	4757	82.5%	990	17.2%	1	0.0%	0	0.0%	5	0.1%	10	0.2%	5763	100%
PM Peak Period	8839	92.0%	755	7.9%	11	0.1%	0	0.0%	2	0.0%	1	0.0%	9608	100%

HOV Lane	Cars		Trucks		Motorcycles		Bicycles		Buses		Taxi		Total Vehicles	
Gaglardi														
AM Peak Period	722	91.6%	9	1.1%	33	4.2%	0	0.0%	17	2.2%	7	0.9%	788	100%
Noon Peak Period	831	96.0%	12	1.4%	17	2.0%	0	0.0%	3	0.3%	3	0.3%	866	100%
PM Peak Period	2952	94.6%	56	1.8%	95	3.0%	0	0.0%	6	0.2%	11	0.4%	3120	100%
Cape Horn														
AM Peak Period	692	92.5%	11	1.5%	29	3.9%	0	0.0%	12	1.6%	4	0.5%	748	100%
Noon Peak Period	755	95.6%	12	1.5%	17	2.2%	0	0.0%	4	0.5%	2	0.3%	790	100%
PM Peak Period	2286	94.2%	54	2.2%	76	3.1%	0	0.0%	8	0.3%	4	0.2%	2428	100%

WESTBOUND

GP Lanes Combined	Cars		Trucks		Motorcycles		Bicycles		Buses		Taxi		Total Vehicles	
Gaglardi														
AM Peak Period	7354	93.2%	539	6.8%	1	0.0%	0	0.0%	0	0.0%	0	0.0%	7894	100%
Noon Peak Period	4799	88.7%	590	10.9%	15	0.3%	0	0.0%	2	0.0%	6	0.1%	5412	100%
PM Peak Period	8274	94.8%	411	4.7%	24	0.3%	0	0.0%	14	0.2%	6	0.1%	8729	100%
Cape Horn														
AM Peak Period	6692	91.3%	633	8.6%	4	0.1%	0	0.0%	1	0.0%	0	0.0%	7330	100%
Noon Peak Period	4283	84.7%	746	14.8%	17	0.3%	0	0.0%	5	0.1%	6	0.1%	5057	100%
PM Peak Period	5641	92.7%	413	6.8%	20	0.3%	0	0.0%	6	0.1%	6	0.1%	6086	100%

HOV Lane	Cars		Trucks		Motorcycles		Bicycles		Buses		Taxi		Total Vehicles	
Gaglardi														
AM Peak Period	2065	94.4%	50	2.3%	59	2.7%	0	0.0%	9	0.4%	5	0.2%	2188	100%
Noon Peak Period	778	94.1%	20	2.4%	23	2.8%	0	0.0%	4	0.5%	2	0.2%	827	100%
PM Peak Period	1093	92.8%	15	1.3%	47	4.0%	0	0.0%	18	1.5%	5	0.4%	1178	100%
Cape Horn														
AM Peak Period	1416	95.2%	22	1.5%	42	2.8%	0	0.0%	7	0.5%	1	0.1%	1488	100%
Noon Peak Period	858	95.0%	13	1.4%	24	2.7%	0	0.0%	0	0.0%	8	0.9%	903	100%
PM Peak Period	1009	94.4%	9	0.8%	24	2.2%	0	0.0%	21	2.0%	6	0.6%	1069	100%

Exhibit 2.1.7 - Mainline Vehicle Classification - Combined Lanes - Sunday Peak Period

EASTBOUND

	Cars		Trucks		Motorcycles		Bicycles		Buses		Taxi		**Total Vehicles**	
Second Narrows Bridge														
AM Peak Period	2442	96.0%	49	1.9%	21	0.8%	0	0.0%	4	0.2%	28	1.1%	2544	100%
Noon Peak Period	6781	97.6%	67	1.0%	59	0.8%	0	0.0%	14	0.2%	28	0.4%	6949	100%
PM Peak Period	10336	97.8%	102	1.0%	76	0.7%	0	0.0%	25	0.2%	33	0.3%	10572	100%
Gaglardi														
AM Peak Period	2718	94.4%	98	3.4%	33	1.1%	0	0.0%	20	0.7%	10	0.3%	2879	100%
Noon Peak Period	6730	97.1%	118	1.7%	61	0.9%	0	0.0%	4	0.1%	16	0.2%	6929	100%
PM Peak Period	12386	97.8%	156	1.2%	92	0.7%	0	0.0%	15	0.1%	19	0.1%	12668	100%
Cape Horn														
AM Peak Period	2957	94.1%	120	3.8%	35	1.1%	0	0.0%	20	0.6%	9	0.3%	3141	100%
Noon Peak Period	6471	96.7%	151	2.3%	56	0.8%	0	0.0%	5	0.1%	8	0.1%	6691	100%
PM Peak Period	10970	97.5%	179	1.6%	69	0.6%	0	0.0%	11	0.1%	17	0.2%	11246	100%
Port Mann Bridge														
AM Peak Period	2827	85.5%	401	12.1%	51	1.5%	0	0.0%	22	0.7%	5	0.2%	3306	100%
Noon Peak Period	6552	94.7%	315	4.6%	42	0.6%	0	0.0%	7	0.1%	5	0.1%	6921	100%
PM Peak Period	10009	97.3%	197	1.9%	56	0.5%	0	0.0%	12	0.1%	10	0.1%	10284	100%

WESTBOUND

	Cars		Trucks		Motorcycles		Bicycles		Buses		Taxi		**Total Vehicles**	
Second Narrows Bridge														
AM Peak Period	2801	95.1%	54	1.8%	43	1.5%	0	0.0%	16	0.5%	30	1.0%	2944	100%
Noon Peak Period	6776	97.1%	77	1.1%	92	1.3%	4	0.1%	9	0.1%	17	0.2%	6975	100%
PM Peak Period	10731	97.5%	103	0.9%	113	1.0%	2	0.0%	23	0.2%	31	0.3%	11003	100%
Gaglardi														
AM Peak Period	3501	96.4%	86	2.4%	32	0.9%	0	0.0%	8	0.2%	6	0.2%	3633	100%
Noon Peak Period	7102	97.7%	88	1.2%	62	0.9%	0	0.0%	8	0.1%	11	0.2%	7271	100%
PM Peak Period	9957	97.4%	147	1.4%	91	0.9%	0	0.0%	29	0.3%	4	0.0%	10228	100%
Cape Horn														
AM Peak Period	3168	94.9%	121	3.6%	35	1.0%	0	0.0%	8	0.2%	8	0.2%	3340	100%
Noon Peak Period	6167	96.8%	129	2.0%	51	0.8%	0	0.0%	10	0.2%	13	0.2%	6370	100%
PM Peak Period	9484	96.6%	179	1.8%	126	1.3%	0	0.0%	28	0.3%	3	0.0%	9820	100%
Port Mann Bridge														
AM Peak Period	2739	94.0%	127	4.4%	31	1.1%	0	0.0%	12	0.4%	4	0.1%	2913	100%
Noon Peak Period	6223	96.3%	155	2.4%	65	1.0%	0	0.0%	9	0.1%	12	0.2%	6464	100%
PM Peak Period	9284	96.5%	204	2.1%	105	1.1%	0	0.0%	23	0.2%	6	0.1%	9622	100%

Exhibit 2.1.8 - Mainline Vehicle Classification - GP vs HOV Lanes - Sunday Peak Period

EASTBOUND

GP Lanes Combined	Cars		Trucks		Motorcycles		Bicycles		Buses		Taxi		Total Vehicles	
Gaglardi														
AM Peak Period	2330	94.9%	97	3.9%	11	0.4%	0	0.0%	9	0.4%	9	0.4%	2456	100%
Noon Peak Period	4851	97.1%	111	2.2%	22	0.4%	0	0.0%	1	0.0%	10	0.2%	4995	100%
PM Peak Period	8430	97.7%	141	1.6%	40	0.5%	0	0.0%	7	0.1%	10	0.1%	8628	100%
Cape Horn														
AM Peak Period	2562	94.5%	120	4.4%	15	0.6%	0	0.0%	8	0.3%	6	0.2%	2711	100%
Noon Peak Period	4721	96.3%	148	3.0%	23	0.5%	0	0.0%	2	0.0%	6	0.1%	4900	100%
PM Peak Period	7927	97.4%	174	2.1%	21	0.3%	0	0.0%	4	0.0%	9	0.1%	8135	100%

HOV Lane	Cars		Trucks		Motorcycles		Bicycles		Buses		Taxi		Total Vehicles	
Gaglardi														
AM Peak Period	388	91.7%	1	0.2%	22	5.2%	0	0.0%	11	2.6%	1	0.2%	423	100%
Noon Peak Period	1879	97.2%	7	0.4%	39	2.0%	0	0.0%	3	0.2%	6	0.3%	1934	100%
PM Peak Period	3956	97.9%	15	0.4%	52	1.3%	0	0.0%	8	0.2%	9	0.2%	4040	100%
Cape Horn														
AM Peak Period	395	91.9%	0	0.0%	20	4.7%	0	0.0%	12	2.8%	3	0.7%	430	100%
Noon Peak Period	1750	97.7%	3	0.2%	33	1.8%	0	0.0%	3	0.2%	2	0.1%	1791	100%
PM Peak Period	3043	97.8%	5	0.2%	48	1.5%	0	0.0%	7	0.2%	8	0.3%	3111	100%

WESTBOUND

GP Lanes Combined	Cars		Trucks		Motorcycles		Bicycles		Buses		Taxi		Total Vehicles	
Gaglardi														
AM Peak Period	3002	96.3%	85	2.7%	22	0.7%	0	0.0%	4	0.1%	4	0.1%	3117	100%
Noon Peak Period	5103	97.5%	86	1.6%	36	0.7%	0	0.0%	2	0.0%	7	0.1%	5234	100%
PM Peak Period	7147	97.3%	139	1.9%	47	0.6%	0	0.0%	7	0.1%	2	0.0%	7342	100%
Cape Horn														
AM Peak Period	2726	94.8%	121	4.2%	18	0.6%	0	0.0%	5	0.2%	6	0.2%	2876	100%
Noon Peak Period	4512	96.3%	128	2.7%	34	0.7%	0	0.0%	5	0.1%	8	0.2%	4687	100%
PM Peak Period	6680	96.6%	179	2.6%	42	0.6%	0	0.0%	8	0.1%	3	0.0%	6912	100%

HOV Lane	Cars		Trucks		Motorcycles		Bicycles		Buses		Taxi		Total Vehicles	
Gaglardi														
AM Peak Period	499	96.7%	1	0.2%	10	1.9%	0	0.0%	4	0.8%	2	0.4%	516	100%
Noon Peak Period	1999	98.1%	2	0.1%	26	1.3%	0	0.0%	6	0.3%	4	0.2%	2037	100%
PM Peak Period	2810	97.4%	8	0.3%	44	1.5%	0	0.0%	22	0.8%	2	0.1%	2886	100%
Cape Horn														
AM Peak Period	442	95.3%	0	0.0%	17	3.7%	0	0.0%	3	0.6%	2	0.4%	464	100%
Noon Peak Period	1655	98.3%	1	0.1%	17	1.0%	0	0.0%	5	0.3%	5	0.3%	1683	100%
PM Peak Period	2804	96.4%	0	0.0%	84	2.9%	0	0.0%	20	0.7%	0	0.0%	2908	100%

2.1.5 Before & After Evaluation

Using data documented in the Phase I Monitoring and Evaluation study and the Phase II "after" data presented above, the MOEs have been used to compare before and after conditions and measure the extent to which the objective of increasing vehicle occupancy has been achieved.

2.1.5.1 Increase in AVO

Measuring an increase in AVOs represents the key MOE for evaluating this objective. Exhibits 2.1.9 to 2.1.11 present the "before" and "after" comparisons of AVO along the HOV section, as well as the parallel routes for the weekday AM peak, mid-day peak, and PM peak periods respectively. All of the AVO measurement comparisons were analyzed for their statistical significance at a 95% confidence limit. On this basis, the minimum AVO required to establish a significant increase is also presented in the exhibits.

TCH - HOV section AVOs

The results indicate that a statistically significant increase in AVO has occurred during the weekday AM and PM peak period, especially in the peak directions.

- Westbound, in the AM peak period, AVOs have increased from 1.16 to 1.24 in the HOV section.

- Eastbound, in the PM peak period, AVOs have increased from 1.25 to 1.31 in the HOV section.

Parallel Routes AVOs

The exhibits also show the change in AVO along the parallel routes (along with a minimum indication showing whether the reduction is statistically significant at the 95% confidence limit). A statistically significant reduction in AVO along the parallel routes would suggest that the increase in AVO along the TCH was attributed to a diversion of existing HOVs from the parallel routes onto the TCH.

It is observed that the majority of the reductions in AVO along the parallel routes are not statistically significant at a 95% confidence limit. Therefore, these non-significant changes in AVOs along the parallel routes indicate that mainline increases in AVO are mostly due to the formation of new carpools.

Along the Fraser River Screenline a significant reduction in AVO is observed on the Pattullo Bridge, with a corresponding significant increase in AVO along the Port Mann Bridge, suggesting a diversion of HOVs from the Pattullo Bridge onto the Port Mann Bridge to take advantage of a portion of the HOV facility. Additional significant AVO reductions are observed along Lougheed Highway (at the east "control" Screenline), confirming the general trend in AVO reduction regionally.

Exhibit 2.1.9 - Weekday AM Peak Period AVOs By Screenline

Exhibit 2.1.10 - Weekday MID-DAY Peak Period AVOs By Screenline

Exhibit 2.1.11 - Weekday PM Peak Period AVOs By Screenline

Overall Screenline AVOs

When considering AVOs across the screenlines analyzed, the results confirm that the person throughput of the HOV section has increased significantly in the weekday AM and PM peak periods. The following tables provide a summary of the "before" and "after" screenline AVOs for the peak directions, at screenlines across the HOV facility, and also at the screenlines at either end of the HOV facility, the Port Mann and Pattullo Bridge in the east and the Second Narrows in the west.

Exhibit 2.1.12A - Summary of "Before" & "After" AVOs at Screenlines

WESTBOUND AM PEAK PERIOD	September 1997 AVO	September 1999 AVO	% Difference
Centre Screenline: Lougheed, TCH, Canada Way (near **Gaglardi**)	1.14	1.19	+4.4%
King Edward Screenline: Lougheed, TCH (east of **Brunette**)	1.13	1.19	+5.3 %
Fraser River Screenline:			
Pattullo Bridge	1.19	1.16	- 2.6 %
Port Mann Bridge	1.13	1.20	+ 6.2 %
Subtotal	***1.16***	***1.19***	***+ 2.6 %***
Second Narrows Screenline: Second Narrows Bridge only	1.11	1.13	+ 1.9%

EASTBOUND PM PEAK PERIOD	September 1997 AVO	September 1999 AVO	% Difference
Centre Screenline: Lougheed, TCH, Canada Way (near **Gaglardi**)	1.24	1.27	+ 2.4 %
King Edward Screenline: Lougheed, TCH (east of **Brunette**)	1.17	1.28	+9.4%
Fraser River Screenline:			
Pattullo Bridge	1.24	1.20	- 3.2 %
Port Mann Bridge	1.16	1.26	+ 8.6 %
Subtotal	***1.20***	***1.23***	***+2.5 %***
Second Narrows Screenline: Second Narrows Bridge only	1.20	1.23	+2.9 %

The AVOs across the screenlines indicate that the increase in vehicle occupancy is greatest across King Edward screenline, where travelers experienced the greatest benefits of the HOV lanes. AVO increases are less but still significant, across the Centre screenline at Gaglardi and the east and west ends. Some diversions in existing HOVs have been observed across the Fraser River screenline (Pattullo Bridge and Port Mann Bridge), where the TCH / Port Mann Bridge AVOs have increased significantly (approximately 3.3 to 6.2%), while the Pattullo Bridge AVOs have decreased significantly (approximately 2.5 to 3.6%). Diversions are also observed across the Centre Screenline in the eastbound PM peak direction where Lougheed Highway AVOs decrease by 2.5% while TCH AVOs increase by 4.8%, both without significant decreases along Canada Way.

In general AVOs are the best measure of person throughput because they are normalized by the before and after number of vehicles. Raw person throughput data can also be used to measure the degree to which this objective is achieved, but is not as reliable since traffic volume variations can significantly sway results. Using the AVOs and the available short count data collected during September of 1997 and 1999, changes in person throughput along Highway 1 near Gaglardi interchange (central and representative portion of the HOV section) are summarized in Exhibit 2.1.12B.

Exhibit 2.1.12B - Before & After Person Throughput at the Central Portion of the HOV Section

Highway at Gaglardi Interchange (Central Portion of HOV Section)			
Peak Period / Direction Person Throughput	**Before**	**After**	**% Change**
AM Period (6:00 –9:00) **Westbound**	11,200	15,700	40%
PM Period (3:00- 6:00) **Eastbound**	9,200	15,900	72%

Review of the person volume data indicates that total person movement throughput along the Highway 1 HOV Section has increased by approximately 40% in the AM westbound peak direction, and 72% in the PM eastbound peak direction. When interpreted with the overall AVO increase observations across all screenlines, it can be confirmed that the increase in person throughput is due to an increase in higher occupant modes, and not just an increase in traffic volumes. The increase in person throughput beyond normal growth can be accounted for by attraction of SOVs and HOVs from parallel routes (such as Lougheed Highway and Canada Way / Pattullo Bridge), and by satisfaction of latent demand (where more people are able to make the trip they want when they want, etc).

2.1.5.2 Increase in the Number of Vanpools and Carpools

Measuring an increase in the number of carpools and vanpools across each screenline is another measure of the mode shift. Exhibits 2.1.13 and 2.1.18 present the "before and after" HOV market shares by time of day and direction of travel – across the screenlines.

It is significant to note that in all cases, the HOV market share has increased across the screenlines considered. Specifically, the following AM peak and PM peak increases were observed:

Exhibit 2.1.13 - Weekday AM Peak Period EB Market Share By Screenline

Exhibit 2.1.14 - Weekday AM Peak Period WB Market Share By Screenline

Exhibit 2.1.15 - Weekday MID-DAY Peak Period EB Market Share By Screenline

Exhibit 2.1.16 - Weekday MID-DAY Peak Period WB Market Share By Screenline

Exhibit 2.1.17 - Weekday PM Peak Period EB Market Share By Screenline

Exhibit 2.1.18 - Weekday PM Peak Period WB Market Share By Screenline

Exhibit 2.1.19 - Summary of "Before" & "After" HOV Market Share

WESTBOUND AM PEAK PERIOD	% of People in HOVs		% Difference
	September 1997	September 1999	
Centre Screenline: Lougheed, TCH, Canada Way (near **Gaglardi**)	27 %	29 %	+2%
King Edward Screenline: Lougheed, TCH (east of **Brunette**)	20 %	29 %	+9%
Fraser River Screenline:			
Pattullo Bridge	12 %	14 %	+ 2 %
Port Mann Bridge	12 %	15 %	+3 %
Subtotal	***25 %***	***30 %***	***+5 %***
Second Narrows Screenline: Second Narrows Bridge only	17 %	21 %	+4%

EASTBOUND PM PEAK PERIOD	% of People in HOVs		% Difference
	September 1997	September 1999	
Centre Screenline: Lougheed, TCH, Canada Way (near **Gaglardi**)	34 %	38 %	+4%
King Edward Screenline: Lougheed, TCH (east of **Brunette**)	27 %	39 %	+12%
Fraser River Screenline:			
Pattullo Bridge	19 %	15 %	- 4 %
Port Mann Bridge	12 %	19 %	+7 %
Subtotal	***31 %***	***34 %***	***+3 %***
Fraser River Screenline: Pattullo Bridge, Port Mann Bridge	31 %	34 %	+3%
Second Narrows Screenline: Second Narrows Bridge only	29 %	33 %	+4%

Again, the shift to HOV mode is most pronounced across the King Edward screenline at King Edward, with less, but still significant increases across the other screenlines. This suggests that the greatest modal shifts are achieved for trips which involve the greatest portion of their route on the HOV facility. Therefore, extension of the HOV facility will encourage even greater shifts to the HOV mode for trips served by the extended facility.

2.1.5.3 Increase in Bus Ridership

Similar to encouraging the generation of new carpools, an effective HOV facility should lead to an increase in bus ridership where applicable. As indicated in the terms of reference for this study, the estimation of TransLink bus occupancies does not apply to the data collection program, as there are currently no transit buses operating along the length of the TCH corridor. The data collected did nevertheless separately classify other types of "buses" (i.e. tour, etc.). Cost Mountain Buslink may take advantage of the HOV lanes in the near future.

2.1.6 Recommendations for Future Phases

Periodic monitoring of vehicle occupancies along the HOV section and the parallel routes should be carried out to determine if these early benefits are sustained over time.

Monitoring of this key indicator will also allow the variability and trends of these benefits to be tracked over time, and indicate when appropriate traffic management measures may be necessary to support changes in the HOV and SOV profiles.

2.2 OBJECTIVE 2: PROVIDE TRAVEL TIME SAVINGS

2.2.1 Description of Objective

The focus of this objective is to provide eligible HOVs with travel time savings over the length of the HOV facility to encourage greater HOV use. Achievement of this objective is critical to the success of an HOV facility, since travel time savings is one of the key incentives for commuters to switch to a high occupancy mode.

2.2.2 MOEs

Specific MOEs which were selected to evaluate the achievement of the objective are:

- lower travel time along the HOV lanes in comparison to the pre-HOV GP lanes.
- lower travel time along the HOV lanes in comparison to the post-HOV GP lanes;

2.2.3 Data Requirements

In order to measure the MOEs identified above, data collection must include:

- "before" travel time measurements in the general purpose lanes;
- "after" travel time measurements in both the HOV and GP lanes.

2.2.4 Phase II Data

Phase II travel times were obtained along the full length of the Study section, from Lynn Valley Road in North Vancouver to the 176 Street Interchange in Surrey. The HOV section is a subset of this full section, approximately from the Grandview Highway overpass to the Cape Horn interchange, is used herein for the evaluation of the HOV lanes. Details of the data are presented in Appendix A-3.

Exhibit 2.2.1 provides a tabulated summary of the travel time data obtained for the HOV lanes, along with calculated average speeds and the delay (compared to free-flow conditions). The data is categorized by time period and lane type.

The Phase II travel time data is consistent with the Phase I data, in that general purpose traffic lanes experience the highest delays in the peak directions – at approximately 5.2 minutes in the AM peak period westbound, and 9.8 minutes in the PM peak period eastbound. HOV traffic on the other hand, experience no delays in the AM peak period westbound, and minimal delays in the PM peak period eastbound, at approximately 1.7 minutes.

Exhibit 2.2.1 - Phase II HOV Section Travel Time, Speed, and Delay Summary

WEEKDAY EASTBOUND

Lane Type	Segment	Distance (km)	Average Travel Time (minutes)		Average Speed (km/hr)		Delay (minutes)	
			AM	PM	AM	PM	AM	PM
GP	Grandview to Cape Horn Overpass	15.77	10.9	20.3	88	53	0.4	9.8
HOV	Begin to End of HOV Lane	14.94	10.0	11.7	90	79	0.0	1.7

WEEKDAY WESTBOUND

Lane Type	Segment	Distance (km)	Average Travel Time (minutes)		Average Speed (km/hr)		Delay (minutes)	
			AM	PM	AM	PM	AM	PM
GP	Cape Horn to Willingdon Overpass	14.61	14.9	10.3	63	88	5.2	0.5
HOV	Begin to End of HOV Lane	14.16	9.4	9.2	91	94	0.0	0.0

Note: Delays are estimated by subtracting the surveyed travel times from a free-flow travel time at 90 km/hr

2.2.5 Before & After HOV Lanes Evaluation

The “before” and “after” comparison of average travel speeds along the HOV section was used to measure the achievement of this objective. Exhibit 2.2.2 provides a graphical summary of average travel speeds and travel time savings along the HOV section for GP traffic before the construction of the HOV lanes, current GP traffic, and current HOV traffic. The comparisons indicate that savings are highest in the peak directions:

PM Peak Period - Eastbound

- HOV traffic save 20.3 minutes when compared to GP travel times before the construction of the HOV lanes, while currently saving 8.7 minutes when compared to current GP travel times.

- GP traffic save 11.7 minutes when compared to GP travel times before the construction of the HOV lanes.

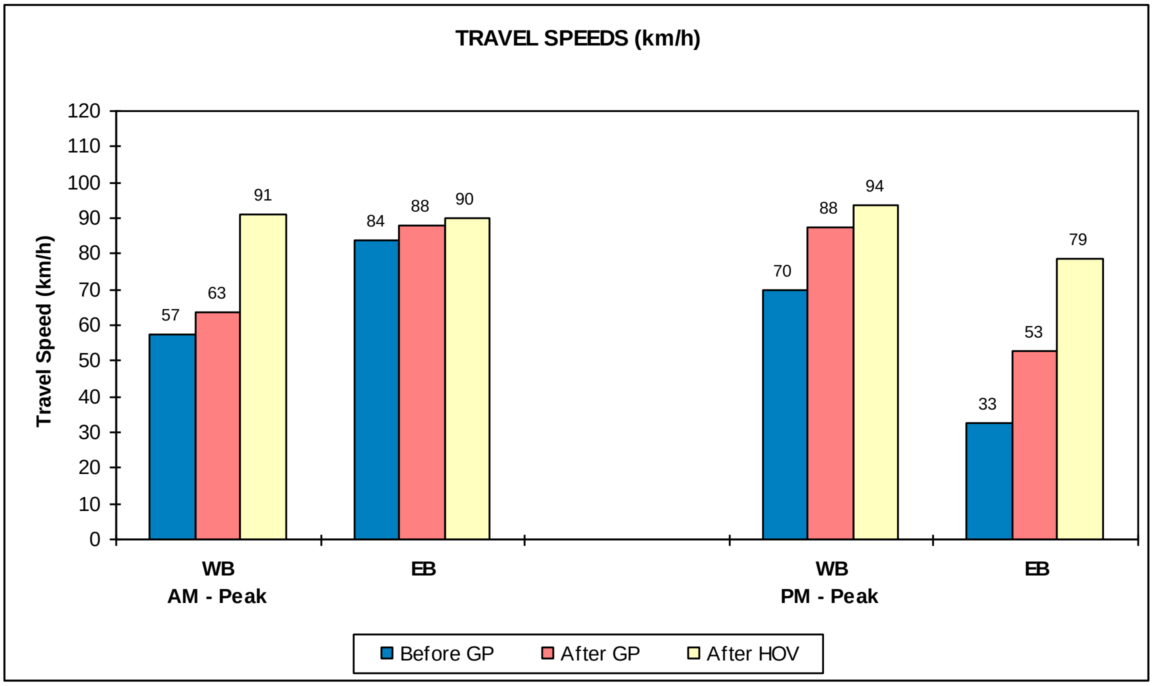
AM Peak Period Westbound

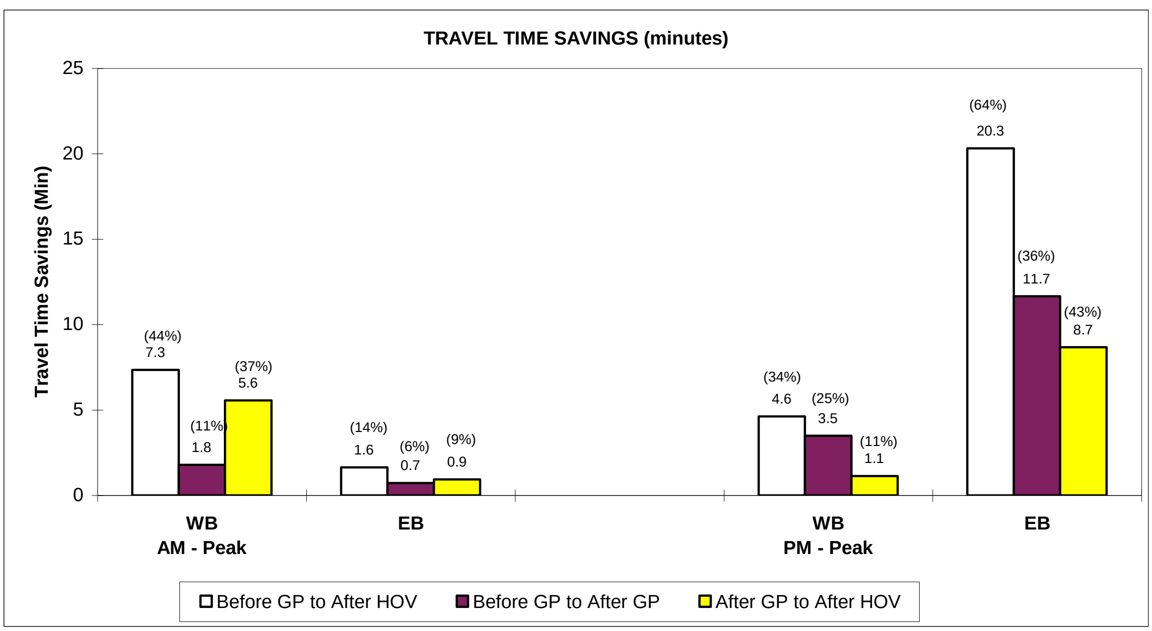
- HOV traffic save 7.3 minutes when compared to GP travel times before the construction of the HOV lanes, while currently saving 5.6 minutes when compared to current GP travel times.

- GP traffic save a 1.8 minutes when compared to GP travel times before the construction of the HOV lanes.

Note: Travel time benefits beyond the HOV section are discussed in Section 3.1.

Exhibit 2.2.2 - Weekday Peak Period - Average Speeds & Travel Time Savings - Before & After HOV Lanes





Additional travel time savings are observed in the westbound PM peak period, likely attributed to higher occupant recreational trips. HOV travel time savings are observed to be 4.6 minutes if compared to GP travel times before the construction of the HOV lanes, and 1.1 minutes if compared to current GP travel times. Before and after GP travel time savings are observed at 3.5 minutes during this same period.

All data were analyzed to confirm that sample sizes were statistically reliable as shown in Exhibit 2.2.3. The before and after comparisons were also analyzed to determine if differences and travel time savings were significant at a 95% confidence limit. It was found that all sample sizes are statistically reliable (i.e. samples were sufficient to make all measured differences significant), and that travel time savings are significant for all periods and directions, and traffic, except for GP traffic during the AM peak period in both directions.

Exhibit 2.2.3 - Weekday Peak Period – Travel Time Savings and Statistical Analysis

		AM - Peak		PM - Peak	
		WB	EB	WB	EB
TRAVEL TIMES (minutes)	**Before GP**	16.7	11.6	13.8	32.0
	After GP	14.9	10.9	10.3	20.3
	After HOV	9.4	10.0	9.2	11.7
		AM - Peak		**PM - Peak**	
		WB	**EB**	**WB**	**EB**
TRAVEL TIME SAVINGS (minutes)	**Before GP to After HOV**	7.3	1.6	4.6	20.3
	Before GP to After GP	1.8	0.7	3.5	11.7
	After GP to After HOV	5.6	0.9	1.1	8.7
		AM - Peak		**PM - Peak**	
		WB	**EB**	**WB**	**EB**
SIGNIFICANT TRAVEL TIME SAVINGS ?	**Before GP to After HOV**	YES	YES	YES	YES
	Before GP to After GP	NO	NO	YES	YES
	After GP to After HOV	YES	YES	YES	YES

NOTE: Shading indicates peak direction

Comparison with Parallel Route Travel Times

Exhibit 2.2.4 provides a comparative tabulation of average travel times and speeds along the HOV-FSP Section versus adjacent parallel routes in the corridor. It can be observed that the Highway 1 travel times are consistently lower than the parallel routes, predominantly due to the arterial nature of those routes. Travel times on the northern parallel (Lougheed Highway) route are lower in the peak direction, than in the off-peak, illustrating the benefits of signal coordination. Comparatively, travel times on the southern route (Canada Way / Pattullo Bridge) are higher in the peak direction – as this section has limited signal coordination.

Exhibit 2.2.4 - HOV/FSP Corridor Phase II Travel Time and Speed Comparison

HIGHWAY 1 vs NORTHERN PARALLEL ROUTE	Distance* (km)	EASTBOUND				WESTBOUND			
		AM		PM		AM		PM	
		Travel Time (min)	Speed (km/hr)	Travel Time (min)	Speed (km/hr)	Travel Time (min)	Speed (km/hr)	Travel Time (min)	Speed (km/hr)
Highway 1	16.2	11.7	83	22.0	44	16.1	60	13.1	73
Northern Route	15.8	18.8	51	24.6	39	31.9	30	28.4	33

Note: Highway 1 - Boundary Road to Cape Horn
Norhthern Route - Boundary Road to United Blvd

HIGHWAY 1 vs SOUTHERN PARALLEL ROUTE	Distance* (km)	EASTBOUND				WESTBOUND			
		AM		PM		AM		PM	
		Travel Time (min)	Speed (km/hr)	Travel Time (min)	Speed (km/hr)	Travel Time (min)	Speed (km/hr)	Travel Time (min)	Speed (km/hr)
Highway 1	22.6	16.6	81	27.9	48	27.2	49	19.4	69
Southern Route	22.3	31.4	43	44.0	30	45.2	30	44.0	30

Note: Highway 1 - Boundary Road to 104 Ave / 160 Street
Southern Route - Boundary Road to 104 Ave / 160 Street

** Two tables are presented above since the two parallel routes are compared to Highway 1 over different distances, i.e. the northern Lougheed Highway Route is parallel over an approximate 16km section (same as the HOV-FSP section), while the southern Canada Way / Pattullo Bridge route is covers a 22km section extending into Surrey.*

2.2.6 Recommendations for Future Phases

A competitive travel time, with significant savings relative to the pre HOV conditions or the current GP conditions is the primary incentive for encouraging a shift to the HOV mode. This important indicator should also be monitored on a regular basis in order to ensure that travel time advantages for the HOVs are sustained over time.

2.3 OBJECTIVE 3: IMPROVE TRIP TRAVEL TIME RELIABILITY

2.3.1 Description of Objective

The focus of this objective is to provide eligible HOVs with improved travel time reliability along the HOV facility. Achievement of this objective, in addition to the travel time advantage over the GP lanes, is also critical to HOV usage, since travel time reliability is also a key incentive for commuters to switch to a high-occupancy mode.

2.3.2 MOEs

Specific MOEs which were selected to evaluate the achievement of this objective are:

- lower variance in travel times along the HOV lanes in comparison to the pre-HOV GP lanes;
- lower variance in travel times along the HOV lanes in comparison to the post-HOV GP lanes;

2.3.3 Data Requirements

In order to measure the MOEs identified above, the data collection program included:

- "before" variance in average speeds in the GP lanes over the length of the HOV facility.

- "after" variance in average vehicle speeds in both the HOV and GP lanes over the length of the facility.

2.3.4 Phase II Data

This objective builds on the benefits of the travel time savings objective by providing HOV lane users with a more reliable trip time in comparison to the GP lane users (both before and after construction of the HOV lanes). The achievement of this objective is measured by comparing the variances in average vehicle speeds along the HOV section. Details of the data supporting this MOE are presented in Appendix A-3. The travel time surveys for this MOE were designed specifically for the purpose of evaluating trip time reliability. The surveys were carried out along the length of the HOV corridor over a 20 day period, during the morning and afternoon peak periods.

Exhibit 2.3.1 provides a tabulated summary of the average speeds measured along the GP and HOV lanes of the corridor, along with their standard deviations, by direction and time period. The results of Phase II trip reliability data are consistent with the Phase I findings, in that general purpose traffic experience the highest trip time variability in the peak directions.

Exhibit 2.3.1 - Phase II Average Speeds with Standard Deviations

Trip Travel Time Reliability	AM		PM	
	Average Speed	Standard Deviation	Average Speed	Standard Deviation
Eastbound				
GP Lanes	88	8.0	53	19.0
HOV Lane	90	2.0	79	11.0
Westbound				
GP Lanes	63	17.0	88	11.0
HOV Lane	91	5.0	94	7.0

** Shading Indicates peak Direction*

2.3.5 Before & After Evaluation

Comparisons of average speed standard deviations for GP traffic before and after the construction of the HOV lanes, and for HOV traffic, provide a measurable indication of the achievement of this objective. Exhibit 2.3.2 provides a graphical summary of these comparisons, whereby the standard deviations are presented as a percentage of the average speed. For the peak directions, the comparisons indicate that:

- **Westbound AM Peak Period** - HOV travel time reliability has improved by 27% relative to GP operations prior to the construction of the HOV lanes. Furthermore, the results indicate that HOV trip time reliability is 24% higher when compared to current operations of GP traffic.

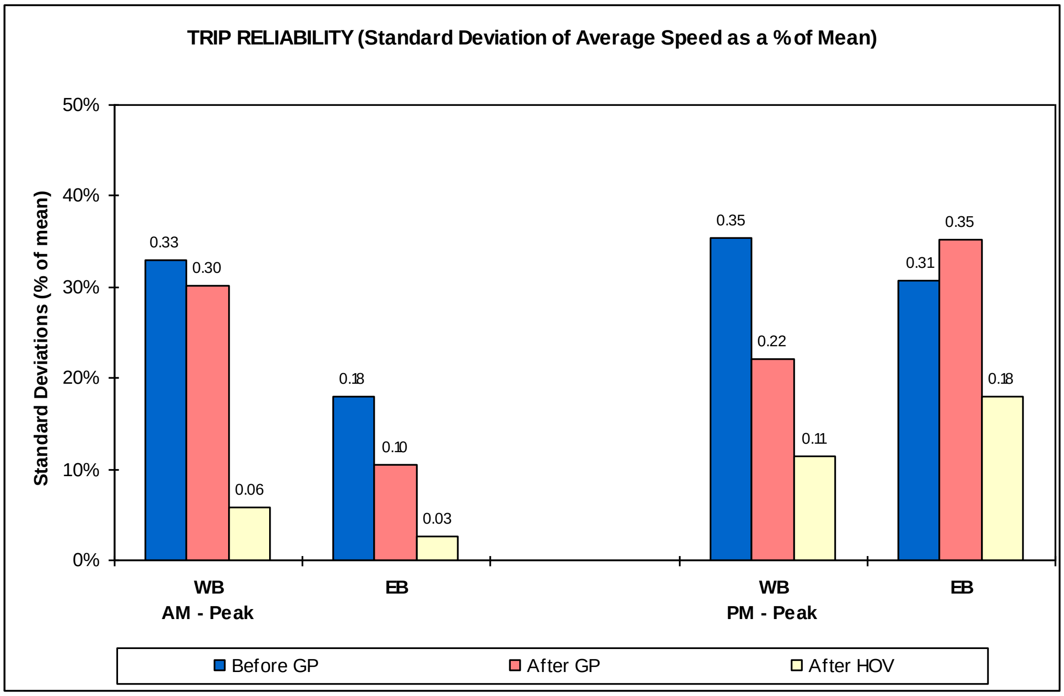
- **Eastbound PM Peak Period** - HOV travel time reliability has improved by 13% relative to GP operations prior to the construction of the HOV lanes. However, the results indicate that HOV trip time reliability is 17% higher when compared to current operations of GP traffic.

For the off-peak direction, HOV trip time reliability improvements are 15% (eastbound AM peak period) and 24% (westbound PM peak period) relative to GP operations prior to construction of the HOV lanes, and 8% (eastbound AM peak period) and 11% (westbound PM peak period) relative to current GP operations.

Some improvements (3% to 13%) in trip time reliability were also observed for the GP traffic before and after construction of the HOV lanes. This is no doubt due to attracting the existing HOV traffic from the GP lanes to the HOV lanes, thus making GP operations better (except for the eastbound PM peak period where “before” GP to “after” GP declined 4%).

Exhibit 2.3.2 also presents the statistical analysis of the trip time reliability analysis to ensure that observed benefits are statistically significant. The analysis indicates that all of the key benefits are statistically significant to a 95 % confidence limit. Before and after benefits to GP traffic during the AM peak period are observed not to be significant to a 95% confidence limit, at the same time these benefits are not relevant to the achievement of this objective.

Exhibit 2.3.2 - Weekday Peak Period – Trip Reliability Analysis



TRIP RELIABILITY (standard deviation of average speed as a % of the mean)

	AM - Peak WB	AM - Peak EB	PM - Peak WB	PM - Peak EB
Before GP	33%	18%	35%	31%
After GP	30%	10%	22%	35%
After HOV	6%	3%	11%	18%

TRIP RELIABILITY CHANGES (standard deviation of average speed as a % of the mean)

	AM - Peak WB	AM - Peak EB	PM - Peak WB	PM - Peak EB
Before GP to After HOV	27%	15%	24%	13%
Before GP to After GP	3%	8%	13%	-4%
After GP to After HOV	24%	8%	11%	17%

SIGNIFICANT SAVINGS IN TRIP RELIABILITY ?

	AM - Peak WB	AM - Peak EB	PM - Peak WB	PM - Peak EB
Before GP to After HOV	YES	YES	YES	YES
Before GP to After GP	NO	YES	YES	YES
After GP to After HOV	YES	YES	YES	YES

NOTE: Shading indicates peak direction

2.4 OBJECTIVE 4: INCREASE PER-LANE EFFICIENCY

2.4.1 Description of Objective

The focus of this objective is to increase the per-lane efficiency of the highway facility expressed in terms of person-kilometres per hour. Since HOV lanes facilitate the movement of higher person-volumes at higher speeds, the overall efficiency of the highway facility is expected to improve.

2.4.2 MOEs

The MOE selected to evaluate the achievement of this objective is based on a comparison of the per-lane efficiency of the highway prior to the provision of HOV lanes, with the per-lane efficiency of the GP and HOV lanes after the implementation of the HOV facility. Per-lane efficiency is calculated by multiplying the person-volume on the highway with the average highway operating speed, as given by the following equation:

$$Efficiency = \frac{ppv \times v_{avg}}{1000 \times (n)}$$

where:

$Efficiency$	= Peak Hour Per-lane Efficiency (1,000 Person – Kilometres/ Hour)
ppv	= Average Per-lane Peak Hour Person Volume (AVO x Vehicles)
v_{avg}	= Average Recorded Speed (kilometers per hour)
n	= Number of Lanes

For the “after” conditions, the facility per-lane efficiency is the weighted combination of the per-lane efficiency of the GP lanes with the HOV lanes.

2.4.3 Data Requirements

In order to measure the MOEs identified above, data collection included:

- “before” and “after” vehicle occupancy counts on a lane basis;
- “before” and “after” vehicle average speeds in the GP and HOV lanes;

2.4.4 Phase II Data

As indicated by the data requirements for this MOE, achievement of this objective is essentially a function of the “increase in AVO” and “lower travel time” objectives.

Exhibits 2.4.1 and 2.4.2 present (Phase II) eastbound westbound per lane efficiency calculations respectively. Interpretation of the Phase II data is not possible without comparison with the "before" data in order to determine the increase or decrease in per-lane efficiency, in the peak and mid-day periods and directions. On its own, a low value for per-lane efficiency does not indicate an inefficient facility, as it could be either a function of low person volumes (i.e. for off-peak conditions and directions) or low speeds (during peak periods). For peak period directions, this MOE shows the compound impact of higher person volumes and speeds on person throughput. The following Phase II per lane efficiencies are computed for a screenline west of Gaglardi Way, and are compared with the Phase I efficiencies for the same location in section 2.4.5 Before and After Evaluation.

Exhibit 2.4.1 – Highway 1 Westbound Per Lane Efficiency (Phase II)

WESTBOUND DEER LAKE	**WEEKDAY**						**SUNDAY**					
	AM		**MID-DAY**		**PM**		**AM**		**MID-DAY**		**PM**	
	GP	**HOV**	**GP**	**HOV**	**GP**	**HOV**	**GP**	**HOV**	**GP**	**HOV**	**GP**	**HOV**
# of Lanes	2	1	2	1	2	1	2	1	2	1	2	1
Traffic Volumes	2919	1095	2359	491	2647	500	1705	393	2377	1042	2167	949
AVO	1.04	2.02	1.16	2.03	1.16	2.06	1.26	2.30	1.48	2.28	1.55	2.26
Total Occupants	3037	2212	2725	996	3082	1032	2153	906	3525	2376	3363	2144
Average Speeds	60	93	68	92	76	92	91	90	90	90	89	90
Per Lane Efficiency	91	205	93	92	118	95	98	82	159	214	149	193
Average Efficiency	**129**		**93**		**110**		**92**		**177**		**164**	

Exhibit 2.4.2 – Highway 1 Eastbound Per Lane Efficiency (Phase II)

EASTBOUND GAGLARDI	**WEEKDAY**						**SUNDAY**					
	AM		**MID-DAY**		**PM**		**AM**		**MID-DAY**		**PM**	
	GP	**HOV**	**GP**	**HOV**	**GP**	**HOV**	**GP**	**HOV**	**GP**	**HOV**	**GP**	**HOV**
# of Lanes	2	1	2	1	2	1	2	1	2	1	2	1
Traffic Volumes	2784	350	2472	494	2699	1037	1414	348	2217	973	2411	1142
AVO	1.06	2.12	1.14	2.21	1.07	2.12	1.26	2.20	1.45	2.16	1.47	2.25
Total Occupants	2960	741	2818	1095	2900	2197	1786	767	3211	2102	3555	2566
Average Speeds	87	93	67	86	47	79	92	90	87	90	88	90
Per Lane Efficiency	129	69	94	94	68	175	82	69	140	189	156	231
Average Efficiency	**109**		**94**		**103**		**78**		**157**		**181**	

2.4.5 Before & After Evaluation

Exhibits 2.4.3 provides a graphical summary of the per-lane efficiency indicator before and after the construction of the HOV lanes – by direction and time period – for weekday and weekend conditions. As in Phase I, the per lane efficiency indicator is computed using a screenline west of the Gaglardi interchange.

The before and after comparison reflects statistically significant increases in both peak directions, AM period westbound and PM period eastbound. In the peak directions, per lane efficiency has increased by 31% for the westbound AM peak period, and an astounding 106% for the PM peak period eastbound, clearly showing the efficiency improvements when capacity is utilized to its potential with higher occupant modes of travel. Both mid-day periods and off-peak directions reflect a reduction in per lane efficiency, since during these off-peak directions volumes are lower, and the speed advantages of the HOV facility are not as pronounced.

Exhibit 2.4.3 - Peak Period Before & After Per Lane Efficiency

2.5 OBJECTIVE 5: MINIMIZE NEGATIVE IMPACTS ON GENERAL PURPOSE (GP) LANES

2.5.1 Description of Objective

The focus of this objective is to minimize adverse impacts to the operations of GP traffic as a result of the introduction of the HOV facility.

2.5.2 MOEs

The primary MOE that can be used to evaluate the achievement of this objective is a comparison of average GP lane operating speeds before and after introduction of the HOV facility. A secondary MOE is the Level of Service (LOS) along the GP lanes within the HOV section. However, this MOE may underestimate the improvement since the operation of the GP lanes in the "before" conditions was capacity constrained and experienced breakdown during the peak periods.

2.5.3 Data Requirements

In support of the MOEs identified above, the following data were collected:

- "before" and "after" vehicle counts by lane type;
- "before" and "after" vehicle average speeds by lane type;

2.5.4 Phase II Data

The GP lane average speed data were presented in detail as part of the objectives associated with improving travel times and trip time reliability objectives. Exhibit 2.2.2 should be used as a reference for baseline speed data along the GP lanes within the HOV section.

Exhibit 2.5.1 provides a summary of the “after” LOS calculations along the GP and HOV lanes. Along the GP lanes, LOS are observed to range between E and D for the peak AM westbound and PM eastbound directions. In the off-peak directions, GP lane LOS are observed to be predominantly C or better, except near the Grandview Highway interchange, where eastbound AM peak LOS are observed to be E.

2.5.5 Before & After Evaluation

Again with reference to Exhibit 2.2.2, before and after average speeds in the GP lanes within the HOV section were observed to improve in all periods and directions. Although the AM period improvements are not statistically significant at a 95% confidence limit, the overall results indicate that this objective has been achieved and the introduction of the HOV lanes has not adversely affected the operation of the GP lanes.

Exhibit 2.5.1 - Phase II Summary of Mainline LOS – Weekday Peak Hour

AM EB	PHASE 2 (GP)			PHASE 2 (HOV)		
Highway Segment East of	Avg. Speed	Highway Volume	LOS	Avg. Speed	Highway Volume	LOS
Grandview	63	3500	E	88	345	A
Willingdon	78					
Sprott	88	2424	C	97	327	A
Deer Lake	87					
Stormont	89	2784	D	92	350	A
Brunette	78					

AM WB	PHASE 2 (GP)			PHASE 2 (HOV)		
Highway Segment East of	Avg. Speed	Highway Volume	LOS	Avg. Speed	Highway Volume	LOS
Willingdon	64	3337	E	94	999	C
Sprott	45					
Deer Lake	43	2919	E	88	1095	C
Stormont	44					
Brunette	78	2955	D	87	689	B

PM EB	PHASE 2 (GP)			PHASE 2 (HOV)		
Highway Segment East of	Avg. Speed	Highway Volume	LOS	Avg. Speed	Highway Volume	LOS
Grandview	87	3333	D	85	893	B
Willingdon	71					
Sprott	77	2871	D	95	1149	C
Deer Lake	66					
Stormont	71	2699	D	86	1037	C
Brunette	28					

PM WB	PHASE 2 (GP)			PHASE 2 (HOV)		
Highway Segment East of	Avg. Speed	Highway Volume	LOS	Avg. Speed	Highway Volume	LOS
Willingdon	89	3040	D	96	602	B
Sprott	83					
Deer Lake	92	2647	C	93	500	A
Stormont	87					
Brunette	85	1949	B	89	363	A

NOTE: Shading indicates peak direction
AM-Peak Hour - 0700 - 0800
PM-Peak Hour - 1600 - 1700

Exhibits 2.5.2 and 2.5.3 provide a graphical summary of before and after LOS calculations along the HOV section, for the AM peak and PM peak periods respectively. The results confirm the observed improvements to GP operations, whereby the predominantly F levels of service from Phase I are now observed at LOS E or D after the introduction of the HOV lanes. It should be noted that in some cases the actual improvement may be much higher than a mere increase from LOS F to E, since during Phase I it was observed that eastbound traffic experienced flow breakdown in the PM peak period.

Exhibit 2.5.2 - Before & After Mainline LOS – AM Peak Hour

Exhibit 2.5.3 - Before & After Mainline LOS – PM Peak Hour

2.6 OBJECTIVE 6: MAINTAIN SAFETY

2.6.1 Description of Objective

The focus of this objective is to ensure that safety of the HOV section of Highway 1 is not compromised as a result of the introduction of the HOV lanes, and that as a minimum, the safety levels existing prior to the construction of the HOV lanes are maintained.

2.6.2 MOEs

The specific MOE which can be used to evaluate the achievement of this objective is "collision rate" which can be broken down into the following categories:

- frequency of collisions by time period (year, month, day of week, and time of day),
- severity of collisions,
- type of collision,
- number of vehicles involved in each collision,
- number of injuries involved in each collision,
- contributing factors to collision,
- spatial distribution of collisions,
- collision severity ratios, and
- collision rates.

2.6.3 Data Requirements

The evaluation methodology developed for this project during Phase I identified the primary source of the first two phases of the project (i.e. before TMP) to be MoTH's Highway Accident System (HAS). Using this data source, the Phase 1 safety analysis was carried out for the full 34-kilometer section of the TCH which comprises the Study Section. Several safety performance targets were identified for the analysis including collision frequency, collision rate, collision severity, as well as temporal, spatial and other characteristic trends. The Phase I analysis recognized the potential differences between 1992 to 1995 reporting level and 1996 reporting levels which were believed to be reduced due to limited accident attendance by the Police. The Phase II effort was to use the HAS database as source, with an attempt to account for variations in the Police reporting of accidents.

Unfortunately however, shortly after the commencement of the Phase II study, MoTH staff advised the project team that the HAS database has not been fully updated to include post-HOV data, and that this component of the study should either be postponed, or carried out using an alternate source of collision data to measure safety impacts.

Subsequent to review of available data sources, the accident claims database maintained by the Insurance Corporation of British Columbia (ICBC) was identified as one source of potential safety data. Although the details and quality of the data were questionable for carrying out a detailed safety analysis similar to Phase I, it was determined that the ICBC claims data could provide a relatively stable comparison of claims before, during, and after construction of the HOV lanes.

On this basis, permission was granted by ICBC to access the database and use an unofficial querying tool to extract the necessary data. ICBC is currently developing a database application for this type of claims records analysis; in the interim, ICBC's Road Improvement Program has developed a tool to access the claims data informally. Therefore, it should be noted that although these data are actual claims data, they have not been officially released by ICBC.

2.6.4 Phase I & II Data

Using this alternate source of data required the querying of data prior to, during, and subsequent to the construction of the HOV lanes, so that an unbiased comparison could be carried out.

The claims data used for this analysis was extracted based on a specific selection criteria. The identification of the location of a claim occurrence was a challenging aspect of this effort, whereby a logical combination of text fields within a claim were used to develop specific querying criteria. For this investigation, the following selection criteria was used:

	1. Claim location occurring on:		Hwy 1	
			or	Hwy1 (no space)
		or	# 1	
		or	Highway 1	
			or	TCH
AND			or	Trans
	2. Claim occurred in the city of:		Burnaby	
			or	Coquitlam
			or	New Westminster
			or	Port Coquitlam

Note that variations of the City names were also included in the search routine (i.e., Coquitlam , Coquit., Coq., etc.). The cities selected in this investigation were selected because the entire city is within the Study Section. This is necessary because it is not possible (at this point) to define longitudinal boundaries within a municipality. Therefore, the cities of North Vancouver and Surrey were omitted because the TCH extends far beyond the Study Section within those municipal boundaries.

2.6.5 Before & After Evaluation

Since the safety evaluation completed in the Phase I report was not useful in this Phase II review (for the reasons specified earlier), it was necessary to redo the analysis for the "pre-implementation" safety performance using the claims records as well. Four periods were used for this safety investigation:

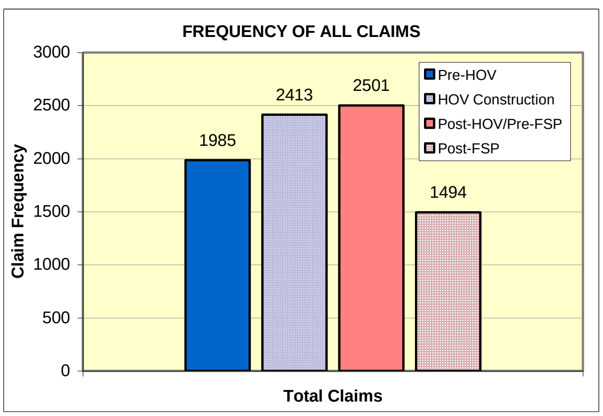
1. Pre-HOV: Oct. 1/96 to Sept. 30/97 (365 days)
2. HOV Construction: Oct. 1/97 to Oct. 28/98 (393 days)
3. Post-HOV/Pre-FSP: Oct. 29/98 to Jan. 3/99 (67 days)
4. Post-FSP: Jan. 4/99 to Sept 30/99 (270 days)

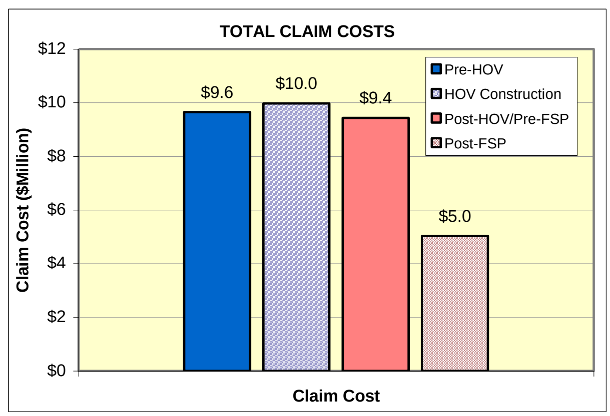
A series of high-level aggregate measures were identified to for comparing the "Pre-HOV", "HOV Construction", "Post-HOV/Pre-FSP" and "Post-FSP" conditions. These measures were limited to the useable fields queried from the claims data. The aggregate measures included the following:

- Frequency of All Claims
- Frequency of Claims by Severity
- Frequency of Claims by Municipality
- Frequency of Claims by Vehicle Type
- Total Claim Costs

Exhibit 2.6.1 provides a summary of the annualized total frequency of claims, and the total claim costs.

Exhibit 2.6.1 - Frequency of Claims and Total Cost of All Claims





Compared to before HOV construction, analysis of the annualized data indicates that total number of claims increased by 22% during construction of the HOV lanes, but decreased by 25% after the opening of the HOV lanes and introduction of the FSP. At the same time the total annualized cost of claims increased by $400,000 during construction of the HOV lanes, but decreased by $4.6 million after the opening of the HOV lanes and introduction of the FSP.

Since it can often take a considerable amount of time to settle an auto insurance claim, the total cost of claims may not be accurate due to outstanding claims – especially relating to the recent "after" data. However, the data obtained from ICBC includes an outstanding reserve estimate associated with each unprocessed claim and this value is used in the total cost summary.

Exhibits 2.6.2 through to 2.6.4 provide a summary of claim frequencies by severity, vehicle type, and municipality respectively.

Exhibit 2.6.2 - Frequency of Claims by Severity

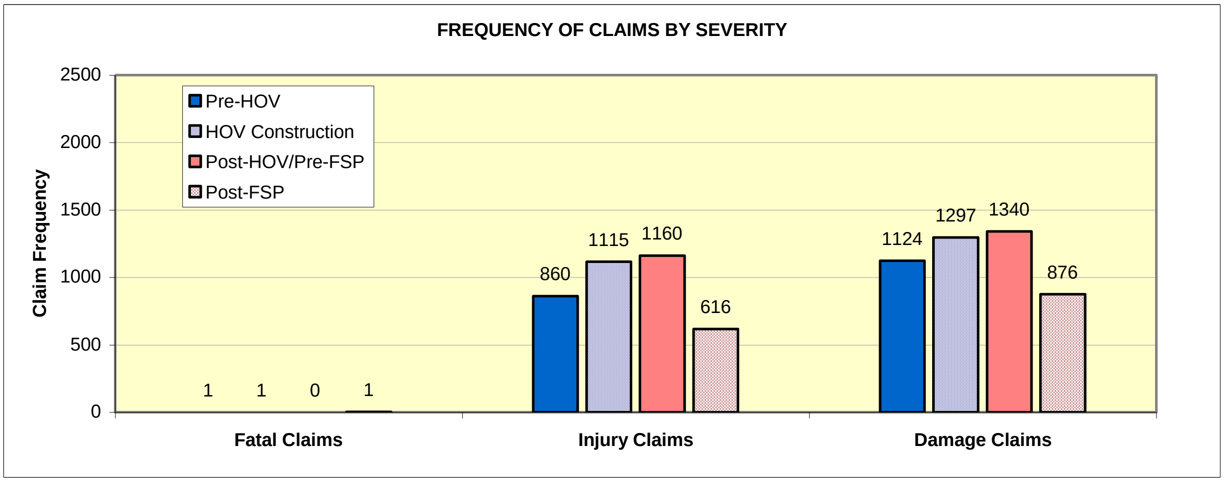


Exhibit 2.6.3 - Frequency of Claims by Vehicle Type

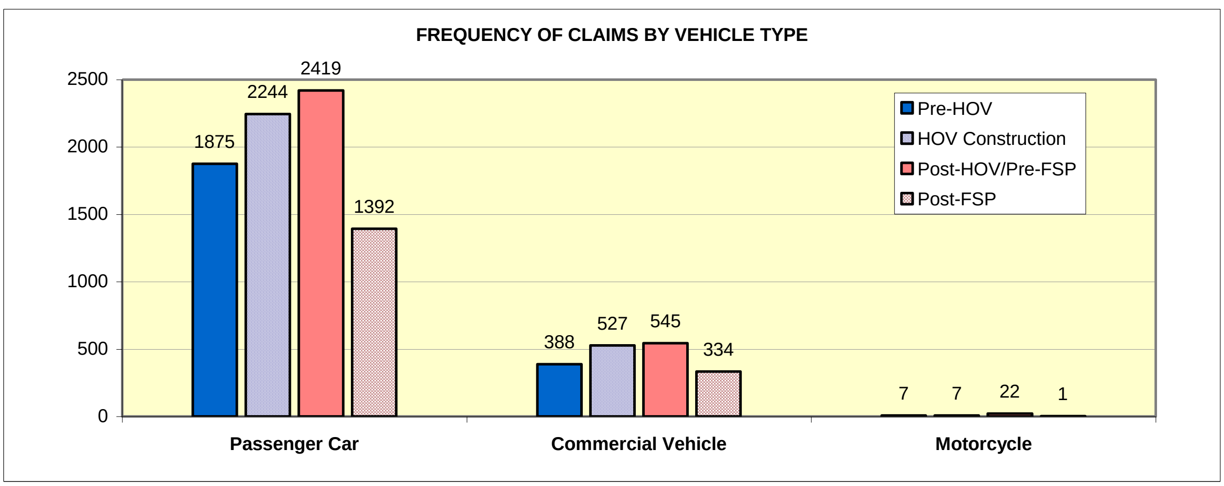
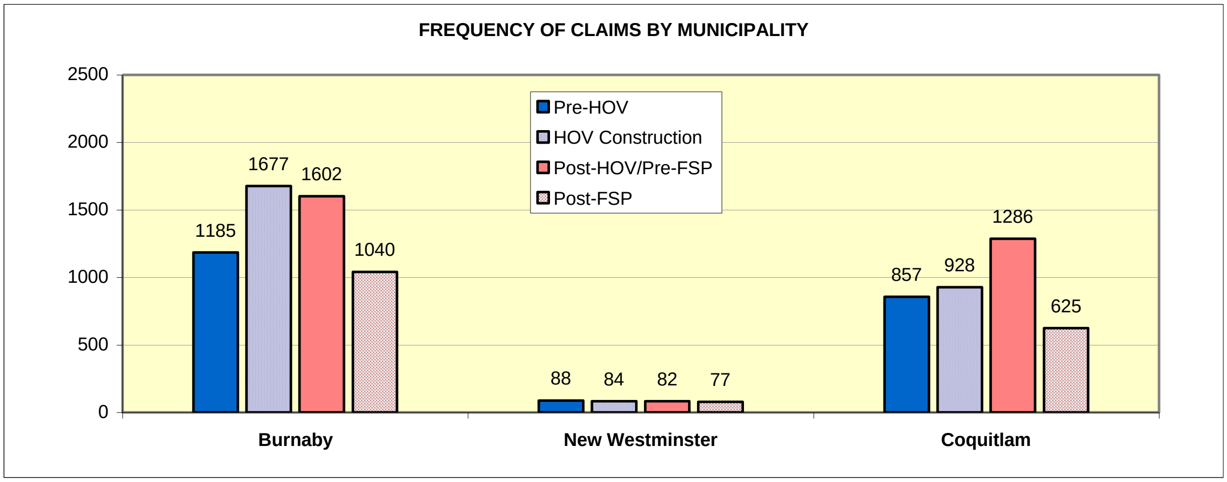


Exhibit 2.6.4 - Frequency of Claims by Municipality



The pre-HOV, HOV construction and post HOV/FSP comparisons of the claims data, as categorized by accident severity, vehicle type, and municipality seem consistent with the total frequency and claim cost data, i.e. in all cases an increase in claims is observed during the construction phase, and a decrease after the construction of the HOV lanes, when compared to conditions prior to the HOV lanes.

The observed reduction in crash claims is attributable to the combination of HOV improvements (such as the provision of 3m left shoulders and continuous median barriers) and FSP improvement (faster incident detection and response) along the HOV section of Highway 1.

These are presented in further detail in Section 3.3 of this report. The potential for safety benefits associated with the provision of continuous lighting between the interchanges (as part of the HOV lanes construction) should however be noted. According to the Journal of Illuminating Engineering Society (Summer 1999), some jurisdictions have observed reductions of up to 40% in the frequency of night-time accidents as a result of continuous lighting. Using pre-HOV collision data (1992 to 1997), MoTH estimates that approximately 20% of crashes along the HOV section occurred during unlit or half-lit conditions (see Appendix 10), suggesting that potential benefits of illumination could range between 0 to 8% of these night-time crashes. Actual reduction of night-time crashes along lit and unlit sections of Highway 1 will require comparison of comparable before and after crash data with sufficient detail to distinguish between unlit and lit locations.

Significance of Results

A simple, modified t-test (t) was used to calculate and compare with the normal Z-value of 1.960 at the 95 percent significance level. This would provide an indication whether the change in claim frequency between time periods was statistically significant or not. A second statistical test (chi-square test, $\chi 2$) was also performed to test the significance of the safety analysis results. The calculated chi-square value was also tested for a 95% confidence limit. This test is considered to be somewhat superior to the t-test. However, it should be noted that the relevance and robustness of these statistical tests is considered somewhat marginal for the data presented herein. Significance tests were completed to evaluate the 'before' to the 'after' periods as well as 'during' to the 'after' periods. The results are as follows:

Exhibit 2.6.5 – Statistical Significance of Safety Analysis

Aggregate Safety Performance Measure	'Pre-HOV' to 'Post-FSP'	'HOV Construction' to 'Post-FSP'	"Post-HOV / Pre-FSP' to 'Post-FSP'
	χ_c^2 - test	χ_c^2 – test	χ_c^2 - test
Frequency Of Total Claims	Significant 57.8	Significant 181.7	Significant 88.0
Frequency Of Fatal Claims	Insignificant 0.05	Insignificant 0.07	Insignificant 0.25
Frequency Of Injury Claims	Significant 33.3	Significant 119.7	Significant 60.1
Frequency Of Damage Claims	Significant 25.7	Significant 68.9	Significant 32.7
Frequency Of Claims in Burnaby	Significant 8.0	Significant 125.8	Significant 40.4
Frequency Of Claims in New Westminster	Insignificant 0.61	Insignificant 0.23	Insignificant 0.04
Frequency Of Claims in Coquitlam	Significant 30.3	Significant 50.1	Significant 85.0
Frequency Of Passenger Vehicle Claims	Significant 59.3	Significant 167.6	Significant 97.1
Frequency Of Commercial Vehicle Claims	Insignificant 3.28	Significant 36.3	Significant 17.4
Frequency Of Motorcycle Claims	Insignificant 2.95	Insignificant 2.64	Significant 11.4

Overall, the trends investigated in this cursory review seem to indicate that the implementation of the HOV lanes on the TCH has "maintained safety", not degrading it, and has to some extent improved it.

The robustness of this safety evaluation is unknown. This statement is made because of the lack of experience associated with the analysis of crash claims data and the high-level aggregate indicators presented. However, given the lack of other road safety data available at this point, the claims data provides the most suitable means to evaluate safety.

2.6.6 Recommendations for Future Phases

It will be useful to replicate the detailed safety analysis undertaken in Phase I prior to implementation of the TMP pilot service applications using the HAS database.

2.7 OBJECTIVE 7: OBTAIN COMPLIANCE

2.7.1 Description of Objective

The focus of this objective is to protect the travel time savings and reliability of the HOV facility from being diminished by SOVs using the HOV lanes.

2.7.2 MOEs

The MOEs selected to evaluate the achievement of this objective are:

- Compliance rate, calculated as the percentage of eligible vehicles observed in the HOV lane divided by the total number of vehicles in the HOV lane over that same period.

- Number of HOV violators

2.7.3 Data Requirements

In support of the MOEs identified above, the following data were collected:

- Vehicle occupancy and classification data
- Enforcement statistics

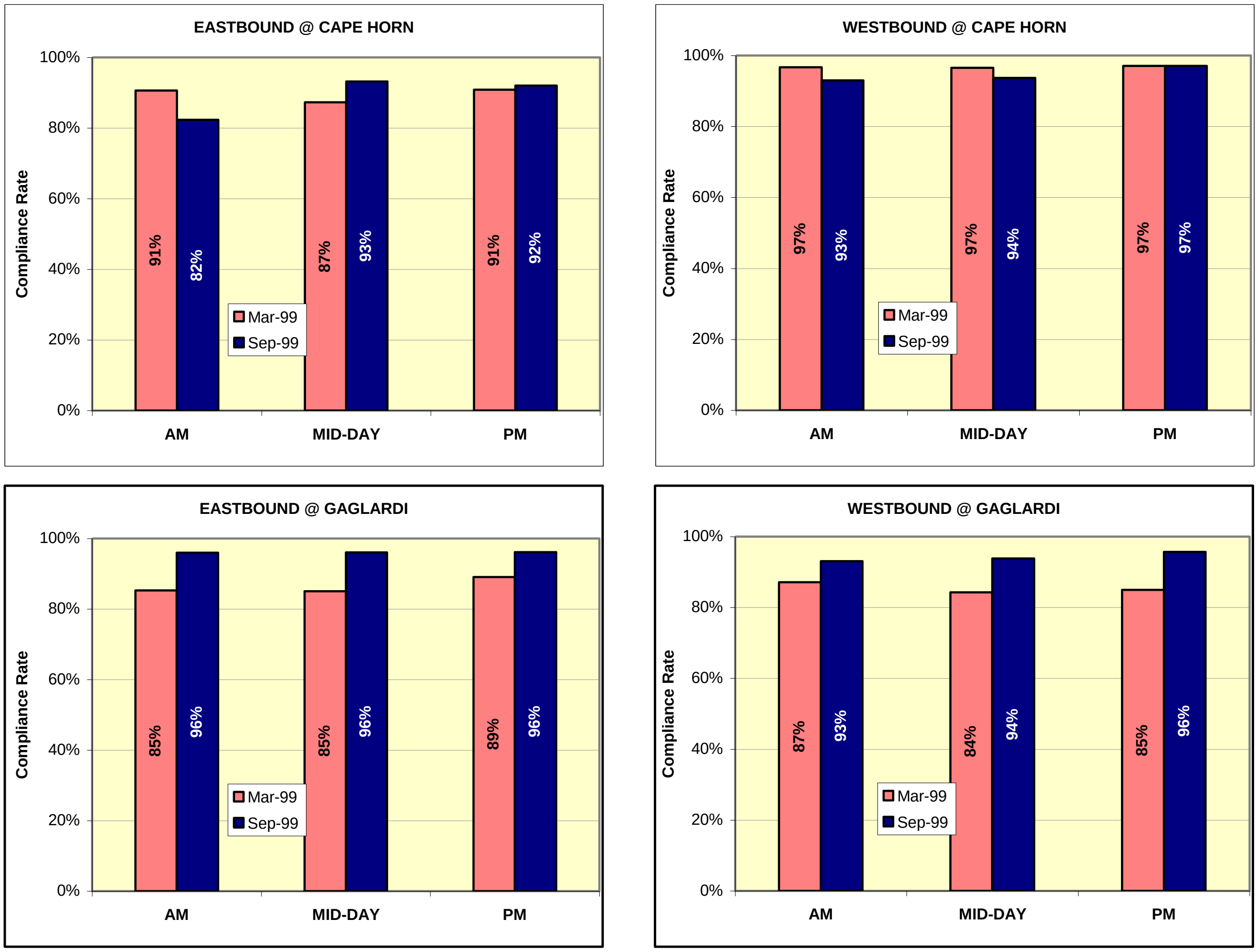
2.7.4 Phase II Evaluation

Based on the vehicle occupancy and classification data presented in section 2.1 of this report, Exhibit 2.7.1 below provides a comparison of the current (September 99) HOV lane compliance rate with a March 1999 HOV compliance rate (using occupancy data collected by MoTH in March 1999) at approximately the same locations.

A very high compliance rate of 93% to 96% is observed for all periods and directions, except for the eastbound AM peak period near the east terminus of the HOV lanes at the Cape Horn interchange where the compliance rate is observed to be 82%.

Comparison with the March 99 data shows an increase in HOV compliances by approximately 6% to 11% near Gaglardi interchange while a slight reduction of 3% to 8% is observed near Cape Horn interchange.

Exhibit 2.7.1 - Compliance Rates



Overall, the compliance rates are observed to meet the minimum requirement of 85% set by MoTH. One of the reasons for low compliance rates near the east terminus of the HOV section may be the proximity of the measurements to the terminus of the lanes. It has been observed that during peak conditions, some GP traffic enters the HOV lanes just before they end.

Exhibit 2.7.2 provides a summary of the weekly average person hours of enhanced enforcement along the HOV section of Highway 1. It can be observed that the enforcement hours were reduced from 140 hours per week in November 1998 to 73 hours per week in March 1999, and to approximately 30 hours per week since May 1999.

Exhibit 2.7.2 – Weekly Average Person Hours of Enforcement

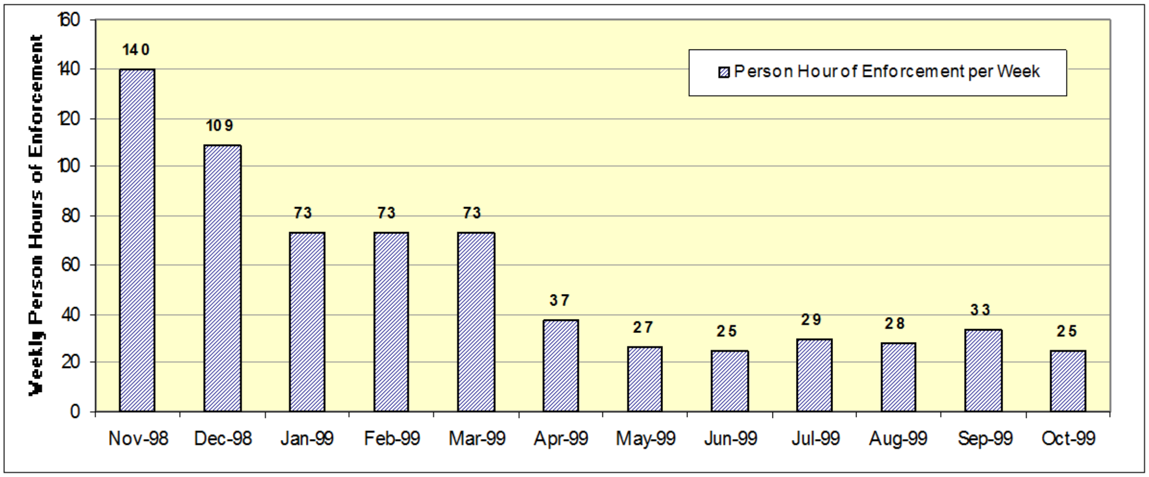
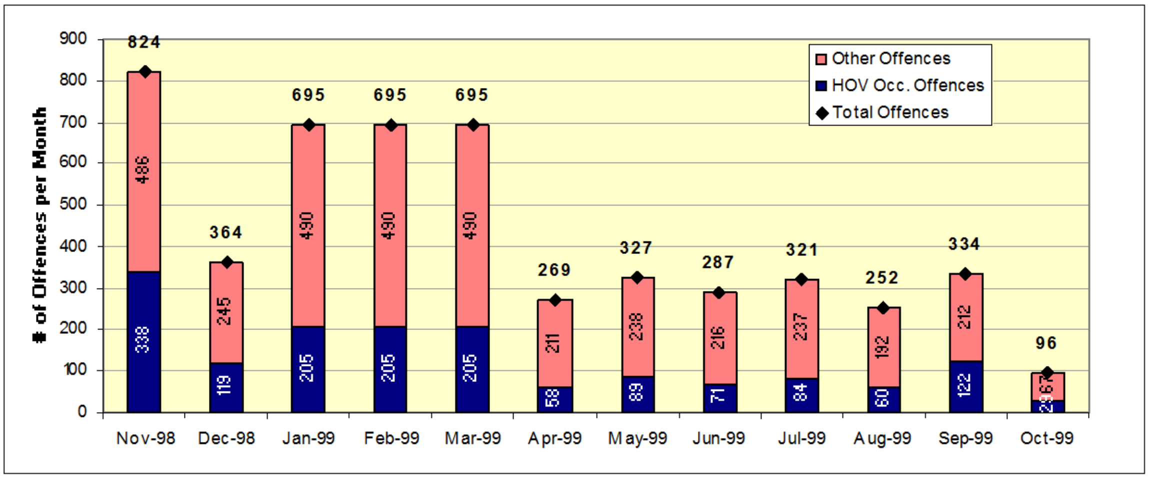


Exhibit 2.7.3 – Total HOV Occupancy and Other Offences

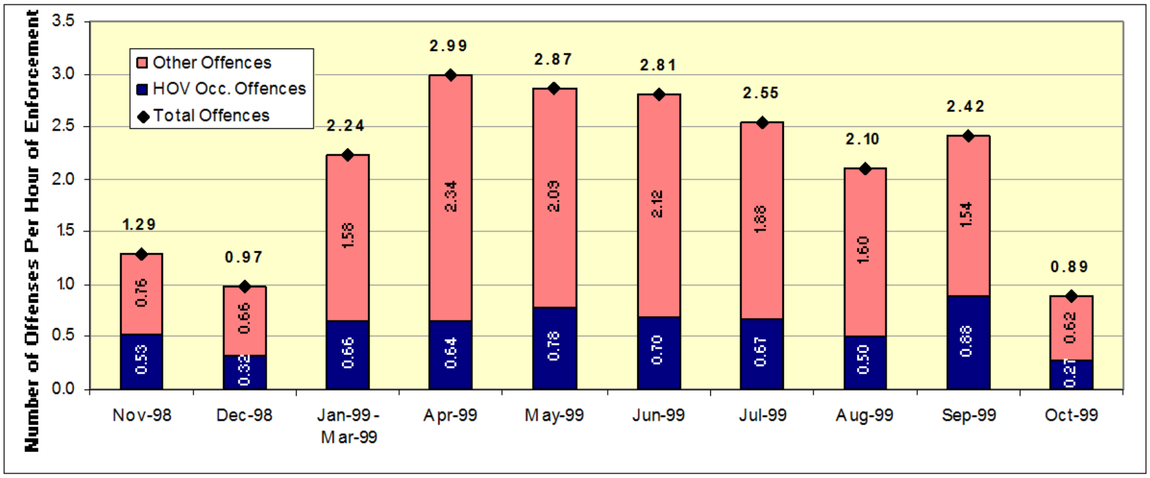


Note: 1. No. of offences between Jan-99 & March-99 are average of the total 3-month offences
2. Other offences refer to Commercial vehicle in HOV lane, Unsafe Lane Changes, Cross Solid Line, Following Too Closely, Speeding etc…

Exhibit 2.7.3 presents the number of monthly offences over the same time period. The observed number of offences follows a similar downward trend as in the enforcement hours, whereby the monthly violations are found to decrease from 824 total offences in November 1998 to approximately 695 in March 1999, and further reduced to approximately 300 after May 1999.

Since the reduction in the number of violations could be due to the reduced enforcement hours (i.e. violators are not being caught), the average number of ticketed offences per hour of enforcement was also calculated, and is presented in Exhibit 2.7.4.

Exhibit 2.7.4 – Hourly Average Violations Rate



Note: Hourly Average Violations rate = Total number of offences / Total number of enforcement hours

It can be observed from Exhibit 2.7.4 that except for October 1999, the average HOV related offenses per hour of enforcement has remained relatively constant as the total enforcement hours were reduced. This suggests that the police have gained experience and efficiency in HOV enforcement, and can maximize the number of tickets issued within the less enhanced enforcement program.

Future considerations could include the use of a user reporting telephone service (snitch line), similar to Washington State's HERO program, where TCH users can report HOV lane violations using a free cellular telephone number.

2.8 OBJECTIVE 8: ACQUIRE PUBLIC ACCEPTANCE AND SATISFACTION

2.8.1 Description of Objective

The focus of this objective is to determine if, or confirm that the users of Highway 1 accept the introduction of the HOV facility as an improvement to their transportation system and are satisfied with the benefits they receive from it as users.

2.8.2 MOEs

The MOE for this objective is direct input from Highway 1 motorists and stakeholder agencies through information, observation, and opinion surveys.

2.8.3 Data Requirements

User satisfaction levels were obtained through the distribution of 2000 mail-back surveys at the following locations:

- ✓ Westbound Highway 1 off-ramp at First Avenue
- ✓ Eastbound Highway 1 off-ramp at 104 Avenue
- ✓ West and Eastbound Highway 1 off-ramps at Gaglardi Way

2.8.4 Phase II Data

Exhibit 2.8.0 below provides a summary of the response rate for SOV and HOV drivers relative to the 566 returns from the 2000 questionnaires handed out.

Exhibit 2.8.0 - Highway 1 User Survey Response Statistics

SURVEY LOCATION		HOV DRIVER		SOV DRIVER		TOTAL		# Questionnaires Handed Out	% Return
		#	% Distribution by Location	#	% Distribution by Location	#	% Distribution by Location		
1	104 Ave (PM EB)	47	28%	118	30%	**165**	29%	800	21%
2	1st Ave (AM WB)	103	61%	209	53%	**312**	55%	800	39%
3	Gaglardi (AM & PM)	18	11%	71	18%	**89**	16%	400	22%
	Total Questionnaires Received	**168**		**398**		**566**		2000	**28%**
	% of Driver Type	**30%**		**70%**					

The results indicate that the split between HOV and SOV respondents was 30% versus 70% respectively for the peak directions. This is very consistent with the market share statistics presented in section 2.1 of this report – where peak direction market shares ranged between 25% to 30% HOVs and 70% to 75% SOVs. Exhibits 2.8.2A to 2.8.2E provide a tabulation of the surveys results pertaining to the HOV facility. The following is a brief summary of the response highlights.

2.8.4.1 Motorist Survey

Approximately 30% of the respondents were HOVs and 70% were SOVs. Also, approximately 62% of the HOVs, and 64% of the SOVs use the TCH five or more times per week. Exhibit 2.8.1 below summarizes the critical attributes of the full sample of HOV respondents, broken down by whether they were newly formed or existing carpools, and whether they were already on the TCH or switched from parallel routes.

Exhibit 2.8.1 - Existing & New HOVs versus TCH & Route Switching HOVs

TCH Sample of HOV Users	Already on Highway 1	Switched from Parallel Routes	Totals
Existing HOVs (i.e. already carpooling prior to HOV lanes)	43%	29%	72%
New HOVs (i.e. carpooling after HOV lanes)	17%	11%	28%
Totals	60%	40%	100%

Of the sample of all HOV users, the surveys indicate that:

- About 28% of the are new carpools, while 72% were already carpooling.
- About 60% of were already on the TCH, while 40% switched from the parallel routes.
- About 17% of the HOVs were new carpools formed by SOVs on the TCH, while 11% were new carpools formed by SOVs on the parallel routes.
- About 43% of the HOVs were carpools already existing on the TCH, while 29% were carpools already on the parallel routes.

HOV Acceptance

- ✓ Approximately 94% of the HOVs and 76% of the SOVs believe that the designated number of occupants for the HOV lanes should be 2 or more persons
- ✓ Approximately 76% of the HOVs and 57% of the SOVs believe that the HOV lanes are being adequately used
- ✓ Approximately 86% of the HOVs and 69% of the SOVs believe that the HOV lanes are convenient to use
- ✓ Approximately 71% of the HOVs and 54% of the SOVs believe that the HOV lanes are safe

HOV Satisfaction

- ✓ Approximately 92% of the HOVs and 86% of the SOVs believe that the HOV lanes are faster than the regular lanes
- ✓ Approximately 86% of the HOVs and 69% of the SOVs believe that the HOV have more predictable travel times
- ✓ Approximately 80% of the HOVs and 87% of the SOVs believe that traffic in the HOV lanes move at or above the speed limit but not "too fast"

Issues

- ✓ Approximately 62% of the HOVs and 71% of the SOVs believe that roadside enforcement causes distraction and results in vehicle slowdowns
- ✓ Approximately 54% of the HOVs and 50% of the SOVs believe that there is too much unnecessary weaving in and out of the HOV lanes
- ✓ Approximately 30% of the SOV would be encouraged to become an HOV user if their hours of work permitted it, while 20% require a "good rideshare opportunity" to become an HOV user

Comments

- ✓ Approximately 40% of the HOVs and 32% of the SOVs commented that more enforcement is needed
- ✓ Approximately 18% of the HOVs suggested "more HOV" (i.e. expansion along Highway 1 and other routes)
- ✓ Approximately 23% of the SOVs commented that the HOV lanes should be open to all traffic during off-peak hours.

Exhibit 2.8.2A - Summary of Motorist Survey – General

2.1 How often do you usually commute on the portion of Highway 1 between Cape Horn and Grandview Highway?

	HOV DRIVER		SOV DRIVER		TOTAL	
	#	%	#	%	#	%
Less than once a week	8	5%	29	7%	37	7%
Once a week	8	5%	13	3%	21	4%
2-4 times per week	29	17%	68	17%	97	17%
5 times per week	**73**	**43%**	**185**	**47%**	**258**	**46%**
6-7 times per week	**32**	**19%**	**69**	**17%**	**101**	**18%**
Other	18	11%	33	8%	51	9%
TOTAL	**168**	**100%**	**397**	**100%**	**565**	**100%**

2.2 What was your most frequent mode of travel on Highway 1 prior to October 1998, before the HOV lanes were opened?

	HOV DRIVER		SOV DRIVER		TOTAL	
	#	%	#	%	#	%
Drive alone	**47**	**28%**	**334**	**84%**	**381**	**68%**
Carpool with one other person	**70**	**42%**	**22**	**6%**	**92**	**16%**
Carpool with two or more people	24	15%	7	2%	31	6%
Vanpool	3	2%	0	0%	3	1%
Other	21	13%	33	8%	54	10%
TOTAL	**165**	**100%**	**396**	**100%**	**561**	**100%**

2.3 Have you changed your travel route to take advantage of the HOV lanes on Highway 1?

	HOV DRIVER		SOV DRIVER		TOTAL	
	#	%	#	%	#	%
All the time	**33**	**20%**	**10**	**3%**	**43**	**8%**
Most of the time	**33**	**20%**	**16**	**4%**	**49**	**9%**
Sometimes	20	12%	60	15%	80	14%
Rarely	12	7%	62	16%	74	13%
Not at all	67	41%	248	63%	315	56%
TOTAL	**165**	**100%**	**396**	**100%**	**561**	**100%**

Exhibit 2.8.2B - Summary of Motorist Survey – Observation & Opinions 1

3.1 The HOV lanes are being adequately used

	HOV DRIVER		SOV DRIVER		TOTAL	
	#	%	#	%	#	%
Strongly Agree	**52**	**32%**	**74**	**19%**	**126**	**23%**
Somewhat Agree	**72**	**44%**	**147**	**38%**	**219**	**40%**
Neutral	17	10%	46	12%	63	11%
Somewhat Disagree	15	9%	69	18%	84	15%
Strongly Disagree	8	5%	53	14%	61	11%
TOTAL	**164**	**100%**	**389**	**100%**	**553**	**100%**

3.2 The HOV lanes are faster than the regular lanes

	HOV DRIVER		SOV DRIVER		TOTAL	
	#	%	#	%	#	%
Strongly Agree	**111**	**66%**	**185**	**47%**	**296**	**53%**
Somewhat Agree	**44**	**26%**	**154**	**39%**	**198**	**35%**
Neutral	4	2%	31	8%	35	6%
Somewhat Disagree	4	2%	19	5%	23	4%
Strongly Disagree	4	2%	3	1%	7	1%
TOTAL	**167**	**100%**	**392**	**100%**	**559**	**100%**

3.3 The HOV lanes have more predictable travel times than the regular lanes

	HOV DRIVER		SOV DRIVER		TOTAL	
	#	%	#	%	#	%
Strongly Agree	**89**	**54%**	**120**	**31%**	**209**	**38%**
Somewhat Agree	**52**	**32%**	**149**	**38%**	**201**	**36%**
Neutral	16	10%	88	23%	104	19%
Somewhat Disagree	6	4%	21	5%	27	5%
Strongly Disagree	2	1%	11	3%	13	2%
TOTAL	**165**	**100%**	**389**	**100%**	**554**	**100%**

3.4 The HOV lanes are convenient to use

	HOV DRIVER		SOV DRIVER		TOTAL	
	#	%	#	%	#	%
Strongly Agree	**100**	**60%**	**139**	**35%**	**239**	**43%**
Somewhat Agree	**43**	**26%**	**134**	**34%**	**177**	**32%**
Neutral	14	8%	58	15%	72	13%
Somewhat Disagree	4	2%	34	9%	38	7%
Strongly Disagree	6	4%	27	7%	33	6%
TOTAL	**167**	**100%**	**392**	**100%**	**559**	**100%**

3.5 The HOV lanes are safe

	HOV DRIVER		SOV DRIVER		TOTAL	
	#	%	#	%	#	%
Strongly Agree	**56**	**34%**	**87**	**22%**	**143**	**26%**
Somewhat Agree	**61**	**37%**	**126**	**32%**	**187**	**34%**
Neutral	29	17%	101	26%	130	23%
Somewhat Disagree	14	8%	53	14%	67	12%
Strongly Disagree	6	4%	24	6%	30	5%
TOTAL	**166**	**100%**	**391**	**100%**	**557**	**100%**

3.6 More HOV enforcement is needed

	HOV DRIVER		SOV DRIVER		TOTAL	
	#	%	#	%	#	%
Strongly Agree	**87**	**53%**	**155**	**40%**	**242**	**44%**
Somewhat Agree	**44**	**27%**	**64**	**16%**	**108**	**19%**
Neutral	25	15%	103	26%	128	23%
Somewhat Disagree	4	2%	34	9%	38	7%
Strongly Disagree	5	3%	35	9%	40	7%
TOTAL	**165**	**100%**	**391**	**100%**	**556**	**100%**

Exhibit 2.8.2C - Summary of Motorist Survey – Observation & Opinions 2

3.7 Roadside enforcement causes distraction, and results in vehicle slowdowns

	HOV DRIVER		SOV DRIVER		TOTAL	
	#	%	#	%	#	%
Strongly Agree	51	31%	168	43%	219	39%
Somewhat Agree	51	31%	109	28%	160	29%
Neutral	30	18%	54	14%	84	15%
Somewhat Disagree	16	10%	34	9%	50	9%
Strongly Disagree	17	10%	28	7%	45	8%
TOTAL	165	100%	393	100%	558	100%

3.8 There is too much unnecessary weaving in and out of the HOV lanes

	HOV DRIVER		SOV DRIVER		TOTAL	
	#	%	#	%	#	%
Strongly Agree	39	23%	87	22%	126	23%
Somewhat Agree	51	31%	109	28%	160	29%
Neutral	37	22%	109	28%	146	26%
Somewhat Disagree	27	16%	62	16%	89	16%
Strongly Disagree	13	8%	25	6%	38	7%
TOTAL	167	100%	392	100%	559	100%

3.9 Vehicles in the HOV lanes move

	HOV DRIVER		SOV DRIVER		TOTAL	
	#	%	#	%	#	%
Very slowly	1	1%	6	2%	7	1%
Belowspeed limit	24	14%	14	4%	38	7%
At speed limit	82	49%	187	49%	269	49%
Above speed limit	51	31%	146	38%	197	36%
Too Fast	8	5%	29	8%	37	7%
TOTAL	166	100%	382	100%	548	100%

3.10 The designated minimum number of persons per vehicle in theHighway 1 HOV lanes should be

	HOV DRIVER		SOV DRIVER		TOTAL	
	#	%	#	%	#	%
1 or more persons	11	7%	91	24%	102	19%
2 or more persons	148	89%	284	74%	432	78%
3 or more persons	8	5%	9	2%	17	3%
4 or more persons	0	0%	0	0%	0	0%
TOTAL	167	100%	384	100%	551	100%

3.11 I would be encouraged or motivated to become an HOV lane user if:

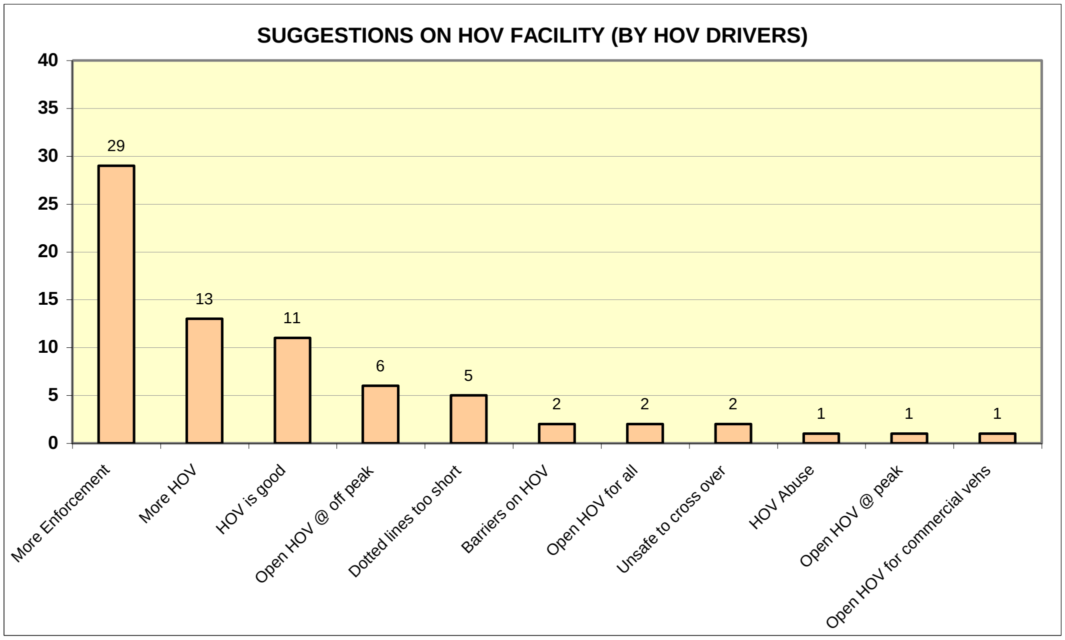
	HOV DRIVER		SOV DRIVER		TOTAL	
	#	%	#	%	#	%
If a good rideshare opportunity were available	43	19%	126	20%	169	20%
If there were a network of HOV priority lanes	63	27%	60	9%	123	14%
If more convenient Park/Ride lots were available	25	11%	47	7%	72	8%
If there were a free regional ridematch program	18	8%	47	7%	65	8%
If my employer subsidized a vanpool	19	8%	41	6%	60	7%
If there were free parking for HOV users at work	36	16%	51	8%	87	10%
My hours of work do not permit me to carpool	19	8%	188	30%	207	24%
Nothing would motivate me to carpool	8	3%	75	12%	83	10%
TOTAL	231	100%	635	100%	866	100%

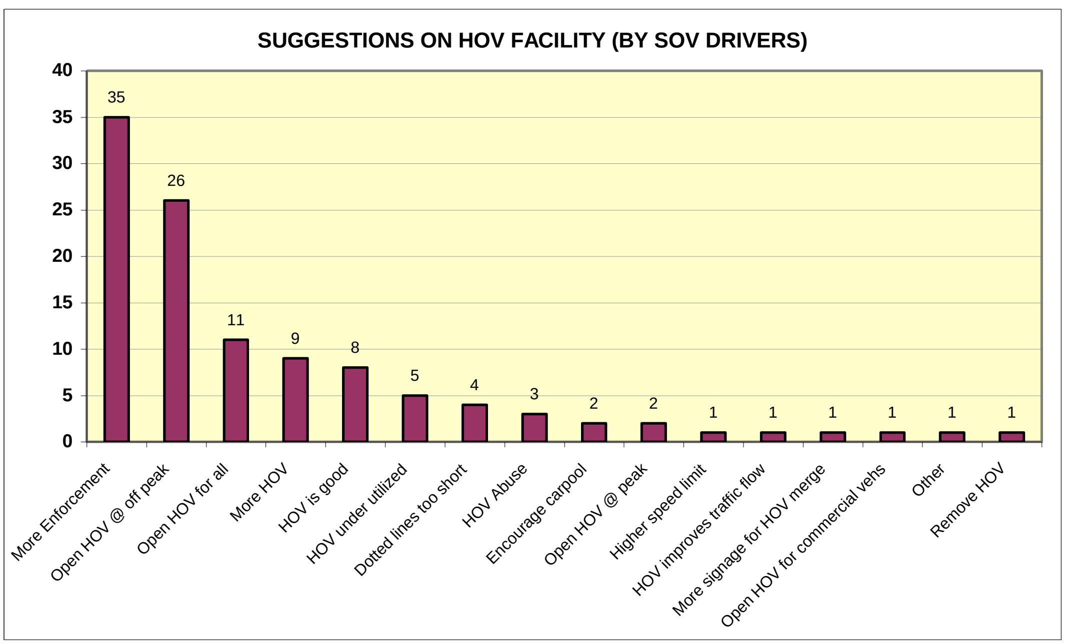
Exhibit 2.8.2D - Summary of Motorist Survey – Comments & Suggestions

HOV SUGGESTIONS ON		
HOV	**#**	**%**
Barriers on HOV	2	3%
Dotted lines too short	5	7%
HOV Abuse	1	1%
HOV is good	11	15%
More Enforcement	29	40%
More HOV	13	18%
Open HOV @ off peak	6	8%
Open HOV @ peak	1	1%
Open HOV for all	2	3%
Open HOV for trucks & commercial vehs	1	1%
Unsafe to cross over	2	3%
Total	**73**	**100%**
BRIDGE	**#**	**%**
Build more bridges	12	67%
Merge problems	4	22%
More Enforcement	1	6%
Put in lane separators	1	6%
Total	**18**	**100%**
GENERAL	**#**	**%**
Build more lanes	1	6%
Improve ramps	1	6%
Improvement noticed	2	13%
More Enforcement	4	25%
Other	8	50%
Total	**16**	**100%**

SOV SUGGESTIONS ON		
HOV	**#**	**%**
Dotted lines too short	4	4%
Encourage carpool	2	2%
Higher speed limit	1	1%
HOV Abuse	3	3%
HOV improves traffic flow	1	1%
HOV is good	8	7%
HOV under utilized	5	5%
More Enforcement	35	32%
More HOV	9	8%
More signage for HOV merge	1	1%
Open HOV @ off peak	26	23%
Open HOV @ peak	2	2%
Open HOV for all	11	10%
Open HOV for trucks & commercial vehs	1	1%
Other	1	1%
Remove HOV	1	1%
Total	**111**	**100%**
BRIDGE	**#**	**%**
Build more bridges	62	70%
Introduce toll bridge	6	7%
Merge problems	18	20%
Overflow lane on bridge	1	1%
Queues problems	1	1%
Total	**88**	**99%**
GENERAL	**#**	**%**
Build more freeway	4	11%
Build more lanes	5	13%
Improve ramps	3	8%
Improvement noticed	1	3%
More Enforcement	4	11%
Other	18	47%
Restriction for trucks & commerctal vehs	3	8%
Total	**38**	**92%**

Exhibit 2.8.2E - Summary of Motorist Survey – Comments & Suggestions (Suggestions on HOV Facility)

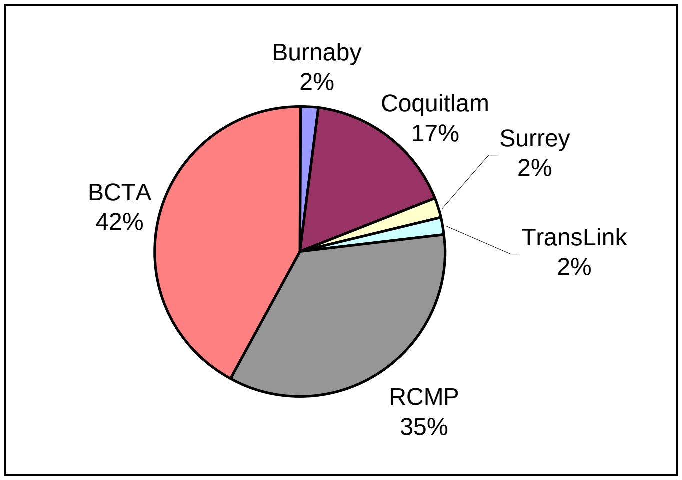




2.8.4.2 Stakeholder Survey

A similar survey (with additional questions on data sharing and FSP/local services interaction) was also distributed to project stakeholders, comprised primarily of the RCMP, BC Trucking Association members, municipalities along the Study Section, and TransLink. A total of 60 responses were received. The breakdown of the stakeholder responses is presented in Exhibit 2.8.3 below.

Exhibit 2.8.3 - Breakdown of Stakeholders Responses



Note: BCTA (BC Trucking Association is comprised of their sample of trucking companies.

The following is a brief summary of their responses relating to the HOV questions. Exhibit 2.8.4.

HOV Acceptance

- ✓ Approximately 92% of Stakeholders believe that the designated number of occupants for the HOV lanes should be 2 or more persons
- ✓ Approximately 54% of the Stakeholders believe that the HOV lanes are being adequately used
- ✓ Approximately 81% of the Stakeholders believe that the HOV lanes are convenient to use
- ✓ Approximately 60% of the Stakeholders believe that the HOV lanes are safe

HOV Satisfaction

- ✓ Approximately 90% of the Stakeholders believe that the HOV lanes are faster than the regular lanes
- ✓ Approximately 67% of the Stakeholders believe that the HOV have more predictable travel times
- ✓ Approximately 93% of the Stakeholders believe that traffic in the HOV lanes moves at or above the speed limit but not "too fast"

Exhibit 2.8.4 - Summary of Stakeholders Responses

	Question	Strongly Agree	Somewhat Agree	Neutral	Somewhat Disagree	Strongly Disagree	Total Number of Responses	TOTAL
1.1	The HOV lanes are being adequately used	10%	44%	8%	24%	14%	59	100%
1.2	The HOV lanes are faster than the regular lanes	47%	43%	5%	2%	3%	60	100%
1.3	The HOV lanes have more predictable travel times than the regular lanes	32%	35%	20%	8%	5%	60	100%
1.4	The HOV lanes are convenient to use	38%	43%	10%	8%	0%	60	100%
1.5	The HOV lanes are safe	23%	37%	28%	10%	2%	60	100%
1.6	More HOV enforcement is needed	54%	27%	8%	7%	3%	59	100%
1.7	Roadside enforcement causes distraction, and results in vehicle slowdowns	22%	36%	15%	22%	5%	59	100%
1.8	There is too much unnecessary weaving in and out of the HOV lanes	33%	32%	17%	13%	5%	60	100%
	Total Number of Responses	**155**	**177**	**67**	**56**	**22**	477	

	Question	Very slowly	Belowspeed limit	At speed limit	Above speed limit	Too Fast	Total Number of Responses	TOTAL
1.9	Vehicles in the HOV lanes move	0%	0%	49%	44%	7%	59	100%
	Total Number of Responses	**0**	**0**	**29**	**26**	**4**	59	

	Question	1 or more persons	2 or more persons	3 or more persons	4 or more persons	Total Number of Responses	TOTAL
1.10	The designated minimum number of persons per vehicle in the Highway 1 HOV lanes should be	8%	77%	13%	2%	60	100%
	Total Number of Responses	**5**	**46**	**8**	**1**	60	

3 TMP MONITORING & EVALUATION

In order to better manage traffic growth in the face of limited capital resources, the Province of British Columbia has been proactively implementing demand management and traffic management measures along the congested corridors of the Lower Mainland. MoTH has a Traffic Management Program (TMP) aimed at taking advantage of Intelligent Transportation System (ITS) technologies for improving the safety and efficiency of the highway network in the Lower Mainland.

The first (pilot) phase of the TMP is a $25 million initiative, over 4 years. This is the first phase of an evolving long-range plan aimed at managing traffic congestion, encouraging more efficient use of roadway infrastructure, improving travel safety, and improving air quality along a 34 km stretch of Highway 1. Subject to further review and clarification, this pilot program includes the section of Highway 1, between Lynn Valley Road in North Vancouver and 160 Street in Surrey, and will include the application of ITS technologies with interagency coordination. The TMP demonstration "pilot" project will deploy two key transportation user service applications on Highway 1, Incident Management and Traveler Information. The TMP pilot project will incorporate the deployment of various components of the two key user service applications. The scope (currently under review) involves the following components:

- Fibre optic communications backbone,
- Coordinated Roadside Assistance/Emergency Service Patrols,
- Digital cameras and automatic incident detection systems;
- Toll-free motorist cell-phone incident reporting system;
- Changeable message signs and other traffic information/control devices;
- Internet and Radio/TV traffic information programming;
- Supporting hardware and software systems, etc.

The TMP is intended to improve efficiency and increase the operational lifecycle of this critical urban section of the Highway 1 corridor by providing Incident Management and Traveler Information services, and thus improving vehicle throughput, reducing delays due to incidents, and reducing accidents, etc.

As an interim traffic management measure, and precursor to the TMP Coordinated Roadside Assistance/Emergency Service Patrols, the FSP were deployed shortly after the opening of the HOV lanes. The FSP project, an ICBC-funded ($1.6 million over 3 years) deployment of Freeway Service Patrols (FSP), started on January 4, 1999. This service is designed to assist motorists by detecting, responding to, and clearing, traffic incidents more quickly. The service includes a tow truck and a push truck with appropriate equipment, as well as a temporary Traffic Management Centre (trailer with radio and CCTV), to provide the following services:

- CCTV monitoring for quick detection and response;
- Tow or push disabled vehicles:
- Provide jump starts, gas, water, and minor repairs:
- Remove debris and clean up spills;

- Transport motorists and pedestrians from the Freeway;
- Provide temporary traffic control;
- Record or log all incidents.

Although the overall objectives of the HOV, TMP and FSP projects are intended to serve common transportation goals, the evaluation of these projects differ. Whereas the evaluation of an HOV facility is based on the introduction of HOV lanes alone, the "before" and "after" evaluation of TMP is based on a number of different – yet mutually supportive – service applications implemented and integrated over time.

The benefits of an integrated traffic management system, through a common centre such as the TMP-proposed Traffic Management Center (TMC), is expected to be far greater than the sum of the benefits of the individual components.

In order to evaluate the TMP pilot implementation, 5 objectives are defined along with their measures of effectiveness and data requirements. The objectives proposed for this evaluation are:

1. Reduce/Manage Recurrent congestion;
2. Reduce/Manage Non-Recurrent congestion;
3. Improve Safety;
4. Optimize Efficient Use of capacity;
5. Acquire Public Acceptance & Satisfaction.

These objectives were identified to allow the evaluation of TMP benefits as a coordinated and integrated system. Each of the objectives identified for evaluation is discussed in the following sub-sections:

- **Description of Objective;**
- **Measures of Effectiveness (MOEs);**
- **Data Requirements;**
- **Phase II Data;**
- **Recommendations For Future Phases.**

The analysis of the TMP objectives under Phase II is limited to the establishing of a second baseline representing post-HOV but pre-TMP conditions. Therefore "before" and "after" comparisons are only provided for discussion, and where applicable. For example, before and after comparisons are provided for the objective of reducing non-recurrent congestion, since the introduction of the FSP between Phases I and II has had a direct impact on this MOE (as well as safety), and associated benefits therefore need to be documented.

3.1 OBJECTIVE 1: REDUCE/MANAGE RECURRENT CONGESTION

3.1.1 Description of Objective

The focus of this objective is to better manage recurring congestion (congestion that typically occurs everyday due to high volume to capacity ratio), and thus to reduce associated delays, by using the capabilities of real-time traffic/road monitoring and various traveler information systems. Congestion occurs as traffic volumes approach capacity, during peak periods. By monitoring the status of traffic and road conditions on a real-time basis, various traveler information media can be used to inform motorists of prevailing conditions. Motorists can then make informed decisions to divert to alternate routes, or change their trip time and/or mode.

3.1.2 MOEs

Specific MOEs selected to evaluate the achievement of this objective are:

- increase in average speeds;
  In the Phase III before and after evaluation of the TMP pilot project, the "increase in average speeds" MOE can be used to estimate the extent to which achieving this objective (i.e. managing recurrent congestion) has helped to defer infrastructure expenditures. Such an estimate assumes a minimum peak direction operating speed threshold below which highway infrastructure expenditures are justified. Before and after comparisons of average peak direction speeds may then be compared against this threshold to determine the extent of deferred expenditures.

- reduction in total travel times;
- reduction in queues along the Study Section and its approaches.

3.1.3 Data Requirements

In order to measure the MOEs identified above, the "before" and "after" data collection included:

- vehicle average speeds, as obtained from travel time, speed and delay surveys;

- supplementary queue measurement data.
  Phase I vehicular queue lengths were observed at interchanges along the Highway 1 Study Section using aerial photographs and videos. This method was abandoned in Phase II since it was proven to be costly and the data were not very representative. Queue measurements in Phase II included actual user estimates obtained through a "motorist observations" survey. Prior to the introduction of the TMP user services, additional estimates of approach queues will need to be obtained to represent "before" conditions.

3.1.4 Phase II Data (Pre-TMP)

3.1.4.1 Average Speed and Travel Time

The primary measure for quantifying the benefits of congestion management have been identified as total travel times and average speeds, "before" and "after" the implementation of specific TMP user services.

The Phase II TMP baseline travel time data were obtained along the full length of the Study Section from 176 Street in Surrey to Lynn Valley Road in North Vancouver. Details of the data are presented in Appendix A-3.

Exhibit 3.1.1 provides a tabulated summary of the Phase II travel time data obtained for the Study Section, along with calculated average speeds, and the delay experienced when compared to free-flow conditions. The data is categorized by weekday and Sunday conditions, and time period.

Exhibit 3.1.1 - Highway 1 Travel Time, Speed, and Delay Summary(Phase II)

WEEKDAY EASTBOUND

Lane Type	Segment	Distance (km)	Average Travel Time (minutes)		Average Speed (km/hr)		Delay (minutes)	
			AM	PM	AM	PM	AM	PM
GP	Lynn Valley to 176 St.	33.73	26.7	35.7	78	59	4.3	13.2

WEEKDAY WESTBOUND

Lane Type	Segment	Distance (km)	Average Travel Time (minutes)		Average Speed (km/hr)		Delay (minutes)	
			AM	PM	AM	PM	AM	PM
GP	176 St. to Lynn Valley	33.74	39.4	33.3	52	65	16.9	10.9

SUNDAY EASTBOUND

Lane Type	Segment	Distance (km)	Average Travel Time (minutes)		Average Speed (km/hr)		Delay (minutes)	
			AM	PM	AM	PM	AM	PM
GP	Lynn Valley to 176 St.	33.73	10.3	9.5	92	91	0.0	0.0

SUNDAY WESTBOUND

Lane Type	Segment	Distance (km)	Average Travel Time (minutes)		Average Speed (km/hr)		Delay (minutes)	
			AM	PM	AM	PM	AM	PM
GP	176 St. to Lynn Valley	33.74	10.7	9.6	88	89	0.0	0.0

Note: Delay is estimated by subtracting the surveyed travel times from a free-flow travel time at 90 km/hr

The Phase II travel time data is consistent with the Phase I data, in that general purpose traffic experienced the highest delays in the peak directions – at approximately 16.9 minutes in the AM peak period westbound, and 13.2 minutes in the PM peak period eastbound. Comparatively, no delays were observed in any of the time period and direction combinations for the Sunday condition.

In general, it can be observed that for the full Study Section, the average delays are higher when compared against similar data for the HOV section (presented in section 2.2.4 of this report). This is the result of collecting data over a longer length of corridor and the fact that the peak direction and period are in opposing directions east and west of First Avenue (i.e. during the AM period, the peak direction is westbound from 176 Street to First Avenue and eastbound from Lynn Valley Road to First Avenue). Therefore, when comparing average speeds along the full Study Section for a given time period, peak and off-peak direction data are mixed.

The before and after comparison of average travel speeds along Highway 1 can be used to measure the achievement of this objective. Although the travel time, speed and delay data presented herein is to represent baseline conditions for the evaluation of TMP benefits relative to recurring congestion delays, a comparison of Phase I and II data is provided to reflect changes over the full Study Section of Highway 1, since Phase I.

Exhibit 3.1.2A provides a graphical summary of average traveling speeds along the Study Section for GP traffic before and after the construction of the HOV lanes. The comparisons indicate negligible differences in all time periods and directions, except for eastbound traffic in the PM peak period where travel time savings of approximately 13.8 minutes are observed when compared to travel times before the construction of the HOV lanes. The breakdown of these times, by the study subsections (North Vancouver, HOV/FSP, and Surrey) is provided in Exhibit 3.1.2B. This breakdown confirms that the 13.8 minute savings observed along the full Study Section is concentrated in the HOV/FSP section with negligible changes in travel time beyond.

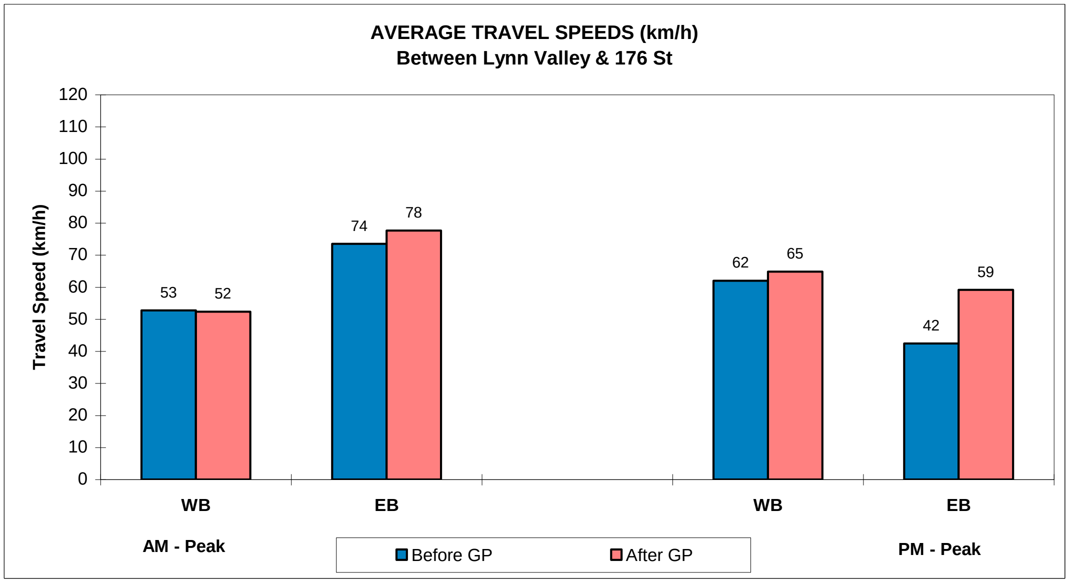
Exhibit 3.1.2B - Before and After Comparisons of Study Section travel Times

Travel Time Comparisons (Minutes)	AM Peak Direction (WB)			PM Peak Direction (EB)		
	Before	After	Savings	Before	After	Savings
North Vancouver & Vancouver Section: Lynn Valley to Grandview Highway	15.7	17.1	**-1.4**	8.7	8.2	**0.5**
Vancouver Coquitlam HOV & FSP Section	16.7	14.9	**1.8**	32	20.3	**11.7**
Coquitlam & Surrey Section: Cape Horn to 176 Street	8.2	7.4	**0.8**	8.8	7.2	**1.6**
Lynn Valley to 176 Street Total Study Section	**40.6**	**39.4**	**1.2**	**49.5**	**35.7**	**13.8**

** Note: Although not reflected in the Coquitlam/Surrey travel time measurements, westbound AM peak queue lengths along the approach to the Port Mann Bridge have been observed to extend "normally" to 176 St. since the opening of the HOV lanes.*

All data were analyzed to confirm that sample sizes are statistically reliable. As tabulated in Exhibit 3.1.3, the before and after comparisons were also analyzed to determine if differences and travel time savings are significant at a 95% confidence limit. While the size of the sample data were found to be statistically adequate, the before and after differences were not found to be significant, except for eastbound traffic during the PM peak period. This is an expected result since the TMP user service applications have yet to be implemented (except for the FSP/CCTV "precursor"), and HOV benefits do not extend to the boundaries of the Study Section.

Exhibit 3.1.2A - Weekday Peak Period – Average Speeds and Travel Time Savings (Before & After HOV)



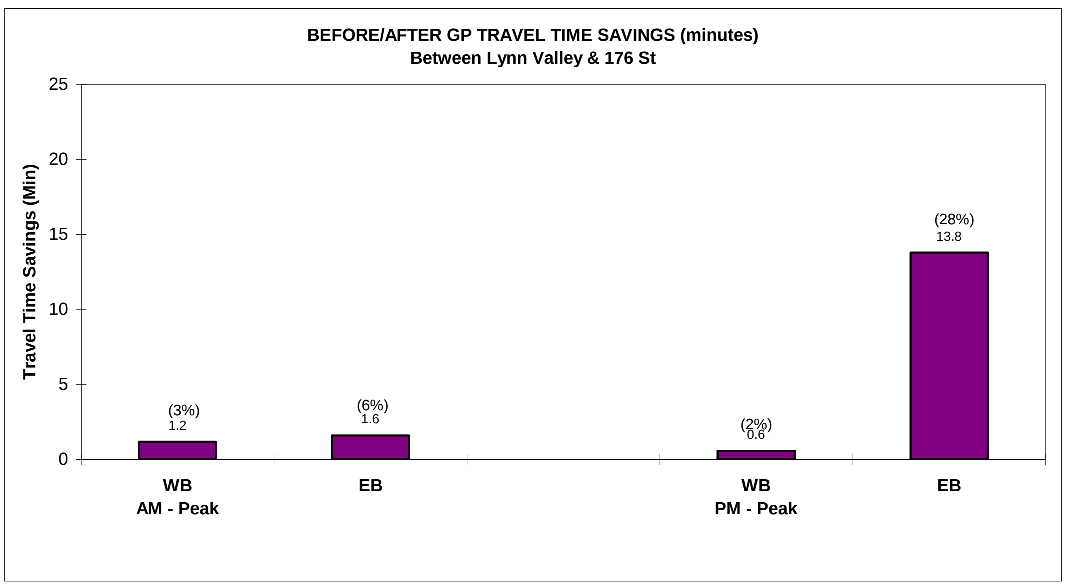


Exhibit 3.1.3 - Weekday Peak Period – Travel Time Statistical Analysis

		AM - Peak		PM - Peak	
		WB	EB	WB	EB
TRAVEL TIMES (minutes)	Before GP	40.6	28.4	33.9	49.5
	After GP	39.4	26.7	33.3	35.7
TRAVEL TIME SAVINGS (minutes)	Before GP to After GP	1.2	1.6	0.6	13.8
SIGNIFICANT TRAVEL TIME SAVINGS ?	Before GP to After GP	No	No	No	YES

NOTE: Shading indicates peak direction

Exhibits 3.1.4 and 3.1.5 provide an alternate representation of the Phase II average speed measurement data, using a thematic map to represent speeds in time and space.

3.1.4.2 Supplementary Queue Measurement Data

Queue measurements were limited to a survey of TCH commuter observations, using a set of questions for 25 on-ramp approaches to the TCH. Exhibit 3.1.6 is a graphical presentation of the results from a sample of 66 responses. Generally speaking, the approaching queues towards Highway 1 are found to be long especially during the AM period on Brunette Avenue. Long PM queues were reported at 104 Ave eastbound, 152 Street northbound, Lougheed (Coleman), Brunette Ave and Grandview Highway.

Peak queues on the Highway, as observed by Ministry staff and traffic reporters from one local radio station, in the Fall of 1999, were normally:

- Highway 1 Westbound from Port Mann Bridge back to 176 Street in the AM peak.
- Highway 1 Eastbound from Port Mann Bridge back to Gaglardi Way in the PM peak.
- Highway 1 Eastbound from 2nd Narrows Bridge back to midway up the "Cut" towards Lynn Valley Road in the AM peak.

This queue length survey method provides only a general idea of the current queuing conditions on Highway 1 within the study area due to the low sample size and the absence of more precise time and distance measuring systems. Further queue length study is therefore recommended through field observations (perhaps supported by micro-simulation techniques), especially for the assessment of various traffic management measures.

Exhibit 3.1.4 - Weekday Eastbound Average Speed Thematic Map

Exhibit 3.1.5 - Weekday Westbound Average Speed Thematic Map

Exhibit 3.1.6 – Approach Queue Length Survey Summary (Fall 1999)

	Approach Route		Queue To: 2	Queue To: 4	Queue To: 6	# of Responses
1	176 St. northbound	AM	97A Ave.	96 Ave.	92 Ave.	3
		PM				1
2	176 St. southbound	AM	Barnston Dr.	100Ave.	Abbey Dr.	1
		PM				1
3	160 St. northbound	AM	103 Ave.	101A Ave.	100 Ave.	2
		PM				1
4	160 St. southbound	AM	104 Ave.	106 Ave.	108 Ave.	1
		PM				1
5	104 Ave. eastbound	AM	158 St.	157 St.	156 St.	1
		PM				1
6	104 Ave. westbound	AM	Fraserglen	164 St.	Parkview	1
		PM				1
7	152 St. northbound	AM	Ferguson Diversion (108 Ave)	Lincoln St.	105 Ave.	1
		PM				1
8	Hwy.7 (Cape Horn)	AM	United Blvd.	Colony Farm Rd.	Pitt River Rd	1
		PM				1
9	Hwy. 7 (Coleman)	AM	Coleman Ave	Cape Horn	United Blvd.	2
		PM				1
10	Mary Hill Bypass	AM	Coquitlam River Br.	Shaughnessy St.	Pitt River Rd.	2
		PM				1
11	Brunette Ave. southbound	AM	Lougheed Hwy.	King Edward Ave.	Schoolhouse St.	1
		PM				2
12	Brunette Ave. northbound	AM	CPR Overpass	Braid St.	Sherbrooke St.	2
		PM				1
13	Gaglardi Way	AM	Cariboo Rd.	Brunette River O/P	Lougheed Hwy.	2
		PM				3
14	Kensington Ave. northbound	AM	Canada Way	Sperling Ave.	Rayside St.	1
		PM				5
15	Kensington Ave. southbound	AM	Thomas St.	Sprott St.	Laurel St.	2
		PM				1
16	Willingdon Ave. northbound	AM	Canada Way	Smith St.	Goard Way	1
		PM				1
17	Willingdon Ave. southbound	AM	Still Creek St.	CNR Overpass	Dawson St.	1
		PM				1
18	Grandview Hwy.	AM	Boundary Rd.	Skeena St.	Rupert St.	1
		PM				1
19	McGill/Wall St.	AM	Bridgeway	Renfrew St.	Slocan St.	1
		PM				1
20	Dollarton Hwy.	AM	Seymour River Br.	Amherst Ave.	Riverside Dr.	1
		PM				1
21	Main St.	AM	Mountain Hwy.	Harbour Ave.	Lynn Creek Br.	1
		PM				1
22	Mountain Hwy.	AM	Bond St.	Crown St.	Fern St.	1
		PM				1
23	Fern St./Keith Rd.	AM	Mountain Hwy (1)	Keith Rd.	Mountain Hwy (2)	1
		PM				1
24	Fern St./ Mt. Seymour Parkway	AM	Lillooet Dr.	Seymour Blvd.	Riverside Dr.	2
		PM				1
25	Lynn Valley Rd.	AM	Morgan St.	William Ave.	Kirkstone Rd.	1
		PM				1
					Total	66

AM Normal Peak Queue Length
PM Normal Peak Queue Length

Note: Graphicial Presentation of Queue Length Not to Scale

3.1.5 Phase III (Post-TMP) "After" Evaluation

In Phase III of this evaluation program, if a Traffic Management Centre (TMC) is in place, it would integrate the traffic monitoring and traveler information functions of the TMP within the pilot corridor. At that time, post-TMP "after" travel time data could be obtained for comparative evaluation against the "before" TMP travel time data obtained after opening of the HOV lanes, and documented in this report.

The collection of post-TMP travel time data will benefit from the availability of a continuous pool of real time data. Specifically, speed data may be available from an Automatic Incident Detection (AID) system, at increments equal to the spacing of the vehicle detection stations and can be aggregated into overall travel time and speed representations.

3.2 OBJECTIVE 2: REDUCE/MANAGE NON-RECURRENT CONGESTION

3.2.1 Description of Objective

The focus of this objective is to reduce the impacts associated with non-recurrent congestion (i.e. congestion resulting from incidents). Major impacts of non-recurrent congestion include vehicular delay and accident risk resulting from lane blockage or other traffic impedance. The FSP and temporary CCTV precursors to the TMP are expected to accomplish this objective to some degree. The future provision of better incident detection, improved incident response and clearance times, advanced incident management, and interagency coordination, as well as up-to-date traveler information, will further reduce these impacts.

3.2.2 MOEs

The specific MOEs selected to evaluate the achievement of this objective are:

- **reduction in incident duration**
  Incident duration is the time between the occurrence of an incident and the clearance of the incident to remove a lane blockage or other impedance. This time period is comprised of three intervals: occurrence to detection, detection to response, and response to clearance of the incident.

- **reduction in vehicular delay due to incidents**
  Vehicular delay due to non-recurrent congestion is calculated as a function of incident duration and the number of lanes blocked. Here, the duration over which one or more lanes and/or a shoulder is blocked, is used to estimate the reduction in available capacity, and the resulting vehicular and person delays.

For illustrative purposes, the magnitude of impacts resulting from incidents is presented in Exhibits 3.2.1 and 3.2.2 which provide eastbound and westbound thematic maps of average speeds as observed during incident conditions. Comparing these exhibits with the non-incident thematic maps presented in Exhibits 3.1.4 and 3.1.5 (section 3.1 Reduce/Manage Recurrent Congestion) illustrates the impacts of an incident, in time and space, in terms of average operating speeds.

Exhibit 3.2.1 - Weekday Eastbound Travel Speeds During Incident Conditions

Exhibit 3.2.2 - Weekday Westbound Travel Speeds During Incident Conditions

3.2.3 Data Requirements

As input to the above MOEs, the "before" and "after" data collection must include incident observation and logging to record separately the occurrence/detection time, response time and clearance times. Exhibit 3.2.3 provides a graphical summary of the incident observation methodology and coverage along Highway 1 for both the Phase I and II efforts. The methodology of the incident observation and logging effort can be summarized as follows:

- **Phase I**
  - Visual observations at high elevations using binoculars (approximate 60% coverage of the corridor between Port Mann Bridge and First Avenue
- **Phase II**
  - Temporary CCTV and video-taping (along North Vancouver & Surrey Sections)
  - Custom Incident Logging Sheets (filled out at the FSP control centre)
  - North Shore maintenance contractor incident logs (Second Narrows Bridge to First Avenue)

Exhibit 3.2.4 provides a summary of the various data collection programs and coverage in terms of the data elements that were captured, and the ratio of the total incidents logged per hour per kilometre per lane. The ratios illustrate the sensitivities associated with the collection of incident data, but confirm consistency in "a logging incident rate" between all of the incident data logging techniques.

As illustrated in Exhibit 3.2.4, the data collected by the FSP is broken down into two categories. The first category is for all the incidents detected by the FSP patrol vehicles, while the second category is for all the incidents detected at the FSP control centre using the temporary CCTV cameras. The point of distinction is that the time of incident occurrence is not known for the first category - since those incidents were already in progress when detected by the FSP vehicle. Therefore, the sample of incident data collected at the FSP control centre is more complete since the detection and occurrence times are the same.

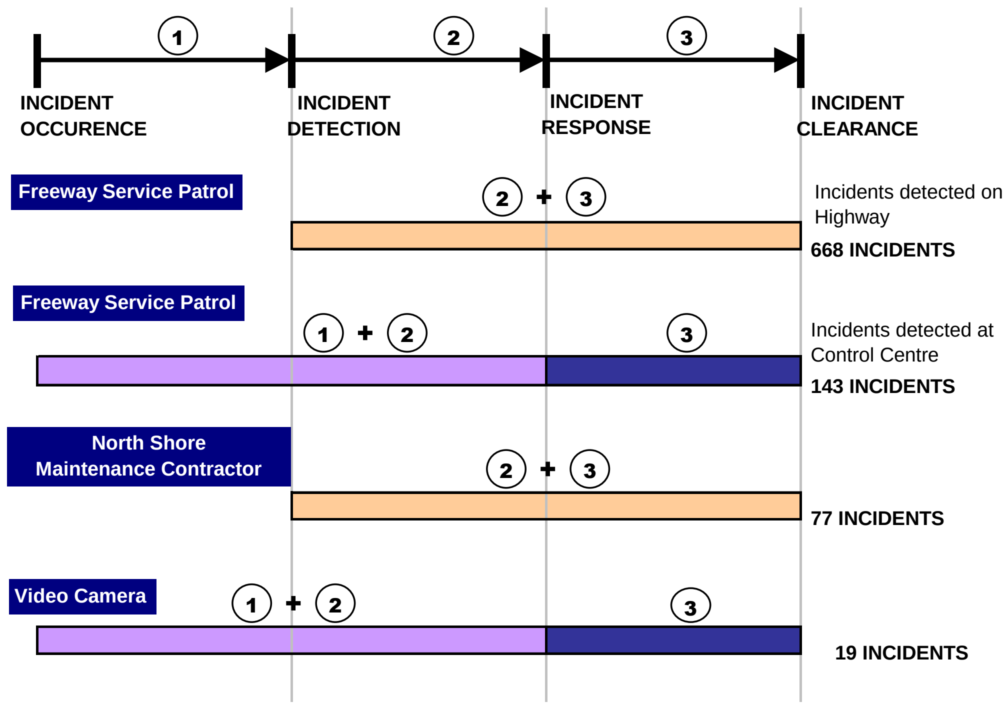
The manual/binocular technique used in Phase I, and the CCTV and video-taping technique used in Phase II, both provide the true incident occurrence time as well. However, the format of the data received from the North Shore maintenance contractor does not reflect whether the incidents were detected by their control centre, or their maintenance duty vehicles.

3.2.4 Phase II Data

The incidents data collected in Phase II can be used to support both of the MOEs identified for this objective, and are presented in the following subsections. Furthermore, comparison of the Phase I and Phase II data can be used to evaluate the interim benefits of the FSP, prior to the implementation of the TMP pilot project service applications.

Exhibit 3.2.3 - Incident Observation Coverage & Methods

Exhibit 3.2.4 - Incident Data Logging



Incident Logging	PHASE I	PHASE II		
	Visual (with binoculars)	Freeway Service Patrol	North Shore Maintenance Contractor	Video Camera
Days of Coverage	15	76	30	20
Hours of Coverage per Day	(varied)	24	24	12
Hours of Coverage	98	1824	720	240
Length of Coverage (km)	12.0	20.4	6.4	4.0
Number of Lanes	4	6	5.5	4
Number of Incidents Recorded	**24**	**811**	**77**	**19**
RATIO	**0.00510**	**0.00364**	**0.00304**	**0.00495**

NOTE : RATIO = No. of Incidents per hour per km per lane
There were total 877 FSP Incidents recorded while only 811 records contained sufficient data for the analysis

3.2.4.1 Reduction of Incident Duration

The duration of an incident is defined as the length of time between the occurrence of an incident to its removal. This duration is comprised of two key elements, the time between occurrence and response (response time), and the time between response and clearance (clearance time), The following is a detailed summary of these time elements, as captured by the three incident data sources used in Phase II.

- **FSP - Incident Data**

  As indicated earlier, the FSP used custom incident logging sheets developed for this project and fully logged approximately 800 incidents over a two and a half month period – which translates to an incident logging rate of approximately 0.004 incidents per hour per kilometre per lane, or about 10 logged incidents per day in the HOV-FSP Section. These incidents were logged between the west terminus of the HOV lanes at Grandview Highway and the west side of the Port Mann Bridge.

  Exhibit 3.2.5 provides a tabulation of the incident response and clearance times logged by the FSP, using the sample of incidents detected at the FSP centre. Average of response time, clearance time, and incident duration are provided by incident type (weighed by the frequency of each incident type), time period, direction, and approximate location (limited to interchange boundaries). The results indicate that within the FSP coverage area:

  - ✓ **Response times** average 7.1 minutes
  - ✓ **Clearance times** average 13.8 minutes
  - ✓ Total **incident duration** average **21.0 minutes**.

  Note: Benefits associated with the FSP are discussed separately in Section 3.2.5, so that comparisons can be made with all of the incident data and MOEs.

  Exhibit 3.2.6 tabulates a further breakdown of the FSP incident data in terms of the order of response between FSP, RCMP, emergency services, and other tow services, along with the order of their arrival. Here, the first four tables provide an average response time, by these other agencies, in order of arrival from 1st response to the 4th response (to the same incident) respectively. The bottom table provides an average response time for each agency (irrespective of the order of arrival):

  - ✓ FSP 7.9 minutes (this average includes times when FSP was not first response)
  - ✓ RCMP 8.6 minutes
  - ✓ Ambulance 8 minutes
  - ✓ Fire 7.7 minutes
  - ✓ Other tow services 58 minutes
  - ✓ Other responses 22.2 minutes

Exhibit 3.2.5 - FSP Incident Data Summary

A	INCIDENTS		AVERAGE INCIDENT DURATION					
			RESPONSE TIME		CLEARANCE TIME		INCIDENT DURATION	
TYPE	**No.**	**%**	**Duration (min)**	**Standard Deviation**	**Duration (min)**	**Standard Deviation**	**Duration (min)**	**Standard Deviation**
Material Spill	3	2%	4.7	1.2	3.0	5.2	7.7	4.7
Motor Vehicle Accident	20	14%	6.2	5.6	22.5	18.5	28.7	19.5
Other	15	11%	5.4	3.3	4.0	9.3	9.4	10.0
Vehicle Breakdown	101	72%	7.7	8.9	13.0	30.5	20.7	30.9
Vehicle Fire	2	1%	2.5	2.1	60.5	64.3	63.0	66.5
TOTAL	**141**	**100%**	**7.1**	**8.0**	**13.8**	**28.4**	**21.0**	**28.8**

B	INCIDENTS		AVERAGE INCIDENT DURATION					
			RESPONSE TIME		CLEARANCE TIME		INCIDENT DURATION	
DIRECTION	**No.**	**%**	**Duration (min)**	**Standard Deviation**	**Duration (min)**	**Standard Deviation**	**Duration (min)**	**Standard Deviation**
EB	75	52%	8.0	10.1	16.4	35.0	24.4	35.1
WB	68	48%	6.1	4.4	10.6	17.7	16.6	18.7
TOTAL	**143**	**100%**	**7.1**	**7.9**	**13.6**	**28.2**	**20.7**	**28.7**

C	INCIDENTS		AVERAGE INCIDENT DURATION					
			RESPONSE TIME		CLEARANCE TIME		INCIDENT DURATION	
PERIOD	**No.**	**%**	**Duration (min)**	**Standard Deviation**	**Duration (min)**	**Standard Deviation**	**Duration (min)**	**Standard Deviation**
AM	50	35%	5.4	3.1	14.2	19.5	19.5	19.8
PM	93	65%	8.0	9.5	13.4	32.0	21.4	32.5
TOTAL	**143**	**100%**	**7.1**	**7.9**	**13.6**	**28.2**	**20.7**	**28.7**

D	INCIDENTS		AVERAGE INCIDENT DURATION					
			RESPONSE TIME		CLEARANCE TIME		INCIDENT DURATION	
LOCATION	**No.**	**%**	**Duration (min)**	**Standard Deviation**	**Duration (min)**	**Standard Deviation**	**Duration (min)**	**Standard Deviation**
Boundary Rd	1	0.7%	5.0		20.0		25.0	
Brunette Ave	23	16.9%	5.9	2.7	13.3	17.6	19.2	17.5
Cape Horn	11	8.1%	5.5	2.1	14.2	15.0	19.6	14.7
Cariboo Rd	14	10.3%	10.2	16.1	12.6	20.4	22.9	23.7
Deer Lake Ave (Kensington)	11	8.1%	14.5	16.6	10.1	10.7	24.6	16.5
Douglas Rd	7	5.1%	6.0	4.0	6.9	10.2	12.9	12.9
Gaglardi Rd	27	19.9%	4.5	2.3	12.7	19.4	17.2	19.9
Gilmore Ave	3	2.2%	7.3	4.6	0.7	1.2	8.0	5.3
Grandview Hwy	2	1.5%	16.0	17.0	15.5	21.9	31.5	38.9
King Edward	8	5.9%	7.5	4.3	4.0	6.9	11.5	8.1
Lougheed Highway	1	0.7%	15.0		0.0		15.0	
North Rd	15	11.0%	5.0	2.6	36.5	72.5	41.5	71.8
Port Mann Bridge - East End	2	1.5%	11.0	8.5	1.5	2.1	12.5	10.6
Port Mann Bridge - West End	1	0.7%	5.0		9.0		14.0	
Sprott Street	3	2.2%	7.3	5.8	9.3	16.2	16.7	14.2
Willingdon Ave	7	5.1%	6.9	4.7	8.0	11.4	14.9	15.0
TOTAL	**136**	**100%**	**7.1**	**8.1**	**13.7**	**28.8**	**20.9**	**29.3**

NOTE:

1. RESPONSE TIME = Time between Incident Occurrence/Detection & 1st Response to Incident
2. CLEARANCE TIME = Time between Incident 1st Response to Incident & Incident Clearance
3. INCIDENT DURATION = Time between Incident Occurrence/Detection & Incident Clearance
4. The variation between the total number of incidents results from incomplete records being excluded from a category. For example, if a record did not have the "direction" of travel recorded, it would still be included in all other summaries except for the one by direction.

Exhibit 3.2.6 – FSP & Other Agency Response Time Averages

- **CCTV & Video Taped- Incident Data**
  Temporary CCTV and video taping stations were installed at the following locations to supplement the collection of incident data in the Study Section:

  - 160 Street - WB Off-ramp: 1 Camera westbound
  - 152 Street Overpass: 2 Cameras east and westbound
  - South of Port Mann Bridge: 2 Cameras east and westbound
  - Fern Street Overpass: 2 Cameras east and westbound
  - Mountain Highway Overpass: 2 Cameras east and westbound

  The CCTV and video taping technique was proposed to cover these areas, since other techniques such as manual observations could not be made due to the lack of high elevation observation points.

  Incident data logged using the above CCTV and video taping stations were not only important in supplementing the sample data, but also to provide a reference group of data representative of the sections of the corridor that are not served by the FSP. Specifically, the North Vancouver sections are served by the North Shore maintenance contractor (tow truck stationed at the Second Narrows Bridge). However, the north shore service does not include CCTV camera monitoring except at the Second Narrows Bridge and Cassiar Tunnel. In the Surrey section there is a maintenance contractor tow truck stationed at the Port Mann Bridge, but there is no permanent CCTV incident monitoring service.

  As summarized earlier, this source of incident data collection led to the logging of 19 incidents over a 20 day period – which translates to an incident logging rate of approximately 0.005 incidents per hour per kilometre per lane.

  Exhibit 3.2.7 provides a tabulation of the incident response and clearance times as logged by the method. Weighted averages of response time, clearance time, and incident duration are provided by incident type, time period, direction, and approximate location (limited to interchange boundaries).

  The summary of incident data by location indicates that approximately half of the incidents occurred just east of the Port Mann Bridge; these incidents are observed to have a very short response time of approximately 3.4 minutes due to the proximity of towing services stationed near the Port Mann Bridge. The response times in the North Vancouver sections are higher, ranging between 7 and 12 minutes.

  On average, for the sections of Highway 1 not served by the FSP, the results indicate the following:

  - ✓ **Response times** average 10.3 minutes
  - ✓ **Clearance times** average 22.0 minutes
  - ✓ Total **incident duration** average **29.3 minutes**.

  Average incident duration times are much higher in this section due to the lack of monitoring, and the associated longer response times to managing and clearing the incident.

Exhibit 3.2.7 – CCTV / Video Taped Incident Data Summary (North Vancouver & Surrey)

A	INCIDENTS		AVERAGE INCIDENT DURATION					
			RESPONSE TIME		CLEARANCE TIME		INCIDENT DURATION	
TYPE	No.	%	Duration (min)	Standard Deviation	Duration (min)	Standard Deviation	Duration (min)	Standard Deviation
Motor Vehicle Accident	5	26%	5.8	6.1	40.0	26.5	36.8	32.1
Other	3	16%	15.5	17.7	13.0	17.0	38.0	16.5
Vehicle Breakdown	11	58%	11.2	20.1	16.0	22.3	23.5	38.2
TOTAL	**19**	**100%**	**10.3**	**16.5**	**22.0**	**24.2**	**29.3**	**33.4**

B	INCIDENTS		AVERAGE INCIDENT DURATION					
			RESPONSE TIME		CLEARANCE TIME		INCIDENT DURATION	
DIRECTION	No.	%	Duration (min)	Standard Deviation	Duration (min)	Standard Deviation	Duration (min)	Standard Deviation
EB	7	37%	3.6	4.2	23.8	30.7	21.6	28.3
WB	12	63%	13.7	19.4	21.1	22.1	33.8	36.5
TOTAL	**19**	**100%**	**10.3**	**16.5**	**22.0**	**24.2**	**29.3**	**33.4**

C	INCIDENTS		AVERAGE INCIDENT DURATION					
			RESPONSE TIME		CLEARANCE TIME		INCIDENT DURATION	
DIRECTION	No.	%	Duration (min)	Standard Deviation	Duration (min)	Standard Deviation	Duration (min)	Standard Deviation
AM	7	37%	18.8	25.4	22.4	27.5	37.9	46.4
PM	12	63%	6.1	8.7	21.8	23.9	24.3	24.1
TOTAL	**19**	**100%**	**10.3**	**16.5**	**22.0**	**24.2**	**29.3**	**33.4**

D	INCIDENTS		AVERAGE INCIDENT DURATION					
			RESPONSE TIME		CLEARANCE TIME		INCIDENT DURATION	
LOCATION	No.	%	Duration (min)	Standard Deviation	Duration (min)	Standard Deviation	Duration (min)	Standard Deviation
152 Street Underpass	2	11%	15.5	17.7	13.0	17.0	28.5	0.7
Fern Street Underpass	1	5%					11.0	
Lynn Creek Bridge	1	5%	11.0		47.0		58.0	
Mountain Highway Underpass	5	26%	26.3	23.9	37.3	25.2	62.2	40.6
Port Mann Bridge - East End	10	53%	1.0	1.1	13.5	22.9	12.0	21.0
TOTAL	**19**	**100%**	**10.3**	**16.5**	**22.0**	**24.2**	**29.3**	**33.4**

- **North Shore maintenance contractor – Incident Data**
  Incident data collected by the North Shore maintenance contractor was obtained to supplement the sample of data. The existing logs maintained by the North Shore maintenance contractor were used for this effort; although the incident response time is not recorded on their incident log sheets, the incident detection and clearance times are – thus permitting the computation of incident duration to support this MOE.

  As summarized earlier, the North Shore maintenance contractor logged 77 incidents over a one month period – which translates to an incident logging rate of approximately 0.003 incidents per hour per kilometre per lane. These incidents were logged between the Cassiar Tunnel and Lynn Valley Road in North Vancouver.

  Exhibit 3.2.8 provides a tabulation of the incident duration averages as logged by the North Shore maintenance contractor. Weighted averages of the incident duration are provided by incident type, time period, direction, and approximate location (limited to interchange boundaries). The results indicate that within this coverage area, the total **incident duration** average is approximately **20 minutes**.

Exhibit 3.2.8 - North Shore maintenance contractor Incident Data Summary

A	INCIDENTS		INCIDENT DURATION	
TYPE	No.	%	Duration (min)	Standard Deviation
Abondoned Vehicle	1	1%	50.0	
Dead Animal	3	4%	0.0	0.0
Debris	12	16%	4.4	4.3
Motor Vehicle Accident	12	16%	52.8	81.7
Other	1	1%	14.0	
Stall	45	58%	14.2	16.9
Suicide	3	4%	43.3	29.2
TOTAL	**77**	**100%**	**19.7**	**37.9**

B	INCIDENTS		INCIDENT DURATION	
DIRECTION	No.	%	Duration (min)	Standard Deviation
EB	46	63%	12.7	14.4
WB	27	37%	18.5	23.5
TOTAL	**73**	**100%**	**14.9**	**18.3**

C	INCIDENTS		INCIDENT DURATION	
PERIOD	No.	%	Duration (min)	Standard Deviation
AM	29	38%	26.2	56.1
PM	48	62%	15.8	20.0
TOTAL	**77**	**100%**	**19.7**	**37.9**

D	INCIDENTS		INCIDENT DURATION	
PERIOD	No.	%	Duration (min)	Standard Deviation
1st Ave	4	5%	12.3	4.1
2nd Narrows Bridge	45	58%	15.3	20.5
Cassiar Tunnel	7	9%	6.6	6.6
Fern	5	6%	15.4	27.5
Hastings / Cassiar Int	6	8%	66.0	115.9
Lynn Creek Bridge	1	1%	66.0	
Lynn Valley	5	6%	14.8	15.6
Main	1	1%	4.0	
McGill I/C	1	1%	39.0	
Mountain Hwy	2	3%	39.0	15.6
Grand Total	**77**	**100%**	**19.7**	**37.9**

The following table provides a summary of the incident duration data presented above, as observed using the 3 methods used in Phase II and relative to the Phase I method.

Exhibit 3.2.9 - Summary of Incident Duration Data for all Methods

Incident Data Source	Coverage Area	Average Response Time (min)	Average Clearance Time (min)	Average Incident Duration (min)
Phase I (Visual Observations)	HOV/FSP Section	23.0	19.0	41.0
Phase II FSP Data Logs	HOV/FSP Section	7.1	13.8	21.0
Phase II CCTV & Video-taping	North Vancouver Section Surrey Section	23.7 3.4 *	38.9 13.4	61.5 14.8
	Average of Both Sections	10.3	22.0	29.3
Phase II North Shore Contractor	First Avenue to 2nd Narrows	19.7 *		19.7

* Low due to the proximity of tow trucks stationed at the Port Mann and Second Narrow Bridges.

The following key observations can be made:

- For the HOV-FSP Section of Highway 1, the reduction between the observed incident duration before and after the introduction of the FSP is approximately 20 minutes, and reflects the benefits of the FSP responding to incidents more quickly. (These and other FSP benefits are discussed further in section 3.2.5).

- For the non-HOV-FSP sections of the corridor, the response times are much higher (10.3 minutes) with the average incident duration ranging between 20 and 30 minutes (up to 43%) higher than the HOV/FSP section.

- Phase 1 data, combined with Phase II data within the non-HOV/FSP sections of the Study Section, can be used as a baseline to evaluate coordinated TMP Roadside Assistance and Emergency Service Patrols relative to conditions when TMP was initially planned, i.e. pre-HOV and FSP.

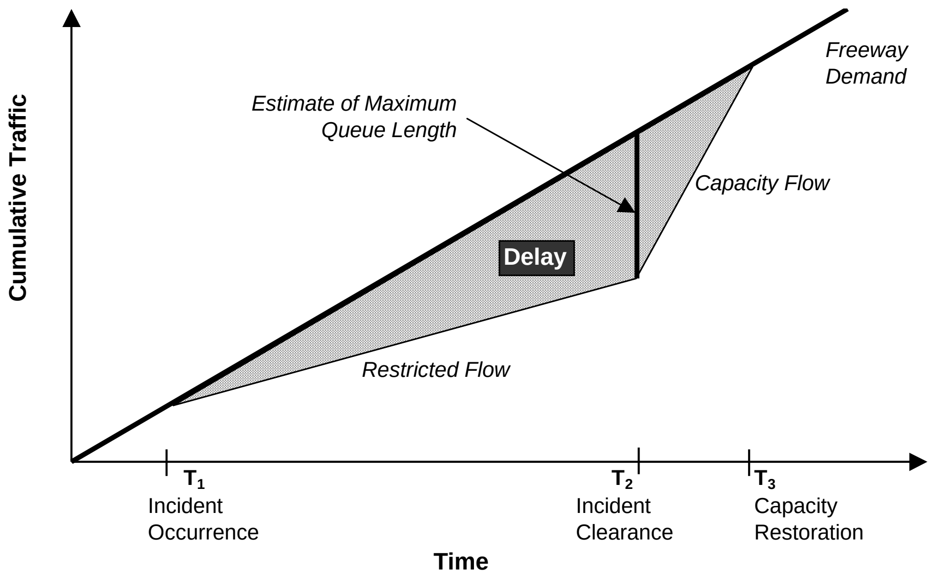
3.2.4.2 Reduction of Delays Due to Incidents

The delay that is caused by an incident is a function of three key factors, the duration of time over which one or more lanes of travel is blocked, the duration of time over which queues dissipate and capacity is restored, and the delays associated with distractions and "rubber-necking" of vehicles slowing down due to an incident on the shoulder.

These data (i.e. duration and number of lanes blocked) were logged by the FSP using the custom incident logging forms prepared for this project. The same information was also logged using the video taped incident data. Of the approximately 800 incidents that were logged, 130 involved some form of lane blockage – of which 39 were Motor Vehicle Accidents (MVAs), 81 were vehicle breakdowns, and 10 due to other incidents such as vehicle fires etc.

Exhibit 3.2.10 below, provides a graphical illustration of the parameters involved in estimating vehicular delay caused by an incident.

Exhibit 3.2.10 - Derivation of Delay Due to Incidents



Using the above approach and parameters, the vehicle hours of delay resulting from each incident was calculated as the area of the triangle formed by hourly demand, restricted flow rate, and service flow rate (close to capacity flow). For each incident, freeway demand was estimated from the 24-hour traffic count data and time of incident, the restricted flow rate was calculated as a function of the number and type of lanes blocked, and the service flow rate was assumed at 1900 vehicles per hour, per lane.

Estimating the restricted flow rate as a function of the lanes blocked incorporated the following reduction factors:

- Shoulder only blocked - 26% capacity reduction
- One of two lanes blocked - 68% capacity reduction
- Two of two lanes blocked - 100% capacity reduction

Since 99% of the incidents occurred in the GP lanes, the analysis was based on a two-lane facility - with the assumption that GP traffic did not have access to available capacity in the HOV lanes.

The analysis was split between the 130 incidents which involved the blockage of one or both of the through GP lanes, and the 603 incidents which involved the blockage of the shoulder. For each scenario, the total vehicular delay resulting from all incidents was calculated by "summing up" all of the "delay triangles" described above. Furthermore, total person-delays were also calculated by multiplying the vehicular delays with the AVOs calculated for the incident's time period and approximate location.

Finally, the total user cost was calculated by multiplying the person-delays with the following factors (taken from the TMP Business Plan):

- $ 10.00 per hour for vehicle drivers
- $ 8.00 per hour for vehicle passengers
- $ 75.00 per hour for trucks

Exhibit 3.2.11A provides a tabulated summary of the average delays and queues caused by the 130 incidents which involved one or more blocked lanes. The last two columns summarize the total delay and total user cost due to the incidents over the observation period between September 1st 1999 and November 15th 1999. Exhibit 3.2.11B provides the same information for the remaining 603 incidents which involved the blockage of the shoulder lane.

Exhibit 3.2.11A - Average and Total Delays & Costs due to Incidents with Lane Blockages

Lane Block	INCIDENTS		AVERAGE DELAY		AVERAGE QUEUE LENGTH		TOTAL DELAY (veh hrs)	TOTAL INCIDENT COST
Type	No.	%	Delay (veh hrs)	Standard Deviation	Length (km)	Standard Deviation		
Motor Vehicle Accident	39	30%	1334	1991	2.6	2.8	52044	$770,521
Other	8	6%	371	446	1.5	1.2	2964	$51,321
Vehicle Breakdown	81	62%	482	827	1.2	1.4	39065	$623,376
Vehicle Fire	2	2%	5999	7984	8.9	10.1	11999	$173,930
TOTAL	**130**	**100%**	**816**	**1636**	**1.8**	**2.4**	**106071**	**$1,619,147**

Exhibit 3.2.11B - Average and Total Delays & Costs due to Incidents with Shoulder Blockages

Shoulder Block	INCIDENTS		AVERAGE DELAY		AVERAGE QUEUE LENGTH		TOTAL DELAY (veh hrs)	TOTAL INCIDENT COST
Type	No.	%	Delay (veh hrs)	Standard Deviation	Length (km)	Standard Deviation		
Material Spill	4	1%	61	42	0.2	0.1	245	$5,068
Motor Vehicle Accident	37	6%	239	439	0.3	0.6	8860	$181,156
Other	100	17%	229	1261	0.1	0.5	22904	$322,378
Vehicle Breakdown	462	77%	167	526	0.2	0.7	77087	$1,628,865
TOTAL	**603**	**100%**	**181**	**697**	**0.2**	**0.7**	**109097**	**$2,137,468**

Based on the above, the estimated cost to the users, over the two and a half month observation period was approximately $1.62 million due to lane blockages and an astounding $2.14 million due to the remaining incidents, totaling to $3.76 million of user costs resulting from incidents.

When extrapolated (divided by 53 days of observation and multiplied by 365 days per year) to an annual value, the costs amount to $ 13.51 million due to lane blockages and $14.72 million due to the remaining incidents involving a shoulder blockage, totaling to

$28.23 million in annual user costs resulting from incidents. The annual cost breakdown by incident type is presented in Exhibit 3.2.12 below.

Exhibit 3.2.12 – Annual Cost of Delay due to Incidents with Lane & Shoulder Blockages

Lane Block Type	ANNUAL COST
Motor Vehicle Accident	$7,459,374
Other	$543,775
Vehicle Breakdown	$4,309,721
Vehicle Fire	$1,197,817
TOTAL	**$13,510,687**

Shoulder Block Type	ANNUAL COST
Material Spill	$34,905
Motor Vehicle Accident	$1,247,586
Other	$2,220,150
Vehicle Breakdown	$11,217,657
TOTAL	**$14,720,299**

The user costs described above are not the only costs that result from traffic incidents. To the commuter, as well as the operating agency, the proportion of time that lanes are blocked means that a portion of available capacity is lost. Therefore, depending on the "demand to capacity" threshold used by an agency to trigger investment in additional infrastructure, regaining capacity through improved incident detection, management, and response will help in deferring such expenditures.

To illustrate this benefit, the incident data collected and analyzed herein has been used to determine the average available capacity of the Highway 1 study segment, by direction and time period. This estimate is summarized in Exhibit 3.2.13 below:

Exhibit 3.2.13 – Average Available Capacity of Highway 1 Study Segment

Average Service Flow Rate	AM	PM
Eastbound	90 %	**88 %**
Westbound	**86 %**	94 %

On this basis for example, recovering the existing 14% potential of the PM peak direction service flow rate would help defer the trigger for infrastructure investment. Using the 1.4% growth in AADT (average between 1995 and 1997) at Port Mann Bridge as an example, a 14% addition to capacity could accommodate traffic for an additional 10 years.

3.2.5 Before & After Evaluation of the FSP

Although the FSP initiative is not an official component of the TMP pilot project, it can be treated as a "precursor" to the TMP, since the benefits of the FSP contribute to this objective of better managing recurrent congestion. This Phase II project includes an evaluation of the FSP based on the pre-HOV/FSP and post-HOV/FSP incident data presented herein. This evaluation is necessary for the following two reasons:

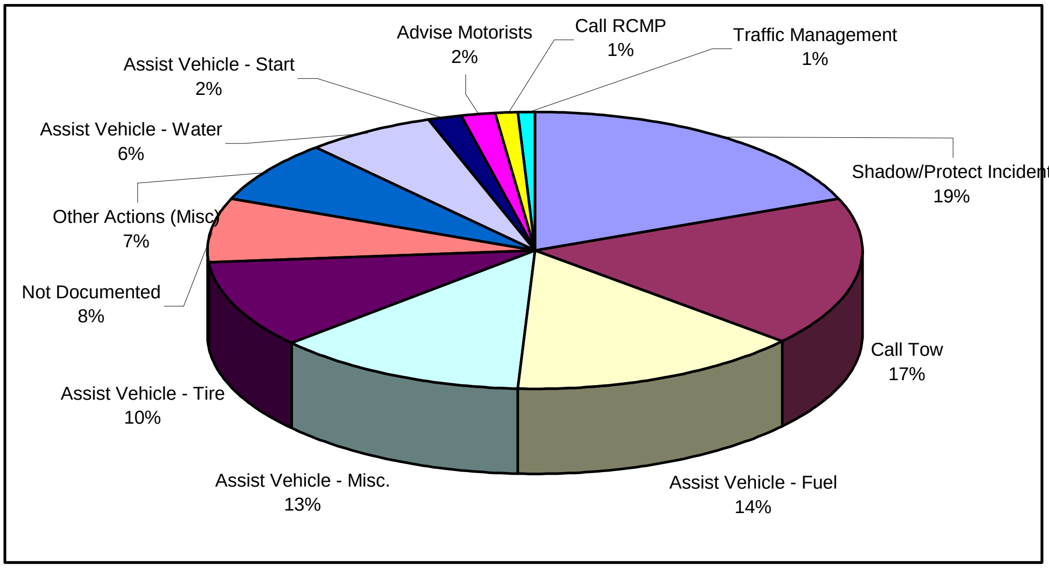
- ✓ to make a rudimentary demonstration of the benefits of patrol services on freeways, especially those relating to improved incident response and management, and therefore duration.
- ✓ to measure the incremental benefit of the FSP so that the coordinated TMP Roadside Assistance and Emergency Service Patrols application can be evaluated against both the pre-HOV/FSP and post-HOV/FSP conditions.

The FSP initiative was introduced January 4, 1999 in the new HOV lane section of Highway 1. The mandated coverage of the FSP is along Highway 1, between First Avenue and the Cape Horn interchange, although they are sometimes observed to assist motorists as far as the east side of the Port Mann Bridge.

The FSP are required to assist during traffic incidents by providing jump-starts, gas, water, minor repairs/service such as assistance with changing flat tires etc. The FSP are also responsible to assist other responding agencies such as the RCMP and emergency services for incident management. The FSP also assist in the removal of vehicles from blocked lanes by towing (one of the incident response vehicles is a tow truck) or pushing vehicles with the FSP vehicles. Where this is not possible in a safe manner, the FSP protect the incident by "shadowing" it from oncoming traffic, i.e. stationing the FSP vehicle behind the incident and illuminating a flashing arrow to safely divert traffic to other lanes. On top of the standard equipment required to perform these tasks, the FSP are also equipped with tube delineators and signs for indicating "ACCIDENT AHEAD", "RIGHT LANE CLOSED", and "LEFT LANE CLOSED" messages.

Based on the incident statistics logged by the FSP for this project, the actions taken by the FSP over the data collection period are summarized below in Exhibit 3.2.14.

Exhibit 3.2.14 - FSP Actions



The two MOEs cited in this section (reduction of incident duration and reduction of delays due to incidents) are applied herein to present the interim benefit of the Highway 1 FSP initiative.

3.2.5.1 Reduction of Incident Duration

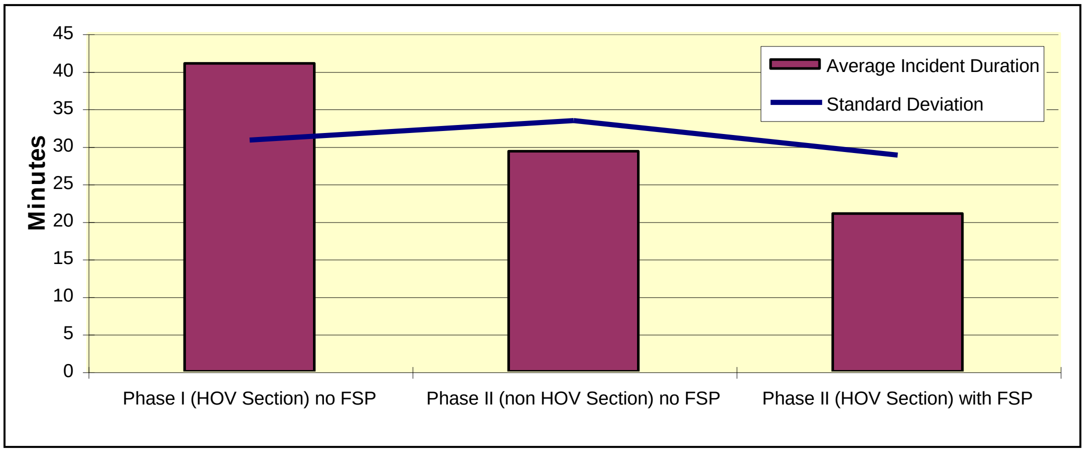
This MOE can be applied using two different data comparisons.

1. First, the Phase I and II average incident duration and standard deviation data can be compared to determine FSP benefits pre and post-construction of the HOV lanes.

2. Second, the Phase II data can be split into the sections of Highway 1 which are not served by the FSP to demonstrate the benefits of FSP during the current post-HOV conditions.

The benefits of FSP in terms of incident duration are summarized below in Exhibit 3.2.15.

Exhibit 3.2.15 - Average Incident Duration Before and After FSP



A significant decrease in the average duration of traffic incidents can be observed since the opening of the HOV lanes and the introduction of the FSP. As presented earlier, this reduction is attributable to the reduction of average response times down from 23.0 minutes (observed in Phase I) to an average of 7.1 minutes by the FSP (observed in Phase II).

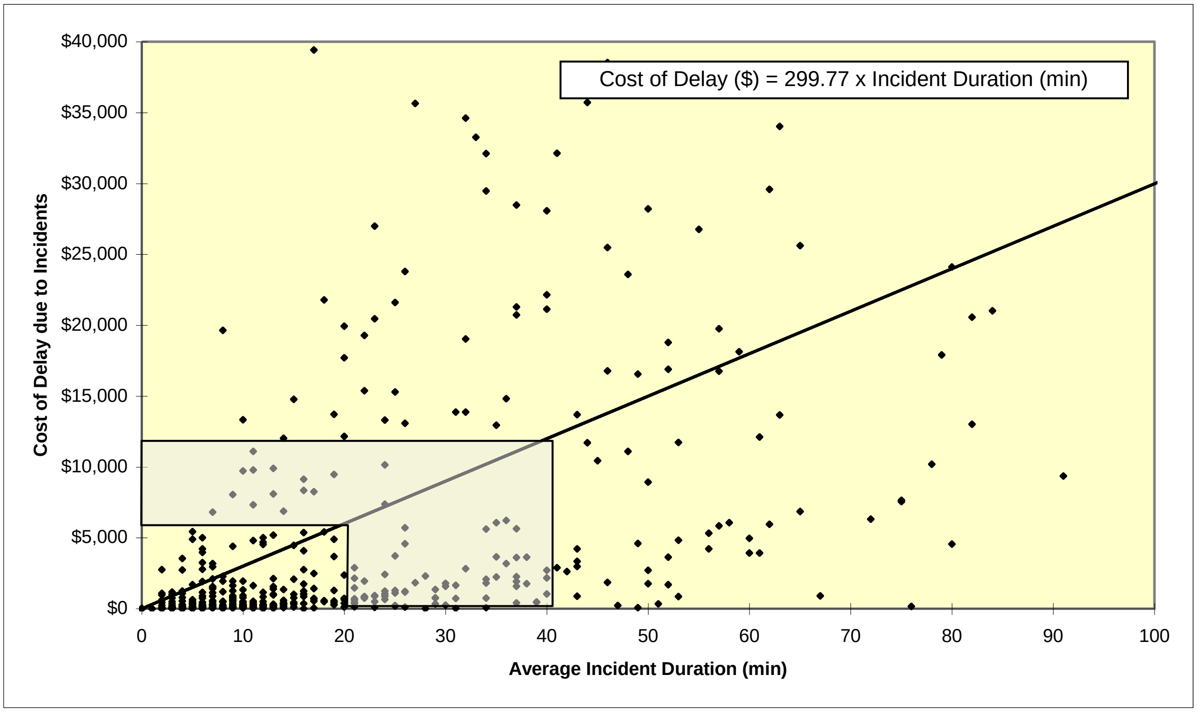
The reduction in response time has led to a reduction of approximately 50% in the average incident duration. This reduction not only shows the benefit of the FSP, but also the potential of benefits that could be derived from the full set of incident detection, management, and response measures associated with the TMP.

3.2.5.2 Reduction of Delays due to Incidents

Naturally, the reduced duration of incidents minimizes the delays caused by that incident. Using the vehicular delay and user cost statistics presented earlier, Exhibit 3.2.16 illustrates the linear relationship between incident duration and the cost of the incident delays to the users.

Using this relationship, comparing the cost of an incident lasting approximately 41 minutes (as estimated to be the before FSP incident duration average) and the cost of an incident lasting 22 minutes (as estimated for current conditions) we can observe that the average cost of an incident has been reduced from $12,000 to $7,000, a 40% reduction.

Exhibit 3.2.16 - Linear Relationship of Average Incident Duration to the Cost of Delay



The total annual cost to users, due to incidents involving the blockage of lanes and or shoulders, was estimated at approximately $28 million, comprised of $13.5 million for lane blockages and $14.7 million for shoulder blockages. This estimate was based on the incident data collected by the FSP during this Phase II project, and reflects a 40% reduction in incident costs as estimated above. Therefore, without FSP, the total potential user cost of the incidents could have been in the range of $46 million.

The current expenditure on FSP is quoted by ICBC at $1.6 million over three years, or $ 533,000 per year. Benefits and costs can be estimated as follows:

Exhibit 3.2.17 – Summary of Incident Delay Costs (in Millions $)

Summary of Delay Costs and Benefits	Lane Blockage	Shoulder Blockage	Total
Phase I Annual Delay Cost (no FSP)	22.5	24.5	47.0
40% Reduction in Delay	9.0	9.8	18.8
Phase II Annual Delay Cost (with FSP)	13.5	14.7	28.2
Annual FSP Cost	**0.533**		
Benefit to Cost Ratio	**16.9**	**18.4**	**35.3**
	17 : 1	**18 : 1**	**35 : 1**

The benefit to cost ratio estimated using total user delays is 35:1. The range of benefit to cost ratio is estimated at 17:1 to 35:1, since the highest benefits relate to the incidents which block lanes, and are quickly cleared to the shoulder by the FSP. These results are comparable with the "higher end" of US results on service patrol benefits and costs which indicate service patrol benefits to range between 2:1 to 17:1. Exhibit 3.2.18 provides a comparison of some US benefit to cost ratios for service patrols. US benefit to cost ratios are predominantly lower than that measured for the FSP, likely due to the higher annual cost of operating those services observed to typically exceed $US 1 million annually.

Exhibit 3.2.18 – Benefit/Cost Ratios Of Selected Programs

Location	Program	Benefit/cost	Year
Charlotte, NC	Motorist Assistance Patrol	7.6:1	1993
Chicago	Emergency Traffic Patrol	7.0:1	1990
Denver	Mile-High Courtesy Patrol	13.5:1	1993
Houston	Motorist Assistance Program	6.6:1	1994
Houston	Motorist Assistance Program	7.0:1	1991
Houston	Freeway Courtesy Patrol	2.0:1	1973
Los Angeles	Freeway Service Patrol	11.0:1	1993
Minneapolis	Highway Helper	2.3:1	1994

3.2.5.3 Reduction in Crashes

A reduction in incident response times, improved incident management, and shorter clearance times can also contribute towards the reduction of secondary collisions.

The insurance claims data presented in section 2.6 of this report reflected a reduction of 25% when comparing the total frequency if claims before the construction of the HOV lanes with claims subsequent to the opening of the HOV lanes and deployment of the FSP, Similarly, the data also reflected a reduction of 48% in total claim costs when making the same comparison.

Although this potential reduction should be confirmed using additional crash data, and calibrated Police MV104 accident data, it is anticipated that the estimate of potential crash reduction is attributable to a combination of accident increasing and decreasing factors associated with the HOV and FSP improvements. **This is explained further in Section 3.3 Improve Safety.**

3.3 OBJECTIVE 3: IMPROVE SAFETY

3.3.1 Description of Objective

The focus of this objective is to improve the overall safety of the highway facility as a result of the provision of incident management and traveler information.

3.3.2 MOEs

Specific MOEs which were selected to evaluate the achievement of this objective are:

- reduction in primary collisions, achieved by improving traffic flow by reducing stop and go conditions

- reduction in secondary collisions
  Secondary collisions are caused when vehicles approaching an incident causing lane blockage, or a queue resulting from slowdown due to shoulder blockage and/or an earlier incident downstream, are unable to stop in time to safely join the end of the queue, or run into other crashed vehicles. The TMP is expected to reduce the incident duration time, thus reducing the queue length and collision risk.

3.3.3 Data Requirements

In order to establish the MOEs identified above, data collection included "before" and "after":

- collision data;

- incident observations and logging.

3.3.4 Phase II Data

Data collected under Phase II was intended to act as a second baseline for the pre-TMP conditions, with the Phase I data being the prime baseline representing pre-HOV and TMP conditions. Phase II safety data were to be retrieved from the HAS database as in Phase I. As described in section 2.6 Maintain Safety (HOV Monitoring & Evaluation) these data were not available at the time of this project; therefore, efforts associated with the data and analysis of this objective were replaced with the collection, analysis, and reporting of both Phase I and II data using the ICBC claims database. Analysis of these data is presented in Section 2.6 of this report.

Exhibit 3.3.1 provides a summary of the key result obtained from the analysis of the claims data.

Exhibit 3.3.1 – Percent Difference in Claim Frequency by Project Phase

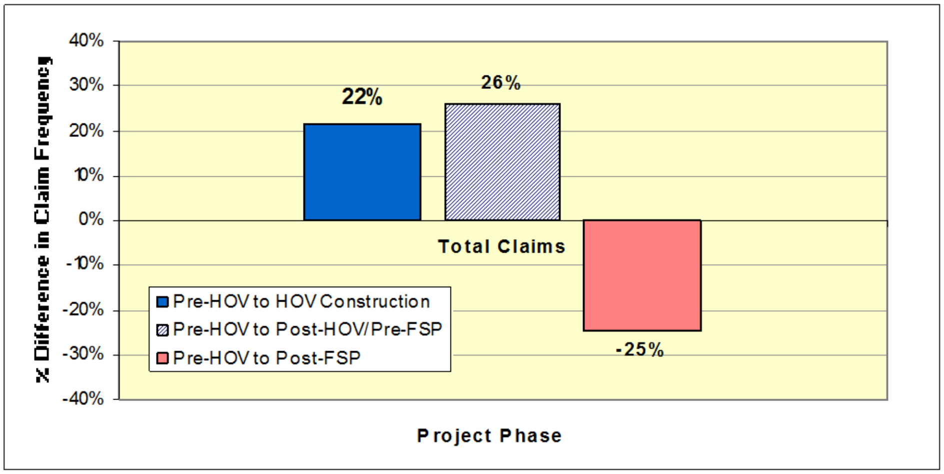


Exhibit 3.3.1 provides a summary of the increase and decrease in accident claim frequencies when comparing pre-HOV lane conditions to post-HOV and pre-FSP, and post-HOV and FSP conditions. An approximate 25% reduction in crashes is observed when comparing the safety performance of the Highway 1 study section before and after the HOV and FSP improvement projects.

Preliminary analysis by MoTH, on MV104 accident data obtained from the Police, indicates a 10% reduction in crashes when comparing the safety performance of the Highway 1 study section before and after the HOV and FSP improvement projects. However, temporary enhanced Police enforcement (paid by BCTFA) may have led to an increase in MV104 reporting after the HOV-FSP improvements (this following a few years of decreased reporting between 1996 and 1999). The MV104 accident reports generally make up 25% to 30% of the ICBC claims data on crashes.

A portion of the above 10% to 25% crash reduction benefits may be attributable to improved incident response, management, and clearance by the FSP, but is difficult to separate from potential safety benefits of other improvements along the HOV and FSP segment. Exhibit 3.3.2 below provides a tabulated summary of potential safety impacts associated with changes in the HOV and FSP segment of Highway 1.

Exhibit 3.3.2 - Safety Impact Contributing Factors

Contributing Factors	Potential Safety Impact
FSP	✓ Positive
Continuous Lighting	✓ Positive
Traffic Growth	✕ Negative
Addition of Capacity through six Laning of Highway 1	✓ Positive
Continuous median barrier	✓ Positive
Provision of 3 meter left shoulder where possible	✓ Positive
Less stop and go	✓ Positive
HOV versus GP Speed Differential with weaving	✕ Negative
Additional lane ends and merge conflicts	✕ Negative

Prior to implementation, it was estimated that the ICBC Freeway Service Patrols and *4444 incident reporting system (CCTV detection was used instead of *4444) would improve safety by clearing incidents more quickly, and thereby reduce accidents by 5 – 12% (TMP Business Plan, by Delcan, 1995; and ICBC Review of Systems for Freeways, by Hamilton Associates, 1997). Although the 25% reduction in collision claims made to ICBC since the construction of the HOV lanes and the deployment of the FSP cannot be broken down, it does tentatively confirm that the safety benefits of recent improvements along the HOV and FSP sections of Highway 1 are substantial and may equal or exceed earlier estimates.

3.3.5 Future Requirements

It should be noted that the detailed MV104 accident report data, collected as part of the Phase I project (extracted from MoTH's HAS database for the period 1992 to 1996), is still representative of pre-TMP conditions. However, due to the evolving state of pre-TMP conditions (i.e. addition of HOV, introduction of the FSP, installation of a ramp signal at the new Coleman on-ramp, and the upcoming widening of the Port Mann Bridge), the baseline crash data for TMP needs to be updated and analyzed incrementally to reflect changes in relation to the TMP evolution.

The FSP proved to be a valuable incident data collection source in the Phase II project. Using detailed incident logging sheets, the FSP control center recorded information regarding over 800 traffic incidents along the HOV/FSP section of Highway 1. This recording mechanism can be modified to include further crash details.

On this basis, the Phase I crash data can be used to represent conditions prior to the HOV and FSP initiatives, while the ongoing recording of incidents by the FSP would capture the crash rate of that section of Highway 1 as it evolves towards the TMP pilot user service applications. Post-TMP crash data may be collected at the TMC using an incident management database.

3.4 OBJECTIVE 4: OPTIMIZE EFFICIENT USE OF CAPACITY

3.4.1 Description of Objective

The focus of this objective is to optimize the efficient use of available capacity on Highway 1 corridor including parallel routes when there is congestion on the mainline.

3.4.2 MOEs

The MOE which can be used to evaluate the achievement of this objective is the optimization of person throughput along the TCH (including its parallel routes).

As indicated in the Phase I study, this MOE can be used at two levels:

1. A “static” measurement of the throughput (vehicles x occupants x average speed) along the mainline and parallel routes “before” and “after” implementation of TMP. As throughput is a function of level of service, this measurement (i.e. LOS) provides a snap-shot of the relative utilization of capacity between two parallel corridors.

2. A “dynamic” measurement of throughput between the mainline and parallel routes after implementation of the TMP - and during congestion/incident conditions – using real-time monitoring along the mainline and parallel route diversion points.

Unlike the representation of “throughput” used in the HOV objectives evaluation, the required representation for TMP objectives evaluation includes the “factoring in” of before and after speeds. The addition of the “speed” dimension to throughput is required since TMP benefits expected to improved flow can be captured through comparison of average operating speeds. On this basis the unit of throughput is person-kilometers per hour.

3.4.3 Data Requirements

The dynamic or real-time measurement of throughput along the TCH and its parallel corridors will require, as a minimum, the TMP traffic monitoring and information services to be in place, along with selected monitoring stations located either at the key diversion points between the TCH and its parallel routes, or along the parallel routes. Alternatively, estimates of the traffic diversion ability and capacity of the corridor can be made using micro-simulation techniques, such as with the INTEGRATION software.

This Phase II second baseline of the pre-TMP conditions has used the static throughput estimates also used in Phase I. On this basis, the following “before” and “after” data is required for this MOE:

- vehicle counts;
- vehicle occupancies;
- average speeds;

3.4.4 Phase II Data

Consistent with the Phase I methodology, since the person throughput of the corridor is a function of the peak hour levels of service (i.e. volumes and speeds), a capacity analysis of the mainline interchange segments was first performed to establish the current LOS of Highway 1.

The levels of service for the highway segments between the Lynn Valley Interchange and the 176 Street Interchange were calculated based on vehicle average speeds collected during September 1999 and the methods outlined in the 1994 Highway Capacity Manual. Exhibits 3.4.1 provides a tabulated summary of the analysis. Exhibits 3.4.2 and 3.4.3 provide a graphical comparison of LOS along the TCH before and after construction of the HOV lanes. Again, caution must be used in the interpretation of these results (due to the capacity constrained operations and traffic flow breakdown of highway operations prior to the construction of the HOV lanes).

Consistent with the Phase I results, peak direction LOS in the non-HOV portions of the TCH are observed to be predominantly E or F, while the LOS along the HOV portion are improved (as reported on in section 2.5 of this report).

Vehicular and Person Throughput

As the intent of the TMP is to optimize the use of existing facilities, while reducing the need to construct new facilities, the measurement of throughput has been identified as a static means of comparing the performance of parallel facilities before and after introduction of the TMP pilot project. Throughput (normalized to reflect level of service) may be defined as the product of occupancy rate, vehicular volume, and travel speed, and can be expressed as person-kilometres per hour. (Calculation of throughput is similar to the Per-lane Efficiency calculation used for HOV evaluation, except that it is not on a per-lane basis). Increased throughput will indicate more efficient use of the existing available capacity.

Exhibit 3.4.4 provides a tabulated summary of throughput along the full Highway 1, with a distinction of GP and HOV lanes in the applicable segments. These throughput estimates can be used as a baseline for measuring the throughput along the TCH segments after the completion of the TMP pilot project. The interpretation of the throughput for this objective must be across a screenline to ensure the maximization of the use of capacity along the TCH and its parallel routes. Exhibit 3.4.5 tabulates the Phase II measured throughput along the centre screenline. The baseline estimates of vehicular and person throughput show that the highest throughput is achieved in the PM peak hour, where the peak direction eastbound person throughput is approximately 503,000 persons per kilometre per hour, and 464,000 persons per kilometre per hour for the westbound PM peak hour. The AM peak hour throughput westbound is observed at 443,000 persons per kilometre per hour.

Reviewing the parallel route components of the screenline, it can be observed that the vehicular and person throughput is significantly less than the mainline, due to their arterial nature, presence of traffic signals, along with lower overall average speeds (ranging between 30 to 50 kilometres per hour) and lower vehicle occupancies.

Exhibit 3.4.1 - Mainline Volume, Speed, and LOS – Phase II

AM EB	PHASE 2 (GP)			PHASE 2 (HOV)		
Highway Segment East of	Avg. Speed	Highway Volume	LOS	Avg. Speed	Highway Volume	LOS
Lynn Valley	43	2667	E			
Fern	24	2612	F			
2nd Narrows	46	5910	F			
McGill	75	3858	E			
Cassiar	85	4183	E			
1st Ave.	91	3784	D			
Boundary	63	3013	E			
Grandview	63	3500	E	88	345	A
Willingdon	78					
Sprott	88	2424	C	97	327	A
Deer Lake	87					
Stormont	89	2784	D	92	350	A
Brunette	78					
Cape Horn	38	3900	F			
152	90	2494	C			
104	89	2774	D			

AM WB	PHASE 2 (GP)			PHASE 2 (HOV)		
Highway Segment East of	Avg. Speed	Highway Volume	LOS	Avg. Speed	Highway Volume	LOS
Lynn Valley	56	2254	E			
Fern	67	2338	D			
2nd Narrows	69	4124	D			
McGill	83	2739	D			
Cassiar	75	3372	E			
1st Ave.	72	4011	E			
Boundary	58	3527	E			
Grandview	81	4336	E			
Willingdon	64	3337	E	94	999	C
Sprott	45					
Deer Lake	43	2919	E	88	1095	C
Stormont	44					
Brunette	78	2955	D	87	689	B
Cape Horn	82	4176	E			
152	25	2920	F			
104	19	3355	F			

PM EB	PHASE 2 (GP)			PHASE 2 (HOV)		
Highway Segment East of	Avg. Speed	Highway Volume	LOS	Avg. Speed	Highway Volume	LOS
Lynn Valley	87	2943	D			
Fern	81	1811	C			
2nd Narrows	59	5057	E			
McGill	84	3268	D			
Cassiar	83	3990	E			
1st Ave.	82	3639	D			
Boundary	81	3109	E			
Grandview	87	3333	D	85	893	B
Willingdon	71					
Sprott	77	2871	D	95	1149	C
Deer Lake	66					
Stormont	71	2699	D	86	1037	C
Brunette	28					
Cape Horn	21	3949	F			
152	89	2716	C			
104	89	3398	D			

PM WB	PHASE 2 (GP)			PHASE 2 (HOV)		
Highway Segment East of	Avg. Speed	Highway Volume	LOS	Avg. Speed	Highway Volume	LOS
Lynn Valley	58	3107	E			
Fern	44	3893	F			
2nd Narrows	34	5585	F			
McGill	32	2651	F			
Cassiar	28	3111	F			
1st Ave.	39	3979	F			
Boundary	36	3361	F			
Grandview	44	3642	F			
Willingdon	89	3040	D	96	602	B
Sprott	83					
Deer Lake	92	2647	C	93	500	A
Stormont	87					
Brunette	85	1949	B	89	363	A
Cape Horn	81	4008	E			
152	41	2871	E			
104	71	3731	E			

Exhibit 3.4.2 - AM Peak LOS Phase I and II Comparison

Exhibit 3.4.3 - PM Peak LOS Phase I and II Comparison

Exhibit 3.4.4 - Mainline Vehicular and Person Throughput Phase I and II Comparison

AM EB	PHASE 1					PHASE 2 (GP)			PHASE 2 (HOV)			PHASE 2 (GP & HOV)		COMPARISON	
Highway Segment East of	Avg. Speed	Highway Volume	AVO	Vehicle Throughput	Person Throughput	Avg. Speed	Highway Volume	AVO	Avg. Speed	Highway Volume	AVO	Combined Vehicle Throughput	Combined Person Throughput	Vehicle Throughput	Person Throughput
Lynn Valley		2410	1.11			43	2667	1.1				115447	126991		
Fern	48	n/a	1.11			24	2612	1.1				61686	67855		
2nd Narrows	47	5515	1.11	259205	287718	46	5910	1.1				273103	300413	5%	4%
McGill	81	3715	1.14	300915	343043	75	3858	1.1				289911	318903	-4%	-7%
Cassiar	82	3985	1.14	326770	372518	85	4183	1.1				356908	392599	9%	5%
1st Ave.	84	3810	1.14	320040	364846	91	3784	1.16				344509	399630	8%	10%
Boundary	66	3090	1.13	203940	230452	63	3013	1.16				190418	220885	-7%	-4%
Grandview	61	4220	1.13	257420	290885	63	3500	1.06	88	345	2.12	249482	296592	-3%	2%
Willingdon	71	3830	1.13	271930	307281	78									
Sprott	83	3495	1.13	290085	327796	88	2424	1.06	97	327	2.12	245015	293293	-16%	-11%
Deer Lake	83	3180	1.12	263940	295613	87									
Stormont	76	3080	1.12	234080	262170	89	2784	1.06	92	350	2.12	280211	331275	20%	26%
Brunette	73	n/a	1.12			78									
Cape Horn	68	3755	1.13	255340	288534	38	3900	1.16				146888	170390	-42%	-41%
152	82	2480	1.12	203360	227763	90	2494	1.15				224850	258577	11%	14%
104	92	2980	1.12	274160	307059	89	2774	1.15				247061	284120	-10%	-7%

AM WB	PHASE 1					PHASE 2 (GP)			PHASE 2 (HOV)			PHASE 2 (GP & HOV)		COMPARISON	
Highway Segment East of	Avg. Speed	Highway Volume	AVO	Vehicle Throughput	Person Throughput	Avg. Speed	Highway Volume	AVO	Avg. Speed	Highway Volume	AVO	Combined Vehicle Throughput	Combined Person Throughput	Vehicle Throughput	Person Throughput
Lynn Valley	63	2135	1.11	134505	149301	56	2254	1.13				125392	141693	-7%	-5%
Fern	78	n/a	1.11			67	2338	1.13				155856	176117		
2nd Narrows	66	3780	1.11	249480	276923	69	4124	1.13				283997	320917	14%	16%
McGill	77	2420	1.14	186340	212428	83	2739	1.13				227514	257090	22%	21%
Cassiar	83	2980	1.14	247340	281968	75	3372	1.13				254456	287536	3%	2%
1st Ave.	82	3170	1.14	259940	296332	72	4011	1.24				290446	360153	12%	22%
Boundary	99	2700	1.14	267300	304722	58	3527	1.24				204450	253518	-24%	-17%
Grandview	65	3840	1.13	249600	282048	81	4336	1.24				352633	437264	41%	55%
Willingdon	77	3905	1.16	300685	348795	64	3337	1.02	94	999	2.03	307982	409253	2%	17%
Sprott	57	3410	1.16	194370	225469	45									
Deer Lake	37	2520	1.16	93240	108158	43	2919	1.02	88	1095	2.03	221762	323039	138%	199%
Stormont	46	n/a	1.16			44									
Brunette	75	3060	1.15	229500	263925	78	2955	1.06	87	689	2.03	289833	365384	26%	38%
Cape Horn	70	3690	1.15	258300	297045	82	4176	1.22				342817	418237	33%	41%
152	30	2680	1.13	80400	90852	25	2920	1.2				73935	88722	-8%	-2%
104	24	n/a	1.13			19	3355	1.2				62702	75243		

PM EB	PHASE 1					PHASE 2 (GP)			PHASE 2 (HOV)			PHASE 2 (GP & HOV)		COMPARISON	
Highway Segment East of	Avg. Speed	Highway Volume	AVO	Vehicle Throughput	Person Throughput	Avg. Speed	Highway Volume	AVO	Avg. Speed	Highway Volume	AVO	Combined Vehicle Throughput	Combined Person Throughput	Vehicle Throughput	Person Throughput
Lynn Valley		2270	1.2			87	2943	1.23				256672	315706		
Fern	69	n/a	1.2			81	1811	1.23				146741	180492		
2nd Narrows	67	4615	1.2	309205	371046	59	5057	1.23				298708	367410	-3%	-1%
McGill	82	2860	1.2	234520	281424	84	3268	1.23				275481	338842	17%	20%
Cassiar	84	3385	1.2	284340	341208	83	3990	1.23				330295	406262	16%	19%
1st Ave.	84	3070	1.21	257880	312035	82	3639	1.31				298143	390567	16%	25%
Boundary	59	2505	1.21	147795	178832	81	3109	1.31				252025	330153	71%	85%
Grandview	56	3360	1.26	188160	237082	87	3333	1.06	85	893	2.13	367483	470937	95%	99%
Willingdon	64	3140	1.26	200960	253210	71									
Sprott	59	2875	1.26	169625	213728	77	2871	1.06	95	1149	2.13	330262	466463	95%	118%
Deer Lake	50	2490	1.25	124500	155625	66									
Stormont	28	2358	1.25	66024	82530	71	2699	1.06	86	1037	2.13	280122	392108	324%	375%
Brunette	25	2970	1.25	74250	92813	28									
Cape Horn	38	3875	1.16	147250	170810	21	3949	1.3				84721	110137	-42%	-36%
152	82	2545	1.16	208690	242080	89	2716	1.27				240699	305687	15%	26%
104	86	3480	1.16	299280	347165	89	3398	1.27				303643	385626	1%	11%

PM WB	PHASE 1					PHASE 2 (GP)			PHASE 2 (HOV)			PHASE 2 (GP & HOV)		COMPARISON	
Highway Segment East of	Avg. Speed	Highway Volume	AVO	Vehicle Throughput	Person Throughput	Avg. Speed	Highway Volume	AVO	Avg. Speed	Highway Volume	AVO	Combined Vehicle Throughput	Combined Person Throughput	Vehicle Throughput	Person Throughput
Lynn Valley	59	2970	1.15	175230	201515	58	3107	1.2				179493	215391	2%	7%
Fern	84	3930	1.15	330120	379638	44	3893	1.2				170777	204932	-48%	-46%
2nd Narrows	62	5260	1.15	326120	375038	34	5585	1.2				191400	229680	-41%	-39%
McGill	67	3230	1.23	216410	266184	32	2651	1.2				84222	101066	-61%	-62%
Cassiar	69	3660	1.23	252540	310624	28	3111	1.2				86065	103278	-66%	-67%
1st Ave.	79	3470	1.23	274130	337180	39	3979	1.24				155428	192730	-43%	-43%
Boundary	109	2870	1.23	312830	384781	36	3361	1.24				119564	148259	-62%	-61%
Grandview	67	3950	1.24	264650	328166	44	3642	1.24				161008	199650	-39%	-39%
Willingdon	80	3820	1.24	305600	378944	89	3040	1.13	96	602	2.05	329857	425938	8%	12%
Sprott	80	2440	1.24	195200	242048	83									
Deer Lake	71	2625	1.24	186375	231105	92	2647	1.13	93	500	2.05	290504	371205	56%	61%
Stormont	88	n/a	1.24			87									
Brunette	85	2400	1.27	204000	259080	85	1949	1.2	89	363	2.05	198384	265492	-3%	2%
Cape Horn	89	3905	1.27	347545	441382	81	4008	1.33				326478	434216	-6%	-2%
152	41	2740	1.24	112340	139302	41	2871	1.27				117424	149128	5%	7%
104	74	n/a	1.24			71	3731	1.27				264169	335495		

Exhibit 3.4.5 - Total Vehicular and Person Throughput Across the Centre Screenline – Phase II

AM EB	SCREENLINE VEHICLE/PERSON THROUGHPUT				
CENTRE SCREENLINE	Avg. Speed	Highway Volume	AVO	Vehicle Throughput	Person Throughput
TCH (GP) @ Gaglardi	89	2784	1.06	247899	262773
TCH (HOV) @ Gaglardi	92	350	2.12	32312	68502
Lougheed Hwy @ North Rd	40	473	1.14	18873	21515
Canada Way @ 10th Ave	45	728	1.16	32833	38086
TOTAL				**331917**	**390876**

AM WB	SCREENLINE VEHICLE/PERSON THROUGHPUT				
CENTRE SCREENLINE	Avg. Speed	Highway Volume	AVO	Vehicle Throughput	Person Throughput
TCH (GP) @ Deer Lake	43	2919	1.02	125879	128397
TCH (HOV) @ Deer Lake	88	1095	2.03	95883	194642
Lougheed Hwy @ North Rd	50	1240	1.12	61504	68884
Canada Way @ 10th Ave	35	1239	1.18	43613	51463
TOTAL				**326879**	**443386**

PM EB	SCREENLINE VEHICLE/PERSON THROUGHPUT				
CENTRE SCREENLINE	Avg. Speed	Highway Volume	AVO	Vehicle Throughput	Person Throughput
TCH (GP) @ Gaglardi	71	2699	1.06	191170	202640
TCH (HOV) @ Gaglardi	86	1037	2.13	88952	189467
Lougheed Hwy @ North Rd	36	1425	1.19	51015	60708
Canada Way @ 10th Ave	28	1447	1.25	40227	50283
TOTAL				**371364**	**503099**

PM WB	SCREENLINE VEHICLE/PERSON THROUGHPUT				
CENTRE SCREENLINE	Avg. Speed	Highway Volume	AVO	Vehicle Throughput	Person Throughput
TCH (GP) @ Deer Lake	92	2647	1.13	243835	275534
TCH (HOV) @ Deer Lake	93	500	2.05	46669	95671
Lougheed Hwy @ North Rd	49	845	1.30	41152	53497
Canada Way @ 10th Ave	31	998	1.28	31038	39728
TOTAL				**362694**	**464430**

Note: Shading indicates peak direction
All average speeds were the average link travel speed from previous landmark

3.5 OBJECTIVE 5: ACQUIRE PUBLIC SUPPORT AND SATISFACTION

3.5.1 Description of Objective

The focus of this objective is to ensure that the users of Highway 1 support the traffic management measures involving the service patrols and ITS technologies and are satisfied with the benefits they receive from it as users.

3.5.2 MOEs

The MOE for this objective is direct input from Highway 1 users through opinion surveys.

3.5.3 Data Requirements

User information, observations and opinions were solicited for this objective through the distribution to motorists of 2000 mail-back surveys (also used for the HOV related questions) at the following locations:

- ✓ Westbound Highway 1 off-ramp at First Avenue
- ✓ Eastbound Highway 1 off-ramp at 104 Avenue
- ✓ West and Eastbound Highway 1 off-ramps at Gaglardi Way

The non-HOV questions included in the surveys related primarily to the benefits of freeway service patrols, since the FSP was also introduced on January 4, 1999. Except for FSP questions, TMP related questions were excluded from the surveys for Phase II. Questions of user opinion relating to acceptance, satisfaction, and responses to post - TMP service applications such as pre-trip and en-route traveler information will need to be surveyed in Phase III.

3.5.4 Phase II Data

The main statistics associated with the sample of survey respondents was presented in section 2.8 and Exhibit 2.8.1, as these results were obtained from the same survey used for the HOV public acceptance and satisfaction objective.

Exhibit 3.5.1 provides a tabulation of the user surveys results pertaining to FSP. It can be observed from this exhibit that of all the HOV and SOV respondents:

- ✓ 51% often see the FSP vehicles responding to incidents

- ✓ 52% agree that clearing incidents quickly helps minimize delays and congestion

- ✓ 57% agree that minimizing congestion results in reduced fuel consumption and improved air quality

Exhibit 3.5.1 - Motorist Survey – FSP Related Responses

4.1 I often see the yellow Freeway Service Patrol vehicles clearing crashes, assisting disabled vehicles, cleaning up after spills, etc. (between the Port Mann Bridge and Grandview Highway)

	HOV DRIVER		SOV DRIVER		TOTAL	
	#	%	#	%	#	%
Strongly Agree	**39**	**24%**	**80**	**21%**	**119**	**22%**
Somewhat Agree	**46**	**28%**	**111**	**29%**	**157**	**29%**
Neutral	41	25%	107	28%	148	27%
Somewhat Disagree	19	12%	54	14%	73	13%
Strongly Disagree	19	12%	34	9%	53	10%
TOTAL	**164**	**100%**	**386**	**100%**	**550**	**100%**

4.2 Quick clearing of accidents, vehicle breakdowns, spills, etc., by the Freeway Service Patrols have helped minimize delay and traffic congestion

	HOV DRIVER		SOV DRIVER		TOTAL	
	#	%	#	%	#	%
Strongly Agree	**34**	**21%**	**81**	**21%**	**115**	**21%**
Somewhat Agree	**58**	**36%**	**110**	**29%**	**168**	**31%**
Neutral	47	29%	134	35%	181	33%
Somewhat Disagree	14	9%	38	10%	52	9%
Strongly Disagree	10	6%	22	6%	32	6%
TOTAL	**163**	**100%**	**385**	**100%**	**548**	**100%**

4.3 Random incidents and accidents cause more traffic delays and congestion than routine peak period traffic volumes

	HOV DRIVER		SOV DRIVER		TOTAL	
	#	%	#	%	#	%
Strongly Agree	**65**	**40%**	**144**	**37%**	**209**	**38%**
Somewhat Agree	**48**	**29%**	**108**	**28%**	**156**	**28%**
Neutral	23	14%	66	17%	89	16%
Somewhat Disagree	20	12%	44	11%	64	12%
Strongly Disagree	7	4%	25	6%	32	6%
TOTAL	**163**	**100%**	**387**	**100%**	**550**	**100%**

4.4 By helping to minimize traffic congestion, the Freeway Service Patrols also help reduce fuel consumption and improve overall air quality

	HOV DRIVER		SOV DRIVER		TOTAL	
	#	%	#	%	#	%
Strongly Agree	**48**	**30%**	**79**	**21%**	**127**	**24%**
Somewhat Agree	**51**	**32%**	**125**	**33%**	**176**	**33%**
Neutral	39	24%	116	31%	155	29%
Somewhat Disagree	14	9%	29	8%	43	8%
Strongly Disagree	8	5%	30	8%	38	7%
TOTAL	**160**	**100%**	**379**	**100%**	**539**	**100%**

4.5 I have (or know someone who has) been assisted by the Freeway Service Patrol during a traffic incident or accident

	HOV DRIVER		SOV DRIVER		TOTAL	
	#	%	#	%	#	%
Yes I Have	6	4%	18	5%	24	4%
Yes I know someone	10	6%	14	4%	24	4%
No	151	90%	348	92%	499	91%
TOTAL	**167**	**100%**	**380**	**100%**	**547**	**100%**

- ✓ Approximately 66% of all respondents (HOV and SOV) agree that random incidents cause more traffic delays and congestion than routine peak period traffic volumes

- ✓ Approximately 9% of all respondents (HOV and SOV) have been helped by, or know someone who has been helped by the FSP

As indicated in section 2.8 of this report, a similar survey was also distributed to a group of key project stakeholders. Exhibit 3.5.3 provides a tabulated summary of the FSP related responses by the stakeholders.

Exhibit 3.5.2 - Stakeholders Survey – FSP Related Responses

	Question	Strongly Agree	Somewhat Agree	Neutral	Somewhat Disagree	Strongly Disagree	Total Number of Responses	TOTAL
2.1	Random incidents and accidents cause more traffic delays and congestion than routine peak period traffic volumes	20%	37%	17%	17%	8%	59	100%
2.2	Quick clearing of accidents, vehicle breakdowns, spills, etc., by the Freeway Service Patrols helps minimize delay and traffic congestion	60%	32%	7%	2%	0%	60	100%
2.3	By helping to minimize traffic congestion, the Freeway Service Patrols also help reduce fuel consumption, and improve overall air quality, as well as defer infrastructure requirements	28%	37%	32%	3%	0%	60	100%
2.4	The yellow Freeway Service Patrol vehicles are frequently visible clearing crashes, assisting disabled vehicles, cleaning up after spills, etc., (between the Port Mann Bridge and Grandview Highway)	32%	31%	29%	8%	0%	59	100%
	TOTAL NUMBER OF RESPONSES	**84**	**81**	**50**	**18**	**5**	**238**	

The stakeholder agencies were also asked to comment on their own traffic and road data collection programs, in terms of electronic management and exchange capabilities (internally and externally), and their observations on the interaction of FSP with local services. Few respondents answered these questions. The municipal and regional agencies only indicated that they do collect some traffic data (like traffic counts and information pertaining to traffic control signals etc.) and store it electronically.

4 NETWORK IMPACTS

An important requirement of the monitoring program is to determine impacts of the HOV facility and the TMP pilot project on the parallel routes within the Study Corridor. Network impacts have been discussed throughout the report in conjunction with the HOV and TMP evaluations. The purpose of this section is to document the network data collection and analysis within a stand-alone chapter. This portion of the data collection program relates to collecting mechanical counts, vehicle classification/occupancy data, travel time/speed data and intersection turning movement counts on adjacent intersections and parallel routes. This data has been used throughout the other sections of the report to determine whether there has been a modal shift in traffic, whether there is an increase in HOV usage, and whether there has been any impact on users of the parallel routes as a result of shift in traffic to/from Highway 1.

4.1 PHASE II CONDITIONS

4.1.1 Traffic Volumes

24 hour traffic volumes were collected at 5 count stations along the parallel routes north and south of Highway 1 as summarized in Exhibit 4.1.1. Count data at Pattullo Bridge, Lougheed at Boundary Road and Lougheed at Colony Farm Road were not available at the time of this study due to the transfer of the count stations to the municipalities, which caused delay in obtaining the data (these data should be obtained by MoTH when available in the future and appended to the Phase II data collected in this project). In addition to these data, manual intersection turning movement counts were also collected along Lougheed Highway and Canada Way and is further elaborated in section 4.1.4.

Exhibit 4.1.1 - Mechanical Count Stations Along Parallel Routes

On	Location
Lougheed Highway (Route 7)	0.2 km east of North Road
Lougheed Highway (Route 7)	west of King Edward Street
Barnet Highway (Route 7A)	0.1 km west of Route 7 at Pine Tree Way
Mary Hill Bypass	0.8 km east of United Boulevard
Canada Way	west of 10th Avenue

Note: Traffic count data along 104 Ave was collected using intersection counts

Exhibit 4.1.2 below presents the tabulated summary of the peak hour traffic volumes on the parallel routes by direction and time period.

Exhibit 4.1.2 - Peak Hour Traffic Volume at Count Stations

LOCATION	EASTBOUND			WESTBOUND		
	AM	NOON	PM	AM	NOON	PM
Route 7/ North Road	473	781	1425	1240	902	845
Route 7A/ Route 7	866	1294	1721	1859	1311	1490
Mary Hill Bypass/ United Blvd	1316	1431	2767	2449	1341	1341
Route 7/ King Edward Street	1069	1423	2589	1849	1846	2028
Canada Way/10th Avenue	728	901	1447	1239	709	998

4.1.2 Vehicle Classification & Occupancy Surveys

The data collection program included vehicle classification and occupancy surveys along the specified parallel routes at the following stations (Exhibit 4.1.3):

Exhibit 4.1.3 - Vehicle Classification & Occupancy Survey

ON	LOCATION
Lougheed Highway	West of Gaglardi Way
Lougheed Highway	West of King Edward Street
Lougheed Highway	West of Colony Farm Road
Canada Way	West of 10th Ave
Barnet Highway	West of Pine Tree Way
Pattullo Bridge	South End
Mary Hill Bypass	East of United Boulevard

The details of the collected occupancy data have been summarized into the following exhibits:

- Exhibit 4.1.4 presents the weekday peak period AVOs, for the AM, Mid-day, and PM peak hours, at all 7 stations along the parallel routes.
- Exhibit 4.1.5 presents the weekday peak period vehicle classification data, for the AM, Mid-day, and PM periods, at all 7 stations along the parallel routes.

The lowest vehicle occupancy is observed during the AM period which comprises largely work trips and trucks, and highest in the mid-day period with the exception of Pattullo Bridge, Barnet Highway and Lougheed Highway, which has the highest occupancy during the PM peak in the eastbound direction away from downtown.

Generally, cars comprise approximately 80-90% of the traffic stream, followed by approximately 3 to 18% trucks, with motorcycles, buses, and taxis comprising less than 2% each. Truck traffic tends to be relatively constant throughout the day except at Mary Hill Bypass and Lougheed Highway (west of Gaglardi) in which a higher proportion of trucks were observed (12-17%). The proportion of truck traffic along the parallel routes is much higher than on the mainline.

4.1.3 Travel Times

The Phase I study recommended the collection of travel time statistics along the parallel routes. A small sample of Phase II travel time surveys were included along the parallel routes as a baseline for future analysis of the network impacts due to enhancement of the mainline. From the Phase I study, the corridor of influence was identified as: Lougheed Highway – Mary Hill Bypass corridor and Canada Way – Pattullo Bridge corridor. Exhibit 4.1.6 illustrate the following parallel routes:

Exhibit 4.1.4 - Parallel Route Vehicle Occupancies – Weekday Peak Period

EASTBOUND

	1 Occupant		2 Occupants		3 Occupants		4+ Occupants		Van Pools		Bus Occupants		Taxi Occupants		Total Occupants	Vehicle Occupancy
Canada Way - West of 10th Avenue																
AM Period	1543	84.7%	217	11.9%	28	1.5%	6	0.3%	0	0.0%	180	7.9%	19	0.8%	2284	1.16
Noon Period	1168	78.9%	241	16.3%	35	2.4%	11	0.7%	0	0.0%	90	4.7%	25	1.3%	1914	1.24
PM Period	2913	78.6%	619	16.7%	99	2.7%	37	1.0%	0	0.0%	325	6.6%	23	0.5%	4944	1.25
Lougheed Highway - West of Gaglardi Way																
AM Period	1588	86.0%	201	10.9%	26	1.4%	5	0.3%	1	0.1%	173	7.6%	6	0.3%	2273	1.15
Noon Period	1750	80.1%	340	15.6%	52	2.4%	20	0.9%	0	0.0%	225	7.8%	9	0.3%	2900	1.23
PM Period	4092	83.1%	695	14.1%	80	1.6%	30	0.6%	0	0.0%	377	6.1%	6	0.1%	6225	1.19
Lougheed Highway - West of King Edward																
AM Period	2722	88.6%	280	9.1%	26	0.8%	8	0.3%	1	0.0%	304	8.2%	25	0.7%	3727	1.12
Noon Period	1717	77.9%	410	18.6%	36	1.6%	23	1.0%	0	0.0%	74	2.6%	7	0.2%	2818	1.25
PM Period	4153	79.9%	867	16.7%	90	1.7%	39	0.7%	0	0.0%	332	5.0%	29	0.4%	6674	1.23
Lougheed Highway - West of Colony Farm Road																
AM Period	2544	88.1%	256	8.9%	29	1.0%	14	0.5%	0	0.0%	141	4.2%	19	0.6%	3359	1.13
Noon Period	2375	79.0%	524	17.4%	69	2.3%	21	0.7%	1	0.0%	84	2.2%	12	0.3%	3816	1.24
PM Period	5994	82.9%	1032	14.3%	128	1.8%	45	0.6%	3	0.0%	466	5.1%	27	0.3%	9133	1.20
Barnet Highway - West of Pine Tree Way																
AM Period	1755	78.6%	321	14.4%	62	2.8%	20	0.9%	1	0.0%	752	21.9%	10	0.3%	3431	1.24
Noon Period	1842	72.9%	543	21.5%	75	3.0%	25	1.0%	0	0.0%	457	12.3%	15	0.4%	3725	1.31
PM Period	3713	73.5%	1019	20.2%	158	3.1%	58	1.1%	0	0.0%	1185	15.5%	19	0.2%	7661	1.30
Pattullo Bridge																
AM Period	4327	89.8%	411	8.5%	53	1.1%	9	0.2%	0	0.0%	71	1.3%	15	0.3%	5430	1.11
Noon Period	2742	76.5%	694	19.4%	83	2.3%	42	1.2%	0	0.0%	0	0.0%	31	0.7%	4578	1.28
PM Period	9858	83.3%	1646	13.9%	210	1.8%	76	0.6%	2	0.0%	144	1.0%	48	0.3%	14288	1.20
Mary Hill Bypass																
AM Period	2705	88.8%	273	9.0%	25	0.8%	22	0.7%	0	0.0%	435	11.3%	0	0.0%	3849	1.13
Noon Period	2258	80.9%	457	16.4%	46	1.6%	6	0.2%	0	0.0%	32	0.9%	3	0.1%	3369	1.20
PM Period	6941	84.0%	1144	13.8%	81	1.0%	50	0.6%	4	0.0%	201	2.0%	7	0.1%	9904	1.18

WESTBOUND

	1 Occupant		2 Occupants		3 Occupants		4+ Occupants		Van Pools		Bus Occupants		Taxi Occupants		Total Occupants	Vehicle Occupancy
Canada Way - West of 10th Avenue																
AM Period	2296	83.4%	371	13.5%	50	1.8%	8	0.3%	0	0.0%	247	7.1%	10	0.3%	3477	1.18
Noon Period	1128	76.7%	282	19.2%	26	1.8%	10	0.7%	0	0.0%	100	5.2%	20	1.0%	1930	1.25
PM Period	2180	76.2%	534	18.7%	91	3.2%	22	0.8%	0	0.0%	288	7.3%	32	0.8%	3929	1.28
Lougheed Highway - West of Gaglardi Way																
AM Period	4482	89.2%	463	9.2%	42	0.8%	10	0.2%	0	0.0%	717	11.4%	7	0.1%	6298	1.12
Noon Period	1837	78.5%	390	16.7%	54	2.3%	30	1.3%	0	0.0%	322	10.0%	10	0.3%	3231	1.25
PM Period	2569	75.2%	663	19.4%	96	2.8%	50	1.5%	0	0.0%	497	10.2%	15	0.3%	4895	1.30
Lougheed Highway - West of King Edward																
AM Period	4044	88.0%	470	10.2%	37	0.8%	3	0.1%	2	0.0%	541	9.5%	12	0.2%	5672	1.12
Noon Period	2333	79.3%	504	17.1%	68	2.3%	8	0.3%	0	0.0%	190	5.0%	14	0.4%	3781	1.23
PM Period	3912	78.2%	899	18.0%	110	2.2%	27	0.5%	0	0.0%	403	6.1%	21	0.3%	6572	1.24
Lougheed Highway - West of Colony Farm Road																
AM Period	3905	88.0%	444	10.0%	60	1.4%	12	0.3%	0	0.0%	363	6.7%	9	0.2%	5393	1.14
Noon Period	2376	77.4%	564	18.4%	97	3.2%	15	0.5%	2	0.1%	158	3.9%	11	0.3%	4036	1.27
PM Period	2188	74.5%	592	20.2%	103	3.5%	24	0.8%	0	0.0%	153	3.9%	22	0.6%	3952	1.30
Barnet Highway - West of Pine Tree Way																
AM Period	4334	82.6%	761	14.5%	64	1.2%	29	0.6%	0	0.0%	4	0.1%	15	0.2%	6183	1.19
Noon Period	1868	70.2%	664	25.0%	83	3.1%	21	0.8%	0	0.0%	5	0.1%	15	0.4%	3549	1.34
PM Period	3745	71.0%	1159	22.0%	230	4.4%	96	1.8%	1	0.0%	45	0.6%	21	0.3%	7209	1.37
Pattullo Bridge																
AM Period	7323	81.0%	1253	13.9%	124	1.4%	44	0.5%	1	0.0%	164	1.5%	50	0.5%	10597	1.19
Noon Period	2967	77.3%	719	18.7%	103	2.7%	33	0.9%	0	0.0%	1	0.0%	27	0.6%	4874	1.27
PM Period	5981	78.5%	1333	17.5%	188	2.5%	92	1.2%	0	0.0%	73	0.8%	35	0.4%	9687	1.26
Mary Hill Bypass																
AM Period	5338	88.2%	580	9.6%	47	0.8%	5	0.1%	0	0.0%	147	2.2%	10	0.1%	6816	1.12
Noon Period	2135	78.3%	472	17.3%	50	1.8%	22	0.8%	0	0.0%	239	6.7%	6	0.2%	3562	1.24
PM Period	3208	79.9%	670	16.7%	41	1.0%	42	1.0%	0	0.0%	116	2.3%	8	0.2%	4963	1.22

Note:
Single Occupant Vehicles include Cars, Trucks, Motorcycles, and Bicycles
Occupancy %s = Number of Vehicles in each Occupancy Category/Total number of Vehicles
Bus Occupancy %s = Number of Bus Occupants/Total Number of Occupants
Vehicle Occupancy = Total Occupants/Total Vehicles (excluding Buses and Taxis)

Exhibit 4.1.5 - Parallel Route Vehicle Classification – Weekday Peak Period

EASTBOUND

	Cars		Trucks		Motorcycles		Bicycles		Buses		Taxi		Total Vehicles	
Canada Way - West of 10th Avenue														
AM Period	1723	94.6%	63	3.5%	8	0.4%	0	0.0%	16	0.9%	11	0.6%	1821	100%
Noon Period	1377	93.0%	75	5.1%	2	0.1%	1	0.1%	9	0.6%	16	1.1%	1480	100%
PM Period	3557	96.0%	93	2.5%	13	0.4%	5	0.1%	20	0.5%	17	0.5%	3705	100%
Lougheed Highway - West of Gaglardi Way														
AM Period	1485	80.4%	329	17.8%	7	0.4%	0	0.0%	20	1.1%	5	0.3%	1846	100%
Noon Period	1884	86.2%	271	12.4%	6	0.3%	1	0.0%	17	0.8%	6	0.3%	2185	100%
PM Period	4642	94.3%	222	4.5%	14	0.3%	19	0.4%	24	0.5%	4	0.1%	4925	100%
Lougheed Highway - West of King Edward														
AM Period	2749	89.5%	254	8.3%	14	0.5%	20	0.7%	18	0.6%	16	0.5%	3071	100%
Noon Period	2043	92.7%	139	6.3%	6	0.3%	0	0.0%	9	0.4%	6	0.3%	2203	100%
PM Period	4898	94.2%	214	4.1%	40	0.8%	11	0.2%	19	0.4%	19	0.4%	5201	100%
Lougheed Highway - West of Colony Farm Road														
AM Period	2589	89.6%	238	8.2%	14	0.5%	2	0.1%	31	1.1%	15	0.5%	2889	100%
Noon Period	2797	93.0%	182	6.1%	11	0.4%	0	0.0%	11	0.4%	6	0.2%	3007	100%
PM Period	6974	96.4%	176	2.4%	42	0.6%	10	0.1%	17	0.2%	13	0.2%	7232	100%
Barnet Highway - West of Pine Tree Way														
AM Period	2040	91.4%	107	4.8%	10	0.4%	7	0.3%	60	2.7%	8	0.4%	2232	100%
Noon Period	2328	92.1%	139	5.5%	10	0.4%	11	0.4%	29	1.1%	10	0.4%	2527	100%
PM Period	4786	94.8%	136	2.7%	35	0.7%	8	0.2%	71	1.4%	14	0.3%	5050	100%
Pattullo Bridge														
AM Period	4544	94.3%	210	4.4%	24	0.5%	22	0.5%	5	0.1%	13	0.3%	4818	100%
Noon Period	3289	91.8%	251	7.0%	17	0.5%	4	0.1%	2	0.1%	19	0.5%	3582	100%
PM Period	11303	95.5%	393	3.3%	89	0.8%	7	0.1%	8	0.1%	31	0.3%	11831	100%
Mary Hill Bypass														
AM Period	2637	86.6%	376	12.3%	12	0.4%	5	0.2%	15	0.5%	0	0.0%	3045	100%
Noon Period	2373	85.1%	386	13.8%	18	0.6%	0	0.0%	11	0.4%	2	0.1%	2790	100%
PM Period	7729	93.5%	460	5.6%	55	0.7%	6	0.1%	7	0.1%	6	0.1%	8263	100%

WESTBOUND

	Cars		Trucks		Motorcycles		Bicycles		Buses		Taxi		Total Vehicles	
Canada Way - West of 10th Avenue														
AM Period	2643	96.0%	68	2.5%	11	0.4%	3	0.1%	19	0.7%	8	0.3%	2752	100%
Noon Period	1374	93.5%	63	4.3%	9	0.6%	0	0.0%	9	0.6%	15	1.0%	1470	100%
PM Period	2752	96.2%	57	2.0%	15	0.5%	3	0.1%	16	0.6%	17	0.6%	2860	100%
Lougheed Highway - West of Gaglardi Way														
AM Period	4676	93.1%	270	5.4%	22	0.4%	29	0.6%	22	0.4%	5	0.1%	5024	100%
Noon Period	2038	87.1%	261	11.2%	9	0.4%	3	0.1%	20	0.9%	8	0.3%	2339	100%
PM Period	3108	91.0%	251	7.3%	10	0.3%	9	0.3%	27	0.8%	10	0.3%	3415	100%
Lougheed Highway - West of King Edward														
AM Period	4119	89.7%	408	8.9%	14	0.3%	20	0.4%	24	0.5%	8	0.2%	4593	100%
Noon Period	2586	87.9%	318	10.8%	11	0.4%	0	0.0%	18	0.6%	9	0.3%	2942	100%
PM Period	4596	91.9%	325	6.5%	28	0.6%	11	0.2%	29	0.6%	14	0.3%	5003	100%
Lougheed Highway - West of Colony Farm Road														
AM Period	4241	95.5%	151	3.4%	19	0.4%	10	0.2%	14	0.3%	5	0.1%	4440	100%
Noon Period	2794	91.0%	250	8.1%	9	0.3%	1	0.0%	8	0.3%	7	0.2%	3069	100%
PM Period	2725	92.8%	167	5.7%	11	0.4%	4	0.1%	17	0.6%	13	0.4%	2937	100%
Barnet Highway - West of Pine Tree Way														
AM Period	4981	94.9%	209	4.0%	35	0.7%	10	0.2%	6	0.1%	9	0.2%	5250	100%
Noon Period	2441	91.8%	175	6.6%	23	0.9%	9	0.3%	1	0.0%	11	0.4%	2660	100%
PM Period	5095	96.6%	135	2.6%	14	0.3%	8	0.2%	13	0.2%	12	0.2%	5277	100%
Pattullo Bridge														
AM Period	8615	95.2%	342	3.8%	46	0.5%	0	0.0%	8	0.1%	35	0.4%	9046	100%
Noon Period	3558	92.7%	238	6.2%	26	0.7%	0	0.0%	2	0.1%	16	0.4%	3840	100%
PM Period	7303	95.8%	237	3.1%	54	0.7%	0	0.0%	7	0.1%	20	0.3%	7621	100%
Mary Hill Bypass														
AM Period	5604	92.6%	390	6.4%	29	0.5%	12	0.2%	7	0.1%	8	0.1%	6050	100%
Noon Period	2297	84.2%	403	14.8%	11	0.4%	0	0.0%	13	0.5%	3	0.1%	2727	100%
PM Period	3599	89.7%	357	8.9%	30	0.7%	4	0.1%	16	0.4%	7	0.2%	4013	100%

Exhibit 4.1.6 - Parallel Route Travel Time Survey Locations

- Northern Route (24.1km): Between Lougheed Highway/Boundary Road and Mary Hill Bypass/Lougheed Highway via Lougheed Highway, United Boulevard and Mary Hill Bypass

- Southern Route (22.3km): Between Canada Way/Boundary Road and 104 Avenue/160 Street via Canada Way, McBride Boulevard, Pattullo Bridge, King George Highway, and 104 Avenue

The travel time-distance plots of the northern and southern routes are shown in Exhibit 4.1.7 and 4.1.8 respectively by direction and time period.

It can be seen that the travel times in the non-peak direction are more consistent while the peak direction travel times have a larger variance. The maximum, minimum and average travel times are tabulated in Exhibit 4.1.9.

Exhibit 4.1.9 - Parallel Route Travel Time

PERIOD	DIR		NORTHERN ROUTE TRAVEL TIME (MIN)	SOUTHERN ROUTE TRAVEL TIME (MIN)
AM-PEAK	EB	MAX	30.3	39.2
		MIN	26.2	28.3
		AVERAGE	**28.1**	**31.4**
	WB	MAX	65.1	58.9
		MIN	30.9	35.1
		AVERAGE	**45.3**	**45.2**
PM-PEAK	EB	MAX	42.7	49.5
		MIN	30.3	36.5
		AVERAGE	**35**	**42.8**
	WB	MAX	46.2	37.4
		MIN	31.4	34.6
		AVERAGE	**37.2**	**36**

Note: Shading indicates peak direction

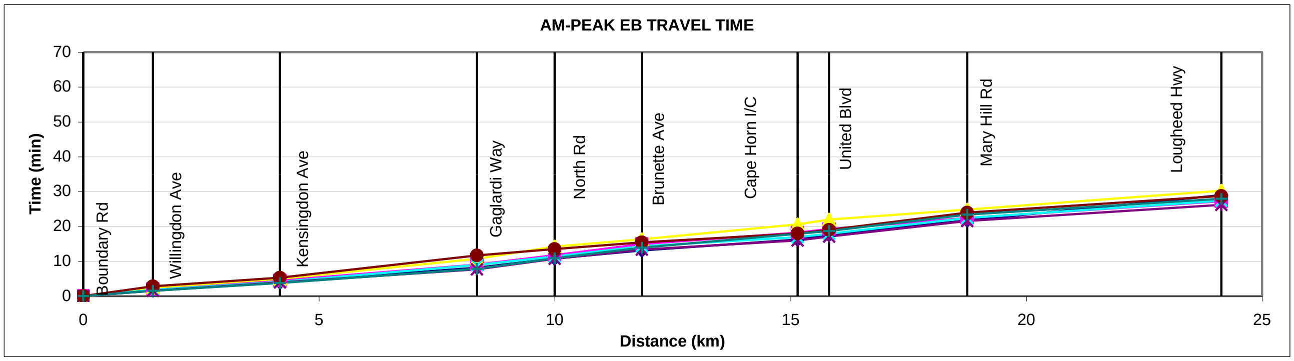
It should be noted that only six AM and six PM peak period return travel time runs were collected, thus contributing to variance high variances above.

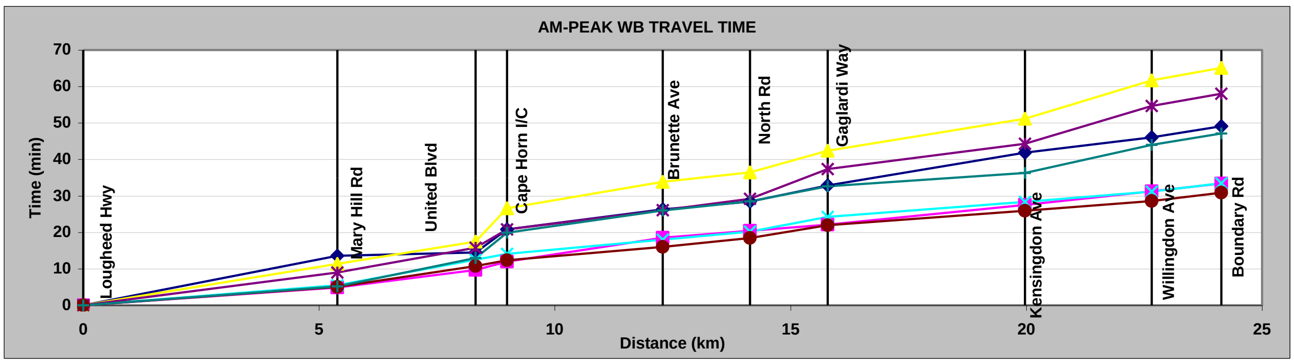
Exhibit 4.1.10 presents the summary charts of the end-to-end average travel time and speed for both parallel routes.

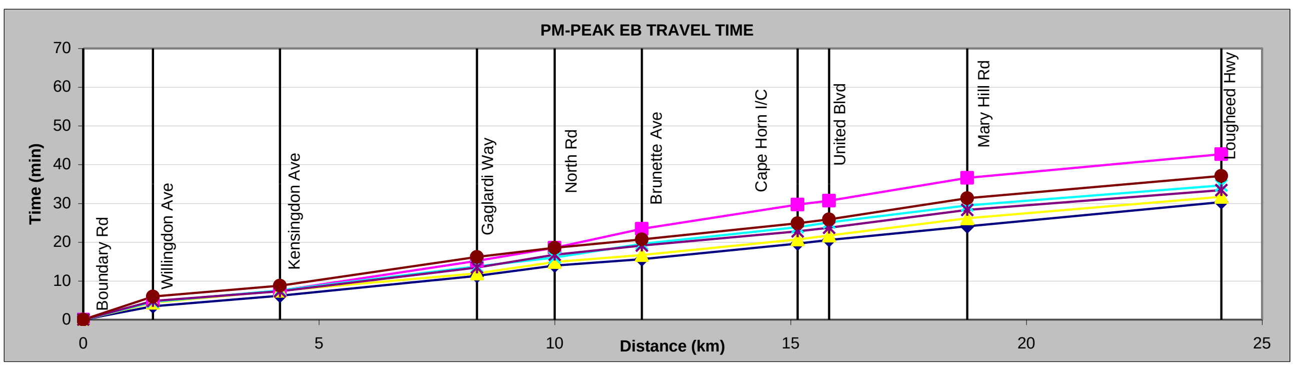
- The off-peak direction average travel speed during AM peak period is found to be approximately 20 km/hr faster on the northern route and 13 km/hr faster on the southern route when comparing to the peak direction speed. However, during the PM peak period the average travel speeds are relatively constant with the off-peak direction slightly faster than the peak direction (slower for the northern route).

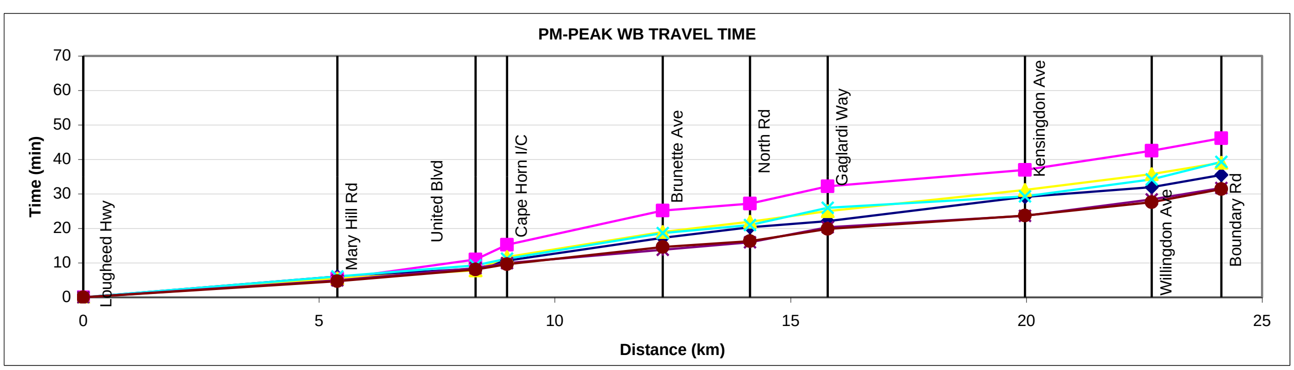
- In the peak direction, traffic on both routes are observed to travel at approximately 30 km/hr (AM westbound), and between 31 and 41 km/hr along the southern and northern routes respectively (PM eastbound direction).

Exhibit 4.1.7 - Northern Parallel Route Time-Distance Diagram



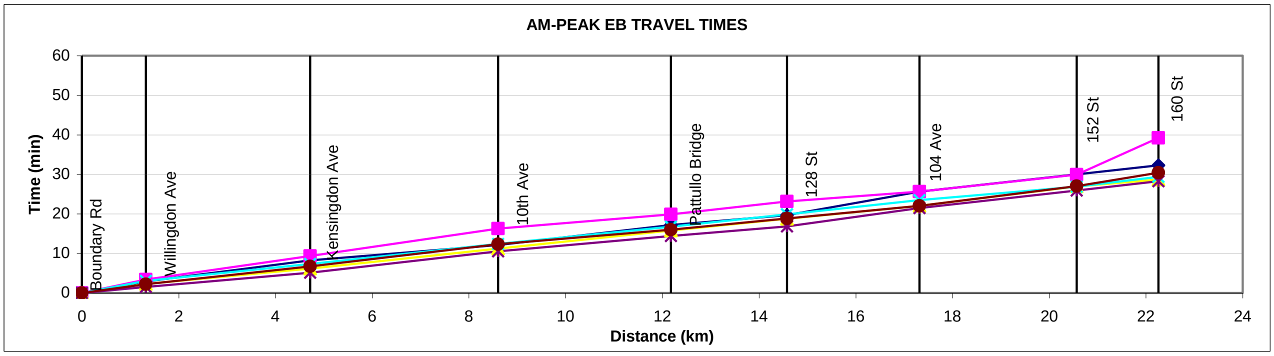


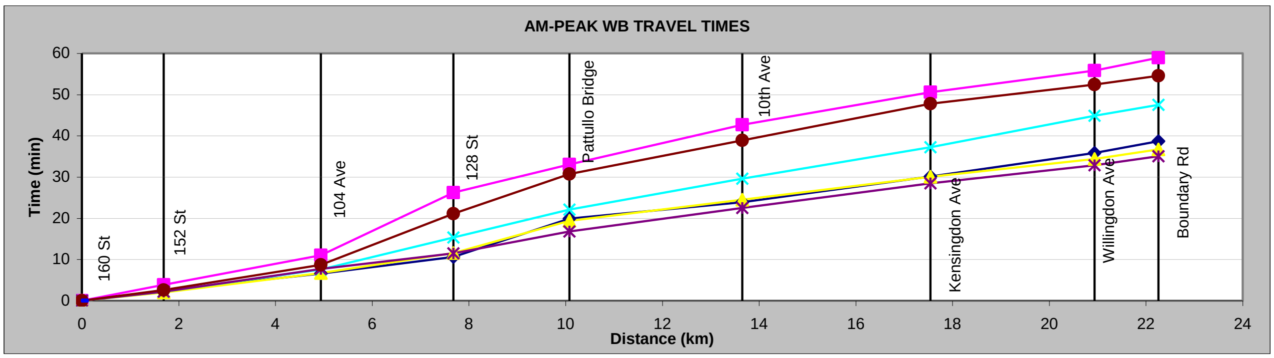


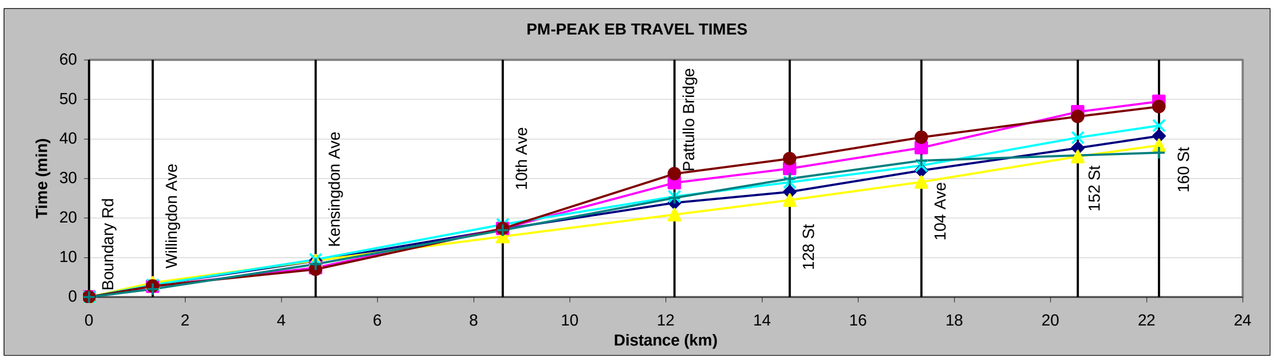


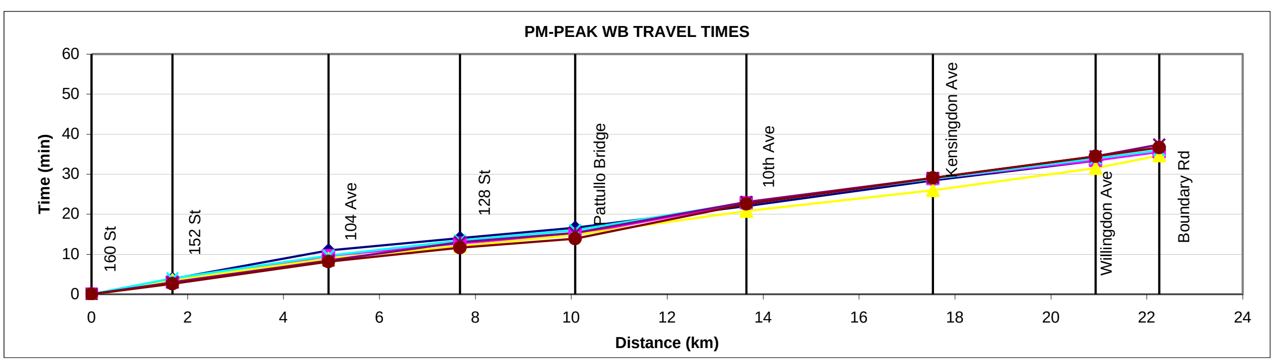
NOTE: Shaded area indicate peak direction

Exhibit 4.1.8 - Southern Parallel Route Time-Distance Diagram







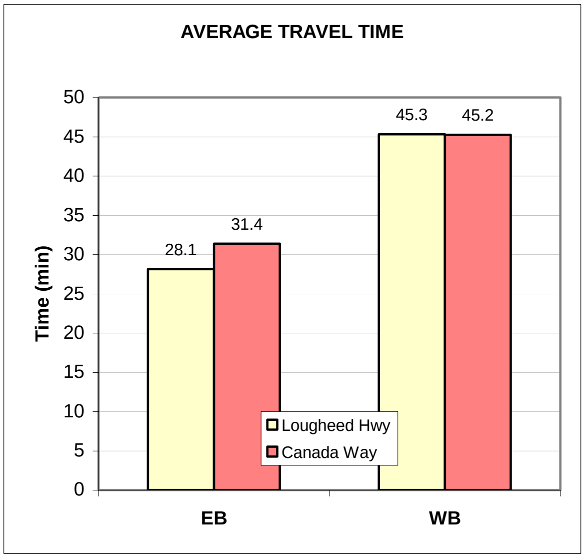


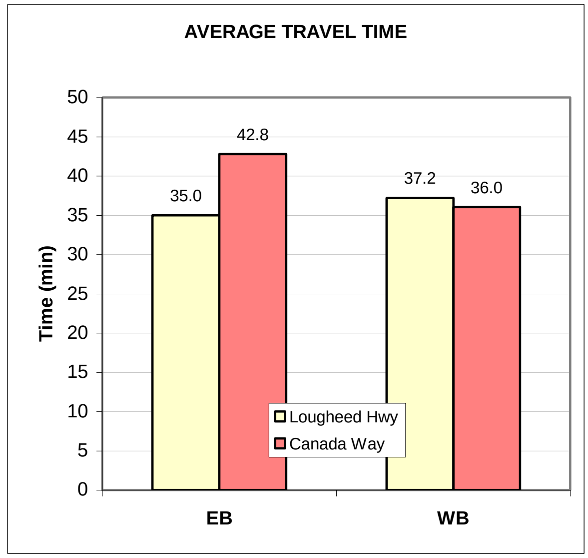
NOTE: Shaded area indicate peak direction

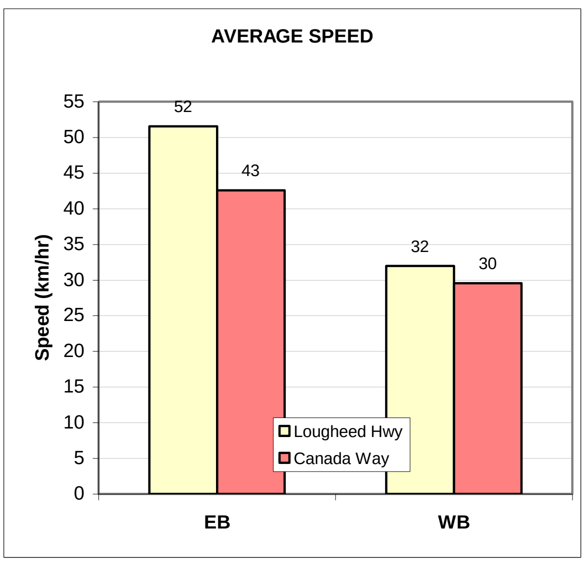
Exhibit 4.1.10 - Parallel Route Average Travel Time & Speed

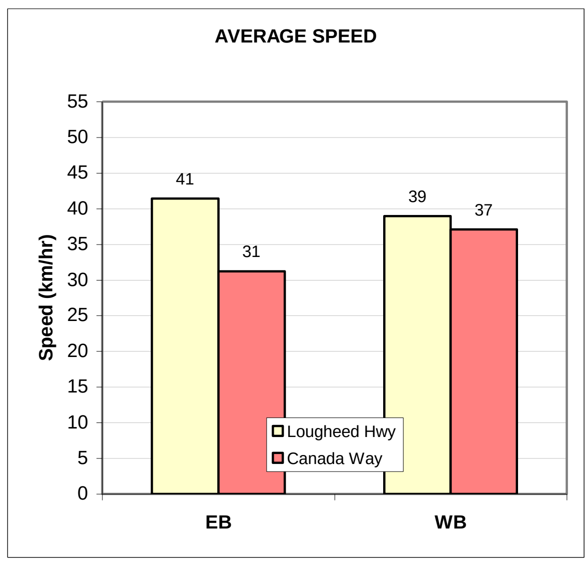
AM - PEAK

PM - PEAK









4.1.4 Intersection Capacities

Manual peak hour turning movement counts at major intersections along the adjacent parallel routes were collected to evaluate the existing intersection performance, and to determine the availability of any spare capacity at these intersections. The parallel route AM, Mid-Day and PM peak hour turning movement intersection counts as well as the level of service analysis are summarized in Exhibit 4.1.11, 4.1.12 and 4.1.13 respectively.

The results indicate that the majority of the intersections evaluated along the parallel routes are operating near capacity during the weekday peak periods, and the opportunity for the redistribution of traffic from Highway 1 onto the parallel routes may therefore be limited during these time periods.

Exhibit 4.1.11 - AM Peak Hour Intersection Capacity Analysis

AM-PEAK HOUR																	
E/W STREET	N/S STREET			EB			WB			NB			SB			INTERSECTION	
				L	T	R	L	T	R	L	T	R	L	T	R	DELAY	LOS
Fern	Route 1 EB Ramp		Lane	1	2			1	1				2		1		
			Volume	364	740			564	378				445		67		
			v/c	0.81	0.31			0.83	0.22				0.71		0.04		
		Lane Gp	Delay	43.2	5.2			35.3	0.3				37.6		0.0+		
			LOS	D	A			D	A				D		A		
		Approach	Delay		17.8			22.1						33.1			
			LOS		B			C						C		23	C
Fern	Mountain Hwy		Lane				1		1		1	1	1	1			
			Volume				337		270		90	234	835	409			
			v/c				0.85		0.23		0.23	0.28	0.83				
		Lane Gp	Delay				57		5.9		30.3	14.3	17.4				
			LOS				E		A		C	B	B				
		Approach	Delay					35.5			19.1						
			LOS					D			B						
Mt Seymour Parkway	Fern		Lane				1 >	2	1	1	2	2	1	2	1		
			Volume				772	827	170	114	1147	670	83	240	300		
			v/c				0.74	0.65	0.1	0.33	1.04	0.23	0.45	0.16	0.18		
		Lane Gp	Delay				30.8	25.2	0.1	31.4	136.5	0.2	59.3	19.8	0.2		
			LOS				C	C	A	C	F	A	E	B	A		
		Approach	Delay					24.9			86			16.4			
			LOS					C			F			B		54.2	D
Main St	Mountain Hwy		Lane	1	2	<	1	2	<	>	2	1	1	1	<		
			Volume	116	1472	13	172	1432	141	46	29	235	396	222	24		
			v/c	0.56	1.04		0.83	1.11			0.35	0.15	1.67	0.99			
		Lane Gp	Delay	51.2	123.3		77.6	230.3			49	0.2		141.3			
			LOS	D	F		E	F			D	A		F			
		Approach	Delay		118.1			215.1			13.1						
			LOS		F			F			B						
Grandview Ave	Boundary Rd		Lane		2	1		2	1	1	2	1	1	3	<		
			Volume		1176	608		1417	70	427	1473	273	63	1188	94		
			v/c		0.89	0.36		1.07	0.11	0.84	1.45	0.16	0.18	1.22			
		Lane Gp	Delay		42.8	0.6		181.4	22.8	57.8	862.3	0.2	42	447.8			
			LOS		D	A		F	C	E	F	A	D	F			
		Approach	Delay		29.5			174.8			603.5			428.7			
			LOS		C			F			F			F		325.6	F
Route 7A	Cassiar		Lane	1	3	1	1	3	1	2	2	1	2	2	1		
			Volume	45	529	215	86	1779	898	507	38	52	510	50	72		
			v/c	0.17	0.4	0.12	0.33	1.36	0.74	0.67	0.05	0.03	0.67	0.06	0.04		
		Lane Gp	Delay	50.7	41.3	0.2	53.8	697.5	16.4	51.5	40.4	0.0+	51.6	40.6	0.0+		
			LOS	D	D	A	D	F	B	D	D	A	D	D	A		
		Approach	Delay		31.5			470.8			46.7			45.4			
			LOS		C			F			D			D		291.5	F
Route 7	Willingdon		Lane	1	2	1	1	2	1	1	3	<	1	3	<		
			Volume	98	979	95	362	1732	187	165	422	190	181	872	90		
			v/c	0.55	0.73	0.05	1.14	1.06	0.11	0.77	0.71		0.85	1.11			
		Lane Gp	Delay	77.9	44.2	0.1	349.9	172.1	0.1	92.4	65.7		107.3	276			
			LOS	E	D	A	F	F	A	F	E		F	F			
		Approach	Delay		43.8			187.8			71.5			249			
			LOS		D			F			E			F		152.8	F
Canada Way	Willingdon		Lane	1	2	<	1	2	1	1	2	1	1	2	1		
			Volume	240	683	136	123	644	390	145	894	130	464	1237	253		
			v/c	0.94	0.72		0.96	0.72	0.22	0.57	1	0.07	1.23	1.09	0.14		
		Lane Gp	Delay	128	46.2		189.4	53.4	0.3	65.3	115.9	0.1	495	222.1	0.2		
			LOS	F	D		F	D	A	E	F	A	F	F	A		
		Approach	Delay		64.9			51.7			97.8			261.6			
			LOS		E			D			F			F		148	F
Canada Way	Kensington		Lane	1	2			2	1				2		1		
			Volume	308	398			1176	1321				1035		840		
			v/c	0.72	0.41			1.22	0.75				0.74		0.48		
		Lane Gp	Delay	65.8	44.9			456.1	3.3				40.1		1		
			LOS	E	D			F	A				D		A		
		Approach	Delay		54			228.5						23.6			
			LOS		D			F						C		151	F
Sprott	Kensington		Lane	1 >	1	<	>	1	<	1	1	<		1	1		
			Volume	376	10	107	37	105	2	324	440	13		773	1164		
			v/c	0.76	1.27			1.27		1.06	0.4			0.93	0.71		
		Lane Gp	Delay	77.1	576.9			608		222.1	11.9			57.9	2.7		
			LOS	E	F			F		F	B			E	A		
		Approach	Delay		386.2			608			99.7			26.1			
			LOS		F			F			F			C		181.9	F

Exhibit 4.1.11 Cont…

AM-PEAK HOUR

E/W STREET	N/S STREET			EB L	EB T	EB R	WB L	WB T	WB R	NB L	NB T	NB R	SB L	SB T	SB R	INTERSECTION DELAY	INTERSECTION LOS
Cariboo	Gaglardi		Lane				1		1		2	1	1	2			
			Volume				547		377		965	338	630	923			
			v/c				1.37		0.23		1.27	0.2	0.89				
		Lane Gp	Delay				726.6		0.3		527.9	0.3	48.1				
			LOS				F		A		F	A	D				
		Approach	Delay					448.4			401.5						
			LOS					F			F						
Braid	Brunette		Lane	2	1	1	1	1	1	>	3	<	1	2	1		
			Volume	524	79	24	38	26	61	2	1159	45	144	1557	842		
			v/c	1.01	0.28	0.01	0.33	0.22	0.04		0.73		0.44	0.81	0.52		
		Lane Gp	Delay	119	33.3	0.0+	44.6	41	0.0+		25.5		15.3	17.5	1.2		
			LOS	F	C	A	D	D	A		C		B	B	A		
		Approach	Delay		104			23.2			25.5			12.4			
			LOS		F			C			C			B		35.1	D
Mary Hill Bypass	United Blvd		Lane	1	2		1		2		2	1	2	2			
			Volume	107	547		2081		780		144	51	489	372			
			v/c	0.51	1.31		3.32		0.35		0.58	0.04	1.21				
		Lane Gp	Delay	59.9	629.8				0.3		66.6	0.0+	451.2				
			LOS	E	F				A		E	A	F				
		Approach	Delay		536.6						50.5						
			LOS		F						D						
Route 7 WB Ramp	United Blvd		Lane				2		1		1	2	1	2			
			Volume				147		228		469	1265	225	317			
			v/c				0.21		0.13		0.53	0.42	1.33				
		Lane Gp	Delay				24.1		0.2		14.9	0.5	664.3				
			LOS				C		A		B	A	F				
		Approach	Delay					10.2			4.7						
			LOS					B			A						
108 Ave	152 St		Lane	1	2	1	1	2	1	1	2	1	1	2	1		
			Volume	230	202	89	17	185	141	42	659	15	118	1150	395		
			v/c	0.71	0.31	0.08	0.07	0.36	0.14	0.17	0.77	0.01	0.48	1.34	0.24		
		Lane Gp	Delay	40.4	27	3.8	27.4	30.1	5.4	33.2	31.7	0.0+	21.7	641.4	0.4		
			LOS	D	C	A	C	C	A	C	C	A	C	F	A		
		Approach	Delay		29.4			20.4			31.2			456.3			
			LOS		C			C			C			F		277.8	F
104 Ave North	160 St		Lane				1	1	<	>	1	<	>	1	<		
			Volume				277	197	34	460	203	217	13	513	91		
			v/c				1.28	1.02	0	0	1.1	0	0	1.03	0		
		Lane Gp	Delay				565.1	162.8	0	0	206.9	0	0	128.5	0		
			LOS				F	F	0	0	F	0	0	F	0		
		Approach	Delay					383.7			206.9			128.5			
			LOS					F			F			F		228	F
104 Ave	160 St		Lane	1	2	1	1	2	1	1	1	1	1	1	1		
			Volume	350	610	299	139	704	6	54	483	56	49	291	302		
			v/c	0.76	0.48	0.18	0.33	0.72	0	0.22	0.87	0.06	0.55	0.52	0.3		
		Lane Gp	Delay	28.3	20.6	0.2	17.2	30.3	0.0+	22.4	44.7	7.1	45.3	26.1	9.1		
			LOS	C	C	A	B	C	A	C	D	A	D	C	A		
		Approach	Delay		18.3			28			39.5			20.1			
			LOS		B			C			D			C		26.4	C
Route 7	United Blvd		Lane	2	2			2	1				1		2		
			Volume	90	1618			1190	323				32		1335		
			v/c	0.38	6.55			0.57	0.22				0.26		0.52		
		Lane Gp	Delay	54.9				8.8	0.3				55.0-		0.7		
			LOS	D				A	A				D		A		
		Approach	Delay					7.2						2.1			
			LOS					A						A			
Route 7	Gaglardi		Lane	1	2	1	1	2	1	1 >	2	1	1 >	2	1		
			Volume	131	482	458	394	1132	200	525	746	194	57	764	355		
			v/c	0.67	0.69	0.28	1.15	1.15	0.12	1.24	1.13	0.12	0.21	1.37	0.22		
		Lane Gp	Delay	66.1	47.9	0.4	357.1	319.2	0.2	505.4	303.7	0.2	43.5	722.1	0.3		
			LOS	E	D	A	F	F	A	F	F	A	D	F	A		
		Approach	Delay		31.2			294.2			330			485.9			
			LOS		C			F			F			F		313.1	F

Exhibit 4.1.12 - MID-DAY Peak Hour Intersection Capacity Analysis

MIDDAY-PEAK HOUR

E/W	N/S			EB			WB			NB			SB			INTERSECTION	
STREET	STREET			L	T	R	L	T	R	L	T	R	L	T	R	DELAY	LOS
Fern	Route 1 EB Ramp		Lane	1	2			1	1				2		1		
			Volume	364	740			564	378				445		67		
			v/c	0.61	0.25			0.66	0.32				0.74		0.05		
		Lane Gp	Delay	32.2	4.9			25.9	0.5				38.7		0.1		
			LOS	C	A			C	A				D		A		
		Approach	Delay		13.5			12.4						32.8			
			LOS		B			B						C		18.1	B
Fern	Mountain Hwy		Lane				1		1		1	1	1	1			
			Volume				262		209		158	251	668	206			
			v/c				0.72		0.19		0.43	0.32	0.77				
		Lane Gp	Delay				42.9		5.6		33.7	14.8	14.9				
			LOS				D		A		C	B	B				
		Approach	Delay					27.3			22.6						
			LOS					C			C						
Mt Seymour Parkway	Fern		Lane				1 >	2	1	1	2	2	1	2	1		
			Volume				596	610	80	98	424	1062	157	474	388		
			v/c				0.9	0.75	0.05	0.34	0.35	0.38	0.37	0.28	0.25		
		Lane Gp	Delay				50.2	28.8	0.1	20.1	18.1	0.4	11.9	10.2	0.4		
			LOS				D	C	A	C	B	A	B	B	A		
		Approach	Delay					34.8			6.8			7			
			LOS					C			A			A		18.1	B
Main St	Mountain Hwy		Lane	1	2	<	1	2	<	>	2	1	1	1	<		
			Volume	115	970	38	151	893	104	110	81	157	257	122	145		
			v/c	0.53	0.87		0.7	0.86			0.46	0.09	0.77	0.78			
		Lane Gp	Delay	50.7	40.8		60.8	40.4			44.7	0.1	55.7	57			
			LOS	D	D		E	D			D	A	E	E			
		Approach	Delay		41.9			43.1			25.8			56.4			
			LOS		D			D			C			E		43	D
Grandview Ave	Boundary Rd		Lane		2	1		2	1	1	2	1	1	3	<		
			Volume		977	353		1105	80	451	1031	271	139	1179	119		
			v/c		0.72	0.2		0.82	0.12	0.87	1	0.16	0.38	1.21			
		Lane Gp	Delay		33.3	0.3		37.3	23	62	91.9	0.2	28.6	427.8			
			LOS		C	A		D	C	E	F	A	C	F			
		Approach	Delay		25.2			36.4			71.1			388.8			
			LOS		C			D			E			F		133.8	F
Route 7A	Cassiar		Lane	1	3	1	1	3	1	2	2	1	2	2	1		
			Volume	81	688	324	74	731	469	245	26	58	452	75	89		
			v/c	0.31	0.52	0.19	0.28	0.55	0.38	0.32	0.03	0.03	0.59	0.09	0.05		
		Lane Gp	Delay	53.3	43.2	0.3	52.7	43.9	8.8	44.1	40.3	0.0+	49.3	41	0.1		
			LOS	D	D	A	D	D	A	D	D	A	D	D	A		
		Approach	Delay		32.2			32.3			36.6			41.8			
			LOS		C			C			D			D		35.4	D
Route 7	Willingdon		Lane	1	2	1	1	2	1	1	3	<	1	3	<		
			Volume	288	900	114	349	1104	209	236	888	298	292	766	81		
			v/c	1.11	0.92	0.07	1.35	1.13	0.13	0.91	1.32	0	1.13	0.94			
		Lane Gp	Delay	303.8	56.1	0.1	704.3	292.4	0.2	96.7	632.8	0	325.6	67.6			
			LOS	F	E	A	F	F	A	F	F	0	F	E			
		Approach	Delay		106.9			346.5			542			134.2			
			LOS		F			F			F			F		295.7	F
Canada Way	Willingdon		Lane	1	2	<	1	2	1	1	2	1	1	2	1		
			Volume	303	424	102	123	515	352	112	920	101	310	1055	319		
			v/c	1.2	0.47		0.98	0.58	0.2	0.44	1.04	0.06	0.83	0.94	0.18		
		Lane Gp	Delay	462.1	39.5		202.2	49.1	0.3	60.7	164.3	0.1	74.5	66.4	0.2		
			LOS	F	D		F	D	A	E	F	A	E	E	A		
		Approach	Delay		195.7			52.7			140.7			56.4			
			LOS		F			D			F			E		108.3	F
Canada Way	Kensington		Lane	1	2			2	1				2		1		
			Volume	334	543			459	796				768		255		
			v/c	0.64	0.58			0.49	0.47				0.56		0.15		
		Lane Gp	Delay	29	48.6			46.5	1				34.9		0.2		
			LOS	C	D			D	A				C		A		
		Approach	Delay		41.1			18.8						26.9			
			LOS		D			B						C		30.1	C
Sprott	Kensington		Lane	1 >	1	<	>	1	<	1	1	<		1	1		
			Volume	377	19	148	23	17	10	179	363	14		368	554		
			v/c	0.67	0.86			0.31		0.51	0.45			0.65	0.34		
		Lane Gp	Delay	42.3	60.7			42.5		20.5	17			32.2	0.6		
			LOS	D	E			D		C	B			C	A		
		Approach	Delay		52.4			42.5			18.1			14			
			LOS		D			D			B			B		34.5	C

Exhibit 4.1.12 Cont…

MIDDAY-PEAK HOUR

E/W STREET	N/S STREET			EB L	EB T	EB R	WB L	WB T	WB R	NB L	NB T	NB R	SB L	SB T	SB R	INTERSECTION DELAY	INTERSECTION LOS
Cariboo	**Gaglardi**		Lane				1		1		2	1	1	2			
			Volume				259		211		747	311	273	675			
			v/c				0.65		0.13		0.98	0.19	0.39				
		Lane Gp	Delay				42.5		0.2		85.1	0.3	12.7				
			LOS				D		A		F	A	B				
		Approach	Delay					24.6			62						
			LOS					C			E						
Braid	**Brunette**		Lane	2	1	1	1	1	1	>	3	<	1	2	1		
			Volume	518	43	39	69	49	121	7	1119	23	94	1108	494		
			v/c	0.83	0.13	0.02	0.4	0.27	0.07		0.67		0.39	0.62	0.29		
		Lane Gp	Delay	44.1	27.8	0.0+	40.4	36.9	0.1		22.8		16.1	14.8	0.5		
			LOS	D	C	A	D	D	A		C		B	B	A		
		Approach	Delay		40.3			20.3			22.8			11			
			LOS		D			C			C			B		22.9	C
Mary Hill Bypass	**United Blvd**		Lane	1	2		1		2		2	1	2	2			
			Volume	79	515		1238		304		278	166	572	366			
			v/c	0.33	1.06		5.12		0.1		0.43	0.1	0.61				
		Lane Gp	Delay	42.7	201.8				0.1		38.4	0.1	34.1				
			LOS	D	F				A		D	A	C				
		Approach	Delay		180.7						25						
			LOS		F						C						
Route 7 WB Ramp	**United Blvd**		Lane				2		1		1	2	1	2			
			Volume				63		157		519	977	229	272			
			v/c				0.1		0.09		0.49	0.32	1.71				
		Lane Gp	Delay				34.3		0.1		14	0.3					
			LOS				C		A		B	A					
		Approach	Delay					10.7			5.4						
			LOS					B			A						
108 Ave	**152 St**		Lane	1	2	1	1	2	1	1	2	1	1	2	1		
			Volume	214	155	129	10	119	69	108	888	13	57	892	297		
			v/c	0.49	0.18	0.07	0.04	0.24	0.04	0.46	0.89	0.01	0.24	0.9	0.17		
		Lane Gp	Delay	31.6	25.9	0.1	32.1	33.8	0.0+	25.1	43.5	0.0+	20.5	44.1	0.2		
			LOS	C	C	A	C	C	A	C	D	A	C	D	A		
		Approach	Delay		22.2			22.7			41.1			33.4			
			LOS		C			C			D			C		36.9	D
104 Ave North	**160 St**		Lane				1	1	<	>	1	<	>	1	<		
			Volume				188	80	36	174	221	179	13	241	23		
			v/c				0.39	0.23			0.74			0.5			
		Lane Gp	Delay				21.2	19.1			17.5			19.6			
			LOS				C	B			B			B			
		Approach	Delay					20.4			17.5			19.6			
			LOS					C			B			B		18.8	B
104 Ave	**160 St**		Lane	1	2	1	1	2	1	1	1	1	1	1	1		
			Volume	252	511	245	139	444	4	54	361	109	44	211	212		
			v/c	0.4	0.37	0.14	0.45	0.68	0	0.16	0.6	0.06	0.2	0.35	0.12		
		Lane Gp	Delay	12.5	17.9	0.2	27.5	36	0.0+	20.3	27.3	0.1	21.7	22.3	0.2		
			LOS	B	B	A	C	D	A	C	C	A	C	C	A		
		Approach	Delay		12.5			33.8			21.3			12.8			
			LOS		B			C			C			B		20.9	C
Route 7	**United Blvd**		Lane	2	2			2	1				1		2		
			Volume	144	1590			1193	94				45		1951		
			v/c	0.46	4.97			0.5	0.06				0.28		0.64		
		Lane Gp	Delay	51.5				8.6	0.1				50.1		1.1		
			LOS	D				A	A				D		A		
		Approach	Delay					8						2.4			
			LOS					A						A			
Route 7	**Gaglardi**		Lane	1	2	1	1	2	1	1 >	2	1	1 >	2	1		
			Volume	129	915	299	312	821	78	258	275	363	80	398	112		
			v/c	0.49	1	0.17	0.87	0.75	0.05	0.66	0.58	0.21	0.27	0.68	0.07		
		Lane Gp	Delay	51.7	102.6	0.2	73	40.5	0.1	57.1	48.9	0.3	44.6	51.8	0.1		
			LOS	D	F	A	E	D	A	E	D	A	D	D	A		
		Approach	Delay		76.7			46.6			32.3			41.8			
			LOS		E			D			C			D		54.1	D

Exhibit 4.1.13 - PM Peak Hour Intersection Capacity Analysis

PM-PEAK HOUR

E/W STREET	N/S STREET			EB L	EB T	EB R	WB L	WB T	WB R	NB L	NB T	NB R	SB L	SB T	SB R	INTERSECTION DELAY	INTERSECTION LOS
			Lane	1	2			1	1				2		1		
			Volume	270	593			435	546				452		91		
Fern	Route 1 EB Ramp		v/c	0.89	0.39			0.78	0.4				1.05		0.07		
		Lane Gp	Delay	58.4	7			33.2	0.7				159.8		0.1		
			LOS	E	A			C	A				F		A		
		Approach	Delay		22.6			15.2						140.1			
			LOS		C			B						F		54.2	D
			Lane				1		1		1	1	1	1			
			Volume				277		213		200	332	939	282			
Fern	Mountain Hwy		v/c				0.76		0.19		0.55	0.42	1.12				
		Lane Gp	Delay				45.8		5.7		36.5	16.3	255.4				
			LOS				D		A		D	B	F				
		Approach	Delay					29.4			24.4						
			LOS					C			C						
			Lane				1 >	2	1	1	2	2	1	2	1		
			Volume				577	637	91	159	437	1804	192	610	442		
Mt Seymour Parkway	Fern		v/c				0.7	0.6	0.06	0.6	0.34	0.63	0.5	0.37	0.27		
		Lane Gp	Delay				32.4	26.9	0.1	33.8	22.7	1.1	19.3	16.3	0.4		
			LOS				C	C	A	C	C	A	B	B	A		
		Approach	Delay					27.1			7.7			11.5			
			LOS					C			A			B		15.3	B
			Lane	1	2	<	1	2	<	>	2	1	1	1	<		
			Volume	124	1476	21	159	1277	161	98	101	312	333	87	127		
Main St	Mountain Hwy		v/c	0.46	1.01		0.59	0.98			0.76	0.19	1.24	0.78			
		Lane Gp	Delay	53.6	95		58.3	64.3			76.1	0.3	511.7	72.8			
			LOS	D	F		E	E			E	A	F	E			
		Approach	Delay		91.8			63.7			31.6			346.3			
			LOS		F			E			C			F		106.7	F
			Lane		2	1		2	1	1	2	1	1	3	<		
			Volume		1225	546		1361	73	549	1409	219	143	1131	106		
Grandview Ave	Boundary Rd		v/c		0.92	0.82		1.02	0.11	1.06	1.38	0.13	0.4	1.16			
		Lane Gp	Delay		46.5	44.4		104	22.8	201.3	722.8	0.2	46.2	349.9			
			LOS		D	D		F	C	F	F	A	D	F			
		Approach	Delay		45.9			100.3			524			318.1			
			LOS		D			F			F			F		267.9	F
			Lane	1	3	1	1	3	1	2	2	1	2	2	1		
			Volume	99	1513	599	92	877	517	204	258	61	655	61	93		
Route 7A	Cassiar		v/c	0.39	1.19	0.36	0.37	0.69	0.44	0.28	0.34	0.04	0.89	0.08	0.06		
		Lane Gp	Delay	55.3	402.5	0.6	54.6	47.1	9.5	43.4	44.3	0.0+	67.1	40.8	0.1		
			LOS	E	F	A	D	D	A	D	D	A	E	D	A		
		Approach	Delay		285.8			35.4			39.3			58			
			LOS		F			D			D			E		152	F
			Lane	1	2	1	1	2	1	1	3	<	1	3	<		
			Volume	218	1440	80	367	1427	227	260	943	339	343	835	148		
Route 7	Willingdon		v/c	1.66	1.32	0.05	1.74	1.14	0.14	1.59	1.37		1.11	0.73			
		Lane Gp	Delay		625.7	0.1		302.3	0.2		740.1		297.6	51.1			
			LOS		F	A		F	A		F		F	D			
		Approach	Delay											115.6			
			LOS											F			
			Lane	1	2	<	1	2	1	1	2	1	1	2	1		
			Volume	362	760	126	124	730	520	130	1045	88	394	1223	289		
Canada Way	Willingdon		v/c	1.44	0.79		0.98	0.83	0.3	0.52	1.18	0.05	1.06	1.09	0.16		
		Lane Gp	Delay	867.1	49		209	59.2	0.5	63.2	397.1	0.1	211.9	220.7	0.2		
			LOS	F	D		F	E	A	E	F	A	F	F	A		
		Approach	Delay		288.6			52.5			337.3			188.3			
			LOS		F			D			F			F		221.4	F
			Lane	1	2			2	1				2		1		
			Volume	601	913			497	1130				1103		281		
Canada Way	Kensington		v/c	1.19	0.98			0.53	0.66				0.81		0.16		
		Lane Gp	Delay	395.5	91.6			47.4	2.2				43.5		0.2		
			LOS	F	F			D	A				D		A		
		Approach	Delay		212.3			17						35.5			
			LOS		F			B						D		95.7	F
			Lane	1 >	1	<	>	1	<	1	1	<		1	1		
			Volume	1205	30	171	23	38	13	190	661	16		404	638		
Sprott	Kensington		v/c	0.57	1.64			0.64		0.79	0.92			0.76	0.38		
		Lane Gp	Delay	36.2				84		53.7	58.9			51.3	0.7		
			LOS	D				F		D	E			D	A		
		Approach	Delay					84			57.8			21.6			
			LOS					F			E			C			

Exhibit 4.1.13 Cont…

PM-PEAK HOUR

E/W	N/S			EB			WB			NB			SB			INTERSECTION	
STREET	STREET			L	T	R	L	T	R	L	T	R	L	T	R	DELAY	LOS
Cariboo	**Gaglardi**		Lane				1		1		2	1	1	2			
			Volume				393		548		910	625	542	842			
			v/c				0.89		0.32		2.06	0.37	0.63				
		Lane Gp	Delay				64.3		0.5			0.6	24.9				
			LOS				E		A			A	C				
		Approach	Delay					28.8									
			LOS					C									
Braid	**Brunette**		Lane	2	1	1	1	1	1	>	3	<	1	2	1		
			Volume	1061	35	35	86	62	157	3	1636	17	48	1110	590		
			v/c	1.02	0.06	0.02	1.01	0.69	0.09		0.85		0.37	0.64	0.35		
		Lane Gp	Delay	114.1	28.8	0.0+	258	96.3	0.1		36		29.5	23.3	0.6		
			LOS	F	C	A	F	F	A		D		C	C	A		
		Approach	Delay		108.4			97.2			36			16.4			
			LOS		F			F			D			B		56.1	E
Mary Hill Bypass	**United Blvd**		Lane	1	2		1		2		2	1	2	2			
			Volume	27	912		1040		233		421	848	1057	360			
			v/c	0.09	1.55		4.71		0.08		0.72	0.49	0.93				
		Lane Gp	Delay	41.9					0.1		53.6	1.1	54.5				
			LOS	D					A		D	A	D				
		Approach	Delay								19.8						
			LOS								B						
Route 7 WB Ramp	**United Blvd**		Lane				2		1		1	2	1	2			
			Volume				63		344		662	989	133	324			
			v/c				0.1		0.21		0.64	0.34	1.02				
		Lane Gp	Delay				34.3		0.3		17.1	0.3	221.6				
			LOS				C		A		B	A	F				
		Approach	Delay					6.1			7.5						
			LOS					A			A						
108 Ave	**152 St**		Lane	1	2	1	1	2	1	1	2	1	1	2	1		
			Volume	318	327	162	13	207	91	126	887	23	91	956	399		
			v/c	0.74	0.38	0.09	0.05	0.42	0.05	0.54	0.9	0.01	0.39	0.97	0.23		
		Lane Gp	Delay	41.1	28.1	0.1	32.2	36.1	0.1	28.4	44.7	0.0+	23.4	67.2	0.3		
			LOS	D	C	A	C	D	A	C	D	A	C	E	A		
		Approach	Delay		28.1			26.1			41.8			47.3			
			LOS		C			C			D			D		44	D
104 Ave North	**160 St**		Lane				1	1	<	>	1	<	>	1	<		
			Volume				306	98	52	353	442	350	11	321	21		
			v/c				1.57	0.74			1.28			1.38			
		Lane Gp	Delay					52.7			519.6			730.4			
			LOS					D			F			F			
		Approach	Delay								519.6			730.4			
			LOS								F			F			
104 Ave	**160 St**		Lane	1	2	1	1	2	1	1	1	1	1	1	1		
			Volume	581	1211	414	219	701	2	63	571	211	55	274	196		
			v/c	0.96	0.9	0.25	0.92	1.11	0	0.23	0.99	0.13	0.62	0.47	0.12		
		Lane Gp	Delay	62.8	33.5	0.4	89.8	249.5	0.0+	21.7	88.3	0.2	52.7	24.3	0.1		
			LOS	E	C	A	F	F	A	C	F	A	D	C	A		
		Approach	Delay		35.7			211			62.9			19			
			LOS		D			F			E			B		78.6	E
Route 7	**United Blvd**		Lane	2	2			2	1				1		2		
			Volume	398	2562			753	231				72		1380		
			v/c	0.9	5.64			0.33	0.14				0.48		0.46		
		Lane Gp	Delay	79.8				8.7	0.2				59.5		0.5		
			LOS	E				A	A				E		A		
		Approach	Delay					6.9						3.8			
			LOS					A						A			
Route 7	**Gaglardi**		Lane	1	2	1	1	2	1	1 >	2	1	1 >	2	1		
			Volume	272	1253	403	323	757	92	227	675	648	175	710	137		
			v/c	1	1.09	0.24	1.19	0.66	0	0.83	1.24	0.38	0.64	1.3	0.08		
		Lane Gp	Delay	154.6	223.8	0.3	423.1	37.9	0	78.5	492.2	0.7	59.7	604.3	0.1		
			LOS	F	F	A	F	D	A	E	F	A	E	F	A		
		Approach	Delay		170.9			153.2			236.1			436			
			LOS		F			F			F			F		239.4	F

4.2 IMPACTS SINCE PHASE I

4.2.1 Traffic Volumes

The "before & after" analysis of the parallel route traffic volumes utilizes the Phase I and II intersection turning movement counts at the intersections adjacent to the study section. Exhibit 4.2.1 summarizes the comparison of the approach volumes (eastbound and westbound) parallel to the mainline. Evaluation of the "before" and "after" peak direction traffic demand indicates the following:

- A general reduction in AM westbound traffic on the eastern section of the two parallel routes was identified. The largest reduction was found on Lougheed Highway in which a 28% reduction was found at United Blvd. Together the increase in highway volume and AVO at Cape Horn, indicates a possible shift of route to the HOV lanes on Highway 1.

- The eastbound PM peak hour traffic was found to increase since Phase I by approximately 10% to 33%. A 33% increase was noted at the Boundary/Grandview intersection eastbound approach to Highway 1. This adversely affects the capacity of the intersection, while the attraction of HOVs to the mainline (AVO increased from 1.21 to 1.30) suggests the parallel route volume increase is mostly SOV.

- A reduction of peak direction traffic (AM westbound and PM eastbound) on Canada Way/Kensington was observed near the middle of the HOV corridor, again suggesting a possible shift to Highway 1.

It should be noted that although the traffic volumes suggest a shift from the parallel routes to Highway 1, the statistical analysis of AVOs did indicate that reductions were not significant.

4.2.2 Vehicle Classification & Occupancy Surveys

Using data documented in the Phase I Monitoring and Evaluation study and the Phase II "after" data presented above, the parallel route vehicle occupancy and classification data were used to support the "Increase Person Throughput" objective of the Highway 1 HOV lanes. The importance of the parallel route AVOs is to determine whether mainline increases were due to diversion of existing HOVs on the parallel routes or not.

Exhibits 4.2.2 to 4.2.4 present the "before and after" comparisons of AVO on the parallel routes (for the weekday conditions) by the AM peak, mid-day peak, and PM peak periods respectively. All of the AVO measurement comparisons were analyzed for their statistical significance at a 95% confidence limit. On this basis, the minimum AVO required to establish a significant decrease is also presented in the exhibits. A statistically significant reduction in AVOs along the parallel routes would suggest that the increase in AVO along Highway 1 was attributed to a diversion of existing HOV from the parallel routes onto Highway 1.

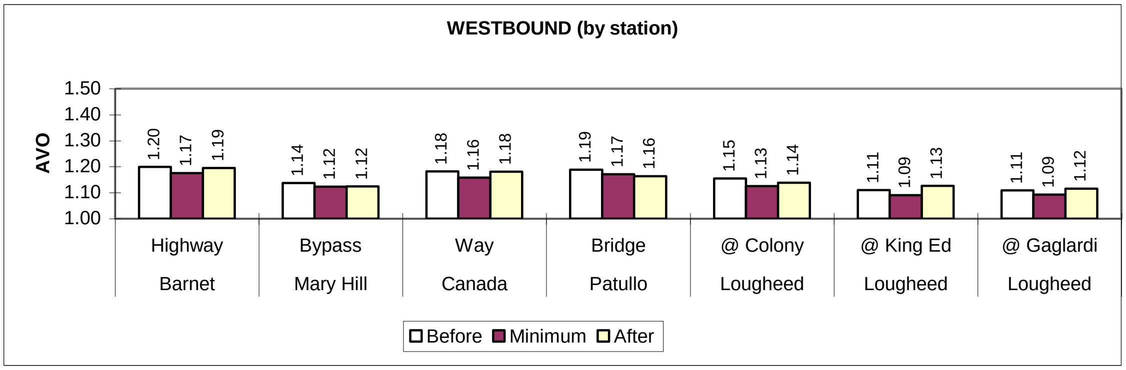
Exhibit 4.2.1 - Parallel Route Before & After Peak Hour Movement

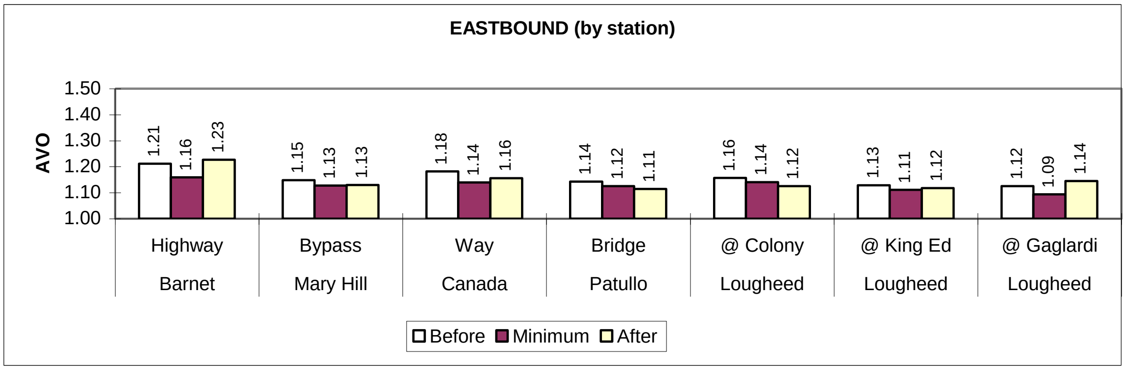
AM-PEAK HR	Phase 1 Volume		Phase 2 Volume		Comparison			
INTERSECTION	EB	WB	EB	WB	EB		WB	
Boundary @ Grandview	1325	1770	1512	1938	Increased	14.1%	Increased	9.5%
Route 7 @ Willingdon	1345	2060	1350	1987	Increased	0.4%	Reduced	3.5%
Canada Way @ Willingdon	1110	1025	1277	1042	Increased	15.0%	Increased	1.7%
Canada Way @ Kensington	1465	2060	1433	2016	Reduced	2.2%	Reduced	2.1%
United @ Mary Hill	1390		1087		Reduced	21.8%		
Route 7 @ United Blvd	1392	3514	1650	2525	Increased	18.5%	Reduced	28.1%
Route 7 @ Gaglardi	790	2310	733	2012	Reduced	7.2%	Reduced	12.9%

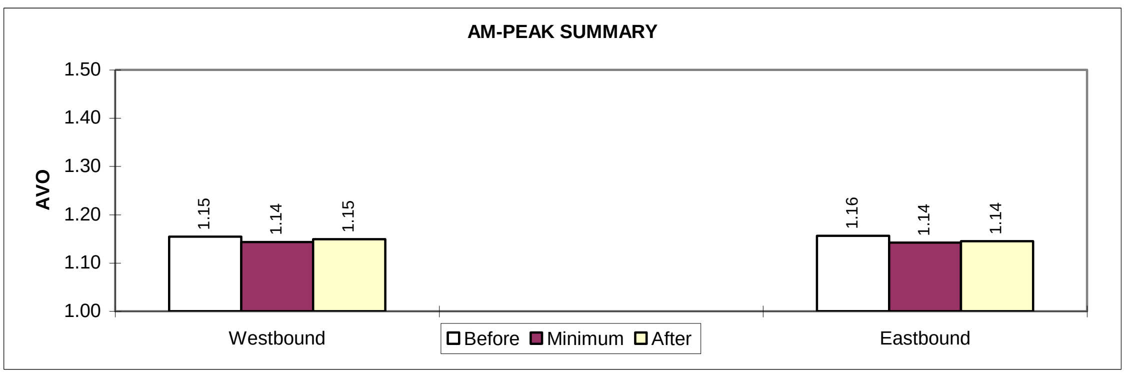
NOON PEAK HR	Phase 1 Volume		Phase 2 Volume		Comparison			
INTERSECTION	EB	WB	EB	WB	EB		WB	
Boundary @ Grandview	1265	1650	1387	1675	Increased	9.6%	Increased	1.5%
Route 7 @ Willingdon	1390	1490	1490	1421	Increased	7.2%	Reduced	4.6%
Canada Way @ Willingdon	875	815	835	946	Reduced	4.6%	Increased	16.1%
Canada Way @ Kensington	1270	775	1311	714	Increased	3.2%	Reduced	7.9%
United @ Mary Hill	1180		1253		Increased	6.2%		
Route 7 @ United Blvd	1424	3165	1635	3144	Increased	14.8%	Reduced	0.7%
Route 7 @ Gaglardi	1225	1225	1358	1191	Increased	10.9%	Reduced	2.8%

PM PEAK HR	Phase 1 Volume		Phase 2 Volume		Comparison			
INTERSECTION	EB	WB	EB	WB	EB		WB	
Boundary @ Grandview	1195	1885	1587	2016	Increased	32.8%	Increased	6.9%
Route 7 @ Willingdon	1925	1570	2122	1835	Increased	10.2%	Increased	16.9%
Canada Way @ Willingdon	1175	850	1242	1149	Increased	5.7%	Increased	35.2%
Canada Way @ Kensington	2300	780	2016	778	Reduced	12.3%	Reduced	0.3%
United @ Mary Hill	2360		2817		Increased	19.4%		
Route 7 @ United Blvd	2273	2590	2634	2133	Increased	15.9%	Reduced	17.6%
Route 7 @ Gaglardi	1805	1115	2076	1121	Increased	15.0%	Increased	0.5%

Exhibit 4.2.2 - Parallel Route Before & After AVOs- AM Peak Period



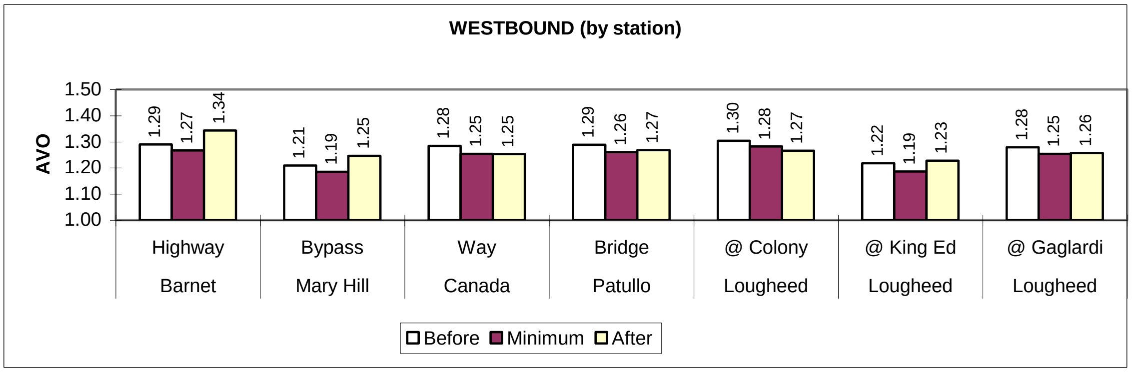


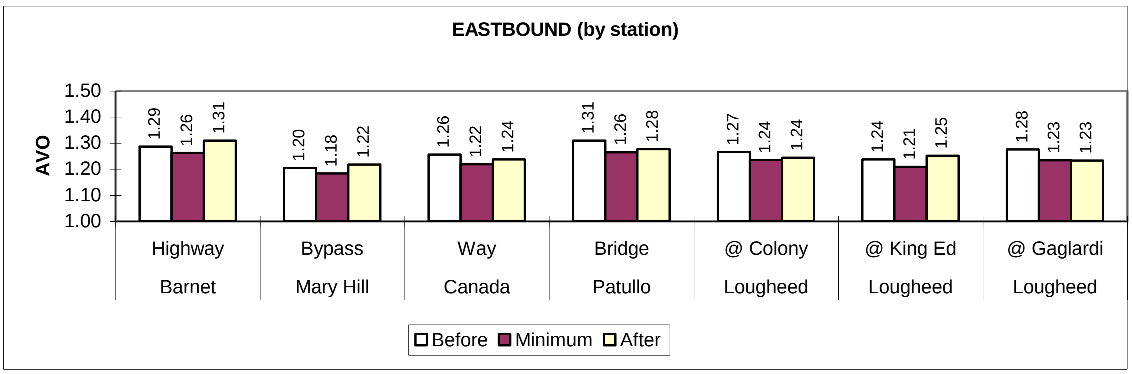


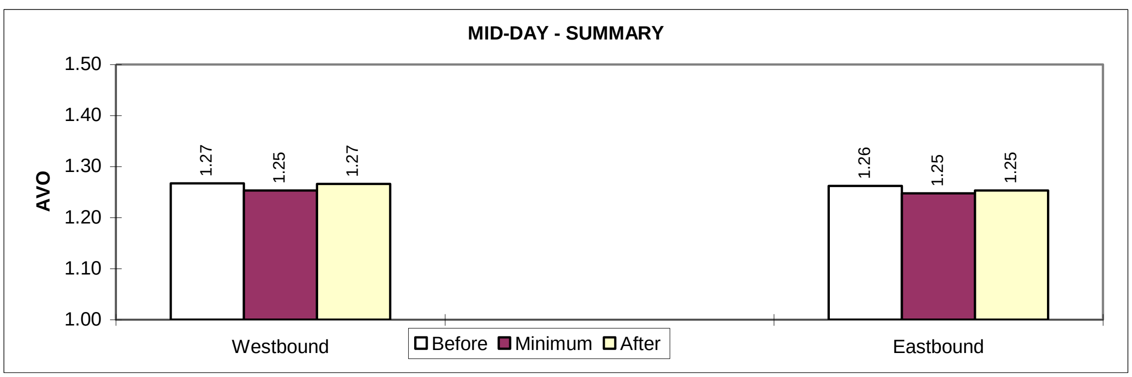
Note:

"Minimum" indicates the minimum change in AVO which is statistically significant.

Exhibit 4.2.3 - Parallel Route Before & After AVOs- MID-DAY Peak Period



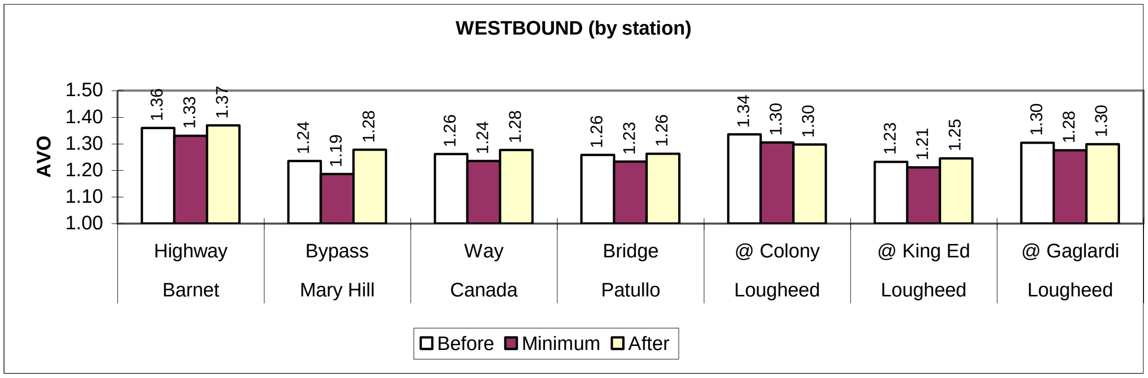


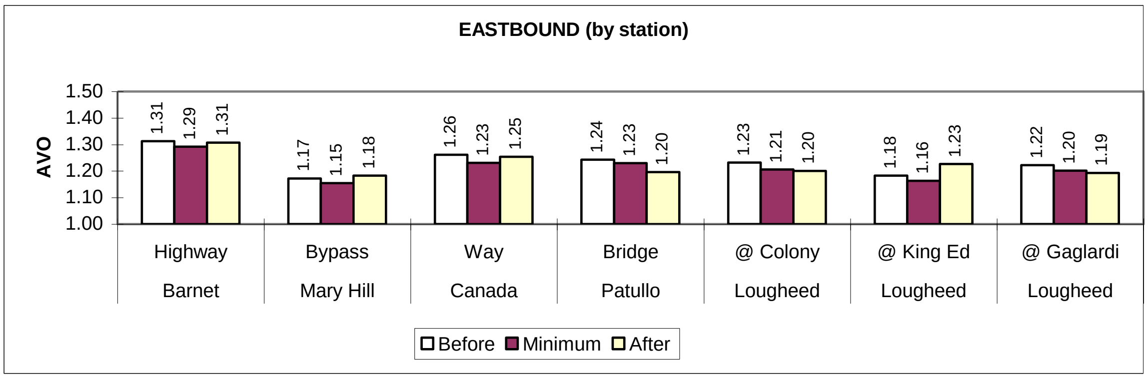


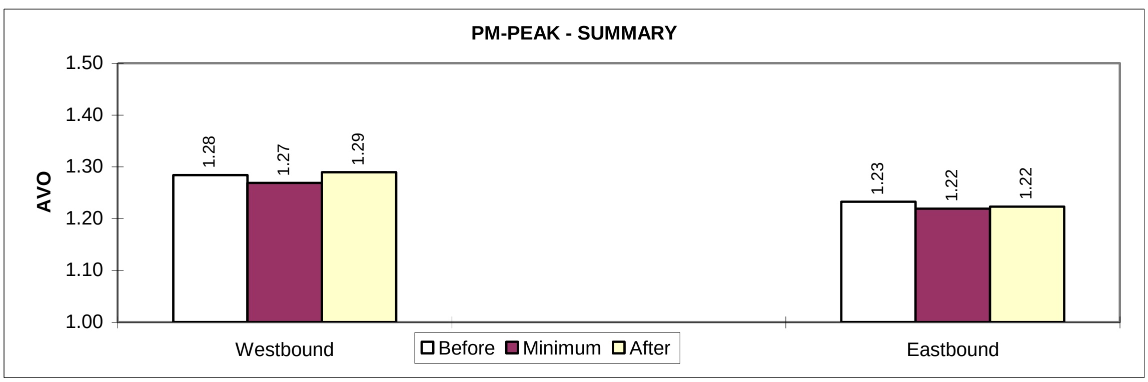
Note:

"Minimum" indicates the minimum change in AVO which is statistically significant.

Exhibit 4.2.4 - Parallel Route Before & After AVOs- PM Peak Period







Note:

"Minimum" indicates the minimum change in AVO which is statistically significant.

It is observed that the majority of the reductions in AVO along the parallel routes are not statistically significant at a 95% confidence limit. Therefore, these non-significant changes in AVOs along the parallel routes help attribute mainline increases in AVO to the attraction/formation of new carpools (which was estimated to be 28% using the Motorist Survey results).

The only significant reduction in AVO is observed on the Pattullo Bridge, with a corresponding significant increase in AVO across the Port Mann Bridge, suggesting a significant diversion of HOVs from the Pattullo Bridge onto the Port Mann Bridge to take advantage of a portion of the HOV related travel time savings – depending on the point of entry onto Highway 1.

4.2.3 Travel Time

The objective of the Phase II parallel routes travel time survey is to provide a baseline "before" data for future evaluation of the TMP impacts. This MOE will provide a general indication of more efficient corridor balancing resulting from overall improved traffic management and traveler information strategies.

Exhibit 4.2.5 – Comparison of Highway 1 & Parallel Route Travel Time & Speed

HIGHWAY 1 vs NORTHERN PARALLEL ROUTE	Distance (km)	EASTBOUND				WESTBOUND			
		AM		PM		AM		PM	
		Travel Time (min)	Speed (km/hr)	Travel Time (min)	Speed (km/hr)	Travel Time (min)	Speed (km/hr)	Travel Time (min)	Speed (km/hr)
Highway 1	16.2	11.7	83	22.0	44	16.1	60	13.1	73
Northern Route	15.8	18.8	51	24.6	39	31.9	30	28.4	33

Note: Highway 1 - Boundary Road to Cape Horn
Norhthern Route - Boundary Road to United Blvd

HIGHWAY 1 vs SOUTHERN PARALLEL ROUTE	Distance (km)	EASTBOUND				WESTBOUND			
		AM		PM		AM		PM	
		Travel Time (min)	Speed (km/hr)	Travel Time (min)	Speed (km/hr)	Travel Time (min)	Speed (km/hr)	Travel Time (min)	Speed (km/hr)
Highway 1	22.6	16.6	81	27.9	48	27.2	49	19.4	69
Southern Route	22.3	31.4	43	44.0	30	45.2	30	44.0	30

Note: Highway 1 - Boundary Road to 104 Ave / 160 Street
Southern Route - Boundary Road to 104 Ave / 160 Street

4.2.4 Intersection Capacities

Impacts of the HOV lanes on the adjacent intersections were determined by comparing the phase I "before" data and the phase II "after" data summarized as follow:

- Exhibit 4.2.6 presents the comparison of Phase I and II intersections volumes at all the signalized intersections considered in this study

- Exhibit 4.2.7 through 4.2.9 present the weekday peak hour LOS, for the AM, Mid-day, and PM peak hours, at adjacent signalized intersections parallel to the study corridor.

Evaluation of the "before and after" comparison indicates the following:

- An overall increase in intersection volumes at the adjacent intersections serving the HOV corridor in Highway 1 during AM and PM peak hour at Boundary/Grandview, Lougheed/Willingdon, Canada Way/Willingdon, Canada Way/Kensington and Gaglardi/Cariboo. This suggests an increase in traffic activities parallel to the HOV corridor, possibly due to increased access and egress to the HOV lanes.

- Since the traffic volumes at most of the intersections adjacent to the HOV corridor increased, the corresponding LOS of these intersection were degraded accordingly. The magnitude, in terms of LOS, however, was not large since most of these intersections were already operating at LOS-E or F.

Exhibit 4.2.6 - Parallel Route Before & After - Intersection Volume

INTERSECTION	AM-PEAK HOUR				NOON-PEAK HOUR				PM-PEAK HOUR			
	Volume		Comparison		Volume		Comparison		Volume		Comparison	
	Phase 1	Phase 2			Phase 1	Phase 2			Phase 1	Phase 2		
Route 1 Off-Ramp @ Fern	3195	2558	Reduced	19.9%	2565	2558	Reduced	0.3%	3110	2387	Reduced	23.2%
Mountain Hwy @ Fern	2245	2175	Reduced	3.1%	2080	1754	Reduced	15.7%	2460	2243	Reduced	8.8%
Mount Seymour @ Fern	3840	4323	Increased	12.6%	3525	3889	Increased	10.3%	4430	4949	Increased	11.7%
Main @ Mountain Hwy	4555	4298	Reduced	5.6%	3300	3143	Reduced	4.8%	4190	4276	Increased	2.1%
Boundary @ Grandview	6260	6789	Increased	8.5%	5285	5705	Increased	7.9%	6255	6762	Increased	8.1%
Route 7A @ Cassiar	4620	4781	Increased	3.5%	3475	3312	Reduced	4.7%	5110	5029	Reduced	1.6%
Route 7 @ Willingdon	5370	5373	Increased	0.1%	4995	5525	Increased	10.6%	5745	6627	Increased	15.4%
Canada Way @ Willingdon	5210	5339	Increased	2.5%	4370	4636	Increased	6.1%	5450	5791	Increased	6.3%
Canada Way @ Kensington	5075	5078	Increased	0.1%	3165	3155	Reduced	0.3%	4775	4525	Reduced	5.2%
Kensington @ Sprott	3220	3351	Increased	4.1%	2020	2072	Increased	2.6%	3485	3389	Reduced	2.8%
Gaglardi @ Cariboo	3375	3780	Increased	12.0%	2596	2476	Reduced	4.6%	3468	3860	Increased	11.3%
Brunette @ Braid	4710	4501	Reduced	4.4%	3840	3684	Reduced	4.1%	4816	4840	Increased	0.5%
United @ Mary Hill	4635	4571	Reduced	1.4%	3330	3518	Increased	5.6%	4615	4898	Increased	6.1%
Route 7 WB Off Ramp @ United Blvd	3150	2651	Reduced	15.8%	2135	2217	Increased	3.8%	2725	2515	Reduced	7.7%
152 @ 108	4220	3243	Reduced	23.2%	3150	2951	Reduced	6.3%	4200	3600	Reduced	14.3%
160 @ 104N	2050	2005	Reduced	2.2%	1215	1155	Reduced	4.9%	1865	1954	Increased	4.8%
160 @ 104	3140	3343	Increased	6.5%	2456	2586	Increased	5.3%	4170	4498	Increased	7.9%
Route 7 @ United Blvd	5371	4588	Reduced	14.6%	4741.6	5017	Increased	5.8%	5527	5396	Reduced	2.4%
Route 7 @ Gaglardi	5525	5438	Reduced	1.6%	4035	4040	Increased	0.1%	5475	5672	Increased	3.6%
			# Reduced	10			# Reduced	9			# Reduced	8
			# Increased	9			# Increased	10			# Increased	11

Exhibit 4.2.7 - Before & After LOS – AM Peak Hour

			AM-PEAK HOUR														
				EB			WB			NB			SB		INTERSECTION	
INTERSECTION	**Phase**	**LOS**	**L**	**T**	**R**	**L**	**T**	**R**	**L**	**T**	**R**	**L**	**T**	**R**	**DELAY**	**LOS**
Boundary @ Grandview	**Phase 1**	Lane Gp		C	B		C	B	C	F	C	C	F			
		Approach		C			C			F			F			
	Phase 2	Lane Gp		**D**	A		**F**	**C**	**E**	F	A	**D**	F			
		Approach		C			**F**			F			F		326	F
Route 7 @ Willingdon	**Phase 1**	Lane Gp	E	C	B	F	F	B	F	D	C	E	F			
		Approach		C			F			E			F			
	Phase 2	Lane Gp	E	**D**	A	F	F	A	F	**E**	0	**F**	F			
		Approach		**D**			F			E			F		153	F
Canada Way @ Willingdon	**Phase 1**	Lane Gp	E	D	B	C	D	C	B	F	B	F	F	C		
		Approach		D			C			F			F			
	Phase 2	Lane Gp	**F**	D	0	**F**	D	A	**E**	F	A	F	F	A		
		Approach		**E**			**D**			F			F		148	F
Canada Way @ Kensington	**Phase 1**	Lane Gp	E	B			F	D				C		A		
		Approach		D			F						B			
	Phase 2	Lane Gp	E	**D**			F	A				**D**		A		
		Approach		D			F						**C**		151	F
United @ Mary Hill	**Phase 1**	Lane Gp	D	E		F		F		E	B	D	F			
		Approach		D			F			D			F			
	Phase 2	Lane Gp	**E**	**F**				A		E	A	**F**				
		Approach		**F**						D						
Route 7 @ United Blvd	**Phase 1**	Lane Gp	D	F			B	A				E		A		
		Approach		F			B						A			
	Phase 2	Lane Gp	D				A	A				D		A		
		Approach					A						A			
Route 7 @ Gaglardi	**Phase 1**	Lane Gp	F	D	B	F	D	B	F	F	C	D	E	F		
		Approach		F			F			F			F			
	Phase 2	Lane Gp	E	D	A	F	**F**	A	F	F	A	D	**F**	A		
		Approach		C			F			F			F		313	F

Exhibit 4.2.8 - Before & After LOS – MID-DAY Peak Hour

			MIDDAY-PEAK HOUR													
				EB			WB			NB			SB		INTERSECTION	
INTERSECTION	Phase	LOS	L	T	R	L	T	R	L	T	R	L	T	R	DELAY	LOS
Boundary @ Grandview	Phase 1	Lane Gp		C	A		C	B	C	C	C	C	F			
		Approach		C			C			C			F		33.4	D
	Phase 2	Lane Gp		C	A		**D**	**C**	**E**	**F**	A	C	F			
		Approach		C			**D**			**E**			F		134	**F**
Route 7 @ Willingdon	Phase 1	Lane Gp	D	D	B	E	F	B	E	E	C	F	F			
		Approach		D			E			E			F			
	Phase 2	Lane Gp	**F**	**E**	A	**F**	F	A	**F**	**F**	0	F	E			
		Approach		**F**			**F**			**F**			F		296	F
Canada Way @ Willingdon	Phase 1	Lane Gp	C	D	B	C	D	B	B	F	B	D	F	C		
		Approach		C			C			F			E		47.4	E
	Phase 2	Lane Gp	**F**	D		**F**	D	A	**E**	F	A	**E**	E	A		
		Approach		**F**			**D**			F			E		108	**F**
Canada Way @ Kensington	Phase 1	Lane Gp	C	B			D	B				C		A		
		Approach		B			C						C		16.5	C
	Phase 2	Lane Gp	C	**D**			D	A				C		A		
		Approach		**D**			B						C		30	C
United @ Mary Hill	Phase 1	Lane Gp	C	D		E		C		D	C	C	D			
		Approach		D			C			D			D		25.7	D
	Phase 2	Lane Gp	**D**	**F**				A		D	A	C				
		Approach		**F**						C						
Route 7 @ United Blvd	Phase 1	Lane Gp	E	F			B	A				E		A		
		Approach		F			B						A			
	Phase 2	Lane Gp	D				A	A				D		A		
		Approach					A						A			
Route 7 @ Gaglardi	Phase 1	Lane Gp	F	D	B	E	C	B	E	E	C	D	D	D		
		Approach		D			D			D			D		33	D
	Phase 2	Lane Gp	D	**F**	A	E	**D**	A	E	D	A	D	D	A		
		Approach		**E**			D			C			D		54	D

Exhibit 4.2.9 - Before & After LOS – PM Peak Hour

			PM-PEAK HOUR													
				EB			WB			NB			SB		INTERSECTION	
INTERSECTION	Phase	LOS	L	T	R	L	T	R	L	T	R	L	T	R	DELAY	LOS
Boundary @ Grandview	Phase 1	Lane Gp		C	B		D	B	D	F	C	C	F			
		Approach		B			C			F			F			
	Phase 2	Lane Gp		**D**	**D**		**F**	**C**	**F**	F	A	**D**	F			
		Approach		**D**			**F**			F			F		268	F
Route 7 @ Willingdon	Phase 1	Lane Gp	E	E	B	F	F	B	E	E	C	F	D			
		Approach		E			F			E			F			
	Phase 2	Lane Gp		**F**	A		F	A		**F**		F	D			
		Approach								0			F			
Canada Way @ Willingdon	Phase 1	Lane Gp	E	D	D	C	D	C	C	F	D	D	F	D		
		Approach		E			C			F			F			
	Phase 2	Lane Gp	**F**	D		**F**	**E**	A	**E**	F	A	**F**	F	A		
		Approach		**F**			**D**			F			F		221	F
Canada Way @ Kensington	Phase 1	Lane Gp	F	C			D	D				D		A		
		Approach		F			D						C			
	Phase 2	Lane Gp	F	**F**			D	A				D		A		
		Approach		F			B						**D**		96	F
United @ Mary Hill	Phase 1	Lane Gp	C	D		E		D		D	F	F	D			
		Approach		D			D			F			F			
	Phase 2	Lane Gp	**D**					A		D	A	D				
		Approach								B						
Route 7 @ United Blvd	Phase 1	Lane Gp	F	F			A	A				E		A		
		Approach		F			A						A			
	Phase 2	Lane Gp	E				A	A				E		A		
		Approach					A						A			
Route 7 @ Gaglardi	Phase 1	Lane Gp	F	D	B	F	C	B	E	F	D	E	F	D		
		Approach		F			F			F			F			
	Phase 2	Lane Gp	F	**F**	A	F	**D**	A	E	F	A	E	F	A		
		Approach		F			F			F			F		239	F

5 SUMMARY & CONCLUSIONS

The goal of the HOV and TMP Monitoring and Evaluation Program developed for the TCH, has been to collect data incrementally and document the impacts and benefits associated with the implementation of the HOV lanes on October 28, 1998 and the FSP on January 4, 1999, and the forthcoming TMP pilot project service applications. This evaluation program has been structured around the following three key phases:

Phase I – Pre-HOV and TMP (September 1997 to March 1998)
Phase II – Post-HOV and FSP, Pre- TMP (this study, September 1999 to March 2000)
Phase III – Post HOV and TMP (dates to be specified)

Each of the phases including the following key efforts:

- Identify performance measures.
- Establish "before" and "after" assessment periods.
- Define data requirements.
- Develop methods for collecting the required data.
- Document critical changes in traffic conditions (demand and capacity) in or near the Study Section during the assessment periods.
- Document the statistical reliability of the data and analysis.

Phase I set the foundations of the monitoring and evaluation program by establishing a detailed study methodology for all phases of the project, while documenting a detailed baseline of traffic conditions along the Study Section prior to major improvements along the TCH.

This Phase II study was activated to coincide with traffic operations two years past the opening of the new HOV lanes and deployment of the FSP. This phase of the monitoring and evaluation program is critical in documenting the benefits of the HOV and FSP, while establishing a second baseline from which the incremental benefits of TMP can be evaluated.

This Phase II study has been based on the study methodology and MOEs approved in Phase I. Based on the lessons learned in the Phase I study, it was proposed that the following also be examined:

- An assessment of the impact of the FSP;
- Opinion surveys of the effectiveness of the HOV and FSP programs;
- Review of HOV enforcement effectiveness.

In addition, the Phase I report recommended a number of improvements and refinements to the data collection program, aimed at cost-effective methodologies that better supported the MOEs. These included deleting redundant portions of the data collection program, developing more efficient methods to collect information and expanding the amount of coverage, and elimination or reduction of efforts which yielded low value. These recommendations included:

- Reduce the numbers of screenlines for the vehicle classification and occupancy counts, since the measures across adjacent screenlines are very similar;
- Use the Freeway Service Patrol to enhance the incident monitoring program and expand the database of incidents;
- Use the video-based traffic monitoring system installed during the HOV construction program to complement the incident monitoring task;
- Eliminate the aerial photo surveying of approach queues as they were expensive and not very representative
- Eliminate the conflict analysis surveys as they are very subjective and are not reliable in establishing safety benefits.

The Phase II study commenced in August of 1999, with primary data collection carried out over the same time period as in Phase I, i.e. during September and October of 1999, with HOV/FSP information, observation and opinion surveys in December 1999.

5.1 HOV EVALUATION & BENEFITS SUMMARY

Using the evaluation objectives identified for the HOV lanes, and the Phase I and II data collected, the following HOV benefits and impacts can be concluded:

All of the HOV project objectives have been achieved, with expected benefits attained:

- ✓ Person movement throughput has increased significantly through the formation of new carpools, as opposed to merely diversion of existing HOV traffic from other parallel facilities
- ✓ HOVs experience significant travel time savings in both peak periods and directions
- ✓ Trip times are significantly more reliable for HOV traffic
- ✓ Per lane efficiency during the peak directions has significantly increased due to the movement of more persons at optimum average speeds
- ✓ GP lanes have not been adversely affected but operate better now due to the added capacity
- ✓ Safety has not been compromised, with the total frequency and cost of claims decreasing
- ✓ Compliance is above the desired 85% minimum for all directions and time periods
- ✓ More than 70% of the SOVs and 85% of the HOVs view the HOV lanes as a benefit to their transportation system and are satisfied with its benefits.

5.2 TMP BASELINE & FSP BENEFITS

Using the MOE and data requirements identified for the TMP evaluation objectives, a second baseline of data was collected and analyzed for the TMP to reflect pre-and post-HOV conditions. Relevant before and after comparisons were made to document background conditions related to TMP as well as the benefits of the FSP.

- ✓ Statistically reliable travel time data has been collected to complement the same data collected in Phase I for the evaluation of reductions in recurrent congestion delays. Marginal differences were observed between Phase I and II, except in the PM peak eastbound direction where significant travel time savings were observed (13 minutes) primarily due to the benefits associated with the HOV and FSP sections.

- ✓ The database of incident data has been expanded to include over 800 incidents. A reduction in average incident duration times of approximately 50% on sections patrolled by the FSP compared to Phase I, Total user cost of delay due to incident lane blockages has been reduced from $46M to $28M per year due to the FSP and overall improved operations with the HOV lanes. Potential capacity to be gained with TMP is between 10% to 15%, which at a 1.4% annual growth rate, could defer infrastructure expenditures by 10 years.

- ✓ All collision data, available at the time of the study, was collected for establishing a second post-HOV and pre-TMP baseline for measuring improved safety. Claims data from ICBC was used to compare frequency of accidents before, during, and after construction of the HOV lanes, and after deployment of the FSP. The accident analysis indicated substantial crash claims reductions as a result of the HOV and FSP implementation programs.

- ✓ Average speed, volume and occupancy data have been used to establish baseline throughput estimates across the west screenline of TCH, Canada Way, and Lougheed Highway at Gaglardi for throughput comparisons with the post TMP data.

- ✓ Public acceptance and satisfaction with the FSP is high, with approximately 60% of the respondents aware of the FSP, and the benefits of short incident duration times due to improved traffic management.

5.2.1 Recommendations

The safety analysis of the corridor should be complemented using a complete sample of data from ICBC's TAS and MoTH's HAS database. Also, additional pre-TMP accident data should be collected continuously by maintaining the HAS database and by using the FSP as an additional source of incident data collection within the HOV portion of the corridor.

A follow-up Phase III study and report should be included as part of the TMP "pilot" project. The scope and timing of the TMP pilot project deployment should be coordinated closely with other improvements along the corridor, such that fundamental data surveys are made as part of each project.

Specific changes to the corridor since the completion of the Phase II data collection program have included the introduction of a ramp signal at the new Coleman on-ramp near Cape Horn interchange, and the corresponding closure of the old westbound on-ramp from the Lougheed Highway. Planned future improvements include the upcoming 5 laning of the Port Mann Bridge, as well as the addition of a westbound on-ramp directly from the Mary Hill Bypass. Therefore, monitoring and evaluation studies associated with these improvements should be carried out to properly document the changing pre-TMP background conditions.

In Phase III, specific surveys will be required for documenting public support and usage of TMP functions.

Driver responses to Changeable Message Signs (CMS) can be used for evaluation of TMP benefits in terms of a number of indicators:

- ease of reading messages;
- ease of understanding messages;
- location of sign versus time for driver to respond;
- the types of messages recalled;
- compliance to messages;
- general usefulness of messages;
- general support for the implementation (i.e. are more CMSs beneficial?).

These and other related indicators can also be used to support the "Optimize Use of Capacity" objective, i.e. determining under what conditions, and how often travelers change their route based on information on prevailing conditions.

Public opinion on other TMP traveler information mediums may be evaluated through similar indicators as those identified for CMSs. Depending on the medium technology, actual usage data may also be obtained. For example, if a World Wide Web page is used to provide real-time traveler information along the corridor, the number of "hits" to the Web page can also be an indicator of usage.