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Economic Development Commission of the Central Okanagan

CENTRAL OKANAGAN TRAFFIC CONGESTION ASSESSMENT

Final Report

HDR|DECISION ECONOMICS

April 15, 2009

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Risk Analysis • Investment and Finance
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Economic Development Commission of the Central Okanagan

CENTRAL OKANAGAN TRAFFIC CONGESTION ASSESSMENT: PROPOSED METHODOLOGY

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EXECUTIVE SUMMARY

This report provides an assessment of traffic congestion and resulting economic costs in the North Okanagan and Central Okanagan Regions. The impacts listed here relate to the amount of congestion that is economically wasteful – above a so called “tipping point”, rather, than above free-flow speed conditions. This approach recognizes that a certain volume of traffic is beneficial to the local economy as it provides means of transporting people and goods from one place to another where they are needed and where they provide the basis for economic activity.

However, in making their travel decisions, road users ignore the delay that their presence on the road causes other motorists. The level of congestion that would occur if road users took proper account of this effect is the *economically efficient* level. Congestion above this level is wasteful or *excess* because the benefits from accommodating the additional traffic are outweighed by the costs of the reduced travel speeds. Reduced speed means additional travel and transit time, and this creates various costs such as delays in transportation of deliveries and resulting increase in the level of inventory in order to guard against them. Also important are the costs that travelers attach to their own unpaid time on the road, and in particular the time needed for commuting to work and back home. The travel delays leave less time for working and less time for leisure and personal pursuits.

This report estimates the current extent and costs of congestion, i.e. the 2007 baseline conditions, and a future 2030 scenario. The 2007 baseline scenario is based on 2007 traffic conditions that were estimated using 2007 household travel survey data from a survey conducted in the Region by Synovate in April 2007. The 2030 scenario is based on plausible assumptions with respect to the traffic growth, expansion of road capacity, and other economic growth assumptions.

The congestion costs are estimated in the form of the following metrics:

1. Travel delays to auto users for personal travel and commuting to work and their monetary value;
2. Increased vehicle operating costs; and,
3. Increased industry costs, reduced economic output, and accompanying reduced employment.

THE SCALE OF THE CONGESTION PROBLEM

The effect of traffic congestion manifests itself most visibly in the form of a reduction in the average speed that motorists are facing. Summary Table 1 shows current average speeds in various areas of the Region during peak and off-peak hours and compares them with optimal speeds, or speeds that would result under an economically efficient traffic/congestion level. The table demonstrates that most areas in the region currently experience significant traffic congestion over the entire day. The problem is most serious in Central Kelowna where average speeds are just about 26 to 27 km/h throughout the entire day, 34 to 37 percent below the optimal speed. This is followed by congestion in the City of Vernon and in suburban Kelowna where the average speeds are about 34 km/h throughout the day, or 16 to 20 percent below the optimal speeds.

Summary Table 1: Current 2007 Actual and Optimal Speeds in the Region by Geographic Sub-Area

Region	Region Name	Actual Speeds Km/h		Optimal Speeds Km/h		Reduction in Actual Speed Compared to Optimal, in Percent	
		Peak Period	Off-Peak	Peak Period	Off-Peak Period	Peak Period	Off-Peak Period
1	Vernon	33.1	34.9	41.6	41.8	20.6%	16.6%
2	Coldstream, Lumby	41.6	45.1	43.0	44.2	3.3%	0%
3	Spallumcheen, Armstrong, Enderby	50.5	41.4	49.6	47.7	0.0%	13.1%
4	Lake Country	38.8	41.4	42.4	43.0	8.6%	3.7%
5	Westside, Westbank, Peachland	42.5	42.1	47.7	47.7	11.1%	11.7%
6	Central Kelowna	27.2	26.1	41.3	41.3	34.3%	36.8%
7	Suburban Kelowna	34.1	33.6	41.7	41.7	18.3%	19.4%
NORD Average		**38.9**	**37.6**	**44.0**	**43.7**	**11.8%**	**13.8%**
CORD Average		**34.4**	**34.4**	**42.8**	**42.9**	**19.6%**	**19.8%**

By 2030, the average speeds are further reduced across the region. As Summary Table 2 shows, the average speeds in Central Kelowna are reduced to about 23 to 24 km/h (43 to 45 percent below the optimal speed), in the City of Vernon, the speeds are reduced to about 30 to 32 km/h (23 to 28 percent below the optimal speeds), and in suburban Kelowna, average actual speeds are reduced to about 30 km/h (or about 26 percent below the optimal speeds).

Summary Table 2: 2030 Estimated Actual and Optimal Speeds in the Region by Geographic Sub-Area

Region	Region Name	Actual Speeds		Optimal Speeds		Reduction in actual speeds (compared to optimal, in %)	
		Peak Period	Off-Peak	Peak Period	Off-Peak	Peak Period	Off-Peak
1	Vernon	29.8	31.8	41.4	41.5	28.1%	23.4%
2	Coldstream, Lumby	39.4	43.7	42.5	43.7	7.3%	-0.1%
3	Spallumcheen, Armstrong, Enderby	48.0	38.2	48.9	47.2	0.0%	19.1%
4	Lake Country	36.1	39.2	42.0	42.5	13.9%	7.7%
5	Westside, Westbank, Peachland	38.8	38.4	47.3	47.2	17.9%	18.7%
6	Central Kelowna	23.6	22.6	41.3	41.3	42.7%	45.3%
7	Suburban Kelowna	30.9	30.4	41.5	41.4	25.5%	26.7%
North Okanagan Average		**35.9**	**34.6**	**43.7**	**43.3**	**17.7%**	**20.0%**
Central Okanagan Average		**31.2**	**31.2**	**42.5**	**42.6**	**26.8%**	**26.8%**

Summary Table 3 shows that currently across the entire Region, about 7.5 percent of the entire traffic is excess, or above the economically optimal level. In Central Kelowna that percentage is even higher at about 13 percent or more (depending on the time of the day). By 2030, excess traffic increases to about 9.6 percent across the region and in Central Kelowna, it increases to over 15 to 16 percent.

Summary Table 3: Excess VKT by Geographic Area

Region	Region Name	Excess VKT as Percentage of Actual; 2007		Excess VKT as Percentage of Actual; 2030	
		Peak VKT	Off-Peak VKT	Peak VKT	Off-Peak VKT
1	Vernon	8.9%	7.6%	11.2%	9.8%
2	Coldstream, Lumby	2.2%	0.0%	4.1%	0.0%
3	Spallumcheen, Armstrong, Enderby	0.0%	5.0%	0.9%	7.2%
4	Lake Country	4.7%	2.4%	6.7%	4.3%
5	Westside, Westbank, Peachland	4.6%	4.9%	6.8%	7.1%
6	Central Kelowna	12.9%	13.7%	15.3%	16.1%
7	Suburban Kelowna	8.2%	8.6%	10.4%	10.8%
North and Central Okanagan Average		**7.5%**	**7.6%**	**9.6%**	**9.7%**

TRAVEL AND RELATED DELAYS

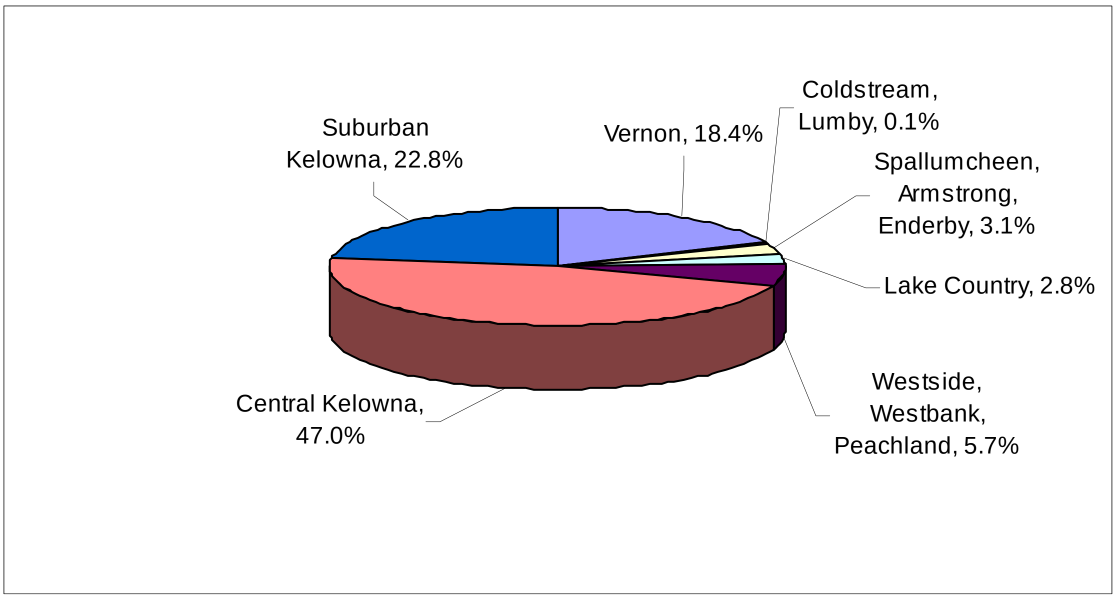
Summary Table 4 shows that currently drivers in the Region incur over 12 million vehicle hours of excess delay per year. At the value of time of $17.68 (that reflects the out-of-pocket costs of driving, time costs, and commercial value of driver time) this is equivalent to a cost of over $206 million. By 2030, the excess delays increase to over 20 million vehicle-hours and $364 million.

Summary Table 4: Excess Travel Delay and Costs for the Entire Region (North and Central Okanagan)

Year	Total Vehicle-Hours of Excess Delay		Monetary Cost of Excess Delay ($ 000)	
	Per Day	Per Year	Per Day	Per Year
2007 Baseline	46,239	12,022,230	$794	$206,544
2030 Baseline	79,317	20,622,388	$1,402	$364,519

Summary Figure 1 shows that 47 percent of the above excess delays are incurred in Central Kelowna, followed by suburban Kelowna at 22.8 percent and Vernon at 18.4 percent.

Summary Figure 1: Distribution of Excess Travel Delay and Costs in the Region



Summary Table 5 shows that the above excess delays translate into an average delay per trip that takes place in the Region during peak hours of about 3.3 minutes. This delay is on average somewhat higher in the Central Okanagan region at 3.7 minutes and lower in the North Okanagan Region at 2.5 minutes. The largest delays are incurred for trips that take place through Central Kelowna, Vernon, and Lake Country.

By 2030, the average delay per trip in the entire region increases to 5 minutes per trip during peak hours. In Central Kelowna, the delay increases to 4.8 minutes per trip, and in Vernon to 4.5 minutes.

Summary Table 5: Excess Travel Delay per Trip by Geographic Region of Travel During Peak Hours in 2007 and 2030, Minutes

Region #	Region Name	2007 Peak	2030 Peak
1	Vernon	3.0	4.5
2	Coldstream, Lumby	0.2	0.4
3	Spallumcheen, Armstrong, Enderby	0.0	0.2
4	Lake Country	2.6	4.6
5	Westside, Westbank, Peachland	1.2	2.1
6	Central Kelowna	3.4	4.8
7	Suburban Kelowna	1.9	3.0
Region Average		**3.3**	**5.0**
Central Okanagan Average		**3.7**	**5.6**
North Okanagan Average		**2.5**	**3.8**

At an average value of time of $16.96 per hour that reflects private out-of-pocket driving costs and value of time, the above delays incurred for each trip translate into an excess cost of commuting to work in the entire region of $546 per year per car commuter. The greatest cost is in Central Kelowna (at $546 per year per car commuter) followed by Vernon (at $410 per year per car commuter). By 2030, the excess cost of commuting to work in the entire region increases to $828 per year per car commuter ($783 per year per car commuter in Central Kelowna and $639 per year per car commuter in Vernon).

Summary Table 6: Monetary Cost of Excess Travel Delay for Commuting to Work by Geographic Area of Travel in 2007 and 2030, $ per Year per Car Commuter

Region #	Region Name	2007	2030
1	Vernon	$410	$639
2	Coldstream, Lumby	$9	$22
3	Spallumcheen, Armstrong, Enderby	$147	$267
4	Lake Country	$280	$554
5	Westside, Westbank, Peachland	$202	$356
6	Central Kelowna	$546	$783
7	Suburban Kelowna	$319	$489
Region Average		**$546**	**$828**
Central Okanagan Average		**$622**	**$937**
North Okanagan Average		**$390**	**$624**

NOTE: Estimates in the table assume 2 trips per day and 260 work days per year. Costs for trips that take place across multiple areas would be additive over the amounts shown.

As Summary Table 7 shows, the excess vehicle operating costs due to reduced speeds and congestion incurred by the region's drivers amount to over $23.5 million per year, or $56.42 per year per car commuter, or $0.11 per each trip in the region. By 2030, the cumulative excess vehicle operating cost in the Region increases to $42.57 million per year, or $89.98 per year per car commuter, or $0.17 per trip.

Summary Table 7: Excess Vehicle Operating Costs in 2007 and 2030

Excess Vehicle Operating Costs (VOC) Metrics	2007	2030
Total annual VOC Region-wide, $ millions	$23.55	$42.57
Annual VOC for commuting, $ per year per car commuter	$56.42	$89.98
VOC per trip	$0.11	$0.17

INDUSTRY ECONOMIC IMPACTS

Congestion resulted in a reduction in employment in the region of 980 jobs (including 704 jobs due to excess commuting costs and an increase in labour costs and 276 due to a reduction in industry revenues and thus a reduction in labour requirements), reduction in industry revenue of about $78.5 million (including about $52 million revenue due to the reduction in activity driven by excess commuting costs and increase in labour costs, and $26 million due to a reduction in demand for industry products driven by excessive transit times), and an increase in costs of $34 million. By 2030, these impacts increase (respectively) to 1,675 jobs, about $138 million business revenues, and $55 in industry costs.

Summary Table 8: Impact of Traffic Congestion on Demand for Labour and Resulting Business Revenue

Category of Impact	2007	2030
Reduction in employment due to excess commuting costs, number of jobs	704	1,211
Reduction in the value of regional economic (business revenue), $ millions	$52.19	$93.99

Summary Table 9: Impact of Congestion on Industry Operations

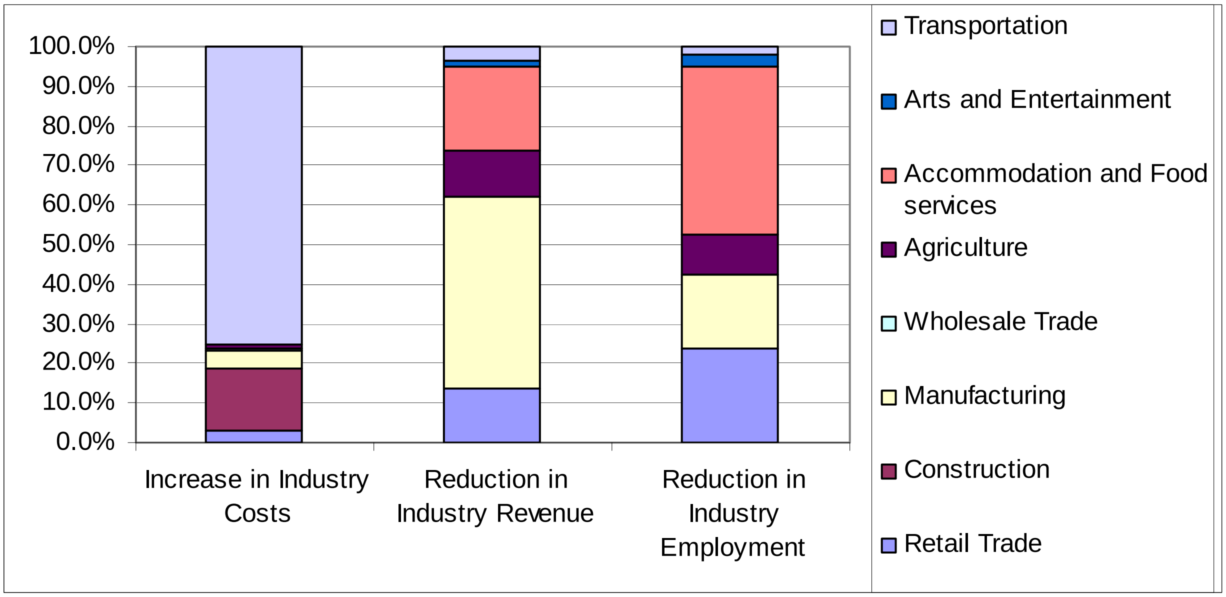
Type of Economic Costs	2007	2030
Increase in industry costs, $ millions	$33.98	$55.10
Reduction in industry revenues, $ millions	$26.27	$44.71
Reduction in industry employment, jobs	276	464

Summary Figure 2 shows the distribution of costs on industry operations reported in Summary Table 9 across the industrial sectors.[1] The chart shows that in terms of increase in industry costs, the largest impact is on the transportation industry which bears over 75 percent of the reported costs. In terms of reduction in industry revenue, the largest impact is on the manufacturing industry and accommodation and food services. Regarding reduction in employment, the largest

[1] Congestion impacts reported in Summary Table 8 could not be distributed in a similar manner due to lack of data as to the industry employment of car commuters, their average employment income, and distances that they travel.

impact is noticed in the accommodation and food services followed by retail trade, manufacturing and agriculture.

Summary Figure 2: Distribution of Congestion Costs Across Industrial Sectors



CONCLUSIONS

The Central and North Okanagan Regions already face significant congestion as manifested by the reduction in average travel speed. In particular, in the worst congested area of Central Kelowna the average speed is just about 28 km/h during the entire day, and in suburban Kelowna and Vernon, the average speeds are in the range of 33 km/h to 35 km/h.

Summary Table 10 provides an overview of the various congestion cost measures reported above. In particular, they include travel delay of about $206 million, excess vehicle operating costs of over $23 million, lost business revenue of over $78 million, increased industry costs of $34 million, and lost jobs of 980 positions. All of these measures are projected to increase by 62 to 80 percent by 2030.

A plan of action and transportation management is needed to mitigate these costs. A number of strategies have been successfully developed in various jurisdictions around the world. They include not only road infrastructure expansion and improvements, but also demand management in the form of road pricing, dedicated lanes (such high occupancy vehicle lanes), as well as strategies intended to promote and support alternative modes of transportation, in particular transit and bicycling.

Summary Table 10: Summary of Congestion Cost Measures; Annual Costs in the Central and North Okanagan Region and Change over 2007-2030

Congestion Cost Measure	2007	2030	Change 2007-2030 (Percent)
Excess travel delays, $ millions	$206.5	$364.5	76.5%
Excess vehicle operating costs, $ millions	$23.5	$42.3	80.0%
Increase in industry costs, $ millions	$34.0	$55.1	62.1%
Lost industry revenues, $ millions	$78.5	$138.7	76.7%
Reduction in industry employment, jobs	980	1,675	70.9%

1: INTRODUCTION

This draft report documents the methodology and assumptions as well as presents the results of a congestion cost model for the Central Okanagan and North Okanagan regions.

This document presents the methodology that will be adopted to estimate the congestion costs in Central Okanagan.

Section 2 presents the key transportation economics concepts that form the foundation of the framework of this model.

Section 3 presents a series of "structure and logic models" or flowcharts that illustrate graphically and in a non-technical way the derivation of the various metrics with the causal relationships between their underlying variables and factors.

Section 4 discusses the model implementation issues including the data that is required for the model, data sources and specific input data assumptions.

Section 5 presents the model results.

Finally, Section 6 provides an overview of congestion management strategies adopted in other cities around the world.

2: APPROACH TO MEASURING EXCESS TRAFFIC CONGESTION

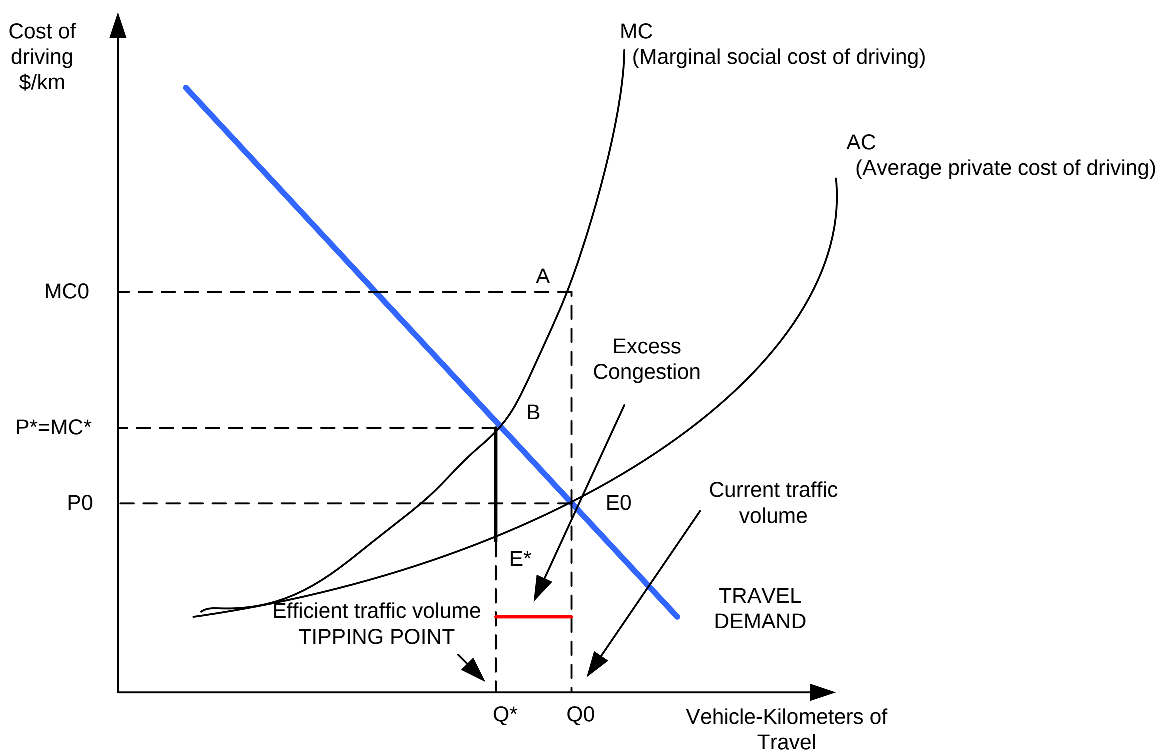
The focus of this analysis is on the economic costs of *excess congestion*, above the level that represents efficient use of road capacity. To acknowledge that some level of congestion is efficient is simply to recognize that increased traffic means additional movements of people and goods, and that these movements yield benefits, for example by generating demand for goods and services offered by local businesses, or by establishing a system of deliveries for those businesses. Therefore, a study that focused on the economic costs of *total* road congestion, relative to travel times under free-flow conditions, would exaggerate the congestion problem.

This section defines in detail the concept of excess congestion and outlines the approach to its measurement.

2.1 Economic Theory of Travel Demand in Congested Conditions

Figure 1 below presents the traditional modeling of travel demand and travel costs under conditions of high traffic congestion.

Figure 1: Approach to Estimation of Efficient Traffic Volume, or "Tipping Point"



The figure above shows the demand for travel (in terms of vehicle-kilometres travelled), as a function of the costs of driving. Drivers face a certain cost of driving which includes both car operating costs (gasoline, oil, maintenance, etc.) as well as the time cost of driving. This cost increases as traffic on the road increases because more heavy traffic reduces the overall travel speed and thus increases the time cost of the driving component. The average private cost function is illustrated in Figure 1 by the curve labelled AC.

The curve labelled MC represents the social marginal costs of driving, or the incremental costs of driving imposed by each additional vehicle entering the road. A key property of this relationship is that the same increment in traffic produces a larger cost for existing traffic, the higher the level of existing traffic (in other words, the marginal cost is increasing with the level of traffic). This is somewhat analogous to what happens when a person jumps to the front of a queue. The longer the line, the larger the number of people in the line behind the queue-jumper who are delayed.

The market equilibrium, or the observed equilibrium, occurs at the traffic level that corresponds to the point where the average private cost of driving curve intersects the travel demand curve. This equilibrium is represented by point E0 and the corresponding private cost of driving P0, and vehicle kilometres travelled Q0.

The efficient traffic volume occurs at the traffic level that corresponds to the point where the marginal social cost curve intersects the travel demand curve, Q*. The economically efficient level of congestion would eventuate if travelers altruistically took the "external cost" they impose on other road users into account when making their travel decisions. Any congestion above that level is excess congestion. In Figure 1, excess congestion is represented graphically by the distance Q*Q0.

2.2 Framework Implementation

The quantitative magnitude of excess congestion as represented by distance Q*Q0 in Figure 1 and the implied corresponding average speed can be derived using an iterative procedure and assumptions with respect to the average cost curve, marginal cost curve, and elasticity of travel demand as outlined below. Figure 2 provides a summary overview with key inputs required for framework implementation.

- **Average costs of driving and average cost curve**

The average cost of driving was assumed to be equal to the cash costs of driving (that includes fuel, maintenance, insurance, etc.) and time cost of driving. This cost can be expressed as:

$AC = c + b/v$,

where c is the cash cost of driving and b/v, value of time divided by average effective or congested speed, represents the time cost of driving. The cash cost of driving is assumed constant. However, the time cost of driving increases as the average effective speed falls.

The average effective speed was modeled using the speed-flow relationship commonly referred to as the BPR curve.[2] A speed flow relationship calculates the actual speed as a function of road congestion and speed in conditions of no congestion and no travel delays (referred to as "free-flow speed"). The speed-flow relationship used in this study is of the following form:

$v = v_0/[1 + a_1(Q/CAP)^{a2}]$,

where

v = congested speed;
v_0 = free-flow speed;
Q = volume of travel;
CAP = road capacity, and
a_1 and a_2 are the coefficients on the BPR curve.

Note that volume of travel divided by road capacity is equal to the VC ratio, or congestion level at which travel occurs, i.e.:

Q/CAP = VC_Ratio

- **Marginal social cost curve**

The marginal cost curve is derived from the total cost curve as follows:

$TC = AC \cdot Q$,

where

TC = total social costs;
Q = volume of travel, and
AC = average private cost of driving shown earlier.

Then, using the definition of marginal costs as the differential of total costs and the expressions derived earlier we have:

$MC = \partial TC/\partial Q = AC + Q \cdot \partial AC/\partial Q$, and

$MC = c + b/v_0 \cdot [1+ d_1 (Q/CAP)^{d2}]$

where MC is the marginal cost and d_1 and d_2 are coefficients on the marginal cost curve.

[2] The BPR curve refers to the speed-flow relationship developed by the US Bureau of Public Roads. The BPR speed-flow relationship is frequently adopted for economic analysis and modelling of congestion.

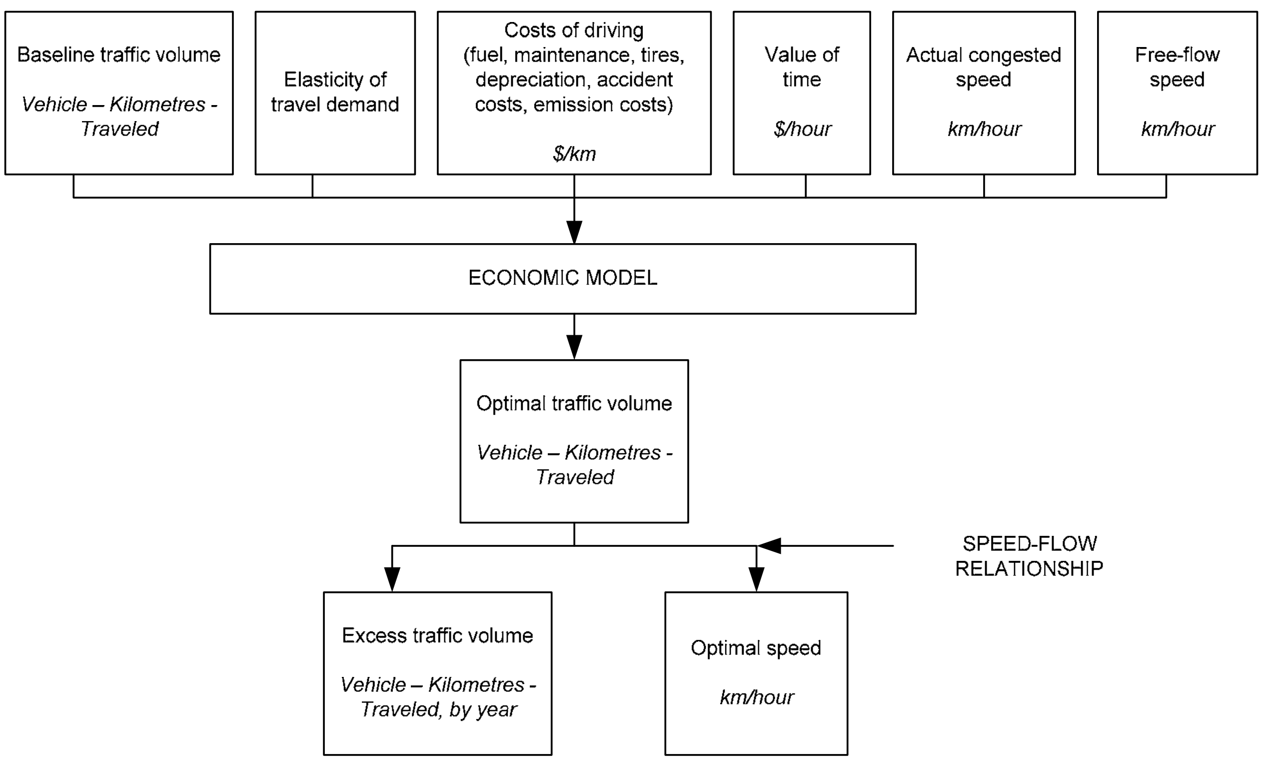
- **Iterative procedure to estimate excess congestion**

The iterative procedure involves finding the intersection point between the marginal cost curve and the demand curve. Assuming a certain travel demand function and calibrating it so that it is consistent with the average cost curve, one can experiment with various levels of travel Q by plugging them in the demand curve and in the marginal cost curve to calculate the corresponding cost of driving shown on the vertical axis in Figure 1. When the results from the two calculations converge, equilibrium is achieved. The traffic level for which equilibrium is achieved represents the optimal traffic volume. The difference between the current market traffic volume and the optimal volume represents excess congestion. The speed-flow relationship discussed above can then be used again to calculate the vehicle speeds corresponding to the optimal volume.

- **Key inputs for framework implementation**

Figure 2 below shows a high level summary of this approach to estimate excess congestion with key input variables.

Figure 2: High-level Summary of Modeling Framework for Estimation of Excess Congestion



Most of the variables shown in Figure 2 were addressed in the framework discussion above. The variable called “elasticity of travel demand” measures the sensitivity of vehicle kilometres travelled with respect to the cost of driving, or percent change in vehicle kilometres travelled for each 1 percent change in the costs of driving.[3] Average accident costs and emission costs are added to marginal costs of driving derived using only private cost components as discussed earlier to obtain a more comprehensive measure of social marginal costs of driving.

The rectangle labelled “Economic Model” represents the modelling exercise described above that involves the calculation of average costs, marginal costs, implied parameters on the travel demand curve and then the iterative procedure to find the traffic volume at which the social marginal cost of driving is equal to the full market costs of driving (or where the social marginal cost curve intersects the demand curve).[4]

The label “speed-flow relationship” refers to the engineering formula that derives the congested speed based on free flow speed, volume of traffic and road capacity. This relationship is used to estimate actual speeds that would prevail under optimal traffic volume by changing the volume of travel variable.

The final outputs of this framework, excess traffic volume and optimal speed are then used to estimate various economy-wide cost impacts of congestion. These are discussed in the next section.

[3] For example, elasticity of travel demand equal to -0.9 would indicate that vehicle kilometres travelled decline by 0.9 percent when costs of travel increase by 1 percent.
[4] The procedure is implemented in Excel through the “Solver” data tool.

3: METHODOLOGY OF ESTIMATING ECONOMY-WIDE IMPACTS OF EXCESS TRAFFIC CONGESTION

This section presents the general methodology for the estimation of economy-wide impacts of excess traffic congestion as represented by:

- Excess traffic (compared to economically optimal volume of traffic); and,
- Reduced average speed.

These two key measures and implications of congestion are estimated within an economic travel demand framework under conditions of high traffic congestion discussed in Section 2. In this section, these two measures serve as the basis for estimation of their broad manifestations in the economy in the form of travel delays and other impacts.

All of the impact measures are estimated for the current 2007 baseline and 2030 baseline.

3.1 Travel Delay, Commuter, and Related Impacts

This sub-section presents the methodology behind the calculations of travel delay and related impacts resulting from congestion, including the following:

(1) Excess delay, i.e. travel delay above the economically justified level, total and per capita;
(2) Excess commuting costs, or excess travel delay during peak hours for work purposes, total and per commuter;
(3) Reduction in demand for labour and employment; and,
(4) Increase in vehicle operating costs.

Excess delay and commuting costs are estimated by geographic sub-area within the North Okanagan and Central Okanagan Regions, including the following:[5]

- Vernon;
- Coldstream and Lumby;
- Spallumcheen, Armstrong, Enderby;
- Lake Country;
- Westside, Westbank, Peachland;
- Central Kelowna; and,
- Suburban Kelowna.

In addition, travel impacts are estimated by peak and off-peak periods. The various breakdowns are intended to better detect the extent of congestion across the Central and North Okanagan and then measure travel delay and its related impacts. For example, it may be the case that

[5] This geographic breakdown is determined by the breakdown adopted in the Synovate travel survey that was used in this study to estimate vehicle kilometres travelled (*2007 North and Central Okanagan Household Travel Survey*, study by Synovate for the City of Vernon and the City of Kelowna, July 13, 2007).

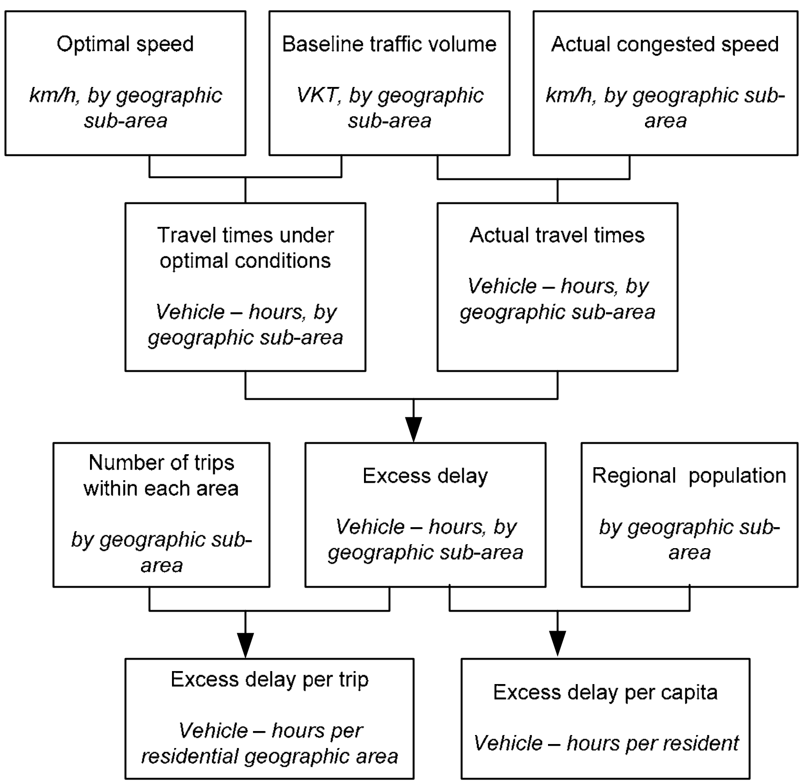
congestion is concentrated within certain sub-areas in the Central Okanagan (such as in central Kelowna) or time of day (AM peak or PM peak). It may not be possible to detect this congestion within a high level model with all-day average traffic data for the entire region.

However, some measures may be aggregated to a higher level of time of day and/or geography depending on the underlying logic and the type of data that was used in the estimation process.

3.1.1 Excess Delay and Related Measures

The optimal speed resulting under the "optimal congestion conditions" can be applied to current traffic volume to calculate the optimal travel times. This can then be subtracted from the actual travel times (i.e. under actual travel speeds) to calculate total excess travel time. This result, in turn can be divided by total population in the Central Okanagan Region to obtain an estimate of excess travel delay per resident, or by the number of trips within each geographic area to obtain excess delay per trip. This logic is illustrated in Figure 3.

Figure 3: Calculation of Excess Delay



The excess delay per capita or per trip could also be expressed in monetary terms as excess delay cost by multiplying the final outputs of Figure 3 by the assumed value of time.

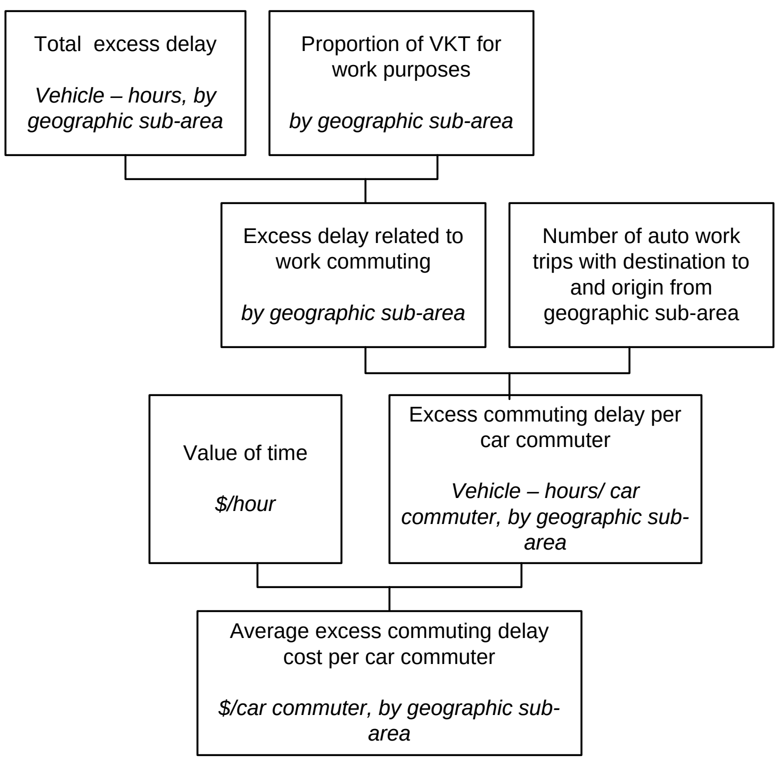
3.1.2 Excess Work Commuting Costs

The travel delay impacts illustrated in Figure 3 can be narrowed down by focussing on car commuters, the group of people who likely bear the greatest cost of excess delay as they use the road network during the times of day when it is most congested.

Calculation of commuting delays may be challenging as it requires some assumptions regarding the typical travel routes from home to work and back home to determine the geographic areas that a commuter passes and average trip length in each of these areas. Then, knowing the actual and optimal speed in each of the areas, the excess commuting delays could be estimated and averaged over an entire geographic area.

We adopt here a simpler but equivalent approach based on vehicle-kilometres travelled for work purposes (by geographic sub-area) and the number of auto trips for work purposes within each area (or destined to and originating in each area).[6] This approach should generate similar results provided that most work trips take place between adjacent geographic sub-areas (or that the number of work trips that would likely have to pass through several geographic areas is relatively small).[7] Figure 4 below illustrates this approach.

Figure 4: Calculation of Excess Commuting Costs per Car Commuter



[6] The estimates of vehicle-kilometres travelled takes into account the average trip length in each of the geographic areas. Section 4 explains in more detail how vehicle-kilometres travelled were estimated.
[7] We show later in this report that this assumption is in fact valid.

3.1.3 Impact on Demand for Labour and Business Activity

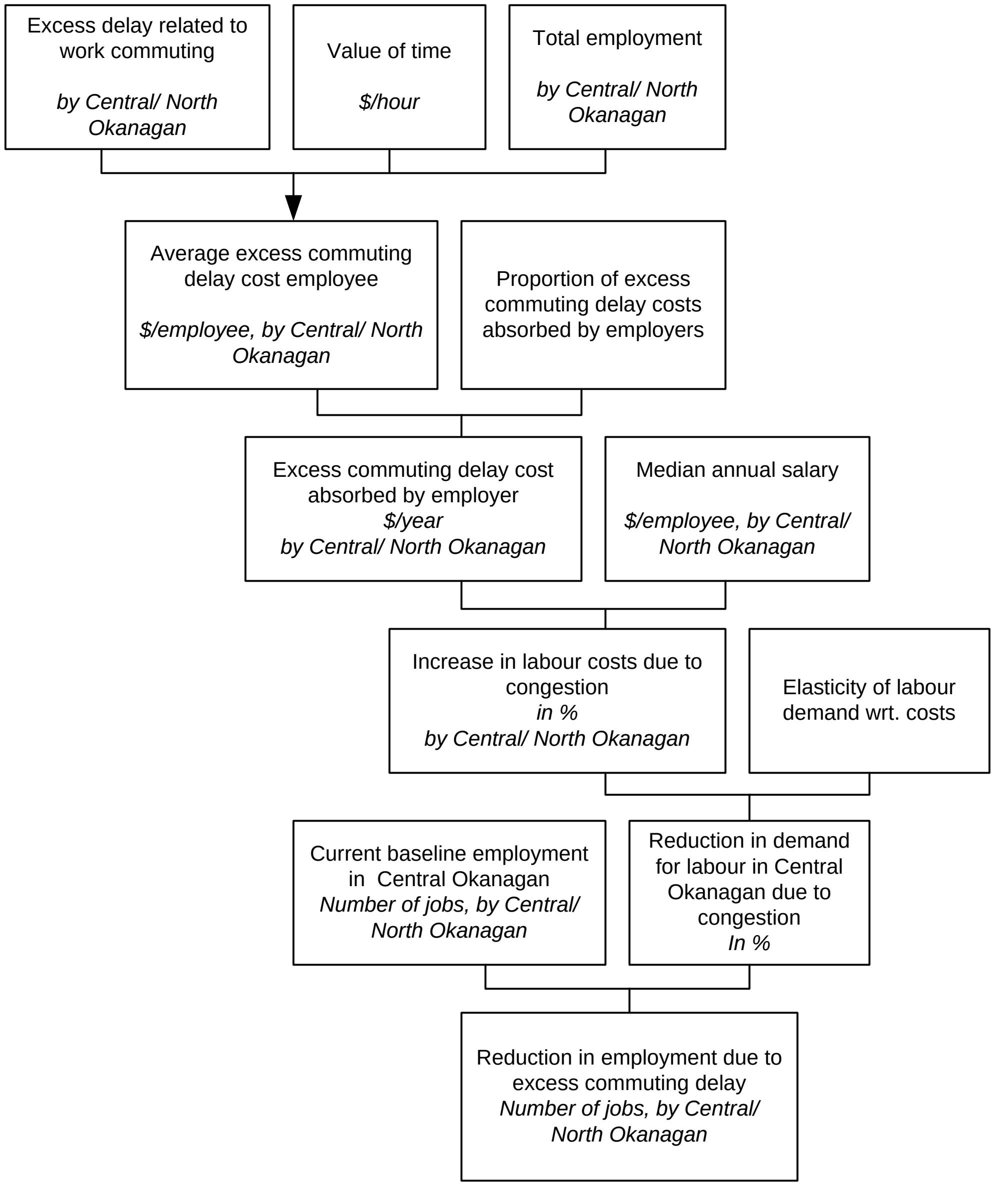
Excess congestion increases workers' commuting costs, including the cost of their own time spent in traffic. Since workers factor these costs into their choices of where to work, increased congestion may force employers to remunerate more generously to attract the workers they need. In some cases, the salary that would be sufficient to compensate for a long commute will be more than the employer can afford. In this case, employers may have to scale down their employee expansion plans, or devote more resources to recruitment, or settle on less suitable employees, with a consequent decrease in labour demand, labour productivity, or both. Congestion on a region's roads, particularly unanticipated congestion, can also have other consequences for employers, such as when an employee misses a meeting because of a traffic jam while en route to work. There is some empirical evidence (although limited and with some qualifications) indicating that employers are sensitive to these delays and costs.

After reviewing the limited evidence on the relationship between pay and commuting costs, NCHRP Report 463 assumed for a modeling exercise similar to this one that in the long run, higher pay offsets half of any increase in commuting costs in a metropolitan region.[8] Using this assumption and the excess commuting cost per employee calculated earlier, one can estimate the average commuting cost per employee absorbed by local employers in the form of higher salaries. This can then be compared with the average salary in the region to calculate the percentage increase in average salary due to congestion. This can then be combined with the elasticity of demand for labour to calculate the percentage reduction in labour demand. Applying this percentage to the current employment data, one can estimate the reduction in employment due to congestion in absolute terms. These effects are illustrated graphically in Figure 5.

As mentioned earlier, excess commuting costs can, in addition to forcing up the cost per worker, reduce worker productivity, but evidence on the magnitude of this effect is lacking. NCHRP Report 463 simulated region-wide reductions in commuting travel time for the Chicago and Philadelphia metropolitan areas and found the effect on labour productivity to be very small relative to the straight change in labor cost (though this may partly have stemmed from the limitations of their model). Therefore, this effect – as somewhat speculative – is not estimated here.

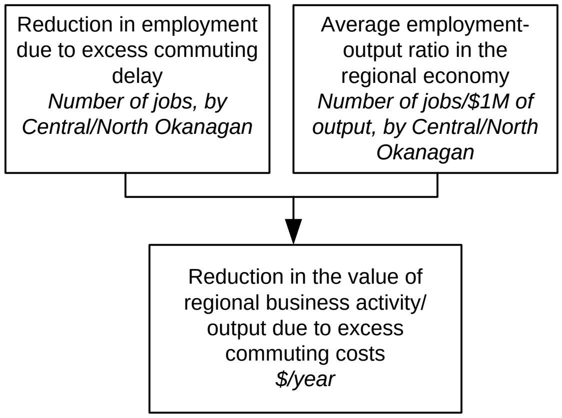
[8] Weissbrod, G., Vary, D. and Treyz, G. 2001. *Economic Implications of Congestion*, National Cooperative Highway Research Program Report 463, National Academy Press, Wash., D.C., 2001, esp. pp. 16, 26 (also available at: gulliver.trb.org/publications/nchrp/nchrp_rpt_463-a.pdf).

Figure 5: Estimation of the Impact of Congestion on Labour Demand.



One could, however, continue the logic illustrated in Figure 5 and argue that reduced employment also results in lost business activity and lost business output or revenues. This effect is illustrated graphically in Figure 6.

Figure 6: Estimation of Business Output Lost due to Congestion



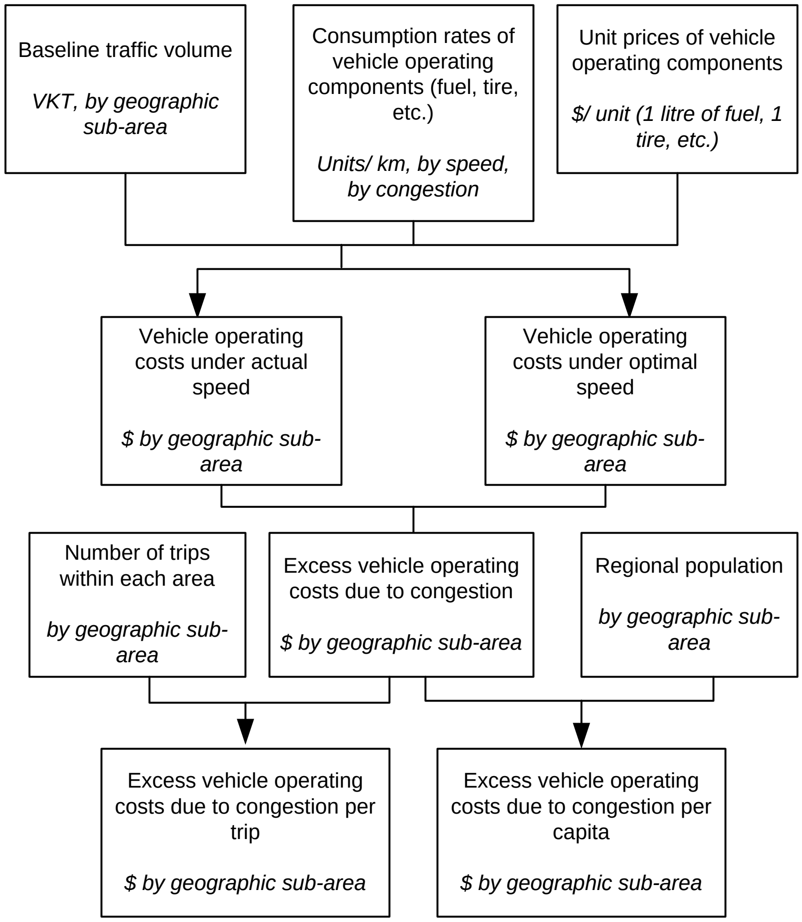
3.1.4 Vehicle Operating Costs Impacts

Over a considerable range of average speed, the technologies embodied in motor vehicles produce a positive relationship with fuel economy. Congestion thus reduces fuel economy because at lower average vehicle speed fuel usage actually increases. In addition, the stop-and-go driving that frequently results from congestion results in speed cycling that further increases fuel consumption.

Our calculation of excess vehicle operating costs are based on readily available estimates of consumption rates per vehicle kilometre published in engineering literature (broken down by average speed and congestion level), unit prices, and vehicle kilometres traveled under baseline conditions. For example, fuel consumption rate at the baseline speed is multiplied by the baseline VKT and fuel price to obtain total cost of fuel under baseline conditions. On the other hand, fuel consumption rate at the optimal speed multiplied by the baseline VKT and fuel price will give total fuel cost under conditions of no excess congestion. The difference between the two is the excess vehicle operating cost.

Figure 7 below shows the logic of these calculations for the entire range of vehicle operating costs (fuel, oil, tires, maintenance and depreciation) for autos. A similar logic model can be adopted for estimation of excess vehicle operating costs for trucks using consumption rates of vehicle operating cost components for trucks.

Figure 7: Estimation of Excess Vehicle Operating Costs



3.2 Industry Level Impacts

This section develops a methodology for the assessment of industry-level congestion impacts. We consider industries which appear particularly sensitive to congestion problems, including the following:

- Retail trade;
- Wholesale trade;
- Agriculture industry
- Manufacturing industry;
- Construction;
- Tourism; and,
- For-hire trucking industry.

The impacts measured are changes in industry revenues, operating costs, and employment, though not all of these impacts are estimated or considered for each industry.

The estimation framework was built up from "structure and logic models", which represent in a flowchart or graph the causal relationships among the relevant factors as well as the underlying logic. The models are grounded in economic theory and coded in a series of equations; values for parameter and variables in these equations are obtained from related published studies, statistical data series, local data, and other data collections. The graphical representation facilitates client and stakeholder evaluation of the model logic.

The models frequently utilize the concept of elasticity. As explained earlier in the context of elasticity of travel demand with respect to the cost of driving, elasticity measures the sensitivity of response when one of the underlying driving factors changes. The response is measured in terms of percent change of the variable in interest when the driving factor of this variable changes by 1 percent. For example, elasticity of vehicle miles traveled with the cost of driving equal to -0.8 indicates that vehicle kilometres of travel increases by 0.8 percent when the cost of driving goes down by 1 percent.

It should be noted that chronic traffic congestion induces certain adaptive responses that evolve only gradually over the long run. Since these tend to be especially hard to model with much confidence, our analysis is largely limited to congestion's short- to medium-term impacts. For example, we do not estimate the inhibiting effects of congestion on consolidation of wholesale operations with the resulting change in cost or employment structure.

The industry impacts are estimated for the entire Central Okanagan and North Okanagan Regions and using all-day average traffic data. This is because a model with sub-regional impacts would require a more complex model than it was possible to develop within this engagement. The model will use all day average traffic data in order to avoid the risk of exacerbating the congestion costs when peak hours of congestion is limited to only a few hours a day leaving plenty of time for transportation arrangements during the not congested part of the day.

As in the case of travel delays and related impacts, all industry level impacts are estimated for the current 2007 baseline and 2030 baseline.

3.2.1 Retail Trade Industry

The impact of congestion on the retail industry could manifest itself in two types of effects:

(1) Effect on shopping habits, or behaviour, and number of shopping trips; and,
(2) Effect on the costs of logistics and inventory held by shop owners.

The two types of effects are discussed below.

Effect of congestion on shopping habits

The literature on the effects of travel times and traffic congestion in particular on shopping behaviour and retail sales in a geographic region is very limited if non-existent. Casual observations suggest that traffic congestion can affect at least the distribution of shopping and retail sales across a geographic region.

However, it seems that high traffic congestion can also impact the net number of shopping trips and retail sales.[9] For example, in conditions of high congestion some individuals may be discouraged to go shopping for some discretionary purposes or items as they want to avoid aggravation and loss of time. The sales lost from that trip may not necessarily be recovered when the individuals go on their next shopping trip. A related marketing study found that consumers do combine multiple shopping purposes and destinations on one trip but the scope for this behaviour is considerably smaller than could be expected if shopping trips were planned based purely on travel cost minimization.[10]

We acknowledge here this possibility. However, in view of the lack of general evidence on the issue, or insights from local data or the local transportation model on trip patterns under various travel costs and travel conditions, we treat this type of impact as somewhat speculative. In addition, the data indicates that heavy congestion with substantial travel speed reductions is limited to primarily Central Kelowna. Therefore, the scope for trip re-scheduling to less congested times of day (or weekends), or less congested geographic areas, may be significant and neutralize the effect of congestion during weekday rush hours in Central Kelowna and adjacent areas. Although retail shops in some congested areas in the Region could be negatively affected by the current traffic situation, shops in other parts of the Region may actually be benefiting in the form of a larger number of shoppers and revenues. The net effect on the industry in the entire Region may well be close to zero. This issue would require a more complex research that was not possible within the timeline and budget of this study. As a result, we do not estimate this effect here.

Effect of congestion on the costs of logistics and inventory in the retail industry

Congestion also can add to logistics costs of local retailers by reducing travel speeds and the reliability of delivery times for merchandise and supplies. Literature indicates that in a wide range of industries this type of effect adds to operation costs directly and also by inhibiting businesses from adopting inventory-saving strategies such as just-in-time inventory systems.[11]

The overall increase in logistics costs can be estimated using information on the ratio of logistics costs to total sales of the sector, existing elasticity estimates of this cost item, and estimates of the increase in average delivery time resulting from congestion.

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[9] Interviews with NYMTC suggest that the agency has developed a land use and transportation model that could potentially be used for the exercise at hand to estimate the effect of travel times on region-wide distribution of travel patterns and resulting employment.

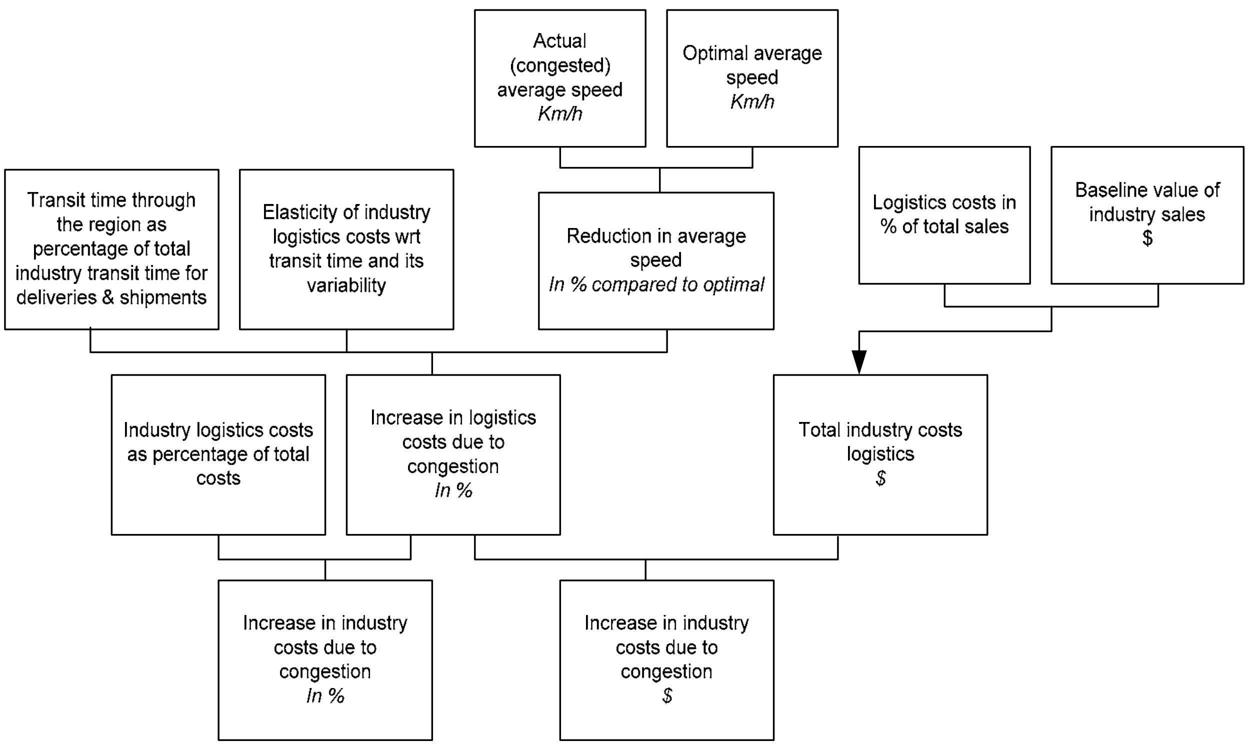
[10] See Dellaert, Benedict, Theo Arentze, Michael Bierlaire, Aloys Borgers, and Harry Timmermans ((1998), "Investigating Consumers' Tendency to Combine Multiple Shopping Purposes and Destinations"; also published in *Journal of Marketing Research*, Vol. 35, No. 2 (May 1998), pp. 177-1888.

[11] See for example: Freight Benefit-Cost Study, a report for Federal Highway Administration, Office of Freight Management and Operations, by ICF Consulting, HLB Decision Economics, and Louis Berger Group, July 2002.

Figure 8 shows the structure and logic of these costs. The difference between actual congested speed and optimal not-congested speed is transformed into a percent reduction in actual speed compared to the optimal speed. This is combined with the industry's elasticity of logistics costs with respect to transit time to give an estimate of the increase in industry logistics costs. This calculation is adjusted by the percentage of the industry transit time for deliveries and shipments that take place in the Region in order to capture the idea that transit through the heavily congested road network within the Central and North Okanagan Regions may account for only a fraction of total transportation distance and time.

Increase in industry logistics costs is, in turn, combined with estimates of industry logistics costs as a percentage of total industry costs to give an estimate of the increase in industry costs.

Figure 8: Effect of Congestion on Industry Logistics Costs



3.2.2 Manufacturing Industry

Traffic congestion impairs the operations of manufacturing businesses by adding to delays and reducing the reliability of deliveries of materials and components as well as shipments of finished products to markets. These effects tend to increase inventory and logistics costs by an amount that can be estimated in our model framework according to a similar approach as that illustrated in Figure 8.

In addition, the literature indicates that high congestion may reduce the market area for a firm's output leading to a reduction in sales. [12] To illustrate this point, let's assume that congestion leads to an increase in production costs because a firm may have to purchase more expensive inputs and supplies from another location, increase its inventories, etc. An increase in production costs may require a firm to increase the price of its product, or make changes in the terms of delivery of a product. This in turn may reduce sales as buyers will be looking for less expensive alternatives. In some industries where final products are highly homogeneous, even a small price differential may induce switching to another supplier who offers a lower price. The reduction in sales (and possibly a reduction in economies of scale in production) results in a loss of output and business revenue.

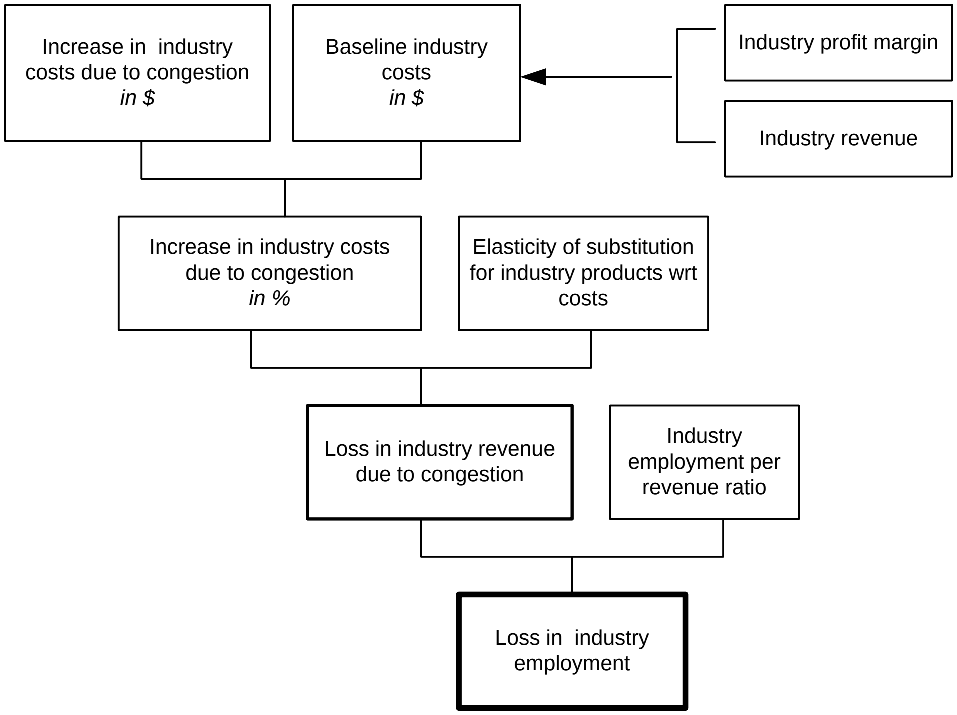
In Central Okanagan, transportation efficiency and reliability is also likely to play an extremely important role in the development and success of manufacturing given that an increasing proportion of manufacturers export goods outside the region to destinations elsewhere in BC, Canada, and the US[13] where they would be directly competing with local similar products or other imported products.

The structure and logic diagram for the estimation of the revenue loss is shown below in Figure 9. The increase in industry costs due to congestion estimated in earlier steps is transformed into a percentage increase based on industry cost structure and combined with elasticity of substitution for that industry's products with respect to costs to obtain an estimate of revenue loss due to congestion. The lost revenue is then combined with statistical industry employment per $1 million of revenue to estimate the resulting loss in employment.

[12] See Weisberg G., D. Vary, and G. Treyz (2001) "Economic Implications of Congestion", NCHRP Report 463, Transportation Research Board, National Cooperative Highway Research Program.

[13] [13] See *Central Okanagan Multi-Modal Corridor Study,* report prepared by Urban Systems and Associated Engineering, September 2007.

Figure 9: Effect of Congestion on Revenues and Employment in the Manufacturing Industry



3.2.3 Construction

Traffic congestion impairs the operations of construction businesses by adding to delays in deliveries and reducing reliability of the transportation network. Again, these effects add to inventory and logistics costs by an amount than can be estimated in our model framework and using an approach similar to that laid out in Figure 8.

3.2.4 Wholesale Industry

For the wholesale industry, congestion, reduced average speeds, and less reliable delivery times will push up inventory levels and logistics costs. This effect can be estimated using an approach similar to that shown in Figure 8.

In addition, the industry may also suffer from congestion indirectly, through the adverse effects on sales in retail trade, manufacturing, and other industries from which the wholesale industry draws business. The wholesale trade can be seen, however, as further down the production/supply chain, which means that including these indirect impacts on the industry's revenues would involve some double-counting. Therefore, this indirect effect of congestion on wholesale trade revenue is omitted here.

3.2.5 Agriculture Industry

Traffic congestion impairs the operation of agricultural businesses by adding to delays, adding to delivery times, and reducing the reliability of deliveries of production inputs and final products to consumer markets.

This may lead to a direct increase in industry logistics, warehousing, and transportation cost by inhibiting cost-saving innovations in storage and transportation management.

In addition, as in the case of the manufacturing industry, higher logistics costs and longer delivery times may induce some buyers to switch to an alternative supplier who can provide the product at a lower cost and deliver it within a shorter period of time. The NCHRP report cited earlier found that the scope for product switching in the agriculture business is particularly high due to the highly homogenous nature of these products.[14]

In the Okanagan Region, transportation efficiency and reliability is also likely to play an extremely important role in the development and success of the agricultural businesses given that the region specializes in the production of fruit, vegetables, and dairy products, and that the majority of the production is exported to the Lower Mainland, Alberta, and the US[15] where they, obviously, actively compete with local produce and imports from other origins.

Both the logistics cost and the output effect of excess congestion discussed above can be estimated using similar approaches and logic models as those for the manufacturing industry.

3.2.6 Tourism

Traffic congestion also increases travel times and stress for tourists. It seems intuitive that they would not want to spend excessive time in traffic and thus that they may be discouraged from coming to a congested geographic area. Although congestion in a particular geographic area may account only for a small portion of the entire trip, there is evidence that delays in some key congestion points or bottlenecks may discourage travel. For example, studies report that delays and waiting times at border crossings reduces the number of cross-border trips.[16] Although direct evidence for Kelowna is not available, it seems reasonable to anticipate similar mechanisms for Kelowna as well.

Figure 10 shows the approach to estimation of these effects. The approach is based on the estimate of speed reduction and elasticity of tourist visits to a geographic area with respect to travel time. This gives an estimate of the reduction in tourist visitations. This is then combined

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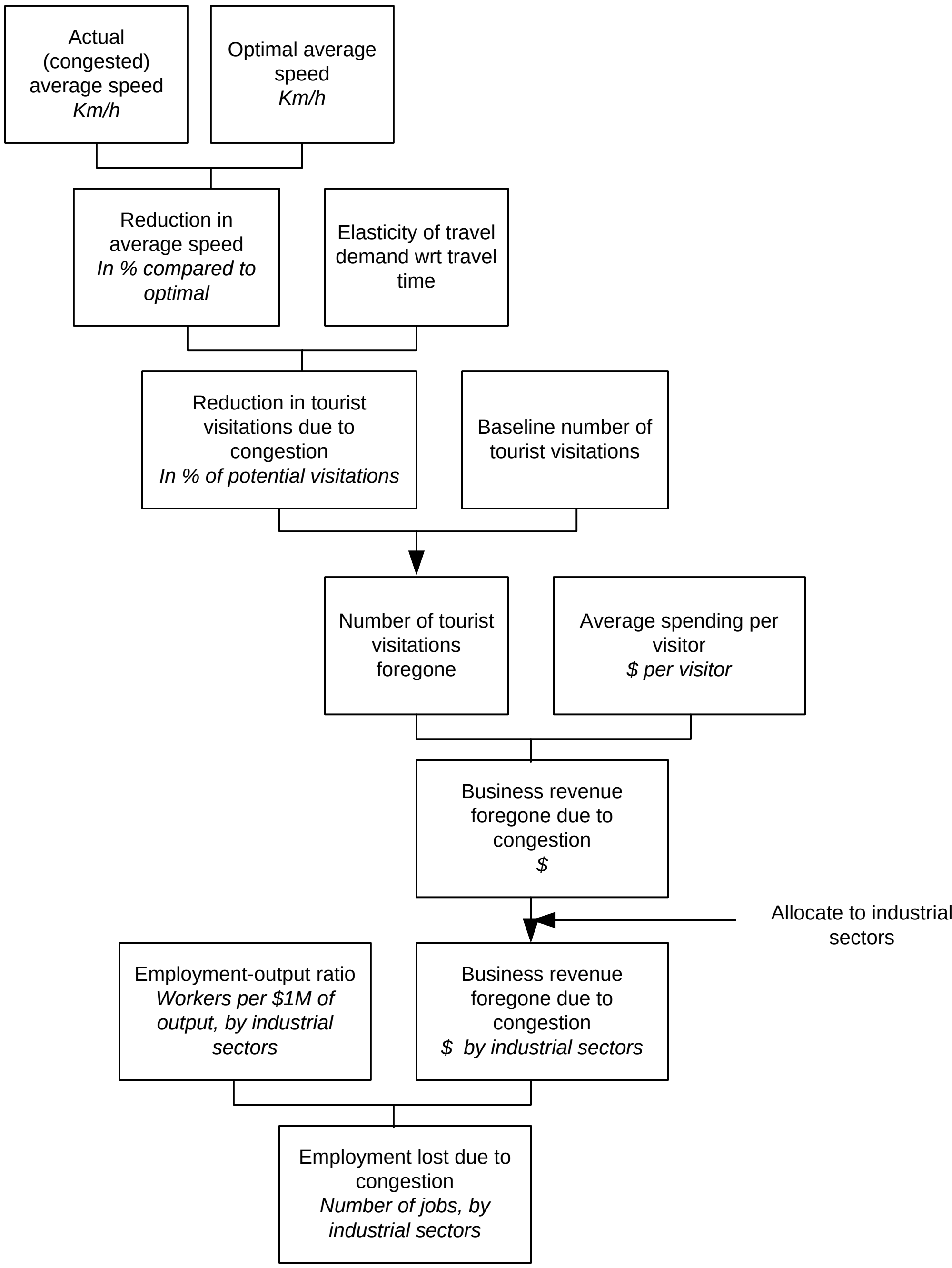
[14] See Weisberg G., D. Vary, and G. Treyz (2001) "Economic Implications of Congestion", NCHRP Report 463, Transportation Research Board, National Cooperative Highway Research Program

[15] See *Central Okanagan Multi-Modal Corridor Study,* report prepared by Urban Systems and Associated Engineering, September 2007.

[16] See for example *Economic Impacts of Wait Times at the San Diego-Baja California Border*, report prepared by HDR|HLB Decision Economics for San Diego Association of Governments and California Department of Transportation (District 11), January 19, 2006 and other studies reported there.

with the average spending by tourist on local goods and services to obtain an estimate of revenues, by industry, lost due to congestion.

Figure 10: Effect of Congestion on Tourism



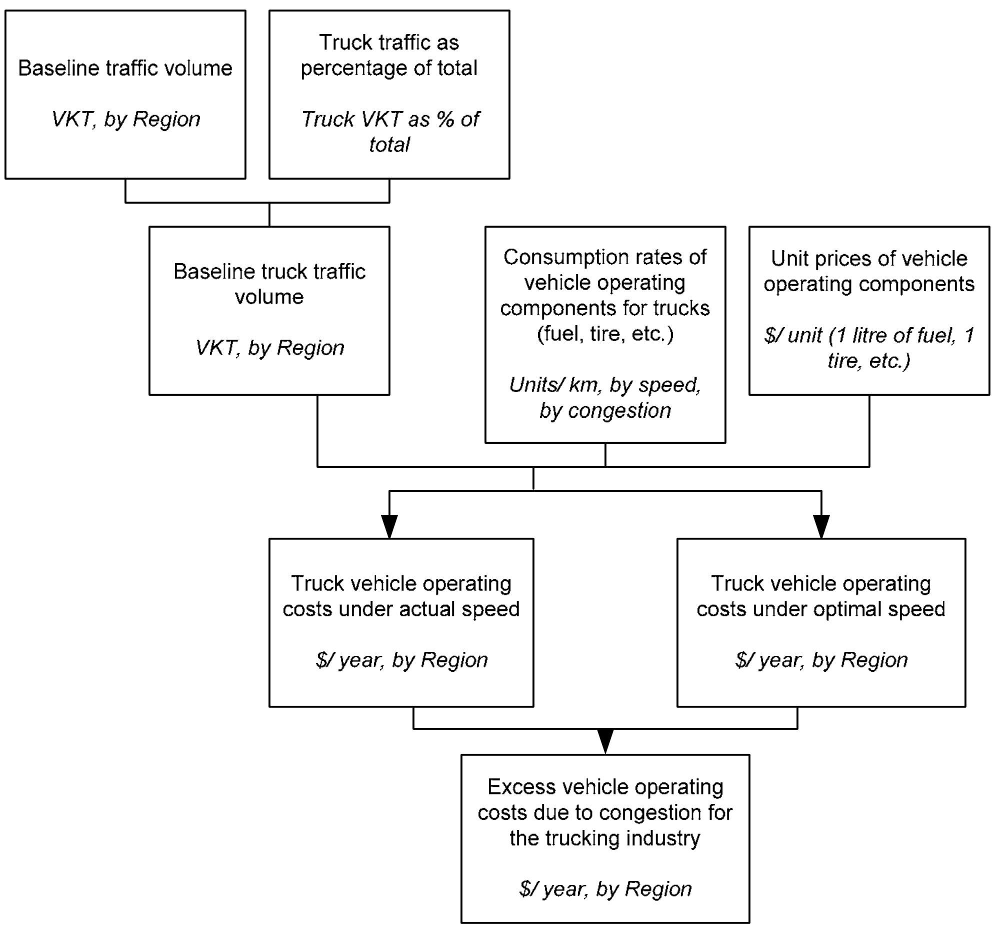
3.2.7 Trucking Industry

Excess congestion can affect the trucking industry in a number of ways, including the following:

(1) Increase in the consumption of fuel and other operating costs due to an increase in the consumption rates of operating costs components under lower average speeds;
(2) Increase in labour costs (i.e. trucker time costs) for a given shipment due to an increase in transit/delivery times;
(3) Reduction in demand for services due to the reduction in output of the industries directly affected by congestion that use the services of the trucking industry for the transportation of their supplies and transportation of finished products; and,
(4) Reduction in opportunities for backhaul loads due to longer transit times and regulations with respect to work hours.

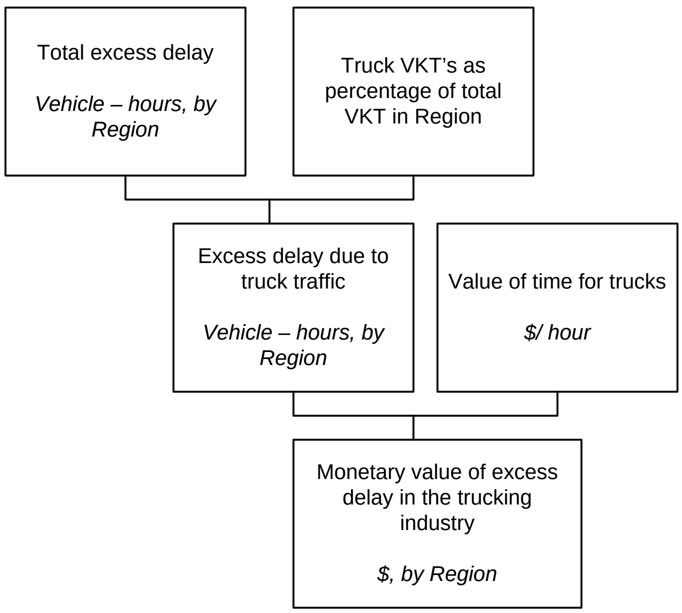
Item (1) will be captured within the excess vehicle operating costs calculations discussed earlier. Figure 11 below illustrates the specific methodology.

Figure 11: Estimation of Excess Vehicle Operating Costs for Trucking Industry



Item (2) will be captured within the excess delay component discussed earlier. The specific magnitude of delay attributable to truck traffic will be estimated (or allocated to traffic) based on the proportion of truck traffic in total traffic. Figure 12 below illustrates the specific calculations involved.

Figure 12: Estimation of Excess Delay Costs for Trucking Industry



Item (3) will be captured within the revenue and output impacts of the other industries. In order to avoid double counting of the same or related effects in functionally related industries, these effects will not be estimated separately here.

Item (4) is more complex in nature and would require more detailed knowledge and research of the local trucking industry, their structure, and markets. A series of interviews would also likely be required in order to understand the dependencies between transit times and operations. This effort will not be possible within this study due to budget limitations. We acknowledge here the potential impacts but do not estimate them quantitatively.

4: MODEL DEVELOPMENT AND IMPLEMENTATION

4.1 Data Required to Populate the Model

Table 1 below presents the data required for the estimation of the congestion cost model, discusses data sources, and provides the specific data input assumption adopted in this study.

Table 1: Data Required for the Model of Congestion Costs

DATA INPUT	DATA SOURCES AND COMMENTS	ASSUMED DATA VALUE
Figure 2		
Baseline traffic volume (vehicle kilometres travelled, VKT)	No direct sources of information for VKT data were identified. "2007 North and Central Okanagan Household Travel Survey", a project completed by Synovate for the City of Vernon and City of Kelowna provided information on the number of origin-destination (OD) trips by time of day (AM peak, PM peak, and off-peak), mode of transportation and purpose. The trip origin and destination were defined in terms of geographic areas within the Central Okanagan and Northern Okanagan Region: (1) City of Vernon, (2) Coldstream and Lumby, (3) Spallmucheen, Armstrong, and Enderby, (4) Suburban Kelowna, (5) Central Kelowna, (6) Westside, Westbank, and Peachland, and (7) Lake Country. The survey data was used to calculate the average trip length for each origin-destination. Multiplying the number of OD trips by average length and aggregating over geographic areas (1) to (7) allows to calculate total VKT in the region.	Varies by geographic area, see Section 4.2 and Table 3 for details.

Table 2: Data Required for the Model of Congestion Costs

DATA INPUT	DATA SOURCES AND COMMENTS	ASSUMED DATA VALUE
Elasticity of travel demand	Elasticity estimates specific for the Central Okanagan were not available. Economics literature and other travel studies indicate that travel demand elasticities are typically in the range of about -0.3 to -1. Elasticities tend to be higher (in absolute terms) in cities with a good transit network as transit offers alternatives to driving a car. For this study a lower range of reported elasticities was selected. The hypothesized range of elasticity is rather low due to a low share of transit.[17]	-0.3
Average costs of driving (fuel, maintenance, depreciation), $/km	Canadian Automobile Association provides annual updates of driving costs in Canada, including fuel, insurance, maintenance, and depreciation. The assumed value is the sum of average operating cost (fuel, oil, maintenance, tires) for Cobalt and Grand Caravan; and 40% of average ownership cost (depreciation, insurance, registration).	$0.32/ km
Value of time, $/hour	HighwayDEC, a Cost-Benefit Model for Highway Infrastructure Investment; model developed by HDR|Decision Economics for Transport Canada, December 2007. The model has an extensive data base of default values of variables relevant for the analysis of highway infrastructure projects. The data was compiled based on literature review as well as a survey of provincial transportation agencies on their use of cost-benefit analysis tools and adopted default values of various parameters for this analysis.	$12.12 per person hour; private travel $27.31 per person hour; trucks $16.96 per vehicle hour; private travel (reflects average car occupancy of 1.4 per vehicle)[18] $17.68 per vehicle hour; total travel (based on share of trucks of 7.5 percentin total traffic)
Actual baseline congested speed	The household travel survey data.	Varies by geographic area. See Section 4.2 and Table 4 for details.
Free-flow speed	Assumed equal to the average posted speed within city limits.	50 km/h or 60 km/h

[17] Based on 2006 Census data, in Kelowna Census Metropolitan Area the share of transit in transportation to work is just 2.6 percent. This compares with 10.3 percent for the entire province of British Columbia and 22.2 percent for Toronto Census Metropolitan Area.

[18] Average occupancy of 1.4 is based on the Synovate survey results.

Table 2: Data Required for the Model of Congestion Costs (Cont'd)

DATA INPUT	DATA SOURCES AND COMMENTS	ASSUMED DATA VALUE
Figure 3		
Baseline traffic volume (vehicle kilometres travelled)	The same as Figure 2	
Actual congested speed	The same as Figure 2	
Optimal speed	From Figure 2	
Regional population	Statistics Canada, 2006 Census data	Varies by geographic area. Total of 206,456 for North and Central Okanagan.
Figure 4		
Total excess delay	From Figure 3	
Proportion of VKT for work purposes	2007 North and Central Okanagan Household Travel Survey data.	About 24 percent in each geographic area.
Number of auto work trips with destination to and origin from a geographic area	2007 North and Central Okanagan Household Travel Survey data.	Varies by region. See Table A-1 in the Appendix.
Value of time	The same as Figure 2	
Figure 5		
Average commuting delay cost and vehicle operating cost per employee	From Figure 4 and Figure 7.	
Proportion of excess commuting delay costs absorbed by employers	Economics literature, e.g. Weisberg G., D. Vary, and G. Treyz (2001) "Economic Implications of Congestion", NCHRP Report 463, Transportation Research Board, National Cooperative Highway Research Program	0.5
Average annual salary	Statistics Canada, 2006 Census data (persons who worked full time full year).	$45,630 in Central Okanagan; $38,794 in North Okanagan

Table 2: Data Required for the Model of Congestion Costs (Cont'd)

DATA INPUT	DATA SOURCES AND COMMENTS	ASSUMED DATA VALUE
Elasticity of labour demand with respect to labour costs	Reasoned assumptions based on related discussions in the literature. For references see another HDR|Decision Economics report: "The Economic Costs of Congestion in the New York City Region", report for Partnership for New York City, November 27, 2006, page 38-39.	-0.75
Baseline employment	Statistics Canada, 2006 Census data	82,010 in Central Okanagan; 26,135 in North Okanagan
Figure 6		
Reduction in employment in Central Okanagan due to excess commuting delay	From Figure 5	
Average employment-output ratio in regional economy	Calculated as the weighted average of employment-output ratios (by industry) from Statistics Canada Inter-Provincial Input-Output Model. Weights based on employment share by industry.	13.46 for Central Okanagan; 13.56 for North Okanagan
Figure 7		
Baseline traffic volume	The same as Figure 2	
Consumption rates of vehicle operating components	HighwayDEC, a Cost-Benefit Model for Highway Infrastructure Investment; model developed by HDR|Decision Economics for Transport Canada, December 2007.	See the Appendix, Table A-3
Prices of vehicle operating components	HighwayDEC, a Cost-Benefit Model for Highway Infrastructure Investment; model developed by HDR|Decision Economics for Transport Canada, December 2007, updated to 2007 conditions.	See the Appendix, Table A-2
Regional population	The same as in Figure 3	

Table 2: Data Required for the Model of Congestion Costs (Cont'd)

DATA INPUT	DATA SOURCES AND COMMENTS	ASSUMED DATA VALUE
Figure 8		
Actual congested speed	The same as Figure 2	
Optimal average speed	The same as Figure 2	
Elasticity of industry logistics costs with respect to transit time (by industry)	"Freight Benefit-Cost Study", a report for Federal Highway Administration, Office of Freight Management and Operations, by ICF Consulting, HLB Decision Economics, and Louis Berger Group, July 2002.	0.27
Logistics costs in percentage of total sales (by industry)	"Freight Benefit-Cost Study", a report for Federal Highway Administration, Office of Freight Management and Operations, by ICF Consulting, HLB Decision Economics, and Louis Berger Group, July 2002	2.5 percent for retail industry; 5 percent for manufacturing, wholesale trade, construction, and agriculture.
Transit time through the region as proportion of total transit time for shipment and deliveries	This variable captures the idea that transit time through the Central and North Okanagan regions may account only for a fraction of total transportation time as shipments may go to destinations beyond the Central/North Okanagan and deliveries may be coming from outside of the Central/North Okanagan. No actual data values were identified for this variable. For modelling purposes, reasoned assumptions were adopted.	1 for retail industry and construction; 0.25 for manufacturing, wholesale trade, and agriculture.
Figure 9		
Increase in industry costs due to congestion	From Figure 8	
Industry profit margins, by industry	No direct data is available. Components of multipliers from Statistics Canada's inter-provincial input-output model, specifically operating surplus components of output, can serve as proxy estimates.	15 percent

Table 2: Data Required for the Model of Congestion Costs (Cont'd)

DATA INPUT	DATA SOURCES AND COMMENTS	ASSUMED DATA VALUE
Baseline value of industry sales (by industry)	Industry sales data at the sub-provincial level are difficult to obtain from Statistics Canada as a lot of data are suppressed for confidentiality reasons. A proxy estimate can be obtained by multiplying available employment by industry data (for example employment by industry figures from the 2006 Census) by provincial employment output ratios from the provincial input-output model.	See the Appendix, Table A-4 and Table A-5.
Elasticity of substitution for industry products with respect to congestion induced costs	Economics literature, e.g. Weisberg G., D. Vary, and G. Treyz (2001) "Economic Implications of Congestion", NCHRP Report 463, Transportation Research Board, National Cooperative Highway Research Program.	7 for manufacturing; 11 for agriculture
Figure 10		
Actual congested average speed.	The same as Figure 2.	
Optimal average speed.	The same as Figure 2.	
Elasticity of travel demand with respect to travel time.	Economics literature, e.g. *Economic Impacts of Wait Times at the San Diego-Baja California Border*, report prepared by HDR|HLB Decision Economics for San Diego Association of Governments and California Department of Transportation (District 11), January 19, 2006 and other studies reported there.	0.12
Baseline number of tourist visitations	Statistics Canada, visits to Kelowna and Vernon, person visits for one or more nights	970,000 for Central Okanagan; 270,500 for North Okanagan.
Average spending per visitor, by category of goods and services.	Statistics Canada, average per person per visit spending for visits for one or more nights.	$366 for Central Okanagan; $324 for North Okanagan.
Allocate tourist expenditures to industrial sectors	2006 Visitor Survey, report for Tourism Kelowna by Kettle Valley Research, October 2006.	See the Appendix, Table A-6.
Figure 11		
Estimation and inputs similar to Figure 7 (with inputs specific for trucks).		
Figure 12		
Estimation and inputs similar to Figure 4 (with inputs specific for trucks and for the entire region only)		

4.2 Estimating Vehicle-Kilometres Travelled and Average Speeds

The 2007 household travel survey provided information on individual trip lengths and travel time. These data were analyzed to derive the 2007 baseline vehicle kilometres travelled and average speed by geographic area and time of day.[19] Below we describe in more detail the steps and assumptions and the results obtained.

4.2.1 Derivation of Vehicle-Kilometres Travelled

The VKT estimate for the Region is based on the survey results for the number of auto driver trips by origin-destination pairs. Specifically, VKT calculations involved the following steps:

1. From the survey data on trips, calculate the average distance traveled for all *i, j* origin-destination (OD) pairs.

2. For each OD pair, calculate VKT traveled by multiplying the number of trips by the average trip length.

3. Aggregate VKT_{ODij} to geographic areas defined by origin/destination areas *i, j*. The VKT traveled within a geographic area, rather than within an OD pair, will be equal to the sum of VKT for trips that originate and end in the same geographic area j plus a fraction of VKT's for other trips that pass through area j. That fraction could be approximated by the proportion of the trip that takes within area j. This proportion was determined based on the geography of the region and relative distances.

4. Pro-rate VKT estimates from Step 3 to account for tourist traffic.

   The estimates above will not include VKT's by non-residents as the 2007 travel survey covered only local resident households. The research conducted within this study was unable to identify VKT specific to tourist traffic. The available studies provided only partial information on the extent of traffic by non-residents. For example, the Okanagan Lake Bridge report indicates that non-residents account for 12 percent of bridge crossings, and that in the summer this proportion would be even higher.[20] The report also indicates that the current traffic on the Okanagan Lake Bridge amounts to about 46,000 AADT, and in the summer it increases to 50,000.[21]

   Therefore, the VKT estimates obtained in step 3 was increased by 12 percent for all geographic areas adjacent to the Okanagan Lake Bridge.[22]

[19] *2007 North and Central Okanagan Household Travel Survey*, a project completed by Synovate for the City of Vernon and City of Kelowna

[20] Okanagan Lake Bridge Comprehensive Traffic Report, May 2004, a report by Halcrow Group Limited with TSi Consultants, page 34.

[21] Okanagan Lake Bridge Report, Executive Summary, page i.

[22] The summer peak increase in traffic is based on the estimated increase in AADT on the Okanagan Lake Bridge during summer months: (50,000 – 46,000)/46,000 = 8.7%

5. Pro-rate VKT estimates from Step 3 to account for truck traffic.

   The research conducted within this study did not identify any data on truck VKT. The report prepared for the Central Okanagan Multi-Modal Corridor Study indicated that truck traffic on Highway 97 accounts for 5 to 10 percent of total traffic.[23]

   Therefore, VKT for geographic areas that span over Highway 97 was adjusted upwards by 7.5 percent (the average of the two figures given above)

Table 3 below presents the results. The table shows that in North and Central Okanagan regions the combined daily vehicle kilometres travelled amounted to over 8 million. North Okanagan accounted for about 32 percent of the travel (or nearly 2.6 million vehicle kilometres), and Central Okanagan accounted for about 68 percent (or over 5.45 million vehicle kilometres travelled).

In North Okanagan, nearly 63 percent of total travel was concentrated in the City of Vernon. In Central Okanagan, also about 63 percent of total travel was taking place in Central and Suburban Kelowna combined (29 percent in Central Kelowna and 34 percent in Suburban Kelowna). In all geographic areas, travel during peak hours accounted for about 30 percent of total vehicle kilometres travelled.

[23] "Corridor Study. Central Okanagan Multi-Modal Corridor", a study by Urban Systems and Associated Engineering, September 2007, page 9.

Table 3: Daily Vehicle-Kilometres Travelled by Geographic Sub-Area

Region	Region Name	AM Peak	PM Peak	Off-Peak	Total	Total Peak	Peak VKT as Percentage of Total within Geographic Sub-area	VKT in Geographic Area as Percentage of Total VKT in Region
North Okanagan Region								
1	Vernon	211,452	286,616	1,136,207	1,634,275	498,068	30.5%	62.9%
2	Coldstream, Lumby	31,942	40,042	165,877	237,861	71,984	30.3%	9.1%
3	Spallumcheen, Armstrong, Enderby	120,433	110,755	496,435	727,622	231,187	31.8%	28.0%
Total North Okanagan		**363,827**	**437,413**	**1,798,519**	**2,599,759**	**801,240**	**363,827**	**100%**
Central Okanagan Region								
4	Lake Country	137,578	169,343	713,394	1,020,314	306,921	30.1%	18.7%
5	Westside, Westbank, Peachland	140,198	147,757	685,549	973,504	287,955	29.6%	17.9%
6	Central Kelowna	199,640	277,984	1,115,239	1,592,863	477,625	30.0%	29.2%
7	Suburban Kelowna	285,905	276,198	1,301,559	1,863,662	562,103	30.2%	34.2%
Total Central Okanagan		**763,321**	**871,282**	**3,815,740**	**5,450,343**	**1,634,603**	**763,321**	**100%**
Total North and Central Okanagan		**1,127,148**	**1,308,695**	**5,614,259**	**8,050,101**	**2,435,842**	**30.3%**	

4.2.2 Derivation of Average Speed in the Region, by Geographic Sub-Areas

Average speeds by geographic sub-areas were derived based on survey data on trip distance and travel times for OD*ii* pairs, i.e. trips which originated and ended in the same geographic sub-area. The analysis of raw survey data revealed several responses with implied average speed that was unreasonably low or unreasonably high indicating that some responses might have coding errors or inaccurate time measurements. This was particularly true for short trips, or trips for purposes other than work. Specifically, the raw survey data was screened as described below.

- Calculations of average speed were based on auto driver trips only (to avoid double counting driver/passenger trips; primary mode = 1);
- Only trips to work and to home were included (trip purpose = 1 and 8);
- Classification into peak/off-peak was based on the classification adopted by Synovate (which in turn was based on trip start time);
- Trips of duration less than 5 minutes were removed from the data set;
- Trips shorter than 5km or longer than 40 km were removed from the data set;
- Trips with implied average travel speed of more than 100 km/hr or less than 10km/hr were removed; and,
- Observations with start/ arrival time or distance information missing were removed.

Table 4 below shows the results.

Table 4: Average Speeds by Geographic Sub-Areas (km/h)

Region	Region Name	Peak Period Average Speed	Off-Peak Average Speed
1	Vernon	33.1	34.9
2	Coldstream, Lumby	41.6	45.1
3	Spallumcheen, Armstrong, Enderby	50.5	41.9
4	Lake Country	38.8	41.4
5	Westside, Westbank, Peachland	42.5	42.1
6	Central Kelowna	27.2	26.1
7	Suburban Kelowna	34.1	33.6

The table demonstrates that the most highly congested area is Central Kelowna where the average peak period speed is just 27 km/h and off-peak period speed is 26 km/h. The City of Vernon and Suburban Kelowna are the next most congested areas in the region with average speeds during the peak and off-peak hours varying between 33 km/h and just under 35 km/h.

The table also shows that for several geographic areas the average speed during off-peak hours is lower than during peak hours. This result is somewhat counterintuitive as typically off-peak periods are associated with the time of day when the volumes of traffic are smaller and the resulting average speeds are higher. One possible explanation of this result is the definition of peak and off-peak hours adopted by Synovate in their analysis of the 2007 household survey which was then used for the estimation of total number of trips by time of day (and which was then used in this study). For example, the AM peak period was defined as the hours between 6AM and 8:59 AM. However, it is not clear whether classification of trips into a time of day period was made based on the time of day when the trip started or when it ended

The analysis of the data revealed that a lot of work trips were taking place after 9 AM (started after 9 AM or ended after 9 AM). In fact, Table 3 presented earlier shows that peak period VKT accounted for only about 30 percent of total VKT.

Table 5 shows the estimated vehicle to capacity ratios implied by the average speeds calculated from the survey data. The data collected and shown in the table implies that currently actual traffic exceeds road capacity across the region. It should be noted, however, that these results reflect primarily the extent of congestion in the direction of travel that is predominant at any given time of day, such as from residential areas to key employment areas in the early morning. If vehicle-to-capacity ratios were calculated over the entire road network that includes all directions of travel, they would likely be much smaller.

Table 5: Vehicle-to-Capacity Ratios by Geographic Sub-Areas

Region	Region Name	Peak Period	Off-Peak
1	Vernon	1.26	1.24
2	Coldstream, Lumby	1.15	1.08
3	Spallumcheen, Armstrong, Enderby	1.14	1.24
4	Lake Country	1.19	1.15
5	Westside, Westbank, Peachland	1.24	1.24
6	Central Kelowna	1.33	1.34
7	Suburban Kelowna	1.25	1.26

4.3 Developing Assumptions for 2030 Scenario

For the future scenarios, many input variables have to be forecasted into the future. These forecasts are based, when possible, on existing related forecasts, for example existing population forecasts for the Region. If such third-party forecasts are not available, the forecasts for the purpose of this model are based on reasoned assumptions. Below, we briefly summarize assumptions made for the 2030 scenario.

4.3.1 Traffic Growth Assumptions

Traffic forecasts for 2030 were not available in the format and detail required for the model. Full scale traffic forecasts were not in the scope and budget of this study. Therefore, the following assumptions were made for the purpose of this model:

1. The volume of travel, or vehicle-kilometres traveled, are increasing over the period from 2007 to 2030 at an annual rate equal to rate of growth in VKT in all of British Columbia over the period 2000 - 2007.
2. The average trip length is assumed to stay the same across all regions. Therefore, the growth in traffic is coming from the increase in the number of trips.
3. The capacity of the road network (in the congested directions) increases by 2030 by 10 percent in all geographic areas.

Table 6 shows the historical pattern of vehicle kilometres travelled in British Columbia over the period from 2000 to 2007. The data demonstrates substantial fluctuations from year to year with reductions in the order of magnitude of 9 percent to double-digit increases. The average annual rate of growth over this period amounted to 0.54 percent. This implies that over the period from 2007 to 2030 total traffic volume would increase by over 13 percent.

Table 6: Historical Vehicle-Kilometres Travelled in British Columbia and Rates of Growth

Year	Total VKT in British Columbia	Rate of Growth
2000	35,121.30	
2001	35,308.10	0.53%
2002	37,789.30	7.03%
2003	34,222.20	-9.44%
2004	35,431.80	3.53%
2005	35,129.00	-0.85%
2006	31,996.50	-8.92%
2007	35,798.70	11.88%
Average Rate of Change 2001-2007		**0.54%**
Implied Cumulative growth 2007-2030		**13.13%**

Source: Total VKT in British Columbia: Statistics Canada. Rates of growth: HDR calculations

The road capacity is assumed to increase by 10 percent, somewhat below the traffic growth during the same period. This is to capture the implications of the road network not catching up on a one-to-one relationship with the general increase in traffic.

4.3.2 Other Forecasting Assumptions

Additional assumptions were required for the model component that estimates the industry costs of congestion to capture the baseline employment and economic output. Based on the 2007 "Central Okanagan Multi-Modal Corridor" by Urban Systems and Associated Engineering, employment was assumed to grow at an annual rate of 0.8 percent. Business revenues/economic output were assumed to grow at an annual rate of 1 percent. Tourist visitations were assumed to grow at an annual rate equal to the population growth rate.

Unit costs, value of time, average spending per tourist, etc. were assumed unchanged. Therefore, all monetary values reported for the 2030 scenario are in constant 2007 dollars terms.

5: MODEL RESULTS

This section reports model simulation results for the 2007 baseline and 2030 baseline scenarios considered in this study.

5.1 Baseline 2007 Scenario

5.1.1 Excess Traffic and Optimal Speed

Table 7 below shows the estimated excess volume of traffic. The table demonstrates that the excess traffic amounted to over 607,000 vehicle kilometres per day (about 182,000 during peak hours and over 426,000 during off-peak hours).

The extent of congestion (as measured by excess traffic) varies by geographic sub-area. As expected, congestion is greatest in absolute and relative terms in Central Kelowna where excess traffic amounts to over 61,000 VKT during peak hours and over 152,000 during off-peak hours and accounts for about 13 to 14 percent of the actual traffic. This is followed by suburban Kelowna and the City of Vernon where excess congestion accounts for about 8 to 9 percent of the actual traffic.

Table 7: Estimated Excess Daily VKT by Geographic Sub-Area

Region	Region Name	Excess VKT		Excess VKT as Percentage of Actual	
		Peak VKT	Off-Peak VKT	Peak VKT	Off-Peak VKT
1	Vernon	44,487	86,828	8.9%	7.6%
2	Coldstream, Lumby	1,580	0	2.2%	0.0%
3	Spallumcheen, Armstrong, Enderby	0	24,765	0.0%	5.0%
4	Lake Country	14,414	17,069	4.7%	2.4%
5	Westside, Westbank, Peachland	13,361	33,361	4.6%	4.9%
6	Central Kelowna	61,766	152,320	12.9%	13.7%
7	Suburban Kelowna	46,141	111,423	8.2%	8.6%
Total		**181,748**	**425,767**	**7.5%**	**7.6%**

Table 8 shows the estimated average speeds that would result under the optimal volume of traffic (i.e. if current traffic was reduced by the amount of the excess traffic). In order to facilitate comparison with the actual conditions, actual average speeds that were first presented in Table 4 are also shown in this table.

Table 8: Comparison of Actual and Optimal Speeds by Geographic Sub-Area

Region	Region Name	Actual Speeds Km/h		Optimal Speeds Km/h		Reduction in Actual Speed Compared to Optimal, in Percent	
		Peak Period	Off-Peak	Peak Period	Off-Peak Period	Peak Period	Off-Peak Period
1	Vernon	33.1	34.9	41.6	41.8	20.6%	16.6%
2	Coldstream, Lumby	41.6	45.1	43.0	44.2	3.3%	0%
3	Spallumcheen, Armstrong, Enderby	50.5	41.4	49.6	47.7	0.0%	13.1%
4	Lake Country	38.8	41.4	42.4	43.0	8.6%	3.7%
5	Westside, Westbank, Peachland	42.5	42.1	47.7	47.7	11.1%	11.7%
6	Central Kelowna	27.2	26.1	41.3	41.3	34.3%	36.8%
7	Suburban Kelowna	34.1	33.6	41.7	41.7	18.3%	19.4%
NORD Average		**38.9**	**37.6**	**44.0**	**43.7**	**11.8%**	**13.8%**
CORD Average		**34.4**	**34.4**	**42.8**	**42.9**	**19.6%**	**19.8%**

As Table 8 shows, average actual speed is similar to the optimal speed only in Coldstream, Lumby, Spallumcheen, Armstrong and Enderby areas. In all other areas the actual speed is reduced below the optimal level by nearly 9 percent or more. The greatest reduction in speed is in Central Kelowna where it amounts to 34 to 37 percent, depending on the time of day. This is followed by reductions in speed in suburban Kelowna and the City of Vernon where it amounts to about 18 to 19 percent, depending on the time of day.

5.1.2 Excess Total Travel Delay and Cost

Table 9 reports the total hours of excess travel delays in the Okanagan Region. Overall, the entire region (North Okanagan and Central Okanagan) experiences over 46,000 hours of delay per day. In Central Okanagan there are 36,254 hours of delay per day, and in North Okanagan there are 9,985 hours of delay per day. These delays translate into 13.4 minutes of delay per Region's resident per day, or 58.2 hours per year.

The costs of these delays (or the value of the lost travel time) in the entire Okanagan amount to $794,000 per day, or $206.5 million per year (see Table 10). These total costs are equivalent to a cost of $3.96 per Region's resident per day or $1000.43 per year.

Table 9: Excess Total Travel Delay, Hours of Auto Travel

Region #	Region Name	Peak Period		Off-Peak Period		Total	
		Per Day	Per Year	Per Day	Per Year	Per Day	Per Year
1	Vernon	3,104	806,931	5,392	1,401,884	8,495	2,208,815
2	Coldstream, Lumby	58	15,053	0	0	58	15,053
3	Spallumcheen, Armstrong, Enderby	0	0	1,432	372,218	1,432	372,218
Total North Okanagan Region		*3,161*	*821,984*	*6,823*	*1,774,102*	*9,985*	*2,596,087*
4	Lake Country	679	176,610	637	165,741	1,317	342,351
5	Westside, Westbank, Peachland	750	195,033	1,908	496,123	2,658	691,156
6	Central Kelowna	6,025	1,566,430	15,722	4,087,647	21,746	5,654,077
7	Suburban Kelowna	3,019	784,967	7,514	1,953,592	10,533	2,738,558
Total Central Okanagan Region		*10,473*	*2,723,040*	*25,781*	*6,703,103*	*36,254*	*9,426,143*
Region Total		**13,635**	**3,545,024**	**32,605**	**8,477,206**	**46,239**	**12,022,230**
Region Total Per Capita		**4.0**	**17.2**	**9.5**	**41.1**	**13.4**	**58.2**
		Minutes	Hours	Minutes	Hours	Minutes	Hours

Table 10: Monetary Value of Excess Travel Delays (Value of Lost Travel Time), $000[24]

Region #	Region Name	Peak Period		Off-Peak		Total	
		Per Day	Per Year	Per Day	Per Year	Per Day	Per Year
1	Vernon	$55	$14,263	$95	$24,795	$150	$39,058
2	Coldstream, Lumby	$1	$266	$0	$0	$1	$266
3	Spallumcheen, Armstrong, Enderby	$0	$0	$25	$6,583	$25	$6,583
Total North Okanagan region		*$56*	*$14,529*	*$121*	*$31,378*	*$177*	*$45,908*
4	Lake Country	$12	$3,122	$11	$2,931	$23	$6,053
5	Westside, Westbank, Peachland	$13	$3,447	$34	$8,775	$47	$12,222
6	Central Kelowna	$106	$27,688	$278	$72,298	$385	$99,986
7	Suburban Kelowna	$53	$13,875	$133	$34,553	$186	$48,428
Total Central Okanagan Region		*$185*	*$48,132*	*$456*	*$118,557*	*$618*	*$160,636*
Region Total		**$241**	**$62,661**	**$577**	**$149,936**	**$794**	**$206,544**
Region per Capita ($ per Capita)		***$1.17***	***$303.51***	***$2.79***	***$726.24***	***$3.96***	***$1,000.43***

In order to better illustrate the extent of excess delays that an average driver may be facing, Table 11 shows excess delay per one-way trip in all geographic areas. The table shows that in Central Kelowna the delay amounted to about 3.6 minutes per trip on average during the day, and in the City of Vernon, the delay amounted to almost 2.4 minutes per trip. Note that trips that

[24] Values in the table are in thousands except for the last row.

were passing through multiple geographic areas would experience a total delay equal to the sum of delays in each geographic area. On average, each car trip in the North and Central Okanagan Region had slightly above 2 minutes of excess delay (with little difference by the time of day).

Table 11: Excess Delay Per Trip (One Way) by Geographic Area of Travel, Minutes

Region #	Region Name	Peak	Off-Peak	All Day
1	Vernon	3.0	2.2	2.4
2	Coldstream, Lumby	0.2	0.0	0.1
3	Spallumcheen, Armstrong, Enderby	0.0	1.4	1.0
4	Lake Country	2.6	1.1	1.5
5	Westside, Westbank, Peachland	1.2	1.3	1.2
6	Central Kelowna	3.4	3.7	3.6
7	Suburban Kelowna	1.9	2.1	2.0
Region Average		**3.3**	**3.3**	**3.3**
Central Okanagan Average		**3.7**	**3.9**	**3.8**
North Okanagan Average		**2.5**	**2.3**	**2.3**

5.1.3 Excess Commuting Delay and Delay Cost

Table 12 translates travel delays in the region into travel delays experienced by workers who commute to work by car, and Table 13 converts these delays into monetary values (value of lost travel time).

Table 12: Excess Commuting Delay per Car Commuter by Geographic Area of Travel, in Minutes

Region #	Region Name	Per Day (Minutes)	Per Year (Hours)
1	Vernon	5.6	24.2
2	Coldstream, Lumby	0.1	0.6
3	Spallumcheen, Armstrong, Enderby	2.0	8.7
4	Lake Country	3.8	16.5
5	Westside, Westbank, Peachland	2.7	11.9
6	Central Kelowna	7.4	32.2
7	Suburban Kelowna	4.3	18.8
Region Average		**7.4**	**32.2**
Central Okanagan Average		**8.5**	**36.7**
North Okanagan Average		**5.3**	**23.0**

NOTE: The commuting delay calculation assumes two trips: one for work and one for home and 260 work days per year.

The largest commuting delays are in Central Kelowna where they amounted to over 7 minutes per day. This is followed by delays in the City of Vernon (over 5 minutes per day) and suburban Kelowna with over 4 minutes per day. Commuters passing through more than one geographic area would experience total delay equal to the sum of delays in each area. On average, the commuting delay in Central Okanagan amounted to nearly 9 minutes per day and in North Okanagan to about 5 minutes per day.

Table 13: Monetary Value of Excess Commuting Delay (Value of Lost Travel Time) by Geographic Area of Travel, $ per Car Commuter

Region #	Region Name	Per Day	Per Year
1	Vernon	$1.58	$410
2	Coldstream, Lumby	$0.04	$9
3	Spallumcheen, Armstrong, Enderby	$0.57	$147
4	Lake Country	$1.08	$280
5	Westside, Westbank, Peachland	$0.78	$202
6	Central Kelowna	$2.10	$546
7	Suburban Kelowna	$1.23	$319
Region Average		**$2.10**	**$546**
Central Okanagan Average		**$2.39**	**$622**
North Okanagan Average		**$1.50**	**$390**

As Table 13 shows the total average cost of the commuting delays in Central Okanagan amounted to $622 per year, and in North Okanagan to $390 per year.

5.1.4 Excess Vehicle Operating Costs

Table 14 presents excess vehicle operating costs (i.e. costs due to excess congestion) in the form of wasted fuel and excessive use of other operating components. The table shows that total such costs to the North and Central Okanagan Region amounted to over $23.5 million per year ($4.79 million in North Okanagan and $18.76 million in Central Okanagan). These costs translated to an average of $114 per capita (i.e. per resident) per year.

Table 14: Total Excess Vehicle Operating Costs by Geographic Area

Region #	Region Name	Daily Total Cost, $			Total Annual, $ millions
		Peak Period	Off-Peak	Total Daily	
1	Vernon	$6,229	$10,506	$16,734	$4.35
2	Coldstream, Lumby	$40	$0	$40	$0.01
3	Spallumcheen, Armstrong, Enderby	$0	$1,636	$1,636	$0.43
Total NORD		*$6,268*	*$12,142*	*$18,410*	*$4.79*
4	Lake Country	$837	$784	$1,621	$0.42
5	Westside, Westbank, Peachland	$949	$2,260	$3,209	$0.83
6	Central Kelowna	$13,174	$33,883	$47,058	$12.24
7	Suburban Kelowna	$6,113	$14,156	$20,269	$5.27
Total CORD		*$21,074*	*$51,082*	*$72,157*	*$18.76*
Total Region		**$27,342**	**$63,225**	**$90,567**	**$23.55**
Total Region per Capita ($ per Capita per Year):				***$114.06***	

Table 15 shows another expression of excess vehicle operating costs in terms of cost per trip and annual cost that car commuters face when commuting to work. The table shows that on average in the North and Central Okanagan regions the excess vehicle operating costs amounted to $0.11 per trip ($0.07 per trip in North Okanagan and $0.13 in Central Okanagan). For car commuting to work, these costs translated into a regional average cost of $56.42 per year per car commuter ($37.25 per year per car commuter in North Okanagan and $66.14 per year per car commuter in Central Okanagan)

Table 15: Excess Vehicle Operating Costs per Trip and Geographic Area of Travel

Region #	Region Name	Cost per Trip	Annual Costs per Car Commuter
1	Vernon	$0.08	$41.40
2	Coldstream, Lumby	$0.00	$0.35
3	Spallumcheen, Armstrong, Enderby	$0.02	$9.91
Average for North Okanagan		*$0.07*	*$37.25*
4	Lake Country	$0.03	$16.25
5	Westside, Westbank, Peachland	$0.02	$12.92
6	Central Kelowna	$0.13	$67.58
7	Suburban Kelowna	$0.07	$33.87
Average for Central Okanagan		*$0.13*	*$66.14*
Total Region Average		**$0.11**	**$56.42**

5.1.5 Demand for Labour and Business Activity Impacts

Table 16 shows the implication of congestion costs related to commuting for work (excess time cost of travel delays as shown in Table 13) on demand for labour and economic activity. The table demonstrates that in the North Okanagan and Central Okanagan regions, the reduction in demand for labour due to excess congestion costs amount to about 704 jobs. Central Okanagan bears the vast majority of this cost with 547 positions. The job loss in North Okanagan amounts to about 157 positions. These losses resulted in a reduction in regional economic activity measured in terms of business revenue of $52.19 million annually ($40.61 million in Central Okanagan and $11.59 million in North Okanagan).

Table 16: Impact of Congestion on Regional Labour Demand and Economic Activity

Category of Impact	Central Okanagan Region	North Okanagan Region	Total
Reduction in employment due to excess commuting costs, number of jobs	547	157	704
Reduction in the value of regional economic (business revenue), $ millions	$40.61	$11.59	$52.19

5.1.6 Industry-Level Impacts

Table 17 lists the industry level congestion cost impacts (Note that not all cost impacts are estimated for all industries and that not all impacts are additive).

Table 17: Industry-Level Congestion Costs Impacts

Industry and Type of Impact	Central Okanagan	North Okanagan	Total
Retail Trade			
Increase in industry costs, $ millions	$0.79	$0.28	$1.07
Reduction in industry revenues, $ millions	$2.96	$0.73	$3.69
Reduction in industry employment, jobs	53	13	66
Construction			
Increase in industry costs, $ millions	$4.12	$1.10	$5.21
Reduction in industry revenues, $ millions			
Reduction in industry employment, jobs			
Manufacturing			
Increase in industry costs, $ millions	$1.13	$0.45	$1.58
Reduction in industry revenues, $ millions	$9.29	$3.69	$12.98
Reduction in industry employment, jobs	37	14	51
Wholesale Trade			
Increase in industry costs, $ millions	$0.22	$0.07	$0.29
Reduction in industry revenues, $ millions			
Reduction in industry employment, jobs			
Agriculture			
Increase in industry costs, $ millions	$0.16	$0.08	$0.24
Reduction in industry revenues, $ millions	$2.07	$0.99	$3.05
Reduction in industry employment, jobs	19	9	28
Accommodation and Food services			
Increase in industry costs, $ millions			
Reduction in industry revenues, $ millions	$4.58	$1.13	$5.71
Reduction in industry employment, jobs	93	23	116
Arts and Entertainment			
Increase in industry costs, $ millions			
Reduction in industry revenues, $ millions	$0.35	$0.09	$0.43
Reduction in industry employment, jobs	7	2	9
Transportation			
Increase in industry costs, $ millions	$20.66	$4.94	$25.60
Increased truck labour costs due to traffic delays	$17.77	$4.89	$22.67
Excess truck vehicle operating costs	$2.89	$0.05	$2.93
Reduction in industry revenues, $ millions	$0.72	$0.18	$0.89
Reduction in industry employment, jobs	4	1	6
TOTAL			
Increase in industry costs, $ millions	**$27.08**	**$6.90**	**$33.98**
Reduction in industry revenues, $ millions	**$19.96**	**$6.80**	**$26.76**
Reduction in industry employment, jobs	**214**	**63**	**276**

Table 17 shows that total industry congestion cost impacts include nearly $34 million in increased industry costs, $26.76 million reduction in revenue and a reduction in jobs of 276. The vast majority of these costs are borne by the Central Okanagan Region: increase in industry costs of over $27 million, reduction in industry revenue of nearly $20 million and reduction in employment of 214 jobs.

5.2 Baseline 2030 Scenario

This section shows the results for the 2030 baseline scenario defined in Section 4.3. To summarize, the key assumptions for that scenario are as follows:

1. The volume of travel, or vehicle-kilometres traveled, are increasing over the period from 2007 to 2030 at an annual rate of 0.54 percent, the rate equal to the average rate of growth in VKT in all of British Columbia over the period 2000 - 2007. Over the period until 2030, this is equivalent to a cumulative growth of 13 percent.
2. The average trip length is assumed to stay the same across all regions. Therefore, the growth in traffic is coming from the increase in the number of trips.
3. The capacity of the road network (in the congested directions) increases by 2030 by 10 percent in all geographic areas.
4. Regional employment growth is assumed equal to 0.8 percent per annum, and regional business output is assumed to grow at an annual rate of 1 percent.
5. Tourist visitations are assumed to increase at an average annual rate equal to the rate of regional population growth. This rate changes over time and implies cumulative growth in tourist visitations of 44 percent by 2030.
6. All unit costs, value of time, and average spending per tourist remain the same.

5.2.1 Average Speeds in 2030

Table 18 shows the expected speed that would result under the assumptions for 2030 traffic conditions specified above.

In addition, the table shows the optimal speed implied by the economic model. Note that this speed is different (and in general lower) than in 2007. This is because of the increase in demand for travel in 2030. However, the actual speed is still lower than the optimal speed and the reduction in actual speed compared to the optimal speed is higher than in 2007.

Average speeds in 2030 are lower than in 2007 by 2 to about 4 km/h, or about 5 to 12 percent. Volume-to-capacity ratios increased in all geographic areas over the period from 2007 (see Table 19).

Table 18: Estimated 2030 Actual and Optimal Speed by Geographic Area

Region	Region Name	Actual Speeds		Optimal Speeds		Reduction in actual speeds (compared to optimal, in %)	
		Peak Period	Off-Peak	Peak Period	Off-Peak	Peak Period	Off-Peak
1	Vernon	29.8	31.8	41.4	41.5	28.1%	23.4%
2	Coldstream, Lumby	39.4	43.7	42.5	43.7	7.3%	0%
3	Spallumcheen, Armstrong, Enderby	48.0	38.2	48.9	47.2	0.0%	19.1%
4	Lake Country	36.1	39.2	42.0	42.5	13.9%	7.7%
5	Westside, Westbank, Peachland	38.8	38.4	47.3	47.2	17.9%	18.7%
6	Central Kelowna	23.6	22.6	41.3	41.3	42.7%	45.3%
7	Suburban Kelowna	30.9	30.4	41.5	41.4	25.5%	26.7%
North Okanagan Average		**35.9**	**34.6**	**43.7**	**43.3**	**17.7%**	**20.0%**
Central Okanagan Average		**31.2**	**31.2**	**42.5**	**42.6**	**26.8%**	**26.8%**

Table 19: Implied 2030 Vehicle-to-Capacity Ratio by Geographic Area

Region	Region Name	Peak Period	Off-Peak
1	Vernon	1.30	1.28
2	Coldstream, Lumby	1.18	1.11
3	Spallumcheen, Armstrong, Enderby	1.17	1.28
4	Lake Country	1.23	1.19
5	Westside, Westbank, Peachland	1.27	1.27
6	Central Kelowna	1.36	1.38
7	Suburban Kelowna	1.29	1.29

5.2.2 Excess Traffic

Table 20 shows the estimated excess VKT. Comparing this table with Table 9, we can see an increase in the absolute amount of excess VKT, as well as relative to actual VKT in all geographic area. For the entire geographic region, excess VKT as percentage of total VKT increased from about 7.5 percent to nearly 10 percent.

Table 20: Estimated 2030 Excess Vehicle Kilometres Travelled

Region	Region Name	Excess VKT		Excess VKT as Percentage of Actual	
		Peak VKT	Off-Peak VKT	Peak VKT	Off-Peak VKT
1	Vernon	62,887	125,988	11.2%	9.8%
2	Coldstream, Lumby	3,365	0	4.1%	0.0%
3	Spallumcheen, Armstrong, Enderby	2,314	40,363	0.9%	7.2%
4	Lake Country	23,388	34,923	6.7%	4.3%
5	Westside, Westbank, Peachland	22,262	54,753	6.8%	7.1%
6	Central Kelowna	82,943	203,148	15.3%	16.1%
7	Suburban Kelowna	66,160	158,477	10.4%	10.8%
Total		**263,319**	**617,652**	**9.6%**	**9.7%**

5.2.3 Excess Travel Delay and Costs

Table 21 shows the vehicle hours of excess travel. As for the previous metrics, we can see an increase in this measure of congestion compared to 2007 reported in Table 9. In terms of per-capita delay for the entire region, the average delay increased by almost one minute per peak period and almost 2 minutes per off-peak period, and almost 3 minutes on trips over the entire day.

Table 21: Estimated 2030 Excess Travel Delay, Vehicle Hours of Travel

Region #	Region Name	Peak Period		Off-Peak Period		Total	
		Per Day	Per Year	Per Day	Per Year	Per Day	Per Year
1	Vernon	5,309	1,380,267	9,480	2,464,723	14,788	3,844,990
2	Coldstream, Lumby	150	39,006	0	0	150	39,006
3	Spallumcheen, Armstrong, Enderby	92	24,014	2,815	731,844	2,907	755,858
Total North Okanagan Region		*5,551*	*1,443,287*	*12,294*	*3,196,567*	*17,846*	*4,639,854*
4	Lake Country	1,338	347,928	1,587	412,715	2,926	760,643
5	Westside, Westbank, Peachland	1,508	391,954	3,778	982,356	5,286	1,374,310
6	Central Kelowna	9,766	2,539,270	25,313	6,581,293	35,079	9,120,563
7	Suburban Kelowna	5,241	1,362,651	12,940	3,364,367	18,181	4,727,018
Total Central Okanagan Region		*17,853*	*4,641,803*	*43,618*	*11,340,731*	*61,471*	*15,982,534*
Region Total		**23,404**	**6,085,090**	**55,913**	**14,537,298**	**79,317**	**20,622,388**
Region Total Per Capita		**4.7 minutes**	**20.5 hours**	**11.3 minutes**	**48.9 hours**	**16.0 minutes**	**69.4 hours**

Table 22 shows the monetary costs corresponding to these delays, and Table 23 shows delays per trip.

Comparing Table 23 and Table 11, we can see that the average delay per trip increased by about 1 to 2 minutes.

Comparing Table 22 and Table 10 we can see that the Region's per capita costs of excess travel delays increased by about $0.23 per peak period and $0.56 for the off-peak period, and $0.79 in total per day.

Table 22: Estimated 2030 Monetary Costs of Excess Travel Delays (Value of Lost Travel Time), $000

Region #	Region Name	Peak Period		Off-Peak		Total	
		Per Day	Per Year	Per Day	Per Year	Per Day	Per Year
1	Vernon	$94	$24,397	$168	$43,566	$261	$67,964
2	Coldstream, Lumby	$3	$689	$0	$0	$3	$689
3	Spallumcheen, Armstrong, Enderby	$2	$424	$50	$12,936	$51	$13,360
Total North Okanagan region		*$98*	*$25,511*	*$217*	*$56,502*	*$315*	*$82,013*
4	Lake Country	$24	$6,150	$28	$7,295	$52	$13,445
5	Westside, Westbank, Peachland	$27	$6,928	$67	$17,364	$93	$24,292
6	Central Kelowna	$173	$44,884	$447	$116,330	$620	$161,214
7	Suburban Kelowna	$93	$24,086	$229	$59,468	$321	$83,554
Total Central Okanagan Region		*$316*	*$82,048*	*$771*	*$200,457*	*$1,087*	*$282,505*
Region Total		**$414**	**$107,559**	**$988**	**$256,959**	**$1,402**	**$364,519**
Region per Capita ($ per Capita)		***$1.39***	***$362***	***$3.33***	***$865***	***$4.72***	***$1,227***

Table 23: 2030 Excess Delay per Trip (One Way) by Geographic Area, Minutes

Region #	Region Name	Peak	Off-Peak	All Day
1	Vernon	4.5	3.4	3.7
2	Coldstream, Lumby	0.4	0.0	0.1
3	Spallumcheen, Armstrong, Enderby	0.2	2.5	1.8
4	Lake Country	4.6	2.3	3.0
5	Westside, Westbank, Peachland	2.1	2.2	2.2
6	Central Kelowna	4.8	5.3	5.1
7	Suburban Kelowna	3.0	3.2	3.1
Region Average		**5.0**	**5.1**	**5.0**
Central Okanagan Average		**5.6**	**5.8**	**5.7**
North Okanagan Average		**3.8**	**3.6**	**3.7**

5.2.4 Excess Commuting Delay and Delay Cost

Table 24 shows the excess commuting delay and Table 25 shows the monetary value of this delay.

Table 24: 2030 Excess Commuting Delay per Car Commuter by Geographic Area of Travel

Region #	Region Name	Minutes Per Day	Hours Per Year
1	Vernon	8.7	38
2	Coldstream, Lumby	0.3	1
3	Spallumcheen, Armstrong, Enderby	3.6	16
4	Lake Country	7.5	33
5	Westside, Westbank, Peachland	4.8	21
6	Central Kelowna	10.6	46
7	Suburban Kelowna	6.7	29
Region Average		**11.3**	**49**
Central Okanagan Average		**12.7**	**55**
North Okanagan Average		**8.5**	**37**

Table 25: 2030 Monetary Value of Excess Commuting Delays (Value of Lost Travel Time) by Geographic Area of Travel, $ per Car Commuter

Region #	Region Name	Per Day	Per Year
1	Vernon	$2.46	$639
2	Coldstream, Lumby	$0.08	$22
3	Spallumcheen, Armstrong, Enderby	$1.03	$267
4	Lake Country	$2.13	$554
5	Westside, Westbank, Peachland	$1.37	$356
6	Central Kelowna	$3.01	$783
7	Suburban Kelowna	$1.88	$489
Region Average		**$3.18**	**$828**
Central Okanagan Average		**$3.60**	**$937**
North Okanagan Average		**$2.40**	**$624**

Comparing the tables above with their counterparts for the 2007 scenario, we can see again, an increase in all measures of congestion. The Region's daily average commuting delay per car-commuter per day increased by nearly 3 minutes (from 7.4 minutes to 11.3 minutes). The monetary value of these delays increased by over $1 per day (from $2.10 1 to $3.18).

5.2.5 Excess Vehicle Operating Costs

Table 26 shows the excess vehicle operating costs and Table 27 shows these costs in the format of cost per trip and costs facing a car commuter.

Table 26: 2030 Excess Vehicle Operating Costs

Region #	Region Name	Daily Total Cost, $			Total Annual, $ millions
		Peak Period	Off-Peak	Total Daily	
1	Vernon	$11,612	$19,517	$31,129	$8.09
2	Coldstream, Lumby	$287	$0	$287	$0.07
3	Spallumcheen, Armstrong, Enderby	$0	$4,286	$4,286	$1.11
Total NORD		*$11,898*	*$23,803*	*$35,701*	*$9.28*
4	Lake Country	$2,841	$2,365	$5,206	$1.35
5	Westside, Westbank, Peachland	$1,916	$5,919	$7,834	$2.04
6	Central Kelowna	$20,884	$52,554	$73,438	$19.09
7	Suburban Kelowna	$11,192	$30,344	$41,536	$10.80
Total CORD		*$36,833*	*$91,182*	*$128,015*	*$33.28*
Total Region		**$48,732**	**$114,985**	**$163,716**	**$42.57**
Total Region per Capita ($ per Capita per Year):					***$143.25***

Table 27: 2030 Excess Vehicle Operating Costs per Trip and per Car Commuter

Region #	Region Name	Cost per Trip	Annual Costs per Car Commuter
1	Vernon	$0.13	$68.07
2	Coldstream, Lumby	$0.00	$2.22
3	Spallumcheen, Armstrong, Enderby	$0.00	$0.00
Average for North Okanagan		*$0.09*	$46.17
4	Lake Country	$0.09	$46.13
5	Westside, Westbank, Peachland	$0.05	$27.88
6	Central Kelowna	$0.09	$46.61
7	Suburban Kelowna	$0.04	$22.35
Average for Central Okanagan		*$0.20*	$103.72
Total Region Average		**$0.17**	$89.98

On average, excess vehicle operating costs per capita in the Region increased by about $29 per year (from about $114 per capita to $143.25 per capita), and excess vehicle operating costs per trip increased by $0.06 (from $0.11 to $0.17).

5.2.6 Demand for Labour and Business Activity Impacts

Table 28 shows the impact on regional labour demand and business revenue. Both the reduction in employment and corresponding reduction in business revenue are larger than for the 2007 scenario. Reduction in employment in Central Okanagan amounts to 929 jobs (up from 547 in 2007) and over $72 million in business revenue (up from about $40.6 million). In North

Okanagan, the losses are proportionately smaller and represented by 282 jobs (up from 157 jobs in 2007) and $21.7 million of business revenue (up from about $11.6 million in 2007).

Table 28: 2030 Impact of Congestion on Regional Labour Demand and Economic Activity

Category of Impact	Central Okanagan Region	North Okanagan Region	Total
Reduction in employment due to excess commuting costs, number of jobs	929	282	1,211
Reduction in the value of regional economic (business revenue), $ millions	$72.26	$21.74	$93.99

5.2.7 Industry Level Impacts

Table 29 shows the effects on the various individual industries. As for other congestion cost metrics, all the reported impacts are larger than for 2007 scenario. In summary, the number of jobs lost in Central Okanagan increased by over 170 from 214 to 386, business revenue loss increased by about $16 million from about $20 million to $36 million, and industry costs due to congestion increased by another $17 million from about $27 to over $44.4 million. In North Okanagan, the increase in congestion cost metrics was smaller as the 2007 baseline costs were smaller as well, but a sizeable increase in all metrics is also noted.

Table 29: 2030 Industry-Level Congestion Costs Impacts

Industry and Type of Impact	Central Okanagan	North Okanagan	Total
Retail Trade			
Increase in industry costs, $ millions	$1.35	$0.33	$1.69
Reduction in industry revenues, $ millions	$5.77	$0.99	$6.77
Reduction in industry employment, jobs	99	17	116
Construction			
Increase in industry costs, $ millions	$7.03	$1.32	$8.35
Reduction in industry revenues, $ millions			
Reduction in industry employment, jobs			
Manufacturing			
Increase in industry costs, $ millions	$1.93	$0.54	$2.47
Reduction in industry revenues, $ millions	$15.88	$4.43	$20.31
Reduction in industry employment, jobs	60	17	76
Wholesale Trade			
Increase in industry costs, $ millions	$0.38	$0.08	$0.46
Reduction in industry revenues, $ millions			
Reduction in industry employment, jobs			
Agriculture			
Increase in industry costs, $ millions	$0.27	$0.09	$0.36
Reduction in industry revenues, $ millions	$3.53	$1.19	$4.72
Reduction in industry employment, jobs	31	10	42
Accommodation and Food services			
Increase in industry costs, $ millions			
Reduction in industry revenues, $ millions	$8.95	$1.54	$10.49
Reduction in industry employment, jobs	174	30	204
Arts and Entertainment			
Increase in industry costs, $ millions			
Reduction in industry revenues, $ millions	$0.68	$0.12	$0.79
Reduction in industry employment, jobs	13	2	16
Transportation			
Increase in industry costs, $ millions	$33.42	$8.36	$41.78
Increased truck labour costs due to traffic delays	$27.79	$8.07	$35.86
Excess truck vehicle operating costs	$5.6	$0.3	$5.92
Reduction in industry revenues, $ millions	$1.40	$0.24	$1.64
Reduction in industry employment, jobs	9	1	$10.20
TOTAL			
Increase in industry costs, $ millions	**$44.39**	**$10.72**	**$55.10**
Reduction in industry revenues, $ millions	**$36.21**	**$8.51**	**$44.71**
Reduction in industry employment, jobs	**386**	**78**	**464**

6: STRATEGIES ADOPTED IN OTHER CITIES TO DEAL WITH TRAFFIC CONGESTION

This section provides a brief overview of the congestion management strategies that have been adopted to-date in an assortment of cities around the world. After introducing the various demand- and supply-side strategies available, a list of examples of cities where these strategies have been adopted is provided, including an indication of their effectiveness in reducing road congestion. Although the most publicized studies have focused on large urban areas (such as London, England and Singapore), several examples have been identified that are of a more comparable scale to the population in the Central Okanagan.

Traffic congestion occurs when demand exceeds the free-flow capacity level. As a result, the strategies implemented to deal with traffic congestion can be classified as either a supply-side strategy (increasing road capacity) or a demand-side strategy (reducing demand levels), and each group will be discussed in turn[25]. Given the modal share dominance of automobile traffic in the Central Okanagan and North Okanagan regions, the following discussion is focused primarily on the effects on automobile traffic.

6.1 Supply-Side Strategies

Of interest is the *effective* capacity of transportation systems, where a system can be an entire network, a defined corridor or route, or a specific point within this network. Effective capacity can be increased either by expanding the level of capacity or by using existing capacity more efficiently. When capacity is being discussed, it is also important to be cognizant of latent demand; often improvements to existing capacity will induce marginal trip-takers to make trips that they would not have made previously in response to decreased congestion levels.

The most common supply-side strategies are as follows:

- Additions to roadway capacity:
  - Adding more capacity at bottlenecks (widening a tunnel, for example);
  - Adding more capacity over the whole of a network or a particular route (such as building additional lanes); and/or,
  - Creating new routes.
- Junction improvements:
  - Constructing overpasses;
  - Altering traffic lights and signage at intersections; and potentially; and,
  - Reducing the number of junctions.
- Creating reversible lanes:
  - Enabling certain sections of highway to operate in the opposite direction during different times of the day or on different days of the week in order to better match asymmetric demand (which typically occurs in daily commuting patterns).

[25] It should be noted that the 'supply-side' versus 'demand-side' demarcation is not always precise, as some strategies may full under both classifications to some extent, as will be discussed.

- Creating local-express lanes:
  - Providing through lanes that bypass junction on-ramp and off-ramp zones.
- Providing separate lanes for specific user groups:
  - Allocating certain lanes for commercial freight vehicles or creating bus lanes as a part of the transit system.
- Grade separation:
  - Using bridges and tunnels to reduce the incidence of cross-traffic movements.
- Traffic demand management:
  - There are numerous methods in which the effective capacity of existing infrastructure can be increased, typically via 'intelligent transportation systems'. Examples include:
    - Ramp signaling that controls the flow of merging traffic onto congested roadways via traffic signals;
    - Traffic reporting via radio, the Internet, GPS navigation systems or mobile phones, that advises road users of traffic conditions;
    - Variable message signs installed along the roadway to advise road users of up-to-date information regarding road conditions ahead; and
    - Traffic counters that provide real-time traffic counts for planners and engineers.

6.2 Demand-Side Strategies

Demand-side strategies are those that aim to influence travel behaviour by altering the 'generalized travel cost', which is the imputed marginal cost of travel comprised of both out-of-pocket expenditures and implicit opportunity costs of time. The demand for automobile travel is thus a function of the price of travel (expenditures on vehicle maintenance, fuel, parking and/or tolls) and the level of capacity, insofar as capacity affects the travel time of various modes.

The most common demand-side strategies are as follows:

- Charges to enter congested areas:
  - Payment (via tolls or the purchase of a license) required for vehicles to enter pre-defined areas, such as the downtown area of a congested city. The area may be defined physically via toll stations, or virtually and controlled by a combination of on-vehicle transponders, cameras and/or spot checks.
  - Examples include Singapore (electronic road pricing) and London (congestion charge upon entry).
- Road pricing and toll facilities:
  - Payment required for access onto a road or specific area.
  - Charges may differ by time and level of congestion, and may be 'dynamic' in that they adjust frequently in response to traffic conditions.
  - Payment typically collected via pre-paid transponder balances for local residents and via digital camera and mail for non-residents and others without transponders.
- Transit improvements:
  - Investment in public transport can reduce the generalized cost of transit relative to auto and lead to a decrease in auto demand by increasing transit modal share.

    - Creation of park and ride facilities that encourage parking at a distance and allowing continuation by public transport. These facilities are typically located at freeway entrances or near public transit stations to encourage both public transit use and ride sharing.
    - Encouraging transit-oriented development, which is when residential and commercial areas are designed to in order to maximize the accessibility of public transport and decrease auto reliance.
- HOV (high occupancy vehicles) lanes:
    - Designation of specific lanes for vehicles with at least three (sometimes at least two) riders, which is intended to encourage carpooling to reduce the number of vehicles on the road.
- HOT (high occupancy/toll) lanes:
    - Allowing vehicles to access designated HOV lanes by paying an optional toll. As with HOV lanes, HOT lanes also have an effect on the effective capacity of the system.
- Parking pricing and supply:
    - Increasing the price of parking or restricting the supply of parking options both have the effect of making motor vehicle use less attractive relative and decrease the demand for auto trips (by reducing the number of trips and/or by affecting modal share).
- Rationing:
    - Rationing occurs when some types of vehicles are not allowed to drive in certain times or in certain areas.
    - Examples: commercial truck bans in certain areas (i.e. traffic calming), or license plate restrictions based on the day of the week (as occurs in Athens, Mexico City and São Paulo).

6.3 Other Strategies

There are other strategies that are more focused on urban planning, policy and land use:

- Urban planning and urban design:
    - In the long-run, city planning and urban design can have a significant effect on traffic volumes and flow. In the short-run however, the impact is minimal.
    - Zoning laws and policies that encourage mixed-use development (which reduces distances between residential, commercial, retail, and recreational destinations) can be useful in both providing alternatives to auto use (via public transport facilities) and by reducing the need for longer trips, thereby facilitating cycling and walking.
    - Promotion, subsidies or restrictions can also have an effect; for example, promoting cycling through legislation, facility improvements, subsidies and awareness campaigns.

The consensus from experience with the aforementioned strategies is that the most significant impact occurs when both demand- and supply-side aspects are combined[26]. The following table provides a brief summary of the most notable implementations of price-based demand-side strategies:

Table 30: Summary of Congestion Management Strategies

City, Country	Facility	Type	Description	Year Implemented	Impact on Traffic Congestion
NORTH AMERICA					
Houston (TX), United States	Interstate 10 (Katy Freeway) and U.S. Route 290	Urban corridor	HOT lanes; HOV3+. 2-person carpools able to use the 3+ HOV lane of I-10 for a $2 per trip fee, under the "QuickRide" program. Tolls collected electronically.	1998	N/A
Lee County (FL), United States	Bridges	Single facility	50 percent discount for off-peak crossings.	1997	Program induced significant shift in traffic out of the peak congestion period: 70+ percent of eligible motorists (i.e., those with vehicle transponders) shifted their time of travel at least once a week to obtain a toll discount amounting to just $0.25.
Minneapolis/St. Paul (MN), United States	Interstate 394	Urban corridor	Prior to 2005, I-94 had HOV lanes that were underused. Have since been converted to two HOT lanes, using MnPASS (transponder system). Tolls dependent upon traffic density, and change every 3 minutes.	2005 (HOT)	N/A
New York & New Jersey (NY), United States	Hudson River crossings and PATH	Single facility	Small peak bridges/tunnel toll differential; switched from fixed to variable tolls in 2001 (16-20 percent discount in off-peak).	1999	7percent reduction in AM peak traffic and 4 percent reduction in PM peak traffic; significant smoothing of traffic volumes.

[26] The Victoria Transport Policy Institute provides the Transportation Demand Management online encyclopaedia that provides several useful references to the various strategies outlined in this section: see http://www.vtpi.org/tdm/index.php

Table 30: Summary of Congestion Management Strategies

City, Country	Facility	Type	Description	Year Implemented	Impact on Traffic Congestion
NORTH AMERICA					
Orange County (CA), United States	SR 91 Express Lanes	Urban corridor	HOT, HOV3+ discount/free off-peak; toll schedule adjusted every 3 months (variable rate depending on time of day).	1995	Drivers save 20-30 minutes with an increase in the reliability of trip time; when tolls increased 50 percent during peak hours, traffic during those hours dropped by about one-third.
San Diego (CA), United States	Interstate 15	Urban corridor	HOT, HOV2+ free; tolls vary dynamically.	1984 (HOV) 1998 (HOT)	Project generates $2m/year; half used to support transit service in corridor. Time savings average 15 minutes per trip.
Toronto (ON), Canada	Highway 407	Urban corridor	Fixed per-kilometre fee that varies between peak and off-peak periods. 70 percent of tolls collected via transponder.	1997	Speeds on Highway 407 are about double that of parallel free highways.
Boulder (CO), United States	Comprehensive TDM	Area-wide TDM	City-wide and employer programs intended to reduce the use of cars and single driving. Some of the measures include extensive development of high frequency transit routes and incentives to use transit (unlimited passes), promotion of carpools, building and promotion of bike facilities.	1996	17 percent reduction in single occupancy driving to work compared to 1990. 3-digit increase I transit ridership
EUROPE					
Bergen, Norway	Inner city area	Urban corridors and toll rings	A fully automated toll plaza system is in place to monitor traffic entering the town; vehicles charged during weekdays from 06.00 through to 22.00.	1986	6-7 percent reduction in daily traffic.

Table 30: Summary of Congestion Management Strategies

City, Country	Facility	Type	Description	Year Implemented	Impact on Traffic Congestion
EUROPE					
Durham, United Kingdom	Central downtown area	Cordon area pricing	Permanent toll introduced for drivers using Saddler Street in the city centre.	2002	In first year of implementation, traffic volume decreased by 85 percent.
London, England	Central downtown area	Cordon area pricing	City of London charges a £5 daily fee (flat rate) for driving private vehicles in an eight square mile central area during weekdays.	2003 (expanded to West London in 2007)	30 percent reduction in traffic per day, improved bus and taxi service, vehicle traffic speeds have increased, and revenues being generated (€122m (net) per year).
Milan, Italy	Inner city area	Cordon area pricing	Congestion pricing scheme introduced in 2008, starting as a one-year trial (goal of reducing traffic by 10 percent and pollution by 30 percent). It is called "Eco-pass", and exempts low-polluting cars.	2008	On the first day of the scheme, traffic was estimated to be 40 percent lower than normal.
Northern France	A1 Autoroute	Single facility	This is a expressway connecting Paris to Lille, and since 1992 congestion prices are applied during weekends with the objective of spreading demand on the trip back to Paris on Sunday afternoons and evenings	1992	13 percent reduction during peak periods.
Oslo, Norway	Inner city area	Urban corridors and toll rings	Initially intended only to raise revenues to finance road infrastructure, the urban toll ring created an unintended congestion pricing effect. In 2008, an automated toll plaza was put in place.	1990	5-11 percent reduction per day

Table 30: Summary of Congestion Management Strategies

City, Country	Facility	Type	Description	Year Implemented	Impact on Traffic Congestion
EUROPE					
Rome, Italy	Limited Traffic Zone	Cordon area pricing	Access to the area is free for residents; other vehicle users can obtain special annual permit which allows them to drive through any of the access gates in to the historical centre.	1998	10 percent reduction in daily traffic.
Stockholm, Sweden	Inner city area	Cordon area pricing	Vehicles charged 10 to 20 kronor (US$1.27 to US$2.54) per trip to enter the inner city area on weekdays between 6:30 a.m. and 6:30 p.m. After a 7-month trial, in late 2006 residents voted to make the system permanent.	2006	The program reduced traffic volumes by about 25 percent, removing 100,000 vehicles from the roads during peak business hours and increasing public transit ridership by 40,000 users per day. About 350,000 vehicles per day pay the fee, generating between 3,500,000 and 21,000,000 kronor (US $500,000 to $2.7 million) in daily revenue.
Trondheim, Norway	City's downtown area	Urban corridors and toll rings	With a population of 140,000, Trondheim implemented a "toll ring" that surrounds the city's downtown area. Charges vary between peak and off-peak periods. Most fees paid via on-vehicle transponders at unmanned booths (occasional users can pay via coins at separate lanes).	1991	Inbound traffic has declined by 10% during toll periods while non-toll period traffic has increased by 9 percent. Weekday bus travel has increased by 7 percent. Revenues are being used for road infrastructure, public transit, and pedestrian and bicycle facilities. Public opinion was initially 72 percent opposed, dropping to 48 percent two months after launch and reducing to 36 percent by 1996.

Table 30: Summary of Congestion Management Strategies

City, Country	Facility	Type	Description	Year Implemented	Impact on Traffic Congestion
EUROPE					
Valletta, Malta	Controlled zone within city	Cordon area pricing	Automatic Number Plate Reading (ANPR) technology and dedicated camera systems are used to monitor and photograph vehicles entering and exiting the zone boundary; system then calculates fee due based on time spent in zone and parking charges.	2007	21percent reduction in daily traffic into zone.
Znojmo, Czech Republic	Town centre	Cordon area pricing	Town center entrance had two toll machines; every car has to pay a toll of approx. 1 euro/24h period for entrance plus a parking fee.	2006	Estimated that more than 2/3 of drivers now park outside the cordon and enter on foot.
Freiburg, Germany	Promotion of land use that reduces the need for car use	Local "grass-root" TDM	Design of new sub-divisions/ neighbourhoods that reduce the need for owning a car, with numerous playgrounds and daycare facilities, promotion of bike facilities and bike use.	Late 1990's	N/A
Copenhagen, Denmark (as well as other cities in Denmark, Netherlands)	Promotion of bike facilities and bicycle use	Area-wide TDM	Bike-friendly infrastructure) and road design (bike lanes and paths, bike parking facilities, bikes for public use programs, safety education.		N/A However, Denmark and Netherlands in general have a much lower share of car in the modal split compared to Canada (42-44 percent in Denmark and Netherland compared to 74 percent in Canada).[27]

[27] Statistics based on discussion in TDM Online Encyclopedia, http://www.vtpi.org/tdm/tdm93.htm .

Table 30: Summary of Congestion Management Strategies

City, Country	Facility	Type	Description	Year Implemented	Impact on Traffic Congestion
ASIA/AUSTRALASIA/LATIN AMERICA					
Melbourne, Australia	'CityLink' Toll road	Single facility	22 kilometres long, the Toll road links three of Melbourne's arterial freeways. Purely automatic vehicle identification technology used to collect fees.	1999	Congestion significantly reduced in north and west Melbourne.
Santiago, Chile	Autopista Central and Autopista Costanera Norte	Urban corridors and toll rings	Non-stop urban toll for concessioned freeways passing through downtown area, charging by distance traveled. Congestion pricing also used during rush hours to maintain speeds within the city's core.	2004-05	Air pollution and number of accidents have decreased; significant amount of traffic diverted from peak periods.
Seoul, South Korea	Two main tunnels	Single facility	Peak/off-peak toll differential	1996	Traffic volume decreased by 20 percent in the first 2 years of operation, and average traffic speed increased by 10 kilometres per hour.
Singapore	Area license scheme	Cordon area pricing	The world's first congestion pricing scheme, implemented in 1975 (via manual system). Electronic system in place since 1998; charging area divided into central business districts, where scheme applies from 7.30 am to 7.00 pm, and expressways/outer ring roads, where scheme applies from 7.30 am to 9.30 am.	1975	Since implementation, traffic speed has increased by 22 percent during peak periods, with traffic volume reduced by 13 percent. Number of solo drivers has also decreased and vehicle trips have shifted from peak to off-peak.

APPENDIX: ADDITIONAL DATA USED IN MODEL

This Appendix presents additional input data used in the model of congestion costs that could not be presented within Table 1 in the main text of this report.

Table A-1: Number of Origin and Destination Auto Work Trips

Trip Destination or Origin	Number of Trips
City of Vernon	43,989
Coldstream, Lumby (east)	13,107
Spallmucheen, Armstrong, Enderby (north)	20,676
Lake Country (north and east)	10,042
Westside, Westbank, Peachland (west)	28,199
Central Kelowna	85,182
Suburban Kelowna	70,678
Out of Region	3,441

Table A-2: Unit Costs of Vehicle Operating Costs Components

Vehicle Operating Cost Component	Unit Cost
Fuel cost per litre - 2007	$1.10
Oil cost per litre - 2007	$2.66
Cost per tire ($) - 2007	$94.36
Number of tires	4
Average M&R Cost per 1,000 KM, Auto	$33.03
Average Depreciable Value, Auto	$30,635

Table A-3: Average Use of Vehicle Operating Cost Components (Autos)

Operating Cost Component	15	20	25	30	35	40	45	50	55	60	65
Fuel, litres/1000km	93.53	83.28	74.04	66.82	61.11	56.41	54.23	53.05	53.39	55.75	58.82
Oil, litres/1000km	1.45	1.18	1.00	0.93	0.87	0.82	0.80	0.78	0.78	0.79	0.79
Tire, Percent wear per 1000 km	0.05	0.07	0.08	0.08	0.08	0.09	0.10	0.11	0.12	0.14	0.16
M&R, Percent of Average M&R per 1000 km	49.19	49.81	50.54	51.49	52.60	53.82	55.31	56.91	58.67	60.65	62.73
Depreciation, percent of depreciable value per 1000 km	0.50	0.46	0.43	0.41	0.39	0.37	0.35	0.34	0.33	0.32	0.31

Table A-4: Economic Activity Central Okanagan

Industry	Employment, workers 15 years+	Direct Employment-Output Ratio, jobs/$1 million	Estimated Industry Output, $ Millions
Total – Industry (NAICS) (3)	**82,010**		**$10,790.51**
Total – Industries – Goods	**19,525**		**$4,369.56**
11 Agriculture, Forestry, Fishing and Hunting	2,215	9.22	$240.16
21 Mining and Oil and Gas Extraction	545	0.90	$607.37
22 Utilities	470	1.71	$275.52
23 Construction	9,625	6.22	$1,548.51
31-33 Manufacturing	6,670	3.93	$1,698.01
Total – Industries – Services	**62,480**		**$6,420.95**
41 Wholesale Trade	3,170	9.54	$332.46
44-45 Retail Trade	10,710	17.95	$596.62
48-49 Transportation and Warehousing	3,345	6.27	$533.82
51 Information and Cultural Industries	1,355	5.62	$240.96
52 Finance and Insurance	3,060	1.89	$1,619.35
53 Real Estate and Rental and Leasing	2,325	2.62	$889.03
54 Professional, Scientific and Technical Services	5,505	11.83	$465.43
55 Management of Companies and Enterprises	50	11.83	$4.23
56 Administrative and Support, Waste Management and Remediation Services	4,115	18.67	$220.41
61 Educational Services	4,555	25.64	$177.63
62 Health Care and Social Assistance	9,025	18.23	$495.16
71 Arts, Entertainment and Recreation	1,725	20.71	$83.27
72 Accommodation and Food Services	6,985	20.36	$343.06
81 Other Services (except Public Administration)	4,215	26.15	$161.21
91 Public Administration	2,345	9.08	$258.31

NOTE: Based on employment data for Kelowna Census Metropolitan Area.

Table A-5: Economic Activity in North Okanagan

Industry	Employment, workers 15 years+	Direct Employment-Output Ratio, jobs/$1 million	Estimated Industry Output, $, millions
Total	**26,135**		**$3,406.46**
Total – Industries – Goods	**6,715**		**$1,556.60**
11 Agriculture, Forestry, Fishing and Hunting	1,060	9.22	$114.93
21 Mining and Oil and Gas Extraction	185	0.90	$206.17
22 Utilities	255	1.71	$149.49
23 Construction	2,565	6.22	$412.67
31-33 Manufacturing	2,645	3.93	$673.35
Total – Industries – Services	**19,420**		**$1,849.86**
41 Wholesale Trade	970	9.54	$101.73
44-45 Retail Trade	3,725	17.95	$207.51
48-49 Transportation and Warehousing	940	6.27	$150.01
51 Information and Cultural Industries	310	5.62	$55.13
52 Finance and Insurance	775	1.89	$410.13
53 Real Estate and Rental and Leasing	615	2.62	$235.16
54 Professional, Scientific and Technical Services	1,470	11.83	$124.28
55 Management of Companies and Enterprises	20	11.83	$1.69
56 Administrative and Support, Waste Management and Remediation Services	1,285	18.67	$68.83
61 Educational Services	1,665	25.64	$64.93
62 Health Care and Social Assistance	3,235	18.23	$177.49
71 Arts, Entertainment and Recreation	635	20.71	$30.65
72 Accommodation and Food Services	1,730	20.36	$84.97
81 Other Services (except Public Administration)	1,215	26.15	$46.47
91 Public Administration	825	9.08	$90.88

NOTE: Based on employment data for Vernon Census Metropolitan Area

Table A-6: Allocation of Tourist Expenditures by Industrial Sector

Industry	Tourist Spending in Industry as Percentage of Total
Accommodation	30.34%
Food and beverage	22.94%
Retail shopping	12.35%
Local transportation	8.32%
Entertainment	4.03%
Other	22.02%
Total	**100%**