CAMBRIDGE SYSTEMATICS

Cascade Gateway Travel Demand Model

Bi-National and Regional Travel Models

draft

report

prepared for

Whatcom Council of Governments

prepared by

Cambridge Systematics, Inc.

with

TranSys International Consultants Limited

July 2004

www.camsys.com

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1.0 Introduction

1.1 OBJECTIVE

The primary objective of the Bi-National and Regional Travel Model project is to serve bi-national and regional planning applications for evaluating impacts of travel demand now and into the future. As a result, the primary goal for this project is to provide sufficient information for decision-makers to evaluate future transportation investments with a strong degree of confidence. The list of stakeholders will include these decision-makers at the bi-national, state, and regional levels. The measures of success will include a list of performance measures that define the types of information that decision-makers will need to evaluate transportation investments.

The models developed in this project will take advantage of existing model-related data in the Whatcom County, Central Puget Sound, Greater Vancouver, and lower mainland B.C regions. All the models will be developed using the EMME/2 software platform in conjunction with ArcView to display results in GIS format. It will be capable of portraying travel demand information in a manner that is easily deciphered by the general public.

The Cascade Gateway bi-national travel demand model was developed using a merged set of regional networks and aggregated regional analysis zones. This model is being used by the Whatcom Council of Governments (WCOG), the Greater Vancouver Regional District (GVRD) and other IMTC member agencies to complete bi-national forecasting and analyses of border crossing alternatives.

The Cascade Gateway bi-national travel demand model estimates passenger and freight demand from socioeconomic and network data developed for both existing conditions and a future year forecast. The model was estimated using the Cross-Border Trade and Travel Study Origin-Destination Survey data on travel behavior. The model identifies demand throughout the study area (from Seattle to Vancouver) by trip purpose; origin-destination patterns; temporal variations (time of day, day of week, and seasons); border crossing choice and local routes for all passenger and freight demand.

1.2 BACKGROUND

The Cascade Gateway bi-national travel demand model was developed as one of three models in the Bi-National and Regional Travel Models project. These three models are described below:

1. **A Cascade Gateway bi-national travel demand model** was developed to enable forecasting and analyses of strategic levels of transportation demand and impacts relating to movement of people and goods across the following

four U.S.-Canada border crossings: 1) Peace Arch, 2) Pacific Highway, 3) Lynden/Aldergrove, and 4) Sumas/Abbotsford. The model will be used to evaluate traffic impacts of international phenomena. The Cascade Gateway travel demand model estimates passenger and freight demand from the origin-destination survey (Cross Border Travel Study) for both existing conditions and a future year forecast. The model identifies demand across the border by trip purpose, origin-destination patterns, temporal variations (time of day, day of week, and seasons) and ports of entry for both passenger and freight demand.

2. **A Whatcom County regional travel demand model** was developed using a countywide network and county-level analysis zones. This model will be used by WCOG and other local entities to complete regional and subregional forecasting and analyses for purposes, including growth management planning, transportation planning, project prioritization, and analyses of build out scenarios. The regional travel demand model estimates passenger demand by adapting existing local models for both existing conditions and a future year forecast. The model identifies demand throughout Whatcom County by trip purpose; origin-destination patterns; temporal variations (time of day, day of week, and seasons); and local routes for all passenger demand.

3. **A Cascade Gateway operations model** will be developed to assist in portraying traffic operations at and near border crossings. In addition to the discussed model components, it will be beneficial to identify ways to assess the operational aspects of the B.C.-WA border. The approach will use a simulation routine developed by Regal Decision Systems, Inc. for Federal Highway Administration (FHWA) and GSA known as the "Border Wizard." This is the only one of the three models that is not complete at this time.

Each of the models developed for this project has been integrated to the degree that this is useful and efficient. This integration requires data transfers from one model to the next.

1.3 CONTENTS OF THIS REPORT

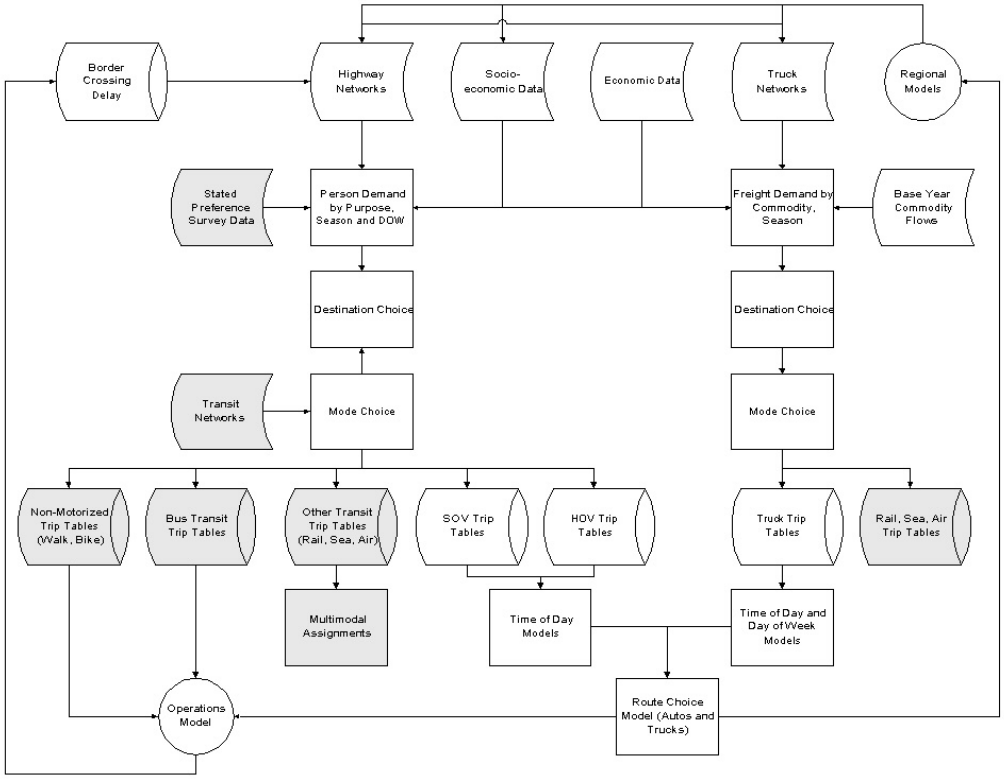
This report contains eight sections and two appendices. This section is the introduction and includes the project objectives, background, and the overall modeling process. The second section is the model framework. The third section is the data development and includes the highway network, the traffic analysis zones, the socioeconomic data, the origin-destination survey data, border wait time data and the integration with the Cascade Gateway Model. The fourth section is the description of the passenger travel demand models, which includes trip generation, trip distribution, time of day, and border crossing choice models. The fifth section is on freight models, which includes trip generation, distribution, time of day, and border crossing choice models. The sixth section is on trip assignment of passenger and freight trips and the integration of these

data with the operations model. The seventh section is on model validation and includes a discussion of validation data sources, as well as the trip behavior and trip assignment validation. Finally, the eighth section includes a discussion of the model application, including performance measures and the forecasts.

2.0 Model Framework

The model framework was developed to identify the overall sequence and interaction of the individual model components. This framework is presented in Figure 2.1. The remainder of this section describes details of the model framework.

Figure 2.1 Cascade Gateway Demand Model Framework



2.1 GEOGRAPHIC COVERAGE

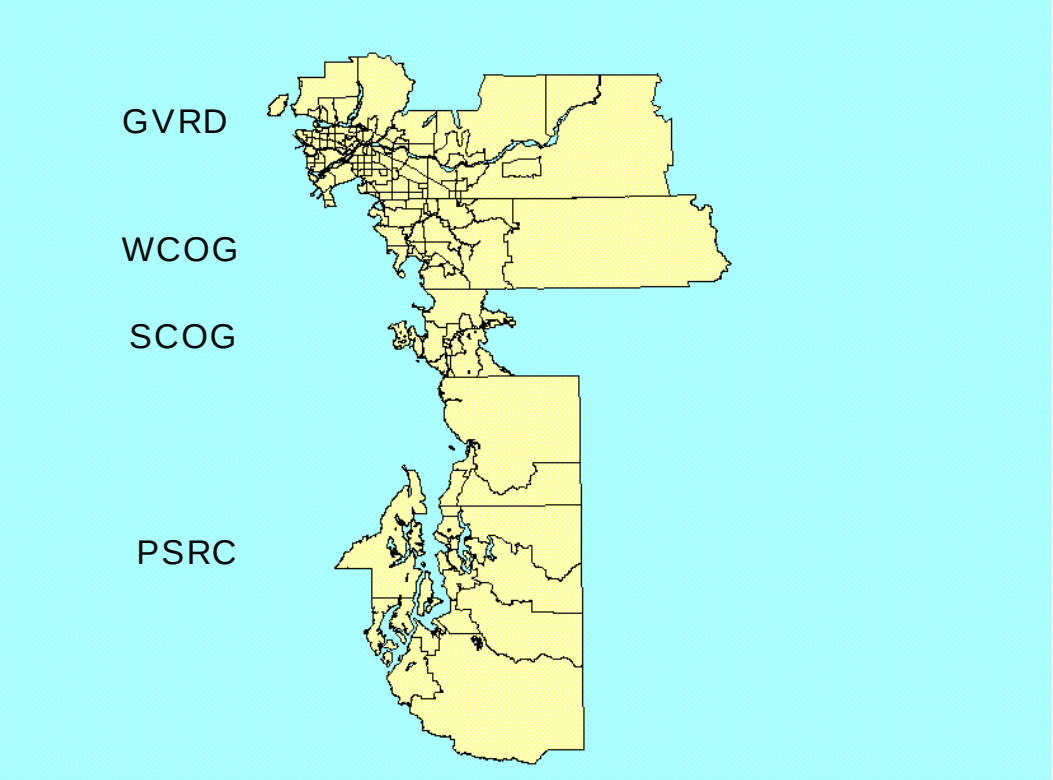
Based on the final results of the origin-destination survey, the areas of the GVRD, Lower Mainland (East and West) in British Columbia, and Whatcom County, Skagit County and Puget Sound in the U.S. represent the study area for the development of the Cascade Gateway travel demand model, as presented in Figure 2.2. This study area is a compilation of four regions:

1. Greater Vancouver Regional District (GVRD) in Vancouver;
2. Whatcom Council of Governments (WCOG);

3. Skagit Council of Governments (SCOG); and
4. Puget Sound Regional Council (PSRC) in Seattle.

This recommendation was based on the fact that 80 to 90 percent of all auto travelers crossing this border reside in this region and approximately 90 percent of all truck origins and destinations are within this region.

Figure 2.2 Cascade Gateway Study Area and Regional Agencies



The focus of the study area was to model "internal trips" crossing the border with origins/destinations within this study area and to separately model "external trips" that cross the border but have origins/destinations outside the study area. The primary reason for separating the internal and external trips is to take advantage of the wealth of socioeconomic, demographic and network data that is available within the study area without requiring that these same data be developed for all areas outside the study area. This allows the internal trip models to be more sophisticated and the external trip models to be based on more simplified methods. The traffic analysis zones (TAZs) are aggregations of the regional TAZs from each of the four regions in the study area. The level of detail is greater near the border and more aggregate further away. The aggregations are provided in Table 2.1.

Table 2.1 Cascade Gateway Traffic Analysis Zone Structure

Region	Agency	Regional Zones	Cascade Gateway Zones	Ratio
Greater Vancouver	GVRD	726	102	7.1
Whatcom County	WCOG	246	31	7.9
Skagit County	SCOG	182	9	20.2
Puget Sound	PSRC	938	19	49.4
Total		2,092	161	13.0

2.2 UNIVERSE OF TRIPS

The current universe of trips is all vehicular traffic across the U.S. and Canadian border at the following four ports of entry:

1. Peace Arch;
2. Pacific Highway;
3. Lynden/Aldergrove; and
4. Sumas/Abbotsford.

The vehicular traffic includes all types of autos and trucks, but does not include air, bus, rail, or pedestrian crossings.

2.3 TRIP PURPOSES AND COMMODITIES

Trip purposes for the Cascade Gateway travel demand model were developed from the trip purposes in the origin-destination survey data. For passenger models, these purposes are the following:

- Work;
- Recreation;
- Shopping;
- Vacation; and
- External.

Since there were similarities between the characteristics of the work commute and business-related trips and these were the two smallest trip purposes, these trip purposes were combined into a single work-related purpose.

Commodities are used for freight models instead of trip purposes to describe the various characteristics of freight movements. These are used because commodity flow is the primary factor that is driving demand. The commodity classes in the Cascade Gateway model are the following:

- Farm;
- Food;
- Manufacturing;
- Wood;
- Empty; and
- Printed matter, bulk and other.

The commodity flow data was disaggregated to zones with this set of commodity/industry classifications.

2.4 VEHICLE CLASSES

Vehicle classes are those vehicle types are important to separate for either policy purposes or for evaluating impacts. For passenger cars, vehicle classes could include auto passenger cars, recreational vehicles and campers, vehicles with trailers, and service and delivery vehicles. From the origin-destination survey data, we know that 98 percent of all passenger vehicles crossing the border are auto passenger cars, so we developed only one vehicle class for passenger trips.

For trucks, vehicle classes are defined by the number of axles and could include one, two, three, four, five or six or more axle groups. From the origin-destination survey data, we know that 89 percent of all trucks have five or more axles (also termed heavy trucks), so we developed a single vehicle class for truck trips as well.

2.5 MODES

There are two modes for this study: autos for passenger travel and trucks for goods movement. Both are highway modes. Other modes of interest include air, water, rail, bus and non-motorized modes for passenger travel and air, water, and rail modes for goods movement. Our approach included developing only the highway modes but allows for the future inclusion of the modeling of other modes.

2.6 TIME PERIODS

Time periods were designed to capture different trip-making characteristics at different times of day, days of the week, and seasons. These characteristics vary by purpose and direction. The following time periods were used to capture the varying characteristics of different types of trips:

- Three time periods during the day represent a.m. peak (8:00 a.m. to 11:00 a.m.), p.m. peak (2:00 p.m. to 5:00 p.m.) and off-peak (all remaining hours) conditions;

- Two time periods during the week represent average weekday and average weekend conditions; and
- Two seasons during the year represent peak conditions (in summer) and off-peak conditions (in fall).

The same time periods were used for passenger cars and trucks.

3.0 Data Development

3.1 MODEL NETWORK

The road network is one of the main model components for estimating trip distribution, cross-border choice, and route choice options. This section describes the road network elements in the Cascade Gateway model.

The road network of the Cascade Gateway Model is shown in Figure 3.1. Both passenger cars and trucks share the same road network. The road network was developed by extracting subsets of network data, including lanes, speeds and capacities (if available) from the four regional models – Greater Vancouver, Whatcom County, Skagit County and the Puget Sound Region. In addition, background traffic information including congested travel time and volume were also imported from regional models to the Cascade Gateway model. Background traffic for a.m. peak, p.m. peak and off peak periods were created. Time period factors were applied for regional models which did not have background traffic for all three time periods.

The road network is comprised of all major highways, freeways, and primary arterials for supporting the development of the cross-border model. The digital network consists of approximately 4,929 nodes and 10,310 links (road segments). The unit of length is specified as miles. Table 3.1 shows the facility type of the road network.

As the Cascade Gateway model is developed by integrating regional models, this approach would be difficult to provide a common basis for developing the volume delay functions (VDFs). Therefore, background traffic, which was extracted from regional models, was used to substitute for VDFs. Extra link attributes (@am, @p.m., @off), as shown in Table 3.2, were introduced for storing the congested travel time. The resulting Cascade Gateway model has a strong correlation with regional models. Any changes to regional models will have an influence on cross-border trips generated by the Cascade Gateway model. One of the advantages of this model structure is to generate accurate cross-border demand forecasting results by retaining model results produced from each regional model.

Figure 3.1 Road Network

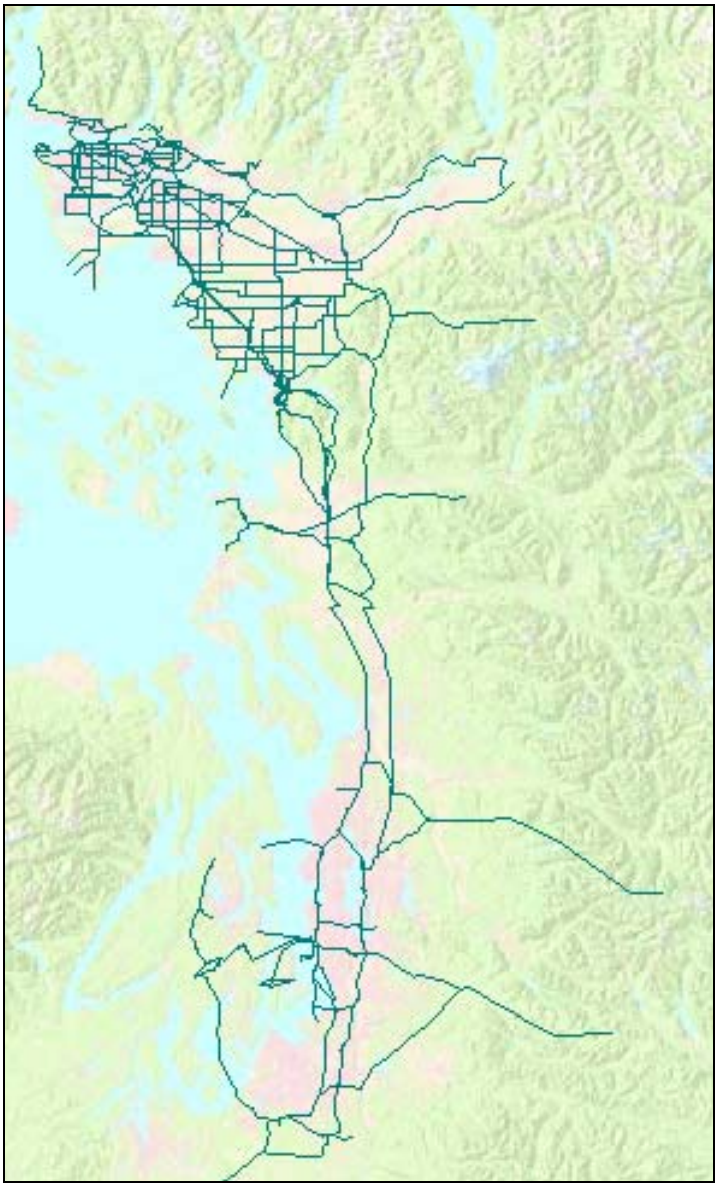


Table 3.1 Facility Type of the Road Network

Facility Type	Description
1	Highway 1, State Highway 5
2	Highway (GVRD)
3	Major Arterial (GVRD)
4	Minor Arterial (GVRD)
5	Major Arterial (Whatcom)
100	Centroid Connector

Table 3.2 Extra Link Attributes

Extra Link Attributes	Description
@ am	a.m. peak congested time
@ p.m.	p.m. peak congested time
@ off	Off-peak congested time

3.2 TRAFFIC ZONE SYSTEM

The Cascade Gateway model is composed of 174 traffic zones, which provides coverage of the four regions of Greater Vancouver, Whatcom County, Skagit County, and Puget Sound Region. The traffic zones were created by aggregating the traffic zones within each existing regional model. For instance, Greater Vancouver Transportation Model which originally had 726 traffic zones at its regional level was aggregated to 102 traffic zones in the Cascade Gateway model. The zone size varies according to the distance from the border crossing. The zone system becomes more detailed around the border crossing area to provide a higher level of accuracy in forecasting cross-border trips.

The traffic zone numbering system has been established in a way that one can easily identify where a traffic zone is located among the four regions. All road network nodes are represented by a six-digit zone numbering system and can readily be distinguished from traffic zone nodes, which have three digits. Figure 3.2 shows the traffic zone map for the entire study area. Figure 3.3 is a traffic zone map focusing on Greater Vancouver, Whatcom County, and Skagit County regions. Table 3.3 provides a summary of the traffic zone numbering scheme by region.

Figure 3.2 Traffic Zone (Study Area)

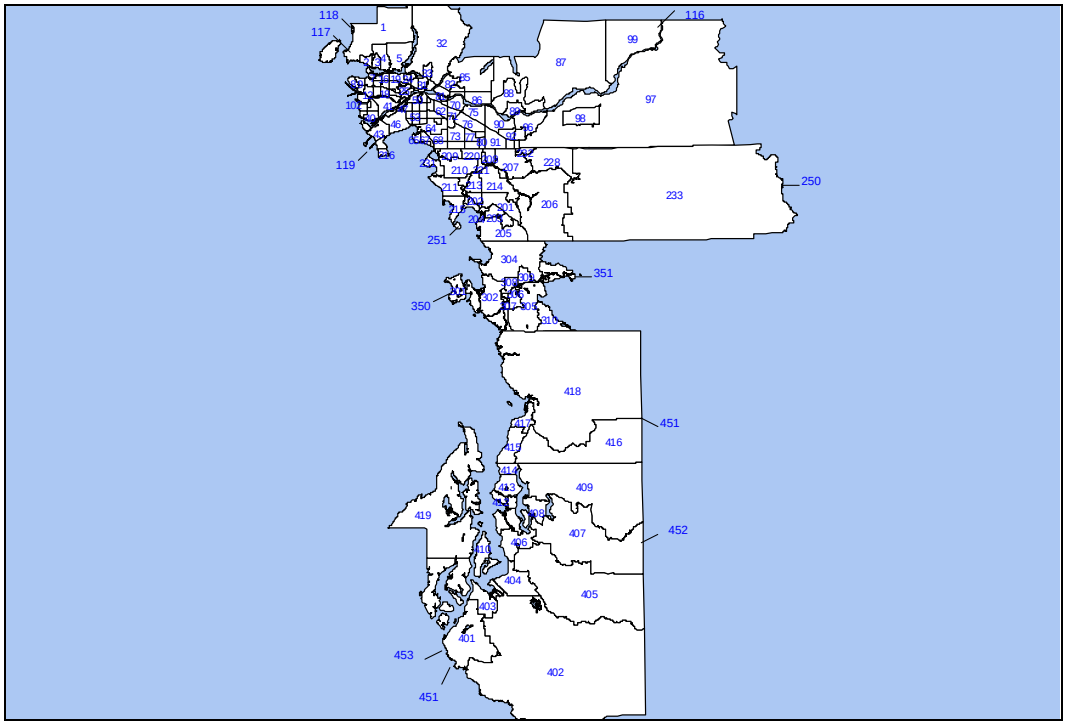


Figure 3.3 Traffic Zone (Greater Vancouver, Whatcom and Skagit)

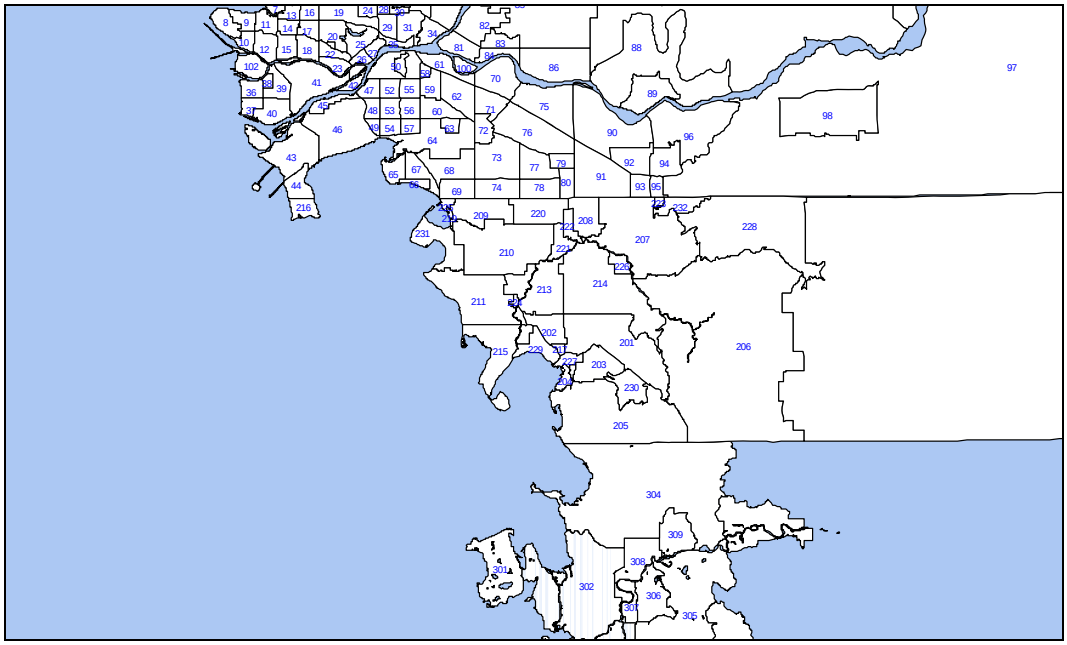


Table 3.3 Traffic Zone Numbering Scheme

Region	Number of Zones	Numbering Schedule
GVRD	102	1-102
Whatcom County	31	201-233
Skagit County	9	301-310
PSRC	19	401-419

Region	Number of External Zones	Numbering Schedule
GVRD	4	116-119
Whatcom County	2	250-251
Skagit County	2	350-351
PSRC	4	451-454

External zones are located at the entry points to the study area to account for traffic entering, leaving, or passing through the study area. They include:

- Highway 99 – North of Horseshoe Bay (Greater Vancouver);
- Horseshoe Bay Ferry Terminal (Greater Vancouver);
- Tsawwassen Ferry Terminal (Greater Vancouver);
- Highway 1 – east of Hope (Greater Vancouver);
- Lummi Island (Whatcom County);
- Whidbey Island (Skagit County);
- State Highway 20 – East of State Highway 530 (Skagit County);
- State Highway 5 – South of State Highway 510 (PSRC);
- State Highway 90 – East of Grotto (PSRC); and
- State Highway 2 – East of Snoqualmie Pass (PSRC).

The approximate location of external zones and the zone number system are also shown in Figure 3.2 and Figure 3.3, respectively.

3.3 SOCIOECONOMIC DATA

The demand for U.S./Canada cross-border trip making behavior is derived from socioeconomic estimates that are contained within traffic zones. Socioeconomic data for year 2000/2001 was provided by the four regions. This information includes total population and employment by industrial category. Year 2000/2001 population data was not available for Skagit County. Interpolation

was needed to project year 1998 household data to year 2001 household data. A conversion factor[1] was then applied to the projected 2001 household data to obtain year 2001 total population. Table 3.4 shows the total population and employment for the four regions. Table 3.5 illustrates the industrial category used for the four regions. There are three main employment categories defined in the passenger model: service, non-service and retail employment categories. As each region has its own employment categories, category consolidation is needed to generate a consistent set of socioeconomic data. Each traffic zone contains detailed socioeconomic data, which is used to determine the amount of cross-border travel generated.

Table 3.4 Year 2000 Population and Employment Totals (in million)

	Year 200	
Region	Total Population	Total Employment
GVRD	2.19	1.06
Whatcom County	0.16	0.08
Skagit County	0.11	0.04
PSRC	3.28	1.75
Total	5.74	2.93

Table 3.5 Year 2000 Employment Totals by Category

Regions	GVRD	Whatcom County	Skabig County	PSRC
Non Service	346,400	19,200	15,800	572,300
Primary	19,400	2,200	2,300	9,000
Manufacture	98,000	8,000	6,200	231,100
TCU	99,700	–	1,700	108,300
Wholesale	66,000	4,500	2,400	108,300
Other	–	4,500	–	–
Retail	131,100	22,900	11,500	320,600
Service	580,100	39,200	17,000	856,400
FIRE	176,800	28,500	1,800	684,600
Other	403,300	10,700	15,100	171,700
Total	1,057,600	81,300	44,300	1,749,300

[1] The conversion factor, 2.51 people per household, was calculated based on the 2000/ 2001 socioeconomic data from Whatcom County.

3.4 ORIGIN-DESTINATION SURVEY DATA

A model calibration of a travel demand forecasting model depends largely on the model input data and baseline travel survey information. The Cascade Gateway model was calibrated to observed border crossing travel behavior and data that were obtained from a variety of sources. The IMTC cross-border origin-destination (OD) survey was one of the data sources used for model calibration. The IMTC cross-border survey consisted of two waves of roadside surveys at the U.S./Canada border crossing during the summer and fall of 2000. Both passenger and commercial vehicle surveys (weekdays and weekends) were conducted for a sample of vehicles at the four U.S./Canada border crossings.

Several procedures were involved for analyzing the OD survey database prior to model calibration. One of the steps was to map all origins and destinations with the traffic zone system defined in the Cascade Gateway model. Another key step was to identify different trip purposes by residency (U.S. or Canada). Initially, the OD survey data was aggregated into 18 main trip purposes that described cross-border travel throughout the survey period as shown in Table 3.6. External trips were defined as trips either originating from or destined to a location outside of the study area. Further trip consolidation was completed based on the mean trip length. For example, to/from other trips were combined with to/from recreation trips as their trip lengths were similar. Finally, the entire OD survey database was factored to a.m. peak (8:00 a.m. to 11:00 a.m.), p.m. peak (2:00 p.m. to 5:00 p.m.) and off peak by port-of-entry, direction, day of week and time of day. Daily trips were obtained by aggregating results from different time periods. Different OD tables and traffic counts were generated to capture varying cross-border travel characteristics for model calibration. The travel characteristics considered include:

- Trip purposes (work, recreation, shopping, vacation, and external trips);
- Residency (U.S., Canada);
- Port-of-entry (Peace Arch, Pacific Highway, Lynden/Aldergrove and Sumas/Abbotsford border crossings);
- Direction (southbound, northbound);
- Day of week (weekday, weekend);
- Time of day (a.m. peak, p.m. peak, off peak, and daily); and
- Season (summer, fall).

Table 3.6 Trip Purposes Consolidation for IMTC OD Survey

Original Trip Purpose	Consolidated Trip Purpose
To Work	To Work
From Work	From Work
To Work Related	To Work
From Work Related	From Work
To Recreation	To Recreation
From Recreation	From Recreation
To Shop	To Shopping
From Shop	From Shopping
To Vacation	To Vacation
From Vacation	From Vacation
To Other	To Recreation
From Other	From Recreation
To Home (Within the study area)	To Home
From Home (Within the study area)	From Home
To Other Canadian Cities (External)	To External
From Other Canadian Cities (External)	From External
To Other American Cities (External)	From External
From Other American Cities (External)	From External

3.5 BORDER WAIT TIME DATA

Border wait time data is also important for model calibration. However, only limited data is available for the four U.S./Canada border crossings. Year 2000 to year 2002 border wait time data provided by the U.S. Citizenship and Immigration Services (USCIS, formerly INS) and the Canada Revenue Agency (CRA, formerly CCRA) were used for calibrating the passenger model. These border wait time data were the best estimates available during the time of model calibration.

Table 3.7 presents the border wait time data used for autos and trucks that were used in model calibration. Year 2000 INS border wait times, as shown in Table 3.8, was used for the Pacific Highway and Peace Arch border crossings, whereas year 2002 INS border wait time data were used for Lynden and Sumas border crossings. For northbound trips, year 2002 border wait time data provided by CCRA were used for model calibration. It was assumed that the border wait times at the Lynden/Aldergrove border crossing were similar to those at the Sumas/Abbottsford border crossing.

Table 3.7 Border Wait Time Data for Southbound and Northbound

Border Crossing	INS Data (Southbound)		CCRA Data (Northbound)	
	Year 2000	Year 2002	Year 2000	Year 2002
Peach Arch	✓			✓
Pacific Hwy	✓			✓
Lynden/Aldergrove		✓		
Sumas/Abbotsford		✓		✓

Table 3.8 Border Wait Time for Southbound (in Minutes)

Border Crossing	Fall Weekday			Fall Weekend			Summer Weekday			Summer Weekend		
	AM Peak	PM Peak	Off Peak	AM Peak	PM Peak	Off Peak	AM Peak	PM Peak	Off Peak	AM Peak	PM Peak	Off Peak
Autos												
Peach Arch	3	4	3	8	37	20	14	25	16	31	86	52
Lynden/Aldergrove	2	1	1	3	2	3	9	19	15	13	41	21
Pacific Hwy	2	3	3	9	36	24	9	23	15	28	88	41
Sumas/Abbotsford	2	2	1	2	3	1	7	14	9	8	13	13
Trucks												
Lynden/Aldergrove	13	21	8	0	0	0	6	21	7	0	16	5
Pacific Hwy	18	25	18	14	16	19	23	24	20	16	13	13
Sumas/Abbotsford	13	21	8	0	0	0	6	21	7	0	16	5

Border wait times were weighted by volume based on the year 2000 IMTC 24-hour volume profile. Border wait times for northbound border crossings are shown in Table 3.9.

Table 3.9 Border Wait Time for Northbound (in Minutes)

	Fall Weekday			Fall Weekend			Summer Weekday			Summer Weekend		
Border Crossing	AM Peak	PM Peak	Off Peak	AM Peak	PM Peak	Off Peak	AM Peak	PM Peak	Off Peak	AM Peak	PM Peak	Off Peak
Autos												
Peach Arch	2	8	7	10	9	16	6	16	11	16	28	34
Lynden/Aldergrove	0	1	0	0	0	0	2	13	12	1	9	12
Pacific Hwy	4	8	7	6	7	8	4	9	6	9	7	4
Sumas/Abbotsford	0	1	0	0	0	0	2	13	12	1	9	12
Trucks												
Lynden/Aldergrove	1	2	0	0	0	0	2	1	1	0	0	0
Pacific Hwy	7	20	14	18	8	14	12	15	13	11	9	9
Sumas/Abbotsford	1	2	0	0	0	0	2	1	1	0	0	0

3.6 INTEGRATION WITH REGIONAL MODELS

The Cascade Gateway model has a strong correlation with the four regional models. Any changes to the regional models will have an influence on cross-border trips generated by the Cascade Gateway model.

When road network changes are made in any one of the four regional models, particularly in the Greater Vancouver and Whatcom County models, the resulting congested travel time, volume, and new road facilities should be imported into the Cascade Gateway model in order to update travel impedances and the road network. If significant road network changes are made, recalibrating the Cascade Gateway model may be necessary.

4.0 Passenger Models

The passenger model structure took a form similar to the traditional 4-step travel demand forecasting model. The model was calibrated to the year 2000 IMTC OD survey data. The passenger models have been developed based on a variety of information sources, including:

- The year 2000 IMTC Cross-Border OD Survey;
- U.S./Canada border wait time information (supplied by INS and CCRA); and
- Socioeconomic information and road networks provided by TransLink, Whatcom County, Skagit County, and the Puget Sound Region.

The model consists of three time periods: a.m. peak period, p.m. peak period and off peak period. Combining all time periods generates a 24-hour model. To capture the changes in cross-border travel characteristic under temporal variations, four models have been developed that respectively estimate border crossing trips made during a summer weekday, summer weekend, fall weekday and fall weekend. They all have been calibrated to year 2000/2001 conditions. All models identify cross-border demand by trip purpose, origin-destination patterns, temporal variations, and ports of entry. This section describes the sub-components of the passenger models in detail.

4.1 Season and Day of Week

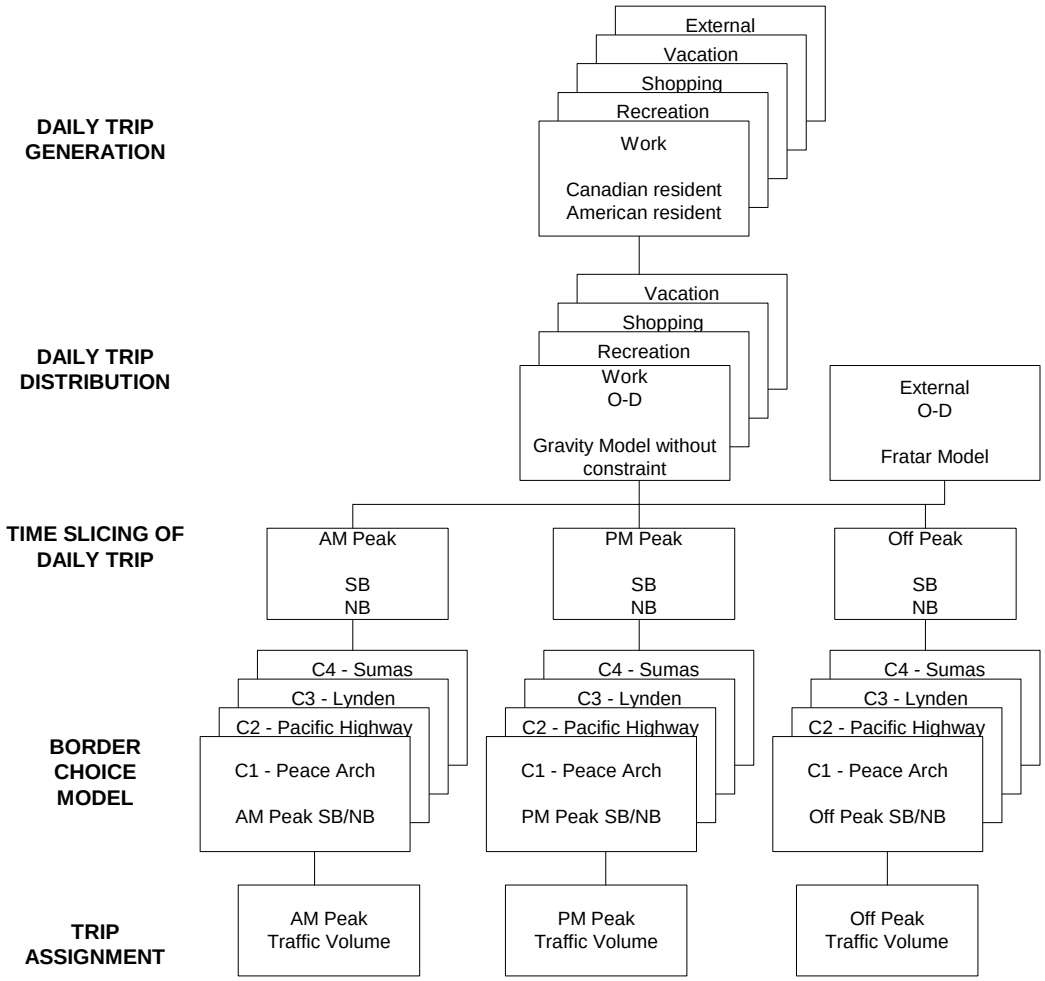
The overall model structure of the passenger model is presented in Figure 4.1. The entire modeling procedure consists of several stages:

- The model begins with a daily trip generation model, which produces daily cross-border trips mainly based on socioeconomic data;
- The next stage is a daily cross-border trip distribution that estimates cross-border travel flows between every origin and every destination based on the total production and attraction obtained from the previous stage;
- After trip distribution, daily cross-border trips are converted to a.m. peak period, p.m. peak period, and off peak period cross-border trips;
- Following time slicing, the border choice model estimates the percentage of border crossing trips that use Peace Arch, Pacific Highway, Lynden/Aldergrove, and Sumas/Abbotsford border crossings; and
- Finally, trip assignment determines the actual route taken by cross-border trips and assigns them to the road network.

Cross-border travel exhibits temporal change. To enable the model to estimate cross-border travel demand for a particular time period within the year, four

models have been developed to cover summer weekdays, summer weekends, fall weekdays, and fall weekends. Each model retains the same model structure. Annual cross-border traffic can also be generated by applying annual factors to the four passenger car models.

Figure 4.1 Overall Structure of the Passenger Model

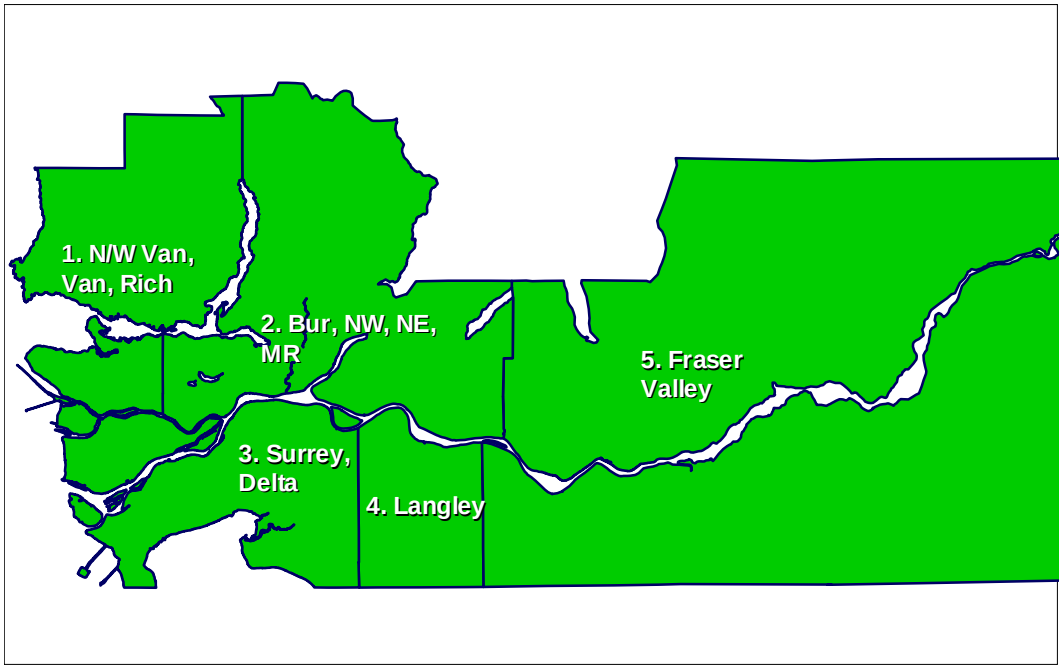


4.2 PASSENGER TRIP GENERATION

Trip generation equations estimate the number of daily cross-border trips produced and attracted by each traffic zone. They are a fundamental component of the passenger model. The trip generation model has been developed in such a way that it is sensitive to changes in border wait times and exchange rates. Factoring procedures have been incorporated into the trip generation model to reflect changes to cross-border demand as a result of changes in the exchange rate. Socioeconomic data collected from all four regions were used for developing the trip generation model.

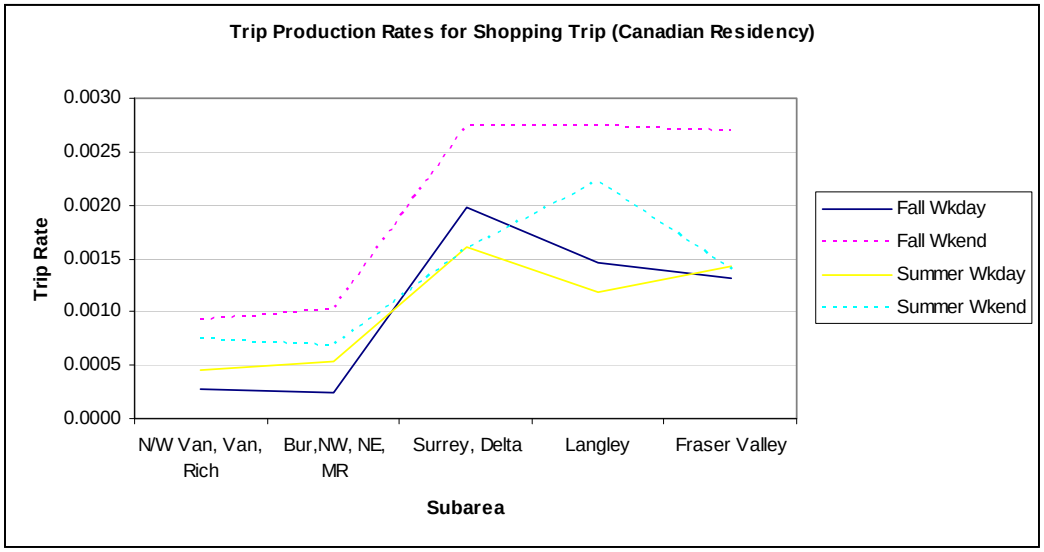
Subarea trip rates were used for estimating total production and attraction trips at each zone. A total of 11 subareas within the entire study area were identified to support development of daily trip rates. Greater Vancouver was aggregated into five subareas, as shown in Figure 4.2, while Whatcom County was grouped into four subareas, mainly Point Roberts, Blaine/Ferndale, Lynden/Sumas, and Bellingham. Skagit County and PSRC were considered as two subareas because they are located further away from the U.S./Canada border crossings.

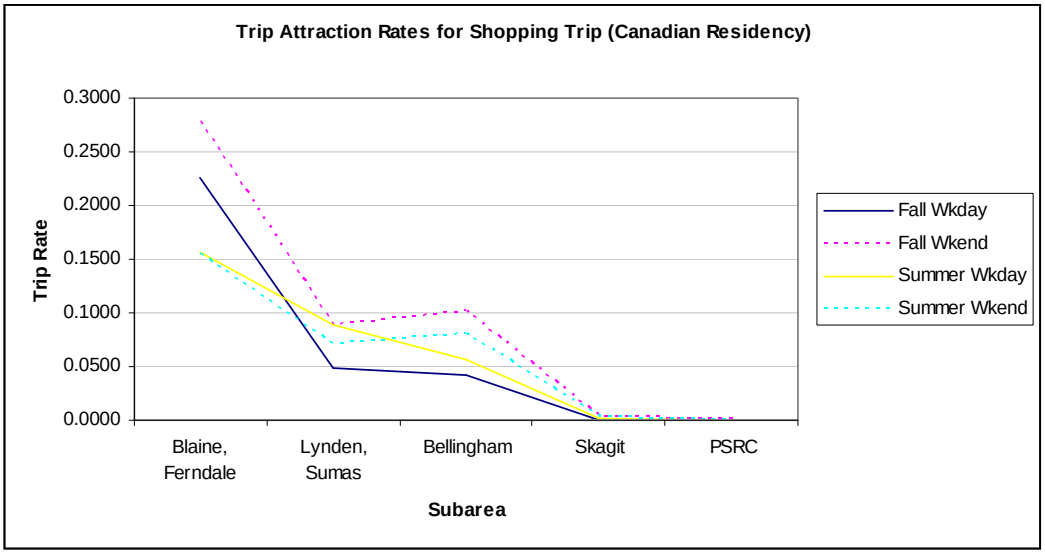
Figure 4.2 Greater Vancouver Subarea



Subarea trip production and attraction equations were developed separately for different trip purposes, subareas, direction, and country of residency. As a result, a total of 176 trip generation equations were developed for each model. Figure 4.3 shows the trip generation rates for southbound Canadian shopping trips. The trip production variable is total population and the trip attraction variable is retail employment. In general, trip generation rates for shopping trips are higher on weekends than on weekdays. People who live close to the border crossings tend to make more cross-border trips. Trip rates for other trip purposes are shown in Appendix A.

Figure 4.3 Southbound Shopping Trip Generation Rates for Canadian Residents





4.3 PASSENGER TRIP DISTRIBUTION

Trip distribution determines the number of cross-border trips between origin-destination pairs for each trip purpose. This is a multi-step process that starts with the calculation of travel impedances between OD pairs. The impedance matrices are then used to calculate friction factors, which describe the propensity to travel between different cross-border locations. Trip distribution models were calibrated by trip purpose, direction, and residency, based on travel impedance and the trip length estimates developed from the cross-border OD survey. Mean trip length estimates for the different trip purposes are shown in Table 4.1. The

trip distribution model has a gravity model formulation, but it is unconstrained. This would be appropriate for an inter-urban model where the trip ends are not fixed. A Fratar model is used for external trips.

Table 4.1 Mean Trip Length for All Trip Purposes (in Miles)

Canadian Residency

Trip purpose	Mean Trip Length (SB)				Mean Trip Length (NB)			
	Summer		Fall		Summer		Fall	
	wkday	wkend	wkday	wkend	wkday	wkend	wkday	wkend
Work	54	60	48	54	40	59	36	64
Recreation	46	72	42	72	43	61	45	53
Shopping	33	40	23	44	28	31	22	31
Vacation	85	106	104	119	71	73	85	73
Externals	155	154	143	150	145	151	141	145

American Residency

Trip purpose	Mean Trip Length (SB)				Mean Trip Length (NB)			
	Summer		Fall		Summer		Fall	
	wkday	wkend	wkday	wkend	wkday	wkend	wkday	wkend
Work	70	72	51	83	58	65	66	77
Recreation	72	83	55	86	62	70	52	85
Shopping	52	68	55	52	67	54	36	62
Vacation	103	130	84	114	120	100	123	116
Externals	144	160	136	161	139	138	142	130

Travel impedance is defined as a function of congested travel time and border wait time, as shown in Equation 4.1. The beta (β) coefficient has been calibrated to the trip length distribution for each trip purpose, by direction and residency. Following the computation of travel impedance, gravity models were calibrated for each trip purpose by direction and residency. As a result, 16 gravity models (four trip purposes, two direction, and two residencies) were developed for each model. The general formulation of the gravity model is presented in Equation 4.2:

Equation 4.1

$$F_{ij}^{p} = \exp(-\beta \cdot (CT_{ij} + BWT))$$

Where:

CT_{ij} = Congested travel time from origin *i* to destination *j*

BWT = Border wait time

Equation 4.2 $$T_{ij}^{p} = \alpha_{p} \cdot (X_{1i} X_{2j} F_{ij}^{p})$$

Where:

T_{ij}^{p} = Cross-border trip from origin *i* to destination *j* for trip purpose p

X_{1i} = Subarea trip production

X_{2j} = Subarea trip attraction

F_{ij}^{p} = Travel impedance

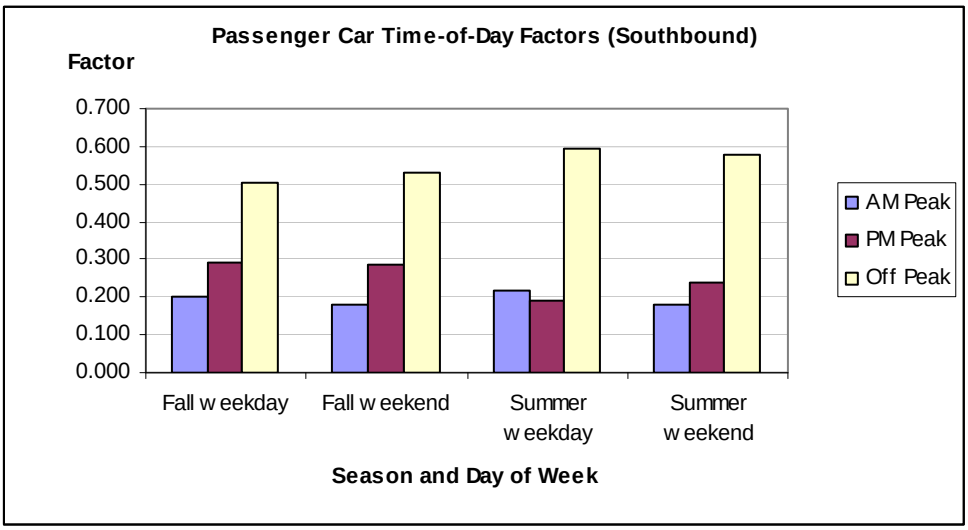
α_{p} = Calibration coefficient

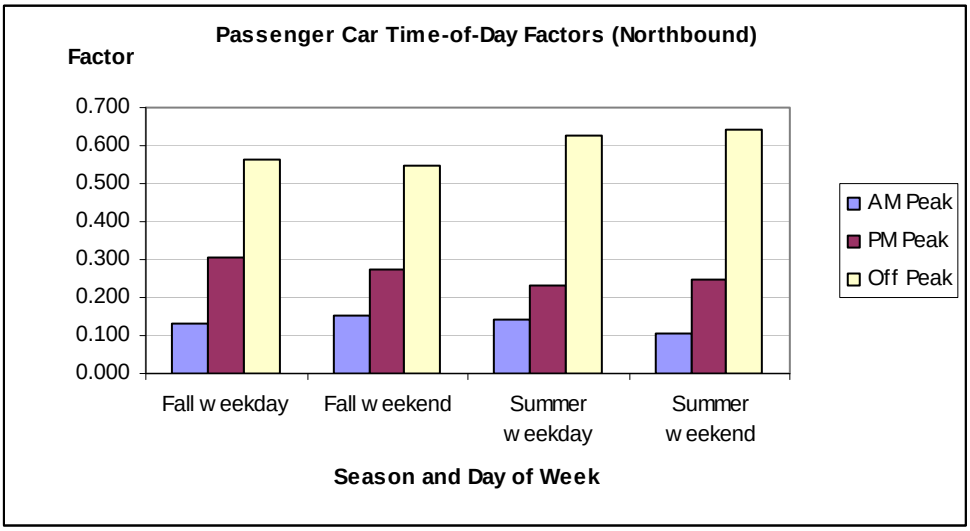
The gravity model distributes trips according to travel impedances in the transportation system. As the model is sensitive to travel impedances on the network, sufficient cross-border trips could not be generated to Skagit County and PSRC, where travel impedances are relatively large. Therefore, K-factors, with a range from 0 to 10, were applied to Skagit County and PSRC for adjusting the remaining differences between observed and predicted cross-border trips that were not captured by the friction factor.

4.4 TIME OF DAY

After daily trip generation and distribution, the next modeling step is to convert daily trip matrices to different time period matrices (a.m. peak, p.m. peak, and off peak). This procedure involves applying peaking factors, which were estimated from the origin-destination survey, to daily trip matrices. Figure 4.4 shows the peaking factors for southbound and northbound directions.

Figure 4.4 Peaking Factors for Southbound and Northbound Traffic





4.5 BORDER CROSSING CHOICE

The border crossing choice model estimates the percentage of border crossing trips that use the Peace Arch, Pacific Highway, Lynden, and Sumas border crossings. This stage requires the following inputs from previous calculations: cross-border trip matrices by time of day and direction, and travel impedances. Border crossing choice is a multi-step process. The first step involves estimating coefficients for border crossing choice variables by time of day and direction. A multinomial logit model (LIMDEP) was used to determine the coefficients for border crossing choice variables. These coefficients are presented by time period and direction in Table 4.2.

The second step estimates the probability of cross-border trips that use the Peace Arch, Pacific Highway, Lynden, and Sumas border crossings from the previous multinomial logit models. Both of these processes use a set of multinomial logit models as shown in Equation 4.3 and a utility function for the border crossing choice model is shown in Equation 4.4.

Equation 4.3

$$P_{ij(C=1)} = \frac{\exp(U_{ij(C=1)})}{\sum_{x=1}^{4} \exp(U_{ij(C=x)})}$$

where:

$U_{ij(C=x)}$ = Utility function for using border crossing x for a cross-border trip from origin *i* to destination *j*

$P_{ij(C=1)}$ = The probability that a cross-border trip would be made from origin *i* to destination *j* through border crossing c=1

Equation 4.4

$$U_{ij(C=x)} = \beta_{(time,dir)} \cdot (\mathrm{B}_{subarea} + CT_{ij(C=x)} + BWT_{(C=x)})$$

where:

$\beta_{(time,dir)}$ = Estimated coefficient by time period and direction from the discrete choice model

$\mathrm{B}_{subarea}$ = Subarea bias

$CT_{ij(C=x)}$ = Congested travel time from origin *i* to destination *j* through border crossing c=x

$BWT_{(C=x)}$ = Border wait time at border crossing c=x

These equations were calibrated for each time period (a.m. peak, p.m. peak and off peak) and direction (northbound and southbound). Table 4.3 shows the calibrated subarea bias parameters for southbound direction during a.m. peak period for the fall weekday model. The subarea bias parameters are used in combination with the congested travel time and border wait time to establish the proportion of cross-border trips that use a given border crossing. Note that a negative subarea bias indicates one border crossing is preferred over another when the impedances are the same. The reason for including the subarea bias is because geographic location has an impact on determining which border crossing will be used. For example, people who reside in the west side of Vancouver (in British Columbia) are unlikely to drive all the way to the eastern border crossings (Sumas and Lynden) when the border wait time at Peace Arch increases by ten minutes.

Table 4.2 Estimated Coefficients by Time Period and Direction from the Discrete Choice Model

	AM Peak Period	PM Peak Period	Off-peak Period
Southbound			
Fall Weekday	-0.1023	-0.1058	-0.1267
Fall Weekend	-0.1235	-0.0987	-0.0832
Summer Weekday	-0.1203	-0.0823	-0.0919
Summer Weekend	-0.1115	-0.0701	-0.0843
Northbound			
Fall Weekday	-0.0709	-0.0626	-0.0487
Fall Weekend	-0.043	-0.0543	-0.0413
Summer Weekday	-0.0431	-0.0477	-0.0498
Summer Weekend	-0.0377	-0.0431	-0.0461

Table 4.3 Subarea Bias Parameters for Southbound AM Peak Period (Fall Weekday Model)

Subarea	Peace Arch	Pacific Hwy	Lynden/Aldergrove	Sumas/Abbotsford
Rich, N/W Van, Van	-37.12	-29.76	0.00	15.03
Bur, NW, NE	-28.52	-35.36	0.00	-14.02
Surrey, Delta, Pt Roberts	27.82	-23.00	0.00	-16.05
Langley	-11.52	-24.36	-14.54	0.00
Fraser Valley	-7.10	-18.01	0.00	-6.04
External	-40.31	0.00	-4.04	1.30

5.0 Freight Models

5.1 SEASON AND DAY OF WEEK

The IMTC cross-border trade and travel survey was conducted at the U.S./ Canada border during summer and fall of 2000, on both, weekdays and weekends. So the freight movements captured by the surveys are modeled for the following seasons and days of week:

- Fall Weekday;
- Fall Weekend;
- Summer Weekday; and
- Summer Weekend.

The commodity being transported by the trucks was also gathered in the surveys and grouped into eight broad categories: bulk, farm, food, wood, printed matters, manufacturing, empty, and unknown. These commodities serve as trip purposes and the trucks carrying them have unique characteristics.

Extensive traffic count data was also collected for different seasons and at all the border crossing locations. This observed data was used as control totals to develop expansion factors by season, border crossing location, time of day and direction of travel. These factors are then applied to the IMTC survey truck database to expand the sample to reflect the actual truck population crossing the U.S./Canada border.

5.2 FREIGHT TRIP GENERATION

The expanded truck trip database is used to develop the freight trip generation model that comprises of production and attraction models. These models involve the derivation of trip rates by commodity group and district for all the four seasons. The independent variables that were used to develop these models include socioeconomic information, such as households and employment by industry; namely, manufacturing, construction, wholesale, retail, service and agriculture.

Owing to similar characteristics of various TAZs in close proximity to one another, these TAZs were aggregated further to large districts for trip generation analyses. The GVRD TAZs were aggregated to eight districts, Whatcom County TAZs to three districts, and one each for Skagit County and Puget Sound region. The truck trip rates were then computed at the district level by commodity group and season. Figures 5.1 through 5.4 show various districts used for freight trip generation models.

Figure 5.1 Greater Vancouver Districts

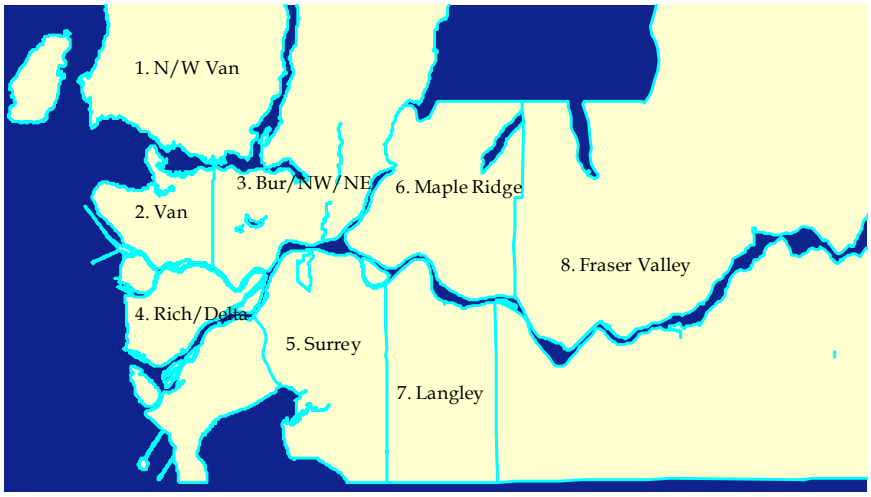


Figure 5.2 Whatcom County Districts

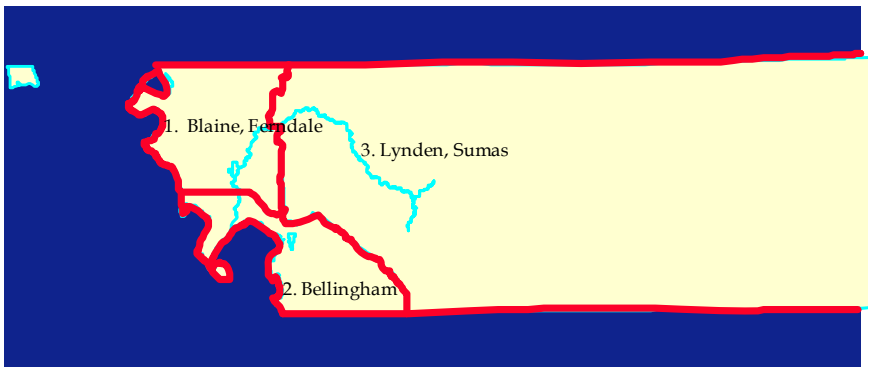
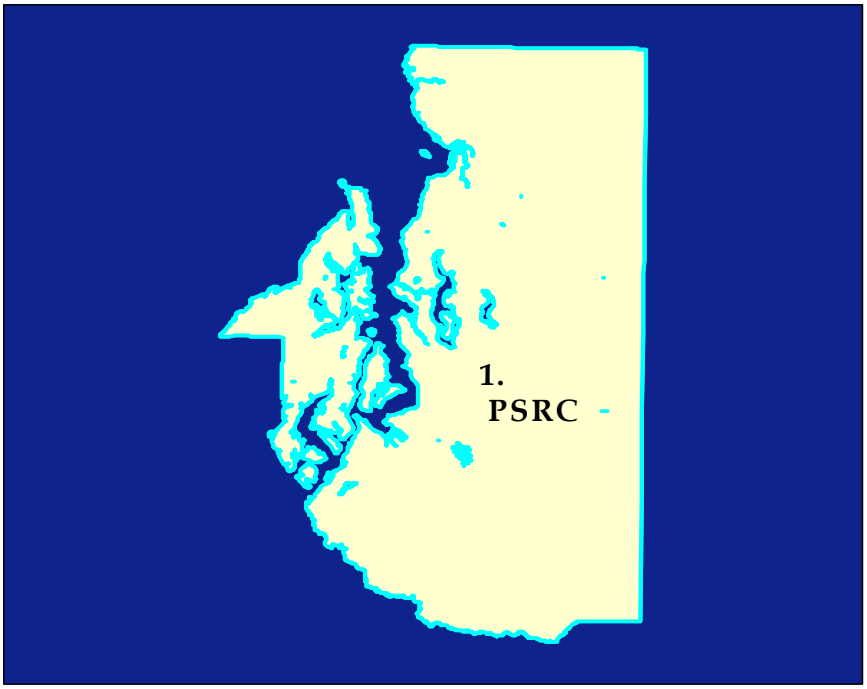


Figure 5.3 Skagit County Districts

Figure 5.4 Puget Sound Districts



In order to better understand the relationships between socioeconomic data and truck trip generation, origin choice models were first estimated. These choice models, estimated by commodity group, gave an indication of the types of variables that influenced the production of truck trips from a district. It was found that different combinations of employment were significantly driving the production of trucks for each commodity type. The commodities 'bulk', 'printed matter', and 'unknown' were grouped into 'other' category because of low sample sizes. These origin choice models are explained in more detail in the ensuing section. The trip generation models by commodity group are presented in Table 5.1.

Table 5.1 Truck Trip Generation Models

Commodity	Combination of Employment
Other (Bulk + Printed Matter + Unknown)	Wholesale, Construction, Agriculture, Manufacturing
Farm	Agriculture
Food	Wholesale, Retail, Agriculture
Wood	Retail, Construction, Manufacturing
Manufacturing	Manufacturing, Wholesale, Service
Empty	Retail, Construction, Wholesale, Manufacturing, Agriculture

The trip rates are computed as a ratio of the number of expanded truck trips from the IMTC survey to the total combination of employment as shown in Table 5.1. These trip rates are calculated separately by season, commodity, and districts.

For instance, trucks carrying 'other' commodity were found to be generated by wholesale, construction, agriculture, and manufacturing jobs. Hence, the trip rate for this category is computed as:

> 'Other' Truck Trip Rate = [Number of Expanded 'Other' Truck Trips / Number of (Wholesale + Construction + Agriculture + Manufacturing) Jobs]

Figures 5.5 through 5.10 present production truck trip rates by commodity, season, day of week and districts. Tabular presentation of both the production and consumption trip rates is provided in Appendix B for reference.

Figure 5.5 Freight Trip Generation for Farm Commodities by Day of Week and Season

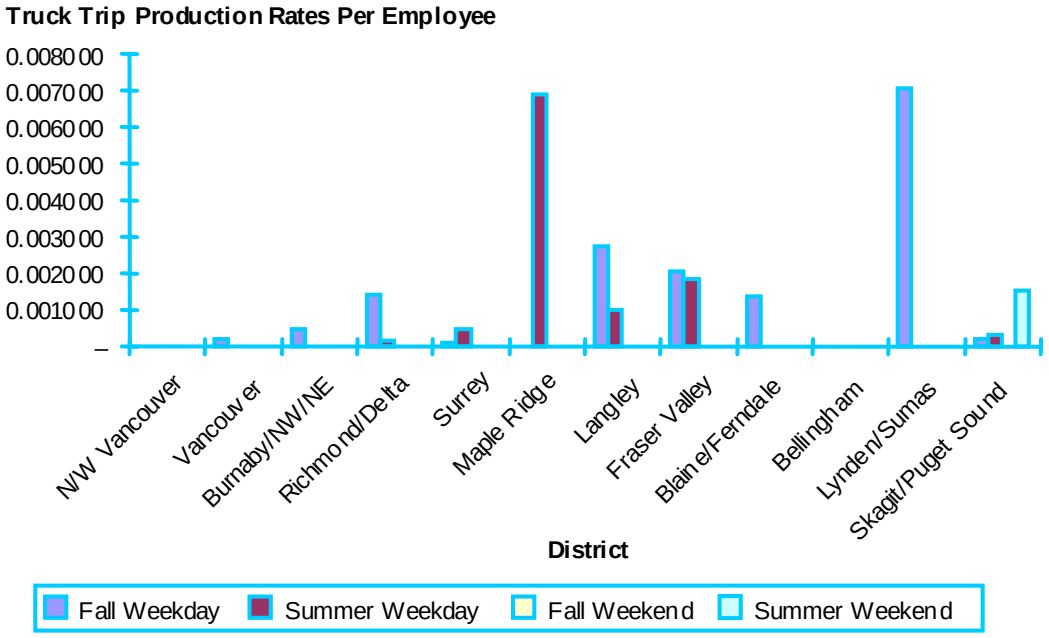


Figure 5.6 Freight Trip Generation for Food Commodities by Day of Week and Season

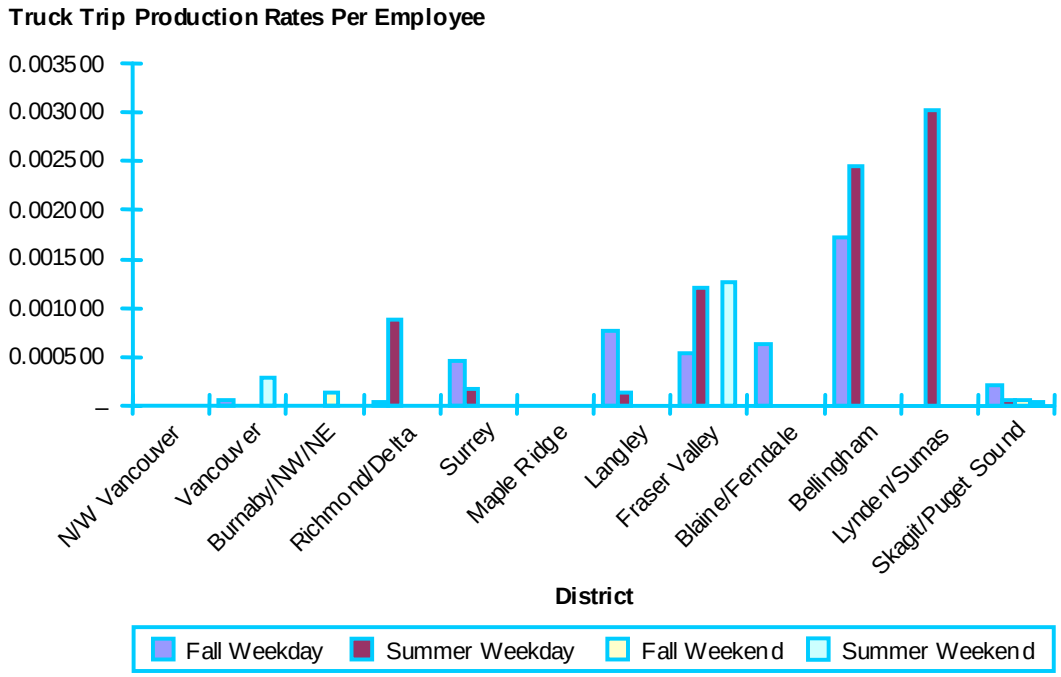


Figure 5.7 Freight Trip Generation for Wood Commodities by Day of Week and Season

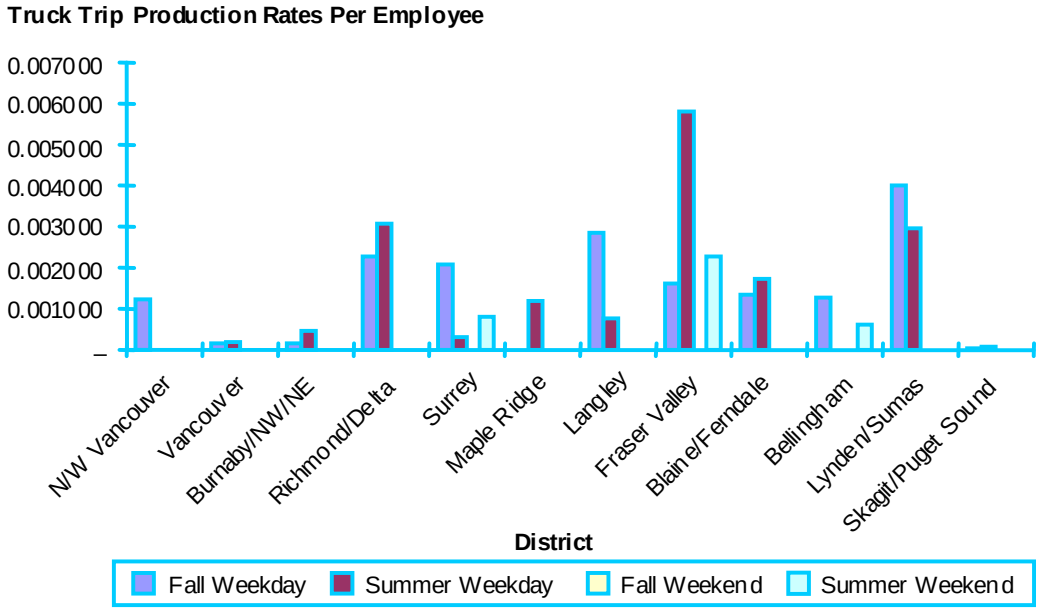


Figure 5.8 Freight Trip Generation for Manufacturing Commodities by Day of Week and Season

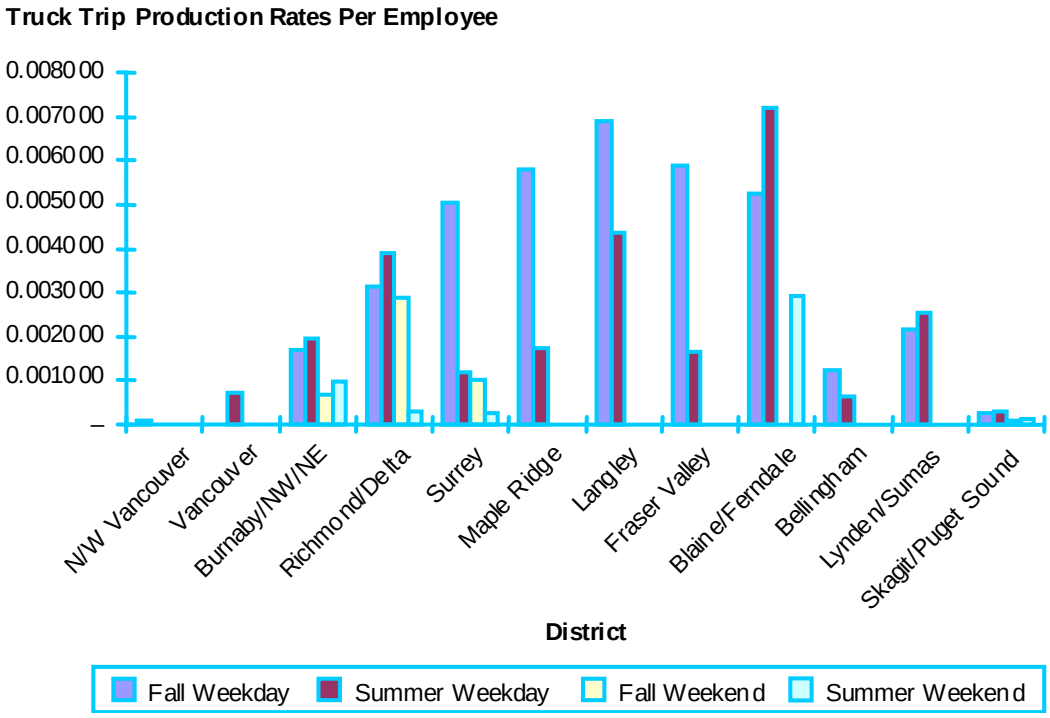


Figure 5.9 Freight Trip Generation for Empty Trucks by Day of Week and Season

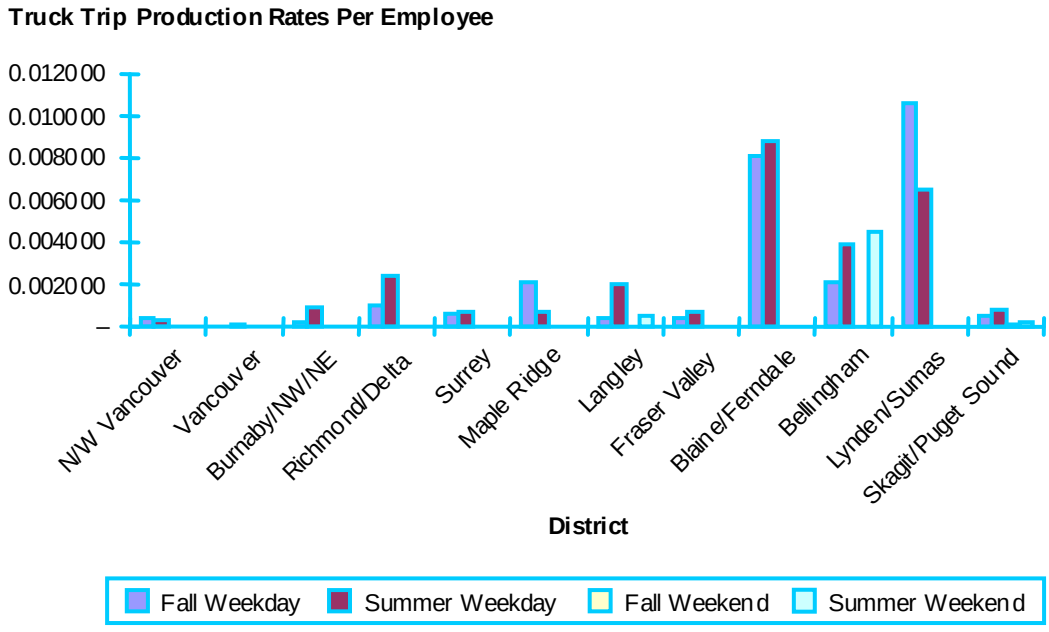
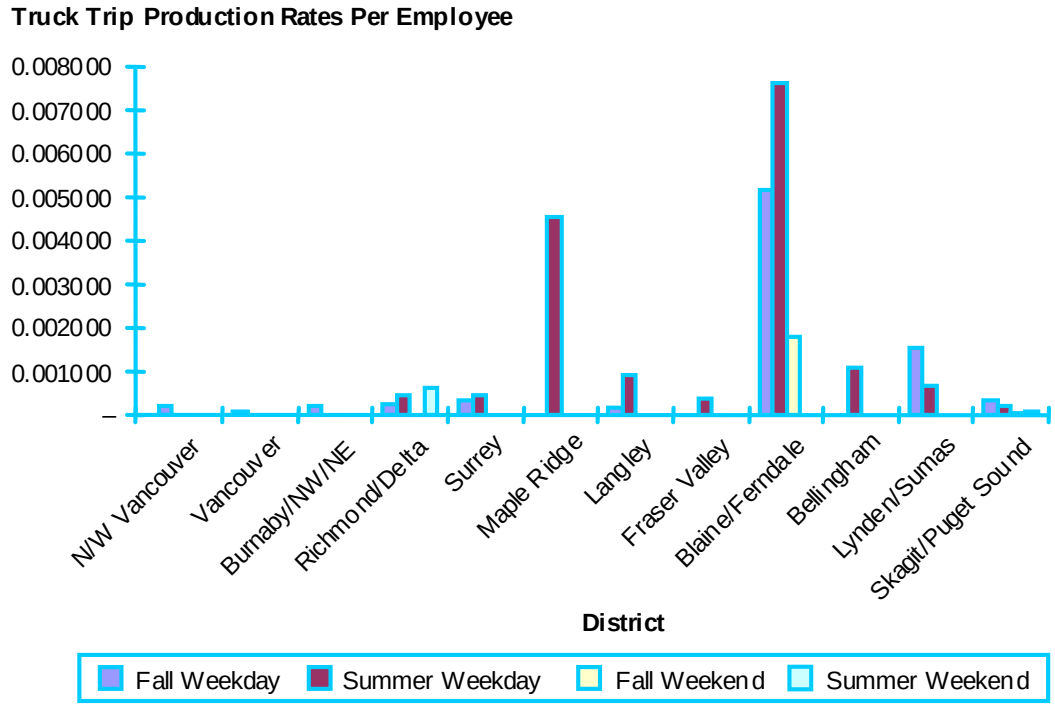


Figure 5.10 Freight Trip Generation for Bulk-Printed-Other Commodities by Day of Week and Season



5.3 FREIGHT TRIP DISTRIBUTION

Origin Choice Models

In order to compute the relative shares of truck trips by commodity originating from each TAZ, choice models were specified in a multinomial logit (MNL) framework. All TAZs that had truck origins in the survey database formed the choice set, that is, each origin TAZ is treated as an alternative. For estimation purposes, owing to lack of variation among adjacent districts, the 13 districts were aggregated to seven districts – four in GVRD and one each in Whatcom, Skagit and Puget Sound region. The alternative specific constants were estimated with respect to the Puget Sound district. As there were no observations in the Skagit County, the Puget Sound utility equation was used to compute Skagit county share of trucks. Different origin choice models were estimated for different commodity groups.

The variables that were found to be significant in generating truck trip origins are as follows:

- **Retail employment –** The number of retail jobs was found to be significant, influencing the origins of truck trips carrying food and wood as well as empty trucks.

- **Manufacturing employment –** As expected this variable was very significant in the generation of truck trips pertaining to the manufacturing and wood industry. This was also strong in the case of trucks that were empty and carrying 'other' commodity which comprises of bulk, printed matter and unknown commodities.
- **Manufacturing employment in Puget Sound –** This variable is specific to the manufacturing industry in the four-county Puget Sound. This is estimated separately from the previous variable to get a sense of the relative explanatory power of manufacturing jobs in this region when compared against the rest of the study area. This was included in only the manufacturing origin choice models.
- **Wholesale employment –** The wholesale jobs seem to significantly generate truck trips pertaining to manufacturing, food, and other industries. As a result it also drives up the amount of empty trucks, probably due to the return trips.
- **Construction employment –** This employment entered into wood, other, and empty truck origin choice models. Trucks carrying wood and other commodities that include lumber products and which are used in construction are obviously influenced by construction jobs.
- **Agriculture/Farming/Fishing employment –** As expected, this variable significantly influences trucks related to food and farming industry. This employment was also strong in other and empty truck origin choice models.
- **Population –** The population of a TAZ is a direct cause for truck trip generation of all types except farming and other commodity groups. The probable reason for this is that farm truck trips are directly proportional to farming and agriculture land rather than population.
- **Travel time from origin TAZ to border-crossing location –** This variable measures the impedance of truck flows across the border, and as expected, has a negative sign and is significant in all the truck origin choice models.

It was found that these variables were very consistent in terms of influencing truck trip generation across fall weekday and summer weekday. However, these origin choice models were not estimated for the weekends due to the lack of enough sample sizes by commodity type from the IMTC survey database. So it was safe to adopt the respective weekday models for the fall and summer weekends. The estimation results by commodity and season are presented in Tables 5.2 and 5.3.

Table 5.2 Freight Origin Choice Models – Fall (Weekday and Weekend)

	Manufacturing		Food		Wood		Empty		Farm		Other	
Variable	Estimate	T-stat	Estimate	T-stat	Estimate	T-stat	Estimate	T-stat	Estimate	T-stat	Estimate	T-stat
GVRD1 (< 40)	9.5769	6.42	-1.4449	-5.16	-0.1794	-0.54	-2.9727	-22.40	2.5382	3.54	-1.7360	-7.99
WCNT (201-233)	9.4007	6.32	2.1279	3.27	0.7192	2.17	0.7312	3.44	4.0978	3.90	2.2506	3.25
GVRD2 (40-102)	9.5831	6.45	3.5725	6.21	0.9214	3.09	-1.5356	-13.11	2.3579	3.45	0.3263	0.83
GVRD3 (25)	9.4713	6.24			-0.4216	-0.82	-3.2282	-11.34	1.9716	2.42	-2.0192	-5.45
GVRD4 (76)	10.2518	6.92			1.8783	5.62	-2.7452	-12.13	5.0563	4.89	3.3819	4.23
Retail employment			0.0011	8.67	0.0004	3.92	-0.0001	-0.44				
Manufacturing employment	0.0003	3.20			0.0003	5.52	0.0019	3.97			0.0044	4.38
Wholesale employment	0.0006	5.02	0.0011	2.24			0.0042	4.22			0.0005	0.54
Population	0.00076	8.78	0.000043	2.69	0.000138	7.06	0.000049	3.69				
Construction employment					0.0005	3.82	0.0007	5.39			0.0014	2.82
Agriculture/farm/fishing employment			0.0002	1.45			0.0049	10.88	0.0035	4.25	0.0010	1.44
Travel time from origin TAZ to border-crossing location	-0.0119	-2.52	-0.1114	-6.40	-0.0159	-2.65	-0.0431	-4.44	-0.0831	-3.91	-0.0366	-1.30
Manufacturing employment in the Puget Sound region	0.0027	8.69										
Model Statistics												
Final Likelihood	-2125.05		-228.03		-1104.15		-1255.81		-126.90		-1731.41	
Rho-Squared (0)	0.2687		0.5042		0.1483		0.4669		0.2389		0.2117	
Rho-Squared (c)	0.0926		0.4246		0.0095		0.2172		0.2027		0.0438	

Table 5.3 Freight Origin Choice Models – Summer (Weekday and Weekend)

	Manufacturing		Food		Wood		Empty		Farm		Other	
Variable	Estimate	T-stat	Estimate	T-stat	Estimate	T-stat	Estimate	T-stat	Estimate	T-stat	Estimate	T-stat
GVRD1 (< 40)	6.2513	8.37	-0.0057	-0.02	-0.0665	-0.35	-2.1128	-23.97	-0.5856	-0.80	3.3244	8.29
WCNT (201-233)	5.9277	7.91	3.9108	6.54	1.6608	5.84	-0.2684	-1.89				
GVRD2 (40-102)	6.7068	9.01	3.7149	7.10	0.7651	4.09	-0.6090	-5.70	1.6338	3.49	3.0516	7.75
GVRD3 (25)	5.9644	7.92			-0.3986	-1.55	-2.5409	-16.12				
GVRD4 (76)	7.7975	10.35			2.6687	11.17	1.1273	6.02	0.4116	0.73	3.5906	7.50
Retail employment			0.0005	5.54	0.0024	8.47	0.0008	12.88				
Manufacturing employment	0.0004	3.67			0.0022	12.80	0.0006	4.35			0.0018	1.78
Wholesale employment	0.0010	7.83	0.0026	4.19			0.0006	2.60			0.0033	4.04
Population	0.000070	11.32	0.000042	3.65	0.000088	5.37	0.000015	5.32				
Construction employment					0.0013	3.79	0.0008	11.32			0.0019	4.73
Agriculture/Farm/Fishing employment			0.0022	8.11			0.0024	12.33	0.0045	3.73	0.0017	5.23
Travel time from Origin TAZ to border-crossing location	-0.0279	-7.13	-0.0417	-5.92	-0.1049	-15.26	-0.0150	-4.29	-0.0348	-3.28	-0.0665	-11.04
Manufacturing employment in the Puget Sound region	0.0019	11.27										
Model Statistics												
Final Likelihood	-2375.79		-520.95		-1553.53		-2825.77		-109.88		-399.38	
Rho-Squared (0)	0.3468		0.2226		0.2975		0.4089		0.2065		0.4595	
Rho-Squared (c)	0.1905		0.1928		0.1773		0.1621		0.0762		0.3662	

Though the estimation was at the seven-district level, the computation of shares was at the 13-district level. The truck productions by commodity and TAZ computed by the production model was used as a control total to estimate truck trip origins based on the relative shares derived from the origin choice models. The estimated truck trip origins are then compared against the IMTC survey database for every commodity and season as a model validation criterion. These model validation results are presented in Chapter 7.

Destination Choice

Destination choice models perform the same general function that trip distribution models, such as the gravity model, do in the traditional four-step modeling process. The estimation of these models is very similar to origin choice models where all destination TAZs form the choice set and are specified as alternatives. Since this is based on a border-crossing choice sample, the intra-country utilities such as Canada-to-Canada and U.S.-to-U.S. are zeroed out, and the utilities are computed at the O-D level. Thus the destination choice shares are also the O-D level. Trip attractions by commodity and district from the attraction model are used here as control totals to estimate the O-D truck trip tables at the TAZ level. So the destination choice models determine not only the trip interchanges but also the total attractions for each zone.

The variables that were found to be significant in attracting truck trip destinations are as follows:

- **Retail employment –** The number of retail jobs was found to be significant in all of the six destination choice models, indicating the importance of retail industry in attracting truck flows.
- **Manufacturing employment –** As expected this variable was very significant in the generation of truck trips pertaining to the manufacturing industry. This was also strong in the case of truck movements that were empty.
- **Manufacturing employment in Puget Sound –** This variable is specific to the manufacturing industry in the four-county Puget Sound. Just like in the origin choice models, this is estimated separately from the rest of the manufacturing jobs, and was included in only the manufacturing destination choice models.
- **Wholesale employment –** The wholesale jobs, like the retail industry, seem to be significantly attracting all kinds of truck trips pertaining to every industry.
- **Construction employment –** This employment entered into wood and empty truck destination choice models. Trucks carrying wood are generally used for construction purposes and hence are obviously influenced by construction jobs.

- **Agriculture/Farming/Fishing employment –** This variable was found to be significant only for empty trucks because TAZs with agriculture and farming land usually tend to produce, and not attract, trucks carrying food and farm products.
- **Service employment –** The presence of service jobs, which include finance, insurance, and real estate, attracts the food industry and hence truck flows carrying food are affected positively by service employment.
- **Population –** The population of a TAZ is a direct cause for truck trip production and attraction of all types.
- **Travel time from origin TAZ to destination TAZ –** This variable measures the impedance of truck flows crossing the border, and as expected, has a negative sign and is significant in all the truck destination choice models.

Similar to origin choice models, it was found that these variables were also consistent in influencing truck trip attractions for fall weekday and summer weekday. So it was safe to adopt the respective weekday models for the fall and summer weekends. The estimation results by commodity and season are presented in Tables 5.4 and 5.5.

Though the estimation was at the seven-district level, the computation of shares was at the 13-district level. The truck attractions by commodity and TAZ computed by the attraction model was used as a control total to estimate truck trip O-D tables based on the relative shares derived from the destination choice models. The total truck trips are then compared against the IMTC survey database for every commodity and season as a model validation criterion. The district-to-district (13x13) truck trip flows are also extracted from the model and compared against the expanded truck flows from the survey. These model validation results are presented in Chapter 7.

5.4 TIME OF DAY

In order to better represent the temporal characteristics of freight flows across the U.S./Canada border, the time at which the truck was intercepted at the border-crossing location was also collected as part of the IMTC truck survey. This survey time served as a way to develop peaking factors or time-of-day factors that were used to split the daily truck trip tables into three time periods: a.m. peak (8 a.m. to 11 a.m.), p.m. peak (2 p.m. to 5 p.m.) and off-peak (remainder hours). These factors were derived from the expanded truck trip database for each of the four seasons as shown in Table 5.6.

Table 5.4 Freight Destination Choice Models – Fall (Weekday and Weekend)

	Manufacturing		Food		Wood		Empty		Farm		Other	
Variable	Estimate	T-stat	Estimate	T-stat	Estimate	T-stat	Estimate	T-stat	Estimate	T-stat	Estimate	T-stat
GVRD1 (< 40)	-0.9494	-3.97	-0.5433	-1.55	-2.3988	-9.49	-0.1158	-0.59	-1.2191	-2.39	1.0217	3.82
WCNT (201-233)	-0.8033	-6.80	-0.1347	-0.32	-0.8489	-5.23	0.6253	2.41	-0.2846	-0.99	3.1899	7.64
GVRD2 (40-102)	-1.4771	-6.37	-0.2921	-0.76	-2.6219	-10.42	0.7617	3.81	-1.1253	-1.99	2.2289	6.25
GVRD3 (25)	-0.4002	-2.47	-0.4078	-0.74	-3.3838	-4.42	-0.8857	-4.12				
GVRD4 (76)	-0.5246	-2.94	0.8175	1.70	-4.4874	-4.45	2.9427	10.14				
Retail employment	0.4565	1.47	0.0002	2.73	0.0003	2.90	0.0003	2.55	0.0006	1.67	0.0003	4.68
Manufacturing employment	1.8929	5.80					0.0008	4.43				
Wholesale employment	3.9253	12.44	0.0005	2.00	0.0004	0.68	0.0017	5.76	0.0061	1.88	0.0028	7.19
Population			0.000012	3.29	0.000006	1.81	0.000043	3.84	0.000012	1.73	0.000020	3.49
Construction employment					0.0021	3.26	0.0007	6.16				
Agriculture/Farming/ Fishing employment							0.0006	4.68				
Travel time of trip from origin TAZ to destination TAZ	-0.0069	-2.97	-0.0078	-2.64	-0.0375	-6.15	-0.0078	-4.53	-0.0208	-2.31	-0.0171	-7.16
Manufacturing employment in Puget Sound region	4.5107	15.25										
Services Employment			0.0003	3.10								
Model Statistics												
Final Likelihood	-2067.13		-374.86		-519.65		-1803.52		-107.99		-472.05	
Rho-Squared (0)	0.2475		0.2245		0.2973		0.2064		0.2935		0.2237	
Rho-Squared (c)	0.0672		0.0790		0.0591		0.0048		0.1596		0.1136	

Table 5.5 Freight Destination Choice Models – Summer (Weekday and Weekend)

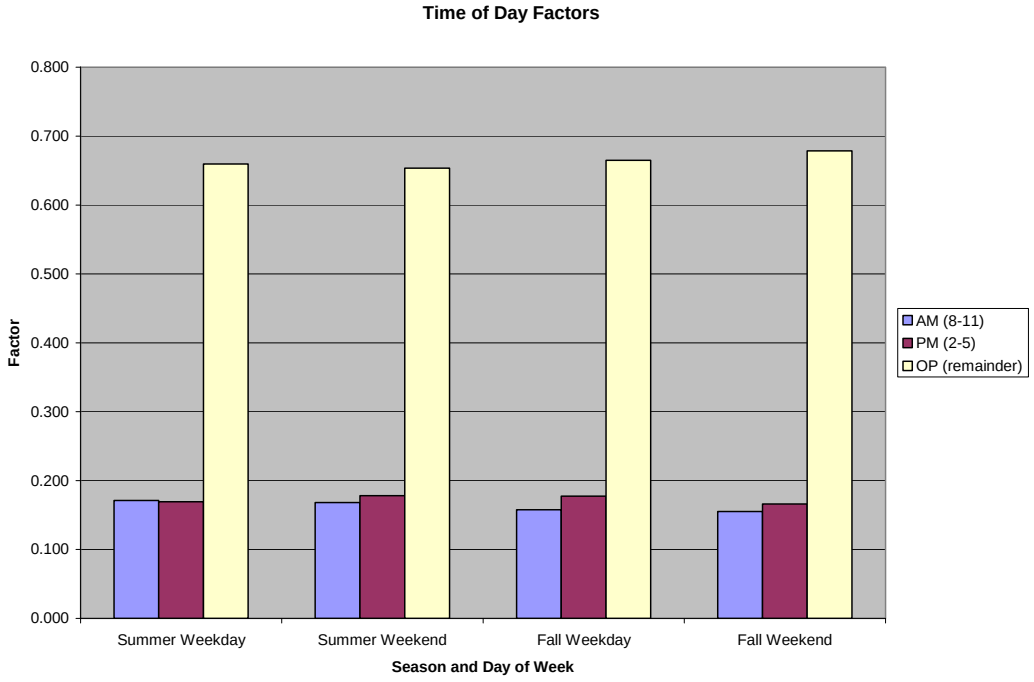
	Manufacturing		Food		Wood		Empty		Farm		Other	
Variable	Estimate	T-stat	Estimate	T-stat	Estimate	T-stat	Estimate	T-stat	Estimate	T-stat	Estimate	T-stat
GVRD1 (< 40)	-1.0511	-8.70	1.7928	5.27	-0.5578	-2.67	6.4464	8.31	-0.0545	-0.14	2.4179	7.90
WCNT (201-233)	0.6010	4.29	3.1739	6.22	0.7391	4.12	7.0387	9.01	-0.3789	-1.43	4.1462	9.80
GVRD2 (40-102)	-0.8355	-7.22	5.9929	10.02	-1.1539	-6.75	6.9388	8.96	-0.3947	-0.76	2.6975	8.36
GVRD3 (25)	-0.0002	0.00					5.3671	6.72				
GVRD4 (76)			4.3842	5.59			7.4631	9.40				
Retail employment			0.0017	5.12	0.0005	4.48	0.0000	1.72	0.0001	1.95	0.0004	6.13
Manufacturing employment	0.0010	9.17					0.0009	20.77				
Wholesale employment	0.0009	6.77	0.0013	4.63	0.0027	8.36	0.0001	3.19	0.0015	1.68	0.0015	5.68
Population	0.000011	6.58	0.000019	5.59	0.000010	4.25	0.000029	8.74	0.000013	2.26	0.000021	3.80
Construction employment					0.0009	3.37	0.0002	7.34				
Agriculture/Farming/Fishing employment							0.0007	6.02				
Travel time of trip from origin TAZ to destination TAZ	-0.0049	-3.25	-0.0328	-6.68	-0.0190	-6.90	-0.0265	-3.51	-0.0090	-1.09	-0.0402	-12.54
Manufacturing employment in the Puget Sound region	0.0010	8.84										
Services Employment			0.0002	3.00								
Model Statistics												
Final Likelihood	-2161.92		-404.37		-1167.42		-3806.84		-192.70		-534.83	
Rho-Squared (0)	0.2125		0.3478		0.2178		0.1845		0.1962		0.3582	
Rho-Squared (c)	0.0525		0.1895		0.0410		0.0740		0.0540		0.2716	

Table 5.6 Truck Time-of-Day Factors by Season

Time-of-Day	Summer Weekday	Summer Weekend	Fall Weekday	Fall Weekend
AM (8AM-11AM)	0.171	0.168	0.158	0.155
PM (2PM-5PM)	0.169	0.178	0.177	0.166
OP (remainder)	0.660	0.654	0.665	0.679

These factors are derived only for the internal-internal trips (internal to the study area) while the external trips namely external-internal, internal-external and external-external are obtained by time period directly from the expanded survey, and added to the internal trips before trip assignment. The time-of-day factors are also graphically presented in Figure 5.11.

Figure 5.11 Truck Time-of-Day Factors by Season



5.5 BORDER CROSSING CHOICE

Out of the four border-crossing locations at the U.S./Canada border, truck traffic is allowed through only three of these locations: Pacific Highway, Lynden, and Sumas. The choice among these three locations is made by the decision-maker or truck driver based on a variety of reasons such as travel time or distance of the whole trip, waiting time and/or queue lengths at the border-crossing, hours of operation of location, daily trade flows across the border, location of paper work,

presence of customs broker, number of crossings across the border per day, etc. The probability of a trip maker choosing a border-crossing location can be expressed as a function of the utility of that location versus the aggregate utility of all available crossing locations. This can be best captured in a multinomial logit formulation.

The variables that were found to be significant in influencing the border-crossing choice are listed below:

- **Travel time of border-crossing trip –** This variable has a negative sign as expected because it measures the impedance of making a trip across the border through on of the three border-crossing ports.
- **Travel distance of border-crossing trip –** This variable was used as a proxy to travel time specific to crossing at Lynden and is found to be negative and significant.
- **Wait time at border-crossing location –** This variable was found to be negative and very significant in influencing a decision-maker's choice of border-crossing location. This time indicates the amount of average time the trip maker has to spend at the port of entry. This was derived from a survey of trip makers across the border by crossing location, direction, time of day and season and are reported in Tables 3.8 and 3.9 for southbound and northbound trips, respectively.
- **Trade flows –** The trade flow through the port per day in U.S. dollars is found to be positively and significantly influencing the border-crossing choice.

These models are estimated separately for each of the four seasons, and the estimation results are presented in Tables 5.7 through 5.10.

Table 5.7 Border-Crossing Choice Models – Fall Weekday

Variable	AM Peak		PM Peak		Off Peak	
	Estimate	T-stat	Estimate	T-stat	Estimate	T-stat
Lynden/Aldergrove	4.2225	-1.12	1.1079	-2.06	1.9556	-1.92
Sumas/Abbotsford	3.7441	-2.37	0.6618	-6.29	0.8559	-5.96
Travel time (minutes)	-0.0177	-0.79	-0.0392	-1.44	-0.0071	-0.26
Travel distance (miles)	-0.0301	-1.37	-0.0555	-2.04	-0.0216	-0.78
Wait Time (minutes)	-0.000030	-0.07	-0.001249	-3.20	-0.000508	-2.02
Daily Trade (USD)	0.00000129	2.81	0.00000050	1.42	0.00000069	3.17
Model Statistics						
Final Likelihood	-189.3511		-191.6871		-407.3881	
Rho-Squared (0)	0.2420		0.2504		0.4639	
Rho-Squared (c)	0.0649		0.0847		0.0484	

Table 5.8 Border-Crossing Choice Models – Fall Weekend

Variable	AM Peak		PM Peak		Off Peak	
	Estimate	T-stat	Estimate	T-stat	Estimate	T-stat
Lynden/Aldergrove	4.2225	-1.12	1.1079	-2.06	-1.9556	-1.92
Sumas/Abbotsford	-3.7441	-2.37	-0.6618	-6.29	-4.8559	-5.96
Travel time (minutes)	-0.0177	-0.79	-0.0392	-1.44	-0.0071	-0.26
Travel distance (miles)	-0.0301	-1.37	-0.0555	-2.04	-0.0216	-0.78
Wait Time (minutes)	-0.000030	-0.07	-0.001249	-3.20	-0.000508	-2.02
Daily Trade (USD)	0.00000129	2.81	0.00000050	1.42	0.00000069	3.17
Model Statistics						
Final Likelihood	-189.3511		-191.6871		-407.3881	
Rho-Squared (0)	0.2420		0.2504		0.4639	
Rho-Squared (c)	0.0649		0.0847		0.0484	

Table 5.9 Border-Crossing Choice Models – Summer Weekday

Variable	AM Peak		PM Peak		Off Peak	
	Estimate	T-stat	Estimate	T-stat	Estimate	T-stat
Lynden/Aldergrove	0.7126	-0.8	3.850	-1.4	4.3322	-7.7
Sumas/Abbotsford	1.4781	-2.1	4.497	-1.0	4.9291	-3.4
Travel time (minutes)	-0.001172	-2.5	-0.002491	-5.4	-0.001032	-4.8
Wait Time (minutes)	-0.01856	-3.6	-0.01895	-5.8	-0.00817	-4.4
Daily Trade (USD)	0.0000007564	2.3	0.000001731	3.9	0.000002013	6.2
Model Statistics						
Final Likelihood	-166.4239		-165.4178		-523.8275	
Rho-Squared (0)	0.3930		0.4387		0.4513	
Rho-Squared (c)	0.0885		0.2054		0.1037	

Table 5.10 Border-Crossing Choice Models – Summer Weekend

Variable	AM Peak		PM Peak		Off Peak	
	Estimate	T-stat	Estimate	T-stat	Estimate	T-stat
Pacific Highway			-0.194	-1.6	0.177	1.5
Lynden/Aldergrove	-6.0321	-3.3	5.003	-4.8	6.298	-6.0
Sumas/Abbotsford	5.1802	-0.5				
Travel time (minutes)	-0.002375	-4.9	-0.000814	-2.2	-0.000939	-4.3
Travel distance (miles)	-0.03991	-5.7	-0.03882	-5.7	-0.01229	-3.1
Wait Time (minutes)	-0.005091	-1.2	-0.00591	-1.4	-0.002852	-1.1
Daily Trade (USD)	0.000001912	3.6	0.000001417	3.5	0.000002056	6.2
Model Statistics						
Final Likelihood	-157.0959		-168.2931		-518.8143	
Rho-Squared (0)	0.4669		0.4289		0.4565	
Rho-Squared (c)	0.2454		0.1916		0.1123	

6.0 Trip Assignment

Route assignment is the final stage of the Cascade Gateway model. Border-crossing trip matrices by time of day, direction, and port-of-entry, which are generated in the border choice model, are assigned to the road network to determine the actual route taken by cross-border trips. This section describes trip assignment procedures and possible directions for integrating the Cascade Gateway travel demand model with future operations models.

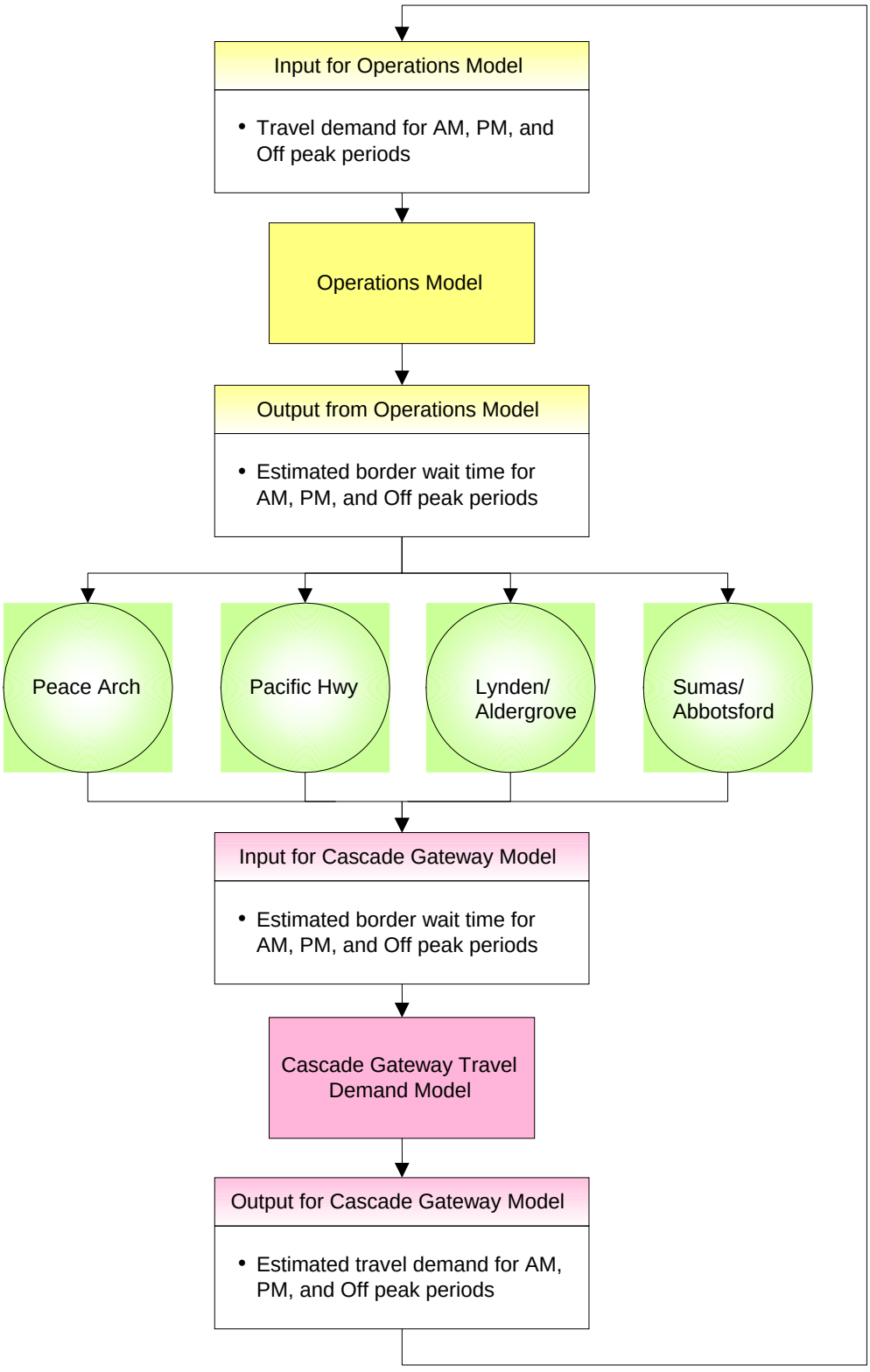
6.1 ROUTE CHOICE

EMME/2 provides several options for equilibrium assignment. The main inputs to this stage are the border-crossing trip matrices by port-of-entry and the road network. The simple form is the single-class assignment which involves a single auto matrix. In the Cascade Gateway model, multi-class assignment was used for both the passenger car and truck models. The concept of route assignment is that each port-of-entry is treated as a type of travel mode resulting in a total of four travel modes for passenger car models (Peace Arch, Pacific Highway, Lynden, and Sumas) and three travel modes for truck models (Pacific Highway, Lynden, and Sumas). Border-crossing trip matrices by port-of-entry are then assigned to the road network in sequence.

6.2 INTEGRATION WITH OPERATIONS MODEL

Estimated border wait times derived from an operations model will be provided as an input into the Cascade Gateway Travel Demand Model. Subsequently, new travel demand for each border crossing will be re-generated based upon the revised border wait time, and will be fed back into the operations model. This cycle will be replicated until equilibrium is achieved. Figure 6-1 illustrates the preliminary structure of the integration of the Cascade Gateway travel demand models with an operations model.

Figure 6-1 Integration with Operations Model



7.0 Model Validation

7.1 VALIDATION DATA

Passenger Model

A key element of the model development and calibration is to ensure that appropriate data sources are accessible. The following lists all the data that was used for the calibration and validation of the passenger car model:

- IMTC Origin-Destination Survey;
- INS Travel Time Data for Passenger Vehicle (southbound) for Year 2000 and 2001; and
- CCRA Pacific Border Wait Time Archives for Year 2002.

From the IMTC OD survey database, auto traffic counts were compiled for the four border crossings by direction, time period and season. Table 7.1 shows the traffic counts by port-of-entry, direction, day of week and time of day.

Freight Model

The purpose of the freight model validation is to compare the performance of the model components to the observed data available. The IMTC cross-border truck and trade survey and traffic counts were the only observed data available to validate the freight model components. The ensuing section includes a discussion of the 'fall-weekday' freight model validation results that were derived from trip generation, destination choice, border-crossing choice, and truck trip assignment model.

From the IMTC OD survey database, truck traffic counts were compiled for the four border crossings by direction, time period and season. Table 7.2 shows the traffic counts by port-of-entry, direction, day of week and time of day.

7.2 MODEL VALIDATION RESULTS

Passenger Model

Validation is the comparison of model results against observed data. Validation is essential to ensure that all sub-components operate properly. This section shows the model validation results for the four passenger models.

Table 7.1 Auto Traffic Counts by Day of Week, Direction, Time of Day, and Port-of-Entry (Summer and Fall)

			US/Canada Border Crossings				
Day of week	**Direction**	**Time of day**	**Peace Arch**	**Pac Hwy**	**Lynden/ Aldergrove**	**Sumas/ Abbotsford**	**Total**
Summer Weekend	**Northbound**	AM Peak	844	381	365	366	1,956
		PM Peak	1,539	1,244	632	813	4,228
		Off Peak	4,361	2,928	1,966	2,015	11,270
		Daily	6,744	4,553	2,963	3,194	17,454
	Southbound	AM Peak	1,407	1,009	603	592	3,611
		PM Peak	1,335	1,015	861	931	4,142
		Off Peak	4,875	3,480	1,889	2,047	12,291
		Daily	7,617	5,504	3,353	3,570	20,044
	Subtotal	**Daily**	**14,361**	**10,057**	**6,316**	**6,764**	**37,498**
Summer Weekday	**Northbound**	AM Peak	1,036	507	158	314	2,015
		PM Peak	1,308	821	447	591	3,167
		Off Peak	3,605	2,265	1,470	1,584	8,924
		Daily	5,949	3,593	2,075	2,489	14,106
	Southbound	AM Peak	1,375	810	504	566	3,255
		PM Peak	1,291	922	466	690	3,369
		Off Peak	4,055	2,613	1,382	1,529	9,579
		Daily	6,721	4,345	2,352	2,785	16,203
	Subtotal	**Daily**	**12,670**	**7,938**	**4,427**	**5,274**	**30,309**
Fall Weekend	**Northbound**	AM Peak	725	425	198	193	1,541
		PM Peak	1,243	847	519	567	3,176
		Off Peak	3,223	1,887	1,127	1,252	7,489
		Daily	5,191	3,159	1,844	2,012	12,206
	Southbound	AM Peak	1,069	666	293	314	2,342
		PM Peak	1,338	757	552	591	3,238
		Off Peak	3,799	1,988	1,185	1,347	8,319
		Daily	6,206	3,411	2,030	2,252	13,899
	Subtotal	**Daily**	**11,397**	**6,570**	**3,874**	**4,264**	**26,105**
Fall Weekday	**Northbound**	AM Peak	562	305	125	181	1,173
		PM Peak	977	506	322	382	2,187
		Off Peak	2,334	1,190	707	879	5,110
		Daily	3,873	2,001	1,154	1,442	8,470
	Southbound	AM Peak	1,033	726	183	250	2,192
		PM Peak	975	597	265	392	2,229
		Off Peak	2,640	1,465	688	1,023	5,816
		Daily	4,648	2,788	1,136	1,665	10,237
	Subtotal	**Daily**	**8,521**	**4,789**	**2,290**	**3,107**	**18,707**

Table 7.2 Truck Traffic Counts by Day of Week, Direction, Time of Day, and Port-of-Entry (Summer and Fall)

			US/Canada Border Crossings			
Day of week	**Direction**	**Time of day**	**Pac Hwy**	**Lynden/ Aldergrove (1)**	**Sumas/ Abbotsford**	**Total**
Summer Weekend	**Northbound**	AM Peak	119	13	11	143
		PM Peak	171	9	11	191
		Off Peak	550	32	37	619
		Daily	840	54	59	953
	Southbound	AM Peak	175	14	23	212
		PM Peak	150	9	26	185
		Off Peak	644	35	81	760
		Daily	969	58	130	1,157
	Subtotal	**Daily**	**1,809**	**112**	**189**	**2,110**
Summer Weekday	**Northbound**	AM Peak	235	29	43	307
		PM Peak	283	38	41	362
		Off Peak	1,076	109	123	1,308
		Daily	1,594	176	207	1,977
	Southbound	AM Peak	316	49	92	457
		PM Peak	263	38	92	393
		Off Peak	1,264	103	268	1,635
		Daily	1,843	190	452	2,485
	Subtotal	**Daily**	**3,437**	**366**	**659**	**4,462**
Fall Weekend	**Northbound**	AM Peak	88	13	11	112
		PM Peak	127	9	11	147
		Off Peak	489	32	37	558
		Daily	703	54	59	816
	Southbound	AM Peak	131	14	23	168
		PM Peak	118	9	26	153
		Off Peak	551	35	81	667
		Daily	801	58	130	989
	Subtotal	**Daily**	**1,504**	**112**	**189**	**1,805**
Fall Weekday	**Northbound**	AM Peak	196	35	36	267
		PM Peak	284	81	40	406
		Off Peak	1,037	144	95	1,276
		Daily	1,517	260	172	1,949
	Southbound	AM Peak	248	64	87	399
		PM Peak	237	69	94	400
		Off Peak	1,158	162	249	1,568
		Daily	1,642	295	430	2,367
	Subtotal	**Daily**	**3,159**	**555**	**602**	**4,316**

(1) Note that Fall Weekend truck counts were not available, so Summer Weekend counts were used.

Tables 7.3 to 7.6 summarize the observed and predicted trip origin and destination totals by trip purpose for the four models. Most of the percentage errors are less than 10 percent, except for a few cases in which the counts are relatively small. For example, an 18-percent error on a count of 28 passenger cars is less significant than an 18-percent error on a count of 2,800 passenger cars. The observed and predicted OD tables by trip purposes are presented in Appendix A. All four models produce a reasonable fit to the survey data (r-squared values ranged from 0.97 to 1.00 when compared to the observed subarea data). Tables 7.7 to 7.8 show the model results by day of week, direction, time of day and port-of-entry in absolute values and percentage errors. Most of the percentage errors shown in Table 7.8 are well below five percent and the daily cross-border trips match remarkably well with the observed data.

Table 7.3 Trip Origin and Distribution Total by Trip Purposes (Fall Weekday)

Fall Weekday - Work Trip

Origin

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	692	692	0%
Bur, NW, NE, MR	290	273	-6%
Surrey, Delta, Langley, Fraser V	1,341	1,364	2%
Point Roberts	174	168	-3%
Blaine,Ferndale	553	557	1%
Lynden, Sumas	687	700	2%
Bellingham	432	411	-5%
Skagit, PSRC	300	306	2%

Destination

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	437	433	-1%
Bur, NW, NE, MR	184	170	-7%
Surrey, Delta, Langley, Fraser V	1,307	1,328	2%
Point Roberts	44	41	-6%
Blaine,Ferndale	936	946	1%
Lynden, Sumas	466	459	-1%
Bellingham	525	511	-3%
Skagit, PSRC	570	582	2%

Fall Weekday - Recreation Trip

Origin

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	643	658	2%
Bur, NW, NE, MR	427	405	-5%
Surrey, Delta, Langley, Fraser V	2,993	3,002	0%
Point Roberts	51	49	-2%
Blaine,Ferndale	907	914	1%
Lynden, Sumas	1,162	1,164	0%
Bellingham	521	520	0%
Skagit, PSRC	495	488	-1%

Destination

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	639	631	-1%
Bur, NW, NE, MR	332	328	-1%
Surrey, Delta, Langley, Fraser V	2,090	2,103	1%
Point Roberts	24	24	-1%
Blaine,Ferndale	1,351	1,393	3%
Lynden, Sumas	1,230	1,217	-1%
Bellingham	850	845	-1%
Skagit, PSRC	682	658	-4%

Fall Weekday - Shopping Trip

Origin

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	282	274	-3%
Bur, NW, NE, MR	110	111	1%
Surrey, Delta, Langley, Fraser V	1,581	1,588	0%
Point Roberts	-	-	0%
Blaine,Ferndale	768	764	-1%
Lynden, Sumas	490	481	-2%
Bellingham	330	330	0%
Skagit, PSRC	173	185	7%

Destination

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	323	337	4%
Bur, NW, NE, MR	151	162	7%
Surrey, Delta, Langley, Fraser V	1,258	1,240	-1%
Point Roberts	28	23	-18%
Blaine,Ferndale	886	897	1%
Lynden, Sumas	286	298	4%
Bellingham	735	719	-2%
Skagit, PSRC	65	59	-9%

Fall Weekday - Vacation Trip

Origin

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	121	128	6%
Bur, NW, NE, MR	93	97	5%
Surrey, Delta, Langley, Fraser V	184	173	-6%
Point Roberts	-	-	0%
Blaine,Ferndale	69	57	-18%
Lynden, Sumas	199	214	7%
Bellingham	22	24	7%
Skagit, PSRC	300	296	-1%

Destination

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	228	213	-7%
Bur, NW, NE, MR	86	96	12%
Surrey, Delta, Langley, Fraser V	277	281	2%
Point Roberts	-	-	0%
Blaine,Ferndale	11	13	14%
Lynden, Sumas	92	98	7%
Bellingham	7	7	-5%
Skagit, PSRC	289	282	-2%

Table 7-4 Trip Origin and Distribution Total by Trip Purposes (Fall Weekend)

Fall Weekend - Work Trip

Origin

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	245	234	-4%
Bur, NW, NE, MR	55	59	9%
Surrey, Delta, Langley, Fraser V	331	337	2%
Point Roberts	10	10	-4%
Blaine,Ferndale	91	95	5%
Lynden, Sumas	79	78	-1%
Bellingham	130	129	-1%
Skagit, PSRC	222	220	-1%

Destination

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	137	136	0%
Bur, NW, NE, MR	24	28	16%
Surrey, Delta, Langley, Fraser V	360	357	-1%
Point Roberts	-	-	0%
Blaine,Ferndale	262	257	-2%
Lynden, Sumas	10	10	-4%
Bellingham	135	134	0%
Skagit, PSRC	234	239	2%

Fall Weekend - Recreation Trip

Origin

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	2,160	2,130	-1%
Bur, NW, NE, MR	1,000	1,066	7%
Surrey, Delta, Langley, Fraser V	3,691	3,657	-1%
Point Roberts	105	103	-2%
Blaine,Ferndale	1,411	1,408	0%
Lynden, Sumas	1,700	1,720	1%
Bellingham	826	803	-3%
Skagit, PSRC	2,642	2,648	0%

Destination

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	2,217	2,197	-1%
Bur, NW, NE, MR	732	778	6%
Surrey, Delta, Langley, Fraser V	3,597	3,573	-1%
Point Roberts	33	32	-4%
Blaine,Ferndale	1,055	1,014	-4%
Lynden, Sumas	1,914	1,930	1%
Bellingham	1,084	1,089	1%
Skagit, PSRC	2,904	2,921	1%

Fall Weekend - Shopping Trip

Origin

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	1,003	1,000	0%
Bur, NW, NE, MR	537	541	1%
Surrey, Delta, Langley, Fraser V	2,632	2,630	0%
Point Roberts	-	0	0%
Blaine,Ferndale	955	953	0%
Lynden, Sumas	515	513	0%
Bellingham	936	935	0%
Skagit, PSRC	312	317	2%

Destination

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	847	843	0%
Bur, NW, NE, MR	272	272	0%
Surrey, Delta, Langley, Fraser V	1,551	1,553	0%
Point Roberts	49	50	2%
Blaine,Ferndale	1,242	1,249	1%
Lynden, Sumas	564	572	1%
Bellingham	1,592	1,581	-1%
Skagit, PSRC	774	770	-1%

Fall Weekend - Vacation Trip

Origin

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	106	115	9%
Bur, NW, NE, MR	10	5	-54%
Surrey, Delta, Langley, Fraser V	185	180	-2%
Point Roberts	-	-	0%
Blaine,Ferndale	93	92	-1%
Lynden, Sumas	108	114	6%
Bellingham	25	25	1%
Skagit, PSRC	357	352	-1%

Destination

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	195	192	-1%
Bur, NW, NE, MR	84	92	9%
Surrey, Delta, Langley, Fraser V	304	300	-1%
Point Roberts	-	-	0%
Blaine,Ferndale	-	-	0%
Lynden, Sumas	20	26	29%
Bellingham	19	20	9%
Skagit, PSRC	262	254	-3%

Table 7-5 Trip Origin and Distribution Total by Trip Purposes (Summer Weekday)

Summer Weekday - Work Trip

Origin

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	705	710	1%
Bur, NW, NE, MR	287	288	0%
Surrey, Delta, Langley, Fraser V	1,116	1,111	0%
Point Roberts	119	117	-2%
Blaine,Ferndale	747	775	4%
Lynden, Sumas	694	692	0%
Bellingham	693	658	-5%
Skagit, PSRC	454	463	2%

Destination

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	766	768	0%
Bur, NW, NE, MR	252	243	-4%
Surrey, Delta, Langley, Fraser V	1,479	1,488	1%
Point Roberts	91	89	-2%
Blaine,Ferndale	657	669	2%
Lynden, Sumas	370	376	2%
Bellingham	528	505	-4%
Skagit, PSRC	671	677	1%

Summer Weekday - Recreation Trip

Origin

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	1,478	1,452	-2%
Bur, NW, NE, MR	731	754	3%
Surrey, Delta, Langley, Fraser V	4,401	4,407	0%
Point Roberts	48	47	-2%
Blaine,Ferndale	1,150	1,147	0%
Lynden, Sumas	1,660	1,682	1%
Bellingham	1,039	1,010	-3%
Skagit, PSRC	919	931	1%

Destination

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	1,128	1,151	2%
Bur, NW, NE, MR	472	462	-2%
Surrey, Delta, Langley, Fraser V	3,142	3,130	0%
Point Roberts	27	27	0%
Blaine,Ferndale	1,555	1,534	-1%
Lynden, Sumas	2,779	2,847	2%
Bellingham	953	917	-4%
Skagit, PSRC	1,372	1,363	-1%

Summer Weekday - Shopping Trip

Origin

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	461	474	3%
Bur, NW, NE, MR	283	284	0%
Surrey, Delta, Langley, Fraser V	1,353	1,339	-1%
Point Roberts	42	42	0%
Blaine,Ferndale	909	918	1%
Lynden, Sumas	532	536	1%
Bellingham	551	555	1%
Skagit, PSRC	277	260	-6%

Destination

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	503	506	1%
Bur, NW, NE, MR	196	179	-8%
Surrey, Delta, Langley, Fraser V	1,544	1,557	1%
Point Roberts	26	27	4%
Blaine,Ferndale	664	663	0%
Lynden, Sumas	403	414	3%
Bellingham	912	904	-1%
Skagit, PSRC	161	159	-1%

Summer Weekday - Vacation Trip

Origin

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	677	687	1%
Bur, NW, NE, MR	296	287	-3%
Surrey, Delta, Langley, Fraser V	661	661	0%
Point Roberts	-	-	0%
Blaine,Ferndale	89	89	0%
Lynden, Sumas	485	487	0%
Bellingham	117	121	4%
Skagit, PSRC	550	544	-1%

Destination

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	468	493	5%
Bur, NW, NE, MR	232	240	3%
Surrey, Delta, Langley, Fraser V	541	508	-6%
Point Roberts	-	-	0%
Blaine,Ferndale	207	226	9%
Lynden, Sumas	396	371	-6%
Bellingham	183	195	7%
Skagit, PSRC	848	842	-1%

Table 7-6 Trip Origin and Distribution Total by Trip Purposes (Summer Weekend)

Summer Weekend - Work Trip

Origin

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	227	232	2%
Bur, NW, NE, MR	90	96	6%
Surrey, Delta, Langley, Fraser V	301	289	-4%
Point Roberts	60	62	4%
Blaine,Ferndale	220	220	0%
Lynden, Sumas	80	79	0%
Bellingham	100	99	-2%
Skagit, PSRC	204	206	1%

Destination

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	181	181	0%
Bur, NW, NE, MR	42	39	-6%
Surrey, Delta, Langley, Fraser V	381	383	1%
Point Roberts	-	1	N/A
Blaine,Ferndale	138	142	3%
Lynden, Sumas	166	162	-3%
Bellingham	151	158	5%
Skagit, PSRC	224	217	-3%

Summer Weekend - Recreation Trip

Origin

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	3,201	3,200	0%
Bur, NW, NE, MR	1,722	1,695	-2%
Surrey, Delta, Langley, Fraser V	4,759	4,780	0%
Point Roberts	66	73	11%
Blaine,Ferndale	1,463	1,464	0%
Lynden, Sumas	3,073	3,076	0%
Bellingham	1,462	1,460	0%
Skagit, PSRC	2,312	2,313	0%

Destination

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	2,440	2,422	-1%
Bur, NW, NE, MR	1,010	995	-1%
Surrey, Delta, Langley, Fraser V	4,830	4,862	1%
Point Roberts	30	34	14%
Blaine,Ferndale	1,484	1,483	0%
Lynden, Sumas	2,664	2,673	0%
Bellingham	1,729	1,727	0%
Skagit, PSRC	3,871	3,865	0%

Summer Weekend - Shopping Trip

Origin

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	750	748	0%
Bur, NW, NE, MR	345	355	3%
Surrey, Delta, Langley, Fraser V	1,513	1,508	0%
Point Roberts	29	25	0%
Blaine,Ferndale	934	963	3%
Lynden, Sumas	355	334	-6%
Bellingham	844	848	0%
Skagit, PSRC	296	285	-4%

Destination

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	494	517	5%
Bur, NW, NE, MR	278	265	-5%
Surrey, Delta, Langley, Fraser V	1,645	1,634	-1%
Point Roberts	13	15	12%
Blaine,Ferndale	648	653	1%
Lynden, Sumas	340	355	4%
Bellingham	1,277	1,255	-2%
Skagit, PSRC	371	373	1%

Summer Weekend - Vacation Trip

Origin

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	613	617	1%
Bur, NW, NE, MR	192	193	0%
Surrey, Delta, Langley, Fraser V	335	331	-1%
Point Roberts	-	-	0%
Blaine,Ferndale	151	149	-1%
Lynden, Sumas	777	776	0%
Bellingham	226	225	0%
Skagit, PSRC	584	589	1%

Destination

Subarea	Observed	Estimated	% Diff
N/W Van, Van, Rich	589	580	-2%
Bur, NW, NE, MR	325	350	8%
Surrey, Delta, Langley, Fraser V	824	808	-2%
Point Roberts	-	-	0%
Blaine,Ferndale	17	20	18%
Lynden, Sumas	157	156	-1%
Bellingham	66	71	8%
Skagit, PSRC	900	893	-1%

Table 7-7 Model Results by Day of Week, Direction, Time of Day, and Port-of-Entry (Summer and Fall)

Day of week	direction	Time of day	US/Canada Border Crossings				Total
			Peace Arch	Pac Hwy	Lynden	Sumas	
Summer Weekend	Northbound	AM Peak	857	400	344	354	1,955
		PM Peak	1,546	1,236	632	800	4,213
		Off Peak	4,414	2,919	1,960	1,995	11,288
		Daily	6,817	4,555	2,936	3,149	17,456
	Southbound	AM Peak	1,394	1,011	611	588	3,604
		PM Peak	1,335	1,016	843	954	4,148
		Off Peak	4,876	3,510	1,886	2,019	12,291
		Daily	7,605	5,537	3,340	3,561	20,043
Summer Weekday	Northbound	AM Peak	1,036	500	172	310	2,018
		PM Peak	1,312	830	451	583	3,177
		Off Peak	3,611	2,289	1,476	1,537	8,913
		Daily	5,959	3,619	2,099	2,430	14,107
	Southbound	AM Peak	1,347	808	512	613	3,280
		PM Peak	1,289	906	479	743	3,416
		Off Peak	3,940	2,594	1,382	1,591	9,507
		Daily	6,576	4,308	2,373	2,947	16,203

Day of week	direction	Time of day	US/Canada Border Crossings				Total
			Peace Arch	Pac Hwy	Lynden	Sumas	
Fall Weekend	Northbound	AM Peak	726	432	197	192	1,547
		PM Peak	1,249	843	531	561	3,185
		Off Peak	3,240	1,856	1,136	1,245	7,477
		Daily	5,216	3,131	1,865	1,998	12,209
	Southbound	AM Peak	1,070	668	290	302	2,330
		PM Peak	1,364	761	569	593	3,287
		Off Peak	3,790	1,970	1,159	1,360	8,279
		Daily	6,225	3,398	2,019	2,255	13,897
Fall Weekday	Northbound	AM Peak	569	304	122	177	1,172
		PM Peak	980	513	320	373	2,186
		Off Peak	2,330	1,200	713	869	5,112
		Daily	3,879	2,017	1,155	1,419	8,470
	Southbound	AM Peak	1,013	720	201	250	2,184
		PM Peak	963	584	266	417	2,230
		Off Peak	2,594	1,443	705	1,083	5,825
		Daily	4,570	2,747	1,172	1,750	10,239

Table 7-8 Percentage Errors of Model Results by Day of Week, Direction, Time of Day, and Port-of-Entry (Summer and Fall)

Day of week	direction	Time of day	US/Canada Border Crossings				Total
			Peace Arch	Pac Hwy	Lynden	Sumas	
Summer Weekend	Northbound	AM Peak	1.6%	5.1%	-5.7%	-3.3%	0.0%
		PM Peak	0.4%	-0.6%	-0.1%	-1.6%	-0.3%
		Off Peak	1.2%	-0.3%	-0.3%	-1.0%	0.2%
		Daily	1.1%	0.0%	-0.9%	-1.4%	0.0%
	Southbound	AM Peak	-0.9%	0.2%	1.3%	-0.7%	-0.2%
		PM Peak	0.0%	0.1%	-2.1%	2.5%	0.1%
		Off Peak	0.0%	0.9%	-0.2%	-1.4%	0.0%
		Daily	-0.2%	0.6%	-0.4%	-0.3%	0.0%
Summer Weekday	Northbound	AM Peak	0.0%	-1.4%	8.9%	-1.3%	0.1%
		PM Peak	0.3%	1.1%	1.0%	-1.4%	0.3%
		Off Peak	0.2%	1.0%	0.4%	-2.9%	-0.1%
		Daily	0.2%	0.7%	1.2%	-2.4%	0.0%
	Southbound	AM Peak	-2.0%	-0.2%	1.6%	8.3%	0.8%
		PM Peak	-0.2%	-1.7%	2.7%	7.6%	1.4%
		Off Peak	-2.8%	-0.7%	0.0%	4.1%	-0.8%
		Daily	-2.2%	-0.9%	0.9%	5.8%	0.0%

Day of week	direction	Time of day	US/Canada Border Crossings				Total
			Peace Arch	Pac Hwy	Lynden	Sumas	
Fall Weekend	Northbound	AM Peak	0.2%	1.7%	-0.3%	-0.7%	0.4%
		PM Peak	0.5%	-0.4%	2.3%	-1.0%	0.3%
		Off Peak	0.5%	-1.7%	0.8%	-0.6%	-0.2%
		Daily	0.5%	-0.9%	1.1%	-0.7%	0.0%
	Southbound	AM Peak	0.1%	0.3%	-0.9%	-3.7%	-0.5%
		PM Peak	2.0%	0.5%	3.1%	0.3%	1.5%
		Off Peak	-0.2%	-0.9%	-2.2%	1.0%	-0.5%
		Daily	0.3%	-0.4%	-0.6%	0.1%	0.0%
Fall Weekday	Northbound	AM Peak	1.2%	-0.3%	-2.4%	-2.2%	-0.1%
		PM Peak	0.3%	1.4%	-0.6%	-2.4%	0.0%
		Off Peak	-0.2%	0.8%	0.8%	-1.1%	0.0%
		Daily	0.2%	0.8%	0.1%	-1.6%	0.0%
	Southbound	AM Peak	-1.9%	-0.8%	9.8%	0.0%	-0.4%
		PM Peak	-1.2%	-2.2%	0.4%	6.4%	0.0%
		Off Peak	-1.7%	-1.5%	2.5%	5.9%	0.2%
		Daily	-1.7%	-1.5%	3.2%	5.1%	0.0%

In general, the passenger model produces remarkably accurate estimates of cross-border travel over the system and reasonable comparisons with observed counts. With the use of the border choice model, the percentage of trips that use the four U.S./Canada border crossings can accurately be estimated.

Freight Model

The first two model components are trip production and attraction models that served as inputs to the origin choice and destination choice models. In order to validate these models, the number of trucks from the survey by commodity groups, which serve as trip purposes here, are derived and compared against the freight model results. These are presented in Table 7.9 for the fall weekday freight model. This table also shows totals by commodity from origin choice and destination choice models.

The destination choice model, which is a trip distribution model, was validated at a more disaggregate level that is at the 13-district level. Table 7.10 shows the number of trucks attracted to each district by commodity group in the expanded survey and the freight model. Though the survey showed no trucks from and to Skagit County, which is not entirely true, the freight model was created to estimate truck trips for this county. All the model parameters like trip rates and model coefficients for the Puget Sound region were used for Skagit County.

Table 7.11 shows the border-crossing choice model summary for all the four seasons by crossing location and time of day. These results are only for the internal-internal trips and so are the other results presented until now. The externals are derived directly from the expanded survey database and added to the internal trips by crossing location and time of day just before trip assignment.

Table 7.12 shows the freight demand model results after trip assignment. This includes both internal and external trips, and is within +/- two percent of the observed data.

Table 7.9 Truck Trip Generation and Distribution Model

	Fall Weekday					Fall Weekend				
Commodity Type	Productions	Attractions	Origins	O-D Trip Table	IMTC Survey	Productions	Attractions	Origins	O-D Trip Table	IMTC Survey
Bulk-Printed-Unknown	242	224	242	224	242	27	27	27	27	27
Farm	118	118	118	118	118	–	–	–	–	–
Food	177	177	177	177	177	36	35	36	35	36
Wood	408	410	408	410	408	–	–	–	–	–
Manufacturing	882	883	882	883	882	285	286	285	286	286
Empty	775	774	775	774	773	51	51	51	51	52
Total	2,602	2,586	2,602	2,586	2,600	400	401	400	401	401

	Summer Weekday					Summer Weekend				
Commodity Type	Productions	Attractions	Origins	O-D Trip Table	IMTC Survey	Productions	Attractions	Origins	O-D Trip Table	IMTC Survey
Bulk-Printed-Unknown	260	260	260	260	260	66	66	66	66	65
Farm	77	77	77	77	77	24	24	24	24	28
Food	171	171	171	171	171	88	88	88	88	88
Wood	412	413	412	413	412	104	104	104	104	104
Manufacturing	834	833	834	833	833	194	194	194	194	194
Empty	1,211	1,213	1,211	1,213	1,209	226	226	226	226	226
Total	2,964	2,967	2,964	2,967	2,962	701	733	701	733	705

Table 7.10 Destination Choice Model

Fall Weekday	GVRD1	GVRD2	GVRD3	GVRD4	GVRD5	GVRD6	GVRD7	GVRD8	WCNT1	WCNT2	WCNT3	SKAG	Puget	Total
From IMTC Survey														
Bulk-Printed-Unknown	0.0	13.0	73.3	41.8	28.7	8.6	5.1	2.1	13.9	20.0	0.0	0.0	35.3	242
Farm	0.0	1.9	1.8	0.0	1.8	0.0	2.1	2.4	14.7	0.0	48.2	0.0	45.4	118
Food	0.0	25.7	17.3	26.5	10.2	12.0	12.0	11.4	0.0	1.6	36.4	0.0	24.0	177
Wood	6.5	0.0	30.8	16.9	2.1	0.0	6.5	20.8	103.2	92.6	32.9	0.0	95.5	408
Manufacturing	6.5	26.2	66.8	108.6	17.1	8.7	46.6	31.6	87.7	86.3	36.1	0.0	359.7	882
Empty	13.0	25.4	74.9	226.0	113.1	6.5	67.2	32.9	57.0	49.9	6.1	0.0	101.0	773
Total	26	92	265	420	173	36	140	101	277	250	160	0	661	2,600
Destination Choice Models														
Bulk-Printed-Unknown	0	13	73.3	41.7	28.7	8.6	5.1	2.1	14	2	0	1.1	34	224
Farm	0	1.9	1.8	0	1.8	0	2.1	2.4	14.8	0	48.2	6.3	39.1	118
Food	0	25.7	17.3	26.5	10.2	12	12	11.4	0	1.6	36.4	0.9	23	177
Wood	6.5	0	30.8	17	2.1	0	6.5	20.8	106	92.6	32.9	3	92.3	411
Manufacturing	6.5	26.3	66.8	109	17.1	8.7	46.6	31.6	88.8	86.3	36.1	12	347.9	883
Empty	13.1	25.4	74.9	226	113	6.5	67.2	32.8	58.2	49.9	6.1	3.4	97.6	774
Total	26	92	265	420	173	36	140	101	282	232	160	26	634	2,586

Table 7.10 Destination Choice Model (continued)

Summer Weekday	GVRD1	GVRD2	GVRD3	GVRD4	GVRD5	GVRD6	GVRD7	GVRD8	WCNT1	WCNT2	WCNT3	SKAG	Puget	Total
From IMTC Survey														
Bulk-Printed-Unknown	0.0	11.6	57.3	47.2	18.2	0.0	6.9	0.0	0.0	8.0	21.4	0.0	89.1	259.7
Farm	0.0	3.8	0.0	0.0	0.0	0.0	1.5	0.0	0.0	15.0	7.9	0.0	49.1	77.3
Food	0.0	40.3	0.0	28.3	5.2	0.0	3.8	5.2	14.7	2.6	0.0	0.0	70.6	170.8
Wood	7.1	1.5	1.5	20.8	23.4	0.0	0.0	13.4	68.3	58.5	55.4	0.0	161.8	411.6
Manufacturing	18.2	67.3	54.1	66.8	123.5	1.5	28.9	18.4	8.0	111.2	68.1	0.0	267.0	833.0
Empty	10.7	97.1	54.7	247.0	192.5	10.1	59.0	88.4	183.4	78.1	10.6	0.0	177.9	1,209.4
Total	36	221	167	410	363	12	100	125	274	273	164	0	816	2,962
Destination Choice Models														
Bulk-Printed-Unknown	0	11.6	57.2	47.2	18.2	0	6.9	0	0	8	21.4	2.8	86.4	259.7
Farm	0	3.8	0	0	0	0	1.4	0	0	15	7.9	6.8	42.3	77.2
Food	0	40.3	0	28.4	5.2	0	3.8	5.2	15.1	2.6	0	2.7	67.8	171.1
Wood	7.1	1.5	1.4	20.8	23.4	0	0	13.4	70.2	58.5	55.4	5.1	156.5	413.3
Manufacturing	18.2	67.3	54	66.8	123	1.4	28.9	18.4	8.1	111	68.1	8.7	258.5	833
Empty	10.7	97.1	54.7	247	192	10.1	59	88.4	187	78.1	10.6	5.9	172	1213
Total	36	222	167	410	362	12	100	125	281	273	163	32	784	2,967

Table 7.10 Destination Choice Model (continued)

Fall Weekend	GVRD1	GVRD2	GVRD3	GVRD4	GVRD5	GVRD6	GVRD7	GVRD8	WCNT1	WCNT2	WCNT3	SKAG	Puget	Total
From IMTC Survey														
Bulk-Printed-Unknown	0.0	0.0	27.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.3
Farm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Food	0.0	0.0	0.0	17.9	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	35.6
Wood	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Manufacturing	0.0	0.0	0.0	51.5	0.0	0.0	42.9	0.0	42.4	33.4	0.0	0.0	115.4	285.6
Empty	0.0	0.0	0.0	0.0	8.6	0.0	42.9	0.0	0.0	0.0	0.0	0.0	0.0	51.5
Total	0	0	27	69	17	0	86	0	42	33	0	0	124	400
Destination Choice Models														
Bulk-Printed-Unknown	0	0	27.3	0	0	0	0	0	0	0	0	0	0	27.3
Farm	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food	0	0	0	17.9	8.6	0	0	0	0	0	0	0.3	8.6	35.4
Wood	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacturing	0	0	0	51.5	0	0	42.9	0	42.9	33.4	0	3.8	111.9	286.4
Empty	0	0	0	0	8.6	0	42.9	0	0	0	0	0	0	51.5
Total	0	0	27	69	17	0	86	0	43	33	0	4	121	401

Table 7.10 Destination Choice Model (continued)

Summer Weekend	GVRD1	GVRD2	GVRD3	GVRD4	GVRD5	GVRD6	GVRD7	GVRD8	WCNT1	WCNT2	WCNT3	SKAG	Puget	Total
From IMTC Survey														
Bulk-Printed-Unknown	0.0	0.0	27.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.88	65.4
Farm	0	0	0	0	0	0.00	27.5	0	0	0	0	0	0	27.5
Food	0	0	0	0	0	0.00	12.2	0	0	0	0	0	75.76	88.0
Wood	0	0	0	0	0	0.00	0	11	0	0	55	0	37.88	103.9
Manufacturing	0	39.7	29.8	27.5	27.5	0.00	0	0	7.89	0	0	0	61.74	194.1
Empty	0	0	27.5	0	0	0.00	185	0	13.5	0	0	0	0	226.0
Total	0	40	85	28	28	0	225	11	21	0	55	0	213	705
Destination Choice Models														
Bulk-Printed-Unknown	0	0	27.5	0	0	0	0	0	0	0	0	1.2	36.9	65.6
Farm	0	0	0	0	0	0	27.5	0	0	0	0	0	0	27.5
Food	0	0	0	0	0	0	12.2	0	0	0	0	2.9	72.8	87.9
Wood	0	0	0	0	0	0	0	11	0	0	55	1.2	36.9	104.1
Manufacturing	0	39.8	29.8	27.5	27.5	0	0	0	8	0	0	2	59.9	194.5
Empty	0	0	27.5	0	0	0	185	0	13.7	0	0	0	0	226.2
Total	0	40	85	28	28	0	225	11	22	0	55	7	207	706

Table 7.11 Border-Crossing Choice Model Summary

Fall Weekday	PacHwy	Lynden/ Aldergrove	Sumas/ Aldergrove	Total
IMTC Survey				
AM	262	92	63	417
PM	297	113	51	461
OP	1,285	252	191	1,729
Total	1,844	458	305	2,607
Border-Crossing Model				
AM	254	85	59	398
PM	324	110	49	484
OP	1,265	250	189	1,704
Total	1,844	445	297	2,586

Fall Weekend	PacHwy	Lynden/ Aldergrove	Sumas/ Aldergrove	Total
IMTC Survey				
AM	43	0	0	43
PM	61	0	0	61
OP	296	0	0	296
Total	400	0	0	400
Border-Crossing Model				
AM	42	1	0	43
PM	57	2	2	61
OP	289	7	0	296
Total	388	10	3	401

Summer Weekday				
IMTC Survey				
AM	384	49	79	511
PM	390	44	102	535
OP	1,510	167	237	1,915
Total	2,284	260	418	2,962
Border-Crossing Model				
AM	382	47	84	513
PM	400	42	95	537
OP	1,534	156	230	1,920
Total	2,316	245	409	2,970

Summer Weekend				
IMTC Survey				
AM	97	0	11	108
PM	40	55	0	95
OP	317	185	0	502
Total	454	240	11	705
Border-Crossing Model				
AM	105	0	3	108
PM	42	53	0	95
OP	325	178	0	502
Total	472	230	3	706

Table 7.12 Freight Demand Model Summary

Fall Weekday	PacHwy	Lynden/ Aldergrove	Sumas/ Aldergrove	Total	Fall Weekend	PacHwy	Lynden/ Aldergrove	Sumas/ Aldergrove	Total
IMTC Survey					IMTC Survey				
AM	443	99	124	666	AM	280	0	0	280
PM	521	150	135	805	PM	300	0	0	300
OP	2,195	306	344	2,844	OP	1,225	0	0	1,225
Total	3,159	555	602	4,316	Total	1,805	0	0	1,805
Border-Crossing Model					Border-Crossing Model				
AM	432	90	125	647	AM	278	1	0	279
PM	544	143	132	819	PM	295	2	2	299
OP	2,155	296	339	2,789	OP	1,213	7	0	1,220
Total	3,131	530	595	4,256	Total	1,786	10	3	1,799
Summer Weekday					Summer Weekend				
AM	551	78	135	764	AM	294	27	34	355
PM	546	76	133	755	PM	321	55		376
OP	2,340	212	391	2,943	OP	1,194	185		1,379
Total	3,437	366	659	4,462	Total	1,809	267	34	2,110
Border-Crossing Model					Border-Crossing Model				
AM	533	74	138	745	AM	325	27	23	375
PM	549	73	113	735	PM	298	50	0	348
OP	2,336	181	354	2,871	OP	1,198	162	0	1,360
Total	3,418	328	606	4,352	Total	1,822	239	23	2,084

8.0 Model Application

8.1 PERFORMANCE MEASURES

In order to determine the relative effectiveness of different strategies and projects in improving system performance, five key performance attributes of the truck-freight system are identified that focus on regional planning goals and objectives:

1. Delay;
2. Reliability;
3. Emissions; and
4. Safety.

Delay and reliability are measured by EMME/2 whereas the other two attributes are post processed in spreadsheets based on lookup tables from FHWA research on benefit-cost analysis[2]. It is to be noted that the significance of all these performance measures is well justified when comparing two or more alternatives. The results from all the four travel demand forecasting models are presented in this section.

Delay

Delay is measured by the difference between congested vehicle hours and free-flow vehicle hours on a systemwide basis. Vehicle hours are computed as the product between the number of vehicular volume and the travel time. Table 8.1 shows the systemwide delay by season and time period. It is assumed that there is no congestion during the off-peak period, and hence the congested times are the same as the free flow times for this period. However, there is a significant delay that is caused due to the waiting times at the border-crossing locations for all time periods.

Autos and trucks are summarized as the percentage contribution to delay they have for each season and time period in Table 8.1. The highest overall delay hours is in the summer weekday and this is approximately five times as high as the delay on a fall weekday. The highest delay for trucks is on a summer weekday, but fall weekdays are almost as high delay for trucks.

[2] This research is found in software developed for FHWA in the Surface Transportation Efficiency Analysis Model (STEAM) and the ITS Deployment Analysis System (IDAS).

Table 8.1 Systemwide Delay by Season Time Period

	AM	PM	OP	Daily	Percent Autos	Percent Trucks
Fall Weekday						
Congested Travel Time (vehicle Hours)	6,605	8,974	19,980	35,560	70%	30%
Free Flow Travel Time (Vehicle Hours)	5,578	6,991	18,708	31,277	71%	29%
Delay (Vehicle Hours)	1,028	1,984	1,272	4,284	67%	33%
Fall Weekend						
Congested Travel Time (vehicle Hours)	8,176	13,483	30,466	52,125	90%	10%
Free Flow Travel Time (Vehicle Hours)	6,640	9,664	26,886	43,191	90%	10%
Delay (Vehicle Hours)	1,535	3,819	3,579	8,935	91%	9%
Summer Weekday						
Congested Travel Time (vehicle Hours)	11,251	15,259	36,133	62,643	84%	16%
Free Flow Travel Time (Vehicle Hours)	8,892	10,959	31,656	51,508	84%	16%
Delay (Vehicle Hours)	2,359	4,299	4,477	11,136	85%	15%
Summer Weekend						
Congested Travel Time (vehicle Hours)	13,705	23,506	53,535	90,747	94%	6%
Free Flow Travel Time (Vehicle Hours)	10,456	15,257	42,109	67,822	93%	7%
Delay (Vehicle Hours)	3,250	8,249	11,426	22,925	97%	3%

Reliability

The reliability performance measure identified was the freeway vehicle hours by time period. This measure would indicate that, as delay on the freeway increases, the overall reliability of the system would tend to decrease. Table 8.2 presents the freeway vehicle hours by season and time period.

Table 8.2 shows similar delay characteristics to the overall delay, where summer weekends have the highest overall delay and the highest truck delay is on summer weekdays.

Table 8.2 Freeway Delay by Season and Time Period

	AM	PM	OP	Daily	Percent Autos	Percent Trucks
Fall Weekday						
Congested Travel Time (vehicle Hours)	5,737	7,746	17,292	30,777	69%	31%
Free Flow Travel Time (Vehicle Hours)	4,800	5,909	16,020	26,729	69%	31%
Delay (Vehicle Hours)	938	1,837	1,272	4,047	66%	34%
Fall Weekend						
Congested Travel Time (vehicle Hours)	7,318	11,940	27,210	46,468	90%	10%
Free Flow Travel Time (Vehicle Hours)	5,880	8,313	23,630	37,825	90%	10%
Delay (Vehicle Hours)	1,438	3,626	3,579	8,644	90%	10%
Summer Weekday						
Congested Travel Time (vehicle Hours)	9,922	13,492	31,857	55,271	84%	16%
Free Flow Travel Time (Vehicle Hours)	7,715	9,380	27,380	44,475	84%	16%
Delay (Vehicle Hours)	2,206	4,112	4,477	10,796	85%	15%
Summer Weekend						
Congested Travel Time (vehicle Hours)	12,447	21,424	48,578	82,449	94%	6%
Free Flow Travel Time (Vehicle Hours)	9,331	13,457	37,151	59,940	93%	7%
Delay (Vehicle Hours)	3,116	7,966	11,426	22,509	97%	3%

Emissions

Table 8.3 presents emissions by type – reactive organic gas (ROG), carbon monoxide (CO) and nitrous oxide (NO_x) emissions. This performance measure depends upon the congested speeds and the rates are derived from MOBILE 6.

As all the cross-border trucks are considered to be heavy trucks, the NO_x emissions have the highest percentage contributions from trucks for all seasons and time periods. Because of the trucks, weekdays have higher NOx emissions than weekends. Since CO and ROG are more dominated by autos, these have higher emissions in the summer weekends, due to the higher volumes of autos.

Table 8.3 Emissions by Season and Time Period

	AM	PM	OP	Daily	Percent Autos	Percent Trucks
Fall Weekday						
ROG (tons)	0.1623	0.2024	0.5133	0.8781	57%	43%
CO (tons)	3.2899	4.0086	10.2934	17.5920	68%	32%
NO_x (tons)	1.8021	2.1681	7.1609	11.1312	13%	87%
Fall Weekend						
ROG (tons)	0.1838	0.2565	0.6965	1.1368	81%	19%
CO (tons)	4.0854	5.7022	15.7161	25.5039	87%	13%
NO_x (tons)	1.3438	1.5736	5.7036	8.6211	32%	68%
Summer Weekday						
ROG (tons)	0.2526	0.2988	0.8545	1.4059	72%	28%
CO (tons)	5.4079	6.4981	18.4462	30.3523	80%	20%
NO_x (tons)	2.1691	2.2619	8.8213	13.2523	23%	77%
Summer Weekend						
ROG (tons)	0.2833	0.4016	1.0565	1.7415	86%	14%
CO (tons)	6.3621	9.1438	24.3834	39.8894	91%	9%
NO_x (tons)	1.8482	2.1235	6.9682	10.9400	41%	59%

Safety

Safety measures the number of accidents by type – fatality, injury and property damage only (PDO) – per million vehicle miles traveled (VMT). Table 8.4 shows the number of accidents by season and time of day. This performance measure depends upon the volume-to-capacity ratio and generally increases as volume-to-capacity ratios increase. This table shows that summer weekends have the highest accident rates for all three types.

Table 8.4 Safety by Season and Time Period

	AM	PM	OP	Daily	Percent Autos	Percent Trucks
Fall Weekday						
Fatalities/Million VMT	0.0022	0.0028	0.0079	0.0128	71%	29%
Injuries/Million VMT	0.1672	0.2122	0.6407	1.0201	72%	28%
PDO/Million VMT	0.2233	0.2842	0.8573	1.3646	73%	27%
Fall Weekend						
Fatalities/Million VMT	0.0026	0.0038	0.0115	0.0181	89%	11%
Injuries/Million VMT	0.2001	0.3030	1.0341	1.5372	91%	9%
PDO/Million VMT	0.2655	0.4048	1.3780	2.0483	91%	9%
Summer Weekday						
Fatalities/Million VMT	0.0035	0.0044	0.0136	0.0216	83%	17%
Injuries/Million VMT	0.2744	0.3479	1.1931	1.8153	84%	16%
PDO/Million VMT	0.3658	0.4649	1.5923	2.4230	85%	15%
Summer Weekend						
Fatalities/Million VMT	0.0041	0.0061	0.0181	0.0283	92%	8%
Injuries/Million VMT	0.3191	0.4990	1.7044	2.5223	94%	6%
PDO/Million VMT	0.4233	0.6643	2.2653	3.3528	94%	6%

8.2 FORECASTS

In order to forecast future travel demand using the Cascade Gateway travel demand model, future year socioeconomic data and background travel times will need to be obtained from the four MPOs in the study area (GVRD, WCOG, SCOG, and PSRC). Appropriate changes to the network should also be made to reflect possible enhancements to the systemwide infrastructure and operations of highway facilities. The future year forecasts can then be estimated by applying the Cascade Gateway Model for the future year.

The Cascade Gateway travel forecasting model will primarily be used to provide an analytical basis for evaluating the benefits of transportation investments throughout the study area. These benefits can be summarized by the aforementioned performance measures. In addition, travel time comparisons across future baseline and alternative scenarios could be made to see the impact on mobility of vehicles on a set of specific key routes in the County.

Appendix A. Origin-Destination Tables for Passenger Trips

Table A.1 Fall Weekday Origin-Destination Tables for Passenger Trips – Southbound Work Trips

Fall Weekday - Work Trip (SB)

Observed

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	246	17	136	0	292	692
Bur, NW, NE, MR	90	76	72	0	52	290
Surrey, Delta, Langley, Fraser V	511	355	269	7	199	1341
Point Roberts	88	18	48	0	20	174
sum	936	466	525	7	563	2497

Modeled

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	252	25	128	2	285	692
Bur, NW, NE, MR	106	51	58	1	57	273
Surrey, Delta, Langley, Fraser V	522	352	288	4	197	1364
Point Roberts	66	31	36	0	36	168
sum	946	459	511	7	575	2497

Difference

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	6	8	-8	2	-7	0
Bur, NW, NE, MR	15	-25	-13	1	5	-17
Surrey, Delta, Langley, Fraser V	11	-2	19	-3	-2	23
Point Roberts	-23	12	-12	0	16	-6
sum	10	-7	-14	0	12	0

R-square 0.99

Table A.2 Fall Weekday Origin-Destination Tables for Passenger Trips – Northbound Work Trips

Fall Weekday - Work Trip (NB)

Observed

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta, Langley	Point Roberts	Sum
Blaine, Ferndale	116	79	351	7	553
Lynden, Sumas	58	41	581	7	687
Bellingham	121	39	242	30	432
Skagit	22	8	60	0	90
PSRC	120	17	73	0	210
sum	437	184	1307	44	1972

Modeled

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta, Langley	Point Roberts	Sum
Blaine, Ferndale	120	50	374	12	557
Lynden, Sumas	57	59	571	14	700
Bellingham	119	34	250	8	411
Skagit	20	8	55	2	86
PSRC	117	19	78	5	220
sum	433	170	1328	41	1973

Difference

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta, Langley	Point Roberts	Sum
Blaine, Ferndale	4	-29	23	5	4
Lynden, Sumas	-1	18	-11	7	12
Bellingham	-2	-5	8	-22	-21
Skagit	-2	1	-5	2	-4
PSRC	-3	2	5	5	10
sum	-4	-14	21	-3	1

R-square 0.99

Table A.3 Fall Weekday Origin-Destination Tables for Passenger Trips – Southbound Recreation Trips

Fall Weekday - Recreation Trip (SB)

Observed

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	172	89	144	20	219	643
Bur, NW, NE, MR	124	151	65	23	64	427
Surrey, Delta, Langley, Fraser V	1044	990	621	67	271	2993
Point Roberts	11	0	20	0	20	51
sum	1351	1230	850	109	573	4113

Modeled

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	209	89	126	15	219	658
Bur, NW, NE, MR	138	123	83	10	51	405
Surrey, Delta, Langley, Fraser V	1030	992	626	79	276	3002
Point Roberts	17	14	10	1	7	49
sum	1393	1217	845	105	553	4113

Difference

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	37	0	-18	-5	1	15
Bur, NW, NE, MR	14	-28	18	-13	-13	-22
Surrey, Delta, Langley, Fraser V	-14	1	5	12	5	9
Point Roberts	5	14	-10	1	-13	-1
sum	42	-13	-4	-4	-20	1

R-square 1.00

Table A.4 Fall Weekday Origin-Destination Tables for Passenger Trips – Northbound Recreation Trips

Fall Weekday - Recreation Trip (NB)

Observed

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	192	79	620	17	907
Lynden, Sumas	213	119	830	0	1162
Bellingham	134	61	325	0	521
Skagit	7	0	10	0	17
PSRC	93	73	304	7	478
sum	639	332	2090	24	3085

Modeled

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	187	103	618	5	914
Lynden, Sumas	237	124	794	9	1164
Bellingham	107	53	356	5	520
Skagit	3	2	11	0	17
PSRC	97	47	323	5	471
sum	631	328	2103	24	3086

Difference

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	-5	24	-1	-12	6
Lynden, Sumas	25	5	-36	9	2
Bellingham	-28	-9	30	5	-1
Skagit	-4	2	1	0	0
PSRC	3	-26	19	-2	-6
sum	-8	-4	13	0	1

R-square 0.99

Table A.5 Fall Weekday Origin-Destination Tables for Passenger Trips – Southbound Shopping Trips

Fall Weekday - Shopping Trip (SB)

Observed

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	45	0	223	7	7	282
Bur, NW, NE, MR	54	20	37	0	0	110
Surrey, Delta, Langley, Fraser V	788	266	476	51	0	1581
Point Roberts	0	0	0	0	0	0
sum	886	286	735	58	7	1973

Modeled

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	52	12	206	4	1	274
Bur, NW, NE, MR	54	20	37	0	0	111
Surrey, Delta, Langley, Fraser V	791	266	476	48	6	1588
Point Roberts	0	0	0	0	0	0
sum	897	298	719	53	6	1973

Difference

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	7	12	-17	-3	-7	-7
Bur, NW, NE, MR	0	0	0	0	0	1
Surrey, Delta, Langley, Fraser V	4	-1	1	-3	6	7
Point Roberts	0	0	0	0	0	0
sum	11	12	-16	-6	-1	0

R-square 1.00

Table A.6 Fall Weekday Origin-Destination Tables for Passenger Trips – Northbound Shopping Trips

Fall Weekday - Shopping Trip (NB)

Observed

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	121	98	541	8	768
Lynden, Sumas	8	11	471	0	490
Bellingham	85	42	183	20	330
Skagit	20	0	17	0	37
PSRC	90	0	46	0	136
sum	323	151	1258	28	1761

Modeled

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	123	99	534	8	764
Lynden, Sumas	9	18	453	1	481
Bellingham	91	42	183	14	330
Skagit	13	2	23	0	38
PSRC	101	0	45	0	147
sum	337	162	1240	23	1761

Difference

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	1	1	-6	0	-4
Lynden, Sumas	1	7	-18	1	-8
Bellingham	6	0	0	-6	0
Skagit	-6	2	6	0	2
PSRC	11	0	-1	0	11
sum	13	11	-19	-5	0

R-square 1.00

Table A.7 Fall Weekday Origin-Destination Tables for Passenger Trips – Southbound Vacation Trips

Fall Weekday - Vacation Trip (SB)

Observed

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	11	0	0	0	110	121
Bur, NW, NE, MR	0	27	7	0	59	93
Surrey, Delta, Langley, Fraser V	0	65	0	20	100	184
Point Roberts	0	0	0	0	0	0
sum	11	92	7	20	269	398

Modeled

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	8	6	3	5	106	128
Bur, NW, NE, MR	0	29	3	6	59	97
Surrey, Delta, Langley, Fraser V	4	62	1	9	97	173
Point Roberts	0	0	0	0	0	0
sum	13	98	7	20	262	399

Difference

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	-3	6	3	5	-3	7
Bur, NW, NE, MR	0	2	-4	6	0	4
Surrey, Delta, Langley, Fraser V	4	-2	1	-11	-3	-11
Point Roberts	0	0	0	0	0	0
sum	2	6	0	0	-7	1

R-square 0.99

Table A.8 Fall Weekday Origin-Destination Tables for Passenger Trips – Northbound Vacation Trips

Fall Weekday - Vacation Trip (NB)

Observed

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	37	8	25	0	69
Lynden, Sumas	56	36	108	0	199
Bellingham	15	0	7	0	22
Skagit	24	0	49	0	73
PSRC	96	42	88	0	226
sum	228	86	277	0	590

Modeled

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	32	8	16	0	57
Lynden, Sumas	57	37	120	0	214
Bellingham	13	4	7	0	24
Skagit	29	12	43	0	85
PSRC	82	34	95	0	211
sum	213	96	281	0	590

Difference

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	-4	0	-8	0	-13
Lynden, Sumas	1	1	12	0	15
Bellingham	-2	4	0	0	2
Skagit	5	12	-6	0	11
PSRC	-14	-8	7	0	-15
sum	-15	10	5	0	0

R-square 0.97

Table A.9 Fall Weekend Origin-Destination Tables for Passenger Trips – Southbound Work Trips

Fall Weekend - Work Trip (SB)

Observed

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	114	10	10	0	111	245
Bur, NW, NE, MR	0	0	0	0	55	55
Surrey, Delta, Langley, Fraser V	138	0	124	0	69	331
Point Roberts	10	0	0	0	0	10
sum	262	10	135	0	234	641

Modeled

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	107	4	17	0	107	234
Bur, NW, NE, MR	4	1	2	0	52	59
Surrey, Delta, Langley, Fraser V	142	5	114	0	76	337
Point Roberts	4	0	1	0	5	10
sum	257	10	134	0	239	641

Difference

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	-7	-7	7	0	-4	-11
Bur, NW, NE, MR	4	1	2	0	-2	5
Surrey, Delta, Langley, Fraser V	4	5	-10	0	7	6
Point Roberts	-7	0	1	0	5	0
sum	-5	0	0	0	5	0
					R-square	**0.99**

Table A.10 Fall Weekend Origin-Destination Tables for Passenger Trips – Northbound Work Trips

Fall Weekend - Work Trip (NB)

Observed

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	9	24	58	0	91
Lynden, Sumas	23	0	56	0	79
Bellingham	9	0	121	0	130
Skagit	0	0	24	0	24
PSRC	96	0	101	0	198
sum	137	24	360	0	521

Modeled

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	10	20	65	0	95
Lynden, Sumas	17	4	56	0	78
Bellingham	11	1	117	0	129
Skagit	3	2	16	0	22
PSRC	94	1	103	0	199
sum	136	28	357	0	522

Difference

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	2	-5	7	0	4
Lynden, Sumas	-5	4	0	0	-1
Bellingham	2	1	-4	0	-1
Skagit	3	2	-8	0	-3
PSRC	-3	1	2	0	1
sum	-1	4	-3	0	0

R-square **0.99**

Table A.11 Fall Weekend Origin-Destination Tables for Passenger Trips – Southbound Recreation Trips

Fall Weekend - Recreation Trip (SB)

Observed

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	169	339	288	123	1241	2160
Bur, NW, NE, MR	180	264	116	10	429	1000
Surrey, Delta, Langley, Fraser V	677	1301	641	168	904	3691
Point Roberts	28	10	38	28	0	105
sum	1055	1914	1084	329	2575	6955

Modeled

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	167	334	284	121	1224	2130
Bur, NW, NE, MR	156	284	157	45	423	1066
Surrey, Delta, Langley, Fraser V	675	1282	632	175	892	3657
Point Roberts	16	30	16	5	35	103
sum	1014	1930	1089	346	2575	6954

Difference

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	-2	-5	-4	-2	-17	-31
Bur, NW, NE, MR	-24	20	41	35	-6	65
Surrey, Delta, Langley, Fraser V	-2	-19	-9	8	-12	-34
Point Roberts	-12	20	-22	-23	35	-2
sum	-41	16	6	17	0	-1

R-square **1.00**

Table A.12 Fall Weekend Origin-Destination Tables for Passenger Trips – Northbound Recreation Trips

Fall Weekend - Recreation Trip (NB)

Observed

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	305	116	966	24	1411
Lynden, Sumas	236	352	1104	9	1700
Bellingham	265	60	502	0	826
Skagit	126	0	182	0	308
PSRC	1284	205	844	0	2333
sum	2217	732	3597	33	6579

Modeled

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	308	117	976	7	1408
Lynden, Sumas	240	358	1115	7	1720
Bellingham	250	77	472	4	803
Skagit	115	18	154	2	289
PSRC	1285	206	855	12	2359
sum	2197	778	3573	32	6579

Difference

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	3	2	10	-18	-3
Lynden, Sumas	4	7	11	-1	20
Bellingham	-16	18	-30	4	-24
Skagit	-11	18	-28	2	-19
PSRC	0	1	12	12	25
sum	-20	45	-25	-1	0

R-square **1.00**

Table A.13 Fall Weekend Origin-Destination Tables for Passenger Trips – Southbound Shopping Trips

Fall Weekend - Shopping Trip (SB)

Observed

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	197	10	471	20	304	1003
Bur, NW, NE, MR	149	0	225	10	153	537
Surrey, Delta, Langley, Fraser V	896	553	896	44	242	2632
Point Roberts	0	0	0	0	0	0
sum	1242	564	1592	75	699	4172

Modeled

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	198	14	469	15	305	1000
Bur, NW, NE, MR	156	4	223	7	152	541
Surrey, Delta, Langley, Fraser V	895	554	889	48	244	2630
Point Roberts	0	0	0	0	0	0
sum	1249	572	1581	70	700	4172

Difference

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	1	3	-3	-5	0	-3
Bur, NW, NE, MR	7	4	-2	-4	-1	5
Surrey, Delta, Langley, Fraser V	-1	1	-7	3	2	-2
Point Roberts	0	0	0	0	0	0
sum	7	8	-11	-5	1	0

R-square **1.00**

Table A.14 Fall Weekend Origin-Destination Tables for Passenger Trips – Northbound Shopping Trips

Fall Weekend - Shopping Trip (NB)

Observed

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	232	119	555	49	955
Lynden, Sumas	79	39	397	0	515
Bellingham	269	98	569	0	936
Skagit	58	4	0	0	62
PSRC	208	12	30	0	250
sum	847	272	1551	49	2718

Modeled

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	232	119	554	49	953
Lynden, Sumas	79	39	395	0	513
Bellingham	268	98	568	1	935
Skagit	58	3	2	0	63
PSRC	207	12	34	0	253
sum	843	272	1553	50	2718

Difference

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	0	0	-1	0	-1
Lynden, Sumas	0	0	-2	0	-2
Bellingham	-1	0	-1	1	-1
Skagit	0	0	2	0	1
PSRC	-1	0	4	0	3
sum	-3	0	2	1	0

R-square **1.00**

Table A.15 Fall Weekend Origin-Destination Tables for Passenger Trips – Southbound Vacation Trips

Fall Weekend - Vacation Trip (SB)

Observed

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	0	0	0	10	96	106
Bur, NW, NE, MR	0	10	0	0	0	10
Surrey, Delta, Langley, Fraser V	0	10	19	0	156	185
Point Roberts	0	0	0	0	0	0
sum	0	20	19	10	252	301

Modeled

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	0	7	9	9	90	115
Bur, NW, NE, MR	0	3	0	0	2	5
Surrey, Delta, Langley, Fraser V	0	16	11	2	151	180
Point Roberts	0	0	0	0	0	0
sum	0	26	20	11	243	300

Difference

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	0	7	9	-1	-6	9
Bur, NW, NE, MR	0	-7	0	0	2	-6
Surrey, Delta, Langley, Fraser V	0	6	-7	2	-5	-4
Point Roberts	0	0	0	0	0	0
sum	0	6	2	0	-9	-1

R-square **0.99**

Table A.16 Fall Weekend Origin-Destination Tables for Passenger Trips – Northbound Vacation Trips

Fall Weekend - Vacation Trip (NB)

Observed

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	0	69	24	0	93
Lynden, Sumas	0	12	96	0	108
Bellingham	22	4	0	0	25
Skagit	0	0	48	0	48
PSRC	173	0	136	0	309
sum	195	84	304	0	582

Modeled

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	4	61	28	0	92
Lynden, Sumas	5	18	92	0	114
Bellingham	20	2	3	0	25
Skagit	2	5	45	0	52
PSRC	162	5	132	0	300
sum	192	92	300	0	584

Difference

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	4	-8	3	0	-1
Lynden, Sumas	5	6	-4	0	6
Bellingham	-2	-1	3	0	0
Skagit	2	5	-3	0	5
PSRC	-11	5	-3	0	-9
sum	-2	7	-4	0	1

R-square **1.00**

Table A.17 Summer Weekday Origin-Destination Tables for Passenger Trips – Southbound Work Trips

Summer Weekday - Work Trip (SB)

Observed

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	142	38	225	31	268	705
Bur, NW, NE, MR	124	40	51	17	55	287
Surrey, Delta, Langley, Fraser V	367	271	205	54	218	1116
Point Roberts	25	20	47	13	13	119
sum	657	370	528	116	555	2227

Modeled

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	162	38	205	39	266	710
Bur, NW, NE, MR	103	50	64	16	55	288
Surrey, Delta, Langley, Fraser V	366	270	207	51	218	1111
Point Roberts	37	19	28	5	27	117
sum	669	376	505	111	566	2226

Difference

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	21	-1	-19	7	-3	6
Bur, NW, NE, MR	-20	10	12	-1	0	1
Surrey, Delta, Langley, Fraser V	-1	-1	2	-4	-1	-5
Point Roberts	12	-2	-19	-8	14	-2
sum	12	6	-24	-5	11	0
					R-square	**0.99**

Table A.18 Summer Weekday Origin-Destination Tables for Passenger Trips – Northbound Work Trips

Summer Weekday - Work Trip (NB)

Observed

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	269	54	399	26	747
Lynden, Sumas	155	88	452	0	694
Bellingham	152	79	410	52	693
Skagit	19	0	44	0	63
PSRC	171	32	176	13	391
sum	766	252	1479	91	2588

Modeled

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	263	70	416	27	775
Lynden, Sumas	154	63	451	23	692
Bellingham	152	62	420	24	658
Skagit	18	6	35	2	61
PSRC	183	42	165	12	402
sum	768	243	1488	89	2588

Difference

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	-6	16	17	2	28
Lynden, Sumas	-1	-24	0	23	-2
Bellingham	0	-17	11	-28	-35
Skagit	-2	6	-9	2	-2
PSRC	12	10	-10	0	11
sum	3	-9	8	-2	0
				R-square	**0.99**

Table A.19 Summer Weekday Origin-Destination Tables for Passenger Trips – Southbound Recreation Trips

Summer Weekday - Recreation Trip (SB)

Observed

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	208	318	261	35	656	1478
Bur, NW, NE, MR	149	279	107	13	183	731
Surrey, Delta, Langley, Fraser V	1163	2182	572	95	390	4401
Point Roberts	34	0	14	0	0	48
sum	1555	2779	953	143	1229	6659

Modeled

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	209	320	230	32	660	1452
Bur, NW, NE, MR	170	316	93	14	162	754
Surrey, Delta, Langley, Fraser V	1144	2193	586	91	393	4407
Point Roberts	11	18	7	1	10	47
sum	1534	2847	917	138	1224	6661

Difference

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	1	2	-30	-2	4	-26
Bur, NW, NE, MR	21	38	-14	0	-22	23
Surrey, Delta, Langley, Fraser V	-19	11	15	-4	3	6
Point Roberts	-23	18	-7	1	10	-1
sum	-20	68	-36	-5	-5	2

R-square **1.00**

Table A.20 Summer Weekday Origin-Destination Tables for Passenger Trips – Northbound Recreation Trips

Summer Weekday - Recreation Trip (NB)

Observed

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	209	110	825	7	1150
Lynden, Sumas	247	201	1212	0	1660
Bellingham	247	71	701	20	1039
Skagit	42	17	90	0	149
PSRC	383	74	313	0	770
sum	1128	472	3142	27	4769

Modeled

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	217	108	815	7	1147
Lynden, Sumas	267	198	1208	8	1682
Bellingham	244	69	690	6	1010
Skagit	37	13	95	1	145
PSRC	385	74	322	5	785
sum	1151	462	3130	27	4769

Difference

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	8	-1	-10	0	-3
Lynden, Sumas	20	-3	-4	8	22
Bellingham	-3	-2	-11	-14	-29
Skagit	-5	-4	4	1	-4
PSRC	2	0	8	5	15
sum	23	-10	-12	0	0

R-square **1.00**

Table A.21 Summer Weekday Origin-Destination Tables for Passenger Trips – Southbound Shopping Trips

Summer Weekday - Shopping Trip (SB)

Observed

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	101	18	267	0	75	461
Bur, NW, NE, MR	32	10	192	0	49	283
Surrey, Delta, Langley, Fraser V	503	375	439	17	19	1353
Point Roberts	28	0	14	0	0	42
sum	664	403	912	17	143	2139

Modeled

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	108	29	264	0	72	474
Bur, NW, NE, MR	31	14	192	0	48	284
Surrey, Delta, Langley, Fraser V	496	371	434	17	21	1339
Point Roberts	28	0	14	0	0	42
sum	663	414	904	18	141	2139

Difference

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	7	11	-3	0	-2	13
Bur, NW, NE, MR	-1	3	0	0	-1	1
Surrey, Delta, Langley, Fraser V	-7	-4	-5	0	1	-14
Point Roberts	0	0	0	0	0	0
sum	-1	11	-8	0	-2	0

R-square **1.00**

Table A.22 Summer Weekday Origin-Destination Tables for Passenger Trips – Northbound Shopping Trips

Summer Weekday - Shopping Trip (NB)

Observed

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	200	85	624	0	909
Lynden, Sumas	44	11	470	7	532
Bellingham	150	63	319	19	551
Skagit	14	0	18	0	31
PSRC	95	37	114	0	245
sum	503	196	1544	26	2268

Modeled

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	202	85	630	1	918
Lynden, Sumas	44	12	473	7	536
Bellingham	151	63	321	19	555
Skagit	14	0	19	0	33
PSRC	95	18	114	0	227
sum	506	179	1557	27	2269

Difference

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	2	1	5	1	9
Lynden, Sumas	0	1	3	0	4
Bellingham	1	0	3	0	4
Skagit	0	0	1	0	2
PSRC	0	-19	1	0	-18
sum	3	-17	13	1	1

R-square **1.00**

Table A.23 Summer Weekday Origin-Destination Tables for Passenger Trips – Southbound Vacation Trips

Summer Weekday - Vacation Trip (SB)

Observed

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	78	111	99	0	390	677
Bur, NW, NE, MR	62	95	25	6	107	296
Surrey, Delta, Langley, Fraser V	67	190	60	74	270	661
Point Roberts	0	0	0	0	0	0
sum	207	396	183	80	767	1634

Modeled

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	79	106	104	8	390	687
Bur, NW, NE, MR	70	82	19	6	109	287
Surrey, Delta, Langley, Fraser V	77	183	72	61	268	661
Point Roberts	0	0	0	0	0	0
sum	226	371	195	75	767	1634

Difference

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	1	-5	5	8	0	9
Bur, NW, NE, MR	8	-13	-5	0	1	-9
Surrey, Delta, Langley, Fraser V	10	-7	12	-13	-2	0
Point Roberts	0	0	0	0	0	0
sum	19	-25	12	-5	-1	0
					R-square	**1.00**

Table A.24 Summer Weekday Origin-Destination Tables for Passenger Trips – Northbound Vacation Trips

Summer Weekday - Vacation Trip (NB)

Observed

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	7	54	28	0	89
Lynden, Sumas	151	134	201	0	485
Bellingham	33	20	63	0	117
Skagit	19	0	24	0	43
PSRC	257	24	225	0	507
sum	468	232	541	0	1241

Modeled

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	31	38	19	0	89
Lynden, Sumas	150	135	201	0	487
Bellingham	44	28	49	0	121
Skagit	18	8	19	0	45
PSRC	249	31	219	0	499
sum	493	240	508	0	1241

Difference

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	25	-16	-8	0	0
Lynden, Sumas	-1	1	1	0	1
Bellingham	11	8	-14	0	4
Skagit	-1	8	-5	0	2
PSRC	-8	7	-7	0	-8
sum	25	8	-33	0	0

R-square **0.99**

Table A.25 Summer Weekend Origin-Destination Tables for Passenger Trips – Southbound Work Trips

Summer Weekend - Work Trip (SB)

Observed

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	36	30	45	0	117	227
Bur, NW, NE, MR	10	31	10	0	39	90
Surrey, Delta, Langley, Fraser V	83	84	66	7	60	301
Point Roberts	10	20	30	0	0	60
sum	138	166	151	7	216	679

Modeled

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	33	40	47	1	110	232
Bur, NW, NE, MR	14	26	18	1	37	96
Surrey, Delta, Langley, Fraser V	83	78	65	3	60	289
Point Roberts	12	18	28	1	3	62
sum	142	162	158	6	210	678

Difference

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	-3	10	2	1	-6	4
Bur, NW, NE, MR	4	-6	8	1	-3	5
Surrey, Delta, Langley, Fraser V	0	-7	-1	-4	0	-13
Point Roberts	2	-2	-2	1	3	2
sum	4	-4	7	-1	-6	-1

R-square **0.99**

Table A.26 Summer Weekend Origin-Destination Tables for Passenger Trips – Northbound Work Trips

Summer Weekend - Work Trip (NB)

Observed

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	38	17	165	0	220
Lynden, Sumas	11	4	64	0	80
Bellingham	7	10	84	0	100
Skagit	25	0	25	0	50
PSRC	101	10	43	0	154
sum	181	42	381	0	603

Modeled

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	45	15	160	0	220
Lynden, Sumas	20	5	55	0	79
Bellingham	10	7	82	0	99
Skagit	12	3	34	0	49
PSRC	94	10	53	0	157
sum	181	39	383	0	603

Difference

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	7	-2	-5	0	0
Lynden, Sumas	9	0	-10	0	0
Bellingham	3	-4	-2	0	-2
Skagit	-12	3	9	0	-1
PSRC	-7	0	10	0	3
sum	0	-2	2	0	0

R-square **0.98**

Table A.27 Summer Weekend Origin-Destination Tables for Passenger Trips – Southbound Recreation Trips

Summer Weekend - Recreation Trip (SB)

Observed

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	295	458	629	77	1742	3201
Bur, NW, NE, MR	172	560	215	66	709	1722
Surrey, Delta, Langley, Fraser V	1002	1636	850	79	1192	4759
Point Roberts	15	10	36	0	5	66
sum	1484	2664	1729	222	3649	9748

Modeled

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	295	468	628	69	1739	3200
Bur, NW, NE, MR	172	560	215	39	709	1695
Surrey, Delta, Langley, Fraser V	1001	1634	848	107	1190	4780
Point Roberts	15	10	36	1	11	73
sum	1483	2673	1727	217	3649	9748

Difference

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	0	11	-1	-8	-4	-1
Bur, NW, NE, MR	0	0	0	-26	0	-27
Surrey, Delta, Langley, Fraser V	-1	-2	-1	28	-2	22
Point Roberts	0	0	0	1	5	7
sum	-1	9	-2	-5	-1	0

R-square **1.00**

Table A.28 Summer Weekend Origin-Destination Tables for Passenger Trips – Northbound Recreation Trips

Summer Weekend - Recreation Trip (NB)

Observed

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	275	112	1055	20	1463
Lynden, Sumas	679	501	1883	10	3073
Bellingham	430	141	890	0	1462
Skagit	115	57	167	0	339
PSRC	940	199	834	0	1973
sum	2440	1010	4830	30	8310

Modeled

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	276	112	1056	20	1464
Lynden, Sumas	680	501	1885	10	3076
Bellingham	431	141	886	2	1460
Skagit	94	41	200	1	336
PSRC	942	199	835	1	1977
sum	2422	995	4862	34	8313

Difference

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	0	0	1	0	1
Lynden, Sumas	1	0	2	0	2
Bellingham	0	0	-4	2	-2
Skagit	-21	-16	33	1	-3
PSRC	1	0	1	1	4
sum	-19	-15	32	4	2

R-square **1.00**

Table A.29 Summer Weekend Origin-Destination Tables for Passenger Trips – Southbound Shopping Trips

Summer Weekend - Shopping Trip (SB)

Observed

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	110	27	455	0	159	750
Bur, NW, NE, MR	53	30	248	0	14	345
Surrey, Delta, Langley, Fraser V	485	283	545	42	157	1513
Point Roberts	0	0	29	0	0	29
sum	648	340	1277	42	329	2636

Modeled

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	109	28	452	1	158	748
Bur, NW, NE, MR	53	41	247	0	14	355
Surrey, Delta, Langley, Fraser V	485	283	543	43	155	1508
Point Roberts	7	3	13	0	2	25
sum	653	355	1255	44	329	2636

Difference

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	-1	1	-2	1	-1	-2
Bur, NW, NE, MR	0	11	-1	0	0	10
Surrey, Delta, Langley, Fraser V	-1	0	-3	1	-2	-4
Point Roberts	7	3	-16	0	2	-4
sum	5	15	-22	2	-1	0

R-square **1.00**

Table A.30 Summer Weekend Origin-Destination Tables for Passenger Trips – Northbound Shopping Trips

Summer Weekend - Shopping Trip (NB)

Observed

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	148	88	692	7	934
Lynden, Sumas	28	48	279	0	355
Bellingham	241	129	468	7	844
Skagit	29	7	47	0	82
PSRC	48	7	159	0	214
sum	494	278	1645	13	2430

Modeled

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	165	95	697	6	963
Lynden, Sumas	59	24	250	1	334
Bellingham	241	131	470	7	848
Skagit	12	6	60	0	79
PSRC	40	8	158	0	206
sum	517	265	1634	15	2430

Difference

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	17	7	5	0	29
Lynden, Sumas	31	-24	-29	1	-21
Bellingham	0	2	2	0	4
Skagit	-16	0	13	0	-3
PSRC	-9	2	-2	0	-8
sum	23	-13	-11	2	0

R-square **0.99**

Table A.31 Summer Weekend Origin-Destination Tables for Passenger Trips – Southbound Vacation Trips

Summer Weekend - Vacation Trip (SB)

Observed

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	0	51	0	21	541	613
Bur, NW, NE, MR	0	50	23	0	120	192
Surrey, Delta, Langley, Fraser V	17	56	43	5	214	335
Point Roberts	0	0	0	0	0	0
sum	17	157	66	26	874	1140

Modeled

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	2	51	9	21	535	617
Bur, NW, NE, MR	1	50	22	1	119	193
Surrey, Delta, Langley, Fraser V	17	56	40	6	212	331
Point Roberts	0	0	0	0	0	0
sum	20	156	71	28	865	1141

Difference

Subarea	Blaine, Ferndale	Lynden, Sumas	Bellingham	Skagit	PSRC	sum
N/W Van, Van, Rich	2	0	9	0	-6	4
Bur, NW, NE, MR	1	0	0	1	-1	0
Surrey, Delta, Langley, Fraser V	0	0	-3	1	-2	-4
Point Roberts	0	0	0	0	0	0
sum	3	-1	5	2	-9	0
					R-square	**1.00**

Table A.32 Summer Weekend Origin-Destination Tables for Passenger Trips – Northbound Vacation Trips

Summer Weekend - Vacation Trip (NB)

Observed

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	23	15	113	0	151
Lynden, Sumas	218	213	346	0	777
Bellingham	73	22	131	0	226
Skagit	18	0	8	0	26
PSRC	257	75	227	0	558
sum	589	325	824	0	1738

Modeled

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	28	24	96	0	149
Lynden, Sumas	214	226	336	0	776
Bellingham	72	22	131	0	225
Skagit	12	1	12	0	25
PSRC	254	77	233	0	564
sum	580	350	808	0	1738

Difference

Subarea	N/W Van, Van, Rich	Bur, NW, NE, MR	Surrey, Delta,	Point Roberts	Sum
Blaine, Ferndale	6	9	-17	0	-2
Lynden, Sumas	-4	13	-10	0	-1
Bellingham	-1	0	0	0	-1
Skagit	-6	1	5	0	-1
PSRC	-3	3	6	0	6
sum	-9	25	-16	0	0

R-square **1.00**

Appendix B. Trip Generation Rates by Season and Day

Tables B.1 through B.4 present auto production trip rates by season, trip purpose, and districts. Tables B.5 through B.8 present auto attraction trip rates by season, trip purpose, and districts.

Tables B.9 through B.12 present truck production trip rates by season, commodity, and districts. Tables B.13 through B.16 present truck attraction trip rates by season, commodity, and districts.

Table B.1 Auto Production Trip Rates – Fall Weekday

Region	District	Population (Work)	Population (Recreation)	Population (Shopping)	Population (Vacation)
GVRD	1	0.000664	0.000879	0.000422	0.000206
GVRD	2	0.000585	0.001062	0.000488	0.000291
GVRD	3	0.002126	0.004380	0.003042	0.000633
GVRD	4	0.002280	0.002615	0.003279	0.000064
GVRD	5	0.001917	0.003596	0.002436	0.000239
Whatcom County	4	0.110821	0.023977	0.021423	0.000000
Whatcom County	1	0.015462	0.017191	0.002345	0.001183
Whatcom County	2	0.011492	0.023005	0.008010	0.000898
Whatcom County	3	0.002803	0.006095	0.002113	0.000172
Skagit	1	0.000649	0.000618	0.000889	0.000155
PSRC	1	0.000124	0.000174	0.000041	0.000049

Table B.2 Auto Attraction Trip Rates – Fall Weekday

Region	District	Non-Service Employees (Work)	Retail Employees (Rec)	Service Employees (Rec)	Retail Employees (Shopping)	Service Employees (Vacation)
GVRD	1	0.003214	0.001250	0.001250	0.003756	0.000481
GVRD	2	0.002395	0.001648	0.001648	0.000917	0.000247
GVRD	3	0.007970	0.011329	0.011329	0.008099	0.000594
GVRD	4	0.015657	0.014663	0.014663	0.013495	0.000000
GVRD	5	0.009014	0.009281	0.009281	0.023776	0.001003
Whatcom County	4	1.643326	0.113788	0.113788	0.000000	0.000000
Whatcom County	1	0.138306	0.150376	0.150376	0.406922	0.005079
Whatcom County	2	0.115493	0.142515	0.142515	0.116070	0.039667
Whatcom County	3	0.106470	0.020681	0.020681	0.059165	0.000564
Skagit	1	0.001732	0.002115	0.002115	0.000000	0.004506
PSRC	1	0.000639	0.000409	0.000409	0.000150	0.000346

Table B.3 Auto Production Trip Rates – Fall Weekend

Region	District	Population (Work)	Population (Recreation)	Population (Shopping)	Population (Vacation)
GVRD	1	0.000224	0.002634	0.001363	0.000186
GVRD	2	0.000110	0.002824	0.001562	0.000190
GVRD	3	0.000493	0.005255	0.003937	0.000308
GVRD	4	0.001096	0.006625	0.005181	0.000491
GVRD	5	0.000309	0.005727	0.003985	0.000270
Whatcom County	4	0.000000	0.080207	0.038003	0.000000
Whatcom County	1	0.003330	0.019269	0.006255	0.000000
Whatcom County	2	0.000574	0.020265	0.012350	0.000763
Whatcom County	3	0.001108	0.007017	0.004019	0.000109
Skagit	1	0.000000	0.003470	0.000867	0.000275
PSRC	1	0.000074	0.000820	0.000118	0.000090

Table B.4 Auto Attraction Trip Rates – Fall Weekend

Region	District	Non-Service Employees (Work)	Retail Employees (Rec)	Service Employees (Rec)	Retail Employees (Shopping)	Service Employees (Vacation)
GVRD	1	0.001092	0.005106	0.005106	0.010247	0.000401
GVRD	2	0.000321	0.002358	0.002358	0.001147	0.000000
GVRD	3	0.002965	0.015407	0.015407	0.012271	0.001022
GVRD	4	0.001917	0.014599	0.014599	0.037215	0.001616
GVRD	5	0.002408	0.018116	0.018116	0.029792	0.002879
Whatcom County	4	0.220326	0.089745	0.089745	0.000000	0.000000
Whatcom County	1	0.034797	0.162316	0.162316	0.508278	0.013898
Whatcom County	2	0.010995	0.270823	0.270823	0.149036	0.015197
Whatcom County	3	0.025144	0.031960	0.031960	0.146235	0.001328
Skagit	1	0.001541	0.009362	0.009362	0.003856	0.001686
PSRC	1	0.000332	0.001887	0.001887	0.001753	0.000309

Table B.5 Auto Production Trip Rates – Summer Weekday

Region	District	Population (Work)	Population (Recreation)	Population (Shopping)	Population (Vacation)
GVRD	1	0.000799	0.001630	0.000814	0.000768
GVRD	2	0.000462	0.002141	0.000836	0.000987
GVRD	3	0.002105	0.006439	0.003280	0.001245
GVRD	4	0.003658	0.009593	0.002677	0.000774
GVRD	5	0.001482	0.007892	0.002896	0.000770
Whatcom County	4	0.110791	0.036951	0.052850	0.000000
Whatcom County	1	0.012460	0.019398	0.003571	0.001610
Whatcom County	2	0.012050	0.011218	0.004399	0.000710
Whatcom County	3	0.005301	0.008387	0.001996	0.000973
Skagit	1	0.000915	0.001086	0.000084	0.000562
PSRC	1	0.000153	0.000304	0.000076	0.000193

Table B.6 Auto Attraction Trip Rates – Summer Weekday

Region	District	Non-Service Employees (Work)	Retail Employees (Rec)	Service Employees (Rec)	Retail Employees (Shopping)	Service Employees (Vacation)
GVRD	1	0.004543	0.002902	0.002902	0.003811	0.001367
GVRD	2	0.004033	0.000999	0.000999	0.002181	0.000346
GVRD	3	0.009143	0.010700	0.010700	0.008301	0.001858
GVRD	4	0.006621	0.010070	0.010070	0.003374	0.003626
GVRD	5	0.008738	0.008239	0.008239	0.020058	0.003844
Whatcom County	4	1.464878	0.071850	0.071850	0.000000	0.000000
Whatcom County	1	0.143410	0.184582	0.184582	0.373151	0.034789
Whatcom County	2	0.097078	0.385006	0.385006	0.192734	0.132681
Whatcom County	3	0.113617	0.031059	0.031059	0.086471	0.008340
Skagit	1	0.005145	0.006169	0.006169	0.003478	0.003739
PSRC	1	0.000778	0.000852	0.000852	0.000438	0.000748

Table B.7 Auto Production Trip Rates – Summer Weekend

Region	District	Population (Work)	Population (Recreation)	Population (Shopping)	Population (Vacation)
GVRD	1	0.000208	0.003924	0.001119	0.000683
GVRD	2	0.000194	0.004664	0.001195	0.000918
GVRD	3	0.000562	0.007810	0.003537	0.000891
GVRD	4	0.001078	0.010669	0.003957	0.001589
GVRD	5	0.000436	0.007417	0.002069	0.001032
Whatcom County	4	0.027130	0.013742	0.032613	0.000000
Whatcom County	1	0.004224	0.023568	0.004521	0.001585
Whatcom County	2	0.000719	0.029336	0.005064	0.000136
Whatcom County	3	0.001177	0.013258	0.002728	0.001503
Skagit	1	0.000061	0.001506	0.000171	0.000242
PSRC	1	0.000057	0.000724	0.000085	0.000234

Table B.8 Auto Attraction Trip Rates – Summer Weekend

Region	District	Non-Service Employees (Work)	Retail Employees (Rec)	Service Employees (Rec)	Retail Employees (Shopping)	Service Employees (Vacation)
GVRD	1	0.001338	0.005375	0.005375	0.003908	0.001768
GVRD	2	0.000465	0.002974	0.002974	0.001024	0.000552
GVRD	3	0.002837	0.011819	0.011819	0.010800	0.000857
GVRD	4	0.001131	0.017830	0.017830	0.018653	0.001654
GVRD	5	0.000618	0.027890	0.027890	0.022436	0.005625
Whatcom County	4	0.538087	0.202635	0.202635	0.000000	0.000000
Whatcom County	1	0.030136	0.191989	0.191989	0.365837	0.015777
Whatcom County	2	0.035968	0.440752	0.440752	0.125308	0.144495
Whatcom County	3	0.022231	0.050123	0.050123	0.126403	0.006248
Skagit	1	0.003190	0.014050	0.014050	0.009203	0.001521
PSRC	1	0.000320	0.002763	0.002763	0.000824	0.000778

Table B.9 Truck Production Trip Rates – Fall Weekday

Region	District	Bulk-Printed-Unknown	Farm	Food	Wood	Manufac-turing	Empty
GVRD	1	0.000194	0.000000	0.000000	0.001240	0.000100	0.000401
GVRD	2	0.000103	0.000203	0.000057	0.000170	0.000016	0.000036
GVRD	3	0.000192	0.000499	0.000000	0.000143	0.001686	0.000183
GVRD	4	0.000231	0.001423	0.000034	0.002259	0.003132	0.001015
GVRD	5	0.000341	0.000126	0.000466	0.002085	0.005056	0.000642
GVRD	6	0.000000	0.000000	0.000000	0.000000	0.005803	0.002085
GVRD	7	0.000152	0.002711	0.000771	0.002857	0.006887	0.000432
GVRD	8	0.000000	0.002048	0.000545	0.001632	0.005877	0.000401
Whatcom County	1	0.005172	0.001351	0.000633	0.001354	0.005249	0.008143
Whatcom County	2	0.000000	0.000000	0.001722	0.001254	0.001215	0.002098
Whatcom County	3	0.001546	0.007056	0.000000	0.003985	0.002141	0.010561
PSRC & Skagit	1	0.000320	0.000204	0.000203	0.000044	0.000234	0.000487

Table B.10 Truck Production Trip Rates – Fall Weekend

Region	District	Bulk-Printed-Unknown	Farm	Food	Wood	Manufac-turing	Empty
GVRD	1	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
GVRD	2	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
GVRD	3	0.000000	0.000000	0.000130	0.000000	0.000661	0.000000
GVRD	4	0.000000	0.000000	0.000000	0.000000	0.002874	0.000000
GVRD	5	0.000000	0.000000	0.000000	0.000000	0.001017	0.000000
GVRD	6	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
GVRD	7	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
GVRD	8	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Whatcom County	1	0.001792	0.000000	0.000000	0.000000	0.000000	0.000000
Whatcom County	2	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Whatcom County	3	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
PSRC & Skagit	1	0.000041	0.000000	0.000066	0.000000	0.000105	7.09E-05

Table B.11 Truck Production Trip Rates – Summer Weekday

Region	District	Bulk-Printed-Unknown	Farm	Food	Wood	Manufac-turing	Empty
GVRD	1	0.000000	0.000000	0.000000	0.000000	0.000000	0.000277
GVRD	2	0.000000	0.000000	0.000000	0.000184	0.000737	0.000146
GVRD	3	0.000000	0.000000	0.000000	0.000457	0.001967	0.000939
GVRD	4	0.000474	0.000153	0.000882	0.003095	0.003890	0.002395
GVRD	5	0.000442	0.000494	0.000164	0.000290	0.001188	0.000738
GVRD	6	0.004543	0.006888	0.000000	0.001182	0.001739	0.000718
GVRD	7	0.000930	0.001024	0.000142	0.000763	0.004354	0.001968
GVRD	8	0.000366	0.001823	0.001209	0.005827	0.001655	0.000671
Whatcom County	1	0.007616	0.000000	0.000000	0.001733	0.007192	0.008834
Whatcom County	2	0.001075	0.000000	0.002439	0.000000	0.000636	0.003869
Whatcom County	3	0.000683	0.000000	0.003029	0.002970	0.002524	0.006461
PSRC & Skagit	1	0.000215	0.000293	0.000059	0.000061	0.000300	0.000755

Table B.12 Truck Production Trip Rates – Summer Weekend

Region	District	Bulk-Printed-Unknown	Farm	Food	Wood	Manufac-turing	Empty
GVRD	1	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
GVRD	2	0.000000	0.000000	0.000293	0.000000	0.000000	0.000000
GVRD	3	0.000000	0.000000	0.000000	0.000000	0.000957	0.000000
GVRD	4	0.000645	0.000000	0.000000	0.000000	0.000311	0.000000
GVRD	5	0.000000	0.000000	0.000000	0.000816	0.000241	0.000000
GVRD	6	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
GVRD	7	0.000000	0.000000	0.000000	0.000000	0.000000	0.000488
GVRD	8	0.000000	0.000000	0.001265	0.002262	0.000000	0.000000
Whatcom County	1	0.000000	0.000000	0.000000	0.000000	0.002936	0.000000
Whatcom County	2	0.000000	0.000000	0.000000	0.000611	0.000000	0.004518
Whatcom County	3	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
PSRC & Skagit	1	0.000064	0.001537	0.000030	0.000000	0.000108	0.00017

Table B.13 Truck Attraction Trip Rates – Fall Weekday

Region	District	Bulk-Printed-Unknown	Farm	Food	Wood	Manufac-turing	Empty
GVRD	1	0.000000	0.000000	0.000000	0.000328	0.000415	0.000355
GVRD	2	0.000097	0.000026	0.000199	0.000000	0.000273	0.000147
GVRD	3	0.001016	0.000065	0.000249	0.000557	0.001325	0.000761
GVRD	4	0.000711	0.000000	0.000567	0.000411	0.002509	0.003080
GVRD	5	0.000502	0.000088	0.000209	0.000045	0.000521	0.001484
GVRD	6	0.001085	0.000000	0.001614	0.000000	0.002141	0.000591
GVRD	7	0.000252	0.000268	0.000658	0.000388	0.004395	0.002439
GVRD	8	0.000071	0.000172	0.000380	0.000854	0.002224	0.000786
Whatcom County	1	0.002670	0.010694	0.000000	0.016740	0.009361	0.006307
Whatcom County	2	0.004142	0.000000	0.000094	0.005148	0.003349	0.002528
Whatcom County	3	0.000000	0.075442	0.006038	0.005067	0.003554	0.000713
PSRC & Skagit	1	0.000081	0.002536	0.000059	0.000155	0.000401	0.000139

Table B.14 Truck Attraction Trip Rates – Fall Weekend

Region	District	Bulk-Printed-Unknown	Farm	Food	Wood	Manufac-turing	Empty
GVRD	1	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
GVRD	2	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
GVRD	3	0.000378	0.000000	0.000000	0.000000	0.000000	0.000000
GVRD	4	0.000000	0.000000	0.000384	0.000000	0.001190	0.000000
GVRD	5	0.000000	0.000000	0.000177	0.000000	0.000000	0.000113
GVRD	6	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
GVRD	7	0.000000	0.000000	0.000000	0.000000	0.004043	0.001556
GVRD	8	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Whatcom County	1	0.000000	0.000000	0.000000	0.000000	0.004524	0.000000
Whatcom County	2	0.000000	0.000000	0.000000	0.000000	0.001295	0.000000
Whatcom County	3	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
PSRC & Skagit	1	0.000000	0.000000	0.000022	0.000000	0.000129	0.000000

Table B.15 Truck Attraction Trip Rates – Summer Weekday

Region	District	Bulk-Printed-Unknown	Farm	Food	Wood	Manufac-turing	Empty
GVRD	1	0.000000	0.000000	0.000000	0.000357	0.001160	0.000290
GVRD	2	0.000086	0.000052	0.000312	0.000018	0.000699	0.000562
GVRD	3	0.000793	0.000000	0.000000	0.000026	0.001071	0.000556
GVRD	4	0.000803	0.000000	0.000607	0.000504	0.001543	0.003367
GVRD	5	0.000319	0.000000	0.000107	0.000504	0.003765	0.002527
GVRD	6	0.000000	0.000000	0.000000	0.000000	0.000356	0.000916
GVRD	7	0.000343	0.000187	0.000209	0.000000	0.002726	0.002141
GVRD	8	0.000000	0.000000	0.000173	0.000552	0.001297	0.002115
Whatcom County	1	0.000000	0.000000	0.002195	0.011085	0.000851	0.020285
Whatcom County	2	0.001651	0.072464	0.000155	0.003249	0.004316	0.003956
Whatcom County	3	0.004635	0.012399	0.000000	0.008542	0.006711	0.001236
PSRC & Skagit	1	0.000206	0.002745	0.000174	0.000263	0.000298	0.000245

Table B.16 Truck Attraction Trip Rates – Summer Weekend

Region	District	Bulk-Printed-Unknown	Farm	Food	Wood	Manufac-turing	Empty
GVRD	1	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
GVRD	2	0.000000	0.000000	0.000000	0.000000	0.000413	0.000000
GVRD	3	0.000381	0.000000	0.000000	0.000000	0.000590	0.000279
GVRD	4	0.000000	0.000000	0.000000	0.000000	0.000635	0.000000
GVRD	5	0.000000	0.000000	0.000000	0.000000	0.000838	0.000000
GVRD	6	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
GVRD	7	0.000000	0.003553	0.000670	0.000000	0.000000	0.006711
GVRD	8	0.000000	0.000000	0.000000	0.000452	0.000000	0.000000
Whatcom County	1	0.000000	0.000000	0.000000	0.000000	0.000843	0.001489
Whatcom County	2	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Whatcom County	3	0.000000	0.000000	0.000000	0.008473	0.000000	0.000000
PSRC & Skagit	1	0.000064	0.001537	0.000030	0.000000	0.000108	0.00017