

# Transport Canada Border Circulation Study

## *Bi-National Commercial Vehicle Transportation Model: Update and Forecasts*

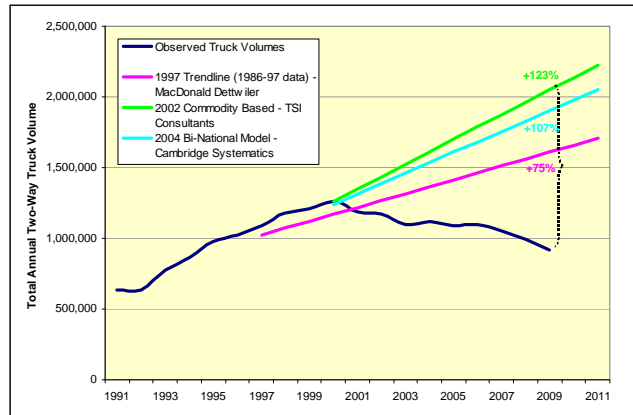


*IMTC Meeting, Blaine WA  
June 16<sup>th</sup>, 2011*

## Presentation Outline

- Introduction/Study Overview
- Review of Previous Truck Border Forecasts and Likely Contributing Factors
- Review of Model Development
  - Traffic zone, land use and road network updates
  - Trip generation (econometrics)
  - Seasonal and time of day adjustment factors
  - Trip distribution
  - Logit border choice
  - Network assignment
- Present Base Case Results
- Present Results from Sensitivity Scenarios
- Present Findings from Risk Analysis
- Study Conclusions

## Review of Previous Truck Border Forecasts



### Key Observations:

- All previous attempts over-estimated truck volumes
- None anticipated a decline in activity
- Several structural changes have occurred since early 2000's

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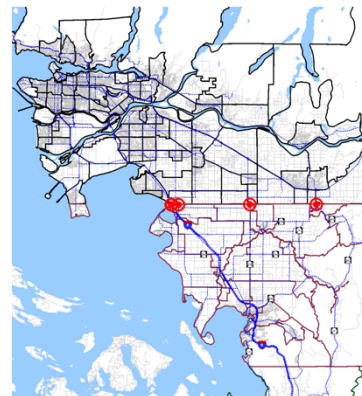
## Likely Contributing Factors

### Reasons why truck volumes have declined:

- Softwood lumber dispute (2001-2006)
- Post 9/11 security requirements
- Collapse of US housing market
- General economic downturn
- More east/west Asia-Pacific trade

### Reasons why truck forecasts were high:

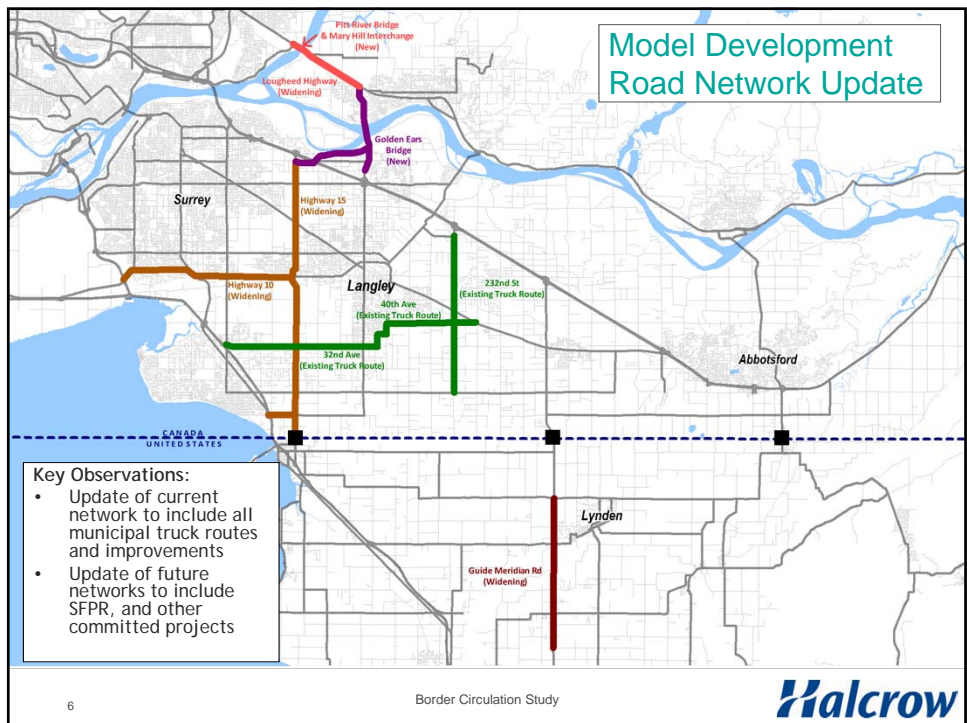
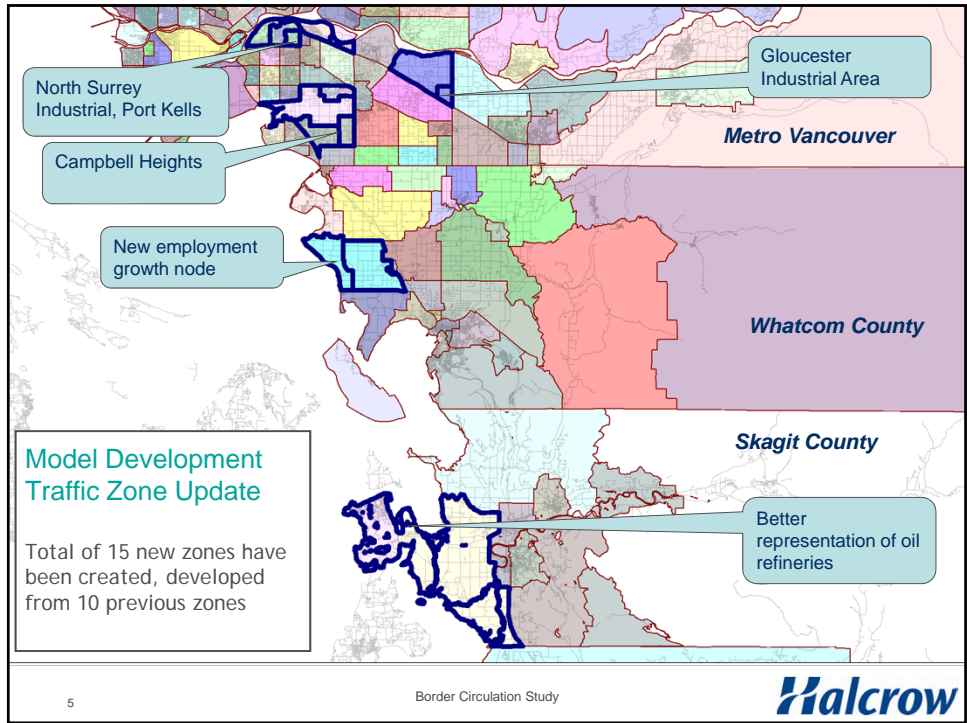
- Historical trend based on rapid growth in 90's
- Optimistic input forecasts (e.g. commodities, exchange rates, demographics)
- Did not account for structural changes in the industry (e.g. NB freight consolidation)



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## Model Framework

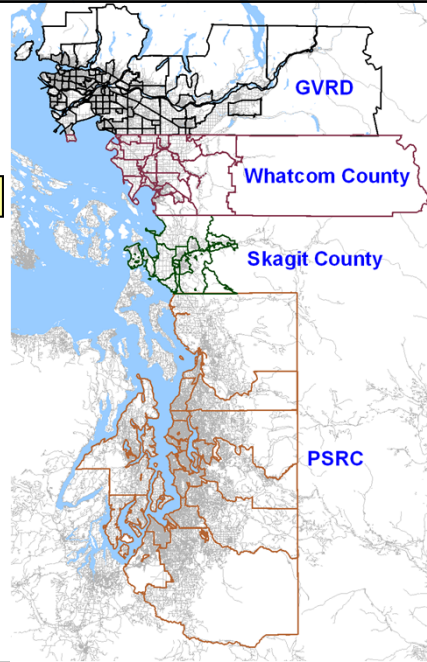
Stage 1 – Aggregate Truck Trip Generation

Stage 2 – Seasonal Adjustment Factors

Stage 3 – Truck Trip Distribution

Stage 4 – Border Choice Logit Model

Stage 5 – Route Choice



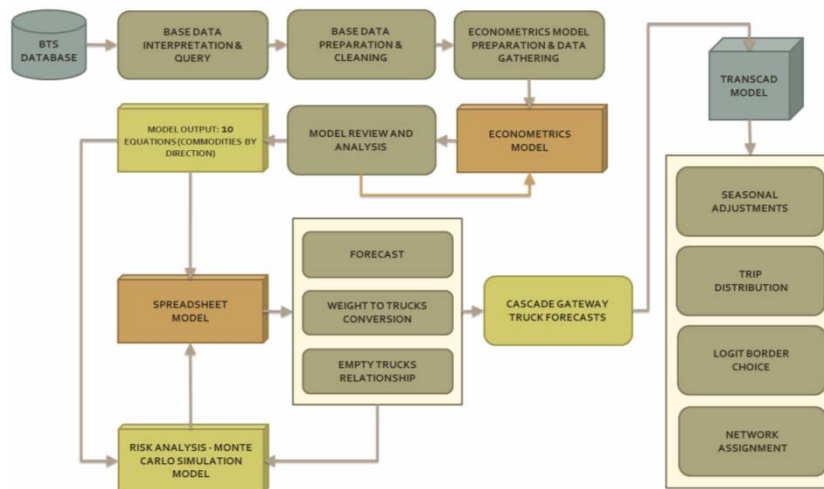
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## Model Update – Trip Generation (Econometrics)

- General approach to econometric modelling



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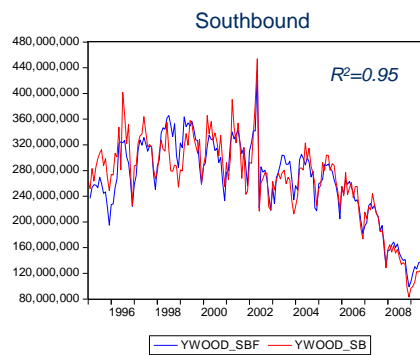
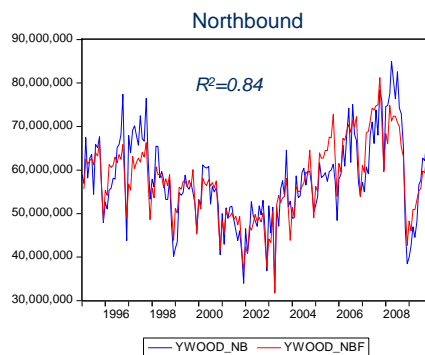
## Model Update – Trip Generation (Econometrics)

- What is Econometrics?
  - Econometrics = economic measurement
  - P. Samuelson “Econometrics may be defined as the quantitative analysis of actual economic phenomena”
  - The use of mathematical and statistical methods (in the field of economics) to verify and develop (economic) theories using empirical data
- What is it used for?
  - Describing economic relationships
  - Hypothesis testing
  - Forecasting

**Famous quote:**

“There are two things you do not want to see in the making: sausages and econometric research” (E. Leamer)

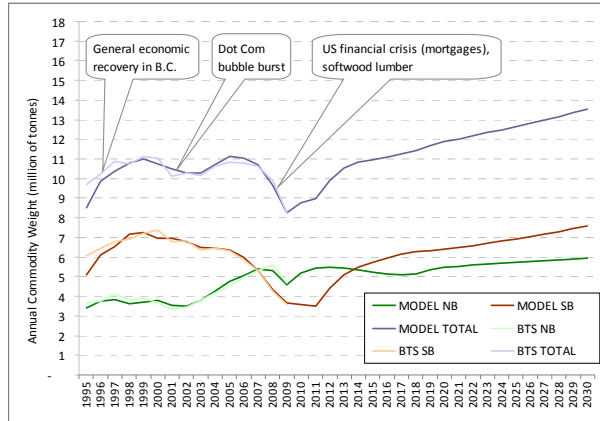
## Model Update – Econometric Backcasts for Wood



Notes:

- Wood destined to Canada is mainly specialized wood and wood products. Usage is both Canadian consumption and also prospects of international exports. Trade demand is highly sensitive to exchange rates. Christmas trees for the local BC market during Christmas season.
- SB is highly correlated to the US housing market
- SB trending down most likely due to collapse of the US housing market

## Model Update – Commodity Weight Backcast and Forecast



Notes:

- Commodity weights rebound with recovery in GDP by 2013
- Long term growth (past 2013) -> 1.3% CAGR

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## Model Update Payload Factors

- Payload factors from US DOT, FHA, “Development of Truck Payload Equivalent Factor (TPEF)” Report, June 2007
- Developed look up table to correspond with 99 BTS categories
- Used to convert from commodity weights to equivalent truck trips

Commodities	Payload (lbs)
Live animals and fish	24,492
Animal feed or products of animal origin	22,957
Cereal grains	27,745
All other agricultural products	22,140
Basic chemicals	29,391
Fertilizers and fertilizer materials	19,833
Pharmaceutical products	10,253
All other chemical products	24,432
Alcoholic beverages	20,573
Bakery and milled grains	11,831
Meat, seafood, and their preparation	30,671
Tobacco products	25,168
All other prepared foodstuffs	25,920
Logs and other wood in rough	35,073
Paper and paperboard articles	26,282
Printed products	11,024
Pulp, newsprint, paper, or paperboard	13,042
Wood products	18,494
Articles of base metal	14,395
Base metal in finished or semi-finished form	24,458
Non-metallic mineral products	31,044
Non-powered tools	6,604
Powered tools	10,698
Electronic and other electrical equipment	13,871
Furniture, mattresses, lamps, etc.	14,103
Machinery	25,072
Miscellaneous manufactured products	16,402
Precision instruments and apparatus	9,024
Textile, leather, and related article	20,608
Vehicle, including parts	15,675
All other transportation equipment	34,230
Coal	43,856
Crude petroleum	28,007
Gravel and crushed stones	30,870
Metallic ores and concentrates	39,454
Nonmetallic or building stones	25,425
Natural sand	29,501
All other nonmetallic minerals	29,101
Fuel oils	23,442
Gasoline and aviation turbine	48,682
Plastic and rubber	19,324
All other coal and refined petroleum	18,608
Hazardous waste	29,113
All other waste and scrap	18,902
Recyclable products	18,858
Mail and courier parcels	11,826
Empty shipping containers	19,129
Passengers	2,613
Mixed freight	33,338
Multiple categories	14,521
Products not classified, blank, not reported or applicable	21,739

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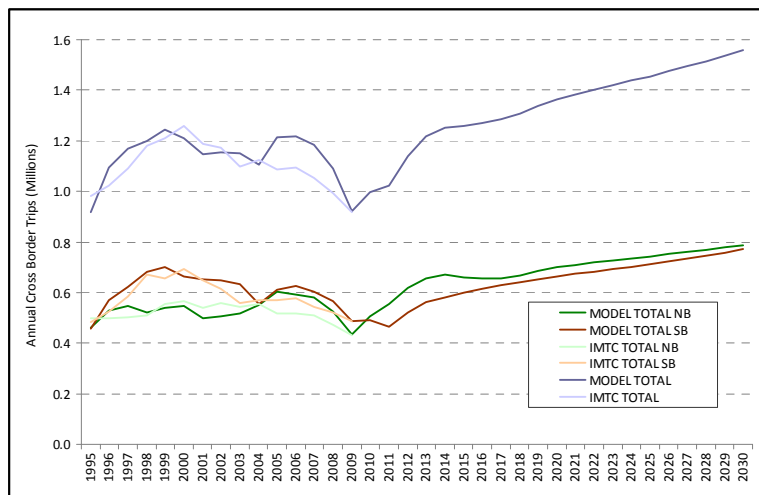


## Model Update – Empties

- Tried to develop econometric relationship but no explanatory variables would fit
- Rate of empties available from BTS (SB only) and CVO surveys
- Relied on these sources to develop factors and estimate empties
- Differences between truck counts and model values were used to develop payload adjustment factors

Year	IMTC Counts		BTS Empties		CVO Empties	
	NB	SB	SB	Percentage	NB	SB
1998	510,200	670,400	159,100	24%		
1999	555,600	654,700	167,400	26%		
2000	567,600	691,600	188,800	27%	41%	19%
2001	541,300	647,900	189,700	29%		
2002	559,300	614,400	179,600	29%		
2003	541,900	556,600	147,000	26%		
2004	555,000	568,100	164,200	29%		
2005	518,700	568,200	165,900	29%		
2006	517,800	577,000	161,800	28%		
2007	510,300	543,200	154,600	28%		
2008	473,700	520,200	134,900	26%		
2009	432,800	485,400	140,500	29%	18%	32%

## Model Update – Total Truck Trips



## Model Update – Trip Distribution Patterns (Survey Data)

2009 CVO Origin Sub Areas	Destination Sub Areas														Grand Total
	Whatcom County	Point Roberts	Puget Sound	West Washington	East Washington	Alaska	West USA	Rest of USA	East Lower Mainland	West Lower Mainland	Rest of BC	Alberta	West Canada	East Canada	
Whatcom County	2	19	0	-	-	1	0	1	164	353	18	5	0	1	565
Point Roberts	10	-	1	-	-	-	1	-	-	-	-	-	-	-	13
Puget Sound	-	1	1	1	-	1	-	-	94	281	20	7	1	7	415
West Washington	-	6	-	-	-	-	-	1	44	188	10	18	6	-	272
East Washington	1	-	-	-	-	-	-	-	10	22	3	-	-	-	35
Alaska	2	-	4	-	-	-	2	0	-	-	-	-	-	-	8
West USA	-	-	-	-	-	1	-	-	72	193	13	6	-	-	285
Rest of USA	-	-	-	1	-	1	-	-	22	60	5	1	1	-	91
East Lower Mainland	236	-	132	54	15	-	103	40	2	3	-	-	-	-	583
West Lower Mainland	405	-	341	171	42	-	276	67	0	2	-	-	-	1	1,306
Rest of BC	32	-	16	12	7	-	21	9	-	-	-	-	-	-	96
Alberta	3	-	5	6	1	-	2	-	-	-	-	-	-	-	16
West Canada	1	-	11	1	1	-	3	-	-	-	-	-	-	-	16
East Canada	-	-	6	-	-	1	4	-	3	-	-	-	-	-	14
<b>Total</b>	<b>691</b>	<b>26</b>	<b>517</b>	<b>246</b>	<b>66</b>	<b>4</b>	<b>412</b>	<b>117</b>	<b>410</b>	<b>1,102</b>	<b>69</b>	<b>37</b>	<b>8</b>	<b>9</b>	<b>3,714</b>

2000 CVO Origin Sub Areas	Destination Sub Areas														Grand Total
	Whatcom County	Point Roberts	Puget Sound	West Washington	East Washington	Alaska	West USA	Rest of USA	East Lower Mainland	West Lower Mainland	Rest of BC	Alberta	West Canada	East Canada	
Whatcom County	-	9	-	-	-	-	-	-	182	365	10	5	-	-	570
Point Roberts	12	-	-	-	-	-	-	-	-	-	-	-	-	-	12
Puget Sound	-	8	-	-	-	3	-	-	178	881	23	7	-	-	1,099
West Washington	-	-	-	-	-	3	-	-	12	70	2	1	-	-	89
East Washington	-	-	-	-	-	-	-	-	12	38	-	-	-	-	50
Alaska	-	-	6	-	-	-	-	-	-	-	-	-	-	-	6
West USA	-	-	-	-	-	-	-	-	25	163	33	13	3	3	239
Rest of USA	-	-	-	-	-	-	-	-	26	69	1	-	-	-	96
East Lower Mainland	292	-	247	41	19	-	126	48	-	-	-	-	-	-	773
West Lower Mainland	425	-	589	36	33	-	317	105	-	-	-	-	-	7	1,512
Rest of BC	57	-	14	11	4	-	39	30	-	-	-	-	-	-	154
Alberta	-	-	18	15	-	-	6	13	9	-	-	-	-	-	61
West Canada	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
East Canada	2	-	-	-	-	-	1	-	-	6	3	-	-	-	13
<b>Total</b>	<b>788</b>	<b>17</b>	<b>874</b>	<b>102</b>	<b>56</b>	<b>5</b>	<b>489</b>	<b>196</b>	<b>443</b>	<b>1,593</b>	<b>72</b>	<b>26</b>	<b>3</b>	<b>10</b>	<b>4,675</b>



## Model Update – Trip Distribution Pattern Changes

2009-2000 Compare Origin Sub Areas	Destination Sub Areas														Grand Total
	Whatcom County	Point Roberts	Puget Sound	West Washington	East Washington	Alaska	West USA	Rest of USA	East Lower Mainland	West Lower Mainland	Rest of BC	Alberta	West Canada	East Canada	
Whatcom County	-	0.3%	-	-	-	-	-	-	0.5%	1.7%	0.3%	-	-	-	3.0%
Point Roberts	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1%
Puget Sound	-	-0.1%	-	-	-	-	-	-	-1.3%	-11.3%	-	-	-	0.2%	-12.4%
West Washington	-	0.2%	-	-	-	-0.1%	-	-	0.9%	3.6%	0.2%	0.5%	0.2%	-	5.4%
East Washington	-	-	-	-	-	-	-	-	-	-0.2%	0.1%	-	-	-	-0.1%
Alaska	-	-	-	-	-	-	0.1%	-	-	-	-	-	-	-	0.1%
West USA	-	-	-	-	-	-	-	-	1.4%	1.7%	-0.4%	-0.1%	-0.1%	-0.1%	2.6%
Rest of USA	-	-	-	-	-	-	-	-	-	0.1%	0.1%	-	-	-	0.4%
East Lower Mainland	0.1%	-	-1.7%	0.6%	-	-	0.1%	-	-	0.1%	-	-	-	-	-0.8%
West Lower Mainland	1.8%	-	-3.4%	3.8%	0.4%	-	0.6%	-0.4%	-	0.1%	-	-	-	-0.1%	2.8%
Rest of BC	-0.4%	-	0.1%	0.1%	0.1%	-	-0.3%	-0.4%	-	-	-	-	-	-	-0.7%
Alberta	0.1%	-	-0.3%	-0.2%	-	-	-0.1%	-0.3%	-0.2%	-	-	-	-	-	-0.9%
West Canada	-	-	0.3%	-	-	-	0.1%	-	-	-	-	-	-	-	0.4%
East Canada	-0.1%	-	0.2%	-	-	-	0.1%	-	0.1%	-0.1%	-0.1%	-	-	-	0.1%
<b>Total</b>	<b>1.7%</b>	<b>0.3%</b>	<b>-4.8%</b>	<b>4.4%</b>	<b>0.6%</b>	<b>0.0%</b>	<b>0.6%</b>	<b>-1.0%</b>	<b>1.5%</b>	<b>-4.4%</b>	<b>0.3%</b>	<b>0.4%</b>	<b>0.2%</b>	<b>0.0%</b>	<b>0.0%</b>

**Significant changes:**

- NB Origins (All trucks) - Puget Sound has dropped dramatically as an origin (11.2% from 23.5%), while Western WA has increased (7.3% from 1.9%)
- NB Destinations (All trucks) - East Lower Mainland is becoming slightly more dominant than it was in 2000 (11% from 9.5%), but is still only one-third of Western LM (30% from 34% in 2000)
- SB Origins (All trucks) - slight increase of Western LM origins (35.2% from 32.3%)
- SB Destinations (All trucks) - mirrors the NB Origin pattern with Puget Sound declining (13.9% from 18.7%) and Western WA increasing (6.6% from 2.2% in 2000)

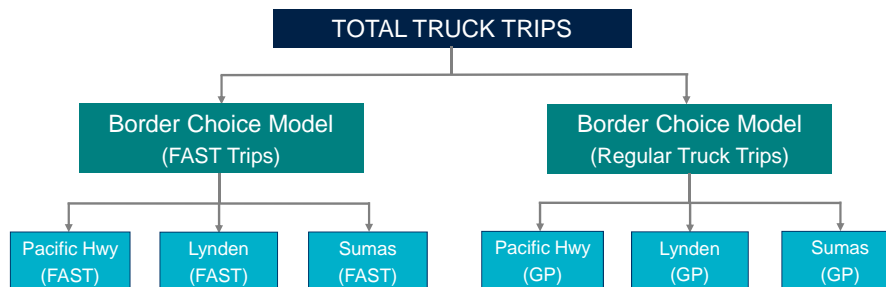


## Model Update – FAST and non-FAST Trucks

- Split is based on CVO survey findings
- Incorporated as a fixed percent
- Can be used in sensitivity testing
- ~9% FAST trucks out of total crossings (14% of Pac Hwy crossings)
- 8 min avg delay for FAST trucks, 20 min for non-FAST

Truck Border Crossing	FAST		GP (Non-FAST)		TOTAL	
	NB	SB	NB	SB	NB	SB
Pacific Highway	20	300	1,270	980	1,280	1,280
Lynden/Aldergrove	-	-	280	90	280	90
Sumas/Huntingdon	-	-	170	600	170	600
All Crossings	20	300	1,720	1,680	1,740	1,980
All Crossings - Both Dir	320		3,390		3,710	

## Model Update – Logit Border Choice



Probability of trip using Pacific Highway Crossing:

$$P_{Pacific} = \frac{e^{U_{Pacific}}}{e^{U_{Pacific}} + e^{U_{Lynden}} + e^{U_{Sumas}}}$$

Where utility:

$$U_{border\ Crossing} = (Travel\ Time + Border\ Delay + Bias\ for\ Brokerage\ Location) \times Scaling\ Parameter$$

## Model Update – Border Choice Validation

- Border crossing bias will reflect actual usage
- Bias will account for availability of brokerage services and other factors that are difficult to obtain data
- Crossing counts based on manual counts and MoTI loop detectors

Truck Border Crossing		2009 Base Model		2010 Base Model		2010 vs. 2009		2010 vs. 2009 (%)	
		NB	SB	NB	SB	NB	SB	NB	SB
FAST	Pacific Highway	20	300	20	300	-	-	0%	0%
	Lynden/Aldergrove	-	-	-	-	-	-	-	-
	Sumas/Huntingdon	-	-	-	-	-	-	-	-
	All Crossings	20	300	20	300	-	-	0%	0%
GP (Non-FAST)	Pacific Highway	1,280	990	1,460	990	180	-	14%	0%
	Lynden/Aldergrove	290	60	50	60	-240	-	-83%	0%
	Sumas/Huntingdon	140	630	200	630	60	-	41%	0%
	All Crossings	1,720	1,680	1,720	1,680	-	-	0%	0%
TOTAL	Pacific Highway	1,300	1,290	1,480	1,290	180	-	14%	0%
	Lynden/Aldergrove	290	60	50	60	-240	-	-83%	0%
	Sumas/Huntingdon	140	630	200	630	60	-	41%	0%
	All Crossings	1,740	1,980	1,740	1,980	-	-	0%	0%

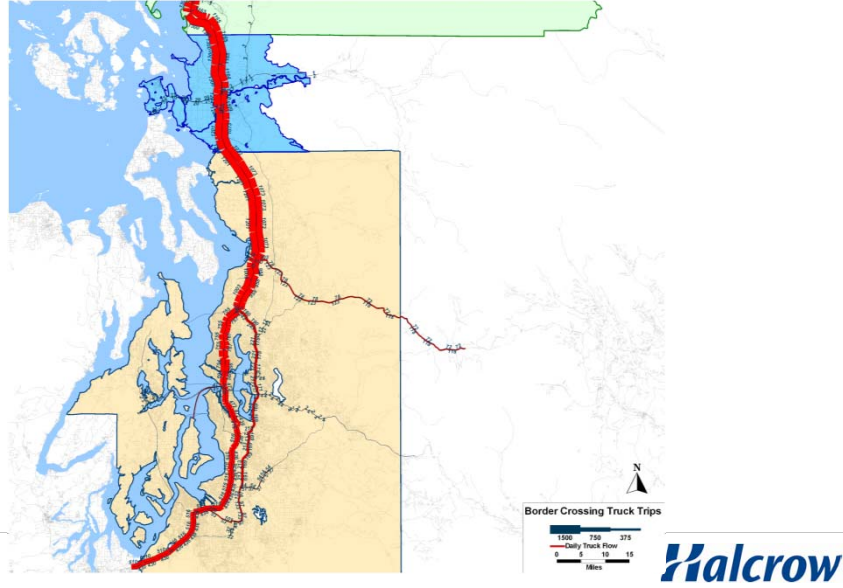
## Model Update – Network Assignment (Northern)

- Network assignment based on shortest time-path assignment



## Model Update – Network Assignment (Southern)

- Many through trips on Interstate 5 travel past PSRC



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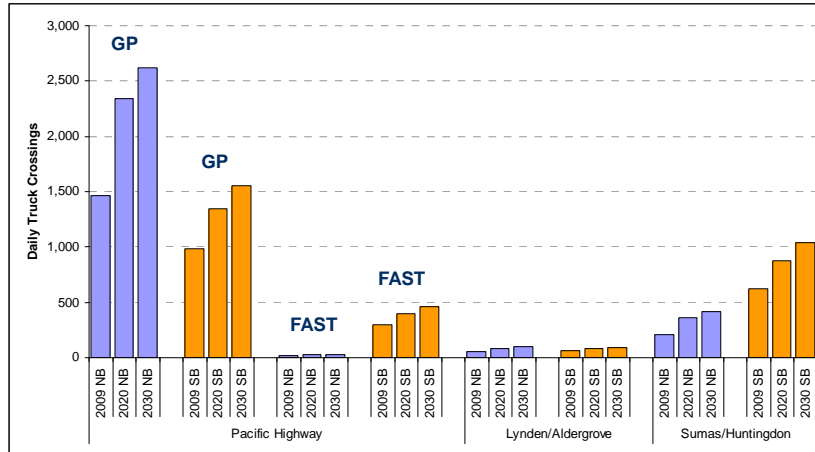
## 2030 Base Volume Growth

- Majority of growth expected on I-5/Hwy 99 corridor



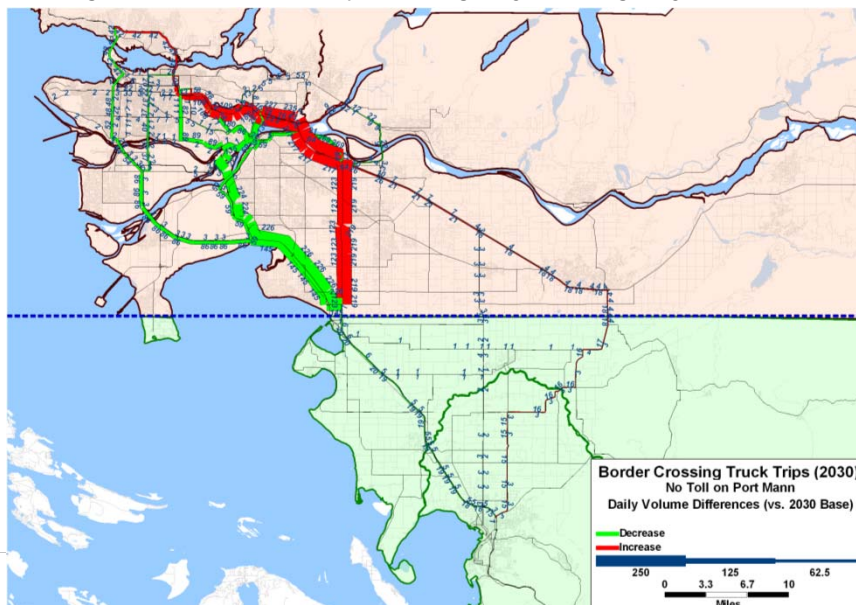
## Forecast Truck Volumes

- Summarized by crossing and direction



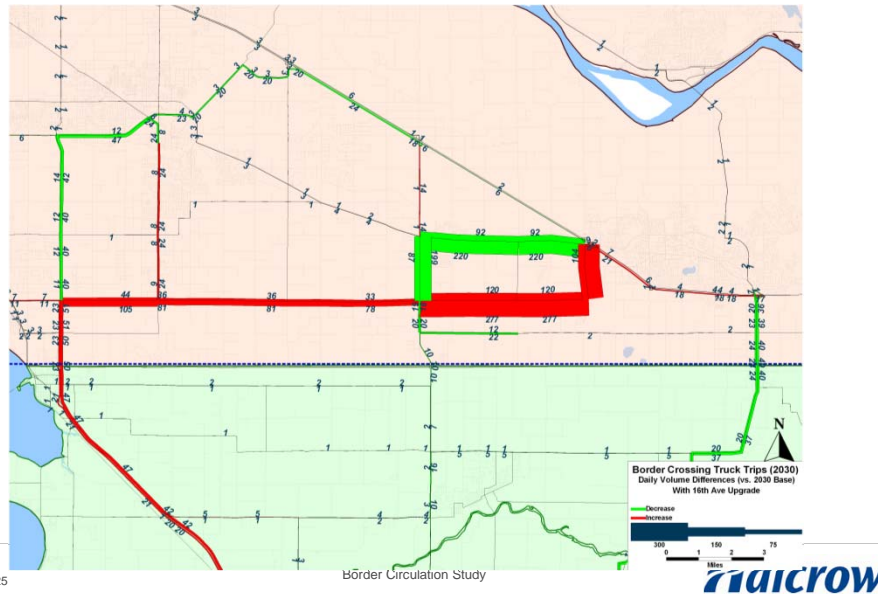
## 2030 Impact of Removing Port Mann Toll

- Significant diversion of trips from Highway 99 to Highway 15



## 2030 Impact of Widening 16<sup>th</sup> Ave

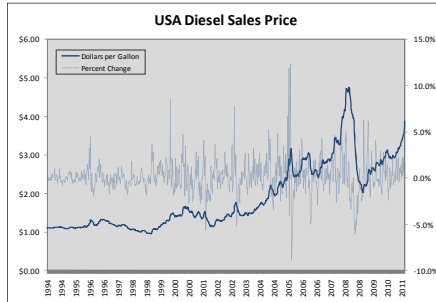
- Diversion of trips from Highway 1 to 16<sup>th</sup> Ave corridor



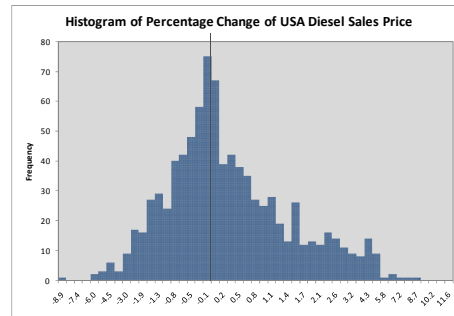
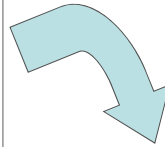
## Sensitivity and Risk Analysis

- Objective is to Identify all the Key Risks
  - - Identify these from Site Visit and Model Results
  - Overall result will provide a measure of reliability of forecasts (+/-)
1. Identify Key Independent Variables
    - Inputs (Land Use, VOT, Socio-Economic Forecasts)
    - Model(s) Ability to Forecast Accurately
    - Uncertainty in Specification, Data Accuracy
  2. How Sensitive are the Forecasts to Changes in Each Variable?
  3. Run the RISK Model (Monte-Carlo Simulation)

## Sensitivity and Risk Analysis - Example



- Slight upside risk on fuel price
- Converts into downside estimate for commodity flow



## Sensitivity and Risk Analysis (cont'd)



PROBABILITY DISTRIBUTION

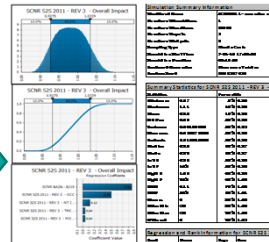
SENSITIVITY RANGES

CONTROL PARAMETERS



Name	Col	Graph	Min	Mean	Max
Variable 1	E16		0.97	0.94	?
Variable 2	C16		0.99	1.10	1.21
Variable 3	E16		1.08	1.08	?
Variable 4	F16		?	1.11	1.12
Variable 5	G16		0.98	1.01	1.04
Variable 6	H16		0.85	1.07	1.14
Variable 7	I16		?	1.02	1.03
Variable 8	J16		0.93	1.00	1.03

RISK MODEL USING MONTE CARLO SIMULATION



MODEL OUTPUT

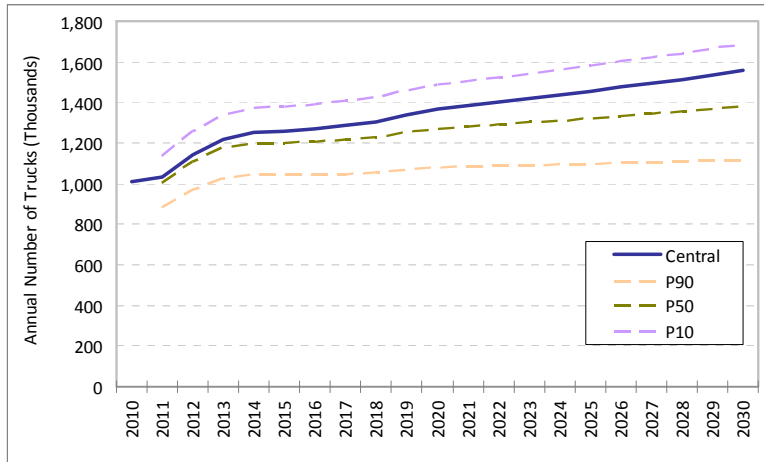
GENERAL DISTRIBUTION

SUMMARY STATISTICS

P90 / P10 / P50 VALUES

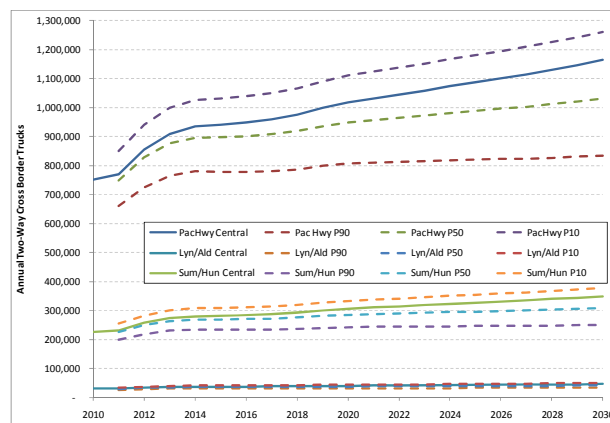
## Sensitivity and Risk Analysis

- More downside risk based on recovery of US housing market



## Sensitivity and Risk Analysis (cont'd)

- Risk ranges by crossing



## Difference Between P50 and Central Case

- 2030 network volume plot



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## Study Conclusions

- Updated freight forecasting tool
  - Useful for strategic and operational planning
- Econometric approach has proven to be effective
  - Based on solid relationship between commodities and explanatory variables
  - Can be easily updated with new information
- Need to collect more detailed data on empties and truck payloads
- Truck volumes forecast to recover to pre-2000 levels with recovery of US housing market and other factors

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