2017 Kate v1.0 Trip-Based Demand Model Validation Report for Base Year 2015

DRAFT VERSION

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1.0   Introduction

The purpose of this document is to outline a performance assessment and validation of Metro's synthesized travel demand model and assignments. The following pages compare results from a year 2015 model run of the *Kate* version of the travel demand model with observed data from the following sources:

- 2010/2011 Oregon Household Activity Survey (OHAS)
  While it is recognized that comparison of model results to survey data doesn't constitute model validation, it is a useful means to confirm that model application code behaves properly
- 2015 American Community Survey (ACS)
- 2014 Longitudinal Employer-Household Dynamics (LEHD) US Census
- 2014 Highway Performance Monitoring System (HPMS)
- 2015 auto and freight counts
- 2015 TriMet transit counts
- 2014 bike counts

Three model classifications are presented. Socioeconomic/demographic models are used to develop key variables for use in trip generation and mode choice. Travel demand models include the traditional trip generation, destination choice, and mode choice models. Finally, the assignment procedure uses pathfinding algorithms to distribute travel demand matrices on the simulated network.

Two 6 sub-regional district aggregations are frequently referenced in this text. The first contains the following districts: Central City, East City and Suburbs (East), Southeast Suburbs (Southeast), Southwest Suburbs (Southwest), West City and Suburbs (West), and Clark County Suburbs (North). The second aggregation limits the Central City district to just the Central Business District (CBD), and adds the remaining Central City zones to the East City and Suburbs district (East+). Figure 2 shows these two district aggregations.

All trip, volume, and ridership data are for the average weekday (AWD) time period unless stated otherwise.

Metro's trip-based model is enhanced to incorporate new data and research findings on a regular basis.

Figure 1: Metro regional model area
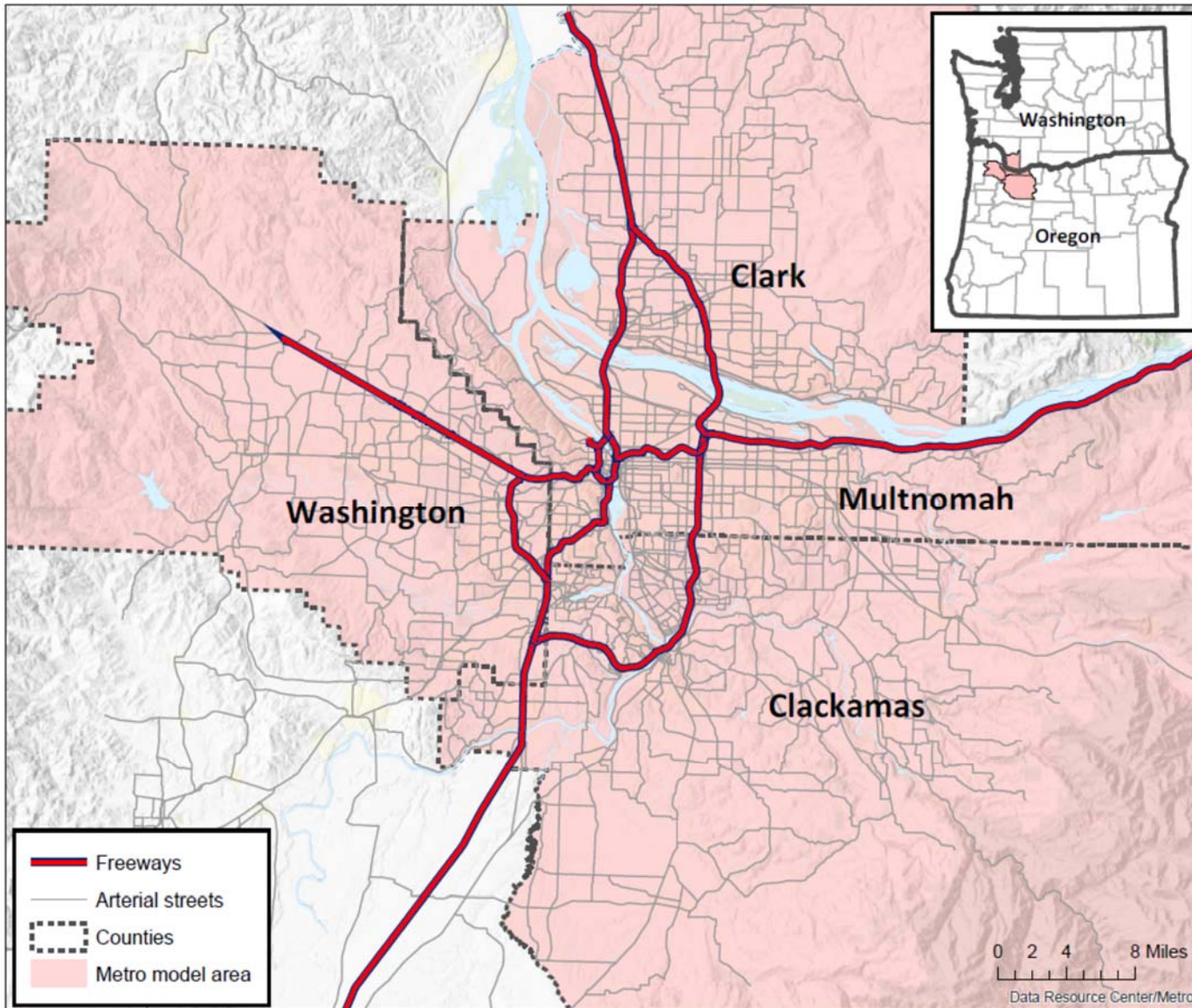
Figure 2: District maps of two aggregations of regional zones used in results comparisons
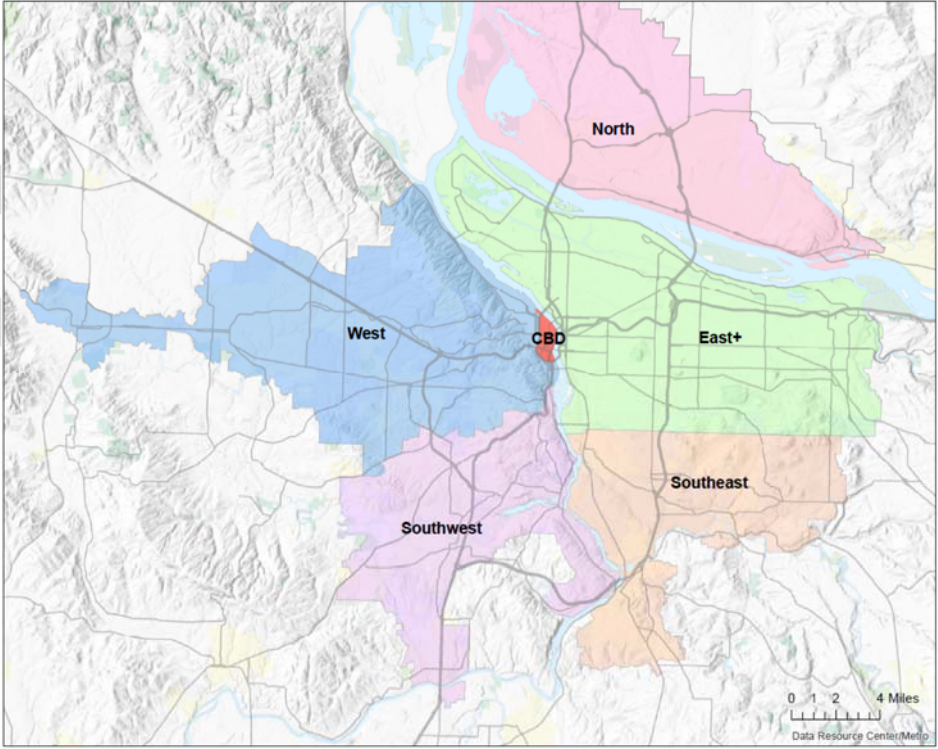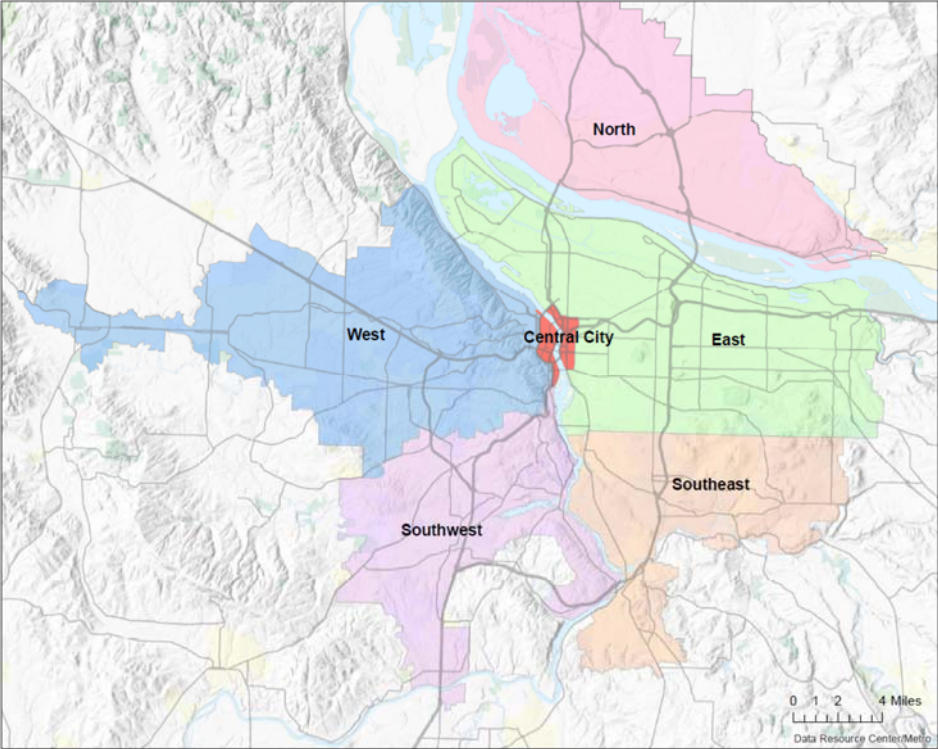
2.0   Regional Snapshot

The model area includes a large portion of the Portland-Vancouver Primary Metropolitan Statistical Area (PMSA) and corresponds to the boundaries of Clackamas, Multnomah, and Washington counties in Oregon and Clark County in Washington.

Table 1 below provides an overview of the region based on input data and data produced by the socioeconomic/demographic models to be discussed in further detail later in this document.

Table 1: Regional snapshot – year 2015

Input	Total Households	850,898
	Average Household Size	2.6
	Total Employment	1,062,954
	Total Retail Employment	119,646
	Total Non-Retail Employment	943,308
Kate Model	Total Workers	972,899
	Total Cars	1,266,867
	Average Workers Per Household	1.1
	Average Cars Per Household	1.5
	Total Vehicle Trips	5,158,239
	Total Person Trips	8,574,505
	Average Vehicle Trips Per Household	6.1
	Average Person Trips Per Household	10.1

3.0   Socioeconomic/Demographic Models

There are several key models in this classification. Tables 2-4 present a comparison of the results of these models and the most recent survey. The child, worker, and auto ownership models are briefly discussed below.

3.1   Child Model

The number of children per household influences school trip generation. Table 2 shows the percentage of households with zero, one, two, or three plus children.

3.2   Worker Model

The number of workers per household influences trip generation across multiple trip purposes. Table 3 presents the percentage of households in each of four worker category.

3.3   Auto Ownership Model

Auto ownership is a key variable for use in the mode choice models. Table 4 shows the percentage of households in each auto ownership category and cross-classification of auto ownership categories by number of workers.

Table 2: Child Model Validation (2015)

Households with:	Kate		Observed*	
	Number of HH	percent	Number of HH	percent
No Children	541,287	63.6%	579,079	69.8%
1 Child	114,613	13.5%	106,700	12.9%
2 Children	143,449	16.9%	96,155	11.6%
3+ Children	51,550	6.1%	46,982	5.7%
Total Households	850,898	100.0%	828,916	100.0%

* from 2015_5yr PUMS

Table 3: Worker Model Validation (2015)

Households with:	Kate		Observed*	
	Number of HH	percent	Number of HH	percent
No Workers	202,322	23.8%	200,806	23.9%
1 Worker	323,071	38.0%	321,367	38.2%
2 Workers	271,761	31.9%	262,988	31.2%
3+ Workers	53,745	6.3%	56,524	6.7%
Total Households	850,898	100.0%	841,685	100.0%

* from ACS_15_1yr_B08203

Table 4: Car Ownership Model Validation (2015)

Households with:	Kate		Observed*	
	Number of HH	percent	Number of HH	percent
0 - Car	69,261	8.1%	72,733	8.6%
1 - Car	309,182	36.3%	282,560	33.6%
2 - Cars	301,274	35.4%	317,748	37.8%
3+ Cars	171,181	20.1%	168,644	20.0%
Total Households	850,898	100.0%	841,685	100.0%

Households with:	Number of HH	percent	Number of HH	percent
No Cars	69,261	8.1%	72,733	8.6%
Cars < Workers	70,900	8.3%	54,461	6.5%
Cars = Workers	316,501	37.2%	335,058	39.8%
Cars > Workers	394,236	46.3%	379,433	45.1%
Total Households	850,898	100.0%	841,685	100.0%

* from ACS_15_1yr_B08203

4.0   Travel Demand Model

The travel demand model consists of several sub-models that determine the number of trips being made, their destinations, and the modes used. This process is completed in the trip generation, destination choice, and mode choice models. The calibration results for each of these modeling steps are outlined below.

4.1   Trip Generation

The number of trips generated by each TAZ is determined in the trip generation model and is a function of unique trip rates applied to various household classifications. Table 5 summarizes the composite trip production rates for each of the following trip purposes:

- Home-based work (HBW)
- Home-based other (HBO)
- Home-based recreation (HBR)
- Home-based shopping (HBS)
- Non-home-based work (NHW)
- Non-home-based non-work (NHNW)
- Home-based college (HBC)

The Kate version of the Metro travel demand model was estimated from the Oregon Household Activity Survey (OHAS), which was conducted during Fall 2010 and Spring 2011. The Kate model is validated for year 2015, which can make a comparison back to 2010/11 difficult. Therefore, Table 5Table 5 also contains model results for a 2010 model year run for Kate.

Total person trips vary from the expanded OHAS dataset, but this is expected since the synthesized population from the OHAS dataset is an estimate. The more important metric is the % of total person trips in each trip purpose, which is closely matched by the 2010 model run, and reasonably close in the 2015 model run.

Table 5: Trip generation by purpose

	# of person trips generated by purpose		
	OHAS 2010/11	**Kate 2010**	**Kate 2015**
HBW	1,090,742	1,243,386	1,445,618
HBO	1,699,885	1,802,050	2,003,621
HBR	534,352	556,145	626,256
HBS	645,945	660,281	718,997
NHW	746,945	937,111	1,089,528
NHNW	1,345,362	1,410,255	1,569,365
HBC	94,571	127,658	137,527
Total	6,157,802	6,736,886	7,590,914

	% of total person trips generated by purpose		
	OHAS 2010/11	**Kate 2010**	**Kate 2015**
HBW	18%	18%	19%
HBO	28%	27%	26%
HBR	9%	8%	8%
HBS	10%	10%	9%
NHW	12%	14%	14%
NHNW	22%	21%	21%
HBC	2%	2%	2%

4.2   Destination Choice

The destination choice model includes an algorithm used to distribute productions to alternative destinations. The accuracy of this model was evaluated by reviewing trip length frequency distributions and origin-destination patterns. Table 6 contains a comparison of trip lengths by trip purpose.

Trip length frequency histograms were prepared for each trip purpose, comparing weighted trip lengths (by distance). These curves are displayed in Figure 3. While a reasonable match can be observed between the model and survey curves, several recurring discrepancies can be noted. The model frequently underestimates the number of very short trips due to the fact that it functions in aggregate at the TAZ level. As a result, times and distances are subject to TAZ size, which creates a minimum distance within and between even the smallest zones that exceeds many trip distances in the OHAS data set. Survey information is taken from digitized data from which "door-to-door" times and distances can be calculated, meaning that no artificial minimum is set.

Table 7 contains a comparison of district-to-district movements (based on the districts shown in Figure 2) of home-based work trips from the model against 2014 LEHD data. For most district movements, there is a very close match between the model and the validation dataset.

Table 6: Trip length comparison by purpose

	Average trip length (miles) by purpose			
	OHAS 2010/11	Kate 2015	Diff (Kate - OHAS)	% diff from OHAS
HBW	9.1	9.1	0.0	0%
HBW - Low	*7.5*	7.8	*0.3*	*3%*
HBW - Medium	*9.1*	9.2	*0.1*	*1%*
HBW - High	*9.7*	9.2	*-0.5*	*-5%*
HBC	8.0	8.8	0.8	10%
HBS	3.7	4.5	0.8	22%
HBR	4.8	4.7	-0.1	-2%
HBO	5.2	6.0	0.8	15%
NHW	6.0	5.1	-0.9	-15%
NHNW	4.2	4.1	-0.1	-3%
School	3.0	2.5	-0.5	-17%
All Purposes*	5.7	5.9	0.2	4%

*no school trips

Figure 3: Trip length frequency by trip purpose (miles)

Home Based Work – All Income

Home Based Work – Low Income

Home Based Work – Middle Income

Home Based Work – High Income
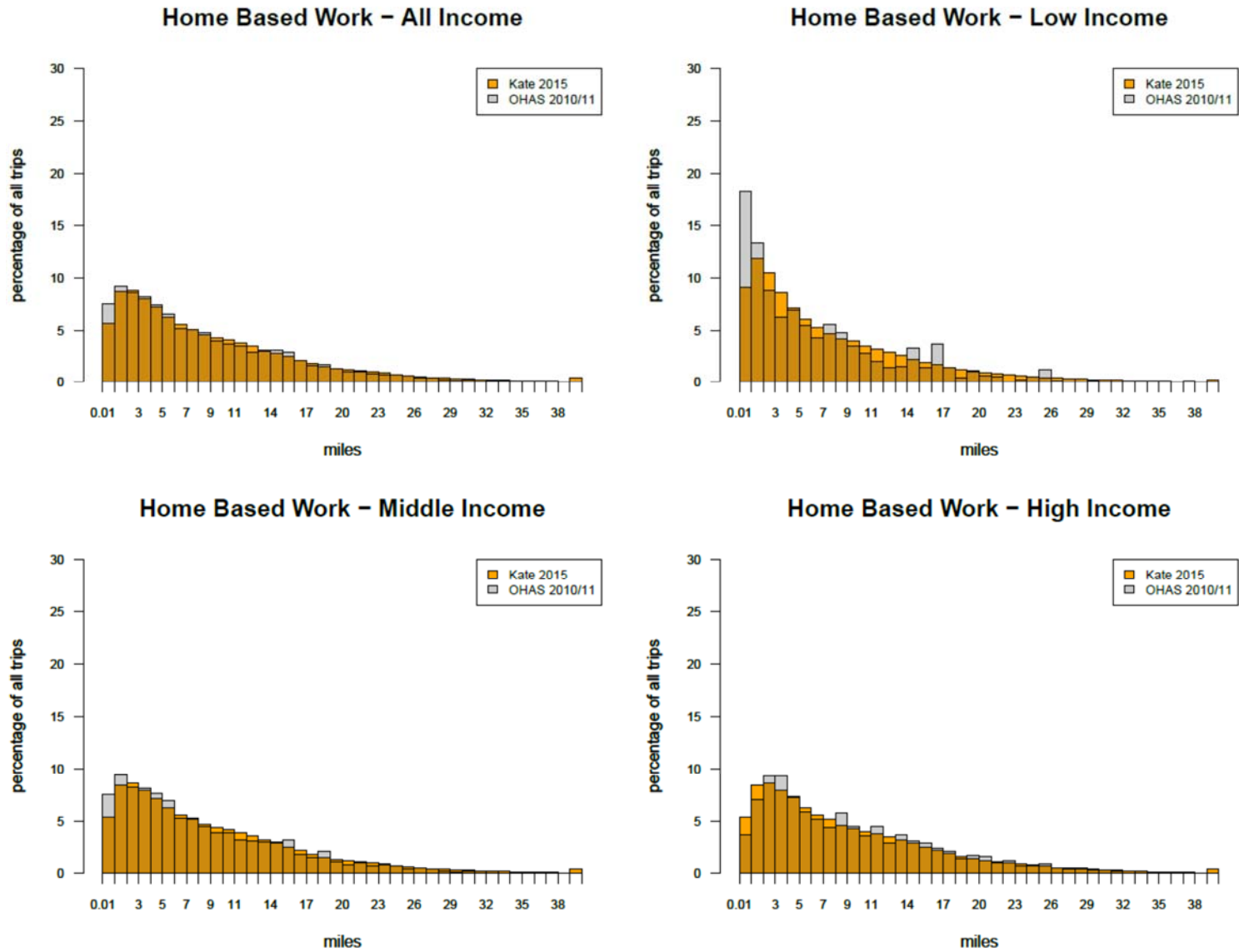
Figure 3 cont'd: Trip length frequency by trip purpose (miles)
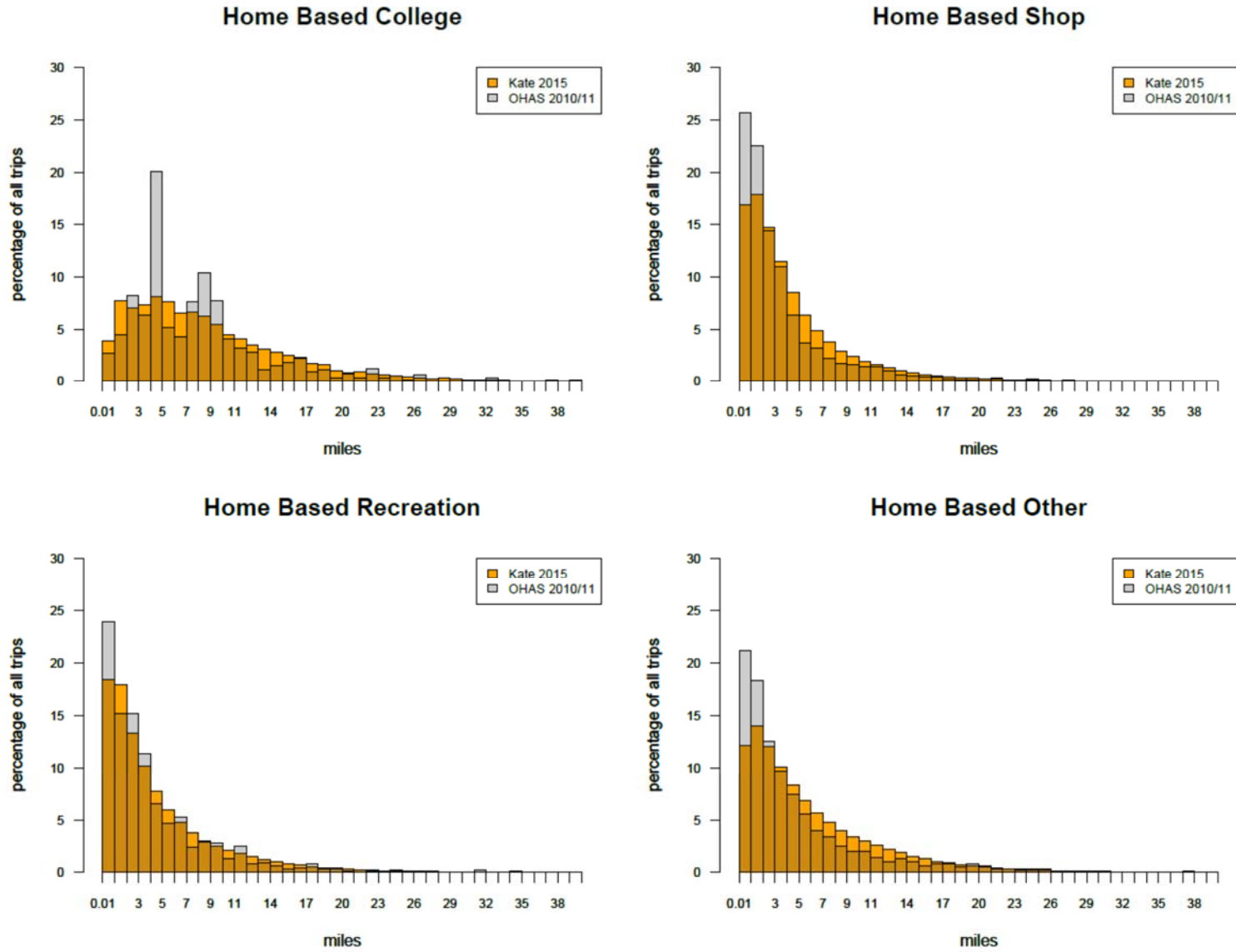
Figure 3 cont'd: Trip length frequency by trip purpose (miles)
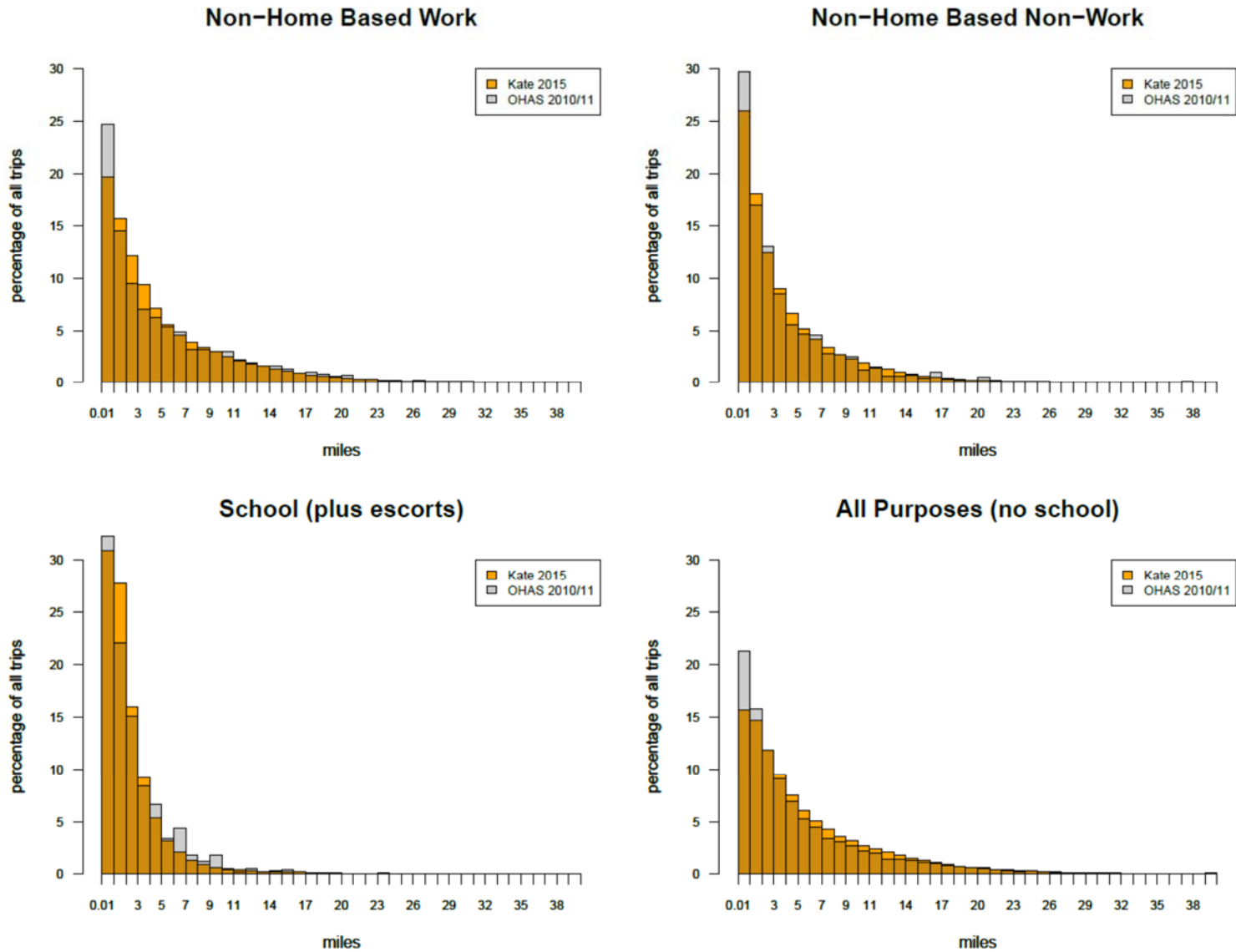
Table 7: Distribution of home based work trips

		Home based work trip distribution		
		LEHD 2014	**Kate 2015**	**Point difference (Kate - LEHD)**
Central City to:				
	Central City	34%	43%	9
	East	20%	23%	3
	Southeast	4%	3%	-1
	Southwest	11%	8%	-3
	West	29%	22%	-6
	North	2%	1%	-1
East to:				
	Central City	20%	20%	0
	East	44%	48%	4
	Southeast	8%	7%	0
	Southwest	9%	7%	-1
	West	17%	16%	-1
	North	3%	2%	-1
West to:				
	Central City	13%	12%	-1
	East	14%	13%	0
	Southeast	4%	3%	0
	Southwest	15%	14%	-1
	West	53%	56%	3
	North	1%	1%	0
North to:				
	Central City	7%	7%	0
	East	20%	17%	-3
	Southeast	3%	2%	-1
	Southwest	4%	3%	0
	West	8%	8%	0
	North	57%	62%	5
CBD from:				
	East+	45%	49%	3
	Southeast	8%	8%	1
	Southwest	14%	9%	-4
	West	26%	24%	-2
	North	7%	9%	2

Table 7 cont'd: Distribution of home based work trips

		Home based work trip distribution		
		LEHD 2014	**Kate 2015**	**Point difference (Kate - LEHD)**
Southeast to:				
	Central City	12%	13%	0
	East	29%	21%	-8
	Southeast	29%	37%	8
	Southwest	15%	14%	0
	West	14%	13%	0
	North	2%	1%	0
Southwest to:				
	Central City	14%	10%	-4
	East	15%	13%	-2
	Southeast	7%	8%	1
	Southwest	36%	48%	12
	West	26%	19%	-7
	North	1%	1%	0

4.3   Mode Choice

Modal accessibility functions measure the utility of choosing one of nine discrete modes for each trip purpose:

- Drive alone (SOV)
- Drive with passenger (HOV)
- Passenger in car (HOV passenger)
- Walk to transit
- Drive to transit (Park & Ride)
- Walk
- Bike

It should be noted that the park-and-ride mode is not available for the two non-home trip purposes (NHW, NHNW) and, additionally, that the school trip purpose (SCH) includes an exclusive school bus mode.

The transit modes include service provided by Tri-Met (Oregon), C-Tran (Washington), and several agencies providing limited service in outlying areas. For Portland, intra-CBD movements are included even though little is known about the true patterns occurring in this area.

Table 8 summarizes the regional mode split by trip purpose, comparing model results to survey data.

Figure 4 shows trip length histograms for each of the trip purposes. The same pattern exists with these histograms as those described in the previous section – lengths closely match between the model and validation data, with some exceptions for short trips. This can again be ascribed to the limitations of TAZ size influencing shortest trips allowed in the model.

Table 8: Mode split summary

		OHAS 2010/11	Kate 2015			OHAS 2010/11	Kate 2015
HBW	SOV drive	70.6%	70.8%	**HBC**	SOV drive	53.5%	54.4%
	HOV drive	3.9%	4.2%		HOV drive	2.9%	4.1%
	HOV passenger	5.0%	5.5%		HOV passenger	11.7%	12.4%
	Transit walk	8.1%	7.1%		Transit walk	17.5%	14.0%
	Transit drive	3.40%	2.40%		Transit drive	4.91%	2.84%
	Bike	4.7%	6.0%		Bike	4.6%	6.0%
	Walk	4.3%	4.0%		Walk	4.8%	6.2%
	Total share	17.5%	16.9%		**Total share**	1.4%	1.6%
HBO	SOV drive	34.5%	35.7%	**HBR**	SOV drive	27.5%	27.6%
	HOV drive	23.3%	26.3%		HOV drive	18.1%	19.5%
	HOV passenger	28.2%	27.1%		HOV passenger	33.7%	33.0%
	Transit walk	2.7%	1.8%		Transit walk	2.8%	2.5%
	Transit drive	0.24%	0.10%		Transit drive	0.15%	0.08%
	Bike	1.6%	2.0%		Bike	3.7%	4.6%
	Walk	9.5%	7.0%		Walk	14.1%	12.7%
	Total share	25.3%	23.4%		**Total share**	7.6%	7.3%
HBS	SOV drive	43.8%	45.1%	**School**	Vehicle	4.3%	21.9%
	HOV drive	16.1%	18.0%		HOV passenger	35.9%	32.6%
	HOV passenger	23.4%	23.7%		Transit walk	2.0%	1.9%
	Transit walk	4.0%	3.2%		Bike	2.4%	2.9%
	Transit drive	0.03%	0.03%		Walk	14.2%	13.4%
	Bike	2.9%	3.3%		Bus	41.1%	27.2%
	Walk	9.7%	6.7%		**Total share**	8.8%	11.5%
	Total share	9.4%	8.4%				
NHW	SOV drive	68.8%	69.6%	**NHNW**	SOV drive	33.5%	34.8%
	HOV drive	8.1%	8.5%		HOV drive	24.1%	24.8%
	HOV passenger	6.6%	6.4%		HOV passenger	30.7%	29.3%
	Transit walk	2.7%	1.6%		Transit walk	2.2%	1.7%
	Bike	2.2%	2.9%		Bike	1.5%	1.9%
	Walk	11.6%	11.0%		Walk	8.1%	7.5%
	Total share	10.8%	12.7%		**Total share**	19.3%	18.3%

Table 8 cont'd: Mode split summary

		OHAS 2010/11	Kate 2015
All Trip Purposes (including school)	**SOV drive**	41.9%	42.2%
	HOV drive	15.4%	18.0%
	HOV passenger	22.7%	21.8%
	Transit walk	3.8%	3.0%
	Transit drive	0.7%	0.5%
	Bike	2.6%	3.2%
	Walk	9.2%	8.2%
	School bus	3.6%	3.1%
	Total vehicles (SOV + HOV)	57.3%	60.2%
	Total transit trips	4.6%	3.5%
	Total active trips (Walk + Bike)	11.8%	11.5%
	Total person trips	100.0%	100.0%

Figure 4: Trip length frequency by mode (miles)
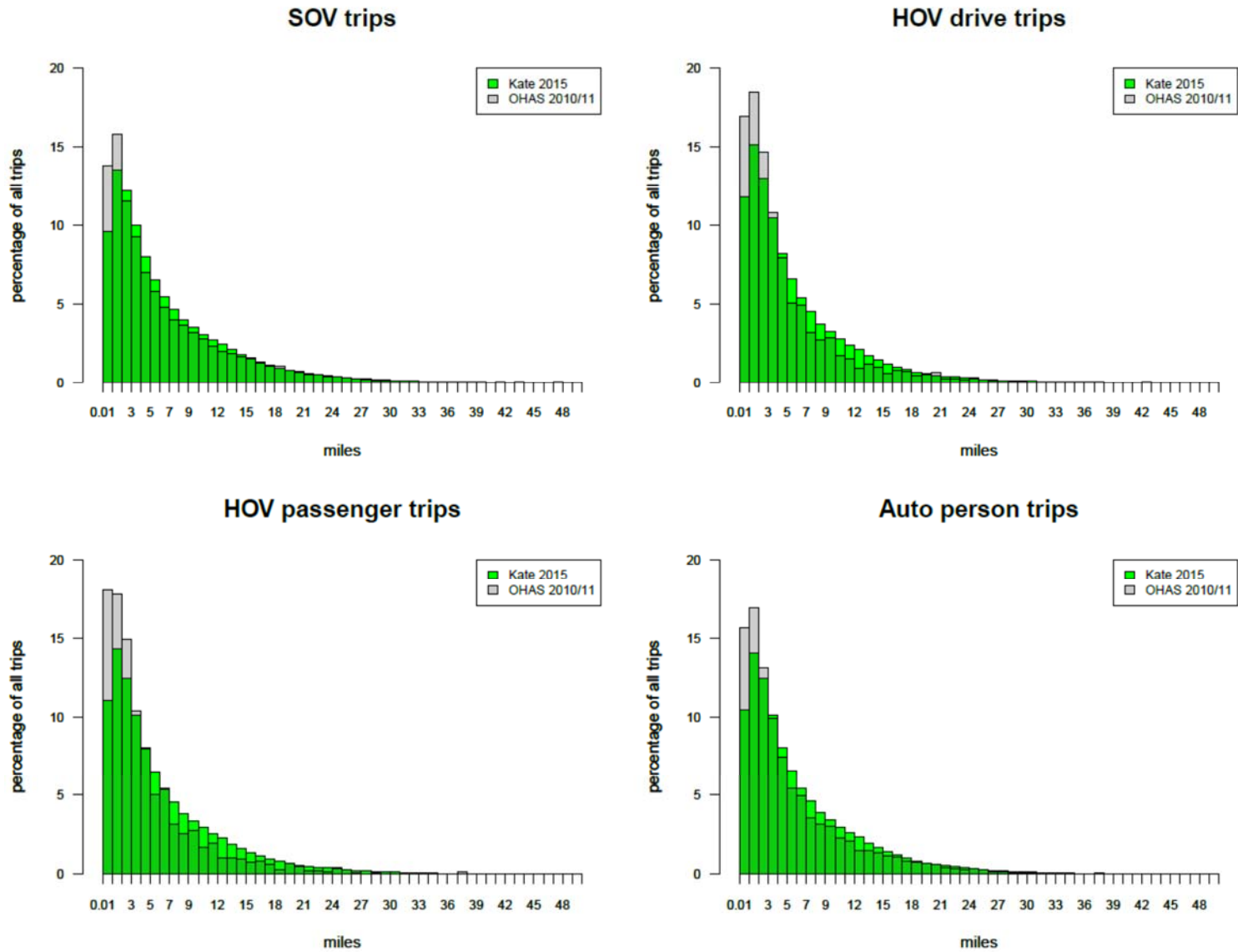
Figure 4 cont'd: Trip length frequency by mode (miles)

Figure 4 cont'd: Trip length frequency by mode (miles)

Bike trips

Walk trips

Active transport trips
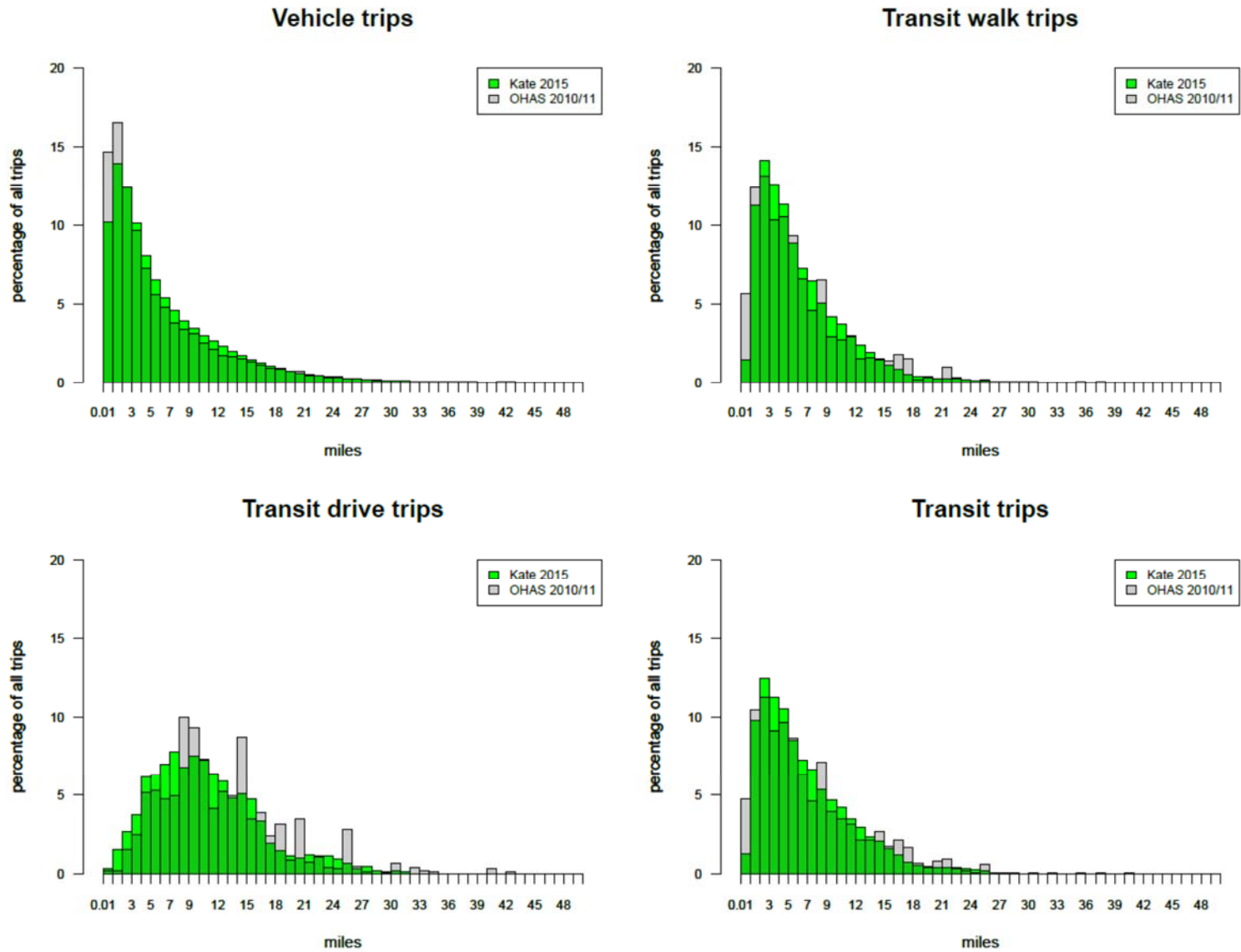
Person trips
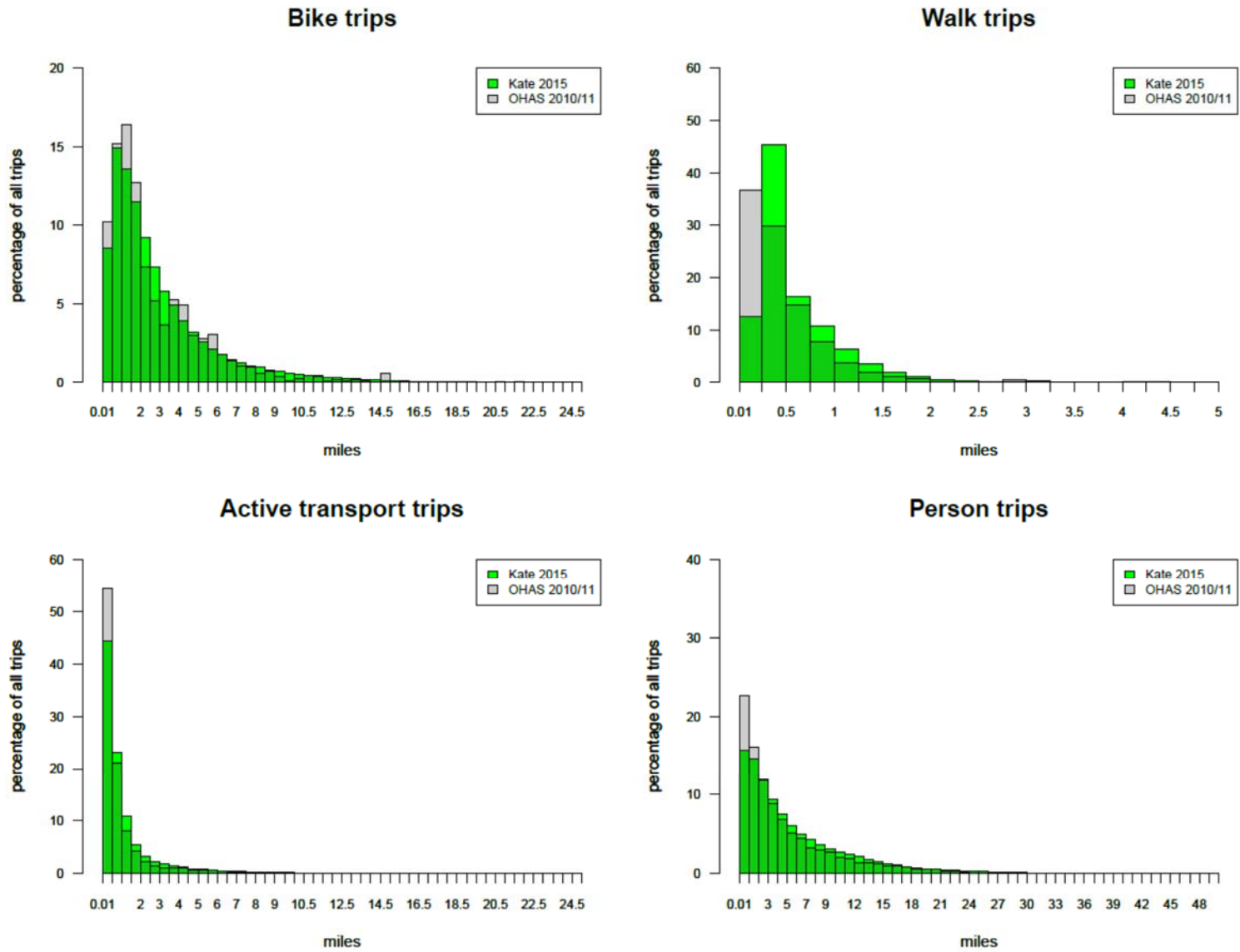
5.0   Assignment

The assignment is validated by comparing model flows to count data.

5.1   Auto Assignment Summary Results

The root mean squared error (RMSE) is a statistical measure of accuracy used to compare observed to reference data, in this case modeled volumes to traffic counts. Table 9 contains RMSE for the average weekday, PM 2-hr and AM 2-hr peak periods. Federal Highway Administration (FHWA) literature suggests that an aggregate percent RMSE below 30 percent is acceptable. With the exception of AM 2-hr peak period Arterials, all categories in Table 9 meet this criteria.

Table 10 is a shows that modeled vehicle miles traveled (VMT) on the auto/truck network very closely matches the estimate of VMT from HPMS at both regional and sub-regional levels.

Figure 5 displays the cutline/screenline locations used to validate the auto assignment.

Figure 6: Diurnal count profile across all cutlines (% of daily counts per hour)

Table 11: Key cutline comparisons – Average Weekday

Cutline	South/West				North/East			
	Kate Volumes	Counts	Difference Kate - Counts	% Δ from Counts	Kate Volumes	Counts	Difference Kate - Counts	% Δ from Counts
R-02 : Willamette River - No Broadway Bridge count in 2015								
207 (26-027): FREMONT BRIDGE (nb & sb)	87,275	80,029	7,246	9%	83,506	71,264	12,242	17%
208: BROADWAY BRIDGE (nb & sb)	****	****	****	****	****	****	****	****
209: STEEL BRIDGE (eb & wb)	14,566	9,560	5,006	52%	13,067	7,724	5,343	69%
210: BURNSIDE BRIDGE (eb & wb)	22,625	15,557	7,068	45%	28,688	18,924	9,764	52%
211: MORRISON BRIDGE (eb & wb)	26,964	28,927	-1,963	-7%	22,591	23,661	-1,070	-5%
212: HAWTHORNE BRIDGE (eb & wb)	23,651	15,032	8,619	57%	19,405	17,986	1,419	8%
213 (26-026): MARQUAM BRIDGE (US I-5) (nb & sb)	91,240	64,249	26,991	42%	98,232	78,348	19,884	25%
214: ROSS ISLAND BRIDGE (eb & wb)	40,188	35,777	4,411	12%	37,690	32,680	5,010	15%
Cutline Summary:	**306,509**	**249,132**	**57,377**	**23%**	**303,179**	**250,587**	**52,592**	**21%**
R-05 & R-07 : Columbia River								
218 (26-004): US I-5 BRIDGE, n/o Hayden Island (nb & sb)	81,134	69,275	11,859	17%	76,513	68,188	8,325	12%
220 (26-024): US I-205 BRIDGE (Glenn Jackson Bridge) (nb & sb)	77,626	80,367	-2,741	-3%	71,601	81,371	-9,770	-12%
Total Columbia River Crossings	**158,760**	**149,642**	**9,118**	**6%**	**148,114**	**149,559**	**-1,445**	**-1%**
W-07 : West Hills								
285: NW CORNELL ROAD (eb & wb)	6,271	3,120	3,151	101%	7,238	4,567	2,671	58%
286: W BURNSIDE ROAD (eb & wb)	12,021	9,698	2,323	24%	13,592	9,560	4,032	42%
288 (26-002): HWY 26 (Sunset), e/o Zoo Rd Interchange (eb & wb)	106,111	86,736	19,375	22%	99,353	82,350	17,003	21%
289: SW PATTON ROAD (eb & wb)	2,924	3,723	-799	-21%	3,657	4,646	-989	-21%
290: SW TALBOT ROAD (eb & wb)	1,622	2,242	-620	-28%	2,136	1,850	286	15%
Cutline Summary:	**128,949**	**105,519**	**23,430**	**22%**	**125,976**	**102,973**	**23,003**	**22%**

Table 12: Key cutline comparisons – PM2 (4pm - 6pm)

Cutline	South/West				North/East			
	Kate Volumes	Counts	Difference Kate - Counts	% Δ from Counts	Kate Volumes	Counts	Difference Kate - Counts	% Δ from Counts
R-02 : Willamette River - No Broadway Bridge count in 2015								
207 (26-027): FREMONT BRIDGE (nb & sb)	10,666	8,960	1,706	19%	12,105	9,029	3,076	34%
208: BROADWAY BRIDGE (nb & sb)	****	****	****	****	****	****	****	****
209: STEEL BRIDGE (eb & wb)	2,134	1,960	174	9%	2,654	1,634	1,020	62%
210: BURNSIDE BRIDGE (eb & wb)	3,026	2,137	889	42%	4,554	3,780	774	20%
211: MORRISON BRIDGE (eb & wb)	3,315	3,315	0	0%	3,886	5,279	-1,393	-26%
212: HAWTHORNE BRIDGE (eb & wb)	3,284	2,188	1,096	50%	3,755	4,150	-395	-10%
213 (26-026): MARQUAM BRIDGE (US I-5) (nb & sb)	11,009	8,115	2,894	36%	12,899	7,772	5,127	66%
214: ROSS ISLAND BRIDGE (eb & wb)	4,826	4,387	439	10%	5,686	5,989	-303	-5%
Cutline Summary:	**38,260**	**31,062**	**7,198**	**23%**	**45,539**	**37,633**	**7,906**	**21%**
R-05 & R-07 : Columbia River								
218 (26-004): US I-5 BRIDGE, n/o Hayden Island (nb & sb)	8,801	8,074	727	9%	12,109	10,147	1,962	19%
220 (26-024): US I-205 BRIDGE (Glenn Jackson Bridge) (nb & sb)	8,114	9,121	-1,007	-11%	13,795	14,134	-339	-2%
Total Columbia River Crossings	**16,915**	**17,195**	**-280**	**-2%**	**25,904**	**24,281**	**1,623**	**7%**
W-07 : West Hills								
285: NW CORNELL ROAD (eb & wb)	1,124	955	169	18%	1,119	817	302	37%
286: W BURNSIDE ROAD (eb & wb)	2,121	2,278	-157	-7%	2,137	1,682	455	27%
288 (26-002): HWY 26 (Sunset), e/o Zoo Rd Interchange (eb & wb)	13,598	12,480	1,118	9%	12,364	10,008	2,356	24%
289: SW PATTON ROAD (eb & wb)	768	759	9	1%	682	833	-151	-18%
290: SW TALBOT ROAD (eb & wb)	491	750	-259	-35%	174	275	-101	-37%
Cutline Summary:	**18,102**	**17,222**	**880**	**5%**	**16,476**	**13,615**	**2,861**	**21%**

Table 13: Key cutline comparisons – AM2 (7am – 9am)

Cutline	South/West				North/East			
	Kate Volumes	Counts	Difference Kate - Counts	% Δ from Counts	Kate Volumes	Counts	Difference Kate - Counts	% Δ from Counts
R-02 : Willamette River - No Broadway Bridge count in 2015								
207 (26-027): FREMONT BRIDGE (nb & sb)	12,916	11,343	1,573	14%	9,781	8,540	1,241	15%
208: BROADWAY BRIDGE (nb & sb)	****	****	****	****	****	****	****	****
209: STEEL BRIDGE (eb & wb)	2,518	1,688	830	49%	1,706	801	905	113%
210: BURNSIDE BRIDGE (eb & wb)	3,780	2,794	986	35%	3,133	1,625	1,508	93%
211: MORRISON BRIDGE (eb & wb)	3,950	5,603	-1,653	-30%	2,093	1,526	567	37%
212: HAWTHORNE BRIDGE (eb & wb)	3,795	3,086	709	23%	2,598	1,778	820	46%
213 (26-026): MARQUAM BRIDGE (US I-5) (nb & sb)	11,620	9,265	2,355	25%	11,430	10,723	707	7%
214: ROSS ISLAND BRIDGE (eb & wb)	5,650	6,139	-489	-8%	4,217	3,190	1,027	32%
Cutline Summary:	**44,229**	**39,918**	**4,311**	**11%**	**34,958**	**28,183**	**6,775**	**24%**
R-05 & R-07 : Columbia River								
218 (26-004): US I-5 BRIDGE, n/o Hayden Island (nb & sb)	13,094	9,459	3,635	38%	7,857	6,177	1,680	27%
220 (26-024): US I-205 BRIDGE (Glenn Jackson Bridge) (nb & sb)	15,547	12,908	2,639	20%	7,314	7,375	-61	-1%
Total Columbia River Crossings	**28,641**	**22,367**	**6,274**	**28%**	**15,171**	**13,552**	**1,619**	**12%**
W-07 : West Hills								
285: NW CORNELL ROAD (eb & wb)	912	272	640	235%	1,134	1,498	-364	-24%
286: W BURNSIDE ROAD (eb & wb)	1,729	1,174	555	47%	2,345	1,967	378	19%
288 (26-002): HWY 26 (Sunset), e/o Zoo Rd Interchange (eb & wb)	12,898	11,508	1,390	12%	12,753	11,478	1,275	11%
289: SW PATTON ROAD (eb & wb)	360	426	-66	-15%	812	1,047	-235	-22%
290: SW TALBOT ROAD (eb & wb)	108	309	-201	-65%	598	504	94	19%
Cutline Summary:	**16,007**	**13,689**	**2,318**	**17%**	**17,642**	**16,494**	**1,148**	**7%**

Table 14 shows the average weekday (AWD) and PM peak counts and assigned volumes. Figure 6 contains a comparison of the total traffic counts and model volume across all cutlines for each hour of the day. While there are certainly sub-regional differences in diurnal patterns for each cutline, the totals shown in this figure validate that the model is doing a relatively good job of reflecting overall regional diurnal allocation of traffic to the network, with the size and width of both the AM and PM peaks in model volume closely resembling those of the count data.

Tables 11-16 show cutline level comparisons of model data against count data for Average Weekday (AWD), PM 2-hr peak period (4pm-6pm), and AM 2-hr peak period (7am-9am). Tables 11-13 show three specific cutlines in detail. These cutlines represent major regional movements that can be calibrated within the destination choice model. Tables 14-16 and Figures 7-9 show all cutlines in the region, as well as plots of the volumes-to-counts comparisons and R^2 values.

Table 9: Root mean squared error (RMSE) for assigned traffic volumes across Tier 1 cutlines

	Average Weekday	PM2 (4pm-6pm)	AM2 (7am-9am)
Highway Summary			
(M-C)^2	2,315,293,774	76,257,514	24,243,254
N	38	38	38
Sum(counts)	2,273,549	295,314	288,357
% RMSE	**13**	**18**	**11**
Arterial Summary			
(M-C)^2	820,039,082	20,581,207	20,657,250
N	158	158	158
Sum(counts)	1,323,756	223,929	183,578
% RMSE	**27**	**26**	**31**

Table 10: Highway Performance Monitoring System (HPMS) Vehicle Miles Traveled (VMT)

	HPMS 2014	Kate 2015	Difference
OR + WA VMT	**36,240,086**	**36,292,558**	**0.14%**
OR VMT	**29,698,086**	29,814,732	0.39%
WA VMT	**6,542,000**	6,477,825	-0.98%

Figure 5: Tier 1 auto cutline locations

Figure 6: Diurnal count profile across all cutlines (% of daily counts per hour)

Table 11: Key cutline comparisons – Average Weekday

Cutline	South/West				North/East			
	Kate Volumes	Counts	Difference Kate - Counts	% Δ from Counts	Kate Volumes	Counts	Difference Kate - Counts	% Δ from Counts
R-02 : Willamette River - No Broadway Bridge count in 2015								
207 (26-027): FREMONT BRIDGE (nb & sb)	87,275	80,029	7,246	9%	83,506	71,264	12,242	17%
208: BROADWAY BRIDGE (nb & sb)	****	****	****	****	****	****	****	****
209: STEEL BRIDGE (eb & wb)	14,566	9,560	5,006	52%	13,067	7,724	5,343	69%
210: BURNSIDE BRIDGE (eb & wb)	22,625	15,557	7,068	45%	28,688	18,924	9,764	52%
211: MORRISON BRIDGE (eb & wb)	26,964	28,927	-1,963	-7%	22,591	23,661	-1,070	-5%
212: HAWTHORNE BRIDGE (eb & wb)	23,651	15,032	8,619	57%	19,405	17,986	1,419	8%
213 (26-026): MARQUAM BRIDGE (US I-5) (nb & sb)	91,240	64,249	26,991	42%	98,232	78,348	19,884	25%
214: ROSS ISLAND BRIDGE (eb & wb)	40,188	35,777	4,411	12%	37,690	32,680	5,010	15%
Cutline Summary:	**306,509**	**249,132**	**57,377**	**23%**	**303,179**	**250,587**	**52,592**	**21%**
R-05 & R-07 : Columbia River								
218 (26-004): US I-5 BRIDGE, n/o Hayden Island (nb & sb)	81,134	69,275	11,859	17%	76,513	68,188	8,325	12%
220 (26-024): US I-205 BRIDGE (Glenn Jackson Bridge) (nb & sb)	77,626	80,367	-2,741	-3%	71,601	81,371	-9,770	-12%
Total Columbia River Crossings	**158,760**	**149,642**	**9,118**	**6%**	**148,114**	**149,559**	**-1,445**	**-1%**
W-07 : West Hills								
285: NW CORNELL ROAD (eb & wb)	6,271	3,120	3,151	101%	7,238	4,567	2,671	58%
286: W BURNSIDE ROAD (eb & wb)	12,021	9,698	2,323	24%	13,592	9,560	4,032	42%
288 (26-002): HWY 26 (Sunset), e/o Zoo Rd Interchange (eb & wb)	106,111	86,736	19,375	22%	99,353	82,350	17,003	21%
289: SW PATTON ROAD (eb & wb)	2,924	3,723	-799	-21%	3,657	4,646	-989	-21%
290: SW TALBOT ROAD (eb & wb)	1,622	2,242	-620	-28%	2,136	1,850	286	15%
Cutline Summary:	**128,949**	**105,519**	**23,430**	**22%**	**125,976**	**102,973**	**23,003**	**22%**

Table 12: Key cutline comparisons – PM2 (4pm - 6pm)

Cutline	South/West				North/East			
	Kate Volumes	Counts	Difference Kate - Counts	% Δ from Counts	Kate Volumes	Counts	Difference Kate - Counts	% Δ from Counts
R-02 : Willamette River - No Broadway Bridge count in 2015								
207 (26-027): FREMONT BRIDGE (nb & sb)	10,666	8,960	1,706	19%	12,105	9,029	3,076	34%
208: BROADWAY BRIDGE (nb & sb)	****	****	****	****	****	****	****	****
209: STEEL BRIDGE (eb & wb)	2,134	1,960	174	9%	2,654	1,634	1,020	62%
210: BURNSIDE BRIDGE (eb & wb)	3,026	2,137	889	42%	4,554	3,780	774	20%
211: MORRISON BRIDGE (eb & wb)	3,315	3,315	0	0%	3,886	5,279	-1,393	-26%
212: HAWTHORNE BRIDGE (eb & wb)	3,284	2,188	1,096	50%	3,755	4,150	-395	-10%
213 (26-026): MARQUAM BRIDGE (US I-5) (nb & sb)	11,009	8,115	2,894	36%	12,899	7,772	5,127	66%
214: ROSS ISLAND BRIDGE (eb & wb)	4,826	4,387	439	10%	5,686	5,989	-303	-5%
Cutline Summary:	**38,260**	**31,062**	**7,198**	**23%**	**45,539**	**37,633**	**7,906**	**21%**
R-05 & R-07 : Columbia River								
218 (26-004): US I-5 BRIDGE, n/o Hayden Island (nb & sb)	8,801	8,074	727	9%	12,109	10,147	1,962	19%
220 (26-024): US I-205 BRIDGE (Glenn Jackson Bridge) (nb & sb)	8,114	9,121	-1,007	-11%	13,795	14,134	-339	-2%
Total Columbia River Crossings	**16,915**	**17,195**	**-280**	**-2%**	**25,904**	**24,281**	**1,623**	**7%**
W-07 : West Hills								
285: NW CORNELL ROAD (eb & wb)	1,124	955	169	18%	1,119	817	302	37%
286: W BURNSIDE ROAD (eb & wb)	2,121	2,278	-157	-7%	2,137	1,682	455	27%
288 (26-002): HWY 26 (Sunset), e/o Zoo Rd Interchange (eb & wb)	13,598	12,480	1,118	9%	12,364	10,008	2,356	24%
289: SW PATTON ROAD (eb & wb)	768	759	9	1%	682	833	-151	-18%
290: SW TALBOT ROAD (eb & wb)	491	750	-259	-35%	174	275	-101	-37%
Cutline Summary:	**18,102**	**17,222**	**880**	**5%**	**16,476**	**13,615**	**2,861**	**21%**

Table 13: Key cutline comparisons – AM2 (7am – 9am)

Cutline	South/West				North/East			
	Kate Volumes	Counts	Difference Kate - Counts	% Δ from Counts	Kate Volumes	Counts	Difference Kate - Counts	% Δ from Counts
R-02 : Willamette River - No Broadway Bridge count in 2015								
207 (26-027): FREMONT BRIDGE (nb & sb)	12,916	11,343	1,573	14%	9,781	8,540	1,241	15%
208: BROADWAY BRIDGE (nb & sb)	****	****	****	****	****	****	****	****
209: STEEL BRIDGE (eb & wb)	2,518	1,688	830	49%	1,706	801	905	113%
210: BURNSIDE BRIDGE (eb & wb)	3,780	2,794	986	35%	3,133	1,625	1,508	93%
211: MORRISON BRIDGE (eb & wb)	3,950	5,603	-1,653	-30%	2,093	1,526	567	37%
212: HAWTHORNE BRIDGE (eb & wb)	3,795	3,086	709	23%	2,598	1,778	820	46%
213 (26-026): MARQUAM BRIDGE (US I-5) (nb & sb)	11,620	9,265	2,355	25%	11,430	10,723	707	7%
214: ROSS ISLAND BRIDGE (eb & wb)	5,650	6,139	-489	-8%	4,217	3,190	1,027	32%
Cutline Summary:	**44,229**	**39,918**	**4,311**	**11%**	**34,958**	**28,183**	**6,775**	**24%**
R-05 & R-07 : Columbia River								
218 (26-004): US I-5 BRIDGE, n/o Hayden Island (nb & sb)	13,094	9,459	3,635	38%	7,857	6,177	1,680	27%
220 (26-024): US I-205 BRIDGE (Glenn Jackson Bridge) (nb & sb)	15,547	12,908	2,639	20%	7,314	7,375	-61	-1%
Total Columbia River Crossings	**28,641**	**22,367**	**6,274**	**28%**	**15,171**	**13,552**	**1,619**	**12%**
W-07 : West Hills								
285: NW CORNELL ROAD (eb & wb)	912	272	640	235%	1,134	1,498	-364	-24%
286: W BURNSIDE ROAD (eb & wb)	1,729	1,174	555	47%	2,345	1,967	378	19%
288 (26-002): HWY 26 (Sunset), e/o Zoo Rd Interchange (eb & wb)	12,898	11,508	1,390	12%	12,753	11,478	1,275	11%
289: SW PATTON ROAD (eb & wb)	360	426	-66	-15%	812	1,047	-235	-22%
290: SW TALBOT ROAD (eb & wb)	108	309	-201	-65%	598	504	94	19%
Cutline Summary:	**16,007**	**13,689**	**2,318**	**17%**	**17,642**	**16,494**	**1,148**	**7%**

Table 14: Auto cutline comparison – Average Weekday

	Cutline	Kate	Count	Difference		Cutline	Kate	Count	Difference
South/West	E-09	180,565	198,593	-9%	**North/East**	E-09	178,200	191,821	-7%
	E-16	128,931	126,973	2%		E-16	124,338	117,958	5%
	E-21	147,366	152,016	-3%		E-21	148,171	148,797	0%
	E-27	96,159	91,167	5%		E-27	96,792	92,786	4%
	R-01	15,826	13,418	18%		R-01	16,805	14,458	16%
	R-02	306,509	249,132	23%		R-02	303,179	250,587	21%
	R-04	76,107	62,413	22%		R-04	78,110	61,320	27%
	R-05	81,134	69,275	17%		R-05	76,513	68,188	12%
	R-07	77,626	80,367	-3%		R-07	71,601	81,371	-12%
	W-03A	205,748	192,403	7%		W-03A	204,097	190,539	7%
	W-03B	430,734	382,994	12%		W-03B	135,700	117,152	16%
	W-07	128,949	105,519	22%		W-07	125,976	102,973	22%
	W-09	95,072	86,746	10%		W-09	97,182	81,892	19%
	W-14	57,742	53,618	8%		W-14	55,349	51,440	8%
	W-16	117,809	99,654	18%		W-16	116,750	101,207	15%
	W-19	128,926	113,037	14%		W-19	130,177	113,738	14%

Figure 7: Auto cutline comparison – Average Weekday

AWD model vs. counts

$R^2 = 0.9714$

33
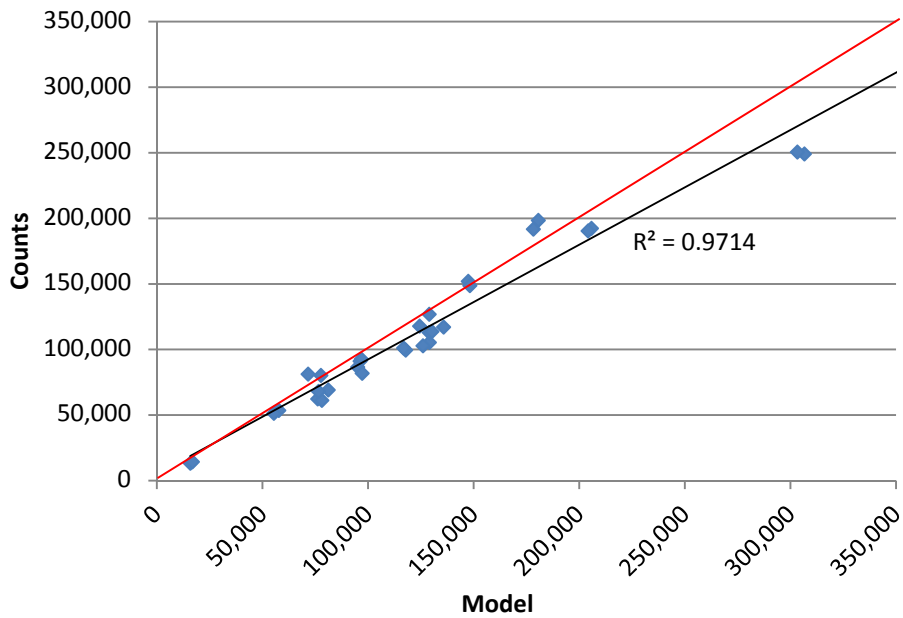
Table 15: Auto cutline comparison – PM2 (4pm - 6pm)

	Cutline	Kate	Count	Difference		Cutline	Kate	Count	Difference
	E-09	23,135	25,962	-11%		**E-09**	28,043	31,746	-12%
	E-16	14,571	15,241	-4%		**E-16**	18,589	15,779	18%
	E-21	20,748	24,028	-14%		**E-21**	21,443	19,933	8%
	E-27	14,548	14,470	1%		**E-27**	13,225	12,960	2%
	R-01	2,277	2,162	5%		**R-01**	2,816	2,920	-4%
South/West	**R-02**	38,260	31,062	23%	**North/East**	**R-02**	45,539	37,633	21%
	R-04	11,000	8,269	33%		**R-04**	11,286	8,850	28%
	R-05	8,801	8,074	9%		**R-05**	12,109	10,147	19%
	R-07	8,114	9,121	-11%		**R-07**	13,795	14,134	-2%
	W-03A	29,783	32,099	-7%		**W-03A**	27,013	28,559	-5%
	W-03B	61,634	63,062	-2%		**W-03B**	18,349	16,286	13%
	W-07	18,102	17,222	5%		**W-07**	16,476	13,615	21%
	W-09	12,017	11,991	0%		**W-09**	13,428	11,110	21%
	W-14	7,176	6,688	7%		**W-14**	8,805	7,290	21%
	W-16	15,654	15,600	0%		**W-16**	16,692	16,037	4%
	W-19	18,170	19,754	-8%		**W-19**	17,178	13,421	28%

Figure 8: Auto cutline comparison – PM2 (4pm – 6pm)

34
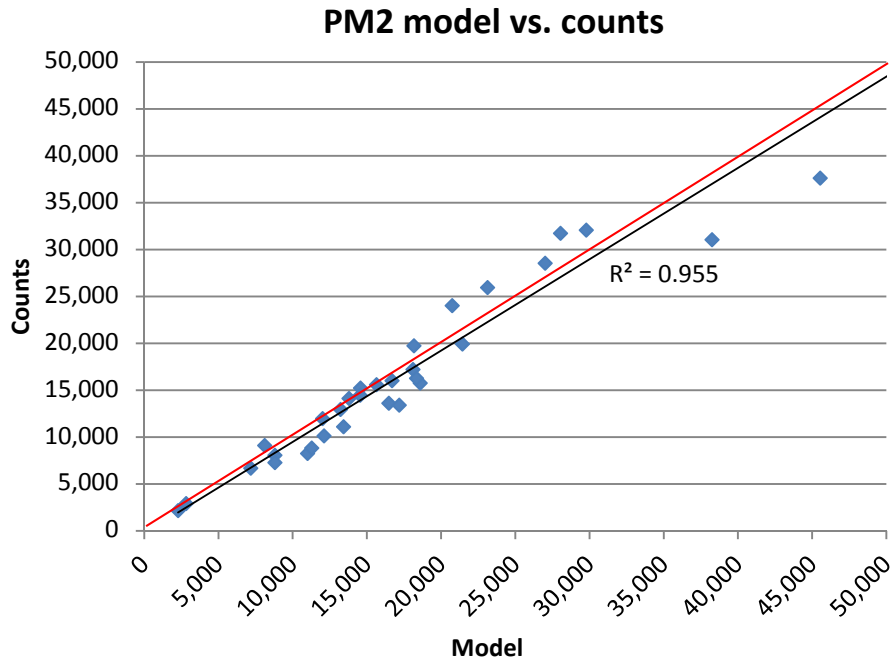
Table 16: Auto cutline comparison – AM2 (7am – 9am)

	Cutline	Kate	Count	Difference		Cutline	Kate	Count	Difference
	E-09	28,014	27,997	0%		**E-09**	20,308	19,334	5%
	E-16	19,606	18,534	6%		**E-16**	12,795	11,455	12%
	E-21	19,431	16,054	21%		**E-21**	19,622	19,392	1%
	E-27	12,454	10,351	20%		**E-27**	14,157	13,558	4%
	R-01	2,561	2,630	-3%		**R-01**	2,346	1,941	21%
	R-02	44,229	39,918	11%		**R-02**	34,958	28,183	24%
South/West	**R-04**	10,475	8,917	17%	**North/East**	**R-04**	10,773	8,365	29%
	R-05	13,094	9,459	38%		**R-05**	7,857	6,177	27%
	R-07	15,547	12,908	20%		**R-07**	7,314	7,375	-1%
	W-03A	24,355	25,243	-4%		**W-03A**	29,189	27,176	7%
	W-03B	49,636	46,039	8%		**W-03B**	18,094	16,901	7%
	W-07	16,007	13,689	17%		**W-07**	17,642	16,494	7%
	W-09	12,418	9,257	34%		**W-09**	12,033	11,741	2%
	W-14	9,120	7,735	18%		**W-14**	6,410	6,156	4%
	W-16	15,770	13,405	18%		**W-16**	14,527	13,264	10%
	W-19	15,514	14,057	10%		**W-19**	18,449	20,696	-11%

Figure 9: Auto cutline comparison – AM2 (7am – 9am)

AM2 model vs. counts

R² = 0.9767

35
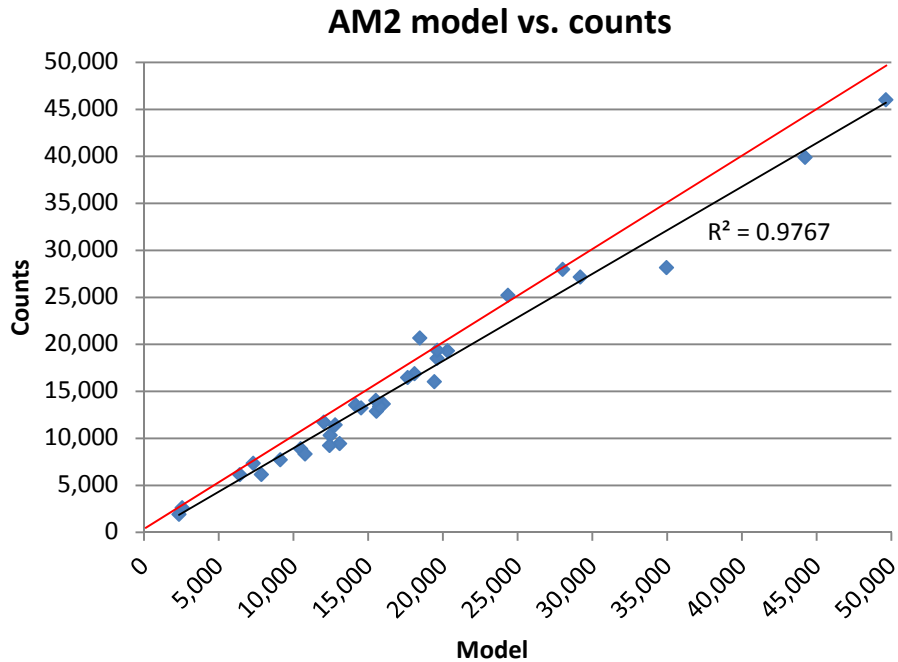
5.1   Transit Assignment

Table 17 shows transit boardings on individual MAX and WES rail lines, as well as on aggregate BUS and STREETCAR routes. The transit boardings by rail lines match relatively well between the Kate model and Automatic Passenger Count (APC) data from the transit service providers.

Table 17: Transit ridership

Route / Route Type	2015 Boardings*	Kate	Diff	% Diff
Blue MAX	60,868	73,611	12,743	20.9%
Green MAX	21,834	28,781	6,947	31.8%
Red MAX	21,874	22,766	892	4.1%
Yellow/Orange MAX	25,466	25,385	-81	-0.3%
WES Commuter Rail	1,812	1,097	-715	-39.5%
All rail	131,854	151,640	19,786	15.0%
All bus + Streetcar	232,511	288,436	55,925	24.1%
Total boardings	364,365	440,076	75,711	20.8%
Originating rides	287,666	300,330		
Transfer rate	1.27	1.47		

*rail boardings approximated from 2015 TriMet daily boardings:
one-half of total ons/offs

Table 18 shows boardings for individual MAX and WES stations. The table has been ordered by station groupings, which represent sections of the rail system sharing similar routes. For most station groupings, the Kate model closely matches TriMet APC data, with exceptions for both the Green MAX and WES Commuter Rail. Discussion for these exceptions is included above. Note that the total rail boardings at all stations for the model differs between this table and the previous table (152,109 and 150,640, respectively). Two stations on the Orange MAX on/near the Tilikum Bridge also share stops with multiple bus routes. Table 18 includes these bus boardings in the analysis due to difficulties associated with isolating these boardings by mode.

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Table 18: MAX station boardings (2015) – colors correspond to servicing MAX route(s)

Station Name	TriMet	Kate
Expo Center	267	467
Delta Park/Vanport	1,251	1,026
Kenton/N Denver	551	283
N Lombard TC	1,426	1,080
Rosa Parks	672	464
N Killingsworth	1,073	784
N Prescott	608	502
Overlook Park	535	480
Albina/Mississippi	304	404
Interstate/Rose Qtr	1,650	2,562
Grouping Total	**8,334**	**8,049**
Diff from Trimet		**-3%**
Union Station/NW 5th	960	740
NW 5th and Couch	709	605
SW 5th and Oak	1,211	1,129
Pioneer Place/SW 5th	2,685	1,839
City Hall/SW 5th	1,058	1,654
PSU Urban Center/SW	1,595	1,808
PSU South/SW 5th	818	376
PSU South/SW 6th	706	1,198
PSU Urban Center/SW	1,417	1,966
SW 6th and Madison	914	1,620
Pioneer Courthouse	2,562	2,182
SW 6th and Pine	1,192	1,136
NW 6th and Davis	685	847
Union Station/NW 6th	946	1,056
Grouping Total	**17,455**	**18,153**
Diff from Trimet		**4%**
Clackamas TC	2,590	3,246
SE Fuller	424	1,244
SE Flavel	586	522
Lents/SE Foster	706	735
SE Holgate	622	593
SE Powell	728	1,213
SE Division	780	1,703
SE Main	857	1,802
Grouping Total	**7,291**	**11,057**
Diff from Trimet		**52%**

Station Name	TriMet	Kate
Old Town/Chinatown	1,372	2,309
Skidmore Fountain	1,252	4,464
Oak/ SW 1st	1,184	419
Morrison/SW 3rd	1,305	1,857
Mall/SW 5th	1,996	1,990
Pioneer Square North	2,522	3,950
Galleria/SW 10th	1,783	1,773
Providence Park	1,399	3,208
Grouping Total	**12,811**	**19,968**
Diff from Trimet		**56%**
Hatfield Government	1,376	377
Hillsboro Central	918	1,580
Tuality Hospital	568	411
Washington/SE 12th	537	714
Fairplex/Hillsboro	984	715
Hawthorn Farm	405	422
Orenco/NW 231st	1,036	875
Quatama/NW 205th	1,423	1,088
Willow Creek/SW 185th	2,020	3,013
Elmonica/SW 170th	1,499	1,055
Merlo Rd/SW 158th	1,000	1,502
Beaverton Creek	821	837
Millikan	1,682	1,795
Beaverton Central	819	660
Grouping Total	**15,085**	**15,041**
Diff from Trimet		**0%**
Beaverton TC	5,110	5,836
Sunset TC	3,150	3,161
Washington Park	847	264
Goose Hollow	1,506	1,787
Kings Hill/SW Salmon	800	502
Providence Park	1,157	2,280
Library/SW 9th	1,790	2,981
Pioneer Square South	3,157	2,514
Mall/SW 4th	1,466	2,307
Yamhill District	995	1,331
Grouping Total	**19,975**	**22,961**
Diff from Trimet		**15%**

Table 15 cont'd: MAX station boardings (2015) – colors correspond to servicing MAX route(s)

	Station Name	TriMet	Kate
	PDX	2,196	1,240
	Mt Hood Ave	321	225
	Cascades	574	221
	Parkrose/Sumner TC	1,124	1,530
	Grouping Total	**4,214**	**3,215**
	Diff from Trimet		**-24%**
	Cleveland Ave	1,220	933
	Gresham Central TC	1,132	2,367
	Gresham City Hall	723	1,170
	Civic Drive	401	579
	Ruby Junction/E 197th	593	441
	Rockwood/E 188th	1,012	862
	E 181st	1,047	719
	E 172nd	555	363
	E 162nd	1,532	987
	E 148th	834	509
	E 122nd	1,809	2,398
	E 102nd	1,238	1,015
	Grouping Total	**12,093**	**12,339**
	Diff from Trimet		**2%**
	Gateway/NE 99th	7,641	4,760
	NE 82nd	2,623	2,922
	NE 60th	1,574	2,965
	Hollywood/NE 42nd	2,511	6,342
	Lloyd Center/NE 11th	4,254	2,816
	NE 7th	1,706	2,464
	Convention Center	1,969	3,097
	Rose Quarter TC	3,915	6,723
	Grouping Total	**26,192**	**32,088**
	Diff from Trimet		**23%**

	Station Name	TriMet	Kate
	Wilsonville WES	365	117
	Tualatin WES	258	162
	Tigard TC	320	235
	Hall/Nimbus WES	153	106
	Beaverton TC WES	718	480
	Grouping Total	**1,812**	**1,098**
	Diff from Trimet		**-39%**
	Lincoln St/SW 3rd	415	391
	S Waterfront	793	645
	OMSI/SE Water	314	465
	Clinton St/SE 12th	380	739
	SE 17th Ave & Rhine	217	478
	SE 17th Ave/Holgate	367	503
	SE Bybee	451	974
	SE Tacoma	708	738
	Milwaukie/Main	731	1,123
	SE Park	2,220	2,090
	Grouping Total	**6,594**	**8,143**
	Diff from Trimet		**23%**

	All Stations	
	TriMet	**Kate**
Total boardings	**131,854**	**152,109**
Diff from TriMet		**20,256**
% Diff from TriMet		**15%**

	Non-CBD Stations	
	TriMet	**Kate**
Total boardings	**81,613**	**91,028**
Diff from TriMet		**9,416**
% Diff from TriMet		**12%**

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5.2   Bicycle Assignment

Figure 10 shows the extent of the Bicycle Residential Preference Area (BRPA), within which relatively elevated levels of bicycle ownership and usage were observed in the 2010/11 household survey. Anecdotal evidence indicates a degree of self selection in the form of cycling-centric demographic groups choosing to reside within this area. The attractiveness of the bicycle mode is increased in the mode choice model for trips produced and attracted within the BRPA.

Table 19 shows how bike mode share for select markets from both the 2010 and 2015 model correspond to the 2010/11 household survey. The modeled results closely match the survey results, with a reasonable increase in bike mode share from 2010 to 2015.

Table 20 contains the single regional bike count cutline currently in place. It represents Willamette River bridge crossings into/out of Portland's Central Business District.

Figure 10: Bicycle Residential Preference Area (BRPA) – higher propensity for owning/utilizing a bike for travel within this district
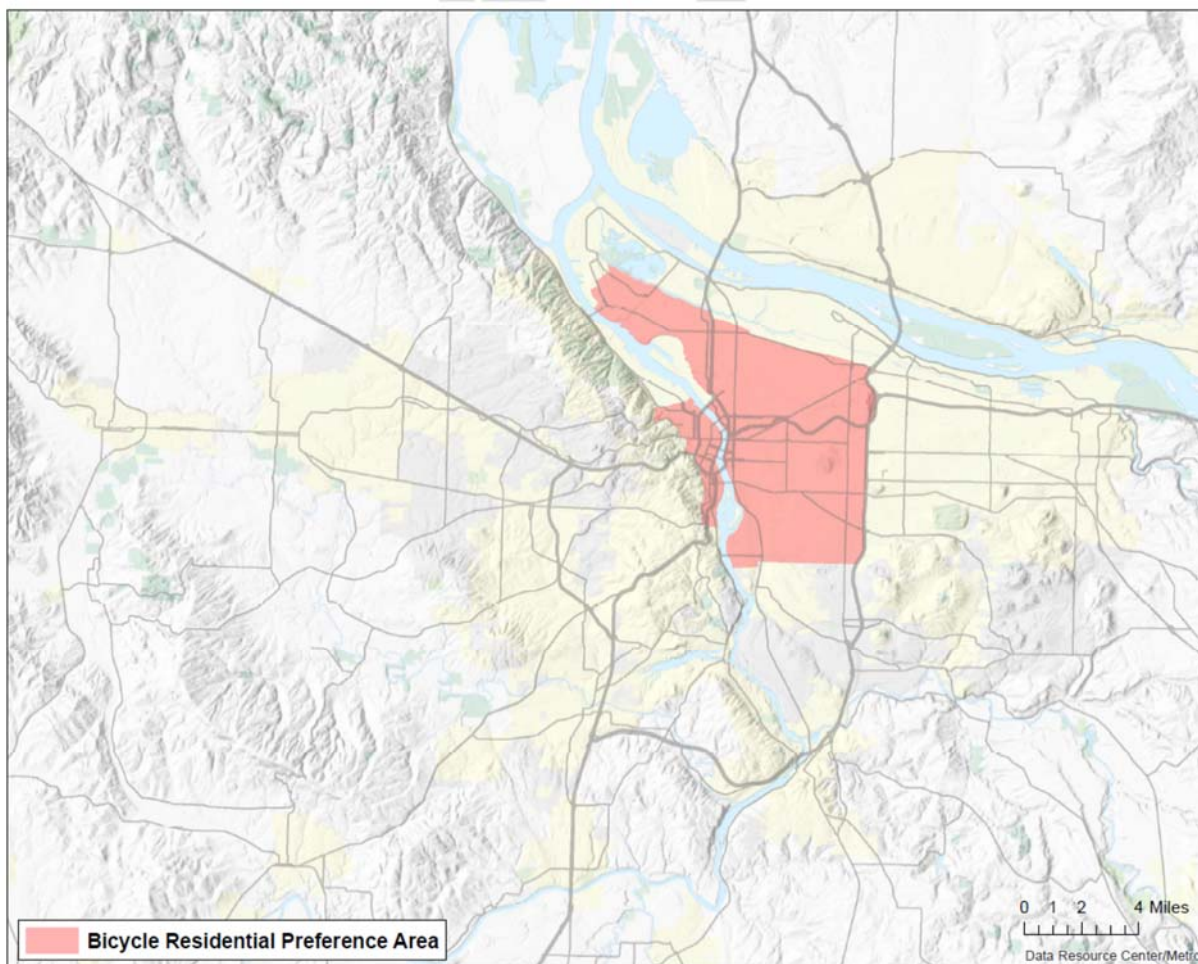
Table 19: Bicycle mode share for select markets

	OHAS 2010/2011		Kate 2010		Kate 2015	
BRPA HBW bike share	--	13.6%	33,097	13.9%	47,202	15.0%
BRPA total bike share	--	7.4%	110,099	7.5%	141,300	7.8%
Regional HBW bike share	--	--	66,805	5.4%	86,970	6.0%
Regional total bike share	--	2.6%	207,293	3.1%	249,802	3.3%

Table 20: Bicycle counts vs. model at CBD Willamette River bridges

Bridge	Count 2014	Kate	Difference	
Broadway	4,501	8,903	4,402	97.8%
Steel	4,559	3,393	-1,166	-25.6%
Burnside	2,345	2,618	273	11.7%
Morrison	805	3,147	2,342	290.9%
Hawthorne	8,287	5,758	-2,529	-30.5%
Tilikum*	2,000	5,292	3,292	164.6%
sum	22,497	29,111	6,614	29.4%

*approximate 2015 count from automated counter reports