2006 Base Year BKR Model Report

Prepared by
Modeling and Analysis Group
Transportation Department
City of Bellevue

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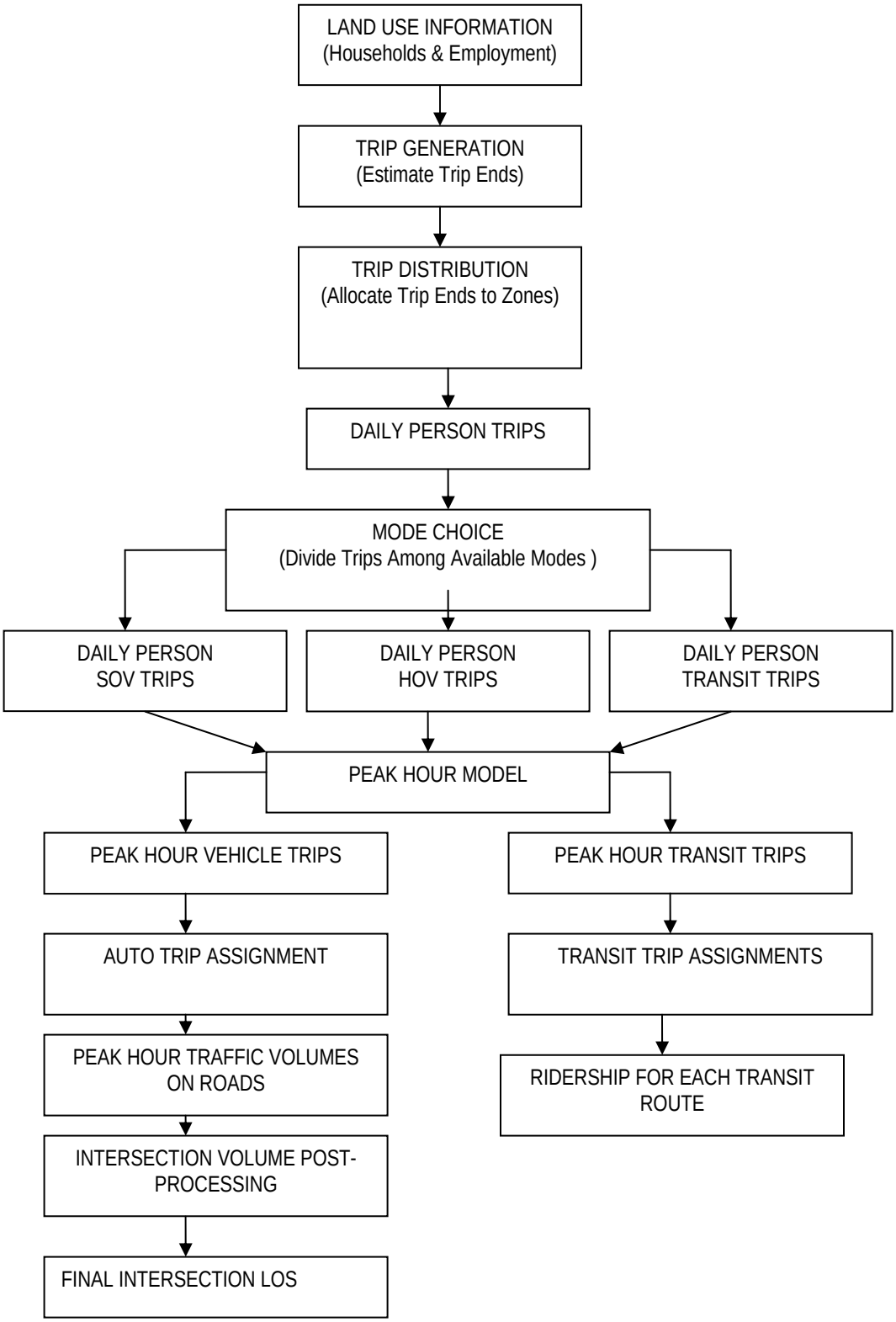
Figure 1: BKR Travel Demand Model Structure



INTRODUCTION

Program Overview

The City of Bellevue Transportation Modeling and Analysis Group develops and maintains existing and future travel demand model platforms to provide traffic forecasts for Bellevue, Kirkland and Redmond (BKR). This collaborative effort provides these cities with a credible source of travel demand forecasts.

The overall program requires forecasts for several future time horizons. Each year the model is updated and the short-range time horizon rolls forward to support transportation planning, capital improvement programming, concurrency, and development review functions of these three cities.

The Base Year Modeling Platform is established as the base for BKR forecasting models. Figure 1 illustrates BKR travel demand model structure for all BKR model platforms. The base year model produces an approximation of the current conditions rather than a forecast. Based on the most current data, forecasting models are built to project future travel demand for the Puget Sound region with a focus on the Eastside.

To be the most current possible, the base-year model platform is updated annually to reflect changes during the prior calendar year. Therefore, in 2006 the model was updated with information consistent with year end 2006 information sources. This involves making land use updates in the BKR area and changes in the transportation network. Both roadway and transit service attributes were updated. Land use data in the BKR fringe area, outside the municipal boundaries but in the internal model area, was updated this year. This effort is only done in alternate years.

The critical analysis made in the base year is whether the model produces an accurate picture of current conditions. The term used for this is to obtain annual validation by comparison to the most current observed data including auto traffic counts, transit data, and household travel surveys. In 2006, a new household travel survey is occurring in the region but will not be available prior to this analysis so the 1999 data is used.

Screen-line data for auto and transit systems are used to summarize the volume of travel produced by the Base Year Model and are compared with actual count data for autos and transit that is summarized at those same locations. Model totals by functional classes and jurisdictions are compared to traffic counts. This test of the base year predictability is key to ensuring that the model produces credible future forecasts. That effort is addressed in the section on Model Validation. A separate report titled “2006 MP0R8 Technical Specifications” addresses these aspects in more detail.

In this 2006 BKR Base Model Update, the following major enhancements were made:

- Bellevue split some big TAZs to add 20 new zones to the 2006 Base model due to the need for more geographic detail to track land development and support planning efforts.
- The 2006 BKR base model was not only updated with all the transit lines coded as one-way routes but also a PM peak hour transit modeling capability was added.
- Non-motorized (walk and bike) trip generation and distribution were developed for the 2006 BKR base model by a consultant, CH2MHill.

The EMME/2 software platform is used to run the travel demand model and operates on a Sun hardware platform. In 2007 the BKR model is being migrated onto the Emme3 software platform on an upgraded Sun server.

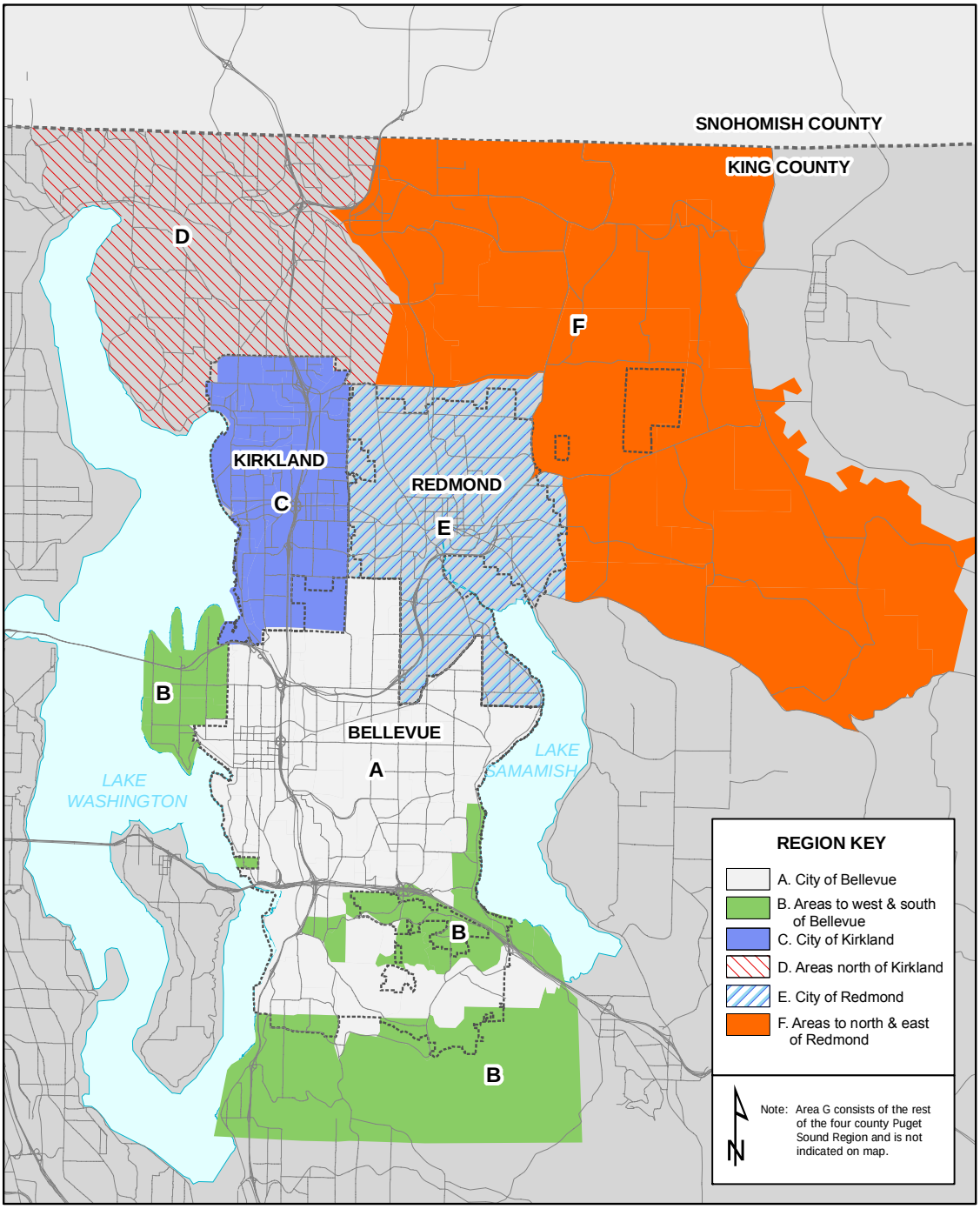
Report Overview

This report documents the 2006 base year model effort including inputs and results:

- Land use changes in the Eastside between 2005 and 2006
- 2006 base year BKR model network update
- Continued base year BKR model enhancements
- 2006 base year BKR model calibration process
- 2006 travel demand model results for the Eastside and in the region
- 2006 base year BKR model validation
- Screenline Level Validation Tables
- Acknowledgements

Figure 2:

Land Use Data Sources



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LAND USE

Land use type, intensity, and relative location produces travel demand. The best practice for modeling reflects known relationships about how types of land use generate different types and numbers of trips. Thus, land use is a starting point of the travel demand modeling process in the BKR model internal area.

For Traffic Analysis Zones (TAZs) outside the BKR area, the starting point is trip productions and attractions adopted directly from the Puget Sound Regional Council (PSRC) regional model that are then interpolated for 2006 from the year 2000 base and the 2010 forecast.

The base year platform incorporates land use changes in the Eastside jurisdictions of Bellevue, Kirkland and Redmond shown on Figure 2 titled "Land Use Data Sources". The 2006 land use data for most zones is from the three jurisdictions' individual permits systems, which track the permits for new residential housing units, commercial office, retail, and industrial buildings. Since not all development occurs on formerly vacant land, the land use information also accounted for demolition and conversions of land use. This provides the net amount of development in the various land use categories.

Areas internal to the BKR model area which are not in these three jurisdictions were updated with new structures completed in 2004 and 2005 as shown in the records from the King County Assessor. These areas only are updated every other year and were updated for 2005. Table 1 shows the overall 2006 land use information in the Eastside summarized by jurisdiction.

Residential Land Use

Figure 3 shows 2006 residential land use density for the BKR area. Table 2 presents the residential land use profiles for 2005 and 2006. In the overall BKR area, the count of Single Family Dwelling Units (SFDU) grew by 0.2% and Multiple Family Dwelling Units (MFDU) grew by 0.92% between 2005 and 2006.

Kirkland increased by 0.4% in SFDU in the 2005-2006 period and grew by 3.75% in MFDU during the same period. Redmond had a growth of 0.58% in SFDU and 0.17% in MFDU. Overall, Bellevue increased by 0.17% in SFDU and 0.54% in multi-family housing.

Within Bellevue, the land use information is summarized by the specific Mobility Management Areas (MMA) as shown in Figure 4. Factoria had the highest growth in SFDU (1.55%). Land use data again reflects the growth trend of multifamily complexes in Downtown Bellevue. From 2005 to 2006, MFDU increased by 4.49% in the downtown area. Demolitions of SFDU caused the decrease of more than 38%. Other MMAs showed notable changes in SFDU counts are Overlake with a 1.36% increase and Crossroads which decreased 1.61%.

Figure 3: 2006 BKR Residential Density

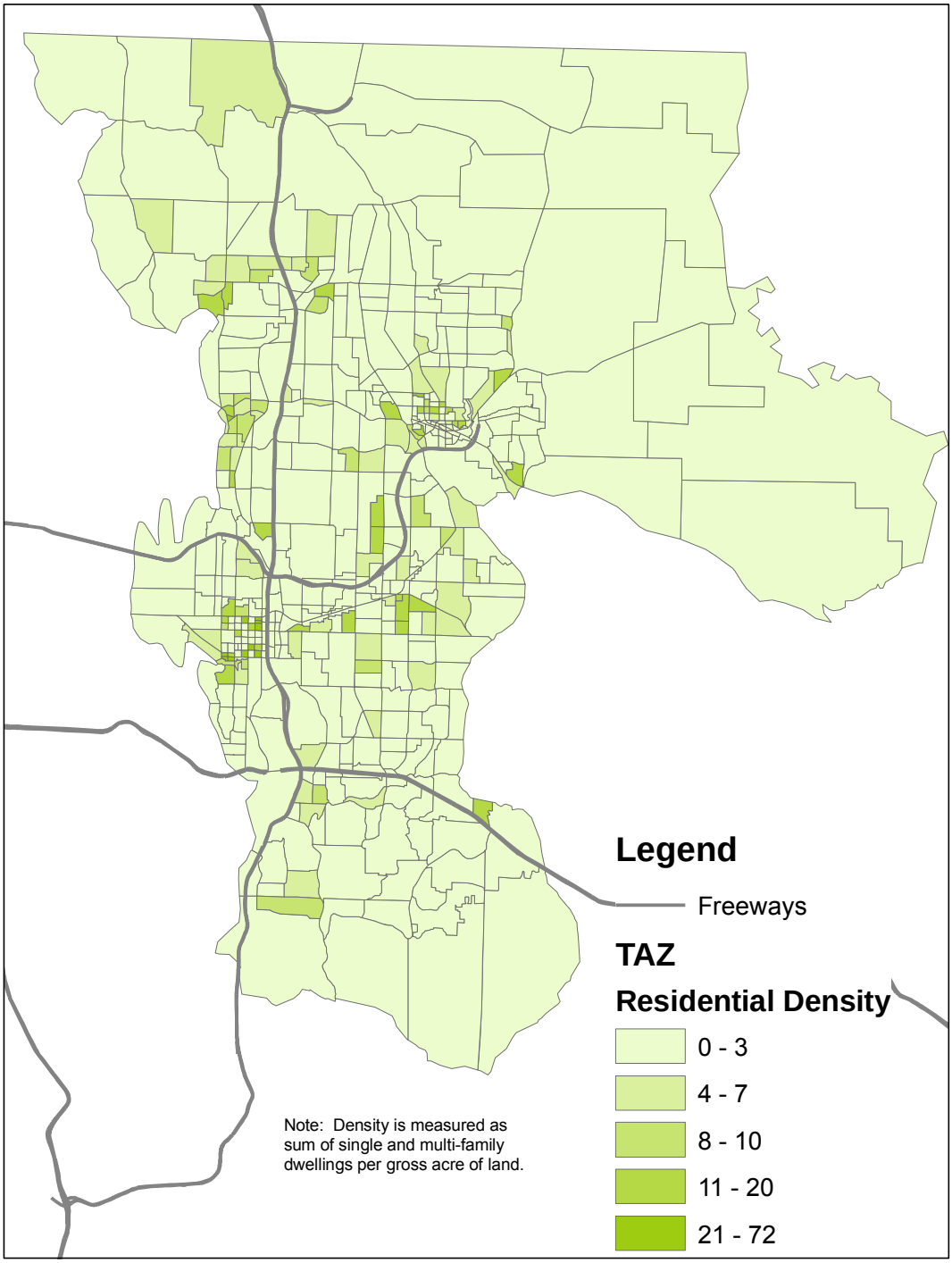

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Figure 4: Mobility Management Areas (MMA) of Bellevue

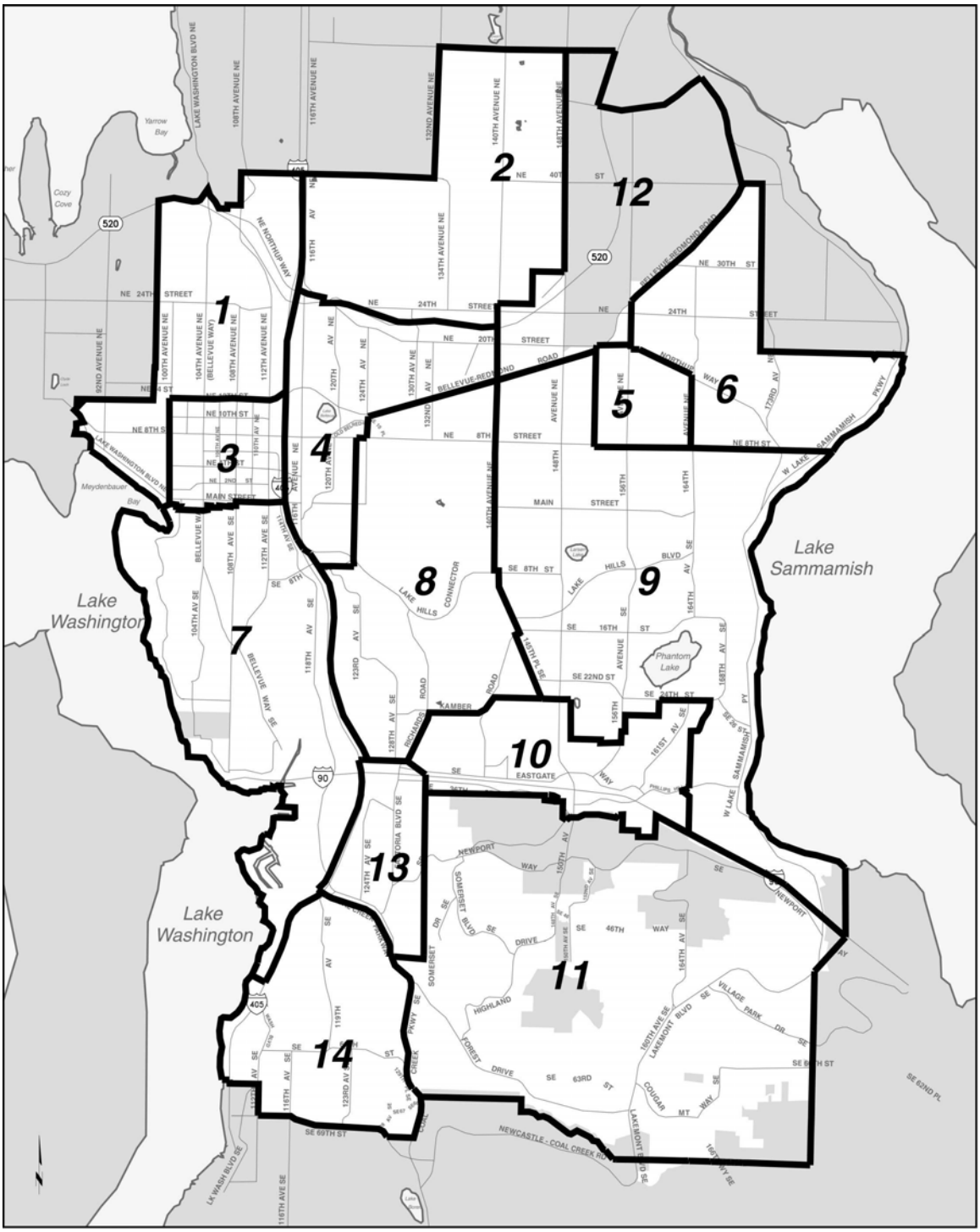

Table 1: 2006 BKR Area Land Use Summary

BKR Model Area	SQUARE FOOTAGE						DWELLING UNITS/Rooms/Students			
	FIRES	RETAIL	INDUSTRIAL	RECREATIONAL *	INSTITUTIONAL *	HOTEL	SFDU	MFDU	HOTEL Rooms	School Enrollmnt
Bel-CBD	6,902,969	3,825,659	80,785	-	569,426	791,691	8	4,125	1,430	119
Bel-Total	21,324,366	10,128,297	6,441,030	557,108	7,597,159	2,033,461	30,507	25,490	3,414	25,823
Bel-Fringe	145,867	93,612	34,450	-	582,531	61,614	8,294	1,705	126	4,147
Kirkland	5,071,804	3,677,057	3,059,133	50,818	1,100,281	425,337	10,519	12,801	755	9,381
Kirk-Fringe	3,338,860	1,552,583	5,583,556	98,121,249	1,290,590	296,174	21,962	12,948	606	20,160
Redmond	14,772,591	3,846,323	12,495,071	111,896	1,802,880	354,036	15,599	12,630	724	12,801
Red-Fringe	4,026	41,015	404,351	7,563	119,911	-	5,074	382	-	1,555
Total	45,002,827	20,058,138	31,564,762	98,848,634	12,782,724	3,170,622	96,333	67,885	5,625	77,481

- This year Land Use for the fringe areas were not updated since they were updated for 2005 data.
- Recreational and Institutional categories were reviewed and standardized between the jurisdictions for the prior update of the model. The Recreational land use data in some cases previously was based the land area rather than building size, but this data was not used to generate trips.
- A slightly different summary geography is used for Bellevue and Bellevue Fringe area geographies for this year compared to past years due to the splitting of zones.

Table 2: Residential Land Use Profiles: 2006 vs. 2005

	2005 Dwelling Units		2006 Dwelling Units		Change (%)	
	Single-Family	Multi-Family	Single-Family	Multi-Family	Single-Family	Multi-Family
Eastside (BKR)Total	96,143	67,263	96,333	67,885	0.20%	0.92%
City of Bellevue	30,456	25,352	30,507	25,490	0.17%	0.54%
Bellevue Fringe	8,294	1,705	8,294	1,705	0.00%	0.00%
City of Kirkland	10,470	12,338	10,519	12,801	0.47%	3.75%
Kirkland Fringe	21,962	12,948	21,962	12,948	0.00%	0.00%
City of Redmond	15,509	12,609	15,599	12,630	0.58%	0.17%
Redmond Fringe	5,074	382	5,074	382	0.00%	0.00%
North Bellevue (MMA 1)	**2039**	**2201**	**2048**	**2201**	**0.44%**	**0.00%**
Bridle Trails (MMA 2)	**1618**	**3176**	**1622**	**3176**	**0.25%**	**0.00%**
Downtown (MMA 3)	**13**	**3785**	**8**	**3955**	**-38.46%**	**4.49%**
BelRed/Northup (MMA 4)	**127**	**1018**	**127**	**1018**	**0.00%**	**0.00%**
Crossroads (MMA 5)	**124**	**3317**	**122**	**3317**	**-1.61%**	**0.00%**
NE Bellevue (MMA 6)	**3229**	**160**	**3230**	**160**	**0.03%**	**0.00%**
South Bellevue (MMA 7)	**2607**	**2070**	**2614**	**2051**	**0.27%**	**-0.92%**
Richards Valley (MMA 8)	**2373**	**3130**	**2378**	**3130**	**0.21%**	**0.00%**
East Bellevue (MMA 9)	**7130**	**2891**	**7142**	**2891**	**0.17%**	**0.00%**
Eastgate (MMA 10)	**293**	**818**	**293**	**818**	**0.00%**	**0.00%**
Newcastle (MMA 11)	**8367**	**1084**	**8435**	**1084**	**0.81%**	**0.00%**
Overlake (MMA 12)	**516**	**1862**	**523**	**1862**	**1.36%**	**0.00%**
Factoria (MMA 13)	**322**	**1112**	**327**	**1120**	**1.55%**	**0.72%**
Newport (MMA 14)	**3663**	**632**	**3668**	**632**	**0.14%**	**0.00%**

Total of MMAs	**32,421**	**27,256**	**32,537**	**27,415**	**0.36%**	**0.58%**

Note: In prior year MP0 reports Bellevue and Bellevue Fringe areas were defined differently so this has been corrected to reflect that geographic shift.

Nonresidential Land Use

In this report, non-residential land use data categories are referred to as the terms from the source data Standard Industrial Code (SIC) as follows:

- FIRES (Finance, Insurance, Real Estate, and Services)
- RETAIL
- MANUFACTURE + WCTU (Wholesale, Communication, Transportation, and Utilities)
- INSTITUTIONAL (Government, Hospital, and Education)
- HOTEL
- RECREATIONAL (Parks, Recreational and Sports Facilities)

Recreational Land was tracked but was handled in the model as a special generator for just the largest parks or facilities. This is because the square footage of the recreational land use is given as the total land area in cases when there is no structured improvement on a park site. This is different than in other categories. Where recreational structures square footage data were known they were treated as Retail in the trip generation.

Trends in the amount of developed square feet of these land use types are displayed in Figure 5. Figure 6 shows the Nonresidential land use density for 2006 in the BKR area. Figure 7 shows the portion of each of these land use types of total Nonresidential development. Table 3 presents the office and retail data for 2005 and 2006.

Figure 5: Nonresidential Land Use Trends in BKR Model Area

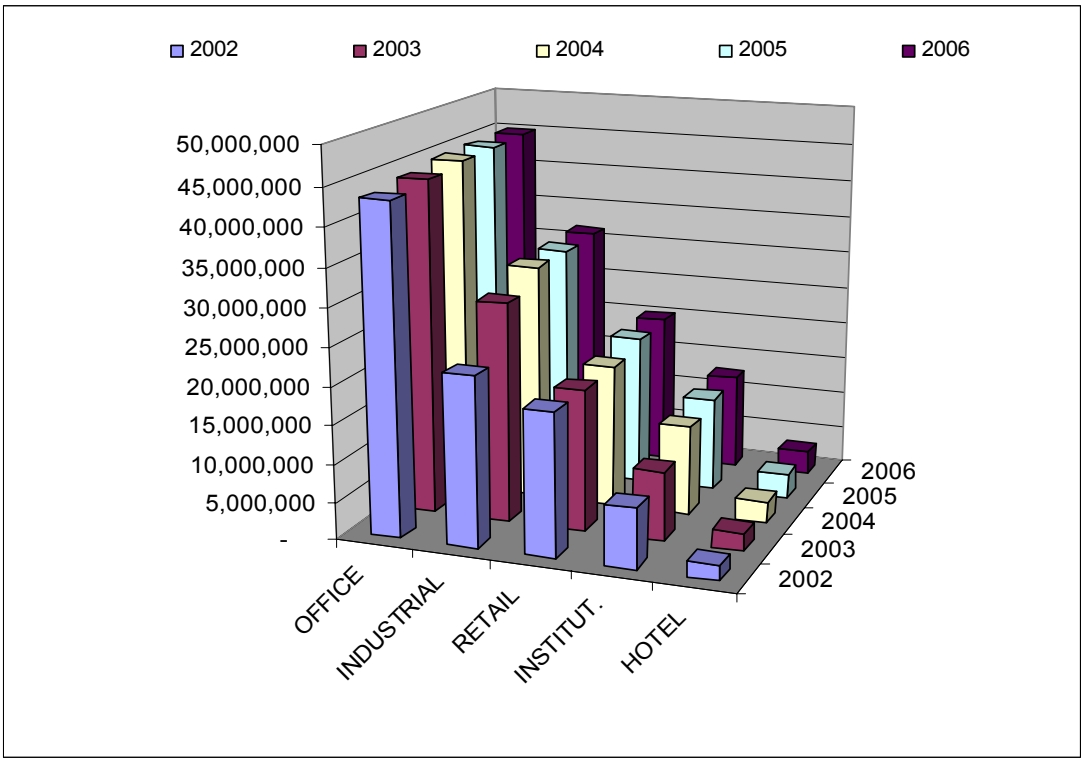

Figure 6: 2006 Nonresidential Land Use Density

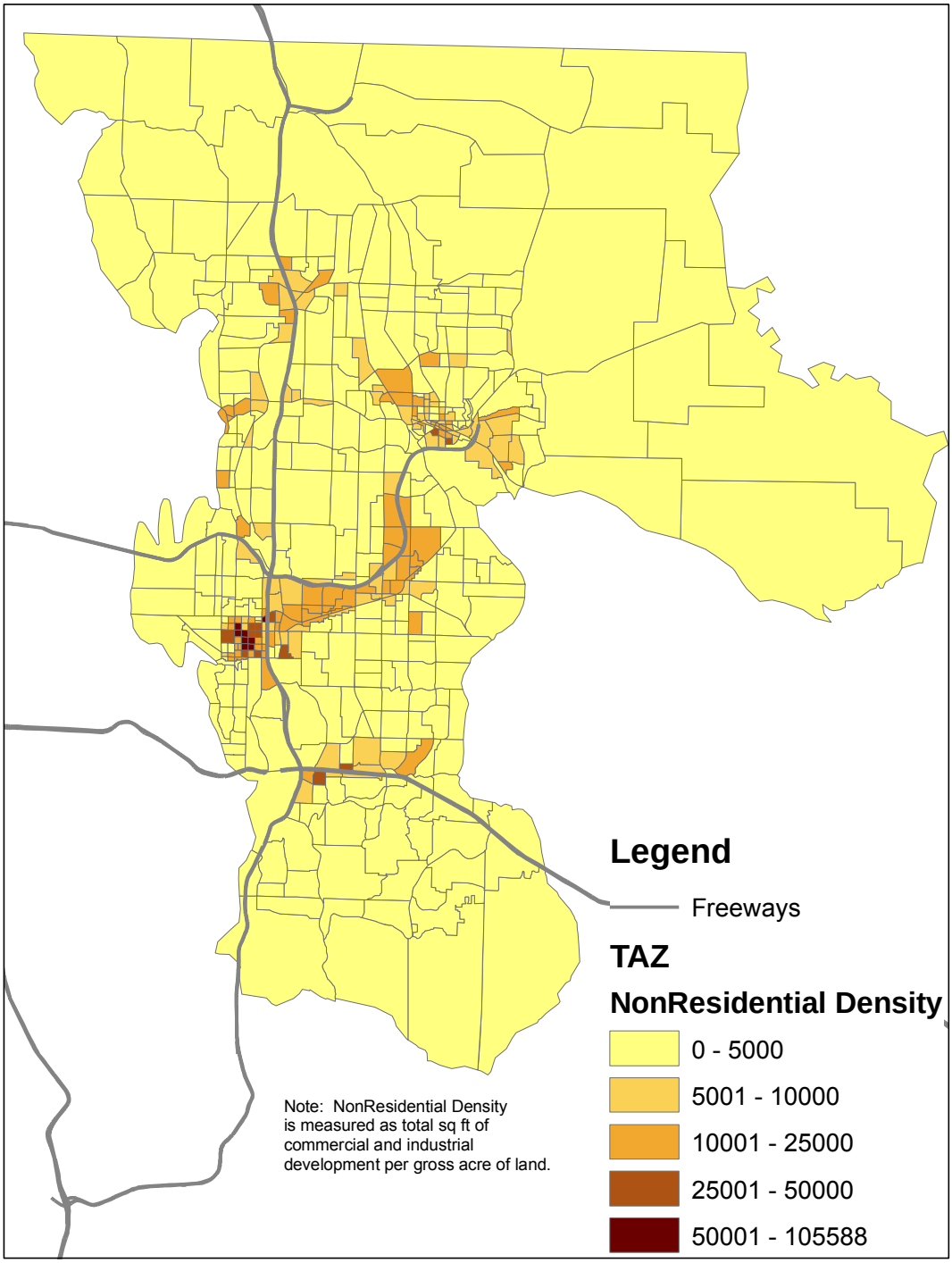

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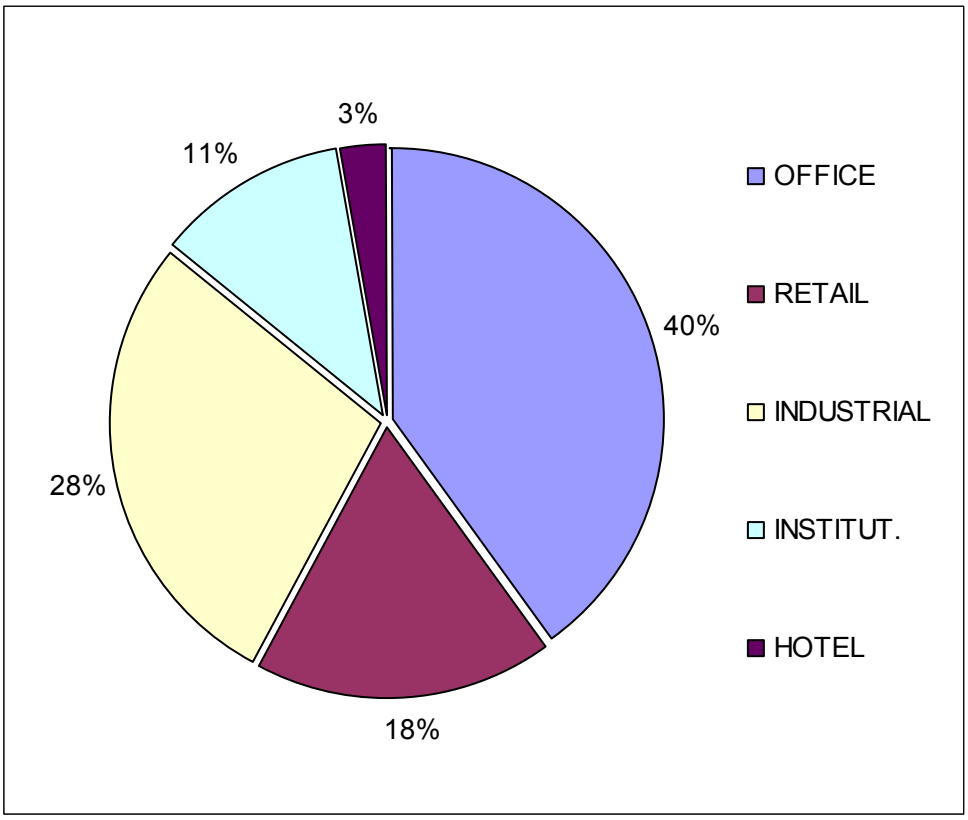
Figure 7: 2006 Nonresidential Land Use Profile



(1) Office

The office land use category includes Financial, Insurance, Real Estate and Service activities. This is the largest category of Eastside nonresidential development, accounting for 40% of the total square feet. Overall, the Eastside area internal to the BKR model grew by 0.5% in this category in 2006.

Redmond registered a 0.8% growth rate while Kirkland office space remained constant during the same period. Bellevue grew by 0.4% in office square footage from 2005 to 2006. The Bellevue CBD declined by 0.2% in the Office category due to clearing land for new development.

(2) Retail

Retail now accounts for 18% of the total nonresidential development. In the BKR area, the growth of retail land use was just 0.6%. Kirkland increased in retail square footage by 1.7% over 2005 and Redmond by 3.9%. Overall, retail in the City of Bellevue declined by 0.9% and grew by 0.1% in the CBD.

(3) Industrial

The category which includes industrial land use is now referred to as Manufacturing, Wholesale, Communication, Transportation and Utilities. It now encompasses 28% of the Nonresidential development in the BKR internal area. The Industrial Land Use trends reflect some decline from conversion as well as growth in the category. The conversion in Kirkland netted a loss of 2.1% of Industrial/WCTU. Redmond declined by just 0.1% while Bellevue increased by 1.6% in the Industrial WCTU category.

(4) Institutional

The institutional category covers several subcategories in the model area; education, government, religious facilities, hospitals and other public buildings. It accounts for 11% of the land use in the BKR internal Area in 2006. There was an increase of 5.9% in this category for the BKR area.

(5) Hotel

The Hotel category accounts for 3% of the land use for the BKR area. Hotels grew as a category by 9.7% in the square footage measure and 10.8% in the number of rooms. The Bellevue CBD area accounted for this growth.

(6) Recreation

Recreation has not been used directly as a land use category for trip generation. The land use data is usually given in square feet but the data for Recreation has been reported on either land area or building area, a unique factor among the land use categories. Because rates are not reliable for trip generation of recreational land use, building amounts were merged into the retail category for trip generation. One facility, Marymoor Park was considered as a special trip generator.

Linkage of Land Use to Travel Demand

Land use figures are used in the travel demand model to predict the trips produced from and attracted to an area. Land use data developed at the TAZ level for the three participating cities was the source of trips generated for the BKR area of the Eastside. The source of trip generation for the rest of the region was the direct import of trip productions and attractions from the regional forecasting model of the Puget Sound Regional Council (PSRC). These trips are generated from land use data by the PSRC travel demand forecasting model. 2006 data was estimated by interpolation from 2000 and 2010 regional forecasts.

Table 3: Nonresidential Land Use Profiles: 2006 vs. 2005

	2005 (in thousands of Sq. Ft)		2006 (in thousands of Sq. Ft)		Change (%)	
	Office	Retail	Office	Retail	Office	Retail
Eastside (BKR)Total	44,688	18,934	44,800	19,940	0.5%	0.6%
City of Bellevue	21,144	9,614	21,225	10,209	0.4%	-0.9%
Bellevue Fringe	154	100	154	100	0.0%	0.0%
City of Kirkland	5,312	3,306	5,277	3,614	0.0%	1.7%
Kirkland Fringe	3,111	1,478	3,133	1,553	0.0%	0.0%
City of Redmond	14,617	3,710	14,661	3,703	0.8%	3.9%
Redmond Fringe	349	727	349	760	0.0%	0.0%
North Bellevue (MMA 1)	1,659	106	1,691	106	1.9%	0.2%
Bridle Trails (MMA 2)	558	498	558	498	-0.1%	0.0%
Downtown (MMA 3)	6,923	3,823	6,910	3,826	-0.2%	0.1%
BelRed/Northup (MMA 4)	4,160	1,955	4,183	1,963	0.6%	0.4%
Crossroads (MMA 5)	124	861	137	861	10.3%	0.0%
NE Bellevue (MMA 6)	392	9	392	9	0.0%	-4.4%
South Bellevue (MMA 7)	1,270	98	1,270	98	0.0%	0.5%
Richards Valley (MMA 8)	539	21	566	21	4.9%	2.0%
East Bellevue (MMA 9)	593	424	602	424	1.5%	0.1%
Eastgate (MMA 10)	2,935	312	2,937	325	0.1%	4.1%
Newcastle (MMA 11)	142	65	147	65	3.8%	0.6%
Overlake (MMA 12)	723	1,333	727	1,330	0.6%	-0.2%
Factoria (MMA 13)	1,428	931	1,428	931	0.0%	0.0%
Newport (MMA 14)	15	180	15	180	-2.0%	-0.2%
Total of MMAs	21,461	10,616	21,561	10,638	0.5%	0.2%

TRANSPORTATION NETWORK UPDATE

The transportation network is a set of links and attributes associated with the roadways and transit routes. The EMME2 network coordinate system is in State Plane Coordinates for the Washington State North grid, and was improved by matching intersections (EMME2 nodes) to nodes from the region-wide Geographic Information System (GIS).

Where actual improvements to the transportation system were made, network elements are updated to keep the model current. Both road capacity configurations and transit operations are transportation aspects that are represented in the model. Modifications in these systems are tracked with information from the responsible agencies. Each year certain network refinements are also made to better represent key elements already present in the base year transportation system.

Zone terminal times have been added to trip length averages to allow for more accurate comparison with survey results. A time delay to represent access weaving for HOV lane users was also incorporated into the model.

Transit Network

The transit network was updated to reflect the Fall 2006 service changes from Metro, Sound Transit, Community Transit, and Pierce Transit. Service changes involved modification of existing lines, adding new transit lines, or removal of some lines. Park and ride capacities and surveyed usage has been updated to 2006 conditions.

Transit service is also represented in the model with information about the frequency, coach type, dwell and layover times, and route number. These attributes were significantly improved and updated to reflect any service changes and to show inbound and outbound directions. All PM peak transit routes were coded as well. The Current AM transit network has a total of 562 transit lines and Midday network has a total of 435 transit lines. The PM Peak transit network comprises 555 routes. Figure 8 shows the percentage of the zone that is within a quarter mile of a transit stop.

Auto Network

Each year, capital improvement projects are implemented and operational changes are made that change street flow characteristics. As a result, roadway capacities and traffic flow are continuously changing as new roadways are opened, new lanes are constructed, and traffic signals are installed. In order to document these changes, the BKR network was updated to reflect new construction projects that were completed before the end of the year 2006. These projects include regional highway projects, Bellevue capacity improvement projects, Redmond and Kirkland roadway capacity projects, and other projects that involve changes in lane geometry. Several network updates were coded in areas external to the BKR model done by King County and WSDOT.

King County Completed CIP Projects and Fixes in 2006

- Widen 124th to 4 lanes - Willows to SR 202
- Add center Turn lane on 124th Ave between 132nd & 146th St
- Widen 140th Ave to 2 lanes each direction between SE Petrovitski Rd & SR-197
- Kent Transit Station Connection
- Renton SR-900 (Park Drive) Fix at Edmond Ave Intersection
- Issaquah Highland Double Connection Fix
- 232nd Ave NE connection to Novelty Hill Road

WSDOT Completed CIP Projects and Fixes in 2006

- I-405 HOV at NE 6th St Bellevue Moved node (Fix)
- I-405 HOV at 128th St Totem Lake Open May 2007 (Prepared for 2007 coding)
- Modify coordinates to correctly position 128th Ave (Fixed previous coding)
- Modify ramp coordinates to correct 124th over-crossing (Fixed)
- 128th Over-crossing not open in 2006 code vdf as 24 (for non-opening)
- Add additional Park & Ride direct access to I-405 from Brickyard
- Lynnwood at 44th on I-5 Direct HOV Access

City of Bellevue Completed CIP Projects and Fixes in 2006

- PW-R-133 Northup Way between 120th & 124th Ave NE
- PW-R-60 NE 24th between 140th & NE 29th
- 142nd Ave Direct HOV/Transit Access Ramps to I-90 Connection

City of Redmond Completed CIP Projects in 2006

- SR-202 between SR-520 & East City Limits
- East Lake Samm Parkway - soon to be two SB lanes

MODEL ENHANCEMENTS

After being established in 1989, the BKR model system has been continuously enhanced by the Bellevue Transportation Modeling and Analysis Group and by work contracted to consultants. The 2006 Base Year Model stems from the Third Generation BKR Model. Advancements made this year were:

Non Motorized Trips

A contract was made with CH2M HILL to assist the City of Bellevue in developing a non-motorized portion of the model. A section of this report describes that additional capability and the results.

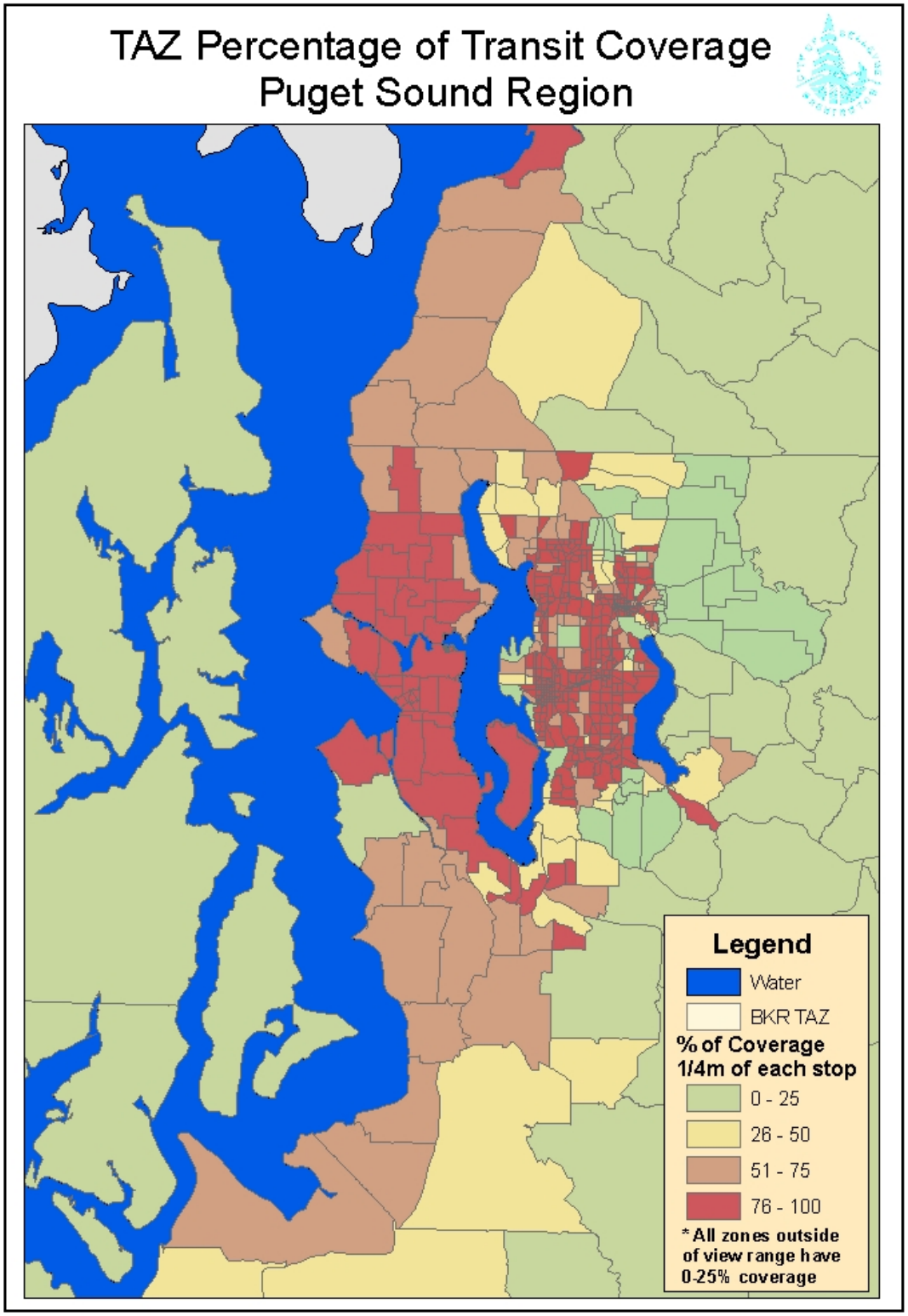
PM Peak Transit Model

The BKR model formerly only covered the AM Peak hour from 7-8 and the midday. This year PM Peak hour was added. Considerable effort was involved in coding the PM Peak transit network and analyzing the transit data for proper representation in the model.

TAZ Specification Splits

Ten zones were split and so ten new zones were added, for a total of twenty modified zones in the BKR Model.

Figure 8:


TAZ Percentage of Transit Coverage
Puget Sound Region
Legend
Water
BKR TAZ
% of Coverage
1/4m of each stop
0 - 25
26 - 50
51 - 75
76 - 100
* All zones outside
of view range have
0-25% coverage

MODEL CALIBRATION

Model calibration is a process to primarily debug the human errors, adjust constants or parameters in individual model components and to test interactions among model components After the land use and network were updated in the base year BKR model, model enhancements were implemented step by step and iteratively tested through the four step modeling process: trip generation, trip distribution, mode share and trip assignments.

A step-wise model calibration process was used to test the model's reasonable fit in trip generation, trip distribution, mode split in BKR area, region-wide, and time of day modeling results. The Puget Sound Regional Council's 1999 Eastside household travel surveys (607 household samples) were the primary benchmark data for the step-wise model calibration process.

2006 Base Model Calibration Runs

In 2006 MP0-R8 BKR model improvements, staff went through eleven rounds of model calibrations. Each model calibration ran through 4-step process in three iterations and took up to 7 hours of computing time. Bellevue staff then further processed the results to pull out step-wise model results and auto/transit screenlines, analyze the model outcomes and identify any improvements. Each model calibration run with model improvements is described below:

- Run 1: Bellevue split some big TAZs by adding 20 new zones to 2006 Base model due to the existing 2006 and potential land development and planning.
- Run 2: Local and regional completed major roadway capacity improvement projects were coded in the 2006 BKR base model network update.
- Run 3: The 2006 BKR base model was not only updated with all the transit lines coded as one-way routes but also was added with PM peak hour transit modeling capability.
- Run 4: 2006 daily trip productions and attractions external to the BKR area were updated by interpolating 2000 and 2010 PSRC regional travel demand model productions and attractions.
- Run 5: The weighted trip production rates from the 1999 Regional Household Travel Survey were applied to the 2006 BKR model and found too low with respect to the eastside focused household travel survey data, and therefore we maintained the original trip rates.
- Run 6: Non-motorized (walk and bike) trip generation was added to 2006 BKR base model and the model results were calibrated against the regional household travel survey.
- Run 7: Non-motorized (walk and bike) trip distribution was added to 2006 BKR base model and average trip lengths by purpose were validated against the regional survey.
- Run 8: 2006 AM peak hour and PM peak hour transit travel times were compared for each route between the 2006 model assignments and 2006 actual average transit travel times by time period until we have goodness-of-fit R-square above 0.80 for the region-wide transit system.

- Run 9: 2006 BKR Model Park-&-Ride capacity and new lots were updated based on the “2006 Fall King County Park-&-Ride Utilization Survey “ and WSDOT Web-Site.
- Run 10: 2006 P-&-R lot biased factors were updated for all zones to equally treat the accessibility of every TAZ to P-&-R lots.
- Run 11: PM peak hour transit time of day factors were adjusted to fit the 2006 actual PM Peak Hour ridership screenlines.

MODELING RESULTS

Four Step Modeling Process

At the end of each calibration process, a stepwise validation was conducted to check the consistency of the four step modeling system as well as the intermediate changes for each step.

Table 4 summarizes the overall results for trip generation and presents a comparison of trip rates between the 2006 BKR model and the 1999 Eastside household travel survey.

Tables 5a, 5b and 5c summarize the trip distribution characteristics including trip length, duration and distribution.

Table 6 summarizes the BKR mode choice model results compared with the 1999 household travel surveys.

Table 7 summarizes the total motorized person trips by time of day (AM Peak Hour, Mid-day Hour and PM Peak Hour).

1999 Eastside Travel Survey as a Reference

Since it became available, the Eastside portion of the 1999 regional household travel survey has been used to validate the BKR base year model. During 2006 the Puget Sound Regional Council and the Washington State Office of Transit Mobility are jointly conducted a more current Household Travel survey. Unfortunately it was not available for this year's work so the 1999 Survey will still be the basis of comparison. We expect to use the upcoming survey results in the next annual update. Potentially measures that are less like the 1999 survey parameters may truly be reflective of the changes that will be apparent in the 2006 data.

Trip Generation Model

According to the trip generation model, about 1.49 million daily person motorized trip productions and more than 2.24 million trip attractions are generated within the BKR and their fringe areas, such as Point cities, Bothell, Woodinville, Sammamish, Newcastle, and Northeast King County. This result reflects the importance of the greater eastside as an employment center as well as a destination for shopping and leisure activities. The growth of technology companies in the eastside and the expansion of shopping centers play an essential role in shaping the commercial characteristics of the greater eastside.

People travel with different purposes from one point to another. In travel demand modeling practice, eight categories of trips are modeled to obtain trip counts for a 24-hour weekday period. The major trip categories are Home Based Work (HBW), Home Based Other (HBO), and Non-Home Based (NHB). As shown in Table 4, the HBO category had the greatest number of trips, the NHB trips were the next largest category, and the HBW trips category had the fewest trips of the three categories. However, HBW trips constitute most of the trips during peak hours when most people commute to/from work.

Table 4: BKR 2006 Trip Productions & Attractions vs 1999 Household Travel Survey

Trip Purpose	2006 Daily BKR Trips Produced	Daily Trips Produced / Household	1999 Eastside Household Survey	Percent Difference	2006 Daily BKR Trips Attracted	Daily Trips Attracted/ Employee
HB-Work	229,265	1.40	1.47	-5.25%	414,992	1.47
HB-College	7,545	0.05	0.05	0.00%	16,883	0.06
HB-Shopping	185,282	1.13	1.17	-3.29%	172,233	0.61
HB-Other	519,103	3.16	3.17	-0.44%	923,255	3.27
HB- School	81,757	0.50	0.51	-2.85%	61,347	0.22
Work-Other	128,681	0.65	0.66	-0.32%	128,681	0.46
Other-Other	335,652	1.70	1.68	1.29%	343,515	1.22
Truck/Freight					175,846	0.62
Total	1,487,285	8.59	8.72	-1.53%	2,236,751	7.93

The modeled daily trip productions per household is 8.59 (excluding truck freight) or slightly less than the 1999 Eastside household travel survey (8.72 excluding truck freight). There is no benchmark data to check the daily trip attraction modeling results, which are based on the national average trip attraction rates. Since the trip attractions are eventually balanced to trip productions, the confidence in the trip generation model is good.

To give an idea of the magnitude of motorized vehicle trips in the Bellevue area, Figure 9 shows 2006 annual average weekday traffic. We used the 2006 PM peak hour traffic counts to validate the auto traffic forecasting in the 2006 BKR model.

To give an idea of the daily transit ridership trends, Figure 10 shows Bellevue area average daily transit ridership from 2002 to 2006. We used the 2006 AM peak hour transit ridership counts to validate the 2006 transit ridership forecasting in the 2006 BKR model.

Trip Balancing

As population growth and employment growth are not identical, daily trip productions and daily attractions estimated from the trip generation model usually do not exactly match. For trip distribution purposes, region-wide totals of daily trip attractions and productions must be equal or balanced by trip purposes. As the BKR model generally includes more accurate estimates of household data (trip productions) than employment data (trip attractions), the model balances the total trip attractions to productions region-wide.

Trip Distribution Model

After trip productions and attractions were generated, trips were distributed among 800 traffic analysis zones (TAZs). Trip duration and distance were used to calibrate the accuracy of the trip distribution model. Table 5a compares the average trip duration between model results and the 1999 PSRC Household Travel Survey for trips originating from the Eastside as well as total regional trips. In the HBW, HBO, and NHB trip categories, the modeled trip durations in the BKR area are very close to those of surveyed trips.

As shown in Table 5a, an average work trip produced in the Eastside takes about 22 minutes in the model and about 19 minutes in the survey. An average regional work trip lasts about 30 minutes in the model and about 26 minutes in the survey. The greater modeled commute time can be explained by the fact that the 1999 Household Travel Survey is six years old while congestion and delay have been growing in the region, especially for commuters.

The differences are greater in some other categories in which survey respondents tend to round up their trip length by the next nearest five minutes. Three reasons may explain the bigger differences for other trip purposes.

- People are more accurate in reporting their work trip length than the trip length in other purposes
- Work trip lengths are more consistent than other trips which may vary in pattern and timing
- The external TAZs are much larger than BKR TAZs, therefore the trip duration and trip length tend to be shorter due to the smaller areas and shorter paths of centroid connectors which suffice as length of trips within zones.

Table 5a: Average Trip Duration by Purpose

Trip Purpose	Trips originated from Eastside (Minutes)			All Regional Trips (Minutes)		
	BKR (2006)	1999 PSRC HH Survey	Percent Difference	BKR (2006)	1999 PSRC HH Survey	Percent Difference
HB-Work	21.59	18.89	14%	29.53	25.50	16%
HB-Other	14.10	12.24	15%	18.02	16.50	9%
Non-HB	12.61	11.40	11%	13.25	15.80	-16%
HB-School	10.32	9.93	4%	12.22	13.40	-9%
Average	14.41	12.99	11%	18.37	17.80	3%

Overall, the trip distribution model is calibrated well with a good match of travel time with survey results. An average modeled trip originated from the Eastside lasts about 15 minutes, compared to about 13 minutes reported from the survey. In the entire region, an average modeled trip in the region lasts about 19 minutes, which is the same as was reported from the survey.

Table 5b shows the average trip length in miles by purpose. Like the average trip duration, the overall modeling results of average trip distances approximate the survey results (about 6 miles originated from the Eastside and about 7 miles from region-wide.

Table 5b: Average Trip Length by Purpose

Trip Purpose	Trips originated from Eastside (Miles)			All Regional Trips (Miles)		
	BKR (2006)	1999 HH Survey	Percent Difference	BKR (2006)	1999 HH Survey	Percent Difference
HB-Work	8.03	9.57	-16%	10.39	11.30	-8%
HB-Other	5.85	5.82	0%	7.37	6.70	10%
Non-HB	5.10	5.35	-5%	4.51	6.10	-26%
HB-School	2.32	4.23	-45%	2.34	4.80	-51%
Average	5.71	6.23	-8%	6.72	7.30	-8%

Table 5c Shows the trip distribution pattern of the model within the BKR and the rest of the region.

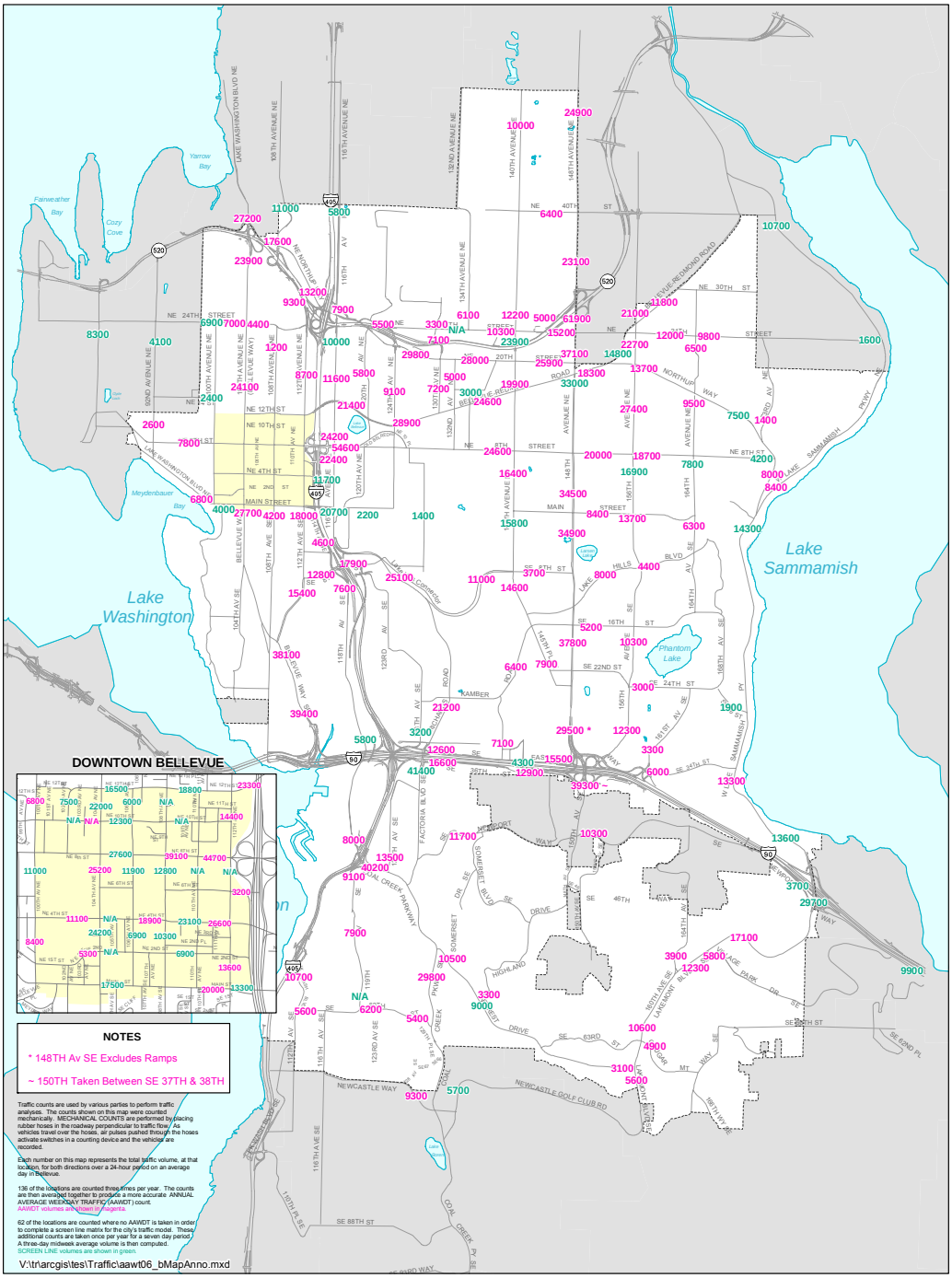
Table 5c: BKR 2006 Percent of All Daily Trips Between Super-Districts

From \ To	Bellevue	Kirkland	Redmond	Rest of Region	Total
Bellevue	60%	6%	15%	20%	100%
Kirkland	21%	37%	17%	25%	100%
Redmond	21%	13%	53%	13%	100%
Rest of Region	13%	9%	8%	70%	100%
Total	7%	4%	5%	84%	100%

FIGURE 9: City of Bellevue 2006 Annual Average Weekday Traffic

City of Bellevue

2006 Annual Average Weekday Traffic



NORTH

= 4,000 feet

City of Bellevue
IT Department
GIS Services
Plot Date: 3/29/2007

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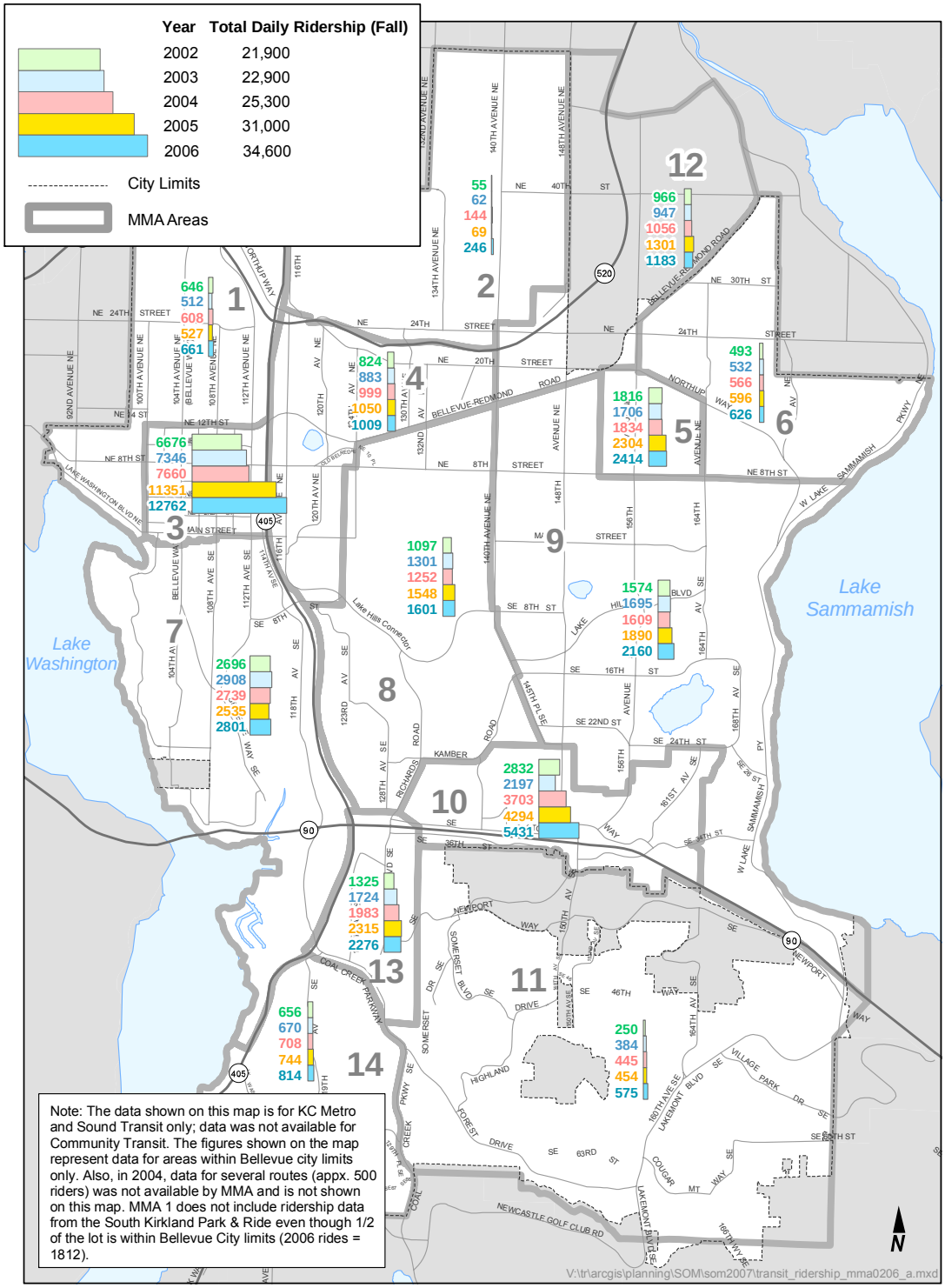
Figure 10: Transit Ridership Trend by MMA



Mode Choice Model

After trips were distributed among 800 TAZs in the Puget Sound Region, the BKR mode choice model was used to estimate travelers' choices of modes. In the utility-based Home Base Work (HBW) mode choice model, travelers have four choices (driving alone, share ride, transit by walk access and transit by auto access). In the Home Based Other (HBO) and Non Home Based (NHB) mode choice model, travelers are limited to only auto trip and walk-access transit trips.

Since HBW trips have the highest concentration of trips during peak hours, the mode split is very important as it could significantly affect the PM peak hour vehicle trip assignment. The mode split model results show that 84.3% of all workers were driving alone to work while 6.1% of the workers shared their rides to work in 2006. Transit riders accounted for 9.6% of the commuters (with 7.2% walk access and 2.4% auto access). A comparison with survey data provides a reality check. Table 6 presents a summary to compare the BKR model Region-wide results with PSRC 1999 Household Survey results.

For HBO and NHB trips, mode splits were divided into two categories: Auto and Transit. HBO had a 99.0% to 1.0% split between auto and transit and NHB had a 99.1 to 0.9% split between auto and transit. HBO and the NHB trips showed only a slight +0.3 or -0.3 % difference between the model and household survey which produces a high level of confidence. The overall mode splits match reasonably well between the 2006 mode choice model and the 1999 survey. Research shows the number of persons per trip is higher in the auto for HBO and NHB than for purely HBW trips.

Table 6: Validation of Eastside Mode Split Model
- 2006 BKR Model vs 1999 PSRC Household Travel Survey

Trip Types and Modes		2006 BKR Model Results	1999 Household Survey for BKR Study Area	**Actual Difference**
HBW Trips	Drive Alone	84.3%	85.8%	-1.5%
	Shared Ride	6.1%	5.2%	0.9%
	Transit – Walk Access	7.2%	7.2%	0.00%
	Transit – Auto Access	2.4%	1.8%	0.6%
	Total	100.0%	100.0%	
HBO Trips	Auto	99.0%	99.3%	-0.3%
	Transit	1.0%	0.7%	0.3%
	Total	100.0%	100.0%	
NHB	Auto	99.1%	98.8%	0.3%
	Transit	0.9%	1.2%	-0.3%
	Total	100.0%	100.0%	

Traffic Assignment Model

PM peak hour trip tables were created from the daily trip tables during the peaking process, where a set of peaking factors was used to estimate PM peak hour auto trips as well as AM peak hour transit trips. A multi-class (SOV and HOV) auto trip assignment was then conducted on the updated base-year PM peak hour network. The assignment was based on shortest-path multimodal equilibrium algorithm.

At the same time, AM transit trips were assigned onto the AM transit network based on the multi-path choice and capacity constrained algorithms. The total region-wide hourly motorized person trips and their respective percentage shares are summarized in Table 7.

Table 7: 2006 BKR Model Motorized Person Trips by Time of Day

Time of Day Modal Trips		Person Trips	2006 BKR MP0 R8
AM Peak Hour	Drive Alone	571,883	77.9%
	Shared Ride	43,021	5.9%
	Transit – Walk Access	108,085	14.7%
	Transit – Auto Access	11,336	1.4%
	Total	734,324	100.0%
Mid-day Hour	Drive Alone	637,941	90.3%
	Shared Ride	48,506	6.9%
	Transit – Walk Access	19,737	2.8%
	Total	706,184	100.0%
PM Peak Hour	Drive Alone	677,550	79.9%
	Shared Ride	73,507	8.7%
	Transit – Walk Access	85,277	10.1%
	Transit – Auto Access	11,337	1.3%
	Total	847,671	100.0%

MODEL VALIDATION

Screenline analysis is used to validate both auto and transit forecast results. Screenlines are imaginary lines that are defined for analysis purposes. As described here, they cut through all traffic corridors in a north-south or east-west direction so that the total traffic in one direction (from multiple streets) could be captured. In screenline analysis, one compares the total model volumes with the total traffic counts in both

directions at each screenline. Figure 11 presents the locations and model forecast/actual count ratios of the auto screenlines and Figure 12 shows the transit screenlines.

The 2006 Base Year Model was validated by comparing the model link auto volumes with 2006 actual average traffic counts made in the three city jurisdictions as well as on King County and Washington State Department of Transportation. The model was validated also by comparing the link ridership estimates on the transit network with actual transit ridership counts for Fall of 2006. Tables 8a and 9a summarize the overall results of auto and transit screenline validations while Tables 8b and 9b show the validation results for each auto and transit screenline, respectively.

Auto Validation

Three levels of screenlines were designated to validate model volumes (as shown in Table 8a). Figure 11 displays the locations and model/actual ratio of the auto screenlines

Level one screenlines frame the study area boundary of the Bellevue, Kirkland and Redmond area. This validation presents a macroscopic picture of traffic flow into and out of the Eastside study area. The comparison between model volumes and actual counts show an overall fit of 98%.

Level two screenlines are regional screenlines that cut through the Eastside at various locations. The comparison shows an overall fit of 103%.

Level three screenlines are local for Bellevue and Redmond city boundaries as well as the major arterials of those cities. In Redmond, the model shows an overall 111% fit with a 109% fit in the Overlake area. In Bellevue, the model shows an overall 101% fit.

Table 8a: 2006 BKR Model Screenline Validation Summary (PM PK Hr. Auto Traffic)

LEVEL	Screenline Group Descriptions	NB/EB			SB/WB			All Directions		
		Actual	Model	M/A	Actual	Model	M/A	Actual	Model	M/A
ONE	Area Boundary	46,796	47,996	1.03	39,414	36,312	0.92	86,210	84,308	0.98
TWO	Regional BKR	159,437	173,023	1.09	147,906	142,697	0.96	307,343	315,720	1.03
THREE	CITY - REDMOND	18,679	21,417	1.15	14,293	15,183	1.06	32,972	36,600	1.11
THREE	CITY - OVERLAKE	74,775	83,519	1.12	37,422	38,788	1.04	112,197	122,307	1.09
THREE	CITY - BELLEVUE	81,961	83,646	1.02	87,643	87,496	1.00	169,604	171,142	1.01
ALL	TOTALS	**381,648**	**409,601**	**1.07**	**326,678**	**320,476**	**0.98**	**708,326**	**730,077**	**1.03**

As shown in Table 8b, among 42 screenlines analyzed, 30 are within plus/minus 10% validation target. Seven screenlines are falling within the 11-15% marginal over/under the target ranges while five are over more than 15%. The overall total shows that the model is within accuracy of 3% over-prediction, which is a good result for the overall modeling system. The whole system has a goodness-of-fit ratio (R-square value) of 0.90 when the model volumes are compared to the actual counts. This indicates that the auto traffic forecasting model is statistically valid for use in forecasting specifically for the Bellevue, Kirkland and Redmond model area.

FIGURE 11: 2006 PM PK Hour Auto Screenlines Model/Actual Ratio

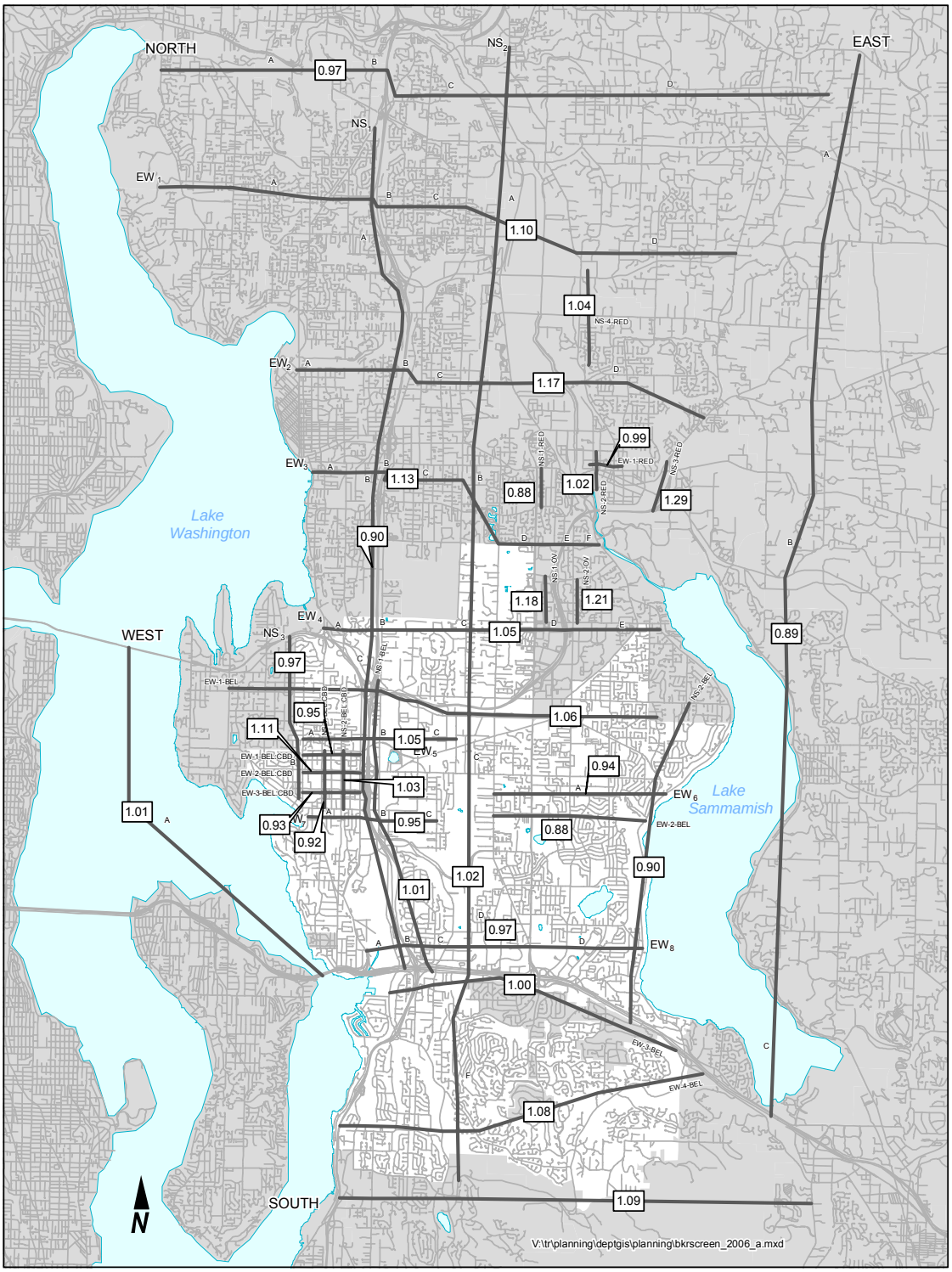


Figure 11b 2006 Redmond PM PK Hour Auto Screenlines Model/Actual Ratio

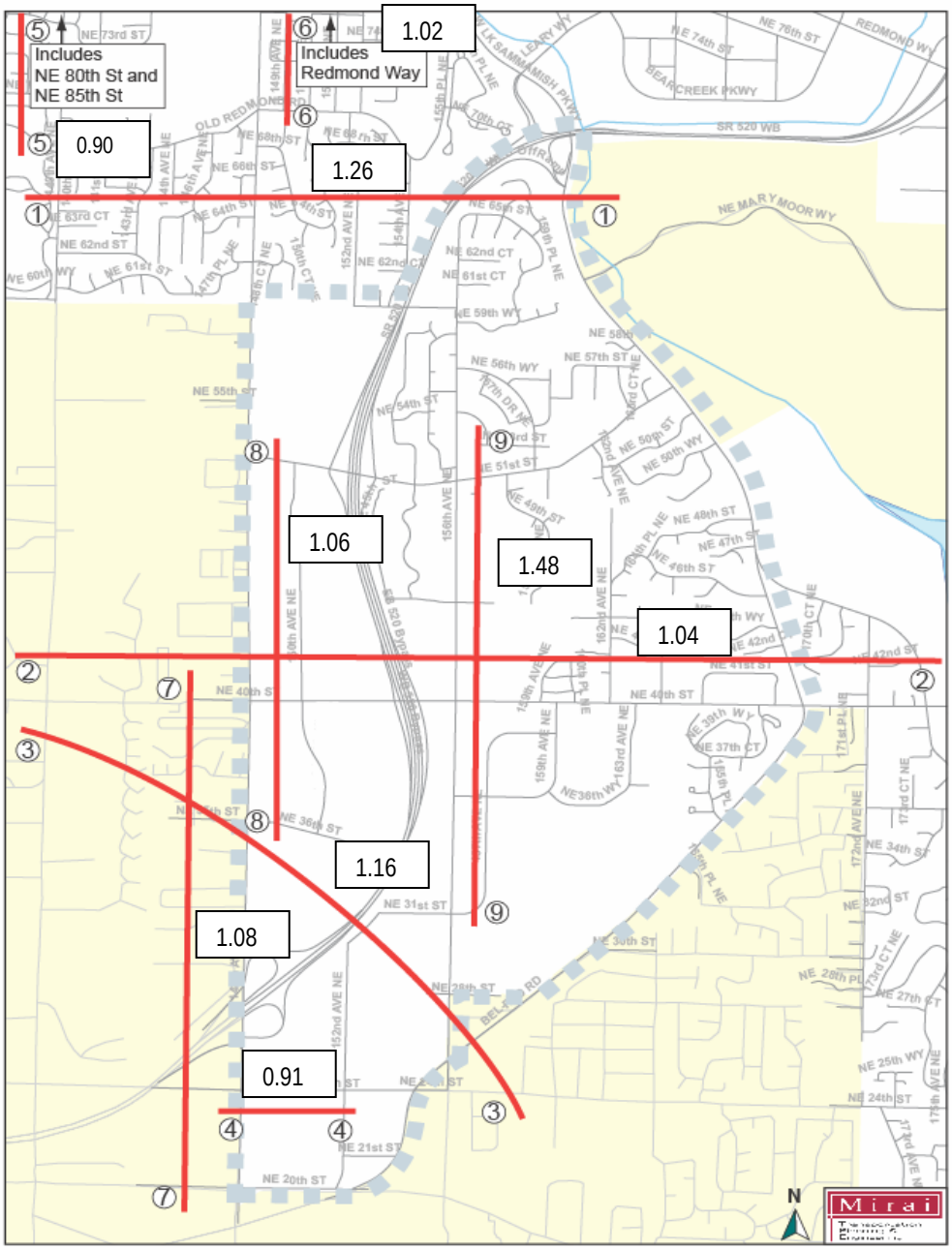


Table 8b: 2006 BKR Model Validation Results for Auto Screenlines

Screenlines	2006 BKR Model PM Peak Hour Auto Volumes Over 2006 Auto Counts		Ratio
1	North Boundary	S/O Bothell Way (SR-522) & Woodinville-Duvall Rd (NE 185th St)	0.97
2	South Boundary	S/O SE 69th Way & Newcastle-Coal Creek Rd	1.09
3	East Boundary	E/O Avondale Rd, 196th Ave NE & W Lk Samm Pkwy	0.89
4	West Boundary	Lake Washington Bridge Crossings - SR-520 & I-90	1.01
5	EW-1	N/O NE 132nd St (W/O 405) & NE 124th St (E/0 405)	1.1
6	EW-2	N/O Central Way, NE 85th St & NE Redmond Way (SR-908)	1.17
7	EW-3	N/O NE 68th St, NE 72nd St, NE 70th St, & NE 51st St	1.13
8	EW-4	N/O SR-520 & S/O NE 40th St	1.05
9	EW-5-BEL	N/O NE 12th St & Bel-Red Rd	1.05
10	EW-6-BEL	S/O NE 8th St & N/O Main St	0.94
11	EW-7-BEL	S/O Main St	0.95
12	EW-8-BEL	N/O I-90 & Eastgate Way	0.97
13	NS-1	W/O I-405	0.9
14	NS-2	E/O 132nd Ave NE, Richards Rd, 128th Ave SE & CC Pkwy	1.02
15	NS-3-BEL	W/O 100th Ave NE	0.97
16	NS-1-OV	W/O SR-520	1.18
17	NS-2-OV	E/O 156th Ave NE	1.21
18	NS-1-RED	W/O W LK Sammamish PkWy	0.88
19	NS-2-RED	W/O 161st Ave NE	1.02
20	EW-1-RED	S/O NE 83rd St	0.99
21	NS-3-RED	W/O Avondale Rd NE & SR-520	1.29
22	EW-1-BEL:CBD	S/O NE 12th St	0.95
23	EW-2-BEL:CBD	S/O NE 8th St	1.11
24	EW-3-BEL:CBD	S/O NE 4th St	0.93
25	NS-1-BEL:CBD	E/O Bellevue Way	0.92
26	NS-2-BEL:CBD	E/O 108th Ave NE	1.03
27	EW-1-BEL	S/O SR-520 & N/O NE 20th St	1.06
28	EW-2-BEL	S/O Main St	0.88
29	EW-3-BEL	S/O of I-90 & Eastgate	1
30	EW-4-BEL	N/O SE 60th St	1.08
31	NS-1-BEL	E/O I-405	1.01
32	NS-2-BEL	W/O SR-901 & W Lk Sammamish PkWy	0.9
33	NS-4-RED	E/O Red-Woodinville Rd (SR-202)	1.04
34	1-EW-Overlake	S/O Old Redmond Road	1.26
35	2-EW-Overlake	N/O NE 40th Street	1.04
36	3-EW-Overlake	N/O NE 24th Street	1.16
37	4-EW-Overlake	S/O NE 24th Street	0.91
38	5-NS-Overlake	W/O 140th Ave NE	0.9
39	6-NS-Overlake	E/O 148th Ave NE	1.02
40	7-NS-Overlake	W/O 148th Ave NE	1.08
41	8-NS-Overlake	E/O 148th Ave NE	1.06
42	9-NS-Overlake	E/O 156th Ave NE	1.48
		Overall Screenline – Model / Actual Ridership Ratio:	**1.03**

Transit Validation

Fall 2006 Automatic Passenger Counts from Metro Transit, and ridership data from Sound Transit and Community Transit were obtained to validate the transit model. The East-West (EW) and North-South (NS) screenlines are drawn in Figures 12a for thee A Peak and 12b for the PM Peak.

As shown in Table 9a for the AM Peak, overall EW screenlines show that the model marginally under-estimates the ridership survey by 2% and NS screenlines over-estimate by 2%. Overall model to actual ratio is 4% under estimation compared with actual ridership counts. Table 9b for the PM Peak shows that EW is 3% under and NS is 3% over estimated. Table 9c indicates that out of 14 transit screenlines, eleven are within the transit calibration target which is 15% over-prediction or under-prediction. Table 9d has PM peak results that show that ten of the 14 are within the calibration target. Both the AM and PM are at 100% overall. The transit screenline analysis statistically suggests that the 2006 BKR transit model is validated for use.

Table 9a: 2006 BKR Transit Model Screenline Validation Summary
- (AM Peak Hour Transit Person Trips)

Screenline Group Descriptions	NB/EB			SB/WB			TOTAL: All Directions		
	Actual	Model	M/A	Actual	Model	M/A	Actual	Model	M/A
EW Total - NB/SB	9,383	7,761	0.83	12,674	13,868	1.09	22,057	21,629	0.98
NS Total - EB/WB	11,114	8,107	0.73	12,145	15,722	1.29	23,259	23,829	1.02
Total	20,497	15,868	0.77	24,819	29,590	1.19	45,316	45,458	1.00

Table 9b: 2006 BKR Transit Model Screenline Validation Summary
- (PM Peak Hour Transit Person Trips)

Screenline Group Descriptions	NB/EB			SB/WB			TOTAL: All Directions		
	Actual	Model	M/A	Actual	Model	M/A	Actual	Model	M/A
EW Total - NB/SB	13,621	14,712	1.08	10,822	8,884	0.82	24,443	23,596	0.97
NS Total - EB/WB	16,020	17,727	1.11	10,225	9,292	0.91	26,245	27,019	1.03
Total	29,641	32,439	1.09	21,047	18,176	0.86	50,688	50,615	1.00

Table 9c: 2006 AM Peak Hour Transit Model to Actual Ridership Screenlines

1	**EW-1**	EW-1 (South of I-90)	**1.29**
2	**EW-2**	EW-2 (North of I-90)	0.99
3	**EW-3**	EW-3 (South of NE 8th St.)	**0.84**
4	**EW-4**	EW-4 (South of SR-520)	0.94
5	**EW-5**	EW-5 (North of SR-520)	0.97
6	**EW-6**	EW-6 (South of Redmond Wy/NE 85th St.)	1.14
7	**EW-7**	EW-7 (North of Redmond Wy/NE 85th St.)	1.04
8	**EW-8**	EW-8 (North of NE 124th St.)	0.86
9	**NS-1**	NS-1 (Lake. Washington Bridges)	1.04
10	**NS-2**	NS-2 (West of I-405)	0.94
11	**NS-3**	NS-3 (East of I-405 / 124th Ave)	1.00
12	**NS-4**	NS-4 (East of 148th Ave NE)	0.95
13	**NS-5**	NS-5 (East of 156th Ave NE & W of Avondale Rd)	**1.37**
14	**NS-6**	NS-6 (East of Avondale Rd. NE/SR520)	1.06
		EW Screenline - NB/SB Volume - Model / Actual	0.98
		NS Screenline - EB/WB Volume - Model / Actual	1.02
		Overall Screenline - Model / Actual Ridership Ratio:	**1.00**

Table 9d: 2006 PM Peak Hour Transit Model to Actual Ridership at Screenlines

1	**EW-1**	EW-1 (South of I-90)	1.13
2	**EW-2**	EW-2 (North of I-90)	0.94
3	**EW-3**	EW-3 (South of NE 8th St.)	**0.81**
4	**EW-4**	EW-4 (South of SR-520)	0.99
5	**EW-5**	EW-5 (North of SR-520)	0.97
6	**EW-6**	EW-6 (South of Redmond Wy/NE 85th St.)	1.15
7	**EW-7**	EW-7 (North of Redmond Wy/NE 85th St.)	1.04
8	**EW-8**	EW-8 (North of NE 124th St.)	**0.79**
9	**NS-1**	NS-1 (Lake. Washington Bridges)	1.12
10	**NS-2**	NS-2 (West of I-405)	1.05
11	**NS-3**	NS-3 (East of I-405 / 124th Ave)	0.92
12	**NS-4**	NS-4 (East of 148th Ave NE)	0.91
13	**NS-5**	NS-5 (East of 156th Ave NE & W of Avondale Rd)	**1.34**
14	**NS-6**	NS-6 (East of Avondale Rd. NE/SR520)	**0.60**
		EW Screenline - NB/SB Volume - Model / Actual	0.97
		NS Screenline - EB/WB Volume - Model / Actual	1.03
		Overall Screenline - Model / Actual Ridership Ratio:	**1.00**

Figure 12a: 2006 AM Peak Hour Transit Screenline Model/Actual Ratio

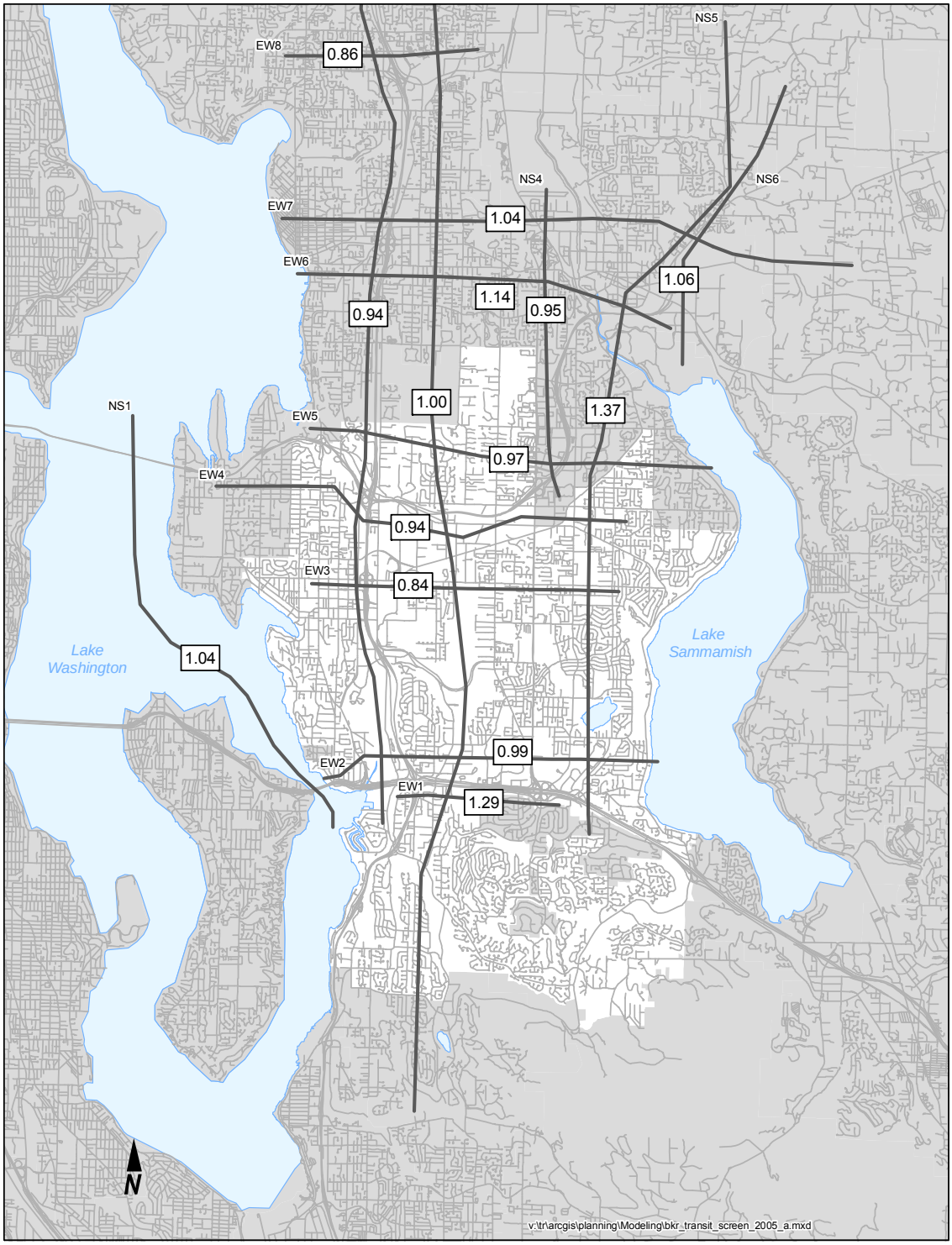
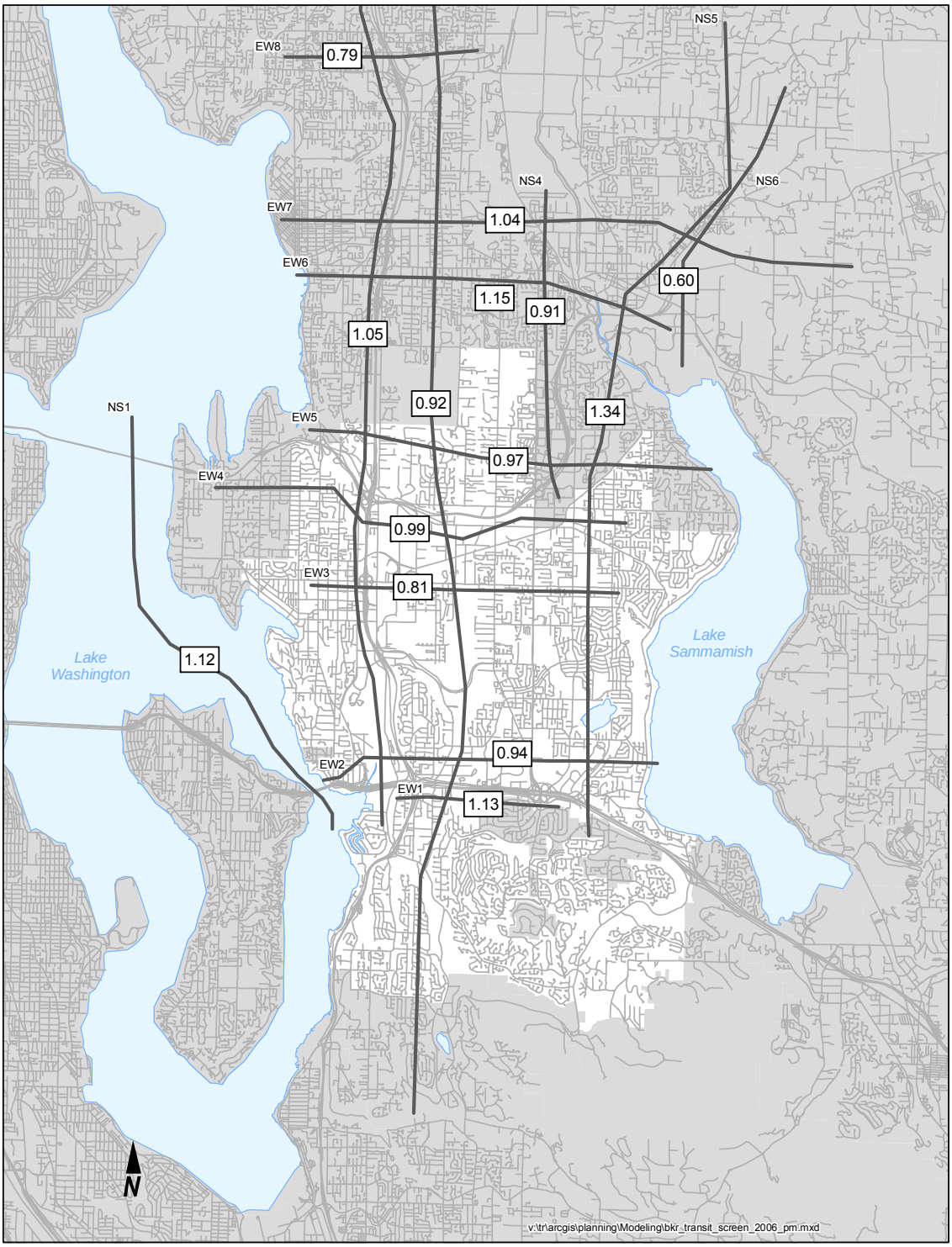


Figure 12b: 2006 PM Peak Hour Transit Screenline Model/Actual Ratio



Section from Consultant

BKR Model enhancement
Non-motorized trip generation and distribution report

August 31st, 2007

Prepared for:
City of Bellevue

Prepared by:
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Introduction

To meet the increasing needs for travel demand modeling and analysis, Bellevue, Kirkland and Redmond partners have jointly identified a list of base model enhancements for implementation in the 2006 annual model update program. The enhancements are expected to develop and incorporate non-motorized trip generation and trip distribution model into the BKR model. This report documents the development and validation of the non-motorized travel demand model for the BKR Model Platform.

Since its inception, BKR model has always been a motorized travel demand model. As population and employment grow in the Eastside rapidly and land use density increase rapidly (especially in Downtown Bellevue area), pedestrian and bicycle trips become more significant in regional and local travel. Modeling non-motorized travel becomes increasingly essential.

In this model development, the focus is on non-motorized trip generation and distribution. The target is to create a set of non-motorized trip tables for each purpose: Home-based Work (HBW), Home-Based Other, Non-home-based (NHB) and School trips by Walk and Bicycle modes separately.

Trip Generation

Approach

Based on the latest released 1999 Puget Sound Regional Council (PSRC) household survey, walk and bicycle mode travel data were obtained. Trip rates were calculated for each trip purpose, stratified by socio-economic cross-classifications such as household size and number of workers per household. Table 1 summarizes the trip rates for non-motorized trips in the Puget Sound region. Attraction rates are estimated based on the BKR motorized trip generation pattern. Assuming that non-motorized trips have similar attraction-to-production rate ratio to motorized trips, non-motorized to motorized trip ratios were calculated to estimate the non-motorized attraction rates. Table 2 lists the BKR attraction rates and the non-motorized to motorized trip ratios. Non-motorized trip productions and attractions are generated for each traffic analysis zones based on the trip rates. Regional productions and attractions for external TAZs were added to the BKR productions and attractions.

Table 1 Trip rates for non-motorized trips in the Puget Sound region

HH HBW NMTRIP RATES	HH Workers				
HH Size	0	1	2	3+	Total
1	0.00	0.09	n/a	n/a	0.06
2	0.00	0.03	0.12	n/a	0.06
3	0.00	0.06	0.10	0.05	0.08
4+	0.10	0.03	0.07	0.15	0.07
Total	0.00	0.06	0.10	0.11	0.06

Table 1 (Continued)

HH HBCOLLEGE NMRTIP RATES College Age Persons in HH	
0	0.01
1	0.03
2+	0.10
Total	0.01

HH HBSCHOOL NMRTIP RATES School Age Persons in HH	
0	0.00
1	0.14
2	0.32
3+	0.54
Total	0.08

HH HBSHOP NMTRIP RATES	HH Workers				
HH Size	0	1	2	3+	Total
1	0.07	0.06	n/a	n/a	0.06
2	0.05	0.05	0.06	n/a	0.05
3	0.06	0.04	0.02	0.00	0.03
4+	0.12	0.00	0.03	0.05	0.03
Total	0.06	0.04	0.04	0.03	0.05

HH HBOTHER NMTRIP RATES	HH Workers				
HH Size	0	1	2	3+	Total
1	0.13	0.12	n/a	n/a	0.12
2	0.13	0.15	0.12	n/a	0.13
3	0.20	0.22	0.21	0.05	0.19
4+	0.46	0.40	0.33	0.26	0.34
Total	0.14	0.20	0.21	0.19	0.19

HH NHB WORK/OTHER NMTRIP RATES	HH Workers				
HH Size	0	1	2	3+	Total
1	0.00	0.13	n/a	n/a	0.08
2	0.00	0.09	0.17	n/a	0.10
3	0.00	0.05	0.10	0.16	0.09
4+	0.00	0.04	0.12	0.13	0.10
Total	0.00	0.09	0.14	0.14	0.09

HH NHB OTHER/OTHER NMTRIP RATES	HH Workers				
HH Size	0	1	2	3+	Total
1	0.08	0.12	n/a	n/a	0.10
2	0.09	0.13	0.08	n/a	0.10
3	0.11	0.11	0.11	0.02	0.10
4+	0.14	0.08	0.13	0.20	0.13
Total	0.08	0.11	0.11	0.14	0.11

Table 2 BKR Model AttractionRates and Non-motorized/Motorized Ratio

Productions			HBW	HBC	HBShop	HBO	SCH	WKO	NHBOther	CMV
Motorized/Non-Motorized			22	6	18	14	6	8	15	
Non-Motorized/Motorized			0.04	0.17	0.06	0.07	0.16	0.13	0.07	
109		Retail	-	-	-	-	-	0.19	0.22	-
110		Retail	-	-	-	-	-	0.19	0.22	-
111		Retail	-	-	-	-	-	0.19	0.22	-
112		FIRES	-	-	-	-	-	0.04	0.05	-
113		FIRES	-	-	-	-	-	0.04	0.05	-
114		FIRES	-	-	-	-	-	0.04	0.05	-
115		GOV	-	-	-	-	-	0.04	0.04	-
116		GOV	-	-	-	-	-	0.04	0.04	-
117		GOV	-	-	-	-	-	0.04	0.04	-
118		EDU	-	-	-	-	-	0.01	0.01	-
119		WTCU	-	-	-	-	-	0.01	0.01	-
120		MANU	-	-	-	-	-	0.05	0.06	-
121		College	-	-	-	-	-	-	-	-

Attractions			HBW	HBC	HBShop	HBO	SCH	WKO	NHBOther	CMV
Motorized/Non-Motorized										
Non-Motorized/Motorized			0.04	0.17	0.06	0.07	0.16	0.13	0.07	
109		Retail	0.07	-	0.24	0.26	-	0.19	0.22	-
110		Retail	0.07	-	0.12	0.12	-	0.19	0.22	-
111		Retail	0.07	-	0.02	0.08	-	0.19	0.22	-
112		FIRES	0.06	-	-	0.24	-	0.04	0.05	-
113		FIRES	0.06	-	-	0.12	-	0.04	0.05	-
114		FIRES	0.06	-	-	0.08	-	0.04	0.05	-
115		GOV	0.06	-	-	0.26	-	0.04	0.04	-
116		GOV	0.06	-	-	0.12	-	0.04	0.04	-
117		GOV	0.06	-	-	0.08	-	0.04	0.04	-
118		EDU	0.07	-	-	0.08	1.29	0.01	0.01	-
119		WTCU	0.07	-	-	0.01	-	0.01	0.01	-
120		MANU	0.07	-	-	0.01	-	0.05	0.06	-
121		College	-	0.15	-	-	-	-	-	-

Walk and Bike Trip Generation

Walk to bicycle trip ratios were calculated for each trip purpose so that distinctive walk productions and attractions and bicycle productions and attractions for each purpose can be calculated. The separation of walk and bike modes enable the model to distribute the walk trips and bicycle trips separately as walkers and bikers have different trip pattern, lengths and speeds. Table 3 shows the walk-to-bicycle trip ratio for each purpose.

Table 3 Walk to bicycle Trip Ratio by Purpose

Walk/Bike Ratio				
	HBW	**HBO**	**NHB**	**SCH**
Walk	110,245	493,673	443,184	169,315
Bike	62,873	73,526	40,228	19,939
Walk Percent	**0.64**	**0.87**	**0.92**	**0.89**
Bike Percent	**0.36**	**0.13**	**0.08**	**0.11**

Validation

To validate the non-motorized trip generation model, the trip generation model results were compared to the PSRC household surveys. The non-motorized trip results were also compared with the motorized trips to that an overall picture of regional trip generation can be painted. Table 4 outlines the overall non-motorized model trip productions and attractions in the region.

Table 4 Non-motorized model trip productions and attractions in the region

BKR Area

Productions		Motorized	Non-motorized		Motorized/Non-motorized Ratio	M/NM Trip Generation Rate Ratio
HBW	MO1	236,811	13,648	MO141	17.31	22
HBO	MO2	735,531	38,052	MO142	19.33	14-18
NHB	MO3	626,816	34,817	MO143	9.00	8-15
SCH	MO4	81,757	11,888	MO144	6.88	6
		1,680,915	98,435			
Attractions						
HBW	MD1	431,874	21,542	MD41	20.05	
HBO	MD2	1,065,862	70,788	MD42	15.06	
NHB	MD3	644,379	26,768	MD43	12.04	
SCH	MD4	61,347	10,017	MD44	6.12	
		2,203,462	129,115			

External Ps and As

Productions		Motorized	Non-motorized		Motorized/Non-motorized Ratio	M/NM Trip Generation Rate Ratio
HBW	MO1	2,403,507	93,477	MO141	25.71	22
HBO	MO2	4,902,902	285,904	MO142	17.15	14-18
SCH	MO3	3,567,597	234,646	MO143	15.20	8-15
NHB	MO4	908,375	352,411	MO144	2.58	6
Attractions						
HBW	MD1	2,285,502	93,419	MD41	24.47	
HBO	MD2	4,596,573	285,450	MD42	16.10	
SCH	MD3	3,467,642	234,645	MD43	14.78	
NHB	MD4	905,343	353,977	MD44	2.56	

External Ps and As

Productions		Motorized	Non-motorized		Motorized/Non-motorized Ratio	M/NM Trip Generation Rate Ratio
HBW	MO1	2,403,507	93,477	MO141	25.71	22
HBO	MO2	4,902,902	285,904	MO142	17.15	14-18
SCH	MO3	3,567,597	234,646	MO143	15.20	8-15
NHB	MO4	908,375	352,411	MO144	2.58	6
Attractions						
HBW	MD1	2,285,502	93,419	MD41	24.47	
HBO	MD2	4,596,573	285,450	MD42	16.10	
SCH	MD3	3,467,642	234,645	MD43	14.78	
NHB	MD4	905,343	353,977	MD44	2.56	

Table 5 Daily Trips Rates per BKR Household

	Motorized	**Non-motorized**	**PSRC HH Survey**
HBW	1.43	0.08	0.07 to 0.08=0.06(HBW)+0.01(HBCol)
HBO	4.46	0.23	0.23 to 0.25=0.19(HBO)+0.05(HBShop)
NHB	3.80	0.21	0.20 = 0.09(Work-Other)+0.11(Other-Other)
SCH	0.50	0.07	0.08
Overall	10.19	0.60	0.60
	Total BKR HH		
	165,038	164,218	

Trip Distribution

Like the BKR motorized model, the non-motorized trip distribution is based on gravity model. A key part of the gravity model is friction factors. Friction factors are the frictions(in terms of time and distance) for each traveler when making a decision how long will they travel to achieve his or her purpose. Most people choose to live closer to where they work or go to school. They may go to shop nearby or drop off their kids in a daycare center within their neighborhood. A friction factor function mimic the collective travel behavior of travelers in terms of travel time and distance for each purpose. PSRC household travel survey data are used to estimate and calibrate the friction factor function curve. The travelers filled out the travel time and distance they travel for each purpose (HBW, HB-College, HB-Shop, HBO, NHB and School) up to 40 minutes or above. Based on the trip travel time data for walk and bicycle trips, trip distribution friction factor functions were created. Initially, the survey data were more step-like (or quantum leap) as people tends to report in 5, 10, 15 and 30 minutes. The survey data were smoothened in order to mimic the actual travel time which are likely to be more continuous than the reported survey data.

Here is the calibration procedure:
• Original friction factors were used in the prior BKR travel models;
• Initial gamma functions were established to emulate the original functions; and
• Final gamma functions were established to match observed trip durations.
The basic functional formula for the friction factors is given by the gamma function as follows:
$f(t) = \alpha \exp(\beta t) t\gamma = \alpha \exp(\beta t + \gamma \ln t)$

Alpha, beta and gamma parameters were tested and adjusted in order to fit the friction function curve. The tail end of the curve terminates at 40 to 60 minutes to realistically represent the real behavior of walkers and bikers: most people don't walk more than 40 minutes for work and most other purposes and most bikers don't travel more than 60 minutes for most purposes. The imposed maximum tail end brings model average travel time much closer to the survey travel time.

Initial friction factor functions were input to the newly developed walk trip distribution and bike trip distribution model. Average trip time was calculated after each model was run. The model walk and bicycle average trip times for each purpose were compared to the average trip times calculated from the survey. Multiple model runs were conducted to test each adjusted friction factor functions. After the friction factors were finalized, final walk and bicycle trip tables were created for each purpose.

Validation

Table 7 shows compare the average trip time between the BKR model and survey data. For walk modes, the average trip time is very close for HBW and school trips. For bike modes, the average trip time is very close for HBO and NHB trips and reasonably close for HBW trips.

Table 7 BKR Non-Motorized Model - Average Trip Time Validation: Actual vs Model

	WALK			
	HBW	**HBO**	**NHB**	**SCH**
Avg Trip time	**16.55**	**11.30**	**8.67**	**14.07**
	All to All			
MODEL run 1	22.5	25.65	16.65	23.22
MODEL run 2	22.23	23.67	14.87	22.65
Model Run 3	16.34	14.22	11.53	15.29
Model Run 4 (Final)	16.34	14.22	11.37	15.27
Model - Survey	-0.21	2.92	2.70	1.20

	BIKE			
	HBW	**HBO**	**NHB**	**SCH**
Avg Trip time	**24.93**	**18.16**	**13.92**	**14.90**
MODEL RUN 1	39.38	28.47	21.65	18.97
MODEL RUN 2	41.63	26.68	20.33	14.96
Model Run 3	22.23	18.1	14.56	26.77
Model Run 3b	18.97			18.66
Model Run 4	23.29	18.1	13.73	18.66
Model - Survey	-1.64	-0.06	0.64	3.76

LOOKING FORWARD

An accurate base model platform is essential to enable the eastside jurisdictions to accurately forecast future travel demand patterns and traffic conditions.

To build a solid foundation for future traffic forecasts, the Bellevue Transportation Modeling and Analysis group will continue to improve the base year model platform, with support from Kirkland, Redmond, PSRC, and/or consultants. The improvements will include but are not limited to the more up to date land use data in the BKR areas and their fringe areas, roadway network changes, the latest transit travel route information, and external trip productions and attractions from PSRC, especially the new 2006 regional household travel survey data. Also, the BKR models are continuously reviewed by the Technical Advisory Committee and enhanced by a number of state-of-art methodologies as they become available.

Based on this new BKR base year model, the Bellevue Modeling and Analysis group will develop a new set of mid- to long-range models (such as 6-Year, 12-Year, 20-Year and 30-year models) in late 2007. During the period prior to the next annual update the software platform will be migrated to Emme3 which will mark a significant change for the users.

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