SOUNDTRANSIT
RIDE THE WAVE

Lynnwood Link Extension

Backcast Test Memorandum

SOUND TRANSIT

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1 INTRODUCTION

The memorandum presents findings from using the new 2014 base networks and demand matrixes to perform a forecast of 2004 ridership. The base year in the Sound Transit (ST) incremental model was recently updated to reflect actual transit services and ridership in 2014.

2 PURPOSE AND OBJECTIVE OF TEST

This section presents the use of the new 2014 base networks and demand matrixes to perform a forecast of 2004 ridership. As this modeling effort estimates transit ridership for an earlier year, this model estimate will be referred to as a "backcast" in this memorandum. Analysis results and findings reflect application of the three-stage ridership forecasting process, as used for the future forecasting, to capture the reaction to changes in demographics, congestion, parking and gasoline prices, transit fares, and transit service levels between 2014 and 2004. This analysis provides useful insights that could potentially benefit and improve the Sound Transit incremental transit model.

3 KEY CHANGES BETWEEN 2014 AND 2004

Key changes between 2014 and 2004 are highlighted in this section. These include changes in:

- Demographics (households and employment)
- Auto travel time and travel costs
- Transit network (bus speeds, frequencies, new or revised lines)

Households and employment, respectively, were lower in 2004 by about 10 percent and 13 percent compared to those in 2014. Year 2014 employment had recovered from the 2008 recession to a level higher than the peak of spring 2008, following a significant decline from 2008 to 2010. This decline in employment was not accompanied by a decline in the number of households.

Highway congestion has generally returned to 2008 levels, which means slightly faster auto travel times in 2004 than in 2014. Prior to the imposition of tolls on the SR 520 floating bridge, travel times were slower in 2004 than in 2014, but highway costs were lower without the tolls. Parking costs have tracked with employment changes, declining briefly during 2008 to 2010, but now returning to at least 2008 levels.

A few significant transit network changes have occurred since 2004, for both rail and bus services:

- ST Sounder commuter rail service on both the North and South line offered significantly fewer peak trips in 2004.
- ST Link service did not exist in 2004 for the line between downtown Seattle and Sea-Tac Airport opening in 2009.
- Some ST Express bus routes were structured differently and with less frequency in 2004 than in 2014.

- All six King County Metro (KCM) RapidRide routes did not exist in 2004, although local service existed in all of the corridors at that time.
- Suburban routes for KCM in East and South King County were different in 2004. These areas were restructured in 2011 and 2007, respectively, with most of these restructures tending to provide a slight shift away from peak downtown express hours to instead providing intra-subarea all-day service.
- Urban routes operated by KCM in northwest and southwest Seattle were also different in 2004 than in 2014. The primary restructure occurred in these areas in 2012 with the start of RapidRide service.
- Community Transit had higher service levels in 2004. In 2010 and 2011, Community Transit, in response to the 2008 recession, reduced local and express service and eliminated all Sunday service.
- Pierce Transit had substantially higher service levels in 2004. In 2010, Pierce Transit, in response to the 2008 recession, made severe frequency cuts on most of its services, typically reducing off-peak frequencies from 30 minutes to 60 minutes, except on the few busiest routes.

4 PREPARATION OF INPUT DATA FOR BACKCAST

Of critical importance to the usefulness of a backcast exercise is the careful preparation of input data. Input values for the past are more known than they are for future forecasts, yet they are still imperfectly known or not readily available. This exercise required some specific decisions on several more 2004 input values than had been anticipated.

Normally, for forecasting applications, the use of non-census years requires interpolation of regional land use forecast to arrive at values for the year of interest. Actual population and employment at county level for 2004 and 2014 were available from the Washington State Office of Financial Management (OFM) and the Washington State Employment Security Department (ESD). These data were used to adjust interpolated 2004 and 2014 land use estimates at county level. While using the county-level OFM and ESD data appeared to be essential for this backcast, there was no data available on actual distribution of land use at a zonal level.

Changes in highway travel times have limited effects on transit ridership in the Sound Transit model, and in the absence of a data source detailed enough to represent actual highway times for 2004, a one-decade highway travel time change matrix was developed from the regional travel demand model.

For parking costs, a more traditional method was applied, basically scaling back the 2014 parking according to changes in employment density, in preference to relying on 2004 parking costs, in order to replicate the method used in forecasting this input. Auto operating costs in 2014 dollars were not changed for 2004, since these are not changed except for special sensitivity tests.

The most critical inputs for an incremental model backcast are the transit network descriptions for 2004. This data was complete allowing more confidence in this input than much of the other input data prepared for the backcast test.

5 BACKCAST TEST RESULTS

5.1 Build-up/down Analysis: 2014 to 2004

The strategy underlying the stepwise development of the 2004 build-up/down backcast is to observe the effect on estimated transit ridership of each change in conditions between 2014 and 2004. The approach uses the same three-stage forecasting analysis procedures and assumptions that are described in the *Transit Ridership Forecasting Methodology Report* (March 2015). Performing forecasting or backcasting analysis in stages explicitly shows the intermediate results of the process. Specific contributions at each stage to changes in ridership are calculated and analyzed separately. The results of the three stages in the backcast are:

- Stage 1—Changes in ridership related to a 10-year change in households and employment
- Stage 2—Changes in ridership related to changes in auto travel times, auto operating costs, parking costs, and median household income
- Stage 3—Changes in ridership related to changes in transit service and fares

Table 5-1 presents district-level 2014 and 2004 land use summaries. Year 2014 land use estimates are identical to those used for the base year to develop the 2035 Stage 1 forecast for the Lynnwood Link Extension. Year 2004 households and employment were linearly interpolated using Puget Sound Regional Council (PSRC) Forecasting Analysis Zones (FAZ) 2000 and 2010 historical land use estimates. Resulting 2004 FAZ-level land use estimates were scaled at the county level to reflect the actual measured changes in households and employment between 2004 and 2014, as documented by OFM and ESD.

Table 5-1: Total Households and Employment from 2014 to 2004

		Year 2014[1]		Year 2004[2]		% Change: 2014 to 2004	
No.	District Name	Households	Employment	Households	Employment	Households	Employment
1	Everett	102,400	139,800	91,000	118,100	-11%	-16%
2	SW Snohomish	178,300	127,000	157,200	107,600	-12%	-15%
3	Shoreline	27,800	20,700	26,500	17,700	-5%	-14%
4	North Seattle	119,100	122,100	111,600	104,200	-6%	-15%
5	Seattle CBD	18,900	139,800	13,600	131,300	-28%	-6%
6	South Seattle	158,500	238,900	144,300	207,700	-9%	-13%
7	East King	229,000	349,600	200,600	283,400	-12%	-19%
8	South King	268,000	331,800	243,800	282,900	-9%	-15%
9	Tacoma	114,500	138,400	106,000	140,400	-7%	1%
10	Pierce	203,900	185,800	179,800	166,700	-12%	-10%
11	Rest of Region	109,700	101,700	100,900	102,900	-8%	1%
ST Area		1,420,400	1,793,900	1,274,400	1,560,000	-10%	-13%
4-County Region		1,530,100	1,895,600	1,375,300	1,662,900	-10%	-12%

[1] Based on PSRC's Land Use Targets Forecast, Maintenance Release 1, April 2014.
[2] Year 2004 land-use was obtained by interpolating between 2000 and 2010 of PSRC's land-use data (April 2014), which was subsequently adjusted at county level such that the 2004 to 2014 observed county-level growth rates were realized. This was based on using Washington State's Office of Financial Management and Employment Security Department databases for 2004 and 2014.

Figure 5-1 shows a map of the 11 summary district boundaries used in Table 5-1 and Table 5-2. The rates of change for the ST area between 2014 and 2004 in households and employment were about 10 and 13 percent, respectively. For downtown Seattle, because of the economic downturns in 2008, employment has decreased by about 6 percent while Seattle downtown households have decreased by about 28 percent.

Table 5-2 presents district-level build-up/down results related to daily transit trips. Results from the first stage of the 2004 backcast analysis indicate that regional demographic change between 2014 and 2004 yields a 10 percent reduction in daily transit trips within the Sound Transit service district. This percentage change in transit trips in Stage 1 of the 2004 backcast relative to 2014 is lower than the rate of demographic changes between 2004 and 2014, potentially because much of the increase in households and employment has occurred in locations with lower levels of transit service than provided within the City of Seattle.

In Stage 2 of the 2004 backcast, the combined effect of changes in auto operating costs, parking costs and highway congestion were taken into consideration. These changes decreased Stage 2 daily transit trips by about 10 percent relative to Stage 1.

Figure 5-1: 11-District Map

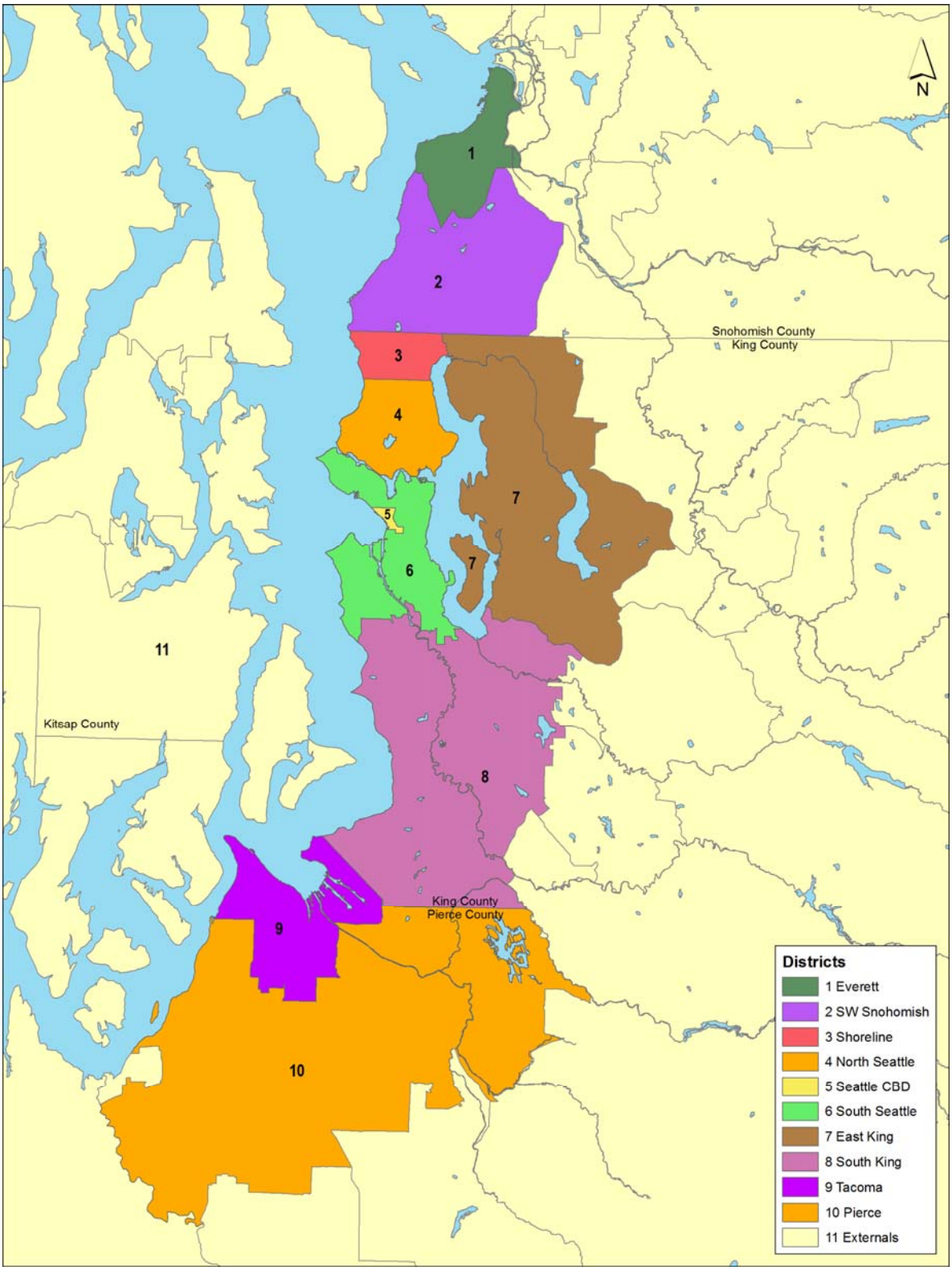


Table 5-2: Build-up/down Analysis: 2014 to 2004 Daily Transit Trip Ends (Origin/Destination Format)

			Staged 2004 Backcast Estimates				
No.	District Name	2014 Base Year[1]	Stage 1 (Demographics)	Stage 2 (External Factors)	Stage 3 (Transit Service Levels & Fares)	2004 Targets[2]	Percent Difference—2004 Estimated vs. Targets
1	Everett	12,200	10,800	10,100	8,600	9,300	-8%
2	SW Snohomish	15,100	13,400	12,500	12,100	11,300	7%
3	Shoreline	6,600	6,100	5,700	5,400	5,400	0%
4	North Seattle	64,400	57,800	52,200	51,000	53,500	-5%
5	Seattle CBD	74,200	68,600	60,600	59,300	64,200	-8%
6	South Seattle	96,100	85,200	78,800	75,000	78,300	-4%
7	East King	39,600	34,300	30,300	30,000	21,600	28%
8	South King	44,100	39,200	35,800	32,900	28,500	13%
9	Tacoma	20,000	19,000	16,900	21,900	19,100	13%
10	Pierce	12,200	11,200	10,100	12,400	8,600	31%
11	Rest of Region	2,700	2,500	1,700	1,600	1,900	-19%
Total Daily Transit Trips		387,200	348,100	314,700	310,200	301,700	3%
% Change Relative to 2014			-10%	-19%	-20%	-22%	
% Change Relative to Previous Step in Build-Up Analysis			-10%	-10%	-1%		

[1] Trip ends were obtained from the Sound Transit model for the year 2014.
[2] Target trip ends were obtained from the Sound Transit model for the year 2004.

In Stage 3 of the 2004 backcast analysis, the changes in transit service levels and fares between 2004 and 2014 were introduced. A 2004 transit network year was built upon the base year 2014 transit network using the same network conventions currently used in the forecasting process. This network was used to produce 2004 transit travel times and perform EMME transit assignments.

Stage 3 total daily transit trips decreased by about 1 percent relative to Stage 2. Table 5-2 also includes differences in Stage 3 estimates relative to 2004 target transit trips. This comparison indicates that the Stage 3 result of total daily transit trips in 2004 is over-estimated by about 3 percent (or 8,500 trips).

5.2 2004 Observed versus Estimated

This section includes comparison of 2004 observed and estimated backcast results of boardings by operator and boardings by route. It also compares 2004 estimated and target district-to-district daily transit trips.

5.2.1 Boardings by Operator

Table 5-3 includes comparison of average weekday observed versus estimated boardings in King, Snohomish, and Pierce Counties. The model has estimated the number of boardings in 2004 within

10 percent of actual boardings in King and Snohomish Counties. These boardings account for about 90 percent of all boardings in the three-county Sound Transit service district and represent the two operators that serve the Lynnwood Link Extension project area. The model has overestimated 2004 boardings by 29 percent in Pierce County, likely due to the headway improvements to very infrequent routes in the 2004 network.

Table 5-3: Comparison of Daily 2004 Observed and Model-estimated Boardings by Transit Operator

Operator[1]	ObservedBoardings[2]	Estimated Boardings	Estimated/ Observed
King County Metro	327,000	351,700	1.08
Sound Transit (Rail)	6,000	5,100	0.85
Pierce Transit	46,000	59,300	1.29
Community Transit	32,000	35,000	1.09
Everett Transit	6,000	6,000	1.00
Three-County Total Boardings	417,000	457,100	1.10

[1]Sound Transit bus boardings are included within the respective totals for the operating agency of each route.
[2]Actual boardings by agency were obtained from National Transit Database for the year 2004.

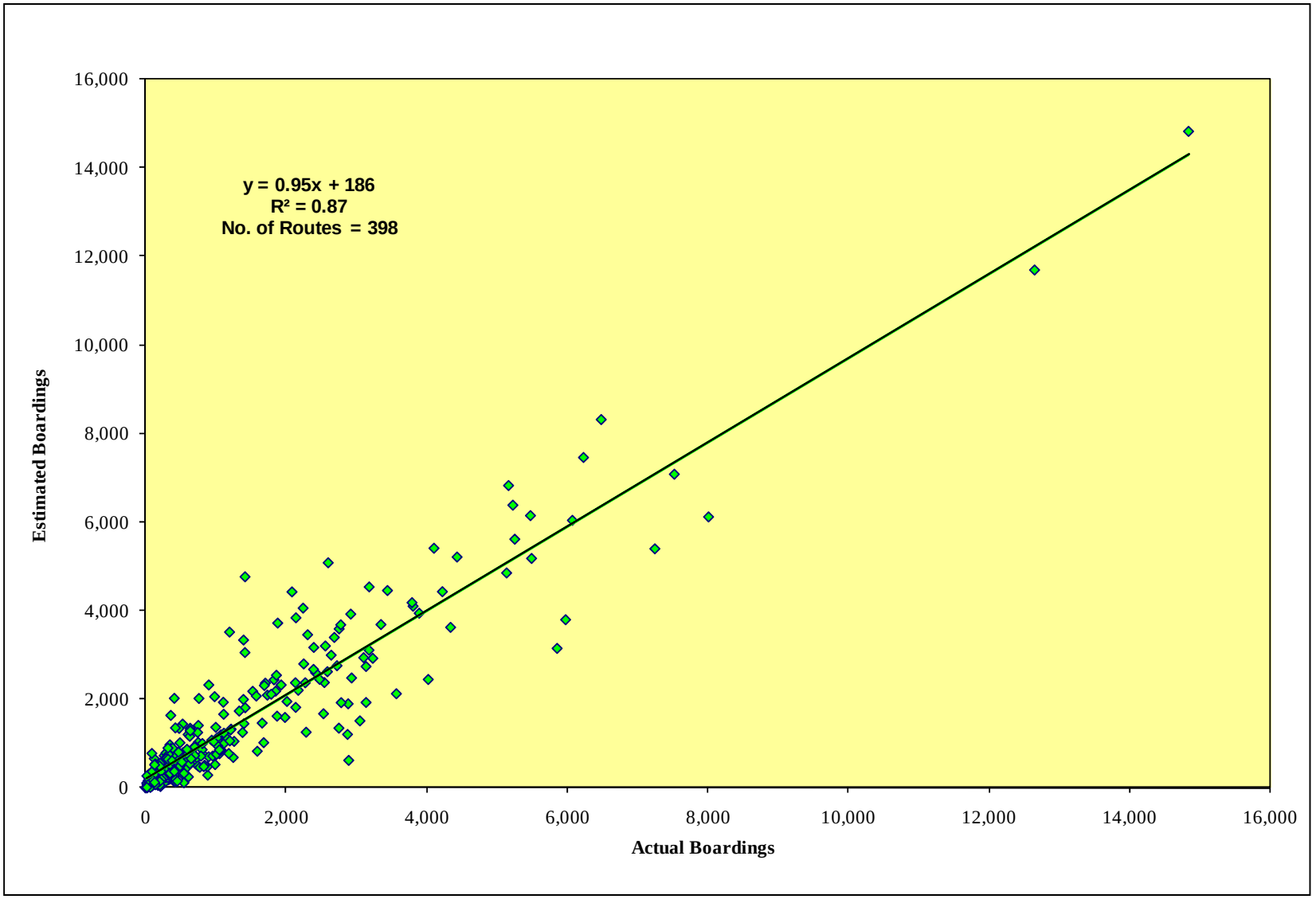
5.2.2 Route-Level Boarding Comparison

Figure 5-2 illustrates the model's replication of route-level boardings in 2004. This figure shows average weekday total boardings on 398 transit lines against the actual boardings on those lines. The model has fairly replicated actual line boardings as indicated by the goodness of fit statistic estimates of 0.95 for slope and 0.87 for R-squared.

Examination of outlier routes in Figure 5-2 shows a significant bias regarding routes below the line versus those above the line, with downtown oriented trolley routes dominating below the line. This under-estimation of boardings on in-city routes with short trips, high rider turnover, and high off-peak ridership has been noticeable in the transit assignment procedure for previous applications of the model. The issue may be traced to the seed matrices used to build the base year demand, which have never adequately captured short transit trips from surveys.

Investigation of outliers above the line was less conclusive, but there is nonetheless a pattern. Recent BRT-style improvements for some longer King County Metro routes increased ridership beyond levels directly attributable to travel time improvements. The backcast then was not able to sufficiently reduce ridership to 2004 levels in these cases, resulting in the most noticeable outliers above the line.

Figure 5-2: Comparison of Daily 2004 Observed and Model-estimated Transit Line Boardings



5.3 Change in Transit Trips

Table 5-4 compares estimated and target daily 2004 transit trips by summary districts. The model under-estimated daily transit trip patterns for intra-subarea local transit markets in King County by about 2,000 to 4,000 trips. Otherwise, the model has reasonably replicated 2004 trips.

Table 5-4: Comparison of Daily 2004 Target and Estimated Transit Trips (Origin/Destination Format: Estimates minus Targets)

ORIGIN \ DESTINATION	Everett 1	SW Snohomish 2	Shoreline 3	North Seattle 4	Seattle CBD 5	South Seattle 6	East King 7	South King 8	Tacoma 9	Pierce 10	Rest of the Region 11	Origin Totals
Everett 1	(70)	(640)	(30)	(240)	(90)	180	150	80	20	20	(90)	(710)
SW Snohomish 2	(640)	610	–	(550)	(30)	650	380	280	80	50	(30)	800
Shoreline 3	(30)	–	(230)	(210)	(210)	420	90	130	40	20	–	20
North Seattle 4	(240)	(550)	(210)	(3,190)	1,640	(690)	–	440	190	130	(60)	(2,540)
Seattle CBD 5	(90)	(30)	(210)	1,640	(3,540)	(2,680)	1,430	(180)	(450)	(600)	(160)	(4,870)
South Seattle 6	180	650	420	(690)	(2,680)	(4,140)	1,770	880	280	160	(80)	(3,250)
East King 7	150	380	90	–	1,430	1,770	2,740	1,170	360	250	40	8,380
South King 8	80	280	130	440	(180)	880	1,170	1,560	(60)	70	40	4,410
Tacoma 9	20	80	40	190	(450)	280	360	(60)	750	1,500	20	2,730
Pierce 10	20	50	20	130	(600)	160	250	70	1,500	2,220	20	3,840
Rest of the Region 11	(90)	(30)	–	(60)	(160)	(80)	40	40	20	20	(10)	(310)
Destination Totals	(710)	800	20	(2,540)	(4,870)	(3,250)	8,380	4,410	2,730	3,840	(310)	8,500

6 OBSERVATIONS AND LESSONS LEARNED

The Sound Transit incremental model three-staged forecasting process is sound and reasonable for transparently performing transit ridership analysis. The following lessons may be drawn from the 2014 to 2004 backcast exercise.

- The Sound Transit data-driven incremental transit model is responsive for short- to mid-term (10-year) changes in service levels and demographics. This is basically true even though the model's response to level-of-service variables appears weak—particularly for markets with considerable change in service levels between 2014 and 2004 such as Kitsap County served by Pierce Transit—and the response to monetary variables appears strong. The model also under-estimated short transit trips.

- Data-driven models should be periodically updated, at least every five years, using current counts, speed measurements, surveys and other data. New sources of travel data should be explored and cultivated to improve shape of base demand matrix. This should provide more accurate representation of transit travel patterns that also rectify apparent under-estimation of short transit trips.

- Special studies should be pursued to provide better travel time and travel cost relationship and sensitivities. The implied value of time in the current model is quite low, and therefore the backcast response to most transit network changes (e.g., transit times) appears to be weak. This analysis needs not necessarily be specific to a region or city. New sources of travel data are increasingly becoming available to allow pursuit of such studies.

- Uncertainty in forecasts increases with farther future forecast year horizons, even in a data-driven model. This backcast of only 10 years made evident the difficulties of specifying inputs, particularly, for non-transit items that accurately reflect a decade's worth of change. Model forecasts over longer periods should be considered in conjunction with a qualitative analysis encompassing long-term uncertainty and risk assessments of those forecasts.