SOUND TRANSIT

HCT Planning

SOUND TRANSIT HCT PLANNING

Sound Transit Long Range Plan ST2 Planning:

Task 2.0 – Methodology Development and Documentation

Subtask 2.4 - Transit Ridership Forecasting Technical Report

Prepared for:

Sound Transit

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February 3, 2006

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1. INTRODUCTION

This report describes the travel forecasting methods, assumptions, and analytical procedures used to produce system, corridor, and project-level transit ridership forecasts to support the Sound Transit Phase 2 (ST2) Project. ST2 is a prioritized program of projects that will be taken to the voters as early as 2006 as the next step in implementing Sound Transit's Long Range Plan (LRP).

In 2004, an Expert Review Panel (ERP) was formed under the auspices of the Legislative Transportation Committee, the Secretary of Transportation, and the Governor, to oversee the technical methods, assumptions, and results in support of ST2. ERP members with expertise on travel forecasting methods and procedures have primary review responsibilities for transit ridership estimation methods, assumptions, and results.

The current version of the model was developed using the underlying analytical ridership forecasting procedures, which were developed over two decades of Sound Transit incremental methods applications. Presented below is a brief history of transit ridership forecasting at Sound Transit.

1.1 History of Transit Forecasting at Sound Transit

The history of transit forecasting analysis at Sound Transit began at Seattle Metro (now King County Metro) in 1986. Work by Brand and Benham, of Charles River Associates, led to Metro's consideration of "a quick-responsive incremental travel demand forecasting method"[1] based on the concept of staged forecasting analysis. Subsequently, in 1986, Metro installed "the logit mode-choice equations for pivot-point analysis"[2] (as described by Ben-Akiva and Atherton[3]; Koppelman[4]; Nickesen, Meyburg and Turrnquist[5]; and many others) on EMME/2 software. In 1988, Metro staff highlighted the relationship[6] between Metro's transit forecasting methods and the Puget Sound Council of Governments (PSCOG) regional model.

Sound Transit and the Regional Transit Project (RTP) then further developed the forecasting analysis procedures in the early 1990s, prior to the November 1996 voter approval, of *Sound Move: The Ten-Year Regional Transit Plan.* An Expert Review Panel (ERP), formed in 1990 under the auspices of the Legislative Transportation Committee, the Secretary of Transportation, and the Governor, oversaw development of the first

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[1] Brand, D., and J.L. Benham, "Elasticity-Based Method for Forecasting Travel on Current Urban Transportation Alternatives," Transportation Research Record No. 895, 1982.

[2] Harvey, R. "Pivot-Point Analysis of Transit Demand Using EMME/2," an Internal Paper, Municipality of Metropolitan Seattle, May 1986.

[3] Ben-Akiva, M. and T. Atherton, "Methodology for Short-Range Travel Demand Predictions," Transportation Economics and Policy, v.7, 1977.

[4] Koppelman, F., "Predicting Transit Ridership in Response to Transit Service Changes," ASCE 109, 1983.

[5] Nickesen A., A. Meyburg and M. Turnquist, "Ridership Estimation for Short-Range Transit Planning," Transportation Research B, v.17B, 1983

[6] Harvey, R. "Comparison of Metro and PSCOG Modeling" a Memorandum to File, March 7, 1988.

generation of the Sound Transit incremental model. This model is described in the November 1993 *Travel Forecasting Methodology Report,* published by the Regional Transit Project.

The Sound Transit model was updated in the late 1990s in support of the Central Link Light Rail Transit Project Environmental Impact Statement (EIS) evaluation as well as the North Link Light Rail Transit Project Supplementary Environmental Impact Statements (SEIS). The underlying Sound Transit model procedures used to perform transit ridership forecasting analysis in support of the North Link Light Rail Projects were documented in the *Transit Ridership Forecasting Technical Report,* issued in November 2003 by Sound Transit.

1.2 Report Organization

This report contains four chapters. This introductory chapter summarizes the methods used to produce ridership forecasts for Sound Transit and discusses important methodological considerations. Chapter 2 describes the individual methods used for each step of the travel forecasting process. Chapter 3 describes the validation of the Sound Transit model to 2004 conditions. The model validation exercise has two purposes: (1) to highlight problems with the forecasting process that might have otherwise been overlooked, and (2) to incorporate changes that could improve the forecasting results. Chapter 4 discusses the specific input data and assumptions used to perform staged ridership forecasting analysis. This includes presentation of build-up analysis results.

1.3 Sound Transit Incremental Planning Model

The Sound Transit incremental model has been updated to a new base year (2004). Development of the base year transit trip tables involved a rigorous analysis of actual ridership volumes along each transit route, as well as a realistic simulation of observed transit service characteristics for both peak and off-peak periods. External changes in demographics, highway travel time, and costs are distinctly incorporated into the process in phases prior to estimating the impacts of incremental changes in transit service. The Sound Transit model relies on the Puget Sound Regional Council (PSRC) regional model for data on external changes.

In the first stage of ridership forecasting analysis, only changes in PSRC model trip distribution results or demographics are considered. In the second stage, other external changes such as highway travel time (congestion), costs (including parking costs), transit fares, and household income are taken into consideration.

The first two stages of ridership forecasting analysis result in a forecast of zone-to-zone transit trips within the RTA district boundaries absent any changes in the transit system. In the third and final stage, incremental changes in the transit level-of-service (i.e., access, wait, and ride travel times) are considered. Finally, transit trips are assigned to the future year transit network.

Like all travel forecasting models, the Sound Transit model has some limitations. Because it uses average daily ridership, it is unable to assess the effects of special events such as sports games or major festivals. Furthermore, the ST model is ill-suited for analyzing structural changes in regional land use beyond those already included in PSRC

demographic forecasts, or to forecasting in outlying areas of the three-county region where there is minimal existing transit service. Finally, the model does not explicitly take into account differences in safety, comfort or user friendliness of bus versus rail transit service.

1.4 Important Considerations and Constraints

This section discusses five important areas of consideration in travel forecasting methods. Most of these considerations and constraints were taken from the FTA guidelines on transit project planning[7]. The considerations described below simply reemphasize the use of best professional practice:

- Careful standards for validation;
- Consistent application of policy assumptions across alternatives;
- Use of identical land use plans and overall travel demand patterns across alternatives;
- Generic attributes of modes; and
- Analysis of service levels and travel forecasts for reasonableness.

1.4.1 Standards for Validation

Validation is a vital component of any travel forecasting effort. It demonstrates that the forecasting procedures can replicate observed travel patterns in a region, to sufficiently support reasonably reliable forecasts of future travel patterns. In project planning, travel forecasting methods are expected to predict the changes in travel patterns caused by general changes between now and the forecast year, as well as by specific changes introduced by each alternative. The Sound Transit model has been validated against actual 2004 transit ridership.

1.4.2 Consistent Policy Assumptions Across Alternatives

A large number of inputs to the travel forecasting process are at least partially subject to the policy decisions of local and state agencies. To isolate which differences are generated by the proposed project itself (e.g., a fixed guideway rail transit system), it is necessary that all conditions not directly attributable to the proposed project be held constant. It is therefore required that the forecasts hold the policy setting constant across all alternatives which are evaluated. These policies include:

- Fare level and structure;
- Levels of service provided by the transit system;
- Zoning policies;

[7] Current procedures and Technical Methods for Transit Project Planning, Federal Transit Administration (FTA).

- Parking policies and prices; and
- Availability of rights-of-way.

This constraint means that forecasts prepared for FTA evaluation and EIS presentation should contain as few differences as possible among the alternatives. Service levels on feeder buses, for example, should reflect a general service policy that is applied consistently across alternatives. Assumptions on land-use development, as well as parking costs, must also be held constant. Rights-of-way that can be used for one alternative should be available for other alternatives, subject to physical constraints that might make the costs unacceptable.

1.4.3 Constant Travel Patterns Across Alternatives

An additional source of potentially confounding effects are forecasts of the overall travel demand for which transit and HOV facilities compete. The FTA requirement that land use policies be consistently applied removes some sources of variability in population and employment forecasts. This requirement goes beyond the constraint mandating that the population and employment forecasts themselves be held constant. It removes any guesses as to the extent to which particular alternatives might shift residential and commercial development from consideration in the basic forecasts for different modes that have higher levels of grade separation.

1.4.4 Generic Attributes of Modes

There is much discussion as to the differences in ridership potential associated with the intangible qualities of various transit technologies. This speculation focuses on the perceived differences between technologies in terms of visibility, comfort, convenience, and other characteristics that are difficult-to-quantify. Because there is limited data to support this speculation, the ST model treats transit modes very generally. However, this is another area for which the FTA is investigating possible approaches to model improvement. Many urban areas now submit forecasts to the FTA that account for differences in reliability between bus and rail.

A few studies have addressed the question directly and indicated that some measurable differences can be isolated. One important result is that these differences appear to be associated with physical differences in facilities and services, not with unexplainable factors. For this reason, Sound Transit now includes a small but quantified reliability difference in the transit forecasts.

1.4.5 Analysis of Service Levels and Travel Forecasts

Developing ridership forecasting requires the estimation of large amounts of supporting data that is of potential interest to a variety of audiences. Examples include population and employment changes in various subareas, increasing congestion levels, travel time savings available from new transit guideways, and transit's share of various travel markets. Reviewing this information can be crucial to isolating problems in initial forecasts and increasing the credibility of the final results.

2. PROCEDURES FOR TRAVEL FORECASTING

This chapter describes the methods and procedures used in the Sound Transit (ST) transit forecasting model, including the input data required by the ST model and its relationship to the Puget Sound Regional Council (PSRC) model.

2.1 Introduction

Section 2.1 describes the methodology used to develop transit forecasts, the data requirements, and the data available. Section 2.2 describes the relationships between the ST and PSRC models. For instance, this section provides an overview of the methodology used by the Puget Sound Regional Council to produce land use forecasts that are critical to the ST model and the ridership forecasting analysis. The transportation analysis zone system is described in Section 2.3. The mode choice model structure, specification, and coefficients are presented in Section 2.4. Summary descriptions of the process used to develop base-year transit trip tables are described in Section 2.5. Possible changes in population/employment, highway congestion and cost (i.e., the application of the staged build-up forecasting analysis) are discussed in Sections 2.6 and 2.7. A discussion on changes in transit service is included in Section 2.8.

2.1.1 Incremental vs. Synthetic Methods

There are two different approaches to developing transit forecasts: synthetic methods and incremental methods. Synthetic methods estimate existing transit travel patterns by using separate sequential models to:

- Allocate regional population and employment projections to zones;
- Estimate the total number of trips from these zones;
- Estimate the origin/destination patterns of these estimated trips;
- Estimate the travel mode share likely for each origin/destination pattern; and
- Estimate specific links and lines in the highway and transit systems used by these trips.

Incremental methods are simpler and more efficient for transit ridership forecasting and analysis because they:

- Are directly based on observed (rather than estimated) baseline travel patterns of transit users;
- Allow for concentrating efforts on transit network analysis, for studies whose primary goals are questions about alternative transit networks;

- Are more conducive to the separate evaluation of population and employment changes, highway congestion and cost, and transit services through the three stages of the forecasting process;

- Focus on direct comparisons rather than on complete simulations of travel behavior;

- Are more usable for intermediate evaluation; and

- Eliminate the often laborious and time-consuming calibration of sub-choice models, since they do not require replication of base-year travel patterns for these markets.

The FTA guidelines on transit project planning[1] summarize the major differences between the two approaches. Figure 2.1 contrasts the setting in which synthetic and incremental methods are applied. The upper part of the figure depicts the application of a conventional mode-choice model – termed "synthetic" because it estimates mode shares entirely from abstract descriptions of times, costs, income levels, etc. The lower part of the figure shows the use of an incremental approach, so labeled because it starts with baseline transit travel patterns and shares and predicts the changes (or increments) in the shares.

Thus, the major difference between the two approaches is that the incremental method uses existing transit travel patterns and shares as the measure of the current attractiveness of each mode whereas the synthetic method uses times and costs.[2]

The FTA guidelines on transit project planning have identified three strong characteristics of the incremental approach that make it attractive for many applications. According to the FTA, the incremental method "is well grounded in the reality of baseline travel patterns; it deals only with marginal changes; and it focuses attention on the changes in land-use and transportation that drive the evolution of travel patterns over time." [3]

The FTA guidelines have also identified a number of limitations that render incremental methods less desirable in some situations. Limitations include "large data requirements, an inability to deal with markets that do not exist today, possible unreliability where markets are poorly developed today, and difficulties in dealing with changes in socio-economic characteristics." [4] Using the following four criteria, the ST model has overcome many of these shortcomings.

[1] Current Procedures and Technical Methods for Transit Project Planning, Federal Transit Administration (FTA)
[2] Ibid
[3] Ibid
[4] Ibid

1. Data Requirements - According to the FTA, “because incremental methods rely solely on data collection to describe base-year travel patterns, data requirements are relatively high." [5]The detailed route-level data by time-of-day from the ridership counts now available via Automatic Passenger Count technology (APC) and from 1992 and 2004 transit on-board surveys provide observed baseline travel patterns within the RTA boundaries for both model validation and applications. ST now has available directional and time-of-day counts for every segment of every transit route in 80 percent of the ST service area and 90 percent of the transit market.

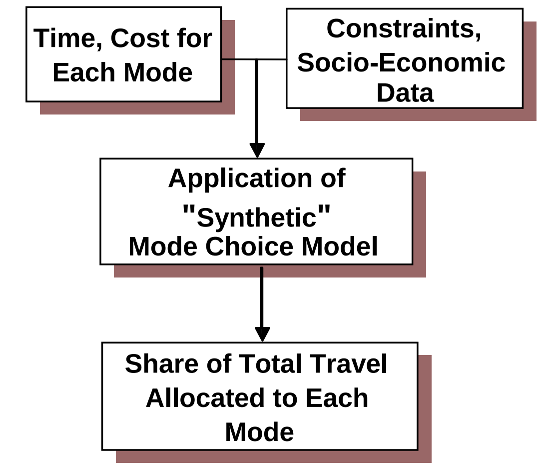
2. New Markets - "Because all incremental methods build from base-year conditions, they cannot be used to forecast future travel patterns for a market that does not exist in the base year."[6] The existing transit market and coverage within the RTA boundaries are quite extensive. Therefore, the use of ST incremental methods would only have limitations in application to rural areas beyond the district boundary.

3. Limited Markets - According to the FTA, "auto-access to transit is perhaps the primary example of a market that plays an important role with many transit guideways but is only marginally developed in the current bus system."[7] Presently, about 15 percent of bus and rail riders within the RTA boundaries use automobile to access transit via formal and informal park-and-ride sites. Therefore, this particular issue does not restrict the application of ST incremental methods.

4. Socio-Economic Changes - "In previous applications of incremental methods to transit project planning, the forecasts have largely ignored the influence of possible changes over time in real income or auto-ownership."[8] The ST model has overcome this particular shortcoming by using a normalizing cost variable with respect to income, to capture some of the historical trends of decline in transit ridership shares over time resulting from the trend in increased income and car ownership. It is important to recognize that the sensitivities to change in the incremental approach are not approximations of the sensitivities in the synthetic approach–they are virtually identical. The incremental methods are mathematically parallel to the synthetic methods and are applied in the same level of detail that would be used in a synthetic approach.

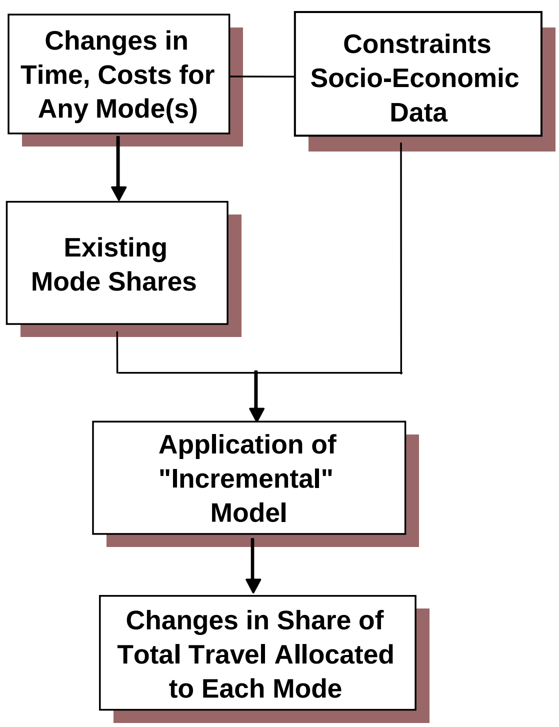
[5] Ibid
[6] Ibid
[7] Procedures and Technical Methods for Transit Project Planning, Federal Transit Administration (FTA), 1992.
[8] Ibid

Figure 2.1: Synthetic and Incremental Approaches to Forecasting



SYNTHETIC APPROACH

- Attractiveness of modes described by their time and costs
- Socio-economic variables included automatically
(if part of model)
- Each application independent of base conditions
- No guarantee that shares reflect baseline conditions



INCREMENTAL APPROACH

- Changes in service levels for one or more of the modes
- Differentiation by socio-economic groups difficult in some methods
- Initial attractiveness of modes measured by current shares of existing travel
- Each application starts with baseline conditions
- Results certain to be “reasonable” in that they are adjustments to current shares

2.1.2 Data Available for ST Planning

The key sources of data available for ST planning include:

- The Puget Sound Regional Council (PSRC);
- Transit operators in the three-county area -- Sound Transit, King County Metro, Pierce Transit, Community Transit, and Everett Transit;
- The U. S. Census Journey-to-Work data;
- The National Transit Database (NTD); and
- State and local agencies.

The PSRC's land use forecasts and median income estimates are key inputs to the modeling effort. The ST model uses the most current land use forecasts available from the PSRC. The estimates of household income are used to normalize all costs in the ST forecasting process.

The PSRC regional forecasting model also generates highway travel times for past and future years. This information includes separate travel times for vehicles that qualify for HOV lanes. The PSRC model also provides traffic volumes on regional highway facilities for traffic impact analysis, and local jurisdictions provide traffic volumes on local arterials for station impact analysis.

The essential basis for incremental mode choice modeling analysis is the detailed route-level transit ridership information by time-of-day for the base year. The 2004 on-board survey conducted by Sound Transit provided additional detail on riders of all Sound Transit services. The 1992 transit surveys conducted by four transit agencies provided a complete cross section of representative transit trips.

The transit operators provided detailed ridership counts by route and time-of-day. The King County Metro Automated Passenger Count (APC) database was the primary source of providing actual (or “observed”) route-segment passenger loads for creating the 2004 PM peak and off-peak trip tables. The transit operators also provided the operating schedules in effect for the base condition (winter 2004). These schedules, along with the Automatic Vehicle Locator (AVL) data from Metro King County on actual speed and reliability for ST and Metro route segments, are the foundation of the transit service descriptions for the base years. Finally, the Census Journey-to-Work data establishes base-year transit and carpool shares for 2000.

The following sections discuss how these various databases were developed, and include more detail on how they are being used on this project.

2.2 Relationship to PSRC Modeling

2.2.1 Summary Comparisons of the PSRC and ST Models

The ST and PSRC modeling procedures are closely inter-related and highly complementary. The ST model uses measures of regional change in travel demand and highway congestion derived from the PSRC model. Summary comparisons of the PSRC and ST modeling procedures are highlighted below:

- The PSRC model is a four-county synthetic modeling system comprising land-use, trip generation, trip distribution, modal split, and assignment models. It also includes several feedback loops based on intra-regional accessibility;

- The ST model is a three-county, three-stage, fully incremental system purposely designed for detailed corridor-level transit planning and transit patronage forecasting;

- The PSRC's regional population and employment forecasts are used to predict travel demand growth;

- ST uses the PSRC's time and cost coefficients for its mode choice model; and

- ST uses PSRC information for all non-transit input to the incremental transit ridership model.

2.2.2 Preparation of Demographic Forecasts

This section summarizes the procedures used by the PSRC to forecast regional population and employment. Figure 2.2 summarizes the PSRC land use and travel forecasting process. The demographic projections that are used for the ST forecasts are prepared by PSRC staff, circulated for review by a wide variety of public, private, and non-profit organizations, and then finalized based upon comments received. The PSRC employment and population projections are used for the ST forecasts because they:

- Are the adopted projections for the region;

- Are the product of technically sound methods and reasonable assumptions; and

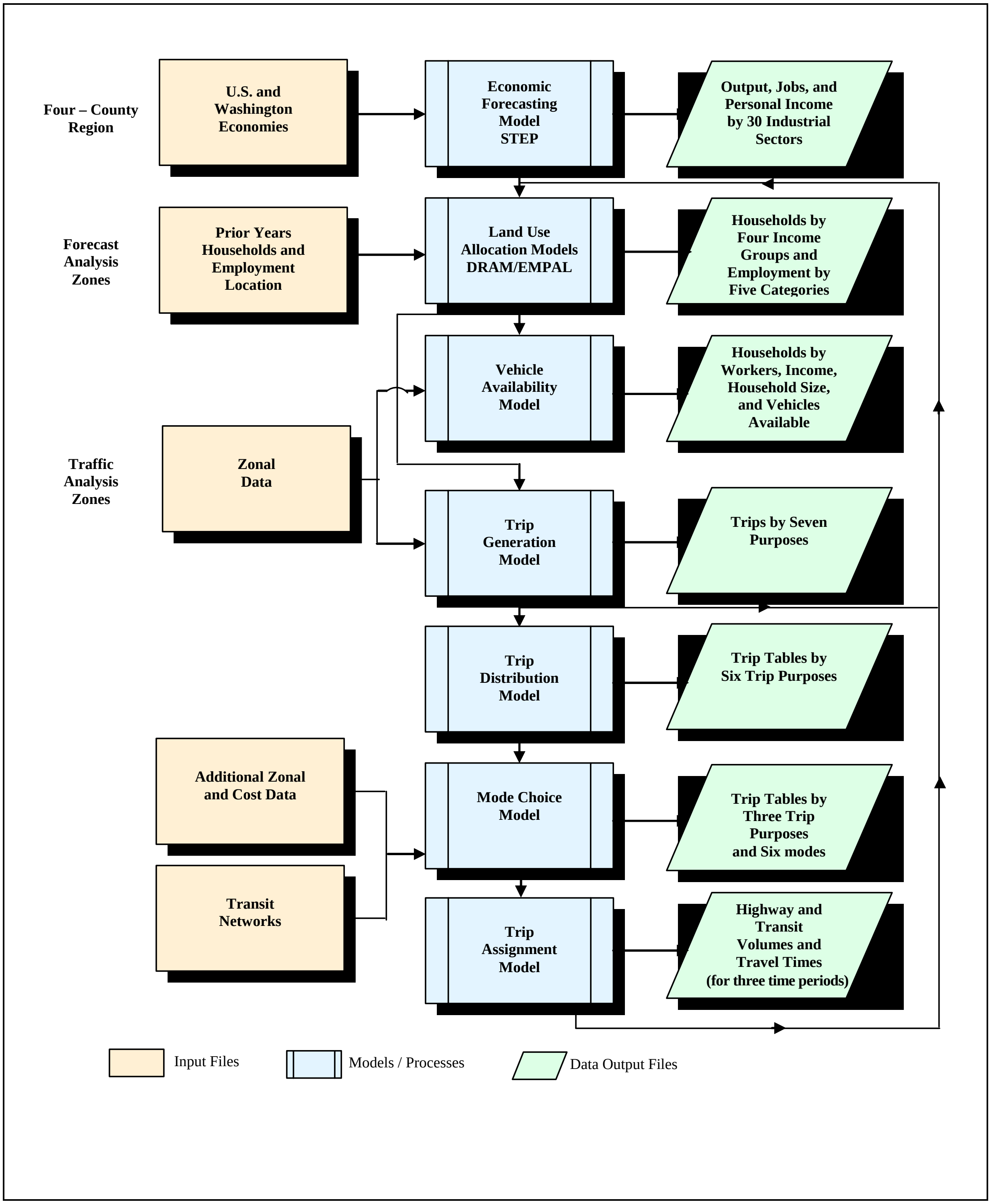
- Have undergone thorough review by the region's counties and local jurisdictions within the context of the State Growth Management Act (GMA).

Development of Regional Control Totals

The PSRC produces population and employment forecasts for the central Puget Sound Region (King, Kitsap, Pierce, and Snohomish Counties) using the STEP regional econometric model.

The STEP model is a simultaneous system of linear and nonlinear equations that predict a total of 116 economic and demographic variables. The database assembled for calibration of the STEP model includes information on annual values for a wide range of economic measures such as regional population, regional jobs and earnings, regional output, national economic and demographic variables, and Washington State output and income variables. Output from the model includes forecasts of population, employment, and income for the four-county area. These forecasts establish control totals for the subsequent allocation of growth to individual subareas of the region.

Figure 2.2: Regional Land Use and Travel Demand Forecasting Process



Allocation of Growth to Subareas

Within the regional forecasts from the STEP model, the PSRC uses an urban activity model to allocate growth to local planning areas throughout the four-county region. The urban activity model consists of the Disaggregated Residential Model (DRAM) and the Employment Allocation Model (EMPAL)

In application, EMPAL first estimates the future-year number of jobs in each Forecast Analysis Zone (FAZ) for each of the five industry sectors based on:

- The base year number of jobs in the FAZ, by sector;
- The proximity of the FAZ to all other job locations in the region;
- The density of employment activity (or rental space) in the FAZ; and
- The travel time to the FAZ from household markets in the region

The total number of jobs in each industry sector is constrained by regional totals for the future year forecasted with the STEP model. Given the projected number of jobs by FAZ from the EMPAL, DRAM then predicts the residential location of the workers based on:

- The composite travel impedance from job locations to each residence zone;
- The base-year proportions of the household income groups in each zone; and
- Several land-use characteristics of the zone including residential land use, residential density, degree of development, and relative accessibility.

DRAM predicts the number of households in each income group from ratios of workers-per-household. It calculates the population by using ratios of average household size derived from the projected regional trend from the base year to future years. Using the number of households projected for each FAZ, DRAM estimates the number of single and multiple family households using a set of variables relative to their regional counterparts. Finally, DRAM predicts residential land per household and total land (used and unused) in the zone from a set of housing, land use, and growth variables. Household and population totals are constrained by regional totals for the future year forecasted with the STEP model.

Demographic Forecasting Review Process

The forecasts are for ten-year increments up to 2030 and include detailed allocations for 219 FAZs. These forecasts and allocations are widely used by the state as well as by local governments, public agencies, and private organizations.

The forecasts undergo extensive review by the staff and elected officials of state, county, and local governments. The PSRC makes adjustments to the allocations in response to concerns of local jurisdictions through a continuing process of review, comments, and negotiation. There are no cases in which the regional control totals are adjusted.

2.2.3 Summary Description of the PSRC Travel Demand Models

The PSRC maintains a four-step conventional synthetic travel-demand modeling system consisting of trip generation, distribution, mode choice, and trip assignment models. Zonal trip ends are estimated using a set of trip rates classified by home-based work, home-based college, home-based other, home-based school, non-home-based, and commercial vehicle trips. Interzonal trip distributions are estimated using a "gravity" model. The PSRC mode-choice model structure is a multinomial logit model comprised of two transit modes, three auto modes, and two non-vehicle modes.

2.3 Development of Zone and District Systems

The ST travel forecasts are produced for a 759-zone system of "alternatives analysis zones" (AAZs) developed specifically for the ST model but based upon the PSRC's zonal system. The 759-zone system includes 23 external zones representing six ferry connections and 17 areas outside the RTA boundaries. Summaries of these forecasts are prepared using 27 summary districts or other levels of aggregation (e.g., by corridor or by county) as needed.

2.3.1 Forecast Analysis Zone and Traffic Analysis Zone Systems

The PSRC's Forecast Analysis Zone (FAZ) structure is each agency's basic land-use zone structure and consists of 219 FAZs that cover all the land area within the four-county region. It is at this level of detail that local jurisdictions, through the PSRC, agree upon allocations of future population and employment throughout the region. FAZ boundaries encompassing Snohomish, King, and Pierce Counties are shown in Appendix B.

2.3.2 Alternatives Analysis Zone (AAZ) System

The AAZ system used to produce the ST travel forecasts is based on the zones maintained by the PSRC for regional forecasts of travel demand within the four-county central Puget Sound region. The ST zone system differs from the PSRC's system in several minor aspects.

Most importantly, the ST system does not have the same geographic boundary as the PSRC system. Whereas the PSRC includes a Four-County region (Snohomish, King, Kitsap and Pierce Counties), the 1993 state - established Regional Transit Authority (RTA) excludes the largely rural areas of north and northeastern Snohomish, south and southeastern Pierce, and eastern King Counties, as well as Kitsap County, Vashon Island, and the Gig Harbor peninsula. Areas outside the RTA district are external to the ST model.

Also, in areas along potential rail lines, the ST zone structure uses smaller zones, split from PSRC zones. Keeping the two zone structures as similar as possible reduces the level of data manipulation that would otherwise be necessary. The ST 759-zone AAZ system is also shown in Appendix B.

2.3.3 Summary Districts

Summary districts were created from the AAZ system in order to:

- Provide a consistent basis for aggregation of certain model inputs, when such aggregation is appropriate;

- Calculate the modal shares required in the model validation and application phases; and

- Prepare summary reports on trip tables and travel time skims.

The 27 summary district breakdown and 11 summary district breakdown are shown in Appendix B. These districts were carefully constructed to provide distinctive summary travel patterns by geographical area and corridor.

2.4 Sound Transit Mode Choice Model Methodology

2.4.1 Model Structure

The ST mode-choice model structure, which is an incremental logit model, uses a pivot approach in the development of forecasts, and uses the PSRC regional mode choice travel time and cost coefficients.

Incremental Logit Model – The incremental approach predicts changes in travel behavior based on existing travel behavior and changes in level of service. The incremental form of the logit model is derived from the standard logit formulation, which is[9] :

(1) $$S_i = \frac{\exp(V_i)}{SUM_j^m [\exp(V_j)]}$$

where,

Vi = utility of mode i in choice set m (j=1,2,3, ..,i,..m)

- Contains measurable components of transportation systems such as travel time and cost as well as socio-economic attributes of trip makers.

S_i = share of using mode i.

Ben-Akiva and Lerman indicate that "using elasticities is one way to predict changes due to modifications in the independent variables. For the linear-in-parameters multinomial logit model there is a convenient form known as the incremental logit which can be used to predict changes in behavior on the basis of the existing choice probabilities of the alternatives and changes in variables." The incremental form of logit model is[10] :

(2) $$S_i^f = \frac{S_i \text{ x } \exp(\text{DIFF } Vi)}{SUM_j^m [S_j \text{ x } \exp(\text{DIFF } V_j)]}$$

where,

S_i = base-year observed probability of using mode i from choice set m

S_i^f = new share (i.e., forecast year) of using mode i (interzonal average)

[9] Domenich, T., and D McFadden, Urban Travel Demand – A Behavioral Analysis, North Holland, Amsterdam, 1975.

[10] Ben-Akiva, M. and S.R. Lerman, Discrete Choice Analysis Theory and Application to Travel Demand, The MIT Press, Cambridge, MA, 1985.

$DIFF\ V_i$ = change in utility of mode i (interzonal average),

= $V_i^f - V_i = (DIFF\ CONST_i) + B_k \times (DIFF\ VAR_{i,k})$

and,

$DIFF\ CONST_i$ = difference (future - base) in mode-specific constant for mode i,

B_k = coefficient for attribute k

$DIFF\ VAR_{i,}{}^{k}$ = difference in numeric variable VAR k of alternative i

f = variable with superscript "f" represents value in forecast year.

All transportation models, including the PSRC synthetic model, assume that the difference between the unmeasured attributes (e.g., comfort and image) between transportation systems in the base year and future years is negligible. As a result, the term representing the difference in mode-specific constants (i.e., DIFF CONSTi) falls out of the computations. The only terms remaining in Equation (2) pertain to those attributes (e.g., travel times and costs) for which a measured change might occur, as well as (3):

(3) $DIFF\ V_i = B_k \times DIFF\ VAR_{i,k}$

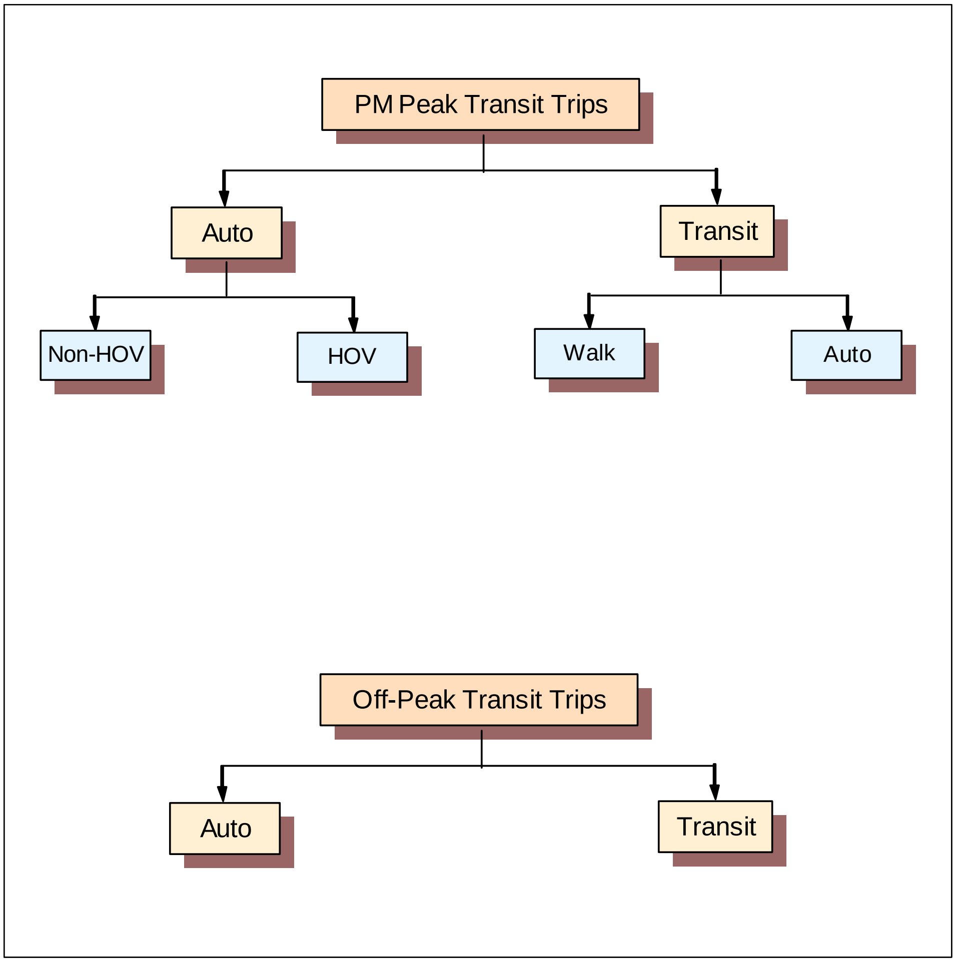
The mode-specific constants in a synthetic model theoretically represent the effects of unmeasured attributes and often account for over half of the explanatory power in synthetic mode choice models. In practice, these constants are quite large and compensate for all types of errors in synthetic models, even network coding idiosyncrasies. They are used as overall adjustment factors to move the model results close to targeted regional totals. The constants typically range as high as 50 to 150 minutes of equivalent in-vehicle time. Without these constants, synthetic models cannot replicate the regional totals for a base year.

Nested Logit Model

According to the Independence from Irrelevant Alternatives (IIA) assumption, logit models require that all of the modes defined in the choice set m (for travelers) be independent of one another. However, the IIA requirement is usually difficult to maintain in a simultaneous structure such as the synthetic model used at the PSRC. In practice, a sequential (or nested) logit model that is less restrictive than the simultaneous form is often used. The nested logit model groups appropriate submodes under the primary modes (i.e., auto and transit), as shown in Figure 2.4. For the auto mode, the sub-choice is between single and multiple occupancy. For the transit mode, the sub-choice is between access to transit by walking or by automobile. Suggestions from the

FTA on the appropriateness of nesting can be found in the FTA presentation by Jim Ryan at the January 2004 Transportation Research Board (TRB) Annual Meeting. [11]

<u>Figure 2.4 – Mode Choice and Modal Structure</u>



The natural logarithm of the denominator of a logit model (Equation 1) is a single "inclusive" index I_m[12] indicating the desirability of the main mode m, and taking into account the attributes of access modes. This index is often called "LogSum" and calculated from:

(4) $$\text{LogSum} = \text{Ln}\ \{\text{SUM}_j^m\ [\exp(V_j)]\}$$

[11] Travel Forecasting for New Starts Projects, TRB 83rd Annual Meeting, Session 501, January 13, 2004.
[12] McFadden,E., A. Talvities and Associates, Demand Model Estimation and Validation, Urban Travel Demand Forecasting Project (UTDFP) Final Report Vol. V, University of California, Berkeley, CA, 1977.

where,

V_j was defined before for Equation (1)

McFadden[13] has identified the coefficients K for the LogSum variable as indices of similarity of the alternatives comprising the inclusive price.

For the transit lower level, the composite disutility of the sub-modes (walk- and auto-access) represents transit to the upper level choice. For transit mode t, the LogSum is:

(5) $$LogSum^t = - \ln [\exp(V_{walk}) + \exp(V_{auto})]$$

where,

V_{auto} = utility of the auto-access mode

V_{walk} = utility of the walk-access mode

The structure for PM peak period shown in Figure 2.4 is fully incremental[14] because it uses the incremental logit model at both the lower-level and upper level nests. The incremental form is highly desirable because it relies on **observed data** that describes current conditions, rather than using models to estimate these conditions.

Derivation of Changes in LogSum Variable

In a fully-incremental mode choice model, the changes in ridership between future and base-year conditions are calculated based on the incremental logit formulation (Equation 2) both at the primary level of hierarchy (i.e., auto vs. transit) and at the lower-levels (i.e., auto occupancy and mode of access).

Because the incremental model requires the difference in the values of LogSum variable (i.e., DIFF $LogSum_t$ for the mode of access), the underlying components of this difference need to be spelled out first within the context of standard logit formulation (Equation 1). The derivation process starts by using the definition of difference in the LogSum values and ends up with a simple formula consisting of the logarithmic summation of the exponential difference in the utility of each mode (i.e., future - base year) weighted by the respective base year observed share. The mathematical derivation is presented below.

Incremental change in LogSumt of Equation (5) can be represented by:

(6) $$DIFF\ LogSum^t = \ln[\exp(V^f_{walk})+ \exp(V^f_{auto})] - \ln[\exp(V^b_{walk}) + \exp(V^b_{auto})]$$

[13] Ibid

[14] Dehghani, Y. and R. Harvey, A Fully Incremental Model for Transit Forecasting: Seattle Experience, Transportation Research Board, Record # 1452, 1994.

Incremental change in LogSum for mode m (i.e., transit or auto), representing the upper-level of the nested logit structure, can be written as:

$$\text{DIFF LogSum}^m = \ln\{\text{Sum}^n_i[\exp(V_i+\text{DIFF } V_i)]\} - \ln\{\text{Sum}^n_i[\exp(V_i)]\}$$

or,

$$= \ln\left[\frac{\text{Sum}^n_i[\exp(V_i+\text{DIFF } V_i)]}{\text{Sum}^n_i[\exp(V_i)]}\right]$$

$$= \ln\left[\frac{\text{Sum}^n_i[\exp(V_i)\times\exp(\text{DIFF } V_i)]}{\text{Sum}^n_i[\exp(V_i)]}\right]$$

(7) $$= \ln[\text{Sum}^n_i(S_i \times \exp(\text{DIFF } V_i))]$$

where,

DIFF LogSum^t	=	difference in LogSum term for transit mode t (future – base year)
V^f_{walk}, V^f_{auto}	=	the utility of walk and auto access modes in future
V^b_{walk}, V^b_{auto}	=	the utility of walk and auto access modes in the base year
DIFF LogSum^m	=	difference in LogSum term for mode m (e.g., auto or transit) in the upper level of the nested structure (future base year)
V_i	=	the utility of submode i (e.g., walk or drive access attributes) under nest n (e.g., transit),
S_i	=	base-year observed share of using submode (e.g.,walk or drive access) under nest n
DIFF V_i	=	difference in the utility (e.g., travel time) of submode i under nest n (future - base year).

The coefficients of variables (e.g., travel time) included in the utility of a submode i are equal to comparable mode-choice coefficients from the upper-level nest for the same variables (e.g., travel time), scaled by the corresponding LogSum coefficient (K^i).

Values for DIFF LogSum variables resulting from Equation (7) are used in the incremental logit formulation (Equation 2) to estimate new interzonal modal shares. Nesting coefficients vary between 0.0 and 1.0 and measure the degree of similarity and dissimilarity of a group of submodes from other modes in the upper-level nest. For example, a nesting coefficient of 1.0 on the transit nest of Figure 2.4 indicates that auto- and walk-access submodes are dissimilar (independent) from auto mode, implying that they should have been structured simultaneously instead of having a nested form. A conservative nesting coefficient of 0.50 is used in the ST model for the PM peak period.

2.4.2 Model Specification and Coefficients

As indicated in the previous section, since the mode-choice model structure is fully incremental, the mode-specific constants fall out of the computations. Therefore, it is not necessary to estimate values for modal constants. The model includes:

- Travel time and cost variables in the utilities of the transit sub-modes, walk and drive access (i.e., in-vehicle, out-of-vehicle times, transit fare); and

- Travel time and cost variables in the utilities of the auto occupancy sub-modes (i.e., parking and auto operating).

The cost variable is normalized with respect to zonal median income. This composite variable is constructed by dividing the auto cost components (i.e., sum of auto operating, parking, and auto ownership costs) and transit fares by the ratio of zonal median income over the base-year regional median income.

The reason for the normalization of the cost variable is to capture change in income and car ownership and their effect on transit ridership shares over time. The ST model uses travel time and cost coefficients similar to the PSRC mode choice models. The coefficients used in the ST model are:

- -0.0253 for in-vehicle travel time (which falls within the FTA's acceptable range of -0.02 to -0.03);

- -0.0022 for travel cost, implying a value of travel time of $6.90/hour, which is about one-third of the average wage rate in 2004 in the Puget Sound Region; and

- A relative ratio of 2.0 for out-of-vehicle over in-vehicle transit travel times, which falls within the FTA's acceptable range of 2.0 to 3.0.

2.4.3 Census Journey-to-Work Data

Base Mode Shares

Equation (2) of Section 2.4.1 highlights the importance of having a reasonable estimate of the Si (the existing shares for each alternative mode). The Census Journey-to-Work (JTW) information provides the base interzonal auto and transit shares required for the ST incremental mode choice model. Summary tabulations of the daily auto and transit trips for 1980, 1990, and 2000 are presented in Table 2.4. As the summary model shares for 2000 indicate, changes between mode shares from 1990 to 2000 are relatively small.

Base mode shares are computed by aggregating shares to the 27 summary districts at the work ends only. Home end shares are calculated at the FAZ level. Calculating the shares at this level (i.e., 27-district -to- FAZ) preserves the variation in current mode-choice behavior and, therefore, the elasticities in the logit model.

Table 2.4 – Summary Share of Transportation Means Used by Workers 1980, 1990 and 2000 Census Journey-to-Work Data Files

Location (Home End)	Year	SOV	Carpool	Transit	Total
Snohomish County	1980	74.0%	22.9%	3.2%	100.0%
	1990	83.4%	13.2%	3.4%	100.0%
	2000	84.6%	11.7%	3.7%	100.0%
King County	1980	68.0%	19.5%	12.5%	100.0%
	1990	78.5%	12.3%	9.2%	100.0%
	2000	76.4%	12.9%	10.7%	100.0%
Pierce County	1980	77.6%	19.2%	3.2%	100.0%
	1990	83.5%	14.4%	2.1%	100.0%
	2000	83.2%	13.1%	3.7%	100.0%
Total	1980	70.6%	19.9%	9.5%	100.0%
	1990	80.4%	12.9%	6.7%	100.0%
	2000	79.5%	12.7%	7.8%	100.0%

NOTE:
The mode shares shown here take into account only the motorized modes. Non-motorized modes such as walk and bicycle have not been included. The "motorcycle" mode was included under the SOV mode and the "ferry" mode was included under the transit mode.

2.4.4 Discussion on Staged Build-Up Analysis Application

The patronage forecasting procedures described in the previous sections are applied in three distinct stages. This application method explicitly recognizes a build-up approach to the ridership forecasts, and encourages the analysis of intermediate results in the process as well as checking results for reasonableness. Specific contributions to changes in ridership at each stage are calculated and analyzed separately as they build on each other. The three stages are:

- Overall growth in travel related to population and employment growth;
- Changes in ridership related to changes in highway congestion and costs; and
- Changes in ridership related to transit service changes.

By applying forecasting analysis in stages, it also ensures that only those changes that are important to the study question will be considered. For example, it is common in ridership forecasting (and preferred by the FTA) that only the change in transit service be carried into the future year analysis of transit alternatives. Therefore, all demographics such as land use, trip distributions as well as gas and parking prices are effectively held constant when comparing transit alternatives.

Staging the forecasts in this way makes these consistencies transparent and reduces superfluous calculations. When only variations in the transit service are under consideration, Stage 3 is the only step needed to calculate each variation.

This method does not preclude varying inputs other than the transit service (i.e., for sensitivity testing), but allows such variation to be addressed simply and specifically rather than as a hidden piece of a very large model.

2.5 Base Trip Table Development

The essential basis for incremental mode choice modeling analysis is the need to rely on actual transit travel patterns. Capturing existing travel patterns was achieved in the ST model by using available, pertinent data that provided a complementary balance between survey data and detailed route-level transit ridership information by time-of-day for the base year. Chapter 3 includes a detailed discussion of the process used to develop base year (2004) peak and off peak transit trip tables.

2.6 Stage 1 – Changes in Demographics

2.6.1 Formulation of Stage 1 Forecasting Analysis

The ST ridership forecasting analysis depends on PSRC model databases for the overall growth in travel demand. Growth estimates could either be derived from PSRC model trip distribution results or directly based on forecasts of demographics. The PSRC model is currently being refined and, until reasonable and stable trip distribution results become available and validated, travel growth will be derived from forecasts of households and employment. A summary tabulation of the demographic forecasts adopted by PSRC is presented in Table 2.6.

Growth in total households and employment between 2004 and a future year is calculated at FAZ-level and applied to the base year (2004) transit trip tables. The results of the Stage 1 analysis are the estimated transit trips for a future year. The secondary impacts of growth on transit demand (i.e., increased highway congestion) are not yet accounted for at the end of Stage 1.

Table 2.6 – Summary of PSRC Four-County Demographic Forecasts

Forecast Year	Total Employment	Households	Population
1970	740,000	630,000	1,939,000
1980	1,033,000	845,000	2,240,000
Percent Change from 1970	**40%**	**34%**	**16%**
1990	1,445,000	1,071,000	2,749,000
Percent Change from 1980	**40%**	**27%**	**23%**
2000	1,749,000	1,283,000	3,276,000
Percent Change from 1990	**21%**	**20%**	**19%**
2020	2,279,000	1,688,000	4,115,000
Percent Change from 2000	**30%**	**32%**	**26%**
2030	2,535,900	1,889,000	4,535,000
Percent Change from 2020	**11%**	**12%**	**10%**

2.7 Stage 2 – Changes in Highway Congestion and Cost

2.7.1 Formulation of Stage 2 Forecasting Analysis

Stage 2 considers how changes in highway congestion, auto costs (including parking costs), transit fares and income will influence mode choice.

For all of the ridership analysis done in the central Puget Sound region, transit fares have been held constant across alternative transit networks. The ST patronage forecasts use the PSRC model to estimate highway travel times. These times are tabulated in the form of 219 x 219 FAZ-to-FAZ times for each highway network. A weighted averaging process is used to convert the more detailed PSRC TAZ-based travel times to FAZ-level travel times. When a transit alternative significantly affects the highway system (e.g., taking freeway lanes for transit facilities), additional PSRC future highway networks and congestion analysis is required.

In the Puget Sound region, transit fares and auto costs (except parking costs) are usually assumed to increase only at the rate of overall inflation, therefore they are usually immaterial to the ST model. The Stage 2 process, however, includes these variables for use in sensitivity tests that are not directly part of project planning ridership forecasts.

Stage 2 transit trip forecasts are calculated using the following incremental logit equation:

(8) $$\text{Stg2Trn} = \frac{\text{Stg1Trn}}{S_t + (1 - S_t) \times [\exp(K \text{ x DIFF LogSum}_h)]}$$

where,

Stg2Trn = Stage 2 transit trip forecasts

Stg1Trn = Stage 1 transit trip forecasts

S_t = the base year observed transit shares from census data

K = nesting coefficient on the auto nest

DIFF LogSum_h = Difference in the LogSum values due to changes in highway congestion and costs (future - base year). Data from the census data (for the baseline share), Highway skims and costs are used in Equation 7 (Section 2.4.1) to estimate DIFF LogSum_h on the auto side.

Stage 2 transit-share forecasts (Stg2Shr) are also calculated as follows:

(9) $$\text{Stg2Shr} = \frac{\text{Stg2Trn} \times S_t}{\text{Stg1Trn}}$$

Resulting from the Stage 2 analysis are the transit trips for a future year, having accounted for factors external to the transit service itself. These results then serve as a platform for analysis of ridership on alternative transit networks.

In most project planning ridership forecasting, Stages 1 and 2 need not be calculated as often as Stage 3. It is only when a transit alternative is presumed to have a strong effect on external factors such as land use or the regional highway network that the entire process would have to be cycled through. However, the Federal Transit Administration's published guidelines strongly discourage such cycling iterations when evaluating transit investments.

2.7.2 Representation of Conditions on the Highway/HOV Networks

The PSRC maintains a number of coded highway networks that represent the highway system in the Puget Sound region at various points in time. Future highway networks represent the adopted highway and HOV improvement plans for a given year.

2.7.3 Estimation of Parking Costs

A conservative 1.5 percent annual (real) growth in parking costs is assumed in the ST model. This is a significant reduction from the 3 percent real growth that was previously assumed by ST and the PSRC. However, according to the limited historic information available, parking costs have averaged 1.6 percent growth since 1960.

2.7.4 Estimation of Other Costs and Median Income

Because transit fares and auto operating costs in the Puget Sound region are usually assumed to increase only at the rate of overall inflation, they are less significant to ST models. Base-year (2004) and future auto operating costs are estimated at 20 cents per mile (in 2004 $). Auto ownership cost is assumed to remain constant (in real terms) at about $2 per trip. Base-year and future-year transit fares are presented in Appendix C.

2.8 Stage 3 – Changes in Transit Service

2.8.1 Formulation of Stage 3 Forecasting Analysis

In the third and final stage of the forecasting analysis, the incremental changes in the transit level of service are considered. This change (as indicated in Section 2.4.1) is reflected in the resulting relative values of the LogSumt variable using the base-year and future transit networks.

The Stage 3 transit shares and ridership forecasts are calculated as follows:

(10) $$P'ac = \frac{P_{ac} \times LOS_{ac}}{P_{ac} \times LOS_{ac} + (1 - P_{ac}) \times LOS_{wlk}}$$

and,

(11) $$Stg3Trn = \frac{Stg2Trn \times [\exp(K \times DIFF\ LogSum_t)]}{Stg2Shr \times [\exp(K \times DIFF\ LogSum_t)] + [1 - Stg2Shr]}$$

where,

LOS_{ac} = Difference in (future - base year) utility of the park-and-ride access submode

LOS_{wlk} = Difference in (future - base year) utility of the walk-access submode

P'ac = Forecasted Stage 3 shares for the auto-access mode

Pac = Base-year observed shares for the auto-access mode, derived from the base trip table development process reflecting actual counts on park-and-ride facilities.

DIFF $LogSum_t$ = Difference in the LogSum values due to changes in transit level-of service (future - base year)

Actual transit service that is taken into consideration in the ST model stage 3 forecasting analysis is represented by means of a “coded network.” Specific details on transit network preparation are included in Appendix C. Treatment of bus speed in the ST

model is based on the degradation of roadway congestion, estimated by the PSRC multi-modal model in a manner developed in consultation with the FTA.[15]

[15] Don Billen, Sound Transit, “Updated Treatment of Bus Speeds in the Sound Transit Model,” Memorandum to Eric Pihl of FTA, dated August 1st 2002.

3. VALIDATION

Before a model can be used for analysis, it must be validated. The purpose of validation is to compare the performance of the model to the most recent observed data sources available in order to confirm that the model is accurately replicating current transit travel patterns and transportation system performance.

In project planning, travel forecasting models are expected to predict changes in travel patterns caused by:

- General changes, such as population, employment, and economic changes, between the base year and the forecast year; and

- Specific changes introduced by each alternative.

Consequently, the best validation tests are those that test the ability of the forecasting methods' to accurately capture response to changes in population and employment levels, parking and gasoline prices, transit fares and service levels, as well as other conditions.

The incremental approach, which is used in the ST model, generally reduces the need for validation because it uses the observed data that typically would be used in validation as its base. However it is still useful to check the overall performance of the forecasting against current known conditions.

This chapter is organized into two sections – the first section describes the overall analysis process for creating the 2004 PM peak and off-peak transit trip tables, while the second section presents validation analysis results.

3.1 Base Year (2004) Transit Trip Table Development

A centerpiece of the ST incremental model is its reliance on "observed" transit travel patterns, as determined through transit ridership data, to create base year (2004) PM peak and off-peak transit trip tables. The ridership data used to develop transit trip tables includes the following:

- **2004 Passenger Load Data** – During the winter of 2004 (October 2003 to February 2004), King County Metro and Sound Transit collected detailed passenger load data on their bus routes using Automated Passenger Count (APC) technology and hand-collected counts. These data include average weekday passenger loads by route segment, direction, and time of day, which provided the necessary information to establish ridership profiles along each route by time-of-day.

- **2004 Sound Transit On-Board Survey** – Between September 2003 and May 2004, Sound Transit conducted an extensive on-board survey of all of its transit services over a 9-month period.

- **2004 Boarding Counts –** Route-level total boardings were obtained from all transit agencies.

- **1992 On-Board Transit Surveys** - In 1992, transit agencies in the Puget Sound region conducted six on-board transit surveys that provided the required data to develop the base-year (1992) transit trip tables for the earlier versions of the ST model[1].

- **Other Counts and Survey Data** - Supplementary counts data from transit operators and from the National Transit Database (NTD) provided control totals for development of the 2004 base transit trips. Other survey data included a special survey of SR-520 riders in 2005 and the 2000 U.S. Census Journey-to-Work data.

Although on-board transit surveys provide the most accurate origin-destination data, it is extremely difficult and costly, if not impossible, for transit agencies to establish "observed" transit travel patterns solely from survey data. A typical on-board transit survey collects origin and destination data for only 30-35 percent of riders. Furthermore, survey experience indicates that surveys include strong sample biases that can not easily be corrected. These sample biases would compromise the accuracy of base trip tables, should they be based solely on survey responses. Because of these shortcomings, an alternative approach to building base year trip tables was developed using ridership count data, as well as survey data.

The survey data was primarily used to establish a "seed" transit trip table embodying representative cells (i.e., zone-interchanges) in the matrices, thus ensuring that important transit markets were represented in the base trip tables. This process also included an analysis of the survey data in order to replicate the average trip length frequency distribution exhibited in a transit trip table produced by the PSRC model. This particular analysis assisted in the further expansion of the open cells in the final seed matrix.

Passenger load profiles from the APC database and other counts provided segment level counts by direction and time period on each route. The frequency of segment-load points required for a given route in the trip development process depended on the variability of load profile for that route. For example, a route that experiences fairly uniform passenger loads throughout its trip did not require more than two or three locations for seeding directional passenger count volumes. Other routes, with more variability in passenger loads, require seeding of counts at more than three locations. About 1700 passenger volumes were hand-coded into the 2004 database for matrix estimation, representing over 25 percent of the route segments or Time-Point-Intervals (TPIs).

The base trip table development process relied on a validated base transit network as well as supplementary ridership count data, control totals, and actual average trip length measures. This process involved pursuit of a rigorous validation analysis, the results of which are discussed below.

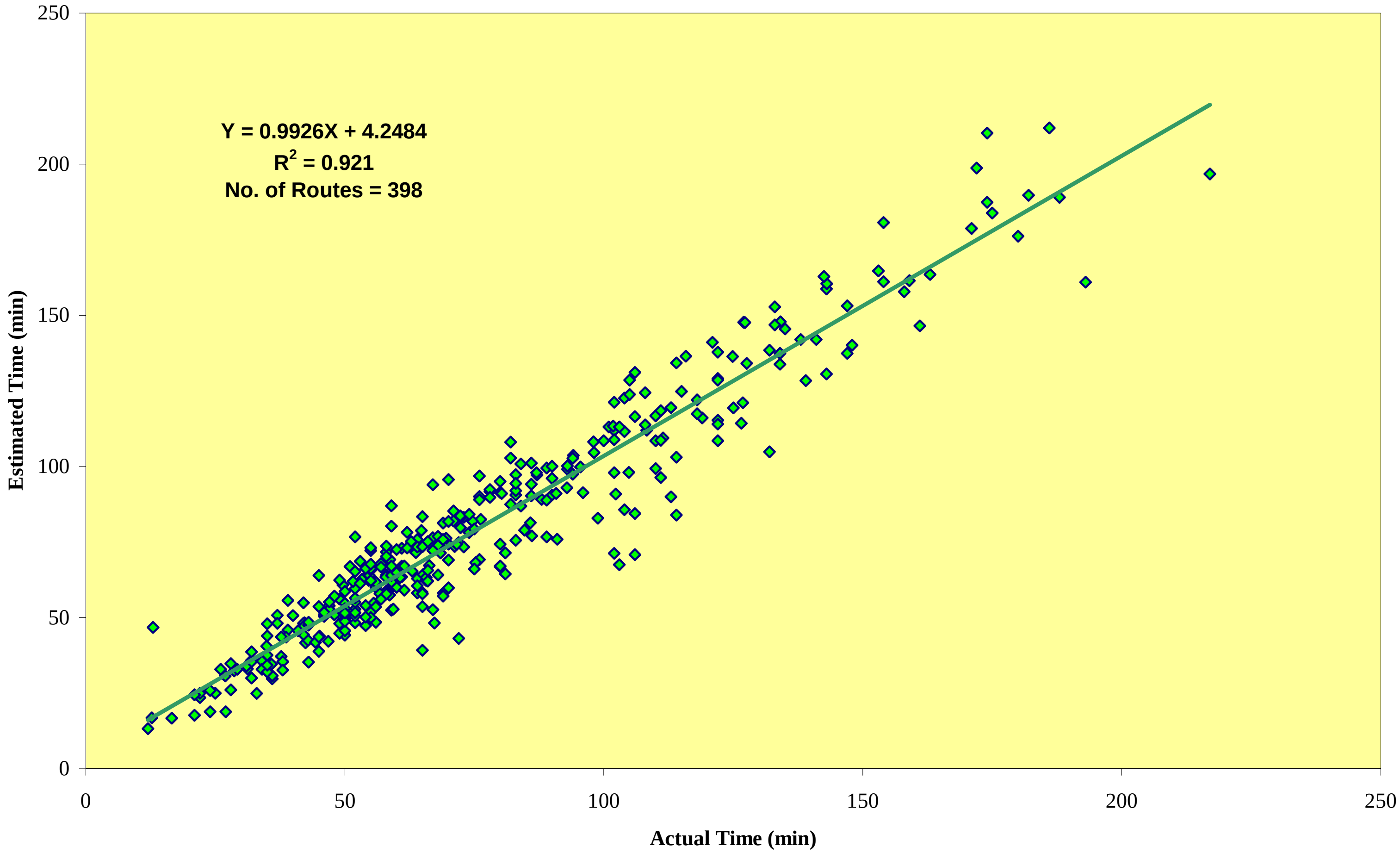
[1] Transit Ridership Forecasting Technical Report, Central Link Light Rail Transit Project (North Link), Sound Transit, November 2003.

Transit Network Preparation

The preparation of the base year transit network was an important and significant part of the overall development of the base year trip table. The accuracy of the resulting base trip tables depended directly on the validity and quality of the base transit network, as well as ridership counts. Therefore, the base year (2004) transit network was prepared and validated to accurately reflect transit service levels, as published in February 2004, as well as actual travel times by time-of-day. The travel times for each time point interval (TPI) were modified according to the automatic vehicle locator (AVL) data for all routes operating within King County, on-time performance reports for routes in the other two counties, as well as on-time performance data for Tacoma Link and Sounder commuter trains.

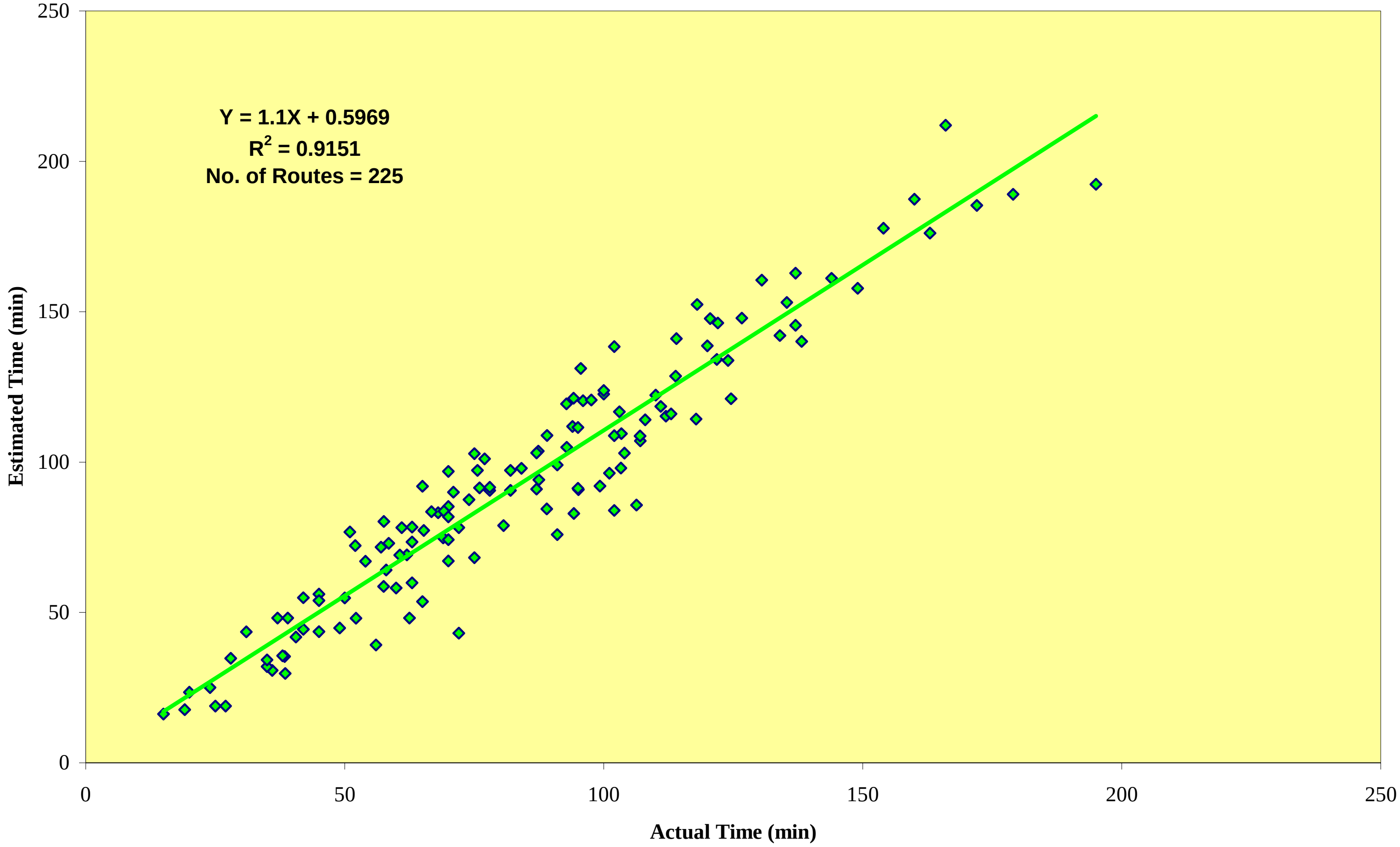
The resulting 2004 transit network operating parameters were compared against revenue hours, miles, and miles per hour in the national transit database (NTD) and were found to be within five percent on all measures. More significantly, as shown in Figures 3.1a and 3.1b, the estimated line times for the 2004 PM peak and off-peak transit networks at the individual route level were very similar to actual line times. Figures 3.1a and 3.1b show the route-level dispersion between modeled and actual transit travel times around a simple regression line. The resulting statistics (R-square over 0.91 and the regression line parameter close to one) indicate a well-calibrated transit network that is capable of reflecting service levels accurately.

Figure 3.1a – Comparison of 2004 PM Peak Actual vs. Estimated Line Times for All Agencies



[1] Actual times were available for most KCM Routes. Otherwise, scheduled times were used for comparitive analysis

Figure 3.1b – Comparison of 2004 Off-Peak Actual vs. Estimated Line Times for All Agencies



[1] Actual times were available for most KCM Routes. Otherwise, scheduled times were used for comparitive analysis

Validation of Transit Service Reliability

The current ST model relies on actual transit vehicle speeds to more realistically represent transit service reliability. Although the long-term decline in bus operating speeds has been measured for the past 40 years, it has not been easy to measure the accompanying decline in service reliability until recently. However, Metro's automatic vehicle locator (AVL) data now give complete information on actual bus times and bus schedule adherence. According to a recent analysis performed using AVL data, a rider must plan on a 9.2 minute delay for bus services. This corresponds to a 1.5 minute delay for rail services.[2]

ST models have been using a boarding penalty to account for uncertainties related to using the transit system, including uncertainties about transferring between vehicles. Table 3.1a presents the model's boarding penalties, including wait time factors and time penalties that are assumed on escalator links. Note that in the ST model, walk and wait time resulting from a transfer is accounted for separately, including pedestrian and escalator links at rail stations.

Validation results using the boarding penalties indicated in Table 3.1 netted a much closer match to observed transfer behavior. These improvements occurred at the system level, the route level and at transit center locations.

According to the prior model, 90 percent of commuter rail riders were estimated to arrive at King Street Station by bus. Consequently, the assignment of transfers between the downtown commuter rail station and the downtown bus tunnel were of particular concern. Sound Transit surveys have shown that only 43 percent of commuter rail riders arrive via downtown bus transfers whereas approximately 50 percent access the King Street Station by walking. Although the current model's estimate of 60 percent arrival by bus is still somewhat high, it is much closer to the observed access pattern.

The current ST model also more accurately replicated the 3-county transfer rate of 1.27, compared to the 1.35 estimated in the earlier ST model versions.

[2] Billen, D., "Application of Transit to LOS Measures in the Seattle North Link Light Rail Corridor," 10th TRB – Transportation Planning Applications Conference, Portland OR, 2005.

Table 3.1 – Boarding Penalty, Wait Time Factor and Escalator Link Assumptions in the 2004 ST model

	PM Peak	Off Peak
Regular Bus Stops		
Boarding Penalty	5.0 min	4.0 min
Wait Time Factor	0.60	0.60
Escalator Link	NA	NA
Transit Centers[1]		
Boarding Penalty	3.0 min	3.0 min
Wait Time Factor	0.50	0.50
Escalator Link	NA	NA
Downtown Bus Tunnel		
Boarding Penalty	3.0 min	3.0 min
Wait Time Factor	0.50	0.50
Escalator Link	1.0 min	1.0 min
Rail Stations (surface)		
Boarding Penalty	2.0 min	2.0 min
Wait Time Factor	0.50	0.50
Escalator Link	0.5 min	0.5 min
Rail Stations (tunnel or elevated)		
Boarding Penalty	2.0 min	2.0 min
Wait Time Factor	0.50	0.50
Escalator Link	1.0 min	1.0 min

[1] **List of Transit Centers:**

1) Bellevue Transit Center
2) Federal Way Transit Center
3) Northgate Transit Center
4) Burien Transit Center
5) Kent Transit Center
6) Auburn Transit Center
7) Kirkland Transit Center
8) Overlake Transit Center
9) Aurora Village Transit Center
10) Renton Transit Center
11) Lynnwood Transit Center
12) Tacoma Dome
13) Lakewood Transit Center
14) Everett Station
15) Tacoma Community College

Note:
In both the path-building and the mode choice applications, all of these out-of-vehicle times are multiplied by 2.0.

Ridership Counts Data Preparation

The King County Metro automated passenger count (APC) database was the primary source of actual (or "observed") ridership data. A comprehensive GIS database has been created at King County Metro to maintain and analyze the historical ridership data recorded by APC machines. The raw database included 24-hour count by time point interval (TPI) segments by direction, corresponding to an average weekday in the spring 2004 for all KCM routes and ST buses operating in King County. Segment count data were extracted from the APC database for the three hour PM peak period (3-6 PM) and 18 hours representing off-peak hours outside the two AM and PM peak periods. In addition to TPI segment count, route-level boarding counts data were also obtained from each transit agency. From these data, the "optimal" TPI segment locations were identified so that an accurate load profile could be replicated on each route and by time-of-day.

Matrix Adjustment Process

A trip matrix adjustment methodology developed by Heinz Spiess[3] was used to assist in development of the base year (2004) PM peak and off-peak transit trip tables. This methodology, which has been used extensively, minimizes the difference between estimated and "observed" volumes seeded at designated segment-load locations for each route. While this methodology achieves a close match of estimated to actual segment loads, additional refinements were necessary to improve accuracy in the resulting transit trip tables. These refinements included:

- New seed matrices were developed to capture sufficient non-zero cells, increasing these from 3 percent in previous model versions to 17 percent; and

- An extensive set of segment-based counts data were used to accurately replicate the load profile on each transit route by time-of-day. This was achieved from an extensive iterative process and resulted in the identification of about 1,700 optimal segment load locations. This constituted about 25 percent of the total TPI segments in the APC database.

Conditions outlined above were complemented by an extensive and rigorous validation analysis effort. The validation analysis results for base year (2004) transit trip development are discussed below.

[3] Spiess, H., "A Gradient Approach for the O-D Matrix Adjustment Problem," Formerly with INRO (EMME/2 Support Center), Haldenstrassee 16, CH-2558 Aegerten, Switzerland.

3.2 Base Year (2004) Validation Analysis Results

The validation analysis focused on evaluating (1) the updated transit trip tables from the matrix adjustment process and (2) the accuracy of the assignment results, which is reflected in:

- System-wide boardings and transfer rate;
- Boardings comparison for Commuter Rail and Regional Express Bus routes.
- Trip length frequency distribution of trip tables;
- Route-level boardings;
- Route-segment volumes by direction and by peak and off-peak periods; and
- PM peak and daily volumes comparison at selected screenlines.

Table 3.2a presents system-wide linked and unlinked transit trips, including a comparison of daily boarding estimates to respective actual boardings. As shown in Table 3.2a, the number of estimated versus actual trips is close, reflecting the breadth and quality of the underlying network and ridership counts data used in the trip table development process. The total estimated PM peak transit trips was 90,000, which is about 28 percent of the total 324,600 daily transit trips. Daily transit boarding results closely match those reported in the National Transit Database (NTD). The system-wide daily boardings reflect an overall transfer rate of 1.25. The validation analysis also replicated closely actual boardings on Commuter Rail and Regional Express Bus routes as shown in Table 3.2b.

Figure 3.2a shows a similarity in the trip length frequency distributions between the two matrices in spite of the overall average trip length being reduced by about 1.6 miles, or 15 percent. Average trip length estimates produced for routes operated by each transit agency compared closely to their actual counterpart values as shown in Table 3.2c. Trip lengths in the ST model for community transit are always shorter in the ST model because the CT service area and routes extend far beyond the ST district boundary and model area.

A route-level comparison of PM peak boardings for KCM and ST routes is shown in Figure 3.2b, while Figure 3.2c shows a similar comparison for daily boardings including routes operated by all transit agencies. These results indicate a close match at the route level for both PM peak and daily boardings as exhibited in slope and R-squared statistics for goodness-of-fit. These measures came close to 1.0 for boardings on 281 PM peak routes and 398 off-peak routes, shown in Figures 3.2b and 3.2c, respectively.

To evaluate the matrix adjustment process, a comparative analysis of load volumes at "optimal" segment locations as well as an analysis of trip length frequency distributions between the seed matrix and final daily transit trip tables were performed. Figures 3.2d and 3.2e highlight the close match of estimated to actual loads at segment locations for 2004 PM peak direction and off-peak transit trips.

Transit volumes estimated from the transit assignment process are compared with actual transit passenger volumes in Table 3.2d at selected screenlines. Estimated PM peak and daily passenger volumes are within 10 percentage points of actual volumes at the screenlines shown in Figure 3.2f.

Table 3.2a – Systemwide 2004 Linked and Unlinked Transit Trip Summaries

	PM Peak[1]	Off-Peak[2]	Daily[3]		
	Estimated	Estimated	Actual[4]	Estimated[5]	Est/Act
Linked Transit Trips	90,000	144,600	NA	324,600	NA
Total Boardings by Operator:					
KC Metro	81,700	144,500	308,000	307,900	1.00
Sound Transit	11,200	13,600	33,000	36,000	1.09
Pierce Transit	7,700	16,000	35,000	31,400	0.90
Community Transit	8,800	7,700	26,000	25,300	0.97
Everett Transit	1,400	2,800	6,000	5,600	0.93
Three-County Total Boardings	**110,800**	**184,600**	**408,000**	**406,200**	1.00
Systemwide Transfer Rate	**1.23**	**1.28**	**NA**	**1.25**	**NA**

[1] PM peak period represents three hours between 3-6 PM.

[2] Off-peak period represents 18 hours outside 6-9 AM and 3-6 PM peak periods.

[3] Daily linked and unlinked transit trips were calculated based on PM peak times two plus off-peak values.

[4] Actual boardings were obtained from the National Transit Database (NTD) and supplemented by available data from transit agencies.

[5] Estimated transit trips in the ST model reflect transit markets only within the ST boundaries that are smaller than the 3-county total boundaries.

Table 3.2b – Rail and Regional Bus Line Boarding Comparisons

	2004 Daily		
	Actual	Estimated	Est/Act
Rail and Regional Bus Boardings:			
Commuter Rail - South	3,800	3,600	0.95
Commuter Rail - North	300	230	0.77
Tacoma Link Light Rail	2,700	1,980	0.73
ST Everett-Seattle Express	3,510	3,120	0.89
ST Bothell-Seattle Express	1,940	1,900	0.98
ST Bellevue-Seattle Express	5,170	5,150	1.00
ST Pierce-Seattle Express	4,770	4,900	1.03

Figure 3.2a – Travel Frequency Distribution for 2004

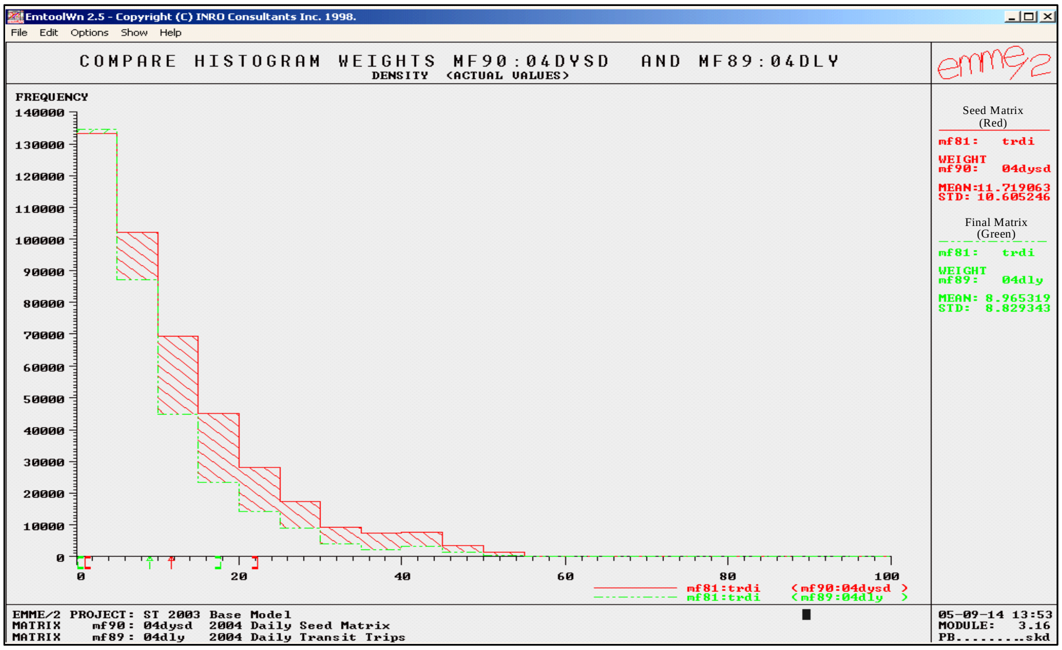


Table 3.2c – Average Trip Length Comparison for 2004

Transit Operator	Actual	Estimated	Est/Obs
King County Metro	5.0	4.5	0.90
Pierce Transit	7.2	7.3	1.01
Community Transit[1]	12.0	10.0	0.83

[1]Note that Community Transit service area extends beyond the RTA Area.

Figure 3.2b – Comparison of 2004 PM Peak Period Actual vs. Estimated Route Level Boardings for KC Metro and ST

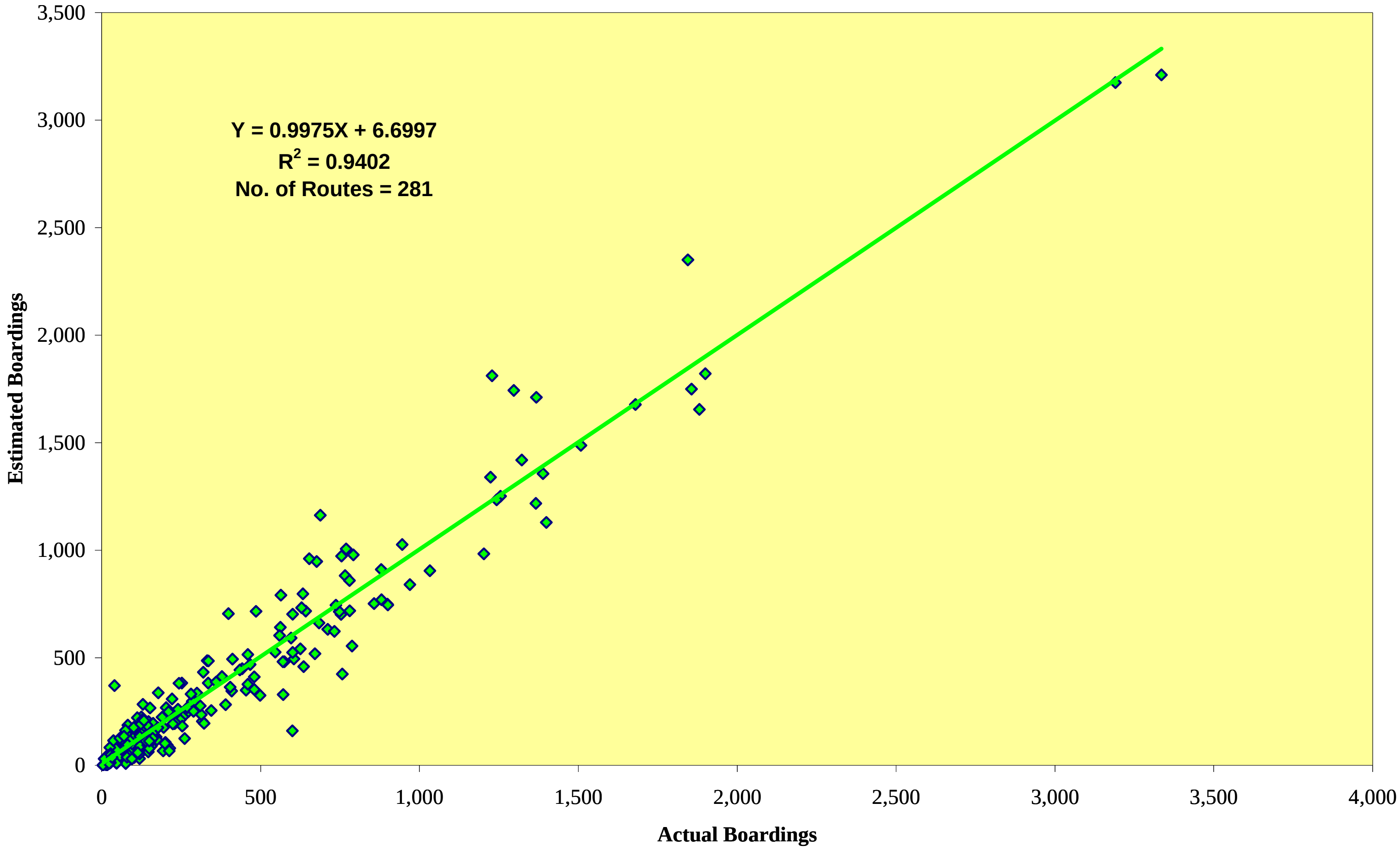


Figure 3.2c – Comparison of 2004 Daily Actual vs. Estimated Route Level Boardings for All Transit Agencies

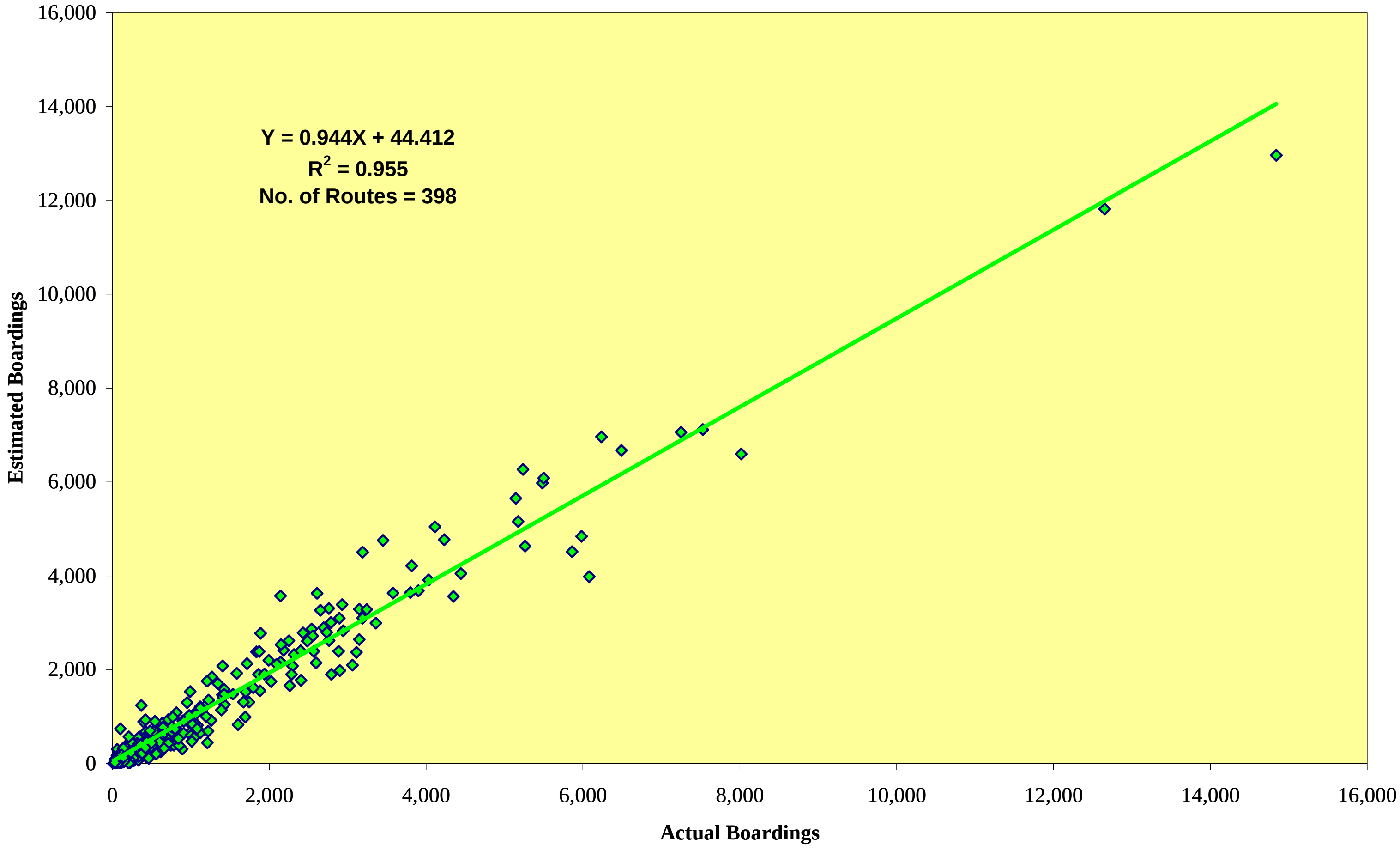


Figure 3.2d – Comparison of 2004 PM Peak (Peak Direction) Actual vs. Estimated Segment Loads for All Transit Agencies

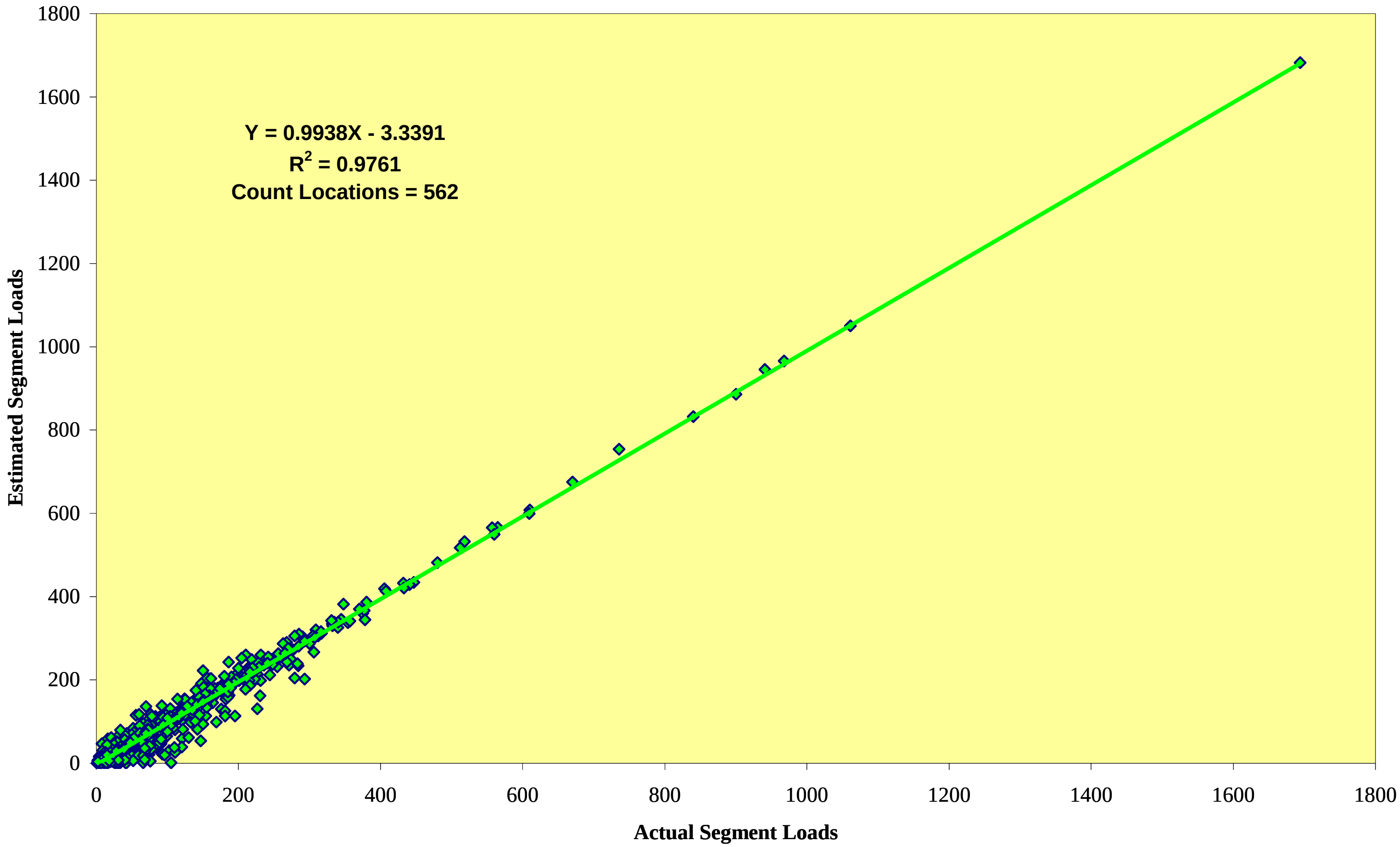


Figure 3.2e – Comparison of 2004 Off-Peak (Both Directions) Actual vs. Estimated Segment Loads for All Transit Agencies

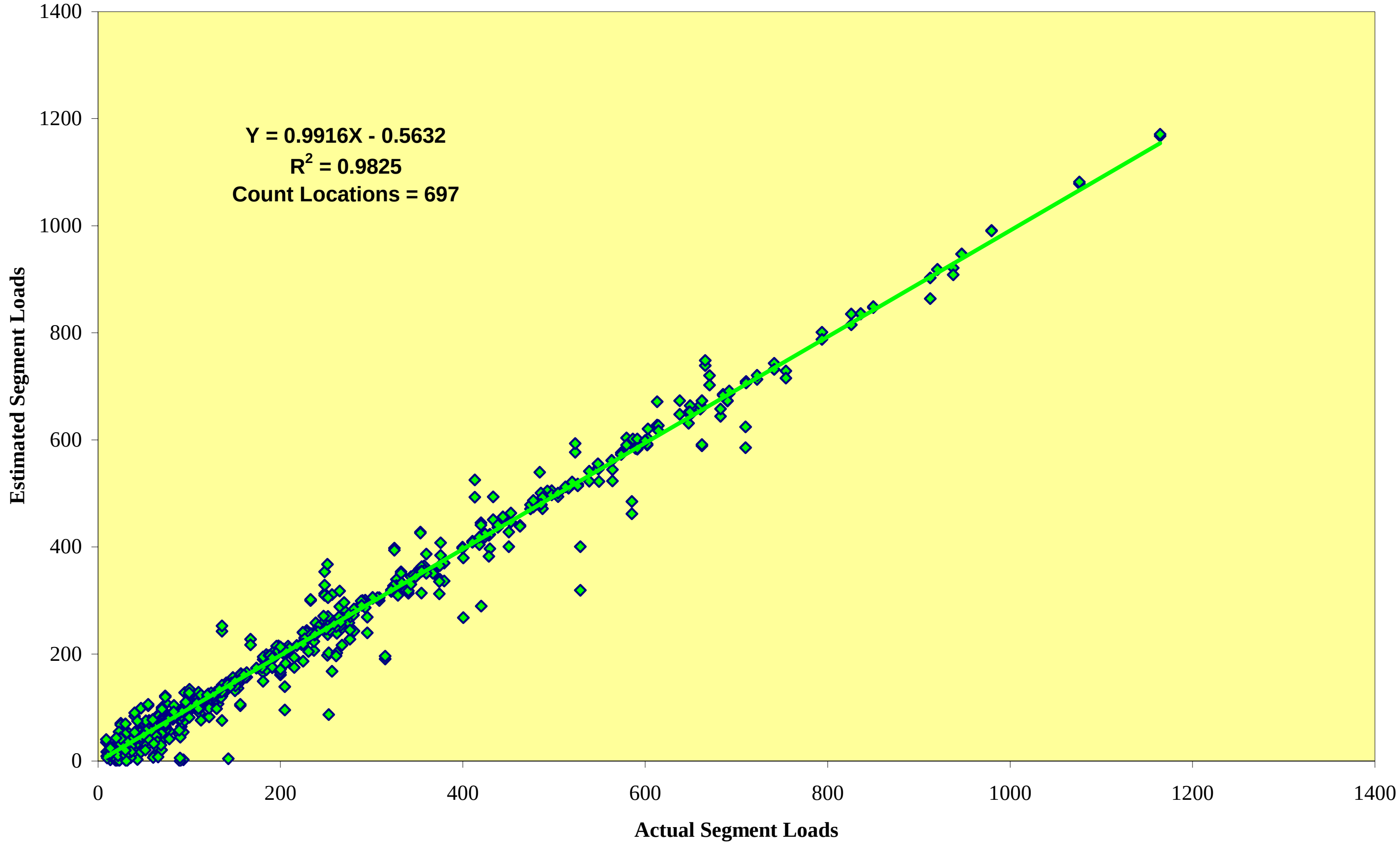
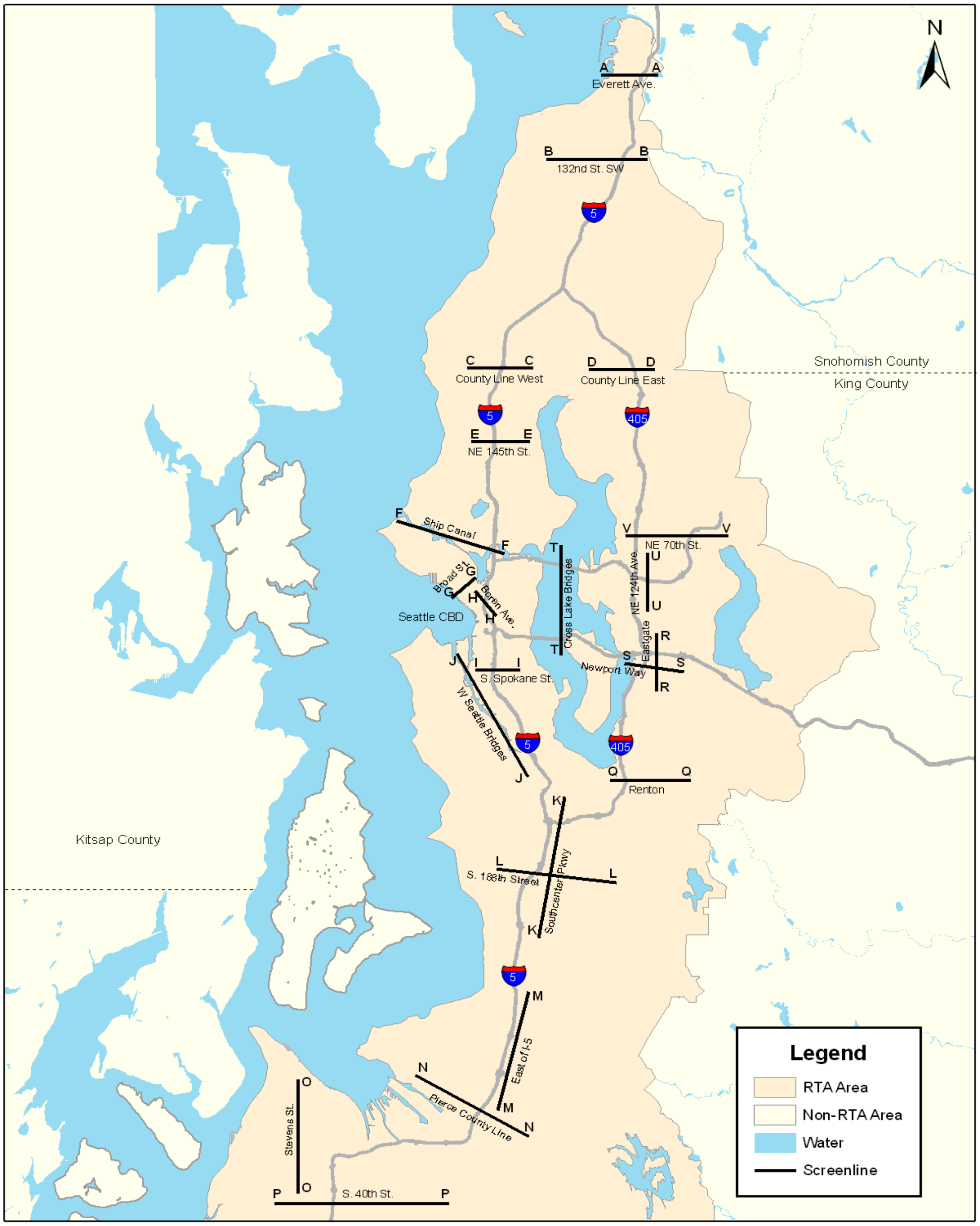


Table 3.2d – Comparison of PM Peak and Daily Transit Volumes at Selected Screenlines
Base Year (2004) ST Model Validation Results

		PM Peak			Daily		
	Screenline	**Actual**	**Estimated**	**Est/Act**	**Actual**	**Estimated**	**Est/Act**
A	Downtown Everett, Everett Avenue	910	760	0.84	2,830	2,550	0.90
B	Snohomish County, 132nd Street SW	2,410	2,280	0.95	6,940	6,660	0.96
C	Snohomish County Line West	6,360	5,940	0.93	17,610	16,920	0.96
D	Snohomish County Line East	660	630	0.95	1,640	1,640	1.00
E	North Seattle, NE 145th Street	8,790	8,930	1.02	26,290	26,540	1.01
F	Ship Canal Bridges	19,630	21,090	1.07	65,240	66,840	1.02
G	Downtown Seattle, Broad Street	8,570	8,000	0.93	32,640	31,340	0.96
H	Downtown Seattle, Boren Avenue	20,070	22,010	1.10	75,570	76,950	1.02
I	South Seattle, S Spokane Street	14,610	14,640	1.00	47,890	48,610	1.02
J	West Seattle Bridges	5,190	5,370	1.03	20,520	21,840	1.06
K	Southcenter Parkway	880	890	1.01	2,970	3,060	1.03
L	South King County, S. 188th Street	7,300	7,490	1.03	20,460	20,220	0.99
M	Federal Way, East of I-5	390	480	1.23	1,640	1,900	1.16
N	Pierce County Line	3,370	3,230	0.96	9,000	8,690	0.97
O	Tacoma, Stevens Street	1,220	1,120	0.92	4,660	4,350	0.93
P	Tacoma, S. 40th Street	1,950	2,170	1.11	7,060	7,310	1.04
Q	Renton	2,400	2,270	0.95	7,410	6,900	0.93
R	Eastside, Eastgate	1,700	1,580	0.93	5,010	4,560	0.91
S	Eastside, Newport Way	1,040	890	0.86	3,070	2,610	0.85
T	Cross Lake Bridges	7,060	6,770	0.96	19,910	19,200	0.96
U	Eastside, NE 124th Avenue	2,270	2,430	1.07	7,790	7,900	1.01
V	Eastside, NE 70th Street	2,880	2,920	1.01	8,370	8,320	0.99

Figure 3.2f – Transit Screenlines Location Map



4. PRIMARY ASSUMPTIONS AND BUILD-UP FORECASTING ANALYSIS RESULTS

This chapter discusses the specific input data and assumptions used to perform staged forecasting analysis to support Sound Transit Phase 2 (ST2) Projects. It is divided into two parts. First, the underlying data and assumptions used in the modeling process are presented, followed by the build-up forecasting analysis for the 2030 Baseline Alternative.

4.1 Key Input Data Assumptions

The 2030 ridership forecasts were developed from the validated 2004 transit trip tables using a staged forecasting process. The Stage 1 forecasts used land use forecasts released by PSRC in February 2004. The highway congestion forecasts were produced accordingly, based on the existing PSRC model databases. The transit service levels were defined by Sound Transit staff, with input from local transit operators, and used to produce Stage 3 2030 ridership forecasts for Baseline Alternative.

Demographic Forecasts

The Stage 1 2030 ridership forecasts were produced using the regional land use forecasts released by PSRC in February 2004 Table 4.1a shows district-level 2004 and 2030 land use forecasts. Figure 4.1 shows a map of district boundaries. FAZ-level 2004 and 2030 total households, population and employment forecasts are shown in Table D1 in Appendix D. The growth rates between 2004 and 2030 in regional total households, population, and employment forecasts (shown in Table 4.1a) are 1.39, 1.32, and 1.44 respectively. This translates into annual compounded average growth rates of 1.27%, 1.07%, and 1.41%.

Highway Congestion

The PSRC maintains transportation networks that represent highway system and HOV improvement plans for a given year. The PSRC's highway models provide peak and off-peak highway times. For production of the 2030 Stage 2 ridership forecasts, highway travel times were based on using a future year baseline (no-build) highway network that includes only financially committed projects. The total person trip tables used in the PSRC model runs reflected the land use forecasts for 2030, which were released in February 2004. Change in roadways performance will be examined as part of benefit analysis for the transit investment packages.

Parking Costs

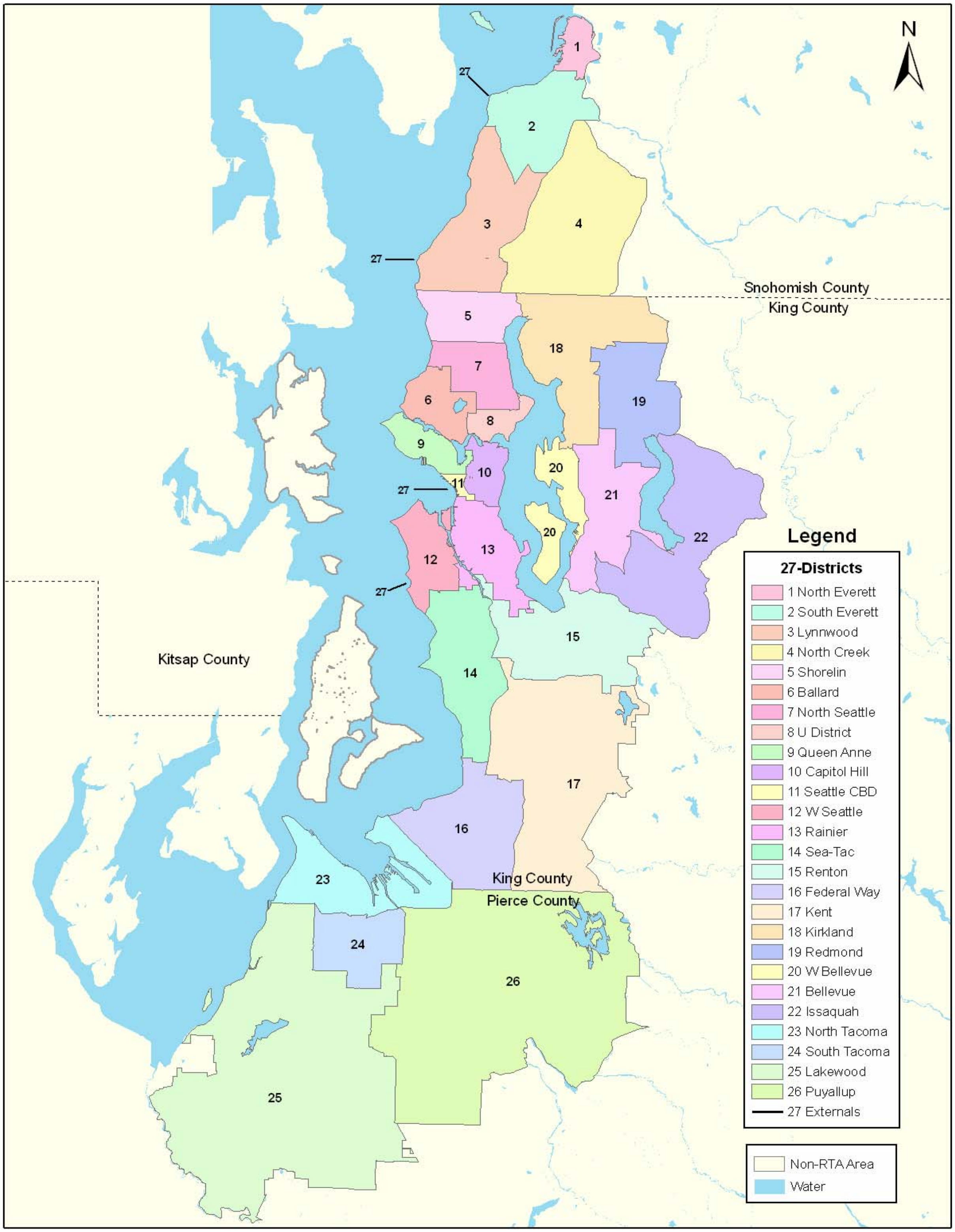
Zonal parking costs used in the ST model reflected a conservative 1.5 percent annual (real) growth in parking costs. This is a significant reduction from the 3 percent real growth that was previously assumed by ST and the PSRC. However, according to the limited historic information available, parking costs have averaged 1.6 percent growth since 1960. Table D2 shows zonal parking costs used in the ST model Stage 2 forecasting analysis.

Table 4.1a
Total Households, Population, and Employment for 2004 and 2030

		Base Year 2004			Year 2030			Growth Rate - 2030 over 2004		
No.	District Name	Households	Population	Employment	Households	Population	Employment	Households	Population	Employment
1	North Everett	55,800	154,100	59,900	91,400	233,900	94,800	1.64	1.52	1.58
2	South Everett	34,200	86,400	59,500	49,900	116,900	90,600	1.46	1.35	1.52
3	Lynnwood	58,600	147,400	51,800	86,300	200,400	87,400	1.47	1.36	1.69
4	North Creek	94,800	268,900	51,400	165,400	434,000	85,500	1.74	1.61	1.66
5	Shoreline	26,600	68,100	17,500	30,600	75,000	22,900	1.15	1.10	1.31
6	Ballard	48,000	97,400	35,200	57,000	110,400	44,900	1.19	1.13	1.28
7	North Seattle	44,400	96,700	34,000	58,500	120,700	54,700	1.32	1.25	1.61
8	University District	17,400	45,700	44,800	22,400	52,700	62,900	1.29	1.15	1.40
9	Queen Anne	31,800	60,300	68,200	52,000	88,000	100,900	1.64	1.46	1.48
10	Capitol Hill	43,700	81,700	62,900	52,500	95,200	77,400	1.20	1.17	1.23
11	Seattle CBD	14,200	25,000	178,300	27,500	45,900	232,200	1.94	1.84	1.30
12	W Seattle	35,500	79,900	19,500	41,300	89,300	26,300	1.16	1.12	1.35
13	Rainier	31,900	90,800	83,700	42,500	116,200	104,200	1.33	1.28	1.24
14	Sea-Tac	50,200	128,800	59,800	60,700	148,400	85,700	1.21	1.15	1.43
15	Renton	49,600	120,700	104,500	67,100	153,600	178,500	1.35	1.27	1.71
16	Federal Way	44,400	119,500	36,900	54,200	139,400	49,600	1.22	1.17	1.34
17	Kent	98,100	266,200	118,000	127,600	333,800	158,600	1.30	1.25	1.34
18	Kirkland	62,700	159,600	69,500	81,500	194,500	96,700	1.30	1.22	1.39
19	Redmond	30,200	76,800	85,900	44,000	106,400	112,100	1.46	1.39	1.31
20	West Bellevue	21,700	49,400	55,400	32,600	66,000	99,700	1.50	1.34	1.80
21	Bellevue	41,200	101,600	78,600	47,600	111,200	105,700	1.16	1.09	1.34
22	Issaquah	41,700	111,700	33,400	55,000	144,800	55,600	1.32	1.30	1.66
23	North Tacoma	70,800	177,300	97,500	102,100	239,400	135,700	1.44	1.35	1.39
24	South Tacoma	32,900	93,400	35,200	49,600	127,600	54,900	1.51	1.37	1.56
25	Lakewood	70,900	190,300	81,400	92,400	231,600	102,400	1.30	1.22	1.26
26	Puyallup	103,900	281,900	55,800	156,100	409,000	91,500	1.50	1.45	1.64
27	Rest of Region	95,500	254,400	93,300	141,100	350,700	124,400	1.48	1.38	1.33
	ST Area	**1,255,200**	**3,179,600**	**1,678,600**	**1,747,800**	**4,184,300**	**2,411,400**	**1.39**	**1.32**	**1.44**
	4-County Region	**1,350,700**	**3,434,000**	**1,771,900**	**1,888,900**	**4,535,000**	**2,535,800**	**1.40**	**1.32**	**1.43**

Source: Demographic forecasts shown in this table correspond to the latest version (dated February 3, 2004) posted at the PSRC website.

Figure 4.1: 27-District Boundary



Other Costs and Income

The PSRC estimated the auto vehicle operating costs used in the ridership forecasting analysis. This rate was 15 cents per mile for auto vehicle operating costs in 1990 dollars. Assuming auto vehicle costs would increase at the rate of inflation, this rate was converted to 20 cents per mile in 2004 dollars, and used in the ST model 2030 Stage 2 ridership forecasts.

For Sound Transit ridership forecasts prepared in the early 1990s, zonal-level median household income data was obtained from PSRC for the base and forecast years. Because PSRC no longer forecasts household income at the zonal level, the current set of Sound Transit ridership forecasts apply PSRC forecasts of the change in regional average household income to base year zonal income data to estimate future year zonal income. The ST model database represents (real) growth in income within one percent per year. This is consistent with the historical rate of (real) growth in income in the Puget Sound Region.

Transit Fares

Transit fares were developed for the ST model update to 2004 and assumed to be: (i) zone-to-zone averages in effect in 2004, and (ii) the same under all alternatives. Transit fares were also assumed to increase at the same rate as the overall rate of inflation in the region, as measured by the Consumer Price Index (CPI). This is a policy assumption consistent with the local transit agencies' practice of periodically adjusting fares to keep up with increased operating costs. Peak and off-peak transit fares used in the ST model are presented in Appendix C.

Transit Service

The bus service changes defined for the Baseline Alternative were based on the work performed to define integration of bus services with Link Light Rail, Sounder Commuter Rail, and ST Express bus services. This plan provides for implementation of high-capacity transit in the three-county region of King, Snohomish, and Pierce counties. The networks identify conceptual routings and headways for the feeder bus system that provides access to the Link Light Rail system at stations. In addition to the feeder bus system, the networks include regional and local bus services operated by Sound Transit, King County Metro, Community Transit, Everett Transit, and Pierce Transit. The services operated by these agencies were considered part of the background bus system, and updated to reflect agency plans for service expansion and bus service revisions recently implemented by the transit agencies.

Major assumptions underlying the Baseline network include the following:

1. There is no Sound Transit capital investment beyond the improvements paid for by Sound Move.
2. Central Link is in operation between the University of Washington and SeaTac Airport.
3. Some joint operation of buses remains in the Downtown Seattle Transit Tunnel (DSTT).
4. There is no increase in ST Express Bus services beyond that listed in the 2006 Service Improvement Plan (SIP) through 2011, except for schedule maintenance hours.
5. There are no new monorail or streetcar lines in the City of Seattle or anywhere else in the Sound Transit District, besides the existing Waterfront Streetcar.
6. There is no increase in Sounder Commuter Rail service beyond the 26 trains allowed by existing contracts between ST and BNSF.

These assumptions provide the background network against which further investment can compared. Investments assumed for ST2 are assumed to be completed by 2025, and the Baseline network is the network in 2025 if no investments are made beyond the Sound Move plan. Ridership forecasts will be for 2030, presumably five years following completion of the investment package. The following details further clarify the above assumptions.

1. **Capital Projects**. Capital projects not yet in construction, but paid for by Sound Move include the extension of Central Link to the University of Washington and three new Sounder stations (Mukilteo, South Tacoma, and Lakewood). Direct access ramps under construction in 2006 are included and a new in-line express bus transit station at Mountlake Terrace is also included.
2. **Central Link.** The Baseline assumes 5-minute peak headways and 7.5-minute off-peak headways between University of Washington and Rainier Beach, and 10-minute peak and 15-minute off-peak headways to the Airport. The travel time for the length of the route is 41 minutes, including dwell times and the slower downtown tunnel speeds due to joint operation.
3. **DSTT Joint Operation**. The joint operation remaining in the DSTT allows for up to 36 buses per hour per direction, which represents approximately half of the peak bus operation in 2005. Trains will operate slower than they would under any future extension of light rail service that precludes joint operation with buses in the DSTT.
4. **ST Express.** The 2006 SIP has only minor increases in service which can be paid for with existing revenues from Sound Move. Sound Transit’s operating budget also includes small annual percentage increases for schedule maintenance, about 0.5 percent per year. These increases cover some of the additional costs related to providing existing services, as well as costs pertaining to slower bus operations in the future.
5. **Monorails and Streetcars**. The only local streetcar assumed in the Baseline is the Waterfront Streetcar in Seattle. Although there have been several other streetcar lines proposed, none are currently funded. No monorail lines are assumed.
6. **Commuter Rail.** Current agreements with BNSF, operator of the Sounder trains, limit commuter rail service to 8 trains per day between Everett and Seattle (i.e., 4 round trips) and 18 trains per day between Lakewood and Seattle (i.e., 9 round trips). A limited amount of special event service is also permitted. These 26 weekday trains are the Sounder Baseline assumption for 2030.

The bus and rail services defined above were coded using the network coding conventions presented in Appendix C. Bus speeds were adjusted for the forecast year to reflect roadway speed degradation. Degradation speed estimates were based on using roadway travel times from the PSRC model (see Appendix C). Stage 3 ridership forecasts for the 2030 Baseline Alternative were produced accordingly.

4.2 Build-Up Analysis Results

As documented in detail in Chapter 2.0, the ST patronage forecasting analyses were performed in three separate stages. This particular process distinguishes and facilitates the evaluation of incremental changes in demographics, costs, and highway and transit travel times. In Stage 1,

implied growth in land use forecasts (at FAZ level) adopted by the PSRC is used to expand base-year transit demand from a base year to a forecast year. Stage 2 of the ST modeling process considers the influence due to changes in highway congestion, auto operating costs, parking costs, transit fares, and income. Change in transit service levels is considered in the last stage of the ST model forecasting analysis. Staged forecasting analysis results for 2030 PM peak and daily are summarized in Tables 4.2a and 4.2b.

The results of the first stage forecasting analysis indicate that regional demographic changes between 2004 and 2030 result in an approximately 36 percent increase in daily transit trips within the three-county region (see Table 4.2b). Total households and employment (for the three-county region) are projected to increase, respectively, by 39 and 44 percent between 2004 and 2030. Employment for the Seattle downtown area is projected to increase by 30 percent between 2004 and 2030. Overall growth in transit demand related to growth is lower than regional employment growth because a slightly higher percentage of the future employment growth occurs away from traditional transit markets.

In Stage 2 of the forecasting analysis, the combined effect of changes in auto operating costs, parking cost, transit fare, highway congestion, and income were taken into consideration. These changes increased daily transit trips by about 13 percent relative to the Stage 1 2030 forecasts. These transit-trip increases resulted from increased parking costs and congestion, as discussed in Section 4.1. The direction of change in most variables would be expected to produce an increase in ridership in Stage 2.

In Stage 3 of the forecasting analysis, changes in transit service (relative to 2004) were considered for the Baseline Alternative. Note that Stage 3 reflects the net combined impact of changes in transit service levels and speeds. Some of these effects are positive, e.g., the addition the Central Link line, and some are negative, e.g., the slight declines in transit speeds in some areas. Changes in transit shares to the PSRC Regional Urban Centers are shown in Table 4.2c. District-level transit trip table summaries for 2004 to 2030 Stages 1, 2 and 3 forecasts are shown in Tables 4.2d through 4.2g for PM peak and in Tables 4.2h through 4.2k for daily transit trips.

Table 4.2a
Build-Up Analysis: 2004 to 2030 Build-Up Peak Transit Trips by PM Origins and PM Destinations

District No.	District Name	PM Origins 2004	PM Origins 2030 Stage 1	PM Origins 2030 Stage 2	PM Origins 2030 Stage 3	PM Destinations 2004	PM Destinations 2030 Stage 1	PM Destinations 2030 Stage 2	PM Destinations 2030 Stage 3
1	North Everett	1,240	2,000	2,520	2,020	1,880	2,800	4,110	3,260
2	South Everett	1,630	2,460	3,240	2,630	2,060	2,940	4,040	3,430
3	Lynnwood	1,780	2,980	3,760	3,350	3,750	5,430	7,450	6,530
4	North Creek	770	1,290	1,330	1,110	2,270	3,850	6,320	4,810
5	Shoreline	840	1,100	1,200	1,120	2,480	2,780	3,720	3,370
6	Ballard	3,480	4,400	4,770	4,400	6,860	7,950	9,840	9,350
7	North Seattle	3,410	5,360	6,390	5,830	6,180	7,950	9,740	9,500
8	University District	7,860	11,310	16,070	16,200	3,390	5,260	5,730	6,340
9	Queen Anne	3,610	5,210	6,350	5,780	4,130	6,630	7,260	7,270
10	Capitol Hill	8,860	11,180	13,510	13,440	8,400	9,880	11,010	11,390
11	Seattle CBD	30,220	38,500	48,870	45,060	8,200	14,700	15,510	15,750
12	W Seattle	1,350	1,830	1,830	1,840	3,690	4,250	4,860	4,930
13	Rainier	6,150	7,720	9,050	9,430	5,970	7,740	8,090	9,350
14	Sea-Tac	1,650	2,370	3,340	3,470	3,210	3,820	4,350	4,470
15	Renton	2,040	3,450	4,590	4,050	3,330	4,770	5,810	5,210
16	Federal Way	550	720	860	860	1,810	2,170	3,450	2,810
17	Kent	1,910	2,660	3,100	2,770	3,090	3,960	5,560	4,590
18	Kirkland	1,080	1,530	1,720	1,610	2,380	3,020	4,530	3,600
19	Redmond	910	1,200	1,570	1,490	1,530	2,150	2,940	2,520
20	West Bellevue	1,700	3,050	4,290	3,600	1,570	2,330	3,020	2,850
21	Bellevue	1,880	2,520	3,100	2,840	2,610	2,940	3,550	3,150
22	Issaquah	150	230	240	320	830	980	1,550	1,100
23	North Tacoma	2,960	4,070	4,100	3,600	3,360	4,860	6,350	5,530
24	South Tacoma	1,880	2,950	2,780	2,470	2,200	3,350	3,790	3,680
25	Lakewood	1,210	1,710	1,690	1,490	2,270	2,960	3,410	2,710
26	Puyallup	540	840	890	890	1,720	2,420	3,910	2,820
27	External	350	450	570	520	890	1,210	1,830	1,830
Total PM Peak Transit Trips		**90,010**	**123,090**	**151,730**	**142,190**	**90,060**	**123,100**	**151,730**	**142,150**
%Change Relative to 2004			37%	69%	58%		37%	69%	58%
%Change Relative to Previous Step in Build-Up Analysis			37%	23%	-6%		37%	23%	-6%

Table 4.2b
Build-Up Analysis: 2004 to 2030 Build-Up Daily Transit Trips (in Origin/Destination Format)

District No.	District Name	2004	2030 Stage 1	2030 Stage 2	2030 Stage 3
1	North Everett	4,920	7,620	9,540	7,950
2	South Everett	5,500	8,060	10,180	8,800
3	Lynnwood	7,820	12,080	15,130	13,700
4	North Creek	4,060	6,880	9,650	7,880
5	Shoreline	5,510	6,530	7,670	7,060
6	Ballard	19,220	23,180	25,770	24,770
7	North Seattle	16,710	23,440	26,670	26,090
8	University District	19,590	28,280	33,570	35,120
9	Queen Anne	15,030	22,390	24,290	23,890
10	Capitol Hill	34,000	41,770	45,470	46,990
11	Seattle CBD	75,480	102,170	112,520	109,800
12	W Seattle	10,490	12,910	13,450	13,950
13	Rainier	23,010	29,400	30,880	34,900
14	Sea-Tac	9,090	11,800	13,420	14,530
15	Renton	9,310	14,590	16,980	15,830
16	Federal Way	3,380	4,220	5,770	5,280
17	Kent	7,760	10,370	12,520	11,400
18	Kirkland	5,300	7,020	8,930	7,790
19	Redmond	3,770	5,120	6,450	5,970
20	West Bellevue	5,140	8,460	10,690	9,820
21	Bellevue	7,060	8,740	10,120	9,430
22	Issaquah	1,400	1,770	2,410	1,990
23	North Tacoma	12,830	18,230	19,760	18,080
24	South Tacoma	7,400	11,450	11,450	10,900
25	Lakewood	5,850	7,920	8,200	7,210
26	Puyallup	3,100	4,560	6,070	4,810
27	External	1,970	2,680	3,850	3,820
Total Daily Transit Trips		**324,700**	**441,640**	**501,410**	**487,760**
%Change Relative to 2004			36%	54%	50%
%Change Relative to Previous Step in Build-Up Analysis			36%	14%	-3%

Table 4.2c
PSRC Urban Center Transit Shares (Work Attractions)

	Regional Urban Centers	Existing[1]	2030 ST2 Baseline[2]
1	Lakewood	3.9%	3.9%
2	Puyallup South Hill[3]	1.0%	1.1%
3	Puyallup Downtown[3]	0.5%	0.6%
4	Tacoma Mall	2.5%	2.5%
5	Tacoma Downtown	4.1%	4.1%
6	Federal Way	2.5%	3.7%
7	Auburn[3]	1.9%	2.1%
8	Kent	3.1%	4.2%
9	SeaTac	4.3%	8.5%
10	Burien[3]	4.1%	5.5%
11	Tukwila	1.5%	1.5%
12	Renton	3.9%	4.8%
13	Bellevue Downtown	8.0%	9.6%
14	Totem Lake	3.4%	3.6%
15	Redmond	1.8%	2.2%
16	Seattle Downtown	39.7%	46.5%
17	Uptown Queen Anne	11.2%	12.6%
18	First Hill/Capitol Hill	16.1%	19.3%
19	University District	18.9%	27.1%
20	Northgate	5.3%	5.9%
21	Bothell Canyon Park[3]	1.3%	1.3%
22	Lynnwood	2.4%	3.0%
23	Everett	2.2%	2.3%
	ST Area	**7.7%**	**8.9%**

[1]2000 U.S. Census Journey-to-Work data were used to calculate transit share to the Regional Urban Centers.
[2]Shares correspond to total PM peak transit trips estimated for 2030 Baseline using ST model.
[3]Note that Census sample size on commute mode for these Centers was below 0.5% for total sample over jobs, or below 1% for transit sample over jobs.

Table 4.2d
PM Peak Transit Trips – Base Year 2004

ORIGIN	DESTINATION	North Everett 1	South Everett 2	Lynnwood 3	North Creek 4	Shorelin 5	Ballard 6	North Seattle 7	University District 8	Queen Anne 9	Capitol Hill 10	Seattle CBD 11	W Seattle 12	Rainier 13	Sea-Tac 14	Renton 15	Federal Way 16	Kent 17	Kirkland 18	Redmond 19	West Bellevue 20	Bellevue 21	Issaquah 22	North Tacoma 23	South Tacoma 24	Lakewood 25	Puyallup 26	External 27	Origin Totals	Origin Shares
North Everett	1	688	282	63	135	8	6	4	2	4	4	16	0	1	1	–	–	0	0	–	–	–	0	0	–	0	–	29	1,242	1.4%
South Everett	2	407	472	256	158	18	11	34	7	5	8	19	0	1	1	61	2	38	16	1	4	11	6	0	0	0	0	88	1,626	1.8%
Lynnwood	3	138	374	690	147	95	30	115	16	7	12	23	0	5	0	0	0	0	47	8	5	10	0	0	0	0	–	55	1,780	2.0%
North Creek	4	144	198	114	141	13	11	56	9	4	21	23	0	5	0	1	0	0	24	2	1	0	0	0	0	3	0	3	773	0.9%
Shorelin	5	15	56	102	5	167	120	172	47	16	26	44	2	11	1	1	0	1	33	2	3	2	0	0	–	0	–	11	838	0.9%
Ballard	6	11	31	40	13	121	945	411	281	426	356	413	84	120	37	47	9	14	15	9	29	28	4	6	1	0	9	25	3,483	3.9%
North Seattle	7	10	88	164	126	299	490	703	383	181	216	296	34	122	28	19	2	9	141	8	28	37	8	2	0	1	2	17	3,411	3.8%
University District	8	38	142	310	159	313	857	1,833	681	381	696	454	99	221	145	91	31	69	491	66	120	255	28	146	57	47	77	55	7,860	8.7%
Queen Anne	9	20	20	77	22	79	504	264	199	515	430	384	131	186	124	100	27	48	47	50	53	44	18	64	14	117	45	30	3,611	4.0%
Capitol Hill	10	40	29	203	91	143	748	496	503	407	1,563	1,379	442	1,376	302	187	93	122	69	146	105	109	66	32	17	40	26	130	8,865	9.8%
Seattle CBD	11	295	279	1,482	1,147	1,016	2,509	1,681	768	1,728	3,628	3,374	1,705	1,963	1,035	1,063	750	945	618	515	537	737	480	409	176	445	646	293	30,223	33.6%
W Seattle	12	0	1	4	1	8	28	18	10	44	115	148	575	129	130	93	10	9	1	4	2	3	0	0	0	0	2	18	1,354	1.5%
Rainier	13	19	20	96	40	98	299	149	227	215	798	696	357	1,118	375	484	256	364	33	64	43	76	28	59	16	27	112	81	6,151	6.8%
Sea-Tac	14	1	0	1	1	3	12	11	7	21	61	81	132	128	469	200	102	96	1	0	2	1	1	145	66	43	62	7	1,655	1.8%
Renton	15	1	1	5	3	4	25	13	10	30	80	109	68	273	281	510	99	335	7	10	27	74	11	15	2	4	37	9	2,042	2.3%
Federal Way	16	0	0	0	0	0	1	1	2	4	12	87	10	13	48	13	167	127	0	1	4	0	0	27	6	10	17	0	550	0.6%
Kent	17	2	2	0	0	1	9	5	9	15	35	130	9	73	138	199	173	802	0	2	7	8	1	69	13	13	193	3	1,910	2.1%
Kirkland	18	2	20	35	17	62	45	70	39	12	24	31	0	6	1	10	0	1	398	83	101	110	17	0	–	0	–	2	1,085	1.2%
Redmond	19	2	3	30	19	4	65	47	54	22	53	48	9	16	1	5	1	5	82	156	58	212	15	3	–	0	1	6	915	1.0%
West Bellevue	20	36	23	46	33	9	58	28	62	27	80	116	5	57	7	77	23	23	199	146	245	319	76	2	1	1	3	4	1,705	1.9%
Bellevue	21	1	5	7	3	5	59	43	49	28	106	136	8	60	17	138	7	25	145	246	187	555	43	2	1	3	0	5	1,885	2.1%
Issaquah	22	2	0	0	1	1	4	3	10	3	12	26	0	8	2	6	0	0	4	10	9	14	29	1	–	0	1	1	146	0.2%
North Tacoma	23	0	0	1	1	1	4	1	3	10	14	64	0	21	33	4	36	29	0	0	0	0	0	1,502	683	374	174	2	2,959	3.3%
South Tacoma	24	–	0	0	–	–	0	0	0	4	2	29	0	8	7	5	4	9	0	0	0	0	–	423	768	562	64	0	1,884	2.1%
Lakewood	25	0	0	0	0	–	0	0	0	1	1	10	0	3	8	0	3	3	0	0	0	0	0	278	326	513	61	0	1,206	1.3%
Puyallup	26	0	–	–	0	–	1	0	1	2	1	17	0	8	7	2	12	10	–	0	0	0	0	171	53	63	189	0	537	0.6%
External	27	7	9	21	11	11	18	18	10	20	42	48	15	39	12	14	1	7	6	4	3	4	2	3	1	1	0	18	346	0.4%
Destination Totals		1,877	2,056	3,748	2,273	2,479	6,860	6,178	3,388	4,130	8,395	8,203	3,685	5,971	3,210	3,331	1,807	3,091	2,377	1,535	1,571	2,607	832	3,357	2,198	2,267	1,720	892	90,039	100.0%
Destination Shares		2.1%	2.3%	4.2%	2.5%	2.8%	7.6%	6.9%	3.8%	4.6%	9.3%	9.1%	4.1%	6.6%	3.6%	3.7%	2.0%	3.4%	2.6%	1.7%	1.7%	2.9%	0.9%	3.7%	2.4%	2.5%	1.9%	1.0%	100.0%	

Table 4.2e
PM Peak Transit Trips – 2030 Stage 1 Forecasts

ORIGIN	DESTINATION	North Everett 1	South Everett 2	Lynnwood 3	North Creek 4	Shorelin 5	Ballard 6	North Seattle 7	University District 8	Queen Anne 9	Capitol Hill 10	Seattle CBD 11	W Seattle 12	Rainier 13	Sea-Tac 14	Renton 15	Federal Way 16	Kent 17	Kirkland 18	Redmond 19	West Bellevue 20	Bellevue 21	Issaquah 22	North Tacoma 23	South Tacoma 24	Lakewood 25	Puyallup 26	External 27	Origin Totals	Origin Shares
North Everett	1	1,088	421	114	244	11	9	6	4	12	5	36	0	3	1	–	–	0	1	–	–	–	0	0	–	0	–	43	1,997	1.6%
South Everett	2	611	677	414	283	24	16	58	17	12	11	45	0	2	1	79	3	53	20	1	5	13	7	0	0	0	0	109	2,461	2.0%
Lynnwood	3	215	591	1,170	317	128	43	190	33	17	17	54	1	7	0	0	0	0	66	13	13	15	0	0	0	0	–	89	2,981	2.4%
North Creek	4	227	299	194	262	18	17	97	21	11	32	56	0	7	0	1	0	0	31	4	4	0	0	0	0	4	0	4	1,289	1.0%
Shorelin	5	19	68	131	7	183	139	230	86	30	31	85	3	15	1	3	0	1	38	4	7	2	0	0	–	0	–	13	1,095	0.9%
Ballard	6	13	31	45	17	121	1,011	479	398	644	398	698	90	144	38	77	10	15	16	12	54	26	5	7	2	0	11	32	4,395	3.6%
North Seattle	7	16	144	259	244	389	673	1,024	724	356	292	592	43	167	36	33	3	12	188	12	59	47	10	2	0	2	2	25	5,358	4.4%
University District	8	51	187	448	270	369	1,143	2,494	1,098	610	939	961	136	341	186	133	41	96	616	96	201	300	33	205	93	65	116	86	11,313	9.2%
Queen Anne	9	29	29	113	40	96	625	357	302	727	566	746	169	275	158	157	36	66	64	78	79	51	23	93	22	195	72	43	5,211	4.2%
Capitol Hill	10	45	32	237	141	146	783	530	710	658	1,711	2,364	476	1,722	328	239	100	121	74	175	130	103	65	34	20	42	32	167	11,183	9.1%
Seattle CBD	11	362	341	1,912	1,780	1,061	2,743	1,978	1,019	2,667	4,163	5,797	1,909	2,495	1,152	1,375	838	1,078	714	676	609	743	535	534	235	525	866	388	38,498	31.3%
W Seattle	12	0	1	5	2	9	33	23	15	87	141	277	689	178	152	147	12	9	1	6	5	3	0	1	0	0	2	25	1,825	1.5%
Rainier	13	22	21	116	62	102	319	167	344	357	879	1,175	386	1,326	396	632	292	440	38	87	47	78	30	81	20	33	163	106	7,717	6.3%
Sea-Tac	14	2	0	1	2	3	16	15	12	46	79	165	171	182	587	336	140	125	1	1	4	1	1	198	113	61	93	11	2,366	1.9%
Renton	15	1	2	8	7	6	40	21	20	76	124	248	106	460	433	867	156	544	10	18	63	100	14	36	3	5	65	17	3,451	2.8%
Federal Way	16	0	0	1	0	0	1	1	3	7	13	127	13	15	56	19	203	157	0	1	6	0	0	47	10	14	26	0	719	0.6%
Kent	17	3	2	1	0	2	9	5	17	33	44	233	10	100	171	277	220	1,088	0	3	19	8	1	103	17	17	268	4	2,656	2.2%
Kirkland	18	2	28	51	28	74	57	88	78	29	29	62	1	9	2	14	0	1	522	125	181	128	23	0	–	0	–	2	1,532	1.2%
Redmond	19	2	4	52	30	4	76	55	95	41	60	86	9	20	1	6	1	7	102	213	86	226	19	4	–	0	1	8	1,205	1.0%
West Bellevue	20	76	44	124	85	16	94	49	123	73	126	252	8	84	12	155	42	43	327	271	426	466	132	5	2	1	5	7	3,050	2.5%
Bellevue	21	1	7	9	6	6	71	57	91	66	132	267	9	82	20	178	8	29	179	335	305	603	45	3	1	3	0	6	2,520	2.0%
Issaquah	22	4	0	0	1	1	5	3	22	6	15	52	0	11	3	7	0	1	6	19	19	15	35	2	–	0	1	1	228	0.2%
North Tacoma	23	0	0	1	3	1	4	1	5	18	18	117	0	25	41	6	44	39	0	1	0	0	0	2,054	1,013	431	244	3	4,070	3.3%
South Tacoma	24	–	0	0	–	–	0	0	1	9	3	65	0	10	9	8	5	12	0	0	0	0	–	719	1,216	798	93	0	2,950	2.4%
Lakewood	25	0	0	0	0	–	0	0	1	2	1	18	0	4	10	1	3	3	0	0	0	0	0	411	501	679	79	0	1,714	1.4%
Puyallup	26	0	–	–	0	–	1	0	1	4	1	31	0	13	9	3	15	11	–	0	0	0	0	312	79	79	283	0	844	0.7%
External	27	7	9	24	15	11	20	21	16	36	49	86	17	48	13	20	1	8	7	5	5	4	2	5	1	2	0	23	454	0.4%
Destination Totals		2,795	2,939	5,429	3,847	2,780	7,948	7,949	5,258	6,635	9,881	14,695	4,245	7,744	3,816	4,774	2,171	3,958	3,020	2,155	2,327	2,935	981	4,855	3,349	2,958	2,424	1,211	123,081	100.0%
Destination Shares		2.3%	2.4%	4.4%	3.1%	2.3%	6.5%	6.5%	4.3%	5.4%	8.0%	11.9%	3.4%	6.3%	3.1%	3.9%	1.8%	3.2%	2.5%	1.8%	1.9%	2.4%	0.8%	3.9%	2.7%	2.4%	2.0%	1.0%	100.0%	

Table 4.2f
PM Peak Transit Trips – 2030 Stage 2 Forecasts

ORIGIN \ DESTINATION		North Everett 1	South Everett 2	Lynnwood 3	North Creek 4	Shorelin 5	Ballard 6	North Seattle 7	University District 8	Queen Anne 9	Capitol Hill 10	Seattle CBD 11	W Seattle 12	Rainier 13	Sea-Tac 14	Renton 15	Federal Way 16	Kent 17	Kirkland 18	Redmond 19	West Bellevue 20	Bellevue 21	Issaquah 22	North Tacoma 23	South Tacoma 24	Lakewood 25	Puyallup 26	External 27	**Origin Totals**	**Origin Shares**
North Everett	1	1,423	433	126	366	12	10	6	3	14	5	30	0	3	1	–	–	0	1	–	–	–	0	0	–	0	–	87	2,520	1.7%
South Everett	2	921	711	466	410	27	18	70	12	12	10	38	1	2	1	120	4	96	22	1	6	16	15	0	0	0	0	261	3,243	2.1%
Lynnwood	3	353	877	1,286	467	132	49	192	27	18	20	51	1	9	0	1	0	0	75	15	12	15	0	0	0	0	–	166	3,764	2.5%
North Creek	4	238	310	197	277	19	18	101	14	11	38	44	0	8	0	1	0	0	34	4	4	0	0	0	0	4	0	8	1,331	0.9%
Shorelin	5	33	117	146	10	186	140	230	86	31	34	82	3	17	1	3	0	2	45	4	7	3	0	0	–	0	–	22	1,203	0.8%
Ballard	6	18	65	70	34	162	1,041	532	413	656	412	675	106	150	48	91	17	23	26	19	82	38	9	14	3	1	18	48	4,773	3.1%
North Seattle	7	31	289	368	417	491	725	1,092	723	387	331	609	56	191	48	41	5	22	314	20	79	80	18	5	0	2	3	41	6,389	4.2%
University District	8	113	410	790	595	530	1,502	3,162	1,223	709	1,154	1,124	182	415	243	194	79	160	1,169	178	341	455	58	556	224	132	257	119	16,074	10.6%
Queen Anne	9	50	55	201	82	147	750	463	325	751	591	762	198	280	201	199	58	106	118	124	114	72	39	171	33	266	134	59	6,349	4.2%
Capitol Hill	10	82	62	413	315	231	1,043	722	783	715	1,881	2,522	562	1,796	404	294	172	192	114	295	185	147	115	72	33	72	63	225	13,511	8.9%
Seattle CBD	11	637	498	2,712	2,902	1,444	3,488	2,464	1,119	2,950	4,659	6,372	2,290	2,554	1,344	1,684	1,280	1,592	1,117	989	845	958	886	989	364	741	1,507	490	48,873	32.2%
W Seattle	12	0	1	9	4	13	39	28	14	83	131	277	673	164	150	149	19	12	2	9	5	4	0	1	0	1	4	39	1,832	1.2%
Rainier	13	39	33	201	117	159	375	212	360	362	866	1,111	406	1,290	432	704	572	666	65	139	67	109	49	172	36	51	310	147	9,049	6.0%
Sea-Tac	14	3	0	3	3	4	23	21	13	52	84	169	174	179	605	386	257	170	1	2	8	2	1	530	284	126	220	17	3,337	2.2%
Renton	15	2	3	13	14	11	58	31	23	86	139	265	122	520	509	1,052	304	886	18	27	87	131	21	99	6	8	125	26	4,587	3.0%
Federal Way	16	0	0	1	0	0	1	1	2	7	15	112	13	15	62	20	249	188	0	1	9	0	0	73	20	26	47	0	862	0.6%
Kent	17	4	4	1	0	3	11	7	13	32	40	169	10	95	171	300	272	1,228	1	4	27	11	2	147	30	36	476	6	3,098	2.0%
Kirkland	18	5	46	71	42	80	70	98	71	35	37	68	1	11	2	20	0	2	575	136	189	132	27	0	–	0	–	4	1,721	1.1%
Redmond	19	4	6	85	56	6	139	80	132	62	86	109	14	27	1	9	1	11	122	240	99	240	23	8	–	0	1	12	1,573	1.0%
West Bellevue	20	134	81	232	167	29	176	91	204	110	185	319	14	117	17	245	71	73	460	335	498	502	186	9	3	2	9	14	4,285	2.8%
Bellevue	21	1	14	14	10	10	123	99	134	90	192	330	17	114	27	245	14	49	232	372	326	613	55	5	2	5	0	10	3,101	2.0%
Issaquah	22	6	1	0	2	1	7	4	22	7	17	45	0	12	4	8	0	1	7	20	18	14	36	2	–	0	1	1	239	0.2%
North Tacoma	23	0	0	1	5	1	5	1	4	19	19	90	0	30	44	6	49	41	0	1	1	1	0	2,081	1,014	415	265	4	4,098	2.7%
South Tacoma	24	–	0	0	–	–	0	0	1	8	3	41	0	10	9	8	6	13	0	0	0	0	–	670	1,166	752	90	0	2,776	1.8%
Lakewood	25	0	0	0	0	–	0	0	0	2	1	10	0	4	9	1	3	4	0	0	0	0	0	389	497	689	78	0	1,687	1.1%
Puyallup	26	0	–	–	0	–	1	0	1	3	1	19	0	13	8	3	16	11	–	0	0	0	0	353	78	73	304	0	885	0.6%
External	27	12	18	42	25	20	30	35	15	44	56	73	21	61	13	23	1	8	13	10	7	7	3	4	1	2	0	21	565	0.4%
Destination Totals		4,110	4,035	7,448	6,320	3,718	9,844	9,744	5,734	7,258	11,006	15,513	4,862	8,086	4,354	5,806	3,451	5,555	4,531	2,944	3,019	3,550	1,546	6,351	3,795	3,406	3,912	1,827	151,725	100.0%
Destination Shares		2.7%	2.7%	4.9%	4.2%	2.5%	6.5%	6.4%	3.8%	4.8%	7.3%	10.2%	3.2%	5.3%	2.9%	3.8%	2.3%	3.7%	3.0%	1.9%	2.0%	2.3%	1.0%	4.2%	2.5%	2.2%	2.6%	1.2%	100.0%	

Table 4.2g
PM Peak Transit Trips – 2030 Stage 3 Forecasts Baseline

ORIGIN / DESTINATION		North Everett 1	South Everett 2	Lynnwood 3	North Creek 4	Shorelin 5	Ballard 6	North Seattle 7	University District 8	Queen Anne 9	Capitol Hill 10	Seattle CBD 11	W Seattle 12	Rainier 13	Sea-Tac 14	Renton 15	Federal Way 16	Kent 17	Kirkland 18	Redmond 19	West Bellevue 20	Bellevue 21	Issaquah 22	North Tacoma 23	South Tacoma 24	Lakewood 25	Puyallup 26	External 27	**Origin Totals**	**Origin Shares**
North Everett	1	1,187	349	99	233	8	9	5	2	12	5	27	0	3	1	–	–	–	0	–	–	–	0	0	–	0	–	77	2,018	1.4%
South Everett	2	645	688	430	291	21	18	61	13	12	11	37	1	2	1	57	2	45	15	1	3	8	6	0	0	0	0	262	2,630	1.8%
Lynnwood	3	348	772	1,117	376	110	54	202	32	20	23	55	1	12	1	0	0	0	54	8	8	8	0	0	0	0	–	147	3,348	2.4%
North Creek	4	172	233	178	257	15	19	86	12	12	33	44	0	8	0	1	0	0	23	1	3	0	0	0	0	2	0	6	1,106	0.8%
Shorelin	5	32	84	128	7	187	130	234	87	29	32	78	3	18	1	2	0	1	36	2	6	2	0	0	–	0	–	19	1,119	0.8%
Ballard	6	14	43	55	23	137	1,022	471	395	614	399	633	92	153	43	71	12	16	18	16	70	30	6	8	2	0	12	45	4,400	3.1%
North Seattle	7	20	181	299	262	465	669	1,059	716	362	333	611	54	252	55	40	3	17	247	14	58	56	9	3	0	2	2	39	5,829	4.1%
University District	8	124	387	731	445	512	1,439	3,196	1,302	775	1,203	1,248	239	609	291	227	68	175	914	134	323	417	57	520	291	144	285	142	16,200	11.4%
Queen Anne	9	32	42	157	58	121	701	431	399	743	584	749	186	328	177	154	37	85	75	95	107	53	26	96	29	165	93	58	5,783	4.1%
Capitol Hill	10	65	57	364	236	196	978	730	932	707	1,869	2,567	622	2,016	396	268	136	158	85	258	183	123	82	57	32	51	41	230	13,440	9.5%
Seattle CBD	11	453	457	2,439	2,329	1,298	3,272	2,336	1,238	2,920	4,804	6,350	2,265	2,923	1,230	1,422	1,029	1,272	813	800	772	785	621	804	338	558	1,032	493	45,055	31.7%
W Seattle	12	0	1	7	2	11	36	28	17	82	135	276	686	199	150	125	17	10	1	6	6	3	0	1	0	0	3	40	1,842	1.3%
Rainier	13	35	31	188	94	147	400	234	482	420	986	1,259	431	1,434	603	762	483	536	47	114	65	90	34	113	29	36	224	155	9,432	6.6%
Sea-Tac	14	4	1	4	2	5	34	31	25	75	136	200	173	292	674	351	215	157	2	2	10	2	1	503	339	100	111	21	3,465	2.4%
Renton	15	2	2	9	9	9	51	28	30	86	162	249	98	567	429	972	216	692	14	26	86	109	15	85	5	5	73	23	4,052	2.9%
Federal Way	16	0	0	1	0	0	1	1	4	9	26	127	12	19	72	23	266	163	0	2	11	0	0	59	16	23	27	0	863	0.6%
Kent	17	3	4	1	0	2	14	8	21	33	50	176	10	106	213	267	213	1,091	0	4	28	8	1	111	42	36	325	6	2,773	2.0%
Kirkland	18	3	27	55	28	75	65	96	110	32	37	69	1	12	2	14	0	1	526	127	172	135	18	0	–	0	–	3	1,611	1.1%
Redmond	19	2	3	57	38	5	121	69	134	57	83	103	12	30	1	11	1	8	124	247	111	245	16	5	–	0	1	11	1,493	1.1%
West Bellevue	20	88	42	161	96	20	157	84	204	102	189	303	12	113	13	189	35	41	383	286	477	451	124	6	2	2	4	16	3,599	2.5%
Bellevue	21	1	8	10	7	7	106	73	130	84	185	303	14	113	21	205	8	30	198	352	326	603	35	3	1	3	0	10	2,836	2.0%
Issaquah	22	17	1	0	3	1	17	6	26	10	22	52	0	26	2	8	0	1	11	21	22	17	50	2	–	0	1	2	317	0.2%
North Tacoma	23	0	0	1	2	1	4	1	5	17	22	75	0	28	54	7	44	47	0	0	1	0	0	1,874	884	334	194	3	3,600	2.5%
South Tacoma	24	–	0	0	–	–	0	0	1	8	4	39	0	9	12	13	5	16	0	0	0	0	–	582	1,114	601	65	0	2,470	1.7%
Lakewood	25	0	0	0	0	–	0	0	1	2	1	11	0	4	9	1	3	4	0	0	0	0	0	343	471	585	52	0	1,485	1.0%
Puyallup	26	0	–	–	0	–	2	0	2	7	3	40	0	15	11	4	13	15	–	0	0	0	0	352	80	64	278	0	891	0.6%
External	27	12	18	34	16	17	28	32	20	43	56	72	21	61	12	18	1	7	8	7	7	6	2	2	0	1	0	22	520	0.4%
Destination Totals		3,258	3,432	6,528	4,814	3,368	9,347	9,502	6,341	7,275	11,393	15,751	4,934	9,354	4,474	5,213	2,807	4,587	3,595	2,522	2,854	3,152	1,105	5,528	3,677	2,714	2,823	1,829	142,179	100.0%
Destination Shares		2.3%	2.4%	4.6%	3.4%	2.4%	6.6%	6.7%	4.5%	5.1%	8.0%	11.1%	3.5%	6.6%	3.1%	3.7%	2.0%	3.2%	2.5%	1.8%	2.0%	2.2%	0.8%	3.9%	2.6%	1.9%	2.0%	1.3%	100.0%	

Table 4.2h
Daily Transit Trips – Base Year 2004

ORIGIN / DESTINATION		North Everett 1	South Everett 2	Lynnwood 3	North Creek 4	Shorelin 5	Ballard 6	North Seattle 7	University District 8	Queen Anne 9	Capitol Hill 10	Seattle CBD 11	W Seattle 12	Rainier 13	Sea-Tac 14	Renton 15	Federal Way 16	Kent 17	Kirkland 18	Redmond 19	West Bellevue 20	Bellevue 21	Issaquah 22	North Tacoma 23	South Tacoma 24	Lakewood 25	Puyallup 26	External 27	**Origin Totals**	**Origin Shares**
North Everett	1	2,229	1,271	294	412	45	25	21	59	26	53	324	1	27	6	1	0	2	6	2	36	1	2	1	–	0	0	75	4,918	1.5%
South Everett	2	1,271	1,421	811	514	125	65	166	265	39	74	373	1	35	2	63	3	41	44	5	30	17	6	1	0	0	0	124	5,496	1.7%
Lynnwood	3	294	811	2,119	387	349	148	581	628	115	278	1,613	8	146	2	6	1	1	114	46	59	21	1	1	0	0	–	94	7,825	2.4%
North Creek	4	412	514	387	432	58	52	207	350	40	135	1,263	2	55	3	5	0	0	54	27	39	6	1	1	0	3	0	16	4,060	1.3%
Shorelin	5	45	125	349	58	682	454	867	607	204	295	1,286	46	164	11	12	0	5	217	14	20	16	2	1	–	0	–	33	5,512	1.7%
Ballard	6	25	65	148	52	454	3,643	1,689	2,384	1,664	2,071	4,555	385	915	142	193	32	38	131	133	183	150	64	15	2	1	11	76	19,223	5.9%
North Seattle	7	21	166	581	207	867	1,689	2,455	3,645	911	1,256	3,024	251	618	127	103	5	22	297	106	134	131	19	5	0	6	2	58	16,706	5.1%
University District	8	59	265	628	350	607	2,384	3,645	2,759	1,097	1,999	1,993	260	791	189	167	46	102	791	185	264	428	51	166	59	50	80	174	19,589	6.0%
Queen Anne	9	26	39	115	40	204	1,664	911	1,097	2,654	1,872	3,546	472	885	248	244	39	96	90	110	135	132	32	96	24	126	49	83	15,030	4.6%
Capitol Hill	10	53	74	278	135	295	2,071	1,256	1,999	1,872	6,895	10,737	1,334	3,809	605	522	143	217	161	273	295	308	117	92	30	56	32	345	34,002	10.5%
Seattle CBD	11	324	373	1,613	1,263	1,286	4,555	3,024	1,993	3,546	10,737	24,569	3,423	5,926	1,728	1,722	998	1,342	857	728	1,017	1,178	628	645	283	521	727	474	75,478	23.2%
W Seattle	12	1	1	8	2	46	385	251	260	472	1,334	3,423	2,353	944	572	245	27	39	7	24	14	17	7	2	1	1	2	52	10,489	3.2%
Rainier	13	27	35	146	55	164	915	618	791	885	3,809	5,926	944	4,298	835	1,362	362	735	72	119	127	167	64	146	43	58	132	178	23,014	7.1%
Sea-Tac	14	6	2	2	3	11	142	127	189	248	605	1,728	572	835	2,356	796	370	405	7	3	18	26	7	294	126	90	86	33	9,086	2.8%
Renton	15	1	63	6	5	12	193	103	167	244	522	1,722	245	1,362	796	2,106	183	851	31	27	182	299	27	53	12	21	48	32	9,312	2.9%
Federal Way	16	0	3	1	0	0	32	5	46	39	143	998	27	362	370	183	522	419	0	1	27	7	0	109	19	17	50	1	3,385	1.0%
Kent	17	2	41	1	0	5	38	22	102	96	217	1,342	39	735	405	851	419	2,890	2	8	39	38	4	145	38	36	233	12	7,760	2.4%
Kirkland	18	6	44	114	54	217	131	297	791	90	161	857	7	72	7	31	0	2	1,202	274	479	416	30	2	0	0	–	11	5,296	1.6%
Redmond	19	2	5	46	27	14	133	106	185	110	273	728	24	119	3	27	1	8	274	500	313	812	39	8	0	0	1	14	3,770	1.2%
West Bellevue	20	36	30	59	39	20	183	134	264	135	295	1,017	14	127	18	182	27	39	479	313	763	835	110	3	1	1	3	9	5,135	1.6%
Bellevue	21	1	17	21	6	16	150	131	428	132	308	1,178	17	167	26	299	7	38	416	812	835	1,945	93	3	1	3	0	12	7,063	2.2%
Issaquah	22	2	6	1	1	2	64	19	51	32	117	628	7	64	7	27	0	4	30	39	110	93	82	2	–	1	1	4	1,396	0.4%
North Tacoma	23	1	1	1	1	1	15	5	166	96	92	645	2	146	294	53	109	145	2	8	3	3	2	7,305	2,131	1,094	506	7	12,832	4.0%
South Tacoma	24	–	0	0	0	–	2	0	59	24	30	283	1	43	126	12	19	38	0	0	1	1	–	2,131	2,772	1,642	219	1	7,404	2.3%
Lakewood	25	0	0	0	3	0	1	6	50	126	56	521	1	58	90	21	17	36	0	0	1	3	1	1,094	1,642	1,931	191	2	5,849	1.8%
Puyallup	26	0	0	–	0	–	11	2	80	49	32	727	2	132	86	48	50	233	–	1	3	0	1	506	219	191	721	0	3,096	1.0%
External	27	75	124	94	16	33	76	58	174	83	345	474	52	178	33	32	1	12	11	14	9	12	4	7	1	2	0	43	1,966	0.6%
Destination Totals		4,918	5,496	7,825	4,060	5,512	19,223	16,706	19,589	15,030	34,002	75,478	10,489	23,014	9,086	9,312	3,385	7,760	5,296	3,770	5,135	7,063	1,396	12,832	7,404	5,849	3,096	1,966	324,692	100.0%
Destination Shares		1.5%	1.7%	2.4%	1.3%	1.7%	5.9%	5.1%	6.0%	4.6%	10.5%	23.2%	3.2%	7.1%	2.8%	2.9%	1.0%	2.4%	1.6%	1.2%	1.6%	2.2%	0.4%	4.0%	2.3%	1.8%	1.0%	0.6%	100.0%	

Table 4.2i
Daily Transit Trips – 2030 Stage 1 Forecasts

ORIGIN \ DESTINATION		North Everett 1	South Everett 2	Lynnwood 3	North Creek 4	Shorelin 5	Ballard 6	North Seattle 7	University District 8	Queen Anne 9	Capitol Hill 10	Seattle CBD 11	W Seattle 12	Rainier 13	Sea-Tac 14	Renton 15	Federal Way 16	Kent 17	Kirkland 18	Redmond 19	West Bellevue 20	Bellevue 21	Issaquah 22	North Tacoma 23	South Tacoma 24	Lakewood 25	Puyallup 26	External 27	**Origin Totals**	**Origin Shares**
North Everett	1	3,550	1,899	489	707	59	33	36	83	45	63	419	1	34	9	2	0	3	9	2	78	1	4	1	–	0	0	99	7,623	1.7%
South Everett	2	1,899	2,031	1,287	835	153	77	273	372	66	89	491	2	44	3	82	4	57	59	6	57	21	8	1	0	0	0	149	8,065	1.8%
Lynnwood	3	489	1,287	3,583	752	448	188	932	952	180	343	2,141	10	189	3	10	1	1	168	76	158	30	2	1	0	1	–	136	12,079	2.7%
North Creek	4	707	835	752	798	87	76	388	597	81	205	1,990	3	84	6	10	0	0	79	42	100	9	2	3	0	4	0	22	6,879	1.6%
Shorelin	5	59	153	448	87	745	481	1,141	767	271	318	1,424	54	180	13	18	0	5	257	17	36	17	2	1	–	0	–	37	6,530	1.5%
Ballard	6	33	77	188	76	481	3,995	2,211	3,096	2,259	2,267	5,490	450	1,032	176	293	38	41	153	155	292	166	73	20	3	2	15	95	23,176	5.2%
North Seattle	7	36	273	932	388	1,141	2,211	3,693	5,300	1,406	1,539	3,967	324	787	173	162	7	27	396	133	250	170	24	8	1	9	3	78	23,437	5.3%
University District	8	83	372	952	597	767	3,096	5,300	4,268	1,662	2,699	3,099	358	1,136	250	256	60	144	1,037	278	452	551	72	236	97	69	121	272	28,284	6.4%
Queen Anne	9	45	66	180	81	271	2,259	1,406	1,662	3,769	2,708	5,462	696	1,344	364	427	56	152	144	177	253	207	48	150	43	210	81	131	22,392	5.1%
Capitol Hill	10	63	89	343	205	318	2,267	1,539	2,699	2,708	7,765	13,808	1,532	4,533	698	742	155	239	181	320	411	339	129	110	40	60	37	442	41,772	9.5%
Seattle CBD	11	419	491	2,141	1,990	1,424	5,490	3,967	3,099	5,462	13,808	34,985	4,218	7,940	2,163	2,475	1,172	1,672	1,053	994	1,437	1,420	750	895	419	630	992	666	102,170	23.1%
W Seattle	12	1	2	10	3	54	450	324	358	696	1,532	4,218	2,799	1,132	699	387	33	44	9	28	23	20	16	3	2	1	3	69	12,913	2.9%
Rainier	13	34	44	189	84	180	1,032	787	1,136	1,344	4,533	7,940	1,132	5,236	992	1,964	411	910	90	155	174	200	78	195	56	73	194	232	29,397	6.7%
Sea-Tac	14	9	3	3	6	13	176	173	250	364	698	2,163	699	992	2,979	1,272	486	516	10	5	32	31	10	413	202	128	128	44	11,804	2.7%
Renton	15	2	82	10	10	18	293	162	256	427	742	2,475	387	1,964	1,272	3,667	288	1,343	47	42	367	412	37	101	21	34	83	52	14,594	3.3%
Federal Way	16	0	4	1	0	0	38	7	60	56	155	1,172	33	411	486	288	637	526	0	2	48	8	0	157	31	22	76	1	4,219	1.0%
Kent	17	3	57	1	0	5	41	27	144	152	239	1,672	44	910	516	1,343	526	3,925	2	10	79	43	5	197	50	46	323	15	10,375	2.3%
Kirkland	18	9	59	168	79	257	153	396	1,037	144	181	1,053	9	90	10	47	0	2	1,584	378	796	511	40	2	0	0	–	14	7,019	1.6%
Redmond	19	2	6	76	42	17	155	133	278	177	320	994	28	155	5	42	2	10	378	687	538	991	57	11	0	0	1	18	5,124	1.2%
West Bellevue	20	78	57	158	100	36	292	250	452	253	411	1,437	23	174	32	367	48	79	796	538	1,350	1,295	202	6	2	2	5	15	8,458	1.9%
Bellevue	21	1	21	30	9	17	166	170	551	207	339	1,420	20	200	31	412	8	43	511	991	1,295	2,166	102	5	2	4	1	14	8,738	2.0%
Issaquah	22	4	8	2	2	2	73	24	72	48	129	750	16	78	10	37	0	5	40	57	202	102	106	3	–	1	1	5	1,773	0.4%
North Tacoma	23	1	1	1	3	1	20	8	236	150	110	895	3	195	413	101	157	197	2	11	6	5	3	10,105	3,359	1,438	801	10	18,230	4.1%
South Tacoma	24	–	0	0	0	–	3	1	97	43	40	419	2	56	202	21	31	50	0	0	2	2	–	3,359	4,412	2,387	327	1	11,454	2.6%
Lakewood	25	0	0	1	4	0	2	9	69	210	60	630	1	73	128	34	22	46	0	0	2	4	1	1,438	2,387	2,550	248	3	7,923	1.8%
Puyallup	26	0	0	–	0	–	15	3	121	81	37	992	3	194	128	83	76	323	–	1	5	1	1	801	327	248	1,118	1	4,559	1.0%
External	27	99	149	136	22	37	95	78	272	131	442	666	69	232	44	52	1	15	14	18	15	14	5	10	1	3	1	56	2,676	0.6%
Destination Totals		7,623	8,065	12,079	6,879	6,530	23,176	23,437	28,284	22,392	41,772	102,170	12,913	29,397	11,804	14,594	4,219	10,375	7,019	5,124	8,458	8,738	1,773	18,230	11,454	7,923	4,559	2,676	441,662	100.0%
Destination Shares		1.7%	1.8%	2.7%	1.6%	1.5%	5.2%	5.3%	6.4%	5.1%	9.5%	23.1%	2.9%	6.7%	2.7%	3.3%	1.0%	2.3%	1.6%	1.2%	1.9%	2.0%	0.4%	4.1%	2.6%	1.8%	1.0%	0.6%	100.0%	

Table 4.2j
Daily Transit Trips – 2030 Stage 2 Forecasts

ORIGIN	DESTINATION	North Everett 1	South Everett 2	Lynnwood 3	North Creek 4	Shorelin 5	Ballard 6	North Seattle 7	University District 8	Queen Anne 9	Capitol Hill 10	Seattle CBD 11	W Seattle 12	Rainier 13	Sea-Tac 14	Renton 15	Federal Way 16	Kent 17	Kirkland 18	Redmond 19	West Bellevue 20	Bellevue 21	Issaquah 22	North Tacoma 23	South Tacoma 24	Lakewood 25	Puyallup 26	Puyallup 27	**Origin Totals**	**Origin Shares**
North Everett	1	4,152	2,249	659	841	81	43	57	146	70	104	697	2	58	16	3	1	5	12	4	137	1	7	1	–	1	0	192	9,536	1.9%
South Everett	2	2,249	2,103	1,662	999	216	122	451	613	99	129	645	3	68	4	124	7	103	81	9	97	31	16	3	0	0	0	350	10,182	2.0%
Lynnwood	3	659	1,662	3,823	925	466	228	1,093	1,298	277	540	2,962	15	291	5	15	2	2	201	112	267	35	2	2	0	1	–	253	15,134	3.0%
North Creek	4	841	999	925	827	98	110	575	1,007	135	398	3,143	4	147	10	17	0	0	99	71	185	14	3	5	0	4	0	37	9,654	1.9%
Shorelin	5	81	216	466	98	739	531	1,246	920	336	422	1,815	67	248	17	26	0	8	277	20	51	22	2	2	–	0	–	64	7,672	1.5%
Ballard	6	43	122	228	110	531	4,029	2,334	3,424	2,431	2,582	6,237	491	1,114	206	345	55	56	194	247	441	250	99	31	4	2	23	145	25,773	5.1%
North Seattle	7	57	451	1,093	575	1,246	2,334	3,828	5,903	1,589	1,824	4,500	370	892	204	199	11	41	551	179	360	266	38	13	1	12	4	130	26,672	5.3%
University District	8	146	613	1,298	1,007	920	3,424	5,903	4,394	1,780	3,013	3,357	400	1,221	305	315	103	203	1,617	416	703	774	97	593	228	137	263	344	33,574	6.7%
Queen Anne	9	70	99	277	135	336	2,431	1,589	1,780	3,761	2,774	5,744	720	1,331	415	486	81	195	218	261	347	270	68	243	57	284	144	179	24,293	4.8%
Capitol Hill	10	104	129	540	398	422	2,582	1,824	3,013	2,774	8,078	14,468	1,581	4,532	773	810	231	309	246	485	544	460	189	166	59	98	69	588	45,471	9.1%
Seattle CBD	11	697	645	2,962	3,143	1,815	6,237	4,500	3,357	5,744	14,468	35,060	4,565	7,790	2,325	2,778	1,599	2,117	1,502	1,356	1,793	1,741	1,109	1,386	541	848	1,630	816	112,525	22.4%
W Seattle	12	2	3	15	4	67	491	370	400	720	1,581	4,565	2,715	1,102	680	403	43	47	12	40	32	30	19	3	2	1	4	100	13,449	2.7%
Rainier	13	58	68	291	147	248	1,114	892	1,221	1,331	4,532	7,790	1,102	5,033	1,004	2,060	703	1,144	131	227	234	270	102	321	79	107	344	322	30,877	6.2%
Sea-Tac	14	16	4	5	10	17	206	204	305	415	773	2,325	680	1,004	2,956	1,403	646	564	15	7	46	41	13	842	395	211	262	58	13,424	2.7%
Renton	15	3	124	15	17	26	345	199	315	486	810	2,778	403	2,060	1,403	4,103	452	1,734	69	60	520	545	45	180	27	45	146	72	16,982	3.4%
Federal Way	16	1	7	2	0	0	55	11	103	81	231	1,599	43	703	646	452	747	614	0	3	81	15	0	194	44	34	103	1	5,772	1.2%
Kent	17	5	103	2	0	8	56	41	203	195	309	2,117	47	1,144	564	1,734	614	4,216	4	16	124	68	6	245	69	69	541	18	12,517	2.5%
Kirkland	18	12	81	201	99	277	194	551	1,617	218	246	1,502	12	131	15	69	0	4	1,692	412	950	571	47	5	0	1	–	26	8,929	1.8%
Redmond	19	4	9	112	71	20	247	179	416	261	485	1,356	40	227	7	60	3	16	412	747	619	1,043	62	25	0	1	1	32	6,455	1.3%
West Bellevue	20	137	97	267	185	51	441	360	703	347	544	1,793	32	234	46	520	81	124	950	619	1,502	1,354	254	11	3	3	9	27	10,694	2.1%
Bellevue	21	1	31	35	14	22	250	266	774	270	460	1,741	30	270	41	545	15	68	571	1,043	1,354	2,170	110	7	2	6	1	24	10,121	2.0%
Issaquah	22	7	16	2	3	2	99	38	97	68	189	1,109	19	102	13	45	0	6	47	62	254	110	108	4	–	1	2	9	2,412	0.5%
North Tacoma	23	1	3	2	5	2	31	13	593	243	166	1,386	3	321	842	180	194	245	5	25	11	7	4	10,099	3,188	1,349	836	11	19,764	3.9%
South Tacoma	24	–	0	0	0	–	4	1	228	57	59	541	2	79	395	27	44	69	0	0	3	2	–	3,188	4,183	2,250	311	1	11,445	2.3%
Lakewood	25	1	0	1	4	0	2	12	137	284	98	848	1	107	211	45	34	69	1	1	3	6	1	1,349	2,250	2,502	233	3	8,202	1.6%
Puyallup	26	0	0	–	0	–	23	4	263	144	69	1,630	4	344	262	146	103	541	–	1	9	1	2	836	311	233	1,147	1	6,074	1.2%
Puyallup	27	192	350	253	37	64	145	130	344	179	588	816	100	322	58	72	1	18	26	32	27	24	9	11	1	3	1	52	3,854	0.8%
Destination Totals		9,536	10,182	15,134	9,654	7,672	25,773	26,672	33,574	24,293	45,471	112,525	13,449	30,877	13,424	16,982	5,772	12,517	8,929	6,455	10,694	10,121	2,412	19,764	11,445	8,202	6,074	3,854	501,455	100.0%
Destination Shares		1.9%	2.0%	3.0%	1.9%	1.5%	5.1%	5.3%	6.7%	4.8%	9.1%	22.4%	2.7%	6.2%	2.7%	3.4%	1.2%	2.5%	1.8%	1.3%	2.1%	2.0%	0.5%	3.9%	2.3%	1.6%	1.2%	0.8%	100.0%	

Table 4.2k
Daily Transit Trips – 2030 Stage 3 Forecasts Baseline

DESTINATION		North Everett	South Everett	Lynnwood	North Creek	Shorelin	Ballard	North Seattle	University District	Queen Anne	Capitol Hill	Seattle CBD	W Seattle	Rainier	Sea-Tac	Renton	Federal Way	Kent	Kirkland	Redmond	West Bellevue	Bellevue	Issaquah	North Tacoma	South Tacoma	Lakewood	Puyallup	External	**Origin Totals**	**Origin Shares**
ORIGIN		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27		
North Everett	1	3,620	1,772	624	608	71	41	42	158	50	88	509	2	53	20	2	1	3	7	2	90	1	17	1	–	0	0	170	7,954	1.6%
South Everett	2	1,772	2,032	1,521	757	171	98	327	597	94	132	617	3	69	7	59	9	51	51	5	52	16	8	2	0	0	0	348	8,796	1.8%
Lynnwood	3	624	1,521	3,430	810	418	216	1,038	1,227	233	496	2,696	14	294	8	11	2	1	153	74	186	23	2	1	0	1	–	223	13,702	2.8%
North Creek	4	608	757	810	774	88	115	407	838	125	312	2,619	2	133	9	12	0	0	70	48	109	11	3	3	0	2	0	25	7,880	1.6%
Shorelin	5	71	171	418	88	735	479	1,199	883	291	375	1,638	52	236	20	20	0	5	254	15	36	16	1	1	–	0	–	56	7,063	1.4%
Ballard	6	41	98	216	115	479	4,021	2,152	3,336	2,267	2,517	5,901	457	1,222	265	321	52	46	162	211	391	209	106	22	3	2	16	136	24,765	5.1%
North Seattle	7	42	327	1,038	407	1,199	2,152	3,770	6,014	1,549	1,866	4,381	403	1,079	262	196	10	38	457	148	361	205	29	10	1	16	3	126	26,091	5.3%
University District	8	158	597	1,227	838	883	3,336	6,014	4,638	2,027	3,333	3,744	564	1,682	421	395	105	237	1,352	369	684	703	101	569	299	154	295	393	35,120	7.2%
Queen Anne	9	50	94	233	125	291	2,267	1,549	2,027	3,721	2,833	5,670	710	1,579	434	418	62	162	165	215	319	232	57	157	52	185	105	173	23,886	4.9%
Capitol Hill	10	88	132	496	312	375	2,517	1,866	3,333	2,833	8,140	14,891	1,748	5,193	917	873	230	281	211	435	560	429	157	163	64	87	50	607	46,988	9.6%
Seattle CBD	11	509	617	2,696	2,619	1,638	5,901	4,381	3,744	5,670	14,891	34,875	4,570	9,160	2,331	2,438	1,365	1,744	1,180	1,140	1,658	1,497	838	1,159	516	687	1,161	816	109,802	22.5%
W Seattle	12	2	3	14	2	52	457	403	564	710	1,748	4,570	2,743	1,349	677	339	39	46	10	32	30	26	21	2	3	1	4	102	13,949	2.9%
Rainier	13	53	69	294	133	236	1,222	1,079	1,682	1,579	5,193	9,160	1,349	5,664	1,425	2,257	604	985	114	205	231	247	97	250	73	99	254	340	34,895	7.2%
Sea-Tac	14	20	7	8	9	20	265	262	421	434	917	2,331	677	1,425	3,259	1,327	683	641	21	7	44	34	12	841	462	181	156	63	14,529	3.0%
Renton	15	2	59	11	12	20	321	196	395	418	873	2,438	339	2,257	1,327	3,873	369	1,472	56	64	436	463	38	174	31	31	92	61	15,828	3.2%
Federal Way	16	1	9	2	0	0	52	10	105	62	230	1,365	39	604	683	369	820	540	0	3	47	8	0	183	39	31	77	2	5,280	1.1%
Kent	17	3	51	1	0	5	46	38	237	162	281	1,744	46	985	641	1,472	540	4,252	3	13	87	44	5	196	80	55	397	16	11,401	2.3%
Kirkland	18	7	51	153	70	254	162	457	1,352	165	211	1,180	10	114	21	56	0	3	1,579	423	898	566	39	4	0	1	–	19	7,794	1.6%
Redmond	19	2	5	74	48	15	211	148	369	215	435	1,140	32	205	7	64	3	13	423	781	602	1,084	50	17	0	1	1	25	5,969	1.2%
West Bellevue	20	90	52	186	109	36	391	361	684	319	560	1,658	30	231	44	436	47	87	898	602	1,446	1,319	187	7	3	2	5	28	9,817	2.0%
Bellevue	21	1	16	23	11	16	209	205	703	232	429	1,497	26	247	34	463	8	44	566	1,084	1,319	2,195	77	4	1	3	1	21	9,433	1.9%
Issaquah	22	17	8	2	3	1	106	29	101	57	157	838	21	97	12	38	0	5	39	50	187	77	131	3	–	2	2	8	1,992	0.4%
North Tacoma	23	1	2	1	3	1	22	10	569	157	163	1,159	2	250	841	174	183	196	4	17	7	4	3	9,521	2,902	1,177	699	8	18,076	3.7%
South Tacoma	24	–	0	0	0	–	3	1	299	52	64	516	3	73	462	31	39	80	0	0	3	1	–	2,902	4,063	2,040	266	1	10,899	2.2%
Lakewood	25	0	0	1	2	0	2	16	154	185	87	687	1	99	181	31	31	55	1	1	2	3	2	1,177	2,040	2,261	184	3	7,206	1.5%
Puyallup	26	0	0	–	0	–	16	3	295	105	50	1,161	4	254	156	92	77	397	–	1	5	1	2	699	266	184	1,047	0	4,815	1.0%
External	27	170	348	223	25	56	136	126	393	173	607	816	102	340	63	61	2	16	19	25	28	21	8	8	1	3	0	52	3,822	0.8%
Destination Totals		7,954	8,796	13,702	7,880	7,063	24,765	26,091	35,120	23,886	46,988	109,802	13,949	34,895	14,529	15,828	5,280	11,401	7,794	5,969	9,817	9,433	1,992	18,076	10,899	7,206	4,815	3,822	487,752	100.0%
Destination Shares		1.6%	1.8%	2.8%	1.6%	1.4%	5.1%	5.3%	7.2%	4.9%	9.6%	22.5%	2.9%	7.2%	3.0%	3.2%	1.1%	2.3%	1.6%	1.2%	2.0%	1.9%	0.4%	3.7%	2.2%	1.5%	1.0%	0.8%	100.0%	

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Appendix A: New Surveys

A. New Surveys

This Appendix includes a summary of the recent surveys which are available to supplement past surveys. The new surveys were geo-coded to the ST model 759 zonal system and pertinent information was used to support the base year (2004) transit trip table development effort.

A.1 Sound Transit Survey

Sound Transit conducted an extensive survey of riders using Sound Transit trains and buses between September 2003 and May 2004. This survey yielded a variety of data including route number, time period, origin and destination location, as well as an expansion factor to expand from daily to annual ridership. The data was subsequently sorted into usable and unusable records, each of which was assigned an origin and destination AAZ. Finally, expansion factors were revised to reflect the lower number of usable records.

Records were deemed **"unusable"** if they were missing x,y coordinates either for the origin or the destination. Table A1, shown below, summarizes the percentage of **"usable"** records.

Table A1a - Usable Records

	Bus	**Sounder**
Total records	10,386	2,618
Total usable	6,867	1,966
% usable	66%	75%

Some of the usable records had either an origin or destination that did not lie within the Sound Transit district, but did lie within the PSRC region. These records were overlayed with the PSRC TAZ map and were assigned the corresponding PSRC TAZ. An equivalency table was then used to assign an appropriate external AAZ from the Sound Transit 759-AAZ system to these records. Table A2 below summarizes the number of records that had an origin, destination, or both in either internal or external zones.

Table A1b - Internal and External Origins and Destinations

	Bus	**Sounder**
Internal-internal	6,455	1,618
Internal-external	403	343
External-external	9	5

A.2 Revising Expansion Factors

After sorting the usable records by bus route and time period (Sounder records were just sorted by time period), expansion factors were revised to reflect the lower number of usable records. Since the expansion factors will be used to expand estimates from daily to annual ridership, each expansion factor needed to be increased to add up to the same ridership number. For each group of records (i.e., route 550 in the AM peak period), the expansion factors were revised using the following equation:

Old Exp Factor* X *(Sum of Total Exp Factors / Sum of Usable Exp Factors)

The resulting new expansion factors were then provided to the modelers along with origin and destination AAZs for each route / time period. Table A3 summarizes the number of usable records by mode and time period.

Table A2 - Usable Records by Mode and Time Period

	Bus	Sounder
AM total records	2,470	1,243
AM usable	1,784	985
AM % usable	72%	79%
PM total records	3,193	1,375
PM usable	2,130	981
PM % usable	67%	71%
Offpeak total records	4,723	n/a
Offpeak usable	2,953	n/a
Offpeak % usable	63%	n/a

A. 3 Survey of SR-520 Riders

A special survey of SR-520 riders was conducted by Northwest Research Group, Inc., in May 2005. This survey provided 944 usable origin-destination records of which 217 zone-pairs were not represented before in other surveys.

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Appendix B: Maps

- *Forecasting Analysis Zones (FAZ’s)*
- *Alternative Analysis Zones (AAZ’s)*
- *27 &11 Summary Districts*

Figure B1: PSRC FAZ Map – Snohomish County

Figure B2: PSRC FAZ Map – King County

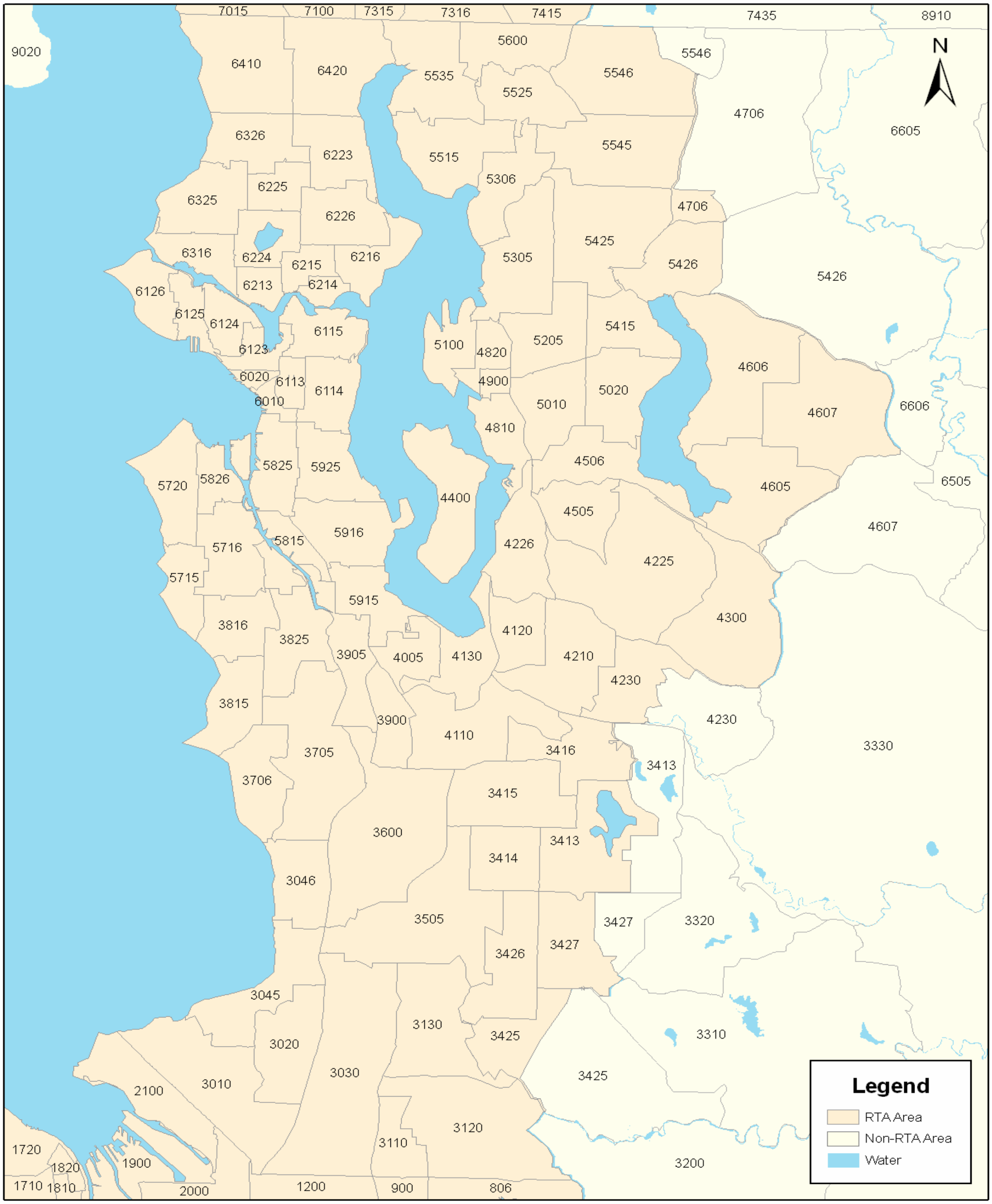


Figure B3: PSRC FAZ Map – Pierce County

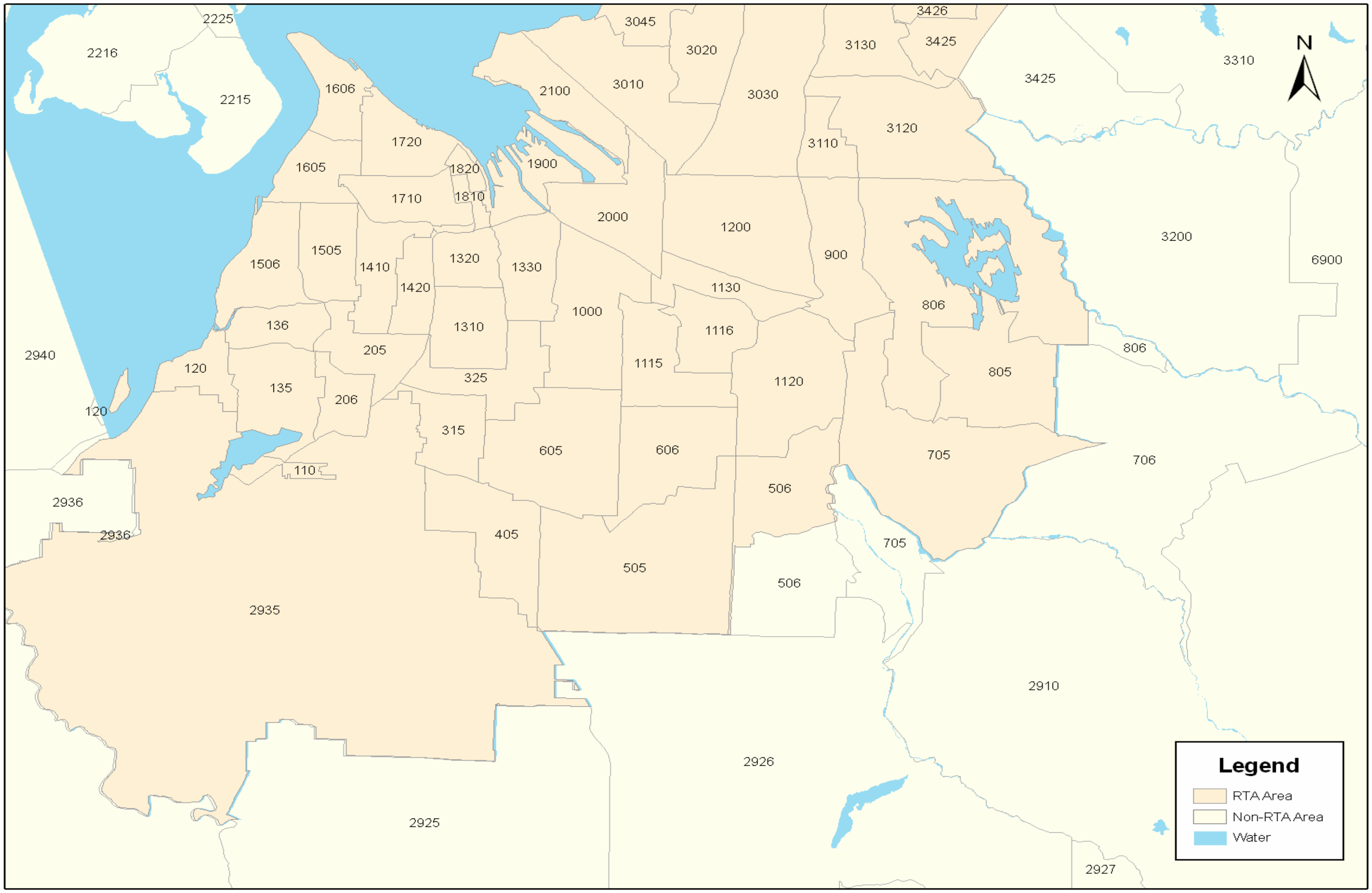


Figure B4: 759 Zonal System – King County

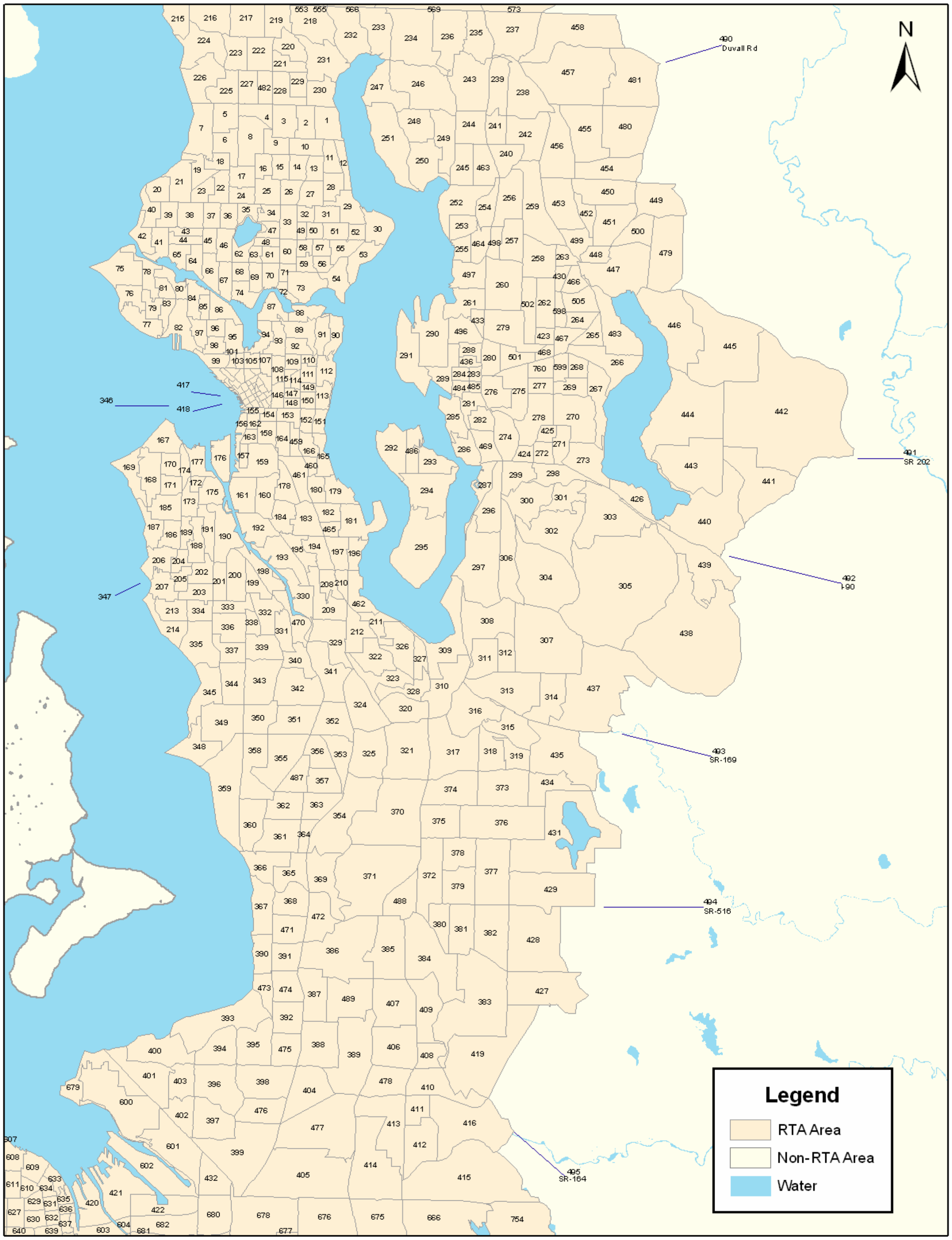


Figure B4a: 759 Zonal System – Seattle CBD

Figure B4b: 759 Zonal System – Capitol Hill, First Hill, Ballard & Queen Anne

Figure B4c: 759 Zonal System – North Seattle

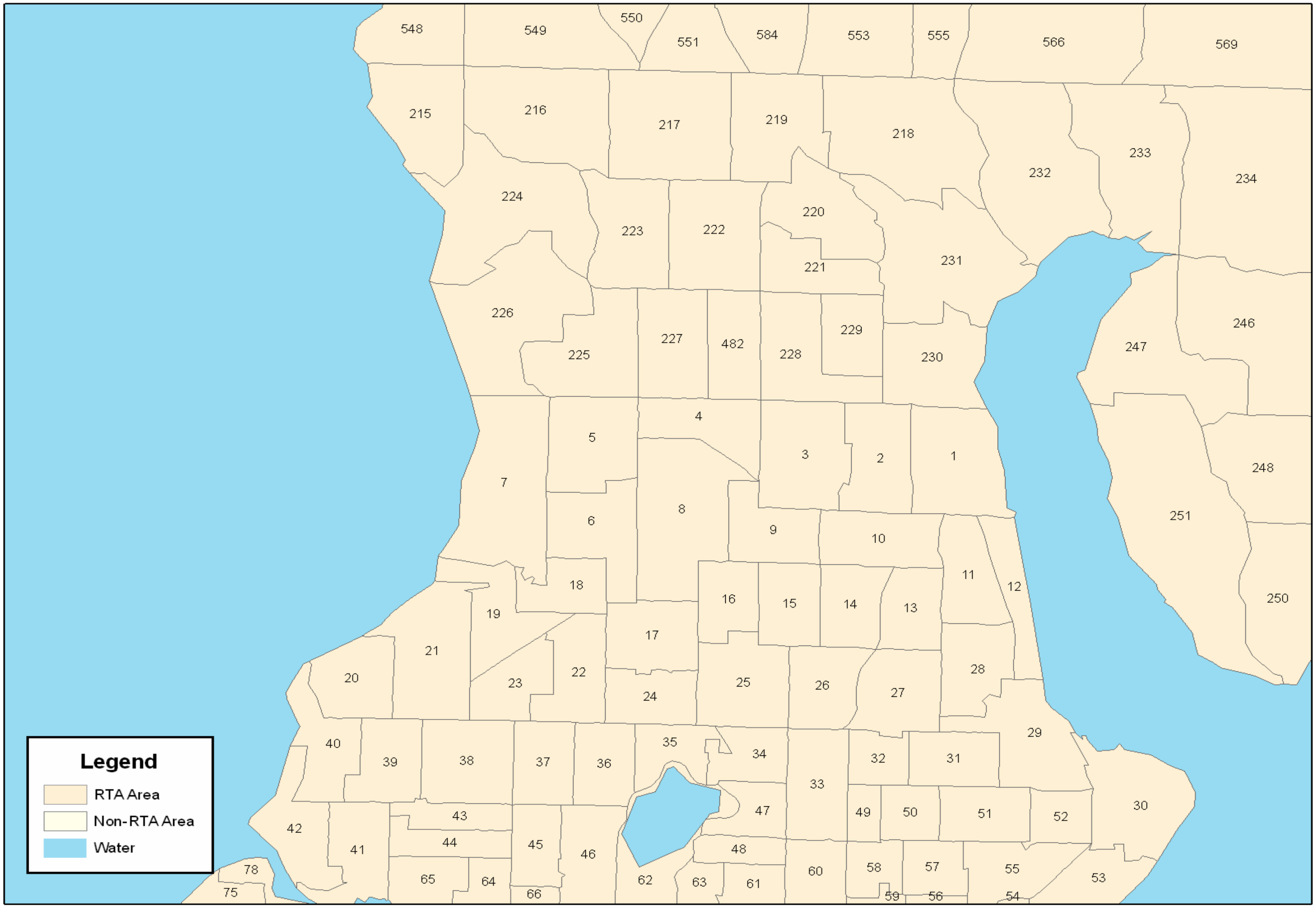


Figure B4d: 759 Zonal System – East King County

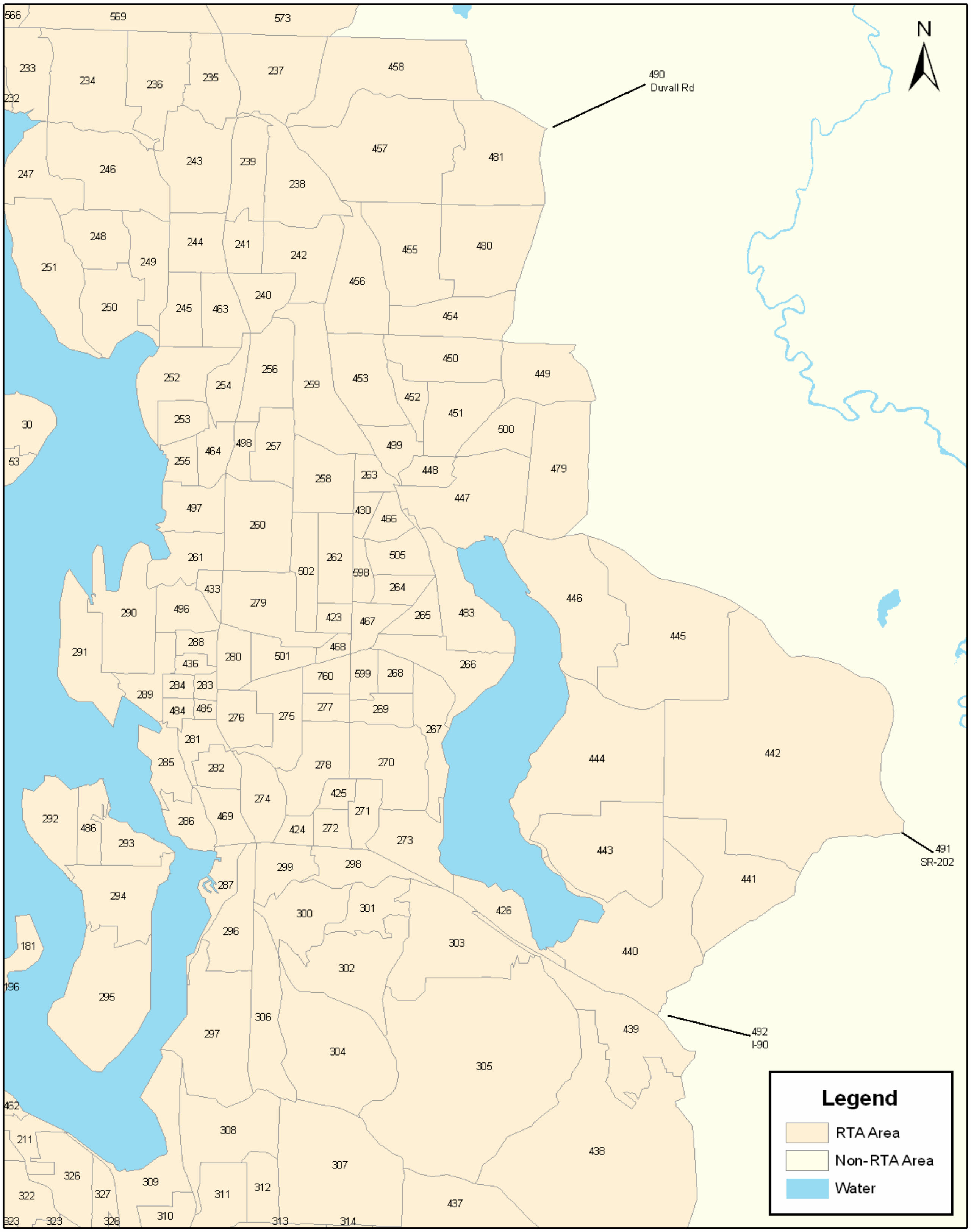


Figure B4e: 759 Zonal System – Southeast/West Seattle

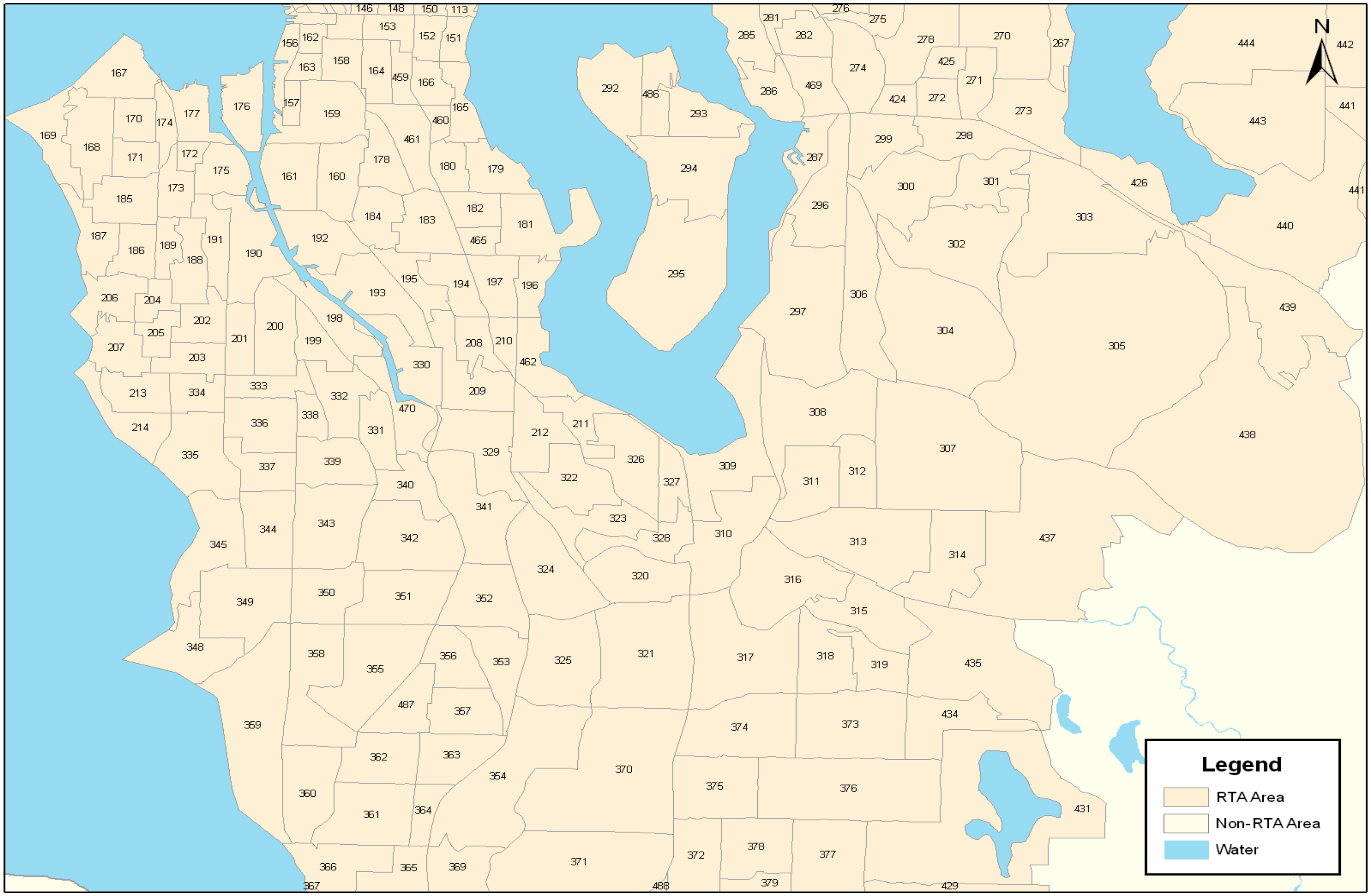


Figure B4f: 759 Zonal System – South King County

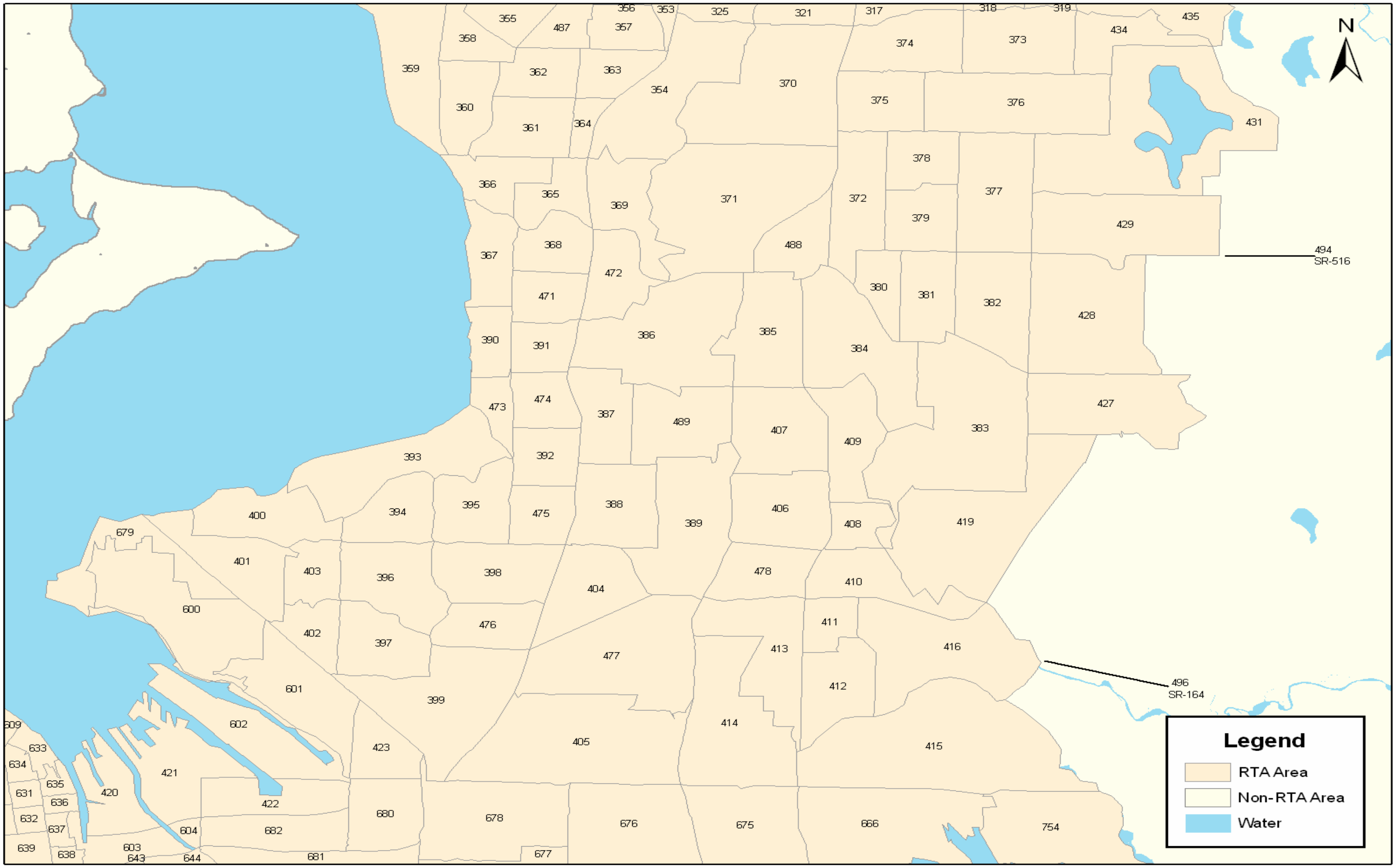


Figure B5: 759 Zonal System – Snohomish County

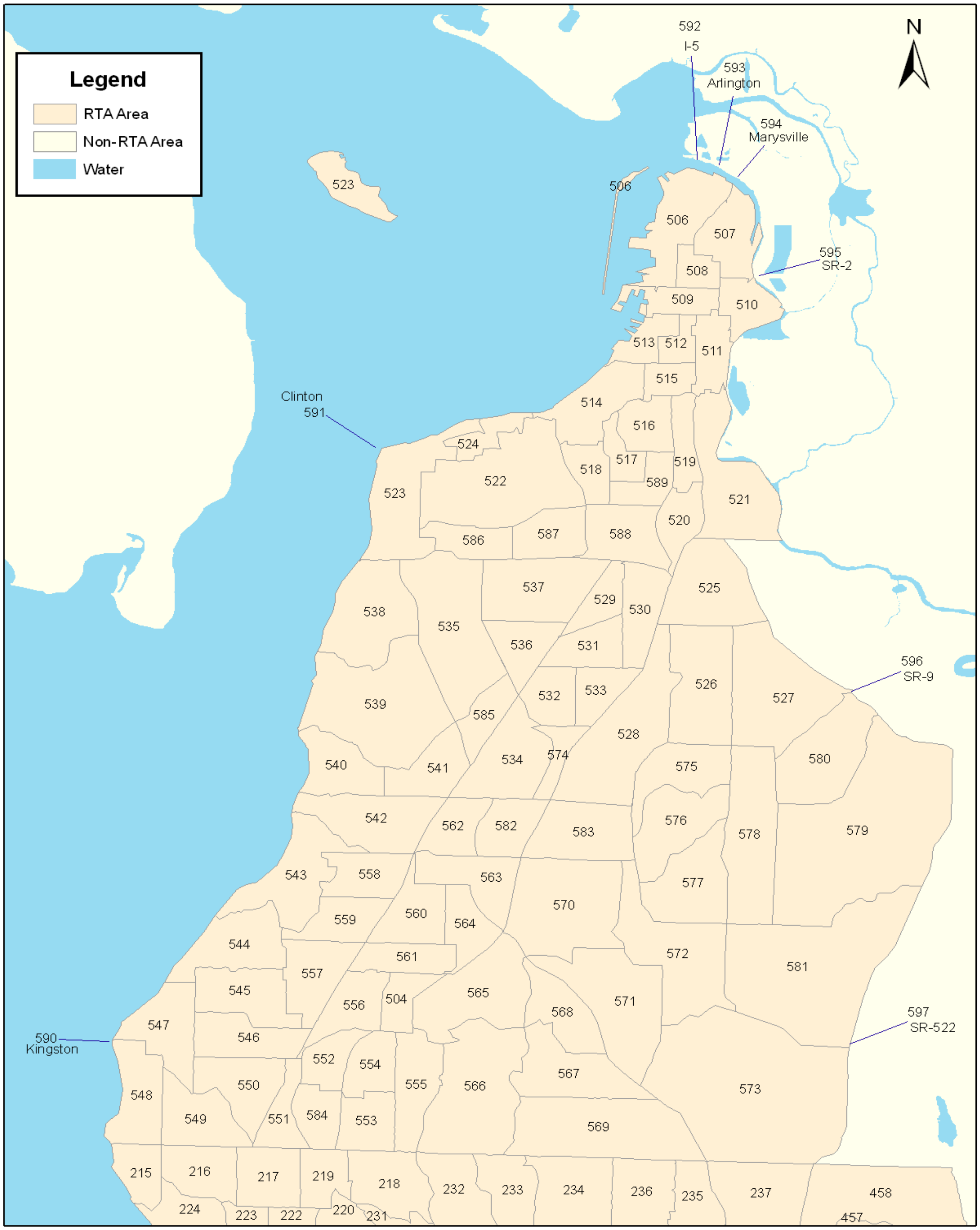


Figure B6: 759 Zonal System – Pierce County

Figure B6a: 759 Zonal System – Tacoma

Figure B7: 27-District Boundary

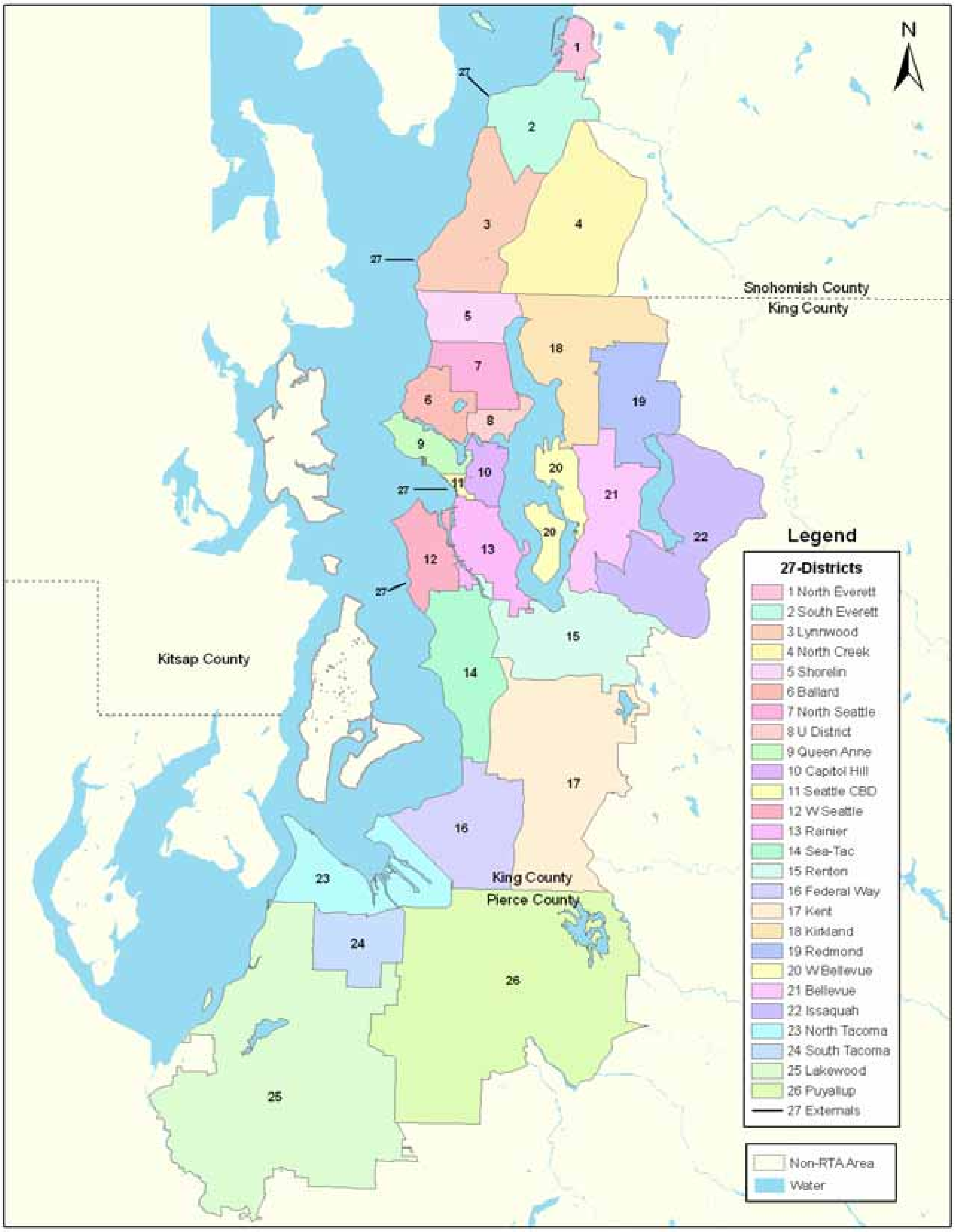
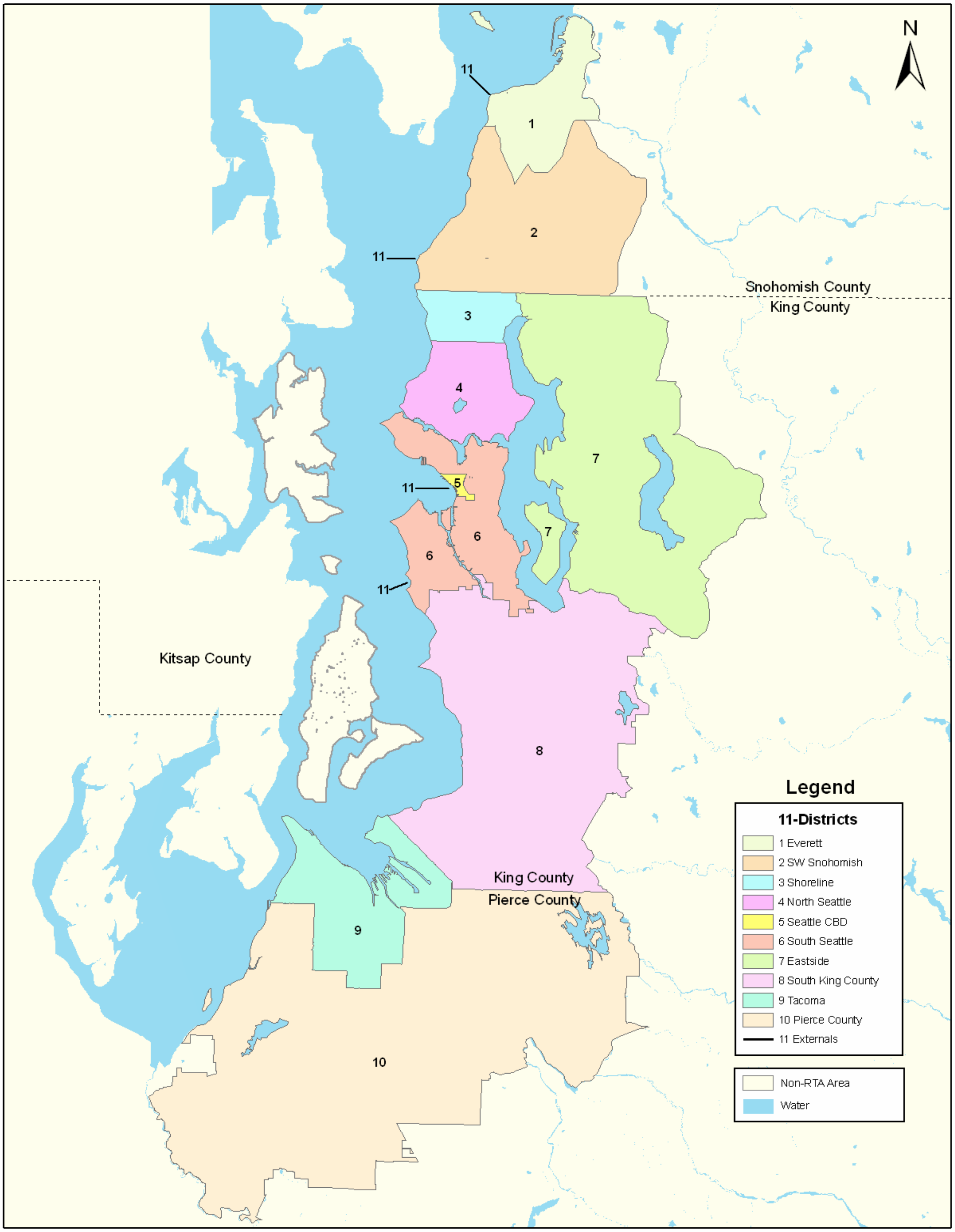


Figure B8: 11-District Boundary



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Appendix C

- *Procedures for Transit Network Preparation*
- *ST Memorandum to FTA (Speed Degradation Procedures)*

C. PROCEDURES FOR TRANSIT NETWORK PREPARATION

Actual transit service is represented in a transit ridership forecasting model by means of a "coded network." This service representation actually consists of two elements:

- A highway network, or "base network," is coded to create a computerized representation of existing and planned roads and exclusive transit right-of-ways in the study region; and

- Transit service assumptions are overlaid on this base highway network.

Significantly, for Sound Transit studies, the base network does not vary among alternatives. A single base network is used for all alternatives - meaning that for each alternative, elements of the base network may exist on which no transit service is coded. For example, rail rights-of-way are coded in every network although no rail service is coded for an all-bus alternative.

ST decided to construct a single base network for several reasons. One advantage of keeping the base network constant is that it eliminates spurious errors caused by roads or walkways which would be coded differently in different alternatives. A second reason for maintaining a single base network is that it minimizes differences in results due to accidental *differences* in access coding. Because a major aim of any forecasting effort is to capture differences among various alternatives, it is important that these differences are attributable to actual differences among the alternatives, rather than coding inconsistencies.

In contrast to the base network, the transit service that operates on this network does vary, both by forecast year and by alternative. The transit service network created for each alternative is represented by a set of bus and rail transit routes operated by local transit agencies.

C.1 Development of the Base Network

The base network is coded within this boundary and consists of links and nodes that represent the road system on which transit and automobiles travel. As mentioned above, exclusive rights-of-way for transit and HOVs (e.g., transitways and rail tracks) are also coded, although they may not be used in every alternative. Park-and-ride lots are also coded, although they too may not be served by transit in every alternative.

Each of the links coded in the base network has a set of attributes consisting of the length of the link, the link type, the modes allowed on the link, the number of lanes on the link, a link speed, and the volume delay function. The link type codes, the modes, the volume delay functions, and link speeds are described in more detail below.

Network outside the study area is not coded, although the major roads leaving the study area are coded by means of external links. These links serve as method of accounting for travel into the study area from areas beyond the study area boundaries.

Link Type Codes

A two-digit number is used to code the link type. The first digit represents a facility type. The second digit can be used in a variety of ways, such as summing by cordons or by geographic area. The chart below shows the convention used for the first digit of the link type code:

Code	Link Type
0	Freeway HOV
1	Freeway HOV
2	Expressway or Highway
3	Arterial HOV
4	Arterial HOV
5	External Roads
6	Rail
7	Pedestrian Only Links
8	Walk Access to Zone Centroids
9	Auto Access to Zone Centroids

The link type coding does not directly affect the mode-choice model or the representation of transit service.

Mode Types

The following eight modes are specified on links within the base network:

Symbol	Mode Represented
c	Car
b	Bus
t	Trolley
r	Rail
a	Auto Access
w	Walk Access
p	General Pedestrian Links
x	Park and Ride Lot Connection (directional link)

The access modes (i.e., modes “a,” “w,” “p,” and “x”) are an important aspect of the base network. There is a minor variation in the way these access modes are represented in the PM peak and off- peak networks. In the peak networks, both auto access and walk access modes are allowed, while in the off-peak only walk access is allowed.

Walk-access links are coded with a speed of three miles per hour. The "w" mode allows walking from the base network to the zone centroid. The "p" mode permits all other walking, including walking from the zone centroid to the base network and streets. The separation of these two walk access modes makes it possible to differentiate between walk access transit trips and auto access transit trips.

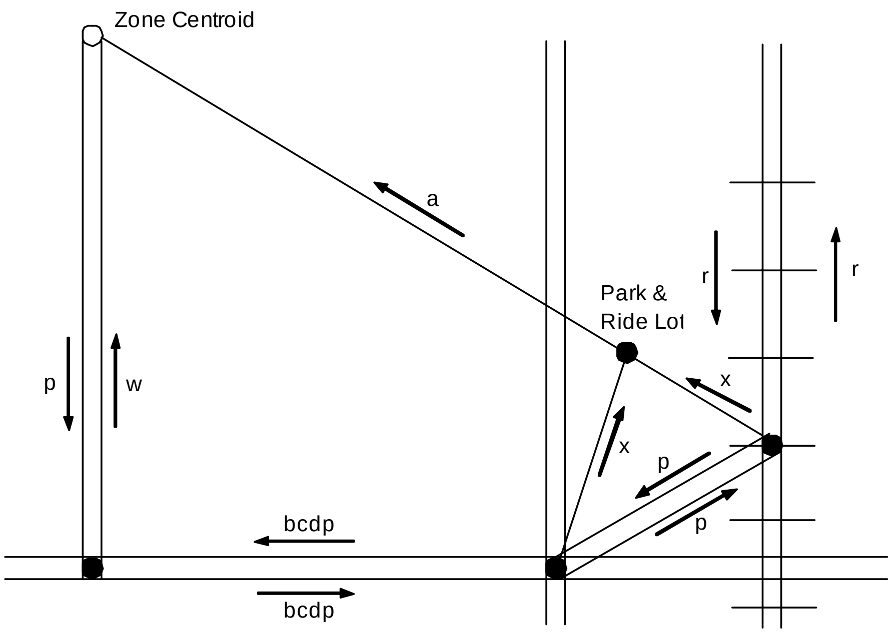
The other two access modes, modes "a" and "x," are associated with the use of park-and-ride lots to access transit. Mode "a" allows auto trips between zone centroids and park-and-ride lots, and mode "x" represents walking within park-and-ride lots. A sample representation of the PM Peak network using the access modes is shown in Figure C1a.

There are several reasons for using x-links to represent park-and-ride access to transit. First of all, using such links allows for counting the number of trips that use park-and-ride lots to access transit. Secondly, the use of such links will allow for modeling the effect of charging fees at park-and-ride lots, should this be desired. Thirdly, there is a certain disutility associated with having to park one's car and walk through a park-and-ride lot in order to get on a bus or train. Using x-links allows for the inclusion of this disutility in the model.

Finally, the use of x-links allows for a more even-handed comparison of park-and-ride access to transit between rail and non-rail alternatives. The use of x-links allows one to connect a single park-and-ride lot to both the street network and rail tracks. This means that under both an all-bus alternative (where transit would access the park-and-ride lot via the street network), and a rail alternative (where transit such as rail transit would access the same park-and-ride lot via the rail system), the park-and-ride lot in question would be connected to the exact same zones.

In the Off Peak network each of the 759 zones in the network are connected with walk access links only. As in the PM Peak, the walk access links are coded with a speed of three miles per hour. Both modes "w" and “p” allow walking from the base network to the zone centroid and vice versa. Mode “p” also allows walking on all surface streets in the network. The other two access modes, modes "a" and "x," are not used in the Off Peak network. A sample representation of the Off-Peak network using the access modes is shown in Figure C1.b.

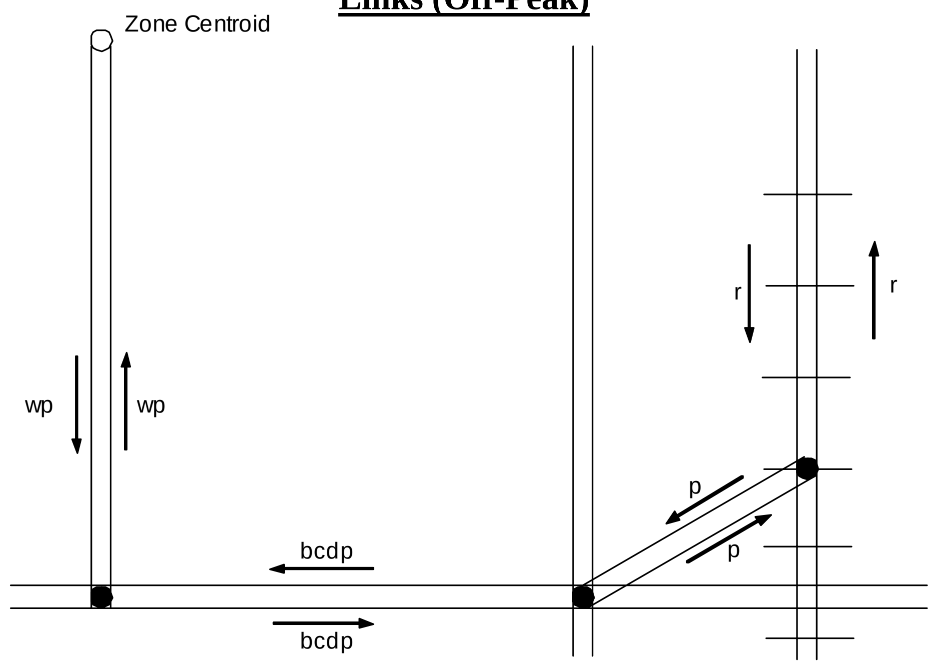
Figure C1a – Sample Mode Coding on Base Network Links (PM-Peak)



LEGEND

Symbol	Mode Represented
a	Auto Access (Directional Link)
b	Bus
a	Car
d	Dual Power Bus
p	General Pedestrian Link
r	Rail
w	Walk Access (Directional Link)
x	Park and Ride Lot Connection Link

Figure C1b – Sample Mode Coding on Base Network Links (Off-Peak)



LEGEND

Symbol	Mode Represented
a	Auto Access (Directional Link)
b	Bus
a	Car
d	Dual Power Bus
p	General Pedestrian Link
r	Rail
w	Walk Access (Directional Link)

Development of the Future Transit Service Networks

Transit service networks are created to represent the transit service planned for each alternative and forecast year, as well as the service operated in the base years used to validate the model. Each service network is characterized by a unique set of routes, which may include rail lines, service on exclusive transitways, or HOV lanes. Each route is described by the nodes and links over which it travels, the travel time on each link, the locations where it stops, and its peak and off-peak headways. Each of these characteristics is described in detail below.

Route Patterns

Each route can be described by its route alignment, or the set of nodes and links over which it travels. The places where passengers are picked up and dropped off are coded by placing a dwell time on the nodes that represent bus stops for each particular route. All Sound Transit, King County Metro, Community Transit, Everett Transit, and Pierce Transit routes within the forecasting study area are coded for each alternative and forecast year, with the exception of any dial-a-ride service and routes that have less than three trips per direction per day.

Route Headways

PM peak and off-peak headways are specified for each route in each transit service network. The PM peak headway reflects the number of trips between 3:00 and 6:00 PM, and the off-peak headway reflects the base headway between 9:00 a.m. and 3:00 p.m. For the base-year network, headways are determined directly from the printed bus schedules from the transit agencies.

A future 2030 ST baseline model was developed based on the 'Build Network' definition from the latest 2030 North Link Model that was submitted to FTA. Route alignments and headways for the future baseline were based on this North Link model. Route patterns and headways for other future alignments will be based on the specific descriptions for each alternative.

Link Speeds and Bus Speeds

For fixed guideway facilities, link speeds representing travel time between two successive stations are calculated as part of the operating plan development that is unique to each alternative under consideration. Bus speeds under mixed operation with general traffic are calculated as follows:

> ***For the base year:*** link speeds are coded so that they result in network bus travel times equal to observed bus travel times.

For future years: base-year link speeds are degraded according to the change in general roadway congestion level estimated by the PSRC model for arterial and freeway facilities and by geographic area.

Since the ST model's development in the early 1990s by the RTA future-year link speeds have been estimated using a constant degradation rate of seven to nine percent per decade. This degradation rate is consistent with historic trends in bus speeds. FTA staff, however, recently expressed concern about extrapolating historical trends in bus speed degradation into future projections. Instead, the FTA suggested basing link speeds degradation on roadway congestion estimated by the PSRC multi-modal model. Subsequently, a number of experimental analyses were performed in consultation with PSRC and City of Seattle travel modeling staff. As a result of this effort, analysis results and a recommended procedure were developed and documented by Sound Transit staff in a memorandum to the FTA. A copy of this memorandum is included in the next pages.

C.2 Transit Fares

Another transit related inputs are is transit fares. Historically, most transit agencies in the Puget Sound Region have increased transit fares at the rate of inflation. Consequently, transit fares are kept unchanged (in constant dollars) in the ST model between the base year (2004) and a future year. Table C2 shows 2004 peak and off-peak fares (in 2004 dollars).

Table C2 – 2004 Peak and Off-peak Transit Fares

	2004 Fares[1]	
Geographic Area	**Peak**	**Off-Peak**
Pierce County-to-Snohomish County	$2.50	$2.50
Pierce County-to-South King County	$2.00	$2.00
Pierce County-to-Seattle	$2.50	$2.50
Snohomish County-to-South King County	$2.00	$2.00
Snohomish County-to-North Seattle	$1.25	$1.25
Snohomish County-to-North King County	$1.75	$1.25
Snohomish County-to-Seattle CBD	$2.00	$2.00
Suburban King County-to-Seattle	$2.00	$1.25
Intra-Suburban King County	$1.50	$1.25
Intra-Seattle	$1.50	$1.25
Intra-Snohomish County	$1.00	$1.00
Intra-Everett	$0.75	$0.75
Intra-Pierce County	$1.00	$1.00
U-Pass Program	$0.49	$0.49
Intra-Seattle CBD	$0.00	$0.00

[1]Transit fares shown in this table are expressed in 2004 constant dollars. These fares are also used in the ST Model for future years.

SOUNDTRANSIT

M E M O

August 1, 2002

TO: Eric Pihl

FROM: Don Billen

SUBJECT: Updated Treatment of Bus Speeds in the Sound Transit Model

This memorandum describes the updated procedures for treating bus speeds in Sound Transit's incremental ridership forecasting process. This is in response to your request that Sound Transit rely on output from the PSRC multi-modal model to estimate changes in bus speeds over time.

Sound Transit Incremental Ridership Model

Sound Transit uses an incremental model to forecast transit ridership consisting of three stages:

- Stage 1: Changes in demographics
- Stage 2: External changes in highway travel time (congestion) and costs (including parking costs), transit fares, and household income are taken into consideration.
- Stage 3: Incremental changes in the transit level-of-service (i.e. access, wait, and ride travel times) are taken into consideration.

The third stage of the forecasting process is where the effects of changes in bus speeds are captured. Base year link speeds in combination with transit travel time functions are used so that they result in network bus travel times equal to observed bus travel times. Individual transit routes are coded with transit travel time functions that account for acceleration/deceleration time, with bus speeds equal to the base year link speed for express portions of a route. Dwell time is similarly coded for individual transit routes, with zero dwell time for express portions of a route.

Future year link bus speeds are degraded relative to base year link speeds and according to the procedures described below.   The transit travel time functions which account for acceleration/deceleration time are the same in the base year and future year. Dwell time similarly remains the same in the base and future year.

Since the model's development in the early 1990's by the Regional Transit Project, future year link speeds have been estimated using a constant degradation rate of seven to nine percent per decade. This degradation rate is consistent with historic trends in bus speeds. However, FTA staff have expressed concern about extrapolating historical trends into the future and suggested relating future bus speeds to road speeds in the PSRC multi-modal model.

Updated Procedure for Estimating Future Bus Speeds

Sound Transit and its ridership consultant have investigated several methods for relating road speeds in the PSRC model to bus speeds in the Sound Transit model. After reviewing these methods with Puget Sound Regional Council and City of Seattle modeling staff, we have arrived at the following procedure.

For arterial bus speeds, weighted average auto travel time within the PSRC model is calculated at an intra 26-district level for the base year and forecast year in the PM peak and off-peak. The ratio between the base year and forecast year intra-district times is calculated. This change in intra-district auto travel times is used to estimate the change in bus speeds and is applied to the base year link speed values in the ST model for each geographic district. Table 1 shows the resulting PM peak bus degradation rates for each of the 26 districts for the period of 1998-2020.

Table 1: PM Peak Arterial Degradation Rates

Comparative Analysis of 1998 to 2020 Weighted Average Intra-District Travel Times

District		1998	2020	2020/1998 Ratio	Change Per Decade
North Everett	1	6.13	6.80	1.11	4.8%
South Everett	2	8.24	9.28	1.13	5.6%
Lynnwood	3	8.04	9.95	1.24	10.2%
North Creek	4	10.13	11.17	1.10	4.5%
Shorelin	5	6.47	6.79	1.05	2.2%
Ballard	6	6.32	6.79	1.07	3.3%
North Seattle	7	6.64	7.29	1.10	4.3%
University District	8	4.55	5.52	1.21	9.2%
Queen Anne	9	6.44	6.94	1.08	3.5%
Capitol Hill	10	4.86	5.07	1.04	1.9%
Seattle CBD	11	2.48	2.63	1.06	2.6%
W Seattle	12	7.28	8.63	1.19	8.1%
Rainier	13	9.17	9.92	1.08	3.6%
Sea-Tac	14	8.01	8.81	1.10	4.4%
Renton	15	10.00	11.58	1.16	6.9%
Federal Way	16	8.26	9.50	1.15	6.5%
Kent	17	9.99	11.16	1.12	5.2%
Kirkland	18	8.75	10.10	1.15	6.7%
Redmond	19	8.60	11.42	1.33	13.8%
West Bellevue	20	5.51	5.68	1.03	1.4%
Bellevue	21	8.85	9.69	1.10	4.3%
Issaquah	22	8.62	10.33	1.20	8.6%
North Tacoma	23	8.48	10.58	1.25	10.6%
South Tacoma	24	6.16	6.78	1.10	4.4%
Lakewood	25	8.30	9.72	1.17	7.4%
Puyallup	26	10.51	11.46	1.09	4.0%
External	27	16.97	19.70	1.16	7.0%
Destination Totals		19.33	22.34	1.16	6.8%

For freeway bus speeds, zone to zone travel times between major entry and exit points for buses along regional freeways are calculated for the base year and future year. As with arterial times, the ratio between the base year and forecast year times is calculated. This change in freeway auto travel times is used to estimate the change in bus speeds and is applied to the base year link speed in the ST model for

each freeway segment. Table 2 shows the resulting bus degradation rates on two freeway segments in the light rail study area.

Table 2: PM Peak Freeway Degradation Rates

Comparative Analysis of 1998 to 2020 Freeway Travel Times					
Freeway Segment		1998	2020	2020/1998 Ratio	Change Per Decade
I-5: Seattle CBD to Northgate		15.50	18.07	1.17	7.2%
SR 520: Seattle to Overlake		22.15	25.12	1.13	5.9%

The resulting rates of degradation for both arterials and highways are somewhat lower than historic changes in bus speeds in the Central Puget Sound Region, so may underestimate actual degradation rates. However, the updated method offers the advantage of being sensitive to varying congestion rates over time and across geographic areas and to changes in these rates with alternative land use or highway network scenarios.

Alternate Method Investigated

Our ridership forecasting consultant originally proposed to simply average PSRC link speeds within a cross-classification of geography and facility type for a base and future year to estimate changes in bus speeds. (see Parsons Brinkerhoff memo of 12-2-01 from Youssef Dehghani to Don Billen).

Investigation of this method between 1998 and 2020 yielded results that varied greatly between geographic areas and on the aggregate showed changes in road times much lower than other analyses of PSRC model output. The average decline in speeds across all facilities was 1% per decade between 1998 and 2020 compared to previous analysis of zone-zone road skims that showed an average decline of 8% per decade (see Parsons Brinkerhoff memo of 11-19-01 from Youssef Dehghani to Don Billen). Furthermore, the change in arterial speeds in different geographic areas varied by factors as high as 16 to 23 times. For instance, major arterial speed degradation in the Eastside of King County was 17 times as high as in Snohomish County, even though both are high growth areas with very limited road expansion currently funded. (Table 3)

Upon review of these results with PSRC and City of Seattle modeling staff, we concluded that simple averaging of link speeds is inaccurate and that it would be better to rely on zone-zone skim times than link level times. The simple averaging of link speeds results in too much influence from low volume roadways and too little influence from highway volume roadways. Also, using link level rather than zone-zone travel time skims created the possibility for the results to be influenced by the density of road networks coded in a geographic area.

Table 3:

Analysis of PM Peak Speed Degradation in PSRC Model By Facility Type and Area Type

(average change per decade from 1998 to 2020)

Facility Type		Area Type							
		All	Seattle CBD	Seattle	Eastside	Rest of King County	Snohomish County	Pierce County	Kitsap County
	All	1.5%	0.9%	0.7%	5.6%	3.0%	0.8%	1.8%	0.2%
	Freeway GP Lanes	6.3%	4.48%		8.8%	3.1%	14.4%	4.0%	6.1%
	Freeway HOV Lanes	1.2%	1.95%		4.2%	5.56%			
	Major Arterials	1.4%	3.4%	0.8%	6.8%	3.0%	0.4%	1.9%	0.2%
	Minor Arterials	1.8%	0.1%	0.2%	3.1%	2.7%	2.1%	0.3%	0.0%

Notes :- The data shown above represents the percentage speed degradation over a period of 22 years from 1998 to 2020.
- The percentage degradation in speed was obtained from the "slope" of the regression equation obtained from a linear regression analysis of PM peak link travel times for a particular facility type and area type.
- The regression analysis showed an R^2 of greater 0.9 for all the categories.
- Major arterials include all those arterials in the PSRC model that have a speed greater than 25 mph, e.g., MLK way, Rainier Avenue, NE 8th (in Bellevue etc.). Minor arterials are arterials with a speed less than 25 mph.

These concerns led PSRC and City of Seattle modeling staff to recommend the use of weighted average auto travel times from zone-zone travel time skims and to Sound Transit's development of the procedures described at the beginning of this memo.

CC: John Witmer, FTA Region X
Larry Blaine, Puget Sound Regional Council
Eric Tweit, City of Seattle
Tracy Reed, Ron Lewis, Mike Williams, Sound Transit

DB <Updated bus speed degradation method.doc>

SOUND TRANSIT

HCT Planning

Appendix D

- *FAZ-Level Land Use Forecasts*
- *Zonal Parking Costs*

Table D1
Total Households, Population, and Employment for 2004 and 2030

	Base Year 2004			Year 2030			Growth Rate - 2030 over 2004		
PSRC FAZ #	Households	Population	Employment	Households	Population	Employment	Households	Population	Employment
110	7,851	31,488	34,225	10,734	37,385	38,099	1.37	1.19	1.11
120	4,271	11,032	996	5,332	12,304	1,903	1.25	1.12	1.91
135	5,903	14,859	1,773	7,420	17,328	2,595	1.26	1.17	1.46
136	4,786	12,524	3,918	5,678	14,384	4,912	1.19	1.15	1.25
205	5,286	12,657	11,069	6,476	14,531	13,513	1.23	1.15	1.22
206	5,644	13,610	6,781	9,528	21,510	12,530	1.69	1.58	1.85
315	5,519	15,021	6,969	6,718	17,103	10,100	1.22	1.14	1.45
325	8,098	20,084	4,914	10,465	25,395	5,452	1.29	1.26	1.11
405	7,002	18,873	3,699	8,806	22,886	4,399	1.26	1.21	1.19
505	9,863	28,465	5,465	13,288	37,813	8,068	1.35	1.33	1.48
506	5,875	17,651	1,822	12,117	34,253	3,942	2.06	1.94	2.16
605	7,229	19,551	2,193	9,725	25,201	3,133	1.35	1.29	1.43
606	5,732	14,587	2,272	8,313	21,344	3,428	1.45	1.46	1.51
705	5,900	16,887	1,236	13,013	34,200	4,012	2.21	2.03	3.25
805	5,895	17,354	2,418	7,713	21,674	3,208	1.31	1.25	1.33
806	6,708	18,475	1,254	13,589	37,083	2,466	2.03	2.01	1.97
900	3,788	9,016	6,741	5,044	11,570	13,875	1.33	1.28	2.06
1000	3,564	9,468	1,117	4,663	11,629	1,887	1.31	1.23	1.69
1115	3,798	9,361	3,691	4,181	10,491	4,486	1.10	1.12	1.22
1116	6,016	14,763	6,626	9,407	21,657	11,896	1.56	1.47	1.80
1120	11,057	28,484	10,441	14,615	36,856	12,400	1.32	1.29	1.19
1130	2,107	4,315	1,816	2,629	5,181	6,325	1.25	1.20	3.48
1200	6,280	15,691	2,902	10,303	24,835	5,593	1.64	1.58	1.93
1310	9,686	27,281	4,097	12,748	32,694	6,130	1.32	1.20	1.50
1320	6,840	18,877	3,160	9,760	24,712	5,138	1.43	1.31	1.63
1330	7,114	22,829	3,018	10,415	30,368	4,310	1.46	1.33	1.43
1410	4,683	12,014	12,687	8,253	19,232	17,407	1.76	1.60	1.37
1420	4,601	12,443	12,227	8,455	20,596	21,950	1.84	1.66	1.80
1505	7,759	18,418	4,171	10,060	22,673	4,802	1.30	1.23	1.15
1506	8,753	21,778	2,917	11,146	26,126	4,131	1.27	1.20	1.42
1605	7,878	17,679	6,224	10,570	22,688	6,929	1.34	1.28	1.11
1606	5,546	12,963	1,531	7,729	16,991	2,748	1.39	1.31	1.80
1710	8,472	21,992	12,223	11,468	27,993	14,749	1.35	1.27	1.21
1720	10,782	26,372	5,639	14,257	32,364	7,751	1.32	1.23	1.37
1810	1,765	5,537	13,182	4,525	11,384	23,839	2.56	2.06	1.81
1820	4,376	6,868	20,041	8,059	11,955	26,952	1.84	1.74	1.34
1900	192	894	13,143	110	1,049	19,966	0.57	1.17	1.52
2000	2,964	6,942	12,506	5,087	11,268	16,929	1.72	1.62	1.35
2100	6,976	18,559	1,484	9,940	25,181	2,099	1.42	1.36	1.41
2216	21,896	59,446	11,502	30,386	78,516	13,784	1.39	1.32	1.20
2910	5,340	15,554	3,235	8,512	23,546	4,261	1.59	1.51	1.32
2925	14,738	42,258	2,594	18,987	51,687	2,530	1.29	1.22	0.98
3010	14,666	41,371	7,472	17,790	48,293	8,336	1.21	1.17	1.12
3020	9,427	22,662	20,130	12,178	28,530	30,424	1.29	1.26	1.51
3030	10,268	29,501	6,899	12,291	32,799	7,365	1.20	1.11	1.07
3045	10,021	25,985	2,358	11,912	29,742	3,456	1.19	1.14	1.47
3046	9,471	24,009	6,099	11,599	29,454	8,952	1.22	1.23	1.47
3110	2,769	8,158	2,162	4,673	12,729	2,585	1.69	1.56	1.20
3120	8,916	24,124	16,778	12,884	32,884	29,226	1.45	1.36	1.74
3130	6,990	16,659	17,634	11,377	25,564	20,589	1.63	1.53	1.17
3200	22,711	64,967	10,092	27,724	75,215	11,620	1.22	1.16	1.15
3330	10,979	29,531	4,922	13,374	32,824	7,083	1.22	1.11	1.44
3413	2,407	6,702	634	2,697	7,085	1,303	1.12	1.06	2.06
3414	8,194	23,922	1,965	10,253	28,525	3,931	1.25	1.19	2.00
3415	7,725	21,552	4,813	10,850	29,064	7,859	1.40	1.35	1.63
3416	7,753	21,024	2,831	8,547	22,032	4,549	1.10	1.05	1.61
3425	5,109	14,831	1,756	7,015	19,855	2,230	1.37	1.34	1.27
3426	5,247	16,492	2,200	7,246	22,037	3,972	1.38	1.34	1.81
3427	6,226	17,763	3,033	7,696	21,213	5,253	1.24	1.19	1.73

Table D1 Continued
Total Households, Population, and Employment for 2004 and 2030

	Base Year 2004			Year 2030			Growth Rate - 2030 over 2004		
PSRC FAZ #	Households	Population	Employment	Households	Population	Employment	Households	Population	Employment
3505	14,246	33,986	14,599	16,896	40,559	22,017	1.19	1.19	1.51
3600	7,608	17,057	42,290	8,326	19,038	48,038	1.09	1.12	1.14
3705	11,953	31,288	33,387	15,067	37,551	50,805	1.26	1.20	1.52
3706	6,138	15,100	3,077	7,068	16,219	4,132	1.15	1.07	1.34
3815	7,999	18,773	9,082	9,639	21,286	10,418	1.20	1.13	1.15
3816	8,050	22,381	2,608	9,923	25,665	4,261	1.23	1.15	1.63
3825	6,567	17,236	5,569	7,372	18,274	7,147	1.12	1.06	1.28
3900	2,522	5,211	24,399	4,223	8,037	44,515	1.67	1.54	1.82
3905	3,396	8,751	17,242	6,892	15,929	28,171	2.03	1.82	1.63
4005	4,460	11,551	1,459	5,695	13,947	2,219	1.28	1.21	1.52
4110	7,249	17,146	27,901	8,683	19,621	49,487	1.20	1.14	1.77
4120	7,625	17,427	2,887	10,226	22,210	4,517	1.34	1.27	1.56
4130	6,694	13,938	24,314	10,987	22,586	40,704	1.64	1.62	1.67
4210	6,560	16,120	2,492	8,145	19,535	3,418	1.24	1.21	1.37
4225	4,397	11,092	1,221	5,152	12,970	1,412	1.17	1.17	1.16
4226	5,882	14,856	1,449	6,536	15,752	8,051	1.11	1.06	5.56
4230	3,366	9,542	980	3,717	9,744	880	1.10	1.02	0.90
4300	4,706	10,641	9,047	5,123	11,469	11,724	1.09	1.08	1.30
4400	8,594	22,486	7,496	10,185	25,106	8,532	1.19	1.12	1.14
4505	5,481	15,831	685	7,044	19,130	1,140	1.29	1.21	1.67
4506	6,488	15,985	26,244	7,099	16,578	31,283	1.09	1.04	1.19
4605	7,591	20,573	9,670	8,385	22,321	16,215	1.10	1.08	1.68
4606	7,617	21,625	1,906	8,956	24,959	4,128	1.18	1.15	2.17
4607	4,144	12,919	4,374	11,427	34,237	10,958	2.76	2.65	2.51
4706	9,465	28,473	3,112	13,364	36,922	4,578	1.41	1.30	1.47
4810	4,088	8,929	7,077	4,655	9,768	10,892	1.14	1.09	1.54
4820	3,416	7,040	4,808	4,339	8,616	6,072	1.27	1.22	1.26
4900	2,877	3,592	34,909	10,751	15,439	72,580	3.74	4.30	2.08
5010	8,154	18,405	15,296	9,678	20,750	20,294	1.19	1.13	1.33
5020	9,774	24,778	6,549	10,778	25,665	9,606	1.10	1.04	1.47
5100	2,729	7,340	1,061	2,704	7,097	1,623	0.99	0.97	1.53
5205	5,374	11,791	28,391	6,507	13,369	35,365	1.21	1.13	1.25
5305	10,349	23,507	18,574	14,222	29,949	26,757	1.37	1.27	1.44
5306	9,688	22,122	15,959	13,605	29,168	25,123	1.40	1.32	1.57
5415	5,886	14,265	48,407	8,877	20,936	57,704	1.51	1.47	1.19
5425	14,951	35,639	25,338	20,770	46,564	37,039	1.39	1.31	1.46
5426	5,520	14,975	9,545	9,796	25,486	13,670	1.77	1.70	1.43
5515	9,005	23,826	2,783	10,111	24,835	3,907	1.12	1.04	1.40
5525	5,014	12,237	5,307	5,714	13,735	5,645	1.14	1.12	1.06
5535	8,251	20,461	4,456	9,601	23,025	6,636	1.16	1.13	1.49
5545	3,819	11,958	2,642	4,555	13,418	3,659	1.19	1.12	1.38
5546	5,600	16,065	8,759	7,486	19,934	12,043	1.34	1.24	1.37
5600	5,309	12,868	10,535	7,351	16,916	12,018	1.38	1.31	1.14
5715	7,340	16,585	875	8,187	17,398	1,133	1.12	1.05	1.29
5716	9,156	25,100	4,975	11,723	30,271	6,829	1.28	1.21	1.37
5720	16,889	33,868	7,588	18,944	36,747	10,312	1.12	1.09	1.36
5815	1,860	5,078	21,853	2,735	6,960	25,255	1.47	1.37	1.16
5825	1,006	2,678	38,000	1,234	3,251	49,587	1.23	1.21	1.30
5826	2,158	4,351	6,049	2,494	4,903	8,026	1.16	1.13	1.33
5915	7,004	20,873	4,189	9,533	26,735	6,009	1.36	1.28	1.43
5916	12,361	36,439	5,234	15,918	46,194	6,414	1.29	1.27	1.23
5925	9,668	25,728	14,405	13,085	33,079	16,976	1.35	1.29	1.18
6010	5,508	12,731	134,554	9,790	21,037	159,729	1.78	1.65	1.19
6020	8,685	12,262	43,788	17,753	24,838	72,422	2.04	2.03	1.65
6113	19,038	30,285	38,781	23,184	35,925	43,379	1.22	1.19	1.12

Table D1 Continued
Total Households, Population, and Employment for 2004 and 2030

	Base Year 2004			Year 2030			Growth Rate - 2030 over 2004		
PSRC FAZ #	Households	Population	Employment	Households	Population	Employment	Households	Population	Employment
6114	14,186	30,752	16,345	17,402	36,776	25,074	1.23	1.20	1.53
6115	10,448	20,620	7,769	11,889	22,469	8,994	1.14	1.09	1.16
6123	8,122	13,356	48,583	24,764	37,563	75,291	3.05	2.81	1.55
6124	13,267	25,193	9,730	15,213	27,421	12,776	1.15	1.09	1.31
6125	4,948	9,390	7,849	5,458	10,268	10,549	1.10	1.09	1.34
6126	5,443	12,387	2,058	6,524	12,726	2,270	1.20	1.03	1.10
6213	9,100	16,647	11,598	11,146	19,887	14,413	1.22	1.19	1.24
6214	235	2,564	24,965	705	3,231	33,088	3.01	1.26	1.33
6215	11,118	28,200	12,544	14,678	33,426	22,021	1.32	1.19	1.76
6216	6,090	14,906	7,269	7,064	16,091	7,828	1.16	1.08	1.08
6223	12,066	26,020	5,735	16,251	34,193	9,991	1.35	1.31	1.74
6224	10,273	21,045	5,391	11,601	22,325	5,995	1.13	1.06	1.11
6225	9,034	18,483	14,600	14,671	28,181	25,614	1.62	1.52	1.75
6226	12,671	29,084	4,811	13,958	30,409	5,851	1.10	1.05	1.22
6316	13,308	25,772	13,389	16,490	30,585	18,607	1.24	1.19	1.39
6325	15,355	33,939	4,774	17,724	37,583	5,885	1.15	1.11	1.23
6326	10,628	23,070	8,839	13,600	27,917	13,243	1.28	1.21	1.50
6410	13,910	35,528	11,424	15,805	38,617	13,969	1.14	1.09	1.22
6420	12,653	32,562	6,113	14,818	36,374	8,884	1.17	1.12	1.45
6505	2,281	5,295	2,284	2,602	6,045	4,090	1.14	1.14	1.79
6930	29,249	78,078	13,959	41,039	104,735	19,642	1.40	1.34	1.41
7015	6,654	16,168	3,377	8,045	18,086	4,540	1.21	1.12	1.34
7025	8,603	19,236	6,826	11,498	24,152	8,339	1.34	1.26	1.22
7026	3,725	10,131	385	4,630	11,521	624	1.24	1.14	1.62
7100	8,047	20,890	7,572	11,625	27,694	9,564	1.44	1.33	1.26
7205	5,335	14,373	6,025	6,436	16,065	11,491	1.21	1.12	1.91
7206	7,135	17,596	11,506	10,184	23,133	20,526	1.43	1.31	1.78
7315	5,711	16,758	2,451	9,381	24,828	4,170	1.64	1.48	1.70
7316	6,735	18,938	2,315	12,019	30,894	3,143	1.78	1.63	1.36
7320	9,157	23,675	5,491	16,982	41,572	10,926	1.85	1.76	1.99
7335	11,792	31,925	6,424	22,148	54,203	12,215	1.88	1.70	1.90
7340	7,988	23,188	2,035	12,365	33,207	3,929	1.55	1.43	1.93
7415	3,044	7,787	8,209	6,627	16,436	13,740	2.18	2.11	1.67
7425	6,829	20,591	1,051	12,358	35,301	2,070	1.81	1.71	1.97
7435	18,400	54,768	11,982	30,287	83,113	17,609	1.65	1.52	1.47
7515	1,443	3,720	6,229	2,391	5,598	16,131	1.66	1.50	2.59
7525	5,443	15,591	1,163	8,081	21,021	2,315	1.48	1.35	1.99
7526	5,423	14,458	5,010	6,689	17,007	8,362	1.23	1.18	1.67
7535	6,762	15,256	3,666	16,732	36,137	5,469	2.47	2.37	1.49
7537	8,139	20,724	11,906	14,105	33,099	20,908	1.73	1.60	1.76
7606	25,125	71,276	11,395	43,225	114,437	17,675	1.72	1.61	1.55
8000	4,249	11,562	28,533	7,032	17,257	39,805	1.66	1.49	1.40
8115	10,917	26,235	8,500	14,730	33,359	12,875	1.35	1.27	1.51
8125	6,132	15,822	4,297	7,928	18,745	6,609	1.29	1.18	1.54
8126	4,776	12,100	6,275	6,129	14,452	10,389	1.28	1.19	1.66
8210	3,942	9,387	16,650	6,342	14,051	28,067	1.61	1.50	1.69
8220	7,056	19,451	14,969	9,451	23,450	21,451	1.34	1.21	1.43
8406	24,499	69,364	12,973	43,407	113,571	16,802	1.77	1.64	1.30
8937	20,327	55,881	15,324	32,221	82,792	28,465	1.59	1.48	1.86
9020	10,466	26,497	3,606	13,319	32,578	3,793	1.27	1.23	1.05
9900	55,750	149,783	75,744	86,778	213,372	101,008	1.56	1.42	1.33
Regional Total	**533,982**	**1,336,023**	**541,917**	**786,547**	**1,847,953**	**807,085**	**1.47**	**1.38**	**1.49**

Source: Demographic forecasts shown in this table correspond to the latest version (dated February 3, 2004) posted at the PSRC website.

Table D2
Zonal Parking Costs for 2004 and 2030 (in 2004 Constant Dollars)

	Daily		Hourly	
TAZ	2004	2030	2004	2030
15	$0.00	$3.86	$0.00	$1.44
16	$0.00	$3.86	$0.00	$1.44
43	$2.94	$4.34	$1.79	$2.63
44	$2.94	$4.34	$1.79	$2.63
47	$0.00	$3.86	$0.00	$1.10
58	$3.76	$5.54	$2.34	$3.45
59	$3.76	$5.54	$2.34	$3.45
60	$3.83	$6.41	$1.09	$1.82
62	$2.94	$4.34	$1.06	$1.56
64	$3.76	$5.54	$2.34	$3.45
65	$3.76	$5.54	$2.34	$3.45
69	$4.71	$6.93	$2.34	$3.45
70	$4.82	$8.07	$2.40	$4.01
71	$9.05	$15.15	$3.86	$6.46
72	$9.65	$16.14	$2.67	$4.47
73	$12.04	$20.15	$2.67	$4.47
94	$7.05	$10.38	$2.61	$3.84
95	$3.43	$5.05	$1.79	$2.63
96	$7.05	$10.38	$2.20	$3.23
97	$4.34	$6.40	$2.10	$3.09
98	$7.89	$11.62	$1.62	$2.38
99	$5.89	$8.67	$3.02	$4.44
100	$9.10	$13.40	$3.28	$4.83
101	$5.91	$8.71	$4.22	$6.22
102	$13.15	$19.37	$3.52	$5.19
103	$1.79	$2.63	$1.09	$1.60
104	$8.01	$11.80	$2.03	$2.99
105	$2.24	$3.31	$0.65	$0.96
106	$11.17	$16.45	$2.85	$4.19
107	$5.32	$8.90	$2.40	$4.01
108	$5.59	$9.35	$2.40	$4.01
109	$5.74	$8.46	$2.34	$3.45
114	$3.40	$5.01	$0.60	$0.89
115	$3.49	$5.84	$1.83	$3.06
116	$9.63	$14.18	$4.08	$6.01
117	$13.47	$19.83	$4.75	$7.00
118	$6.37	$9.38	$2.36	$3.48
119	$8.98	$13.22	$3.62	$5.33
120	$14.07	$20.72	$5.04	$7.43
121	$17.98	$26.48	$5.96	$8.78
122	$17.08	$25.16	$5.16	$7.61
123	$10.11	$14.89	$3.19	$4.69
124	$13.15	$19.37	$6.90	$10.16
125	$14.31	$21.07	$4.46	$6.57
126	$21.28	$31.34	$6.59	$9.70
127	$12.89	$18.98	$4.37	$6.43
128	$12.23	$18.02	$4.80	$7.07
129	$9.03	$15.11	$3.09	$5.17
130	$9.50	$15.89	$2.18	$3.64
131	$11.99	$17.66	$3.76	$5.54

	Daily		Hourly	
TAZ	2004	2030	2004	2030
132	$18.07	$26.62	$3.64	$5.37
133	$21.69	$31.95	$5.55	$8.17
134	$16.12	$23.74	$4.97	$7.32
135	$17.18	$25.30	$6.27	$9.24
136	$14.36	$21.15	$3.50	$5.15
137	$6.18	$10.35	$0.77	$1.28
138	$12.14	$20.32	$1.81	$3.02
139	$8.98	$15.02	$1.81	$3.02
140	$10.91	$16.06	$2.73	$4.02
141	$7.20	$12.04	$2.28	$3.81
142	$7.02	$11.75	$2.42	$4.06
143	$9.22	$15.44	$1.85	$3.10
144	$4.65	$7.78	$2.62	$4.39
145	$14.60	$21.50	$4.95	$7.29
146	$4.25	$7.12	$2.40	$4.01
147	$3.35	$4.94	$1.54	$2.27
148	$3.35	$4.94	$1.54	$2.27
149	$3.35	$4.94	$1.54	$2.27
150	$3.35	$4.94	$1.54	$2.27
153	$3.35	$4.94	$1.54	$2.27
154	$2.63	$3.87	$1.06	$1.56
155	$8.95	$13.18	$2.80	$4.12
158	$1.42	$2.10	$1.16	$1.71
162	$8.33	$12.26	$2.99	$4.41
240	$0.00	$3.86	$0.00	$1.94
255	$0.00	$3.86	$0.00	$1.94
262	$0.00	$1.94	$0.00	$0.95
263	$0.00	$3.86	$0.00	$1.94
264	$0.00	$1.94	$0.00	$0.95
280	$0.00	$7.73	$0.00	$3.87
281	$0.00	$3.86	$0.00	$1.94
283	$10.01	$15.10	$1.77	$2.67
284	$10.81	$16.31	$0.75	$1.14
309	$0.00	$3.86	$0.00	$0.97
310	$0.00	$3.86	$0.00	$1.16
325	$0.00	$3.86	$0.00	$1.93
351	$0.00	$3.86	$0.00	$1.94
355	$12.46	$18.35	$4.22	$6.22
356	$0.00	$3.86	$0.00	$1.94
357	$0.00	$3.86	$0.00	$1.94
361	$0.00	$1.94	$0.00	$0.39
362	$0.00	$7.18	$0.00	$3.58
363	$0.00	$3.86	$0.00	$1.93
364	$0.00	$1.94	$0.00	$0.39
372	$0.00	$3.86	$0.00	$1.93
385	$0.00	$3.24	$0.00	$1.62
392	$0.00	$3.86	$0.00	$1.94
395	$0.00	$3.86	$0.00	$1.94
398	$0.00	$3.86	$0.00	$1.93
418	$4.03	$5.93	$1.18	$1.74

	Daily		Hourly	
TAZ	2004	2030	2004	2030
423	$0.00	$1.94	$0.00	$0.95
430	$0.00	$1.94	$0.00	$0.95
436	$0.00	$7.73	$0.00	$3.81
448	$0.00	$3.86	$0.00	$0.97
451	$0.00	$3.24	$0.00	$0.82
452	$0.00	$3.86	$0.00	$1.94
453	$0.00	$3.24	$0.00	$0.82
466	$0.00	$3.86	$0.00	$1.94
467	$0.00	$1.94	$0.00	$0.95
475	$0.00	$3.86	$0.00	$1.94
476	$0.00	$6.48	$0.00	$3.24
484	$11.08	$16.31	$0.77	$1.14
485	$10.26	$15.10	$1.81	$2.67
487	$12.46	$18.35	$4.22	$6.22
488	$0.00	$6.48	$0.00	$3.24
511	$0.00	$4.05	$0.00	$0.49
512	$2.75	$4.05	$0.34	$0.50
513	$2.75	$4.05	$0.34	$0.50
522	$0.00	$3.86	$0.00	$1.94
535	$0.00	$3.86	$0.00	$1.94
537	$0.00	$3.86	$0.00	$1.94
561	$0.00	$3.86	$0.00	$1.93
564	$0.00	$3.86	$0.00	$1.93
585	$0.00	$3.86	$0.00	$1.94
586	$0.00	$3.86	$0.00	$1.94
587	$0.00	$3.86	$0.00	$1.94
598	$0.00	$1.94	$0.00	$0.95
603	$0.00	$3.86	$0.00	$1.94
609	$1.08	$1.40	$0.54	$0.70
610	$1.08	$1.40	$0.54	$0.70
611	$1.08	$1.40	$0.54	$0.70
612	$1.11	$1.63	$0.56	$0.82
631	$5.48	$8.07	$0.56	$0.82
632	$5.48	$8.07	$0.56	$0.82
633	$3.28	$4.83	$0.56	$0.82
634	$3.28	$4.83	$0.56	$0.82
635	$6.03	$8.88	$1.33	$1.95
636	$6.03	$8.88	$1.33	$1.95
637	$6.03	$8.88	$1.33	$1.95
638	$6.03	$8.88	$1.33	$1.95
639	$0.00	$0.95	$0.00	$0.50
657	$0.00	$3.86	$0.00	$1.94
672	$0.00	$5.78	$0.00	$1.94
673	$0.00	$5.78	$0.00	$1.94
713	$0.00	$4.04	$0.00	$1.62
734	$0.00	$3.86	$0.00	$1.94
735	$0.00	$1.94	$0.00	$0.95
737	$0.00	$3.86	$0.00	$1.94