City of Kirkland

Request for Proposal

Comprehensive Impact Fee Update

Job # 17-20-FA

Issue Date: February 7, 2020
Due Date: March 4, 2020–5:00 p.m. (Pacific Time)

REQUEST FOR PROPOSALS

Notice is hereby given that proposals will be received by the City of Kirkland, Washington, for:

Comprehensive Impact Fee Update

File with Financial Operations Manager, Finance Department, 123 - 5th Ave, Kirkland WA, 98033

Proposals received later than **5:00 p.m. on March 4, 2020 will not** be considered.

A copy of this Request for Proposal (RFP) may be obtained from City's web site at http://www.kirklandwa.gov/. Click on the Business tab at the top of the page and then click on the Request for Proposals link found under "Doing Business with the City".

The City of Kirkland reserves the right to reject any and all proposals, and to waive irregularities and informalities in the submittal and evaluation process. This RFP does not obligate the City to pay any costs incurred by respondents in the preparation and submission of a proposal. Furthermore, the RFP does not obligate the City to accept or contract for any expressed or implied services.

A Service Provider response that indicates that any of the requested information in this RFP will only be provided if and when the Service Provider is selected as the apparently successful Service Provider is not acceptable, and, at the City's sole discretion, may disqualify the proposal from consideration.

The City of Kirkland assures that no person shall, on the grounds of race, color, national origin, or sex be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity. The City of Kirkland further assures that every effort will be made to ensure non-discrimination in all of its programs and activities, whether those programs are federally funded or not.

In addition to nondiscrimination compliance requirements, the Service Provider(s) ultimately awarded a contract shall comply with federal, state and local laws, statutes and ordinances relative to the execution of the work. This requirement includes, but is not limited to, protection of public and employee safety and health; environmental protection; waste reduction and recycling; the protection of natural resources; permits; fees; taxes; and similar subjects.

Dated this 7th day of February 2020

Greg Piland
Financial Operations Manager
425-587-3123

Background Information

The City of Kirkland, Washington is located in the Seattle metropolitan area, on the eastern shore of Lake Washington and approximately 10 miles east of downtown Seattle. It has a population of over 88,000 and is the thirteenth largest city in the State of Washington and the sixth largest city in King County, Washington.

Since its incorporation in 1905, Kirkland has grown in geographic size and now occupies 18 square miles. The city employs over 600 regular employees.

Kirkland operates under a Council-Manager form of government. The City Council is the policy-making branch of Kirkland's government and consists of seven members elected at large to staggered, four-year terms. The Mayor is elected from within the Council. The City Council is supported by several advisory boards and commissions and the City Manager. The City Manager is appointed by the City Council and serves as the professional administrator of the organization, coordinating its day-to-day activities.

Purpose of Request

The goal of the City's impact fee program is to create mechanisms to charge and collect fees to ensure that development bears its proportionate share of the capital facility and improvement costs necessitated by development. The City of Kirkland ("City") is requesting proposals from qualified firms to perform a comprehensive impact fee update including analysis, review and recommendation based upon the scope of services contained in this Request for Proposal ("RFP"). The intent is to select one firm to perform the tasks associated with the RFP, but a firm may propose a team approach for completing the comprehensive impact fee update with one firm being named the primary consultant responsible for contracting and overall scope performance.

Scope of Services and Desired Qualifications

The City is seeking a qualified consultant to support an update to its impact fee program. Specifically, the successful proposer will:

a) use the existing parks impact fee methodology to develop a parks impact fee study and provide an option to assess fees on non-residential uses;
b) use the existing transportation impact fee methodology to develop a transportation impact fee study; and
c) develop an impact fee methodology to develop a fire impact fee study and assess the feasibility of implementing the resulting fire impact fee.

In each program area, the successful proposer will update all assumptions and information, and provide fee study outcomes in a manner supporting general public review, policy discussions and city council decision making.

Parks: Utilizing the methodology described in the 2015 Parks, Recreation and Open Space Plan and 2015 rate study (Attachment C in Background Document 2 below) and requirements

outlined in Municipal Code 27.06, conduct a park impact fee rate study that will allow the City to approve updated park impact fees. The study should include assessing and updating all information needed to recalculate the park impact fee formula based on the current methodology. The study should provide an update of the current fees assessed on residential developments. The proposer shall propose an option for expanding application of the fee to non-residential development.

Transportation: Utilizing the methodology described in the City of Kirkland Transportation Impact Fee Update Rate Study from October 2015 (Attachment A in Background Document 2 below) and requirements outlined in Municipal Code 27.04, conduct a transportation impact fee rate study that will allow the City to approve updated transportation impact fees. The study should include assessing and updating all information needed to recalculate the transportation impact fee formula based on the current multimodal methodology. The consultant shall use the BKR Transportation Model (see Background Document 6 below) to establish travel forecasts and trip patterns (based on land use data and the future transportation network) including a select link analysis. The study should base transportation impact fees on projects that add capacity for new person trips. The most updated and approved land use plan shall be used for the transportation impact fee rate study. All land use and traffic model assumptions shall be documented for Public Works staff review. The consultant shall verify that the land use within the BKR Transportation Model is updated and verify that the transportation analysis zones (TAZ) are coded correctly. Provide an updated impact fee schedule spreadsheet using the land use types and trip generation rates from ITE's 10th Edition Trip Generation Handbook and other national data. The City applies its impact fee schedule citywide.

Fire: Conduct a fire impact fee rate study that will allow the City to consider implementing fire impact fees. The study should include assessing all information needed to calculate a fire impact fee using a methodology that satisfies the requirements of the law. The study should evaluate the feasibility of applying fire impact fees to both to residential and non-residential developments.

Parks, Transportation, and Fire:

Proposers will meet with City staff to review and evaluate current data and methodology; identify specific changes to the Kirkland Municipal Code that may be needed for the impact fee; estimate potential revenue from the updated impact fee; brief City staff and assist in reviewing the proposed rate study, ordinance (written by City staff), and revenue forecast; and present and participate in discussions about the updated impact fee, ordinance, and revenue forecast at up to six public meetings (possibly 2 with City Council, 1 with Park Board, 1 with Transportation Commission and 2 for other groups as need).

Deliverables to include (in electronic and hard copy format):

- Data tables with raw data, calculations, sources, and links
- Fee schedule
- Revenue forecasts
- Impact fee study report outlining calculations and methodology, including spreadsheets and other document as appendices
- Presentation in Microsoft PowerPoint format
- Any items specific to the particular impact fee included above.

Background Documents

1. Impact fee rate studies and related issues – September 15, 2015
2. Impact fee update adoption – November 17, 2015
3. Impact fees, Concurrency, and CIP – May 23, 2018
4. Kirkland Comprehensive Plan
5. Kirkland Parks, Recreation & Open Space Plan
6. BKR Transportation Model (Attachment B)

Minimum Qualifications/Requirements

- Years conducting governmental impact fee studies.
- Information describing bidders background and experience with work related to the scope of work.
- Relevant sample work products.
- Professional references.

Length of Contract

The initial length of the contract will be through December 31, 2020, however, draft results are due to the City no later than 7/31/2020 with adoption on or before 12/08/2020. At the sole discretion of the City, this contract may be extended for up to three additional years for subsequent updates.

Evaluation Process and Selection of Proposals

Proposals will be evaluated on the basis of both the firm(s) and individual team member's experience and expertise on similar projects, as well as upon the team/firm's capacity (personnel and other resources) to complete the project within the proposed schedule. Factors that will be considered in the evaluation of the Scope of Work submitted will include:

1. Responsiveness of the written proposal to the purpose and scope of services;
2. Qualifications of key individuals in terms of what personnel will be committed to this project and what their qualifications are in producing the end product;
3. Cost/Budget;
4. Ability and history of successfully completing contracts of this type, meeting projected deadlines and experience in similar work;
5. Successful and timely public presentation of results.

The City will make a selection based on the evaluation of the written proposals and interviews. The City may elect to interview some or all proposers. The City reserves the right to make a selection based only on the evaluation of the written proposals. Written proposals and interviews will be evaluated based on the following criteria:

- Experience/suitability criteria – 40%

- Methodology – 40%
- References and professional expertise – 20%

A selection committee will evaluate each submitted written proposal and each interview (if necessary), to determine the responsible proposer whose proposal is most advantageous to the City based on the evaluation process and evaluation criteria outlined in this RFP. The City will award the contract to the highest ranked responsive proposer.

It is anticipated that the contract will be an hourly rate with a not to exceed maximum amount. A cost proposal is required as part of the submission. During the final selection process, the City will discuss available project funds and a firm scope of work that will obtain the City's objectives within the funds available.

Submission Criteria

All proposals must include the following items as described in the scope of work:

- Submit information describing proposer's background and experience with work related to the scope of work, including years conducting governmental impact fee studies.
- Submit relevant sample work products.
- Submit professional references.

Submission Instructions

Proposals must be received by no later than **5:00 pm PDT on March 4, 2020.**
We encourage that proposals be submitted by email. Emailed proposals should include "Proposal-Job #17-20-FA" in the subject line and be addressed to: purchasing@kirklandwa.gov. (Emailed proposals must be in PDF format and cannot exceed 20MB).

As an alternate to email, proposals can be mailed or delivered to:

City of Kirkland
Attn: Greg Piland – Job #17-20-FA
123 5th Avenue
Kirkland, WA 98033

If submitting a paper proposal, the original plus four (4) copies of all proposals in printed form must be submitted in a sealed envelope or box with the following words clearly marked on the outside of the envelope, Comprehensive Impact Fee Update. The supplier's name and address must be clearly indicated on the envelope.

Proposals should be prepared simply and economically, providing a straightforward, concise description of provider capabilities to satisfy the requirements of the request. Special bindings, colored displays, promotional materials, etc. are not required or desired. Emphasis should be on completeness and clarity of content. Use recycled paper for responses and any printed or

photocopied material created pursuant to a contract with the City whenever practicable. Use both sides of the paper for any submittal to the City whenever practicable.

Submittal Deadlines

February 7, 2020	Release RFP
February 19, 2020	Proposer questions due
February 26, 2020	Answers to RFP questions posted on website
March 4, 2020	Proposals Due by 5:00 PM PDT
March 18, 2020	Notify proposers of interviews
March 30 through April 1, 2020	Interviews
April 6, 2020	Notify selected proposer
April 13,2020	Contract negotiation/preparation/signature
April 20, 2020	Anticipated start work date
July 31, 2020	Delivery of update draft results
No later than December 08, 2020	Delivery of final report and adoption of fees

Questions

Upon release of this RFP, all proposer communications concerning the RFP should be directed to the City's RFP Coordinator listed below via email. Unauthorized contact regarding this RFP with any other City employees may result in disqualification. Any oral communications will be considered unofficial and non-binding on the City. Service Providers should rely only on written statements issued by the RFP Coordinator. The City's RFP Coordinator for this project is:

Name:	Greg Piland
Address:	City of Kirkland, Finance and Administration 123 5th Avenue, Kirkland, Washington 98033
E-mail:	gpiland@kirklandwa.gov

Terms and Conditions

1. The City reserves the right to request clarification of information submitted, and to request additional information on any proposal.

2. The City reserves the right to award any contract to the next most qualified agency, if the successful agency does not execute a contract within 30 days of being notified of selection.

3. Any proposal may be withdrawn up until the date and time set above for opening of the proposals. Any proposal not so timely withdrawn shall constitute an irrevocable offer, for a period of one hundred and twenty (120) days to sell to the City the services described in the attached specifications, or until one or more of the proposals have been approved by the City administration, whichever occurs first.

4. The contract resulting from acceptance of a proposal by the City shall be in a form supplied or approved by the City and shall reflect the specifications in this RFP. A copy of the City's standard Professional Services Agreement is available for review (see attachment A). The City reserves the right to reject any proposed agreement or contract that does not conform to the specifications contained in this RFP and which is not approved by the City Attorney's office.

5. The City shall not be responsible for any costs incurred by the agency in preparing, submitting or presenting its response to the RFP.

6. Any material submitted by a proposer shall become the property of the City. Materials submitted after a contract is signed will be subject to the ownership provision of the executed contract.

7. All proposals and information submitted by proposers shall be public records and subject to disclosure pursuant to the Washington Public Records Act (RCW 42.56.270)

8. The selected proposer will be required to obtain a City business license.

9. The firm and all applicable personnel must be legally qualified in the State of Washington (i.e. be appropriately licensed or certified) to practice the work proposed to be performed.

10. Proposers responding to this RFP must follow the procedures and requirements stated in the RFP document. Adherence to the procedures and requirements of this RFP will ensure a fair and objective analysis of your proposal. Failure to comply with or complete any part of this RFP may result in rejection of your proposal.

11. Chapter 39.34 RCW allows cooperative purchasing between public agencies in the State of Washington. Public agencies which have filed an Intergovernmental Cooperative Purchasing Agreement with the City may purchase from City contracts, provided that the consultant agrees to participate. The City does not accept any responsibility for contracts issued by other public agencies, however.

12. Once submitted to the City, proposals shall become the property of the City, and all proposals shall be deemed a public record as defined in "The Public Records Act," chapter 42 section 56 of the RCW. Any proposal containing language which copyrights the proposal, declares the entire proposal to be confidential, declares that the document is the exclusive property of the proposer, or is any way contrary to state public disclosure laws or this RFP, could be removed from consideration. The City will not accept the liability of determining what the proposer considers proprietary or not. Therefore, any information in the proposal that the proposer claims as proprietary and exempt from disclosure under the provisions of RCW

42.56.270 must be clearly designated as described in the "Proprietary Material Submitted" section above. It must also include the exemption(s) from disclosure upon which the proposer is making the claim, and the page it is found on must be identified. With the exception of lists of prospective proposers, the City will not disclose RFP proposals until a bid selection is made. At that time, all information about the competitive procurement will be available with the exception of: proprietary/confidential portion(s) of the proposal(s), until the proposer has an adequate opportunity to seek a court order preventing disclosure. The City will consider a proposer's request for exemption from disclosure; however, the City will make a decision predicated upon RCW 42.56.

PROFESSIONAL SERVICES AGREEMENT **Attachment A**

Comprehensive Impact Fee Update

The City of Kirkland, Washington, a municipal corporation ("City") and _____, whose address is _____ ("Consultant"), agree and contract as follows:

I. SERVICES BY CONSULTANT

A. The Consultant agrees to perform the services described in Attachment ____ to this Agreement, which attachment is incorporated herein by reference.

B. All services and duties shall be conducted and performed diligently, completely and in accordance with professional standards of conduct and performance.

II. COMPENSATION

A. The total compensation to be paid to Consultant for these services shall not exceed $_____, as detailed in Attachment _____.

B. Payment to Consultant by the City in accordance with the payment ceiling specified above shall be the total compensation for all services performed under this Agreement and supporting documents hereto as well as all subcontractors' fees and expenses, supervision, labor, supplies, materials, equipment or the use thereof, reimbursable expenses, and other necessary incidentals.

C. The Consultant shall be paid monthly on the basis of invoices submitted. Invoicing will be on the basis of percentage complete or on the basis of time, whichever is applicable in accordance with the terms of this Agreement.

D. The City shall have the right to withhold payment to Consultant for any services not completed in a satisfactory manner until such time as Consultant modifies such services to the satisfaction of the City.

E. Unless otherwise specified in this Agreement, any payment shall be considered timely if a warrant is mailed or is available within 45 days of the date of actual receipt by the City of an invoice conforming in all respects to the terms of this Agreement.

III. TERMINATION OF AGREEMENT

The City or the Consultant may terminate this Agreement at any time, with or without cause, by giving ten (10) days' notice to the other in writing. In the event of termination, all finished or unfinished reports, or other material prepared by the Consultant pursuant to this Agreement, shall be provided to the City. In the event the City terminates prior to completion without cause, consultant may complete such analyses and records as may be necessary to place its files in order. Consultant shall be entitled to receive just and equitable compensation for any satisfactory services completed on the project prior to the date of termination, not to exceed the payment ceiling set forth above.

IV. OWNERSHIP OF WORK PRODUCT

A. Ownership of the originals of any reports, data, studies, surveys, charts, maps, drawings, specifications, figures, photographs, memoranda, and any other documents which are developed, compiled or produced as a result of this Agreement, whether or not completed, shall be vested in the City. Any reuse of these materials by the City for projects or purposes other than those which fall within the scope of this Agreement or the project to which it relates, without written concurrence by the Consultant will be at the sole risk of the City.

B. The City acknowledges the Consultant's plans and specifications as instruments of professional service. Nevertheless, the plans and specifications prepared under this Agreement shall become the property of the City upon completion of the services. The City agrees to hold harmless and indemnify consultant against all claims made against Consultant for damage or injury, including defense costs, arising out of any reuse of such plans and specifications by any third party without the written authorization of the Consultant.

C. Methodology, materials, software, logic, and systems developed under this Agreement are the property of the Consultant and the City, and may be used as either the consultant or the City sees fit, including the right to revise or publish the same without limitation.

V. GENERAL ADMINISTRATION AND MANAGEMENT

The _____ for the City of Kirkland shall review and approve the Consultant's invoices to the City under this Agreement, shall have primary responsibility for overseeing and approving services to be performed by the Consultant, and shall coordinate all communications with the Consultant from the City.

VI. COMPLETION DATE

The estimated completion date for the Consultant's performance of the services specified in Section I is _____.

Consultant will diligently proceed with the services contracted for, but consultant shall not be held responsible for delays occasioned by factors beyond its control which could not reasonably have been foreseen at the time of the execution of this Agreement. If such a delay arises, Consultant shall forthwith notify the City.

VII. SUCCESSORS AND ASSIGNS

The Consultant shall not assign, transfer, convey, pledge, or otherwise dispose of this Agreement or any part of this Agreement without prior written consent of the City.

VIII. NONDISCRIMINATION

Consultant shall, in employment made possible or resulting from this Agreement, ensure that there shall be no unlawful discrimination against any employee or applicant for employment in violation of RCW 49.60.180, as currently written or hereafter amended, or other applicable law prohibiting discrimination, unless based

upon a bona fide occupational qualification as provided in RCW 49.60.180 or as otherwise permitted by other applicable law. Further, no person shall be denied or subjected to discrimination in receipt of the benefit of any services or activities made possible by or resulting from this Agreement in violation of RCW 49.60.215 or other applicable law prohibiting discrimination.

IX. HOLD HARMLESS/INDEMNIFICATION

To the greatest extent allowed by law the Consultant shall defend, indemnify and hold the City, its officers, officials, employees and volunteers harmless from any and all claims, injuries, damages, losses or suits including attorney fees, arising out of or resulting from its negligence or breach of any of its obligations in performance of this Agreement.

In the event of liability for damages arising out of bodily injury to persons or damages to property caused by or resulting from the concurrent negligence of the Consultant and the City, its officers, officials, employees, and volunteers, the Consultant's liability hereunder shall be only to the extent of the Consultant's negligence. It is further specifically and expressly understood that the indemnification provided herein constitutes the Consultant's waiver of immunity under Industrial Insurance, Title 51 RCW, solely for the purposes of this indemnification. This waiver has been mutually negotiated by the parties. The provisions of this section shall survive the expiration or termination of this Agreement.

X. LIABILITY INSURANCE COVERAGE

The Consultant shall procure and maintain for the duration of the Agreement, insurance against claims for injuries to persons or damage to property which may arise from or in connection with the performance of the work hereunder by the Consultant, its agents, representatives, or employees. A failure to obtain and maintain such insurance or to file required certificates and endorsements shall be a material breach of this Agreement.

Consultant's maintenance of insurance as required by the agreement shall not be construed to limit the liability of the Consultant to the coverage provided by such insurance, or otherwise limit the City's recourse to any remedy available at law or in equity.

A. Minimum Scope of Insurance

Consultant shall obtain insurance of the types described below:

1. Automobile Liability insurance covering all owned, non-owned, hired and leased vehicles. Coverage shall be as least as broad as Insurance Services Office (ISO) form CA 00 01 or a substitute form providing equivalent liability coverage. If necessary, the policy shall be endorsed to provide contractual liability coverage.

2. Commercial General Liability insurance shall be as least as broad as ISO occurrence form CG 00 01 and shall cover liability arising from premises, operations, stop-gap independent contractors and personal injury and advertising injury. The City shall be named as an additional insured under the Consultant's Commercial General Liability insurance policy with respect

to the work performed for the City using an additional insured endorsement at least as broad as ISO CG 20 26.

3. Workers' Compensation coverage as required by the Industrial Insurance laws of the State of Washington.

4. Professional Liability insurance appropriate to the Consultant's profession.

B. **Minimum Amounts of Insurance**

Consultant shall maintain the following insurance limits:

1. Automobile Liability insurance with a minimum combined single limit for bodily injury and property damage of $1,000,000 per accident.

2. Commercial General Liability insurance shall be written with limits no less than $1,000,000 each occurrence, $2,000,000 general aggregate.

3. Professional Liability insurance shall be written with limits no less than $1,000,000 per claim and $1,000,000 policy aggregate limit.

C. **Other Insurance Provisions**

The insurance policies are to contain, or be endorsed to contain, the following provisions for Automobile Liability and Commercial General Liability insurance:

1. The Consultant's insurance coverage shall be primary insurance as respects the City. Any insurance, self-insurance, or self-insured pool coverage maintained by the City shall be excess of the Consultant's insurance and shall not contribute with it.

2. The Consultant shall provide the City and all Additional Insureds for this services with written notice of any policy cancellation, within two business days of their receipt of such notice.

D. **Acceptability of Insurers**

Insurance is to be placed with insurers with a current A.M. Best rating of not less than A:VII.

E. **Verification of Coverage**

Consultant shall furnish the City with original certificates and a copy of the amendatory endorsements, including but not necessarily limited to the additional insured endorsement, evidencing the insurance requirements of the Consultant before commencement of the services.

F. **Failure to Maintain Insurance**

Failure on the part of the Consultant to maintain the insurance as required shall constitute a material breach of contract, upon which the City may, after giving five business days' notice to the Consultant to correct the breach, immediately

terminate the contract or, at its discretion, procure or renew such insurance and pay any and all premiums in connection therewith, with any sums so expended to be repaid to the City on demand, or at the sole discretion of the City, offset against funds due the Consultant from the City.

G. **City Full Availability of Consultant Limits**

If the Consultant maintains higher insurance limits than the minimums shown above, the City shall be insured for the full available limits of Commercial General and Excess or Umbrella liability maintained by the Consultant, irrespective of whether such limits maintained by the Consultant are greater than those required by this contract or whether any certificate of insurance furnished to the City evidences limits of liability lower than those maintained by the Consultant.

XI. COMPLIANCE WITH LAWS/BUSINESS LICENSE

The Consultant shall comply with all applicable State, Federal, and City laws, ordinances, regulations, and codes. Consultant must obtain a City of Kirkland business license or otherwise comply with Kirkland Municipal Code Chapter 7.02.

XII. FUTURE SUPPORT

The City makes no commitment and assumes no obligations for the support of Consultant activities except as set forth in this Agreement.

XIII. INDEPENDENT CONTRACTOR

Consultant is and shall be at all times during the term of this Agreement an independent contractor and not an employee of the City. Consultant agrees that he or she is solely responsible for the payment of taxes applicable to the services performed under this Agreement and agrees to comply with all federal, state, and local laws regarding the reporting of taxes, maintenance of insurance and records, and all other requirements and obligations imposed on him or her as a result of his or her status as an independent contractor. Consultant is responsible for providing the office space and clerical support necessary for the performance of services under this Agreement. The City shall not be responsible for withholding or otherwise deducting federal income tax or social security or for contributing to the state industrial insurance of unemployment compensation programs or otherwise assuming the duties of an employer with respect to the Consultant or any employee of Consultant.

XIV. EXTENT OF AGREEMENT/MODIFICATION

This Agreement, together with all attachments and addenda, represents the final and completely integrated Agreement between the parties regarding its subject matter and supersedes all prior negotiations, representations, or agreements, either written or oral. This Agreement may be amended only by written instrument properly signed by both parties.

XV. ADDITIONAL WORK

The City may desire to have the Consultant perform work or render services in connection with the project other than provided for by the express intent of this

Agreement. Any such work or services shall be considered as additional work, supplemental to this Agreement. This Agreement may be amended only by written instrument properly signed by both parties.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement on the dates written below:

CONSULTANT:	CITY OF KIRKLAND:
By: _____	By: _____ Tracey Dunlap, Deputy City Manager
Date:_____	Date: _____

1.1.1.1.1 Header 1

BKR Travel Demand Model Report

Prepared by

Modeling and Analysis Group
Transportation Department
City of Bellevue, WA

December 2011

CONTENTS

ACKNOWLEDGMENT VIII

1 INTRODUCTION 1

2 MODEL STRUCTURE 3

2.1 IDENTIFICATION OF MODEL REQUIREMENTS 3
2.2 MODEL STRUCTURE 3

3 TAZ SYSTEM AND NETWORKS 12

3.1 TAZ SYSTEM 12
3.2 DISTRICT SYSTEMS 13
3.3 HIGHWAY NETWORK 19
3.4 TOLLING AND HOT LANES 22
3.5 TRANSIT NETWORK 24
3.5.1 Transit Route Coding 24
3.5.2 Transit Walk Access Coding 27
3.5.3 Park-and-Ride Coding 28

4 DATA SOURCES 30

4.1 PSRC HOUSEHOLD TRAVEL SURVEY 30
4.1.1 Survey Data Preparation 30
4.2 INPUT DATA 31
4.2.1 Land Use and Socioeconomic Data for Trip Generation (by TAZ) 31
4.2.2 Special Trip Generators 32
4.2.3 Travel Time Data 32
4.2.4 Mode Choice Variables 32
4.2.5 Transit Route/Network Data 33
4.2.6 Auto Network Update 33

5 MODEL COMPONENTS 36

5.1 PRE-GENERATION 36
5.1.1 Create Land Use Vectors (lumf2mo.mac) 37
5.1.2 Create Household Data for Trip Generation (tg_hh.mac) 39
5.1.3 Create Employment Data for Trip Generation (emploagg_800zones.mac) 40
5.1.4 Add New Households for Trip Generation (add-hh-new.mac) 42
5.1.5 Add New Employment for Trip Generation (add-emp-new.mac) 44
5.1.6 Add College Enrollment for Trip Generation (add_FTE.mac) 46
5.1.7 Check HH, Employment Data for Trip Generation (mf24lu-chk.mac) 47
5.2 TRIP GENERATION 49
5.2.1 Internal Trip Generation 49
5.2.2 External Trip Generations 52
5.2.3 Special Generator 52

DRAFT

5.2.4 Trip Generation Model (generate.mac) 54
5.2.5 Change Production/Attraction Format (change.mac) 57
5.2.6 Combine Productions/Attractions (combine.mac) 59
5.2.7 Aggregate Non-BKR Area Productions/Attractions (ensemble_2010.mac) 61
5.3 AUTO SKIMS 64
5.3.1 Create Extra Attributes for SOV, HOV Volumes (extra-attr.mac) 65
5.3.2 Create AM Peak Hour Auto Skims (am0mcskim1_tollhov2.mac and am_mcskim1_tollhov2.mac) 67
5.3.3 Revise AM Peak Hour Auto Skims (am_mcskim2.mac) 69
5.3.4 Create Composite AM Peak Hour Auto Skims (am_mcskim3.mac) 70
5.3.5 Create Mid-day Auto Skims (md0mcskim1_tollhov2.mac and md_mcskim1_tollhov2.mac) 71
5.3.6 Revise Mid-day Auto Skims (md_mcskim2.mac) 73
5.3.7 Create Composite Mid-day Auto Skims (md_mcskim3.mac) 74
5.3.8 Add Intrazonal Times and Distances to Auto Skims (dist_tt.mac) 75
5.3.9 Calculate Average Auto Time and Distance Skims (avg_mcskim.mac) 77
5.3.10 Save Auto Skims for Trip Distribution (save0mcskim.mac and save_mcskim.mac) 79
5.4 TRIP DISTRIBUTION 80
5.4.1 Travel Time Impedance 80
5.4.2 Balancing Trip Attractions to Trip Productions 81
5.4.3 Home-Based Work Trip Distribution Model (hbw_dist.mac) 82
5.4.4 Home-Based Other Trip Distribution Model (hbo_dist.mac) 85
5.4.5 Non-Home-Based Trip Distribution Model (nhb_dist.mac) 87
5.4.6 Home-Based School Trip Distribution Model (sch_dist.mac) 89
5.5 TRANSIT SKIMS 92
5.5.1 Create AM Peak Hour Transit Skims (amtrnhdw.mac) 93
5.5.2 Calculate Initial AM Peak Hour Effective Headways (effhdwy0.mac) 95
5.5.3 Perform AM Peak Hour Transit Assignment (amtranhw.mac) 96
5.5.4 Calculate AM Peak Hour Capacity Constrained Headways (effhdwy.mac) 98
5.5.5 Calculate AM Peak Hour Park-and-Ride Skims (ampkrskm2.mac) 100
5.5.6 Create Mid-day Transit Trip Table (mdpktran.mac) 103
5.5.7 Perform Mid-day Transit Assignment (md-tran-asgn.mac) 104
5.5.8 Calculate Total Transit Impedances (trans-imp.mac) 106
5.5.9 Calculate Average Transit Impedances (avg_transkim.mac) 108
5.5.10 Save Total Transit Impedances (save_transkim.mac) 110
5.6 MODE CHOICE 111
5.6.1 HBW Mode Choice Model 113
5.6.2 HBO Mode Choice Model 114
5.6.3 NHB Mode Choice Model 115
5.6.4 SOV/LOV/HOV Split 116

5.6.5 Home-Based Work Mode Choice Model (hbw_mc.mac) 117
5.6.6 Split HBW Transit Park-and-RIde Trips (prsplit_RA.mac) 119
5.6.7 Home-Based Other Mode Choice Model (hbo_mc.mac) 120
5.6.8 Non-Home-Based Mode Choice Model (nhb_mc.mac) 122
5.7 TIME-OF-DAY 124
5.7.1 Create AM Peak SOV, LOV, and HOV Trip Tables (run_slhov.mac) 126
5.7.2 Create Daily Person Trip Tables for SOV/LOV/HOV (slov_tt.mac) 127
5.7.3 Create Extra Link Attributes for SOV/LOV/HOV (slhov_extra.mac) 129
5.7.4 Create SOV/LOV/HOV Auto Trip Table for PM Peak Hour (pmslhov.mac) 130
5.7.5 Create SOV/LOV/HOV Auto Trip Table for MD Peak Hour (mdslhov.mac) 132
5.7.6 Create SOV/LOV/HOV Auto Trip Table for AM Peak Hour (amslhov.mac) 134
5.7.7 Create AM Peak Hour HOV2+ Trip Table (am2pr+hov.mac) 136
5.7.8 Create Mid-Day Peak Hour HOV2+ Trip Table (md2pr+hov.mac) 137
5.7.9 Create AM Peak Hour LOV and HOV3+ Trip Table (am3pr+hov3c.mac) ... 138
5.7.10 Create Mid-Day Peak Hour LOV + HOV3+ Trip Table (md3pr+hov3c.mac) 139
5.7.11 Create PM Peak Hour LOV + HOV3+ Trip Table (pm3pr+hov3c.mac) 140
5.7.12 Create AM Peak Hour Transit Trip Tables (ampktran.mac) 141
5.7.13 Create PM Peak Hour Transit Trip Tables (pmpktran.mac) 143
5.8 TRIP ASSIGNMENT 145
5.8.1 Auto Assignment Procedures 145
5.8.2 Perform AM Peak Hour Auto Assignment (am_assign_3c.mac) 146
5.8.3 Perform Mid-day Auto Assignment (md_assign_3c.mac) 147
5.8.4 Perform PM Peak Hour Auto Assignment (pm_assign_3c.mac) 148
5.8.5 Create PM Peak Hour Transit Skim (pmtrnhdw.mac) 149
5.8.6 Perform PM Peak Hour Transit Assignment (pmtranhw.mac) 151
5.8.7 Perform Walk and Bicycle Assignments (walkbike.mac) 153

6 MODEL CALIBRATION AND VALIDATION 154

6.1 MODEL CALIBRATION 154
6.1.1 Trip Generation Model 154
6.1.2 Trip Distribution Model 155
6.1.3 Mode Choice Model 162
6.2 MODEL VALIDATION 164

7 MODEL APPLICATION 176

7.1 PREPARATION OF MODEL INPUT DATA 176
7.1.1 Land Use Input Procedure 176
7.1.2 Cross-classification Trip Generation Model Procedure 177
7.1.3 Network Data 180
7.1.4 Transit Data 180
7.1.5 Toll 181
7.1.6 Special Generator 181

7.2 MODEL PROCESSING 181
7.3 POST-PROCESSING 182

APPENDIX A PSRC-BKR TAZ EQUIVALENCY 185

APPENDIX B EMME MACRO FLOW CHART 191

APPENDIX C METHODOLOGY FOR IMPLEMENTING SOV, LOV, AND HOV APPLIED TO CITY OF BELLEVUE BKR 2020 AND 2030 MODELS 196

APPENDIX D MACRO CALL HIERARCHY 206

APPENDIX E POST-PROCESSING ALGORITHM.....212

DRAFT

List of Figures

Figure 2-1 BKR Travel Demand Model Process 7
Figure 2-2 BKR Model Platforms 8
Figure 2-3 BKR Model Application Processing 9
Figure 3-1 BKR Model TAZ System (the Whole Region) 15
Figure 3-2 BKR Model TAZ System (the BKR Area) 16
Figure 3-3 BKR Model Subarea by Jurisdictional Boundaries and Fringe Area 17
Figure 3-4 City of Bellevue Mobility Management Area (MMA) 18
Figure 3-5 Sample EMME Transit Line Batchin File 26
Figure 3-6 Transit Walk Access AM and PM Peak Coding 27
Figure 3-7 2030 Park and Ride Lot Coding 28
Figure 6-1 Calibrated Friction Factors by Trip Purpose 157
Figure 6-2 MP0R12 HBW Trip Duration Histogram 160
Figure 6-3 MP0R12 HBSchool Trip Duration Histogram 160
Figure 6-4 MP0R12 HBO Trip Duration Histogram 161
Figure 6-5 MP0R12 NHB Trip Duration Histogram 161
Figure 6-6 2010 MP0R12 Model PM Peak Hour Screenlines for Auto Traffic 171
Figure 6-7 Correlation between Model Estimate and Observed Auto Traffic Volumes 172

DRAFT

List of Tables

Table 3-1 BKR Model Subarea TAZs 12
Table 3-2 Zone Partitions in 2010 MP0R12 13
Table 3-3 City of Bellevue Mobility Management Area 14
Table 3-4 Node Attributes 19
Table 3-5 Link Attributes 19
Table 3-6 Link Capacity Look-Up Table 20
Table 3-7 Weight Factors for Toll 23
Table 3-8 Transit Line Coding Keywords 24
Table 3-9 Transit Time Functions by Facility Type 25
Table 3-10 2030 Park and Ride Capacity 29
Table 4-1 Land Use Data 31
Table 4-2 Socioeconomic Data 31
Table 4-3 Special Generators in MP0R12 (2010) 32
Table 4-4 Model Choice Variables for the BKR Base Year Model (mp0r12) 33
Table 4-5 BKR Model Input 34
Table 5-1 BKR Production and Attraction Trip Rates in mf09 49
Table 5-2 Update BKR Trip Attraction Rates 50
Table 5-3 Original PSRC and Updated BKR Trip Production Rates 51
Table 5-4 Production and Attraction from PSRC Model 52
Table 5-5 Mode Choice Model Matrices and Coefficients 111
Table 5-6 Mode Choice Model Matrices and Coefficients 112
Table 5-7 BKR Time-of-Day Factors by Purpose and Direction 124
Table 5-8 MP0R12 Motorized Person Trip Totals by Time-of-Day 125
Table 6-1 MP0R12 Trip Production Calibration for the BKR Study Area 155
Table 6-2 MP0R12 Trip Attraction Calibration for the BKR Study Area 155
Table 6-3 Calibrated Parameters for the Friction Factor Gamma Function 156
Table 6-4 Averaged Trip Duration by Purpose (Region-Wide) 157
Table 6-5 Averaged Trip Duration by Purpose (BKR Area) 158
Table 6-6 Averaged Trip Length by Purpose (Region-Wide) 158
Table 6-7 Averaged Trip Duration by Purpose (BKR Area) 158
Table 6-8 Percent of Trips to and from Each Super-District 159
Table 6-9 2010 MP0R12 Mode Choice Results (Region-Wide) 162
Table 6-10 2010 MP0R12 Mode Choice Results (BKR Area) 162
Table 6-11 2010 MP0R12 Mode Share for Bellevue Downtown 163
Table 6-12 2010 MP0R12 Mode Share by Time-of-Day 163
Table 6-13 2010 MP0R12 Model PM Peak Hour Screenline Summary by Region 164
Table 6-14 2010 MP0R12 Model PM Peak Hour Screenline Summary - Boundary 165
Table 6-15 2010 MP0R12 Model PM Peak Hour Screenline Summary - Regional 165
Table 6-16 2010 MP0R12 Model PM Peak Hour Screenline Summary - Redmond 166
Table 6-17 2010 MP0R12 Model PM Peak Hour Screenline Summary - Bellevue 166
Table 6-18 2010 MP0R12 Model PM Peak Hour Screenline Summary - Overlake 167

Table 6-19 2010 MP0R12 Model PM Peak Hour Screenline Summary – Freeway GP Lanes 167
Table 6-20 2010 MP0R12 Model PM Peak Hour Screenline Summary – Freeway HOV Lanes 169
Table 6-21 2010 MP0R12 Model PM Peak Hour Screenline Summary – Freeway 170
Table 6-22 2010 MP0R12 Model PM Peak Hour Screenline Summary – Arterial..... 170
Table 6-23 MP0R12 Model PM Peak Hour Transit Screenline Summary..... 170
Table 6-24 2010 MP0R12 Model PM Peak Hour Screenline Summary by Functional Class .....**Error! Bookmark not defined.**
Table 6-25 2010 MP0R12 Model PM Peak Hour Screenline Summary by Jurisdiction 172
Table 7-1 Land Use Data Input Format 176
Table 7-2 Land Use Data Aggregated by Jurisdictions for Error Checking..... 177
Table 7-3 Household Cross-classification Data Format Used in the PSRC Regional Travel Forecast Model 178
Table 7-4 Household Cross-classification Data Format Used in BKR Model 178
Table 7-5 BKR Employment Data Format and Conversion into PSRC Employment Type 179
Table 7-6 Output from mf24-lu.mac, Aggregated by Jurisdictions..... 180
Table 7-7 File Format for the Toll Table 181

DRAFT

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1 Introduction

In 1986, Bellevue staff built the Bellevue travel demand forecasting model by consulting with DKS Associates, Inc. --- creating the first generation of Bellevue Model.

The BKR Model is shorthand for the Bellevue-Kirkland-Redmond travel demand forecasting model, which was built in 1991 by Bellevue staff and RAO Associates with cooperation and support of the other two cities --- the second generation of the BKR Model. The original model was based on the late 80s travel survey characteristics in the Puget Sound region. Since then, Bellevue staff has taken the lead in annually revalidating base year model platform (MP-0) using traffic count survey data. In addition to the MP-0 base year model used by all three cities, Bellevue built a 6-year model for land use/transportation concurrency analysis, 12-year model for mid-range transportation facility plan (TFP) and environmental impact statements, and 2020-year and 2030-year models for long-range transportation planning purposes.

In the 90s, Puget Sound Regional Council (PSRC) collected numerous travel survey data to improve the regional travel demand forecasting model. To take advantage of the regional travel survey data and improved model, Bellevue has been undergoing a series of short-term model improvements on the BKR Model in the past few years --- creating a third generation of the BKR model improvements. Cambridge Systematics, Inc. has provided consulting services for the short-term model improvements and Parsons Brinckerhoff Quade & Douglas, Inc. was consulted with transit network coding and modeling. Since 2002, the BKR Model has been enhanced in the following areas:

- The four-step modeling process was integrated into a single EMME/2 modeling application platform.
- The trip generation model was upgraded, consistent with the PSRC regional model to employ household cross-classified 2000 census data, such as family and worker size.
- The trip distribution models were validated by the 1999 regional household travel survey.
- The mode split models were calibrated to more accurately predict transit and rideshare.
- Time-of-day (or peaking) factors were updated based on the 1999 regional household travel survey data.
- A region-wide transit model with focus on the Eastside (with transit capacity constrained trip assignments and Park-&-Ride capacity constrained mode split process) was built and validated for use.
- Region-wide Park-&-Ride lots were updated annually with the counted capacity and usage data to check the goodness-of-fit of P-&-R lot modeling results.

- Transit coverage percentages (percentage of areas within quarter mile radius from each transit stop) were updated based on GIS systems from transit agencies (in 2005).
- Special trip generations were updated in the BKR area and region-wide areas based on the PSRC travel demand model (in 2005).
- Home based school trip distribution was constrained to school districts only.
- Average vehicle occupancies for Home-based work, Home-based other and non-home based were updated to 1999 regional household travel survey results.
- Extra delay penalties were added to short-distance HOV vehicle trips on freeways
- 2006 Fall King County Park-&Ride lot utilization survey data was used to check against the model P&R lot assignments (in 2006).
- Bellevue split 10 big TAZs to add 10 new zones to 2006 Base model to refine the geography for 2006 base year and potential land development and planning support.
- All the transit lines coded as one-way routes. PM peak hour transit modeling was added.
- Non-motorized (walk and bike) trip generation and distribution were added to 2006 BKR base model by CH2MHill as a consultant.
- Freeway network was rebuilt with centralized HOV lanes and directional freeway links. HOV 2 (LOV) was separated from HOV 3+ in the mode choice module.
- Tolling was implemented on SR 520 and SR 167, with separate tolls for SOV, LOV and HOV mode.

In 2008, DKS Associates was contracted to conduct an independent review on the BKR model platform. A number of model enhancement were recommended and many of them have been implemented in the past a few years.

This report documents the technical specifications of the 2010 base year model platform (MP0R12) and highlights the major enhancements and implementation procedure for the modeling process. It is mainly intended for the technical audience who has a basic understanding of travel demand modeling process and whoever is interested in a detailed description of BKR model development.

Chapter 2 describes the component structure of the Bellevue-Kirkland-Redmond (BKR) model platform and its work flow.
Chapter 3 describes network elements and its zonal system.
Chapter 4 introduces all input data requirements.
Chapter 5 module level details are given with descriptions about each individual macros grouped by module.
Chapter 6 describes model calibration and validation results.
Chapter 7 includes all necessary steps to apply this model platform in forecasts and alternative testing, including data preparation, model execution and post processing.

2 Model Structure

2.1 Identification of Model Requirements

The City of Bellevue Transportation Modeling and Analysis Group develops and maintains the BKR model platforms that include MP-0, MP-6, MP-12, MP-20 and MP-30. Each of the model platforms follows the traditional four-step modeling process that has several key model components, as shown in Figure 2-1:

- Trip Generation --- computes daily motorized person trip productions & attractions based on land use characteristics and trip generation rates.
- Trip Distribution --- distributes daily motorized person trips between Traffic Analysis Zone (TAZ) pairs based on the gravity model using accessibility and attractiveness.
- Mode Split --- splits the daily zonal trip interchanges by mode of travel based on relative modal utilities.
- Trip Assignments --- assigns auto trips to roadway network and transit person trips to transit routes; three sub-processes are needed for trip assignment implementation.
    - Time of Day Factors – break down daily motorized person trip tables into auto trip tables in different time periods, such as A.M. peak hour, Mid-day off-peak hour and P.M. peak hour.
    - Multi-class Auto Traffic Assignment --- loads traffic on the roadway network based on user equilibrium principles and highway capacity constrained algorithm.
    - Multi-path Transit Assignments --- load transit person trips on the transit routes based on the least weighted multi-path travel time and transit vehicle capacity constrained algorithm and P&R capacity constrained as well.

2.2 Model Structure

BKR models are built to project future travel demand for the Puget Sound region with the focus on the Eastside. The base-year model platform is updated annually to reflect changes in land use and roadway network. Validation against latest observed data such as traffic counts and transit ridership survey is performed in an annual basis. As travel survey data becomes available, enhancements are made to the BKR base model to more accurately project travel demand.

MODEL STRUCTURE

Trip Generation

The trip generation model is the first of the four primary model components identified as part of the four-step planning process. It estimates the number of trips produced and attracted to each of the TAZs. The trips produced are estimated from households and their socioeconomic characteristics. The trips attracted are estimated from employment categorized by type.

The trip generation model includes the application of both trip production and trip attraction models for each of the seven trip purposes (work, college, school, shopping, other, non-home-based, and commercial vehicle). It also involves adding trips generated in the study area, but destined outside the study area, as well as trips generated outside the study area, but destined to places within the study area.

The trip production models are of the cross-classification form in which, for each zone, the number of households and/or employment in each category is multiplied by a production rate. Trip rates were adjusted by Cambridge Systematics in 2002 through a model enhancement contract. Trip ends for zones outside of the BKR area are obtained from the PSRC model by interpolating the values from the PSRC 2000 and 2010 production and attraction matrices. The trip attraction models consist of a set of regression equations. The trip productions and attractions are then combined into the four trip purposes (HBW, HBSchool, HBO, and NHB). The final productions and attractions are inputs to the trip distribution module.

Trip Distribution

The trip distribution model is the second of the four primary model components identified as part of the four-step planning process. The trip distribution models estimate the number of trips from each TAZ to each other traffic analysis zone. The trips are estimated as a function of the travel impedance from one zone to another, using a gravity model technique. Trip distribution models are applied for each of four trip purposes (same as in trip generation, except several trip purposes are combined).

Friction factor functions were updated to fit the model trip distribution curves and average travel times more closely to the 1999 PSRC household travel survey results.

Mode Split

The mode choice model is the third step of the four-step travel demand planning process. Productions and attractions of the trip generation model are linked in trip distribution, creating zone-to-zone person-trip movements. These trips are then apportioned to the available travel modes through the application of the mode choice model. Mode choice

models split the total daily person trips into motorized daily trip tables for each motorized mode based on their share of utilities.

- Mode choice model parameters were adjusted to the 1999 PSRC survey results.
- New transit skims were created directly from the BKR Model transit assignments. PSRC transit skims were longer used as in the original BKR model.
- PSRC park-and-ride choice model was implemented to allow a flexible transit choice of HBW walk access and park-and-ride auto access using the logit auto and transit utilities with P-&-R lot capacity constrained.
- HOV2(LOV) and HOV3+ were split from original HOV2+ trip table.

Trip Assignments

The trip assignment model is the last of the four primary model components identified as part of the four-step planning process. It estimates the volume on each link in the transportation system. In addition, the trip assignment model generates specific performance measures, such as the congested speed or travel time on a highway link. Trip assignment is performed separately for each of the three peak time periods (morning, mid-day and afternoon peak hour).

Time of Day Process --- The old peaking factors were replaced with the new regional peaking factors derived from the 2006 PSRC household activity Survey. The daily motorized person trip tables are broken down into AM peak, Midday peak and PM peak hourly auto trip tables.

Transit Modeling Process --- Transit modeling capability was added to the BKR modeling systems by Bellevue staff with support from Parsons Brinkerhoff, Inc. AM and PM 2010 peak hour transit trips, generated from the BKR mode choice models, were assigned to the transit network in the BKR model. In 2005, transit capacity constraint trip assignment was applied to the new model platform to reflect the actual capacity of transit vehicles so that ridership does not exceed the capacity.

Park and Ride Transit Trip Assignment --- Park and Ride capacity constraint was also applied to limit the number of cars allowed to park in specific park and ride lots. In addition, transit coverage (in the BKR area and region-wide) was updated to reflect the actual accessibility of transit riders in each TAZ to the nearest (1/4 mile) transit stop using walk access.

Auto and Transit Network Update --- The BKR model auto network and transit route information were enhanced on freeway and local streets to primarily serve the transit modeling purpose, including:

- A region-wide transit network that includes King County Metro Transit, Snohomish County Community Transit, Pierce Transit and Sound Transit (including commuter rail), was built.
- In the original BKR Model, there were only 32 Park-&-Ride lots connected to the highway network. In the new model, 128 Park-&-Ride lots were built in the BKR model with parking capacity identified, to more reasonably forecast auto-access trips (to park-&-ride lots) and transit person trips (from P&R lots to destinations).
- Seven flyer bus stops along the freeways were coded to more reasonably forecast walk-access transit trips using freeway flyer stops.
- Downtown Seattle transit tunnel network was coded with details about pedestrian walk-access connection to capture bus and light rail ridership and to reflect tunnel transit routes and services more realistically; for instance, while in the tunnel, bus travel time is not impacted by street traffic congestion unlike other bus routes.
- I-90 freeway connections with ramps between Issaquah via Mercer Island to downtown Seattle were built to reflect what are on the ground by the end of 2010.
- I-405 new ramps and improved interchanges were all coded in the 2010 BKR MP0_R12 Model network.
- Freeway network was recoded with centralized HOV lanes and directional freeway links.

The trip tables generated from a BKR model are SOV, LOV and HOV for each peak hour. In the base year model, LOV is combined with HOV3 as HOV2. In the future models, LOV is combined with SOV as SOV in compliance of the State's HOV policy. LOV and HOV are further broken down to travel distance shorter and higher than 5 miles.

Postprocessing

Future turning movement volumes at an intersection have to be post processed for the LOS calculation. The City of Bellevue has established a methodology and a standard procedure to post process the BKR model raw turning movement output. The methodology is documented in Appendix E. The procedure is given in Chapter 7.

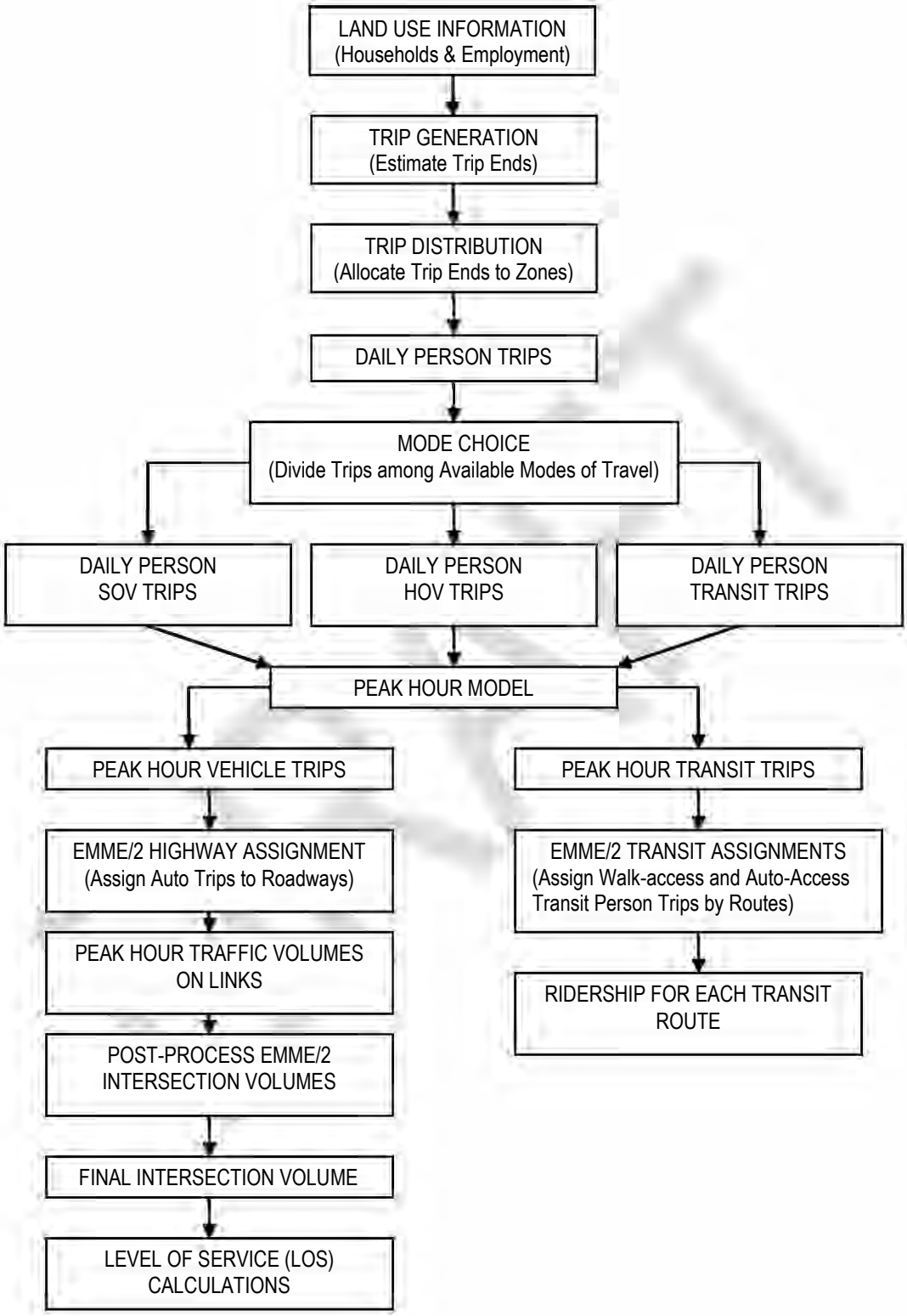
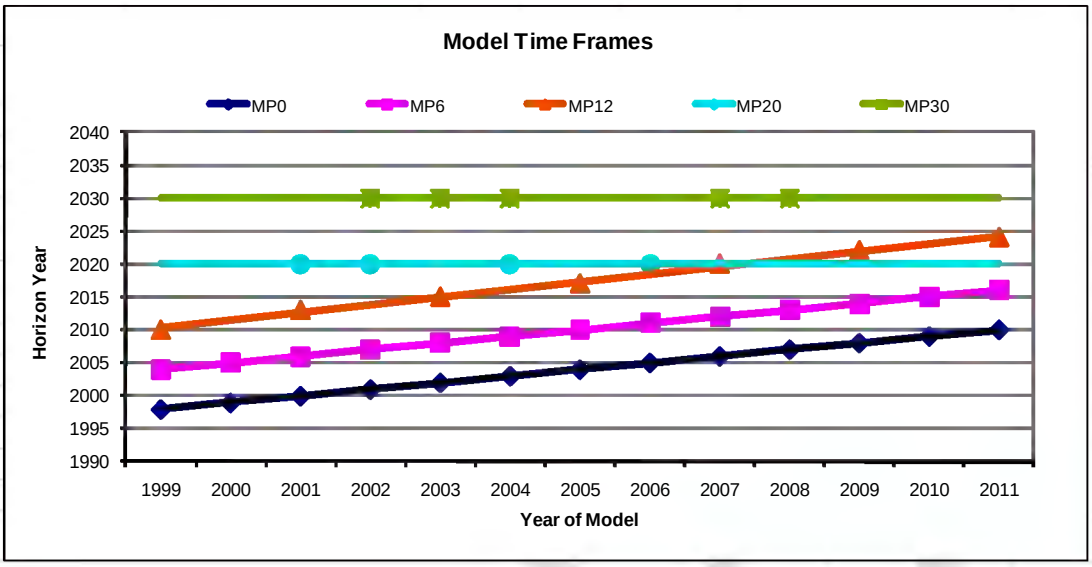


Figure 2-1 BKR Travel Demand Model Process



"Official" 1999-2009 BKR Model Platform Releases (Updated on 2/11/2010

Base Year	MP0	Done in Year	MP6	Horizon Year	MP12	Horizon Year	MP20	Horizon Year	MP30	Horizon Year
1999	R1	2000	R2	2006	R1/R2	2010				
2000	R2	2001	R3	2007						
2001	R3.3	2002	R4	2008	R2	2013	R1	2020		
2002	R4	2003	R5.1	2009			R2	2020	R1	2030
2003	R5	2004	R6	2010	R3	2015			R2	2030
2004	R6/R6.1	2005	R7/R7.1	2011	R4	2017	R3	2020	R3/R4	2030
2005	R7	2006	R8	2012						
2006	R8	2007	R9	2013			R4	2020		
2007	R9	2008			R5	2020			R4.5	2030
2008	R10	2009							R5	2030
2009	R11	2010	R10	Stress					R5.5	2030
2010										
2011										
2012										

note: Year is Base Year
Work is done in next calendar year

Figure 2-2 BKR Model Platforms

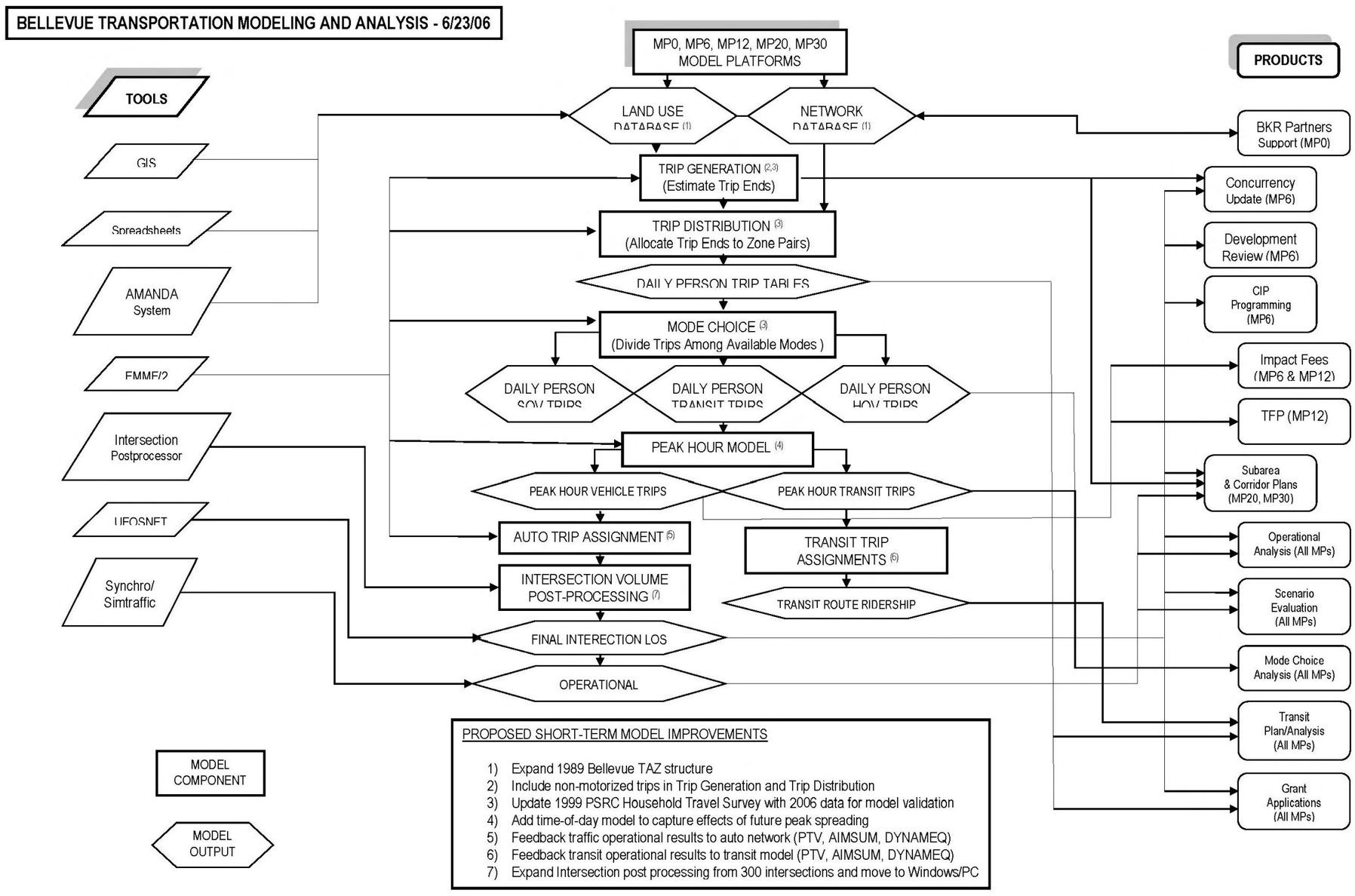


Figure 2-3 BKR Model Application Processing

MODEL STRUCTURE

Model Platforms (MP)

BKR model platforms currently have four models, each of which is designed for a different horizon year. All these models are used to forecast auto traffic and transit ridership in the Bellevue, Kirkland and Redmond sub-region. To distinguish which version of each model platform from others, a release number is assigned when a platform is updated. See the Figure 2-2 for details.

- MP0
  A base year model, identified by MP0 series, simulates current traffic volumes and transit ridership for the existing year. This model is updated annually with the latest land use and network data.

- MP6
  With regard to the short term, the City of Bellevue bi-annually builds a concurrency platform against which the 6 year Capital Improvement Program transportation infrastructure is tested against growth from approved development. It first must be evaluated at the program level and found to be within legislated Level of Service standards (the City's level of service standards and concurrency methodology are outlined in City code). New development projects submitted thereafter must be evaluated using this platform at the project level and cannot exceed the level of service standard in order to be given a certificate of concurrency to be approved

- MP12
  Every two years the City of Bellevue updates its Transportation Facility Plan (TFP) based on a 12 year horizon to reflect travel demand from the land use changes forecast for that time frame. A programmatic Environmental Impact Statement for the TFP serves to assess all projects coming forward that are within the parameters of the forecast.

- MP30
  MP30 is used as a primary model platform by the City of Bellevue to screen and evaluate any proposed transportation project or land use change for its long range plan. MP30 platforms may have a number of variations which include slightly different network and land use assumptions, due to long term uncertainties and financial constraints.

Model Supporting Tools

- EMME/3 – The primary computer software used for modeling in the BKR Model Platforms. EMME/3 is developed and supported by the INRO Corporation.

- The Highway Capacity Manual (HCM) – Provides standard techniques for estimating capacity and level of service for transportation facilities.
- The Puget Sound Regional Council (PSRC) Model – A regional travel demand model covering counties of King, Pierce, Snohomish and Kitsap.
- UFOSNET – Computer software used by Bellevue to measure the intersection level of service at planning level.
- Synchro/Simtraffic – Traffic operational computer software that evaluate intersection operation performance in operational level.
- GIS – Geographical Information System, computer software for creating, storing, analyzing and managing spatial data.
- AMANDA – Application Management and Data Automation, a source of city's building permit information.

Modeling Products

The BKR model platform produces a number of standard products to support the City's transportation planning and management.

- Concurrency – An assessment of whether transportation improvements with committed funding are adequate to handle the projected demand created by proposed developments.
- Transportation Facility Plan (TFP) – The City's 12-year, intermediate range transportation plan. Land use forecasts are used to evaluate the adequacy of planned transportation facility investments without committed funding.
- Transportation Impact Fees (TIF) – The City Council establishes fees that are charged to developers based on the predicted trip generation caused by development.
- Subarea and Corridor Plans – Land use/transportation alternative analysis; i.e. Bel-Red modeling, Wilburton/NE 8th St, Bellevue-Redmond-Overlake Area transportation study, Eastgate study and Downtown implementation plan.
- Scenario Evaluation – Site traffic impact study; i.e. Auto Row, Overlake Hospital Expansion, NE 29th Pl, SE 145th Pl, 148th Ave Speed Study, and east link segment C concept design.
- Transit Plans/Analysis – High Capacity Transit Modeling Analysis, and Regional Transit Trip Distribution.
- Annual reports for the Transportation Commission, the City Council and Development Review section.
    a) Annual base year model update
    b) Annual concurrency update – A LOS Snapshot
    c) Development review modeling reports (per every development review)

3 TAZ System and Networks

3.1 TAZ System

The BKR model geography is based on the PSRC regional travel demand model geography, which includes the four county areas encompassed by King, Pierce, Snohomish and Kitsap counties. The BKR focus area includes the cities of Bellevue, Kirkland, and Redmond and their fringe areas, as shown in Figure 3-3. The regional model traffic analysis zones (TAZs) are disaggregated within the BKR internal area, while the TAZs outside of the BKR internal area are aggregated into larger zones. Inside the internal area, the BKR model TAZs are usually split from the regional model TAZs by census block or block group boundaries, natural barriers, jurisdictional limits, and land use patterns. The correlation between the PSRC regional model TAZs and the BKR model TAZs are summarized in the tables in Appendix A.

The BKR model has a total of 791 zones. There are 502 zones within the BKR internal area, 117 zones external to the BKR area, 141 park-and-ride zones, and 31 dummy zones. The internal and external TAZs associated with subareas of the BKR model are listed below in Table 3-1 below. TAZ 651 and above are reserved to park and ride use and should not be used for any other purpose. Any missing TAZ numbers in park and ride are dummy zones for future use. Figure 3-1 and 3-2 depict the BKR TAZ system in over the region.

Kirkland is adding area due to latest annexation in 2011. The new areas will appear in the 2011 base year model MP0R13 update.

Table 3-1 BKR Model Subarea TAZs

BKR Subareas	TAZs
Downtown Bellevue	1-43
Bellevue Other	44-143, 145-155,158-162, 165-166, 173, 175, 179-182, 187-235,446, 640, 643, 645-650
Bellevue Fringe	144, 156-157, 163-164, 167-172, 174, 176-178, 183-186, 641-642, 644
Kirkland	236-302
Kirkland Fringe	303-322
Redmond	326-399, 401-402, 410-431, 444-445, 576-595, 599, 601-626
Redmond Fringe	400, 403-409, 432-443, 596-598, 600
Dummy Zones	323-325, 447-450, 568-575, 627-639

BKR Subareas	TAZs
Park and Ride Lot Zones	651-714, 716-767, 770-771, 777-779, 785, 789-790, 792, 797-801, 804, 806-808, 813, 817, 822, 825, 832, 843, 849
External Zones	451-567

3.2 District Systems

There are 18 zone partitions defined in the BKR model, as shown in the Table 3-2. Partitions "gl" and "ga" are utilized during model runs within the trip generation (partition "gl") and trip distribution (partition "ga") steps. The other partitions are used for model validation or data summary.

Table 3-2 Zone Partitions in 2010 MP0R12

Partition	Description
ga	SchDist 1Bel/2LW/3Se/4Sn/5NS/6Re/7Is/8PC
gb	1=DT,2=OBel,3=Ovlk,4=Red,5=Kirk,6=Ext
gc	0=P&R, 1=Dummy, 2=BKR+Ext
gd	BKR internals=1, externals=0
ge	1B,2K,3R,4Sea,5king,6Sno,7Pierce,8Kitp
gf	1B,2Bf,3K,4Kf,5R,6Rf,7S,8K,9Sn,10P,11Kp
gi	Belleuve (gi1) and others (gi0)
gk	1BelDT,2BelOth,3Kirk,4Red,5Ext
gl	gl0=P&R, gl1=BKR+F, gl2=Ext, gl3=Dummy
gm	14 MMAs(gm1-gm14) Splits + Seattle (gm15)
gn	14 MMAs(gn1-gn14) + Other (gn15)
go	Cross-classification (go1=1-121)
gp	New MMA Definition
gr	1Bdt2B3Pt4Kk6R7Ns8eK10S11Sdt13Sn14P15Kp
gs	1Bel,2Kirk,3Red,4King,5Sea,6SnPiKitp
gt	gtXX equivalent to valid TAZ-XX
gu	Bel-Fact-Ovlk-RedEK-RentnSKP-SnKikSamm
gw	gw0=dummy,gw1=BKR+F,gw2=Ext,gw3=P&R
gx	PSRC aggregate to be Expanded to CoB

Within the City of Bellevue, the land use data is also summarized by Mobility Management Areas (MMAs) for model validation. The MMAs are stored in partition "gp" and are shown in Table 3-3 below and Figure 3-4.

Table 3-3 City of Bellevue Mobility Management Area

MMA No.	Description	TAZs
1	North Bellevue	44-63, 649-650
2	Bridle Trails	64-68, 187-195
3	Downtown	1-43
4	Wilburton	99-101,, 212, 213, 221-223,225-226,234-235
5	Crossroads	80, 82, 86-88, 208
6	NE Bellevue	84, 85, 89-92, 180, 182,209, 646
7	South Bellevue	126-142, 178, 179
8	Richards Valley	74, 97, 98, 111-113, 115, 198-201, 211, 215, 640
9	East Bellevue	76, 81, 93-96, 102-110, 119-121, 124, 125, 166, 167, 207, 210, 214, 218, 645,647, 648
10	Eastgate	114,116-118, 122, 123, 145, 216, 217, 219, 220, 231, 232
11	Newcastle	143, 144, 146-148, 156-163, 171, 173-175
12	Bel-Red/Northup	69-73,75,79,77-78, 83, 181, 196-197,202-206, 224,227,446
13	Factoria	149, 150, 152, 228-230,643
14	Newport	151, 153-155, 165, 233

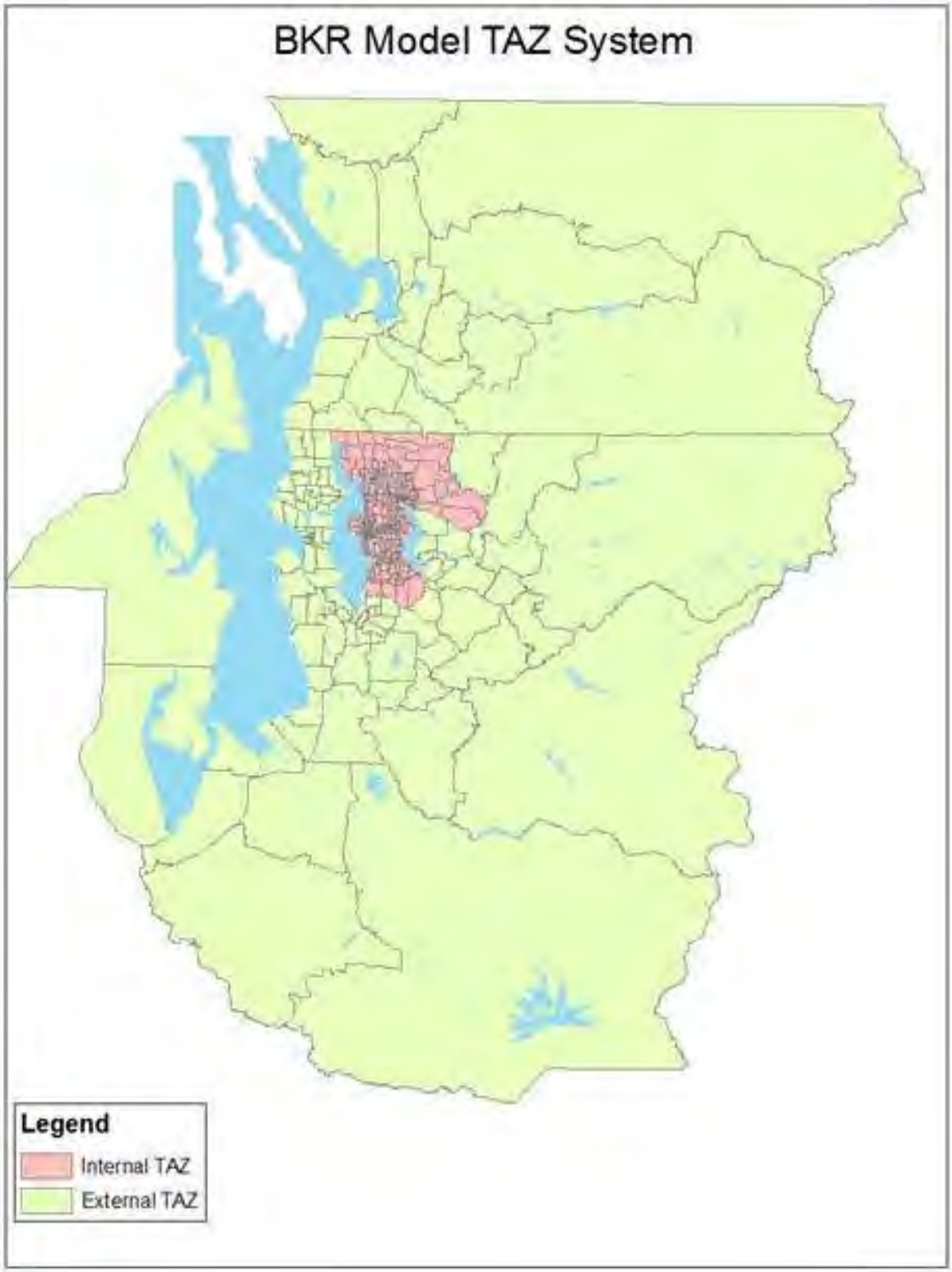


Figure 3-1 BKR Model TAZ System (the Whole Region)

Figure 3-2 BKR Model TAZ System (the BKR Area)

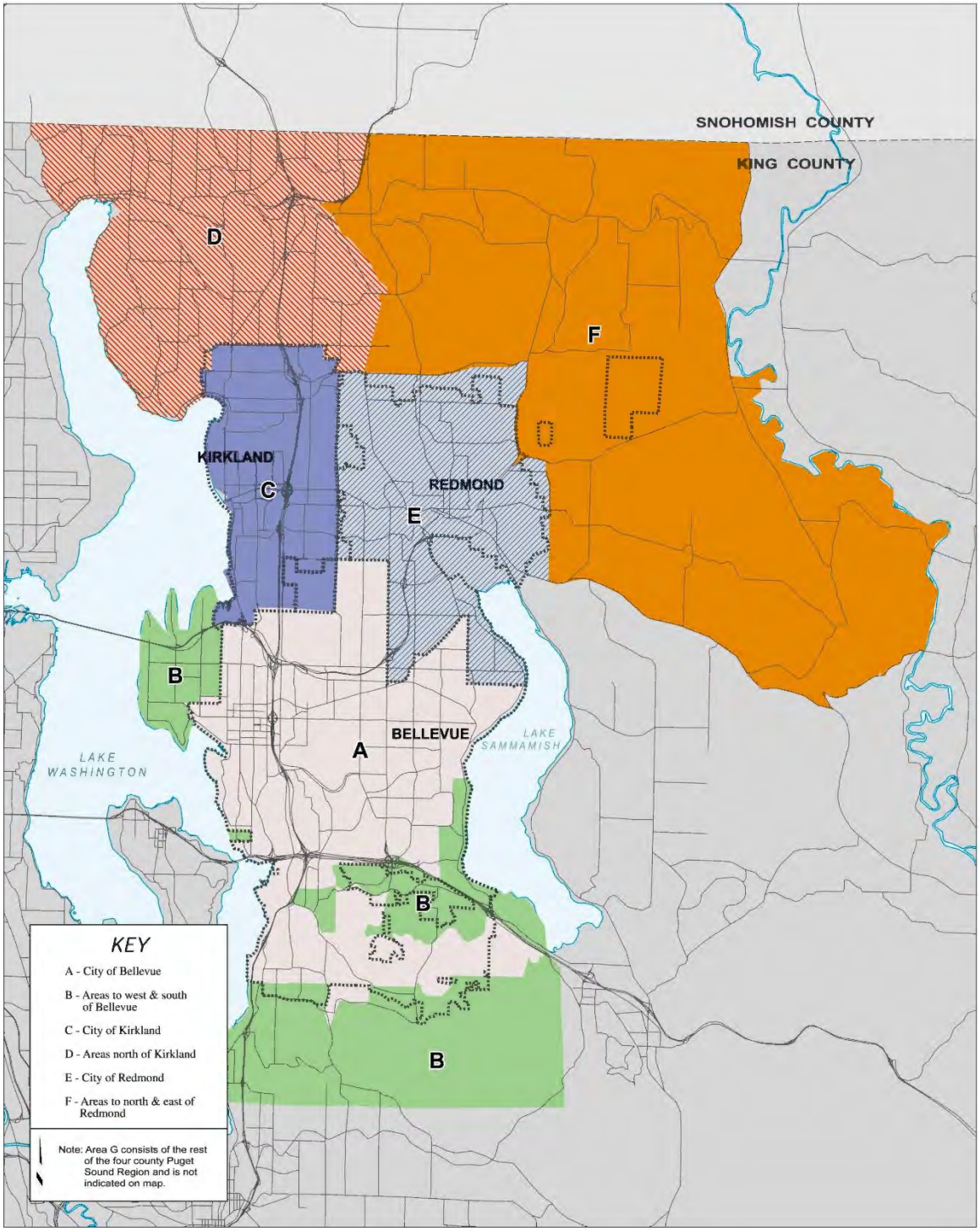


Figure 3-3 BKR Model Subarea by Jurisdictional Boundaries and Fringe Area

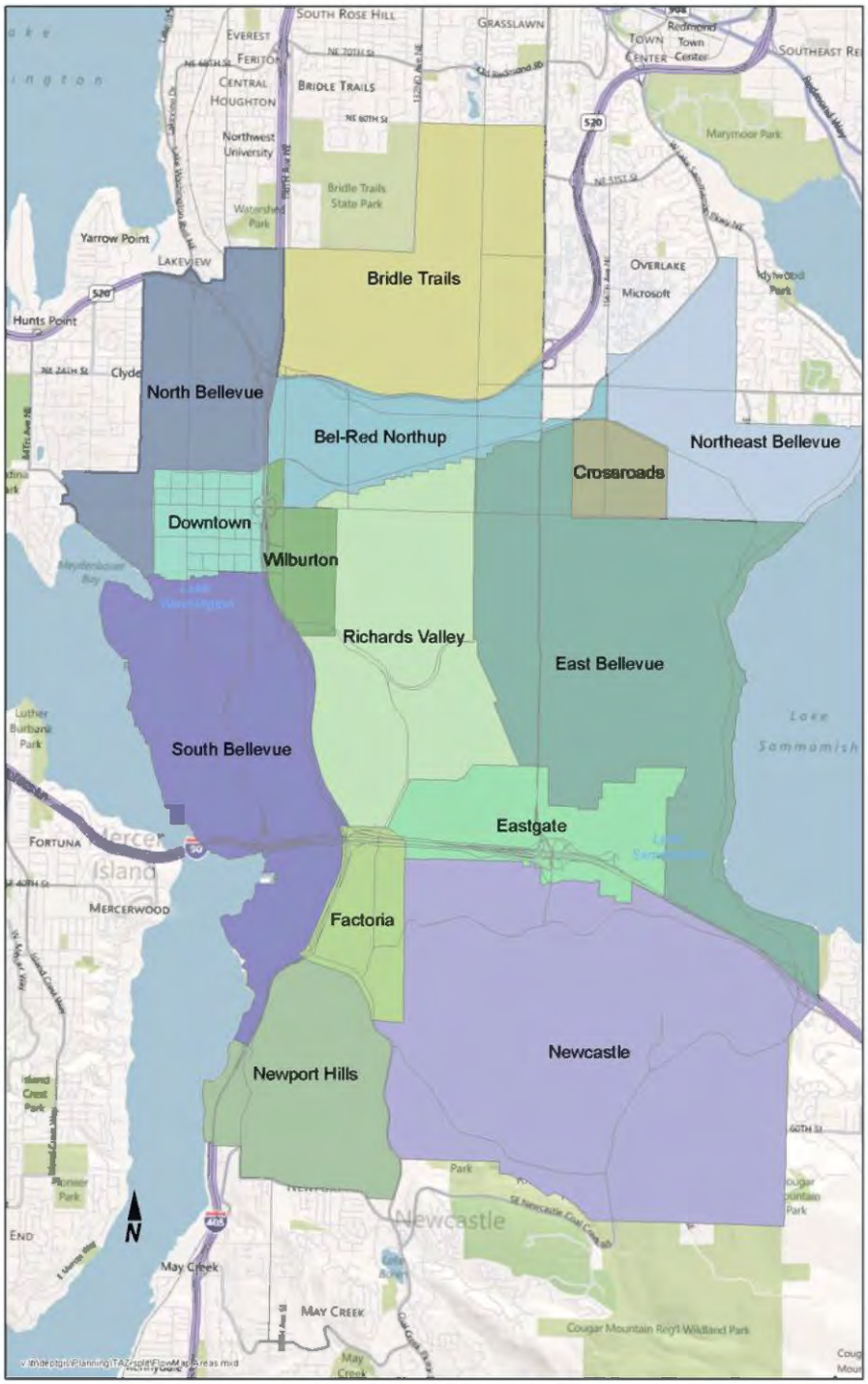


Figure 3-4 City of Bellevue Mobility Management Area (MMA)

3.3 Highway Network

All roads in the internal area with a functional classification of minor collector or higher are generally included in the coded highway network. Local roads are only coded where necessary to complete the network. Tables 3-4 and 3-5 contain the important node and link attributes used in network coding.

Table 3-4 Node Attributes

Attribute	Value	Description
I.D.	1-650	Zone centroid
	651-850	Park-and- ride lot
	>850	Regular node
User Field 1	Default = 0.5	
User Field 2	Blank	
User Field 3	Default = 0	Non-zero values represent intersection IDs assigned within the City of Bellevue limit or park-and ride lots with corresponding labels. For park-and ride lots, ui3 represents lot capacity.
		Park-and-ride lot names.

Table 3-5 Link Attributes

Attribute	Value	Description
Length	0 – 9999	Link length (miles)
Type	Default = 1	Link type
Modes	z = auto c = car b = bus d = dual (transit) t = trolley (transit) r = rail (transit) f = ferry (transit) a = auto_access w = walk_access p = pedestrian x = pnr_pedestrian l = LOV (2) h = HOV (3+)	Allowable modes
Lanes	0 – 9	Number of lanes
VDF	1 – 47	Volume delay functions
User Field 1	Not Defined	Not Defined
User Field 2	Not Defined	Not Defined
User Field 3	0 – 9999	Lane capacity (vph)

Free flow speeds are not stored as a link attribute in the network, but instead are imbedded directly into the VDFs.

While capacities are not strictly coded by roadway facility type, the vehicles per lane per hour (vplph) capacities assigned to links generally correspond to the values listed in Table 3-6 below.

Table 3-6 Link Capacity Look-Up Table

Facility Type	Capacity (vplph)
CBD	800
Minor Arterial	900
Roadways with TWLTLs	ul3*((thru lanes+1)/thru lanes)
Freeway	1800-2000
Off-ramps	1500
On-ramps	1200
Centroid Connector	9999

Volume-Delay Functions

Volume delay functions (VDFs) are defined and used to determine how travel demand and roadway capacity (congestion) interact to produce travel times on the network links. The VDFs are defined so that as the demand for a link increases, the time to travel on that link would increase. As the travel time increases the demand for that link would decrease since trips would search for a quicker path to the destination. This process is called demand and supply equilibrium.

The BKR Model auto assignments utilize conical delay function (CDF), in lieu of the BPR (Bureau of Public Roads) curves. The advantage is that CDF is sensitive to v/c ratio, and thus will converge quicker, whereas BPR is still operating at free-flow speed for v/c of 0.7.

Link travel time is calculated using the following equation, which includes a volume-delay component:

The basics: Time (hr) = distance / speed,
therefore <u>Uncongested</u> Link Travel Time (min) = 60 * link length/free flow speed
and <u>Congested</u> Link Travel Time (min) = 60 * link length/free flow speed * f(x)

Where, f(x) is the general conical curve, producing a congestion factor (multiplier) defined as,

$f(x) = (2-\beta) - \alpha (1-x) + (\alpha^2(1-x)^2 + \beta^2)^{0.5}$

and where:

x = Volume/Capacity ratio on a link (degree of saturation) $x>=0$

α = a user-specified coefficient, currently $\alpha=3$ (arterials) & $\alpha=9$ (freeways)

$\beta = (2\alpha -1)/ (2\alpha -2)$

such that, $\forall\ \alpha \subset \Re$, when $x = 0$, i.e. $v/c = 0$, $f(x) = 1$ (uncongested, free flow conditions), and when $x = 1$, i.e. $v/c = 1$, $f(x) = 2$ (100% congested, doubles travel time on that link) The smaller the value of α, the more sensitive it is to link v/c.

For $x >= 2$, the curve continues as the linear expression producing large multipliers.
$\alpha = 3$, $x >= 2$, the curve continues as the linear expression $f(x) =6x-5$
$\alpha = 9$, $x >= 2$, the curve continues as the linear expression $f(x) =18x-17$
Due to these large multipliers, during the equilibrium process, trips will choose another route, if available, making it very rare for any link to yield a v/c ratios >2

Typically two types of conical VDFs are used as shown below, and coded as:

Type 1, for freeways with speeds from 50 to 75 mph
fd(type1) = 60 * length / speed * (.9375 - 9 * put(1 - (volau + volad) / (ul3 *lanes)) + sqrt(81 * get(1) * get(1) + 1.1289))

Type 2, arterials with speeds from 5 to 49 mph
fd(Type2) = 60 * length / speed * (.75 - 3 * put(1 - (volau + volad) / (ul3 * lanes)) + sqrt(9 * get(1) * get(1) + 1.5625))

In addition, <u>ramp metering</u> is also considered.

The primary intent of ramp metering is to smooth the traffic flow on the freeway mainline and reduce overall delay for freeway travelers. By limiting the input volume to the freeway, overall freeway speeds can be increased. Further, by spacing out merging vehicles from the freeway on ramps, the probability of acceptable gaps in the freeway traffic is much higher, causing fewer perturbations to the traffic flow. The overall traffic flow is smoother and faster, resulting in lower emissions.

<u>Ramp Metered</u> Link Travel Time (min) = Congested Link Time + an additional queue/wait time base on a specified capacity
= 60 * link length/free flow speed * f(x) + g(x)

Where g(x) is an additional time (in min) added to the link with reference to capacity
If x<=0.90, 60* 1/(C-V)
If 0.90<x<=1.20, (9+(X-9)/(1.2-0.9)*(.1*C-9))* 60/C per lane
If x>1,20, 60/C per lane * 1/(V-C)/2

v/c	Sec of queue time
0.50	4
0.90	36
0.95	90
1.00	144
1.20	360
1.25	562

Typically four types of conical VDFs are used for ramp metering as shown below, and coded as:

Where free flow speed = 35mph
And capacity varies btw 450, 600, 750 or 900

```
fd26 = (60*length/35*(.75-3*put(1-(volau + volad)/(ul3*lanes))
     + sqrt(9*get(1)*get(1)+ 1.5625)))
     + ((put((volau+ volad)/(900*lanes))<=0.9)*(60/(900*lanes-(volau+volad)))
     + (get(2)> 1.2)*((((volau+volad)-(900*lanes))/2)*60/900)
     + (get(2)>0.9 .and. get(2)<= 1.2)*((9 +(get(2)-0.9)/(1.2-0.9)*(.1*900*lanes-9))
     *60/900))
```

fd27 substitute c=750
fd28 substitute c=600
fd29 substitute c=450

3.4 Tolling and HOT Lanes

Tolling has been implemented in the model to accommodate a variety of toll road facilities, such as SR 167 HOT lanes (toll for SOV only), SR 520 toll bridge (toll for all traffic), and I405 HOT lanes. The tolling method designed in the model has the following features:

- The BKR model has been modified to include options for tolling and HOT lanes. 2030 BKR model previously include flat tolls only.
- Tolls are specified for each individual class and time period.

- Only the final assignment has 3 classes (SOV, LOV and HOV3+) and tolls for LOV class are only specified in final assignment. Assignments that generate network skims for the distribution macros are only 2-class (SOV/HOV). LOV trips are combined with HOV in base year and with SOV in 2030 model.
- Toll on I-405 is configured to apply tolls on a per-mile rate. Trips using part of the tolled route pay only a partial fee.
- Toll on SR-167 is configured to toll a fixed flat fee for any vehicle using any portion of the tolled section. Tolls are only on entry links and full tolls are applied.
- Toll on SR520 applies to all auto classes.
- HOT lane tolling is modeled by allowing all vehicle classes in HOT lanes and setting HOV (3+) tolls to zero.

The tolls are read in from an external data file and stored in the following link attributes:

- @stoll: toll for SOV
- @ltoll: toll for LOV
- @htoll: toll for HOV

Toll is further adjusted by multiplying a weight factor which is different from auto mode and time period. The weight is given in Table 3-7.

Table 3-7 Weight Factors for Toll

Time Period	Weight Factors for Toll	Value (min/cent)
AM Peak Hour	SOV	0.055
	HOV (skims)	0.0244
	HOV (final assignment)	0.0185
MD Peak Hour	SOV	0.0659
	HOV (skims)	0.0290
	HOV (final assignment)	0.02197
	LOV (final assignment only)	0.03295
PM Peak Hour	SOV	0.05*
	HOV (final assignment)	0.1667
	LOV (final assignment)	0.025

* What does this mean?
The cost of the toll is compared to the value one's of time. I.e. how many minutes must one work to pay the toll?

Assume TOLL = $1 and VOT = $12/hr. Minutes per $1 of toll = $1/$12 * 60 = 5 min. This implies that a $1 toll is worth 5 min of one's time; or 1 min of time is worth 20c; or 0.05 min of time is worth 1c. The table above shows factors in min/cent.

$	Min
1.00	5
0.20 (20cents)	1
0.01 (1 cent)	.05

3.5 Transit Network

Transit service with the BKR model area is provided by a number of different agencies, including: Community Transit, King County Metro, Pierce Transit, and Sound Transit. The transit networks for each of these providers are represented within the BKR model as one-way transit lines, with headways and stops coded to reflect current route schedules and stops. The BKR model includes transit service for the AM, Midday, and PM peak hour. The network coding conventions for walk access and park-and-ride access are described in the subsequent sections.

3.5.1 Transit Route Coding

Transit line coding follows the standard Emme format. The transit network includes typical transit line coding keywords, which are described in Table 3-8 below. A sample transit line "batch in" file is shown in Figure 3-5.

Table 3-8 Transit Line Coding Keywords

Keyword	Description	Value	Notes
mode	Mode of line	b = bus d = dual r = rail	Several other types are available but not utilized in any transit route.
veh. dec.	Vehicle description	Std_diesel Art_dual Rail	
hdwy	Headway	5 - 170	Transit headway (minutes)
speed	Vehicle default speed	15 (bus and dual) 25	
dwt	Dwell time per line segment	0.00 – 1.00	Based on facility type
ttf	Transit time function number on links and turns	11 - 16	Based on facility type
us1	Segment user data item 1	N/A	
lay1	Layover time	Default = 5	
ut1	Line user data 1	ut1 = hdwy (AM – scenario 6)	Equivalent to value for AM headway

ut2	Line user data 2	ut2 = hdwy (MD – scenario 60)	Equivalent to value for mid-day headway
ut3	Line user data 3	ut3 = hdwy (PM –scenario 4)	Equivalent to value for PM headway

The headways coded in "ut1", "ut2", and "ut3", reflect the published headways for each route during the AM, Midday, and PM periods, respectively. The travel time functions, given in Table 3-9, assigned to each transit segment are typically set according to the facility type over which the transit line is operating, following the guidelines listed in the table below:

Table 3-9 Transit Time Functions by Facility Type

Transit Time Function	Facility Type	Typical Dwell Time
ttf = 11	Local Streets	dwt = .15
ttf = 12	Other Arterials	dwt = +.00, except for major stops where dwt = .25
ttf = 13	BKR Area Arterials	dwt = +.00, except for major stops where dwt = .25
ttf = 14	Freeways	dwt = +.00, except for major stops/stations where dwt = .25
ttf = 15	Downtown Seattle	dwt = 0.25
ttf = 15	Downtown Seattle Tunnel	dwt = +.00, except for stations where dwt = .25

```
c Emme Module:     2.24(v9.06)  Date: 09-01-09 15:28   User: E802/DKS2000...wad
c Project:         MP0R9 2007 Baseyear 850 zone BKR Multimodal Model
c Scenario    6:  07 Base MP0R9 AM RUN9 >LU final fix
t lines init
a'C100-I' b   1  20.00  15.00 'AuroraTC-EverretST  '     20    999     20
  path=no    2159 dwt=.15  ttf=12    2160    2159    2169    2170
     2171    1360    2184    1362    2885    2192    2006    2193
     2196    2752    2291    2302    2763    2305    2767    3314
     2317    2287    2318    2338    2337    2347    2454
    lay=5
a'C101-I' b   1  21.00  15.00 'AuroraTC-MarinerP&R '     21     15     27
  path=no    2144 dwt=.15  ttf=12    2142    2143    2394    2154
     2153    2159    2169    2170    2171    1360    2184    1362
     2885    2192    2006    2193    2196    2752    2291    2302
     2293    2765    3280    2277   lay=5
a'C101-O' b   1  15.00  15.00 'MarinerP&R-AuroraTC '     15     30     16
  path=no    2277 dwt=.15  ttf=12    3280    2765    2293    2302
     2291    2752    2196    2193    2006    2192    2885    1362
     2184    1360    2171    2170    2169    2159    2153    2154
     2394    2143    2142    2144   lay=5
a'C105-I' b   1  19.00  15.00 'BothelP&R-MarinerP&R'     19     25     20
  path=no    6547 dwt=.15  ttf=12    6546    2253    2252    3142
     3136    3143    2247    7504    7500    7501    2644    8887
     3145    2264    2263    2760    2266    2756    2268    2274
     2276    2294    2277    3280    2765    2293    2292
    lay=5
a'C105-O' b   1  19.00  15.00 'MarinerP&R-BothelP&R'     19     12     22
  path=no    2292 dwt=.15  ttf=12    2293    2765    3280    2277
     2294    2276    2274    2268    2756    2266    2760    2263
     2264    3145    8887    2644    7501    7500    7504    2247
     2248    2254    6520    6547   lay=5
a'C110-I' b   1  30.00  15.00 'EdmondsCtr-LynnwP&R '     30     24     34
  path=no    2175 dwt=.25  ttf=12    2174    2173    2158    2173
     2172    2197    2208    2169    2168    2881    2882    2186
    lay=5
a'C110-O' b   1  30.00  15.00 'LynnwP&R-EdmondsCtr '     30     24     30
  path=no    2186 dwt=.25  ttf=12    2882    2881    2168    2169
     2208    2197    2206    2158    2173    2179    2178    2177
     2175   lay=5
a'C112-I' b   1  20.00  15.00 'EdmondCC-MukilteoFry'     20    999     20
  path=no    2208 dwt=.15  ttf=12    2182    2181    2180    2179
     2173    2158    2206    2207    2159    2160    2150    2151
     2152    3274    2146    2148     994    2162    2166    2167
     4038    3276    2186    2185    2187    4030    2191    2564
     2194    2196    2752    2196    8030    2951    2198    2761
     2304    3316    2316    2315    2314    2313    2310    2311
     2312    2343   lay=5
a'C112-O' b   1  20.00  15.00 'MukilteoFry-EdmundTC'     20     20     23
  path=no    2343 dwt=.15  ttf=12    2312    2311    2310    2313
     2314    2315    2316    3316    2304    2761    2198    2951
     8030    2196    2194    2564    2191    4032    4031    4030
```

Figure 3-5 Sample EMME Transit Line Batchin File

3.5.2 Transit Walk Access Coding

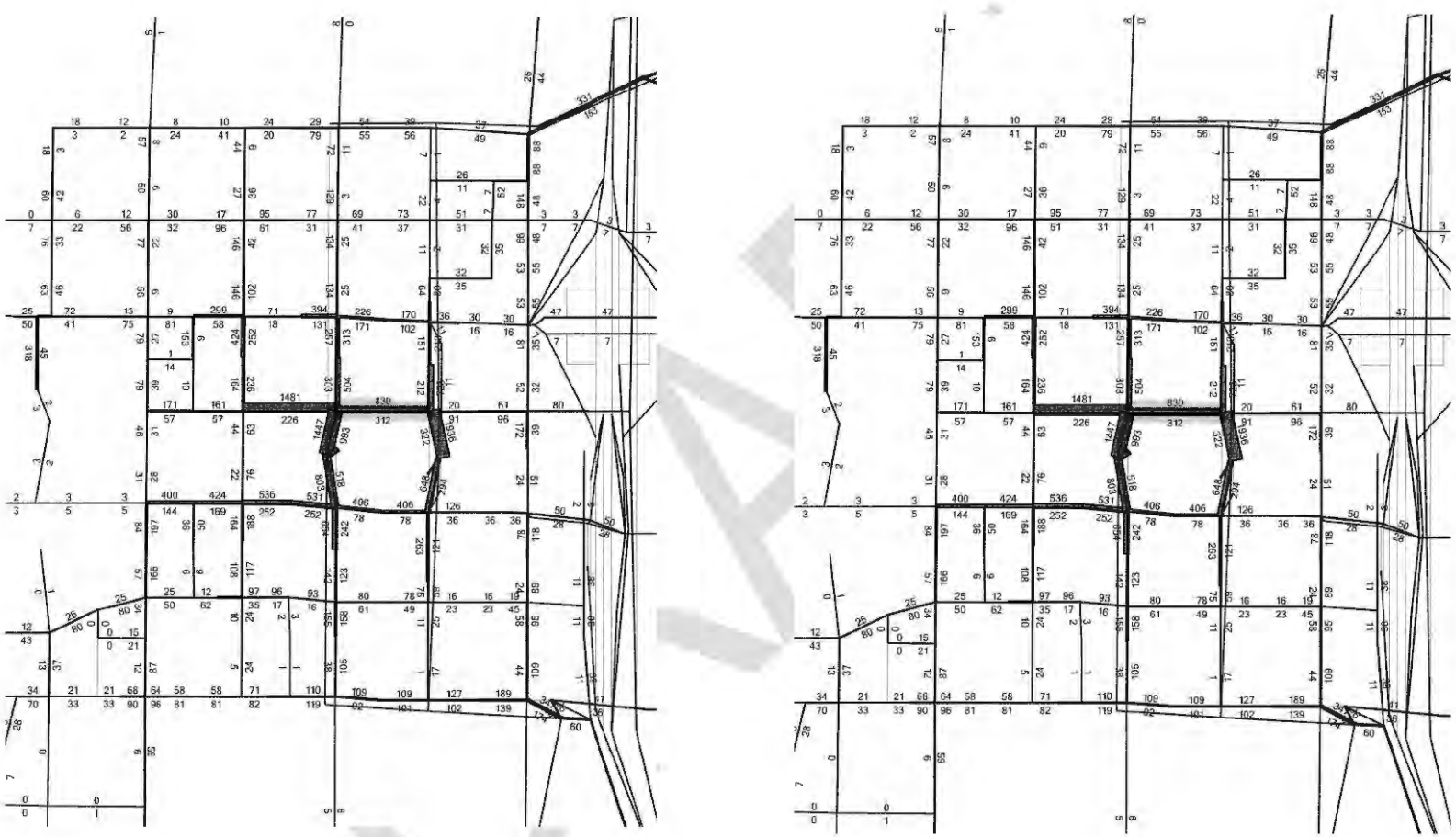


Figure 3-6 Transit Walk Access AM and PM Peak Coding

3.5.3 Park-and-Ride Coding

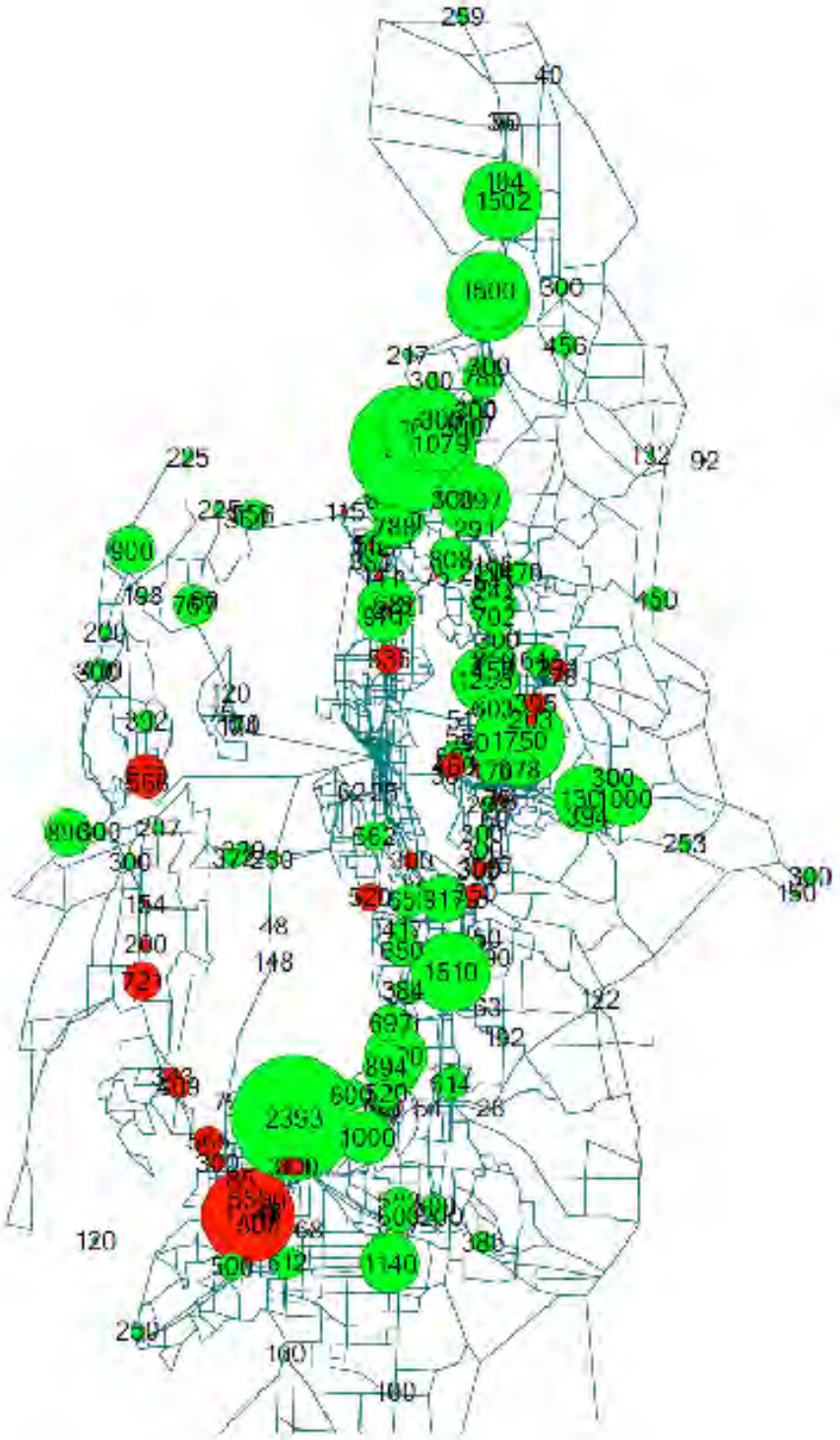


Figure 3-7 2030 Park and Ride Lot Coding

Table 3-10 2030 Park and Ride Capacity

PnR No	Stalls
651	343
652	409
653	100
654	1140
655	612
656	1791
657	85
658	150
659	81
660	48
661	565
662	721
663	79
664	520
665	32
666	40
667	92
668	921
669	367
670	630
671	63
672	384
673	729
674	520
675	307
676	122
677	373
678	93
679	146
680	1301
681	607
682	30
683	292
684	60
685	75
686	570
687	190
688	1750
689	300
690	51
691	50
692	1253
693	203
694	850
695	50
696	644
697	52
698	148
699	334
700	902
701	647
702	0
703	808
704	75
705	220
706	470
707	562
708	62
709	536
710	1112
711	971
712	68
713	81
714	384
715	400
716	48
717	230
718	880
719	51

PnR No	Stalls
720	115
721	840
722	2418
723	1660
724	680
725	450
726	456
727	1502
728	104
729	35
730	40
731	259
732	132
733	1200
734	207
735	330
736	392
737	75
738	184
739	198
740	767
741	556
742	60
743	170
744	327
745	68
746	2393
747	300
748	60
749	178
750	559
751	141
752	64
753	100
754	90
755	192
756	50
757	786
758	447
759	1397
760	112
761	225
762	900
763	120
764	896
765	372
766	154
767	350
768	250
769	300
770	300
771	1079
772	386
773	1600
774	800
775	650
776	0
777	47
778	46
779	1000
780	300
781	583
782	500
783	0
784	400
785	25
786	300
787	225

PnR No	Stalls
788	150
789	253
790	364
791	300
792	600
793	200
794	300
795	200
796	100
797	566
798	300
799	150
800	120
801	917
802	300
803	550
804	1370
805	200
806	217
807	1510
808	614
809	500
810	300
811	650
812	300
813	300
814	300
815	300
816	300
817	1500
818	417
819	300
820	600
821	291
822	54
823	300
824	0
825	350
826	788
827	0
828	156
829	247
830	702
831	450
832	395
833	603
834	300
835	678
836	470
837	75
838	460
839	394
840	300
841	0
842	384
843	697
844	300
845	894
846	70
847	1000
848	520
849	26
850	300
sum	86934

4 Data Sources

4.1 PSRC Household Travel Survey

Puget Sound Regional Council (PSRC) conducted a household travel survey in 1999. The participating households recorded their travel log for each household member during a 48-hour period. An attitude survey regarding transportation and land use issues was also administered on household members sixteen years or older of the participating households. For details about this travel survey, please reference 1999 Puget Sound Household Travel Survey. (http://psrc.org/assets/1475/1999_Final_Report.pdf) 1999 PSRC travel survey resultant data were used in generating modules of trip generation, trip distribution, and mode split.

To better assess the travel activity and pattern change since 1999, PSRC conducted another household activity survey in 2006. In this 2-day period survey, basic demographics, activities, tour and activity characteristics were collected from all members of respondent households on all out-of-home and some in-house activities through travel diary. To understand trip underreporting and potential bias, GPS tracking was used on a small subset of the households participating in the travel diary. A stated preference (SP) survey was organized with focus on public transit and highway toll facilities. For details about this household travel survey, please reference PSRC 2006 Household Activity Survey Analysis Report. 2006 PSRC survey resultant data were used in developing time-of-day factors for auto mode for the time of day module.

4.1.1 Survey Data Preparation

The BKR model mp0r12 inherits model parameters in trip generation, distribution and mode split modules in mp0r11, in which 1999 survey resultant data were applied.

An Access database was used to populate data samples from 2006 PSRC survey database and Excel spreadsheet was used to calculate statistics, such as time of day factors, average trip length, average trip duration, mode share, production rate, and etc. These statistics were segmented by trip purpose and trip mode if necessary.

4.2 Input Data

There are numerous modeling input data, such as land use and socioeconomic data; trip rates and special generators; coefficients and impedance in gravity model for trip distribution; mode choice modal utility variables and parameters; auto network data; and transit route data. They are created before running the four step modeling process. In addition, there are a few modeling outputs, such as auto and transit travel skims or times, that serve as inputs to the 4-step modeling process. These model inputs are listed below.

4.2.1 Land Use and Socioeconomic Data for Trip Generation (by TAZ)

Land use data, aggregated by TAZ, are stored in mo vectors in square footage format for office, retail, industrial, recreational, institutional, and hotel categories; in number of units for single and multi-family dwelling units and hotel categories; in number of persons in college FTE enrollment and school enrollment (K12) categories. These land use data can be prepared in an Excel spreadsheet and loaded through a procedure established in Chapter 7.1.

Table 4-1 Land Use Data

	Category	Unit	Matrix
1	Office	Sqft	Mo21
2	Retail	Sqft	Mo22
3	Industrial	Sqft	Mo23
4	Recreational	Sqft	Mo24
5	Institutional	Sqft	Mo25
6	Hotel	Sqft	Mo26
7	College FTE enrollment	Number of enrollment	Column 121 of mf24
8	Single-family dwelling units	Units	Mo30
9	Multi-family dwelling units	Units	Mo31
10	Hotel Rooms	Number of rooms	Mo32
11	School enrollment	Number of enrollment	Mo33

Households are stratified by household size, number of workers per household, and income level, as shown in Table 4-2.

Table 4-2 Socioeconomic Data

Household size	
	1
	2
	3
	4+
# of workers per household	
	0
	1

	2
	3+
Income	
	<$15K
	$15~25K
	$25~35K
	$35~55K
	>$55K

4.2.2 Special Trip Generators

Some facilities in the region show unique trip generation pattern due to their land use characteristics. Special trip generators are applied to accommodate its characteristics. The special trip generators are coded in mo43 (HBO) and mo44 (NHB). They are additional to the existing HBO and NHB trips, respectively. The BKR model mp0r12 has special generators for Bellevue square and Marymoor recreational park.

Table 4-3 Special Generators in MP0R12 (2010)

TAZ	Mo43 (HBO)	Mo44 (NHB)	Description
11	4,000	7,000	Bellevue Square Mall
417	2,600	1,400	Marymoor Recreational Park

4.2.3 Travel Time Data

Initial network auto skims (travel times) generated from free-flow auto assignments are:

- AM free flow auto travel time (EMME/2 macro am0mcskim1.mac)
- Midday free flow auto travel time (EMME/2 macro md0mcskim1.mac)

Congested auto skims from AM peak hour and mid-day hour multi-class auto assignments are:

- AM congested auto travel time (EMME/2 macro am_mcskim1.mac)
- Midday congested auto travel time (EMME/2 macro md_mcskim1.mac)

Network transit impedance (weighted travel time) generated from transit assignments are:

- AM peak transit travel time (EMME/2 macros AMTRANHW.MAC, AMTRNHDW.MAC, EFFHDW0.MAC, EFFHDWY.MAC)
- Midday transit travel time (EMME/2 macro md-tran-asgn.mac)

4.2.4 Mode Choice Variables

A number of variables, as shown in Table 4-4, are identified as significant to calculate model choice utility.

Table 4-4 Model Choice Variables for the BKR Base Year Model (mp0r12)

List #	Data Category Description	Matrix Numbers and Names (Bold boxes: model outputs serving as inputs)		
1	Highway In-vehicle Time	mf12"MDSVFT"	Mf14"AMSVCT"	
2	Transit Impedance Matrix Files	mf5"amimpw"	mf6"amimpa"	mf7"mdimpw"
3	Auto Operating Cost (15x miles)	mf13"AMSVCD"	mf11"MDSVFD"	
4	P&R Auto Cost (5.9xminutes)	mf35"PRAccT"		
5	Transit Fare for Peak and Off-peak	mf18"pkfare"	mf19"mdfare"	
6	Auto Ownership Bias	mo13"HBWauo"	mo15"HNWauo"	
7	Household Transit Coverage	mo12"hhtran"		
8	Employment Transit Coverage	md11"empcov"		
9	Long-term Parking Costs	md12"ltpkng"		
10	Short-term Parking Costs	md13"stpkng"		
11	Auto Terminal Time	mo11"auttim"		
12	Share Ride Bias or Factors	md14"srbias"	md99"HBWSRB"	
13	Park and Ride Bias or Factors	mo97"PRBIAS"		
14	Household Density Factors	mo14"HBWden"	mo16"HNWden"	mo17"NHBden"

4.2.5 Transit Route/Network Data

The following data are required to update transit network:

- Transit vehicle capacity
- Transit routes and stops
- Transit service frequency (AM and Mid-day)
- Transit dwell time
- Park and ride locations

Data for Calibration of the Transit Model:

- Actual bus route travel time for King County Metro, Sound Transit, Community Transit, Pierce Transit Fall 2010 schedules (562 transit lines coded in AM peak hour, 435 in mid-day hour, 555 in PM peak hour)
- 85 percentile maximum riders by Time Point Interval (TPI Data) from King County Metro
- Ridership survey data by routes from Community Transit

4.2.6 Auto Network Update

- Network node or link additions or removals
- Link attributes: mode, capacity, number of lanes, VDF, etc.
- Turn penalty for specific turning movements
- Park and ride lot auto connection

Table 4-5 BKR Model Input

Description	Matrix Name/No.	Input To	Notes
Pre-Generation			
Zonal land use data for BKR area	mf111/mf111	lumf2mo.mac	Land use data. Data come from external file.
Zonal special generator employment	spgemp/mo40	emploagg_800zones.mac	Mo40 is not used.
Zonal household data for BKR area	xclass/mf24	add-hh-new.mac	Data in matrix is for previous model base year. Matrix format is: Columns 1 – 65: Households by income group/household size/number of workers Columns 66 – 85: Households by income group/number of school-age persons Columns 86 – 100: Households by income group/number of college age persons
Zonal household cross-classification and employment percentages	hh00in/mf22	add-hh-new.mac add-emp-new.mac	Calculated from PSRC socioeconomic database for corresponding PSRC zones.
Trip Generation			
Daily trip production and attraction rates by trip purpose	rates/mf09	generate.mac	Data come from PSRC regional model?
Daily HBOther supplemental generator trip ends	hbospg/mo43	combine.mac	Included for Bellevue Square and Marymoor Park only. Data come from external resource
Daily NHB supplemental generator trip ends	nhbspg/mo44	combine.mac	Included for Bellevue Square and Marymoor Park only. Data come from external resource
2000 Daily PSRC HBWork + HBCollege trip productions	hbwpro/mo53	ensemble_2010.mac	Data come from PSRC regional model ?
2000 Daily PSRC HBWork + HBCollege trip attractions	hbwatt/mo54	ensemble_2010.mac	Data come from PSRC regional model ?
2000 Daily PSRC HBOther trip productions	hbopro/mo55	ensemble_2010.mac	Data come from PSRC regional model ?
2000 Daily PSRC HBOther trip attractions	hboatt/mo56	ensemble_2010.mac	Data come from PSRC regional model ?
2000 Daily PSRC NHB + Commercial Vehicle trip productions	nhbpro/mo57	ensemble_2010.mac	Data come from PSRC regional model ?
2000 Daily PSRC NHB + Commercial Vehicle trip attractions	nhbatt/mo58	ensemble_2010.mac	Data come from PSRC regional model ?
2000 Daily PSRC HBSchool trip productions	schpro/mo59	ensemble_2010.mac	Data come from PSRC regional model ?
2000 Daily PSRC HBSchool trip attractions	schatt	ensemble_2010.mac	Data come from PSRC regional model ?
Daily trip ends for dummy TAZs	?/mo61	ensemble_2010.mac	
2010 Daily PSRC HBWork + HBCollege trip productions	hbwpro/mo79	ensemble_2010.mac	Data come from PSRC regional model ?
2010 Daily PSRC HBWork + HBCollege trip attractions	hbwatt/mo80	ensemble_2010.mac	Data come from PSRC regional model ?
2010 Daily PSRC HBOther trip productions	hbopro/mo81	ensemble_2010.mac	Data come from PSRC regional model ?
2010 Daily PSRC HBOther trip attractions	hboatt/mo82	ensemble_2010.mac	Data come from PSRC regional model ?
2010 Daily PSRC NHB + Commercial Vehicle trip productions	nhbpro/mo83	ensemble_2010.mac	Data come from PSRC regional model ?
2010 Daily PSRC NHB + Commercial Vehicle trip attractions	nhbatt/mo84	ensemble_2010.mac	Data come from PSRC regional model ?
2010 Daily PSRC HBSchool trip productions	schpro/mo85	ensemble_2010.mac	Data come from PSRC regional model ?
2010 Daily PSRC HBSchool trip attractions	schatt/mo86	ensemble_2010.mac	Data come from PSRC regional model ?
Auto Skims			
Scalar demand matrix	scale1/ms11	am0mcskim1.mac am_mcskim1.mac md0mcskim1.mac md_mcskim1.mac	
Trip Distribution			
Auto terminal times	auttim/mo11	hbw_dist.mac hbo_dist.mac nhb_dist.mac	**Data come from PSRC regional model?**

		sch_dist.mac	
Unit scalar matrix	ones/ms01	hbw_dist.mac hbo_dist.mac nhb_dist.mac sch_dist.mac	
HBWork friction factors	hbwff/mo06	hbw_dist.mac	Friction factors derived from calibrated friction factor function for BKR area.
HBOther friction factors	hboff/mo07	hbo_dist.mac	Friction factors derived from calibrated friction factor function for BKR area.
NHB friction factors	nhbff/mo8	nhb_dist.mac	Friction factors derived from calibrated friction factor function for BKR area.
HBSchool friction factors	schff/mo9	sch_dist.mac	Friction factors derived from calibrated friction factor function for BKR area.
Transit Skims			

5 Model Components

5.1 Pre-Generation

The objective of the pre-generation model is to update base year (2010) household and employment data by creating data for new households and employment within the BKR area for the current year and adding it to the total households and employment for the previous year. As a part of this process, land use data is loaded into mf111 from external database (usually Excel spreadsheet). Then the total new households for each zone are broken down by trip generation household cross-classification category according to the distribution of households for the corresponding zone with the decennial census cross classification data in mf22. New employment by type is created by converting building square footages for new development to employees based on employee density ratios. For some of the employment types, the new employment is re-categorized according to the trip generation employment categories prior to adding it to the previous year's data. The household cross-classification and number of jobs by type are saved in mf24. In the final step in the process, the new household and employment totals derived from mf111 are summarized and reported by BKR subarea, exported to mf24lu-chk.rpt, for reasonableness checking.

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5.1.1 Create Land Use Vectors (lumf2mo.mac)

The lumf2mo.mac reformats the non-household zonal land use data used as input to the trip generation model from full matrix format to origin vector format. In full matrix format, this data is stored columnwise, with one column for each of 11 land use types. The column lengths are equal to the number of zones. The macro copies this data into separate origin vector matrices, one for each land use type, with the vector length equal to the number of zones. These vectors are used as input to the tg_hh.mac and emploagg_800zones.mac macros.

USER PARAMETERS

Parameter No.	Description	Default Value
N/A		

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
mf111	mf111	Zonal land use data	N/A

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
off-sf	mo21	Zonal office square footage	emploagg_800zones.mac
ret-sf	mo22	Zonal retail square footage	emploagg_800zones.mac
ind-sf	mo23	Zonal industrial square footage	emploagg_800zones.mac
rec-sf	mo24	Zonal recreational square footage	emploagg_800zones.mac
ins-sf	mo25	Zonal institutional square footage	emploagg_800zones.mac
hot-sf	mo26	Zonal hotel square footage	emploagg_800zones.mac
spg-sf	mo27	Zonal special generator square footage	emploagg_800zones.mac
sf-du	mo30	Zonal number of single-family dwelling units	tg_hh.mac
mf-du	mo31	Zonal number of multi-family dwelling units	tg_hh.mac
hot-rm	mo32	Zonal number of hotel rooms	emploagg_800zones.mac

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
sc-enr	mo33	Zonal school enrollment	emploagg_800zones.mac

REPORTS: LUMF2MO.RPT

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5.1.2 Create Household Data for Trip Generation (tg_hh.mac)

The tg_hh.mac macro calculates the total households by zone by summing the single-family dwelling unit and multi-family dwelling unit matrices output by the lumf2mo.mac macro. The total household data are input to the add-hh-new.mac macro.

USER PARAMETERS

Parameter No.	Description	Default Value
N/A		

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
sf-du	mo30	Zonal single-family dwelling units	lumf2mo.mac
mf-du	mo31	Zonal multi-family dwelling units	lumf2mo.mac

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
sfmfhh	mo29	Zonal total households	add-hh-new.mac

REPORTS: tg_hh.rpt

5.1.3 Create Employment Data for Trip Generation (emploagg_800zones.mac)

The emploagg_800zones.mac macro converts the land use quantities contained in the vector matrices produced by the lumf2mo.mac macro into employment estimates. For some of the land use types, an assumed vacancy rate is first applied to the land use quantities. The net land use quantities are then multiplied by an employee density rate. For some of the land use types, different vacancy and density rates are used for subareas within the BKR area as well as the external modeling area. Total employment is calculated by summing the employment by type. Other employment is calculated as the sum of institutional, hotel, school, and special generator employment. An "other square footage" estimate is also calculated as the sum of recreational, institutional, hotel, and special generator square footage. The employment estimates are input to the add-emp-new.mac macro.

USER PARAMETERS

Parameter No.	Description	Default Value
1	Office employment vacancy rate (%)	10
2 - 4	Office employee density rates (per 1,000 gsf)	3.08, 3.64, 4.0
5, 6	Retail employment vacancy rates (%)	5, 4
7 - 9	Retail employee density rates (per 1,000 gsf)	2.24, 2.06 , 2.0
10, 11	Industrial employment vacancy rates (%)	7.5, 4
12 - 14	Industrial employee density rates (per 1,000 gsf)	3.84, 1.43, 1.7
15	Institutional employee density rate (per 1,000 gsf)	2.5
16	Hotel employee density rates (per room)	0.44, 0.36
17	School employee density rate (per student)	0.1

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
off-sf	mo21	Zonal office square footage	lumf2mo.mac
ret-sf	mo22	Zonal retail square footage	lumf2mo.mac
ind-sf	mo23	Zonal industrial square footage	lumf2mo.mac
rec-sf	mo24	Zonal recreational square footage	lumf2mo.mac
ins-sf	mo25	Zonal institutional square footage	lumf2mo.mac
hot-sf	mo26	Zonal hotel square footage	lumf2mo.mac
spg-sf	mo27	Zonal special generator square footage	lumf2mo.mac

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
hot-rm	mo32	Zonal hotel rooms	lumf2mo.mac
sc-enr	mo33	Zonal school enrollment	lumf2mo.mac
spgemp	mo40	Zonal special generator employment	N/A

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
offemp	mo34	Zonal office employment	add-emp-new.mac
retemp	mo35	Zonal retail employment	add-emp-new.mac
indemp	mo36	Zonal industrial employment	add-emp-new.mac
insemp	mo37	Zonal institutional employment	add-emp-new.mac
hotemp	mo38	Zonal hotel employment	add-emp-new.mac
schemp	mo39	Zonal school employment	add-emp-new.mac
othsqf	mo28	Zonal other square footage	N/A
totemp	mo41	Zonal total employment	N/A
othemp	mo42	Zonal other employment	N/A

REPORTS: emploagg_800zones.rpt

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5.1.4 Add New Households for Trip Generation (add-hh-new.mac)

The add-hh-new.mac macro adds the new households by cross-classification category to a matrix of households for the previous model base year. The cross-classification schemes in mf22 are:

- Households by income group/number of workers/number of workers (column 1~65)
- Households by income group/number of school-age persons (column 66~85)
- Households by income group/number of college-age persons (column 86~100)

The cross-classified households are derived by multiplying the total new households for each BKR zone output by the tg_hh.mac macro by the percentage of total households within each cross-classification category for the corresponding zone within the PSRC socioeconomic database. The matrix with the decennial census cross-classification percentages is developed with the following procedure:

- A table containing the number of households within each category is summed by row to obtain total households by zone.
- The percentage of households within each category is calculated by dividing the number of households within each category by the total households.
- The appropriate household percentages to use for each BKR zone are determined based on a PSRC – BKR zonal equivalence table. In cases where two or more PSRC zones correspond to a single BKR zone, the average percentages for the PSRC zones are applied to the BKR zone.

The updated base year household data is stored in columns 1 – 100 of the matrix containing the previous base year's household data, so these values are overwritten.

USER PARAMETERS

Parameter No.	Description	Default Value
N/A		

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
xclass	mf24	Zonal household data (previous base year)	N/A

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
sfmfhh	mo29	Zonal total households	tg_hh.mac
hh00in	mf22	Zonal household cross classification and employment percentages	N/A

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
xclass	mf24	Zonal household data (updated)	add-emp-new.mac

REPORTS: add-hh-new.rpt

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5.1.5 Add New Employment for Trip Generation (add-emp-new.mac)

The add-emp-new.mac macro adds the estimates of new employment produced by the emploagg_800zones.mac macro to the employment for the previous model base year. This is done in the following manner:

- Office, institutional, and hotel employment is added to FIRES employment.
- Industrial employment is split between the WTCU and manufacturing categories according to a table of fixed allocation factors and added to the employment for these categories.
- Retail employment is added directly to retail employment.
- School employment is added to education employment.

The updated base year employment data is stored in columns 101 – 120 of the same matrix used for the updated household data. This matrix is input to the add_FTE.mac macro.

USER PARAMETERS

Parameter No.	Description	Default Value
N/A		

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
xclass	mf24	Zonal household data	add-hh-new.mac
hh00in	mf22	Zonal household cross classification and employment percentages	N/A
offemp	mo34	Zonal office employment	emploagg_800zones.mac
retemp	mo35	Zonal retail employment	emploagg_800zones.mac
indemp	mo36	Zonal industrial employment	emploagg_800zones.mac
insemp	mo37	Zonal institutional employment	emploagg_800zones.mac
hotemp	mo38	Zonal hotel employment	emploagg_800zones.mac
schemp	mo39	Zonal school employment	emploagg_800zones.mac

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
xclass	mf24	Zonal household and employment data (updated)	add-FTE.mac

REPORTS: add-emp-new.rpt

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5.1.6 Add College Enrollment for Trip Generation (add_FTE.mac)

The add_FTE.mac macro adds FTE college enrollment to the updated zonal household and employment matrix output by the add-emp-new.mac macro. The zone numbers for zones that college enrollment is to be added as well as the enrollment values are "hard-coded" within the macro. The updated FTE college enrollment data is stored in column 121 of the same matrix used for the updated household and employment data. This matrix is input to the mf24lu-chk.mac macro.

USER PARAMETERS

Parameter No.	Description	Default Value
1 - 5	Zone numbers for college enrollment zones	116, 212, 246, 278, 320
6 – 10	Zonal FTE college enrollment	10784, 2606, 1118, 3397, 1280

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
xclass	mf24	Zonal household and employment data	add-emp-new.mac

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
xclass	mf24	Zonal household, employment, and FTE college enrollment data (updated)	mf24lu-chk.mac

REPORTS: add_FTE.rpt

5.1.7 Check HH, Employment Data for Trip Generation (mf24lu-chk.mac)

The mf24lu-chk.mac is used to check the reasonableness of the land use data prior to the input of the data to the trip generation model. The total number of households is calculated and reported by subarea for each of the three household distributions contained in the land use data:

- Households by income group, household size, and number of workers
- Households by income group and number of school-age persons
- Households by income group and number of college age persons

The subareas are defined by the following zone groups within partition "gf":

1. Bellevue
2. Bellevue fringe
3. Kirkland
4. Kirkland fringe
5. Redmond
6. Redmond fringe

Similarly, total employment is calculated and reported by subarea for each of the employment types contained in the land use data:

- Retail
- FIRES
- Government
- Education
- WTCU
- Manufacturing
- FTE college enrollment

The only output of the mf24lu-chk.mac macro is the mf24lu-chk.rpt file containing the household and employment totals.

USER PARAMETERS

Parameter No.	Description	Default Value
1 - 6	Zone groups for subarea reporting of household and employment totals	gf1 – gf6

Parameter No.	Description	Default Value
7 - 9	Column numbers for household distributions in land use matrix	1, 65/66, 85/86, 100
10 - 16	Column numbers for employment by type in land use matrix	109, 112, 115, 118, 119, 120, 121

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
xclass	mf24	Zonal household, employment, and FTE college enrollment data	add_FTE.mac

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
N/A			

REPORTS: mf24lu-chk.rpt

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5.2 Trip Generation

The trip generation model is the first of the four primary model components identified as part of the four-step planning process. The trip generation models estimate the number of trips produced and attracted to each of the TAZs. The trips produced are estimated from households and their socioeconomic characteristics. The trips attracted are estimated from employment categorized by type.

The trip generation model includes the application of both trip production and trip attraction models for each of the seven trip purposes (work, college, school, shopping, other, non-home-based, and commercial vehicle). It also involves adding trips generated in the study area, but destined outside the study area, as well as trips generated outside the study area, but destined to places within the study area.

The trip production models are of the cross-classification form in which, for each zone, the number of households and/or employment in each category is multiplied by a production rate. Trip ends for zones outside of the BKR area are obtained from the PSRC model by interpolating the values from the PSRC 2000 and 2010 production and attraction matrices. The trip attraction models consist of a set of regression equations. The trip productions and attractions are then combined into the four trip purposes (HBW, HBSchool, HBO, and NHB). The final productions and attractions are input to the trip distribution module.

5.2.1 Internal Trip Generation

As listed in Tables 4.6 and 4.7, the third generation of BKR trip generation model is based on the updated daily motorized person trip production rates and attraction rates from the original PSRC trip rates by eight different trip purposes: Home-Based Work, Home-Based College, Home-Based School, Home-Based Shopping, Home-Based Other, Non-Home Based Work, Non-Home Based Other, and Commercial Vehicles.

BKR trip production rates and attraction rates are given in Table 5-2 and 5-3, respectively. The rates were assembled in mf09, whose format is given in Table 5-1.

Table 5-1 BKR Production and Attraction Trip Rates in mf09

	1	…….	8	9	…….	16
1						
2						
3		Trip production rates			Trip attraction rates	
.		(See Table 5-3)			(See Table 5-2)	
.						
121						

The first eight columns of mp09 are for production rates, and the last eight columns are for attraction rates. This matrix has 121 rows which match the transpose of mf24. The first 100 rows are for household cross-classification, and the last 21 rows are for employment by type.

After mf24 and mf09 have been completed, the 16 trip generation vectors will be computed using the following matrix convolution:

$$mf61_{pq} = SUM_{k} (mf24_{pk} * mf09_{kq})$$

Where:

mf24 – household and employee data;
mf09 – trip generation rates;
mf61 – trip generation vectors;
p – origin zone – correspond to the 650 traffic zones;
q – destination zone – correspond to the 121 household and employee variables;
k – intermediate zone – correspond to the 16 trip generation coefficients.

Table 5-2 Update BKR Trip Attraction Rates

LAND USE	HB-work	HB-College	HB-Shopping	HB-Other	HB-School	NHB-Work	NHB-Other	Commercial Vehicles
SF Households	0.10	-	-	0.48	-	-	0.29	0.32
MF Households	0.10	-	-	0.43	-	-	0.17	0.19
Retail Employees	1.57	-	4.36	3.74	-	1.44	3.31	0.76
FIRES Employees	1.35	-	-	3.44	-	0.33	0.76	0.33
Government Employees	1.35	-	-	3.74	-	0.30	0.68	0.32
Educational Employees	1.48	-	-	1.20	7.90	0.06	0.13	0.19
WCTU Employees	1.46	-	-	0.20	-	0.08	0.19	0.79
Manufacturing Employees	1.46	-	-	0.21	-	0.36	0.84	0.79
College (FTE Enrollment)	-	0.88	-	-	-	-	-	0.02
Total	8.87	0.88	4.36	13.44	7.90	2.57	6.37	3.71

Table 5-3 Original PSRC and Updated BKR Trip Production Rates

	Original PSRC Rates				*New BKR Rates*			
Home-Based Work								
Household Size	Workers				Workers			
	0	1	2	3+	0	1	2	3+
1	0	1.47			-	1.16	-	-
2	0	1.47	2.48		-	1.16	1.96	-
3	0	1.47	2.48	3.87	-	1.16	1.96	3.06
4+	0	1.47	2.48	4.02	-	1.16	1.96	3.18
Home-Based College								
Persons Age 18-24	0	1	2+		0	1	2+	
	0.07	0.3	0.71		0.03	0.13	0.30	
Home-Based School								
Persons Age 5-17	0	1	2	3+	0	1	2	3+
	0.01	1.45	3.05	4.89	0.01	1.02	2.15	3.44
Home-Based Shop								
Household Size	Workers				Workers			
	0	1	2	3+	0	1	2	3+
1	0.89	0.46			0.99	0.51	-	-
2	1.49	1.06	0.78		1.66	1.18	0.87	-
3	1.06	1.11	1.21	1.13	1.18	1.24	1.35	1.26
4+	1.13	1.41	1.27	1.53	1.26	1.57	1.42	1.71
Home-Based Other								
Household Size	Workers				Workers			
	0	1	2	3+	0	1	2	3+
1	1.75	0.97			1.95	1.08	-	-
2	3.41	2.55	2.05		3.80	2.84	2.29	-
3	4.62	3.25	3.32	2.88	5.15	3.62	3.70	3.21
4+	3.75	4.32	5.25	5.04	4.18	4.82	5.85	5.62
Non-Home-Based Work								
	Density				Density			
Employment	Low	Medium	High	All	All			
Retail	6.06	2.88	1.07	5.11	1.44			
FIRES	1.42	0.83	0.5	1.18	0.33			
Govt	1.6	0.83	0.5	1.05	0.30			
Edu	0.2	0.2	0.2	0.2	0.06			
WTCU	0.3	0.3	0.3	0.3	0.08			
Manuf.	1.29	1.29	1.29	1.29	0.36			
Non-Home-Based Other								
Household Size	1	2	3	4+				
	0.19	0.25	0.32	0.32	0.17	0.23	0.29	0.29
	Density				Density			
Employment	Low	Medium	High	All	All			
Retail	6.06	2.88	1.07	5.11	3.31			
FIRES	1.42	0.83	0.5	1.18	0.76			
Govt	1.6	0.83	0.5	1.05	0.68			
Edu	0.2	0.2	0.2	0.2	0.13			
WTCU	0.3	0.3	0.3	0.3	0.19			
Manuf.	1.29	1.29	1.29	1.29	0.84			

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5.2.2 External Trip Generations

For the remaining zones (451 to 567) in the Central Puget Sound Region outside Bellevue, Kirkland and Redmond, productions (Ps) and attractions (As) are obtained by interpolating 2000 and 2010 PSRC Databank, as detailed by the following procedure.

1. Extract Ps and As from the 2000 and 2010 PSRC banks.
   Productions and attractions from PSRC 2000 and 2010 databank were aggregated by PSRC-BKR TAZ equivalence table to match BKR zone system. Aggregated Ps and As were imported into BKR base year model mp0r12, as given in Table 5-4.

   Table 5-4 Production and Attraction from PSRC Model

mo	Description
mo53	HBW and HBCollege production 2000
mo54	HBW and HBCollege attraction 2000
mo55	HBO production 2000
mo56	HBO attraction 2000
mo57	NHB and commercial vehicles production 2000
mo58	NHB and commercial vehicles attraction 2000
mo59	HBSchool production 2000
mo60	HBSchool attraction 2000
mo79	HBW and HBCollege production 2010
mo80	HBW and HBCollege attraction 2010
mo81	HBO production 2010
mo82	HBO attraction 2010
mo83	NHB and commercial vehicles production 2010
mo84	NHB and commercial vehicles attraction 2010
mo85	HBSchool production 2010
mo86	HBSchool attraction 2010

2. Compute Ps and As for external TAZs in non-BKR area by interpolating 2000 and 2010 PSRC Ps and As. The finalized productions and attractions for HBW, HBO, NHB, and HBSchool are saved in mo1~mo4, and md1~md4, respectively.

5.2.3 Special Generator

Special generators are implemented for Bellevue Square (TAZ 11) and TAZ 417 (Marymoor recreational park) in HBO and NHB categories. They are in addition to the existing HBO and NHB trips. Special generators are saved in mo43 for HBO and mo44 for NHB and are transposed to md matrix in combine.mac.

MODEL COMPONENTS-TRIP GENERATION

The trip generation module estimates average weekday trip productions and attractions for the HBWork, HBOther, HBSchool, and NHB trip purposes within the following macros:

- Trip generation model (generate.mac)
- Change production/attraction format (change.mac)
- Combine productions/attractions (combine.mac)
- Aggregate non-BKR area productions/attractions (ensemble_2010.mac)

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5.2.4 Trip Generation Model (generate.mac)

The generate.mac macro estimates average weekday trip productions and attractions within the BKR area for seven trip purposes: HBWork, HBShop, HBOther, HBCollege, HBSchool, NHBWork, NHBOther, and Commercial Vehicles. The number of productions and attractions for each zone is calculated by multiplying the number of households and/or the amount of employment in each category by a production or attraction rate. All of the trip production models are of the cross-classification form, while the attraction models consist of a set of regression equations. The productions and attractions are input to the trip distribution model.

TRIP PRODUCTION MODELS

Variable Definitions

HBWork model:	Number of households by household size (1, 2, 3, 4+) and number of workers (0, 1, 2, 3+)
HBShop model:	Number of households by household size (1, 2, 3, 4+) and number of workers (0, 1, 2, 3+)
HBOther model:	Number of households by household size (1, 2, 3, 4+) and number of workers (0, 1, 2, 3+)
HBCollege model:	Number of households by number of persons age 18 - 24
HBSchool model:	Number of households by number of persons age 5 - 17
NHBWork model:	Employment by type (retail, FIRES, government, education, WTCU, manufacturing)
NHBOther model:	1. Number of households by household size (1, 2, 3, 4+) 2. Employment by type (retail, FIRES, government, education, WTCU, manufacturing)
Commercial Vehicle:	1. Number of households by household size (1, 2, 3+) 2. Employment by type (retail, FIRES, government, education, WTCU, manufacturing) 3. FTE college enrollment

Calibrated Trip Production Rates

TRIP ATTRACTION MODELS

Variable Definitions

TotHh	=	total households
OneHh	=	1-person households
TwoHh	=	2- person households

Three+Hh	=	3+ person households
RetEmp	=	retail employment
FIRESEmp	=	finance, insurance, real estate, and services employment
GovtEmp	=	government employment
EducEmp	=	education employment
WTCUEmp	=	wholesale, transportation, communications, and utilities employment
MfgEmp	=	manufacturing employment
CollFTE	=	college FTE enrollment

HBWork

Attractions = 0.10*TotHh + 1.57*RetEmp + 1.35*FIRESEmp + 1.35*GovtEmp + 1.48*EducEmp + 1.46*WTCUEmp + 1.46*MfgEmp

HBShop

Attractions = 4.36*RetEmp

HBOther

Attractions = 0.43*OneHh + 0.45*TwoHh + 0.48*Three+Hh + 3.74*RetEmp + 3.44*FIRESEmp +3.74*GovtEmp + 1.20*EducEmp + 0.20*WTCUEmp + 0.21*MfgEmp

HBCollege

Attractions = 0.88*CollFTE

HBSchool

Attractions = 7.90*EducEmp

NHBWork

Attractions = 1.44*RetEmp + 0.33*FIRESEmp +0.30*GovtEmp + 0.06*EducEmp + 0.08*WTCUEmp + 0.36*MfgEmp

NHBOther

Attractions = 0.17*OneHh + 0.23*TwoHh + 0.29*Three+Hh + 3.31*RetEmp + 0.76*FIRESEmp +0.68*GovtEmp + 0.13*EducEmp + 0.19*WTCUEmp + 0.84*MfgEmp

Commercial Vehicles

Attractions = 0.19*OneHh + 0.25*TwoHh + 0.32*Three+Hh 0.76*RetEmp + 0.33*FIRESEmp +0.32*GovtEmp + 0.19*EducEmp + 0.79*WTCUEmp + 0.79*MfgEmp+0.02*CollFTE

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USER PARAMETERS

Parameter No.	Description	Default Value
N/A		

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
xclass	mf24	Cross-classified household and employment data	add_FTE.mac
rates	mf09	Daily trip production and attraction rates by trip purpose	N/A

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
tgvect	mf61	Daily trip productions and attractions by trip purpose (table format)	change.mac

REPORTS: generate.rpt

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5.2.5 Change Production/Attraction Format (change.mac)

The change.mac macro converts the trip productions and attractions produced in table format by the generate.mac macro to vector format. The trip attractions are temporarily copied to origin vectors and then transposed into destination vectors. The trip productions are copied directly into origin vectors. The reformatted trip ends are used as input to the combine.mac macro.

USER PARAMETERS

Parameter No.	Description	Default Value
N/A		

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
tgvect	mf61	Daily trip productions and attractions by trip purpose (table format)	generate.mac

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
hbwp	mo71	Daily HBWork trip productions	combine.mac
hbcp	mo72	Daily HBCollege trip productions	combine.mac
hbsp	mo73	Daily HBShop trip productions	combine.mac
hbop	mo74	Daily HBOther trip productions	combine.mac
schp	mo75	Daily HBSchool trip productions	combine.mac
wkop	mo76	Daily NHBWork trip productions	combine.mac
otop	mo77	Daily NHBOther trip productions	combine.mac
cmvp	mo78	Daily Commercial Vehicle trip productions	combine.mac
hbwa	md71	Daily HBWork trip attractions	combine.mac
hbca	md72	Daily HBCollege trip attractions	combine.mac
hbsa	md73	Daily HBShop trip attractions	combine.mac
hboa	md74	Daily HBOther trip attractions	combine.mac
scha	md75	Daily HBSchool trip attractions	combine.mac

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
wkoa	md76	Daily NHBWork trip attractions	combine.mac
otoa	md77	Daily NHBOther trip attractions	combine.mac
cmva	md78	Daily Commercial Vehicle trip attractions	combine.mac

REPORTS: N/A

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5.2.6 Combine Productions/Attractions (combine.mac)

The combine.mac macro combines the daily trip productions and attractions for the eight trip purposes produced by the generate.mac macro into productions and attractions for four trip purposes. This is done in the following manner:

$\text{HBWork Prods}_{\text{Comb.}}$ = HBWork Prods + HBCollege Prods
$\text{HBOther Prods}_{\text{Comb.}}$ = HBShop Prods + 1.06 * HBOther Prods
$\text{HBSchool Prods}_{\text{Comb.}}$ = HBSchool Prods
$\text{NHB Prods}_{\text{Comb.}}$ = NHBWork Prods + NHBOther Prods + Commercial Vehicle Prods + 0.50 * NHB SuppGen Trip Ends
$\text{HBWork Attrs}_{\text{Comb.}}$ = HBWork Attrs + HBCollege Attrs
$\text{HBOther Attrs}_{\text{Comb.}}$ = HBShop Attrs + HBOther Attrs + HBO SuppGen Trip Ends
$\text{HBSchool Attrs}_{\text{Comb.}}$ = HBSchool Attrs
$\text{NHB Attrs}_{\text{Comb.}}$ = NHBWork Attrs + NHBOther Attrs + Commercial Vehicle Attrs + 0.50 * NHB SuppGen Trip Ends

As shown above, a calibration factor of 1.06 is applied to the HBOther productions when they are combined with the HBShop productions. The supplemental generator trip ends added for he HBOther and NHB trip purposes are for the Bellevue Square and Marymoor Park TAZs. The trip attractions are transposed from destination vector to origin vector format for final storage. The output of the combine.mac macro is used as input to the ensemble_2007.mac macro.

USER PARAMETERS

Parameter No.	Description	Default Value
N/A		

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
hbospg	mo43	Daily HBOther supplemental generator trip ends	N/A
nhbspg	mo44	Daily NHB supplemental generator trip ends	N/A
hbwp	mo71	Daily HBWork trip productions	change.mac
hbcp	mo72	Daily HBCollege trip productions	change.mac
hbsp	mo73	Daily HBShop trip productions	change.mac

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
hbop	mo74	Daily HBOther trip productions	change.mac
schp	mo75	Daily HBSchool trip productions	change.mac
wkop	mo76	Daily NHBWork trip productions	change.mac
otop	mo77	Daily NHBOther trip productions	change.mac
cmvp	mo78	Daily Commercial Vehicle trip productions	change.mac
hbwa	md71	Daily HBWork trip attractions	change.mac
hbca	md72	Daily HBCollege trip attractions	change.mac
hbsa	md73	Daily HBShop trip attractions	change.mac
hboa	md74	Daily HBOther trip attractions	change.mac
scha	md75	Daily HBSchool trip attractions	change.mac
wkoa	md76	Daily NHBWork trip attractions	change.mac
otoa	md77	Daily NHBOther trip attractions	change.mac
cmva	md78	Daily Commercial Vehicle trip attractions	change.mac

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
hbw-p	mo45	Daily HBWork trip productions (comb.)	ensemble_2010.mac.mac
hbw-a	mo46	Daily HBWork trip attractions (comb.)	ensemble_2010.mac.mac
hbo-p	mo47	Daily HBOther trip productions (comb.)	ensemble_2010.mac.mac
hbo-a	mo48	Daily HBOther trip attractions (comb.)	ensemble_2010.mac.mac
sch-p	mo49	Daily HBSchool trip productions (comb.)	ensemble_2010.mac.mac
sch-a	mo50	Daily HBSchool trip attractions (comb.)	ensemble_2010.mac.mac
nhb-p	mo51	Daily NHB trip productions (comb.)	ensemble_2010.mac.mac
nhb-a	mo52	Daily NHB trip attractions (comb.)	ensemble_2010.mac.mac

REPORTS: combine.rpt

5.2.7 Aggregate Non-BKR Area Productions/Attractions (ensemble_2010.mac)

The ensemble_2007.mac macro creates the final set of daily trip productions and attractions for the 4 trip purposes by adding productions and attractions for TAZs outside of the BKR area to the productions and attractions for the BKR area output by the combine.mac macro. The trip ends for TAZs within the PSRC model area outside of the BKR area are developed using the process described in Section V. – Input Data. A partition (partition "gl") is used to assemble the trip ends for each area from the production and attraction matrices :

Zone group "gl01" – TAZs within the BKR area
Zone group "gl02" – TAZs within the PSRC model area outside of the BKR area
Zone group "gl03" – Dummy TAZs outside the BKR area

The trip end matrices for the dummy TAZs outside of the BKR area defined by zone group "gl03" are zero-valued. A complete listing of the partition "gl" is provided in Appendix _.

The trip ends for TAZs within the PSRC model area outside of the BKR area are calculated for the BKR model base year by interpolating the values from the input PSRC 2000 and 2010 production and attraction matrices.

Following this, the trip ends are stored in the final production and attraction matrices. For the final trip attraction matrices, the last step of the process is to convert the attractions to destination vector format by transposing the origin vectors in which the attractions are temporarily stored during the macro execution.

The final trip production and attraction matrices are input to the trip distribution model.

USER PARAMETERS

Parameter No.	Description	Default Value
1	Factor for interpolating values from PSRC 2000 and 2010 production and attraction matrices	**N/A**

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
hbw-p	mo45	Daily HBWork trip productions	combine.mac
hbw-a	mo46	Daily HBWork trip attractions	combine.mac
hbo-p	mo47	Daily HBOther trip productions	combine.mac
hbo-a	mo48	Daily HBOther trip attractions	combine.mac
sch-p	mo49	Daily HBSchool trip productions	combine.mac
sch-a	mo50	Daily HBSchool trip attractions	combine.mac
nhb-p	mo51	Daily NHB trip productions	combine.mac
nhb-a	mo52	Daily NHBWork trip attractions	combine.mac
hbwpro	mo53	2000 Daily PSRC HBWork + HBCollege trip productions	N/A
hbwatt	mo54	2000 Daily PSRC HBWork + HBCollege trip attractions	N/A
hbopro	mo55	2000 Daily PSRC HBOther trip productions	N/A
hboatt	mo56	2000 Daily PSRC HBOther trip attractions	N/A
nhbpro	mo57	2000 Daily PSRC NHB + Commercial Vehicle trip productions	N/A
nhbatt	mo58	2000 Daily PSRC NHB + Commercial Vehicle trip attractions	N/A
schpro	mo59	2000 Daily PSRC HBSchool trip productions	N/A
schatt	mo60	2000 Daily PSRC HBSchool trip attractions	N/A
?	mo61	Daily trip ends for dummy TAZs	N/A
hbwpro	mo79	2010 Daily PSRC HBWork + HBCollege trip productions	N/A
hbwatt	mo80	2010 Daily PSRC HBWork + HBCollege trip attractions	N/A
hbopro	mo81	2010 Daily PSRC HBOther trip productions	N/A
hboatt	mo82	2010 Daily PSRC HBOther trip attractions	N/A
nhbpro	mo83	2010 Daily PSRC NHB + Commercial Vehicle trip productions	N/A
nhbatt	mo84	2010 Daily PSRC NHB + Commercial Vehicle trip attractions	N/A

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
schpro	mo85	2010 Daily PSRC HBSchool trip productions	N/A
schatt	mo86	2010 Daily PSRC HBSchool trip attractions	N/A

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
hbw-pf	mo01	Daily HBWork trip productions (final)	hbw_dist.mac
hbw-af	md01	Daily HBWork trip attractions (final)	hbw_dist.mac
hbo-pf	mo02	Daily HBOther trip productions (final)	hbo_dist.mac
hbo-af	md02	Daily HBOther trip attractions (final)	hbo_dist.mac
nhb-pf	mo03	Daily NHB trip productions (final)	nhb_dist.mac
nhb-af	md03	Daily NHB trip attractions (final)	nhb_dist.mac
sch-pf	mo04	Daily HBSchool trip productions (final)	sch_dist.mac
sch-af	md04	Daily HBSchool trip attractions (final)	sch_dist.mac

REPORTS: ensemble_2010.rpt

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5.3 Auto Skims

The auto skims module creates the auto time and distance skims that are used within the trip distribution and mode choice modules. This is done within the following macros:

- Create extra attributes for SOV, HOV volumes (extra-attr.mac)
- Create AM peak hour auto skims (am0mcskim1.mac and am_mcskim1.mac)
- Revise AM peak hour auto skims (am_mcskim2.mac)
- Create composite AM peak hour auto skims (am_mcskim3.mac)
- Create mid-day auto skims (md0mcskim1.mac and md_mcskim1.mac)
- Revise mid-day auto skims (md_mcskim2.mac)
- Create composite mid-day auto skims (md_mcskim3.mac)
- Add intrazonal times and distances to auto skims (dist_tt.mac)
- Calculate average auto time and distance skims (avg_mcskim.mac)
- Save auto skims for trip distribution (save0mcskim.mac and save_mcskim.mac)

Skims for the AM peak hour and mid-day hour are developed using the same process. In the first iteration of model processing, free flow SOV and HOV skims for each time period are created by performing multi-class assignments using a scalar matrix having a value of 0.0001. Composite auto travel time skims are computed by weighting the SOV and HOV travel times. Intrazonal times and distances are then added to the auto time and distance skims. The distance skims are input to the mode choice model. The AM peak hour travel time skims are input to the HBWork and HBSchool trip distribution models. The mid-day hour travel time skims are input to the non-work trip distribution and mode choice models.

The skim building process is the same in the second and subsequent iterations of model processing, except that the SOV and HOV vehicle trip matrices from the previous iteration are used in the assignments to produce congested auto time and distance skims and the skims are averaged with the skims from the previous iterations using a successive averaging technique prior to their input to the trip distribution and mode choice models.

5.3.1 Create Extra Attributes for SOV, HOV Volumes (extra-attr.mac)

The extra-attr.mac macro creates extra link and extra turn attributes used for the storage of AM peak hour, mid-day peak hour, and PM peak hour link and turn volumes produced by the macros am_assign_3c.mac, md_assign_3c.mac, and pm_assign_3c.mac.

USER PARAMETERS

Parameter No.	Description	Default Value
N/A		

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
N/A			

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
@sovv	N/A	Extra link attribute used for storage of PM peak hour SOV link volumes	pm_assign.mac
@hovv	N/A	Extra link attribute used for storage of PM peak hour HOV link volumes	pm_assign.mac
@sovt	N/A	Extra link attribute used for storage of PM peak hour SOV turn volumes	pm_assign.mac
@hovt	N/A	Extra link attribute used for storage of PM peak hour HOV turn volumes	pm_assign.mac
@asovv	N/A	Extra link attribute used for storage of AM peak hour SOV link volumes	am_assign.mac
@ahovv	N/A	Extra link attribute used for storage of AM peak hour HOV link volumes	am_assign.mac
@asovt	N/A	Extra link attribute used for storage of AM peak hour SOV turn volumes	am_assign.mac
@ahovt	N/A	Extra link attribute used for storage of AM peak hour HOV turn volumes	am_assign.mac
@msovv	N/A	Extra link attribute used for storage of mid-day peak hour SOV link volumes	md_assign.mac

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
@mhovv	N/A	Extra link attribute used for storage of AM peak hour HOV link volumes	md_assign.mac
@msovt	N/A	Extra link attribute used for storage of AM peak hour SOV turn volumes	md_assign.mac
@mhovt	N/A	Extra link attribute used for storage of AM peak hour HOV turn volumes	md_assign.mac

REPORTS: extra-attr.rpt

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5.3.2 Create AM Peak Hour Auto Skims (am0mcskim1_tollhov2.mac and am_mcskim1_tollhov2.mac)

The am0mcskim1.mac and am_mcskim1.mac macros are used to develop AM peak hour travel time skims for the SOV and HOV modes and AM peak hour distance skims for the SOV mode only. An AM peak hour multi-class assignment is performed within each macro. Within the am0mcskim1.mac macro, a scalar demand matrix with a value of 0.0001 is assigned to produce free-flow travel time and distance skims. This macro is run for the first iteration of model processing only. Within the am_mcskim1_tollhov2.mac macro, AM peak hour SOV and HOV vehicle trip matrices are assigned to produce congested travel time and distance skims. This macro is run for the second and subsequent iterations of model processing. The same output matrices are used by both macros, so the free-flow travel time and distance skims produced by the am0mcskim1_tollhov2.mac macro are overwritten by the am_mcskim1_tollhov2.mac macro. The skims are input to the am_mcskim2.mac macro.

Toll is set for SOV and HOV2+ for appropriate facilities.

USER PARAMETERS

Parameter No.	Description	Default Value
1	Scenario number of scenario used for auto assignment	6
2	Assignment stopping criterion for maximum number of assignment iterations	100
3	Assignment stopping criterion for size of relative gap	1
4	Assignment stopping criterion for size of normalized gap	0.1
5	Weight factor for @stoll	0.0555
6	Weight factor for @htoll	0.0244

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
am0mcskim1.mac			
scale1	ms11	Scalar demand matrix with value of 0.0001 used for first iteration assignment	N/A
@stoll		Toll for SOV	N/A
@htoll		Toll for HOV	N/A

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
am_mcskim1.mac			
famsov	mf143	AM peak hour SOV vehicle trips	amslhov.mac
famhov	mf144	AM peak hour HOV vehicle trips	am2pr+hov.mac
@stoll		Toll for SOV	N/A
@htoll		Toll for HOV	N/A

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
am0mcskim1.mac			
amsovt	mf23	AM peak hour free-flow SOV travel times	am_mcskim2.mac
amsvcd	mf13	AM peak hour free flow SOV travel distances	am_mcskim2.mac
amhovt	mf25	AM peak hour free-flow HOV travel times	am_mcskim2.mac
am_mcskim1.mac			
amsovt	mf23	AM peak hour congested SOV travel times	am_mcskim2.mac
amsvcd	mf13	AM peak hour congested SOV travel distances	am_mcskim2.mac
amhovt	mf25	AM peak hour congested HOV travel times	am_mcskim2.mac

REPORTS: am0mcskim1.rpt/am_mcskim1.rpt

5.3.3 Revise AM Peak Hour Auto Skims (am_mcskim2.mac)

The am_mcskim2.mac macro revises the AM peak hour SOV and HOV travel time and distance skims output by the am0mcskim1.mac and am_mcskim1.mac macros by replacing any matrix values of less than 0 or greater than 9999 with a value of 9999. This macro uses the same output matrices as those for the am0mcskim1.mac and am_mcskim1.mac macros, so the initial free-flow travel time and distance skims are overwritten. The revised matrices are input to the am_mcskim3.mac and dist_tt.mac macros.

USER PARAMETERS

Parameter No.	Description	Default Value
N/A		

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
amsovt	mf23	AM peak hour free-flow/congested SOV travel times	am0mcskim1.mac am_mcskim1.mac
amsvcd	mf13	AM peak hour free flow/congested SOV travel distances	am0mcskim1.mac am_mcskim1.mac
amhovt	mf25	AM peak hour free flow/congested HOV travel times	am0mcskim1.mac am_mcskim1.mac

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
amsovt	mf23	AM peak hour free-flow/congested SOV travel times (revised)	am_mcskim3.mac hbw_mc.mac
amsvcd	mf13	AM peak hour free flow/congested SOV travel distances (revised)	dist_tt.mac
amhovt	mf25	AM peak hour free flow/congested HOV travel times (revised)	am_mcskim3.mac hbw_mc.mac

REPORTS: am_mcskim2.rpt

5.3.4 Create Composite AM Peak Hour Auto Skims (am_mcskim3.mac)

The am_mcskim3.mac macro computes composite AM peak hour auto travel time skims by weighting the SOV and HOV travel times produced by the am_mcskim2.mac macro in the following manner:

Composite Travel Time = 0.85 * SOV Travel Time + 0.15 * HOV Travel Time

The composite travel time skims are input to the dist_tt.mac macro.

USER PARAMETERS

Parameter No.	Description	Default Value
1	SOV travel time weight	0.85
2	HOV travel time weight	0.15

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
amsovt	mf23	AM peak hour free-flow/congested SOV travel times (revised)	am_mcskim2.mac
amhovt	mf25	AM peak hour free flow/congested HOV travel times (revised)	am_mcskim2.mac

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
amsvct	mf14	AM peak hour composite auto travel times	dist.tt.mac

REPORTS: am_mcskim3.rpt

5.3.5 Create Mid-day Auto Skims (md0mcskim1_tollhov2.mac and md_mcskim1_tollhov2.mac)

The md0mcskim1.mac and md_mcskim1.mac macros are used to develop mid-day hour travel time skims for the SOV and HOV modes and mid-day hour distance skims for the SOV mode only. A mid-day hour multi-class assignment is performed within each macro. Within the md0mcskim1.mac macro, a scalar demand matrix with a value of 0.0001 is assigned to produce free-flow travel time and distance skims. This macro is run for the first iteration of model processing only. Within the md_mcskim1.mac macro, mid-day hour SOV and HOV vehicle trip matrices are assigned to produce congested travel time and distance skims. This macro is run for the second and subsequent iterations of model processing. The same output matrices are used by both macros, so the free-flow travel time and distance skims produced by the md0mcskim1_tollhov2.mac macro are overwritten by the md_mcskim1_tollhov2.mac macro. The skims are input to the md_mcskim2.mac macro.

Toll is set for SOV and HOV2+ for appropriate facilities.

USER PARAMETERS

Parameter No.	Description	Default Value
1	Scenario number of scenario used for auto assignment	60
2	Assignment stopping criterion for maximum number of assignment iterations	100
3	Assignment stopping criterion for size of relative gap	1
4	Assignment stopping critierion for size of normalized gap	0.1
5	Weight factor for @stoll	0.0659
6	Weight factor for @htoll	0.029

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
md0mcskim1.mac			
scale1	ms11	Scalar demand matrix with value of 0.0001 used for first iteration assignment	N/A
@stoll		Toll for SOV	N/A
@htoll		Toll for SOV	N/A
md_mcskim1.mac			

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
fmdsov	mf145	Mid-day hour SOV vehicle trips	mdslhov.mac
fmdhov	mf146	Mid-day hour HOV vehicle trips	md2pr+hov.mac
@stoll		Toll for SOV	N/A
@htoll		Toll for SOV	N/A

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
md0mcskim1.mac			
mdsovt	mf63	Mid-day hour free-flow SOV travel times	md_mcskim2.mac
mdsvfd	mf11	Mid-day hour free flow SOV travel distances	md_mcskim2.mac
mdhovt	mf65	Mid-day hour free-flow HOV travel times	md_mcskim2.mac
md_mcskim1.mac			
mdsovt	mf63	Mid-day hour congested SOV travel times	md_mcskim2.mac
mdsvfd	mf11	Mid-day hour congested SOV travel distances	md_mcskim2.mac
mdhovt	mf65	Mid-day hour congested HOV travel times	md_mcskim2.mac

REPORTS: md0mcskim1.rpt/md_mcskim1.rpt

5.3.6 Revise Mid-day Auto Skims (md_mcskim2.mac)

The md_mcskim2.mac macro revises the mid-day hour SOV and HOV travel time and distance skims output by the md0mcskim1.mac and md_mcskim1.mac macros by replacing any matrix values of less than 0 or greater than 9999 with a value of 9999. This macro uses the same output matrices as those for the md0mcskim1.mac and md_mcskim1.mac macros, so the initial free-flow travel time and distance skims are overwritten. The revised matrices are input to the md_mcskim3.mac and dist_tt.mac macros.

USER PARAMETERS

Parameter No.	Description	Default Value
N/A		

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
mdsovt	mf63	Mid-day hour free-flow/congested SOV travel times	1. md0mcskim1.mac 2. md_mcskim1.mac
mdsvfd	mf11	Mid-day hour free flow/congested SOV travel distances	1. md0mcskim1.mac 2. md_mcskim1.mac
mdhovt	mf65	Mid-day hour free flow/congested HOV travel times	1. md0mcskim1.mac 2. md_mcskim1.mac

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
mdsovt	mf63	Mid-day hour free-flow/congested SOV travel times (revised)	md_mcskim3.mac
mdsvfd	mf11	Mid-day hour free flow/congested SOV travel distances (revised)	dist_tt.mac
mdhovt	mf65	Mid-day hour free flow/congested HOV travel times (revised)	md_mcskim3.mac

REPORTS: md_mcskim2.rpt

5.3.7 Create Composite Mid-day Auto Skims (md_mcskim3.mac)

The md_mcskim3.mac macro computes composite mid-day hour auto travel time skims by weighting the SOV and HOV travel times produced by the md_mcskim2.mac macro in the following manner:

Composite Travel Time = 0.85 * SOV Travel Time + 0.15 * HOV Travel Time

The composite travel time skims are input to the dist_tt.mac macro.

USER PARAMETERS

Parameter No.	Description	Default Value
1	SOV travel time weight	0.85
2	HOV travel time weight	0.15

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
mdsovt	mf63	Mid-day hour free-flow/congested SOV travel times (revised)	md_mcskim2.mac
mdhovt	mf65	Mid-day hour free flow/congested HOV travel times (revised)	md_mcskim2.mac

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
mdsvft	mf12	Mid-day hour composite auto travel times	dist.tt.mac

REPORTS: md_mcskim3.rpt

5.3.8 Add Intrazonal Times and Distances to Auto Skims (dist_tt.mac)

The dist_tt.mac macro is used to add intrazonal travel times and distances to the AM peak hour and mid-day hour travel time and distance skims. For each skim matrix, the intrazonal times or distances are estimated as 0.75 times the minimum time or distance to the nearest neighboring zone. This is done by:

- Inserting a value of "9999" into the zero-valued intrazonal cells of the skim matrix;
- Creating a temporary origin matrix containing the minimum value of each row of the skim matrix; and
- Multiplying the origin matrix by 0.75 and inserting the resulting values into the intrazonal cells of the skim matrix.

The modified skim matrices are input to the save0mcskim.mac, save_mcskim.mac, and avg_mcskim.mac macros.

USER PARAMETERS

Parameter No.	Description	Default Value
N/A		

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
mdsvfd	mf11	Mid-day hour free flow/congested SOV travel distances	md_mcskim2.mac
mdsvft	mf12	Mid-day hour composite auto travel times	md_mcskim3.mac
amsvcd	mf13	AM peak hour free flow/congested SOV travel distances	am_mcskim2.mac
amsvct	mf14	AM peak hour composite auto travel times	am_mcskim3.mac

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
mffds	mf31	Mid-day hour auto distances (modified)	1. save0mcskim.mac 2. save_mcskim.mac 3. avg_mcskim.mac
mfftt	mf32	Mid-day hour auto travel times (modified)	1. save0mcskim.mac 2. save_mcskim.mac 3. avg_mcskim.mac
mconds	mf33	AM peak hour auto distances (modified)	1. save0mcskim.mac 2. save_mcskim.mac 3. avg_mcskim.mac
mcontt	mf34	AM peak hour auto travel times (modified)	1. save0mcskim.mac 2. save_mcskim.mac 3. avg_mcskim.mac

REPORTS: dist_tt.rpt

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5.3.9 Calculate Average Auto Time and Distance Skims (avg_mcskim.mac)

The avg_mcskim.mac macro calculates average auto travel time and distance skims for use in the trip distribution model. A successive averaging procedure is used in which the average skim values from the previous iterations of model processing are averaged with the current skim values contained in the travel time and distance matrices output by the dist_tt.mac macro. The avg_mcskim.mac macro is executed starting with the second iteration of model processing, once an initial set of travel time and distance matrices are available from the first iteration. The input matrices containing the current skims are also used as the output matrices for this macro, so the current skims are overwritten with the average skim values. The average distance skims are input to the mode choice model and the save_mcskim.mac macro. The average mid-day hour travel time skims are input to the non-work trip distribution and mode choice models and the save_mcskim.mac macro. The average AM peak hour travel time skims are input to the HBWork and HBSchool trip distribution models and the save_mcskim.mac macro.

USER PARAMETERS

Parameter No.	Description	Default Value
N/A		

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
1stmdd	mf01	Mid-day hour auto distances (previous iteration)	1. save0mcskim.mac 2. save_mcskim.mac
1stmdt	mf02	Mid-day hour auto travel times (previous iteration)	1. save0mcskim.mac 2. save_mcskim.mac
1stamd	mf03	AM peak hour auto distances (previous iteration)	1. save0mcskim.mac 2. save_mcskim.mac
1stamt	mf04	AM peak hour auto travel times (previous iteration)	1. save0mcskim.mac 2. save_mcskim.mac
mffds	mf31	Mid-day hour auto distances (current iteration)	dist_tt.mac
mfftt	mf32	Mid-day hour auto travel times (current iteration)	dist_tt.mac
mconds	mf33	AM peak hour auto distances (current iteration)	dist_tt.mac

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
mcontt	mf34	AM peak hour auto travel times (current iteration)	dist_tt.mac

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
mffds	mf31	Mid-day hour auto distances (averaged)	1. hbo_mc.mac 2. nhb_mc.mac 3. save_mcskim.mac
mfftt	mf32	Mid-day hour auto travel times (averaged)	1. hbo_dist.mac 2. nhb_dist.mac 3. hbo_mc.mac 4. nhb_mc.mac 5. save_mcskim.mac
mconds	mf33	AM peak hour auto distances (averaged)	1. hbw_mc.mac 2. save_mcskim.mac
mcontt	mf34	AM peak hour auto travel times (averaged)	1. hbw_dist.mac 2. sch_dist.mac 3. save_mcskim.mac

REPORTS: avg_mcskim.rpt

DRAFT

5.3.10 Save Auto Skims for Trip Distribution (save0mcskim.mac and save_mcskim.mac)

The save0mcskim.mac saves the auto travel time and distance skim matrices from the initial iteration of model processing into separate matrices. These matrices are used by the avg_mcskim.mac to calculate average skim values from the first and second iterations. The save_mcskim.mac function in an identical manner, except that it is executed starting with the second iteration of model processing.

Parameter No.	Description	Default Value
N/A		

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
save0mcskim.mac			
mffds	mf31	Mid-day hour auto distances	dist_tt.mac
mfftt	mf32	Mid-day hour auto travel times	dist_tt.mac
mconds	mf33	AM peak hour auto distances	dist_tt.mac
mcontt	mf34	AM peak hour auto travel times	dist_tt.mac
save_mcskim.mac			
mffds	mf31	Mid-day hour auto distances	avg_mcskim.mac
mfftt	mf32	Mid-day hour auto travel times	avg_mcskim.mac
mconds	mf33	AM peak hour auto distances	avg_mcskim.mac
mcontt	mf34	AM peak hour auto travel times	avg_mcskim.mac

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
1stmdd	mf01	Mid-day hour auto distances	avg_mcskim.mac
1stmdt	mf02	Mid-day hour auto travel times	avg_mcskim.mac
1stamd	mf03	AM peak hour auto distances	avg_mcskim.mac
1stamt	mf04	AM peak hour auto travel times	avg_mcskim.mac

REPORTS: save0mcskim.rpt/save_mcskim.rpt.rpt

5.4 Trip Distribution

The trip distribution model is the second of the four primary model components identified as part of the four-step planning process. The trip distribution models estimate the number of trips from each TAZ to each other traffic analysis zone. The trips are estimated as a function of the travel impedance from one zone to another, using a gravity model technique. Trip distribution models are applied for each of four trip purposes (same as in trip generation, except several trip purposes are combined).

5.4.1 Travel Time Impedance

A.M. peak hour congested auto travel times were estimated from the BKR Model to run the Home-Base Work trip distribution model, while non-congested Mid-day hour auto travel times were used to run the other trip distribution models.

Congested Auto Travel Times
A.M. peak hour multi-class auto trip tables were assigned onto the network to obtain drive-alone and share-ride auto skims that were weighted to represent the composite auto travel time in a congested traffic condition.

- am_mcskim1.mac
- am_mcskim2.mac
- am_mcskim3.mac

Non-Congested Auto Travel Times
Midday Multi-class auto trip tables were assigned onto the network to obtain drive-alone and share-ride auto skims that were weighted to represent the composite auto travel time in a non-congested traffic condition.

- md_mcskim1.mac
- md_mcskim2.mac
- md_mcskim3.mac

Averaging Process via Iterative Feedback Looping
The travel skims derived from the initial round of four-step process may not reach real-world equilibrium especially for the peak hour situation because the initial trip tables used were derived from the free-flow modeling process. As it was used, the initial round of travel skims were averaged with the second and the third round of travel skims to bring equilibrium to the modeling system; that is, the modeling results from trip distribution, mode choice and assignments all stay stable or consistent.

- dist_tt.mac
- avg_mcskim.mac
- save_mcskim.mac

5.4.2 Balancing Trip Attractions to Trip Productions

Trip distribution model runs were doubly constrained by trip attractions and trip productions; that is, the total origin-destination trips by each trip purpose were iteratively balanced to attractions and eventually balanced to trip productions. Because the cross-classified household trip production rates (as shown in Table 4.6) were statistically extracted from a very large sample size (over 120,000 trips in the 1999 PSRC Household Travel Survey), and housing information is more accurate in the BKR jurisdictions, staff have much greater confidence in balancing the total trips to trip productions for four combined trip purposes:

- HB-Work + HB-College
- HB-Other + HB-Shopping
- NHB-Work and Non-Work
- HB-School

The following macros are called in this module:

- Home-Based Work Trip Distribution Model (hbw_dist.mac)
- Home-Based Other Trip Distribution Model (hbo_dist.mac)
- Non-Home-Based Trip Distribution Model (nhb_dist.mac)
- Home-Based School Trip Distribution Model (sch_dist.mac)

DRAFT

5.4.3 Home-Based Work Trip Distribution Model (hbw_dist.mac)

The hbw_dist.mac macro implements the home-based work trip distribution model. The model performs trip distribution for internal-internal, internal-external, and external-internal trips. Prior to the trip distribution, several preliminary tasks are performed within the macro:

- Terminal times are added to the destination end of the AM peak hour auto travel times. Following this, an additional 2 minutes of terminal time is added to the intrazonal times of TAZs within the BKR area.
- The modified travel times are rounded to the nearest integer for the development of a friction factor matrix.
- An origin vector matrix with values equal to the zone numbers is created for use in the development of the friction factor matrix.
- A matrix convolution is performed to create the friction factor matrix using a unit scalar ("ones") matrix, the rounded travel times and zone number vector, and a vector matrix containing the calibrated HBWork friction factors.
- The friction factors for E-E zone pairs are set equal to zero to exclude E-E trips from the trip distribution.
- The friction factors for Bellevue CBD intrazonal travel are set equal to zero to exclude Bellevue CBD intrazonal trips from the trip distribution.

The trip distribution is conducted using a two dimensional balancing procedure in which the friction factor matrix is iteratively balanced between the zonal production and attraction totals. A total of 20 balancing iterations are performed.

The final step in the process is to factor the external – to – Bellevue CBD trips in the resulting HBWork person trip matrix. This is done by:

- Dividing these trips by a factor of 2.162 and saving a new (temporary) HBWork person trip matrix.
- Calculating row sums for the new matrix.
- Multiplying the new matrix by the ratio of the row sums for the new matrix to the original HBWork productions. This has the effect of restoring the original production and attraction totals for the external zones and Bellevue CBD by increasing the external –to-non-Bellevue CBD trips by the amount of the reduced external – to Bellevue CBD trips.

VARIABLE DEFINITIONS

HBWork friction factors
Zonal HBWork trip productions
Zonal HBWork trip attractions

CALIBRATED IMPEDANCE FUNCTION

$F_t = \alpha * \exp(\beta t + \gamma \ln t)$

where:

F_t = Friction factor for travel time t
t = AM peak hour auto travel time
α = 35,000
β = -0.094
γ = -0.096

USER PARAMETERS

Parameter No.	Description	Default Value
1	Added terminal time for BKR area TAZs (mins.)	2
2	External zone – to –Bellevue CBD trip adjustment factor	2.162
3	Number of balancing iterations for trip distribution	20

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
mcontt	mf34	AM peak hour auto travel times	avg_mcskim.mac
auttim	mo11	Auto terminal times	N/A
ones	ms01	Unit scalar matrix	N/A
hbwff	mo06	HBWork friction factors	N/A
hbw-pf	mo01	Daily HBWork trip productions	ensemble.mac
hbw-af	md01	Daily HBWork trip attractions	ensemble.mac

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
mhbwat	mf84	AM peak hour auto travel times with terminal times	N/A
hbwtrp	mf36	HBWork person trips	hbw_mc.mac

REPORTS: hbw_dist.rpt

DRAFT

5.4.4 Home-Based Other Trip Distribution Model (hbo_dist.mac)

The hbo_dist.mac macro implements the home-based other trip distribution model. The model performs trip distribution for internal-internal, internal-external, and external-internal trips. Prior to the trip distribution, several preliminary tasks are performed within the macro:

- Terminal times are added to the destination end of the mid-day hour auto travel times. Following this, an additional 2 minutes of terminal time is added to the intrazonal times of TAZs within the BKR area.
- The modified travel times are rounded to the nearest integer for the development of a friction factor matrix.
- An origin vector matrix with values equal to the zone numbers is created for use in the development of the friction factor matrix.
- A matrix convolution is performed to create the friction factor matrix using a unit scalar ("ones") matrix, the rounded travel times and zone number vector, and a vector matrix containing the calibrated HBOther friction factors.
- The friction factors for E-E zone pairs are set equal to zero to exclude E-E trips from the trip distribution.
- The friction factors for Bellevue CBD intrazonal travel are set equal to zero to exclude Bellevue CBD intrazonal trips from the trip distribution.

The trip distribution is conducted using a two dimensional balancing procedure in which the friction factor matrix is iteratively balanced between the zonal production and attraction totals. A total of 20 balancing iterations are performed.

The final step in the process is to add HBOther special generator trips to the resulting HBOther person trip matrix. This is done by:

- Calculating the sum of all HBO trip productions.
- Adding special generator trips from each TAZ to the special generators in proportion to each TAZ's share of total HBO productions.

VARIABLE DEFINITIONS

HBOther friction factors
Zonal HBOther trip productions
Zonal HBOther trip attractions

CALIBRATED IMPEDANCE FUNCTION

$$F_t = \alpha * \exp(\beta t + \gamma \ln t)$$

where:

F_t = Friction factor for travel time t
t = Mid-day hour auto travel time
α = 50,000
β = -0.24
γ = -0.24

USER PARAMETERS

Parameter No.	Description	Default Value
1	Added terminal time for BKR area TAZs (mins.)	2
2	Number of balancing iterations for trip distribution	20

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
mfftt	mf32	Mid-day hour auto travel times	avg_mcskim.mac
auttim	mo11	Auto terminal times	N/A
ones	ms01	Unit scalar matrix	N/A
hboff	mo07	HBOther friction factors	N/A
hbo-pf	mo02	Daily HBOther trip productions	ensemble.mac
hbo-af	md02	Daily HBOther trip attractions	ensemble.mac

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
mhboat	mf86	Mid-day hour auto travel times with terminal times	N/A
hbotrp	mf37	HBOther person trips	hbo_mc.mac

REPORTS: **hbo_dist.rpt**

5.4.5 Non-Home-Based Trip Distribution Model (nhb_dist.mac)

The nhb_dist.mac macro implements the non-home-based trip distribution model. The model performs trip distribution for internal-internal, internal-external, and external-internal trips. Prior to the trip distribution, several preliminary tasks are performed within the macro:

- Terminal times are added to the destination end of the mid-day hour auto travel times. Following this, an additional 6 minutes of terminal time is added to the intrazonal times of TAZs within the BKR area.
- The modified travel times are rounded to the nearest integer for the development of a friction factor matrix.
- An origin vector matrix with values equal to the zone numbers is created for use in the development of the friction factor matrix.
- A matrix convolution is performed to create the friction factor matrix using a unit scalar ("ones") matrix, the rounded travel times and zone number vector, and a vector matrix containing the calibrated NHB friction factors.
- The friction factors for Bellevue CBD –to- Bellevue CBD zone pairs are multiplied by a factor of 3.75. A second factor of 0.613 is applied to the friction factors for these zone pairs with auto travel time equal to 5 minutes.
- The friction factors for E-E zone pairs are set equal to zero to exclude E-E trips from the trip distribution.
- The friction factors for Bellevue CBD intrazonal travel are set equal to zero to exclude Bellevue CBD intrazonal trips from the trip distribution.

The trip distribution is conducted using a two dimensional balancing procedure in which the friction factor matrix is iteratively balanced between the zonal production and attraction totals. A total of 20 balancing iterations are performed.

VARIABLE DEFINITIONS

NHB friction factors
Zonal NHB trip productions
Zonal NHB trip attractions

CALIBRATED IMPEDANCE FUNCTION

$F_t = \alpha * \exp(\beta t + \gamma \ln t)$

where:

F_t = Friction factor for travel time t
t = Mid-day hour auto travel time
α = 45,000
β = -0.170
γ = -0.172

USER PARAMETERS

Parameter No.	Description	Default Value
1	Added terminal time for BKR area TAZs (mins.)	6
2	First friction factor adjustment factor for Bellevue CBD - to-Bellevue CBD zone pairs	3.75
3	Second friction factor adjustment factor for Bellevue CBD – to - Bellevue CBD zone pairs with auto travel time equal to 5 minutes	0.613
4	Number of balancing iterations for trip distribution	20

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
mfftt	mf32	Mid-day hour auto travel times	avg_mcskim.mac
auttim	mo11	Auto terminal times	N/A
ones	ms01	Unit scalar matrix	N/A
nhbff	mo08	NHB friction factors	N/A
nhb-pf	mo03	Daily NHB trip productions	ensemble.mac
nhb-af	md03	Daily NHB trip attractions	ensemble.mac

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
mnhbat	mf78	Mid-day hour auto travel times with terminal times	N/A
nhbtrp	mf38	NHB person trips	nhb_mc.mac

REPORTS: nhb_dist.rpt

5.4.6 Home-Based School Trip Distribution Model (sch_dist.mac)

The sch_dist.mac macro implements the non-home-based trip distribution model. The model performs trip distribution for each of 20 school districts within the BKR and external model areas. Prior to the trip distribution, several preliminary tasks are performed within the macro:

- 1.25 minutes is added to the AM peak hour auto travel times used to prepare the friction factor matrix.
- Terminal times are added to both the origin and destination ends of the AM peak hour travel times; the resulting times are rounded to the nearest integer value.
- An origin vector matrix with values equal to the zone numbers is created for use in the preparation of the friction factor matrix.
- Potential negative values contained in the HBSchool production and attraction matrices are set to zero.
- A matrix convolution is performed to create the friction factor matrix using a unit scalar ("ones") matrix, the rounded travel times and zone number vector, and a vector matrix containing the calibrated NHB friction factors.
- The friction factors for E-E zone pairs are set equal to zero to exclude E-E trips from the trip distribution.
- The friction factors for Bellevue CBD intrazonal travel are set to zero to exclude Bellevue CBD intrazonal trips from the trip distribution.

The trip distribution is performed within a loop procedure, in which one iteration of the loop is run for each school district. Within each iteration, the following steps are followed:

- A temporary matrix for storing the school district trips is initialized.
- School trip productions and attractions for zones within the school district are extracted from the HBSchool trip production and attraction matrices using partition "ga".
- Trip distribution is performed using a two dimensional balancing procedure in which the friction factor matrix is iteratively balanced between the zonal productions and attractions. A total of 20 balancing iterations are performed.
- The distributed trips for the school district are added to a total HBSchool trip matrix.

Upon completion of the last iteration of loop processing, the total HBSchool matrix contains the school trips for all of the school districts.

VARIABLE DEFINITIONS

HBSchool friction factors
Zonal HBSchool trip productions
Zonal HBSchool trip attractions

CALIBRATED IMPEDANCE FUNCTION

$F_t = \alpha * \exp(\beta t + \gamma \ln t)$

where:

F_t = Friction factor for travel time t
t = AM peak hour hour auto travel time
α = 67,500
β = -0.345
γ = -0.325

USER PARAMETERS

Parameter No.	Description	Default Value
1	Added AM peak hour travel time (mins.)	1.25
2	Number of balancing iterations for trip distribution	20
3	Number of school districts	20

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
mcontt	mf34	AM peak hour auto travel times	avg_mcskim.mac
auttim	mo11	Auto terminal times	N/A
ones	ms01	Unit scalar matrix	N/A
schff	mo09	HBSchool friction factors	N/A
sch-pf	mo04	Daily HBSchool trip productions	ensemble.mac
sch-af	md04	Daily HBSchool trip attractions	ensemble.mac

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
rschat	mf80	AM peak hour auto travel times with added travel time and terminal times	N/A
hbstrp	mf39	HBSchool person trips	1. ampktran.mac 2. mdpktran.mac 3. pmpktran.mac 4. slov_tt.mac

REPORTS: sch_dist.rpt

DRAFT

5.5 Transit Skims

Description of the transit skims module, including:

- ***what is done within the step, in general, and its relationship to other steps in the modeling chain; and***
- ***a listing of the macros that are used.***

The following macros are used in calculate transit skims.

- Create AM Peak Hour Transit Skims (amtrnhdw.mac)
- Calculate Initial AM Peak Hour Effective Headways (effhdwy0.mac)
- Perform AM Peak Hour Transit Assignment (amtranhw.mac)
- Calculate AM Peak Hour Capacity Constrained Headways (effhdwy.mac)
- Calculate AM Peak Hour Park-and-Ride Skims (ampkrskm2.mac)
- Create Mid-day Transit Trip Table (mdpktran.mac)
- Perform Mid-day Transit Assignment (md-tran-asgn.mac)
- Calculate Total Transit Impedances (trans-imp.mac)
- Calculate Average Transit Impedances (avg_transkim.mac)
- Save Total Transit Impedances (save_transkim.mac)

DRAFT

5.5.1 Create AM Peak Hour Transit Skims (amtrnhdw.mac)

The amtrnhdw.mac macro executes a sequence of other macros (effhdwy0.mac, amtranhw.mac, and effhdwy.mac) within a loop structure to produce a capacity-restrained AM peak hour transit assignment. With this procedure, the headways for transit routes having ridership volumes that exceed total vehicle capacity are adjusted upward in an attempt to divert the excess demand to other routes. A total of six transit assignments is performed (amtranhw.mac), with the headways adjusted at the end of each assignment in proportion to the excess demand. Prior to the first assignment, the wait time factor used in the assignments is stored in node user data item 1 ("ui1") with a value of 0.5.

A successive averaging technique is used to average the adjusted headways with the average headways from the previous assignments (effhdwy.mac). The updated headways are then used for the next iteration of assignment and headway adjustment. At the end of the last assignment, the objective is to have the total transit ridership demand reasonably distributed among alternative transit routes based on available capacity, similar to the way that a capacity-restrained auto assignment works. In the last step of the macro, the transit impedance components produced in the last assignment are copied from temporary matrices to permanent matrices. These are used as inputs to the ampkrskm2.mac and hbw_mc.mac macros.

USER PARAMETERS

Parameter No.	Description	Default Value
1	Scenario number of scenario to be used for performing transit assignments	6
2	Wait time factor	0.5

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
N/A	mf91	AM peak hour transit time - walk (weighted sum of transit time components)	amtranhdw.mac
N/A	mf92	AM peak hour transit in-vehicle time - walk	amtranhdw.mac
N/A	mf93	AM peak hour auxiliary transit time - walk	amtranhdw.mac

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
N/A	mf94	AM peak hour total waiting time - walk	amtranhdw.mac
N/A	mf95	AM peak hour first waiting time - walk	amtranhdw.mac
N/A	mf96	AM peak hour boarding time - walk	amtranhdw.mac
N/A	mf97	AM peak hour average number of boardings - walk	amtranhdw.mac

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
amtrtw	mf49	AM peak hour transit time – walk (weighted sum of transit time components)	1. ampkrskm2.mac 2. trans-imp.mac
amivtw	mf50	AM peak hour transit in-vehicle time - walk	ampkrskm2.mac
amaxtw	mf51	AM peak hour auxiliary transit time - walk	ampkrskm2.mac
amtwtw	mf52	AM peak hour total waiting time - walk	ampkrskm2.mac
am1wtw	mf53	AM peak hour first waiting time - walk	ampkrskm2.mac
ambrdw	mf54	AM peak hour boarding time - walk	ampkrskm2.mac
amabdw	mf55	AM peak hour average number of boardings - walk	ampkrskm2.mac

REPORTS: amtrnhdw.rpt

5.5.2 Calculate Initial AM Peak Hour Effective Headways (effhdwy0.mac)

The effhdwy0.mac macro is used to establish initial values for effective transit headways prior to performing the first AM peak hour transit assignment. An extra transit segment attribute ("@ehdwy") is first defined and set equal to zero. This attribute is then set equal to the actual line headway ("hdwy" keyword) for each transit line.

USER PARAMETERS

Parameter No.	Description	Default Value
N/A		

5.5.2.1 INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
N/A			

5.5.2.2 OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
@edhwy	N/A	Extra transit segment attribute for storage of effective headways	amtranhw.mac

5.5.2.3 REPORTS: N/A

5.5.3 Perform AM Peak Hour Transit Assignment (amtranhw.mac)

The amtranhw.mac macro performs an AM peak hour transit assignment using the transit trip table developed with the ampktran.mac macro. The following transit impedance components are produced by the assignment and saved in temporary matrices:

- Transit time (weighted sum of transit time components)
- In-vehicle travel time
- Auxiliary (walk) travel time
- Total waiting time
- First waiting time
- Boarding time
- Average number of boardings

Once the final transit assignment has been performed within the loop to calculate effective headways, the amtrnhdw.mac macro copies the contents of these matrices into another set of matrices for permanent storage.

The effective headways for the assignment are obtained from the extra transit segment attribute "@ehdwy" defined in the effhdwy0.mac and effhdwy.mac macros. Wait time factors are obtained from the node user data item 1 ("ui1"). These factors have a value of 0.5 for all nodes.

In the final step of the macro, walk access times from origin zones and to destination zones are added to the auxiliary transit times. These times have values of 0, 1, or 2 minutes.

USER PARAMETERS

Parameter No.	Description	Default Value
1	Boarding time	4 (mins.)
2	Wait time weight	2.8
3	Auxiliary transit time weight	2.1
4	Boarding time weight	2.0

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
atrnst	mf62	AM peak hour transit trips - walk	ampktran.mac
walkac	mo10	Walk access time from origin zones	N/A
walkac	md10	Walk access time to destination zones	N/A

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
N/A	mf91	AM peak hour transit time - walk(weighted sum of transit time components)	amtrnhdw.mac
N/A	mf92	AM peak hour transit in-vehicle time - walk	amtrnhdw.mac
N/A	mf93	AM peak hour auxiliary transit time - walk	amtrnhdw.mac
N/A	mf94	AM peak hour total waiting time - walk	amtrnhdw.mac
N/A	mf95	AM peak hour first waiting time - walk	amtnrhdw.mac
N/A	mf96	AM peak hour boarding time - walk	amtrnhdw.mac
N/A	mf97	AM peak hour average number of boardings - walk	amtrnhdw.mac
voltr	N/A	Segment transit volumes	effhdwy.mac
board	N/A	Boardings at i-node of segments	effhdwy.mac

REPORTS: N/A

5.5.4 Calculate AM Peak Hour Capacity Constrained Headways (effhdwy.mac)

The effhdwy.mac macro calculates a revised effective headway for each transit segment based on the ratios of excess transit volume to the number of boardings and single-vehicle capacity along the segment from the transit assignment performed in the amtranhw.mac macro. This is done by:

- Calculating the ratio of excess demand (transit volume minus total vehicle capacity) to total boardings along the segment;
- Calculating the ratio of excess demand (transit volume minus total vehicle capacity) to single vehicle capacity along the segment;
- Determining the minimum of the two ratios, with the resulting ratio not to exceed a value of 2.0;
- Mulitplying the minimum ratio by the actual headway; and
- Adding the actual headway to the product from the previous step.

The result of these steps is a revised effective headway that is higher than the previous headway in proportion to the amount of excess ridership demand in the last assignment iteration, with the constraint that it cannot be more than three times higher than the actual headway.

In the final step of the procedure, the revised effective headway is averaged with the effective headway used in the previous assignment iteration. The averaged headway is then used for the next assignment iteration.

USER PARAMETERS

Parameter No.	Description	Default Value
1	Maximum increase in the number of actual headway values	2

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
voltr	N/A	Segment transit volumes from previous assignment iteration	amtranhw.mac
vcapt	N/A	Single-vehicle capacities for segments	N/A
hdwy	N/A	Actual line headways	N/A

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
board	N/A	Boardings at i-node of segments	amtranhw.mac
@ehdwy	N/A	Effective headways for segments (previous assignment iteration)	N/A

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
@ehdwy	N/A	Effective headways for segments (revised)	amtranhw.mac

REPORTS: N/A

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5.5.5 Calculate AM Peak Hour Park-and-Ride Skims (ampkrskm2.mac)

The ampkrskm2.mac macro creates AM peak hour skim matrices for park-and-ride access transit trips for the following travel impedance components:

- Total transit time
- Auxiliary auto time (park-and-ride access time)
- Transit in-vehicle travel time
- Total waiting time
- First waiting time
- Boarding time
- Average number of boardings

For each origin – destination zone pair, the skim values represent a weighted average of the impedances for traveling from the origin zone to the destination zone via each of the 128 park-and-ride lots coded in the model. The weights that are used in calculating the average impedances are the utilities of traveling from the origin zone to the park-and-ride lot and from the park-and-ride lot to the destination zone. These are expressed as:

$$U_{P\&R\ Access} = \exp(-0.199*(Amsvct - Prbal))$$

$$U_{P\&R\ Egress} = \exp(-0.034*(Amtrtw.min.1000))$$

where:

Amsvct = AM peak hour auto travel times
Prbal = Park-and-ride lot balancing factors
Amtrtw = AM peak hour transit times - walk

The sum of the weights ($U_{P\&R\ Access} + U_{P\&R\ Egress}$) is computed using a matrix convolution, with TAZs 1 – 650 selected as the origin and destination zones and TAZs 651 – 850 selected as the intermediate (park-and-ride) zones.

The creation of the weighted average park-and-ride access skims is done in the following steps:

- The AM peak hour auto travel times from the origin zones, plus a park-and-ride lot delay penalty, are multiplied by the park-and-ride access weights.
- A matrix convolution is performed that adds the park-and-ride egress weights to the weighted auto travel times from the first step.
- The weighted average park-and-ride access skims are computed by dividing the results of the second step by the sum of the weights.

- The weighted average transit time and boarding skims are developed in an identical manner, except that these impedances are multiplied by the park-and-ride egress weights rather than the park-and-ride access weights.

- In the final step of the macro, the park-and-ride access auto times are added to the park-and-ride access total transit times (without auto times) to produce park-and-ride access total transit times.

USER PARAMETERS

Parameter No.	Description	Default Value
1	Coefficient for auto times (for calculation of park-and-ride access weights)	-0.199
2	Coefficient for transit times – walk (for calculation of park-and-ride egress weights)	-0.034

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
amtrtw	mf49	AM peak hour transit time – walk	amtrnhdw.mac
amivtw	mf50	AM peak hour transit in-vehicle time - walk	amtrnhdw.mac
amtwtw	mf52	AM peak hour total waiting time - walk	amtrnhdw.mac
am1wtw	mf53	AM peak hour first waiting time - walk	amtrnhdw.mac
ambrdw	mf54	AM peak hour boarding time - walk	amtrnhdw.mac
amabdw	mf55	AM peak hour average number of boardings - walk	amtrnhdw.mac

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
amtrta	mf56	AM peak hour transit time – auto	trans-imp.mac
amivta	mf57	AM peak hour transit in-vehicle time - auto	N/A
amauxa	mf58	AM peak hour auxiliary transit time - auto	N/A
amtwta	mf59	AM peak hour total waiting time – auto	N/A

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
am1wta	mf60	AM peak hour first waiting time - auto	N/A
ambrda	mf64	AM peak hour boarding time - auto	N/A
amabda	mf66	AM peak hour average number of boardings - auto	N/A

REPORTS: ampkrskm.rpt

DRAFT

5.5.6 Create Mid-day Transit Trip Table (mdpktran.mac)

The mdpktran.mac macro creates a transit walk access matrix for the mid-day hour. In the first step of the macro, an adjustment factor matrix is developed. Within the matrix, all zone pairs with one end in Kitsap County have a value of 0.25 and all other zone pairs have a value of 1.0. Following this, the mid-day hour transit walk access trip matrix is calculated by applying the mid-day hour time-of-day factors to the daily transit walk access trip matrices by trip purpose. The HBSchool trips are also multiplied by a calibration factor of 0.502. The time-of-day factors are shown in Table 5-7.

All trip interchanges within the mid-day hour transit walk access trip matrix, except those with one end at the Bellevue Square Mall (TAZ 11), are also multiplied by the Kitsap County adjustment factors. The transit walk access trips are input to the md-tran-asgn.mac macro.

USER PARAMETERS

Parameter No.	Description	Default Value
N/A		

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
hbwtwa	mf41	Daily HBWork transit walk access trips	hbw_mc.mac
hbotwa	mf45	Daily HBOther transit walk access trips	hbo_mc.mac
nhbtwa	mf47	Daily NHB transit walk access trips	nhb_mc.mac
hbstrp	mf39	Daily HBSchool transit walk access trips	sch_dist.mac

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
mdtrwa	mf67	Mid-day hour transit walk access trips	md-tran-asgn.mac

REPORTS: mdpktran.rpt

5.5.7 Perform Mid-day Transit Assignment (md-tran-asgn.mac)

The md-tran-asgn.mac macro performs an mid-day hour transit assignment using the transit trip table developed with the mdpktran.mac macro. The following transit impedance components are produced by the assignment and saved in temporary matrices:

- Transit time (weighted sum of transit time components)
- In-vehicle travel time
- Auxiliary (walk) travel time
- Total waiting time
- First waiting time
- Boarding time
- Average number of boardings

The effective headways for the assignment are obtained from the user-defined line attribute "ut2". Wait time factors are obtained from the node user data item 1 ("ui1"). These factors have a value of 0.5 for all nodes.

USER PARAMETERS

Parameter No.	Description	Default Value
1	Boarding time	2 (mins.)
2	Wait time weight	2.8
3	Auxiliary transit time weight	2.1
4	Boarding time weight	2.0

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
mdtrwa	mf67	Mid-day hour transit trips - walk	mdpktran.mac

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
mdtrtw	mf70	Mid-day hour transit time - walk(weighted sum of transit time components)	trans-imp.mac
mdivtw	mf71	Mid-day hour transit in-vehicle time - walk	N/A
mdaxtw	mf72	Mid-day hour auxiliary transit time - walk	N/A
mdtwtw	mf73	Mid-day hour total waiting time - walk	N/A
md1wtw	mf74	Mid-day hour first waiting time - walk	N/A
mdbrdw	mf75	Mid-day hour boarding time - walk	N/A
mdabdw	mf76	Mid-day hour average number of boardings - walk	N/A

REPORTS: md-tran-asgn.rpt

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5.5.8 Calculate Total Transit Impedances (trans-imp.mac)

The trans-imp.mac macro adds intrazonal transit times and walk access times from the origin zones/to the destination zones to the AM peak hour – walk, AM peak hour – auto, and mid-day hour transit times output by the amtrnhdw.mac, ampkrskm2.mac, and md-tran-asgn.mac macros. The minimum row values from the transit time matrices are identified and added to these matrices as the intrazonal transit time values. For the auto access transit time matrix, the minimum row value is multiplied by 0.75. Origin/destination zone walk access times of 0, 1, or 2 minutes are then added to the transit times. In the final step of the macro, zero-valued transit times are replaced with a value of "9999". The total transit time matrices are input to the save_transkim.mac, hbw_mc.mac, hbo_mc.mac, and nhb_mc.mac macros.

USER PARAMETERS

Parameter No.	Description	Default Value
1	Range of transit times to be included in the identification of intrazonal transit times	0, 500
2	Intrazonal transit time factor for the auto access transit time matrix	0.75

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
amtrtw	mf49	AM peak hour transit times – walk	amtrnhdw.mac
amtrta	mf56	AM peak hour transit times – auto	ampkrskm2.mac
mdtrtw	mf70	Mid-day hour transit times - walk	md-tran-asgn.mac
walkac	mo10	Walk access time from origin zones	N/A
walkac	md10	Walk access time to destination zones	N/A

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
amimpw	mf05	AM peak hour transit times – walk (with intrazonal times)	1. save_transkim.mac 2. hbw_mc.mac 3. avg_transkim.mac
amimpa	mf06	AM peak hour transit times – auto (with intrazonal times)	1. save_transkim.mac 2. hbw_mc.mac 3. avg_transkim.mac
mdimpw	mf07	Mid-day hour transit times – walk	1. save_transkim.mac

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
		(with intrazonal times)	2. hbo_mc.mac 3. nhb_mac.mac 4. avg_transkim.mac

REPORTS: trans-imp.rpt

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5.5.9 Calculate Average Transit Impedances (avg_transkim.mac)

The avg_transkim.mac macro calculates average AM peak hour and mid-day hour transit travel time skims for use in the mode choice models. A successive averaging procedure is used in which the average skim values from the previous iterations of model processing are averaged with the current skim values contained in the travel time matrices output by the trans-imp.mac macro. The avg_transkim.mac macro is executed starting with the second iteration of model processing, once an initial set of travel time matrices are available from the first iteration. The input matrices containing the current skims are also used as the output matrices for this macro, so the current skims are overwritten with the average skim values. The average AM peak hour travel times are input to the HBWork mode choice model and the save_transkim.mac macro. The average mid-day hour travel times are input to the non-work mode choice models and the save_transkim.mac macro.

USER PARAMETERS

Parameter No.	Description	Default Value
N/A		

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
amimpw	mf05	AM peak hour transit times – walk (current iteration)	amtrnhdw.mac
amimpa	mf06	AM peak hour transit times – auto (current iteration)	ampkrskm2.mac
mdimpw	mf07	Mid-day hour transit times – walk (current iteration)	md-tran-asgn.mac
1stamw	mf15	AM peak hour transit times – walk (previous iteration)	save_transkim.mac
1stama	mf16	AM peak hour transit times – auto (previous iteration)	save_transkim.mac
1stmdw	mf17	Mid-day hour transit times – walk (previous iteration)	save_transkim.mac

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
amimpw	mf05	AM peak hour transit times – walk (averaged)	1. save_transkim.mac 2. hbw_mc.mac 3. avg_transkim.mac
amimpa	mf06	AM peak hour transit times – auto (averaged)	1. save_transkim.mac 2. hbw_mc.mac 3. avg_transkim.mac
mdimpw	mf07	Mid-day hour transit times – walk (averaged)	1. save_transkim.mac 2. hbo_mc.mac 3. nhb_mac.mac 4. avg_transkim.mac

REPORTS: avg_transkim.rpt

DRAFT

5.5.10 Save Total Transit Impedances (save_transkim.mac)

The save_transkim.mac macro copies the transit times produced by the trans-imp.mac macro in the first iteration of model processing and saves them in temporary matrices for use in the avg_transkim.mac macro in the second iteration of model processing.

USER PARAMETERS

Parameter No.	Description	Default Value
N/A		

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
amimpw	mf05	AM peak hour transit times – walk	trans-imp.mac
amimpa	mf06	AM peak hour transit times – auto	trans-imp.mac
mdimpw	mf07	Mid-day hour transit times – walk	trans-imp.mac

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
1stamw	mf15	AM peak hour transit times – walk (first iteration)	avg_transkim.mac
1stama	mf16	AM peak hour transit times – auto (first iteration)	avg_transkim.mac
1stmdw	mf17	Mid-day hour transit times – walk (first iteration)	avg_transkim.mac

REPORTS: save_transkim.rpt

5.6 Mode Choice

The mode choice model is the third step of the four-step travel demand planning process. Productions and attractions of the trip generation model are linked in trip distribution, creating zone-to-zone person-trip movements. These trips are then apportioned to the available travel modes through the application of the mode choice model.

Mode choice models split the total daily person trips into motorized daily trip tables for each motorized mode. This section presents the BKR mode choice model structure, including multinomial logit model functions, model parameters, coefficients, constants, and matrices, as shown in Table 5-5.

Table 5-5 Mode Choice Model Matrices and Coefficients

	ALL	HBW		HBO	NHB	Common for HBO and NHB
Trip Tables						
Daily Person Trips	mf40	mf36		mf37	mf38	
Transit Walk		mf41		mf45	mf47	
Transit P&R		mf42				
Drive Alone		mf43				
Shared Ride		mf44				
Auto + Park-and-Ride			See	mf46	mf48	See
Totals			Text			Text
mf(90+91+92+93)	total4		For			For
mf(90+91+92)	total3		Equations			Equations
mf(90+91)	total2					
Raw Utility						
Raw Transit Utility	mf93					
Raw Transit P&R Utility	mf92					
Raw Drive Alone Utility	mf91					
Raw Shared Ride Utility	mf90					
Cost						
Shared Ride Cost	mf94		mf95/2			
Drive Alone Cost	mf95		mf33*ms84+md12/2			mf31*ms84+md13/2
P&R Auto Cost	mf96		mf35*ms85+md12			
Time						
Shared Ride Auto Time	mf97		mf34+5			
Shared Ride Terminal Time	mf98		mf99+5			
Auto Terminal Time	mf99		mo11+mo11'			mo11+mo11'
Transit						
Transit Impedance-Walk		mf5	AM Peak	mf7	mf7	Midday
Transit Impedance-Drive		mf6	AM Peak			

Transit Fare		mf18	AM Peak	mf19	mf19	Midday
Auto Skim						
Auto Distance		mf33	Modify Cong. Auto Dist			
Auto Time		mf34	Modify Cong. Auto Time	mf32	mf32	Free Flow Auto Time
Park and Ride Access Time		mf35	P&R Auto Travel Time			

Table 5-6 Mode Choice Model Matrices and Coefficients

	MO	MD	All Purpose	HBW	HBO	NHB
Mode-Specific Constants						
DA Modal Constant	mo88			1.385		3.90
TWA Modal Constant	mo89			0.58	-3.68	
P&R Modal Constant	mo90			2.28		
Transit Factors						
HH Transit Coverage	mo12		0-100%			
Employment Transit Coverage		md11	0-100%			
Bias I						
HBW HH Auto Ownership Bias	mo13, mo15			e.g. 1.18		
HBW HH Density Bias	mo14, mo16, mo17			e.g. 0.5		
Parking						
HBW Long Term Parking Cost		md12		e.g. 480		
Auto Operating cost	MS					
Auto Op Cost per Mile	ms84		15			
P&R Auto Op Cost per Minute	ms85		5.9			
Bias II						
Shared Ride Bias		md99				
Default				-5		
Bellevue CBD, 1-43				1.00		
Eastside, 44-450				0.90		
Non-Eastside, 451-575**				1.80		
Non-South Seattle, 454-484				1.10		
South Snohomish, 542-545				2.70		
CBD Dummy		md98				

Default				0	0	0
TAZ 471				1.25	0.15	0.90
TAZ 480-484				0.3	0.70	1.10
Park and Ride Bias (all TAZs)		md97		-3.85		

5.6.1 HBW Mode Choice Model

The utility for mode choice for HBW trips are given below.

U-da = EXP (ATLT *(-0.1619) + IVT * (-0.0813) + Cost * 0.4345 * (-0.0073) + HBW HH Auto Ownership Bias + HBW DA Modal Constant)
U-sr = EXP (ATLT * (-0.1619) + IVT * (-0.0813) + Cost * 0.4345 * (-0.0073)+ HBW SR Bias

U-tr = EXP (Transit Impedance Walk*(-0.0311)+ Pk Transit Fare*0.4345*(-0.0073) + CBD Dummy + HBW HH Density Bias + HBW TWA Modal constant

U-pr = EXP(Transit Impedance-Drive*(-0.0311) + P&R Auto Travel Time*(-0.0813) + P&R Auto Cost*0.4345*(-0.0073) + HBW HH Auto Ownership Bias + P&R Bias + CBD Dummy + HBW HH Density Bias + HBW P&R Modal Constant)

Transit Impedance = OVT + IVT

Weight Factors Wait=2.8, Aux=2.1, Boarding=2.0

Where

ATLT: auto terminal time
IVT: in vehicle time
OVT: out of vehicle time
FFAT: free flow auto time
U-da: utility of drive alone
U-sr: utility of share ride
U-tr: utility of transit walk access
U-pr: utility of transit P&R access

The travel mode for HBW trips is chosen by the following probability functions

P(da) = U-da / (U-da + U-sr + U-tr + U-pr)
P(sr) = U-sr/ (U-da + U-sr + U-tr + U-pr)
P(tr) = U-tr/ (U-da + U-sr + U-tr + U-pr)
P(pr) = U-pr / (U-da + U-sr + U-tr + U-pr)
P(pr/da+sr+pr) = U-pr / (U-da + U-sr + U-pr)

Where

P(da): probability of drive alone
P(sr): probability of share ride
P(tr): probability of transit walk access
P(pr): probability of transit P&R access
P(pr/da+sr+pr): probability of transit P&R access without walk transit access)

HBW daily person trip tables by modes are calculated by the equations.

HBWTWA = HBWDT * [P(tr) * (HH Transit Coverage /100) * (Emp. Transit Coverage /100)]
HBWTAA = HBWDT * [P(pr) * (HH Transit Coverage /100) * (Emp. Transit Coverage/100) + P(pr/da+sr+pr) * (1- HH Transit Coverage /100)*(Emp. Transit Coverage /100)]
HBWDA = HBWDT * [P(da) * (HH Transit Coverage /100) * (Emp. Transit Coverage/100) + P(pr/da+sr+pr) * (1- HH Transit Coverage /100)*(Emp. Transit Coverage /100) + P(da/da+sr)*(1- Emp. Transit Coverage /100)]
HBWSR = HBWDT – (HBW Transit Walk Access Trips + HBW Transit P&R Trips + HBW Drive Alone)

Where:
HBWTWA: HBW transit walk access trips
HBWTAA: HBW transit P&R trips
HBWDA: HBW drive alone trips
HBWSR: HBW shared ride
HBWDT: HBW daily person trips

HBW mode choice daily trip tables are obtained by hbw_mc.mac.

5.6.2 HBO Mode Choice Model

The utility for mode choice for HBO trips are given below.

U-au = EXP (ATLT *(-0.1544) + FFAT* (-0.0775) + Cost * 0.4345(-0.0156) + HBNW Auto Ownership Factor)

U-tr = EXP (MD Transit Impedance*(-0.0297)+ MD Transit Fare*0.4345*(-0.0156) + CBD Dummy+ HBNW HH Density Bias + HBO TWA Modal Constant)

Where:
ATLT: auto terminal time
FFAT: free flow auto time
U-au: Utility for auto mode
U-tr: Utility for transit mode

The travel mode for HBO trips is chosen by the following probability functions

P(au) = U-au / (U-au + U-tr)
P(tr) = U-tr / (U-au + U-tr)

Where:

P(au):	probability of auto mode for HBO
P(tr):	probability of transit mode for HBO

HBO daily person trip tables by modes are calculated by the equations.

HBOTWA = HBODT * P(tr) * (HH Transit Coverage /100) * (Emp. Transit Coverage /100)
HBOAA = HBODT – HBO Transit Walk Access Trips

Where:

HBOTWA:	HBO transit walk access
HBOAA:	HBO auto
HBODT:	HBO daily trips

HBO mode choice daily trip tables are obtained by hbo_mc.mac.

5.6.3 NHB Mode Choice Model

The utility for mode choice for NHB trips are given below.
U-au = EXP (ATLT *(-0.0436) + FFAT* (-0.0219) + Cost * 0.4345(-0.0091) + 3.9)

U-tr = EXP (MD Transit Impedance*(-0.0084)+ MD Transit Fare*0.4345*(-0.0317) + CBD Dummy+ NHB HH Density Bias)

Where:

ATLT:	auto terminal time
FFAT:	free flow auto time
U-au:	Utility for auto mode
U-tr:	Utility for transit mode

The travel mode for NHB trips is chosen by the following probability functions

P(au) = U-au / (U-au + U-tr)
P(tr) = U-tr / (U-au + U-tr)

Where:

P(au): probability of auto mode for NHB
P(tr): probability of transit mode for NHB

NHB daily person trip tables by modes are calculated by the equations.

NHBTWA = NHBDT * P(tr) * (Transpose of Emp. Transit Coverage/100) * (Emp. Transit Coverage /100)
NHBAA = NHBDT – NHB Transit Walk Access Trips

Where:
NHBTWA: NHB transit walk access
NHBAA: NHB auto
NHBDT: NHB daily trips

NHB mode choice daily trip tables are obtained by nhb_mc.mac.

5.6.4 SOV/LOV/HOV Split

Auto vehicle person trip matrices are split between SOV and 2+ HOV trips by the mode choice macros. The macro 'run_slhov.mac' then splits the HOV trip matrices into LOV (2) and HOV (3+) matrices. This is done using proportions from the PSRC model for base and future years.

The LOV and HOV(3+) trip matrices are then recombined and assigned in a 2-class assignment. For the final assignment, the LOV and HOV (3+) trips are assigned separately in a 3-class assignment. This allows for toll and HOV lanes to distinguish between 2 and 3+ HOVs.

For additional information refer to the report in Appendix C.

The following macros are used in the mode choice module.

- Home-Based Work mode choice model (hbw_mc.mac)
- Split HBW Transit park-and-ride trips (prsplit_ra.mac)
- Home-Based Other mode choice model (hbo_mc.mac)
- Non-Home-Based mode choice model (nhb_mc.mac)

5.6.5 Home-Based Work Mode Choice Model (hbw_mc.mac)

The macro hbw_mc.mac calculates daily person trips for HBW transit walk access, HBW transit P&R access, HBW drive alone, and HBW shared ride based on their utilities which are also calculated by this macro.

VARIABLE DEFINITIONS

AmImpw = AM peak hour walk access transit time
PkFare = AM peak hour transit fare
CbdDum = CBD dummy
HbwDen = HBW household density factor
AmImpa = AM peak hour auto access transit time
PrAccT = AM peak hour park-and-ride access time
PrCost = AM peak hour park-and-ride cost
HbwAo = HBW auto ownership factor
PrBias = Park-and-ride bias factor
DaTerm = Drive alone auto terminal time
VehCst = Drive alone operating + parking cost
AmSovT = AM peak hour drive alone travel time
SrTerm = Shared-ride terminal time
SrCost = Shared ride operating + parking cost
AmSrT = AM peak hour shared-ride travel time
SrBias = Shared-ride bias factor

CALIBRATED CHOICE UTILITIES

Drive Alone

U = exp (-0.1619*DaTerm - 0.0073*0.4345*VehCst + HbwAo – 0.0813*AmSovT + 1.385)

Shared Ride

U = exp (-0.1619*SrTerm - 0.0073*0.4345*SrCost – 0.0813*AmSrT + SrBias)

Transit Walk Access

U = exp (-0.0311*AmImpw – 0.0073*0.4345*PkFare + CbdDum + HbwDen + 0.58)

Transit Park-and-Ride Access

U = exp (-0.0311*AmImpa – 0.0813*PrAccT - 0.0073*0.4345*PrCost + HbwAo + PrBias + CbdDum + HbwDen + 2.28)

USER PARAMETERS

Parameter Name	Description	Default Value
	Transit IVTT coefficient	-0.0311
	Cost factor	0.4345
	Cost coefficient	-0.0073
	Drive time coefficient	-0.0813
	Auto terminal time coefficient	-0.1619
	For detailed user parameters, see Table 5-5 and 5-6.	

INPUT DATA

Data Name	Matrix Name/ No.	Description	Output From
HBWTRP	Mf36	HBW daily trip table	Hbw_dist.mac

OUTPUT DATA

Data Name	Matrix Name/ No.	Description	Input To
HBWTWA	Mf41	HBW transit walk access trip table	Ampktran.mac, mdpktran.mac, pmpktran.mac
HBWTPR	Mf42	HBW transit P&R access trip table	Ampktran.mac, mdpktran.mac, pmpktran.mac
HBWDAT	Mf43	HBW drive alone trip table	Amslhov.mac, pmslhov4.mac
HBWSRT	Mf44	HBW shared ride trip table	Amslhov.mac, pmslhov4.mac

REPORTS: hbw_mc.rpt

5.6.6 Split HBW Transit Park-and-RIde Trips (prsplit_RA.mac)

This macro splits HBW transit P&R trips (mf42, HBWTPR) into HBW P&R auto access (mf87) and HBW P&R transit egress (mf88) using the macro parkride.mac developed by Heinz Spiess.

USER PARAMETERS

Parameter Name	Description	Default Value
Capacity ratio	% of the HBW transit P&R trips	0.59

INPUT DATA

Data Name	Matrix Name/ No.	Description	Output From
AMSVCT	Mf14	AM auto congested time	am_mcskim3.mac
prcap	Md20	WSDOT P&R capacity	
amtrtw	Mf49	AM Peak hour transit walk time	AMTRNHDW.MAC
prfac	Md19	P&R factors	mdprfac.311
HBWTPR	Mf42	HBW transit P&R trips	Hbw_mc.mac

OUTPUT DATA

Data Name	Matrix Name/ No.	Description	Input To
HBWTAA	Mf87	HBW P&R auto access	Amslhov.mac, mdslhov.mac,pmslhov4.mac
HBWTAT	Mf88	HBW P&R transit egress	Amslhov.mac, mdslhov.mac,pmslhov4.mac

REPORTS: prsplit.rpt

5.6.7 Home-Based Other Mode Choice Model (hbo_mc.mac)

The macro hbo_mc.mac calculates daily person trips for HBO transit walk access trips and HBO auto/P&R trips based on their utilities which are also calculated by this macro.

VARIABLE DEFINITIONS

AUTOTT = Auto terminal times
VEHCST = Vehicle cost
HNWauo = HBNW auto ownership factor
MFFTT = Modified free flow travel time
mdimpw = MD walk-access transit impedance
mdfare = 1997 midday transit fare
CBDDum = CBD dummy
HNWden = HBNW HH density factor
WAMC-O = HBO transit walk access modal constant

CALIBRATED CHOICE UTILITIES

Auto

U = exp (AUTOTT * -0.1544 + VEHCST*0.4345*-0.0156 + HNWauo + MFFTT * (-0.0775))

Transit

U = exp (mdimpw * -0.0297 + mdfare * 0.4345 * -0.0156 + CBDDUM + HNWden + WAMC-O)

USER PARAMETERS

Parameter Name	Description	Default Value
	Transit IVTT coefficient	-0.0297
	Cost factor	0.4345
	Cost coefficient	-0.0156
	Drive time coefficient	-0.0775
	Auto terminal time coefficient	-0.1544
	For detailed user parameters, see Table 5-5 and 5-6.	

INPUT DATA

Data Name	Matrix Name/ No.	Description	Output From
MFFDS	Mf31	Modified MD free flow travel distance	Dist_tt.mac, avg_mcskim.mac

Data Name	Matrix Name/ No.	Description	Output From
MFFDS	Mf31	Modified MD free flow travel distance	Dist_tt.mac, avg_mcskim.mac
Aucost	Ms84	Auto operating cost per mile	
Stpkng	Md13	Short term (non HBW) parking	
Mdimpw	Mf7	MD walk access transit impedance	trans-imp.mac
Mdfare	Mf19	1997 MD transit fare matrix	
CBDDUM	Md98	CBD Dummy	
HNWden	Mo16	HBNW HH density factor	
WAMC-O	Mo87	HBO transit walk access modal constant	
HNWauo	Mo15	HBNW auto ownership factor	
MFFTT	Mf32	Modified MD free flow travel time	
HBOTRP	Mf37	HBO daily trip table	hbo_dist.mac
Hhtran	Mo12	Household accessibility to transit	
Empcov	Md11	Employment transit coverage factor	

OUTPUT DATA

Data Name	Matrix Name/ No.	Description	Input To
HBOaut	Mf46	HBO auto/P&R trips	Slov_tt.mac, mdpktran.mac
HBOTWA	Mf45	HBO transit walk access trip	Ampktran.mac, mdpktran.mac, pmpktran.mac

REPORTS: hbo_mc.rpt

DRAFT

5.6.8 Non-Home-Based Mode Choice Model (nhb_mc.mac)

The macro nhb_mc.mac calculates daily person trips for NHB transit walk access trips and NHB auto/P&R trips based on their utilities which are also calculated by this macro.

VARIABLE DEFINITIONS

AUTOTT = Auto terminal times
VEHCST = Vehicle cost
MFFTT = Modified free flow travel time
mdimpw = MD walk-access transit impedance
mdfare = 1997 midday transit fare
CBDDum = CBD dummy
NHBden = NHB HH density factor

CALIBRATED CHOICE UTILITIES

Auto

U = exp (AUTOTT * -0.0436 + VEHCST*0.4345*-0.0091 + 3.9 + MFFTT * (-0.0219))

Transit

U = exp (mdimpw * -0.0084 + mdfare * 0.4345 * -0.0317 + CBDDUM + NHBden)

USER PARAMETERS

Parameter Name	Description	Default Value
	Transit IVTT coefficient	-0.0084
	Cost factor	0.4345
	Cost coefficient (auto)	-0.0091
	Cost coefficient (transit)	-0.0317
	Drive time coefficient	-0.0219
	Auto terminal time coefficient	-0.0436
	For detailed user parameters, see Table 5-5 and 5-6.	

INPUT DATA

Data Name	Matrix Name/ No.	Description	Output From
Aucost	Ms84	Auto operating cost per mile	
Stpkng	Md13	Short term (non HBW) parking	
MFFDS	Mf31	Modified MD free flow auto distance	
Mdimpw	Mf7	MD walk access transit impedance	trans-imp.mac

Data Name	Matrix Name/ No.	Description	Output From
Aucost	Ms84	Auto operating cost per mile	
Mdfare	Mf19	1997 MD transit fare matrix	
CBDDUM	Md98	CBD Dummy	
NHBden	Mo17	NHB HH density factor	
MFFTT	Mf32	Modified MD free flow travel time	
NHBTRP	Mf38	NHB daily trip table	nhb_dist.mac
Empcov	Md11	Employment transit coverage factor	

OUTPUT DATA

Data Name	Matrix Name/ No.	Description	Input To
NHBTWA	Mf47	NHB transit walk access trip table	Ampktran.mac, mdpktran.mac, pmpktran.mac
NHBaut	Mf48	NHB auto / P&R trip table	SLOV_tt.mac, mdpktran.mac

REPORTS: nhb_mc.rpt

DRAFT

5.7 Time-of-Day

The time-of-day model is not one of the four primary model components identified as part of the four-step planning process, but occurs in this case after mode choice and before trip assignment. The time-of-day model estimates the number of trips from each traffic analysis zone to each other TAZ in each time period. There are three time periods in this model:

- A.M. peak (7-8 a.m.);
- Midday (12-1 p.m.); and
- P.M. peak (5-6 p.m.);

Replacing the old peaking factors, regional time-of-day (peaking) factors from the PSRC 2006 Survey, were applied to daily trip tables to break down into AM, Midday and PM peak hour trip tables. The new time-of-day factors are shown in Table 5-7. Be aware only the auto mode factors were updated per 2006 PSRC survey results. The transit factors were still using 2006 Metro factors. The new time of day factors reflect more accurately the periodic distribution of the trips. Table 5-8 shows the 2010 MP0R12 motorized trip totals by morning, mid-day hour and afternoon peak hour time periods.

AM peak hour, mid-day off-peak hour and PM peak hour trip tables are derived using the following EMME/2 macros (see Appendix A):

- Create AM Peak SOV, LOV, and HOV Trip Tables (run_slhov.mac)
- Create Daily Person Trip Tables for SOV/LOV/HOV (slov_tt.mac)
- Create Extra Link Attributes for SOV/LOV/HOV (slhov_extra.mac)
- Create SOV/LOV/HOV Auto Trip Table for PM Peak Hour (pmslhov.mac)
- Create SOV/LOV/HOV Auto Trip Table for MD Peak Hour (mdslhov.mac)
- Create SOV/LOV/HOV Auto Trip Table for AM Peak Hour (amslhov.mac)
- Create AM Peak Hour LOV + HOV Trip Table (am2pr+hov.mac)
- Create Mid-Day Hour LOV + HOV Trip Table (md2pr+hov.mac)
- Create AM Peak Hour LOV and HOV3+ Trip Table (am3pr+hov3c.mac)
- Create Mid-Day Peak Hour LOV + HOV3+ Trip Table (md3pr+hov3c.mac)
- Create PM Peak Hour LOV + HOV3+ Trip Table (pm3pr+hov3c.mac)
- Create AM Peak Hour Transit Trip Tables (ampktran.mac)
- Create PM Peak Hour Transit Trip Tables (pmpktran.mac)

Table 5-7 BKR Time-of-Day Factors by Purpose and Direction

Mode and Purpose	SOV		HOV		Transit		Other	
	P->A	A->P	P->A	A->P	P->A	A->P	P->A	A->P
Home-based Work+College								
AM Peak (7-8 AM)	0.136	0.002	0.149	0.002			0.119	0.002
MD Peak (12-1 PM)	0.013	0.015	0.010	0.012	0.217	0.025	0.017	0.014

Mode and Purpose	SOV		HOV		Transit		Other	
	P->A	A->P	P->A	A->P	P->A	A->P	P->A	A->P
PM Peak (5-6 PM)	0.007	0.102	0.009	0.096	-	0.017	0.008	0.106
Off-peak (other hours)	0.386	0.339	0.395	0.328	0.03	0.259	0.360	0.337
Home-based Shop+Other					0.283	0.299		
AM Peak (7-8 AM)	0.029	0.015	0.044	0.003			0.029	0.009
MD Peak (12-1 PM)	0.030	0.032	0.021	0.026	0.087	0.009	0.019	0.029
PM Peak (5-6 PM)	0.029	0.049	0.051	0.053	0.113	0.022	0.037	0.050
Off-peak (other hours)	0.372	0.445	0.381	0.421	0.026	0.13	0.410	0.430
Home-based School					0.278	0.36		
AM Peak (7-8 AM)	0.296	0.000	0.198	0.000			0.164	0.000
MD Peak (12-1 PM)	0.019	0.038	0.011	0.025	0.105	-	0.004	0.019
PM Peak (5-6 PM)	0.028	0.025	0.001	0.070	-	-	0.000	0.038
Off-peak (other hours)	0.217	0.377	0.386	0.310	-	0.013	0.314	0.402
Non-home-based+CV					0.395	0.395		
AM Peak (7-8 AM)	0.023	0.023	0.018	0.018			0.015	0.020
MD Peak (12-1 PM)	0.050	0.050	0.044	0.044	0.026	0.026	0.073	0.050
PM Peak (5-6 PM)	0.037	0.037	0.043	0.043	0.04	0.04	0.025	0.038
Off-peak (other hours)	0.390	0.390	0.395	0.395	0.125	0.125	0.386	0.391

Source: 2006 PSRC household activity survey for SOV, HOV and others. Factors for transit were inherited from 2006 Base Year BKR Model Report.

Table 5-8 MP0R12 Motorized Person Trip Totals by Time-of-Day

Time of Day Modal Trips		Person Trips	%
AM Peak Hour	Drive Alone	568,612	68.1%
	Shared Ride	141,742	17.0%
	Transit – Walk Access	118,933	14.2%
	Transit – Auto Access	6,036	0.7%
	Total	835,323	100.0%
Mid-day Hour	Drive Alone	478,889	74.6%
	Shared Ride	141,547	22.1%
	Transit – Walk Access	21,426	3.3%
	Total	641,862	100.0%
PM Peak Hour	Drive Alone	648,149	66.4%
	Shared Ride	229,099	23.5%
	Transit – Walk Access	93,461	9.6%
	Transit – Auto Access	6,036	0.6%
	Total	976,744	100.0%

5.7.1 Create AM Peak SOV, LOV, and HOV Trip Tables (run_slhov.mac)

This macro generates SOV, LOV (2 person) and HOV (3+) trip tables for the AM peak hour.

The following macros are called within this macro:

Slov_tt.mac
Slhov_extra.mac
Pmslhov.mac
Mdslhov.mac
Amslhov.mac

USER PARAMETERS

Parameter Name	Description	Default Value
N/A		

INPUT DATA

Data Name	Matrix Name/ No.	Description	Output From
N/A			

OUTPUT DATA

Data Name	Matrix Name/ No.	Description	Input To
N/A			

5.7.2 Create Daily Person Trip Tables for SOV/LOV/HOV (slov_tt.mac)

This macro creates daily LOV (2 person) and HOV (3+) auto trip table for HBW, and SOV/LOV/HOV trip tables for HBO, HBSchool, and NHB trip purposes.

HBW Shared Ride
Mf123 = mf44 * mf101
Mf124 = mf44 – mf123

HBO
Mf125 = mf46 * mf102
Mf126 = mf46 * mf117
Mf127 = mf46 – mf125 – mf126

HBSchool
Mf128 = mf39 * mf104
Mf129 = mf39 * mf119
Mf130 = mf39 – mf128 – mf129

NHB
Mf131 = mf48 * mf103
Mf132 = mf48 * mf118
Mf133 = mf48 – mf131 – mf132

USER PARAMETERS

Parameter Name	Description	Default Value
N/A		

INPUT DATA

Data Name	Matrix Name/ No.	Description	Output From
HBWSRT	Mf44	HBW shared ride daily trip table	Hbw_mc.mac
W3prs	Mf101	HBW 3+ person split factors	N/A
HBOaut	Mf46	HBO auto / P&R daily trip table	Hbo_mac.mac
O3prs	Mf102	HBO 3+ person split factors	N/A
O2prs	Mf117	HBO 2 person split factors	N/A
HBSTRP	Mf39	HBSchool daily trip table	Sch_mc.mac
S3prs	Mf104	HBSchool 3+ person split	N/A

Data Name	Matrix Name/ No.	Description	Output From
HBWSRT	Mf44	HBW shared ride daily trip table	Hbw_mc.mac
		factors	
S2prs	Mf119	HBSchool 2 person split factors	N/A
NHBaut	Mf48	NHB auto / P&R daily trip table	Nhb_mc.mac
N3prs	Mf103	NHB 3+ person split factors	N/A
N2prs	Mf118	NHB 2 person split factors	N/A

OUTPUT DATA

Data Name	Matrix Name/ No.	Description	Input To
Whov	Mf123	HBW 3+ person daily auto trips	Amslhov.mac, Mdslhov.mac Pmslhov.mac
Wlov	Mf124	HBW 2 person daily auto trips	Amslhov.mac, Mdslhov.mac Pmslhov.mac
Ohov	Mf125	HBO 3+ person daily auto trips	Amslhov.mac, Mdslhov.mac Pmslhov.mac
Olov	Mf126	HBO 2 person daily auto trips	Amslhov.mac, Mdslhov.mac Pmslhov.mac
Osov	Mf127	HBO SOV daily auto trips	Amslhov.mac, Mdslhov.mac Pmslhov.mac
Shov	Mf128	HBSchool 3+ person daily auto trips	Amslhov.mac, Mdslhov.mac Pmslhov.mac
Slov	Mf129	HBSchool 2 person daily auto trips	Amslhov.mac, Mdslhov.mac Pmslhov.mac
ssov	Mf120	HBSchool SOV daily auto trips	Amslhov.mac, Mdslhov.mac Pmslhov.mac
Nhov	Mf131	NHB 3+ person daily auto trips	Amslhov.mac, Mdslhov.mac Pmslhov.mac
Nlov	Mf132	NHB 2 person daily auto trips	Amslhov.mac, Mdslhov.mac Pmslhov.mac
Nsov	Mf133	NHB SOV daily auto trips	Amslhov.mac, Mdslhov.mac Pmslhov.mac

REPORTS: slov_tt.rpt

5.7.3 Create Extra Link Attributes for SOV/LOV/HOV (slhov_extra.mac)

This macro creates a number of extra user defined link attributes for SOV, LOV and HOV. If these link attributes already exist, delete them first.

USER PARAMETERS

Parameter Name	Description	Default Value
N/A		

INPUT DATA

Data Name	Matrix Name/ No.	Description	Output From
N/A			

OUTPUT DATA

Data Name	Matrix Name/ No.	Description	Input To
@sov		SOV	
@lov5		LOV within 5 miles	
@lov		LOV > 5 miles	
@hov5		HOV within 5 miles	
@hov		HOV > 5 miles	
@sovt		SOV turns	
@lov5t		LOV within 5 miles turns	
@lovt		LOV > 5 miles turns	
@hov5t		HOV within 5 miles turns	
@hovt		HOV > 5 miles turns	

REPORTS: N/A

5.7.4 Create SOV/LOV/HOV Auto Trip Table for PM Peak Hour (pmslhov.mac)

This macro creates PM peak hour trip tables for SOV, LOV (travel distance shorter than 5 miles and longer than 5 miles), and HOV3+ (travel distance shorter than 5 miles and longer than 5 miles). In the first step of the macro, an adjustment factor matrix is developed. Within the matrix, all zone pairs with one end in Kitsap County have a value of 0.25 and all other zone pairs have a value of 1.0. SOV/LOV/HOV trip tables are then calculated by applying PM time-of-day factors to daily auto trip tables by purpose and mode. The time-of-day factors are shown in Table 5-7. An adjustment peak factor of 0.839 for the Microsoft HBW is applied to HBW auto trips. The HBSchool trips are multiplied by a adjustment factor of 0.498.

All trips, except those with one end at the Bellevue Square Mall (TAZ 11), are also multiplied by the Kitsap County adjustment factors. LOV and HOV (for all travel distance) are further broken down to travel distance shorter or longer than 5 miles.

USER PARAMETERS

Parameter Name	Description	Default Value
	SOV Occupancy	1
	LOV Occupancy	2
	HOV Occupancy	3.5
	Microsoft HBW peak factor	0.839
	HBSchool SOV adjustment factor	0.498

INPUT DATA

Data Name	Matrix Name/ No.	Description	Output From
HBWTAA	Mf87	HBW P&R auto access	Prsplit_RA.mac
HBWDAT	Mf43	HBW drive alone trip table	Hbw_mc.mac
Osov	Mf127	HBO SOV auto trip table	Slov_tt.mac
nsov	Mf133	NHB SOV auto trip table	Slov_tt.mac
ssov	Mf130	HBSchool SOV trip table	Slov_tt.mac
Wlov	Mf124	HBW LOV trip table	Slov_tt.mac
Olov	Mf126	HBO LOV trip table	Slov_tt.mac
nlov	Mf132	NHB LOV trip table	Slov_tt.mac
Slov	Mf129	HBSchool LOV trip table	Slov_tt.mac

OUTPUT DATA

Data Name	Matrix Name/ No.	Description	Input To
Pmlov5	Mf134	Pm peak hour trip table for LOV <5 miles	Pm3pr+hov3c.mac
Plv5+	Mf136	PM peak hour trip table for LOV > 5 miles	Pm3pr+hov3c.mac
Pmhov5	Mf135	PM peak hour trip table for HOV < 5 miles	Pm3pr+hov3c.mac
Phv5+	Mf137	PM peak hour trip table for HOV > 5 miles	Pm3pr+hov3c.mac
fpmsov	Mf147	PM peak hour trip table for SOV	Pm_assign_3c.mac
Pmsov	Mf69	Pm peak hour trip table for sov (mf69==mf147)	N/A

REPORTS: pmpkhr_veh.rpt

DRAFT

5.7.5 Create SOV/LOV/HOV Auto Trip Table for MD Peak Hour (mdslhov.mac)

This macro creates MD peak hour trip tables for SOV, LOV (travel distance shorter than 5 miles and longer than 5 miles), and HOV3+ (travel distance shorter than 5 miles and longer than 5 miles). In the first step of the macro, an adjustment factor matrix is developed. Within the matrix, all zone pairs with one end in Kitsap County have a value of 0.25 and all other zone pairs have a value of 1.0. SOV/LOV/HOV trip tables are then calculated by applying MD time-of-day factors to daily auto trip tables by purpose and mode. The time-of-day factors are shown in Table 5-7. The HBSchool trips are multiplied by an adjustment factor of 0.498.

All trips, except those with one end at the Bellevue Square Mall (TAZ 11), are also multiplied by the Kitsap County adjustment factors. LOV and HOV (for all travel distance) are further broken down to travel distance shorter or longer than 5 miles.

USER PARAMETERS

Parameter Name	Description	Default Value
	SOV Occupancy	1
	LOV Occupancy	2
	HOV Occupancy	3.5
	HBSchool trip Adjustment factor	0.498

INPUT DATA

Data Name	Matrix Name/ No.	Description	Output From
HBWTAA	Mf87	HBW P&R auto access	Prsplit_RA.mac
HBWDAT	Mf43	HBW drive alone trip table	Hbw_mc.mac
Osov	Mf127	HBO SOV auto trip table	Slov_tt.mac
nsov	Mf133	NHB SOV auto trip table	Slov_tt.mac
ssov	Mf130	HBSchool SOV trip table	Slov_tt.mac
Wlov	Mf124	HBW LOV trip table	Slov_tt.mac
Olov	Mf126	HBO LOV trip table	Slov_tt.mac
nlov	Mf132	NHB LOV trip table	Slov_tt.mac
Slov	Mf129	HBSchool LOV trip table	Slov_tt.mac

OUTPUT DATA

Data Name	Matrix Name/ No.	Description	Input To
Mdsov	Mf138	MD SOV trip table	N/A
Mdlov5	Mf139	MD peak hour trip table for LOV < 5 miles	Md2pr+hov.mac, md3pr+hov3c.mac
Mlv5+	Mf141	MD peak hour trip table for LOV > 5 miles	Md2pr+hov.mac, md3pr+hov3c.mac
Mdhov5	Mf140	MD peak hour trip table for HOV < 5 miles	Md2pr+hov.mac, md3pr+hov3c.mac
Mhv5+	Mf142	MD peak hour trip table for HOV >5+ miles	Md2pr+hov.mac, md3pr+hov3c.mac
Fmdsov	Mf145	Final MD SOV trip table (mf145==mf138)	Md_assign_3c.mac

REPORTS: mdpkhr_veh.rpt

DRAFT

5.7.6 Create SOV/LOV/HOV Auto Trip Table for AM Peak Hour (amslhov.mac)

This macro creates AM peak hour trip tables for SOV, LOV (travel distance shorter than 5 miles and longer than 5 miles), and HOV3+ (travel distance shorter than 5 miles and longer than 5 miles). In the first step of the macro, an adjustment factor matrix is developed. Within the matrix, all zone pairs with one end in Kitsap County have a value of 0.25 and all other zone pairs have a value of 1.0. SOV/LOV/HOV trip tables are then calculated by applying AM time-of-day factors to daily auto trip tables by purpose and mode. The time-of-day factors are shown in Table 5-7. The HBSchool trips are multiplied by a adjustment factor of 0.498.

All trips, except those with one end at the Bellevue Square Mall (TAZ 11), are also multiplied by the Kitsap County adjustment factors. LOV and HOV (for all travel distance) are further broken down to travel distance shorter or longer than 5 miles.

USER PARAMETERS

Parameter Name	Description	Default Value
	SOV Occupancy	1
	LOV Occupancy	2
	HOV Occupancy	3.5
	HBSchool SOV adjustment factor	0.498

INPUT DATA

Data Name	Matrix Name/ No.	Description	Output From
HBWTAA	Mf87	HBW P&R auto access	Prsplit_RA.mac
HBWDAT	Mf43	HBW drive alone trip table	Hbw_mc.mac
Osov	Mf127	HBO SOV auto trip table	Slov_tt.mac
nsov	Mf133	NHB SOV auto trip table	Slov_tt.mac
ssov	Mf130	HBSchool SOV trip table	Slov_tt.mac
Wlov	Mf124	HBW LOV trip table	Slov_tt.mac
Olov	Mf126	HBO LOV trip table	Slov_tt.mac
nlov	Mf132	NHB LOV trip table	Slov_tt.mac
Slov	Mf129	HBSchool LOV trip table	Slov_tt.mac

OUTPUT DATA

Data Name	Matrix Name/ No.	Description	Input To
amsov	Mf26	AM peak hour trip table for SOV	N/A
amlov5	Mf27	AM peak hour trip table for LOV < 5 miles	am2pr+hov.mac, am3pr+hov3c.mac
alv5+	Mf29	AM peak hour trip table for LOV > 5 miles	am2pr+hov.mac, am3pr+hov3c.mac
AMhov5	Mf28	AM peak hour trip table for HOV < 5 miles	am2pr+hov.mac, am3pr+hov3c.mac
ahv5+	Mf68	AM peak hour trip table for HOV >5+ miles	am2pr+hov.mac, am3pr+hov3c.mac
famsov	Mf143	Final AM SOV trip table (mf143==mf26)	Am_assign_3c.mac, am_mcskim1_TOLLhov2.mac

REPORTS: ampkhr_veh.rpt

DRAFT

5.7.7 Create AM Peak Hour HOV2+ Trip Table (am2pr+hov.mac)

This macro creates final AM trip table for HOV 2+ by adding up LOV and HOV3+ AM trip table together. This macro is only used in the first two feedback loop.

Mf144 = mf27 + mf28 + mf29 + mf68

USER PARAMETERS

Parameter Name	Description	Default Value
N/A		

INPUT DATA

Data Name	Matrix Name/ No.	Description	Output From
amlov5	Mf27	AM peak hour trip table for LOV < 5 miles	Amslhov.mac
alv5+	Mf28	AM peak hour trip table for LOV > 5 miles	Amslhov.mac
AMhov5	Mf29	AM peak hour trip table for HOV < 5 miles	Amslhov.mac
ahv5+	Mf68	AM peak hour trip table for HOV >5+ miles	Amslhov.mac

OUTPUT DATA

Data Name	Matrix Name/ No.	Description	Input To
famhov	Mf144	Final AM peak hour trip table for HOV2+	am_mcskim1_TOLLhov2.mac

REPORTS: famlhov.rpt

5.7.8 Create Mid-Day Peak Hour HOV2+ Trip Table (md2pr+hov.mac)

This macro creates final MD trip table for HOV 2+ by adding up LOV and HOV3+ MD trip table together. This macro is only used in the first two feedback loop.

Mf146 = mf139 + mf140 + mf141 + mf142

USER PARAMETERS

Parameter Name	Description	Default Value
N/A		

INPUT DATA

Data Name	Matrix Name/ No.	Description	Output From
Mdlov5	Mf139	MD peak hour trip table for LOV < 5 miles	Mdslhov.mac
Mlv5+	Mf141	MD peak hour trip table for LOV > 5 miles	Mdslhov.mac
Mdhov5	Mf140	MD peak hour trip table for HOV < 5 miles	Mdslhov.mac
Mhv5+	Mf142	MD peak hour trip table for HOV >5+ miles	Mdslhov.mac

OUTPUT DATA

Data Name	Matrix Name/ No.	Description	Input To
Fmdhov	Mf146	Final MD peak hour trip table for HOV2+	md_mcskim1_TOLLhov 2.mac

REPORTS: fmdlhov.rpt

5.7.9 Create AM Peak Hour LOV and HOV3+ Trip Table (am3pr+hov3c.mac)

This macro creates final AM trip table for LOV by adding up LOV less than 5 miles and LOV longer than 5 miles; final HOV3+ by adding up HOV less than 5 miles and longer than 5 miles. This macro is only used in the last feedback loop.

Mf144 = mf27 + mf29
Mf165 = mf28 + mf68

USER PARAMETERS

Parameter Name	Description	Default Value
N/A		

INPUT DATA

Data Name	Matrix Name/ No.	Description	Output From
amlov5	Mf27	AM peak hour trip table for LOV < 5 miles	Amslhov.mac
alv5+	Mf28	AM peak hour trip table for LOV > 5 miles	Amslhov.mac
AMhov5	Mf29	AM peak hour trip table for HOV < 5 miles	Amslhov.mac
ahv5+	Mf68	AM peak hour trip table for HOV >5+ miles	Amslhov.mac

OUTPUT DATA

Data Name	Matrix Name/ No.	Description	Input To
famlov	Mf144	Final AM peak hour trip table for LOV	am_assign_3c.mac, am_mcskim1_TOLLhov2.mac
famhov	Mf165	Final AM peak hour trip table for HOV3+	am_assign_3c.mac

REPORTS: famlhov.rpt

5.7.10 Create Mid-Day Peak Hour LOV + HOV3+ Trip Table (md3pr+hov3c.mac)

This macro creates final MD trip table for LOV by adding up LOV less than 5 miles and LOV longer than 5 miles; final HOV3+ by adding up HOV less than 5 miles and longer than 5 miles. This macro is only used in the last feedback loop.

Mf146 = mf139 + mf141
Mf167 = mf140 + mf142

USER PARAMETERS

Parameter Name	Description	Default Value
N/A		

INPUT DATA

Data Name	Matrix Name/ No.	Description	Output From
Mdlov5	Mf139	MD peak hour trip table for LOV < 5 miles	Mdslhov.mac
Mlv5+	Mf141	MD peak hour trip table for LOV > 5 miles	Mdslhov.mac
Mdhov5	Mf140	MD peak hour trip table for HOV < 5 miles	Mdslhov.mac
Mhv5+	Mf142	MD peak hour trip table for HOV >5+ miles	Mdslhov.mac

OUTPUT DATA

Data Name	Matrix Name/ No.	Description	Input To
Fmdlov	Mf146	Final MD peak hour trip table for LOV	Md_assign_3c.mac
Fmdhov	Mf167	Final MD peak hour trip table for HOV3+	Md_assign_3c.mac

REPORTS: fmdlhov.rpt

5.7.11 Create PM Peak Hour LOV + HOV3+ Trip Table (pm3pr+hov3c.mac)

This macro creates final PM trip table for LOV by adding up LOV less than 5 miles and LOV longer than 5 miles; final HOV3+ by adding up HOV less than 5 miles and longer than 5 miles. This macro is only used in the last feedback loop.

Mf148 = mf134 + mf136
Mf169 = mf135 + mf137

USER PARAMETERS

Parameter Name	Description	Default Value
N/A		

INPUT DATA

Data Name	Matrix Name/ No.	Description	Output From
pmlov5	Mf134	PM peak hour trip table for LOV < 5 miles	pmslhov.mac
plv5+	Mf136	PM peak hour trip table for LOV > 5 miles	pmslhov.mac
pmhov5	Mf135	PM peak hour trip table for HOV < 5 miles	pmslhov.mac
phv5+	Mf137	PM peak hour trip table for HOV >5+ miles	pmslhov.mac

OUTPUT DATA

Data Name	Matrix Name/ No.	Description	Input To
Fpmlov	Mf148	Final MD peak hour trip table for LOV	pm_assign_3c.mac
Fpmhov	Mf169	Final MD peak hour trip table for HOV3+	pm_assign_3c.mac

REPORTS: fpmlhov.rpt

5.7.12 Create AM Peak Hour Transit Trip Tables (ampktran.mac)

The ampktran.mac macro creates transit walk access, transit auto access, and total transit trip matrices for the AM peak hour. In the first step of the macro, an adjustment factor matrix is developed. Within the matrix, all zone pairs with one end in Kitsap County have a value of 0.25 and all other zone pairs have a value of 1.0. Following this, the AM peak hour transit walk access and auto access trip matrices are calculated by applying the AM peak hour time-of-day factors to the daily transit walk access and auto access trip matrices by trip purpose. The time-of-day factors are shown in Table 5-7.

For the transit walk access trips, the HBSchool trips are also multiplied by a calibration factor of 0.502. For the transit auto access trips, only the HBW trip purpose is included. The auto access trips are limited to those trips with an auto access distance of greater than 0.25 miles.

All trip interchanges within the AM peak hour transit walk access and auto access matrices, except those with one end at the Bellevue Square Mall (TAZ 11), are also multiplied by the Kitsap County adjustment factors. In the last step of the macro, the transit walk access and auto access matrices are summed to produce AM peak hour total transit trips.

Mf62 = mf20 + mf21

USER PARAMETERS

Parameter No.	Description	Default Value
N/A		

INPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Output From
hbwtwa	mf41	Daily HBWork transit walk access trips	hbw_mc.mac
hbotwa	mf45	Daily HBOther transit walk access trips	hbo_mc.mac
nhbtwa	mf47	Daily NHB transit walk access trips	nhb_mc.mac
hbstrp	mf39	Daily HBSchool transit walk access trips	sch_dist.mac
hbwtat	mf88	Daily HBWork transit auto access trips	presplit_ra.mac
amsvcd	mf13	AM peak hour free flow/congested SOV travel distances	am_mcskim2.mac

OUTPUT DATA

Matrix Name/ Attribute Name	Matrix No.	Description	Input To
amtrwa	mf20	AM peak hour walk access transit trips	n/a
amtrau	mf21	AM peak hour auto access transit trips	n/a
atrnst	mf62	AM peak hour total transit trips	Amtranhw.mac

REPORTS: ampktran.rpt

DRAFT

5.7.13 Create PM Peak Hour Transit Trip Tables (pmpktran.mac)

The pmpktran.mac macro creates transit walk access, transit auto access, and total transit trip matrices for the PM peak hour. In the first step of the macro, an adjustment factor matrix is developed. Within the matrix, all zone pairs with one end in Kitsap County have a value of 0.25 and all other zone pairs have a value of 1.0. Following this, the PM peak hour transit walk access and auto access trip matrices are calculated by applying the PM peak hour time-of-day factors to the daily transit walk access and auto access trip matrices by trip purpose. The time-of-day factors are shown in Table 5-7.

For the transit auto access trips, only the HBW trip purpose is included. The auto access trips are limited to those trips with an auto access distance of greater than 0.25 miles.

All trip interchanges within the PM peak hour transit walk access and auto access matrices, except those with one end at the Bellevue Square Mall (TAZ 11), are also multiplied by the Kitsap County adjustment factors. In the last step of the macro, the transit walk access and auto access matrices are summed to produce PM peak hour total transit trips.

Mf81 = mf82 + mf83

USER PARAMETERS

Parameter Name	Description	Default Value
N/A		

INPUT DATA

Data Name	Matrix Name/ No.	Description	Output From
hbwtwa	mf41	Daily HBWork transit walk access trips	hbw_mc.mac
hbotwa	mf45	Daily HBOther transit walk access trips	hbo_mc.mac
nhbtwa	mf47	Daily NHB transit walk access trips	nhb_mc.mac
hbstrp	mf39	Daily HBSchool transit walk access trips	sch_dist.mac
hbwtat	mf88	Daily HBWork transit auto access trips	presplit_ra.mac
amsvcd	mf13	AM peak hour free flow/congested SOV travel distances	am_mcskim2.mac

OUTPUT DATA

Data Name	Matrix Name/ No.	Description	Input To
Pmtrwa	Mf82	PM Peak hour transit trips walk access	N/A
Pmtrau	Mf83	PM peak hour transit trips auto access	N/A
Ptrnst	Mf81	PM peak hour transit trips	Pmtranhw.mac

REPORTS: pmpktran.rpt

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5.8 Trip Assignment

The trip assignment model is the last of the four primary model components identified as part of the four-step planning process. The trip assignment model estimates the volume on each link in the transportation system. In addition, the trip assignment model generates specific performance measures, such as the congested speed or travel time on a highway link. Trip assignment is performed separately for each of the three peak time periods (morning, mid-day and afternoon peak hour).

5.8.1 Auto Assignment Procedures

When link volume increases, traffic would shift to other links if another shortest path is found. After a number of iterations, traffic would not find a better route (cannot reduce its travel time) so the network reaches a stable condition named equilibrium. The morning, mid-day and afternoon peak hour assignments are performed to replicate the travel situations during different time periods of weekday although only the P.M. peak hour assignments are validated on the screenlines against the traffic counts. A.M. and mid-day auto assignments are performed to approximate travel skims to serve mode choice models, trip distribution models and transit travel time functions and ridership forecasting.

The following macros are used in the traffic assignment module.

- Perform AM peak hour auto assignment (am_assign_3c.mac)
- Create AM peak hour transit skims (amtrnhdw.mac) See Chapter 5.5
- Perform AM peak hour transit assignment (amtranhw.mac) See Chapter 5.5
- Perform Mid-day auto assignment (md_assign_3c.mac)
- Perform PM peak hour auto assignment (pm_assign_3c.mac)
- Create PM peak hour transit skim (pmtrnhdw.mac)
- Perform PM peak hour transit assignment (pmtranhw.mac)

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5.8.2 Perform AM Peak Hour Auto Assignment (am_assign_3c.mac)

This macro assigns AM SOV, LOV and HOV 3+ trip tables to the network through multi-class assignment procedure.

Toll is applied in all three classes with different weight, as shown below.

Class	Toll Weight
SOV	0.0555
LOV	0.02775
HOV	0.0185

USER PARAMETERS

Parameter Name	Description	Default Value
	Mimimum relative GAP	0.01
	Max iterations	150
@stoll	Toll for SOV	
@ltoll	Toll for LOV	
@htoll	Toll for HOV3+	

INPUT DATA

Data Name	Matrix Name/ No.	Description	Output From
Famsov	Mf143	Final AM trip table for SOV	amslhov.mac
Famlov	Mf144	Final AM trip table for LOV	am3pr+hov3c.mac
Famhov	Mf165	Final AM trip table for HOV3+	am3pr+hov3c.mac

OUTPUT DATA

Data Name	Matrix Name/ No.	Description	Input To
N/A			

REPORTS: am_assign.rpt

5.8.3 Perform Mid-day Auto Assignment (md_assign_3c.mac)

This macro assigns MD SOV, LOV and HOV 3+ trip tables to the network through multi-class assignment procedure.

Toll is applied in all three classes with different weight, as shown below.

Class	Toll Weight
SOV	0.0659
LOV	0.03295
HOV	0.02197

USER PARAMETERS

Parameter Name	Description	Default Value
	Minimum relative GAP	0.01
	Max iterations	150
@stoll	Toll for SOV	
@ltoll	Toll for LOV	
@htoll	Toll for HOV3+	

INPUT DATA

Data Name	Matrix Name/ No.	Description	Output From
Fmdsov	Mf145	Final MD trip table for SOV	Mdslhov.mac
Fmdlov	Mf146	Final MD trip table for LOV	md3pr+hov3c.mac
fmdhov	Mf167	Final MD trip table for HOV3+	md3pr+hov3c.mac

OUTPUT DATA

Data Name	Matrix Name/ No.	Description	Input To
N/A			

REPORTS: md_assign.rpt

5.8.4 Perform PM Peak Hour Auto Assignment (pm_assign_3c.mac)

This macro assigns PM SOV, LOV and HOV 3+ trip tables to the network through multi-class assignment procedure.

Toll is applied in all three classes with different weight, as shown below.

Class	Toll Weight
SOV	0.05
LOV	0.025
HOV	0.01667

USER PARAMETERS

Parameter Name	Description	Default Value

INPUT DATA

Data Name	Matrix Name/ No.	Description	Output From
Fpmsov	Mf147	Final PM trip table for SOV	Pmslhov.mac
Fpmlov	Mf148	Final PM trip table for LOV	pm3pr+hov3c.mac
fpmhov	Mf169	Final PM trip table for HOV3+	pm3pr+hov3c.mac

OUTPUT DATA

Data Name	Matrix Name/ No.	Description	Input To

REPORTS: pm_assign.rpt

5.8.5 Create PM Peak Hour Transit Skim (pmtrnhdw.mac)

The pmtrnhdw.mac macro executes a sequence of other macros (effhdwy0.mac, amtranhw.mac, and effhdwy.mac) within a loop structure to produce a capacity-restrained PM peak hour transit assignment. With this procedure, the headways for transit routes having ridership volumes that exceed total vehicle capacity are adjusted upward in an attempt to divert the excess demand to other routes. A total of six transit assignments is performed (pmtranhw.mac), with the headways adjusted at the end of each assignment in proportion to the excess demand. Prior to the first assignment, the wait time factor used in the assignments is stored in node user data item 1 ("ui1") with a value of 0.5.

A successive averaging technique is used to average the adjusted headways with the average headways from the previous assignments (effhdwy.mac). The updated headways are then used for the next iteration of assignment and headway adjustment. At the end of the last assignment, the objective is to have the total transit ridership demand reasonably distributed among alternative transit routes based on available capacity, similar to the way that a capacity-restrained auto assignment works. In the last step of the macro, the transit impedance components produced in the last assignment are copied from temporary matrices to permanent matrices. These are used as inputs to the pmpkrskm2.mac and hbw_mc.mac macros.

USER PARAMETERS

Parameter Name	Description	Default Value
1	Scenario number of scenario to be used for performing transit assignments	4
2	Wait time factor	0.5

INPUT DATA

Data Name	Matrix Name/ No.	Description	Output From
N/A			

OUTPUT DATA

Data Name	Matrix Name/ No.	Description	Input To
pmtrtw	Mf70	PM peak hour transit time	pmtranhw.mac
pmivtw	Mf71	PM Peak hour transit in vehicle time	pmtranhw.mac
pmaxtw	Mf72	PM peak hour transit aux time	pmtranhw.mac
pmtwtw	Mf73	Pm peak hour transit total time	pmtranhw.mac
pm1wtw	Mf74	PM peak hour transit wait time	pmtranhw.mac
pmbrdw	Mf75	PM peak hour transit boarding time	pmtranhw.mac
pmabdw	Mf76	PM peak hour average boardings	pmtranhw.mac

REPORTS: pmtrnhdw.rpt

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5.8.6 Perform PM Peak Hour Transit Assignment (pmtranhw.mac)

The pmtranhw.mac macro performs PM peak hour transit assignment using the transit trip table developed with the pmpktran.mac macro. The following transit impedance components are produced by the assignment and saved in temporary matrices:

- Transit time (weighted sum of transit time components)
- In-vehicle travel time
- Auxiliary (walk) travel time
- Total waiting time
- First waiting time
- Boarding time
- Average number of boardings

Once the final transit assignment has been performed within the loop to calculate effective headways, the pmtrnhdw.mac macro copies the contents of these matrices into another set of matrices for permanent storage.

The effective headways for the assignment are obtained from the extra transit segment attribute "@ehdwy" defined in the effhdwy0.mac and effhdwy.mac macros. Wait time factors are obtained from the node user data item 1 ("ui1"). These factors have a value of 0.5 for all nodes.

In the final step of the macro, walk access times from origin zones and to destination zones are added to the auxiliary tranist times. These times have values of 0, 1, or 2 minutes.

USER PARAMETERS

Parameter Name	Description	Default Value
1	Boarding time	4 (mins.)
2	Wait time weight	2.8
3	Auxiliary transit time weight	2.1
4	Boarding time weight	2.0

INPUT DATA

Data Name	Matrix Name/ No.	Description	Output From
ptrnst	Mf81	PM peak hour transit trips - walk	pmpktran.mac
walkac	mo10	Walk access time from origin zones	N/A
walkac	md10	Walk access time to destination zones	N/A

OUTPUT DATA

Data Name	Matrix Name/ No.	Description	Input To
N/A	mf91	PM peak hour transit time - walk(weighted sum of transit time components)	Pmtrnhdw.mac
N/A	mf92	PM peak hour transit in-vehicle time - walk	Pmtrnhdw.mac
N/A	mf93	PM peak hour auxiliary transit time - walk	Pmtrnhdw.mac
N/A	mf94	PM peak hour total waiting time - walk	Pmtrnhdw.mac
N/A	mf95	PM peak hour first waiting time - walk	Pmtrnhdw.mac
N/A	mf96	PM peak hour boarding time - walk	Pmtrnhdw.mac
N/A	mf97	PM peak hour average number of boardings - walk	Pmtrnhdw.mac
voltr	N/A	Segment transit volumes	effhdwy.mac
board	N/A	Boardings at i-node of segments	effhdwy.mac

REPORTS: pmtranhw.rpt

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5.8.7 Perform Walk and Bicycle Assignments (walkbike.mac)

This is for non-motorized assignment and is currently under development and review stage. It will be added when it becomes available in the future.

USER PARAMETERS

Parameter Name	Description	Default Value

INPUT DATA

Data Name	Matrix Name/ No.	Description	Output From

OUTPUT DATA

Data Name	Matrix Name/ No.	Description	Input To

6 Model Calibration and Validation

6.1 Model Calibration

Model calibration is the process of adjusting the model parameters until the model's estimates replicate travel patterns exhibited by observed travel data, such as a household travel survey or origin-destination survey. Calibration was not carried out for the BKR base year model mp0r12. Only validation was performed to ensure the model outputs are still in line with survey and field observation.

In 2002, Cambridge Systematics was contracted to enhance each individual model component and calibrate/validate each module to 1999 PSRC travel survey and field observation data. For the detailed calibration results, please refer to "2002 Bellevue Model Update and Calibration Report".

The following macros are used to produce validation model outputs:

- Trip generation (sum_8.mac)
- Trip distribution
  - Td_valid1.mac
  - Td_valid2.mac
  - Td_valid3.mac
- Mode share by time-of-day (AM-MD-PM.mac)
- Mode share in Bellevue downtown (ms-daily-beltown.mac)
- Mode share by trip purpose in BKR area (sum_mc_bkr.mac)
- Mode share by trip purpose in whole region (sum_mc.mac)

The output files have the same filenames but with ".rpt" as their extension name. These rpt files need to be loaded into an Excel spreadsheet to produce reader-friendly report.

6.1.1 Trip Generation Model

Trip rates were calibrated by Cambridge Systematics in 2002 based on 1999 PSRC survey. They were not changed since then. Several trip purposes included more than one of the original trip purposes, it was decided that the final validation would be completed by individual trip purpose rather than combined trip purpose. Since commercial vehicles were not included in the household survey, they are reported separately from the total. The production and attraction by purpose are shown in Table 6-1 and 6-2, respectively.

Table 6-1 MP0R12 Trip Production Calibration for the BKR Study Area

	MP0R12 Trip Productions	MP0R12 Trip Production per HHs	1999 PSRC Activity Survey	2006 PSRC Activity Survey	Difference (1999)	Percent Difference
HBW	237,387	1.39	1.47	1.48	-0.08	-5.60%
HBC	7,817	0.05	0.05	0.05	-0.01	-16.31%
HBShop	191,521	1.12	1.17	0.77	-0.04	-3.81%
HBO	536,525	3.14	3.17	3.54	-0.03	-0.99%
HBSchool	84,486	0.50	0.51	0.76	-0.02	-3.40%
Work-Other	132,734	0.78	0.66	0.73	0.12	18.72%
Other-Other	346,276	2.03	1.68	1.71	0.35	20.65%
Total	1,536,746	9.00	8.72	9.04	0.29	3.27%

Notes: 2006 PSRC survey results listed here are just for informational purpose. The trip rates were not adjusted based on 2006 PSRC survey, so the trip generation model actually reflects the 1999 household characteristics.

Table 6-2 MP0R12 Trip Attraction Calibration for the BKR Study Area

	MP0R12 Trip Attractions	MP0R12 Attractions Per Employee
Home-Based Work	420,624	1.45
Home-Based College	16,883	0.06
Home-Based Shop	180,476	0.62
Home-Based Other	795,249	2.74
Home-Based School	57,723	0.20
Work-Other	132,734	0.46
Other-Other	342,412	1.18
Commercial Vehicles	177,105	0.61
Total	2,123,206	7.42

6.1.2 Trip Distribution Model

Trip distribution models were enhanced in two major areas: Friction Factor Functions and Auto Travel Time Estimation.

Model calibration for trip distribution is carried out by adjusting the friction factor functions for each trip purpose until the average trip duration (in minutes) matches reasonably well with observed data. Figures 4.1 through 4.4 present a summary of this process for home-based work, home-based school, home-based other and non-home-

based trips, respectively. These figures present the following friction factor functions for each purpose:

- Original friction factors used in the prior BKR travel models;
- Initial gamma functions established to emulate the original functions; and
- Final gamma functions established to match observed trip durations.

The basic functional formula for the friction factors is given by the gamma function as follows:

$$f(t) = \alpha \exp(\beta t) t^{\gamma} = \alpha \exp(\beta t + \gamma \ln t)$$

where:

Alpha, beta and gamma are parameters to be calibrated; and
t is the impedance.

Calibration of the gamma function is a complex process. Initially, three model function parameters (alpha, beta and gamma) are tested using different values to fit the model curves to the PSRC model curves. The friction factors derived from the tested Gamma Function are then applied to the trip distribution models by four trip purposes: home-based work, home-based other, non-home based and home-based school. Multi-class auto trip assignments are run to obtain the average travel times by trip purposes. The results are compared to the observed average travel times by the corresponding trip purposes. The calibrated parameters are given in Table 6-3. Figure 6-1 depicts the friction factor functions for each trip purpose.

Besides refining the functions based on the BKR's original gamma functions, a different approach is applied to calibrate the friction factor functions. In that approach, raw 1999 PSRC survey data are used to develop gamma functions for testing. The raw data are grouped by trip purpose and smoothed out to resemble the real observations. Initial functions are developed and are further fitted to exponential functions similar to the gamma functions. The results are not satisfactory but the process helped the staff to comprehensively understand the survey data results.

Table 6-3 Calibrated Parameters for the Friction Factor Gamma Function

Parameters	HB-Work	HB-Other	Non-HB	HB-School
Alpha	35,000	50,000	45,000	67,500
Beta	-0.09	-0.24	-0.170	-0.345
Gamma	-0.09	-0.24	-0.172	-0.325

The trip length and duration by purpose, as well as 1999 and 2006 PSRC survey results, are given in Table 6-4 to 6-7. Table 6-8 presents the percent of trips to and from each super district.

Figure 5.1: Final Calibrated Friction Factors by Trip Purpose

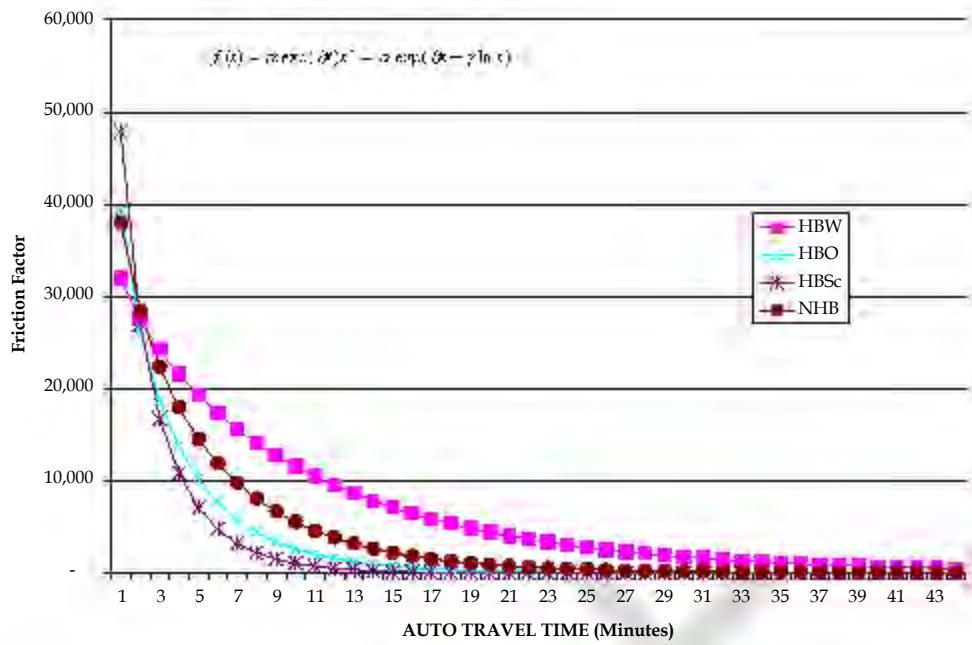

Figure 6-1 Calibrated Friction Factors by Trip Purpose

Table 6-4 Averaged Trip Duration by Purpose (Region-Wide)

	MP0R12	1999 PSRC Household Survey	2006 PSRC HH Survey	Difference (1999)	Percent Difference
HBW+HBC	30.20	25.50	33.15	4.70	18%
HBO+HB-Shop	17.42	16.50	16.92	0.92	6%
NHB	12.59	15.80	17.09	-3.21	-20%
HB-School	12.12	13.40	18.36	-1.28	-10%
Average	18.04	17.80	19.77	0.24	1%

Units: minutes

Table 6-5 Averaged Trip Duration by Purpose (BKR Area)

	MP0R12	1999 Household Survey for BKR Study Area	2006 PSRC HH Survey	Difference (1999)	Percent Difference
HBW+HBC	22.84	18.89	30.97	3.94	21%
HBO+HBShop	15.09	12.24	16.32	2.79	23%
NHB	12.51	11.40	15.80	1.11	10%
HBSch	11.12	9.93	17.65	1.19	12%
Average	15.04	12.99	18.68	2.02	16%

Units: minutes

Table 6-6 Averaged Trip Length by Purpose (Region-Wide)

	MP0R12	1999 PSRC Household Survey	2006 PSRC HH Survey	Difference (1999)	Percent Difference
HBW+HBC	10.00	11.30	11.39	-1.30	-11%
HBO+HB-Shop	7.23	6.70	5.15	0.53	8%
NHB	4.39	6.10	5.26	-1.71	-28%
HB-School	2.15	4.80	3.84	-2.65	-55%
Average	6.52	7.30	6.26	-0.78	-11%

Units: miles

Table 6-7 Averaged Trip Duration by Purpose (BKR Area)

	MP0R12	1999 Household Survey for BKR Study Area	2006 PSRC HH Survey	Difference (1999)	Percent Difference
HBW+HBC	8.07	9.57	10.92	-1.50	-16%
HBO+HBShop	6.41	5.82	5.33	0.59	10%
NHB	5.31	5.35	5.26	-0.04	-1%
HBSch	2.55	4.23	4.06	-1.68	-40%
Average	6.05	6.23	6.26	-0.18	-3%

Units: miles

Table 6-8 Percent of Trips to and from Each Super-District

Super-District	Bellevue	Kirkland	Redmond	Outside BKR	Total Trips
MP0R12					
Bellevue	61%	6%	12%	21%	100%
Kirkland	21%	39%	13%	27%	100%
Redmond	25%	15%	45%	15%	100%
Outside BKR study area	2%	1%	2%	94%	100%
Total	7%	3%	5%	85%	100%
1999 Household Survey for BKR Study Area					
Bellevue	62%	12%	10%	17%	100%
Kirkland	16%	60%	10%	14%	100%
Redmond	32%	25%	35%	8%	100%
Outside BKR study area	1%	0%	0%	99%	100%
Total	4%	3%	1%	91%	100%
2006 Household Survey for BKR Study Area					
Bellevue	56%	3%	8%	33%	100%
Kirkland	8%	46%	10%	36%	100%
Redmond	14%	6%	47%	33%	100%
Outside BKR study area	2%	1%	1%	97%	100%
Total	4%	1%	2%	92%	100%
Difference (1999)					
Bellevue	0%	6%	-3%	-4%	0%
Kirkland	-5%	21%	-3%	-13%	0%
Redmond	7%	10%	-10%	-7%	0%
Outside BKR study area	-2%	-1%	-2%	4%	0%
Total	-3%	0%	-4%	7%	0%

Origin-destination trip distribution patterns in terms of travel time duration were plotted by trip purpose. Figures 6-2 to 6-5 display the trip length (travel time in minutes) frequency distribution density histograms by trip purpose. The curves reflect the significance of travel time on trip making patterns of the different trip purposes. Travel time is a relatively less important factor in work trip patterns compared to other purposes. This can be seen as HBW trips have the longest weighted average trip length as well as the longest 'tail' on the graph. HBO trips are significantly shorter on average as travel time is a more significant factor in determining travel patterns. NHB trips are shorter still, and SCH trips are constrained to remain within school district boundaries.

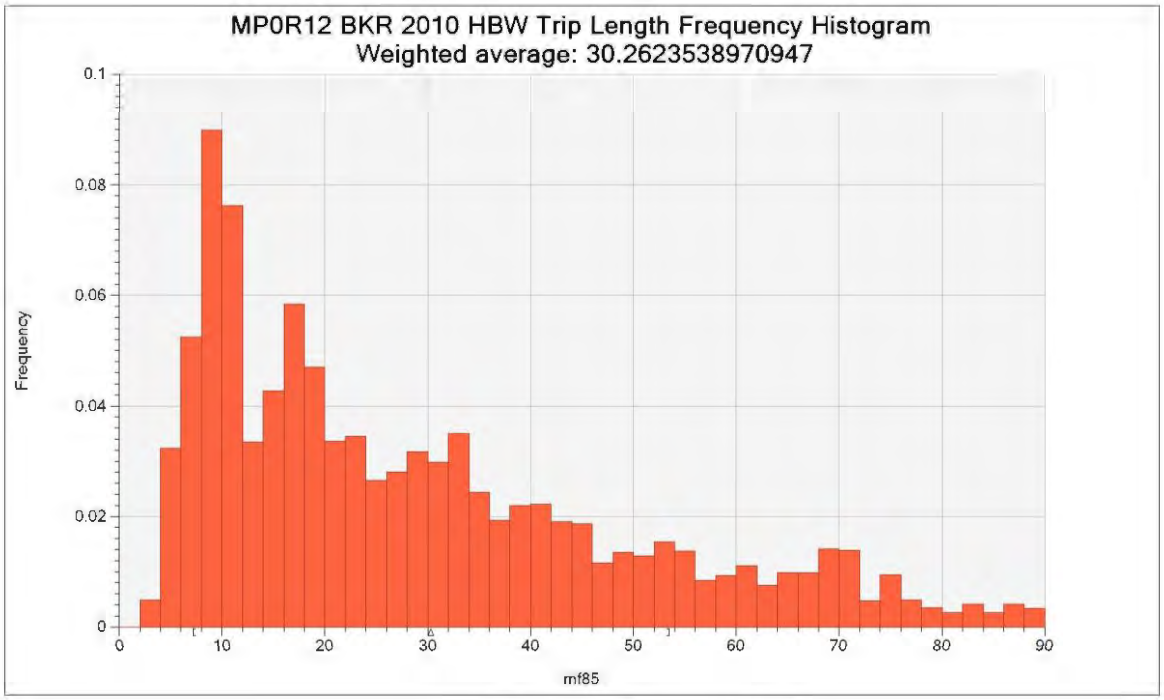

Figure 6-2 MP0R12 HBW Trip Duration Histogram

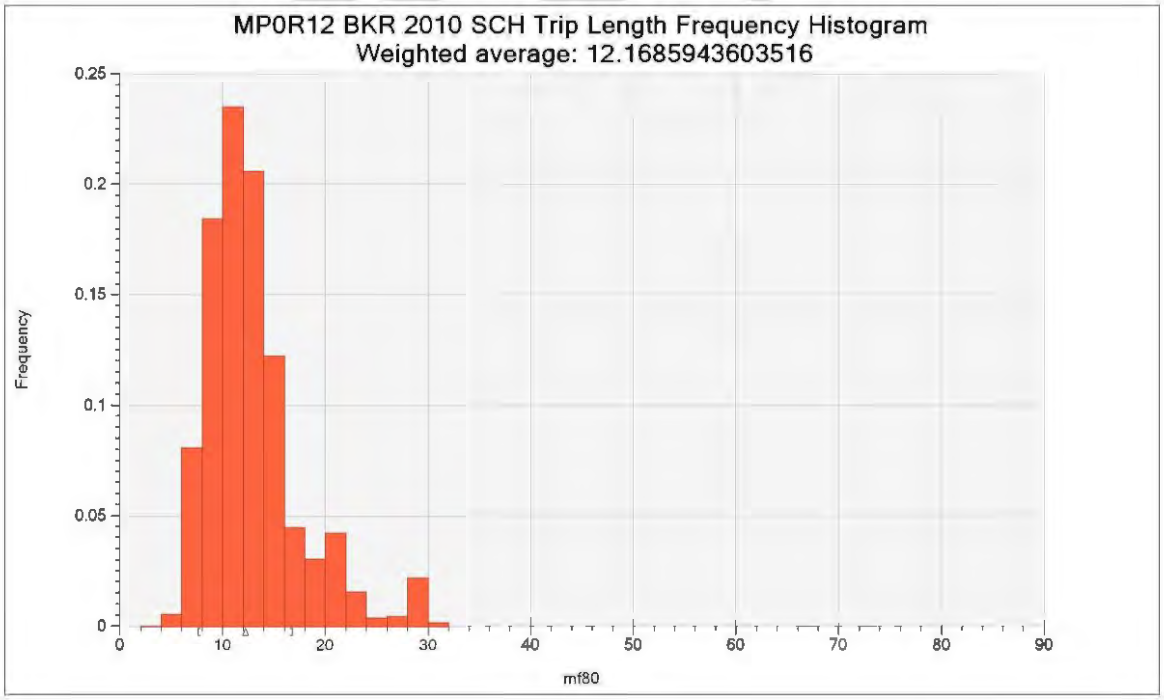

Figure 6-3 MP0R12 HBSchool Trip Duration Histogram

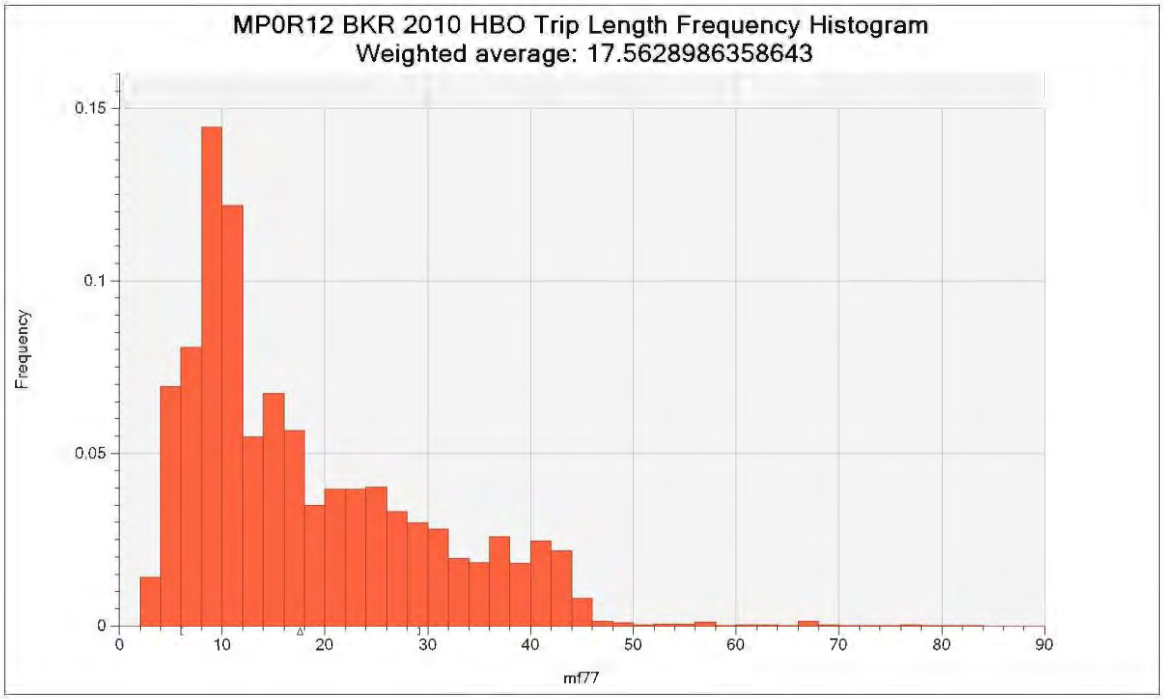

Figure 6-4 MP0R12 HBO Trip Duration Histogram

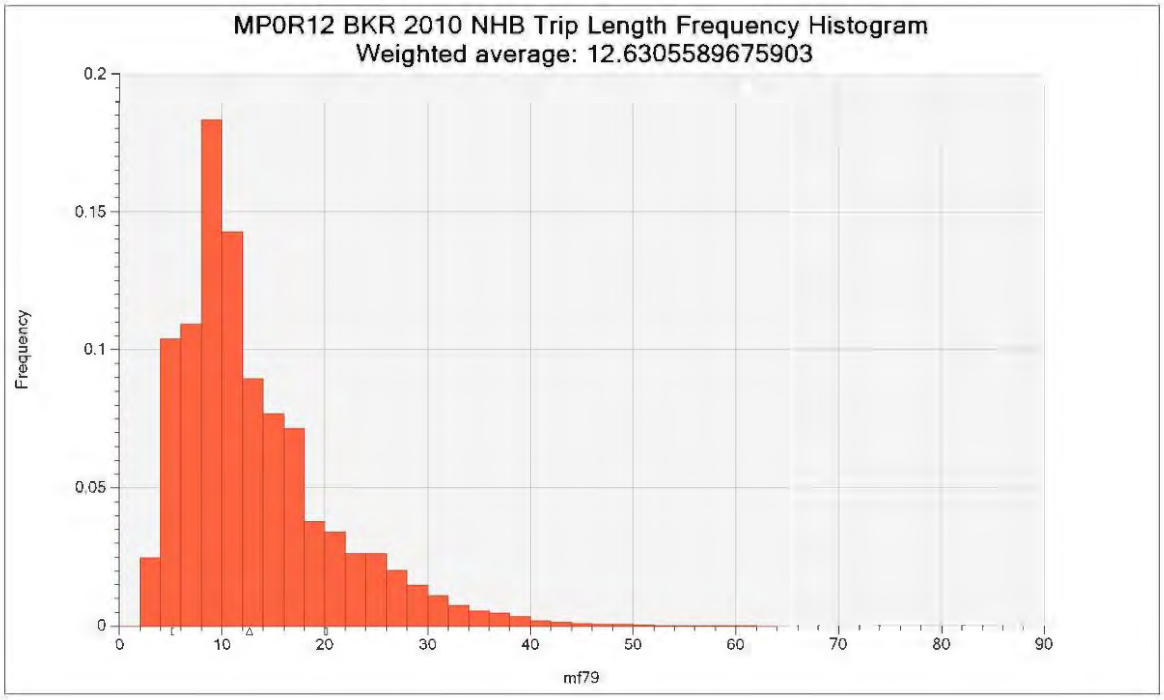

Figure 6-5 MP0R12 NHB Trip Duration Histogram

6.1.3 Mode Choice Model

The final BKR mode choice modeling results are validated by the 1999 PSRC region-wide survey data with close fits as shown Tables 6-9 and 6-10. This validation test shows that overall mode shares are within +/- one percent of observed values. The model share for the Bellevue downtown is shown in Table 6-11. Mode share by time of day is given in Table 6-12.

Table 6-9 2010 MP0R12 Mode Choice Results (Region-Wide)

		Daily Motorized Person Trips	%	PSRC 1999 Household Survey	PSRC 2006 Household Survey	Absolute Difference
HBW Trips	Drive Alone	2,316,451	83.0%	82.7%	76.6%	0.3%
	Shared Ride	238,091	8.5%	9.5%	8.7%	-0.8%
	Transit – Walk Access	223,035	8.0%	6.9%	5.0%	1.1%
	Transit – Auto Access	14,090	0.5%	1.0%	9.6%	-0.5%
	Total	2,791,667	100.0%	100.0%	100.0%	
HBO Trips	Auto	5,991,452	98.5%	98.9%	98.9%	-0.3%
	Transit	91,092	1.5%	1.1%	1.1%	0.4%
	Total	6,082,545	100.0%	100.0%	100.0%	
NHB Trips	Auto	4,321,922	98.8%	98.8%	98.8%	0.0%
	Transit	54,063	1.2%	1.2%	1.2%	0.0%
	Total	4,375,984	100.0%	100.0%	100.0%	

Table 6-10 2010 MP0R12 Mode Choice Results (BKR Area)

		Daily Motorized Person Trips	%	PSRC 1999 Household Survey	PSRC 2006 Household Survey	Absolute Difference
HBW Trips	Drive Alone	210,073	85.7%	85.8%	84.3%	-0.1%
	Shared Ride	14,719	6.0%	5.2%	6.1%	0.8%
	Transit – Walk Access	17,519	7.1%	7.2%	7.2%	-0.1%
	Transit – Auto Access	2,892	1.2%	1.8%	2.4%	-0.6%
	Total	245,203	100.0%	100.0%	100.0%	
HBO Trips	Auto	763,904	98.6%	99.3%	99.2%	-0.8%
	Transit	11,182	1.4%	0.7%	0.9%	0.8%
	Total	775,086	100.0%	100.0%	100.0%	
NHB Trips	Auto	636,013	99.0%	98.8%	98.4%	0.2%
	Transit	6,139	1.0%	1.2%	1.6%	-0.2%
	Total	642,151	100.0%	100.0%	100.0%	

Table 6-11 2010 MP0R12 Mode Share for Bellevue Downtown

		CBD-Other	Other-CBD	CBD-CBD	Mode Split	
HBW Trips	Transit – Walk Access	1016	4253	440	5709	10%
	Transit – Auto Access	20	344	5	369	1%
	Drive Alone	4923	40600	936	46459	81%
	Shared Ride	658	3938	124	4720	8%
	Total	6617	49134	1505	57257	100%
HBO Trips	Transit – Walk Access	469	1755	294	2519	1%
	Drive Alone	14331	152013	13365	179709	99%
	Total	14800	153768	13659	182227	100%
NHB Trips	Transit – Walk Access	599	830	814	2243	2%
	Drive Alone	47095	50579	47449	145123	98%
	Total	47695	51408	48263	147366	100%

Table 6-12 2010 MP0R12 Mode Share by Time-of-Day

	AM		MD		PM	
SOV Auto (mf143)	568,704	68.2%	478,900	74.8%	648,217	67.1%
HOV2+ Auto (mf144)	141,685	17.0%	141,534	22.1%	229,051	23.7%
LOV (mf27+mf29)	99,362		101,215		164,457	
HOV3+ (mf28+mf68)	42,323		40,319		64,593	
Walk-Access Transit (mf 20)	117,917	14.1%	19,711	3.1%	82,855	8.6%
Auto-Access Transit (mf21)	6,059	0.7%			6,059	0.6%
Total	834,364	100.0%	640,145	100.0%	966,181	100.0%

6.2 Model Validation

Model validation is the assessment of the model's overall performance by comparison of observed counts (i.e., traffic counts and transit boardings) to estimated auto and transit volumes produced by running the entire model chain with base year model inputs. The data used for the assignment validation are 2010 PM peak hour traffic counts on freeway and local arterial system within the BKR study area. The tube counts and intersection turning movement accounts come from the Cities of Bellevue, Kirkland, Redmond, King County, and WSDOT. The data had been reconciled before input into the validation spreadsheet.

Screenline Analysis

As shown in Figure 6-6 (for BKR area), 32 imaginary lines were drawn to screen traffic crossing northbound, southbound, eastbound and westbound on roadway facilities. Individual directional auto traffic forecasts were compared to 2010 actual counts at the same location. Both model forecasts and counts were summarized by screenlines, and further aggregated by screenline locations and jurisdictions. The goal of screenline analysis is to have each screenline traffic forecast total match with the count total within + or – 10% ranges. As shown in Table 6-14 through 6-17, the majority of screenlines (25) reach the goal while 8 screenlines are outside the 10% target. Figure 6-6 depicts screenline locations and model-to-actual ratios within the BKR area. Table 6-13 shows in screenline summarized by region. Since the counts for the Redmond/Overlake area are out-of-date, they are not included in the validation but the model-to-actual ratio is only given for informational purpose.

Screenline validation is further grouped by facility type, i.e freeway general purpose (GP) lane, freeway HOV lane, and arterial, as shown in Table 6-19 through 6-22. The modeled volumes match well with field counts.

Table 6-13 2010 MP0R12 Model PM Peak Hour Screenline Summary by Region

D4	ALL LEVELS	BKR REGION - Arterials and Freeways	Total Link Vol		
SL #	SL Name	SL Locations	Actual	Model	M/A
A1	LEVEL ONE	Study Area Boundary Screenlines	88,946	91,043	1.02
A2	LEVEL TWO	BKR Regional Screenlines	306,042	341,255	1.12
A3	LEVEL THREE	CITY Screenlines - REDMOND	37,536	39,358	1.05
A4	LEVEL THREE	CITY Screenlines - BELLEVUE	170,020	173,083	1.02
ALL LEVELS		**Screenline Total**	**602,544**	**644,739**	**1.07**

Table 6-14 2010 MP0R12 Model PM Peak Hour Screenline Summary - Boundary

A1	LEVEL ONE	Study Area Boundary Screenlines	Total Link Vol		
SL #	SL Name	SL Locations	Actual	Model	M/A
1	North Boundary	S/O Bothell Way (SR-522) & Wd-Duvall Rd (NE 185th St)	26,180	27,349	1.04
2	South Boundary	S/O SE 69th Way & Newcastle-Coal Creek Rd	16,552	17,987	1.09
3	East Boundary	E/O Avondale Rd, 196th Ave NE & W Lk Samm Pkwy	24,674	23,583	0.96
4	West Boundary	Lake Washington Bridge Crossings - SR-520 & I-90	21,540	22,124	1.03
LEVEL ONE		**Screenline Total**	**88,946**	**91,043**	**1.02**

Table 6-15 2010 MP0R12 Model PM Peak Hour Screenline Summary - Regional

A2	LEVEL TWO	BKR Regional Screenlines	Total Link Vol		
SL #	SL Name	SL Locations	Actual	Model	M/A
13	NS-1	W/O I-405	43,641	46,380	1.06
14	NS-2	E/O 132nd Ave NE, Richards Rd, 128th Ave SE & CC Pkwy	45,467	48,750	1.07
15	NS-3-BEL	W/O 100th Ave NE	10,734	9,853	0.92
5	EW-1	N/O NE 132nd St (w side of 405) & NE 124th St (east side of 405)	24,929	30,848	1.24
6	EW-2	N/O Central Way, NE 85th St & NE Redmond Wy (SR-908)	28,450	35,768	1.26
7	EW-3	N/O NE 68th St, NE 72nd St, NE 70th St, & NE 51st St	34,638	42,262	1.22
8	EW-4	N/O SR-520 & S/O NE 40th St	38,219	42,894	1.12
9	EW-5-BEL	N/O NE 12th St & Bel-Red Rd	22,777	24,875	1.09
10	EW-6-BEL	S/O NE 8th St & N/O Main St	8,388	8,213	0.98
11	EW-7-BEL	S/O Main St	21,609	23,201	1.07
12	EW-8-BEL	N/O I-90 & Eastgate Way	27,190	28,211	1.04
LEVEL TWO		**Screenline Total**	**306,042**	**341,255**	**1.12**

Table 6-16 2010 MP0R12 Model PM Peak Hour Screenline Summary - Redmond

A3	LEVEL THREE	CITY Screenlines - REDMOND	Total Link Vol		
SL #	SL Name	SL Locations	Actual	Model	M/A
16	NS-1-OV	W/O SR-520	2,863	3,036	1.06
17	NS-2-OV	E/O 156th Ave NE	2,467	3,439	1.39
18	NS-1-RED	W/O W LK Sammamish PkWy	3,044	2,959	0.97
19	NS-2-RED	E/O 160th Ave NE	7,925	6,145	0.78
21	NS-3-RED	W/O Avondale Rd NE & SR-520	14,542	17,230	1.18
33	NS-4-RED	E/O Woodinville-Redmond Rd (SR-202)	2,567	2,643	1.03
20	EW-1-RED	S/O NE 83rd St	4,128	3,906	0.95
LEVEL THREE		**Screenline Total**	**37,536**	**39,358**	**1.05**

Table 6-17 2010 MP0R12 Model PM Peak Hour Screenline Summary - Bellevue

A4	LEVEL THREE	CITY Screenlines - BELLEVUE	Total Link Vol		
SL #	SL Name	SL Locations	Actual	Model	M/A
25	NS-1-BEL:CBD	E/O Bellevue Way	7,856	7,593	0.97
26	NS-2-BEL:CBD	E/O 108th Ave NE	11,380	12,056	1.06
31	NS-1-BEL	E/O I-405	30,608	31,821	1.04
32	NS-2-BEL	W/O SR-901 & W Lk Sammamish PkWy	13,410	13,005	0.97
22	EW-1-BEL:CBD	S/O NE 12th St	6,179	5,697	0.92
23	EW-2-BEL:CBD	S/O NE 8th St	10,050	10,228	1.02
24	EW-3-BEL:CBD	S/O NE 4th St	7,677	7,666	1.00
27	EW-1-BEL	S/O SR-520 & N/O NE 20th St	35,785	37,015	1.03
28	EW-2-BEL	S/O Main St	7,814	6,934	0.89
29	EW-3-BEL	S/O of I-90 & Eastgate	22,698	23,385	1.03
30	EW-4-BEL	N/O SE 60th St	16,563	17,683	1.07
LEVEL THREE		**Screenline Total**	**170,020**	**173,083**	**1.02**

Table 6-18 2010 MP0R12 Model PM Peak Hour Screenline Summary - Overlake

A5	LEVEL THREE	CITY Screenlines - REDMOND/Overlake	Total Link Vol		
SL #	SL Name	SL Locations	Actual	Model	M/A
38	5-NS-Redmond	W/O 140th Ave NE	4,929	5,070	1.03
39	6-NS-Redmond	E/O 148th Ave NE	3,044	2,959	0.97
40	7-NS-Redmond	W/O 148th Ave NE	12,809	14,246	1.11
41	8-NS-Redmond	E/O 148th Ave NE	3,438	3,738	1.09
42	9-NS-Redmond	E/O 156th Ave NE	4,132	6,870	1.66
34	1-EW-Redmond	S/O Old Redmond Road	15,037	20,349	1.35
35	2-EW-Redmond	N/O NE 40th Street	16,472	19,855	1.21
36	3-EW-Redmond	N/O NE 24th Street	13,553	18,145	1.34
37	4-EW-Redmond	S/O NE 24th Street	3,473	3,023	0.87
LEVEL THREE		**Screenline Total**	**76,887**	**94,255**	**1.23**

Notes: Counts on these locations are out-of-date.

Table 6-19 2010 MP0R12 Model PM Peak Hour Screenline Summary – Freeway GP Lanes

D1		BKR REGION - Freeway GP	Total Link Vol		
SL #	SL Name	SL Locations	Actual	Model	M/A
B1	GP I-405	BKR REGION (From North To South)	133,970	148,013	1.10
B2	GP SR-520	BKR REGION (From West To East)	52,890	57,748	1.09
B3	GP I-90	BKR REGION (From West To East)	57,140	55,937	0.98
GP		**Screenline Total**	**244,000**	**261,698**	**1.07**

B1	GP I-405	BKR REGION (From North To South)	Total Link Vol		
SL #	SL Name	SL Locations	Actual	Model	M/A
1	North Boundary	S/O Bothell Way (SR-522) & Wd-Duvall Rd (NE 185th St)	11,480	12,757	1.11
5	EW-1	N/O NE 132nd St (w side of 405) & NE 124th St (east side of 405)	9,950	12,128	1.22
6	EW-2	N/O Central Way, NE 85th St & NE Redmond Wy (SR-908)	12,520	16,051	1.28
7	EW-3	N/O NE 68th St, NE 72nd St, NE 70th St, & NE 51st St	11,850	14,218	1.20
8	EW-4	N/O SR-520 & S/O NE 40th St	12,180	13,902	1.14
27	EW-1-BEL	S/O SR-520 & N/O NE 20th St	13,470	13,386	0.99

9	EW-5-BEL	N/O NE 12th St & Bel-Red Rd	13,100	13,233	1.01
11	EW-7-BEL	S/O Main St	11,130	12,222	1.10
12	EW-8-BEL	N/O I-90 & Eastgate Way	12,400	13,409	1.08
29	EW-3-BEL	S/O of I-90 & Eastgate	10,590	10,787	1.02
30	EW-4-BEL	N/O SE 60th St	7,650	7,960	1.04
2	South Boundary	S/O SE 69th Way & Newcastle-Coal Creek Rd	7,650	7,960	1.04
GP I-405		**Screenline Total**	**133,970**	**148,013**	**1.10**

B2	**GP SR-520**	**BKR REGION (From West To East)**	**Total Link Vol**		
SL #	**SL Name**	**SL Locations**	**Actual**	**Model**	**M/A**
4	West Boundary	Lake Washington Bridge Crossings - SR-520 & I-90	7,700	8,286	1.08
15	NS-3-BEL	W/O 100th Ave NE	7,630	7,575	0.99
13	NS-1	W/O I-405	8,210	8,326	1.01
31	NS-1-BEL	E/O I-405	8,600	9,064	1.05
14	NS-2	E/O 132nd Ave NE, Richards Rd, 128th Ave SE & CC Pkwy	6,830	6,989	1.02
8	EW-4	N/O SR-520 & S/O NE 40th St	6,620	8,141	1.23
7	EW-3	N/O NE 68th St, NE 72nd St, NE 70th St, & NE 51st St	7,300	9,367	1.28
GP SR-520		**Screenline Total**	**52,890**	**57,748**	**1.09**

B3	**GP I-90**	**BKR REGION (From West To East)**	**Total Link Vol**		
SL #	**SL Name**	**SL Locations**	**Actual**	**Model**	**M/A**
4	West Boundary	Lake Washington Bridge Crossings - SR-520 & I-90	11,840	11,917	1.01
13	NS-1	W/O I-405	7,880	8,087	1.03
31	NS-1-BEL	E/O I-405	6,060	6,172	1.02
14	NS-2	E/O 132nd Ave NE, Richards Rd, 128th Ave SE & CC Pkwy	11,790	11,238	0.95
32	NS-2-BEL	W/O SR-901 & W Lk Sammamish PkWy	9,730	9,372	0.96
3	East Boundary	E/O Avondale Rd, 196th Ave NE & W Lk Samm Pkwy	9,840	9,151	0.93
GP I-90		**Screenline Total**	**57,140**	**55,937**	**0.98**

Table 6-20 2010 MP0R12 Model PM Peak Hour Screenline Summary – Freeway HOV Lanes

D2		BKR REGION - Freeway HOV	Total Link Vol		
SL #	SL Name	SL Locations	Actual	Model	M/A
C1	HOV I-405	BKR REGION (From North To South)	27,350	34,428	1.26
C2	HOV SR-520	BKR REGION (From West To East)	6,560	6,045	0.92
C3	HOV I-90	BKR REGION (From West To East)	6,410	6,587	1.03
4	West Boundary	I-90 (Freeway) EB Express PM	1,040	639	0.61
HOV		**Screenline Total**	**41,360**	**47,699**	**1.15**

C1	HOV I-405	BKR REGION (From North To South)	Total Link Vol		
SL #	SL Name	SL Locations	Actual	Model	M/A
1	North Boundary	S/O Bothell Way (SR-522) & Wd-Duvall Rd (NE 185th St)	1,880	2,853	1.52
5	EW-1	N/O NE 132nd St (w side of 405) & NE 124th St (east side of 405)	2,040	3,191	1.56
6	EW-2	N/O Central Way, NE 85th St & NE Redmond Wy (SR-908)	2,120	3,140	1.48
7	EW-3	N/O NE 68th St, NE 72nd St, NE 70th St, & NE 51st St	2,330	2,955	1.27
8	EW-4	N/O SR-520 & S/O NE 40th St	2,540	2,881	1.13
27	EW-1-BEL	S/O SR-520 & N/O NE 20th St	2,310	2,933	1.27
9	EW-5-BEL	N/O NE 12th St & Bel-Red Rd	2,120	3,086	1.46
11	EW-7-BEL	S/O Main St	2,290	2,407	1.05
12	EW-8-BEL	N/O I-90 & Eastgate Way	2,430	2,506	1.03
29	EW-3-BEL	S/O of I-90 & Eastgate	2,230	2,780	1.25
30	EW-4-BEL	N/O SE 60th St	2,530	2,848	1.13
2	South Boundary	S/O SE 69th Way & Newcastle-Coal Creek Rd	2,530	2,848	1.13
HOV I-405		**Screenline Total**	**27,350**	**34,428**	**1.26**

C2	HOV SR-520	BKR REGION (From West To East)	Total Link Vol		
SL #	SL Name	SL Locations	Actual	Model	M/A
4	West Boundary	Lake Washington Bridge Crossings - SR-520 & I-90	0	0	0.00
15	NS-3-BEL	W/O 100th Ave NE	710	71	0.10
13	NS-1	W/O I-405	630	78	0.12
31	NS-1-BEL	E/O I-405	1,400	1,439	1.03

14	NS-2	E/O 132nd Ave NE, Richards Rd, 128th Ave SE & CC Pkwy	1,430	1,439	1.01
8	EW-4	N/O SR-520 & S/O NE 40th St	1,000	1,415	1.42
7	EW-3	N/O NE 68th St, NE 72nd St, NE 70th St, & NE 51st St	1,390	1,603	1.15
HOV SR-520		**Screenline Total**	**6,560**	**6,045**	**0.92**

C3	**HOV I-90**	**BKR REGION (From West To East)**	**Total Link Vol**		
SL #	**SL Name**	**SL Locations**	**Actual**	**Model**	**M/A**
4	West Boundary	Lake Washington Bridge Crossings - SR-520 & I-90	960	1,282	1.34
13	NS-1	W/O I-405	1,030	701	0.68
31	NS-1-BEL	E/O I-405	910	701	0.77
14	NS-2	E/O 132nd Ave NE, Richards Rd, 128th Ave SE & CC Pkwy	840	1,095	1.30
32	NS-2-BEL	W/O SR-901 & W Lk Sammamish PkWy	1,290	1,404	1.09
3	East Boundary	E/O Avondale Rd, 196th Ave NE & W Lk Samm Pkwy	1,380	1,404	1.02
HOV I-90		**Screenline Total**	**6,410**	**6,587**	**1.03**

Table 6-21 2010 MP0R12 Model PM Peak Hour Screenline Summary – Freeway

D3		**BKR REGION - Freeway GP + HOV**	**Total Link Vol**		
SL #	**SL Name**	**SL Locations**	**Actual**	**Model**	**M/A**
C1&B1	GP+HOV I-405	BKR REGION (From North To South)	161,320	182,441	1.13
C2&B2	GP+HOV SR-520	BKR REGION (From West To East)	59,450	63,793	1.07
C3&B3	GP+HOV I-90	BKR REGION (From West To East)	63,550	62,524	0.98
4	West Boundary	I-90 (Freeway) EB Express PM	1,040	851	0.82
GP + HOV		**Screenline Total**	**285,360**	**309,609**	**1.08**

Table 6-22 2010 MP0R12 Model PM Peak Hour Screenline Summary – Arterial

D4	**ALL LEVELS**	**BKR REGION - Arterials Only**	**Total Link Vol**		
SL #	**SL Name**	**SL Locations**	**Actual**	**Model**	**M/A**
	ALL LEVELS	Screenline Total	317,184	335,130	1.06

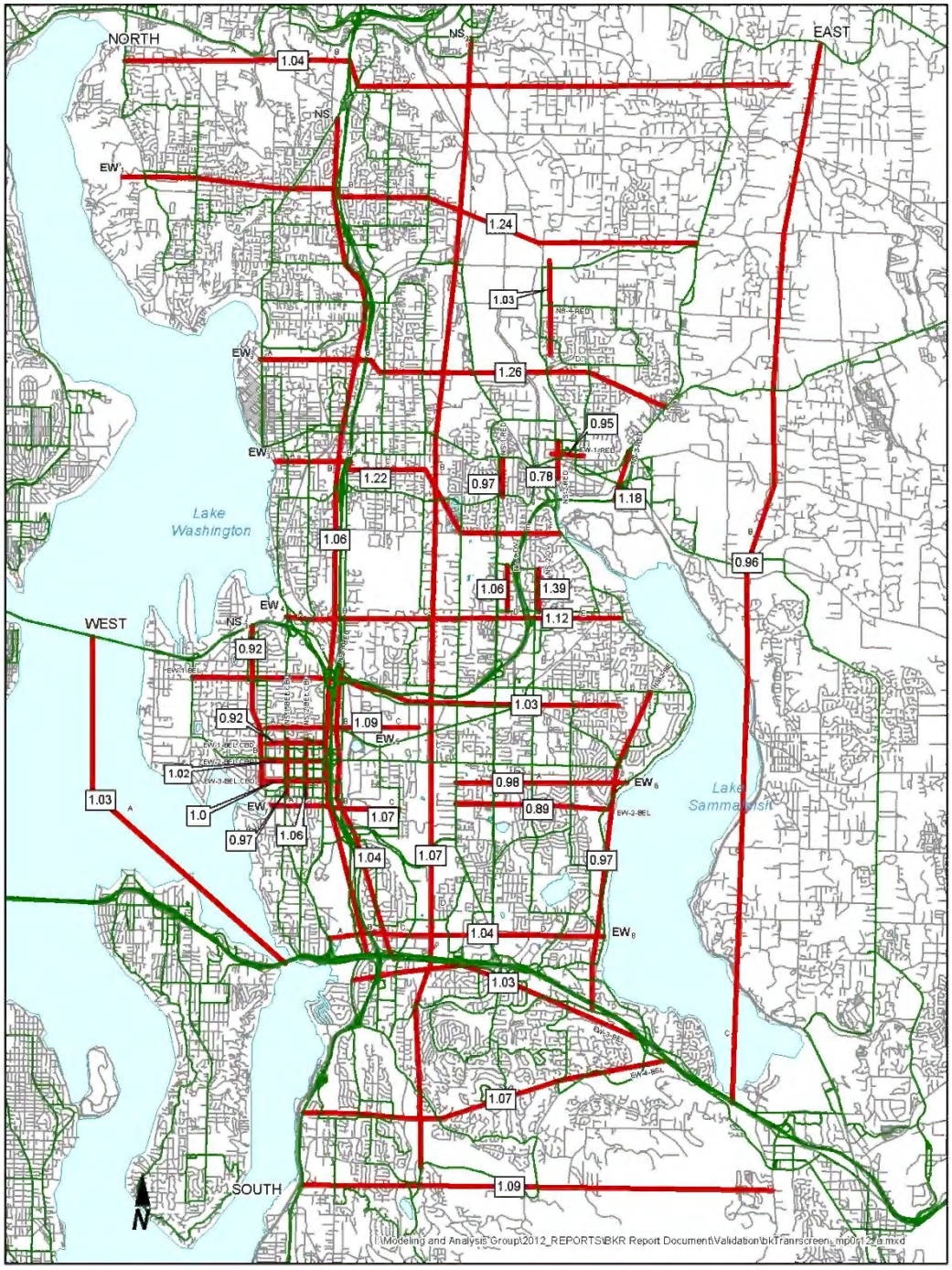

Figure 6-6 2010 MP0R12 Model PM Peak Hour Screenlines for Auto Traffic

Numbers are model/observed ratios.

R-Square Test and Linear Regression Analysis

As shown in Figure 6-7, 529 P.M. peak hour auto traffic counts were correspondingly compared with the model forecasts in the BKR area. The result of R-Square of 0.94 was obtained, indicating a strong correlation between model forecasts and actual counts.

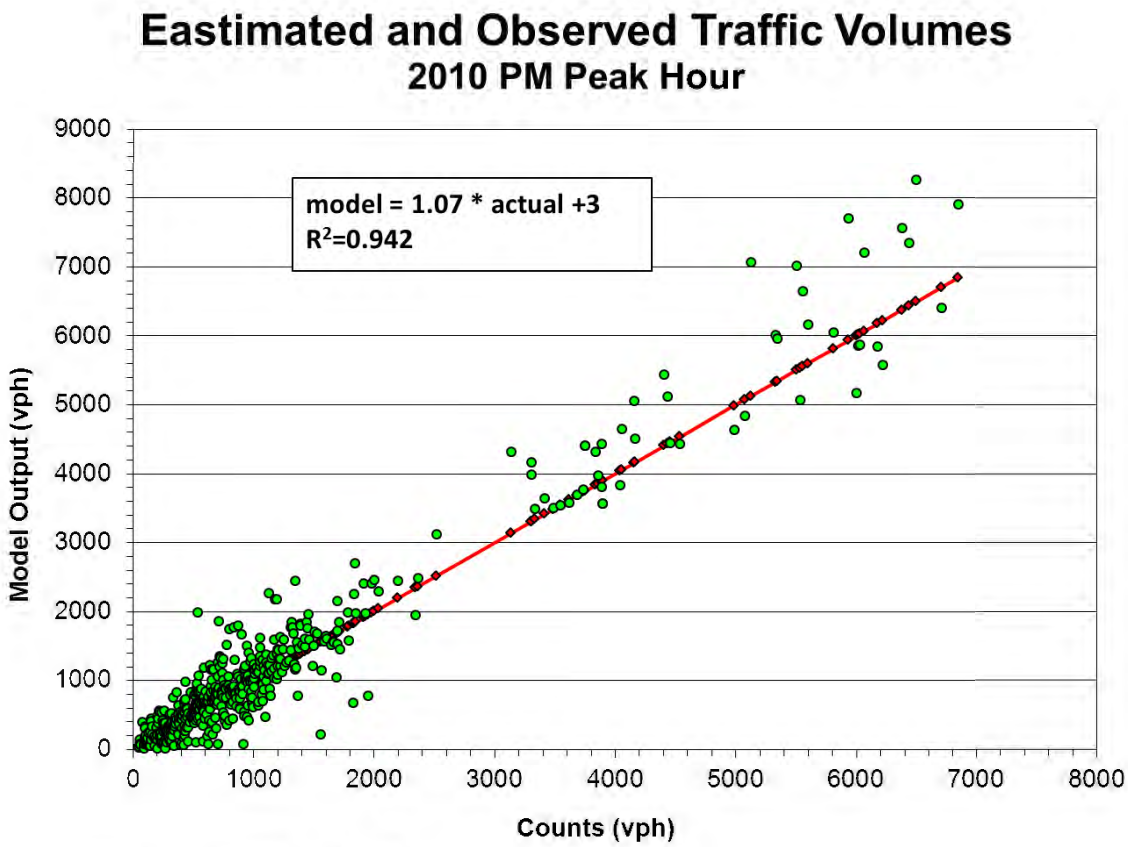

Figure 6-7 Correlation between Model Estimate and Observed Auto Traffic Volumes

Total Volume vs Total Counts by Jurisdiction

PM peak hour auto volume forecasts are compared with traffic counts. As shown in Table 6-23, not only BKR area has good match with the jurisdictional total traffic counts, but also other Eastside shows good matches. An overall ratio of 109% is reached between total forecast and total jurisdictional counts.

Table 6-23 2010 MP0R12 Model PM Peak Hour Screenline Summary by Jurisdiction

Jurisdiction	Number	Counts	Volau	Avg Error	Ratio
Bellevue	320	337,067	352,778	49	1.05
Redmond	80	74,952	87,819	161	1.17
Kirkland	57	89,069	105,497	288	1.18
King	34	40,988	43,060	61	1.05
Woodinville	10	8,475	7,271	120	0.86
Bothell	8	15,414	17,986	321	1.17
Clyde Hill	4	1,022	1,771	187	1.73
Newcastle	4	3,061	4,321	315	1.41
Renton	2	1,598	1,396	101	0.87
Issaquah	2	1,297	937	180	0.72
Sammamish	2	1,895	2,029	67	1.07
Kenmore	2	3,104	2,849	128	0.92
	525	577,942	627,712	95	1.09

Percent Root Mean Square of Error (RMSE) and R-Square by Functional Classes

As shown in Table 6-24, by functional classifications the BKR model is doing a good job on forecasting PM peak hour auto volumes. When compared with counts, the overall %RMSE is 37%, indicating that about 68% of the volume forecasts fall within 37% range of counts while freeway facilities indicate 26% and major arterials 36%.

Table 6-24 2010 MP0R12 Model PM Peak Hour Screenline Summary by Functional Class

FC	Number	Counts	Volau	Avg Error	Total Error	Target	r2	%RMSE
Collector	104	37,923	40,141	21	6%	20-25%	0.53	58%
Minor	164	103,743	104,066	2	0%	10-15%	0.71	36%
Major	151	156,921	173,398	109	11%	7-10%	0.60	36%
Freeway	104	298,204	331,428	319	11%	6-7%	0.92	26%
Total	533	598,302	650,360	98	9%	5%	0.93	37%

Transit Validation

Transit screenlines were setup to check the accuracy of the transit forecast subarea. As shown in Figure 6-8, eight of fourteen AM peak hour screenlines are within the target range of ±15% of the actual automatic passenger count (APC) data, which is based on the 85th percentile of maximum AM peak hour observations. Two NS screenlines are

overestimate by 35% plus. One EW screenline is overestimate by 35% plus and three more is underestimate by 15% plus.

Several factors could contribute to either overestimate or underestimate:

1. The APC data is not complete in some areas because the Community Transit (Snohomish County) transit ridership count data is not given route by route;
2. Some counts are an average of a long route segment while the model forecast is pulled out of small transit link segments;
3. Minimum transit services in some isolated areas may not give enough statistical significance in comparative testing;
4. Some residential areas may experience higher percentile of maximum APC data.

Table 6-25 shows aggregated model estimate ridership across EW or NS matches APC data very well. A 97% fit of total ridership forecast to the total passenger counts during the PM peak hours is found for the overall screenlines.

Table 6-25 MP0R12 Model PM Peak Hour Transit Screenline Summary

Screenline		Description	Model/Actual
EW Screenlines - NB/SB Volume			**0.91**
EW-1 Sub-total	EW-1	EW-1 (South of I-90)	1.38
EW-2 Sub-total	EW-2	EW-2 (North of I-90)	0.83
EW-3 Sub-total	EW-3	EW-3 (South of NE 8th St.)	0.85
EW-4 Sub-total	EW-4	EW-4 (South of SR-520)	0.99
EW-5 Sub-total	EW-5	EW-5 (North of SR-520)	0.80
EW-6 Sub-total	EW-6	EW-6 (South of Redmond Wy/NE 85th St.)	0.94
EW-7 Sub-total	EW-7	EW-7 (North of Redmond Wy/NE 85th St.)	0.98
EW-8 Sub-total	EW-8	EW-8 (North of NE 124th St.)	0.83
NS Screenline - EB/WB Volume			**1.01**
NS-1 Sub-total	NS-1	NS-1 (Lake. Washington Bridges)	0.85
NS-2 Sub-total	NS-2	NS-2 (West of I-405)	0.93
NS-3 Sub-total	NS-3	NS-3 (East of I-405 / 124th Ave)	0.97
NS-4 Sub-total	NS-4	NS-4 (East of 148th Ave NE)	1.36
NS-5 Sub-total	NS-5	NS-5 (East of 156th Ave NE & W of Avondale Rd)	1.64
NS-6 Sub-total	NS-6	NS-6 (East of Avondale Rd. NE/SR520)	0.87
Overall Screenline - Model / Actual			**0.97**
Number of screenlines with ratio between 0.85 and 1.15			**8**
Number of screenlines with ratio outside range of 0.85 and 1.15			**6**

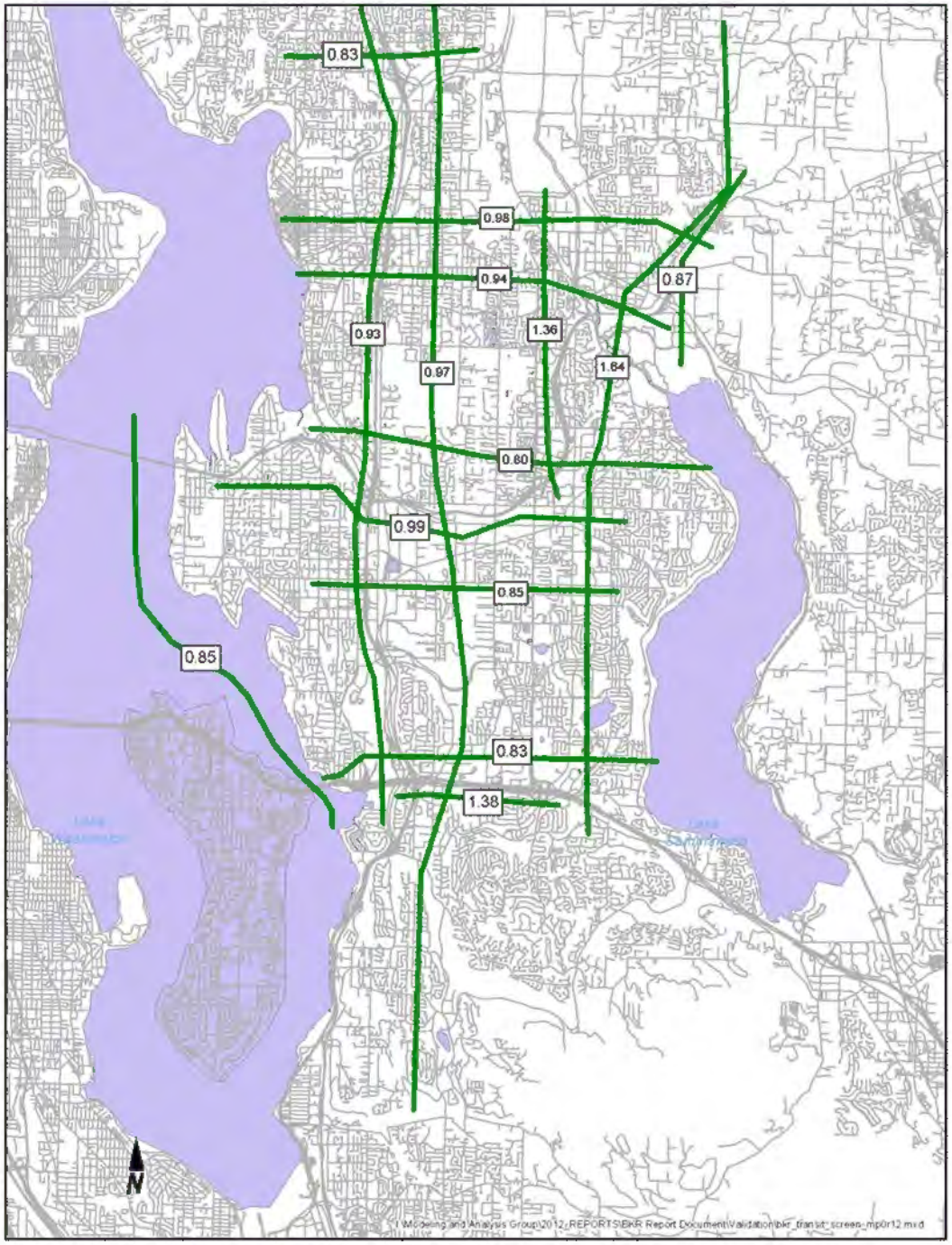

Figure 6-8 2010 MP0R12 Model PM Peak Hour Transit Screenlines

Numbers are model/observed ridership ratios.

7 Model Application

7.1 Preparation of Model Input Data

7.1.1 Land Use Input Procedure

Land use data, aggregated by TAZ level, should be prepared in an Excel spreadsheet following the same format shown as in Table 5-1. Depending on the data resource, absolute land use data or growth data from the previous year can be used in the data preparation. Data come from a number of different jurisdictions and their format and contents/definition may be different. Sometimes data may conflict each other. In this case, data need to be reconciled in the first place. The land use data need to be summarized to each jurisdiction level as shown in Table 5-2 and compared to previous year for any suspicious changes, such as unexpected negative change or huge growth.

Table 7-1 Land Use Data Input Format

	SQUARE FOOTAGE						DWELLING UNITS/Rooms/Students				
TAZ	FIRES (Sq Ft)	RETAIL (Sq Ft)	WCTU + MANU (Sq Ft)	RECREAT. (Sq Ft)	INSTITUT. (Gov+Hosp+Edu)Sq Ft)	HOTEL (Sq Ft)	FTE College Enrollmt.	SFDU	MFDU	HOTEL Rooms	K-12 School Enrollmt.
1	481383	0	0	0	0	0	0	0	0	0	0
2	1750	8520	0	0	0	0	0	0	361	0	0
3	22139	2400	0	0	0	0	0	0	202	0	0
4	16210	1199	0	0	82001	0	0	0	159	0	27
5	29599	22399	0	0	2717	41080	0	1	662	100	0
6	6000	99883	0	0	0	0	0	0	0	0	0
7	9408	52520	22398	0	55950	0	0	0	0	0	0
8	13604.5	7004.5	0	0	0	0	0	2	129	0	0
9	0	99675	0	0	0	0	0	0	79	0	0
10	16270	154879	0	0	0	0	0	0	396	0	0
11	16457	1534994	0	0	0	0	0	0	0	0	0

Note: This table is for 2009 mp0r11.

Any error or suspicion has to be investigated and fixed before importing them to an EMME model.

Table 7-2 Land Use Data Aggregated by Jurisdictions for Error Checking

	SQUARE FOOTAGE						DWELLING UNITS/Rooms/Students				
BKR Model	FIRES (Sq Ft)	RETAIL (Sq Ft)	WCTU + MANU (Sq Ft)	RECREAT. (Sq Ft)	INSTITUT. (Gov+Hosp+Edu)Sq Ft)	HOTEL (Sq Ft)	FTE College Enrollmt.	SFDU	MFDU	HOTEL Rooms	K-12 School Enrollmt.
TAZ 1-235	22619897	11467867	6358084	557108	8359324	2304040	13390	39615	30005	3680	28010
TAZ 236-325	9250695	5400790	8499807	113817383	3282219	834060	1280	33440	26674	1458	30611
TAZ 325-450, 576-626,640-650	18368576	4726165	13807158	45723494	1870480	414576	0	27172	19279	724	18758
Bellevue CBD	8841275	4486040	137047	0	572143	1000656	0	8	7441	1570	119
Bellevue Total	23805455	11146410	6497484	557108	7911375	2242426	13390	29617	28504	3554	24725
Bel-Fringe	171315	406855	34450	0	937713	61614	0	10459	2598	126	5245
Kirkland	5654299	3826010	2907311	15696134	1991629	537886	0	10804	13401	852	10451
Kirk-Fringe	3596396	1574780	5592496	98121249	1290590	296174	1280	22636	13273	606	20160
Redmond	16492358	3646250	9454862	45715931	671243	414576	0	11141	14232	724	6959
Red-Fringe	519345	994517	4178446	7563	709473	0	0	15570	3950	0	9839
Total	**50239168**	**21594822**	**28665048**	**160097985**	**13512023**	**3552676**	**14670**	**100227**	**75958**	**5862**	**77379**

Note: This table is for 2009 mp0r11.

When all land use data are checked and reconciled, they are loaded into mf111 within an EMME model by the following procedure:

1. Save the lane use data as csv format (table head is not included).
2. In EMME prompt console, run this line of command.
   ~<csv2mat –i mp0r12lu.csv –m mf111 2010lu –o mf111.in.
3. Open mf111.in in a text editor. Replace the mf111 description as "2010 land use data". This step is optional.
4. In EMME, delete mf111 if it exists.
5. In EMME prompt console, batch in mf111.in in 3.11.

7.1.2 Cross-classification Trip Generation Model Procedure

Trip generation models comprise of trip production and trip attraction models. PSRC's cross-classification model is applied to BKR's socioeconomic data.

Household Cross-Classification

Household cross-classification data are derived from number of households by BKR TAZ and household cross-classification data used in PSRC regional travel forecast model.

mo29 = mo30 + mo31
where: mo29: number of households
mo30: number of single family dwelling units
mo31: number of multi-family dwelling units

The format for the cross-classification data used in PSRC model is given in Table 7-3. There are 850 zones in the PSRC model. The data table has 121 columns, in which the

first 100 columns are for household cross-classification, and the rest are for employments.

The following steps are used to generate household cross-classification data for the mp0r12. The data is saved in mf24.

1. Compute percentage splits for every row in Table 7-3 for the first 100 columns based on the row totals;
2. Look into PSRC-BKR TAZ equivalence table to get a correspondence between every BKR zone and PSRC zone(s);
3. Using mo29, split the # HH into 100 columns (classifications) based on the corresponding PSRC zone splits. If two or more BKR zones correspond to 1 PSRC zone, then use the same percentage split across all the BKR zones; if 1 BKR zone corresponds to two or more PSRC zones, then use the average percentage splits of the PSRC zones to split the BKR zone
4. At this point, the BKR HH matrix should be in the format shown in Table 7-4.

Table 7-3 Household Cross-classification Data Format Used in the PSRC Regional Travel Forecast Model

	1	**2**	**3**	**……**	**100**	**101 ……121**	
1	hh1,1	hh1,2	Hh1,3	……	hh1,100		
2							
3							
.		Household Data				Employment Data	
.							
850					Hh850,100		

Notes: All zeros in TAZ 651~850.

Table 7-4 Household Cross-classification Data Format Used in BKR Model

	1	**2**	**3**	**……**	**100**	**101-121**	
1	hh1,1	hh1,2	Hh1,3	……	hh1,100		
2							
3							
.		Household Data				Employment Data	
.							
.							
850					Hh850,100		

Notes: All zeros in TAZ 651~850.

Employment

BKR employment is estimated from the existing land use of Bellevue, Kirkland and Redmond. Employment matrices (mo33-mo39) are generated from the land use matrices (mo21-mo28) by employment density in subarea. The employment matrices are entered into column 101~121 of mf24 according to Table 7-5.

Table 7-5 BKR Employment Data Format and Conversion into PSRC Employment Type

PSRC employment		BKR employment data		Notes
Mf24 Column #		Matrix #	Description	
101-108	Not used	Zero Values		
109	RETAIL	mo35	Retail employment	
110-111	Not used	Zero Values		
112	FIRES	mo34 + mo37 + mo38	Finance, Insurance, Real Estate, and Services	Office employment Institutional employment Hotel employment
113-114	Not used	Zero Values		
115	Not used	GOV category eliminate and grouped it into FIRES as trip rates are similar		
116-117	Not used	Zero Values		
118	EDU	mo39	School employment	Elementary, Middle and High Schools
119	WTCU	mo36 * mf22: WTCU/(WTCU+MANU)	Industrial employment	mo36 will be split into WTCU and MANU based on mf22: PSRC percentage splits;
120	MANU	mo36*mf22: MANU/(WTCU+MANU)	Industrial employment	Same as above
121	FTE_UNIV	FTE college enrollment		Only at TAZ where colleges/universities are located.

Seven macros were developed to convert the socioeconomic data into household cross-classification data and employment data, saved in mf24, per the specification discussed above. When the socioeconomic data were loaded into mf111, run the following macros to produce mf24:

- Create land use vectors (lumf2mo.mac)
- Create household data (tg_hh.mac)
- Create employment data (emploagg_800zones.mac)
- Add new households (add-hh-new.mac)

- Add new employment (add-emp-new.mac)
- Add college enrollment (add_FTE.mac)
- Check household and employment data (mf24lu-chk.mac)

Table 7-6 Output from mf24-lu.mac, Aggregated by Jurisdictions

Area	mf24LU	HHs (1-100)	Retail (109)	FIRES (112)	GOV (115)	EDU (118)	WTCU (119)	MANU (120)	FTE-Uni (121)	Total Employees
Bellevue	gf1	56,407	21,616	87,155	0	2,114	7,016	1,400	13,390	**120,640**
Bel-Fringe	gf2	9,257	493	2,292	0	453	46	0	0	**3,283**
Kirkland	gf3	24,854	7,269	26,620	0	1,100	3,415	3,017	4,515	**41,873**
Kirk-Fringe	gf4	35,261	2,992	15,412	0	1,961	4,858	2,077	1,280	**27,427**
Redmond	gf5	31,373	7,373	61,897	0	1,162	5,033	10,464	0	**85,929**
Red-Fringe	gf6	13,520	1,612	3,057	0	517	6,648	171	0	**12,006**
Total	**1-450, 575-626**	**170,672**	**41,356**	**196,433**	**0**	**7,307**	**27,015**	**17,128**	**19,185**	**291,158**

7.1.3 Network Data

City of Bellevue maintains four model platforms and a number of different scenarios for each horizon year. The key issue to keep consistency across all the scenarios is to have a consistent node system. With the same node system, it is a lot easier to compare two network settings and results, and transfer network difference or individual project from one scenario to others.

To achieve this goal, a master network databank for the base year is created. Any network structure related change (such as add/remove/modify a node) should be done in this databank. A separate project script file for each horizon year is maintained to up-to-date. A future horizon year network is always obtained by executing the project script on the master base year network.

7.1.4 Transit Data

To efficiently manage transit networks across all scenarios, a similar methodology to the network data update is designed. A transit master network is maintained to up-to-date with all information for all time periods, such as transit routes, stops, and headways. This network is saved in scenario 9999 in the base year model MP0R12. Specific time period headways are stored in user fields as follows:

- ut1 AMPK (scenario 6) headway
- ut2 MDPK (scenario 60) headway
- ut3 PMPK (scenario 4) headway

If a transit route is not present during a specific time period, the value 999 is used as the headway. During the initial configuration of the 4-step model run, transit networks are punched out from Scenario 9999. These transit networks are then read into the

appropriate scenarios by Module 2.21.It is done by running a macro named "tran_setup5.mac".

Files created by the macro "tran_setup5.mac" are:

- am_tran1.224
- md_tran1.224
- pm_tran1.224

7.1.5 Toll

Toll can be set on a link for SOV, LOV or HOV, or all of them. The toll is saved in @stoll, @ltoll, and @htoll, respectively. To update a toll value, one needs to update the toll table, which is saved in an external file named "tolls_mp0r12.241" for base year and "tolls_mp30r6.241" for 2030, and load it back to the network by calling a macro named "load_tolls_mp0r12.mac" for base year or load_tolls_mp30r6.mac for 2030. The format for the toll table is shown in Table 7-7.

Table 7-7 File Format for the Toll Table

inode	jnode	AM_SOV	AM_LOV	AM_HOV	MD_SOV	MD_LOV	MD_HOV	PM_SOV	PM_LOV	PM_HOV
3025	4720	0	0	0	0	0	0	0	0	0
4552	4827	0	0	0	0	0	0	0	0	0
4552	4829	0	0	0	0	0	0	0	0	0

Unit: cents.

7.1.6 Special Generator

As discussed in Chapter 4.2, two special generators were implemented for TAZ 11 and 417 in the base year BKR model mp0r12. User can choose to update individual values in the matrix editor module or batch in through 3.11. The values for these special generators do not necessarily change every year.

7.2 Model Processing

The four step model run is executed by calling the macro "BKR_mp0r12_r38.mac". The macro call hierarchy is given in Appendix D.

7.3 Post-Processing

The model raw outputs have to be post processed for the intersection LOS analysis. City of Bellevue MAG group developed a suite of software programs to streamline the turning movement post processing and LOS calculation. The post processing programs are based on UNIX platform and the LOS calculation is based on a specially designed module named "Bellevue Concurrency" in UFOSNET. The algorithm is documented in Appendix E.

The post processing programs take the following data as their input:
Address, geometry, intersection definition, base year counts, base year model output, future year model output, and output from a special scenario named "base year land use on future year network".

The "Bellevue Concurrency" module takes post processed turning movement volumes from post processing programs, as well as address, geometry, intersection definition, and network definition files as inputs and produces LOS (delay-based and v/c ratio based) for individual intersection and aggregated LOS for each MMA.

The procedure is described as follows.

1. Run 4-step model macro "BKR_mp0r12_r38.mac".
2. Copy scenario 4 to scenario 4000 and scenario 6 to scenario 6000 if AM is asked for.
3. Load 2010 SOV & HOV trip tables into mf171 and mf172, respectively, if it is not done yet.
4. Run macro "pm_assign_09fn.mac".
5. Punch out post_proccesing input data by calling macro "post_processing_PM_FLFN.mac" in the console mode.
   This macro will produce 7 files:
   - mLinkVol_pm_0004_flfn.prn
   - mLinkVol_pm_4000_06fn.prn
   - mNetwork_pm_0004_flfn.211
   - mTMplots_pm_0004_flfn.plt
   - mTMplots_pm_4000_06fn.plt
   - mTurnVol_pm_0004_flfn_241.prn
   - mTurnVol_pm_4000_06fn_241.prn

   FTP these files to a folder in the UNIX computer.
6. Under UNIX console, edit intersection definition file (or link file, links_2030_pos_YYY.prn) with an editor to incorporate the latest changes on the adjacent nodes around an intersection.

7. Under UNIX console, edit intersection channelization file (or geometry file, geometry_2030_YYY.prn) with an editor to incorporate the latest channelization changes on an intersection.
8. Under UNIX console, run postprocessing program named "tm611".
   The interactions with tm611 are given below as an example.
   key in the emme2 link node file name: links_2030_pos_YYY.prn
   key in the link vol file name: mTurnVol_pm_4000_09fn_241.prn
   key in the output file name: mTM_pm_4000_09fn_241.prn
   Check error.f and error2.f, and fix link file if necessary. Then repeat tm611
9. Under UNIX console, edit output file mTM_pm_4000_09fn_241.prn to combin the volumes from the 5th leg into appropriate "regular" movements. Usually intersection #26, #30, #224 and #225.
10. Under UNIX console, edit job string file fs_turnadj_2pm to make sure all input file names are correct.
    address_2030.prn
    links_2030_pos_YYY.prn
    turns_2pm_09_w0s.cleaned
    mTM_pm_0004_0909_241.prn
    mTM_pm_4000_09fn_241.prn
    turns_adj.null
    turns_adj_2pm_09fn_YYY
11. Run turnadj.
    The interactions are given as follows.
        1
        y
        TM_restrictions_17mp12r4_nc.prn
        fs_turnadj_2pm
        4
        inter.allstop
    Go through each individual intersection by choosing a postprocessing method.
12. Under UNIX console, edit job string file fs_newint_2pm to make sure all input file names are correct.
    2030_2pm_09Base_7/02/08
    ADDRESS_09.PRN
    address_2030.prn
    GEOMETRY_09.PRN
    geometry_2030.prn
    LINKS_09POS.PRN
    links_2030_pos_YYY.prn
    turns_2pm_09.prn
    turns_adj.null
    turns_adj_2pm_09fn_YYY
    turns_adj.null

mLinkVol_pm_0004_0909.prn
mLinkVol_pm_4000_09fn.prn
0
mLinkVol_pm_0004_flfn.prn

13. Run newint.
    The interactions are given as follows.
    fs_newint_2pm
    4
    3
    2
    all
    2
    pptm_2pm_2030_pp2
    5
    4
    9
14. Under UNIX console, run clean
    The interactions are given as follows.
    pptm_2pm_2030_pp2
    The output file is named as "pptm_2pm_2030_pp2.cleaned".
15. Overwrite the old pptm_2pm_2030_pp2.prn with this cleaned copy by the UNIX command "mv pptm_2pm_2030_pp2.cleaned pptm_2pm_2030_pp2.prn"

DRAFT

Appendix A PSRC-BKR TAZ Equivalency

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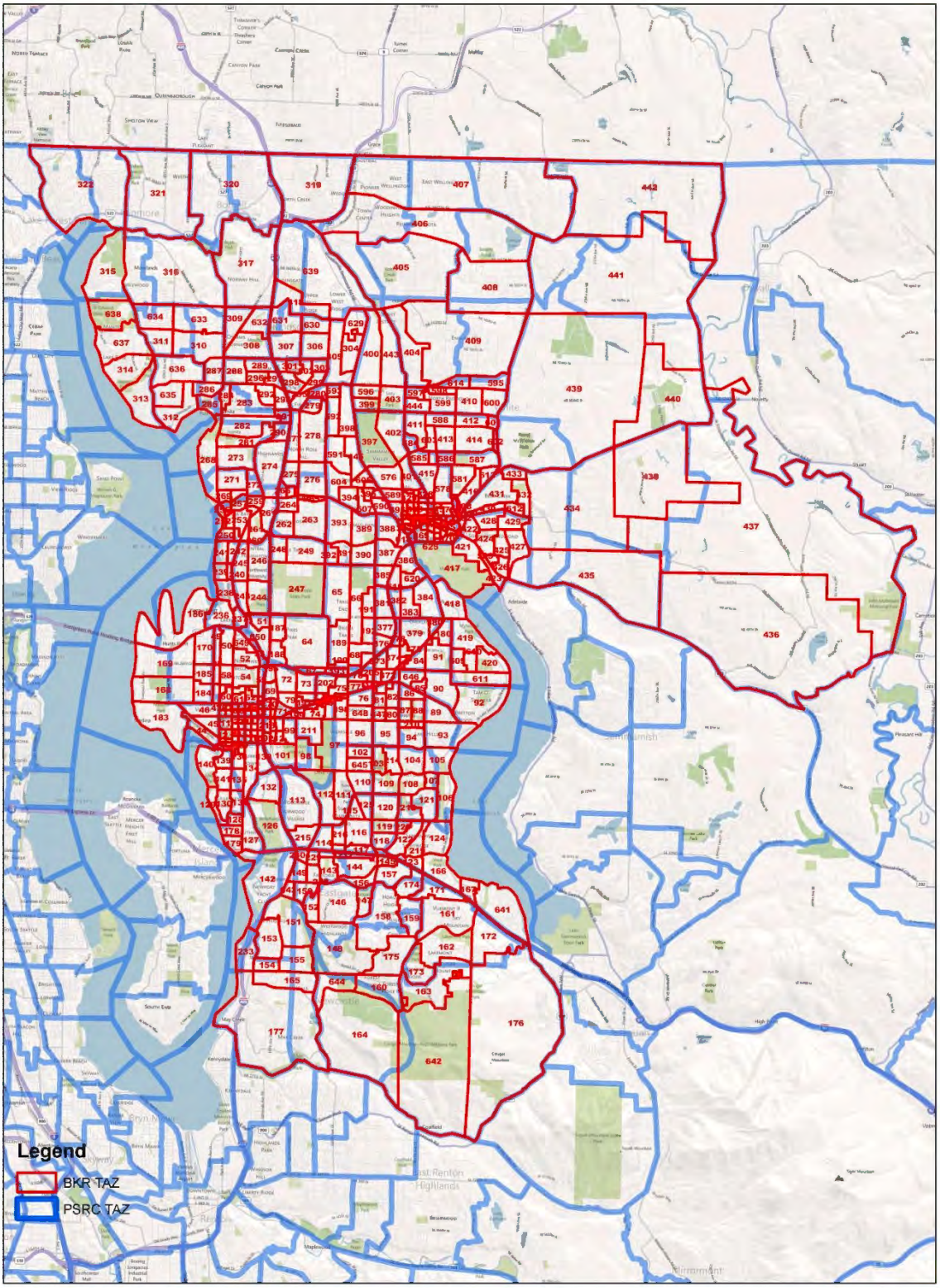
APPENDIX A PSRC-BKR TAZ EQUIVALENCY



APPENDIX A PSRC-BKR TAZ EQUIVALENCY

Internal BKR TAZ	PSRC TAZ	FAZ00
1	296	4900
2	296	4900
3	296	4900
4	296	4900
5	295	4900
6	295	4900
7	295	4900
8	295	4900
9	295	4900
10	295	4900
11	294	4900
12	294	4900
13	294	4900
14	294	4900
15	294	4900
16	294	4900
17	294	4900
18	294	4900
19	291	4810
20	294	4900
21	293	4900
22	293	4900
23	293	4900
24	293	4900
25	293	4900
26	293	4900
27	294	4900
28	294	4900
29	294	4900
30	294	4900
31	294	4900
32	293	4900
33	293	4900
34	293	4900
35	293	4900
36	293	4900
37	294	4900
38	294	4900
39	295	4900
40	295	4900
41	296	4900
42	296	4900

Internal BKR TAZ	PSRC TAZ	FAZ00
162	316	4225
163	318	4225
164	317	4225
165	310	4226
166	282	4506
167	282	4506
168	303	5100
169	303	5100
170	302	5100
171	316	4225
172	316	4225
173	316	4225
174	314	4505
175	315	4505
176	318	4225
177	310	4226
178	298	4810
179	298	4810
180	273	5415
182	272	5415
183	303	5100
184	302	5100
185	302	5100
186	302	5100
187	288	5205
188	288	5205
189	268	5205
190	268	5205
191	268	5205
192	268	5205
193	288	5205
194	268	5205
195	288	5205
196	289	5205
197	289	5205
198	286	5010
199	284	5010
200	284	5010
201	286	5010
202	290	5205
203	290	5205
204	290	5205

Internal BKR TAZ	PSRC TAZ	FAZ00
336	516	5425
337	516	5425
338	518	5425
339	516	5425
340	516	5425
341	516	5425
342	516	5425
343	516	5425
344	518	5425
345	516	5425
346	516	5425
347	516	5425
348	516	5425
349	516	5425
350	515	5425
351	515	5425
352	515	5425
353	515	5425
354	515	5425
355	515	5425
356	515	5425
357	515	5425
358	515	5425
359	516	5425
360	516	5425
361	516	5425
362	516	5425
363	515	5425
364	515	5425
365	515	5425
366	515	5425
367	516	5425
368	516	5425
369	515	5425
370	515	5425
371	272	5415
372	272	5415
373	272	5415
374	272	5415
375	272	5415
376	270	5415
377	270	5415

43	296	4900
44	301	4820
45	301	4820
46	301	4820
47	300	4820
48	300	4820
49	300	4820
50	300	4820
51	288	5205
52	300	4820
53	300	4820
54	300	4820
55	300	4820
56	300	4820
57	300	4820
58	300	4820
59	300	4820
60	300	4820
61	300	4820
62	300	4820
63	300	4820
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66	268	5205
67	288	5205
68	268	5205
69	289	5205
70	289	5205
71	289	5205
72	289	5205
73	289	5205
74	284	5010
75	290	5205
76	286	5010
77	290	5205
78	290	5205
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81	277	5020
82	277	5020
83	275	5020
84	273	5415
85	275	5020
86	278	5020
87	278	5020
88	278	5020

205	290	5205
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207	277	5020
208	277	5020
209	273	5415
210	278	5020
211	284	5010
212	285	5010
213	285	5010
214	279	5020
215	283	5010
216	281	4506
217	281	4506
218	279	5020
219	282	4506
220	282	4506
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229	312	4506
230	312	4506
231	312	4506
232	311	4506
233	310	4226
236	265	5305
237	265	5305
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239	265	5305
240	265	5305
241	265	5305
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257	260	5305
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415	518	5425
416	519	5425
417	499	5426
418	274	5415
419	274	5415
420	274	5415
421	499	5426
422	499	5426

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90	275	5020
91	273	5415
92	275	5020
93	276	5020
94	278	5020
95	277	5020
96	286	5010
97	284	5010
98	285	5010
99	285	5010
100	285	5010
101	285	5010
102	287	5010
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105	276	5020
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108	279	5020
109	279	5020
110	287	5010
111	287	5010
112	287	5010
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121	279	5020
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123	282	4506
124	282	4506
125	281	4506
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128	298	4810
129	297	4810
130	297	4810
131	297	4810
132	292	4810
133	291	4810

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264	262	5305
265	262	5305
266	262	5305
267	262	5305
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290	259	5305
291	250	5306
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294	244	5306
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296	249	5306
297	249	5306
298	244	5306
299	244	5306
300	244	5306
301	244	5306
302	244	5306
303	244	5306
304	246	5545

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424	499	5426
425	499	5426
426	499	5426
427	499	5426
428	499	5426
429	499	5426
430	500	5426
431	500	5426
432	500	5426
433	500	5426
434	501	5426
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436	503	5426
437	503	5426
438	501	5426
439	498	4706
440	498	4706
441	496	4706
442	494	4706
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578	518	5425
579	518	5425
580	519	5425
581	519	5425
582	499	5426
583	499	5426
584	518	5425
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590	263	5425
591	263	5425
592	263	5425
593	263	5425
594	515	5425
595	513	5545
596	511	5545
597	513	5545

134	291	4810
135	291	4810
136	291	4810
137	291	4810
138	294	4900
139	297	4810
140	297	4810
141	297	4810
142	299	4810
143	312	4506
144	311	4506
145	311	4506
146	313	4505
147	313	4505
148	315	4505
149	312	4506
150	312	4506
151	309	4226
152	313	4505
153	309	4226
154	310	4226
155	319	4226
156	311	4506
157	311	4506
158	314	4505
159	315	4505
160	315	4505
161	316	4225

305	246	5545
306	246	5545
307	245	5306
308	248	5515
309	248	5515
310	254	5515
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312	255	5515
313	256	5515
314	256	5515
315	251	5535
316	252	5535
317	247	5525
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319	241	5600
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322	236	6420
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327	516	5425
328	516	5425
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330	516	5425
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332	518	5425
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334	516	5425
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604	263	5425
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614	513	5545
615	518	5425
616	263	5425
617	519	5425
618	269	5425
619	269	5425
620	269	5425
621	515	5425
622	515	5425
623	515	5425
624	515	5425
625	515	5425

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Appendix B EMME Macro Flow Chart

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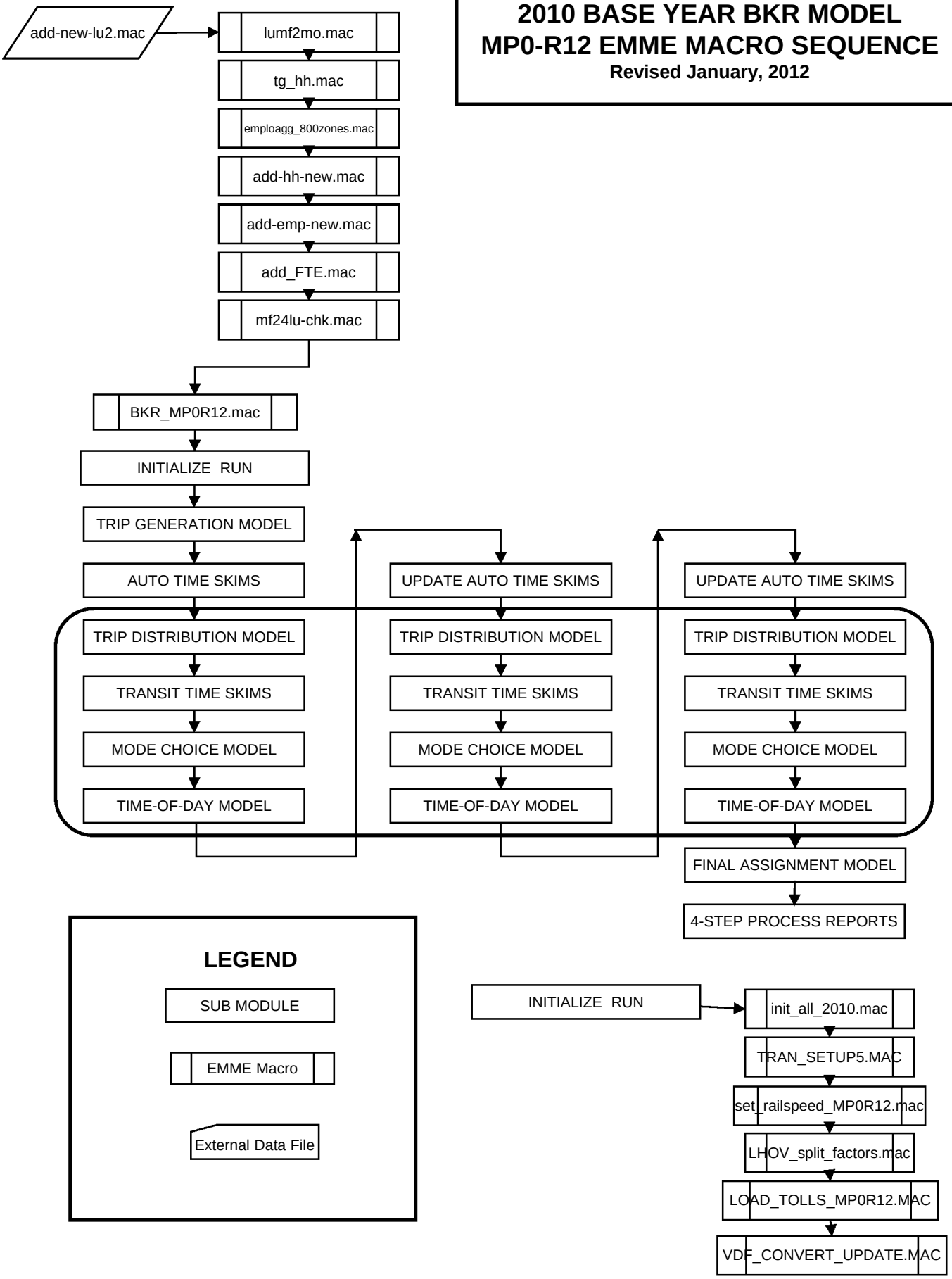
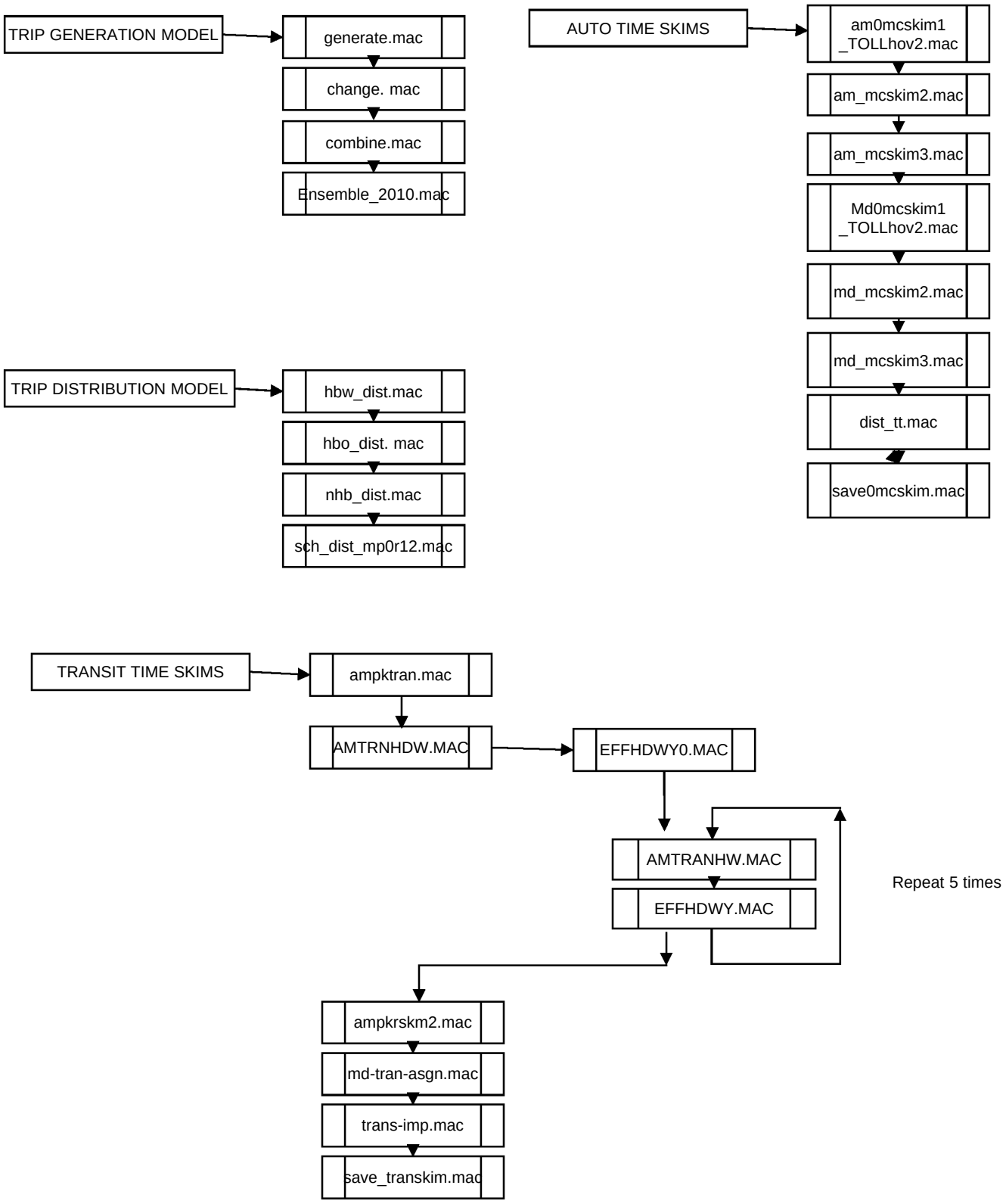
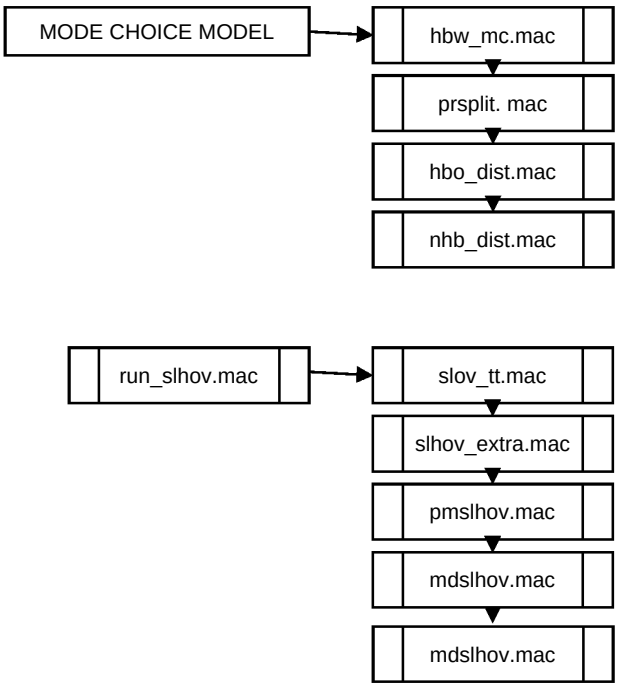
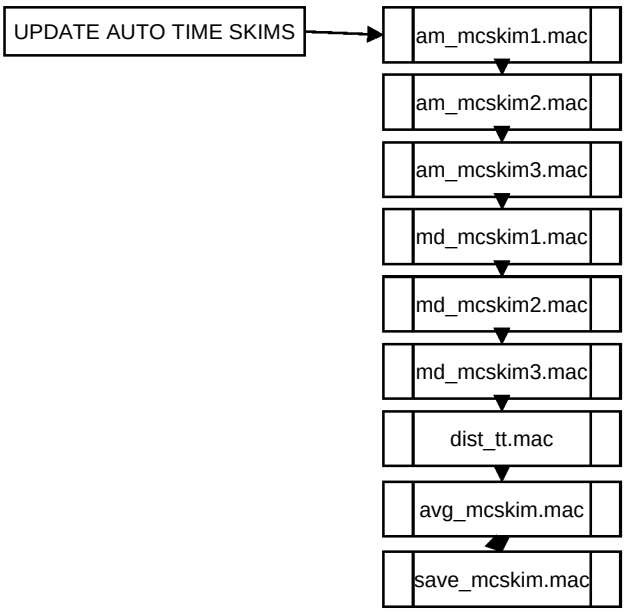
2010 BASE YEAR BKR MODEL
MP0-R12 EMME MACRO SEQUENCE

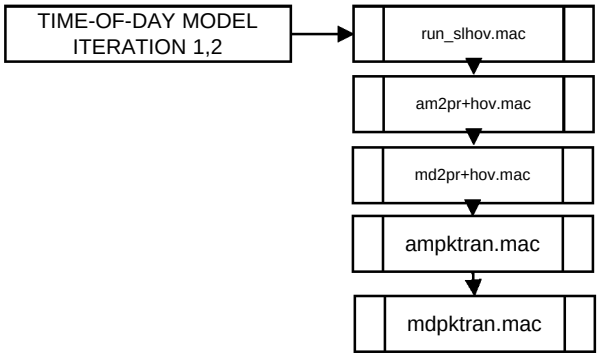
Revised January, 2012

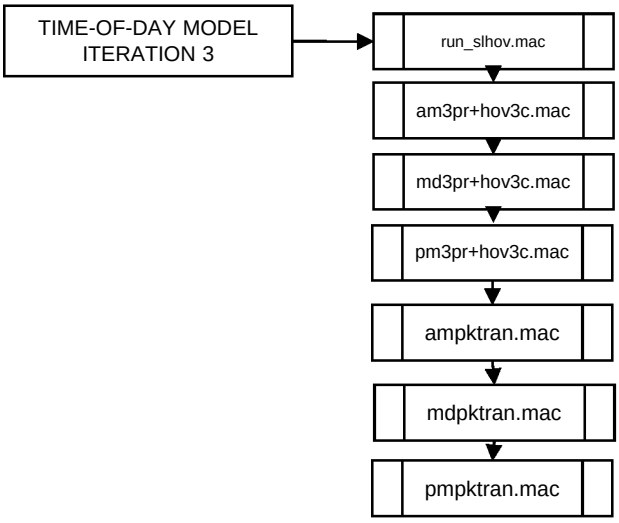


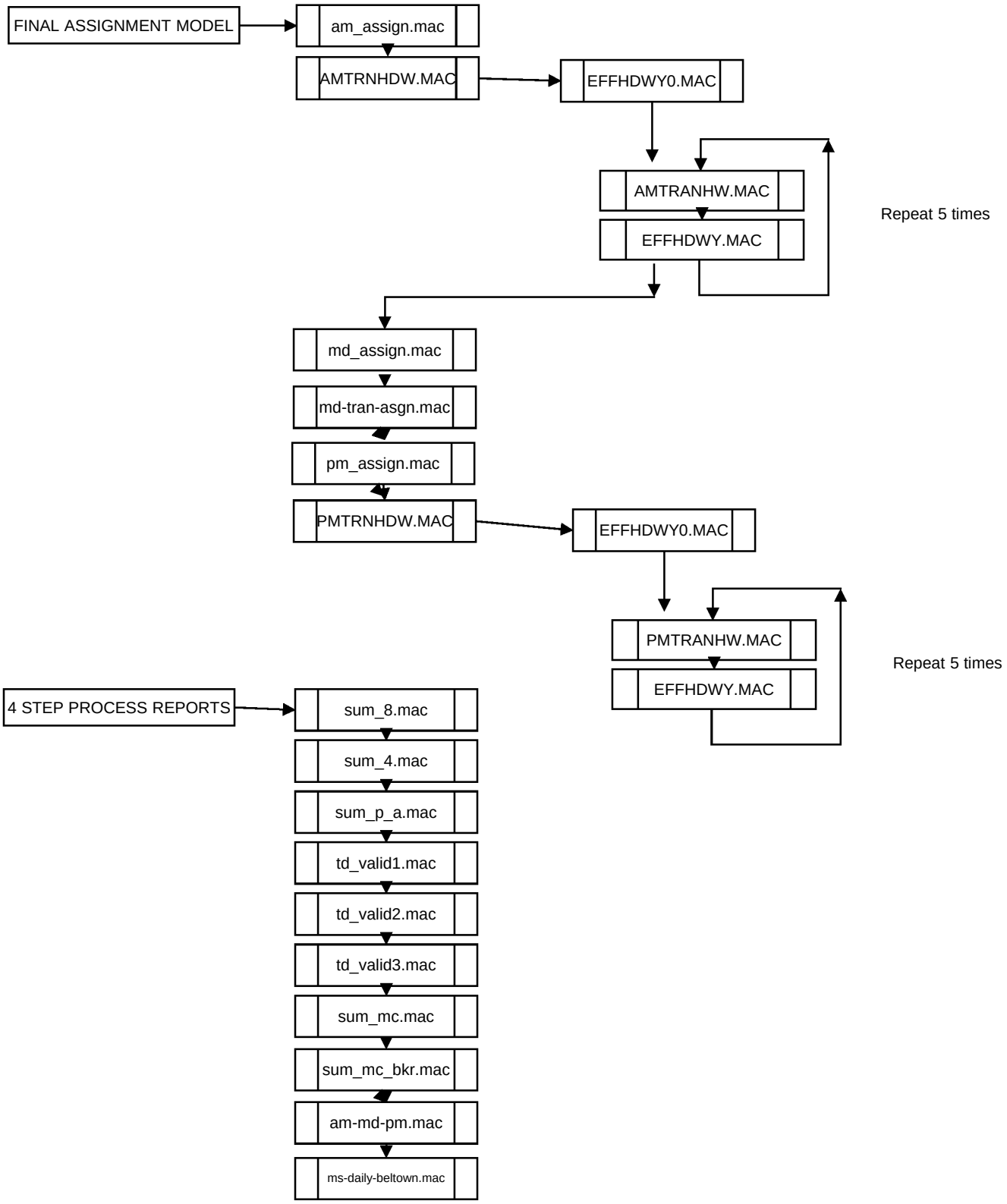

TRIP GENERATION MODEL
generate.mac
change. mac
combine.mac
Ensemble_2010.mac
AUTO TIME SKIMS
am0mcskim1 _TOLLhov2.mac
am_mcskim2.mac
am_mcskim3.mac
Md0mcskim1 _TOLLhov2.mac
md_mcskim2.mac
md_mcskim3.mac
dist_tt.mac
save0mcskim.mac
TRIP DISTRIBUTION MODEL
hbw_dist.mac
hbo_dist. mac
nhb_dist.mac
sch_dist_mp0r12.mac
TRANSIT TIME SKIMS
ampktran.mac
AMTRNHDW.MAC
EFFHDWY0.MAC
AMTRANHW.MAC
EFFHDWY.MAC
Repeat 5 times
ampkrskm2.mac
md-tran-asgn.mac
trans-imp.mac
save_transkim.mac


MODE CHOICE MODEL
hbw_mc.mac
prsplit. mac
hbo_dist.mac
nhb_dist.mac
run_slhov.mac
slov_tt.mac
slhov_extra.mac
pmslhov.mac
mdslhov.mac
mdslhov.mac


UPDATE AUTO TIME SKIMS
am_mcskim1.mac
am_mcskim2.mac
am_mcskim3.mac
md_mcskim1.mac
md_mcskim2.mac
md_mcskim3.mac
dist_tt.mac
avg_mcskim.mac
save_mcskim.mac


TIME-OF-DAY MODEL
ITERATION 1,2
run_slhov.mac
am2pr+hov.mac
md2pr+hov.mac
ampktran.mac
mdpktran.mac


TIME-OF-DAY MODEL
ITERATION 3
run_slhov.mac
am3pr+hov3c.mac
md3pr+hov3c.mac
pm3pr+hov3c.mac
ampktran.mac
mdpktran.mac
pmpktran.mac


FINAL ASSIGNMENT MODEL
am_assign.mac
AMTRNHDW.MAC
EFFHDWY0.MAC
AMTRANHW.MAC
EFFHDWY.MAC
Repeat 5 times
md_assign.mac
md-tran-asgn.mac
pm_assign.mac
PMTRNHDW.MAC
EFFHDWY0.MAC
PMTRANHW.MAC
EFFHDWY.MAC
Repeat 5 times
4 STEP PROCESS REPORTS
sum_8.mac
sum_4.mac
sum_p_a.mac
td_valid1.mac
td_valid2.mac
td_valid3.mac
sum_mc.mac
sum_mc_bkr.mac
am-md-pm.mac
ms-daily-beltown.mac

Appendix C Methodology for Implementing SOV, LOV, and HOV Applied to City of Bellevue BKR 2020 and 2030 Models

Prepared by Perteet, Inc. 2008

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Methodology for Implementing SOV, LOV, and HOV Applied to City of Bellevue BKR 2020 and 2030 Models

The implementation of PSRC trip table based splits of SOV 2 person Hov (LOV), and 3+ person Hov (HOV) has little impact on the model. The 3 maps on this page show the assigned volume difference in the AM peak hour for HOV lanes and GP lanes. The differences show little impact on trip distribution and mode choice when the process is implemented in each iteration of the model run.

Figure 1 shows the difference in volumes for the AM HOV lane volumes. **Figure 2** show the difference for GP lane volume for the City of Bellevue. **Figure 3** zooms in on the difference for the Bel-Red sub-area.

Figure 1. Difference in AM HOV lane volumes between 2007 SLHOV and MPO_R8

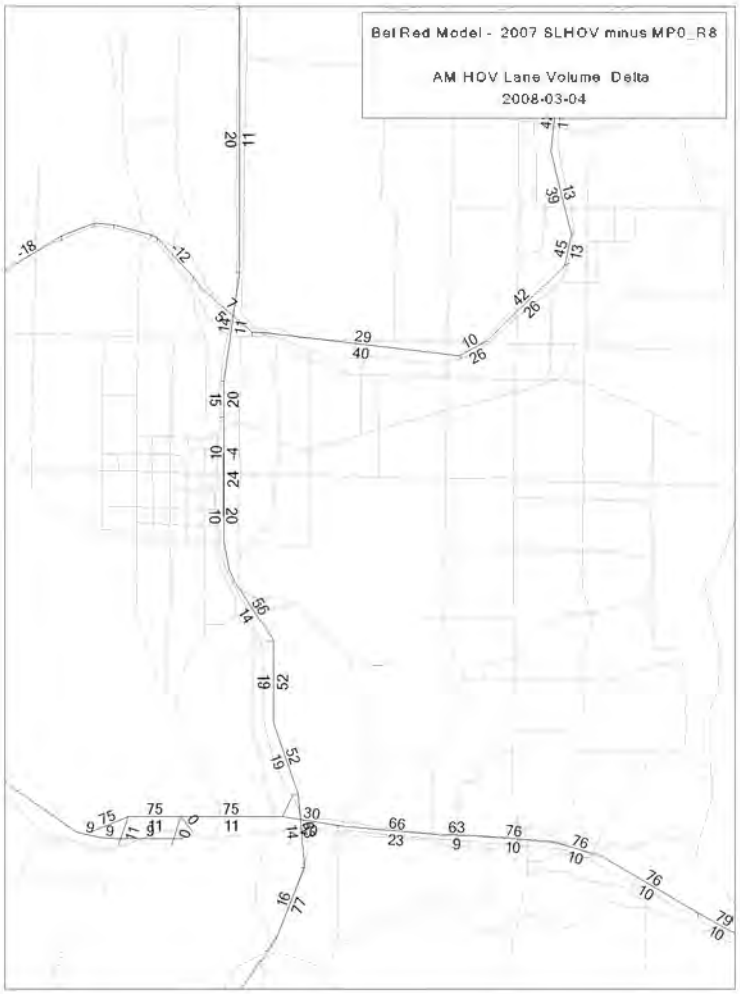


Figure 2. Difference in Bellevue AM GP lane volumes between 2007 SLHOV and MPO_R8

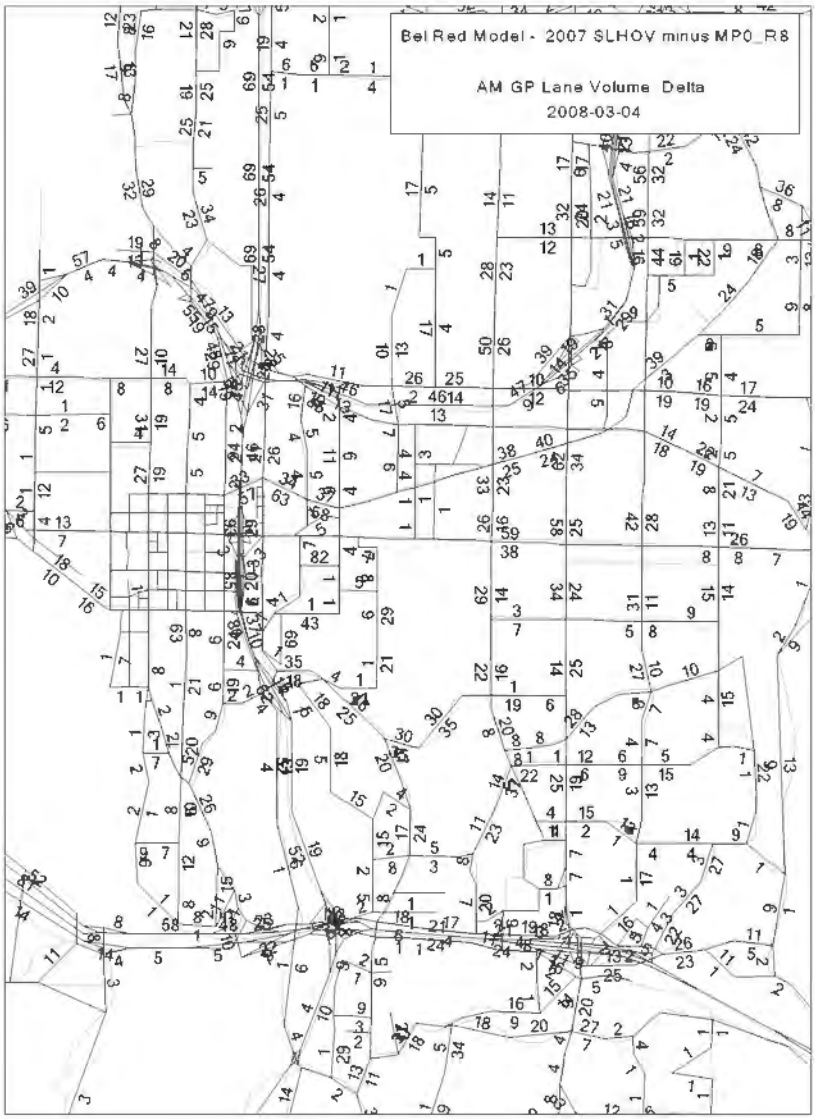
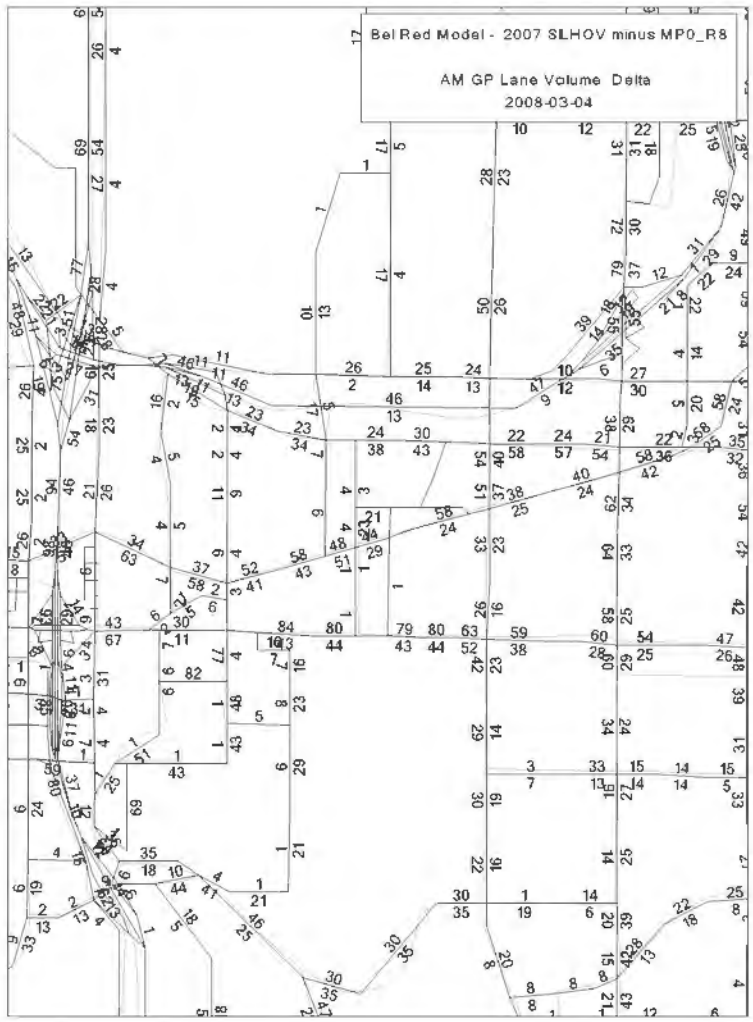


Figure 3. Difference in Bellevue AM GP lane volumes between 2007 SLHOV and MPO_R8



The macro set used to calculate SOV, LOV, and HOV splits by trip purpose use split factors derived from PSRC databanks for the years 2006, 2020, and 2030.

Direct comparison to COB Model generated SOV, & HOV trip tables can't be done. The COB process, when processing the trip tables by trip length 0-5 miles and grater than 5 miles used a distance skim in which the intra zonal distance is 0. This leads to some trips being dropped from the final trip tables, and a good portion of the intra zonal trips are allocated to SOV regardless of the actual trip length. This doesn't impact trip assignments to the network as intra zonal trips are not assigned.

In addition MD peak period trip tables inadvertently calculate 50% of NHB rather than 5%.

Again the 2006 delta plots show all trips remain either in SOV, LOV, or HOV. There could be, although slight, some modal and distributional effects during the iterative trip table estimation.

Table 1 summarizes the final control totals for all three horizon years. The SLHOV implementation replaces original COB model run assignment trips tables.

Table 1. AM, MD and PM Trip Tables for 2006, 2020 and 2030 with SLHOV Implementation

mf	Period		2006 2+ HOV	2020 2+ HOV	2030 3+ HOV
143	AM	sov	704,608	830,813	958,661
144		hov	49,127	57,238	21,349
145	MD	sov	540,091	644,479	763,114
146		hov	53,426	57,796	18,961
147	PM	sov	729,833	867,323	1,033,598
148		hov	82,983	93,898	29,005

The new model run macro set printed in the following table has highlighted in red those macros that where changed or added as new. The macros that were changed are the am_mcskim1.mac, md_mcskim1.mac, am_assign.mac, md_assign.mac and pm_assign.mac files in which the appropriate assignment trip tables are run. The remaining (run_slhov.mac, am2pr+hov.mac, md2pr+hov.mac, pm2pr+hov.mac) are the new sov, lov, hov macro calls. The new macros run in 2006 and 2020 platforms. A separate set of macros (am3pr+hov.mac, md3pr+hov.mac, pm3pr+hov.mac) run in the 2030 platform. Each of the 3 platforms has their own model run macro call set. Year 2006 is new_run06bkr.mac. Year 2020 is new_run20bkr.mac. Year 2030 is new_run30bkr.mac. For all platforms the macros reside in the same folder as the databank.

The following model implementation setup highlights the macros adjusted and new macros to implement the vehicle class split (as shown in red).

```
~/run06bkr.mac: Batch to run 2006 4-step BKR Model for HOV2+
~/
~/----- 1st Iteration -------
~/TRIP GENERATION MODEL
~<generate.mac
~<change.mac
~<combine.mac
~<ensemble.mac
~/
~/Prepare Initial Free-flow 0 Assignment skims for Trip Distribution
~/<extra-attr.mac
```

```
~<am0mcskim1.mac
~<am_mcskim2.mac
~<am_mcskim3.mac
~<md0mcskim1.mac
~<md_mcskim2.mac
~<md_mcskim3.mac
~<dist_tt.mac
~<save0mcskim.mac
~/
~/TRIP DISTRIBUTION MODEL-Check TD Inputs Prior to Run 4-Step
~<hbw_dist.mac
~<hbo_dist.mac
~<nhb_dist.mac
~<sch_dist.mac
~/
~/Prepare AM PK HR. and MD OP Hr.Transit Skims for Mode Choices
~<ampktran.mac
~<AMTRNHDW.MAC
~<ampkrskm2.mac
~<mdpktran.mac
~<md-tran-asgn.mac
~<trans-imp.mac
~<save_transkim.mac
~/
~/MODE CHOICE MODEL - Using AM Skims for HBW and MD Skims for Others
~<hbw_mc.mac
~<prsplit.mac
~<hbo_mc.mac
~<nhb_mc.mac
~/
~/TIME OF DAY MODEL
~<run_slhov.mac /
~<am2pr+hov.mac
~<md2pr+hov.mac
~<ampktran.mac
~<mdpktran.mac
~/
~/
~/------- 2nd Iteration --------
~/
~/Prepare AM PK Hr. and MD off-peak Hr. skims for Trip Distribution
~<am_mcskim1.mac
~<am_mcskim2.mac
~<am_mcskim3.mac
~<md_mcskim1.mac
~<md_mcskim2.mac
```

```
~<md_mcskim3.mac
~<dist_tt.mac
~<avg_mcskim.mac
~<save_mcskim.mac
~/
~/TRIP DISTRIBUTION MODEL-Check TD Inputs Prior to Run 4-Step
~<hbw_dist.mac
~<hbo_dist.mac
~<nhb_dist.mac
~<sch_dist.mac
~/
~/Prepare AM PK HR. and MD OP Hr.Transit Skims for Mode Choices
~<ampktran.mac
~<AMTRNHDW.MAC
~<ampkrskm2.mac
~<mdpktran.mac
~<md-tran-asgn.mac
~<trans-imp.mac
~<avg_transkim.mac
~<save_transkim.mac
~/
~/MODE CHOICE MODEL - Using AM Skims for HBW and MD Skims for Others
~<hbw_mc.mac
~<prsplit.mac
~<hbo_mc.mac
~<nhb_mc.mac
~/
~/TIME OF DAY MODEL
~<run_slhov.mac /
~<am2pr+hov.mac
~<md2pr+hov.mac
~<ampktran.mac
~<mdpktran.mac
~/
~/
~/------- 3rd Iteration --------
~/
~/Prepare AM PK Hr. and MD off-peak Hr. skims for Trip Distribution
~<am_mcskim1.mac
~<am_mcskim2.mac
~<am_mcskim3.mac
~<md_mcskim1.mac
~<md_mcskim2.mac
~<md_mcskim3.mac
~<dist_tt.mac
~<avg_mcskim.mac
```

```
~/
~/TRIP DISTRIBUTION MODEL-Check TD Inputs Prior to Run 4-Step
~<hbw_dist.mac
~<hbo_dist.mac
~<nhb_dist.mac
~<sch_dist.mac
~/
~/Prepare AM PK HR. and MD OP Hr.Transit Skims for Mode Choices
~<ampktran.mac
~<AMTRNHDW.MAC
~<ampkrskm2.mac
~<mdpktran.mac
~<md-tran-asgn.mac
~<trans-imp.mac
~<avg_transkim.mac
~/
~/MODE CHOICE MODEL - Using AM Skims for HBW and MD Skims for Others
~<hbw_mc.mac
~<prsplit.mac
~<hbo_mc.mac
~<nhb_mc.mac
~/
~/TIME OF DAY MODEL
~<run_slhov.mac
~<am2pr+hov.mac
~<md2pr+hov.mac
~<pm2pr+hov.mac
~<ampktran.mac
~<mdpktran.mac
~/<pmpktran.mac
~/
~/FINAL TRIP ASSIGNMENT MODEL
~<am_assign.mac
~<AMTRNHDW.MAC
~<md_assign.mac
~<md-tran-asgn.mac
~<pm_assign.mac
~/<PMTRNHDW.MAC
~/<walkbike.mac
~/
~/FOUR-STEP PROCESS REPORTS
~<sum_8.mac
~<sum_4.mac
~<sum_p_a.mac
~<td_valid1.mac
~<td_valid2.mac
```

```
~<td_valid3.mac
~<sum_mc.mac
~<sum_mc_bkr.mac
~<am-md-pm.mac
~/<ms-daily-beltown.mac
~/
~/========== COMPLETION OF 3 ITERATIONS ============
~/
```

Appendix D Macro Call Hierarchy

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APPENDIX D MACRO CALL HIERARCHY

BKR_mp0r12_r38.mac
- init_all_2010.mac
- TRAN_SETUP5.MAC
- set_railspeed_MP0R12.mac
- LHOV_split_factors.mac
- LOAD_TOLLS_MP0R12.MAC
- VDF_CONVERT_UPDATE.MAC
- generate.mac
- change.mac
- combine.mac
- ensemble_2010.mac
- am0mcskim1_TOLLhov2.mac
- am_mcskim2.mac
- am_mcskim3.mac
- md0mcskim1_TOLLhov2.mac
- md_mcskim2.mac
- md_mcskim3.mac
- dist_tt.mac
- save0mcskim.mac
- hbw_dist.mac
- hbo_dist.mac
- nhb_dist.mac
- sch_dist.mac
- ampktran.mac
- AMTRNHDW.MAC
  - EFFHDWY0.MAC
  - AMTRANHW.MAC
  - EFFHDWY.MAC
  - AMTRANHW.MAC
  - EFFHDWY.MAC
  - AMTRANHW.MAC
  - EFFHDWY.MAC
  - AMTRANHW.MAC
  - EFFHDWY.MAC
  - AMTRANHW.MAC
  - EFFHDWY.MAC
  - AMTRANHW.MAC
- ampkrskm2.mac
- mdpktran.mac
- md-tran-asgn.mac
- trans-imp.mac
- save_transkim.mac
- hbw_mc.mac

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APPENDIX D MACRO CALL HIERARCHY

prsplit_RA.mac
    parkride.mac
hbo_mc.mac
nhb_mc.mac
run_slhov.mac
    slov_tt.mac
    slhov_extra.mac
    pmslhov.mac
    slhov_extra.mac
    mdslhov.mac
    slhov_extra.mac
    amslhov.mac
am2pr+hov.mac
md2pr+hov.mac
ampktran.mac
mdpktran.mac
am_mcskim1_TOLLhov2.mac
am_mcskim2.mac
am_mcskim3.mac
md_mcskim1_TOLLhov2.mac
md_mcskim2.mac
md_mcskim3.mac
dist_tt.mac
avg_mcskim.mac
save_mcskim.mac
hbw_dist.mac
hbo_dist.mac
nhb_dist.mac
sch_dist.mac
ampktran.mac
AMTRNHDW.MAC
    EFFHDWY0.MAC
    AMTRANHW.MAC
    EFFHDWY.MAC
    AMTRANHW.MAC
    EFFHDWY.MAC
    AMTRANHW.MAC
    EFFHDWY.MAC
    AMTRANHW.MAC
    EFFHDWY.MAC
    AMTRANHW.MAC
    EFFHDWY.MAC
    AMTRANHW.MAC

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APPENDIX D MACRO CALL HIERARCHY

ampkrskm2.mac
mdpktran.mac
md-tran-asgn.mac
trans-imp.mac
avg_transkim.mac
save_transkim.mac
hbw_mc.mac
prsplit_RA.mac
    parkride.mac
hbo_mc.mac
nhb_mc.mac
run_slhov.mac
    slov_tt.mac
    slhov_extra.mac
    pmslhov.mac
    slhov_extra.mac
    mdslhov.mac
    slhov_extra.mac
    amslhov.mac
am2pr+hov.mac
md2pr+hov.mac
ampktran.mac
mdpktran.mac
am_mcskim1_TOLLhov2.mac
am_mcskim2.mac
am_mcskim3.mac
md_mcskim1_TOLLhov2.mac
md_mcskim2.mac
md_mcskim3.mac
dist_tt.mac
avg_mcskim.mac
hbw_dist.mac
hbo_dist.mac
nhb_dist.mac
sch_dist.mac
ampktran.mac
AMTRNHDW.MAC
    EFFHDWY0.MAC
    AMTRANHW.MAC
    EFFHDWY.MAC
    AMTRANHW.MAC
    EFFHDWY.MAC
    AMTRANHW.MAC

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EFFHDWY.MAC
AMTRANHW.MAC
EFFHDWY.MAC
AMTRANHW.MAC
EFFHDWY.MAC
AMTRANHW.MAC
ampkrskm2.mac
mdpktran.mac
md-tran-asgn.mac
trans-imp.mac
avg_transkim.mac
hbw_mc.mac
prsplit_RA.mac
parkride.mac
hbo_mc.mac
nhb_mc.mac
run_slhov4.mac
slov_tt.mac
slhov_extra.mac
pmslhov4.mac
slhov_extra.mac
mdslhov.mac
slhov_extra.mac
amslhov.mac
am3pr+hov3c.mac
md3pr+hov3c.mac
pm3pr+hov3c.mac
ampktran.mac
mdpktran.mac
pmpktran.mac
am_assign_3c.mac
AMTRNHDW.MAC
EFFHDWY0.MAC
AMTRANHW.MAC
EFFHDWY.MAC
AMTRANHW.MAC
EFFHDWY.MAC
AMTRANHW.MAC
EFFHDWY.MAC
AMTRANHW.MAC
EFFHDWY.MAC
AMTRANHW.MAC
EFFHDWY.MAC

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AMTRANHW.MAC
md_assign_3c.mac
md-tran-asgn.mac
pm_assign_3c.mac
PMTRNHDW.MAC
EFFHDWY0.MAC
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PMTRANHW.MAC
EFFHDWY.MAC
PMTRANHW.MAC
EFFHDWY.MAC
PMTRANHW.MAC
EFFHDWY.MAC
PMTRANHW.MAC
update_mf40.mac

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Appendix E Post-processing Algorithm

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APPENDIX E POST-PROCESSING ALGORITHM

POST PROCESSING ALGORITHM [12/09/89]
Dave Tallent

During the "mathematical" design of the City of Bellevue's turning movement post processor, it was necessary to create many innovative mathematical techniques to address anomaly and unacceptable results from

In1988, it was standard practice to use a method of row/column balancing with arrival/departure volumes as inputs to create future turning movements. This method, often referred to as "frataring" (Furness bi-proportional balancing method) was a satisfactory procedure when the modeled "future" arterial system looked very similar to present base conditions. However, when modeled intersection geometry radically changed i.e. new approach leg, removal of an intersection leg as in a one-way system, or more than four legs entering or leaving an intersection, "fracturing" did not produce acceptable results. In addition, delta changes "wiped-out" base year volumes (actual observed counts) and some turning movements did not exist in the base year or in the future year model, balancing was problematic. Furthermore, balancing to future raw AD volumes from the model, makes the assumption that the future raw volumes are "correct" and the magnitude of the resulting post-processed volumes are constrained by the model output. See Appendix

For Arrival/Departure volume balancing to be successful, and meaningful values for future turning movements produced, the following assumptions must be a given:

1. The future network is built on a well calibrated base
2. All elements (possible turns) in the matrix must be > 0
3. Values for individual turning movements and/or arrival/departure volumes exist concurrently in the actual counts, base model & future model.

Often, this was not the case. What if the future "raw" model volumes were not defensible? [Calibration]. What if there are negative deltas and corresponding turning movements are not represented at every stage?

With this in mind, the strategy was to create a post-processor than did not entirely rely on balancing but employed other techniques: incremental, proportional and inflexion adjustments.

In 1991, together with June Ma we created a (INT) a semi-automated, and user interactive c program replacing the previous 1988 LOTUS version. This current program has served us well for 21 years. However, an automated process was always desirable.

Mathematics:
Post-processing of "non-stationary" flow data requires significant effort concerning the involved mathematical methods, the algorithmically tools and the computational realization. However, the mathematics is deceptively simple.

APPENDIX E POST-PROCESSING ALGORITHM

Before I try to describe this deceptively simple mathematical model, let us introduce the terminology:

BAD = Base Year arrival/departure volumes
MAD = Model year arrival/departure volumes
SAD = Simulated (final) arrival/departure volumes

$_{i =}$ from (inflow, origin)
$_{j =}$ to (outflow, destination)
● = operation representing iterative row/column balancing

Balancing technique:
$SAD_{ij} = BAD_{ij} \bullet MAD_{ij}$

where
$T_{ij}b$ = base turns from i to j
$T_{ij}f$ = future turns from i to j
O = origin
D = destination
1st iteration (row): $T_{ij}f = O_i f / O_i b * T_{ij}b$
1st iteration (column): $T_{ij}f' = D_j f / D_j f' * T_{ij}f$

2nd iteration (row): $T_{ij}f'' = O_i f / O_i f' * T_{ij}f'$
2nd iteration (column): $T_{ij}f''' = D_j f / D_j f'' * T_{ij}f''$

This process is continued until the row & column sum approximately the desired future model arrival/departure volumes.

Modifying the balancing technique to
$SAD_{ij} = BAD_{ij} \bullet MAD_{ij}$ where future arrival/departure values
MAD_{ij} were evaluated from $BAD_{ij} + (MAD_{ijFLFN} - MAD_{ijBLBN})$

One very important observation, as noted above, was that when base year and future networks were identical, with only land use being different, the incremental approach using only turning movements and the balancing techniques using arrival/departure volumes yielded very similar results with many of the movements being almost equal. This gave one a sense of security that there was merit in the proposed method and it was defensible.

Hence, we can redefine the equation as:
Future $tm_{i =}$ Actual tm_i + ($ModFLFNtm_i$ – $ModBLBNtm_i$) and forgo frataring altogether

Where
tm = turning movement
ModFLFN = Modeled Future land use on Future Network
ModBLBN = Modeled Base year land use on Base year network

Note: we are only interested in the inflow turning movement i, and the issue of potential "poor" calibration has been addressed by taking the delta between the future model (FLFN) – and base model (BLBN) and adding this delta to the actual base year turning movements.

To address the issue of major changes in network, and model links with zeros, I added an additional term. This also gave an opportunity to "hand adjust", i.e. interactively make modifications to turns if necessary.

Future tm_i = Actual tm_i + ($ModFLFNtm_i$ – $ModBLFNtm_i$) + ($ModBLFNtm_i$ – $ModBLBNtm_i$)

Where
ModBLFN = Modeled Base year land use on Future network

Note: if there are no network changes then the $ModBLFNtm_i$ terms cancel out.

What this is saying is that a future turn is equal to actual observed counts + changes due to network + changes due to growth.

Delta 1 = ($ModBLFNtm_i$ – $ModBLBNtm_i$) = changes due to network, land use is kept constant. When this delta is added to the actual counts, we have produced what today's counts would look like if counted on the future network if in place today.
$d_1 = (m_1 - m_0)$

Delta 2 = ($ModFLFNtm_i$ – $ModBLFNtm_i$) = changes due to growth, network is kept constant
$d_2 = (m_2 - m_1)$

$c_f = c_0 + (m_2 - m_1) + (m_1 - m_0)$
Or
$c_f = [c_0 + (m_1 - m_0)] + (m_2 - m_1)$

Post processing can now be achieved in two steps:
1st step $c_{turnadj} = [c_0 + (m_1 - m_0)]$ using turning movements

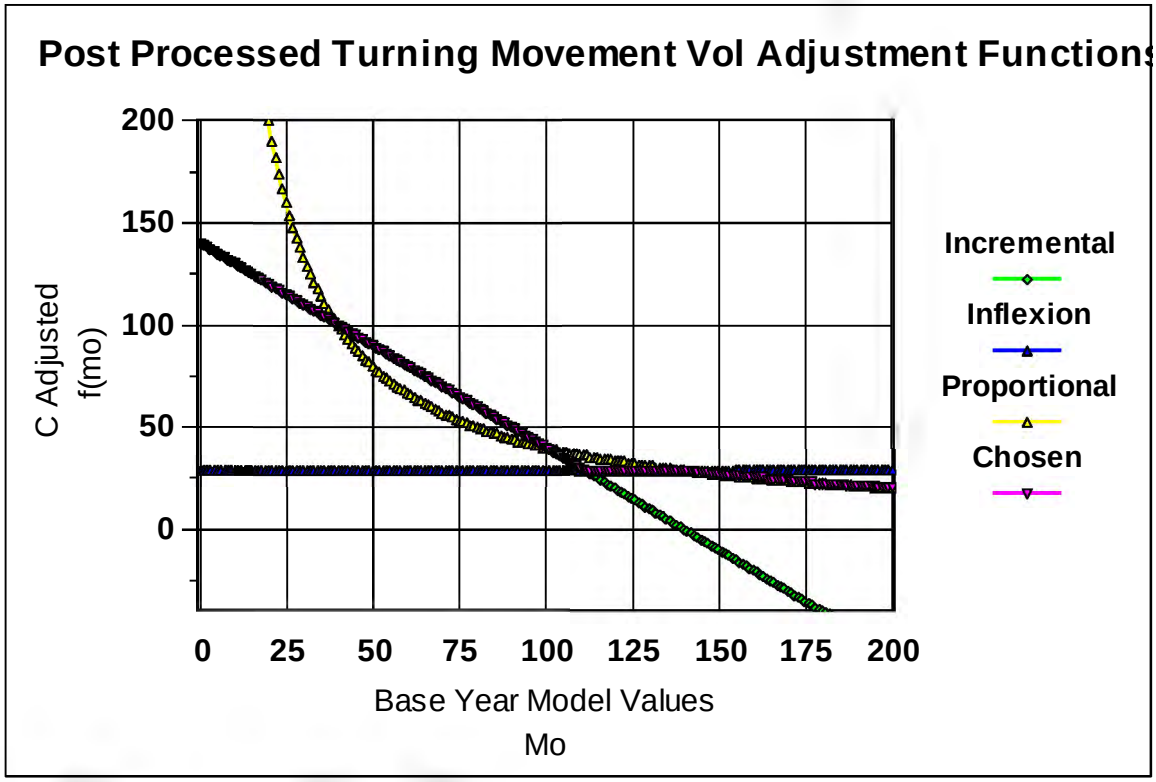
2nd step $c_f = [c_{turnadj} + (m_2 - m_1)]$ using turning movements or
return to arrival/departure summation
where $MAD_{ij} = C_{turnadj}AD_{ij} + (MAD_{ijFLFN} - MAD_{ijBLFN})$ and balancing.

Two techniques that were employed extensively where incremental & proportional deltas, the latter of which was added to address the issues of zero & negative deltas. However, one must still be selective.

When changes were large, proportional results are also outrageously large and must be rejected. Therefore, the conclusion was always to accept the incremental deltas when positive. However, if negative, adjust proportionally. Problem solved? Unfortunately

not. What was observed was a small portion of the incremental curve, whose results were smaller than the "first" possible proportional result at incremental delta zero. With this in mind, it was necessary to introduce a third component – and inflexion value. The "inflection" constant, a bridge value between the incremental & proportional curves addressed the potential "jump"when incremental delta <=0.

Finally, the decision equation says: if incremental > inflexion, then incremental. If Inflexion <= proportional, then inflexion, otherwise choose proportional. Alternatively, if incremental < 0 proportional, and if incremental >0, but < inflexion then inflexion.



Chosen adjustment curve is a three part function:

$$f(m_o) = \begin{cases} f(inc) = c_0 + (m_1 - m_0) & 0 < m_0 < (c_0+m_1) - (c_0*m_1)/(c_0+m_1) \\ f(inf) = (c_0 * m_1) / (c_0 + m_1) & (c_0+m_1)-(c_0*m_1)/(c_0+m_1) <= c_0*m_1/ m_0 \\ f(pro) = c_0 * m_1/ m_0 & \text{for } m_0 > c_0 + m_1 \end{cases}$$

Example above:
Let $c_0 = 100$ (for example)
Let $m_1 = 40$ (for example)
Let m_0 vary any value >= 0

Curve Sketching

	Incremental	**Inflexion**	**Proportional**
$f(m_o)$	$f(inc) = c_0 + (m_1 - m_0)$	$f(inf) = (c_0*m_1)/(c_0+m_1)$	$f(pro) = c_0 * m_1 / m_0$
$f(0)$	$c_0 + m_1$	$(c_0*m_1)/(c_0+m_1)$	∞
$f(c_o)$	$+ m_1$	$(c_0*m_1)/(c_0+m_1)$	m_1
$f(m_1)$	$+ c_0$	$(c_0*m_1)/(c_0+m_1)$	c_0
$f(c_{o+} m_1)$	0	$(c_0*m_1)/(c_0+m_1)$	$(c_0*m_1)/(c_0+m_1)$
		Always same value. $f(inf)$ is a linear function	

Finally, what should be done if one or more of c0, m_0 and m_1 are zeros.

c_o	m_o	m_1	**What to do C_{adjust}**
0	0	0	OK
0	0	+	$+m_1$
0	+	0	Check for Network error, or 0
0	+	+	$+m_1$
+	0	0	$+c_0$
+	0	+	$+m_1$
+	+	0	Check for Network error, or 0
+	+	+	OK

David Tallent
12/9/89 LOTUS
3/4/1991 C NEWINT
Updated 2007. Changed fonts. Added a few dates, and changed s_0 to m_0 etc

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Current Post-Processing techniques

Method	Focus	Equations	Issues	Author	Recommended NCHRP-255
Use future model **raw Volumes**	TM	m_2	• Constrained by model output • Calibration error not accounted for • Model may not reflect reasonable-ness w.r.t. to actual base year vols		
Balancing (Fratar)	TM→AD ● →TM	$c_0 \bullet m_2$	• Constrained and cannot exceed model output • Calibration error not accounted for • Preserves c_0 characteristics -multiplies all approach TM's by same ratio, thus preserving proportionality • pp output does not reflect policy ramifications		1976 Mekky
One step process Combining Incremental Δ growth & network changes then **Balancing**	TM→AD ● →TM	$c_2 = c_0 + (m_2 - m_0)$ then $c_0 \bullet c_2$	• Zero and negative links possible √ Not constrained by m_2	1988 Jose Farah 1988 Dave Tallent	1998 Mike Bitner
Two-step process **Incremental "cocktail"** (Incremental, proportion, inflexion) Repeated for Δ network changes and then Δ land use changes	TM→TM TM→TM	$c_1 = c_0 + (m_1 - m_0)$ or $c_0 * m_1/m_0$ or $c_0 * m_1/(c_0 + m_0)$	√ Not constrained by m_2 √ Calibration error addressed √ Zeros addressed √ Base year characteristics not necessarily preserved √ reflects policy	1989 Tallent 1989 Tallent 1991Programs (D Tallent) turnadj Newint	Submitted in 2008