City of Duvall

TRAVEL DEMAND MODEL DOCUMENTATION

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Chapter 1. Introduction

The City of Duvall Travel Demand Model (Duvall Model) was developed to provide a solid technical basis for evaluating transportation system needs in coordination with long-term planning in the City of Duvall. The Duvall Model was built using Visum software and is consistent with local and regional growth plans within the region. The scope of the model is subarea of western King County generally east of the Snoqualmie River between NE Cherry Valley Road and NE Big Rock Road. Figure 1 illustrates the Duvall Model extents.

1.1 Model Overview

The Duvall Model has a base year of 2015 and a forecast horizon year of 2035. The model trip assignment represents the PM peak hour period (one-hour volumes) between 4 p.m. and 6 p.m. on a typical weekday. The model has a total of 86 Transportation Analysis Zones (TAZs), including 7 external TAZs. The 2015 Duvall Model has 53 lane miles coded that represent freeways, expressways, arterials, collectors, and a few local streets. Trip generation is performed directly within the Visum model software. This model documentation was developed based on the Visum 15.00-06 software version.

1.2 Model Documentation Outline

This report provides details about the structure of the model and the assumptions used in constructing the model.

- **Chapter 2 - Using the Model**. This section explains the basics of the model and how to do routine analysis with the model. This includes quality control checklists to help confirm that the model will perform as designed. Specific model details are presented in later chapters and appendices.
- **Chapter 3 - Travel Demand Inputs**. This section explains the various model inputs relative to estimating travel demands including land use, trip generation, trip distribution, mode choice, and other parameters.
- **Chapter 4 - Travel Supply Inputs**. This section explains the various model inputs relative to the supply or capacity of the network including planned improvements, roadway capacities, and other parameters.
- **Chapter 5 - Validation and Reasonableness Checks**. This section explains how existing data sets compare to the modeled travel conditions.

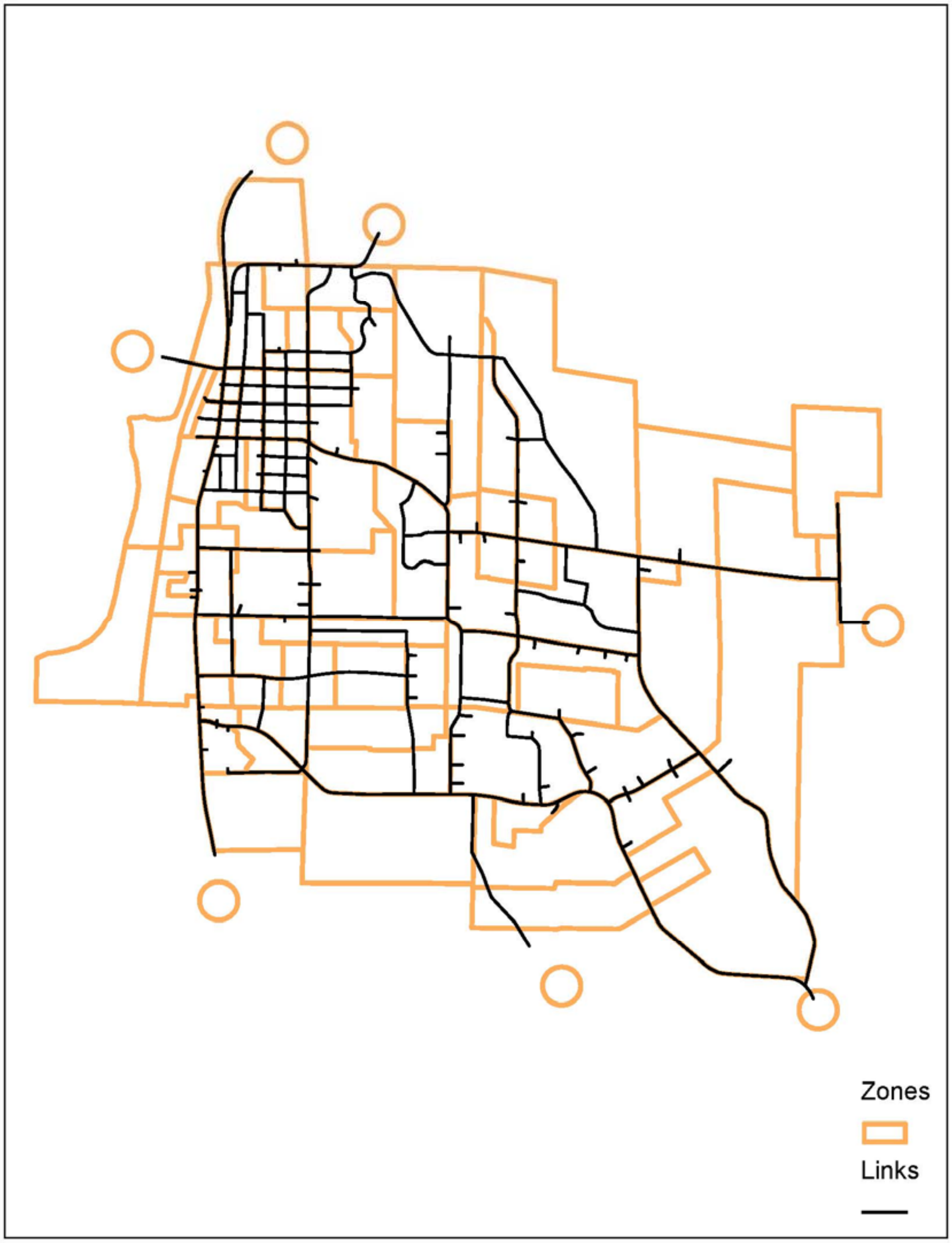

Figure 1. Duvall Travel Demand Model

Chapter 2. Using the Model

The main purpose of the model is to run various model scenarios to understand impacts and/or output traffic volume characteristics. Outlined below is how the model can be used or adapted for scenario testing or other analysis. This section describes how the model operates, how to use it when evaluating scenarios, and the method to post-process model volumes.

The anticipated model users of the Duvall Model fall into the two general categories below. Chapter 2 is intended primarily for the basic model user.

- **Basic Model User.** These model users are able to perform basic model analysis including select-link/select-zone analysis, small edits to the model network, land use updates to several TAZs, exporting volumes for post-processing, and model plots.
- **Advanced Model User.** These model users can perform all the basic model user tasks as well as changing the TAZ structure, developing a new analysis horizon year, and calibration/validation of the model.

2.1 Select-Link or Select-Zone Analysis

Using Visum's internal "flow bundle" application, trips using a specific link or zone can be isolated for review. The path volumes are saved for the PM peak period, so flow bundle analysis of the PM peak period does not require the model to be rerun.

Quality Control Tip:
Be sure to be careful on how multiple links or zones are selected. The order they are clicked as well as the "and" versus "or" parameters can have significant impacts on the resulting output. In addition, be sure that both origins and destinations are chosen when doing select-zone analyses.

2.2 Changing the Model Network

The model was developed with the anticipation that the model network would be changed to test various scenarios. Some of the network editing is streamlined so that when the model procedures are run, many network attributes are automatically updated.

2.2.1 Model Links

The model relies on "link types" to assist in link editing. Link types are based on the number of lanes and free-flow (posted) speeds. After editing a link, be sure that the link type attribute is correctly coded. The number of lanes, capacity, and speed are updated for every link when the model is run. NOTE: The "transport system" link attribute is also automatically set, so use the correct link type to disable links. See Appendix A for link types.

2.2.2 Model Nodes

The model relies on "node types" to help define intersection delays. When the model runs, the turn capacities, turn delays, and intersection capacities are automatically updated and applied based on node type. After editing the network, be sure that the node type attribute is correctly coded. NOTE: The "ControlType" node parameter is not used in the Duvall Model. See Appendix A for node types.

2.2.3 Model Turns

Model turn attributes need to be checked, because they can impact how the intersection delays are calculated. Besides two-way stop control (TWSC) intersections (Node Type 5), all node types assign turn capacities and delays based only on major-street/minor-street designations as well as turn types (1-left, 2-thru, 3-right, 4-u-turn). Be sure that the nodes "major flows" are correctly oriented, and that the turn type attribute is correctly coded.

In some cases the default turn capacity based on the node type may not best reflect unique circumstances at select intersection locations. The Duvall Model includes a turn attribute called "TurnCapFactor" that is used as a coefficient to increase or decrease the default turn capacity at specific turn locations. By default, this coefficient is set to 1.0 for turns. Typically, this adjustment is only used for less than ten percent of model intersections.

For two-way stop control intersections (Node Type 5), the intersection delay is based on intersection capacity and delays are only applied to the stopped approach. To make this work properly, the approach with the stop sign should have the link attribute "TModel delay link for turns" set to one (1). The rest of the approaches should be set to zero (0).

2.2.4 Running the Model

After making network edits, make sure to activate the procedure steps in "Group Set Network Attributes" when running the model. To run the full model, activate all the procedures. If only the trip assignment needs to be run, only activate the procedures in the "Group Trip Assignment" along with "Group Set Network Attributes."

Quality Control Checklist:
The following is a checklist to review after making any network edits. Using graphic parameters to illustrate the active parameters makes the review go quickly.

1. When editing the shape of a link, is the box to "take over length-polygon" checked?
2. Are the link types coded correct?
3. Are the node types coded correct?
4. Is the "TModel delay link for turns" set for stop-controlled approach links?
5. Are the major flows correctly oriented at nodes with traffic control?
6. Are turn type numbers correct at nodes with traffic control?
7. Does the "TurnCapFactor" coefficient factor need updating?
8. Are there any "prohibited turns" and "u-turns" in places not expected?
9. When running the model after network edits, were the procedure steps run in "Group Set Network Attributes"?

2.3 Changing Land Use

Land use inputs, trip generation, and trip balancing occur in the Visum software during the "Group Trip Generation" set of procedures.

2.3.1 Residential Land Use

Residential land use inputs are summarized by number of dwelling units per TAZ (See Appendix B for detailed map showing TAZ numbers and boundaries.) The dwelling units are subdivided into two categories, single-family dwelling units (SFDU) and multi-family dwelling units (MFDU).

To make residential land use changes, open the Visum model version file and then open a zone list (List>Network>Zone). Open the saved layout named "LandUseImport.lla" which clearly shows the land use categories used in the model. Make edits to the number of dwelling units for the appropriate TAZ directly in the list.

2.3.2 Employment Land Use

Employment land use inputs are summarized by number of employees per TAZ (See Appendix B for detailed map showing TAZ numbers and boundaries.) The employment is subdivided into several categories (see Chapter 3 for details).

To make employment land use changes, open the Visum model version file and then open a zone list (List>Network>Zone). Open the saved layout named "LandUseImport.lla" which clearly shows the land use categories used in the model. Make edits to the number of employees for the appropriate TAZ directly in the list.

2.3.3 Running the Model

After making the land use edits, make sure to activate all the procedure steps. All model steps should be run when making land use edits.

Quality Control Checklist:
The following is a checklist to review after making any land use edits.

1. Were the dwelling units and employees assigned to the correct categories and TAZs? Check after the trip assignment that the trips generated at the TAZ are consistent with the magnitude of land use adjustments.
2. For future horizon scenarios, remember that the land use in the zone list being edited represent <u>totals</u>, not growth only land use quantities.
3. When running the model after land use edits, were all the procedure steps run?

2.4 Changing the TAZ Structure

Given the complexity of model procedures, it is not recommended to change the TAZ structure (the number of TAZs). The model does use multipoint assignment (MPA), so an alternate method to control where trips enter/exit the model is to provide more TAZ centroid connectors and assign shares (weights) to each connector.

2.5 Changing Model Horizon Year

Changing the model horizon year involves both land use changes and changes to external TAZ assumptions. It is not recommended to change the model horizon year without careful adjustments to land use by TAZ, external traffic volume forecasts, and forecasts of the external-to-external trip table.

2.6 Post-Processing Model Volumes

Post-processing refers to adjusting raw future model volumes to account for model calibration or validation differences inherent in all travel demand models.

The “difference method” is the recommended method to estimate post-processed future turning movement volumes at study intersections. The difference method works by subtracting the existing model volume from the future model volume, and adding that difference to existing counts. The difference method does not produce reasonable results 100 percent of the time, so the results need to be checked for reasonableness, similar to all model post-processing methodologies.

A basic model user can easily copy a Visum listing of turns (or links) and paste into a premade spreadsheet to automate the bulk of the post-processing work.

Chapter 3. Travel Demand Inputs

Travel demand inputs relate to any element that places trips on study area roadways. Land use plans, trip generation rates, and trip distribution parameters are discussed. Trips linked to areas outside the model study area (external trips) are discussed, as well as traffic counts.

3.1 Land Use

Socio-economic information is the basis for estimating the quantity of travel activity in the study area. This land use information was summarized by the categories shown in Table 1. These land use categories are the basic building blocks of travel demand.

Table 1. Land Use Categories

Type	Code	Units	Description
Residential	SFDU	Dwelling Units	Single-family dwelling units
	MFDU	Dwelling Units	Multi-family dwelling units
Employment	NRC	Employees	Natural resources and construction
	Manuf	Employees	Manufacturing, warehouse, transportation, utilities
	Retail-Low	Employees	Retail trade, food services
	Retail-High	Employees	Retail trade, food services
	FIRE	Employees	Finance, insurance, real estate
	Edu	Employees	Education
	Med	Employees	Medical/dental
	Office	Employees	Office, services
	GOV	Employees	Government
Externals	XI-O	Peak Hour Trips	Trips entering the model from external TAZs
	IX-D	Peak Hour Trips	Trips exiting the model to external TAZs

Source: Transpo Group, 2016

To generalize travel activity by small areas, transportation analysis zones (TAZs) were developed. The Duvall Model has a total of 86 TAZs and are consistent with TAZs in the 2009 Duvall Travel Demand Model. Figure 1 show the general size and extents of the model TAZs, and Appendix B shows a more detailed TAZ map. Existing and future land use allocations to model TAZs are based on information developed by the City.

3.2 Trip Generation

Trips are generated by land uses and are assigned a trip type. In the Duvall Model, there are five basic trip types (or the general purpose of the trip):

- Home-to-Work (HW): Vehicle trips that have their origin at the place of residence and destination at the resident’s place of employment.
- Work-to-Home (WH): Vehicle trips that have their origin at the resident’s place of employment and destination at the place of residence.
- Home-to-Other (HO): Vehicle trips that have their origin at the place of residence and destination at somewhere other than the resident’s place of employment.

- Home-to-Other (OH): Vehicle trips that have their origin at somewhere other than the resident's place of employment and destination at the place of residence.
- Non-Home Based (NHB): Vehicle trips with no residential trip end.

Trip generation rates used in the Duvall Model reflect weekday PM peak hour trips. Dwelling units generate a certain amount of weekday PM peak hour trips, and employment areas also generate trips. Trip rates were not changed from the ones used in the 2009 Duvall Model. Trip rates for residential areas range from 0.69 to 0.90 depending on the dwelling unit category. Trip rates for employees range from 1.20 to 6.00 depending on the employee classification. Detailed trip generation rates by trip type are included in Table 2.

Table 2. Trip Generation Rates

		Productions[2]					Attractions[3]				
Code[1]	**Total**	**HW**	**WH**	**HO**	**OH**	**NHB**	**HW**	**WH**	**HO**	**OH**	**NHB**
SFDU	0.69	0.01		0.23				0.27		0.18	
MFDU	0.90	0.02		0.30				0.38		0.20	
NRC	1.25		1.04		0.06	0.03			0.02		0.10
Manuf	1.50		0.74		0.08	0.02	0.03		0.16		0.47
Retail-Low	1.97		0.20		0.40	0.31	0.04		0.32		0.70
Retail-High	6.00		0.61		1.21	0.94	0.13		0.97		2.14
FIRE	1.52		0.94		0.11	0.16	0.02		0.09		0.20
Edu	1.24		0.41		0.09	0.06	0.03		0.20		0.45
Med	4.25		1.95		0.62	0.11	0.08		0.61		0.88
Office	1.20		0.84		0.08	0.04	0.01		0.07		0.16
GOV	1.50		0.88		0.05	0.07	0.01		0.12		0.37
XI-O	1.00	0.03	0.30	0.10	0.24	0.33					
IX-D	1.00						0.03	0.30	0.35	0.18	0.14

Source: Transpo Group, 2016

1. Code represents the land use category. See Table 1 for land use definitions and units.
2. Productions represent trip origins, meaning where trips begin during weekday PM peak hour. This is slightly different to the generic model definition of productions (trips generated by residential land uses only).
3. Attractions represent trip distributions, meaning where trips end during weekday PM peak hour. This is slightly different to the generic model definition of attractions (trips generated by employment land uses only).

3.3 Trip Distribution

Trips are distributed between TAZs using the "gravity" model, which is incorporated into the Visum software. This gravity model is built on the theory that, all else being equal, the attraction between two masses will be proportional to the size of the masses and inversely proportional to the distance between the masses. In the travel demand model, the number of trips in a TAZ is used to reflect the size of the mass, and route travel time is used to reflect the distance factor in the gravity model.

The gravity model has parameters to adjust these relationships for each trip purpose. Simply put, these parameters influence average trip lengths of each trip type. In the Duvall Model, the "Combined" utility function controls the impact of the distance factor in the gravity model. In equation form, the function is $f(U) = a*(U^b)*(e^{cU})$ where U is travel time between zones. Congested travel times are used for distributing trips. The parameters differ by trip type as shown in Table 3 and are based on guidance in *NCHRP 716 Travel Demand Forecasting: Parameters and Techniques* (TRB, 2012).

Table 3. Gravity Model Distribution Parameters

	Distribution Function Parameters		
Trip Type	**a**	**b**	**c**
Home-to-Work (HW)	100	-0.30	-0.125
Work-to-Home (WH)	100	-0.30	-0.125
Home-to-Other (HO)	100	-0.70	-0.10
Other-to-Home (OH)	100	-0.70	-0.10
Non-Home Based (NHB)	100	-0.60	-0.10

Source: Transpo Group, 2015

Trip distribution in the Duvall Model assigns productions (origins) to attractions (destinations) for PM peak hour trips, which creates origin-destination matrices. These origin-destination matrices are used directly in the model trip assignment steps.

3.4 Externals

External TAZs account for trips which start and/or end outside the model study area. The Duvall Model has 7 external TAZs. Trip generation for these TAZs is based on the following data sources:

- Current daily traffic volumes
- Historical traffic volumes
- Land use growth forecasts

Existing and forecasted external trips were converted to either productions or attractions by trip type in the trip generation process. Trips from both internal and external TAZs were then distributed according to the gravity model process. External-to-external trips were estimated separately, and were influenced by past Origin-Destination surveys in the area. The externals forecasts in the Duvall Model are very sensitive to the city land use forecasts and would need to be updated if land use forecasts changed significantly.

3.5 Mode Choice

Trip generation procedures produce vehicle trips directly from land use inputs. The conversion of daily person trips to vehicle trips by trip type is built into the trip generation rate.

3.6 Time-of-Day

Trip generation procedures produce weekday PM peak hour trips directly from land use inputs. The conversion of daily person trips to weekday PM peak hour trips by trip type is built into the trip generation rate.

3.7 Traffic Counts

Existing traffic counts are significant in the development of the model because they directly account for existing travel demands. These existing volume inputs are used in key metrics that determine the validation and reasonableness of the existing year model. Local and regional roadway counts (daily and hourly) were obtained from local agencies and WSDOT and represent year 2013 or later.

Chapter 4. Travel Supply Inputs

Travel supply inputs relate to any elements that process trips on study area roadways. Overall network structure is explained as well as link and node types. Volume-delay relationships for various link and nodes types are also discussed.

4.1 Existing Street Network

The street network models the available travel supply. In the travel demand model, the street network is composed of links (roadways segments) and nodes (intersections). At the nodes, capacities at turns (turning movements) are used to represent basic traffic control constraints. Travel demand enters and exits the street network at nodes called TAZ centroids. These centroids are connected to the network with links called connectors.

In the Duvall Model, the scope of the street network includes most major roads in the City of Duvall and nearby areas. Street alignments and attributes of the existing street network (such as posted speeds, lanes, and traffic controls) were obtained from GIS data sources and field observation in spot areas. Visum software allows direct integration with available GIS information. A map of the network is shown in Figure 1.

4.2 Future Baseline Street Network

Adapted from the existing street network, the future baseline street network typically includes various planned, programmed, or otherwise committed network improvements. As part of the Duvall Model development and planning process, the following future 2035 baseline network improvements were assumed.

- Extend 1st Avenue NE north to NE Cherry Valley Road.
- Connect 275th Ave NE to Manion Way NE (NE 175th Street)
- 1st Avenue NE connection between NE 145th Street and NE 143rd Street
- 265th Avenue NE (approximate) connection between NE 143rd Street and NE Big Rock Road
- 3rd Avenue NE connection between NE 143rd Street and NE Big Rock Road
- 273rd Avenue NE connection between NE 143rd Street and NE Big Rock Road
- Upgrade capacity at Wood-Duvall Road/SR 203 signal
- New signal at NE 145th Street/SR 203
- New roundabout at NE Big Rock Road/3rd Avenue NE

The Duvall Model is only sensitive to projects that make major changes to roadway capacities, roadway posted speeds, and intersection traffic controls. Projects with minor capacity changes or related only to safety, maintenance, and non-motorized facilities are not applicable for Duvall Model scenarios.

4.3 Link Types

Link types are used to define the basic roadway attributes assumed by the model. Specific link capacities are assigned to each link type based on access control type, posted speeds, restricted vehicle modes, and number of lanes. For consistency and quality control purposes, the Duvall Model automatically updates link speeds and capacities based on a link type lookup table (when the model runs). This reduces the risk for link attribute errors in the model. The link type look up table is provided in Appendix A.

4.4 Node Types and Turn Capacities

Similar to link types, node types are used to define basic intersection control types. These types account for most basic types of intersections. These node types set the assumed turn capacities and basic turn delays from the major and minor approaches. Specific turn capacities are assigned to each node type, based on whether the intersection is uncontrolled, stop-controlled, or controlled with a traffic signal or roundabout.

For consistency purposes, the Duvall Model automatically updates capacities and base delays of turns based on the node type. This reduces the risk for model coding error, and reduces the effort in maintaining the model. Node type descriptions are included in Appendix A.

4.5 Volume-Delay Functions

Volume-delay functions dictate the level of delay along roadways or at intersections as traffic volumes approach network capacity. In other words, they calculate traffic congestion. Volume-delay functions were used to calculate both link (roadway) delays and turn (intersection-related) delays.

In the Duvall Model, link delays were calculated with "Conical" functions and generally follow the characteristics outlined below:

- Freeway Links. Congested speeds remained at freeway speeds until approximately 80 percent of capacity. At 90 percent, speeds drop close to 45 mph. At capacity, speeds represent stop and go conditions (about 30 mph).
- Non-Freeway Links. At 80 percent of capacity, congested speeds drop to about 60 to 70 percent of free-flow speeds. At capacity, congested speeds drop to about 30 to 35 percent of free-flow speeds.

In the Duvall Model, base turn delays were assigned to each turn based on intersection type. Additional turn delays were calculated with the "TModel Nodes" function. This function is sensitive to the volume-to-capacity ratios at the turning movement level. Characteristics of this function parameter set include:

- At 50 percent of turn capacity, additional delays are less than 5 seconds per vehicle.
- At 80 percent of capacity, additional delays are approximately 30 seconds per vehicle.
- At capacity, additional delays are approximately 75 seconds per vehicle.

4.6 Other Inputs

Multipoint assignment (MPA) was used for several TAZs in the Duvall Model. MPA refers to assigning a specific percentage of travel demand to a connector for TAZs that have multiple connectors, rather than allowing the shortest path to the centroid dictate connector traffic. However, the default setting for each TAZ is to not use MPA unless it is needed.

Chapter 5. Validation and Reasonableness Checks

The process of model validation and reasonableness checks confirms if the model building blocks, if correctly applied, reasonably predict real world travel patterns and is valid for forecasting and other transportation planning purposes. Several statistics were reviewed that were associated with screen line volumes and individual link volumes. Distribution and trip generation characteristics were reviewed using various checks.

5.1 Screen Line Analysis

Screen lines (a boundary line which identifies all links between two areas) were defined to compare model travel patterns to actual travel patterns between two areas. Screen line locations for each county model are shown in Figure 2.

Table 4 shows the screen line results for the Duvall Model. Percent difference maximums vary by volume and are based on guidance from *Travel Model Validation and Reasonableness Checking Manual* (FHWA, 2010), but generally anything less than 22 percent is acceptable.

Table 4. Screen Line Results

	Southbound/ Eastbound[1]			Northbound/ Westbound[2]			Both Directions		
	Model[3]	Count[4]	Diff[5]	Model	Count	Diff	Model	Count	Diff
East of SR 203 (South)	728	625	16%	419	420	0%	1147	1045	10%
East of SR 203 (North)	569	505	13%	342	425	-20%	911	930	-2%
EW Central	759	865	-12%	890	985	-10%	1649	1850	-11%

1. Volumes crossing screenline going southbound or eastbound
2. Volumes crossing screenline going northbound or westbound
3. Represents the sum of all model volumes crossing the screen line in that direction
4. Represents the sum of all count volumes crossing the screen line in that direction
5. Represents to percent difference between the count and model volumes. Percent difference maximums vary by volume and are based on guidance from *Travel Model Validation and Reasonableness Checking Manual* (FHWA, 2010), but generally anything less than 22 percent is acceptable.

As shown in Table 4, all screen lines performed within an acceptable difference of 22 percent, based on recommendations in the *FHWA Manual*. Given overall model travel patterns, these results were considered acceptable.

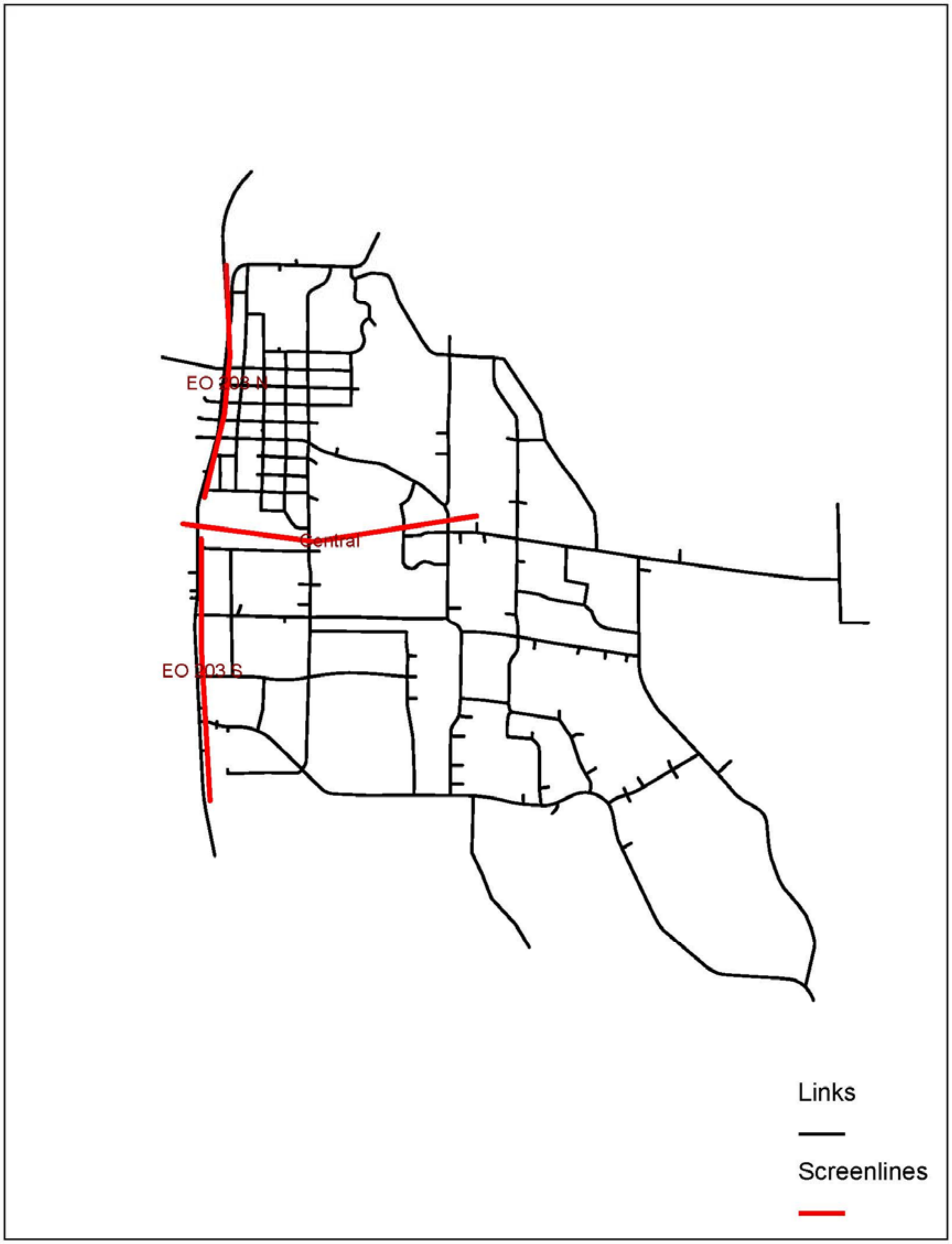

Figure 2. Screen Lines in Duvall Model

5.2 Link Volume Analysis

The analysis of roadway link volumes compares roadway model volumes to actual traffic counts, by direction, for all locations where actual traffic counts are provided. Two common link volume statistics were reviewed to evaluate the model validity: Percent Root-Mean-Square-Error (RMSE) and R-squared or "goodness of fit".

Percent RMSE was calculated by roadway group to understand model behavior on key facilities. Percent RMSE is essentially the average of all the link-by-link percent differences—a good statistic to understand percent difference variability on links of a particular functional class. Table 5 shows the percent RMSE results for the different roadway groups during each respective time period. Generally, results below 40 percent RMSE are considered acceptable.

R-squared indicates how well the model volumes represent the actual traffic counts. If model volumes exactly matched the actual counts, the R-squared value would be 1.00. For the Duvall Model the overall model R-squared was 0.96, which is better than the maximum 0.88 suggested in the *Travel Model Validation and Reasonableness Checking Manual* (FHWA, 2010).

Table 5. Link Volume Statistics

	RMSE[1]	R-squared[2]	Difference[3]
State Routes	13%	0.82	9%
Arterial Streets	16%	0.93	12%
Collector Streets	34%	0.81	26%
Other Streets	36%	0.82	30%
Total	21%	0.96	14%

1. Percent Root-Mean-Square-Error (RMSE) refers to the percent difference on an average link-by-link basis.
2. R-squared indicates how well the model volumes represent the actual traffic counts. If model volumes exactly matched the actual counts, the R-squared value would be 1.00.
3. Refers to the percent difference on a total volume basis (sum total of all links).

Based on the data shown in Table 5 the Duvall Model link-by-link variability (Percent RSME and R-squared) was considered acceptable. Maximums were established based on guidance from FHWA (*Travel Model Validation and Reasonableness Checking Manual*, FHWA, 2010). The link analysis scatterplot is shown in Figures 3.

5.3 Distribution Checks

Distribution checks relate to how the model is distributing and assigning trips through the model. The following types of distribution checks were performed.

5.3.1 Average Trip Lengths

In large area travel demand models, the average trip lengths for the main trip types are compared back to regional travel survey results. In the Duvall Model, the geographic extents are too small to compare back to typical survey results. It is still useful to confirm that commute trips are longer than the typically short non-home based trips.

The average trips lengths were compiled for the main trip types: home-based work (HBW) which is composite of HW and WH trips; home-based other (HBO) which is composite of HO and OH trips; and non-home based (NHB). For the Duvall Model, average trip lengths were 4.2, 4.2, and 2.6 minutes for the HBW, HBO, and NHB trips, respectively. These average trip lengths are acceptable given the geographic extents of the model and the location of land uses.

5.3.2 Select-Link and Select-Zone Analysis

Select-link and select-zone refers to isolating a roadway or TAZ and flagging only those trips on the model network that are associated with that link or zone. This can identify problems with trip generation, trip distribution, and/or trip assignment model parameters. Select-link and select-zone analysis was performed at key roadways and TAZs to test the reasonableness of the model. This included major bridges, external TAZs, and major employment centers. In addition, select-link analysis was compared to past Origin-Destination surveys for major roadways in the Duvall area.

For the Duvall Model this process resulting in adjustments to external distribution parameters and improved network coding (nodes, links, and centroid connectors).

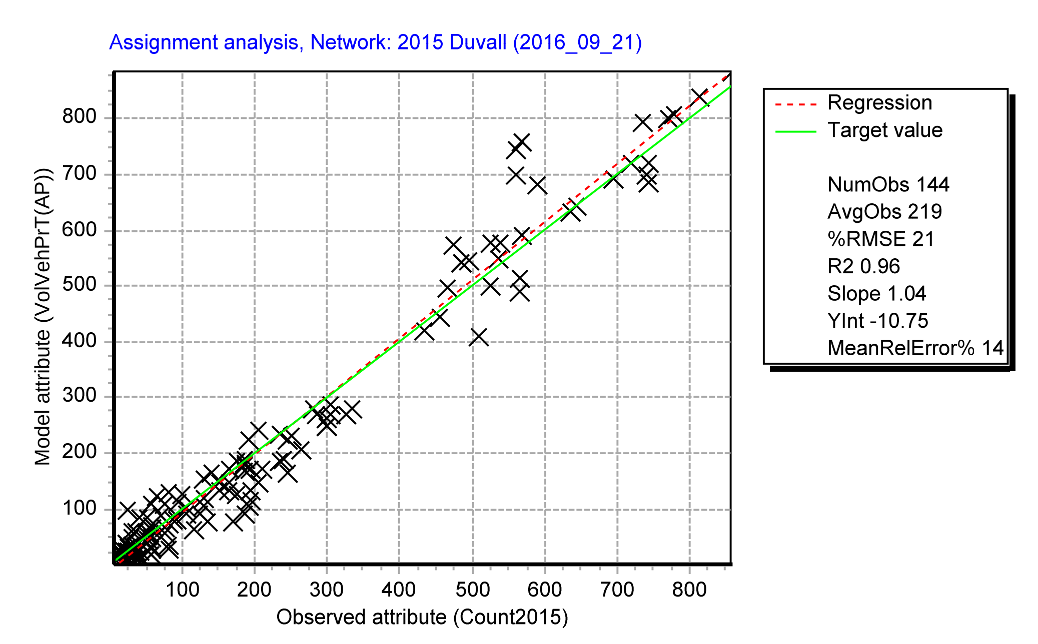

Figure 3. Link Analysis Scatterplot

Appendix A: Link and Node Types

APPENDIX A
Link Type Descriptions

Link Type	Description	Number of Lanes (per direction)	Capacity (vehicles per hour)	Speed (mph)
1	Blocked	0	0	0
2	Freeway (60mph, 2ln per dir)	2	3,600	60
3	Freeway (60mph, 3ln per dir)	3	5,400	60
4	Freeway (60mph, 4ln per dir)	4	7,200	60
5	Freeway (60mph, 5ln per dir)	5	9,000	60
6	Freeway (60mph, 6ln per dir)	6	10,800	60
7	Freeway (70mph, 2ln per dir)	2	3,600	70
8	Freeway (70mph, 3ln per dir)	3	5,400	70
11	Ramps (45mph, 1ln per dir)	1	1,500	45
12	Ramps (45mph, 2ln per dir)	2	3,000	45
13	Ramps (45mph, 3ln per dir)	3	4,500	45
14	Ramps (35mph, 1ln per dir)	1	1,200	35
15	Ramps (35mph, 2ln per dir)	2	2,400	35
16	Ramps (35mph, 3ln per dir)	3	3,600	35
17	Ramps (25mph, 1ln per dir)	1	1,200	25
18	Ramps (25mph, 2ln per dir)	2	2,400	25
19	Ramps (25mph, 3ln per dir)	3	3,600	25
20	HOV (55mph, 1ln per dir)	1	1,600	55
21	HOV (55mph, 2ln per dir)	2	3,200	55
22	Non-Freeway (55mph, 2ln)	1	1,600	55
23	Non-Freeway (55mph, 3ln)	1	1,700	55
25	Non-Freeway (55mph, 5ln)	2	3,000	55
26	Freeway (55mph, 2ln per dir)	2	3,600	55
27	Freeway (55mph, 3ln per dir)	3	5,400	55
28	Freeway (55mph, 4ln per dir)	4	7,200	55
29	Freeway (55mph, 5ln per dir)	5	9,000	55
32	Non-Freeway (50mph, 2ln)	1	1,600	50
33	Non-Freeway (50mph, 3ln)	1	1,700	50
35	Non-Freeway (50mph, 5ln)	2	3,000	50
40	HOV (45mph, 1ln per dir)	1	800	45
42	Non-Freeway (45mph, 2ln)	1	1,350	45
43	Non-Freeway (45mph, 3ln)	1	1,500	45
44	Non-Freeway (45mph, 4ln)	2	2,700	45
45	Non-Freeway (45mph, 5ln)	2	3,000	45
47	Non-Freeway (45mph, 7ln)	3	4,500	45
50	HOV (40mph, 1ln per dir)	1	800	40
52	Non-Freeway (40mph, 2ln)	1	900	40
53	Non-Freeway (40mph, 3ln)	1	1,100	40
54	Non-Freeway (40mph, 4ln)	2	1,650	40
55	Non-Freeway (40mph, 5ln)	2	2,200	40
57	Non-Freeway (40mph, 7ln)	3	4,500	40
60	HOV (35mph, 1ln per dir)	1	800	35
62	Non-Freeway (35mph, 2ln)	1	900	35
63	Non-Freeway (35mph, 3ln)	1	1,100	35
64	Non-Freeway (35mph, 4ln)	2	1,650	35
65	Non-Freeway (35mph, 5ln)	2	2,200	35
67	Non-Freeway (35mph, 7ln)	3	3,300	35
68	Non-Freeway (35mph, 8ln)	4	4,500	35
70	HOV (30mph, 1ln per dir)	1	800	30
72	Non-Freeway (30mph, 2ln)	1	900	30
73	Non-Freeway (30mph, 3ln)	1	1,100	30
74	Non-Freeway (30mph, 4ln)	2	1,400	30
75	Non-Freeway (30mph, 5ln)	2	2,000	30
80	HOV (25mph, 1ln per dir)	1	800	25
82	Non-Freeway (25mph, 2ln)	1	550	25
83	Non-Freeway (25mph, 3ln)	1	825	25
84	Non-Freeway (25mph, 4ln)	2	900	25
85	Non-Freeway (25mph, 5ln)	2	1,300	25
90	HOV (60mph, 1ln per dir)	1	1,600	60
91	HOV (60mph, 2ln per dir)	2	3,200	60
92	Non-Freeway (20mph, 2ln)	1	350	20
93	Non-Freeway (20mph, 3ln)	1	550	20
99	Connector	1	99,999	25

Source: Transpo Group

APPENDIX A - Continued
Node Type Descriptions

Node Type	Description
1	Shape node (no delay)
5	TWSC (uses node delay, in addition to turn delay)
10	AWSC
20	Roundabout[1]
30	Traffic Signal[2]

Source: Transpo Group

1. Roundabout defaut capacities reflect single-lane roundabout
2. Traffic signal default capacities reflect unbalanced major-minor volumes, and single left-turn lanes

Turn Capacities and Delays based on Node Types

	Turn Capacities (vehicles per hour)						Initial Turn Delay (seconds)					
	Major Approach			Minor Approach			Major Approach			Minor Approach		
Node Type	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
1	99999	99999	99999	99999	99999	99999	0	0	0	0	0	0
5	800	99999	99999	800	500	500	5	2	5	15	15	8
10	500	500	500	500	500	500	15	15	15	15	15	15
20	800	800	800	800	800	800	5	5	5	5	5	5
30	300	2800	1000	300	1000	500	12	3	6	15	5	8

Source: Transpo Group

NOTE: Use the turn attribute "TurnCapFactor" to manually adjust any of the above default turn capacities.

Appendix B: Detailed TAZ Map