Section 3
Assumptions and Methods

ASSUMPTIONS AND METHODS

The following sub-sections describe the assumptions and methods used to develop the existing and future conditions analysis. Readers primarily interested the results of the existing and future conditions results can proceed to Sections 4 through 9, which present the results for the specific geographic sub-areas within Clackamas County as well as the County as a whole.

EXISTING CONDITIONS ANALYSIS

The existing conditions analysis includes an inventory and evaluation of the existing Clackamas Country transportation system. The purpose of the existing conditions analysis is to document the baseline transportation system within the Transportation System Plan (TSP) project area. The following describes the methodology and approach to the analysis.

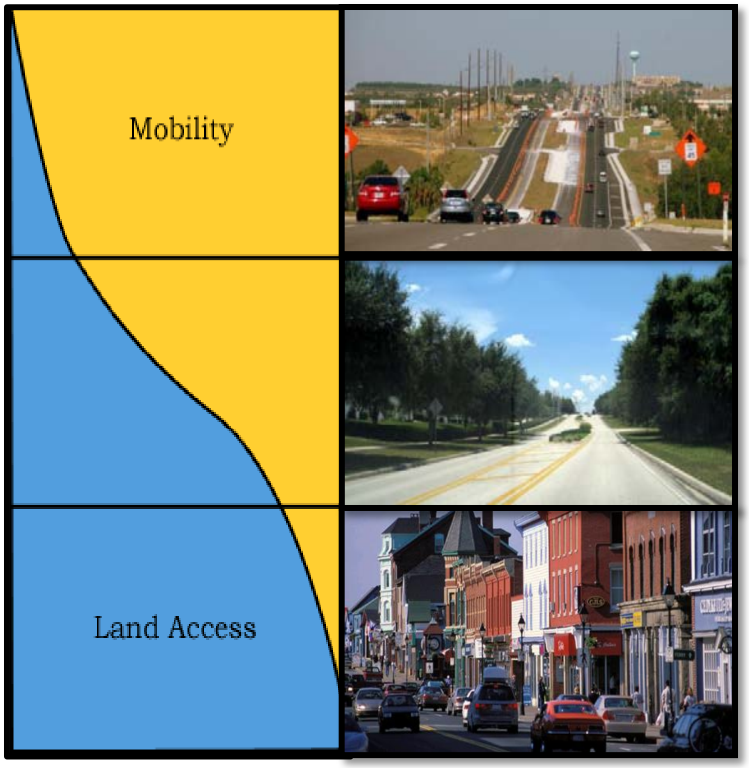
Roadway System

The following section describes the approach for characterizing the roadway system in Clackamas County. It is intended to define the functional classifications, roadway jurisdictions, and access management policies currently used by the County. Maps characterizing the roadway system are provided in each geographic sub-area.

Roadway Functional Classifications

A street's functional classification reflects its role in the transportation system and defines desired operational and design characteristics. Classifying roadways creates a mechanism through which a balanced transportation system can be developed that facilities mobility for all modes of transportation as well as access to adjacent land uses. Mobility is defined as the ease with which people and goods move through the transportation system. Exhibit A1 illustrates the relationship between access and mobility relative to street classification. A roadway's classification determines its intend purposes and helps guide design features such number of travel lanes, right-of-way width, multi-modal facilities, landscaping, and street furniture. Typically, the higher the classification of a roadway, the more mobility is a priority and the less access is allowed. Exhibit A1 illustrates arterials emphasize mobility, with fewer accesses to adjacent land uses and roadways. Mobility refers vehicular speed and the ease with which people and goods move, implying a multi-modal view of mobility. Roadways with lower classifications provide increasing access, but less mobility. Local roadways typically provide access to adjacent land uses and developments at the cost of moving people and goods quickly.

Exhibit A1 Relationship between Access, Mobility, and Functional Classification



Clackamas County has established a functional classification system for roadways owned by the County in its current Comprehensive Plan. A brief description of each classification is provided below. Further information related to these classifications, including design guidelines, is provided in *Appendix 1: Functional Classifications.*

Freeway and Expressway

The primary function of freeways and expressways is to serve interregional and intraregional trips. They are intended to carry a heavy volume of traffic at a high speed. Therefore, access is limited and roadside parking is only allowed for emergency purposes. Bike, pedestrian, and transit facilities are not provided on freeways and expressways. I-205 and Hwy 224 are both examples of freeways and expressways within Clackamas County.

Major Arterial

The primary functions of major arterials are to carry local and through traffic to and from destinations outside local communities and to connect cities and rural centers. Traffic volumes are typically moderate to heavy, and speeds are expected to be moderate to high. Access is limited on major arterials. Sidewalks and landscape strips should be provided in urban areas. Major arterials are also intended to serve as bikeways[1],

[1] Bikeways typically include bicycle lanes, multi-use paths, or other facilities specifically designated for bicycle travel, whether exclusively or with other vehicles or pedestrians.

emergency response routes, and transit routes. SE McLoughlin Boulevard is an example of a major arterial within Clackamas County.

Minor Arterial

The primary function of minor arterials is to connect collectors to higher order roadways. They carry a moderate volume of traffic at a moderate speed. Access is restricted, but may be allowed if no other alternatives are available. Like with major arterials, sidewalks and landscape strips are provided in urban areas. Minor arterials are intended to serve as bikeways, emergency response routes, and transit routes. SE River Road and SE Oatfield Road are examples of minor arterials in Clackamas County.

Collector

The primary function of collectors is to carry traffic within neighborhoods or single land use areas. They link neighborhoods with major activity centers, other neighborhoods, and arterials. Generally collectors are not used for through traffic and should intersect minor arterials rather than major arterials. Traffic volumes are low to moderate and travel at low to moderate speed. Access is generally allowed, but may be restricted on collectors with high volume, high access, impaired visibility, or other significant problems. Access to residential driveways is limited. Parking is generally allowed on collectors, but again may be restricted if there are significant problems. Sidewalks and landscape strips are provided in urban areas. Collectors also serve as bikeways, emergency response routes, and transit routes. SE 132nd Avenue and SE 122nd Avenue are examples of collectors within Clackamas County.

Connector

The primary function of a connector street is to collect traffic from and distribute traffic to local streets within neighborhoods or industrial districts. Connectors are usually longer than local streets, but have lower traffic volumes and speeds than collectors. Connectors primarily serve access and local circulation functions, not through traffic. Traffic calming measures may be used to slow traffic on connector streets. Connectors should connect to collector and minor arterials. Access is allowed and roadside parking is allowed if width is sufficient. Sidewalks are required on all new connector streets within urban areas only. Connectors may also serve as bikeways if right-of-way allows.

Local Streets

The primary function of local streets is to provide access to abutting property and connect properties to higher order roads. New local roads should intersect connector, collectors, or, if necessary, minor arterials. Local streets are not intended for through traffic. Traffic calming measures may be used to slow traffic on local streets. Access is allowed and roadside parking is allowed if width is sufficient. Sidewalks are required on all new local streets within the UGB when development or redevelopment occurs on existing streets. Local streets are not intended to serve as bikeways.

ODOT Classifications

The Oregon Highway Plan (OHP) provides functional classifications for all state facilities. The classifications recognize that different highway types have importance for certain areas and users. They help to guide

ODOT priorities for system investment and management. The Oregon Transportation Commission is responsible for establishing and modifying the classification system and routes in them. The classifications used on ODOT facilities include Interstate Highways (NHS), Statewide Highways (NHS), Regional Highways, District Highways, and Local Interest Roads. The classifications on ODOT facilities dictate roadway design and performance standards. The OHP was revised in 2011 and the most current ODOT classifications can be found on ODOT's website at http://www.oregon.gov/ODOT/TD/TP/docs/ohp/policyelement.pdf.

Roadway Jurisdiction

Public roadways in Clackamas County are operated and maintained by cities within the County, Clackamas County, or the Oregon Department of Transportation (ODOT). Each jurisdiction is responsible for the following:

- Determining the road's functional classification;
- Defining the roadway's major design and multimodal features;
- Maintenance and operations; and,
- Approving construction and access permits.

Coordination is required among the jurisdictions to plan, operate, maintain and improve the transportation system. The TSP Update's existing conditions analysis will include analysis of only County and ODOT facilities located outside of incorporated areas. County roadway facilities located within incorporated will be analyzed as part of ongoing or future city TSP projects.

Access Spacing and Management

The access spacing allowed on a roadway depends on the roadway's functional classification. Typically, providing additional access on a roadway reduces the roadways' mobility. Therefore, roadways on the higher end of the functional classification system (i.e., arterials and major collectors) tend to have higher spacing standards, while facilities such as minor collectors and local streets allow more closely spaced access points. Managing access on the street system is important in order to preserve street function for carrying through traffic.

The Oregon Transportation Planning Rule (TPR) defines access management as a set of measures regulating access to streets, roads, and highways, from public roads and private driveways. The TPR requires that new connections to arterials and state highways be consistent with designated access management categories.

Clackamas County Access Requirements

Clackamas County access requirements for urban areas are provided in the County's Comprehensive Plan and shown in Table A 1. The access standards intend to balance the need for mobility with the need for access to property. When feasible, access should be limited on roadways with higher functional classifications and joint accesses between developments shall be encouraged.

Table A 1 Clackamas County Access Requirements by Functional Classification, Urban Areas Only

Function Classification	Signal Spacing	Street Access	Driveway Access
Major and Minor Arterials	**Major Arterials**: 1,000 feet apart **Minor Arterials**: 600 feet apart	Only collectors, connectors, or other arterials should intersect arterials. **Major Arterials**: 400 feet between unsignalized and signalized intersections **Minor Arterials**: 300 feet between unsignalized and signalized intersections	Access for single family residential driveways should not access a major or minor arterial. Access for developments should be located on streets with a lower functional classification when possible. **Major Arterials**: 400 from intersections **Minor Arterials**: 300 feet from intersections
Collector			Single family driveways should not access a collector street if feasible. When allowed, driveway spacing should be at least 100 feet. Development access requires a minimum driveway spacing of 150 feet when feasible.
Local			25 feet of the right-of-way lines at an intersection.

ODOT Access Management Standards

The Oregon Highway Plan (OHP) specifies Access Management Policies and standards that should be applied to the development of all projects along ODOT facilities as well as planning processes involving state highways. Future developments along state facilities (new development, redevelopment, zone changes, and/or comprehensive plan amendments) will be required to meet the OHP Access Management policies and standards. The policies manage the location, spacing and type of road and street intersections and approach roads on state highways based on highway classification and posted speed limit. The intent is to assure the safe and efficient operation of state highways consistent with the function of the highways. The Classification and Spacing Standards in the OHP were revised in 2011 and can be found on ODOT's website at http://www.oregon.gov/ODOT/HWY/ACCESSMGT/docs/pdf/734-051.pdf.

Intersection Traffic Operations Analysis

Existing traffic operations were assessed at 125 selected study intersections throughout the County. These intersections were selected based on input from the County staff and ODOT. Intersections were selected for several reasons, including:

- Intersections that have been affected by transportation projects since the last TSP Update;
- Intersections that will be affected by planned transportation projects;
- Intersections that are suspected of performing poorly under existing conditions; and
- Intersections that are expected to perform poorly in the future based on anticipated travel demand.

The following sub-sections describe the scope of this analysis, methodology, performance standards, and traffic count data used in the evaluation.

Scope of Analysis

The TSP organized the County into two basic areas for purposes of establishing the scope of analysis for the traffic operations analysis. The scope for each of the two areas is described below.

1. **Areas Inside the Metro Urban Growth Boundary (UGB)**

Within the Metro UGB, analysis was conducted on selected County and ODOT facilities that are in unincorporated areas outside of city planning areas. ODOT methods and procedures in the *Analysis Procedures Manual* were used to guide analysis on ODOT facilities. No analysis was conducted on City facilities. No analysis was conducted for County or ODOT facilities within incorporated areas or city planning areas.

2. **Areas Outside the Metro UGB**

For areas outside the Metro UGB, analysis was conducted on selected County and ODOT facilities. ODOT methods and procedures in the *Analysis Procedures Manual* were used to guide analysis on ODOT and County facilities. However, County facilities were not seasonally adjusted as described below. As within the UGB, no analysis was conducted on city facilities.

The traffic operations analysis for the 125 study intersections are discussed within Sections 4 through 8.

Methodology and Performance Standards

Intersection operations were analyzed in accordance with the procedures stated in the 2000 *Highway Capacity Manual (HCM)* and the Analysis Procedures Manual (APM). Based on guidance in the APM, the default value for base saturation flow rates of 1750 passenger cars per hour of green per lane (pcphgl) outside the Portland MPO urban areas and 1900 pcphgl inside the UGB were used. Traffic operations at intersections are generally described using three measures:

- **Level of Service** (LOS): represents ranges in the average amount of delay that motorists experience when passing through the intersection. LOS is measured on a scale from "A" (best) to "F" (worst). At signalized, all-way stop-controlled intersections, and roundabouts, LOS is based on the average delay experienced by all vehicles entering the intersection. At two-way stop controlled intersections, LOS is based on the average delay experienced by the critical movement at the intersection, typically a left-turn from the stop controlled street.
- **Volume-to-capacity ratio** (V/C): represents the relationship between the vehicular demand at an intersection and the capacity of the intersection. In general, a v/c ratio less than 0.85 indicates that the intersection is operating at adequate capacity and vehicles are not expected to experience significant queues and delays. As v/c ratio approaches or exceeds 1.0, traffic flow may become unstable and extensive delays and queues result. At signalized intersections, the v/c is based on all movements and is given for the overall intersection. At roundabouts and two-way stop controlled intersections, the v/c ratio expressed is for the critical movement.
- **Delay** (expressed in seconds): represents the expected delay experienced by motorists at the intersection. At a signalized, all-way stop-controlled intersections, and roundabouts, the delay

reported is typically the average delay experienced by all vehicles entering the intersection. At a two-way stop controlled intersections, the delay reported is typically the average delay experienced by the critical movement at the intersection, typically a left-turn from the stop-controlled approach.

These existing standards by which the performance is measured (the TSP Update may select alternative measures during the alternative analysis activities) were used to compare the performance of the study intersections to performance standards and identify deficiencies. The performance standards applied vary based on jurisdiction and facility type. The performance standards applied are discussed in general below, and further described in *Appendix 2: Performance Standards.*

County Intersections

Clackamas County intersections inside the Metro UGB are subject to the standards shown in Table 3.08-2 of the Metro Regional Transportation Plan (RTP). Metro has developed motor vehicle performance indicators that vary based on location of the facility. The standards are based on volume-to-capacity ratios for the 1st hour and 2nd hour during the PM 2-Hour Peak, as well as during the Mid-Day One-Hour Peak. The v/c ratio standards for the 1st hour during the PM 2-Hour Peak were used. For signalized intersections, the v/c ratio standard applies to the overall intersection v/c ratio. At roundabouts, all-way stop-controlled intersection, and two-way stop controlled intersections, the v/c ratio applies to the critical movement. *Table 3.08-2 is provided in Appendix 2: Performance Standards.*

According to the Clackamas County Comprehensive Plan, County intersections outside the Metro UGB have a performance standard of LOS “D.” This standard refers to the average LOS experience by all vehicles entering the intersection at signalized, all-way stop-controlled intersections, and roundabouts. At two-way stop controlled intersections, this standard refers to the LOS experienced by the critical movement at the intersection, typically a left-turn from the stop-controlled road. The operations of the County study intersections are compared to these performance standards to identify deficiencies.

ODOT intersections

ODOT presently uses volume-to-capacity ratio standards to measure vehicular highway mobility performance and make initial determinations of facility needs necessary to maintain acceptable and reliably levels of mobility. However, achieving necessary v/c targets will not necessarily be the determinant of the transportation solutions. ODOT recognizes that other transportation modes and regional and local planning objectives need to be considered as well. Highway mobility targets are used in transportation system planning to provide a measure by which the existing and future performance of the highway system can be evaluated. The Oregon Highway Plan (OHP) provides maximum volume-to-capacity ratios for all signalized and unsignalized intersections and interchange ramp terminals. Performance standards vary based on the highway category, the location of the facility (within a Special Transportation Area, Metropolitan Planning Organization, Urban Growth Boundary, unincorporated community or rural lands), and the posted speed on the facility. The Portland metropolitan area has separate v/c targets that were adopted with the understanding of the unique context and policy choices that have been made by local governments in that area. Higher v/c ratios indicate that the area is anticipated to have more traffic congestion because of the land use pattern that a region or local jurisdiction has committed to through adopted local policy.

Operations on ODOT facilities are compared to the performance standards outlined in the OHP to identify deficiencies.

The Mobility Standard Guidelines for unsignalized intersections and signalized intersections other than crossroads of freeway ramps are provided in Table 6 and Table 7 of the OHP. At unsignalized intersections, the volume to capacity ratios in Tables 6 and 7 shall not be exceeded for either of the state highway approaches that are not stopped.. Unsignalized non-state highway approaches are expected to meet or not to exceed the volume to capacity ratios for District/Local Interest Roads in Table 6, except within the Portland metropolitan area UGB where non-state highway approaches are expected to meet or not to exceed a v/c of 0.99. At signalized intersections other than crossroads of freeway ramps, the volume to capacity ratio for the intersection shall not exceed the volume to capacity ratios in Tables 6 and 7. Where two state highways of different classifications intersect, the lower of the volume to capacity ratios in the tables shall apply. Where a state highway intersects with a local road or street, the volume to capacity ratio for the state highway shall apply. At crossroads of freeway ramps, the maximum volume to capacity ratio for the ramp terminals of the interchange shall be the smaller of the values of the volume to capacity ratios for the crossroad, or 0.85. At interchanges within an urban area, the maximum v/c may be increased to as much as 0.90 if certain provisions are met. The Oregon Highway Plan provides additional guidance on mobility standards and can be found at http://www.oregon.gov/ODOT/TD/TP/pages/ohp2011.aspx. *Tables 6 and 7 are provided in Appendix 2: Performance Standards.*

Traffic Volume Development for Existing Conditions Analysis

Traffic volumes were collected for the study intersections during February and March, 2012. Counts were taken between 4:00 and 6:00 p.m. on a weekday to identify the weekday p.m. peak hour for each intersection. For intersections located on ODOT facilities, the ODOT procedures in the *Analysis Procedures Manual* (APM – Reference 1) were used to develop design hour volumes. The existing count volumes were seasonally adjusted to reflect the 30th highest hour of traffic at the intersection. Seasonal factors were developed based on the On-Site ATR Method, ATR Characteristic Table Method, and ATR Seasonal Trend Table Method. A more extensive discussion of the seasonal adjustments made to each facility is included in *Appendix 3: ODOT Seasonal Adjustments.*

Roadway Segment Traffic Operations Analysis

Roadway segment traffic operations were evaluated using planning level roadway link volumes from Metro's travel demand model using the Beta Forecast; this is consistent with direction provided by Metro on May 2nd, 2012 (see *Appendix 4: Metro Memorandum*). The following sub-sections discuss the scope of the analysis, performance standards, and the traffic volumes used.

Scope of Analysis

The roadway segments included in this analysis are the roadways represented in Metro's regional travel demand model both inside and outside of urban growth boundary. In general, these are roadways with a functional classification of a major collector or higher. The analysis performed for the roadway segments under existing conditions were:

- Total roadway segment weekend evening peak period volumes; and
- Approximate level of congestion during the evening period.

The results of the existing conditions analysis is also compared to the results of the same type of analysis for the future base conditions.

Methodology and Performance Standards

Roadway segment link volumes from Metro's model using the Beta Forecast were applied in the roadway segment analysis to allow for consistent comparison of roadway volume, delay, and level of congestion across the existing conditions, 2035 Low Build Scenario and 2035 Full Build Scenario.

The level of congestion for the roadway segments were approximated by comparing the weekday evening peak period roadway link volumes to their estimated capacity. The capacity is based on the number of through lanes provided on the roadway. The volumes were obtained from Metro's regional travel demand model using the Beta Forecast. Comparing the values for volume and capacity in a volume-to-capacity ratio, which approximates what percentage of the roadway's overall capacity is being used (e.g., a roadway with a volume-to-capacity ratio of 1.0 is full or at its capacity). Table A 2 summarizes the ranges of the volume-to-capacity ratios assigned to varying degrees of congestion.

Table A 2 Volume-to-Capacity Ranges for Roadway Segment Congestion Estimates

Congestion Level	Volume to Capacity Range
Very Congested	1.1 or greater
Congested	1.0 to 1.1
Some Congestion	0.9 to 1.0
Nearing Congestion	0.8 to 0.90
Less Congested	0.0 to 0.80

It is possible for the study intersection analysis results to indicate there are intersections experiencing relatively high amounts of delay on roadway segments that are shown as experiencing relatively minimal congestion. The roadway segment analysis considers only the capacity of the lanes on the segment and the volumes on the segment. It is an idealized assessment of volume to capacity (e.g., if all vehicles were traveling in the same direction along a roadway, how many vehicles could the roadway carry). In actuality, motorists experience congestion on roadway segments due to intersection operations. The purpose of the roadway segment analysis is to help identify if the delay being experienced (or anticipated to be experienced in the future) is primarily related to the intersection or the roadway segment. Sections 4 through 8 present the results of this analysis for the roadways within each geographic sub area.

Traffic Volume Development

Metro maintains a regional travel demand model, which uses population and employment information to estimate the traffic volumes on the roadways within the Metro region and into outlying areas (e.g., rural Clackamas County). Within Clackamas County, Metro's model extends as far east as the US 26/Highway 35 junction, as far southeast as approximately 20 miles south on OR 224 from Estacada, and in the southwest extends to the Clackamas County Boundary. Weekday evening peak period volumes from Metro's Beta Forecast model were used to conduct the analysis described above.

Pedestrian and Bicycle System Analysis

The analysis of pedestrian and bicycle system included in this report is based on existing inventory data obtained from the County, Trimet, and ODOT. The intent is to compare existing facilities with the County's current roadway standards, which state that all Major Arterials, Minor Arterials, Connectors, and Collectors are intended to serve as bikeways (bike lanes in urban areas and 6-foot shoulder bikeways in rural areas) and that sidewalks should be provided on all Major Arterials, Minor Arterials, Collectors, and Local Streets in urban areas. In rural areas, sidewalks are only required in "unincorporated communities". These are identified as Rural Centers in the pedestrian maps and include Rural Communities, Rural Service Centers, Resort Communities and Urban Unincorporated Communities as defined by the County's Comprehensive Plan. Within "unincorporated communities", sidewalks or walkways should be provided adjacent to or within areas of development, such as schools, businesses, or employment centers near or along highways. The County's current comprehensive plan identifies the Essential Pedestrian Network in the urban area and the Essential Bicycle Network in the urban and rural areas (included in *Appendix 5: Essential Pedestrian and Bicycle Networks*).

The Essential Pedestrian Network includes nearly all arterials and collectors and identifies the local roadways that are critical links in the pedestrian network. The Essential Bicycle Networks for the urban and rural areas include nearly all arterials and collectors plus planned multi-use trails.

Gaps in the pedestrian and bicycle networks are defined as anything on the Essential Networks that is not completed. Gaps in the rural area pedestrian network include all facilities within the Rural Centers that do not have a sidewalk or walkway adjacent to or within areas of development, such as schools, businesses, or employment centers near or along highways. Deficiencies in the system include areas where the facility is sub-standard (too narrow or poor pavement conditions) or where the roadway crossings are inadequate. The County's Pedestrian and Mike Master Plans have identified priority projects for filling in the network gaps. This report seeks to verify the existing networks in order to gain an updated view of the gaps in the current pedestrian and bicycle networks. Subsequent phases of the TSP Update process will include evaluating potential changes to the Essential Networks and updating priorities for completing the Essential Networks, including a revaluation of the Pedestrian and Bike Master Plan projects to determine if they should remain high priority projects based on the TSP Vision and Goals evaluation criteria.

Transit Level-of-Service Analysis

The transit level-of-service analysis included in this report is based on the methodology described in *TCRP Report 100: Transit Capacity and Quality of Service Manual* (TCQSM-Reference 2). Chapter 3 of the TCQSM provides an extended discussion on quality of service, which is the evaluation of transit service from the passenger's point-of-view. The TCQSM uses six measures to quantify service quality. Each of these measures is assigned a letter value, where LOS A represents the best service from the passenger perspective and LOS F represents the worst service. *(Note that high LOS values, such as LOS A or B, may not reflect optimal service from the transit agency's perspective, because the market may not support those service levels. The* *development of agency service standards helps to bridge the gap between the kind of service passengers would ideally want and the kind of service that is reasonable to provide, given available resources.)* The transit LOS approach mirrors the system commonly used for streets and highways, and allows a speedy comparison of service performance to transit passenger desires.

Of the six available measures, three were selected for this analysis as being most relevant to a long-range planning effort. Table A 3 summarizes the TCQSM measures used and the ranges of values used to determine the LOS result for each measure.

Table A 3 Transit Capacity and Quality of Service Manual - Level of Service (LOS) Measures

Level of Service	Transit Capacity and Quality of Service Measures		
	Service Frequency (minutes)	Hours of Service	Service Coverage
LOS A	<10	19-24	90.0-100.0%
LOS B	10-14	17-18	80.0-89.9%
LOS C	15-20	14-16	70.0-79.9%
LOS D	21-30	12-13	60.0-69.9%
LOS E	31-60	4-11	50.0-59.9%
LOS F	>60	0-3	<50.0%

Service Frequency

From the user's perspective, *service frequency* determines how many times an hour a user has access to transit service, assuming that service is provided within acceptable walking distance (measured by *service coverage*) and at the times the user wishes to travel (measured by *hours of service*). Service frequency also measures the convenience of transit service to choice riders and is one component of overall transit trip time (helping to determine the wait time at a stop). Table A 4 describes the level of service thresholds for service frequency.

Table A 4 Service Frequency – Level of Service Thresholds

Level of Service	Description of Service Frequency
LOS A	Passengers are assured that a transit vehicle will arrive soon after they arrive at a stop. The delay experienced if a vehicle is missed is low.
LOS B	Service is still relatively frequent, but passengers will consult schedules to minimize their wait time at the transit stop.
LOS C	Service frequencies still provide a reasonable choice of travel times, but the wait involved if a bus is missed becomes long.
LOS D	Service is only available about twice per hour and requires passengers to adjust their routines to fit the transit service provided.
LOS E	Service is provided approximately once per hour and puts passengers in the position of potentially spending long periods of time waiting for service and/or rearranging schedules to be able to take transit.
LOS F	Service is provided frequencies greater than 1 hour, which entails creative planning or considerable wasted time on the part of passengers.

Hours of Service

Hours of service, also known as "service span," is the number of hours during the day when transit service is provided along a route, a segment of a route, or between two locations. It plays as important a role as *frequency* and *service coverage* in determining the availability of transit service to potential users: if transit service is not provided at the time of day a potential passenger needs to take a trip, it does not matter where or how often transit service is provided the rest of the day. Table A 5 describes the level of service thresholds for hours of service.

Table A 5 Hours of Service – Level of Service Thresholds

Level of Service	Description of Hours of Service
LOS A	Service is available for most or all of the day. Workers who do not work traditional 8-to-5 jobs receive service and all riders are assured that they will not be stranded until the next morning if a late-evening bus is missed.
LOS B	Service is available late into the evening, which allows a range of trip purposes other than commute trips to be served.
LOS C	Bus service runs only into the early evening, but still provides some flexibility in one's choice of time for the trip home.
LOS D	Service meets the needs of commuters who do not have to stay late and still provides service during the middle of the day for others.
LOS E	Midday service is limited or non-existent and/or commuters have a limited choice of travel times.
LOS F	Transit service is offered only a few hours per day or not at all.

Service Coverage

Service Coverage is a measure of the area within walking distance of transit service. Areas must be within 1/4-mile of a bus stop (or service route if there are no designated stops) or 1/2 mile of a transit station to be considered an area served by transit. As with the other availability measures, service coverage does not provide a complete picture of transit availability by itself, but when combined with frequency and hours of service, it helps identify the number of opportunities people have to access transit from different locations. Service coverage LOS evaluates the percentage of transit-supportive areas—areas that would typically produce the majority of a system's ridership—that are served by transit.

To qualify as a transit-supportive area (TSA) one of the following thresholds must be met:

- Minimum population density of 3 households/gross acre; or
- Minimum job density of 4 employees/gross acre.

Service coverage is an all-or-nothing issue for transit riders—either service is available for a particular trip or it is not. As a result, there is no direct correlation between service coverage LOS and what a passenger would experience for a given trip. Rather, service coverage LOS reflects the number of potential trip origins and destinations available to potential passengers. As noted in Table A 3, at LOS A, 90 percent or more of the TSA's have transit service; at LOS F, less than half of the TSA's have service.

While transit service coverage area includes everything within a ¼ mile of scheduled service, paratransit service coverage is typically provided up to ¾ of a mile of scheduled service.

Transit Gaps and Deficiencies

Gaps in the transit system are defined as the areas that have future densities supportive of transit that are not currently served by transit. The County does not currently have transit level-of-service standards; however, a target standard could be set for frequency (how long between buses) and hours of service (how many hours per day the bus operates).

Crash Analysis

The existing conditions crash analysis considered: 1) Locations within the County identified as safety priorities by the Oregon Department of Transportation; 2) Primary crash types contributing to the majority of serious injury and fatal crashes in the County; and 3) Specific safety focus intersections County staff has identified.

Statewide Safety Priority Locations

On an annual basis, the Oregon Department of Transportation identifies safety priority locations through their Statewide Priority Index System (SPIS). The SPIS process identifies locations for review and potential improvements based on their crash history. SPIS locations listed in the top 5% and 10% represent locations that have historically experienced a higher number and/or higher severity of crashes than other locations in the state. Clackamas County applies the same methodology as ODOT to County roadways to identify the top 20 to 25 locations on which to focus safety reviews and improvements.

For each geographic sub-area, report sections 4 through 8 present the top 5% and 10% SPIS locations identified by ODOT and the top County specific locations identified by Clackamas County staff.

Primary Crash Types Contributing to the Majority of Serious Injury and Fatal Crashes

The County is working towards an aspirational goal of eliminating serious injury and fatal crashes on roadways within the County. To help them make progress towards that aspirational goal, they are in the process of developing their first Transportation Safety Action Plan (TSAP). The TSAP development began in the fall of 2010. At the writing of this report, a complete draft of the TSAP has been completed and is under review.

The TSAP outlines a strategy for the County to build and implement a County-wide Safety Culture to reduce transportation related fatalities and injuries. In order to create this culture and effectively meet this goal, the TSAP employs a 5 “E’s” approach, with action items related to engineering, education, enforcement, emergency medical services, and evaluation activities.

One of the key components of the TSAP is the identification of the most common contributing circumstances to fatality and serious injury[2] crashes in Clackamas County. The TSAP identifies three emphasis areas: 1) Roadway departure crashes; 2) Crashes involving young drivers; and 3) Crashes involving

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[2] A serious injury crash is defined as a crash involving an incapacitating, or Injury A, injury.

aggressive driving. These three areas are further analyzed in this report, along with crashes involving pedestrians and bicyclists.

Sections 4 through 8 of this report present maps and discussion of where each of the following crash types has occurred.

- Roadway Departure Crashes ;
- Crashes Involving Young Drivers;
- Crashes Involving Aggressive Driving (Driving Too Fast, Following Too Close);
- Crashes Involving Pedestrians; and
- Crashes Involving Bicyclists.

Roadway departure crashes, crashes involving young drivers, crashes involving aggressive driving, crashes involving pedestrians and crashes involving bicycles are not mutually exclusive categories. This means one crash could involve a young driver who ran off the road and hit a pedestrian; this crash would be mapped as a roadway departure crash, a crash involving a young driver, and a crash involving a pedestrian. The purpose of this crash analysis is to identify corridors with higher frequencies of crashes reflecting one or more of the five focus areas identified above.

The term corridor refers to a series of roadway segments and intersections. By concentrating on these focus areas, the County is able to target their resources on reducing serious injury and fatal crashes. Separate from the TSP update activities, the County will review the crash data for the candidate road safety audit corridors in greater detail, assess the existing physical features of the corridor (e.g., shoulder width, signs, pavement markings) and identify improvements to reduce crashes. Improvements would range from lower cost signing or pavement marking treatments to road reconstruction. Potential improvements include updating and/or installing new signs, new or enhanced pavement markings (e.g., STOP AHEAD pavement markings), moving roadside fixed objects, and adjusting roadside vegetation. Further study of the candidate road safety audit corridors and improvements to them will be addressed programmatically. This enables the County to assess each corridor in more detail on a case by case basis, identify cost-effective solutions and determine if other corridors within the County would also benefit from similar improvements.

Specific Safety Focus Intersections

County staff identified a list of 134 specific safety focus intersections. These intersections were identified for one or more of the following geometric design characteristics:

- Approaching roads are offset;
- Sight distance at or on approach to the intersection is limited;
- Intersecting roads are skewed (do not intersect at 90-degrees);
- Geometry of approaching roads is challenging for motorists; and/or
- Intersection geometry or lane configuration is unconventional.

The purpose of identifying these types of intersections is to proactively consider potential improvements in advance of the intersections appearing on the County's safety priority location list discussed above. The basic characteristics noted above are some geometric features that may make the driving task more difficult and therefore increase the risk of crashes occurring. For example, AASHTO's *Highway Safety Manual* notes skewed stop controlled intersections tend to experience more crashes than intersections intersecting at 90-degrees.[3] Sections 4 through 8 identify these intersections within the respective geographic sub-areas. In a forthcoming TSP Update's Alternative Analysis report, potential projects, programs, studies and/or policies to improve these locations will be discussed.

FUTURE CONDITIONS ANALYSIS

The future conditions analysis evaluates the transportation system in the year 2035 assuming growth and development occurs and some planned modifications are made to the transportation system. Two future base scenarios were analyzed:

1) 2035 Low Build Scenario

The low-build scenario assumes that transportation projects in the existing Clackamas County TSP and Metro Regional Transportation Plan (RTP) with funding currently committed are completed. The roadway cross-sections and intersection configurations were adjusted to reflect this scenario. The specific changes made are highlighted in each sub-area's section. The signal timing for study intersections was optimized where appropriate, but no changes to coordination between signals were made. The committed transportation projects included in the 2035 Low Build Scenario are listed in *Appendix 6: Low Build Projects*.

2) 2035 Existing TSP Full Build Scenario

The full build scenario includes all planned transportation projects in the existing Clackamas County TSP and Metro RTP, regardless of whether funding is currently identified or not. Adjustments to roadway cross-sections, intersection configurations, and signal timing were made to reflect this scenario. The transportation projects included in the 2035 Full Build Scenario are listed in *Appendix 7: Full Build Projects*.

The Metro VISUM network model was used to project traffic volumes in the year 2035 under both scenarios. The Beta forecast model was used for the existing conditions and both the 2035 Low Build and Full Build scenario, based on recommendations from Metro and County staff. Although not yet regionally adopted, Metro Staff believes the Beta model is the most realistic and best captures the impacts of the recent recession and Urban Reserves decisions. The methodology for developing traffic volumes and evaluating roadway and intersection operations is described below.

Model Population and Employment Growth Assumptions

Future base conditions analysis was conducted using Metro's 2035 Beta regional travel demand model. The 2035 Beta model includes population and employment forecast for areas across Clackamas County (both urban and rural). The model is organized into Transportation Analysis Zones (TAZ). Each TAZ includes assumptions on the number of households (population) and the employment available. This information is then used to estimate traffic volumes on the primary roadways within the region.

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[3] AASHTO. *1st Edition of the Highway Safety Manual*. 2010. (See Volume 3, Part D, page 14-16).

Intersection Operations Analysis

Under the 2035 Low Build Scenario, the same 125 selected study intersections evaluated in existing conditions were assessed. The intersections within the 2035 Low Build Scenario that did not meet their respective performance standards were evaluated in the 2035 Full Build Scenario. The methodology and performance standards applied in the existing conditions intersection operations analysis were also applied for the two future scenarios.

Roadway Segment Operations Analysis

Future conditions roadway segment operations analysis was conducted for the 2035 Low Build Scenario and 2035 Full Build Scenario. The scope of analysis, methodology, and performance standards used for the future scenario analysis are the same as what was used and discussed above for the existing conditions analysis.

Traffic Volume Forecast

2035 turning movement volumes were developed for the study intersections using the methodology presented in NCHRP Report 255 *Highway Traffic Data for Urbanized Area Project Planning and Design* (Reference 3). While the Metro Model produce turn movement volumes directly, those volumes have not been directly validated to traffic count data. Therefore, a combination of existing turning movement count volume and forecast volumes were used to develop forecast turning movement volumes for the 2035 future scenarios considered in this Transportation System Plan update. The following information was used to develop forecast turning movement volumes for two 2035 scenarios:

- Existing weekday evening peak period turning movement counts;
- 2010 base model link and turning movement volumes;
- 2035 low build model link and turning movement volumes; and
- 2035 full build model link and turning movement volumes.

The resulting forecast evening peak period volumes were used in the future base conditions analysis discussed in Sections 4 through 8.

The following sub-sections describe in greater detail the specific steps involved in estimating the forecast turning movement volumes used in the Transportation System Plan analysis.

Overview of Applying NCHRP 255

The information listed above was used in a stepwise process that bases turn movement forecasts on turn movement count data, while reflecting traffic growth represented by the base and future year model runs. In essence, this methodology corrects for errors in the base year travel model in cases where the travel model produces volumes that are lower or higher than observed data. The turn movement adjustment procedures discussed herein are based on methods described in NCHRP Report 255[4].

All turn movement forecasts represent the evening peak hour condition. Because the Metro Model includes a 2-hour PM peak period, and the results of this analysis were to be integrated in one-hour traffic operations analysis it was necessary to factor 2-hour weekday p.m. volumes to compute peak one-hour volumes. Based on guidance from Portland Metro, 2-hour weekday p.m. period volumes were factored by 0.52 to produce PM peak hour volumes.

Intersection Approach Adjustments

Intersection approach adjustments are necessary because the Metro Model does not always match observed traffic count data. While the Metro Model has been validated to traffic count data, aggregate tend to reproduce existing traffic volumes within 10 or 20% for most, but not all, links where count data is present. The adjustment methodology described below accounts for this potential error in the base year model volumes.

The first step in the two-phase intersection adjustment process is to produce forecast intersection approach and departure volumes. These volumes can be prepared using one of three model volume adjustment methods described in NCHRP Report 255. The ratio and difference methods are defined by equations (2) and (3), while the average method is applied by taking the average result from the ratio and difference methods.

$$AdjVol_{Ratio} = Volume_{forecast} \cdot \frac{Count_{base}}{Volume_{base}} \qquad (2)$$

$$AdjVol_{Difference} = Volume_{forecast} + (Count_{base} - Volume_{base}) \qquad (3)$$

Where:

$AdjVol_{Ratio} =$ Adjusted link volume using the ratio method
$AdjVol_{Difference} =$ Adjusted link volume using the difference method
$Volume_{forecast} =$ Unadjusted forecast year model volume
$Volume_{base} =$ Unadjusted base year model volume
$Count_{base} =$ Base year actual or estimated traffic count

Although NCHRP 255 defines the adjustment methods, the report does not provide guidance on the most appropriate method to use in any particular case. In some situations, certain adjustment methods may produce unreasonable results. For example, unintended consequences can result when the difference between the base year count and volume is relatively small yet the count to volume ratio is large. In a high

[4] NCHRP Report No. 255, Highway Traffic Data for Urbanized Area Project Planning and Design (Transportation Research Board, National Research Council, December 1982).

growth area where the forecasted traffic volume is large, applying a large NCHRP adjustment ratio would not be appropriate. An example application is shown in Table A 6 below.

Table A 6 Example NCHRP Application with Unreasonable Results

Variable	Volume	Notes
Base Year Volume	10	The count is similar to the volume, but the ratio of count to volume is very high (5).
Base Year Count	50	
Forecast Year Volume	1,000	This area is currently undeveloped, but experiences future growth.
Ratio Method	5,000	The ratio and average methods produce unreasonably high volumes. The difference method produces a potentially more reasonable result.
Difference Method	1,040	
Average Method	3,020	

To avoid use of unreasonable results in traffic forecasts, a series of rules are used to determine the most appropriate adjustment methodology. These rules, defined in Table A 7, are applied individually for each intersection approach and departure volume. In most cases within the study area, the process results in use of the average method.

Table A 7 Selection of NCHRP Adjustment Methodology

No.	Test (both conditions must be true)		Method	If Adjustment Results in Negative Flow, use:
	Growth Factor (GF) or Error Factor (EF)	Forecast Model Volume (2-way, daily)		
1	GF > 4	<= 1,000	Difference	Forecast Model Volume
2	GF > 3	> 1,000	Difference	
3	EF < 1/4 or EF > 4	<= 1,000	Difference	Base Year Count Volume
4	EF < 1/3 or EF > 3	> 1,000 and <= 3,000	Difference	
5	EF < ½ or EF > 2	> 3,000	Difference	
6	All Other Conditions		Average	Ratio Method*

* The ratio method is used if the difference method alone would result in negative flow.

Where:

Growth Factor (GF) = Forecast Model Volume / Base Year Model Volume

Error Factor (EF) = Traffic Count / Base Year Model Volume

Intersection Turn Movement Forecast Method

Once intersection approach volumes have been defined, the next step is to prepare detailed intersection turn movements. Detailed turn movement forecasts are prepared using the iterative method described in NCHRP Report 255. This methodology treats turn movement volumes as an origin-destination matrix and adjusts base year turn movement forecasts to match adjusted approach and departure volumes using iterative proportional factoring (sometimes referred to as a Fratar process). If the total adjusted approach volume does not equal the total adjusted departure volume, the lower of the two is scaled upwards so that the two totals match.

In some cases, one of the data items required for the adjustment described above is unavailable. Table A 8 identifies situations in which alternate methods were required and identifies the alternate methodology used.

Table A 8 summarizes the majority of conditions that required diversion from the NCHRP 255 method. However, there were also additional anomalies at several other intersections due to unreasonable initial forecasts. In these cases manual intervention was required. To do so all available data was reviewed to produce a reasonable turn movement estimate.

Table A 8 Alternate Forecasting Methodology

Special Case	Turn Movement Methodology
Count Data Unavailable	Estimated turn movement produced by the model software were used in most cases. In some situations, turn movement forecasts were manually adjusted for consistency with forecast turn movements at adjacent intersections.
One leg of a 4-legged intersection is not modeled	The NCHRP adjustment process described above is used, but approach and departure volumes on the non-modeled leg are held constant.
The intersection is not modeled, but occurs in the middle of a model link	Base year turn movement volumes are increased based on growth on the corresponding model link. The average, difference, or ratio method was selected based on a manual review of each intersection.

The Clackamas County TSP included analysis of well over 100 intersections across the three analysis scenarios. Due to the large number of intersections considered, turn movement forecasts were, with a few exceptions, performed automatically and only reviewed if specific problems were observed. Therefore, the intersection forecasts included in the Clackamas TSP should be used for planning level analysis only.

COUNTYWIDE MEASURES

Several countywide measures were developed to compare the performance of the current transportation system and the two future 2035 scenarios (2035 Low Build Scenario and 2035 Full Build Scenario) at a holistic level. The measures used for this high-level comparison were the total vehicles miles traveled, total congestion delay, and average travel time across the County. The sub-sections below describe how each of these measures was developed.

Vehicle Miles Traveled

Vehicle miles traveled represents the total vehicle miles traveled on roads throughout the County on an annual average basis. Because all vehicular travel is included, travel related to trips to, from, within, and through the County impacts this measure. For the Clackamas County Transportation System Plan, vehicle miles traveled represents travel only on modeled roadway links.

The Metro Model produces traffic volume data for three time periods: morning, evening, and mid-day. Each of these time periods reflects a peak period in which congestion was observed on the roadway network. The Metro Model runs used for this analysis do not, however, include off-peak travel. Based on guidance from Portland Metro, 24-hour vehicle miles traveled was estimated based on evening peak period volumes using the factors shown in Table A 9. Twenty-four hour vehicle miles traveled was converted to annual vehicle miles traveled using an annualization factor of 300.

Table A 9 Evening Peak Period to 24-Hour Conversion Factors

Vehicle Type	Factor
Passenger Vehicles	0.17
Heavy Duty Trucks	0.09

Note: 2-Hour PM peak period volumes are divided by these factors to estimate 24-hour VMT.

Congestion Delay

Congestion delay represents the time spent in traffic due to congestion on the roadway network. This measure does not include intersection delay that is experienced regardless of congestion (i.e., delay due to a red light). As with vehicle miles traveled, congestion delay is measured for all travel on modeled roadway links in Clackamas County. Weekday delay from the travel model is converted to annual delay using a factor of 300.

Congestion delay occurs in all three of the peak periods included in the Metro Model, and may also occur to some degree in the off-peak period. Because off-peak model results are not available for this analysis, the Clackamas County Transportation System Plan performance measures reflect congestion delay occurring in the morning, evening, and mid-day peak periods.

Congestion delay was computed as the difference between two different calculations of vehicle hours traveled. First, free-flow vehicle hours traveled was computed by multiplying traffic volumes by free-flow (i.e., uncongested) travel time on each link. The total free-flow vehicle hours traveled for all links in the County represents a hypothetical situation in which all travel occurs unimpeded by congestion. Second, actual vehicle hours traveled was computed by multiplying traffic volumes on each link by the congested travel time resulting from the traffic assignment process. The total vehicle hours traveled represents the model’s best estimate of the total time spent traveling in the County. Congestion delay was then computed as the difference between actual vehicle hours traveled and free-flow vehicle hours traveled.

To help make this measure more meaningful, countywide delay for all vehicles is divided by the County population to produce annual congestion delay per person. This measure is roughly equivalent to the average annual daily delay experienced by each county resident. However, it should be noted that this measure represents vehicle delay rather than person delay and that the measure includes delay experienced by all vehicles traveling on Clackamas County roadways, including delay experienced by vehicles passing through the County. Despite these simplifications, the congestion delay measure is useful in comparing different forecast year scenarios.

Average Travel Time

The average travel time measure represents the average trip time for all trips in the county. The measure includes numerous trips on uncongested roadways as well as trips that experience high levels of congestion. To represent worst case conditions, the average travel time measures all represent evening peak period conditions.

Unlike the previously described measures, this metric explicitly connects trip origins and destinations to the congested travel time between each origin/destination pair. Therefore, average travel time can be computed for trips to, from and within Clackamas County, or can be limited to trips that occur entirely within the county. Trips traveling through the county without stopping are not included this measure.

Prior to computing average travel time, each traffic analysis zone in the model is identified as either within or outside of Clackamas County. Average travel time is then calculated using aggregated matrices, with aggregation performed as shown in Table A 10. Average trip time calculations are then be computed for the markets of interest using equation (1).

Table A 10 Trip Table Aggregation

		Trip Destination	
		Clackamas County	Other
Trip Origin	Clackamas County	Within Clackamas County	From Clackamas County
	Other	To Clackamas County	Through or Unrelated to Clackamas County

$$t_{avg} = \frac{\sum_{o,d}(t_{o,d} \cdot Trips_{o,d})}{\sum_{o,d}(Trips_{o,d})} \quad (1)$$

Where:

t_{avg} = Average travel time

$t_{o,d}$ = Congested travel time from zone o to d

$Trips_{o,d}$ = Number of trips from zone o to d