APPENDIX G

Level of Service Methodology

Scope

The purpose of this appendix is to document the methodology utilized to determine the level of service (LOS) for Freeways and Arterials in the EO-WB project.

Background

Operating conditions of the arterials and freeways were calculated using the LOS procedures published in the *Highway Capacity Manual* (2000). LOS is a grading system for the quality of operation on a street system. LOS measures the quality of traffic service and may be determined for each roadway segment on the basis of delay, congested speed, volume to capacity (v/c) ratio, or vehicle density by functional roadway class. LOS ranges from "A" for the best traffic operation to "F" for the poorest, and is described as follows:

- LOS A describes primarily free flow operation at average travel speeds, usually about 90 percent of the free-flow speed for the arterial classification.

- LOS B represents reasonably unimpeded operations at average travel speeds, usually about 70 percent of the free-flow speed for the arterial classification.

- LOS C represents stable operations. Ability to maneuver and change lanes in mid-block locations may be more restricted that at LOS B, and longer queues, adverse signal coordination, or both, may contribute to average travel speeds that are about 50 percent of the average free-flow speed for the arterial classification.

- LOS D borders on a range in which small increases in flow may cause substantial increases in delay, and hence decreases in arterial speed. Average travel speeds are about 40 percent of free-flow speeds. LOS D is often used as a limiting design criterion

- LOS E is characterized by significant delays and average travel speeds of one-third of the free-flow speed or less. LOS E sometimes is accepted as a limiting design criterion when restricted conditions make it impractical to consider a higher LOS.

- LOS F characterizes arterial flow at extremely low speeds, below one-third to one-fourth of the free-flow speed. Intersection congestion is likely at critical signalized locations with high delays and extensive queuing. LOS F is never used as a design standard. It represents a condition that is intolerable to most motorists.

Methodology

LOS for the project study area was calculated for the eight CMAP time periods using two different criteria for the two existing roadway type. For arterials the LOS is calculated using average arterial speed (Table G-1). The LOS for freeway segments is directly related to the volume to capacity (v/c) ratio (Table G-2).

TABLE G-1
LOS for Urban Streets

Urban Street Class Range of free-flow speeds_(FFS) Typical FFS	I 55 to 45 mi/h 50 mi/h	II 45 to 35 mi/h 40 mi/h	III 35 to 30 mi/h 35 mi/h	IV 35 to 25 mi/h 30 mi/h
LOS	Average Travel Speed (mi/h)			
A	>42	>35	>30	>25
B	> 32–42	> 28–35	>24–30	> 19–25
C	>27–34	>22–28	>18–24	> 13–19
D	>21–27	> 17–22	>14–18	>9–13
E	> 16–21	> 13–17	>10–14	>7–9
F	≤ 16	≤ 13	≤ 10	≤ 7

Exhibit 15-2 Urban Street LOS by Class. Source: *Highway Capacity Manual* 2000 Chapter 15. page 15-3

TABLE G-2
LOS Criteria for Basic Freeway Segments

Criteria	LOS A	LOS B	LOS C	LOS D	LOS E
FFS = 75 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	75	74.8	70.6	62.2	53.3
Maximum v/c	0.34	0.56	0.76	0.9	1
Maximum service flow rate (pc/h/ln)	820	1350	1830	2170	2400
FFS = 70 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	70	70	68.2	61.5	53.3
Maximum v/c	0.32	0.53	0.74	0.9	1
Maximum service flow rate (pc/h/ln)	770	1260	1770	2150	2400
FFS = 65 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	65	65	64.6	59.7	52.2
Maximum v/c	0.3	0.5	0.71	0.89	1
Maximum service flow rate (pc/h/ln)	710	1170	1680	2090	2350
FFS = 60 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	60	60	60	57.6	51.1
Maximum v/c	0.29	0.47	0.68	0.88	1
Maximum service flow rate (pc/h/ln)	660	1080	1560	2020	2300
FFS = 55 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	55	55	55	54.7	50
Maximum v/c	0.27	0.44	0.64	0.85	1
Maximum service flow rate (pc/h/ln)	600	990	1430	1910	2250

Exhibit 23-2 Urban Street LOS by Class. Source: *Highway Capacity Manual* 2000 Chapter 23. p 23-4

Arterials Level of Service

LOS for arterials is based on average through-vehicle travel speed for a segment or street under consideration. As noted, LOS was calculated for eight time periods. Data used for these calculations are obtained from the CMAP-EO-WB existing travel demand model, and forecasted volumes output.

The first step was to obtain the initial speed. Equation 7.5 in the *CMAP Transportation Conformity Analysis,* Appendix B, was used to compute an initial speed to readjust and calculate the final speed of the link. In order to reduce the number of iterations required to reach equilibrium, the initial speed for a specific time period is the final speed of the previous time period. For instance, the initial speed for the P.M. peak period would be the final speed from the pre-P.M. peak time period. There is only one exception: the initial speed for the off-peak time period is the free flow speed for the same time period. This is because the off-peak period is when the traffic assignment process begins. During the off-peak assignment, it is assumed that the network is operating at free flow conditions, and the speeds get readjusted until the completion of the number of iterations assigned. Then, the next time period will be assigned as initial speed the readjusted off peak speed and so on. Equation 7.5 is listed below:

$$S = S_0 \cdot \frac{1}{\left(\ln(S_0)*0.249\right)+0.153*\left(\dfrac{V}{0.75*C}\right)^{3.98}}$$

where:

S	=	speed on link used for emission calculation
S_0	=	initial speed on link
v/c	=	volume-to-capacity ratio for the link

The v/c ratio is also required to readjust speed. The v/c ratio is based on volume passenger car equivalent (PCE) by direction and hourly directional capacity times hours in a given period. The volume PCE is used in the calculations because it takes into account the presence of heavy trucks in the traffic stream.

After calculating the average arterial speed for every link by direction for each time period, a weighted average speed for the aggregate links comprising the route is computed. The weighted calculation is directional and is required to translate information from the TransCAD network to a GIS roadway layer. Segments located between major cross roads are formed by multiple links, which are assigned with a common link name to identify the segments. The weighted average is calculated by volume, and accounts for multiple link speeds that are part of a segment.

Next, the calculation of directional LOS is computed using free flow speed and weighted average arterial speed. Exhibit 15-2 from the *Highway Capacity Manual* specifies the LOS for Urban Streets based on Free Flow and Average Travel Speed, as shown in Table G-1.

Finally, to estimate the LOS of each segment, the worst directional LOS is selected, and assigned to the segment. Based on field observations, adjustments were made to the segment LOS computed from the TransCAD outputs.

Freeways and Expressways Level of Service

Basic freeways segments can be characterized by density (passenger cars per mile per lane), speed (mean passenger-car speed), and v/c ratio. Each of these performance measures characterizes the traffic flow and how it is being accommodated within the freeway.

V/c ratio is the measure selected to calculate freeways LOS in the EO-WB project. First, volume and capacity values are gathered to calculate a ratio. The v/c ratio is based on volume PCE by direction and hourly directional capacity times hours in a given period. After the calculation of the v/c ratio for each link by direction for each time period, a weighted average v/c (by volume) is obtained. The process is similar as previously described for the calculation of the weighted average arterial speed.

The calculation of directional LOS for freeways and expressways is performed using Free Flow Speed and Weighted v/c. Exhibit 23-2 LOS Criteria for Basic Freeway Segments from the *Highway Capacity Manual* specifies the LOS thresholds for this facility class (see Table G-2).

The worst LOS is selected from the LOS for each direction of the freeway.