Appendix B: Bicycle Performance Measure

The existing conditions report describes the current level of accommodation provided to bicyclists by the study network roadways. As discussed in that report, the selected performance measure to describe existing conditions is Bicycle Level of Service. This appendix provides technical descriptions of the Bicycle Level of Service Model.

B.1 DESCRIPTION OF THE BICYCLE LEVEL OF SERVICE MODEL

On-road bicycling conditions in Palm Beach County have a tremendous effect on people's choice to bicycle and the selection of their route. As part of this study, the Consultant will perform an evaluation of bicycling conditions on the County's collector and arterial roadway network. The *Bicycle Level of Service*[1] *Model (Version 2.0)* will be used as the foundation of the evaluation of the existing bicycling conditions in Palm Beach County. This statistically-calibrated mathematical equation is the most accurate method of evaluating the bicycling conditions of shared roadway environments. It uses the same measurable traffic and roadway factors that transportation planners and engineers use for other travel modes. With statistical precision, the *Model* clearly reflects the effect on bicycling suitability or "compatibility" due to factors such as roadway width, bike lane widths and striping combinations, traffic volume, pavement surface conditions, motor vehicles speed and type and on-street parking.

The *Bicycle LOS Model* is based on the proven research documented in *Transportation Research Record 1578*[2] published by the Transportation Research Board of the National Academy of Sciences. It was developed with a background of over 200,000 miles of evaluated urban, suburban, and rural roads and streets across North America. It has been adopted by the Highway Capacity Committee of the Transportation Research Board and will be included in the 2010 update of the Transportation Research Board. The model has also been adopted by numerous states and metropolitan areas as the recommended standard methodology for determining existing and anticipated bicycling conditions. Many urbanized area planning agencies and state highway departments are using this established method of evaluating their roadway networks. These include metropolitan areas across North America such as Atlanta GA, Baltimore MD, Gainesville FL, Birmingham AL, Philadelphia PA, San Antonio TX, Houston TX, Buffalo NY, Anchorage AK, Lexington KY, and Tampa FL as well as state departments of transportation such as Florida Department of Transportation (FDOT), Delaware Department of Transportation (DelDOT), New York State Department of Transportation (NYDOT), Maine Department of Transportation (MeDOT) and others.

In addition to describing the *Model*, this section also documents the necessary data requirements and the associated data collection and compilation guidelines.

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1 Landis, Bruce W. "Real-Time Human Perceptions: Toward a Bicycle Level of Service" *Transportation Research Record 1578*, Transportation Research Board, Washington DC 1997.

2 FDOT, 2002 Quality / Level of Service Handbook, Florida Department of Transportation (2002), pp.20-21.

BICYCLE LEVEL OF SERVICE MODEL

Version 2.0 of the *Bicycle LOS Model* will be employed to evaluate the study network segments. Its form is shown below:

$$\text{Bicycle LOS} = a_1 \ln(Vol_{15}/L_n) + a_2 SP_t(1+10.38HV)^2 + a_3(1/PC_5)^2 + a_4(W_e)^2 + C$$

Where:

Vol_{15} = Volume of directional traffic in 15 minute time period

$$Vol_{15} = (ADT \times D \times K_d) / (4 \times PHF)$$

where:

ADT = Average Daily Traffic on the segment or link

D = Directional Factor

K_d = Peak to Daily Factor

PHF = Peak Hour Factor

L_n = Total number of directional *through* lanes

SP_t = Effective speed limit

$$SP_t = 1.1199 \ln(SP_p - 20) + 0.8103$$

where:

SP_p = Posted speed limit (a surrogate for average running speed)

HV = percentage of heavy vehicles (as defined in the 1994 Highway Capacity Manual)

PC_5 = FHWA's five point pavement surface condition rating

W_e = Average effective width of outside through lane:

where:

$W_e = W_v - (10\text{ ft} \times \%\ OSPA)$ and $W_l = 0$

$W_e = W_v + W_l(1 - 2 \times \%\ OSPA)$ and $W_l > 0$ & $W_{ps} = 0$

$W_e = W_v + W_l - 2(10 \times \%\ OSPA)$ and $W_l > 0$ & $W_{ps} > 0$ and a bike lane exists

where:

W_t = total width of outside lane (and shoulder) pavement

OSPA = percentage of segment with occupied on-street parking

W_l = width of paving between the outside lane stripe and the edge of pavement

W_{ps} = width of pavement striped for on-street parking

W_v = Effective width as a function of traffic volume
and:
$W_v = W_t$ if ADT > 4,000veh/day
$W_v = W_t$(2-0.00025 x ADT) if ADT £ 4,000 veh/day, and if the street/road is undivided and unstriped

a_1: 0.507 a_2: 0.199 a_3: 7.066 a_4: - 0.005 C: 0.760

(a_1 - a_4) are coefficients established by the multi-variate regression analysis

The *Bicycle LOS* score resulting from the final equation is stratified into service categories "A, B, C, D, E, and F" (according to the ranges shown below) to reflect users' perception of the road segment's level of service for bicycle travel. This stratification is in accordance with the linear scale established during the referenced research (i.e., the research project bicycle participants' aggregate response to roadway and traffic stimuli). The *Model* is particularly responsive to the factors that are statistically significant. An example of its sensitivity to various roadway and traffic conditions is shown below.

Bicycle Level-of-Service Categories

LEVEL-OF-SERVICE	BLOS SCORE
A	£ 1.5
B	> 1.5 and £ 2.5
C	> 2.5 and £ 3.5
D	> 3.5 and £ 4.5
E	> 4.5 and £ 5.5
F	> 5.5

Bicycle LOS = $a_1 \ln (Vol_{15}/L_n) + a_2 SP_t(1+10.38HV)^2 + a_3(1/PR_5)^2 + a_4 (W_e)^2 + C$

a_1: 0.507 a_2: 0.199 a_3: 7.066 a_4: -0.005 C: 0.760
Baseline inputs:

ADT	=	12,000 vpd	% HV	=	1	L	= 2 lanes
SP_p	=	40 mph	W_e	=	12 ft	PR_5	= 4
(good pavement)							

	BLOS	% Change
Baseline Bicycle LOS Score	3.98	N/A

Lane Width and Lane striping changes (T-statistic = 9.844)

W_t	=	10 ft	4.20	6% increase
W_t	=	11 ft	4.09	3% increase
W_t	=	12 ft - - (baseline average) - - - -	3.98 - - -	no change
W_t	=	13 ft	3.85	3% reduction
W_t	=	14 ft	3.72	7% reduction
W_t	=	15 ft (W_l = 3 ft)	3.57 (3.08)	10%(23%) reduction
W_t	=	16 ft (W_l = 4 ft)	3.42 (2.70)	14%(32%) reduction
W_t	=	17 ft (W_l = 5 ft)	3.25 (2.28)	18%(43%) reduction

Traffic Volume (ADT) variations (T-statistic = 5.689)

ADT	=	1,000	Very Low	2.75	31% decrease
ADT	=	5,000	Low	3.54	11% decrease
ADT	=	12,000	Average (baseline average) - -	3.98	no change
ADT	=	15,000	High	4.09	3% increase
ADT	=	25,000	Very High	4.35	9% increase

Pavement Surface conditions (T-statistic = 4.902)

PR_5	=	2	Poor	5.30	33% increase
PR_5	=	3	Fair	4.32	9% reduction
PR_5	=	4	Good (baseline average)	3.98	no change
PR_5	=	5	Very Good	3.82	4% reduction

Heavy Vehicles in percentages (Combined speed and heavy vehicles T-statistic = 3.844)

HV	=	0	No Volume	3.80	5% decrease
HV	=	1 - - -	Very Low - (baseline average)	3.98	no change
HV	=	2	Low	4.18	5% increase
HV	=	5	Moderate	4.88	23% increase[a]
HV	=	10	High	6.42	61% increase[a]
HV	=	15	Very High	8.39	111% increase[a]

DATA COLLECTION AND INVENTORY GUIDELINES

Following is the list of data required for computation of the *Bicycle LOS* scores as well as the associated guidelines for their collection and compilation into the programmed database. Unless otherwise specified, the Consultant will collect the data.

Average Daily Traffic (ADT) - is the average daily traffic volume on the segment or link. The

programmed database will convert these volumes to Vol_{15} using the Directional Factor (D), Peak to Daily Factor (K_d) and Peak Hour Factor (PHF) for the road segment. This data will be provided by ARC.

Percent Heavy Vehicles(HV) - is the percentage of heavy vehicles (as defined in the *1994 Highway Capacity Manual*). This data will be estimated by ARC.

Number of lanes of traffic (L) - is the total number of *through* traffic lanes of the road segment and its configuration. (e.g., D = Divided, U = Undivided, OW = One Way, S = Center Turning Lane). The programmed database will convert these lanes into directional lanes. The presence of continuous right-turn lanes should be noted in the comments field.

Posted Speed Limit (S_p) – is recorded as posted.

W_t total width of pavement - is measured from the center of the road, yellow stripe, or (in the case of a multilane configuration) the lane separation striping to the edge of pavement or to the gutter pan of the curb. When there is angled parking adjacent to the outside lane, W_t is measured to the traffic-side end of the parking stall stripes.

W_{ps} width of pavement striped for on-street parking – is recorded only if there is parking to the right of a striped bike lane. If there is parking on two sides on a one-way, single lane street, report the combined width of the striped parking.

W_l width of paving between the outside lane stripe and the edge of pavement - is measured from the outside lane stripe to the edge of pavement or to the gutter pan of the curb. When there is angled parking adjacent to the outside lane, W_l is measured to the traffic-side end of the parking stall stripes.

OSPA % - is an estimate the percentage of the segment (excluding driveways) along which there is occupied on-street parking at the time of survey. Record each side separately. If the parking is allowed only during off-peak periods and parking restrictions change widths and laneage, indicate the geometric changes in the comments field. Note: Indicate any “angled parking” in the comments field.

Designated Bike Lane – is indicated as “Y” if there is a bike lane on the segment; otherwise the field is coded as “N.”

Pavement Condition:

Travel Lane (PC_t) - is the pavement condition of the motor vehicle travel lane according to the FHWA’s five-point pavement surface condition rating shown below. Half-point values (4.5, 3.5, and occasionally 2.5) may also be coded.

Shoulder or Bike lane (PC_l) - is the pavement condition of the shoulder or bike lane

according to the FHWA's five point pavement surface condition rating shown below. Half-point values (4.5, 3.5, and occasionally 2.5) may also be coded.

RATING	PAVEMENT CONDITION
5.0 (Very Good)	Only new or nearly new pavements are likely to be smooth enough and free of cracks and patches to qualify for this category.
4.0 (Good)	Pavement, although not as smooth as described above, gives a first class ride and exhibits signs of surface deterioration
3.0 (Fair)	Riding qualities are noticeably inferior to those above; may be barely tolerable for high-speed traffic. Defects may include rutting, map cracking, and extensive patching.
2.0 (Poor)	Pavements have deteriorated to such an extent that they affect the speed of free-flow traffic. Flexible pavement has distress over 50 percent or more of the surface. Rigid pavement distress includes joint spalling, patching, etc.
1.0 (Very Poor)	Pavements that are in an extremely deteriorated condition. Distress occurs over 75 percent or more of the surface.

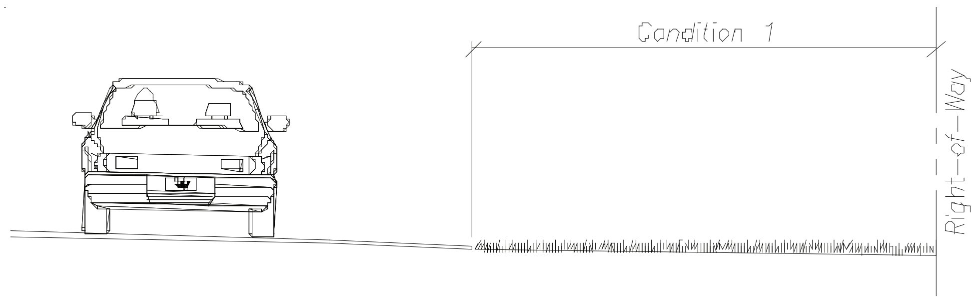
Source: U.S. Department of Transportation. Highway Performance Monitoring System-Field Manual. Federal Highway Administration. Washington, DC, 1987

This evaluation method is easily updated in the future. As traffic and roadway conditions change (primarily only traffic volumes will change, unless road reconstruction occurs) the database or programmed spreadsheet can be updated.

Cross-section – a "C" is recorded if there is a curb and gutter on the segment, an "S" if there is an open shoulder. Note: Indicate any ditches or swales adjacent to the edge of pavement of the segment in the comments field.

Roadside Profile Condition – This data item is collected to assist in determining the lateral area available for bicycle lane or paved shoulder and sidewalk construction. It is the area between the outside edge of the pavement and the right-of-way line. The profile condition assists in determining the type of facility, hence its cost [i.e., bicycle lane or paved shoulder or bike path]. Roadside profiles were classified as one of the three types illustrated below. Condition 1, buildable shoulder, is defined as an area adjoining the edge of pavement with a minimum width of seven feet and a maximum cross-slope of 6%. Condition 2 is a swale. Condition 3 is a ditch or canal. The ARC is to provide total right-of-way width.


Palm Beach County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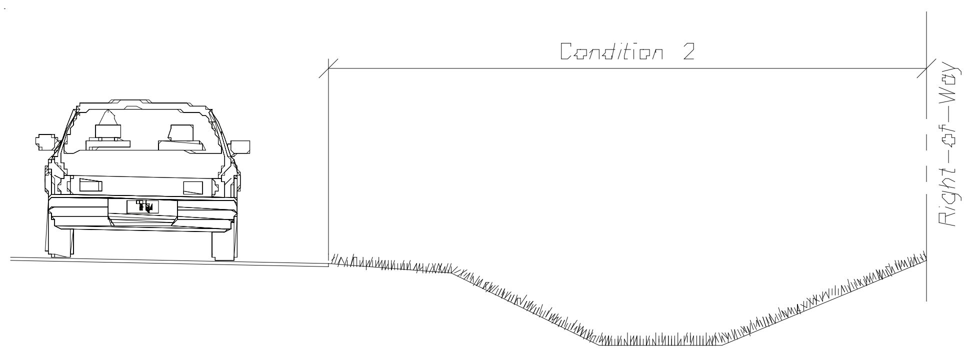
Right-of-Way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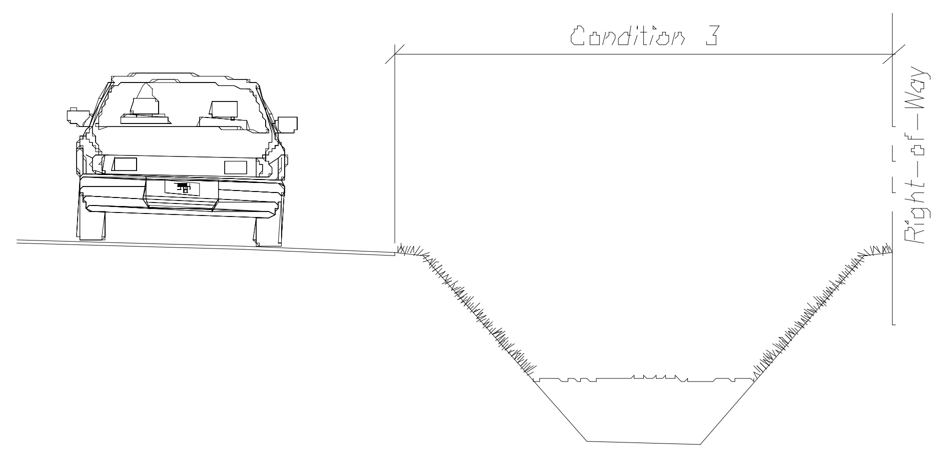
Right-of-Way


Condition 3
Right-of-Way