

# Methodology To Assess Level of Service on US-1 in the Florida Keys

RAFAEL E. DE ARAZOZA AND DOUGLAS S. MCLEOD

The methodology developed to assess level of service (LOS) on US-1 in the Florida Keys is presented. Although US-1 is predominantly an uninterrupted-flow two-lane roadway in the Keys, its uniqueness warrants an LOS evaluation different than that found in the 1985 *Highway Capacity Manual* (HCM). US-1 extends from Key West to the Florida mainland with no major roads intersecting it. Furthermore, no other principal arterial serves the Keys or the Keys' resident and tourist population of well over 100,000. Its unique geography, land use patterns, and trip-making characteristics presented a challenge in developing and applying a reasonable and acceptable method of assessing its LOS. A uniform method was developed to assess LOS on US-1 to cover both its overall arterial length from Key West to the Florida mainland and 24 delineated roadway segments. The methodology, which employs average travel speed as the main measure of effectiveness, was developed from basic principles, criteria, and speed relationships contained in Chapters 7 (Rural Multilane Highways), 8 (Rural Two-Lane Highways), and 11 (Urban and Suburban Arterials) of the 1985 HCM. The results of the study correlate well with perceived operating conditions on US-1, and over a 2-year period the methodology appears to have a good level of reliability. The authors recommend that for uninterrupted flow conditions in developed areas (e.g., in communities and along beaches), Chapter 8 of the 1985 HCM incorporate average travel speed as the main measure of effectiveness to determine LOS.

The purpose of this paper is to present the methodology developed by the Monroe County US-1 level of service (LOS) Task Force to assess LOS on US-1 (the Overseas Highway) in the Florida Keys (1). The authors are members of the task force.

US-1, which is mostly a two-lane highway, has unique geographic and trip characteristics. It extends through the Florida Keys, covering approximately 180 km (112 mi) from the city of Key West to the Florida mainland. There are 48 bridges that cross water for a total length of 35 km (22 mi), and the longest bridge is approximately 11 km (7 mi). No other road provides vehicular access to the Florida Keys from the rest of Florida or anywhere else. Few local roads are 5 km (3 mi) in length. Consequently, US-1 is not only a regional principal arterial serving intra- as well as interstate travel, but also the local road for most of the trips within the Keys. US-1 annual average daily traffic (AADT) volumes range from 4,700 to 37,200. The road serves a large tourist demand and is one of the most scenic in the United States. The linear

geography with the narrow land width of most of the Florida Keys are further characteristics.

Most of the surrounding land use is rural developed and suburban in nature; however, some areas are totally rural and others are urban, such as Key West and its suburbs. With the exception of the few completely rural segments and the bridges, strip commercial stores, motels, and restaurants are common throughout the Keys along US-1. Many driveways and intersecting local roads provide access to the surrounding residential areas.

Part of the growth management process in Florida is to assess roadway LOS to determine if roadway facilities meet standards established by state regulations. From a state transportation perspective, the overall operating condition of US-1 is important, not the condition of any smaller segment. With Key West a major tourist destination at the southern end of the Keys and no alternative routes to it, the logical analysis section of highway extends from Key West to the mainland. From perspectives of local transportation and development approval, shorter segments for analysis are desirable.

For planning purposes the Florida Department of Transportation (FDOT) has adopted LOS standards for all state roads. The applicable peak hour of analysis is the 100th highest hour of the year, representative of a typical peak hour during a 3-month peak season. FDOT's LOS standards vary by road and area type, with LOS C being the applicable standard in the Keys. TRB's *Special Report 209: Highway Capacity Manual* (HCM) (2), FDOT's *Level of Service Manual* (3), based on the HCM, and accompanying software are used extensively throughout Florida to determine highway capacities, LOS, and compatibility with LOS standards.

The US-1 LOS study encompassed approximately 174 km (108 mi) of US-1 from Key West/Stock Island to the Monroe-Dade county line, broken down as follows:

- 129 km (80 mi), 74 percent two-lane uninterrupted flow;
- 32 km (20 mi), 19 percent four-lane uninterrupted flow; and
- 13 km (8 mi), 7 percent four-lane urban/suburban interrupted flow.

HCM Chapters 7 (Rural Multilane Highways), 8 (Rural Two-Lane Highways), and 11 (Urban and Suburban Arterials) were consulted to determine applicability to the unique conditions and vehicular traffic operations and characteristics of the Florida Keys. Only the 13 km (8 mi) of urban/suburban interrupted flow and the small percentage of two-lane truly rural portions are believed to correlate directly to HCM Chap-

R. E. De Arazoza, Florida Department of Transportation, District 6, 602 South Miami Avenue, Miami, Fla. 33130. D. S. McLeod, Florida Department of Transportation, Mail Station 19, 605 Suwannee Street, Tallahassee, Fla. 32399-0450.

ters 11 and 8. Thus, the challenge was to develop a methodology to assess arterial LOS along US-1 without deviating from the principles of the HCM. Toward that end, a task force was created consisting of representatives from state and local agencies and an engineering consulting firm. An interim methodology was developed during the latter part of 1990, with the final methodology completed in June 1991. The final methodology was applied to the 1992 study data.

### NEED FOR SPEED-BASED METHODOLOGY

Chapter 8 of the HCM presents a methodology that applies primarily to the typical rural undeveloped situation. Essentially, these two-lane facilities are long stretches of roads with few side intersecting streets and driveways connecting directly to the roads. Chapter 8 methodology relies mainly on percentage time delay to assess LOS.

Throughout the United States many two-lane uninterrupted-flow highways pass through developed areas such as small communities and pass along beaches. However, the HCM does not directly address ways of handling these two-lane uninterrupted-flow highways. Frequently in these areas, posted speeds are also lower than they are on open highways, and it is believed that motorists expect to be traveling at somewhat lower speeds under these conditions. After much discussion, Florida's LOS Measurement Task Team (as well as the project task team) took the position that most motorists are more concerned about maintaining a decent travel speed under these uninterrupted-flow conditions in developed areas than trying to pass. Similarly, it is believed that the average motorist in the Florida Keys is concerned mostly with operating at an acceptable average travel speed, not with the ability to pass. This assumption is supported by the physical and traffic characteristics of the Keys (e.g., adjacent land development, sightseeing tourists), local knowledge, and discussions with motorists. Furthermore, average speeds comparable to the ability to pass appearing in Table 8-1 of the HCM are appreciably higher than the typical operating speeds of US-1 in the Florida Keys.

With regard to the four-lane uninterrupted-flow portions of US-1, a similar dilemma occurred. HCM Chapter 7 methodology applies to multilane highways with operating characteristics generally unlike those of US-1 through the Florida Keys. For instance, average travel speeds depicted by Table 7-1 of the HCM are also higher than those encountered in the Keys. Furthermore, the methodology inherent in Equations 7-1, 7-2, and 7-3 is closely related to those of freeways with their higher service flow rates, which again neither simulate nor resemble those of US-1 in the Keys. The four-lane portion is found mostly in Key Largo (the northeastern end of the Keys), which has a weighted posted speed limit of 72.5 km/hr (45 mph). Key Largo is developed with strip commercial and residential development. It has many driveway connections and side streets directly accessing US-1.

The remaining 7 percent of the total US-1 mileage is four-lane interrupted flow. These are the portions encompassing Marathon (in the middle of the Keys) and Stock Island (near Key West). The operating characteristics here are truly urban/

suburban and interrupted flow in nature, resembling those of HCM Chapter 11. Thus, the methodology of HCM Chapter 11 was used in assessing LOS on these segments.

From the preceding discussion, it was evident that for most of US-1 in the Keys the HCM was not directly applicable and a distinct method to assess LOS on US-1 should be developed. The task team concentrated on keeping consistency with the basic philosophy of the HCM and yet being sensitive to the Keys' uniqueness. Thus, the proposed methodology correlates measured travel speeds along US-1 with LOS speed thresholds developed as part of this study. This is in line with the concept behind the HCM of average travel speed being the main parameter for measuring arterial LOS.

### DEVELOPMENT OF LOS MEASURES OF EFFECTIVENESS

Assuming that average travel speed is the most appropriate measure of effectiveness for LOS on uninterrupted-flow facilities in developed areas, the challenge became that of developing appropriate criteria while still generally conforming to the HCM. Or, in other words, can reasonable speed-based criteria be inferred from Table 8-1, and to a lesser extent Table 7-1, of the HCM?

In the United States, posted speed limits for two-lane and multilane highways are no higher than 55 mph even though design or free-flow speeds are generally higher. Although it is accepted practice to base speed limits on the 85th-percentile speed, it is widely recognized that posted speed limits are set below that criterion. As in other parts of the country, posted speed limits in the Keys appear to be influenced more by the number of access points and level of residential and commercial development than by prevailing speeds. From Tignor's research (4) it can be inferred that average free-flow speeds in urban areas generally range from 2 to 8 mph—or approximately 5 mph—higher than posted speed limits. Interestingly, the level of service A speed criterion for two-lane (and multilane) highways is approximately the average of typical 55-mph posted speed limits and more typical 60-mph free-flow speeds. Assuming that this relationship is appropriate, analysts may reasonably make LOS A speed criteria for uninterrupted highways on the basis of posted speed limits.

Toward this end, the speed ratios between LOS thresholds from Tables 7-1, 8-1, and 11-1 of the HCM were used in the analysis. These ratios were weighted against actual mileage of US-1 in the Florida Keys to represent the prevailing type of flow: two-lane uninterrupted flow, four-lane uninterrupted flow, and four-lane interrupted flow. For example, from the level terrain portion of HCM Table 8-1, the ratio of LOS B speed to LOS A speed is 55/58, or 0.948. The ratio LOS C/LOS A is 52/58, or 0.897; the ratio LOS D/LOS A is 50/58, or 0.862, and so on. The same process was applied to Tables 7-1 (96.6 km/hr, or 60 mph) and 11-1. Then each ratio was weighted to account for the length of the section of US-1 to which that type of traffic flow applied. Once all the ratios were developed, the weight criteria were applied as in the following example:

Type of Flow	LOS C/LOS A Ratio	Weight
Two-lane uninterrupted	52/58 = 0.897	74
Four-lane uninterrupted	44/50 = 0.880	19
Four-lane interrupted	22/35 = 0.629	7

Therefore, the overall speed ratio between LOS C and LOS A is

$$\frac{74(0.897) + 19(0.880) + 7(0.629)}{100} = 0.875$$

This process was applied to develop all the required ratios. Further observations with reference to Tables 8-1, 7-1, and 11-1 yielded the following. From Table 8-1 the difference between LOS A and LOS B speeds is 4.8 km/hr (3 mph), or 4.8 km/hr (3 mph) above an assumed posted speed limit of 88 km/hr (55 mph). From Tables 7-1 and 11-1 the differences are 3.2 and 11.3 km/hr (2 and 7 mph), respectively, with LOS A lower than assumed speed limits. Therefore, from these observations, previous discussion in this paper, and local knowledge, it was determined that the overall US-1 posted speed limit of 79.6 km/hr (49.5 mph) fell reasonably between the LOS A and B thresholds. This assumption is not far from the premise that if a vehicle is able to sustain a travel speed equal to the posted speed limit, then it will correspond typically with the upper ranges of LOS (i.e., LOS A or LOS B).

With these speed differentials and the LOS range premise in mind, the US-1 overall speed thresholds for LOS A and B became 82.1 km/hr (51 mph) [2.4 km/hr (1.5 mph) above 79.6 km/hr (49.5 mph)] and 77.3 km/hr (48 mph), respectively. Applying the ratio developed LOS C/LOS A to the LOS A speed resulted in 72.0 km/hr (45 mph), rounded off [i.e., 0.875

× 82.1 km/hr (51 mph) = 71.8 km/hr (44.6 mph)], which then became the threshold for LOS C. After applying all the ratios, the overall LOS criteria for US-1 were developed, as given in the following:

LOS	Speed [km/hr (mph)]
A	≥82 (51)
B	≥77 (48)
C	≥72 (45)
D	≥68 (42)
E	≥58 (36)
F	<58 (36)

Thus, in essence, the state minimum operating speed standard (LOS C) for US-1 became 72 km/hr (45 mph). Or, in other words, drivers can reasonably expect to average at least 72 km/hr (45 mph) at any time of the year from the Monroe-Dade county line to Key West.

The next step was to develop LOS-speed threshold values for the individual segments of US-1. Twenty-four segments were selected, as presented in Table 1. Each segment is fairly homogeneous having a uniform roadway cross section and traffic flow. No further work was needed to cover the 7 percent mileage of the interrupted portions of US-1 found on Marathon and Stock Island, adjacent to Key West. As was discussed earlier, these segments correlate with Chapter 11 of the HCM. Therefore, direct application of Table 11-1 LOS-speed criteria for a Class I arterial was made.

The remaining segments fell within the two-lane and four-lane uninterrupted-flow criteria. It was decided to make the LOS A speed criterion 2.4 km/hr (1.5 mph) higher than the weighted posted speed limit to keep consistency with the overall criteria. LOS C speed was set at 9.7 km/hr (6 mph) below

**TABLE 1 Segment Description**

Segment No.	Mile Markers	Key(s)
1	4 - 5	Stock Island, Key Haven
2	5 - 9	Boca Chica, Rockland
3	9 - 10.5	Big Coppitt
4	10.5 - 16.5	Shark, Saddlebunch
5	16.5 - 20.5	Lower Sugarloaf, Upper Sugarloaf
6	20.5 - 23	Cudjoe
7	23 - 25	Summerland
8	25 - 27.5	Ramrod
9	27.5 - 29.5	Torch
10	29.5 - 33	Big Pine
11	33 - 40	W. Summerland, Bahia Honda, Ohio
12	40 - 47	7-mile bridge
13	47 - 54	Marathon, Key Colony Beach
14	54 - 60.5	Fat Deer, Crawl, Grassy
15	60.5 - 63	Duck, Conch
16	63 - 73	Long, Fiesta, Craig
17	73 - 77.5	Lower Matecumbe
18	77.5 - 79.5	Fill
19	79.5 - 84	Upper Matecumbe
20	84 - 86	Windley
21	86 - 91.5	Plantation
22	91.5 - 99.5	Tavernier
23	99.5 - 106	Key Largo
24	106 - 112.5	Key Largo, Cross Key

the LOS A speed, consistent with Tables 7-1 and 8-1 of the HCM. LOS B and D speed criteria were set to provide equal increments between LOS A and LOS D [i.e., LOS B 4.8 km/hr (3 mph) below LOS A speed and LOS D 4.8 km/hr (3 mph) below LOS C speed]. LOS E was set 9.7 km/hr (6 mph) below the LOS D speed. This makes the segmental speed differential between LOS thresholds consistent with the differentials in the overall criteria, except for one consideration. On any segment, intersection delay would be deducted from the segment's travel time to account for the influence of that signal on the segment (i.e., signal delay =  $1.0 \times 15$  sec average stopped delay). This corresponds to an LOS C delay due to isolated signals. LOS C delay was chosen because LOS C is the state LOS standard for US-1 in the Florida Keys.

The rationale behind deducting signal delay from the segment analysis was to recognize for the impact of signals in reducing travel time. This provides the required sensitivity in the segment that is to assess the impact not only of regional vehicular trips but also of those that are local in nature. The following tables illustrate the concept and give an example for the US-1 segmental LOS-speed relationship.

The uninterrupted-flow segment criteria are as follows:

LOS	Speed [km/hr (mph)]
A	$\geq 2.4$ (1.5) above the posted speed limit
B	$\geq 4.8$ (3.0) below LOS A
C	$\geq 9.7$ (6.0) below LOS A
D	$\geq 14.5$ (9.0) below LOS A
E	$\geq 24$ (15.0) below LOS A
F	$< 24$ (15.0) below LOS A

A segment having a weighted posted speed limit of 72 km/hr (45 mph) has the following criteria:

LOS	Speed [km/hr (mph)]
A	$\geq 74.9$ (46.5)
B	$\geq 70.0$ (43.5)
C	$\geq 65.2$ (40.5)
D	$\geq 60.4$ (37.5)
E	$\geq 50.7$ (31.5)
F	$< 50.7$ (31.5)

The LOS-speed criteria for interrupted-flow segments (Marathon and Stock Island) are based directly on a Class 1 arterial from Table 11-1 of the HCM.

Speed data from both the overall length of US-1 and the individual segments were compared with the applicable LOS-speed thresholds. This arrangement provided for an assessment of the facility LOS plus an indication of reserve speed, if any.

Under the growth management processes of Florida and Monroe County, if the overall LOS for US-1 fell below the LOS C standard then no additional land development would be allowed to proceed in the Florida Keys, unless the proposed new development traffic impact were mitigated. If the overall LOS for US-1 was C or better, additional development could take place in those segments in which reserve speed was available (i.e., the segment's speed was higher than the standard threshold).

In addition to meeting highway LOS standards there are many other considerations in Florida's growth management process pertaining to the Florida Keys. These are beyond the scope of this paper.

## SPEED STUDIES

Considering the types of trips served by US-1, it was decided to conduct travel time and delay runs to cover the entire length of US-1 from Key West to the Monroe-Dade county line (mainland) and each segment of the highway along the way. Travel speeds for the overall length (from Key West to the mainland) provide an indication of the LOS for the regional trips. Travel speeds for each segment also provide an opportunity to assess the impact of local trips.

The floating-car technique, as defined by the *Manual of Traffic Engineering Studies* (5) published by ITE, was used. In this technique the test vehicle "floats" with the traffic by passing as many vehicles as pass the test vehicle. A safe operation was maintained and applied in passing maneuvers (where permitted), following other vehicles and changing speeds. The equipment used was an electronic distance measuring instrument with both distance and time features and ability to download data into a personal computer.

The next step in the process was to determine the number of travel time runs and how, when, to where, and from where. Runs were started at both ends of US-1. For example, one run started on Stock Island (Key West city limits) and proceeded to the mainland (Dade County). After reaching this point, the vehicle turned back and proceeded to end the run where it started, on Stock Island. On another day the reverse was true (i.e., the run started in Dade County instead of Stock Island). It was decided to perform 14 two-way runs, or 28 in each direction, covering the 174 km (108 mi) study portion of US-1. Twenty-eight runs provide enough data for statistical significance. Control points were established at each of the 24 segments to record travel time and speed data specific to each one of those segments. Seven runs were started at Stock Island and seven in Dade County covering the hours between 9 a.m. and 7 p.m. Each began at staggered hours to cover the varied trip purposes and time frames within the Keys with the intent to cover peak travel periods of all the segments.

For each run the process provided data, such as running speed and travel speed, in each direction of US-1. Vehicular traffic counts were also collected at three locations covering 7 days.

As stated before, Florida's LOS standards are based on the concept of the typical peak hour during the peak season, which is approximately the 100th highest volume hour of the year in developed areas. Whereas it is normally reasonable to conduct an analysis based on this peak hour for roadways, it is impractical to evaluate a 174-km (108-mi) roadway for a peak hour; full-length trips are approximately 2½ hr in duration. To meet the intent of Florida's LOS standards, it was agreed to conduct the travel time studies during the peak travel hours of the peak month (March) and to use the median speed of the travel time runs. Using this approach, compatibility with LOS standards is developed on the basis of a typical drive during the peak month. Compared with other roads in Florida this approach is somewhat tougher because it uses the highest-volume month instead of the peak season, but it is somewhat more lenient because it uses a typical driving hour instead of one of the highest-volume hours. The median value was also selected, instead of the average, to avoid the influence of extremely high or low speed values at either end of the survey population.

## STUDY RESULTS

The 1991 travel time field runs were conducted between March 1 and March 21. Fourteen runs were made to cover both directions along US-1 (total of 28 one-way runs), at the rate of one run per day in each direction. The 1992 field runs were conducted between February 29 and March 20 in the same manner as in 1991. Seven-day traffic counts were made, at three locations, during 1991 and 1992 and converted to AADT. These are given in Table 2.

Tables 3 and 4 present a summary of the results of the field studies for the years 1991 and 1992 (6,7). The tables cover both the overall length of US-1 and the individual segments plus the applicable LOS.

The results were not surprising. Overall, the US-1 median travel speeds of 76.7 km/hr (47.7 mph) for 1991 and 75.5 km/hr (46.9 mph) for 1992 reflected an acceptable LOS C. This overall rating is supported by the data collected plus local knowledge and the authors' experience in the area. It is interesting to see that for the overall speed data, the mean (average) speed is either identical or very close to the median speed for both years, suggesting fairly good individual data items with few extremes. Worth noting is the fact that for both years, the survey vehicle was able to maintain an overall median speed relatively close to the weighted posted speed limit [i.e., 2.9 km/hr (1.8 mph) below in 1991 and 4.1 km/hr (2.6 mph) below in 1992]. This fact supports the LOS C assessment of US-1 and the discussions presented earlier in this paper.

The results from the segmental analyses were not surprising either. The resulting LOS accurately reflect traffic operations and perceived levels of congestion. From the 1991 data, only

TABLE 2 Average Annual Daily Traffic

LOCATION	1991	1992	% CHANGE
Big Pine	18,199	17,529	-3.7
Marathon	24,043	25,933	7.9
Upper Matecumbe	17,357	17,564	1.2

one segment failed to meet the LOS C standard. This is Segment 19 in the Upper Matecumbe area. The two segments (17 and 18) south of it, covering the Lower Matecumbe and Tea Table areas, showed speeds at the lower ends of LOS C with little reserve available. These assessments corresponded well with the authors' knowledge of traffic operations and development conditions of the area. In 1992 these three segments failed the LOS C standard. All three of them were assessed at LOS D.

The authors were pleased with the results of the study. The 1991 and 1992 LOS assessments for US-1 accurately reflect local knowledge, field experience, and perceived conditions in the Florida Keys. Inspection of the survey data also supports this claim. For instance, looking at the 1992 speeds for the segments, with the exception of 3 segments of 24, the difference between the median and mean speeds was less than 1.6 km/hr (1 mph). For the 2 segments the difference between the median and mean was less than 3.2 km/hr (2 mph). In keeping with the 1992 data, 13 of 24 segments (54 percent) have standard deviations less than 4.8 km/hr (3 mph). Of the other 11 segments with standard deviations greater than 4.8 km/hr (3 mph), only 1 had a standard deviation greater than 9.7 km/hr (6 mph). The standard deviations for the segments came out higher for the 1991 data. However, 18 of the 24 had

TABLE 3 Summary of 1991 Travel Speed Data

Segment No.	Mean (kmh)	Median (kmh)	Std. Dev. (kmh)	Standard (kmh)	Reserve (kmh)	LOS
1	57.7	57.5	8.6	35.4	22.1	A
2	91.1	91.0	2.0	75.3	15.7	A
3	78.5	78.4	6.7	68.4	10.0	B
4	84.0	84.0	5.5	75.3	8.7	C
5	82.4	82.3	5.5	72.6	9.7	C
6	69.8	69.6	5.8	61.6	8.0	C
7	74.5	74.9	5.4	61.6	13.3	A
8	77.8	77.5	5.0	61.6	15.9	A
9	75.7	75.0	5.3	61.6	13.4	A
10	61.9	62.1	6.1	61.6	0.5	C
11	87.0	86.3	2.8	73.4	12.9	B
12	85.1	85.2	5.9	68.4	16.8	A
13	65.4	65.2	3.2	35.4	29.8	A
14	86.2	86.1	4.2	73.9	12.2	B
15	87.4	87.9	4.7	75.3	12.6	B
16	81.2	83.5	15.8	73.9	9.6	C
17	81.6	82.5	6.3	75.3	7.2	C
18	80.0	81.5	6.5	75.3	6.2	C
19	63.0	63.2	5.1	61.6	1.6	D
20	68.7	69.1	7.9	61.6	7.5	C
21	64.2	65.5	8.0	61.6	3.9	C
22	79.6	80.1	3.2	61.6	18.5	A
23	76.2	77.4	4.5	61.6	15.8	A
24	81.2	82.9	6.0	69.7	13.2	B
OVERALL	76.3	76.7	2.5	72.4	4.3	C

TABLE 4 Summary of 1992 Travel Speed Data

Segment No.	Mean (kmh)	Median (kmh)	Std. Dev. (kmh)	Standard (kmh)	Reserve (kmh)	LOS
1	57.3	58.2	7.3	35.4	22.8	A
2	91.3	90.3	3.4	81.3	9.0	B
3	72.9	75.1	11.0	73.2	1.9	C
4	82.9	83.4	4.4	81.3	2.1	C
5	80.2	80.9	4.3	78.0	2.9	C
6	69.5	69.2	6.3	65.2	4.0	C
7	72.0	72.2	4.6	65.2	7.0	B
8	76.9	77.7	4.6	65.2	12.5	A
9	74.6	74.9	4.1	65.2	9.7	A
10	61.3	62.6	6.7	62.1	0.5	C
11	85.8	85.7	3.3	79.2	6.5	B
12	85.2	84.3	5.4	73.2	11.1	A
13	63.9	63.8	2.9	35.4	28.4	A
14	82.2	82.2	6.1	79.6	2.6	C
15	83.9	84.6	5.3	81.3	3.3	C
16	81.8	81.7	4.3	79.6	2.1	C
17	79.9	81.2	5.7	81.3	-0.1	D
18	79.5	79.9	5.9	81.3	-1.4	D
19	64.8	64.6	4.7	65.2	-0.6	D
20	67.1	69.8	7.1	65.2	4.6	C
21	62.0	62.2	4.5	63.4	-1.2	D
22	78.6	77.5	4.5	67.1	10.4	A
23	75.8	75.4	4.3	64.0	11.4	A
24	80.0	82.4	8.3	74.7	7.7	B
OVERALL	75.4	75.5	1.9	72.4	3.1	C

deviations less than 6.4 km/hr (4.0 mph). The results imply that for the most part the assessed LOS will not go beyond one letter change when the standard deviation is added or subtracted to the mean. Finally, the standard deviations for the 1991 and 1992 overall US-1 speeds were 2.5 and 1.9 km/hr (1.6 and 1.2 mph), respectively.

### CONCLUDING REMARKS

From the 1992 highway LOS determinations and adopted LOS standards, it was concluded that additional land development may occur in the Florida Keys. However, based on the adopted LOS criteria, unless the traffic impact is adequately mitigated, development should not be approved on the four segments that failed to meet the LOS C standard. Although one other segment, Big Pine, was at LOS C, it had a very low reserve speed. This means that any proposed land development should be closely monitored.

The methodology developed to assess LOS on US-1 in the Florida Keys followed the basic concept of arterial analyses in the HCM with average travel speed as the main measure of effectiveness. The results accurately reflect perceived levels of congestions and local knowledge. For example, motorists can compare their travel speed with the posted speed limit. The methodology has been formally approved by both state agencies principally involved in transportation aspects of Florida's growth management process, the Department of Community Affairs and the Department of Transportation. County commissioners have also incorporated formally the methodology into Monroe County's land use regulations.

As the result of this study, it is recommended that for uninterrupted-flow conditions in developed areas Chapter 8 of the HCM consider average travel speed as the main pa-

rameter for determining LOS. Because the results of the study reflect local conditions in the Florida Keys, additional data collection and studies are recommended for nationwide applications.

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