CHAPTER 4

ROADWAY LEVEL OF SERVICE (LOS) MONITORING

Key Topics:

- **Legislative Requirements**
- **Legislative Intent and Application to San Francisco**
- **Technical Approach**
- **Monitoring Results**
- **Future Monitoring Approach**
- **Caltrans' Role**
- **Work Program Items – Key Milestones**

This chapter describes the methodology used to monitor the system, and compares the biennial monitoring results from 1991 through 2007.

1. Legislative Requirements

The California Government Code requires that San Francisco use LOS standards to measure the performance of the CMP roadway network, but allows CMAs a choice among the following permitted methods for measuring level of service (LOS):

- Transportation Research Board Circular 212 (TRC 212),
- Transportation Research Board's Special Report 209: *Highway Capacity Manual (HCM*), latest version
- A uniform methodology adopted by the CMA that is consistent with *the Highway Capacity Manual.*

Biennially, the CMA is required to determine the City's conformance with the CMP, including attainment of LOS standards.

If actual system performance falls below the set LOS standards, (i.e. congestion worsens) actions must be taken to restore or improve LOS. Section 65089(b)(1)(B) states that "In no case shall the LOS standards established be below the LOS E or the current level, whichever is farthest from LOS A. When the level of service on a segment or at an intersection fails to attain the established level of service standard, a deficiency plan shall be adopted pursuant to section 65089.4". In addition, Section 65089.3 establishes that "The [California] [D]epartment [of Transportation] is responsible for data collection and analysis on state highways, unless the agency designates that responsibility to another entity."

> *"The maintenance of LOS standards on CMP roadways in San Francisco requires a comprehensive and multimodal approach which takes into account the congestion relief potential of transit and other non-automobile based solutions, as well as operational improvements to roadways."*

2. Legislative Intent and Application to San Francisco

LOS is a traffic engineering concept designed to describe the operating conditions on a roadway. LOS describes operating conditions on a scale of A to F, with "A" describing free flow, and "F" describing bumper-to-bumper conditions. Attributes that make up the A to F degrees of the LOS scale are a mixture of quantitative measures (such as speed and travel time), and qualitative observations, such as freedom to maneuver.

As a result, LOS is used as the main indicator of congestion and as the uniform yardstick for measurement of improvement in transportation service, as well as to gauge the congestion relief potential of proposed transportation solutions. The choice of LOS for this purpose reflects the suburban roots of the congestion management legislation: congestion relief is to be measured by the ability of the transportation system to move automobiles, because in the suburbs the single-occupant automobile is still the dominant mode of transporta-

tion. It also reflects the fact the LOS has been used and codified more extensively and systematically than any other transportation facility performance method. Therefore, LOS is also the method that offers least potential for controversy or challenge when a CMA makes a finding of nonconformance.

Improvements on the LOS scale ensure better travel conditions for motorists, but the LOS scale does not take into account the *people throughput* potential of a roadway. A city arterial may carry the maximum number of automobiles at acceptable speed, but if each vehicle carries only the driver, then throughput of the facility is suboptimal. San Francisco faces a double challenge on this issue: on the one hand the City must comply with the LOS requirements and prevent LOS conditions from deteriorating below the set standards. On the other hand, it must strive to identify a performance measurement method that reflects San Francisco's transportation realities more appropriately than LOS. The Authority has already begun the effort to develop multimodal performance measures appropriate to San Francisco. These are described in detail in Chapter 5 *Multimodal Performance Element*.

The Level of Service on CMP roadways in San Francisco requires a comprehensive, multimodal approach that takes into account the congestion relief potential of transit and other non-automobile based solutions, as well as operational improvements to roadways.

3. Technical Approach

The Authority monitors LOS biennially on the CMP network. The Authority, as the CMA, assesses the City's conformance with LOS standards based on the monitoring results. The CMA ensures that LOS measurement methods used by its contractors, Caltrans, or any other agencies involved in monitoring the CMP network are consistent with State law.

a. LOS Standard

The traffic LOS standard for San Francisco is consistent with CMP mandated criteria and was established at E in the initial (1991) CMP network. Facilities that were already operating at LOS F at the time of baseline monitoring, conducted to develop the first CMP in 1991, are legislatively exempt from the LOS standards. Since 2005, monitoring has included the exempt facilities in addition to the rest of the CMP network.

b. Methodology

The Authority uses the 1985 HCM methodology to monitor LOS on the CMP network. All freeway and arterial segments in the network are monitored using the floating vehicle method (see section iii, below), which allows for determination of LOS on the basis of average operating speed. The CMP segment classifications are shown in Figure 4-1. The specific methodologies used for monitoring freeway and arterial segments are listed below per HCM definitions:

- Freeway Segments (Chapter 3) – Evaluated using the "basic freeway sections" methodology where the LOS for each freeway segment was determined using its average travel speed.
- Arterial Segments (Chapter 11) – Evaluated using the "urban and suburban arterials" methodology where LOS is based on the average through-vehicle travel speed for the segment or for the entire street under consideration. Travel speed is the basic service measure for urban streets. The average travel speed is computed from the running times on the urban street and the control delay of through movements at signalized intersections.

i. Global Positioning System (GPS)

Historical travel time runs were done manually using stop watches due to the "urban canyon effect", whereby the Global Positioning System (GPS) signals are blocked by high buildings (i.e. downtown core) and there are not enough satellites signals in estimating the positions of the user. The equipment received consistent GPS signals in

the area but the positional accuracy of the vehicle does not meet the system requirements. Therefore, the driver was asked to use the GPS display as a stop-watch and call out the times into a tape recorder for later adjustment of the GPS points in the Geographic Information System (GIS)

Before starting the travel time runs, all roadway miles were mapped using GPS technology.

The Trimble receiver was mounted to a vehicle and used in the mapping. The receiver uses differential GPS (DGPS) to provide position information to sub-meter accuracy. These receivers were used in combination with the controlling software while driving each roadway to inventory all roadway attributes related to speed.

The data collection process was made more efficient by collecting data electronically using GPS technology. The methodology provided the Authority with background mapping and traffic-related elements that can be integrated with the agency's GIS system for future use. This is the first year that the Authority has used GPS to monitor LOS on the CMP network. GPS data collection was also chosen to be compatible with the Municipal Transportation Agency's transit LOS data collection effort, which this CMP update utilizes to incorporate transit LOS measures.

ii. Mapping Runs

The roadway mapping was done in-vehicle using the Trimble GPS equipment and software. Mapping was done in one direction for each roadway segment during off-peak periods. For each segment, an appropriate offset was input as an adjustment so that data points were collected along the approximate centerline.

Certain traffic elements were recorded such as the posted speed limit, presence of traffic signals, number of through lanes, and construction areas. This information would be used later to determine the segment lengths and theoretical travel times, and to provide better insight into the resulting travel time runs.

iii. Travel Time Runs

Travel time runs were conducted using the floating car method. In the floating car method, the driver of the test vehicle "floats" with the traffic by attempting to safely pass as many vehicles as pass the test vehicle.

Travel time runs were conducted during the morning and afternoon peak periods on all roadway segments. Four runs were made in each direction during each peak period, for a total of eight runs per peak period. Where LOS F was found, two additional runs (each direction) were performed to verify results. During those travel time runs, the GPS equipment recorded position and time at one-second intervals. The driver of the test vehicle drove the speed limit if no other cars were present and at the school zone speed limit if a school zone speed limit was in effect at the time of the travel time run.

For quality control purposes, precautions were also taken to ensure that individual travel time runs were within an acceptable range relative to the combined runs for segments between each intersection. If the speed of an individual travel time run between intersections was more than two standard deviations from the average of all other runs at the same location, within the same time period, and there were four or more runs, then it was designated as an outlier and excluded from the remaining calculations.

iv. Video on Mapping Runs

The roadway segments were videotaped during the mapping process in order to provide a reference of the conditions. The digital videos were later linked to the GIS results for future reference. This provides a video log of the CMP network roadways. These video logs can be invaluable for future tasks such as asset management where all traffic signals, signs, sidewalks, and other items can be easily inventoried and mapped.

v. Factors That May Affect Results

Several issues were evaluated during the travel time runs.

Some concerns were raised that initial travel time runs could be affected, as they coincided with the spring break schedules in neighboring counties and with San Francisco State University's spring break. However, no significant difference was found after comparing these travel times to the

ones made after spring break, thus the data was retained.

Similarly, before and after comparisons were also performed on travel time runs on the Bay Bridge after the fire on the I-880 connector ramp in Oakland on April 29, 2007. It was expected that traffic would initially be lighter while the ramp was closed, resulting in higher travel speeds. However, travel time runs were actually slightly longer a week after the accident.

The San Francisco side of the Bay Bridge freeway approach is undergoing construction due to a seismic retrofit. This construction has been ongoing for years, and may affect the observed travel times on I-80 in San Francisco

c. Network Segmentation Documentation of Method and Criteria

The 1993 CMP documented the criteria used in 1991 to segment the CMP roadway network in San Francisco, including freeway facilities. The following five criteria determine segment limits for the city arterials in the CMP: predominant development patterns (e.g., number of driveways, institutional uses); changes in speed limits; major cross streets; significant changes in traffic volumes; and freeway ramps. These criteria are generally recognized as significant in explaining the operating behavior of a roadway.

For freeway facilities the segmentation criteria are simpler. They include interchange on and off ramps, and points were two freeway facilities merge or bifurcate. Segment limits for freeways in the San Francisco CMP are also shown in Appendix III.

Segmentation changes

Table 2 in Appendix III lists all CMP arterials where segmentation changes were introduced as part of the 1993 CMP, including a technical justification. Changes were introduced in the segmentation of 18 arterials in the network. The new arterial segments follow more closely the five segmentation criteria described above, and improve comparability of LOS results among similar facilities. By better reflecting local conditions, these revised segments enhance the reliability and explanatory power of LOS measurements on the network.

All CMP network segments were evaluated in the Spring 2007 monitoring cycle with minor adjustments due to current field conditions along I-80 at Treasure Island, US 101 to the County Line, and other miscellaneous minor changes. The Brannan Street segmentation was changed in 2007 from two discontinuous segments to four adjoining segments. This change was approved by the MTC. See Appendix III for documentation of this change.

4. Monitoring Results

In order to determine initial (baseline) LOS conditions, the Department of Parking and Traffic monitored the CMP network during the summer of 1991. Network segments already at LOS F were legislatively exempted from conformance with the established LOS E standard. However, the Authority does monitor LOS on these segments when the rest of the CMP network is surveyed.

For LOS monitoring purposes, the CMP segments are categorized by exempt or non-exempt status:

- **Exempt** – segments which were at LOS F during the first (1991) monitoring cycle and are legislatively exempted from the LOS E standard.
- **Non-exempt** – all other segments. If a non-exempt segment fails for three consecutive CMP cyles, it is classified as deficient.

Tables I and II in Appendix IV show LOS monitoring results for all segments of arterials and freeways in the CMP network. The information includes segment length, direction of travel, time of day (AM and PM peak), average operating speed measured, and LOS results for 1991, 1993, 1995, 1997, 1999, and 2001, 2004, 2006, and 2007.

Table 4-1 lists the segments at LOS F during the 2007 monitoring. The segments are also shown in Figures 4-2 and 4-3. Exempt segments are shown in Figures 4-4 and 4-5. The 2007 monitoring identified six (6) non-exempt LOS F segments, three (3) occurred during the AM peak period and three (3) during thePM peak period. For all six

non-exempt LOS F segments, this was the first CMP monitoring cycle for which LOS F was observed.

Figure 4-1

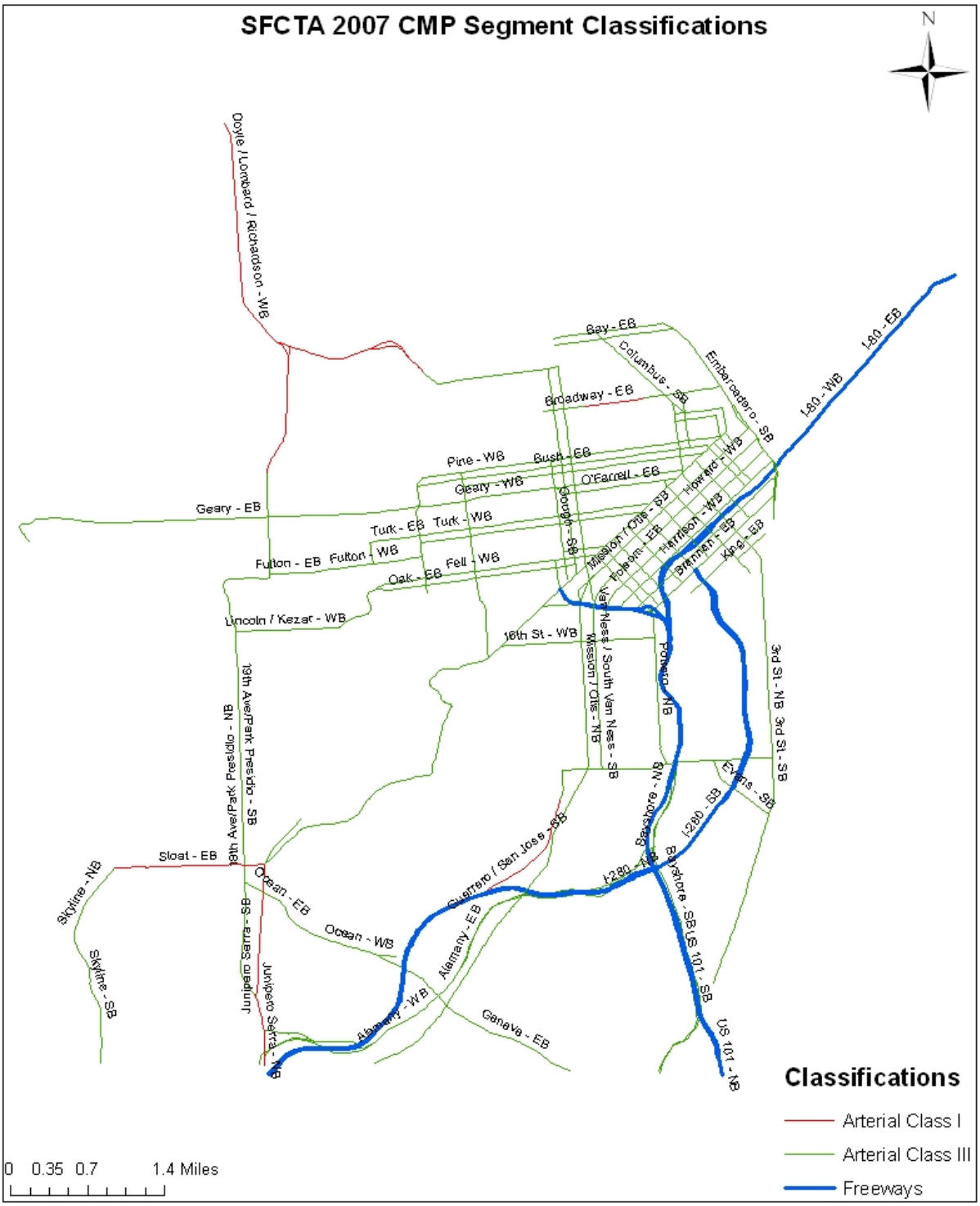

SFCTA 2007 CMP Segment Classifications
N
Doyle / Lombard / Richardson - WB
Bay - EB
Columbus - SB
Embarcadero - SB
Broadway - EB
I-80 - WB
I-80 - EB
Pine - WB
Bush - EB
Geary - WB
O'Farrell - EB
Howard - WB
Geary - EB
Stockton - SB
Mission / Otis - EB
Folsom - EB
Harrison - WB
Tuck - EB
Tuck - WB
Fulton - EB
Fulton - WB
Oak - EB
Fell - WB
Brannan - EB
King - EB
Lincoln / Kezar - WB
16th St - WB
Van Ness / South Van Ness - SB
Mission / Otis - NB
Potrero - NB
3rd St - NB
3rd St - SB
19th Ave/Park Presidio - NB
19th Ave/Park Presidio - SB
Evans - SB
Bayshore - NB
I-280 - SB
Guerrero / San Jose - SB
I-280 - NB
Bayshore - SB
US 101 - SB
Sloat - EB
Skyline - NB
Ocean - EB
Ocean - WB
Alemany - EB
Junipero Serra - SB
Junipero Serra - NB
Skyline - SB
Alemany - WB
Geneva - EB
US 101 - NB
Classifications
Arterial Class I
Arterial Class III
Freeways
0 0.35 0.7 1.4 Miles

Figure 4-2

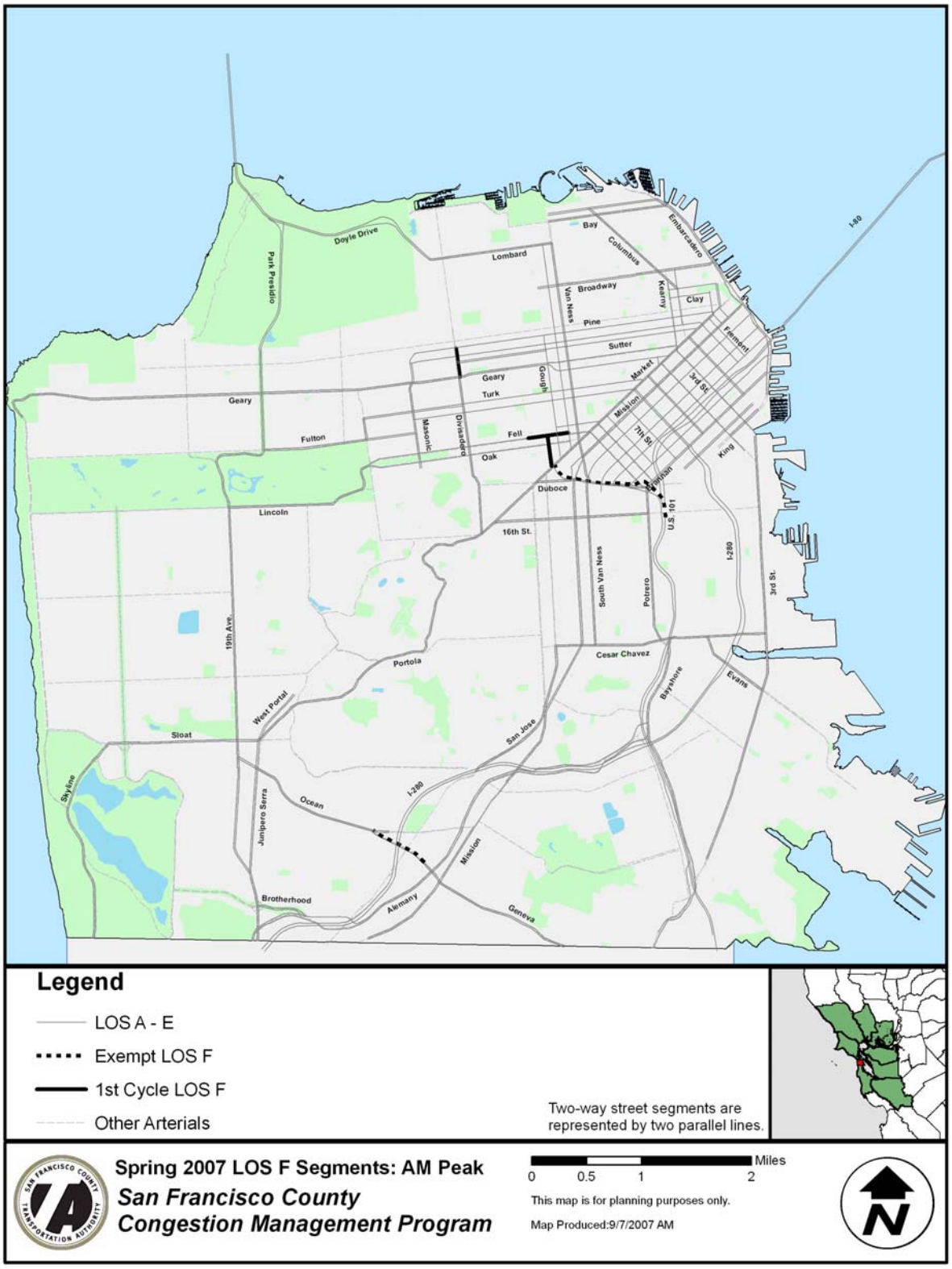
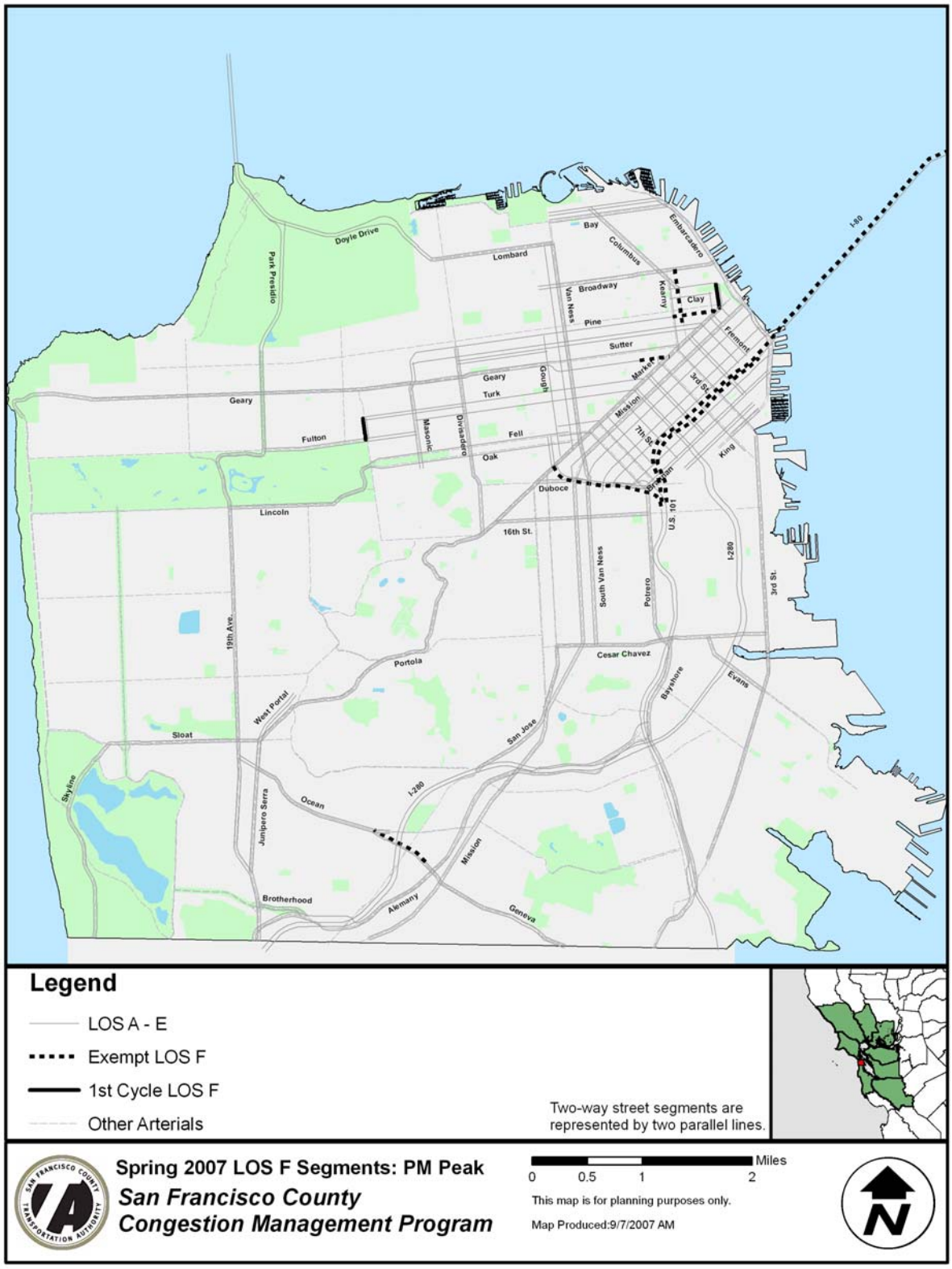

Doyle Drive
Park Presidio
Lombard
Bay
Columbus
Embarcadero
I-80
Broadway
Van Ness
Kearny
Clay
Pine
Sutter
Fremont
Geary
Turk
Gough
Market
Mission
3rd St.
Geary
Fulton
Masonic
Divisadero
Fell
Oak
7th St.
King
Duboce
Lincoln
Buchanan
U.S. 101
16th St.
I-280
South Van Ness
Potrero
3rd St.
19th Ave.
Portola
Cesar Chavez
Bayshore
Evans
West Portal
Sloat
San Jose
Skyline
Ocean
I-280
Junipero Serra
Mission
Brotherhood
Alemany
Geneva
Legend
LOS A - E
Exempt LOS F
1st Cycle LOS F
Other Arterials
Two-way street segments are represented by two parallel lines.
Spring 2007 LOS F Segments: AM Peak
San Francisco County
Congestion Management Program
Miles
0
0.5
1
2
This map is for planning purposes only.
Map Produced:9/7/2007 AM
N

Figure 4-3


Doyle Drive
Park Presidio
Lombard
Bay
Columbus
Embarcadero
I-80
Broadway
Van Ness
Kearny
Clay
Pine
Sutter
Fremont
Geary
Turk
Gough
Market
3rd St
Mission
7th St
King
Fulton
Masonic
Divisadero
Fell
Oak
Duboce
Lincoln
16th St.
U.S. 101
I-280
3rd St
South Van Ness
Potrero
19th Ave.
Portola
Cesar Chavez
Bayshore
Evans
West Portal
Sloat
San Jose
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Junipero Serra
Mission
Brotherhood
Alemany
Geneva
Legend
LOS A - E
Exempt LOS F
1st Cycle LOS F
Other Arterials
Two-way street segments are represented by two parallel lines.
Spring 2007 LOS F Segments: PM Peak
San Francisco County
Congestion Management Program
Miles
0
0.5
1
2
This map is for planning purposes only.
Map Produced:9/7/2007 AM
N

Figure 4-4

San Francisco County CMP

Segments Exempt from Mitigation Requirements: AM period

Level of Service (LOS)

Exempt

Not exempt

Two-way street segments are represented by two parallel lines.

Other arterials

Segments which were at LOS F during the first (1991) monitoring cycle are exempted from CMP legislation mitigation requirements.

Figure 4-5

San Francisco County CMP

Segments Exempt from Mitigation Requirements: PM period

Level of Service (LOS)

Exempt

Not exempt

Two-way street segments are represented by two parallel lines.

Other arterials

Segments which were at LOS F during the first (1991) monitoring cycle are exempted from CMP legislation mitigation requirements.

Table 4-1
2007 Roadway Level of Service (LOS) Monitoring Results – LOS F Segments

A.M. Peak Period

CMP Route	Limits (Direction)	Average Speed (mph)	LOS	Comments
Castro/ Divisadero	Geary to Pine (N)	1992/3: 10.8 1995: 7.7 1997: 7.5 1999: 7.4 2001: 7.3 2004: 8.4 2006: 7.1 2007: 6.1	D E E E E E E F	1st Cycle LOS F: Segment requires follow-up monitoring
Fell	Gough to Laguna (W)	1992/3: 26.7 2001: 11.8 2004: 11.1 2006: 7.2 2007: 6.2	A D D E F	1st Cycle LOS F: Segment requires follow-up monitoring
Geneva	Cayuga to Phelan (W)	1992/3: 4.5 1995: 15.5 2001: 15.0 2006: 11.0 2007: 6.9	F C C D F	Exempt: Segment monitored at LOS F during baseline cycle and therefore does not constitute a deficiency
Octavia	Fell to Market (S)	2006: 14.5 2007: 6.8	C F	1st Cycle LOS F: Segment requires follow-up monitoring
US-101*	I-80 to Market (N)	1991: 18.7 1992/3: 45.4 1995: 44.8 1997: 37.6 1999: 36.9 2006: 15.9 2007: 20.9	F E E E E F F	Exempt: Segment monitored at LOS F during baseline cycle and therefore does not constitute a deficiency

** Study Results prior to 2004 are for the US-101 segment from/to I-80 to/from Fell/Laguna.*

P.M. Peak Period

CMP Route	Limits (Direction)	Average Speed (mph)	LOS	Comments
Drumm	Washington to Market (S)	1992/3: 9.3 1995: 3.6 2001: 17.4 2006: 9.7 2007: 6.1	D F C D F	1st Cycle LOS F: Segment requires follow-up monitoring

CMP Route	Limits (Direction)	Average Speed (mph)	LOS	Comments
Geneva	Cayuga to Phelan (W)	1991: 6.7 1992/3: 10.4 1995: 12.0 1997: 9.6 1999: 14.2 2006: 7.9 2007: 6.9	F D D D C E F	1st Cycle LOS F: Segment requires follow-up monitoring
Montgomery	Broadway to Bush (S)	1991: 6.2 1992/3: 2.4 2001: 12.4 2004: 8.2 2006: 8.2 2007: 5.5	F F D E E F	Exempt: Segment monitored at LOS F during baseline cycle and therefore does not constitute a deficiency
O'Farrell	Mason to Market (E)	1991: 6.9 1992/3: 7.9 2001: 4.2 2004: 6.7 2006: 6.7 2007: 6.1	F E F F F F	Exempt: Segment monitored at LOS F during baseline cycle and therefore does not constitute a deficiency
Pine	Market to Kearny (W)	1991: 4.6 1992/3: 10.8 1995: 7.3 1997: 10.7 1999: 6.7 2001: 8.0 2004: 2.4 2006: 8.9 2007: 5.9	F D E D F E F F F	Exempt: Segment monitored at LOS F during baseline cycle and therefore does not constitute a deficiency
Stanyan	Turk to Fulton (S)	1992/3: 7.6 1995: 10.5 1997: 8.0 1999: 13.3 2006: 8.9 2007: 6.4	D D E C C F	1st Cycle LOS F: Segment requires follow-up monitoring
I-80	Treasure Island to Fremont Exit (W)	1991: 27.5 1992/3: 26.3 2001: 31.6 2004: 21.7 2006: 41.9 2007: 21.8	F F E F E F	Exempt: Segment monitored at LOS F during baseline cycle and therefore does not constitute a deficiency
I-80	Fremont to US-101 (W)	1991: 18.6 1992/3: 21.5 2001: 24.9 2004: 13.8 2006: 22.4 2007: 18.2	F F F F E F	Exempt: Segment monitored at LOS F during baseline cycle and therefore does not constitute a deficiency

CMP Route	Limits (Direction)	Average Speed (mph)	LOS	Comments
US-101*	Market to I-80 (S)	1991: 18.8 1992/3: 13.4 2004: 14.9 2006: 2007: 18.9	F F F F F	Exempt: Segment monitored at LOS F during baseline cycle and therefore does not constitute a deficiency
I-80	US-101 to Fremont (E)	1991: 19.0 1992/3: 29.5 2001: 14.8 2004: 10.0 2006: 8.9 2007: 19.6	F F F F F F	Exempt: Segment monitored at LOS F during baseline cycle and therefore does not constitute a deficiency

** Study Results prior to 2004 are for the US-101 segment from/to I-80 to/from Fell/Laguna.*

5. Future Monitoring Approach

In years past, the Authority has discussed with the Department of Parking and Traffic the possibility of using mechanical tube counts of arterial traffic volumes for CMP purposes. These counters would also by provide additional data for DPT at regular intervals. Traffic counting loop detectors could be installed at permanent counter stations, as well as locations designed to collect cordon counts of downtown (the last one was in 1983). These discussions should be revived. The Authority will also explore the idea of conducting monitoring using a corridor-level approach, and expanding the trips monitored to include other modes.

Consideration may also be given to evaluating LOS based on the newer HCM2000 arterial standard. Currently, the Authority uses the 1985 HCM standard that was current at the time of the original CMP legislation. The 2000 HCM standard calls for four arterial designations, rather than three. This may be more appropriate for San Francisco as many of the City's arterials do not fit the suburban stereotype that the 1985 HCM assumes.

The Authoity has enlisted the help of our LOS Monitoring Consultant to give preliminary recommendations of reclassifying our CMP segments using the new HCM 2000 standard. The Authority will meet with the Planning Department and MTA to finalize new segment recommendations for the 2009 monitoring cycle.

6. Caltrans' Role

Although Section 65089.3 establishes that Caltrans is responsible for LOS monitoring on the State highway system, the department has not been able to fully address this obligation due to budget constraints. The Authority continues to work with Caltrans District 4, MTC and the other Bay Area CMAs to ensure that freeway operations data still being collected by Caltrans is put to the best possible use to help satisfy CMP monitoring requirements. Until a budget solution is found, the Authority will continue to include state highways in its periodic LOS monitoring efforts to ensure that the information is available to satisfy CMP conformance determination requirements.

In September 2002 the Governor signed AB 2535 (Diaz). This legislation, called Transportation Congestion Data Collection, requires Caltrans to, within existing resources, collect, analyze and summarize highway congestion data for District 4 (Bay Area) and provide it to Congestion Management Agencies for LOS monitoring on state routes and highways. This bill would put the burden to do the monitoring on state routes back on Caltrans. Ideally, this reform will ensure uniform measurements and save the Authority this ongoing expense.

In light of the current state budget crisis, it unlikely that Caltrans will find the necessary resources to comply with the requirement to provide LOS data on state routes to the CMAs on a biennial basis.

7. Work Program Items – Key Milestones

- Monitor level-of-service in spring 2009, as well as follow up monitoring for the potentially deficient segments remaining from the 2007 cycle to determine whether there is a deficiency. Report results to the Plans & Programs Committee by October 2009.