



CITY OF HAYWARD AGENDA REPORT

AGENDA DATE 04/28/98

AGENDA ITEM _____
WORK SESSION ITEM WS #2

TO: Mayor and City Council
FROM: Director of Public Works
SUBJECT: **I-880 Ramp Metering Project**

Recommendation:

It is recommended that the City Council review and comment on the attached Final Report for the I-880 ramp-metering project.

Background/Discussion:

Caltrans and the Metropolitan Transportation Commission (MTC) have been studying the effects of ramp metering on I-880 between I-238 and Whipple Road. This ramp metering implementation is called the "Mini-Cornerstone" project. The City Council received a briefing on this project at a September 10, 1996, Work Session (see Exhibit A).

The MTC contracted with the consulting firm of TJKM to conduct the data collection and analysis before and after ramp metering. The original scope of work also included traffic counts not only on the I-880 mainline and ramps, but also at several key intersections within the City of Hayward. A key issue presented to Council was the possible impact of ramp metering on streets and intersections within the City of Hayward and the County of Alameda. TJKM completed a report on the impact of ramp metering on I-880 and local arterials and made recommendations regarding future ramp metering efforts. Although only the Final Report (see Exhibit B) is attached, the other reports from this study are available to the Council at its request.

Staff had originally intended to present an update on the ramp-metering project to the Council last fall. However, subsequent delays in obtaining reliable data resulted in the postponement of the presentation. Although the report has been completed, much of the data collected for the study is still not reliable. The table on Page 2 shows TJKM's conclusions from the study.

TJKM has concluded that metering enabled the freeway to handle higher volumes of traffic, with traffic moving at higher speeds than before metering. Additionally, some arterial links showed increased speeds and improved traffic flow, while other, most notably on Hesperian Boulevard, showed that traffic became more congested (see Exhibit C). The study did not provide an analysis of the effect of ramp metering on City of Hayward intersections, which is of major importance to the City.

Subsequently, Caltrans provided additional data, which had not been used in TJKM's final report, and completed an analysis of intersections. Additional work is continuing.

TJKM CONCLUSIONS FROM THE STUDY

<u>TJKM Conclusion</u>	<u>City of Hayward Staff Response</u>
1. Traffic speeds and volumes increased on the mainline, meaning that more vehicles were able to use the freeway and travel at higher speeds.	Agree
2. TJKM notes that some of the traffic formerly using the freeway shifted to arterials, such as Hesperian Boulevard. However, TJKM concludes that these were short trips of two-to-six miles.	Unsure as to how TJKM arrived at conclusion regarding trip length.
3. Traffic did not increase on local collector and access streets, such as Hathaway Avenue and Santa Clara Street, because there was little advantage between the metered ramps in terms of delays.	Insufficient data was presented to document this conclusion.
4. Traffic decreased on West "A" Street at I-880 due to the reduction of on-ramp volumes after metering.	Decrease on West "A" Street and the on-ramps was likely due to the major construction that was in progress during the evaluation period.
5. I-880 mainline conditions were improved at no real cost to levels of service on Hayward streets.	Insufficient data was presented to document this conclusion.
6. The results present a more qualitative than quantitative analysis and that more work needs to be done in order to arrive at quantitative recommendations that can form the basis of a ramp metering agreement between Hayward, Caltrans, the Alameda County Congestion Management Agency, and the MTC.	Agree. Also, the agreement would be more of a cooperative agreement as there is no legal requirement for a formal agreement.
7. The metering of I-880 is a qualified success, to date.	There is insufficient data to arrive at this conclusion, particularly relative to Hayward streets and intersections.

Ramp metering within Hayward is presently demand-responsive in that meters are timed to the vehicle arrival rate. A goal of this study was to identify how to transition from a demand rate to an active rate, which is based upon the conditions on I-880.

Another goal of this project is to improve mobility without interfering with local trip movements. TJKM noted that the coordination of the freeway and arterial systems implies a need to provide traffic-adaptive ramp metering for the freeway and traffic-responsive operations for major arterials.

While Caltrans ultimately intends to move from demand metering to active metering, they do not plan to implement this measure until the entire I-880 corridor is metered, probably within the next 18 months. City staff feels that active metering within Hayward should not occur until the impact of ramp metering on local intersections is more fully analyzed and, if necessary, mitigated.

Unresolved Problems and Issues

As stated above, insufficient data has been provided or analyzed which would help the City determine the impact of ramp metering on City streets and intersections. Additional analyses are continuing.

Even if this analysis is completed, staff agrees with the comment made in the Final Report that more work needs to be done in order to arrive at quantitative recommendations that can form the basis of a ramp metering agreement between the interested parties. However, in recognition of the fact that ramp metering has had some adverse effects on City of Hayward streets, Caltrans is looking at potential mitigation measures. One of these measures would be to expand the Winton Avenue northbound collector to two lanes, so that there would be less likelihood of ramp traffic backing up onto eastbound Winton Avenue. Caltrans is trying to get this project funded in the 1998-99 fiscal year. In addition, MTC has funded two Traffic Systems Management projects (on East 14th Street-Mission Boulevard and on Hesperian Avenue-Union City Boulevard) with the intention of mitigating any negative impacts from ramp metering.

If the results of the Caltrans analysis do not meet the prerequisites defined early in the program (i.e., elimination of adverse impacts of ramp metering on local streets and neighborhoods), staff recommends that the Council confirm its previous position on ramp metering, which is that active ramp metering should not be implemented until the City's concerns relative to the impact of such metering on City streets and intersections are resolved.

At the March 16, 1998, I-880 Intermodal Study Steering Committee meeting, our City representative, Council Member Hilson, reiterated many of the concerns expressed by staff in this report. As a result, the entire agenda of the Steering Committee's April 20, 1998, meeting was devoted to I-880 ramp metering. Many of the same concerns discussed in this agenda report were repeated by Council Member Hilson and other members of the Steering Committee. Caltrans and MTC staffs noted that ramp metering was being extended to other segments of the I-880 corridor. However, there was no further discussion as to future efforts regarding the transition from demand metering to active metering.

MTC's Next Steps

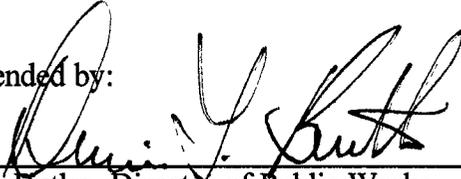
MTC and Caltrans plan to use the information gained from this study in the next phase of the ramp metering effort on I-880, and Caltrans plans to proceed with the metering effort in the next part of the corridor, which is between San Leandro and I-980 in Oakland, later this year.

Prepared by:



Robert A. Bauman, Deputy Director of Public Works

Recommended by:



Dennis L. Butler, Director of Public Works

Approved by:



Jesús Armas, City Manager

Attachments: Exhibit A: September 10, 1996 Work Session Agenda Report
Exhibit B: TJKM Final Report
Exhibit C: Analysis of arterial traffic conditions six months after ramp metering



CITY OF HAYWARD AGENDA REPORT

AGENDA DATE 9/10/96

AGENDA ITEM _____

WORK SESSION ITEM WS 2

To: Mayor and City Council
From: Director of Public Works
Subject: I-880 RAMP METERING PROJECT

Recommendation:

It is recommended that the City Council receive this informational report on the planned October 29, 1996, implementation of ramp metering in the I-880 corridor.

Background/Discussion:

The California Department of Transportation (Caltrans) has finalized construction within the I-880 corridor in anticipation of implementing the metering of on-ramps along I-880 through the City of Hayward. This informational report is being provided so that City and Caltrans staff can reply to any questions from Council prior to actual implementation of the metering. The ramp-metering project is part of Caltrans' overall Transportation Operating System (TOS) for the Bay Area. The intent of the TOS is to reduce congestion, emissions, and delays on highways using Intelligent Vehicle Highway System (IVHS) technologies. These technologies include loop detectors, closed circuit television cameras, a transportation monitoring center, changeable message signs, highway advisory radio to inform drivers of delays and alternate routes, and ramp metering to regulate the flow of traffic onto the highway. This project, dubbed the "Cornerstone Project," will eventually employ all of these systems.

Caltrans' "Cornerstone Project" will be implemented in three phases. The first phase, dubbed the "Mini-Cornerstone Project," is scheduled to begin operation on Tuesday, October 29, 1996. During Phase I, ramp metering will be implemented on the northbound and southbound on-ramps of I-880 between I-238 (at the San Leandro/Hayward border) and Whipple Road in Union City, thereby encompassing all access points onto I-880 within the City of Hayward (see Exhibit A). Initially, Caltrans will be activating the ramp meters on I-880 in the southbound direction between I-238 and Whipple Road. After a period of fine tuning, Caltrans will turn on the meters in the northbound direction. During this phase of the project (approximately two years), the ramp-metering lights will be operating at "demand" or "arrival" rates. Metering at arrival rates means the metering rate essentially is the same as the vehicle arrival rate on the ramp. The typical cycle length for "arrival" rate metering is four seconds per cycle. For example, in a group of 15 vehicles, the first vehicle in the group would experience four seconds of delay awaiting the "green" light. Consequently, the last vehicle in the 15-vehicle group would experience 60 seconds of delay before clearing the ramp. This equates to a maximum metering, or "clearance" rate of 900 vehicles per hour. Metering at "demand" rates helps familiarize drivers to ramp meters and breaks up groups of cars entering the freeway, thereby mitigating a common cause of mainline congestion.

Phase II of the "Cornerstone Project," scheduled to be operational in the spring of 1999, includes the northbound and southbound segments of I-880 between I-238 and I-980. These ramp meters will be integrated with the Phase I "Mini-Cornerstone Project" to create a single continuous metering corridor from Jackson Street in Oakland to Whipple Road in Union City. During Phase II, metering rates will be adjusted from "arrival" rates to a more restrictive "real time" metering requirement. In essence, this means that the metering rates are established based on the actual operation of the freeway. Assuming a more "restrictive" metering cycle of six seconds per vehicle, the maximum clearance rate at a ramp would be 600 vehicles per hour. That same group of 15 vehicles would now take 90 seconds to completely clear the ramp. Caltrans is adamant that metering rates will be adjusted to ensure that vehicle queues do not exceed the ramp storage and will not impede through movements on the local streets.

Phase III of the "Cornerstone Project," scheduled to be operational dependent upon completion of the Measure B interchange modifications projects in the Fremont area will complete ramp metering within the I-880 corridor in Alameda County. The northbound and southbound segment of I-880 between Whipple Road and the Santa Clara County line will be integrated with the Phase I and Phase II projects to complete the I-880 ramp-metering corridor.

Staff has actively participated in the process of developing the overall strategy associated with the "Mini-Cornerstone Project" through the I-880 Technical Working Group (TWG), composed of representatives of the various transportation agencies and affected local jurisdictions. In addition, policies concerning operation of the TOS were established by the I-880 Steering Committee, which comprises Caltrans representatives and elected officials from the aforementioned agencies.

Throughout the process, staff has expressed concern about the potential for the ramp metering to back traffic onto City arterial streets; for example, West A Street and Route 92. West A Street is of particular concern because of the relatively short ramp storage distance and Route 92 is an existing bottleneck which generates citizen concerns about both the amount of congestion and its impact on the surrounding neighborhoods. In response to staff's comments, Caltrans has agreed to conduct extensive "before" studies, which include conducting traffic counts, videotaping ramp queues, and conducting travel-time studies to establish a "baseline" condition as a measure by which the impact of metering may be evaluated. Staff, with the cooperation of Caltrans, has developed a program to monitor traffic conditions on key arterials and intersections (see Exhibit B).

Upon implementation of the "Mini-Cornerstone Project," monitoring of freeway operations and ramp queues will be conducted on an on-going basis. Potential diversion routes, such as Hesperian Boulevard or W. Jackson/Foothill to Route 580, will be monitored to determine any changes in the level of service (LOS). Metering rates will also be adjusted to mitigate adverse impacts on local roadways.

In the event that issues surrounding the effect of ramp metering upon local streets cannot be resolved between the City and Caltrans, there exists a three-step conflict resolution process. If issues cannot be resolved locally with Caltrans, they will be brought before the I-880 Technical Working Group. If still unresolved, the issue will then be addressed by the I-880 Steering Committee. If no agreement can be reached at this point, then the issue will be addressed by the full CMA Board. If still unresolved at this point, Caltrans, in prior correspondence, has agreed to terminate an individual metering signal operation should no reasonable solution be identified to mitigate impacts to the local roadway network (see Exhibit C). It should be noted, however, that to date, Caltrans has successfully resolved all disputes with local jurisdictions within the state concerning ramp metering. No jurisdiction, as of yet, has asked that the metering lights be "turned off."

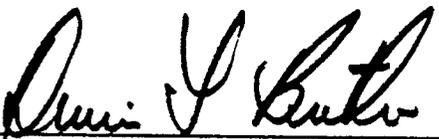
When operated correctly, ramp metering can prove to be an effective traffic operations tool to maximize the overall efficiency of a transportation corridor, providing equitable benefits to both the freeway drivers and local residents. Staff believes Caltrans' extensive data collection and monitoring efforts will assist in improving the overall efficiency of the transportation corridor. Caltrans and staff will continue to work in a cooperative manner to identify any corrective measures that might be required.

Prepared by:



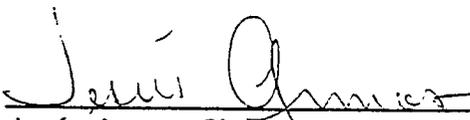
Robert A. Bauman, Deputy Director of Public Works

Recommended by:



Dennis L. Butler, Director of Public Works

Approved by:

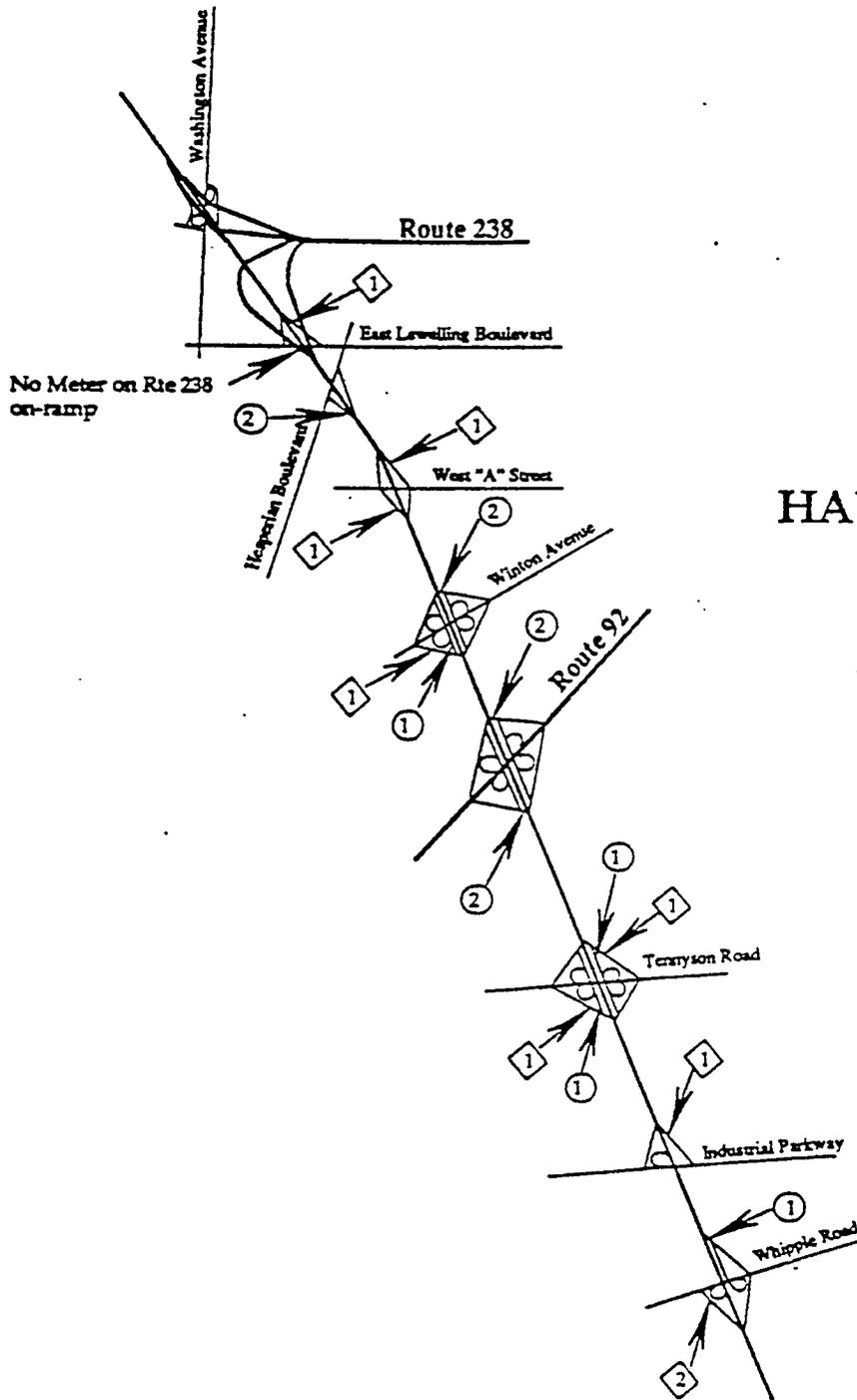


Jesús Armas, City Manager

Attachments: Exhibit A - Map of "Mini-Cornerstone" Phase I Ramp Meters
Exhibit B - Caltrans' 11/6/95 letter
Exhibit C - Caltrans' 7/18/94 letter

PW-E&T FDK/ew AGENDA96\1880CORR.FDK 9/4/96

to Oakland



HAYWARD

to San Jose

KEY	
①	One-Lane SOV Ramp Meter
②	Two-Lane SOV Ramp Meter
①	One-Lane SOV Ramp Meter and One-Lane HOV Bypass Meter
②	Two Lane SOV Ramp Meter and One-Lane HOV Bypass Meter

STATE OF CALIFORNIA BUSINESS AND TRANSPORTATION AGENCY DEPARTMENT OF TRANSPORTATION DISTRICT 04			
EXHIBIT A Phase 1 Ramp Meters			
DRAWN BY	CLP/udl	DATE	Dec. 1993
		SCALE None	
CO.	RTE.	P.M.	DR. NO.
ALA	680	137/207	1 of 1

No Scale

DEPARTMENT OF TRANSPORTATION

BOX 23660
OAKLAND, CA 94623-0660
(415) 286-4444



November 6, 1995

RECEIVED

NOV 10 1995

DEPT. OF PUBLIC WORKS
ENGINEERING AND
TRANSPORTATION DIVISION

Mr. FRED D. KELLEY
Senior Transportation Planner
Department of Public Works
City of Hayward
25151 Clawiter Road
Hayward, CA 94545-2731

Subject: Mini-Cornerstone Project

Dear Mr. Kelley:

This letter documents the results of our October 31, 1995 meeting in response to your letter dated October 16, 1995. The meeting purpose was to define performance measures for before/after ramp meter implementation. The issues discussed were as follows:

- Data collection and who does the collection
- Evaluation of data (methodology) and software utilized
- Frequency of "after" monitoring.

Data collection before and after ramp meter implementation will be performed by Caltrans and will consist of travel time studies, traffic counts, and videotaping. This data will be collected for both the AM (0600-0900 hrs) and PM (1500-1900 hrs) commute period.

Caltrans will conduct travel time studies on the Route 880 mainline and on three local roadway routes which are identified as potential diversion routes. Using the floating car method, travel time runs will be performed at approximately 30 minute intervals in each direction along the following routes:

- Mainline Route 880 between Washington Avenue and Alvarado-Niles
- Hesperian Blvd. between Lewelling and Alvarado-Niles/Rte 880 Interchange
- Route 92/Jackson St./Foothill Blvd. between Clawiter and the Rte 580 Interchange
- Industrial Parkway/Mission Blvd./A Street

Traffic Counts will be performed at the following locations:

- All Route 880 Interchanges between Hesperian and Whipple (inclusive)
- Lewelling/Hesperian Intersection
- Winton/Hesperian Intersection
- Hesperian Interchange @ Route 92

Mr. Fred Kelley
November 6, 1995
page 2 of 2

- Industrial Parkway/Hesperian Intersection
- A Street/Santa Clara Intersection
- Winton/Santa Clara Intersection
- Route 92/Santa Clara Intersection
- Rte 92 off-ramp at Industrial Blvd.
- Alvarado-Niles Diagonal on-ramp to SB and NB Route 880

Additionally, Caltrans will videotape the local street intersections (particularly the left turn pocket) at:

- A Street on-ramp to NB and SB Route 880
- Hesperian on-ramp to EB Route 92

The data collected before ramp meter implementation will be used as baseline comparison for the data collected after implementation. Evaluations will be performed to determine the corridor efficiency and any changes in the traffic patterns.

Caltrans will perform the studies and prepare reports upon ramp meter implementation and at 3 months, 6 months, and one year after ramp meter implementation. Additionally, both Caltrans and the City of Hayward will regularly monitor the ramp meter system and identify any corrective measures.

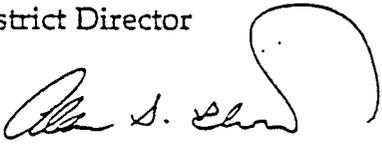
The City of Hayward and Caltrans agreed to use the same software in evaluations. This software shall be determined by the TWG meetings.

We look forward to working with the City of Hayward in ensuring the success of this first phase of ramp metering on the Route 880 corridor. If you have any questions, please contact me or Cesar Pujol at (510) 286-4577 and (510) 286-4520 respectively.

Sincerely,

JOE BROWNE
District Director

By


ALAN S. CHOW
Senior Engineer
Traffic Systems Branch

Attachment

cc: Dan Collins
Jean Hart, Alameda County CMA

DEPARTMENT OF TRANSPORTATION

BOX 23660

OAKLAND, CA 94623-0660

(415) 286-4444

(510) 286-4454

RECEIVED

JUL 25 1994

Dept. of Public Works



July 18, 1994

4-Ala-880-13.7/20.7
4396-150051

Mr. Robert A. Bauman
Director
Department of Public Works
City of Hayward
25151 Clawiter Road
Hayward, CA 94545-2731

Dear Mr. Bauman:

This letter is to inform you that Caltrans has a project under construction to include I-880 in the region's Transportation Operations System (TOS). This project is also being developed to enable us to maintain the operational improvements that will be provided by the widening projects currently underway. We are installing ramp metering hardware and propose to begin metering all on-ramps on I-880 in both directions between the Whipple Road interchange and the State Route 238 interchange. In addition, the project will implement a portion of our freeway TOS incident detection and motorist information system. This will involve the installation of loop detectors and closed circuit television cameras for monitoring traffic conditions, changeable message signs and highway advisory radio to provide motorists with real-time traffic information.

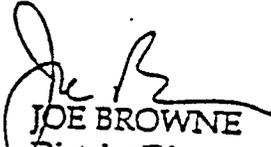
Ramp metering with High Occupancy Vehicle (HOV) bypass lanes is an integral part of the TOS. Ramp metering has proven to be an effective traffic operations tool to maximize the overall efficiency of a transportation corridor and provides equitable benefits to both the freeway drivers and local residents. Since an effective metering operation could impact the traffic operation on the local network, Caltrans wants to work closely with you to accomplish this objective. We have met with Daniel Collins of your staff to begin to establish this relationship. We want to work closely and in cooperation with your staff through the entire TOS development, implementation and operation process. As a result of this working relationship, identification of unanticipated situations and necessary mitigations can be accomplished with your staff's input and assistance.

Mr. Robert A. Bauman
July 18, 1994
Page 2 of 2

Our basic ramp metering policy is not to generate adverse impacts at the adjacent intersection or on the local street network. We want to coordinate with you the monitoring of the local intersections before, during, and after implementation of ramp metering. If any mitigation measures requiring additional work are necessary, we do have funding available through the Traffic Systems Management (TSM) program. In cases where we and your staff can not identify any reasonable mitigations, and the on-ramp metering does impact the local roadway network, we will revise the ramp metering plan and if necessary, terminate that individual metering signal operation. We believe that any issues encountered can be resolved to the satisfaction of all involved.

We hope that by working closely with you, we can provide a better service to both the motoring public and the residents of Hayward. We would appreciate your staff's assistance and support in this effort. If you have any questions, please contact Jim McCrank of my staff at (510) 286-4559.

Sincerely,


JOE BROWNE
District Director

MEMO

February 1, 1998

Project No.: 260-001

To: Shawn Gage, MTC

From: Gary Kruger 

Subject: Mini-Cornerstone Project, Task 6: Recommendations for Active Metering

TJKM has submitted the technical reports for Tasks 3 through 5 for this project. The final task is to develop recommendations for active ramp metering in Hayward, from Hesperian Boulevard on the north through Industrial Parkway on the south. Metering in this section of I-880 cannot be entirely effective without extending ramp metering both north and south; presently, I-880 southbound queues just north of Industrial because of the drop lane. Once the I-880 improvements are in place, including the remaining ramp meters and improved interchanges to the south, this queuing on the mainline may clear up at Industrial. Therefore, these recommendations only apply for the current situation where I-880 is metered from Hesperian Boulevard through Industrial Parkway.

As you know there were problems with the data collection, especially the "before-metering" data taken in October, 1996. TJKM was unable to develop complete statistical relationships between traffic patterns on I-880, the on ramps and the arterial routes serving this portion of the I-880 Corridor. Therefore, these recommendations are more qualitative than quantitative, and more work needs to be done in order to arrive at quantitative recommendations that can form the basis of a ramp metering agreement between Hayward, Caltrans, the Alameda County CMA and MTC.

This memo report first reviews the findings and conclusions of Task 5, and then develops recommendations for how to proceed from this point.

Findings and Conclusions to this Date

The Task 5 report provided us with important information regarding the impact of metering in the Hayward area. These include:

1. The metering implemented in late 1996 is "active" (e.g., the metering rate established for ramps was significantly *less* than the observed volumes before metering was turned on). This means many drivers using the ramp no longer had access. For example, if 800 cars per hour used a specific on ramp between 7 and 8 a.m. before metering, and after metering, only 500 cars could use that same ramp between 7 and 8 a.m., the queue at 8 a.m. would be 300 vehicles long (7,500 feet back of the stop line!) if all the before-metering drivers tried to use the same ramp. With a metering rate of 500 cars per hour (or one car every 7.2 seconds), the delay entering I-880 from that ramp would be 36 minutes given no changes in the demand to use the ramp between 7 and 8 a.m. Obviously, this did not happen; in fact, traffic shifted to other streets such as Hesperian Boulevard to make trips formerly made on I-880.

Most likely, the trips diverting from I-880 are the shorter trips spanning two to three interchanges, for example, from A Street to Tennyson. Other drivers may have used southbound Hesperian to get to the first non-metered southbound on ramp to I-880, Industrial Parkway. TJKM believes, however, that most of the drivers formerly using I-880 before metering who are now using Hesperian after metering was turned on are making relatively short trips of two to six miles.

2. Traffic did not increase on the local access and collector streets in Hayward such as Hathaway Avenue and Santa Clara Street because there was little advantage between the metered ramps in terms of delays. In Hayward, there are few convenient routes to use to cut in front of a queue backed from a ramp meter, so there was probably little, if any, diversion between ramps using local streets. There was diversion to the southbound Industrial ramp, but this diversion took place on Hesperian Boulevard, (from perhaps as far north as A Street). Because Hesperian Boulevard is a major, regional arterial route, it is appropriate for some of the north-south corridor traffic to use the facility, especially the shorter trips of a few miles. Most of these shorter trips essentially have an origin and destination in Hayward.

TJKM also found that traffic decreased on A Street at I-880, and this is due to the reduction of on-ramp volumes after metering. TJKM does not have volume data for Winton Avenue and Tennyson Road, but it is quite probable that volumes on these freeway access routes also dropped after metering.

3. As stated above, active metering is in effect at this time on almost every ramp in Hayward. This means that October, 1996 ramp volumes were somewhat higher in the a.m. and p.m. peak periods than they are today. The probable reductions (some cannot be entirely substantiated due to limitations of the data) are:

A.M. Peak, Southbound

-600/hour on A Street ramps
-1,050/hour on SR 92 ramps (two lane)

A.M. Peak, Northbound

-300/hour on Winton Avenue
-200/hour on A Street
-250/hour on Industrial Parkway
-200+/hour on Jackson Avenue based on metering rate and calculated former ramp volumes)

P.M. Peak, Southbound

-400/hour on A Street
-950/hour on SR 92
-50/hour on Tennyson Road

P.M. Peak, Northbound

-300/hour on Jackson Avenue (calculated)
-550/hour on Winton Avenue
-100/hour on A Street
-450/hour on Industrial Parkway

4. The metering established in late 1996 on all the ramps in Hayward improved I-880 mainline operations and traffic flow significantly at no real cost to levels of service on Hayward streets. As stated in the Task 5 technical report, entering ramp volumes have a significant deleterious effect on traffic flow on a freeway, and the ramp volumes in Hayward with volumes of 700 to over 2,000 vehicles per hour literally stop I-880 mainline traffic to the point that I-880 is flowing at only 65% to 80% of its capacity for several hours in the a.m.

and p.m. peak periods. Below, I have attached a copy of the freeway speed-flow traffic curve to illustrate this point.

EXAMPLE OF FREEWAY SPEED-FLOW RELATIONSHIPS

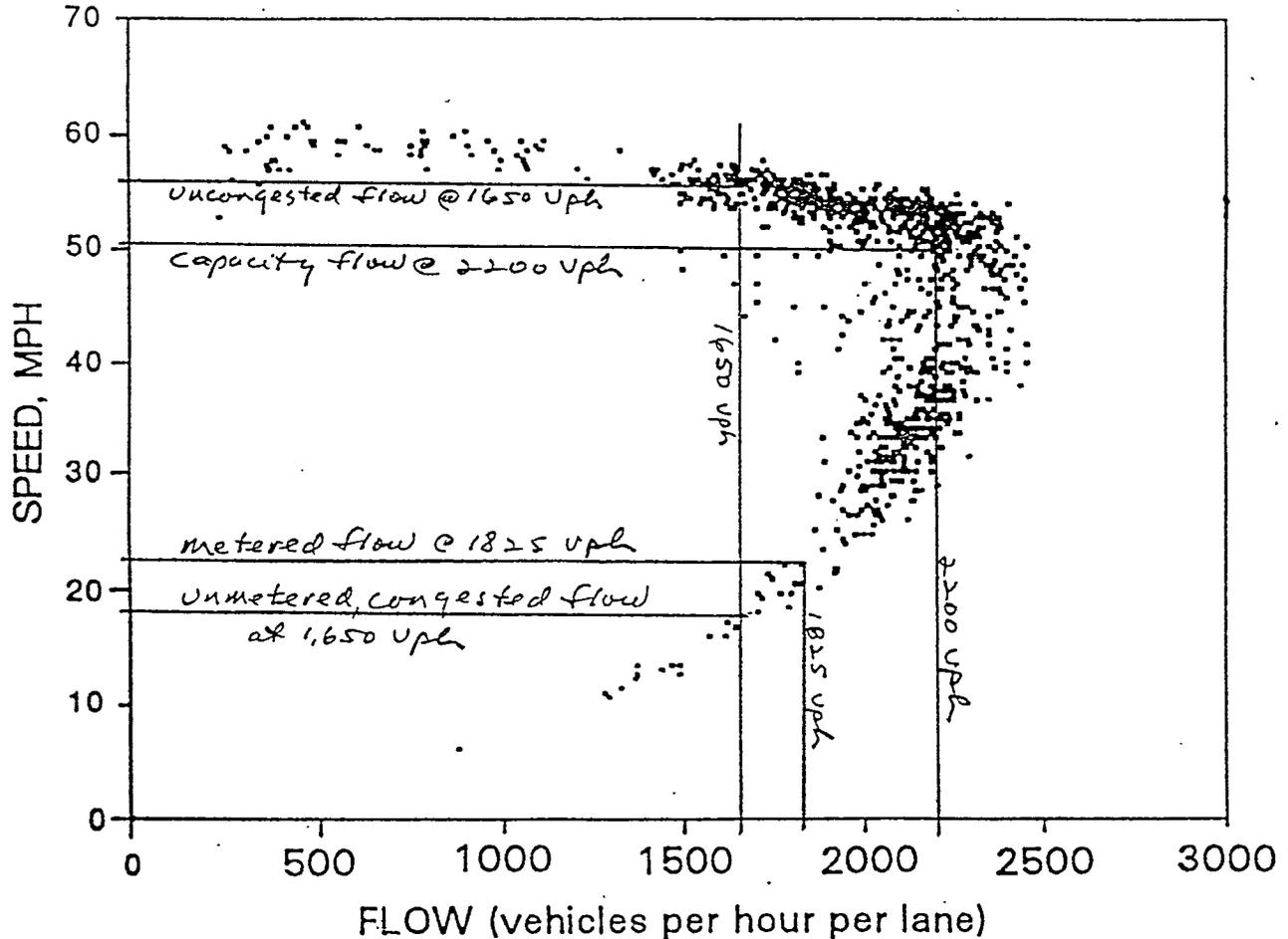


Figure 2-21. Observed speed-flow relationship on a San Diego freeway in 6-min sampling intervals (Interstate Highway 8, 1987) (Source: Ref. 21)

Generally, the feature with the most impact on freeway capacity is ramp entrances with high entering traffic volumes. The entering traffic directly displaces vehicles on the freeway mainline, and if the volume on the mainline is approaching capacity, the additional vehicles from the ramp increases the density of traffic on the mainline to an unsustainable level. Drivers on the mainline then slow down to put extra distance between them and the entering vehicles, which starts the process of forcing other drivers further upstream to slow down to maintain the desired headway of approximately 1.64 seconds (2,200 vehicles per lane per hour is freeway capacity, generally). As traffic slows, traffic flows drop below 2,200 cars per lane per hour. If speeds drop to 7 mph, it takes 1.64 seconds just for a 17-foot long car to pass by a point on the freeway (leaving no space in between cars for the 1.64 second

average headway). That is why, at the highest demand times on I-880, traffic flows per lane per hour are *below* capacity.

The speed-flow curve shows this seeming paradox. If I-880 is flowing at 1,650 cars per lane per hour, it could be that traffic demand is only 75% of capacity and everyone enjoys a speedy ride at 57 mph. Traffic could also flow at 1,650 cars per hour at only 18 mph, again only 75% of capacity. The influx of ramp volumes *lowers the capacity of the mainline* at ramp junctions, with the capacity of the mainline lowering most at the higher entering ramp volumes. As ramp volumes are decreased, freeway speeds and volumes also increase.

It is a short step to concluding that if freeway volumes and speeds can be maintained near 2,200 vehicles per lane per hour and 50 to 53 mph, more cars can pass through the system (including cars entering from ramps) than they can at 1,650 cars per lane per hour at 18 mph. Keeping the freeway operating near capacity should serve most drivers better, even given some delays at ramp meters, than allowing unlimited access to the freeway which penalizes everyone, both drivers on the mainline as well as on the entry ramps. That is why we found freeway volumes increased after metering - the active metering resulted in higher speeds and volumes on I-880. The freeway system is processing more cars now than it could before metering - demand itself has probably not changed significantly.

5. TJKM also found that the majority of peak periods had an incident on every day of the study. This is because with volumes of 200,000 vehicles per day over the eight mile Mini-Cornerstone project area, there are 1,600,000 vehicle miles of travel. If the collision rate is 1 accident per million vehicle miles of travel on the freeway, there would be an average of 1.6 collisions daily on I-880 in the study area. TJKM found this to be representative of the conditions on I-880. Incidents are "normal" on a daily basis, with some, say 25% during peak periods, and others (75%) outside peak periods.

Principles for Setting Active Metering Within Hayward

The Alameda County Congestion Management Agency Board adopted a *general policy* on ramp metering for the I-880 Corridor. That policy provides very good guidance on how to address this specific question: what to do now that the Mini-Cornerstone project has been completed to the extent that it can be (given data limitations).

There are two general objectives for managing freeway operations on I-880. They are the delivery of the maximum number of **people** to jobs in the shortest amount of time during peak commute times, and in non-peak commute times, the preservation of reliable movement of freight for overall economic development while still recognizing the need to maintain high levels of service for movement of people. This implies that metering could be in effect during both peak and non-peak periods to the extent that is necessary to ensure that good traffic flow is maintained during the period between peaks.

There is also an adopted goal to coordinate the management of the freeway, arterial and transit systems to improve mobility while ensuring that the regulation and controls on traffic flow impose no inequitable burden on any community or group of trip makers. In other words, the ramp meters cannot create extreme delays and block local access to the freeway. The coordination of freeway and arterial management systems implies a need to provide traffic adaptive ramp metering for the freeway and traffic responsive operation for the major arterials in the corridor, both arterials paralleling the freeway as well as arterial access routes to the interchanges. The emphasis on the movement of people rather than vehicles implies HOV lanes on the freeway and HOV bypass lanes at ramp meters, perhaps in effect for more and more hours of the day as traffic volumes build on I-880 and in the corridor.

The policy goes on to state that the amount of on-ramp traffic entering the freeway prior to metering (we assume this to be 1996 entry volumes - as this is the year the policy was adopted) from any community shall not be reduced after metering. The policy also states that ramp queues should not extend onto intersecting arterial streets serving the interchange, and in cases where the queues do extend back onto intersecting arterials, the metering rate shall be increased, or if necessary, turned off until the queue dissipates to an appropriate length, even if this action causes the freeway mainline to congest.

Using the information in the Mini-Cornerstone Project, "access" to I-880 by Hayward drivers before metering was perhaps over-used, because many drivers diverted to alternate arterial routes, *even though the delays at the ramp meter were typically less than one minute*. This is significant. "Access to I-880" might be re-defined as the drivers using ramps in the community to make trips of six miles or longer, rather than defining a driver hopping down I-880 for two interchanges as one who needs access to I-880. It is clear that the active metering in the corridor inconvenienced only a minor proportion of drivers in corridor, if we define inconvenience as less than a minute of added delay due to the meter - obviously, the alternate route was almost just as fast. In some instances, however, delays to drivers reached six to seven minutes; very likely, these are drivers entering I-880 to make trips with destinations far outside of Hayward.

It should be emphasized that this project was concerned with recurring delays rather than non-recurring delays due to collisions and breakdowns (incidents), or highway maintenance and construction. It is estimated that fully 50% of all freeway delays are non-recurring. Traffic adaptive metering along with traffic responsive signal operations and speedy clearance of incidents can also work to reduce non-recurring delays which are common on I-880.

On the basis of the discussion above, TJKM recommends:

- *"Access" to I-880 from any community should be defined as the number of vehicles entering I-880 in 1996 that are travelling at least six miles on the freeway system. The number of entering vehicles can be derived through an analysis of the countywide model at the Alameda County Congestion Management Agency. The access to I-880 should further be defined as the sum total of vehicles entering I-880 from that community by direction, rather than by individual ramp.*
- *Traffic adaptive ramp metering should be established and maintained for more than the peak periods within the I-880 Corridor, and the signal interconnect systems being installed with TSM funds on Hesperian and Mission Boulevards should be traffic responsive along segments of those arterial systems subject to additional traffic due to freeway incidents. "System loops" used for selecting arterial signal timing plans in traffic responsive mode should also include some on ramp and I-880 mainline loops.*
- *Caltrans and the California Highway Patrol, in cooperation with the City of Hayward and Alameda County Fire Departments, the Hayward Police Department and the County Sheriff Department should develop an aggressive program of incident management, with the highest priority being segments of I-880 that are metered.*

While there are many questions regarding the accuracy of the CMA model with regard to estimating the downstream distribution of destinations of vehicles entering from any on ramp in the community, the fact that the model has been validated indicates that model estimates are probably within 10% of the real numbers.

Specific Recommendations for a Ramp Metering Agreement in Hayward

TJKM would include the above three recommendations in any agreement on ramp metering in the Mini-Cornerstone project area. The scope of work for this project for Task 6 includes the following requirements:

- identify and recommend ways of eliminating localized problems,
- assess the likelihood of queuing on intersecting arterials at interchanges,
- identify the means of eliminating diversion of commute traffic through neighborhoods, where that diverted traffic is the result of ramp metering,
- develop recommendations on how to resolve the impacts from ramp metering,
- develop recommendations on continued monitoring of ramp metering and traffic conditions, and
- develop recommendations on specific active metering for each ramp.

The specific recommendations, if adopted by Hayward and Caltrans (and presumably reviewed by the CMA and MTC), would form the basis for the specific agreement between Caltrans and Hayward for continued ramp metering on I-880 ramps within the City of Hayward.

The first four items are not necessary, because TJKM found no localized problems nor commuter traffic diversion in neighborhoods nor queuing on intersecting arterials (hence no need to resolve the impacts of ramp metering). TJKM does have some recommendations on the continued monitoring of ramp metering and traffic conditions, and finally, TJKM suggests the means of developing specific ramp metering recommendations for each ramp which will necessarily be beyond this project's current scope of work (because the available data are not sufficient for this work).

TJKM recommends:

- *That the monitoring of ramp metering conditions on I-880 be incorporated into the development of the arterial advanced traffic signal system within Hayward to the extent that continuous speed-flow information from on-ramp and I-880 mainline loops is made a part of the "system loops" for selecting signal coordination plans under traffic responsive arterial signal system operation.*
- *A means should be developed in a future project to connect the City of Hayward signal system to the Caltrans Traffic Operations Center in Oakland. In this way the city could continuously monitor freeway speeds and flows (or density) as well as metering rates significantly below typical entry volumes in any specific time period. The information could be in mapped form on a computer monitor or pictures from video feeds. This system should also have an alarm to notify city signal operations staff when I-880 Mainline traffic flows and speeds or low entry ramp volumes indicate either significantly worse than average congestion or incidents that are likely to cause diversion of traffic onto city arterials.*
- *A model of I-880 freeway operations along with parallel arterial operations should be developed on the basis of the information and data in the I-880 Mini-Cornerstone Project. Additional volume data will need to be collected in areas where volumes are missing,*

particularly on arterials. This model should be developed using FREQ11 which will enable the determination of appropriate metering rates to achieve optimum I-880 operations during both peak and non-peak periods. The results should be used for the development of adaptive metering algorithms needed for metering on I-880.

- The CMA countywide model should be used to estimate the total amount of entry ramp traffic from ramps within Hayward, by direction, using the freeway system for trips of less than six miles; ramp volumes for 1996 conditions would be adjusted by removal of these volumes for the calculation of "equitable I-880 access." The 1996 volumes, then, would form the basis for the lower-bound metering rates for the set of ramps within the City of Hayward.*

Conclusion

Ramp metering on I-880 in Hayward is currently not optimized. Ramp metering rates have been set on the basis of historic data rather than current traffic conditions. The current rates are also not sensitive to freeway operations in real time. This leads to lower than needed metering rates during the times when the freeway traffic is flowing well, and too-high metering rates when the freeway is stopped or very slow moving due to heavier than normal volumes, or incidents.

Regardless, metering during the six month period under study did result in significant improvements in traffic operations on the freeway with increased delays to a minor proportion of drivers using the I-880 on ramps. There were also few negative impacts on the arterial street system in the City of Hayward. Because the length of freeway being metered does not cover the entire length of the freeway, there are still substantial problems in the corridor, especially at the southern and northern ends where queuing exists due to lane drops and construction (south end) and queues from I-238 (north end). In addition, the backup of traffic from the San Mateo Bridge also causes poor I-880 Mainline operations, but this cannot be helped with metering to the extent that the congestion will be reduced; the problem is beyond the control of traffic systems (or even auxiliary and storage lanes) on I-880.

Continued improvements can be made in I-880 operations if a FREQ model could be developed as the basis for a specific, traffic adaptive metering plan within the project area. Such work would naturally be continued on other segments of I-880 beyond the project area as additional ramps are metered.

In conclusion, the metering of I-880 is a qualified success to date.

Table 3: Arterial Analysis Before and After Metering

Route	From	To	Miles	Before Metering				After Metering			
				A.M. Peak		P.M. Peak		A.M. Peak		P.M. Peak	
				Speed	LOS	Speed	LOS	Speed	LOS	Speed	LOS
NB Mission:	Whipple Road	Industrial Boulevard	0.98	27.1	B	28.6	B	31.7	A	30.5	A
	Industrial Boulevard	Mission Boulevard	1.03	20.1	C	20	C	21.7	C	17.1	D
	Mission Boulevard	Tennyson Road	0.63	35.4	A	35.7	A	39	A	34.7	A
	Tennyson Road	Harder Road	1.23	29.5	B	24.7	B	30.6	A	27.8	B
	Harder Road	SR 92	1.42	25.1	B	18.2	C	29.9	B	16.9	D
	SR 92	A Street/Mission Blvd.	0.38	14.4	D	10.9	E	13.4	E	10.1	E
	A Street/Mission Blvd.	Santa Clara Avenue	1.13	25.3	B	19.8	C	25.5	B	23.2	C
	Santa Clara Avenue	I-880	0.24	12.3	E	19.4	C	nodata	N/A	nodata	N/A
	I-880	Hesperian Boulevard	0.51	19.5	C	17.9	C	nodata	N/A	nodata	N/A
	TOTAL/AVERAGE			7.55	24.9	B	22.2	C	28.2	B	23.2
SB Mission:	Hesperian Boulevard/A St.	I-880	0.6	19.7	C	19.7	C	nodata	N/A	nodata	N/A
	I-880	Santa Clara Avenue	0.22	24.8	B	26.2	B	nodata	N/A	nodata	N/A
	Santa Clara Avenue	A Street/Mission Blvd.	1.13	24.1	B	19.1	C	22.9	C	19.4	C
	A Street/Mission Blvd.	SR 92	0.4	12.6	E	12.4	E	17.1	D	15.9	D
	SR 92	Harder Road	1.39	22.1	C	19.4	C	20.3	C	19.1	C
	Harder Road	Tennyson Road	1.24	30.7	A	29.5	B	31.7	A	31.3	A
	Tennyson Road	Industrial Parkway	0.64	28.1	B	31.3	A	26.9	B	34.2	A
	Industrial Parkway	Industrial Boulevard	1.12	23.9	C	22.4	C	29.2	B	33.3	A
	Industrial Boulevard	Whipple Road	0.84	27.1	B	24.7	B	20.3	C	17.1	D
	TOTAL/AVERAGE			7.58	24.5	B	22.9	C	24.6	B	24.5
NB Hesperian:	Industrial Boulevard	Tennyson Road	0.86	29.7	B	33.7	A	30.6	A	21.1	C
	Tennyson Road	SR 92 Overcrossing	1.05	34	A	30	A	35.5	A	32.7	A
	SR 92 Overcrossing	Winton Avenue	0.42	23.6	C	21.4	C	23.6	C	15.2	D
	Winton Avenue	A Street	1.27	26.7	B	19	C	34.9	A	16.6	D
	A Street	Grant Avenue	0.97	30.3	A	27.5	B	24	B	27.8	B
	Grant Avenue	Lewelling Boulevard	1.33	20.7	B	24.1	B	22.9	C	19.6	C
	TOTAL/AVERAGE			5.9	28.6	B	26.9	B	29.1	B	22.5
SB Hesperian:	Lewelling Boulevard	Grant Avenue	1.34	26.7	B	27.2	B	24.2	B	20.2	C
	Grant Avenue	A Street	0.95	32.5	A	27.2	B	22.8	C	29.8	B
	A Street	Winton Avenue	1.3	25.4	B	19.8	C	24	B	21.5	C
	Winton Avenue	SR 92 Overcrossing	0.4	25.8	B	15.3	D	24	B	14	D
	SR 92 Overcrossing	Tennyson Road	1.04	30.9	A	26.7	B	27.8	B	27.7	B
	Tennyson Road	Industrial Boulevard	0.87	27.7	B	27.8	B	36.2	A	31.9	A
	TOTAL/AVERAGE			5.9	26.6	B	24.7	B	26.3	B	24.6
SB Foothill & WB Jackson:	I-580	A Street	1.18	23.4	C	23.8	C	26.4	B	29.4	B
	A Street	Mission Boulevard	0.29	15.4	D	23.6	C	26.6	B	30.3	A
	Mission Boulevard	Santa Clara Avenue	1.64	16.7	C	23	C	20.5	C	19.8	C
	Santa Clara Avenue	I-880 off-ramp	0.14	29.3	B	41.2	A	32.9	A	35.8	A
	TOTAL/AVERAGE			3.25	21.2	B	27.9	B	26.6	B	28.8
EB Jackson & NB Foothill:	I-880 on-ramp	Santa Clara Avenue	0.23	31.3	A	19.9	C	42.9	A	18.9	C
	Santa Clara Avenue	Mission Boulevard	1.46	25.7	B	18.5	C	20.3	C	15.9	D
	Mission Boulevard	A Street	0.51	18.5	C	14.5	D	20.4	C	16	D
	A Street	I-580	0.85	28.7	B	22.9	C	35.9	A	27.9	B
	TOTAL/AVERAGE			3.05	26.1	B	19.0	C	29.9	B	19.7
WB SR 92	I-880 off-ramp	I-880 on-ramp	0.36	28.8	F	19.3	F	28.1	F	44.6	F
	I-880 on-ramp	Hesperian Boulevard off-ramp	0.38	30.5	F	54.9	F	27.7	F	55	F
	Hesperian Boulevard off-ramp	Hesperian Boulevard on-ramp	0.3	30	F	57.7	E	29.6	F	58	E
	Hesperian Boulevard on-ramp	Industrial Boulevard off-ramp	0.51	33.7	F	57.1	E	33.8	F	56	E
	Industrial Boulevard off-ramp	Industrial Boulevard on-ramp	0.09	34.8	F	51.9	F	31.4	F	52.2	F
	Industrial Boulevard on-ramp	Clawiter Road	0.29	33.6	F	51.2	F	34	F	51.8	F
	TOTAL/AVERAGE			1.93	31.9	F	48.7	F	30.8	F	52.9
EB SR 92	Clawiter Road	Industrial Boulevard off-ramp	0.6	39.5	F	26.8	F	40.6	F	23.9	F
	Industrial Boulevard off-ramp	Industrial Boulevard on-ramp	0.1	58.1	E	41.2	F	54.4	F	31.5	F
	Industrial Boulevard on-ramp	Hesperian Boulevard off-ramp	0.56	29.7	F	39.2	F	55.8	F	25.9	F
	Hesperian Boulevard off-ramp	Hesperian Boulevard on-ramp	0.2	29.3	F	34.7	F	26.8	F	23.1	F
	Hesperian Boulevard on-ramp	I-880 off-ramp	0.45	55.6	F	24.1	F	52.9	F	22.7	F
	I-880 off-ramp	I-880 on-ramp	0.26	49.5	F	38.4	F	48.4	F	36.7	F
	TOTAL/AVERAGE			2.17	43.6	F	34.1	F	46.5	F	27.3

speeds underlined and in bold indicate an increase from Before Metering conditions