BOSTON REGION METROPOLITAN PLANNING ORGANIZATION

Stephanie Pollack, MassDOT Secretary and CEO and MPO Chair
Karl H. Quackenbush, Executive Director, MPO Staff

TECHNICAL MEMORANDUM

DATE: **December 3, 2015**
TO: **Boston Region Metropolitan Planning Organization (MPO)**
FROM: **Seth Asante, MPO Staff**
RE: **Low-Cost Improvements to Express-Highway Bottleneck Locations**

This memorandum summarizes the results of the analyses and improvement alternatives resulting from the Low-Cost Improvements to Express-Highway Bottleneck Locations study. The opening sections provide background information and describe the purpose of the study. The selection of study locations and an assessment of the safety and operational problems, as well as a discussion of the potential improvement strategies, follow the background sections. The memorandum's final section presents study recommendations. Also included are technical appendices, which cite the study methods and how the data were applied, including detailed reports about the freeway merge and diverge analyses. If implemented, the report's recommendations would result in improved freeway facilities; they would increase traffic safety, make traffic operations more efficient, and reduce congestion at the bottlenecks.

1 BACKGROUND

According to the Federal Highway Administration (FHWA), "Much of recurring congestion is due to physical bottlenecks—potentially correctible points on the highway system where traffic flow is restricted. While many of the nation's bottlenecks can only be addressed through costly major construction projects, there is a significant opportunity for the application of operational and low-cost infrastructure solutions to bring about relief at these chokepoints."[1] In general, recurring bottlenecks, the subject of this study, are influenced by the design or operation present at the point where the bottleneck begins (e.g., merges, diverges, lane drops, traffic weaving, and abrupt changes in highway alignment).

Previously, Boston Region Metropolitan Planning Organization (MPO) staff analyzed several express-highway bottleneck locations in two consecutive studies, Low-Cost Improvements to Bottlenecks Phase I and Phase II, which were very well received by the Massachusetts Department of Transportation

[1] Federal Highway Administration, *Recurring Traffic Bottlenecks: A Primer: Focus on Low-Cost Operations Improvements,* US Department of Transportation, Federal Highway Administration, June 2009, p. 1.

(MassDOT) and the FHWA.[2,3] Some of the recommendations from those studies already have been executed, and the FHWA has interviewed MPO staff about the successful implementation. The MPO has been conducting these studies to identify low-cost methods to reduce congestion, increase safety, and improve traffic operations in the Boston Region.

2 PURPOSE OF STUDY

The purpose of this study is twofold:

- Identify two bottleneck segments or points where low-cost mitigation improvements seem applicable.
- Recommend low-cost mitigation improvements based on analysis of geometric design, traffic volumes and other data, and projected service performance associated with the improvements at each location.

3 SELECTION OF STUDY LOCATIONS

The selection of study locations was a two-stage process that included the inventorying and screening of candidate locations.[4] MPO staff developed an initial list of candidate locations in the MPO region based on the following parameters:

- Staff knowledge of bottleneck locations in the Boston MPO region
- Review of Congestion Management Process (CMP) monitoring data and recent MPO and other planning studies
- Consultations with the MassDOT Highway Division
- Input from MPO members

The inventory process yielded five bottleneck locations for screening:

- Location 1: I-93 southbound between I-95 and Montvale Avenue in Woburn and Stoneham
- Location 2: I-95 southbound at the I-90 Interchange in Weston
- Location 3: I-93 southbound at the lane drop near Sullivan Square in Somerville/Charlestown
- Location 4: Route 2 Concord Rotary in Concord
- Location 5: I-95 northbound at the lane drop at Interchange 37 in Reading, Stoneham, and Wakefield

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[2] Seth Asante, MPO staff, memorandum to the Transportation Planning and Programming Committee of the Boston Region Metropolitan Planning Organization, "Low-Cost Improvements to Bottleneck Locations, Phase I," June 2, 2011.

[3] Chen-Yuan Wang, MPO staff, memorandum to the Transportation Planning and Programming Committee of the Boston Region Metropolitan Planning Organization, "Low-Cost Improvements to Bottleneck Locations, Phase II," March 12, 2012.

[4] Seth Asante, MPO staff, memorandum to the Boston Region Metropolitan Planning Organization, "Low-Cost Improvements to Express-Highway Bottleneck Locations: Selection of Study Locations," April 2, 2015.

3.1 Selection Criteria

MPO staff used the following three criteria to screen the bottleneck locations.

- Does the location qualify as a bottleneck? A repetitive long traffic queue upstream trailing free-flowing traffic downstream usually characterizes the location as a bottleneck. In other words, the location experiences routine and predictable congestion because traffic volume exceeds the available capacity at that location.
- Is a physical design constraint or operational conflict inherent in the location the cause of the bottleneck? Examples of these include:
    - Lane drop: one or more travel lanes are lost, requiring traffic to merge
    - Weaving area: drivers must merge across one or more lanes in order to access an entry or exit ramp
    - Merge area: on-ramp traffic merges with mainline traffic in order to enter the freeway
    - Major interchanges: high-volume traffic is directed from one freeway to another
- Can the bottleneck be fixed with low-cost operational and geometric improvements? These would exclude costly long-term solutions such as expansion or widening of the roadway. Examples of low-cost operational and geometric improvements include:
    - Using a short section of shoulder as an additional travel lane or for lengthening an acceleration or deceleration lane
    - Restriping merge and diverge areas to better serve traffic demand
    - Providing all-purpose reversible lanes
    - Changing or adding signs and striping

3.2 Study Locations

After consulting with MassDOT Highway Division staff, MPO staff selected Locations 1 and 2 for study. The study locations were also presented to the Boston Region MPO for discussions and approval. Through the selection process, MPO staff determined that these two locations likely could be corrected with low-cost mitigation strategies, whereas the other bottleneck locations likely could not be corrected in a low-cost manner. Appendix A contains comments about the study from the MassDOT Highway Division and a memorandum to the MPO that describes the selection process in detail.

Location 1: I-93 Southbound Between I-95 and Montvale Avenue in Woburn and Stoneham

This section of highway is frequently congested because of merging and diverging activities, and also because of inadequate length of the deceleration lane to Montvale Avenue. During peak periods, I-93 southbound carries as many as 7,700 vehicles per hour, the on-ramp from I-95 northbound carries as many as

1,800 vehicles per hour, and as many as 1,400 vehicles per hour exit to Montvale Avenue at Exit 36. The merging and diverging activities of these vehicles slow down I-93 southbound mainline traffic upstream of the Montvale Avenue interchange and cause many crashes near the diverge to Montvale Avenue. Section 6 of this memorandum contains a detailed description of the bottleneck, including the problems, causes, impacts, improvement alternatives, and recommendations.

Location 2: I-95 Southbound at the I-90 Interchange in Weston

This bottleneck is located on I-95 southbound at the point where traffic from I-90 and Route 30 merges onto I-95. During peak periods, between 2,300 and 2,900 vehicles per hour exit I-95 southbound to I-90 and Route 30. Farther downstream, between 2,000 and 2,400 vehicles per hour enter I-95 southbound from the same roads. However, the four I-95 southbound lanes in that section are not allocated efficiently to serve demand. As a result, during peak periods, a long traffic queue forms on the I-90 connector ramp heading southbound on I-95. Section 7 of this memorandum contains a detailed description of the bottleneck, including the problems, causes, impacts, improvement alternatives, and recommendations.

3.3 Rationale for Not Selecting Locations for Study

MPO staff did not select Locations 3, 4, and 5 for study. The reasons are described below.

Location 3: I-93 Southbound at the Lane Drop near Sullivan Square in Somerville/Charlestown

This section of highway is frequently congested because of a lane drop and intensive merging and diverging activities, especially during the AM peak period. During that period, the on-ramp carries between 1,300 and 1,700 vehicles per hour in an auxiliary lane; the off-ramp to Leverett Circle, Exit 26, carries between 1,200 and 1,600 vehicles per hour.[5] The merging and diverging activities of these vehicles slow down mainline traffic and seriously affect traffic on the upstream section of I-93. The distance between the two ramps is about 2,000 feet long. The reasons for not selecting this location for study include:

- Removing the lane drop would require widening the I-93 bridge over Alfred Lombardi Street to provide a new auxiliary lane for the on-ramp traffic or converting the existing auxiliary lane to an acceleration lane.
- Widening the I-93 Bridge could be expensive.

[5] Express-Highway Traffic Volumes, I-93 Southbound 2010 Balanced Traffic Volumes, Estimated by the Central Transportation Planning Staff.

- Converting the existing auxiliary lane to an acceleration lane might create a queue backup on the ramp that could affect traffic on Route 38 (Mystic Avenue) and the collector-distributor roads. In addition, there might not be enough space to provide sufficient acceleration distance because of the I-93 bridge over Alfred Lombardi Street.

Location 4: Route 2 Concord Rotary in Concord

This rotary, the intersection of Concord Turnpike (Route 2), Commonwealth Avenue, Barretts Mill Road, and Great Road (Route 119), is frequently congested because of high traffic volume and inadequate capacity during peak periods. The rotary is a challenge to navigate during these periods, and drivers often use local streets to avoid congestion. The MassDOT Highway Division is planning to replace the rotary with an overpass for safer and more efficient operation, and to minimize environmental impacts. The Highway Division also is exploring opportunities to improve neighborhood connections, incorporate the Bruce Freeman Rail Trail and wildlife corridors, improve water and air quality, and enhance the area's design aesthetics to the extent possible. Although this site is a major bottleneck, staff did not select this location for study because

- Low-cost solutions at this location likely would not be feasible. MassDOT and MPO staff have already studied the Route 2 Concord Rotary to examine potential short- and long-term improvement alternatives for the rotary.[6,7]
- The project was removed from the funded portion of the MPO's Long Range Transportation Plan in August 2009 and currently is on hold.

Location 5: I-95 Northbound at the Lane Drop at Interchange 37 in Reading, Stoneham, and Wakefield

This section of highway frequently is congested because of a lane drop and intensive merging and diverging activities, especially during the PM peak period, which slows down mainline traffic. During peak hours, the Exit 37 off-ramps carry as many as 3,200 vehicles per hour, and the Exit 37 on-ramps carry as many as 2,300 vehicles per hour.[8] Adding an auxiliary lane northbound on I-95 would provide more room for the merging and diverging activities and reduce disturbance to mainline traffic. Staff did not select this location for study because an auxiliary lane would need to be extended for a long distance (about three or

[6] Chen-Yuan Wang, Route 2 Improvements from Route 111 in Acton to Baker Avenue in Concord: A Feasibility Study, report produced by the Central Transportation Planning Staff for the Massachusetts Department of Transportation, February 2003.

[7] Route 2 Reconstruction at the Concord Rotary, Concord Board of Selectmen Presentation, November 24, 2008.

[8] Express-Highway Traffic Volumes, I-95 Northbound 2007 Balanced Traffic Volumes, Estimated by the Central Transportation Planning Staff.

four interchanges downstream) to reduce congestion and the queue, which could be expensive. In addition, the I-93 and I-95 Interchange project in Reading, Stoneham, and Woburn would address this bottleneck; currently this project is on hold.

4 DATA COLLECTION

4.1 Traffic Volume Data

The MassDOT Highway Division's Traffic Data Collection Program conducted automatic traffic recorder (ATR) counts for the ramps and freeways at the locations selected for study. The ATR counts are continuous traffic counts for at least 48 hours that are used to determine the average weekday daily traffic of a highway. For Location 1, MPO staff used ATR counts from the MassDOT Highway Division's traffic count database that were conducted in April 2014 and January 2015. For Location 2, MPO staff used actual ATR counts that were conducted in April 2015 for the four I-95 southbound ramps. The ATR count data are included in Appendix B.

4.2 Crash Data

MPO staff used crash data from January 2010 through December 2012 from the MassDOT's Registry of Motor Vehicles database to evaluate safety for motorists. Crash data are included in Appendix C.

4.3 Speed Data

MPO staff used speed data from spring 2012 and fall 2012 from the MPO's CMP. The CMP maintains average speed data on express-highway systems in the MPO region with use of the INRIX historical traffic speed data archive of real-time traffic.

5 LEVEL OF SERVICE CRITERIA FOR FREEWAY MERGE, DIVERGE, AND BASIC SEGMENTS

The Highway Capacity Manual (HCM) methodology demonstrates driving conditions on freeways in terms of level-of-service (LOS) ratings from A through F.[9] The LOS criteria characterize freeway performance measures in terms of density (passenger cars per mile per lane, [pc/mi/ln]). Table 1 shows the LOS criteria for basic freeway and ramp merge/diverge and weaving segments. LOS A represents the best operating conditions (unrestricted operations), while LOS F represents the worst operating conditions (queuing on the freeway and/or ramp). LOS A through LOS D represent acceptable operating conditions. LOS E

[9] Highway Capacity Manual 2010, Transportation Research Board of the National Academies, Washington, DC, December 2010.

represents operating conditions at capacity. LOS F represents failing conditions (demand exceeds capacity).

TABLE 1
Level of Service Criteria for Basic Freeway, Ramp Merge/Diverge, and Weaving Segments

--	Basic Freeway Segment	Ramp Merge/Diverge and Weaving Segments
Level of Service	Density (in passenger cars per mile per lane [pc/mi/ln])	Density (in passenger cars per mile per lane [pc/mi/ln])
A	≤ 11	≤ 10
B	> 11-18	> 10-20
C	> 18-26	> 20-28
D	> 26-35	> 28-35
E	> 35-45	> 35
F	> 45, Demand exceeds capacity	Demand exceeds capacity

Source: Highway Capacity Manual 2010.

6 LOCATION 1: I-93 SOUTHBOUND BETWEEN I-95 AND MONTVALE AVENUE IN WOBURN AND STONEHAM

This bottleneck is located on the I-93 southbound barrel between I-95 and Montvale Avenue. The MassDOT Highway Division's District 4 has jurisdiction of this roadway. Figure 1 shows the location of the bottleneck and the ramp configuration near it (all figures are included at the end of the memorandum). This section, approximately 1.2 miles long, experiences intense interruption of traffic flow because of the merging and diverging maneuvers of high-volume traffic entering and exiting the freeway.

6.1 Existing Freeway Characteristics

Basic Freeway Section

The basic freeway section of I-93 southbound has four 12-foot travel lanes, a 12-to-13-foot right shoulder, and an 11-to-12-foot left shoulder. This section carries up to 7,700 vehicles per hour. The posted speed limit is 65 mph on the I-93 southbound mainline. Freeway exit signs are posted at one-mile and half-mile intervals to guide drivers to Montvale Avenue. Rumble strips have been installed on both sides of the southbound barrel to alert drivers and prevent run-off collisions.

Entrance Ramp

An entrance ramp is a one-way roadway that allows traffic to enter a freeway from other crossing highways. Sufficient acceleration distance is needed to allow a vehicle to enter the freeway mainline safely and comfortably; drivers on the

entrance ramp need to be able to see a sufficient distance upstream from the entrance to locate the gaps in the traffic stream within which to merge. The entrance ramp from I-95 northbound to I-93 southbound is a one-lane, one-way roadway. It carries as many as 1,800 vehicles per hour during peak hours. The length of the acceleration lane for traffic entering the section from I-95 northbound is approximately 1,600 feet long, and the posted speed limit on the entrance ramp is 30 mph. Based on highway design and entrance ramp curve design speeds, the length of the acceleration lane meets MassDOT's standards. The MassDOT Highway Division's current Project Development and Design Guide specifies a minimum acceleration lane of 1,230 feet for a freeway facility with a design speed of 70 miles per hour, an entrance ramp curve design speed of 35 mph, and a grade of two percent or less.

Exit Ramp

An exit ramp is a one-way roadway that allows traffic to exit from the freeway and provide access to other crossing highways. Sufficient deceleration distance is needed to allow a vehicle to leave the freeway mainline safely and comfortably. The exit ramp from I-93 southbound to Montvale Avenue is a one-way, one-lane roadway. It carries as many as 1,400 vehicles per hour during peak hours. The length of the deceleration lane for traffic exiting to Montvale Avenue is about 350 feet long, and the posted speed limit on the exit ramp is 30 mph. Based on highway design and exit ramp curve design speeds, the length of the deceleration lane **does not meet** MassDOT's standards. The MassDOT Highway Division's current Project Development and Design Guide specifies a minimum deceleration length of 490 feet for a freeway facility with a design speed of 70 miles per hour, an exit ramp curve design speed of 35 mph, and a grade of two percent or less.

6.2 Problems

The existing bottleneck creates intense interruption of traffic flow during peak travel periods, felt by virtually all drivers in the section. It reduces travel speeds on the freeway mainline to 25 to 45 mph during the AM peak period (6:00 AM to 10:00 AM). In addition, the bottleneck causes many crashes in this area and results in poor operating LOS, especially at the diverge area connecting the exit ramp to Montvale Avenue.

6.3 Causes

There are two primary contributing factors to this bottleneck: high volume of traffic and a short deceleration lane.

High Volume of Traffic

Figures 2 and 3 show the traffic flows during the AM and PM peak periods. High-volume traffic from I-95 enters I-93 southbound at the upstream of the section, and high-volume traffic exits to Montvale Avenue at the downstream section during the AM peak period. The merging and diverging maneuvers of the entering and exiting vehicles interrupt traffic flow in this section, resulting in a traffic bottleneck.

Short Deceleration Lane

A short deceleration lane for the high-volume traffic exiting I-93 southbound to Montvale Avenue forces drivers to diverge quickly and does not give them the ample distance needed to allow a vehicle to leave the freeway mainline safely and comfortably. The intense diverging maneuvers slow down traffic, causing recurring congestion upstream from the diverge location.

6.4 Impacts

Crashes

A summary of the crashes in this segment is presented in Table 2. There were 61 crashes in this area between 2010 and 2012 (Appendix C). Figure 4 shows the location and number of crashes. The majority (52 crashes) occurred in the vicinity of the short deceleration lane to Montvale Avenue.

TABLE 2
Crash Summary (2010-2012)
I-93 Southbound Segment between I-95 and Montvale Avenue

Crash Variable	Number of Crashes
Crash severity	—
Fatal injury	1
Nonfatal injury	20
Property damage only	39
Not reported/unknown	1
Manner of collision	—
Angle	6
Rear-end	37
Sideswipe, same direction	9
Single vehicle crash	9
Road surface conditions	—
Dry	49
Wet	8
Snow	3

Other	1
Ambient light conditions	—
Daylight	29
Dark: lighted roadway	28
Dark: nonlighted roadway	2
Dawn	1
Dusk	1
Weather conditions	—
Clear	35
Cloudy	6
Rain	5
Snow	3
Not reported or unknown	12
Travel period	—
Peak	33
Off-peak	28
Total crashes	61
Three-year average (rounded)	20
Segment crash rate	0.57
MassDOT Highway Division average crash rate for urban interstate roadways	0.54

The AM peak period is 6:00 AM to 10:00 AM, and the PM peak period is 3:00 PM to 7:00 PM.
Source: Central Transportation Planning Staff.

The segment crash rate of 0.57 crashes per million vehicle-miles traveled (MVMT) was greater than the MassDOT Highway Division average crash rate for urban interstate highways in Massachusetts, which is 0.54 MVMT. Below is a summary of the crashes in this segment.

- Thirty-four percent of the crashes resulted in injury, including one fatal injury.
- Sixty-one percent of the crashes were rear-end collisions.
- Fifty-four percent of the crashes occurred during the peak travel period.
- Fifty-two percent of the crashes occurred outside daylight conditions.
- Eighty percent of the crashes occurred under dry roadway conditions.

Travel Speed

Figure 5 is a congestion scan that shows the average travel speeds on I-93 southbound at the bottleneck location between I-95 and Montvale Avenue. The bottleneck reduces travel speed to 25 to 45 mph. Many motorists on I-93 southbound move out of the rightmost lane to avoid the high volume of merging and diverging traffic entering and exiting the freeway at this location.

Level of Service

MPO staff conducted traffic operations analyses consistent with HCM methodologies. Using the data collected, MPO staff built traffic analysis networks for the AM and PM peak hours with the 2010 Highway Capacity Software (HCS) to assess the capacity and quality of traffic flow at the bottleneck area (included in Appendix D).[10] Table 3 presents the results of the LOS analyses for the existing conditions. The analyses indicate that the merge area upstream of the section operates well at LOS D during the AM and PM peak hours; however, the Exit 36 diverge area downstream of the section near Montvale Avenue operates at LOS E during the AM and PM peak hours (highlighted in yellow color in Table 3).

TABLE 3
Freeway Segment Analysis: Existing Conditions
I-93 Southbound Segment between I-95 and Montvale Avenue

Freeway Component	AM Density (pc/mi/ln)	AM Speed (mph)	AM LOS*	PM Density (pc/mi/ln)	PM Speed (mph)	PM LOS*
2015 Existing Conditions	—	—	—	—	—	—
Merge area: ramp from I-95 northbound	27.3	54.3	C	30.0	51.9	D
Basic freeway segment: between the ramps	32.7	60.4	D	36.0	58.2	E
Diverge area: Exit 36, Montvale Avenue	36.2	50.4	E	40.4	51.2	E

*LOS A through LOS D represent acceptable operating conditions; LOS E represents operating conditions at capacity; and LOS F represents failing conditions (demand exceeds capacity).
mph = miles per hour. pc/mi/ln = passenger cars per mile per lane
Source: Central Transportation Planning Staff.

6.5 Improvement Alternatives

MPO staff developed two improvement alternatives to address the bottleneck:

- Alternative 1: Lengthen the deceleration lane at the Exit 36 diverge area
- Alternative 2: Create an auxiliary lane for merging and diverging traffic

The alternatives were analyzed using projected year 2025 traffic volumes. MPO staff estimated a five percent total background growth from 2015 to 2025.

Alternative 1: Lengthen the Deceleration Lane at the Exit 36 Diverge Area

The existing deceleration lane is short; it does not meet MassDOT's standards and contributes to poor traffic operations and a high number of crashes. MPO staff recommends lengthening the deceleration lane at Exit 36.

[10] Highway Capacity Software 2010, Version 6.65, McTrans Center, PO Box 116585, Gainesville, Florida, October 2014.

Figure 6 shows the improvements recommended in Alternative 1.

- Use a portion of the existing right shoulder to lengthen the deceleration lane from 350 feet to 1200 feet. The improvement would upgrade the deceleration lane to meet MassDOT's standards and provide drivers with ample distance to exit the freeway to Montvale Avenue safely and comfortably.
- Relocate signs or install new guide signs to direct drivers to Montvale Avenue.
- Modify pavement markings to delineate the deceleration lane from travel lanes.

Alternative 2: Create an Auxiliary Lane for Merging and Diverging Traffic

An auxiliary lane is defined as the portion of the roadway adjoining the traveled freeway for speed change, merging, diverging, weaving, and other purposes supplementary to through-traffic movement. Alternative 2 would transform the right shoulder from the entrance ramp to the exit ramp into an auxiliary lane for merging or diverging traffic maneuvers and would provide sufficient distance to accommodate speed changes and weaving maneuvers. The auxiliary lane would also upgrade the short deceleration lane to meet MassDOT's standards.

Figure 7 (Sections 1, 2, and 3) shows the improvements recommended in Alternative 2.

- Use the existing right shoulder to create an auxiliary lane.
- Create emergency pullover or stopping areas on the southbound barrel to address incidents and safety concerns related to the use of the shoulder as a travel lane.
- Relocate existing guide signs or install new guide signs and pavement markings to direct drivers to merge onto the mainline or diverge to exit onto Montvale Avenue.
- Modify pavement markings to delineate the auxiliary lane from the mainline travel lanes.

6.6 Effectiveness and Cost of the Improvements

Alternatives 1 and 2 were analyzed as freeway merge/diverge and basic freeway segments. Table 4 presents the results of the 2025 future LOS analyses for Alternatives 1 and 2. Alternative 1 results in LOS E at the mainline basic freeway segment (highlighted in yellow in Table 4). Analysis indicates that Alternative 2 would improve traffic operations at the bottleneck to LOS D or better during peak periods (compared to LOS E with no action). Alternative 2 is expected to

increase AM peak period average travel speed to 50 to 55 mph (compared to 25 to 45 mph with no action) and reduce crashes by as much as 30 percent.[11]

Improvement Alternative 1 is estimated to cost between $200,000 and $250,000 to construct. Improvement Alternative 2 is estimated to cost between $500,000 and $750,000 to construct.

TABLE 4
Freeway Segment Analysis: Improvement Alternatives
I-93 Southbound Segment between I-95 and Montvale Avenue

Freeway Component	AM Density (pc/mi/ln)	AM Speed (mph)	AM LOS*	PM Density (pc/mi/ln)	PM Speed (mph)	PM LOS*
Alternative 1: 2025 Future Conditions	—	—	—	—	—	—
Merge area: ramp from I-95 northbound	17.4	58.2	B	30.8	51.0	D
Basic freeway segment: between the ramps	35.3	58.6	E	39.5	55.8	E
Diverge area: Exit 36 Montvale Avenue	27.7	50.1	C	31.0	51.2	D
Alternative 2: 2025 Future Conditions	—	—	—	—	—	—
Merge area: ramp from I-95 northbound	17.4	58.2	B	30.8	51.0	D
Basic freeway segment: between the ramps	24.9	64.4	C	26.9	63.6	D
Diverge area: Exit 36, Montvale Avenue	27.7	50.1	C	30.9	51.2	D

*LOS A through LOS D represent acceptable operating conditions; LOS E represents operating conditions at capacity; and LOS F represents failing conditions (demand exceeds capacity).
mph = miles per hour. pc/mi/ln = passenger cars per mile per lane
Source: Central Transportation Planning Staff.

6.7 Recommendations

MPO staff recommends Alternative 2 because it improves operational efficiency and safety by removing entering and exiting traffic from the mainline travel lanes to the auxiliary lane. Alternative 1 forces traffic to merge onto the mainline as well as diverge from the mainline to exit the freeway, which interrupts traffic flow.

There is space within the existing right-of-way to construct Alternative 2. The right shoulder appears to have a consistent 12-to-13-foot space, which is wide enough to accommodate a full-travel lane (auxiliary lane). In addition, there is

[11] Crash Modification Factors Clearinghouse, US Department of Transportation Federal Highway Administration.

space to construct an emergency pullover/stopping area, which would not be expensive to build. Alternative 2 would mirror the recently constructed northbound auxiliary lane and emergency pullover area.

Alternative 2 would require a Design Exception Report (DER) for the less-than-minimal right shoulder (i.e., a 12-foot auxiliary lane and a 2-foot offset [no shoulder] to the guardrail). The DER could be easily produced by MassDOT Highway District 4, similar to the DER submitted and approved for the I-93 northbound auxiliary lane.

7 LOCATION 2: I-95 SOUTHBOUND AT THE I-90 INTERCHANGE IN WESTON

There are two bottleneck locations on the I-95 southbound barrel at the I-90 Interchange in Weston. The interchange and roadways are under the jurisdiction of MassDOT Highway Division's District 6. Figure 8 shows the locations of the bottlenecks and the ramp configurations near them. The affected section, about one mile long, extends from Exit 25 (I-90) to the Recreation Road overpass.

7.1 Existing Freeway Characteristics

Basic Freeway Section

The basic freeway section has four 12-foot travel lanes, a 2-to-3-foot right shoulder, and an 11-to-12-foot left shoulder. During peak hours, I-95 southbound carries as many as 7,500 vehicles per hour upstream of the section under study.[12] The posted speed limit is 55 mph. Exit signs are posted at one-mile, one-half-mile, and one-quarter-mile intervals to guide motorists exiting the freeway to I-90 and Route 30. Rumble strips have been installed on both sides of the southbound barrel to alert drivers and prevent run-off collisions. In June 2015, MassDOT Highway District 6 implemented signs and pavement markings in the study area.

Although, the posted speed limit on I-95 southbound is 55 mph, the 85th-percentile speed on the freeway is usually around 70 mph. Based on the 85th-percentile speed, MPO staff used a design speed of 70 mph to evaluate the minimum length of the acceleration and deceleration lanes described below.

Exit Ramps

Exit ramps are one-way roadways that allow traffic to exit from the freeway and provide access to other crossing highways. Sufficient deceleration distance is needed to allow a vehicle to leave the freeway mainline safely and comfortably.

[12] AM peak period begins at 6:00 AM and ends at 10:00 AM; PM peak period begins at 3:00 PM and ends at 7:00 PM.

At Exit 25, the exit ramp to I-90 is a one-way, one-lane roadway on the freeway that widens to two lanes on the connecting ramp roadway. It carries as many as 2,300 vehicles per hour during peak hours. The length of the deceleration lane is about 350 feet long. Based on the highway design and exit ramp curve design speeds, the length of the deceleration lane **does not meet** MassDOT's standards. The posted speed limit on the exit ramp curve to I-90 is 25 mph.

At Exit 24, the exit ramp to Route 30 is a one-way, one-lane roadway that carries as many as 900 vehicles per hour during peak hours. The advisory speed limit on the exit ramp curve to Route 30 is 25 mph. The length of the deceleration lane for the traffic exiting to Route 30 is about 500 feet long. Based on the highway design and exit ramp curve design speeds, the length of the deceleration lane meets MassDOT's standards. However, the sharp hairpin curve would require slower speeds and enhanced signs to warn and guide drivers through the curve. The MassDOT Highway Division's current Project Development and Design Guide specifies a minimum deceleration length of 520 feet for a freeway facility with a design speed of 70 mph, an exit ramp curve design speed of 30 mph, and a grade of two percent or less.

Entrance Ramps

Entrance ramps are one-way roadways that allow traffic to enter a freeway from other crossing highways. Sufficient acceleration distance is needed to allow a vehicle to enter the freeway mainline safely and comfortably; drivers on the entrance ramp need to be able to see a sufficient distance upstream from the entrance to locate the gaps in the traffic stream within which to merge. The entrance ramp from I-90 to I-95 southbound carries up to 2,000 vehicles per hour during peak periods that merge onto I-95 southbound at the bottleneck. The length of the existing acceleration lane on I-95 southbound for the traffic entering the freeway from I-90 is approximately 450 feet long. Based on the highway design and entrance ramp curve design speeds, the length of the acceleration lanes **does not meet** MassDOT's standards.

The entrance ramp from Route 30 to I-95 southbound carries up to 600 vehicles per hour during peak periods. The length of the existing acceleration lane on I-95 southbound for the traffic entering the freeway from Route 30 is approximately 400 feet long. Based on the highway design and entrance ramp curve design speeds, the length of the acceleration lanes **does not meet** MassDOT's standards.

Interstate 95, also called Route 128, was constructed in the 1950s to design standards of the time. It has been reconstructed along various portions over time to address some design deficiencies associated with updated standards. The

MassDOT Highway Division's current Project Development and Design Guide specifies a minimum acceleration length of 1,230 feet for a freeway facility with a design speed of 70 miles per hour, an entrance ramp curve design speed of 35 mph, and a grade of two percent or less. Because of space limitations (i.e., short spacing between the ramps, bridges, and overhead roadways and railroads), there is no room at the interchange to lengthen both acceleration lanes.

7.2 Problems

The existing bottlenecks, along with substandard acceleration and deceleration lanes, result in a long traffic queue on the I-90 connector during AM and PM peak periods when high volumes of traffic merge onto I-95 southbound. This queue affects I-90 traffic on the connector heading to I-95 northbound as well.

7.3 Causes

MPO staff identified four factors that contribute to form the bottlenecks:

- High-volume traffic from I-90 that merges onto I-95 southbound
- Short acceleration lane for the I-90 traffic merging onto I-95 southbound
- Short deceleration lane for the I-95 traffic exiting to I-90
- Lane imbalance in the section

High-Volume Traffic

Figures 9 and 10 show the traffic flows during the AM and PM peak periods. As many as 2,000 vehicles per hour enter I-95 southbound from I-90 during the peak period. These entry volumes are quite high for a single-lane entrance ramp given the high volume of traffic on I-95 southbound with which it has to merge. The intense merging maneuvers interrupt traffic for all drivers and cause a bottleneck. Many motorists on I-95 southbound move out of the rightmost lane to avoid the merge with high-volume traffic entering the freeway.

Short Acceleration Lane

The acceleration lane for the high-volume traffic merging onto I-95 southbound from I-90 is inadequate and does not meet MassDOT's standards. It forces drivers to merge quickly, causing intense merging and queuing on the I-90 entrance ramp. Presently, there is no room to lengthen the acceleration lane because of the bridges downstream of the section. In addition, the problem of forced merging at this location is exacerbated by the close proximity of the Route 30 and I-90 entrance ramps.

Short Deceleration Lane

The length of the deceleration lane at Exit 25 for the high-volume traffic exiting to I-90 is inadequate; it forces drivers to diverge quickly and does not give them

ample distance needed to allow a vehicle to leave the freeway mainline safely and comfortably. The intense diverge and lane-change maneuvers cause traffic interruption and wide variability in traffic speeds, resulting in many crashes.

Lane Imbalance

Travel lanes in the study area are not in balance with the volume of traffic entering and exiting this section. At Exit 25 and Exit 24, approximately 2,300 to 2,900 vehicles per hour exit the freeway to I-90 and Route 30. The exit traffic flow rate exceeds the capacity of a full travel lane. Downstream of Exit 24, up to 2,400 vehicles per hour enter the freeway from the same roads. Likewise, the entry traffic flow rate is equivalent to the capacity of the full travel lane. Therefore, maintaining four continuous lanes in the study area creates a lane imbalance, which also results in intense merging and bottlenecks at the diverge and merge points.

7.4 Impacts

Crashes

Figure 11 shows the location and number of crashes in the study area. A summary of the crashes is also presented in Table 5. There were 77 crashes in this section between 2010 and 2012 (Appendix C). The majority, 53 of the crashes, occurred in the vicinity of the diverge area at Exit 25. MPO staff believe that many of the rear-end and sideswipe crashes were caused by drivers slowing down to exit the freeway to I-90 or by drivers changing lanes. It appears that the short deceleration lane at this location may be contributing to poor traffic operations and the high number of crashes. There were only five recorded crashes near the bottleneck location where traffic from I-90 merges onto I-95 southbound.

The average crash rate of the freeway segment was 1.06 crashes per MVMT, which was significantly higher than the average of 0.54 crashes per MVMT for urban interstate highways in Massachusetts. Below is a summary of the crashes in this segment.

- Thirty-nine percent of the crashes resulted in injury.
- Sixty-eight percent of the crashes were rear-end collisions.
- Eighty-three percent of the crashes occurred under dry roadway conditions.
- Thirty percent of the crashes occurred outside daylight conditions.
- Sixty-six percent of the crashes occurred at peak travel periods.

TABLE 5
Crash Summary (2010-2012)
I-95 Southbound Segment between Exit 25 and Recreation Road

Crash Variable	Number of Crashes
Crash severity	—
Fatal injury	0
Nonfatal injury	30
Property damage only	40
Not reported/unknown	7
Manner of collision	—
Angle	4
Rear-end	52
Sideswipe, same direction	6
Single vehicle crash	15
Road Surface conditions	—
Dry	64
Wet	11
Snow	1
Other	1
Ambient light conditions	—
Daylight	54
Dark: lighted roadway	5
Dark: nonlighted roadway	10
Dawn	2
Dusk	6
Weather conditions	—
Clear	50
Cloudy	8
Rain	8
Snow	1
Fog/smog/smoke	1
Not reported/unknown	9
Travel period	—
Peak	51
Off-peak	26
Total crashes	77
Three-year average (rounded)	26
Segment crash rate	1.06
MassDOT Highway Division average crash rate for urban interstate roadways	0.54

* The AM peak period is 6:00 AM to 10:00 AM, and the PM peak period is 3:00 PM to 7:00 PM.
Source: Central Transportation Planning Staff.

Travel Speed

The bottleneck affects travel on I-95 southbound and on the entrance ramp from I-90. Figure 12 is a congestion scan that shows the average travel speeds on I-95 southbound in the study area. The bottleneck reduces travel speed to 35 to 45 mph. A traffic queue resulting from the bottleneck forms on the I-90 entrance ramp, which extends onto the I-90 connector as well as onto I-95 southbound.

Level of Service

Using the data collected, MPO staff analyzed the AM and PM peak hours with the 2010 HCS to assess the capacity and quality of traffic flow at the bottleneck area (included in Appendix D).[13] Table 6 presents the results of the existing freeway merge/diverge analyses. Analyses indicate that traffic entering I-95 southbound from I-90 operates at LOS E during peak hours due to intense merging. The merging and diverging activities in the section interrupt and slow down traffic on the mainline and entrance ramps. In addition, analyses show that the traffic exiting from the freeway to I-90 upstream of the section operates well at LOS F during peak hours.

TABLE 6
Freeway Segment Analysis: Existing Conditions
I-95 Southbound Segment between Exit 25 and Recreation Road

Freeway Component	AM Density (pc/mi/ln)	AM Speed (mph)	AM LOS*	PM Density (pc/mi/ln)	PM Speed (mph)	PM LOS*
2015 Existing Conditions	—	—	—	—	—	—
Diverge segment: Exit 25, I-90	39.5	45.5	F	43.7	45.0	F
Diverge segment: Exit 24, Route 30	27.1	46.6	C	24.5	47.0	C
Merge segment: Entrance ramp from Route 30	12.6	50.9	B	23.4	50.4	C
Merge segment: Entrance ramp from I-90	37.1	46.5	E	35.9	47.2	E

*LOS A through LOS D represent acceptable operating conditions; LOS E represents operating conditions at capacity; and LOS F represents failing conditions (demand exceeds capacity).
mph = miles per hour. pc/mi/ln = passenger cars per mile per lane
Source: Central Transportation Planning Staff.

[13] Highway Capacity Software 2010, Version 6.65, McTrans Center, PO Box 116585, Gainesville, Florida, October 2014.

7.5 Improvement Alternatives

MPO staff developed the following improvements to increase safety and address the bottleneck:

- Convert rightmost lane at Exit 25 to an “Exit Only” lane.
- Consider the possibility of using a portion of the shoulder on I-95 southbound at Exit 25 to create a two-lane exit ramp (i.e., two lanes on the freeway diverge area to connect to the existing two-lane connector). If a full two-lane exit ramp is not feasible, an alternative would be a shared through and exit lane in addition to the Exit Only lane.
- Restripe lanes to serve traffic demand better at the bottleneck.
- Installation of a highly visible curve sign or chevron warning signs on the exit ramp to Route 30.

Convert Rightmost Lane at Exit 25 to an “Exit Only” Lane

The objectives of the improvement at this location are to reduce traffic interruption and increase safety at the Exit 25 diverge area. The conversion would extend the deceleration lane to meet MassDOT’s standards and provide drivers with ample distance to exit the freeway to I-90 safely and comfortably. In addition, it would improve traffic operation at the diverge area and reduce the high number of crashes at this location.

MPO staff suggests that the MassDOT Highway Division looks into the possibility of using a section of the right shoulder on I-95 southbound at Exit 25 to create a full two-lane exit-ramp (i.e., two lanes on the freeway diverge area to connect to the existing two-lane exit ramp connector as illustrated in Figure 13 [Section 1]). A full two-lane exit ramp would improve safety and operations significantly. This improvement would require relocation of signs or installation of new guide signs to direct drivers to I-90 and modifying of pavement markings to delineate the “Exit Only” lane from the mainline travel lanes.

It is possible that a full two-lane exit is not feasible because of the following reasons:

- The need for additional overhead signage (including placement of brand-new overhead full-span sign support structures)
- The desire to discourage drivers from making the dangerous but often-observed move from the I-95 southbound center lanes to the left lane of the exit ramp by removing the second lane on the exit ramp
- Removal of the shoulder may raise safety concerns for maintenance operations using the access drive from River Road

An alternative to resolve these issues would be a shared through and exit lane in addition to the Exit Only lane as shown in Figure 14.

Restripe Lanes to Serve Traffic Demand Better at the Bottleneck (I-95 Southbound Subtract-a-Lane at the I-90 Interchange)

The objective of this improvement is to restripe the southbound lanes at the bottleneck locations to serve traffic demand better. Figure 13 (Sections 1 and 2) shows the recommended improvements. After Exit 25, I-95 southbound would have three travel lanes instead of the current four lanes. The high-volume traffic entering I-95 southbound from I-90 would pick up the extra lane to head southbound on I-95. The modifications would provide the I-90 traffic merging onto I-95 southbound with an auxiliary lane, which would also address the issue of the inadequate acceleration lane at the merge area. Because of the high volume of traffic that exits the freeway at Exits 25 and 24 to I-90 and Route 30, respectively, subtracting a lane would not affect travel on I-95 southbound.

In addition to the new auxiliary lane for traffic from I-90 to merge onto I-95 southbound, MPO staff also proposes the following improvements:

- Relocate existing signs or install new guide signs to direct drivers into appropriate lanes to exit the freeways or proceed through the section.
- Modify pavement markings to define the acceleration, deceleration, and auxiliary lanes from the mainline travel lanes.

7.6 Effectiveness and Cost of the Improvements

The improvements were analyzed as freeway merge/diverge and basic freeway segments. Ramp LOS analysis for 2025, presented in Table 7 indicates that the improvements would improve traffic operations at the bottleneck.

- At the location where traffic from I-90 merges onto I-95 southbound, the LOS would improve to LOS D from LOS E during PM peak hours. During the AM peak hours, there is slightly improved traffic operation, but it is not enough to change the LOS from LOS E.
- At Exit 25, where traffic exits to I-90, the LOS would improve to LOS B from LOS F during the AM and PM peak periods.
- The improvements are expected to reduce crashes by as much as 30 percent.[14]

The improvements are estimated to cost approximately $50,000 to construct.

[14] Crash Modification Factors Clearinghouse, US Department of Transportation Federal Highway Administration.

TABLE 7
Freeway Segment Analysis: Improvement Alternatives
I-95 Southbound Segment between Exit 25 and Recreation Road

Freeway Component	AM Density (pc/mi/ln)	AM Speed (mph)	AM LOS*	PM Density (pc/mi/ln)	PM Speed (mph)	PM LOS*
2025 With Improvements: Two-Lane Exit and Restripe Lanes to Serve Traffic Demand Better	—	—	—	—	—	—
Diverge segment: Exit 25, I-90	12.2	45.5	B	15.5	45.7	B
Diverge segment: Exit 24, Route 30	33.0	48.3	D	32.1	47.0	D
Merge segment: Entrance ramp from Route 30	30.6	49.2	D	32.1	48.8	D
Merge segment: Entrance ramp from I-90	35.9	54.4	E	34.5	54.8	D

*LOS A through LOS D represent acceptable operating conditions; LOS E represents operating conditions at capacity; and LOS F represents failing conditions (demand exceeds capacity).
mph = miles per hour. pc/mi/ln = passenger cars per mile per lane
Source: Central Transportation Planning Staff.

7.7 Recommendations

MPO staff recommend two improvements for the I-90 interchange: designating an “Exit Only” lane at Exit 25, and subtracting a lane between Exit 25 and the entrance ramp from I-90. The proposed improvements would require approval from FHWA. MassDOT Highway District 4 office could easily produce the necessary documentation, which would be similar to the documentation that was submitted and approved for the I-95 northbound subtract-a-lane project at the I-90 interchange.

The I-95 southbound subtract-a-lane improvement project at the I-90 interchange is expected to benefit from the I-95 Add-a-Lane project, which would remove a downstream bottleneck (lane drop) on I-95 southbound just north of Route 9 in Wellesley. The I-95 Add-a-Lane project includes bridge and roadway reconstruction, namely the installation of an additional 12-foot travel lane and 10-foot shoulder in each direction; this project is scheduled to be completed in spring 2019. **Therefore, executing or planning the above-described improvements, which would benefit from the I-95 Add-a-Lane project, is very important.**

Currently, as a result of bridge maintenance work on I-95 southbound in the vicinity of the study area, the MassDOT Highway Division has implemented some form of these improvements as a traffic management plan for the work zone.

8 CONCLUSION AND NEXT STEPS

MPO staff, working in conjunction with the MassDOT Highway staff, identified, developed, and evaluated improvements for two bottleneck locations in the MPO region. The study provides the MassDOT Highway Division with an opportunity to begin identifying the needs at the two bottleneck locations and to start planning design and engineering efforts. If implemented, these low-cost, short-term improvements would increase traffic safety, make traffic operations more efficient, and reduce congestion at the bottlenecks. The study aligns with the MPO goals of reducing congestion and increasing safety on the region's highway system.

The MassDOT Highway Division is responsible for implementing the improvements recommended for the two bottleneck locations. The next steps are for the MassDOT Highway Division to examine the design of the improvement alternatives and work with the FHWA to advance the projects. Transportation decision-making is complex and is influenced by factors such as financial limitations and agency programmatic commitments. Project development is the process that takes a transportation improvement plan from concept to construction. Appendix E includes an overview of the MassDOT Highway Division's project development process.

SA/sa

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FIGURE 1
I-93 Southbound Segment: Between I-95 and Montvale Avenue
Study Area Map

Low-Cost Improvements
to Express-Highway
Bottleneck Locations

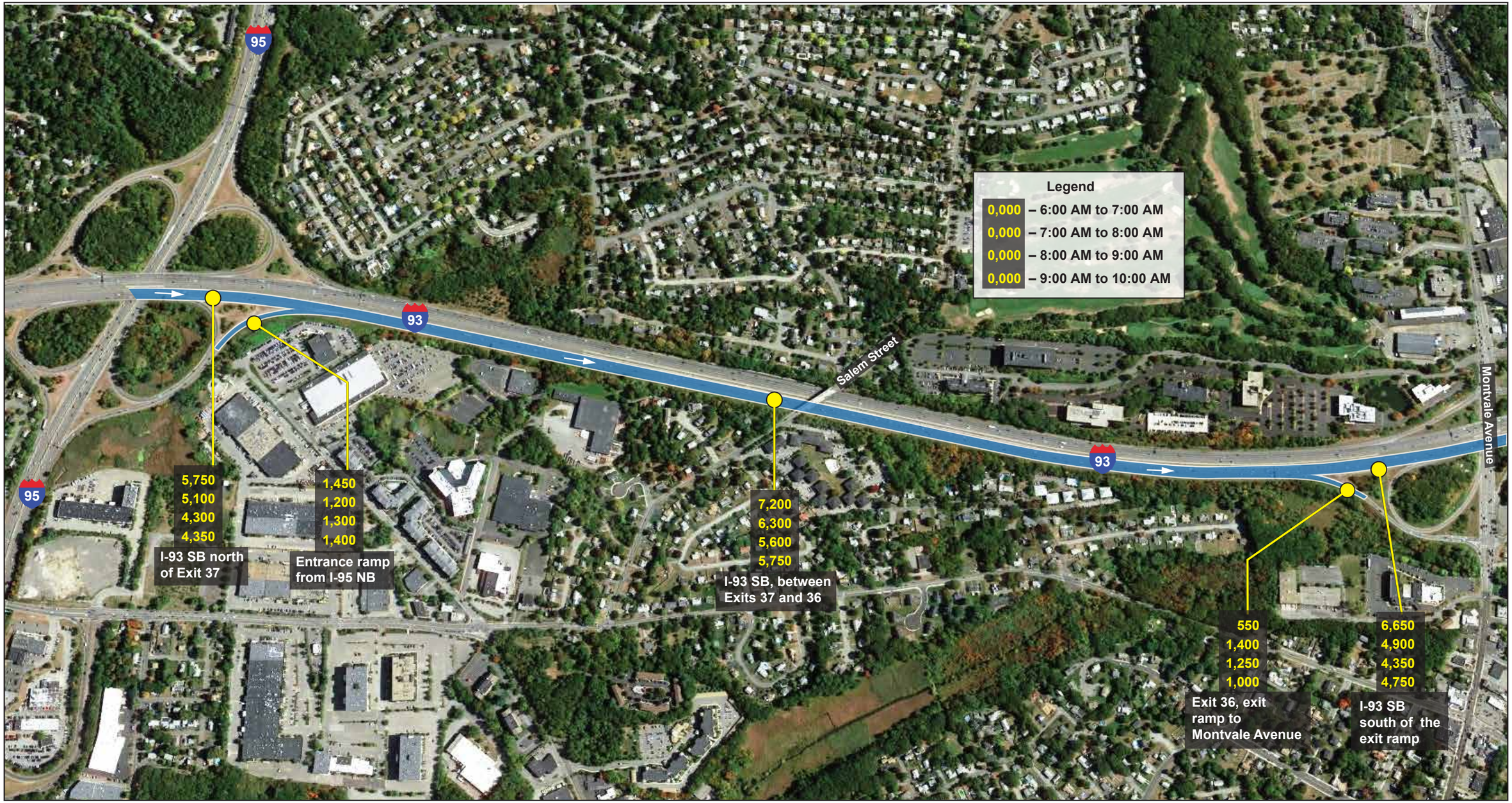

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FIGURE 2
I-93 Southbound Segment: Between I-95 and Montvale Avenue
AM Peak Period Balanced Traffic Volumes

Low-Cost Improvements to Express-Highway Bottleneck Locations

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FIGURE 3
I-93 Southbound Segment: Between I-95 and Montvale Avenue
PM Peak Period Balanced Traffic Volumes

Low-Cost Improvements to Express-Highway Bottleneck Locations

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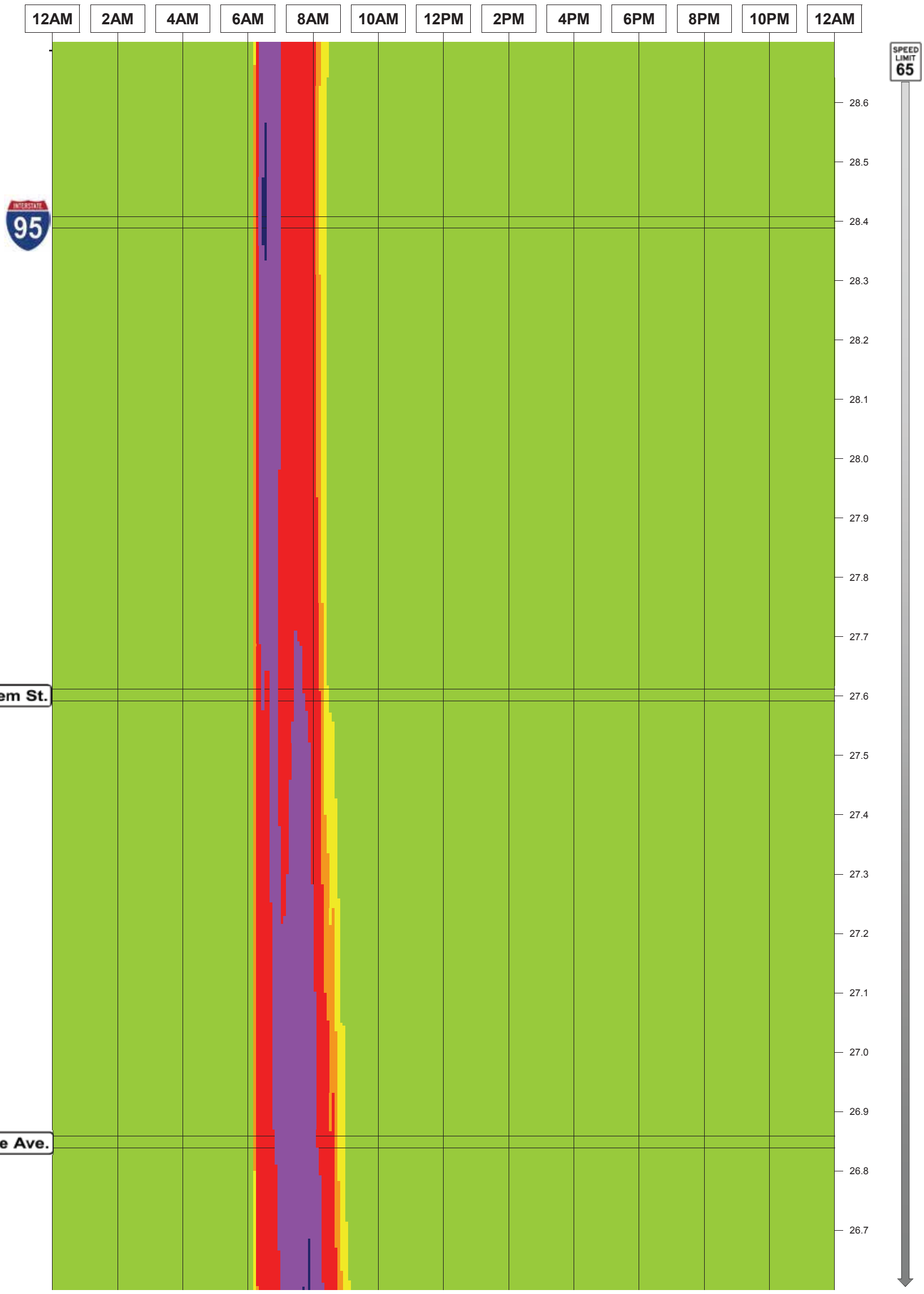
FIGURE 4
I-93 Southbound Segment: Between I-95 and Montvale Avenue
Location and Number of Crashes (2010 to 2012)

Low-Cost Improvements
to Express-Highway
Bottleneck Locations

I-93 Southbound



Average Travel Speed (Miles Per Hour)

1-24 mph | 25-34 mph | 35-44 mph | 45-49 mph | 50-54 mph | 55+ mph

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FIGURE 5
I-93 Southbound Segment: Between I-95 and Montvale Avenue
Congestion Scan

Low-Cost Improvements to Express-Highway Bottleneck Locations

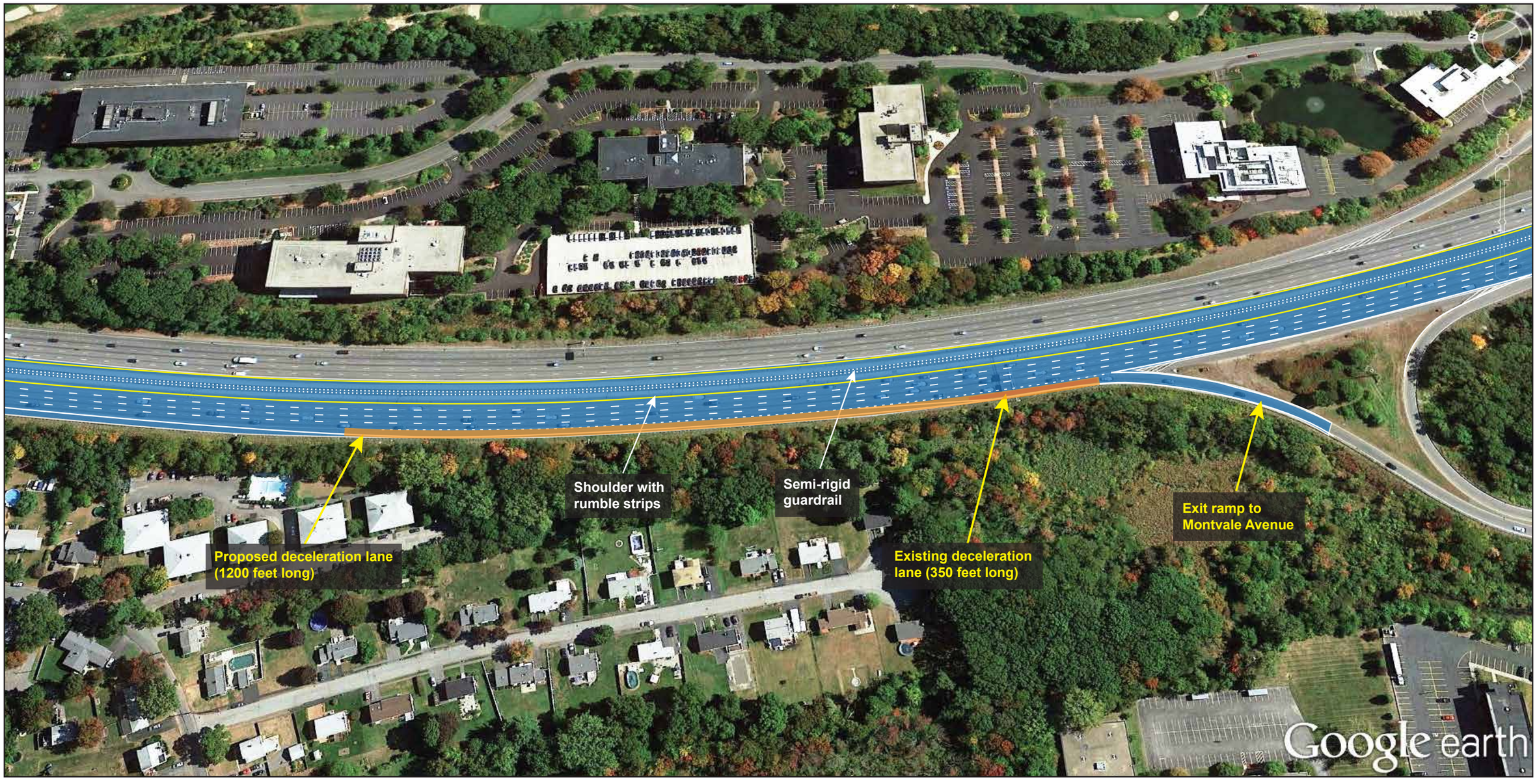

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FIGURE 6
I-93 Southbound Segment: Between I-95 and Montvale Avenue
Alternative 1: Lengthen Existing Deceleration Lane

Low-Cost Improvements
to Express-Highway
Bottleneck Locations

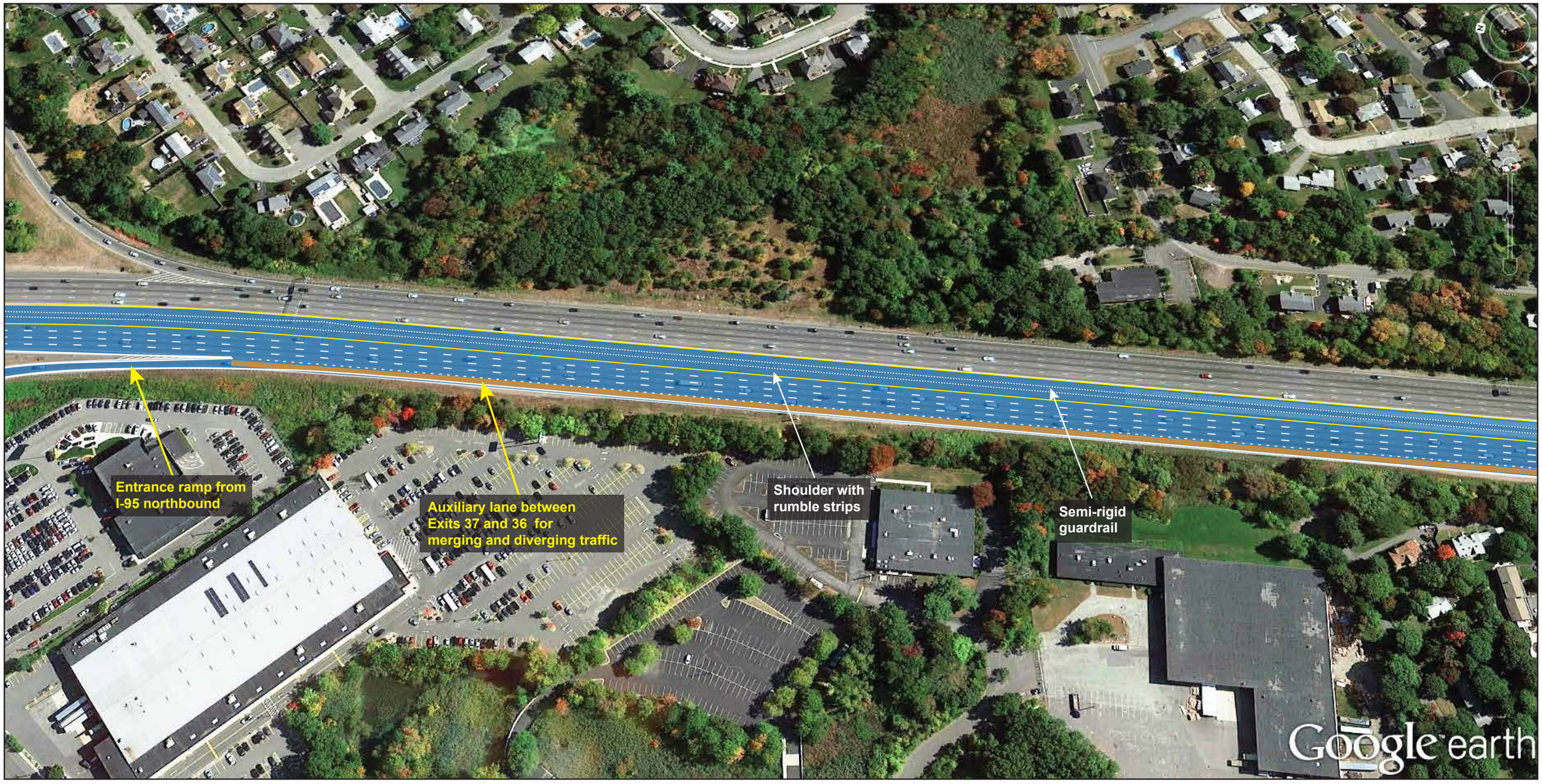

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FIGURE 7 (Section 1)
I-93 Southbound Segment: Between I-95 and Montvale Avenue
Alternative 2: Construct an Auxiliary Lane Using Existing Right Shoulder

Low-Cost Improvements to Express-Highway Bottleneck Locations

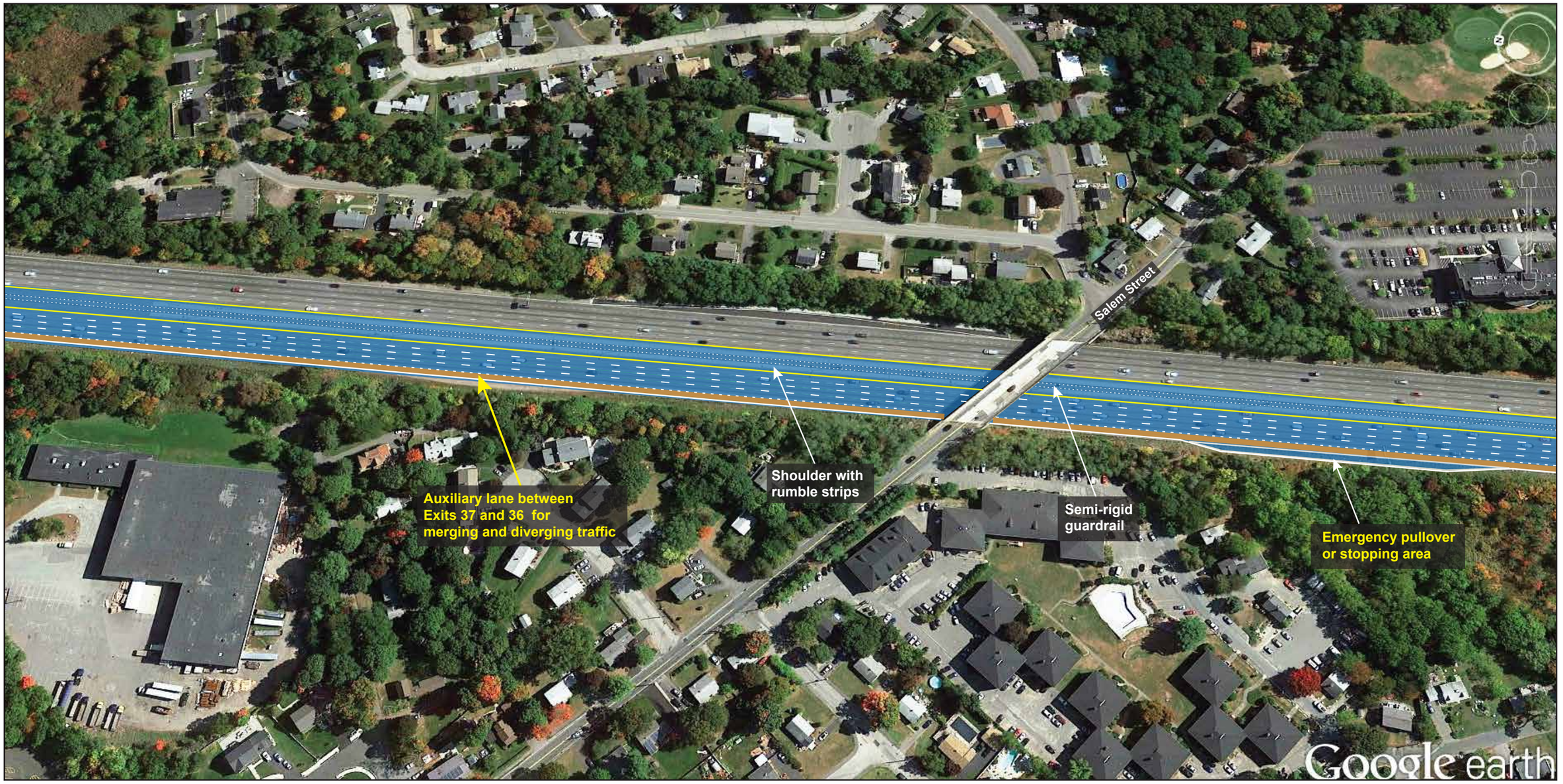

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FIGURE 7 (Section 2)
I-93 Southbound Segment: Between I-95 and Montvale Avenue
Alternative 2: Construct an Auxiliary Lane Using Existing Right Shoulder

Low-Cost Improvements
to Express-Highway
Bottleneck Locations

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FIGURE 7 (Section 3)
I-93 Southbound Segment: Between I-95 and Montvale Avenue
Alternative 2: Construct an Auxiliary Lane Using Existing Right Shoulder

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Low-Cost Improvements to Express-Highway Bottleneck Locations

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FIGURE 8
I-95 Southbound Segment: Between Exit 25 and Recreation Road
Study Area Map

Low-Cost Improvements
to Express-Highway
Bottleneck Locations

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FIGURE 9
I-95 Southbound Segment: Between Exit 25 and Recreation Road
AM Peak Period Balanced Traffic Volumes

Low-Cost Improvements to Express-Highway Bottleneck Locations

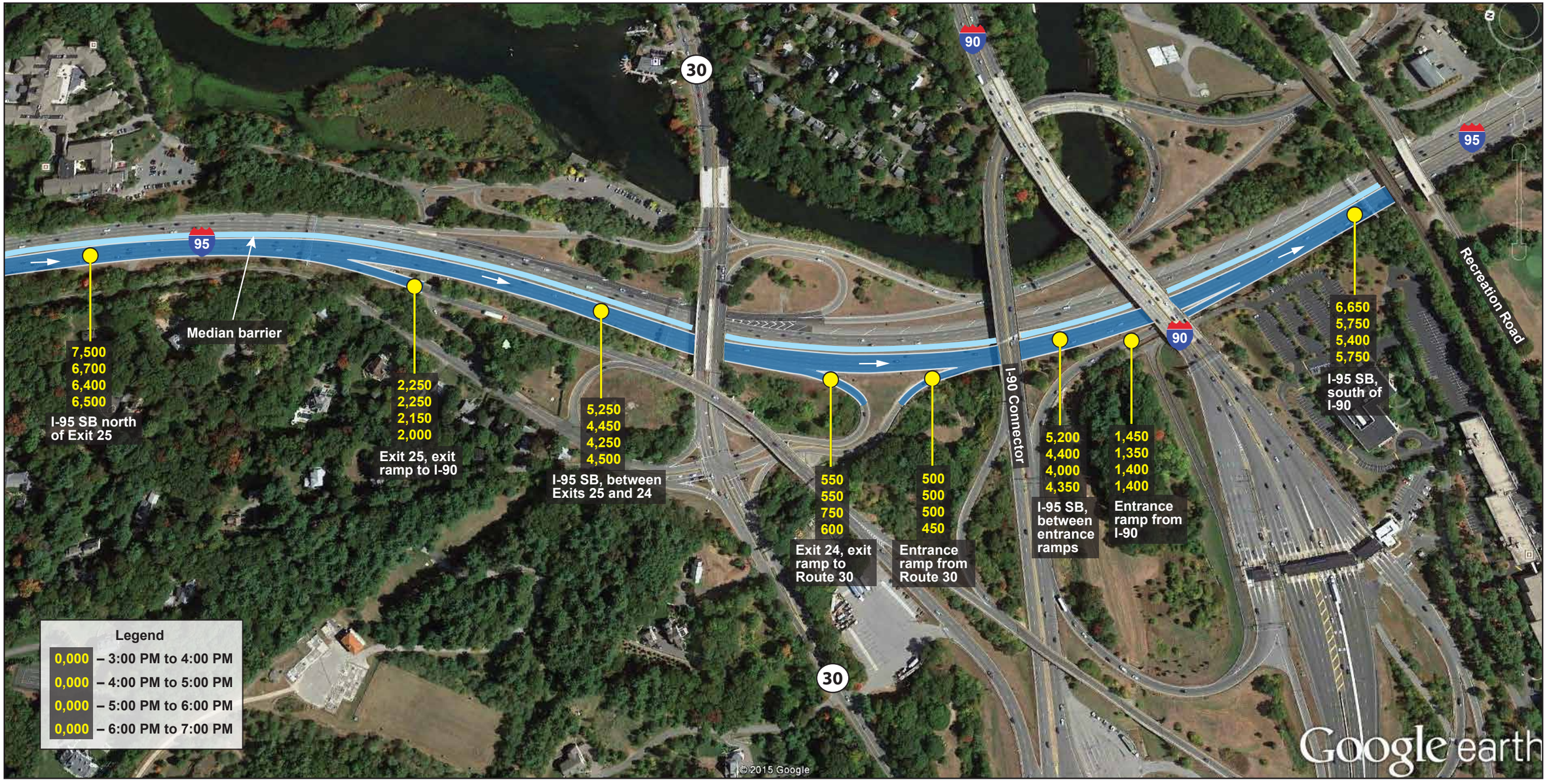

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FIGURE 10
I-95 Southbound Segment: Between Exit 25 and Recreation Road
PM Peak Period Balanced Traffic Volumes

Low-Cost Improvements to Express-Highway Bottleneck Locations

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FIGURE 11
I-95 Southbound Segment: Between Exit 25 and Recreation Road
Location and Number of Crashes (2010 - 2012)

Low-Cost Improvements
to Express-Highway
Bottleneck Locations

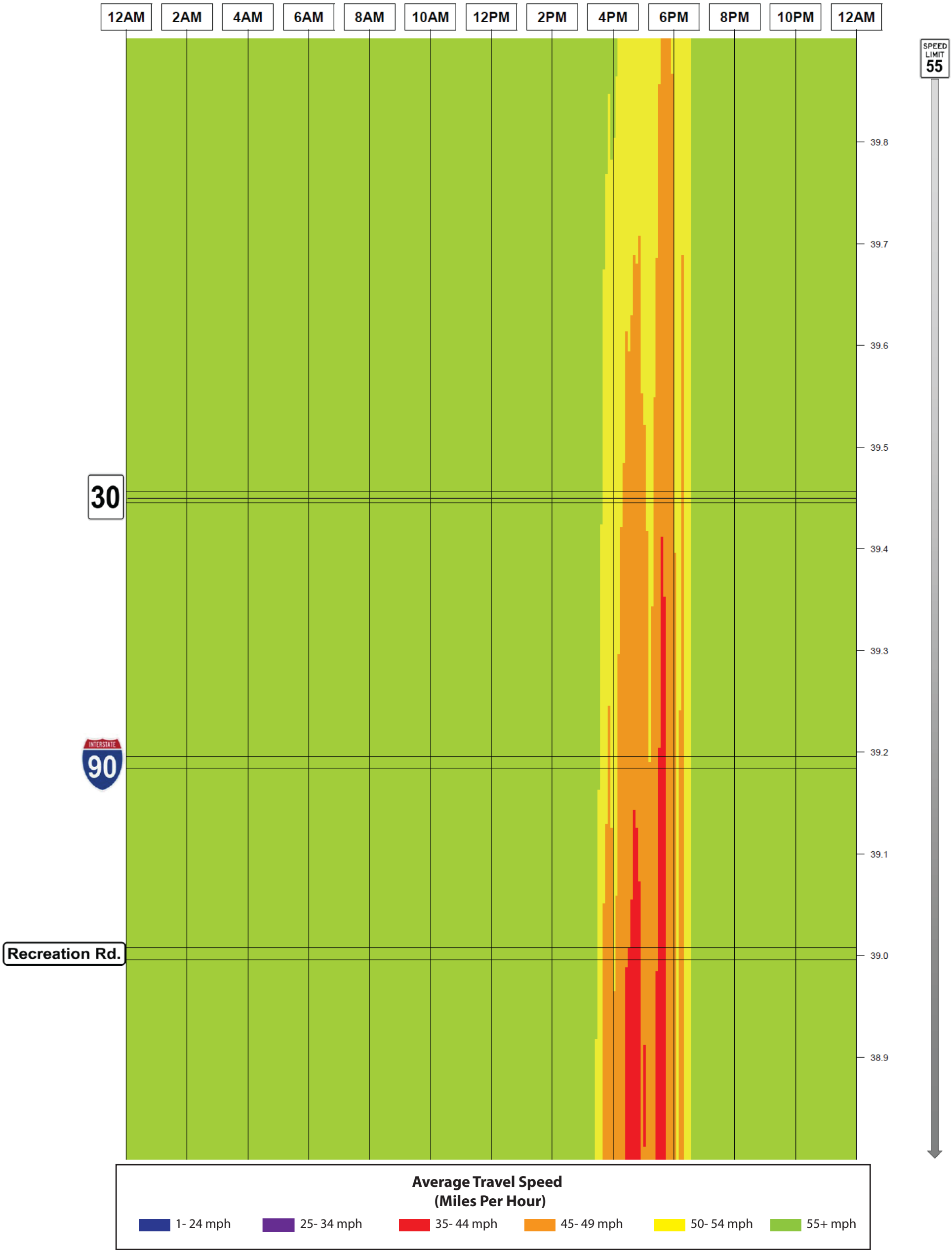

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FIGURE 12
I-95 Southbound Segment: Between Exit 25 and Recreation Road Congestion Scan

Low-Cost Improvements to Express-Highway Bottleneck Locations

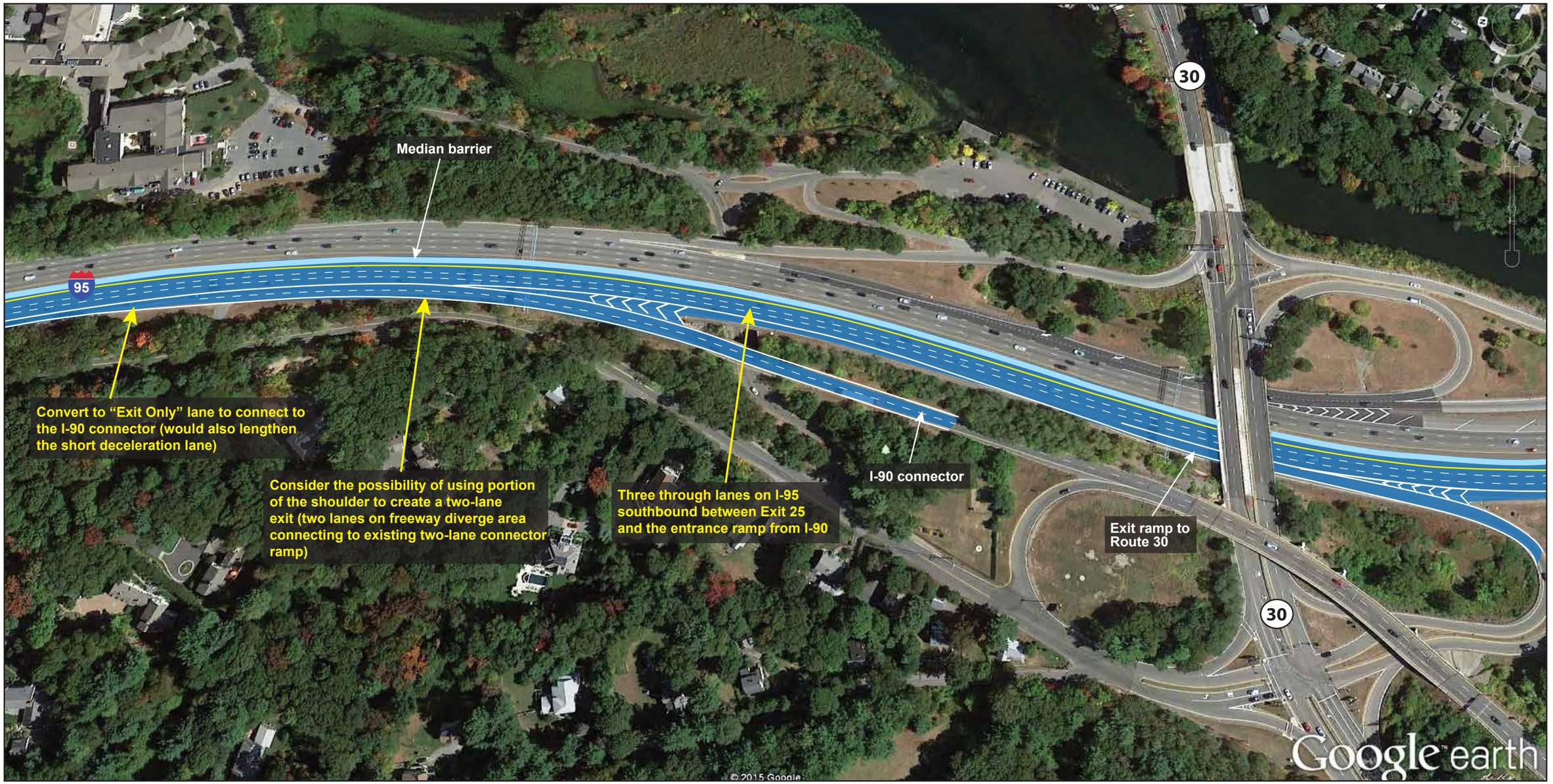

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FIGURE 13 (Section 1)
I-95 Southbound Segment: Between Exit 25 and Recreation Road
Restripe Travel Lanes to Serve Demand Better

N

Low-Cost Improvements to Express-Highway Bottleneck Locations

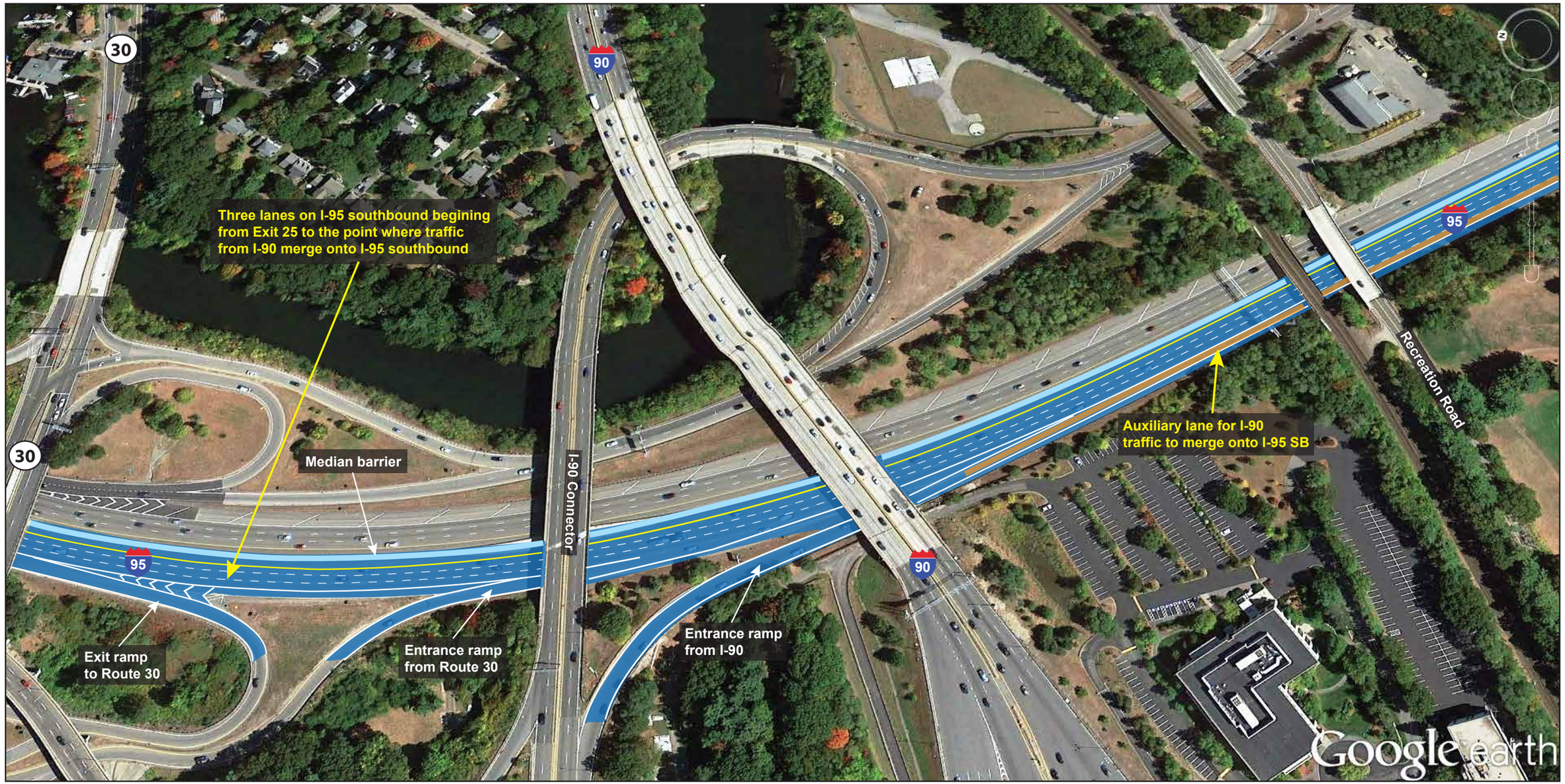

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FIGURE 13 (Section 2)
I-95 Southbound Segment: Between Exit 25 and Recreation Road
Restripe Travel Lanes to Serve Demand Better

Low-Cost Improvements to Express-Highway Bottleneck Locations

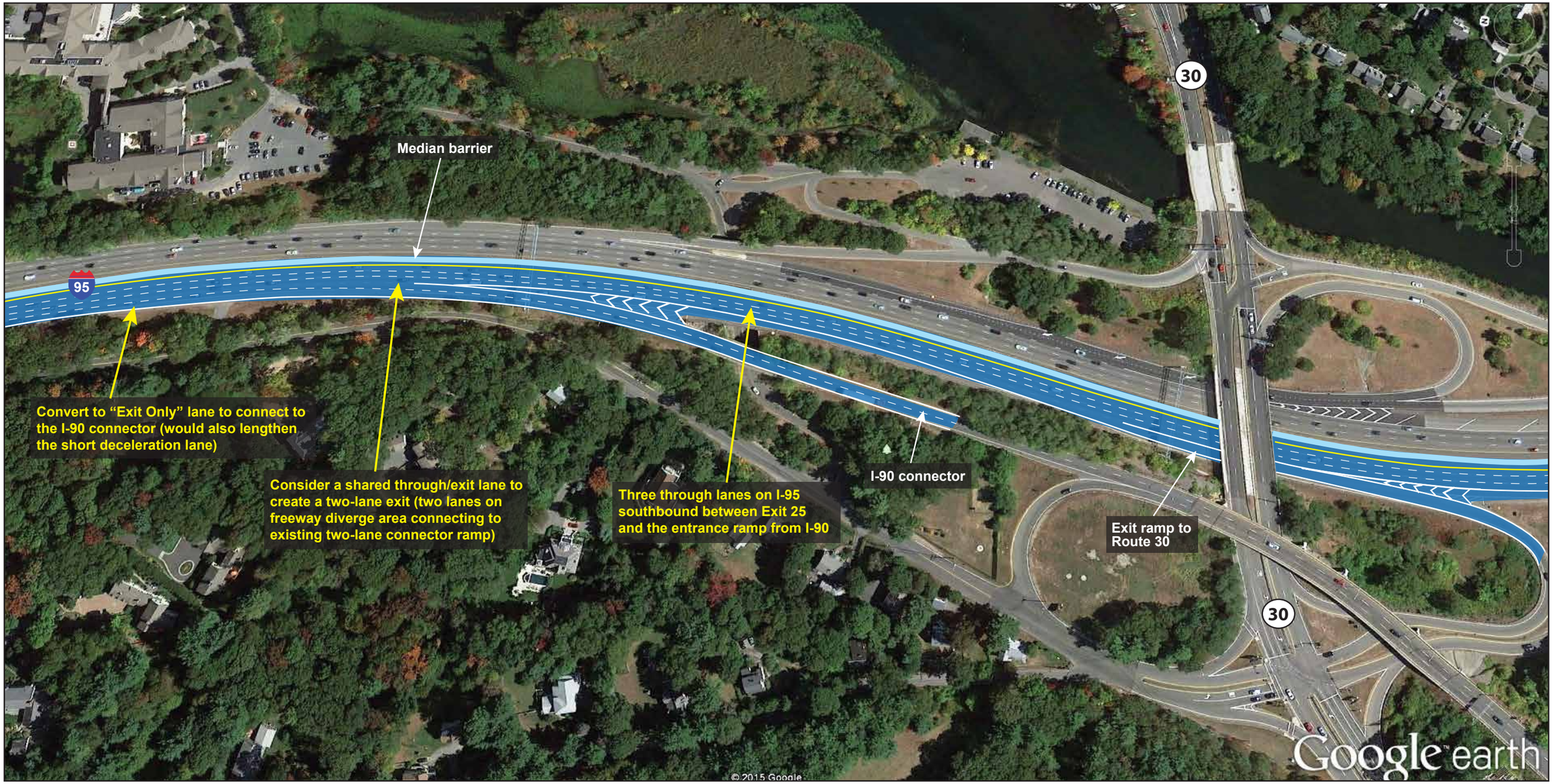

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FIGURE 14
I-95 Southbound Segment: Between Exit 25 and Recreation Road
Two-Lane Exit with a Shared Through/Exit Lane

Low-Cost Improvements to Express-Highway Bottleneck Locations

APPENDIX A

1. Review Comments
2. Selection Process

1. Review Comments

Seth Asante

From: Raphael, Connie (DOT)
Sent: Wednesday, November 04, 2015 11:11 AM
To: Seth Asante
Subject: RE: Low-Cost Improvements to Express-Highway Bottleneck Locations

Hi Seth,

The District has reviewed the revised memo. Overall you put together a good explanation and plan for moving forward. Here are some comments.

Location 1: I-93 SB between I-95 and Montvale Ave appears to be the only one that could be implemented short-term, low-cost. Alternative 2, providing an auxiliary lane for the entire length between interchanges, is the better solution. The shoulder area appears to be wide enough to accommodate full-time travel and the emergency turnout would not be overly expensive to build. It would also match up well with the auxiliary lane on I-93 NB between the same interchanges. This solution would mirror the recently constructed northbound auxiliary lane and emergency pull off. The Design Exception Report required for the less than minimum right shoulder could be easily produced as it is similar to the DER submitted and approved for the northbound auxiliary lane.

Thanks Seth

Connie Raphael
District Four Planning Coordinator
MassDOT – Highway Division
519 Appleton Street
Arlington, MA 02476
781-641-8468

From: Seth Asante [mailto:sasante@ctps.org]
Sent: Wednesday, October 28, 2015 11:17 AM
To: Raphael, Connie (DOT)
Subject: Low-Cost Improvements to Express-Highway Bottleneck Locations

Hi Connie,

The attachment is a revised memo with Figures 2 and 9 legends corrected to AM hours.

Thanks,
Seth

Seth A. Asante | Chief Transportation Planner
CENTRAL TRANSPORTATION PLANNING STAFF
857.702.3644 | sasante@ctps.org
www.ctps.org/bostonmpo

Seth Asante

From: Lipton, Amitai (DOT)
Sent: Thursday, November 05, 2015 12:25 PM
To: Seth Asante (sasante@ctps.org)
Cc: Boudreau, Neil (DOT); Kulen, Raj (DOT); Pervez, Hameed (DOT)
Subject: RE: Low-Cost Improvements to Express-Highway Bottleneck Locations
Attachments: 20150114 Memo Heller to Leavenworth w-appendices.pdf; 20151007 Memo Heller to Leavenworth - scanned signed by DHD.pdf

Hi Seth,

This is a very thorough analysis of the bottleneck at I-95 SB at I-90 in Weston. I'd like to second Raj's suggestion that it may be worthwhile to send your memo to FHWA ASAP (in draft version), as they are in the middle of evaluating our request to make the modifications permanent.

I do have a few minor notes/suggestions for your consideration:

Please note District 6 implemented the sign and pavement marking modifications in June 2015. Were the field observations and traffic volume measurements conducted before or after the modifications were implemented? In Table 5 (page 18), the existing conditions are labeled as "2015", and I was curious if these were counts actually conducted in 2015, or if they were older counts with a growth rate applied?

There seems to be a little inconsistency regarding speeds and terminology in certain parts of pages 14-15. The existing geometry was evaluated in reference to either a 65 mph (exit ramp to Route 30) or 70 mph (entrance ramps) design speed on I-95. While the posted speed limit on I-95 is 55 mph, and the original speed regulation for this roadway was 60 mph, the 85th-percentile speeds are usually around 70-72 mph. Do you know why design speeds of 65-70 mph were chosen for this report?

On the exit ramp to Route 30, the sign is actually an "advisory speed," not a "speed limit." Given how sharp the hairpin curve is, an even lower speed of 15 or 20 mph may be more appropriate than the posted "25 mph". Perhaps we can install a few supplemental high-visibility curve or chevron warning signs at some point.

On page 14, where the exit ramp from I-95 SB to I-90 is discussed, I feel the running speed on the ramp is fairly close to that of the I-95 mainline, and the horizontal curve has a fairly large radius at the exit gore, so most likely very little deceleration distance is needed.

On page 16, in the Lane Imbalance section, I would note that the entering and exiting volumes (2300-2900 vph) actually exceed the capacity of a full travel lane, making the imbalance even more severe.

That brings me to page 19 and a discussion of the exit to I-90, whether it should be a two-lane ramp vs. a one-lane ramp. We did discuss the pros and cons of each alternative, and we ended up deciding on a one-lane ramp. Some of the reasons we chose not to pursue this alternative were:
- The need for additional overhead signage (including replacement of brand-new overhead full-span sign support structures);
- Desire to discourage drivers from making the dangerous but oft-observed move from the I-95 SB center lanes to the left lane of the exit ramp by removing the second lane on the exit ramp; and
- Removal of shoulder raised safety concerns for maintenance operations using access drive from River Road (seen on Figure 13 Section 1 at the start of the 5th lane).

Costs: I'm still waiting to see the final invoices for the work we did, but my ballpark estimate for the signage (overhead and ground-mounted) is $10-15,000 and for the pavement markings it's $3-5,000. We still need to install final markings, reset 2 signs on permanent posts, and re-install pavement markers and rumble strips, but I think a ballpark estimate of $25-50,000 for all the work is reasonable.

I think Figure 2 also has AM/PM swapped like Figure 9 did.

As we discussed on Wednesday, I am attaching for your information the memos that District 6 prepared for this project. The first memo was sent to FHWA on 1/22/2015 and approved by them on 2/13/2015. The second memo, requesting permanent approval for the modifications, was signed by District 6 DHD on 10/7/2015 for transmission to the Chief's office and then FHWA. Please consider the second memo a "draft" until we receive confirmation that it's been approved.

Thank you very much, I look forward to seeing the final report!

Amitai

From: Kulen, Raj (DOT)
Sent: Tuesday, October 27, 2015 12:16
To: Seth Asante (sasante@ctps.org)
Cc: Boudreau, Neil (DOT); Lipton, Amitai (DOT); hameed.pervez@state.ma.us
Subject: FW: Low-Cost Improvements to Express-Highway Bottleneck Locations

Hi Seth,
This is intersecting. We have already implemented the I-93-SB lane configuration this summer as part of bridge deck work as a test and collected travel time data, now we are waiting for FHWA final approval for permanent marking.

Neil, this is good if you want to send this to FHWA as well.

Raj

From: Seth Asante [mailto:sasante@ctps.org]
Sent: Tuesday, October 27, 2015 11:29 AM
To: Kulen, Raj (DOT)
Subject: Low-Cost Improvements to Express-Highway Bottleneck Locations

Hi Raj,

The attached technical memorandum—Low-Cost Improvements to Express-Highway Bottleneck Locations is available for review.

MPO staff selected two locations for this study:

Location 1: I-93 southbound between I-95 and Montvale Avenue in Woburn and Stoneham
Location 2: I-95 southbound at the I-90 Interchange in Weston

The result of the study for Location 2, which is in MassDOT Highway Division's District 6, is presented in Section 7 of the memorandum.

Please review the attached documents and provide any comments or questions you may have by November 10, 2015.

Thank you,
Seth

Seth A. Asante | Chief Transportation Planner
CENTRAL TRANSPORTATION PLANNING STAFF
857.702.3644 | sasante@ctps.org
www.ctps.org/bostonmpo

Seth Asante

From: Patel, Hasmukh (DOT)
Sent: Friday, October 30, 2015 4:17 PM
To: Seth Asante (sasante@ctps.org)
Cc: Wood, Stanley (DOT); Jasmin, Matthew (DOT)
Subject: FW: Low-Cost Improvements to Express-Highway Bottleneck Locations Study
Attachments: 2015-09-15 Low-Cost Bottlenecks MEM SA 1.pdf; Appendix A-E.pdf

Hi Seth,

I have reviewed the draft document for the subject study and have following comments.

I concur with the selection of following two locations for the study.
Location 1: I-93 Southbound between I-95 & Montvale Ave in Stoneham & Woburn
Location 3: I-95 Southbound at I-90 Interchange in Weston

Location 1: Location 1: I-93 Southbound between I-95 & Montvale Ave in Stoneham & Woburn

- Preferred Alternative 2 – Create Auxiliary Lane for Merging & Diverging Traffic
  This alternative would require roadway widening. Existing right shoulder is 10 ft +-. Auxiliary lane would require 12' wide lane and at least 6' shoulder. Anything less than 6' wide shoulder will require design exception approval. Also, if we go with 12' wide auxiliary lane, and 2' offset (no shoulder) to guard rail, it will require design exception approval. It will also require emergency pool over area.
- Cost of $200,000-$300,000 seems low. Consider $500,000

Location 3: I-95 Southbound at I-90 Interchange in Weston

- Concur with the improvements suggested at this interchange. No additional comments.

Hardy

From: Seth Asante [mailto:sasante@ctps.org]
Sent: Tuesday, September 15, 2015 12:41 PM
To: Patel, Hasmukh (DOT)
Subject: Low-Cost Improvements to Express-Highway Bottleneck Locations Study

Hello Hardy,

As we discussed in our recent telephone conversation, I have attached a draft document of the Boston Region MPO's Low-Cost Improvements to Express-Highway Bottleneck Locations study for review. The document has not been reviewed by the Highway Districts yet.
Please review and comment—I will address your comments before I forward it to Districts 4 and 6 for further review.

I will appreciate it if you can give me comments by Tuesday September 29, 2015.

Thanks,
Seth

Seth A. Asante | Chief Transportation Planner
CENTRAL TRANSPORTATION PLANNING STAFF
857.702.3644 | sasante@ctps.org
www.ctps.org/bostonmpo

2. Selection Process

TECHNICAL MEMORANDUM

DATE: April 2, 2015
TO: Boston Region Metropolitan Planning Organization (MPO)
FROM: Seth Asante, MPO Staff
RE: Low-Cost Improvements to Express-Highway Bottleneck Locations
Selection of Study Locations

1 BACKGROUND

This memorandum presents the results of Task 2 of the work program for Low-Cost Improvements to Express-Highway Bottleneck Locations: FFY 2015.[1] MPO staff indicated in Task 2—screen bottleneck locations and select locations for analysis—that we will present the results to the MPO for discussion.

According to the Federal Highway Administration (FHWA), "Much of recurring congestion is due to physical bottlenecks—potentially correctible points on the highway system where traffic flow is restricted. While many of the nation's bottlenecks can only be addressed through costly major construction projects, there is a significant opportunity for the application of operational and low-cost infrastructure solutions to bring about relief at these chokepoints."[2]

In the past, MPO staff analyzed several express-highway bottleneck locations in two consecutive studies, Low-Cost Improvements to Bottlenecks Phase I and Phase II, which were very well received by the Massachusetts Department of Transportation (MassDOT) and FHWA.[3,4] Previous study locations included sections of I-95 in Weston and Burlington and sections of Route 3 in Braintree.

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[1] Karl H Quackenbush, CTPS Executive Director, work program to the Boston Region Metropolitan Organization, "Low-Cost Improvements to Express-Highway Bottleneck Locations: FFY 2015," November 20, 2014.

[2] Federal Highway Administration, *Recurring Traffic Bottlenecks: A Primer: Focus on Low-Cost Operations Improvements,* US Department of Transportation, Federal Highway Administration, June 2009, p. 1.

[3] Seth Asante, MPO staff, memorandum to the Transportation Planning and Programing Committee of the Boston Region Metropolitan Planning Organization, "Low-Cost Improvements to Bottleneck Locations, Phase I," June 2, 2011.

[4] Chen-Yuan Wang, MPO staff, memorandum to the Transportation Planning and Programing Committee of the Boston Region Metropolitan Planning Organization, "Low-Cost Improvements to Bottleneck Locations, Phase II," dated March 12, 2012.

Some of the recommendations from those studies have been executed, such as the I-95 northbound subtract-a-lane at Interchange 24 in Weston; and FHWA has interviewed MPO staff about their successful implementation.

The cause and duration of highway bottlenecks vary. In general, recurring bottlenecks, the subject of this work program, are influenced by the design or operation present at the point where the bottleneck begins, for example: merges, diverges, lane drops, traffic weaving, abrupt changes in highway alignment, low-clearance structures, lane narrowing, intended disruption of traffic for management purposes, and less-than-optimal express-highway design.
This memorandum presents the process used to select the bottleneck study locations. MPO staff will submit this proposal to the MPO for discussion and approval.

2 SELECTION OF STUDY LOCATIONS

Selection of study locations was a two-stage process that comprised inventorying and screening candidate locations.

2.1 Inventorying Candidate Locations

MPO staff developed an initial list of candidate locations in the MPO region based on the following parameters:

- Staff knowledge of bottleneck locations in the Boston MPO region
- Review of congestion management process (CMP) monitoring data and recent MPO and other planning studies
- Consultations with MassDOT Highway Division
- Input from MPO members

The inventory process yielded five bottleneck locations for screening:

1. I-93 southbound between I-95 and Montvale Avenue in Stoneham and Woburn
2. I-93 southbound at the lane drop near Sullivan Square in Somerville/Charlestown
3. I-95 southbound at I-90 Interchange in Weston
4. Route 2 Concord Rotary
5. I-95 northbound, lane drop at interchange 37 in Reading, Stoneham, and Wakefield

2.2 Screening Candidate Locations

MPO staff selected two bottleneck locations for analysis. After consulting with MassDOT Highway Division, staff determined that these two locations likely could be corrected with low-cost mitigation strategies, whereas the other bottlenecks likely could not be correctible in a low-cost manner. MPO staff used the following criteria to screen the bottleneck locations:

- Does the location qualify as a bottleneck? A long traffic queue upstream trailing free-flowing traffic downstream usually characterizes the location as a bottleneck. In addition, the upstream congestion must be recurring—in other words, the location experiences routine and predictable congestion because traffic volume exceeds the available capacity at that location.
- Is a physical design constraint or operational conflict inherent in the location the cause of the bottleneck? Examples of these are:
    - Lane drop—one or more travel lanes are lost, requiring traffic to merge
    - Weaving area—drivers must merge across one or more lanes in order to access an entry or exit ramp
    - Merge area—on-ramp traffic merges with mainline traffic in order to enter the freeway
    - Major interchanges—high-volume traffic is directed from one freeway to another
    - Horizontal curves—abrupt changes in highway alignment force drivers to slow down because of safety concerns
- Can the bottleneck be fixed with low-cost operational and geometric improvements? These would exclude costly long-term solutions such as expansion and major transit investments that alter driver mode choice. Examples of low-cost operational and geometric improvements are:
    - Using a short section of shoulder as an additional travel lane, an auxiliary lane, or for lengthening an acceleration or deceleration lane
    - Restriping merge and diverge areas to better serve traffic demand
    - Providing better traveler information to allow drivers to respond to temporary changes in lane assignment, such as using a shoulder as an additional travel lane during peak periods
    - Providing all-purpose reversible lanes
    - Changing or adding signs and striping

Based on the screening criteria and consultations with MassDOT Highway Division officials, MPO staff selected Locations 1 and 3 for study. Below are staff's rationale for not selecting Locations 2, 4, and 5:

Location 2: I-93 Southbound at the Lane Drop near Sullivan Square in Somerville/Charlestown

This section of highway is frequently congested because of a lane drop and intensive merging and diverging activities, especially during the AM peak period. During that period, the on-ramp carries between 1,300-and-1,700 vehicles per hour in an auxiliary lane; and the off-ramp to Leverett Circle, Exit 26, carries between 1,200-and-1,600 vehicles per hour.[5] The merging and diverging activities of these vehicles slow down mainline traffic and seriously affect traffic on the upstream section on I-93. The distance between the two ramps is about 0.4 miles long. The reasons for not selecting this location are:

- Removing the lane drop would require widening the I-93 bridge over Alfred Lombardi Street to provide a new auxiliary lane for the on-ramp traffic or converting the existing auxiliary lane to an acceleration lane.
- Widening the I-93 Bridge could be expensive.
- Converting the existing auxiliary lane to an acceleration lane might create a queue backup on the ramp that might affect traffic on Route 38 (Mystic Avenue) and the collector-distributor roads. In addition, there might not be enough space to provide sufficient acceleration distance because of the I-93 bridge over Alfred Lombardi Bridge.

Location 4: Route 2 Concord Rotary

This rotary, the intersection of Concord Turnpike (Route 2), Commonwealth Avenue, Barretts Mill Road, and Great Road (Route 119) is frequently congested because of high traffic volume and inadequate capacity during the AM and PM peak periods. The rotary is a challenge to navigate during these periods, and drivers often use local streets to avoid congestion. MassDOT Highway Division is planning to replace the rotary with an overpass for safer and more efficient operation, and to minimize environmental impacts. The Highway Division also is exploring opportunities to improve neighborhood connections, incorporate the Bruce Freeman Rail Trail and wildlife corridors, improve water and air quality, and enhance the area's design aesthetics to the extent possible.

Although this site is a major bottleneck, staff did not select this location because:

- Low-cost solutions at this location likely would not be feasible. MassDOT and MPO staff already studied the Route 2 Concord Rotary

[5] Express-Highway Traffic Volumes, I-93 Southbound 2010 Balanced Traffic Volumes, Estimated by CTPS.

to examine potential short- and long-term improvement alternatives for the rotary.[6,7]

- The project was removed from the funded portion of the MPO's Long Range Transportation Plan (LRTP) in August 2009 and currently is on hold.

Location 5: I-95 Northbound, Lane Drop at Interchange 37 in Reading, Stoneham, and Wakefield

This section of highway frequently is congested because of a lane drop and intensive merging and diverging activities, especially during the PM peak period, which slows down mainline traffic. During that time, the Exit 37 off-ramps carry about 3,200 vehicles per hour and the Exit 37 on-ramps carry about 2,300 vehicles per hour.[8] Adding an auxiliary lane northbound on I-95 would provide more room for the merging and diverging activities and reduce disturbance to mainline traffic. Staff did not select this location because an auxiliary lane would need to be extended for a long distance (about three-to-four interchanges downstream) to reduce congestion and queue, which could be expensive.

3 SELECTED BOTTLENECK LOCATIONS FOR STUDY

Location 1: I-93 Southbound Between I-95 and Montvale Avenue in Stoneham and Woburn

This section of highway, about two miles long, frequently is congested because of merging and diverging activities, especially during the AM and PM peak periods. The southbound off- and on-ramps connect to and from Montvale Avenue. During peak periods, I-93 southbound carries about 8,000 vehicles per hour; the on-ramp from I-95 northbound carries about 2,000 vehicles per hour; and about 900 vehicles per hour exit to Montvale Avenue at Exit 36. In addition, about 800 vehicles per hour enter I-93 southbound from Montvale Avenue during the same period.[9] The merging and diverging activities of these vehicles slow down I-93 southbound mainline traffic upstream of the Montvale Avenue interchange. In addition, these activities affect traffic entering I-93 southbound from I-95 northbound.

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[6] Chen-Yuan Wang, Route 2 Improvements from Route 111 in Acton to Baker Avenue in Concord: A Feasibility Study, report produced by the Central Transportation Planning Staff for the Massachusetts Department of Transportation, February 2003.

[7] Route 2 Reconstruction at the Concord Rotary, Concord Board of Selectmen Presentation, November 24, 2008.

[8] Express-Highway Traffic Volumes, I-95 Northbound 2007 Balanced Traffic Volumes, Estimated by CTPS.

[9] Express-Highway Traffic Volumes, I-93 Southbound 2010 Balanced Traffic Volumes, estimated by CTPS.

Location 3: I-95 Southbound at I-90 Interchange in Weston

This bottleneck is located on I-95 southbound at the point where traffic from I-90 and Route 30 merges onto I-95. During peak periods, between 2,000-to-2,600 vehicles per hour exit I-95 southbound to I-90 and Route 30. Further downstream about the same volume of traffic enters I-95 from the same roads. However, the four I-95 southbound lanes in that section are not allocated efficiently to serve demand. As a result, during peak periods a long traffic queue forms on the I-90 and Route 30 connector ramps heading southbound on I-95.

4 SUMMARY

By identifying and evaluating a comprehensive list of potential improvements at the two locations, MPO staff will rely on their technical expertise and judgment regarding the nature of bottlenecks. MPO staff will seek input from MassDOT Highway Division staff that are familiar with the region's express-highway system operations.

This study addresses the MPO's goal of reducing congestion and increasing safety on the region's highway system. MPO staff will submit this proposal to the MPO for discussion and approval. If the MPO approves this selection, staff will meet with officials from MassDOT and discuss the study specifics, conduct field visits, collect data, and perform various analyses.

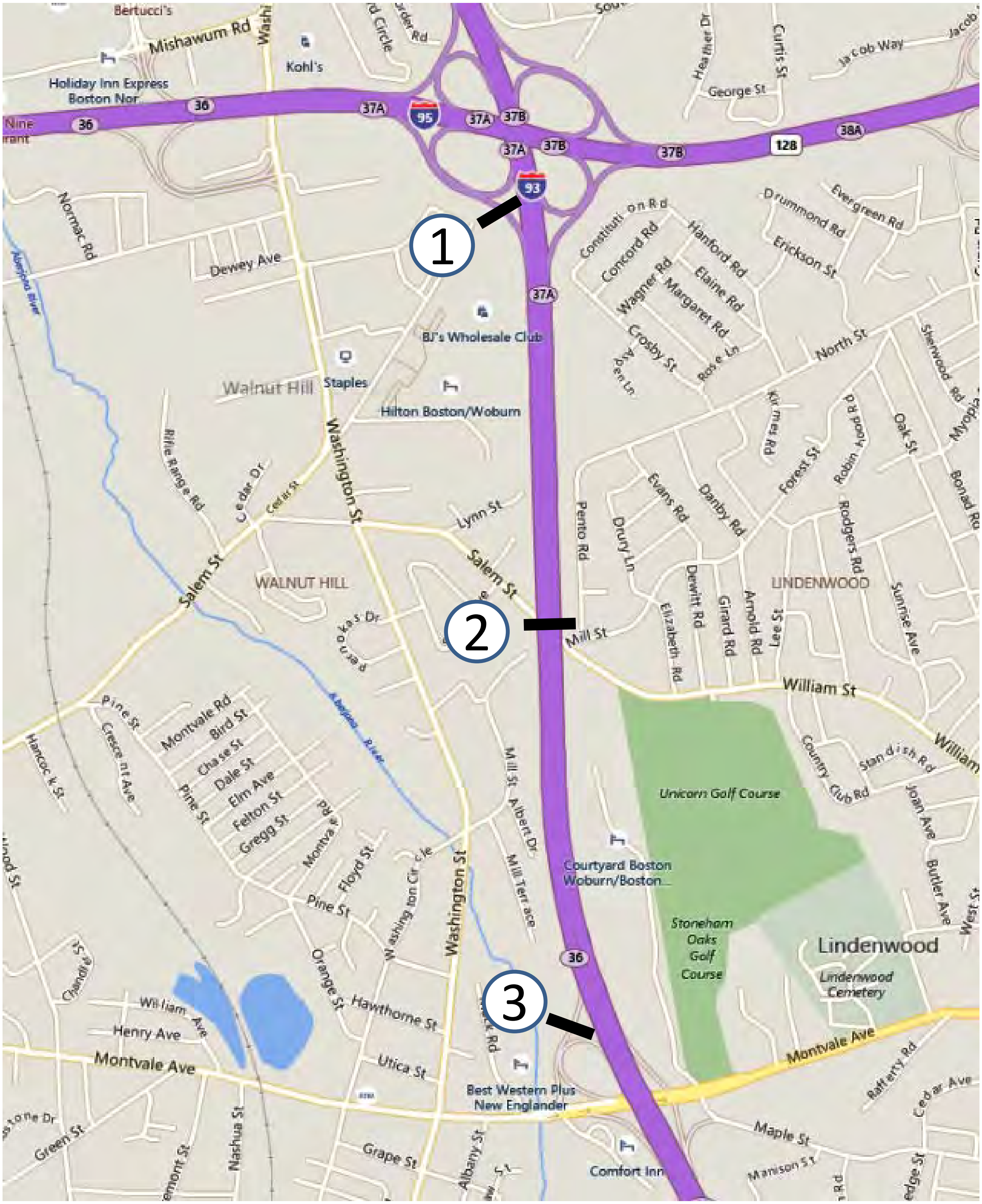
SAA/saa

APPENDIX B

Automatic Traffic Recorder (ATR) Count Data

LOCATION 1

I-93 Southbound Between I-95 and Montvale Avenue in Woburn and Stoneham



1
2
3
Bertucci's
Mishawum Rd
Kohl's
Holiday Inn Express Boston Nor
36
37A
95
37B
93
128
38A
Dewey Ave
Normac Rd
BJ's Wholesale Club
Staples
Walnut Hill
Hilton Boston/Woburn
Washington St
Salem St
Lynn St
WALNUT HILL
Mill St
William St
LINDENWOOD
North St
Unicorn Golf Course
Courtyard Boston Woburn/Boston...
Stoneham Oaks Golf Course
Lindenwood
Lindenwood Cemetery
Montvale Ave
Best Western Plus New Englander
Comfort Inn
Pine St
Hawthorne St
Utica St
Grape St
Maple St
Green St
Nashua St
Henry Ave
William Ave

Transportation Data Management System

Record	2	of 2	Goto Record

Location ID	4098	MPO ID	
Type	SPOT	HPMS ID	
On NHS		On HPMS	No
LRS ID		LRS Loc Pt.	
SF Group	-	Route Type	
AF Group	-	Route	
GF Group	U1-Boston		
QC Group	Perm		
Fnct'l Class	(1) Interstate	Milepost	
Located On	INTERSTATE 93		
Loc On Alias			
SOUTH OF	RTE.I- 95(128)		

PR	MP	PT

More Detail

STATION DATA

Directions:

AADT

	Year	AADT	DHV-30	K %	D %	PA	BC	Src
	2013	86,756						
	2007	92,586						

Travel Demand Model

	Model Year	Model AADT	AM PHV	AM PPV	MD PHV	MD PPV	PM PHV	PM PPV	NT PHV	NT PPV

VOLUME COUNT

	Date	Int	Total
	Tue 1/6/2015	60	91,613
	Mon 1/5/2015	60	92,408
	Sun 1/4/2015	60	63,202
	Sat 1/3/2015	60	77,240
	Fri 1/2/2015	60	90,136
	Thu 1/1/2015	60	56,207
	Wed 12/31/2014	60	93,433
	Tue 12/30/2014	60	97,073
	Mon 12/29/2014	60	94,374
	Sun 12/28/2014	60	70,519
	1-10 of 339		

VOLUME TREND

Year	Annual Growth
2014	7%
2013	-3%
2010	0%
2009	-2%
2008	4%

SPEED

CLASSIFICATION

Transportation Data Management System

Volume Count Report

LOCATION INFO	
Location ID	4098_SB
Type	SPOT
Fnct'l Class	1
Located On	INTERSTATE 93
SOUTH OF	RTE.I- 95(128)
Direction	SB
Community	WOBURN
MPO ID	
HPMS ID	
Agency	MHD

COUNT DATA INFO	
Count Status	Accepted
Start Date	Mon 1/5/2015
End Date	Tue 1/6/2015
Start Time	12:00:00 AM
End Time	12:00:00 AM
Direction	SB
Notes	
Count Source	
Weather	
Study	
Speed Limit	
Description	
Sensor Type	Tube Class

INTERVAL:60-MIN	
Time	Hourly Count
0:00-1:00	434
1:00-2:00	275
2:00-3:00	273
3:00-4:00	510
4:00-5:00	1,617
5:00-6:00	6,466
6:00-7:00	6,654
7:00-8:00	5,213
8:00-9:00	4,877
9:00-10:00	4,994
10:00-11:00	5,003
11:00-12:00	4,824
12:00-13:00	4,601
13:00-14:00	4,674
14:00-15:00	5,211
15:00-16:00	5,398
16:00-17:00	6,134
17:00-18:00	7,619
18:00-19:00	6,382
19:00-20:00	3,848
20:00-21:00	2,650
21:00-22:00	2,104
22:00-23:00	1,605
23:00-24:00	1,042
Total	92,408
AM Peak	06:00-07:00 6,654
PM Peak	17:00-18:00 7,619

Transportation Data Management System

Volume Count Report

LOCATION INFO	
Location ID	4098_SB
Type	SPOT
Fnct'l Class	1
Located On	INTERSTATE 93
SOUTH OF	RTE.I- 95(128)
Direction	SB
Community	WOBURN
MPO ID	
HPMS ID	
Agency	MHD

COUNT DATA INFO	
Count Status	Accepted
Start Date	Tue 1/6/2015
End Date	Wed 1/7/2015
Start Time	12:00:00 AM
End Time	12:00:00 AM
Direction	SB
Notes	
Count Source	
Weather	
Study	
Speed Limit	
Description	
Sensor Type	Tube Class

INTERVAL:60-MIN	
Time	Hourly Count
0:00-1:00	469
1:00-2:00	323
2:00-3:00	279
3:00-4:00	472
4:00-5:00	1,550
5:00-6:00	6,518
6:00-7:00	7,008
7:00-8:00	5,134
8:00-9:00	4,790
9:00-10:00	5,220
10:00-11:00	5,110
11:00-12:00	4,698
12:00-13:00	4,737
13:00-14:00	4,557
14:00-15:00	4,925
15:00-16:00	5,046
16:00-17:00	5,596
17:00-18:00	7,085
18:00-19:00	6,137
19:00-20:00	4,169
20:00-21:00	2,839
21:00-22:00	2,177
22:00-23:00	1,675
23:00-24:00	1,099
Total	91,613
AM Peak	06:00-07:00 7,008
PM Peak	17:00-18:00 7,085

Transportation Data Management System

Classification Report

Location ID	4098_SB	**Located On**	INTERSTATE 93	**Community**	WOBURN
Counted By	TCDS_Combined	**SOUTH OF**	RTE.I- 95(128)	**County**	MIDDLESEX
Start Date	Tue 1/6/2015	**Loc On Alias**		**Module**	
Start Time	12:00:00 AM	**Direction**	SB	**Agency**	MHD
Source	Syst_Combine	**Sensor**	Tube Class		
Axle Factor	0.976	**Count Status**	Accepted		

FHWA-Scheme F Classification

Start Time	Motor cycle	Car	Pick up	Bus	2A SU	3A SU	>3A SU	<5A 2U	5A 2U	>5A 2U	<6A >2U	6A >2U	>6A >2U	14	15	TOTAL
12:00 AM	0	430	4	5	6	3	0	4	16	1	0	0	0	0	0	469
1:00 AM	0	278	6	2	7	1	0	9	16	3	1	0	0	0	0	323
2:00 AM	0	219	7	0	7	9	0	3	27	7	0	0	0	0	0	279
3:00 AM	0	378	12	5	12	18	0	8	36	3	0	0	0	0	0	472
4:00 AM	0	1346	90	5	31	12	0	17	47	2	0	0	0	0	0	1550
5:00 AM	12	5923	404	15	39	26	0	28	67	4	0	0	0	0	0	6518
6:00 AM	14	6698	173	20	29	24	1	16	31	2	0	0	0	0	0	7008
7:00 AM	7	4708	245	28	54	23	6	13	43	7	0	0	0	0	0	5134
8:00 AM	1	4342	257	14	59	28	3	17	63	6	0	0	0	0	0	4790
9:00 AM	4	4687	262	24	80	29	6	21	99	8	0	0	0	0	0	5220
10:00 AM	8	4550	267	20	84	31	5	28	106	11	0	0	0	0	0	5110
11:00 AM	9	4180	267	15	62	45	4	33	73	9	0	1	0	0	0	4698
12:00 PM	8	4275	231	19	65	33	2	19	73	12	0	0	0	0	0	4737
1:00 PM	7	4106	247	15	50	30	3	25	68	6	0	0	0	0	0	4557
2:00 PM	9	4523	241	18	49	26	2	19	35	3	0	0	0	0	0	4925
3:00 PM	1	4710	216	16	42	19	0	13	27	2	0	0	0	0	0	5046
4:00 PM	2	5316	186	18	41	13	1	6	13	0	0	0	0	0	0	5596
5:00 PM	2	6830	174	20	31	9	0	5	12	2	0	0	0	0	0	7085
6:00 PM	1	5929	125	19	27	5	0	7	21	3	0	0	0	0	0	6137
7:00 PM	0	3988	97	9	16	7	0	11	38	3	0	0	0	0	0	4169
8:00 PM	0	2695	74	7	14	3	0	11	30	4	1	0	0	0	0	2839
9:00 PM	0	2081	53	3	11	1	0	2	19	6	0	1	0	0	0	2177
10:00 PM	1	1566	65	4	5	3	0	2	27	2	0	0	0	0	0	1675
11:00 PM	0	1027	32	4	6	2	0	5	19	3	1	0	0	0	0	1099
TOTAL	86	84785	3735	305	827	400	33	322	1006	109	3	2	0	0	0	91613

Transportation Data Management System

Classification Report

Location ID	4098_SB	**Located On**	INTERSTATE 93	**Community**	WOBURN
Counted By	TCDS_Combined	**SOUTH OF**	RTE.I- 95(128)	**County**	MIDDLESEX
Start Date	Mon 1/5/2015	**Loc On Alias**		**Module**	
Start Time	12:00:00 AM	**Direction**	SB	**Agency**	MHD
Source	Syst_Combine	**Sensor**	Tube Class		
Axle Factor	0.977	**Count Status**	Accepted		

FHWA-Scheme F Classification

Start Time	Motor cycle	Car	Pick up	Bus	2A SU	3A SU	>3A SU	<5A 2U	5A 2U	>5A 2U	<6A >2U	6A >2U	>6A >2U	14	15	TOTAL
12:00 AM	0	375	26	4	5	0	0	5	19	0	0	0	0	0	0	434
1:00 AM	0	219	21	4	3	3	0	8	15	2	0	0	0	0	0	275
2:00 AM	1	222	20	0	5	8	0	2	13	2	0	0	0	0	0	273
3:00 AM	0	381	53	6	16	16	0	5	29	4	0	0	0	0	0	510
4:00 AM	5	1302	199	8	28	15	0	15	42	3	0	0	0	0	0	1617
5:00 AM	4	5418	869	19	44	26	0	21	61	4	0	0	0	0	0	6466
6:00 AM	8	6058	457	19	43	21	2	13	31	1	0	0	1	0	0	6654
7:00 AM	8	4619	449	28	37	19	6	12	33	0	0	2	0	0	0	5213
8:00 AM	4	4228	457	16	51	22	5	23	68	2	1	0	0	0	0	4877
9:00 AM	2	4313	446	22	65	32	7	21	79	6	1	0	0	0	0	4994
10:00 AM	5	4227	511	22	70	36	2	31	96	2	0	1	0	0	0	5003
11:00 AM	8	4059	512	16	65	34	4	22	97	7	0	0	0	0	0	4824
12:00 PM	6	3821	544	23	67	25	4	20	85	5	0	0	1	0	0	4601
1:00 PM	8	3954	477	21	71	35	6	12	83	7	0	0	0	0	0	4674
2:00 PM	4	4507	498	18	70	30	1	19	60	3	0	0	1	0	0	5211
3:00 PM	4	4818	448	18	47	19	0	10	33	1	0	0	0	0	0	5398
4:00 PM	2	5651	383	15	36	13	0	5	28	0	0	1	0	0	0	6134
5:00 PM	1	7258	280	22	28	9	0	9	9	0	0	1	2	0	0	7619
6:00 PM	7	6059	237	16	19	5	0	16	22	1	0	0	0	0	0	6382
7:00 PM	3	3671	104	11	18	6	0	13	20	2	0	0	0	0	0	3848
8:00 PM	1	2522	68	7	11	3	0	7	27	4	0	0	0	0	0	2650
9:00 PM	1	2004	48	5	11	4	0	7	21	3	0	0	0	0	0	2104
10:00 PM	1	1517	44	6	6	4	0	3	21	2	1	0	0	0	0	1605
11:00 PM	0	979	23	5	7	2	0	7	18	1	0	0	0	0	0	1042
TOTAL	83	82182	7174	331	823	387	37	306	1010	62	3	5	5	0	0	92408

Transportation Data Management System

Classification Report

Location ID	4098_SB	**Located On**	INTERSTATE 93	**Community**	WOBURN
Counted By	TCDS_Combined	**SOUTH OF**	RTE.I- 95(128)	**County**	MIDDLESEX
Start Date	Mon 12/22/2014	**Loc On Alias**		**Module**	
Start Time	12:00:00 AM	**Direction**	SB	**Agency**	MHD
Source	Syst_Combine	**Sensor**	Tube Class		
Axle Factor	0.975	**Count Status**	Accepted		

FHWA-Scheme F Classification

Start Time	Motor cycle	Car	Pick up	Bus	2A SU	3A SU	>3A SU	<5A 2U	5A 2U	>5A 2U	<6A >2U	6A >2U	>6A >2U	14	15	TOTAL
12:00 AM	0	493	22	3	4	2	0	5	16	4	0	0	0	0	0	549
1:00 AM	0	280	14	4	5	2	0	5	21	3	0	0	0	0	0	334
2:00 AM	2	241	26	0	4	11	0	5	24	6	0	0	0	0	0	319
3:00 AM	3	372	42	6	17	16	0	10	34	6	0	0	0	0	0	506
4:00 AM	2	1123	178	8	21	21	0	19	60	6	1	0	0	0	0	1439
5:00 AM	6	5190	1044	17	56	26	1	19	63	6	1	1	0	0	0	6430
6:00 AM	14	5873	564	25	51	31	0	17	27	1	0	0	0	0	0	6603
7:00 AM	4	4531	543	23	62	28	6	18	51	2	0	0	0	0	0	5268
8:00 AM	5	4358	530	17	71	25	3	22	72	4	0	1	0	0	0	5108
9:00 AM	7	4763	594	25	81	34	8	28	109	11	1	0	0	0	0	5661
10:00 AM	0	4967	629	19	86	26	4	38	105	4	0	0	0	0	0	5878
11:00 AM	1	4765	582	19	82	45	6	23	109	6	1	0	0	0	0	5639
12:00 PM	4	4598	555	12	60	43	6	14	91	6	0	0	1	0	0	5390
1:00 PM	4	4505	500	22	80	34	2	17	72	2	0	0	1	0	0	5239
2:00 PM	7	5008	504	17	61	34	4	19	50	4	3	0	0	0	0	5711
3:00 PM	1	4848	505	20	60	18	1	9	25	1	1	1	0	0	0	5490
4:00 PM	1	4850	381	16	53	6	0	4	24	1	1	0	0	0	0	5337
5:00 PM	1	5460	346	15	39	6	0	12	20	2	0	1	0	0	0	5902
6:00 PM	4	5118	258	14	39	7	0	4	29	0	1	1	0	0	0	5475
7:00 PM	1	3766	209	12	20	6	0	7	26	1	0	0	0	0	0	4048
8:00 PM	3	2880	162	6	16	5	0	13	24	1	0	0	0	0	0	3110
9:00 PM	1	2423	143	6	6	6	1	5	35	2	0	0	0	0	0	2628
10:00 PM	0	2070	123	4	9	5	0	7	25	0	0	0	0	0	0	2243
11:00 PM	0	1296	68	4	5	2	0	5	16	2	1	0	0	0	0	1399
TOTAL	71	83778	8522	314	988	439	42	325	1128	81	11	5	2	0	0	95706

Transportation Data Management System

Classification Report

Location ID	4098_SB	**Located On**	INTERSTATE 93	**Community**	WOBURN
Counted By	TCDS_Combined	**SOUTH OF**	RTE.I- 95(128)	**County**	MIDDLESEX
Start Date	Fri 12/19/2014	**Loc On Alias**		**Module**	
Start Time	12:00:00 AM	**Direction**	SB	**Agency**	MHD
Source	Syst_Combine	**Sensor**	Tube Class		
Axle Factor	0.98	**Count Status**	Accepted		

FHWA-Scheme F Classification

Start Time	Motor cycle	Car	Pick up	Bus	2A SU	3A SU	>3A SU	<5A 2U	5A 2U	>5A 2U	<6A >2U	6A >2U	>6A >2U	14	15	TOTAL
12:00 AM	1	751	36	2	7	4	0	9	19	3	0	0	0	0	0	832
1:00 AM	1	391	22	4	2	1	0	9	14	2	0	0	0	0	0	446
2:00 AM	5	281	25	1	11	13	0	9	15	4	0	0	0	0	0	364
3:00 AM	2	422	51	2	15	15	0	15	26	4	0	0	0	0	0	552
4:00 AM	3	1179	203	14	27	14	0	39	48	4	0	0	0	0	0	1531
5:00 AM	13	5241	1019	20	38	32	1	37	54	4	0	0	0	0	0	6459
6:00 AM	10	5579	597	27	49	31	3	23	32	3	0	0	1	0	0	6355
7:00 AM	14	4608	483	24	58	25	8	17	54	4	1	2	0	0	0	5298
8:00 AM	9	4424	475	29	62	26	6	17	50	4	1	0	2	0	0	5105
9:00 AM	13	4660	533	27	80	35	4	39	79	5	0	0	1	0	0	5476
10:00 AM	6	4849	552	21	63	54	4	36	76	7	1	0	0	0	0	5669
11:00 AM	14	4973	560	21	71	37	11	42	88	4	1	0	1	0	0	5823
12:00 PM	12	4716	535	15	73	40	9	32	68	3	0	0	0	0	0	5503
1:00 PM	6	4786	530	20	51	32	5	20	38	6	0	0	0	0	0	5494
2:00 PM	11	5513	536	22	53	31	4	23	42	2	1	0	0	0	0	6238
3:00 PM	3	5741	497	22	47	14	1	12	20	1	1	2	1	0	0	6362
4:00 PM	4	6160	427	13	35	13	0	11	11	0	0	1	0	0	0	6675
5:00 PM	7	6933	301	18	27	6	0	6	12	1	0	1	0	0	0	7312
6:00 PM	4	6061	259	20	29	2	0	5	14	1	0	0	0	0	0	6395
7:00 PM	2	4361	234	13	20	10	0	9	14	0	1	0	0	0	0	4664
8:00 PM	5	3304	155	10	14	3	0	7	14	3	0	0	0	0	0	3515
9:00 PM	1	2855	139	6	12	2	0	6	15	2	0	0	1	0	0	3039
10:00 PM	0	2586	125	2	8	1	0	7	20	3	0	0	0	0	0	2752
11:00 PM	0	2046	98	9	6	4	0	3	13	3	0	0	0	0	0	2182
TOTAL	146	92420	8392	362	858	445	56	433	836	73	7	6	7	0	0	104041

Transportation Data Management System

Volume Count Report

LOCATION INFO	
Location ID	R12697
Type	SPOT
Fnct'l Class	-
Located On	I-95
	Exit 37A I-93 South Boston
Direction	RAMP
Community	Woburn
MPO ID	
HPMS ID	
Agency	MHD

COUNT DATA INFO	
Count Status	Accepted
Start Date	Thu 4/10/2014
End Date	Fri 4/11/2014
Start Time	12:00:00 AM
End Time	12:00:00 AM
Direction	
Notes	
Count Source	000000000590
Weather	
Study	
Speed Limit	
Description	
Sensor Type	Tube

INTERVAL:60-MIN	
Time	Hourly Count
0:00-1:00	199
1:00-2:00	124
2:00-3:00	115
3:00-4:00	177
4:00-5:00	363
5:00-6:00	1,344
6:00-7:00	1,316
7:00-8:00	958
8:00-9:00	1,010
9:00-10:00	1,377
10:00-11:00	1,604
11:00-12:00	1,552
12:00-13:00	1,606
13:00-14:00	1,676
14:00-15:00	1,823
15:00-16:00	1,769
16:00-17:00	1,492
17:00-18:00	1,538
18:00-19:00	1,669
19:00-20:00	1,541
20:00-21:00	1,207
21:00-22:00	1,095
22:00-23:00	780
23:00-24:00	405
Total	26,740
AM Peak	10:00-11:00 1,604
PM Peak	14:00-15:00 1,823

Transportation Data Management System

Volume Count Report

LOCATION INFO	
Location ID	R12697
Type	SPOT
Fnct'l Class	-
Located On	I-95
	Exit 37A I-93 South Boston
Direction	RAMP
Community	Woburn
MPO ID	
HPMS ID	
Agency	MHD

COUNT DATA INFO	
Count Status	Accepted
Start Date	Tue 4/8/2014
End Date	Wed 4/9/2014
Start Time	12:00:00 AM
End Time	12:00:00 AM
Direction	
Notes	
Count Source	000000000590
Weather	
Study	
Speed Limit	
Description	
Sensor Type	Tube

INTERVAL:60-MIN	
Time	Hourly Count
0:00-1:00	178
1:00-2:00	103
2:00-3:00	92
3:00-4:00	141
4:00-5:00	376
5:00-6:00	1,322
6:00-7:00	1,228
7:00-8:00	890
8:00-9:00	767
9:00-10:00	1,127
10:00-11:00	1,497
11:00-12:00	1,447
12:00-13:00	1,520
13:00-14:00	1,604
14:00-15:00	1,768
15:00-16:00	1,877
16:00-17:00	1,837
17:00-18:00	1,781
18:00-19:00	1,882
19:00-20:00	1,402
20:00-21:00	1,084
21:00-22:00	946
22:00-23:00	623
23:00-24:00	305
Total	25,797
AM Peak	10:00-11:00 1,497
PM Peak	18:00-19:00 1,882

Transportation Data Management System

Volume Count Report

LOCATION INFO	
Location ID	R12697
Type	SPOT
Fnct'l Class	-
Located On	I-95
	Exit 37A I-93 South Boston
Direction	RAMP
Community	Woburn
MPO ID	
HPMS ID	
Agency	MHD

COUNT DATA INFO	
Count Status	Accepted
Start Date	Wed 4/9/2014
End Date	Thu 4/10/2014
Start Time	12:00:00 AM
End Time	12:00:00 AM
Direction	
Notes	
Count Source	000000000590
Weather	
Study	
Speed Limit	
Description	
Sensor Type	Tube

INTERVAL:60-MIN	
Time	Hourly Count
0:00-1:00	164
1:00-2:00	99
2:00-3:00	80
3:00-4:00	143
4:00-5:00	350
5:00-6:00	1,379
6:00-7:00	1,371
7:00-8:00	986
8:00-9:00	977
9:00-10:00	1,256
10:00-11:00	1,595
11:00-12:00	1,566
12:00-13:00	1,596
13:00-14:00	1,769
14:00-15:00	1,895
15:00-16:00	1,883
16:00-17:00	1,834
17:00-18:00	1,724
18:00-19:00	1,781
19:00-20:00	1,431
20:00-21:00	1,123
21:00-22:00	969
22:00-23:00	668
23:00-24:00	361
Total	27,000
AM Peak	10:00-11:00 1,595
PM Peak	14:00-15:00 1,895

Transportation Data Management System

Volume Count Report

LOCATION INFO	
Location ID	R12697
Type	SPOT
Fnct'l Class	-
Located On	I-95
	Exit 37A I-93 South Boston
Direction	RAMP
Community	Woburn
MPO ID	
HPMS ID	
Agency	MHD

COUNT DATA INFO	
Count Status	Accepted
Start Date	Thu 4/10/2014
End Date	Fri 4/11/2014
Start Time	12:00:00 AM
End Time	12:00:00 AM
Direction	
Notes	
Count Source	000000000590
Weather	
Study	
Speed Limit	
Description	
Sensor Type	Tube

INTERVAL:60-MIN	
Time	Hourly Count
0:00-1:00	199
1:00-2:00	124
2:00-3:00	115
3:00-4:00	177
4:00-5:00	363
5:00-6:00	1,344
6:00-7:00	1,316
7:00-8:00	958
8:00-9:00	1,010
9:00-10:00	1,377
10:00-11:00	1,604
11:00-12:00	1,552
12:00-13:00	1,606
13:00-14:00	1,676
14:00-15:00	1,823
15:00-16:00	1,769
16:00-17:00	1,492
17:00-18:00	1,538
18:00-19:00	1,669
19:00-20:00	1,541
20:00-21:00	1,207
21:00-22:00	1,095
22:00-23:00	780
23:00-24:00	405
Total	26,740
AM Peak	10:00-11:00 1,604
PM Peak	14:00-15:00 1,823

Transportation Data Management System

Volume Count Report

LOCATION INFO	
Location ID	4098_SB
Type	SPOT
Fnct'l Class	1
Located On	INTERSTATE 93
SOUTH OF	RTE.I- 95(128)
Direction	SB
Community	WOBURN
MPO ID	
HPMS ID	
Agency	MHD

COUNT DATA INFO	
Count Status	Accepted
Start Date	Thu 1/22/2015
End Date	Fri 1/23/2015
Start Time	12:00:00 AM
End Time	12:00:00 AM
Direction	SB
Notes	
Count Source	
Weather	
Study	
Speed Limit	
Description	
Sensor Type	Loop

INTERVAL:60-MIN	
Time	Hourly Count
0:00-1:00	481
1:00-2:00	317
2:00-3:00	295
3:00-4:00	544
4:00-5:00	1,550
5:00-6:00	6,542
6:00-7:00	6,791
7:00-8:00	5,291
8:00-9:00	4,886
9:00-10:00	5,556
10:00-11:00	5,355
11:00-12:00	4,984
12:00-13:00	5,122
13:00-14:00	5,016
14:00-15:00	5,721
15:00-16:00	5,806
16:00-17:00	6,662
17:00-18:00	7,654
18:00-19:00	6,592
19:00-20:00	4,399
20:00-21:00	3,240
21:00-22:00	2,523
22:00-23:00	2,007
23:00-24:00	1,209
Total	98,543
AADT	95,390
AM Peak	06:00-07:00 6,791
PM Peak	17:00-18:00 7,654

Transportation Data Management System

Volume Count Report

LOCATION INFO	
Location ID	4098_SB
Type	SPOT
Fnct'l Class	1
Located On	INTERSTATE 93
SOUTH OF	RTE.I- 95(128)
Direction	SB
Community	WOBURN
MPO ID	
HPMS ID	
Agency	MHD

COUNT DATA INFO	
Count Status	Accepted
Start Date	Wed 1/21/2015
End Date	Thu 1/22/2015
Start Time	12:00:00 AM
End Time	12:00:00 AM
Direction	SB
Notes	
Count Source	
Weather	
Study	
Speed Limit	
Description	
Sensor Type	Loop

INTERVAL:60-MIN	
Time	Hourly Count
0:00-1:00	497
1:00-2:00	303
2:00-3:00	290
3:00-4:00	442
4:00-5:00	1,516
5:00-6:00	6,582
6:00-7:00	6,987
7:00-8:00	5,140
8:00-9:00	4,537
9:00-10:00	5,338
10:00-11:00	5,112
11:00-12:00	5,034
12:00-13:00	5,056
13:00-14:00	4,932
14:00-15:00	5,433
15:00-16:00	5,736
16:00-17:00	6,330
17:00-18:00	7,501
18:00-19:00	6,474
19:00-20:00	4,153
20:00-21:00	2,970
21:00-22:00	2,539
22:00-23:00	1,759
23:00-24:00	1,074
Total	95,735
AADT	98,416
AM Peak	06:00-07:00 6,987
PM Peak	17:00-18:00 7,501

Transportation Data Management System

Volume Count Report

LOCATION INFO	
Location ID	4098_SB
Type	SPOT
Fnct'l Class	1
Located On	INTERSTATE 93
SOUTH OF	RTE.I- 95(128)
Direction	SB
Community	WOBURN
MPO ID	
HPMS ID	
Agency	MHD

COUNT DATA INFO	
Count Status	Accepted
Start Date	Thu 1/15/2015
End Date	Fri 1/16/2015
Start Time	12:00:00 AM
End Time	12:00:00 AM
Direction	SB
Notes	
Count Source	
Weather	
Study	
Speed Limit	
Description	
Sensor Type	Loop

INTERVAL:60-MIN	
Time	Hourly Count
0:00-1:00	537
1:00-2:00	330
2:00-3:00	323
3:00-4:00	491
4:00-5:00	1,570
5:00-6:00	6,132
6:00-7:00	6,840
7:00-8:00	5,009
8:00-9:00	4,134
9:00-10:00	4,799
10:00-11:00	4,849
11:00-12:00	4,881
12:00-13:00	4,986
13:00-14:00	4,975
14:00-15:00	5,495
15:00-16:00	5,622
16:00-17:00	6,146
17:00-18:00	6,465
18:00-19:00	6,650
19:00-20:00	4,276
20:00-21:00	3,046
21:00-22:00	2,588
22:00-23:00	2,031
23:00-24:00	1,206
Total	93,381
AADT	90,393
AM Peak	06:00-07:00 6,840
PM Peak	18:00-19:00 6,650

Transportation Data Management System

Volume Count Report

LOCATION INFO	
Location ID	4098_SB
Type	SPOT
Fnct'l Class	1
Located On	INTERSTATE 93
SOUTH OF	RTE.I- 95(128)
Direction	SB
Community	WOBURN
MPO ID	
HPMS ID	
Agency	MHD

COUNT DATA INFO	
Count Status	Accepted
Start Date	Wed 1/21/2015
End Date	Thu 1/22/2015
Start Time	12:00:00 AM
End Time	12:00:00 AM
Direction	SB
Notes	
Count Source	
Weather	
Study	
Speed Limit	
Description	
Sensor Type	Loop

INTERVAL:60-MIN	
Time	Hourly Count
0:00-1:00	497
1:00-2:00	303
2:00-3:00	290
3:00-4:00	442
4:00-5:00	1,516
5:00-6:00	6,582
6:00-7:00	6,987
7:00-8:00	5,140
8:00-9:00	4,537
9:00-10:00	5,338
10:00-11:00	5,112
11:00-12:00	5,034
12:00-13:00	5,056
13:00-14:00	4,932
14:00-15:00	5,433
15:00-16:00	5,736
16:00-17:00	6,330
17:00-18:00	7,501
18:00-19:00	6,474
19:00-20:00	4,153
20:00-21:00	2,970
21:00-22:00	2,539
22:00-23:00	1,759
23:00-24:00	1,074
Total	95,735
AADT	98,416
AM Peak	06:00-07:00 6,987
PM Peak	17:00-18:00 7,501

Transportation Data Management System

Volume Count Report

LOCATION INFO	
Location ID	4098_SB
Type	SPOT
Fnct'l Class	1
Located On	INTERSTATE 93
SOUTH OF	RTE.I- 95(128)
Direction	SB
Community	WOBURN
MPO ID	
HPMS ID	
Agency	MHD

COUNT DATA INFO	
Count Status	Accepted
Start Date	Tue 1/13/2015
End Date	Wed 1/14/2015
Start Time	12:00:00 AM
End Time	12:00:00 AM
Direction	SB
Notes	
Count Source	
Weather	
Study	
Speed Limit	
Description	
Sensor Type	Loop

INTERVAL:60-MIN	
Time	Hourly Count
0:00-1:00	509
1:00-2:00	322
2:00-3:00	307
3:00-4:00	493
4:00-5:00	1,598
5:00-6:00	6,608
6:00-7:00	6,443
7:00-8:00	5,269
8:00-9:00	4,748
9:00-10:00	5,457
10:00-11:00	5,419
11:00-12:00	4,934
12:00-13:00	5,022
13:00-14:00	4,763
14:00-15:00	5,226
15:00-16:00	5,648
16:00-17:00	6,440
17:00-18:00	7,298
18:00-19:00	6,550
19:00-20:00	4,236
20:00-21:00	3,158
21:00-22:00	2,382
22:00-23:00	1,809
23:00-24:00	1,068
Total	95,707
AADT	100,205
AM Peak	05:00-06:00 6,608
PM Peak	17:00-18:00 7,298

Transportation Data Management System

Volume Count Report

LOCATION INFO	
Location ID	R12177
Type	SPOT
Fnct'l Class	1
Located On	I-93
	Exit 36 Montvale Ave Stoneham Woburn
Direction	RAMP
Community	Woburn
MPO ID	
HPMS ID	
Agency	MHD

COUNT DATA INFO	
Count Status	Accepted
Start Date	Wed 4/30/2014
End Date	Thu 5/1/2014
Start Time	12:00:00 AM
End Time	12:00:00 AM
Direction	
Notes	
Count Source	000000000761
Weather	
Study	
Speed Limit	
Description	
Sensor Type	Tube

INTERVAL:60-MIN	
Time	Hourly Count
0:00-1:00	65
1:00-2:00	40
2:00-3:00	23
3:00-4:00	47
4:00-5:00	112
5:00-6:00	440
6:00-7:00	545
7:00-8:00	1,373
8:00-9:00	1,237
9:00-10:00	1,077
10:00-11:00	867
11:00-12:00	737
12:00-13:00	770
13:00-14:00	791
14:00-15:00	838
15:00-16:00	777
16:00-17:00	849
17:00-18:00	1,011
18:00-19:00	747
19:00-20:00	517
20:00-21:00	416
21:00-22:00	320
22:00-23:00	250
23:00-24:00	121
Total	13,970
AADT	12,208
AM Peak	07:00-08:00 1,373
PM Peak	17:00-18:00 1,011

Transportation Data Management System

Volume Count Report

LOCATION INFO	
Location ID	R12177
Type	SPOT
Fnct'l Class	1
Located On	I-93
	Exit 36 Montvale Ave Stoneham Woburn
Direction	RAMP
Community	Woburn
MPO ID	
HPMS ID	
Agency	MHD

COUNT DATA INFO	
Count Status	Accepted
Start Date	Tue 4/29/2014
End Date	Wed 4/30/2014
Start Time	12:00:00 AM
End Time	12:00:00 AM
Direction	
Notes	
Count Source	000000000761
Weather	
Study	
Speed Limit	
Description	
Sensor Type	Tube

INTERVAL:60-MIN	
Time	Hourly Count
0:00-1:00	54
1:00-2:00	31
2:00-3:00	38
3:00-4:00	48
4:00-5:00	106
5:00-6:00	456
6:00-7:00	596
7:00-8:00	1,368
8:00-9:00	1,006
9:00-10:00	912
10:00-11:00	814
11:00-12:00	735
12:00-13:00	779
13:00-14:00	795
14:00-15:00	832
15:00-16:00	837
16:00-17:00	871
17:00-18:00	1,036
18:00-19:00	727
19:00-20:00	506
20:00-21:00	356
21:00-22:00	276
22:00-23:00	209
23:00-24:00	115
Total	13,503
AADT	11,982
AM Peak	07:00-08:00 1,368
PM Peak	17:00-18:00 1,036

Transportation Data Management System

Volume Count Report

LOCATION INFO	
Location ID	R12177
Type	SPOT
Fnct'l Class	1
Located On	I-93
	Exit 36 Montvale Ave Stoneham Woburn
Direction	RAMP
Community	Woburn
MPO ID	
HPMS ID	
Agency	MHD

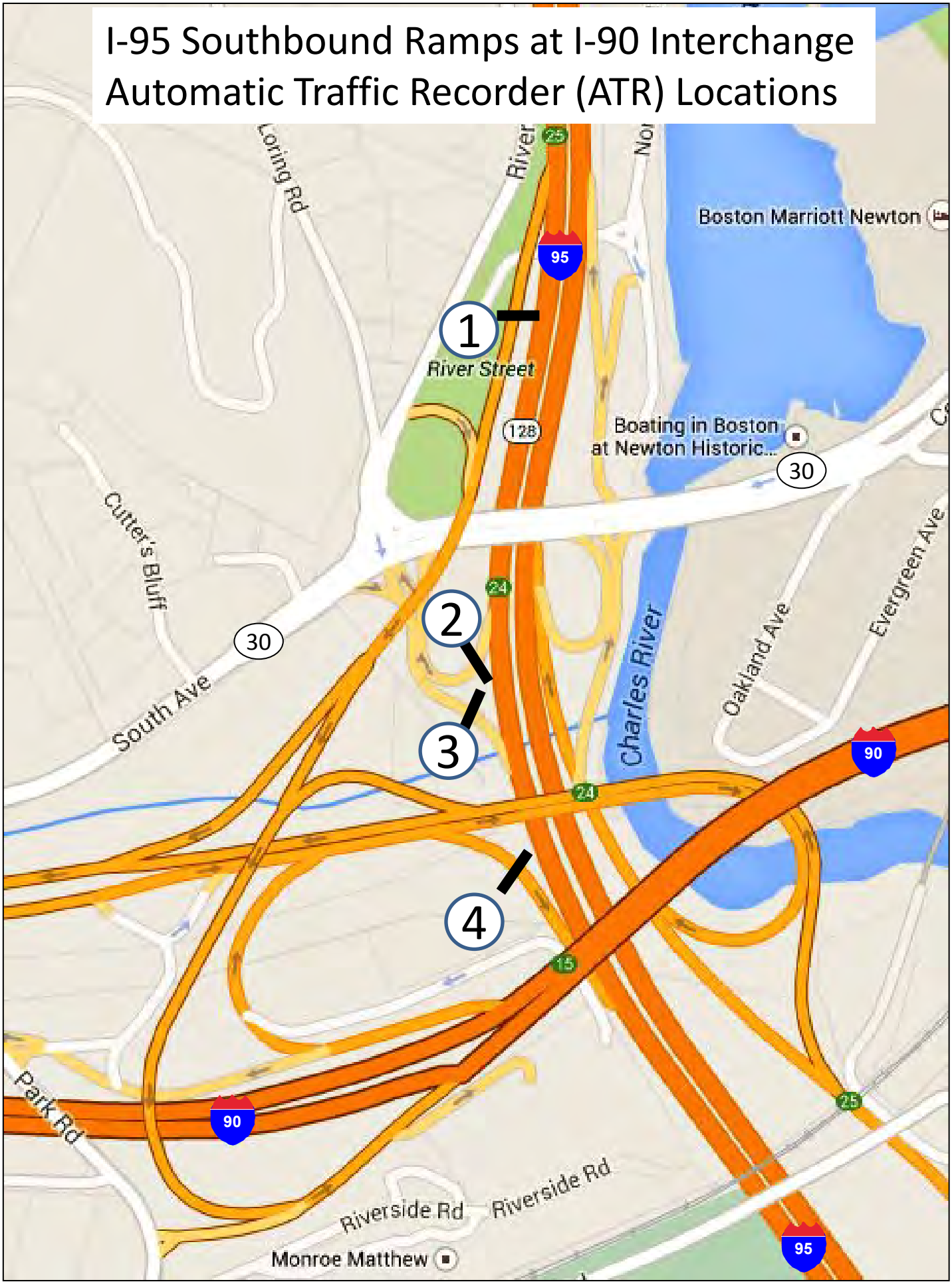
COUNT DATA INFO	
Count Status	Accepted
Start Date	Mon 4/28/2014
End Date	Tue 4/29/2014
Start Time	12:00:00 AM
End Time	12:00:00 AM
Direction	
Notes	
Count Source	000000000761
Weather	
Study	
Speed Limit	
Description	
Sensor Type	Tube

INTERVAL:60-MIN	
Time	Hourly Count
0:00-1:00	48
1:00-2:00	30
2:00-3:00	37
3:00-4:00	46
4:00-5:00	117
5:00-6:00	412
6:00-7:00	529
7:00-8:00	1,132
8:00-9:00	997
9:00-10:00	884
10:00-11:00	712
11:00-12:00	705
12:00-13:00	691
13:00-14:00	698
14:00-15:00	804
15:00-16:00	844
16:00-17:00	769
17:00-18:00	958
18:00-19:00	670
19:00-20:00	483
20:00-21:00	275
21:00-22:00	270
22:00-23:00	192
23:00-24:00	90
Total	12,393
AADT	11,345
AM Peak	07:00-08:00 1,132
PM Peak	17:00-18:00 958

LOCATION 2

I-95 Southbound at the I-90 Interchange in Weston

I-95 Southbound Ramps at I-90 Interchange
Automatic Traffic Recorder (ATR) Locations



Massachusetts Highway Department
WEEKLY SUMMARY FOR LANE 1
Starting: 4/28/2015

STA. 1

Site Reference: 150110000624 File: V100.prn
Site ID: 000000000100 City: WESTON
Location: EXIT 25 RAMP FROM I-95 SB TO I-90 County: VOL
Direction:

TIME	MON 4	TUE 28	WED 29	THU 30	FRI 1	WKDAY AVG	SAT 2	SUN 3	WEEK AVG	TOTAL
01:00	184	219	192	190	245	206	277	268	225	1575
02:00	118	165	168	120	198	153	176	320	180	1265
03:00	84	117	128	137	132	119	160	135	127	893
04:00	112	173	150	149	189	154	123	89	140	985
05:00	291	282	284	302	321	296	213	105	256	1798
06:00	822	877	874	815	826	842	376	188	682	4778
07:00	1880	2056	1743	1869	1741	1857	637	466	1484	10392
08:00	1950	1631	1634	1604	1834	1730	1013	604	1467	10270
09:00	1378	1352	1568	1650	1970	1583	1368	822	1444	10108
10:00	1622	1654	1713	1803	1868	1732	1591	1285	1648	11536
11:00	1800	1636	1734	1733	1789	1738	1912	1626	1747	12230
12:00	1623	1644	1605	1724	1958	1710	1835	1767	1736	12156
13:00	1500	1718	1637	1766	2032	1730	1896	1723	1753	12272
14:00	1508	1624	1604	1874	1978	1717	1741	1746	1725	12075
15:00	1881	1973	2134	2241	2190	2083	1709	1819	1992	13947
16:00	2174	2305	2409	2220	2090	2239	1695	1732	2089	14625
17:00	2029	2253	2462	2268	2089	2220	1583	1750	2062	14434
18:00	1885	2140	2405	2135	2032	2119	1629	1541	1966	13767
19:00	2101	2157	2037	2096	1637	2005	1613	1443	1869	13084
20:00	1262	1431	1359	1401	1495	1389	1167	1039	1307	9154
21:00	937	958	1122	1058	995	1014	960	886	988	6916
22:00		837	890	859	802	847	887	618	815	4893
23:00		580	617	560	678	608	607	389	571	3431
24:00		350	345	375	495	391	440	238	373	2243
TOTALS	27141	30132	30814	30949	31584	30482	25608	22599	28646	198827
% AVG WKDY	89	98.8	101	101.5	103.6		84	74.1		
% AVG WEEK	94.7	105.1	107.5	108	110.2		89.3	78.8		
AM Times	08:00	07:00	07:00	07:00	09:00	07:00	11:00	12:00	11:00	
AM Peaks	1950	2056	1743	1869	1970	1857	1912	1767	1747	
PM Times	16:00	16:00	17:00	17:00	15:00	16:00	13:00	15:00	16:00	
PM Peaks	2174	2305	2462	2268	2190	2239	1896	1819	2089	

Massachusetts Highway Department
WEEKLY SUMMARY FOR LANE 1
Starting: 4/28/2015

STA. 2

Site Reference: 150110000862
Site ID: 000000000200
Location: EXIT 24 RAMP FROM I-95 SB TO RTE 30
Direction:

File: V200.prn
City: WESTON
County: VOL

TIME	MON 4	TUE 28	WED 29	THU 30	FRI 1	WKDAY AVG	SAT 2	SUN 3	WEEK AVG	TOTAL
01:00	16	25	33	15	26	23	30	47	27	192
02:00	12	19	17	12	10	14	29	53	21	152
03:00	9	13	9	12	7	10	18	28	13	96
04:00	8	6	17	9	6	9	5	11	8	62
05:00	24	30	31	28	18	26	11	8	21	150
06:00	114	143	137	122	109	125	36	27	98	688
07:00	509	671	541	490	521	546	134	61	418	2927
08:00	766	1115	901	816	778	875	215	100	670	4691
09:00	590	755	788	690	652	695	242	135	550	3852
10:00	591	690	636	642	462	604	293	209	503	3523
11:00	397	492	481	471	429	454	369	298	419	2937
12:00	357	440	427	388	356	393	363	345	382	2676
13:00	353	431	459	527	448	443	388	387	427	2993
14:00	351	435	430	451	456	424	420	389	418	2932
15:00	459	472	458	468	554	482	395	420	460	3226
16:00	554	593	546	473	415	516	470	401	493	3452
17:00	491	592	651	479	515	545	384	417	504	3529
18:00	605	736	887	732	746	741	446	399	650	4551
19:00	615	684	670	595	493	611	369	320	535	3746
20:00	325	347	378	339	281	334	274	251	313	2195
21:00	233	250	255	223	192	230	192	141	212	1486
22:00		166	178	141	155	160	201	149	165	990
23:00		95	106	100	132	108	148	83	110	664
24:00		48	52	53	72	56	76	35	56	336
TOTALS	7379	9248	9088	8276	7833	8424	5508	4714	7473	52046
% AVG WKDY	87.5	109.7	107.8	98.2	92.9		65.3	55.9		
% AVG WEEK	98.7	123.7	121.6	110.7	104.8		73.7	63		
AM Times	08:00	08:00	08:00	08:00	08:00	08:00	11:00	12:00	08:00	
AM Peaks	766	1115	901	816	778	875	369	345	670	
PM Times	19:00	18:00	18:00	18:00	18:00	18:00	16:00	15:00	18:00	
PM Peaks	615	736	887	732	746	741	470	420	650	

Massachusetts Highway Department
WEEKLY SUMMARY FOR LANE 1 Page: 1
Starting: 4/28/2015

STA. 3

Site Reference: 150110000467 File: V300.prn
Site ID: 000000000300 City: WESTON
Location: ON-RAMP FROM RTE. 30 TO I-95 SB County: VOL
Direction:

TIME	MON 4	TUE 28	WED 29	THU 30	FRI 1	WKDAY AVG	SAT 2	SUN 3	WEEK AVG	TOTAL
01:00	31	30	40	33	40	34	56	62	41	292
02:00	13	17	33	22	35	24	30	81	33	231
03:00	15	15	19	27	22	19	20	26	20	144
04:00	21	26	21	13	27	21	13	16	19	137
05:00	33	24	37	32	27	30	22	14	27	189
06:00	93	112	105	107	99	103	46	34	85	596
07:00	329	330	337	329	335	332	120	89	267	1869
08:00	506	544	541	557	543	538	252	170	444	3113
09:00	557	561	546	544	566	554	341	219	476	3334
10:00	429	444	480	477	458	457	393	296	425	2977
11:00	412	384	421	414	426	411	439	327	403	2823
12:00	389	385	400	408	418	400	419	388	401	2807
13:00	409	440	414	456	444	432	432	439	433	3034
14:00	397	435	453	462	462	441	379	389	425	2977
15:00	466	461	470	505	505	481	407	376	455	3190
16:00	461	494	467	455	464	468	387	368	442	3096
17:00	422	539	557	543	496	511	344	309	458	3210
18:00	518	524	515	490	497	508	372	291	458	3207
19:00	436	427	452	466	396	435	283	214	382	2674
20:00	300	351	300	349	283	316	278	218	297	2079
21:00	211	271	243	228	210	232	187	152	214	1502
22:00		253	206	178	154	197	224	153	194	1168
23:00		127	98	110	194	132	195	81	134	805
24:00		82	80	76	137	93	112	52	89	539
TOTALS	6448	7276	7235	7281	7238	7169	5751	4764	6622	45993
% AVG WKDY	89.9	101.4	100.9	101.5	100.9		80.2	66.4		
% AVG WEEK	97.3	109.8	109.2	109.9	109.3		86.8	71.9		
AM Times	09:00	09:00	09:00	08:00	09:00	09:00	11:00	12:00	09:00	
AM Peaks	557	561	546	557	566	554	439	388	476	
PM Times	18:00	17:00	17:00	17:00	15:00	17:00	13:00	13:00	17:00	
PM Peaks	518	539	557	543	505	511	432	439	458	

Massachusetts Highway Department
WEEKLY SUMMARY FOR LANE 1
Starting: 4/28/2015

STA. 4

Site Reference: 150110000625
Site ID: 000000000400
Location: ON-RAMP FROM I-90 TO I-95 SB
Direction:

File: V400.prn
City: WESTON
County: VOL

TIME	MON 4	TUE 28	WED 29	THU 30	FRI 1	WKDAY AVG	SAT 2	SUN 3	WEEK AVG	TOTAL
01:00	171	164	208	215	303	212	276	263	228	1600
02:00	135	108	106	139	159	129	190	276	159	1113
03:00	77	90	63	76	107	82	127	151	98	691
04:00	91	80	86	97	104	91	87	65	87	610
05:00	148	192	173	177	172	172	79	45	140	986
06:00	568	552	600	562	575	571	175	107	448	3139
07:00	1080	1198	1248	1265	1276	1213	432	280	968	6779
08:00	1736	1896	1861	1874	1795	1832	672	440	1467	10274
09:00	1774	1849	1760	1771	1833	1797	987	572	1506	10546
10:00	1719	1788	1815	1851	1575	1749	1177	805	1532	10730
11:00	1273	1368	1186	1430	1448	1341	1428	1181	1330	9314
12:00	1177	1220	1194	1333	1347	1254	1688	1333	1327	9292
13:00	1244	1271	1331	1282	1341	1293	1638	1356	1351	9463
14:00	1255	1247	1475	1263	1512	1350	1462	1418	1376	9632
15:00	1494	1563	1588	1570	1571	1557	1564	1464	1544	10814
16:00	1370	1566	1450	1446	1428	1452	1441	1526	1461	10227
17:00	1185	1389	1376	1333	1322	1321	1434	1400	1348	9439
18:00	1345	1363	1410	1346	1366	1366	1337	1406	1367	9573
19:00	1253	1342	1323	1419	1491	1365	1080	1140	1292	9048
20:00	968	1128	1052	1047	1198	1078	917	986	1042	7296
21:00	675	731	748	748	763	733	700	768	733	5133
22:00		558	727	704	718	676	713	617	672	4037
23:00		429	526	521	636	528	726	441	546	3279
24:00		307	298	368	455	357	473	306	367	2207
TOTALS	20738	23399	23604	23837	24495	23519	20803	18346	22389	155222
% AVG WKDY	88.1	99.4	100.3	101.3	104.1		88.4	78		
% AVG WEEK	92.6	104.5	105.4	106.4	109.4		92.9	81.9		
AM Times	09:00	08:00	08:00	08:00	09:00	08:00	12:00	12:00	10:00	
AM Peaks	1774	1896	1861	1874	1833	1832	1688	1333	1532	
PM Times	15:00	16:00	15:00	15:00	15:00	15:00	13:00	16:00	15:00	
PM Peaks	1494	1566	1588	1570	1571	1557	1638	1526	1544	

MassDOT Highway Division
WEEKLY SUMMARY
Starting:4/28/2015

STA. 1

Site Reference: 150110000624
Site ID: 000000000100
Location: EXIT 25 RAMP FROM I-95 SB TO I-90
Direction: ROAD TOTAL

File: V100.prn
City: WESTON
County: VOL

TIME	MON 4		TUE 28		WED 29		THU 30		FRI 1		SAT 2		SUN 3		WK TOT		WK AVG	
Lane 2	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm
00:15	53	400	64	445	64	390	45	453	75	497	89	438	75	390	465	3013	66	430
00:30	58	372	47	429	43	470	39	488	70	527	69	448	64	434	390	3168	55	452
00:45	33	354	54	430	45	382	64	393	63	526	70	538	74	429	403	3052	57	436
01:00	40	374	54	414	40	395	42	432	37	482	49	472	55	470	317	3039	45	434
01:15	27	351	46	389	67	407	40	456	56	468	64	481	87	453	387	3005	55	429
01:30	28	439	51	410	33	374	22	458	57	475	41	426	111	474	343	3056	49	436
01:45	35	352	39	397	39	403	27	451	42	498	32	407	61	409	275	2917	39	416
02:00	28	366	29	428	29	420	31	509	43	537	39	427	61	410	260	3097	37	442
02:15	12	424	31	435	45	490	27	546	31	532	40	408	52	478	238	3313	34	473
02:30	16	410	15	505	13	500	26	541	43	596	50	417	30	482	193	3451	27	493
02:45	23	503	30	512	44	541	40	563	29	544	43	463	26	445	235	3571	33	510
03:00	33	544	41	521	26	603	44	591	29	518	27	421	27	414	227	3612	32	516
03:15	22	557	32	561	31	612	22	583	54	513	30	430	17	413	208	3669	29	524
03:30	31	544	46	569	28	638	32	540	47	505	30	408	24	449	238	3653	34	521
03:45	32	488	48	585	42	609	28	565	42	535	25	446	28	431	245	3659	35	522
04:00	27	585	47	590	49	550	67	532	46	537	38	411	20	439	294	3644	42	520
04:15	52	589	49	603	48	655	57	515	61	548	44	433	18	434	329	3777	47	539
04:30	64	557	69	522	67	579	63	559	58	531	45	410	25	433	391	3591	55	513
04:45	69	471	75	574	70	581	80	581	77	463	73	372	39	481	483	3523	69	503
05:00	106	412	89	554	99	647	102	613	125	547	51	368	23	402	595	3543	85	506
05:15	114	487	122	583	129	661	99	561	101	502	75	361	35	407	675	3562	96	508
05:30	174	461	166	452	162	557	159	531	133	497	89	424	47	364	930	3286	132	469
05:45	236	450	247	556	258	570	243	491	262	587	87	463	54	365	1387	3482	198	497
06:00	298	487	342	549	325	617	314	552	330	446	125	381	52	405	1786	3437	255	491
06:15	449	538	482	567	419	578	444	483	394	430	107	425	74	352	2369	3373	338	481
06:30	479	554	527	550	519	496	528	588	424	398	145	401	92	418	2714	3405	387	486
06:45	473	556	544	541	406	500	447	591	448	397	197	451	170	358	2685	3394	383	484
07:00	479	453	503	499	399	463	450	434	475	412	188	336	130	315	2624	2912	374	416
07:15	505	382	480	449	386	398	404	438	460	416	195	305	105	285	2535	2673	362	381
07:30	608	314	399	372	433	367	437	391	451	391	254	328	137	276	2719	2439	388	348
07:45	458	307	400	313	373	331	382	303	503	343	295	283	178	250	2589	2130	369	304
08:00	379	259	352	297	442	263	381	269	420	345	269	251	184	228	2427	1912	346	273
08:15	370	239	370	274	413	284	432	274	500	276	292	267	187	216	2564	1830	366	261
08:30	351	229	306	256	372	258	409	296	457	253	361	229	188	250	2444	1771	349	253
08:45	316	214	339	214	397	326	400	251	497	251	392	233	211	210	2552	1699	364	242
09:00	341	255	337	214	386	254	409	237	516	215	323	231	236	210	2548	1616	364	230
09:15	305		367	215	378	258	435	222	432	191	346	239	270	159	2533	1284	361	214
09:30	382		396	236	398	208	449	241	493	210	411	234	326	165	2855	1294	407	215
09:45	432		422	215	458	231	462	182	433	209	426	204	345	142	2978	1183	425	197
10:00	503		469	171	479	193	457	214	510	192	408	210	344	152	3170	1132	452	188
10:15	529		453	187	436	171	461	147	479	171	470	172	370	124	3198	972	456	162
10:30	432		371	155	439	162	419	153	429	198	491	164	366	95	2947	927	421	154
10:45	446		396	131	431	140	432	151	436	165	483	151	426	93	3050	831	435	138
11:00	393		416	107	428	144	421	109	445	144	468	120	464	77	3035	701	433	116
11:15	425		386	95	372	81	406	118	514	136	442	127	423	58	2968	615	424	102
11:30	411		419	97	409	106	464	103	486	143	470	125	452	63	3111	637	444	106
11:45	394		407	84	417	93	421	94	482	113	441	93	399	61	2961	538	423	89
12:00	393		432	74	407	65	433	60	476	103	482	95	493	56	3116	453	445	75
TOTALS	27141		30132		30814		30949		31584		25608		22599		198827		28617	
AM Times	6:45		6:15		9:45		6:15		8:15		10:15		11:15		10:00		10:00	
AM Peaks	2065		2056		1812		1869		1970		1912		1767		12365		1764	
PM Times	15:45		15:30		16:30		16:30		14:00		12:30		12:45		15:30		15:30	
PM Peaks	2219		2347		2468		2314		2209		1939		1826		14733		2102	

MassDOT Highway Division
WEEKLY SUMMARY
Starting:4/28/2015

STA. 2

Site Reference: 150110000862
Site ID: 000000000200
Location: EXIT 24 RAMP FROM I-95 SB TO RTE 30
Direction: ROAD TOTAL

File: V200.prn
City: WESTON
County: VOL

TIME	MON 4		TUE 28		WED 29		THU 30		FRI 1		SAT 2		SUN 3		WK TOT		WK AVG	
Lane 2	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm
00:15	2	91	8	100	3	132	6	145	11	101	10	82	16	92	56	743	8	106
00:30	2	84	11	114	6	113	5	151	7	95	9	110	14	76	54	743	7	106
00:45	6	100	4	119	15	116	2	100	3	136	7	91	6	117	43	779	6	111
01:00	6	78	2	98	9	98	2	131	5	116	4	105	11	102	39	728	5	104
01:15	4	83	12	98	2	107	1	113	2	106	9	108	10	101	40	716	5	102
01:30	3	82	2	129	2	94	2	99	4	113	11	102	24	102	48	721	6	103
01:45	5	73	1	106	6	122	5	108	2	117	4	103	14	105	37	734	5	104
02:00	0	113	4	102	7	107	4	131	2	120	5	107	5	81	27	761	3	108
02:15	1	97	2	103	1	98	7	87	2	117	4	109	11	113	28	724	4	103
02:30	2	107	1	126	3	111	3	103	3	117	3	103	5	90	20	757	2	108
02:45	5	122	3	118	3	119	1	129	1	165	8	92	6	126	27	871	3	124
03:00	1	133	7	125	2	130	1	149	1	155	3	91	6	91	21	874	3	124
03:15	2	143	1	134	2	126	2	144	1	114	1	114	3	106	12	881	1	125
03:30	2	151	1	145	12	142	1	126	1	98	3	124	2	92	22	878	3	125
03:45	3	142	3	183	3	139	2	119	2	108	0	124	2	110	15	925	2	132
04:00	1	118	1	131	0	139	4	84	2	95	1	108	4	93	13	768	1	109
04:15	2	116	3	121	1	151	6	112	4	96	2	89	3	101	21	786	3	112
04:30	5	118	5	149	9	149	6	113	1	138	5	96	0	110	31	873	4	124
04:45	8	115	9	135	6	163	4	102	3	146	0	103	1	90	31	854	4	122
05:00	9	142	13	187	15	188	12	152	10	135	4	96	4	116	67	1016	9	145
05:15	11	118	9	165	6	191	14	160	12	171	8	106	1	106	61	1017	8	145
05:30	21	160	25	170	27	229	14	178	24	184	8	109	5	94	124	1124	17	160
05:45	26	157	53	166	41	212	38	208	26	209	9	114	8	79	201	1145	28	163
06:00	56	170	56	235	63	255	56	186	47	182	11	117	13	120	302	1265	43	180
06:15	66	147	83	221	70	239	74	175	77	172	11	95	11	95	392	1144	56	163
06:30	115	158	146	188	122	172	93	142	107	118	30	92	16	86	629	956	89	136
06:45	140	171	182	156	161	142	134	155	146	102	38	96	12	86	813	908	116	129
07:00	188	139	260	119	188	117	189	123	191	101	55	86	22	53	1093	738	156	105
07:15	193	90	281	127	240	115	198	110	211	71	47	66	24	58	1194	637	170	91
07:30	219	83	327	82	262	103	246	94	207	86	46	91	22	74	1329	613	189	87
07:45	177	90	268	74	196	82	185	75	174	64	54	52	30	53	1084	490	154	70
08:00	177	62	239	64	203	78	187	60	186	60	68	65	24	66	1084	455	154	65
08:15	158	56	204	96	204	72	199	58	190	47	52	52	22	37	1029	418	147	59
08:30	165	69	216	54	178	69	167	51	170	49	44	52	37	40	977	384	139	54
08:45	139	62	173	48	218	62	165	52	138	47	65	47	37	29	935	347	133	49
09:00	128	46	162	52	188	52	159	62	154	49	81	41	39	35	911	337	130	48
09:15	137		202	51	175	48	171	34	126	41	55	61	48	40	914	275	130	45
09:30	141		155	34	151	57	196	35	111	33	77	51	50	47	881	257	125	42
09:45	181		148	38	146	42	135	40	105	36	85	45	48	35	848	236	121	39
10:00	132		185	43	164	31	140	32	120	45	76	44	63	27	880	222	125	37
10:15	130		139	33	125	33	134	30	132	35	90	32	71	27	821	190	117	31
10:30	91		109	22	119	28	106	29	101	36	103	34	63	22	692	171	98	28
10:45	95		122	26	129	21	128	24	91	39	90	40	70	21	725	171	103	28
11:00	81		122	14	108	24	103	17	105	22	86	42	94	13	699	132	99	22
11:15	68		100	17	117	21	95	13	83	26	91	29	77	9	631	115	90	19
11:30	76		108	12	92	7	94	14	96	15	96	16	90	14	652	78	93	13
11:45	107		113	10	122	18	73	14	81	21	87	17	89	4	672	84	96	14
12:00	106		119	9	96	6	126	12	96	10	89	14	89	8	721	59	103	9
TOTALS	7379		9248		9088		8276		7833		5508		4714		52046		7441	
AM Times	7:00		7:00		7:15		7:00		7:00		10:30		11:00		7:00		7:00	
AM Peaks	777		1136		901		818		783		370		350		4700		669	
PM Times	18:00		17:45		17:30		17:30		17:30		15:15		12:45		17:30		17:30	
PM Peaks	646		810		935		747		747		470		422		4678		666	

MassDOT Highway Division
WEEKLY SUMMARY
Starting:4/28/2015

STA. 3

Site Reference: 150110000467
Site ID: 000000000300
Location: ON-RAMP FROM RTE. 30 TO I-95 SB
Direction: ROAD TOTAL

File: V300.prn
City: WESTON
County: VOL

TIME	MON 4		TUE 28		WED 29		THU 30		FRI 1		SAT 2		SUN 3		WK TOT		WK AVG	
Lane 2	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm
00:15	9	93	11	91	18	112	10	111	14	100	21	102	17	101	100	710	14	101
00:30	5	96	4	131	4	104	9	114	8	109	9	117	16	125	55	796	7	113
00:45	10	104	11	97	10	101	7	128	12	121	15	96	12	112	77	759	11	108
01:00	7	116	4	121	8	97	7	103	6	114	11	117	17	101	60	769	8	109
01:15	4	93	4	115	15	106	11	109	12	121	14	88	32	103	92	735	13	105
01:30	6	100	3	105	6	118	3	113	11	122	3	103	27	90	59	751	8	107
01:45	1	102	5	117	5	122	4	126	4	120	7	96	17	108	43	791	6	113
02:00	2	102	5	98	7	107	4	114	8	99	6	92	5	88	37	700	5	100
02:15	4	104	2	105	4	106	11	104	4	133	7	104	8	110	40	766	5	109
02:30	5	128	6	117	2	140	5	140	6	146	6	102	6	102	36	875	5	125
02:45	3	117	1	126	5	126	6	140	6	117	6	99	7	79	34	804	4	114
03:00	3	117	6	113	8	98	5	121	6	109	1	102	5	85	34	745	4	106
03:15	4	134	6	118	6	126	4	119	4	123	2	97	4	91	30	808	4	115
03:30	9	106	6	140	8	139	4	112	5	108	2	103	5	89	39	797	5	113
03:45	4	107	8	123	1	101	3	100	8	109	5	97	3	87	32	724	4	103
04:00	4	114	6	113	6	101	2	124	10	124	4	90	4	101	36	767	5	109
04:15	2	132	0	139	9	131	2	127	2	104	6	76	2	74	23	783	3	111
04:30	3	111	8	133	7	123	2	140	6	131	10	91	3	94	39	823	5	117
04:45	15	104	4	136	10	142	14	133	7	135	2	80	5	74	57	804	8	114
05:00	13	75	12	131	11	161	14	143	12	126	4	97	4	67	70	800	10	114
05:15	18	116	16	159	13	140	19	145	15	131	9	81	10	79	100	851	14	121
05:30	20	125	15	145	14	141	14	136	14	120	9	100	5	65	91	832	13	118
05:45	27	137	45	123	37	112	41	106	36	119	13	95	6	78	205	770	29	110
06:00	28	140	36	97	41	122	33	103	34	127	15	96	13	69	200	754	28	107
06:15	63	134	51	108	61	111	44	112	54	116	22	74	18	50	313	705	44	100
06:30	58	101	59	109	65	130	74	125	65	97	25	64	21	66	367	692	52	98
06:45	98	106	117	127	95	113	112	125	118	106	35	71	26	45	601	693	85	99
07:00	110	95	103	83	116	98	99	104	98	77	38	74	24	53	588	584	84	83
07:15	118	93	130	102	137	85	127	86	135	88	49	81	44	66	740	601	105	85
07:30	122	76	128	93	121	77	127	92	121	77	68	79	43	51	730	545	104	77
07:45	135	67	140	73	142	80	146	76	149	64	72	60	41	55	825	475	117	67
08:00	131	64	146	83	141	58	157	95	138	54	63	58	42	46	818	458	116	65
08:15	143	56	153	88	146	91	132	76	139	57	76	47	63	43	852	458	121	65
08:30	152	58	120	62	127	55	149	60	152	54	84	62	48	37	832	388	118	55
08:45	135	46	145	61	151	50	133	51	142	55	91	44	60	38	857	345	122	49
09:00	127	51	143	60	122	47	130	41	133	44	90	34	48	34	793	311	113	44
09:15	113		130	84	123	48	124	59	140	44	80	61	66	37	776	333	110	55
09:30	106		114	82	124	64	128	51	120	40	100	52	74	57	766	346	109	57
09:45	112		106	56	130	53	117	35	109	28	108	63	77	29	759	264	108	44
10:00	98		94	31	103	41	108	33	89	42	105	48	79	30	676	225	96	37
10:15	105		92	35	107	31	110	23	97	38	104	39	72	21	687	187	98	31
10:30	93		93	33	117	27	92	30	107	69	103	49	101	21	706	229	100	38
10:45	101		102	27	105	22	104	22	108	44	116	60	86	23	722	198	103	33
11:00	113		97	32	92	18	108	35	114	43	116	47	68	16	708	191	101	31
11:15	87		97	35	96	31	96	25	100	39	104	43	86	24	666	197	95	32
11:30	103		86	16	81	14	92	14	103	35	110	19	94	14	669	112	95	18
11:45	102		107	19	108	20	123	22	106	33	106	30	99	11	751	135	107	22
12:00	97		95	12	115	15	97	15	109	30	99	20	109	3	721	95	103	15
TOTALS	6448		7276		7235		7281		7238		5751		4764		45993		6586	
AM Times	7:45		7:30		8:00		7:45		7:45		10:45		11:15		8:00		8:00	
AM Peaks	561		567		565		584		578		446		388		3359		477	
PM Times	17:30		16:45		16:45		16:30		16:30		12:15		12:30		16:45		16:45	
PM Peaks	536		571		584		561		523		432		441		3287		467	

MassDOT Highway Division
WEEKLY SUMMARY
Starting:4/28/2015

STA.4

Site Reference: 150110000625
Site ID: 000000000400
Location: ON-RAMP FROM I-90 TO I-95 SB
Direction: ROAD TOTAL

File: V400.prn
City: WESTON
County: VOL

TIME	MON 4		TUE 28		WED 29		THU 30		FRI 1		SAT 2		SUN 3		WK TOT		WK AVG	
Lane 2	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm
00:15	53	337	47	246	43	321	69	317	80	293	83	427	70	346	445	2287	63	326
00:30	46	279	32	316	54	310	45	313	70	317	73	416	70	287	390	2238	55	319
00:45	35	302	40	368	45	352	50	310	76	358	56	383	64	358	366	2431	52	347
01:00	37	326	45	341	66	348	51	342	77	373	64	412	59	365	399	2507	57	358
01:15	40	310	27	286	36	341	35	274	48	354	63	365	64	349	313	2279	44	325
01:30	37	311	28	323	26	346	44	310	44	353	46	352	84	371	309	2366	44	338
01:45	30	326	21	300	26	424	33	300	32	403	36	386	62	367	240	2506	34	358
02:00	28	308	32	338	18	364	27	379	35	402	45	359	66	331	251	2481	35	354
02:15	20	342	31	370	21	353	24	355	37	411	41	386	64	340	238	2557	34	365
02:30	20	381	25	410	20	422	17	377	26	407	28	386	29	385	165	2768	23	395
02:45	19	382	16	384	15	427	25	478	28	374	34	419	31	361	168	2825	24	403
03:00	18	389	18	399	7	386	10	360	16	379	24	373	27	378	120	2664	17	380
03:15	18	368	11	388	11	374	24	364	28	382	16	347	16	342	124	2565	17	366
03:30	23	290	27	419	17	376	23	383	18	322	25	349	24	393	157	2532	22	361
03:45	23	344	21	361	31	357	21	348	24	365	18	372	13	406	151	2553	21	364
04:00	27	368	21	398	27	343	29	351	34	359	28	373	12	385	178	2577	25	368
04:15	25	327	26	358	40	353	28	344	36	360	16	378	12	331	183	2451	26	350
04:30	26	296	44	358	29	325	38	322	30	301	26	353	11	355	204	2310	29	330
04:45	43	259	65	323	49	347	43	334	45	333	12	350	12	334	269	2280	38	325
05:00	54	303	57	350	55	351	68	333	61	328	25	353	10	380	330	2398	47	342
05:15	65	309	70	329	77	310	65	346	83	325	25	345	16	347	401	2311	57	330
05:30	115	334	99	324	118	338	115	336	105	340	40	348	16	362	608	2382	86	340
05:45	162	336	154	354	168	351	164	328	166	338	54	360	27	340	895	2407	127	343
06:00	226	366	229	356	237	411	218	336	221	363	56	284	48	357	1235	2473	176	353
06:15	247	327	285	399	276	334	319	331	264	379	73	283	42	306	1506	2359	215	337
06:30	236	356	271	302	287	310	282	382	287	383	119	255	59	318	1541	2306	220	329
06:45	294	319	298	291	332	342	290	350	347	388	111	293	95	272	1767	2255	252	322
07:00	303	251	344	350	353	337	374	356	378	341	129	249	84	244	1965	2128	280	304
07:15	372	268	413	344	428	338	394	303	395	347	148	237	85	272	2235	2109	319	301
07:30	407	241	452	308	449	256	444	254	453	316	156	228	92	267	2453	1870	350	267
07:45	445	272	489	276	486	251	491	235	484	282	149	227	140	219	2684	1762	383	251
08:00	512	187	542	200	498	207	545	255	463	253	219	225	123	228	2902	1555	414	222
08:15	440	176	495	193	458	195	419	207	373	210	200	171	118	197	2503	1349	357	192
08:30	460	180	502	178	451	202	440	207	556	193	213	193	162	210	2784	1363	397	194
08:45	409	172	392	194	425	178	479	165	479	178	295	166	136	177	2615	1230	373	175
09:00	465	147	460	166	426	173	433	169	425	182	279	170	156	184	2644	1191	377	170
09:15	457		415	130	450	182	533	170	411	158	249	178	176	169	2691	987	384	164
09:30	461		489	158	472	185	480	184	412	195	302	193	170	158	2786	1073	398	178
09:45	432		477	168	444	207	442	197	360	197	286	183	219	156	2660	1108	380	184
10:00	369		407	102	449	153	396	153	392	168	340	159	240	134	2593	869	370	144
10:15	346		324	108	264	184	362	166	347	181	356	186	249	110	2248	935	321	155
10:30	295		351	103	298	130	346	118	364	152	326	182	290	131	2270	816	324	136
10:45	326		339	125	311	110	356	133	364	150	360	175	318	116	2374	809	339	134
11:00	306		354	93	313	102	366	104	373	153	386	183	324	84	2422	719	346	119
11:15	268		300	100	281	86	339	111	313	127	402	155	293	89	2196	668	313	111
11:30	289		313	79	294	73	326	79	327	109	467	131	383	94	2399	565	342	94
11:45	317		303	63	290	85	334	88	367	111	421	89	321	67	2353	503	336	83
12:00	303		304	65	329	54	334	90	340	108	398	98	336	56	2344	471	334	78
TOTALS	20738		23399		23604		23837		24495		20803		18346		155222		22361	
AM Times	7:45		7:45		7:45		8:45		7:45		11:15		11:15		7:45		7:45	
AM Peaks	1857		2028		1893		1925		1876		1688		1333		10873		1551	
PM Times	14:30		14:45		14:30		14:00		13:45		12:15		15:15		14:30		14:30	
PM Peaks	1520		1590		1609		1589		1623		1638		1526		10822		1544	

APPENDIX C

Crash Data

LOCATION 1

I-93 Southbound Between I-95 and Montvale Avenue in Woburn and Stoneham

Count	Crash Number	Crash Year	Crash Time	Crash Date	Crash Severity	Number of Vehicles	Total Nonfatal Injury	Total Fatal Injury	Manner of Collision	Road Surface	Ambient Light Condition	Weather Condition	Vehicle Traveled Direction	Roadway	Location
1	2645141	2010	2:05 PM	23-Sep-2010	Property damage only (n	2	0	0	Single vehicle crash	Dry	Daylight	Not Reported	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
2	2555994	2010	8:00 AM	18-Jan-2010	Property damage only (n	2	0	0	Sideswipe, same direction	Snow	Daylight	Not Reported	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
3	2567185	2010	4:55 PM	12-Feb-2010	Property damage only (n	2	0	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
4	2590453	2010	8:57 AM	23-Mar-2010	Property damage only (n	3	0	0	Rear-end	Wet	Daylight	Cloudy/Rain	V1:Southbound / V2:Southbound / V3:	Rte 93 S	Exit 36 on Rte 93 S
5	2591433	2010	8:59 AM	15-Apr-2010	Property damage only (n	2	0	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound	Rte 93 / MONTVALE AVENUE	
6	2598097	2010	4:16 AM	16-May-2010	Property damage only (n	1	0	0	Single vehicle crash	Dry	Dark - lighted roadway	Clear	V1:Southbound	Rte 93 S	Exit 36 on Rte 93 S
7	2614147	2010	8:30 PM	22-Jun-2010	Non-fatal injury	1	1	0	Single vehicle crash	Other	Dark - lighted roadway	Not Reported	V1:Southbound	Rte 93 S	Exit 36 on Rte 93 S
8	2670945	2010	11:26 PM	14-Dec-2010	Non-fatal injury	4	1	0	Sideswipe, same direction	Dry	Dark - lighted roadway	Cloudy	V1:Southbound / V2:Not reported / V3	Rte 93 S	Exit 36 on Rte 93 S
9	2649274	2010	7:57 AM	30-Sep-2010	Non-fatal injury	4	2	0	Rear-end	Dry	Daylight	Cloudy	V1:Southbound / V2:Southbound / V3:	Rte 93 S	Exit 36 on Rte 93 S
10	2653156	2010	11:44 PM	18-Oct-2010	Non-fatal injury	1	1	0	Single vehicle crash	Dry	Dark - lighted roadway	Clear	V1:Southbound	Rte 93 S	Exit 36 on Rte 93 S
11	2662901	2010	6:15 PM	08-Nov-2010	Non-fatal injury	2	1	0	Angle	Dry	Dark - roadway not lighted	Clear/Rain	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
12	2663635	2010	9:25 AM	22-Nov-2010	Property damage only (n	4	0	0	Rear-end	Dry	Daylight	Not Reported	V1:Southbound / V2:Southbound / V3:	Rte 93 S	Exit 36 on Rte 93 S
13	2666188	2010	11:16 AM	01-Dec-2010	Non-fatal injury	1	1	0	Single vehicle crash	Wet	Daylight	Not Reported	V1:Southbound	RAMP-MONTVALE AVE	
14	2700876	2011	7:40 AM	17-Feb-2011	Property damage only (n	2	0	0	Rear-end	Dry	Daylight	Not Reported	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
15	2703014	2011	5:53 PM	03-Mar-2011	Property damage only (n	2	0	0	Rear-end	Dry	Dark - lighted roadway	Clear	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93
16	2728282	2011	11:38 PM	20-May-2011	Non-fatal injury	1	1	0	Sideswipe, same direction	Dry	Dark - lighted roadway	Clear	V1:Southbound	Rte 93 S	Exit 36 on Rte 93 S
17	2744167	2011	12:30 PM	24-Jul-2011	Non-fatal injury	2	2	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
18	2778968	2011	10:28 PM	05-Oct-2011	Non-fatal injury	4	2	0	Rear-end	Dry	Dark - lighted roadway	Clear	V1:Southbound / V2:Southbound / V3:	Rte 93 S	Exit 36 on Rte 93
19	2812191	2011	5:33 PM	29-Nov-2011	Property damage only (n	2	0	0	Rear-end	Dry	Dark - lighted roadway	Cloudy	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
20	2709812	2011	9:45 PM	24-Mar-2011	Property damage only (n	1	0	0	Single vehicle crash	Wet	Dark - lighted roadway	Snow	V1:Southbound	Rte 93 S	Exit 36 on Rte 93 S
21	2709816	2011	8:45 PM	25-Mar-2011	Non-fatal injury	3	1	0	Rear-end	Dry	Dark - lighted roadway	Clear	V1:Southbound / V2:Southbound / V3:	Rte 93 S	Exit 36 on Rte 93 S
22	2718150	2011	3:31 PM	01-Apr-2011	Property damage only (n	2	0	0	Rear-end	Wet	Daylight	Rain	V1:Southbound / V2:Southbound		
23	2700863	2011	9:30 AM	20-Jan-2011	Property damage only (n	2	0	0	Rear-end	Wet	Daylight	Clear	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
24	2702746	2011	1:59 AM	13-Feb-2011	Property damage only (n	1	0	0	Single vehicle crash	Dry	Dark - lighted roadway	Cloudy	V1:Southbound	Rte 93 S	Exit 36 on Rte 93 S
25	2716293	2011	8:25 PM	20-Apr-2011	Property damage only (n	4	0	0	Rear-end	Dry	Dark - lighted roadway	Clear	V1:Southbound / V2:Southbound / V3:	Rte 93 S	Exit 36 on Rte 93 S
26	2721013	2011	7:15 PM	24-Apr-2011	Property damage only (n	2	0	0	Rear-end	Dry	Dusk	Clear	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
27	2719038	2011	9:00 AM	26-Apr-2011	Non-fatal injury	3	1	0	Angle	Dry	Daylight	Clear	V1:Southbound / V2:Southbound / V3:	Rte 93 S	Exit 36 on Rte 93 S
28	2727262	2011	9:10 PM	08-May-2011	Property damage only (n	2	0	0	Angle	Dry	Dark - lighted roadway	Clear	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
29	2782648	2011	6:30 AM	07-Oct-2011	Property damage only (n	3	0	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound / V3:	Rte 93 S	Exit 36 on Rte 93 S
30	2814845	2011	11:27 AM	31-Oct-2011	Property damage only (n	2	0	0	Angle	Dry	Daylight	Clear	V1:Southbound / V2:Westbound		
31	2941666	2011	11:15 PM	02-Dec-2011	Non-fatal injury	2	1	0	Sideswipe, same direction	Dry	Dark - lighted roadway	Not Reported	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
32	3226326	2012	6:30 PM	01-Aug-2012	Non-fatal injury	3	1	0	Rear-end	Wet	Daylight	Clear	V1:Southbound / V2:Southbound / V3:	Rte 93 S	Exit 36 on Rte 93 S
33	3243304	2012	00:00 AM	15-Aug-2012	Property damage only (n	2	0	0	Sideswipe, same direction	Dry	Dark - lighted roadway	Clear	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93
34	3248871	2012	6:36 AM	22-Aug-2012	Property damage only (n	4	0	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound / V3:	Rte 93 S	Exit 36 on Rte 93
35	3278879	2012	9:48 AM	16-Oct-2012	Non-fatal injury	3	1	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound / V3:	Rte 93	Exit 36 on Rte 93
36	3252668	2012	7:44 AM	14-Sep-2012	Property damage only (n	2	0	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
37	2951592	2012	7:30 PM	27-Feb-2012	Non-fatal injury	2	1	0	Sideswipe, same direction	Dry	Dark - lighted roadway	Not Reported	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
38	3321446	2012	6:16 AM	13-Dec-2012	Property damage only (n	2	0	0	Rear-end	Dry	Dark - lighted roadway	Not Reported	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
39	2853093	2012	6:00 PM	05-Jan-2012	Property damage only (n	2	0	0	Rear-end	Dry	Dark - lighted roadway	Clear	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
40	2872386	2012	6:52 AM	13-Jan-2012	Property damage only (n	2	0	0	Rear-end	Dry	Dark - lighted roadway	Clear	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
41	2894055	2012	5:45 PM	27-Jan-2012	Property damage only (n	2	0	0	Rear-end	Wet	Dark - lighted roadway	Rain	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
42	2894059	2012	7:25 AM	01-Feb-2012	Property damage only (n	3	0	0	Rear-end	Dry	Daylight	Not Reported	V1:Southbound / V2:Southbound / V3:	Rte 93 S	Exit 36 on Rte 93 S
43	2914850	2012	6:20 PM	09-Feb-2012	Property damage only (n	2	0	0	Rear-end	Dry	Dark - lighted roadway	Not Reported	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
44	2937668	2012	7:50 PM	01-Mar-2012	Property damage only (n	4	0	0	Angle	Snow	Dark - lighted roadway	Snow	V1:Southbound / V2:Southbound / V3:	Rte 93 S	Exit 36 on Rte 93 S
45	2976134	2012	8:00 AM	19-Mar-2012	Non-fatal injury	2	1	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
46	3018135	2012	8:27 AM	03-Apr-2012	Property damage only (n	2	0	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
47	3019528	2012	3:30 AM	09-Apr-2012	Non-fatal injury	2	1	0	Rear-end	Dry	Dark - lighted roadway	Clear	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
48	3207184	2012	6:21 AM	23-Jul-2012	Property damage only (n	2	0	0	Sideswipe, same direction	Wet	Daylight	Cloudy/Rain	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
49	3245395	2012	00:00 AM	24-Aug-2012	Property damage only (n	1	0	0	Single vehicle crash	Dry	Dark - lighted roadway	Clear	V1:Southbound	Rte 93 S	Exit 36 on Rte 93 S
50	3266539	2012	7:44 AM	20-Sep-2012	Property damage only (n	2	0	0	Sideswipe, same direction	Dry	Daylight	Clear	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
51	3278621	2012	8:35 PM	14-Oct-2012	Property damage only (n	2	0	0	Angle	Dry	Dark - lighted roadway	Cloudy	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
52	3286145	2012	2:11 PM	22-Oct-2012	Property damage only (n	2	0	0	Sideswipe, same direction	Dry	Daylight	Clear	V1:Southbound / V2:Southbound		
53	3282338	2012	6:10 PM	24-Oct-2012	Non-fatal injury	5	2	0	Rear-end	Dry	Dark - roadway not lighted	Clear	V1:Southbound / V2:Southbound / V3:	Rte 93 S	Exit 36 on Rte 93 S
54	3285757	2012	5:59 AM	01-Nov-2012	Property damage only (n	2	0	0	Rear-end	Dry	Dawn	Clear	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S

Count	Crash Number	Crash Year	Crash Time	Crash Date	Crash Severity	Number of Vehicles	Total Nonfatal Injury	Total Fatal Injury	Manner of Collision	Road Surface	Ambient Light Condition	Weather Condition	Vehicle Traveled Direction	Roadway	Location
55	3290936	2012	6:25 AM	14-Nov-2012	Property damage only (n	2	0	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
56	3293154	2012	6:12 AM	19-Nov-2012	Property damage only (n	2	0	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound	Rte 93 S	Exit 36 on Rte 93 S
57	3325690	2012	2:03 AM	30-Dec-2012	Non-fatal injury	1	1	0	Single vehicle crash	Snow	Dark - lighted roadway	Snow	V1:Southbound	Rte 93 S	Exit 36 on Rte 93 S
58	3378131*	2012	3:26 AM	01-Apr-2012	Fatal injury	2	1	1	Rear-end	Dry	Dark - lighted roadway	Clear	V1:Southbound / V2:Southbound	RTE 95	
59	3378030*	2012	4:19 AM	01-Apr-2012	Property damage only (n	3	0	0	Rear-end	Dry	Dark - lighted roadway	Clear	V1:Southbound / V2:Southbound / V3:	RTE 95	
60	3123331*	2012	8:35 AM	06-Jun-2012	Not Reported	4	0	0	Rear-end	Dry	Daylight	Cloudy	V1:Southbound / V2:Southbound / V3:	S/ OF RT 128	
61	3154571*	2012	8:15 AM	15-Jun-2012	Non-fatal injury	2	1	0	Rear-end	Dry	Daylight	Not Reported	V1:Southbound / V2:Southbound		Exit 37 on Rte 93 S

LOCATION 2

I-95 Southbound at the I-90 Interchange in Weston

Count	Crash Number	Crash Year	Crash Time	Crash Date	Crash Severity	Number of Vehicles	Total Nonfatal	Total Fatal Injury	Manner of Collision	Road Surface	Ambient Light	Weather Condition	Vehicle Traveled Direction	Roadway	Location
1	2641964	2010	7:45 AM	24-Aug-2010	Non-fatal injury	1	1	0	Single vehicle crash	Wet	Daylight	Cloudy/Rain	V1:Southbound	Rte 95 S	Exit 24 on Rte 95 S
2	2606670	2010	4:05 PM	01-Jun-2010	Property damage only (no	3	0	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound / V3:South	Rte 95 S	Exit 25 on Rte 95
3	2610642	2010	6:31 PM	15-Jun-2010	Property damage only (no	2	0	0	Rear-end	Dry	Daylight	Not Reported	V1:Southbound / V2:Southbound	Rte 95 S	Exit 25 on Rte 95 S
4	2618905	2010	3:32 PM	18-Jun-2010	Non-fatal injury	3	1	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound / V3:South	Rte 95 S	Exit 25 on Rte 95 S
5	2612071	2010	9:52 AM	21-Jun-2010	Property damage only (no	1	0	0	Single vehicle crash	Dry	Daylight	Clear	V1:Southbound	Rte 95 S	Exit 24 on Rte 95 S
6	2634065	2010	5:10 PM	19-Aug-2010	Property damage only (no	3	0	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound / V3:South	Rte 95 S	Exit 24 on Rte 95 S
7	2595266	2010	4:55 PM	19-Mar-2010	Non-fatal injury	2	1	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound	Rte 95 S	Exit 25 on Rte 95 S
8	2592131	2010	9:20 AM	24-Mar-2010	Non-fatal injury	2	1	0	Sideswipe, same direction	Dry	Daylight	Cloudy	V1:Southbound / V2:Southbound	Rte 95 S	RAMP-RT 90 TO RT 95 SB
9	2620862	2010	3:20 PM	06-Jul-2010	Non-fatal injury	1	1	0	Single vehicle crash	Dry	Daylight	Clear	V1:Southbound	Rte 95 S	Exit 24 on Rte 95 S
10	2624720	2010	2:27 PM	23-Jul-2010	Non-fatal injury	2	1	0	Rear-end	Dry	Daylight	Cloudy	V1:Southbound / V2:Southbound	Rte 95 S	Exit 25 on Rte 95 S
11	2638740	2010	3:28 PM	26-Aug-2010	Non-fatal injury	4	1	0	Rear-end	Dry	Daylight	Not Reported	V1:Southbound / V2:Southbound / V3:South	Rte 95 S	Exit 25 on Rte 95 S
12	2647835	2010	7:05 AM	04-Oct-2010	Non-fatal injury	2	1	0	Rear-end	Wet	Daylight	Cloudy/Rain	V1:Southbound / V2:Southbound	Rte 95 S / Rte 30	RAMP-RT 30 TO RT 95 SB
13	2745183	2010	4:50 PM	14-Oct-2010	Property damage only (no	2	0	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound	Rte 95	Exit 25 on Rte 95
14	2656562	2010	12:40 PM	01-Nov-2010	Non-fatal injury	1	1	0	Single vehicle crash	Dry	Daylight	Clear	V1:Southbound	Rte 95 S	Exit 24 on Rte 95 S
15	2663166	2010	3:50 PM	05-Nov-2010	Property damage only (no	4	0	0	Rear-end	Dry	Daylight	Cloudy	V1:Southbound / V2:Southbound / V3:South	Rte 95 S	Exit 25 on Rte 95 S
16	2676822	2010	5:51 PM	07-Dec-2010	Non-fatal injury	2	1	0	Rear-end	Dry	Dark - roadway not lighted	Not Reported	V1:Southbound / V2:Southbound	Rte 95 S	Exit 25 on Rte 95 S
17	2749846	2011	12:03 PM	04-Aug-2011	Non-fatal injury	1	1	0	Rear-end	Dry	Daylight	Clear	V1:Southbound	Rte 95 S	Exit 24 on Rte 95 S
18	2765897	2011	6:24 AM	21-Sep-2011	Property damage only (no	2	0	0	Sideswipe, same direction	Dry	Dawn	Fog, smog, smoke	V1:Southbound / V2:Southbound	Rte 95	Exit 24 on Rte 95
19	2835781	2011	4:00 PM	09-Dec-2011	Property damage only (no	2	0	0	Rear-end	Dry	Dusk	Clear	V1:Southbound / V2:Southbound	Rte 95 S	Exit 24 on Rte 95 S
20	2680997	2011	4:58 PM	11-Jan-2011	Non-fatal injury	3	1	0	Rear-end	Dry	Dusk	Clear	V1:Southbound / V2:Southbound / V3:South	Rte 95 S	Exit 25 on Rte 95 S
21	2702374	2011	10:15 AM	22-Feb-2011	Property damage only (no	2	0	0	Angle	Dry	Daylight	Clear	V1:Southbound / V2:Southbound	Rte 95 S	Exit 25 on Rte 95 S
22	2705755	2011	11:25 AM	26-Feb-2011	Non-fatal injury	1	1	0	Single vehicle crash	Dry	Daylight	Clear	V1:Southbound	Rte 95 S	RAMP-RT 90 TO RT 95 SB
23	2709946	2011	4:29 PM	18-Mar-2011	Property damage only (no	4	0	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound / V3:South	Rte 95 S	Exit 25 on Rte 95 S
24	2727714	2011	3:52 PM	25-Mar-2011	Property damage only (no	2	0	0	Angle	Dry	Daylight	Not Reported	V1:Southbound / V2:Southbound	Rte 95 S	Exit 25 on Rte 95 S
25	2728134	2011	4:11 PM	02-May-2011	Non-fatal injury	3	1	0	Sideswipe, same direction	Dry	Daylight	Clear	V1:Southbound / V2:Southbound / V3:South	Rte 95 S	Exit 25 on Rte 95 S
26	2727785	2011	4:14 PM	06-May-2011	Non-fatal injury	3	1	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound / V3:South	Rte 95 S	Exit 25 on Rte 95 S
27	2728138	2011	4:30 PM	13-May-2011	Property damage only (no	2	0	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound	Rte 95 S	Exit 25 on Rte 95 S
28	2737919	2011	6:00 PM	20-Jun-2011	Non-fatal injury	2	1	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound	Rte 95 S	Exit 25 on Rte 95 S
29	2786844	2011	7:40 PM	22-Jun-2011	Property damage only (no	3	0	0	Rear-end	Dry	Dusk	Clear	V1:Southbound / V2:Southbound / V3:South	Rte 95 S	Exit 25 on Rte 95 S
30	2738606	2011	3:39 PM	28-Jun-2011	Non-fatal injury	3	2	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound / V3:South	Rte 95 S	Exit 25 on Rte 95 S
31	2749813	2011	4:45 PM	14-Jul-2011	Property damage only (no	2	0	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound	Rte 95 S	Exit 25 on Rte 95 S
32	2749844	2011	5:15 PM	20-Jul-2011	Property damage only (no	3	0	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound / V3:South	Rte 95 S	Exit 25 on Rte 95 S
33	2751662	2011	4:25 PM	21-Jul-2011	Property damage only (no	3	0	0	Rear-end	Dry	Daylight	Not Reported	V1:Southbound / V2:Southbound / V3:South	Rte 95 S	Exit 24 on Rte 95 S
34	2750709	2011	4:11 PM	11-Aug-2011	Non-fatal injury	3	1	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound / V3:South	Rte 95 S	Exit 25 on Rte 95 S
35	2827961	2011	8:10 AM	24-Sep-2011	Non-fatal injury	1	1	0	Single vehicle crash	Wet	Daylight	Rain	V1:Southbound	Rte 95 S	Exit 25 on Rte 95 S
36	2782652	2011	5:08 PM	05-Oct-2011	Non-fatal injury	3	2	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound / V3:South	Rte 95 S	Exit 25 on Rte 95 S
37	2787675	2011	3:20 PM	07-Oct-2011	Property damage only (no	3	0	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound / V3:South	Rte 95 S	Exit 24 on Rte 95 S
38	2786846	2011	4:25 PM	20-Oct-2011	Property damage only (no	4	0	0	Rear-end	Dry	Daylight	Cloudy	V1:Southbound / V2:Southbound / V3:South	Rte 95 S	Exit 25 on Rte 95 S
39	2793997	2011	5:20 PM	09-Nov-2011	Not Reported	1	0	0	Single vehicle crash	Dry	Dark - roadway not lighted	Clear	V1:Southbound	Rte 95 S	Exit 25 on Rte 95 S
40	2793998	2011	4:17 PM	11-Nov-2011	Property damage only (no	4	0	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound / V3:South	Rte 95 S	Exit 25 on Rte 95 S
41	2887405	2011	4:18 PM	18-Nov-2011	Property damage only (no	2	0	0	Rear-end	Dry	Dusk	Clear	V1:Southbound / V2:Southbound	Rte 95 S	Exit 24 on Rte 95 S
42	2805793	2011	7:57 PM	22-Nov-2011	Property damage only (no	2	0	0	Rear-end	Dry	Dark - roadway not lighted	Clear	V1:Southbound / V2:Southbound	Rte 95 S	Exit 25 on Rte 95 S
43	3374698	2011	11:59 AM	29-Nov-2011	Not Reported	1	0	0	Single vehicle crash	Dry	Daylight	Cloudy	V1:Southbound	Rte 95 S	Exit 24 on Rte 95 S
44	2833764	2011	5:34 PM	13-Dec-2011	Property damage only (no	4	0	0	Rear-to-rear	Dry	Dark - roadway not lighted	Clear	V1:Southbound / V2:Southbound / V3:South	Rte 95 S	Exit 25 on Rte 95 S
45	3235162	2012	6:30 PM	14-Jun-2012	Property damage only (no	2	0	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound	Rte 95 S	Exit 25 on Rte 95 S
46	2954168	2012	12:26 PM	29-Feb-2012	Property damage only (no	1	0	0	Sideswipe, same direction	Wet	Daylight	Rain	V1:Southbound	Rte 95 S	Exit 25 on Rte 95 S
47	3069207	2012	8:20 AM	06-Mar-2012	Not Reported	2	0	0	Angle	Dry	Daylight	Clear	V1:Southbound / V2:Southbound	Rte 95 S	Exit 25 on Rte 95 S
48	3381262	2012	3:41 AM	06-Oct-2012	Property damage only (no	1	0	0	Single vehicle crash	Wet	Dark - unknown roadway light	Cloudy	V1:Southbound		
49	2889040	2012	11:35 PM	16-Jan-2012	Property damage only (no	1	0	0	Single vehicle crash	Snow	Dark - roadway not lighted	Snow	V1:Southbound	Rte 95	Exit 25 on Rte 95
50	2896829	2012	8:40 PM	30-Jan-2012	Property damage only (no	1	0	0	Single vehicle crash	Dry	Dark - lighted roadway	Clear	V1:Southbound	Rte 95 S	Exit 24 on Rte 95 S
51	3049843	2012	4:12 PM	17-Feb-2012	Non-fatal injury	3	3	0	Rear-end	Dry	Dusk	Clear	V1:Southbound / V2:Southbound / V3:South	Rte 95 S	Exit 25 on Rte 95 S
52	3065707	2012	6:27 PM	05-Apr-2012	Not Reported	2	0	0	Rear-end	Dry	Dusk	Clear	V1:Southbound / V2:Southbound	Rte 95 S	Exit 25 on Rte 95 S
53	3049845	2012	3:28 PM	12-Apr-2012	Non-fatal injury	2	1	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound	Rte 95 S	Exit 24 on Rte 95 S
54	3068814	2012	4:05 PM	27-Apr-2012	Not Reported	2	0	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound	Rte 95 S	Exit 25 on Rte 95 S
55	3095220	2012	5:05 PM	01-May-2012	Not Reported	2	0	0	Rear-end	Wet	Daylight	Not Reported	V1:Southbound / V2:Southbound	Rte 95 S	Exit 25 on Rte 95 S
56	3118659	2012	3:37 PM	17-May-2012	Not Reported	2	0	0	Angle	Dry	Daylight	Not Reported	V1:Southbound / V2:Southbound	Rte 95 S	Exit 24 on Rte 95 S
57	3381249	2012	3:35 PM	23-May-2012	Non-fatal injury	2	2	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound	Rte 95 S	
58	3158785	2012	4:43 AM	13-Jun-2012	Property damage only (no	1	0	0	Single vehicle crash	Wet	Dawn	Rain	V1:Southbound	Rte 95 S	Exit 24 on Rte 95 S
59	3163119	2012	11:00 AM	21-Jun-2012	Property damage only (no	3	0	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound / V3:North	Rte 95 S	Exit 25 on Rte 95 S
60	3168335	2012	5:36 PM	08-Jul-2012	Non-fatal injury	4	3	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound / V3:South	Rte 95 S	Exit 25 on Rte 95 S
61	3207355	2012	3:18 PM	20-Jul-2012	Non-fatal injury	2	1	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound	Rte 95 S	Exit 25 on Rte 95 S
62	3235165	2012	4:06 PM	01-Aug-2012	Property damage only (no	2	0	0	Rear-end	Wet	Daylight	Cloudy/Rain	V1:Southbound / V2:Southbound	Rte 95 S	Exit 25 on Rte 95 S
63	3242532	2012	2:17 PM	10-Aug-2012	Property damage only (no	2	0	0	Rear-end	Dry	Daylight	Cloudy	V1:Southbound / V2:Southbound	Rte 95 S	Exit 25 on Rte 95 S
64	3248907	2012	2:22 PM	24-Aug-2012	Non-fatal injury	6	3	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound / V3:South	Rte 95 S	Exit 25 on Rte 95 S
65	3247322	2012	3:30 PM	29-Aug-2012	Property damage only (no	2	0	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound	Rte 95 S	Exit 25 on Rte 95 S
66	3251460	2012	8:50 PM	01-Sep-2012	Property damage only (no	2	0	0	Sideswipe, same direction	Dry	Dark - lighted roadway	Clear	V1:Southbound / V2:Southbound	Rte 95 S	Exit 25 on Rte 95 S
67	3381374	2012	7:30 PM	02-Sep-2012	Property damage only (no	2	0	0	Sideswipe, same direction	Dry	Dark - lighted roadway	Clear	V1:Southbound / V2:Southbound	Rte 95 S	RAMP-RT 90 TO RT 95 SB
68	3286163	2012	3:46 PM	26-Oct-2012	Non-fatal injury	2	1	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound	Rte 95 S	Exit 25 on Rte 95 S

Count	Crash Number	Crash Year	Crash Time	Crash Date	Crash Severity	Number of Vehicles	Total Nonfatal	Total Fatal Injury	Manner of Collision	Road Surface	Ambient Light	Weather Condition	Vehicle Traveled Direction	Roadway	Location
69	3284865	2012	9:00 AM	30-Oct-2012	Non-fatal injury	1	1	0	Single vehicle crash	Water (standing, r	Daylight	Rain	V1:Southbound	Rte 95 S	Exit 25 on Rte 95 S
70	3292327	2012	5:40 PM	16-Nov-2012	Property damage only (n	2	0	0	Rear-end	Dry	Dark - roadway not lighted	Clear	V1:Southbound / V2:Southbound	Rte 95 S	Exit 24 on Rte 95 S
71	3381270	2012	9:59 AM	06-Dec-2012	Property damage only (n	2	0	0	Rear-end	Dry	Daylight	Clear	V1:Southbound / V2:Southbound		
72	3301816	2012	4:40 PM	06-Dec-2012	Non-fatal injury	3	1	0	Rear-end	Dry	Dark - roadway not lighted	Not Reported	V1:Southbound / V2:Southbound / V3:Southl	Rte 95 S	Exit 25 on Rte 95 S
73	3309434	2012	12:22 PM	08-Dec-2012	Non-fatal injury	1	1	0	Single vehicle crash	Wet	Daylight	Cloudy	V1:Southbound	Rte 95 S	Exit 24 on Rte 95 S
74	3310225	2012	4:44 PM	12-Dec-2012	Property damage only (n	2	0	0	Rear-end	Dry	Dark - lighted roadway	Clear	V1:Southbound / V2:Southbound	Rte 95 S	Exit 25 on Rte 95 S
75	3321378	2012	5:40 PM	17-Dec-2012	Property damage only (n	3	0	0	Rear-end	Wet	Dark - roadway not lighted	Rain	V1:Southbound / V2:Southbound / V3:Southl	Rte 95 S	Exit 25 on Rte 95 S
76	3321474	2012	5:59 PM	19-Dec-2012	Property damage only (n	2	0	0	Rear-end	Dry	Dark - lighted roadway	Not Reported	V1:Southbound / V2:Southbound	Rte 95 S	Exit 25 on Rte 95 S
77	3381273	2012	10:39 PM	25-Dec-2012	Property damage only (n	1	0	0	Single vehicle crash	Wet	Dark - roadway not lighted	Clear	V1:Southbound		RAMP-RT 30 TO RT 95 SB

APPENDIX D

Level of Service (LOS) Analysis
Freeway Ramp Merge and Diverge AnalysŜs

LOCATION 1

I-93 Southbound Between I-95 and Montvale Avenue in Woburn and Stoneham

2015 Existing Conditions

1. **2015 AM Merge**
2. **2015 AM Diverge**
3. **2015 AM Basis Freeway**

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Merge Analysis

Analyst:	Seth
Agency/Co.:	CTPS
Date performed:	5/20/2015
Analysis time period:	AM Peak Hour
Freeway/Dir of Travel:	I-93 SB (I-95 to Montvale Ave)
Junction:	Merge from I-95 NB to I-93 SB
Jurisdiction:	Highway District 4
Analysis Year:	2015 Existing
Description:	Low-Cost Improvements to Bottleneck Locations

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	5750	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	30.0	mph
Volume on ramp	1450	vph
Length of first accel/decel lane	1500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	850	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	Off	
Distance to adjacent Ramp	1000	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	5750	1450	850	vph
Peak-hour factor, PHF	0.95	0.95	0.95	
Peak 15-min volume, v15	1513	382	224	v
Trucks and buses	4	3	3	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.980	0.985	0.985	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	6300	1581	927	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 0.020 Using Equation 0

$v_{12} = v_F (P_{FM})$ = 127 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	7881	9400	No
v_3 or v_{av34}	3086 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		Yes	
Is v_3 or v_{av34} > 1.5 v_{12} /2		Yes	

If yes, v_{12A} = 2520 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	4101	4600	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 27.3 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable,	M_S = 0.467	
Space mean speed in ramp influence area,	S_R = 54.3	mph
Space mean speed in outer lanes,	S_O = 60.0	mph
Space mean speed for all vehicles,	S = 56.9	mph

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:	Seth Asante
Agency/Co.:	
Date performed:	5/20/2015
Analysis time period:	AM Peak Hour
Freeway/Dir of Travel:	I-93 SB (I-95 to Montvale Ave)
Junction:	Diverge I-93 SB to Montvale
Jurisdiction:	Highway District 4
Analysis Year:	2015 Existing
Description:	Low-Cost Improvement to Bottleneck Locations

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	6300	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	30.0	mph
Volume on ramp	1400	vph
Length of first accel/decel lane	350	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	150	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	700	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	6300	1400	150	vph
Peak-hour factor, PHF	0.95	0.95	0.95	
Peak 15-min volume, v15	1658	368	39	v
Trucks and buses	4	3	3	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	3.0*	3.0*	3.0*	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.926	0.943	0.943	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	7308	1594	171	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 0.436 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 4085 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	7308	9400	No
$v_{FO} = v_F - v_R$	5714	9400	No
v_R	1594	2000	No
v_3 or v_{av34}	1611 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12} /2		No	

If yes, v_{12A} = 4085 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	4085	4400	No

Level of Service Determination (if not F)

Density, $D = 4.252 + 0.0086 v_R - 0.009 L_D$ = 36.2 pc/mi/ln

Level of service for ramp-freeway junction areas of influence E

Speed Estimation

Intermediate speed variable,	D_S = 0.636	
Space mean speed in ramp influence area,	S_R = 50.4	mph
Space mean speed in outer lanes,	S_O = 68.9	mph
Space mean speed for all vehicles,	S = 57.1	mph

HCS 2010: Basic Freeway Segments Release 6.70

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	Seth
Agency or Company:	CTPS
Date Performed:	8/31/2015
Analysis Time Period:	AM Peak Hour
Freeway/Direction:	I-93 Southbound
From/To:	I-95 to Montvale Avenue
Jurisdiction:	Highway District 4
Analysis Year:	2015
Description:	Low-Cost Improvements to Bottleneck Locations

Flow Inputs and Adjustments

Volume, V	7200	veh/h
Peak-hour factor, PHF	0.95	
Peak 15-min volume, v15	1895	v
Trucks and buses	4	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	-	%
Segment length	-	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fHV	0.980	
Driver population factor, fp	0.98	
Flow rate, vp	1972	pc/h/ln

Speed Inputs and Adjustments

Lane width	-	ft
Right-side lateral clearance	-	ft
Total ramp density, TRD	-	ramps/mi
Number of lanes, N	4	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	-	mi/h
Lateral clearance adjustment, fLC	-	mi/h
TRD adjustment	-	mi/h
Free-flow speed, FFS	65.0	mi/h

LOS and Performance Measures

Flow rate, vp	1972	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S	60.4	mi/h
Number of lanes, N	4	
Density, D	32.7	pc/mi/ln
Level of service, LOS	D	

2015 Existing Conditions

1. **2015 PM Merge**
2. **2015 PM Diverge**
3. **2015 PM Basis Freeway**

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Merge Analysis

Analyst:	Seth Asante
Agency/Co.:	CTPS
Date performed:	5/20/2015
Analysis time period:	PM Peak Hour
Freeway/Dir of Travel:	I-93 SB (I-95 to Montvale Ave)
Junction:	Merge from I-95 NB to I-93 SB
Jurisdiction:	Highway District 4
Analysis Year:	2015 Existing)
Description:	Low-Cost Improvements to Bottleneck Locations

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	5950	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	30.0	mph
Volume on ramp	1700	vph
Length of first accel/decel lane	1500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	950	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	Off	
Distance to adjacent Ramp	1000	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	5950	1700	950	vph
Peak-hour factor, PHF	0.95	0.95	0.95	
Peak 15-min volume, v15	1566	447	250	v
Trucks and buses	4	3	3	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.980	0.985	0.985	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	6519	1853	1036	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = -0.014 Using Equation 0

$v_{12} = v_F (P_{FM})$ = -89 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	8372	9400	No
v_3 or v_{av34}	3304 pc/h	(Equation 13-14 or 13-17)	

Is v_3 or v_{av34} > 2700 pc/h? Yes

Is v_3 or v_{av34} > 1.5 v_{12} /2 Yes

If yes, v_{12A} = 2607 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	4460	4600	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 30.0 pc/mi/ln

Level of service for ramp-freeway junction areas of influence D

Speed Estimation

Intermediate speed variable,	M_S = 0.568		
Space mean speed in ramp influence area,	S_R = 51.9	mph	
Space mean speed in outer lanes,	S_0 = 59.8	mph	
Space mean speed for all vehicles,	S = 55.3	mph	

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:	Seth Asante
Agency/Co.:	CTPS
Date performed:	5/20/2015
Analysis time period:	PM Peak Hour
Freeway/Dir of Travel:	I-93 SB (I-95 to Montvale Ave)
Junction:	Diverge I-93 SB to Montvale
Jurisdiction:	Highway District 4
Analysis Year:	2015 Existing
Description:	Low-Cost Improvements to Bottleneck Locations

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	7650	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	30.0	mph
Volume on ramp	1000	vph
Length of first accel/decel lane	350	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	350	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	700	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	7650	1000	350	vph
Peak-hour factor, PHF	0.94	0.94	0.94	
Peak 15-min volume, v15	2035	266	93	v
Trucks and buses	4	4	3	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	3.0*	3.0*	3.0*	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.926	0.926	0.943	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	8969	1172	403	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 0.436 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 4571 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	8969	9400	No
$v_{FO} = v_F - v_R$	7797	9400	No
v_R	1172	2000	No
v_3 or v_{av34}	2199 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12} /2		No	

If yes, v_{12A} = 4571 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	4571	4400	Yes

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 40.4 pc/mi/ln

Level of service for ramp-freeway junction areas of influence E

Speed Estimation

Intermediate speed variable, D_S = 0.598

Space mean speed in ramp influence area, S_R = 51.2 mph

Space mean speed in outer lanes, S_0 = 66.6 mph

Space mean speed for all vehicles, S = 57.8 mph

HCS 2010: Basic Freeway Segments Release 6.70

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	Seth
Agency or Company:	CTPS
Date Performed:	8/31/2015
Analysis Time Period:	PM Peak Hour
Freeway/Direction:	I-93 Southbound
From/To:	I-95 to Montvale Avenue
Jurisdiction:	Highway District 4
Analysis Year:	2015
Description:	Low-Cost Improvements to Bottleneck Locations

Flow Inputs and Adjustments

Volume, V	7650	veh/h
Peak-hour factor, PHF	0.95	
Peak 15-min volume, v15	2013	v
Trucks and buses	4	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	-	%
Segment length	-	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fHV	0.980	
Driver population factor, fp	0.98	
Flow rate, vp	2095	pc/h/ln

Speed Inputs and Adjustments

Lane width	-	ft
Right-side lateral clearance	-	ft
Total ramp density, TRD	-	ramps/mi
Number of lanes, N	4	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	-	mi/h
Lateral clearance adjustment, fLC	-	mi/h
TRD adjustment	-	mi/h
Free-flow speed, FFS	65.0	mi/h

LOS and Performance Measures

Flow rate, vp	2095	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S	58.2	mi/h
Number of lanes, N	4	
Density, D	36.0	pc/mi/ln
Level of service, LOS	E	

Alternative 1: Lengthen the Deceleration Lane at the Exit 36 Diverge Area

1. **2025 AM Merge**
2. **2025 AM Diverge**
3. **2025 AM Basis Freeway**

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Merge Analysis

Analyst:	Seth Asante
Agency/Co.:	CTPS
Date performed:	5/20/2015
Analysis time period:	AM Peak Hour
Freeway/Dir of Travel:	I-93 SB (I-95 to Montvale Ave)
Junction:	Merge from I-95 NB to I-93 SB
Jurisdiction:	Highway District 4
Analysis Year:	2025 Future Year
Description:	Low-Cost Improvements to Bottleneck Locations

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	6050	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	30.0	mph
Volume on ramp	1470	vph
Length of first accel/decel lane	1500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	890	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	Off	
Distance to adjacent Ramp	1000	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	6050	1470	890	vph
Peak-hour factor, PHF	0.95	0.95	0.95	
Peak 15-min volume, v15	1592	387	234	v
Trucks and buses	4	3	3	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.980	0.985	0.985	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	6628	1603	970	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 0.017 Using Equation 0

$v_{12} = v_F (P_{FM})$ = 115 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	8231	9400	No
v_3 or v_{av34}	3256 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		Yes	
Is v_3 or v_{av34} > 1.5 v_{12} /2		No	

If yes, v_{12A} = 1228 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	2831	4600	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 17.4 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable, M_S = 0.297

Space mean speed in ramp influence area, S_R = 58.2 mph

Space mean speed in outer lanes, S_O = 56.1 mph

Space mean speed for all vehicles, S = 56.8 mph

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:	Seth Asante
Agency/Co.:	CTPS
Date performed:	5/20/2015
Analysis time period:	AM Peak Hour
Freeway/Dir of Travel:	I-93 SB (I-95 to Montvale Ave)
Junction:	Diverge I-93 SB to Montvale
Jurisdiction:	Highway District 4
Analysis Year:	2025 Future Year
Description:	Low-Cost Improvements to Bottleneck Locations

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	6600	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	30.0	mph
Volume on ramp	1500	vph
Length of first accel/decel lane	1500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	160	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	700	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	6600	1500	160	vph
Peak-hour factor, PHF	0.95	0.95	0.95	
Peak 15-min volume, v15	1737	395	42	v
Trucks and buses	4	3	3	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	3.0*	3.0*	3.0*	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.926	0.943	0.943	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	7656	1708	182	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 0.436 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 4301 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	7656	9400	No
$v_{FO} = v_F - v_R$	5948	9400	No
v_R	1708	2000	No
v_3 or v_{av34}	1677 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34}	> 2700 pc/h?	No	
Is v_3 or v_{av34}	> 1.5 v_{12} /2	No	

If yes, v_{12A} = 4301 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	4301	4400	No

Level of Service Determination (if not F)

Density, $D = 4.252 + 0.0086\, v_R - 0.009\, v_{12}$ L_D = 27.7 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable, D_S = 0.647

Space mean speed in ramp influence area, S_R = 50.1 mph

Space mean speed in outer lanes, S_0 = 68.7 mph

Space mean speed for all vehicles, S = 56.9 mph

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	Seth
Agency or Company:	CTPS
Date Performed:	8/31/2015
Analysis Time Period:	AM Peak Hour
Freeway/Direction:	I-93 Southbound
From/To:	I-95 to Montvale Avenue
Jurisdiction:	Highway District 4
Analysis Year:	2025
Description:	Low-Cost Improvements to Bottleneck Locations

Flow Inputs and Adjustments

Volume, V	7560	veh/h
Peak-hour factor, PHF	0.95	
Peak 15-min volume, v15	1989	v
Trucks and buses	4	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	-	%
Segment length	-	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fHV	0.980	
Driver population factor, fp	0.98	
Flow rate, vp	2071	pc/h/ln

Speed Inputs and Adjustments

Lane width	-	ft
Right-side lateral clearance	-	ft
Total ramp density, TRD	-	ramps/mi
Number of lanes, N	4	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	-	mi/h
Lateral clearance adjustment, fLC	-	mi/h
TRD adjustment	-	mi/h
Free-flow speed, FFS	65.0	mi/h

LOS and Performance Measures

Flow rate, vp	2071	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S	58.6	mi/h
Number of lanes, N	4	
Density, D	35.3	pc/mi/ln
Level of service, LOS	E	

Alternative 1: Lengthen the Deceleration Lane at the Exit 36 Diverge Area

1. **2025 PM Merge**
2. **2025 PM Diverge**
3. **2025 PM Basis Freeway**

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Merge Analysis

Analyst:	Seth Asante
Agency/Co.:	CTPS
Date performed:	5/20/2015
Analysis time period:	PM Peak Hour
Freeway/Dir of Travel:	I-93 SB (I-95 to Montvale Ave)
Junction:	Merge from I-95 NB to I-93 SB
Jurisdiction:	Highway District 4
Analysis Year:	2025 Future Year
Description:	Low-Cost Improvements to Bottleneck Locations

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	6300	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	30.0	mph
Volume on ramp	1700	vph
Length of first accel/decel lane	1500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	890	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	Off	
Distance to adjacent Ramp	1000	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	6300	1700	890	vph
Peak-hour factor, PHF	0.96	0.96	0.96	
Peak 15-min volume, v15	1641	443	232	v
Trucks and buses	4	3	3	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.980	0.985	0.985	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	6830	1834	960	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = -0.011 Using Equation 0

$v_{12} = v_F (P_{FM})$ = -77 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	8664	9400	No

v_3 or v_{av34} 3453 pc/h (Equation 13-14 or 13-17)

Is v_3 or v_{av34} > 2700 pc/h? Yes

Is v_3 or v_{av34} > 1.5 v_{12} /2 Yes

If yes, v_{12A} = 2732 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	4566	4600	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 30.8 pc/mi/ln

Level of service for ramp-freeway junction areas of influence D

Speed Estimation

Intermediate speed variable, M_S = 0.606

Space mean speed in ramp influence area, S_R = 51.1 mph

Space mean speed in outer lanes, S_O = 59.4 mph

Space mean speed for all vehicles, S = 54.7 mph

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:	Seth Asante
Agency/Co.:	CTPS
Date performed:	5/20/2015
Analysis time period:	PM Peak Hour
Freeway/Dir of Travel:	I-93 SB (I-95 to Montvale Ave)
Junction:	Diverge I-93 SB to Montvale Av
Jurisdiction:	Highway District 4
Analysis Year:	2025 Future Year
Description:	Low-Cost Improvements to Bottleneck Locations

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	8000	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	30.0	mph
Volume on ramp	1050	vph
Length of first accel/decel lane	1500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	370	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	700	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	8000	1050	370	vph
Peak-hour factor, PHF	0.96	0.96	0.96	
Peak 15-min volume, v15	2083	273	96	v
Trucks and buses	4	4	3	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	3.0*	3.0*	3.0*	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.926	0.926	0.943	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	9184	1205	417	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 0.436 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 4684 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	9184	9400	No
$v_{FO} = v_F - v_R$	7979	9400	No
v_R	1205	2000	No
v_3 or v_{av34}	2250 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12} /2		No	

If yes, v_{12A} = 4684 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	4684	4400	Yes

Level of Service Determination (if not F)

Density, $D = 4.252 + 0.0086\, v_R - 0.009\, v_{12} - L_D$ = 31.0 pc/mi/ln

Level of service for ramp-freeway junction areas of influence D

Speed Estimation

Intermediate speed variable, D_S = 0.601

Space mean speed in ramp influence area, S_R = 51.2 mph

Space mean speed in outer lanes, S_0 = 66.4 mph

Space mean speed for all vehicles, S = 57.7 mph

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	Seth
Agency or Company:	CTPS
Date Performed:	8/31/2015
Analysis Time Period:	PM Peak Hour
Freeway/Direction:	I-93 Southbound
From/To:	I-95 to Montvale Avenue
Jurisdiction:	Highway District 4
Analysis Year:	2025
Description:	Low-Cost Improvements to Bottleneck Locations

Flow Inputs and Adjustments

Volume, V	8050	veh/h
Peak-hour factor, PHF	0.95	
Peak 15-min volume, v15	2118	v
Trucks and buses	4	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	-	%
Segment length	-	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fHV	0.980	
Driver population factor, fp	0.98	
Flow rate, vp	2205	pc/h/ln

Speed Inputs and Adjustments

Lane width	-	ft
Right-side lateral clearance	-	ft
Total ramp density, TRD	-	ramps/mi
Number of lanes, N	4	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	-	mi/h
Lateral clearance adjustment, fLC	-	mi/h
TRD adjustment	-	mi/h
Free-flow speed, FFS	65.0	mi/h

LOS and Performance Measures

Flow rate, vp	2205	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S	55.8	mi/h
Number of lanes, N	4	
Density, D	39.5	pc/mi/ln
Level of service, LOS	E	

Alternative 2: Create an Auxiliary Lane for Merging and Diverging Traffic

1. **2025 AM Merge**
2. **2025 AM Diverge**
3. **2025 AM Basis Freeway**

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Merge Analysis

Analyst:	Seth Asante
Agency/Co.:	CTPS
Date performed:	5/20/2015
Analysis time period:	AM Peak Hour
Freeway/Dir of Travel:	I-93 SB (I-95 to Montvale Ave)
Junction:	Merge from I-95 NB to I-93 SB
Jurisdiction:	Highway District 4
Analysis Year:	2025 Future Year Alternative 2
Description:	Low-Cost Improvements to Bottleneck Locations

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	6050	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	30.0	mph
Volume on ramp	1470	vph
Length of first accel/decel lane	1500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	890	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	Off	
Distance to adjacent Ramp	1000	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	6050	1470	890	vph
Peak-hour factor, PHF	0.95	0.95	0.95	
Peak 15-min volume, v15	1592	387	234	v
Trucks and buses	4	3	3	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.980	0.985	0.985	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	6628	1603	970	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 0.017 Using Equation 0

$v_{12} = v_F (P_{FM})$ = 115 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	8231	9400	No
v_3 or v_{av34}	3256 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		Yes	
Is v_3 or v_{av34} > 1.5 v_{12} /2		No	

If yes, v_{12A} = 1228 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	2831	4600	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 17.4 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable, M_S = 0.297

Space mean speed in ramp influence area, S_R = 58.2 mph

Space mean speed in outer lanes, S_O = 56.1 mph

Space mean speed for all vehicles, S = 56.8 mph

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:	Seth Asante
Agency/Co.:	CTPS
Date performed:	5/20/2015
Analysis time period:	AM Peak Hour
Freeway/Dir of Travel:	I-93 SB (I-95 to Montvale Ave)
Junction:	Diverge I-93 SB to Montvale
Jurisdiction:	Highway District 4
Analysis Year:	2025 Future Year Alt 2
Description:	Low-Cost Improvements to Bottleneck Locations

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	6600	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	30.0	mph
Volume on ramp	1500	vph
Length of first accel/decel lane	1500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	160	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	700	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	6600	1500	160	vph
Peak-hour factor, PHF	0.95	0.95	0.95	
Peak 15-min volume, v15	1737	395	42	v
Trucks and buses	4	3	3	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	3.0*	3.0*	3.0*	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.926	0.943	0.943	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	7656	1708	182	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 0.436 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 4301 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	7656	9400	No
$v_{FO} = v_F - v_R$	5948	9400	No
v_R	1708	2000	No
v_3 or v_{av34}	1677 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34}	> 2700 pc/h?	No	
Is v_3 or v_{av34}	> 1.5 v_{12} /2	No	

If yes, v_{12A} = 4301 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	4301	4400	No

Level of Service Determination (if not F)

Density, $D = 4.252 + 0.0086\, v_R - 0.009\, v_{12}$ L_D = 27.7 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable, D_S = 0.647

Space mean speed in ramp influence area, S_R = 50.1 mph

Space mean speed in outer lanes, S_0 = 68.7 mph

Space mean speed for all vehicles, S = 56.9 mph

HCS 2010: Basic Freeway Segments Release 6.70

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	Seth
Agency or Company:	CTPS
Date Performed:	8/6/2015
Analysis Time Period:	AM Peak
Freeway/Direction:	I-93 Southbound
From/To:	Auxiliary Lane
Jurisdiction:	Highway District 4
Analysis Year:	2025 Future Year
Description:	Low-cost Improvements to Bottlenecks - I-93 SB

Flow Inputs and Adjustments

Volume, V	7550	veh/h
Peak-hour factor, PHF	0.96	
Peak 15-min volume, v15	1966	v
Trucks and buses	4	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	-	%
Segment length	-	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fHV	0.980	
Driver population factor, fp	1.00	
Flow rate, vp	1604	pc/h/ln

Speed Inputs and Adjustments

Lane width	-	ft
Right-side lateral clearance	-	ft
Total ramp density, TRD	-	ramps/mi
Number of lanes, N	5	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	-	mi/h
Lateral clearance adjustment, fLC	-	mi/h
TRD adjustment	-	mi/h
Free-flow speed, FFS	65.0	mi/h

LOS and Performance Measures

Flow rate, vp	1604	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S	64.4	mi/h
Number of lanes, N	5	
Density, D	24.9	pc/mi/ln
Level of service, LOS	C	

Alternative 2: Create an Auxiliary Lane for Merging and Diverging Traffic

1. **2025 PM Merge**
2. **2025 PM Diverge**
3. **2025 PM Basis Freeway**

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Merge Analysis

Analyst:	
Agency/Co.:	CTPS
Date performed:	5/20/2015
Analysis time period:	PM Peak Hour
Freeway/Dir of Travel:	I-93 SB (I-95 to Montvale Ave)
Junction:	Merge from I-95 NB to I-93 SB
Jurisdiction:	Highway District 4
Analysis Year:	2025 Future Year Alternative 2
Description:	Low-Cost Improvements to Bottleneck Locations

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	6300	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	30.0	mph
Volume on ramp	1700	vph
Length of first accel/decel lane	1500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	890	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	Off	
Distance to adjacent Ramp	1000	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	6300	1700	890	vph
Peak-hour factor, PHF	0.96	0.96	0.96	
Peak 15-min volume, v15	1641	443	232	v
Trucks and buses	4	3	3	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.980	0.985	0.985	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	6830	1834	960	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = -0.011 Using Equation 0

$v_{12} = v_F (P_{FM})$ = -77 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	8664	9400	No

v_3 or v_{av34} 3453 pc/h (Equation 13-14 or 13-17)

Is v_3 or v_{av34} > 2700 pc/h? Yes

Is v_3 or v_{av34} > 1.5 v_{12} /2 Yes

If yes, v_{12A} = 2732 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	4566	4600	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 30.8 pc/mi/ln

Level of service for ramp-freeway junction areas of influence D

Speed Estimation

Intermediate speed variable, M_S = 0.606

Space mean speed in ramp influence area, S_R = 51.1 mph

Space mean speed in outer lanes, S_O = 59.4 mph

Space mean speed for all vehicles, S = 54.7 mph

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:	Seth Asante
Agency/Co.:	CTPS
Date performed:	5/20/2015
Analysis time period:	PM Peak Hour
Freeway/Dir of Travel:	I-93 SB (I-95 to Montvale Ave)
Junction:	Diverge I-93 SB to Montvale Av
Jurisdiction:	Highway District 4
Analysis Year:	2025 Future Year
Description:	Low-Cost Improvements to Bottleneck Locations

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	8000	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	30.0	mph
Volume on ramp	1050	vph
Length of first accel/decel lane	1500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	370	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	700	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	8000	1050	370	vph
Peak-hour factor, PHF	0.96	0.96	0.96	
Peak 15-min volume, v15	2083	273	96	v
Trucks and buses	4	3	3	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	3.0*	3.0*	3.0*	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.926	0.943	0.943	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	9184	1183	417	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 0.436 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 4671 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	9184	9400	No
$v_{FO} = v_F - v_R$	8001	9400	No
v_R	1183	2000	No
v_3 or v_{av34}	2256 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12} /2		No	

If yes, v_{12A} = 4671 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	4671	4400	Yes

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 30.9 pc/mi/ln

Level of service for ramp-freeway junction areas of influence D

Speed Estimation

Intermediate speed variable, D_S = 0.599

Space mean speed in ramp influence area, S_R = 51.2 mph

Space mean speed in outer lanes, S_O = 66.4 mph

Space mean speed for all vehicles, S = 57.7 mph

HCS 2010: Basic Freeway Segments Release 6.70

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	Seth
Agency or Company:	CTPS
Date Performed:	8/6/2015
Analysis Time Period:	PM Peak
Freeway/Direction:	I-93 Southbound
From/To:	Auxiliary Lane
Jurisdiction:	Highway District 4
Analysis Year:	2025 Future Year
Description:	Low-cost Improvements to Bottlenecks - I-93 SB

Flow Inputs and Adjustments

Volume, V	8050	veh/h
Peak-hour factor, PHF	0.96	
Peak 15-min volume, v15	2096	v
Trucks and buses	4	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	-	%
Segment length	-	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fHV	0.980	
Driver population factor, fp	1.00	
Flow rate, vp	1711	pc/h/ln

Speed Inputs and Adjustments

Lane width	-	ft
Right-side lateral clearance	-	ft
Total ramp density, TRD	-	ramps/mi
Number of lanes, N	5	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	-	mi/h
Lateral clearance adjustment, fLC	-	mi/h
TRD adjustment	-	mi/h
Free-flow speed, FFS	65.0	mi/h

LOS and Performance Measures

Flow rate, vp	1711	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S	63.6	mi/h
Number of lanes, N	5	
Density, D	26.9	pc/mi/ln
Level of service, LOS	D	

LOCATION 2

I-95 Southbound at the I-90 Interchange in Weston

2015 Existing Conditions

1. **2015 AM Diverge to I-90**
2. **2015 AM Diverge to Route 30**
3. **2015 AM Merge onto Route 30**
4. **2015 AM Merge onto I-90**

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:	Seth
Agency/Co.:	CTPS
Date performed:	6/1/2015
Analysis time period:	AM Peak Hour
Freeway/Dir of Travel:	I-95 Southbound
Junction:	Diverge to Mass Pike
Jurisdiction:	Highway District 6
Analysis Year:	2015 Existing
Description:	Low-Cost Improvements to Bottleneck Locations

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	55.0	mph
Volume on freeway	7100	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	25.0	mph
Volume on ramp	1750	vph
Length of first accel/decel lane	350	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	900	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	Off	
Distance to adjacent ramp	1400	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	7100	1750	900	vph
Peak-hour factor, PHF	0.95	0.95	0.95	
Peak 15-min volume, v15	1868	461	237	v
Trucks and buses	4	3	3	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.980	0.985	0.985	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	7779	1908	981	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 0.436 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 4468 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	7779	9000	No
$v_{FO} = v_F - v_R$	5871	9000	No
v_R	1908	1900	Yes
v_3 or v_{av34}	1655 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34}	> 2700 pc/h?	No	
Is v_3 or v_{av34}	> 1.5 v_{12} /2	No	

If yes, v_{12A} = 4468 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	4468	4400	Yes

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 39.5 pc/mi/ln

Level of service for ramp-freeway junction areas of influence F

Speed Estimation

Intermediate speed variable, D_S = 0.730

Space mean speed in ramp influence area, S_R = 45.5 mph

Space mean speed in outer lanes, S_0 = 57.8 mph

Space mean speed for all vehicles, S = 50.0 mph

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:	Seth
Agency/Co.:	CTPS
Date performed:	6/2/2015
Analysis time period:	AM Peak
Freeway/Dir of Travel:	I-95 Southbound
Junction:	Diverge to Route 30
Jurisdiction:	Highway District 6
Analysis Year:	2015 Existing
Description:	Low-cost Improvements to Bottleneck Locations

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	55.0	mph
Volume on freeway	5350	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	25.0	mph
Volume on ramp	900	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	550	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	400	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	5350	900	550	vph
Peak-hour factor, PHF	0.93	0.92	0.92	
Peak 15-min volume, v15	1438	245	149	v
Trucks and buses	4	4	4	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.980	0.980	0.980	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	5987	1018	622	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 0.436 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 3184 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	5987	9000	No
$v_{FO} = v_F - v_R$	4969	9000	No
v_R	1018	1900	No
v_3 or v_{av34}	1401 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12} /2		No	

If yes, v_{12A} = 3184 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	3184	4400	No

Level of Service Determination (if not F)

Density, $D = 4.252 + 0.0086\, v_R - 0.009\, v_{12}$ L_D = 27.1 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable, D_S = 0.650

Space mean speed in ramp influence area, S_R = 46.6 mph

Space mean speed in outer lanes, S_0 = 58.8 mph

Space mean speed for all vehicles, S = 51.6 mph

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Merge Analysis

Analyst:	Seth
Agency/Co.:	CTPS
Date performed:	6/2/2015
Analysis time period:	AM Peak
Freeway/Dir of Travel:	I-95 SB
Junction:	Merge from Route 30
Jurisdiction:	Highway District 6
Analysis Year:	2015 Existing
Description:	Low-cost Improvements to Bottleneck Locations

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	55.0	mph
Volume on freeway	4450	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	25.0	mph
Volume on ramp	550	vph
Length of first accel/decel lane	450	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	1850	vph
Position of adjacent Ramp	Downstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	800	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	4450	550	1850	vph
Peak-hour factor, PHF	0.94	0.94	0.89	
Peak 15-min volume, v15	1184	146	520	v
Trucks and buses	4	4	4	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.980	0.980	0.980	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	4927	609	2163	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 0.142 Using Equation 0

$v_{12} = v_F (P_{FM})$ = 698 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	5536	9000	No
v_3 or v_{av34}	2114 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12} /2		No	

If yes, v_{12A} = 698 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{R12}	1307	4600	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 12.6 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable,	M_S = 0.313		
Space mean speed in ramp influence area,	S_R = 50.9	mph	
Space mean speed in outer lanes,	S_0 = 49.2	mph	
Space mean speed for all vehicles,	S = 49.6	mph	

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Merge Analysis

Analyst:	Seth
Agency/Co.:	CTPS
Date performed:	6/2/2015
Analysis time period:	AM Peak Hour
Freeway/Dir of Travel:	I-95 Southbound
Junction:	Merge from Mass Pike
Jurisdiction:	Highway District 6
Analysis Year:	2015
Description:	Low-cost Improvements to Bottleneck Locations

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	55.0	mph
Volume on freeway	5000	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	25.0	mph
Volume on ramp	1850	vph
Length of first accel/decel lane	400	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	550	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	800	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	5000	1850	550	vph
Peak-hour factor, PHF	0.89	0.89	0.94	
Peak 15-min volume, v15	1404	520	146	v
Trucks and buses	4	4	4	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.980	0.980	0.980	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	5847	2163	609	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = -0.053 Using Equation 0

$v_{12} = v_F (P_{FM})$ = -306 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	8010	9000	No
v_3 or v_{av34}	3076 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		Yes	
Is v_3 or v_{av34} > 1.5 v_{12} /2		Yes	

If yes, v_{12A} = 2338 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	4501	4600	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 37.1 pc/mi/ln

Level of service for ramp-freeway junction areas of influence E

Speed Estimation

Intermediate speed variable, M_S = 0.652

Space mean speed in ramp influence area, S_R = 46.5 mph

Space mean speed in outer lanes, S_O = 50.5 mph

Space mean speed for all vehicles, S = 48.2 mph

2015 Existing Conditions

1. **2015 PM Diverge to I-90**
2. **2015 PM Diverge to Route 30**
3. **2015 PM Merge onto Route 30**
4. **2015 PM Merge onto I-90**

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:	Seth
Agency/Co.:	CTPS
Date performed:	6/1/2015
Analysis time period:	PM Peak Hour
Freeway/Dir of Travel:	I-95 Southbound
Junction:	Diverge to Mass Pike
Jurisdiction:	Highway District 6
Analysis Year:	2015

Description: Low-cost Improvements to Bottleneck Locations

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	55.0	mph
Volume on freeway	7500	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	25.0	mph
Volume on ramp	2250	vph
Length of first accel/decel lane	350	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	550	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	Off	
Distance to adjacent ramp	1400	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	7500	2250	550	vph
Peak-hour factor, PHF	0.94	0.99	0.93	
Peak 15-min volume, v15	1995	568	148	v
Trucks and buses	4	4	4	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.980	0.980	0.980	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	8304	2365	616	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 0.436 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 4954 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	8304	9000	No
$v_{FO} = v_F - v_R$	5939	9000	No
v_R	2365	1900	Yes
v_3 or v_{av34}	1675 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34}	> 2700 pc/h?	No	
Is v_3 or v_{av34}	> 1.5 v_{12} /2	No	

If yes, v_{12A} = 4954 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	4954	4400	Yes

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 43.7 pc/mi/ln

Level of service for ramp-freeway junction areas of influence F

Speed Estimation

Intermediate speed variable,	D_S = 0.771	
Space mean speed in ramp influence area,	S_R = 45.0	mph
Space mean speed in outer lanes,	S_O = 57.7	mph
Space mean speed for all vehicles,	S = 49.4	mph

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:	Seth
Agency/Co.:	CTPS
Date performed:	6/2/2015
Analysis time period:	PM Peak Hour
Freeway/Dir of Travel:	I-95 Southbound
Junction:	Diverge to Route 30
Jurisdiction:	Highway District 6
Analysis Year:	2015 Existing
Description:	Low-cost Improvements to Bottleneck Location

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	55.0	mph
Volume on freeway	5250	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	25.0	mph
Volume on ramp	550	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	500	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	450	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	5250	550	500	vph
Peak-hour factor, PHF	0.93	0.93	0.94	
Peak 15-min volume, v15	1411	148	133	v
Trucks and buses	2	2	2	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.990	0.990	0.990	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	5818	610	548	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 0.436 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 2881 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	5818	9000	No
$v_{FO} = v_F - v_R$	5208	9000	No
v_R	610	1900	No
v_3 or v_{av34}	1468 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12} /2		No	

If yes, v_{12A} = 2881 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	2881	4400	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 24.5 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable,	D_S = 0.613	
Space mean speed in ramp influence area,	S_R = 47.0	mph
Space mean speed in outer lanes,	S_O = 58.5	mph
Space mean speed for all vehicles,	S = 52.2	mph

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Merge Analysis

Analyst:	Seth
Agency/Co.:	CTPS
Date performed:	6/2/2015
Analysis time period:	PM Peak Hour
Freeway/Dir of Travel:	I-95 Southbound
Junction:	Merge from Route 30
Jurisdiction:	Highway District 6
Analysis Year:	2015 Existing
Description:	Low-cost Improvements to Bottleneck Location

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	55.0	mph
Volume on freeway	4700	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	25.0	mph
Volume on ramp	500	vph
Length of first accel/decel lane	450	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	1800	vph
Position of adjacent Ramp	Downstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	850	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	4700	500	1800	vph
Peak-hour factor, PHF	0.92	0.92	0.94	
Peak 15-min volume, v15	1277	136	479	v
Trucks and buses	4	4	4	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.980	0.980	0.980	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	5317	566	1993	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 0.147 Using Equation 0

$v_{12} = v_F (P_{FM})$ = 782 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	5883	9000	No
v_3 or v_{av34}	2267 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12} /2		Yes	

If yes, v_{12A} = 2126 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	2692	4600	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 23.4 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable, M_S = 0.356

Space mean speed in ramp influence area, S_R = 50.4 mph

Space mean speed in outer lanes, S_0 = 51.1 mph

Space mean speed for all vehicles, S = 50.7 mph

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Merge Analysis

Analyst:	Seth
Agency/Co.:	CTPS
Date performed:	6/2/2015
Analysis time period:	PM Peak Hour
Freeway/Dir of Travel:	I-95 Southbound
Junction:	Merge from Mass Pike
Jurisdiction:	Highway District 6
Analysis Year:	2015 Existing
Description:	Low-cost Improvements to Bottleneck Location

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	55.0	mph
Volume on freeway	5200	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	25.0	mph
Volume on ramp	1800	vph
Length of first accel/decel lane	400	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	400	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	800	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	5200	1800	400	vph
Peak-hour factor, PHF	0.93	0.93	0.89	
Peak 15-min volume, v15	1398	484	112	v
Trucks and buses	4	4	4	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.980	0.980	0.980	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	5820	2014	468	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = -0.034 Using Equation 0

$v_{12} = v_F (P_{FM})$ = -197 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	7834	9000	No
v_3 or v_{av34}	3008 pc/h	(Equation 13-14 or 13-17)	

Is v_3 or v_{av34} > 2700 pc/h? Yes

Is v_3 or v_{av34} > 1.5 v_{12} /2 Yes

If yes, v_{12A} = 2328 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	4342	4600	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 35.9 pc/mi/ln

Level of service for ramp-freeway junction areas of influence E

Speed Estimation

Intermediate speed variable,	M_S = 0.601		
Space mean speed in ramp influence area,	S_R = 47.2	mph	
Space mean speed in outer lanes,	S_0 = 50.5	mph	
Space mean speed for all vehicles,	S = 48.6	mph	

2025 With Improvements

1. **2025 AM Diverge to I-90**
2. **2025 AM Diverge to Route 30**
3. **2025 AM Merge onto Route 30**
4. **2025 AM Merge onto I-90**

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:	Seth
Agency/Co.:	CTPS
Date performed:	6/1/2015
Analysis time period:	AM Peak Hour
Freeway/Dir of Travel:	I-95 Southbound
Junction:	Diverge to Mass Pike
Jurisdiction:	Highway District 6
Analysis Year:	2025 Future Year

Description: Low-cost Improvements to Bottleneck Location

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	55.0	mph
Volume on freeway	7450	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	2	
Free-Flow speed on ramp	25.0	mph
Volume on ramp	1750	vph
Length of first accel/decel lane	1000	ft
Length of second accel/decel lane	500	ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	950	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	Off	
Distance to adjacent ramp	1400	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	7450	1750	950	vph
Peak-hour factor, PHF	0.95	0.95	0.95	
Peak 15-min volume, v15	1961	461	250	v
Trucks and buses	4	4	4	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.980	0.980	0.980	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	8162	1917	1041	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 0.260 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 3541 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	8162	9000	No
$v_{FO} = v_F - v_R$	6245	9000	No
v_R	1917	3800	No
v_3 or v_{av34}	2310 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34}	> 2700 pc/h?	No	
Is v_3 or v_{av34}	> 1.5 v_{12} /2	No	

If yes, v_{12A} = 3541 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	3541	4400	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 12.2 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable, D_S = 0.731

Space mean speed in ramp influence area, S_R = 45.5 mph

Space mean speed in outer lanes, S_0 = 55.2 mph

Space mean speed for all vehicles, S = 50.5 mph

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:	Seth
Agency/Co.:	CTPS
Date performed:	6/2/2015
Analysis time period:	AM Peak Hour
Freeway/Dir of Travel:	I-95 Southbound
Junction:	Diverge to Route 30
Jurisdiction:	Highway District 6
Analysis Year:	2025 Future Year
Description:	Low-cost Improvements to Bottleneck Location

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	3	
Free-flow speed on freeway	60.0	mph
Volume on freeway	5500	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	25.0	mph
Volume on ramp	950	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	550	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	450	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	5500	950	550	vph
Peak-hour factor, PHF	0.94	0.94	0.94	
Peak 15-min volume, v15	1463	253	146	v
Trucks and buses	4	4	4	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.980	0.980	0.980	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	6090	1052	609	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 0.559 Using Equation 9

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 3870 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	6090	6900	No
$v_{FO} = v_F - v_R$	5038	6900	No
v_R	1052	1900	No
v_3 or v_{av34}	2220 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12} /2		No	

If yes, v_{12A} = 3870 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	3870	4400	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 33.0 pc/mi/ln

Level of service for ramp-freeway junction areas of influence D

Speed Estimation

Intermediate speed variable,	D_S = 0.653	
Space mean speed in ramp influence area,	S_R = 48.3	mph
Space mean speed in outer lanes,	S_O = 61.1	mph
Space mean speed for all vehicles,	S = 52.2	mph

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Merge Analysis

Analyst:	Seth
Agency/Co.:	CTPS
Date performed:	6/2/2015
Analysis time period:	AM Peak Hour
Freeway/Dir of Travel:	I-95 Southbound
Junction:	Merge from Route 30
Jurisdiction:	Highway District 6
Analysis Year:	2025 Future Year
Description:	Low-cost Improvements to Bottleneck Location

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	3	
Free-flow speed on freeway	55.0	mph
Volume on freeway	4600	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	25.0	mph
Volume on ramp	550	vph
Length of first accel/decel lane	450	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	1900	vph
Position of adjacent Ramp	Downstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	850	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	4600	550	1900	vph
Peak-hour factor, PHF	0.94	0.94	0.89	
Peak 15-min volume, v15	1223	146	534	v
Trucks and buses	4	4	4	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.980	0.980	0.980	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	5093	609	2222	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 0.590 Using Equation 3

$v_{12} = v_F (P_{FM})$ = 3005 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	5702	6750	No
v_3 or v_{av34}	2088 pc/h	(Equation 13-14 or 13-17)	

Is v_3 or v_{av34} > 2700 pc/h? No

Is v_3 or v_{av34} > 1.5 v_{12} /2 Yes

If yes, v_{12A} = 3005 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	3614	4600	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 30.6 pc/mi/ln

Level of service for ramp-freeway junction areas of influence D

Speed Estimation

Intermediate speed variable,	M_S = 0.443		
Space mean speed in ramp influence area,	S_R = 49.2	mph	
Space mean speed in outer lanes,	S_O = 49.3	mph	
Space mean speed for all vehicles,	S = 49.3	mph	

HCS 2010: Basic Freeway Segments Release 6.70

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	Seth
Agency or Company:	CTPS
Date Performed:	6/8/2015
Analysis Time Period:	AM Peak Hour
Freeway/Direction:	I-95 Southbound
From/To:	Auxiliary Lane--Ramp Mass Pike
Jurisdiction:	Highway District 6
Analysis Year:	2025 Future Year
Description:	Low-cost Improvements to Bottleneck Location

Flow Inputs and Adjustments

Volume, V	7200	veh/h
Peak-hour factor, PHF	0.96	
Peak 15-min volume, v15	1875	v
Trucks and buses	4	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	-	%
Segment length	-	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fHV	0.980	
Driver population factor, fp	0.98	
Flow rate, vp	1952	pc/h/ln

Speed Inputs and Adjustments

Lane width	-	ft
Right-side lateral clearance	-	ft
Total ramp density, TRD	-	ramps/mi
Number of lanes, N	4	
Free-flow speed:	Measured	
FFS or BFFS	55.0	mi/h
Lane width adjustment, fLW	-	mi/h
Lateral clearance adjustment, fLC	-	mi/h
TRD adjustment	-	mi/h
Free-flow speed, FFS	55.0	mi/h

LOS and Performance Measures

Flow rate, vp	1952	pc/h/ln
Free-flow speed, FFS	55.0	mi/h
Average passenger-car speed, S	54.4	mi/h
Number of lanes, N	4	
Density, D	35.9	pc/mi/ln
Level of service, LOS	E	

Overall results are not computed when free-flow speed is less than 55 mph.

2025 With Improvements

1. **2025 PM Diverge to I-90**
2. **2025 PM Diverge to Route 30**
3. **2025 PM Merge onto Route 30**
4. **2025 PM Merge onto I-90**

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:	Seth
Agency/Co.:	CTPS
Date performed:	6/1/2015
Analysis time period:	PM Peak Hour
Freeway/Dir of Travel:	I-95 Southbound
Junction:	Diverge to Mass Pike
Jurisdiction:	Highway District 6
Analysis Year:	2025 Future Year
Description:	Low-cost Improvements to Bottleneck Locations

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	55.0	mph
Volume on freeway	7500	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	2	
Free-Flow speed on ramp	30.0	mph
Volume on ramp	2250	vph
Length of first accel/decel lane	1000	ft
Length of second accel/decel lane	500	ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	550	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	Off	
Distance to adjacent ramp	1400	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	7500	2250	550	vph
Peak-hour factor, PHF	0.96	0.96	0.96	
Peak 15-min volume, v15	1953	586	143	v
Trucks and buses	4	4	3	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.980	0.980	0.985	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	8131	2439	593	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 0.260 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 3919 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	8131	9000	No
$v_{FO} = v_F - v_R$	5692	9000	No
v_R	2439	4000	No
v_3 or v_{av34}	2106 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12} /2		No	

If yes, v_{12A} = 3919 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	3919	4400	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 15.5 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable,	D_S = 0.713	
Space mean speed in ramp influence area,	S_R = 45.7	mph
Space mean speed in outer lanes,	S_O = 56.0	mph
Space mean speed for all vehicles,	S = 50.5	mph

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:	Seth
Agency/Co.:	CTPS
Date performed:	6/2/2015
Analysis time period:	PM Peak Hour
Freeway/Dir of Travel:	I-95 Southbound
Junction:	Diverge to Route 30
Jurisdiction:	Highway District 6
Analysis Year:	2025 Future Year
Description:	Low-cost Improvements to Bottleneck Locations

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	3	
Free-flow speed on freeway	55.0	mph
Volume on freeway	5400	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	25.0	mph
Volume on ramp	550	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	500	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	450	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	5400	550	500	vph
Peak-hour factor, PHF	0.93	0.93	0.94	
Peak 15-min volume, v15	1452	148	133	v
Trucks and buses	4	4	4	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.980	0.980	0.980	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	6043	616	554	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 0.581 Using Equation 9

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 3767 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	6043	6750	No
$v_{FO} = v_F - v_R$	5427	6750	No
v_R	616	1900	No
v_3 or v_{av34}	2276 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12} /2		No	

If yes, v_{12A} = 3767 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	3767	4400	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 32.1 pc/mi/ln

Level of service for ramp-freeway junction areas of influence D

Speed Estimation

Intermediate speed variable,	D_S = 0.613	
Space mean speed in ramp influence area,	S_R = 47.0	mph
Space mean speed in outer lanes,	S_O = 55.4	mph
Space mean speed for all vehicles,	S = 49.9	mph

HCS 2010: Freeway Merge and Diverge Segments Release 6.70

Phone: Fax:
E-mail:

Merge Analysis

Analyst:	Seth
Agency/Co.:	CTPS
Date performed:	6/2/2015
Analysis time period:	PM Peak Hour
Freeway/Dir of Travel:	I-95 Southbound
Junction:	Merge from Route 30
Jurisdiction:	Highway District 6
Analysis Year:	2025 Future year
Description:	Low-cost Improvements to Bottleneck Location

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	3	
Free-flow speed on freeway	55.0	mph
Volume on freeway	4850	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	25.0	mph
Volume on ramp	500	vph
Length of first accel/decel lane	450	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	1850	vph
Position of adjacent Ramp	Downstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	850	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	4850	500	1850	vph
Peak-hour factor, PHF	0.92	0.92	0.94	
Peak 15-min volume, v15	1318	136	492	v
Trucks and buses	4	4	4	%
Recreational vehicles	0	0	0	%
Terrain type:	Level	Level	Level	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	

Heavy vehicle adjustment, fHV	0.980	0.980	0.980	
Driver population factor, fP	0.98	0.98	0.98	
Flow rate, vp	5487	566	2048	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 0.590 Using Equation 3

$v_{12} = v_F (P_{FM})$ = 3238 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	6053	6750	No
v_3 or v_{av34}	2249 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12} /2		Yes	

If yes, v_{12A} = 3238 (Equation 13-15, 13-16, 18, or 19)

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	3804	4600	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 32.1 pc/mi/ln

Level of service for ramp-freeway junction areas of influence D

Speed Estimation

Intermediate speed variable, M_S = 0.474

Space mean speed in ramp influence area, S_R = 48.8 mph

Space mean speed in outer lanes, S_O = 48.7 mph

Space mean speed for all vehicles, S = 48.8 mph

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	Seth
Agency or Company:	CTPS
Date Performed:	6/8/2015
Analysis Time Period:	PM Peak
Freeway/Direction:	I-95 Southbound
From/To:	Auxiliary Lane: Ramp from Mass
Jurisdiction:	Highway District 6
Analysis Year:	2025 Future Year
Description:	Low-cost Improvements to Bottleneck Location

Flow Inputs and Adjustments

Volume, V	6900	veh/h
Peak-hour factor, PHF	0.95	
Peak 15-min volume, v15	1816	v
Trucks and buses	4	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	-	%
Segment length	-	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fHV	0.980	
Driver population factor, fp	0.98	
Flow rate, vp	1890	pc/h/ln

Speed Inputs and Adjustments

Lane width	-	ft
Right-side lateral clearance	-	ft
Total ramp density, TRD	-	ramps/mi
Number of lanes, N	4	
Free-flow speed:	Measured	
FFS or BFFS	55.0	mi/h
Lane width adjustment, fLW	-	mi/h
Lateral clearance adjustment, fLC	-	mi/h
TRD adjustment	-	mi/h
Free-flow speed, FFS	55.0	mi/h

LOS and Performance Measures

Flow rate, vp	1890	pc/h/ln
Free-flow speed, FFS	55.0	mi/h
Average passenger-car speed, S	54.8	mi/h
Number of lanes, N	4	
Density, D	34.5	pc/mi/ln
Level of service, LOS	D	

Overall results are not computed when free-flow speed is less than 55 mph.

APPENDIX E

MassDOT Highway Division
Project Development Process

Overview of the Project Development Process

Transportation decision-making is complex and can be influenced by legislative mandates, environmental regulations, financial limitations, agency programmatic commitments, and partnering opportunities. Decision-makers and reviewing agencies, when consulted early and often throughout the project development process, can ensure that all participants understand the potential impact these factors can have on project implementation. Project development is the process that takes a transportation improvement from concept through construction.

The MassDOT Highway Division has developed a comprehensive project development process which is contained in Chapter 2 of the *MassDOT Highway Division's Project Development and Design Guide*. The eight-step process covers a range of activities extending from identification of a project need, through completion of a set of finished contract plans, to construction of the project. The sequence of decisions made through the project development process progressively narrows the project focus and, ultimately, leads to a project that addresses the identified needs. The descriptions provided below are focused on the process for a highway project, but the same basic process will need to be followed for non-highway projects as well.

1. Needs Identification

For each of the locations at which an improvement is to be implemented, MassDOT leads an effort to define the problem, establishes project goals and objectives, and defines the scope of the planning needed for implementation. To that end, it has to complete a Project Need Form (PNF), which states in general terms the deficiencies or needs related to the transportation facility or location. The PNF documents the problems and explains why corrective action is needed. For this study, the information defining the need for the project will be drawn primarily, perhaps exclusively, from the present report. Also, at this point in the process, MassDOT meets with potential participants, such as the Metropolitan Planning Organization (MPO) and community members, to allow for an informal review of the project.

The PNF is reviewed by the MassDOT Highway Division district office whose jurisdiction includes the location of the proposed project. MassDOT also sends the PNF to the MPO, for informational purposes. The outcome of this step determines whether the project requires further planning, whether it is already well supported by prior planning studies, and, therefore, whether it is ready to move forward into the design phase, or whether it should be dismissed from further consideration.

2. Planning

This phase will likely not be required for the implementation of the improvements proposed in this planning study, as this planning report should constitute the outcome of this step. However, in general, the purpose of this implementation step is for the project proponent to identify issues, impacts, and approvals that may need to be obtained, so that the subsequent design and permitting processes are understood.

The level of planning needed will vary widely, based on the complexity of the project. Typical tasks include: define the existing context, confirm project need, establish goals and objectives, initiate public outreach, define the project, collect data, develop and analyze alternatives, make recommendations, and provide documentation. Likely outcomes include consensus on the project definition to enable it to move forward into environmental documentation (if needed) and design, or a recommendation to delay the project or dismiss it from further consideration.

3. Project Initiation

At this point in the process, the proponent, MassDOT Highway Division, fills out a Project Initiation Form (PIF) for each improvement, which is reviewed by its Project Review Committee (PRC) and the MPO. The PRC is composed of the Chief Engineer, each District Highway Director, and representatives of the Project Management, Environmental, Planning, Right-of-Way, Traffic, and Bridge departments, and the MassDOT Federal Aid Program Office (FAPO). The PIF documents the project type and description, summarizes the project planning process, identifies likely funding and project management responsibility, and defines a plan for interagency and public participation. First the PRC reviews and evaluates the proposed project based on the MassDOT's statewide priorities and criteria. If the result is positive, MassDOT Highway Division moves the project forward to the design phase, and to programming review by the MPO. The PRC may provide a Project Management Plan to define roles and responsibilities for subsequent steps. The MPO review includes project evaluation based on the MPO's regional priorities and criteria. The MPO may assign project evaluation criteria score, a Transportation Improvement Program (TIP) year, a tentative project category, and a tentative funding category.

4. Environmental Permitting, Design, and Right-of-Way Process

This step has four distinct but closely integrated elements: public outreach, environmental documentation and permitting (if required), design, and right-of-way acquisition (if required). The outcome of this step is a fully designed and permitted project ready for construction. However, a project does not have to be fully designed in order for the MPO to program it in the TIP. The sections below provide more detailed information on the four elements of this step of the project development process.

Public Outreach

Continued public outreach in the design and environmental process is essential to maintain public support for the project and to seek meaningful input on the design elements. The public outreach is often in the form of required public hearings, but can also include less formal dialogues with those interested in and affected by a proposed project.

Environmental Documentation and Permitting

The project proponent, in coordination with the Environmental Services section of the MassDOT Highway Division, will be responsible for identifying and complying with all applicable federal, state, and local environmental laws and requirements. This includes determining the appropriate project category for both the Massachusetts Environmental Protection Act (MEPA) and the National Environmental Protection Act (NEPA). Environmental documentation and permitting is often completed in conjunction with the **Preliminary Design** phase described below.

Design

There are three major phases of design. The first is **Preliminary Design**, which is also referred to as the 25-percent submission. The major components of this phase include full survey of the project area, preparation of base plans, development of basic geometric layout, development of preliminary cost estimates, and submission of a functional design report. Preliminary Design, although not required to, is often completed in conjunction with the Environmental Documentation and Permitting. The next phase is **Final Design**, which is also referred to as the 75-percent and 100-percent submission. The major components of this phase include preparation of a subsurface exploratory plan (if required), coordination of utility relocations, development of traffic management plans through construction zones, development of final cost estimates, and refinement and finalization of the construction plans. Once Final Design is complete, a full set of **Plans, Specifications, and Estimates (PS&E)** is developed for the project.

Right-of-Way Acquisition
A separate set of Right-of-Way plans are required for any project that requires land acquisition or easements. The plans must identify the existing and proposed layout lines, easements, property lines, names of property owners, and the dimensions and areas of estimated takings and easements.

5. Programming (Identification of Funding)
Programming, which typically begins during the design phase, can actually occur at any time during the process, from planning to design. In this step, which is distinct from project initiation, the proponent requests that the MPO place the project in the region's Transportation Improvement Program (TIP). The proponent requesting the project's listing on the TIP can be the community or it can be one of the MPO member agencies (the Regional Planning Agency, MassDOT, and the Regional Transit Authority). The MPO then considers the project in terms of state and regional needs, evaluation criteria, and compliance with the regional Transportation Plan and decides whether to place it in the draft TIP for public review and then in the final TIP.

6. Procurement
Following project design and programming of a highway project, the MassDOT Highway Division publishes a request for proposals. It then reviews the bids and awards the contract to the qualified bidder with the lowest bid.

7. Construction
After a construction contract is awarded, MassDOT Highway Division and the contractor develop a public participation plan and a management plan for the construction process.

8. Project Assessment
The purpose of this step is to receive constituents' comments on the project development process and the project's design elements. MassDOT Highway Division can apply what is learned in this process to future projects.

Project Development Schematic Timetable

Description	Schedule Influence	Typical Duration
Step I: Problem/Need/Opportunity Identification The proponent completes a Project Need Form (PNF). This form is then reviewed by the MassDOT District office which provides guidance to the proponent on the subsequent steps of the process.	The Project Need Form has been developed so that it can be prepared quickly by the proponent, including any supporting data that is readily available. The District office shall return comments to the proponent within one month of PNF submission.	1 to 3 months
Step II: Planning Project planning can range from agreement that the problem should be addressed through a clear solution to a detailed analysis of alternatives and their impacts.	For some projects, no planning beyond preparation of the Project Need Form is required. Some projects require a planning study centered on specific project issues associated with the proposed solution or a narrow family of alternatives. More complex projects will likely require a detailed alternatives analysis.	Project Planning Report: 3 to 24+ months
Step III: Project Initiation The proponent prepares and submits a Project Initiation Form (PIF) and a Transportation Evaluation Criteria (TEC) form in this step. The PIF and TEC are informally reviewed by the Metropolitan Planning Organization (MPO) and MassDOT District office, and formally reviewed by the PRC.	The PIF includes refinement of the preliminary information contained in the PNF. Additional information summarizing the results of the planning process, such as the Project Planning Report, are included with the PIF and TEC. The schedule is determined by PRC staff review (dependent on project complexity) and meeting schedule.	1 to 4 months
Step IV: Design, Environmental, and Right of Way The proponent completes the project design. Concurrently, the proponent completes necessary environmental permitting analyses and files applications for permits. Any right of way needed for the project is identified and the acquisition process begins.	The schedule for this step is dependent upon the size of the project and the complexity of the design, permitting, and right-of-way issues. Design review by the MassDOT district and appropriate sections is completed in this step.	3 to 48+ months
Step V: Programming The MPO considers the project in terms of its regional priorities and determines whether or not to include the project in the draft Regional Transportation Improvement Program (TIP) which is then made available for public comment. The TIP includes a project description and funding source.	The schedule for this step is subject to each MPO's programming cycle and meeting schedule. It is also possible that the MPO will not include a project in its Draft TIP based on its review and approval procedures.	3 to 12+ months
Step VI: Procurement The project is advertised for construction and a contract awarded.	Administration of competing projects can influence the advertising schedule.	1 to 12 months
Step VII: Construction The construction process is initiated including public notification and any anticipated public involvement. Construction continues to project completion.	The duration for this step is entirely dependent upon project complexity and phasing.	3 to 60+ months
Step VIII: Project Assessment The construction period is complete and project elements and processes are evaluated on a voluntary basis.	The duration for this step is dependent upon the proponent's approach to this step and any follow-up required.	1 month

Source: MassDOT Highway Division Project Development and Design Guide