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MEMORANDUM

DATE **June 2, 2011**

TO **Transportation Planning and Programming Committee of the Boston Region Metropolitan Planning Organization**

FROM **Seth Asante, MPO Staff**

RE **Low-Cost Improvements to Bottleneck Locations**

BACKGROUND

Over the past 20 years, congestion in the Boston Region Metropolitan Planning Organization (MPO) area has grown in duration, extent, and intensity. The hours of congestion, which typically stretched from two to three hours per peak period in the 1980s, have increased to three to four hours currently. The extent of the congestion, which was somewhat concentrated in the area within Route 128, has now reached areas further west, south, and north of Route 128. Congestion has many effects—it wastes millions of person-hours and fuel, reduces productivity and highway safety, and takes away time from family and friends. In 2005, the Texas Transportation Institute estimated that it costs the United States $63 billion annually for the 3.7 billion hours of delay and 2.3 billion gallons of wasted fuel in the top 85 urban areas.[1]

Much of the congestion that occurs every day at the same location and time period—which is known as recurring congestion—is due to physical constraints, operational conflicts, or inability of a facility to handle the volume of traffic that occurs during those time periods. A physical constraint or inadequate capacity of a facility that results in recurring congestion is referred to as a bottleneck or choke point. According to the Federal Highway Administration (FHWA), bottlenecks cause about 40 percent of traffic congestion.[2]

The primary strategy used to address bottlenecks has been costly major construction projects that increased the capacity of a facility or provide alternative modes of travel that reduce highway congestion. However, as funding for major transportation projects has become scarce, there is significant opportunity for applying low-cost infrastructure solutions to reduce congestion impacts resulting from bottlenecks. Consistent with this guidance, the Massachusetts Division of the Federal Highway Administration has recommended, as part of its comments on the Unified Planning Work Program process, that the MPO identify the three worst bottlenecks in the region that can be mitigated with low-cost improvements and develop recommendations for such improvements at these locations.

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[1] 2005 Urban Mobility Study, The Texas Transportation Institute (TTI), 2005.
[2] Source: http://www.fhwa.dot.gov/congestion/describing_problems.htm.

This memorandum summarizes the results of a study performed by MPO staff in response to FHWA's recommendation.

PURPOSE OF STUDY

The purpose of this study is twofold:

1. Identify three bottleneck segments or points where low-cost mitigation improvements seem applicable.
2. 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.

SELECTION OF STUDY LOCATIONS

The selection of study locations was a two-stage process; it comprised inventorying and screening candidate locations.

Inventorying of Candidate Locations

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

- 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 TPPC members and private parties

The inventory process yielded six bottleneck locations for screening. Figure 1 (all figures in this memorandum are in the appendix) shows the six locations, which are listed below.

1. Location 1: I-95 northbound, ramp merge area at interchange 24 in Weston
2. Location 2: Route 3 northbound, ramp merge area at interchange 17 in Braintree
3. Location 3: I-95 northbound, off- and on-ramps at interchange 32 in Burlington
4. Location 4: Route 3 southbound, lane drop near the Hingham-Weymouth town line
5. Location 5: I-95 northbound, lane drop at interchange 37 in Stoneham
6. Location 6: Cambridge Street and River Street and Soldiers Field Road intersection in Cambridge

Screening of Candidate Locations

MPO staff screened the six candidate locations and selected four locations for analysis. The four bottlenecks selected for study were not the worst in the region, as the worst bottlenecks may not be correctible with low-cost mitigation strategies. MPO staff screened the bottleneck locations using the following criteria:

- Does the location qualify as a bottleneck? A long traffic queue upstream trailing free-flowing traffic downstream usually characterizes the location as a bottleneck location. In addition, the congestion upstream of the bottleneck must be recurring congestion—in other words, the location experiences routine and predictable congestion because traffic volume exceeds the available capacity at that location.
- Does the location have a physical design constraint or operational conflict that causes the bottleneck? Examples of physical constraints and operational conflicts that cause bottlenecks are:
  - "Lane drop," where one or more travel lanes are lost, requiring traffic to merge
  - "Weaving area," where traffic must merge across one or more lanes in order to access an entry or exit ramp
  - "Merge area," where on-ramp traffic merges with mainline traffic in order to enter the freeway
  - Major interchanges, where high-volume traffic is directed from one freeway to another
  - Horizontal curves, where 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? Low-cost operational and geometric improvements exclude costly long-term improvements such as corridorwide 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 serve traffic demand better
  - Providing better traveler information to allow drivers to respond to temporal changes in lane assignment such as the use of shoulders as an additional travel lane during peak periods
  - Provide all-purpose reversible lanes
  - Change or add signs and striping

Based on the screening criteria, consultations, and field visits with MassDOT Highway Division officials, MPO staff selected four candidate locations for analysis. The four locations are Locations 1, 2, 3, and 4. MPO staff did not select Location 5 because of traffic congestion downstream at the I-95 and I-93 interchange. In addition, MPO staff did not select Location 6 because it appears to require major and costly long-term improvements.

The following sections describe the existing conditions and proposed low-cost improvements at the four locations selected for study. Comments and questions from MassDOT Highway Division Districts 4 and 6 on some of the proposed low-cost improvements are included in the appendix with responses from MPO staff. The modifications described in the responses have been incorporated into the body of this memorandum.

LOCATION 1: I-95 NORTHBOUND, RAMP MERGE AREA AT INTERCHANGE 24 IN WESTON

This bottleneck is located on I-95 northbound at the merge area where traffic from Interstate 90 (I-90, referred to as Turnpike), Route 30 eastbound, and the collector-distributor road merge onto I-95. Figure 2 shows the location of the bottleneck and the ramp configuration near it. Figure 3 shows the bottleneck location on I-95 northbound under the Route 30 bridge—there are four travel lanes and an acceleration lane about 500 feet long under the bridge. The columns of the bridge are very close to the acceleration lane and leftmost travel lane, leaving no room for an extra lane under the bridge.

Problem

The bottleneck results in a long traffic queue on the Turnpike connector during AM and PM peak periods, when high volumes of traffic merge onto I-95 northbound. This queue sometimes affects Turnpike traffic on the connector heading to I-95 southbound as well.

Causes

MPO staff identified three factors that contribute to the formation of this bottleneck during peak travel periods. The first factor is the high volume of traffic from the Turnpike that heads northbound on I-95 during peak hours of travel. Figures 4 and 5 show the 2007 AM and PM peak-period traffic volumes to and from I-95 northbound near the bottleneck. According to the figures, about 2,000 vehicles per hour from the Turnpike connector and collector-distributor road, and 300 vehicles per hour from Route 30, merge onto I-95 northbound during the peak period of travel. The total volume is quite high for a single-lane on-ramp; in addition, its traffic has to merge with a high volume of traffic on I-95 northbound.

The second factor is that high-volume traffic from the Turnpike and collector-distributor road has to merge with traffic from Route 30 eastbound before proceeding in a single lane to merge with traffic on northbound I-95, about 300 feet away (see Figure 2). In addition, there is a weaving area, where the high-volume traffic from the Turnpike merges across the collector-distributor traffic in order to access the on-ramp. Both merges and weave slow traffic down considerably and contribute to a traffic queue on the Turnpike connector.

The third factor is a short acceleration lane on I-95 northbound for the high-volume on-ramp traffic merging onto I-95 northbound. The existing acceleration length is less than 500 feet long and does not meet the standards for an interstate highway. Interstate 95 (I-95), also called Route 128 in some sections, 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-curve design speed of 35 mph, and a grade of two percent or less.

Impacts

Figure 6 shows the PM peak-period average travel speeds collected by MPO staff on I-95 northbound near the bottleneck location. The AM peak-period average travel speeds (not shown in this memo) are similar to the PM peak-period speeds. As Figure 6 shows, the bottleneck has little impact on travel speed northbound on I-95, as the average travel speed is over 55 mph upstream of the bottleneck location. Many motorists on I-95 northbound move out of the rightmost lane to avoid the merge with high-volume on-ramp traffic. Hence, the bottleneck affects mostly traffic from the Turnpike, collector-distributor road, and Route 30 heading to I-95 northbound. A traffic queue resulting from the bottleneck backs up onto the Turnpike connector and on some occasions affects traffic exiting to I-95 southbound as well.

Figure 7 shows the crashes on I-95 northbound near the bottleneck. There were 65 crashes on I-95 northbound near the bottleneck location in 2006–08. The resulting crash rate for this section of I-95 northbound is 0.88 crashes per million vehicle miles traveled (MVMT), which is higher than the average of 0.64 crashes per MVMT for urban interstate highways in the Commonwealth. Thirty-eight (58 percent) of the crashes were rear-end and 23 (35 percent) were sideswipes; together, rear-end and sideswipe crashes accounted for 93 percent of the total crashes. Analysis of the crash times indicated 31 of the 65 crashes occurred during the AM peak period of travel (6:00–10:00 AM), and 10 of the 65 crashes during the PM peak period of travel (3:00–7:00 PM). Together, 63 percent of the crashes occurred during the AM and PM peak periods of travel. MPO staff did not analyze police crash reports and did not prepare collision diagrams from police crash reports; however, staff believe that many of the rear-end and sideswipe crashes were due to motorists changing lanes and/or slowing down to merge with on-ramp traffic.

On the other hand, there were only six recorded crashes near the bottleneck location on the Turnpike connector, collector-distributor road, and Route 30 eastbound ramp in 2006–08.

Recommendations

MPO staff, working with the MassDOT Highway Division, developed three alternatives for addressing problems identified at this bottleneck location. The following is a detailed description of the alternatives.

Alternative 1: Restripe Lanes at the Bottleneck to Serve Demand Better

The objective of Alternative 1 is to restripe lanes at the bottleneck to better meet the demand. Figures 8A and 8B show the improvements recommended in Alternative 1. In Alternative 1, the rightmost lane on I-95 northbound is dropped a short distance after exit 23. The high-volume traffic from the collector-distributor road and the Turnpike would pick up the extra lane to enter I-95 northbound. In this fashion, the Route 30 eastbound traffic headed for I-95 northbound would have the exclusive use of an extended acceleration lane (Figure 8B).

Due to the high volume of traffic (2,200 vehicles per hour during the PM peak hour) exiting I-95 northbound at exit 23 to the Turnpike, Route 30, and Recreational Road in Newton, dropping the rightmost lane would not affect travel on I-95 northbound. An additional improvement would be to extend the short acceleration lane by about 200 feet. An on-ramp serving traffic from Route 30 westbound, located just downstream of the bottleneck location, would limit lengthening of the acceleration lane to some extent.

Alternative 2: Close the Route 30 Eastbound On-Ramp to I-95 Northbound

The objective of Alternative 2 is to reduce the existing on-ramp traffic volume at the merge by closing the Route 30 eastbound on-ramp to I-95 northbound. Figure 9 shows the improvements proposed in Alternative 2. In Alternative 2, traffic using the Route 30 eastbound on-ramp would tend to turn left to access the low-volume ramp located in the northeast quadrant of the interchange serving Route 30 westbound traffic heading to I-95 northbound. In addition, MPO staff recommend lengthening the existing acceleration by about 200 feet (as in Alternative 1).

Currently, there appears to be enough room on the Route 30 bridge to carry out these improvements. The width of Route 30 on the bridge, including the median, is about 75 feet, and there is about 320 feet of space available to install a left-turn bay. Generally, four 12-foot travel lanes (two in each direction of Route 30), a 12-foot eastbound left-turn bay, two 2-foot shoulders, a 6-foot median, and accommodation for lane markings would require a roadway width of 73 feet. MPO staff did not perform a signalized-intersection capacity analysis of the proposed changes, but we suggest that this analysis be carried out before making a recommendation.

Alternative 3: Restripe Lanes at the Bottleneck to Serve Demand Better; Close the Route 30 Eastbound On-Ramp to I-95 Northbound

Alternative 3 is a combination of Alternatives 1 and 2, and includes the objectives of both.

In addition to the three alternatives, MPO staff suggest that the MassDOT Highway Division review the lane configuration and assignment on the collector-distributor road for ways to better serve traffic demand on that road. MPO staff did not do this review, as it was beyond the scope of this study. There are two merge areas and a weave area on the section of the collector-distributor road after the traffic diverge to the Turnpike; these areas impede traffic flow heading to I-95 northbound and Route 30. Efficient and safe lane reconfiguration of the collector-distributor road would improve traffic flow and reduce queues on the Turnpike connector as well.

Benefits

The benefits of the alternatives were assessed qualitatively in terms of the costs and time frame for implementation. In addition, MPO staff used VISSIM traffic simulation software to quantify benefits of the alternatives in terms of capacity and queue length. The benefits of Alternatives 1, 2, and 3 are:

1. Each of the alternatives would fit into the existing roadway layout and would not require any widening of any sort.
2. Each of the alternatives would reduce the impact of the bottleneck.
    a. In Alternative 1, the high-volume traffic from the Turnpike and the collector-distributor road would enter I-95 northbound without merging with the traffic on the mainline. In addition, the low-volume traffic from Route 30 heading to I-95 northbound would have the exclusive use of the acceleration lane. A VISSIM analysis indicates that implementing Alternative 1 would increase capacity at the bottleneck location by about 250 vehicles per hour and would reduce a traffic queue on the Turnpike connector to the point where it merges with the collector-distributor road.
    b. In Alternative 2, closing the low-volume Route 30 eastbound ramp to I-95 northbound would eliminate the merge with traffic from the Turnpike and collector-distributor road and reduce the volume of traffic merging onto I-95 northbound by 250 vehicles per hour. It would also reduce a traffic queue on the Turnpike connector to the point where it merges with the collector-distributor road.
    c. In Alternative 3, analysis shows that implementing this alternative would increase capacity at the bottleneck location by about 250 vehicles per hour, reduce the volume of traffic merging onto I-95 northbound by 250 vehicles per hour, and eliminate the bottleneck.
3. Each of the alternatives is a low-cost and short-term improvement, would not require any bridge widening or lengthening, and could be implemented in a short time frame.

An important difference between the three alternatives is that in Alternatives 1 and 3, lane congruency with adjacent sections of I-95 northbound is lost (three travel lanes at the section where a travel lane is lost and four travel lanes upstream and downstream of that section). Alternative 2 maintains lane congruency on I-95 northbound. Lane congruency is a critical safety factor in freeway operations because it eliminates safety impacts that are associated with traffic merging at high speeds. However, in the case of Alternatives 1 and 3, the high volume of traffic exiting the freeway at exit 23 might justify the resulting lane incongruence.

Cost

Implementing Alternative 1 would cost between $2 million and $3 million and would require the following:

- Re-striping lanes
- Installing new overhead signs on gantries informing motorists of the lane drop
- Reconfiguring the ramps from Route 30 and the collector-distributor road
- Lengthening the acceleration lane on I-95 northbound

Implementing Alternative 2 would cost between $2 million and $3 million and would require the following:

- Making moderate geometric changes on the Route 30 bridge and its ramp-arterial junction east of I-95, as shown in Figure 9
- Installing new signal heads, modifying the existing signal phase plan to accommodate left turns, and retiming the traffic signal
- Installing signs to direct motorists on Route 30 to I-95 northbound
- Lengthening the acceleration lane on I-95 northbound

Implementing Alternative 3 would require constructing the improvements proposed in both Alternatives 1 and 2. Alternative 3 could be implemented in phases. This would provide time to conduct surveys to determine the structural capacity of the Route 30 bridge and additional analyses for Alternative 2. Phase I could be the implementation of Alternative 1, as it consists of restriping lanes and installing signs to guide motorists. It would cost roughly $4 million to $5 million to implement Alternative 3.

LOCATION 2: ROUTE 3 NORTHBOUND, MERGE AREA AT INTERCHANGE 17 IN BRAINTREE

This bottleneck is located at the merge area on Route 3 northbound at interchange 17 in Braintree. It is the location where traffic from Union Street merges with traffic on Route 3 northbound. Figure 10 shows the bottleneck location and the ramp configuration. There are three travel lanes, a 10-foot right shoulder, and a 6-foot left shoulder on Route 3 upstream and downstream of the bottleneck location. The acceleration lane for the on-ramp traffic is about 1,100 feet long.

Problem

During the AM peak period, a long traffic queue forms upstream of the bottleneck on Route 3 northbound. The queue extends about five miles upstream of the bottleneck to interchange 15 (Derby Street) in Hingham. During the PM peak period, there is no bottleneck, and traffic operates satisfactorily.

Causes

Three main factors contribute to this bottleneck. The first factor is high-volume traffic from Union Street that merges onto Route 3 northbound during the AM peak period. The second factor is high-volume traffic northbound on Route 3 during the AM peak period. Figure 11 shows that during the AM peak hour, about 1,800 vehicles per hour from Union Street and 4,700 vehicles per hour on Route 3 northbound pass through the bottleneck location. The combined 6,500 vehicles per hour is the capacity of the bottleneck (2,200 vehicles per hour per lane for the three travel lanes at the bottleneck location). Because traffic demand exceeds the capacity of the bottleneck, a long traffic queue forms upstream of the bottleneck location.
The third factor is a short merge area for the high-volume traffic from Union Street to merge onto Route 3 northbound. Route 3 was constructed in the 1950s to design standards of the time and does not meet today's stricter standards. The existing acceleration length of 1,100 feet appears to be adequate. However, this distance does not safely allow a vehicle to merge into the mainline because traffic volumes are high (at capacity) on Route 3 northbound and on the ramp, and the majority of the acceleration length achieved is on the ramp. The Highway Division's Project Development and Design Guide specifies that where the mainline and ramp carry traffic volumes approaching the design capacity of the merging area, the acceleration lane length should be extended by 200 feet or more.

Impacts

Figure 12 shows the 2008 AM peak-period average travel speeds, collected by MPO staff, upstream and downstream of the bottleneck on Route 3 northbound. Downstream of the bottleneck, traffic flows faster (45-54 mph). Upstream of the bottleneck, traffic flows slowly (under 34 mph, starting at exit 15 in Hingham). Figure 13 shows the collisions just upstream of the bottleneck. There were 59 crashes in 2006–08 near the bottleneck, and the majority of these crashes (75 percent) were rear-end collisions. The resulting crash rate for this section of Route 3 northbound is 1.01 crashes per million vehicle miles traveled (MVMT), which is higher than the average of 0.64 crashes per MVMT for urban interstate highways in the Commonwealth. Of the 59 crashes, 32 (54 percent) occurred during the AM peak period of travel (between 6:00 and 10:00 AM), when there are traffic queues upstream of the bottleneck.

Recommendations

The objective of the improvements for this location is to reduce the impacts of the bottleneck with low-cost improvements. To accomplish this, MPO staff developed two alternatives:

Alternative 1: Using a Short Section of the Shoulder as an Auxiliary Lane

This alternative calls for using a short section of the traffic-bearing right shoulder (about 1,500 feet) as an auxiliary lane to reduce the impacts of the bottleneck. The existing 10-foot right shoulder would have to be converted into a 12-foot travel lane for a distance of approximately 1,500 feet, and would be used exclusively by the on-ramp traffic to merge with traffic on Route 3. The auxiliary lane would end before the Route 3 bridge over the MBTA train tracks to avoid the need for bridge widening. Figure 14A shows the improvements.

Alternative 2: Constructing an Auxiliary Lane between Exits 17 and 19

This alternative calls for constructing an auxiliary lane (fourth lane) on Route 3 northbound for a distance of approximately 1.3 miles beginning from the merge area at interchange 17 and terminating at the diverge area at interchange 19 to increase capacity at the bottleneck. Alternative 2 would require widening of the existing right shoulder from 10 feet to 12 feet plus a 2-foot shoulder into an auxiliary lane. The auxiliary lane would be used exclusively by Union Street traffic to merge with traffic on Route 3 and for traffic to exit Route 3 at interchange 19 (MBTA Quincy Adams Station, at Burgin Parkway). Figure 14B shows the improvements.

Benefits

The benefits of Alternatives 1 and 2 were assessed qualitatively in terms of the costs and time frames for implementation. In addition, MPO staff used VISSIM traffic simulation software to quantify the benefits associated with the proposed auxiliary lane.

The benefits of Alternative 1 are:

1. It would require minimal widening and would fit into the existing roadway layout.
2. This is a low-cost and short-term improvement; it can be implemented in a short time frame.
3. It would make it easier for traffic to merge onto Route 3 northbound.

Regardless of the above benefits, analysis shows that Alternative 1 would not eliminate the bottleneck and it is not a feasible alternative. At the end of the auxiliary lane, traffic would have to merge into three travel lanes on Route 3 northbound. During the AM peak hour, demand at the end of the auxiliary lane, where traffic would merge into three travel lanes, would exceed the capacity of the bottleneck (which is between 6,000 and 6,600 vehicles per hour). As a result, Alternative 1 would move the bottleneck to another location (at the end of the auxiliary lane). Analysis indicates there would be a long traffic queue on Route 3 northbound up to interchange 15 (Derby Street).

The benefits of Alternative 2 are:

1. It would make it easier for traffic to merge onto Route 3 northbound.
2. It would reduce the AM northbound traffic queue on Route 3 significantly, and could potentially eliminate the bottleneck. Our analysis did not indicate any significant traffic queue on Route 3 northbound in the AM peak hour.
3. It would maintain lane congruency on Route 3 northbound.

Alternative 2 is not a short-term improvement; it might require environmental review because of its length, location, and cost (Alternative 2 would require widening three bridges). In addition, the costs of Alternative 2 (between $20 million and $25 million) preclude its being a viable low-cost solution at this location.

Cost

Implementing Alternative 1 would cost between $4 million and $5 million and would require the following improvements:

- Widening the existing 10-foot shoulder into a 12-foot auxiliary lane plus a 2-foot shoulder for a distance of about 1,500 feet
- Relocating four catch basins and the existing guardrail
- Installing new merge signs

Implementing Alternative 2 would cost between $20 million and $25 million and would require the following:

- Widening the existing 10-foot shoulder into a 12-foot auxiliary lane for a distance of about 1.3 miles
- Widening three bridges in its path
- Relocating catch basins, guardrails, and sign gantries

Alternative 1 is low-cost but does not relieve the bottleneck; it simply moves it downstream. Alternative 2 relieves the bottleneck significantly but is not a low-cost solution. It therefore appears that there is no viable low-cost solution at this location.

LOCATION 3: I-95 NORTHBOUND, EXIT AND ENTRANCE RAMP AT INTERCHANGE 32 IN BURLINGTON

This bottleneck is located on I-95 northbound at interchange 32 in Burlington, where traffic exits onto Route 3 and Middlesex Turnpike. There are four travel lanes, a 10-foot traffic-bearing right shoulder, and a 4-foot left shoulder on the I-95 northbound stretch passing through interchange 32. The length of the deceleration lane for traffic exiting onto Route 3 and Middlesex Turnpike is about 800 feet long. The acceleration lane for traffic entering I-95 northbound from Route 3 and Middlesex Turnpike is about 800 feet long. Figure 15 shows the location of the bottleneck and the exit ramp configuration near it.

Problem

There is recurring congestion upstream of the bottleneck location during PM peak periods; it backs up traffic for several miles and affects the traffic operations of other upstream interchanges. During the AM peak period, there is no congestion near the bottleneck location.

Causes

The primary factor contributing to the formation of this bottleneck is the high volume of traffic on I-95 northbound that exits to Route 3 northbound and Middlesex Turnpike during the PM peak period. Figure 16 shows the 2007 PM peak-period traffic volumes on I-95 northbound and the off- and on-ramps near the bottleneck. According to the figure, about 2,600 vehicles per hour exit from I-95 northbound to Route 3 and Middlesex Turnpike during the PM peak hour.

It should be noted that the existing single-lane exit ramp could not handle 2,600 vehicles per hour continuously for three hours, as shown in Figure 16. What happens at the exit ramp during the PM peak hours when there is congestion on I-95 northbound is that some motorists use this single-lane exit ramp as a two-lane exit ramp—hence the higher-than-usual traffic volumes that were counted on the exit ramp. Because the volume of traffic exiting I-95 northbound exceeds the capacity of a single-lane exit ramp, the rightmost of the four travel lanes is jammed with vehicles exiting I-95, and some motorists resort to using the lane next to the rightmost lane to exit I-95 as well. This occurrence leaves less than three full lanes on I-95 northbound for serving traffic heading straight on I-95, causing recurring congestion upstream from the diverge location.

In addition, during the PM peak period, a high volume of traffic (2,200 vehicles per hour) from Route 3 and Middlesex Turnpike merge onto I-95 northbound a short distance downstream of the bottleneck. The high-volume merge also contributes to the formation of a traffic queue on the collector-distributor road. I-95 (Route 128) was constructed in the 1950s to design standards of the time and does not meet the stricter standards in use today. The existing acceleration length of about 800 feet appears to be inadequate for current standards. The Highway Division's Project Development and Design Guide specifies a minimum acceleration length of 1,230 feet for a freeway facility with a design speed of 70 mph and an entrance-curve design speed of 35 mph. These distances may not safely allow a vehicle to merge into the mainline because traffic volumes are high on I-95 northbound and at capacity on the on-ramp. The Project Development and Design Guide specifies that where the mainline and ramp carry traffic volumes approaching the design capacity of the merging area, the acceleration lane length should be extended by 200 feet or more.

Impacts

Figures 17 and 18 show AM and PM average travel speeds collected by MPO staff on I-95 near the bottleneck in 2005. Figure 17 shows no traffic bottleneck at the location during the AM peak period because average travel speeds are over 55 mph upstream and downstream of the bottleneck on I-95 northbound.

The average travel speeds shown in Figure 18 indicate a traffic bottleneck during the PM peak period on I-95 northbound because the average travel speed is less than 40 mph upstream of the bottleneck and over 50 mph downstream of the bottleneck. A traffic queue that forms because of the bottleneck backs up for about three miles, affecting other interchanges upstream.

Figure 19 shows the crashes near the bottleneck on I-95 northbound. There were 42 crashes near the off-ramp (section 1), 7 crashes near the on-ramp (section 3), and 76 crashes in between the off- and on-ramp (section 2) during the period 2006–08. The resulting crash rate for this segment of I-95 northbound near the bottleneck is 0.84 crashes per million vehicle miles traveled (MVMT), which is higher than the average of 0.64 crashes per MVMT for urban interstate highways in the Commonwealth. Between 72 and 82 percent of the crashes in each of the sections were rear-end crashes, which are typically attributed to traffic congestion or queuing. None of these crashes involved a fatality; all of them involved injury and property-damage-only.

Recommendations

The objective of the improvements proposed for addressing this bottleneck was to reduce the impacts on through traffic northbound on I-95 of traffic diverging and merging. To accomplish this objective, MPO staff recommend the following:

1. **Improvements at the exit ramp:** Add a fifth lane on I-95 northbound for a distance of approximately 1,500 feet beginning just north of the Grove Street underpass to eliminate the need for any bridge widening.

   Extend the collector-distributor road approximately 1,500 feet farther south and provide a two-lane exit for the exclusive use of traffic exiting to Route 3 northbound and Middlesex Turnpike. (The existing distance between the Grove Street bridge and the gore of the I-95 exit ramp is about 3,300 feet. This space is adequate to accommodate the fifth lane on I-95 and to allow the collector-distributor road to be extended farther south. The new length of the deceleration lane onto the extended collector-distributor road should be 600 feet, assuming a design speed of 70 mph for I-95 and an average exit curve speed of 30 mph.)

   Provide a 10-foot shoulder or median with a median barrier (Jersey barrier) between the collector-distributor road and the mainline.

   Figure 20 shows the recommended improvements. These improvements would provide adequate capacity for the traffic exiting I-95 northbound and, as a result, would reduce the impact of the bottleneck significantly.

2. **Improvements at the entry ramp:** Use a section of the traffic-bearing right shoulder (approximately 1,000–1,500 feet) as an auxiliary lane for use by traffic entering I-95 northbound from the collector-distributor road and add a 10-foot shoulder. Figure 21 shows the recommended improvement. With the improvement, traffic from Route 3 northbound and Middlesex Turnpike entering I-95 northbound would use the auxiliary lane and would have ample distance to merge with traffic on I-95 northbound.

Benefits

The benefits of the two-lane exit ramp and the auxiliary lane for the traffic entering I-95 northbound were assessed qualitatively in terms of the costs and time frame for implementation. In addition, MPO staff used VISSIM traffic simulation software to quantify the benefits associated with the proposed auxiliary lanes.

The following are the benefits of the two-lane exit ramp:

1. It would fit into the existing roadway layout. The current right-of-way width for I-95 is about 300 feet.
2. It would reduce the impact of the bottleneck. A VISSIM analysis indicates that providing a two-lane exit ramp and extending the collector-distributor road would increase the

capacity at the bottleneck by 300 vehicles per hour northbound on I-95 and would likely eliminate the bottleneck.

3. It is a low-cost and short-term improvement; it can be implemented in a short time frame.
4. It would maintain lane congruency on I-95 northbound.
5. It would require only moderate widening

The following are the benefits of the auxiliary lane:

1. It would require only minimal widening of the existing right shoulder into a 12-foot auxiliary lane and a 2-foot shoulder for a distance of 1,000–1,500 feet.
2. It would fit into the existing roadway layout.
3. It would reduce the impact of the bottleneck. A VISSIM analysis indicates that extending the acceleration lane would increase the capacity at the bottleneck by 200 vehicles per hour northbound on I-95 and would reduce the queue on the collector-distributor road.
4. It is a low-cost and short-term improvement, and it could be implemented in a short time frame.

At this planning stage of the project, the only work expected to be necessary related to potential environmental impacts would be for the protection of the Turning Mill Pond, located along I-95 northbound north of Grove Street in Lexington.

Cost

Implementing the improvements recommended for the two-lane exit ramp would cost between $8 million and $10 million and would require the following:

- Adding a fifth lane on I-95 northbound for a distance of approximately 1,500 feet
- Constructing a two-lane collector-distributor road of approximately 1,500 feet
- Constructing a 10-foot shoulder between the mainline and the collector distributor road
- Relocating and/or installing guardrails, catch basins, and signs gantries in the area
- Installing new signs to direct motorists to Route 3 and the Middlesex Turnpike

Implementing the auxiliary lane recommended for the entering traffic would cost between $2 million and $3 million and would require the following:

- Converting the 10-foot traffic-bearing right shoulder into a 12-foot travel lane for a distance of approximately 1,000 –1,500 feet
- Relocating the guardrail and sign gantries in the project area

LOCATION 4: ROUTE 3 SOUTHBOUND, LANE-DROP AT THE HINGHAM-WEYMOUTH TOWN LINE

This bottleneck is located on Route 3 southbound at the Weymouth-Hingham town line, where the number of travel lanes decreased from three to two. In addition, it is the location where motorists begin traveling in the right shoulder during the PM peak travel period (3:00–7:00 PM). Outside of the PM peak-travel period, motorists merge into two travel lanes from three lanes and are not allowed to travel on the shoulder. Figure 22 shows the bottleneck location and the lane-drop.

Problem

The lane drop causes a bottleneck that reduces travel speeds on Route 3 southbound during the PM peak period.

Causes

During PM peak periods, when the shoulder is open to traffic, motorists in the rightmost lane are advised to travel on the right shoulder as much as possible to reduce congestion. However, a significant proportion of motorists in the rightmost lane choose to merge into two travel lanes because of the existing pavement striping at the lane drop (which is designed to have that effect), as they are supposed to during the off-peak period. The merging that takes place because of the lane drop and existing pavement striping slows traffic and results in a traffic queue. There are signs adjacent to the right shoulder that advise motorists to travel in the right shoulder during the PM s; however, these signs do not appear to effectively convey the intended message to motorists.

Impacts

Field observations confirmed that the shoulder lane on Route 3 southbound is underutilized in comparison to shoulder-lane use on I-95/Route 128. Data on average PM peak period travel speeds collected by MPO staff on Route 3 southbound indicate speeds between 45 and 55 mph upstream from the bottleneck and 60 mph or more downstream from the bottleneck.

Recommendations

The objective of the improvements recommended by MPO staff to address the problem is to give motorists advance notice that the shoulder lane is open to traffic a short distance downstream (about 500 feet) and direct motorists in the three travel lanes upstream to transition into two travel lanes and the shoulder lane downstream with minimal interruption.

To accomplish this, MPO staff suggest the following improvements:

1. Installing a shoulder-use sign about 500 feet upstream of the lane-drop to inform motorists that the shoulder lane is open to traffic (Figure 23).
2. Installing a shoulder-lane-control signal at the lane drop where the motorists are permitted to begin to travel in the shoulder lane (Figure 24). The green arrow in the

figure points to the middle of the shoulder lane. This type of shoulder-lane-control signal is recommended by MUTCD and is presently in use on I-66 in Virginia.

3. Restriping the merge area to show motorists how to transition into the shoulder lane during the PM peak period (Figure 25).

Benefits

The proposed improvements have several benefits.

1. They would not require any widening.
2. They would fit into the existing roadway layout.
3. They are low-cost and short-term improvements; they can be implemented in a short time frame.

Cost

Implementing the recommended improvements would cost $2 million and would require the following:

- Restriping of the merge area to show how motorists should use it during the PM peak period when the right shoulder is open to traffic.
- Installing an overhead shoulder-lane-control signal
- Installing overhead variable message signs

NEXT STEPS

The steps that should follow this planning study are:

- Perform further review the MPO staff recommendations.
- Initiate projects through MassDOT and the MPO process.
- Advance projects to the design phase.

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APPENDIX

LIST OF FIGURES

COMMENTS FROM HIGHWAY DIVISION'S DISTRICT 6 AND MPO STAFF RESPONSES

Location 1: I-95 Northbound, Ramp Merge Area at Interchange 24 in Weston

- The project should be implemented in phases. This would provide time to conduct surveys to determine the structural capacity of the Route 30 bridge and additional analyses for Alternative 2.

  Response: Staff agree with this recommendation. Phase I should be the implementation of Alternative 1, as it consists of restriping lanes and installing signs to guide motorists.

- Could the present lane assignment of the collector-distributor road be reviewed as part of this study?

  Response: MPO staff did not do this review, as it was beyond the scope of this study. There are two merge areas and a weave area on the section of the collector-distributor road after the traffic diverge to the Turnpike; these areas impede traffic flows heading to I-95 northbound and Route 30. Efficient and safe lane reconfiguration of the collector-distributor road would improve those traffic flows and also improve traffic flows and reduce queues on the Turnpike connector.

- What are the lengths of queues that will be expected to form at the approaches to the Route 30 traffic signals?

  Response: MPO staff did not perform a signalized-intersection capacity analysis of the proposed changes, but we suggest that this analysis be carried out before making a decision regarding improvements at this location.

COMMENTS FROM HIGHWAY DIVISION'S DISTRICT 4 AND MPO STAFF RESPONSES

Location 3: I-95 Northbound, Exit and Entrance Ramps at Interchange 32 in Burlington

- How much farther south will the collector-distributor road be extended?

  Response: The distance between the Grove Street bridge and the gore of the I-95 exit ramp is about 3,300 feet. This space is adequate to accommodate a fifth lane on I-95 and a parallel deceleration lane for a total distance of 1,500 feet and to allow the collector-distributor road to be extended about 1,500 feet farther south.

- What is the length of the deceleration lane for the exit ramp?

  Response: The length of the proposed deceleration lane from I-95 onto the collector-distributor road is 600 ft. This was calculated assuming a design speed of 70 mph for I-95 and an average exit curve speed of 30 mph.

- Will a disabled vehicle be able to safely pull off the ramp with a 2-foot shoulder?

  Response: The shoulder width will be increased to 10 feet to accommodate disabled vehicles. There appears to be space to accommodate a 10-foot shoulder.

- Shoulder width is less than 2 feet for a distance of 1,000–1,500 feet. Would a design exception be required?

  Response: The shoulder width of the auxiliary will be increased to 10 feet.

- Improvements include a 10-foot shoulder or median between the collector road and the mainline. Should it be a 10-foot shoulder with a median barrier between the collector road and the shoulder?

  Response: A 10-foot shoulder with a median barrier (Jersey barrier) between the collector-distributor road and the mainline shoulder will be proposed.

- What type of environmental impacts are anticipated? Will the Burlington Conservation Commission need to sign off on the project?

  Response: At this planning stage of the project, the only work expected to be necessary related to potential environmental impacts would be for the protection of the Turning Mill Pond, located along I-95 northbound north of Grove Street in Lexington.

  The project area is located partly in Lexington and partly in Burlington. The question regarding Burlington Conservation Commission would need to be addressed in a functional design report and 25% design submission. At that stage, detailed information concerning the project would have been assembled through surveys and design plans.

- What type of condition is the bridge in? Does general maintenance make sense or are there structural deficiencies that may need to be corrected at the time of construction?

  Response: None of the bridges over I-95 in the project area is functionally obsolete. The Grove Street bridge has an AASHTO rating of 56.6; the Route 3 NB bridge has an AASHTO rating of 83; the Route 3 SB bridge has an AASHTO rating of 95. MassDOT Highway Division’s project information database has no bridge maintenance projects at these locations.

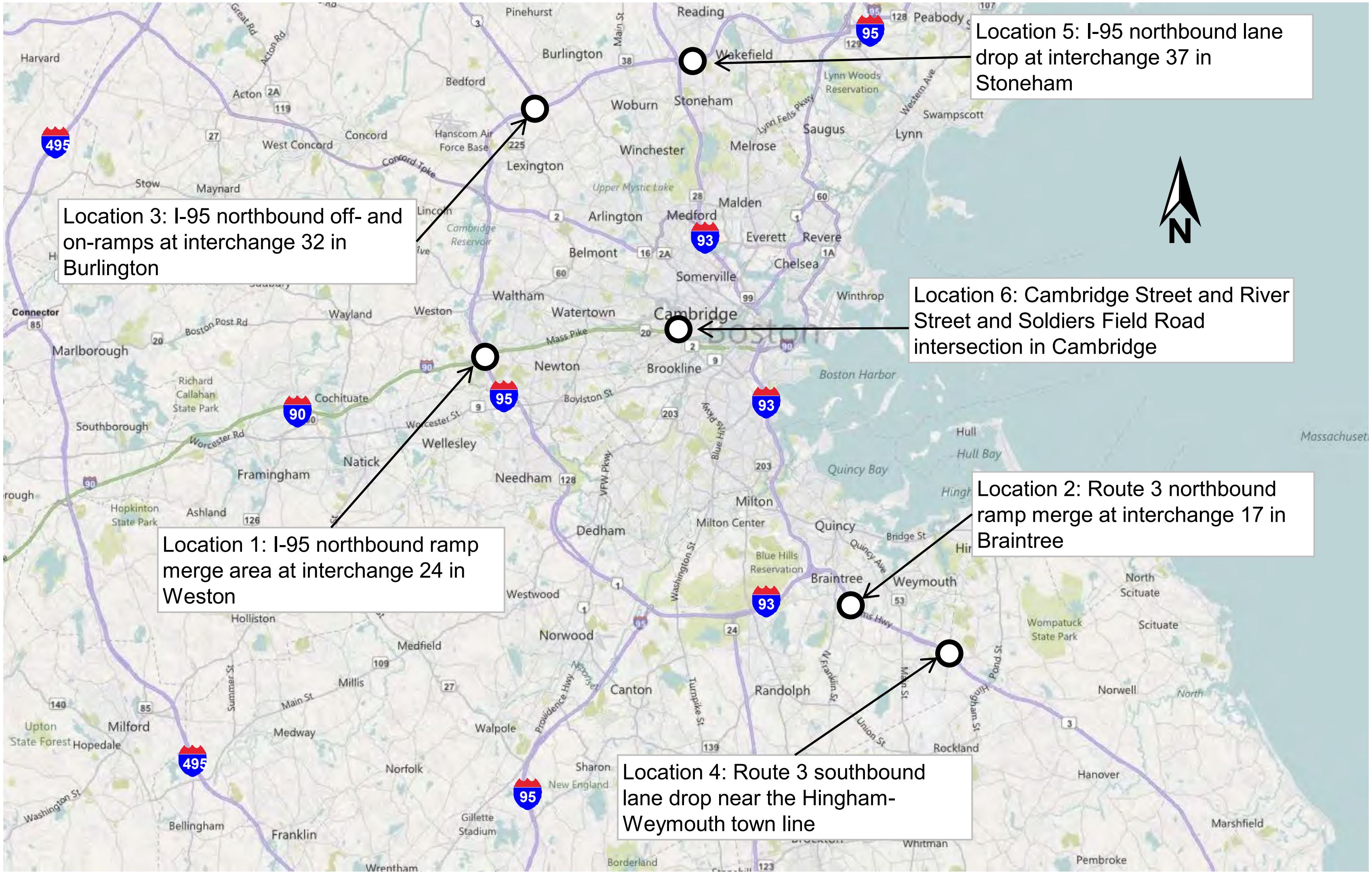

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FIGURE 1
Candidate Bottleneck Locations

Low-Cost Bottleneck Improvements

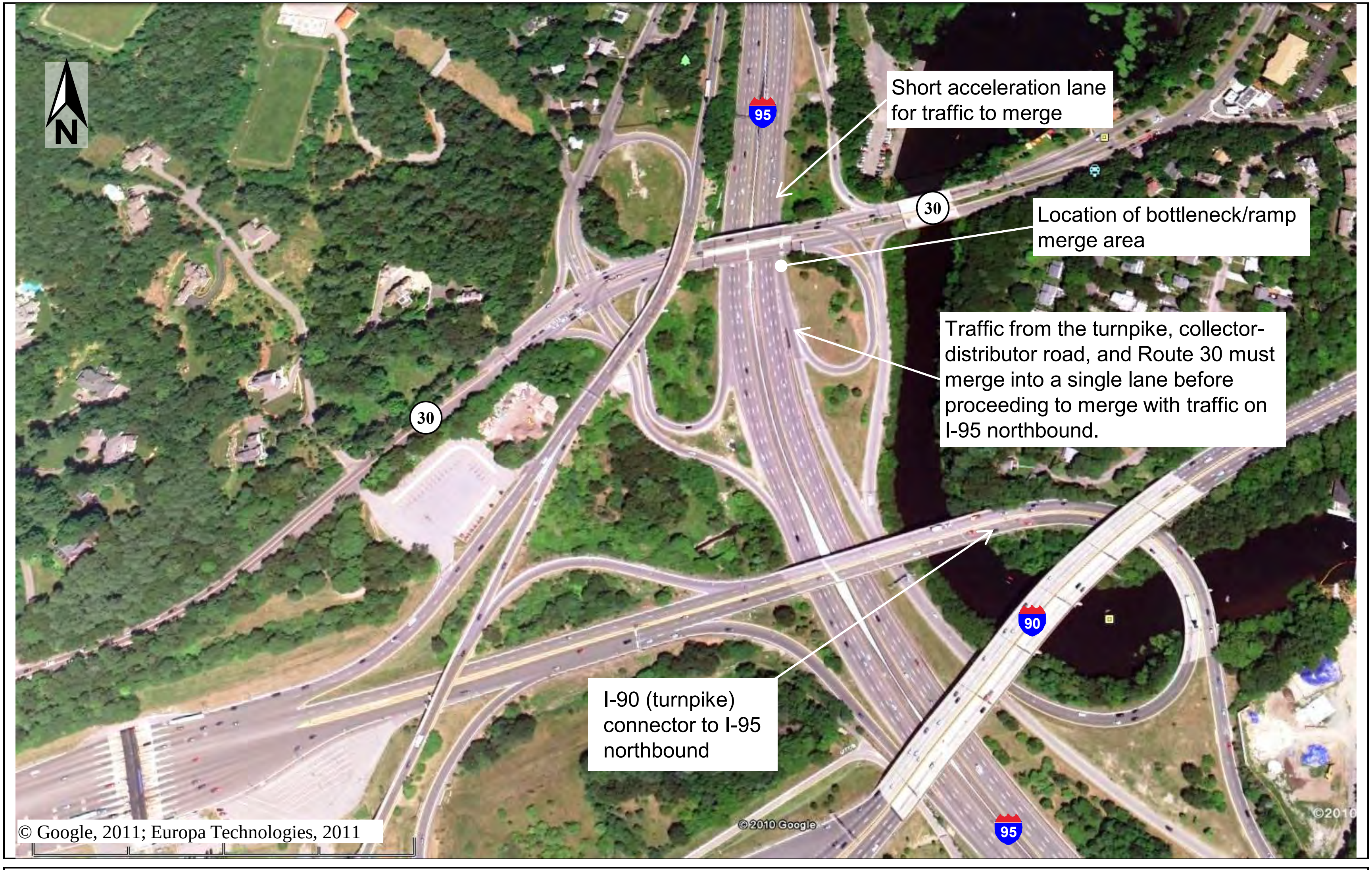

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FIGURE 2
Location of Bottleneck on I-95 Northbound at Interchange 24 in Weston

Low-Cost Bottleneck Improvements

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FIGURE 3
I-95 Northbound Travel Lanes and Acceleration Lane under Route 30 Bridge in Weston

Low-Cost Bottleneck Improvements

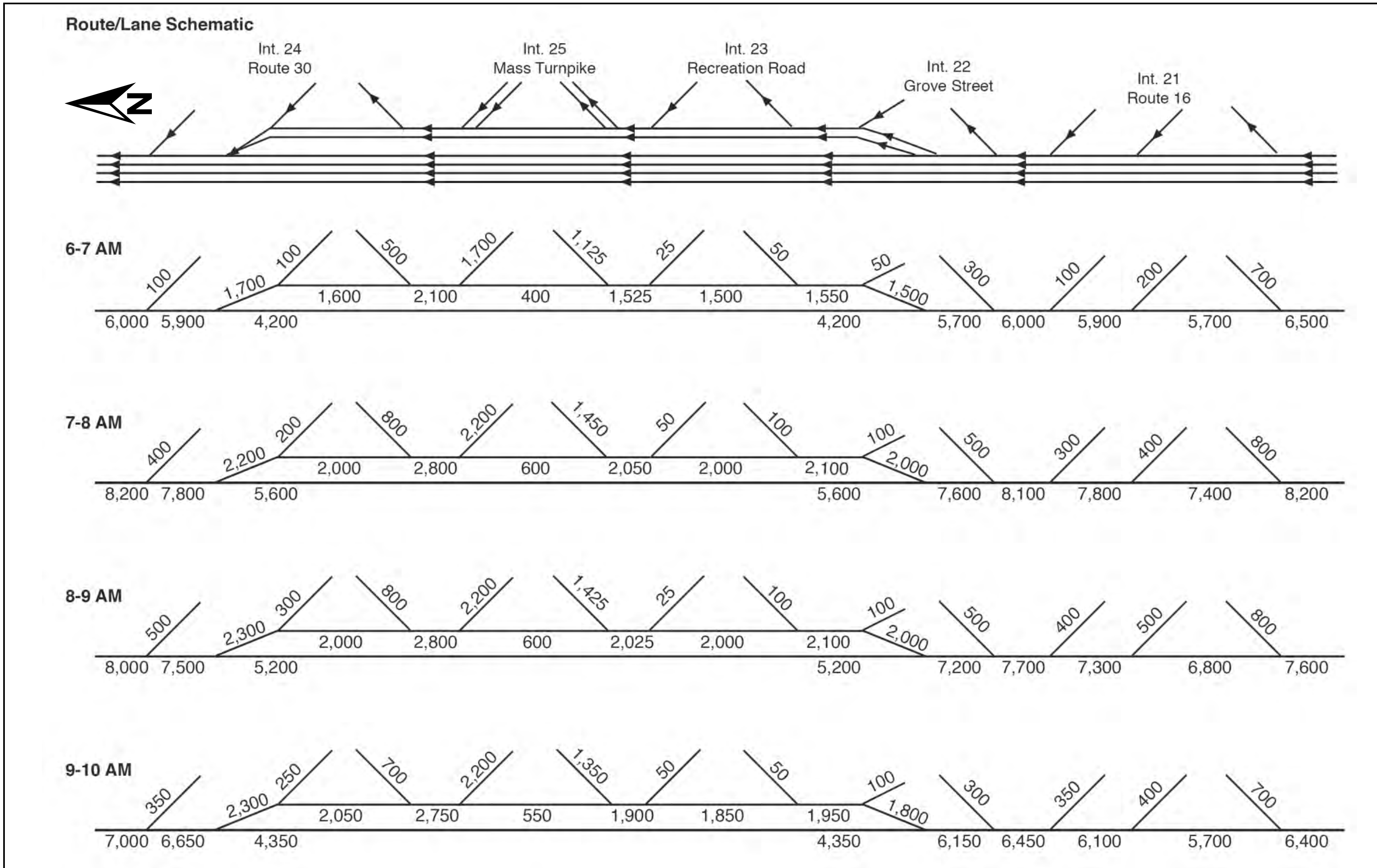

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FIGURE 4
2007 AM Peak-Period Traffic Volumes
on I-95 Northbound near the Bottleneck

Low-Cost
Bottleneck
Improvements

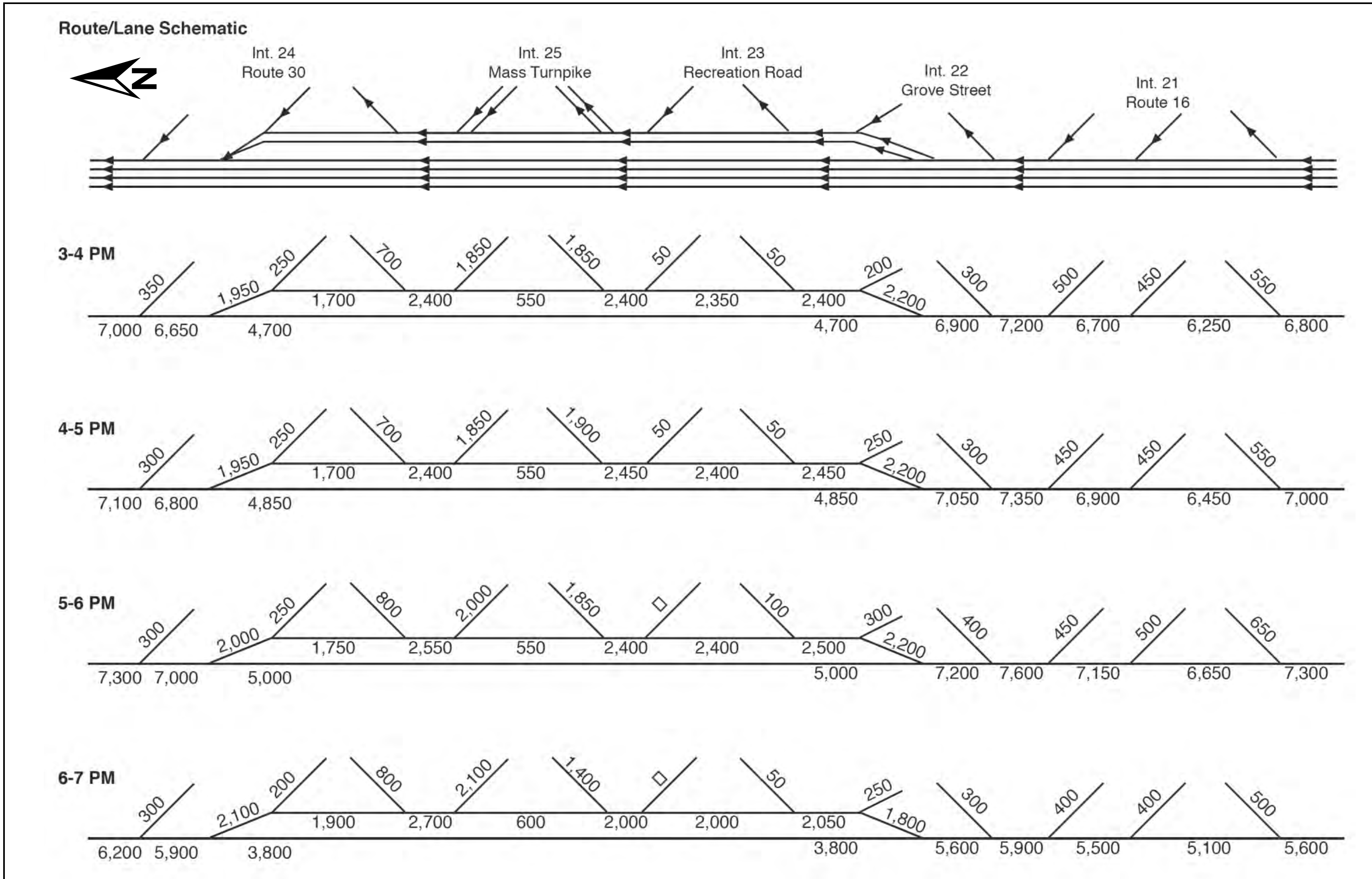

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FIGURE 5
2007 PM Peak-Period Traffic Volumes on I-95 Northbound near the Bottleneck

Low-Cost Bottleneck Improvements

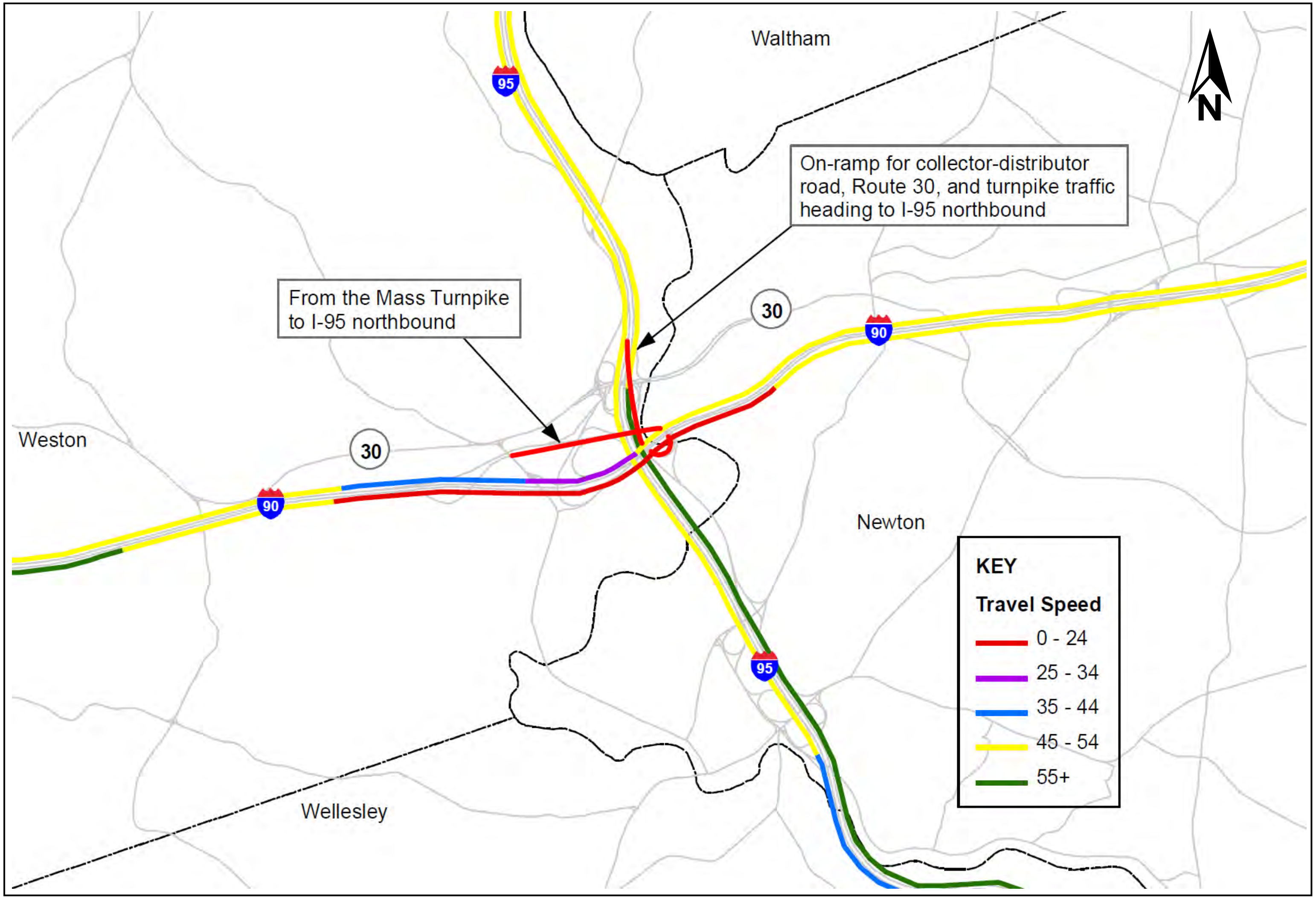

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FIGURE 6
2005 PM Peak-Period Travel Speeds on I-95 Northbound near the Bottleneck

Low-Cost Bottleneck Improvements

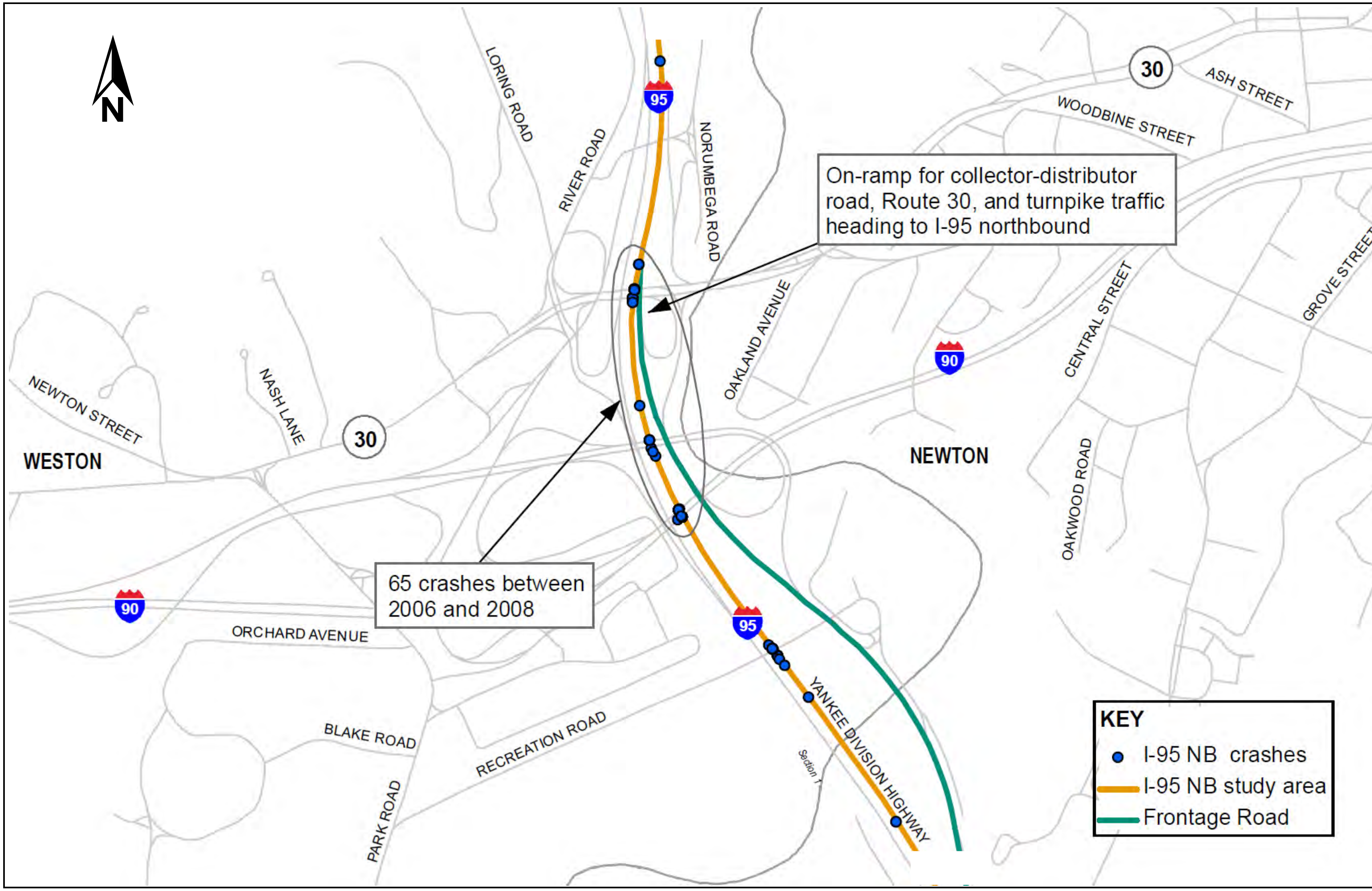

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FIGURE 7
Crashes on I-95 Northbound near the Bottleneck, 2006–08

Low-Cost Bottleneck Improvements

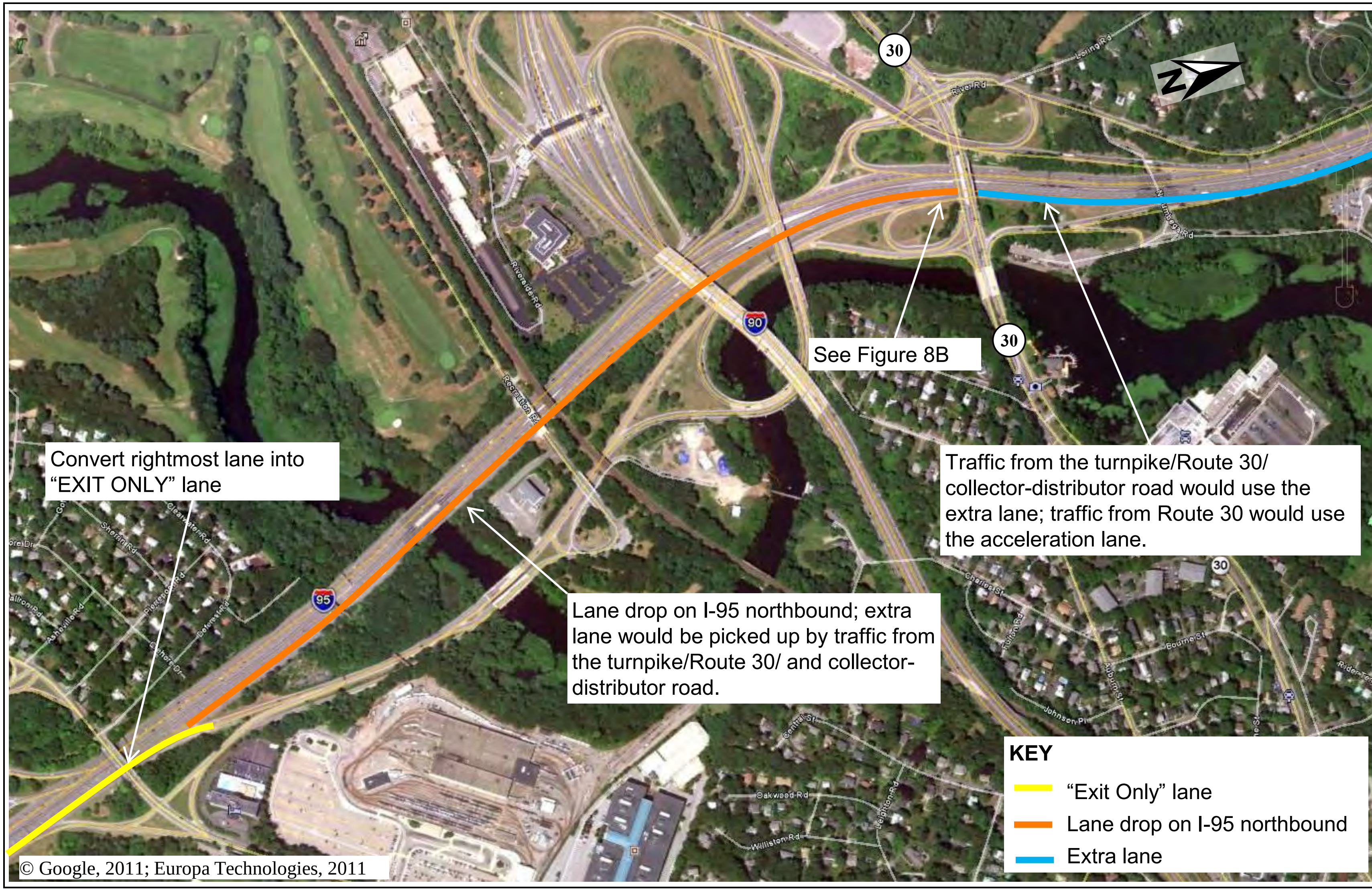

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FIGURE 8A
Alternative 1: Drop the Rightmost Lane on I-95 Northbound and Reconfigure Collector-Distributor Road to Pick Up Extra Lane

Low-Cost Bottleneck Improvements

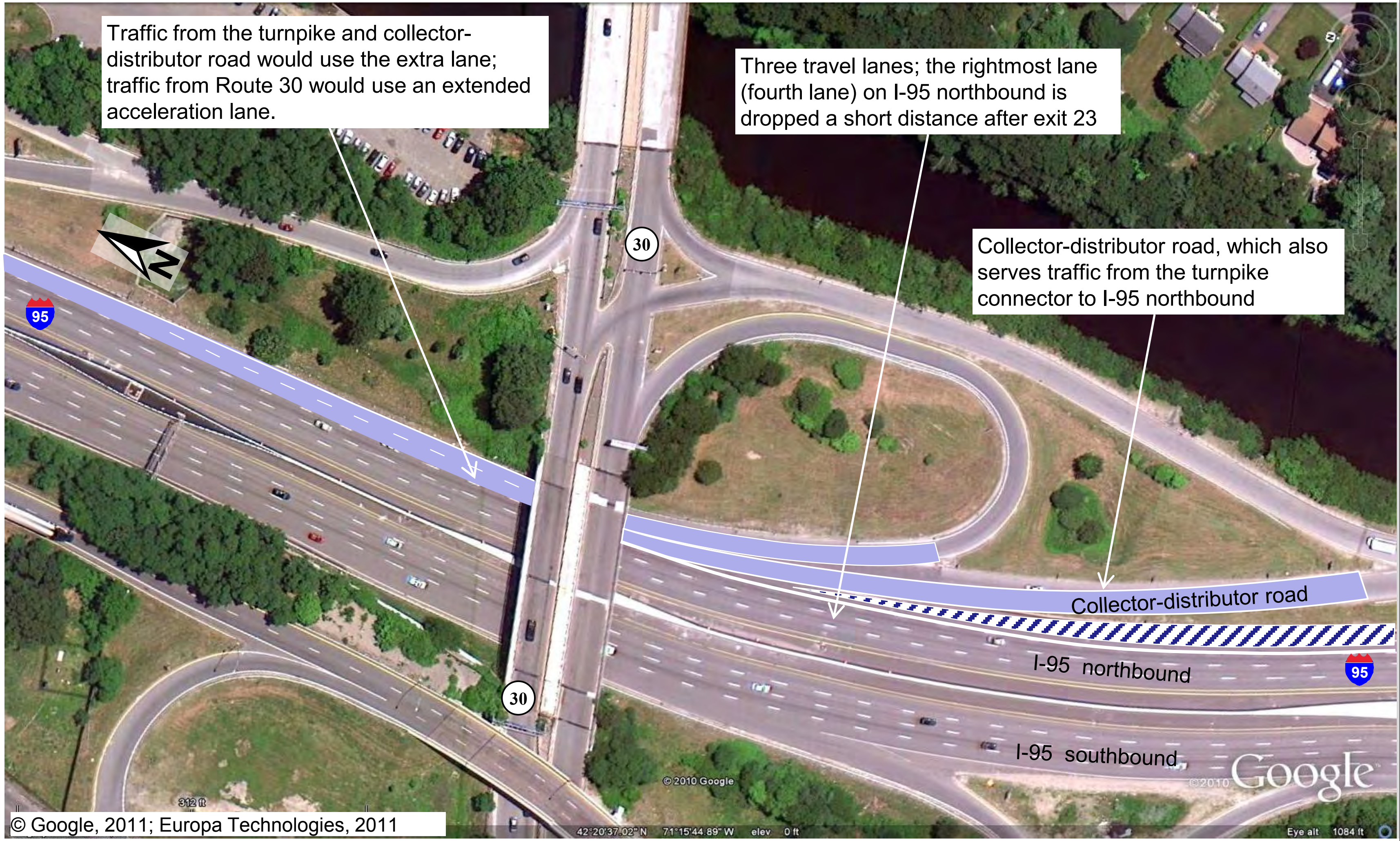

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FIGURE 8B
Alternative 1: Detail of Proposed Improvement near the Bottleneck

Low-Cost Bottleneck Improvements

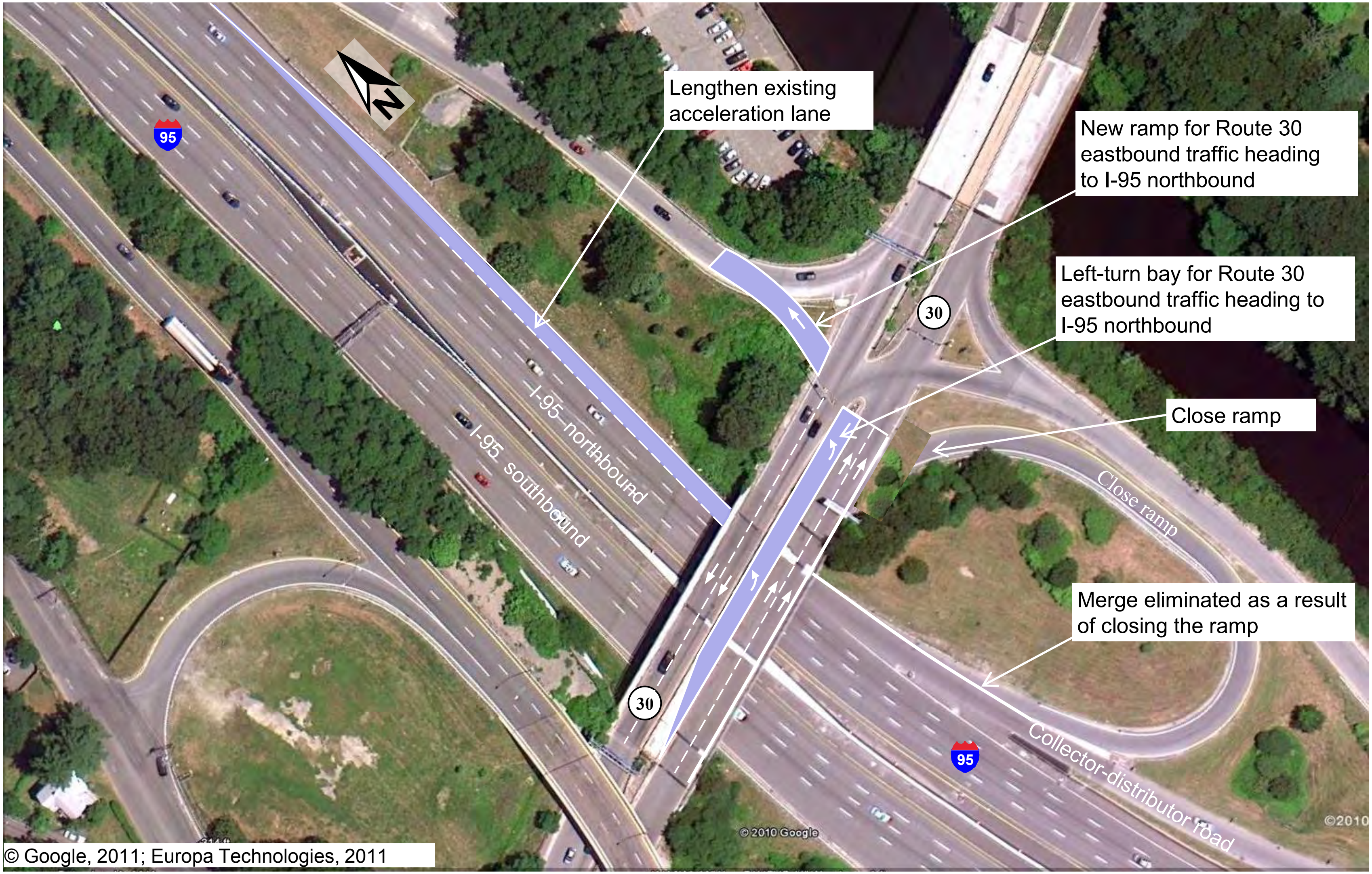

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FIGURE 9
Alternative 2: Close Route 30 Eastbound Ramp to I-95 Northbound

Low-Cost Bottleneck Improvements

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FIGURE 10
Location of Bottleneck on Route 3 Northbound at Interchange 17 in Braintree

Low-Cost Bottleneck Improvements

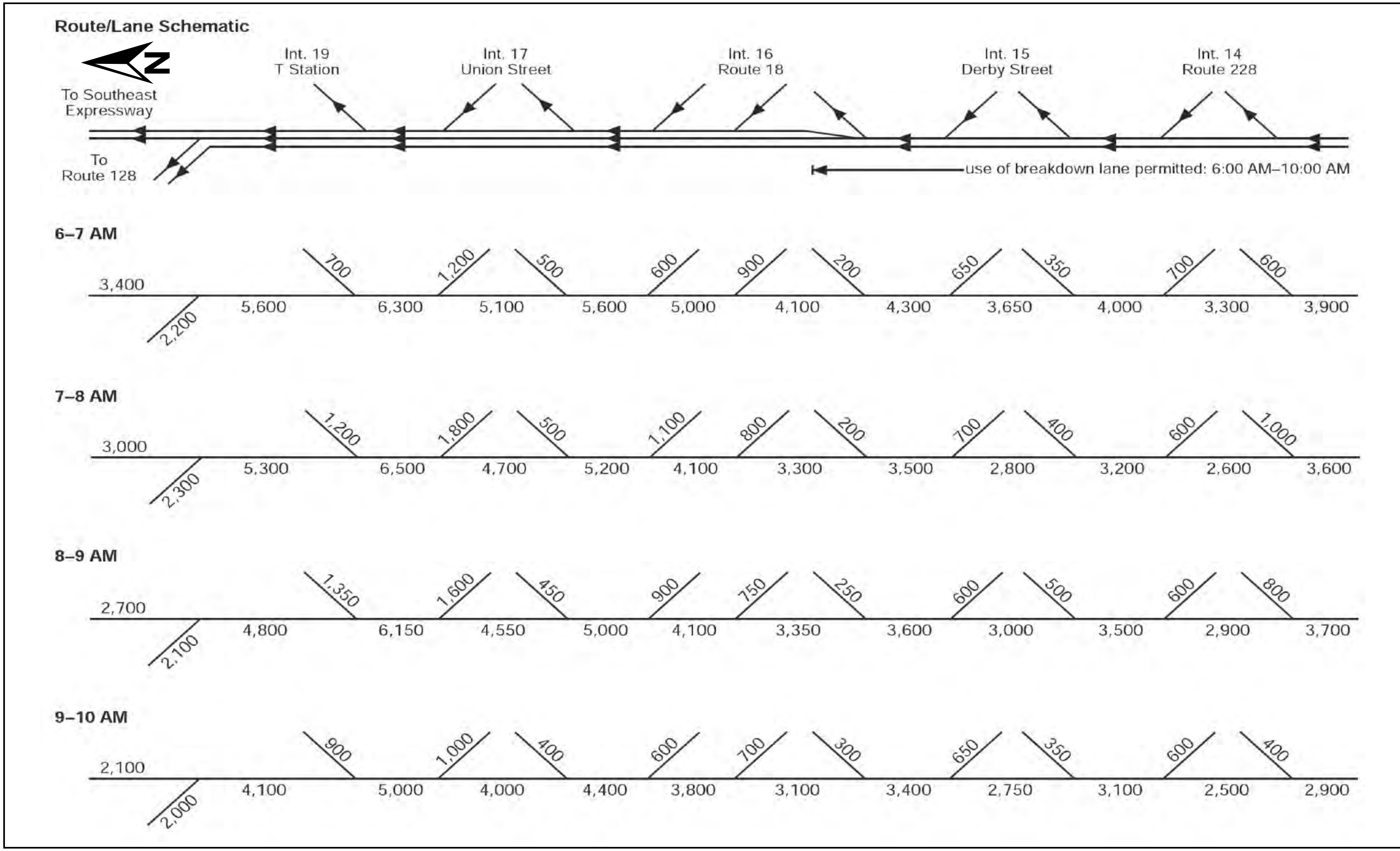

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FIGURE 11
2008 AM Peak-Period Traffic Volumes on Route 3 Northbound near the Bottleneck at Interchange 17 in Braintree

Low-Cost Bottleneck Improvements

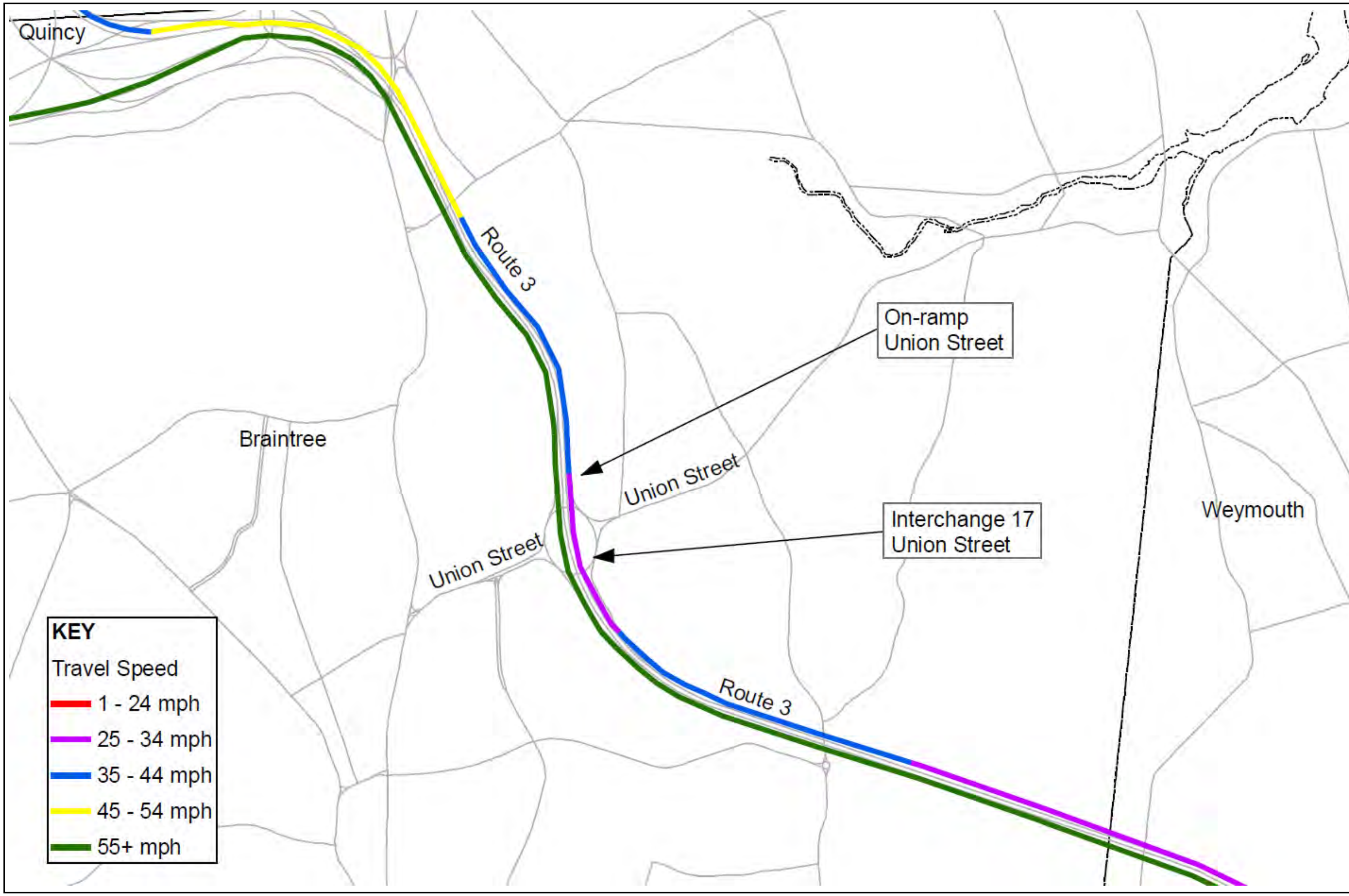

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FIGURE 12
2004 AM Peak-Period Travel Speeds on Route 3 Northbound near the Bottleneck

Low-Cost Bottleneck Improvements

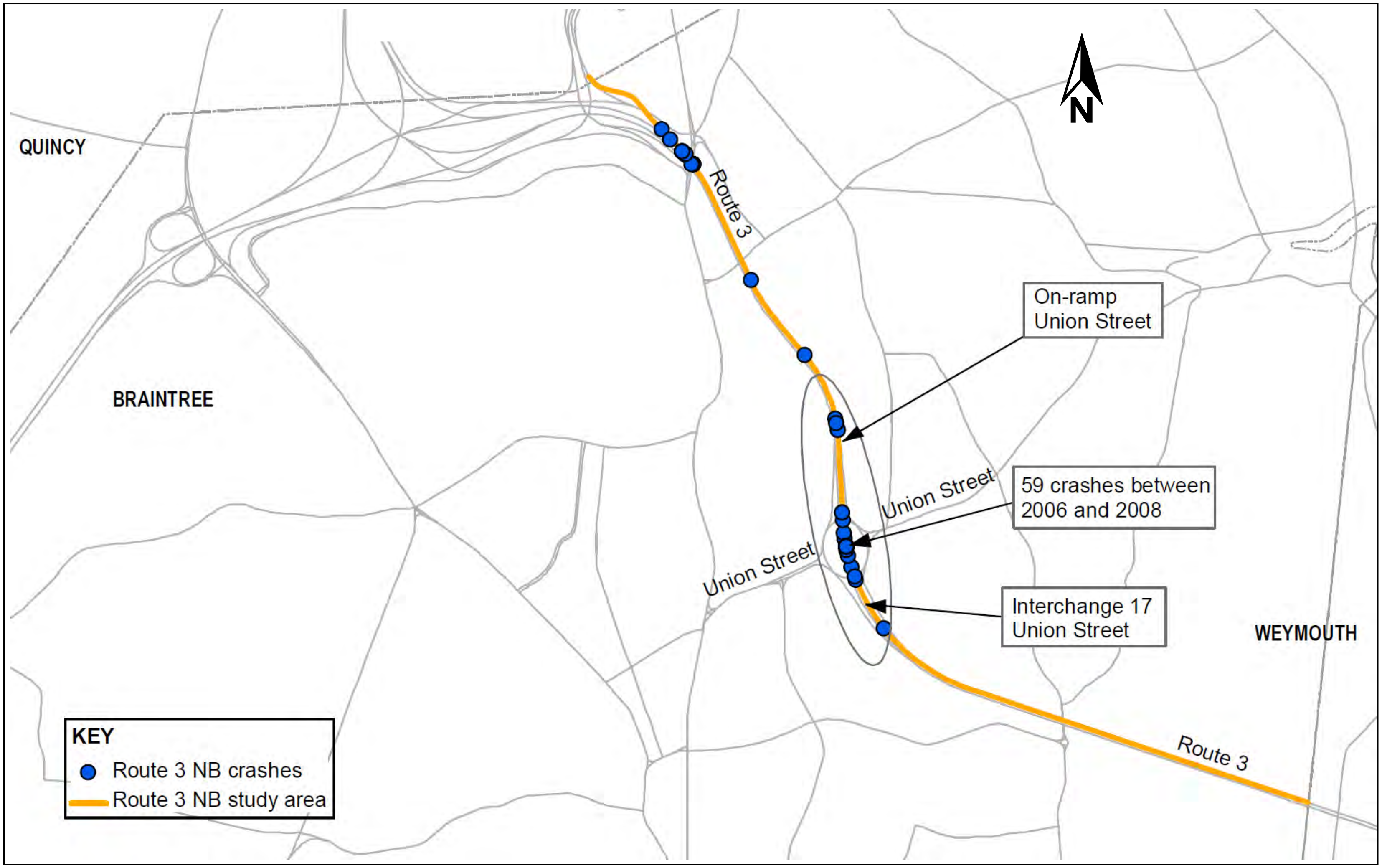

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FIGURE 13
Crashes on Route 3 Northbound near the Bottleneck at Interchange 17 in Braintree, 2006–08

Low-Cost Bottleneck Improvements

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FIGURE 14A
Alternative 1: Use a Short Section of the Right Shoulder as an Auxiliary Lane on Route 3 Northbound

Low-Cost Bottleneck Improvements

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FIGURE 14B
Alternative 2: Add an Auxiliary Lane (Fourth Lane) on Route 3 Northbound between Interchanges 17 and 19

Low-Cost Bottleneck Improvements

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FIGURE 15
Location of Bottleneck and Configuration of Ramps at Interchange 32 in Burlington

Low-Cost Bottleneck Improvements

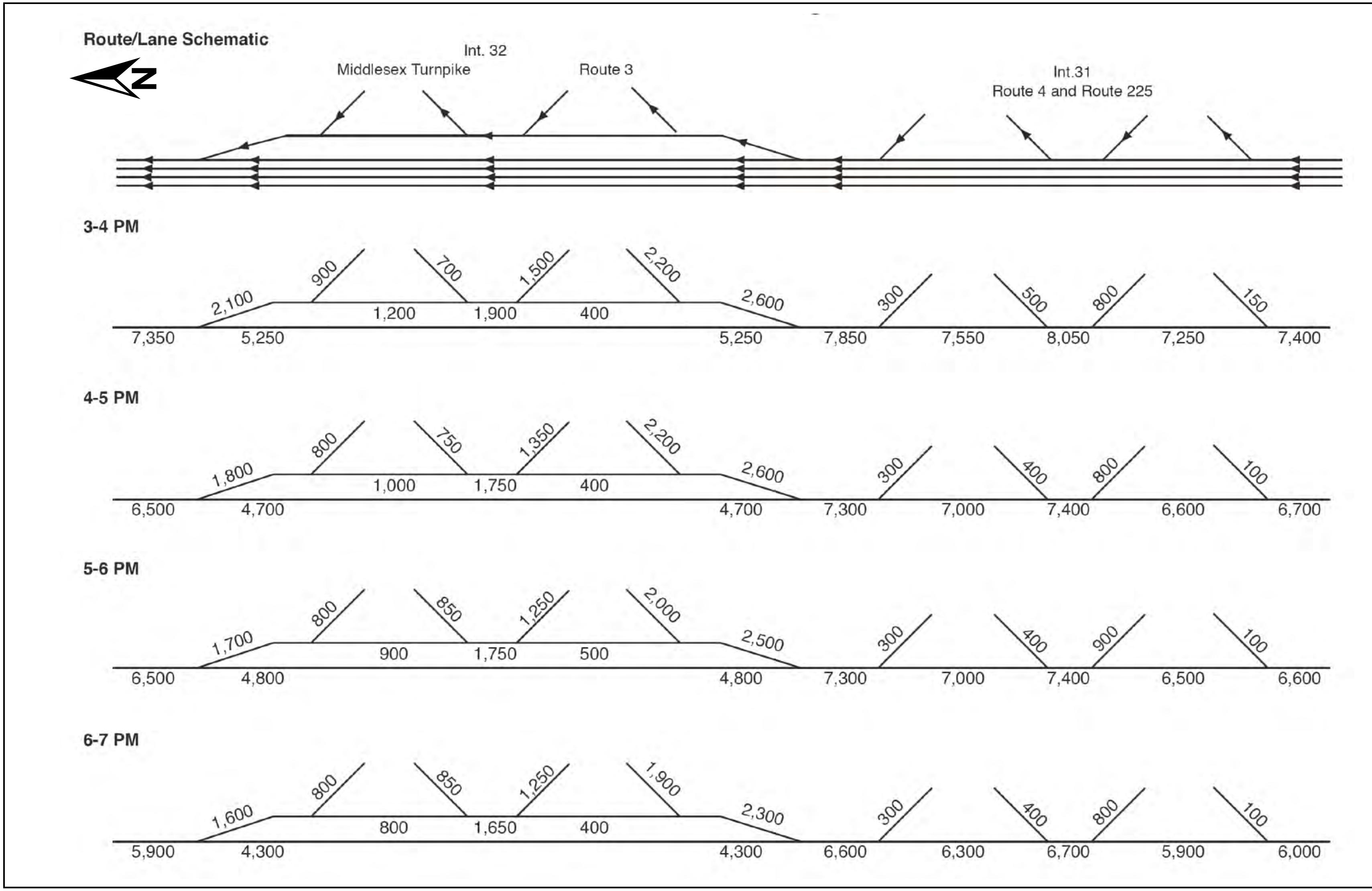

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FIGURE 16
2007 PM Peak-Period Traffic Volumes on I-95 Northbound near the Bottleneck at Interchange 32 in Burlington

Low-Cost Bottleneck Improvements

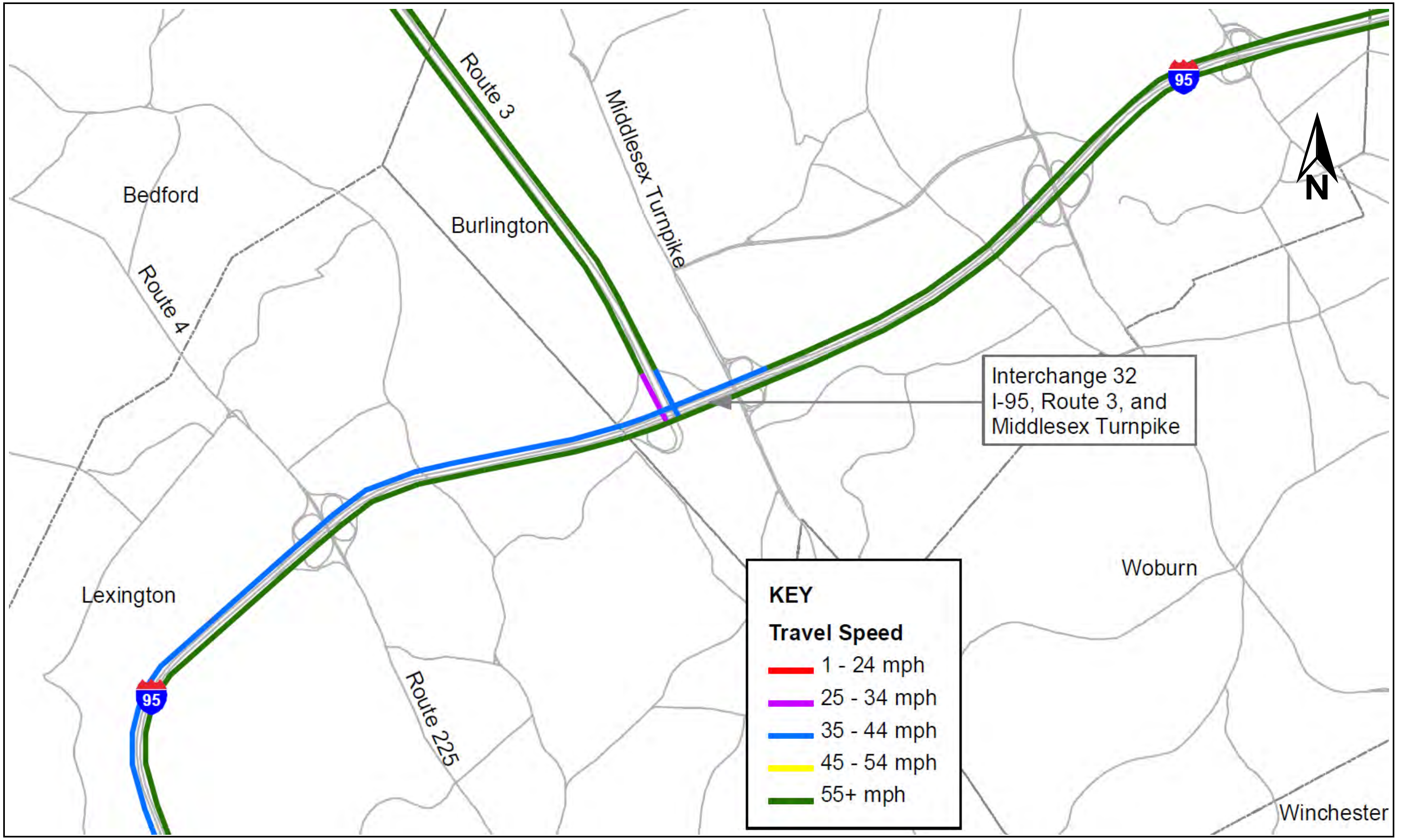

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FIGURE 17
2005 AM Peak-Period Travel Speeds on I-95 Northbound near the Bottleneck at Interchange 32 in Burlington

Low-Cost Bottleneck Improvements

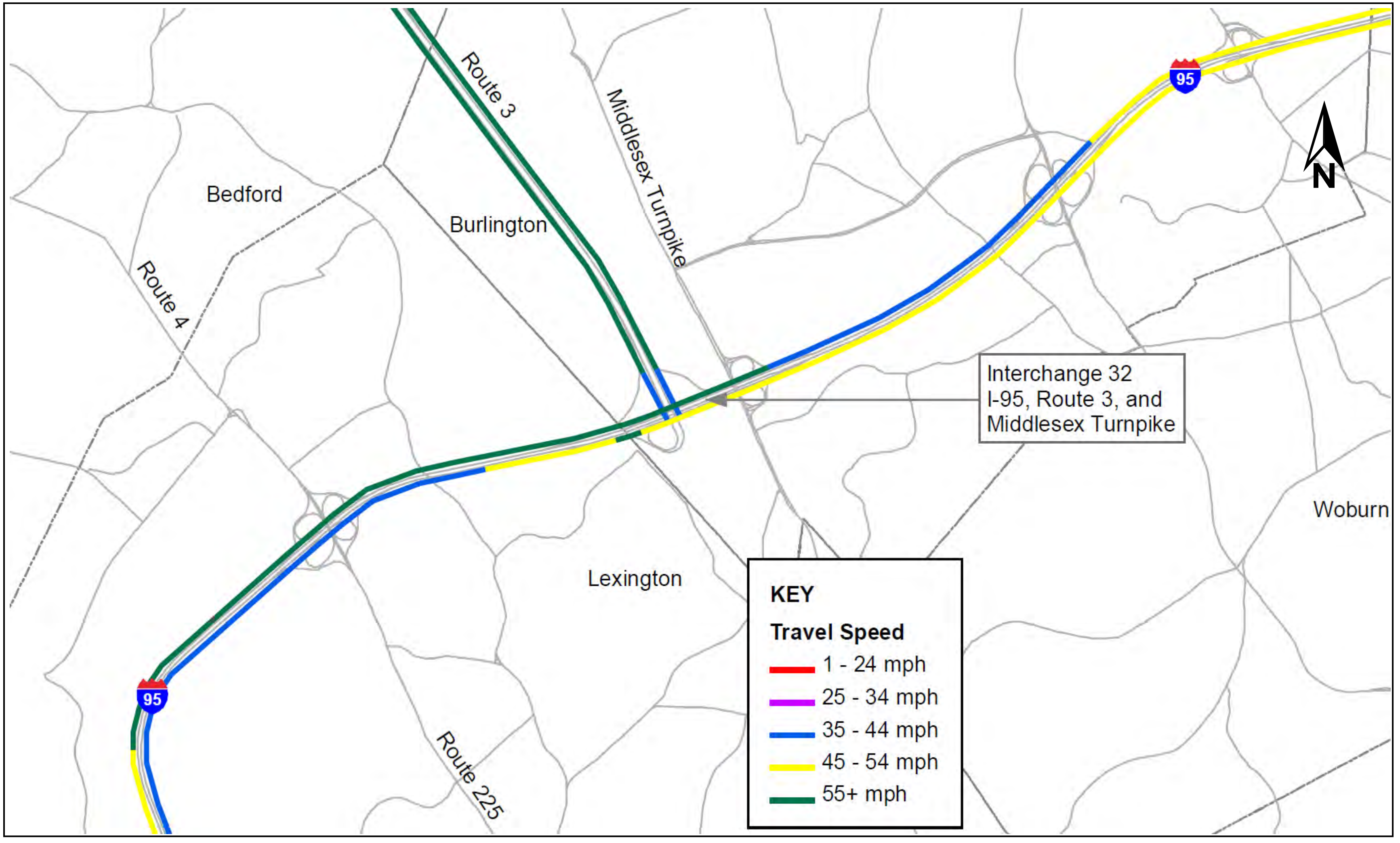

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FIGURE 18
2005 PM Peak-Period Travel Speeds on I-95 Northbound near the Bottleneck at Interchange 32 in Burlington

Low-Cost Bottleneck Improvements

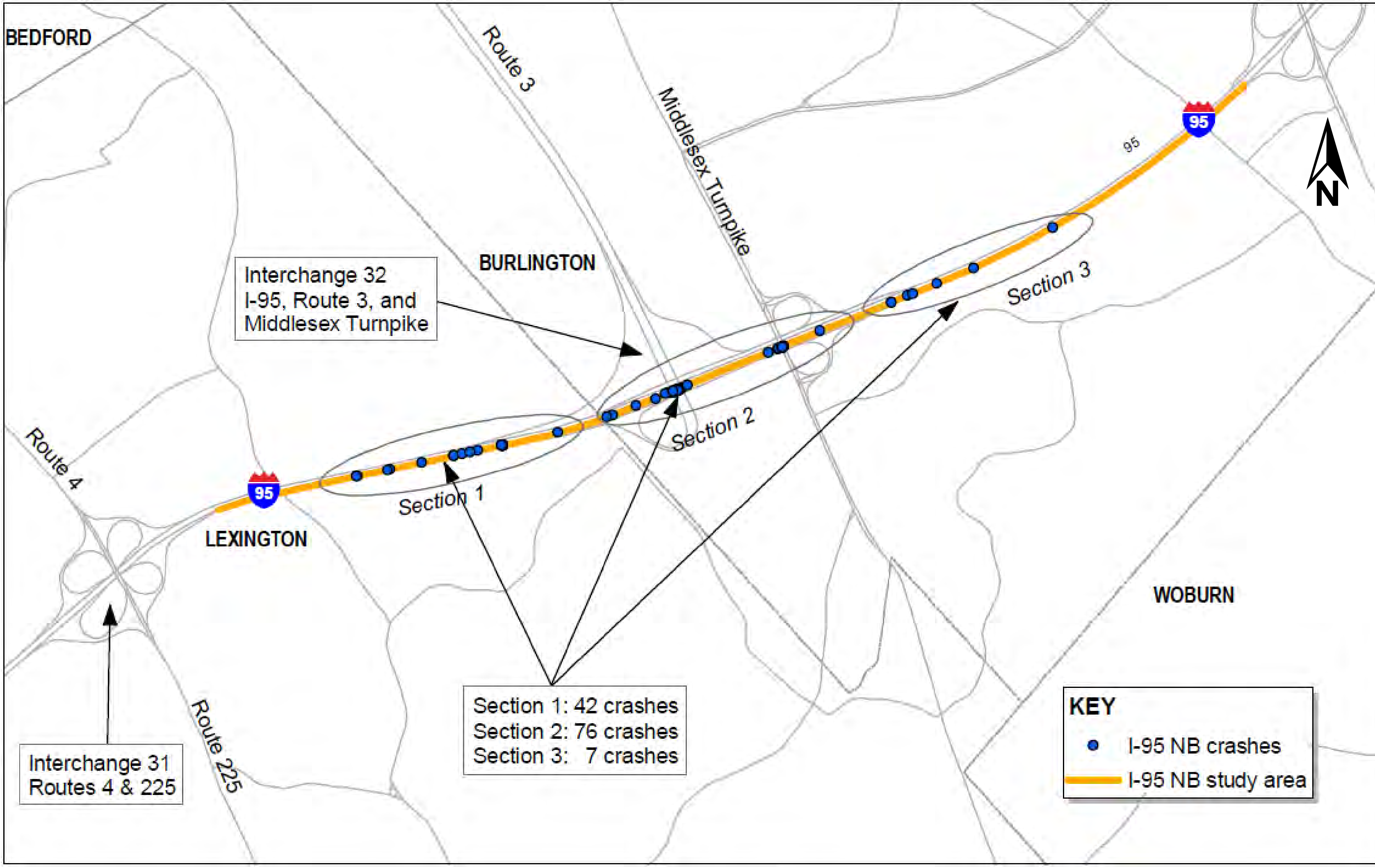

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FIGURE 19
Crashes on I-95 Northbound near the Bottleneck at Interchange 32 in Burlington, 2006–08

Low-Cost Bottleneck Improvements

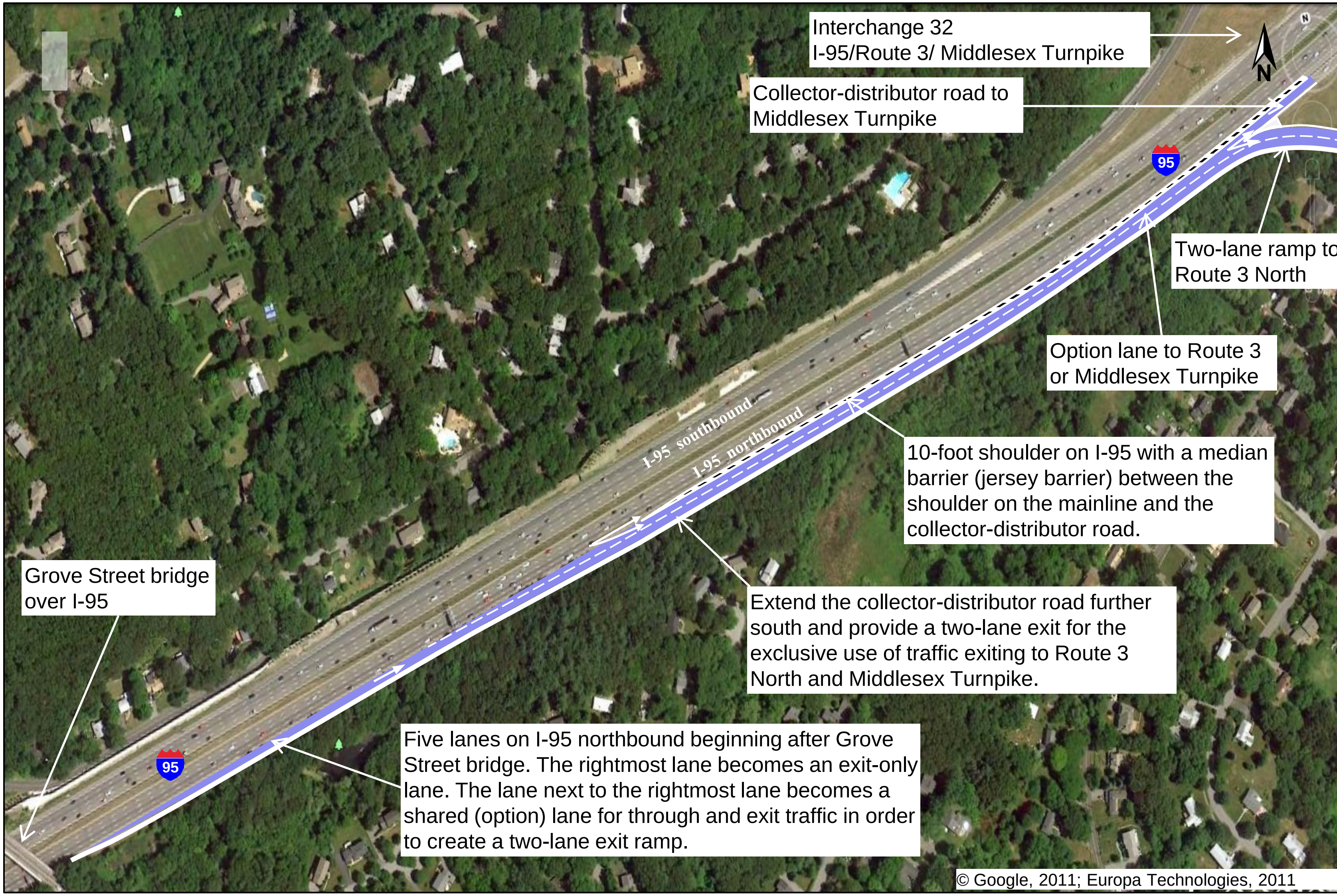

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FIGURE 20
Construct a Two-Lane Exit Ramp for Traffic Exiting I-95 Northbound to Route 3 and Middlesex Turnpike

Low-Cost Bottleneck Improvements

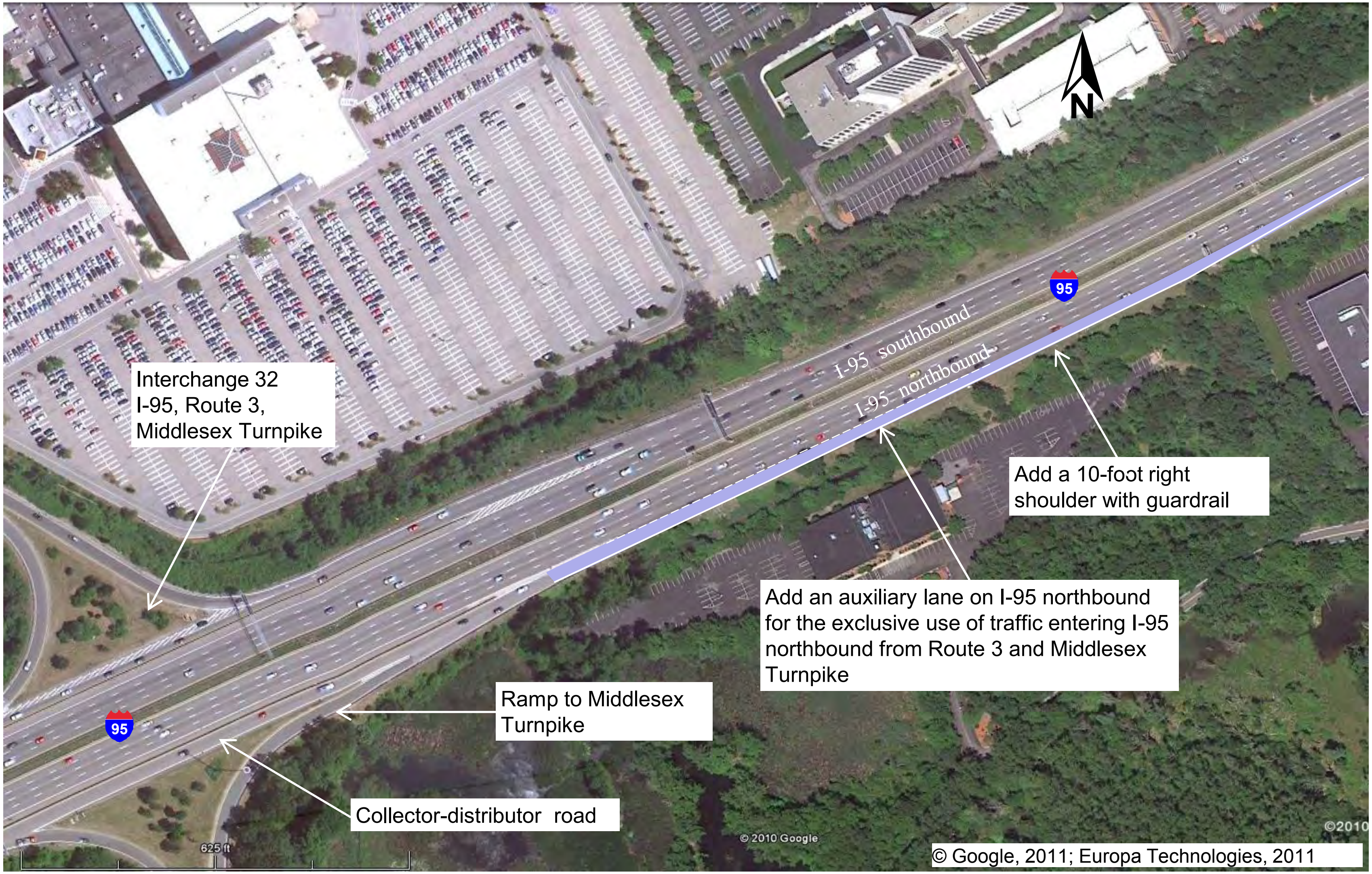

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FIGURE 21
Use a Short Section of the Traffic-Bearing Right Shoulder as an Auxiliary Lane for the Exclusive Use of Traffic Entering I-95 Northbound

Low-Cost Bottleneck Improvements

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FIGURE 22
Location of Bottleneck on Route 3 Southbound

Low-Cost Bottleneck Improvements

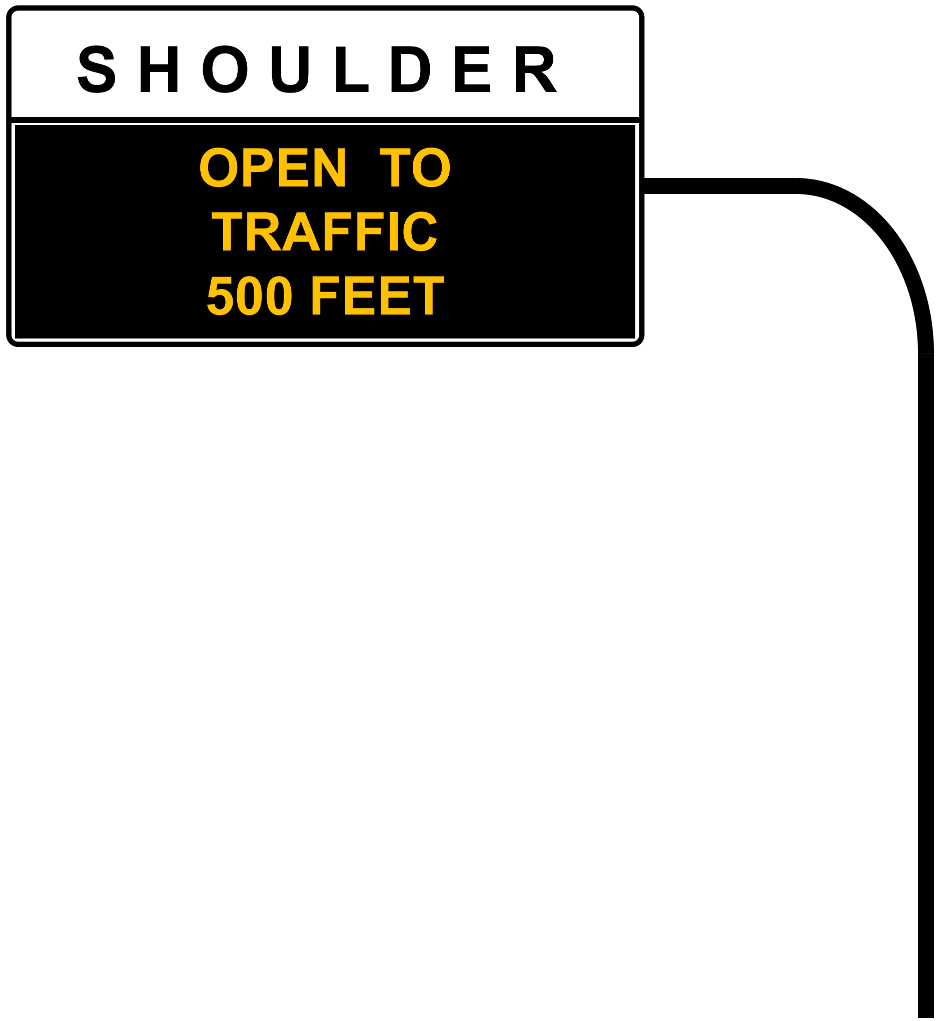

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FIGURE 23
Variable Message Sign Communicating Status of Shoulder

Low-Cost Bottleneck Improvements

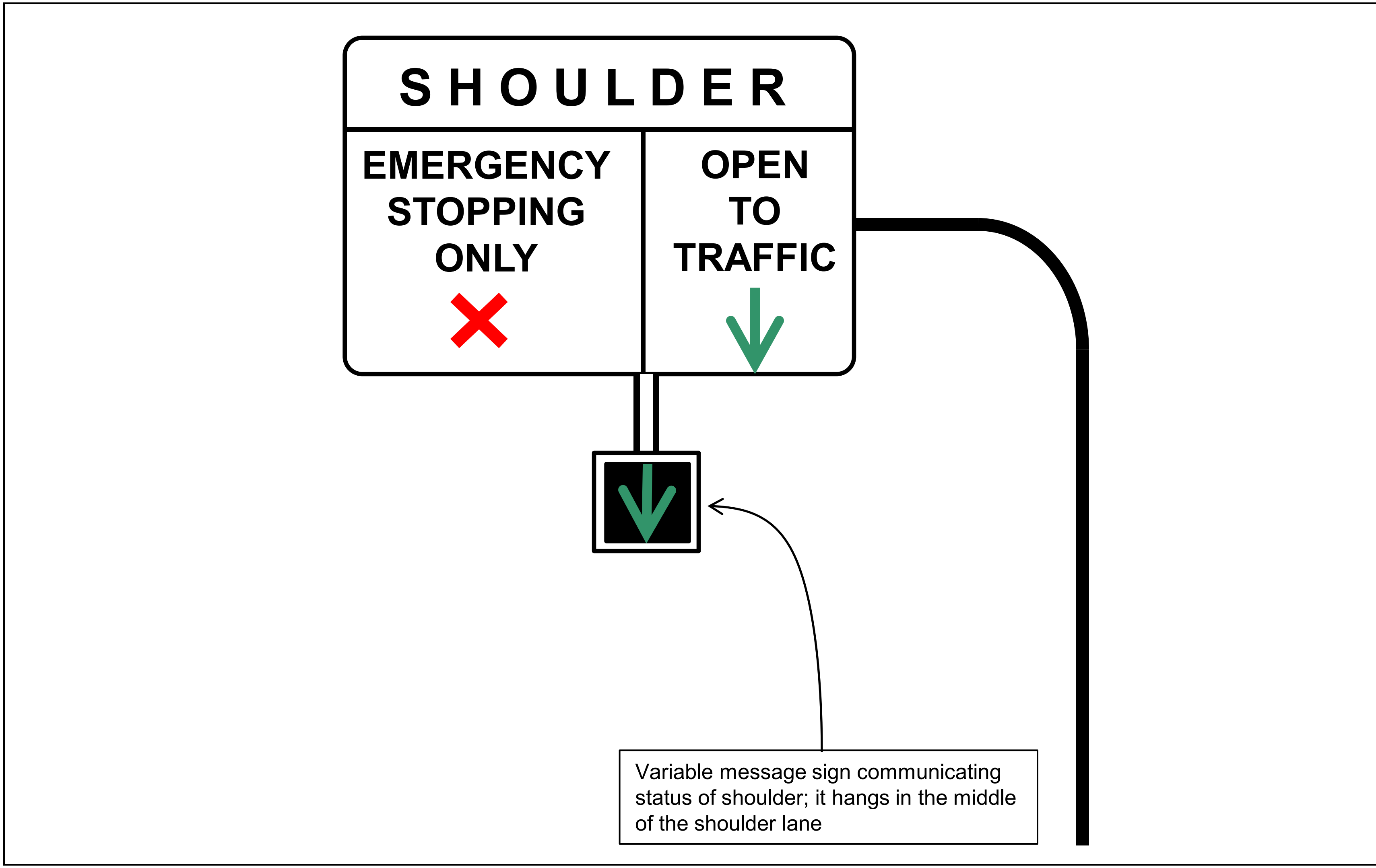

FIGURE 24
Shoulder-Lane-Control Signal

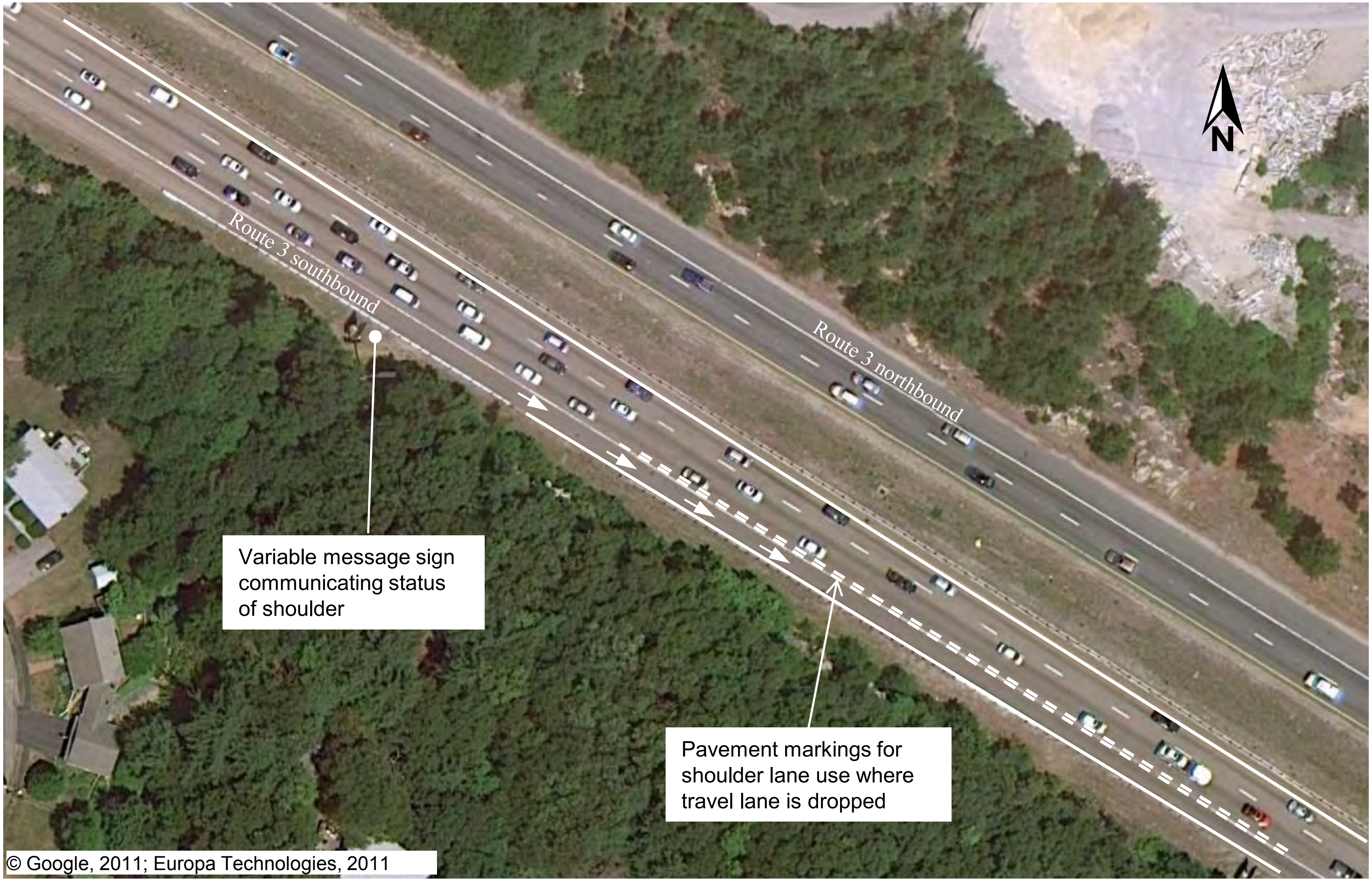

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FIGURE 25
Restripe the Pavement near the Lane Drop

Low-Cost Bottleneck Improvements