I-95/I-476 Interchange Improvement Feasibility Study

Produced by RK&K for DVRPC

April 2012

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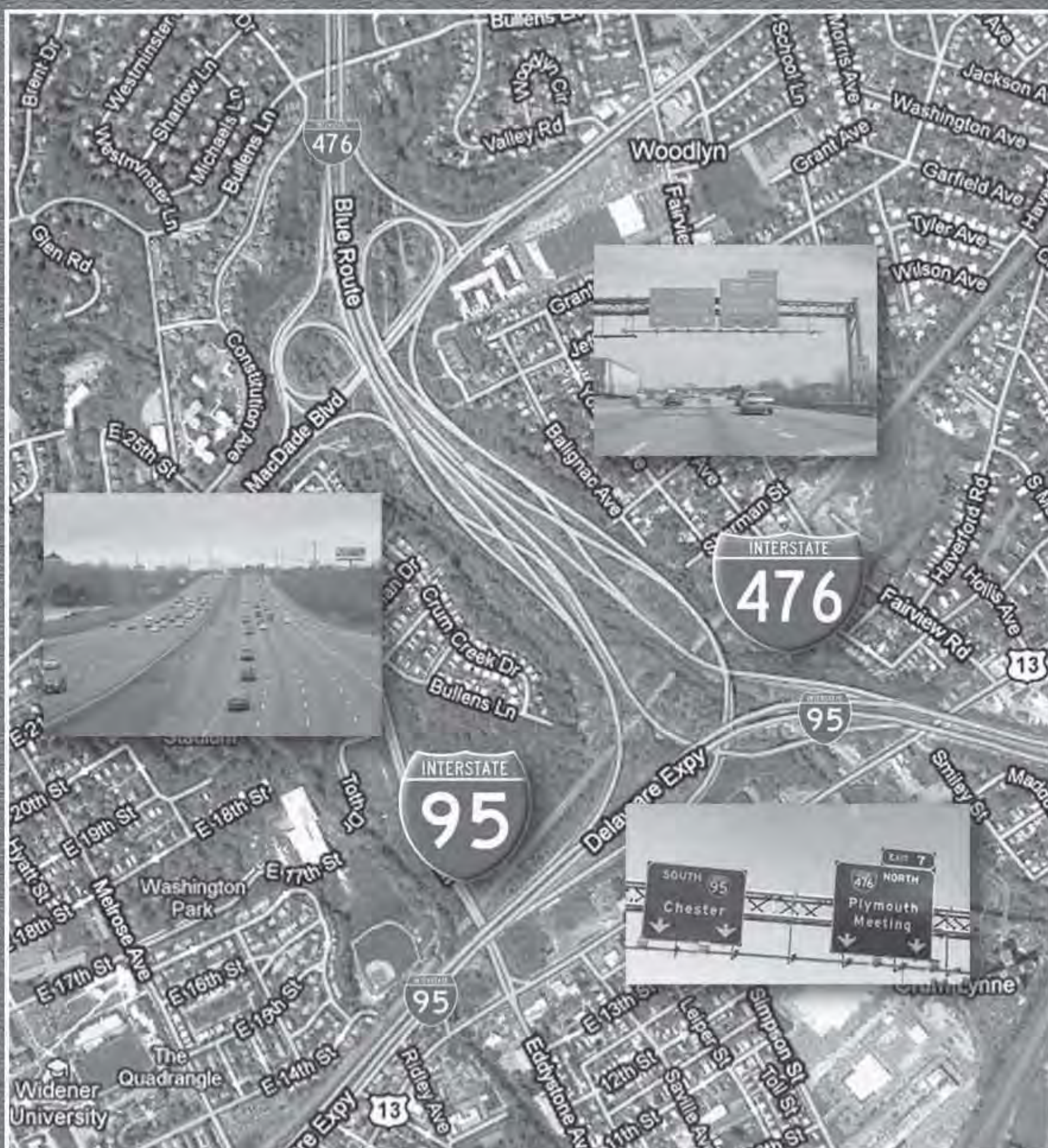

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The Delaware Valley Regional Planning Commission is dedicated to uniting the region's elected officials, planning professionals, and the public with a common vision of making a great region even greater. Shaping the way we live, work, and play, DVRPC builds consensus on improving transportation, promoting smart growth, protecting the environment, and enhancing the economy. We serve a diverse region of nine counties: Bucks, Chester, Delaware, Montgomery, and Philadelphia in Pennsylvania; and Burlington, Camden, Gloucester, and Mercer in New Jersey. DVRPC is the federally designated Metropolitan Planning Organization for the Greater Philadelphia Region — leading the way to a better future.

The symbol in our logo is adapted from the official DVRPC seal and is designed as a stylized image of the Delaware Valley. The outer ring symbolizes the region as a whole while the diagonal bar signifies the Delaware River. The two adjoining crescents represent the Commonwealth of Pennsylvania and the State of New Jersey.

DVRPC is funded by a variety of funding sources including federal grants from the U.S. Department of Transportation's Federal Highway Administration (FHWA) and Federal Transit Administration (FTA), the Pennsylvania and New Jersey departments of transportation, as well as by DVRPC's state and local member governments. The authors, however, are solely responsible for the findings and conclusions herein, which may not represent the official views or policies of the funding agencies.

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EXECUTIVE SUMMARY

The I-95/I-476 interchange is located just north of the City of Chester, in Delaware County, Pennsylvania, at the intersection of two of the most heavily traveled corridors in the Delaware Valley. Traffic congestion at this interchange, and in its immediate vicinity, occurs on a daily basis and is a major impediment to the traveling public. The Delaware Valley Regional Planning Commission (DVRPC), in conjunction with the Delaware County Planning Department (DCPD), is conducting this feasibility study of potential congestion mitigation and operational improvements to the I-95/I-476 interchange. The purpose of the study is to identify small-scale interchange improvements to help reduce the current traffic congestion issues.

The I-95/I-476 Interchange Improvement Feasibility Study (study) consisted of traffic and roadway data collection, an assessment of existing conditions, identification of potential improvements, traffic analysis, development of preliminary cost estimates, identification of potential impacts, consideration of implementation time, and prioritization of the improvements.

Stakeholder input was vital to identify existing issues and feasible solutions. Three Study Advisory Committee (SAC) meetings were conducted to discuss the existing interchange conditions, potential solutions, and prioritization of improvements that should be studied further. In addition, an Environmental Justice (EJ) meeting was conducted with citizens and interested parties from the City of Chester to gather input on the potential improvements.

Existing Conditions

A roadway deficiency review of the interchange and adjacent mainline sections of I-95 and I-476 was completed to identify deficiencies that contribute to travel congestion through the interchange. The deficiencies identified included:

- discontinuous lane balance and inadequate basic number of lanes on the mainline and interchange ramps;
- insufficient number of travel lanes to accommodate traffic demand;
- substandard horizontal sight distance;
- substandard merging/weaving lengths; and
- concurrent merge and lane drop locations.

In total, nine geometric and operational deficiencies were identified along I-95 and I-476 within or directly adjacent to the interchange.

The I-95/I-476 interchange carries nearly 190,000 vehicles daily, with I-95 carrying approximately 132,000 of the daily volume. As is characteristic of system-to-system freeways, the volume of traffic using one freeway to connect to the other is high, with approximately 45 percent of all I-95 traffic approaching the interchange exiting I-95 either via I-476 or MacDade Boulevard. As a result, traffic approaching and traveling through the interchange experiences significant congestion for several hours a day. A Highway Capacity Manual-based review of the interchange operations found that several I-95/I-476 interchange components operate at Level of Service “F” for one or both peak periods, indicating that several interchange components are over capacity.

Prior to this study, DVRPC completed a crash data analysis for I-95 through the interchange. A notable finding was that northbound I-95 approaching the I-476 interchange contained the highest incidence of rear-end crashes for the entire 12-mile corridor in Delaware County, at a rate nearly four times the statewide average for similar facilities. A high rear-end crash rate is typical of a congested roadway. For this study, a crash analysis was completed for each of the interchange ramps and the segment of I-476 immediately north of the interchange for the five-year period from 2005 to 2009. Total crashes, crash types, and severities were reviewed and a pattern could be identified. A total of 163 crashes occurred within the interchange (I-95 mainline excluded) during the five-year period, and overall crash rates for individual segments ranged from significantly under (less than 50 percent) to greater than the statewide average.

A correlation could be seen from the five-year crash data and rates and the identified roadway deficiencies and poor traffic operations at the interchange. As a result, several segments within the interchange emerged as candidate locations for cost-effective solutions to reduce traffic congestion and improve safety.

Potential Improvements

Potential improvements were developed assuming that large-scale widening, bridge structure reconstruction, and right-of-way and environmental impacts would be avoided. Instead, lower-cost, short-term and mid-term improvements were developed that could alleviate the roadway deficiencies and operational issues without large impacts and cost. These included:

- restriping the highway within the existing roadway section to either add lanes or modify the lane configuration,
- extending acceleration and/or deceleration lanes into existing shoulders,
- improved signing,
- improved lighting,
- peak period shoulder use,
- localized/small scale widening for auxiliary lanes, and
- ramp closure.

Thirteen potential improvements were identified (not in order of preference):

1. **Close Chestnut Street Entrance Ramp to Northbound (NB) I-95** to improve the operations of NB I-95 and eliminate the safety concern at the ramp merge
2. **Provide Two-Lane Exit from NB I-95 to NB I-476** to provide additional capacity to NB I-476
3. **Provide an Emergency Vehicle Access at Ridley Avenue** to improve emergency access to NB I-95
4. **Reconfigure the Merge of I-95 Ramps to NB I-476** to provide two continuous lanes from NB I-95 to NB I-476
5. **Drop the Right Lane of NB I-476 Prior to MacDade Boulevard** to provide a standard right side lane drop and be consistent with improvements (2) and (4)
6. **Implement Peak Period Shoulder Use on NB I-476** to provide an additional peak period lane
7. **Extend the MacDade Blvd. Entrance Ramp Acceleration Lane** to provide a longer merging area
8. **Implement Peak Period Shoulder Use on Southbound (SB) I-476** to provide an additional peak period Lane
9. **Provide Two-Lane Ramp from SB I-476 to SB I-95** to provide two continuous lanes
10. **Provide Four Lanes on SB I-95 between I-476 and Chestnut Street** to provide an additional lane and weaving area on SB I-95 and be consistent with improvement (9)
11. **Improve NB I-95 Advanced Signing** to provide better direction approaching the interchange
12. **Repair and/or Improve Interchange Lighting** to improve nighttime visibility
13. **Erect Advanced Curve Warning Signage** to alert drivers to slow on the NB I-95 to NB I-476 ramp

Evaluation and Prioritization of Improvements

Each improvement was evaluated focusing on operational and safety benefits, cost, and implementation considerations. All 13 improvements demonstrated some type of quantifiable improvement; however, total benefits vary widely.

Nine improvements (Improvements 1, 2, and 4 to 10) are expected to improve the traffic operations within and/or approaching the interchange. Inherent safety benefits are anticipated from the expected improvements in traffic operations. An important finding in the evaluation process is that the traffic operations at the I-95/I-476 interchange are constrained by those on I-476, north of the interchange. The traffic demand for I-476 exceeds the capacity of a four-lane freeway (two lanes in each direction) during both peak hours.

All of the operational improvements are anticipated to improve traffic conditions over the existing conditions until at least 2025. Several improvements (5, 6, and 8 to 10) may provide operational improvements beyond 2035. In particular, the improvements associated with southbound I-476 approaching and traveling through the interchange (Improvements 8 and 9) and I-95 southbound (Improvement 10) appear to provide significant operational benefit over a long time frame.

Eight improvements could be implemented individually (1, 3, 6 to 8, and 11 to 13), but the other five improvements would have to be combined into "packages" to provide benefits. Package A would combine Improvements 9 and 10 (SB I-476 to SB I-95) and Package B would combine Improvements 2, 4, and 5 (NB I-95 to NB I-476).

After the improvement packages were established, the improvements were given a priority ranking. Several evaluation metrics were included to prioritize the improvements. These included: ability to mitigate congestion and/or alleviate bottleneck points; ability to address identified safety concern(s); improvement lifespan; estimated cost, including qualitative estimates of level of anticipated improvement relative to estimated cost; and time frame and ease of implementation.

Based on these metrics, three priority tiers were established: High Priority, in which each improvement received high marks in multiple metrics; Medium Priority, where the level of improvement relative to estimated cost would not be expected to be as great as those receiving a high priority ranking; and Low Priority, where the improvements to interchange operations and safety would be expected to be lowest. The improvements were ranked as summarized in the list following.

Although both Improvement 6 and Improvement 8 would implement peak period shoulder use on I-476, Improvement 8 (on the southbound lanes) may be a low priority from the perspective of improving operations at the I-95/I-476 interchange. It has a higher priority from a regional perspective in terms of reducing congestion on I-476 outside the study area.

Summary Ranking of the Improvements

Rank	Improvement	Cost[1]	Priority
1	***Package A*** – Improvements 9 and 10	$3.8M to $5.1M	High
2	***Package B*** – Improvements 2, 4, and 5	$1.9M to $2.6M	High
3	Improvement 6	$5.6M to $7.4M	High
4	Improvement 13	$15K to $300K	High
5	**Improvement 1** – *no longer in consideration; a ramp relocation study is suggested instead*	$170K to $200K [Ramp Closure Only]	Medium
6	Improvement 12	$25K to $365K	Medium
7	Improvement 7	$530K to $700K	Medium
8	Improvement 8	$5.4M to $7.2M	Low
9	Improvement 11	$75K to $100K	Low
10	Improvement 3	$15K to $300K	Low

Notes:
[1] The cost range accounts for a 50% planning contingency and 45% project cost for design, project administration, and construction inspection. No right-of-way acquisition is included and assumed to be zero for all projects.
Summarized from Evaluation Matrix (Report Table 9)

Next Steps

DVRPC and Delaware County could continue with a more detailed evaluation of the potential improvements. The improvement concepts should be evaluated in more detail to further determine system-level operational benefit, to determine if there are any fatal flaws in the concepts, and to refine the associated cost estimates and project impacts, which will allow for proper project planning and programming. Detailed analyses utilizing more sophisticated traffic simulation modeling software would be required to confirm the traffic and operational benefits for the potential improvements.

Additional engineering analysis would be needed for all improvements, especially those that include modified lane configurations, access changes, or widening and other roadside improvements to identify limits of disturbance and any impacts to roadside features. More detailed cost estimates would be developed using the additional engineering analysis to give transportation programming staff better information from which to program constrained long-range transportation project funding, as well as to identify effects to the Transportation Improvement Program (TIP) and State Transportation Improvement Program (STIP) plans. The appropriate level and detail of environmental study and documentation would have to be considered for each improvement. In addition, for improvements that include operational changes, like peak period shoulder use, additional analysis would be required to develop a Concept of Operations (ConOps) that defines how the highway would be operated.

1. INTRODUCTION

The I-95/I-476 interchange is located just north of the City of Chester, in Delaware County, Pennsylvania, at the intersection of two of the most heavily traveled corridors in the Delaware Valley (see **Figure 1**). Traffic congestion at this interchange, and in its immediate vicinity, occurs on a daily basis and is a major impediment to the traveling public.

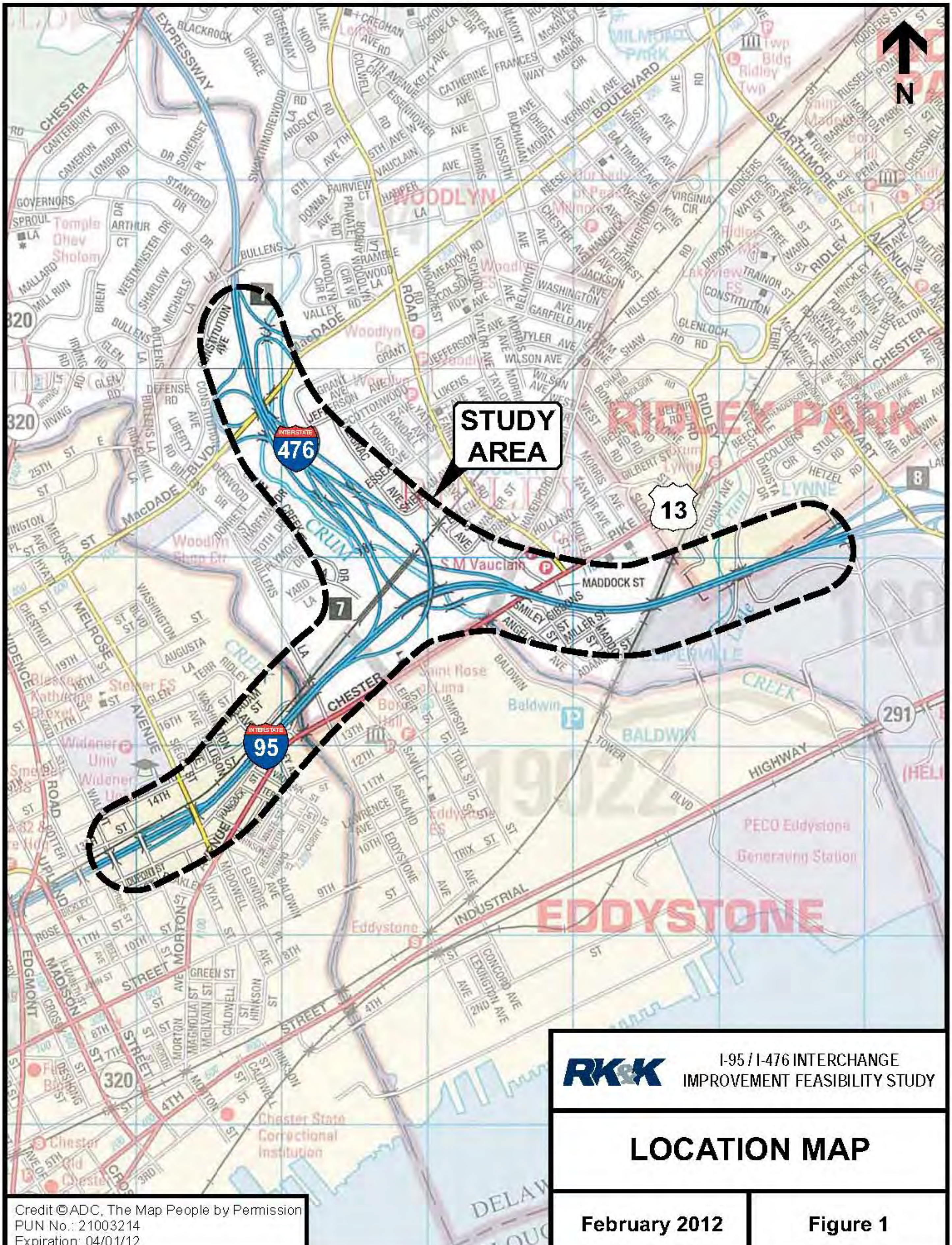
The Delaware Valley Regional Planning Commission (DVRPC), in conjunction with the Delaware County Planning Department (DCPD), is conducting this feasibility study of potential improvements for the I-95/I-476 Interchange to address the current traffic congestion issues. The traffic congestion is caused by existing conditions, such as lane drops and single lane merges. Member agencies of the Metropolitan Planning Organization (MPO) have been reluctant to program a major project to reconstruct the interchange and address traveler delay due to high project costs associated with right-of-way constraints, tight geometrics, and the amount of improvements necessary to address all the ramp movements of adjacent interchanges. Instead, DVRPC is taking an alternative approach to large-scale reconstruction or widening of the existing interchange footprint by identifying smaller, more manageable projects that could help reduce congestion.

I-95 is a vital regional and commuter link through the interchange. Carrying more than 130,000 vehicles daily on average, I-95 functions as a local freeway for commuters traveling between Philadelphia and its southern suburbs and as a regional highway connecting points north and south of the city. The portion of I-95 through Chester was constructed in the early 1960s, and it divides the community. The right-of-way along I-95 is very constrained with homes, roads, and businesses built adjacent to the highway. The highway is comprised of six lanes (three per direction) south of I-476, four lanes (two per direction) within the interchange, and eight lanes (four per direction) north of the interchange. Congestion occurs because of the over-capacity six-lane section south of the interchange; the lane drops and adds within the interchange; and the associated high traffic volumes using the interchange ramps and mainline.

I-476, which carries more than 85,000 vehicles daily, functions as a major north-south link west of Philadelphia, connecting with I-95 at Chester on the south and with I-76 and I-276 (the Pennsylvania Turnpike) at Plymouth Meeting on the north. I-476 was completed in the early 1990s as a six-lane (three per direction) highway between I-95 and MacDade Boulevard and a four-lane (two per direction) highway between MacDade Boulevard and West Chester Pike. The Environmental Impact Statement's Record of Decision for the project required the highway to stay within the existing right-of-way north of MacDade Boulevard. Daily congestion occurs because of the over-capacity four-lane section north of the interchange.

In addition to this study, there are numerous on-going projects along I-95 and local roads near the interchange. These include:

- safety improvements to address needs identified in the Pennsylvania Department of Transportation's (PennDOT) Road Safety and Operations Audit (RSOA) along the entire length of I-95 within Delaware County;
- the PennDOT I-95 Master Plan Study, which will identify long-term improvements to all of I-95 in Pennsylvania;
- proposed improvements to the northbound (NB) I-476 ramp to eastbound MacDade Boulevard; and
- ongoing improvements at the I-95/US 322 interchange south of the project area.


N
STUDY AREA
476
95
13
RK&K
I-95 / I-476 INTERCHANGE
IMPROVEMENT FEASIBILITY STUDY
LOCATION MAP
February 2012
Figure 1
Credit ©ADC, The Map People by Permission
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All of these efforts lie outside of the scope of the I-95/I-476 Interchange Study, but were considered in the development and evaluation of improvements.

2. PURPOSE OF THE FEASIBILITY STUDY

DVRPC, in cooperation with the DCPD, conducted this feasibility study to identify potential congestion mitigation and operational improvements to the I-95/I-476 interchange and its immediate vicinity. The purpose of the study is to identify small-scale, low-cost, and manageable projects to help reduce the daily interchange traffic congestion.

3. SCOPE OF STUDY

a. Project Limits

The limits of this study extend along I-95 from just south of Exit 6 (Chestnut Street, including the Chestnut Street entrance and exit ramps) to just north of Exit 7 (I-476) and along I-476 from I-95 to just north of Exit 1 (MacDade Boulevard), as depicted in Figure 1. Approaching the interchange from the south, I-95 is a six-lane (three in each direction) freeway with a speed limit of 55 miles per hour (mph). North of the I-476 interchange, I-95 is an eight-lane freeway with a speed limit of 55 mph. I-476 is a four-lane freeway with a speed limit of 55 mph; however, through the interchange, I-476 carries three travel lanes in each direction. Both the I-95/I-476 and I-476/MacDade Boulevard interchanges carry the State Route (SR) 8025 designation, with each ramp designated as its own segment.

b. Study Activities

The I-95/I-476 Interchange Feasibility Study consisted of three separate stages, as described below:

The initial study stage kicked off and began with data collection, identification of the existing deficiencies, and identifying types of solutions, as follows:

- data collection consisting of traffic counts and safety analyses conducted by DVRPC, procurement of as-built plans, and interviews with PennDOT for bridge condition status;
- travel forecasting and traffic analyses for existing and future no-build conditions, including traffic forecasting;
- identification of roadway deficiencies; and
- brainstorming on examples of low-cost improvements.

The second study stage, the conceptual study stage, was conducted after the initial stage and consisted of the following:

- assessment of existing conditions;
- identification of low-cost geometric improvements to remedy and/or alleviate congestion; and
- preparation of initial improvements evaluation matrix.

The third and final study stage consisted of the following:

- finalization of potential improvements, finalization of future build traffic analysis; and
- potential improvements evaluation, including completion of the evaluation matrix.

c. Stakeholder Input

Three Study Advisory Committee (SAC) meetings were held with stakeholders to present the existing roadway and traffic issues and discuss potential solutions. The invited stakeholders represented a large group of interested parties, ranging from several transportation and planning agencies including DVRPC, DCPD, PennDOT Engineering District 6-0, and the Federal Highway Administration (FHWA), along with other key stakeholders such as the City of Chester, Chester Economic Development Authority, Pennsylvania State Police, Delaware County Transportation Management Association, Ridley Township, Ridley Park Borough, Eddystone Borough, Nether Providence Township, Crozer-Chester Medical Center, and Widener University. The SAC meeting summaries are provided in **Appendix A**.

Meeting 1 was conducted on April 13, 2011. At this meeting, the project team presented the existing roadway conditions, operational issues, and high-accident locations. In addition, the team presented a range of potential short-term and mid-term solutions. Examples of these types of solutions are listed in **Appendix C**.

Meeting 2 was conducted on May 25, 2011. At this meeting, the project team presented a preliminary list of potential improvements and outlined the approach for evaluating the improvements.

Meeting 3 was conducted on July 13, 2011. At this meeting, the project team presented the final improvements, evaluation of the improvements, and a priority list for the improvements.

At each meeting, project information and study results were presented to the stakeholders. Following the presentations, an interactive discussion was held between the stakeholders and project team. The stakeholders provided input on existing conditions, critiqued the potential improvements, identified implementation issues, and made suggestions on how to evaluate and prioritize the improvements. The project team used the stakeholder input to identify and refine the potential improvements.

In addition to the three stakeholder meetings, an Environmental Justice (EJ) meeting was conducted on May 25, 2011. At this meeting, the study efforts and potential improvements were presented to local representatives of organizations and neighborhoods that would be potentially affected if the transportation improvements being considered were implemented. Notes from this meeting are provided in **Appendix B**. The project team used input provided at this meeting to refine the potential improvements.

4. EXISTING AND NO-BUILD CONDITIONS

a. Roadway Deficiencies

A roadway deficiency review of the interchange and adjacent mainline sections of I-95 and I-476 was completed for the study area. The primary goal of this overview was to identify deficiencies that contribute to travel congestion through the interchange, whether they contribute to recurring (capacity/operational) or nonrecurring (incident-based) congestion. The deficiencies identified included:

- discontinuous lane balance and inadequate basic number of lanes on the mainline and interchange ramps;
- insufficient number of travel lanes to accommodate traffic demand;
- substandard horizontal sight distance;
- substandard merging/weaving lengths; and
- concurrent merge and lane drop locations.

Figure 2 graphically depicts where these deficiencies are located within/near the interchange area. The deficiencies are numbered based on geographic location, starting northbound along I-95, continuing north along I-476 past MacDade Boulevard, and then south along I-476 from north of MacDade to I-95.

Deficiency 1 – Northbound I-95: Minimal Merge Area for Chestnut Street Entrance
There is a substandard acceleration lane for vehicles entering northbound I-95 from the Chestnut Street ramp. In addition, there is a retaining wall along the roadside that is offset only a few feet from the travel lane. The lack of merge distance, combined with the lack of shoulder, provides drivers with very little distance to merge with I-95 traffic.

The configuration of the exit to northbound I-476, just north of this ramp, effectively makes the right lane of I-95 through the Chestnut Street interchange an extension of the exit ramp for all vehicles exiting I-95 to northbound I-476. When traffic is heavy, such as during the peak periods, vehicles attempting to enter I-95 are forced to either merge abruptly or slow substantially to wait for a gap in traffic. It is not uncommon for traffic to queue at the end of the ramp while waiting for a gap in traffic. These conditions affect the safety and traffic operations of both the ramp and northbound I-95.

Deficiency 2 – Northbound I-95: Single-Lane Exit to Northbound I-476
Northbound I-95 is comprised of three lanes approaching the split to northbound I-476. The right lane drops at the split and heads to northbound I-476, and the left two lanes continue on I-95. Just beyond the exit, the ramp from northbound I-95 to northbound I-476 widens to two lanes.

Peak period traffic demand for the ramp from northbound I-95 to northbound I-476 exceeds the capacity of a single lane. As a result, the right lane congests approaching the split and the congestion affects the other two lanes of I-95.

I-95 / I-476 INTERCHANGE IMPROVEMENT FEASIBILITY STUDY

EXISTING ROADWAY CONDITIONS

RK&K | February 2012 | Figure 2

Deficiency 1 – Northbound I-95: Minimal Merge Area for Chestnut Street Entrance

- **Substandard acceleration lane**
- **Minimal taper for entrance due to retaining wall for adjacent surface street (Hancock Street).**
- **Yield-controlled freeway entrance results in difficult entrance movement due to congestion and proximity of I-476 split.**
- **High accident rate is compounded by lack of pull-off area to assist with incident removal from the travel lanes.**

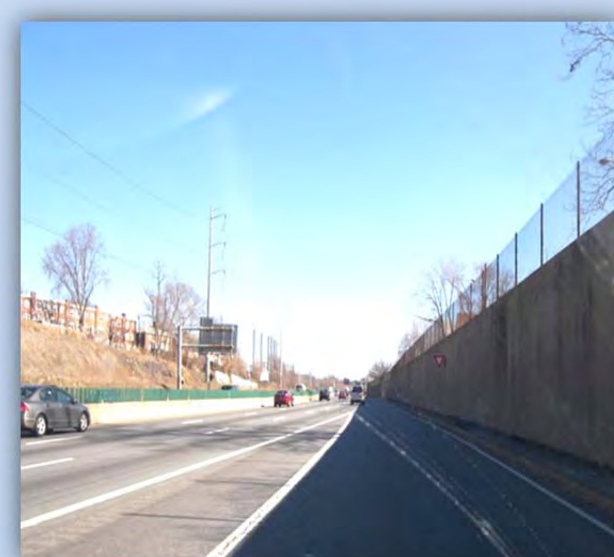


Photo Source: RK&K, 2011

Deficiency 2 – Northbound I-95: Single Lane Exit to Northbound I-476

- **Demand volume for traffic using this ramp exceeds the capacity of a single-lane ramp.**
- **Ramp widens to two lanes north of exit gore and carries two lanes across bridge over I-95 mainline.**
- **Observed traffic queued in northbound I-95 right lane approaching I-476.**
- **High rear-end accident location.**

Photo Source: RK&K, 2011

Deficiency 3 – Northbound I-95 to Northbound I-476: Horizontal Sight Distance
The horizontal stopping sight distance (measured for the left, inside lane) for the ramp from northbound I-95 to northbound I-476 is equivalent to a 35 mph design speed through the horizontal curve that begins a few hundred feet after the diverge from northbound I-95. This sight distance is substantially less than recommended for the posted speed of 55 mph, and well below driver expectation for a system-to-system interchange ramp. The American Association of State Highway and Transportation Officials (AASHTO) provides guidance in *A Policy on Geometric Design of Highways and Streets* (Green Book) which indicates that the minimum desired stopping sight distance should be equal to or greater than the distance required to stop. Vehicles traveling at or above the posted speed limit on this ramp have inadequate stopping sight distance.

Lower sight distance can affect a driver's ability to avoid stopped vehicles or other debris in the road when traveling at the posted speed. In addition, the lower sight distance can affect overall speed and traffic flow, especially in congested conditions.

Deficiency 3 – Northbound I-95 to Northbound I-476: Horizontal Sight Distance

- **Lower sight distance can affect traffic operations and safety.**
- **High fixed-object crash rate is greater than twice the statewide average.**

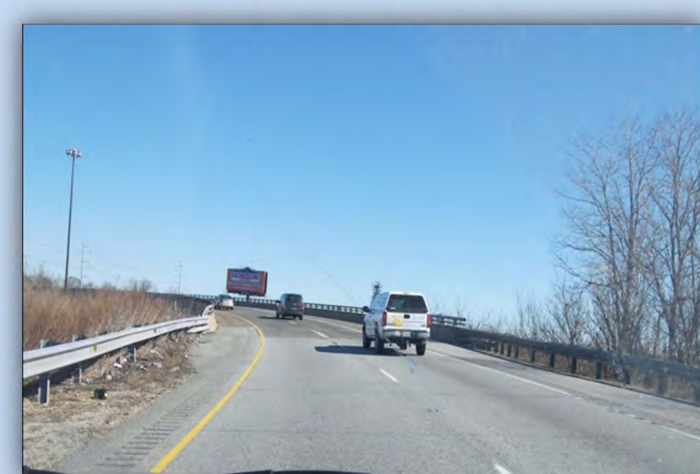


Photo Source: RK&K, 2011

Deficiency 4 – Northbound I-476: Lane Drop at Ramp Merge from Southbound I-95
The ramp from northbound I-95 to northbound I-476 widens to two lanes after the diverge from I-95. Similarly, the ramp from southbound (SB) I-95 to northbound I-476 is two lanes. At the merge, the left lane of the northbound I-95 to northbound I-476 ramp drops within the merge, and three lanes continue on northbound I-476. AASHTO indicates that when two multilane ramps merge and one lane is dropped, the preferred approach is to drop the outside lane, and not an interior lane, as is the case with this merge. Further, AASHTO guidance notes that the lane drop should occur prior to or after the merge and not within the merge area.

The lane drop on the ramp from northbound I-95 occurs at the same location as the merge with the ramp from southbound I-95, which results in multiple concurrent merging movements. Further, the lane drop on the ramp from northbound I-95 to northbound I-476 results in congestion that backs-up along the ramp and onto northbound I-95. Effectively, the ramp from northbound I-95 to northbound I-476 changes from having one lane at the split from I-95, to having two lanes for the length of the ramp, and back to having one lane at the merge with the ramp from southbound I-95. This configuration does not provide sufficient capacity to meet the traffic demand.

Deficiency 4 – Northbound I-476: Lane Drop at Ramp Merge from Southbound I-95

- **Lane drop occurs at the merge with the ramp from SB I-95.**
- **Reduces the through capacity of the ramp from NB I-95 to one lane.**
- **Observed queuing along northbound ramp within merge area.**
- **Violates driver expectancy of right lane drop.**

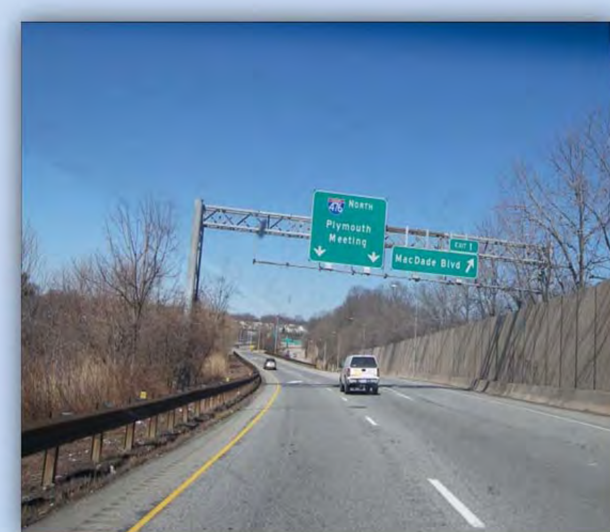


Photo Source: RK&K, 2011

Deficiency 5 – Northbound I-476: Left Lane Drop Prior to MacDade Boulevard

After the merge of the ramps from I-95, northbound I-476 has three lanes until just before the entrance ramp from MacDade Boulevard, where the left lane drops. The intent of this lane drop is to reduce the northbound highway to a two-lane section: one lane each from northbound and southbound I-95.

AASHTO indicates that when a highway lane is dropped, it is preferable to drop a lane on the right side of the highway, where speeds are likely to be lower. Further, right side lane drops are more familiar to drivers.

<u>**Deficiency 5 – Northbound I-476: Left Lane Drop Prior to MacDade Boulevard**</u>

- **More standard to provide a right lane drop.**
- **Observed queuing along northbound ramps from I-95 within merge area.**
- **Violates driver expectancy of right lane drop.**

Photo Source: RK&K, 2011

Deficiency 6 – I-476 (both directions): Two-Lane Section North of MacDade Boulevard

I-476 is only two lanes per direction north of MacDade Boulevard. The four-lane section continues until West Chester Pike (Exit 9). Two travel lanes in each direction provide insufficient capacity to accommodate the peak period traffic demand. This section of I-476 routinely congests. In the northbound direction, the congestion backs-up into the interchange and can affect operations all the way back to I-95.

<u>**Deficiency 6 – I-476 (both directions): Two-Lane Section North of MacDade Boulevard**</u>

- **Peak period traffic demand greatly exceeds the capacity of two travel lanes.**
- **Two-lane section is a bottleneck for MacDade traffic entering NB I-476.**
- **Reduced capacity may meter traffic approaching interchange along SB I-476.**

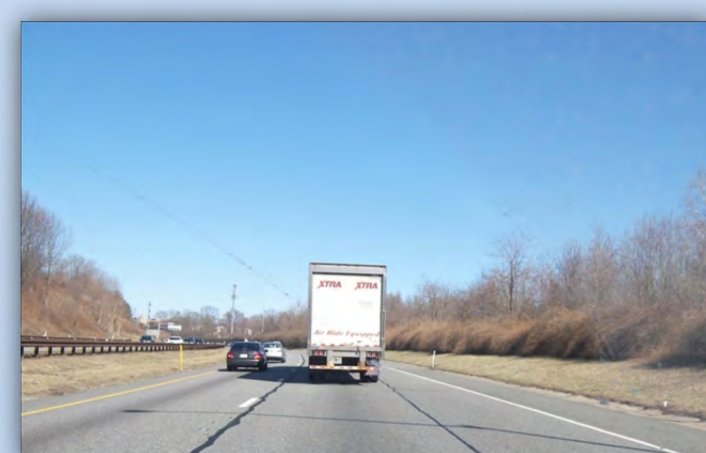


Photo Source: RK&K, 2011

Deficiency 7 – Concurrent Lane Drop: Ramp from Southbound I-476 to Southbound I-95

Southbound I-476 has three lanes approaching the split to northbound and southbound I-95. The three lanes split into two lanes to northbound I-95 and two lanes to southbound I-95; the middle lane is a shared lane that can be used to go in either direction. After the split, the ramp to southbound I-95 narrows from two lanes to one lane. This lane reduction occurs at the same location as the merge of the entrance ramp from MacDade Boulevard. The result is multiple merging movements occurring at the same location. AASHTO guidance indicates that the number of lanes downstream of a major split should be equal to the number of lanes preceding the split plus one to maintain lane balance and provide sufficient capacity for the traffic demand. In this case, four total lanes, two lanes on each ramp, are needed. Further, traffic routinely congests on this ramp due to the lane drop and merge from MacDade Boulevard. The congestion backs up to the mainline of southbound I-476.

Deficiency 7 – Concurrent Lane Drop: Ramp from Southbound I-476 to Southbound I-95

- **SB ramp to I-95 drops from two lanes to one lane as the ramp from MacDade Blvd. merges.**
- **Multiple traffic maneuvers at the same location.**
- **Traffic demand higher than capacity of single lane.**
- **Functions as bottleneck for southbound I-476.**

Photo Source: RK&K, 2011

Deficiency 8 – Southbound I-476 to Southbound I-95: 45 mph Sight Distance

The horizontal stopping sight distance for the ramp from southbound I-476 to southbound I-95 is equivalent to a 45 mph design speed through the horizontal curve that begins prior to the merge with southbound I-95. This sight distance is less than recommended for the posted speed of 55 mph and below driver expectation for an interstate-to-interstate interchange ramp. AASHTO guidance indicates that the minimum desired stopping sight distance should be equal to or greater than the distance required to stop. Vehicles traveling at or above the posted speed limit on this ramp have inadequate stopping sight distance.

Lower sight distance can affect a driver's ability to avoid stopped vehicles or other debris in the road when travelling at the posted speed. In addition, the lower sight distance can affect overall speeds, and traffic flow, especially in congested conditions, which is common for this ramp (see Deficiency 7 above). The sight distance may be a contributory factor in the higher-than-average accident rate along this ramp.

Deficiency 8 – SB I-476 to SB I-95: 45 mph Sight Distance

- **Lower sight distance can affect traffic operations and safety.**
- **High crash rates, including most severe accidents in study area.**

Photo Source: RK&K, 2011

Deficiency 9 – Southbound I-95: Lane Configuration between I-476 and Chestnut Street

Southbound I-95 consists of two lanes through the I-476 interchange. The ramp from southbound I-476 adds a third lane on the right side of the highway. Approximately 1,500 feet south of the I-476 entrance ramp, there is a short deceleration lane provided for the exit ramp to Chestnut Street.

This section of I-95 consistently congests during the peak periods. The substantial volume of traffic entering from the I-476 ramp interacts with the traffic on the two southbound lanes on I-95, and with traffic from southbound I-95 maneuvering to the right to exit at Chestnut Street. This traffic weaving in a relatively short section of highway and limited to only three through lanes results in recurring congestion.

The recurring congestion from this deficiency appears to be a significant contributor to I-95 southbound congestion approaching the interchange. During the PM peak, vehicles approaching the interchange from Philadelphia via I-95 southbound typically experience heavy congestion north of the I-95/I-476 diverge. Vehicles continuing on southbound I-95 travel along a tight horizontal curve with minimal shoulders. Once through the curve, these vehicles then approach the I-476 merge, entering the immediate area of influence for this deficiency.

Deficiency 9 – SB I-95: Lane Configuration between I-476 and Chestnut Street

- **One lane adds from the ramp from SB I-476; short deceleration lane at Chestnut Street exit.**
- **Heavy merging/weaving affects traffic operations.**
- **Bottleneck area for I-95 traffic.**

Photo Source: RK&K, 2011

b. Existing Traffic Conditions

The I-95/I-476 interchange is a major system-to-system facility within the Delaware Valley, linking two major regional freeways that can be viewed as a "beltway" surrounding Philadelphia and its inner ring Pennsylvania suburbs. I-95 and I-476, classified as Urban Interstates, function as the main freeways traveling through Delaware County. As is characteristic of system-to-system freeways, the volume of traffic using one freeway to connect to the other is high, with approximately 45 percent of all I-95 traffic approaching the interchange exiting I-95 either via I-476 or MacDade Boulevard. **Table 1** summarizes the Average Daily Traffic (ADT) for the interchange.

Peak Hour Traffic Volumes (2010)

Peak hour traffic volumes were developed using traffic counts conducted by DVRPC. Mainline traffic counts for I-95 and I-476 were obtained by DVRPC on a monthly basis from roadway sensors, with the count information broken into hourly counts. For this study, hourly counts over the course of one year were averaged to develop hourly traffic counts for mainline I-95 and I-476. For each of the ramps, hourly percentages from DVRPC counts in December 2010 were applied to normalized Average Annual Daily Traffic (AADT) data shown in **Table 1**. Travel volumes were also compared along I-95 and I-476 outside of the interchange study area to ensure that the existing volumes reflected demand volumes, as compared to service volumes.

Table 1. Average Daily Traffic Volumes (2009) Throughout the Corridor

	Direction of Travel			
	Northbound		Southbound	
Roadway Segment	**Volume (vpd)** [1]	**Truck %**	**Volume (vpd)** [1]	**Truck %**
I-95 North of Chestnut Street (Segments 0060/0061)	64,779	10	68,325	10
I-95 North of I-476 (Segments 0080/0081)	65,636	8	68,092	12
I-476 North of MacDade Boulevard (Segments 0002/0003)	43,118	8	44,281	7
Ramp Traffic				
SR 8025 (I-95/I-476/MacDade Boulevard)	**Volume (vpd)** [1]			
I-95 NB to I-476 NB (Segment 0010)	25,126			
I-95 SB to I-476 NB (Segment 0500)	27,236			
I-95 NB to MacDade Boulevard (Segment 0520)	5,086			
I-95 SB to MacDade Boulevard (Segment 0510)	5,116			
I-476 SB to I-95 NB (Segment 0260)	25,762			
I-476 SB to I-95 SB (Segment 0250)	26,341			
MacDade Boulevard to I-95 NB (Segment 0270)	6,774			
MacDade Boulevard to I-95 SB (Segment 0280)	5,383			

Notes: 1. vpd = vehicles per day
Source: DVRPC, 2010

The AM and PM peak hour volumes are presented in **Figure 3.** I-476 peak hour travel volumes appear to be relatively evenly split between the AM and PM peaks. However, I-95 traffic exhibits peak hour directionality, which increases north of the interchange. As shown in **Table 2**, the AM peak hour split appears to be "inbound" toward destinations on I-95 to the north (such as central Philadelphia and Philadelphia International Airport) and reverses towards an "outbound" split from those locations during the PM peak. Interestingly, the peak-hour split for movements between I-95 to the south (Chester, Wilmington) and I-476 does not exhibit a high peak hour directional split, suggesting that travel to/from destinations to the north accounts for the highest fluctuations in traffic throughout the day.

Table 2. Peak Hour Direction Splits

Roadway/Direction	AM Split	PM Split
I-95 South of Interchange	54% NB	53% SB
I-95 North of Interchange	60% NB	53% SB
I-476 North of Interchange	51% SB	52% NB
I-95 N of Interchange ↔ I-476 North of Interchange	63% "Inbound"	54% "Outbound"
I-95 S of Interchange ↔ I-476 North of Interchange	53% SB	50%

Source: DVRPC, 2010

Existing (2010) Level of Service

Capacity analyses of the peak hour traffic volumes were completed using the methodologies in the 2000 *Highway Capacity Manual* (HCM). The result of each analysis is a Level of Service (LOS), a qualitative measure characterizing the operational conditions of a traffic stream, generally in terms of service measures such as travel time, delay, traffic interruptions, and comfort and convenience. Six LOS are defined for each facility that has analysis procedures available. Letters designate each level, with LOS A representing the best operating conditions, and LOS F representing the worst. **Table 3** describes the operational characteristics of each LOS.

Table 3. LOS Operational Characteristics

Level of Service	Description
A	Free-flow
B	Reasonably free flow
C	Stable flow
D	Approaching unstable flow
E	Unstable flow
F	Forced or breakdown flow

Source: Highway Capacity Manual, 2000

For the purposes of this study, each interchange component (freeway, ramp, and weave) was analyzed as an independent component using the methodologies in Chapters 23 to 25 of the 2000 HCM. Taking this approach allowed for identification of locations in the interchange where operational deficiencies contribute to the congestion plaguing the study area. Completing these analyses for every location within the interchange allowed for establishment of a baseline for comparing the effect that studied improvements may have on traffic operations within the study area. It should be noted that while the 2010 version of the HCM was released during this initial study phase, the 2000 HCM continued to be used to retain continuity with the baseline traffic conditions and to remain consistent with current PennDOT policy utilizing the 2000 HCM.

Figure 3 also illustrates the 2010 LOS for each component through the study area. **Table 4** identifies several locations where traffic operations are approaching LOS E (unstable flow – roadway at capacity) or LOS F (forced flow – roadway above capacity).

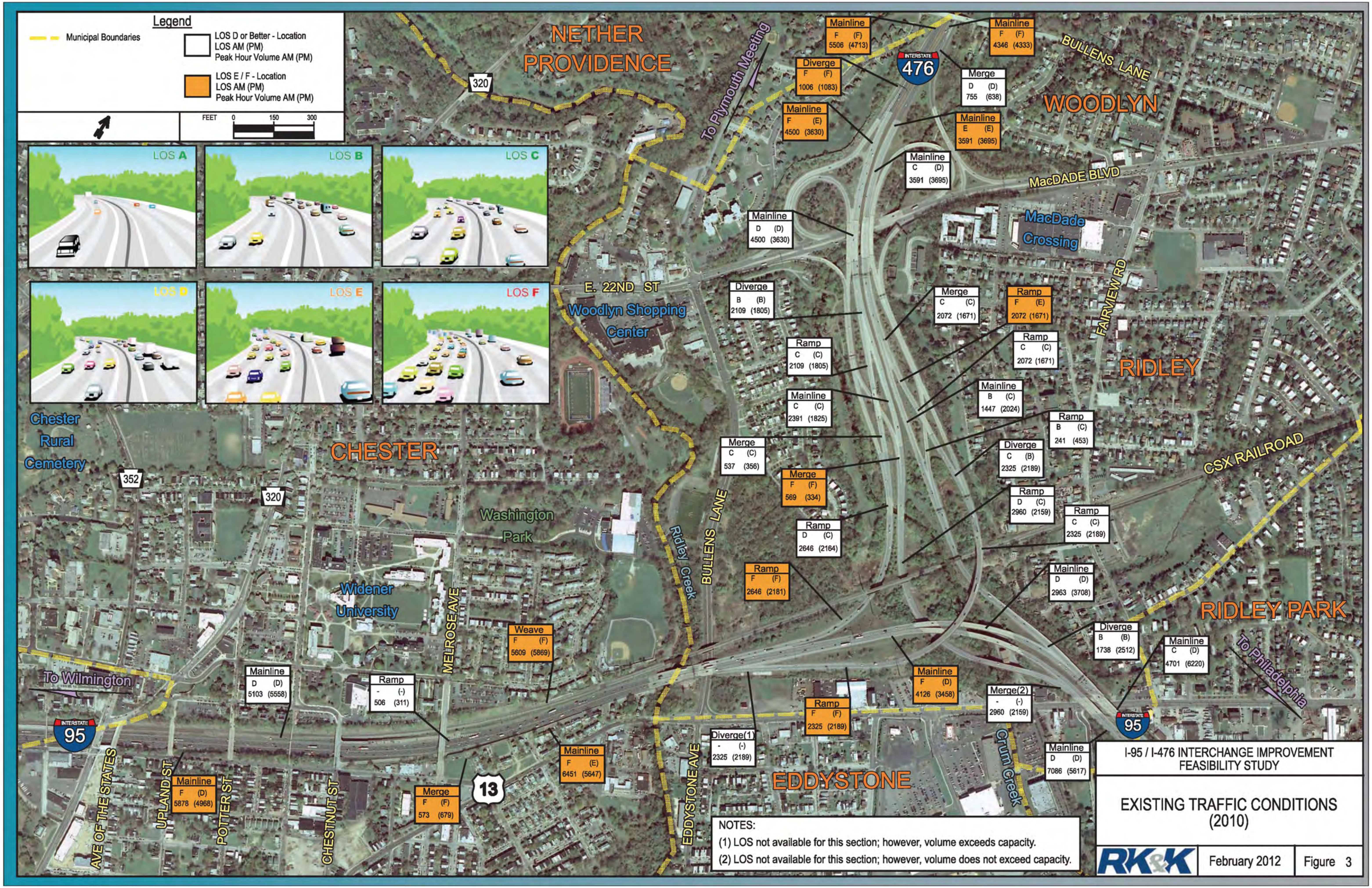

Legend
Municipal Boundaries
LOS D or Better - Location
LOS AM (PM)
Peak Hour Volume AM (PM)
LOS E / F - Location
LOS AM (PM)
Peak Hour Volume AM (PM)
FEET 0 150 300
LOS A
LOS B
LOS C
LOS D
LOS E
LOS F
NETHER PROVIDENCE
WOODLYN
RIDLEY
RIDLEY PARK
CHESTER
EDDYSTONE
To Plymouth Meeting
BULLENS LANE
MacDADE BLVD
MacDade Crossing
FAIRVIEW RD
E. 22ND ST
Woodlyn Shopping Center
Chester Rural Cemetery
Washington Park
Widener University
CSX RAILROAD
To Philadelphia
To Wilmington
Ridley Creek
BULLENS LANE
MELROSE AVE
AVE OF THE STATES
UPLAND ST
POTTER ST
CHESTNUT ST
EDDYSTONE AVE
Crum Creek
320
352
476
95
13
Mainline F (F) 5506 (4713)
Mainline F (F) 4346 (4333)
Diverge F (F) 1006 (1083)
Merge D (D) 755 (638)
Mainline F (E) 4500 (3630)
Mainline E (E) 3591 (3695)
Mainline C (D) 3591 (3695)
Mainline D (D) 4500 (3630)
Diverge B (B) 2109 (1805)
Merge C (C) 2072 (1671)
Ramp F (E) 2072 (1671)
Ramp C (C) 2109 (1805)
Ramp C (C) 2072 (1671)
Mainline C (C) 2391 (1825)
Mainline B (C) 1447 (2024)
Ramp B (C) 241 (453)
Merge C (C) 537 (356)
Diverge C (B) 2325 (2189)
Merge F (F) 569 (334)
Ramp D (C) 2960 (2159)
Ramp C (C) 2325 (2189)
Ramp D (C) 2646 (2164)
Ramp F (F) 2646 (2181)
Mainline D (D) 2963 (3708)
Weave F (F) 5609 (5869)
Diverge B (B) 1738 (2512)
Mainline C (D) 4701 (6220)
Mainline D (D) 5103 (5558)
Ramp - (-) 506 (311)
Mainline F (D) 4126 (3458)
Merge(2) - (-) 2960 (2159)
Ramp F (F) 2325 (2189)
Diverge(1) - (-) 2325 (2189)
Mainline F (E) 6451 (5647)
Mainline D (D) 7086 (5617)
Mainline F (D) 5878 (4968)
Merge F (F) 573 (679)
NOTES:
(1) LOS not available for this section; however, volume exceeds capacity.
(2) LOS not available for this section; however, volume does not exceed capacity.
I-95 / I-476 INTERCHANGE IMPROVEMENT FEASIBILITY STUDY
EXISTING TRAFFIC CONDITIONS (2010)
RK&K
February 2012
Figure 3

Table 4. Interchange Components with LOS E/F

Roadway	Segment	LOS AM / [PM]
Northbound I-95	South of Chestnut Street	**F** / [D]
	Chestnut Street (Exit 6) On-Ramp	**F** / **[F]**
	Between Exit 6 and I-476 Split (Exit 7)	**F** / [*E*]
	I-476 Split	N/A[1]
	Between I-476 Ramps	**F** / **[D]**
Southbound I-95	Between I-476 Merge and Chestnut Street Off-Ramp	**F** / **[F]**
Interchange Ramps	I-95 NB to I-476 NB (Single-Lane Section)	**F** / **[F]**
	I-95 NB to I-476 NB (North of MacDade Boulevard Off-Ramp)	**F** / [*E*]
	I-476 SB to I-95 SB	**F** / **[F]**
	MacDade Boulevard On-Ramp to I-476 SB Ramp to I-95 NB	**F** / **[F]**
Northbound I-476	Between MacDade Boulevard Ramps (Exit 1)	*E* / [*E*]
	North of MacDade Boulevard Ramps	**F** / **[F]**
Southbound I-476	North of MacDade Boulevard Ramps	**F** / **[F]**
	MacDade Boulevard Exit (Exit 1)	**F** / **[F]**
	South of MacDade Boulevard (Two-Lane Section)	**F** / [*E*]

Notes:
1. *LOS not available for this segment; however, volume exceeds capacity.*

Source: RK&K

These locations represent bottleneck points, locations where traffic congestion is caused in part due to traffic demand exceeding capacity. A closer look at several of these points relates to previously identified roadway deficiencies:

Deficiency 1 – Northbound I-95: Minimal Merge Area for Chestnut Street Entrance:

The substandard merge distance for traffic merging onto I-95 from Chestnut Street is made more difficult by the volume of traffic on I-95 approaching and/or exceeding traffic capacity.

Photo Source: Pennsylvania Department of Transportation

Deficiency 2 – Northbound I-95: Single Lane Exit to Northbound I-476:

The traffic analysis confirms that the demand volume for the I-95 northbound ramp to I-476 exceeds the capacity of the single-lane exit. I-95 northbound traffic destined for I-476 queues in the right lane approaching the interchange – not only affecting operations for mainline I-95, but further exacerbating the first deficiency at the Chestnut Street on-ramp.

Photo Source: Pennsylvania Department of Transportation

Deficiency 6 – I-476 (both directions): Two-Lane Section North of MacDade Boulevard:

The traffic analysis confirms that the demand volume exceeds the capacity of I-476 north of MacDade Boulevard, at a minimum to the next interchange to the north at Baltimore Pike (Exit 3).

Photo Source: Pennsylvania Department of Transportation

Deficiencies 7 and 8 – Concurrent Lane Drop on Ramp from Southbound I-476 to Southbound I-95 and Southbound I-476 to Southbound I-95 – 45 mph Sight Distance:

The traffic analysis confirms that the demand volume for this ramp exceeds the capacity of the single-lane ramp. This capacity constraint, combined with the MacDade Boulevard on-ramp, presents a bottleneck point that appears to be a cause of recurring delay for I-476 southbound as it approaches I-95.

Photo Source: Google

Deficiency 9 – Southbound I-95: Lane Configuration Between I-476 and Chestnut Street:

The I-476 bottleneck noted in Deficiencies 7 and 8 is further exacerbated by the lane configuration on southbound I-95 between I-476 and the Chestnut Street exit ramp. The traffic analysis also suggests that I-95 southbound congestion approaching the interchange may be the result of the geometrics through the weave area.

Photo Source: Google

Safety Conditions

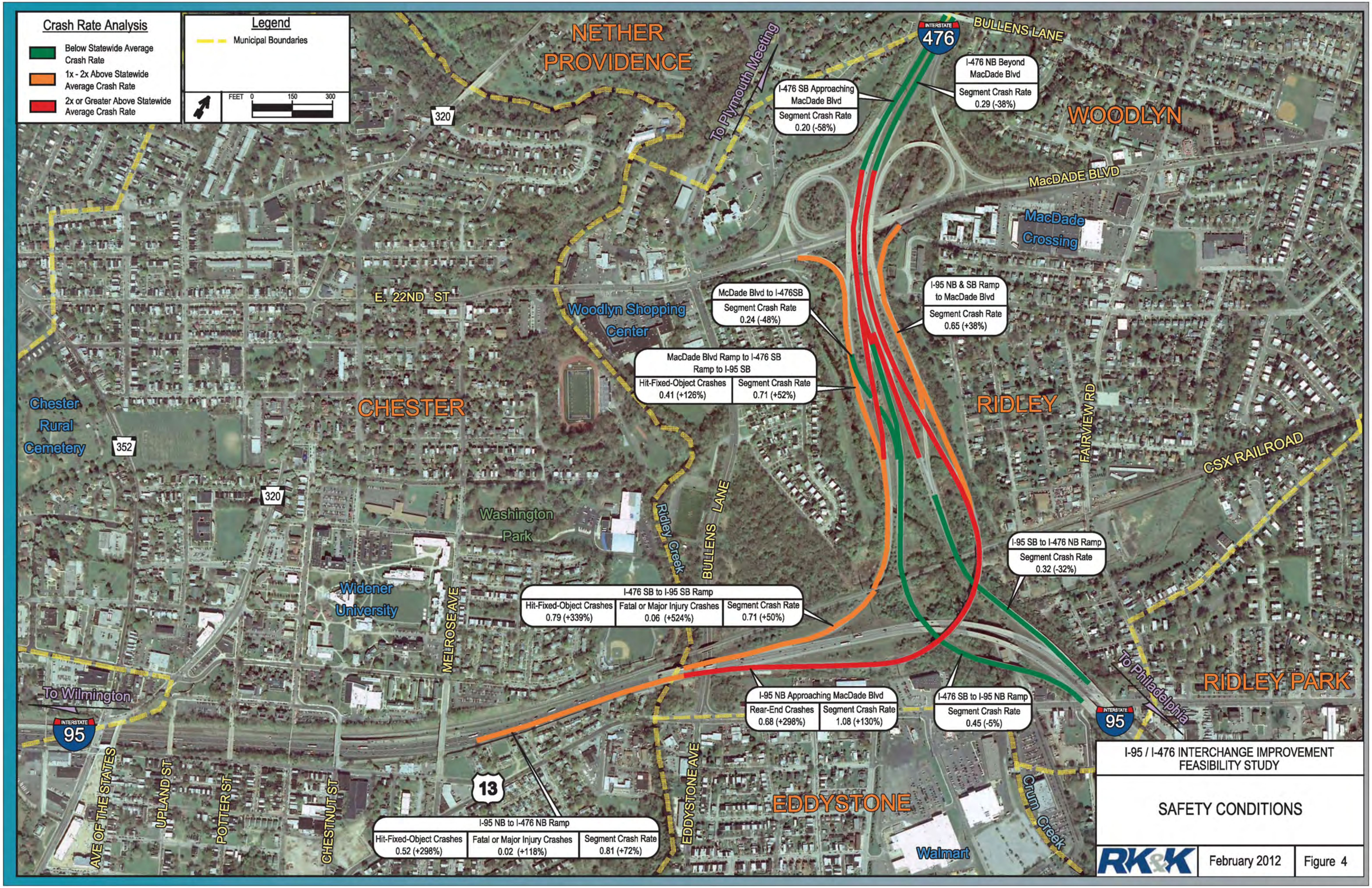
In addition to addressing operational considerations, smaller, more manageable improvements should also address any safety concerns. Prior to this study, DVRPC completed a crash data analysis for I-95 through the interchange as part of a RSOA for the length of I-95 through Delaware County. A notable finding was that northbound I-95 approaching the I-476 interchange contained the highest incidence of rear-end crashes for the entire 12-mile corridor for the period 2007 to 2009. Furthermore, rear-end crashes for this segment occur at almost four times the statewide average for similar facilities. A high rear-end crash rate is typical of a congested roadway. No other significant crash history was identified as part of the RSOA.

Supplementing the RSOA, a crash analysis was completed for each of the interchange ramps and the segment of I-476 immediately north of the interchange for the five-year period from 2005 to 2009. Total crashes were reviewed, as well as selected crash types and severities where a pattern appeared to emerge. A total of 163 crashes occurred within the interchange (I-95 mainline excluded), and as **Table 5** illustrates, overall crash rates for individual segments range from significantly under (less than 50 percent) to greater than the statewide average. **Figure 4** graphically depicts the overall crash rates, and targeted crash rates are shown in **Table 5**.

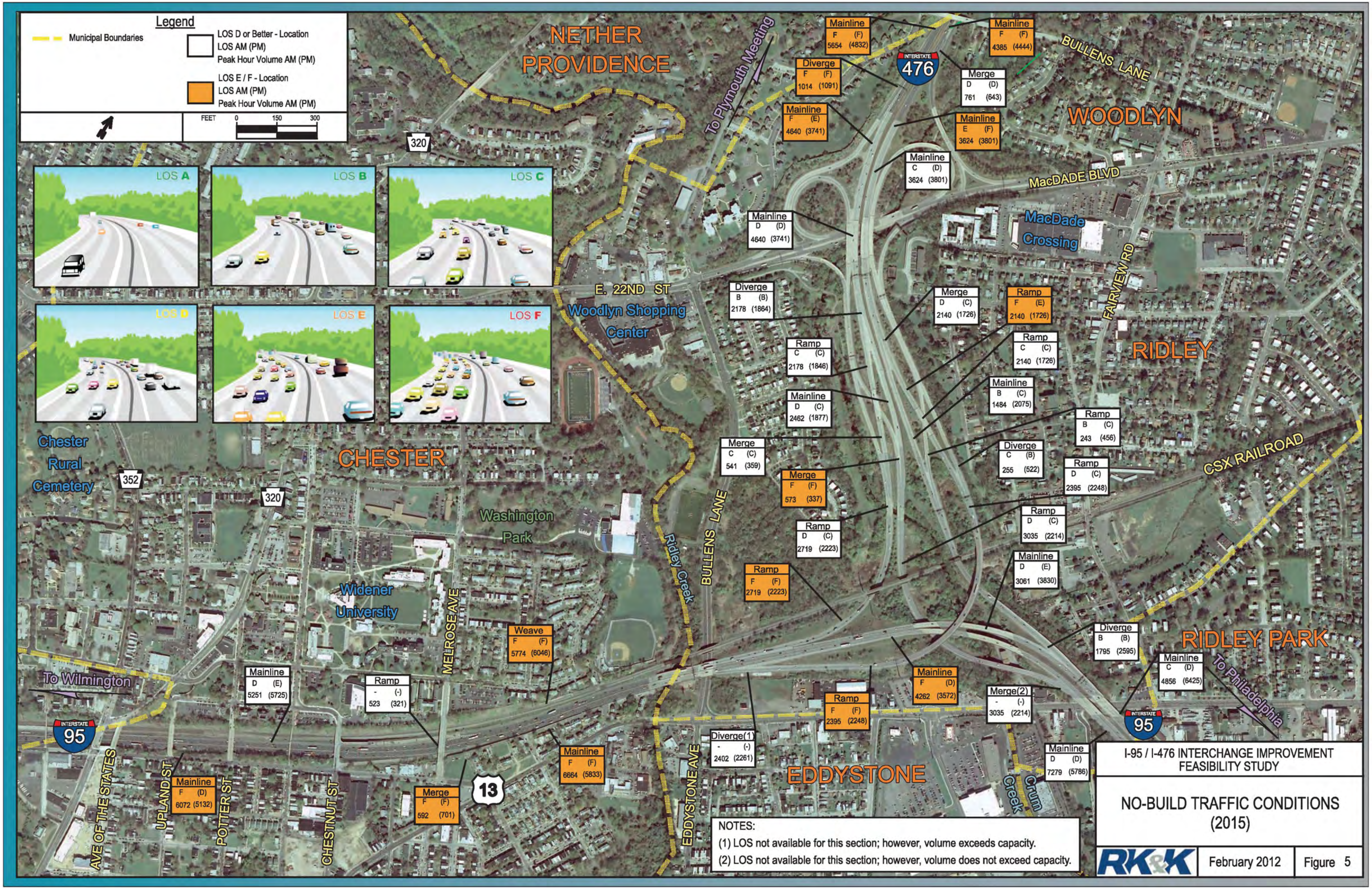
Table 5. Overall Crash Rate by Roadway Segment

Roadway Segment	Crash Rate (per mvm[1])	Comparison to Statewide Average
Mainline I-95 NB approaching I-476 interchange	1.08	+130%
Rear-End Crashes	0.68	+298%
Ramp from I-95 NB to I-476 NB	0.81	+72%
Fatal/Major Injury	0.02	+118%
Hit-Fixed-Object	0.52	+298%
I-95 SB to I-476 NB (Segment 0500)	0.32	-32%
I-95 NB to MacDade Boulevard (Segment 0520)	0.65	+38%
I-95 SB to MacDade Boulevard (Segment 0510)	-	-
I-476 SB to I-95 NB (Segment 0260)	0.45	-5%
I-476 SB to I-95 SB (Segment 0250)	0.71	+50%
Fatal/Major Injury	0.06	+524%
Hit-Fixed-Object	0.79	+339%
MacDade Boulevard to I-95 NB (Segment 0270)	0.24	-48%
MacDade Boulevard to I-95 SB (Segment 0280)	0.71	+52%
Hit-Fixed-Object	0.41	+126%
I-476 Northbound Exiting (Segment 0002)	0.29	-38%
I-476 Southbound Approach (Segment 0003)	0.20	-58%

Notes:
1 mvm = million vehicle miles
Source: Pennsylvania Department of Transportation, 2011



Crash Rate Analysis
Below Statewide Average Crash Rate
1x - 2x Above Statewide Average Crash Rate
2x or Greater Above Statewide Average Crash Rate
Legend
Municipal Boundaries
FEET 0 150 300
NETHER PROVIDENCE
WOODLYN
CHESTER
RIDLEY
RIDLEY PARK
EDDYSTONE
BULLENS LANE
To Plymouth Meeting
MacDADE BLVD
MacDade Crossing
E. 22ND ST
Woodlyn Shopping Center
Chester Rural Cemetery
Washington Park
Widener University
Ridley Creek
BULLENS LANE
MELROSE AVE
FAIRVIEW RD
CSX RAILROAD
To Philadelphia
To Wilmington
AVE OF THE STATES
UPLAND ST
POTTER ST
CHESTNUT ST
EDDYSTONE AVE
Crum Creek
Walmart
476
320
352
95
13
I-476 SB Approaching MacDade Blvd
Segment Crash Rate 0.20 (-58%)
I-476 NB Beyond MacDade Blvd
Segment Crash Rate 0.29 (-38%)
McDade Blvd to I-476SB
Segment Crash Rate 0.24 (-48%)
I-95 NB & SB Ramp to MacDade Blvd
Segment Crash Rate 0.65 (+38%)
MacDade Blvd Ramp to I-476 SB Ramp to I-95 SB
Hit-Fixed-Object Crashes 0.41 (+126%)
Segment Crash Rate 0.71 (+52%)
I-95 SB to I-476 NB Ramp
Segment Crash Rate 0.32 (-32%)
I-476 SB to I-95 SB Ramp
Hit-Fixed-Object Crashes 0.79 (+339%)
Fatal or Major Injury Crashes 0.06 (+524%)
Segment Crash Rate 0.71 (+50%)
I-95 NB Approaching MacDade Blvd
Rear-End Crashes 0.68 (+298%)
Segment Crash Rate 1.08 (+130%)
I-476 SB to I-95 NB Ramp
Segment Crash Rate 0.45 (-5%)
I-95 NB to I-476 NB Ramp
Hit-Fixed-Object Crashes 0.52 (+298%)
Fatal or Major Injury Crashes 0.02 (+118%)
Segment Crash Rate 0.81 (+72%)
I-95 / I-476 INTERCHANGE IMPROVEMENT FEASIBILITY STUDY
SAFETY CONDITIONS
RK&K
February 2012
Figure 4



Legend
Municipal Boundaries
LOS D or Better - Location
LOS AM (PM)
Peak Hour Volume AM (PM)
LOS E / F - Location
LOS AM (PM)
Peak Hour Volume AM (PM)
FEET 0 150 300
LOS A
LOS B
LOS C
LOS D
LOS E
LOS F
NETHER PROVIDENCE
WOODLYN
RIDLEY
RIDLEY PARK
CHESTER
EDDYSTONE
To Plymouth Meeting
BULLENS LANE
MacDADE BLVD
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Chester Rural Cemetery
Washington Park
Widener University
Ridley Creek
BULLENS LANE
MELROSE AVE
CSX RAILROAD
To Wilmington
To Philadelphia
AVE OF THE STATES
UPLAND ST
POTTER ST
CHESTNUT ST
EDDYSTONE AVE
Crum Creek
320
352
13
476
95
Mainline F (F) 5654 (4832)
Mainline F (F) 4385 (4444)
Diverge F (F) 1014 (1091)
Merge D (D) 761 (643)
Mainline F (E) 4640 (3741)
Mainline E (F) 3624 (3801)
Mainline C (D) 3624 (3801)
Mainline D (D) 4640 (3741)
Diverge B (B) 2178 (1864)
Merge D (C) 2140 (1726)
Ramp F (E) 2140 (1726)
Ramp C (C) 2178 (1846)
Ramp C (C) 2140 (1726)
Mainline D (C) 2462 (1877)
Mainline B (C) 1484 (2075)
Ramp B (C) 243 (456)
Merge C (C) 541 (359)
Diverge C (B) 255 (522)
Ramp D (C) 2395 (2248)
Merge F (F) 573 (337)
Ramp D (C) 3035 (2214)
Ramp D (C) 2719 (2223)
Mainline D (E) 3061 (3830)
Ramp F (F) 2719 (2223)
Diverge B (B) 1795 (2595)
Weave F (F) 5774 (6046)
Mainline C (D) 4856 (6425)
Mainline D (E) 5251 (5725)
Ramp - (-) 523 (321)
Mainline F (D) 4262 (3572)
Merge(2) - (-) 3035 (2214)
Ramp F (F) 2395 (2248)
Diverge(1) - (-) 2402 (2261)
Mainline F (F) 6664 (5833)
Mainline D (D) 7279 (5786)
Mainline F (D) 6072 (5132)
Merge F (F) 592 (701)
I-95 / I-476 INTERCHANGE IMPROVEMENT FEASIBILITY STUDY
NO-BUILD TRAFFIC CONDITIONS (2015)
RK&K
February 2012
Figure 5
NOTES:
(1) LOS not available for this section; however, volume exceeds capacity.
(2) LOS not available for this section; however, volume does not exceed capacity.

c. Future Traffic Growth

Traffic growth projections were provided by DVRPC's Office of Modeling and Analysis and applied to the project area. The projections incorporated study area demographics and future demographic/land use changes. Traffic forecasts for I-95, I-476, and MacDade Boulevard, using DVRPC's Travel Improvement Model (Version 1.0), were also incorporated into the growth rates for these roadways. Based on these projections, the annual growth rates are provided in **Table 6**.

Table 6. Future Traffic Growth Projections

Roadway	Annual Growth Rate (2010-2020)	Annual Growth Rate (2020-2035)
I-95	0.65%	0.40%
I-476	0.50%	0.25%
MacDade Boulevard	0.15%	0.10%

Source: DVRPC, 2011

The resulting annual growth rates are lower than those forecast by PennDOT for urban interstates or interstates within Delaware County, as forecast by PennDOT's Bureau of Planning and Research. This low growth rate is reflective of the built-out nature of the surrounding area, not only at the immediately adjacent interchanges, but along I-95 and I-476 throughout Delaware County. This low growth rate also reflects I-95 and I-476 reaching their roadway capacities as they are currently configured. While some growth in demand is to be expected, it does not appear that it will match traffic demand growth throughout the region.

For the purposes of this study, an initial horizon year of 2015 was assumed. Using identical methodology to the existing traffic analysis, 2015 No-Build Traffic Conditions were established, as shown in **Figure 5.** As the level of improvements considered in this study is to provide immediate congestion relief and/or safety mitigation, a five-year horizon was considered the best way to determine the initial efficacy of proposed improvements in lieu of the 20-year design horizon used in major capacity expansion projects. Additionally, traffic volumes were subsequently grown using the factors in **Table 6** to estimate when each of the proposed improvements would no longer provide any operational benefit; that is, the anticipated timeframe when any anticipated operational benefit would be offset by traffic growth. These travel volumes and operational analyses were used as part of the evaluation of improvements.

d. Summary

Each of the existing conditions investigation components, when reviewed together, revealed a correlation between identified roadway deficiencies, high crash rates, and poor traffic operations at the interchange, as shown in **Table 7**. As a result, several segments within the interchange emerged as candidate locations for cost-effective and "easily constructible" solutions to reduce traffic congestion within and approaching the I-95 and I-476 Interchange. In turn, understanding the related nature of the roadway deficiencies to recurring (operational) and non-recurring (safety and incident management) congestion allows for targeted solutions to be developed. Furthermore, these results become important and the combination and prioritization of solutions is considered further in the study.

Table 7. Existing Conditions Summary

Highway Segment		Roadway/Geometric Issues	Safety Issues	Traffic Operation Issues
NB I-95	Approaching I-476 diverge	• No merge area for Chestnut Street entrance ramp • One lane exit to NB I-476	High total accident rate	AM- LOS F PM- LOS D to F
	Within interchange	• No lane balance or maintenance of the basic number of lanes	None specified in RSOA	AM- LOS F PM- LOS D
	North of I-476 merge	• None identified	None identified	AM- LOS D PM- LOS D
SB I-95	Approaching I-476 diverge	• Peak period congestion is possibly caused by spill-back from the I-476 merge to the south, not by traffic operations at the diverge	None identified	AM- LOS C PM- LOS D
	Within interchange	• No lane balance or maintenance of the basic number of lanes	None specified in RSOA	AM- LOS D PM- LOS D
	South of I-476 merge	• Short weave section between I-476 merge and Chestnut Street diverge; • Short deceleration lane at Chestnut Street exit	None specified in RSOA	AM- LOS F PM- LOS F
Interchange Ramps	NB I-95 to NB I-476	• Left lane drop on two-lane ramp within gore area of merge with ramp from SB I-95 • Horizontal sight distance (35 mph)	Very high total accident rate	AM- LOS C to F PM- LOS C to F
	SB I-95 to NB I-476	• None identified	None identified	AM-LOS B PM-LOS C to B
	SB I-476 to SB I-95	• Consecutive merge (from MacDade Boulevard) and lane drop • Horizontal sight distance (45 mph)	High total accident rate	AM- LOS D to F PM- LOS C to F
	SB I-476 to NB I-95	• Horizontal sight distance (35 mph)	None identified	AM-LOS D PM-LOS C
NB I-476	Between merge of I-95 ramps and MacDade Boulevard merge	• Left lane drop	Very high total accident rate	AM- LOS C to E PM- LOS C to E
	North of MacDade Boulevard merge	• Two-lane section	None identified	AM- LOS F PM- LOS F
SB I-476	North of MacDade Boulevard diverge	• Two-lane section	None identified	AM- LOS F PM- LOS F
	Between MacDade Boulevard diverge and split of I-95 ramp	• None identified	Very high total accident rate	AM- LOS D to F PM- LOS D to E

Source: RK&K, 2011

5. POTENTIAL IMPROVEMENTS

a. Approach

The study considered potential improvements that could address the roadway deficiencies, operational issues, and safety issues described in Section 4. In order to address the purpose and scope of the study, the improvements were developed assuming that large-scale widening, bridge structure reconstruction, and right-of-way and environmental impacts would have to be avoided due to current funding constraints. Instead, the improvements focused on modifications to the existing access, signing, striping, and modified operations that would utilize the existing pavement or require limited, minor widening.

A "toolbox" of lower-cost, short-term and mid-term concepts was developed to identify potential solutions that could be applicable to alleviate the deficiencies and operational issues described in Section 4. These concepts included:

- restriping a highway within the existing roadway section to either add lanes or modify the lane configuration,
- ramp metering,
- ramp closures,
- extending acceleration and/or deceleration lanes into existing shoulders,
- improved signing,
- improved lighting,
- peak period shoulder use, and
- localized/small scale widening for auxiliary lanes.

The potential improvements described below were developed considering these approaches. Examples of these types of concepts are provided in **Appendix C**.

b. Improvements

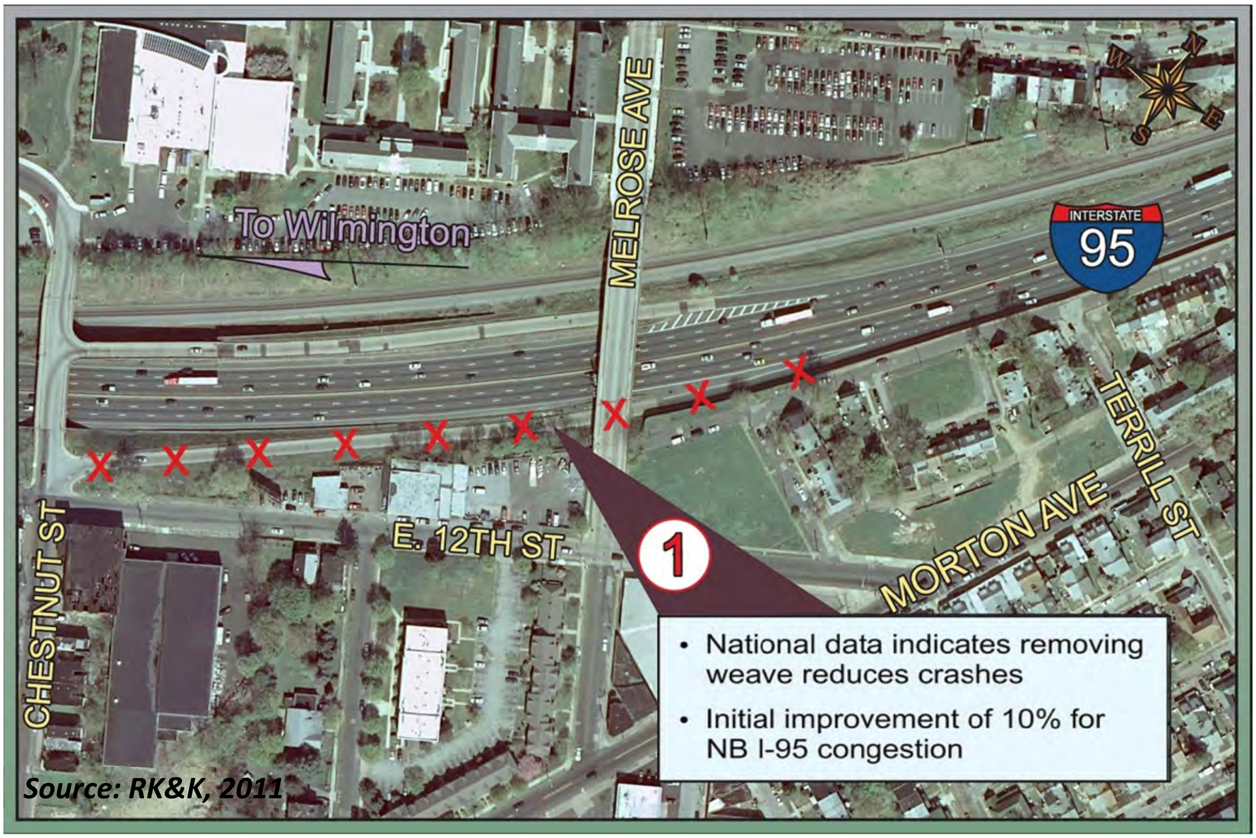
The improvements considered for the I-95/I-476 Interchange Improvement Feasibility Study are described in detail below and summarized in **Table 8** following the detailed descriptions. The improvements are numbered 1 to 13 and include:

1. Close Chestnut Street Entrance Ramp to NB I-95
2. Provide Two-Lane Exit from NB I-95 to NB I-476
3. Provide an Emergency Vehicle Access at Ridley Avenue
4. Reconfigure the Merge of I-95 Ramps to NB I-476
5. Drop the Right Lane of NB I-476 Prior to MacDade Boulevard
6. Implement Peak Period Shoulder Use on NB I-476
7. Extend the MacDade Boulevard Entrance Ramp Acceleration Lane
8. Implement Peak Period Shoulder Use on SB I-476
9. Provide Two-Lane Ramp from SB I-476 to SB I-95
10. Provide Four Lanes on SB I-95 between I-476 and Chestnut Street
11. Improve NB I-95 Advanced Signing
12. Repair and/or Improve Interchange Lighting
13. Erect Advanced Curve Warning Signage

Improvement 1 - Close Chestnut Street Entrance Ramp to Northbound I-95

Improvement 1 would close the Chestnut Street entrance ramp to northbound I-95 for non-emergency vehicles. The ramp would not be demolished, but the entrance would be blocked by a concrete traffic barrier or gate (temporary or permanent). If a concrete barrier is provided, an adequate opening would remain to allow emergency vehicles access to the ramp. Improvement 1 is shown in **Figure 6**.

Figure 6. Improvement 1 - Close Chestnut Street Entrance Ramp to Northbound I-95



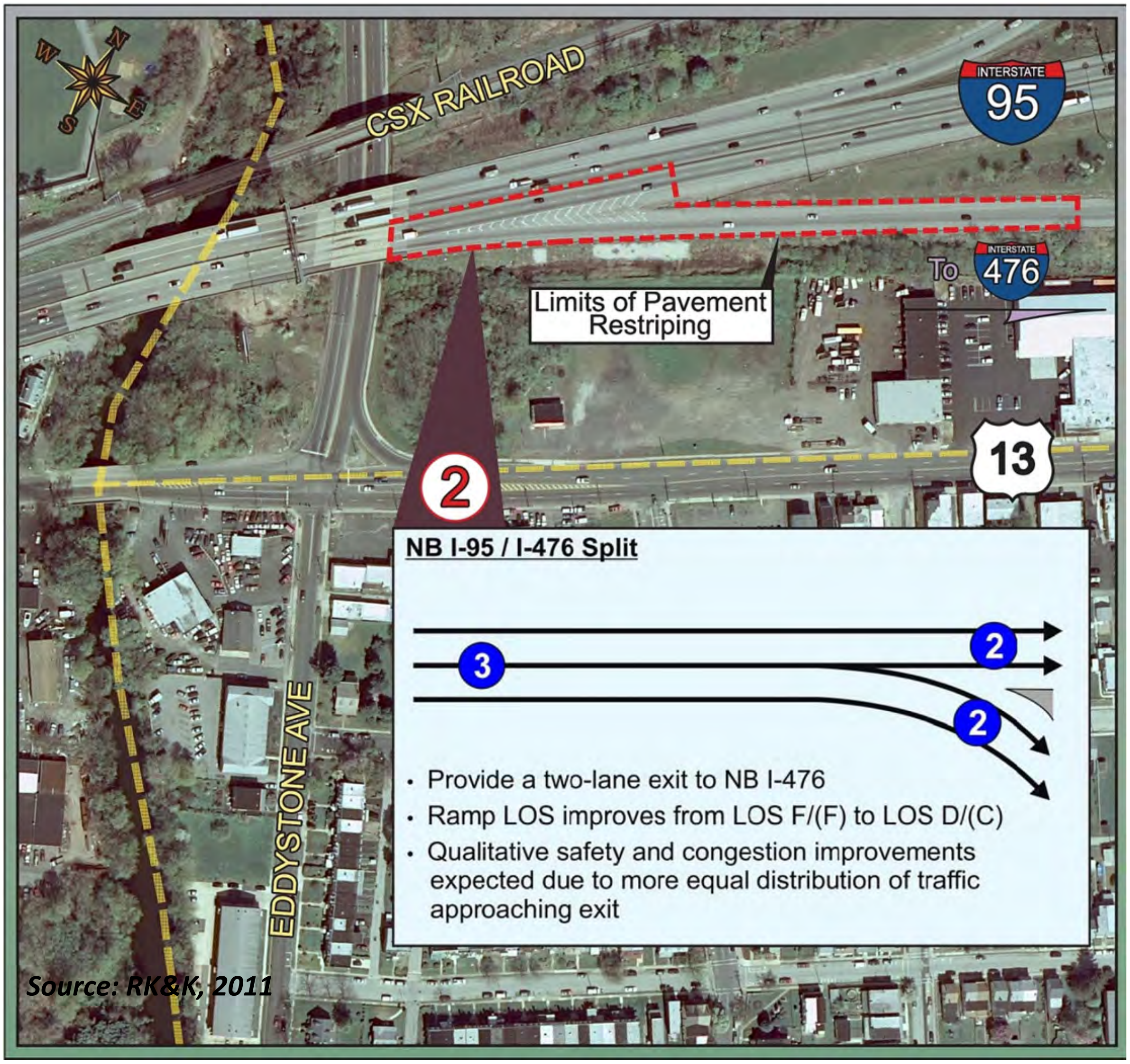
As described in Section 4, the lack of an acceleration lane for this ramp on I-95 and the close proximity of the roadside retaining wall affect traffic operations and safety along northbound I-95. Removing the ramp could improve the operations of northbound I-95 and eliminate the safety concern at the ramp merge. Problems include hit-fixed-object crashes into the wall adjacent to the lane and heavy traffic volume in the right lane waiting to exit onto I-476 northbound. Closing this ramp would require a point of access study, as discussed later in this report. During the SAC meetings, it was suggested to consider a ramp relocation study to determine the best solution to resolve the traffic operations near the ramp merge area.

The ramp closure cost, including engineering, construction, and project administration, would range from $170,000 to $200,000.

Improvement 2 - Provide Two-Lane Exit from Northbound I-95 to Northbound I-476

Improvement 2 would modify the northbound I-95 lane configuration at the ramp diverge to northbound I-476. Currently, I-95 is comprised of three lanes approaching this diverge: the right lane drops at the ramp and the left two lanes continue as northbound I-95. Improvement 2 would modify the diverge to create an even split, with two lanes continuing on northbound I-95 and two lanes exiting to the ramp to northbound I-476. The three I-95 lanes would not be modified; instead, the center lane would be a shared lane where drivers could continue on I-95 or exit to I-476. The right lane would exit to I-476 (as it does today) and the left lane would continue on northbound I-95. Improvement 2 is shown in **Figure 7**.

Figure 7. Improvement 2 - Provide Two-Lane Exit from Northbound I-95 to Northbound I-476



The reconfiguration of this split would provide additional capacity to northbound I-476. Today, as noted in Section 4, the existing peak period traffic demand from northbound I-95 to northbound I-476 exceeds the capacity of a single-lane exit.

Northbound I-95 would have to be restriped in the vicinity of the split. In addition, the gore area and portion of the exit ramp would have to be reconstructed to provide full-depth pavement for the additional exit lane. The northbound I-95 to northbound I-476 exit ramp widens to two lanes after the exit; the restriped exit will tie into the existing ramp alignment. The advance guide signing along northbound I-95 would have to be modified to accommodate the reconfigured split. These modifications would include new overhead and cantilever sign structures and sign panels.

The cost, including engineering, construction, and project administration, would range from $900,000 to $1,200,000.

Improvement 3 - Provide an Emergency Vehicle Access at Ridley Avenue

Improvement 3 would provide an emergency access to northbound I-95 at Ridley Avenue. A section of the existing concrete traffic barrier separating I-95 from the intersection of Hancock Street and Ridley Avenue would be removed and replaced by an emergency access gate. This is one of the few places in the interchange area where I-95 is at grade with an adjacent local street. Providing an emergency access here would also require a Point of Access Study. Improvement 3 is shown in **Figure 8**.

Figure 8. Improvement 3 - Provide an Emergency Vehicle Access at Ridley Avenue

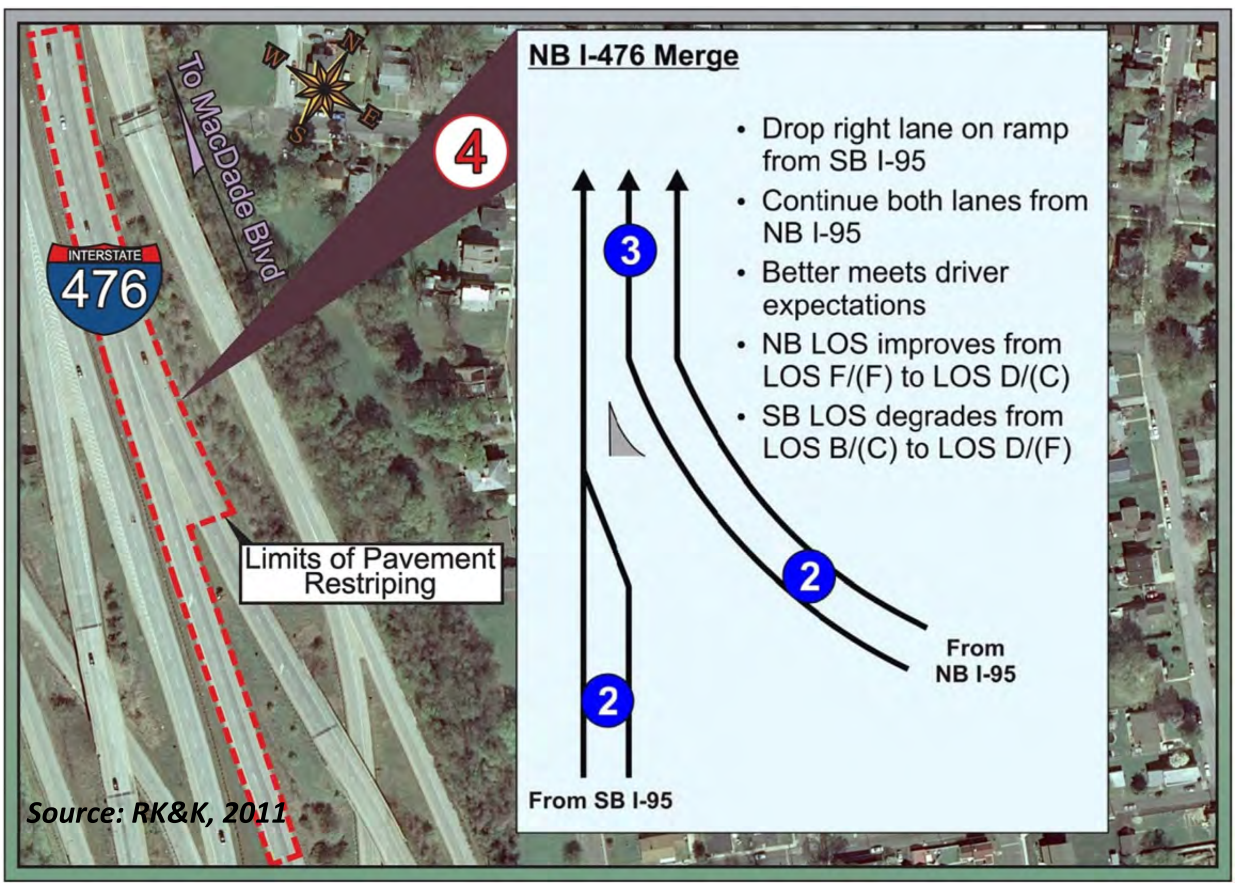
The access gate could be used by emergency responders in the event that nearby ramps to northbound I-95, such as Chestnut Street, are blocked or inaccessible. The ramp would remain closed at all times, except for specific emergencies, and could not be used by the general public. Improvement 3 would require removal of a portion of concrete traffic barrier and minor pavement work around the gate.

The cost, including engineering, construction, and project administration, would range from $100,000 to $130,000.

Improvement 4 - Reconfigure the Merge of I-95 Ramps to Northbound I-476
Improvement 4 would modify the lane configuration at the merge of the ramp from I-95 to northbound I-476. Currently, the left lane of the ramp from northbound I-95 drops at the merge with the ramp from southbound I-95; three lanes continue as northbound I-476, two from southbound I-95 and one from northbound I-95.

This lane configuration would not be compatible with potential Improvement 2, which would provide two lanes for the northbound I-95 to northbound I-476 movement. Therefore, Improvement 4 would modify the merge to maintain the two lanes of the northbound I-95 ramp through the merge. The right lane of the ramp from southbound I-95 would drop prior to the merge. Three lanes would continue on northbound I-476. Reconfiguring the merge would provide two continuous lanes from northbound I-95 to northbound I-476. As noted in Section 4, there is significant peak period congestion along northbound I-95 and the ramp to northbound I-476. Providing additional capacity between northbound I-95 and northbound I-476 may alleviate some of this congestion. Improvement 4 is shown in **Figure 9**.

Figure 9. Improvement 4 - Reconfigure the Merge of I-95 Ramps to Northbound I-476



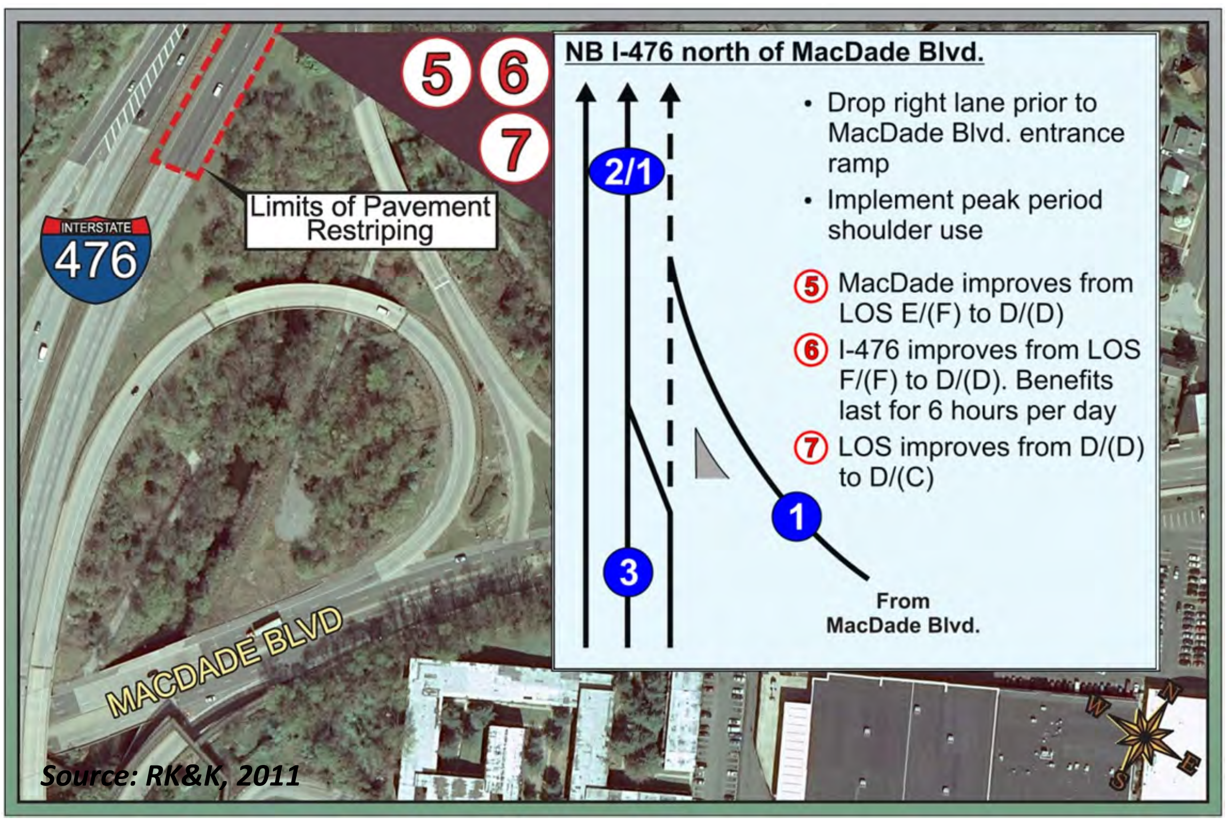
Improvement 4 would require restriping of both ramps from I-95 prior to the merge, and of northbound I-476 through the merge. Signing changes, including new cantilever sign structures, would be required on the ramps to accommodate the modified lane configuration. The cost, including engineering, construction, and project administration, would range from $700,000 to $930,000.

Improvement 5 - Drop the Right Lane of Northbound I-476 Prior to MacDade Boulevard

Improvement 5 would modify the lane drop on northbound I-476 prior to the entrance ramp from MacDade Boulevard. Currently, the left lane drops prior to MacDade Boulevard, leaving two lanes on northbound I-476. Effectively, these two lanes represent one lane from northbound I-95 (right lane) and one lane from southbound I-95 (left lane). Improvement 5 would drop the right lane of northbound I-476 prior to the MacDade Boulevard entrance ramp. The southern limit of Improvement 5 is shown in **Figure 10**.

Modifying the location of the lane drop would provide two benefits. First, as noted in AASHTO, a right side lane drop is more standard and more expected by drivers. Second, a right-lane drop would be consistent with the other modifications to the northbound I-95 and northbound I-476 lane configurations (see Improvements 2 and 4) and would effectively maintain one lane from northbound I-95 (right lane) and one lane from southbound I-95 (left lane) beyond the lane drop.

Figure 10. Improvements 5 and 7 - Drop the Right Lane of Northbound I-476 Prior to MacDade Boulevard and Extend the MacDade Boulevard Entrance Ramp Acceleration Lane



Improvement 5 would require restriping of I-476 through the existing/proposed merge. Signing changes, including a new cantilever sign structure, would be required to accommodate the modified lane configuration. The cost, including engineering, construction, and project administration, would range from $340,000 to $450,000.

Improvement 6 - Implement Peak Period Shoulder Use on Northbound I-476

Improvement 6 would provide peak period shoulder use in the right shoulder of northbound I-476 between MacDade Boulevard and Baltimore Pike. The shoulder would be operated as a travel lane during peak periods or other times of high traffic demand. The status of the shoulder would be communicated by overhead lane-use control signals, static signing, and dynamic message signs. The lanes would be monitored from the PennDOT's Traffic Management Center using closed-circuit television (CCTV) cameras equipped with pattern recognition software. The southern limit of Improvement 6 is shown on **Figure 10**; Improvement 6 extends north beyond the interchange area.

One of the major constraints along northbound I-476 is the two-lane segment north of MacDade Boulevard. As described in Section 4, the peak period traffic demand exceeds the capacity of two lanes. Therefore, the segment of highway frequently congests, and that congestion spills back into the I-95/I-476 interchange, even affecting traffic operations along I-95.

Active Traffic Management allows for shoulder to be closed outside of peak travel periods.
Photo Source: Virginia Department of Transportation

Accommodating travel demand by providing a full-time third lane along I-476 is anticipated to be extremely costly. Additionally, the final Record of Decision for the original I-476 construction included provisions that downsized I-476 between West Chester Pike and MacDade Boulevard to reduce the footprint of the right-of-way, minimizing impacts to park lands, historic resources, and streams. Even though this action was taken to minimize environmental impacts and was not based upon traffic considerations, peak hour shoulder use would likely require revisiting the Environmental Impact Statement (EIS). Furthermore, any approach to managing travel demand must be consistent with the region's Congestion Management Process. For all these reasons, peak period shoulder use was evaluated as an operational strategy that provides additional capacity during high volume time periods without adding a full-time lane. The strategy also allows for expected operational improvements without having to widen the road and bridges, affect right-of-way, or impact environmental features.

Improvement 6 would require lane-use control signs and dynamic message signs, along with the associated sign structures. Emergency pull-off areas would be constructed along the shoulder approximately every half mile to provide a location for breakdowns, incident response vehicles, and police enforcement. In addition to the CCTV cameras, other Intelligent Transportation Systems (ITS) devices like in-shoulder traffic detectors would be included to augment the management of the shoulder.

The cost, including engineering, construction, and project administration, would range from $5,550,000 to $7,380,000 (this estimate is for I-476 between MacDade Boulevard and Baltimore Pike).

Improvement 7 - Extend the MacDade Boulevard Entrance Ramp Acceleration Lane

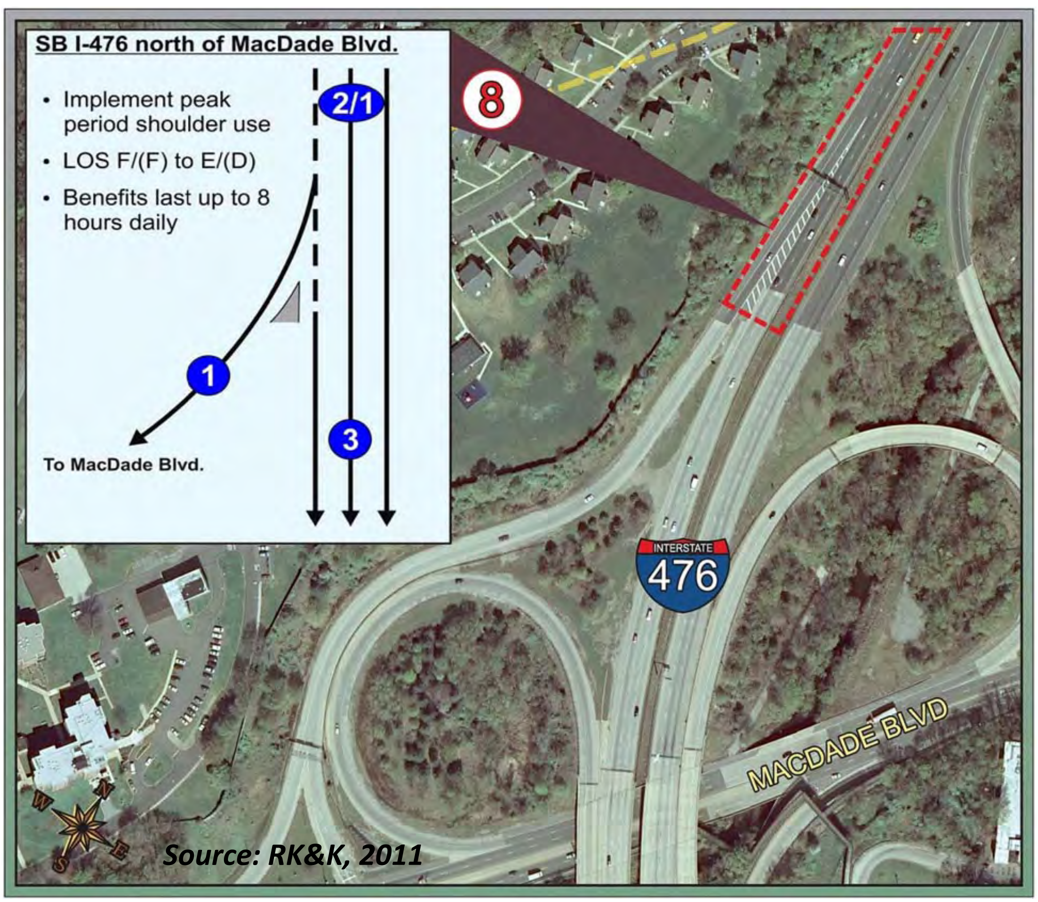
Improvement 7 would extend the acceleration lane of the entrance ramp from MacDade Boulevard to northbound I-476. Additional acceleration distance would provide more time for drivers to merge into northbound I-476, which could help to improve traffic operations, especially during congested periods. Extending the MacDade Boulevard on-ramp is an independent project that can stand alone or be incorporated into the peak shoulder use. The design will vary slightly based on conditions. The southern limit of Improvement 7 is shown in **Figure 10**.

Improvement 7 would require minor shoulder widening along northbound I-476 and restriping for the modified merge condition. The cost, including engineering, construction, and project administration, would range from $530,000 to $700,000.

Improvement 8 - Implement Peak Period Shoulder Use on Southbound I-476

Improvement 8 would provide peak period shoulder use in the right shoulder of southbound I-476 between Baltimore Pike and MacDade Boulevard. As with Improvement 6, the shoulder would be operated as a travel lane during peak periods or other times of high traffic demand. The status of the shoulder would be communicated by overhead lane-use control signals, static signing, and dynamic message signs. The lanes would be monitored from the regional traffic management center using CCTV cameras equipped with pattern recognition software. The southern limit of Improvement 8 is shown in **Figure 11**.

Figure 11. Improvement 8 - Implement Peak Period Shoulder Use on Southbound I-476



Similar to northbound, a major constraint along southbound I-476 is the two-lane segment north of MacDade Boulevard. As described in Section 4, the peak period traffic demand exceeds the capacity of two lanes. Therefore, the segment of highway frequently congests, affecting traffic operations along southbound I-476 north of the I-95/I-476 interchange. Peak period shoulder use is an approach that could provide additional capacity during high volume times without having to widen the road and bridges, affect right-of-way, or impact environmental features.

Improvement 8 would require lane-use control signs and dynamic message signs, along with the associated sign structures. Emergency pull-off areas would be constructed along the shoulder approximately every half mile to provide a location for breakdowns, incident response vehicles, and police enforcement. In addition to the CCTV cameras, other ITS devices like in-shoulder traffic detectors would be included to augment the management of the shoulder. The two-lane segment of I-476, from West Chester Pike south to the interchange, currently meters traffic coming into the I-95/I-476 Interchange. Peak hour shoulder use will remove the bottleneck and impact the longevity of Improvements 9 and 10. Further study will be needed to determine the extent of the impacts to Improvements 9 and 10.

The cost, including engineering, construction, and project administration, would range from $5,410,000 to $7,200,000 (this estimate is for I-476 between MacDade Boulevard and Baltimore Pike).

Improvement 9 - Provide Two-Lane Ramp from Southbound I-476 to Southbound I-95

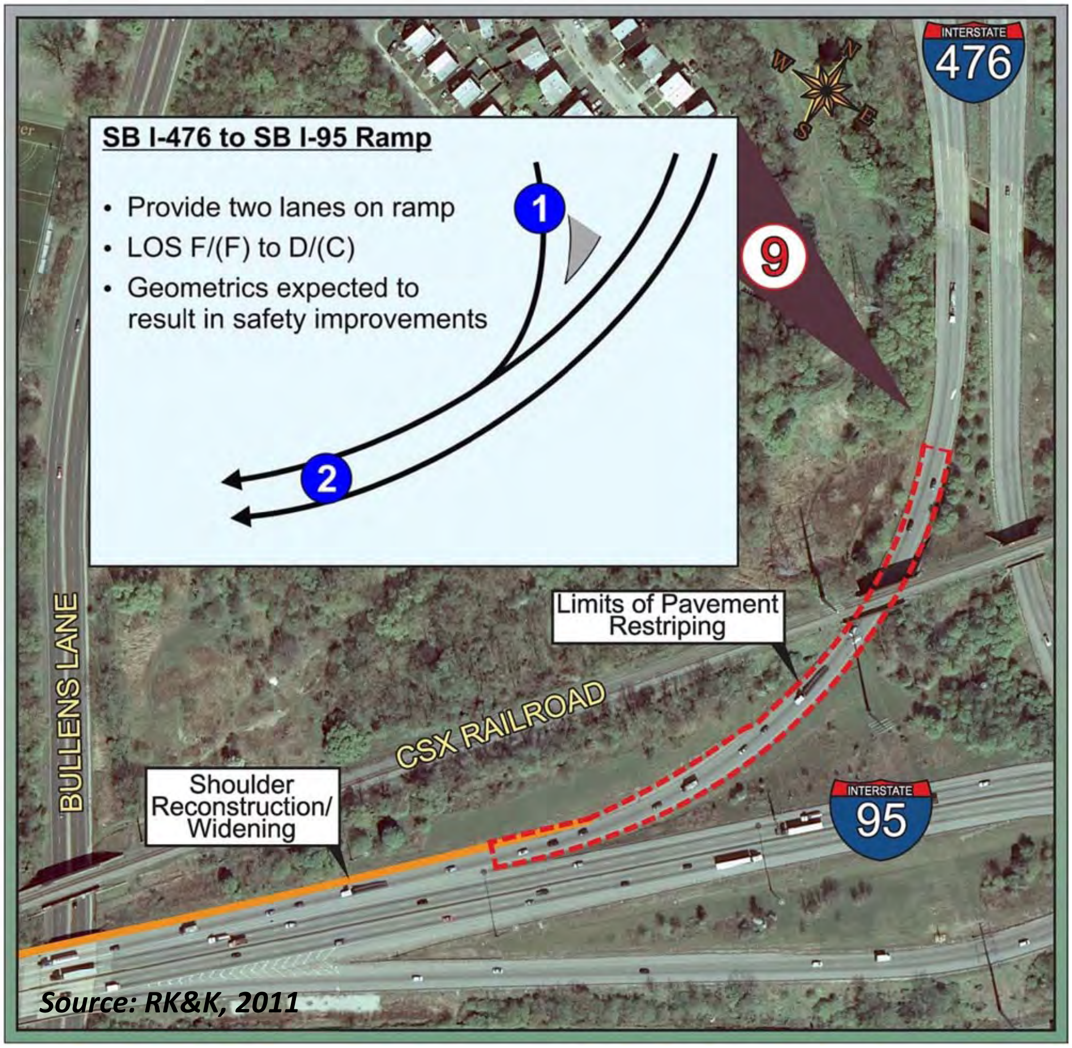
Improvement 9 would provide a two-lane ramp from southbound I-476 to southbound I-95. Currently, three lanes are provided along southbound I-476 approaching the split to northbound and southbound I-95. The three lanes split with two lanes directed to northbound I-95 and two lanes directed to southbound I-95 (the center lane is a choice lane). The two lane ramp to southbound I-95 narrows to one lane concurrent with the merge of the lane from MacDade Boulevard to southbound I-95. Improvement 9 would maintain the two lanes on the ramp to southbound I-95. There is sufficient clearance for a second lane under the CSX Railroad bridge. Improvement 9 is shown in **Figure 12**.

The lane drop and merge on the southbound I-476 to southbound I-95 ramp causes frequent congestion that often backs up onto the mainline of southbound I-476. This improvement, in addition to increasing capacity for this movement, extends merging movements beyond the MacDade Boulevard on-ramp and subsequent curve, which should reduce congestion.

Improvement 9 would require resurfacing and restriping along the ramp, and minor widening along the right side of the ramp approaching the merge with southbound I-95 (south of the CSX Railroad bridge) to maintain a useable right shoulder.

The cost, including engineering, construction, and project administration, would range from $300,000 to $400,000.

Figure 12. Improvement 9 - Provide Two-Lane Ramp from Southbound I-476 to Southbound I-95



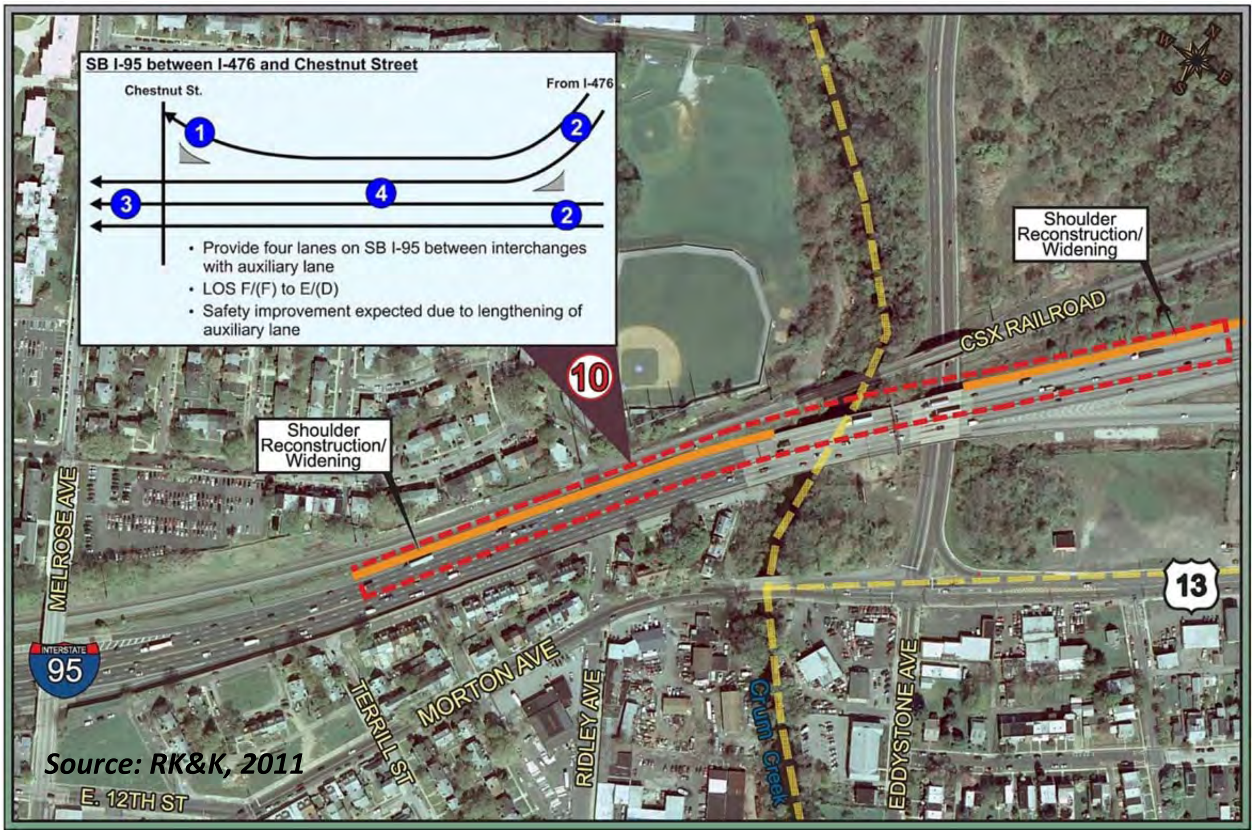
Improvement 10 - Provide Four Lanes on SB I-95 between I-476 and Chestnut Street

Improvement 10 would reconfigure southbound I-95 between I-476 and Chestnut Street. Consistent with Improvement 9, the two southbound I-95 lanes would merge with the two-lane ramp from southbound I-476. The right lane would act as an auxiliary lane between the I-476 entrance ramp and the Chestnut Street exit ramp. The left three lanes would continue as southbound I-95. The auxiliary lane would be approximately 2,000 feet long. Improvement 10 is shown in **Figure 13**.

Improvement 10 would provide additional capacity for southbound I-95 between I-476 and Chestnut Street. Currently, three lanes are provided in this section. The combination of heavy peak period traffic volumes along southbound I-95 and the single-lane merge from southbound I-476 produces substantial traffic friction that results in congestion along southbound I-95 and the entrance ramp from southbound I-476. In addition, the weaving of drivers maneuvering to exit at Chestnut Street, where only a short deceleration lane is provided, contributes to the congestion. Providing four lanes in this section would allow greater weaving distance to merge with southbound I-95 and exit at Chestnut Street. In addition, the two-lane entrance should cause less friction at the merge with southbound I-95 because the ramp traffic will be spread in two lanes and traveling at a higher speed as a result of lower congestion.

Reduction of congestion on I-95 may have a secondary benefit of improving traffic operations along southbound I-95 at the diverge to northbound I-476. Spill-back congestion at the I-476 merge is a contributory factor to congestion at the split.

Figure 13. Improvement 10 - Provide Four Lanes on SB I-95 between I-476 and Chestnut Street



Improvement 10 would require resurfacing and restriping of southbound I-95 between the I-476 entrance ramp and the Chestnut Street exit ramp. Widening would be required along southbound I-95 to provide a useable right shoulder. The I-95 bridge over Bullens Lane and Ridley Creek would not be widened, and only minimal offsets would be provided between the edge of the right lane and bridge parapet. A concrete traffic barrier or small retaining wall would be required along the right shoulder south of this bridge to minimize the grading adjacent to the CSX Railroad tracks. Signing modifications, including a new cantilever sign structure, would be required to accommodate the modified lane configuration.

The cost, including engineering, construction, and project administration, would range from $3,500,000 to $4,700,000.

Improvement 11 - Improve the Northbound I-95 Advanced Signing

Currently, traffic traveling north along I-95 approaching I-476 does not receive any warning regarding the interchange until the one-mile advanced guide sign. The exiting lane is often queued due to capacity constraints, and those drivers who are unfamiliar with the interchange may be forced to make an undesirable move into that congested lane. Providing additional advance warning for the interchange may improve this condition; however, it must be completed under the context of signing for I-95 as it stands today and in the future. Two options that could be considered include:

- Adding a two-mile Advanced Guide Sign, located in advance of the Kerlin Street/Avenue of the States exit; and
- Adjusting the “Chester Exits” to interchange sequence signs, and adding a supplemental guide sign stating “Chester Next 5 Exits” in advance of Exit 3, as shown schematically in **Figure 14**, which is taken from the *Manual on Uniform Traffic Control Devices* (MUTCD).

The cost, including engineering, construction, and project administration, would range from $75,000 to $100,000, assuming that major sign structure work is not necessary. However, recent guide sign upgrades may provide additional guidance that the options would also provide.

Figure 14. Improvement 11 - Sample Northbound I-95 Advanced Signing Improvements

The existing Interchange Sequence Signs show only Chester interchanges. Modifying these signs can provide more advanced notice of the I-476 interchange. A supplemental guide sign would be needed to keep the message directing drivers to Chester.
Photo Source: RK&K, 2012

Improvement 12 - Repair and/or Improve Interchange Lighting
For the southbound I-476 ramp to southbound I-95, the lack of roadway lighting also may be a contributing crash factor, as a significant portion of those crashes have been reported as having “dark” conditions. The crash history supports anecdotal information offered by the SAC, stating that there appears to be some locations/ramps through the interchange that are currently dark.

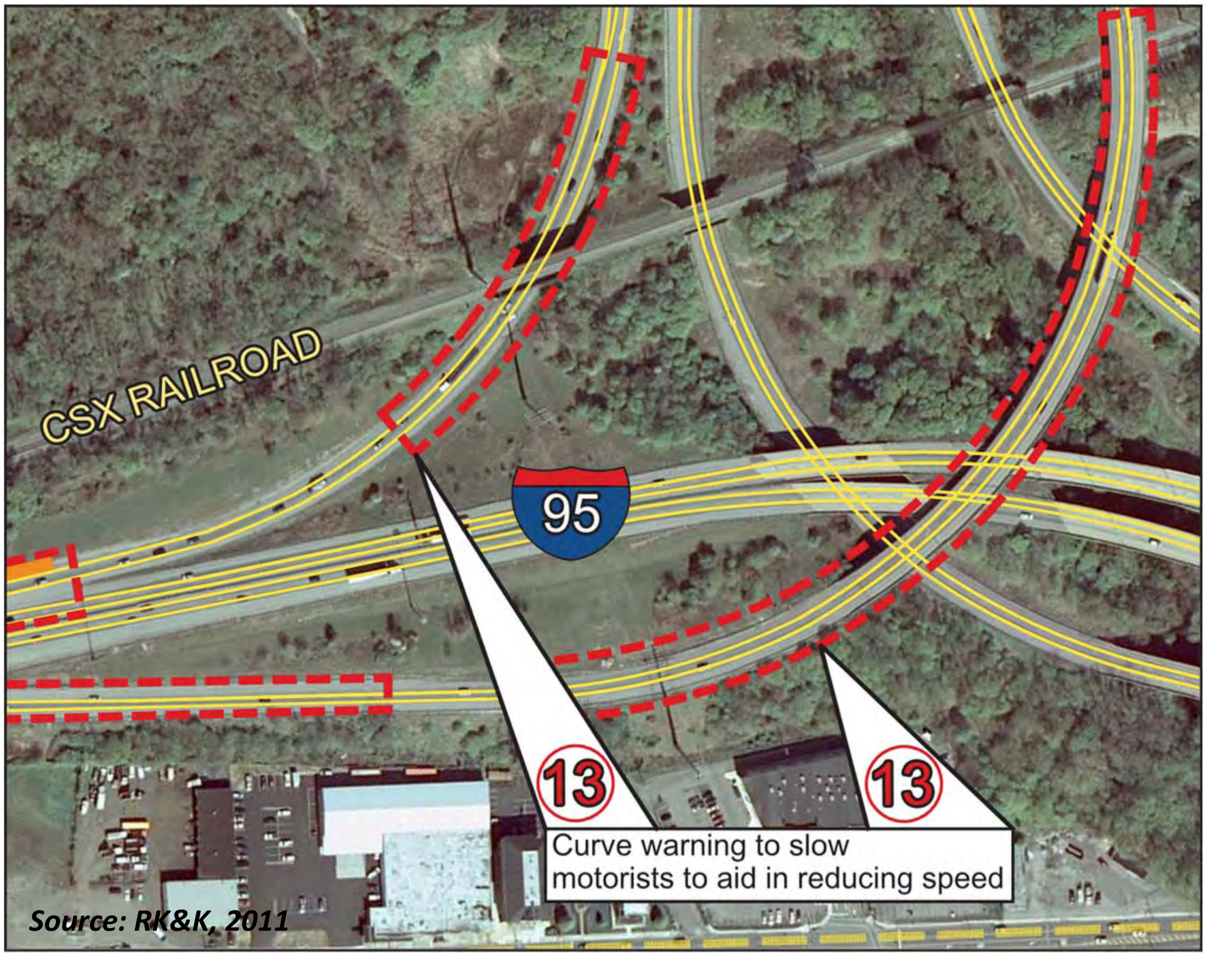
Using a combination of high-mast lighting and low-level lights, it appears that the interchange was designed to have continuous lighting throughout. As such, it appears that a comprehensive assessment of the lighting electrical system should be completed. This will allow for District Maintenance to understand the scope of repairs necessary to reestablish continuous lighting at the interchange. Once completed, lighting improvements, such as wiring, fixture, or even light pole replacements, can be included to restore the lighting to its original design.

The cost for these improvements could range from $25,000 (simple electrical fixes) to upwards of $365,000 for the replacement of several poles, and is dependent on the full electrical diagnostic assessment.

Improvement 13 - Erect Advanced Curve Warning Signage

The highest rates of fixed-object crashes occur along both the northbound I-95 to northbound I-476 and the southbound I-476 to southbound I-95 ramps, where the curvature of the ramp requires travel speeds of 35 to 45 mph, a much slower travel speed than the 55 mph posted speed approaching the interchange. Often, driver expectation for larger system-to-system interchanges is a travel speed matching the approach speed. This reduced speed is exacerbated by the lack of visible signage along the both ramps warning drivers to slow down in advance of the reduced speed curve. The location of Improvement 13 is shown in **Figure 15**.

Figure 15. Improvement 13 – Erect Advanced Curve Warning Signage



Several solutions could be considered to reduce those crashes due to high speeds entering these ramps, including advanced curve warning signs, automated speed warning systems, and pavement rumble strips.

Large, high-visibility signs could be placed in advance of the curves, informing drivers of the potential hazard of high-speed travel through the curve. A larger W1-2L Left Curve sign with a supplementary advisory speed plaque could be a minimal treatment; however, flashing beacons and/or larger guide sign-style warning signage could provide additional visibility for the message. At a cost of approximately $15,000 to $20,000 per sign, these treatments could provide a relatively low-cost countermeasure.

Another countermeasure to combat high speed around curves would be installing an advance sign that would only warn drivers of excessive speed if they were above a certain predefined speed. These systems would utilize speed detection, either via video detection or in-pavement loops, and then activate a flashing beacon system or a dynamic sign. These types of treatments have been installed successfully on various applications, including by PennDOT at the I-70/I-79 interchange in Washington County, or along US 22/US 322 in Dauphin County. For a similar installation by Maryland State Highway Administration along SR 135 in Garrett County, a significant reduction in truck roll-overs has been reported. This type of system, estimated at approximately $75,000 per installation, appears to have increased effectiveness due to the messages only being displayed when excessive speeds are present. This treatment could prove to be an effective countermeasure for both the northbound I-95 to northbound I-476 and the southbound I-476 to southbound I-95 ramps.

A combination of transverse rumble strips, static warning signs, and speed-based active advanced warning signs have proven effective in reducing accidents due to excessive speeds, as shown on I-79 in Washington County, PA
Photo Source: Google

Transverse rumble strips in advance of the curves can be used to alert drivers of upcoming roadway changes, in this case, a lower speed along the ramp curves. Similarly, edge line rumble strips have historically proven to be a successful countermeasure to vehicles veering off the roadway. For both ramps, edge line rumble strips are already present along at-grade asphalt roadway sections. However, a significant portion of the I-95 northbound ramp to I-476 is on structure, as it crosses over the I-95 mainline roadway. While installing edge line rumble strips is not feasible on the bridge deck as currently configured, future edge line treatments that do not compromise bridge deck integrity could be considered.

The cost, including engineering, construction, and project administration, would range from $15,000 for basic sign installations, to up to $300,000 for the combination of all three safety improvements along both ramps.

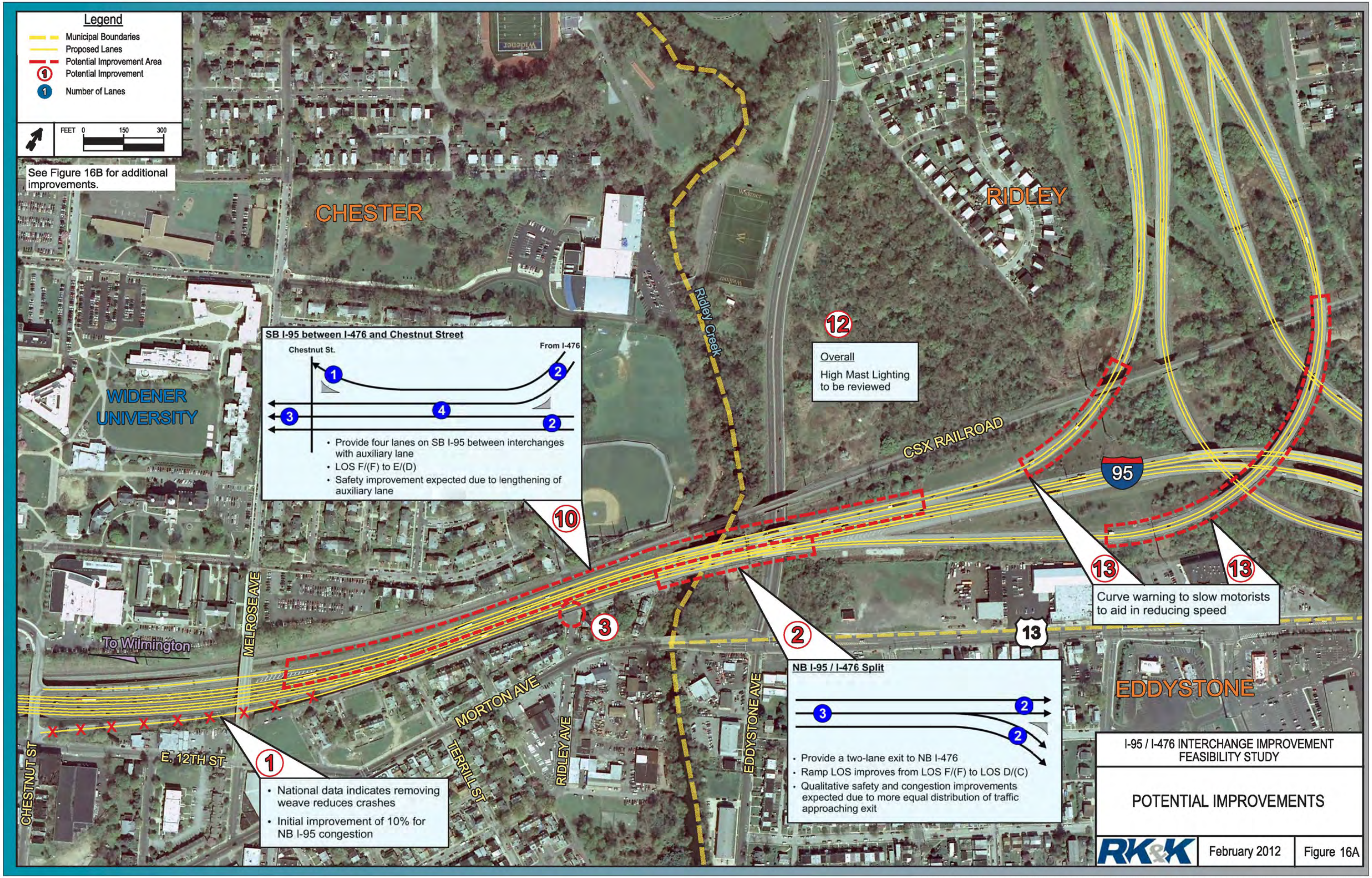
c. Summary

The potential improvements are summarized in **Table 8** and shown in **Figures 16A and 16B**.

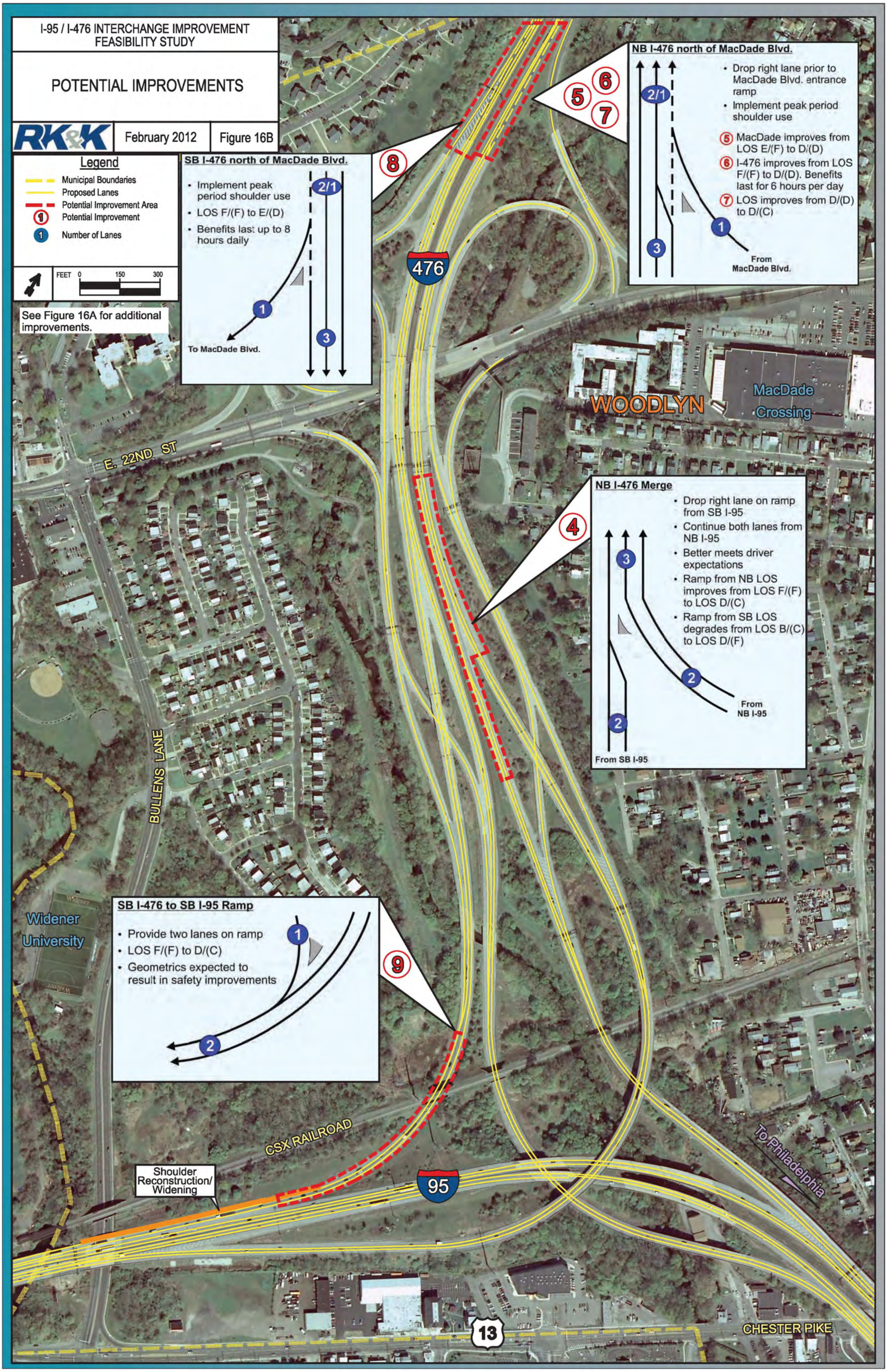
Table 8. Potential Improvements Summary

Improvement		Rationale/Potential Benefit	Cost Range
I-95 Northbound			
1.	Close Chestnut Street Entrance Ramp to NB I-95	• Improve safety along NB I-95 • Improve traffic operations along NB I-95	$170K to $200K
2.	Provide Two-Lane Exit from NB I-95 to NB I-476	• Improve traffic operations along NB I-95 • Improve safety along NB I-95	$900K to $1.2M
3.	Provide an Emergency Vehicle Access at Ridley Avenue	• Provide additional access for emergency vehicles	$100K to $130K
I-476 Northbound			
4.	Reconfigure the Merge of I-95 Ramps to NB I-476	• Improve NB I-476 traffic operations at merge of I-95 ramps • Continue two lanes from NB I-95	$700K to $930K
5.	Drop the Right Lane of NB I-476 Prior to MacDade Boulevard	• Maintain one continuous lane from each ramp from I-95	$340K to $450K
6.	Implement Peak Period Shoulder Use on NB I-476	• Provide additional peak hour capacity on I-476 north of the interchange	$5.6M to $7.4M
7.	Extend the MacDade Boulevard Entrance Ramp Acceleration Lane	• Improve traffic operations along NB I-476	$530K to $700K
I-476 Southbound			
8.	Implement Peak Period Shoulder Use on SB I-476	• Provide additional peak hour capacity on I-476 north of interchange	$5.4M to $7.2M
9.	Provide Two-Lane Ramp from SB I-476 to SB I-95	• Improve traffic operations along SB I-476; reduce accident rates	$300K to $400K
I-95 Southbound			
10.	Provide Four Lanes on SB I-95 between I-476 and Chestnut Street	• Improve traffic operations along SB I-95	$3.5M to $4.7M
General			
11.	Improve NB I-95 Advanced Signing	• Provide additional guide signage for NB I-95 to NB I-476 movement	$75K to $100K
12.	Repair and/or Improve Interchange Lighting	• Improve lighting in "dark" areas; areas with high nighttime accidents	$25K to $365K
13.	Erect Advanced Curve Warning Signage	• Warn drivers to reduce ramp speed on ramps with design speed lower than 55 mph	$15K to $300K

Source: RK&K, 2011



Legend
Municipal Boundaries
Proposed Lanes
Potential Improvement Area
Potential Improvement
Number of Lanes
FEET 0 150 300
See Figure 16B for additional improvements.
CHESTER
RIDLEY
EDDYSTONE
WIDENER UNIVERSITY
Ridley Creek
CSX RAILROAD
95
13
To Wilmington
MELROSE AVE
MORTON AVE
CHESTNUT ST
E. 12TH ST
TERRILL ST
RIDLEY AVE
EDDYSTONE AVE
SB I-95 between I-476 and Chestnut Street
Chestnut St.
From I-476
• Provide four lanes on SB I-95 between interchanges with auxiliary lane
• LOS F/(F) to E/(D)
• Safety improvement expected due to lengthening of auxiliary lane
12
Overall
High Mast Lighting to be reviewed
10
3
2
NB I-95 / I-476 Split
• Provide a two-lane exit to NB I-476
• Ramp LOS improves from LOS F/(F) to LOS D/(C)
• Qualitative safety and congestion improvements expected due to more equal distribution of traffic approaching exit
1
• National data indicates removing weave reduces crashes
• Initial improvement of 10% for NB I-95 congestion
13
Curve warning to slow motorists to aid in reducing speed
I-95 / I-476 INTERCHANGE IMPROVEMENT FEASIBILITY STUDY
POTENTIAL IMPROVEMENTS
RK&K
February 2012
Figure 16A


I-95 / I-476 INTERCHANGE IMPROVEMENT FEASIBILITY STUDY
POTENTIAL IMPROVEMENTS
RK&K
February 2012
Figure 16B
Legend
Municipal Boundaries
Proposed Lanes
Potential Improvement Area
Potential Improvement
Number of Lanes
FEET 0 150 300
See Figure 16A for additional improvements.
SB I-476 north of MacDade Blvd.
• Implement peak period shoulder use
• LOS F/(F) to E/(D)
• Benefits last up to 8 hours daily
To MacDade Blvd.
8
NB I-476 north of MacDade Blvd.
• Drop right lane prior to MacDade Blvd. entrance ramp
• Implement peak period shoulder use
5 MacDade improves from LOS E/(F) to D/(D)
6 I-476 improves from LOS F/(F) to D/(D). Benefits last for 6 hours per day
7 LOS improves from D/(D) to D/(C)
From MacDade Blvd.
5
6
7
476
WOODLYN
MacDade Crossing
E. 22ND ST
NB I-476 Merge
• Drop right lane on ramp from SB I-95
• Continue both lanes from NB I-95
• Better meets driver expectations
• Ramp from NB LOS improves from LOS F/(F) to LOS D/(C)
• Ramp from SB LOS degrades from LOS B/(C) to LOS D/(F)
From NB I-95
From SB I-95
4
BULLENS LANE
Widener University
SB I-476 to SB I-95 Ramp
• Provide two lanes on ramp
• LOS F/(F) to D/(C)
• Geometrics expected to result in safety improvements
9
CSX RAILROAD
To Philadelphia
Shoulder Reconstruction/ Widening
95
13
CHESTER PIKE

6. EVALUATION OF IMPROVEMENTS

The next step taken in this study was to evaluate the 13 potential improvements described in Section 5. The evaluation focused on operational and safety benefits, cost, and implementation considerations. The improvements were presented to stakeholders for their comments and suggested adjustments. This step evaluated each improvement independently, as shown in the following sections.

a. Evaluation Approach

The potential improvements were developed to address the existing roadway deficiencies, operational issues and safety issues presented in Section 4. The improvements were then evaluated based on the following factors:

- operational and safety benefits;
- anticipated improvement lifespan;
- stakeholder input;
- implementation issues;
- timeframe to implement; and
- cost.

Operational and Safety Benefits and Anticipated Lifespan

Future year traffic operational analyses were completed using *Highway Capacity Manual 2000* methodologies, consistent with the existing conditions traffic analyses. The initial analysis was completed for a 2015 opening year, and the results were compared to the future no-build traffic conditions. The operational analyses were only completed for the specific interchange components (freeway, ramp, weave) that each improvement addressed. For example, for Improvement 2 (Provide Two-Lane Exit from NB I-95 to NB I-476), the freeway section approaching the exit, the exit diverge, and the I-476 ramp section immediately downstream of the improvement were the only components analyzed for that improvement. For the purposes of this initial evaluation, it was assumed that all improvements do not influence travel forecasts; as such, all interchange components where the configuration was not directly changed by the improvement were considered to have operations equivalent to the no-build conditions.

After the initial effectiveness of proposed improvements was evaluated, the operational analysis was then carried forth to estimate the improvement lifespan, loosely defined as the anticipated timeframe when any anticipated operational benefit would be offset by future traffic growth. Traffic volumes were grown in five-year increments between 2015 and 2035 using the factors in **Table 6**, including the lower projected growth rate in traffic volumes after 2020. Using these projected traffic volumes, the "build" operational analyses were then recomputed at each five-year interval to estimate the five-year range where traffic operations would resemble the 2015 conditions. The year 2035 was assumed to be the maximum build-out year. Establishing 2035 as the maximum build-out year allowed the final analyses to be consistent with how traffic benefits are more customarily analyzed (*i.e.*, Opening Year + 20).

Typically, capacity improvements, targeted widening, and geometric modifications accomplished through signing and striping were expected to improve safety due to operational benefits. In particular, high rear-end crash rates were expected to decrease when congestion is reduced. Other improvements, such as advance warning systems, were specifically targeted as safety improvements. The *Highway Safety Manual* (HSM) was used to quantitatively estimate the crash reduction capabilities of each improvement; however, for each improvement considered in this study, the research contained in the HSM does not result in a definitive estimate of safety improvements. As such, safety benefits were only qualitatively considered throughout the evaluative process.

Stakeholder Input

As discussed in Section 3, three meetings were held with stakeholders to present the existing roadway and traffic issues and discuss potential solutions. At each meeting, information was presented to the stakeholders and there followed an interactive discussion between the stakeholders and project team. The stakeholders provided input on existing conditions, critiqued the potential improvements, identified implementation issues, and made suggestions on how to evaluate and prioritize the improvements. This collaboration is exemplified in the discussions held for two specific improvements, as follows:

Close Chestnut Street Entrance Ramp to Northbound I-95

Both the SAC and EJ meeting participants voiced opposition to closing the ramp. Chester is an economically disadvantaged city; it has been the city's long-term goal to create a circulation system that would better tie the city to I-95. Completion of the widening of PA 291 and the new I-95 ramps at the Commodore Barry Bridge are steps to achieving this goal. Closing the ramp would negate the city's northern access point to I-95. There was consensus, however, that the ramp should be relocated to the south further away from I-476. Ideally, the Chestnut Street ramps should be at Edgmont Avenue, where the I-95 ramps to and from the south are located. Due to this opposition, the final recommendation calls for a study of a long-term ramp relocation instead of closing the ramp.

Implement Peak Hour Shoulder Use on I-476

The Pennsylvania State Police, which patrols I-476, felt shoulder use would interfere with its ability to reach an accident scene, especially if all lanes are closed. It was explained that the road would be constantly monitored, and any accident would automatically trigger a closure of the shoulder as a travel lane. While this somewhat alleviated its concern, further investigation of how other states deal with this issue is needed.

Implementation Issues

The study focused on short- and mid-term improvements that could be implemented relatively quickly and at significantly less expense than would be required for larger-scale, widening/reconstruction type of improvements. However, the potential improvements cannot be implemented without more detailed study to better understand potential traffic effects, environmental impacts, and access modifications. The complexities of these studies, along with their design and construction, all contribute to the varying timeframe of each improvement.

Several of the potential improvements include changes to access, either by modifying existing lane configurations, closing ramps altogether, or providing new access to the interstate. Any improvements that modify access must complete a Point of Access study. A Point of Access study considers the proposed impacts of adding and/or modifying access to a limited-access facility (such as I-95 and I-476), to ensure that the proposed access is developed properly with minimal adverse impact to the existing system. For similar types of access modifications, the Point of Access study process can range, on average, from between six and eighteen months, depending on the complexity of the proposed improvements.

Several of the improvements require a public involvement process. In addition to federal and state requirements, such as complying with National Environmental Policy Act (NEPA) and inclusion in an adopted Transportation Improvement Program (TIP), evidence of public input is required before any Point of Access approval is granted. Additionally, the interchange is located within and in close proximity to the City of Chester, an economically depressed section of Delaware County predominantly comprised of a minority population. Therefore, EJ issues must be considered. These include impacts to the community from roadway or access changes.

Timeframe to Implement

An estimated timeframe was developed for each improvement accounting for each of these implementation considerations. The complexity of each improvement was factored in, not only from a study and design standpoint, but also from a policy and procedural standpoint. Relative timeframe ranges were identified for each improvement as follows:

- Short-Term – Less than three years (some short-term improvements could become PennDOT Maintenance projects because of the relative ease to design and implement; though the specific improvements that could become PennDOT Maintenance projects will have to be determined),
- Mid-Term – Three to five years,
- Long-Term – Greater than five years.

Costs

Costs were developed based on major quantities, such as resurfacing area, widening or new full depth pavement area, new sign structures, lane-use control signals, new sign panels, etc. Percentages were used to estimate costs for maintenance of protection of traffic, drainage and stormwater management, landscaping, and potential utility impacts. In addition, a 40 percent contingency was added to the construction-related costs to account for unknown project elements at this early stage. Costs for planning and other studies, engineering, and project overhead and administration were added to the construction costs to develop the total costs ranges for each improvement.

b. Evaluation Results

All 13 improvements demonstrated some type of quantifiable improvement; however, the operational and safety benefits, implementation considerations, costs, and timeframes varied for each of the improvements. **Table 9** summarizes the evaluation for each of the improvements. The evaluation results, considered by each criterion, are recapped below:

Operational and Safety Improvements

Of the 13 proposed improvements, nine (Improvements 1, 2, and 4 to 10) are expected to improve the traffic operations within and/or approaching the interchange. Inherent safety benefits are anticipated from the expected improvements in traffic operations.

- Improvement 2 is expected to improve operations for the northbound I-95 to northbound I-476 movement, reducing the recurring queue. This improvement is expected to reduce the high number of rear-end collisions approaching this interchange, which has been identified as a high crash location.
- Improvement 10 (four southbound I-95 lanes) is expected to improve operations between the I-476 entrance ramp and the Chestnut Street exit ramp. A reduction in rear-end accidents is anticipated. Improvement 10 may also improve traffic flow at the southbound I-95 split with I-476.

Table 9: Evaluation Matrix

Timeframe: ♦ Short-Term (<3 yrs.) ♦ Mid-Term (3 to 5 yrs.) ♦ Long-Term (>5 yrs.)

Improvement	Rationale	Operational Benefit	Anticipated Improvement Lifespan (2015)	Cost Range	Implementation	Timeframe	Priority
I-95 Northbound							
1. Close Chestnut Street Entrance Ramp to Northbound I-95	• Improve safety along NB I-95 • Improve traffic operations along NB I-95	• National data demonstrates that removing weaving area reduces crashes • Approximately 10 percent reduction in congestion levels expected	• Estimated level of congestion approaches current level by 2025	$170,000 to $200,000 – ***Ramp Closure Only***	• Requires FHWA Point of Access Study • Requires traffic study to understand traffic impacts in Chester if the ramp is closed • Must be tied to planning study to relocate or reconstruct ramp	Long-Term	Medium
2. Provide Two-Lane Exit from NB I-95 to NB I-476	• Improve traffic operations along NB I-95 • Improve safety along NB I-95	• Improved traffic operations at exit gore and along NB I-476 Ramp o NB I-476 Ramp improves from LOS F/[F] to LOS D/[C] o While NB I-95 approaching interchange at capacity during AM Peak, more even distribution across I-95 lanes results in improved traffic flow	• Congestion improvements on I-476 NB ramp expected beyond 2035 • Independently, estimated level of congestion on I-95 approaches current levels by 2025 • Combined with Chestnut Street closure, estimated level of congestion on I-95 approaches current level by 2035	$900,000 to $1,200,000	• Requires additional design and traffic analyses • Must be implemented with Improvements 4 and 5	Short-Term	High
3. Provide an Emergency Vehicle Access at Ridley Avenue	• Provide additional access for emergency vehicles	• Benefits may be quantified by emergency responders on a case-by-case basis.	• N/A	$100,000 to $130,000	• Requires FHWA Point of Access Study • Requires coordination with emergency responders	Mid-Term	Low
I-476 Northbound							
4. Reconfigure the Merge of I-95 Ramps to NB I-476	• Improve NB I-476 traffic operations at merge of I-95 ramps • Continue two lanes from NB I-95	• NB I-476 Ramp operations improve from LOS F/[F] to LOS D/[C] • Southbound I-476 Ramp operations degrade from LOS B/[C] to LOS D/[F]	• Further study needed to estimate when queues resulting from SB I-95 ramp bottleneck will affect SB I-95 mainline operations	$700,000 to $930,000	• Requires a FHWA Point of Access Study • Requires additional design and traffic analyses • Must be implemented with Improvements 2 and 5	Short-Term	High
5. Drop the Right Lane of NB I-476 Prior to MacDade Boulevard	• Maintain one continuous lane from each ramp from I-95	• Reconfiguration results in one travel lane from both I-95 NB and SB carrying through north of interchange. Balance in traffic flow from I-95 NB and I-95 SB expected to result in improved traffic flow • Operations at MacDade Boulevard entrance ramp improve from LOS E/[F] to LOS D/[D]	• Congestion improvements expected beyond 2035	$340,000 to $450,000	• May require a FHWA Point of Access Study • Requires additional design and traffic analyses • Must be implemented with Improvements 2 and 4	Short-Term	High
6. Implement Peak Period Shoulder Use on NB I-476	• Provide additional capacity on I-476 north of the interchange	• Between MacDade Boulevard and Baltimore Pike (Exit 3), northbound I-476 is expected to be near or above capacity (LOS F) for six hours daily • LOS improves from LOS F/[F] to LOS D/[D] during peak hours	• Congestion improvements expected beyond 2035	$5,550,000 to $7,380,000	• Requires additional traffic analyses • Requires additional investigation of design, lane control elements, and Active Traffic Management • As project advances, a NEPA reevaluation of EIS ROD impacts and commitments may be required. • Incident management requirements need to be coordinated with emergency responders	Mid-Term/ Long-Term	High

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Table 9: Evaluation Matrix (continued)

Timeframe: ♦ Short-Term (<3 yrs.) ♦ Mid-Term (3 to 5 yrs.) ♦ Long-Term (>5 yrs.)

Improvement	Rationale	Operational Benefit	Anticipated Improvement Lifespan (2015)	Cost Range	Implementation	Timeframe	Priority
7. Extend the MacDade Boulevard Entrance Ramp Acceleration Lane	• Improve traffic operations along NB I-476	• Operations at MacDade Boulevard entrance ramp improve from LOS D/[D] to LOS D/[C]	• Congestion improvements expected beyond 2035 • Marginal traffic benefit results if Improvements 5 and 6 are implemented	$530,000 to $700,000	• Requires additional traffic analyses	Short-Term/ Mid-Term	Medium
I-476 Southbound							
8. Implement Peak Period Shoulder Use on SB I-476	• Provide additional capacity on I-476 north of the interchange	• Between Baltimore Pike (Exit 3) and MacDade Blvd, southbound I-476 is expected to be near or above capacity (LOS F) for eight hours daily • LOS improves from LOS F/[F] to LOS E/[D] during peak hours	• With third peak period southbound travel lane open, I-476 SB mainline anticipated to reach capacity during peak period by 2020 • With the third peak period southbound travel lane open, future (2035) levels of congestion are significantly lower than current (2010) levels of congestion as presently configured	$5,410,000 to $7,200,000	• Requires additional traffic analyses • Requires additional investigation of design, lane control elements, and Active Traffic Management • Incident management requirements need to be coordinated with emergency responders • As project advances, a NEPA reevaluation of EIS ROD impacts and commitments may be required.	Mid-Term/ Long-Term	Low
9. Provide Two-Lane Ramp from SB I-476 to SB I-95	• Improve traffic operations along SB I-476	• Traffic Operations improve from LOS F/[F] to LOS D/[C] during peak hour	• Congestion improvements expected beyond 2035	$300,000 to $400,000	• Requires additional design analyses • Must be implemented with Improvement 10	Mid-Term	High
I-95 Southbound							
10. Provide Four Lanes on SB I-95 between I-476 and Chestnut Street	• Improve traffic operations along SB I-95	• Traffic Operations improve from LOS F/[F] to LOS E/[D] during peak hour	• Congestion improvements expected beyond 2035	$3,500,000 to $4,700,000	• Requires additional design and traffic analyses • Must be implemented with Improvement 9	Mid-Term/ Long-Term	High
General							
11. Improve the NB I-95 Advanced Signing	• I-95 NB advanced guide signage for I-476 • Modify NB I-95 signing to eliminate inadequate I-476 exit warning for drivers	• Provides more guidance to drivers to avoid making last minute lane changes in congested conditions	• Ancillary improvements expected for typical signing lifespan (20 years) • Improvements can be completed independently or as part of other improvements	$75,000 to $100,000	• Must complete detailed sign installation review and signing design • Must be coordinated with selected High Priority projects, PennDOT District Maintenance and Roadway Audit	Short-Term	Low
12. Repair and/or Improve Interchange Lighting	• I-476 ramp to I-95 southbound • Accident reports designate area as having "dark" conditions	• Increased visibility may result in reduced crashes • Focus lighting improvements to areas of high nighttime accident clusters, i.e. SB I-476 ramp to SB I-95 and NB I-95 between Chestnut Street and NB I-476 exit ramp gore	• Improvements can be completed independently or as part of other improvements	$25,000 to $365,000	• Must complete detailed lighting system review and lighting design • Must be coordinated with selected High-Priority projects, PennDOT District Maintenance, and Roadway Audit	Short-Term	Medium
13. Erect Advanced Curve Warning Signage	• I-95 NB ramp to I-476 ramp does not warn drivers of reduced speeds due to traffic congestion • Also applies to I-476 SB ramp to I-95 ramp	• I-95 NB to I-476 ramp high-fixed-object accident rate reflects drivers traveling too fast for conditions. Signing (with flashing beacons) may provide sufficient warning	• Ancillary improvements expected for typical signing lifespan (20 years) • Improvements can be completed independently or as part of other improvements	$15,000 to $300,000	• Must coordinate design of flashing beacons with PennDOT	Short-Term	High

Source: RK&K, 2011

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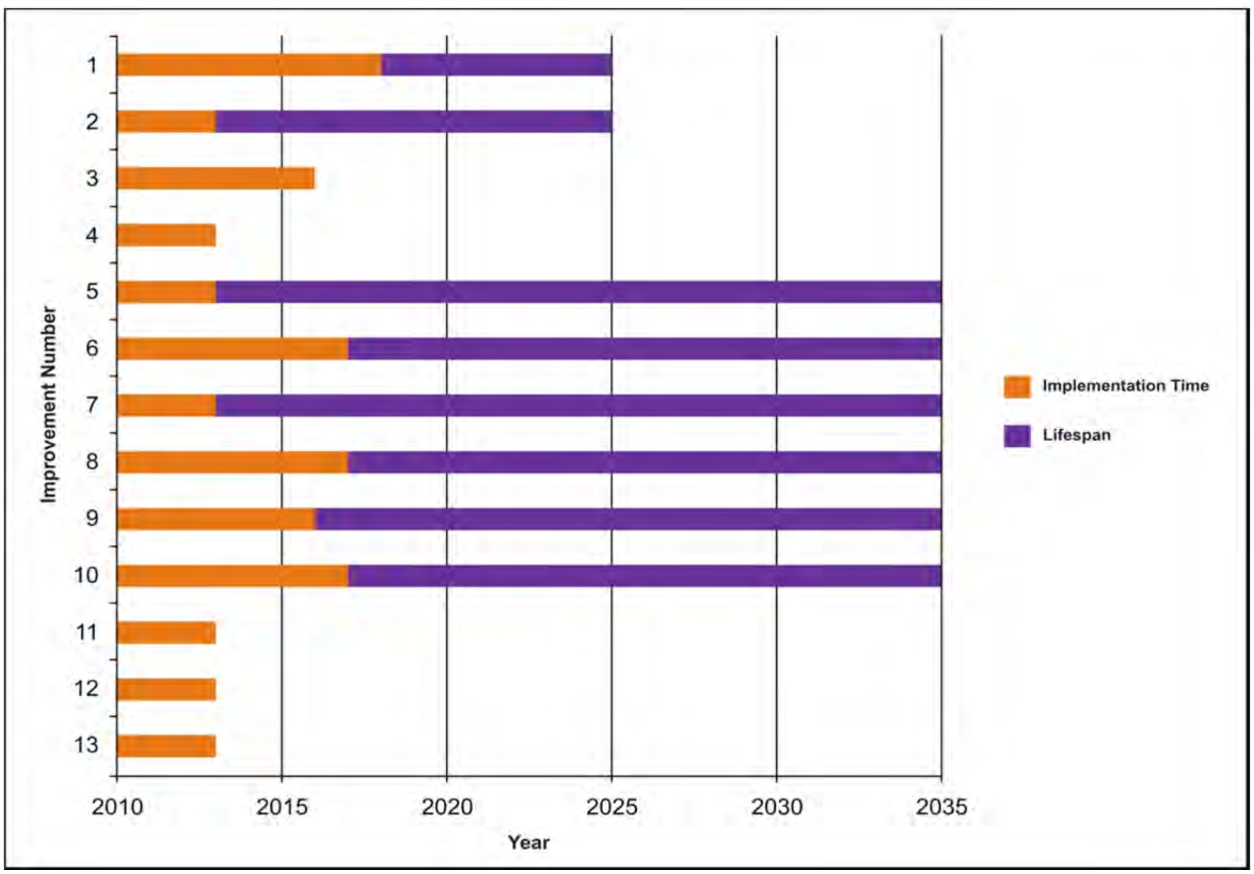
- The four potential improvements that do not show a direct operational benefit (3, 11, 12, and 13) were developed with a targeted purpose of improving access or safety within the interchange.

An important finding in the evaluation process is that the traffic operations at the I-95/I-476 interchange are constrained by the traffic operations on I-476 north of the interchange. The traffic demand for I-476 exceeds the capacity of a four-lane freeway (two lanes in each direction) during both peak hours. By 2035, that travel demand is expected to exceed capacity up to eight hours in an average day, resulting in peak hour spreading that approaches the AM and PM peaks combining into a full day “rush hour”.

Anticipated Lifespan

All of the operational improvements are anticipated to improve traffic conditions over the existing conditions until at least 2025. As shown in **Figure 17,** several improvements (5 to 10) may provide operational improvement beyond 2035. In particular, the improvements associated with I-476 southbound approaching and traveling through the interchange (Improvements 8 and 9) and I-95 southbound (Improvement 10) appear to provide significant operational benefit over a long timeframe. A similar improvement lifespan for I-95 northbound may be achieved when Improvement 1 and Improvement 2 are both implemented.

Figure 17. Implementation Timeline



Source: RK&K, 2011

Figure 17 compares the anticipated implementation timeframe for each operational improvement with the estimated lifespan for each improvement. Most of the improvements show a benefit lifespan that significantly outweighs its implementation timeframe – an important finding given the nature of these targeted improvements.

Implementation Issues and Timeframe to Implement
All 13 improvements require some sort of design or maintenance-level effort to refine the improvement prior to construction:

- Additional detailed geometric and final roadway plans are required for Improvements 2, 4, 5, 9, and 10;
- Final design plans are required for Improvements 11 and 13;
- Field verification of the electrical system is required for Improvement 12; and
- Point of Access study is required for Improvements 1, 3, 4, and 5.

The relocation of the Chestnut Street entrance ramp to NB I-95 would require significant design and coordination efforts prior to implementation. Maintaining access to and from downtown Chester via Chestnut Street was identified as a critical element by several stakeholders. In particular, a simple closure of the ramp would complicate access from downtown Chester, Crozer-Chester Medical Center, and Widener University to I-95 north of Chester and I-476. Initial public input, garnered from the EJ meeting held for this study, also shared the sentiment that the stakeholders presented.

Given the public and stakeholder input from the SAC and EJ meetings, there is no support for the ramp closure. Consequently, the ramp closure concept presented in Improvement 1 has been dropped and a study to examine long-term relocation of the ramp has been substituted. That study is independent of this effort and should reexamine the relocation of both Chestnut Street ramps to Edgmont Avenue.

The implementation of peak hour shoulder use (Improvements 6 and 8) will likely require extensive agency and public coordination. This type of system is currently in use in several locations in the United States, including I-66 in Northern Virginia's Washington, D.C. suburbs; I-95, I-93, and SR 3 in Boston; and I-35W in Minneapolis. However, this application would be the first of its kind in Pennsylvania.

During the stakeholder process, the primary concern raised was the removal of the shoulder as a breakdown area and its impacts on incident response and management. Existing and future traffic would need to be further evaluated to determine the extents (length, time periods) that peak period shoulder use would need to be implemented to achieve the desired operations. Engineering issues would also need to be further investigated, including detailed evaluations of the roadway section and drainage facilities, as well as the impacts on interchange geometrics. There is also a logical termini determination that needs to be addressed; there may be different limits in each direction depending on traffic. As the impacts of changes in design may affect the limits of disturbance, there may be a need for a NEPA reevaluation of the ROD impacts and commitments. Finally, the Active Traffic Management techniques required for successful implementation will also need to be further vetted. A comprehensive study examining each of these considerations is likely needed to further these improvements.

Cost
Costs were used to quantify the scope of the improvements; however, they were not used to directly compare improvements or to identify the overall viability of the individual improvements.

7. PRIORITIZATION OF IMPROVEMENTS

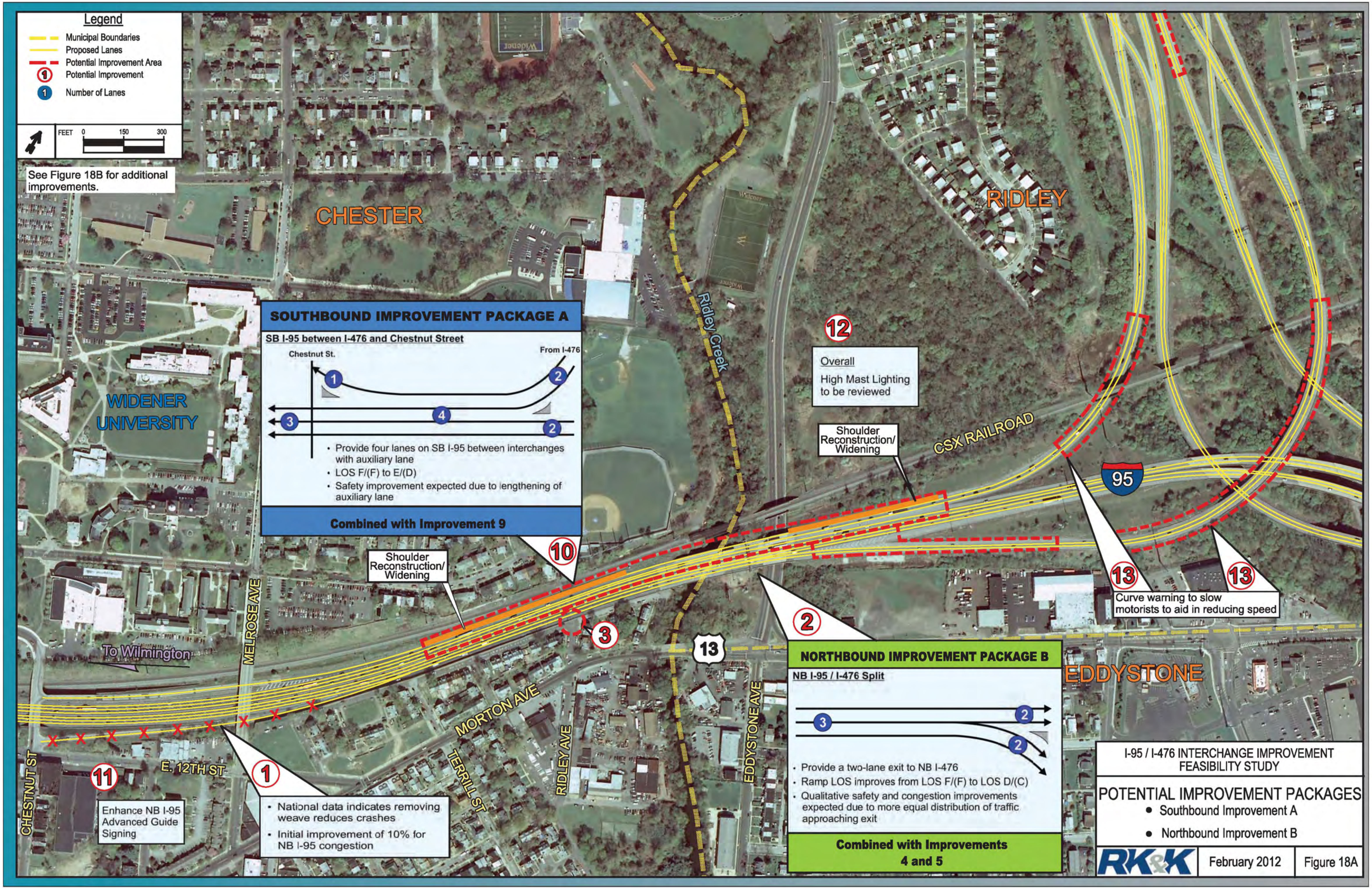
Following the evaluation of the potential improvements, each was then assessed to determine if it could be implemented independently of other potential improvements or must be combined with one or more other improvements in an improvement "package". Independent improvements could provide operational benefits without any other improvements being implemented. Improvements packages would be needed for groups of improvements that would only offer operational benefits in combination. The evaluation revealed that five of the potential improvements would have to be grouped into two improvement packages.

a. Improvement Combinations

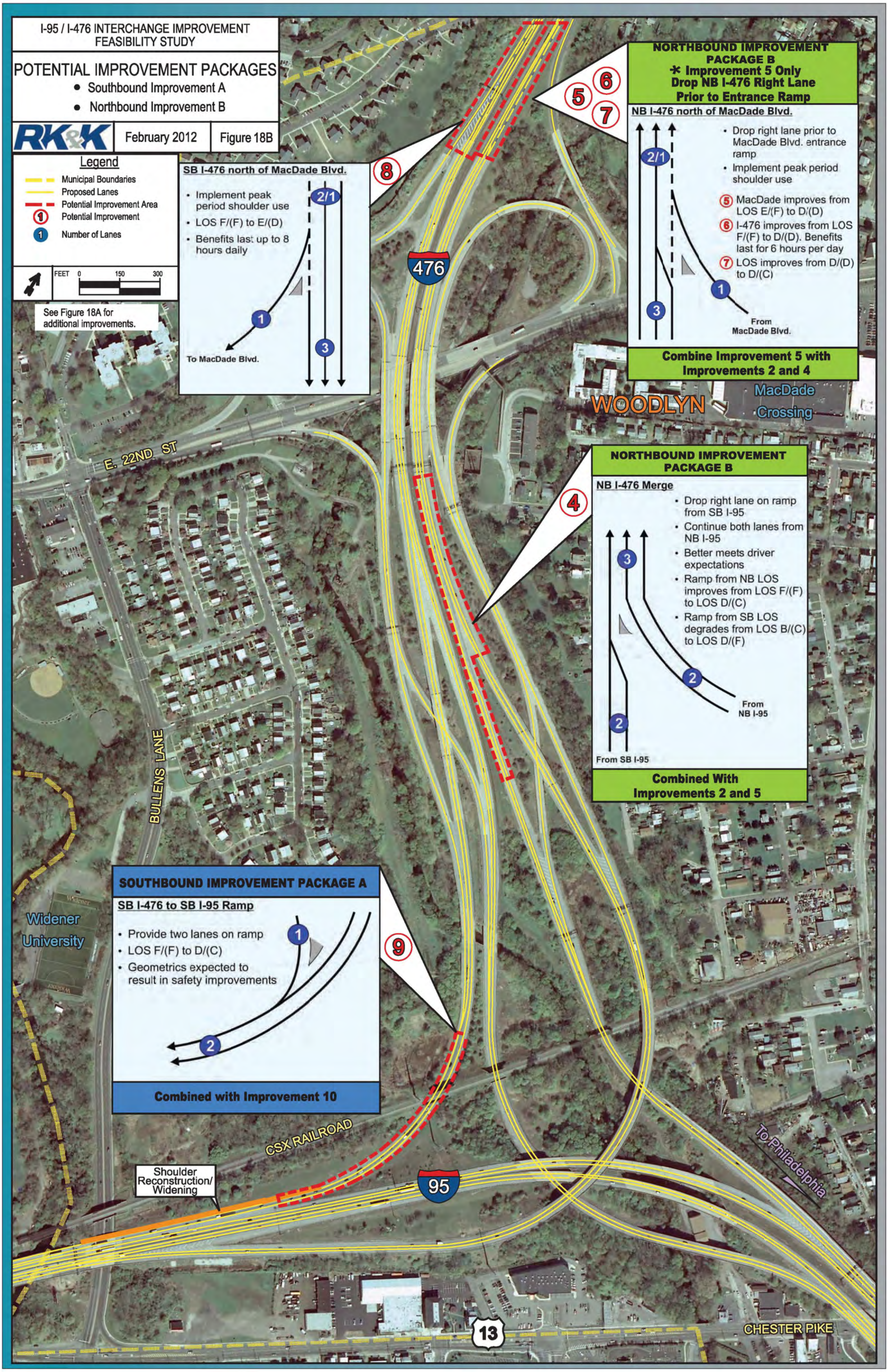
Of the 13 improvements evaluated in this study, eight of the improvements have independent utility and do not need to be implemented in combination with any other improvements. The remaining improvements, however, require that they be implemented in combination to properly achieve the anticipated level of congestion and/or safety mitigation. These improvements could be consolidated into improvement packages based on the direction of travel through the interchange.

- **Southbound Improvement Package A** would target southbound travel, specifically the I-476 southbound ramp to I-95 southbound. This package would combine Improvements 9 (Provide Two-Lane Ramp from SB I-476 to SB I-95) and 10 (Provide Four Lanes on SB I-95 between I-476 and Chestnut Street). Both improvements have been developed in order to target the existing bottleneck along this ramp. Implementing Improvement 9 independently would simply result in shifting the bottleneck approximately 500 feet south. Similarly, while implementing Improvement 10 would be expected to relieve congestion along I-95 southbound, its effectiveness in reducing congestion along I-476 southbound would be compromised without removing the bottleneck along the ramp. By combining the two alternatives, the bottleneck along the ramp would be eliminated and the expected congestion could be significantly reduced.
- **Northbound Improvement Package B** would target northbound travel, specifically the I-95 northbound ramp to I-476. This package would combine Improvement 2 (Provide Two-Lane Exit from NB I-95 to NB I-476), Improvement 4 (Reconfigure the Merge of I-95 Ramps to NB I-476), and Improvement 5 (Drop the Right Lane of I-476 Prior to MacDade Boulevard). In order for the roadway geometrics to function properly, Improvements 4 and 5 would need to be implemented nearly simultaneously. As with the southbound improvements, implementing Improvement 2 independently would have the effect of moving the bottleneck approximately three-quarters of a mile downstream; similarly, implementing Improvements 4 and 5 independent of Improvement 2 would compromise its ability to reduce congestion along I-95 approaching the interchange.

The improvements with the Southbound and Northbound Improvements Packages are shown in **Figures 18A and 18B**.



Legend
Municipal Boundaries
Proposed Lanes
Potential Improvement Area
Potential Improvement
Number of Lanes
FEET 0 150 300
See Figure 18B for additional improvements.
CHESTER
RIDLEY
WIDENER UNIVERSITY
EDDYSTONE
Ridley Creek
CSX RAILROAD
95
13
To Wilmington
MELROSE AVE
MORTON AVE
TERRILL ST
RIDLEY AVE
EDDYSTONE AVE
CHESTNUT ST
E. 12TH ST
SOUTHBOUND IMPROVEMENT PACKAGE A
SB I-95 between I-476 and Chestnut Street
Chestnut St.
From I-476
• Provide four lanes on SB I-95 between interchanges with auxiliary lane
• LOS F/(F) to E/(D)
• Safety improvement expected due to lengthening of auxiliary lane
Combined with Improvement 9
12
Overall
High Mast Lighting to be reviewed
Shoulder Reconstruction/ Widening
Shoulder Reconstruction/ Widening
10
3
2
13
13
Curve warning to slow motorists to aid in reducing speed
NORTHBOUND IMPROVEMENT PACKAGE B
NB I-95 / I-476 Split
• Provide a two-lane exit to NB I-476
• Ramp LOS improves from LOS F/(F) to LOS D/(C)
• Qualitative safety and congestion improvements expected due to more equal distribution of traffic approaching exit
Combined with Improvements 4 and 5
1
• National data indicates removing weave reduces crashes
• Initial improvement of 10% for NB I-95 congestion
11
Enhance NB I-95 Advanced Guide Signing
I-95 / I-476 INTERCHANGE IMPROVEMENT FEASIBILITY STUDY
POTENTIAL IMPROVEMENT PACKAGES
• Southbound Improvement A
• Northbound Improvement B
RK&K
February 2012
Figure 18A



I-95 / I-476 INTERCHANGE IMPROVEMENT FEASIBILITY STUDY
POTENTIAL IMPROVEMENT PACKAGES
• Southbound Improvement A
• Northbound Improvement B
RK&K
February 2012
Figure 18B
Legend
Municipal Boundaries
Proposed Lanes
Potential Improvement Area
Potential Improvement
Number of Lanes
FEET 0 150 300
See Figure 18A for additional improvements.
SB I-476 north of MacDade Blvd.
• Implement peak period shoulder use
• LOS F/(F) to E/(D)
• Benefits last up to 8 hours daily
To MacDade Blvd.
NORTHBOUND IMPROVEMENT PACKAGE B
* Improvement 5 Only
Drop NB I-476 Right Lane Prior to Entrance Ramp
NB I-476 north of MacDade Blvd.
• Drop right lane prior to MacDade Blvd. entrance ramp
• Implement peak period shoulder use
5 MacDade improves from LOS E/(F) to D/(D)
6 I-476 improves from LOS F/(F) to D/(D). Benefits last for 6 hours per day
7 LOS improves from D/(D) to D/(C)
From MacDade Blvd.
Combine Improvement 5 with Improvements 2 and 4
WOODLYN
MacDade Crossing
E. 22ND ST
NORTHBOUND IMPROVEMENT PACKAGE B
NB I-476 Merge
• Drop right lane on ramp from SB I-95
• Continue both lanes from NB I-95
• Better meets driver expectations
• Ramp from NB LOS improves from LOS F/(F) to LOS D/(C)
• Ramp from SB LOS degrades from LOS B/(C) to LOS D/(F)
From NB I-95
From SB I-95
Combined With Improvements 2 and 5
BULLENS LANE
SOUTHBOUND IMPROVEMENT PACKAGE A
SB I-476 to SB I-95 Ramp
• Provide two lanes on ramp
• LOS F/(F) to D/(C)
• Geometrics expected to result in safety improvements
Combined with Improvement 10
Widener University
CSX RAILROAD
Shoulder Reconstruction/ Widening
476
95
13
To Philadelphia
CHESTER PIKE

b. Priority Ranking of Benefiting Improvements

After the improvement combinations were established, the eight separate improvements and the two combined packages were given a priority ranking. Several evaluation metrics were included in prioritizing these improvements; these metrics included:

- ability to mitigate congestion and/or alleviate bottleneck points;
- ability to address identified safety concern(s);
- improvement lifespan;
- estimated cost, including qualitative estimates of level of anticipated improvement relative to estimate cost; and
- timeframe and ease of implementation.

Based on these metrics, a priority was established for each improvement, as shown in **Table 10**. Three priority tiers were established: High Priority, in which each improvement received high marks in multiple metrics, including a high rate of anticipated improvement relative to estimated cost; Medium Priority, where the level of improvement relative to estimated cost would not be expected to be as great as those receiving a high priority; and Low Priority, where the impacts of the improvements on interchange operations and safety would be expected to be lowest.

Table 10. Improvement Priority

Rank	Improvement	Cost[1]	Priority
1	***Southbound Improvement Package A:*** • Improvement 9 – Provide Two-Lane Ramp from SB I-476 to SB I-95 • Improvement 10 – Provide Four Lanes on SB I-95 between I-476 and Chestnut Street	$3,800,000 to $5,100,000	High
2	***Northbound Improvement Package B:*** • Improvement 2 – Provide Two-Lane Exit from NB I-95 to NB I-476 • Improvement 4 – Reconfigure the Merge of I-95 Ramps to NB I-476 • Improvement 5 – Drop the Right Lane of I-476 Prior to MacDade Boulevard	$1,940,000 to $2,580,000	High
3	**Improvement 6** – Implement Peak Period Shoulder Use on NB I-476 [MacDade Boulevard to Baltimore Pike, 2.5 miles]	$5,550,000 to $7,380,000	High
4	**Improvement 13** – Erect Advanced Curve Warning Signage [on NB I-95 to NB I-476 ramp and on SB I-476 to SB I-95 ramp]	$15,000 to $300,000	High
5	**Improvement 1** – Close Chestnut Street entrance ramp ****No longer in consideration- a ramp study has been substituted instead of the ramp closure.***	$170,000 to $200,000 ***[Study Only]***	Medium

Table 10. Improvement Priority

Rank	Improvement	Cost[1]	Priority
6	**Improvement 12** – Repair and/or Improve Interchange Lighting [maintenance and replacement improvements]	$25,000 to $365,000	Medium
7	**Improvement 7** – Extend the MacDade Boulevard Entrance Ramp Acceleration Lane	$530,000 to $700,000	Medium
8	**Improvement 8** – Implement Peak Period Shoulder Use on SB I-476 [MacDade Boulevard to Baltimore Pike, 2.5 miles]	$5,410,000 to $7,200,000	Low
9	**Improvement 11** – Improve NB I-95 Advanced Signing [to include interchange sequence signing]	$75,000 to $100,000	Low
10	**Improvement 3** – Provide an Emergency Vehicle Access at Ridley Avenue	$100,000 to $130,000	Low

Notes:

1. *The cost range accounts for a 50% planning contingency and 45% project cost for design, project administration, and construction inspection. No right-of-way acquisition is included and assumed to be zero for all projects.*

Source: RK&K, 2011

Within each high/medium/low priority tier, the improvements were ranked to establish the final rankings for all improvements. The relative merits of each improvement are fairly close within each priority tier. However, certain factors for each improvement led to the final rankings, including:

- ***Southbound Improvement Package A*** was selected as the top-ranked improvement and placed ahead of ***Northbound Improvement Package B*** due to its ability to completely remove the bottleneck for the southbound I-476 ramp to I-95 southbound. This ramp was also the location of the most severe accidents within the interchange, and this improvement package addresses some of the hit-fixed-object and sideswipe accidents resulting from the substandard movements present along for this ramp. Package A may indirectly improve congestion at the southbound I-476 diverge from I-95 by reducing spill-back from the I-476 merge.

Package B and I-476 Peak Shoulder Use both may be needed to alleviate northbound I-95 to I-476 congestion.
Photo Source: PennDOT

- ***Northbound Improvement Package B*** was ranked second due to its relative ease to implement, particularly when compared to ***Improvement 6 (Implement Peak Hour Shoulder Use on Northbound I-476)***. In particular, peak hour shoulder use is a relatively new concept to both PennDOT and to the commuters throughout the Delaware Valley. The vetting of several design and operational concepts, such as Active Traffic Management, may extend the timeframe needed to implement Improvement 6. From an operational standpoint, while both improvements are needed to truly alleviate the congestion resulting from the northbound I-95 to northbound I-476 movement, implementing Package B ahead of implementing peak hour shoulder use shifts the bottleneck point from the I-95 exit to the point where I-476 narrows to two travel lanes. Implementing Package B also creates the potential to lessen the amount of time that queues from the northbound I-476 bottleneck reach the I-95 mainline. Implementing Improvement 6 first may still result in bottlenecks along northbound I-95 approaching the interchange.

- ***Improvement 13 (Erect Advance Curve Warning Signage)*** was ranked fourth due to its inherent safety benefits. These enhancements are generally low cost and are relatively easy to implement; however, they were ranked lower since many of these enhancements (such as rumble strips and/or advance warning systems) may be better implemented as part of Improvement Packages A and B.

- ***Improvement 1 (Close Chestnut Street Entrance Ramp to Northbound I-95)*** was listed as a medium priority; the community opposition and associated EJ concerns associated with the ramp closure necessitated its substitution with a ramp relocation, raising the estimated timeframe for completion of a Point of Access Study to long term, or greater than five years. While a noticeable reduction in congestion may be expected, and relocating the ramp would address the safety concern due to the short acceleration lane, the level of improvement at this location would not be expected to be as notable as those improvements ranked ahead.

- ***Improvement 8 (Implement Peak Hour Shoulder Use on Southbound I-476)*** was listed as a low priority for two reasons. First, the effectiveness of this improvement would be compromised if Package A were not implemented in advance, as the addition of a third peak period travel lane on southbound I-476 would simply push more traffic to the existing bottleneck. Second, with freeway peak hour shoulder use being a new concept, focusing implementation efforts on one direction of travel as a first implementation appears to make some sense.

  Implementing northbound peak hour shoulder use would provide a greater impact to travelers at this interchange, and potentially for the entire I-476 system.

Active Traffic Management allows for travel lanes on I-476 to be closed nearly instantaneously.
Photo Source: Virginia Department of Transportation

An important distinction to make is that the priority rankings do not necessarily reflect a sequential method to implement each improvement. In some cases, the timeframe for implementing a lower-ranked alternative may be significantly longer than an improvement ranked ahead of it. For example, the timeframe to implement peak hour shoulder use could be longer than Package B. In these cases, consideration should be given to advancing lower ranked improvements simultaneously with the higher ranked improvements to achieve desired implementation timeframes. Likewise, independent lower ranking improvements, such as the relocation of the northbound entrance ramp from Chestnut Street, could benefit from advancing on a separate track in order to accommodate the longer timeframes associated with the improvement.

8. NEXT STEPS

The report documents the first phase of this study, which identified 13 cost effective improvements to reduce traffic congestion within and approaching the I-95 and I-476 Interchange. **Table 10** in Section 7 of this report summarizes a prioritization of these improvements, as identified by the project team and SAC. The completion of this report represents the completion of the first phase of this study.

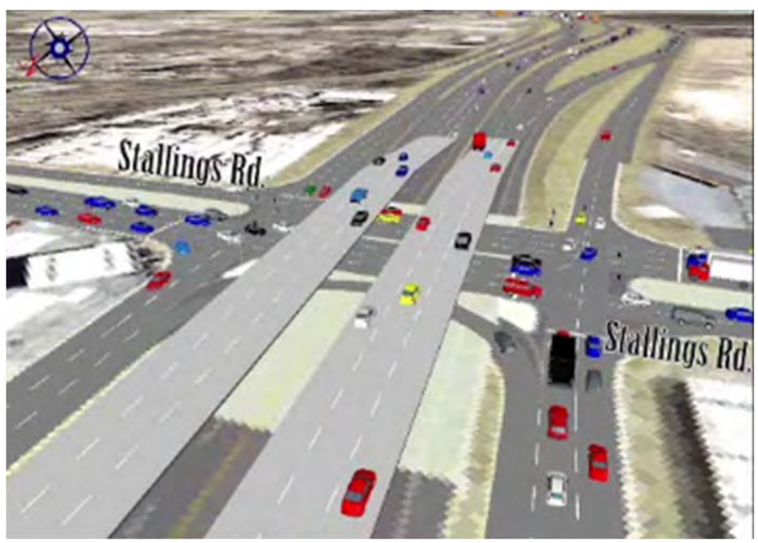
DVRPC and Delaware County could continue with a more detailed evaluation of the potential improvements in Phase II. In addition, the implementation of potential improvements will have to be considered in the overall context of the function of I-95 and I-476. This section provides a general overview for these next steps.

a. Phase II Study

For Phase II of the study, the improvement concepts should be evaluated in more detail to further determine system-level operational benefit, to determine if there are any fatal flaws in the concepts, and to refine the associated cost estimates and project impacts, which will allow for proper project planning and programming. The following next steps will need to be completed as part of this more detailed analysis:

Detailed Traffic Analysis

During this first phase of the study, the potential operational benefits were quantified using HCM methods, which focus on the lane configuration and traffic characteristics of discreet highway or interchange segments. These methods are appropriate for a broad analysis consistent with the preliminary nature of the first phase. However, detailed analyses utilizing more sophisticated traffic simulation modeling software would be required to confirm the traffic benefits for the potential improvements. Traffic simulation is more capable of integrating specific highway geometry with individual driver behaviors and could provide a much more detailed and complete traffic analysis. In particular, traffic simulation could more completely identify the effects of a single improvement (or combination of improvements) on the operational characteristics of the entire interchange.



Traffic Simulation tools can help analyze the effects on the entire system by implementing improvements.
Photo Source: RK&K, 2011

Bottleneck-reducing improvements, such as Southbound Improvement Package A – Southbound Improvements and Peak Period Shoulder Use, may induce additional traffic to the interchange as a result of improved travel times resulting from the removal of the bottleneck. The detailed traffic analysis should incorporate these changes into the regional travel demand model to produce demand volumes that account for these changes in expected travel conditions. One of the results that the modeling will yield is the effect of the Package A improvements on the I-95 southbound diverge, which cannot be answered using HCM methodology.

Engineering Refinements
Additional engineering analysis would be needed for all improvements, especially those that include modified lane configurations, access changes, or widening and other roadside improvements. This analysis would include horizontal layouts and typical sections showing the proposed lane configuration, lane and shoulder widths, roadside features, widening, and grading/limits of disturbance. Any impacts to roadside features would have to be identified and quantified. More detailed cost estimates would be developed.

It is not anticipated that the potential improvements described in the evaluation will result in significant impacts that would require an extensive NEPA study and associated documentation. However, the appropriate level and detail of environmental study and documentation would have to be considered for each improvement. In particular, as any changes to I-476 (such as hard shoulder running) advance through the project delivery process, a NEPA reevaluation of I-476 EIS ROD impacts and commitments may be required.

In addition, for improvements that include operational changes, like peak period shoulder use, additional analysis would be required to develop a Concept of Operations (ConOps) that defines how the highway would be operated. Details would be defined, such as who is responsible for what actions, what procedures are followed for a variety of operational conditions, and how information is communicated, etc.

Programming Requirements
The refined traffic analysis, cost estimates, and project impacts would allow decision makers to appropriately find and/or assign funding sources for any improvements that would be advanced through design and construction. The timeframes and project priorities determined during this first phase should be revisited to properly reflect the resulting refinements.

b. Regional Perspective

Agencies involved in the decision-making process for each of these improvements would need to be cognizant of the timeframes necessary to implement each improvement. In particular, Improvement 6 – Implement Peak Period Shoulder Use on Northbound I-476, appears to provide significant traffic relief to the interchange. However, due to the first-of-its kind nature of that improvement in the Delaware Valley, further study of the improvement concept would likely extend the timeframe needed to implement the improvement. Similarly, the relocation of the Chestnut Street ramps would require extensive study. While these improvements are not identified as the first two items, the extents of their timeframes would make it important for the agencies to consider their viability while advancing those improvements that were prioritized ahead of them.

Throughout this study, several ideas were discussed by the SAC that may benefit the interchange, but they would need to be reviewed on a more regional basis. These ideas could include improved incident management techniques, as is being furthered by the Delaware County Incident Management Task

Force. This study focused on smaller-scale operational and safety improvements within and adjacent to the interchange, and, as such, the identified improvements all focus on improving operations as opposed to reducing demand. Demand management techniques, such as expanded park-and-ride services, as well as enhanced transit, could prove beneficial for the interchange; however, these also should be reviewed in a more comprehensive, regional manner.

Finally, this study has identified 13 improvements that may be considered to provide cost-effective, small-scale improvements for this interchange. While these improvements appear to provide localized improvement for the interchange, the interchange is part of the larger I-95 and I-476 systems. PennDOT is currently completing a long-term master plan for I-95 throughout Pennsylvania. The improvements identified in this study will provide some relief while PennDOT evaluates the full reconstruction/ reconfiguration of I-95 to address the long-term needs of I-95 in Pennsylvania. Continued coordination should allow for the improvements included in this study to be considered in the overall I-95 Master Plan.

APPENDIX A

STUDY ADVISORY COMMITTEE MEMBERS AND MEETING NOTES

Study Advisory Committee Members

Stan Platt, Project Manager
Delaware Valley Regional Planning Commission
The ACP Building – 8th Floor
190 N. Independence Mall West
Philadelphia, PA 19106-1520
(215)238-2851
splatt@DVRPC.org

Louis Hufnagle
Senior Planner
Delaware County Planning Department
Court House & Government Center Building
201 W. Front St
Media, PA 19063
(610) 891-5379
hufnaglel@co.delaware.pa.us

Lou Belmonte
District Traffic Engineer
PennDOT District 6-0
7000 Geerdes Rd.
King of Prussia, PA 19406
(610) 205-6550
lbelmonte@state.pa.us

Manny Anastasiadis
Manager, Traffic Freeway Management
PennDOT District 6-0
7000 Geerdes Boulevard
King of Prussia, PA 19406
(610) 205-6590
eanastasia@state.pa.us

Dave Sciocchetti
Executive Director
Chester Economic Development Authority
P.O. Box 407
Chester, PA 19016
(610) 447-7850
dns@ceda.cc

Carmine Fiscina
Technology and Safety Engineer
Philadelphia Metropolitan Office
Federal Highway Administration
1760 Market Street, Suite 510
Philadelphia, PA 19103
(215) 656-7111
carmine.fiscina@fhwa.dot.gov

Tom Shaffer
Manager - Transportation Planning
Delaware County Planning Department
Court House & Government Center Building
201 W. Front St
Media, PA 19063
(610) 891-5217
shaffert@co.delaware.pa.us

William Payne
Director
Division of Planning
City of Chester
1 Fourth Street
Chester, PA 19013
(610) 447-7707
wpayne@chestercity.com

James Johnson
Fire Commissioner
City of Chester
320 East 14th Street
Chester, PA 19013
(610) 447-7765
jjohnson@chestercity.com

Lt. Tony Sivo
Station Commander Media Barracks
Pennsylvania State Police
1342 W. Baltimore Pike
Media, PA 19063
(610) 450-4510
asivo@state.pa.us

Cecile Charlton
Director
Delaware County Transportation Management Association
102 West Front Street
Media, PA 19063
(610) 892-9440
ccharlton@dctma.org

Pat Keegan
Township Manager
Ridley Township
100 E. MacDade Blvd.
Folsom, PA 19033
(610) 534-4806
pkeegan@mail.twp.ridley.pa.us

Carole Nasella
Borough Manager
Ridley Park Borough
Ridley Park Borough Hall
105 East Ward St.
Ridley Park, PA 19078
(610) 532-2100
manager@ridleyparkborough.org

Francie Howat
Borough Manager
Eddystone Borough
300 East 12th Street
Eddystone, PA. 19022
(610) 874-1100
fhowat@eddystoneboro.com

Gary Cummings
Township Manager
Nether Providence Township
214 Sykes Lane
Wallingford, PA 19086
(610) 566-4516
gcummings@netherprovidence.org

Robert Reeder
Chief, Emergency Medical Services
Crozer-Chester Medical Center
One Medical Center Boulevard
Upland, PA 19013
(610) 447-2406
robert.reeder@crozer.org

Carl Pierce
Widener University
One University Place
Chester, PA 19013
(610) 499-4555
cgpierce@widener.edu

Study Advisory Committee Meeting Summary

Meeting #1 – April 13, 2011

Chester City Hall

Attendees:

Name	Representing
Stan Platt	Delaware Valley Regional Planning Commission
Tom Shaffer	Delaware County Planning Department
Louis Hufnagle	Delaware County Planning Department
William Payne	City of Chester
Lou Belmonte	PennDOT District 6-0
James Johnson	City of Chester
Lt. Tony Sivo	Pennsylvania State Police – Troop K
Cecile Charlton	Delaware County Transportation Management Association
Gary Cummings *Represented by: Chief of Police – Thomas Flannery*	Nether Providence Township
Robert Reeder *Represented by: Richard Micun*	Crozer-Chester Medical Center
Carl Pierce	Widener University
Pat Keegan *Represented by: Charles Catania, Jr., Municipal Engineer*	Ridley Township
Jeff Roberta	RK&K
Mahmood Shehata	RK&K
Todd Rousenberger	RK&K
Brian Horn	RK&K

Handouts:

SAC Notebook – Meeting #1 Contents:

- Study Advisory Committee (SAC) Membership
- SAC Meeting #1 Agenda
- SAC Work Plan
- Aerial Map Showing I-95/I-476 Interchange Improvement Feasibility Study Area
- Figure 1: Existing Roadway Conditions
- Figure 2: Safety Conditions
- Figure 3: Existing Traffic Conditions (2010)
- Figure 4: No-Build Traffic Conditions (2015)
- Existing Conditions Summary Table
- Toolbox of Potential Short-term and Mid-term Solutions
- Examples of Potential Solutions

Introductions/Meeting and Study Purpose

The meeting came to order at about 9:00 AM. Stan Platt of the Delaware Valley Regional Planning Commission (DVRPC) welcomed all attendees and invited introductions around the table. Brian Horn, RK&K, continued by describing the meeting purpose – to begin the process of developing and presenting study materials and findings to the Study Advisory Committee (SAC) and to obtain SAC input to help guide the study recommendations. The I-95/I-476 Interchange Improvement Feasibility Study goal is to identify small-scale, low-cost and manageable improvement projects that help mitigate congestion at the interchange. He stressed the goal is not to solve or eliminate congestion as that would require complete reconstruction of the interchange and its approaches. A project of that magnitude would be too large for the region's transportation funding to support. He next reviewed the study objectives.

Study Objectives:

1. Determine Location and Causes of Study Area Congestion
2. Determine a Potential Solutions List
3. Recommend Feasible, Low-cost Geometric Improvements for Detailed Development

Mr. Horn concluded by reviewing the proposed study work plan. The notebook handout listed the individual scope of work tasks (Tasks 1 thru 6) the study team will follow to prepare the examination of study area congestion causes, develop a potential project solutions list, evaluate those potential solutions, develop conceptual cost estimates, prepare a candidate project recommendation list, and document the findings of the overall study effort in a study report for publication by the DVRPC. After discussion and clarification with the SAC, Mr. Horn reviewed the individual components of the work plan including what proposed topics and findings will be reviewed during today's meeting as well as the two following SAC meetings. It is envisioned the study effort would require three total SAC meetings prior to concluding the study with the final report.

Existing Conditions

Jeff Roberta and Mahmood Shehata next described the existing transportation conditions and issues observed for I-95 and I-476 within the study area. Mr. Roberta noted the geometric conditions of the study area ramp merge and diverge areas for I-95, I-476 and within the I-95/I-476 interchange, the lane balance deficiency for I-95 north of I-476 and the lack of horizontal sight distance for the northbound I-95 ramp to northbound I-476. Mr. Shehata described the accident history for I-95 and I-476 in the study area. He highlighted the history using Figure 2 where the red roadway links showed a two times greater than statewide average crash rate and orange roadway links showed between a one to two times greater than statewide average crash rates. The predominance of these red and orange roadway links covered the movements primarily between I-95 south and I-476. Mr. Shehata and Mr. Roberta noted these movements will be of particular interest to the study team as we proceed with identifying potential solutions to help mitigate interchange congestion.

Traffic Analysis – Existing and Future 2015 No-Build

Mr. Shehata began the traffic analysis review by referencing the existing traffic conditions (2010) shown on Figure 3. The figure showed existing condition (2010) levels of service (LOS) for each roadway segment and ramp merge and diverge point within the study area. The levels of service were calculated using the 2000 Highway Capacity Manual methodologies. Of the 37 analysis points, 14 showed LOS E or F condition in either the 2010 AM or PM peak hour at that location. Next, Mr. Shehata presented the Future No-Build (2015) traffic conditions. To obtain traffic volumes for year 2015, forecast data were obtained from DVRPC's traffic forecast model for the area. The levels of service analysis was performed similarly to the existing condition (2010) analysis and of the 37 analysis points, the same 14 locations showed LOS E or F conditions in either the 2015 AM or PM peak hour and no new sites went from an acceptable to unacceptable LOS value.

Existing Conditions Summary

Mr. Roberta summarized these findings with the Existing Conditions Summary table distributed in the SAC notebook. The study team divided the study area roadways into segments (NB I-95, SB I-95, interchange ramps, NB I-476 and SB I-476) to list the issues associated with roadway/geometric, safety and traffic operations. The study team recommended efforts be focused to find example solutions on the following roadway segments:

- NB I-95: Approaching I-476 ramp diverge
- SB I-95: South of I-476 ramp merge
- Interchange Ramp: NB I-95 to NB I-476
- Interchange Ramp: SB I-476 to SB I-95
- NB I-476: Between merge of I-95 ramps and MacDade Boulevard interchange
- NB I-476: North of MacDade Boulevard merge
- SB I-476: North of MacDade Boulevard diverge

The SAC offered comments regarding their own personal observations regarding recurring congestion within the study area. These included:

- Southbound I-95 signing approaching the I-476 interchange could be improved
- Southbound I-95 through the City of Chester is often congested
- Southbound I-95 exit to Chestnut Street is a source of congestion
- Inadequate shoulders for I-95 south of the I-476 interchange make it difficult for accidents and breakdowns to completely move off the roadway
- Accidents occur more frequently than on other roadways in the region
- Southbound I-95 level of service analysis doesn't reflect the recurring segment congestion
- There are adequately designed exit ramps for northbound I-95 into Chester but they are limited and inadequate for southbound I-95 into Chester

With these comments from the SAC, the study team stated they would include these observations along with their field notes and the initial analyses presented during this meeting and would proceed to evaluate the potential solutions to help mitigate the interchange area traffic congestion.

Toolbox of Short-term/Mid-term Solutions

Mr. Roberta described for the SAC a table included in the project notebook that listed various highway improvement strategies that could be considered for the study and would be potential short-term and/or mid-term projects. He noted that short-term solutions are those types of projects that could be designed and constructed within the next three years. Mid-term solutions are those projects that could be designed and constructed within the next three to five years. He reviewed the list and provided visual or descriptive examples of each solution for the SAC. In addition, the project notebook handout included illustrations of peak period shoulder use lanes on I-66 in northern Virginia, restriping of an elevated I-95 roadway in Maryland, a restriping/shoulder use typical section, and an example of interstate exit ramp signing sequence for closely-spaced interchanges.

Discussion

Mr. Horn asked if there were any other SAC comments or questions regarding the Meeting #1 materials and information presented. One further question was raised regarding our future horizon build year and if proposed development was included in the traffic forecasts. The study team responded the future no-build and build years were identified to be 2015 since the improvements are to be implemented in a short timeframe. The study team will examine the effectiveness of the potential improvements by conducting a lifespan analysis to determine how many years each improvement would continue to provide traffic benefit. The analysis would use year 2035 as the lifespan horizon year and the traffic growth rate from DVRPC would be used to grow traffic to year 2035. It was further noted DVRPC's traffic forecast model incorporates the latest approved land use forecast model in the region.

Closing

Mr. Platt closed the meeting by thanking the SAC attendees for their input and questions. The next meeting of the SAC will be held on Wednesday, May 25th.

Study Advisory Committee Meeting Summary
Meeting #2 – May 25, 2011
Chester City Hall

Attendees:

Name	Representing
Stan Platt	Delaware Valley Regional Planning Commission (DVRPC)
Tom Shaffer	Delaware County Planning Department
Louis Hufnagle	Delaware County Planning Department
William Payne	City of Chester
Lou Belmonte	PennDOT District 6-0
Dave Sciocchetti	Chester Economic Development Authority
Carmine Fiscina	Federal Highway Administration
Lt. Tony Sivo *Represented by: Cpl Tim Keaveney and Tpr. Tim Greene*	Pennsylvania State Police – Troop K
Kara Rahn	Delaware County Transportation Management Association
Gary Cummings *Represented by: Chief of Police - Thomas Flannery*	Nether Providence Township
Robert Reeder *Represented by: Rich Micun*	Crozer-Chester Medical Center
Carl Pierce	Widener University
Pat Keegan *Represented by: Charles Catania, Jr., Municipal Engineer*	Ridley Township
Jeff Roberta	RK&K
Mahmood Shehata	RK&K
Carolyn Washburn	CH2M Hill (representing the PennDOT I-95 Master Plan Team)
Jim Moorcroft	CH2M Hill (representing the PennDOT I-95 Master Plan Team)
Todd Rousenberger	RK&K
Brian Horn	RK&K

Handouts:

SAC Notebook – Meeting #2 Contents: SAC Meeting #2 Agenda SAC Work Plan Expanded Existing Conditions Summary Table Potential Improvements Table Figures 1 and 2 showing Potential Improvements Improvements Evaluation Matrix

Introductions / Meeting Purpose

The meeting came to order at about 9:00 AM. Stan Platt, DVRPC, welcomed all attendees and invited introductions around the table. Brian Horn continued by stating the purpose for Meeting #2 of the Study Advisory Committee is to review the study area existing conditions assessment, to review potential improvements and the year 2015 build traffic analysis, view the initial potential improvements evaluation matrix and receive SAC comments, questions and input. Mr. Horn continued by reviewing the study team work plan and displaying the items covered during the SAC Meeting #1 as well as to note the items the study team is preparing for SAC Meeting #3.

Summary of SAC Meeting #1
Mr. Horn provided a short summary of Meeting #1 by reviewing the displays and information presented. He directed the SAC to their project notebooks and highlighted the existing roadway conditions, safety conditions, existing traffic conditions (2010) and no-build (2015) traffic conditions shown on Figures 1 through 4 at Meeting #1. He also highlighted the initial existing conditions summary and the toolbox of potential solutions tables as well as illustrations of a few of the potential solutions.

A few questions were posed regarding Meeting #1 material regarding the anticipated timeframe to replace highway guide signs, how peak shoulder use lanes would operate and would State Police retain enforcement capabilities if a peak shoulder use lane were to be implemented. PennDOT responded that highway guide sign replacement, pending funding availability, would take less than six months to fabricate and install. The study team responded to the peak shoulder use questions and stated the peak shoulder use lanes would be operated during the AM and PM peak weekday hours for general traffic (and possibly restricted to autos only). Their use would be controlled via overhead lane use control signals (red “x”/green “arrow”) and monitored for vehicle breakdowns. Accident investigation/emergency pull-off areas would also be included with the peak shoulder use lane to aid in keeping the lane free-flowing during the AM and PM peak weekday hours. The frequency and distances between the pull-off areas would be determined during following design studies if the strategy is determined feasible.

Existing Condition Assessment
Jeff Roberta reviewed the existing conditions (referencing the handout from Meeting #1). He noted the gray highlighted rows represented the highway segments which are garnering the most attention from the study team to identify potential solutions to resolve geometric, safety and/or traffic operations issues. There are two remaining safety related evaluations the study team has yet to conclude. These two areas are along northbound and southbound I-95 (within the I-95/I-476 interchange). The study team will complete these evaluations prior to SAC Meeting #3. A question was posed by the SAC regarding the southbound I-476/MacDade Boulevard lane drop on the ramp to I-95 southbound and what is causing this ramp to break down. Mr. Roberta responded that the ramp is experiencing traffic congestion from both the ramp merge with I-95 southbound and the ramp lane reduction north of the railroad bridge. In addition, the ramp sight distance is below the prevailing speed of traffic which is a likely contributor, along with the congestion, to the higher than average crash rate (greater than two times statewide average).

Mahmood Shehata continued by noting the safety related issues for the highlighted roadway segments. He said the combination of the geometric deficiencies and traffic congestion are evident in the high correlation to the study area crash rates.

Potential Improvements and Future 2015 Build Traffic Analysis
Mr. Roberta and Mr. Shehata reviewed the potential improvements and the future 2015 build traffic analysis materials. They referenced the project notebook handout table of potential improvements and noted they referred to the Meeting #1 potential solutions table to select improvements that may provide a traffic benefit to each roadway segment identified as being deficient with its geometrics, operations or crash rate. The potential improvement table listed the improvement, its rationale for being proposed, the issues to be addressed if implemented, the operational benefit to be gained in year 2015, and the anticipated improvement lifespan showing how long the improvement would provide

traffic benefit. In addition, two figures were distributed with the project notebooks that located the potential improvements within the interchange study area. Each potential improvement (improvement number in parentheses), as listed below, was reviewed and discussed among the committee members.

(1) *Close Chestnut Street Entrance Ramp to Northbound (NB) I-95* – this improvement was not favored by the SAC as a short-term improvement since the ramp is the only I-95 north access from the northern half of Chester. It was discussed that the closure could only be implemented as a long-term improvement if the ramp were replaced with an alternative northbound I-95 interchange access ramp elsewhere into Chester. The SAC also noted the importance of the existing ramp for emergency vehicle access to I-95 and the close proximity of fire, police and medical services. The net result of the committee discussion is not to include the ramp closure as short-term improvement, but they would consider a long-term relocation of this access.

(2) *Provide Two-Lane Exit from NB I-95 to NB I-476* – this improvement would include a modest pavement addition and associated lane striping and signing. The improvement would modify the existing northbound I-95 to northbound I-476 diverge to be restriped as an exit only lane paired with a choice lane leading to two striped lanes on the ramp structure over I-95. The committee was supportive of this improvement.

(3) *Provide an Emergency Vehicle Access at Ridley Avenue* – access is possible at Ridley Avenue by installing a gated access for use by emergency vehicles. The Federal Highway Administration noted a Point of Access study would be required but likely no environmental study is needed. Emergency personnel representatives on the committee appreciated the idea but stated they would not view the gated access as beneficial to their response needs and prefer to maintain their access routes via the existing Chestnut Street entrance ramp.

(4) *Reconfigure the Merge of I-95 Ramps to NB I-476* – this restriping improvement would favor the northbound I-95 ramp over the southbound I-95 ramp at the merge to northbound I-476. The committee was supportive of this improvement.

(5) *Drop the Right Lane of NB I-476 Prior to MacDade Boulevard* – the committee was supportive of this improvement.

(6&8) *Implement Peak Period Shoulder Use on NB and SB I-476* – this proposed improvement garnered several questions about physical operations: lane control signals, signing, monitoring (cameras/Transportation Management Center), emergency vehicle response/incident management; and emergency pull-off areas. The initial assessment is the existing right shoulder is wide enough. FHWA noted the I-476 Record of Decision document would need to be examined to see if implementing peak period shoulder use would constitute a capacity improvement and require subsequent environmental clearance. There were many issues/questions raised by the committee including: need to establish a snow removal policy; incident response would become more difficult; control of the lane use signals will require an interagency agreement for emergency vehicle response; need to develop a concept of operations plan for peak shoulder use; potential to add a left shoulder for emergency vehicles use with peak shoulder strategy. The committee has several questions but is willing to continue evaluating the peak shoulder use strategy to see if the traffic operational benefit is strong. If the benefit is strong, then further development of the operations concept is required.

(7) *Extend MacDade Boulevard Entrance Ramp Acceleration Lane* – this improvement involves using the existing shoulder and requires minor pavement restriping. The committee was supportive of this improvement.

(9&10) *Provide Two-Lane Ramp from SB I-476 to SB I-95/Provide Four Lanes on SB I-95 between I-476 and Chestnut Street* – these two improvements would be implemented simultaneously and add lanes to maintain adequate lane balance through the southbound I-476 to southbound I-95 roadway segment leading to the Chestnut Street exit. Four lanes on I-95 will provide an auxiliary lane to assist weaving vehicles in the segment. Issues discussed included: I-95 mainline width constraints; widening the I-95 bridge over Bullens Lane; minor pavement widening; location of CSX right-of-way along I-95; a Point of Access study is required. The committee was supportive of this improvement.

(11) *Improve Signing* – this improvement suggests upgrading the northbound I-95 guide signage in advance of the I-476 exit, adding northbound I-95 ramp to northbound I-476 curve warning signs, other active warning devices, and additional advisory signage. PennDOT suggested the I-95 advance signage for the I-476 exit be a separate project and considered by the I-95 Master Plan project. The northbound I-95 ramp to northbound I-476 curve warning signs, etc., would be an appropriate measure to recommend as part of this study. The committee was supportive of this improvement.

(12) *Repair and/or Improve Interchange Lighting* – this improvement was suggested due to accident reports citing dark conditions or poor visibility during the accident investigation. Increased visibility may result in fewer crashes within the study area. PennDOT responded this item can be handled through the District's Lighting Maintenance Program.

Initial Evaluation Matrix

Mr. Horn introduced the SAC to the initial evaluation matrix format. In the project notebook, a draft table was included that depicts how the study team plans to report the improvement project evaluations, identify implementation issues, tally the project cost range and estimate the approximate project implementation timeframe. The committee members asked if the cost range were suitable for the project types identified and the study team acknowledged affirmatively. PennDOT and FHWA stressed the key evaluation measure will be the lifespan of the traffic benefit (both for safety and operations) which have already been identified by the study team. For SAC Meeting #3 the study team will have specific cost estimate ranges, implementation issues, schedule timeframe and a priority ranking established for all improvements as well as potential improvement packages.

Discussion/Closing

Mr. Horn asked if there were any further SAC comments or questions regarding the Meeting #2 materials and information presented. No further questions or comments were offered. Mr. Platt closed the meeting by thanking the SAC attendees for their input and questions. The next meeting of the SAC will be held on Wednesday, July 13th.

Study Advisory Committee Meeting Summary
Meeting #3 – July 13, 2011
Widener University, Schwartz Athletic Center

Attendees:

Name	Representing
Stan Platt	Delaware Valley Regional Planning Commission
Tom Shaffer	Delaware County Planning Department
William Payne	City of Chester
Manny Anastasiadis	PennDOT District 6-0
Lou Belmonte	PennDOT District 6-0
Carmine Fiscina	Federal Highway Administration
Cpl Tim Keaveney	Pennsylvania State Police – Troop K
Lt. Tony Sivo	Pennsylvania State Police – Troop K
Gary Cummings *Represented by Dennis Sheehan*	Nether Providence Township
Carl Pierce	Widener University
Pat Keegan *Represented by: Charles Catania, Jr., Municipal Engineer*	Ridley Township
Jeff Roberta	RK&K
Mahmood Shehata	RK&K
Carolyn Washburn	CH2M Hill (representing the PennDOT I-95 Master Plan Team)
Jim Moorcroft	CH2M Hill (representing the PennDOT I-95 Master Plan Team)
Brian Horn	RK&K

Handouts:

SAC Notebook – Meeting #3 Contents:
- SAC Meeting #3 Agenda
- SAC Work Plan
- Figures 1 and 2 showing Potential Improvements
- Improvements Evaluation Matrix with Priority Ratings
- Table showing Potential improvements (individual and packages) with Cost and Priority

Introductions / Meeting Purpose

The meeting came to order at about 9:30 AM. Stan Platt, DVRPC, welcomed all attendees and invited introductions around the table. Brian Horn stated the purpose for Meeting #3 of the Study Advisory Committee (SAC) is to review the potential improvements and initial evaluation matrix, and for the study team to present the draft improvements priority list. The SAC will have the opportunity to provide comments, questions and input. Mr. Horn continued by reviewing the study team work plan and noting this is the last meeting of the Phase I Study Advisory Committee. Today's meeting focus will be the Improvements Evaluation Matrix and the Draft Improvements Priority Ranking.

Summary of SAC Meetings #1 and #2

Mr. Horn provided a short summary of Meetings #1 and #2 by reviewing the displays and information presented during those meetings. He directed the SAC to their project notebooks and highlighted the existing roadway conditions, safety conditions, existing traffic conditions (2010) and no-build (2015) traffic conditions shown on Figures 1 through 4 at Meeting #1. He next reviewed the initial existing conditions summary and potential improvement tables, and the potential improvement figures and draft evaluation matrix format discussed during Meeting #2. In response to a question, Mr. Horn noted the proposed improvement to close the Chestnut Street on-ramp to northbound I-95 is not a short-term or mid-term solution by the study team. This proposed improvement is a long-term timeframe solution and would require a NEPA planning study to evaluate alternatives.

Draft Evaluation Matrix

Mr. Roberta and Mr. Shehata next reviewed the draft evaluation matrix for the SAC. In addition to reviewing the matrix contents, they also referred the SAC to their notebook materials, especially Meeting #3: Figures 1 and 2 – Potential Improvements. Mr. Roberta explained the improvement numbering remained the same from Meeting #2 materials but a new project number was added to separate the northbound I-95 mainline signing improvements from the northbound I-95 ramp to northbound I-476 curve warning sign improvements. He explained the draft evaluation matrix format is unchanged from Meeting #2 and that the study team had completed its evaluation of the proposed improvements for rationale, operational benefit and anticipated improvement lifespan. The draft evaluation matrix is further completed with proposed improvement cost estimate ranges, implementation issues to be resolved, a recommended timeframe for when the improvement should be contemplated by DVRPC/Delaware County/PennDOT, and the draft recommendation on the project priority against the other projects. Mr. Shehata added the project priority tended to favor those improvements which had the most probability of improving traffic safety conditions within the study area. Each potential improvement (improvement number in parentheses), as listed below, was reviewed and discussed among the committee members:

(1) *Close Chestnut Street Entrance Ramp to Northbound (NB) I-95* – the closure of the Chestnut Street on-ramp to northbound I-95 is assigned a "Long-term" timeframe due to the likely requirement for a NEPA planning study to relocate the ramp elsewhere in the city. The committee recommends not pursuing as a closure project but only as part of a larger planning study to evaluate northbound I-95 access from Chester.

(2) *Provide Two-Lane Exit from NB I-95 to NB I-476* – the committee was supportive of this improvement and the study team recommendation as a high priority improvement.

(3) *Provide an Emergency Vehicle Access at Ridley Avenue* – the emergency responder committee members noted the access gate does not give them a strong operational advantage over use of the existing northbound Chestnut Street on-ramp. The committee was supportive of listing this improvement as a low priority.

(4) *Reconfigure the Merge of I-95 Ramps to NB I-476* – the improvement would restripe the existing lane drop to favor the ramp lanes from northbound I-95 over the lanes from southbound I-95. The committee inquired if there is a distinct peak volume ramp for both peak periods or if the peak volume switches from AM peak hour to PM peak hour. The study team will evaluate this possibility during Phase II and also examine the traffic simulation predicted vehicle queuing for both northbound and southbound I-95 ramps to determine the restriping plan. The committee was supportive of this improvement and the study team recommendation as a high priority improvement.

(5) *Drop the Right Lane of NB I-476 Prior to MacDade Boulevard* – the committee was supportive of this improvement and the study team recommendation as a high priority improvement.

(6&8) *Implement Peak Period Shoulder Use on NB and SB I-476* – the study team recommend the northbound I-476 peak period shoulder use lane (Improvement 6) be prioritized over the southbound I-476 peak period shoulder use lane (Improvement 8). The study team reasoned a northbound shoulder lane would help ease traffic congestion within the study area but a southbound shoulder lane would bring traffic volumes to the interchange at a faster rate than the ramps are designed to handle. Mr. Platt summarized a brief review of the I-476 Record of Decision document and concluded a peak period shoulder use lane may not qualify as a capacity improvement but an environmental analysis would be required to determine if there are any environmental impacts. The study team noted that the peak shoulder use lane would be monitored with in-pavement traffic sensors and closed-circuit television cameras by a PennDOT Traffic Operations Center, incorporate emergency pull-off areas alongside of the shoulder use lane, and be controlled with overhead lane use signals and dynamic message signs. In addition, further Active Traffic Management techniques would be evaluated for this highway segment. The study team acknowledged a full concept of operations plan would need to be developed in concert with the local and state emergency responders before any design/construction commitment is made for this proposed improvement. The committee was supportive of this improvement (prior comment noted) and the study team recommendation as a high priority improvement.

(7) *Extend MacDade Boulevard Entrance Ramp Acceleration Lane* – the study team noted the relatively low traffic benefit this improvement adds to the study area and the predicted ramp merge level of service (LOS) is LOS D. The committee was supportive of this improvement and the study team recommendation as a medium priority improvement.

(9&10) *Provide Two-Lane Ramp from SB I-476 to SB I-95/Provide Four Lanes on SB I-95 between I-476 and Chestnut Street* – the study team noted the high traffic benefit of improving the southbound I-476 to southbound I-95 ramp movement with Improvements 9 and 10. The committee offered the following comments: consider adding right-side shoulder width for the southbound I-95 bridge over Bullens Lane; consider adding advisory signing identifying the area as a "High Crash Area"; consider adding shoulder edge rumble strips along travel lanes. The committee was supportive of this improvement and the study team recommendation as a high priority improvement.

(11) *Improve NB I-95 Advance Signing* – the study team described the benefit of modifying the advance guide signing to aid with the proposed northbound I-95 improvement at the northbound I-476 ramp diverge. The committee was supportive of this improvement and the study team recommendation as a low priority improvement.

(12) *Repair and/or Improve Interchange Lighting* – the study team noted that accident reports from within the study area noted "dark areas" existed. Further review and visual inspection coordination with PennDOT is recommended to determine if the existing lighting system requires upgrades or improvements. The committee was supportive of this improvement and the study team recommendation as a medium priority improvement.

(13) *Install Advance Curve Warning Signage* – the study team identified installation of curve warning chevrons, hazard identification beacons and advance curve warning signs with advisory speed panels would improve safety for the northbound I-95 to northbound I-476 ramp. The committee was supportive of this improvement and the study team recommendation as a high priority improvement.

Draft Improvements Priority List

The study team reviewed the draft improvements priority list include in the project notebook materials. They explained there were improvements that are complimentary to each other and would be best if implemented as a "package" or group. The draft ranking order of the improvements accounted for this complimentary grouping of projects. The study team also noted the project costs were affordable by the region's Transportation Improvement Program (TIP) if the identified study projects were supported by the region's TIP Committee. Four projects were listed as "high" priority and included:

1. Package A: Improvements 9 and 10 combined — $3.8M to $5.1M
2. Package B: Improvements 2, 4 and 5 combined — $1.94M to $2.58M
3. Improvement 6 — $5.55M to $7.38M
4. Improvement 13 — $15K to $20K

Discussion

The SAC members offered comments and questions. In response to a question, the study team noted the Phase II study would prepare a traffic simulation model of the interchange traffic conditions and the model would give a better understanding of which improvements may have a higher relative benefit among the top three high priority improvements. PennDOT recommended the costs for Improvement 13 be reviewed. The City of Chester concurred that Improvement Package A, Improvement 13 and programming study funds for Improvement 1 would be supported by the City. Delaware County recommended Improvement 1 description be revised to say the future action is a "Planning Study". State Police offered that the recommended maintenance projects should be advanced and installed as soon as feasible.

With these SAC comments, questions and input, Mr. Platt concluded the discussion by stating the study team will consider these valuable and insightful comments as they prepare the final report. He noted the recommended projects are achievable within the framework of the region's TIP and have met the study's original goal (low-cost and manageable projects to help mitigate interchange congestion) and objectives (identify cause/location of congestion, develop a solutions list, and recommend low-cost improvements). The final recommendations will be documented in the final report.

Closing

Mr. Platt closed the meeting by thanking the SAC attendees for their input and questions. He stated the Phase II effort will also invite stakeholder input and may seek to reconvene this committee for their assistance.

APPENDIX B
ENVIRONMENTAL JUSTICE MEETING NOTES (MAY 25, 2011)

ENVIRONMENTAL JUSTICE MEETING NOTES (May 25, 2011)

Existing Conditions Overview: Jeff Roberta and Mahmood Shehata provided an overview of the existing conditions within the project study area for the I-95/I-476 interchange. The overview summarized the collection of traffic volume data, an analysis of the existing traffic operations for levels of service and congestion, and included an examination of the accident history of study area mainline and ramp lanes. Jeff and Mahmood also identified where the congestion issues are occurring within the study area and the likely causes. Primary congestion issues occur for northbound I-95 exiting to northbound I-476, the northbound I-476 merge area from southbound/northbound I-95, northbound north of MacDade Boulevard, and the southbound I-476 merge area with southbound I-95.

Toolbox of Potential Improvements: Jeff reviewed the list of potential improvements that are likely to help alleviate congestion in the interchange area. The list ranged from basic traffic safety improvements (additional/updated signing, pavement striping and lighting) to roadway operational improvements including modifying the lane arrangements at ramp exits, restriping lane arrangements at ramp merges, implementing peak shoulder use, and eliminating ramp movements.

Potential Improvements Being Initially Considered: Jeff and Mahmood reviewed the list of potential improvements being considered for detailed evaluation. Jeff described each improvement and Mahmood highlighted the potential traffic and safety benefits of each improvement. The following are general comments provided by the citizens:

a. Peak Shoulder Use – how would enforcement be conducted?
b. Peak Shoulder Use – would the shoulder lane be on the left or right?
c. Restriping –narrower mainline lanes could be safer, as this would slow traffic in the area.

1. *Close Chestnut Street:* The citizens noted that closing the Chestnut Street ramp to northbound I-95 would be very detrimental to the community. This is the only access to northbound I-95 within the City of Chester. They requested we show the evidence of why closing the ramp would be beneficial to I-95 and then how the community would be served. Wouldn't slowing I-95 northbound traffic be more productive? If you do have to close Chestnut Street, is there another location where a northbound on-ramp could be installed?
2. *Northbound I-95 exit to I-476 – create choice lane exit:* The citizens reacted favorably to the idea of creating a northbound I-95 exit choice lane. They appreciated the potential to improve safety for the Chestnut Street on-ramp merge area. The primary problem for Chestnut Street merging vehicles is the speed of I-95 drivers – could a speed camera help to lower I-95 speeds?
3. *Emergency vehicle access gate to northbound I-95 at Ridley Avenue:* The citizens reacted favorably to the idea of installing an emergency personnel/vehicle access gate to northbound I-95 from Ridley Avenue. They believed this could provide an alternative whenever the Chestnut Street ramp was blocked by queued vehicles and didn't see a major impact to the adjacent community. The team explained that the emergency responders are uncertain if the access would be an advantage to them or not.
4. *Northbound I-476 merge (from southbound/northbound I-95):* There was general agreement that modifying the northbound I-476 merge to give more lane priority to the northbound I-95 ramp versus the southbound I-95 ramp would not cause a negative community impact and that it would be favorable to the improvement idea.

5. *Northbound I-476 north of MacDade Boulevard including northbound Peak Shoulder Use Lane (Improvements 5/6/7):* There was much discussion on the peak shoulder use lane. Comments centered on how disabled vehicles would be monitored, how would emergency vehicles respond to incidents, and how far would the peak shoulder use lane extend. The team answered these questions and there was general acceptance that if the emergency responders could be satisfied with their concerns, then they wouldn't see a negative impact to the community.
6. *Southbound I-476 north of MacDade Boulevard – southbound Peak Shoulder Use Lane (Improvement 8):* Comments similar to those from the northbound peak shoulder use lane apply to this improvement idea for the southbound peak shoulder use lane.
7. *Southbound I-476 ramp to southbound I-95:* The citizens agreed that this improvement would be a benefit, but only if combined with Improvement 10 – developing a southbound I-95 auxiliary lane.
8. *Southbound I-95 – add 4th mainline lane between I-476 entrance and Chestnut exit ramp (Improvement 10):* The citizens were positive on the improvement idea but asked several questions about the physical space/width needed for the improvement; if the CSX bridge over the southbound I-476 ramp will need to be lengthened; and if the southbound I-95 traffic exiting to Chestnut Street will find it too difficult to change lanes. Since the Chestnut Street ramp is the primary access route directly into the City of Chester, the citizens wanted to know if a better access location to/from the city were available along I-95.

Additional Citizen Comment: A citizen offered a comment on whether our study was factoring in the health effects of the close proximity of transportation corridors to nearby residents. He cited the high rate of strokes, asthma, and other diseases that occur in Chester compared to the average for Delaware County and Pennsylvania.

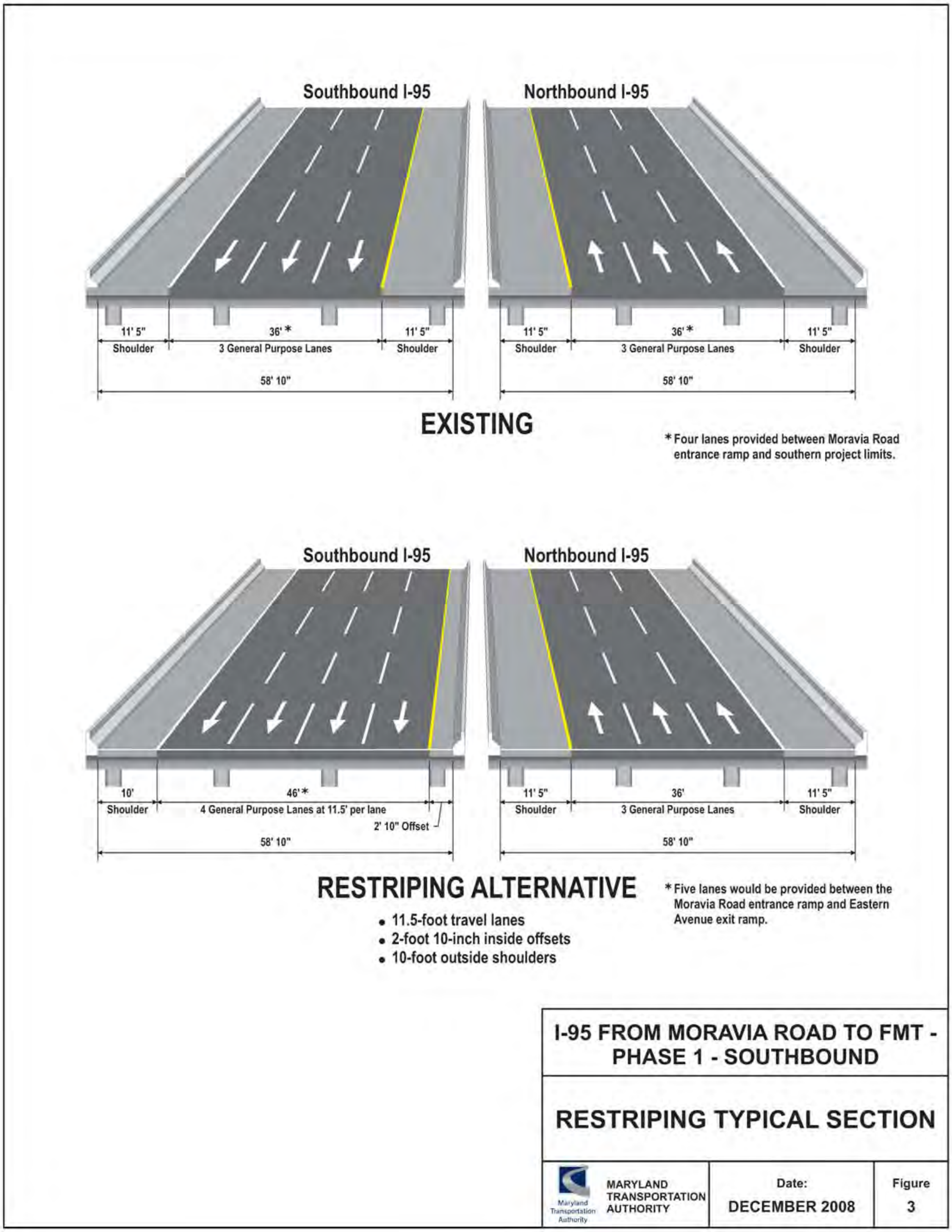
APPENDIX C
EXAMPLES OF SHORT-TERM AND MID-TERM IMPROVEMENTS

Toolbox of Potential Short-term and Mid-term Improvements

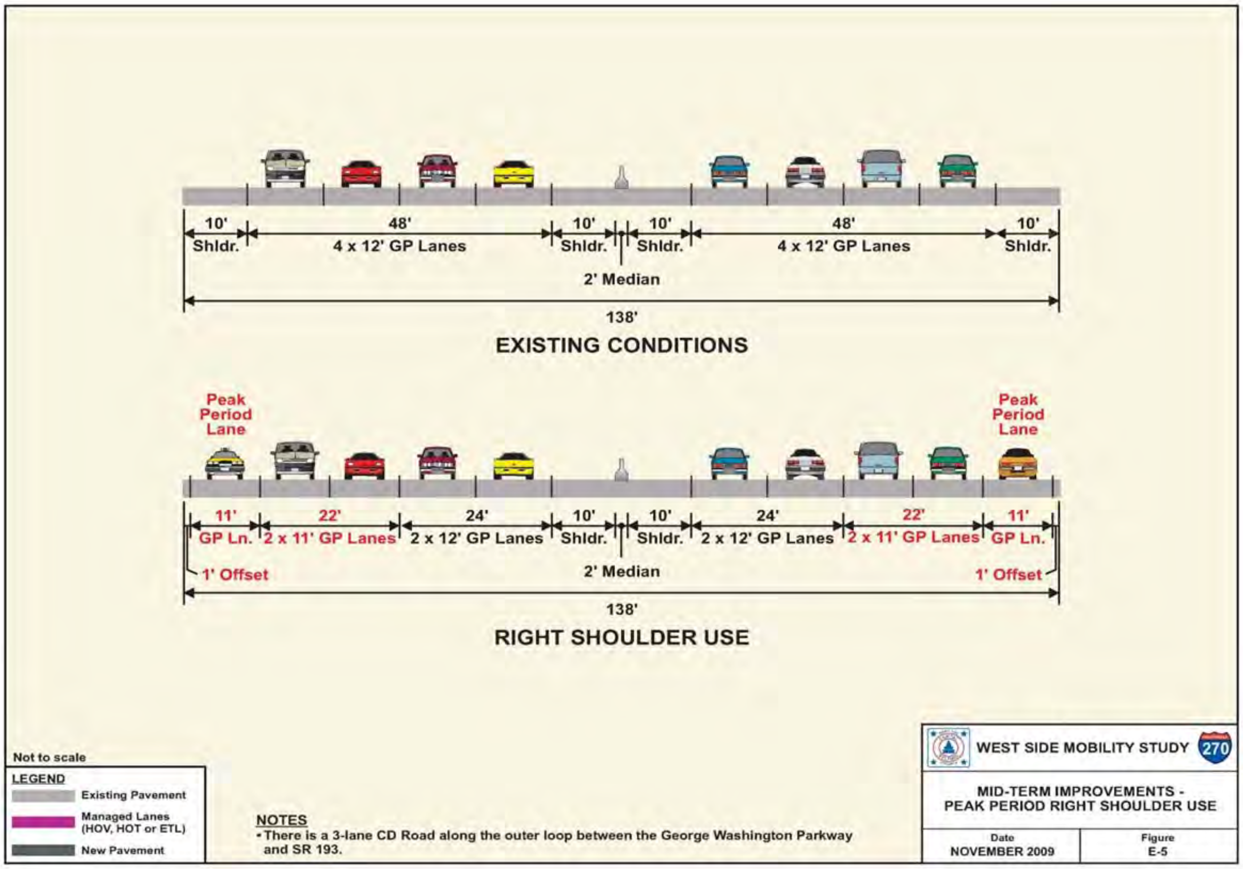
- Short-term solutions – implemented within 3 years
- Mid-term solutions – implemented within 3 to 5 years

Solution	Timeframe	Description and Potential Benefit
Restriping within existing highway typical section	Short-term	• Add lanes within existing section; modify existing lane configuration; move locations of lane add/drops • Allows for additional capacity without the need for expensive widening • Existing lane configuration could be modified to optimize traffic operations
Ramp metering	Short-term	• Add signals at ramp entrances to I-95 and/or I-476 (already in place on some MacDade Blvd. movements) • Controls the volume of traffic entering mainline to reduce operational effects of merging traffic
Ramp closure	Short-term	• Completely eliminate ramp movements • Eliminates merge/diverge operational issues • Traffic would have to use alternate access points
Extend acceleration/ deceleration lanes	Short-term	• Lengthen acceleration/deceleration lanes to provide adequate merge and/or queue areas • Improves safety at interchanges • Allows for better merging/diverging operations
Improve/augment signing	Short-term/ mid-term	• Add signs to better direct motorists for interchange movements and advise for roadway conditions • Improve operations by providing sufficient advance guidance to motorists
Improve/augment lighting	Mid-term	• Add lighting to improve visibility at specific points within interchange • Improve safety and operations by increasing visibility at critical locations
Peak-period shoulder use	Short-term/ mid-term	• Add lane-use control signals and static signing that would allow shoulders to be used during peak periods • Provides additional capacity during peak periods, but maintains shoulders during all other times
Localized, small scale widening within ROW (no structure widening)	Short-term/ mid-term	• Widen in specified locations to provide auxiliary lanes, acceleration/deceleration lanes, queuing areas at ramp intersections, etc. • Provides additional mainline capacity, ramp merging/diverging areas, or ramp storage area • Allows for improved operations near interchanges

Examples of short-term and mid-term solutions: static and dynamic signing for hard shoulder running
Photo Source: RK&K

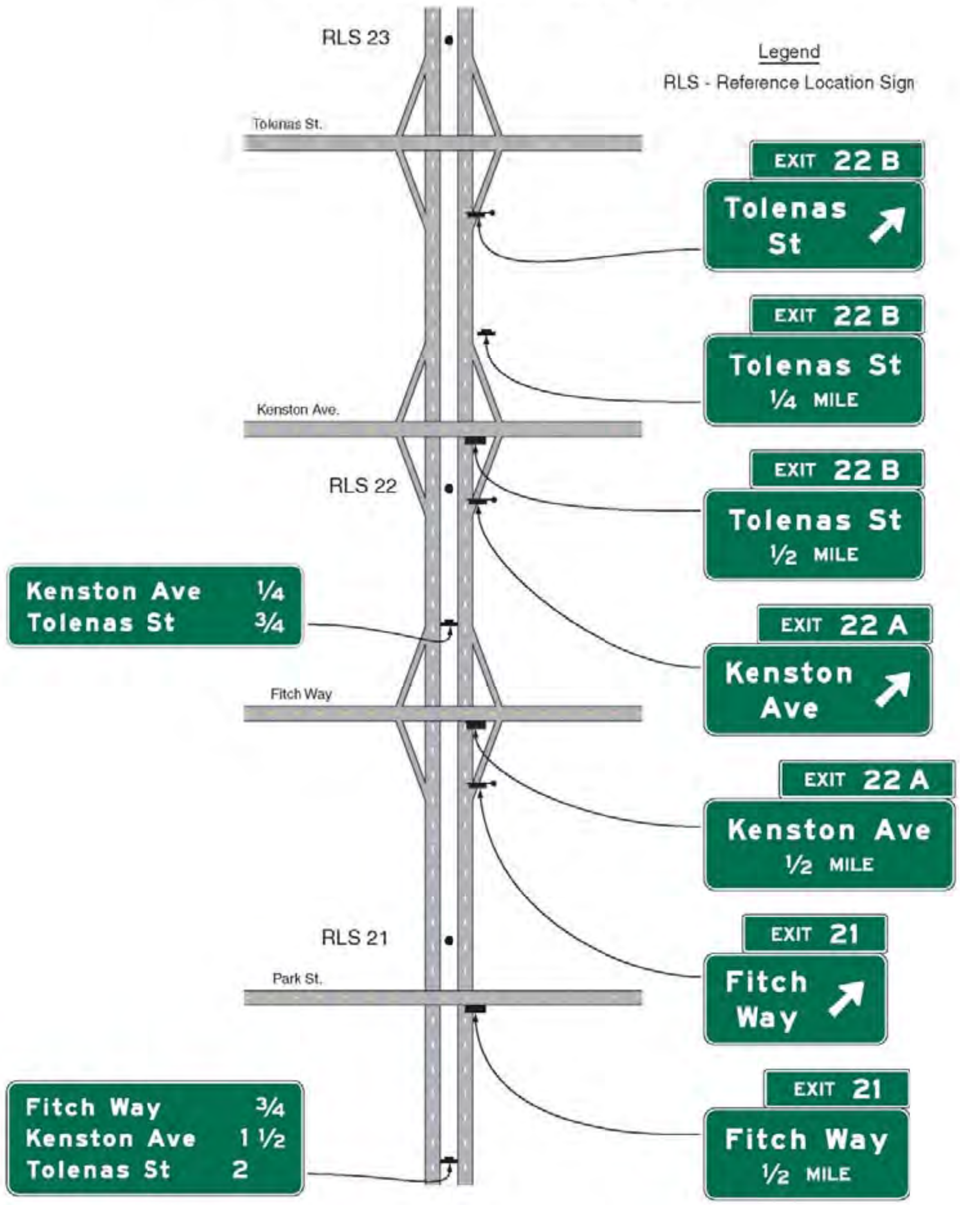


Source: RK&K, 2008



Source: RK&K, 2009

Figure 2E-30. Example of Using an Interchange Sequence Sign for Closely-Spaced Interchanges



Source: *Manual on Uniform Traffic Control Devices*, 2009 Edition

ABSTRACT

Publication Title:	I-95/I-476 Interchange Feasibility Study
Publication Number:	11026
Date Published:	April 2012
Geographic Area Covered:	I-95/I-476 Interchange area in Delaware County
Key Words:	Traffic conditions, roadway deficiencies, safety, traffic operational improvements
Abstract:	This document is a study of the I-95/I-476 Interchange and its immediate vicinity. Traffic, roadway, and safety deficiencies were identified. Thirteen potential improvements were identified, and a high level analysis of their costs and benefits was conducted. Three packages encompassing six high priority operational improvements are recommended for further study.
Staff Contact:	Stan Platt Manager, Transportation Operations Management ☏ (215) 238-238-2851 splatt@dvrpc.org

Delaware Valley Regional Planning Commission
190 N. Independence Mall West, 8th Floor
Philadelphia PA 19106
Phone: (215) 592-1800
Fax: (215) 592-9125
Internet: www.dvrpc.org

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dvrpc
REGIONAL
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