DELAWARE VALLEY
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REGIONAL
PLANNING COMMISSION

I-76 / I-476 Interchange Area
Traffic and Conceptual Engineering Study

Technical Report

April 2009

The Delaware Valley Regional Planning Commission is dedicated to uniting the region's elected officials, planning professionals and the public with the 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 official metropolitan planning organization for the Greater Philadelphia Region — leading the way to a better future.

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 its findings and conclusions, which may not represent the official views or policies of the funding agencies.

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Executive Summary

The Schuylkill Expressway (I-76) is the main east-west highway through the Philadelphia Region, carrying upwards of 115,000 vehicles per day just east of the I-76 / I-476 interchange. Between US 202 and City Avenue, it is mainly two travel lanes in each direction, confined on either side by steep slopes, the Schuylkill River, and a rail right-of-way. Because of these constraints, additional capacity cannot be achieved without large capital expenditures. Therefore, both the Federal Highway Administration and the Pennsylvania Department of Transportation are supportive of relatively low-cost measures to eliminate bottlenecks and reduce recurring congestion. In the vicinity of the Schuylkill Expressway's interchange with I-476, congestion and ramp queue spillbacks hamper the flow of through traffic and have significant impacts on the local road network.

In FY 2007, DVRPC staff initiated Phase 1 of the *Schuylkill Expressway / I-76 Widening Feasibility Study*. The breadth of the work investigated prior studies and current highway plans, addressing possible spot improvements, conventional widening, and double-decking the highway at various locations to provide more efficient highway operations. The work was developed with the participation of a multi-jurisdictional steering committee comprised of the Federal Highway Administration (FHWA), the Pennsylvania Department of Transportation District 6-0, County and Municipal stakeholders. Conceptual designs and preliminary costs were formulated for elements of the project which were summarized into a DRAFT technical memorandum[1].

Opportunity to advance the *Schuylkill Expressway / I-76 Widening Feasibility Study* was identified in the DVRPC's *Schuylkill Crossings Traffic Study*[2]. The *Schuylkill Crossings Traffic Study* included analyzing peak hour traffic volumes and operating conditions, identifying study area travel patterns, and developing 2030 traffic forecasts to identify a set of long-term improvements to ease the river crossing bottleneck. The *Schuylkill Crossings* study culminated in identifying the most feasible area to serve regional access across the river: the I-76 / I-476 Interchange / Matsonford Road Bridge area. Conceptual improvements identified in the *Schuylkill Expressway / I-76 Widening Feasibility Study* technical memorandum complemented and enhanced the long-term recommendations of the *Schuylkill Crossings Traffic Study*. This study combines traffic operations modeling with highway design services to refine the recommendations of the two previous studies and further identify other

1 DVRPC, Schuylkill Expressway / I-76 Widening Feasibility Study, June 2007

2 DVRPC, Schuylkill Crossings Traffic Study, January 2008

feasible highway / roadway improvements to enhance mobility and reduce congestion. In effect, this represents the second phase of the *Schuylkill Expressway / I-76 Widening Feasibility Study*.

The Louis Berger Group, Inc. (Berger) served as the engineering consultant for the study, providing design enhancements, environmental screenings, constructability evaluations, and cost estimates for the study's Build Scenarios. DVRPC's regional travel simulation model was used to simulate travel patterns and traffic volumes for 2030 conditions assuming a No-Build and two Build Scenarios. The output of the regional model served as inputs to the VISSIM traffic operations simulation software. In turn, VISSIM outputs supplied the performance measures to evaluate the design enhancements to the study area's infrastructure.

A 2005 Base Year and four 2030 future Scenarios were developed and examined for this study. The future Scenarios included the following:

- No-Build Scenario that includes all committed projects for the region
- Build 1 Scenario that examines lengthening and widening the southbound I-476 exit ramp to I-76 and Matsonford Road
- Build 1A Scenario that is the same as Build 1, but with a slight modification to the I-76 eastbound ramp just prior to the I-76 underpass
- Build 2 Scenario that realigns the I-76 ramps with Matsonford Road and adds an additional right-turn lane on PA 23 from Barr Harbor Drive to the Fayette Street intersection

The Build 1 Scenario was favorably viewed by the Steering Committee members and, as of March 2009, the lengthening and widening of the I-476 southbound ramp is currently in design. The Build 1A and Build 2 Scenarios may be revisited for future consideration.

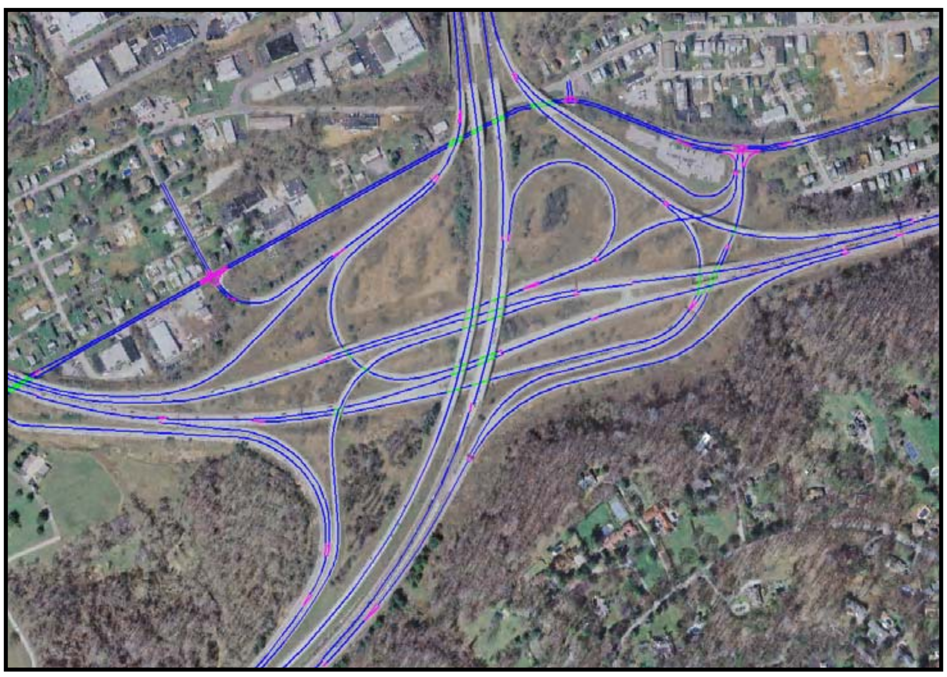
The project's Steering Committee (comprised of staff from FHWA, PennDOT, Montgomery County Planning Commission, West Conshohocken Borough, Conshohocken Borough and Lower Merion Township) served as the guiding body for the study.

Study Area Characteristics

Highway Network

The traffic operations simulation and subsequent performance measure outputs were completed using the VISSIM software package. VISSIM is a powerful, behavior-based multipurpose traffic simulation program, capable of integrating highways, local roads, ramps and merge areas, toll plazas, pedestrians, signalized and unsignalized intersections, roundabouts, and a whole host of other transit and transportation applications.

Figure 1: Traffic Operations Highway Network



Source: DVRPC 2008

All of the blue lines (along with the pink connectors and green underpasses) represented in Figure 1 are part of the evaluated VISSIM highway network for this study. Figure 1 shows a portion of the 22 mile network that includes 17 signalized intersections and 8 unsignalized intersections spanning five municipalities, including Conshohocken Borough, West Conshohocken Borough, Plymouth Township, Upper Merion Township, and Lower Merion Township. Apart from the entire I-76 / I-476 Interchange, some of the key local roads include Balligomingo Road, PA 23, Fayette Street, Elm Street, South Gulph Road, Matsonford Road, Trinity Road, and the entire I-76 / I-476 interchange.

As inputs to the VISSIM operations model, data was gathered from a variety of sources. The roadway network was traced on top of 2005 DVRPC aerials, and scaled for accuracy. Intersection turning movement counts were collected from DVRPC, the Pennsylvania Department of Transportation (PennDOT), and Pennoni Associates Inc. PennDOT Traffic Signal Plans were used for intersection geometry, signal timing and phasing, and signal configuration. Variations in signal timing plans for the AM and PM periods were also accounted for. For calibrating the Base Year network in terms of speed and traffic volumes on the Interstate highway system, data was collected from the Mobility Technology's sensors.

Current Conditions

The highway network in the study area is plagued by traffic congestion, poor circulation, and long delays on the local roads. Most notably, the Fayette Street Bridge, Matsonford Road, and PA 23 are particularly troublesome. The Matsonford Road and PA 23 intersection, at the base of the Fayette Street Bridge, is, by volume, the busiest intersection in the entire study area. All four approaches experience significant volumes, resulting in extensive queues on multiple legs of the intersection, both in the AM and PM peak periods. Exacerbating the situation, this intersection also serves as a ramp terminus for I-76 to / from the east. Another issue related to this intersection is that the Fayette Street Bridge is one of only a handful of Schuylkill River crossing points in the entire region. Future population and employment growth in Conshohocken Borough will continue to put traffic demand pressure on an already congested bridge.

There is also significant congestion on PA 23 in West Conshohocken. The succession of traffic signals at Woodmont Road, Barr Harbor Drive, Moorehead Avenue, and Matsonford Road exacerbates the very slow progression of traffic through this area.

On the interstate and associated ramp system, slow travel speeds and bottlenecks impede the flow of traffic well beyond the limits of the peak hour. I-76 eastbound in particular is plagued with heavy volumes and consecutive merge areas. These conditions create backups along the entire length of the mainline, in turn spilling back onto the ramps in the interchange. I-76 is also hampered by the effects of congestion that originate well beyond the limits of the study area. I-476 southbound experiences heavy exiting volumes at the I-76 / Matsonford Road ramp. The queues negatively affect southbound mainline traffic operating conditions, particularly in the AM peak hour.

Table 1 shows the Base Year, No-Build, Build 1, and Build 2 Average Daily Traffic Volumes for the I-476 / I-76 interchange. The Base Year counts are scaled to coincide with a 2005 network. The total volume for each Scenario is shown at the bottom of the page. There is a 10.55% expected increase in total daily traffic from the Current to the No-Build in the interchange area. There are only minor changes in total interchange volumes between the No-Build, the Build 1 Scenario, and the Build 2 Scenario.

The highest daily volumes, on I-76 and I-476, are represented in the table as one-way volumes entering the network. The I-76 eastbound ramp to I-476 southbound carries the highest volume in the interchange at 17,100 vehicles per day.

The effects of the highway improvements can also be observed in Table 1. From the No-Build and Build 1 Scenarios, the average daily traffic of the I-76 westbound exit ramp to Balligomingo Road decreases by 2,300 vehicles. This is a direct result of the new I-76 westbound off ramp at Henderson Road. Conversely, the improvement to the southbound I-476 ramp to I-76 / Matsonford Road increases volumes in the Build 1 Scenario by 7.69%.

Table 2 shows the totals from selected highway links in the vicinity of the I-476 / I-76 Interchange. The area totals, from the Base Year to the No-Build, increase by 25,000 vehicles, or 17.47%. This increase is somewhat higher than the growth of the interchange total, which is forecasted to grow by 10.55%.

Figure 2 graphically shows (in 1,000's) all of the counts from Table 1 and some of the counts from Table 2 at the location of where the counts are applicable. The volumes are color-coded in coordination with the Base Year, No-Build, Build 1, and Build 2 Scenarios.

Table 1: 2005 and 2030 Average Daily Traffic Volumes – Interchange Totals

	2005	2030	Base Yr to No-Build		2030	No-Build to Build 1		2030	Build 1 to Build 2	
Location	Base Yr	No-Build	Diff.	Percent	Build 1	Diff.	Percent	Build 2	Diff.	Percent
I-76 EB to I-476 NB & Matsonford Rd	13,800	15,300	1,500	10.87%	14,900	-400	-2.61%	15,200	300	2.01%
I-76 EB to I-476 NB	8,500	8,800	300	3.53%	8,700	-100	-1.14%	9,000	300	3.45%
I-76 WB to I-476 NB	16,600	18,100	1,500	9.04%	17,600	-500	-2.76%	17,200	-400	-2.27%
I-476 NB to I-76 EB	4,800	5,500	700	14.58%	5,600	100	1.82%	5,600	0	0.00%
I-476 NB to Matsonford Rd	5,100	5,900	800	15.69%	5,800	-100	-1.69%	6,000	200	3.45%
I-476 NB to I-76 WB	16,800	20,000	3,200	19.05%	20,200	200	1.00%	20,700	500	2.48%
Matsonford Rd to I-76 WB	5,000	6,200	1,200	24.00%	6,300	100	1.61%	6,200	-100	-1.59%
I-76 WB to I-476 SB	4,800	5,200	400	8.33%	5,300	100	1.92%	5,100	-200	-3.77%
I-76 EB to I-476 SB	17,100	18,200	1,100	6.43%	18,600	400	2.20%	18,100	-500	-2.69%
I-476 SB to I-76 EB	13,900	15,000	1,100	7.91%	16,600	1,600	10.67%	16,200	-400	-2.41%
I-476 SB to I-76 WB	8,100	8,700	600	7.41%	9,100	400	4.60%	9,000	-100	-1.10%
I-476 SB to Matsonford Rd	6,500	7,000	500	7.69%	7,600	600	8.57%	7,700	100	1.32%
Matsonford Rd to I-476 NB	6,600	7,300	700	10.61%	7,400	100	1.37%	7,300	-100	-1.35%
Matsonford Rd to I-76 EB	6,000	7,000	1,000	16.67%	7,100	100	1.43%	7,400	300	4.23%
I-76 WB to Matsonford Rd	6,300	7,200	900	14.29%	7,000	-200	-2.78%	7,400	400	5.71%
I-76 WB - Hollow Rd to PA 23	57,600	64,500	6,900	11.98%	64,900	400	0.62%	64,400	-500	-0.77%
I-476 SB - Ridge Pike to Front Street	65,500	70,900	5,400	8.24%	72,000	1,100	1.55%	71,400	-600	-0.83%
I-76 EB - Gulph Rd to Matsonford Rd	48,700	54,200	5,500	11.29%	54,200	0	0.00%	53,700	-500	-0.92%
I-476 NB - Montgomery Ave to Gulph Rd	57,300	63,300	6,000	10.47%	63,300	0	0.00%	62,800	-500	-0.79%
I-76 WB to Balligomingo Rd	8,100	9,000	900	11.11%	6,700	-2,300	-25.56%	6,300	-400	-5.97%
Gulph Rd to I-76 EB	9,600	10,600	1,000	10.42%	10,600	0	0.00%	10,900	300	2.83%
I-76 EB to Gulph Rd	8,600	9,100	500	5.81%	9,100	0	0.00%	9,400	300	3.30%
Interchange Totals:	**395,300**	**437,000**	**41,700**	**10.55%**	**438,600**	**1,600**	**0.37%**	**437,000**	**-1,600**	**-0.36%**

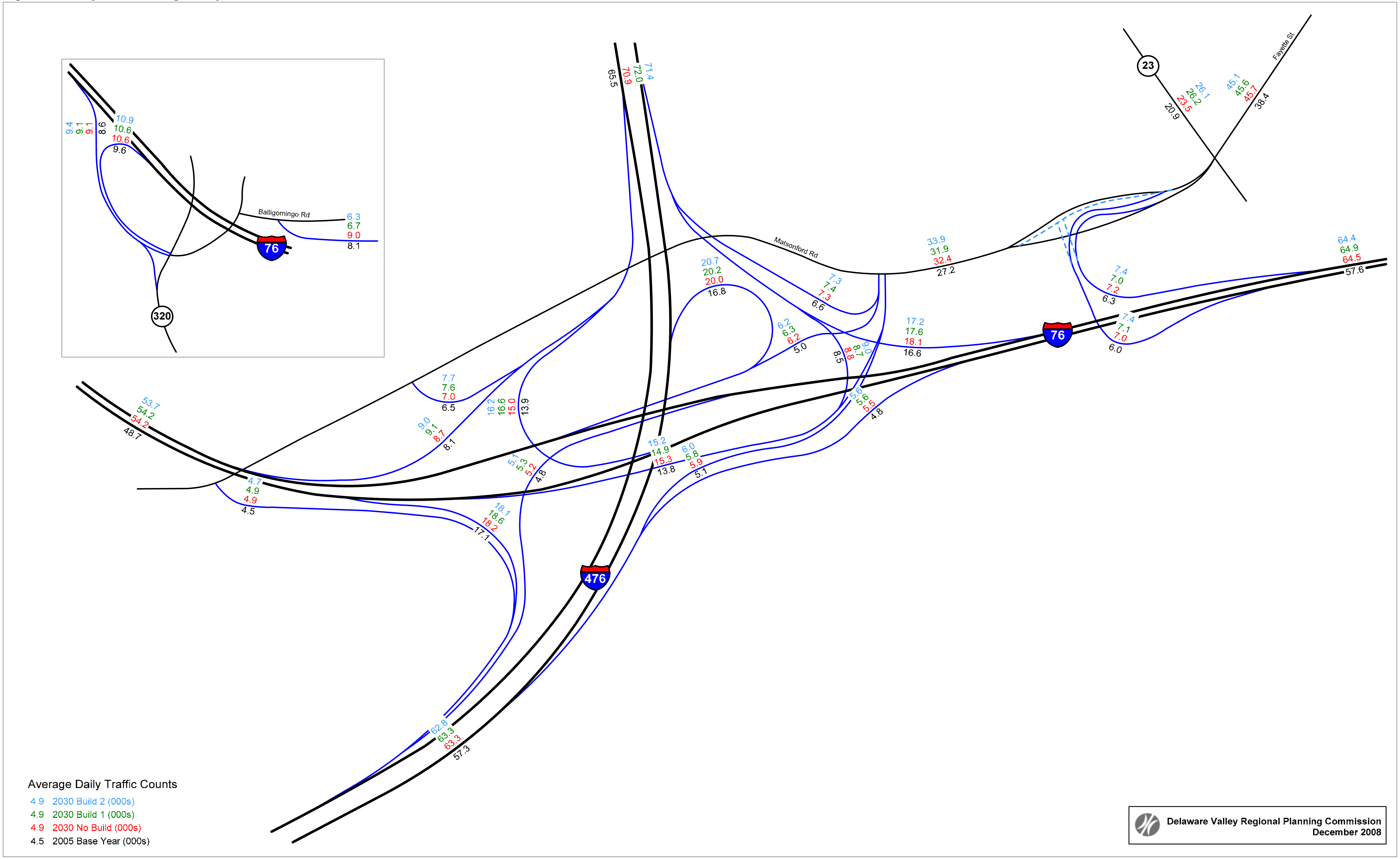
Source: DVRPC 2008

Table 2: 2005 and 2030 Average Daily Traffic Volumes – Area Totals

	2005	2030	Base Yr to No-Build		2030	No-Build to Build 1		2030	Build 1 to Build 2	
Location	**Base Yr**	**No-Build**	**Diff.**	**Percent**	**Build 1**	**Diff.**	**Percent**	**Build 2**	**Diff.**	**Percent**
PA 23 - Balligomingo Rd to Ford St	20,900	23,500	2,600	12.44%	26,200	2,700	11.49%	26,100	-100	-0.38%
Matsonford Rd - I-476 Ramp to I-76 Ramp	27,200	32,400	5,200	19.12%	31,900	-500	-1.54%	33,900	2,000	6.27%
PA 23 - I-76 Overpass to Arrowmink Rd	18,100	20,400	2,300	12.71%	19,900	-500	-2.45%	19,700	-200	-1.01%
Elm St - Maple Ave to Fayette St	6,800	8,100	1,300	19.12%	7,900	-200	-2.47%	7,700	-200	-2.53%
Elm St - Fayette St to Poplar St	14,100	16,200	2,100	14.89%	16,300	100	0.62%	16,300	0	0.00%
Fayette St - Elm St to 2nd Ave	17,600	21,800	4,200	23.86%	20,900	-900	-4.13%	20,600	-300	-1.44%
Fayette St - Front St to Elm St	38,400	45,700	7,300	19.01%	45,600	-100	-0.22%	45,100	-500	-1.10%
Area Totals:	**143,100**	**168,100**	**25,000**	**17.47%**	**168,700**	**600**	**0.36%**	**169,400**	**700**	**0.41%**

Source: DVRPC 2008

Figure 2: Study Area Average Daily Traffic Volumes



Improvement Scenarios

Traffic forecasts were prepared and evaluated for the 2030 forecast year under three different Scenarios: No-Build, Build 1, and Build 2. For each of these Scenarios, the DVRPC travel simulation model was modified to reflect the given set of projects and improvements and is used to prepare travel forecasts representative of that Scenario.

Socioeconomic Inputs

As part of the preparation for the regional travel demand forecasting model, DVRPC staff reviewed its current population and employment estimates, its long-range population and employment forecasts, and all proposed land use developments in the study area. Based on this review, DVRPC developed 2030 municipal level population and employment forecasts for use as inputs to the traffic simulation models. The demographic data used in this study is the same population and employment estimates used for the *Schuylkill Crossings Traffic Study*.

Table 3 summarizes the population totals of municipalities within the study area roadway network. Between 2005 and 2030, the population of the greater study area is projected to increase by 4,662 to total 115,980. Conshohocken Borough will have the greatest increase in new residents with over 1,700 or 22.5%.

Table 3: Study Area Population

	Population			Change 2005 to 2030	
Municipality	**2000**	**2005**	**2030**	**Absolute**	**Percent**
Conshohocken Borough	7,589	7,757	9,500	1,743	22.5%
Lower Merion Township	59,860	58,568	59,500	932	1.6%
Plymouth Township	16,045	16,341	17,000	659	4.0%
Upper Merion Township	26,860	27,131	28,480	1,349	5.0%
West Conshohocken Borough	1,446	1,521	1,500	-21	-1.4%
Total	**111,800**	**111,318**	**115,980**	**4,662**	**4.2%**

Source: DVRPC 2008

The study area will also add over 21,000 jobs, an increase of 16.9% between 2005 and 2030, as shown in Table 4. Conshohocken Borough, Plymouth and Upper Merion Townships will see the greatest increases. Because the area's employment will grow over four times faster than its population between 2005 and 2030, there will be an increase in the proportion of workers who commute into the study area from the surrounding portions of the region.

Table 4: Study Area Employment

	Employment			Change 2005 to 2030	
Municipality	**2000**	**2005**	**2030**	**Absolute**	**Percent**
Conshohocken Borough	6,597	6,713	10,000	3,287	49.0%
Lower Merion Township	43,287	43,975	44,450	475	1.1%
Plymouth Township	20,845	21,169	30,300	9,131	43.1%
Upper Merion Township	52,424	54,144	62,400	8,256	15.2%
West Conshohocken Borough	2,988	3,168	3,800	632	19.9%
Total	**126,141**	**129,169**	**150,950**	**21,781**	**16.9%**

Source: DVRPC 2008

The population and employment totals for 2005 were used as inputs to the DVRPC regional travel demand for the 2005 Base Year network, while the 2030 totals were used for the future year Scenarios.

No-Build

The No-Build Scenario provides a future year reference point, or base line, against which any impacts with the Build Scenarios may be compared and quantified. The No-Build includes improvements to local and regional facilities included in DVRPC's Transportation Improvement Plan and Long Range Plan (*Destination 2030*) that are currently in or imminent for construction.

The 2030 No-Build network developed for the *Schuylkill Crossings Traffic Study* served as the basis for the No-Build network for this Interchange Study. This Scenario contains regional projects such as the US 422 River Crossing Complex, which will modernize the US 422 / PA 23 and US 422 / PA 363 interchanges, widen US 422 from US 202 to PA 363, and reopen the Betzwood Bridge to vehicular traffic. Also included is the widening of the Pennsylvania Turnpike between Valley Forge and Norristown, which is now complete.

Two local highway improvement projects were added to the *Schuylkill Crossings Traffic Study* 2030 No-Build network to complete the *Interchange Area* network. The first is a Highway Occupancy Permit (HOP) that will widen the westbound side of Matsonford Road between Front Street (PA 23) and the I-76 / I-476 ramps from one to two lanes. The second project is the intersection improvements at PA 23 / Balligomingo Road. This project will realign the Balligomingo Road eastbound approach so that it intersects PA 23 at nearly a 90 degree angle. Adding turn lanes at the approaches and signalizing the intersection are also planned.

Build 1

The key element of the Build 1 Scenario, also referred to as the Operations Improvement, consisted of widening and extending the I-476 southbound exit ramp to I-76 and Matsonford Road. This concept emanated from Figure 15 of the *Schuylkill Expressway / I-76 Widening Feasibility Study - Phase 1 of 2*, which provides an additional deceleration lane from just south of the Schuylkill River Bridge to the Matsonford Road Bridge. A second aspect of the Operations Improvement Scenario, to introduce a flyover for the I-476 southbound ramp to eastbound I-76, was eliminated from consideration by the Steering Committee due to the large capital expense.

The Build 1 Scenario also consisted of several other key regional projects, including:

- The PA 23 Relocation Project, which will construct a four-lane controlled access highway approximately 3.5 miles in length between US 422 and its current interchange with US 202 just south of the Dannehower Bridge.
- The Lafayette Street Extension, which involves constructing a partial interchange at the Dannehower Bridge and Lafayette Street intersection, widening and extending Lafayette Street past its terminus at Ford Street to Conshohocken Road, and building a full slip ramp to connect Lafayette Street to the Pennsylvania Turnpike.
- A new off ramp will be constructed at Henderson Road to serve I-76 westbound, while the current I-76 westbound on ramp will be relocated to the Henderson Road / Gulph Road intersection.

It should be noted that scope of the PA 23 Relocation Project has changed since the I-76 / I-476 Interchange Project began. The Relocation Project is now envisioned to be a two lane arterial as opposed to the four lane highway.

Build 2

The Build 2 Scenario, also referred to as the Long Range Plan, consisted of relocating the I-76 Ramps and widening Matsonford Road. The current on / off ramps serving I-76 eastbound are shifted out of the Matsonford Road / Fayette Street and PA 23 intersection and relocated to a new signalized intersection on Matsonford Road between PA 23 and the Elizabeth Street overpass. Matsonford Road will be widened to two lanes in each direction between PA 23 and the I-476 / I-76 Ramp intersection. The Matsonford Road eastbound approach leg at the Fayette Street and PA 23 intersection will be realigned and Matsonford Road shifted slightly to the north of its current location. This alignment generally follows the *Matsonford Road and Fayette Street Realignment Plan* prepared by Pennoni Associates Inc.

A second element to the Build 2 Scenario adds a second right-turn lane on westbound PA 23 from Barr Harbor Drive, through the Moorehead Avenue / Spring Garden Street intersection, to the Fayette Street Bridge. Also included in the model for the Build 2 Scenario is the widening of Henderson Road between US 202 to South Gulph Road for a consistent four lane cross-section and widening South Gulph Road from Henderson Road to PA 320 / Trinity Lane.

Performance Measures

In order to gauge the effects of the AM and PM network of each Scenario, a set of performance measures was computed from the output of the VISSIM software. Performance measures were calculated to reflect peak hour data in both the AM and PM networks. These performance measures include travel speeds, travel times, intersection levels of service, and average delay times. Performance measures were also aggregated and summarized for the entire modeled highway network and in the immediate vicinity of the modeled improvement.

The intersection average vehicle delay was calculated in the VISSIM software using the Highway Capacity Software methodology, and is expressed in terms of Level of Service (LOS). Level of Service is a qualitative measure describing operational conditions within a traffic stream, generally in terms of speed, delay, travel time, freedom to maneuver, and traffic interruptions. Letter grades designate each level, assigned from A to F, with LOS A representing the best operating conditions and LOS F the worst. Each LOS represents a range of operating conditions and the driver's perception of those conditions. For signalized intersections, LOS is a function of delay associated with the traffic signal control and is determined by the following tabulation:

Table 5: Level of Service at Signalized Intersections

Average Delay per Vehicle (seconds)	Level of Service
≤ 10	A
> 10 - 20	B
> 20 - 35	C
> 35 - 55	D
> 55 - 80	E
> 80	F

Source: Highway Capacity Manual 2000

According to the Highway Capacity Manual, control delay is the portion of the total delay attributed to traffic signal operation for signalized intersections. Control delay includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay. For this study, Level of Service was calculated for two intersections in the Base Year, No-Build, and Build 1 Scenario, and three intersections in the Build 2 Scenario. These intersections include Fayette Street / Matsonford Road and PA 23, Matsonford Road and the I-76 / I-476 ramps, and the reconfigured Matsonford Road and the I-76 eastbound on / off ramps intersection.

Eight travel time surveys were set up within the VISSIM evaluation files and are listed, along with the approximate distance, in Table 6. For the travel links, AM and PM travel link delay, measured in seconds, and average link speed, in miles per hour, was calculated and summarized into tables. The purpose of the travel times is to quantify degrees of congestion, to provide an alternative measure to traditional volume / capacity, and to allow for comparisons across the different Scenarios. In the VISSIM software, travel times are set up with a defined start and end point, and the data is tabulated for every vehicle that completes the trip within the simulation analysis time period.

Table 6: Simulation Travel Links

Name	Limits	Distance (feet)
I-476 SB	Brook Rd to I-76 / Matsonford Rd exit ramp	11,155
Matsonford Rd WB	PA 23 to Ford St	2,662
Matsonford Rd EB	Ford St to PA 23	2,680
PA 23 WB	Spruce St / Four Falls to Fayette St	2,030
PA 23 WB	Spruce St / Four Falls to Ford St	2,080
PA 23 WB	Spruce St / Four Falls to Matsonford Rd	2,035
I-76 EB	I-476 Southbound Ramp to PA 23 overpass	3,675
Fayette St EB	PA 23 to Elm St	1,780

Source: DVRPC 2008

Each travel time segment was set up to capture key changes in the highway network across improvement Scenarios. The I-476 travel link isolates the southbound through vehicles, from south of the Ridge Pike exit to just past the I-76 / Matsonford Road exit ramp. It does not include the exiting vehicles in the calculations, and is primarily measuring the effect that the lengthened and widened ramp will have on the southbound through traffic. Matsonford Road is widened in the westbound direction, between Fayette Street and the I-76 / I-476 ramps intersection in the No-Build Scenario. The same section of Matsonford Road is widened in the eastbound direction in the Build 2 Scenario, as the I-76 eastbound on / off ramps are relocated westward to intersect with Matsonford Road. The PA 23 travel times are primarily designed to show the effects of an additional westbound right-turn lane feeding the Fayette Street Bridge in the Build 2 Scenario. The I-76 eastbound travel time segment gauges the relocated on ramp with the additional volume in the Build 2 Scenario and how it affects the eastbound through traffic. The last travel time segment captures the Fayette Street Bridge in the eastbound direction to measure how improvements at or near the Matsonford Road / Fayette Street and PA 23 intersection influence eastbound Bridge traffic.

A *Travel Link Average* and *Network Average* are found at the bottom of each travel time delay and travel speed table. The travel link average represents an average of all the travel links for that particular AM or PM Comparison under the given Scenario. The Network Average is a figure that represents travel time delay or travel speeds for the entire highway modeled network. This data can be used to relate link average compared to the rest of the highway network.

2005 Base Year and 2030 No-Build Conditions

Performance Measures

The Base Year modeled highway network for the study area was calibrated to reflect 2005 conditions and the 2030 No-Build network reflects the Region's committed projects.

Table 7 and 8 show the eight travel time sections in terms of delay in seconds across the 2005 Base Year and 2030 No-Build Scenarios. As indicated by the results of the performance measures, most of the travel links show an increase in delay for both the AM and PM peak hour. However, Matsonford Road in the westbound direction shows an improvement in travel time in both peak periods. This is due to the HOP project that will widen Matsonford Road in the westbound direction by one lane between Front Street and the I-76 / I-476 ramps.

Table 7: AM Base Year and No-Build Travel Time Delay (in seconds)

AM Delay Comparison	2005	2030	Base Year to No-Build	
Travel Link	Base Year	No-Build	Difference	Percent
I-476 SB	54.7	99.9	45.2	82.6%
Matsonford Rd WB	36.5	30.6	-5.9	-16.3%
Matsonford Rd EB	65.6	79.8	14.2	21.6%
PA 23 WB to Fayette St	252.5	278.7	26.2	10.4%
PA 23 WB to Ford St	256	299.0	43.0	16.8%
PA 23 WB to Matsonford Rd	229.1	269.6	40.5	17.7%
I-76 EB	64.1	72.0	7.9	12.3%
Fayette St EB	23.9	28.7	4.8	20.0%
Travel Link Average	122.8	144.8	22.0	17.9%
Network Average	116.6	184.1	67.6	57.9%

Source: DVRPC 2008

Table 8: PM Base Year and No-Build Travel Time Delay (in seconds)

PM Delay Comparison	2005	2030	Base Year to No-Build	
Travel Link	Base Year	No-Build	Difference	Percent
I-476 SB	3.6	4.1	0.5	13.9%
Matsonford Rd WB	31.4	23.4	-8.0	-25.5%
Matsonford Rd EB	155.5	298.9	143.4	92.2%
PA 23 WB to Fayette St	301.6	345.2	43.6	14.5%
PA 23 WB to Ford St	327.1	340.6	13.5	4.1%
PA 23 WB to Matsonford Rd	304.1	318.9	14.8	4.9%
I-76 EB	83.2	93.2	10.0	12.0%
Fayette St EB	43.5	56.7	13.2	30.3%
Travel Link Average	156.3	185.1	28.9	18.5%
Network Average	133.3	218.6	85.4	64.1%

Source: DVRPC 2008

The I-476 southbound travel time delay increases 82.6% in the AM peak hour period. This link is currently congested, with backups from the I-76 / Matsonford Road exit ramp exceeding capacity, and spilling back into the mainline. Forecasted traffic volumes, shown in Table 1, indicate that daily traffic levels on southbound I-476 rise by 8% in the 2030 No-Build. The VISSIM simulation reveals that in the 2030 No-Build AM peak hour, the spillback effects of the added volume is so great that only one effective lane will remain for southbound I-476 traffic.

For both the AM and PM travel time delay network average, the measures show an increase in congestion between the Base Year and No-Build networks. The AM network average increases 57.9% while the PM network average increases 64.1%. The increase in population and employment between 2005 and 2030 translates into more trips and thus higher volumes on the highway network, both on local and interstate facilities. This, combined with very little added capacity, is the reason for the decrease in travel link speed and increases in delay in the No-Build vs. the Base Year network.

Tables 9 and 10 compare the AM and PM travel speeds in miles per hour for the eight travel links under the 2005 Base Year and the 2030 No-Build Scenarios. Similar to travel delay shown in Tables 7 and 8, most of the travel links show a decline in travel speeds between the 2005 Base Year and the 2030 No-Build.

Table 9: AM Base Year and No-Build Travel Link Speeds (in MPH)

AM Speed Comparison	2005	2030	Base Year to No-Build	
Travel Link	Base Year	No-Build	Difference	Percent
I-476 SB	36.6	30.6	-6.0	-16.3%
Matsonford Rd WB	20.6	22.1	1.5	7.2%
Matsonford Rd EB	14.4	13.2	-1.2	-8.3%
PA 23 WB to Fayette St	4.6	4.2	-0.4	-9.0%
PA 23 WB to Ford St	4.7	4.1	-0.6	-13.1%
PA 23 WB to Matsonford Rd	5	4.3	-0.7	-13.4%
I-76 EB	11	10.6	-0.4	-3.4%
Fayette St EB	21	19.5	-1.5	-7.3%
Travel Link Average	14.7	13.6	-1.2	-7.9%
Network Average	25.8	21.0	-4.9	-18.8%

Source: DVRPC 2008

Table 10: PM Base Year and No-Build Travel Link Speeds (in MPH)

PM Speed Comparison	2005	2030	Base Year to No-Build	
Travel Link	Base Year	No-Build	Difference	Percent
I-476 SB	54.1	53.8	-0.3	-0.6%
Matsonford Rd WB	22.1	24.4	2.3	10.4%
Matsonford Rd EB	8.7	5.2	-3.5	-40.2%
PA 23 WB to Fayette St	4	3.6	-0.4	-10.0%
PA 23 WB to Ford St	3.8	3.7	-0.1	-2.6%
PA 23 WB to Matsonford Rd	4	3.8	-0.2	-5.0%
I-76 EB	10.2	9.7	-0.5	-4.9%
Fayette St EB	15.7	13.4	-2.3	-14.6%
Travel Link Average	15.3	14.7	-0.6	-4.1%
Network Average	24.1	19.4	-4.8	-19.8%

Source: DVRPC 2008

The PA 23 travel links in the AM peak found in Table 9 reveal the slow progression of traffic through this portion of PA 23. Travel speeds are generally just over four miles per hour in the 2030 No-Build Scenario.

Table 11 and Table 12 illustrate the Level of Service analysis for the two study intersections. The Matsonford Road / Fayette Street and PA 23 intersection shows only a slight increase in delay comparing the Base Year to the No-Build for both the AM and PM peak hours. On the other hand, the Matsonford Road and I-76 / I-476 Ramps intersection shows a rather substantial increase in the PM peak hour. One approach leg of this intersection is widened under the HOP project on Matsonford Road. This HOP project assumes that westbound Matsonford Road is widened for an additional lane from PA 23 to the I-476 Ramps intersection. Despite this improvement, increased backups occur on the Matsonford Road eastbound approach. Average vehicle delay is also increased due to longer queues on the I-76 off ramp approach. This increased delay on eastbound Matsonford Road and on the I-76 off ramp approaches far outweigh the benefits to the westbound Matsonford Road approach delivered by the HOP project.

Table 11: AM Base Year and No-Build Intersection Level of Service

AM Peak Hour	2005 Base Year		2030 No-Build	
Intersection	**Delay (sec)**	**LOS**	**Delay (sec)**	**LOS**
Matsonford Rd & PA 23	66.8	E	74.6	E
Matsonford Rd & I-76 / I-476 Ramps	10.5	B	11.1	B

Source: DVRPC 2008

Table 12: PM Base Year and No-Build Intersection Level of Service

PM Peak Hour	2005 Base Year		2030 No-Build	
Intersection	**Delay (sec)**	**LOS**	**Delay (sec)**	**LOS**
Matsonford Rd & PA 23	70	E	79.3	E
Matsonford Rd & I-76 / I-476 Ramps	22	C	45.1	D

Source: DVRPC 2008

2030 Build 1 and Build 2 Scenarios

Build 1 Scenario

The Build 1 Scenario specifically analyzes the proposed improvement of extending and widening the I-476 southbound exit ramp to I-76 and Matsonford Road to provide increased deceleration length and adds a second exit lane for additional storage. Currently, the queue from the exiting vehicles exceeds the length of the ramp and spills into the through lanes, impeding the flow of the southbound vehicles.

Figure 3: I-476 Southbound Exit Ramp

Source: Berger 2008

Figure 3 shows the current alignment of southbound I-476's exit ramp to I-76 / Matsonford Road. The single lane exit ramp is roughly 1,100 feet in length and 12 feet in width. A second lane forms on the bridge over Matsonford Road.

In order to advance a feasible design of the expanded ramp, The Louis Berger Group coordinated with DMJM-Harris AECOM regarding the current I-476 Ramp RES reconstruction project. The operational improvements for the southbound exit ramp were determined using American Association of State Highway and Transportation Officials (AASHTO) guidelines for a parallel type exit terminal, as shown in Figure 4. The basic elements of the lengthened ramp would involve two 300 foot taper sections, sandwiched between a 1,500 foot long auxiliary lane. This allows traffic to exit in a safe an orderly manner, permitting enough distance for vehicles to diverge into the appropriate exit lane.

Figure 4: Exhibit 10-77 from *A Policy on Geometric Design of Highways and Streets*

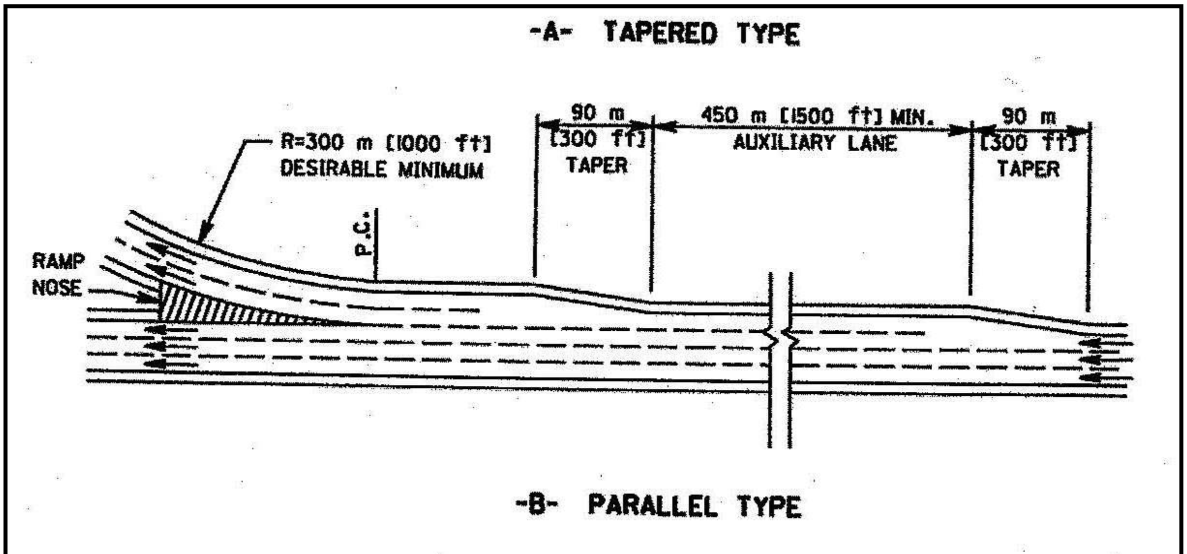


Exhibit 10-77. Two-Lane Exit Terminals

Source: American Association of State Highway and Transportation Officials 2004

Figure 5 shows the composite improvement for the entire length of the exit ramp. The exit lane begins just south of the Schuylkill River Bridge and widens to a two-lane exit ramp south of the Balligomingo Road Bridge. The new ramp begins with a 300 foot taper and is followed by a 1,500 foot long deceleration lane. The second exit lane begins with a 300 foot taper and extends approximately 1,060 feet where it meets the existing two-lane ramp on the bridge over Matsonford Road. The right shoulder is replaced throughout the length of the exit ramp. The entire ramp widening and lengthening improvement shown in Figure 5 is within the PennDOT right-of-way. The width of the Balligomingo Road Bridge is 51 feet 3 inches, and will not change for the ramp improvements.

Figure 5: I-476 Southbound Composite Improvement

Source: Berger 2008

Figure 6: Cantilever Sign

Source: Berger 2008

Two sign structures are proposed for this improvement. One cantilever sign structure is recommended at the beginning of the deceleration lane, similar to the one shown in Figure 6, and an overhead truss structure is recommended at the beginning of the two-lane exit ramp. The existing guide signs in advance of the improvement area should be examined to determine if they should be modified.

Table 13 is a cost construction estimate for the southbound exit ramp improvement. This estimate assumes the construction will occur as part of the ongoing I-476 reconstruction project.

Table 13: I-476 Southbound Improvement Construction Cost Estimate

Description	Cost
Class 1 Excavation	$40,000
Subbase, 9" Depth	$25,000
Plain Cement Concrete Pavement, 9" Depth	$345,000
Superpave Asphalt Mixture Design, HMA Wearing Course, 4" Depth	$32,000
Single Face Concrete Barrier, 42" Height	$75,000
Structure Mounted Flat Sheet Aluminum Signs	$30,000
Cantilever Sign Structure	$56,000
Truss Sign Structure	$140,000
Subtotal	**$743,000**
Contingency (20%)	$148,600
Total	**$891,600**

Source: Berger 2008

Performance Measures

The performance measures, comparing the No-Build with the Build 1 Scenarios, generally show an improvement for both the AM and PM peak hours. According to Table 1, the interchange total average daily traffic increases about by 1,600 vehicles, or a negligible 0.37%. Other than the southbound I-476 exit ramp improvement, the Build 1 VISSIM modeled network is virtually identical to the No-Build Network. The overall network performance in terms of delay and travel speed improves in the Build 1 Scenario vs. the No-Build.

Tables 14 and 15 highlight average delay along the study travel link sections for the No-Build and Build 1 Scenarios. The most notable change is the over 16% reduction in delay for the I-476 southbound travel link during the AM peak hour, while the southbound ramp carries an additional 2,600 vehicles per day. This reduction reflects the nature of the ramp improvement, where operationally, two lanes are restored for the southbound through movement.

Table 14: AM No-Build and Build 1 Travel Time Delay (in seconds)

AM Delay Comparison	2030	2030	No-Build to Build 1	
Travel Link	**No-Build**	**Build 1**	**Difference**	**Percent**
I-476 SB	99.9	83.6	-16.2	-16.2%
Matsonford Rd WB	30.6	34.9	4.3	14.1%
Matsonford Rd EB	79.8	68.5	-11.3	-14.2%
PA 23 WB to Fayette St	278.7	259.3	-19.4	-7.0%
PA 23 WB to Ford St	299.0	308.8	9.7	3.3%
PA 23 WB to Matsonford Rd	269.6	290.2	20.5	7.6%
I-76 EB	72.0	73.3	1.4	1.9%
Fayette St EB	28.7	27.6	-1.1	-3.7%
Travel Link Average	144.8	143.3	-1.5	-1.0%
Network Average	184.1	173.6	-10.6	-5.7%

Source: DVRPC 2008

Table 15: PM No-Build and Build 1 Travel Time Delay (in seconds)

PM Delay Comparison	2030	2030	No-Build to Build 1	
Travel Link	**No-Build**	**Build 1**	**Difference**	**Percent**
I-476 SB	4.1	4.2	0.1	2.9%
Matsonford Rd WB	23.4	27.2	3.8	16.1%
Matsonford Rd EB	298.9	248.9	-50.1	-16.7%
PA 23 WB to Fayette St	345.2	370.7	25.5	7.4%
PA 23 WB to Ford St	340.6	367.9	27.3	8.0%
PA 23 WB to Matsonford Rd	318.9	361.9	43.0	13.5%
I-76 EB	93.2	90.3	-3.0	-3.2%
Fayette St EB	59.2	99.4	40.2	67.9%
Travel Link Average	185.1	196.3	11.2	6.0%
Network Average	218.6	178.9	-39.7	-18.2%

Source: DVRPC 2008

In the PM peak hour, the largest increase in travel time delay is on the Fayette Street Bridge in the eastbound direction. The additional volume due to the PA 23 Relocation project results in an increase in vehicles turning from westbound PA 23 onto Fayette Street Bridge in the PM peak hour. This results in extensive queues across the Bridge and longer backups at the Fayette Street and Elm Street intersection, impeding the vehicles on the travel link.

Table 16: AM No-Build and Build 1 Travel Link Speeds (in MPH)

AM Speed Comparison	2030	2030	No-Build to Build 1	
Travel Link	No-Build	Build 1	Difference	Percent
I-476 SB	30.6	33.3	2.6	8.6%
Matsonford Rd WB	22.1	21.1	-1.0	-4.7%
Matsonford Rd EB	13.2	13.3	0.1	0.9%
PA 23 WB to Fayette St	4.2	4.7	0.5	11.4%
PA 23 WB to Ford St	4.1	4.1	0.0	1.0%
PA 23 WB to Matsonford Rd	4.3	4.2	-0.1	-2.4%
I-76 EB	10.6	10.6	-0.1	-0.5%
Fayette St EB	19.5	19.6	0.2	0.8%
Travel Link Average	13.6	13.9	0.3	2.1%
Network Average	21.0	21.7	0.7	3.4%

Source: DVRPC 2008

Table 16 and Table 17 show the AM and PM travel link speeds for the No-Build and Build 1 Scenarios. Travel speeds on the southbound I-476 link in the AM peak increased by 8.6%. In the AM peak hour, the widened and lengthened ramp will shorten delays and improve operating speeds while accommodating 8% more traffic. The network average, in terms of link speed and travel time delay, outperforms the travel link in the Build 1 Scenario.

Table 17: PM No-Build and Build 1 Travel Link Speeds (in MPH)

PM Speed Comparison	2030	2030	No-Build to Build 1	
Travel Link	No-Build	Build 1	Difference	Percent
I-476 SB	53.8	53.8	0.0	0.0%
Matsonford Rd WB	24.4	23.1	-1.3	-5.4%
Matsonford Rd EB	5.2	6.1	.09	17.8%
PA 23 WB to Fayette St	3.6	3.4	-0.2	-6.4%
PA 23 WB to Ford St	3.7	3.5	-0.2	-6.3%
PA 23 WB to Matsonford Rd	3.8	3.4	-0.4	-9.9%
I-76 EB	9.7	9.8	0.1	0.5%
Fayette St EB	13.4	9.1	-4.3	-32.2%
Travel Link Average	14.7	14.0	-0.7	-4.7%
Network Average	19.4	21.4	2.1	10.8%

Source: DVRPC 2008

The level of service comparison, shown in Table 18 and Table 19, reveals little change between the No-Build and Build 1 Scenarios.

Table 18: AM No-Build and Build 1 Intersection Level of Service

AM Comparison	2030 No-Build		2030 Build 1	
Intersection	Delay (sec)	LOS	Delay (sec)	LOS
Matsonford Rd & PA 23	74.6	E	77.6	E
Matsonford Rd & I-76 / I-476 Ramps	11.1	B	11.9	B

Source: DVRPC 2008

Table 19: PM No-Build and Build 1 Intersection Level of Service

PM Comparison	2030 No-Build		2030 Build 1	
Intersection	Delay (sec)	LOS	Delay (sec)	LOS
Matsonford Rd & PA 23	79.3	E	81.8	F
Matsonford Rd & I-76 / I-476 Ramps	45.1	D	35.2	D

Source: DVRPC 2008

Build 1 A Scenario

At the December 16, 2008 Pennsylvania Department of Transportation (PennDOT) District 6-0 Executive Design Review Committee Meeting, Montgomery County requested the project study team operationally test a slight variation of the I-476 southbound improvement examined in the Build 1 Scenario. This Build 1A Scenario is identical to the Build 1 Scenario with just a slight modification to the exit ramp.

Currently, and in all future Scenarios, the southbound exit splits at the Matsonford Road Bridge into two separate ramps: I-76 eastbound and I-76 westbound / Matsonford Road. This iteration would contain the lengthened and widened improvement as the Build 1 Scenario, but extend a two-lane cross-section to the I-76 eastbound entrance ramp to just prior to the I-76 underpass. This would double the capacity and storage of the eastbound entrance ramp for approximately 890 feet. The extra storage for eastbound I-76 traffic would reduce delays for vehicles heading toward I-76 westbound or Matsonford Road, and reduce queues to I-476 southbound.

Holding all other parameters constant between the Build 1 and Build 1A except for the ramp widening adjustment, the AM travel time delay and travel link speed performance measures were again obtained. A comparison of the Build 1 and Build 1A Scenarios performance measures are shown in Tables 20 and 21. The alteration to the exit ramp has a significant impact through the exit ramp area. By further reducing queues on the I-476 southbound exit ramp, mainline through travel would be improved.

Table 20: AM Build 1 and Build 1A Travel Time Delay

AM Delay Comparison	2030	2030	No-Build to Build 1	
Travel Link	Build 1	Build 1A	Difference	Percent
I-476 SB	83.6	51.9	-31.7	-37.9%

Source: DVRPC 2009

Table 21: AM Build 1 and Build 1A Travel Link Speeds

AM Speed Comparison	2030	2030	No-Build to Build 1	
Travel Link	Build 1	Build 1A	Difference	Percent
I-476 SB	33.3	37.6	4.3	13.1%

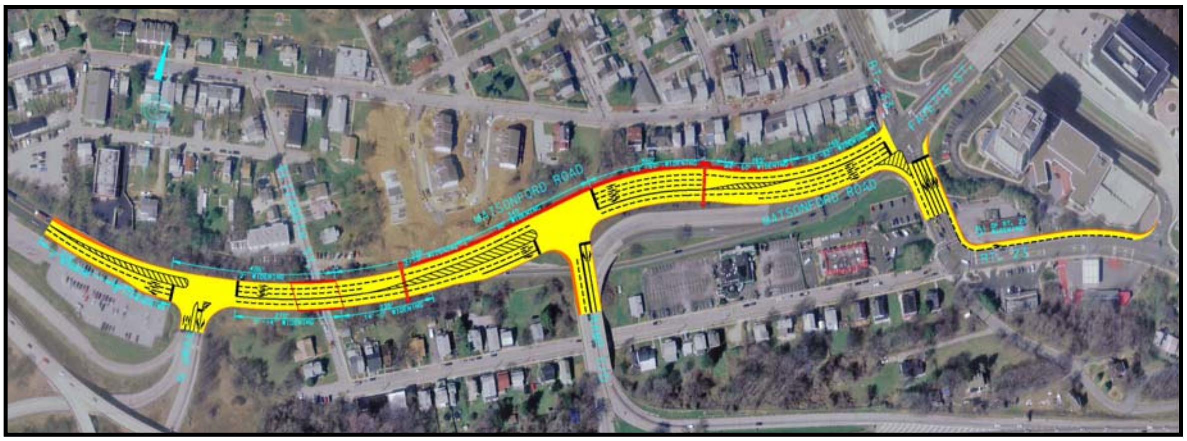
Source: DVRPC 2009

Tables 20 and 21 enumerate the expected changes in delays and speeds. The through traffic on I-476 southbound experience nearly a 38% decrease in delay and over a 13% increase in travel speeds. The additional ramp capacity introduced in the Build 1A improvement further aids the flow of southbound traffic by shifting queues off the mainline onto the exit ramp. No construction cost estimates for this improvement are provided.

Build 2 Scenario

The Build 2 Scenario consists of the Build 1 Scenario plus two major projects: the realignment / relocation of the I-76 eastbound on / off ramps from the Matsonford Road / Fayette Street and PA 23 intersection and an additional right-turn lane on PA 23 westbound from Barr Harbor Drive to Fayette Street. The new alignment for Matsonford Road widens the cartway to a four lane cross-section, adds turn lanes at the I-476 / I-76 intersection, and incorporates a signalized intersection where the realigned I-76 ramps intersect Matsonford Road east of Elizabeth Street. The additional lane on PA 23 serves as a second right-turn lane approaching the Fayette Street intersection to allow for two lanes of traffic to turn onto the Bridge.

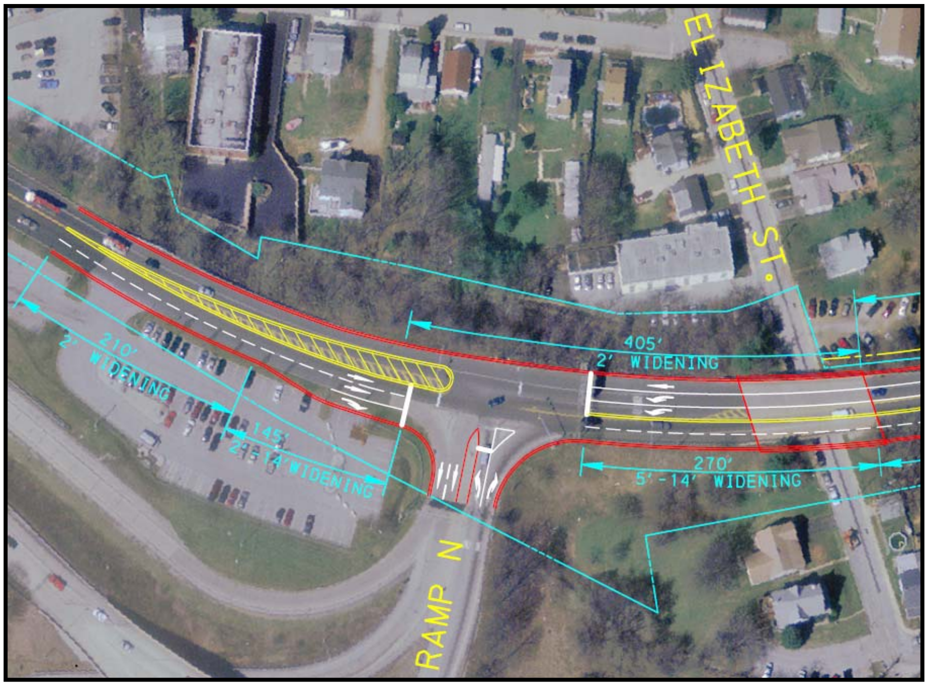
Figure 7: Matsonford Road and PA 23 Composite Improvement



Source: Berger 2008

The area in yellow, highlighted in Figure 7, shows the improvement composite plan of the Build 2 Scenario. The widening of Matsonford Road begins just west of the I-76 / I-476 ramps intersection, near the entrance of the Park & Ride Lot, and extends eastward to PA 23. The additional right-turn lane is shown from Barr Harbor Drive, through the Moorehead Avenue intersection, to the base of the Fayette Street Bridge.

Figure 8: Matsonford Road and I-476 / I-76 Ramps

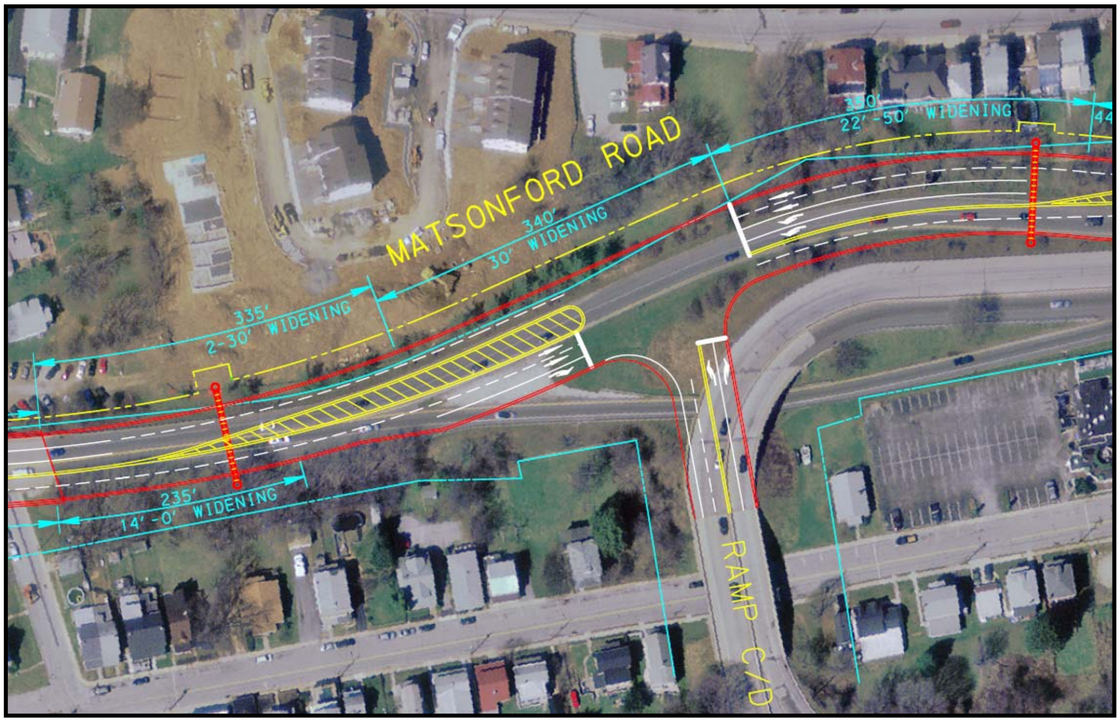


Source: Berger 2008

Figure 8 shows the proposed alignment of the Matsonford Road & I -476 / I-76 ramps intersection. Eastbound Matsonford Road opens to a three lane cross-section, with two through and one right-turn lane. The westbound approach has a dual left-turn lane and one through lane, as the bridge over Elizabeth Street is widened to five lanes. The exit / entrance ramp leg of the intersection remains relatively unchanged. The conceptual plan shows a short right-turn lane on Mansonford Road. It was suggested by the Steering Committee to examine the feasibility of lengthening this right-turn lane, and incorporating a right-turn overlap phase to the signal.

Figure 9 shows the configuration of the realigned / relocated I-76 eastbound on / off ramps into Matsonford Road at a new T-intersection. The off ramp will have a right-turn and a left-turn lane. The westbound approach will have dual left-turn lanes and two through lanes. On the eastbound approach, a right-turn only lane and two through lanes will be provided. With the relocated ramp pulled out of the Matsonford Road and PA 23 intersection, vehicles will have the ability to access westbound Matsonford Road directly from the I-76 westbound off ramp. It also eliminates the eastbound weaving movement approaching PA 23, where vehicles from Matsonford Road and the I-76 westbound off ramp merge together just before the traffic signal.

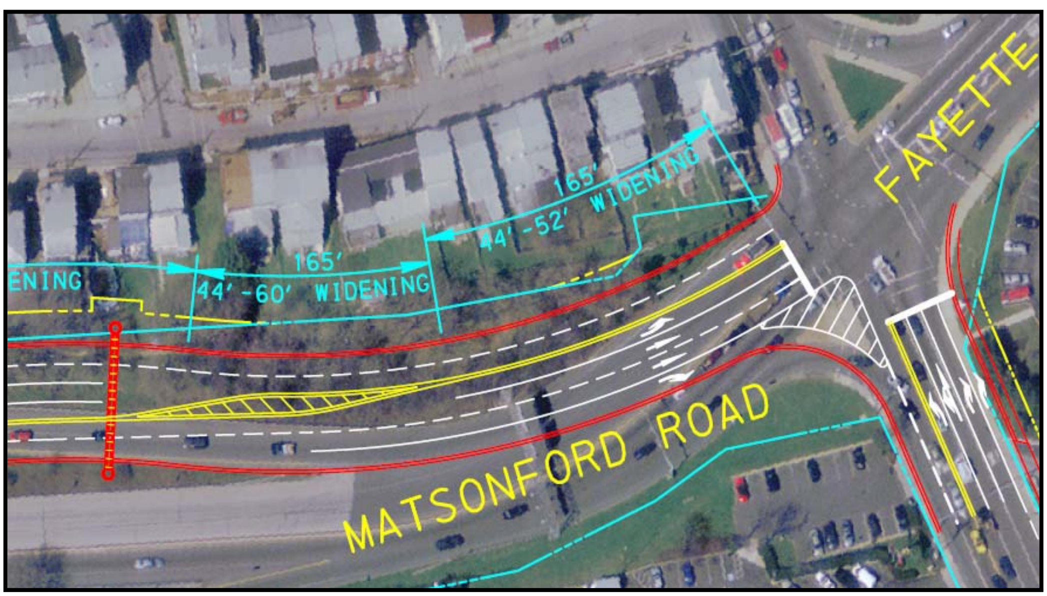
Figure 9: Matsonford Road and the Realigned I-76 Ramps



Source: Berger 2008

Figure 9 also shows the placement of two sign structures, both located on Matsonford Road, indicated by the red bars that bisect the entire cross-section of the roadway.

Figure 10: Matsonford Road West of PA 23



Source: Berger 2008

Figure 10 shows the realigned approach and lane configuration of Matsonford Road, just west of the Fayette Street Bridge. The configuration remains relatively the same as it presently exists, with one left-turn lane, two through lanes, and a right-turn lane. However, the eastbound right-turn lane is lengthened to allow for additional storage. Approximately 0.49 acres of acquisition are anticipated with this alignment. This assumes a 15 foot buffer between the retaining wall and the proposed right-of-way line. It is important to note that the alignment is representational, and the exact right-of-way could be adjusted to minimize the impact on adjacent property.

Table 22 contains the construction cost estimate for the improvements to Matsonford Road and the realigned I-76 eastbound on / off ramps. The most significant portion of the total cost is the bridge replacement over Elizabeth Street. However, it was suggested by the Steering Committee that the cost, depending on the condition of this bridge or the condition of the I-76 exit ramp structure over Matsonford Road, may warrant funding from other sources. The cost estimate does not include possible right-of-way acquisition, utility relocation, or a potential noise wall that may be required along Matsonford Road.

Table 22: Matsonford Road Improvement Construction Cost Estimate

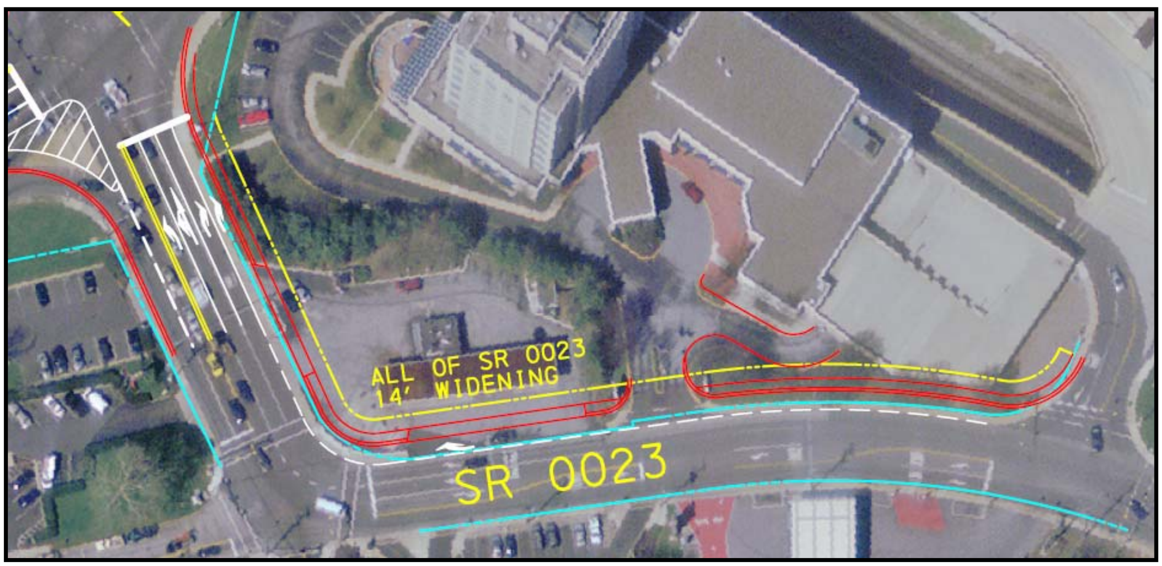
Description	Cost
Class 1 Excavation - Roadway	$195,000
Borrow / Embankment	$35,000
Subbase, 8" Depth (No. 2A)	$135,000
Bituminous Binder Course, ID-2, 2" Depth	$165,000
Bituminous Wearing Course ID-2, 1.5" Depth	$110,000
Single Face Concrete Barrier, 42" Height	$10,000
8 Structure Mounted Flat Sheet Aluminum Signs @ 240 SF Per Sign	$70,000
Bridge Structure	$2,400,000
Retaining Wall	$865,000
Plain Cement Concrete Curb	$150,000
Truss Sign Structure	$285,000
Signalized Intersection	$120,000
2 Existing Signalized Intersection Modifications	$160,000
Subtotal	**$4,700,000**
Contingency (20%)	$940,000
Total	**$5,640,000**

Source: Berger 2008

The second element of the Build 2 Scenario is widening the westbound PA 23 approach leg to allow for a second right-turn lane. The widening for this additional lane extends from Barr Harbor Road to Fayette Street, as shown in Figure 11. The lane, which would function as a second right-turn lane onto the Fayette Street Bridge, would also supply additional storage through the improvement area.

In order to ensure the radii needed to accommodate large vehicles, it was recommended that truck turning templates be provided for the triple right-turn movement at PA 23 and Moorehead Avenue and the dual right-turn from PA 23 on to the Fayette Street Bridge. Advanced overhead signage would also be needed on westbound PA 23 in the improvement area to inform motorists of lane designations. This would allow motorists enough time to progress into the appropriate lane for the desired destination.

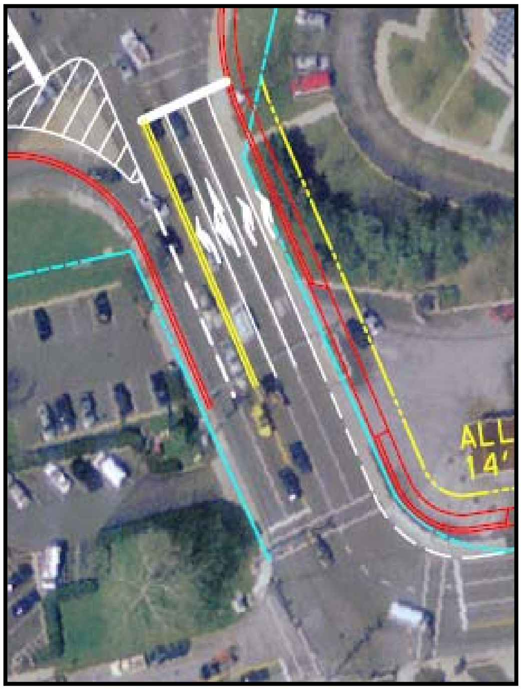
Figure 11: PA 23 Improvements at Barr Harbor Drive



Source: Berger 2008

Figure 12 highlights the additional right-turn lane between Moorehead Avenue and Fayette Street. Current traffic counts at the Matsonford Road and PA 23 intersection indicate that approximately 38% of approaching westbound PA 23 vehicles in the AM and 47% of vehicles in the PM make a right-turn at this location. 2030 projected turning volumes also indicate a high percentage of right-turning vehicles for each future Scenario. The current configuration of just one right-turn lane creates long back ups on PA 23 that extend past the Four Falls / Spruce Street intersection. As demonstrated by the performance measures, the second turn lane in this area yields a significant benefit in travel time savings. This improvement would likely require the acquisition of the service station at the northeast corner of PA 23 and Moorehead Avenue.

Figure 12: PA 23 Improvements at Fayette Street



Source: Berger 2008

Table 23 provides a construction cost estimate for the additional lane on PA 23 from Barr Harbor Drive to Matsonford Road / Fayette Street. Assuming a 15 foot buffer between the proposed curb and the right-of-way line, 0.36 acres would be required for this improvement. This estimate does not include the cost of right-of-way acquisition, utility relocation, or any modification to the existing traffic signals. The cost estimate also does not include the right-of-way acquisition for the service station, which would most likely require a taking.

Table 23: PA 23 Improvement Construction Cost Estimate

Description	Cost
Class 1 Excavation - Roadway	$15,000
Borrow / Embankment	$5,000
Subbase, 8" Depth (No. 2A)	$10,000
Bituminous Binder Course, ID-2, 2" Depth	$15,000
Bituminous Wearing Course, ID-2, 1.5" Depth	$10,000
Plain Cement Concrete Curb	$20,000
Concrete Sidewalk	$25,000
Retaining Wall	$50,000
1 Existing Signalized Intersection Modification	$80,000
Subtotal	**$230,000**
Contingency (20%)	$46,000
Total	**$276,000**

Source: Berger 2008

Performance Measures

The link based performance data, shown in Tables 24 and 25, paints a much more focused picture compared to the network average performance measure. The I-476 southbound travel link in the AM peak hour shows little change. However, the same link in the PM peak hour notes a significant increase in delay. The most likely source of this increase stems from the relocated I-76 eastbound on ramp on Matsonford Road. Vehicles would enter the ramp from eastbound Matsonford Road via dual left-turn lanes regulated by the signalized intersection, at a 10 to 20 vehicle per signal cycle interval. This platoon effect negatively impacts the eastbound vehicles on I-76, resulting in lane changes and merging delays experienced on the mainline, significantly impeding the through traffic. This friction at the merge area reverberates upstream on mainline I-76, allowing fewer vehicles to merge from the southbound I-476 ramp, and thus creating more backup on mainline I-476. Although travel delay on southbound I-476 in the PM peak hour shows a significant increase, the travel speeds decrease only 16.3% for the same link. This observation is revealed in the I-76 Eastbound travel link. In the PM peak hour, this link sees nearly a 19% increase in delay and a 5.7% decrease in travel speeds. It was suggested by FHWA, because of platooning of vehicles on the realigned I-76 eastbound on ramp, that this location would be a good candidate for ramp metering. Ramp metering is the use of traffic signals at the entrance to or on freeway on ramps to control the rate of vehicles entering the main facility, ensuring less disruption to mainline flow and a faster and safer merge.

Table 24: AM Build 1 and Build 2 Travel Time Delay (in seconds)

AM Delay Comparison	2030	2030	Build 1 to Build 2	
Travel Link	**Build 1**	**Build 2**	**Difference**	**Percent**
I-476 SB	83.6	81.4	-2.2	-2.7%
Matsonford Rd WB	34.9	42.5	7.7	22.0%
Matsonford Rd EB	68.5	76.5	8.0	11.7%
PA 23 WB to Fayette St	259.3	111.3	-147.9	-57.1%
PA 23 WB to Ford St	308.8	217.5	-91.2	-29.5%
PA 23 WB to Matsonford Rd	290.2	208.6	-81.5	-28.1%
I-76 EB	73.3	78.7	5.4	7.3%
Fayette St EB	27.6	30.1	2.5	9.0%
Travel Link Average	143.3	105.8	-37.4	-26.1%
Network Average	173.6	164.1	-9.4	-5.4%

Source: DVRPC 2008

Table 25: PM Build 1 and Build 2 Travel Time Delay (in seconds)

PM Delay Comparison	2030	2030	Build 1 to Build 2	
Travel Link	Build 1	Build 2	Difference	Percent
I-476 SB	4.2	29.2	25.0	592.7%
Matsonford Rd WB	27.2	36.6	9.4	34.7%
Matsonford Rd EB	248.9	110.7	-138.2	-55.5%
PA 23 WB to Fayette St	370.7	210.5	-160.2	-43.2%
PA 23 WB to Ford St	367.9	274.4	-93.5	-25.4%
PA 23 WB to Matsonford Rd	361.9	258.8	-103.2	-28.5%
I-76 EB	90.3	107.3	17.0	18.9%
Fayette St EB	99.4	57.0	-42.3	-42.6%
Travel Link Average	196.3	135.6	-60.7	-30.9%
Network Average	179.0	189.7	10.7	6.0%

Source: DVRPC 2008

The benefits of implementing a second right-turn lane on PA 23 are demonstrated in terms of reduced travel time delay and increased travel speed. The travel link, PA 23 WB to Fayette St, captures the effects of this improvement. This link, in terms of travel time delay, showed a reduction of 57% and 43% in the AM and PM peak hour, respectively. Travel speeds increased 92% in the AM and 61% in the PM peak hour, as referenced in Tables 26 and 27. The additional lane also has a positive impact for the other movements at the intersection, as demonstrated by the PA 23 to Ford St and PA 23 to Matsonford WB link travel delay and speed comparisons.

The Matsonford EB and Matsonford WB travel links were set up to measure the effects of the widening and associated improvements to Matsonford Road in the No-Build and Build 2 Scenarios. Although the new intersection at Matsonford Road and I-76 eastbound ramps adds some delay and lowers travel speeds, performance is not severely impeded with the new signal. For Matsonford WB, travel time delay and speeds are negatively affected in both the AM and PM peak hour. This is to be expected, as the travel link in the Build 2 Scenario must traverse two signalized intersections, as there was just one in the Build 1 Scenario. In the Matsonford EB travel link, the performance benefit of the improved Matsonford Road and PA 23 intersection outweigh the incurred delay at the Matsonford Road and I-76 eastbound ramps intersection. In the PM peak period, this link sees a 78.4% increase in travel speed.

Table 26: AM Build 1 and Build 2 Travel Link Speeds (in MPH)

AM Speed Comparison	2030	2030	Build 1 to Build 2	
Travel Link	**Build 1**	**Build 2**	**Difference**	**Percent**
I-476 SB	33.3	33.2	0.0	-0.1%
Matsonford Rd WB	21.1	19.4	-1.7	-7.9%
Matsonford Rd EB	13.3	14.0	.07	5.5%
PA 23 WB to Fayette St	4.7	9.0	4.3	92.2%
PA 23 WB to Ford St	4.1	5.4	1.3	31.1%
PA 23 WB to Matsonford Rd	4.2	5.5	1.3	30.4%
I-76 EB	10.6	10.3	-0.2	-2.4%
Fayette St EB	19.6	19.1	-0.6	-2.8%
Travel Link Average	13.9	14.5	0.6	4.6%
Network Average	21.7	22.4	0.7	3.3%

Source: DVRPC 2008

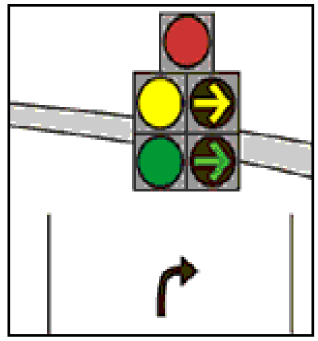
Table 27: PM Build 1 and Build 2 Travel Link Speeds (in MPH)

PM Speed Comparison	2030	2030	Build 1 to Build 2	
Travel Link	**Build 1**	**Build 2**	**Difference**	**Percent**
I-476 SB	53.8	45.1	-8.8	-16.3%
Matsonford Rd WB	23.1	20.7	-2.4	-10.3%
Matsonford Rd EB	6.1	10.9	4.8	78.4%
PA 23 WB to Fayette St	3.4	5.4	2.0	60.6%
PA 23 WB to Ford St	3.5	4.4	0.9	26.6%
PA 23 WB to Matsonford Rd	3.4	4.6	1.1	33.5%
I-76 EB	9.8	9.2	-0.6	-5.7%
Fayette St EB	9.1	13.3	4.3	46.9%
Travel Link Average	14.0	14.2	0.2	1.3%
Network Average	21.4	20.3	-1.1	-5.2%

Source: DVRPC 2008

The two major improvements in the Build 2 Scenario came together to create a distinctive situation on the Fayette Street Bridge in the eastbound direction. The widening of eastbound Matsonford Road, combined with the second right-turn lane on PA 23, allows for greater through-put of traffic, thus expediting the flow of traffic onto the bridge. The VISSIM simulation in the Build 2 Scenario revealed dramatic and unacceptable back-ups occurring, beginning at the Elm Street intersection and extending the entire length of the Fayette Street Bridge. In order for the Bridge to handle the additional volumes, slight adjustments were made to the signal timing at the Fayette Street and Elm Street signal. Additionally, a right-turn overlap signal was installed at the intersection to allow for eastbound Bridge traffic to make a right-turn onto Elm Street when northbound Elm Street receives a green ball.

Figure 13: Five-Section Signal Head



Source: FHWA 2008

According to PennDOT's *Engineering and Construction Management Systems* website, a five-section signal head, shown in Figure 13, was recently bid between $1,000 and $1,750. This does not include the cost of installation.

The effects of the right-turn overlap signal can be identified in Table 25 and Table 27. Although the benefits of the signal improvement is offset by the increased volume in the AM peak hour, the PM peak hour sees a substantial benefit in terms of travel speeds and delay.

The improvements to Matsonford Road and PA 23 are reflected in the level of service analysis for the Build 2 Scenario. In the AM peak hour the Matsonford Road & PA 23 intersection shows a seven second per vehicle improvement over the Build 1 Scenario. Although the Matsonford Road and I-76 / I-476 ramps intersection shows a slight increase in average vehicle delay, it remains level of service B. During the PM peak, traffic operations are improved to level of service E conditions versus Build 1 Scenario at the PA 23 intersection, and to level of service B at the I-76 / I-476 Ramps intersection.

Table 28: AM Build 1 and Build 2 Intersection Level of Service

AM Comparison	2030 Build 1		2030 Build 2	
Intersection	**Delay (sec)**	**LOS**	**Delay (sec)**	**LOS**
Matsonford Rd & PA 23	77.6	E	70.5	E
Matsonford Rd & I-76 / I-476 Ramps	12.0	B	19.2	B
Matsonford Rd & I-76 EB Ramps	*	*	21.6	C

Source: DVRPC 2008

Table 29: PM Build 1 and Build 2 Intersection Level of Service

PM Comparison	2030 Build 1		2030 Build 2	
Intersection	Delay (sec)	LOS	Delay (sec)	LOS
Matsonford Rd & PA 23	81.8	F	79.4	E
Matsonford Rd & I-76 / I-476 Ramps	35.2	D	12.0	B
Matsonford Rd & I-76 EB Ramps	*	*	20.7	C

Source: DVRPC 2008

Once the traffic signals along the PA 23 corridor were optimized for the 2030 No-Build Scenario, these timings were used for all of the 2030 Scenarios. This was done to preserve the integrity of the networks, and to allow for an apples-to-apples comparison across the different Scenarios. However, if and when either Build 2 improvement, the widening of Matsonford Road or the additional right turn lane on PA 23, were to be constructed, new signal timings and coordination would most likely be necessary to further enhance the benefits of the improvement.

Project Follow-up

The project team of Louis Berger Group, Inc. (Berger) and DVRPC were invited to present the findings of this project to the Pennsylvania Department of Transportation (PennDOT) District 6-0 Executive Design Review Committee, held on December 16, 2008. The purpose of the meeting was to reach an agreement on the final alignment of the proposed improvement to the I-476 exit ramp, and if / or when it could be incorporated into the current I-476 construction project. DVRPC provided a quick background as to the events that preceded this meeting and gave an overview of the highway operations and performance measures for the Build 1 Scenario. Berger gave a PowerPoint presentation detailing Berger's effort to determine the physical improvements necessary to increase the length of the I-476 SB exit ramp approaching the I-76 interchange. The following are highlights:

- Berger coordinated with AECOM regarding the current I-476 reconstruction design efforts in this area. Through this initial coordination, Berger was aware that the Schuylkill River and Balligomingo Road bridges would not be widened during reconstruction efforts.
- Operational improvements for this exit ramp were determined using AASHTO guidelines for a parallel type two-lane exit terminal (Exhibit 10-77 from the Green Book).
- Using the AASHTO guidelines, Berger determined that a two-lane exit ramp could be designed. The exit lane begins south of the Schuylkill River Bridge with a 300 foot taper and is followed by a 1,500 feet long deceleration lane that extends through the Balligomingo Road Bridge. South of the Balligomingo Bridge, the second exit lane begins with a 300 foot taper and extends approximately 1,060 feet where it meets the existing two-lane ramp on the bridge over Matsonford Road.
- At a November 24, 2008 meeting with AECOM and PennDOT, a sight distance issue was discussed because of the inside parapet height on the Balligomingo Road Bridge. I-476 currently has a 60 mph design speed, but the stopping sight distance on the bridge restricts the design speed to 50 mph.
- The existing Balligomingo Road Bridge width, combined with four proposed travel lanes, necessitates a design exception. The current available width between parapets was measured as 51 feet 3 inches, which will not allow for minimum required shoulder widths. A proposed

design requires 3 foot 3 inch inside shoulder and four 12 foot lanes. Berger determined that this 3 foot 3 inch inside shoulder only accommodates a 45 mph design speed because of the aforementioned stopping sight distance issue.

- FHWA expressed concern about a bridge shoulder width that is between 4 feet and 8 feet wide since it could potentially give motorists the wrong impression that they can pull over into this tight shoulder safely and open a car door without being struck by a passing vehicle.

- Berger checked the sign area for the proposed overhead truss south of the Balligomingo Road Bridge and it is less than the 650 square foot ultimate sign area calculated by AECOM. Berger calculated a total sign area of 402 square feet.

- Berger revised their construction cost estimate from the November 24, 2008 meeting since the truss structure is already accounted for in the Ramp RES project. The additional construction cost for this effort was reduced from approximately $845,000 to approximately $435,000.

- PennDOT District 6-0 stated that the guide signs in advance of the interchange would have to be investigated to determine if adjustments would be necessary.

After the presentation, an open discussion yielded the following:

- PennDOT District 6-0 stated that sight distance should not be an issue at the Balligomingo Road Bridge because the parapet height will not exceed a 42 inch height.

- PennDOT Capital Projects said this project should be a stand alone project. Capital Projects also proposed an idea to move the I-476 SB to I-76 WB movement from the existing exit ramp and construct a new exit ramp south of the existing gore but prior to the crossing of I-76.

- PennDOT Construction suggested that this improvement not be a part of the Ramp RES project. It should be part of the RDC contract if this concept moves forward.

- PennDOT Construction also said that time is of the essence because the overhead truss for the Ramp RES contract will be erected soon. Phase 1 is from March 2009 through December 2009. The old truss structure will be removed and the proposed truss structure will be erected. ITS equipment will be installed in the vicinity as well as on this structure. The PennDOT Construction group has told the contractor that ITS equipment such as television poles, cabinetry, tag readers, conduits, and junction boxes must be in place prior to Stage 1. Therefore, if this concept moves forward and there is a delay, the contractor will likely submit a delay claim. The need for a bigger sign structure or additional ITS will likely result in a time extension request.

- Montgomery County suggested the possibility of having the existing two-lane section of the ramp extend a few hundred feet onto the single ramp bound for I-76 EB before tapering back to a single lane. This might reduce concerns of "line jumpers" on I-476 SB and shift this concern to the ramp, where lower speeds are expected. This Scenario was evaluated in the Build 1A section of this Report.

- PennDOT Traffic Freeway Management raised concern about the cross-slope of the Balligomingo Road Bridge for an option requiring four travel lanes. The existing outside shoulder is 10 feet wide and sloped away from the roadway. The cross-slopes and superelevation should be investigated further.

- PennDOT Traffic Freeway Management stated that the shoulder widths must account for scuppers.

- All in attendance agreed that the concept should be pursued. The remaining question was whether to have this project as a stand-alone project, included as part of the Ramp RES project, or included as part of the RDC project. This issue was to be decided by PennDOT within a short time horizon.

At the end of the open discussion, the following next steps were requested:

- AECOM will perform an engineering investigation into the conceptual plan presented by Berger and the DVRPC. This includes providing four 12 foot wide lanes on the Balligomingo Road Bridge. Their investigation will include the following:

    - Cross-slopes and/or superelevation on the Balligomingo Road Bridge

    - Final shoulder width layout on the Balligomingo Road Bridge, taking scuppers into account.

    - Two-lane exit ramp extension onto the existing single lane ramp from I-476 SB to I-76 EB. DVRPC modeled this iteration in VISSIM and the findings can be found in this Report.

    - Design exception request for shoulder widths and possibly for cross-slope and/or superelevation.

As of March 2009, the I-476 southbound ramp lengthening and widening project of Scenario 1 is moving forward. AECOM is proceeding with the plans, specifications, and cost estimates. The project is scheduled to go out for bid by Summer 2009. The are no plans to implement the project improvements associated with the Build 1A and Build 2 Scenarios, but both remain viable options for future consideration.

- The final design included 12 foot lanes over the Balligomingo Bridge with a 3 foot 3 inch left side shoulder.

- There are two design exceptions in the design of the project: sight distance and the width of the Balligomingo Bridge. AECOM is incorporating landscape improvements to help with the sight distance issue.

Appendix A

Crash Data Summary

Crash Data Analysis

The Steering Committee requested an investigation as to the safety within the vicinity of the I-476 southbound exit ramp. Crash data was collected on the southbound portion of I-476 from the Schuylkill River Bridge to the I-76 and Matsonford Road exit ramp, a length of approximately 3,130 feet. This area covers the portion of the interstate where queuing during a typical AM peak hour usually occurs.

According to Pennsylvania Department of Transportation's Publication 212, crash rates, defined as the number of all reportable crashes per million vehicle miles traveled along a specific segment of roadway, is calculated using the following formula:

$$R = \frac{(C*1,000,000)}{(T*V*L)}$$

Where:
R = crash rate per million vehicle miles traveled
C = number of crashes at the study location within a given time period
T = time period in days when crashes are occurring
V = average daily traffic
L = length of road segment in miles

Over the five year period between 2003 and 2007, there were a total of 20 reported crashes in the data collection area. Using the formula, this equates to a crash rate of .2781. No fatal crashes were recorded between 2003 and 2007 in the limits of the crash analysis area.

Table A1 is a summary of crashes on Interstate highways in the state of Pennsylvania between 2003 and 2007. According to the *Pennsylvania Crash Facts and Statistics* booklet published by PennDOT's Bureau of Highway Safety and Traffic Engineering, crash rates for the interstate highways varied between .42 and .50 from 2003 to 2007.

Table A1: Pennsylvania Interstate Crash Totals

	2003	2004	2005	2006	2007
Total Number of Crashes	8,895	8,767	9,314	8,232	8,655
Miles of Maintained Road	1,285	1,285	1,285	1,286	1,285
Crashes / MVM*	0.50	0.47	0.49	0.42	0.44

* Denotes Million Vehicle Miles Source: *Pennsylvania Crash Facts and Statistics 2003-2008*

In the I-476 southbound exit ramp area, the calculated crash rate of .2781 is far below average crash rates of Pennsylvania Interstates between 2003 and 2007, which ranged from .42 to .50. The following tables are a summary of the crashes collected from the Pennsylvania Department of Transportation database within the vicinity of the I-476 southbound exit ramp, from the I-76 & Matsonford Road exit ramp up to the Schuylkill River Bridge.

Table A2: Annual Crash Totals

Year	Number	Percent
2003	8	40%
2004	2	10%
2005	2	10%
2006	1	5%
2007	7	35%
Total	**20**	**100%**

Source: PennDOT 2008

Table A3: Crash Type

Collision Type	Number	Percent
Non-collision	1	5%
Rear-end	10	50%
Angle	3	15%
Sideswipe	2	10%
Hit fixed object	3	15%
Other or unknown	1	5%
Total	**20**	**100%**

Source: PennDOT 2008

Table A4: Crash Severity

Severity	Number	Percent
Not injured	9	45%
Moderate injury	3	15%
Minor injury	5	25%
Unknown	3	15%
Total	**20**	**100%**

Source: PennDOT 2008

The crash data used in this report was provided by the Pennsylvania Department of Transportation for DVRPC's traffic safety related transportation planning and programming purposes only. The raw data remains the property of PennDOT and its release to third parties is expressly prohibited without the written consent of the Department.

Abstract Page

Report Title:	I-76 / I-476 Interchange Area Traffic and Conceptual Engineering Study
Publication Number:	08074
Date Published:	April 2009
Geographic Area Covered:	Conshohocken Borough, West Conshohocken Borough, Lower Merion Township and Upper Merion Township in Montgomery County, PA
Key Words:	Fayette Street, PA 23, Matsonford Road, I-76 / I-476 Interchange, performance measures, level of service, travel times, crash rate, VISSIM
Abstract:	This report documents 2005 and 2030 traffic forecasting and operations testing in the I-76 / I-476 Interchange and the Fayette Street Bridge River crossing area. AM and PM peak hour level-of-service, travel times, and network speeds and delays performance measures were derived by using the VISSIM. The Louis Berger Group, Inc. provided highway engineering services to identify design enhancements and construction cost estimates associated with two Build Scenarios in the studied interchange network.

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