Prepared for:

pennsylvania
DEPARTMENT OF TRANSPORTATION

# US Route 422 West Shore Bypass Reconstruction Study

## Final Report

### District 5-0, Berks County

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## Introduction

The purpose of the US 422 West Shore Bypass Reconstruction Study was to identify transportation projects that will improve the safety, operations, regional mobility and local access of the existing corridor. Additionally the projects will reconstruct the aging corridor infrastructure and provide motorists with an updated facility.

The existing corridor was constructed 50 years ago and has many design deficiencies (lack of proper width shoulders, inadequate sight distance, insufficient ramp acceleration lanes) that are common with expressways constructed in the 1960s. The existing pavement is deteriorated. There are five major structures (500'+) either on or over the corridor that are at the end of their service life.

The main corridor traffic and safety issues are located at three of the interchanges within the corridor: I-176, Lancaster Avenue and Penn Street. Two of the interchanges (Penn Street and Lancaster Avenue) are located within 3/4 mile of each other in the western portion of the corridor, with US 422 as the most travelled connection between areas serviced by their interchanges. Safe driving on US 422 is exacerbated by the close proximity of the two interchanges. The geometries of the two interchange further compromise safety with left lane exit and entrance ramps for the Lancaster Avenue Interchange while the Penn Street Interchange has all ramps access from the right lane. This requires commuters to merge over two lanes in a short distance to enter on one interchange and exit at the other.

The I-176 Interchange issues are related to the ramp geometrics. The entrance ramps to US 422 do not provide sufficient acceleration length to safely merge onto US 422. The substandard acceleration lane results in a safety concern at the US 422/ramp merge as well as on the ramps.

## Study Goals

The goals of the Study were to identify existing deficiencies and needs, generate proposed alternatives to address those needs and identify the costs and impacts associated with those alternatives. The Study included the following:

1. Identified existing infrastructure deficiencies and classified when these should be replaced
2. Documented locations with existing safety issues
3. Conducted a traffic analysis of the corridor and access points to determine existing deficiencies and document deficiencies in a proposed design year
4. Documented missing movements that limit local access to the corridor, thereby putting additional strain on the local road network
5. Documented locations where regional mobility is impacted by limitations of the corridor
6. Provided alternatives that present solutions to deficiencies documented above.

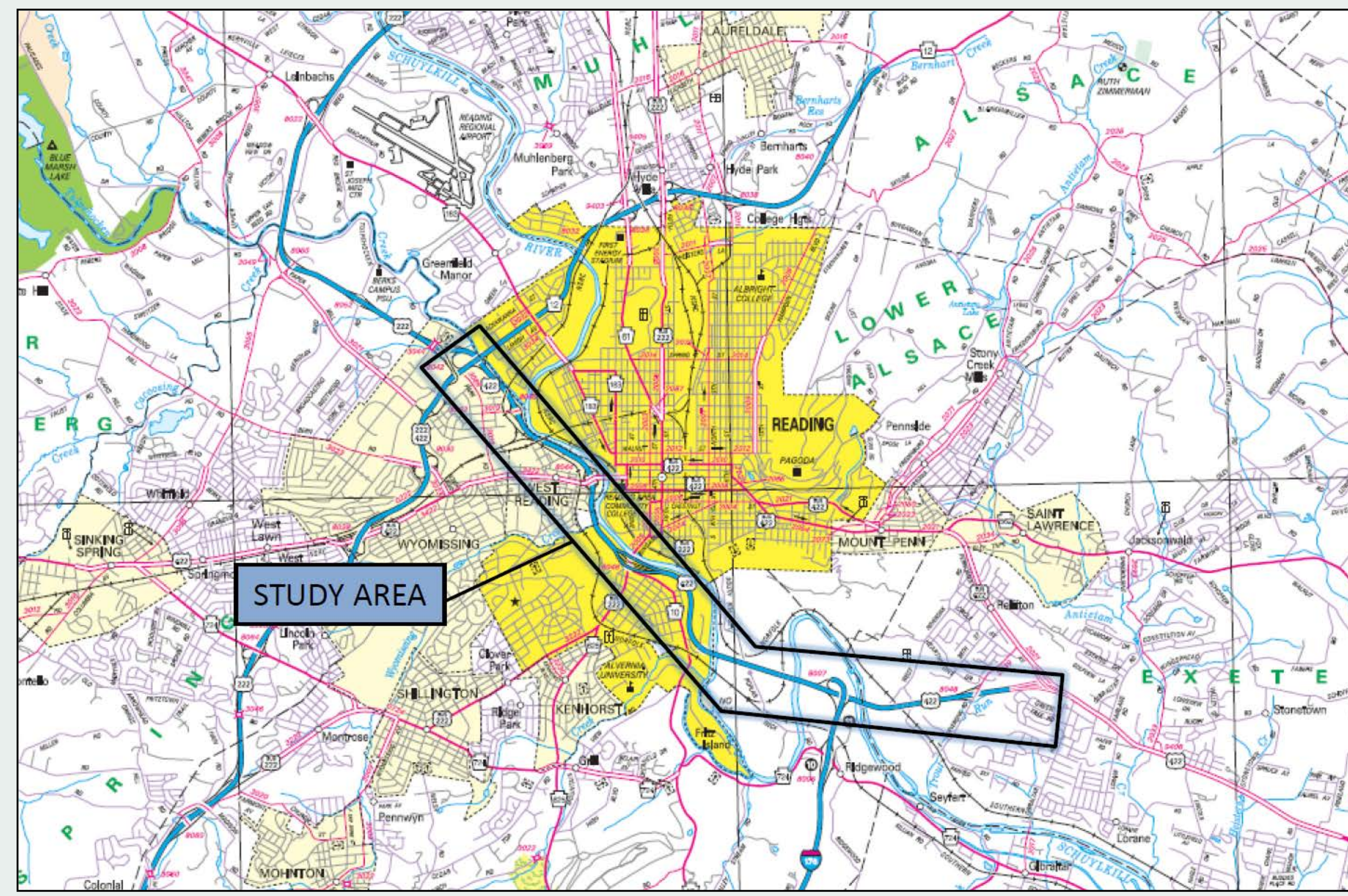



**Figure 1 – US 422 West Shore Bypass Corridor**

## Needs

The US 422 West Shore Bypass Study is an evaluation of the corridor that begins in the west at the Warren Street overpass (SR 12) and ends at the Perkiomen Avenue (SR 2021) in the east (See **Figure 1** on the previous page). The needs were identified by conducting traffic studies, reviewing the existing road geometry, reviewing existing bridge inspection reports, reviewing crash data and conducting an extensive public involvement program including meetings with local municipalities and county government, trucking interests, large employers and emergency service providers.

These evaluations identified the following needs:

1. Overall Infrastructure Condition
2. Safety
3. Operations
4. Local Access
5. Regional Mobility.

### 1. Overall Infrastructure Condition

The US 422 West Shore Bypass was constructed in the late 1950s and early 1960s. In the last few years, the Pennsylvania Department of Transportation (PennDOT) has improved the conditions of the roads to maintain the serviceability of the corridor until a full reconstruction can be completed. The existing infrastructure is near the end of its service life. Before the bituminous overlay, placed in 2012, the original concrete pavement showed signs of deterioration. Numerous spalled joints and potholes were visible along the corridor. The current bituminous overlay has masked the underlying issues with the pavement for a few years, but the ultimate need is complete reconstruction.

Within the corridor, there are six overpass bridges and 15 mainline bridges that are owned by PennDOT. In addition, there are two railroad viaduct overpasses that are owned by Norfolk Southern and a concrete arch overpass at Buttonwood Street that is owned by Berks County.

Of the 15 mainline bridges:

- Three are Functionally Obsolete (FO)
- Five are Structurally Deficient
- Twelve have a Sufficiency Rating of less than 80
- Two have a SR less than 50
- Many of the non-SD/FO bridges are the existing box or arch culverts.

Of the six PennDOT-owned overpasses:

- Four are either Structurally Deficient or Functionally Obsolete
- Three have a Sufficiency Rating of less than 80
- One is a SR less than 50.

In addition, these bridges contain vertical clearances that do not meet current requirements (**Table 1**). Currently there are four mainline bridges and five overpass bridges that have substandard vertical clearances of less than 16'-6". Additionally, there are three overpasses not owned by PennDOT, including Buttonwood Street (owned by Berks County) and the two Norfolk Southern owned overpasses.

| Field View ID | Section | Feature Intersected | Facility Carried | BMS# | Vertical Clearance Existing | Vertical Clearance Required |
|---|---|---|---|---|---|---|
| W | 1 | SR 422, TULPEHOCKEN CREEK, & MONTGOMERY ST. | PA12 | 06 0012 0010 0000 | 14'-0" | 16'-6" |
| V | | SR 422 & TULPEHOCKEN CREEK | NORFOLK SOUTHERN RR WEST CROSSING (1 Track) | N/A | NO INFO AVAILABLE | 16'-6" |
| T | | SR 422, RR, & SCHUYLKILL RIVER | NORFOLK SOUTHERN RR EAST CROSSING (2 Tracks) | N/A | NO INFO AVAILABLE | 16'-6" |
| S | | SR 422 | BUTTONWOOD STREET | 06 7301 0000 9171 | 13'-8" | 16'-6" |
| R | | SR 422 | PENN STREET | 06 3422 0050 1146 | 15'-2" | 16'-6" |
| Q | 2 | FRANKLIN STREET | SR 422 (LR793) | 06 0422 0372 0401 | 12'-1" | 14'-6" |
| M | | SR2005 (LANCASTER AVE / BINGAMAN ST) | SR 422 WB | 06 0422 0383 1730 | 14'-7" | 16'-6" |
| I | 3 | NORFOLK SOUTHERN RR & SERVICE RD | SR 422 | 06 0422 0430 0000 | 22'-5" (RR), 22'-2" (Road) | 23'-0" (RR), 14'-6" (Road) |
| G | | SR 422 | I-176 | 06 0176 0110 1913 | 15'-4" | 16'-6" |
| E | 4 | NORFOLK SOUTHERN RR | SR 422 | 06 0422 0440 2528 | 22'-6" | 23'-0" |
| B | | SR 422 | E. NEVERSINK ROAD (SR 2039) | 06 2039 0010 0210 | 14'-7" | 16'-6" |
| A | | SR 422WB | PERKIOMEN AVE - BUSINESS 422EB | 06 2021 0011 0401 | 14'-7" | 16'-6" |

Table 1: Bridge Vertical Clearances

**LEGEND:**

**Mainline Bridge**

**Overpass Bridge**

The 24 structures in the study area have the following structure configuration in relation to the number of spans, superstructure type and material makeup:

- Six – Multi-span continuous, multi-stringer steel (rolled or built-up)
- Three – Multi-span, continuous/simple, dual-girder steel (built-up)
- Two – Multi-span, simple, dual-girder steel Railroad Bridges – Owned by NS
- One – Single-span, multi-stringer steel (built-up)
- Four – single-span, pre-stressed concrete beams (box or I-beam)
- Three – Three-span simple, pre-stressed concrete beams
- Four – Concrete culverts (arch or box)
- One – Concrete rigid arch/open spandrel arch (Buttonwood Street) – Owned by Berks County

In order to maintain the serviceability of the overall infrastructure along this corridor, these structures have required expensive and time-consuming repairs throughout their life to preserve bridge deck slabs, expansion joints and steel girders. Repair and rehabilitation operations date back to the original construction and continue into today. In recent years, there have been projects to extend the service life of the roads and bridges via preservation projects until the time when a reconstruction and upgrade of the corridor was possible.

The combination of these structures requiring frequent maintenance, the deteriorated and outdated condition of the corridor, and their 50 year age are all indications that the corridor is nearing the end of its useful life and is in need of either major rehabilitation or replacement.

### 2. Safety

Along the corridor, safety is an important issue, and evaluating the crashes and causes of those crashes along the corridor is a high priority. A Confidential Safety Study of the corridor was completed. Certain locations were documented where safety concerns exist in the existing conditions discussion of each section. For a more detailed breakdown or analysis of the crash history of the corridor, see the Confidential Safety Study in Appendix A.

### 3. Operations

The Study included the collection of traffic volumes to obtain daily and peak hour traffic volumes, projections of the traffic volumes to the design year of 2034, and utilizing those projected volumes to evaluate and analyze the various mainline and interchange alternatives quantified by level-of-service (LOS) results.

Most agencies, including PennDOT, identify LOS A through D as constituting acceptable operating conditions. LOS E represents operating conditions where traffic volumes are approaching capacity, and is often considered the threshold of acceptable peak hour operating conditions for very low volume, unsignalized (stop-sign controlled) intersections. LOS F represents failure, or operating conditions where volumes exceed capacity and delays are lengthy. Our design assumption for this study was LOS D for all mainline sections.

The Study identified LOS for the freeway sections, ramp junctions and weave sections, along with all signalized and unsignalized intersections at the interchanges. Overall the corridor operates at acceptable LOS along the mainline and the interchanges with the exception of two locations, the Lancaster Avenue Interchange and the Penn Street Interchange. The ramp junction and weaving analysis show unacceptable LOS within these interchanges.

The Lancaster Avenue Interchange operates with left entrance and exit ramps, and the signal that controls the interchange is in close proximity to the intersection with PA Route 10 which creates congestion and queuing between the intersections. The maneuvering between US 422 and PA Route 10 is difficult as well, and may contribute to the overall congestion within this interchange. The Study evaluated several alternatives to reconstruct this interchange to accommodate future traffic volumes and take into account the intersection with PA Route 10.

The Penn Street Interchange also experiences congestion due to the high volumes of traffic exiting and entering US 422. During peak hours, the traffic exiting the ramps to Penn Street often backs up onto the mainline, creating congestion within the interchange that spills back onto the highway. These issues are due to limited storage, limited distance between the on/off ramps and operational issues along Penn Street. The Study evaluated several alternatives to reconstruct this interchange to accommodate future traffic volumes and resolve the merging, diverging and weaving issues at this interchange.

A full traffic report is included in Appendix B.

### 4. Improve Local Access

There are currently five interchanges within the US 422 corridor with a sixth as the western boundary of the project. Four of the five within the corridor have all available movements while the fifth (Neversink Road) has only access to and from the west. In discussions with the local municipalities and the trucking industry, adding these movements are viewed as instrumental to eliminate trucks and vehicles using other streets that were not constructed or designed to handle this traffic.

### 5. Regional Mobility

The West Shore Bypass, designated as US 422, is considered the heart of the regional highway transportation system in the Reading area as it is the convergence and connection between key transportation arteries, including US 222, I-176, and PA Route 12. US 422 provides connections to Pottstown, King of Prussia and I-76 to Philadelphia to the east and Lebanon and Hershey to the west. At the western end of the study area, there is an interchange with US 222, which provides connections to Allentown and Bethlehem to the east and Lancaster to the west. Finally, an interchange with I-176 in the middle of the study area provides a connection south to the PA Turnpike Interchange at Morgantown. Regional mobility on the West Shore Bypass is impeded by congestion on the mainline and inadequate interchange geometrics that do not meet current design standards or serve current traffic volumes.

In addition to carrying regional vehicular traffic, the broader West Shore Bypass corridor supports other transportation modes, including BARTA Bus service, the Thun Trail segment of the Schuylkill River Trail, and Norfolk Southern rail lines that parallel and cross the expressway.

- *BARTA Bus Service:* BARTA Bus Route 21 operates along the West Shore Bypass between the Penn Street Interchange and I-176 Interchange and provides express weekday peak period service between downtown Reading and the Morgantown Business Park for over 6,000 passengers annually. Additionally, eight BARTA Bus Routes cross the West Shore Bypass, providing service along Lancaster Avenue or Penn Street/Penn Avenue and through both interchanges.
- *Thun Trail Segment of the Schuylkill River Trail:* The Thun Trail parallels the West Shore Bypass between the Thun Trail Viaduct (south of the Penn Street Interchange) and the I-176 Interchange. The Thun Trail is part of the 130-mile Schuylkill River Trail that stretches from Pottsville to Philadelphia and provides regional mobility for bicyclists and pedestrians. The crushed stone surface trail follows a former rail line and includes several bridges over the Schuylkill River, as well as a bicycle and pedestrian bridge over Lancaster Avenue. The segment of the Thun Trail within the study area is maintained by the Schuylkill River Heritage Area.
- *Norfolk Southern:* Norfolk Southern's Crescent Corridor includes the former Reading Railroad Mainline between Philadelphia and Reading, which parallels the West Shore Bypass and the Schuylkill River. Norfolk Southern's facilities within the study area also include two railroad bridges over the West Shore Bypass to the east and west of the Wyomissing Boulevard Interchange, as well as a rail line below US 422 to the west of the I-176 Interchange.

Maintaining regional transit service, bicycle and pedestrian connections, and goods movement along the West Shore Bypass corridor can help to reduce congestion and enhance regional mobility for all transportation modes.

## Environmental Overview

The Study included a preliminary desktop analysis of the environmental features within the US 422 corridor to assist with the evaluation of project alternatives and to identify potential resource impacts associated with the proposed improvement alternatives. The following presents a brief summary of the environmental features identified in the project study corridor which may have a significant impact on project design, cost, permitting requirements and mitigation.

### 1. Natural Resources

***Aquatic Resources***

The US 422 Study area is located within the Middle Schuylkill River Watershed (HUC-10), which is part of the larger Schuylkill River Watershed (HUC-8). The Schuylkill River drains to the Lower Delaware River at Philadelphia. Four sub-watersheds (HUC-12) are located within the project study area and include the Antietam Creek sub-watershed, the Angelica Creek-Schuylkill River sub-watershed, the Wyomissing Creek sub-watershed and the Lower Tulpehocken Creek sub-watershed. All of the sub-watersheds within the project study area drain to the Schuylkill River.

The Schuylkill River is designated as a Pennsylvania State Scenic River within the project study area. The river supports multiple recreational uses including boating and fishing. The Schuylkill River is also a PA Fish and Boat Commission designated water trail. The Water Trail runs the length of the entire river to the confluence with the Delaware River.

Within the project study area, two tributaries which flow directly to the Schuylkill River are present. Trout Run supports warm water fishes (WWF), and Wyomissing Creek supports cold water fishes (CWF). Both these tributaries also support migratory fishes (MF). The Schuylkill River within the project study area supports WWF and MF. Based on PAFBC information, Wyomissing Creek within the project study area supports the natural reproduction of trout.

U.S. Fish and Wildlife Service National Wetlands Inventory (NWI) mapping indicated several wetland complexes are associated with the Schuylkill River floodplain within the project study area. NWI mapping indicated that three wetlands were present within the project study area, which consisted of palustrine forested (PFO) or mixed palustrine forested and palustrine scrub-shrub (PFO/PSS) wetlands.

***Threatened and Endangered Species***

Based on the online Pennsylvania National Diversity Index search performed in January 2014, additional coordination with the PA Department of Conservation and Natural Resources (DCNR) for plants, as well as coordination with the PA Fish and Boat Commission (PAFBC) and U.S. Fish and Wildlife Service (USFWS) for various animals will be required.

Under the DCNR's jurisdiction, additional coordination will be required for the following plant Species of Special Concern: spring coral-root (Corallorhiza wisteriana), Schweinitz's flatsedge (Cyperus schweinitzii), and lion's-foot (Prenanthes serpentaria). Based on Plants of Pennsylvania by Ann Rhoads and Timothy Block, spring coral-root is found on rocky, wooded slopes on limestone and diabase. Schweinitz's flatsedge is found in calcareous marshes and stream banks. Lion's-foot is found in dry woods, clearings and gravelly roadsides. Based on the types of habitat present within the project study area, habitat for these species of special concern may be present.

Under the PAFBC jurisdiction, further review is required for a threatened species, which is likely red-bellied turtle (Pseudemys rubriventris). Based on the Pennsylvania Natural Heritage Program Factsheet, red-bellied turtles are found in larger bodies of water including lakes, ponds and slow moving rivers. Basking sites, which are also an essential part of this species habitat, include logs and downed trees. Upland nesting sites are typically located within 100 meters of the water. Known red-bellied turtle habitat is present throughout the Schuylkill

River floodplain and potentially within the project study area.

Under the USFWS jurisdiction, a Phase 1 bog turtle survey will be required. The bog turtle (Glyptemys muhlenbergii) is federally threatened and state endangered. Based on the Pennsylvania Natural Heritage Program Factsheet, bog turtles are found in wet meadows and bogs where tussock sedge and grasses are dominant. Mucky soils fed by groundwater seeps are also an essential component of their habitat. Berks County is a known area where bog turtles are found.

***Natural and Wild Areas***

Based on GIS layers, no state game lands, state forests, or state parks are present within the project study area. Additionally, no DCNR-listed wild and natural areas are present within the project. No federally listed parks or National Natural Landmarks are present within the project study area. No properties owned by land conservancies such as the Nature Conservancy or Natural Lands Trust are present within the project study area.

***Hazardous Waste and Materials***

Based on available GIS layers, several hazardous or residual waste sites are present within or immediately adjacent to the project study area. The GIS layers indicated that several PADEP Act 2 addresses, which are sites where environmental cleanup has taken place, are present immediately adjacent to the project study area. The data associated with this GIS layer did not indicate the property boundary or extent of the work at these addresses. No other hazardous waste sites were present based on the GIS layers.

***Agricultural Resources***

Based on GIS data from Berks County Planning Department, no Agricultural Conservation Easements or Agricultural Security areas are present within the project study area. Additionally, based on existing land use GIS layers (2000) provided by the Planning Department, limited agricultural lands are present within the project area. Two small parcels are located in the southern portion of the project study area near East Neversink Road. An investigation of recent aerial photography indicated that these parcels are not active agricultural land and appear to be fallow, infrequently mowed fields. Based on future land use GIS layers, no agricultural preservation areas are present within the project study area.

## 2. Cultural Resources

A preliminary assessment of cultural resources was undertaken in accordance with the Federal Highway Act of 1966, as amended in 1968; the National Environmental Policy Act of 1969; the National Historic Preservation Act of 1966 (as amended); Executive Order 11593; the Archaeological and Historic Preservation Act of 1974; and the Commonwealth of Pennsylvania State Act No. 1978-273, amended as Act No. 1988-72. The preliminary assessment was undertaken for both historic resources and archaeological resources.

Historic Resources were identified through a search of the Pennsylvania Historical and Museum Commission's on-line database CRGIS. This database provided information concerning historic resources that had been previously surveyed. Previously surveyed properties had been evaluated as eligible or listed for the National Register of Historic Places, not eligible for the National Register or undetermined. A windshield survey was undertaken to ensure that eligible or listed properties were still extant or had not lost integrity. Eligible or listed Historic Resources adjacent to the US 422 corridor were few but include two Schuylkill River bridges which connect Reading with West Reading - Penn Street and Buttonwood Street. The majority of historic resources were present along proposed detour routes. These resources included a number of historic districts in the City of Reading as well as potential historic districts in communities to the west of Reading.

Archaeological Resources were identified through a search of the Pennsylvania Historical and Museum Commission's on-line database CRGIS, historic map research and a pedestrian reconnaissance. Two precontact archaeological sites and one historic archaeological were recorded in or adjacent to the project corridor. An archaeological sensitivity model was used to identify the potential for encountering archaeological sites along the US 422 corridor. This model found that there was precontact archaeological potential along nearly all of the undisturbed portion of the corridor due in part to the proximity of the Schuylkill River. Historic archaeological potential was low throughout the corridor, although some areas of historic archaeological potential are present.

## 3. Site Geology Overview

The geologic conditions vary widely along the length of the study area, and different geotechnical solutions will be required to address the varying needs of the highway improvements. At the western end of the study area, particularly in the area between the west end of the West Shore Bypass to just east of the Penn Street Interchange, rock outcrops are prominent along the southern side of the existing highway alignment, and will have a significant impact on the planning, design and construction of the highway improvements. Further east along the project alignment, from where the Schuylkill River Trail crosses under the Bypass east of 1st Avenue, to the east end of the Bypass, bedrock is expected to remain shallow in most areas; rock outcrops are not prevalent in this section of the study area, and bedrock is less likely to prominently impact highway construction.

Within the project corridor, bedrock is anticipated to be shallow, ranging from at the ground surface to less than 20 feet below the existing grade across much of the project study area. Significant rock excavation, and potentially rock slope remediation measures, will be an integral part of the construction associated with this project.

Several significant bedrock outcrops are visible along US 422 west of the Penn Street Interchange, and there is also a prominent outcrop east of the interchange, just west of the US 422 bridge over the end of South 1st Avenue, adjacent to the Schuylkill River Trail bridge over the Schuylkill River. The rock outcrop at this location

supports an electrical substation, and a portion of the outcrop may be impacted by the proposed highway improvements.

## 4. Community Resources

US 422 traverses five municipalities in Berks County, including the City of Reading, Cumru Township, Exeter Township, West Reading Borough and Wyomissing Borough. The Berks County Comprehensive Plan 2030 (2013) identifies the study area as predominantly developed with a mix of residential, commercial and industrial uses, and some pockets of open space. The County's 2030 Future Land Use Plan designates most of the study area as existing development with some specific areas for designated growth and rural conservation.

The areas for growth are primarily located in the urban areas of Reading, West Reading, and Wyomissing and reflect redevelopment opportunities. The areas for rural conservation are located near the I-176 Interchange adjacent to the Schuylkill River. The overall vision for the County includes continued protection of agricultural land, expansion of parks and trails, and growth reflective of smart growth policies and practices. Reconstruction of the West Shore Bypass is consistent with the County's vision and the Reading Area Transportation Study (RATS) Long Range Transportation Plan goals to maintain the existing transportation system, provide a variety of transportation choices for the efficient movement of people and goods, improve safety and reduce congestion.

In addition to Berks County and RATS regional plans, there are four municipal comprehensive plans for the study area, as well as specific master plans for Downtown Reading, Reading Area Community College (RACC), RiverPlace and the Schuylkill River Trail. Common themes in local plans include redevelopment of urban areas (City of Reading, West Reading, and Wyomissing), revitalization of the Schuylkill River waterfront, and expansion of parks, trails, and recreational opportunities along the Schuylkill River.

The West Shore Bypass provides access to numerous community facilities located throughout the study area municipalities, including schools, places of worship, municipal buildings and fire stations. However, the only community facility buildings within a quarter mile of the West Shore Bypass are two fire stations, one church and the RACC campus, which is across the Penn Street Bridge on the east side of the Schuylkill River. In terms of emergency response, the West Shore Bypass is patrolled and serviced by five municipal police forces, five fire departments and three EMS/ambulance services.

Based on Census 2010, the total population of the five study area municipalities is 143,452, which is 34% of the total population of Berks County. The area is the most densely populated part of the County, with approximately 2,390 people/square mile. Over the last twenty years (1990 – 2010), the total population of the study area municipalities has increased by 16.9%, which is below Berks County's growth rate of 22.9% for the same period. The growth was focused in the suburban areas of Cumru and Exeter Townships, as well as the City of Reading. Given existing land uses and the urban and suburban development pattern, there are limited opportunities for new "greenfield" development in the study area.

In terms of the economy and employment, three of the top five employers in Berks County in 2010 were headquartered within the study area municipalities, including the Reading Health System, Reading School District and Berks County Government. Also within the study area municipalities, there are two higher educational institutions (RACC and Alvernia University), several cultural and entertainment establishments (Reading Public Museum, Goggle Works, Santander Arena and Performing Arts Center), and regional shopping areas (VF Outlet, Penn Avenue in West Reading, Penn Street in Reading). This highlights the importance of the West Shore Bypass for commuting, as well as access to arts and education.

| | | Minority Population | Hispanic Population | 75 Years or Older Population | Below Poverty Population | Limited English Proficiency Population | Female Head of Household with Child | Households with Zero Vehicles Available |
|---|---|---|---|---|---|---|---|---|
| **West Shore Bypass** | City of Reading *Census Tract 26* | 15.4% | 68.7% | 4.4% | 54.4% | 28.3% | 35.6% | 38.8% |
| | City of Reading *Census Tract 29* | 10.1% | 20.9% | 11.9% | 17.0% | 9.7% | 5.9% | 4.9% |
| | Cumru Township *Census Tract 116.03* | 3.9% | 3.7% | 9.6% | 2.7% | 2.8% | 4.2% | 4.4% |
| | Exeter Township *Census Tract 120.02* | 5.3% | 3.4% | 7.2% | 5.4% | 1.2% | 4.3% | 1.3% |
| | West Reading Borough *Census Tract 112* | 11.0% | 18.3% | 10.6% | 11.5% | 3.8% | 11.3% | 9.9% |
| | Wyomissing Borough *Census Tract 111.01* | 8.9% | 9.6% | 24.5% | 9.2% | 0.0% | 2.7% | 16.5% |
| | **Berks County** | **6.5%** | **16.4%** | **7.3%** | **13.1%** | **6.4%** | **7.1%** | **8.7%** |

**Table 2: Census Tracts bordering the West Shore Bypass with higher concentrations of special populations compared to Berks County (Source: Census 2010 and American Community Survey 2011 – Five Year Estimates)**

The study area population is diverse and includes concentrations of special population groups. Based on data from Census 2010 and the American Community Survey 2011 – Five Year Estimates, the Census Tracts bordering the West Shore Bypass in Reading, West Reading and Wyomissing have higher concentrations of special population groups compared to aggregate data for Berks County. As highlighted in **Table 2**, this area includes higher concentrations of minorities, Hispanics, elderly (75 years or older), people living below poverty, people with limited English proficiency, households with zero vehicles available, or households with a female head and child.

### 5. Parks, Recreation and 4(f) Resources

Parks and recreation resources are clustered along the banks of the Schuylkill River and Tulpehocken Creek and along the West Shore Bypass corridor. The facilities are located adjacent to the highway, below elevated segments of the highway, and within the Schuylkill River and Tulpehocken Creek floodplain. The park and recreation facilities within the study area include bicycle and pedestrian trails, a water trail, active parks and passive recreation areas.

- *Bicycle and Pedestrian Trails:* The Thun Trail Segment of the Schuylkill River Trail is a significant regional multi-use trail that parallels the West Shore Bypass between the Thun Trail Viaduct (south of the Penn Street Interchange) and the I-176 Interchange. At the Thun Trail Viaduct, US 422 is elevated above a crossing of the trail. East of this crossing, the trail is located just south of the West Shore Bypass, including a section of the trail built within the highway right-of-way near Brentwood Drive. In addition to the Thun Trail, the West Shore Bypass crosses over Exeter Township's Scenic River Trail along the east bank of the Schuylkill River just east of the I-176 Interchange. Also, the westbound US 422 ramp to eastbound PA Route 12 is elevated above the Union Canal Towpath at the Stonecliff Recreation Area. Finally, the Angelica Creek Trail terminates south of the West Shore Bypass at Brentwood Drive.
- *Water Trail:* The Schuylkill River is designated as a National and State Recreation Water Trail from Pottsville to the confluence with the Delaware River in Philadelphia. It is recognized by the American Canoe Association as a Recommended Water Trail. It is a navigable waterway used by kayakers, canoeists and recreational boaters. Within the study area, there are two boat landings on the east side of the river within the City of Reading.
- *Active Parks:* There are three active parks adjacent to the West Shore Bypass. At the western end of the study area, the Stonecliff Recreation Area is a 15-acre park located below and south of the westbound West Shore Bypass ramp to eastbound PA Route 12. The park is owned by Berks County and includes several athletic fields and courts, an action park for skates and bikes, fitness station, children's play area, fishing dock, pavilion, picnic areas, and the Union Canal Towpath.

  The Bertolet Fishing Dock and five parking spaces for the dock are located under the Thun Trail Viaduct, near the terminus of First Avenue in West Reading. The dock is owned by West Reading Borough and can also be accessed from the Thun Trail.

  Schlegel Park, which is owned by the City of Reading, is located south of US 422 and north of Lancaster Avenue. The 24-acre park includes a large recreational pool, tot pool, volleyball court, basketball court, three baseball fields, pavilion and picnic areas. Access to the park is provided at the intersection of Lancaster Avenue and PA Route 10/Wyomissing Boulevard, near the Lancaster Avenue Interchange.

  There are also several parks that are not directly adjacent to the Bypass but are within the floodplain for the Schuylkill River and Tulpehocken Creek. They include Confluence Point Park, Dana Memorial Park, Riverfront Park and Heritage Park within the City of Reading.
- *Passive Recreation Areas:* There are two areas of publicly-owned open space that are used for passive recreation. One passive recreation area is north (and east) of US 422 and is located between Brentwood Drive and the Schuylkill River. The property is owned by the City of Reading and has recreational trails and is also used for maintenance access to sanitary sewer lines. The other passive recreation area is located north of US 422 between West Neversink Road and East Neversink Road in Exeter Township. This Township-owned open space is accessed from West Neversink Road and is used informally for recreation purposes.

### 6. Floodplain Encroachment

According to the Federal Emergency Management Agency's (FEMA) Flood Insurance Study for Berks County, the Tulpehocken Creek and the Schuylkill River are regulated watercourses. This assessment is confirmed by the data presented on the Flood Insurance Rate Map (FIRM) of the project area. The FIRM maps indicate that this project area is in Flood Zone AE, an area where base flood elevations have been determined. Any encroachment upon the floodplain that results in a 0.01' or greater flood elevation increase will require a FEMA map revision. Additionally, any increase of flood elevation at a regulated structure (i.e., building) will require the building to be purchased and demolished.

Currently the defined floodplain parallels the existing road and encroaches at two locations. The first location centers around the Buttonwood Street overpass. The base flood elevation of the Schuylkill River is above the road elevation and this area does flood periodically. The second location is under the Thun Trail Viaduct. Currently the area underneath and south of the viaduct is also below the Schuylkill River base flood elevation. Other than the two locations discussed, the existing road is the western edge of the floodplain and the road is above the base flood elevations.

## Stakeholder and Public Involvement

PennDOT believes in an informed and educated public, and values the inputs of citizens. This input is especially critical when it pertains to the transportation system. An extensive and inclusive public involvement process leads to better decision making on improvements to the transportation and community environment, including all modes of transportation. Stakeholder and public input was sought throughout the planning process to gather information and review and refine the alternatives throughout the project corridor. Below is a summary of the key project presentations and coordination meetings that were held. Copies of presentations and meeting summaries are included in Appendix K.

### Study Advisory Committee (SAC)

A Study Advisory Committee (SAC) was formed to review and provide input throughout the planning process. The SAC included representatives from PennDOT District 5-0, Berks County Planning Commission/Reading Area Transportation Study (RATS), BARTA, Greater Reading Chamber of Commerce and the five study area municipalities (City of Reading, Cumru Township, Exeter Township, West Reading Borough and Wyomissing Borough). The first SAC meeting was held on May 31, 2013 and included a presentation of the project overview and preliminary alternatives for key interchanges along the corridor. The second SAC meeting was held on February 11, 2014 and included a presentation of the project status and concept design alternatives for the mainline, Thun Trail Viaduct and key interchanges. Additionally, there was individual coordination with SAC members regarding environmental resources, public involvement and other project related items.

### Special Interest Group Meetings

Three Special Interest Group meetings were held on June 12, 2013. The invitees included representatives from major employers and institutions in the greater Reading area, emergency responders and trucking interests that utilize the corridor. The invite list for the Special Interest Group meetings was developed through consultation with RATS and the Greater Reading Chamber of Commerce. Over 30 attendees participated in the meetings. The agenda for each meeting included a presentation of the project overview and preliminary alternatives for key interchanges along the corridor. Additionally, participants were given an opportunity to ask questions and provide comments regarding the preliminary alternatives.

In addition to the Special Interest Group Meetings, letters were sent to federal and state elected officials in June to make them aware of the planning process and provide a point of contact for project related questions or concerns.

### Stakeholder Presentations

A project status update was provided to a joint meeting of the Government Affairs Committee and Transportation Committee of the Greater Reading Chamber of Commerce on August 16, 2013. Additionally, verbal project status updates were provided to the Transportation Committee on November 22, 2013 and February 21, 2014.

A presentation of concept design alternatives for the mainline and key interchanges was provided to the RATS Coordinating Committee on March 20, 2014. The Reading Eagle provided a front-page article covering of the West Shore Bypass presentation at the RATS meeting on March 21, 2014.

### Public Meeting

A Public Open House Meeting was held on May 1, 2014. An announcement for the meeting was distributed to numerous stakeholders, including SAC members, Special Interest Group invitees and attendees, RATS Coordinating Committee, RATS Technical Committee, Berks County Planning Commission, all Berks County municipalities, RATS E-mail listing of interested parties, Greater Reading Chamber of Commerce Transportation Committee and elected officials. Additionally, PennDOT District 5-0 provided a press release announcing the meeting on April 24, 2014. News coverage announcing the meeting included a front-page article in the Reading Eagle on April 26, 2014; article in the Lehigh Valley Business (LVB.com) on April 28, 2014; and highlights during WFMZ Evening News show on April 22, 2014. Over 60 people attended the open house to review boards that presented an overview of project goals, corridor needs, environmental resources and improvement concepts for the mainline and interchanges.

## Mainline Existing Conditions

### Existing Roadways

The overall state of the pavement throughout the corridor is poor and needs to be replaced. The guide rail was updated along the corridor, but its foundation (sideslopes) is undermined and needs to be brought to current standards. Additionally, the median is 4' wide throughout the corridor, and in some locations guide rail exists rather than concrete barrier. Guide rail and median barrier issues occur throughout the corridor.

In order to discuss location specific existing highway conditions, the corridor is broken into four separate sections. The sections will be described from interchange to interchange with the exception of Section 1 which will extend between Warren Street and Penn Street, through the Wyomissing Boulevard Interchange.

### Existing Structures

There are 24 structures (bridges or culverts) located within the corridor. The existing structure types vary widely throughout the corridor. Existing structures include overpasses, waterway crossings, deep valley crossings, railroad overpasses and structures that cross a combination of features. It appears that the site features at each structure generally dictated the structure type in the original design of the corridor, which would explain the widely varying structure types.

To extend the remaining life of the existing corridor until a full reconstruction can be completed, various bridge improvement projects have recently been completed, are underway or are planned. In addition, some of the off-line Schuylkill River crossings that tie into the US 422 corridor are planned to be rehabilitated in the future. As of January 2014, improvement projects include:

| Recently Completed Construction | |
|---|---|
| **MPMS** | **BMS#** |
| 88697<br>Bridge Repairs | 06-0012-0040-1135<br>06-0422-0372-1174<br>06-0422-0420-0000<br>06-0422-0430-0000<br>06-0422-0430-0427<br>06-0422-0440-0638<br>06-8042-0010-0694 |
| 92820<br>Resurfacing/Preservation | 06-0422-0372-1174<br>06-0422-0382-2106<br>06-0422-0383-1730<br>06-0422-0410-1293<br>06-0420-0420-0000<br>06-0420-0430-0000<br>06-0422-0430-0427<br>06-0422-0440-0638<br>06-0422-0440-2528<br>06-0422-0450-0000 |
| 96028<br>Bridge Painting | 06-0012-0060-0000<br>06-0422-0430-0427<br>06-8042-0010-0694<br>06-0422-0440-0638 |
| 86929<br>I-176 ITS | 06-0176-0110-1913 |

| Ongoing Construction | |
|---|---|
| **MPMS** | **BMS#** |
| 91941<br>Bridge Repairs | 06-0012-0010-0000 |
| 63191 & 58174<br>I-176 Reconstruction | 06-0176-0110-1913 |

| Planned Construction | |
|---|---|
| **MPMS** | **BMS#** |
| 10824<br>Bingaman Street<br>Rehabilitation | 06-2005-0010-0000 |
| 10713 Buttonwood Street<br>Bridge Rehabilitation | County Owned |
| 10740 Penn Street<br>Rehabilitation | 06-3422-0050-1493 |
| 81743 SR 222/422 Urban<br>Corridor | New ITS Structures |

A brief overview of the impacted structures along the corridor, categorized by structure type, is below. Off-Line/adjacent structures that may not be impacted by this work (i.e., Buttonwood Street, Bingaman Street, Thun Trail Viaduct and Penn Street) are discussed in the next section.

Figure 2: US 422 over Thun Trail

1. **Multi-span, continuous/simple, multi-girder/ stringer steel (rolled or built-up) bridge (Figure 2)**: The six bridges in the corridor of this type include:
   - PA 12 over US 422, Tulpehocken Creek and Montgomery Road
   - US 422 westbound off-ramp to PA 12 EB
   - US 422 over Thun Trail
   - Brentwood Drive over US 422
   - US 422 over NS Railroad and service road.

Figure 3: Schuylkill River Crossing #1

2. **Multi-span, continuous/simple, dual-girder steel (built-up) bridge (Figure3):** This structure type exists at the three Schuylkill river crossings in the eastern portion of the corridor.

Figure 4: NS over Tulpehocken and US 422

3. **Multi-span simple, dual-girder steel (built-up) railroad bridge (Figure 4):** The two bridges, owned by the Norfolk Southern Railroad, carry the railroad over US 422 and either the Schuylkill River or the Tulpehocken Creek.

Figure 5: Penn Street over US 422

4. **Single-span, multi-girder steel (built-up) bridge (Figure 5)**: Penn Street over US 422 is the only structure of this type.

Figure 6: **US 422 over West Neversink Road**

Figure 7: **Perkiomen Avenue over US 422 WB**

Figure 8: **US 422 over Schuylkill River Tributary**

5. **Single-span, pre-stressed concrete (I-beam or box beam) bridge (Figure 6):** The four bridges in the corridor of this type include:
   - North Wyomissing Boulevard over US 422
   - US 422 eastbound over Lancaster Avenue
   - I-176 over US 422
   - US 422 over West Neversink Road.

6. **Three-span simple, pre-stressed concrete (spread or adjacent) box-beam bridge (Figure 7):** The three bridges in the corridor of this type include:
   - US 422 westbound over Lancaster Avenue
   - East Neversink Road over US 422
   - Perkiomen Avenue over US 422 westbound.

7. **Concrete culvert (Figure 8):** There are four culverts that will likely be impacted by the reconstruction of US 422. All of these culverts support a tributary to the Schuylkill River except for US 422 over Franklin Street, which will likely be replaced by a conventional spread box-beam bridge.
   - US 422 over Franklin Street
   - US 422 over Wyomissing Creek
   - US 422 over tributary to the Schuylkill River
   - US 422 over tributary to Trout Run.

## Typical Structure Conditions

Of the 24 structures in the corridor, six are classified as Structurally Deficient (SD) and seven are considered Functionally Obsolete (FO). Five bridges within the corridor are fracture critical structures.

Bridges are classified as Structurally Deficient (SD) when the condition of the superstructure, substructure and/or deck is considered poor. SD bridges are inspected regularly to ensure that safety of the traveling public is not compromised. Generally, SD bridges require more frequent (and costly) maintenance. Several of the SD bridges throughout this corridor have decks in poor condition. See **Figure 9** for an example.

A bridge is classified as Functionally Obsolete when its deck geometry, load carrying capacity, clearance or approach roadway alignment no longer meets the criteria for the system for which the bridge is a part. An example of a FO bridge with substandard clearances can be found in **Figure 10**.

A fracture-critical bridge is one in which failure of one main load carrying member will result in the collapse of the entire structure. This is because of their makeup as a non-redundant structural system (**Figure 11**) composed of one or two main load carrying members. However, these bridges are not considered SD or FO. The bridges in the corridor include the three mainline Schuylkill River crossings and the two railroad overpass crossings.

Appendix C is a table of all bridges in the study area by proposed construction section with their existing structure information, inspection condition, overall length and underclearance information contained therein.

**Figure 9: US 422 over Brentwood Drive; Structurally Deficient due to Deck Condition**

**Figure 10: Perkiomen Avenue over US 422 Westbound; Functionally Obsolete Due to Substandard Clearances**

**Figure 11: US 422 over Schuylkill River (Crossing #1); One of Five Non-Redundant Fracture Critical Structural Systems**

## Offline Adjacent Structures

Several bridges tie into or cross the mainline in the corridor. These bridges connect Reading with the adjacent municipalities on the south bank of the Schuylkill River. Some of these structures are currently under some phase of rehabilitation and are not included in the US 422 reconstruction study. These bridges include (from west to east):

- Buttonwood Street Bridge – combination open/ closed spandrel concrete arch bridge (planned rehabilitation)
- Penn Street Bridge – combination open/closed spandrel concrete arch bridge (planned rehabilitation)
- Thun Trail Bridge – dual steel girder, multi-simple span bridge (no work planned)
- Bingaman Street Bridge – combination open/closed spandrel concrete arch bridge (planned rehabilitation).

No replacement of these bridges is considered for the mainline reconstruction study; however, there may be minor impacts to these structures as a result of US 422 widening and interchange reconfiguration.

It is anticipated that impacts to Buttonwood Street, Penn Street and the Thun Trail will either be avoided or be very minimal. US 422 improvements around these bridges will need to be coordinated to minimize impacts to bridges that will have been recently rehabilitated by the time US 422 construction begins.

The Bingaman Street Bridge (which ties into Lancaster Avenue, Bus. 222) will likely have some impacts due to the US 422 construction. The interchange options studied do not impact the main portion of the bridge, but there are a series of approach spans that extend below the existing US 422 westbound structure and through the signalized ramp intersection. The east and west side of these approach spans were enclosed by retaining walls during the original US 422 construction. These walls retain the fill outside the footprint of the Bingaman Street Bridge. These approach spans will need to be either removed or filled in for the reconstruction. See **Figures 12 a through c.**

**Figure 12a: Bingaman Street Bridge (near) at WB US 422 Overpass (far)**

**Figure 12b: Bingaman Street Closed Spans Below Interchange**

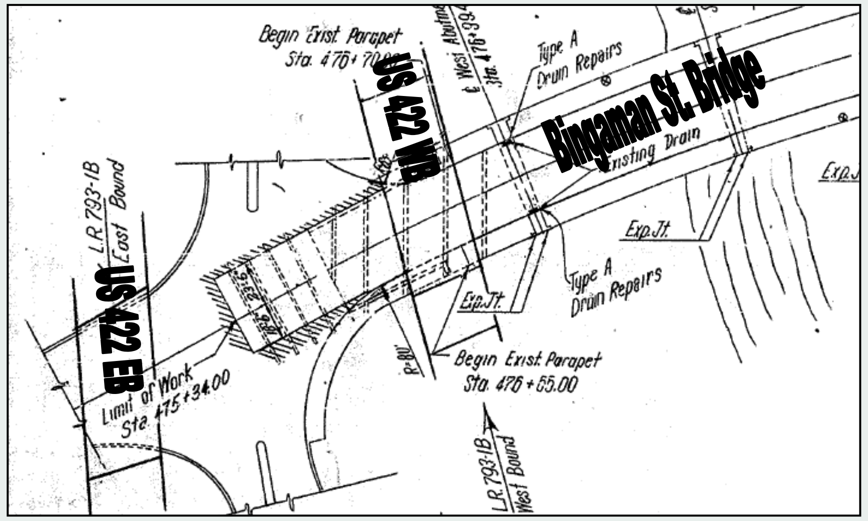



**Figure 12c: US 422 Westbound over Bingaman Street Buried Spans**


## Section 1 – Warren Street Bypass to Penn Street Interchange

The existing US 422 corridor in this section has a curvilinear alignment including some broken back curve sections. The radii of all curves in this section meet current standard for the posted speed of 55 mph.

There are two typical sections in this area which change at the Wyomissing Boulevard Interchange. West of Wyomissing Boulevard, the corridor is six lanes (**Figure 13**). The section consists of four through lanes and two auxiliary lanes. The right (outside) shoulders are approximately 8’ wide (eastbound) and 12’ wide (westbound). The westbound shoulder meets current criteria while the eastbound does not. Approximately 1000’ west of the Wyomissing Boulevard overpass is a Norfolk Southern overpass bridge. The bridge spans the road completely but does not allow for the existing shoulder widths (8’ eastbound, 12’ westbound) to pass through the bridge. At the bridge the right shoulders are 4.5’ wide in both directions, less than current criteria.

East of Wyomissing Boulevard the corridor is four lanes (**Figure 14**). The right shoulders are approximately 10’ wide (eastbound) and 8’ wide (westbound). Neither meets the current 12’ criteria. Approximately 1800’ east of Wyomissing Boulevard is a second Norfolk Southern overpass which causes the US 422 shoulders to narrow down to 7’ in both directions. Similarly, the Buttonwood Street bridge also restricts US 422 as it passes under the bridge at a skew to the Buttonwood Street piers. This causes the right shoulders to narrow approaching the overpass.

The median is 4’ wide in this section with the exception of where it expands and then contracts at the Buttonwood Street pier in the median.

Using US 422 as an east/west line this section is flanked by the Tulpehocken Creek and Schuylkill River on the north side and various commercial properties (self-storage property, apartment complex and an engineering firm) and a Norfolk Southern rail line on the south side. A sound wall currently exists along the apartment complex. Also in this section is a Met-Ed transmission line on the south side within the Norfolk Southern right-of-way. The line starts at the eastern Norfolk Southern overpass and continues east through the Penn Street Interchange where it leaves the corridor.

Although the traffic analysis shows the corridor to function at a LOS E westbound in the PM Peak and eastbound in the AM Peak, there is no general indication of congestion.

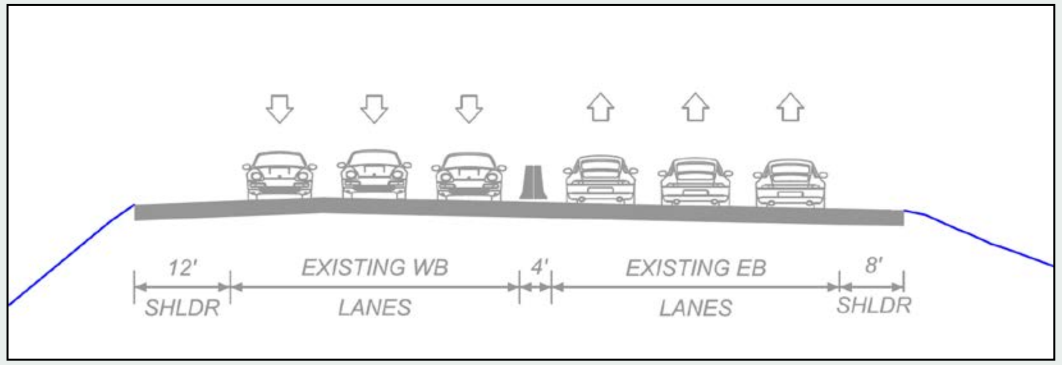



**Figure 13: Typical Section of Existing Conditions**
**Section 1 – West of Wyomissing Boulevard Interchange**

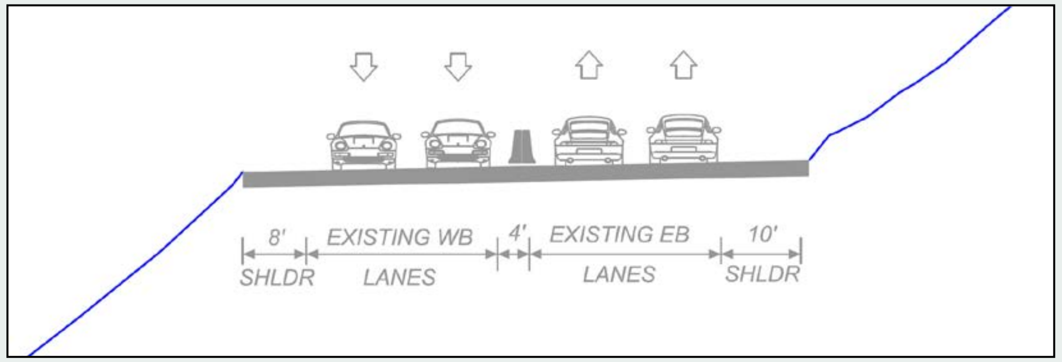



**Figure 14: Typical Section of Existing Conditions**
**Section 1 – East of Wyomissing Boulevard Interchange**


There are six overpass bridges (See **Table 3A** for a complete listing) and one US 422 ramp bridge within this section (**Table 3B**). The six overpass bridges include a dual girder railroad bridge carrying a single Norfolk Southern track (**Figure 15**), a, twin dual girder railroad bridge carrying two Norfolk Southern tracks (**Figure 16**), the Buttonwood Street concrete arch bridge (**Figure 17**) and end at Penn Street Interchange Bridge which is a multi-girder bridge.


**Figure 15: Single Track Dual-Girder Railroad Crossing 1**

**Figure 16: Two-Track, Dual Girder Railroad Crossing 2**

**Figure 17: Buttonwood Bridge Overpass**

Except for the ramp structure, the PennDOT-owned bridges in this section of the study area are generally in satisfactory or better condition with an overall NBIS Structure Condition rating of 6 or better. The two overhead riveted plate girder bridges were recently rehabilitated and show minimal deterioration, while the overpass at the Wyomissing Boulevard Interchange was constructed in 1995 and also exhibits minimal deterioration.

The US 422 westbound ramp to PA 12 eastbound has a rating of 5 due to its fair substructure condition. No inspection information is available for the two railroad structures over mainline US 422 or the Buttonwood Street Bridge.

Three of the four PennDOT-owned bridges have sufficiency ratings above 80; however, all four structures are considered functionally obsolete due to inadequate vertical or lateral clearance for structures on an interstate system as shown in Table 3A.

| Feature Intersected | Facility Carried | BMS# | Structure Type | Suff. Rating | Structure Cond. | Condition Ratings | | | | Structurally Deficient (SD) / Functionally Obselete (FO) ? | Vertical Clearance |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Super. | Sub. | Deck | Culvert | | |
| US 422, TULPEHOCKEN CR, & MONTGOMERY ST. | WARREN STREET (PA 12) | 06 0012 0010 0000 | 3 SPAN CONTINUOUS STEEL MULTI-RIVETED PLATE GIRDER | 71 | 6 | 6 | 6 | 6 | N | FO | 14'-0" |
| US 422 & TULPEHOCKEN CREEK | NORFOLK SOUTHERN RR (1 EXISTING TRACK) | N/A | MULTI-SIMPLE SPAN, STEEL RIVETED DUAL PLATE GIRDER | OWNED BY NORFOLK SOUTHERN | | | | | | | |
| US 422 | N. WYOMISSING BLVD. (PA 3019) | 06 3019 0030 0511 | 1 SPAN, P/S SPREAD BOX BEAM | 90 | 7 | 7 | 7 | 7 | N | FO | 16'-11" |
| US 422, RR, & SCHUYLKILL RIVER | NORFOLK SOUTHERN RR (2 TRACK) | N/A | MULTI-SIMPLE SPAN, STEEL RIVETED DUAL PLATE GIRDER | OWNED BY NORFOLK SOUTHERN | | | | | | | |
| US 422 | BUTTONWOOD ST | 06 7301 0000 9171 | MIXED - RIGID ARCHES, OPEN SPANDREL ARCHES | OWNED BY BERKS COUNTY | | | | | | | |
| US 422 | PENN AVE | 06 3422 0050 1146 | 1 SPAN, STEEL MULTI-RIVETED PLATE GIRDER | 81 | 7 | 7 | 7 | 7 | N | FO | 15'-2" |

**Table 3A: Bridges over Mainline US 422 in Section 1**

| Feature Intersected | Facility Carried | BMS# | Structure Type | Suff. Rating | Structure Cond. | Condition Ratings | | | | Structurally Deficient (SD) / Functionally Obselete (FO) ? | Vertical Clearance |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Super. | Sub. | Deck | Culvert | | |
| TULPEHOCKEN CREEK & MONTGOMERY RD | OFF RAMP FROM US 422 WB ONTO PA 12 EB | 06 8042 0010 0694 | 5 SPAN CONTINUOUS, ROLLED STEEL STRINGERS | 83 | 5 | 6 | 5 | 6 | N | FO | 14'-9" |

**Table 3B: US 422 WB Ramp Bridge Located at the PA 12 Interchange in Section 1**



## Section 2 – Penn Street Interchange to Lancaster Avenue Interchange

US 422 through this corridor contains three curves to the left with tangents between each curve creating broken back curves. The first broken back curve is short (230') and centered over the Thun Trail viaduct. The second (1380') is between the viaduct and the Lancaster Avenue Interchange. The radii of the curves meet current standards for the posted speed limit of 55 mph.

This section is four lanes, two in each direction (**Figure 18**). The four lanes split at the Lancaster Avenue Interchange. The right shoulders are approximately 10' wide (eastbound) and 7' wide (westbound). The shoulders do not meet current criteria. The shoulders narrow to 4' across the Thun Trail viaduct.

The median is 4' wide, consistent along the corridor. It has a metal median barrier rather than a concrete median barrier or glare screen.

Using US 422 as an east/west line, this section is flanked by the Schuylkill River on the north side and various commercial properties on the south side.

The traffic analysis in this section indicates that it currently operates at or better than a LOS D. The primary operational issue with this section is that it is a connection segment between the Penn Street Interchange and the Lancaster Avenue Interchange. The short distance between the two interchanges, and the fact that the Lancaster Avenue ramps access US 422's left lane while the Penn Street ramps access the right lane of US 422, create a scenario where traffic travelling between the two interchanges will have to merge over one lane in the 3/4 mile between interchanges. Additionally, the on-ramps accessing the left (fast) lane instead of the normal right (slow) lane creates a safety issue as well.

There are six mainline structures in Section 2 (See **Table 4** for details). From the west, mainline structures include: Franklin Street box culvert, the Thun Trail Viaduct multi-girder bridge, two concrete culverts spanning streams and two pre-stressed concrete bridges over Lancaster Avenue.

There are no overpass bridges in this section.

The two culverts (Franklin Street and Wyomissing Creek) are in satisfactory or better condition with an overall NBIS Structure Condition rating of 6 or better. These two concrete structures show only minor deterioration. The arch culvert over the tributary to the Schuylkill River, with a condition rating of 5, is governed by the fair structural condition of the culvert.

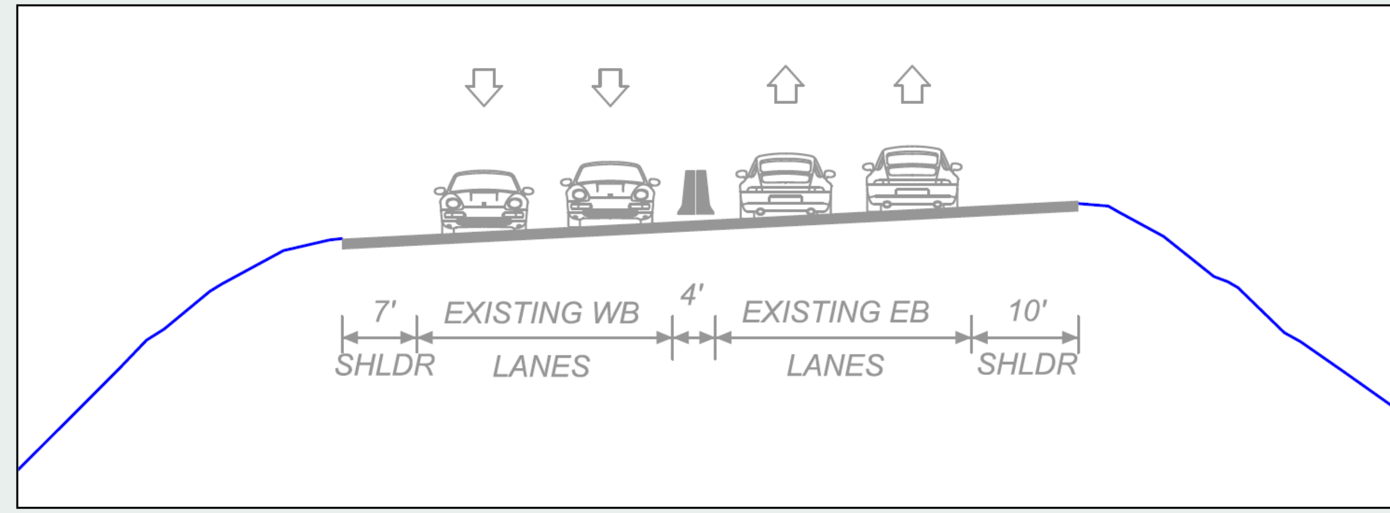



**Figure 18: Typical Section of Existing Conditions**
**Section 2 – Penn Street Interchange to Lancaster Avenue**

| Feature Intersected | Facility Carried | BMS# | Structure Type | Suff. Rating | Structure Cond. | Condition Ratings | | | | Structurally Deficient (SD) / Functionally Obselete (FO) ? | Vertical Clearance |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Super. | Sub. | Deck | Culvert | | |
| FRANKLIN STREET | US 422 | 06 0422 0372 0401 | CONCRETE BOX CULVERT | 72 | 7 | N | N | N | 7 | --- | 12'-1" |
| THUN RECREATIONAL TRAIL BRIDGE | US 422 | 06 0422 0372 1174 | 8 SPAN CONTINUOUS, STEEL MULTI-RIVETED PLATE GIRDER | 52 | 4 | 5 | 4 | 5 | N | SD | N/A |
| WYOMISSING CREEK | US 422 | 06 0422 0372 1921 | CONC ARCH CULVERT | 73 | 6 | N | N | N | 6 | --- | N/A |
| TRIB. TO SCHUYLKILL RIVER | US 422 | 06 0422 0382 2004 | CONC ARCH CULVERT | 59 | 5 | N | N | N | 5 | --- | N/A |
| SR2005 (LANCASTER AVE / BINGAMAN ST) | US 422 WB | 06 0422 0383 1730 | 3 SPAN, P/S SPREAD BOX BEAM | 49 | 3 | 6 | 6 | 4 | N | SD | 14'-7" |
| SR2005 (LANCASTER AVE / BINGAMAN ST.) | US 422 EB | 06 0422 0382 2106 | 1 SPAN, P/S I-BEAM | 71 | 5 | 7 | 6 | 4 | N | SD | 16'-6" |

**Table 4: Bridges Located East of Penn Street through the Lancaster Avenue Interchange**



The remaining structures are in fair to serious condition with NBIS Structure Condition ratings of 5 to 3. The US 422 eastbound and westbound structures over Lancaster Avenue have condition ratings of 5 and 3 respectively, and are both governed by their inventory rating (**Figure 19**). The Thun Recreational Trail Bridge has a rating of 4 due to the poor condition of its substructure (**Figure 20**).


**Figure 19: US 422 Westbound (near) and Eastbound (far) Bridges over Lancaster Avenue**

**Figure 20: Thun Trail Bridge (Note Thun Trail Viaduct over the Schuylkill River to the Left)**

The sufficiency ratings of these bridges are all below 80 with the US 422 westbound over Lancaster Avenue having a sufficiency rating of 49.

In addition, two of the bridges have substandard vertical clearances and three bridges are considered Structurally Deficient.

There is also a pedestrian bridge carrying the Thun Trail over Lancaster Avenue just south of the eastbound overpass. It is a single span structure comprising three adjacent box beams. It is a newer structure and likely will not require replacement as a result of the mainline reconstruction.



## Section 3 – Lancaster Avenue to I-176

US 422 through this section has an S curve at the western end with a long tangent in the eastern end. The radii of the curves meet current standards for the posted speed limit of 55 mph.

This section is four lanes, two in each direction (**Figure 21**). The right shoulders are 7' wide in each direction which do not meet current standards. The shoulders narrow to 4' across both Schuylkill River crossings.

Using US 422 as an east/west line, this section is flanked by the Brentwood Industries complex on the north side at Brentwood Drive. From Brentwood Drive to I-176, the land is undeveloped to the north of US 422. The Thun Trail parallels US 422 on the south side, and is within the right-of-way of US 422 in some areas. Closer to I-176, Thun Trail moves further away from US 422.

A Met-Ed distribution pole line is located between US 422 and the Trail. Starting east of Lancaster Avenue the Met-Ed transmission line runs parallel to the corridor on the south side. The transmission line remains parallel to US 422 until it crosses US 422 at the tangent between the curves of the S curve west of Brentwood Drive. The line then crosses the Schuylkill River north of US 422.

The traffic analysis shows the corridor to function at a LOS D or better. The I-176 northbound on-ramp has a short acceleration length which does not allow entering traffic to accelerate to the proper speed before entering US 422. The S curve does not have proper sight distance as a result of the tight median barrier against the lane and the small curve radius at the curves. Both issues create safety concerns.

There is one overpass bridge and four mainline bridges in this section (See **Table 5** for details). The overpass is a pre-stressed concrete box beam bridge located at the I-176 Interchange. This bridge superstructure has been replaced as part of the I-176 mainline reconstruction.

Of the four mainline bridges in this section, two bridges are multi-span dual-girder floorbeam stringer systems carrying US 422 over two Schuylkill River crossings (crossings #1 and #2 from the west). Multi-span multi-stringer bridges each carry US 422 over Brentwood Drive and Norfolk Southern Railroad in this section as well.

Two bridges in this section, US 422 over Brentwood Drive and a Norfolk Southern rail line, are in satisfactory condition with an overall NBIS Structure Condition rating of 6. However, the deck of the bridge over Brentwood Drive is seriously deteriorated with a deck condition rating of 3. The sufficiency rating of this structure is 75 and due to the condition of the deck is considered structurally deficient. The crossing over the Norfolk Southern railroad has a sufficiency rating of 80 and is considered functionally obsolete as a result of the vertical clearance from the top of rail to the bottom of structure.

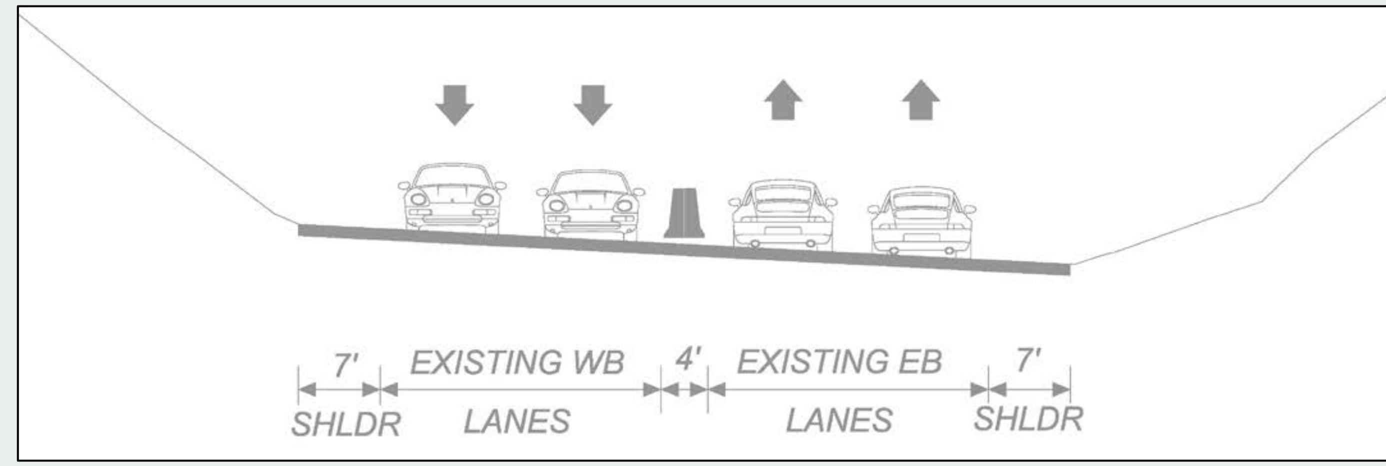



**Figure 21: Typical Section of Existing Conditions**
**Section 3 – Lancaster Avenue to I-176**

| Feature Intersected | Facility Carried | BMS# | Structure Type | Suff. Rating | Structure Cond. | Condition Ratings | | | | Structurally Deficient (SD) / Functionally Obselete (FO) ? | Vertical Clearance |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Super. | Sub. | Deck | Culvert | | |
| BRENTWOOD DRIVE | US 422 | 06 0422 0410 1293 | 3 SPAN CONTINUOUS, ROLLED STEEL STRINGERS | 75 | 6 | 6 | 6 | 3 | N | SD | 19'-6" |
| SCHUYLKILL RIVER CROSSING 1 (FROM WEST TO EAST) | US 422 | 06 0422 0420 0000 | 5 SPAN SIMPLE/CONT, DUAL RIVETED PLATE GIRDER | 49 | 4 | 5 | 4 | 5 | N | SD | N/A |
| NORFOLK SOUTHERN RR & SERVICE RD | US 422 | 06 0422 0430 0000 | 3 SPAN CONTINUOUS, ROLLED STEEL STRINGERS | 80 | 6 | 6 | 7 | 6 | N | FO | 22'-5" (RR) 22'-2" (Road) |
| SCHUYLKILL RIVER CROSSING 2 (FROM WEST TO EAST) | US 422 | 06 0422 0430 0427 | 5 SPAN SIMPLE/CONT, DUAL RIVETED PLATE GIRDER | 67 | 5 | 5 | 6 | 6 | N | --- | N/A |
| US 422 | I-176 | 06 0176 0110 1913 | 1 SPAN SIMPLE, P/S, SPREAD BOX-BEAM | NEW | NEW | NEW | 6 | NEW | N | --- | 14'-1" (Old) 15'-4" (New) |

**Table 5: Bridges Located East of Lancaster Avenue Interchange through the I-176 Interchange**



The two mainline US 422 Schuylkill River Crossings (#1 and #2) are in fair to poor condition with overall NBIS structure condition ratings of 4 and 5 from west to east. Crossing #1 is governed by the condition of the substructure, while Crossing #2 is controlled by the superstructure condition. Both bridges have been repaired due to the formation of fatigue cracks in recent years. Crossing #1 has a sufficiency rating of 49, while the sufficiency rating of Crossing #2 is currently 67 (**Figure 22**).

The I-176 bridge over the mainline is currently being replaced (superstructure only) as part of the overall interchange reconstruction project (MPMS 63191/58174). The condition of the substructure to remain is currently 6 (**Figure 23**).

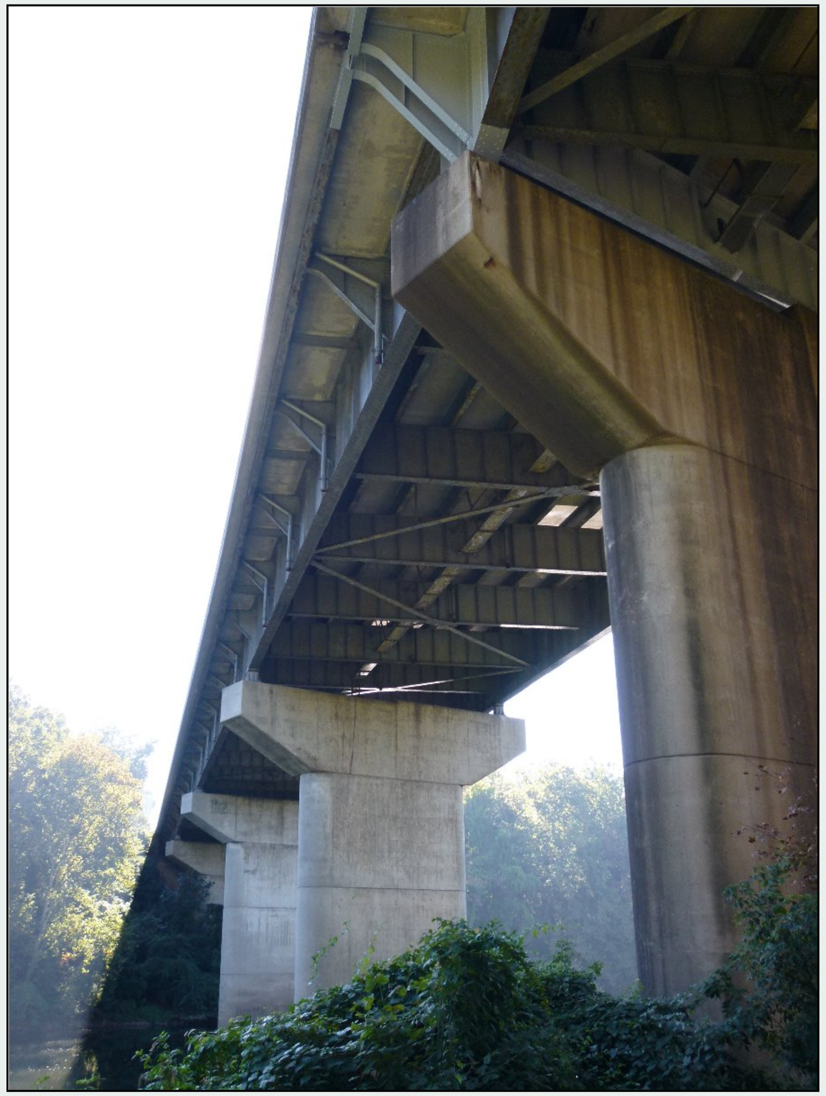


**Figure 22: Schuylkill River Crossing #1**

**Figure 23: I-176 Overpass (currently being replaced)**


## Section 4 – I-176 to Perkiomen Avenue

US 422 through this section has one horizontal curve adjacent to the river crossing and connects to Perkiomen Avenue at the eastern end. The radius of the mainline curve meets current standards for the posted speed limit of 55 mph. The two curves that connect US 422 to Perkiomen Avenue meet current standards for 45 mph.

This section is four lanes, two in each direction (**Figure 24**). The right shoulders are 7'to 8' wide in each direction which does not meet current criteria. The shoulders narrow to 4' across the Schuylkill River crossing.

Using US 422 as an east/west line, this section is flanked by mostly undeveloped land on the north side with some park land and residences in the area. On the south side there are commercial properties associated with the trucking industry with some undeveloped land. There is a utility access road to a sanitary sewer pump house south of US 422 that starts at East Neversink Road that also provides access to one residential property. There is also a distribution pole line along the access road.

The traffic analysis shows the corridor to function at a LOS C or better. The US 422 eastbound on-ramp from I-176 northbound has a short acceleration length which does not allow entering traffic to accelerate to the proper speed before accessing US 422. This situation is a safety concern.

This section contains two overpass bridges and four mainline bridges (See **Table 6** for details). The two overpass bridges are pre-stressed box beam bridges carrying East Neversink Road (at the interchange) and carrying Perkiomen Avenue over the westbound lanes of US 422 at the east end of the study area.

The first mainline bridge carries US 422 over the Schuylkill River (Crossing #3). This bridge is composed of a multi-span dual-girder floorbeam stringer system similar to the previous two Schuylkill River crossings to the west.

A multi-span multi-stringer bridge carries US 422 over Norfolk Southern Railroad, followed by a prestressed spread box beam bridge over West Neversink.

Further east, the mainline is carried by a box culvert carrying a tributary to the Schuylkill River.

There are three bridges in this section with an overall NBIS Structure Condition rating of 6 (satisfactory) or better. These bridges carry US 422 over Norfolk Southern rail line, West Neversink Road and a tributary to the Schuylkill River. The sufficiency ratings of theses bridges from west to east are 81, 82 & 70.

The remaining structures are in fair to poor (condition ratings of 5 to 4). The US 422 Schuylkill River Crossings (#3) has a condition rating 5 of due to the condition of the superstructure (**Figure 25**). This structure has had various structural retrofits due to the formation of fatigue cracks in the tie-plates connecting the overhang brackets to the floorbeams.

East Neversink Road over mainline US 422 has a condition rating of 4 due to the substructure condition. It has a sufficiency rating of 21 (**Figure 26**).

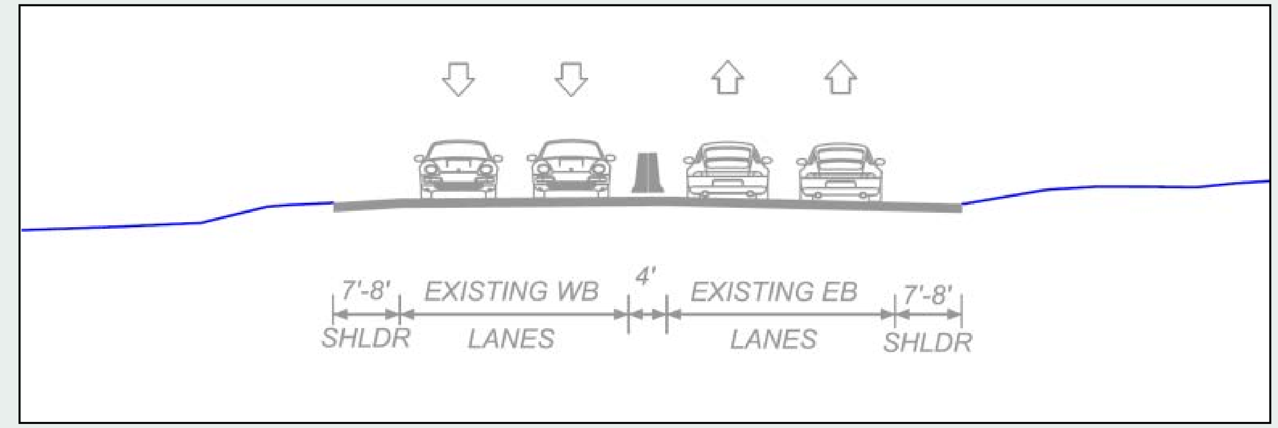


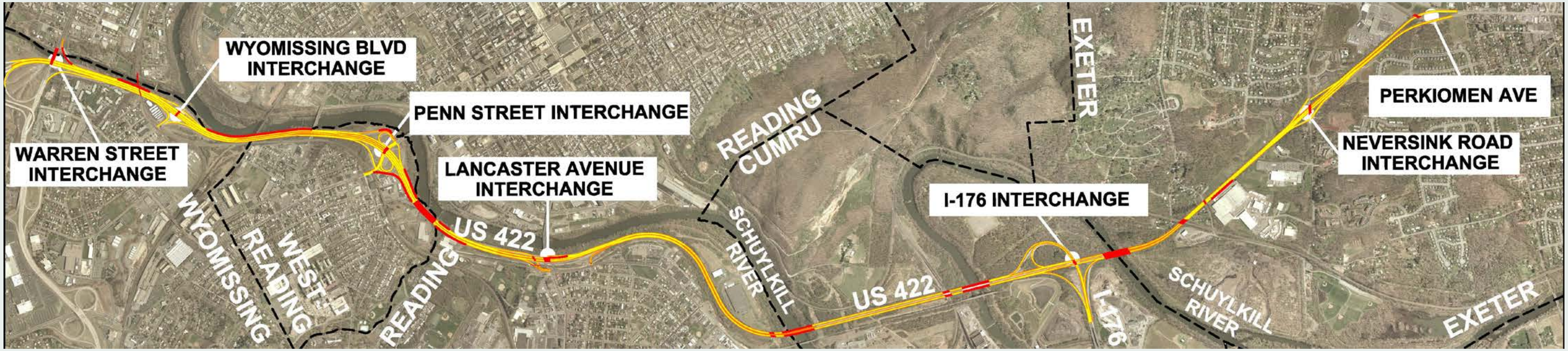

**Figure 24: Typical Section of Existing Conditions**
**Section 4 – I-176 to Perkiomen Avenue**

| Feature Intersected | Facility Carried | BMS# | Structure Type | Suff. Rating | Structure Cond. | Condition Ratings | | | | Structurally Deficient (SD) / Functionally Obselete (FO) ? | Vertical Clearance |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Super. | Sub. | Deck | Culvert | | |
| SCHUYLKILL RIVER CROSSING 3 (FROM WEST TO EAST) | US 422 | 06 0422 0440 0638 | 4 SPAN CONTINUOUS, DUAL RIVETED PLATE GIRDER | 61 | 5 | 5 | 7 | 6 | N | FO | N/A |
| NORFOLK SOUTHERN RR | US 422 | 06 0422 0440 2528 | 3 SPAN CONTINUOUS, ROLLED STEEL STRINGERS | 81 | 6 | 6 | 6 | 5 | N | --- | 22'-6" |
| TOWNSHIP ROAD 443 (W. NEVERSINK RD) | US 422 | 06 0422 0450 0000 | 1 SPAN, P/S SPREAD BOX BEAM | 82 | 6 | 6 | 6 | 6 | N | --- | 14'-8" |
| TRIB. TO SCHUYLKILL RIVER | US 422 | 06 0422 0450 1830 | CONCRETE BOX CULVERT | 70 | 7 | N | N | N | 7 | --- | N/A |
| US 422 | E. NEVERSINK ROAD (SR 2039) | 06 2039 0010 0210 | 3 SPAN SIMPLE, P/S BOX BEAM | 21 | 4 | 6 | 4 | 6 | N | SD | 14'-7" |
| US 422 WB | PERKIOMEN AVE - BUSINESS 422EB | 06 2021 0011 0401 | 3 SPAN SIMPLE, P/S SPREAD BOX BEAM | 78 | 5 | 6 | 6 | 7 | N | FO | 14'-7" |

**Table 6: Bridges located east of the I-176 Interchange through the Perkiomen Avenue Interchange**

**Figure 25: Schuylkill River Crossing #3**

**Figure 26: East Neversink over Mainline 422**




## Proposed Conditions

In developing design options it is necessary to establish the proper design criteria. It was determined to use 60 mph for the design speed. This design speed balanced the demands of higher speed vehicles with the negative impacts on adjacent properties if a flatter horizontal geometry, with a higher design speed, was selected. The existing posted speed limit of 55 mph will be maintained.

It was verified that the existing horizontal curve radii throughout the corridor met the requirements for 60 mph. Additionally, it was decided that the traffic analysis would achieve a LOS D or better for all mainline sections. At the intersections created by the interchange ramps, a lower LOS than D would be evaluated on a case by case basis.

### Mainline Traffic Analysis

Utilizing the traffic data collected, future traffic projections were developed to evaluate the various mainline and interchange alternatives. The future growth rate for the study area was determined by utilizing information from PennDOT, researching historical growth trends and coordinating with the Berks County Planning Commission.

As shown on **Table 7**, the design year (2034) LOS results showed that there was a need for three lanes in each direction from the Warren Street Bypass to the Lancaster Avenue Interchange, and two lanes in each direction east of the Lancaster Avenue Interchange to the study area limits at Perkiomen Avenue.

| Mainline Section | Existing Conditions (2014) | Future Conditions (Base) (2034) | Future Conditions (Proposed) (2034) |
|---|---|---|---|
| Warren Street Bypass to Wyomissing Blvd. | **4 Lanes** LOS C(E) WB LOS E(D) EB | **4 Lanes** LOS C(F) WB LOS F(D) EB | **6 Lanes** LOS B(C) WB LOS C(B) EB |
| Wyomissing Blvd. to Penn Street | **4 Lanes** LOS C(D) WB LOS E(C) EB | **4 Lanes** LOS C(E) WB LOS F(D) EB | **6 Lanes** LOS B(D) WB LOS C(C) EB |
| Penn Street to Lancaster Avenue | **4 Lanes** LOS C(D) WB LOS D(C) EB | **4 Lanes** LOS C(E) WB LOS E(D) EB | **6 Lanes** LOS B(C) WB LOS C(C) EB |
| Lancaster Avenue to I-176 | **4 Lanes** LOS B(D) WB LOS C(C) EB | **4 Lanes** LOS C(D) WB LOS D(C) EB | **4 Lanes** LOS C(D) WB LOS D(C) EB |
| I-176 to Perkiomen Avenue | **4 Lanes** LOS C(C) WB LOS C(C) EB | **4 Lanes** LOS C(D) WB LOS C(C) EB | **4 Lanes** LOS C(D) WB LOS C(C) EB |

**Table 7: Mainline Traffic Analysis**

### Typical Section

Using AASHTO's *A Policy on Geometric Design of Highways and Streets 2011 6th Edition*, 12' lane widths are required for the proposed reconstruction. In the four lane sections, 12' outside shoulders and a 10' wide median (i.e., two 4' shoulders and a 2' barrier) are required. To accommodate wider median bridge barriers, the Study utilized a 12' median in certain portions of the mainline to avoid bump outs or design exceptions at mainline bridges.

It was verified that the width of the proposed typical section is adequate to maintain traffic during construction. **Figure 27** shows the existing and proposed typical section in the four lane section. A three stage MPT scheme can be used without the need for additional widening.

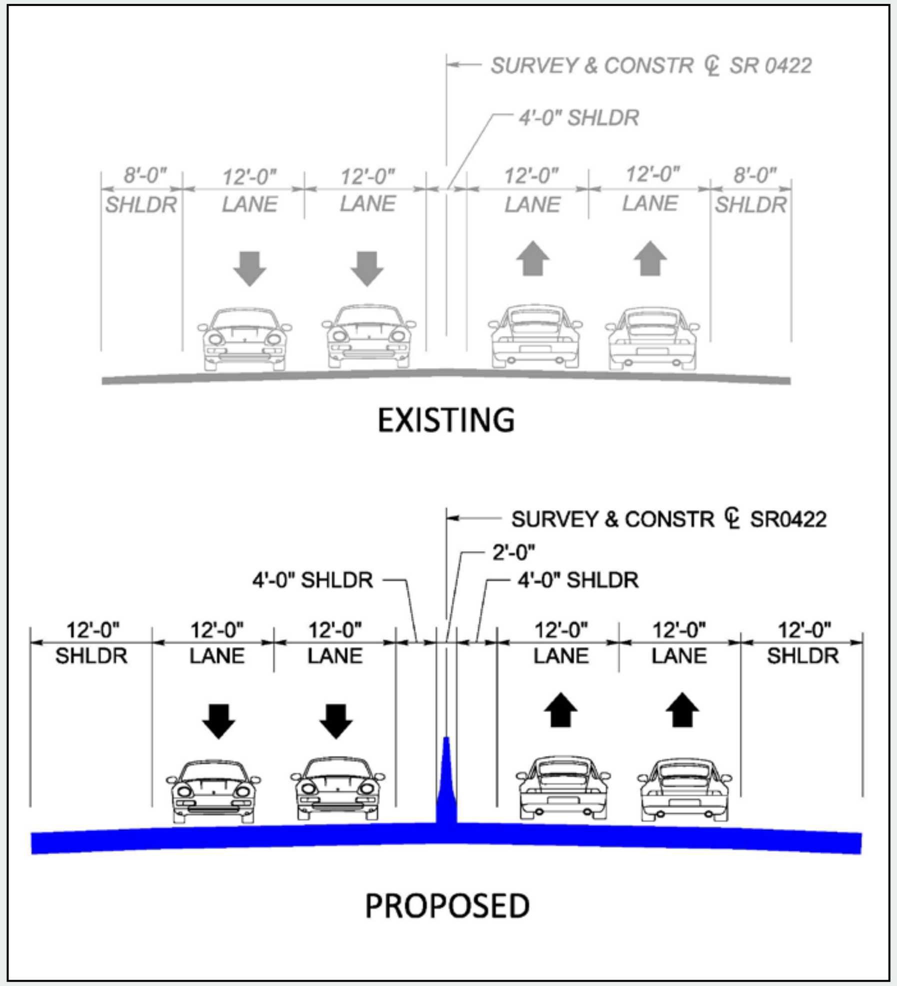
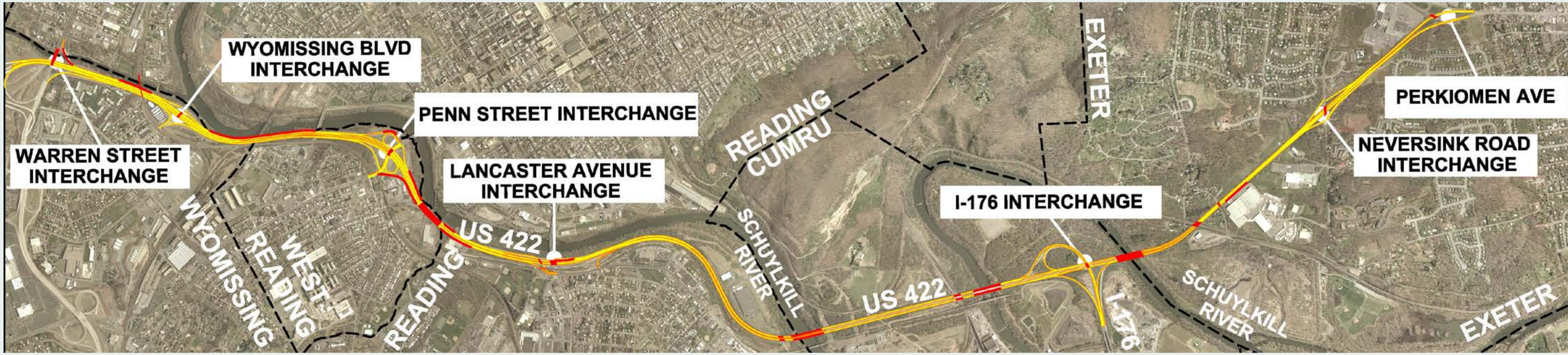



**Figure 27: Existing and Proposed Typical Section for Four Lane Section**




In the six lane sections **(Figure 28)** three options were considered. The first had three 12' lanes in each direction with 12' inside and outside shoulders. Additional widening for bridges was not a concern in this location as there is only one mainline structure (Thun Trail viaduct). The existing viaduct is on a horizontal curve that requires additional widening for sight distance.

The second six lane option assumes the outside or right lanes are auxiliary lanes in lieu of through lanes. This option required six 12' lanes with 10' outside shoulders (instead of 12') and a 10' wide median. This assumes that the four inside lanes are considered through lanes while the outside lanes are auxiliary lanes carrying traffic between the interchanges. The high volume of traffic exiting and entering US 422 at the Warren Street, Penn Street and Lancaster Avenue Interchanges lends itself to this determination. However, the three lanes would be carried through the Wyomissing Boulevard Interchange since traffic utilizing this interchange does not warrant dropping the auxiliary lane at this interchange. Since a determination of the viability of this option would be developed during preliminary engineering, any impacts associated with widening to six lanes utilized the first option since it had the wider footprint.

A third option was also investigated for the six lane section west of Penn Street that utilized a C-D Road for the eastbound traffic from Warren Street to east of Penn Street. This option takes the C-D Road utilizing the additional southern span of Buttonwood Street Bridge and extends it west to the Warren Street Bypass. This option would separate the mainline through traffic with traffic accessing the interchanges, allowing through traffic to avoid being impacted by exiting and entering vehicles.

## Mainline and Overhead Structures

To provide a reconstructed highway using the proposed highway options previously discussed, the mainline and overhead structures (except Buttonwood Street) will require replacement. Several of the bridges also have substandard underclearances that need to be addressed. Therefore, for the purpose of this Study, it is anticipated that all the mainline and overhead structures will be replaced to address the mainline condition, substandard vertical clearances, alignments (vertical and horizontal) as well as the MPT to maintain traffic.

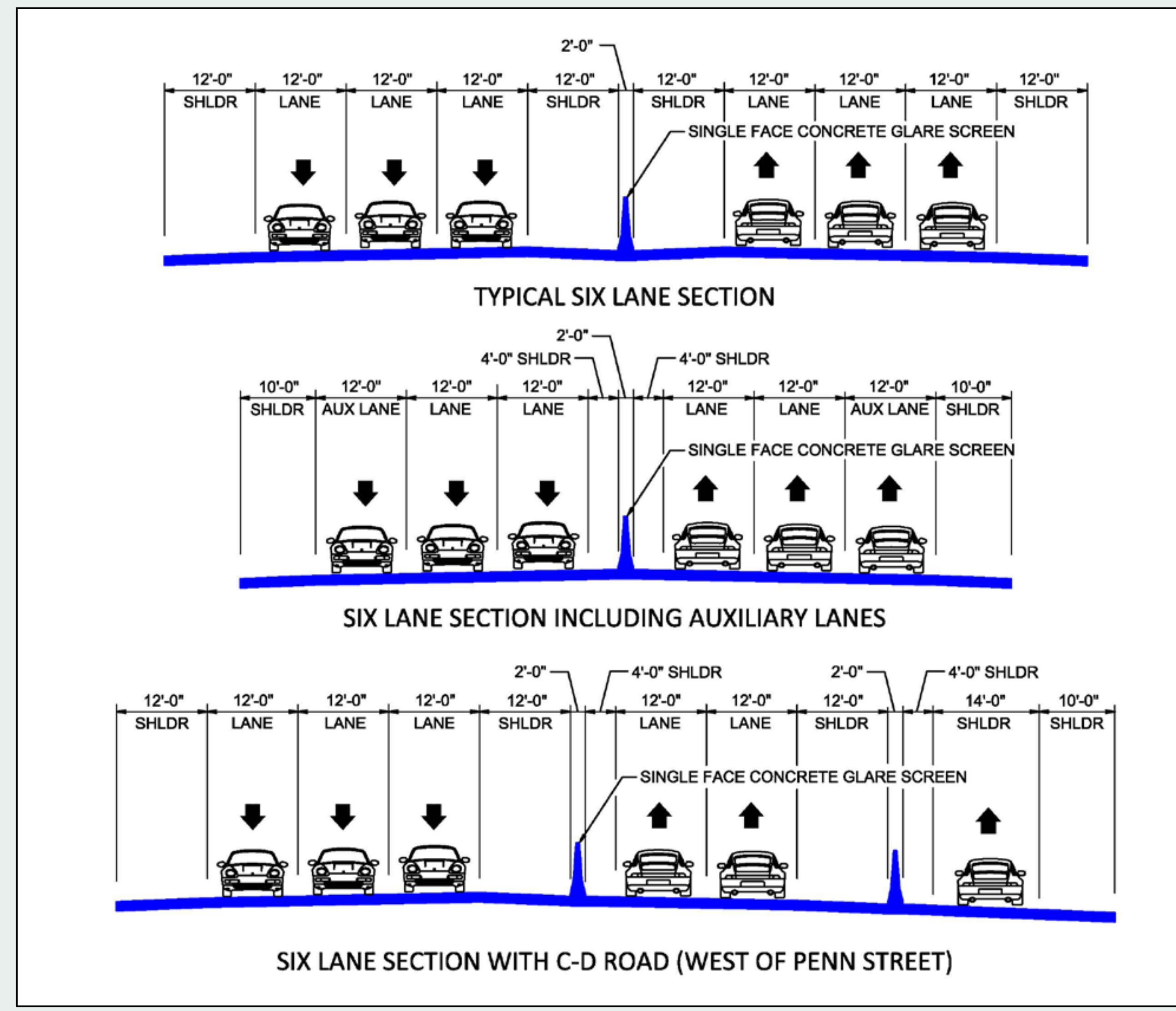
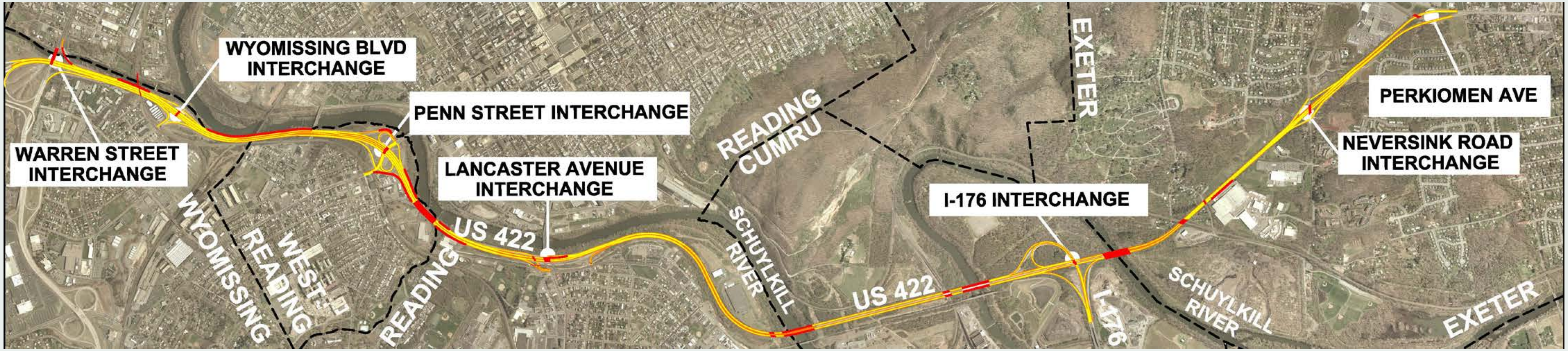



**Figure 28: Proposed Six Lane Options**




Although most overhead and mainline bridges are assumed to be replaced close to their current alignment using staged reconstruction, several bridge replacement options within the project area were developed considering one or more of the following factors:

- Maintenance and protection of traffic
- Interchange configuration
- Necessity for a replacement structure
- Presence of existing adjacent structures to remain
- Geologic and geographic constraints
- Highway design criteria
- Right-of-way concerns.

Examples of how these factors drove bridge replacement options are examined further in the following sections of the study and include:

- The three Schuylkill River crossings are non-redundant structures and require all traffic to be removed before demolition. This influenced development of the staged traffic options for the reconstruction of the highway and bridge structures in the eastern portion of the study area.
- Replacement bridge structures at the Lancaster Avenue Interchange depend on the reconfiguration options evaluated, the vicinity of the adjacent Bingaman Street Bridge and the need to eliminate left lane ramps.
- The mainline in the west end of the study area in the vicinity of the two railroad overpasses is enclosed between the piers to the north side and rock outcrops the south side. These piers must be removed to allow for a wider roadway below, but it may not be necessary to replace the entire structure.
- The current Thun Trail Bridge has several spans over a road and trail that may be relocated to allow for complete or partial removal of the entire structure. In addition, its vicinity to adjacent properties and vertical alignment requires placing retaining walls along this stretch of the study area.

Some bridge sites were considered to be potential candidates for utilizing accelerated bridge construction (ABC) techniques for reconstruction. This includes utilizing both accelerated construction techniques and prefabricated bridge elements and systems (PBES) to complete a bridge replacement more quickly than conventional construction.

Several sources were consulted to determine which structures would benefit from ABC techniques to accelerate bridge construction. These sources include:

- FHWA; Accelerated Bridge Construction Manual, 2006; Publication No: HIF-12-013
- Washington State DoT; Strategic Plan on Accelerated Bridge Construction, 2009
- Utah DOT; Accelerated Bridge Construction Decision Making Process, 2010
- NJTA; Policy and Guidelines for Accelerated Bridge Construction, 2012; Summary Report OPS-A3240.
- FHWA/IN/JTRP; Review Construction Techniques for Accelerated Construction and Cost Implications, 2009

The primary driver for consideration of using ABC is the duration of closures and resulting effects to the road user. For this study area, ADT is relatively high but reconstruction of the bridges on the mainline will generally coincide with the reconstruction of the roadway and thus provide minimal benefit from accelerated construction. In addition, accelerated bridge construction typically adds a 10 to 30 percent premium to the cost of construction. Therefore, this additional cost will not be justified for many of the bridges over the mainline that have relatively low ADT.

The interchange and railroad overpasses were the two location types that were examined further for ABC techniques. The interchanges with higher ADT were examined since the replacement structure could be on the critical path in the construction schedule.

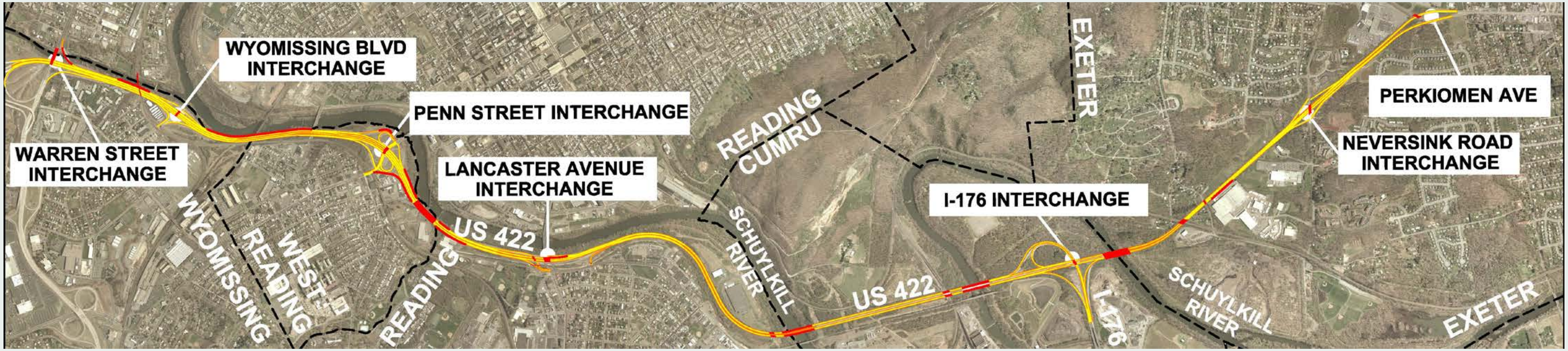
The railroad overpasses in Section 1 have high traffic and will likely allow only very short duration closures during construction. Therefore, only these site types were considered for exploring ABC techniques and/or prefabricated bridge elements (PBES) for replacement and will be discussed later in each Section discussion.

Proposed structure replacement options for the entire study area were developed assuming the replacement structure would maintain the existing alignment and skew as well as carry the current number of travel lanes over the design roadway being crossed. The estimated span lengths were used to develop proposed superstructure depths based on the type of beams likely to be used for the replacement. These structure depths were used to set required underclearances for overpasses when developing the proposed vertical profile of the mainline. Design lane, shoulder and barrier widths were assumed to estimate the replacement structure width. (Appendix D).

### Retaining Walls and Rock Cuts

Based on the Study, the widening of the roadway throughout this corridor will require walls and rock cuts at various points along the mainline. The assumption was made that right-of-way will be taken where the highway is to be widened in order to provide adequate slopes except at locations along the mainline where the highway alignment is generally influenced by geologic or geographic features such rock outcrops, water bodies and areas of large urban development. In these areas, retaining walls and rock cuts were assumed to minimize impacts to these site features.

In the western Sections 1 and 2, walls will be required to minimize encroachment into the south shore of the Schuylkill River and Tulpehocken Creek at various locations where the highway fits tightly between these

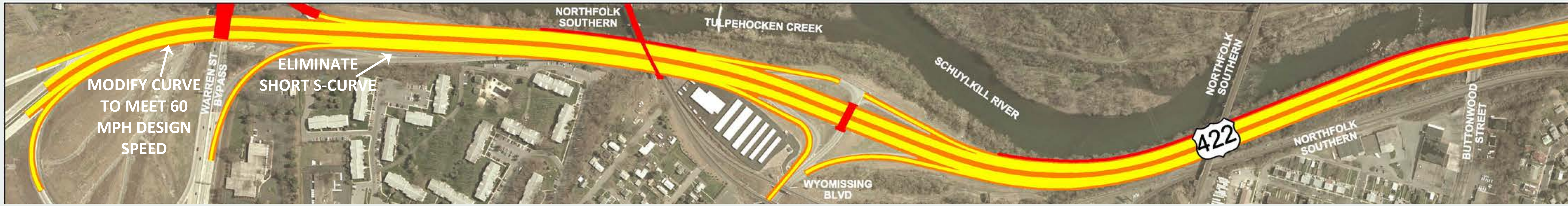



water bodies to the north and the rock cuts that are present to the south.

The Penn Street Interchange reconfiguration will require retaining walls to mitigate impacts to adjacent properties and the south shore of the Schuylkill River. Just east of the Penn Street Interchange, the Thun Trail bridge replacement options involve the use of retaining walls to eliminate portions of the spans that are no longer needed.

At the Lancaster Avenue Interchange, due to the vicinity of the Bingaman Street Bridge to the westbound mainline bridge, a grade separation retaining wall may be needed between westbound mainline traffic and the westbound on- and off-ramps to Lancaster Avenue.

Further east, in the vicinity of West Neversink Road, there are commercial and residential properties adjacent to the mainline. Retaining walls may be required in order to avoid impacting the right-of-way of these properties.




## Section 1 – Warren Street Bypass to Penn Street Interchange

### General

The design for this section utilizes the six lane typical section discussed previously. As indicated in the traffic section, it was determined that this roadway section required six lanes, three in each direction. With the four-lane typical section on US 222 north of the project area, an evaluation was conducted to determine where to drop the additional westbound lane and start the additional eastbound lane. The lanes can be added/dropped east of Warren Street or carried past the Warren Street overpass.

When considering the traffic volumes and continuity for the westbound side, the lane should be dropped at the ramp to US 222 south/US 422 westbound. This ramp carries the higher volume and is the continuation of US 422. This ramp is north of the Warren Street overpass, requiring three westbound through lanes under the structure. The existing span width and lane orientation under that structure (four lanes with 12' shoulders and a 4' median) require the structure to be replaced. Replacing the structure allows more flexibility on the eastbound side. Both the Warren Street southbound loop ramp to US 422 eastbound and the US 222 northbound ramp to US 422 eastbound have approximately the same traffic volumes, making both ramps suitable for adding a lane. Assuming the structure is to be replaced, it is proposed to add the US 422 eastbound lane starting at the Warren Street southbound loop ramp which also provides the opportunity to address the insufficient acceleration length on the ramp (**Figure at top of page**).

When modeling the new section throughout the corridor, it was determined that the four existing overpasses (two Norfolk Southern bridges, Wyomissing Boulevard and Buttonwood Street) did not have long enough spans to accommodate the wider mainline section.

### Structures

The western Norfolk Southern railroad viaduct carries one track across US 422 and the Tulpehocken Creek (**Figure 29**). The eastern Norfolk Southern Bridge carries two tracks across US 422 and the Schuylkill River (**Figure 30**).

**Figure 29: Western NS Railroad Viaduct over US 422**

There are currently six lanes under the western Norfolk Southern bridge (one track bridge) with shoulders and median that do not meet current criteria; therefore, to avoid design exceptions, it will need to be replaced to accommodate a typical section that meets current criteria. US 422 passes beneath the bridge between a rock outcrop and a bridge pier. Even though the girders are straight, the railroad alignment in the area is curved. Thus, the existing geometry can accommodate a replacement off line, eliminating the need for a temporary structure and eliminating the need for the additional cost of accelerated bridge construction (discussed later).


**Figure 30: Existing Norfolk Southern Crossing**

It should be noted that although this bridge only carries one track, the rail line on either side of the bridge contains two tracks. Thus, coordination will be required with Norfolk Southern as they will likely request two tracks for a replacement bridge. For this study, it is assumed that Norfolk Southern will require this bridge to carry two tracks to avoid the bridge being a constraint to the railroad's operations. During the design phase, the cost sharing for this bridge replacement should be discussed with the railroad.

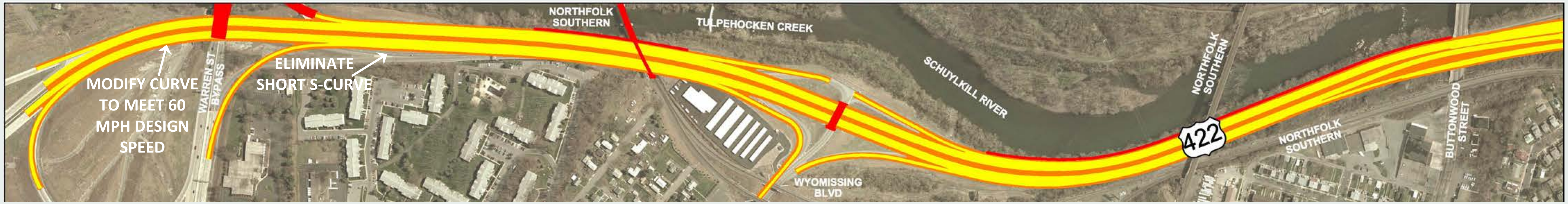
Assuming two tracks will be required, building the off-line replacement can allow one track to be built with minimal disruptions to rail and US 422 traffic. After the main portion of the bridge is constructed, the ends could be tied into the existing tracks to divert rail traffic onto the new structure. With rail traffic on the new bridge, the structure carrying the second adjacent track can be constructed where the existing bridges currently exist. After construction of the second track, interlockings on both approaches can be constructed to accommodate a two track alignment in accordance with Norfolk Southern's requirements. As previously mentioned, if the railroad requires two tracks, it will be important to coordinate the costs to be borne by the Department since the railroad would be upgraded in this area.

The eastern Norfolk Southern overpass (**Figure 30**) currently has four lanes with substandard shoulders on US 422. Thus, the bridge, or a portion of it, will have to be replaced to allow for the proposed roadway section to meet current criteria. Similar to the railroad bridge to the west, US 422 fits tightly between a rock outcrop and a bridge pier. This railroad alignment is also on a curve, similar to the western railroad bridge.
There are three options for constructing this 7-span bridge:

- Replace the entire structure in-line
- Replace the entire structure with a partial shift
- Replace only the impacted spans in line.

**Replace entire structure in-line**: Because this structure is a dual structure supporting two tracks, it may be possible, with approval by the railroad, to replace the bridge while maintaining one track. This can be done by installing interlockings to direct traffic onto one track while replacing the adjacent structure. Then the staging can be reversed, where rail traffic is diverted onto the new one track bridge while the second track bridge is replaced. The resulting bridge will be in the existing footprint which will minimize impacts.

**Replace the entire structure with a partial shift**: If the railroad requires two tracks to be maintained, the structure can be replaced in a similar way as the previous option, but with the first stage built off-line. This will allow the two existing tracks to be maintained




while a third track is built. After tie-ins, the traffic on one track could then be shifted to the new bridge allowing two tracks to be maintained while one of the existing bridges (for one track) is replaced. At the end of stage 2, there would be two new bridges and one existing bridge. Thus, the final stage would be to divert traffic onto the two new bridges and remove the third track. The final result would be a bridge that is partially shifted by one track. For the purpose of cost estimate for this study, this option is assumed as the highest cost of the options.

**Replace only the impacted spans in line**: The option that likely would be the least cost option would be to replace only the impacted spans in-line. Because there is excessive vertical clearance over US 422, it could be possible to replace the span over the mainline with a longer structure supported by new piers. The adjacent spans could then be replaced with shorter spans so the resulting loads on the existing piers are not increased (**Figure 31**).

This would require the railroad to agree to maintain a single track for portions of construction.

To minimize impacts to rail traffic, the substructure elements can be built below the superstructure without affecting rail traffic. The existing pier caps would likely need to be reworked slightly, but this effort would be minimal if the geometry of the new shorter spans mimicked the existing.

To minimize the duration of the track outages, the new girders can be constructed slightly deeper than the existing so that the new piers can be completely constructed without impacting the existing structure. The ends of the girders could then be dapped, if required, at the existing piers where it is desirable to minimize geometry changes/pier modifications.

To further minimize impacts to rail traffic, ABC methods (e.g. roll-in structure on temporary bents) and prefabricated bridge elements (precast deck, modular superstructure) can then be used (while always maintaining one track) to replace each track separately with only short disruptions to the impacted track. This will result in less and shorter track outages and will reduce overall construction duration.

The other notable bridge in this section is the Wyomissing Boulevard Bridge. To accommodate a proposed section that meets current criteria, it will need to be replaced. Due to the low traffic volumes at this interchange, it is anticipated that this bridge can be replaced under a detour.

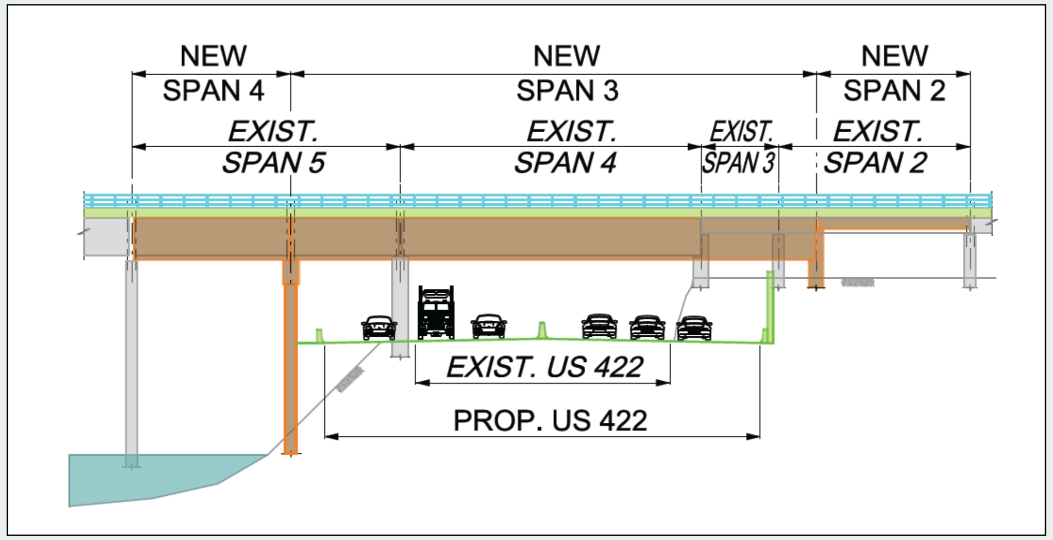



**Figure 31: Option to Replace Only Impacted Spans on Rail Road Bridge**

## Roadway

When modeling the new section throughout the corridor it was noted that the widened roadway will encroach upon Tulpehocken Creek's existing FEMA floodplain starting just west of the first Norfolk Southern overpass to the Wyomissing Boulevard Interchange. It also encroaches on the Schuylkill River's FEMA defined floodplain east of Wyomissing Boulevard Interchange to the Buttonwood Street overpass.

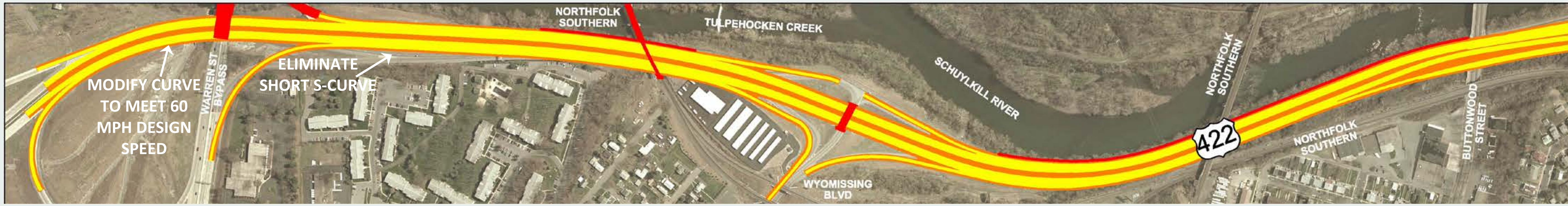
Relocating US 422 to the south, away from the Tulpehocken Creek, would require impacting the parallel Norfolk Southern rail lines, an apartment complex and a self-storage business. As mentioned previously, any flood raise over 0.01' would require the acquisition and removal of any impacted structure within the floodplain. Impacts to the north shore of the Tulpehocken Creek and the Schuylkill River in this area were reviewed to determine how many, if any, structures would be impacted.

The north shore of the Tulpehocken Creek and the Schuylkill River in this area is much lower than US 422 on the south side. Therefore, any widening on the US 422 side will have a larger impact on the north side. There are no structures impacted along the Schuylkill River north shore in this section. Therefore, the floodplain encroachment along the Schuylkill River can be mitigated by the acquisition of Occasional Flowage Easements on the north side of the River.

Along the Tulpehocken Creek the documented flood elevation is elevation 213. This elevation starts at the confluence with the Schuylkill River and extends upstream above the Warren Street Bypass. The FEMA elevation of the Tulpehocken Creek is most likely set by backwater of the Schuylkill River and not flow in the Tulpehocken Creek. An encroachment of the floodplain by the project on the Tulpehocken Creek has the potential of not impacting the FEMA floodplain and therefore not impacting the single Stonecliff Recreation Area structure that exists (a pavilion with restrooms and a utility closet, **Figure 32**). With the Stonecliff Recreation Area structure being upstream of the encroachment and realizing that the flood raise may dissipate before the structure, it is uncertain of its potential as a regulated structure.

For this Study, it was decided to show the road impacting (**Figure 33**) the floodplain and not impacting the adjacent properties. This impact can be better determined during preliminary engineering.
An alternative six lane mainline typical section (mainline option B, **Figure 34**) was analyzed through the corridor west of Buttonwood Street bridge. As discussed previously, in this option the eastbound lane configuration is modified from three adjacent lanes to two lanes and a separate C-D Road for the third eastbound through lane. This option separates the traffic utilizing the ramps from the through traffic, minimizing its impact on through traffic. As shown in **Figure 34**, the impacts associated with this option are


**Figure 32: Stonecliff Recreation Area Pavilion**




larger than the six lane option. The traffic analysis showed no additional benefit, and the cost is higher. Additionally, the approach signing required to inform drivers that they need to exit near Warren Street to get to Wyomissing Boulevard and Penn Street was difficult and confusing.

When applying the six lane section through the Buttonwood Street Bridge, the Study looked at the width of the existing spans. The current configuration contains substandard shoulders and a widened median to accommodate the center pier which is skewed to US 422 (**Figure 35– Existing Condition**).

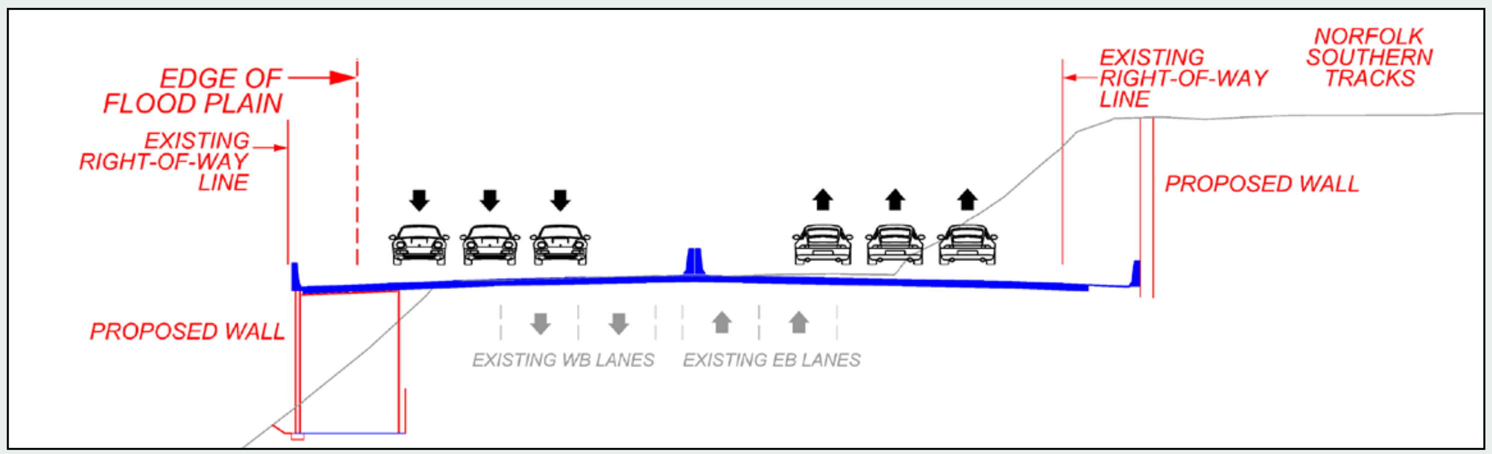
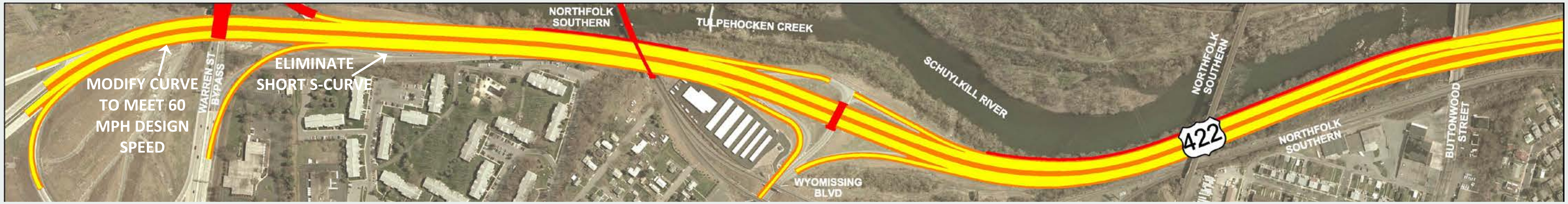



Figure 33: Proposed Roadway Cross Section Showing Floodplain Encroachment

Figure 35: Buttonwood Existing Condition


Figure 34: Section 1 Mainline Option B




It was determined that there is 50 feet between piers if the road is realigned to be parallel to the piers. Even when the section could be realigned to be parallel to the piers, substandard shoulders will exist in the proposed condition.

Since there is an unused span adjacent to the span passing the eastbound lanes, the Study looked at the option of a C-D road since the amount of traffic utilizing the Penn Street Interchange (the cloverleaf interchange to the east) would lend itself to this potential option. The configuration through the Buttonwood Street Bridge in this option would add a C-D Road in the currently unused south span that would consist of two lanes (including the ramp). The two eastbound through lanes would use the existing eastbound span with three westbound through lanes using the westbound span (**Figure 36– Proposed Condition**). There are still design exceptions required for vertical clearance at all three spans, but the shoulder width design exception will only be needed in the westbound span. Also, utilization of the C-D Road relaxes the criteria for acceleration/deceleration lane length because of the lower design speed and also relaxes the criteria for ramp spacing. In the tight confinement of the Penn Street Interchange, this is helpful.

The US 422 reconstruction plans to avoid impacts to the Buttonwood Street Bridge during roadway reconstruction. The option to use the third unused span for construction of an eastbound C/D road will likely require thicker pavement boxes than the current pavement. Thus, careful consideration of the location of the existing Buttonwood Bridge footings will be required since it is expected that the roadway will take the entire width of the spans that will carry traffic.

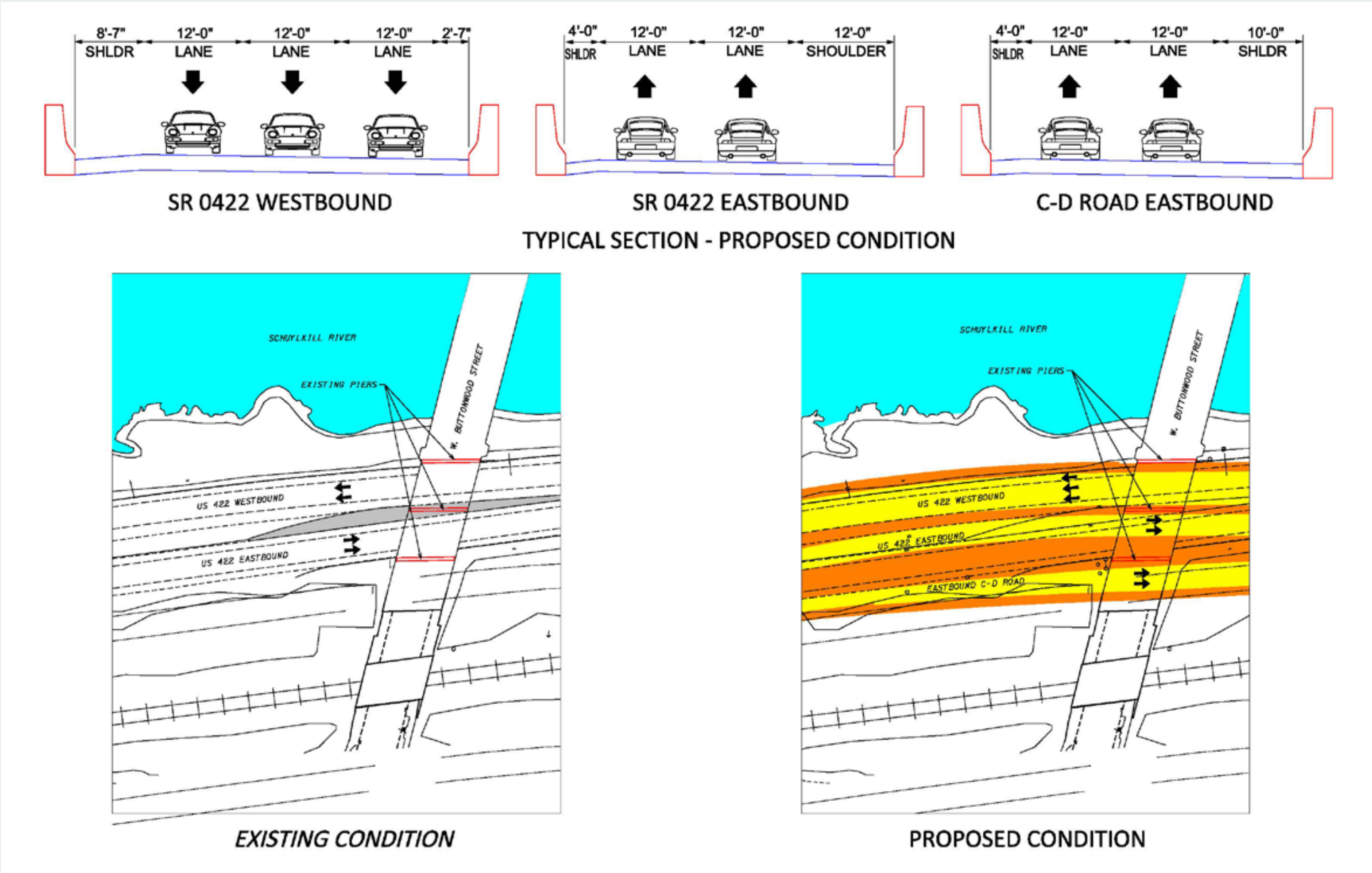
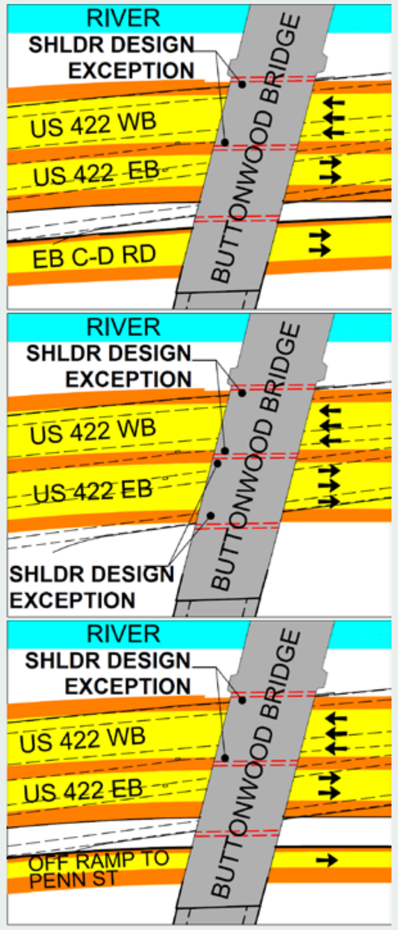
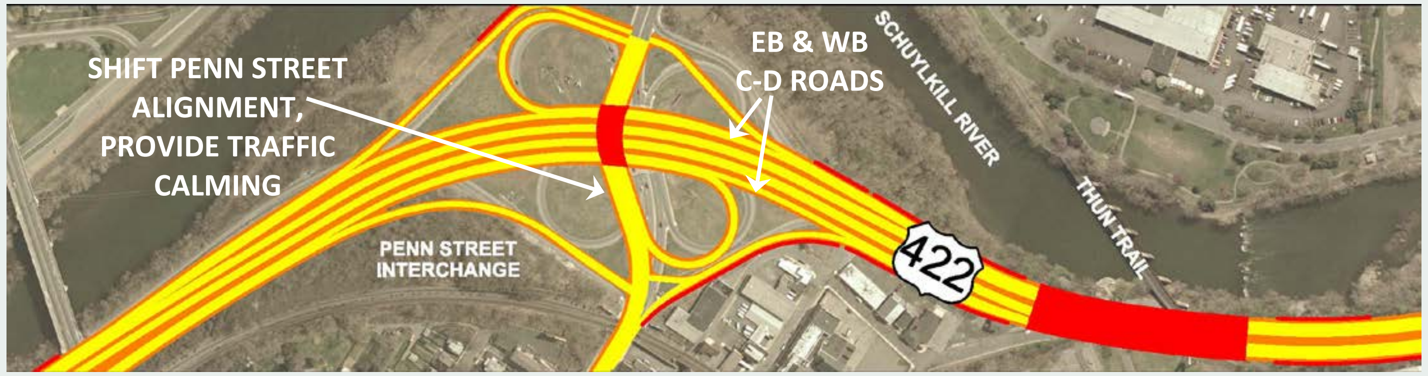



Figure 36: Buttonwood Street Existing and Proposed Condition







## Section 2 – Penn Street Interchange to Lancaster Avenue Interchange

As discussed in previous sections of this Study, it was determined that this portion of US 422 required six lanes, three in each direction. When modeling the new section, it was determined that the widened six-lane roadway would encroach upon the existing FEMA floodplain before any slopes are applied. As previously discussed, any floodraise over 0.01' would require acquisition and removal of any impacted structure within the floodplain.

The north shore of the Schuylkill River in this area was reviewed to determine how many, if any, structures would be impacted. The river and the north shore is much lower than US 422 in this area. Unlike in Section 1, there are a variety of structures in the floodplain which could be impacted by a flood raise and therefore would have to be purchased and removed.

To minimize impacts, the alignment was shifted to the south while holding the defined floodplain elevation contour as the northern boundary (**Figure 37**). This shifted US 422 to the south away from the River. This shift allows for the introduction of several horizontal compound curves which eliminates the existing undesirable broken back geometry.

Utilizing retaining walls from the end of the Thun Trail viaduct to approximately 1500' west of the viaduct, realigned US 422 is kept out of the floodplain and avoids flood impacts to the properties on the north side of the river as well as physical impacts to most of the properties south of US 422. The property along the south side beyond the retaining wall is occupied by billboards and the Thun Trail. The shift to the south brings the road closer to a commercial property building but does not physically impact it.

The existing Lancaster Avenue Interchange configuration presents operational and safety issues with the diamond-leg ramps entering and exiting from the US 422 left hand lanes. The interchange geometrics can be improved by "flipping" the location of US 422 with the ramps to a more conventional diamond. The alignment shift of US 422 was set to minimize construction impacts to the ramps. This realignment of the mainline, coupled with ramp reconfigurations, will minimize the amount of time the ramps need to be closed/detoured during construction. This interchange is discussed in more detail in a later section.

### Thun Trail

The Thun Trail bridge was originally built to span the railroad bridge that crosses the Schuylkill River and First Avenue. One track of the two track railroad bridge has since been converted to a pedestrian trail and now carries the Thun Trail into Reading. The remainder of the Thun Trail bridge spans First Avenue which essentially acts as a driveway into the RM Palmer facility and the parking lot under the bridge that serves the fishing dock (See **Figures 38 and 39**).

**Figure 38: Fishing Dock**

**Figure 39: Spanning the Thun Trail Bridge**

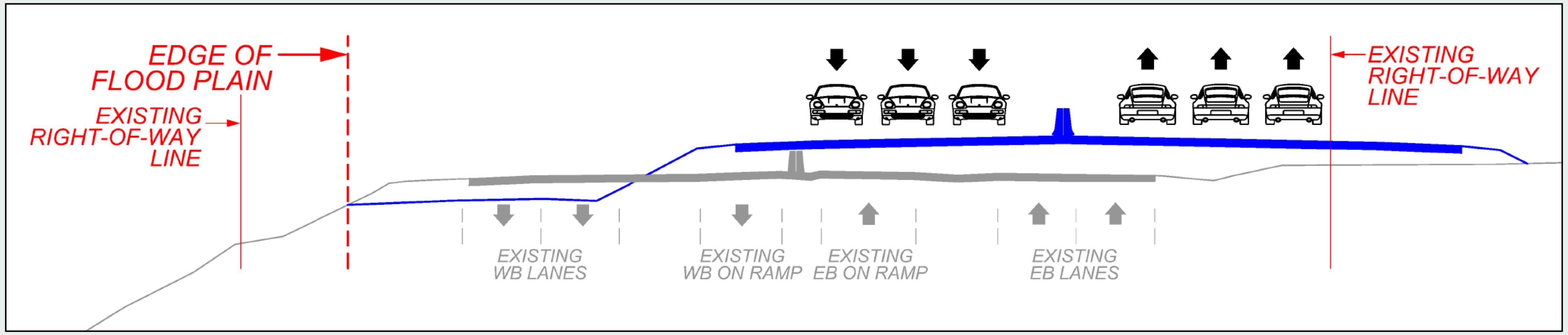
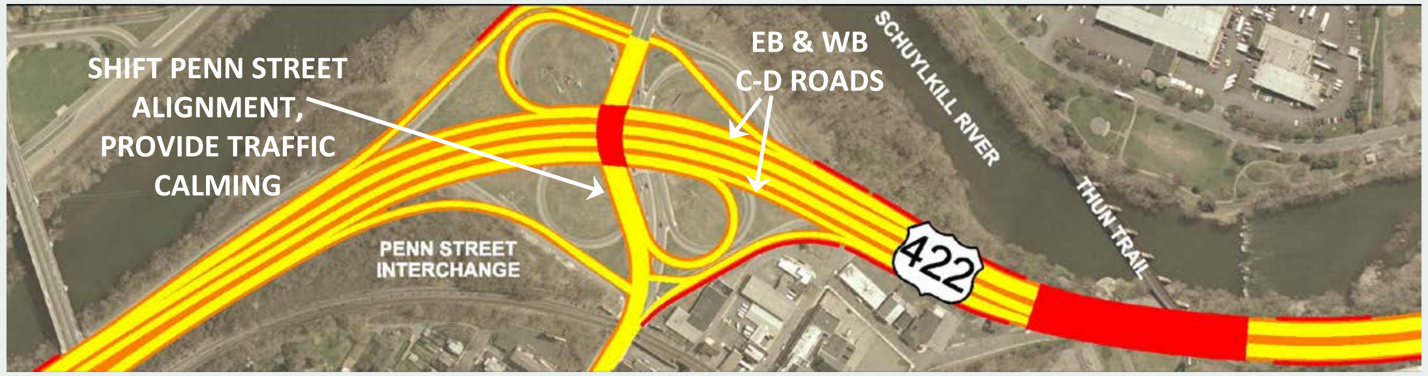



**Figure 37: Proposed Roadway Cross Section Showing Avoidance of Floodplain Encroachment**





Three options were evaluated for the Thun Trail Bridge:

- Option 1: In-Kind Replacment
- Option 2: Single Span Replacement
- Option 3: Eliminate the Bridge

As previously indicated, the design was developed to eliminate flood impacts to the Schuylkill River to avoid flood raise impacts to the north side of the river. As a result it was decided to hold the existing north parapet line and widen to the south. In Option 1, which involves a structure, the use of piers would code this area as ineffective flow, causing it to act in a stream model similar to an embankment or a wall.

Option 1 (**Figure 40**) replaces the existing bridge with a slightly shorter bridge with new retaining walls closing the existing end spans to allow all existing facilities to remain. In this option, the profile of US 422 can be lowered slightly since the required vertical clearance is less than the current clearance to First Avenue and the Thun Trail.

Option 2 (**Figure 41**) maintains the Thun Trail across the Schuylkill River via a much shorter single span bridge, with new retaining walls occupying the majority of existing spans. This option eliminates access to the fishing pier (including its parking) and closes First Avenue at the entrance to the RM Palmer Facility. With the fishing pier being a 4(f) resource, coordination will be required to determine the acceptability of this option; but it is anticipated that a more desirable location may be possible based on meetings conducted during this study.

For Option 2, consideration could be given to relocating the fishing dock to the northern end of the Thun Trail Bridge which could be retrofitted to serve as a fishing dock. Access to the RM Palmer facility could be relocated from Chestnut Street adjacent to the railroad tracks. In this option, the profile of US 422 could be lowered in a similar way as Option 1.

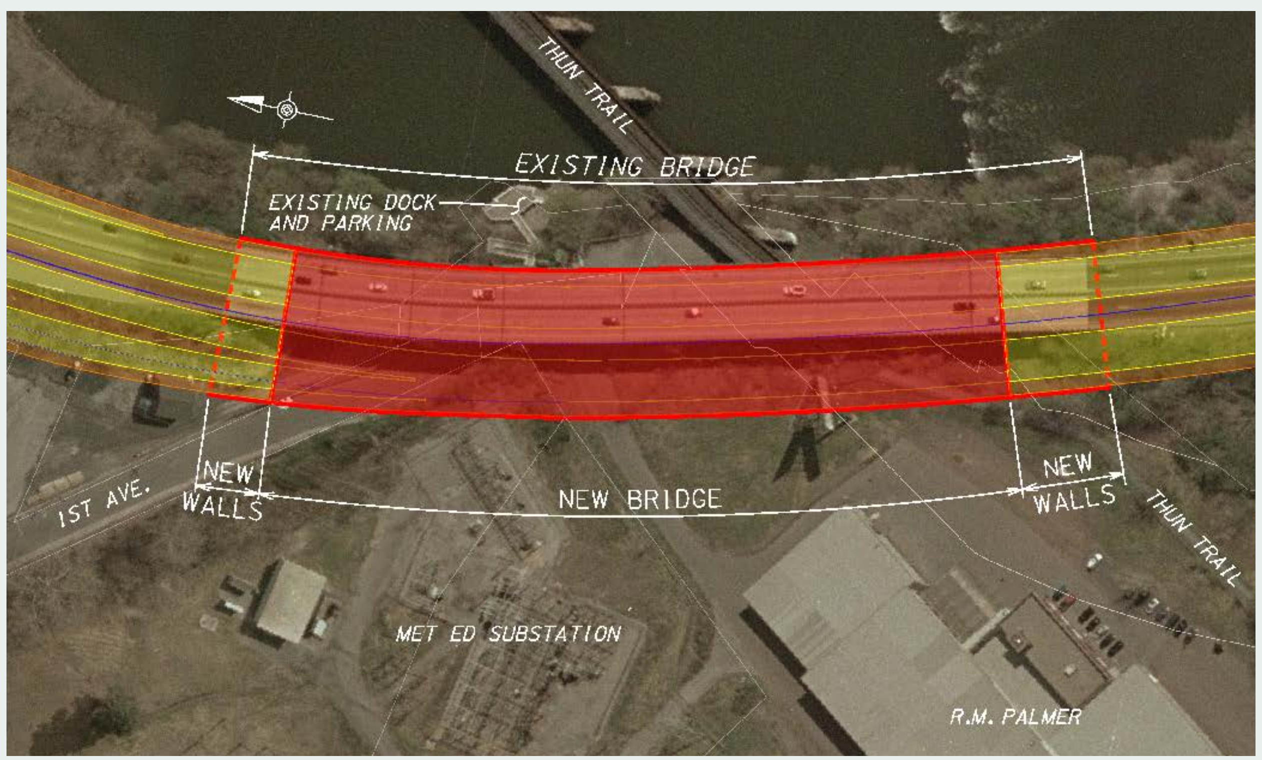



**Figure 40: Option 1 – "In-Kind" Replacement**

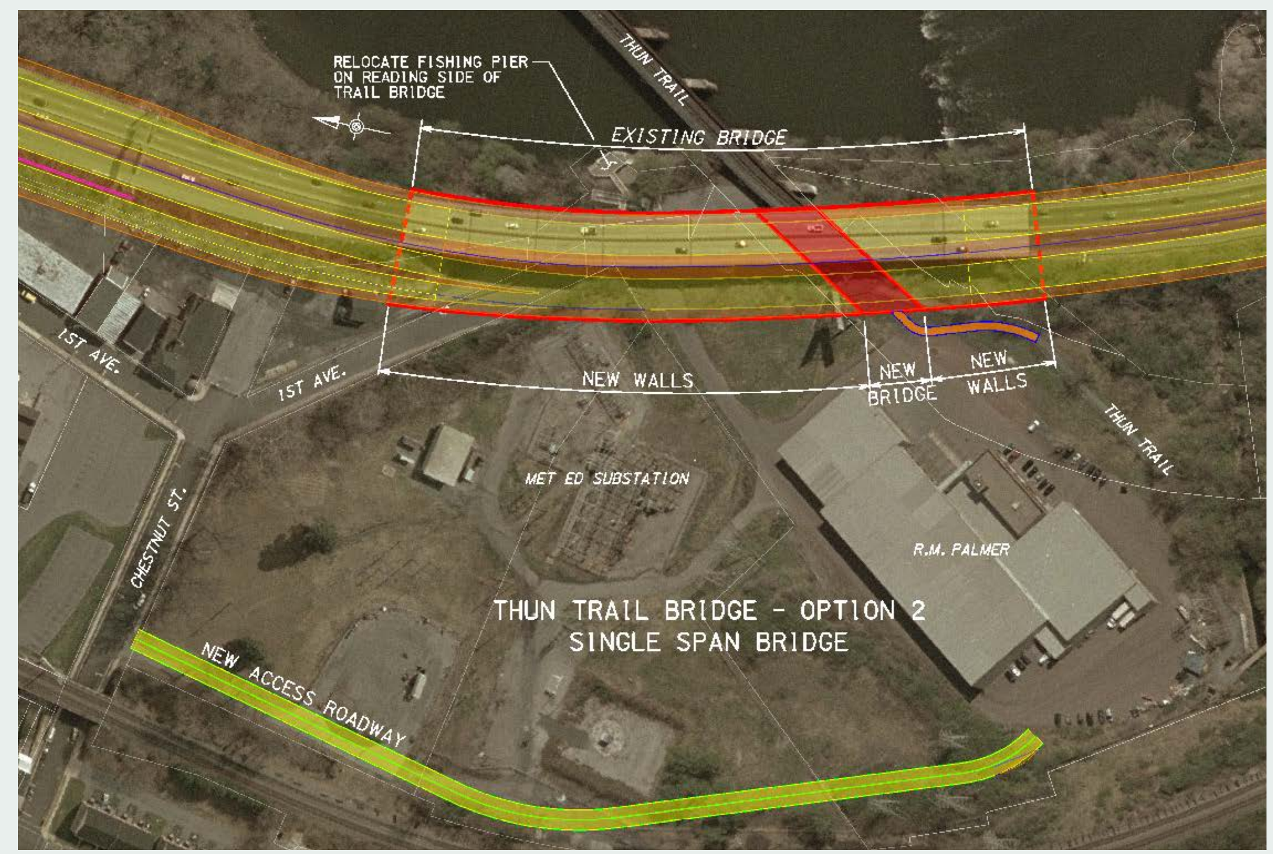
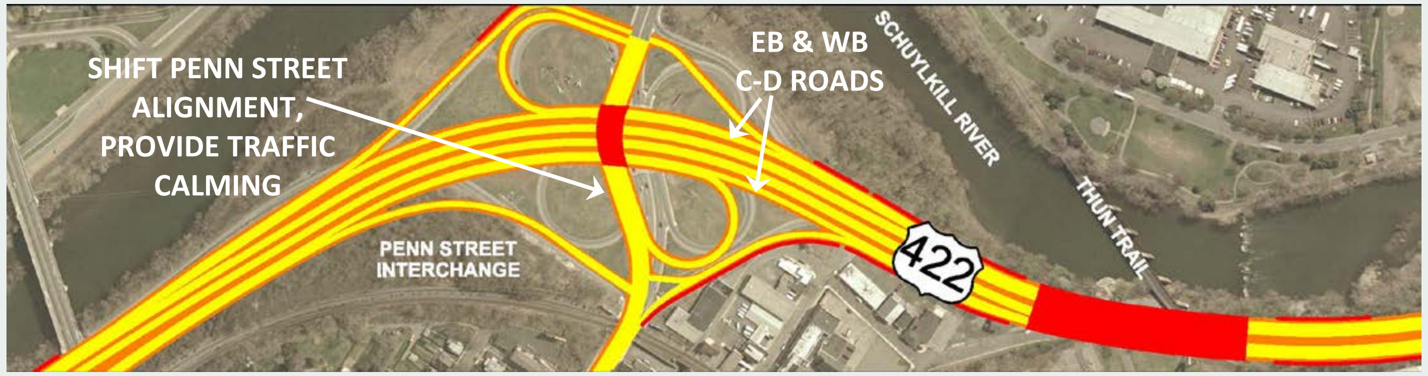



**Figure 41: Option 2 – Single Span Replacement**





Option 3 (**Figure 42**) eliminates the bridge and supports a much lower US 422 profile on new retaining walls. The Thun Trail would be relocated onto Chestnut Street and First Avenue and then cross under US 422 at the existing Franklin Street underpass. All three of these roadways have extremely low traffic volumes. In this area, the sidewalks and, if necessary, roadways could be upgraded to accommodate the relocated trail. After passing under US 422, the trail could then continue on the existing service road to Penn Street or use the existing ramp. The trail would then use the Penn Street Bridge to continue into Reading. This option does have the negative effect of placing the trail on roadways. It also would require coordination with the Penn Street Project.

All three options impact the Met-Ed property where a substation exists (See **Figure 43**). Although impacts to the actual substation are not anticipated, coordination will be required to determine the appropriate setback distance from US 422 to the substation. Further discussion is included in the utility section.

For Options 2 & 3, because of the clearance from ground to the underside of the deck, a portion of the retaining walls could be constructed while the bridge above is still in service, which would shorten the duration of impacts to traffic.

The Lancaster Avenue Interchange is included in this section. For details, refer to the Interchanges section.

**Figure 43: Standing Under Thun Trail Viaduct with View of Met-Ed Station**

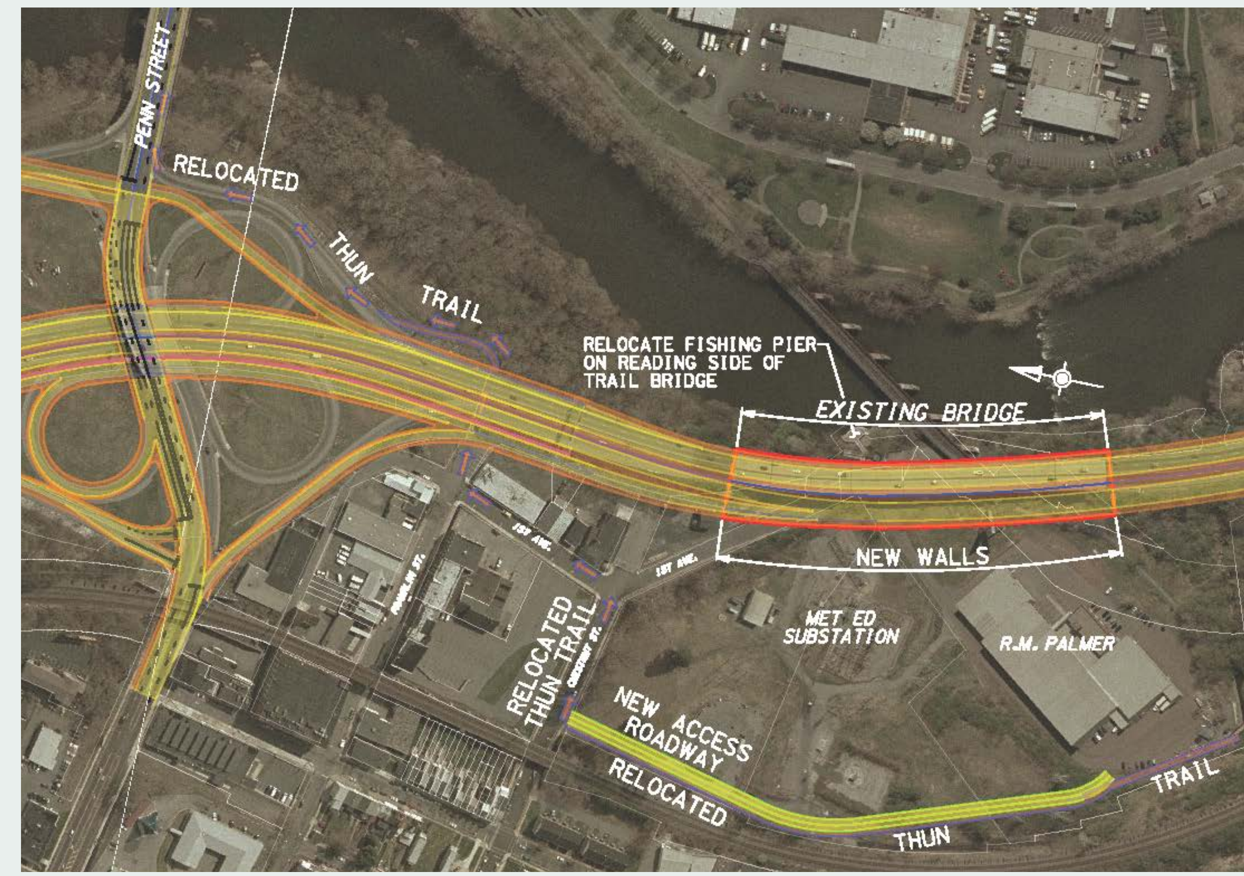
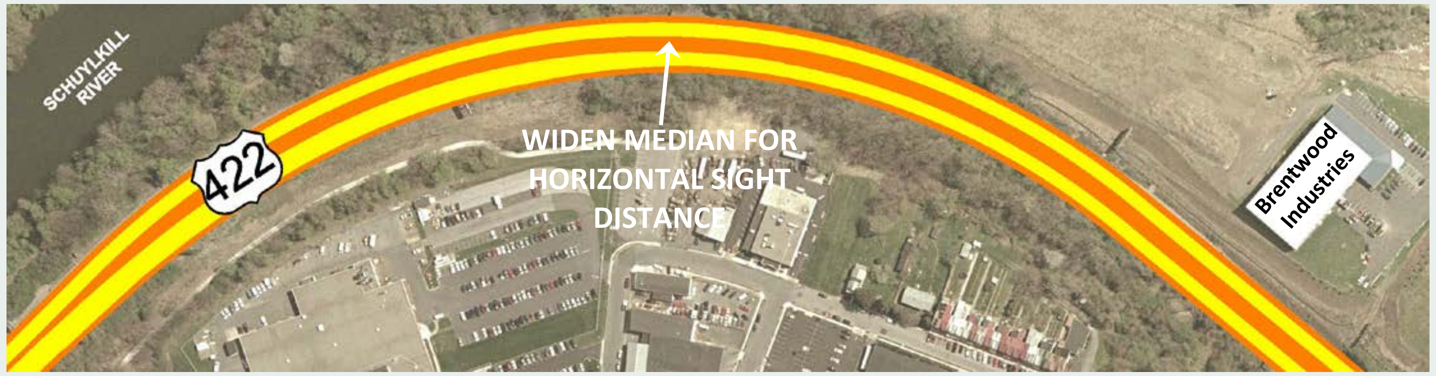
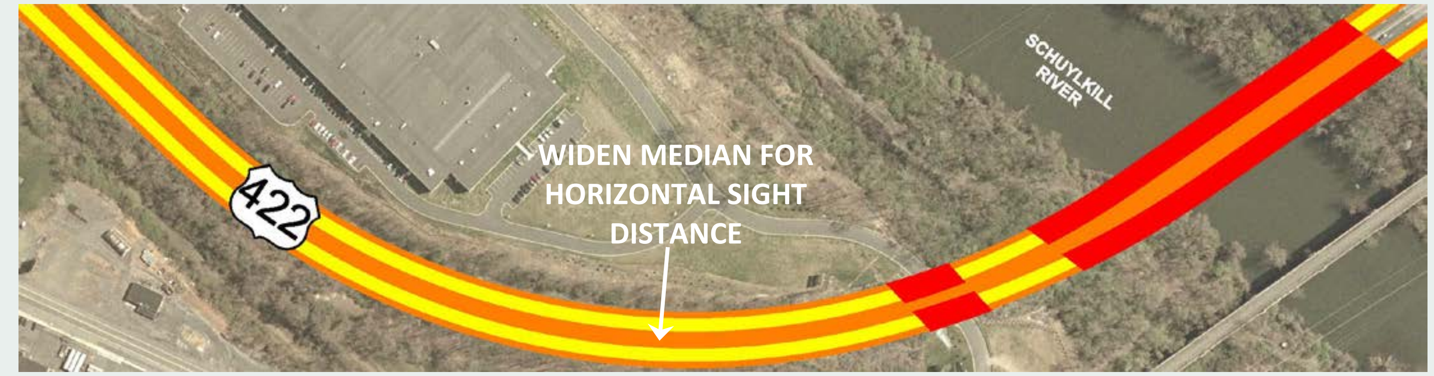



**Figure 42: Option 3 – Eliminate Bridge**




## Section 3 – Lancaster Avenue to I-176

This section begins east of Lancaster Avenue and retains four lanes. There are two horizontal curves in this section (see graphics above) which when analyzed require approximately 30’ of offset from the center of the left travel lane. The proposed cross section requires a 4’ inside shoulder but does not provide sufficient sight distance (when added to half the lane width). This results in the need to overwiden the median through both curves to provide the necessary sight distance. The median barrier would shift laterally through the S-curve in the wide median to provide appropriate sight distance (**Figure 44**).

As discussed in the Existing Conditions section, the western end of this section is flanked by the Brentwood Industries complex on the north and the Thun Trail on the south. Additionally, the Met-Ed transmission line is also on the south side of this section through the first curve. There is a berm at the top of the south side that in some portions holds the Thun Trail and in some sections screens the Thun Trail from US 422. The proposed alignment holds the existing westbound edge of shoulder through this section and widens to the south asymmetrically. This will eliminate an impact to the Brentwood Industries. This alignment impacts the Thun Trail, which would be relocated as some of it is currently in the Department’s right-of-way. The proposed roadway will be primarily in the existing right-of-way with additional right-of-way required to relocate the Thun Trail. The proposed design will impact some of the Met-Ed transmission line towers.

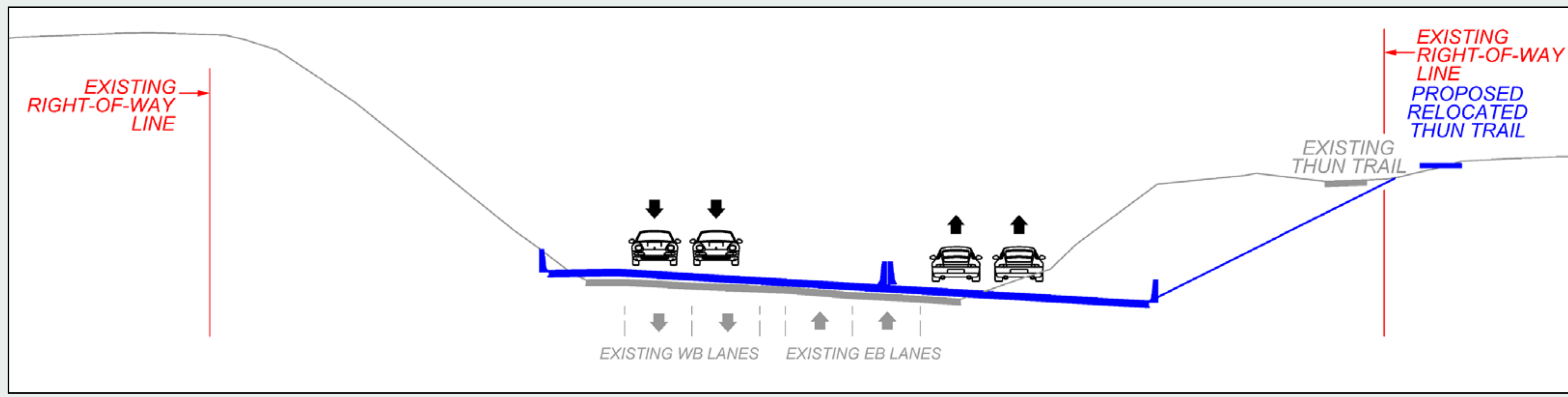
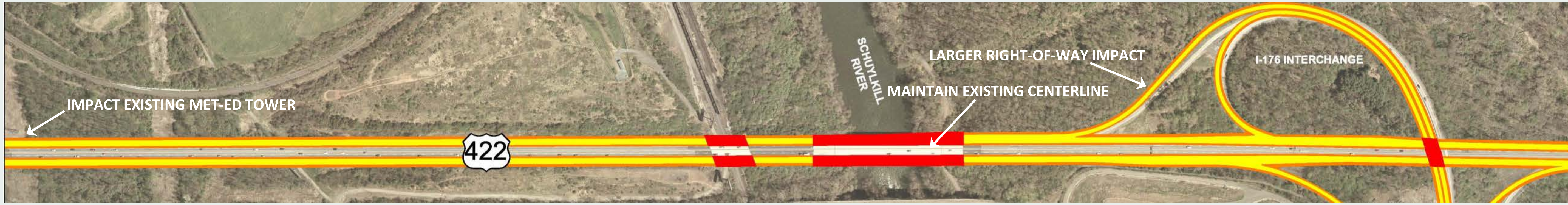



**Figure 44: Proposed Roadway Crossing Showing Asymmetrical Widening**




The western half of this section is essentially a tangent between the Brentwood Drive overpass and the I-176 Interchange. The replacement of the two mainline Schuylkill River structures are the most important influences in setting the US 422 alignment and the staged construction. The two structures are two-girder fracture bridges that have ongoing maintenance issues with limited remaining fatigue life. The structure type does not easily lend itself to partial width construction. Thus, two alignment options were developed in this area to allow for reconstruction of these bridges without the need for partial width construction.

The first option, Mainline Option A (**Figure 45 and above**), proposes to separate the mainline and builds enough of the eastbound and westbound bridges outside of the existing bridges to shift two lanes from the existing bridge onto the new portion of the new bridges. After traffic is shifted outside of the existing bridge footprint, the current bridge can be removed and the remaining portion of the new bridge constructed within the footprint of the current bridge. This option will maintain the existing centerline of US 422. To reduce future costs related to any future widening of US 422, this option could construct piers that are wider than the new bridges to accommodate a future widening in the median. If this is done while constructing the piers, then a future widening could be done without having to add foundations and widen existing piers. A similar approach could be done at the US 422 Bridge over Brentwood Avenue as well, if desired; however, the cost of a future widening at this bridge is less since pier construction is less difficult to access.

The second option, Mainline Option B (**Figure 46 and below**), proposes to shift the entire alignment to the south to build enough bridge to shift four lanes of traffic onto the new bridge outside of the footprint of the existing bridge. After traffic is shifted onto the new bridge, the existing bridge can be removed and the remaining portion of the bridge constructed within the footprint of the existing bridge. This option will shift the centerline of US 422 south.

Mainline Option A maintains the existing centerline but widens the proposed roadway by approximately 26’ to either side. This will require additional right-of-way on both sides to accommodate the added footprint. Another downside to this option is that the I-176 northbound on-ramp to US 422 westbound will have to be realigned to accommodate the mainline widening, requiring additional right-of-way. This option will also impact an existing Met-Ed transmission line tower.

Mainline Option B shifts the alignment to the south onto a property that is currently occupied by a Met-Ed distribution line and the Thun Trail, although both will not be impacted by the shift. The I-176 northbound ramp can be maintained within existing right-of-way, and the Met-Ed transmission tower is avoided.

To minimize traffic impacts, both options could be designed with span arrangements that clear the existing piers and footings so that most of the piers can be constructed under the bridge prior to impacting traffic. Hydraulic analysis would be required for the temporary condition when both existing and proposed piers would exist to confirm this would be hydraulically acceptable.

This section includes three ramps of the I-176 interchange and is included in a later section.

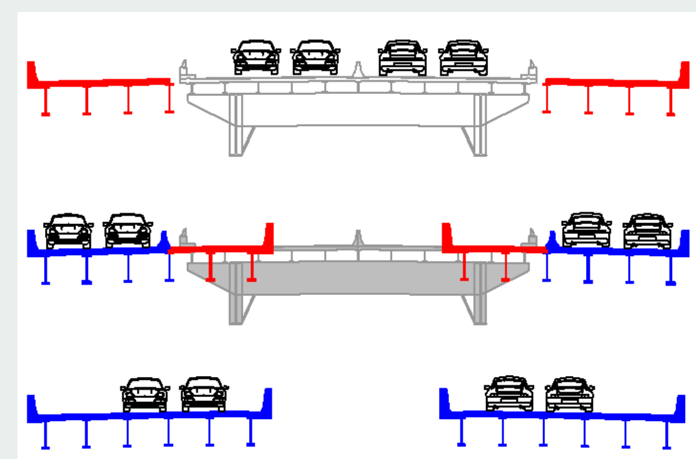


**Figure 45: Symmetrical Reconstruction**

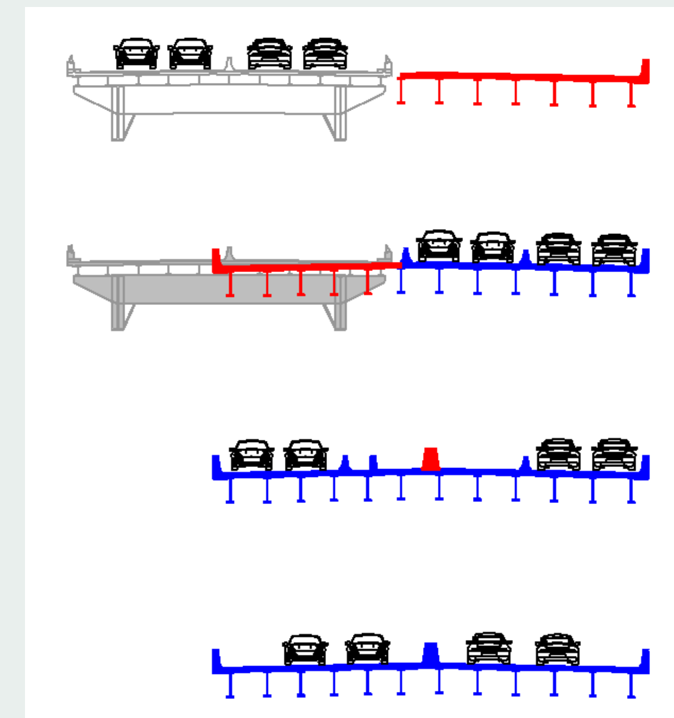
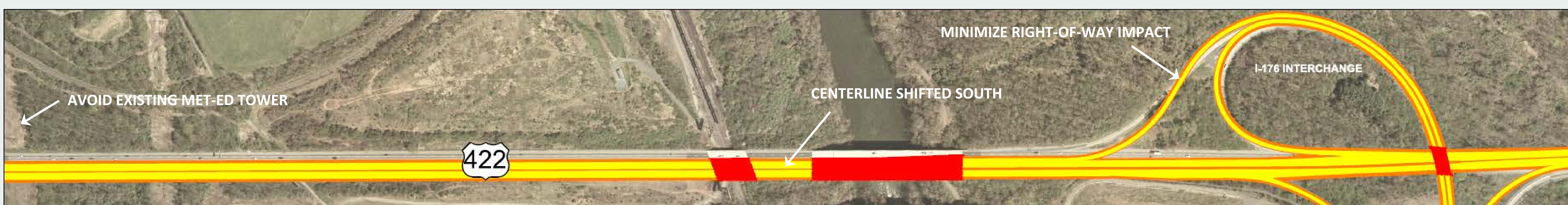
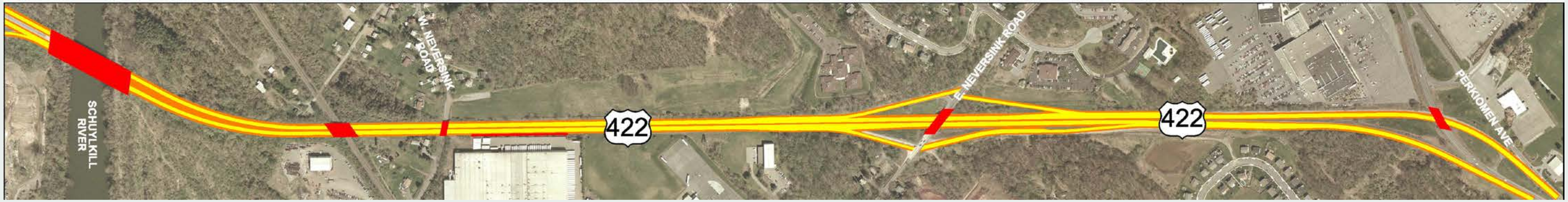


**Figure 46: Reconstruction with Alignment Shift**






## Section 4 – I-176 to Perkiomen Avenue

This section begins just east of I-176 and extends to the east end of the study area (**Mainline Option A, see above**). This section's alignment is primarily a curve east of the Schuylkill River crossing with the remainder being on tangent. A four-lane typical section symmetrical about the existing centerline is proposed. The wider slopes would require the acquisition of right-of-way. The configuration of the connection to Perkiomen Avenue is proposed to be maintained. The profile of US 422 would have to be raised to provide the required vertical clearance at West Neversink Road and at the Norfolk Southern crossing. The remainder of the US 422 profile can be maintained.

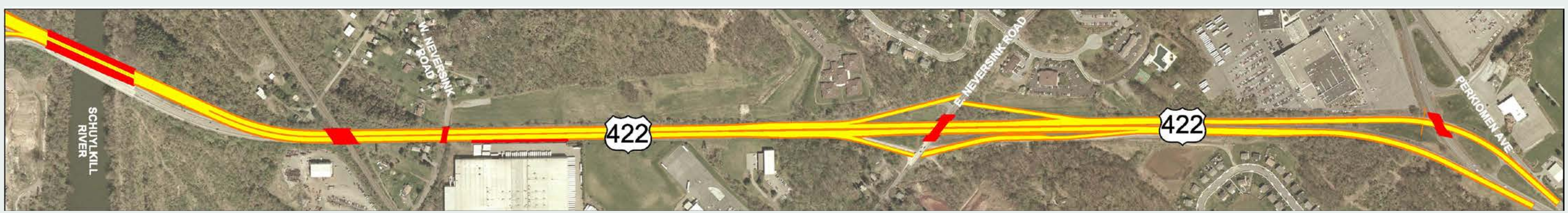
Some horizontal line modifications should be considered to minimize impacts to the adjacent properties. A westbound lane line shift at the shopping center located west of Perkiomen Avenue is a consideration. The Study recognized possible impacts from profile changes to the truck scale at the Mascaro truck yard. If the road is shifted to build the river crossing offline, a shift to the north **(Mainline Option B, see below)** would be desirable, as it would minimize the impact to this property, but that shift would impact properties to the north. The alignment could be configured such that the shift would tie back before the I-176 bridge, leaving this work separate from this construction stage, if desired.

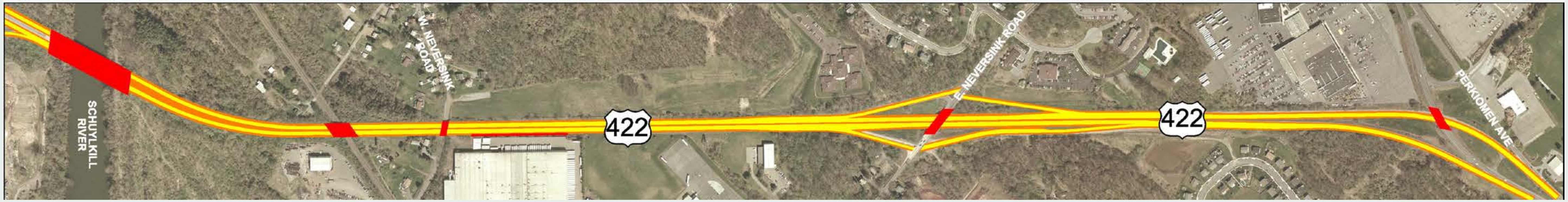
The structures in this section include four mainline bridges and two overpass bridges. Several of the bridges in these sections are typical multi-beam type and can be staged along with the roadway work. These bridges include Perkiomen Avenue over US 422 westbound, US 422 over West Neversink Road and US 422 over Norfolk Southern. There is one box culvert that carries a tributary under US 422. This culvert can either be replaced or extended to carry the new typical section.

The bridge carrying US 422 over the Schuylkill River is very similar to the other two bridges discussed previously, except that this bridge has an acceleration lane from I-176 northbound that extends across the bridge. The approach to construction of this bridge is similar to those discussed in Section 3 with the added complication of needing to maintain the on-ramp which can be accommodated with either Mainline Option.

The US 422 over Norfolk Southern bridge would require coordination with Norfolk Southern to determine if additional clearances to the tracks are desired. If so, the profile could be adjusted to accommodate a raised profile.

For discussion on the East Neversink bridge/ interchange, refer to the Interchange Section.






## Order of Magnitude Cost Estimates by Section

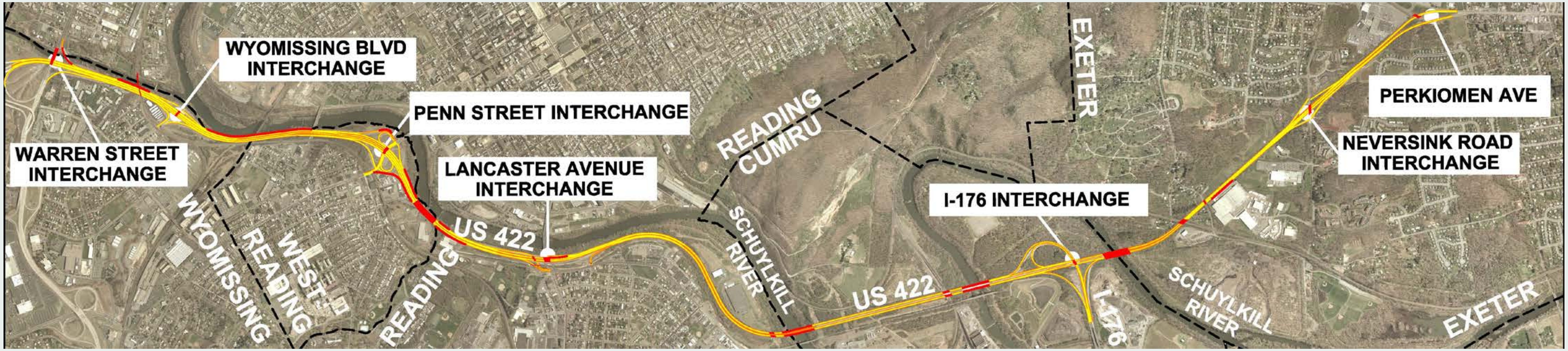
Costs for the corridor were determined by using the historic percentage of pavement and excavation costs for roadways affected, and these values represent the entire non-structure cost of the projects. The historic percentage is based on the cost data from large corridor projects (SR 0202, SR 0309, etc.). The costs of structures were added separately. This combined (structure and non-structure) cost was then increased using a 20% contingency and then escalated at 4% per year for a specified amount of years. Section 1 and Section 2 require a longer time frame (12 years) to construction as a result of complex coordination with outside entities (Met-Ed and Norfolk Southern). Section 3 and Section 4 are anticipated at 8 years.

Costs for each section for the mainline options discussed previously are illustrated in **Table 8.** Table 8 also includes details on potential Waterway Encroachments (USACOE-PADEP permit), Floodplain Encroachments (FEMA CLOMR), number of property acquisitions and description on total impact, Section 4(f) impacts and other pertinent issues.

The costs and impacts shown assume worst case scenarios. Certain mainline and interchange scenarios minimize impacts but were not assumed in this overall comparison. The cost of utilizing ABC techniques for bridge replacement was not considered in developing proposed costs.

| | Section 1 | | Section 2 | Section 3 | | Section 4 | |
|---|---|---|---|---|---|---|---|
| | A | B | A | A | B | A | B |
| **Name** | EB 2 lanes + C-D | EB 3 lanes adjacent | 6 lane | Symmetric Widening | Widen to the South | Symmetric Widening | Widen to the North |
| **Cost** | $225 million | $215 million | $147 million | $173 million | $173 million | $121 million | $121 million |
| **CLOMR** | Yes | Yes | No | No | No | No | No |
| **Waterway Encroachment** | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **Floodplain Encroachment** | Yes | Yes | No | No | No | No | No |
| **Property Acquisitions** | 20 | 20 | 8 | 21 | 19 | 30 | 26 |
| **Right of Way Impact Notes** | More acreage than Option B | | | | Similar acreage as Option A, but with less properties required | | Similar acreage as Option A, but with less properties required |
| **Section 4(f) impacts** | Possible | Possible | Yes | Yes | Yes | Possible | Possible |
| **Other Issues** | Separates EB through traffic from vehicles accessing three interchanges | Minimizes impact to adjacent properties | Option eliminates impact to Schuylkill River floodplain | | Minimize impacts to the north - avoid expanding I-176 interchange and impacting Met Ed Transmission tower | Impact Weigh Station - Increase right of way cost | Avoid Impact Weigh Station -lower right of way cost |

**Table 8: Mainline Summary Matrix**




## Interchanges

There are six interchanges within the defined corridor. The sixth interchange forms the western boundary. The interchanges are:

1. Warren Street (western boundary)
2. Wyomissing Boulevard
3. Penn Street
4. Lancaster Avenue
5. I-176
6. Neversink Avenue (access to & from west only).

The interchanges were evaluated for overall safety, operations and regional mobility.

### Warren Street Interchange

Only two ramps of this interchange were evaluated: the on-ramp to US 422 eastbound from Warren Street northbound and the US 422 westbound off-ramp to Warren Street. Both ramps are direct ramps and have advisory signs for 30 mph. The interchange as a whole is missing one leg (Warren Street southbound to US 222 northbound). The addition of this missing movement was not considered in the Study. Also, the work on the on-ramp to US 422 eastbound from Warren Street southbound is considered part of the Mainline projects.

According to the 2011 AASHTO Green Book, direct ramps at an interchange should have a minimum design speed of 40 mph. Both ramps are able to be reconfigured to meet the 40 mph design speed.
The proposed alignment is shown in **Figure 47**. There is a bridge carrying the WB ramp to Warren Street over Tulpehocken Creek (**Table 9**). Both ramps can be constructed offline with the tie-ins at the end. This will make MPT easier and will eliminate the existing undesirable broken back curve on the WB off-ramp. A retaining wall will be required adjacent to the US 422 EB ramp to minimize impact to the existing commercial property.

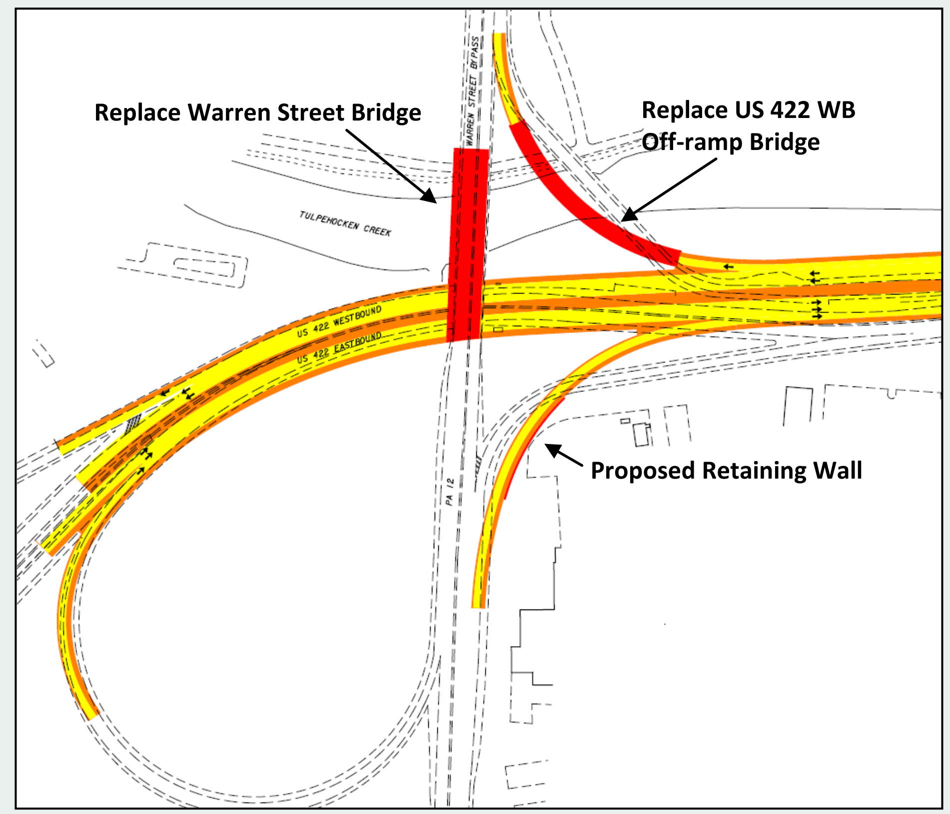


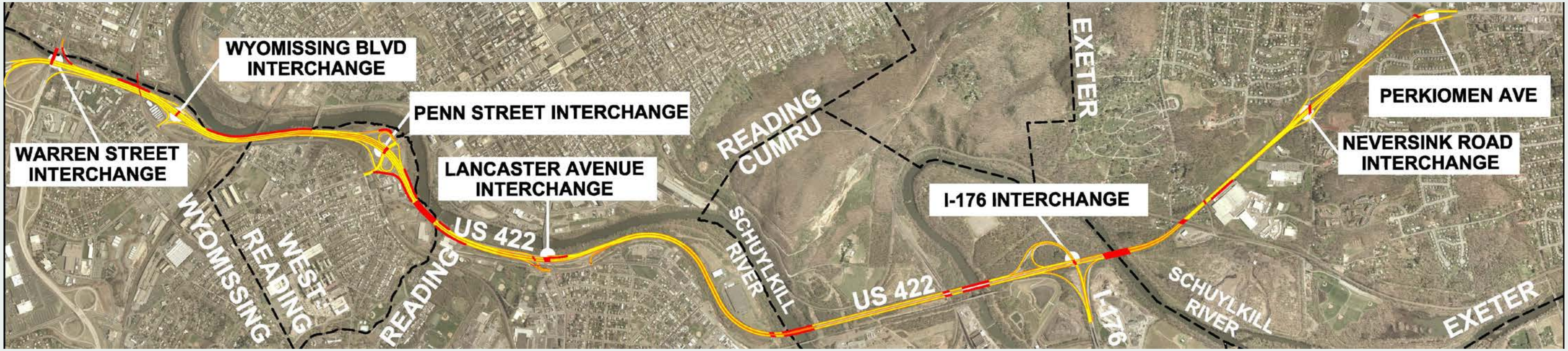

**Figure 47: Proposed Alignment**

| Feature Intersected | Facility Carried | BMS# | Structure Type | Suff. Rating | Structure Cond. | Condition Ratings | | | | Structurally Deficient (SD) / Functionally Obselete (FO) ? | Vertical Clearance |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Super. | Sub. | Deck | Culvert | | |
| Tulpehocken Creek & Montgomery Rd | Off Ramp from US 422 WB onto PA 12 EB | 06 8042 0010 0694 | 5 Span Continuous, Rolled Steel Stringers | 83 | 5 | 6 | 5 | 6 | N | FO | 14'-9" |

**Table 9: Ramp Bridge located at the Warren Street Interchange**

### Wyomissing Boulevard Interchange

The existing configuration of this interchange is a diamond ending at Wyomissing Boulevard. Wyomissing Boulevard ends at the interchange. This interchange currently meets all criteria and provides all movements. No upgrade is needed at this interchange, but it would still need to be reconstructed to allow for the wider corridor in order for US 422 to meet current criteria. It is assumed that work at this interchange will occur under a detour. This approach will accelerate the construction of the structure and the ramps at this location and also will minimize conflict points in a tight MPT corridor.




## Penn Street Interchange

The existing configuration of this interchange is a full cloverleaf with weave lanes on both US 422 and Penn Street. The weave lanes create safety issues for vehicles on US 422 and Penn Street and for pedestrians on Penn Street. Penn Street has sidewalks on both sides of the roadway, with a high pedestrian volume. The existing configuration does not easily allow pedestrians to use the sidewalks due to the fact that all movements are uncontrolled and, at some movements, there is minimal sight distance for drivers to see the crossing pedestrian. The local municipalities indicated that although Penn Street has a posted speed of 25 mph, it has become a high speed corridor as it physically resembles a highway through the interchange; the geometry of the road lends itself to higher speeds, as well as the lack of traffic control devices.

Considering US 422 as an east/west highway, the north and south boundaries are fixed. On the north side is the Schuylkill River and its floodplain. As discussed previously, any encroachment in the floodplain could cause a flood raise in the model which will require buildings to be purchased and removed. As with the rest of the corridor, when buildings are threatened on the Reading side of the river, it was assumed encroachments into the floodplain were to be avoided.

On the south side, running parallel are the Norfolk Southern heavy freight line and many commercial properties. It was assumed that impacts to the railroad could not be mitigated as relocation options are limited. Therefore, all options remain within the existing footprint.

As discussed in the Mainline section, the eastbound approach was split into a C-D Road as a result of the additional span of the Buttonwood Street bridge. Therefore, all options considered a C-D Road on the eastbound side. This drops the design speed of the through road from 60 mph to 50 mph while also relaxing the criteria concerning on-ramp spacing. In a tight configuration such as at Penn Street, this is very beneficial. Since the volumes accessing the Penn Street Interchange were relatively high and the design benefits were essential, it was recommended to include a C-D Road on the westbound side as well. Another benefit to the C-D Roads is that the loop ramps would be designed for 20 mph, not the 25 mph minimum called for in the 2011 AASHTO Green Book. The use of the C-D Roads mitigates the impact of the tight ramp on the mainline.

Another design constriction at the Penn Street Interchange is the Schuylkill River crossing. This bridge is eligible for the National Register of Historic Places. The bridge is currently under design as a separate project, with a proposed road typical section of four 11’ lanes, a 6’ median, and 5’ shoulders. The location of the westbound signalized intersection from the Penn Street Bridge for all options is such that only one additional lane could be added for a dedicated left turn lane onto US 422 westbound.

The Full Diamond option would not require design exceptions or the C-D Roads. However, it would require double left turn lanes on Penn Street for both the eastbound and westbound on-ramps. On the westbound side, the double left lane would be too close to the Penn Street Bridge; thus, the through lanes would not be in the proposed Penn Street configuration before the beginning of the bridge. Modifying the typical section on the Penn Street Bridge was not investigated as the stakeholders involved in both projects (West Shore Bypass Study and Penn Street Bridge Rehabilitation) made it clear that maximizing bike and pedestrian usage through the corridor is paramount.

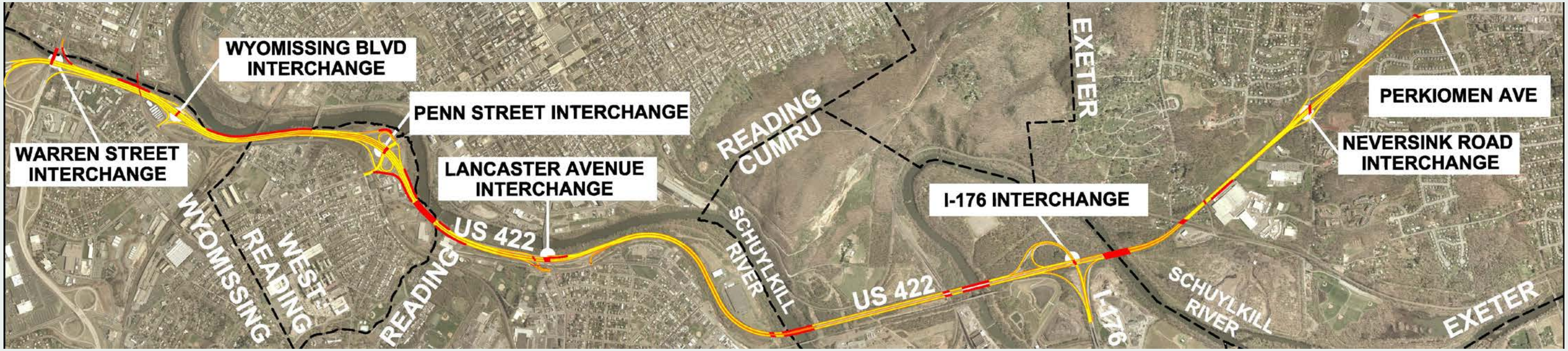
In considering Partial Cloverleaf (Parclo) options discussed below, within the constraints discussed previously, it was not possible to design a loop ramp in any quadrant to meet the AASHTO 2011 Green Book minimum radius of 144’ for 25 mph, which is the required minimum design speed for a loop ramp. Therefore, all loop ramps would require a design exception for design speed.

The westbound access ramp signal location was set by holding the end of the Penn Street Bridge and moving it west far enough to allow for one left turn lane to the westbound on-ramp. Using that signal location, recreating the NE loop ramp within that confined space is impractical without extending the direct off-ramp past its existing location. This would fill in the floodplain with the potential of a flood raise. Therefore, any option maintaining this ramp was not progressed.

**Table 10** shows the various options that were evaluated at the Penn Street Interchange. **Figures 48 and 49,** which depict Options 1 and 2, are shown on the following page.

| Penn Street Interchange Options | Design Exceptions | LOS – EB Ramps | LOS – WB Ramps |
|---|---|---|---|
| **Option 1 (Parclos in NW and SE quadrants)** | **Yes (Radii for loop ramps)** | **D (C)** | **B (D)** |
| **Option 2 (Parclos in NW and SW quadrants) **** | **Yes (Radii for loop ramps)** | **D (C)** | **C (D)** |
| Option 3 (Full Diamond) | No | F (F) | D (F) |
| Option 4 (Parclos with no direct ramps) | Yes (Radii for loop ramps) | F (E) | C (F) |
| Option 5 (Diamond WB, Parclo in SE quadrant) | Yes (Radii for loop ramp) | D (C) | D (F) |
| Option 6 (Parclos in NE and SW quadrants) * | Yes (Radii for loop ramps) | D (C) | C (D) |
| * Ramp in NE quadrant undesignable without increased fill towards River; assume this would require a CLOMR and potentially take buildings from the RAC. Option not progressed. | | | |
| ** Acceleration length for EB loop not met; would require acquiring adjacent property. | | | |

**Table 10: Penn Street Interchange Matrix**




The traffic operations for Options 1 and 2 operate the best compared to the other options and have acceptable LOS overall at the ramp intersections.

Options 3, 4, and 5 all operate at unacceptable LOS overall during one or more peak hours. They also result in queuing through the interchange that could cause spillback onto the mainline.

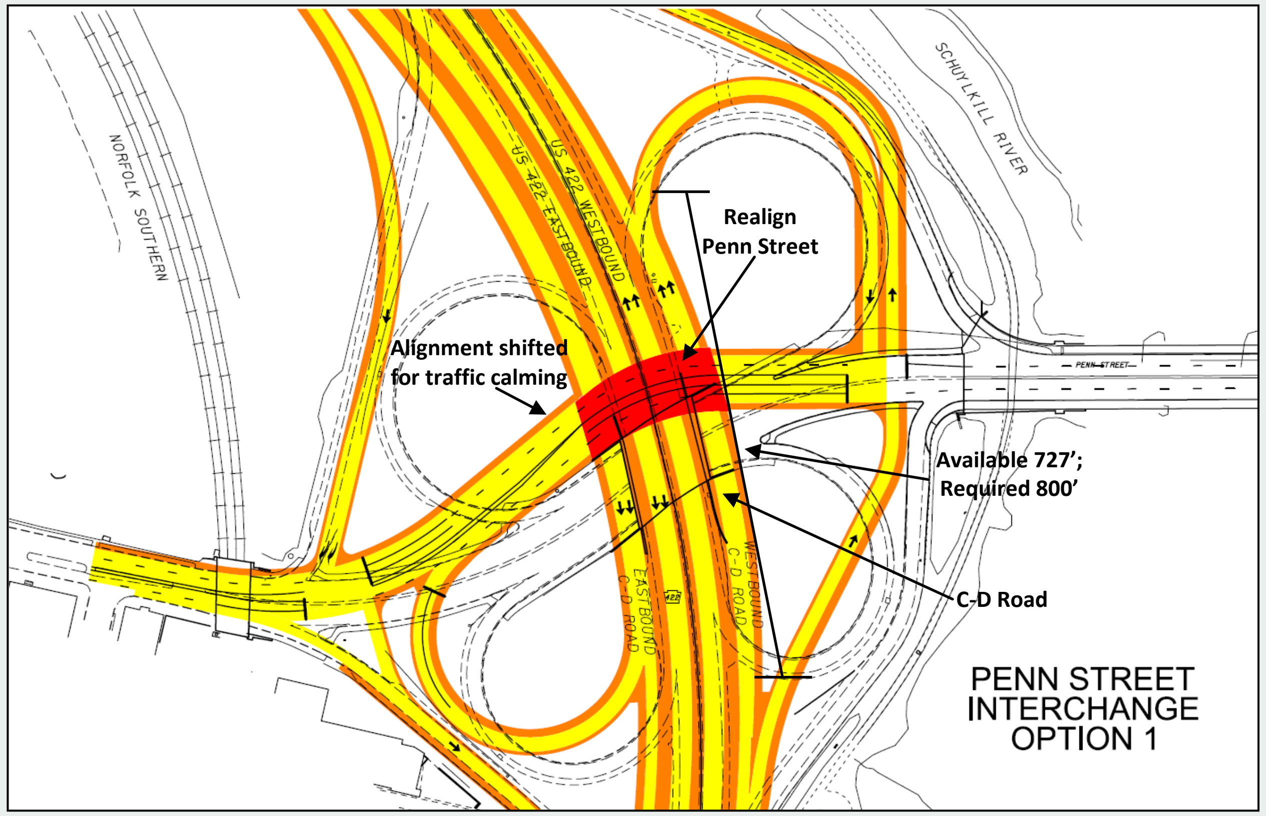



Figure 48: Penn Street Interchange Option 1

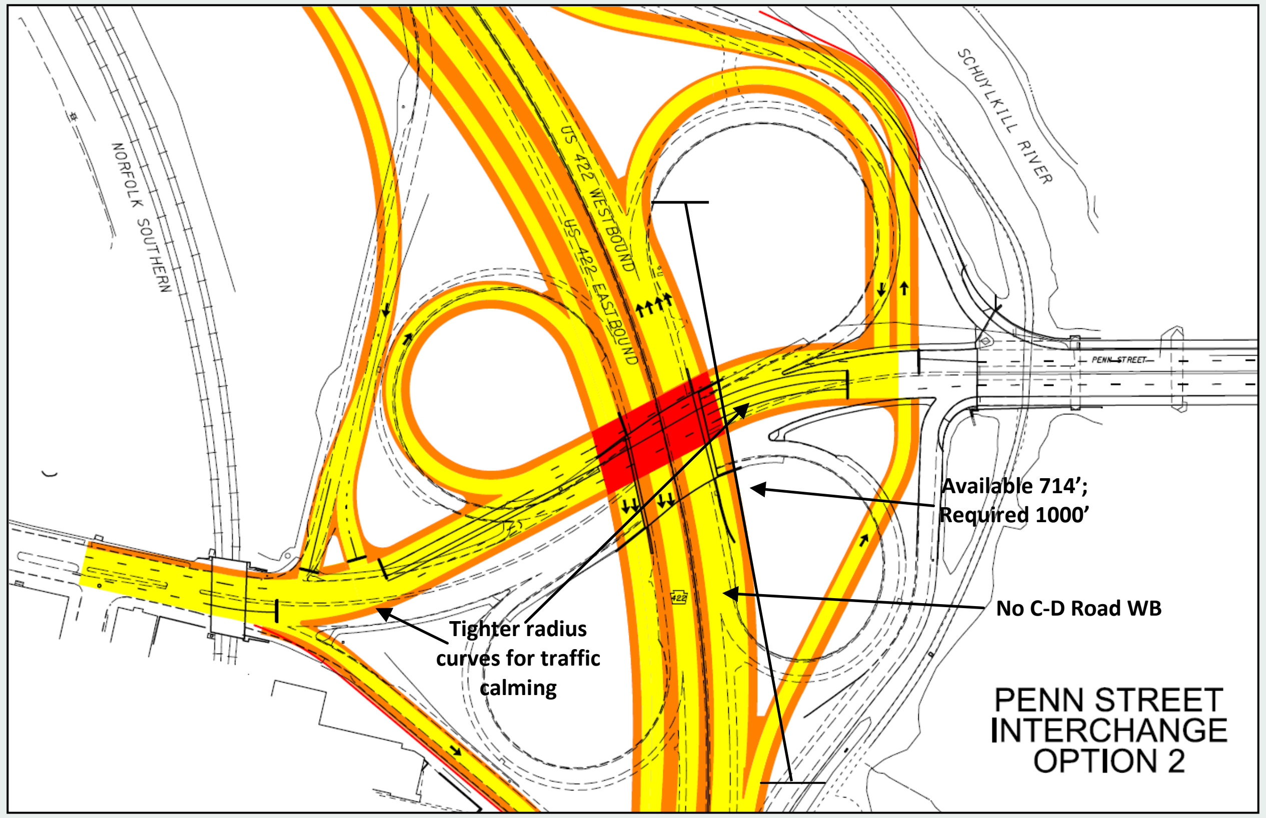
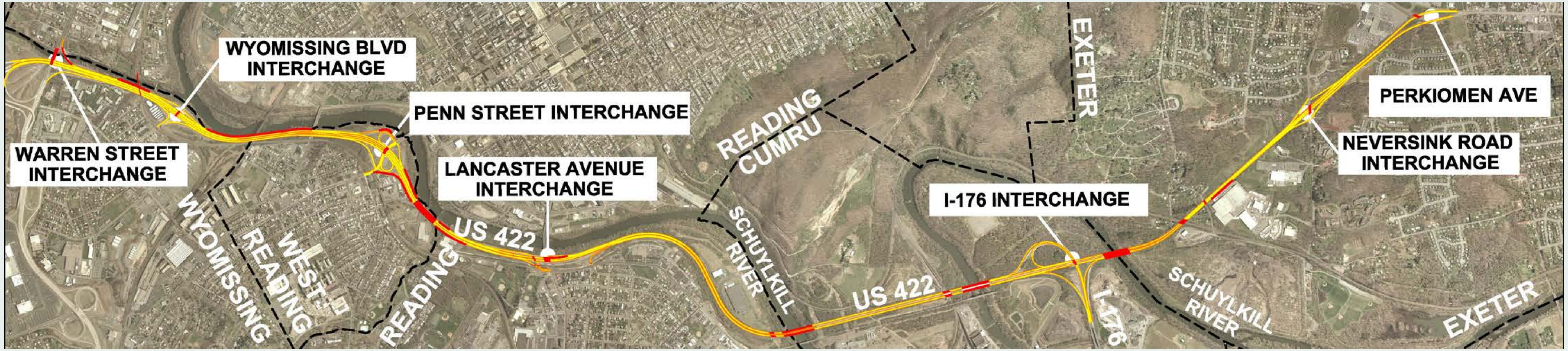



Figure 49: Penn Street Interchange Option 2




## Lancaster Avenue Interchange

The existing configuration for this interchange is a left diamond where all the ramps are in a diamond configuration but access is from the left lanes of US 422 instead of the right. This theoretically would improve performance on Lancaster Avenue, only requiring one signal; but it has created unsafe conditions on both US 422 and Lancaster Avenue. The on-ramps and the intersection are safety concerns. The traffic flow from the ramps predominantly heads south, away from Reading, with a large percentage of that traffic making a left and continuing south onto PA Route 10. The two intersections are approximately 150’ apart, and queues from one impact the other.

The PA Route 10 intersection is essentially a three-leg intersection with an access to Schlegel Park and a township road (E. Wyomissing Road) as the fourth leg; this leg produces very little traffic and does not impact the functionality of the existing intersection. Additionally, all traffic on the PA Route 10 leg of the intersection is forced to turn right.

Two major issues were considered in evaluating the different options at this interchange. The first was the amount of traffic going to and from US 422 and Morgantown Road (PA Route 10). The large amount of traffic making two turns, to US 422 westbound and to PA Route 10 southbound, creates the need for a dedicated left turn lane for traffic turning to US 422 westbound and to PA Route 10. The second issue was the small distance between the Bingaman Street Bridge and the PA Route 10 intersection (approximately 350’) coupled with the makeup of the Bingaman Street Bridge. The Bingaman Street Bridge is a 1200’ open spandrel arch that crosses the Schuylkill River, Norfolk Southern and Front Street. Widening this structure would be very costly and replacing it entirely would be cost prohibitive. Therefore, all options will assume the bridge in its current configuration (4 lanes).

Three other physical features (in close proximity) that also must be taken into consideration when determining interchange options were the Thun Trail which parallels US 422 on the south side, an historic cemetery located in the southeast quadrant and the Schuylkill River floodplain.

Option 1 (**Figure 50**) would be to recreate the existing condition while relocating the ramps to access the right lanes of US 422, flipping the mainline and ramps. At the connection point with Lancaster Avenue, the ramps would be angled as to align to pass under relocated US 422 in a SPUI configuration. This will maintain the signalized intersection as it currently exists. This option has LOS issues associated with the current needs of traffic utilizing the intersections (US 422 ramps and PA Route 10), as well as having inadequate intersection spacing (less than 200’). This option does not impact Thun Trail, Schlegel Park or the sanitary sewer pump house. This option would require all four access ramps to be detoured during construction.

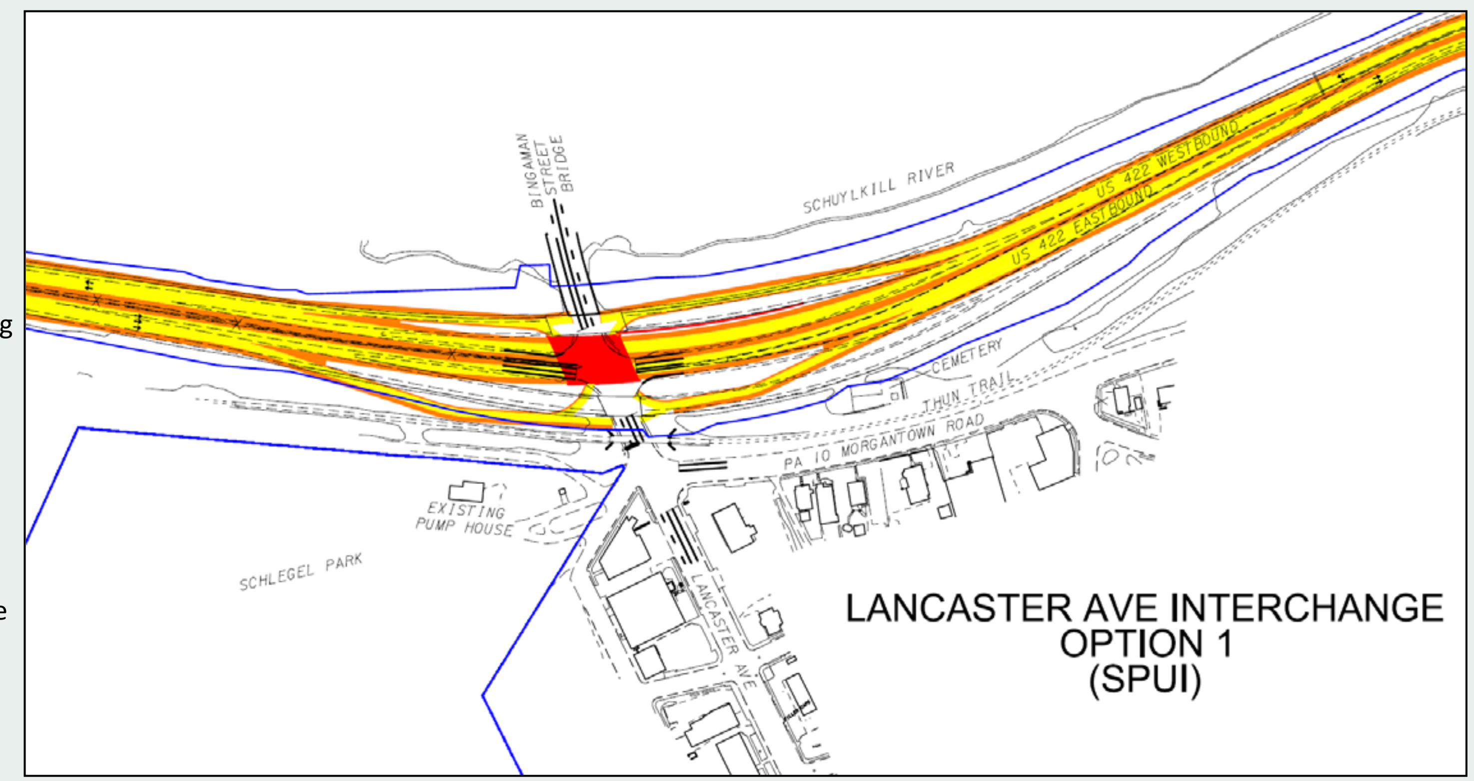
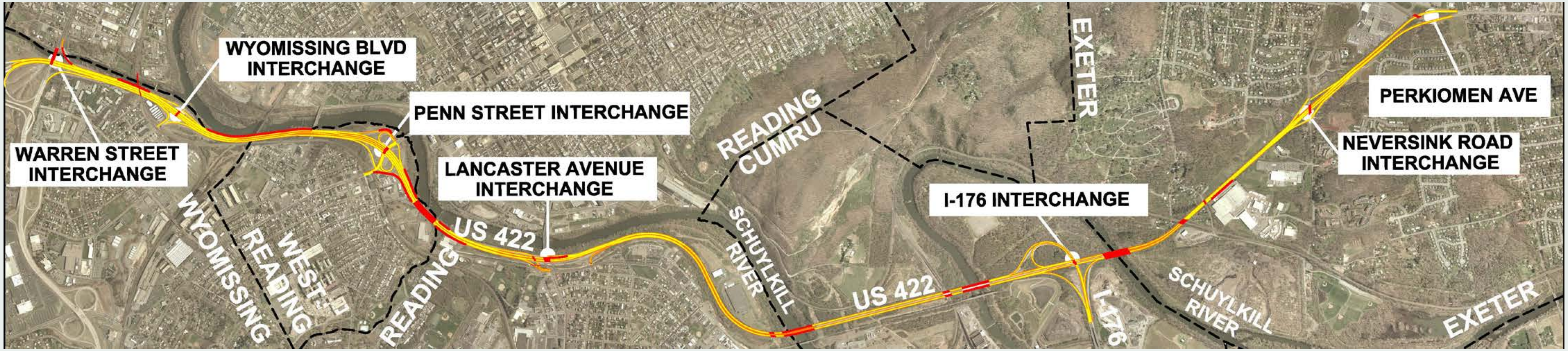



**Figure 50: Lancaster Avenue Interchange Option 1**




Option 2 (**Figure 51)** would be a diamond interchange with the on-ramps accessing the right lanes of US 422 and US 422 moved into the center on top of the existing ramps. This option would create three signalized intersections within 350'. This was considered impractical, resulting in the option being refined to bring the eastbound off-ramp into the intersection of PA Route 10 as a fourth leg. The westbound ramps would connect to Lancaster Avenue adjacent to the Bingaman Street Bridge. Although this approach will cut off this particular access point to Schlegel Park and E. Wyomissing Road, there are other multiple access points that can be utilized. The eastbound on-ramp was placed at the same location as a loop ramp access to US 422 eastbound.

This option was analyzed from a traffic perspective and failed, as the additional left turn lanes needed to accommodate traffic heading south on PA Route 10 and west on US 422 were as long as, or longer than, the 350' between intersections. Additionally, the roadway would need to be widened to accommodate the lanes requiring shadow lanes on the Bingaman Street bridge. As discussed previously, this is cost prohibitive and ruled out as the LOS could not be improved. This option had the largest impact to Schlegel Park, requiring two additional Thun Trail overpasses, and impacting a sanitary sewer pump house. This option could maintain the eastbound access ramps during construction but would require a detour for the westbound ramps for at least one construction season.

The next option (**Figure 52**) relocated the eastbound on-ramp south on PA Route 10 as a separate access point to create Option 3 (Split Diamond). It was placed adjacent to the road where PA Route 10 traffic heading south on Lancaster Avenue must turn. The location also avoids impacting the cemetery. The amount of traffic turning onto US 422 westbound and PA Route 10 southbound still required dedicated left turn lanes which created the

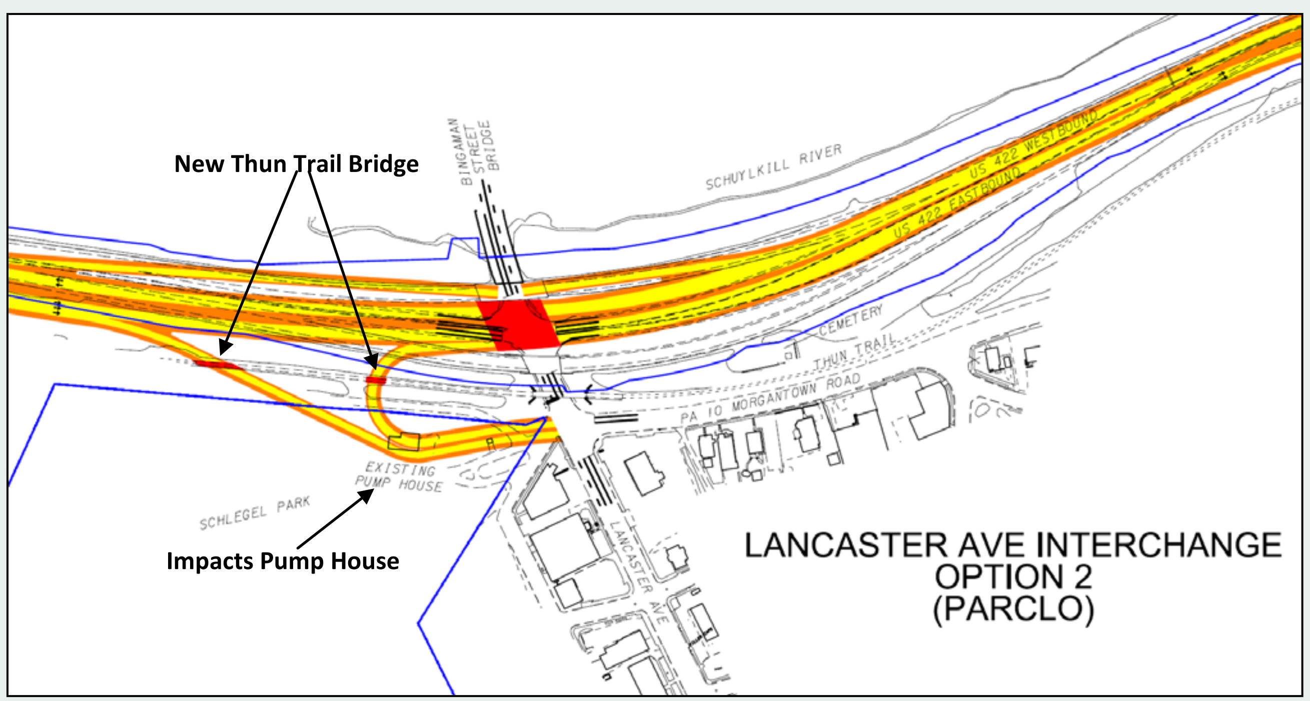



Figure 51: Lancaster Avenue Interchange Option 2

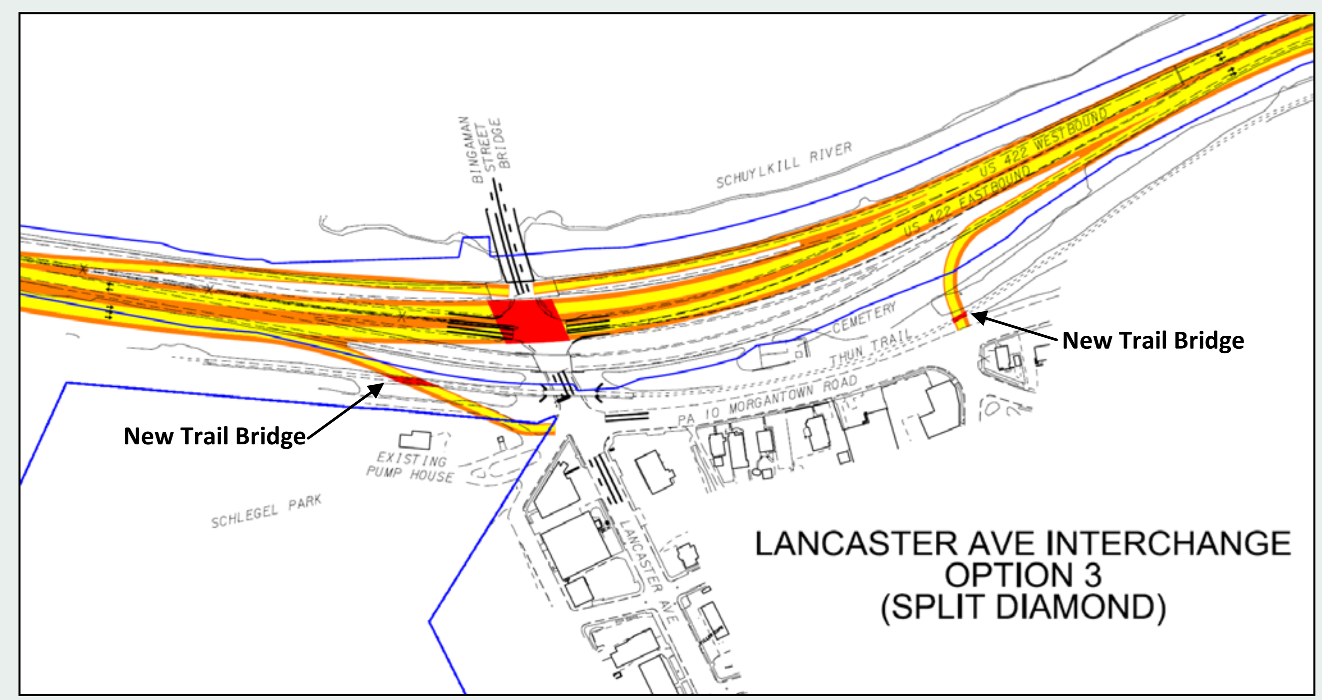
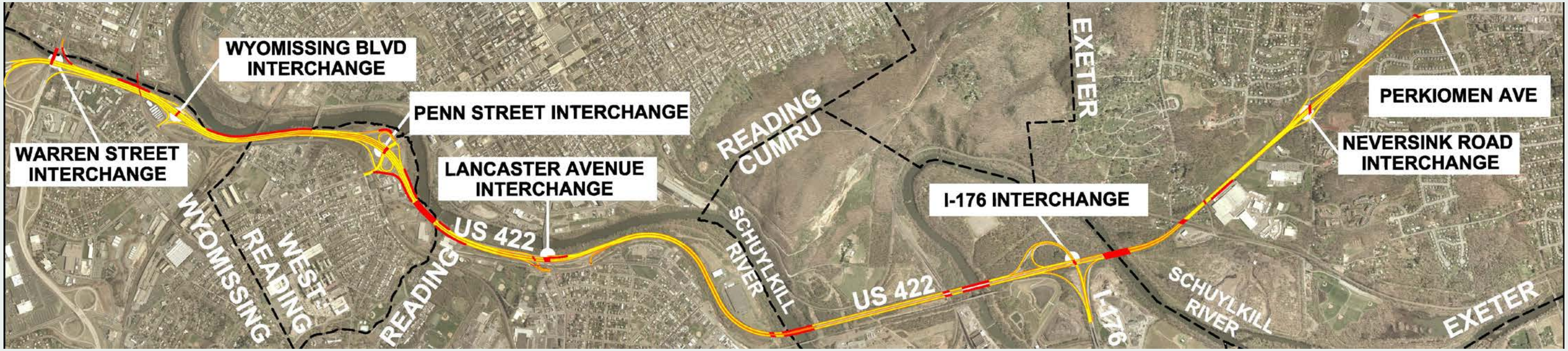



Figure 52: Lancaster Avenue Interchange Option 3




same issues as the eastbound Loop Ramp Option; therefore, the LOS was not improved.

This option had a smaller impact to Schlegel Park than the loop ramp, and required two additional Thun Trail overpasses; however, it did not impact the sanitary sewer pump house. This option maintained the eastbound access ramps during construction but would require a detour for the westbound ramps for at least one construction season.

Option 4 (**Figure 53**) used the base of the split diamond option while relocating the US 422 westbound on-ramp to the intersection with PA Route 10. To access US 422 westbound, a grade separated ramp (over or under US 422) would be required. When considering the grade difference, it was determined that the ramp would have to go under US 422. Left turn lanes are still needed to access PA Route 10 southbound and US 422 westbound, but they are relocated away from the Bingaman Street Bridge and they are not side to side. This will require widening south of PA Route 10 on Lancaster Avenue, but it can be accomplished. This option has a smaller impact to Schlegel Park than the loop ramp, and requires two additional Thun Trail overpasses; however, it does not impact the sanitary sewer pump house. This option could maintain the eastbound access ramps during construction but would require a detour for the westbound ramps for at least one construction season.

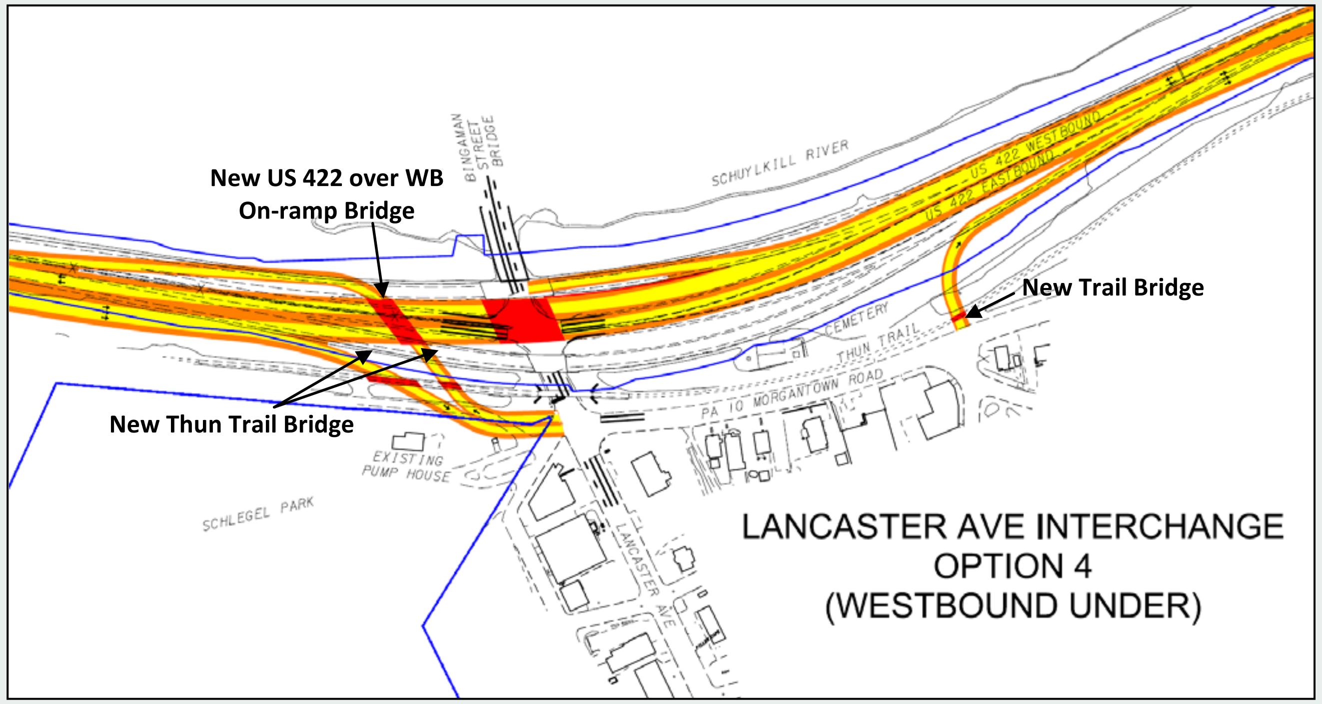



Figure 53: Lancaster Avenue Interchange Option 4

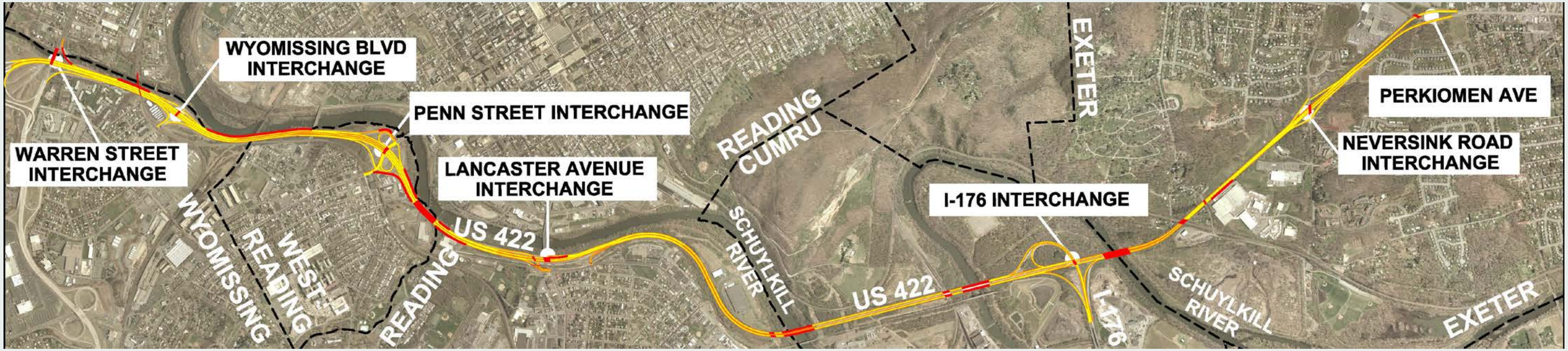
For each interchange reconfiguration option, consideration should be made relative to the remaining spans of the Bingaman Street Bridge that are buried below Lancaster Avenue and extend into the middle of the access road intersection.

Each replacement option terminates the eastbound on/off ramps near these existing structures. Structure backfill may be required at these structures to avoid problems with relative settlement between the existing rigid structure and the fill required to support the ramps. In addition, the strength of the vertical wall supporting the fill will need to be studied.

Another alternative would be to remove these buried spans and fill them in. However, the extent to which the Bingaman Street Bridge will be impacted by any modifications will also need to be evaluated. Costs to remove these spans versus the costs required to keep them intact should be studied.

There will be significant impacts to the traveling public at this interchange during reconstruction and replacement of the bridges which will likely drive the construction schedule. ABC (Accelerated Bridge Construction) methods and PBES (Prefabricated Bridge Elements and Systems) should be evaluated in designing the replacement of these structures to minimize the duration of traffic impacts.

**Table 11** shows the LOS of the various options evaluated at the Lancaster Avenue Interchange.




| Lancaster Avenue Interchange Options | Design Exceptions | LOS – WB Ramps | LOS – PA10/ Ramps | Impacts to Schlegel Park | Impacts to Pump House | Impacts to Thun Trail | Cost | Constructability |
|---|---|---|---|---|---|---|---|---|
| Option 1 (SPUI) | No | D (E) | D (D) | No | No | No | Medium (larger US 422 structure over Lancaster Avenue) | Bad – detour all ramps |
| Option 2 (Parclo EB, Diamond WB) | Yes | E (E) | E (E) | Large | Yes | Yes | Large (additional right of way + 3 Thun Trail bridges + new pump house | Good – only detour WB ramps one season |
| Option 3 (Split Diamond) | No | C (D) | E (C) | Small | No | Yes | Medium (2 Thun Trail bridges) | Good – only detour WB ramps one season |
| Option 4 (WB on ramp underpass) | No | B (C) | C (B) | Small | No | Yes | Large (additional US 422 bridge + 3 Thun Trail bridges | Good – only detour WB ramps one season |

Table 11: Lancaster Avenue Options Matrix

## I-176 Interchange

The existing configuration is a trumpet interchange with one loop ramp. All direct ramps currently meet design criteria for 40 mph with the exception of the connections with US 422. The acceleration lengths are substandard causing traffic to stop on the ramps. This situation is a safety concern. The loop ramp currently meets the design criteria for 25 mph.

The design team looked at two options. The first option is to maintain the existing design speed of 40 mph (**Figure 54**) with a shift of the bridge over US 422 to allow it to be staged and not impact construction staging. The second option is a 45 mph option. The minimum design speed for direct ramps is 40 mph, while 45 mph is the midpoint design speed. Both options upgrade the connections to US 422 and improve the safety issue that occurs with the substandard length acceleration lanes.

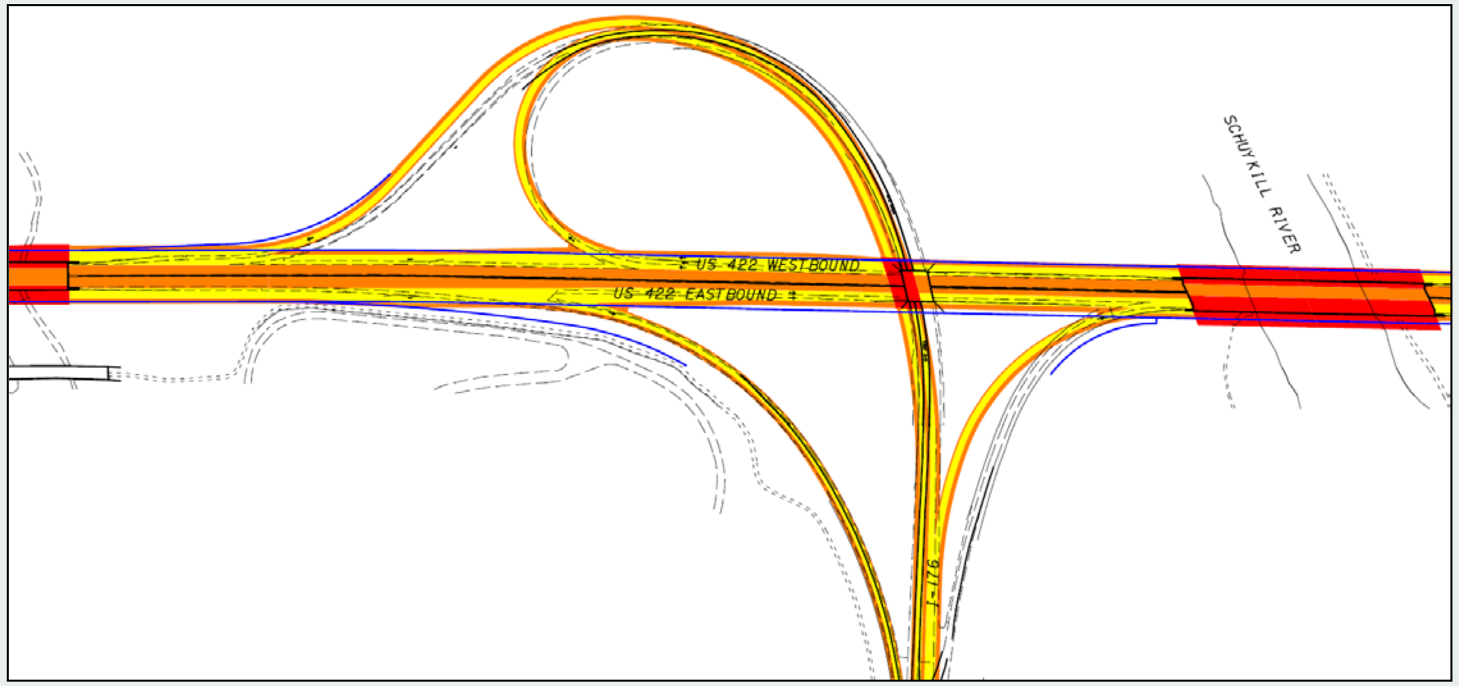
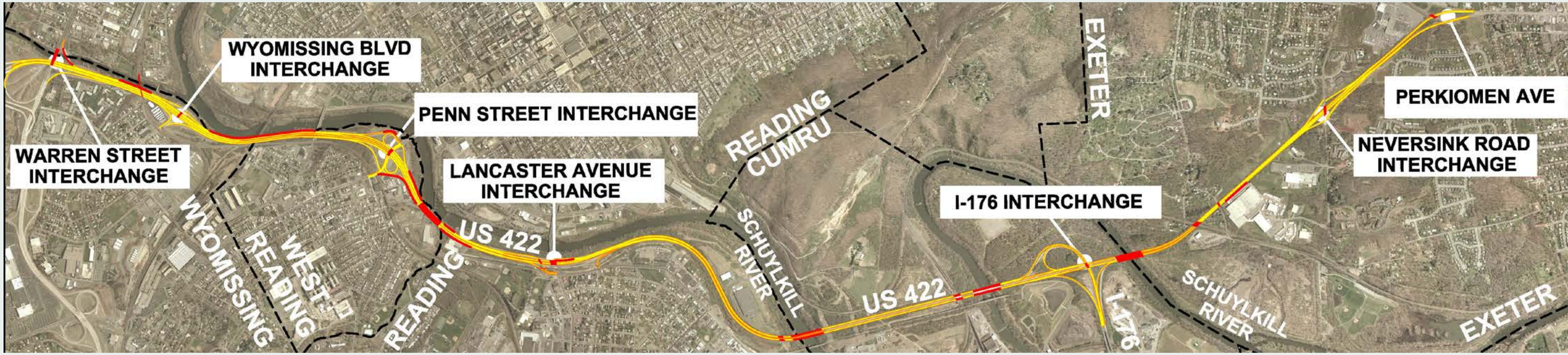



Figure 54: I-176 Interchange 40 mph Option




## Neversink Road (Mt. Penn)

The existing configuration of this interchange is a half diamond interchange with access to and from the west and no access to the east. There are currently no operational or safety issues at this interchange. In meeting with the Study Advisory Committee and other stakeholders, there was almost unanimous approval to complete this interchange.

The obvious option is to complete the diamond with direct ramps accessing US 422 on the east side. On the southeast quadrant, there currently is a utility access ramp that provides access to a Met-Ed pole line and a pump house. Additionally, this road provides access to one residential property. The diamond option shown continues to provide access to the residential property. It includes a two-way road from the residential driveway to Neversink Road. The downside to this option is the length of the ramp between Neversink Road and the property is not limited access, allowing adjacent property owners to access the ramp as the residence does.

A second option would be to buy the property, and the third option is to provide access to the residence from the other end of the utility access road which comes off of an existing development.

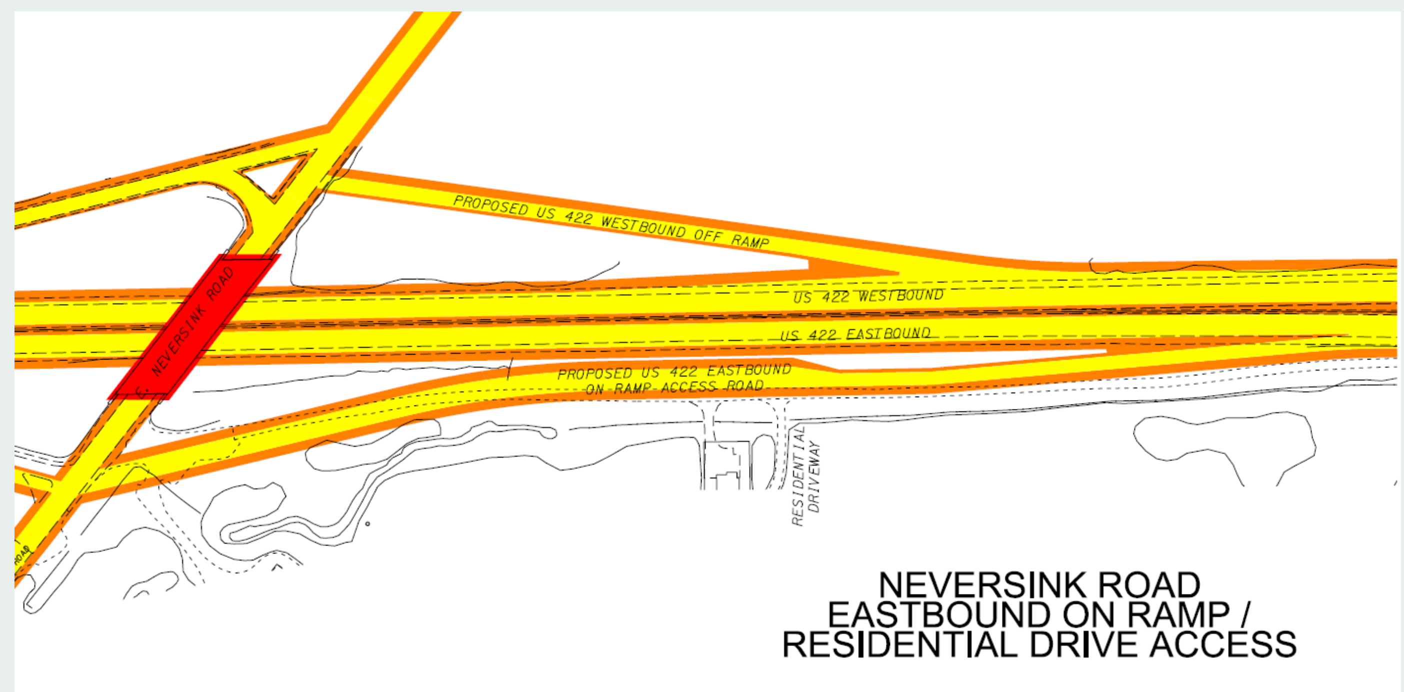



Figure 55: Neversink Road


## Overpasses

There are seven road overpasses within the study corridor; two are located in the eastern half, four in the western half, with the I-176 ramps in the middle. Five of the overpasses are within interchanges (Wyomissing Boulevard, Penn Street, I-176, Neversink Road, Warren Street) while the other two are road overpasses (Buttonwood Street and Perkiomen Avenue). Only Wyomissing Boulevard has the required 16’6” vertical clearance needed to bring the corridor to current criteria; however, it is not wide enough to pass the proposed three lane typical section so it must be replaced. Buttonwood Street currently has 13’8”clearance and cannot be modified as it is an historic structure. The other overpasses must be replaced to accomplish the 16’6” vertical clearance to bring the corridor to current standards.

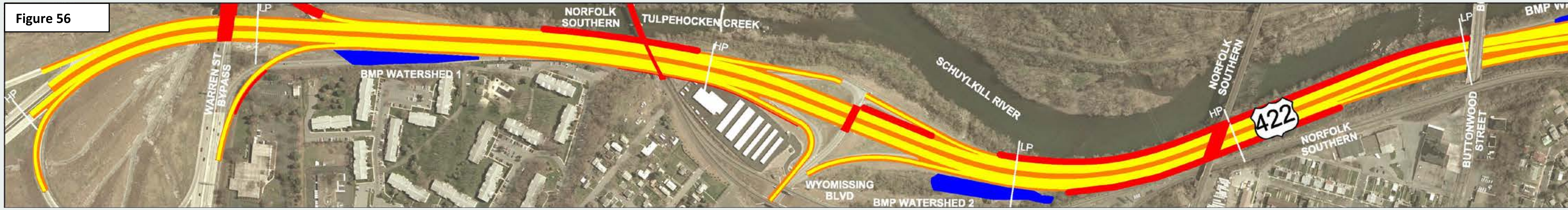
Overpass bridges are difficult to include in the staging of mainline US 422 if they are not being detoured, because a complete removal of the existing bridge must occur before the roadway underneath can be widened. If the widened road underneath is needed for traffic control, the stage shift on US 422 will have to wait until the overpass is completely removed. As a result of this, it is normal practice to construct overpasses separate from the mainline construction.

Only Wyomissing Boulevard has a low enough traffic volume to be considered for a detour and the design of I-176 ramp’s bridge is such that much of it can be built offline. The others could be constructed as separate construction packages.

The proposed Penn Street Interchange options suggest a realignment of the road to improve ramp design and slow Penn Street traffic. Also, the bridge profile must be raised approximately two feet to meet 16’6”required vertical clearance. This interchange ramp should be included in the construction package.

East Neversink Road must be raised four feet to meet the 16’6” vertical clearance. In addition, the existing bridge is close to the ramps of the existing and proposed reconfigured interchange. The resulting rise in vertical profile of the bridge and the proximity of the ramps to the interchange will require the ramps to be replaced with the overpass bridge.

Figure 56




## Drainage BMP Locations

The proposed US 422 West Shore Bypass project is comprised of 10 subwatersheds, all of which drain into the Schuylkill River directly. The project is within the Berks County Schuylkill River Watershed Act 167 Plan. The entire model ordinance for the Act 167 Plan is included in Appendix E. The direct discharge areas within the project will be in Management District C Conditional Direct Discharge District. This states that no rate control is needed for storms greater than the 5-year storm.

The Act 167 plan does require BMPs to promote Groundwater Recharge (Section 305) and Water Quality (Section 306) and to mitigate the project's impact on Streambank Erosion (Section 307). Preliminary BMP sites throughout the corridor have been identified for this Study. These sites are selected because they minimize right-of-way impacts and it is believed runoff could be efficiently collected. Investigations will need to be performed in Preliminary Design to determine the viability of the sites.

The beginning of the project is the Warren Street Bypass Interchange which is at a high point (HP). Watershed 1 begins at this HP and ends at the HP just west of the Wyomissing Boulevard Interchange. The low point (LP) for this watershed is approximately 150' west of Warren Street Bypass. The BMP for Watershed 1 could be located near this LP along the eastbound lanes of US 422 (**Figure 56** above). This location will take advantage of the old pavement area that the realignment removed.

Watershed 2 is from the west end of Watershed 1 (HP just west of the Wyomissing Boulevard Interchange) to the HP approximately 80' east of the Norfolk Southern Railroad west crossing. The LP for this watershed is approximately 850' east of Wyomissing Boulevard. The BMP for Watershed 2 could be located at this LP in the driveway along the eastbound lanes of US 422 (**Figure 56**).

Starting at the western end of Watershed 2 (approximately 80' east of the Norfolk Southern Railroad west crossing) to the HP approximately 960' west of Penn Street is Watershed 3. The LP for this watershed is located approximately 50' west of Buttonwood Street. At this LP, US 422 is located between the railroad and the Schuylkill River with no area for a BMP. Therefore, the BMP for Watershed 3 could be located east of the LP in the area along the westbound lanes of US 422 where the existing roadway was located before the proposed realignment of US 422 (**Figure 57**).

Watershed 4 is from the western end of Watershed 3 (HP approximately 960' west of Penn Street) to the HP approximately 1600' east of Penn Street. The LP for this watershed is at Penn Street. The BMP for Watershed 4 could be located in the loop of the eastbound off-ramp of the Penn Street Interchange (**Figure 57**).

Watershed 5 begins at the western end of Watershed 4 (HP approximately 1600' east of Penn Street) and ends at the HP at Lancaster Avenue. The LP for this watershed is approximately 1300' west of Lancaster Avenue. The BMP for Watershed 5 could be located at this LP along the eastbound lanes of US 422 (**Figure 58**).

Starting at the western end of Watershed 5 (HP at Lancaster Avenue) to the HP approximately 620' east of the Schuylkill River crossing is Watershed 6. The LP for this watershed is approximately 1400' east of Lancaster Avenue. The BMP for this watershed could be located to the west of the LP along the eastbound lanes of US 422 where the existing ramp was located before the proposed realignment of the Lancaster Avenue Interchange (**Figure 58**).


Figure 57

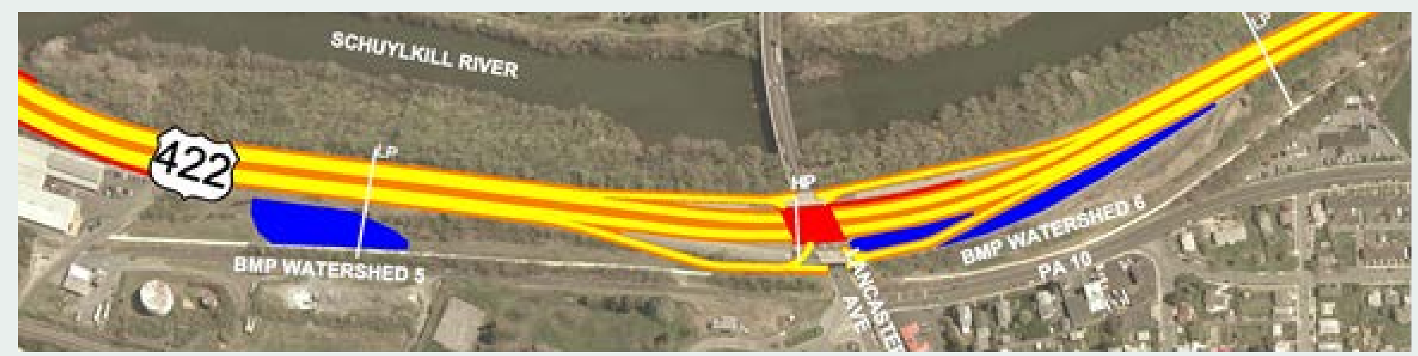



Figure 58

Figure 59: Mainline Option A


Figure 60: Mainline Option B


Watershed 7 is from the western end of Watershed 6 (HP approximately 620’ east of the Schuylkill River crossing) to the HP over the railroad. The LP for this watershed is approximately 1330’ west of the railroad crossing. The BMP for Watershed 7 could be located at this LP in the median of US 422 for Mainline Option A (**Figure 59**) and along the eastbound lanes of US 422 for Mainline Option B (**Figure 60**).

Starting at the western end of Watershed 7 (HP over the railroad) to the HP in the I-176 Interchange is Watershed 8. The LP for this watershed is located approximately 150’ east of Schuylkill River crossing. Due to this LP’s proximity to the Schuylkill River and the adjacent steep slopes and dense trees, the BMP for Watershed 8 should be located east of the LP in the loop of the westbound off-ramp of the I-176 Interchange (**Figures 59 and 60**).

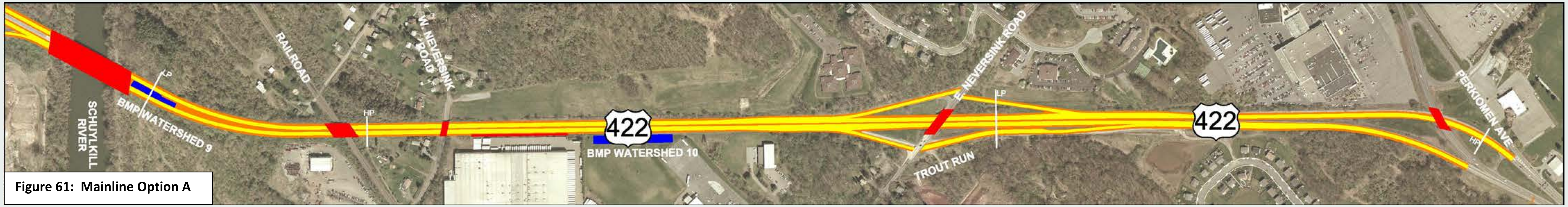



Figure 61: Mainline Option A


Figure 62: Mainline Option B

Watershed 9 is from the western end of Watershed 8 (HP in the I-176 Interchange) to the HP approximately 160’ east of the railroad crossing. The LP for this watershed is approximately 300’ east of the Schuylkill River crossing. The BMP for Watershed 9 could be located at this LP in the median of US 422 for Mainline Option A (**Figure 61**) and along the eastbound lanes of US 422 for Mainline Option B (**Figure 62**).

The proposed US 422 West Shore Bypass project ends at Perkiomen Avenue where there is a HP. Watershed 10 ends at this HP near Perkiomen Avenue and begins at the western end of Watershed 9 (HP approximately 160’ east of the railroad crossing). The LP for this watershed is located in the E. Neversink Road Interchange approximately 350’ east of E. Neversink Road. The BMP for Watershed 10 could be located west of the LP approximately 1100’ east of W. Neversink Road (**Figures 61 and 62**). This BMP would outlet to Trout Run a tributary to the Schuylkill River.


## Right-of-Way Impacts

Using existing PennDOT right-of-way plans and tax maps, an existing right-of-way mosaic was created for the project area. Conceptual right of way lines were approximated throughout the project area based on proposed cut and fill lines. Total right-of-way costs were generated by assuming the following generic land values to the impacted properties:

- Commercial Properties - $500,000/acre
- Residential - $100,000/acre
- Open Space - $50,000/acre.

Using the above costs per acre and adding 20% and the conceptual right-of-way lines, it is approximated that right-of-way acquisition costs may range between $8.2 million (for Option B) and $8.9 million (for Option A). Twenty percent has been added to cover acquisition cost (appraisal fees, etc.), depreciation, acquisition of improvements, billboards, etc. Additional information regarding location and sizes of conceptual right-of-way impacts can be found in Appendix F.

| Design Section | Option A | | | Option B | | |
|---|---|---|---|---|---|---|
| | Commercial Properties | Residential Properties | Open Space Properties | Commercial Properties | Residential Properties | Open Space Properties |
| **Section 1** | 9 | - | 11 | 9 | - | 11 |
| **Section 2** | - | - | 8 | | - | 8 |
| **Section 3** | 6 | - | 15 | 6 | - | 13 |
| **Section 4** | 9 | 9 | 12 | 8 | 8 | 10 |

**Table 12: Number of Properties Impacted Per Design Section**


## Utility Impacts

Major utility impacts along the project corridor are discussed below. Lower cost utility impacts such as pole lines, manholes, underground facilities, etc. were not evaluated.

### Towers and Poles

Along the US 422 corridor, there are six utility poles and six towers that may need to be relocated. It is approximated that six poles may cost $250,000 each to relocate, and six towers may cost $500,000 each to relocate, for a total cost of $4.5 million. Additional information regarding specification locations of poles and towers can be found in Appendix G.

### Sanitary Sewer Pump House

The pump house adjacent to Schlegel Park may need to be relocated to allow for the Lancaster Avenue Interchange reconstruction. As shown previously in this report, Interchange Option 2 (Parclo) would require the pump house to be relocated, due to the proposed eastbound on- and off-ramps. Relocation costs are approximated at $1 million.

### Met-Ed Substation

The Met-Ed West Reading Substation is located adjacent to US 422 at the Thun Trail Viaduct. Several modifications will be needed to accommodate the US 422 improvement in this location. Please refer to adjacent aerial view of the Met-Ed West Reading Substation (**Figure 63**) in addition to the text detailing necessary modifications.

The magnitude of cost to relocate the 13.2kV Switchgear (SWGR) is approximated to be $2 million. This magnitude of costs assumes the following:

- The expanded US 422 will impact the vertical plane of both the outer and inner southeast fences of the Met-Ed West Reading Substation closest to the 13.2kV SWGR (location 4 on Figure 63). The Study Team met with Met-Ed to discuss the project and potential impacts to the site. The initial design shows that the outside fence will be breached, but the inside fence will remain intact. US 422 will be approximately 5 feet outside of the inner fence (backside of the eastbound parapet). Met-Ed stated that this is an impact that can be mitigated, but they would like a physical barrier erected to the height of the substation to protect their facility.

- Certain options presented previously will possibly impact the rock foundation of the substation. Therefore, it might be better to relocate the substation. Met-Ed mentioned that there is room to place the relocated substation within their existing property. It is assumed to relocate the 13.2kV Switchgear portion of the substation in this area to the west or southwest section of the substation property (location 5 on Figure 63). It is assumed that the new 13.2kV line will require an approximately 75' x 130' area (approximately one-quarter acre) based on the current configuration of seven bays. Relocation of the substation will allow existing N. First Avenue to be relocated adjacent to US 422 rather than on the other side of the Med-Ed property.

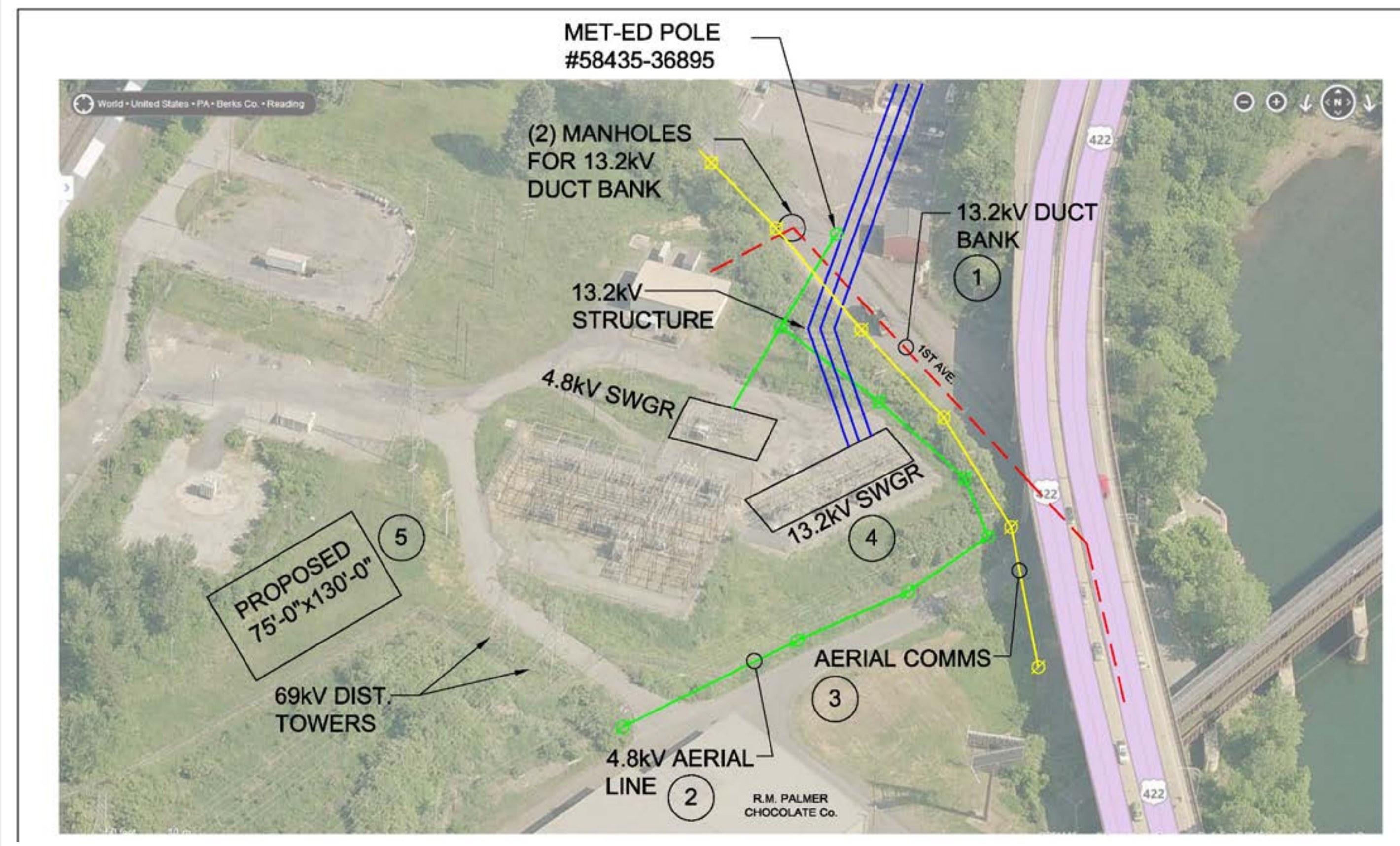



**Figure 63: Met-Ed West Reading Substation**


## Geological and Geotechnical Considerations

The construction along the project alignment will include widening and realignments of portions of the existing highway, as well as incorporating new ramps and collector-distribution roads in some areas.

The geologic conditions vary widely along the length of the study area, and different geotechnical solutions will be required to address the varying needs of the highway improvements. At the western end of the study area, particularly in the area between the west end of the West Shore Bypass to just east of the Penn Street interchange, rock outcrops are prominent along the southern side of the existing highway alignment, and will have a significant impact on the planning, design and construction of the highway improvements.

### Site Geology Overview

According to *The Geology of Pennsylvania* (Ed. Shultz, 1999), the study area west of the US 422 bridge over the Schuylkill River, adjacent to Brentwood Drive and Morgantown Road, is described as being located in the Great Valley Section of the Ridge and Valley physiographic province. The study area east of that river crossing is located in the Gettysburg-Newark Lowland Section of the Piedmont Province. A portion of the Reading Prong Section of the New England physiographic province extends into the region, and traverses the project study area near Brentwood Drive in the City of Reading. This isolated portion of the prong also forms Neversink Mountain, north of US 422 and the Schuylkill River, in the area of Lower Alsace Township, Cumru Township, Mt. Penn, and Exeter Township. A Geology Map has been included as **Figure 64**.

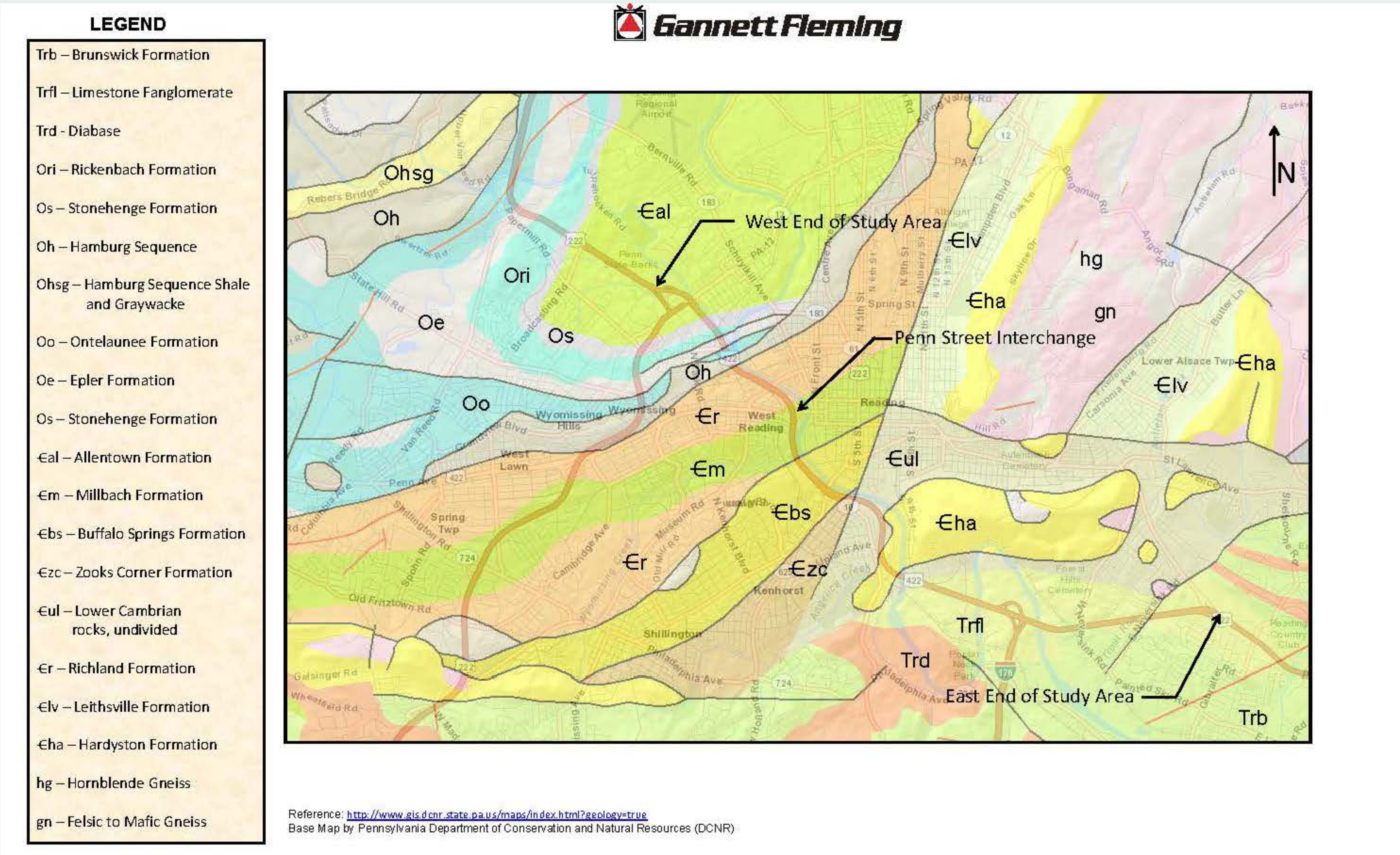



**Figure 64: Geology Map**


According to the Pennsylvania Department of Conservation and Natural Resources (DCNR) online interactive map (http://www.gis.dcnr.state.pa.us/maps), the topography of the Great Valley Section consists of very broad lowland, with gently undulating hills eroded into shales and siltstones on the north side of the valley, and a lower elevation flatter landscape developed on limestone and dolomites on the south side of the valley. Local relief is less than 100 feet, particularly in the carbonate area, but may be up to 300 feet in local areas underlain by shale. Elevation ranges from 140 feet to 1,100 feet for the entire section. The bedrock units that underlie the site within the Great Valley Section consist of a sequence of Ordovician- and Cambrian-age carbonate limestone and dolomite formations (Rickenbach, Stonehenge, Ontelaunee, Epler, Stonehenge, Allentown, Millbach, Buffalo Springs, Zooks Corner, and Leithsville Formations), and interbedded shale, sandstone and limestone of the Hamburg Sequence.

The topography of the Gettysburg-Newark Lowland Section consists mainly of rolling low hills and valleys developed on red sedimentary rock. The Section also includes isolated higher hills developed on diabase, baked sedimentary rock (hornfels) and conglomerates. Almost all of the underlying sedimentary rock dips to the north or northwest and the basic drainage pattern is dendritic. Relief is generally in the area of 100 to 200 feet, but may be up to 600 feet on some of the isolated hills. Elevation in the Section ranges from 20 to 1,355 feet. In general, the Section is underlain by carbonate limestone fanglomerate and interbedded sandstone, shale, siltstone and mudstone of the Brunswick Formation that were deposited in a long, narrow, inland basin that formed when the continents of North America and Africa separated more than 200 million years ago.

The topography of the Reading Prong Section in the vicinity of the study area is characterized by steeply sloped ridges underlain by hard metamorphic rocks consisting of quartzite of the Hardyston Formation, hornblende gneiss and felsic to mafic gneiss.

### Site Geology Near the Penn Street Interchange

According to the Pennsylvania Geological Survey *Reading Quadrangle Map*, and Pennsylvania DCNR online interactive map (http://www.gis.dcnr.state.pa.us/maps), the area immediately north and south of the Penn Street Interchange is underlain by interbedded Cambrian-age dolomite and limestone of the Richland and Millbach Formations.

*Engineering Characteristics of the Rocks of Pennsylvania* (Geyer et al. 1982) describes the Richland and Millbach Formations as finely crystalline dolomite interbedded with oolitic limestone, chert, calcarenite, and conglomerate and laminated limestone interbedded with finely crystalline dolomite. The bedrock is thickly bedded. The joints have a blocky pattern, are well-developed, open and steeply dipping, with moderate distance between the fractures. The bedrock is typically moderately-resistant to weathering and generally is slightly weathered to a shallow depth. The overlying mantel varies in thickness, and the interface between bedrock and mantle is usually characterized by pinnacles. The natural slopes of the formation are considered to be gentle and stable. Maintenance of good surface drainage is required since poor surface drainage may result in potential sinkhole formation.

Some solution channel openings are present in the rock that provide a secondary porosity of low to moderate magnitude, and in some cases contribute to very large groundwater yields. The presence of bedrock pinnacles along with numerous sandstone beds and chert lenses makes it difficult to excavate; however, the bedrock typically offers good cut-slope stability. The foundation stability is good; however, solution openings and bedrock pinnacles should be thoroughly investigated prior to any construction activities.

Due to the carbonate nature of dolomite and limestone, karst features such as irregular bedrock surface, pinnacles and extensive interconnected fractures and solution cavities may be encountered in the subsurface across this region. Based on the DCNR online interactive map, there are no historically mapped sinkholes or closed surface depressions in the immediate study area, with the exception of the far west end of the study area, in the vicinity of the US 422 and US 222 interchange near Berkshire Boulevard, where two surface depressions are mapped.

Various unnamed faults have been mapped at the contacts between several of the adjacent formations within the study area. Although these faults are likely not active, and are the result of ancient tectonic episodes, the geological combination of karst features and disturbed geomaterials associated with disrupted zones along faults can increase the risk for hazards associated with sinkhole activity.

Within the project corridor, bedrock is anticipated to be shallow, ranging from at the ground surface to less than 20 feet below the existing grade across much of the project study area. Significant rock excavation, and potentially rock slope remediation measures, will be an integral part of the construction associated with this project.

Several significant bedrock outcrops are visible along the US 422 corridor west of the Penn Street Interchange, and there is also a prominent outcrop east of the interchange, just west of the US 422 bridge over the end of South 1st Avenue, adjacent to the Schuylkill River Trail bridge over the Schuylkill River. The rock outcrop at this location supports an electrical substation, and a portion of the outcrop may be impacted by the proposed highway improvements.


Available water well data in the region, as well as Gannett Fleming's previous subsurface investigation activities in the area, suggest a groundwater table of typically less than 25 feet below the ground surface in the study area. This will vary locally, and is affected by proximity to the Schuylkill River, localized water drawdown from production wells, secondary porosity of the bedrock and seasonal fluctuations in the groundwater table.

### Highway Support Solutions in Fill Areas

Where fills are required and right-of-way allows, traditional embankments, with 2H:1V side slopes, are typically employed. Where right-of way restrictions do not allow this approach, reinforced soil slopes or retaining walls can be utilized, with the particular solution depending on the right-of-way available in a given area. Where retaining walls are required, mechanically stabilized earth (MSE) walls are likely to provide the most economical fill support solution; however, prefabricated modular (PM) wall systems may also be cost competitive, and could be recommended as an alternate.

In the western portion of the study area, some sections of the highway are in close proximity to the Schuylkill River. Where the highway improvements require moving the roadway closer to the river, flood and scour conditions will need to be considered in determining the best support solution for the roadway. Steep slopes with reinforcement or rock toe construction can be considered in areas where there is enough right-of-way available adjacent to the river. Where the proposed highway features are too close to the river to allow for construction of some type of stabilized slope, a retaining wall, either full-height or partial-height, will be required to minimize encroachment on the flood plain and to maintain stability of the roadway embankment. Reinforced concrete cantilever walls would be one alternative for support of the roadway in these areas, to help mitigate potential scour and stability issues related to flood events. Depending on the depth to rock along the wall alignment, the walls could be supported on bedrock or on driven piles. Another alternative would be to use soldier beam walls in areas where a traditional wall footprint creates constructability issues. Any wall falling within the 100- or 500-year flood plain limits would need to be designed for the effects of any anticipated scour that could impact the long-term stability of the retaining wall. Scour mitigation measures would likely need to be incorporated in the design of any walls falling within the flood plain limits, particularly if soldier beam walls are utilized, as they rely on passive earth pressure at the front face of the wall for stability of the wall system.

### Geotechnical Solutions in Cut Areas

Where cuts are required as part of the highway improvements, different options are available depending on the location and configuration of the cut required. Where right-of-way allows, cut slopes in soil overburden are typically laid back at 2H:1V. Steeper cut slopes can be considered, but the final slope geometry will be dependent on the strength of the soil strata in and adjacent to the cut, as well as the configuration of the cut slope itself. It may be possible to use surface treatments such as a turf reinforcement mat or a layer of riprap-type rock to minimize the potential for surface sloughing and allow for marginally steeper cut slopes. All cut slopes will need to be analyzed with PennDOT-approved slope stability software during the design phases of the project to ensure that the required factors of safety against slope failure are achieved.

Where right-of-way constraints are too tight to allow for traditional cut slopes, retaining walls will be required. Different types of walls can be evaluated, and the selected wall type will depend on the wall height and length, the proximity of the wall to the final right-of-way line (and whether or not a permanent underground easement can be obtained) and the type of soil or rock material which the wall will be supporting and will be supported by.

Soldier pile walls are often used where there are tight right-of-way constraints in cut situations. The soldier piles can consist of steel beams or precast concrete piles, and the wall facing can be constructed with concrete lagging or with a cast-in-place concrete facing, depending on the functional and aesthetic requirements of the wall, as well as cost considerations. Where the exposed wall height is less than about 15 feet, soldier pile walls can typically be constructed as nongravity cantilevered walls, without any tiebacks. Where walls exceed more than 15 feet in height, one or more rows of ground anchor tiebacks are required to provide adequate wall support. In situations where tiebacks are required, the limits of the anchors should be kept within the right-of-way if at all possible; otherwise, a permanent underground easement will be required to accommodate the anchors.

Another option for cut walls in areas of soil overburden or weathered rock is to construct soil-nailed walls. Soil-nailed walls are typically utilized where cut slopes are required in weathered rock, granular soils, or some types of clayey soils. Soil-nailed walls can be utilized to save time and money during construction compared to other wall types, because they are installed using a top-down construction technique, offer construction flexibility in differing subsurface conditions, do not require the higher capacity structural facing required by soldier pile walls, can be installed with relatively compact construction equipment and offer a significant wall system redundancy. Soil nail lengths are also typically much shorter than ground anchor lengths required for anchored soldier pile walls of the same height, thus offering an advantage in right-of-way requirements. It is desirable to have the installed nails fall within the permanent right-of-way; however, soil nailing may also be feasible if PennDOT can obtain a permanent underground easement in situations where nail lengths would need to extend over the right-of-way line. Facing for soil-nailed walls can consist of shotcrete,


cast-in-place concrete, or precast concrete panels attached to the nails, with a drainage system incorporated behind the facing. Different techniques can be used to add aesthetic treatments to the completed wall facing, including the use of precast textured panels, form liners for cast-in-place facing, or sculpted shotcrete which can be designed to mimic local rock formations, helping to blend the completed structure with its surroundings.

If the required retaining wall is of a low enough height, and sufficient distance is available from the front face of the wall alignment to the right-of-way, it may be possible to construct an MSE or PM wall. However, if the wall alignment is in close proximity to the right-of-way line, some form of temporary excavation support is typically required to protect adjacent properties during the wall construction, which adds additional cost to these wall options in cuts.

## Rock Cuts

As discussed above, there are several locations within the project study area where rock outcrops are present and will be impacted by the proposed construction. There are several outcrops present at the west side of the Penn Street Interchange and extend westward to the west end of the study area. There is also an outcrop present at the end of South 1st Avenue, eastward on US 422 from the Penn Street Interchange. Additionally, it is anticipated that rock may be encountered when excavating the cuts to realign the ramps at the I-176 Interchange, particularly at the westbound on-ramp to US 422 from I-176.

Where rock is present, either over the full height of the cut slope, or only a portion of it, the steepness of the slopes can often be increased from a typical 2H:1V configuration to take advantage of the additional stability provided by the rock mass. Where the quality of a rock mass and the orientation of discontinuities within the mass are favorable, cut slopes in rock of up to 0.25H:1V may be possible. Where rock type, strength, weathering, or orientation and frequency of discontinuities are not advantageous, flatter slopes and/or rock stabilization measures will be required to obtain an adequate factor of safety for the final slope configuration.

To prevent potential future rockfall from impacting the adjacent roadway after the project construction is completed, it may be necessary to incorporate mid-slope benches and/or rock catchment ditches at the toe of the cut slopes. Stabilization of the slope face may also be required, and include techniques such as rock bolting, anchored mesh, shotcreting, or erosion protection (for flatter slopes).

Another alternative for providing long-term stability of a rock cut is to construct a retaining wall in front of the excavated rock face to minimize the right-of-way required or potential impacts to adjacent properties and facilities. Retaining walls may be required particularly in areas where the rock is highly weathered or fractured, and where the orientation of rock discontinuities is unfavorable for the stability of the exposed rock mass.

During the design phases of the project, rock cut slopes will need to be evaluated with PennDOT-approved software to ensure that the required factor of safety against slope failure is achieved. Extensive field and subsurface investigations will be required to obtain sufficient data to perform these analyses. Potential field investigations are discussed in more detail later on in the text.

## Rock Excavation Costs and Techniques

The cost of rock excavation in areas where cuts are required is dependent on a number of factors, including, among others:

- the volume of rock to be removed
- ease of access of excavation equipment and dump trucks to the area to be cut
- the amount of room available to work in the cut area
- whether the rock mass is massive or broken
- the degree of weathering in the rock mass
- the hardness of the rock.

Based on Gannett Fleming's experience with other projects requiring large-scale rock excavations, it is estimated that rock excavation in highway cuts would be approximately $30 per cubic yard if the excavated rock remains onsite. This assumes that work is proceeding in a linear fashion, with convenient access for equipment to work and for trucks to haul off excavation material; that the rock excavation quantities are large (thousands of cubic yards); and that blasting or ripping can be performed (depending on the competency of the formation) to facilitate the excavation. This would be typical of the rock excavation work being performed from the Penn Street Interchange to the west, where the rock outcrops follow the southern side of the roadway and large-scale excavation of rock would be required. This would also be the case if rock is encountered in the excavation for the realigned westbound on-ramp to US 422 at the I-176 Interchange.

Where small-quantity rock excavations are required in areas that are more difficult to access, the rock excavation prices may be as high as $100 per cubic yard. This would apply if rock excavation is required at the rock outcrop supporting the electric substation adjacent to South 1st Avenue, adjacent to a section of US 422 supported by an existing bridge. Rock excavation quantities at that location would most likely be on the order of several hundred cubic yards or more, depending on the alternative selected for support of the reconstructed highway in this area.

For highway rock excavation work in highly-competent rock formations, blasting, often using a pre-splitting technique, is usually the preferred method of breaking


up the rock mass for removal by conventional excavation equipment. Blasting is typically used where the rock is massive (with few discontinuities) and has high strength, or where conventional ripping equipment may not be effective. Where the rock mass conditions are such that ripping the rock with large-scale equipment is feasible, this is typically the preferred method of excavation, because it eliminates many of the additional precautions and costs associated with using blasting techniques in urban areas. These items are discussed further below.

Rock blasting requires that certain precautions be taken. When blasting next to an active roadway, a short-term road closure (in both directions) is typically required during the blast period to make sure no fly rock impacts vehicles traveling along the roadway. After the blast, the Contractor has to verify that no fly rock has landed on the roadway; and if any rock has landed on or directly adjacent to the roadway, the Contractor needs to remove it prior to allowing the roadway to re-open. Additionally, blasting requires that pre- and post-construction surveys and vibration monitoring of any nearby residences, businesses, sensitive utilities and/or structures be performed. If, during the course of the blasting, vibration monitoring reveals that any of these facilities are being negatively impacted, the blasting methodology would need to be revised, or another method of rock excavation would need to be selected in the vicinity of the affected facility. The pre- and post-construction surveys typically consist of performing visual inspections of the exterior and interior of buildings (or exterior of structures such as walls and bridge piers) that may be affected by the blasting, and taking high-resolution photographs and/or video of the structures in question to document their pre-construction condition. The same process is repeated subsequent to the construction activities so that a comparison can be made between the pre- and post-construction conditions of a given structure. This helps to protect PennDOT and the Contractor from unwarranted damage claims by nearby property owners.

Blasting may not be desirable, or even feasible, where sensitive structures are nearby, or where there is a concern that the blasts may damage the remaining rock face, resulting in future instability of the rock mass, or where blasting may create unacceptable negative traffic impacts. An alternative to traditional blasting is to use chemical or hydraulic expanders in drill holes to split the rock mass; however, these methods may be more expensive and take longer than traditional blasting methods. Some cost savings may be realized if vibration monitoring and/or pre- and post-condition surveys can be reduced or eliminated as a result of using non-explosive rock fracturing techniques.

Non-explosive methods of rock excavation may be required adjacent to the two existing Norfolk Southern structures over US 422 to avoid disturbing the existing foundations supported on rock, and in other areas where blasting may disturb local residents or businesses. Staging of the bridge reconstruction and highway construction activities at these locations is important to maintain railroad operations throughout the course of construction.

### Field Investigations

Once the project proceeds to preliminary engineering, a significant field investigation effort will be required to support the geotechnical design of the highway improvements, particularly where rock cuts are anticipated. The investigation would include traditional subsurface exploration techniques such as test borings and geotechnical laboratory testing of rock and soil samples. To accurately determine the orientation of the discontinuities encountered when performing rock coring in the testing borings, it will be necessary to use oriented coring techniques, or an optical or acoustic televiewer to log the hole once coring has been completed. A geotechnical engineer and geologist should perform a detailed field reconnaissance of the site during preliminary engineering to identify and record features that will potentially impact the geotechnical design and/or construction of the proposed highway improvements.

A geologist should map rock structural data at existing rock cut sections or outcrops where new rock cuts are anticipated. Information obtained during field mapping of structural data can include the rock strike and dip, the types of rock discontinuities present, the spacing and persistence of discontinuities, any filling of joints or fractures, asperities and roughness of the rock discontinuities, presence or absence of water seepage, weathering of the exposed rock mass and the presence of localized zones of very broken or highly weathered rock. The field mapping can be supplemented with digital photogrammetry to create three-dimensional models of the exposed rock masses and to provide highly accurate structural mapping of the features. This information is highly useful in designing the proposed rock slopes and determining what rock remediation measures may be required to create a stable rock face after cuts are made in the rock.

Additionally, geophysical explorations could be used to characterize the top of rock profile (where rock is not at the ground surface) and the shear wave velocities of the rock mass, which is a general indicator of how competent the rock mass is and how difficult the rock will be to excavate. This information is valuable to the contractors when determining their excavation prices when the construction contracts go out to bid.


## Maintenance and Protection of Traffic

### Mainline

Maintaining the corridor during construction with minimum disruption to the public is just as paramount a task as rebuilding the corridor. Although some inconvenience is to be anticipated by the travelling public as a result of the construction, it should be kept to a minimum. The first goal should be maintaining the existing condition to the maximum extent possible. This is achieved by maintaining two through-lanes within the corridor as well as all ramp movements.

Providing two through-lanes from Warren Street (PA 12) to Lancaster Avenue during construction is simplified by the overwidening of the corridor. The first stage of construction could be overwidening to the south and then placing the eastbound traffic on that overwidened portion. Then the sequence would involve rebuilding eastbound or westbound first, move traffic over to the rebuilt area and finally rebuild the remaining area.

A key concern involves the tie-in points. However, long-term temporary conditions can be utilized in the median crossover points until the next section is rebuilt and then the median can be completed.

East of Lancaster Avenue in the existing S-curve, the median will need to be overwidened to accommodate sight distance. This approach will allow the additional room required for maintenance of two lanes of traffic. Along the tangent where the three river crossings and the I-176 interchange the three fracture critical structures set the staging. The mainline alternatives presented take into consideration the MPT staging needed for this area. However, the choice of a selected alternative will set the MPT staging.

East of the river crossings to the end of the West Shore Bypass, the staging shown in **Figure 65** can be utilized. This three stage concept provides a scenario to rebuild this section without overwidening in three stages.

### Interchanges

There are six interchanges within the defined corridor. The sixth interchange forms the western boundary. The interchanges are:

1. Warren Street (western boundary)
2. Wyomissing Boulevard
3. Penn Street
4. Lancaster Avenue
5. I-176
6. Neversink Avenue (access to & from west only).

Evaluating these interchanges for MPT only, the Wyomissing Boulevard and Lancaster Avenue interchanges require specific attention. The other four interchanges can more easily be maintained, as the staged reconstruction on the existing ramps can be accomplished by the early placement of proposed signals and the staged closings of the ramps during the interchange reconstruction.

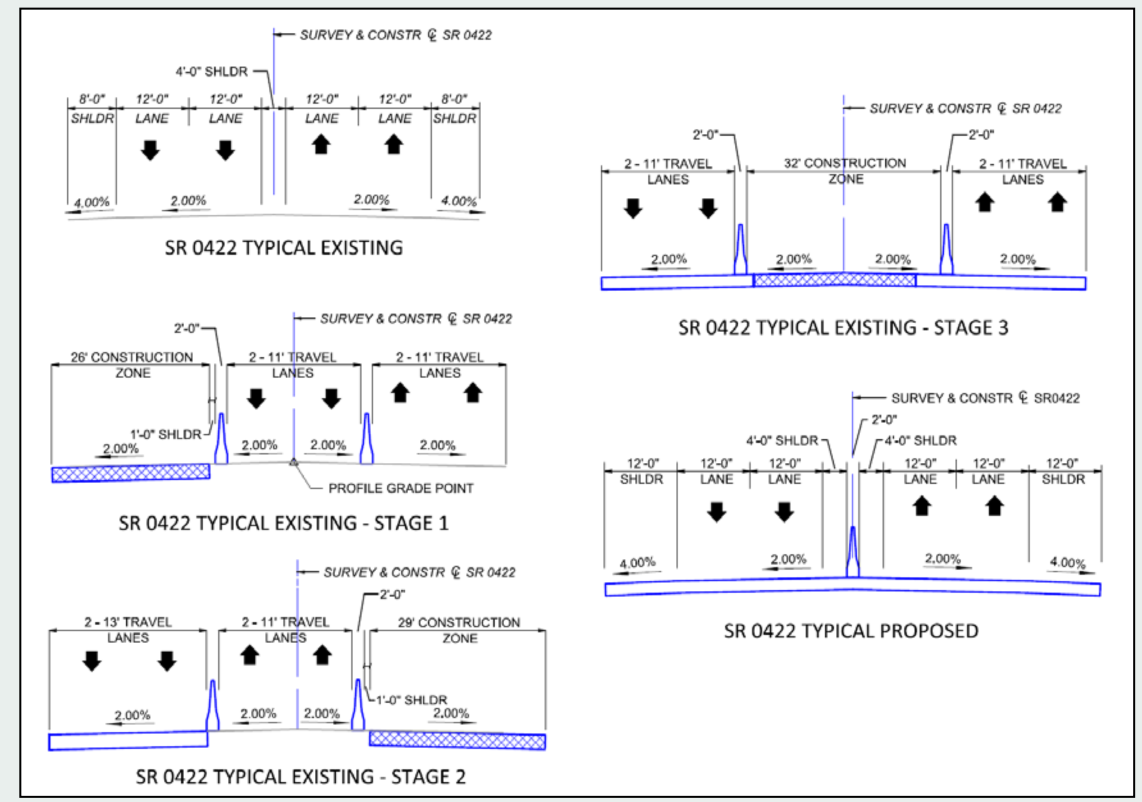



**Figure 65: Traffic Staging**

Wyomissing Boulevard Interchange has the lowest volume of traffic of any of the interchanges. It is also located in the tightest part of the corridor. This Study presents the option of detouring the interchange to minimize conflict points on the mainline during construction. Additionally, it gives the contractor the ability to construct the Wyomissing Boulevard bridge without staging concerns on Wyomissing Boulevard or US 422. The section below provides a detailed discussion of the impacts of that detour. The detour assumes all traffic will utilize the US 422 Penn Street Interchange; however, the US 222/US 422 Slate Hill Road Interchange is also a viable alternative for traffic accessing the VF Outlets and other businesses in the Borough of West Reading.

The Lancaster Ave Interchange is more problematic with the existing ramps accessing the left side of US 422. Since the viable interchange alternatives all include the eastbound ramps accessing PA 10 directly from the right side of the US 422 eastbound outside of the existing


road, those ramps could be constructed first with temporary connections to existing US 422 eastbound. This approach would remove US 422 eastbound access from the left side, which is desirable. And since the westbound access ramps are proposed where existing US 422 westbound is located or go under the entire road, these ramps will need to be detoured during construction. This detour is discussed below.

## Detour Route Analysis Summary

### Detour Route Analysis Summary for Construction of the Wyomissing Interchange

The Wyomissing detour analysis provides an evaluation of the anticipated transportation operating characteristics for the detour area during construction. The detour assumes that the whole interchange will be closed during construction and all traffic will instead use the nearby Penn Street Interchange. The detour route includes traveling along Park Road for the northbound/ southbound direction and along Penn Avenue for the eastbound/westbound direction.

Figures **H-1** through **H-8** are included in their entirety in Appendix H. They include detailed information regarding existing and future volumes (both with and without the detour) as well as corresponding levels of service.

Manual turning movement traffic counts were conducted in May 2013 for the following intersections during the weekday morning peak period (7:00 AM – 9:00 AM) and the weekday afternoon peak period (4:00 PM – 6:00 PM):

- Park Road & Wyomissing Boulevard
- Park Road & Hill Avenue
- Park Road & Penn Avenue
- Penn Avenue & 7th Avenue
- Penn Avenue & 5th Avenue
- Penn Avenue & 4th Avenue

These intersections, along with the Penn Avenue & 8th Avenue and Penn Avenue & 6th Avenue (volumes derived), were subjected to detailed capacity/level-of-service (LOS) analysis in order to assess the existing traffic conditions. All intersections operate at LOS D or above for existing conditions.

Future traffic volumes without the detour were projected utilizing the traffic growth rate of 0.75% (as consistent with the rest of the corridor study). The future traffic volumes were then projected to the anticipated detour year (2018) at the study intersections and were then subjected to detailed capacity/level-of-service analysis. All intersections are expected to operate at LOS D or above in 2018 without the detour, however some approaches are expected to experience a decrease in level of service.

For the anticipated future year (2018) with the detour, the traffic added by the detour was established based on the detour route established by the project team. The detour assignments were then added to the 2018 future without detour traffic volumes and subjected to detailed capacity/level-of-service analysis to assess the future traffic conditions expected during the detour. Since this analysis assumed that the whole interchange would be closed at one time, there is expected to be significant volumes added to the eastbound and westbound approaches along Penn Avenue. As such, LOS decreases for all intersections along Penn Avenue for future conditions. At the intersections of Penn Avenue & Park Road, Penn Avenue & 5th Avenue, and Penn Avenue & 4th Avenue, overall level of service decreases to a LOS E or worse in both AM and PM peak periods with detour volumes. As expected, volumes decrease at the intersection of Wyomissing Boulevard & Park Road due to the interchange being closed; therefore, capacity increases to LOS A or LOS B at that intersection.

With signal timing modifications only (including overall cycle length change to 110 seconds) as well as signal and phase adjustments, it is expected that the overall LOS for the AM peak period at the intersection of Penn Avenue & Park Road could operate at LOS D which is an improvement from base detoured conditions. Although overall delay would decrease with signal improvements, both the intersections of Penn Avenue & 5th Avenue, and Penn Avenue & 4th Avenue would still remain at LOS E or F during both peak periods. Without adding additional temporary capacity along the Penn Avenue corridor, signal timing modifications are the only mitigation that can occur during the detour. If it is determined that adding temporary capacity along Penn Avenue would be a desirable mitigation measure during construction, it is expected that temporarily eliminating parking, as well as removing the curb bump-outs, would allow for this improvement.

It is important to note that this analysis is conservative in that it was assumed all traffic from the Wyomissing Interchange would take this specific route along Penn Avenue and Park Road. Most likely what will occur is that motorists more familiar with the area will find their own way through the city grid and traffic impacts will be dissipated along the proposed detour route.

### Detour Route Analysis Summary for Construction of the Lancaster Road Interchange

The Lancaster Road Interchange detour analysis provides an evaluation of the anticipated transportation operational characteristics for the detour area during construction. The detour assumes that the westbound on/off ramps would be closed completely during construction and traffic would instead use the Penn Street Interchange. For this detour it was assumed that the off-ramp traffic would exit at Penn Street and then take 2nd street to Franklin Street to 4th street and then to Bingaman Street. For the on-ramp traffic, it was assumed motorists would travel from Bingaman Street


to 5th Street, west along Washington Street and then travel along 2nd street to the Penn Street Interchange.

Figures **H-9** through **H-16** are included in their entirety in Appendix H. They include detailed information regarding existing and future volumes (both with and without the detour) as well as corresponding levels of service.

The detour analysis included 15 intersections. Existing manual turning movement (MTM) counts (weekday morning and weekday afternoon peak periods) were utilized from 2003 for many of the intersections. In addition, manual turning movement counts were collected at some intersections during 2013. The intersections are listed below along with the date of the MTM data collection.

- 2nd Street & Penn Street (2012)
- 2nd Street & Franklin Street (2013)
- 4th Street & Franklin Street (2013)
- 4th Street & Chestnut Street (2003)
- 4th Street & Spruce Street (2003)
- 4th Street & Pine Street (2003)
- 5th Street & Laurel Street (2003)
- 5th Street & Spruce Street(2003)
- 5th Street & Chestnut Street (2003)
- 5th Street & Franklin Street (2013)
- 5th Street & Penn Street(2003)
- 5th Street & Washington Street (2013)
- 4th Street & Washington Street(2013)
- 3rd Street & Washington Street(2003)
- 2nd Street & Washington Street (2003)

Due to the varying nature of the volumes for this detour project area, volumes were projected and balanced to create an existing 2013 condition. They were then subjected to a detailed/level-of-service analysis in order to assess the existing conditions. Under existing conditions, the following intersections already operate at LOS E or worse:

- 2nd Street & Penn Street
- 5th Street & Washington (PM only)
- 2nd Street & Washington (PM only)

Future traffic volumes without the detour were projected utilizing the traffic growth rate of 0.75% (as consistent with the rest of the corridor study). The future traffic volumes were then projected to the anticipated detour year (2018) at the study intersections and were then subjected to detailed capacity/level-of-service analysis. For the future 2018 conditions, most intersections are expected to operate similarly to existing conditions, with the exception of 2nd Street & Washington Street, which decreases from LOS E to LOS F in PM peak hour conditions.

For the anticipated future year (2018) with the detour, the traffic added by the detour was established based on the detour route established by the project team. The detour assignments were then added to the 2018 future without detour traffic volumes and subjected to detailed capacity/level-of-service analysis to assess the future traffic conditions expected during the detour. When the detour volume is added to the network, the following intersections are expected to begin to operate at LOS E or worse under the future base 2018 projections (no improvements or signal modifications):

- 4th Street & Penn Street (AM & PM)
- 5th Street & Chestnut Street (AM only)
- 5th Street & Franklin Street (AM & PM)
- 4th Street & Washington Street (PM only)
- 3rd Street & Washington Street (PM only)

It is expected that many of the capacity problems associated with adding the detour volumes can be mitigated largely through network-wide signal and timing modifications. These modifications include increasing the cycle length to 120 seconds for all 15 intersections, as well as adjusting the splits and offsets for each intersection. In addition, it is proposed to temporarily remove the northbound parking along 5th Street between Penn Street and Washington Street and modify the existing northbound through lane into an additional left turning lane (allowing for dual northbound left turns). It is expected that Washington Street can accommodate this lane change.

The above described improvements are expected to increase the LOS at all intersections with the exception of 2nd Street & Penn Street which already operates at LOS F under existing conditions.

Again, this analysis is conservative in that it was assumed all traffic from the westbound Lancaster Road on- and off-ramps would take these specific detour routes. Most likely what will occur is that motorists more familiar with the area will find their own way through the city grid, and traffic impacts will be dissipated along the proposed detour route.