PENNSYLVANIA AVENUE TRAFFIC ALTERNATIVES ANALYSIS

FINAL REPORT

Prepared for the
National Capital Planning Commission

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SECTION 1.0 - INTRODUCTION

This report examines means of re-establishment of cross-town connectivity that was disrupted in 1995 with the closure of Pennsylvania Avenue, N.W. between 15th and 17th Streets in Washington, D.C, to public vehicular traffic. In particular, traffic implications are evaluated for Transportation Systems Management initiatives as well as for a vehicular tunnel within the alignment of Pennsylvania Avenue, N.W. and for a tunnel connecting Pennsylvania Avenue south of the White House to the E Street Expressway. Four Pennsylvania Avenue tunnel alternatives, of different lengths, were examined, as well as an at-grade alternative; all were compared to a no-build alternative.

For the Pennsylvania Avenue tunnels, certain constraints were established prior to traffic evaluation, including:

- Tunnel width shall be 50’-0”, face-to-face of walls.
- Roadway through the tunnel shall consist of four lanes, two in each direction.
- Portals to the tunnels must be east of Madison Place and west of Jackson Place and not be located closer than existing security checkpoints.
- Traffic limitations must be examined for 10-foot and 14-foot clearances.

The at-grade alternative for Pennsylvania Avenue was constrained to four lanes, two in each direction.

The E Street tunnel was evaluated in conjunction with the at-grade alternative and the no-build alternative for Pennsylvania Avenue.

Each alternative, with the exception of the no-build, assumed that certain Transportation Systems Management improvements to the existing street network and its operational characteristics were in place and operational.

The alternatives discussed in this report may or may not satisfy other objectives, such as security, historic, aesthetic, or socio-economic impacts.

1.1 BACKGROUND

In May 1995, Pennsylvania Avenue, N.W. between 15th and 17th Streets was closed to public vehicular traffic in response to security concerns associated with the President of the United States and the White House. At the same time, Madison Place to the northeast, Jackson Place to the northwest (which was already limited access), and State Place to the west and south of the White House were also closed. The latter closing effectively eliminated all westbound traffic from immediately south of the White House. At the time of the closings, Pennsylvania Avenue was operational in both eastbound and westbound directions and carried approximately 26,000 daily vehicular trips. E Street was also operational in eastbound and westbound directions between 15th and 17th Streets, and it carried approximately 12,000 daily vehicular trips in the westbound direction and 11,000 in the eastbound direction, according to the 1992 edition of the District of Columbia Traffic Volume Map. (Westbound traffic was completely removed from E Street at the closing.)

The closings had immediate and enduring impacts on the traffic movements on all streets and in all directions around the White House. Traffic that had utilized the two closed streets was forced to relocate to, in most cases, streets immediately adjacent to the area of closure. This resulted in similar traffic volumes through the area, but with significantly fewer travel lanes available to accommodate that traffic. As a result, certain locations in the network experienced increased levels of congestion. After the street closings, the District of Columbia Department of Public Works and the Federal Highway Administration identified numerous localized traffic operations improvements, which were intended to mitigate the negative impacts of the closures on traffic movement, without re-opening the closed streets. Although most of these measures have been implemented, there is still concern that traffic in the area remains constrained.

Since the closings, there have been continuing efforts, including those in the political arena, to re-open Pennsylvania Avenue and to improve traffic flow on E Street. These efforts have required the examination of means by which traffic connectivity across the city in the vicinity of the White House, severed in 1995, might be restored. One of these major efforts resulted in the opening of the westbound lanes of E Street in November 2000. The newly-opened E Street is on a different alignment than the original, bypassing State Place, and created a jog to New York Avenue via 17th Street.

The National Capital Planning Commission formed an Interagency Security Task Force in March 2001 to address issues related to integration of urban design and necessary security at federal properties in the Monumental Core of the Nation’s Capital. As part of this effort, the Task Force examined Pennsylvania Avenue, north of the White House and identified several alternative design options that appeared to have the potential of responding to needs associated with the closing.

The purpose of this study is to evaluate the traffic alternatives related to the re-opening of Pennsylvania Avenue to vehicular traffic and to make engineering-based conclusions. This study does not address issues related to national security or terrorism. The tragic events and consequences of September 11 are not addressed in this study. Those issues will be evaluated and addressed appropriately by others.

1.2 RECENT STUDIES

Concerns by the District, the Federal Government, and the local business community about the existing condition of Pennsylvania Avenue led to the undertaking of numerous studies of traffic in the area. Each study, however, was focused on particular aspects of the environment around the White House that was affected by the closings, but no single study provided a complete picture of the traffic impacts of the closings. The intent of this study is to complete the analysis of traffic impacts and of selected suggested physical improvements to address the traffic problems.

The numerous studies and reports undertaken since the closings provide traffic data which served as a basis for the analysis performed for this report. The data has been supplemented with field traffic counts taken in August 2001, and adjusted to provide a consistent database for analysis.

The existing studies and data sources used include:

- “Analysis of Transportation Conditions After Traffic Restrictions and Street Modifications in the Vicinity of the White House”, May 1997.

  This study was commissioned by the Federal Highway Administration to assist the District of Columbia to more clearly identify actions necessary to minimize the effects of the street closings on mobility in the vicinity of the White House. Objectives of the study included measurement of usage of the transportation system, identification of immediate-action transportation improvements and identification of other transportation improvements to address problems that could not be solved through immediate-action measures.

- “Environmental Assessment for Restoration of Westbound Traffic in the E Street Corridor, Washington, D.C.”, July 1999.

  This study addressed the plans of the Federal Highway Administration, the National Park Service and the D.C. Department of Public Works to restore westbound vehicular traffic to E Street between 15th and 18th Streets. The study identified a preferred alternative to accomplish the re-opening of E Street to pre-closure conditions. The document determined aspects of the preferred alternative with social, economic and environmental impacts. A substantial portion of the study detailed the analysis and evaluation of traffic conditions and impacts.

- “Environmental Assessment: Implementation of White House Security Review Vehicular Traffic Restriction Recommendations, June 1997 (FONSI: September 1997)

- “Comprehensive Design Plan and Final Environmental Impact Statement, The White House and President’s Park”, December 1999; Traffic Management Plan, April 2000.

Given that Pennsylvania Avenue and westbound E Street were closed with little prior notification, traffic use of the two streets was not measured immediately prior to the closings. Re-establishment of the connectivity severed in 1995 would be expected to accommodate traffic similar to that which used the streets prior to the closings. To establish operational characteristics prior to the closings, the following information was examined:

- “President’s Park”, December 1993, and technical appendices.

- District of Columbia Department of Public Works (DCDPW) Weekday Average Daily Traffic Counts, 1993 and 1998.

1.3 STUDY AREA BOUNDARY

The effects on traffic of the closings of Pennsylvania Avenue and State Place are most prominent on streets nearest the closings. On streets progressively farther from the closings, impacts of the closings are progressively less severe. Therefore, geographic limits were established to the area of consideration for this traffic study, beyond which the effects of the closings were minimal. The boundaries for the study area are:

- K Street, N.W. to the north
- Constitution Avenue, N.W., to the south
- 19th Street, N.W., to the west (with an extension along Pennsylvania Avenue, to incorporate the intersections of Pennsylvania Avenue with 20th and 21st Streets).
- 14th Street, N.W. to the east (with an extension along New York Avenue to incorporate the intersection of New York Avenue, H Street and 13th Street).

Figure 1.1 depicts the study area boundary.

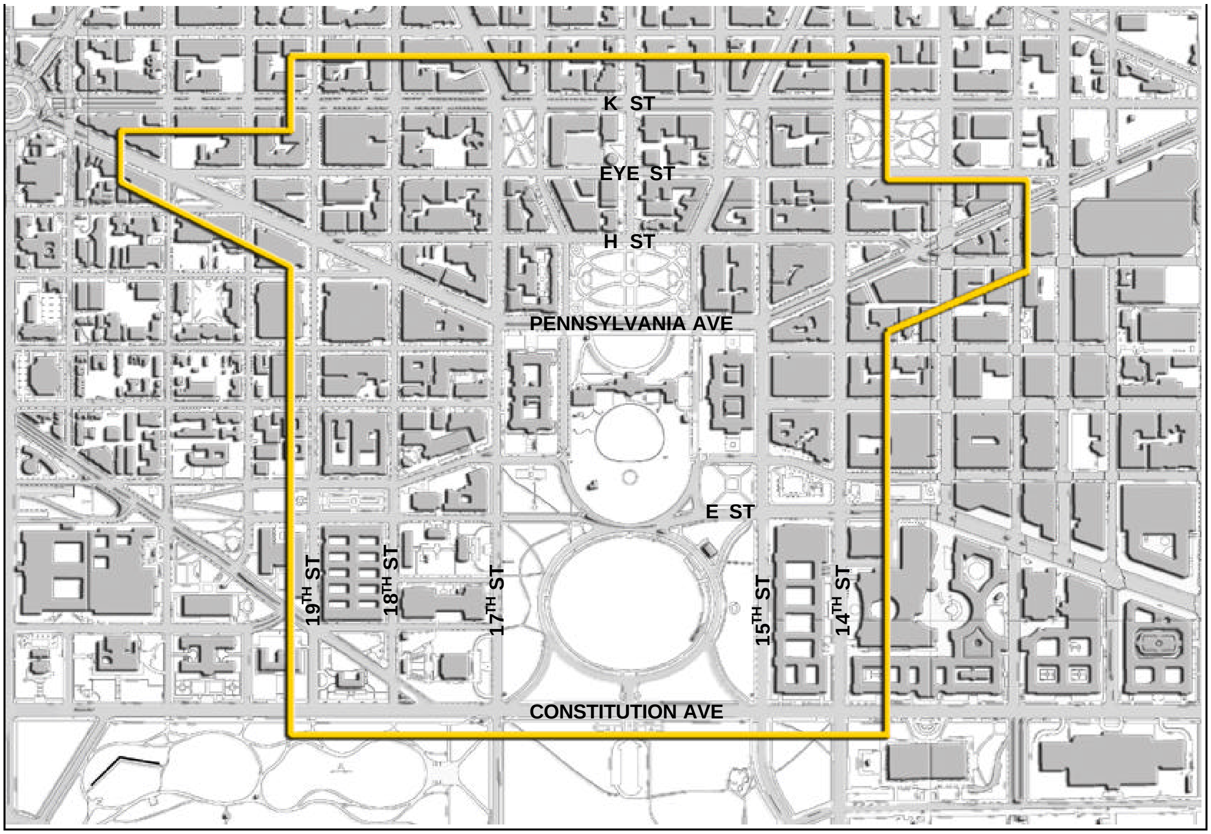


Figure 1.1: Study Area Boundary

SECTION 2.0 - DESCRIPTION OF ALTERNATIVES

Each alternative was evaluated for traffic operations impacts, and for factors other than traffic-carrying efficiency that may contribute to the feasibility of implementation. Included were geometric and design requirements, accessibility, traffic safety, utilities, construction cost, and construction schedules.

2.1 EXISTING CONDITIONS

An existing conditions traffic simulation model was developed and calibrated to sufficiently replicate real world traffic conditions during morning and afternoon peak periods. This model, which is described in more detail in Section 3, incorporated summer 2001 traffic volumes, existing traffic signal timings, and construction-related lane blockages that were in place during the first week of August 2001. (Construction blockages are detailed in Appendix C.)

2.2 NO-BUILD ALTERNATIVE

This alternative would retain the existing closed condition on Pennsylvania Avenue between 15th and 17th Streets. In accordance with historical data provided by DCDPW, traffic volumes were increased by 9 percent to reflect the seasonal change in traffic volumes between August 2001 and September 2001. Existing traffic signal timing and sequence plans from DCDPW were used for the traffic signal control. Construction-related lane blockages were removed from this model. This alternative is the baseline to which all other alternatives were compared.

2.3 TSM STRATEGIES ALTERNATIVE

This alternative is based on the no-build alternative, with the addition of selected Transportation Systems Management (TSM) strategies as agreed upon by the Technical Working Group. (This group, composed of representatives from the National Capital Planning Commission, the Federal Highway Administration, the District of Columbia Division of Transportation, and the United States Secret Service, guided the progress of this study.) The more significant TSM measures included were:

- Optimization of traffic signal timing throughout the study area
- Reconfiguration of traffic islands at the intersection of 13th Street, H Street and New York Avenue
- Parking restrictions and enhanced turning capacity along the 18th Street corridor
- Improved enforcement of parking, standing and loading restrictions in the study area
- Correction of deficient traffic signage and pavement markings in the study area

The TSM strategies applied to this alternative were also applied uniformly to all subsequent alternatives analyzed.

A detailed discussion of all TSM measures employed is included in Appendix B.

2.4 AT-GRADE ALTERNATIVE

This alternative would re-open the closed portion of Pennsylvania Avenue between 15th and 17th Streets at grade to vehicular traffic.

Location and Geometric Design

The re-opened roadway would include four traffic lanes, two each in the eastbound and westbound directions. Further, the north curb line of Pennsylvania Avenue re-opened to traffic would be the same as the north curb line prior to closing. Since there would be fewer traffic lanes in the at-grade alternative than existed prior to closing, the new south curb line of Pennsylvania Avenue would be approximately 34 feet further north than the south curb line prior to closure. Modifications to traffic lane configurations at the intersections with 15th Street and 17th Street would also be required.

A preliminary cross section of Pennsylvania Avenue re-opened to traffic is shown in Figure 2.1. The intersections of Pennsylvania Avenue with 15th and 17th Streets are shown in plan view in Figure 2.2.

Traffic Accessibility

Under this alternative, Pennsylvania Avenue will be re-opened to traffic at grade and will largely restore the conditions that existed prior to the closing. Traffic to and from 15th Street and 17th Street will have open access via Pennsylvania Avenue. Madison and Jackson Places

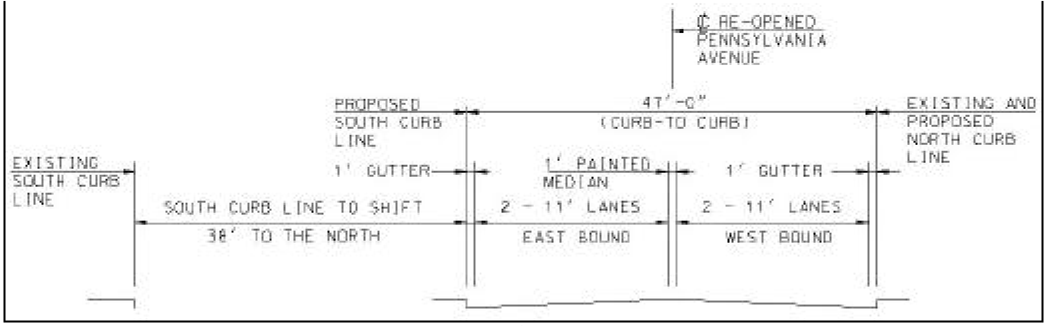


Figure 2.1: Preliminary Cross-Section of Pennsylvania Avenue At Grade

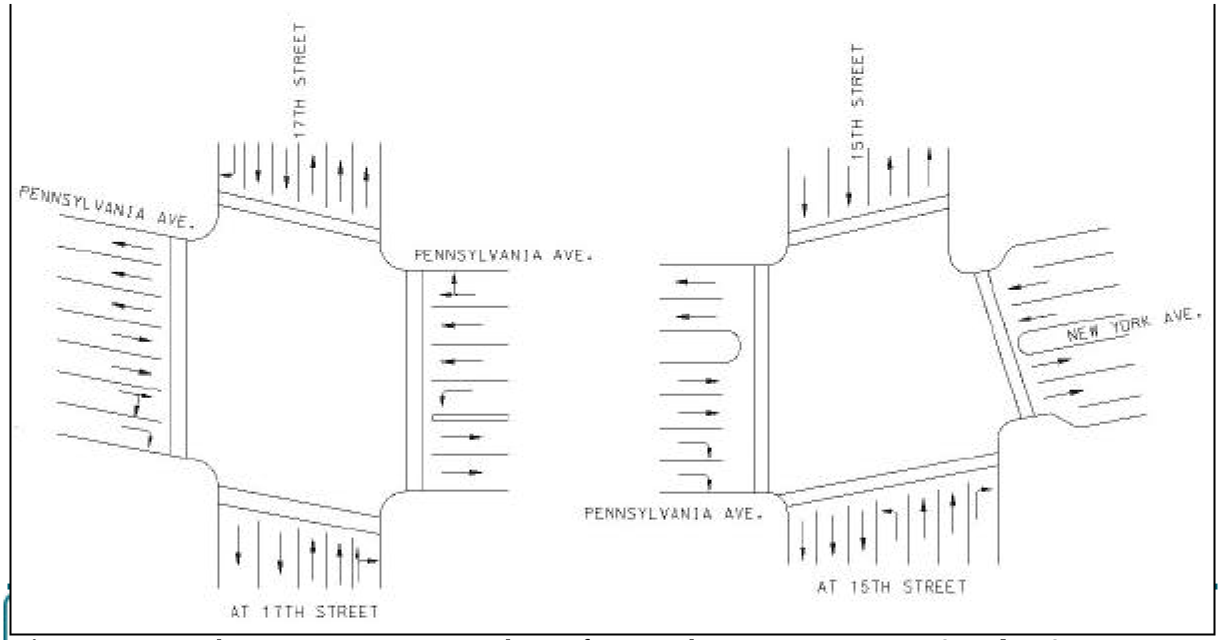


Figure 2.2: Preliminary Intersection Plans of Pennsylvania Avenue at 15th and 17th Streets

will remain closed to public travel.

Traffic Safety

The four travel lanes that are proposed for the at-grade alternative are fewer than the six travel lanes that existed prior to closing. The reduced roadway width will result in less operational flexibility than pre-closure; there will not be sufficient width for such activities as bus loading or tourist stopping. However, the capacity of the re-opened street will be sufficient to accept the anticipated traffic volumes without congestion.

The intersections of Pennsylvania Avenue with 15th and 17th Streets will remain at existing dimensions. These intersections were sized to accept the roadway width prior to closing and will therefore be wider than the through roadway. This transition in width may create some confusion at the intersections for traffic on Pennsylvania Avenue, but careful pavement markings and clear signage can mitigate these negative aspects.

Construction Impacts

The impacts from construction of this alternative on traffic would be minor. Some lane closures, short in duration and easily accommodated in off-peak hours, would be necessary for pavement marking placements in the intersections of Pennsylvania Avenue with 15th and 17th Streets.

Utility Impacts

The impact on existing utilities under this alternative will be small. The re-establishment of streetlights on a new south curb line will be required. Other existing utilities will not be affected.

Construction Schedule

Construction requirements will be straightforward. The south curb line will require re-establishment at a new location and streetlights will be placed behind the new curb. TSM measures will be required as well. This work is expected to require about 4 months to accomplish.

Construction Cost

The cost to open Pennsylvania Avenue, including construction of new south curb line and relocation of streetlights, new pavement markings, signal timing and all other aspects necessary for a complete project is estimated at less than $1 million, excluding security enhancements and landscaping.

2.5 SHORT TUNNEL ALTERNATIVE

This alternative would feature a tunnel with a west portal between 17th Street and Jackson Place and an east portal between 15th Street and Madison Place. Pennsylvania Avenue would remain closed at grade. The short tunnel is depicted in Figure 2.3.

Location and Geometric Design

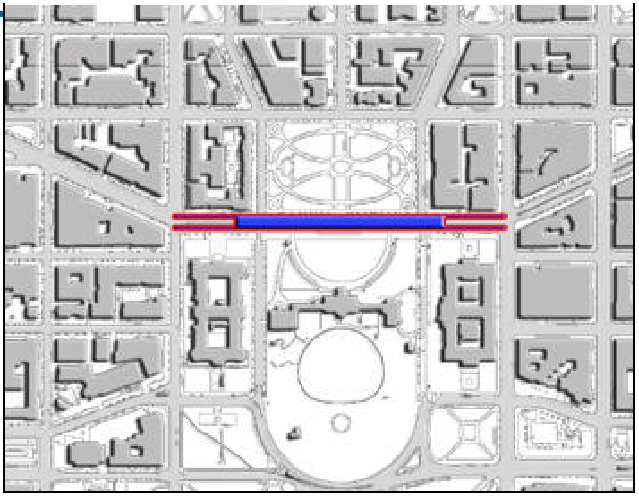


Figure 2.3: Short Tunnel Alternative

The short tunnel, with portals approximately at the existing security control points, would have a length of approximately 870 feet. The tunnel geometry would include approach grades of approximately 7% to the east and 6% to the west. The same roadway profiles can be utilized for portal clearances of 10 feet and 14 feet. It is recommended that the tunnel be constructed with a 14-foot vertical clearance and that barriers be installed at the portals to limit the entry clearance to 10 feet. The tunnel profile was developed assuming a superstructure depth above the tunnel of four feet. Detailed design may result in a deeper positioning of the tunnel, with resultant increases in approach grades.

At-grade service roadways could be developed at both the east and west portals. These roadways would serve authorized security and emergency access only, and would not extend beyond existing security check points.

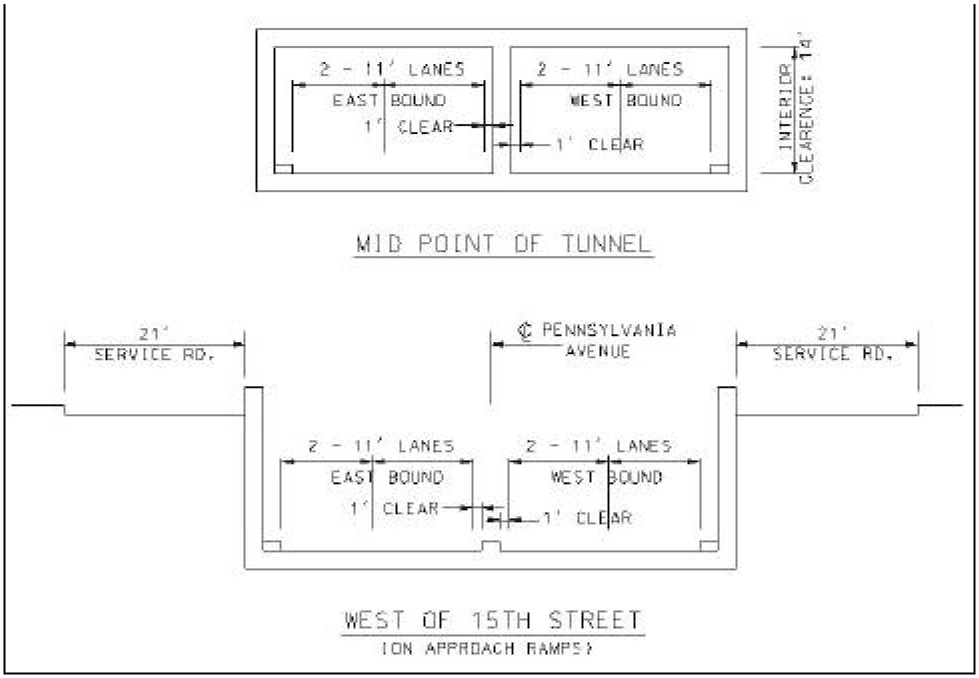


Figure 2.4: Preliminary Short Tunnel Cross-Sections

The length of the tunnel may allow proper ventilation without the need for ventilation towers.

Cross-sections at critical points along the tunnel are shown in Figure 2.4. A preliminary profile is included in Appendix D.

Traffic Accessibility

Under this alternative, access to Pennsylvania Avenue (via the tunnel) from adjacent streets will be restored to the conditions prior to the closing, with the exception that Madison and Jackson Places will not be re-opened. Turning movements from streets, including 15th and 17th

Streets, will be the same as prior to the closing of Pennsylvania Avenue. Because of sight-distance limitations for traffic exiting the tunnel, left turns will be prohibited onto 15th and 17th Streets from Pennsylvania Avenue.

Traffic Safety

The roadway profile geometry includes vertical curves that are marginally within acceptable limits for 30-mph design speeds. Because of physical constraints, more desirable geometrics cannot be achieved. A significant deficiency in the geometry is that the approach inclines meet existing street grades within short distances from the intersections of 15th Street and Pennsylvania Avenue (50 feet) and 17th Street and Pennsylvania Avenue (20 feet). This condition may create safety problems since sight distances, particularly for vehicles on 15th Street and 17th Street, may be severely limited. Placement of the tunnel portals at greater distances from the intersections would improve this safety problem. However, the security constraints offer little opportunity to move the portals further from the intersections.

Construction Impacts

The impacts from construction of this alternative on traffic, for the 15th Street and 17th Street areas, would be the same as under the at-grade alternative, i.e., lane closures during pavement marking placement. However, the ingress and egress of construction equipment, probably under restrictive security conditions, will likely cause some delays in traffic movements on 15th and 17th Streets. Construction will require protection of the existing Metrorail tunnel, but there should be no interruption to Metrorail service.

Utility Impacts

The impact on utilities under this alternative would require relocation and temporary support of the utilities within the area of tunnel construction. The utilities in the area of tunnel access ramps would be relocated to the service roads. There would be no impact of utilities in adjacent intersections, so that construction delays due to utility work on adjacent streets would not occur.

Construction Schedule

Given the restricted construction area, expected security requirements, utilities considerations, and accommodation of existing Metrorail tunnel within the construction area, construction of the short tunnel is estimated to require 24 to 30 months.

Construction Cost

Cost to design and construct the short tunnel, including excavation, utilities accommodation, protection of Metrorail tunnel and all other aspects necessary for a complete project is estimated at $55 million. This estimate does not include any necessary tunnel strengthening for security reasons, or landscaping.

2.6 INTERMEDIATE TUNNEL ALTERNATIVE

This alternative would feature a tunnel with a west portal between 17th and 18th Streets and an east portal between 15th Street and Madison Place. Pennsylvania Avenue would remain closed at grade. The intermediate tunnel is depicted in Figure 2.5.

Location and Geometric Design

The intermediate tunnel's length would be approximately 1,470 feet, with approach roadway grades of 7% on the east and 6% on the west. The same profile could be used for tunnel clearances of 10 feet or 14 feet.

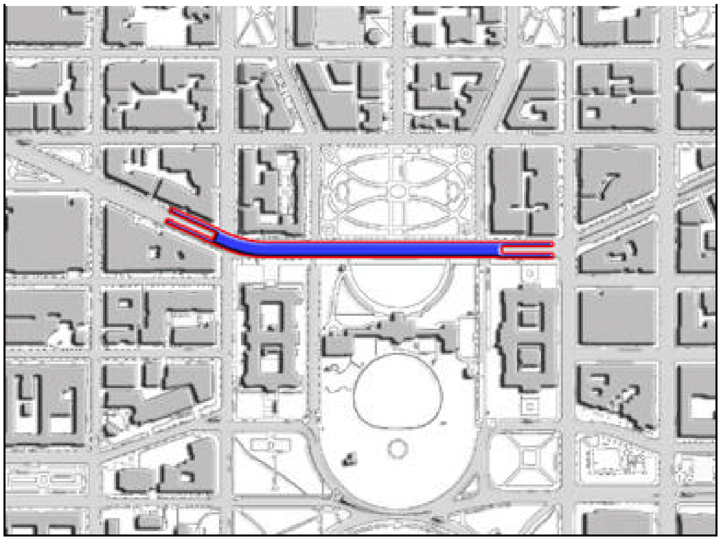


Figure 2.5: Intermediate Tunnel Alternative

At the west end of the intermediate tunnel, the horizontal alignment changes to meet that of Pennsylvania Avenue, which moves from an east-west alignment to a southeast-northwest alignment. This combination of vertical and horizontal geometry, while not ideal, can accommodate the tunnel roadway safely.

While it is not within the intent of this report to evaluate ventilation requirements, it should be noted that the length of the intermediate tunnel is such that a more complex ventilation system may be required.

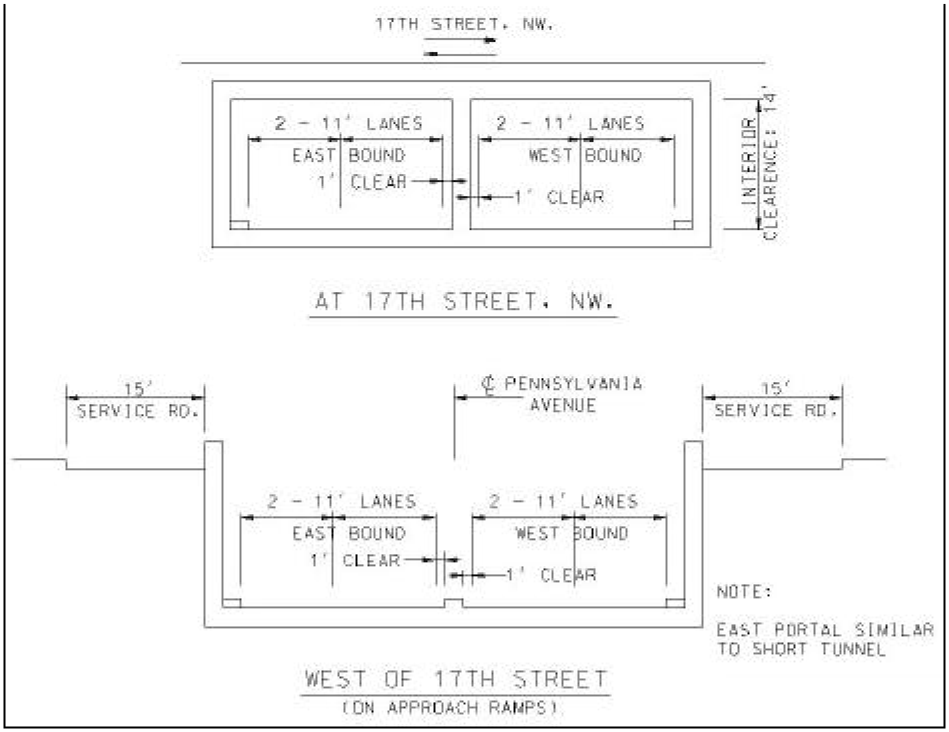


Figure 2.6: Preliminary Intermediate Tunnel Cross-Sections

At-grade service roads at the west end of this tunnel could be developed. These service roads would allow vehicular movements from eastbound Pennsylvania Avenue to 17th Street and from southbound 17th Street to westbound Pennsylvania Avenue. Service roadways at the east portal would be available for authorized security and emergency access only.

Cross sections at critical points along the tunnel are shown in Figure 2.6. A preliminary profile is included in Appendix D.

Traffic Accessibility

Under this alternative, certain turning movements that were present prior to the closing of Pennsylvania Avenue will not be available. Westbound Pennsylvania Avenue traffic will not be able to access 17th Street, and 17th Street traffic will not be able to access eastbound Pennsylvania Avenue. Traffic wishing to access eastbound Pennsylvania Avenue via the tunnel will be required to use Pennsylvania Avenue west of 18th Street to be able to enter the tunnel. Similarly, westbound traffic in the Pennsylvania Avenue tunnel will be required to use 18th Street or streets further west to reach 17th Street. Turning to and from Pennsylvania Avenue west of 17th Street will be available via service roads at the tunnel's west portal.

Turning movements at 15th Street and Pennsylvania Avenue will be restored to those available prior to the closing.

Traffic Safety

The roadway geometry includes vertical curves that are marginally acceptable for 30-mph design speeds. As in the case of the short tunnel, the east portal incline reaches existing grade very close to the intersection with 15th Street, which may create safety problems due to sight distance deficiencies. However, extension of the tunnel beyond 17th Street to the west removes this potential problem at the west portal area.

Construction Impacts

The impacts from construction of this alternative on traffic at 15th Street would be the same as the previous alternatives, i.e., lane closures during pavement marking placement, protection of Metrorail tunnel but no interruption of service. At 17th Street and on Pennsylvania Avenue west of 17th Street, the effect would be considerably greater. There would be lane reductions and closures for longer periods during excavation and other construction activities. These impacts would result in increased traffic congestion on 17th Street and Pennsylvania Avenue. There are several ways to schedule construction, and the issue would be evaluated in further detail during final design. However, one option would be to schedule work in two phases:

- Excavation of the tunnel alignment through the intersection. This would require about 6 months to accomplish, after which the excavation would be closed with temporary coverings and traffic returned to the intersection. Work on the tunnel would then resume under the streets.
- Removal of the temporary covering, construction of the tunnel roof and placement of new roadway. This would probably require about 4 months to accomplish.

Utility Impacts

The impact on utilities under this alternative would require relocations, reconstruction and temporary support of major utilities within the area of tunnel construction. Since the tunnel would pass under 17th Street and surface in an area of Pennsylvania Avenue under active traffic, relocation or replacement of existing utilities in these areas would extend the time required for construction. The utilities affected by construction included:

- Water lines (12” and 20”)
- Telephone conduits (16-4” ducts)
- 20” gas line
- Electrical conduits
- 2’-6” x 3’-6” combined sewer
- 5’-0” steam tunnel

Most of these utilities can be relocated or supported temporarily during construction. The combined sewer is located to the east and south of the intersection of 17th Street and Pennsylvania Avenue and may only require protection during construction. The 5’-0” steam line, however, passes through the intersection and may require relocation.

Construction Schedule

Construction of the intermediate tunnel, including considerable utilities accommodation and phased construction on the areas of Pennsylvania Avenue under traffic, as well as the intersection of 17th Street and Pennsylvania Avenue, is estimated to require about 2 ½ to 3 years to complete.

Construction Cost

Cost to design and construct the intermediate tunnel, including excavation, utilities support and relocation, protection of Metrorail tunnel, phased construction and all other aspects necessary for a complete project is estimated at $80 million, excluding security enhancements to the tunnel or landscaping.

2.7 LONG TUNNEL ALTERNATIVE

This alternative would feature a four-lane tunnel with a west portal between 17th and 18th Streets and an east portal between 14th and 15th Streets on New York Avenue. Pennsylvania Avenue would remain closed at grade. The long tunnel is depicted in Figure 2.7.

Location and Geometric Design

The long tunnel’s length would be approximately 1,860 feet, with approach grades at both the east and west ends of approximately 6%. As with the other tunnel alternatives, the same profile can be used for tunnel clearances of 10 feet or 14 feet.

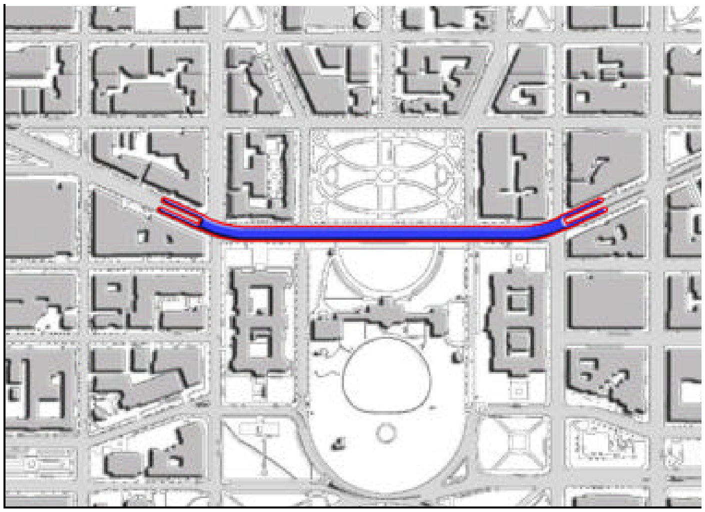


Figure 2.7: Long Tunnel Alternative

The roadway profile geometry includes vertical curves that are marginally within acceptable limits for 30-mph design speeds. At both the east and west ends of the tunnel, the horizontal alignment changes to meet that of New York Avenue and Pennsylvania

Avenue, respectively. The resulting combination of vertical and horizontal geometry in the same area is acceptable.

As with the intermediate tunnel, the length of the tunnel will be such that special considerations for ventilation may be required.

At-grade service roads will be developed at each end of the tunnel. At the west portal, these roads will accommodate vehicular movements from eastbound Pennsylvania Avenue to 17th Street, and from 17th Street to northwestbound Pennsylvania Avenue. At the east portal, these roads will accommodate vehicular movements from 15th Street to eastbound New York Avenue and from southwestbound New York Avenue to 15th Street. However, the existing roadway width on New York Avenue is insufficient to allow development of fully operational service roads, including parking. If the tunnel portal and service roads were to be constructed within the existing curb lines, the resulting service roadways would be in the range of 10 feet in width, which is marginally acceptable for traffic movement, but would preclude curbside parking. A more desirable service roadway width of 18 feet (similar to the service roads on K Street, N.W.) would require intrusion into the existing wide sidewalks on New York Avenue.

Cross sections at critical points along the tunnel are shown in Figure 2.8. A preliminary profile is included in Appendix D.

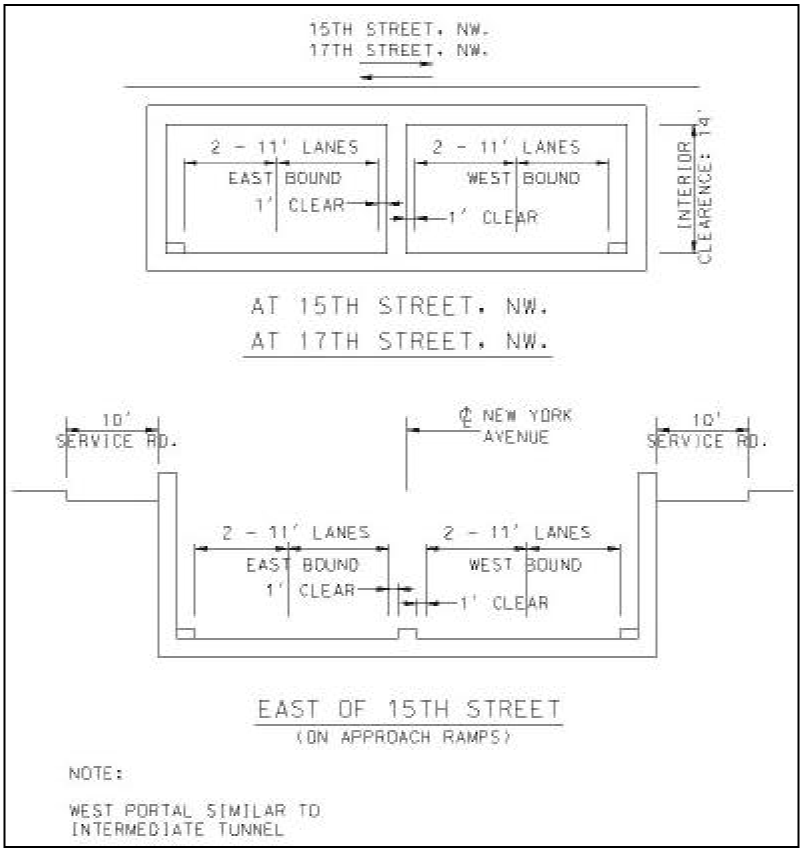


Figure 2.8: Preliminary Long Tunnel Cross-Sections

Traffic Accessibility

Under this alternative, certain turning movements that were permitted prior to the closure of Pennsylvania Avenue will not be available. Westbound Pennsylvania Avenue traffic will not be able to access 17th Street, and 17th Street traffic will not be able to access eastbound Pennsylvania Avenue. Similarly, turns to and from 15th Street to Pennsylvania Avenue west of 15th Street will not be available. Traffic seeking access to Pennsylvania Avenue from either east or west will be required to move to 14th Street to the east and to 18th Street to the west to access the tunnel. These conditions may adversely affect the attractiveness of the tunnel for vehicular traffic.

Traffic Safety

Extension of the tunnel west of 17th Street removes potential safety deficiencies at the cross street intersection, since the tunnel portal will be located a considerable distance from the intersection. The east portal, however, will reach grade immediately west of the intersection with 14th Street, and the potential safety problem due to sight distance deficiencies will be more severe here than under other alternatives.

Construction Impacts
The impacts from construction of this alternative on traffic would be substantial, and in areas both east and west of the closed portion of Pennsylvania Avenue. Tunnel construction, probable decking of excavated areas, utility relocations, phased construction in areas of active traffic and other construction activities would require lane closures and possible street closures for extended periods of time. Again, the Metrorail tunnel would be protected during construction, but service would not be interrupted.

Utility Impacts
The impact on utilities under this alternative would require relocations, reconstruction and temporary support of major utilities within the area of tunnel construction, which would impact 15th Street, 17th Street, Pennsylvania Avenue and New York Avenue. Utilities affected by the intermediate tunnel at 17th Street and Pennsylvania Avenue would be similarly affected by the long tunnel. Traffic on these streets would be disrupted and delayed during the construction period. Particular delay and expense would result from tunnel construction in the intersection of 15th Street and Pennsylvania Avenue and on New York Avenue east of 15th Street, since a large sewer, 6’-3” in diameter is located in New York Avenue, and turns through the intersection of 15th Street and New York Avenue.

Construction Schedule
Construction of the long tunnel, including major utilities relocation, protection of the Metrorail tunnel, and phased construction on areas of Pennsylvania Avenue and New York Avenue under active traffic, and of the intersections with 15th and 17th Streets, is estimated to require 3 to 3½years to complete.

Construction Cost
Cost to design and construct the long tunnel, including excavation, major utilities work, protection of the Metrorail tunnel, phased construction and all other aspects necessary for a complete project is estimated at $97 million, excluding security enhancements to the tunnel and landscaping.

2.8 SPLIT-PORTAL TUNNEL ALTERNATIVE

This alternative would combine certain characteristics of the intermediate and long tunnels, mitigating some of the negative aspects of each. However, separating the east portals may cause confusion to some drivers. The exit portal for eastbound traffic would be between Madison Place and 15th Street. The entry portal for westbound traffic would be between 14th and 15th Streets. Pennsylvania Avenue would remain closed at grade. The split-portal tunnel is depicted in Figure 2.9.

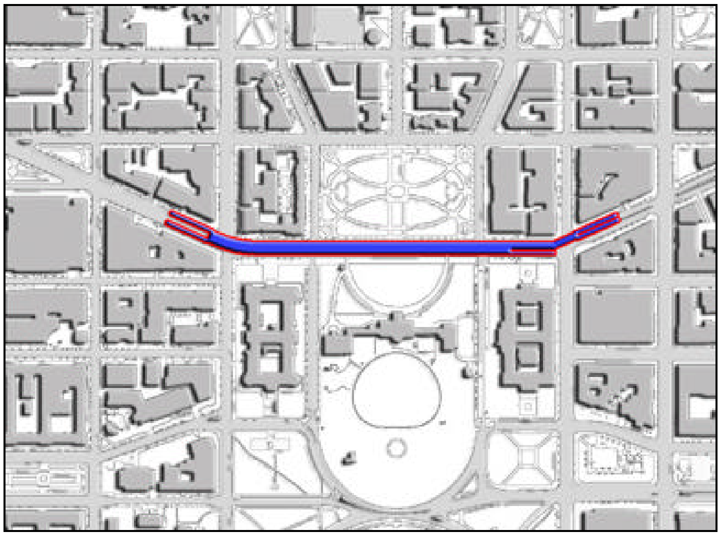


Figure 2.9: Split-Portal Tunnel Alternative

Location and Geometric Design

The west portal of this alternative would be at the same location as the west portal of the intermediate and long tunnels. The east portal, however, would be in two locations. The egress portal for eastbound traffic would be between Madison Place and 15th Street, as in the intermediate tunnel. The ingress portal for westbound traffic, however, would be between 14th and 15th Streets, as in the long tunnel. This separation of portals will result in greater space to develop service roadways around the east portals, mitigation of traffic safety issues at the east portal of the long tunnel, less interaction with existing utilities, and less visual impact at a given location than either the intermediate or long tunnel.

The tunnel length, as with the long tunnel, would be approximately 1,860 feet. The approach grades at the west end and at the westbound ingress will be approximately 6%. The grade for the eastbound egress will be approximately 7%. The same profile can be used for tunnel clearances of 10 feet or 14 feet.

As with the long tunnel, the roadway profile geometry includes vertical curves that are marginally within acceptable limits for 30-mph design speeds. At the west end and the westbound ingress portal, the horizontal alignment changes to meet that of Pennsylvania Avenue and New York Avenue, respectively. The resulting combination of vertical and horizontal geometry in the same area is acceptable.

The length of the tunnel is such that special considerations for ventilation may be required.

At-grade service roads will be developed at each of the three portals. At the west portal, these roads will accommodate vehicular movements from eastbound Pennsylvania Avenue to 17th Street, and from 17th Street to westbound Pennsylvania Avenue. At the eastbound egress portal, service roads would serve security and emergency access only. The service roads at the westbound ingress portal, in New York Avenue, could be wide enough to accommodate traffic to and from New York Avenue and 15th Street, and permit curbside parking without reduction in existing sidewalk widths.

Cross-sections at critical points along the tunnel are shown in Figure 2.10. A preliminary profile is included in Appendix D.

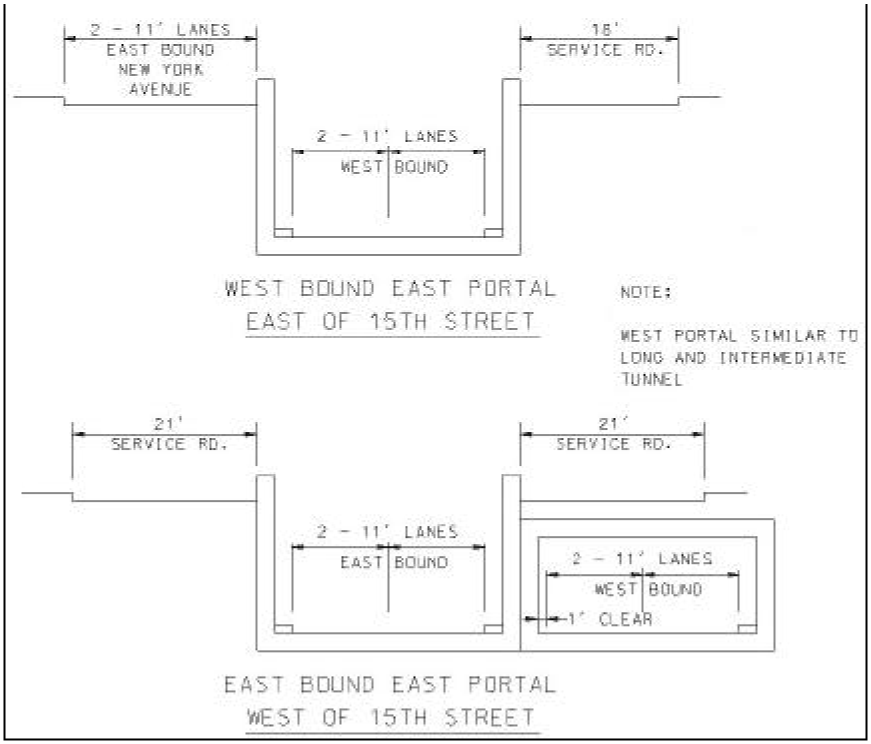


Figure 2.10: Preliminary Split-Portal Tunnel Cross-Sections

Traffic Accessibility

Under this alternative, certain turning movements that were present prior to the closing of Pennsylvania Avenue will not be available. At the west end, turns to and from 17th Street and eastbound Pennsylvania Avenue will not be possible. Traffic wishing to access eastbound Pennsylvania Avenue via the tunnel will be required to use Pennsylvania Avenue west of 18th Street to be able to enter the tunnel. Similarly, westbound traffic in the tunnel will be required to use 18th Street or streets further west to reach 17th Street. Turning to and from Pennsylvania Avenue west of 17th Street will be available via service roads at the tunnel's west portal.

At the east end, some of the traffic movements removed at the closing will be restored. Eastbound traffic on Pennsylvania Avenue will be able to access 15th Street, north or south. 15th Street traffic will be able to access eastbound New York Avenue via service roads east of 15th Street. Traffic from 15th Street, however, will not be able to directly access the Pennsylvania Avenue westbound tunnel. This traffic will be required to move further east to 14th Street to enter the west bound tunnel. Westbound New York Avenue traffic can access 15th Street via the access roads at 15th Street.

Traffic Safety

The split portal tunnel provides somewhat better traffic safety conditions than does the long tunnel by reducing the potential safety deficiencies at the cross street intersections. The eastbound egress incline reaches street grade about 50 feet west of 15th Street. This is in lieu of the same incline reaching street grade at the west curb line of 14th Street, as in the long tunnel. Also, by extending only the westbound tunnel east of 15th Street, there will be ample horizontal distance to develop full width service roads east of 15th Street, thereby eliminating the potential safety deficiencies of narrow service roads, as in the long tunnel.

Construction Impacts

The impacts of construction of this alternative on traffic west of 15th Street would be the same as for the intermediate tunnel, i.e., lane closures during excavation and other construction activities. In the intersection of 15th Street and Pennsylvania Avenue, there would be disruption during tunnel excavation, but significantly less than with the long tunnel. Since the eastbound traffic would exit west of 15th Street, the construction in the intersection would likely not impact the existing large sewer under 15th Street and the intersection of 15th Street and New York Avenue, thereby reducing construction time and associated negative impacts on traffic. Also, the single tunnel portal between 14th and 15th Streets on New York Avenue would provide greater roadway width around the construction zone with resultant easier maintenance of traffic.

Utility Impacts

The impacts on utilities under this alternative would require relocations, reconstruction and temporary support of major utilities within the area of tunnel construction. Since the tunnel would pass under 17th Street and surface in an area of Pennsylvania Avenue under active traffic, there would be significant disruption and delay to traffic on both 17th Street and Pennsylvania Avenue. On the east, however, the separation of the ingress and egress portal will serve to reduce construction complications compared to the long tunnel. Between 14th Street and 15th Street, the construction will be in a narrower area and maintenance of traffic on either side of the construction zone will be eased. Also, since the east bound lanes exit before reaching 15th Street, the tunnel does not interfere with an existing major sewer line in the south portion of the 15th Street and Pennsylvania Avenue intersection, and therefore reduces the need to relocate this sewer.

Construction Schedule

Construction of the split portal tunnel, including utility accommodation, phased construction in both Pennsylvania Avenue and New York Avenue, and protection of the Metrorail tunnel is estimated to require about 33 to 39 months to complete.

Construction Cost

Cost to construct the split portal tunnel, including excavation, utilities support and relocation, protection of Metrorail tunnel, phased construction and all aspects necessary for a complete project is estimated at $88 million, excluding security enhancements and landscaping.

2.9 E STREET TUNNEL ALTERNATIVES

These alternatives would feature a tunnel south of the White House connecting Pennsylvania Avenue between 14th and 15th Streets to the E Street Expressway. One alternative would include Pennsylvania Avenue north of the White House retained in its present closed condition. The second alternative with the E Street tunnel would include the currently closed portion of Pennsylvania Avenue between 15th street and 17th Street opened at grade to vehicular traffic. Figure 2.11 depicts one of several possible alignments of the E Street Tunnel.

Location and Geometric Design

The E Street Tunnel would be approximately 2,500 feet in length and would accommodate four traffic lanes (two eastbound and two westbound). Approach grades at the east and west portals would be 6%. Roadway geometry within the tunnel would be designed for speeds of 30 mph. The vertical clearance at each portal would be 16'-6".

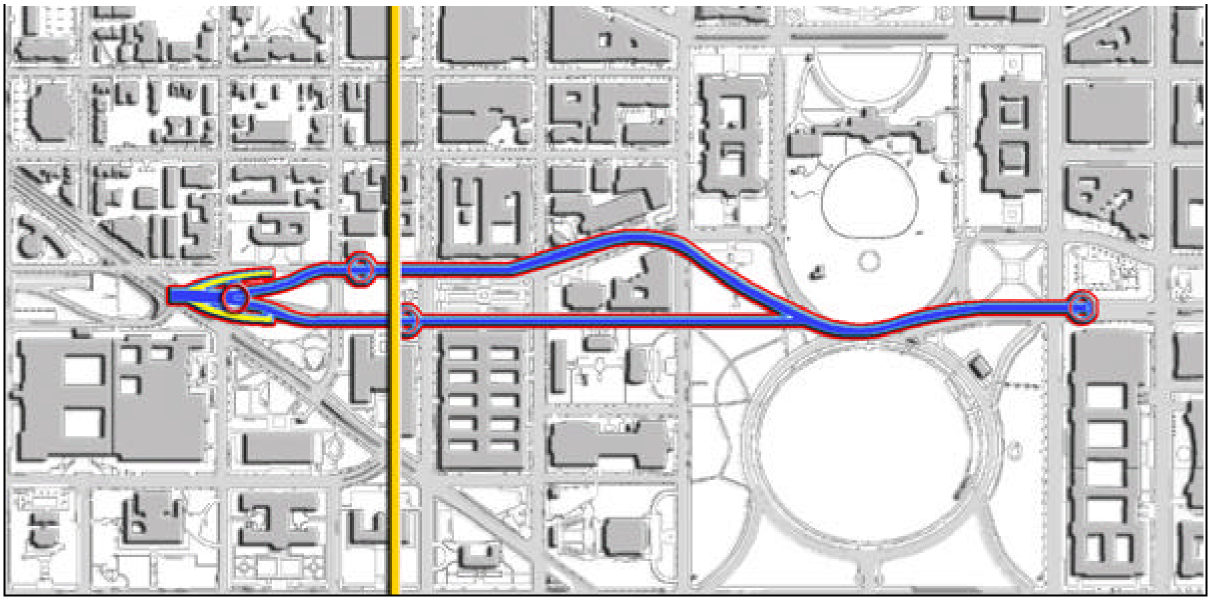


Figure 2.11: E Street Tunnel Alternative

The alignment of the E Street Tunnel selected for analysis assumed separate alignments for the eastbound and westbound traffic. This creates difficult horizontal geometry for the westbound tunnel that will require careful design.

The existing E Street surface roadway would remain in service. This would allow continued access to abutting properties, including the Corcoran Gallery of Art and several office buildings.

Accessibility
Under these alternatives, all existing turning movements along E Street would be retained. (since E Street at grade would remain in service). Access to the E Street tunnel, however, would be restricted to 14th Street to the east and west of 18th Street to the west.

Traffic Safety
There are no obvious compromises to traffic safety associated with these alternatives. However, the proximity to 14th Street at which the east portal incline reaches street grade may be problematic and must be more fully evaluated.

Construction Impacts
Construction of the E Street Tunnel under either of these alternatives will be in a narrow corridor and will probably require closing of E Street for extended periods of time. The construction will be further complicated by the requirement to maintain access to adjoining properties throughout the construction period.

Excavation for the tunnel through the active intersections at 15th Street and 17th Street would require phased construction to allow maintenance of traffic on the cross streets.

Utility Impacts

There are significant existing utilities within the construction zone that will require accommodation. Most significant is a large (9’-8”) combined sewer that will require relocation. Due to the nature of the sewer, change in grade of the sewer will require a lift or pumping station to account for a lowering of the sewer. The cost of such a station and the associated maintenance may be very costly.

There is also a large (8’-0”) sewer in 15th Street that will require considerable attention. Steam tunnels in 15th Street and 18th Street will require relocation.

There is a large (8’-0” x 7’-7”) pedestrian tunnel under the 1800 block of E Street. Relocation of the tunnel would be impractical, and consideration must be given to abandonment of the facility.

Construction Schedule

Construction of the E Street tunnel under these alternatives, including considerable utilities accommodation, including relocations, maintenance of property access, pumping station and ventilation requirements, is expected to require 36 to 48 months to complete.

Construction Cost

Cost to construct the E Street tunnels, including excavation, utilities accommodation, phased construction, and all other aspects necessary for a complete project is estimated at $135 million, excluding security, architectural and streetscape enhancements.

SECTION 3.0 - TRAFFIC SIMULATION MODEL INPUTS

3.1 *SYNCHRO* AND *SIMTRAFFIC* SIMULATION MODELING SOFTWARE

The objective of this report section is to describe the traffic simulation modeling procedures used to assess the roadway network alternatives for the study area. The *Synchro* and *SimTraffic* software programs collectively form a state-of-the-art traffic evaluation package for a network of intersections. *Synchro* and *SimTraffic* respectively implement the methods of Chapter 16 of the 2000 *Highway Capacity Manual* and the vehicle and driver performance characteristics developed for use in traffic modeling through research by the Federal Highway Administration over the past 20 years.

Synchro is useful for the calculation of vehicle capacity of traffic systems and the optimization of signal timing networks based on minimizing the total delay across a given study area, but has no microscopic modeling capabilities. *SimTraffic* is a microscopic traffic simulation modeling program that tracks the movements of individual vehicles which respond to surrounding circumstances such as traffic signals, the speed and location of other vehicles on the roadway network, pedestrian activity and driver behavior characteristics. Each vehicle represents an element on the roadway network that is affected by these internal and external factors. *Synchro* was used in this study to supply the data such as traffic volume, signal timing and roadway lane geometry necessary to run the *SimTraffic* microscopic model.

3.2 TRAFFIC SIGNAL SYSTEM

The study area includes over 60 signalized intersections, each of which operates with a unique timing plan during both morning and evening peak hours. To effectively model existing conditions, it was necessary to code existing signal timing information into *Synchro*.

Timing plans for the signals in the study area were furnished by DC Department of Public Works and are included in Appendix E. Information collected from the timing plans and coded into the simulation model includes:

- Signal type/operation
- Cycle length
- Phase lengths
- Yellow and all-red intervals
- Pedestrian walk and clearance intervals
- Offset

The traffic signals included in the study are virtually all pretimed signals with 80-second cycle lengths. The one exception is the signal at 17th Street and the Eisenhower Executive Office Building north court driveway, which is pedestrian- and vehicle-actuated. Most of the signals in the study area were retimed after the closure of Pennsylvania Avenue.

A few traffic signals in the study area were excluded from the model. These signals include the pedestrian signals on E Street between 15th and 17th Streets, and the signal on Constitution Avenue on the 16th Street alignment. These signals are not critical to evaluating the alternatives because they interrupt main street traffic flow much less than other signals in the network.

For the TSM Alternative, and all subsequent alternatives, the traffic signal system was optimized to reduce delay. *Synchro* includes an algorithm for optimizing the signal system, which was employed as a starting point for this portion of the analysis.

Synchro's phase and offset optimization occasionally needs minor adjustments to be most effective in *SimTraffic*'s stochastic environment. For example, turning movements that conflict with high pedestrian volumes often need to be lengthened somewhat to serve the entire movement demand. Closely-spaced intersections may need offset or phase-order adjustments to prevent blocking of lanes.

At selected heavily-congested intersections, the 80-second cycle was increased during analysis of some alternatives. (One such instance is the intersection of 14th Street and Pennsylvania Avenue South, which was modified to a 100-second cycle for the E Street Tunnel alternatives.) Longer cycles help clear more vehicles per unit time because the phases change less often. In addition, the proportion of green time allocated to minor movements can be reduced without violating pedestrian crossing requirements.

At key intersections, such as those near tunnel portals, additional phases, such as left-turn arrows, were added if required to serve the demand. Occasionally, intersection phasing plans were adjusted on a larger scale, by changing phase order and phase overlaps, when helpful to reduce delay.

During the morning peak, traffic conditions are generally much less congested than in the afternoon peak, and network delay can be reduced effectively without modifying phases and offsets at each traffic signal. Phases and offsets were adjusted at intersections where problems occurred, but the existing timings were modified only when necessary.

Using any software to optimize a traffic signal system has a distinct advantage: the software is using the input traffic volumes to optimize the signals, and is then using the same volumes as a way to measure the system's effectiveness. In an actual system, traffic volumes vary daily, sometimes significantly. If actual volumes differ from the volumes used to prepare the timing plans, the signal system may suffer from increased delay. The problem is compounded in a pretimed traffic signal system which cannot respond to variations in traffic patterns. Completing multiple runs of each alternative helps to mitigate this problem, but the study's traffic signal optimization should be considered a best-case scenario. Actual results would be anticipated to be somewhat less effective because of the variation in driving patterns.

Signal timing plans used for each alternative are provided electronically as included in Appendix K on a Compact Disc.

3.3 TRAFFIC VOLUME DATA

Traffic counts taken within the past three years existed at several intersections in the study area, reducing the need for new traffic counts. The locations and age of previous counts were evaluated, and additional traffic counts were conducted as needed. It was determined that the study would benefit from new traffic data at 46 intersections. Figure 3.1 shows intersections where new traffic counts were taken, and the sources of existing data at intersections that were not counted as a part of this study. Data from the previous studies was found to be largely consistent with the newly collected data, confirming the study's assumption that traffic data changes little enough from year to year that the impact is negligible. The newly-collected traffic count data is included in Appendix G.

At a few locations within the study area, traffic data did not balance well between intersections. For instance, one intersection's traffic count might show 1000 vehicles per hour departing the intersection, but an adjacent intersection's count might show 1400 vehicles per hour arriving. At some locations, this imbalance can be explained, as when vehicles enter the traffic stream from a parking garage. At other locations, the imbalance is not as logical, and can be due to data collection occurring on different days.

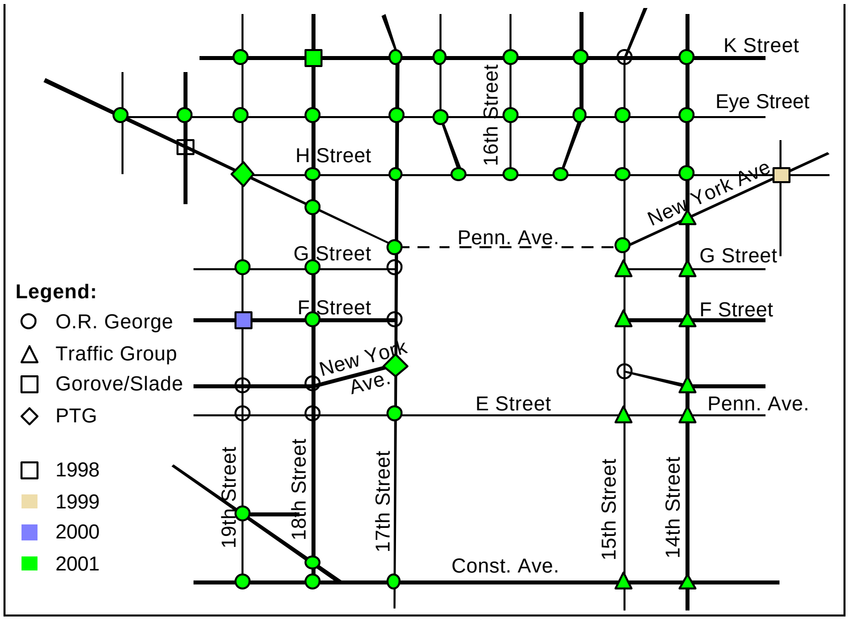


Figure 3.1: Sources and Ages of Traffic Data Used in the Study

When the imbalances were severe, on the order of 300 to 400 vehicles per hour, raw field data were adjusted to lessen the imbalance. The imbalances were seldom eliminated, but often they could be reduced to approximately 100 vehicles per hour by making adjustments at several nearby intersections. A complete description of these adjustments is included in Appendix F.

The process of re-assigning traffic assumed no net change in traffic volume across the study area. In fact, new roadway capacity usually attracts new trips, which would tend to increase the total traffic in the study area. This study did not include a basis for making judgments about increases in traffic for the various alternatives, and made the simplifying assumption to neglect these increases. This assumption is valid in this study because the alternatives are being compared against each other. However, in reality, this "induced demand" will likely lessen the benefits recorded by the models.

Complete sets of traffic volumes, including each intersection in every alternative, are included electronically in Appendix K on Compact Disc.

3.4 STREET AND INTERSECTION LANE DESIGNATIONS

An accurate representation of the lane configurations in the study area is critical to the simulation model's effectiveness. A detailed field review was conducted to record existing lane designations in the study area. Elements recorded as part of the field review include:

- Number of through lanes and turning lanes on each intersection approach
- Mid-block lane drops
- Locations and hours of turn prohibitions, including NO TURN ON RED restrictions
- Locations where lanes are blocked by construction activities
- Differences in traffic control between morning and evening peak periods, such as the peak-hour one-way operation on 15th and 17th Streets in the north part of the study area.
- Locations where traffic lanes are typically blocked by parked vehicles during morning and/or evening peak hours

Existing lane designations were coded into the traffic simulation models to the extent possible. Unfortunately, no traffic simulation software is sophisticated enough to realistically model every element in the study area. The models are unquestionably sufficient to evaluate the alternatives, but they differ slightly from real-world conditions, as follows:

- There is no effective way to model the service roads along K Street. As such, the service roads were not modeled, and right-turning vehicles which would normally use the service roads were omitted from the model. Eastbound right-turning vehicles rejoin the traffic stream at the appropriate intersection on Eye Street.

- Several minor streets were excluded from the model. The exclusion of these streets is reasonable, because they have little impact on the overall behavior of the network. The following minor streets were excluded:
  - C Street between 17th and 18th Streets
  - D Street between 17th and 18th Streets
  - The Ellipse, and roadways accessing the Ellipse
  - Roadways closed to public travel, such as Madison, Jackson, State, and Alexander Hamilton Places, and East, West, and South Executive Avenues.
  - H Street west of 18th Street
  - Eye Street west of 20th Street

- Private driveways intersecting public streets were generally excluded from the model. Driveways exist on nearly every block in the study area, and collecting data to accurately model driveways would have been an extreme undertaking. Volumes on some driveways are significant, but *SimTraffic* is designed to accommodate vehicles entering and leaving the traffic stream mid-block, so all the models' intersections operate accurately.

- When parking is permitted in a travel lane during either the AM or PM analysis period, through traffic is excluded from that travel lane for the entire analysis period in the model. Likewise, when parking is prohibited in a travel lane in either AM or PM, that travel lane is open for travel in the model. Often, vehicles park or stop illegally in travel lanes at various locations at various times and for various durations, but this dynamic behavior cannot be modeled in *SimTraffic*.

Minor changes to the models' lane designations were required as part of model calibration. These changes are discussed more completely in section 4.3.

Primary lane configuration elements of the alternatives are discussed in the report section to follow; specific information about lane configurations can be found in Appendix H.

3.5 NO-BUILD ALTERNATIVE

Traffic Volume

At intersections counted as a part of this study, traffic volumes were collected during late July and early August, 2001, times of the year when traffic volumes tend to be at their lowest. The study is intended to represent traffic volumes during peak times of the year, so the summer 2001 traffic volumes are generally too low for use in the study.

It was necessary to determine a factor by which to increase the summer 2001 volumes so they would be representative of a peak traffic time of year. The District of Columbia Department of Public Works maintains historical traffic volume data collected by permanent traffic count stations citywide. The most current data dates to 1986, but it is believed that seasonal trends have not changed significantly since then.

Data was not reported every month for each count station; in fact, only six count stations reported data every month for an entire year. These six count stations showed that traffic volume in September was the highest of the year. As a further refinement, 19 count stations reported data for the months of July, August, September, and October. Analysis of data from these 19 stations showed that traffic volume was approximately 9 percent higher in September than it was in August. To convert summer traffic to peak seasonal traffic, each turning movement volume was increased by 9 percent for the no-build alternative and subsequent alternatives.

Lane Configurations

The No-Build Alternative includes the same lane configurations as the existing conditions, except that lane blockages due to construction activities were removed. Some construction will likely occur somewhere in the study area at all times, but at unknown locations. Excluding construction is a reasonable simplification. (DCDPW and FHWA conducted a separate analysis on behalf of NCPC which supported this modeling assumption.)

3.6 TSM STRATEGIES ALTERNATIVE

Traffic Volume

Volumes in the TSM Alternative are identical to those in the No-build Alternative.

Lane Configurations

Many proposed TSM strategies, such as parking enforcement, do not directly impact the models' lane configurations. Those strategies which directly impact the model are as follows:

- A left-turn only lane was added on the north curb of eastbound E Street approaching 18th Street. This lane was created by restricting peak hour parking; it was coded with a 250-foot storage length.
- A third northbound lane was added on 17th Street between F Street and Pennsylvania Avenue. This lane is currently blocked by parked vehicles.
- In the evening peak hour only, a southbound lane was added on 15th Street between Constitution and E Streets by prohibiting on-street parking and street vending activities.
- The intersection of H and 13th Streets was reconfigured with two westbound lanes and three eastbound lanes instead of the current three westbound and two eastbound lanes. The third eastbound lane was extended upstream, creating three eastbound lanes on H Street between New York Avenue and 13th Street.

3.7 AT-GRADE ALTERNATIVE

Traffic Volume

In the at-grade alternative and all subsequent alternatives, traffic volumes were redistributed to simulate the effects of changes to the street network. Detailed information about traffic redistribution can be found in Appendix I.

In brief, traffic volume was added to Pennsylvania Avenue and subtracted from parallel streets. The volumes assigned to Pennsylvania Avenue for the at-grade alternative were based heavily on traffic counts taken before the street's 1995 closure. However, some traffic conditions are different in the at-grade alternative than in the pre-closure condition. For instance, Madison Place was open to through traffic pre-closure, but it is not envisioned for re-opening in the at-grade alternative.

In the at-grade alternative, the following amounts of traffic were assigned to the re-opened portion of Pennsylvania Avenue:

	Eastbound		Westbound	
	AM Peak	PM Peak	AM Peak	PM Peak
Vehicles per hour on Pennsylvania Avenue between 15th and 17th Streets	900	863	1150	980

The at-grade alternative also features significant increases in traffic on Pennsylvania Avenue west of the White House and New York Avenue east of the White House, as would be expected once the avenue is re-opened. Truck travel would be permitted, as there is no mechanism to prohibit truck traffic.

Lane Configurations

The at-grade alternative differs from pre-closure conditions because, in this study, Pennsylvania Avenue would have only two lanes in each direction as it passes the White House, a configuration which is sufficient to carry traffic demand. To facilitate intersection operations, the approaches to 15th and 17th Streets widen to four lanes.

At Pennsylvania Avenue and 17th Street, all movements—left turns, throughs, and right turns—are restored for eastbound and westbound traffic; northbound and southbound left turns remain prohibited. At Pennsylvania Avenue and 15th Street, the eastbound left-turn remains prohibited; the westbound two-lane approach retains the exclusive left-turn lane, but allows through traffic and right turns from the right lane.

The section of 15th Street between H and K Streets currently operates as one-way northbound. This operation was initiated post-closure to provide more northbound capacity for traffic diverted from Pennsylvania Avenue to Eye and K Streets. If Pennsylvania Avenue were opened at grade, this one-way section would no longer be needed, since northbound traffic could again turn left on Pennsylvania Avenue. This link would be restored to two-way operation.

In the at-grade alternative (and all other alternatives), H and Eye Streets would retain their current one-way pair configuration, and not revert back to their pre-closure configuration.

3.8 SHORT TUNNEL ALTERNATIVE

Traffic Volume

Access opportunities in the short tunnel are similar to those in the at-grade alternative (two lanes in each direction). However, the following traffic operational differences exist between the at-grade and short tunnel alternatives:

- Trucks would be prohibited in a short tunnel, but permitted at grade. The traffic stream includes about 3 percent trucks, which were redistributed to other streets for the short tunnel.
- The westbound left turn from Pennsylvania Avenue to 17th Street is prohibited in the short tunnel, but permitted for the at-grade alternative. Some of the vehicles making this left turn were moved to 19th Street; others were moved out of the tunnel and reassigned to other streets. (The complementary eastbound left turn from Pennsylvania Avenue to 15th Street was prohibited pre-closure and remains prohibited in all alternatives.)

The short tunnel would be expected to carry the following amounts of traffic:

	Eastbound		Westbound	
	AM Peak	PM Peak	AM Peak	PM Peak
Vehicles per hour on Pennsylvania Avenue between 15th and 17th Streets	873	828	1116	942

Lane Configurations

The short tunnel's portals would surface near the intersections of 15th and 17th Streets, precluding additional turning lanes as were provided in the at-grade alternative. At Pennsylvania Avenue and 17th Street, westbound left turns are prohibited because of the reduction in turning lanes and the reduced sight distance. The study showed that prohibiting this turn improves the operation of that intersection. If Pennsylvania Avenue were opened at grade, additional reductions in network delay could likely be observed by prohibiting this turn.

At Pennsylvania Avenue and 15th Street, the high volume of eastbound right turns in the evening peak hour demanded that right turns be segregated in an exclusive lane; all through traffic uses the left lane. The high volume of turns at this intersection contributes to a poor level of service in the short and intermediate tunnel alternatives, despite the prohibition of pedestrians on certain legs.

Two-way traffic is restored to 15th Street between H and K Streets as in the at-grade alternative.

3.9 INTERMEDIATE TUNNEL ALTERNATIVE

Traffic Volume

The configuration of the east portal of the intermediate tunnel is the same as that for the short tunnel. However, the west portal moves one block west, affecting conditions on Pennsylvania Avenue at 17th and 18th Streets. The following conditions change between the short and intermediate tunnels:

- No access to 17th Street is provided for westbound tunnel traffic. This only impacts right-turning traffic, since left turns are prohibited with the short tunnel. Some vehicles making this right turn were moved to 18th Street; others were moved out of the tunnel completely and reassigned to other streets.
- Traffic on 17th Street cannot directly enter the tunnel eastbound. This only affects northbound right-turning traffic, since southbound left-turns are prohibited under all alternatives. Some northbound right turns were relocated to 18th Street; others were moved out of the tunnel and back to H Street.
- Traffic volume at 18th Street and Pennsylvania Avenue increases under this alternative because of the lack of access opportunities at 17th Street.

The intermediate tunnel would be expected to carry the following amounts of traffic:

	Eastbound		Westbound	
	AM Peak	PM Peak	AM Peak	PM Peak
Vehicles per hour on Pennsylvania Avenue between 15th and 17th Streets	792	748	1001	818

Lane Configurations

The intersection of 17th Street and Pennsylvania Avenue reverts to much the same operation as today, but the four-lane eastbound approach is pared to three. The northbound and southbound approaches retain the same configuration as in the TSM alternative.

At the tunnel portal just east of 18th Street, eastbound and westbound traffic can bypass the tunnel portals on public service roads, which provide access between 17th and 18th Streets. Meanwhile, the primary lanes, two eastbound and two westbound, submerge into the tunnel.

The intersection of Pennsylvania Avenue and 15th Street remains the same as in the short tunnel, and the section of 15th Street between H and K Streets also reverts to two way.

3.10 LONG TUNNEL ALTERNATIVE

Traffic Volume

The west portal of the long tunnel is identical to the intermediate tunnel, but the east portal has shifted east by one block. These changes exist between the intermediate and long tunnels:

- In the long tunnel, eastbound tunnel traffic no longer has access to 15th Street. This only affects eastbound right turns, because left turns are prohibited in the intermediate tunnel. Eastbound right-turning traffic is shifted to 14th Street, or moved out of the tunnel and reassigned to other routes.
- Traffic on 15th Street can no longer enter the tunnel westbound. This affects northbound left turns and southbound right turns; this traffic was shifted to 14th Street or relocated to other routes outside the tunnel.
- Northbound left-turns from 14th Street to New York Avenue are currently prohibited, but with a long tunnel in place, this left-turn will be in high demand as a way to access the westbound tunnel. As such, this turn prohibition is removed in the long tunnel.
- Traffic at the intersection of 14th Street and New York Avenue increases under this alternative because of the lack of access opportunities at 15th Street.

The cumulative effect of the reduction in access opportunities at both the east and west portals, and the increased congestion at the 14th Street and 18th Street intersections, result in a significantly lower volume of traffic using the long tunnel than other tunnel alternatives.

The long tunnel would be expected to carry the following amounts of traffic:

	Eastbound		Westbound	
	AM Peak	PM Peak	AM Peak	PM Peak
Vehicles per hour on Pennsylvania Avenue between 15th and 17th Streets	648	495	713	496

Lane Configurations

Conditions at the west portal match those of the intermediate tunnel, but conditions at the east portal are unique to the long tunnel. At 15th Street and New York Avenue, lane configurations match those in the TSM alternative. And, since 15th Street traffic cannot access the tunnel, the section of 15th Street between H and K Streets uses one-way northbound operation as in the TSM alternative. At 14th Street and New York Avenue, a northbound left-turn pocket was created, assuming a restriping of existing pavement occurs from the southbound left-turn lane at G Street.

The tunnel portal between 14th and 15th Streets includes service roads to provide direct access between 14th and 15th Streets, much like the west portal's service roads. However, conditions are more constrained in this block, resulting in narrower service roads and fewer lanes east of the portal.

3.11 SPLIT-PORTAL TUNNEL ALTERNATIVE

Traffic Volume

The west portal of the split-portal tunnel is identical to the intermediate and long tunnels, but the east portal is split: eastbound traffic exits the tunnel at 15th Street, but westbound traffic enters the tunnel from 14th Street.

Eastbound traffic using the split-portal tunnel encounters the same traffic conditions as in the intermediate tunnel, so eastbound traffic patterns in the split-portal tunnel will closely resemble eastbound patterns in the intermediate tunnel. Likewise, westbound traffic using the split-portal tunnel encounters the same conditions as in the long tunnel, so westbound traffic patterns in the split-portal tunnel will match those of the long tunnel.

The split-portal tunnel is expected to carry the following amounts of traffic:

	Eastbound		Westbound	
	AM Peak	PM Peak	AM Peak	PM Peak
Vehicles per hour on Pennsylvania Avenue between 15th and 17th Streets	792	748	713	496

Lane Configurations

Again, eastbound lane configurations match those of the intermediate tunnel, and westbound lane configurations match those of the long tunnel. Since there is no ingress to the tunnel from 15th Street, the section of 15th Street between H and K Streets operates as one-way northbound.

3.12 E STREET TUNNEL ALTERNATIVE

Traffic Volume

The methodology for redistributing traffic under the E Street Tunnel Alternative was somewhat different from the Pennsylvania Avenue alternatives. Pennsylvania Avenue was open in the recent past, so historical traffic volumes were a reliable guide to predicting future volumes. However, the E Street Tunnel has no similar historical volumes to use as a starting point.

Instead, the E Street Tunnel Alternative began by assuming that traffic volume per lane on E Street, Constitution Avenue, and the E Street Tunnel would be roughly equal. Essentially, traffic is moved from E Street and Constitution Avenue to the E Street Tunnel, until the tunnel reaches the same volume per lane as the other two routes. Using this methodology, the following traffic volumes were assigned to the E Street Tunnel:

	Eastbound		Westbound	
	AM Peak	PM Peak	AM Peak	PM Peak
Vehicles per hour in the E Street Tunnel between 15th and 17th Streets	894	868	680	836

The following factors affect the E Street Tunnel:

- The tunnel suffers from very infrequent access opportunities when compared with the Pennsylvania Avenue alternatives. The tunnel is thus expedient for long-distance trips, but it is not an attractive route for short trips, or trips which have their origin or destination between 14th and 18th Streets. The amount of traffic using the tunnel is lower than it might be if additional access opportunities existed.

- The E Street Tunnel's east portal is just west of 14th Street, which increases traffic volume at the intersection of 14th Street and Pennsylvania Avenue South.
- Additional study is desirable to evaluate the capacity of the E Street Expressway and the Potomac River bridges west of downtown relative to the E Street Tunnel. The E Street Tunnel will not significantly alleviate peak-hour congestion if downstream roadways are already operating at capacity. (The environmental study of the Theodore Roosevelt Bridge, currently underway, may be of value in making these determinations.)

Lane Configurations

The E Street Tunnel is an extension of the E Street Expressway. The existing expressway ends at 20th Street, and the E Street Tunnel would extend that limited-access facility to 14th Street. The alignment of the E Street Tunnel has not been finalized, but as long as the end points of the tunnel are fixed, the underground route the tunnel takes is not relevant to traffic operations.

Of the numerous alternatives for E Street Tunnel access, one was chosen for analysis in this study. The tunnel's existing 20th Street ramps—eastbound exit ramp and westbound entrance ramp—would remain. Two new ramps would be added. A second eastbound exit ramp would be provided at 18th Street, and a westbound exit ramp would be provided at 20th Street. The tunnel would not offer an eastbound entrance ramp.

The three ramps west of 19th Street are outside the study area. Further study of this alternative would be needed before considering it as a viable alternative.

Lane configurations in the E Street Tunnel alternative match those in the TSM alternative, with a few minor differences. The single-lane eastbound exit ramp from the E Street Tunnel intersects E Street just west of 18th Street. Surface E Street serves as a frontage road system for the E Street Tunnel. At the east portal of the E Street Tunnel, service roads bypass the tunnel portals as in the Intermediate and Long Pennsylvania Avenue tunnels.

The section of Pennsylvania Avenue North between 14th and 15th Streets currently operates as one-way westbound. However, under the E Street Tunnel alternative, the demand for westbound traffic on this link drops significantly, and at the same time, eastbound demand increases, as 15th Street traffic proceeds toward the tunnel portal. As such, this section of Pennsylvania Avenue North is converted to two-way operation in the E Street Tunnel Alternatives. At 14th Street and Pennsylvania Avenue North, the newly-formed eastbound approach provides for only right-turn movements as a means of accessing the E Street Tunnel.

3.13 E STREET TUNNEL / AT-GRADE ALTERNATIVE

Traffic Volume

Traffic in the E Street Tunnel / At-Grade Alternative was re-assigned using a similar method as the E Street Tunnel Alternative. However, the balance of volume per lane was extended to include Pennsylvania Avenue as well. The volumes using the E Street Tunnel and the reopened portion of Pennsylvania Avenue are expected to be as follows:

	Eastbound		Westbound	
	AM Peak	PM Peak	AM Peak	PM Peak
Vehicles per hour in the E Street Tunnel between 15th and 17th Streets	894	868	794	908
Vehicles per hour on Pennsylvania Avenue between 15th and 17th Streets	900	863	713	877

The E Street Tunnel/At-Grade Alternative combines many of the elements of the E Street Tunnel and at-grade alternatives. The two additional routes across downtown increase access opportunities and disperse traffic demand among more intersections.

Lane Configurations

With both the E Street Tunnel and Pennsylvania Avenue open, the lane configurations for the Pennsylvania Avenue intersections match those for the at-grade alternative, and the configurations for the E Street intersections match those for the E Street Tunnel Alternative. Both 15th Street and Pennsylvania Avenue North operate as two-way streets.

SECTION 4.0 - TRAFFIC SIMULATION MODEL PROCESS

4.1 ANALYTICAL METHODOLOGY

The intent of the analysis was to measure the relative effects of the various alternatives on the movement of traffic through the study area. It was necessary to establish the times at which the effects of the alternatives were to be measured and compared. It was determined that traffic would be measured during the morning rush hour (AM peak) and the evening rush hour (PM peak). Studies indicated that morning traffic was heaviest between 8:00 and 9:00 AM and that evening traffic was heaviest between 5:30 and 6:30 PM; traffic from these time periods was used for the analysis.

Traffic volumes from recent studies were evaluated for all intersections within the study area. For 46 of these intersections there was no data, or the existing data was deemed unreliable. As a result, new traffic data was collected for these intersections in July and August 2001. Traffic volumes vary throughout the year, so data collected in summer was adjusted by applying a 9% factor to bring the traffic measurements to a typical yearly maximum level. This adjustment was based on historical data provided by DCDPW.

Traffic signal timings, traffic volume data, and lane configuration data collected from the field were then coded into *Synchro*, and traffic simulation models were developed for existing conditions in *SimTraffic*. Several travel time and speed sample drives were conducted through the study area during the morning and evening rush hours, and the speeds for these trips were compared to the speeds for the same trips as generated by the computer models of existing conditions. The computer models were then calibrated to provide matches, or near matches, to the field test runs. Other reality checks were made at intersections and street links and the models were again adjusted to best reflect actual traffic conditions.

Once the existing conditions models were shown to accurately portray field conditions, no-build models were created. These models incorporated the 9% seasonal adjustment factor discussed earlier, and all existing lane blockages due to construction activities were removed. The no-build models were then used as a baseline against which to compare the other alternatives.

The TSM strategies alternative was created by incorporating the TSM measures previously discussed, and itemized in Appendix B, into the computer models.

Traffic volumes based on expected re-distribution for each of the remaining alternatives were determined. This re-distribution considered conditions prior to the closing of Pennsylvania Avenue and principles of traffic engineering. The computer models were then constructed and executed for the remaining alternatives. The models resulted in certain measures of traffic operational effectiveness that were then compared to determine the relative improvements resulting from each of the alternatives. The primary measures of effectiveness selected to relate the results of the computer simulations were:

- Total Network Delay: a measure of the cumulative delay experienced by all vehicles traversing the study area.
- Average Corridor Speed: a measure of the average speeds attained on the streets within the study area.
- Failed Intersections: an accounting of those intersections at which traffic operations were below a given level of operational efficiency.

A detailed description of other measures of effectiveness generated by the analysis is given in Section 5.1.

4.2 SUMMARY OF ANALYSIS ASSUMPTIONS

A field reconnaissance was made throughout the study area to identify the existing roadway network characteristics including the lane configuration, parking restrictions and traffic control of each roadway link and intersection. Additionally, existing signal timing information was collected for each intersection within the study area from DCDPW. All of this information was entered directly into *Synchro.*

In addition to the information required above, a key input for the *Synchro* program is the hourly traffic volume. In preparation of the existing conditions traffic volume information, several adjustments were made to the traffic volume information collected. The existing traffic volumes were taken from current traffic counts (summer 2001) in addition to counts from studies completed since 1998. As anticipated, the volumes were generally well balanced when placed schematically on the study area map. However, minor adjustments were made to better balance these volumes throughout the system. See Appendix F for the specific adjustments made.

Many factors combine to create an unbalanced condition between intersections. These include, but are not limited to:

- Parking garages and on-street parking create mid-block changes in traffic volumes from link to link.
- Traffic count information for the study area is taken from different days and years and therefore differs.
- Slight differences in starting times of counts can introduce a slight variability of the consecutive 60 minutes that are counted for a given peak hour.

The preparation of the traffic volume estimates for each of the alternative network scenarios were made using pre-closure traffic counts and engineering judgment. Vehicles were assigned to the most logical route based on the access opportunities of each scenario. See Appendix I for the specific traffic assignments for each scenario.

4.3 MODEL CALIBRATION

Calibration of the *SimTraffic* model is a process intended to verify that the traffic conditions in the real world are sufficiently replicated by the simulation. No matter how sophisticated a computer simulation program is, it is difficult to successfully model human behavioral characteristics. In *SimTraffic*, vehicles behave according to complex mathematical algorithms. Real-world drivers are infinitely more complex, often displaying erratic behavior and complicating attempts to mimic their behavior with a simulation model. This is especially true of central business district locations such as in the vicinity of the White House.

The study area includes high traffic volumes on short block segments. Large proportions of vehicles make turns mid-block, into and out of parking garages, causing friction with the traffic stream. Large volumes of pedestrians, buses, on-street parking, and taxicabs all add to the complications present in the study area. The following are examples of operational characteristics of *SimTraffic* patterns that typically differ from real-world conditions:

- *SimTraffic* drivers are much more hesitant to turn in the presence of pedestrians than real-world drivers. In the real world, drivers move into a crosswalk even when pedestrian volume is heavy, but in the model, drivers will not leave the stop bar until every pedestrian is out of the street.
- *SimTraffic* drivers are diligent about not blocking intersections. They are careful to observe conditions downstream of the intersection and do not enter the intersection when it is not possible to continue all the way through. Real-world drivers block intersections much more often. A prime example of this behavior in the real world occurs at 17th and K Streets.
- *SimTraffic* drivers will not change lanes to bypass a queue when stopped. Stopped *SimTraffic* vehicles wait until the preceding vehicle moves before changing lanes to bypass a queue. Real-world drivers, in contrast, will not remain stopped in a congested lane for long before moving to an adjacent free-flowing lane.
- *SimTraffic* drivers choose to change lanes at pre-defined points in advance of planned turns. If the lane a driver wants to enter is blocked with other vehicles, that vehicle will wait for the blockage to clear before moving, even when space exists in the current lane. Some real-world drivers exhibit this behavior, but nearly *all SimTraffic* drivers do so.
- *SimTraffic* pedestrians will not cross mid-block and will only cross when the WALK signal indication is displayed. Real-world pedestrians can be more unpredictable.
- *SimTraffic* drivers never stop in a travel lane to park or load or unload passengers. Trucks exhibit this same behavior, making it difficult to model the double-parked loading conditions which sometimes occur.

Because of these and other *SimTraffic* algorithm characteristics, behavior of the simulation model can differ from real-world conditions absent additional steps to “calibrate” the simulation. This is particularly true when conditions are congested and over-saturated, as they are in the study area during the peak hours, notably the PM rush period.

The calibration process begins by analysis of two measures of effectiveness: corridor speed and hourly vehicle throughput are analyzed to determine if they are similar to existing conditions. Existing speed data was collected in the field during a series of travel time runs in July and August 2001. Data was collected for all the major corridors on block-by-block intervals, and then summarized for the entire corridor. To adjust the model and make it more reflective of real-world conditions, the following methods were employed in *SimTraffic*:

- Driver parameters were modified. In *SimTraffic*, all drivers fall into ten categories. Each category has a complete set of 14 driver characteristics, such as how quickly the driver decelerates upon seeing a yellow light and how much room the driver allows between his own vehicle and the preceding vehicle. Specifically, these factors were adjusted as necessary to increase speeds and throughputs of the model. For a complete summary of the detailed changes made, refer to Appendix K, which includes electronic files of driver parameters.
- "Dummy signals" were created. Outside the study area is a significant amount of congestion that propagates back into the study area. This external congestion was modeled using "dummy signals," which meter traffic as it exits the study area, creating artificial downstream congestion that mimics field conditions.
- Minor changes were made to lane configurations. In the District, drivers occasionally operate using lane configurations different than those painted on the pavement. For instance, drivers may make right turns from an adjacent through lane if the right-turn lane is heavily congested. These configurations can usually not be added to the model, so the lane configurations must be adjusted to give the best possible representation of real-world conditions. This process is often iterative, requiring some trial and error.
- Pedestrian volumes were reduced. Because *SimTraffic* drivers are less assertive around pedestrians than real drivers, the presence of pedestrians can be more disruptive in the model than in the real world. Reducing pedestrian volumes can cause drivers to behave more realistically.
- Turning speeds for certain turns were adjusted slightly to make minor changes to capacity of turning movements.
- Minor streets were fragmented in the model when needed to prevent excessive queues on one corridor from propagating to nearby corridors.
- Traffic volumes were adjusted, especially in cases where changes were made to existing volumes to "smooth" data. Such smoothing occasionally result in more vehicles making certain movements.

Traffic operations differ slightly every day and month of the year. For example, summer traffic is typically lighter than in the fall, drivers are not as aggressive in rainy weather. The objective of the calibration is to arrive at a baseline traffic model that is similar enough to field conditions to allow conclusions to be drawn from the study results. Once this has been achieved, the parameters are kept constant for subsequent model runs for the entire set of analysis alternatives.

4.4 MODEL RUN PROCEDURES

After the proper inputs previously described were put into the *Synchro* file, then each scenario was modeled using *SimTraffic*. Since simulation models generate output that is affected by random processes, it is important to make multiple runs of the same scenario to determine that an average value lies within an acceptable confidence interval. Each scenario was therefore run with different random number seeds, which in effect simulates traffic conditions for different "days." For example, a slight variation is anticipated in traffic conditions for each day of the week, and sometimes an event such as a broken down vehicle will have a significant impact on traffic flow. Multiple runs with different random number seeds allow an average to be determined and reduce the risk that a single simulation run had an extremely good or bad "day."

The confidence interval objective set was at a level of 90 percent certainty that the average value is within plus or minus 10 percent of variation. Usually this was achieved by performing between five and 10 model runs. The average of these runs was used in the comparison of each of the measures of effectiveness. The results of each model run are provided in Appendix J.

SECTION 5.0 - RESULTS OF TRAFFIC SIMULATION MODELS

5.1 MEASURES OF EFFECTIVENESS

The Measures of Effectiveness (MOE) are the primary means to quantitatively compare the traffic flow efficiency of the study alternatives. The results and conclusions of this study regarding traffic flow are drawn largely from the analysis of the roadway network alternatives made using *Synchro* and the *SimTraffic* micro simulation model. These traffic signal optimization and modeling programs were used to determine the quantitative MOE of the transportation alternatives considered in the study. Statistics are kept internally for each vehicle within the *SimTraffic* simulation model that provide in-depth MOE information such as total network delays, average travel speed, fuel consumption and others for each roadway link and intersection over specified time intervals (usually a morning or evening peak hour). A detailed description of the key MOE is provided as follows.

- **Total Network Delay**, measured in hours, is equal to the travel time for all vehicles minus the time it would have taken all vehicles to complete their trips with no other vehicles or traffic control devices present.
- **Signal Delay per Vehicle** is equal to the average cumulative delay due to traffic signals, in seconds, that a motorist would experience during the course of a trip on some portion of the study area network.
- **Total Stops** is a count of vehicle stops. Whenever a vehicle is traveling less than seven miles per hour, one stop is added to the total.
- **Average Corridor Speed** is calculated by dividing the distance traveled by all vehicles on an arterial by the time required for all these movements. Average speed is weighted by volume and link length and includes stopped time.
- **Travel Time**, measured in hours, is a total of the time all vehicles were present in the study area.
- **Fuel Consumption**, measured in gallons, is determined by the vehicle type, speed and acceleration.
- **Failed Intersections** are classified as individual locations where the average delay per vehicle exceeds 55 seconds for all traffic movements combined.

Intersections are therefore simulated together as an interconnected traffic system rather than viewed under isolated conditions. The events at one intersection usually have a direct impact on adjacent intersections. *SimTraffic* gives transportation professionals a highly efficient means of analyzing the operations of a street network. The software provides tremendous flexibility since multiple scenarios may be investigated to ascertain the most effective travel lane and signal timing configuration in an effort to maximize traffic flow throughout a roadway network. In this manner, the MOE were compared for the potential roadway network alternatives to ascertain the relative benefits and disadvantages of each.

5.2 AM PEAK HOUR ANALYSIS

AM Peak Hour Total Network Delay

The results of the *SimTraffic* analysis indicate that the AM Peak Hour total network delay is approximately 1,600 total hours for the baseline No-Build scenario. This is equal to the total travel time minus the total time it would take a vehicle with no other vehicles or traffic control devices and represents the cumulative delay experienced by all motorists within the study area during the hour.

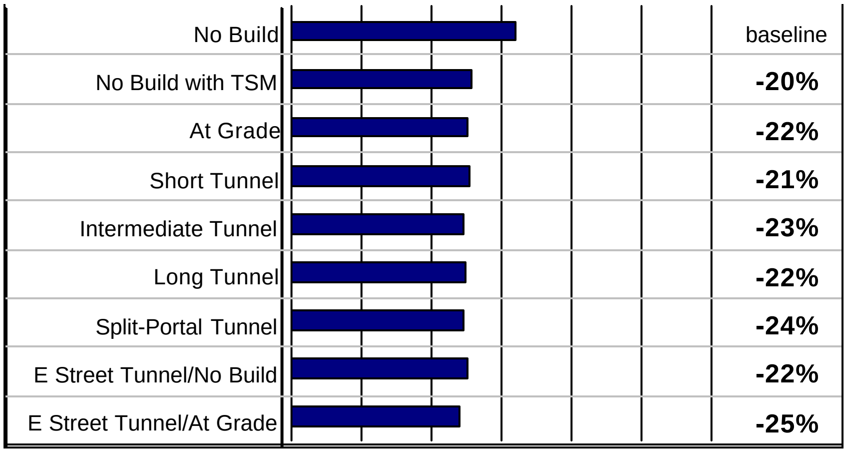


Figure 5.1: AM Peak Hour Total Network Delay (hours) with percent reduction in delay over No-Build conditions

Figure 5.1 presents network delay results of the other seven alternatives. A review of these values indicates total network delays generally between 1,200 and 1,300 hours for each of the studied alternatives. The TSM Strategies network delay is approximately 1,280 hours, or a 20 percent reduction from No-Build conditions. The E Street Tunnel with At-Grade alternative network delay is 1,195 hours, or a 25 percent reduction from No-Build conditions. The network delays for the other five alternatives fall between these 20 to 25 percent reduction thresholds. Thus, implementation of any of the seven build alternatives would be anticipated to result in a 20 to 25 percent reduction in total delay.

Of note, the confidence interval for each scenario set was at a level of 90 percent certainty that the average value is within plus or minus 10 percent of variation. A variability of approximately five percent of the total therefore exists in the results of the analysis. Furthermore, the existence of a group of average values within a five-percent range of one-another (such as the case with the seven build alternatives being considered) tends to indicate that each of these scenarios would provide nearly the same reduction in the total amount of network delay.

AM Peak Hour Failed Corridors

As shown in Figure 5.2, the results of the *SimTraffic* analysis indicate that three corridors operate under failing conditions for the No-Build alternative:

- 18th Street
- 15th Street
- K Street

These corridors experience congested conditions and an average travel speed of less than seven miles per hour during the hour. A review of results of all of the build scenarios (Figure 5.3) indicates that the 18th and 15th Street corridors can be improved through signal timing and TSM modifications such that averages speeds increase above the level of failure. The K Street corridor would be anticipated to operate under failing conditions unless some of the vehicle trips are diverted from this street to Pennsylvania Avenue as part of one of the scenarios featuring restoration of traffic.

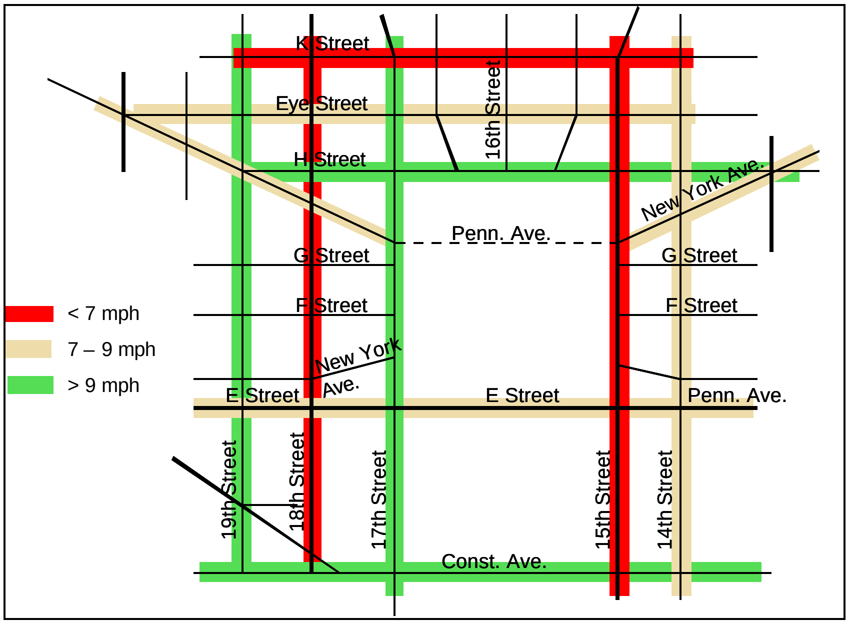
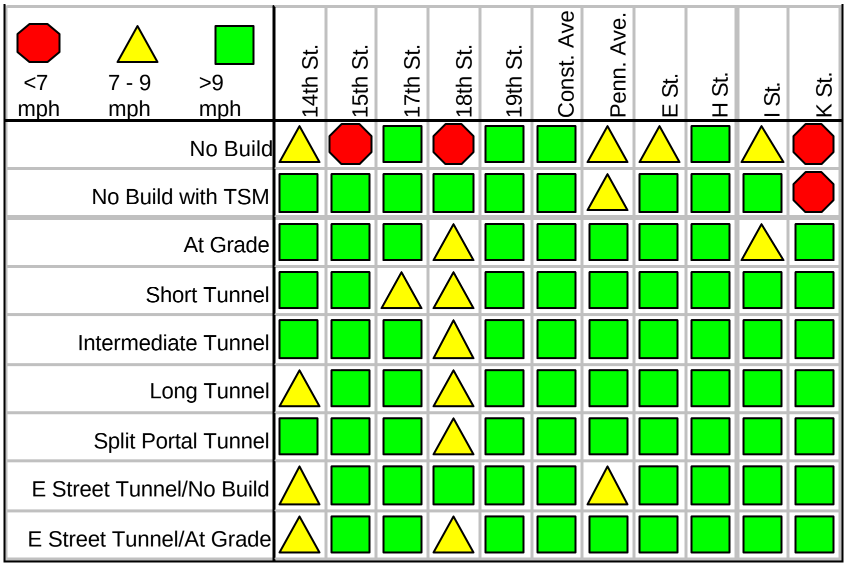


Figure 5.2: AM Peak Hour Corridor Speeds, No Build



🛑 <7 mph ▲ 7 - 9 mph 🟩 >9 mph	14th St.	15th St.	17th St.	18th St.	19th St.	Const. Ave	Penn. Ave.	E St.	H St.	I St.	K St.
No Build	▲	🛑	🟩	🛑	🟩	🟩	▲	▲	🟩	▲	🛑
No Build with TSM	🟩	🟩	🟩	🟩	🟩	🟩	▲	🟩	🟩	🟩	🛑
At Grade	🟩	🟩	🟩	▲	🟩	🟩	🟩	🟩	🟩	▲	🟩
Short Tunnel	🟩	🟩	▲	▲	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Intermediate Tunnel	🟩	🟩	🟩	▲	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Long Tunnel	▲	🟩	🟩	▲	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Split Portal Tunnel	🟩	🟩	🟩	▲	🟩	🟩	🟩	🟩	🟩	🟩	🟩
E Street Tunnel/No Build	▲	🟩	🟩	🟩	🟩	🟩	▲	🟩	🟩	🟩	🟩
E Street Tunnel/At Grade	▲	🟩	🟩	▲	🟩	🟩	🟩	🟩	🟩	🟩	🟩

Figure 5.3: AM Peak Hour Corridor Speeds

AM Peak Hour Fuel Consumption

The *SimTraffic* fuel consumption results (Figure 5.4) show improvements of approximately three to five percent above No-Build conditions for all of the build scenarios except the E Street tunnels, where the E Street Tunnel with No-Build and At-Grade alternatives show a reduction of six and nine percent, respectively. Of note, each percent improvement represents approximately 25 gallons of fuel per hour.

Alternative	*Fuel Use (gallons)*
No-Build	2432
TSM	2307
At-grade	2355
Short Tunnel	2358
Intermediate Tunnel	2328
Long Tunnel	2351
Split-Portal Tunnel	2326
E Street Tunnel	2273
E Street Tunnel/At-Grade	2218

Figure 5.4: AM Peak Hour Fuel Use

AM Peak Hour Failed Intersections

As shown in Figure 5.5, the number of failed intersections within the study area during the AM Peak Hour are approximately 24 under No-Build conditions. Figure 5.6 further shows that 10 intersections would be anticipated to operate under failing conditions for the two build scenarios where vehicular traffic *is not* restored to Pennsylvania Avenue. One or two intersections would be expected to fail for the build scenarios *with* the full restoration of Pennsylvania Avenue. Of note, the failed intersections closely correspond with the failed corridors.

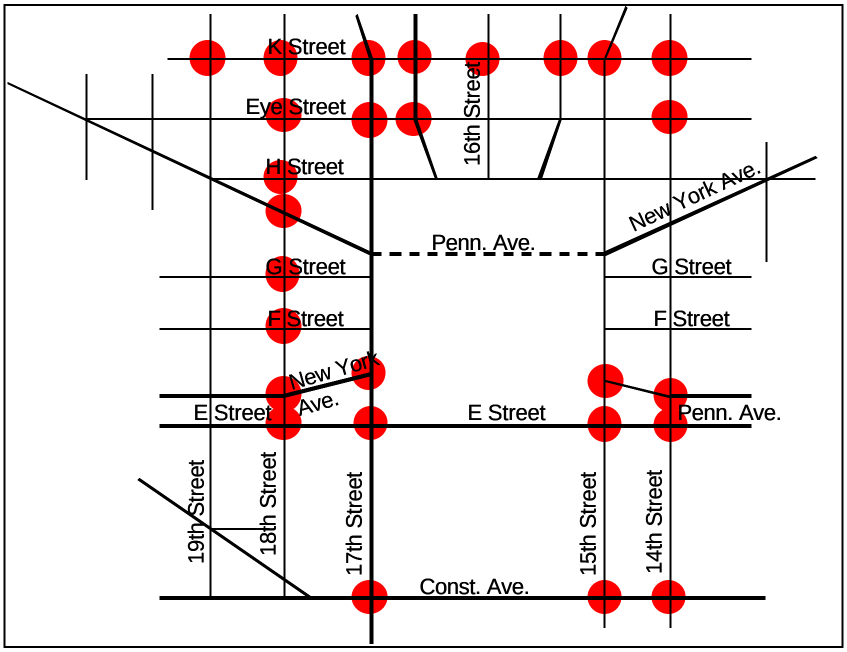


Figure 5.5: AM Peak Hour Failed Intersections, No-Build

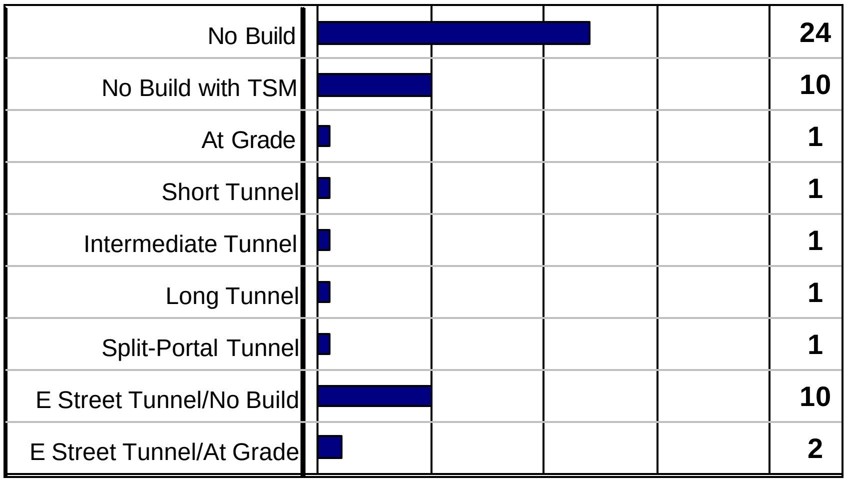


Figure 5.6: AM Peak Hour Failed Intersections

5.3 PM PEAK HOUR ANALYSIS

PM Peak Hour Total Network Delay

The results of the *SimTraffic* analysis indicate that the PM Peak Hour total network delay is approximately 3,000 total hours for the baseline No-Build scenario, or approximately double of that during the AM Peak Hour. Traffic is more concentrated in the PM peak, resulting in more vehicles during the one heaviest hour. Total delay is equal to the total travel time minus the total time it would take the vehicle with no other vehicles or traffic control devices and represents the cumulative delay experienced by all motorists within the study area during the hour.

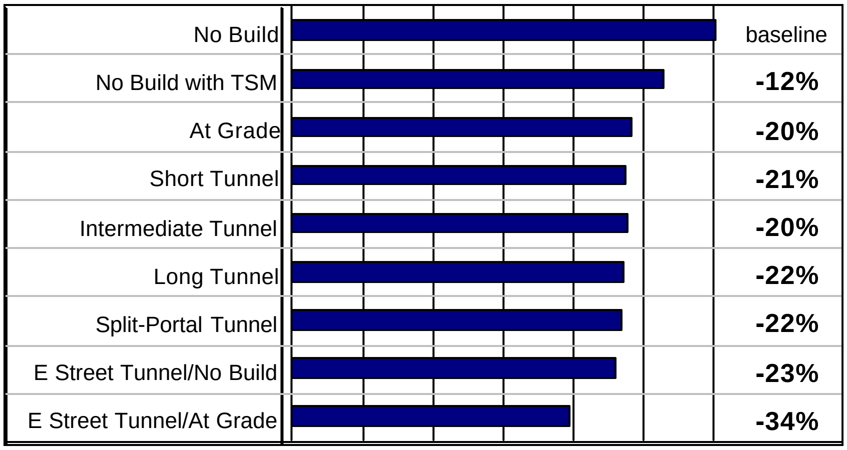


Figure 5.7: PM Peak Hour Total Network Delay (hours) with percent reduction in delay over No-Build conditions

A review of the other seven alternatives indicates a wide range of total network delays between 2,650 hours for the TSM Strategies alternative (a 12 percent reduction) to the E Street Tunnel with At-Grade option network delay of 1,975 hours (a 34 percent reduction) compared to the No-Build conditions. The network delays for the other five alternatives fall between a close range of 2,300 to 2,400 total hours, or a 20 to 23 percent reduction.

PM Peak Hour Failed Corridors

The results of the *SimTraffic* analysis indicate that eight corridors currently (for the No-Build scenario) operate under failing conditions:

- 14th Street
- 17th Street
- 19th Street
- Constitution Avenue
- Pennsylvania Avenue
- E Street
- Eye Street
- K Street

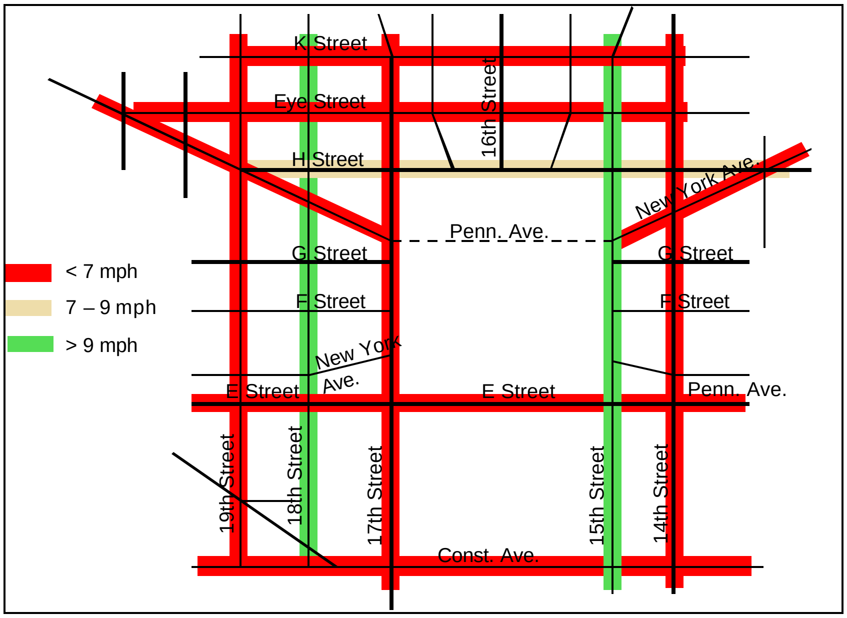
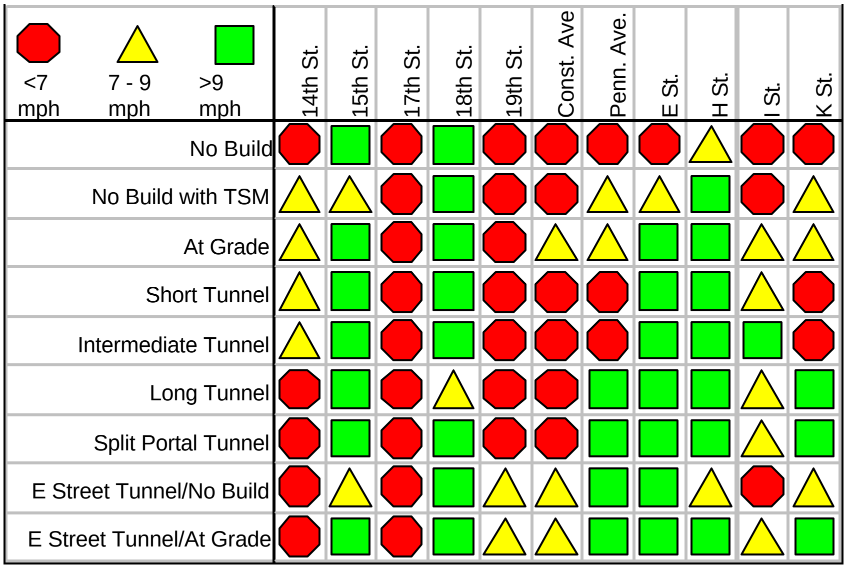


Figure 5.8: PM Peak Hour Corridor Speeds, No-Build

These corridors experience congested conditions and an average travel speed of less than seven miles per hour during the hour. A review of the TSM with No-Build scenarios indicate that the E Street, K Street, Pennsylvania Avenue and 14th Street corridors can be improved through signal timing and the stated TSM modifications such that average speeds increase above the level of failure. However, these average speeds would remain dangerously near failing conditions and would be considered at capacity.



🛑 <7 mph
△ 7 - 9 mph
🟩 >9 mph

	14th St.	15th St.	17th St.	18th St.	19th St.	Const. Ave	Penn. Ave.	E St.	H St.	I St.	K St.
No Build	🛑	🟩	🛑	🟩	🛑	🛑	🛑	🛑	△	🛑	🛑
No Build with TSM	△	△	🛑	🟩	🛑	🛑	△	△	🟩	🛑	△
At Grade	△	🟩	🛑	🟩	🛑	△	△	🟩	🟩	△	△
Short Tunnel	△	🟩	🛑	🟩	🛑	🛑	🛑	🟩	🟩	△	🛑
Intermediate Tunnel	△	🟩	🛑	🟩	🛑	🛑	🛑	🟩	🟩	🟩	🛑
Long Tunnel	🛑	🟩	🛑	△	🛑	🛑	🟩	🟩	🟩	△	🟩
Split Portal Tunnel	🛑	🟩	🛑	🟩	🛑	🛑	🟩	🟩	🟩	△	🟩
E Street Tunnel/No Build	🛑	△	🛑	🟩	△	△	🟩	🟩	△	🛑	△
E Street Tunnel/At Grade	🛑	🟩	🛑	🟩	△	△	🟩	🟩	🟩	△	🟩

Figure 5.9: PM Peak Hour Corridor Speeds

17th Street is anticipated to operate under failing conditions regardless of the improvements implemented due to a tremendous traffic demand along this corridor. 19th Street and Constitution Avenue would generally be anticipated to fail in the absence of one of the two E Street alternatives. 14th Street, K Street, Eye Street and Pennsylvania Avenue would be expected to pass or fail depending on the access opportunities for each specific roadway alternative. The full set of arterial service level information is contained in Appendix J.

PM Peak Hour Fuel Consumption

The *SimTraffic* Fuel Consumption results (Figure 5.10) show improvements of approximately four to eight percent above No-Build conditions for all of the build scenarios except the E Street tunnels, where the E St. Tunnel with No-Build and At-Grade alternatives show a reduction of 11.5 and 15 percent, respectively. Each percent improvement represents approximately 32 gallons of fuel per hour.

Alternative	*Fuel Use (gallons)*
No-Build	3169
TSM	3031
At-Grade	2933
Short Tunnel	2926
Intermediate Tunnel	2956
Long Tunnel	2919
Split-Portal Tunnel	2893
E Street Tunnel	2804
E Street Tunnel/At-Grade	2681

Figure 5.10: PM Peak Hour Fuel Use

PM Peak Hour Failed Intersections

As shown in Figure 5.11, the number of failed intersections within the study during the PM Peak Hour area is approximately 38 under No-Build conditions. A further examination of the build scenarios (Figure 5.12) reveals that between 19 (E Street Tunnel with At-Grade) and 28 intersections (Long and Split-Portal Tunnels) would continue to operate under failing conditions, regardless of which alternative is implemented in the future. This is due to the heavy traffic demand throughout several of the conflicting roadway arterials during the PM Peak Hour.

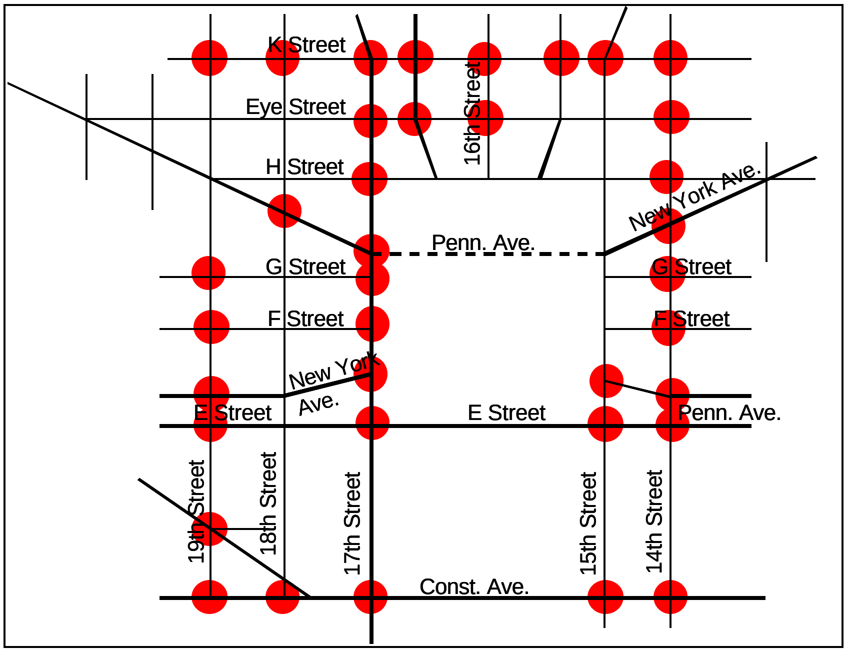


Figure 5.11: PM Peak Hour Failed Intersections, No-Build

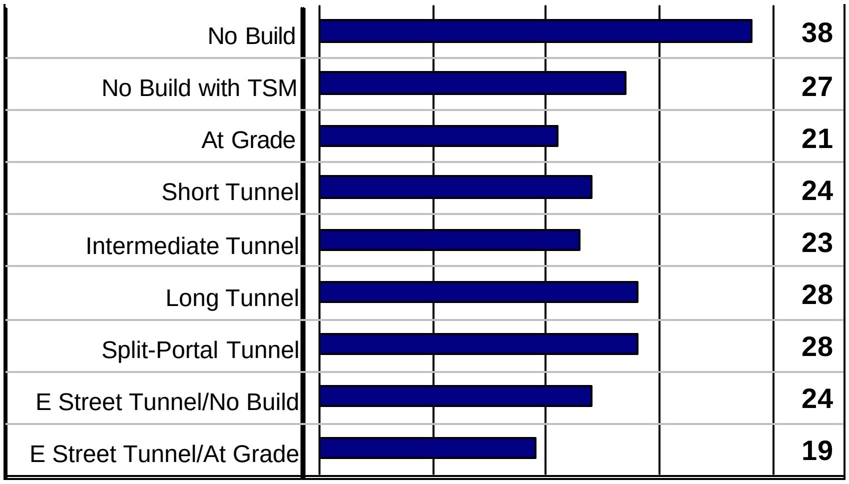


Figure 5.12: PM Peak Hour Failed Intersections

5.4 CONCLUSIONS FROM TRAFFIC SIMULATION

The following conclusions are drawn based on the *SimTraffic* modeling analysis:

The PM Peak Hour conditions are nearly twice as congested as the AM Peak Hour, with several more failing arterials and intersections. The seven build alternatives (including TSM Strategies) would generally produce an equal level of improvement in traffic flow during the morning peak hour that would be considered acceptable.

In the PM Peak hour, the TSM alternative offers the least improvement in total network delay, the E Street Tunnel/At-Grade offers the most improvement, and the other alternatives fall between these two extremes.

In the PM peak hour, corridors are expected to pass or fail depending on the tunnel access opportunities associated with each alternative. Traffic demand will be greater, and a corridor is more likely to fail, when it provides a primary access point to a tunnel, such as 14th Street for the Long Tunnel and E Street Tunnel alternatives.

Fuel Consumption results show improvements during the PM Peak Hour of approximately four to eight percent above No-Build conditions for all of the build scenarios except the E Street tunnels, where the E Street Tunnel with No-Build and At-Grade alternatives indicate a reduction of 11.5 and 15 percent, respectively.

The number of failed intersections within the study area during the PM Peak Hour is approximately 38 under No-Build conditions. A further examination of the build scenarios reveals that between 19 (E Street Tunnel with At-Grade) and 28 intersections (Long and Split-Portal Tunnels) would continue to operate under failing conditions, regardless of which alternative is implemented in the future. This is due to the heavy traffic demand throughout several of the conflicting roadway arterials during the PM Peak Hour.

SECTION 6.0 - REFERENCES

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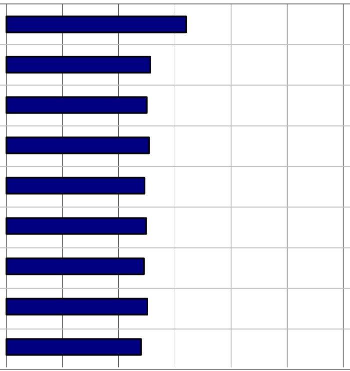
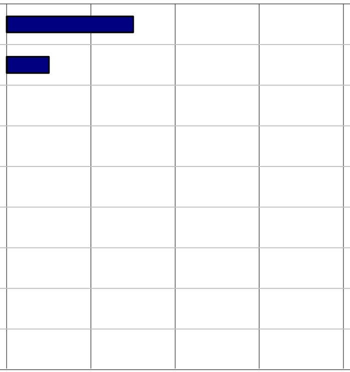
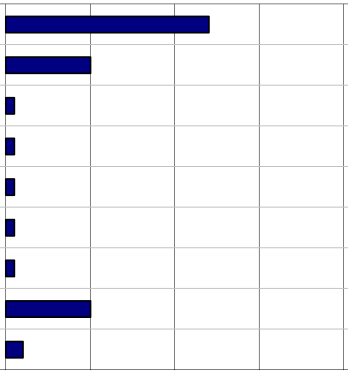
- *A Policy on Geometric Design of Highways and Streets*, American Association of State Highway and Transportation Officials, 2001.

- *Highway Capacity Manual*, Transportation Research Board, 2000.

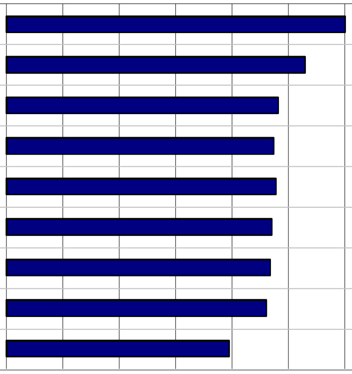
Appendix A: Summary of traffic-related measures of effectiveness

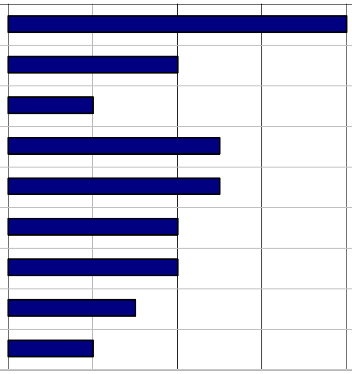


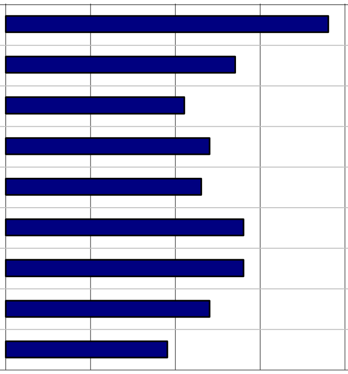




			Vehicles per hour on Pennsylvania Avenue between 15th and 17th Streets			Peak Hour Fuel Use (gallons)
AM Peak Hour	*Total Network Delay (hours)*	*Number of failed corridors*	*Number of failed intersections*	*Eastbound*	*Westbound*	*Total*	
No Build	baseline	**3**	**24**	0	0	0	2432
No Build with TSM	**-20%**	**1**	**10**	0	0	0	2307
At Grade	**-22%**	**0**	**1**	900	1150	2050	2355
Short Tunnel	**-21%**	**0**	**1**	873	1116	1989	2358
Intermediate Tunnel	**-23%**	**0**	**1**	792	1001	1793	2328
Long Tunnel	**-22%**	**0**	**1**	648	713	1361	2351
Split-Portal Tunnel	**-24%**	**0**	**1**	792	713	1505	2326
E Street Tunnel/No Build	**-22%**	**0**	**10**	0	0	0	2273
E Street Tunnel/At Grade	**-25%**	**0**	**2**	900	713	1613	2218







PM Peak Hour	*Total Network Delay (hours)*	*Number of failed corridors*	*Number of failed intersections*	*Eastbound*	*Westbound*	*Total*	*Fuel Use*
No Build	baseline	**8**	**38**	0	0	0	3169
No Build with TSM	**-12%**	**4**	**27**	0	0	0	3031
At Grade	**-20%**	**2**	**21**	863	980	1843	2933
Short Tunnel	**-21%**	**5**	**24**	828	942	1770	2926
Intermediate Tunnel	**-20%**	**5**	**23**	748	818	1566	2956
Long Tunnel	**-22%**	**4**	**28**	495	496	991	2919
Split-Portal Tunnel	**-22%**	**4**	**28**	748	496	1244	2893
E Street Tunnel/No Build	**-23%**	**3**	**24**	0	0	0	2804
E Street Tunnel/At Grade	**-34%**	**2**	**19**	863	877	1740	2681

General Measures	*Approx. Construction Cost (millions)*	*Construction Schedule (months)*	*Access to Abutting Properties*	*Traffic Safety*	*Impact on Utilities*	*Traffic Access*
No Build	$ 0	0	No change.	No effect.	None.	No change.
No Build with TSM	Less than 1	3	No change.	No effect.	None.	No change.
At Grade	Less than 1	6	Improved on Penn. Ave. between 15th and 17th Streets.	Some changes at intersections. Signing and marking required.	Minor.	Restored to pre-closure conditions.
Short Tunnel	55	24 - 30	Truncated service roads at 15th and 17th Streets.	Marginal. Sight distance deficiencies at both egress portals.	Minor. Temporary relocations/support.	Access to tunnel equivalent to pre-closure conditions.
Intermediate Tunnel	80	30 - 36	Full service roads at west end. Truncated service roads at east end.	Marginal. Sight distance deficiencies at both egress portals.	Substantial. Temporary support/relocations.	East end same as pre-closure; some movements not available at west end.
Long Tunnel	97	36 - 42	Full service roads at west end. Narrow, substandard service roads at east end.	Poor. Severe sight distance deficiencies at east egress portal.	Major. Temporary support/ permanent relocations.	Access at both ends constrained. No access from 15th St.
Split-Portal Tunnel	88	33 - 39	Full service roads at west end and east of 15th St. Truncated west of 15th St.	Marginal. Sight distance deficiencies at both egress portals.	Substantial. Temporary support/relocations.	No east end ingress from 15th St. West end constrained.
E Street Tunnel/No Build	135	36 - 48	E St. at-grade retained.	Marginal. Proximity of egress portal to intersection is undesirable.	Major. Large utilities relocated.	Access from north-south streets constrained.
E Street Tunnel/At Grade	135	36 - 48	E St at-grade retained. Improved on Penn. Ave. between 15th and 17th Streets.	Marginal. Proximity of egress portal to intersection is undesirable.	Major. Large utilities relocated.	Access from north-south streets constrained.