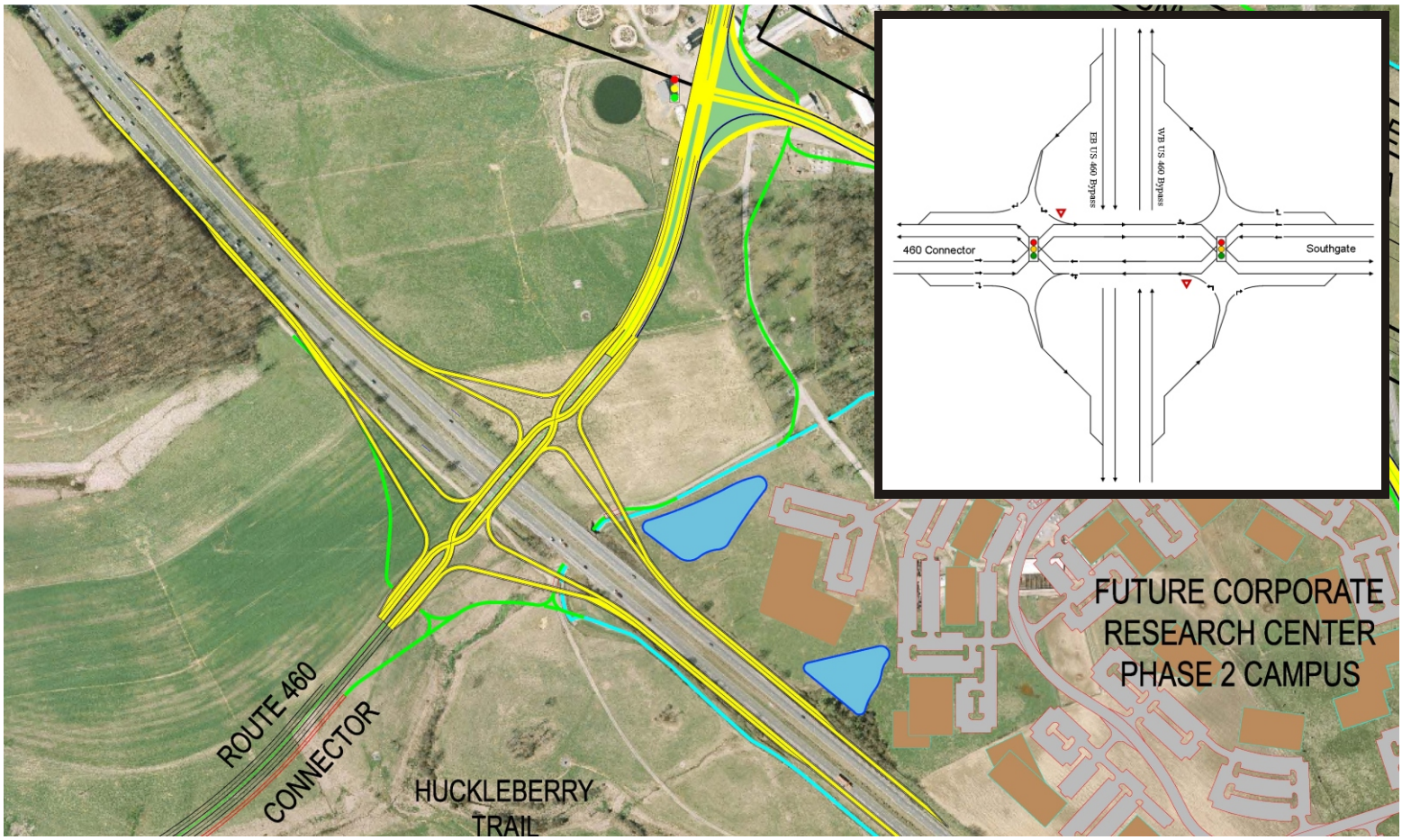
Analysis for a New Interchange on the

US Route 460 Bypass in the Vicinity of Southgate Drive

Montgomery County, Virginia



Developed by the
Blacksburg-Christiansburg-Montgomery
Area Metropolitan Planning Organization

In cooperation with
Virginia Tech
Virginia Department of Transportation
Federal Highway Administration

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Blacksburg-Christiansburg-Montgomery Area Metropolitan Planning Organization
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TABLE OF CONTENTS

Section 1: Introduction and Study Background 1
Section 2: Federal Policy Requirements for New or Modified Interchange 5
Section 3: Existing and Baseline Conditions in the Study Area 8
Section 4: Future Conditions in the Study Area 16
Section 5: Alternatives Development and Comparisons 21
Section 6: Comparison of Alternatives 26

Exhibit 1: Study Area 2
Exhibit 2: Existing Roadway Network 8
Exhibit 3: Roadway Network for Baseline Scenario 9
Exhibit 4: Daily Traffic Volumes for 2010 10
Exhibit 5: AM Peak Hour Traffic Volumes for 2010 11
Exhibit 6: PM Peak Hour Traffic Volumes for 2010 12
Exhibit 7: Base Year (2010) Levels of Service 13
Exhibit 8: Areas Previously Studied for Environmental Features 14
Exhibit 9: Interchange Area Features 15
Exhibit 10: Trip Generation for the Corporate Research Center Phase II 16
Exhibit 11: Daily Traffic Volumes for 2040 17
Exhibit 12: AM Peak Hour Traffic Volumes for 2040 18
Exhibit 13: PM Peak Hour Traffic Volumes for 2040 19
Exhibit 14: Base Year (2010) and Design Year (2040) Levels of Service 20
Exhibit 15: Schematic for Alternative 1: Standard Diamond Interchange 22
Exhibit 16: Schematic for Alternative 2: Diverging Diamond Interchange 23
Exhibit 17: Schematic for Alternative 3: Rotary Interchange 24
Exhibit 18: Schematic for Alternative 4: Partial Cloverleaf Interchange 25
Exhibit 19: Traffic Volumes for Year 2040 Analysis of Build Alternatives 27
Exhibit 20: Summary of Alternative 1: Standard Diamond Interchange 29
Exhibit 21: Summary of Alternative 2: Diverging Diamond Interchange 30
Exhibit 22: Summary of Alternative 3: Rotary Interchange 31
Exhibit 23: Summary of Alternative 4: Partial Cloverleaf Interchange 32
Exhibit 24: Queue Lengths for Year 2040 Analysis of Build Alternatives 33
Exhibit 25: Refined Breakdown of Estimated Costs for Recommended Alternative (Diverging Diamond Interchange) 35
Exhibit 26: Comparison of Travel Times in 2040 between the Preferred Alternative and the No-Build Alternative 36

Section 1: Introduction and Study Background

A new interchange, the Southgate Drive Interchange, is being proposed to replace an existing at-grade intersection on the primarily grade-separated US Route 460 Bypass in Blacksburg, Virginia. The at-grade roadway connection to be replaced is located at existing Southgate Drive (Route 314), a primary roadway connection into the campus of Virginia Tech that also leads into the central downtown area of the Town of Blacksburg. While located within the limits of the Town of Blacksburg, properties on both sides of US Route 460 Bypass in the vicinity of the proposed interchange are owned by Virginia Tech.

The proposed interchange is located within the Blacksburg-Christiansburg-Montgomery Area Metropolitan Planning Organization (MPO) area and is included in the MPO's current *Year 2035 Long Range Transportation Plan*, with partial funding for the proposed interchange included in the Financially Constrained Long Range Plan (CLRP). The Southgate Drive Interchange would be located just to the south of the existing Southgate Drive at-grade intersection, allowing this intersection to remain open during construction, thereby minimizing costs and impacts associated with the need to maintain traffic during construction. The new interchange would connect to the localized roadway network via a relocated Southgate Drive and Tech Center Drive. These roads are being relocated to facilitate the planned extension of the runway at the Virginia Tech Montgomery Executive Airport with funding from the Federal Aviation Administration. The *Year 2035 Long Range Transportation Plan* also includes extending Southgate Drive to the west along a corridor called the Route 460 Connector. This connector project is included in the Vision Plan component of the *Year 2035 Long Range Transportation Plan* and does not affect the need for the proposed interchange. Prudent planning, however, suggests that interchange designs need to allow for this extension when and if it is funded.

This study evaluated a range of options for the proposed new interchange to replace the Southgate Drive/US Route 460 Bypass at-grade intersection. Assessments were made of the operational characteristics of multiple interchange types in order to determine which would most appropriately address current and future travel and safety needs in the area. In addition to operations and safety, other considerations used to determine the most appropriate interchange configuration included effectiveness in serving pedestrians, bicycles, and transit; estimated costs; and potential environmental impacts (assessed at an overview level).

This study specifically included the following elements:

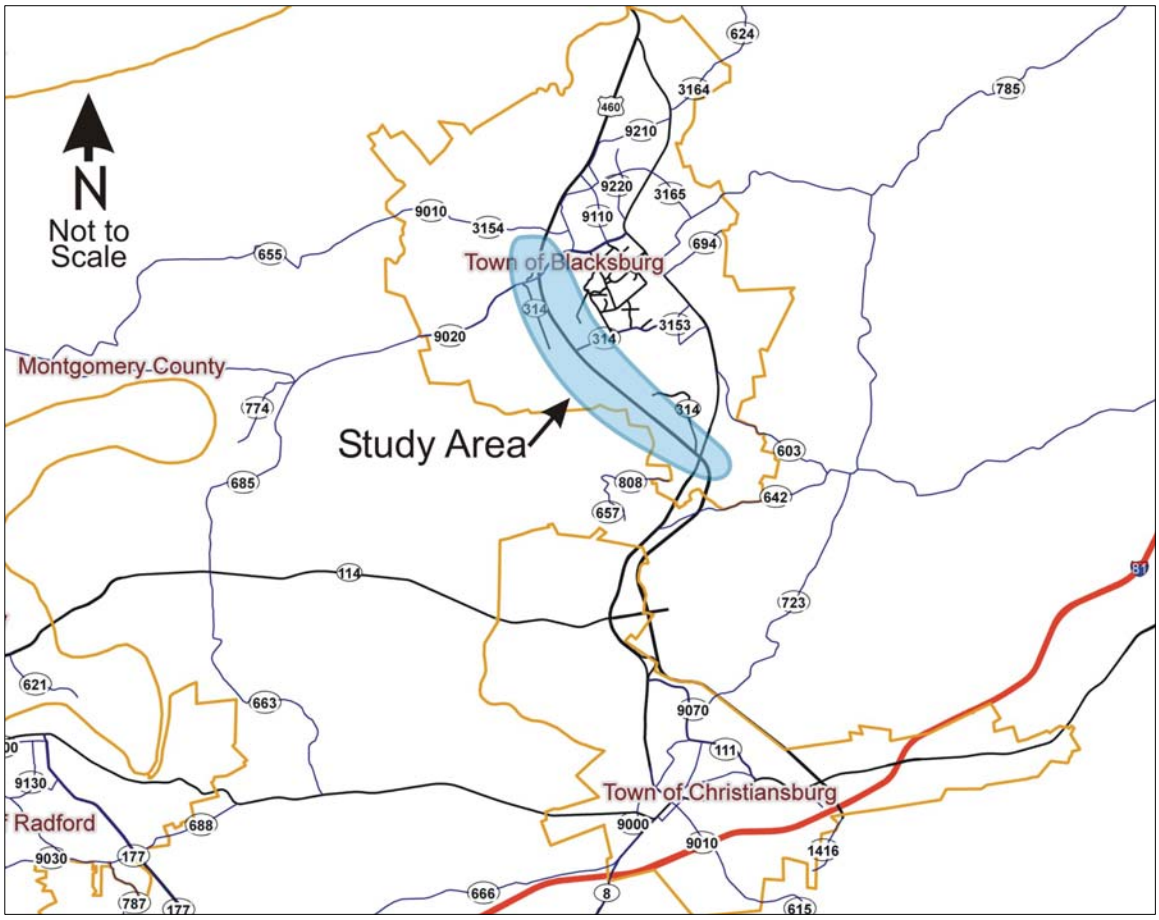
- Traffic counts and field reviews
- Development of traffic forecasts to the year 2040
- Development of preliminary and refined alternatives
- Analysis of the traffic and safety operations of the alternatives
- Consideration of impacts of the alternatives on adjacent interchanges on US Route 460 Bypass and on Southgate Drive and Southgate Drive Relocated
- Consideration of the impacts of alternatives on bicycle and pedestrian travel

- Garnering input from the public on the alternatives
- Selection of a recommended alternative

Study Area

The project is located in the Blacksburg/Christiansburg/Montgomery metropolitan area, specifically in the Town of Blacksburg in Montgomery County (see Exhibit 1). The proposed interchange would serve Virginia Tech (26,000 students), the Town of Blacksburg (17,000 residents), as well as the metropolitan region and beyond. Since the interchange is located on US Route 460, the benefits of the interchange would accrue not only within the metropolitan area itself but also to longer distance statewide and regional traffic.

Exhibit 1
Study Area



Need for the Project

The proposed Southgate Drive Interchange would address regional and localized transportation needs related to roadway safety, congestion relief, and accessibility to

major traffic generators. In addition, the project will support economic growth within planned growth areas that, by being centrally located within the region, promote transportation efficiencies, and accessibility via transit services and carpools. While an integral part of the region's transportation system in all these areas, the project would provide benefits in each area independently of any other project (i.e., the project would provide independent utility in addressing needs).

Traffic Congestion: The at-grade intersection of Southgate Drive and US Route 460 Bypass currently serves approximately 35,000 vehicles on an average weekday. This intersection also serves special events traffic including that created by Virginia Tech football games (Virginia Tech's Lane Stadium holds more than 66,000 persons), basketball games, and other special events. Traffic forecasts show a 51 percent increase in weekday traffic to 52,800 by the year 2040 and a projected level of service of E.

Safety and Security: The intersection of US Route 460 Bypass and Southgate Drive is one of only two at-grade intersections on the 11-mile segment of the US Route 460 Bypass from Interstate 81 to its terminus at US Route 460 Business north of Blacksburg (the second at-grade intersection is at this northern terminus). While improvements have been and will continue to be made to ensure safety at this location, having a single at-grade intersection along a predominantly limited access roadway is not preferred in terms of safety. The intersection ranks sixth in the region in terms of number of crashes between 2006 and 2008. The proposed interchange would also substantially increase the capacity of the roadway system to evacuate the campus and immediate areas in the event of an emergency.

Transit Support: The Blacksburg-Christiansburg-Montgomery region is served by Blacksburg Transit (BT) which provides 3 million trips per year using 43 buses. While BT buses do use the existing Southgate Drive-US Route 460 Bypass intersection to make the northbound to eastbound movement (northbound right turn), the routing plan avoids the more frequently congested westbound to southbound left turn. Converting this intersection to a grade-separated interchange would allow for substantially increased use of the intersection for transit service, including game-day and special event traffic.

Pedestrian and Bicycle Connections: The proposed Southgate Drive Interchange would include shifting and reconfiguring the Huckleberry Trail underpass which is deficient in terms of horizontal and vertical geometry and its ability to effectively serve persons with physical challenges and disabilities. In addition, interchange designs would incorporate bicycle and pedestrian features to maximize connections for bicyclists and pedestrians across the US Route 460 Bypass (over and under US Route 460) as well as connections across the relocated Southgate Drive. Grade separated crossings for the Huckleberry Trail are recommended within the project area.

Regional Employment and Activity Center: In addition to its role as one of the two key entrances to the Virginia Tech campus, the proposed interchange will serve both vehicular and transit service to the Virginia Tech Corporate Research Center (CRC), a major regional employment and activity center and keystone element of efforts to provide

added value to the regional and national economy by increasing corporate and government research relationships with Virginia Tech. Currently housing 2,200 employees in just under one million square feet of space in its first phase, the CRC is beginning a second phase that will double its square footage and add another 3,000 employees.

Independent Utility: The proposed interchange has independent utility in terms of addressing the transportation needs described above. As noted previously, roadway connections to the interchange on the east side of US Route 460 Bypass are funded by the Federal Aviation Administration as part of the runway extension project. It is anticipated that the relocation of Tech Center Drive and construction of a portion of Southgate Drive Relocated will be completed as part of the airport project prior to the start of construction on the Southgate Interchange project. Should this not occur, the Southgate Interchange project would include the construction of Southgate Drive Relocated between US Route 460 Bypass and Duck Pond Road. Accordingly, full and effective operation and benefits of this project do not rely on any other planned projects.

Section 2: Federal Policy Requirements for New or Modified Interchange

The improvements analyzed in this study will result in a new grade-separated interchange being constructed on the US Route 460 Bypass. Such improvements require assessments of the new interchange from both policy and operational standpoints. Eight Federal Highway Administration (FHWA) policy requirements are listed in the Federal Register; these are discussed in detail in this section of the report. Note that while the policy wording uses the word "interstate", this study is assessing the effects of adding a new interchange access point on a US highway.

1. ***FHWA policy states: "The existing interchanges and/or local roads and streets in the corridor can neither provide the necessary access nor be improved to satisfactorily accommodate the design-year traffic demands while at the same time providing the access intended by the proposal."*** The existing at-grade intersection at Southgate Drive does not provide the necessary access to the Virginia Tech campus and its associated major trip generators, including the Corporate Research Center. The addition of turn lanes at this location will not provide adequate levels of service in the design year, and maintaining the current at-grade configuration, even with improvements, will continue to degrade travel times and adversely affect safety on the US Route 460 Bypass. The analysis in Sections 4 and 6 of this document supports these conclusions.
2. ***FHWA policy states: "All reasonable alternatives for design options, location, and transportation system management type improvements (such as ramp metering, mass transit, and HOV facilities) have been assessed and provided for if currently justified, or provisions are included for accommodating such facilities if a future need is identified."*** A range of design options were assessed as part of this study, and the preferred diverging diamond interchange (DDI) provides the best service for motor vehicles, pedestrians, bicycles, and transit while also minimizing the number of junctions with the mainline of the US Route 460 Bypass. The analysis shows that the proposed interchange would not adversely affect the current year or design year operations of interchanges to the north and south of the proposed Southgate Drive Interchange.
3. ***FHWA policy states: "The proposed access point does not have a significant adverse impact on the safety and operation of the Interstate facility based on an analysis of current and future traffic. The operational analysis for existing conditions shall, particularly in urbanized areas, include an analysis of sections of Interstate to and including at least the first adjacent existing or proposed interchange on each side. Crossroads and other roads and streets shall be included in the analysis to the extent necessary to assure their ability to collect and distribute traffic to and from the interchange with the new or revised access points."*** The proposed action will replace an at-grade access point that experiences safety concerns with a grade-separated interchange that will greatly improve safety by substantially reducing the number of vehicle conflict points through grade separation and converting the remaining vehicle conflicts to merges from ramps onto the mainline of US Route 460. The preferred recommendation

of a DDI has been shown to provide improved safety based on fewer and more spread out conflict points, better sight distance, shorter pedestrian crossings, and the ability to incorporate traffic calming features (crash data for the Springfield, Missouri, interchange indicated a 60 percent reduction in collisions compared to those recorded for the previous interchange configuration).

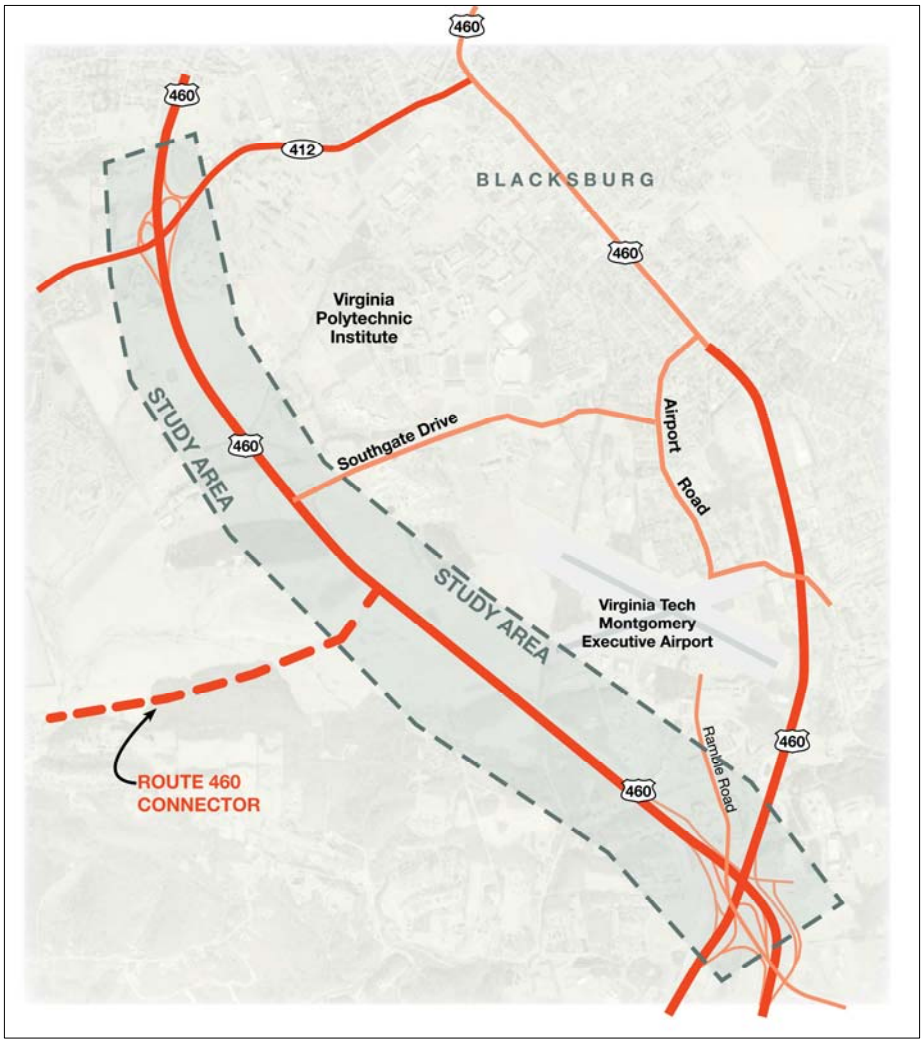
4. ***FHWA policy states: "The proposed access connects to a public road only and will provide for all traffic movements. Less than "full interchanges" for special purpose access for transit vehicles, for HOV's, or into park and ride lots may be considered on a case-by-case basis. The proposed access will be designed to meet or exceed current standards for Federal-aid projects on the Interstate System."*** The proposed interchange will allow for all movements, with access to and from US Route 460 Bypass both north and south of the interchange, as well as relocated Southgate Drive. All three legs are public roads. In addition, the interchange will allow for expansion to provide access to the planned Route 460 Connector (this project, also a public road, is included in the region's *Year 2035 Long Range Transportation Plan* as a vision plan project). The interchange will be designed to meet all current standards for Federal-aid projects.
5. ***FHWA policy states: "The proposal considers and is consistent with local and regional land use and transportation plans. Prior to final approval, all requests for new or revised access must be consistent with the metropolitan and or statewide transportation plan, as appropriate, the applicable provisions of 23 CFR part 450 and transportation conformity requirements of 40 CFR parts 51 and 93."*** The proposed interchange is included the region's *Year 2035 Long Range Transportation Plan*. Locality land use plans, as well as the Virginia Tech master plan, include this project.
6. ***FHWA policy states: "In areas where the potential exists for future multiple interchange additions, all requests for new or revised access are supported by a comprehensive Interstate network study with recommendations that address all proposed and desired access within the context of a long-term plan."*** The potential does not exist within the study area for future multiple interchange additions.
7. ***FHWA policy states: "The request for a new or revised access generated by new or expanded development demonstrates appropriate coordination between the development and related or otherwise required transportation system improvements."*** There are a number of components related to the need for a new interchange at this location. One contributing factor to the need for the project is the ongoing development of the Corporate Research Center which is a private, wholly-owned subsidiary of the Virginia Tech Foundation. Throughout the development of the design of the proposed interchange, coordination took place with staff at the Corporate Research Center, and the traffic forecasts developed for the design year operations analysis reflect future plans for the Corporate Research Center. The planning for this project included coordination with the anticipated relocation of Tech Center Drive as part of the airport's runway extension – such coordination will continue through design and construction of the proposed interchange.

8. ***FHWA policy states: "The request for new or revised access contains information relative to the planning requirements and the status of the environmental processing of the proposal."*** The proposed interchange was developed based on an understanding of the VDOT project planning and development process, which includes coordination between planning the NEPA (the National Environmental Policy Act) process.

Section 3: Existing and Baseline Conditions in the Study Area

This section describes existing conditions in the study area relative to traffic volumes, traffic operations, safety, and the man-made and natural environment. The roadway network is shown in Exhibit 2.

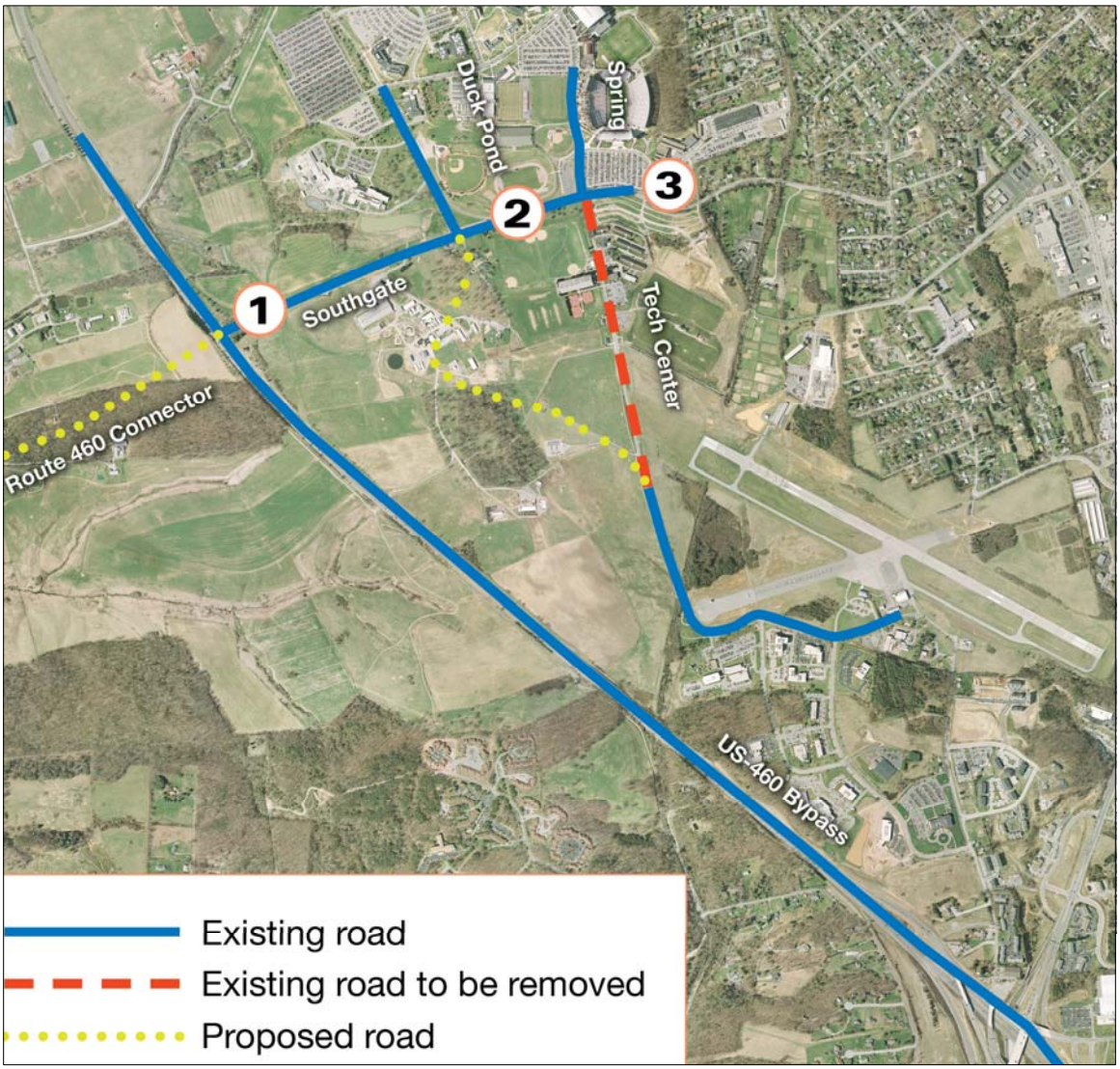
Exhibit 2
Existing Roadway Network



This study assumes that certain roadway improvements and land uses will be in place by the year 2040 or before, and the improvements being assessed would tie into and work integrally with these other plans. From a land use standpoint, Phase II of the Corporate Research Center is anticipated to be open and occupied, and the proposed improvements to the Virginia Tech Montgomery Executive Airport (including the runway extension and roadway relocations) would be implemented. Assumed roadway improvements in the future Baseline scenario (shown in Exhibit 3) include the relocation of Tech Center Drive, which currently intersects Southgate Drive at Spring Road, to accommodate the runway extension, to tie in to Southgate Drive at its intersection with

Duck Pond Road. The study also assumes that the previously studied Route 460 Connector will intersect with the US Route 460 Bypass at its intersection with Southgate Drive.

Exhibit 3
Roadway Network for Baseline Scenario



Existing and Baseline Traffic Volumes

Existing traffic data was obtained from 2007 counts provided by Virginia Tech as well as counts performed for this study in January/February of 2010. The primary data set used for the estimates of existing traffic were the 2010 intersection counts and 48-hour interchange ramp counts, with the 2007 data used to a limited extent. The 2007 data sets that were used were adjusted to a common year of 2010 based on a comparison of the two sets of count data. The count data was then balanced and smoothed, and the resulting traffic volumes are shown in Exhibits 4 through 6.

Exhibit 4
Daily Traffic Volumes for 2010

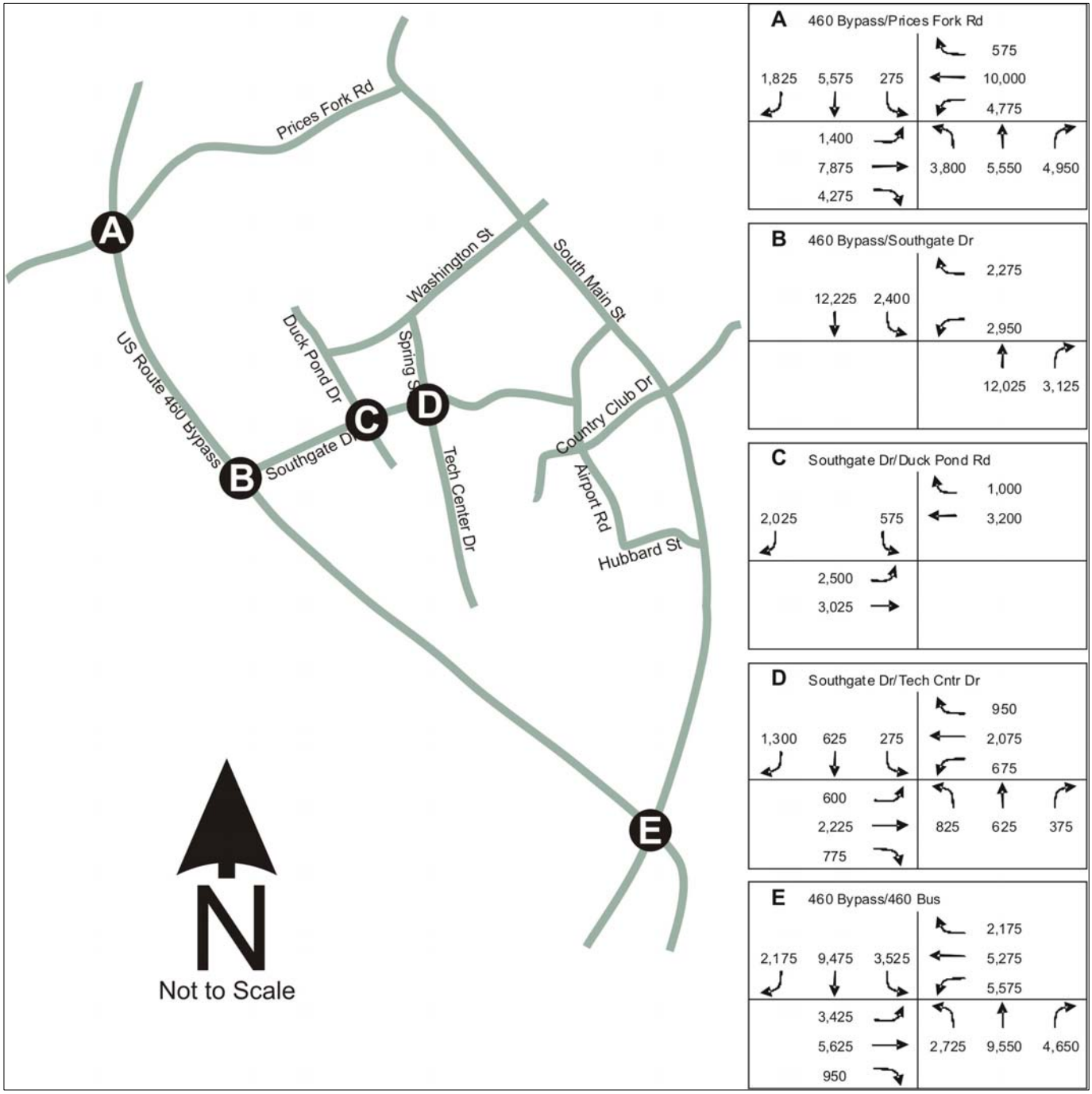


Exhibit 5
AM Peak Hour Traffic Volumes for 2010

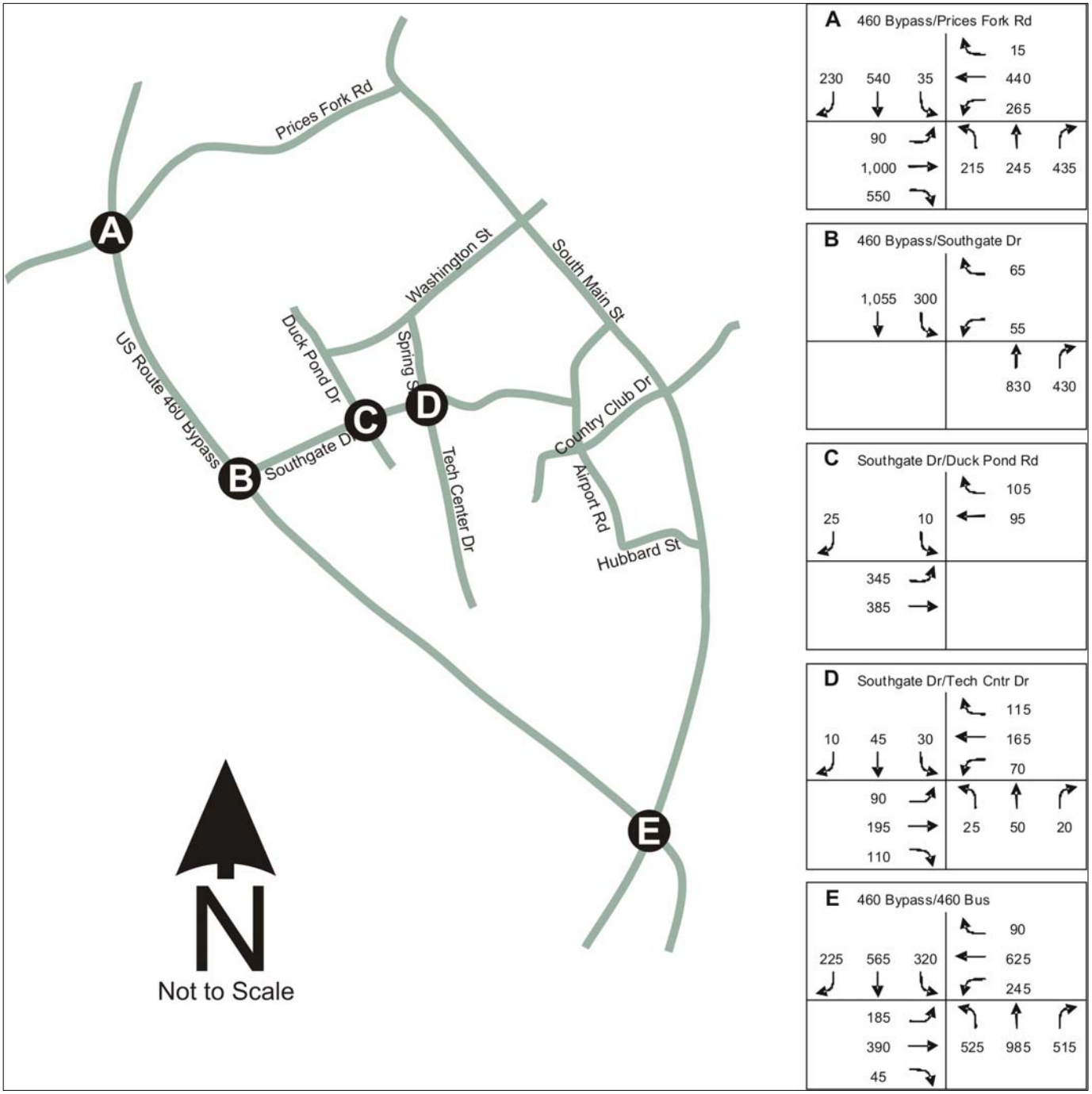
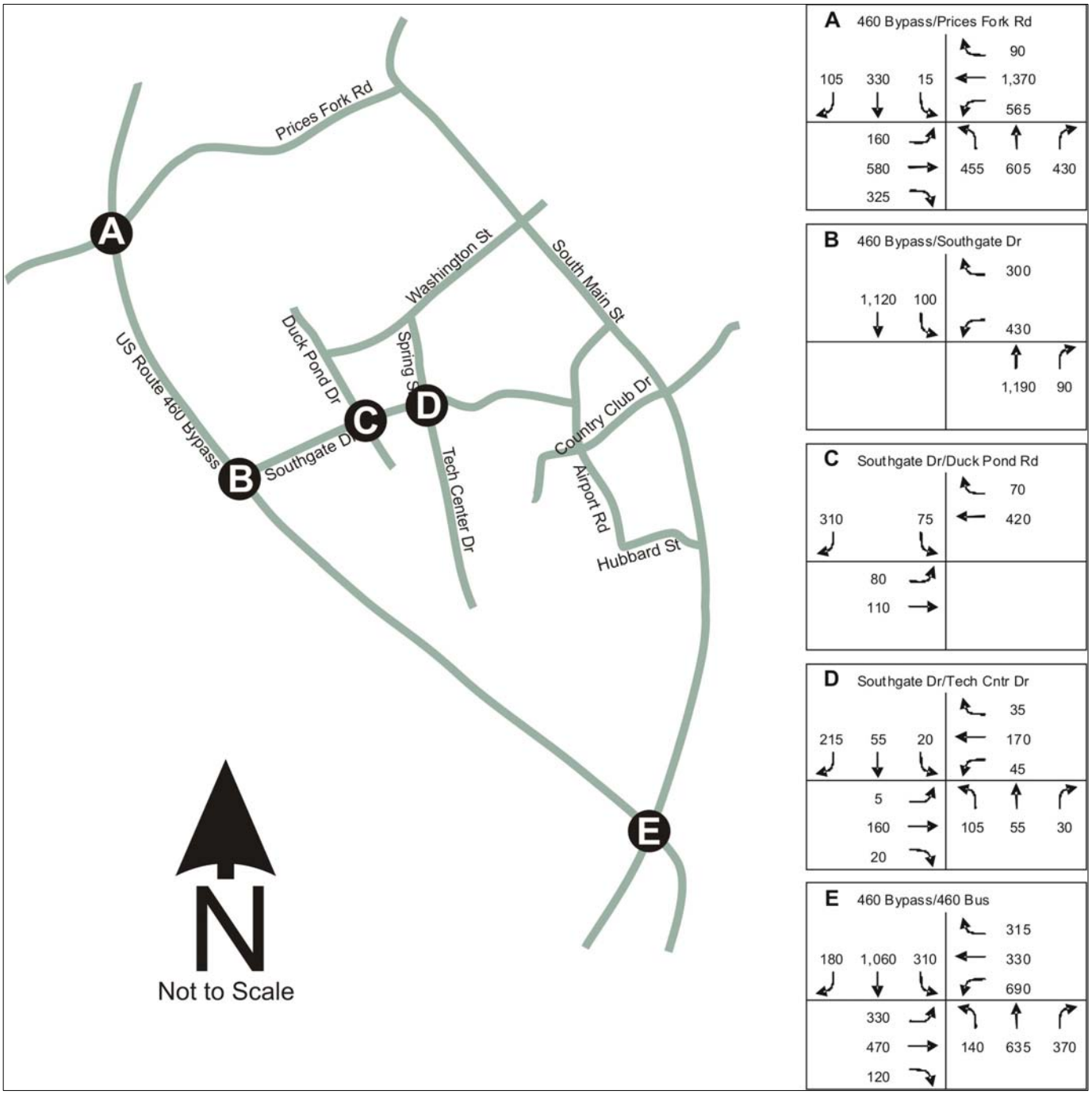


Exhibit 6

PM Peak Hour Traffic Volumes for 2010



Existing and Baseline Traffic Operations

Traffic operations were assessed using standard level of service analysis techniques. Level of service is a measure used by transportation engineers to grade the operations of roadways based on a scale from A to F. Similar to a report card, a level of service A represents excellent travel conditions with little or no delay. Level of service F represents failure or gridlock conditions with very high amounts of delay. The Virginia Department of Transportation generally applies the standard that level of service D or better represents adequate operations during peak periods. Exhibit 7 table below summarizes level of service at the key intersections within the study area.

Exhibit 7
Base Year (2010) Levels of Service

	Levels of Service	
Intersection Location	**AM Peak**	**PM Peak**
US Route 460 Bypass at Southgate Drive	B	C
Southgate Drive at Duck Pond Road	C	E
Southgate Drive at Tech Center Drive	B	C

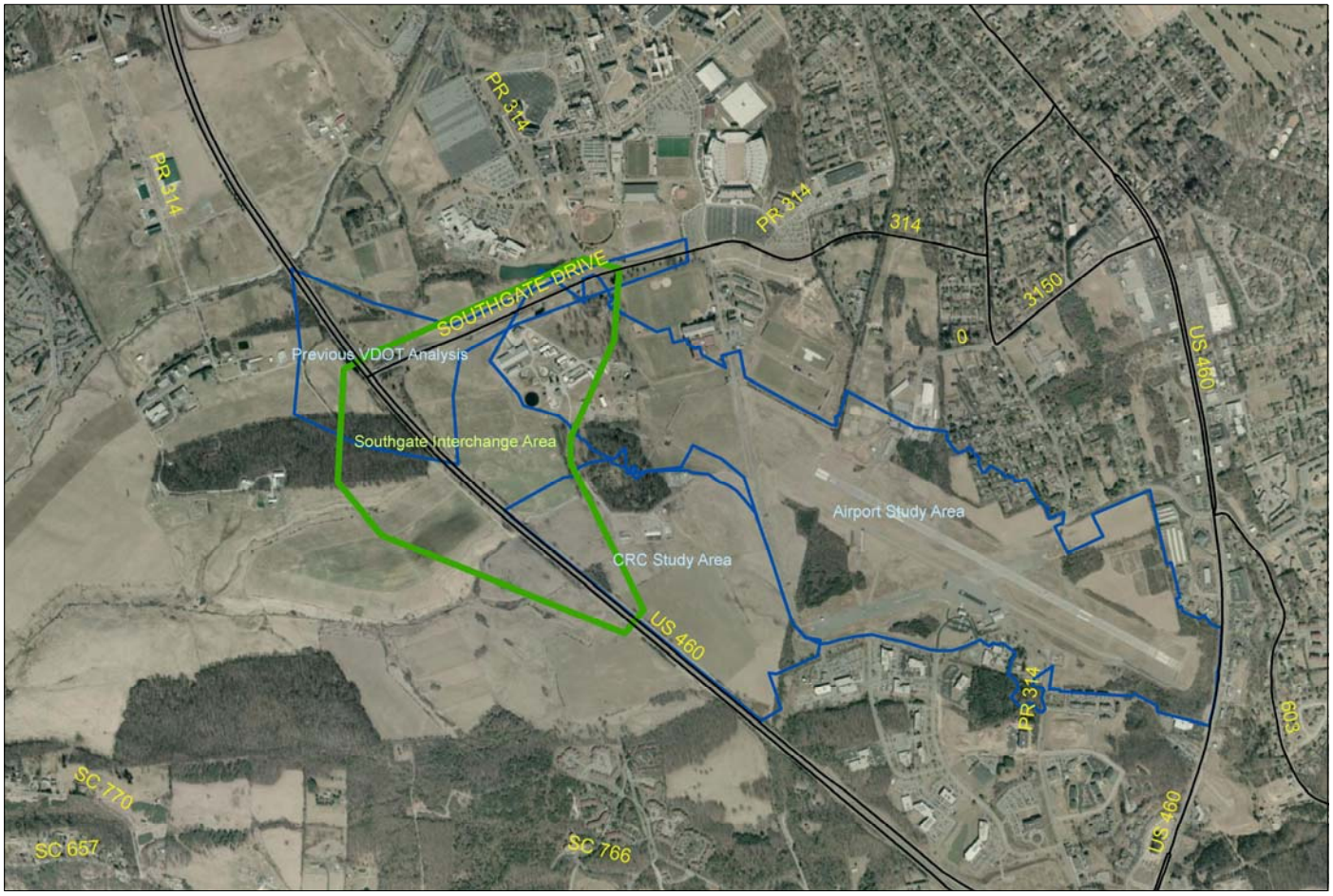
Safety

The current at-grade intersection of Southgate Drive and the US Route 460 Bypass is one of the region's top safety locations based on crash experience. Long planned to be an interchange as well, the intersection is located between freeway interchanges both to the north and south. One result of this is that traffic travels at higher speeds than is appropriate, creating safety situations that are currently being addressed partially through reduced speed limits, warning signage, and lengthened turn lanes. The increased congestion that is projected at this location is anticipated to severely exacerbate safety issues at this location as queue lengths are extended further from the intersection. The proposed interchange will enhance safety by eliminating at-grade conflicts for the majority of traffic that travels through on US Route 460 Bypass, as well as providing a facility that meets current geometric standards. As indicated earlier, the DDI interchange also represents a configuration that has been shown to be safer than many other options, both for motorists and for bicyclist and pedestrians.

Natural Environment

Ending with a public hearing in June of 2001, VDOT previously performed environmental analysis within portions of the study area as part of assessing the potential impacts of an interchange at the existing Southgate Drive intersection location. In addition, both the CRC and airport have recently obtained environmental and historic analyses of the area adjacent to and (with some overlap) within the project area for the proposed interchange. The areas studied by the CRC and airport are shown in Exhibit 8.

Exhibit 8
Areas Previously Studied for Environmental Features

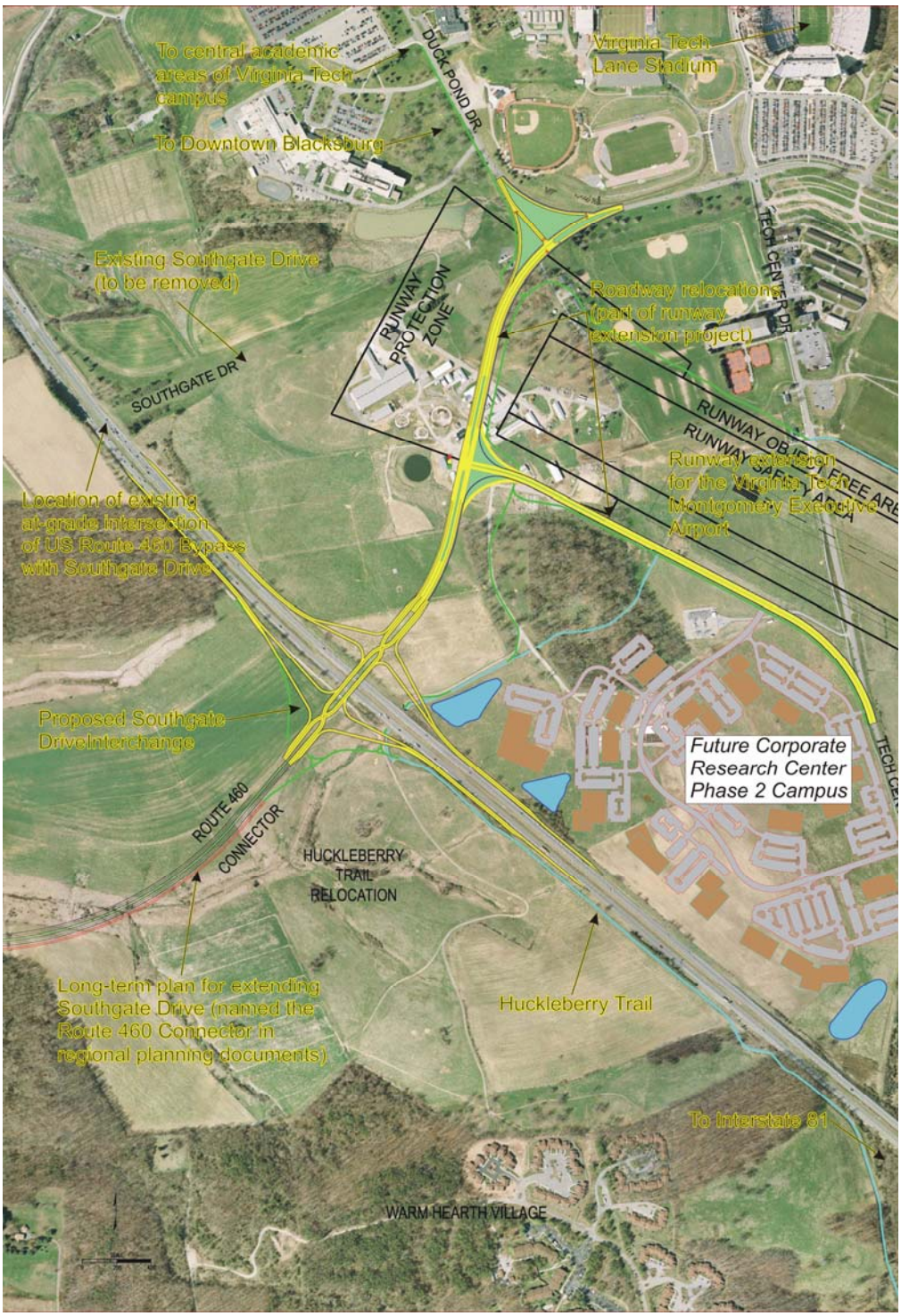


Man-Made Environment

The study area includes the area adjacent to the US Route 460 Bypass, extending to the north of the interchange with Prices Fork Road and to the south of the interchange with US Route 460 Business (Main Street). The US Route 460 Bypass is a four-lane, divided facility with a posted speed limit of 65 mph, except for a reduced 55 mph speed limit area approaching the intersection with Southgate Drive. Southgate Drive is signed for a 35 mph speed limit, and is primarily an undivided, two-lane facility, though it is flared to five lanes of pavement width (three westbound approaching the intersection, two eastbound leaving the intersection) in the functional area of the intersection. Prices Fork Road is a four-lane urban arterial with a partial cloverleaf interchange at the intersection of the Bypass. US Route 460 Business is also a four-lane divided urban arterial, with a non-typical interchange composed of various directional ramps between the Bypass, as well as Ramble Road and Industrial Park Road. Exhibit 9 highlights some of the other features in and near the study area, including the Corporate Research Center, Virginia Tech's Lane Football Stadium, the Huckleberry Trail, the Virginia Tech Montgomery

Executive Airport runway extension, and the relocation of Tech Center Drive to accommodate the extension of the runway. As noted, the proposed Southgate Interchange project will tie into the roadway projects associated with the airport runway extension; depending on the status of the runway project, the interchange project may include the relocation of Southgate Drive up to Duck Pond Drive.

Exhibit 9
Interchange Area Features



Section 4: Future Conditions in the Study Area

Forecasted daily volumes were developed using the regional travel demand model in conjunction with analysis of planned increases in employment at the Corporate Research Center that were not included in the model demographic assumptions. The design year for the Southgate Interchange is 2040; therefore the 2030 regional travel demand model output was adjusted as described below to reflect additional growth to the year 2040 (note that the region's 2035 travel demand model was not available at the time of this analysis).

The forecasting process involved the development of a basic origin-destination matrix based on the balanced base year traffic counts, with the trip ends being the extremities of the study area (the US Route 460 Bypass north of Prices Fork Road, Prices Fork Road east and west of the Bypass, etc.). This trip matrix was used with forecasted traffic to determine traffic volumes throughout the study area. To produce traffic forecasts for the desired analysis year of 2040, the model results were used to produce a linearly extrapolated scaling factor to estimate 2040 traffic volumes from the existing (year 2010) balanced traffic counts. With estimates for 2040 traffic volume at the trip ends, an origin-destination matrix (and subsequent turning movement and link volumes), was produced for the year 2040, using the year 2010 matrix as a reference. The process involved the application of a standard matrix factoring technique known as FRATAR.

The final step of the traffic estimation process involved trip generation for the proposed CRC Phase II. Using the ITE Trip Generation Manual with an estimated employment of 2,515 at the CRC Phase II facility, daily and peak hour trips were estimated and added to the existing "background" traffic estimations. It was assumed that 60% of the traffic generated by the new research facility would enter or leave via Southgate Drive, with the remainder entering via US Route 460 Business and other routes and, therefore, not included in the study. Exhibit 10 summarizes the generated traffic for the development, showing that over 550 trips are attracted to the CRC Phase II via Southgate during the a.m. peak hour, and as many originate from the development in the p.m. peak hour.

Exhibit 10

Trip Generation for the Corporate Research Center Phase II

Employees: 2515 ITE Trip Generation Code: 760						
	Daily		AM Peak Hour		PM Peak Hour	
Rate (trips/employee)	2.77		0.43		0.41	
Distribution	In	Out	In	Out	In	Out
	50%	50%	86%	14%	10%	90%
Generated Trips - Total	3,483	3,484	930	151	103	928
Assumed Percentage Traveling North of Development (i.e to/from Southgate)	60%					
Generated Trips - Study Area	**2,090**	**2,090**	**558**	**91**	**62**	**557**

The estimated trips going to/from the Corporate Research Center were then added to the "background" 2040 traffic estimates as predicted by the adjusted regional travel demand model. Total year 2040 peak hour traffic volumes are shown in Exhibits 10 through 12

Exhibit 11

Daily Traffic Volumes for 2040

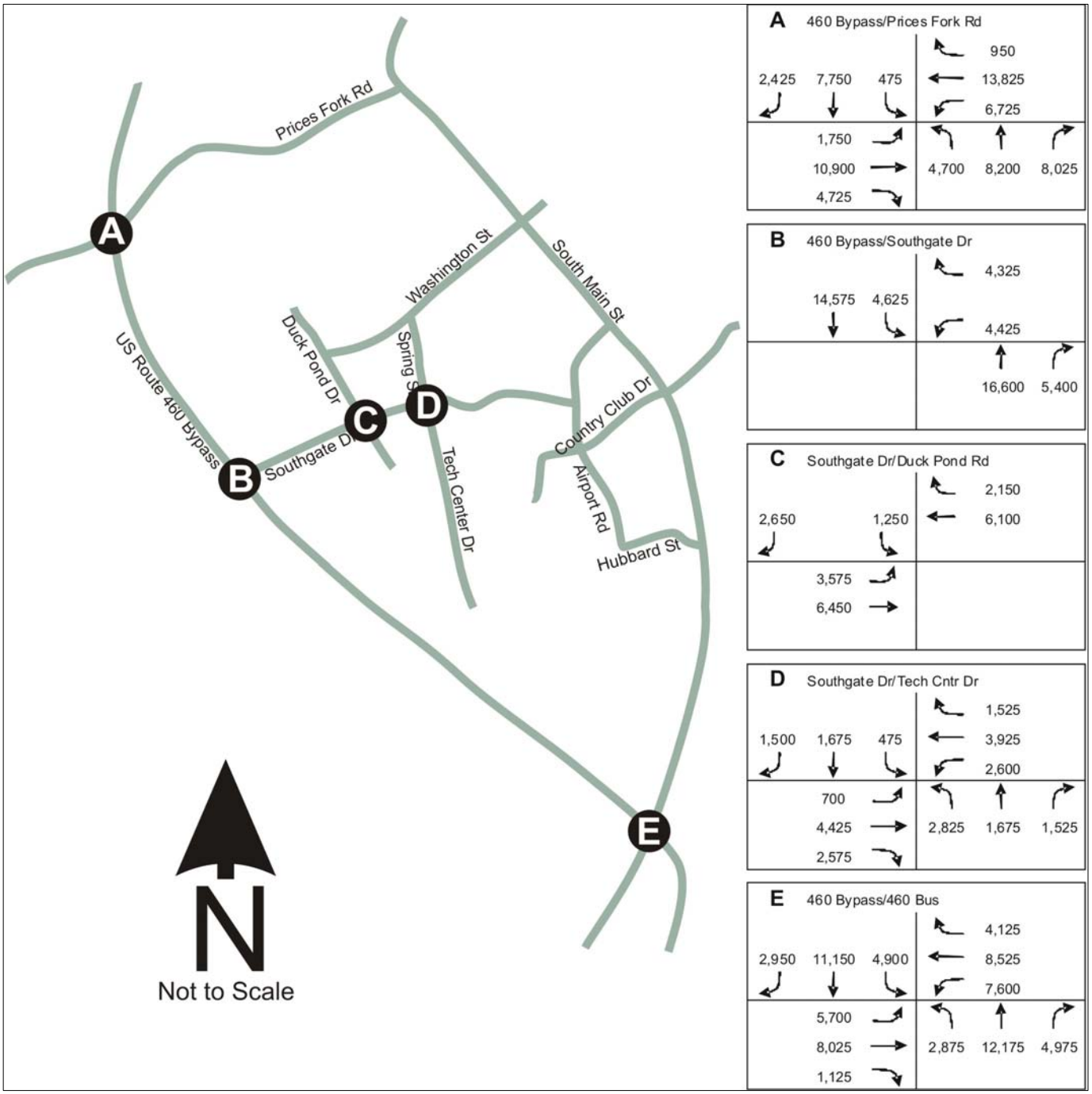


Exhibit 12
AM Peak Hour Traffic Volumes for 2040

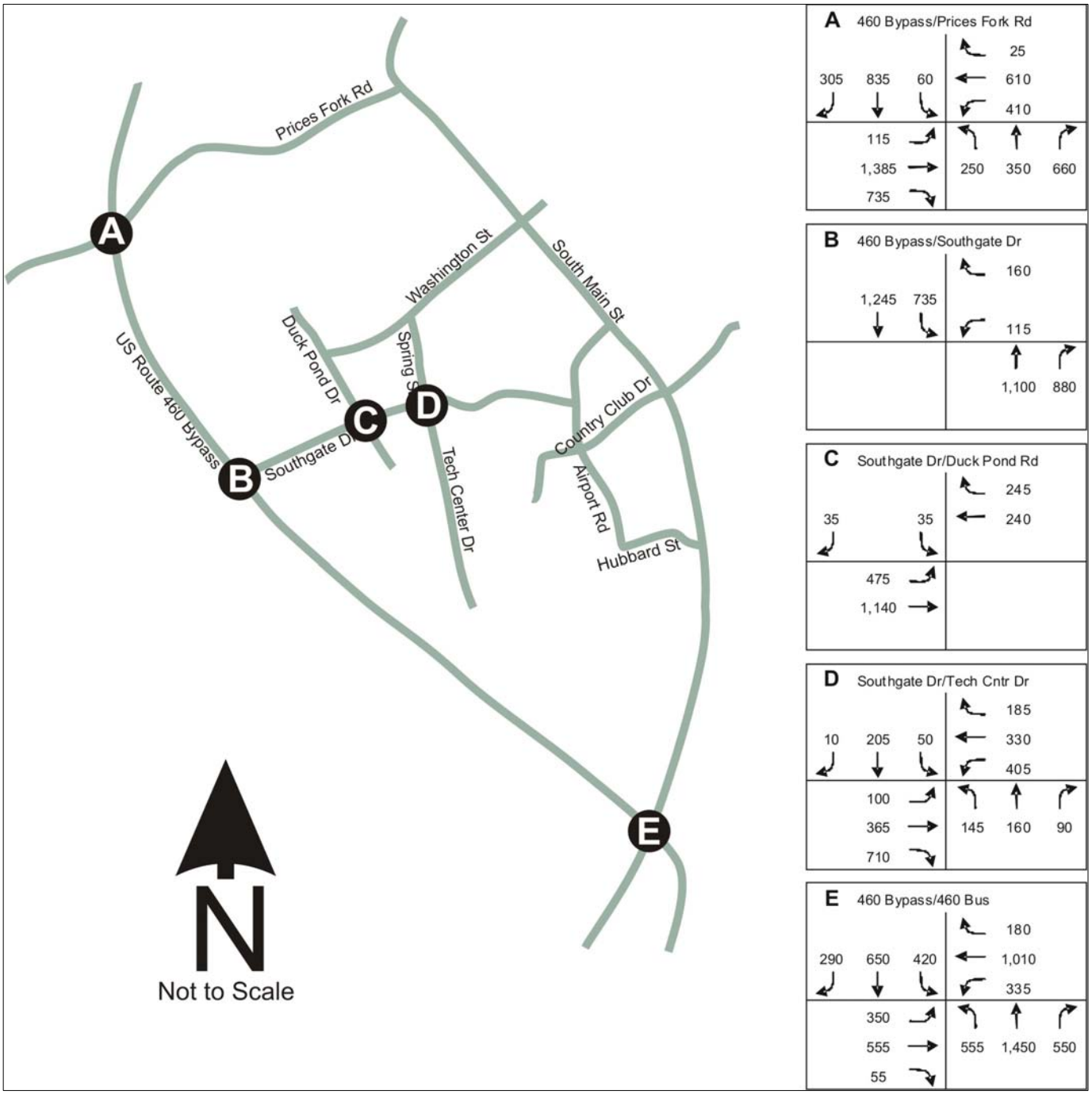
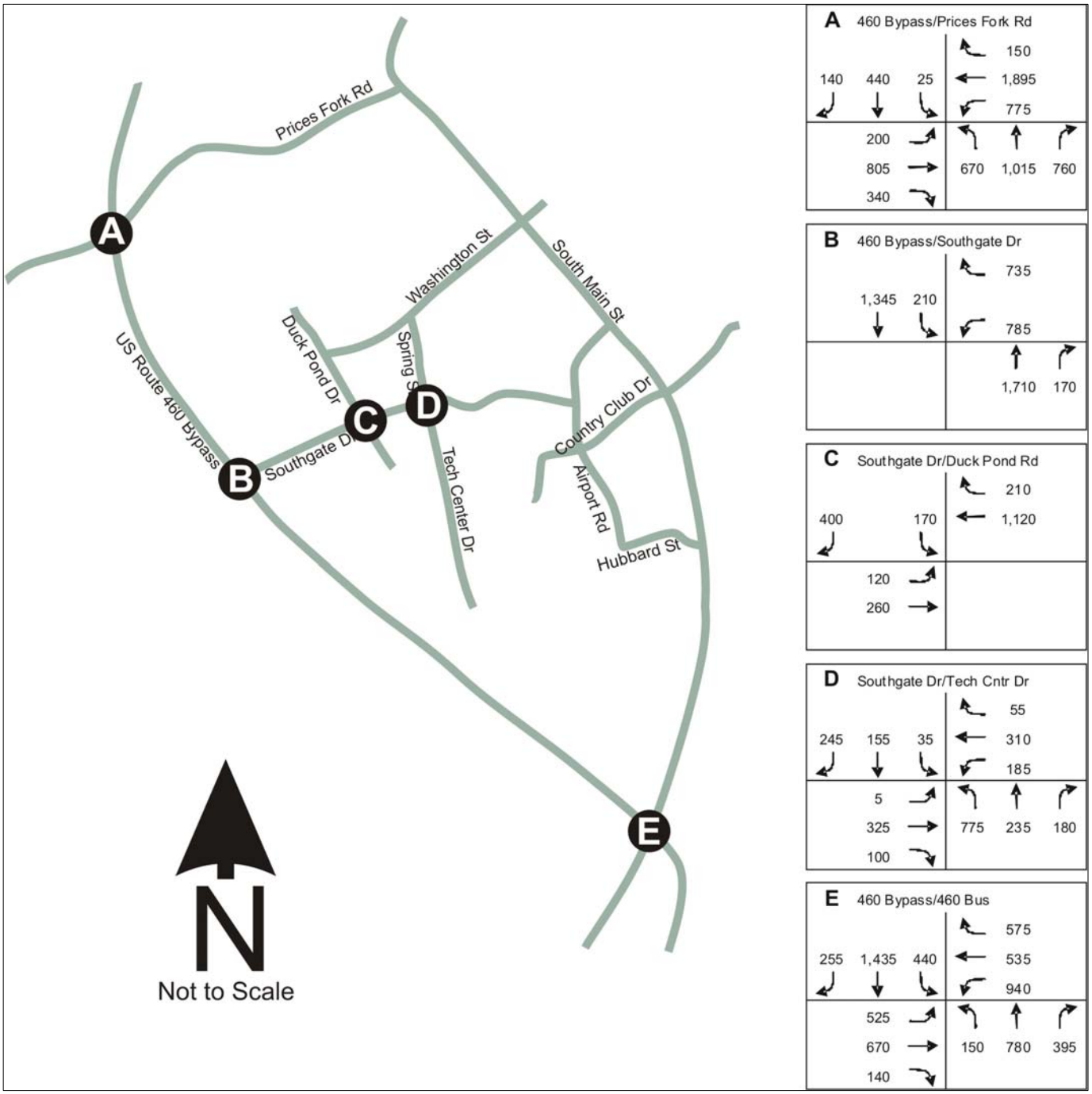


Exhibit 13

PM Peak Hour Traffic Volumes for 2040



The at-grade intersection of Southgate Drive and the US Route 460 Bypass currently serves approximately 35,000 vehicles on an average weekday. Projections show that weekday traffic will increase by 51 percent to 52,800 vehicles per day by the year 2040. The resulting levels of service based on these projected increases are shown in Exhibit 14. This table highlights a substantial degradation of levels of service at the key study intersections with the at-grade intersection of the US 460 Bypass and Southgate Drive expected to experience operations at failing, or level of service F, conditions.

Exhibit 14

Base Year (2010) and Design Year (2040) Levels of Service

	2010 Level of Service		**2040 Level of Service**	
Intersection Location	**AM Peak**	**PM Peak**	**AM Peak**	**PM Peak**
US Route 460 Bypass at Southgate Drive	B	C	F	F
Southgate Drive at Duck Pond Road	C	E	E	F
Southgate Drive at Tech Center Drive	B	C	C	B

Section 5: Alternatives Development and Comparisons

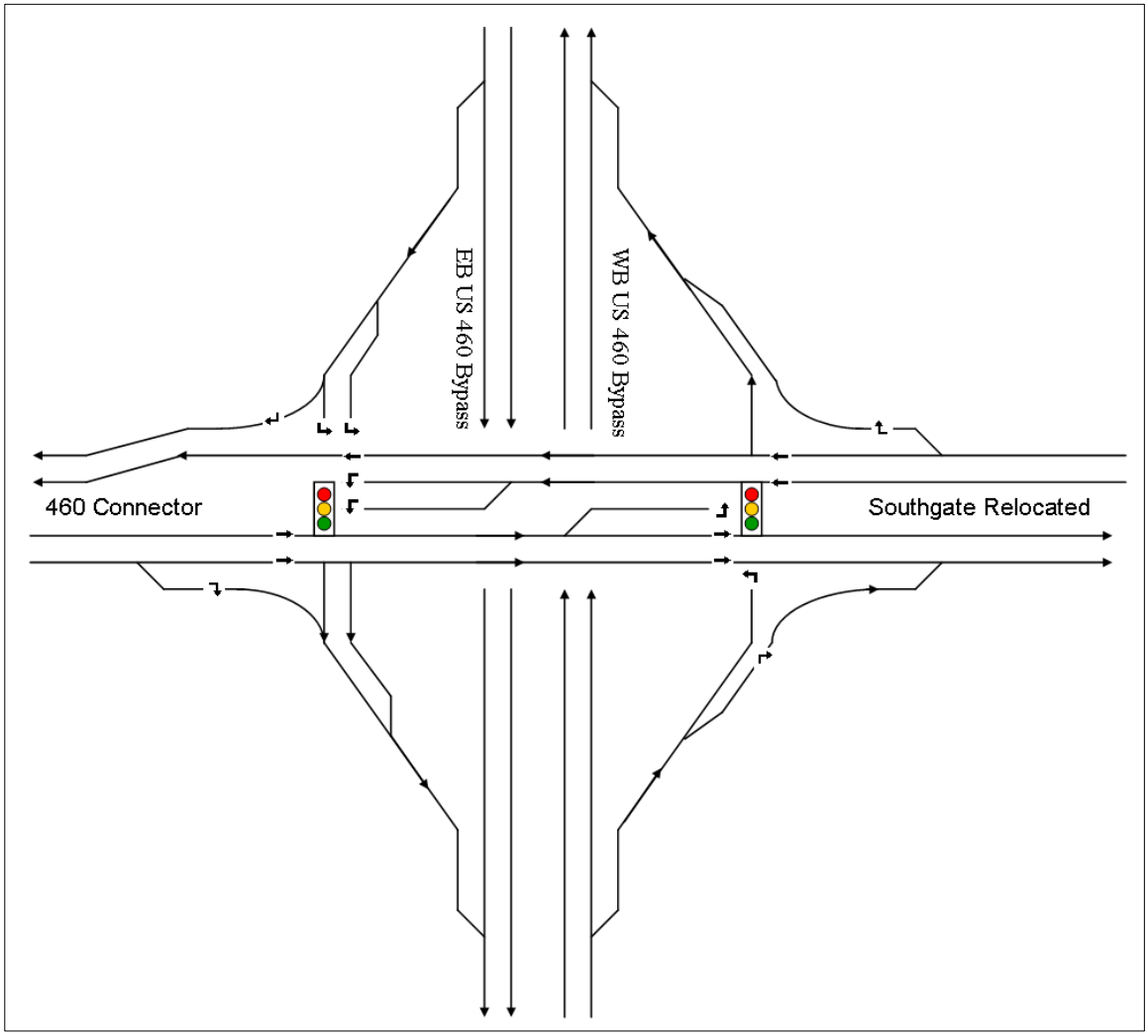
Based on the expected travel demands, the physical aspects of the proposed interchange location, and input from Virginia Tech, MPO staff, and other interested parties, four interchange configurations were identified as potential candidates for detailed analysis.

The four configurations are 1) a standard diamond interchange, 2) a diverging diamond interchange, 3) a rotary interchange, and 4) a partial cloverleaf interchange. Each of these is described on the following pages. In terms of alternatives development, the standard diamond interchange represents the most basic interchange option, while the partial cloverleaf was considered due to the high volumes of left turns on certain movements which could benefit from free-flow operations. The rotary design was considered due to its ability to provide service to all vehicles without the need for a traffic signal, allowing for less delay for low volume approaches. The diverging diamond was identified as a possible alternative due to its relatively small footprint and ability to handle high turn volumes with less delay.

Alternative 1: Standard Diamond Interchange

This configuration is a standard diamond interchange design with a single ramp from and to each direction of US Route 460 Bypass. Signalized intersections would be located at the terminus of each ramp. A lane diagram schematic is included in Exhibit 15.

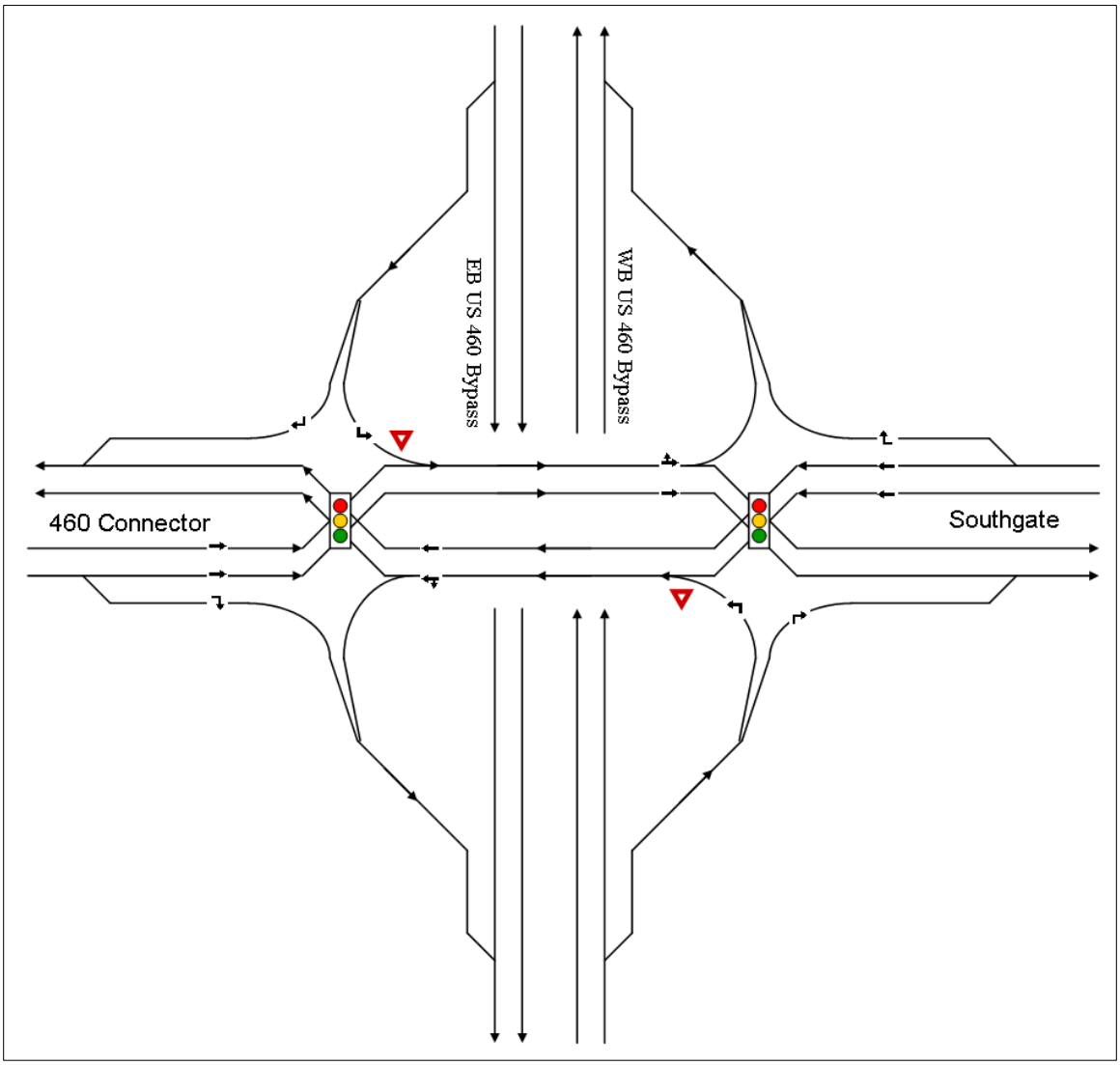
Exhibit 15
Schematic for Alternative 1: Standard Diamond Interchange



Alternative 2: Diverging Diamond Interchange

This alternative represents an adaptation of the standard diamond interchange design whereby the signalized intersections on either side of the bridge over the main highway include a cross-over to allow traffic to switch to the opposite side of the road, where traffic from exit ramps is able to merge without, as is otherwise typical, opposing traffic coming in the opposite direction. With traffic on the left, left turns are conducted without conflict onto the US Route 460 Bypass on-ramps. Through traffic crosses back over to the right at the signalized intersection on the opposite side of the diamond. As with the standard diamond interchange, there are single ramps from and to each direction of US Route 460 Bypass. A lane diagram schematic is included in Exhibit 16.

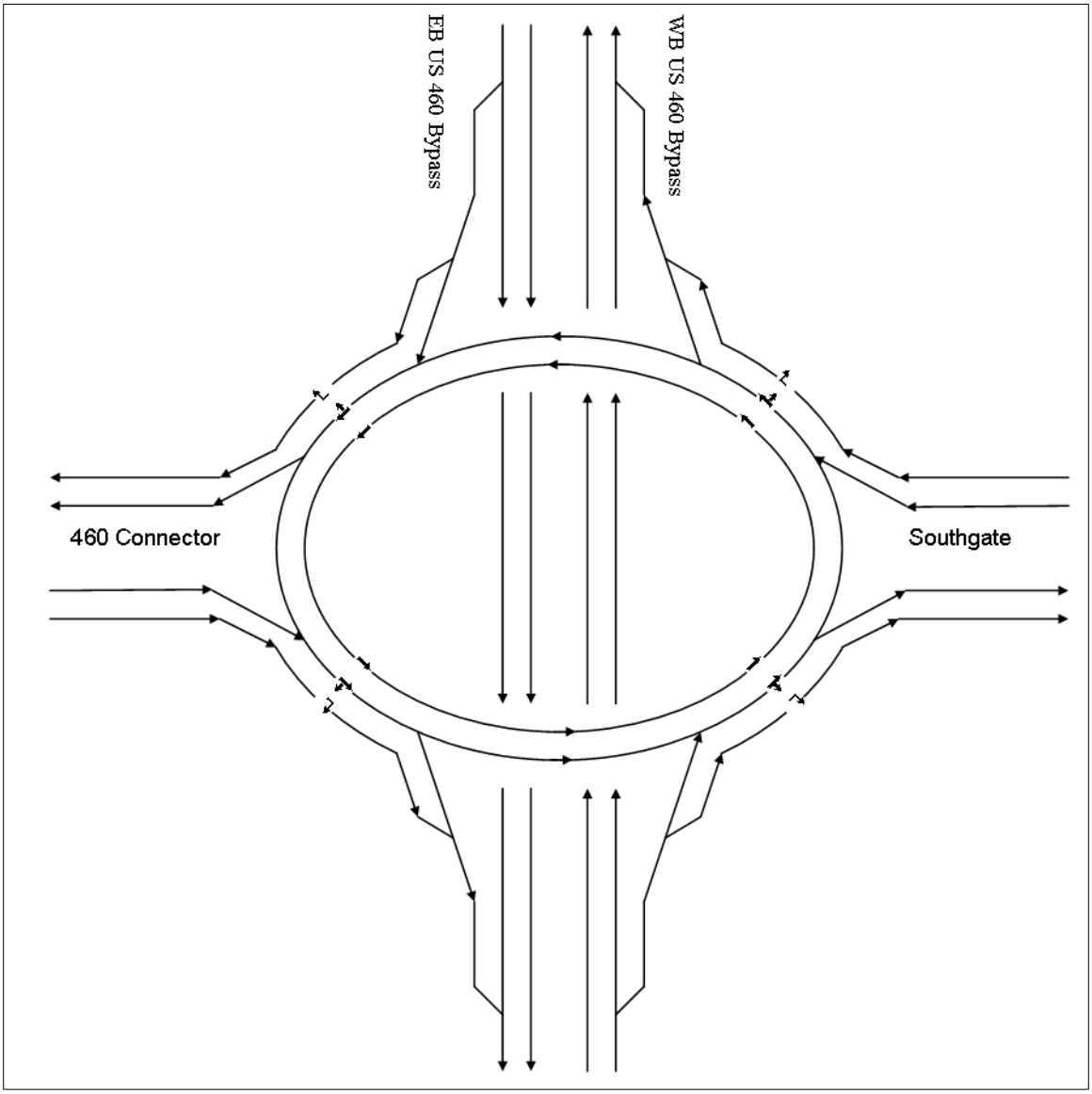
Exhibit 16
Schematic for Alternative 2: Diverging Diamond Interchange



Alternative 3: Rotary Interchange

This alternative is a large oblong driving circle which provides access between the freeway and cross street without the use of any traffic signals; thereby allowing for free-flowing movements inside the rotary. As with the standard diamond and diverging diamond interchanges, there are single ramps from and to each direction of the US Route 460 Bypass. A lane diagram schematic is included in Exhibit 17.

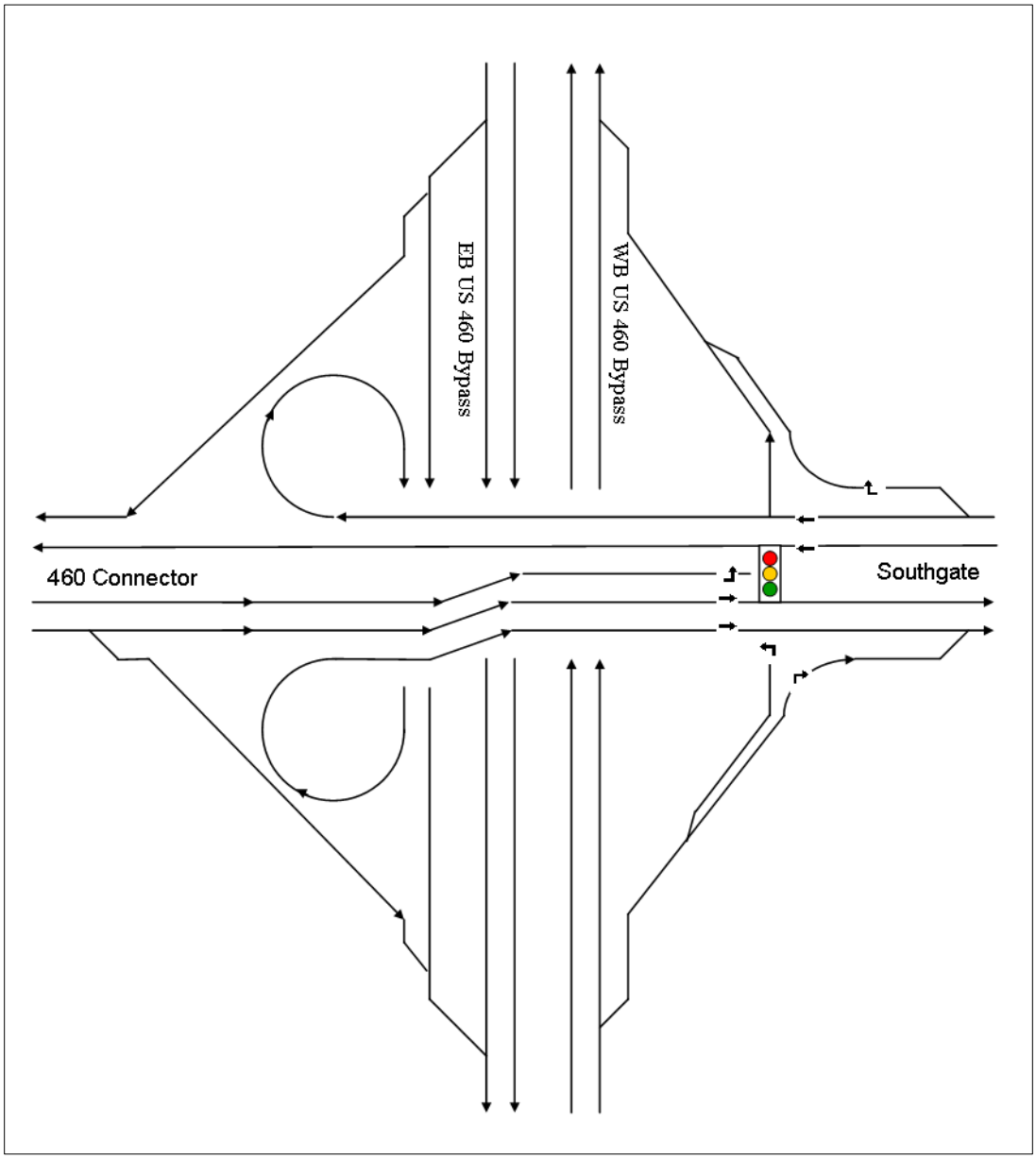
Exhibit 17
Schematic for Alternative 3: Rotary Interchange



Alternative 4: Partial Cloverleaf Interchange

This alternative is a combination of standard diamond interchange and a cloverleaf interchange. The concept provides unsignalized access to and from eastbound US Route 460 Bypass, along with a signalized treatment and a smaller footprint for ramps associated with WB US Route 460 Bypass. There are single ramps from and to the westbound US Route 460 Bypass, but multiple access points onto eastbound US Route 460 Bypass would need to be addressed with a collector-distributor road. A lane diagram schematic is included in Exhibit 18.

Exhibit 18
Schematic for Alternative 4: Partial Cloverleaf Interchange



Section 6: Comparison of Alternatives

The four interchange alternatives were compared based on operations, safety, cost, right-of-way requirements, and an overview of potential environmental impacts. They were also reviewed with the general public and stakeholders at a public meeting held on April 29, 2010.

Operations

The operations of the four interchange concepts were analyzed using two traffic engineering software packages – VISSIM and Highway Capacity Software (HCS). VISSIM was used to model the study area with each different scenario, allowing for a visual check of operations and collection of quantitative statistics. Additionally, the micro-simulation performed with VISSIM allows for estimations of measures of effectiveness (MOEs) such as travel time. Travel time was chosen as a desired MOE because the variations in the interchange options preclude a single level of service (LOS) indicator being uniformly compared across alternatives. Travel time, as estimated by the VISSIM simulation was found for all movements at the interchange, measured from the same points upstream and downstream of the interchange in each scenario. For the basic freeway components such as basic segments and ramps, Highway Capacity Software (HCS) was used to determine the level of service.

The future No-Build scenario analysis was performed with traffic forecasts that assumed no new roadway connections and with the existing connection where Southgate Drive currently intersects US Route 460 Bypass. Beyond the immediate vicinity of Southgate Drive, improvements were assumed at adjacent locations for all of the alternatives, including the No-Build, in order to reflect improvements that would be needed. This ensured that the alternatives were being tested with networks that did not constrain traffic with upstream or downstream bottlenecks. The improvements implemented in the VISSIM simulation model were as follows:

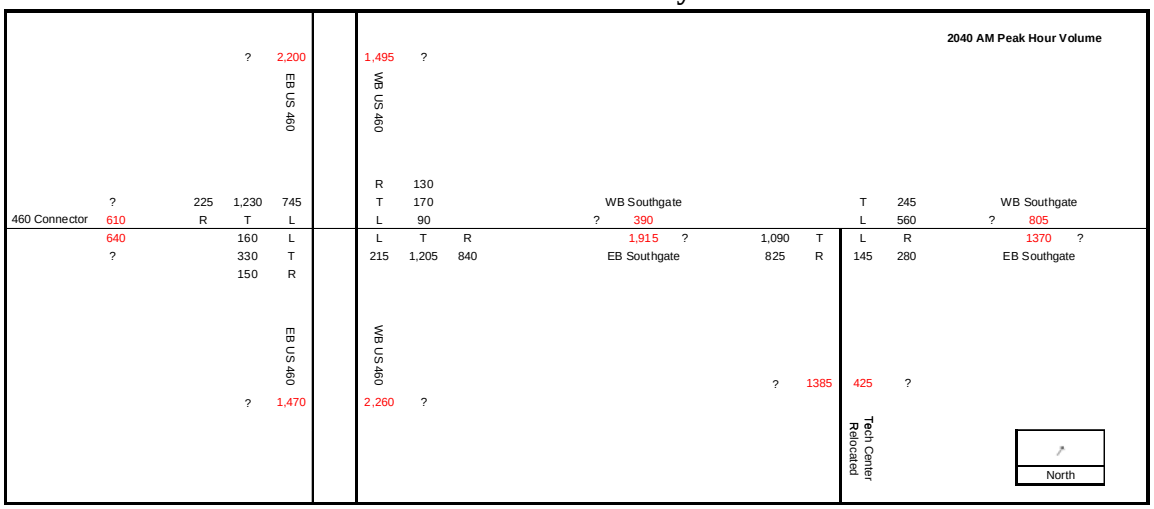
- Prices Fork Road interchange: Signalization of Prices Fork Road at the junction of the eastbound US Route 460 Bypass exit ramp and the westbound US Route 460 Bypass entrance ramp.
- Duck Pond Road and Southgate Drive intersection: Addition of a free-right-turn ramp for southbound Duck Pond Road; a widened approach for eastbound Southgate Drive with double exclusive-left-turn bays and single through lane; a merge (accepting) lane for the westbound Southgate Drive free-right-turns; and turn bays for free-right turns.
- Spring Street/Tech Center Drive and Southgate Drive intersection: Addition of right-turn bays for all approaches and double-left-turn bays for westbound Southgate Drive and northbound Tech Center Drive (double left-turn bays apply only to scenario where Tech Center Drive is not relocated, i.e. the No Build).
- Southgate Drive: Widened to four lanes between Duck Pond Road and the US Route 460 Bypass with Tech Center Drive Relocated, or, widen to four lanes

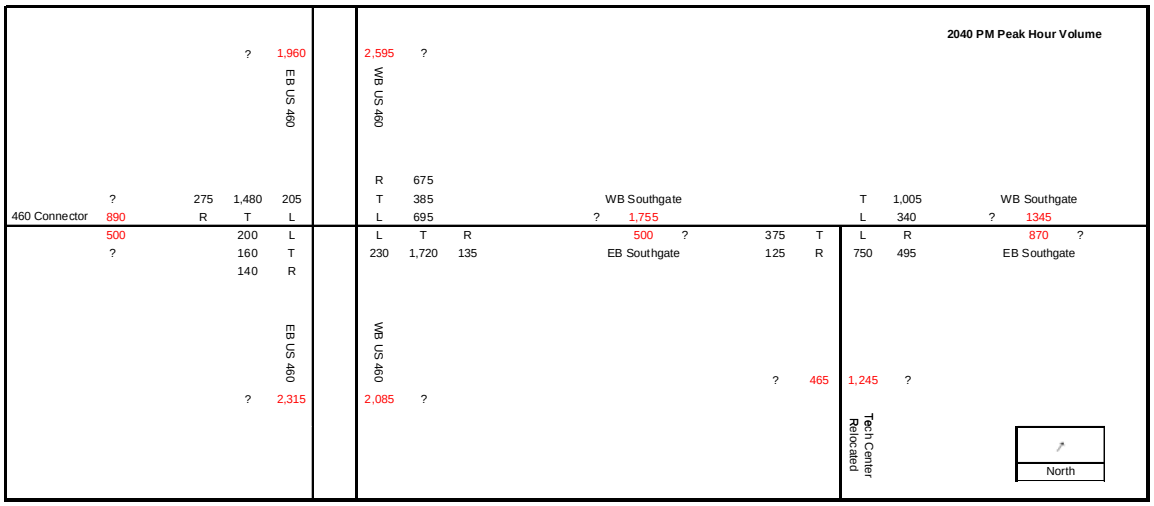
between Spring Street/Tech Center Drive and US Route 460 Bypass if Tech Center Drive is not relocated (i.e. the No Build)

Future build scenarios were modeled with the full forecasted traffic which assumed roadway improvements such as the Route 460 Connector. Each interchange scenario was modeled separately, and in each scenario, the improvements to the roadway network away from the interchange, as mentioned above, were also included. Because these alternatives also included the relocation of Southgate Drive, the traffic volumes used for the build scenarios included a reassignment of traffic that is reflected in the diagrams in Exhibit 19.

Exhibit 19

Traffic Volumes for Year 2040 Analysis of Build Alternatives





Exhibits 20 through 23 on the following pages provide a summary of the features, advantages, and disadvantages of each of the alternatives.

From an operations standpoint, selection of a single preferred alternative was based on measures that could be compared consistently among the alternatives – specifically travel time and queue. Since the alternatives have various signals and directional ramps, a single LOS criterion from the Highway Capacity Manual would not be sufficient for comparisons. Travel time and queue estimates were derived from a VISSIM model of each alternative.

Travel time through the interchange was estimated from points 2,500 feet away from the center of the interchange along the US Route 460 Bypass, and 1,000 feet from the center of the interchange along the Route 460 Connector and Southgate Drive. The travel time results, shown in Exhibits 20 through 23, are the average of five simulation runs for each peak hour. For most movements, the diverging diamond interchange alternative results in travel times that are on par or less than with other alternatives. The other alternatives vary in terms of which results in the next-shortest travel times for each movement, with movements that go through multiple signals, non-dominant movements, and longer routes (such as loop ramps on the partial cloverleaf) tending to have higher travel times.

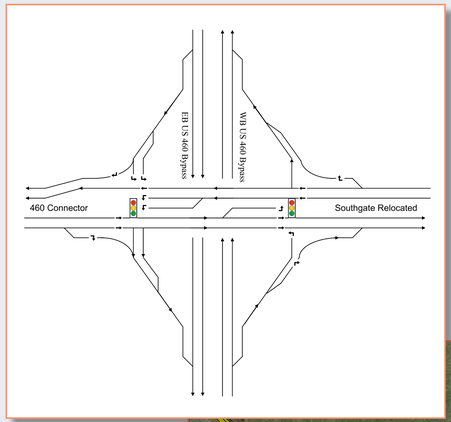
In general, each of the alternatives provides adequate overall service levels. As noted above, the alternatives serve the various movements with differing effectiveness. Overall, the diverging diamond provides the least amount of total travel time for all vehicles, largely because it serves two of the heaviest movements (the eastbound US Route 460 Bypass to easbound/northbound Southgate Drive, and the opposing westbound/southbound Southgate Drive to westbound US Route 460 Bypass) most effectively and with the least amount of delay.

Queues for the interchange options were evaluated primarily to determine what effects, if any, the interchanges may have on the free-flow operations of the US Route 460 Bypass. As long as queues do not reach the gore area of the US Route 460 Bypass, then the freeway will not generally be negatively affected. Additionally, shorter overall queues are correlated with less congestion and waiting through the interchange. Exhibit 24 shows the maximum queue on the approaches to the interchange coming from the freeway exits, as estimated from the VISSIM model runs. Because the geometrics of the interchange ramps change across the alternatives, an estimate of how far the back of the longest queue gets to the US Route 460 Bypass gore area is also provided in Exhibit 24.

The queue estimates show that for all scenarios, the back of the queue does not reach the US Route 460 Bypass. As a result, under the forecasted conditions, the proposed interchange at Southgate Drive and the US Route 460 Bypass will not adversely affect freeway operations. However, some lengthy queues do develop, particularly with the rotary interchange during the morning peak. Of the alternatives, the diverging diamond produces some of the shortest overall queues in comparison to the other scenarios.

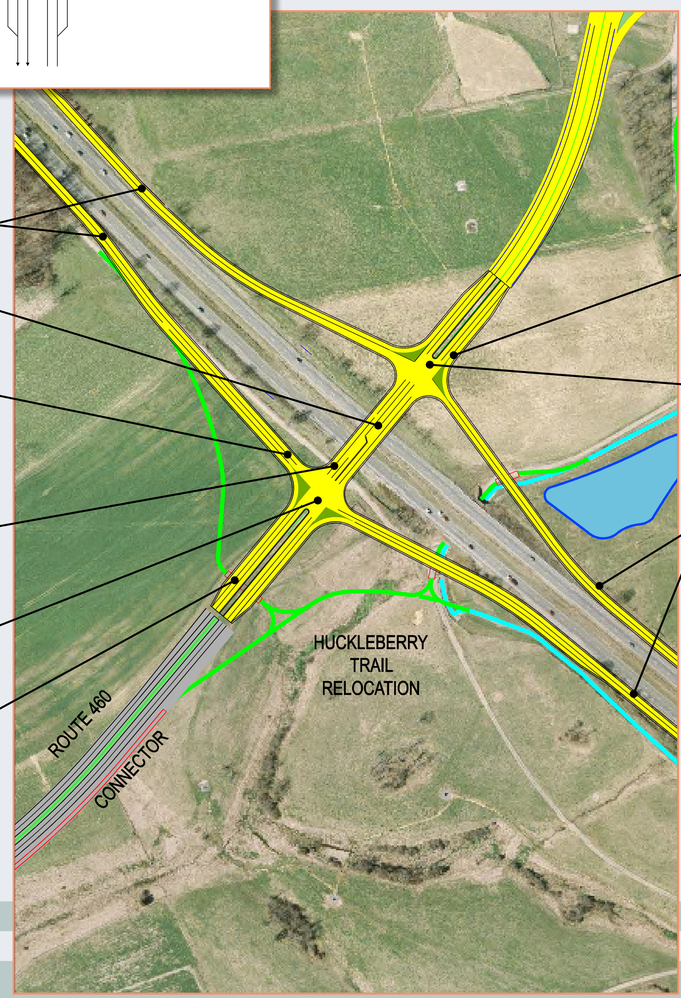
STANDARD DIAMOND INTERCHANGE

ALTERNATIVE 1



Features

- Signalized intersections would be located on both the west and east sides of diamond.
- The bridge over Route 460 Bypass would be five lanes.



Ramps taper to single lane at junction with 460 Bypass

Five lane bridge

Two left turn lanes from eastbound 460 Bypass exit to accommodate morning traffic

Two left turn lanes on southwest-bound Southgate to accommodate evening traffic

Signalized intersection LOS: C/C

Merge section to accommodate free right turn traffic from eastbound 460 Bypass

Merge section required to accommodate free right-turn traffic from westbound 460 Bypass

Signalized intersection LOS: B/B

Ramps taper to single lane at junction with 460 Bypass

Advantages

- This represents a traditional configuration, easily recognized and navigated by drivers.
- The relatively low volume of traffic going through the interchange between relocated Southgate Drive and the Route 460 Connector allows for the majority of signal time in the a.m. peak to be given to the eastbound Route 460 Bypass exit approach which is a heavy left turn movement (725 vehicles).

Disadvantages

- Increased demand beyond that which is forecasted for going through the interchange between relocated Southgate Drive and the Route 460 Connector could result in over-capacity conditions since the signal's operation assumes a large proportion of green time is given to the movement cited above (the left turn from eastbound Route 460 Bypass to Southgate Drive Relocated in the a.m. peak).
- The heavy Southgate Drive Relocated to eastbound Route 460 Bypass movement in p.m. peak requires double left turn lanes, forcing the through movement to the Route 460 Connector to either a single lane or a shared left-through lane plus a dedicated through lane.
- Traffic from westbound Route 460 Bypass going right onto Southgate Drive Relocated should be a free-flow movement in order to avoid potentially long delays that would occur if this traffic needed to go through the traffic signal.
- A minimum of five lanes would be required on the bridge.

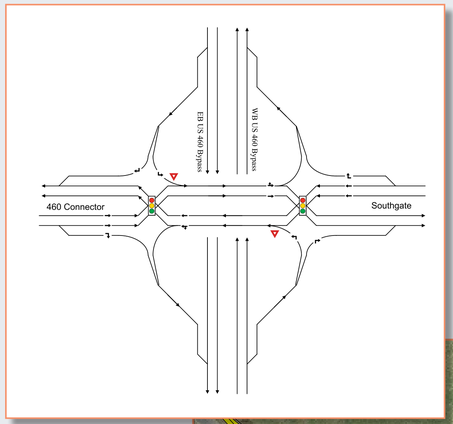
Level of Service (based on Synchro analysis of the two signalized intersections):

- LOS on the western intersection (eastbound Route 460 Bypass exit/entrance) – AM: C, PM: C
- LOS on the eastern intersection (westbound Route 460 Bypass exit/entrance) – AM: B, PM: B

MOVEMENT														
	EB 460 Connector to WB US 460 Bypass	EB 460 Connector to EB Southgate	EB 460 Connector to EB US 460 Bypass	EB US 460 Bypass to EB Southgate	EB US 460 Bypass to EB US 460 Bypass	EB US 460 Bypass to WB 460 Connector	WB Southgate to EB US 460 Bypass	WB Southgate to WB 460 Connector	WB Southgate to WB US 460 Bypass	WB US 460 Bypass to WB 460 Connector	WB US 460 Bypass to WB US 460 Bypass	WB US 460 Bypass to EB Southgate	Average All Vehicles	Average of all movements except through movements on the US 460 Bypass
TRAVEL TIME														
ALTERNATIVE 1 STANDARD DIAMOND	138 / 128	67 / 78	48 / 53	105 / 111	59 / 59	51 / 49	158 / 123	67 / 75	51 / 61	124 / 117	58 / 59	55 / 52	70 / 73	80 / 87
ALTERNATIVE 2 DIVERGING DIAMOND	86 / 78	62 / 86	48 / 49	83 / 80	59 / 59	50 / 48	96 / 78	66 / 58	49 / 51	87 / 85	58 / 59	51 / 48	63 / 62	66 / 65
ALTERNATIVE 3 ROTARY	80 / 80	52 / 52	52 / 53	84 /89	58 / 59	54 / 53	77 / 102	49 / 73	53 / 82	88 / 77	59 / 59	55 / 53	62 / 69	65 / 79
ALTERNATIVE 4 PARTIAL CLOVERLEAF	89 / 80	46 / 52	53 / 53	97 / 90	59 / 59	51 / 42	109 / 102	62 / 73	51 / 70	88 / 77	58 / 59	55 / 53	65 / 68	70 / 76

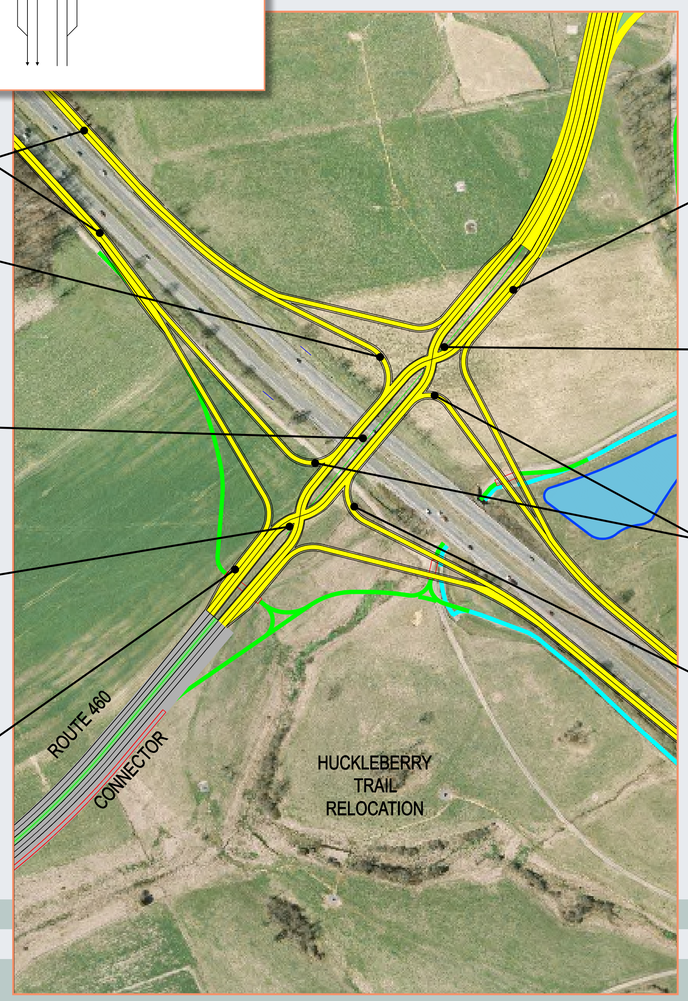
DIVERGING DIAMOND INTERCHANGE

ALTERNATIVE 2



Features

- Provides a significant capacity improvement as compared to standard diamond interchanges because traffic crosses landside (narrowing bridge structure requirements) and traffic turning left onto ramps does not have to stop for oncoming traffic.
- Through movements criss-cross at signals, meaning traffic appears to be driving on the left hand side while crossing the bridge.
- With traffic on the left-hand side, left turns from exit ramps are made through a yield sign in to the traffic stream, (and, as noted above, left turns to Route 460 Bypass entrances have no conflicts).
- Bridge can be four lanes.



Ramps taper to single lane at junction with 460 Bypass

Left-turning traffic destined for westbound 460 Bypass performs turn from left side of bridge, and therefore without conflict

Four lane bridge with traffic driving on the left-hand side

Signalized intersection allowing traffic to cross over to opposite side of the road LOS: A/B

Merge section to accommodate free right turn traffic from eastbound 460 Bypass

Merge section required to accommodate free right-turn traffic from westbound 460 Bypass

Signalized intersection allowing traffic to cross over to opposite side of the road. LOS: B/B

Yield-controlled ramps from 460 Bypass integrates traffic into flow on bridge

As with left-turns onto westbound 460 Bypass, left-turns onto the eastbound Bypass are made freely from the left-hand side of the bridge

Advantages

- Left turns are made without conflict, substantially reducing overall delay.
- Signals are provide only to allow traffic streams to criss-cross, therefore a simple two-phase signal plan is all that is required. This reduces overall delays and lost time.
- Turns from exit are yield controlled, keeping them away from the signals, which reduces delay and demand for other movements at the signal.

Disadvantages

- Drivers will be unfamiliar with concept (one of these is in place in the mid-west, multiple other state DOTs are considered and/or designing this type of interchange), and driving on the left-hand side may initially cause confusion.

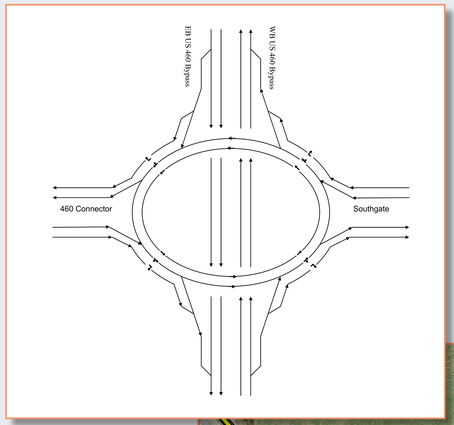
Level of Service (based on Synchro analysis of the two signalized intersections):

- LOS on the western intersection (eastbound traffic crosses to left-hand side prior to bridge) – AM: B, PM: A
- LOS on the eastern intersection (westbound traffic crosses to left-hand side prior to bridge) – AM: B, PM: B

MOVEMENT														
	EB 460 Connector to WB US 460 Bypass	EB 460 Connector to EB Southgate	EB 460 Connector to EB US 460 Bypass	EB US 460 Bypass to EB Southgate	EB US 460 Bypass to EB US 460 Bypass	EB US 460 Bypass to WB 460 Connector	WB Southgate to EB US 460 Bypass	WB Southgate to WB 460 Connector	WB Southgate to WB US 460 Bypass	WB US 460 Bypass to WB 460 Connector	WB US 460 Bypass to WB US 460 Bypass	WB US 460 Bypass to EB Southgate	Average All Vehicles	Average of all movements except through movements on the US 460 Bypass
TRAVEL TIME														
ALTERNATIVE 1 STANDARD DIAMOND	138 / 128	67 / 78	48 / 53	105 / 111	59 / 59	51 / 49	158 / 123	67 / 75	51 / 61	124 / 117	58 / 59	55 / 52	70 / 73	80 / 87
ALTERNATIVE 2 DIVERGING DIAMOND	86 / 78	62 / 86	48 / 49	83 / 80	59 / 59	50 / 48	96 / 78	66 / 58	49 / 51	87 / 85	58 / 59	51 / 48	63 / 62	66 / 65
ALTERNATIVE 3 ROTARY	80 / 80	52 / 52	52 / 53	84 /89	58 / 59	54 / 53	77 / 102	49 / 73	53 / 82	88 / 77	59 / 59	55 / 53	62 / 69	65 / 79
ALTERNATIVE 4 PARTIAL CLOVERLEAF	89 / 80	46 / 52	53 / 53	97 / 90	59 / 59	51 / 42	109 / 102	62 / 73	51 / 70	88 / 77	58 / 59	55 / 53	65 / 68	70 / 76

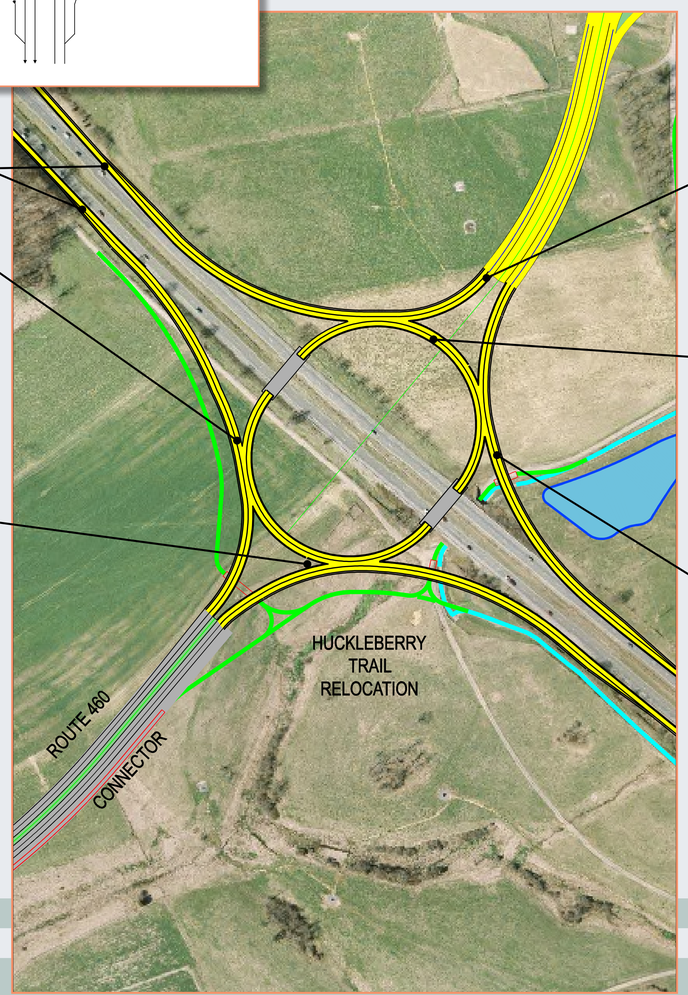
ROTARY INTERCHANGE

ALTERNATIVE 3



Features

- Two lane rotary interchange.
- Two lane access and egress points between interchange and US 460 ramps, Southgate Drive Relocated and the Route 460 Connector.
- Rotary is expanded to three lane segment in the four "corners" between an entrance and exit from rotary.



Ramps taper to single lane at junction with 460 Bypass

Unsignalized turns onto rotary from eastbound 460 Bypass exit

LOS: F/D

(Yield controlled, unsignalized analysis)

Unsignalized turns onto rotary from Route 460 Connector

LOS: E/F

(Yield controlled, unsignalized analysis)

Without control on rotary, evening peak period traffic will have difficulty accessing interchange from Southgate Drive

Unsignalized turns onto rotary from Southgate Drive

LOS: B/F

(Yield controlled, unsignalized analysis)

Unsignalized turns onto rotary from westbound 460 Bypass exit

LOS: C/B

(Yield controlled, unsignalized analysis)

Advantages

- Constant movement of traffic in interchange under uncongested conditions
- Without traffic signals, there will be minimal delays for traffic accessing rotary, assuming interchange is not congested.
- Movement from westbound Route 460 Bypass to eastbound Southgate Drive Relocated only has to use one quadrant of interchange (forecasted to be a heavy a.m. peak movement in 2035).

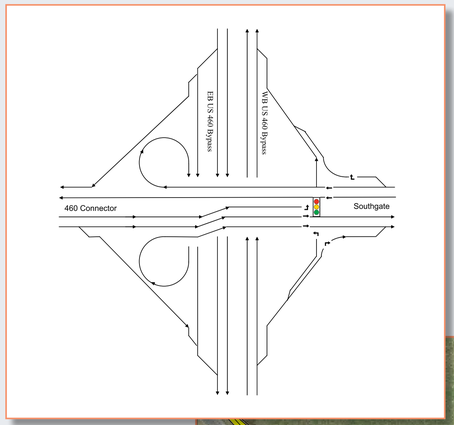
Disadvantages

- Heavy forecasted p.m. peak westbound Southgate Drive Relocated to eastbound Route 460 Bypass movement must navigate three-quarters of rotary, which will delay vehicles accessing the rotary from the eastbound Route 460 Bypass exit and from the Route 460 Connector.
- Two-lane rotary must be expanded to three-lane cross section in the "corners" to allow a right-turn only lane on the approaches to the interchange.
- The high number of conflict points in this design creates potential safety concerns, and lack of signals to stop traffic creates potential pedestrian and bicycle safety issues.
- Capacity of this configuration is based on spacing requirements (i.e., weaving distances in each quadrant of the rotary) – adding capacity in the future is severely limited by the fact that options for enlarging the radius of the rotary would be cost-prohibitive.

MOVEMENT														
	EB 460 Connector to WB US 460 Bypass	EB 460 Connector to EB Southgate	EB 460 Connector to EB US 460 Bypass	EB US 460 Bypass to EB Southgate	EB US 460 Bypass to EB US 460 Bypass	EB US 460 Bypass to WB 460 Connector	WB Southgate to EB US 460 Bypass	WB Southgate to WB 460 Connector	WB Southgate to WB US 460 Bypass	WB US 460 Bypass to WB 460 Connector	WB US 460 Bypass to WB US 460 Bypass	WB US 460 Bypass to EB Southgate	Average All Vehicles	Average of all movements except through movements on the US 460 Bypass
TRAVEL TIME														
ALTERNATIVE 1 STANDARD DIAMOND	138 / 128	67 / 78	48 / 53	105 / 111	59 / 59	51 / 49	158 / 123	67 / 75	51 / 61	124 / 117	58 / 59	55 / 52	70 / 73	80 / 87
ALTERNATIVE 2 DIVERGING DIAMOND	86 / 78	62 / 86	48 / 49	83 / 80	59 / 59	50 / 48	96 / 78	66 / 58	49 / 51	87 / 85	58 / 59	51 / 48	63 / 62	66 / 65
ALTERNATIVE 3 ROTARY	80 / 80	52 / 52	52 / 53	84 /89	58 / 59	54 / 53	77 / 102	49 / 73	53 / 82	88 / 77	59 / 59	55 / 53	62 / 69	65 / 79
ALTERNATIVE 4 PARTIAL CLOVERLEAF	89 / 80	46 / 52	53 / 53	97 / 90	59 / 59	51 / 42	109 / 102	62 / 73	51 / 70	88 / 77	58 / 59	55 / 53	65 / 68	70 / 76

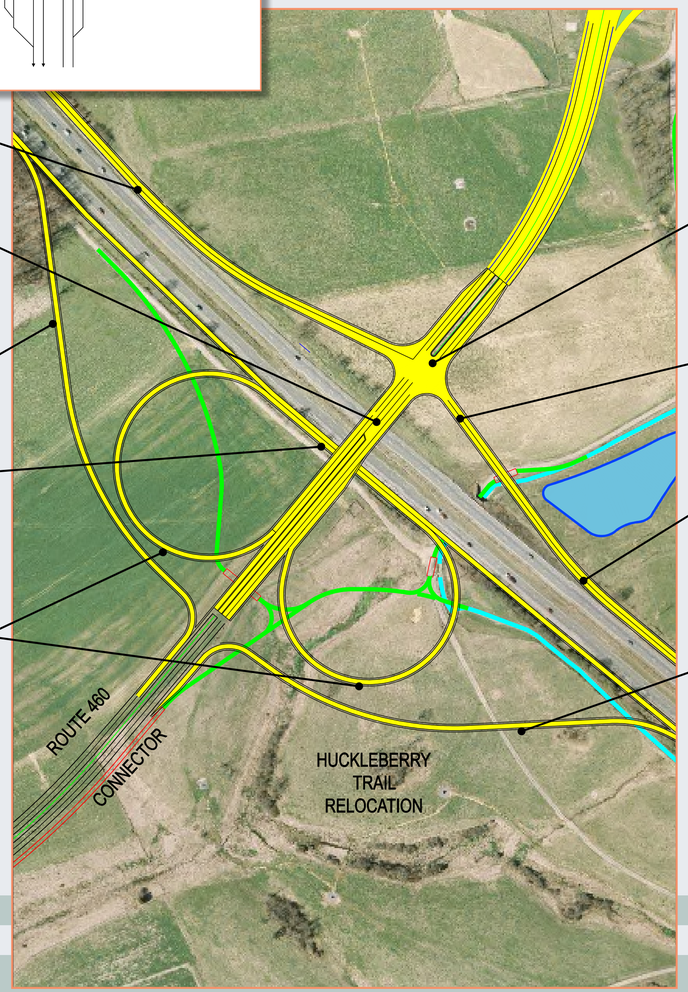
PARTIAL CLOVERLEAF INTERCHANGE

ALTERNATIVE 4



Features

- Collector-distributor type road for exits and entrances to eastbound Route 460 Bypass
- Loop ramps provide higher-capacity, uninterrupted flow for the heaviest forecasted traffic movements: westbound Southgate Drive Relocated to eastbound Route 460 Bypass, and eastbound Route 460 Bypass to eastbound Southgate Drive Relocated.
- Half diamond configuration for movements to and from westbound Route 460 Bypass.



Ramps taper to single lane at junction with 460 Bypass

Bridge requires 5 lanes of width to accommodate through and turning lanes

Single lane ramp for collector-distributor road from eastbound 460 Bypass

Weave section on eastbound 460 Bypass collector-distributor road

LOS: C/C

Loop ramps provide uninterrupted flow to and from collector-distributor road

Signalized intersection

LOS: C/C

Merge section required to accommodate free right-turn traffic from westbound 460 Bypass

Ramps taper to single lane at junction with 460 Bypass

Single lane ramp for collector-distributor road to eastbound 460 Bypass

- Single continuous lane provided westbound from Southgate Drive Relocated to the Route 460 Connector, which could be increased to two continuous lanes to allow for growth in traffic to the west. Two continuous lanes provided in the eastbound direction.

Advantages

- Heavy a.m. peak movement from eastbound Route 460 Bypass to eastbound Southgate Drive Relocated is accommodated on a loop ramp, allowing for less overall delay. Likewise, the heavy p.m. peak movement from westbound Southgate Drive Relocated to eastbound Route 460 Bypass is also performed via a loop ramp.
- Collector-distributor road keeps the weave between the loop ramps off eastbound Route 460 Bypass.

Disadvantages

- Signalization of east side of interchange is required to allow for left turns from the Route 460 Connector to the westbound Route 460 Bypass entrance ramp.
- Widening the Route 460 Bypass increases impacts and costs; allowing for sufficient spacing to ensure adequate weaving distances on the collector-distributor road may increase footprint and costs.

MOVEMENT														
	EB 460 Connector to WB US 460 Bypass	EB 460 Connector to EB Southgate	EB 460 Connector to EB US 460 Bypass	EB US 460 Bypass to EB Southgate	EB US 460 Bypass to EB US 460 Bypass	EB US 460 Bypass to WB 460 Connector	WB Southgate to EB US 460 Bypass	WB Southgate to WB 460 Connector	WB Southgate to WB US 460 Bypass	WB US 460 Bypass to WB 460 Connector	WB US 460 Bypass to WB US 460 Bypass	WB US 460 Bypass to EB Southgate	Average All Vehicles	Average of all movements except through movements on the US 460 Bypass
TRAVEL TIME														
ALTERNATIVE 1 STANDARD DIAMOND	138 / 128	67 / 78	48 / 53	105 / 111	59 / 59	51 / 49	158 / 123	67 / 75	51 / 61	124 / 117	58 / 59	55 / 52	70 / 73	80 / 87
ALTERNATIVE 2 DIVERGING DIAMOND	86 / 78	62 / 86	48 / 49	83 / 80	59 / 59	50 / 48	96 / 78	66 / 58	49 / 51	87 / 85	58 / 59	51 / 48	63 / 62	66 / 65
ALTERNATIVE 3 ROTARY	80 / 80	52 / 52	52 / 53	84 /89	58 / 59	54 / 53	77 / 102	49 / 73	53 / 82	88 / 77	59 / 59	55 / 53	62 / 69	65 / 79
ALTERNATIVE 4 PARTIAL CLOVERLEAF	89 / 80	46 / 52	53 / 53	97 / 90	59 / 59	51 / 42	109 / 102	62 / 73	51 / 70	88 / 77	58 / 59	55 / 53	65 / 68	70 / 76

Exhibit 24

Queue Lengths for 2040 Analysis of Build Alternatives

Alternative	Direction of exit ramp	Maximum queue (feet) due to interchange	Distance from back of maximum queue to gore area of exit ramp on US 460 Bypass
Standard Diamond	WB US 460	270 / 365	655 / 555
	EB US 460	405 / 190	505 / 725
Diverging Diamond	WB US 460	80 / 155	845 / 770
	EB US 460	270 / 160	620 / 730
Expanded Rotary	WB US 460	695 / 120	10 / 585
	EB US 460	640 / 210	75 / 510
Partial Cloverleaf	WB US 460	265 / 480	620 / 405
	EB US 460	0 / 0	1685 / 1685

Safety and Security

The intersection of US Route 460 Bypass and Southgate Drive is one of only two at-grade intersections on the 11-mile segment of the US Route 460 Bypass from Interstate 81 to its terminus at US Route 460 Business north of Blacksburg (the second at-grade intersection is at this northern terminus). While improvements have been and will continue to be made to ensure safety at this at-grade intersection, having a single at-grade intersection along a predominantly limited access roadway is not ideal in terms of safety. The intersection ranks sixth in the region in terms of number of crashes between 2006 and 2008. All of the alternatives, except for the No-Build, will substantially improve safety by providing a grade separation that will remove much of the conflict that occurs today with the at-grade intersection. As noted in Section 3, however, the diverging diamond in Alternative 2 has been shown to be one of the safest interchange configurations based on the fact that it spreads out the conflict points, provides better sight distance and shorter pedestrian crossings, and allows for the ability to incorporate traffic calming features. Any of the proposed interchanges would also substantially increase the capacity of the roadway system to evacuate the campus and immediate areas in the event of an emergency. The diverging diamond interchange provides an additional benefit in terms of evacuation because of its flexibility.

Cost

Preliminary comparative cost estimates for the four alternatives indicate that Alternative 3 would be the least costly at $17.6 million; and roughly comparable costs for the remaining three alternatives ($20.1 million for Alternatives 1 and 2, and $20.8 million for Alternative 4). These costs do not include rights-of-way.

Environmental Impacts

Each of the four alternatives would have a generally similar footprint, with the diverging diamond in Alternative 2 having the smallest footprint and the partial cloverleaf having the largest due to the loop ramps and the inclusion of a collector-distributor road.

Public Review and Input

A public meeting to review the alternatives and the supporting information on operations, safety, environmental features, and estimated costs was held on April 29, 2010. Approximately 20 persons attended the meeting. Input from the public was in the following general areas:

- General support for the construction of an interchange to alleviate traffic and safety concerns at and near the current at-grade intersection. Several comments noted that diverging diamond interchange did provide the least amount of motorist delay.
- Concern with respect to the impact of the interchange on Virginia Tech's agricultural research lands.
- Concern with respect to the effects of the interchange on potential traffic increases on Southgate Drive to and from residential areas near South Main Street. Conversely, some felt that there was potential for the new interchange to shift (and alleviate) some of the traffic currently using South Main Street (US Route 460 Business) onto US Route 460 Bypass.
- Concern that the diverging diamond interchange could be confusing to motorists.
- Concern about the effects of the interchange on the Huckleberry Trail, and support for the improvements to the trail that would be part of the interchange project.

Recommended Alternative

Based on public input, overall roadway operations, safety, flexibility, and small footprint, the diverging diamond (Alternative 2) is the recommended alternative of this study.

Following the selection of a recommended alternative, more detailed cost estimates were developed. As noted previously in this report, the cost estimates used for the alternatives comparison were based on generalized per-mile unit costs by roadway type. As long as this costing methodology is used consistently across all alternatives, this methodology provides a good basis for comparison. Additional costing detail is needed to advance a project in the VDOT project development process in the process to identify and secure funding. The refined cost estimates developed for the diverging diamond recommended alternative account for cost items at a greater level of detail and, in addition, include estimated costs for rights-of-way, design, and contingencies. These refined costs, shown in Exhibit 25, indicate that the total cost for the Southgate Drive diverging diamond interchange is $46.65 million.

Exhibit 25

Refined Breakdown of Estimated Costs for Recommended Alternative (Diverging Diamond Interchange)

Preliminary activities, earthwork, drainage, utility relocation	$6,782,470
Bridge structure, MSE walls	$3,040,000
Roadway	$3,999,893
Signing and marking, maintenance of traffic control measures, erosion control, roadside development	$1,719,357
Traffic and safety items	$950,000
Duck Pond Drive intersection	$2,000,000
Contingencies based on preliminary estimate	$5,547,516
Construction engineering	$4,438,013
Inflation factor (end of construction in 2016)	$3,417,270
Preliminary Engineering	$3,417,270
Environmental document (NEPA)	$120,000
Detailed Interchange Justification Report (enhancements to existing analysis)	$40,000
Permitting	$20,000
Rights-of-way	$11,162,000
Total Estimated Cost	**$46,653,789**

Comparison of the Recommended Alternative to the No-Build Alternative

For purposes of comparing the four build alternatives against each other, the analysis looked at an ultimate configuration that includes the long-term plan for constructing the Route 460 Connector west to join Prices Fork Road south of the Prices Fork community. It is also necessary to consider the effects of the interchange proposed in this study in the event that it is constructed prior to the Route 460 Connector. Additionally, while the diverging diamond of Alternative 2 was found to be the most desirable of the proposed alternatives, it must also demonstrate clear advantage over a No-Build Alternative.

Given the differences between the grade-separated diverging diamond interchange and the existing at-grade signalized intersection, travel-time was again considered to be an appropriate measure of effectiveness to compare the alternatives. The comparison is shown in Exhibit 25, highlighting that the diverging diamond would perform considerably better than the signalized intersection with much lower travel times. The primary issue with the signalized intersection is that all traffic on the US Route 460 Bypass, whether it is destined for Southgate Drive or beyond, must pass through the signal, and therefore must conflict with other movements. With a grade-separated interchange however, all through movements on the US Route 460 Bypass avoid any conflicts with other movements (aside from the merge and diverge sections of the on- and off-ramps), and therefore do not further delay the other movements. The at-grade intersection's traffic signal also restricts flow for through movements, resulting in a reduced capacity for through movements which consequently increases delay substantially.

If, as anticipated, the Route 460 Connector is not built when the new interchange is constructed, the diverging diamond interchange can be built as a three-leg interchange with the capability for expansion. As a three-leg interchange, only the eastern traffic signal need be activated, and the ramps from and to the eastbound lanes of the US Route 460 Bypass will act as directional ramps for the interchange. If and when the Route 460 Connector is constructed west of the interchange, the western traffic signal can be activated and the signage updated in order to allow for full operations of a four-leg interchange.

Exhibit 26

Comparison of Travel Times in 2040 Between the Preferred Alternative and the No-Build Alternative

				Travel Time (seconds)	
	From	To		No Build	Diverging Diamond (3 legs)
Movement	EB 460 Bypass	Southgate	↳	262 / 120	76 / 77
		EB 460 Bypass	↓	192 / 76	63 / 64
	Southgate	EB 460 Bypass	↱	131 / 170	78 / 80
		WB 460 Bypass	↰	82 / 121	49 / 55
	WB 460 Bypass	WB 460 Bypass	↑	259 / 161	66 / 73
		Southgate	↱	196 / 109	55 / 53
	Average for All Vehicles			221 / 130	64 / 68

Note: This table compares travel times through the US Route 460 Bypass/ Southgate Drive intersection with travel times through a three-leg US Route 460 Bypass/Southgate Drive diverging diamond interchange (does not include the Route 460 Connector leg).