

Frontier Drive Corridor Improvement Study

Final Corridor Plan



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Transportation
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HNTB

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Executive Summary

Study Purpose

Many undeveloped and low density sections along the Frontier Drive corridor are beginning to experience additional development, bringing greater traffic volumes. Higher density urbanized development is anticipated in the future, so existing traffic concerns are expected to grow. The purpose of this study was to determine what improvements are necessary to facilitate the movement of traffic, including automobile, pedestrian and bicycle, through the study area while minimizing impacts to existing private property. The approximate cost of such improvements was also estimated.

This was a preliminary planning study aimed at identifying potential future roadway improvements. Construction funding has not been secured, and much additional planning will be required before any project is built.

Study Steps

This study had the following tasks:

- Traffic forecast for potential new developments
- Traffic analysis if no roadway improvements are made
- Identify deficiencies and strategies for overcoming them
- Develop alternatives
- Evaluate alternatives, including traffic analysis
- Share study progress with stakeholders
- Document preferred corridor plan

Concept Development

Several alternative concepts were developed with planning staff from VDOT, Augusta County, and the City of Staunton. These concepts ranged from minor improvements to the existing roads to new roads on new alignments. These concepts were screened using criteria such as protection of conservation areas and cultural resources, resulting in three Alternatives for further study. The three Alternatives underwent further evaluation, examining elements such as construction cost, traffic operations, bicycle and pedestrian accommodation, and impacts to existing buildings and residential areas.

As a result of this evaluation, Alternative 1 was found to be cost prohibitive. Alternative 3, which would follow existing Frontier Drive more closely, would have great impacts to existing residential areas. Alternative 2 performs the best recognizing it still would have impacts on existing residential areas. With minor modifications, Alternative 2 is advanced as the preferred corridor plan. A qualitative evaluation matrix comparing alternatives is given in Table ES-1 and a graphic showing the recommended alternative is shown in Figure ES-1.

Table ES-1: Qualitative Evaluation Matrix

Evaluation Matrix	No Build	Alt 1	Alt 2	Alt 3
Environmental				
Cultural resources	○	○	○	○
Open space	○	○	○	○
Social justice	○	○	○	○
Engineering				
Construction cost	+	—	○	○
Intersection level of service	—	+	+	○
Corridor travel times	—	○	+/○	+
Bike / ped accommodation	—	+	+	+
Geometry	—	+/○	+/○	○
Social				
Support comp plan goals	—	+	+	○
Impact to structures	+	○	—	—
Impact to residential areas	—	+	○	—
Right-of-way needs	+	—	—	—

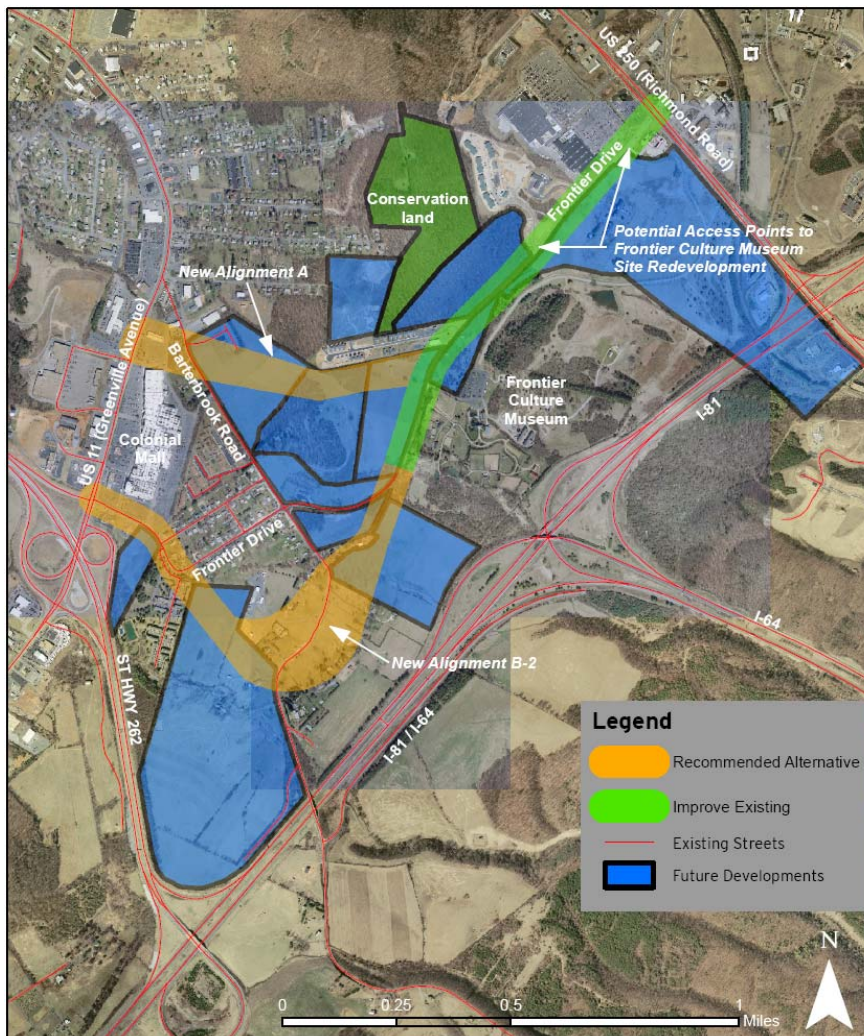
Evaluation Matrix Key:

⊕ = better than the other alternatives

○ = about the same as the other alternatives

— = worse than the other alternatives

Figure ES-1: Recommended Alternative



The roadway and right-of-way features shown on this map are conceptual and FOR TRANSPORTATION PLANNING PURPOSES ONLY and are not to be regarded as final locations. The actual location and detail of these improvements will be determined at the conclusions of NEPA studies and the preliminary engineering stage.

1. Introduction

1.1 Study Purpose

At approximately two miles in length, Frontier Drive is an important link between US 11 in Augusta County and US 250 in the City of Staunton. It serves important commercial developments in both jurisdictions, literally “linking” County and City commercial sectors, as well as rapidly expanding residential neighborhoods. A recent traffic study found that the intersection of Frontier Drive and US 250 operates at conditions approaching full saturation. This same study indicated inadequate storage lane lengths for the intersection of Frontier Drive and US 11. In the future, many undeveloped and low density sections along the Frontier Drive corridor are anticipated to grow into higher density urbanized development, adding to the existing traffic concerns. The purpose of this study is to create a future corridor plan that will facilitate the movement of traffic, including automobile, pedestrian, and bicycle, through the study area while minimizing impacts to existing private property and enhancing quality of life for local residents.

1.2 Overview of Report

This report includes a review of the study process. It contains summaries of the existing and future conditions, including the traffic forecast. It reviews the development and operational analysis of the proposed alternatives. A quantitative analysis follows, as well as a proposed access management plan for implementation with any of the alternatives. Finally, this report outlines a recommended corridor plan with details of the preferred alternative.

2. Existing Conditions

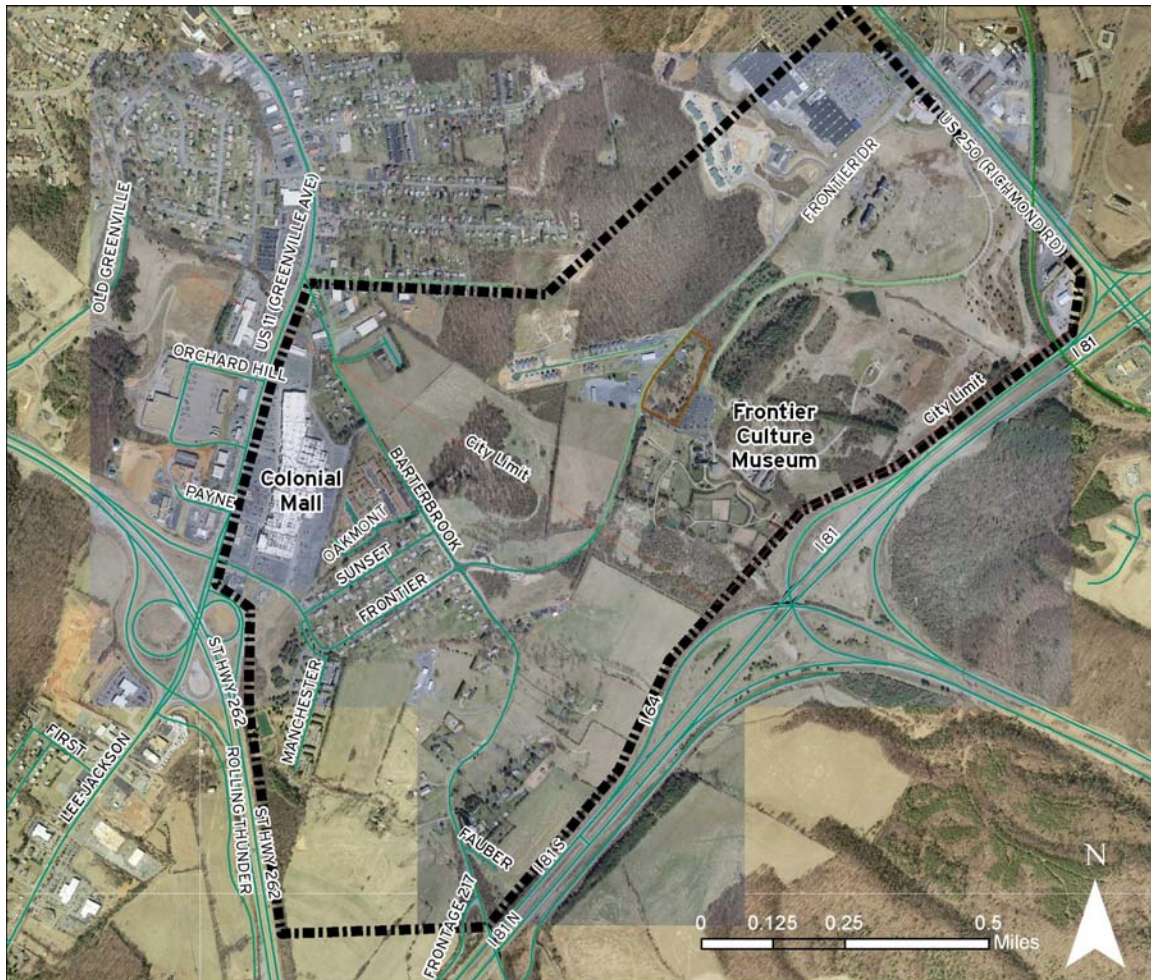
2.1 Network Configuration

The study area, shown in **Figure 1**, encompasses Frontier Drive between US 11 (Greenville Avenue) and US 250 (Richmond Road), and Barterbrook Road between US 11 and I-81. The study area includes portions of both the City of Staunton and Augusta County.

Within the study area, Frontier Drive has one travel lane in each direction and is approximately 24 feet wide. Frontier Drive has a rural typical cross section with open drainage and minimal shoulders for most of its length. A wider shoulder is found along the south side of Frontier Drive in the residential area west of Barterbrook Road. Short segments of curb-and-gutter section exist near US 11, US 250, and around Barterbrook Road. Barterbrook Road has one travel lane in each direction and is approximately 22 feet wide. Barterbrook Road also has a rural typical cross section with open drainage and no shoulders for most of its length. Short segments of curb-and-gutter section exist near US 11 and around Frontier Drive.

The intersection of Frontier Drive and Barterbrook Road was recently reconstructed to improve sight distance and upgrade the traffic signal. All approaches have exclusive left turn lanes, and the westbound approach also has an exclusive right turn lane. At US 11, Frontier Drive has an exclusive right turn lane and a shared through and left turn lane. At US 250, Frontier Drive has an exclusive left turn lane, an exclusive right turn lane, and two through lanes. At US 11, Barterbrook Road has one lane for all movements.

Figure 1: Study Area Boundary



2.2 Existing Traffic Operations

Turning movement counts and 48-hour volume counts taken in 2007 for this study were used to create AM and PM peak hour traffic models using Synchro 7 software. Signal timing plans were provided by VDOT and the City of Staunton. The existing intersection level of service was then evaluated for each of the intersections in the study area using the traffic models.

Level of service (LOS) is an estimate of the performance efficiency and quality of an intersection. The degree of delay at an intersection is measured using the letter rating “A”

for the least amount of congestion and the letter rating “F” for the most amount of congestion. The City of Staunton and Augusta County have judged that a LOS D or worse is unacceptable for the intersections in the study area. Figure 2 below depicts each of the level of service ratings.

Figure 2: Level of Service Designations

A	B	C	D	E	F
Free-Flow Operations	Reasonably Free-Flow	Stable Operations	Borderline Unstable	Extremely Unstable	Breakdown
					
Good			Fair	Poor	Very Poor
Speeds vary from free-flow speed to near free-flow speed. None to minimal restrictions in freedom to maneuver			Speed begins to decline with increasing flow Freedom to maneuver is more limited	Speeds reduce significantly and turbulence is felt by all drivers. Small changes in demand or disruptions can result in queues	Demands exceeds capacity. Breakdown conditions. Queues form behind breakdown points

The existing intersection levels of service are generally acceptable in the peak hours. However, the intersection of Frontier Drive and US 11 operates at an undesirable LOS D in the afternoon peak. Existing traffic volumes and existing LOS are shown in **Appendix A**.

3. Future Conditions

3.1 Traffic Forecast

Trip generation was calculated on the basis of anticipated land uses from comprehensive plans and proposed developments. Assumptions used in the trip generation calculations and locations of future development and/or redevelopment are detailed in the Existing Conditions and Traffic Forecast report, which is attached as an addendum to this report.

Forecast future trips were distributed to and from the four portals of the study area using the same distribution percentages currently observed. Morning and afternoon peak hours have different distributions. These are detailed in the Existing Conditions and Traffic Forecast report, which is attached as an addendum to this report.

Turning volumes were forecast at Frontier Drive and US 11, at Frontier Drive and US 250, and at Barterbrook Road and US 11 using the same turning percentages as measured during the turning movement counts. Turning volumes were forecast at Frontier Drive

and Barterbrook Road based on the trip distribution to and from the portals and the location of the anticipated development access to the roadway network.

Forecast turning volumes from anticipated development were then added to existing turning volumes. Based on professional judgment and on staff-level discussions with VDOT, Augusta County, and the City of Staunton, it has been assumed that background (existing) traffic will grow at a rate of 0.25% per year to 2035, the planning horizon year. Total forecast volumes are detailed in the Existing Conditions and Traffic Forecast report, which is attached as an addendum to this report.

3.2 No Build Condition

The No-Build condition is the future condition that will exist if land development occurs without corresponding road improvements. No roadway network improvements are currently planned for the study area. The No-Build intersection level of service was evaluated at the intersections where future turning movement volumes were assigned following the trip generation and distribution process. Signal timing plans were optimized for the future No-Build condition.

The No-Build intersection levels of service are generally unacceptable in the peak hours. In the AM peak hour, all intersections except those on US 11 have at least one approach that operates at LOS F. In the PM peak hour, all signalized intersections operate at LOS F and all unsignalized intersections have at least one approach that operates at LOS F. The LOS for No-Build traffic operations are shown in **Appendix B**.

4. Alternatives Development

4.1 Deficiencies

The first step in developing alternative improvements for the future is to identify existing deficiencies of the roadway network. The deficiencies of the Frontier Drive Corridor study area include:

- Poor existing LOS at the intersection of Frontier Drive & US 11
- Poor/failing future no-build LOS at many intersections
- Geometry on Frontier Drive (90-degree turn west of Barterbrook)
- Lack of shoulders on Frontier Drive
- Awkward angle/line of sight issues at intersection of Barterbrook Road & US 11
- Potential for multiple new access points
- History of crashes
- Adverse topography

These deficiencies will become more pronounced in the future as development advances in the corridor, if transportation system improvements are not made. The alternatives presented later in this section attempt to address as many of these deficiencies as possible.

4.2 Strategies

There are various strategies for overcoming deficiencies in the existing roadway network and future no-build conditions. Levels of service can be improved using a combination of minor and major enhancements of intersections and alignments, operational and regulatory changes, and access management. The following strategies were considered in the development of general solution concepts:

- Land Use Controls
 - Limit size of development
 - Limit density
 - Limit retail in favor of office and residential land uses
- Intersections
 - Signalize
 - Add lanes
 - Extend turn bays
 - Realignment
 - Alternative configuration (such as a roundabout)
- Alignments
 - Existing alignment with minor fixes and widening
 - Largely new alignment
 - Multiple parallel routes
- Operational Changes
 - Signal timing
 - Speed limit
 - Lighting
 - Traffic calming
- Access Management
 - Limit number and spacing of driveways
 - Require interparcel access
 - Use frontage or backage roads
 - Set minimum driveway offsets to intersections
 - Build cross streets to handle access points

4.3 Screening Criteria

The alternatives developed for this study were evaluated with a unique set of criteria designed to support the goals of the stakeholders. These criteria include environmental, engineering, and social considerations. In the City of Staunton, for example, there are several conservation areas and cultural resources that must be maintained regardless of future development. These environmental criteria provide a basis for initial screening of preliminary concepts, thus they are categorized as Tier 1 criteria. The engineering and social criteria in Tier 2 are more quantitative and require more fully developed alternatives to analyze, so they were primarily used later in the formal evaluation process.

Tier 2 criteria include cost and traffic operations, as well as impacts to existing residential areas.

Tier 1

- Environmental
 - Cultural resource impacts
 - Open space / conservation area impacts
 - Social justice

Tier 2

- Engineering
 - Construction cost
 - Traffic operations (intersection level of service, corridor travel times)
 - Multimodal (accommodation of pedestrians and bicycles, particularly through intersections)
 - Geometry (ability to accommodate desired intersection spacing)
- Social
 - Supports development goals of comprehensive plans
 - Impact to structures
 - Impact to existing residential areas
 - Right-of-way (acreage)

4.4 Preliminary Concepts

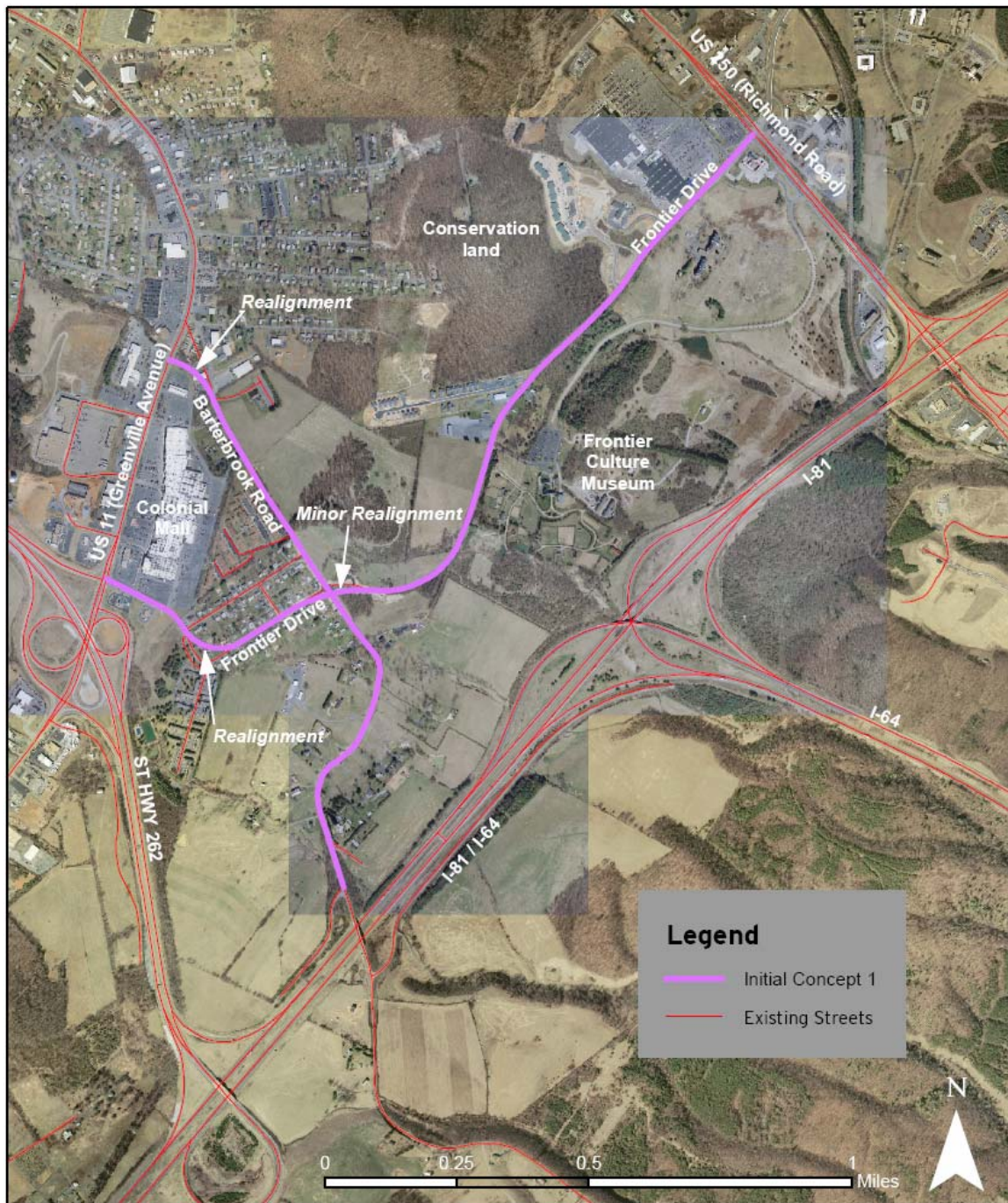
Three initial concepts that addressed deficiencies of the existing roadway network were developed. The first initial concept, which focused on minor improvements to the existing alignment, is shown in **Figure 3**. In this concept, the intersection of Frontier Drive and Barterbrook Road would be flattened out, straightening the alignment and creating a longer line of sight for the southwest-bound approach. The 90-degree turn on Frontier Drive between Barterbrook Road and US 11 would be replaced by a flatter curve, and the northwest-bound approach at the intersection of Barterbrook Road and US 11 would be realigned to the south to straighten the alignment and create a longer line of sight.

The second initial concept, which depicted a largely new alignment, is shown in **Figure 4**. This concept would include a new roadway between Frontier Drive (just south of Red Oak Drive) and US 11 (across from Orchard Hill Circle, north of the mall). This new alignment would direct the majority of traffic using Frontier Drive to get to US 11 away from the residential areas and poor geometry of Frontier Drive west of Barterbrook Road. This alignment would be supported by modifications to several of the existing

intersections which would further hinder drivers from using the residential section of Frontier Drive as a thoroughfare.

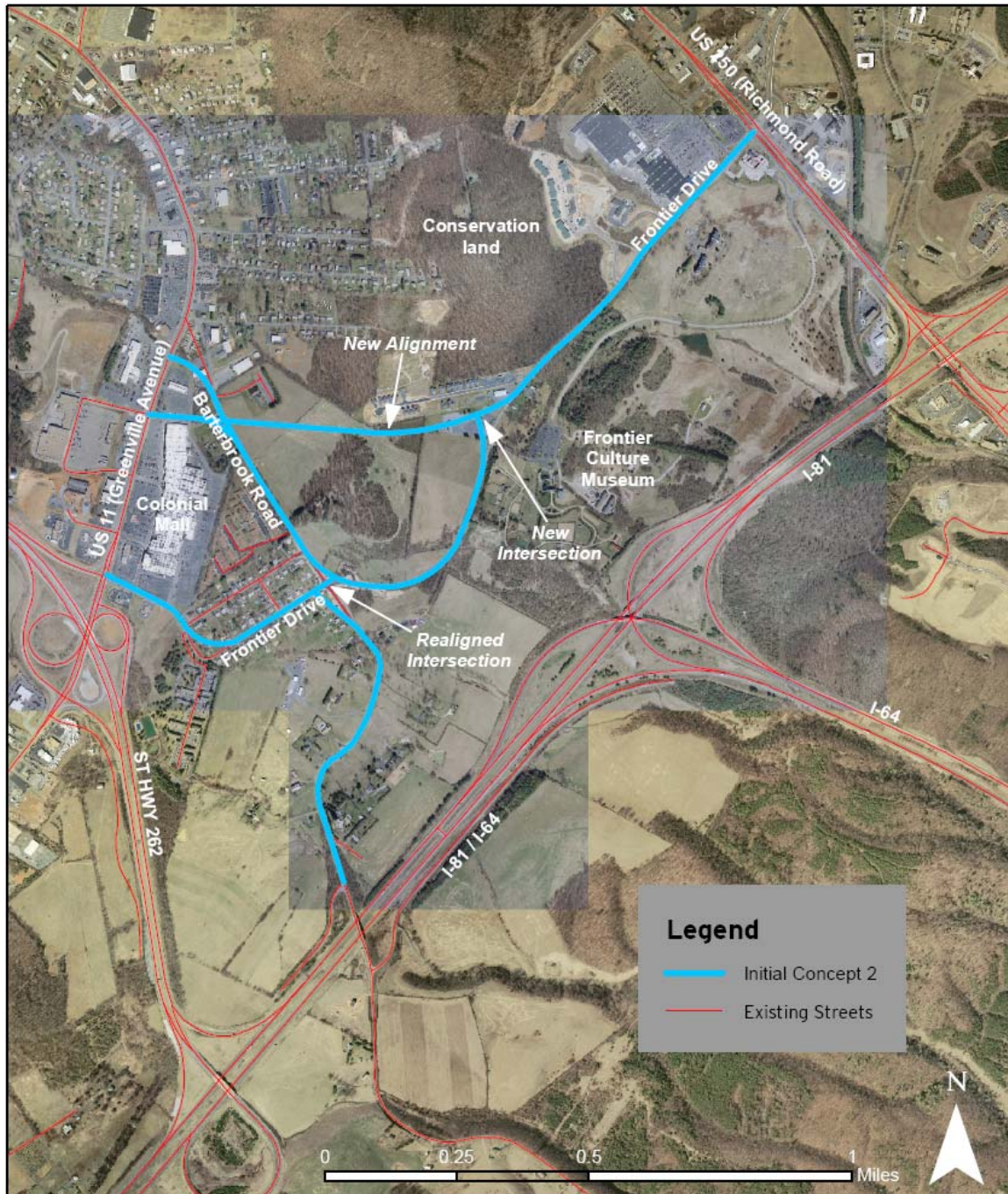
The third initial concept, shown in **Figure 5**, depicted parallel routes that could be added within the study area to ease forecast congestion on the existing roads. These new alignments would include a roadway that would run southeast of the Frontier Culture Museum between US 250 and Barterbrook Road, an extension of this new roadway from Barterbrook Road through the potential residential development site that would tie in at the 90-degree turn on Frontier Drive, and some access roadways to the potential residential development site from Frontier Drive. This concept also would include an extension of Red Oak Drive west to Barterbrook Road and through to US 11, as well as an extension of Betsy Bell Road east to US 250.

Figure 3: Initial Concept 1 – Minor Improvements



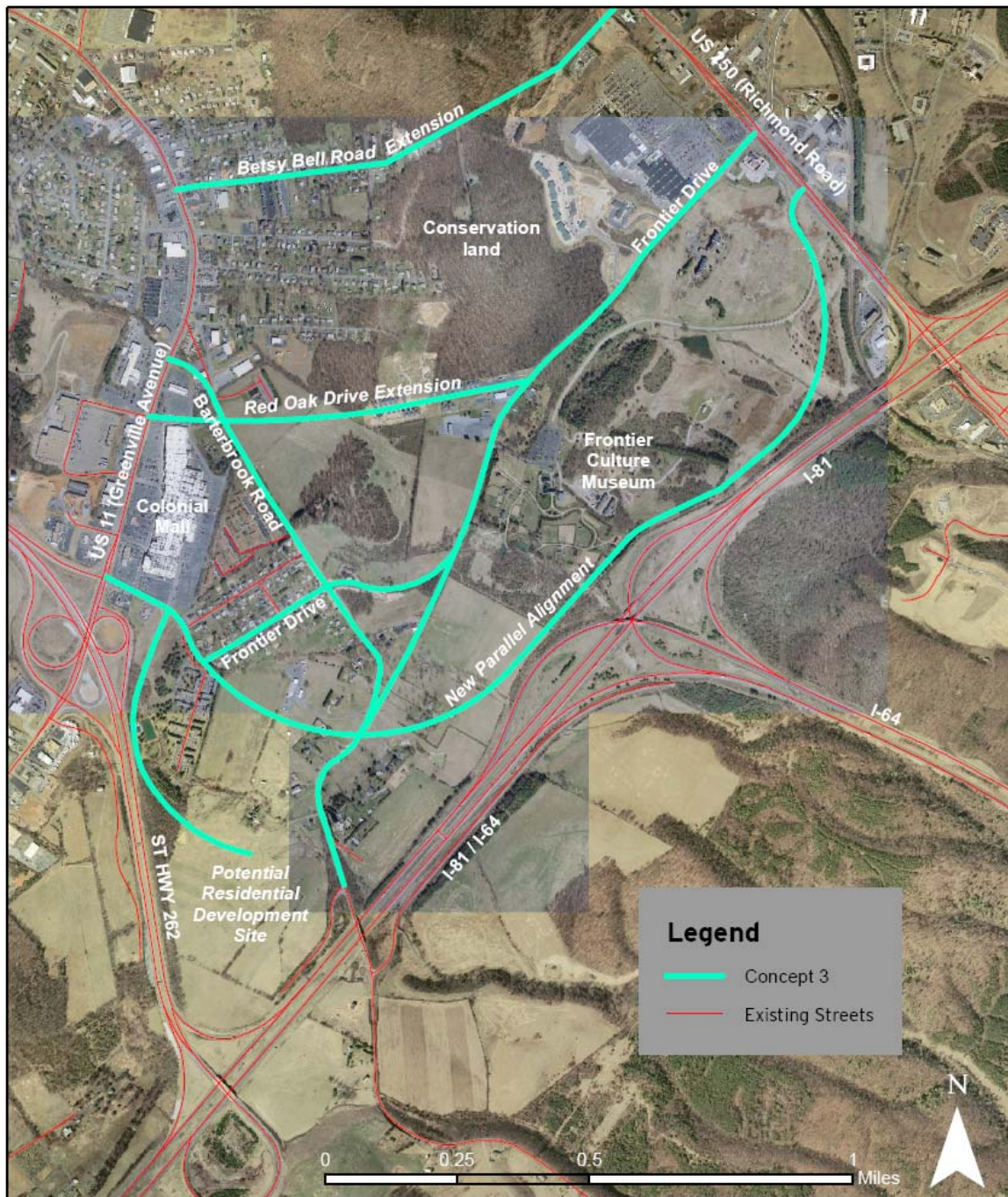
The roadway and right-of-way features shown on this map are conceptual and FOR TRANSPORTATION PLANNING PURPOSES ONLY and are not to be regarded as final locations. The actual location and detail of these improvements will be determined at the conclusions of NEPA studies and the preliminary engineering stage.

Figure 4: Initial Concept 2 – New Alignment



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Figure 5: Initial Concept 3 – Parallel Routes



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4.4.1 Initial Screening

A workshop was held with stakeholders to review the deficiencies, strategies, and initial concepts for the Frontier Drive corridor. Stakeholders from VDOT, Augusta County, and the City of Staunton applied screening criteria described under Tier 1 listed above,

which are impacts to cultural resources, impacts to conservation and open space areas, and social justice impacts.

4.4.1.1 *Minor improvements concept*

The minor improvements concept had no identified impacts to cultural resources or to open spaces. There would likely be impacts to the existing residential neighborhood west of Barterbrook Road due to widening, realignment, and additional traffic volume. Elements of the minor improvements concept were favored by the team for advancement, particularly following the general existing alignment of Frontier Drive as a lower-cost solution.

4.4.1.2 *New alignments concept*

As **Table 1** indicates, the new alignments concept had no identified impacts to cultural resources or to open spaces. There would potentially be minor impacts to the existing residential neighborhood west of Barterbrook Road due to realignment of Frontier Drive. Elements of the new alignments concept were favored by the team for advancement, particularly a new road connecting Frontier Drive to US 11 parallel to Red Oak Drive.

4.4.1.3 *Parallel routes concept*

The parallel routes concept would impact cultural resources: the route along the Frontier Culture Museum property would impact an historic structure. This concept would also impact open spaces: the Betsy Bell Road extension would traverse a conservation area. In addition, the Red Oak Drive extension would impact an existing residential neighborhood by increasing traffic volumes. Many specific elements of this concept were not favored for advancement by the team. However, the idea of a parallel route bypassing the existing residential neighborhood west of Barterbrook Road was met with favor among stakeholders, particularly the idea of improving connections to the potential residential development in Augusta County.

Table 1: Initial Screening Summary

Concept	Cultural Resources	Open Space	Social Justice
1 – Minor improvements	No impacts identified	No impacts identified	Impacts to existing neighborhood
2 – New alignments	No impacts identified	No impacts identified	Potential minor impacts to existing neighborhood
3 – Parallel routes	Alignment along Frontier Culture Museum property impacts historic structure	Betsy Bell Rd extension traverses conservation area	Red Oak Dr extension impacts existing neighborhood by increasing traffic volumes

4.5 Alternatives

As a result of the workshop and subsequent discussions, the stakeholder team crafted three alternatives to be carried forward. Alternatives 1, 2, and 3 are shown in **Figure 6**, **Figure 7**, and **Figure 8**. The new alignments are depicted with wide lines to represent a general area in which the new roadway could lay. A more specific, final alignment would be determined in a future study, after a closer evaluation of social and environmental impacts is undertaken.

4.5.1 Alternative 1

Alternative 1 would include a new connection between Frontier Drive (northeast of Barterbrook Road and southwest of Red Oak Drive) and US 11 (approximately across from Orchard Hill Circle, north of the mall). This segment is called New Alignment A.

Alternative 1 also would include a southwest alignment intended to remove new traffic from Frontier Drive between Barterbrook Road and US 11 and relieve congestion at those intersections. The alignment would start on Frontier Drive southwest of Red Oak Drive and would cross Barterbrook Road south of Frontier Drive, would go through the potential residential development, and would be grade-separated over Route 262. It would merge with Rolling Thunder Lane and would connect to US 11 south of the interchange with Route 262. This segment is called New Alignment B-1.

Finally, Alternative 1 would include a loop road through the future developed portion of the Frontier Culture Museum site. This loop road would provide three points of access for traffic accessing this site – one on US 250 (outside the present study area) and two on Frontier Drive. One of the Frontier Drive driveways would be located at or near the existing Sheetz driveway, across from a relocated Lowe's entrance. The other driveway would be located approximately 400 yards to the south, across from the Frontier Ridge apartment complex entrance on Frontier Ridge Court. The purpose of this alignment is to facilitate improved access to the Frontier Culture Museum redevelopment area while mitigating traffic impacts to Frontier Drive at US 250. This segment is called New Alignment C.

4.5.2 Alternative 2

Alternative 2 is similar in concept to Alternative 1. It would include both New Alignment A and New Alignment C exactly as they are described for Alternative 1. The main difference between the alternatives is the new southwest alignment.

In Alternative 2, the southwest alignment is intended to remove new traffic from the intersection of Frontier Drive and Barterbrook Road and the nearby residential areas. This alignment would start at Frontier Drive southwest of Red Oak Drive, would cross Barterbrook Road south of Frontier Drive, then would reconnect to Frontier Drive at the existing ninety-degree turn on that road. The intersection of the new alignment with

existing Frontier Drive at this turn then would become a T-intersection, where the east-west portion of Frontier Drive that runs through the residential area would become the minor street, and the new alignment would become the major movement. This segment is called New Alignment B-2.

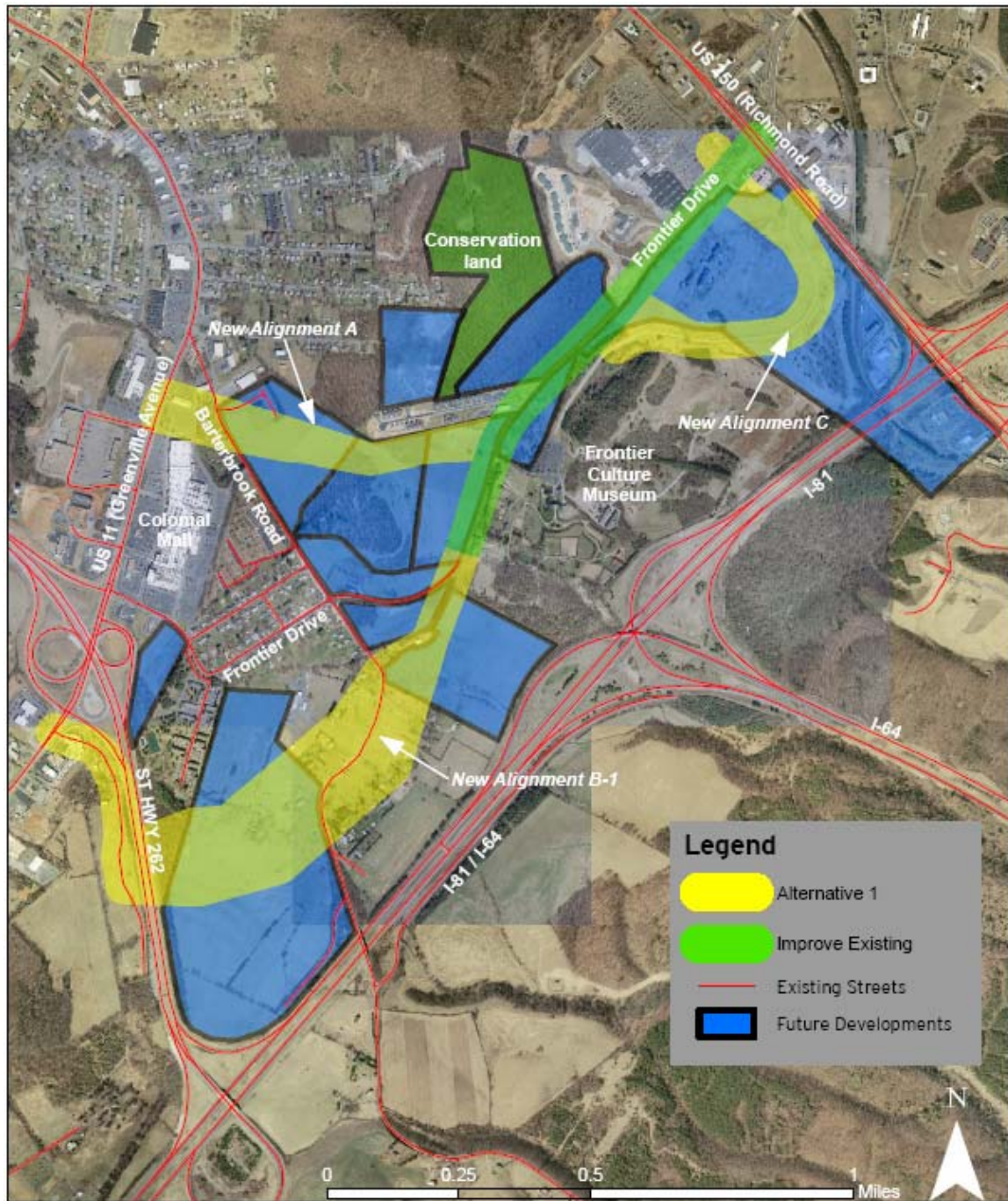
4.5.3 Alternative 3

Among the alternatives, Alternative 3 most closely follows the existing alignment of Frontier Drive. It would include both New Alignment A and New Alignment C exactly as they are described for Alternatives 1 and 2.

Alternative 3 incorporates New Alignment D, which generally would follow existing Frontier Drive from ¼ mile east of Barterbrook Road to US 11 and also would encompass Sunset Boulevard. In addition, Alternative 3 has connections to the potential residential development either on new location or following existing Barterbrook Road.

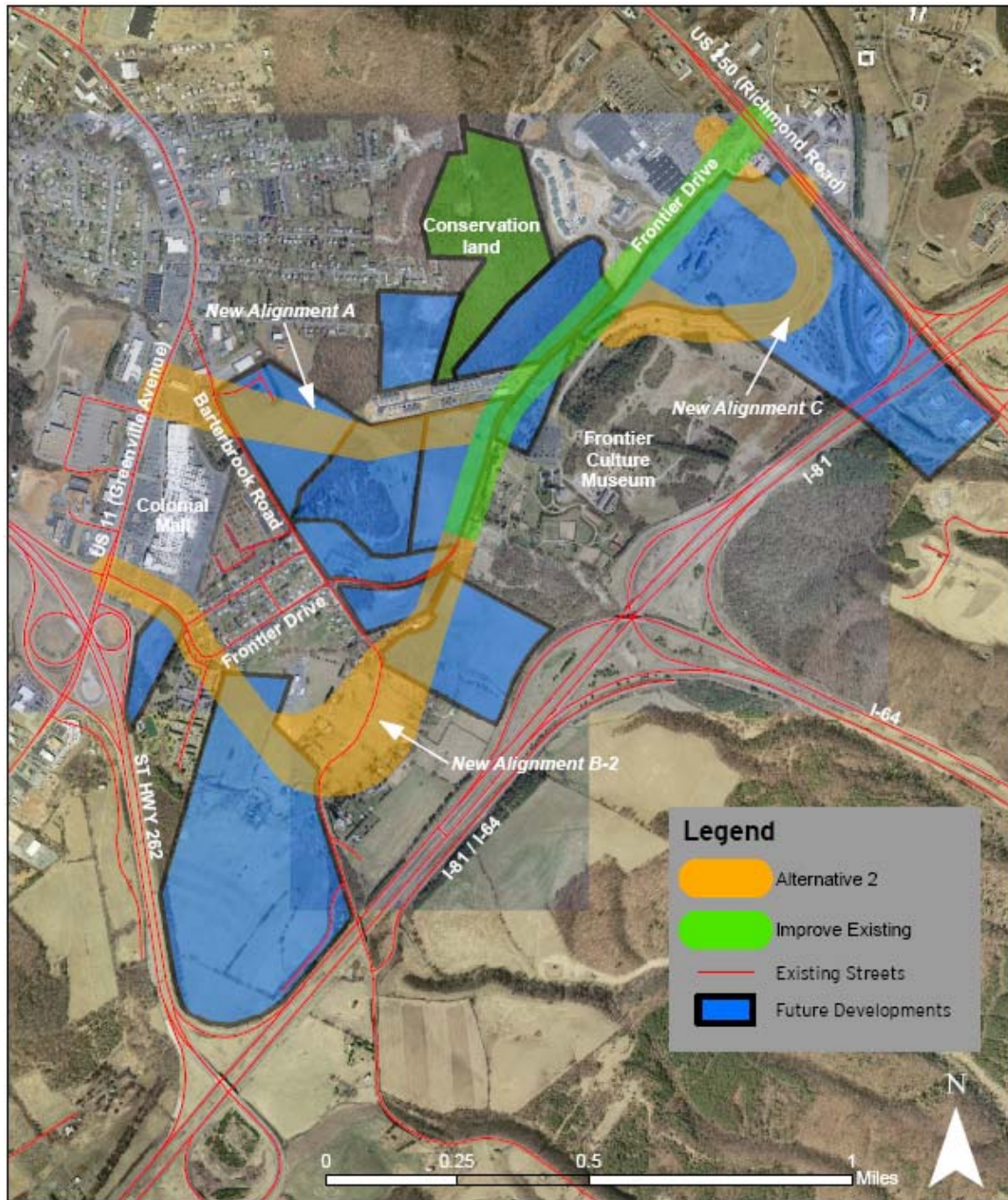
For all alternatives, the northeast segment of Frontier Drive would be improved from US 250 to the starting point of either New Alignment B-1, New Alignment B-2, or New Alignment D (depending on the alternative). The typical section for the improved Frontier Drive and all new alignments would be four lanes with curb and gutter and a raised landscaped median. In areas where topography or right-of-way is a constraint, the typical section would be four lanes with curb and gutter and without a median. See **Figure 9**, **Figure 10**, and **Figure 11** for the typical sections.

Figure 6: Alternative 1



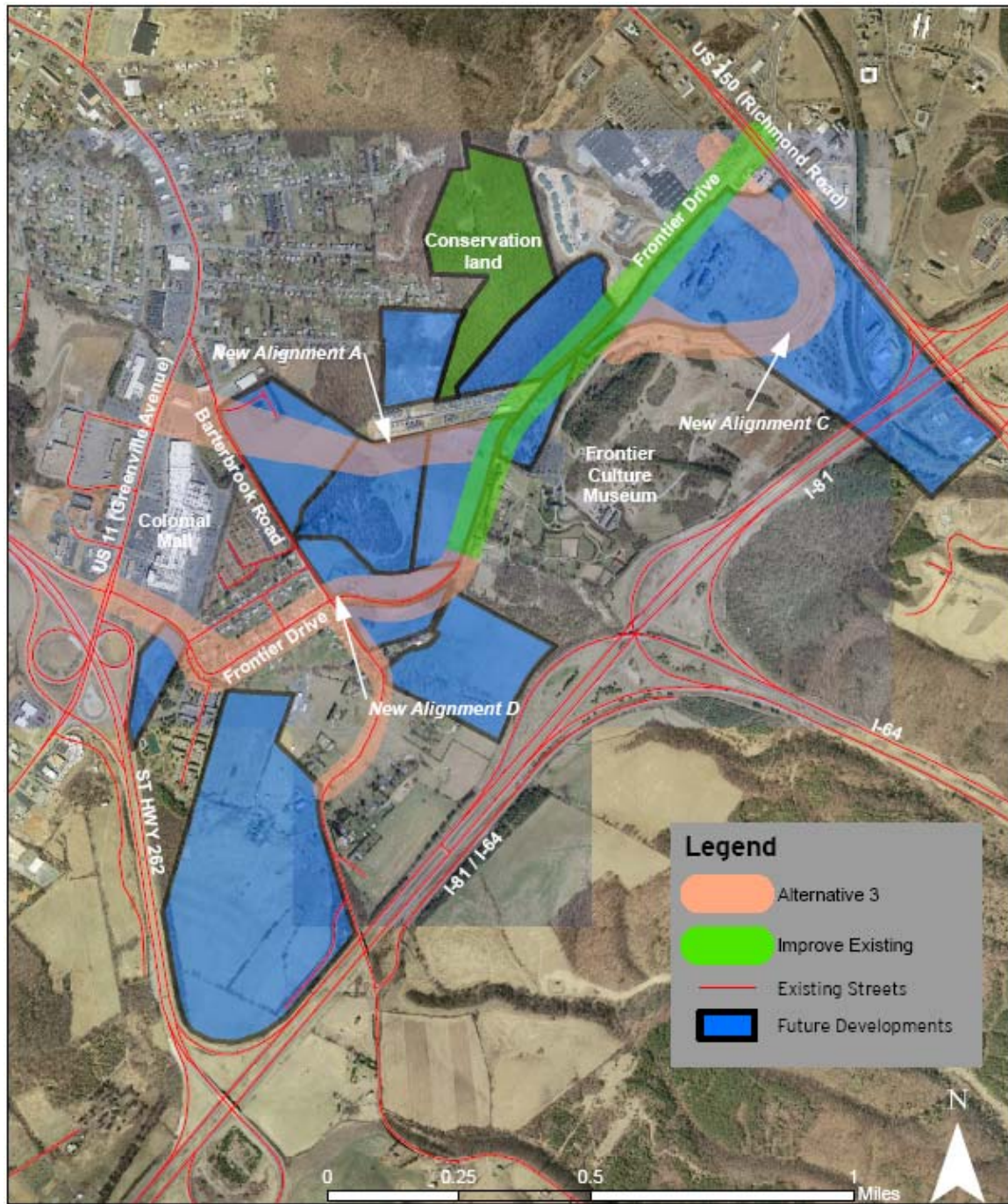
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Figure 7: Alternative 2



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Figure 8: Alternative 3



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Figure 9: Existing Typical Section

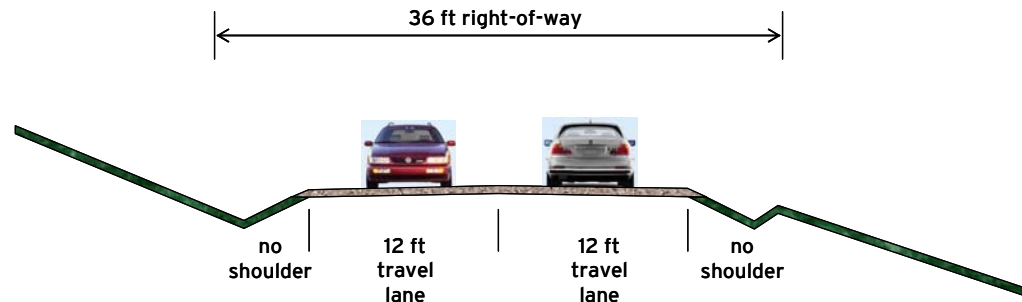


Figure 10: Future Typical Section – Four-Lane Divided

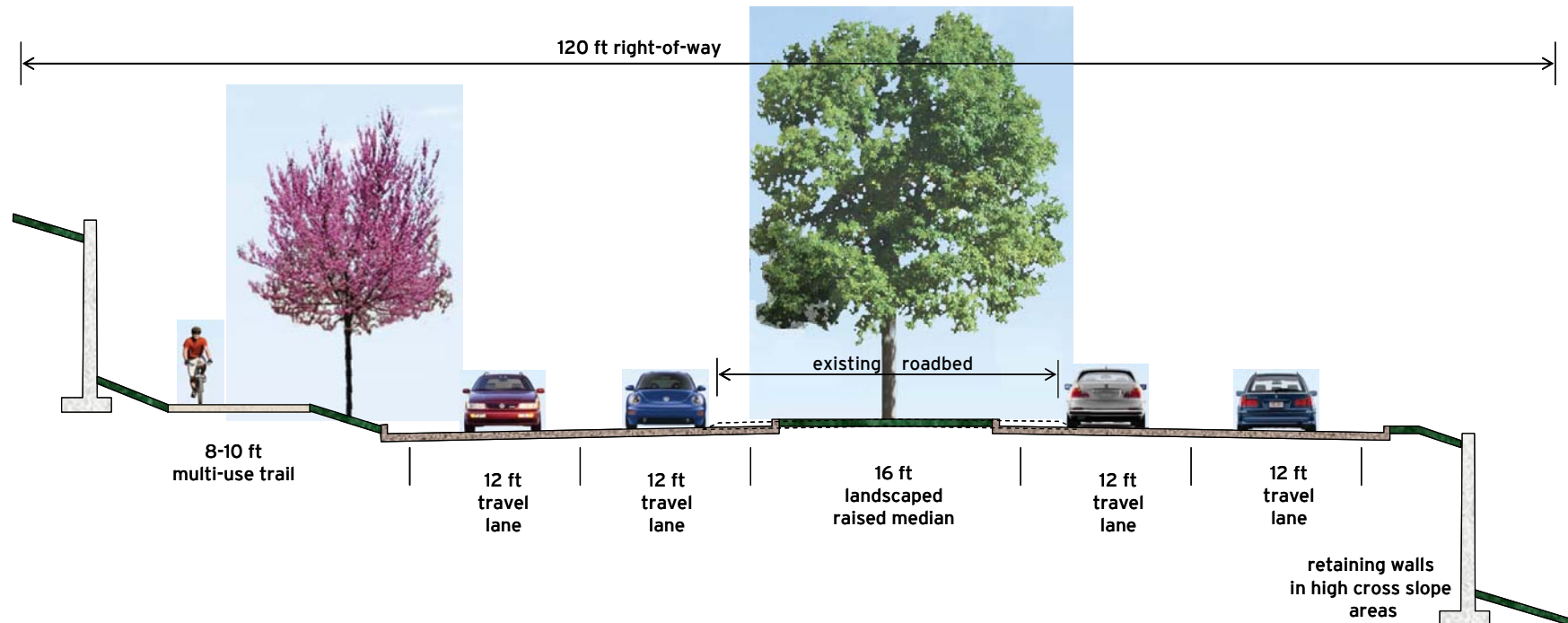
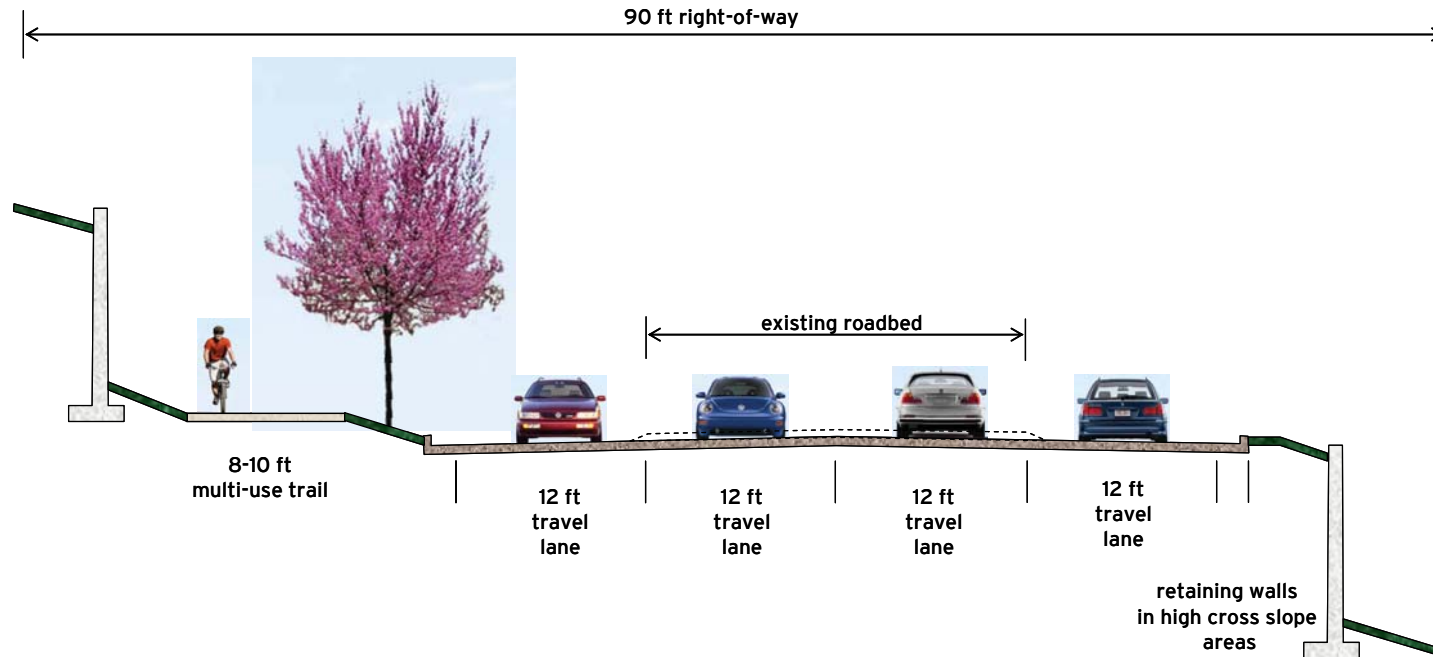


Figure 11: Future Typical Section – Four-Lane Undivided



5. Evaluation of Alternatives

The alternatives were evaluated both qualitatively and quantitatively. This section includes a general qualitative evaluation that shows how the alternatives perform relative to each other using all of the screening criteria identified earlier in this report. It also includes detailed qualitative and quantitative evaluations of select criteria. The following engineering and social screening criteria were used for the more detailed evaluation:

- Traffic Operations (summary of operational analysis)
 - Intersection LOS
 - Travel Times
- Multimodal – Bicycle and Pedestrian Accommodations
- Geometry
- Supports Development Goals of Comprehensive Plans
- Impact to Structures
- Impact to Existing Residential Areas
- Right-of-Way Needs
- Construction Cost Estimate

5.1 Qualitative Evaluation of Alternatives

Table 2 contains a qualitative evaluation of the alternatives. This is a general comparison of alternatives using the screening criteria identified earlier in this report.

This initial qualitative assessment suggests that all three Build Alternatives are beneficial in terms of the engineering criteria. The lower construction cost and travel time advantages of the shorter alignments in Alternative 2 and Alternative 3 mean that these alternatives perform better than Alternative 1. The No Build alternative does not meet the traffic operations, multimodal, or geometric goals of the project.

In terms of the social criteria, the No Build alternative appears neutral: the absence of right-of-way impacts is counterbalanced by neighborhood impacts of additional traffic and the inability to support anticipated commercial development. Alternative 1 performs better than Alternative 2 from a social perspective because New Alignment B-1 completely avoids the existing residential neighborhood. Similarly, Alternatives 1 and 2 perform better than Alternative 3 because of reduced impacts to the existing residential neighborhood.

Overall, all three Build Alternatives perform similarly using these qualitative criteria, and all three alternatives are superior to the No Build alternative with the exception of impacts to existing neighborhoods. However, it is likely that Alternative 1, with its grade separation at Route 262, would be prohibitively expensive to construct. Also, Alternative

1 serves an area east of Route 262 where no additional development is planned and therefore no transportation improvements are warranted at this time.

Table 2: Qualitative Evaluation Matrix

	No Build	Alternative 1	Alternative 2	Alternative 3
Environmental				
o Cultural resources	○	○	○	○
o Open space	○	○	○	○
o Social justice	○	○	○	○
Engineering				
o Construction cost	+	—	○	○
o Traffic operations (intersection level of service)	—	+	+	○ **
o Traffic operations (corridor travel times)	—	○	+ / ○ *	+ ***
o Multimodal (accommodation of pedestrians and bicycles, particularly through intersections)	—	+	+	+
o Geometry (ability to accommodate desired intersection spacing)	—	+ / ○ *	+ / ○ *	○
Social				
o Supports development goals of comprehensive plans	—	+	+	○
o Impact to structures	+	○	—	—
o Impact to existing residential areas	—	+	○	—
o Right-of-way needs	+	—	—	—

Key:

⊕ = better than the other alternatives

○ = neutral as compared to the other alternatives

— = worse than the other alternatives

* Depends on which option is chosen for intersection configuration

** More traffic will be directed to US 11 along Frontier Drive as compared to the other alternatives, so the level of service would be expected to be worse at Frontier Dr/US 11 and Frontier Dr/Barterbrook Rd as compared to the other alternatives.

*** Because New Alignment D is shorter than New Alignment A, New Alignment B-1, and New Alignment B-2, it is expected that travel times would be shorter for Alternative 3.

5.2 Detailed Evaluation

5.2.1 Traffic Operations

In general, it was assumed that all new trips associated with future development would be assigned to the new alternative alignments. Turning volumes were forecast at the portal intersections in the study area using the same cumulative turning percentages as under the no-build condition. Using professional judgment, turning volumes were forecast at Barterbrook Road and Frontier Drive and at all of the new interior intersections formed by the New Alignments based on the revised traffic assignment assumptions for the Build condition alternatives.

Forecast turning volumes from anticipated development were then added to existing turning and through volumes. Based on professional judgment and on staff-level discussions with VDOT, Augusta County, and the City of Staunton, it has been assumed that background (existing) traffic will grow at a rate of 0.25% per year to the target year of 2035 and will be assigned to the existing network, following the same paths as in the no-build condition.

The morning and evening peak hour forecast volumes can be found in **Appendix C**.

5.2.1.1 Intersection LOS

The traffic forecast for 2035 was used to create AM and PM peak hour traffic models of each Alternative using Synchro 7 software. Signal timing plans were optimized for each Alternative, and intersections were configured or reconfigured within reason to accommodate forecast volumes. The future year (2035) intersection level of service was then evaluated for each of the intersections in the study area using the traffic models.

Table 3 shows the overall intersection levels of service for each of the signalized intersections in Alternatives 1, 2, and 3, respectively. The overall intersection levels of service are all acceptable in Alternatives 1 and 2, with LOS of C or better. The overall intersection levels of service are generally acceptable in Alternative 3, except for the intersection of Frontier Drive with US 11. This intersection performs at LOS D due to the lack of alternatives to the Frontier Drive route through the study area and the impacts of this configuration on traffic flows. The LOS for all Build traffic operations are shown in **Appendix D**.

Table 3: Overall Intersection LOS Comparison for Year 2035

INTERSECTION	AM PEAK HOUR LOS			PM PEAK HOUR LOS		
	ALT 1	ALT 2	ALT 3	ALT 1	ALT 2	ALT 3
GREENVILLE AVENUE (ROUTE 11) BARTERBROOK ROAD	B	B	B	C	C	C
GREENVILLE AVENUE (ROUTE 11) NEW ALIGNMENT A	B	B	B	C	C	C
GREENVILLE AVENUE (ROUTE 11) FRONTIER DRIVE	B	B	B	B	B	D
BARTERBROOK ROAD NEW ALIGNMENT A	B	B	C	C	C	C
BARTERBROOK ROAD FRONTIER DRIVE	B	B	C	C	C	C
FRONTIER DRIVE RICHMOND ROAD (ROUTE 250)	C	C	C	C	C	C
FRONTIER DRIVE NEW ALIGNMENT A	B	B	A	B	C	B
FRONTIER DRIVE NEW ALIGNMENT B-1/B-2 (EAST)	B	B	N/A	B	B	N/A
FRONTIER DRIVE NEW ALIGNMENT B-2 (WEST)	N/A	A	N/A	N/A	B	N/A

N/A: Not Applicable

5.2.1.2 Travel Times

Travel times were calculated for four of the main routes through the study area. These routes include the two paths between each of the following sets of intersections:

- US 250 & Frontier Drive and US 11 & Barterbrook Road
- US 250 & Frontier Drive and US 11 & Frontier Drive

In the Build Alternatives, the paths between the main study area intersections followed the New Alignments when available. In the same way that most of the trips associated with future development were assigned to the New Alignments, it was assumed that the primary paths between intersections would follow the improved roadway segments. **Table 4** shows the travel time in seconds for each of the routes in each of the Alternatives, as well as for the No-Build condition.

Table 4: Travel Time Comparison for Year 2035

Travel Time (minutes)	AM				PM			
	No Build	Alt 1	Alt 2	Alt 3	No Build	Alt 1	Alt 2	Alt 3
US 250/Frontier Dr to US 11/Barterbrook Rd	4.7	2.6	2.6	2.6	12.7	4.0	4.1	4.1
US 11/Barterbrook Rd to US 250/Frontier Dr	6.3	2.9	2.9	3.4	15.6	3.8	3.8	4.7
US 250/Frontier Dr to US 11/Frontier Dr	4.8	4.4	3.7	3.2	23.6	4.3	4.0	4.1
US 11/Frontier Dr to US 250/Frontier Dr	6.0	4.0	3.2	3.3	12.5	4.2	3.4	3.6

None of the Build alternatives shows a clear travel time advantage over any of the others. However, all of the Build alternatives have significantly better travel times than the No-Build condition.

5.2.2 Multimodal – Bicycle and Pedestrian Accommodations

All Build alternatives include a multi-use trail along all New Alignments and improved roadway segments. This trail will be 8 to 10 feet wide and is intended to accommodate both pedestrians and bicyclists. Since all Build alternatives include provisions for a continuous multi-use trail along the major paths within the study area, they all meet the multimodal criterion equally. The No-Build condition does not meet the multimodal criterion.

5.2.3 Geometry

The geometry evaluation criterion measures the ability of an alternative to accommodate desired intersection spacing, as outlined in the access management plan in the next section. Alternatives 1 and 2 have the ability to accommodate desired intersection spacing, including signalized and unsignalized intersections and median openings. Desired intersection spacing is more difficult to achieve in Alternative 3, specifically on New Alignment D between Barterbrook Road and US 11. This section of the study area includes a dense residential community, Manchester Apartments, and Colonial Mall, all of which need greater accessibility than can be accommodated with the access spacing guidelines for improved sections of roadway. The No-Build condition does not have the ability to accommodate the desired intersection spacing, because the existing access (particularly on Frontier Drive and Barterbrook Road west of the Frontier/Barterbrook intersection) does not meet the recommended spacing guidelines.

5.2.4 Supports Development Goals of Comprehensive Plans

One of the goals of this study is to create a future corridor plan that will facilitate the movement of traffic generated by potential future development identified in the comprehensive plans. Alternatives 1 and 2 meet this goal by providing additional alignments throughout the study area which will aid in facilitating access to and from

future development areas. Alternative 3 lacks direct access to the potential residential development site, a significant mixed-density neighborhood, and thus traffic from this development would load directly onto Barterbrook Road. Although Alternative 3 provides for the improvement of Barterbrook Road between the potential residential development entrance and Frontier Drive, this alternative is less effective than the others in supporting future development as outlined in the current comprehensive plans. The No-Build condition does not support the development goals of the comprehensive plans, as it does not provide the capacity to accommodate future growth in the study area.

5.2.5 Impact to Structures

All Build alternatives would impact structures in the study area. **Table 5** shows the number of potentially impacted structures for each of the alternatives. Because this study is being performed for preliminary planning purposes and alignments are far from finalized, all structures that fell within the wide bands or “swaths” depicting the new or improved alignments were counted as potentially impacted. The actual number of displacements will depend on the final configuration of the new alignments and the location of the widening improvements on existing roadways. Nevertheless, the estimates show each alternative’s impact to structures relative to the other alternatives. Alternative 1, which avoids the denser residential areas in the study area, has the least impact to structures. Alternative 3, which follows the existing Frontier Drive alignment through the densest areas in the study, has the most impact to structures. Alternative 2 has less impact on the medium density residential areas but more impact on the high density residential areas than Alternative 1, thus is close to equal with that alternative. The No-Build condition does not impact any structures in the study area.

Table 5: Potentially Impacted Structures

	No Build	Alternative 1	Alternative 2	Alternative 3
Potentially Impacted Structures	0 structures	51 structures	53 structures	77 structures

5.2.6 Impact to Existing Residential Areas

There are several defined residential areas in the study area, ranging from medium-density single-family housing to high-density apartment homes. The majority of these residential areas are located in or near the triangular area defined by Frontier Drive, Barterbrook Road, and US 11.

Alternative 1 has little impact to these residential areas. New Alignment A, which is present in all Build alternatives, impacts a few residences west of Barterbrook and east of Colonial Mall. New Alignment B-1 impacts a medium-density residential area on both sides of Barterbrook Road south of the intersection with Frontier Drive; however, the extent of this impact remains to be seen when the alignment is more precisely defined in the design phase of this project.

Alternative 2 has more impact to existing residential areas. New Alignment A has the same impacts as in Alternative 1. New Alignment B-2 impacts the same medium-density residential area as B-1, as well as part of the high-density apartment and single-family home area on Frontier Drive between US 11 and Barterbrook Road. Because of the higher density of homes in this area, designers will have less flexibility to avoid impacts with the final configuration of New Alignment B-2.

Alternative 3 has the most impact to existing residential areas. New Alignment A has the same impacts as in Alternatives 1 and 2. New Alignment D avoids medium-density residential areas but goes directly through the high-density residential area on Frontier Drive west of Barterbrook Road. Because of the higher density of homes in this area, designers will have less flexibility to avoid impacts with the final configuration of New Alignment D. Alternative 3 will likely impact all homes on both sides of Frontier Drive west of Barterbrook Road, as well as some of the Manchester Apartments buildings.

The No-Build condition does not directly impact residential areas. Because no new alignments will be built or roadway improvements made, the No-Build alternative does not require takings of parcels or structures. However, because of the significantly worse traffic conditions that can be expected if no improvements are made in the study area, residents will be indirectly and not insignificantly impacted by future traffic.

5.2.7 Right-of-Way Needs

All Build alternatives require right-of-way (ROW) acquisition that impacts parcels in the study area. **Table 6** shows the estimated ROW needed and parcels impacted for each of the alternatives. Because this study is being performed for preliminary planning purposes and alignments are far from finalized, all parcels that fell within the wide bands or “swaths” depicting the new or improved alignments were counted as potentially impacted. The actual degree of ROW acquisition and the number of parcel impacts will depend on the final configuration of the new alignments and the location of the widening improvements on existing roadways.

Alternative 1, which contains the greatest total length of new alignment segments, requires the most ROW. Alternative 2, which contains a shorter total length of new alignment segments than Alternative 1, requires less ROW. Alternative 3, which contains the shortest total length of new alignment segments and primarily consists of widened existing roadways, requires the least additional ROW.

While Alternatives 2 and 3 require less right-of-way (acreage) than Alternative 1, they potentially impact a greater number of parcels. As noted in the Impact to Structures and Impact to Existing Residential Areas sections, Alternative 1 avoids the more densely developed residential portions of the study area, so it impacts the fewest number of

parcels. Alternative 2 affects portions of the dense residential areas, so it impacts more parcels. Alternative 3 follows the existing Frontier Drive alignment through the densest areas in the study, so it impacts the most parcels.

The No-Build condition does not require any ROW acquisition and does not impact any parcels.

Table 6: Estimated Right-of-Way Needs

	No Build	Alternative 1	Alternative 2	Alternative 3
Estimated Right-of-Way Acquisition	0 acres	37 acres	33.2 acres	29.6 acres
Potential Parcel Impacts	0 parcels	63 parcels	73 parcels	125 parcels

5.2.8 Construction Cost Estimate

Planning level construction costs were estimated for the alternatives in this study. These costs, shown in **Table 7**, are based on widening existing roadways, building new alignments, and upgrading intersections and traffic signals. Right-of-way acquisition costs were not estimated because the exact number of parcels that would be required is not known. All costs include management and incidental items as well as an overall contingency and inflation. These costs are based on preliminary alignments and assumptions; the actual costs will depend on the final configuration of the new alignments and the location of the widening improvements on existing roadways.

Table 7: Estimated Construction Cost (Not Including Right-of-Way)

	No Build	Alternative 1	Alternative 2	Alternative 3
Estimated Construction Cost	\$0	\$76,000,000	\$55,000,000	\$57,000,000

Alternative 1 is the most costly alternative because it includes a structure that spans Route 262 in New Alignment B-1. Alternative 2, which includes substantial new alignments, is approximately the same cost as Alternative 3, which does not include as much new roadway but significantly impacts the densest residential area in the study area. The No-Build condition has no construction cost. The construction cost details for all three Build alternatives are given in **Appendix E**.

6. Recommended Alternative

Following the qualitative and quantitative evaluations and the receipt of public input during a public open house on the study, Alternative 2 is recommended with the following modification:

- New Alignment C is eliminated. Instead, simple connections from the Frontier Culture Museum redevelopment site to Frontier Drive and Richmond Road are included.
- New Alignment A is shifted to the south to reduce impacts to Red Oak Drive.

Alternative 2 meets the best balance between the environmental, engineering, and social criteria. It provides the roadway improvements and additions necessary to facilitate the movement of traffic, including automobile, pedestrian and bicycle, through the study area. It also supports the development goals of the City and County comprehensive plans while minimizing impacts to existing commercial and residential areas in the corridor.

Public input was fundamental in the decision to eliminate New Alignment C from the recommended alternative, as the plans for the Frontier Culture Museum redevelopment site are still evolving. It is important to the future operations of the Frontier Drive corridor that access to the Frontier Culture Museum redevelopment site be established by way of a “gateway” style entrance into the development from Frontier Drive so that capacity constraints at the intersection of Frontier Drive and US 250 can be minimized to the greatest extent possible.

The public input process, as well as further discussions with project stakeholders, also influenced the decision to move New Alignment A to the south to reduce impacts to Red Oak Drive. This change was implemented in all alternatives, as well as the recommended alternative.

A summary of the public meeting and comments can be found in **Appendix F**.

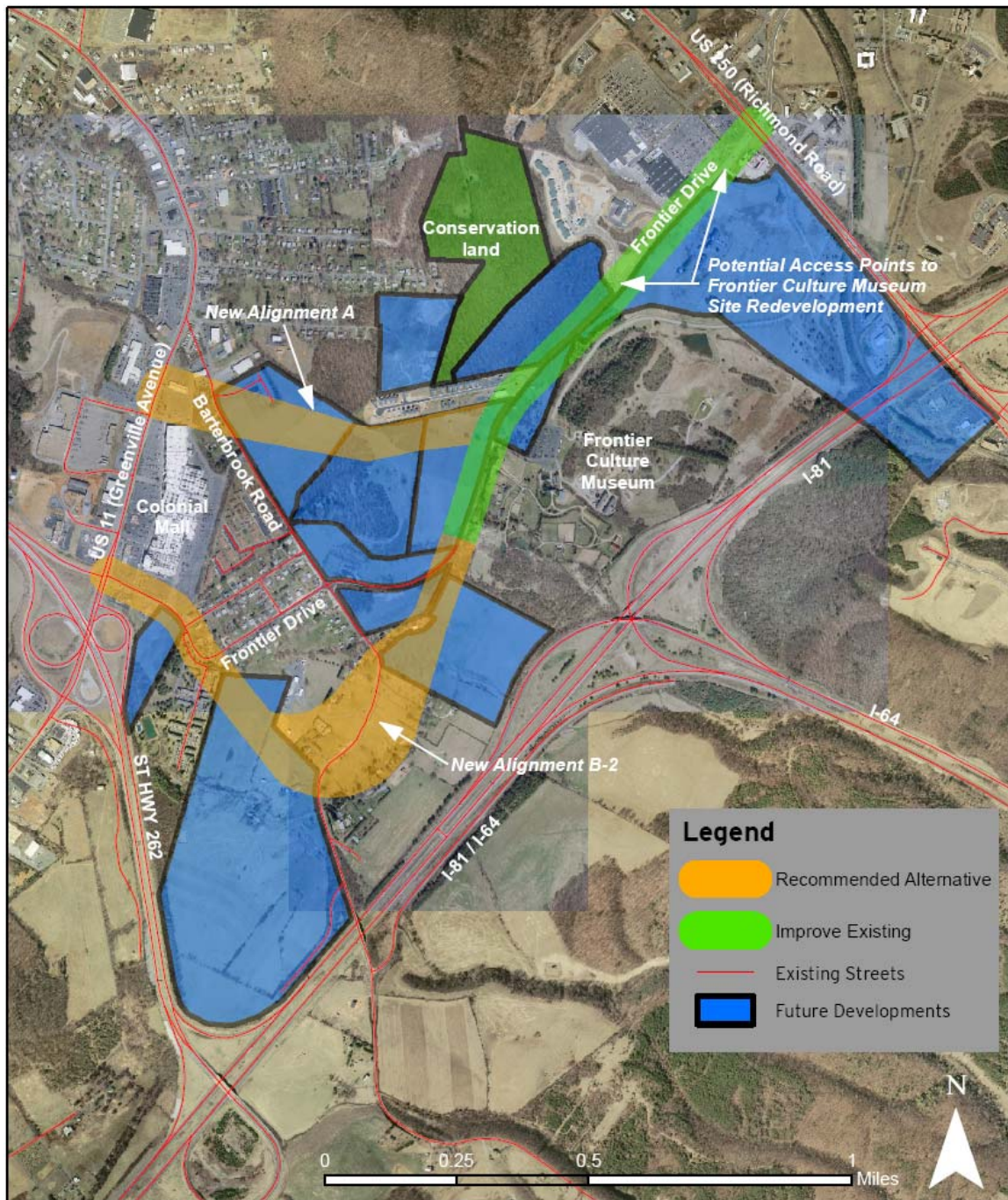
6.1 Summary of Features

The recommended alternative, shown in **Figure 12**, includes the following features:

- New Alignment A, which connects Frontier Drive (just south of Red Oak Drive) to US 11 (south of Barterbrook Road and north of Colonial Mall)
- New Alignment B-2, which connects the east section of Frontier Drive (between New Alignment A and Barterbrook Road) to the west section of Frontier Drive (southeast of Sunset Boulevard)
- Widened and improved sections of Frontier Drive from US 250 to the east connection of New Alignment B-2, and from the west connection of New Alignment B-2 to US 11

- A continuous, multi-use trail along all sections of new alignment and improved existing roadway
- Improved intersection configurations and upgraded, optimized signals at the following intersections:
 - Route 11/Barterbrook Road
 - Route 11/Frontier Drive
 - Frontier Drive/Barterbrook Road
 - Frontier Drive/US 250
- New intersections at the following intersections:
 - New Alignment A/Route 11
 - New Alignment A/Barterbrook Road
 - New Alignment A/Frontier Drive
 - New Alignment B-2/Frontier Drive (west of Barterbrook Road)
 - New Alignment B-2/Barterbrook Road
 - New Alignment B-2/Frontier Drive (east of Barterbrook Road)

Figure 12: Recommended Alternative



The roadway and right-of-way features shown on this map are conceptual and FOR TRANSPORTATION PLANNING PURPOSES ONLY and are not to be regarded as final locations. The actual location and detail of these improvements will be determined at the conclusions of NEPA studies and the preliminary engineering stage.

The recommended typical section consists of four 12-foot travel lanes with a separate 8- to 10-foot multi-use trail. Where possible, this roadway should include a 16-foot landscaped raised median. This typical section applies to all new alignments as well as

improved sections of existing roadway. The recommended typical section was shown in **Figure 10** and **Figure 11** with and without a landscaped raised median, respectively.

Preliminary intersection configurations in the recommended alternative are shown in **Appendix G**. The intersection of Frontier Drive, New Alignment A and New Alignment B-2 (with a possible fourth leg at the entrance to the Frontier Culture Museum) should be evaluated for possible use of a roundabout. Signal warrant studies will need to be performed for all intersections created by the new alignments once those alignments are refined in subsequent studies.

6.2 Access Management Plan

Access management is a strategy to control access to existing and future development while maintaining an acceptable flow of traffic on the surrounding roadway network. The various strategies in the access management toolbox are intended to improve safety (e.g., reduce the number of crashes) and improve traffic operations (e.g., reduce delays) on critical transportation corridors.

One of the most important aspects of access management pertains to the concept of developing and applying varying spacing and design standards for roadways with different functions. For example, to preserve the function of a principal arterial, which is to provide higher speed through movement between large activity centers, there should be fewer traffic conflicts on the roadway, which means that the spacing of driveways, median openings, and traffic signals should be greater than the spacing on a minor arterial road.

Since Frontier Drive connects two principal arterials, Richmond Road (US 250) and Greenville Avenue (US 11), the functional classification of the roadway fits in the minor collector category. Because the corridor is included within an urban boundary, it would be functionally classified as an urban minor arterial. By extension, New Alignments A and B-2 will also be classified as urban minor arterials. It is recommended that Frontier Drive, New Alignment A, and New Alignment B-2 be classified as urban minor arterials. **Table 8** gives the VDOT spacing standards for an urban minor arterial.

Table 8: VDOT Spacing Standards for Commercial Entrances and Intersections

Highway Functional Classification	Legal Speed Limit (mph)	Centerline to Centerline Spacing in Feet		
		Signalized Intersections	Unsignalized Intersections & Full Access Entrances	Partial Access Two Way Entrance
Urban Minor Arterial	35 to 45 mph	1,320	660	325

*Source: VDOT Access Management Design Standards for Entrances and Intersections, December 2007

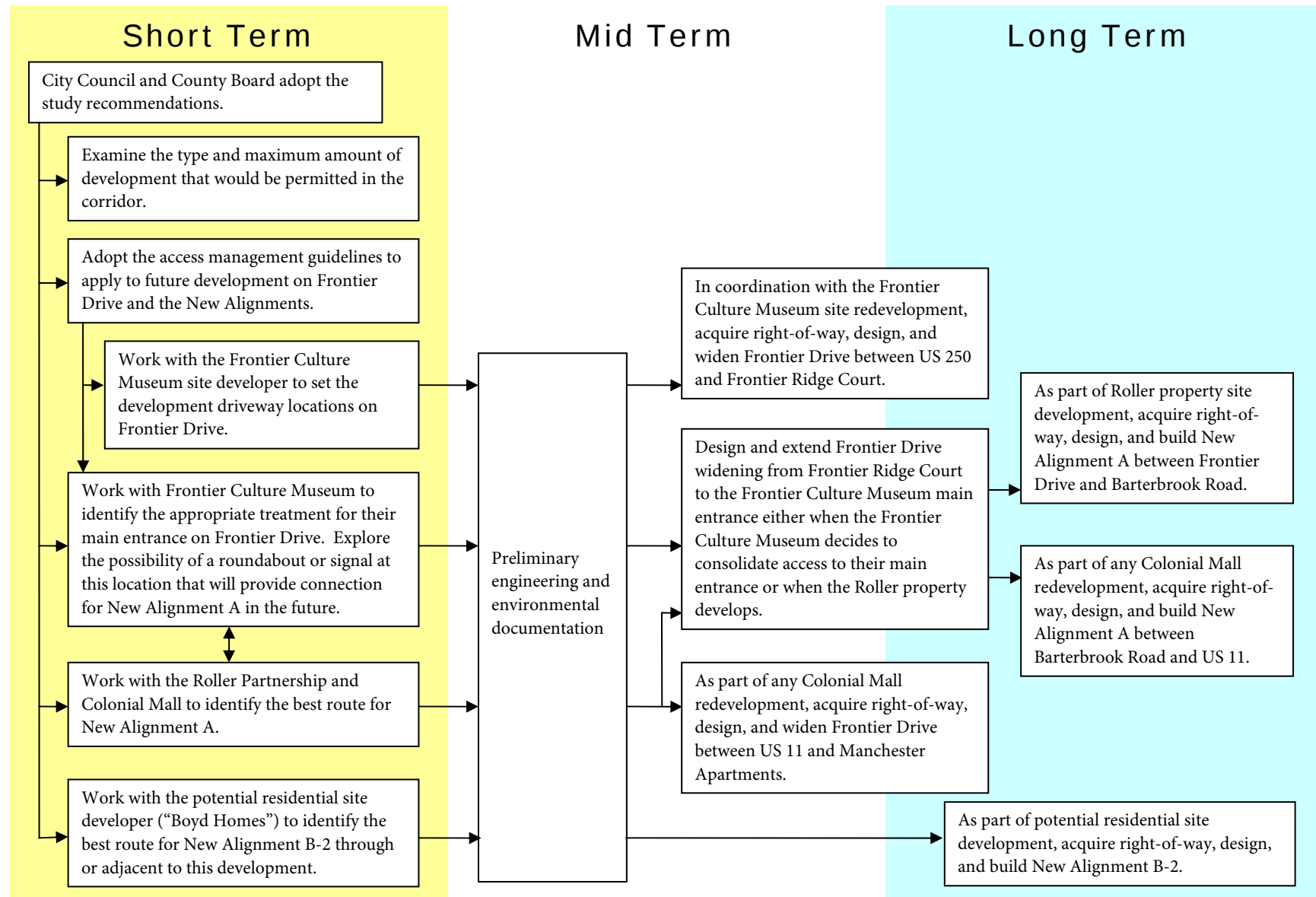
Based on VDOT policy, it is recommended that signalized intersections on the improved sections of Frontier Drive, New Alignment A, and New Alignment B-2 be spaced no closer than 1320 feet (1/4 mile). Unsignalized intersections and full access entrances should be no closer than 660 feet (1/8 mile), and partial access entrances should be at least 325 feet (1/16 mile) apart. A map of potential locations of signalized intersections, unsignalized intersections, and partial access points for the recommended alternative, following the recommended spacing can be found in **Appendix H**, along with a more comprehensive description of access management benefits and guidelines.

The intersection and entrance spacing should be implemented as land in the corridor is developed or redeveloped. Existing access points would remain until those parcels being accessed are redeveloped. Depending on the size of parcels in the future, interparcel access may be necessary to meet the spacing standards.

6.3 Implementation Sequencing

Several parts of the recommended corridor plan can be implemented in the short-term; others will occur in the mid- and long-term after engineering design work is performed for the recommended corridor and funding is secured. Implementation of improvements is tied closely with future development, and the sequence of development projects is unknown. However, continued planning and coordination can occur. **Figure 13** shows a generalized implementation sequence for the recommended corridor improvements, in the form of a flow chart.

Figure 13: Implementation Sequencing



7. Conclusion

As analyzed in this study, the ultimate amount of development in the Frontier Drive corridor is anticipated to produce high traffic volumes. Local jurisdictions should give careful consideration to the type and amount of development that will be permitted in the Frontier Drive corridor. If all undeveloped parcels are fully built out according to current land-use designations, significant measures will need to be taken to mitigate the effects of the additional traffic that will be generated.

Several alternatives were studied as part of this project. The recommended alternative, Alternative 2, incorporates roadways on new alignment, improvements to existing roads, pedestrian and bicycle improvements, and access management strategies to address safety and capacity issues and to support additional development in the corridor. Alternative 2 provides the best balance among the alternatives studied in terms of the trade-offs of cost, community impacts, and traffic operational effectiveness. While impacts to the existing residential neighborhoods and other private land owners exist, it is important for local decision makers to understand the cause, effect, and consequences of existing “by-right” development within the corridor, and how each may cumulatively impact the operation of the corridor, thus necessitating the sizeable improvements identified within this study. Understanding that many of the identified improvements may only be accomplished via public-private partnerships, the study process should continue with coordination among elected officials, jurisdictional staff, VDOT, the public, and developers to refine the recommended alignments and implement access management.

Appendix A: Existing Condition Traffic Operations

Existing Condition (2007) Capacity Analysis Results – Level of Service

INTERSECTION	TYPE OF CONTROL	MOVEMENT APPROACH***	AM PEAK HOUR		PM PEAK HOUR	
			LEVEL OF SERVICE	DELAY (SEC/VEH)	LEVEL OF SERVICE	DELAY (SEC/VEH)
1 GREENVILLE AVENUE (ROUTE 11) BARTERBROOK ROAD	SIGNALIZED	EB	C	34.2	D	36.7
		NB	B	10.1	B	15.8
		SB	A	7.4	B	11.6
		NWB	C	32.9	D	38
		OVERALL	B	12	B	17.3
2 FRONTIER DRIVE GREENVILLE AVENUE (ROUTE 11)	SIGNALIZED	WB	C	23.2	D	37.5
		NB	B	10.1	D	49.8
		SB	A	6.9	B	11
		OVERALL	B	10.9	D	37.3
3 FRONTIER DRIVE MALL/BANK ENTRANCE	UNSIGNALIZED	EB TL	A	1.5	A	4.7
		EB R	*	*	*	*
		WB TL	*	*	A	0.2
		WB R	*	*	*	*
		NB	B	12.5	D	32.6
		SB	B	11.1	C	19.1
4 BARTERBROOK ROAD FRONTIER DRIVE	SIGNALIZED	NB	C	32.1	C	33.3
		SB	C	24	C	23.6
		NEB	A	7.8	B	10.1
		SWB	A	6.8	A	8.4
		OVERALL	B	13.2	B	13.2
5 FRONTIER DRIVE SHEETZ ENTRANCE	UNSIGNALIZED	NW L	B	14.1	C	18
		NW R	A	9.5	A	9.5
		NE T	*	*	*	*
		NE R	*	*	*	*
		SW	A	4.3	A	2.8
6 FRONTIER DRIVE LOWES ENTRANCE	UNSIGNALIZED	SE L	C	15.7	D	29.4
		SE R	A	9.5	B	11.8
		NE L	A	8.1	A	9.2
		NE T	*	*	*	*
		SW	*	*	*	*
7 FRONTIER DRIVE RICHMOND ROAD (ROUTE 250)	SIGNALIZED	SEB	C	24.2	C	34
		NWB	B	17.1	C	23.2
		NEB	C	33	D	38.5
		SWB	C	34.8	D	40.5
		OVERALL	C	22.7	C	30.4

* SYNCHRO does not provide level of service or control delay for movements without conflicting volumes.

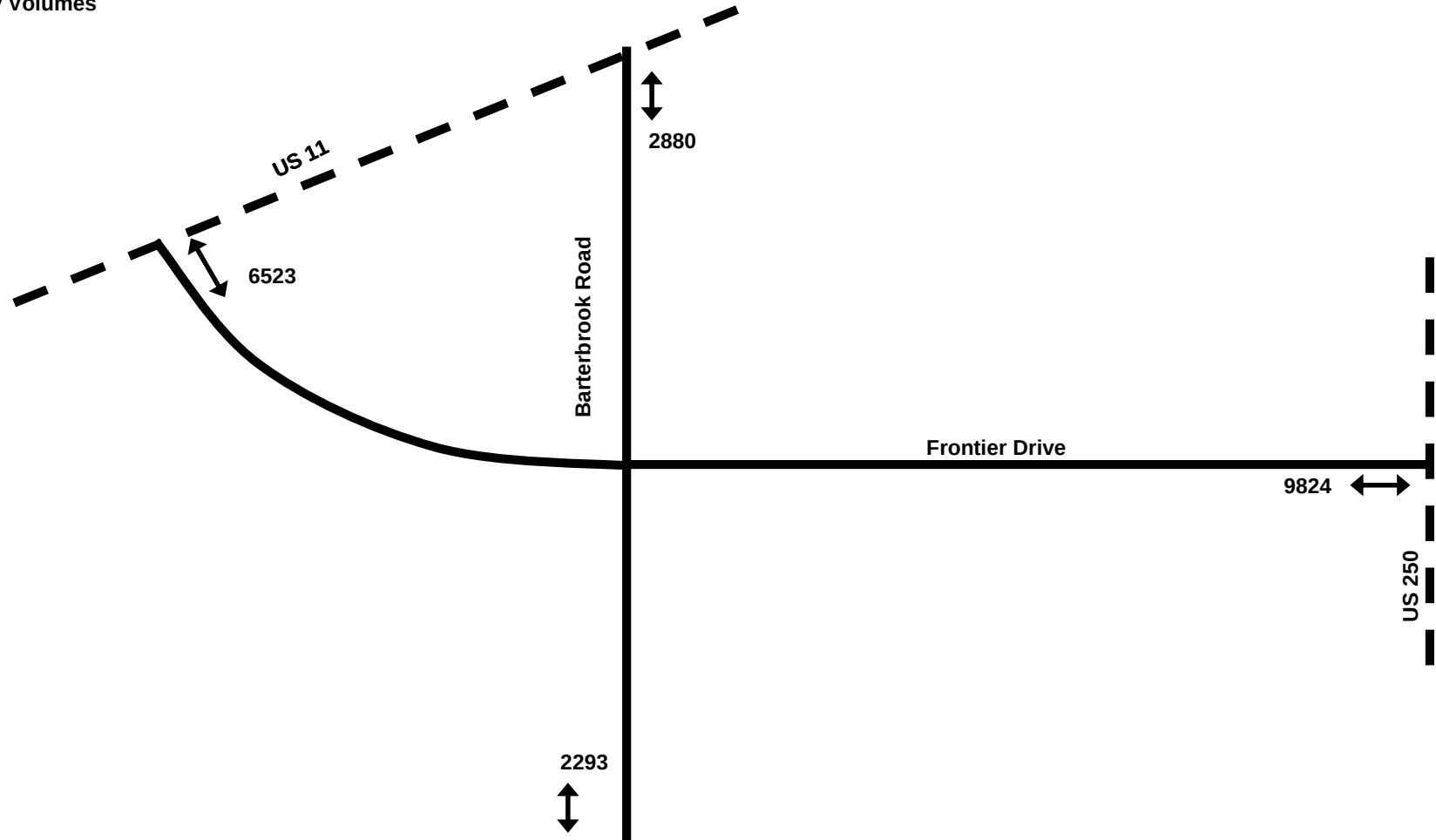
SYNCHRO also does not provide overall level of service for unsignalized intersections.

** SYNCHRO does not report control delay greater than 9,999 seconds.

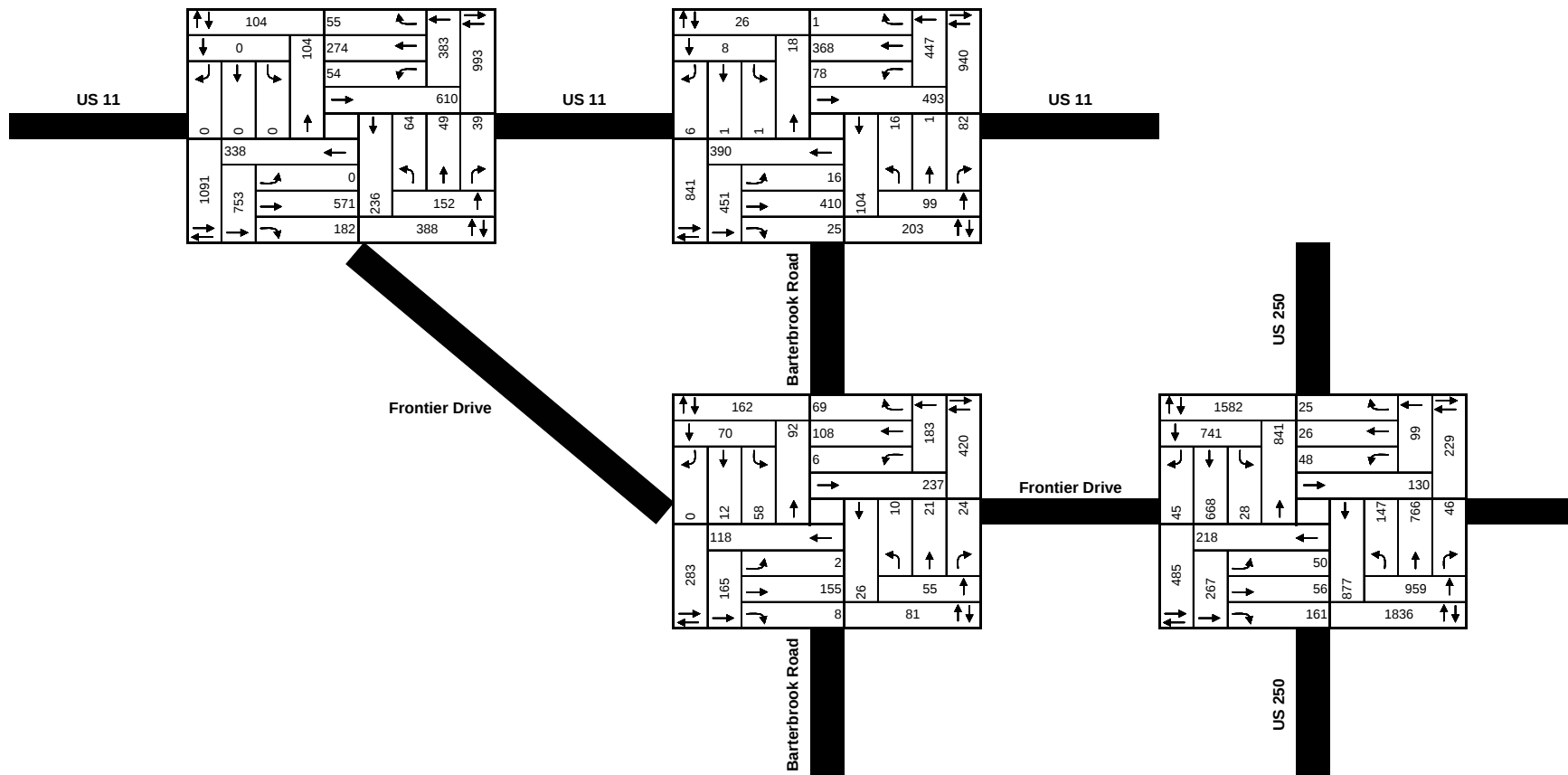
*** NB = Northbound, SB = Southbound, EB = Eastbound, WB = Westbound

NE(B) = Northeast (bound), NW(B) = Northwest (bound), SE(B) = Southeast (bound), SW(B) = Southwest (bound),
L = Left, T = Through, R = Right

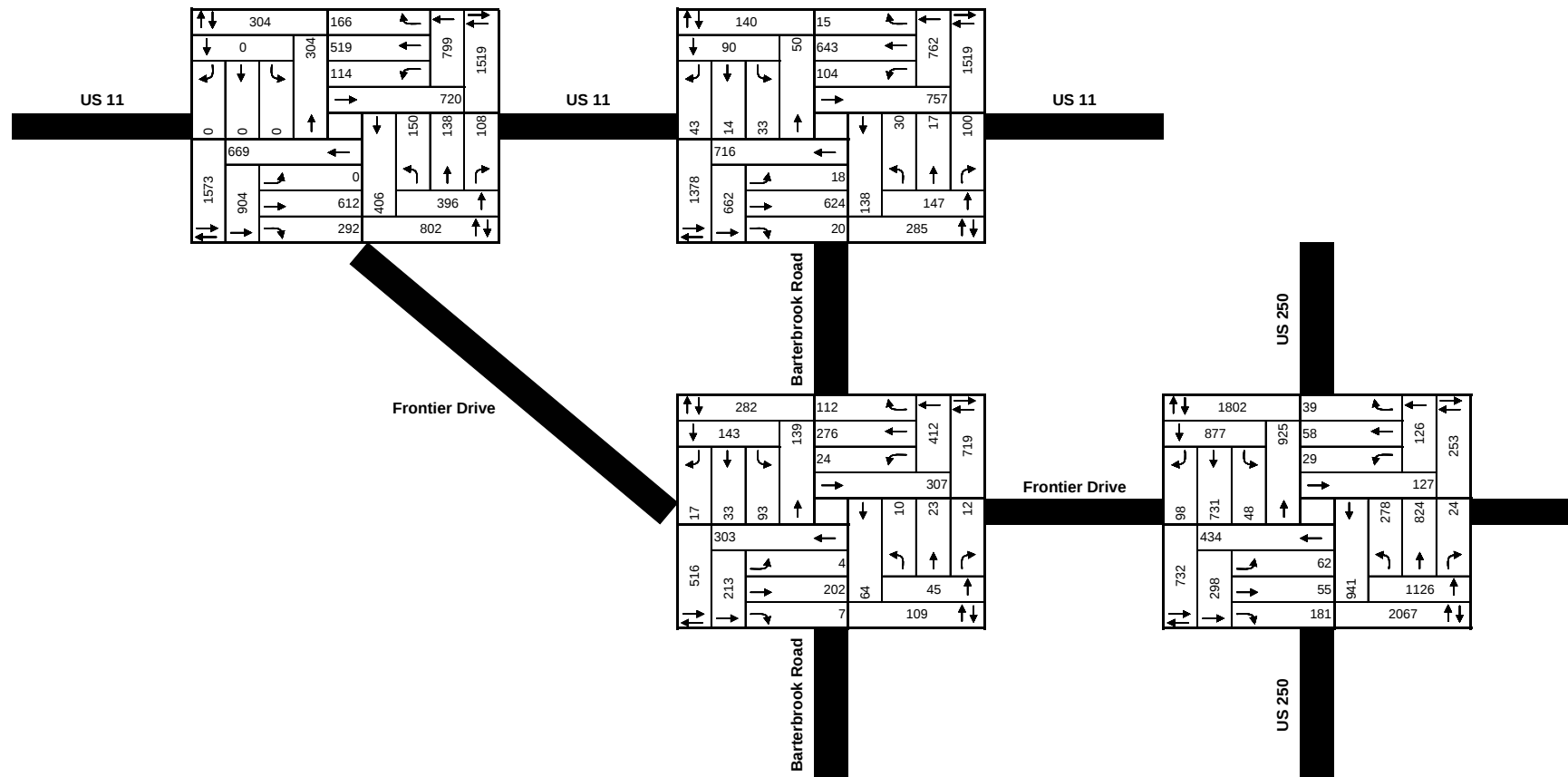
**Existing Trips
Daily Volumes**



Existing Turning Movement Counts
AM Peak Hour



Existing Turning Movement Counts
PM Peak Hour



Appendix B: No-Build Condition Traffic Operations

Future (2035) No-Build Capacity Analysis Results –Level of Service

INTERSECTION	TYPE OF CONTROL	MOVEMENT APPROACH***	AM PEAK HOUR		PM PEAK HOUR	
			LEVEL OF SERVICE	DELAY (SEC/VEH)	LEVEL OF SERVICE	DELAY (SEC/VEH)
1 GREENVILLE AVENUE (ROUTE 11) BARTERBROOK ROAD	SIGNALIZED	EB	C	26.1	F	84.4
		NB	B	18.4	F	107.5
		SB	B	15.1	F	92.6
		NWB	C	31.1	F	161.9
		OVERALL	C	20.2	F	115
2 FRONTIER DRIVE GREENVILLE AVENUE (ROUTE 11)	SIGNALIZED	WB	D	40.2	F	654.5
		NB	C	28.4	F	1524.1
		SB	B	18.2	F	271.3
		OVERALL	C	29	F	1173.6
3 FRONTIER DRIVE MALL/BANK ENTRANCE	UNSIGNALIZED	EB TL	A	1.4	C	19.2
		EB R	*	*	*	*
		WB TL	*	*	A	6.2
		WB R	*	*	*	*
		NB	F	54.1	F	**
		SB	E	47.5	F	**
4 BARTERBROOK ROAD FRONTIER DRIVE	SIGNALIZED	NB	F	144.6	F	397
		SB	F	135.8	F	572.3
		NEB	F	133.8	F	459.8
		SWB	E	65.7	F	533
		OVERALL	F	118.7	F	510.6
5 FRONTIER DRIVE SHEETZ ENTRANCE	UNSIGNALIZED	NW L	F	79	F	**
		NW R	B	13.7	C	18.3
		NE T	*	*	*	*
		NE R	*	*	*	*
		SW L	A	3.9	A	7.8
6 FRONTIER DRIVE LOWES ENTRANCE	UNSIGNALIZED	SE L	F	152.2	F	F
		SE R	B	13.2	F	210.9
		NE L	B	11.2	F	118.1
		NE T	*	*	*	*
		SW	*	*	*	*
7 FRONTIER DRIVE RICHMOND ROAD (ROUTE 250)	SIGNALIZED	SEB	F	115.2	F	344.1
		NWB	E	58	F	376.2
		NEB	E	58.4	F	380.3
		SWB	F	141.7	F	411.5
		OVERALL	E	78.1	F	372

* SYNCHRO does not provide level of service or control delay for movements without conflicting volumes.

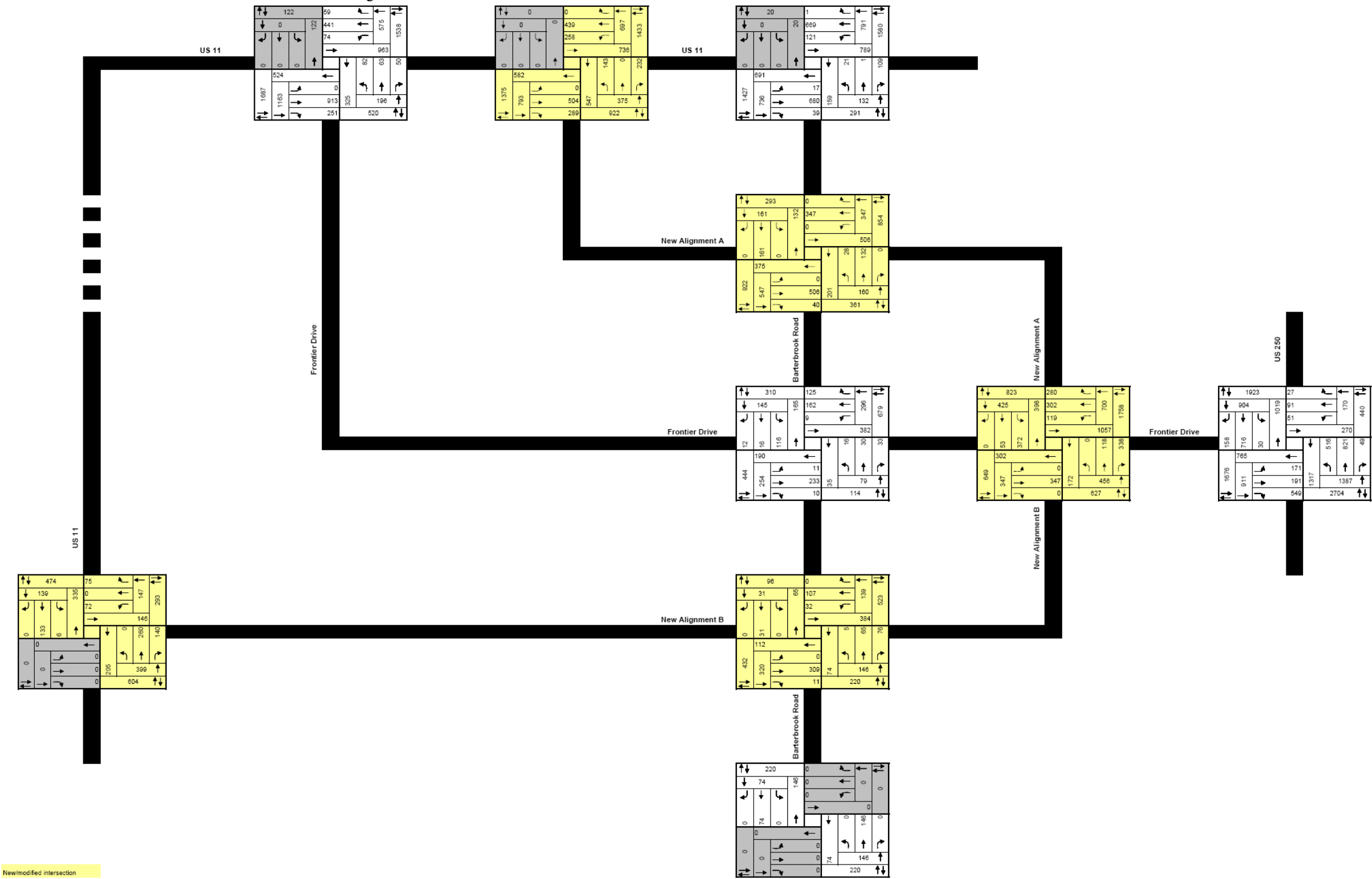
SYNCHRO also does not provide overall level of service for unsignalized intersections.

** SYNCHRO does not report control delay greater than 9,999 seconds.

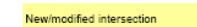
*** NB = Northbound, SB = Southbound, EB = Eastbound, WB = Westbound
NE(B) = Northeast (bound), NW(B) = Northwest (bound), SE(B) = Southeast (bound), SW(B) = Southwest (bound),
L = Left, T = Through, R = Right

Appendix C: Build Condition Traffic Assignment

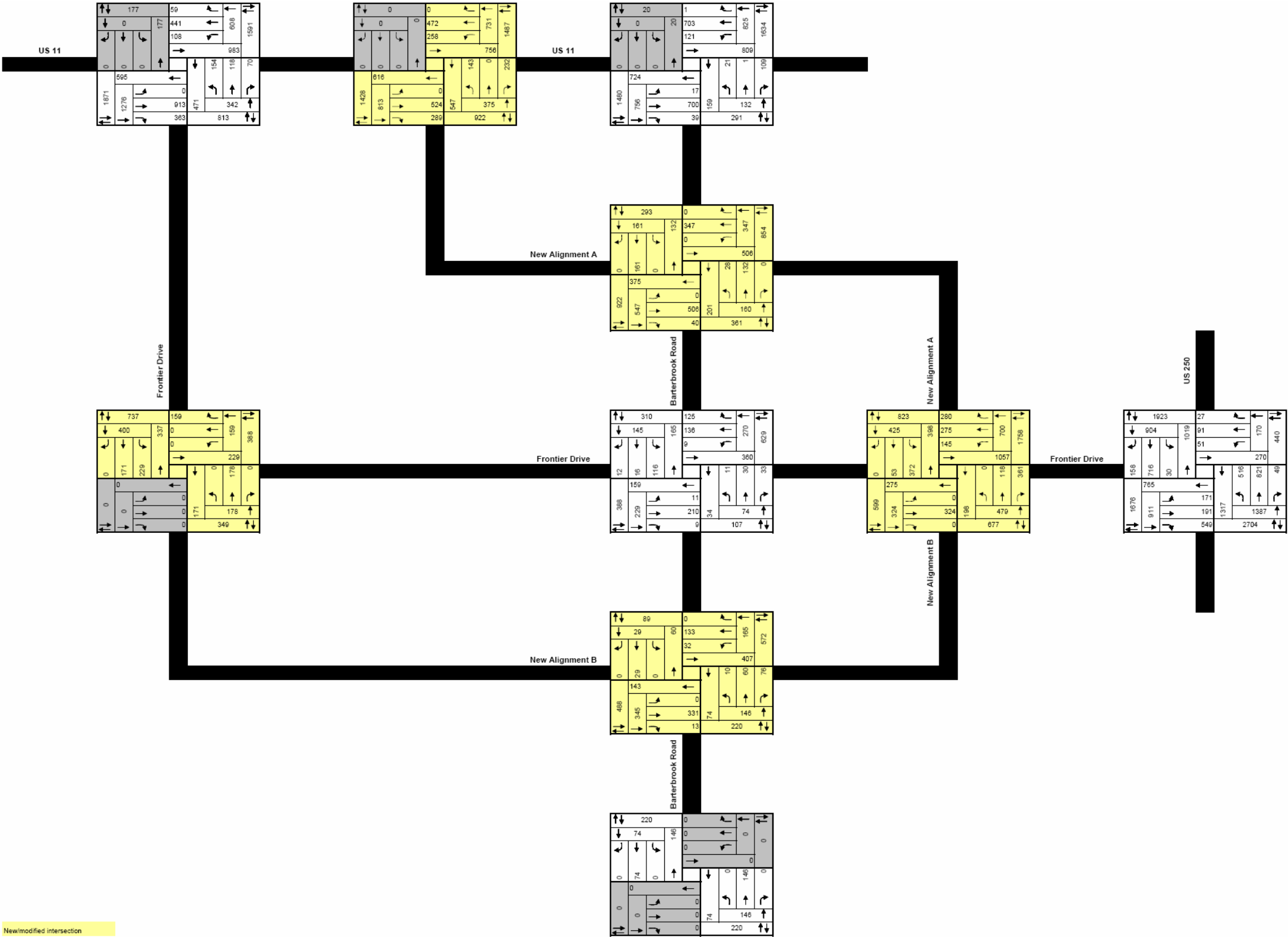
Alternative 1 – AM Peak Hour – Forecast Turning Volumes



Alternative 1 – PM Peak Hour – Forecast Turning Volumes



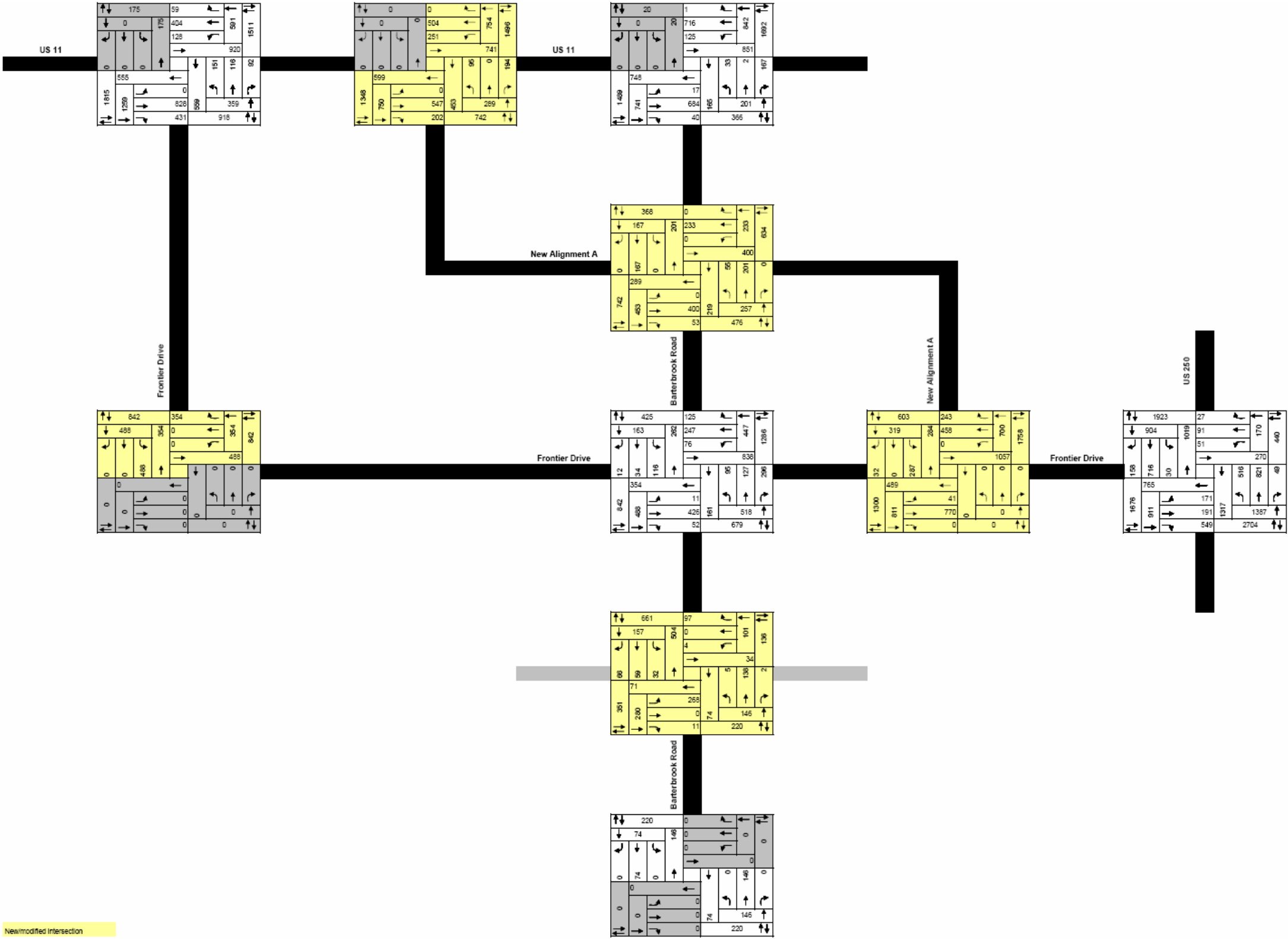
Alternative 2 – AM Peak Hour – Forecast Turning Volumes



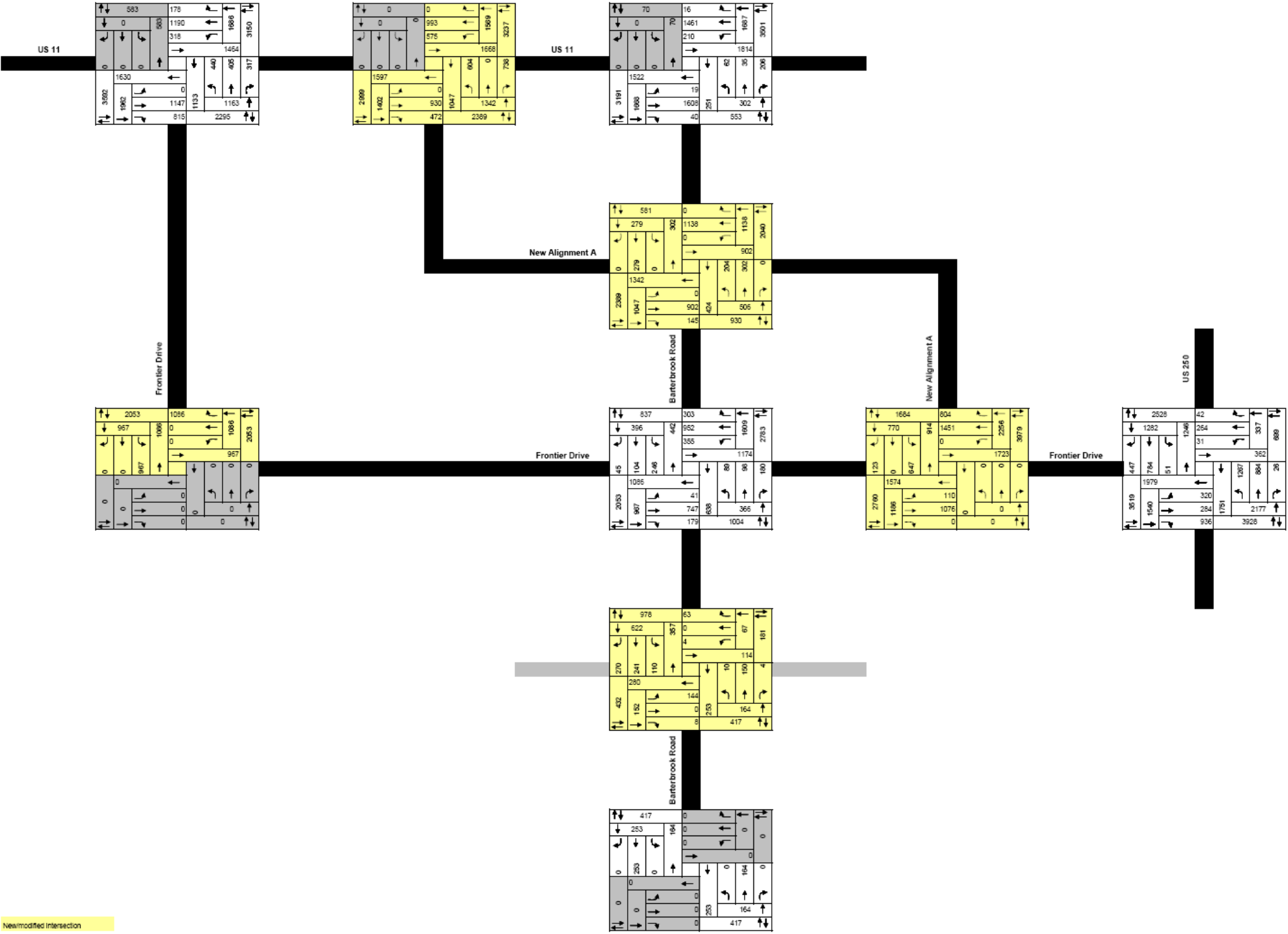
The diagram illustrates a proposed road network with the following features:

- US 11:** A major north-south corridor on the left side of the map.
- Frontier Drive:** A major east-west corridor running horizontally across the middle of the map.
- Barterbrook Road:** A north-south road located to the right of Frontier Drive.
- New Alignment A:** A proposed north-south road to the right of Barterbrook Road.
- New Alignment B:** A proposed north-south road to the right of New Alignment A.
- US 250:** A major north-south corridor on the far right side of the map.
- Intersections:** Key intersections are highlighted in yellow and labeled as "New/modification intersection". These include:
 - US 11 and Frontier Drive
 - Frontier Drive and Barterbrook Road
 - Frontier Drive and New Alignment A
 - Frontier Drive and New Alignment B
 - Barterbrook Road and New Alignment A
 - Barterbrook Road and New Alignment B
 - New Alignment A and US 250
 - New Alignment B and US 250
- Traffic Flow:** Arrows indicate the direction of traffic flow at each intersection.
- Vehicle Counts:** Numerical values are provided for various approaches, representing traffic volume or vehicle counts.

Alternative 3 – AM Peak Hour – Forecast Turning Volumes



Alternative 3 – PM Peak Hour – Forecast Turning Volumes



Appendix D: Build Condition Traffic Operations

Future (2035) Alternative 1 Capacity Analysis Results –Level of Service

INTERSECTION	TYPE OF CONTROL	MOVEMENT APPROACH***	AM PEAK HOUR		PM PEAK HOUR	
			LEVEL OF SERVICE	DELAY (SEC/VEH)	LEVEL OF SERVICE	DELAY (SEC/VEH)
1 GREENVILLE AVENUE (ROUTE 11) BARTERBROOK ROAD	SIGNALIZED	EB	C	32.5	C	34.8
		NB	B	12.8	C	33
		SB	A	9.3	B	18.9
		NWB	C	22.9	C	30.7
		OVERALL	B	12.4	C	26.8
2 GREENVILLE AVENUE (ROUTE 11) NEW ALIGNMENT A	SIGNALIZED	WB	C	22.4	C	34.1
		NB	C	21.2	C	28.7
		SB	A	7.9	B	18.7
		OVERALL	B	16.5	C	27.3
3 FRONTIER DRIVE GREENVILLE AVENUE (ROUTE 11)	SIGNALIZED	WB	C	29.4	C	20.8
		NB	B	10.1	B	10.9
		SB	A	6.7	B	11.4
		OVERALL	B	11.3	B	12.3
4 GREENVILLE AVENUE (ROUTE 11) NEW ALIGNMENT B-1	UNSIGNALIZED	WB L	B	11.9	B	19
		WB R	A	9.5	B	10.5
		NB T	*	*	*	*
		NB R	*	*	*	*
		SB L	A	8.2	A	9.1
		SB T	*	*	*	*
5 BARTERBROOK ROAD NEW ALIGNMENT A	SIGNALIZED	EB	B	10.7	B	18.1
		WB	A	8.2	C	20.5
		NB	C	20.2	B	19.2
		SB	C	29.7	C	34.2
		OVERALL	B	13.9	C	20.5
6 BARTERBROOK ROAD FRONTIER DRIVE	SIGNALIZED	EB	B	11.7	C	21.6
		WB	A	9.4	C	25.4
		NB	C	28.1	C	34.5
		SB	B	18.9	C	33.9
		OVERALL	B	14.2	C	26.6
7 BARTERBROOK ROAD NEW ALIGNMENT B-1	UNSIGNALIZED	NB	B	13.3	E	36.6
		SB	B	13.8	F	52.3
		NB L	*	*	*	*
		NB TR	*	*	*	*
		SB L	A	8	A	8.4
		SB TR	*	*	*	*
8 FRONTIER DRIVE RICHMOND ROAD (ROUTE 250)	SIGNALIZED	SEB	C	27.5	C	33.5
		NWB	C	23.7	C	34.7
		NEB	B	16.1	B	18.5
		SWB	C	34.7	C	34.7
		OVERALL	C	23.3	C	29.4
9 FRONTIER DRIVE NEW ALIGNMENT A	SIGNALIZED	SB	B	12	C	31
		NB	B	17.6	C	30.3

INTERSECTION	TYPE OF CONTROL	MOVEMENT APPROACH***	AM PEAK HOUR		PM PEAK HOUR	
			LEVEL OF SERVICE	DELAY (SEC/VEH)	LEVEL OF SERVICE	DELAY (SEC/VEH)
NEW ALIGNMENT B-1		WB	C	25.2	C	30.5
		EB	C	32.3	C	31.6
		OVERALL	C	21.8	C	30.7

- * SYNCHRO does not provide level of service or control delay for movements without conflicting volumes.
 SYNCHRO also does not provide overall level of service for unsignalized intersections.
- ** SYNCHRO does not report control delay greater than 9,999 seconds.
- *** NB = Northbound, SB = Southbound, EB = Eastbound, WB = Westbound
 NE(B) = Northeast (bound), NW(B) = Northwest (bound), SE(B) = Southeast (bound), SW(B) = Southwest (bound)
 L = Left, T = Through, R = Right

Future (2035) Alternative 2 Capacity Analysis Results –Level of Service

INTERSECTION	TYPE OF CONTROL	MOVEMENT APPROACH***	AM PEAK HOUR		PM PEAK HOUR	
			LEVEL OF SERVICE	DELAY (SEC/VEH)	LEVEL OF SERVICE	DELAY (SEC/VEH)
1 GREENVILLE AVENUE (ROUTE 11) BARTERBROOK ROAD	SIGNALIZED	EB	C	32.5	C	34.8
		NB	B	12.9	C	34.8
		SB	A	9.4	C	20.1
		NWB	C	22.9	C	30.7
		OVERALL	B	12.5	C	28
2 GREENVILLE AVENUE (ROUTE 11) NEW ALIGNMENT A	SIGNALIZED	WB	C	23	C	34.2
		NB	C	21.4	C	29.8
		SB	A	8	B	18.9
		OVERALL	B	16.6	C	27.5
3 FRONTIER DRIVE GREENVILLE AVENUE (ROUTE 11)	SIGNALIZED	WB	C	28.2	C	34.5
		NB	A	10	B	13.7
		SB	A	7.7	B	17.5
		OVERALL	B	12.5	B	17.8
4 FRONTIER DRIVE NEW ALIGNMENT B-2	SIGNALIZED	WB	C	26.4	C	24.5
		SB	A	1.6	A	4.1
		NB	A	6.7	B	12.3
		OVERALL	A	8.2	B	12
5 BARTERBROOK ROAD NEW ALIGNMENT A	SIGNALIZED	EB	B	11	B	18.1
		WB	A	8.8	C	20.5
		NB	C	20.2	B	18.7
		SB	C	29.7	C	34.2
		OVERALL	B	14.1	C	20.4
6 BARTERBROOK ROAD FRONTIER DRIVE	SIGNALIZED	EB	B	11.7	C	21.3
		WB	A	9.4	C	22.1
		NB	C	27.5	C	34.5
		SB	B	18.5	C	34.7
		OVERALL	B	14.3	C	25.3
7 BARTERBROOK ROAD NEW ALIGNMENT B-2	UNSIGNALIZED	NB	B	14.1	F	79.1
		SB	B	14.6	F	78.7
		NB L	*	*	*	*
		NB TR	*	*	*	*
		SB L	A	8.1	A	8.7
		SB TR	*	*	*	*

INTERSECTION	TYPE OF CONTROL	MOVEMENT APPROACH***	AM PEAK HOUR		PM PEAK HOUR	
			LEVEL OF SERVICE	DELAY (SEC/VEH)	LEVEL OF SERVICE	DELAY (SEC/VEH)
8 FRONTIER DRIVE RICHMOND ROAD (ROUTE 250)	SIGNALIZED	SEB	C	27.5	C	33.5
		NWB	C	23.7	C	34.7
		NEB	B	16.1	B	18.5
		SWB	C	34.7	C	34.7
		OVERALL	C	23.3	C	29.4
9 FRONTIER DRIVE NEW ALIGNMENT A NEW ALIGNMENT B-2	SIGNALIZED	SB	B	13.6	C	28.6
		NB	B	18.2	C	30.6
		WB	C	23.8	C	24.5
		EB	C	33.2	C	33.6
		OVERALL	C	21.8	C	27.3

- * SYNCHRO does not provide level of service or control delay for movements without conflicting volumes.
SYNCHRO also does not provide overall level of service for unsignalized intersections.
- ** SYNCHRO does not report control delay greater than 9,999 seconds.
- *** NB = Northbound, SB = Southbound, EB = Eastbound, WB = Westbound
NE(B) = Northeast (bound), NW(B) = Northwest (bound), SE(B) = Southeast (bound), SW(B) = Southwest (bound)
L = Left, T = Through, R = Right

Future (2035) Alternative 3 Capacity Analysis Results –Level of Service

INTERSECTION	TYPE OF CONTROL	MOVEMENT APPROACH***	AM PEAK HOUR		PM PEAK HOUR	
			LEVEL OF SERVICE	DELAY (SEC/VEH)	LEVEL OF SERVICE	DELAY (SEC/VEH)
1 GREENVILLE AVENUE (ROUTE 11) BARTERBROOK ROAD	SIGNALIZED	WB	C	32.1	D	48.3
		NB	B	14.1	C	21.7
		SB	A	3	B	15.5
		Overall	A	11.5	C	21.3
2 GREENVILLE AVENUE (ROUTE 11) NEW ALIGNMENT A	SIGNALIZED	WB	C	31	D	50.8
		NB	A	2.9	C	30
		SB	B	14.3	C	20.3
		Overall	B	12.2	C	32.9
3 FRONTIER DRIVE GREENVILLE AVENUE (ROUTE 11)	SIGNALIZED	WB	C	32.3	D	40.1
		NB	A	7.8	E	71.5
		SB	A	9.1	C	20.6
		Overall	B	12.7	D	53.8
4 BARTERBROOK ROAD NEW ALIGNMENT A	SIGNALIZED	EB	C	27	C	25.7
		WB	C	32.6	D	39.9
		NB	A	4	C	22.7
		SB	A	6.7	D	47
		Overall	B	19.8	C	32.6
5 BARTERBROOK ROAD FRONTIER DRIVE	SIGNALIZED	EB	B	18.1	C	23
		WB	B	14.1	C	22.9
		NB	C	22.2	C	26.4
		SB	C	22.7	C	34.3
		Overall	B	18.9	C	24.7
6 FRONTIER DRIVE RICHMOND ROAD (ROUTE 250)	SIGNALIZED	SEB	C	27.5	C	33.5
		NWB	C	23.7	C	34.7
		NEB	B	16.1	B	18.5

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			SWB	C	34.7	C	34.7
			OVERALL	C	23.3	C	29.4
7	FRONTIER DRIVE	SIGNALIZED	EB	C	20.4	D	42
	NEW ALIGNMENT A		NB	A	4.5	B	12.4
			SB	A	2.7	A	6.3
			Overall	A	6.6	B	14.5

*** NB = Northbound, SB = Southbound, EB = Eastbound, WB = Westbound
NE(B) = Northeast (bound), NW(B) = Northwest (bound), SE(B) = Southeast (bound), SW(B) = Southwest (bound)
L = Left, T = Through, R = Right

Appendix E: Construction Cost Estimate Details

Alternative 1

Description	Type	Length (LF)	Cross Section (FT)	Quantity	Unit	Unit Cost	Amount
Frontier Drive widening	Roadway	5250	64	336,000	SF	\$12.00	\$4,032,000
	Demolition	5250	24	126,000	SF	\$1.25	\$158,000
	Sidewalk	5250	8	4,667	SY	\$48.00	\$224,000
	Earthwork	2625		81,667	CY	\$10.00	\$817,000
	Earthwork	2625		20,417	CY	\$10.00	\$204,000
	Retaining Wall	2625	10	52,500	SF	\$75.00	\$3,938,000
	Total						\$9,373,000
New Alignment A	Roadway	3500	64	224,000	SF	\$12.00	\$2,688,000
	Sidewalk	3500	8	3,111	SY	\$48.00	\$149,000
	Earthwork			47,963	CY	\$10.00	\$480,000
	Total						\$3,317,000
New Alignment B-1	Roadway	6700	64	428,800	SF	\$12.00	\$5,146,000
	Bridge	400	76	30,400	SF	\$200.00	\$6,080,000
	Sidewalk	6700	8	5,956	SY	\$48.00	\$286,000
	Earthwork			91,815	CY	\$10.00	\$918,000
	Earthwork-Bridge	100	76	8,593	CY	\$10.00	\$86,000
	Total						\$12,516,000

Roadway Improvements Subtotal \$25,206,000

Additional Items Based on Percentage of Roadway Subtotal

Description	Percentage	Amount
Drainage and Stormwater Management Items	30%	\$7,562,000
Roadside Development and Incidental Items	20%	\$5,041,000
Signing and Pavement Marking Items	20%	\$5,041,000
Maintenance of Traffic Items	15%	\$3,781,000
Lighting	10%	\$2,521,000

Traffic Signals

Description	Type	Quantity	Unit Cost	Amount
Frontier Drive / New Alignments A & B	Signal	1.00	\$200,000	\$200,000
New Alignment A / Barterbrook Road	Signal	1.00	\$200,000	\$200,000
New Alignment A / US 11	Signal	1.00	\$200,000	\$200,000
New Alignment B / Barterbrook Road	Signal	1.00	\$200,000	\$200,000
Frontier Drive / US 11	Signal adjustments	1.00	\$100,000	\$100,000
Frontier Drive / US 250	Signal adjustments	1.00	\$100,000	\$100,000
Barterbrook Road / US 11	Signal adjustments	1.00	\$100,000	\$100,000

Project Subtotal \$50,252,000

Items Based on Project Subtotal

	Percentage	Amount
Construction Surveying (1% of Project Subtotal)	1%	\$503,000
Mobilization [\$80,000 + 5% x (Project Subtotal - \$1,000,000)]	5%	\$2,543,000
Engineering (15% of Project Subtotal)	15%	\$7,538,000
Contingency (10% of Project Subtotal)	10%	\$5,025,000
Inflation (0.68% per year)	20%	\$10,050,000

PROJECT CONSTRUCTION TOTAL \$75,911,000

Say \$76,000,000

Alternative 2

Description	Type	Length (LF)	Cross Section (FT)	Quantity	Unit	Unit Cost	Amount
Frontier Drive widening	Roadway	5250	64	336,000	SF	\$12.00	\$4,032,000
	Demolition	5250	24	126,000	SF	\$1.25	\$158,000
	Sidewalk	5250	8	4,667	SY	\$48.00	\$224,000
	Earthwork	2625		81,667	CY	\$10.00	\$817,000
	Earthwork	2625		20,417	CY	\$10.00	\$204,000
	Retaining Wall	2625	10	52,500	SF	\$75.00	\$3,938,000
	Total						\$9,373,000
New Alignment A	Roadway	3500	64	224,000	SF	\$12.00	\$2,688,000
	Sidewalk	3500	8	3,111	SY	\$48.00	\$149,000
	Earthwork			47,963	CY	\$10.00	\$480,000
	Total						\$3,317,000
New Alignment B-2	Roadway	5700	64	364,800	SF	\$12.00	\$4,378,000
	Sidewalk	5700	8	5,067	SY	\$48.00	\$243,000
	Earthwork			78,111	CY	\$10.00	\$781,000
	Total						\$5,402,000

Roadway Improvements Subtotal \$18,092,000

Additional Items Based on Percentage of Roadway Subtotal

Description	Percentage	Amount
Drainage and Stormwater Management Items	30%	\$5,428,000
Roadside Development and Incidental Items	20%	\$3,618,000
Signing and Pavement Marking Items	20%	\$3,618,000
Maintenance of Traffic Items	15%	\$2,714,000
Lighting	10%	\$1,809,000

Traffic Signals

Description	Type	Quantity	Unit Cost	Amount
Frontier Drive / New Alignments A & B	Signal	1.00	\$200,000	\$200,000
New Alignment A / Barterbrook Road	Signal	1.00	\$200,000	\$200,000
New Alignment A / US 11	Signal	1.00	\$200,000	\$200,000
New Alignment B / Barterbrook Road	Signal	1.00	\$200,000	\$200,000
Frontier Drive / US 11	Signal adjustments	1.00	\$100,000	\$100,000
Frontier Drive / US 250	Signal adjustments	1.00	\$100,000	\$100,000
Barterbrook Road / US 11	Signal adjustments	1.00	\$100,000	\$100,000

Project Subtotal \$36,379,000

Items Based on Project Subtotal

	Percentage	Amount
Construction Surveying (1% of Project Subtotal)	1%	\$364,000
Mobilization [\$80,000 + 5% x (Project Subtotal - \$1,000,000)]	5%	\$1,849,000
Engineering (15% of Project Subtotal)	15%	\$5,457,000
Contingency (10% of Project Subtotal)	10%	\$3,638,000
Inflation (0.68% per year)	20%	\$7,276,000

PROJECT CONSTRUCTION TOTAL \$54,963,000

Say \$55,000,000

Frontier Drive Corridor Improvement Study
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Alternative 3

Description	Type	Length (LF)	Cross Section (FT)	Quantity	Unit	Unit Cost	Amount
Frontier Drive widening (north/east of Barterbrook Road)	Roadway	6750	64	432,000	SF	\$12.00	\$5,184,000
	Demolition	6750	24	162,000	SF	\$1.25	\$203,000
	Sidewalk	6750	8	6,000	SY	\$48.00	\$288,000
	Earthwork	2625		81,667	CY	\$10.00	\$817,000
	Earthwork	4125		32,083	CY	\$10.00	\$321,000
	Retaining Wall	2625	10	52,500	SF	\$75.00	\$3,938,000
	Total						\$10,751,000
Frontier Drive widening (south/west of Barterbrook Road)	Roadway	2800	64	179,200	SF	\$12.00	\$2,150,000
	Demolition	2800	24	67,200	SF	\$1.25	\$84,000
	Sidewalk	2800	8	2,489	SY	\$48.00	\$119,000
	Earthwork			38,370	CY	\$10.00	\$384,000
	Total						\$2,737,000
New Alignment A	Roadway	3500	64	224,000	SF	\$12.00	\$2,688,000
	Sidewalk	3500	8	3,111	SY	\$48.00	\$149,000
	Earthwork			47,963	CY	\$10.00	\$480,000
	Total						\$3,317,000
Barterbrook Road Improvements to Boyd Homes	Roadway	2300	64	147,200	SF	\$12.00	\$1,766,000
	Sidewalk	2300	8	2,044	SY	\$48.00	\$98,000
	Earthwork			31,519	CY	\$10.00	\$315,000
	Total						\$2,179,000

Roadway Improvements Subtotal \$18,984,000

Additional Items Based on Percentage of Roadway Subtotal

Description	Percentage	Amount
Drainage and Stormwater Management Items	30%	\$5,695,000
Roadside Development and Incidental Items	20%	\$3,797,000
Signing and Pavement Marking Items	20%	\$3,797,000
Maintenance of Traffic Items	15%	\$2,848,000
Lighting	10%	\$1,898,000

Traffic Signals

Description	Type	Quantity	Unit Cost	Amount
Frontier Drive / New Alignment A	Signal	1.00	\$200,000	\$200,000
New Alignment A / Barterbrook Road	Signal	1.00	\$200,000	\$200,000
New Alignment A / US 11	Signal	1.00	\$200,000	\$200,000
Frontier Drive / US 11	Signal adjustments	1.00	\$100,000	\$100,000
Frontier Drive / US 250	Signal adjustments	1.00	\$100,000	\$100,000
Barterbrook Road / US 11	Signal adjustments	1.00	\$100,000	\$100,000

Project Subtotal \$37,919,000

Items Based on Project Subtotal

	Percentage	Amount
Construction Surveying (1% of Project Subtotal)	1%	\$379,000
Mobilization [\$80,000 + 5% x (Project Subtotal - \$1,000,000)]	5%	\$1,926,000
Engineering (15% of Project Subtotal)	15%	\$5,688,000
Contingency (10% of Project Subtotal)	10%	\$3,792,000
Inflation (0.68% per year)	20%	\$7,584,000

PROJECT CONSTRUCTION TOTAL \$57,288,000
Say \$57,000,000

Appendix F: Public Meeting Summary and Comments

A public information meeting was held on Wednesday, May 21, 2008, from 4:00 p.m. to 6:00 p.m. The meeting was held at the Augusta County Government Center, 18 Government Center Lane, Verona, VA 24482. The meeting was an open house format with six display boards showing existing conditions, the range of concepts considered, three draft alternatives, and an evaluation matrix.

Sixty-six members of the public signed the sign-in sheet. It was noted that many attendees did not wish to sign in, mainly because a member of their party already signed in. It was estimated that over 100 members of the public attended the meeting. The meeting was also attended by print and television news media staff.

Representatives of VDOT, Augusta County, the City of Staunton, and the consultant team were on hand to answer questions about the study. Comment forms and a study summary handout were distributed at the meeting.

Sixteen written comment forms were completed and submitted at the meeting, and two additional written comments were submitted within two weeks of the meeting. In addition, some attendees made comments that were posted on the display boards. The written comments received to date can be categorized as follows.

Comment	Number of Responses
Support Alternative 1	3
Support Alternative 2	5
Support Alternative 3	1 (follow Old County Road alignment)
Oppose Alternative 1	1
Alternative 1 negatively affects my home/business	2
Alternative 2 negatively affects my home/business	4
Alternative 3 negatively affects my home/business	6
Oppose New Alignment A (northern connection between Frontier Dr and US 11)	1

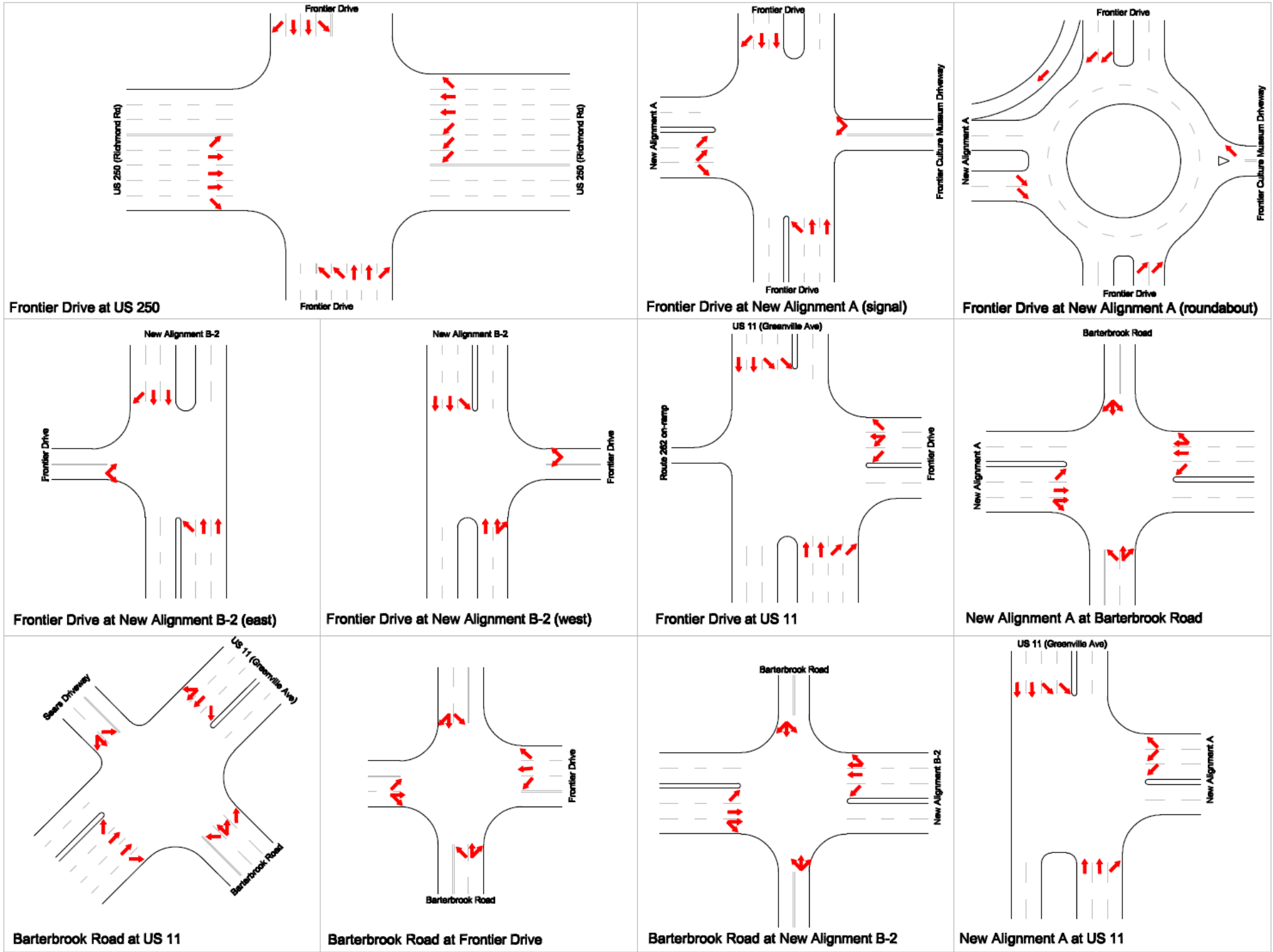
Comment	Number of Responses
Oppose New Alignment C (internal road to Frontier Culture Museum site redevelopment property)	1
Prefer none of the Alternatives, but Alternative 2 is the least objectionable	3
Support sidewalk/multi-use trail	1
Support using Red Oak Drive as alignment	1
Oppose using Red Oak Drive as alignment	1
Install signal at Red Oak Drive and Frontier Drive	2
Do not install signal or roundabout at Red Oak Drive and Frontier Drive	1
Roadway widening should occur on new development parcels	1
Roadway widening in neighborhood should be made only on one side to avoid taking homes on both sides	1
Install speed bumps on residential portion of Frontier Drive	1
Make Frontier Drive a dead-end at Manchester Apartments – force drivers to take another route around study area	2
Encourage Statler Boulevard as an alternative route from US 11 to US 250	1
Connect Frontier Drive to Route 262 at-grade	1
Concern about access to Frontier Drive in neighborhood	1
Concern about losing land/house and compensation	1
Keep public/homeowners informed so they can make appropriate decisions	1
Frontier Culture Museum expanding exhibits to northeast	1

Comment	Number of Responses
Create direct access to Frontier Culture Museum from Frontier Drive – do not mix museum and non-museum traffic	1

Other themes expressed by attendees as recollected by the study team were:

- Several attendees were upset about the recent intersection improvements at Barterbrook and Frontier and were distrustful of the planning and implementation process.
- Several people asked that nothing be done to the road - slow down traffic, increase law enforcement, and basically make it so nobody wants to travel the road.
- Questions were raised about access management and road design (why divided instead of 5 lane section).
- Residents of Frontier Drive and Sunset Boulevard didn't support anything that impacts them. However, some residents did speak to how hard it is to access their properties now with all the traffic.
- Residents of Barterbrook Drive didn't support options that impact them.
- Concerns were raised about the impact on Third Presbyterian Church.
- Concerns were raised by property owners about the impact of potential road plans on their individual property values.
- Attendees asked how the County could allow anything on the potential residential development site; it will just make things worse. However, the developer wanted to know if the County was going to condemn properties so the connection to Frontier Drive could be made.
- Several attendees suggested the old alignment of Route 635 was better and we should revert back to that.
- Alternatives were too vague to provide real comments.
- People did not like the alternatives that took properties in the denser residential area in the County, affected by both Alternatives 2 and 3. They were in favor of Alternative 1 which bridged Route 262.
- People are worried about losing their house/business and the details of that acquisition process.
- Many people had the opinion that if an alternative negatively affected them, then they would not support it.
- Everyone wanted to be kept informed.
- Representatives from the Frontier Culture Museum expressed their strong desire to be an active participant in future planning efforts.
- One attendee who lived across from Red Oak Drive wanted to keep his house and not be taken out in improvements.
- Attendees who lived at the sharp curve on Frontier Drive felt they would not be able to sell their house because of the announcement of the proposed improvements.

Appendix G: Recommended Alternative Intersection Configurations



Conceptual Intersection Configurations

Not to scale

Appendix H: Access Management Recommendations

Access management is a strategy to control access to existing and future development while maintaining an acceptable flow of traffic on the surrounding roadway network. The various strategies in the access management toolbox are intended to improve safety (e.g., reduce the number of crashes) and improve traffic operations (e.g., reduce delays) on critical transportation corridors.

By properly managing access to the roadway network, government agencies can extend the life of roads and highways and improve the appearance and quality of the built environment. Based on years of research and implementation of access management strategies on critical transportation corridors throughout the country, the following benefits have been determined:

- Fewer and less severe crashes
- Reduced congestion and traffic delays
- Reduced travel times
- Reduced air pollution due to fewer stops
- Reduced need for widening and new construction
- Preservation of public investment in transportation system
- Better access to businesses
- Improved mobility
- Land uses compatible with function of corridor

One of the most important aspects of access management pertains to the concept of developing and applying varying spacing and design standards for roadways with different functions. For example, to preserve the function of a principal arterial, which is to provide higher speed through movement between large activity centers, there should be fewer traffic conflicts on the roadway, which means that the spacing of driveways, median openings, and traffic signals should be greater than the spacing on a minor arterial road.

A traffic conflict occurs when the paths of vehicles (including pedestrians and bicycles) intersect, including merging, diverging, stopping, weaving, or crossing movements. Each conflict point is the potential for a collision. For this reason, VDOT has developed a chart for spacing of these features that shows higher values for principal arterials, lower values for minor arterials, and even lower values for collector roads.

Some of the other key principles of access management include separating conflict areas, removing turning vehicles from the through lane, and limiting the number of conflict points. By separating conflict areas, the driving task is simplified, which leads to improved safety and traffic operations. Providing left and right turn lanes at key

locations in a corridor can greatly improve the capacity and reduce the potential for crashes. By reducing the number of conflict points, vehicular, pedestrian, and bicycle operations are improved. Studies have shown that the left turn into an entrance and the left turn out of an entrance contribute to almost seventy-five percent of all crashes at an intersection. Therefore, it is critical to determine the most appropriate location for these full movement entrances to reduce the potential for crashes.

Since Frontier Drive connects two principal arterials (Richmond Road (US 250) and Greenville Avenue (US 11)), the functional classification of the roadway fits in the minor collector category. Because the corridor is included within an urban boundary, it would be functionally classified as an urban minor arterial.

Late last fall the Virginia Department of Transportation developed new access management regulations and standards for principal arterials that go into effect on July 1, 2008. All roadways with a functional classification lower than principal arterial (i.e., minor arterials, collectors, and locals) will be delayed for implementation until October 1, 2009, after a rigorous public review through the Administrative Process Act. Therefore, since the proposed standards that are presented herein are in alignment with the currently proposed VDOT standards, they may be changed slightly next year depending on public and governmental comments from around the state.

The recommendations for access management standards for this corridor should be consistent with the direction that VDOT is heading. Therefore, the following spacing information for entrances, median openings, and traffic signals were derived from the VDOT draft policy for urban minor arterials that presented for public review in December 2007. For the purposes of selecting an applicable spacing standard for the corridor, it was assumed that the legal speed limit on the facility would be posted at 35 mph.

Based on recommendations from national publications such as the *Access Management Manual* that was published in 2003, there are several other design standards that should be adhered to in this corridor. For example, the minimum corner clearance of entrances from intersecting streets should be 325 feet based on the information provided in **Table H-1**. Other design considerations such as intersection sight distance, entrance grades, and left/right turn storage, and taper lengths should be derived from Appendix C of the VDOT Road Design Manual.

Table H-1: Spacing Standards for Commercial Entrances and Intersections				
Highway Functional Classification	Legal Speed Limit (mph)①	Centerline to Centerline Spacing in Feet		
		Signalized Intersections②	Unsignalized Intersections & Full Access Entrances③	Partial Access Two Way Entrance④
Urban Minor Arterial⑤	≤ 30 mph	1,320	660	270
	35 to 45 mph	1,320	660	325
	≥ 50 mph	1,760	1,050	510

- ① **Legal Speed Limit** – Use legal speed limit unless the design speed is available and approved for use by VDOT.
- ② **Signalized Intersection Spacing** – Allocated in fractions of a mile: (1/2 mile, 2,640 ft); (1/3 mile, 1,760 ft); (1/4 mile, 1,320 ft); (1/5 mile, 1,050 ft); (1/8 mile, 660 ft); (1/16 mile, 330 ft). Based on Transportation and Land Development by Vergil Stover and Frank Koepke, Institute of Transportation Engineers, pages 4-23 to 4-32 and Figure 4-16 Relationship Between Progression Speed, Cycle Length, and Signal Spacing. Page 4-23: “Traffic signal control applied in a sequential pattern according to specific spacing criteria optimize traffic efficiency” ... “to reduce fuel consumption, reduce delay, reduce vehicular emissions and improve safety.”
- ③ **Unsignalized Intersections and Full Access Entrances** – These operate in a similar manner such that spacing standards can apply to both equally. Because some intersections and entrances can eventually become signalized, spacing should relate to signalized intersection spacing. Therefore, the spacing standards are generally one half of those for signalized intersections.
- ④ **Partial Access Two Way Entrances: Arterials** – Left turn movements are limited. Spacing for this type of entrance, e.g. right in/right out with/without left in movement, on arterials is based on the length of a right auxiliary turn lane (entering taper, deceleration length, storage length) needed for a safe deceleration from the full design speed of the highway for turning into an entrance. A Policy on Geometric Design of Highways and Streets 2004, AASHTO, pages 713 to 716. Calculations: (30 mph, 270 ft); (35 mph, 325 ft); (40 mph, 375 ft); (45 mph, 440 ft); (50 mph, 510 ft); (55 mph, 585 ft).
- ⑤ **Minor Arterials** – “Urban” is an abbreviation of “urban area” as defined in the Introduction to this document. On older, established business corridors of a locality where existing entrances and intersections did not meet the above spacing standards prior to the effective date of the Access Management Regulations (24 VAC 30-72) for highways with a functional classification as an urban arterial or urban collector, spacing for new entrances and intersections may be allowed by the District Administrator or designee that is consistent with the established spacing along the highway, provided that reasonable efforts are made to comply with the access management requirements in 24 VAC 30-72-120 of the Access Management Regulations including restricting entrances within the functional areas of intersections, sharing entrances with and providing vehicular and pedestrian connections between adjacent properties, and physically restricting entrances to right-in or right-out or both movements.



LEGEND

Potential Signalized Intersection Location

Potential Unsignalized Intersection Location

Existing Signalized Intersection Location

Existing Network

Potential Future Network

Alignment Alternatives

FUTURE ACCESS
MANAGEMENT
CONCEPT

Frontier Drive Corridor Improvement Study Existing Conditions and Traffic Forecast

This report documents the existing conditions traffic analysis and the future traffic forecast for the Frontier Drive Corridor Improvement Study.

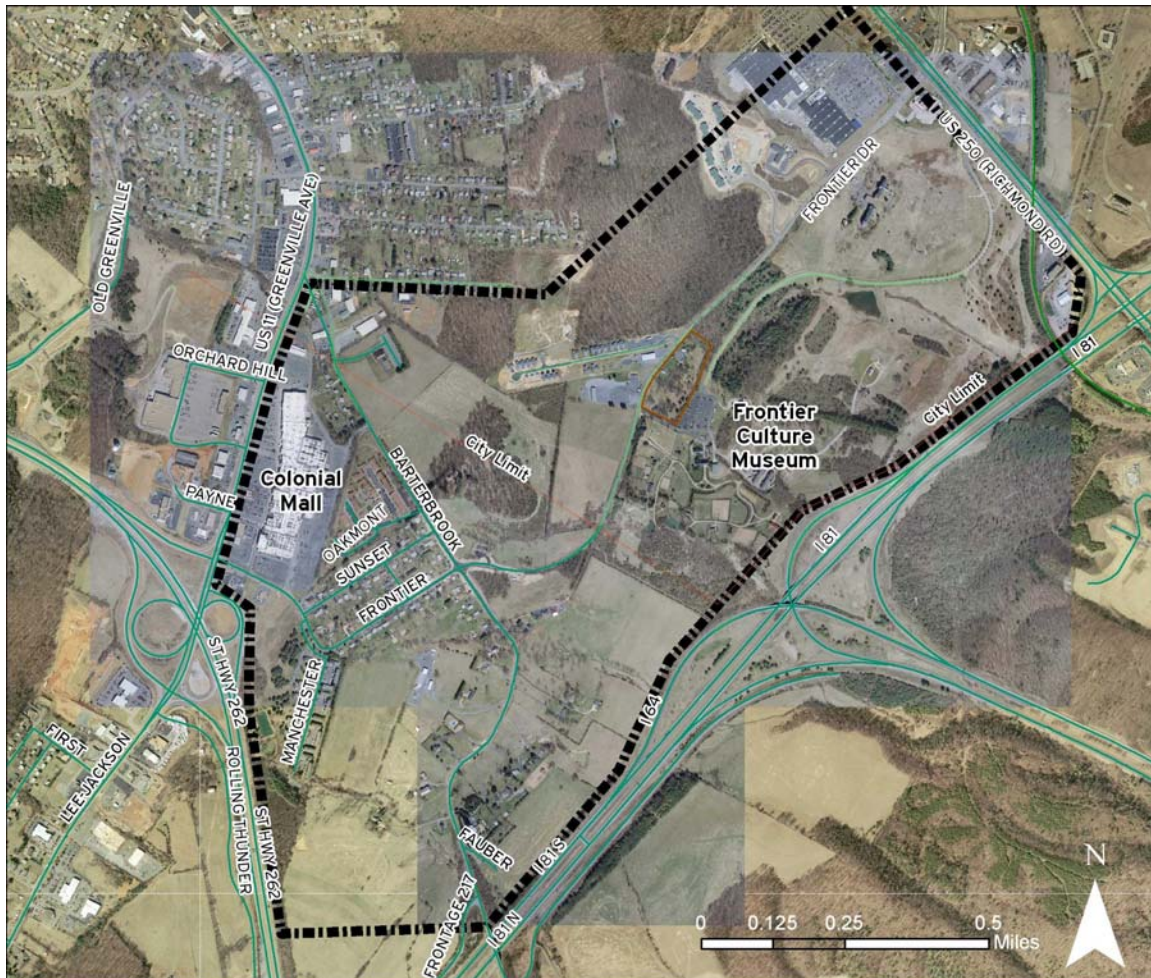
Existing Conditions

This section describes the main roadways within the study area (Frontier Drive and Barterbrook Road), reviews traffic data collected, and presents the existing intersection performance.

Study area

The study area encompasses Frontier Drive between US 11 (Greenville Avenue) and US 250 (Richmond Road) and Barterbrook Road between US 11 and I-81. The study area includes portions of both the City of Staunton and Augusta County.

Figure 1: Study Area Boundary



Within the study area, Frontier Drive has one travel lane in each direction and is approximately 24 feet wide. Frontier Drive has a rural typical cross section with open drainage and minimal shoulders throughout most of its length. A wider shoulder is found along the south side of Frontier Drive in the residential area west of Barterbrook Road. Short segments of curb-and-gutter section exist near US 250, around Barterbrook Road, and again near US 11. Barterbrook Road has one travel lane in each direction and is approximately 22 feet wide. Barterbrook Road also has a rural typical cross section with open drainage and no shoulders for most of its length. Short segments of curb-and-gutter section exist near US 11 and around Frontier Drive.

The intersection of Frontier Drive and Barterbrook Road was recently reconstructed to improve sight distance and upgrade the traffic signal. All approaches have exclusive left turn lanes, and the westbound approach also has an exclusive right turn lane.

At US 11, Frontier Drive has an exclusive right turn lane and a shared through and left turn lane. At US 250, Frontier Drive has an exclusive left turn lane, an exclusive right turn lane, and two through lanes. At US 11, Barterbrook Road has one lane for all movements.

Traffic counts

Turning movement counts were collected by City of Staunton staff on April 16–26, 2007, at the following locations:

- Frontier Drive at Barterbrook Road
- Frontier Drive at US 11 (Greenville Avenue)
- Frontier Drive at Colonial Mall driveway
- Frontier Drive at Lowe's/Sheetz driveway
- Frontier Drive at US 250 (Richmond Road)
- Barterbrook Road at US 11 (Greenville Avenue)

These counts were conducted during morning and evening peak periods.

In addition, 48-hour volume counts were taken by VDOT in January, March, and April 2007 at the following locations:

- Frontier Dr between US 11 to Staunton city limit (0.75 mi from US 11)
- US 11 between Staunton city limit and Statler Blvd (0.01 mi from Staunton city limit)
- Barterbrook Rd between Staunton city limit and Greenville Ave (0.1 mi from Staunton city limit)
- Barterbrook Rd south of Frontier Dr (0.28 mi from Rt 1428)

- Barterbrook Rd between Frontier Dr and Staunton city limit (0.30 mi from Frontier Dr)
- Frontier Dr between Staunton city limit and Richmond Rd (0.47 mi from Staunton city limit)
- US 250 between Statler Blvd and Frontier Rd (0.2 mi From Statler Blvd)
- US 250 between US 11 and Statler Blvd (0.5 mi from US 11)

Intersection performance

The intersection level of service was evaluated at the intersections where turning movement counts were taken.

Synchro 7 software was used to evaluate levels of service. AM and PM peak hour volumes at each individual intersection were used rather than a global peak hour for the study area. The reason for this decision is that the intersections are far enough apart not to interact, and there are many sources and sinks between intersections to alter volumes. Signal timing plans were provided by VDOT and the City of Staunton. Analysis results are given in Table 1.

The existing intersection levels of service are generally acceptable in the peak hours. However, the intersection of Frontier Drive and Greenville Avenue operates at an undesirable Level of Service (LOS) D in the afternoon peak.

Crash analysis

Crash data supplied by the City of Staunton and VDOT were reviewed. Four roadway segments were analyzed: Frontier Drive between the Staunton city limit and US 250, Frontier Drive between US 11 and the Staunton city limit, Barterbrook Road between the Staunton city limit and Frontier Drive, and Barterbrook Road between Frontier Drive and Rt 1428. For the first location (in the City), data was available for January 2001 through December 2004. For the remaining locations (in the County), data was available for March 2002 through February 2007. Rear end and angle crash types predominated along Frontier Drive, while along Barterbrook Road fixed object crash types predominated. Table 2 summarizes the findings. Crash rates are highest on Barterbrook Road south of Frontier Drive and on Frontier Drive within the Staunton city limits. These are the least developed portions of the study area.

Table 1: Existing Condition (2007) Capacity Analysis Results

	INTERSECTION	TYPE OF CONTROL	MOVEMENT APPROACH***	AM PEAK HOUR		PM PEAK HOUR	
				LEVEL OF SERVICE	DELAY (SEC/VEH)	LEVEL OF SERVICE	DELAY (SEC/VEH)
1	GREENVILLE AVENUE (ROUTE 11) BARTERBROOK ROAD	SIGNALIZED	EB	C	34.2	D	36.7
			NB	B	10.1	B	15.8
			SB	A	7.4	B	11.6
			NWB	C	32.9	D	38
			OVERALL	B	12	B	17.3
2	FRONTIER DRIVE GREENVILLE AVENUE (ROUTE 11)	SIGNALIZED	WB	C	23.2	D	37.5
			NB	B	10.1	D	49.8
			SB	A	6.9	B	11
			OVERALL	B	10.9	D	37.3
3	FRONTIER DRIVE MALL/BANK ENTRANCE	UNSIGNALIZED	EB TL	A	1.5	A	4.7
			EB R	*	*	*	*
			WB TL	*	*	A	0.2
			WB R	*	*	*	*
			NB	B	12.5	D	32.6
			SB	B	11.1	C	19.1
4	BARTERBROOK ROAD FRONTIER DRIVE	SIGNALIZED	NB	C	32.1	C	33.3
			SB	C	24	C	23.6
			NEB	A	7.8	B	10.1
			SWB	A	6.8	A	8.4
			OVERALL	B	13.2	B	13.2
5	FRONTIER DRIVE SHEETZ ENTRANCE	UNSIGNALIZED	NW L	B	14.1	C	18
			NW R	A	9.5	A	9.5
			NE T	*	*	*	*
			NE R	*	*	*	*
			SW	A	4.3	A	2.8
6	FRONTIER DRIVE LOWES ENTRANCE	UNSIGNALIZED	SE L	C	15.7	D	29.4
			SE R	A	9.5	B	11.8
			NE L	A	8.1	A	9.2
			NE T	*	*	*	*
			SW	*	*	*	*
7	FRONTIER DRIVE RICHMOND ROAD (ROUTE 250)	SIGNALIZED	SEB	C	24.2	C	34
			NWB	B	17.1	C	23.2
			NEB	C	33	D	38.5
			SWB	C	34.8	D	40.5
			OVERALL	C	22.7	C	30.4

* SYNCHRO does not provide level of service or control delay for movements without conflicting volumes.

SYNCHRO also does not provide overall level of service for unsignalized intersections.

** SYNCHRO does not report control delay greater than 9,999 seconds.

*** NB = Northbound, SB = Southbound, EB = Eastbound, WB = Westbound
NE(B) = Northeast (bound), NW(B) = Northwest (bound), SE(B) = Southeast (bound), SW(B) = Southwest (bound),
L = Left, T = Through, R = Right

Table 2: Crash Analysis

Segment	Time Period	Crashes	Injuries or Deaths	Crashes per million VMT	Injuries or Deaths per million VMT
Frontier Dr between US 11 and Staunton C/L	3/1/02 - 2/28/07	19	7	2.47	0.78
Barterbrook Rd between Staunton C/L and Frontier Dr	3/1/02 - 2/28/07	2	1	0.78	0.39
Barterbrook Rd between Frontier Dr and Rt 1428	3/1/02 - 2/28/07	10	2	10.99	2.20
Frontier Dr between Staunton C/L and US 250	1/1/01 - 12/31/04	61	22	9.57	3.45

Traffic Forecast

This section describes the trip generation, trip distribution, and trip assignment steps for the future traffic forecast. The traffic forecast is for the ultimate anticipated development within the study area.

Trip generation

Anticipated land uses from comprehensive plans for the City of Staunton and Augusta County were used as the basis for trip generation. In addition, proposed developments in two locations — the Frontier Culture Museum site and the Boyd Homes site — were included based on information supplied by Augusta County and the City of Staunton. Trip generation rates for these two developments were as reported by traffic impact studies for these sites. For the remaining development, trip generation rates published by the Institute of Transportation Engineers were used.¹ Most of this remaining development was assumed to be shopping centers to reflect mix of higher trip generators like fast food restaurants and lower trip generators like professional offices.

Assumptions used in the trip generation calculations were:

- Floor Area Ratio (FAR) of 0.35
- Assumed no pass-by² because existing land uses are mainly residential, so their inbound trips will not be intercepted by retail land uses, particularly in the morning.

Sites of future development and/or redevelopment are shown in Figure 2. Trip generation rates and calculated number of trips are given in Table 3. The parcel numbers assigned to the sites in Figure 2 correlate to the parcel numbers listed in the second column of Table 3.

¹ *Trip Generation*, 7th edition. Institute of Transportation Engineers (2003)

² Pass-by trips are those trips already using the roadway accessing a new land use that are forecast to make a stop at the new land use.

Figure 2: Future Land Use Parcel Numbers

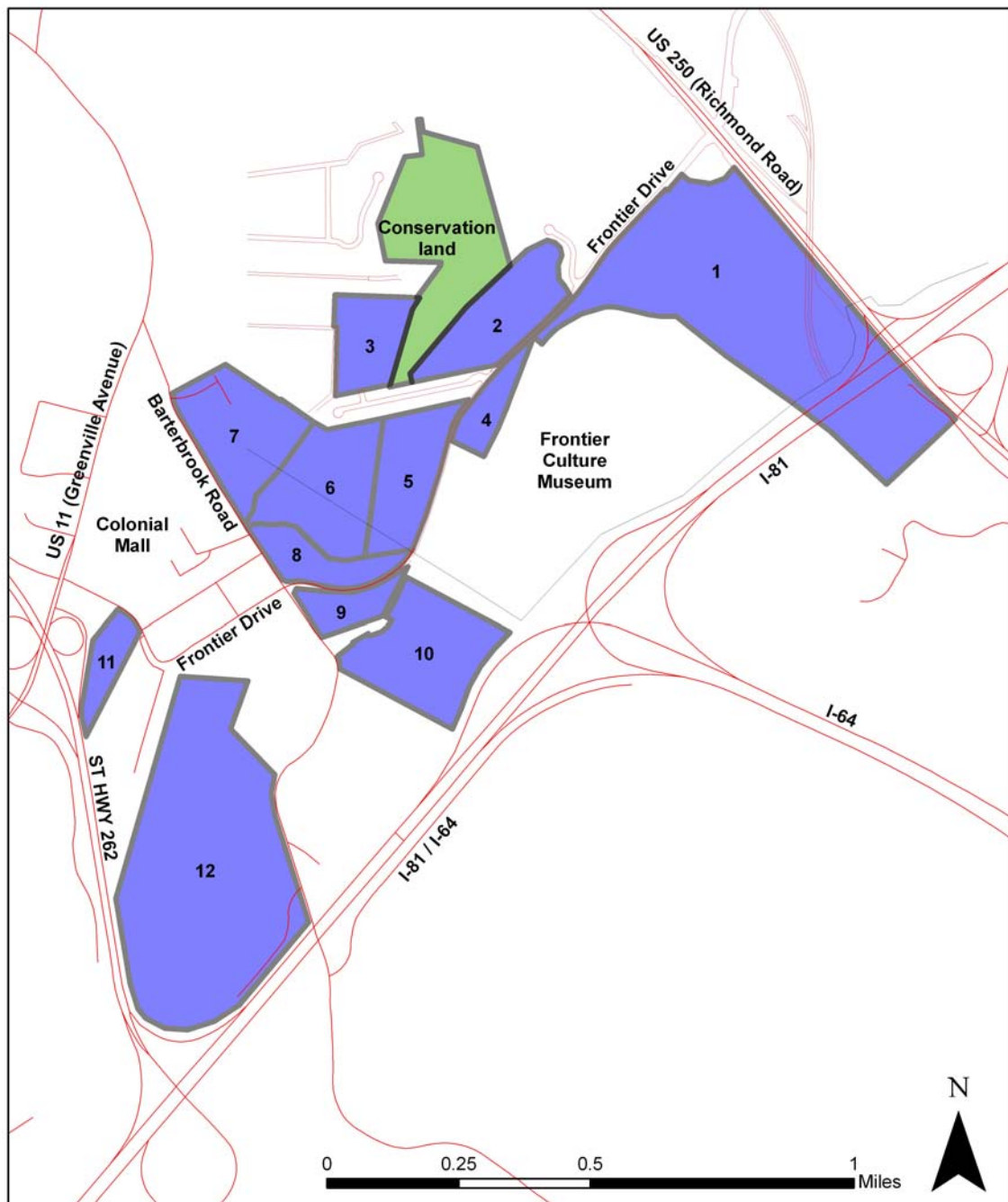


Table 3: Trip Generation for Ultimate Development

Jurisdiction	Parcel #	Parcel Location	Land Use	ITE Code	Amount/Unit		VEHICLE TRIPS				
							Daily	AM Peak		PM Peak	
							Rate Trips	Rate Trips Entering	Rate Trips Exiting	Rate Trips Entering	Rate Trips Exiting
City of Staunton	1	Frontier Culture Museum site (1)	Retail	Shopping Center	350,000	square feet	42.9	0.6	0.4	1.8	1.9
				820			7,508	105	70	315	333
			Office	General Office	300,000	square feet	11.0	1.4	0.2	0.3	1.2
				710			1,650	210	30	45	180
			Restaurants	Sit-Down Restaurant	9,500	square feet	130.0	4.8	4.4	6.5	4.3
				832			618	23	21	31	20
			Manufactured Home Park	Mobile Home Park	250	dwelling units	4.8	0.1	0.3	0.3	0.2
				240			600	13	38	38	25
			Motel	Motel	200	rooms	5.6	0.2	0.3	0.3	0.2
				320			560	20	30	30	20
			Hotel/Conference Center	Hotel	300	rooms	8.2	0.3	0.2	0.3	0.3
				310			1,230	45	30	45	45
	2	22 acres northwest of Frontier Dr (2)	Mixed Use	(3)	83,853	square feet	42.94	0.63	0.40	1.80	1.95
			Residential	Single-Family Detached Housing			3,601	53	34	151	164
				210			9.57	0.19	0.56	0.64	0.37
	3	14.5 acres on Scarlet Oak Dr (future)	Residential	Single-Family Detached Housing	58	dwelling units	421	8	25	28	16
				210			9.57	0.19	0.56	0.64	0.37
Augusta County	4	7.5 acres east of Frontier Dr and west of Frontier Culture Museum site	Planned Business	(3)	114,345	square feet	555	11	32	37	21
							42.94	0.63	0.40	1.80	1.95
	5	20 acres northwest of Frontier Dr	Planned Business	(3)	304,920	square feet	4,910	72	46	206	223
							42.94	0.63	0.40	1.80	1.95
	6	27.5 acres northeast of Barterbrook Rd; spans Staunton city limits (2)	Mixed Use	(3)	104,816	square feet	13,093	192	122	549	595
							42.94	0.63	0.40	1.80	1.95
	7	25.5 acres northeast of Barterbrook Rd; spans Staunton city limits	Residential	Single-Family Detached Housing	55	dwelling units	4,501	66	42	189	204
							9.57	0.19	0.56	0.64	0.37
	8	11.5 acres on north corner of Frontier Dr and Barterbrook Rd	Mixed Use (The Roller Family Partnership Property)	(3)	175,329	square feet	526	10	31	35	20
							42.94	0.63	0.40	1.80	1.95
	9	8 acres on east corner of Frontier Dr and Barterbrook Rd	Mixed Use	(3)	121,968	square feet	7,529	110	70	316	342
							42.94	0.63	0.40	1.80	1.95
	10	30 acres south of Frontier Culture Museum site and west of I-81/I-64	Mixed Use	Single-Family Detached Housing	180	dwelling units	5,237	77	49	220	238
							9.57	0.19	0.56	0.64	0.37
				210			1,723	34	101	115	67

Jurisdiction	Parcel #	Parcel Location	Land Use	ITE Code	Amount/Unit		VEHICLE TRIPS				
							Daily	AM Peak		PM Peak	
							Rate	Rate	Rate	Rate	Rate
							Trips	Trips Entering	Trips Exiting	Trips Entering	Trips Exiting
	11	7.5 acres south of Frontier Dr and northeast of State Highway 262	Mixed Use	(3)	114,345	square feet	42.94	0.63	0.40	1.80	1.95
	12	86 acres on north corner of I-81/I-64 and State Highway 262	Mixed Use (Boyd Homes Concept Zoning Master Plan)	Single-Family Detached Housing	138	dwelling units	4,910	72	46	206	223
							9.57	0.19	0.56	0.64	0.37
				210	276	dwelling units	1,321	26	77	88	51
				Apartment			6.72	0.10	0.41	0.40	0.22
				220	237	dwelling units	1,855	28	113	110	61
				Residential Condominium/Townhouse			5.86	0.07	0.37	0.35	0.17
	230	1,389	17	88	83	40					
TOTAL							71,380	1,437	1,249	3,536	3,646
Notes											
(1) Trips calculated for the Frontier Culture Museum site were reduced by 50% because one of the site's two access points is out of our study area.											
(2) Due to excessive slopes, only 50% of the land area of these parcels was considered developable.											
(3) "Shopping Center" trip rates were used for the land uses "Planned Business" in the City of Staunton and "Mixed Use" (where it was deemed appropriate for commercial development) in Augusta County.											

Trip distribution

Forecast future trips were distributed to the four portals of the study area using the same distribution percentages currently observed. The portals are:

- Frontier Drive at US 11 (Greenville Avenue)
- Frontier Drive at US 250 (Richmond Road)
- Barterbrook Road at I-81
- Barterbrook Road at US 11 (Greenville Avenue)

Morning and afternoon peak hours have different distributions. These are given in Figure 3 and Figure 4.

Figure 3: Existing trip distribution — morning peak hour

Existing Trip Percentages
AM Peak Hour

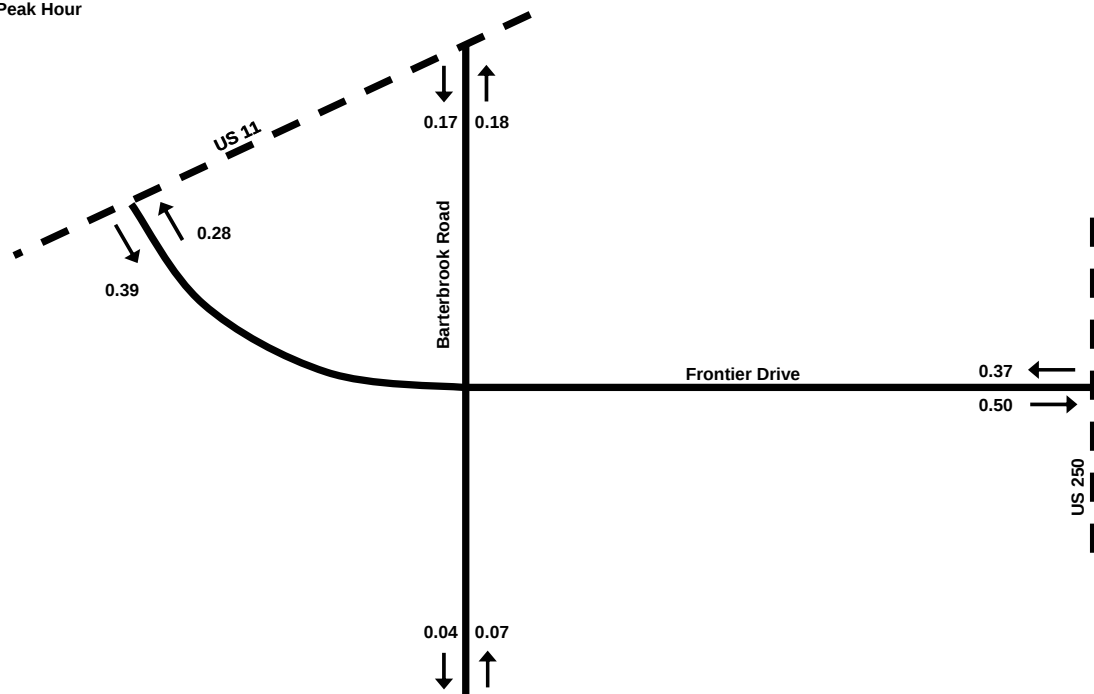
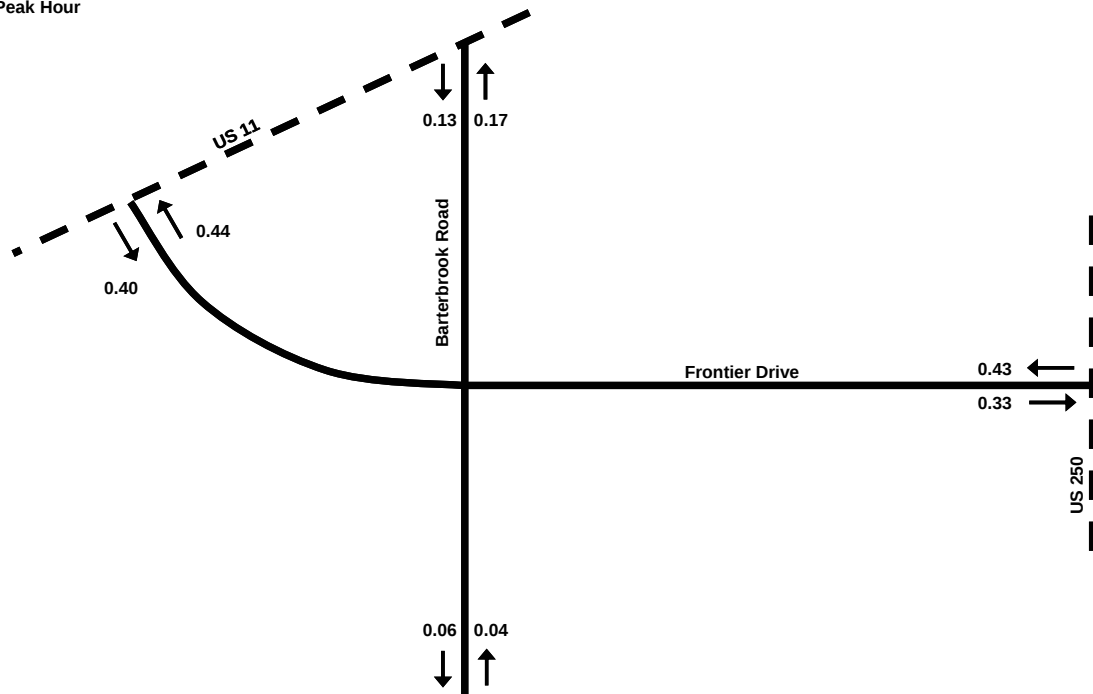


Figure 4: Existing trip distribution — afternoon peak hour

Existing Trip Percentages
PM Peak Hour



Trip assignment

Trips were assigned to and from new development to the portals along Frontier Drive and Barterbrook Road. Turning volumes were forecast at Frontier Drive and US 11, at Frontier Drive and US 250, and at Barterbrook Road and US 11 using the same turning percentages as measured during the turning movement counts. Turning volumes were forecast at Barterbrook Road and Frontier Drive based on the trip distribution to the portals and the location of the anticipated development access to the roadway network.

Forecast turning volumes from anticipated development were then superimposed on existing turning volumes. Based on professional development and on discussions and consensus with VDOT, Augusta County, and the City of Staunton, it has been assumed that background (existing) traffic will grow at a rate of 0.25% per year to the target year of 2035 and will be assigned to the existing network, following the same paths as in the no-build condition.

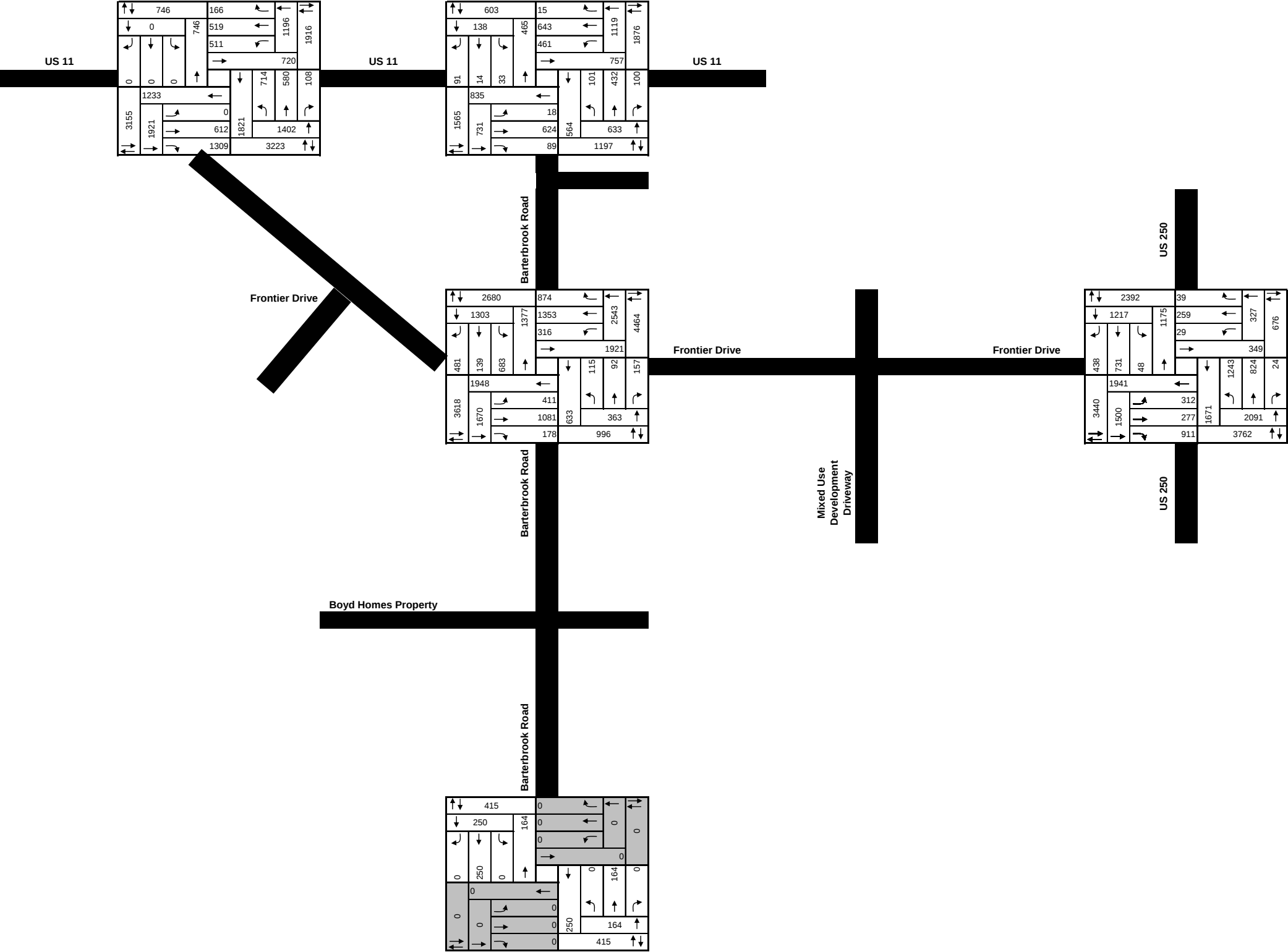
Total forecast volumes (existing plus anticipated future) are shown in Figure 5 and Figure 6.

The diagram illustrates a complex intersection involving US 11, Barterbrook Road, and Frontier Drive. The layout is divided into several key sections:

- Top Section (US 11):** Shows traffic flow entering from the left and right. The left side has a large volume of 1675 moving south, while the right side has a volume of 938 moving south. Various lane movements are indicated with arrows and smaller numbers.
- Center Section (Frontier Drive):** A diagonal road crossing the intersection. It shows traffic flow from the bottom-left towards the top-right. Key volumes include 1189 and 571 moving south, and 1305 moving north.
- Right Section (Barterbrook Road):** A vertical road running through the intersection. It shows traffic flow from the top and bottom. Key volumes include 368 and 264 moving west, and 683 and 272 moving east.
- Bottom Section (Boyd Homes Property):** A horizontal road at the bottom of the diagram. It shows traffic flow from the left and right. Key volumes include 218 and 73 moving north, and 144 and 0 moving south.

The diagram uses a color-coded system to distinguish between different types of traffic or movements. Grey areas represent one category, while white areas represent another. Arrows indicate the direction of travel, and numbers represent the volume of traffic for each movement.

Figure 6: Forecast turning volumes — ultimate development — afternoon peak hour



Next Steps

The next steps in this study are:

1. Analyze the “no-build” condition – that is, the future volumes on the existing network.
2. Identify potential deficiencies and improvement alternatives