Naval Station Norfolk Transit Extension Study

Norfolk, Virginia

FINAL REPORT

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Norfolk, Virginia

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Executive Summary

1.0 EXECUTIVE SUMMARY

Hampton Roads Transit (HRT), the City of Norfolk, and the citizens of Norfolk and Hampton Roads are partnering to study the feasibility of extending fixed guideway transit to Naval Station Norfolk (NSN). This study, the Naval Station Norfolk Transit Extension Study (NSNTES), is looking at the potential opportunities, benefits, and impacts of a fixed guideway transit connection between The Tide, NSN, and other key destinations in the City.

1.1 INTRODUCTION

The efficient movement of military and civilian personnel to NSN is critical for national military readiness as well as for achieving the economic development goals of the City of Norfolk. NSN is the largest naval base in the world and is the region's largest employment center - between 60,000 to 70,000 people may be working at NSN and nearby facilities at any given time. As part of the region's daily commuting patterns, automobile travel demand to the base regularly exceeds the capacity of the surrounding streets and highways, including Hampton Boulevard, Terminal Boulevard, W. Little Creek Road, I-64, and I-564. Delay on these roadways is expected to worsen over time. Efficient, high-capacity transit would provide an alternative to automobile travel and a way for employees to avoid daily congestion around NSN. A transit extension connecting NSN to The Tide would leverage the significant investment the region has made in fixed guideway transit and offer the region's residents multiple mobility options to the largest employment center.

The NSNTES is also examining the transportation needs of other key destinations in Norfolk, including Old Dominion University (ODU), Ghent-area commercial and retail on Colley Avenue and 21st Street, Norfolk International Airport, the Lake Wright Business Park, the Military Highway commercial and retail corridor, and other adjacent local communities. Additional mobility choices can enhance Norfolk's economic potential by improving access to employment and activity centers and by creating transit-oriented development (TOD) opportunities. This effort supports local and regional plans and policies, including Norfolk's general plan, known as plaNorfolk2030, and the Virginia Department of Rail and Public Transportation's Hampton Roads Regional Transit Vision Plan, with both calling for a balanced, multi-modal transportation system.

1.2 STUDY PROCESS

The NSNTES was completed in two phases referred to as Tier 1 and Tier 2. The Tier 1 phase began with an initial set of public meetings in June 2013 to identify issues and opportunities arising from connecting The Tide to NSN. The results of these meetings led to the development of a draft of the NSNTES' *Purpose and Need* statement and a set of seven project themes. The *Purpose and Need* statement is shown in its entirety in Section 2.1.2 on page 2-2, but the core message is that the NSNTES would be:

"An efficient, high-capacity transit connection to Naval Station Norfolk would provide an alternative to driving in congested traffic to access NSN" and that the NSNTES would:

"…Create a more multi-modal transportation system that helps support the region's economic competitiveness."

The project themes accompany the *Purpose and Need* statement in defining the goals of the NSNTES by identifying what a transit extension to NSN should accomplish. The project themes are:

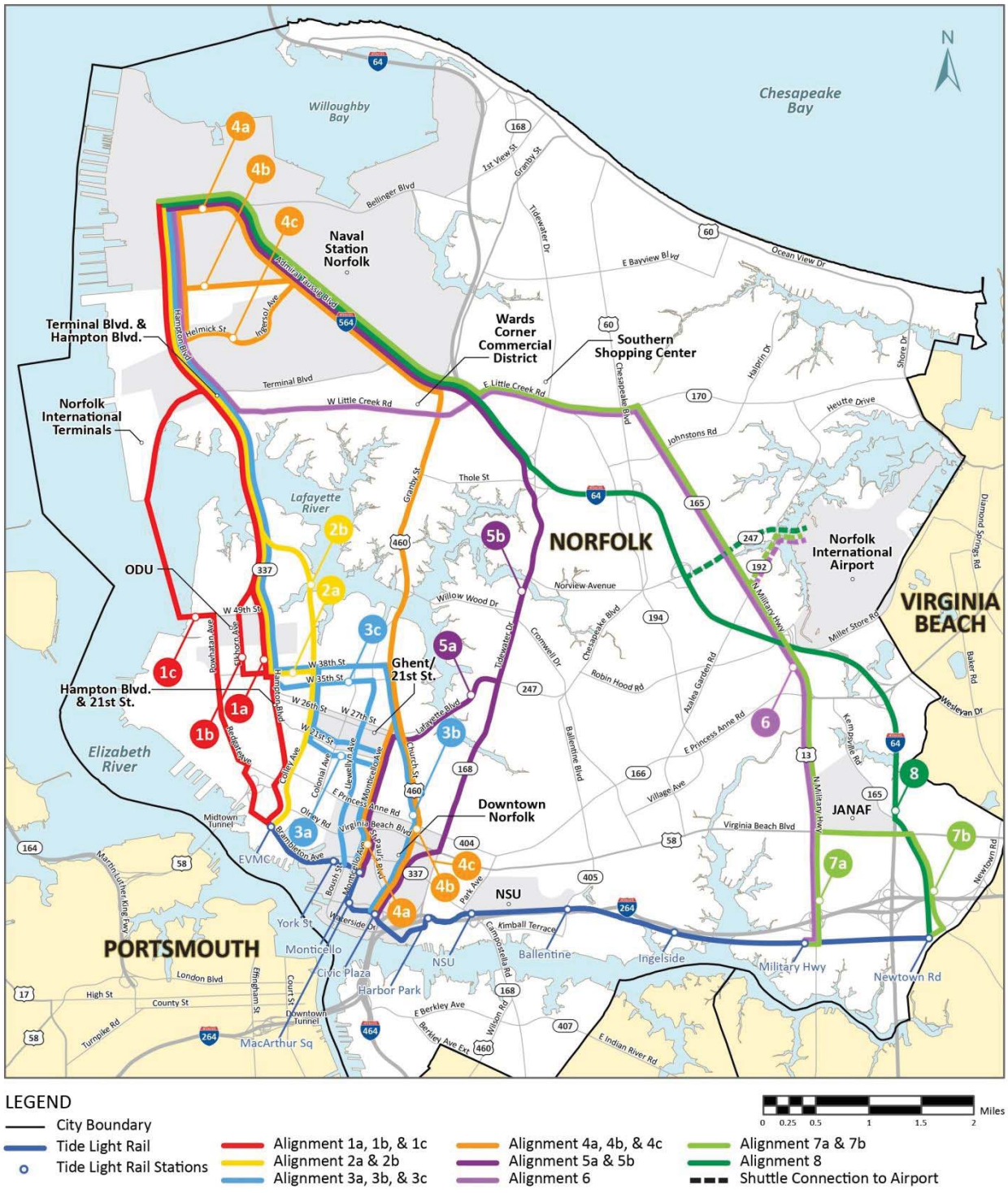
1. The transit extension should connect many points within Norfolk, not just the Naval Station.
2. The transit extension should provide an alternative to heavy traffic and congestion.
3. A fixed guideway transit connection between The Tide and NSN should make travel time more reliable.
4. The transit extension should provide parking for transit riders.
5. The transit extension should connect to other transit modes.
6. Planning for the transit extension should ensure it can be expanded in the future.
7. Identify environmental impacts, right-of-way constraints, economic development and neighborhood revitalization, and resiliency.

A second set of public meetings held in September 2013 refined the *Purpose and Need* statement and project themes, ranked the study priorities, located key activity centers, and identified preferred study corridors and 17 preliminary conceptual alignments as shown on the following page in **Figure 1**.

Following the September 2013 meetings, a set of technical evaluation criteria were developed based on public input and the project themes. The Tier 1 screening analyzed the 17 preliminary conceptual alignments using data from HRT, the City of Norfolk, and other sources. The results of the analysis were presented to the public in set of workshops in February/March 2014. Based on public feedback from the February/March 2014 workshops, the technical analysis of the alignments, and input from HRT and the City of Norfolk, a subset of six conceptual alignments (shown in **Figure 3**) were advanced to the Tier 2 screening phase.

The Tier 2 screening of the conceptual alignments included an analysis of potential station service areas and right-of-way along each alignment, preliminary ridership forecasts, potential environmental impacts, and traffic effects of each alignment on selected intersections. After the completion of the Tier 2 technical analysis, the six alignments and accompanying results were presented to the public in a series of workshops in October 2014. Based upon public input at the October 2014 workshops and review by HRT, five options were presented as potential options for advancement to the next stage in the transit study. The five options are shown in **Figure 4** through **Figure 8**.

Figure 1. Alignments for Tier 1 Screening Analysis



1.3 STUDY MILESTONES

Figure 2 below displays the major study milestones throughout the project's timeline.

Figure 2. Overall Study Process and Schedule

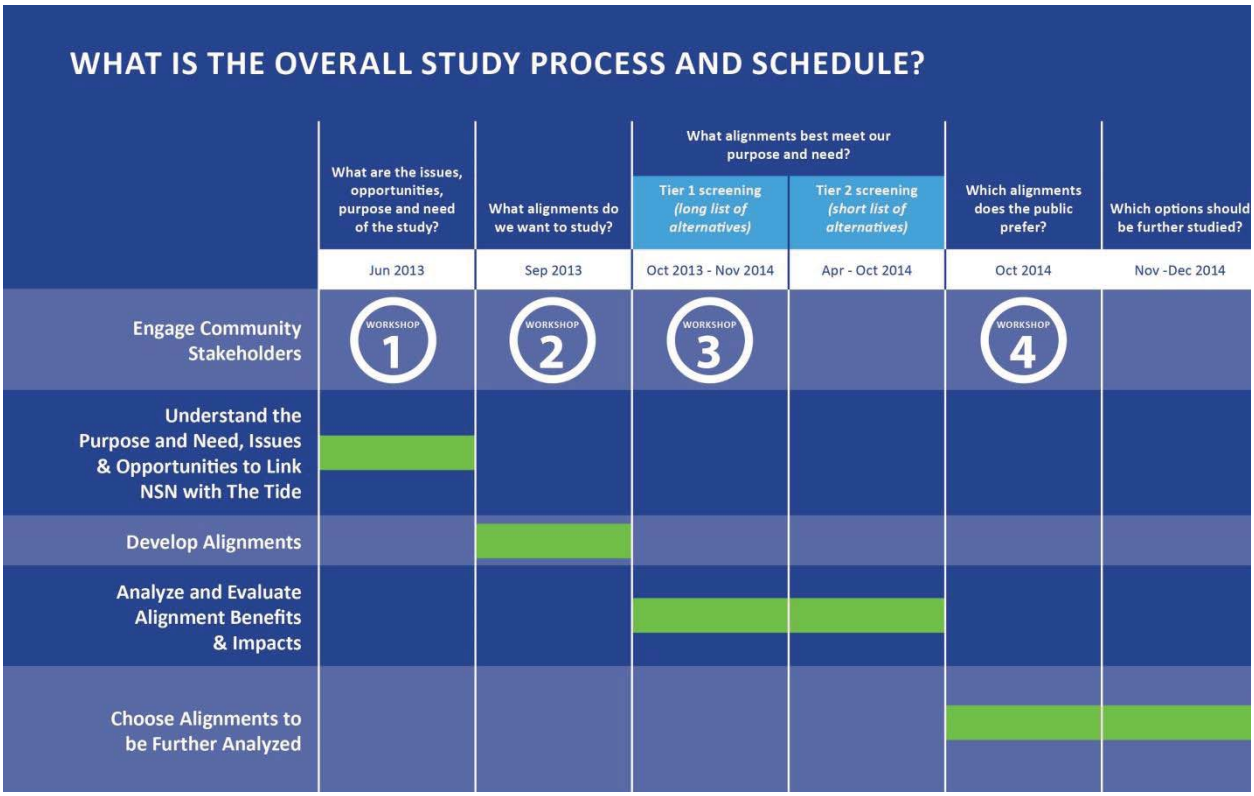


Figure 3. Alignments for Tier 2 Screening Analysis

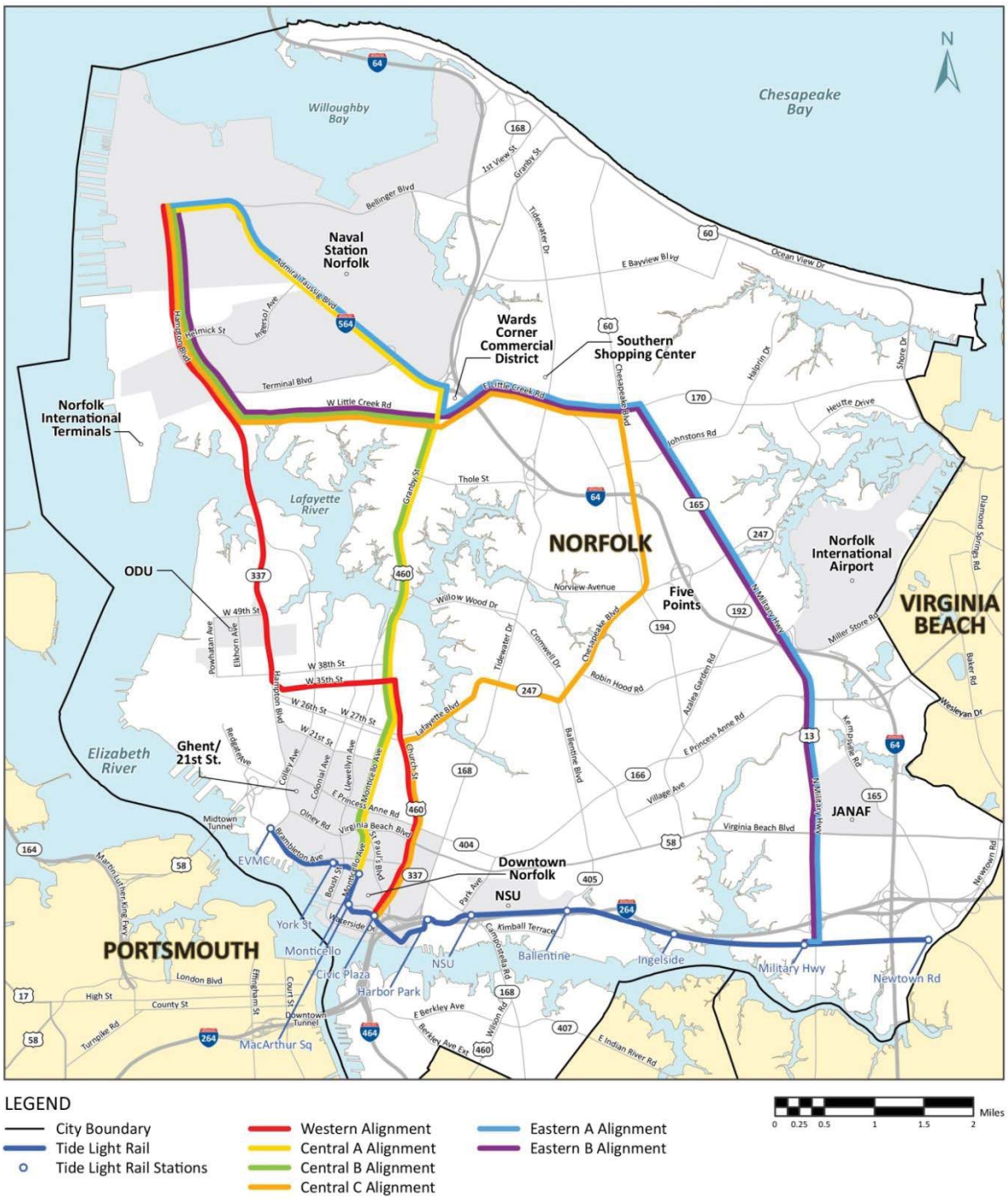


Figure 4. Option 1

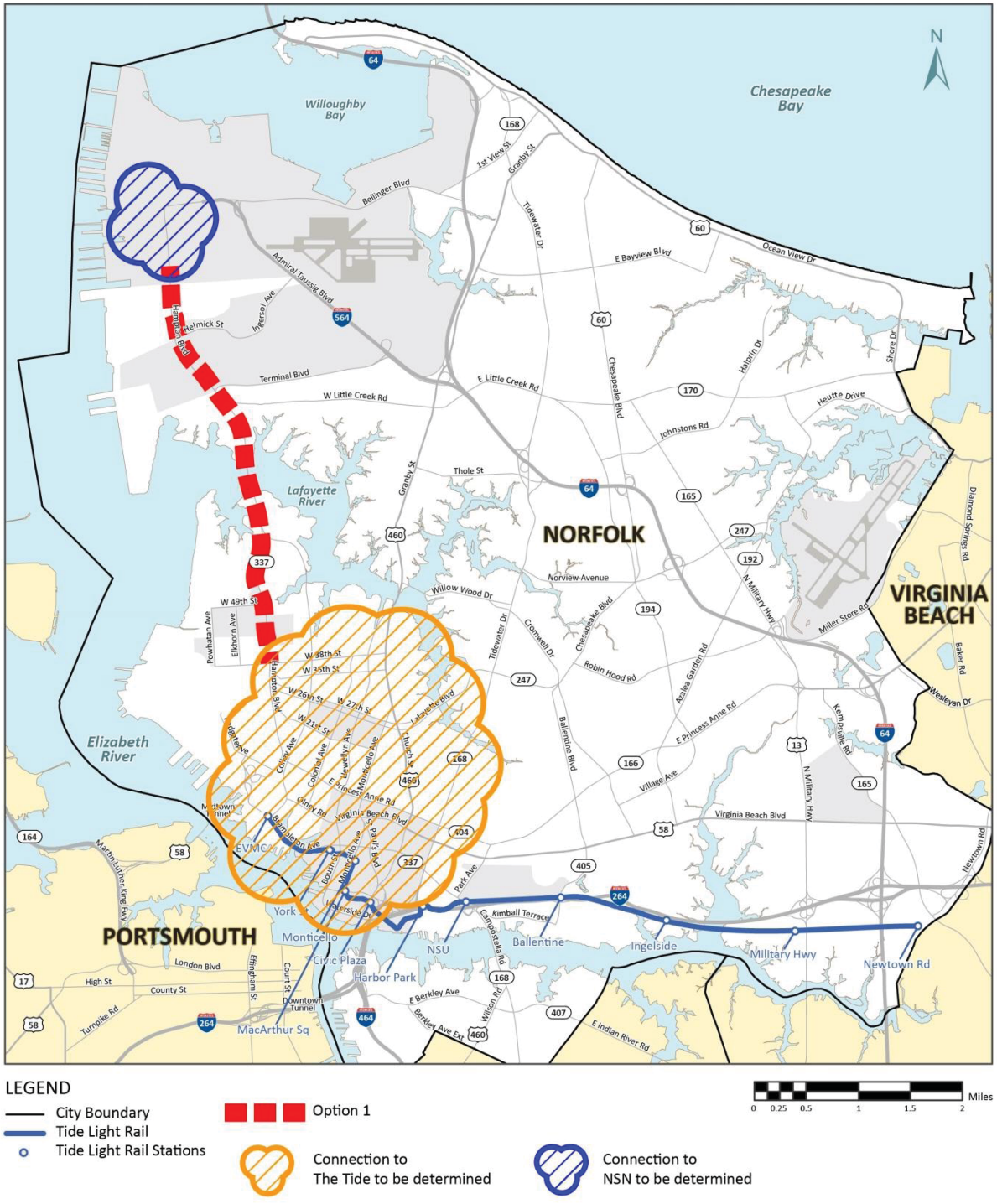


Figure 5. Option 2

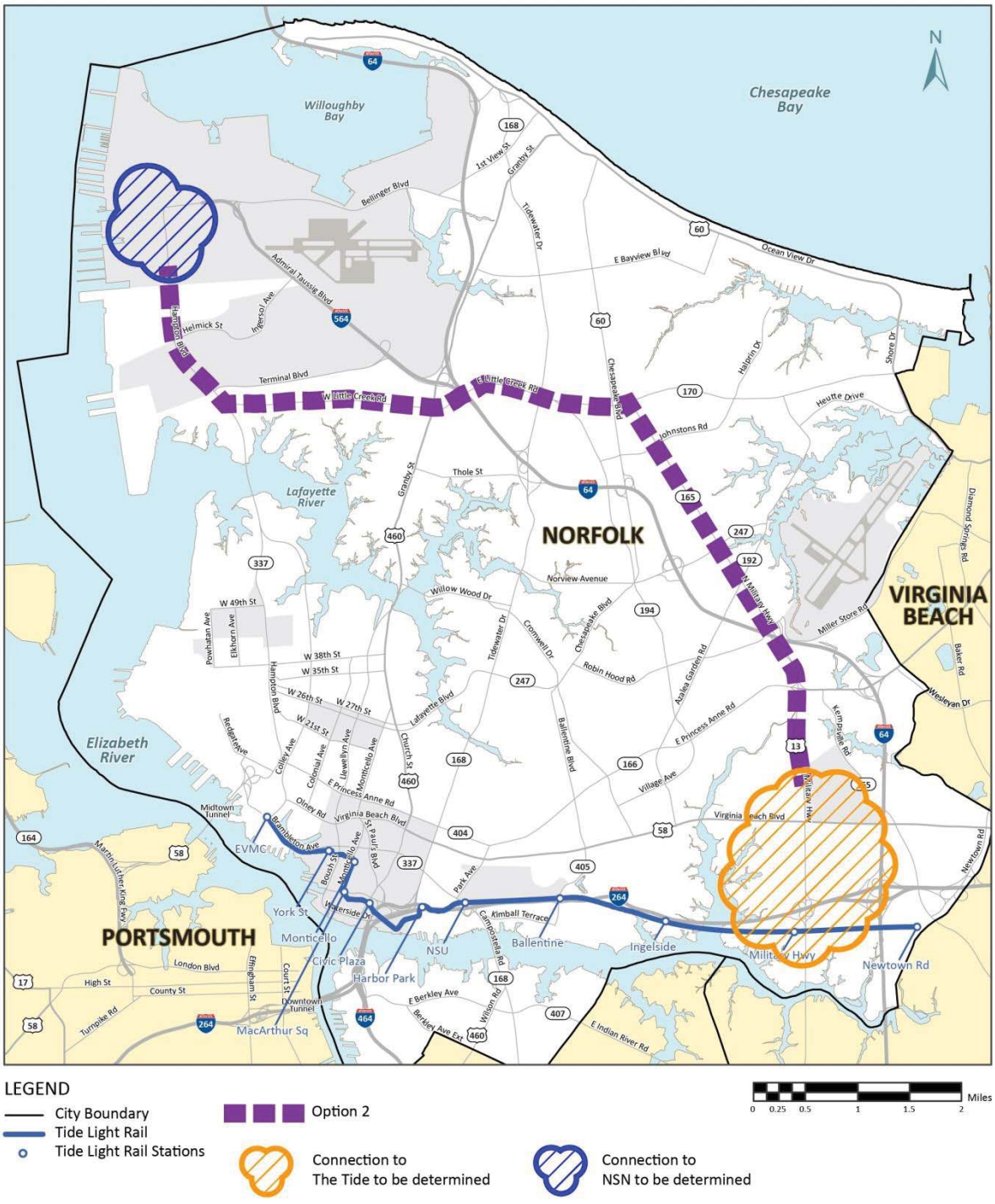


Figure 6. Option 3

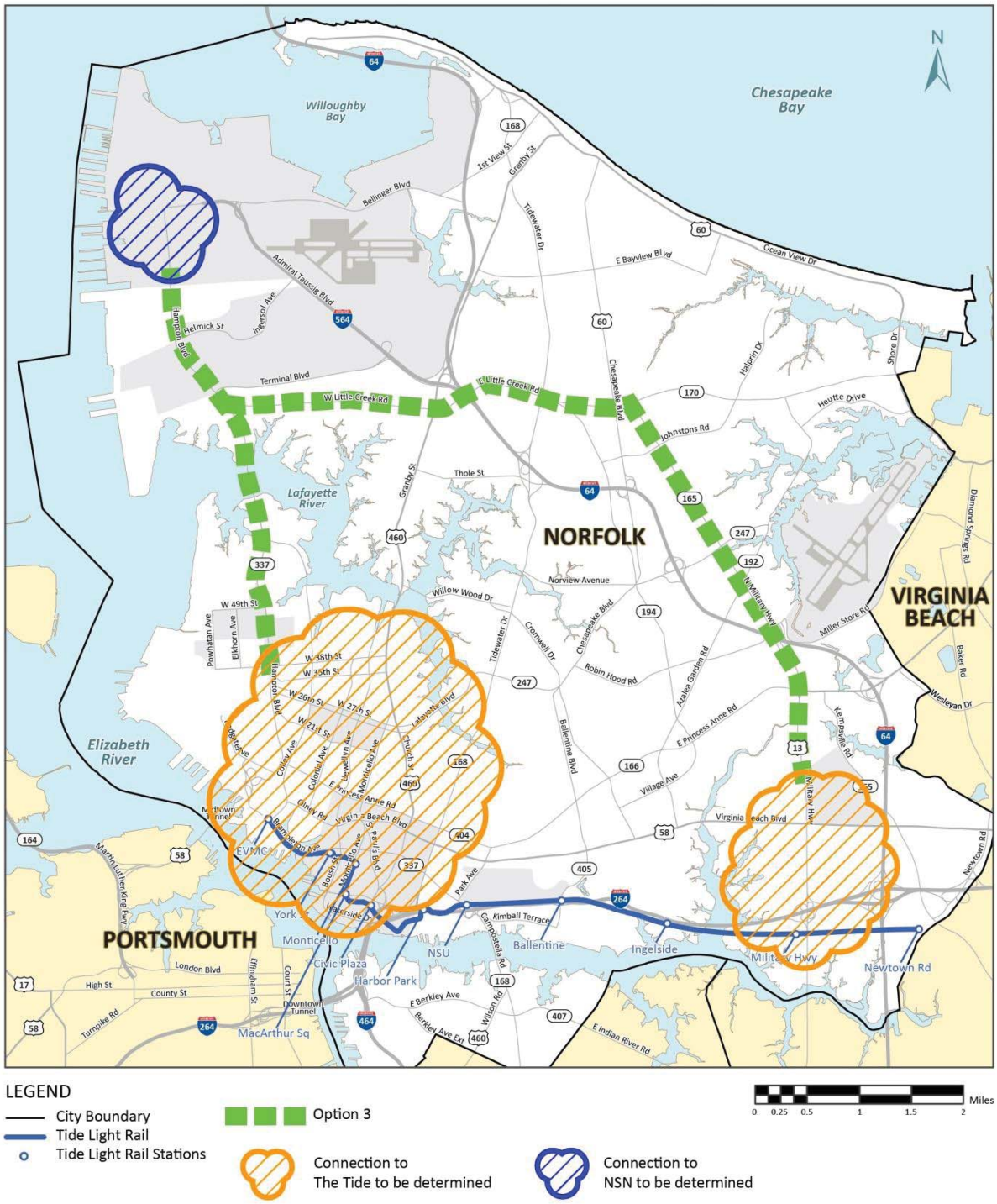


Figure 7. Option 4

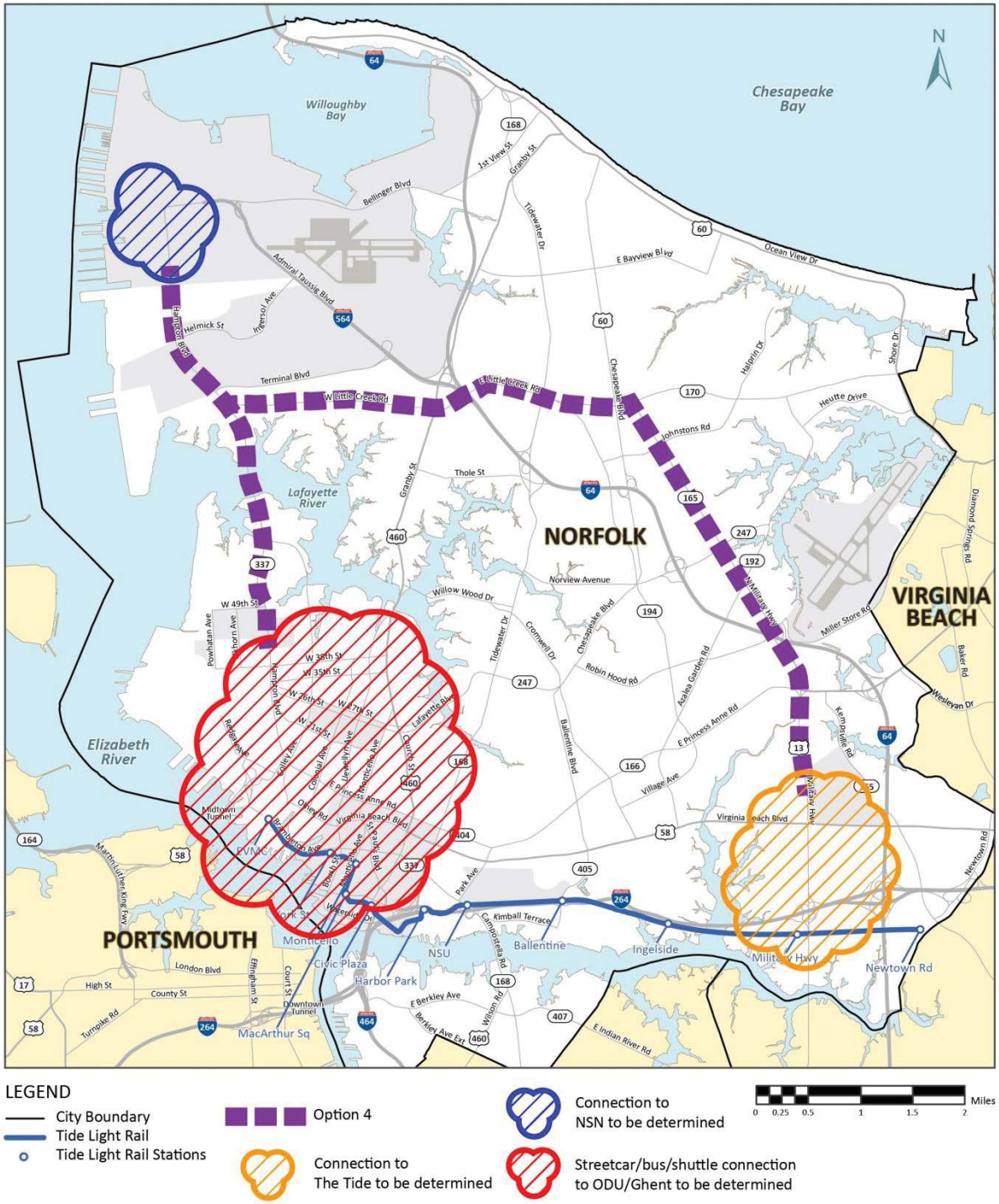
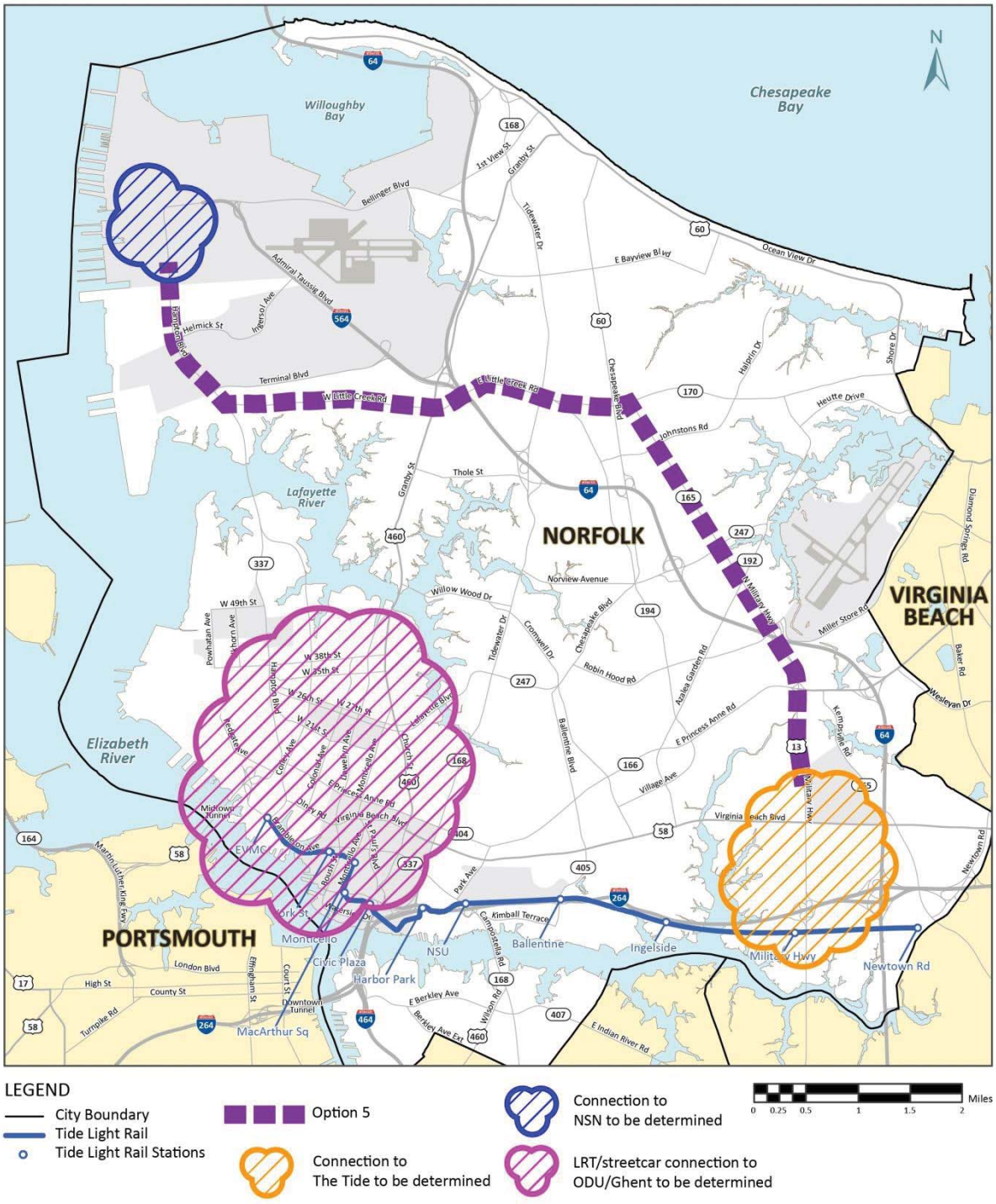


Figure 8. Option 5



Section 2

Tier 1 Screening of Alignments

2.0 TIER 1 SCREENING OF ALIGNMENTS

The goal of the Tier 1 screening process for the NSNTES was to evaluate the set of unconstrained, conceptual alignments and to establish a short list of the most feasible and community-supported alignments for a more detailed technical evaluation. The Tier 1 screening process included three sets of public meetings that helped define the NSNTES *Purpose and Need* statement, identify the project themes, locate key activity centers, develop an initial set of 17 alignments, create a set of evaluation criteria, analyze the alignments, and select a subset of the most feasible and promising alignments for more detailed analysis as part of the Tier 2 screening process.

2.1 DEVELOPMENT OF THE PURPOSE AND NEED

As defined by the US Department of Transportation, the purpose and need of a project is essential in establishing a basis for the development of the range of reasonable alternatives required in an environmental impact statement and assists with the identification and eventual selection of a preferred alternative[1]. The *Purpose and Need* statement helps guide a project through the planning process, serves to provide the basis for the development of alternatives and the eventual selection of a preferred alternative. Soliciting and incorporating public input is a key component in developing a *Purpose and Need* statement, and the NSNTES held a series of meetings in June 2013 that asked the public to comment on a potential transit extension.

2.1.1 June 2013 Public Meetings

The City of Norfolk and HRT conducted the first set of public meetings in June 2013 to solicit public input to help HRT define the project's *Purpose and Need* statement and to identify the project's themes. The *Purpose and Need* public workshops were held on June 12 at Blair Middle School, June 17 at Granby High School, and June 19 at the Hilton Norfolk Airport. The public workshops were held on three different dates and locations in order to provide multiple opportunities for public participation. Approximately 100 community members participated in the June workshops. Workshop attendees watched a PowerPoint presentation given by HRT to learn about the scope, goals, and timeline for the study. Attendees then broke into small groups (see **Figure 9**) to answer two questions:

1. What are the travel needs or problems between The Tide (and any future extension of The Tide) and Naval Station Norfolk?
2. What goals would a successful transit system to NSN need to achieve?

[1] http://environment.fhwa.dot.gov/projdev/tdmelements.asp

Figure 9. June 2013 Public Meeting Break Out Group

Each breakout group of 7-10 people was facilitated by a member of the NSNTES team. Each group identified a reporter to record key discussion points on both questions. Groups spent fifteen minutes on each of the two questions, and then were asked to identify their top two priorities for each question. At the close of the meeting, each group reported to all attendees their top two priorities for both questions.

Members of the public were encouraged to record their thoughts, concerns, and suggestions on the comment sheets provided at the registration tables. Those in attendance were informed that comments would be featured on Open City Hall, an online civic engagement tool the City of Norfolk is making available for this study. Members of the public were also informed that they could directly enter their feedback online at the NSNTES website. A complete summary of the June 2013 public meetings and all other public involvement activities for the NSNTES can be found in **Appendix A**.

2.1.2 Purpose and Need Statement

The initial set of public meetings in June 2013 helped HRT produce the NSNTES' *Purpose and Need* statement, which is:

> NSN is the largest naval base in the world and is the region's largest employment center. The efficient movement of military and civilian personnel to and from NSN is critical for regional military readiness and for maintaining the ability to meet national military strategic demands. Most days, as many as 60,000 to 70,000 people come to work at NSN, and most access the base by driving. On most days, high automobile traffic volumes create congestion during the peak commuting hours and along the surrounding streets and highways (Interstate 64/564, Hampton Boulevard, Terminal Boulevard, and W. Little Creek Road). This congestion is projected to worsen over time as surrounding areas continue to develop. **An efficient, high-capacity transit connection to Naval Station Norfolk would provide an alternative to driving in congested traffic to access NSN.**
>
> This study supports local and regional visions set out by plaNorfolk2030 (The City of Norfolk's General Plan) and the Virginia Department of Rail and Public Transportation (DRPT) Regional Transit Vision Plan **to create a more multi-modal transportation system that helps support the region's economic competitiveness.** Additional mobility options enhance Norfolk's economic potential by linking more residents to employment and activity centers and by fostering more sustainable (transit-supportive) land development patterns. This proposed project will develop a high-capacity transit connection that will support key regional activity centers, potentially including key destinations as downtown Norfolk, Old Dominion University, Ghent-area commercial uses in the

Colley Avenue and 21st Street corridors, Norfolk International Airport, Lake Wright Business Park, and the Military Highway corridor.

2.1.3 Project Themes

The project themes accompany the *Purpose and Need* statement in defining the goals of the NSNTES by identifying what a transit extension to NSN should accomplish. The project themes were developed based on the answers to the two questions asked during the June 2013 meetings, public feedback received on comment sheets, and through discussions at the meetings. The results of the public input at the June 2013 meetings helped identify and formulate the major themes of the NSNTES:

1. The transit extension should connect many points within Norfolk, not just the Naval Station.
2. The transit extension should provide an alternative to heavy traffic and congestion.
3. A fixed guideway transit connection between The Tide and NSN should make travel time more reliable.
4. The transit extension should provide parking for transit riders.
5. The transit extension should connect to other transit modes.
6. Planning for the transit extension should ensure it can be expanded in the future.
7. Identify environmental impacts, right-of-way constraints, economic development and neighborhood revitalization, and resiliency.

The seventh theme was added by HRT after the June 2013 meetings because of the importance those criteria would have during the alignment evaluation process.

2.2 DEVELOPMENT OF TRANSIT CORRIDORS AND PRELIMINARY CONCEPTUAL ALIGNMENTS

After the June 2013 public meetings, the next step in the project was to develop transit corridors and preliminary conceptual alignments that would meet the NSNTES' *Purpose and Need* statement and themes. These alignments would serve as the set of unconstrained, conceptual ideas that would be assessed in the Tier 1 technical evaluation process.

2.2.1 September 2013 Public Meetings

The second set of public workshops was conducted in September 2013. HRT considered public feedback from the September workshops in the development of potential transit corridors and the refinement of the *Purpose and Need* statement for extending The Tide to NSN. Public workshops were held on September 10 at the Holiday Inn Greenwich Road, September 11 at Norview High School, and September 12 at ODU. Approximately 200 community members participated in the workshops.

Workshop attendees watched a brief PowerPoint presentation given by HRT about the study and the results of the first round of public meetings and then broke into small groups to complete three interactive workshop activities as follows:

1. **Ranking Study Priorities:** Using stickers, attendees ranked the importance of the priorities identified during the June workshops.
2. **Identify Connectivity-Critical Areas/Locations:** Using a large map of Norfolk and push pins, attendees identified areas most in need of premium transit service (green pins), as well as areas to avoid (red pins).
3. **Identify Preferred Corridors:** Using string and without the constraint of existing city roads, attendees connected The Tide to NSN and other key destinations and activity centers.

Members of the NSNTES team facilitated each breakout group of 7-10 people. A reporter was identified in each group and asked to report back on the top corridor preferences at the conclusion of the interactive activities. The results of the September 2014 meetings were a list of areas that the public felt most needed premium transit access, locations to avoid, a set of potential alignments, comments on the draft *Purpose and Need* statement, and a ranking of the project themes. Each of these elements were reviewed by the study team and used to develop the initial set of 17 conceptual alignments.

2.2.2 Description of Preliminary Conceptual Alignments

After removing duplicates, summarizing the results, and incorporating comments from City of Norfolk staff and key stakeholders, a total of 17 discrete conceptual alignments were identified. The alignments were grouped based on their geographic location within Norfolk (western corridor, central corridor, or eastern corridor), as described below. The conceptual alignments assumed that The Tide would be extended to NSN using light rail technology; however, other technologies such as streetcar or bus rapid transit remain under consideration.

Western Alignments: These eight alignments would connect NSN to the west side of Norfolk. These alignments would serve downtown, Ghent, West Ghent, ODU, Norfolk International Terminals, and other neighborhoods and business districts.

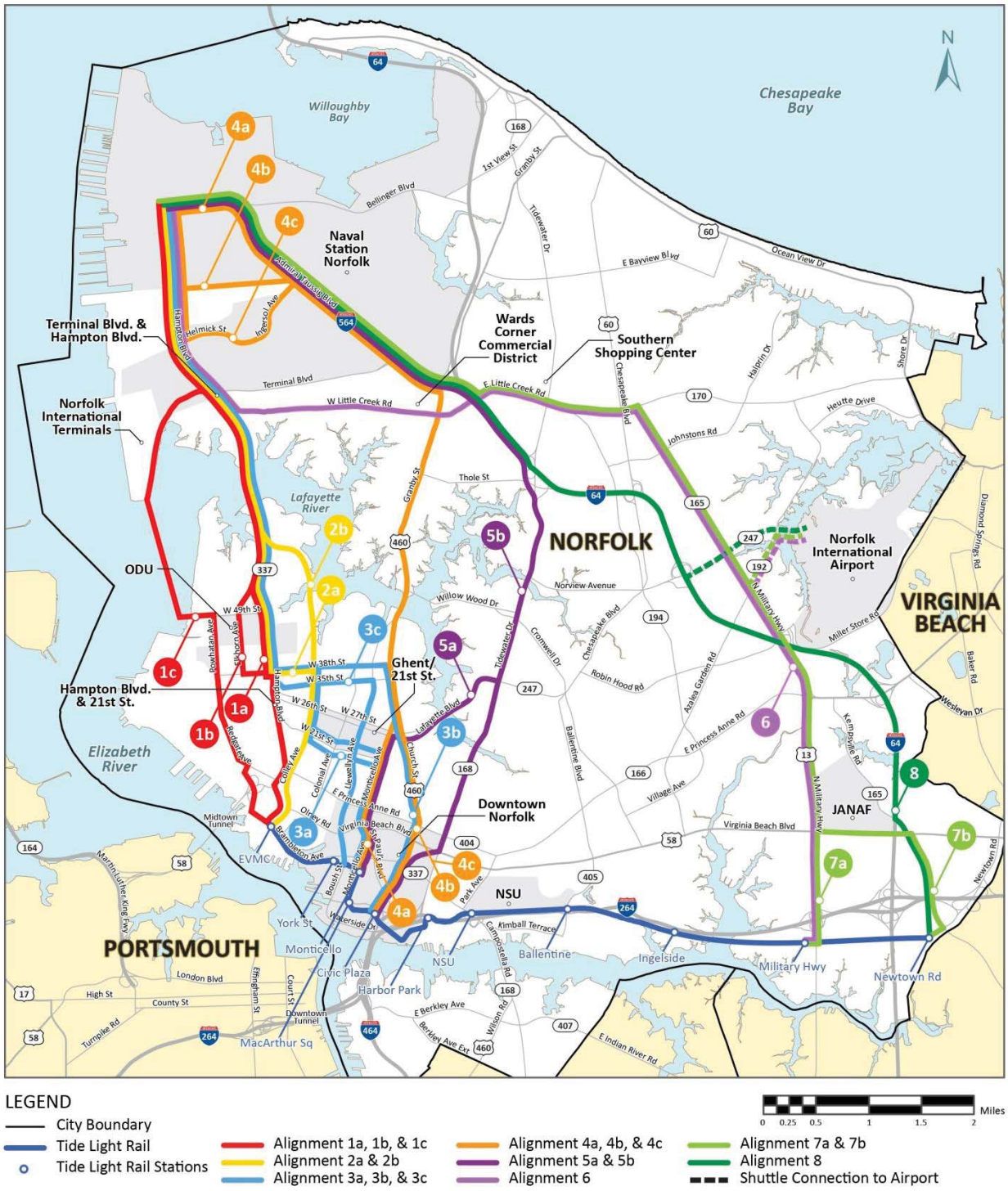
Central Alignments: These five alignments would connect central Norfolk (primarily areas east of the Lafayette River) to NSN. Areas that would be serviced include downtown, Ghent, Wards Corner, and other neighborhoods and business districts.

Eastern Alignments: Four alignments were identified in the Military Highway/I-64 Corridor on the eastern side of Norfolk. These alignments would serve the Military Highway commercial area, JANAF, Norfolk International Airport, and Wards Corner.

All alignments would have the potential to connect many activity centers in Norfolk, attract new transit riders, and provide an alternate means to and from NSN. Depending on the route, the alignments would provide varying levels of direct access and mobility to/from NSN and downtown Norfolk, and this would affect each alignment's ability to attract riders. The alignments would enable connections that would expand the regional transit network, provide increased interconnectivity between transit modes, and support development of adjacent Park & Ride lots.

Figure 10 displays a map of the 17 Tier 1 alignments. **Appendix B** includes a report that provides additional detail on the conceptual alignments studied.

Figure 10. Alignments for Tier 1 Screening



2.3 TIER 1 TECHNICAL EVALUATION

The goal of the Tier 1 screening process for the NSNTES was to evaluate the set of unconstrained, conceptual alignments shown in **Figure 10** and to establish a short list of the most feasible and community-supported alignments for a more detailed technical evaluation. This was accomplished by using the project themes to create technical evaluation criteria, then analyzing each of the 17 conceptual alignments with local and regional transportation and land use data.

2.3.1 Tier 1 Technical Evaluation Methodology

All alignments were evaluated to understand which would best meet the project's purpose and need and were rated on their potential environmental impacts, economic development benefits, and order-of-magnitude (a planning-based method of determining initial cost estimates) costs.

A number of data sets were used to establish the Tier 1 technical evaluation criteria:

- Regional data
    - Hampton Roads Transportation Planning Organization (HRTPO) Transportation Analysis Zone (TAZ) 2034 socioeconomic data
    - HRTPO analysis of INRIX vehicle data as contained in the 2013 Hampton Roads Regional Travel Time Reliability Study
    - Planned and programmed transportation projects in HRTPO priorities lists
- City of Norfolk data
    - Land use data from plaNorfolk2030
    - Potential environmentally sensitive and historic properties (e.g., parks, historic properties, and wetlands)
- Transit data
    - Existing bus routes in Norfolk
    - Location of existing and potential Park & Ride facilities
- Data identified by the public
    - Location of key regional activity centers identified during the public workshops
    - Preliminary assumptions on length of each alignment in shared right-of-way and in exclusive right-of-way
- Google Traffic historical data

The evaluation criteria reflect the project's *Purpose and Need* statement and the seven themes that were developed through the first two sets of public workshops. Goals such as providing an alternative to heavy traffic and congestion, providing direct access to NSN, meeting the transportation needs within Norfolk, enhancing transit opportunities to activity centers, and reducing travel times to NSN were mentioned by the public.

The project team assigned evaluation criteria to the seven themes as a basis for assessing the alignment options. Part of the process of assigning criteria to themes included choosing a method for evaluating

each criterion and picking the data to use in each evaluation. The themes and evaluation criteria used in the Tier 1 evaluation process are listed in **Table 1**. Detailed discussion of each theme and its criteria follow.

Table 1. Tier 1 Evaluation – Themes and Evaluation Criteria

	Theme	Evaluation Criteria
1A	Connect to Many Points within Norfolk	Connect to activity centers
2A	Provide an Alternative to Heavy Traffic and Congestion	Reduce hours of daily roadway congestion
2B		Ability to attract riders
3A	Reduce Travel Time – Make Travel Time More Reliable between Destinations	Opportunity to increase travel time reliability along alignment corridor
3B		Directness of route
4A	Parking – Provide Parking to Accommodate Riders	Proximity to Park & Rides
5A	Interconnectivity of Transit Modes	Ability to connect to other transit services in Norfolk
6A	Future Expansion – Ensure That the System Can Be Expanded in the Future	Ability to leverage other planned regional transportation system projects
7A	Other	Environmental considerations
7B		Right-of-way constraints and project cost
7C		Economic development and neighborhood revitalization
7D		Resiliency

Each conceptual alignment was ranked relative to the rest of the alignments for each criterion in a summary matrix with the following general ratings:

- **"Least Desirable"** - Does not meet the criteria as well as the other alignments – substantial impacts and/or minimal benefits
- **"More Desirable"** - Meets the criteria better than some alignments, but not as well as the highest performing alignments – moderate level of impacts and/or some benefits
- **"Most Desirable"** - Meets the criteria better than most of the alignments – low level of impacts and/or high level of benefits

In general, if an alignment scored below the 25th percentile with respect to a given criterion, it was categorized as "least desirable" and represented with an open circle. If an alignment scored between the 25th and 75th percentiles with respect to a given criterion, it was categorized as "more desirable" and represented with a half-full circle. If an alignment scored above the 75th percentile with respect to a given criterion, it was categorized as "most desirable" and represented with a solid circle. Some of the evaluation criteria (e.g. Park & Rides) were not evaluated using the percentile methods and used natural breakpoints to determine each level of desirability. Overall, solid circles represent alignments that scored better in terms of their desirability than alignments receiving half-full or open circles.

A memorandum that describes the complete technical analysis methodology for each criterion can be found in **Appendix C**.

2.3.2 Tier 1 Technical Evaluation Results

For the Tier 1 technical evaluation, the alignments and corridors shown in **Table 2** were the best performing for each the project themes and evaluation criteria.

Table 2. Tier 1 Evaluation – Results by Evaluation Criteria

	Theme	Evaluation Criteria	Best Performing Alignment(s)	Best Performing Corridor(s)
1A	Connect to Many Points within Norfolk	Connect to activity centers	1a, 1b, 2a, 2b, 3a, 3b	Western
2A	Provide an Alternative to Heavy Traffic and Congestion	Reduce hours of daily roadway congestion	4a, 7a, 8	Eastern
2B		Ability to attract riders	3a, 3b, 4a, 5a, 5b	Central
3A	Reduce Travel Time – Make Travel Time More Reliable between Destinations	Opportunity to increase travel time reliability along alignment corridor	4a, 5a, 7a, 8	Central/Eastern
3B		Directness of route	4b, 5a, 5b, 8	Central
4A	Parking – Provide Parking to Accommodate Riders	Proximity to Park & Rides	6	Eastern
5A	Interconnectivity of Transit Modes	Ability to connect to other transit services in Norfolk	3a, 3b, 4a, 4b, 4c, 5a	Central
6A	Future Expansion – Ensure That the System Can Be Expanded in the Future	Ability to leverage other planned regional transportation system projects	6, 7a, 7b	Eastern
7A	Other	Environmental considerations	1c, 6, 7a, 7b, 8	Eastern
7B		Right-of-way constraints and project cost	1a, 1b, 2a, 2b	Western
7C		Economic development and neighborhood revitalization	1b 4a, 5a, 7b	Central
7D		Resiliency	1c, 8	Eastern

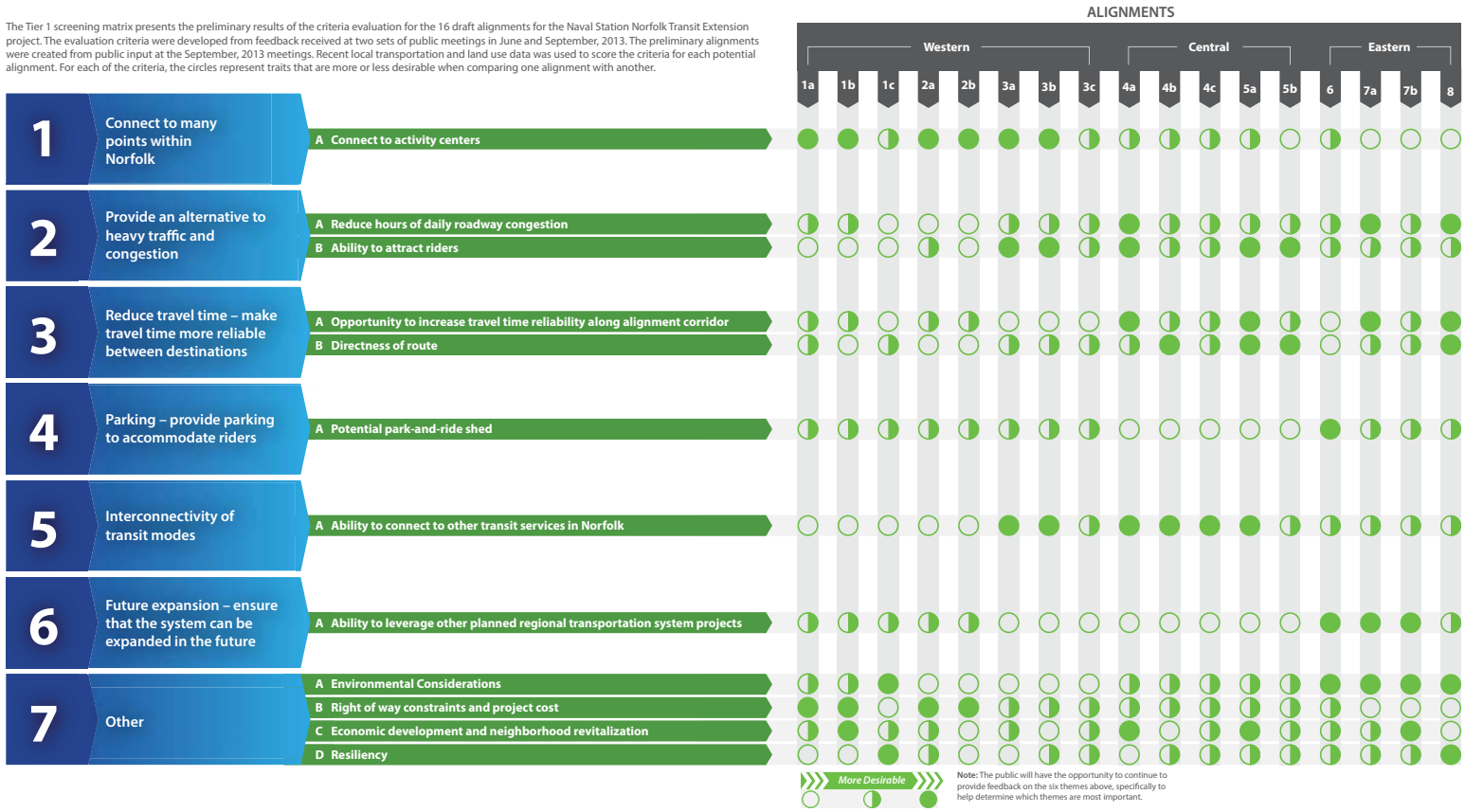
Figure 11 on the following page displays the Tier 1 screening matrix, which includes the results of the criteria evaluation for the 17 conceptual alignments for the NSNTES. The results of the Tier 1 technical evaluation indicated that the following three alignments represent the overall best performing alignments, based on the technical results, from each of the study corridors:

- Western Corridor: Alignment 3b
- Central Corridor: Alignment 5a
- Eastern Corridor: Alignment 7a

Figure 11

Naval Station Norfolk Transit Extension Study
Tier 1 Screening Matrix

The Tier 1 screening matrix presents the preliminary results of the criteria evaluation for the 16 draft alignments for the Naval Station Norfolk Transit Extension project. The evaluation criteria were developed from feedback received at two sets of public meetings in June and September, 2013. The preliminary alignments were created from public input at the September, 2013 meetings. Recent local transportation and land use data was used to score the criteria for each potential alignment. For each of the criteria, the circles represent traits that are more or less desirable when comparing one alignment with another.



Note: The public will have the opportunity to continue to provide feedback on the six themes above, specifically to help determine which themes are most important.

2.3.3 February/March 2014 Public Review of Tier 1 Technical Evaluation Results

The third set of public workshops was conducted in February/March 2014 after the completion of the Tier 1 technical evaluation. Workshop attendees watched a brief PowerPoint presentation given by HRT that described the results of the Tier 1 technical evaluation. The goal of the meeting was to have the public suggest their preference for an alignment, corridor, or location for future expansion of the system. Attendees then broke into small groups, were provided handouts with the results of the Tier 1 technical evaluation, and were asked to identify the following by placing stickers next to each of their selections of:

1. A preferred alignment (selection of one out of a possible 17 alignments)
2. A preferred corridor (selection of one out of a possible three corridors: western, central or eastern)
3. A preferred location for future expansion (selection of a nearby community such as Virginia Beach or Hampton to expand The Tide to in the future)

The results of the February/March 2014 public meetings indicated a preference for the following alignments from each of the study corridors:

- Western Corridor: Alignment 2a
- Central Corridor: Alignment 4a
- Eastern Corridor: Alignment 6

2.3.4 Selection of Alignments to Advance to Tier 2 Screening Process

Based on the Tier 1 technical evaluation results and input from the February/March 2014 public meetings, six alignments were recommended for advancement to the Tier 2 screening process. These six alignments included the highest-scoring alignments from the technical evaluation and the highest-ranked alignments from the public preference results from each of the three corridors (western, central, and eastern). In addition to those six alignments selected based on technical results or public preference, two additional alignments were advanced forward based on stakeholder input. These two alignments are:

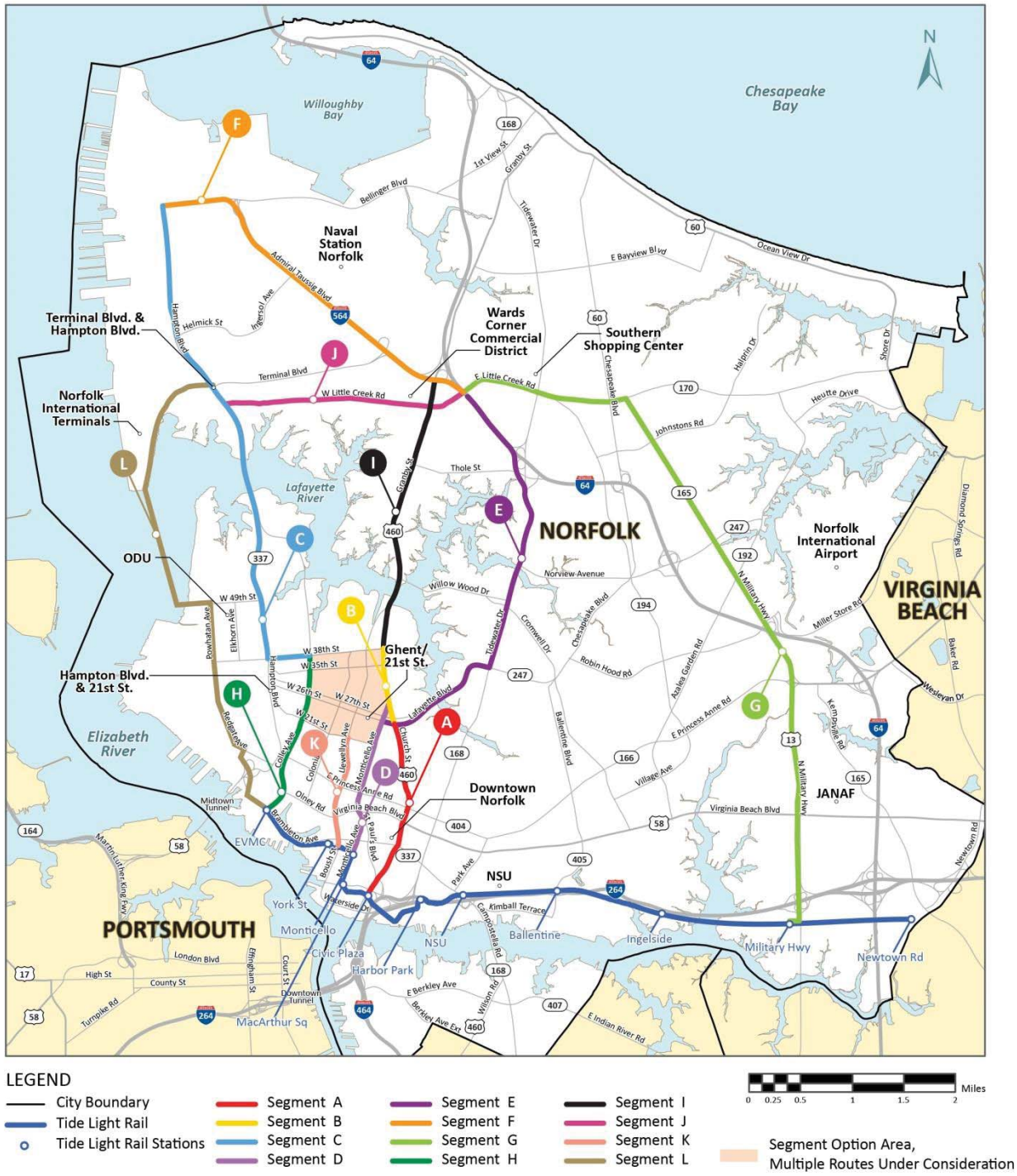
- Alignment 1c
- Alignment 3c

Each of the eight alignments chosen for more detailed analysis in the Tier 2 screening process was divided into individual segments as described below and shown in **Figure 12.**

- Alignment 1c, composed of segments L and C
- Alignment 2a, composed of segments H and C
- Alignment 3b, composed of segments A, B, and C
- Alignment 3c, composed of segments K and C
- Alignment 4a, composed of segments D, B, I, and F

- Alignment 5a, composed of segments D, E, and F
- Alignment 6, composed of segments G, J, and C
- Alignment 7a, composed of segments G and F

Figure 12. Potential Alignment Segments Advanced to Tier 2 Screening Analysis



The Segment Option Area (bounded by W. 20th Street, Colley Avenue, W. 38th Street, and Monticello Avenue) has multiple possibilities for east-west and north-south routes that would connect alignments originating in downtown Norfolk with either Hampton Boulevard or Granby Street. The routing possibilities through this area were examined for alignments 2a, 3b, 3c, and 4a.

After the eight alignments were identified, project staff met with engineering and planning staff from HRT and the City of Norfolk to discuss potential fatal flaws of each alignment and segment. The meeting provided project staff with additional planning and engineering information on each alignment segment. The data was used by project staff to refine the eight alignments to avoid potential fatal flaws.

After reviewing the technical data for the eight alignments and their component segments, and taking into account input from engineering and planning staff at HRT and the City of Norfolk, the following segments were dropped from further consideration:

- **Segment E** was dropped because Tidewater Drive has little available right-of-way for a dedicated transit-way and it would be difficult to make a connection to NSN through the Tidewater Drive/I-64 interchange.
- **Segment L** was dropped because of the risk, cost, and engineering challenges in constructing a transit-way on top of a Lafayette River seawall and the need to span the Norfolk Southern railroad tracks near Lambert's Point.
- **Segment H** was removed from further consideration because of the potential difficulty in traversing the Colley Avenue/Brambleton Avenue intersection, the lack of available right-of-way on Colley Avenue north of Brambleton Avenue, and the width of the Norfolk Southern underpass north of W 21st Street.
- **Segment K** was removed from consideration because of the potential for flooding issues on Llewellyn Avenue and the difficulty in mitigating the existing at-grade crossing of the railroad tracks near 23rd Street.

The remaining segments were combined into six alignments that closely followed the routes of the alignments selected through the Tier 1 technical evaluation and public preference. The six alignments were organized by corridor (western, central or eastern) and were advanced to the Tier 2 screening process. The Tier 2 screening process is described in detail in the following section of the report.

Section 3

Tier 2 Screening of Alignments

3.0 TIER 2 SCREENING OF ALIGNMENTS

Based on the results of the Tier 1 screening process, the six alignments comprised of the highest ranking segments were advanced for further evaluation as part of the Tier 2 screening process, which included a technical evaluation and a set of public meetings. The alignments are illustrated in **Figure 13** and are as follows:

- **Western Alignment (Based on Tier 1 Alignment 3b - Segments, A, B, and C):** This alignment would connect the Ghent neighborhood, ODU, and NSN along Hampton Boulevard.
- **Central A Alignment (Based on Tier 1 Alignment 4a - Segments D, B, I, and F):** This alignment would use Monticello Avenue to head north from downtown along Granby Street.
- **Central B Alignment (Based on Tier 1 Alignments 2a and 4a - Segments B, C, D, I, and J):** This alignment would use Monticello Avenue, head north and turn to run along W. Little Creek Road and Hampton Boulevard.
- **Central C Alignment (Based on Tier 1 Alignment 5a - Segments D, E, and F):** This alignment was proposed and refined in discussions with the City of Norfolk. The alignment would run along Lafayette Boulevard and Chesapeake Boulevard before connecting to W. Little Creek Road and NSN.
- **Eastern A Alignment (Based on Previous Alignment 7a - Segments G and F):** This alignment would travel along Military Highway, W. Little Creek Road, and Admiral Taussig Boulevard.
- **Eastern B Alignment (Based on Previous Alignment 6 - Segments G, C, and J):** This alignment would travel along Military Highway, W. Little Creek Road, and Hampton Boulevard.

The Tier 2 technical evaluation and analysis results of the six conceptual alignments are discussed below.

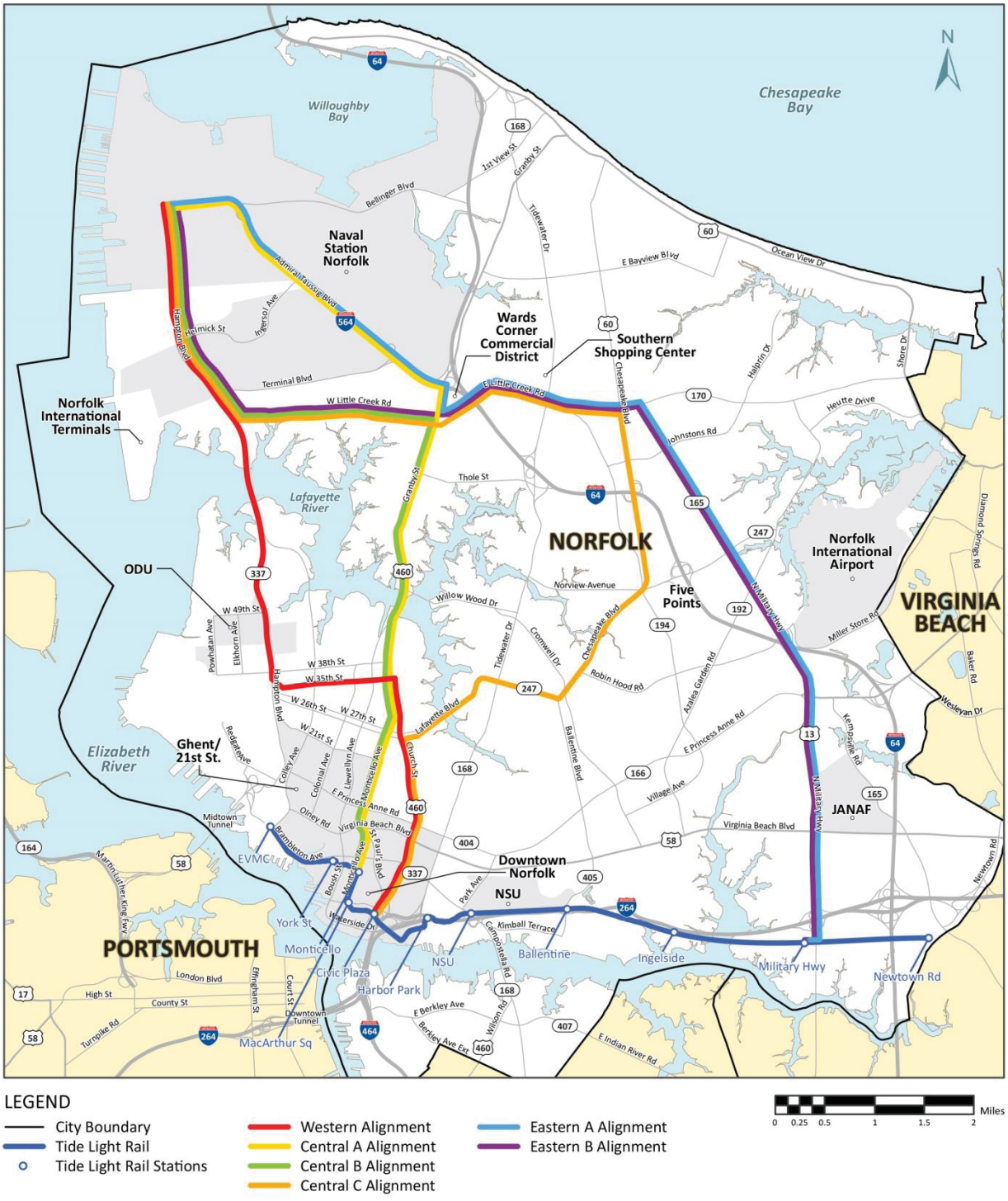
3.1 TIER 2 TECHNICAL EVALUATION

The Tier 2 technical evaluation of the conceptual alignments included an analysis of potential station areas and right-of-way along each alignment, preliminary ridership forecasts, potential environmental impacts, and traffic impacts of each alignment on selected intersections. The results of the Tier 2 technical evaluation were presented to the public at a series of meetings in October 2014.

3.1.1 Station Service Area Analysis

The Tier 2 analysis evaluated each alignment based on the influence and impact of its potential station service areas. By analyzing the catchment areas served by stations, rather than using a ½-mile buffer area as in Tier 1, the Tier 2 evaluation was able to better understand the land use, transportation, socioeconomic, and environmental benefits and impacts. The result of the station area analysis is an understanding of the potential ridership, existing transit supportive land uses, and potential future transit-oriented development (TOD) in the catchment areas of each station.

Figure 13. Alignments for Tier 2 Analysis



3.1.1.1 Methodology

Step 1: Determine Preliminary Station Locations

As part of the station area analysis, potential station locations were identified for each of the six selected alignments. Potential stations were selected based on "rule of thumb" operating criteria for light rail transit (LRT), since LRT is the primary transit technology under consideration. For typical LRT, the average distance between stations ranges from ½ mile to two miles within urban areas and two miles or greater in suburban settings. Potential station locations were selected to support each alignment's key activity centers as identified by the public during the first series of public meetings. Station location selection also considered existing transit origins or destinations and transit-supportive land uses such as key commercial destinations, employment centers, or high-density residential areas. Major intersections were identified as potential station locations to optimize access by all modes. At this stage of analysis, specific parcels or intersection quadrants were not identified for the station locations. **Figure 14** displays the preliminary station locations identified for each of the conceptual alignments.

Step 2: Determine Station Service Areas

Station service areas were defined as the area that can be reached within a typical half-mile walk, which is generally considered the catchment area in which transit can attract the most riders and encourage the highest level of transit-oriented development. For this study, these areas were determined using the half-mile network distance along existing public streets. The network analysis was based on the City of Norfolk's existing streets geographic information systems (GIS) dataset. The aggregate service area of all of the stations along each of the alignments was used as the basis for many of the Tier 2 criteria applied to evaluate each alignment.

Table 3, Figure 15, and **Figure 16** summarize and display the aggregate station service areas for each of the alignment options. The density of streets within a station area influences the effective station area size. Station areas with denser and more connected patterns of street networks show more coverage compared to stations with sparser street networks. The Eastern A Alignment and the Eastern B Alignment have stations that appear to have "half a station area" because of Military Highway's and other public streets access limitations within a half-mile of station locations.

The Central C Alignment would have the greatest potential reach with 3,370 acres of effective service area for 11 stations. The Western Alignment has the second highest total of 2,700 acres of effective service area for 11 stations. The total station area reach is greatly influenced by the number of stations along each alignment. Some alignments have more destinations and reasons to have more stations, while other alignments show fewer stations because of limited access roadways or fewer destinations/activity centers.

Table 3. Station Service Areas and Number of Stations

Highest Ranked
Second Highest Ranked

Evaluation Criteria	Western	Central A	Central B	Central C	Eastern A	Eastern B
Number of Stations	11	6	9	11	8	11
Station Service Areas (Acres)	2,700	1,510	2,570	3,370	1,520	2,580

Figure 14. Preliminary Station Locations for Tier 2 Analysis

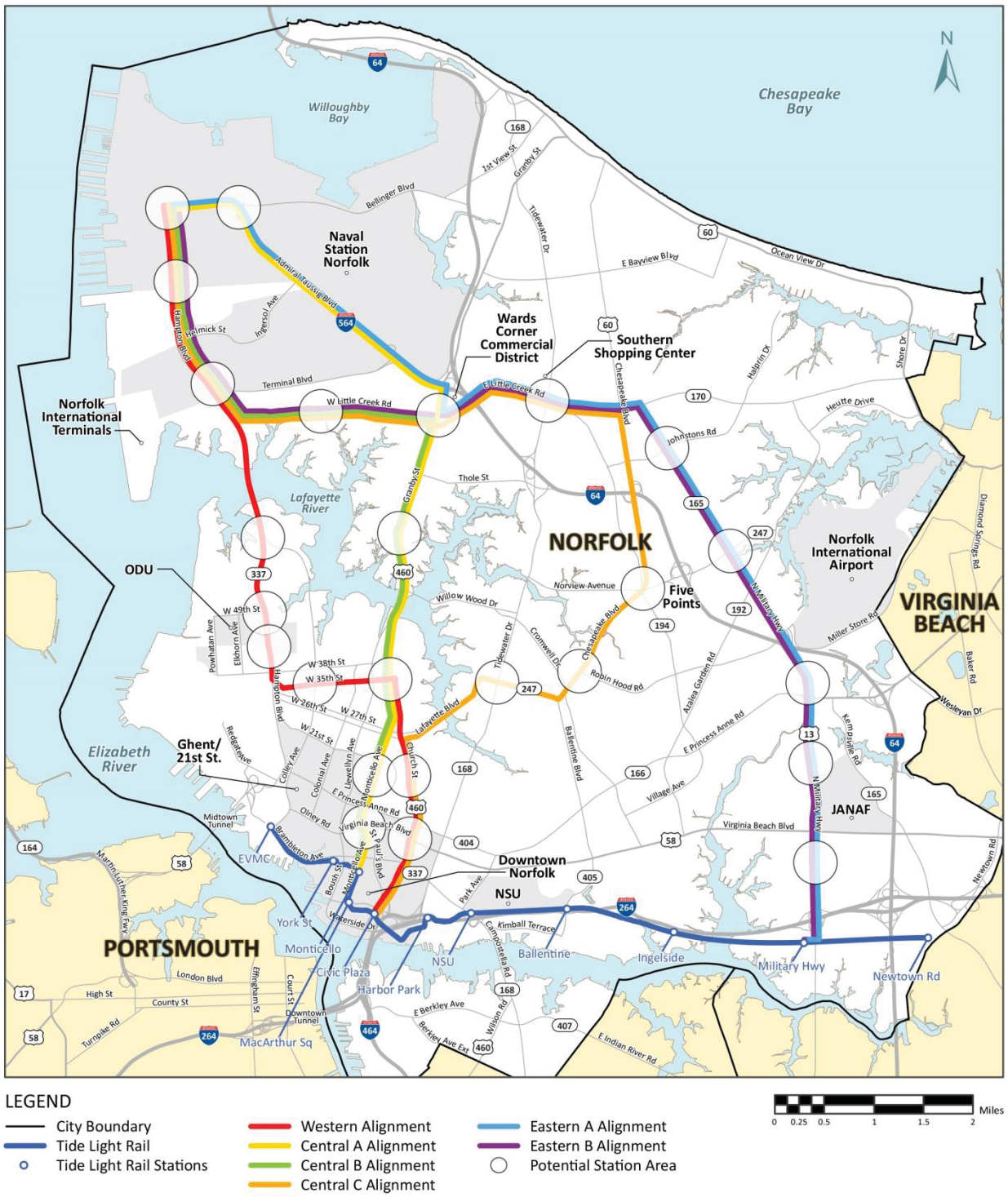


Figure 15. Station Service Areas for the Western, Central A, and Eastern A Alignments

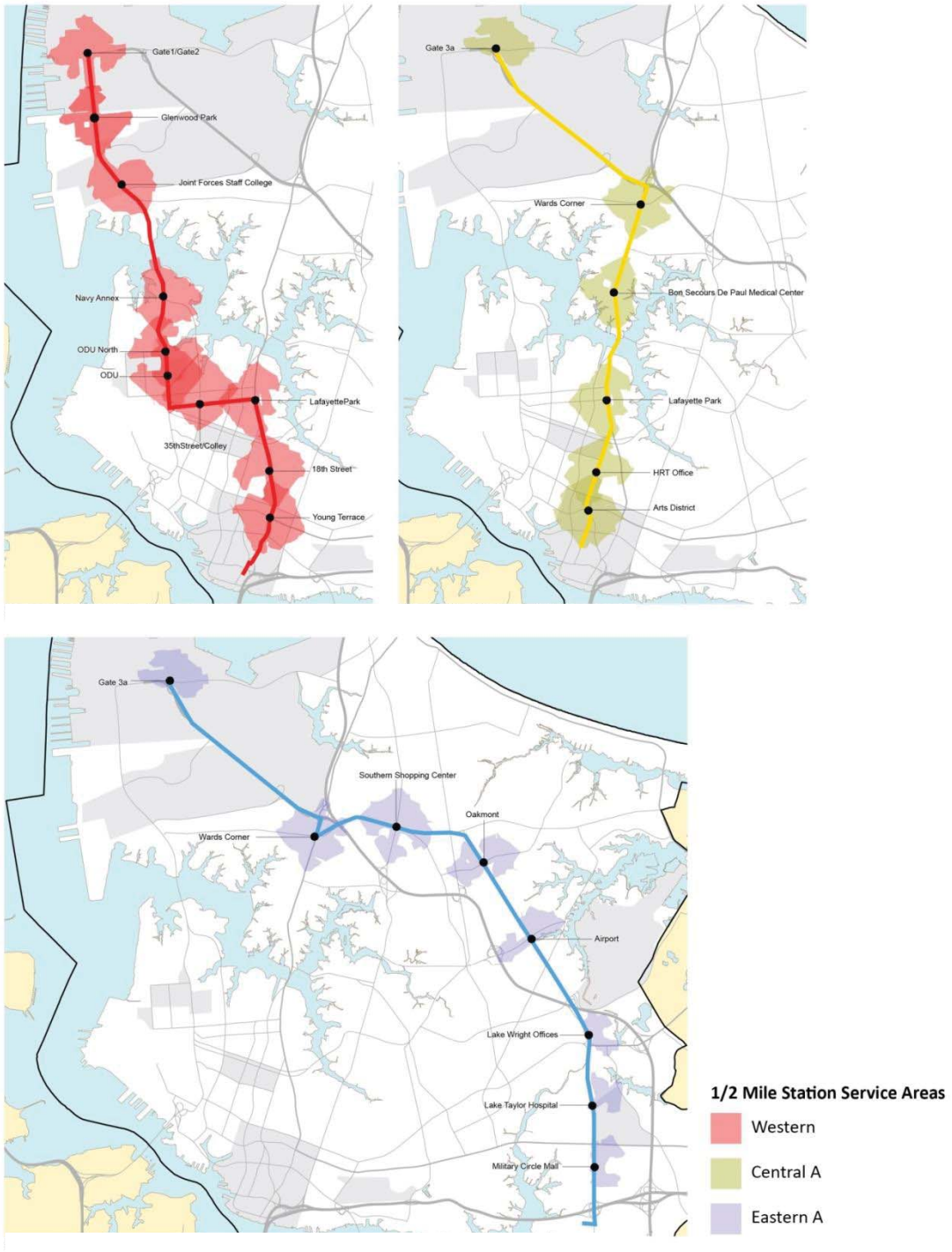
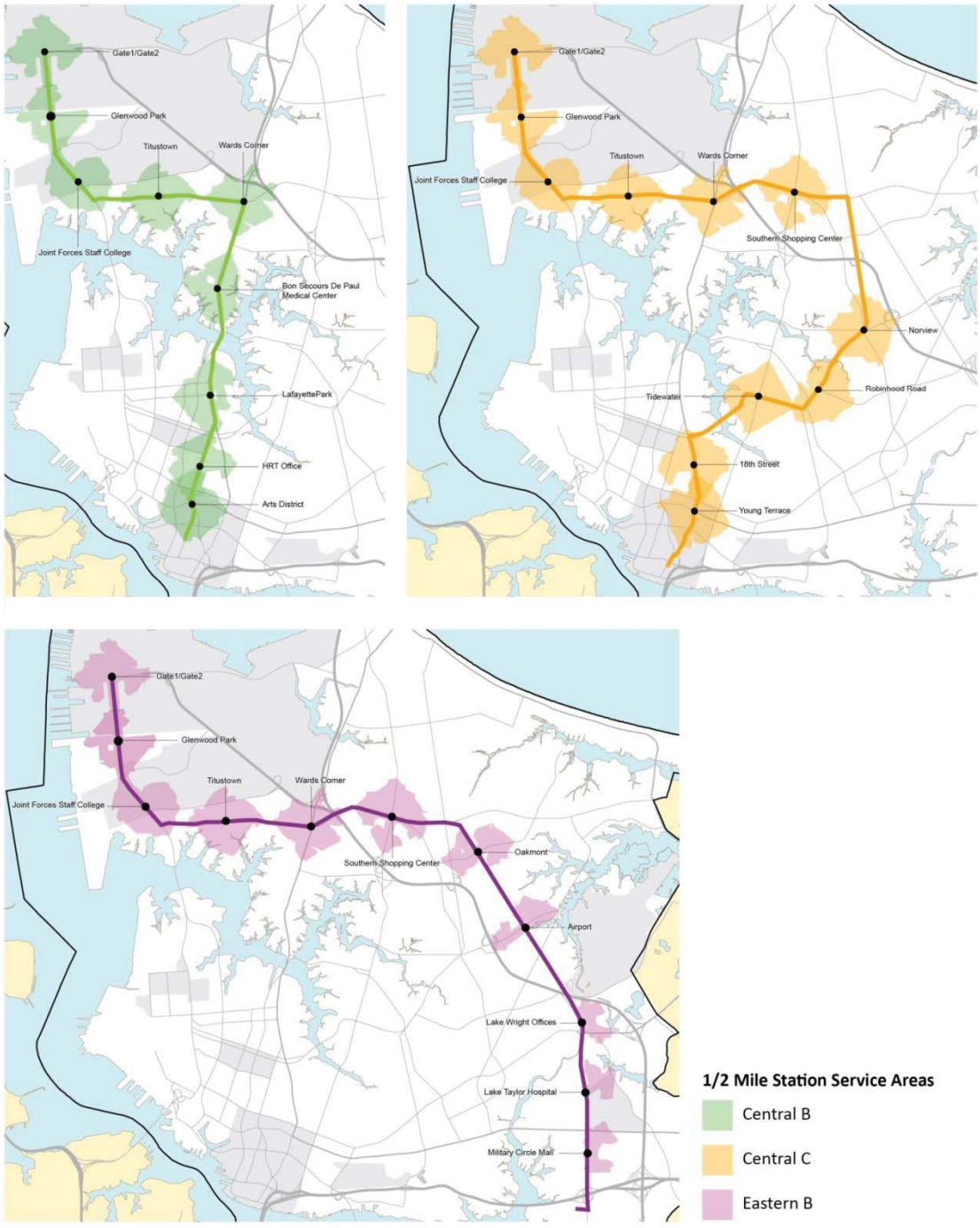


Figure 16. Station Service Areas for the Central B, Central C, and Eastern B Alignments



Step 3: Apply Station Service Areas to each of the Criteria

Based on the aggregate station areas for each alignment, the station area analysis measured the performance of each alignment for each of the following criteria, selected to align with the project themes:

- Connect to Activity Centers: (Relates to Theme 1: Connect to Many Points within Norfolk)
- Existing Transit Supportive Land Uses: (Relates to Theme 1: Connect to Many Points within Norfolk)
- Population within the Station Service Areas: (Relates to Theme 2: Provide an Alternative to Heavy Traffic and Congestion)
- Employees within the Station Service Areas: (Relates to Theme 2: Provide an Alternative to Heavy Traffic and Congestion)
- Total Population within Five-Minute Drive from Station Locations: (Relates to Theme 4: Provide Parking to Accommodate Riders)
- Number of Transit Stops within Station Service Areas: (Relates to Theme 5: Interconnectivity of Transit Modes)
- Sidewalks within Station Service Areas: (Relates to Theme 5: Interconnectivity of Transit Modes)
- Bicycle-friendly Streets: (Relates to Theme 5: Interconnectivity of Transit Modes)
- Future Jobs within Station Service Areas: (Relates to Theme 7: Economic Development and Neighborhood Revitalization)
- Zero-car Households: (Relates to Theme 7: Economic Development and Neighborhood Revitalization)
- Potential for Transit-Oriented Development (TOD) : (Relates to Theme 7: Economic Development and Neighborhood Revitalization)
- Potential to Expand Access to Tide Area Jobs: (Relates to Theme 7: Economic Development and Neighborhood Revitalization)
- Potential to Connect Tide Area Residents to Jobs: (Relates to Theme 7: Economic Development and Neighborhood Revitalization)
- 4(f) Sites and Historic Resources: (Relates to Theme 7: Environmental Considerations)
- 100-year Floodplain: (Related to Theme 7: Resiliency)

3.1.1.2 Station Service Area Analysis Results

Connect to Activity Centers (Relates to Theme 1: Connect to Many Points within Norfolk)

This criterion was evaluated by determining the number of activity centers that are located within the aggregate effective service areas of each alignment. The analysis used the list of key activity centers identified by the community during the set of public workshops in September 2013.

The number of activity centers within the effective service areas for each alignment ranged from 3 to 11. The Western Alignment and the Central B Alignment would have the greatest number of key activity centers (11 each) within their effective service areas. **Table 4** summarizes the results for this criterion for all of the alignment options. Maps illustrating the analysis results for this criterion are included in **Appendix D**.

Table 4. Number of Activity Centers within Station Service Areas

Highest Ranked
Second Highest Ranked

Evaluation Criteria	Western	Central A	Central B	Central C	Eastern A	Eastern B
Number of Activity Centers within Station Service Areas	11	8	11	10	3	5

Existing Transit Supportive Land Uses (Relates to Theme 1: Connect to Many Points within Norfolk)

This criterion measures the total existing transit-supportive land uses within the aggregate service area for each alignment option. Alignment service areas with a higher density of transit supportive land uses are forecast to generate more potential transit ridership. Transit-supportive uses include stable single-family and multi-family residential, office, retail, and institutional developments that have densities that support transit use and are likely to generate or attract transit trips. Industrial-zoned properties, vacant parcels, and low-density commercial uses are not considered transit-supportive.

The total building square footage within each parcel was used to determine the amount of existing transit-supportive use. Using building square footage rather than parcel size gives a more accurate reflection of actual development density and prevents the evaluation from being skewed by large parcels with low-density development. Parcel-level land use, building footprints, and building height data from the City of Norfolk were used to analyze this criterion.[2] This criterion was evaluated by adding total building square footages for all parcels with transit-supportive uses within the station service areas.

[2] Since existing building floor area data was not available for many of the parcels, the building footprint and building height data were used to arrive at an estimated total building floor area value for each parcel.

The Central C Alignment, with 44,131,000 square feet of building floor area, would have the highest level of transit-supportive uses within the station service areas. The Western Alignment would have the second highest level of transit-supportive uses, with 36,890,000 square feet. **Table 5** summarizes the results for this criterion for all the alignment options. Maps illustrating the parcels with transit-supportive uses for each of the alignments are included in **Appendix D**.

Table 5. Transit Supportive Land Uses within Station Service Areas

Highest Ranked
Second Highest Ranked

Transit-Supportive Land Use (1,000 ft^2)	Western	Central A	Central B	Central C	Eastern A	Eastern B
Retail	2,344	4,832	5,169	5,246	8,316	8,654
Office	3,581	6,281	6,766	3,884	3,654	4,004
Multi-Family	8,750	6,722	9,028	11,434	4,961	6,429
Single Family	14,962	8,033	11,712	19,744	7,156	10,753
Institutional	7,257	3,086	3,496	3,822	876	1,049
Total	**36,894**	**28,954**	**36,172**	**44,131**	**24,964**	**30,888**

Population and Employees within the Station Service Areas (Relates to Theme 2: Provide an Alternative to Heavy Traffic and Congestion)

These two criteria were evaluated by determining the total population and number of employees within each alignment's effective station service area based on socioeconomic data from the HRTPO 2034 Transportation Analysis Zones (TAZ). The analysis used GIS to determine the proportional percentage of each TAZ's population and employment that is located within the station service areas of the alignments.

With a population forecast of 31,520 residents, the Central C Alignment would be able to reach the largest number of residents. The Western Alignment would be able to reach 26,530 residents, second highest of the six alignments. The Central B Alignment, with 32,810 employees, would reach the highest number of employees within the station service areas. The Western Alignment would reach the second highest number of employees, with 25,580 employees working within its station service areas.

Table 6 shows the total population and total number of employees within the station service areas for the various alignments. **Appendix D** includes maps that display how each alignment performs based on these two measures.

Table 6. Total Population and Employment within Station Service Areas

Highest Ranked
Second Highest Ranked

Evaluation Criteria	Western	Central A	Central B	Central C	Eastern A	Eastern B
Total Population within Station Service Areas	26,530	13,770	21,460	31,520	11,940	19,630
Total Employees within Station Service Areas	25,580	24,930	32,810	24,150	13,880	21,770

Total Population within a Five-Minute Drive from Station Locations (Relates to Theme 4: Provide Parking to Accommodate Riders)

At this stage of the study, the parking provisions for each station area have not yet been determined. To understand how well each alignment might be able to accommodate parking for transit riders, the Tier 2 analysis evaluated the forecast population within a five-minute drive of stations if Park & Ride or Kiss & Ride facilities were provided. Five-minute drivesheds from each station location were created using network analysis tools in GIS. Similar to the methodology in determining the half-mile effective service areas, the five-minute drivesheds were calculated using the City of Norfolk's existing street network data. The five-minute driveshed is based on posted speeds for each street, less 10 miles per hour to account for congestion, traffic signals, and other sources of vehicle delay.

The HRTPO TAZ 2034 socioeconomic data was used as the source of the population data. The analysis used GIS to determine the proportional percentage of each TAZ's population that would be located within the five-minute drivesheds. The results indicate that the Central C Alignment would serve the highest number of residents (152,980) within a five-minute drive of the transit stations. The Eastern B Alignment, with 109,660 residents within a five-minute driving distance from a station, would serve the second-highest number of residents.

Table 7 summarizes the results for this criterion for all the alignment options. Maps illustrating the population reached within five-minute drive sheds for each alignment are included in **Appendix D**.

Table 7. Total Population Reached within a Five-Minute Drive of Station Service Areas

Highest Ranked
Second Highest Ranked

Evaluation Criteria	Western	Central A	Central B	Central C	Eastern A	Eastern B
Total Population reached within 5-minute Drive of Station Service Areas	95,950	88,200	104,860	152,980	93,010	109,660

Number of Transit Stops within Station Service Areas (Relates to Theme 5: Interconnectivity of Transit Modes)

The Tier 2 analysis considered how potential stations for each alignment would connect to existing transit, walking, and bicycling networks to assess connections with other modes for each alternative. First, evaluation of this criterion determined the number of local bus stops that would be within the half-mile station service areas for each alignment to assess connectivity with the local transit network. Hampton Roads Transit's bus stop GIS data was used to conduct this analysis.

The Central C Alignment would have the greatest number of bus stops (220) located within its effective station service area, followed by the Western Alignment with 155 bus stops. **Table 8** summarizes the results for this criterion for all the alignment options. Maps illustrating the locations of the bus stops and the service areas for each alignment are included in **Appendix D**.

Table 8. Number of Local Transit Stops within Station Service Areas

Highest Ranked
Second Highest Ranked

Evaluation Criteria	Western	Central A	Central B	Central C	Eastern A	Eastern B
Number of Transit Stops within Station Service Areas	166	119	159	220	67	107

Sidewalks within Station Service Areas (Relates to Theme 5: Interconnectivity of Transit Modes)

To understand how well each alignment performs in terms of pedestrian connectivity, the Tier 2 analysis determined the total linear feet of existing sidewalk within each alignment's effective station service area. The sidewalk GIS shapefile from the City of Norfolk was used for this analysis.

The Central C Alignment would have the greatest amount of sidewalk within its station service areas with 542,000 linear feet of sidewalk, followed by the Western Alignment with 474,000 linear feet of sidewalk. **Table 9** summarizes the results for this criterion for all the alignment options. Maps illustrating the sidewalks within each alignment's station service area are included in **Appendix D**.

Table 9. Sidewalks within Station Service Areas

Highest Ranked
Second Highest Ranked

Evaluation Criteria	Western	Central A	Central B	Central C	Eastern A	Eastern B
Sidewalks within Station Service Areas (Linear Feet)	474,000	259,000	371,000	542,000	172,000	284,000

Bicycle-friendly Streets (Relates to Theme 5: Interconnectivity of Transit Modes)

To understand how each alignment can be supported by bicycling, the Tier 2 analysis evaluated existing bicycle access to and from the proposed station locations. To measure bicycle access to the stations, streets with less than a 25 mph posted speed limit were considered bicycle-friendly streets. These streets generally allow bicyclists to comfortably share the road with motorists. The analysis used GIS to

determine the total length of streets with posted speed limits of 25 mph or less within each alignment's effective station service area.

With 545,000 linear feet, the Central C Alignment would have the highest density of bicycle-friendly streets within its service areas, followed by the Western Alignment, with 460,000 linear feet. **Table 10** summarizes the results for this criterion for all the alignment options. Maps illustrating the bicycle-friendly streets within each alignment's service area are included in **Appendix D**.

Table 10. Bicycle-friendly Streets within Station Service Areas

Highest Ranked
Second Highest Ranked

Evaluation Criteria	Western	Central A	Central B	Central C	Eastern A	Eastern B
Bicycle-friendly Streets within Station Service Areas (Linear Feet)	460,000	257,000	418,000	545,000	202,000	363,000

Future Jobs within Station Service Areas (Relates to Theme 7: Economic Development and Neighborhood Revitalization)

The total number of future jobs within the effective station service areas of each alignment was used to evaluate the ability of the alignments to serve future job locations. The HRTPO TAZ 2034 socioeconomic data was used as the source for the employment data. GIS was used to determine the proportional percentage of each TAZ's forecast 2034 jobs within each alignment's station service areas.

The Central B Alignment would serve the highest number of future employees (26,100) while the Western Alignment would serve the second highest number of employees (25,250). **Table 11** summarizes the total number of future employees within the station service areas for all alignment options. Maps illustrating the future employment within each alignment's service areas are included in **Appendix D**.

Table 11. Future Jobs within Station Service Areas (2034 Jobs)

Highest Ranked
Second Highest Ranked

Evaluation Criteria	Western	Central A	Central B	Central C	Eastern A	Eastern B
Future Jobs within Station Service Areas (2034 Jobs)	25,250	20,130	26,100	23,890	13,660	19,640

Zero-car Households (Relates to Theme 7: Economic Development and Neighborhood Revitalization)

Households without cars are more dependent on transit for their overall transportation needs. The zero-car household information used to evaluate this criterion is based on data from the 2010 Census. GIS was used to determine the percentage of each census block within the station service area of the alignments. An area-based proportional calculation was then used to determine the total number of zero-car households that fall within each station service area.

For this criterion, alignments with higher concentrations of zero-car households performed better than those with fewer zero-car households. The Central C Alignment, with 1,980 zero-car households, ranked the highest in this criterion, followed by the Western Alignment, with 1,700 zero-car households. **Table 12** summarizes the total number of zero-car households within the station service areas for all alignment options. Maps illustrating the distribution of zero-car households along each alignment are included in **Appendix D**.

Table 12. Zero-Car Households within Station Service Areas

Highest Ranked
Second Highest Ranked

Evaluation Criteria	Western	Central A	Central B	Central C	Eastern A	Eastern B
Zero-Car Households within Station Service Areas	1,700	1,030	1,250	1,980	480	690

Potential for Transit-Oriented Development (TOD) (Relates to Theme 7: Economic Development and Neighborhood Revitalization)

This criterion compared the potential for TOD within the service areas for all alignment options. The highest potential for TOD is on currently vacant and underutilized parcels within the station service areas. In addition, parcels larger than one acre were considered to have a higher propensity for TOD because they might not need to be combined with other parcels prior to redevelopment.

Parcel-level tax data from the City of Norfolk containing land and building values was used for this analysis. Parcels with a building value of zero were considered vacant, and parcels with building values less than 40 percent of the total property value (building and land values combined) were considered underutilized[3]. Since redevelopment of smaller parcels is less likely than larger parcels, only vacant and underutilized parcels one acre and larger were considered in the analysis.

The Eastern B Alignment, with 136 acres of vacant and underutilized land, would have the highest potential for TOD, followed by the Eastern A Alignment with 130 acres of vacant and underutilized land. **Table 13** summarizes the results for this criterion for all alignment options. Maps illustrating the location of parcels with that have the highest potential for TOD along each alignment are included in **Appendix D**.

[3] Market economists use this industry standard as an indicator of propensity for an owner to redevelop a property.

Table 13. Potential TOD within Station Service Areas

Highest Ranked
Second Highest Ranked

Evaluation Criteria	Western	Central A	Central B	Central C	Eastern A	Eastern B
Vacant (Acres)	33	28	30	46	61	65
Underutilized (Acres)	33	53	56	71	69	71
Potential TOD within Station Service Areas (Acres)	**66**	**81**	**86**	**117**	**130**	**136**

Potential to Expand Access to Tide Area Jobs (Relates to Theme 7: Economic Development and Neighborhood Revitalization)

It is important that transit investments support economic development, leverage existing infrastructure, and complement ongoing development policies. Because expansion of The Tide would be a substantial investment in the City of Norfolk, this criterion considers how each of the alignments would further the ability of residents in the City to access their existing jobs along The Tide line. The data and analysis for this criterion come from US Bureau of Census and Department of Labor Longitudinal Employment and Housing Dynamics (LEHD), 2012[4]. **Figure 17** shows the home locations of workers who have jobs within half-mile service areas of Tide stations.

Based on the results of the analysis, the Central C Alignment and the Central B Alignment would have the greatest number of people who currently work in The Tide station areas and live in each of the new alignments' station areas. The Central C Alignment, with 1,560 people, would have the largest number of Tide station area workers living in the new alignment station areas, followed by the Central B Alignment, with 1,170 workers. Based on this analysis, the Central C Alignment would increase the reach of existing Tide stations by more than 240 percent, and the Central B Alignment would increase their reach by 180 percent, based on the number of people who would have the option to take premium transit and both work and live within a station area (Tide or future alignment station area). **Table 14** shows workers along each alignment who would be able to access their current Tide area jobs using The Tide and the potential alignment extensions.

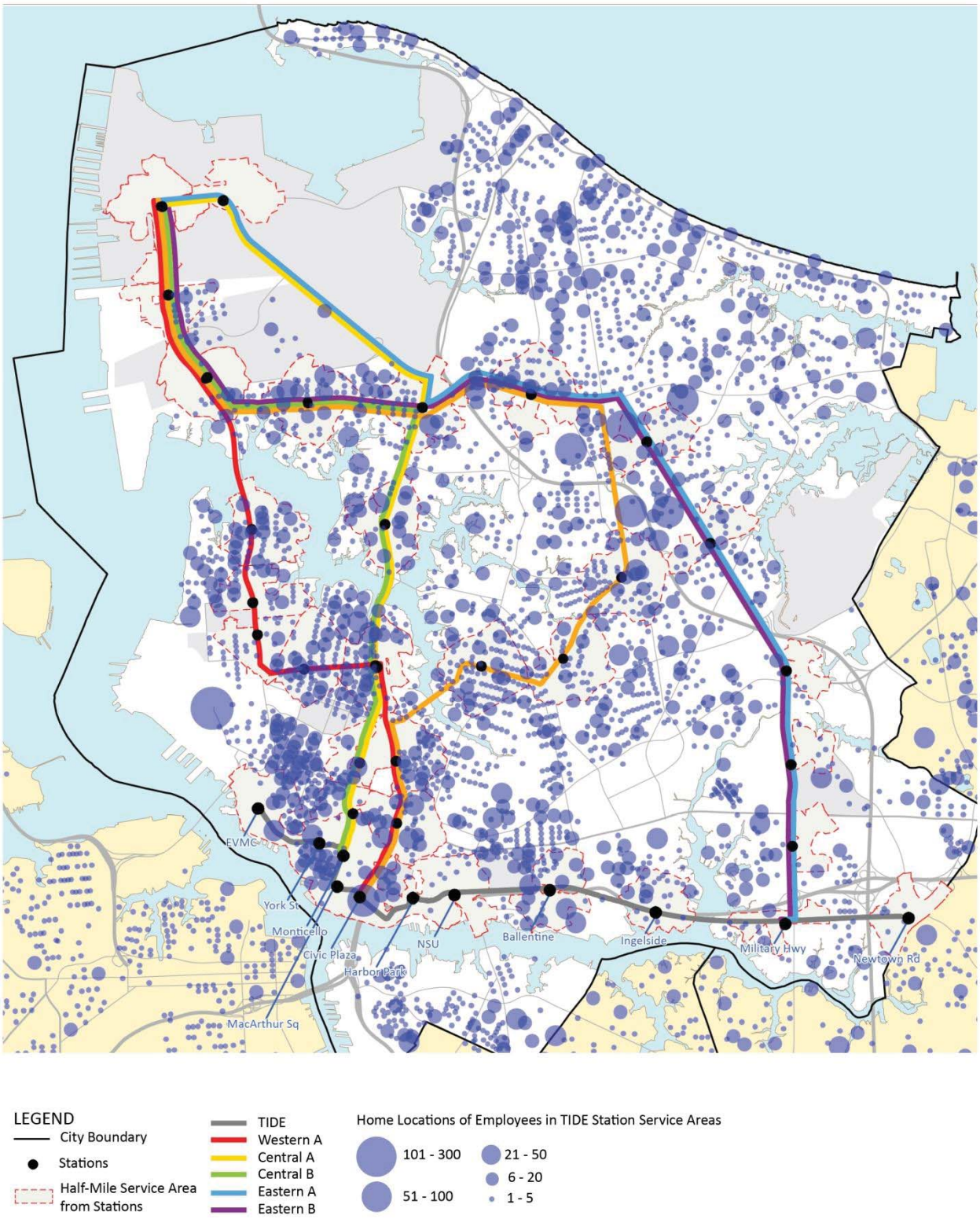
Table 14. Tide Station Area Employees Living within Alignment Station Service Areas

Highest Ranked
Second Highest Ranked

Evaluation Criteria	Western	Central A	Central B	Central C	Eastern A	Eastern B
TIDE Station Area Employees living in Alignment Station Areas	1,040	880	1,170	1,560	550	840

[4] These numbers are based on US Census Bureau and Department of Labor surveys, as reported by employers. The data may be limited in how NSN report their employment numbers.

Figure 17. Home Locations of Workers Who Work within Half-mile of Tide Stations



Potential to Connect Tide Area Residents to Jobs (Relates to Theme 7: Economic Development and Neighborhood Revitalization)

Similar to the previous criterion, this analysis evaluated the ability of each alignment to capitalize on the benefits of the existing Tide line. This criterion considers the ability of Tide area residents to access jobs within station areas along each new alignment. **Figure 18** and **Table 15** show the current job locations of residents who live within a half-mile of The Tide stations. The map shows the concentration of jobs in downtown and along part of Military Highway. The residential areas along The Tide are not as dense when compared to the number of jobs along The Tide, and the extension alignment options do not travel through areas with a large concentration of jobs, except for NSN. As a result, the number of residents served would be lower compared to the prior criterion.

The Western Alignment, with 170 residents, would have the largest number of Tide station area residents working in the alignment station areas, followed by the Central B Alignment, with 150 residents. There would be a 27 percent increase in the number of Tide station area residents who would be able to access jobs without driving if the Western Alignment was built, and a 23 percent increase if the Central B Alignment was built.

Table 15. Tide Station Area Residents Working within Alignment Station Service Areas

Highest Ranked
Second Highest Ranked

Evaluation Criteria	Western	Central A	Central B	Central C	Eastern A	Eastern B
TIDE Station Area Residents working in Alignment Station Areas	170	130	150	100	60	80

3.1.1.3 Summary of Station Service Area Analysis

The station area analysis conducted as part of the Tier 2 screening process compared six alignments based on the 13 evaluation criteria. The results show that the Central C Alignment and the Western Alignment performed the best for the majority of the evaluation criteria and across all project themes. The Central B Alignment ranked third on many criteria, and ranked first or second on other criteria. Although the Eastern A Alignment and the Eastern B Alignment did not perform as strongly on most of the measures, these two alignments represent a greater potential for TOD because of the greater number of large vacant and underutilized parcels around the station locations. **Table 16** summarizes the results for each of the evaluation criteria for all of the alignment options.

Figure 18. Job Locations of Residents Living within Half-mile of Tide Stations

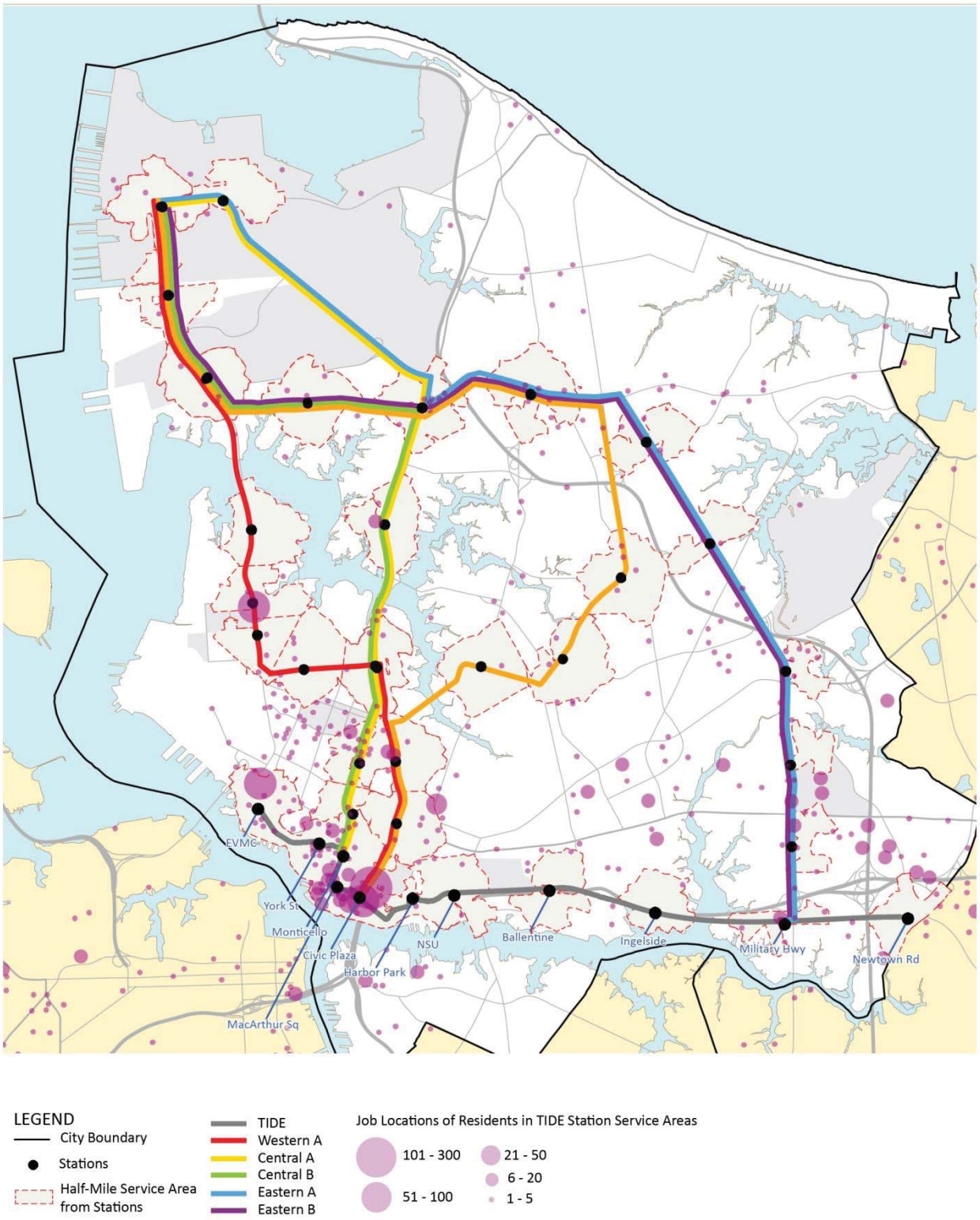


Table 16. Summary of Station Service Area Analysis

Highest Ranked
Second Highest Ranked

Project Themes	Evaluation Criteria	Western	Central A	Central B	Central C	Eastern A	Eastern B
Station Service Areas (Acres)		2,700	1,510	2,570	3,370	1,520	2,580
Number of Stations		11	6	9	11	8	11
Connect to Many Points within Norfolk	Number of Activity Centers with Station Service Areas	11	8	11	10	3	5
	Total Transit Supportive Land Uses (1,000 ft^2)	36,894	28,954	36,172	44,131	24,964	30,888
Provide an Alternative to Heavy Traffic and Congestion	Total Population within Station Service Areas	26,530	13,770	21,460	31,520	11,940	19,630
	Total Employees within Station Service Areas	25,580	24,930	32,810	24,150	13,880	21,770
Provide Parking to Accommodate Riders	Total Population within 5-minute Drive of Station Areas	95,950	88,200	104,860	152,980	93,010	109,660
Interconnectivity of Transit Modes	Number of Local Transit Stops within Station Service Areas	166	119	159	220	67	107
	Sidewalks within Station Service Areas (Linear Feet)	474,000	259,000	371,000	542,000	172,000	284,000
	Bicycle-friendly Streets (posted speed of 25mph or less) within Station Service Areas (Linear Feet)	460,000	257,000	418,000	545,000	202,000	363,000
Economic Development and Neighborhood Revitalization	Future Jobs within Station Service Areas (2034 Jobs)	25,250	20,130	26,100	23,890	13,660	19,640
	Potential TOD within Station Service Areas (Acres)	66	81	86	117	130	136
	Number of Zero-car Households Served	1,700	1,030	1,250	1,980	480	690
	Tide Station Area Employees living in Alignment Station Areas	1,040	880	1,170	1,560	550	840
	Tide Station Area Residents working in Alignment Station Areas	170	130	150	100	60	80

3.1.2 Right-of-Way Analysis

The identification of potential right-of-way impacts for the Tier 2 alignments followed a similar process as the analysis performed for the Tier 1 screening. This analysis relates to project Theme 7: Right-of-Way Constraints. The following assumptions were made in determining the extent of the right-of-way impacts:

- All corridors would have exclusive at-grade LRT operations[5] (except at railroad crossings, crossings of interstate highways, or along portions of Military Highway south of I-64 where the alignment would be grade separated).
- Grade separation structures will be required at all railroad crossings, crossings with interstate highways, and under the runway at I-564.
- Typical sections are based on maintaining the existing number of through travel lanes on each roadway.
- On-street parking would be removed[4] from streets where the alignment would be located.
- Limits of impact do not include turn lanes or bike lanes.
- Limits of impact do not include station platforms or Park & Ride facilities.
- Limits of impact do not include operations and maintenance facilities (vehicle storage and maintenance facilities, traction power substations, other wayside equipment).
- Dimensions are as shown in typical sections, including 11 feet minimum travel lane width and a minimum of 10 feet for sidewalks, utilities, and other right-of-way needs.
- No landscaped median or buffer would be added where the proposed section is wider than the existing right-of-way.

The typical sections used for this analysis are shown in **Figure 19** through **Figure 23**.

[5] For the purposes of this study, LRT operations were assumed. If another transit vehicle technology such as streetcar or bus rapid transit were selected, some of assumptions (e.g. exclusive right of way or removal of on-street parking) above would not be applicable to the right-of-way analysis.

Figure 19. Typical Section, One Lane in Each Direction

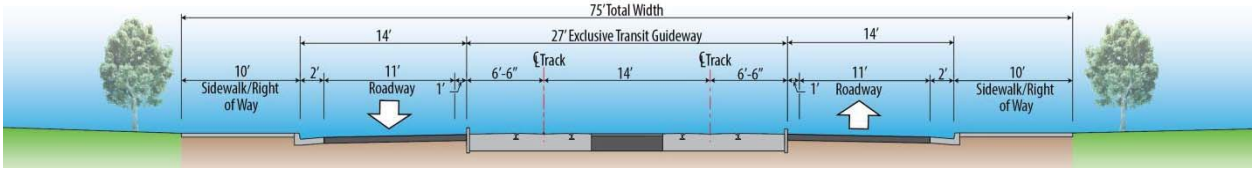


Figure 20. Typical Section, Two Lanes in Each Direction

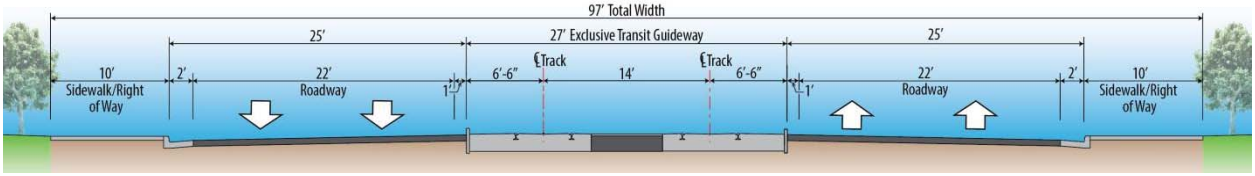


Figure 21. Typical Section, Three Lanes in Each Direction

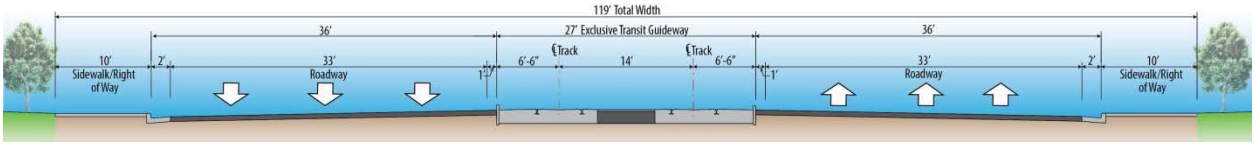


Figure 22. Typical Section with Guideway in Existing Median

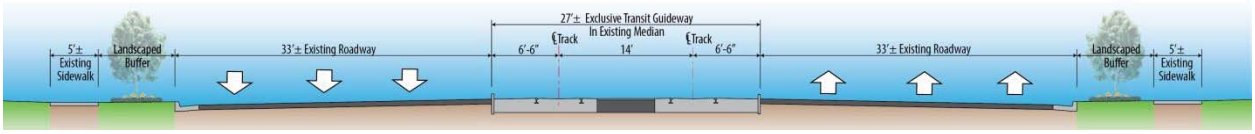
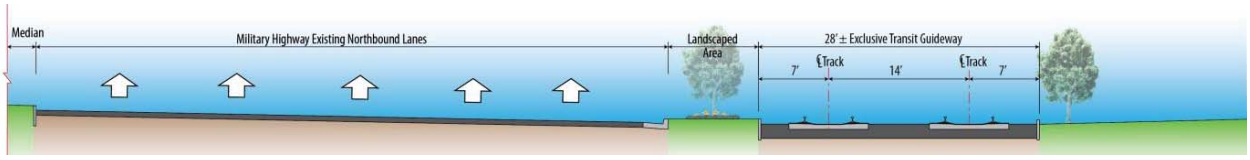


Figure 23. Typical Section with Guideway adjacent to Military Highway



The alignments were developed on a basemap consisting of the City of Norfolk's GIS parcel shapefile and 2013 aerial photography. While the City's right-of-way limits are not delineated in the shapefile, it was assumed for this analysis that the parcel lines adjacent to roadways formed the right-of-way boundaries in most cases.

The total requirement for the potential right-of-way consists of the combined widths of the transit guideway, adjacent roadways, and sidewalks. For each of the transit alignment segments, conceptual level track alignments were drawn on the basemap so that the complete section was approximately centered on the right-of-way. Placing the section in the center of the existing right-of way produces the most conservative estimate of the number of parcels that would have potential right-of-way impacts.

Where the transit guideway would be in exclusive lanes within roadway rights-of-way, the proposed typical section for each segment was selected based on maintaining the existing number of through lanes. The widths of the transit guideway, adjacent roadway, and sidewalks were drawn on the basemap as offsets from the centerlines using the dimensions shown in the typical sections. Outside existing rights-of-way, a typical transit guideway width of 27 feet was applied and sidewalks or other buffers were added where appropriate.

To determine the potential impacts, the potential right-of-way width was compared to the existing parcel data using GIS. This process identified the total land area of the estimated impacts and the number of parcels that would be impacted based on the assumptions made in developing the alignments. The analysis also identified locations with insufficient right-of way-width to add an exclusive transit guideway while also maintaining existing roadway capacity.

3.1.2.1 Right-of-Way Analysis Results

Table 17 shows the potential total right-of-way requirements for the Tier 2 alignments. The Central C Alignment would impact the greatest number of parcels, while the Central A Alignment would impact the fewest number of parcels. The Eastern B Alignment would potentially impact the greatest land area outside of existing rights-of-way and the Central A Alignment would require the least amount of additional property.

Table 17. Right-of-Way Analysis Results

Highest Ranked
Second Highest Ranked

Evaluation Criteria	Western	Central A	Central B	Central C	Eastern A	Eastern B
Total Area of Right of Way Impacts (acres)	7.2	4.3	11.6	12.9	9.0	16.4
Total Number of Parcels Impacted	491	115	299	611	220	408

3.1.3 Ridership Analysis

Ridership was modeled for the Tier 2 alignments to determine the potential demand and projected number of transit riders that would use the expanded system. Ridership forecasting relates to project Theme 6: Future System Expansion. Ridership was modeled for each of the alignments as a distinct

system separate from the existing Tide alignment. The results demonstrate the estimated daily ridership for each of the Tier 2 alignments.

3.1.3.1 Ridership Analysis Methodology

The ridership model considered various input components that affect transit usage, including residential population and employment density around the proposed stations, highway and roadway congestion levels and associated travel times, costs associated with automobile ownership (for example, parking costs near places of employment), fares for existing transit modes, and transit travel and wait times. The model incorporated each of these factors to estimate the ridership potential for each of the alignments under consideration. Data incorporated into the model was provided by local government agencies and Hampton Roads Transit.

3.1.3.2 Ridership Analysis Results

The projected opening year (2034) daily ridership for the Tier 2 alignments is provided in **Table 18**. The Eastern A Alignment has the highest ridership potential, with 5,150 projected transit riders daily. The Central A Alignment had the lowest projected daily ridership, with 2,500 riders. The variations of the central and eastern alignments that include W. Little Creek Road have higher ridership projections than their counterparts that would use I-564 to get to NSN. The Western Alignment, which would travel through dense residential neighborhoods and Old Dominion University between downtown and NSN, has lower projected ridership levels (4,000 riders) than variations of the central and eastern alignments.

Table 18. Projected Opening Year (2034) Ridership for Tier 2 Alignments

Highest Ranked
Second Highest Ranked

Evaluation Criteria	Western	Central A	Central B	Central C	Eastern A	Eastern B
Ridership on Norfolk extension only (not inclusive of the entire Tide system)	4,000	2,500	4,550	2,850	5,150	4,700

3.1.4 4(f) Sites and Historic Resources Analysis

The environmental analysis included three components to identify the proximity of 4(f) sites to each of the Tier 2 alignments options. Section 4(f) of the Department of Transportation (DOT) Act of 1966 stipulates that the Federal Highway Administration and other DOT agencies cannot approve the use of land from publicly owned parks, recreational areas, wildlife and waterfowl refuges, or public and private historical sites unless the following conditions apply:

- There is no feasible and prudent alternative to the use of land.
- The action includes all possible planning to minimize harm to the property resulting from use[6].

[6] Taken from: http://www.environment.fhwa.dot.gov/4f/

The environmental analysis helped determine the impact each alignment could have on: historic structures, historic districts, and parklands. These criteria are related to project Theme 7: Environmental Consideration and Resiliency.

3.1.4.1 4(f) Sites and Historic Resources Analysis Methodology

The City of Norfolk is primarily built-out and any future transit extension would travel through already developed areas. Therefore, the process for evaluating 4(f) sites and historic resources recognized the locations of City-owned parklands, historic structures, and historic districts and their proximity to the Tier 2 alignments. Identifying the locations of historic resources and parklands relative to the Tier 2 station areas facilitates an understanding of the relative sensitivity to future transit development within certain areas of the City.

This analysis quantified the presence of historic resources and parklands within the station service areas. The process for determining the quantity and proximity of historic resources to a potential transit extension involved isolating the locations of historic sites and historic districts within a half-mile of the station areas. Data provided by the City of Norfolk of locations listed on the National Register of Historic Places, which include historic structures and historic districts, was integrated with GIS mapping to determine the proximity of historic resources within a half-mile of the station areas. Parklands within a half-mile of the station areas were identified using data provided by the City in GIS format, which allowed existing parklands to be mapped and the potential acreage affected to be quantified.

3.1.4.2 4(f) Sites and Historic Resources Analysis Results

Table 19 summarizes the outcomes of the 4(f) and historic resources analysis. The Western Alignment would impact the greatest number of historic structures (eight) and the highest acreage of parklands (149 acres). Both the Central A Alignment and Central B Alignment affect the most historic districts (eight), while the eastern alignments affect no historic districts. The Central B Alignment would impact the second highest acreage of parklands (147 acres) among the Tier 2 alignments. The eastern alignments would impact the lowest acreage of parklands. The lack of historic structures and historic districts, as well as parklands, along the eastern alignments can be explained by the auto-centric development pattern along the corridor and the timing of the development. The western and central alignments travel through historic residential neighborhoods, while the eastern alignments follow roadways with development occurring post World War II. Maps illustrating the locations of 4(f) sites and historical resources relative to the Tier 2 station areas are included in **Appendix D**.

Table 19. 4(f) Sites and Historic Resources within Station Service Areas

Highest Ranked
Second Highest Ranked

Evaluation Criteria	Western	Central A	Central B	Central C	Eastern A	Eastern B
Historic Structures	8	6	6	7	0	0
Historic Districts	5	8	8	6	0	0
Parklands (acres)	149	132	147	109	36	51

3.1.5 100-year Floodplain Analysis

In addition to the 4(f) sites and historic resources, the environmental analysis included an assessment of the potential impacts of flooding. This criterion is related to project Theme 7: Environmental Consideration and Resiliency. This criterion evaluated potential flood impacts for each alternative by determining the sections of each alignment within the 100-year floodplain. Analyzing the potential impacts of flooding also acknowledges the City's emphasis on addressing resiliency through future efforts focused on flood mitigation and preparedness measures.

3.1.5.1 100-year Floodplain Analysis Methodology and Data

The purpose of the analysis was to determine the sections of each alignment that would pass through the 100-year floodplain and the total linear miles of each alignment within the 100-year floodplain. The 100-year floodplain, as developed by the Federal Emergency Management Agency (FEMA), is the land that is predicted to flood during a 100-year storm and has a one percent chance of occurring in any given year. The alignments were evaluated using GIS mapping that isolated and added the sections of each alignment within the 100-year floodplain. Data indicating the extent of the 100-year floodplain was provided by the City of Norfolk and FEMA. **Table 20** provides the total length of each alignment that is within the 100 year floodplain. Maps identifying the portions of each alignment that pass through the 100-year floodplain are included in **Appendix D**.

Table 20. Length of Tier 2 Alignments within 100-year Floodplain

Highest Ranked
Second Highest Ranked

Evaluation Criteria	Western	Central A	Central B	Central C	Eastern A	Eastern B
Length of Alignment within 100-year Flood Plain (miles)	1.22	1.10	1.06	0.21	0.13	0.24

3.1.5.2 100-year Floodplain Analysis Results

The Western Alignment has the largest number of linear miles passing through the 100-year floodplain, with 1.22 miles, while the Eastern A Alignment has the least, with 0.13 miles. This is because the most flood-prone areas in the City of Norfolk are in western area neighborhoods such as Ghent and Larchmont. The existing roadways the eastern alignments follow avoid flood prone areas and are not located adjacent to existing water bodies. The Central A Alignment has the second greatest number of linear miles in the 100-year floodplain at 1.10 miles.

3.1.6 Traffic Analysis

This section describes the traffic analysis methodology used to evaluate the intersections along the possible transit alignment routes for a Tide extension to Naval Station Norfolk. The traffic analysis methodology consists of a critical movement analysis of selected intersections. The objective of this planning-level analysis is to identify potential capacity issues at intersections. This analysis relates to Theme 3: A fixed guideway connection between The Tide and NSN should make travel time more reliable.

3.1.6.1 Intersection Analysis Methodology

The intersection analysis was conducted for important signalized intersections on the possible transit alignment routes. The focus of this planning-level methodology is to examine the signalized intersections that control the capacity of each segment that would form a potential transit alignment. The approach is as follows:

1. **Obtain traffic volumes for the a.m. and p.m. peak hours.** Turning movement counts were collected during June 2014 at signalized intersections within the alignment segments.
2. **Perform a critical movement analysis for each intersection.** The critical movement analysis technique is a *simplified* approach to estimate the capacity utilization at each intersection and identifies the maximum number of vehicles that need to be served during each signal phase.
3. **Estimate the volume to capacity (v/c) ratio for each intersection.** Based on the estimated number of signal phases and using the sum of critical movement volumes, the volume-to-capacity ratio was computed for each intersection.

Critical movement analysis is a simplified technique that allows for an estimate of whether an intersection is operating below, at, or above capacity based upon specific critical traffic movements. The typical threshold used in critical movement analysis for determining whether intersections are under capacity/near capacity is a v/c ratio of 0.85[7]. However, as this methodology does not take into account many real-world conditions including pedestrian movements, consistent values of capacity across all travel lanes, and complex signal phasing, a lower threshold of 0.80 was used to identify intersections that are or would be near capacity. The results of the critical movement analysis are approximations and may overestimate the amount of remaining capacity available at an intersection. Before any decisions regarding possible transit alignments are made, a more detailed operational analysis must be conducted.

The intersection analysis was performed separately for the a.m. and p.m. peak hours. The larger of the a.m. and p.m. peak hour intersection v/c ratios was used to compare operations. Further details about the intersection analysis methodology can be found in **Appendix E**.

3.1.6.2 Year 2034 No-Build Scenario

The next step of the analysis computed future v/c ratios for each intersection after accounting for traffic volume increases. This approximates a "No-Build" scenario analysis, where volume is increased and the lane configuration at each intersection would remain the same as in existing conditions. One of the main advantages of using the v/c ratio to represent the traffic operations of each existing intersection is that the analysis of future intersection traffic operations can be computed once the existing v/c ratios are determined. For purposes of future conditions, the study assumed a 0.5 percent annual growth rate

[7] http://ops.fhwa.dot.gov/publications/fhwahop08024/chapter3.htm#3.3 (see Table 3-2 in Section 3.3.6)

over 20 years, which would result in a growth factor of approximately 10.5 percent. The existing v/c ratios were multiplied by a factor of 1.105 to obtain the future v/c ratios. While this adjustment does not consider localized growth or decline due to changes in land use and demographics, it is a reasonable assumption for a high-level analysis.

3.1.6.3 Year 2034 Lane Removal Scenario

The last component of the intersection analysis was to perform a planning-level analysis of a future lane removal scenario where through travel lanes would be removed to provide space for transit operations. For each intersection, a critical movement analysis was performed with the intersection lane configurations altered by removing one travel lane in either direction. At intersections where two or more segments would meet, the critical movement analysis examined the cases where lanes were removed in the east-west direction or the north-south direction. The larger calculated v/c ratio between the two analyses was used as the representative v/c ratio.

The decision to remove lanes did not consider whether a median or other potentially available right-of-way was present along the roadway. Although several roadways within the study area contain a median (e.g. Hampton Boulevard, Church Street, Granby Street, and Llewellyn Avenue) lanes were still removed to support a "worst-case" level of analysis.

Alignments were evaluated by counting the number of intersections with a v/c ratio at or greater than 0.80 under the Year 2034 Lane Removal Scenario.

3.1.6.4 Existing Conditions Results

The existing conditions critical movement analysis indicates that higher v/c ratios generally occur during the p.m. peak hour than the a.m. peak hour. Four intersections (Military Highway/Poplar Hall Road, Military Highway/Princess Anne Road, Military Highway/Norview Avenue, and Chesapeake Boulevard/W. Little Creek Road) along the Eastern A Alignment and the Eastern B Alignment have a v/c ratio higher than 0.80. According to the critical movement analysis, four intersections (Tidewater Drive/Lafayette Boulevard, Chesapeake Boulevard/W. Little Creek Road, Chesapeake Boulevard/Johnstons Road, and Sewell's Point Road/Chesapeake Boulevard/Norview Avenue) along the Central C Alignment have a v/c ratio higher than 0.80.

Based on the results of the critical movement analysis, the Western Alignment, Central A Alignment, and Central B Alignment do not have any intersections that currently operate with a v/c ratio greater than 0.80. The results of the intersection analysis can be seen in

Table 21. A map displaying the existing conditions intersection results can be found in **Appendix E, Figure E.1.** The complete results for the intersection analysis are contained in tabular form in **Appendix E, Table E.1.**

Table 21. Summary of Existing Conditions Results

Highest Ranked

Evaluation Criteria	Western	Central A	Central B	Central C	Eastern A	Eastern B
Number of intersections operating at v/c > 0.80	0	0	0	4	4	4

3.1.6.5 Year 2034 No-Build Scenario Results

Traffic volumes were increased from existing conditions by 10.5 percent in the Year 2034 No-Build Scenario while the number and configuration of lanes remained the same at intersections. According to the critical movement analysis, three intersections (Military Highway/Poplar Hall Road, Military Highway/Norview Avenue, and Chesapeake Boulevard/W. Little Creek Road) along the Eastern A Alignment and the Eastern B Alignment would have a v/c ratio higher than 0.80. The Military Highway/Princess Anne Road intersection would be grade-separated in the future so this intersection was removed from the results. According to the critical movement analysis, four intersections (Tidewater Drive/Lafayette Boulevard, Chesapeake Boulevard/W. Little Creek Road, Chesapeake Boulevard/Johnstons Road, and Sewell's Point Road/Chesapeake Boulevard/Norview Avenue) along the Central C Alignment would have a v/c ratio higher than 0.80.

According to the critical movement analysis,the Western Alignment, Central A Alignment, and Central B Alignment would not have any intersections with a v/c ratio greater than 0.80. The results of the analysis can be seen in **Table 22.** A map displaying the Year 2034 No-Build intersections results can be found in **Appendix E, Figure E.2.** The complete results for the intersection analysis are contained in tabular form in **Appendix E, Table E.1.**

Table 22. Summary of Year 2034 No-Build Scenario Results

Highest Ranked
Second Highest Ranked

Evaluation Criteria	Western	Central A	Central B	Central C	Eastern A	Eastern B
Number of intersections operating at v/c > 0.80	0	0	0	4	3	3

3.1.6.6 Year 2034 Lane Removal Scenario Results

Traffic volumes were increased from existing conditions by 10.5 percent in the Year 2034 Lane Removal Scenario while one lane in each direction was removed from each intersection along an alignment.

According to the critical movement analysis, the Western Alignment would have three intersections with a v/c ratio greater than 0.80:

- Hampton Boulevard/W. 38th Street
- Hampton Boulevard/W. 43rd Street

- Granby Street/W. 38th Street

This would be an increase of three intersections from the Year 2034 No-Build Scenario. **Table 23** lists the number of intersections with v/c greater than 0.80 along each alignment.

According to the critical movement analysis, both the Central A Alignment and the Central B Alignment would have four intersections with a v/c ratio greater than 0.80:

- Granby Street/W. Little Creek Road
- Granby Street/Willow Wood Drive
- Granby Street/W. 38th Street
- Monticello Street/Virginia Beach Boulevard

This would be an increase of four intersections from the Year 2034 No-Build Scenario.

According to the critical movement analysis, the Central C Alignment would have six intersections with a v/c ratio greater than 0.80:

- Granby Street/W. Little Creek Road
- I-64 Eastbound Ramps/W. Little Creek Road
- Chesapeake Boulevard/W. Little Creek Road
- Chesapeake Boulevard/Johnstons Road
- Sewell's Point Road/Chesapeake Boulevard/Norview Avenue
- Tidewater Drive/Lafayette Boulevard

This would be an increase of two intersections from the Year 2034 No-Build Scenario.

According to the critical movement analysis, both the Eastern A Alignment and the Eastern B Alignment would have six intersections with a v/c ratio greater than 0.80:

- Granby Street/W. Little Creek Road
- I-64 Eastbound Ramps/W. Little Creek Road
- Chesapeake Boulevard/W. Little Creek Road
- Military Highway/W. Little Creek Road
- Military Highway/Norview Avenue
- Military Highway/Poplar Hall Road

This would be an increase of three intersections from the Year 2034 No-Build Scenario. The Military Highway/Princess Anne Road intersection would be grade-separated in the future so this intersection was removed from the results.

Table 23. Summary of Year 2034 Lane Removal Scenario Results

Highest Ranked
Second Highest Ranked

Evaluation Criteria	Western	Central A	Central B	Central C	Eastern A	Eastern B
Number of intersections operating at v/c > 0.80	3	4	4	6	6	6
Increase in the number of intersections operating at v/c > 0.80 compared to No-Build	3	4	4	2	3	3

According to the critical movement analysis, the eastern alignments and the Central C Alignment would have the most intersections with a v/c ratio greater than 0.80 in the Year 2034 Lane Removal Scenario. The Central A Alignment and the Central B Alignment would have the largest increase in the number of intersections with a v/c greater than 0.80. The Western Alignment would have the fewest number of intersections with a v/c greater than 0.80. From an intersection capacity perspective, the results indicate that each of the alignments would have some intersections that could potentially act as a bottleneck to traffic flow along the possible transit alignments. The critical movement analysis does not indicate any substantial differences in potential impacts between the alignments.

A map displaying the Year 2034 Lane Removal scenario intersections results can be found in **Appendix E, Figure E.3.** The complete results for the intersection analysis are contained in tabular form in **Appendix E, Table E.1**.

3.2 OCTOBER 2014 PUBLIC REVIEW OF TIER 2 TECHNICAL EVALUATION RESULTS

The final set of public workshops was conducted in October 2014. They were held on October 20 at ODU, October 23 at the Mary D. Pretlow Anchor Branch Library, October 27 at the Ray and Joan Kroc Corps Community Center, and October 30 at Tidewater Community College. Approximately 140 community members participated in the workshops. The goal of the workshops was to have the public review the results of the Tier 2 technical evaluation and to identify their preferred alignments and corridors from the Tier 2 subset of six alignments.

Workshop attendees watched a PowerPoint presentation given by HRT to learn about the study and review the preliminary results of the Tier 2 technical analysis. An explanation of the preferred corridor selection activity was given before attendees broke into small groups of 7-10 people to vote on their preferred alignment of the six alignments studied in the Tier 2 technical evaluation process. **Table 24** on the following displays the results for each public meeting and the totals for each alignment.

Table 24. October 2014 Public Meeting Results

Public Meeting	Western	Central A	Central B	Central C	Ea	Ranked B
October 20, 2014	39	0	4	2	4	7
October 23, 2014	5	0	5	4	4	3
October 27, 2014	4	1	4	1	8	7
October 30, 2014	16	3	2	0	2	9
Totals	**64**	**4**	**15**	**7**	**18**	**26**

Highest Ranked
Second Highest Ranked

Section 4

Conclusions and Options for Further Study

4.0 CONCLUSIONS AND OPTIONS FOR FURTHER STUDY

The Tier 2 technical analysis evaluated the six alignments that advanced from the Tier 1 screening process across a range of criteria intended to understand which alignments would best meet the study's *Purpose and Need* and project themes. The Tier 2 screening process consisted of analyses of potential station areas along each alignment; potential impacts to right-of-way, historical properties and parklands; resiliency; ridership; and a planning-level traffic analysis of intersections. At the conclusion of the technical analyses, members of the public were invited to four workshops in October 2014 to weigh in and vote on their preferred alignment to connect The Tide with NSN.

Based upon the results of the Tier 2 screening process, five options have been selected to be advanced for further discussion. The five options are based primarily on refinement of the Western Alignment and the Eastern B Alignment, which were the two alignments that performed best across the range of Tier 2 technical analyses and had the broadest public support.

The Western Alignment would connect many key activity centers in the City of Norfolk, serve a wide range of residents and employment locations, integrate well and complement HRT's bus system, travel through areas of Norfolk that have a dense network of sidewalks and bicycle-friendly streets, and would have ridership numbers on the new alignment similar to the existing Tide. However, the Western Alignment would have the greatest potential impact to historic properties, parklands, right-of-way, and would be primarily located in low-lying areas that are prone to flooding.

The Eastern B Alignment would not connect as many key activity centers in Norfolk as the Western Alignment, but it would provide a more direct trip from the existing Tide to NSN and potentially serve the Norfolk International Airport via a shuttle from a nearby transit station. While the Eastern B Alignment would not travel through existing dense residential or employment areas, it would have the second-highest ridership forecast because of its ability to provide a direct trip to NSN. The properties near the likely station areas of the Eastern B Alignment may have the highest potential for future TOD sites because those properties have larger parcel sizes than those around other alignment station areas. The Eastern B Alignment has the benefit of being located in areas with relatively high elevation in the City of Norfolk, and therefore would have the lowest propensity for flooding during major storm events. This alignment would have fewer impacts to historic sites and parklands compared with the other alignments.

While the Western Alignment and the Eastern B Alignment performed best across the range of technical analyses and public input, all five options would meet NSNTES' *Purpose and Need* and project themes. The five options are shown in **Figure 24** through **Figure 28**.

Option 1

Option 1 would use the Western Alignment as studied in the Tier 2 technical analysis. This option would connect the Ghent neighborhood, ODU, and NSN along Hampton Boulevard as shown in **Figure 24**. The

connection to NSN at the north end of the alignment, the route through Ghent, and the connection to The Tide are to be determined.

Option 2

Option 2 would use the Eastern B Alignment as studied in the Tier 2 technical analysis. This option would travel along Military Highway, W. Little Creek Road, and Hampton Boulevard to NSN as shown in **Figure 25**. The connection to NSN at the north end of the alignment and the connection to The Tide are to be determined.

Option 3

Option 3 would use both the Western Alignment and Eastern B Alignment as studied in the Tier 2 technical analysis. This option would connect the Ghent neighborhood, ODU, and NSN along Hampton Boulevard on the west side of Norfolk and would travel along Military Highway and W. Little Creek Road on the east side of Norfolk before linking with the Western Alignment at a station near the Joint Forces Staff College on Hampton Boulevard. The connection to NSN at the north end of the alignment, the route through Ghent, and the two connections to The Tide are to be determined. Option 3 is illustrated in **Figure 26.**

Option 4

Similar to Option 3, Option 4 would use both the Western Alignment and Eastern B Alignment as studied in the Tier 2 technical analysis and connect the Ghent neighborhood, ODU, and NSN along Hampton Boulevard on the west side of Norfolk and would travel along Military Highway and W. Little Creek Road on the east side of Norfolk before linking with the Western Alignment at a station near the Joint Forces Staff College on Hampton Boulevard. The connections to NSN and to the eastern end of The Tide are to be determined. A route from the western end of The Tide through the Ghent neighborhood could include a streetcar, bus, or shuttle connection and is to be determined. Option 4 is illustrated in **Figure 27.**

Option 5

Option 5 would use the Eastern B Alignment as studied in the Tier 2 technical analysis. This option would travel along Military Highway, W. Little Creek Road, and Hampton Boulevard to NSN as shown in **Figure 28**. The connections to NSN and to the eastern end of The Tide are to be determined. A route from the western end of The Tide to the Ghent neighborhood and ODU could include an LRT or streetcar connection and is to be determined.

Figure 24. Option 1

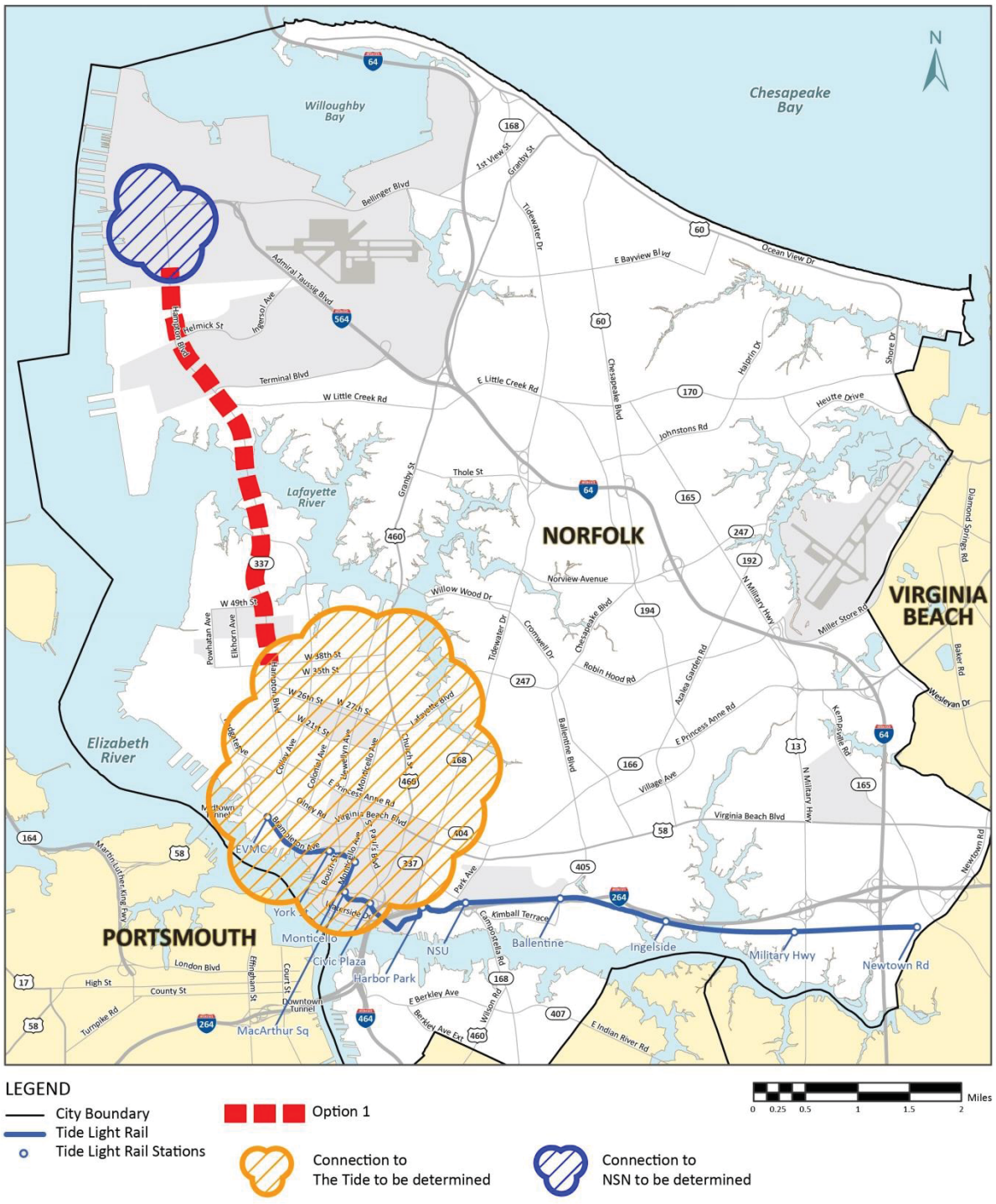


Figure 25. Option 2

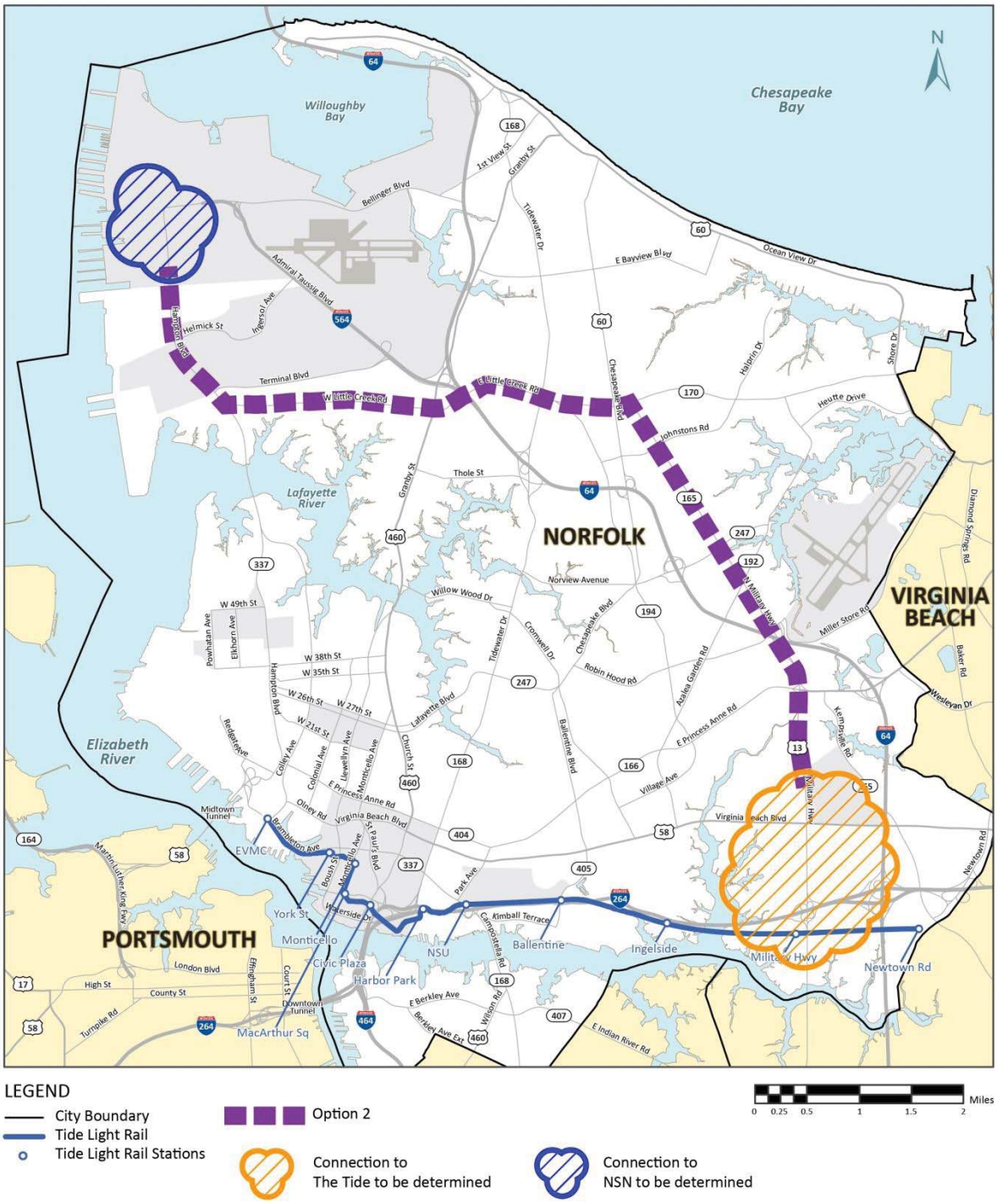


Figure 26. Option 3

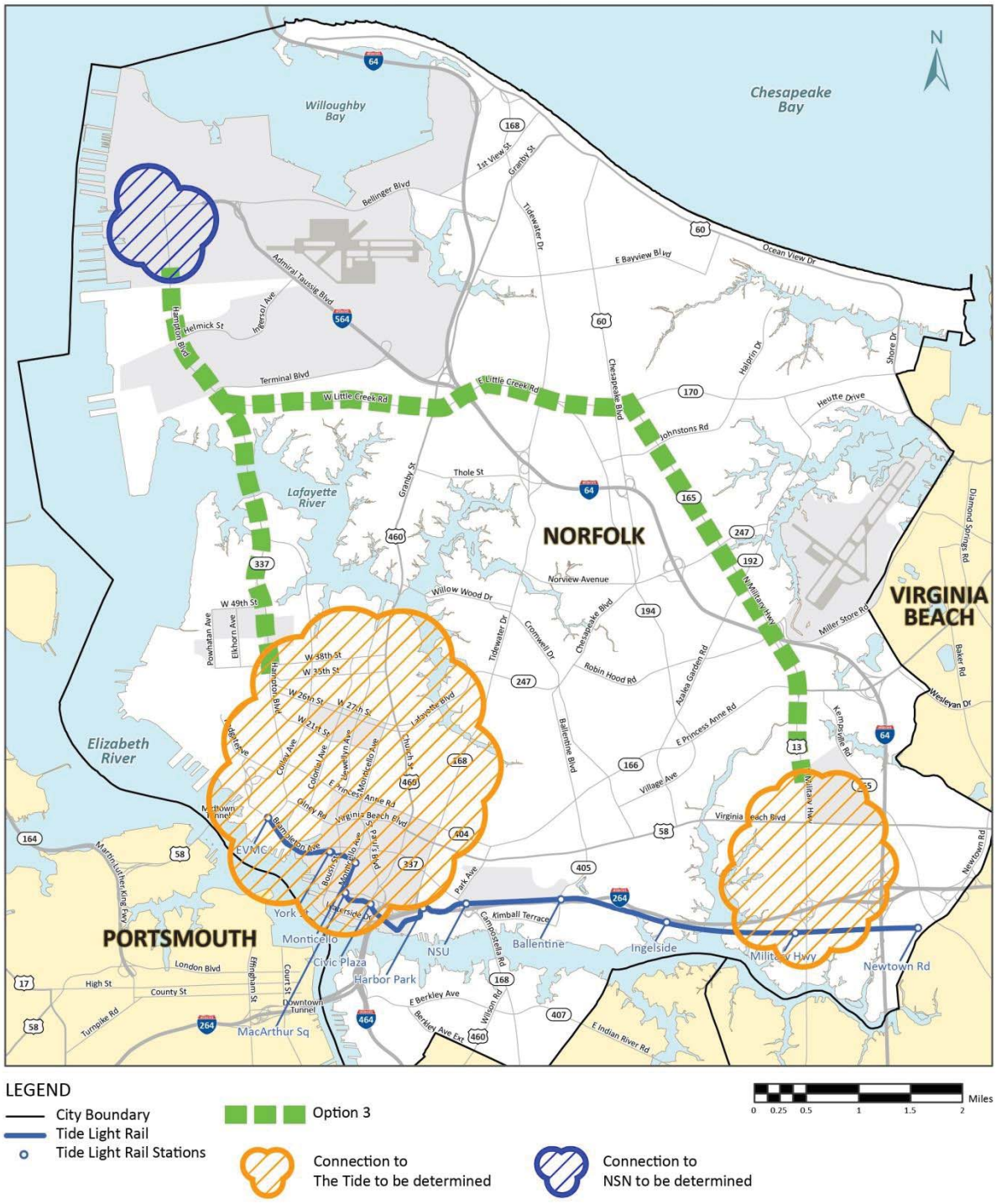


Figure 27. Option 4

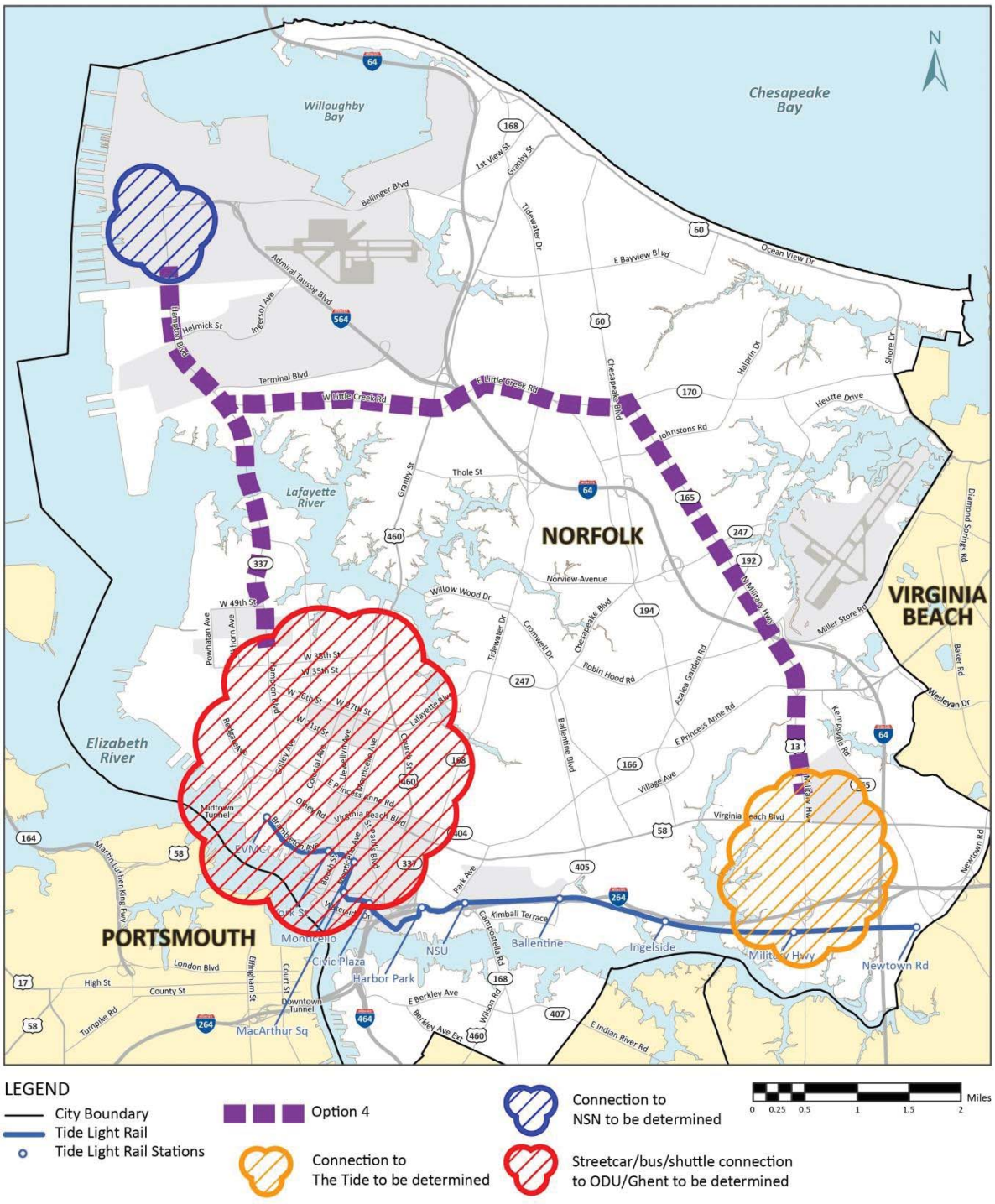
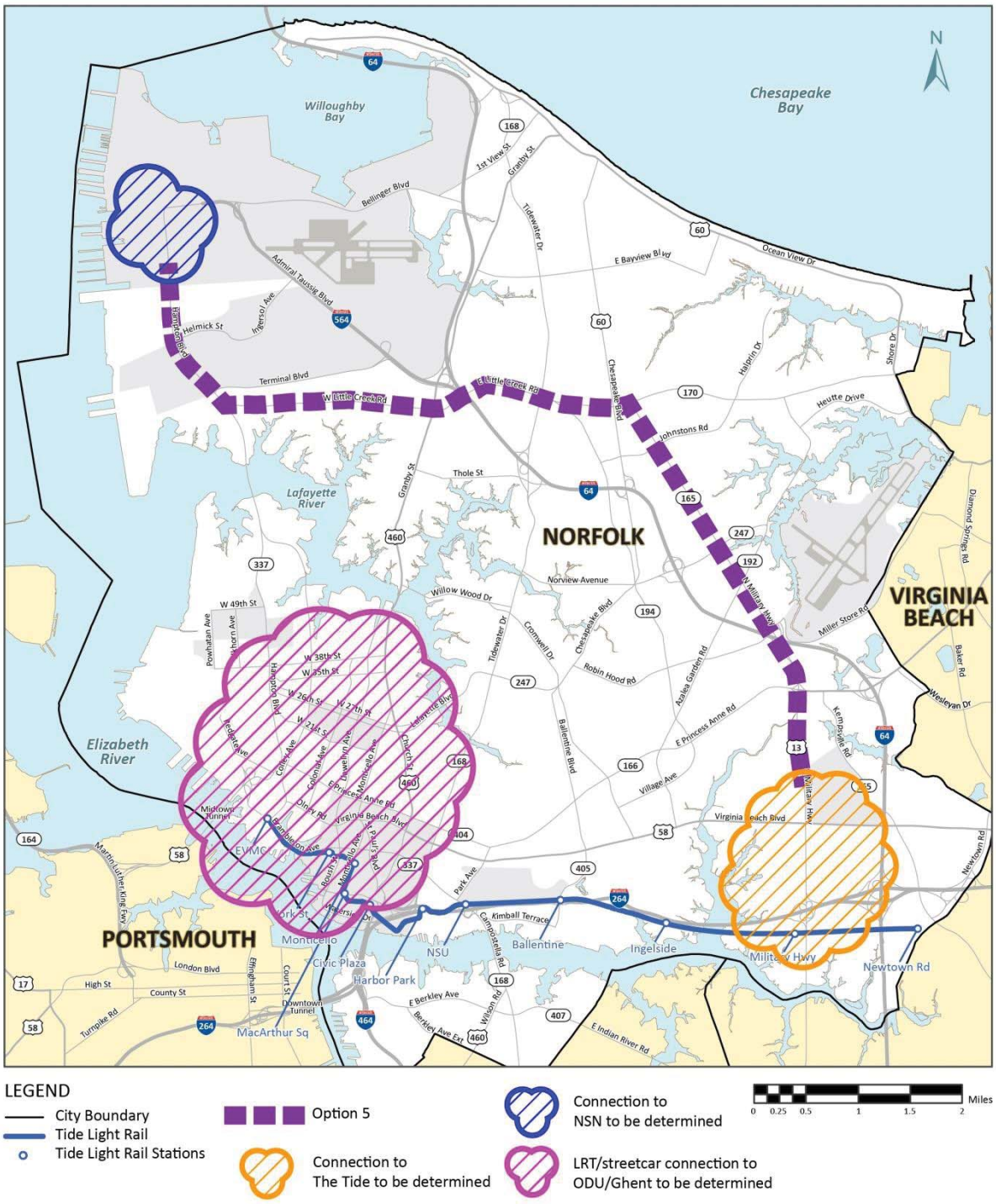
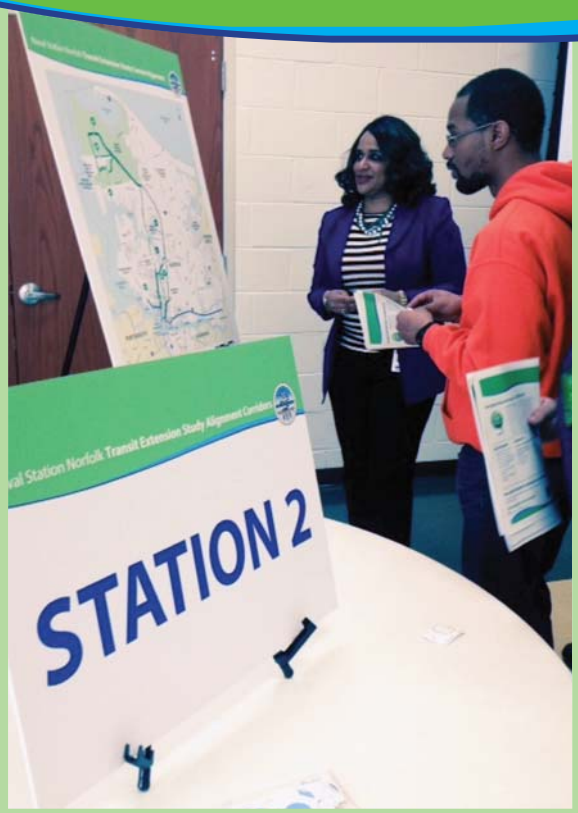


Figure 28. Option 5



APPENDIX A
PUBLIC INVOLVEMENT SUMMARY

Naval Station Norfolk **Transit Extension Study**



Final Public Involvement Report

December 2014

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Project Overview

Naval Station Norfolk (NSN) is the largest naval base in the world and the region's largest employment center. Every day, between 60,000 to 70,000 people come to work at NSN. On most days, automobiles trying to access the base exceed the capacity of the surrounding streets and highways. Regional Navy leaders have cited traffic and vehicular access to NSN as a significant challenge to military readiness in Hampton Roads.

Norfolk is also home to Virginia's first light rail line system. Opened in August 2011, The Tide runs 7.4 miles with 11 stations serving neighborhoods, universities, and downtown Norfolk. The Tide carries more than 5,300 weekday passengers and 4,600 passengers on a typical Saturday.

In October 2012, Norfolk City Council passed a resolution asking Hampton Roads Transit (HRT) for a formal study to help identify obstacles and the possible cost of a Tide extension. The Naval Station Norfolk Transit Extension Study (NSNTES) began in April 2013 and is the first step in a years-long process to pursue federal funding for an extension of The Tide light rail or another high-capacity mass transit to NSN. The NSNTES is a partnership between HRT and the City of Norfolk.

Public involvement was crucial to the success of the NSNTES. Members of the public contributed ideas throughout the study on how to connect the current Tide line to NSN. Project outreach centered around four sets of public workshops. All workshops included interactive activities to collaboratively develop transit solutions. Public workshop results produced a wide range of possible routes that have been evaluated against technical feasibility. The project team also identified and coordinated with area stakeholders, local neighborhood task forces, Navy leadership at NSN, and key City of Norfolk staff throughout the study.

The study process defined the project's "Purpose and Need" as well as "Reasonable Alternatives" for detailed analysis in a future Draft Environmental Impact Statement (EIS). In early 2015, Norfolk City Council will select their preferred option for study in the Draft EIS, scheduled to begin in mid-2015.

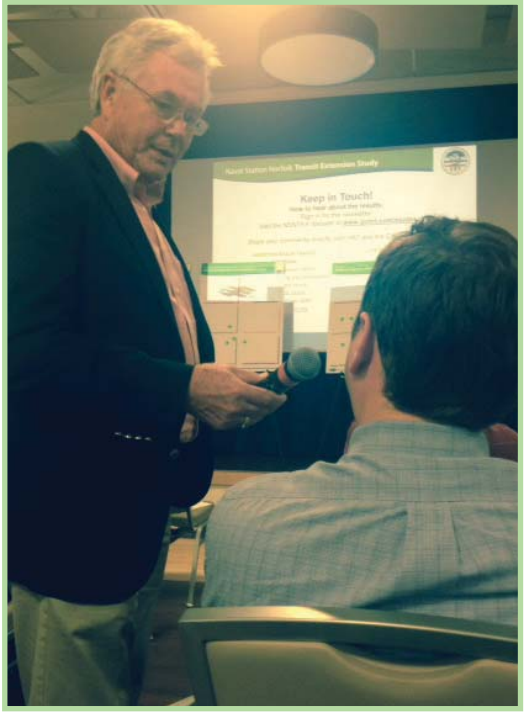
Public Involvement Outreach at a Glance

- 15 public workshops
- 459 documented public comments
- 10 stakeholder meetings
- 7 task force briefings
- 1 Neighborhood Expo
- 10 newspaper advertisements
- 3 project newsletters
- 6 project email updates
- 266 posts on Open City Hall
- 1 project video
- 38 media articles
- 100+ social media posts

Outreach Process

The City of Norfolk and HRT established an active and open community partnership with area residents, businesses, community groups, and government representatives throughout the NSNTES to ensure that the study met local needs and addressed any concerns that arose during the study process.

The project team created a favorable environment for meaningful public input, utilizing a broad range of outreach methods to involve local residents in this multi-phase study, including public workshops, stakeholder interviews, task force briefings, advertising, social media, and an online civic engagement forum to reach the largest possible project audience. Outreach activities aimed to make participation convenient and accessible for community members of all ages. Feedback from the public was carefully captured and documented throughout the study.



Bob Batcher of the City of Norfolk listens to a question from a workshop participant during an October 2014 workshop.

The NSNTES was completed in two phases, referred to as Tier 1 and Tier 2. Public workshops in June 2013, September 2013, February and March 2014 were part of the Tier 1 screening process. The study team completed a technical review of the Tier 1 data before the final set of public workshops were held in October 2014, as part of Tier 2. A total of fifteen public workshops were held during the NSNTES. Comprehensive summaries of each public workshop with documentation of all public comments were featured on the project website (www.gohrt.com/nsntes).

An outreach database was created and maintained over the course of the study and regular email updates and project newsletters were distributed digitally and in print at select HRT hubs. The project website was updated with news and project documents throughout the study. A project video produced by HRT and the City of Norfolk was hosted on the project website, Open City Hall, and HRT's YouTube page. A brand identity was developed for the study and was incorporated into all study materials, including project area maps, advertisements, letterhead, newsletters, flyers, and PowerPoint presentations.

Members of the public review an area map with possible Tide alignments during a March 2014 workshop.

NSNTES Public Workshops

June 2013 Workshops

June 12, 2013, 6:00-7:30 p.m.
Blair Middle School

June 17, 2013, 6:00-7:30 p.m.
Granby High School

June 19, 2013, 6:00-7:30 p.m.
Hilton Norfolk Airport

September 2013 Workshops

September 10, 2013, 6:00-7:30 p.m.
Holiday Inn Greenwich Road

September 11, 2013, 6:00-7:30 p.m.
Norview High School

September 12, 2013, 6:00-7:30 p.m.
ODU's Ted Constant Convocation Center

February and March 2014 Workshops

February 24, 2014, 6:00-7:30 p.m.
Granby High School

February 25, 2014, 6:00-7:30 p.m.
ODU's Ted Constant Convocation Center

February 26, 2014, 6:00-7:30 p.m.
Norfolk Waterside Marriott

March 24, 2014, 6:00-7:30 p.m.
Mary D. Pretlow Anchor Branch Library

March 26, 2014, 6:00-7:30 p.m.
Norview Community Center

October 2014 Workshops

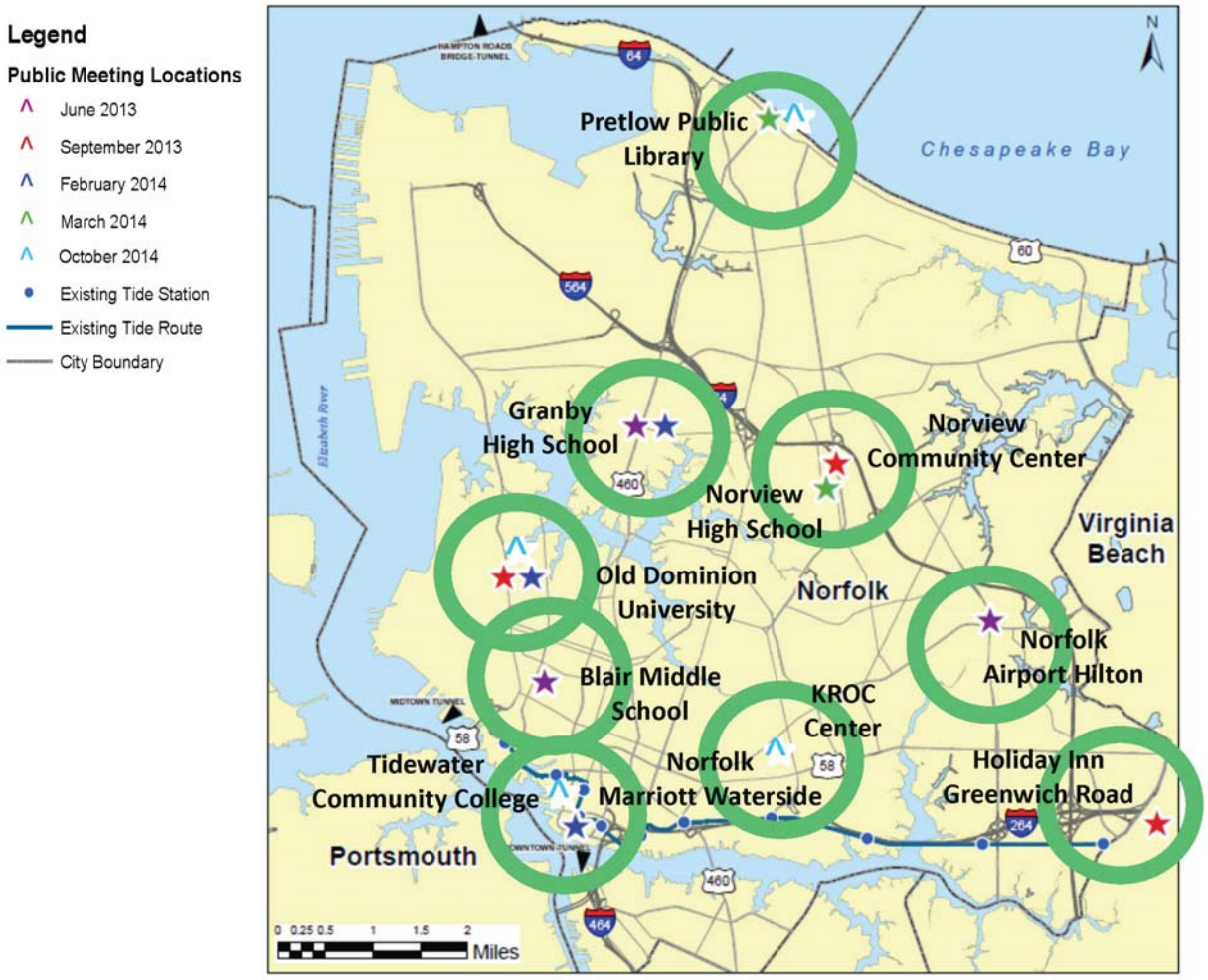
October 20, 2014, 6:00-7:30 p.m.
ODU's Ted Constant Convocation Center

October 23, 2014, 6:00-7:30 p.m.
Mary D. Pretlow Anchor Branch Library

October 27, 2014, 6:00-7:30 p.m.
Ray and Joan Kroc Corps Community Center

October 30, 2014, 6:00-7:30 p.m.
Tidewater Community College Norfolk Campus

Public Workshop Locations



June 2013 Workshops

The City of Norfolk and HRT hosted the first set of public workshops in June 2013. Workshops were held on three different dates and locations to provide multiple opportunities for public participation. Each workshop presented the same information and asked the same questions. Approximately 100 community members participated in the June workshops.

After registration, attendees watched a PowerPoint presentation given by HRT to learn about the scope, goals, and timeline for the study. Attendees then broke into small groups of 7-10 people to answer two questions:

1. What are the travel needs or problems between The Tide (and any future extension of The Tide) and Naval Station Norfolk?
2. What goals would a successful transit system to NSN need to achieve?

Each breakout group was facilitated by a member of the NSNTES team and a reporter was identified to record key discussion points on an easel for both questions. Groups spent fifteen minutes on each question and were asked to identify their top two priorities per question. At the close of the workshop, each group's reporter identified their top two priorities for both questions to all attendees.

Participants were encouraged to record additional thoughts, concerns, and suggestions on the comment sheets provided during registration. Members of the public were also informed that they could directly submit feedback to HRT and the City of Norfolk via email at nsntes@hrtransit.org.

Workshop attendees identify travel needs and problems between The Tide and NSN.

Summary of Comments

The study team received 45 comment sheets at the June 2013 workshops. Themes identified during the small group activities and on the comment sheets were the foundation of the study's "Purpose and Need" statement and were used in the technical analysis of prospective corridors and alignments. Six major themes were identified by the public:

Connection to Many Points – A prospective transit line/ alignment should serve many points of interest between downtown Norfolk and NSN.

Future Expansion – Consider regional expansion of light rail beyond the completion of a line to NSN.

Heavy Traffic/Congestion – Heavy traffic and the resulting congestion is a travel problem, especially during morning and afternoon peak hours.

Parking – Adequate parking at stations is needed.

Interconnectivity of Transit Modes – Study how The Tide could best connect with other modes of transit.

Travel Time – Consider travel time between stations when planning an extension.

"I live 5 miles from the base (where I work) and it takes me over an hour by car or 50 minutes by HRT bus to get to work." –Christopher S, Norfolk

"Balance speed of trip with access to neighborhoods and riders." –Ross M, Newport News

"An extension of The Tide to Norfolk NAVSTA should improve upon the existing system's connections to Norfolk's greatest assets." –Scott S, Norfolk

"Having stops at ODU, Ghent neighborhoods should be important besides just the Navy base." –Noel F, Norfolk

"I would love to see The Tide all over the region and at the Naval Base." – Eunice J, Norfolk

"Be able to get to a destination with reasonable time instead of hours waiting to feed through congestion." –G.W., Norfolk

"Provide an interconnected transit network to build on strengths of The Tide, bus, MAX, and ferry." –Gabor E, Norfolk

"Plan to connect to Portsmouth in the future (especially with the new tunnel being built)." –Larry P, Norfolk

September 2013 Workshops

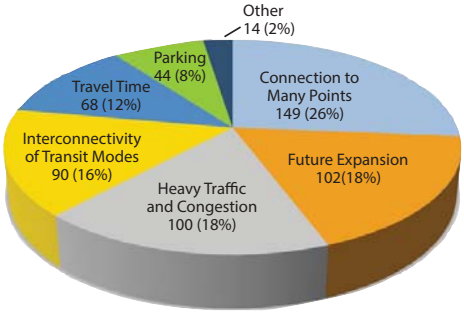
The second set of public workshops were held in September 2013. Workshops were held on three different dates and locations to provide multiple opportunities for public participation. Each workshop shared the same information and presented the same interactive activities. Approximately 200 community members participated in September workshops.

After registration, attendees watched a PowerPoint presentation given by HRT to learn about the NSNTES and the results of the first round of public workshops in June 2013. Attendees then broke into small groups of 7-12 people, each facilitated by a member of the NSNTES team, to complete three interactive workshop activities: Ranking Study Priorities, Identify Connectivity-Critical Areas/ Locations, and Identify Preferred Corridors.

An interactive station with theme voting board and large map of Norfolk.

Workshop attendees identified areas most in need of premium transit service and used string to connect the current Tide line to NSN.

1. Ranking Study Priorities:



Using stickers, attendees ranked the importance of the six main project themes identified during the June 2013 workshops. Each participant was given four stickers to prioritize these themes: Connection to Many Points, Heavy Traffic and Congestion, Travel Time, Parking, Interconnectivity of Transit Modes, and Future Expansion. Space and Post-it notes were provided to write in additional themes. All stickers could be applied to one theme, or the stickers could be used to proportionately express support for multiple themes. Fifteen minutes was provided for this activity.

Combining the totals from all three workshops, Connection to Many Points received the most stickers, with 149 (26% of the total). Future Expansion received 102 stickers (18%), and Heavy Traffic and Congestion received 100 stickers (18%).

2. Identify Connectivity-Critical Areas/Locations:

Using a large map of Norfolk and push pins, attendees identified areas most in need of premium transit service (green push pins), as well as areas to avoid (red push pins). Each participant was given up to five green push pins to distribute all in one key activity center or over multiple locations. Participants were also given five red push pins to mark areas they felt should be avoided. Facilitators instructed participants that identified themes from the first activity should inform the work done on the maps. Fifteen minutes was provided for this activity.

Old Dominion University received the most green pins over the three workshops, with 135 pins. Norfolk International Airport received 109 green pins, and Ghent/21st Street received 62 green pins. Norfolk Industrial Park received the most red pins over the three workshops, with 13 pins.

Green Pin Locations	
Activity Center	# of pins
1. Old Dominion Universtiy	135
2. Norfolk International Airport	109
3. Ghent/21st Street	62
4. Wards Corner	53
5. JANAF	39

Red Pin Locations	
Activity Center	# of pins
1. Norfolk Industrial Park	13
2. JANAF	10

3. Identify Preferred Corridors:

Using string and without the constraint of existing city roads, attendees connected The Tide to NSN and other key destinations and activity centers. Facilitators asked groups to create broad corridors. Each group worked together to identify three corridors. Twenty five minutes was provided for this activity. The identified corridors helped the NSNTES team determine which potential alignments would receive future evaluation.

Summary of Comments

The study team received 117 evaluation/comment sheets at the September 2013 workshops. In addition to workshop evaluation questions, attendees were asked to provide a response to the "Purpose and Need" question from the June workshops and were given space for additional comments. Comments are summarized by key themes. Several themes identified during the June workshops were repeated.

Connection to Many Points – A prospective transit line/alignment should serve many points of interest between downtown Norfolk and NSN. Old Dominion University, Norfolk International Airport, and the Ghent neighborhood were commonly mentioned locations.

Future Expansion – Consider regional expansion of light rail beyond the completion of a line to NSN.

Heavy Traffic/Congestion – Heavy traffic and the resulting congestion is a travel problem, especially during morning and afternoon peak hours.

Parking – Adequate parking at stations is needed.

Interconnectivity of Transit Modes – Study how The Tide could best connect with other modes of transit.

Travel Time – Consider travel time between stations when planning an extension.

Express Line – Consider an express line of The Tide, with reduced stops during peak hours.

Hampton Boulevard – A corridor along Hampton Boulevard corridor was frequently identified as a top corridor preference.

Loop – Consider a Tide extension that loops around Norfolk.

Base Security – Keep on-base security in mind as a Tide line onto or near NSN is planned.

Revitalization – A Tide extension could revitalize select Norfolk neighborhoods and stimulate the local economy.

"Travel to points with high population."
–David W, Norfolk

"Connectivity is the key issue—finding the best route that connects greatest number of potential current and future riders." –Paula S, Norfolk

"Include the busiest parts of Hampton Blvd on the transit route."
–Chris S, Norfolk

"The idea of having an express line was a great thought brought up tonight - the express caters to travel time, while a regular line could cater to multiple stops/connecting areas."
–Ashley M, Virginia Beach

"A great need for parking and service that uses its own right of way to shorten travel times for commuters while creating less traffic delays for drivers."
–Asa H, Norfolk

"Please help reduce the daily traffic jam on Hampton Boulevard. Every day traffic backs up from 21st to the Midtown Tunnel. My commute from Ghent to NSN (only 6 miles) is regularly one hour long. Joggers pass me on the road." –Agnes S, Norfolk

"The loop idea seems right."
–Randall S, Norfolk

February and March 2014 Workshops

The third set of public workshops were held in February and March 2014. Workshops were held on five different dates and locations to provide multiple opportunities for public participation. Each workshop shared the same information and presented the same interactive activities. Approximately 200 community members participated in the February and March workshops.

Workshop attendees review Western corridor alignments.

After registration, attendees watched a PowerPoint presentation given by HRT to learn about the study and results of the June 2013 and September 2013 public workshops. The presentation explained how the NSNTES team reviewed the results of the September workshops and identified 16 discrete conceptual alignments. The alignments were grouped by their geographic location within Norfolk (Western corridor, Central corridor, and Eastern corridor).

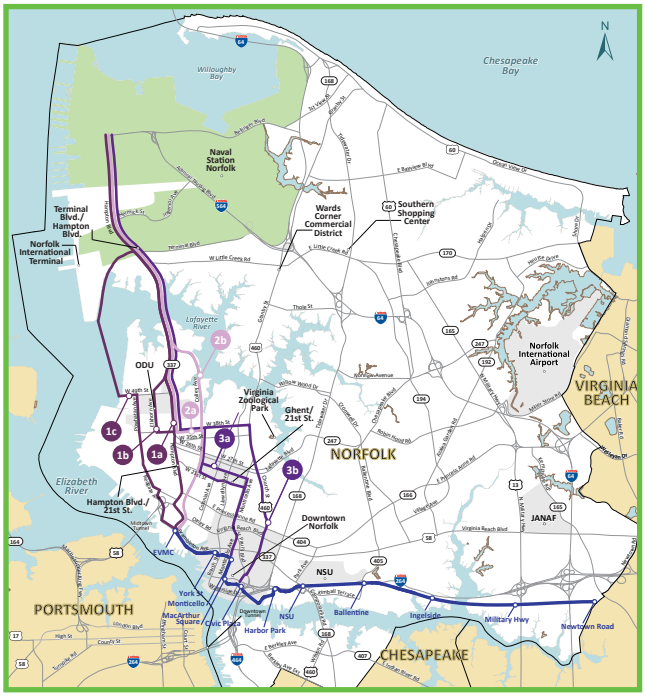
Attendees then broke into small groups to rotate through four stations, reviewing corridor maps and identifying preferred alignments in the Western, Central, and Eastern areas of Norfolk, as well as selecting an overall corridor preference and a future expansion preference. Workshop attendees voted at each board with large blue stickers.

Western Alignments: These seven alignments would connect NSN to the west side of Norfolk. These alignments would serve downtown, Ghent, West Ghent, ODU, Norfolk International Terminals, and other neighborhoods and business districts.

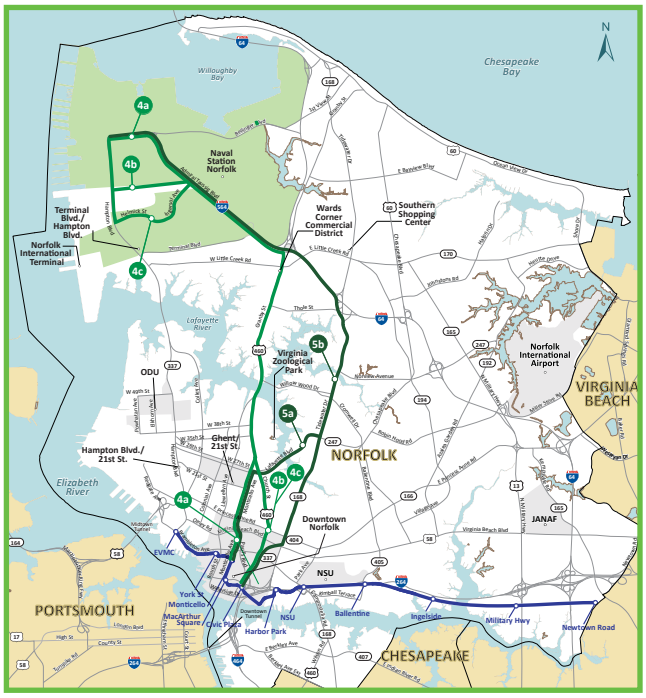
Central Alignments: These five alignments would connect central Norfolk (primarily areas east of the Lafayette River) to NSN. Areas that would be serviced include downtown, Ghent, Wards Corner, and other neighborhoods and business districts.

Eastern Alignments: Four alignments were identified in the Military Highway/I-64 Corridor on the eastern side of Norfolk. These alignments would serve the Military Highway commercial area, JANAF, Norfolk International Airport, and Wards Corner.

Western Map



Central Map



Eastern Map

Corridor Map

Alignment Preference Results

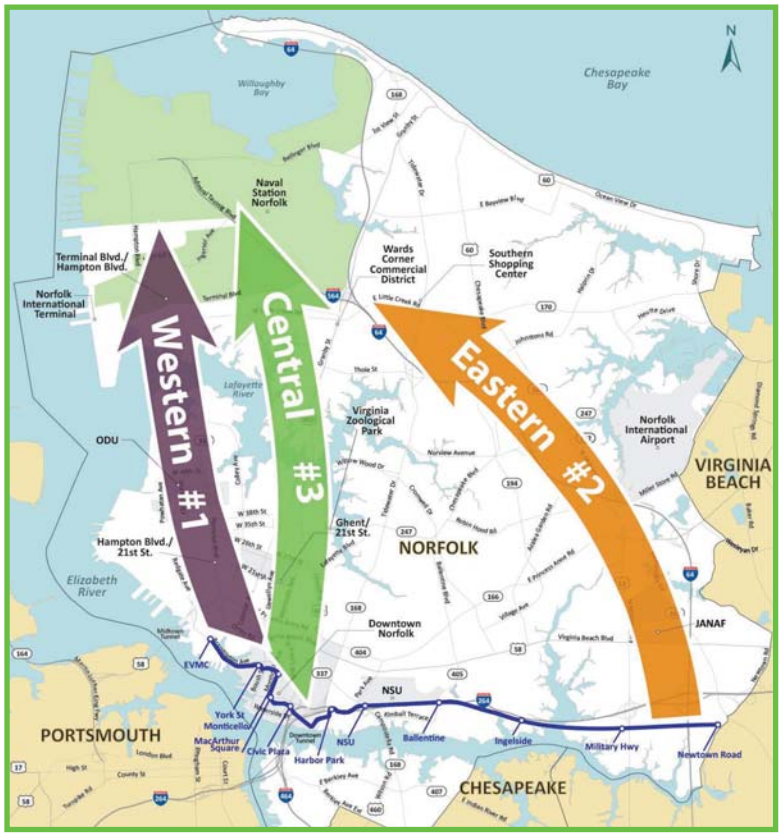
In the Western corridor, alignment 2a received the most total votes over the workshops (73 votes). In the Central corridor, alignment 4a received the most total votes (141 votes). In the Eastern corridor, alignment 6 received the most votes (87 votes).

Top right: Alignments 2a, 4a, and 6 received the most votes at the February and March workshops.

Corridor Preference Results

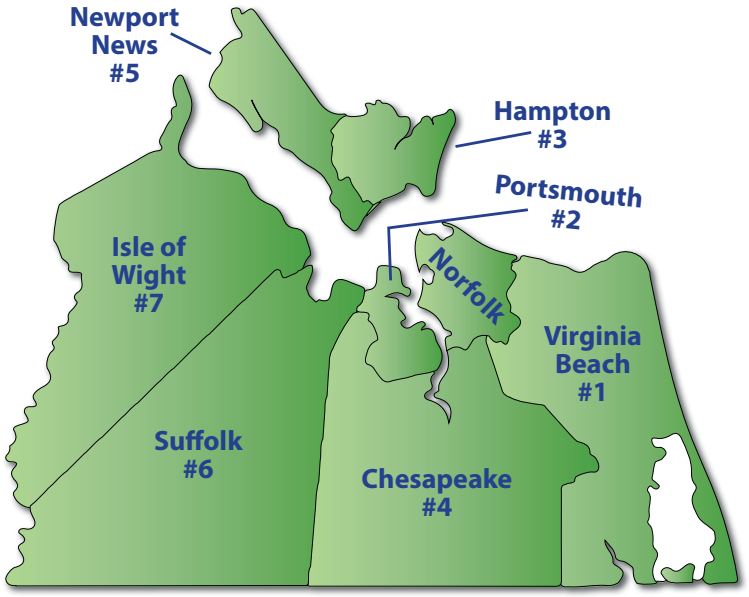
At the final station attendees were given two blue stickers and asked to vote on two different boards: overall corridor preference and future expansion preference. The Western corridor was the overall first choice (118 votes); the Eastern corridor was the second choice (75 votes); the Central corridor received the fewest votes (27 votes).

Bottom right: Overall corridors and their rankings by workshop participants.



Future Expansion Preference Results

Attendees were asked to vote on their regional expansion preference beyond the NSNTES. Virginia Beach was the top choice (121 votes); Portsmouth was the second choice (36 votes). The map below displays the surrounding Hampton Roads cities and the preference order.



At conclusion of each workshop, Julie Timm of HRT and Bob Batcher of the City of Norfolk reviewed the results of the station activities and answered any questions. Citizens were encouraged to record their thoughts, concerns, and suggestions on the evaluation/comment sheets provided at the registration tables.

Julie Timm of HRT and Bob Batcher of the City of Norfolk review overall vote totals.

Summary of Comments

The study team received 186 evaluation/comment sheets at the February and March 2014 workshops. In addition to workshop evaluation questions, attendees were asked to provide a response to the "Purpose and Need" question from the June workshops and were given space for additional comments. Comments are summarized by key themes.

Connection to Many Points – A prospective transit line/alignment should serve many points of interest between downtown Norfolk and NSN. Old Dominion University, Norfolk International Airport, and the Ghent neighborhood were commonly mentioned locations.

Future Expansion – Consider regional expansion of light rail beyond the completion of a line to NSN.

Heavy Traffic/Congestion – Heavy traffic and the resulting congestion is a travel problem, especially during morning and afternoon peak hours.

Parking – Adequate parking at stations is needed.

Interconnectivity of Transit Modes – Study how The Tide could best connect with other modes of transit.

Western Corridor – The top overall corridor, receiving the most corridor preference votes. The need for service to Old Dominion University and the Ghent neighborhood was frequently mentioned.

Transportation on Base – Important to keep on-base transportation in mind as an expansion onto or near NSN is considered.

Travel Time – Consider travel time between stations when planning an extension.

Flood Sensitivity – Build a Tide extension that is sensitive to Norfolk's low-lying coastal geography. Consider an elevated system.

Loop – Consider a Tide extension that loops around Norfolk.

"It is important to consider that many users of public transportation are young people, and bypassing ODU in an extension of the Tide would be a huge mistake."
–Stacey S, Virginia Beach

"We should not dismiss the idea of a hybrid system between western and eastern that forms a loop with the current Tide route." –Adam L, Norfolk

"Consideration of sea-level rise should be key in planning." –Stuart D, Norfolk

"The route that serves the most desirable destinations (zoo, ODU, Ghent, Park Place) while causing the fewest traffic problems will be the best choice." –Peter B, Norfolk

"Just the massive congestion on Hampton Boulevard, which creates an everyday hassle. An alternative transportation method has long been needed." –William B, Hampton

"Extending the Tide would decrease congestion but also provide access to ODU, Ghent, and Downtown from shopping and entertainment for base personnel." –Marilyn S, Norfolk

"Would need efficient shuttles on base."
–Micahel W, Portsmouth

October 2014 Workshops

The fourth and final set of public workshops were held in October 2014. Workshops were held on four different dates and locations to provide multiple opportunities for public participation. Each workshop shared the same information and presented the same interactive activity. Approximately 140 community members participated in the October workshops.

Workshop attendees review six potential alignments.

After registration, attendees watched a PowerPoint presentation given by HRT to learn about the results of the Tier 2 screening technical evaluation the NSNTES team conducted in the summer of 2014. Attendees then broke into small groups of 7-12 people, each facilitated by a member of the NSNTES team, to review six potential alignments and vote on their preferred choice. Technical experts were available by each station to answer questions.

Western Alignment: This alignment would connect the Ghent neighborhood, ODU, and NSN along Hampton Boulevard.

Central A Alignment: This alignment would use Monticello Avenue to head north from downtown along Granby Street.

Central B Alignment: This alignment would use Monticello Avenue, head north and turn to run along W. Little Creek Road and Hampton Boulevard.

Central C Alignment: This alignment was proposed and refined in discussions with the City of Norfolk. The alignment would run along Lafayette Boulevard and Chesapeake Boulevard before connecting to W. Little Creek Road and NSN.

Eastern A Alignment: This alignment would travel along Military Highway, W. Little Creek Road, and Admiral Taussig Boulevard.

Eastern B Alignment: This alignment would travel along Military Highway, W. Little Creek Road, and Hampton Boulevard.

Alternative Alignment Voting Results

The Western alternative (see below) received the most votes over the four workshops (64 votes). The two Eastern alternatives, which would provide a more direct route from Virginia Beach to Naval Station Norfolk, received 26 votes (Eastern B) and 18 votes (Eastern A), respectively. The three Central alternatives received the least support.

Alignment Rankings

Western Alternative
1st Place (64 votes)

Eastern B Alternative
2nd Place (26 votes)

Eastern A Alternative
3rd Place (18 votes)

Central B Alternative
4th Place (15 votes)

Central C Alternative
5th Place (7 votes)

Central A Alternative
6th Place (3 votes)

At the conclusion of each workshop, Julie Timm and Bob Batcher reviewed the small group voting results and answered questions from those in attendance. Citizens were encouraged to record their thoughts, concerns, and suggestions on the evaluation/comment sheets provided at the registration tables.

Julie Timm of HRT and Bob Batcher of the City of Norfolk review overall vote totals.

Summary of Comments

The study team received 111 evaluation/comment sheets at the October workshops. In addition to workshop evaluation questions, attendees were asked to provide a response to the "Purpose and Need" question and were given space for additional comments. Comments are summarized by key themes.

Connection to Many Points – A prospective transit line/alignment should serve many points of interest between downtown Norfolk and Naval Station Norfolk. Old Dominion University, Norfolk International Airport, and the Ghent neighborhood were commonly mentioned locations.

Future Expansion – Consider regional expansion of light rail beyond the completion of a line to Naval Station Norfolk.

Heavy Traffic/Congestion – Heavy traffic and the resulting congestion is a travel problem, especially during morning and afternoon peak hours.

Parking – Adequate parking at stations is needed.

Travel Time – Consider travel time between stations when planning an extension.

Express Line – Consider an express line of the Tide, with reduced stops during peak hours.

Flood Sensitivity – Build a Tide extension that is sensitive to Norfolk's low-lying coastal geography. Consider an elevated system.

Loop – Consider a Tide extension that loops around Norfolk.

Western Corridor – The Western alternative received the most votes at the October workshops. The need for service to Old Dominion University was frequently mentioned.

Eastern Corridor—The Eastern alternatives received support from those interested in Virginia Beach connectivity to Naval Station Norfolk. The Eastern alternatives were also supported for their proximity Norfolk International Airport.

Central Corridor—The Central alternatives received the fewest overall votes, however supporters emphasized the possibility of reaching a large number potential riders and revitalizing central areas of Norfolk.

"The Western alternative and Eastern B route have the most potential." –Blount H, Norfolk

"To serve the Naval Base and ODU efficiently the connection or extension requires use of western alternative." –Martha R, Norfolk

"I really would like to see the Eastern B route because my dad was in the Navy in this area for 29 years so I understand the importance of Navy personnel reaching NOB from VA Beach." –David B, Norfolk

"The eastern alignments especially Eastern B seems to connect the region to the Naval Base best and follows Norfolk areas with great redevelopment potential." –Peter O, Norfolk

"I think you should use Eastern B/A alternative - near airport, for VB connection, less in flood zone." –Shirley R, Norfolk

"The goal of light rail should be to connect the most people to the economic development potential of the city. The western side of the city has gotten all the attention - please focus on taking The Tide through the middle of Norfolk." –Taylor G, Norfolk

Stakeholder Interviews

To maximize community investment, the NSNTES team identified project stakeholders—key business and community influencers—for targeted outreach. Stakeholders offered valuable feedback on best communications approaches for their respective constituencies.

Stakeholder	Interview Date
Navy Leadership at NSN	6/25/2013, 4/4/2014, 12/5/2014
Visit Norfolk	1/21/2014
Downtown Norfolk Council	2/12/2014
Hampton Roads Chamber of Commerce	2/18/2014
HRTPO/HRPDC	3/6/2014
Park Place Business Association	3/6/2014
Norfolk Redevelopment and Housing Authority	3/13/2014
Elizabeth River Project	3/14/2014
Ghent Business Association	3/20/2014
Sentara	4/7/2014

Each identified project stakeholder received a letter from Project Manager Julie Timm of HRT explaining the timeline and goals of the study and requesting an interview. At each interview, shareholders had the opportunity to learn about the study, identify concerns, identify best modes of communication, and establish the basis for communication throughout the study. The NSNTES team held one-on-one briefings with ten stakeholder groups.

As the end users for a possible Tide extension to NSN, Navy leadership at NSN was identified as the project's largest stakeholder. Involvement from those who commute to NSN everyday was crucial to identifying and meeting project needs. Key members of the project team, including Project Manager Julie Timm, were in regular contact with Navy leadership. At every stage of the study Navy leadership provided valuable feedback, for example, asking the study team to keep in mind various levels of restricted access that need to be considered as an extension is studied. At the first meeting with Navy leadership on June 25, 2013, the idea of a Tide line inside the base was suggested for consideration. Navy leadership were also given the opportunity to complete the interactive workshop activities presented to the public at the February and March 2014 public workshops and October 2014 public workshops.

Task Force Briefings

The City of Norfolk organizes neighborhood task forces comprised of City Council members, City of Norfolk administration, civic league presidents, local businesses owners, and invested community members. Each task force is typically chaired and co-chaired by two City Council members who serve as a liaison to Norfolk City Council. Each task force meets monthly, quarterly, or as needed to discuss economic and business development, housing, homeownership and conservation, infrastructure, public facilities and services, public safety, and any other issues impacting the community. The NSNTES team briefed seven of these task forces between November 2013 and May 2014 to share information about the study and increase opportunities for feedback.

At each briefing, Project Manager Julie Timm gave a brief PowerPoint presentation explaining the goals, scope, and timeline of the study before answering questions. Project materials, including the most recent NSNTES newsletter, were provided. All in attendance were encouraged to follow up via phone or email with any questions or concerns and to visit Open City Hall to share additional written feedback with the project team.

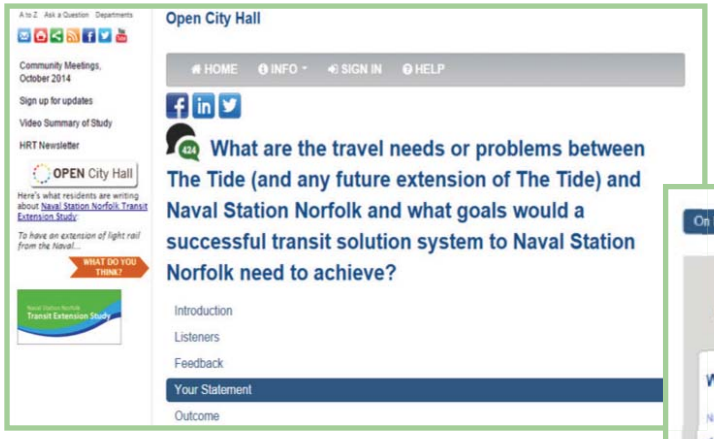
Task Force	Briefing Date	Council Members
Southside	11/5/2013	Paul Riddick Angelia Williams
Ghent	11/8/2013	Barclay Winn Theresa Whibley
Greater Wards Corner	12/12/2013	Mayor Paul Fraim
Greater Norview	1/8/2014	Anthony Burfoot
Ocean View	3/20/2014	Barclay Winn Tommy Smigiel Andy Protogyrou
Greater Park Place	4/23/2014	Theresa Whibley Angela Williams
Church Street/Huntersville	5/8/2014	Angelia Williams

Online Civic Engagement

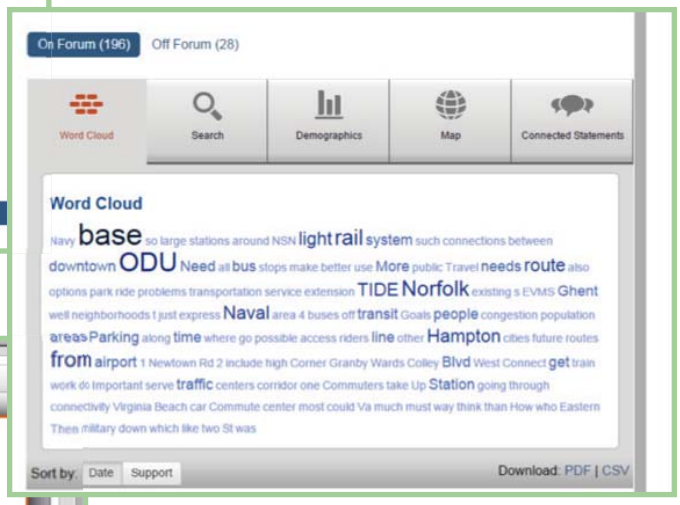
Maximizing opportunities for online participation in the NSNTES was a project priority. Beginning in June 2013, the study's "Purpose and Need" question was featured on Open City Hall. Visitors could post a statement and respond directly to the statements of other users. Each visitor chooses whether to publish their name alongside their statement.

Written comments on the evaluation/comment sheets from all four rounds of public workshops were also featured on Open City Hall, contributing to the discussion. Open City Hall visitors could view a word cloud that pulls the most frequently mentioned words from all user statements. Visitors could also view an area map displaying which areas of Norfolk comments were posted are coming from. This feature also helped the study team identify which areas of Norfolk should host public workshops in an effort to maximize and expand outreach.

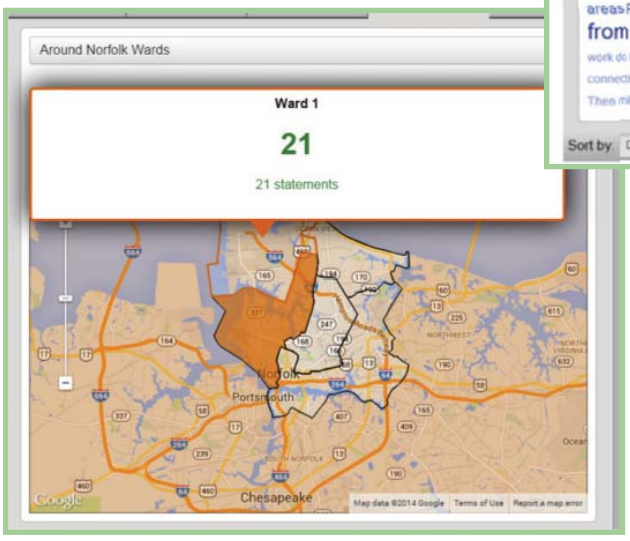
To date, 266 comments have been posted on Open City Hall.



"Purpose and Need" question on Open City Hall.



A word cloud displays the most frequently mentioned words from all user statements.



A map displays which areas of Norfolk comments were posted from.

Advertising and Social Media

Successful public workshops require careful preparation and coordination. Notifying members of the public about how and where they can participate requires paid advertising, earned media (PR) and shared (social media) approaches. Information regarding the workshop purpose, date/time, and location were clearly conveyed to the public in a timely manner. Advertisements for all sets of public workshops were placed in The Virginian-Pilot, The New Journal and Guide, and The Flagship. Press releases were distributed to local media in advance of each set of workshops. The NSNTES website (www.gohrt.com/nsntes) was updated regularly with project news and workshop announcements. Flyers and newsletters advertising the public workshops were placed at select HRT hubs and distributed digitally to the NSNTES database.

June 2013 Advertisement

Naval Station Norfolk
Transit Extension Study

Join us for a Workshop!

Help the Study Team answer important questions.

The Naval Station Norfolk Transit Extension Study (NSNTES) is a process that will define potential routes and transit modes in Norfolk that will link The Tide light rail system with Naval Station Norfolk. This study will have three phases spanning approximately 15 months. Each phase will kick off with Workshops to facilitate broad community involvement.

The three Workshops where you can join in this important study are:

▶ **Wednesday, June 12**
6-7:30 p.m.
Blair Middle School
730 Spotswood Ave.
Norfolk, VA 23517
This meeting is served by HRT route 16.

▶ **Monday, June 17**
6-7:30 p.m.
Granby High School
7101 Granby St.
Norfolk, VA 23505
This meeting is served by HRT route 1.

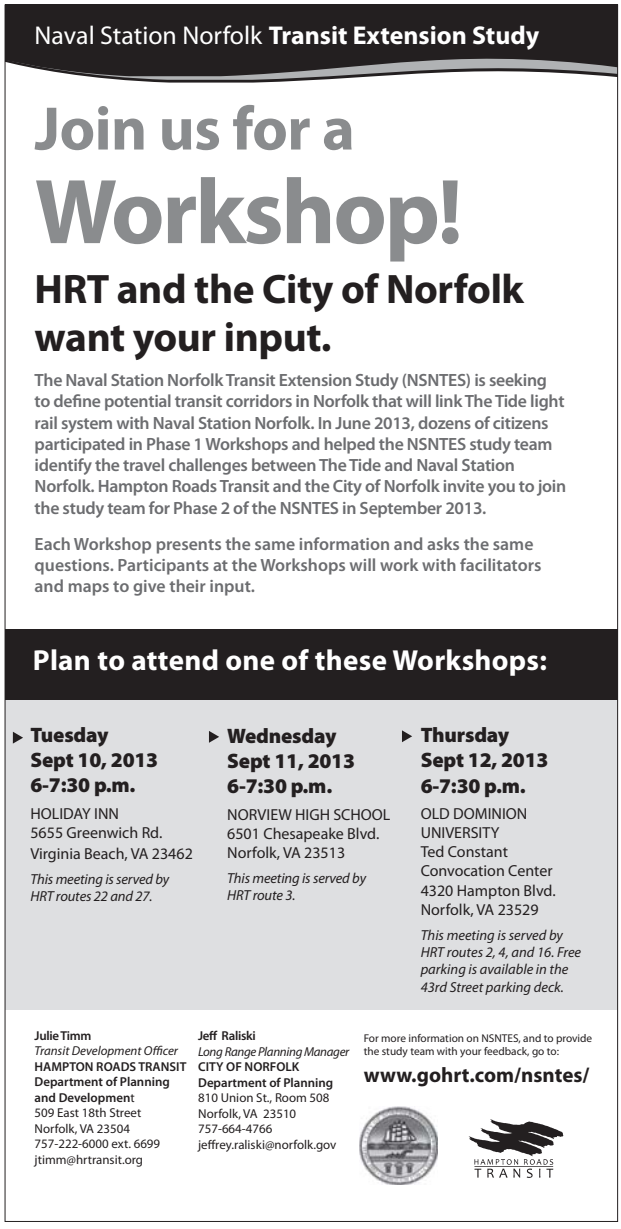
▶ **Wednesday, June 19**
6-7:30 p.m.
Hilton Norfolk Airport
1500 North Military Highway
Norfolk, VA 23502
This meeting is served by HRT routes 15 & 23.

For More Information:
www.gohrt.com/nsntes/

Share Your Comments Directly with HRT:
Julie Timm, *Transit Development Officer*
HAMPTON ROADS TRANSIT
Department of Planning and Development
509 East 18th Street
Norfolk, VA 23504
757-222-6000 ext. 6699
jtimm@hrtransit.org

HAMPTON ROADS TRANSIT

September 2013 Advertisement



Naval Station Norfolk **Transit Extension Study**

Join us for a Workshop!

HRT and the City of Norfolk want your input.

The Naval Station Norfolk Transit Extension Study (NSNTES) is seeking to define potential transit corridors in Norfolk that will link The Tide light rail system with Naval Station Norfolk. In June 2013, dozens of citizens participated in Phase 1 Workshops and helped the NSNTES study team identify the travel challenges between The Tide and Naval Station Norfolk. Hampton Roads Transit and the City of Norfolk invite you to join the study team for Phase 2 of the NSNTES in September 2013.

Each Workshop presents the same information and asks the same questions. Participants at the Workshops will work with facilitators and maps to give their input.

Plan to attend one of these Workshops:

▶ **Tuesday**
Sept 10, 2013
6-7:30 p.m.
HOLIDAY INN
5655 Greenwich Rd.
Virginia Beach, VA 23462
This meeting is served by HRT routes 22 and 27.

▶ **Wednesday**
Sept 11, 2013
6-7:30 p.m.
NORVIEW HIGH SCHOOL
6501 Chesapeake Blvd.
Norfolk, VA 23513
This meeting is served by HRT route 3.

▶ **Thursday**
Sept 12, 2013
6-7:30 p.m.
OLD DOMINION UNIVERSITY
Ted Constant Convocation Center
4320 Hampton Blvd.
Norfolk, VA 23529
This meeting is served by HRT routes 2, 4, and 16. Free parking is available in the 43rd Street parking deck.

Julie Timm
Transit Development Officer
HAMPTON ROADS TRANSIT
Department of Planning and Development
509 East 18th Street
Norfolk, VA 23504
757-222-6000 ext. 6699
jtimm@hrtransit.org

Jeff Raliski
Long Range Planning Manager
CITY OF NORFOLK
Department of Planning
810 Union St., Room 508
Norfolk, VA 23510
757-664-4766
jeffrey.raliski@norfolk.gov

For more information on NSNTES, and to provide the study team with your feedback, go to:
www.gohrt.com/nsntes/

HAMPTON ROADS TRANSIT

February 2014 Advertisement

Naval Station Norfolk **Transit Extension Study**

Join us for a Workshop!

HRT and the City of Norfolk need your input.

The Naval Station Norfolk Transit Extension Study (NSNTES) is seeking to identify potential transit corridors in Norfolk that would link The Tide with Naval Station Norfolk (NSN).

Participants at the February 2014 workshops will work with the study team to identify the most reasonable and feasible alignments linking The Tide and Naval Station Norfolk. Each workshop presents the same information and asks the same questions.

Plan to attend one of these workshops:

- **Monday**
  Feb 24, 2014
  6-7:30 p.m.
  GRANBY HIGH SCHOOL
  7101 Granby St.
  Norfolk, VA 23505
  This meeting is served by HRT route 1.
  Free parking is available in the High School parking lot.
- **Tuesday**
  Feb 25, 2014
  6-7:30 p.m.
  OLD DOMINION UNIVERSITY
  Ted Constant Convocation Center
  4320 Hampton Blvd.
  Norfolk, VA 23529
  This meeting is served by HRT routes 2, 4, and 16.
  Free parking is available in the 43rd Street parking deck.
- **Wednesday**
  Feb 26, 2014
  6-7:30 p.m.
  NORFOLK WATERSIDE MARRIOTT
  235 E. Main St.
  Norfolk, VA 23510
  This meeting is served by HRT routes 6, 8, 45, 960, and 961, as well as The Tide.
  Parking is available in the Main Street and Waterside parking decks.

The HRT will strive to provide reasonable accommodations and services for persons who require special assistance to participate in this public involvement opportunity.

Para información en español, llame al 757-222-6000.

For more information on NSNTES, and to provide the study team with your feedback, call 757-222-6000 or visit:

www.gohrt.com/nsntes/

HAMPTON ROADS TRANSIT

March 2014 Advertisement

Naval Station Norfolk **Transit Extension Study**

More Workshops Added

Join us for a Workshop!

HRT and the City of Norfolk need your input!

The Naval Station Norfolk Transit Extension Study (NSNTES) is seeking to identify potential transit corridors in Norfolk that would link The Tide with Naval Station Norfolk (NSN).

In February 2014, HRT and the City of Norfolk conducted public workshops in which participants identified preferred alignments and corridors linking The Tide and Naval Station Norfolk. Turnout exceeded expectations and additional workshops are scheduled. Come join in these important discussions. Both workshops present the same information and ask the same questions as the February workshops.

Plan to attend one of these workshops:

- **Monday**
  March 24, 2014
  6-7:30 p.m.
  MARY D. PRETLOW ANCHOR BRANCH LIBRARY
  111 W. Ocean View Ave.
  Norfolk, VA 23503
  This meeting is served by HRT routes 1, 3, and 5.
  Free parking is available in the library parking lot.
- **Wednesday**
  March 26, 2014
  6-7:30 p.m.
  NORVIEW COMMUNITY CENTER
  6380 Sewells Point Rd.
  Norfolk, VA 23513
  This meeting is served by HRT routes 3 and 9.
  Free parking is available in the community center parking lot.

HRT will strive to provide reasonable accommodations and services for persons who require special assistance to participate in this public involvement opportunity.

Para información en español, llame al 757-222-6000.

For more information on NSNTES, and to provide the study team with your feedback, call 757-222-6000 or visit:

www.gohrt.com/nsntes/

HAMPTON ROADS TRANSIT

October 2014 Advertisement

Naval Station Norfolk **Transit Extension Study**

Join us for a Workshop!

HRT and the City of Norfolk need your input.

The Naval Station Norfolk Transit Extension Study (NSNTES) is seeking to identify potential transit corridors in Norfolk that would link The Tide with Naval Station Norfolk (NSN).

This summer, the NSNTES team conducted a technical review of the corridors identified by the public in Spring 2014. At the upcoming workshops, participants will review the analysis and will have the opportunity to express their preference for the transit corridor that should be studied further. Each workshop will present the same information and ask the same questions. Attend the workshop most convenient for you!

Plan to attend one of these workshops:

1 Monday
Oct 20, 2014
6-7:30 p.m.

OLD DOMINION UNIVERSITY
Ted Constant Convocation Center
4320 Hampton Blvd.
Norfolk, VA 23529

This workshop is served by HRT routes 2 and 4.

Free parking is available in the metered parking spots on the first floor of Garage C on 43rd Street. Guests may park on additional floors of Garage C if the first floor is full.

2 Thursday
Oct 23, 2014
6-7:30 p.m.

MARY D. PRETLOW ANCHOR BRANCH LIBRARY
111 W. Ocean View Ave.
Norfolk, VA 23503

This meeting is served by HRT routes 1, 3, and 5.

Free parking is available in the library parking lot.

3 Monday
Oct 27, 2014
6-7:30 p.m.

RAY AND JOAN KROC CORPS COMMUNITY CENTER
1401 Ballentine Blvd.
Norfolk, VA 23504

This workshop is served by HRT routes 18 and 23.

Free parking is available in the community center parking lot.

4 Thursday
Oct 30, 2014
6-7:30 p.m.

TIDEWATER COMMUNITY COLLEGE
Norfolk Student Center
Fifth Floor, Room 5509
310 Granby St.
Norfolk, VA 23510

This workshop is served by The Tide and the Downtown Norfolk Transit Center.

Parking is available on street, in the Bank Street and Freemason Street parking garages, and at MacArthur Mall.

The HRT will strive to provide reasonable accommodations and services for persons who require special assistance to participate in this public involvement opportunity.

Para información en español, llame al 757-222-6000.

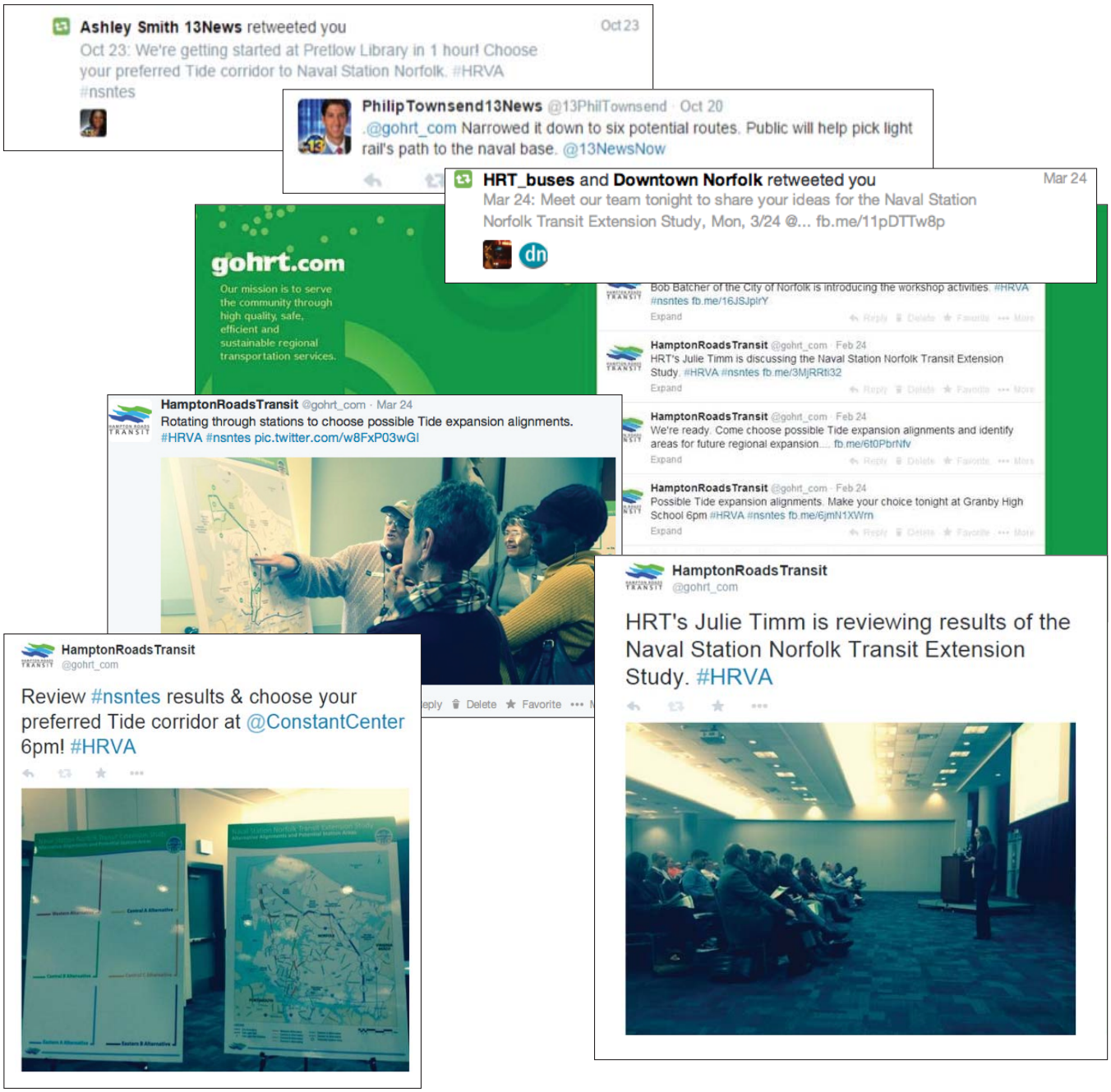
For more information on NSNTES, and to provide the study team with your feedback call 757-222-6000 or visit:

www.gohrt.com/nsntes/

HAMPTON ROADS TRANSIT

Social Media

Social media was used extensively to educate Hampton Roads residents and media about the NSNTES and the public workshops. Tweets were sent from HRT's Twitter account (@gohrt_com) in the days before workshops to raise awareness about dates and locations as well as during the workshops to provide those unable to attend with real-time updates on workshop speakers and activities. After the workshops, tweets directed citizens to Open City Hall to share feedback online. In a coordinated effort, the City of Norfolk (@NorfolkVA) retweeted select HRT tweets to their followers. Local media and engaged citizens retweeted content and replied to tweets. More than 100 project tweets and Facebook updates were posted over the course of the study.



Media Articles

Local and state publications reported on the NSNTES beginning with the study's launch in April 2013 through the final round of public workshops in October 2014. Most print articles covered the dates and times of the 15 workshops and the materials presented to the public at these workshops. Several articles provided opinion and commentary. The majority of coverage was positive and expressed support for the project.

The following are 38 articles about the study:

- Tide to Naval Station study to begin (Wavy, 4/11/13)
- Light rail to Naval Station Norfolk studied (WTOP, 4/11/13)
- Study of Hampton Roads Transit extension to naval base begins (RT&S, 4/11/13)
- HRT light rail study gaining momentum (Wavy, 4/11/13)
- Public workshops on light rail expansion study (Wavy, 6/5/13)
- 3 Hearings in June about light rail to Naval Station Norfolk (WVEC, 6/6/13)
- Meeting Tonight on Mass Transit to Naval Station Norfolk (WVEC, 6/12/13)
- Meetings set on transit extension to Naval Station Norfolk (Marine Corps Times, 6/12/13)
- Meetings set on transit extension to Norfolk base (NBC 12, 6/12/13)
- Meetings set on transit extension to Naval Station Norfolk (Navy Times, 6/12/13)
- Workshop being held to discuss extending light rail to Naval Station Norfolk (WTKR, 6/19/13)
- HRT wants input on light rail routes to Naval Station Norfolk (WVEC, 8/27/13)
- Input sought for Norfolk Naval Station LRT (Railway Age, 8/29/13)
- Some living in West Ghent concerned over light rail to Naval Base (WVEC, 9/5/13)
- HRT seeks input on naval station Tide route (The Virginian-Pilot, 9/9/13)
- Meetings begin on mass transit to Naval Station Norfolk (WVEC, 9/10/13)
- Workshops this week on light rail to NSN (Wavy, 9/10/13)
- Residents plot out possible light rail lines to NSN (The Virginian-Pilot, 9/11/13)
- Workshops to identify light rail route to Naval Station Norfolk (WAVY, 2/19/2014)
- Routes proposed for Norfolk light rail extension (The Washington Times, 2/20/2014)
- HRT shares maps of Norfolk light-rail extension options (The Virginian-Pilot, 2/21/2014)
- Norfolk LTR extension options mapped (Railway Age, 2/21/2014)
- Rail extension to be discussed in Norfolk (Richmond Times-Dispatch, 2/23/2014)
- Workshop tonight on light rail extension to Navy base (The Virginian-Pilot, 2/24/2014)
- Workshop tonight on light rail expansion to Naval Station Norfolk (WVEC, 2/24/2014)
- Citizen's Guide: Engaging the Light Rail Extension Debate (AltDaily, 2/24/2014)
- Workshop participants pick favorite Tide routes to naval base (Inside Business, 2/28/2014)
- HRT announces additional light rail extension workshops (WAVY, 3/19/2014)
- HRT holding meetings on Naval Station transit extension (Daily Press, 3/24/2014)
- Light rail routes to Naval Station Norfolk narrowed to 6 (The Virginian-Pilot, 10/20/2014)
- Meetings set on Norfolk light rail extension (WAVY, 10/20/2014)
- HRT to hold public meetings on extending light rail (13News Now, 10/20/2014)
- HRT narrows down Norfolk light rail routes (13News Now, 10/20/2014)

- Transit agency to hold public meetings on extending light rail to Naval Station Norfolk (Greenfield Reporter, 10/20/2014)
- Meetings set on Norfolk light rail extension (TriCities, 10/20/2014)
- Norfolk's light rail choice: Embrace the city, or follow the highway? (Greater Greater Washington, 10/21/2014)
- Virginia Beach or Naval Station Norfolk? What's next for light rail (WTKR, 10/23/2014)
- Choices for rail expansion in Norfolk (The Virginian-Pilot, 10/27/2014)

Next Steps

After reviewing the results of the October workshops and the analysis of the technical data, HRT and the City of Norfolk provided recommendations and refinements to develop the final set of alignment options to move forward to a more detailed engineering evaluation. Five options have been selected to be advanced for further study. These five options represent a set of potential choice of corridors, transit vehicle technologies, and project scales. All five options would meet NSNTES' "Purpose and Need" and project themes. In early 2015, Norfolk City Council will select the option(s) that should be moved forward for future analysis in the Draft Environmental Impact Statement (EIS), scheduled to begin in mid-2015. Public involvement will again be crucial to the success of the next phase of study.

APPENDIX B
TIER 1 ALIGNMENT REPORT

Naval Station Norfolk Transit Extension Study

Norfolk, Virginia

Draft

April 2014

Task 5.1 Conceptual Definition of Fixed Guideway Options Report

Naval Station Norfolk Transit Extension Study

Norfolk, Virginia

Prepared For:
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April 2014

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Section 1

Executive Summary

1.0 EXECUTIVE SUMMARY

This report describes the alignment concepts for the Naval Station Norfolk Transit Extension Study (NSNTES). Based on public and agency input, 16 distinct alignments were developed through a series of public meetings held in June and September 2013. The first set of public meetings in June 2013 resulted in the study's Purpose and Need Statement, which defines the reason and rationale for the proposed transit extension. At the June meetings, the public identified six themes for the study that were later used to develop and evaluate the alignments. The study team presented the six themes at the second series of public meetings in September 2013 and asked the public to comment on which themes were most important and why. In addition, the September meetings included a planning exercise wherein the public nominated corridors for an extension of the transit system. The September meetings featured an exercise in which the public was asked to identify key activity centers in Norfolk that should be linked via an extension of the transit system.

A total of 16 conceptual alignments were identified after the public meetings. These conceptual alignments are categorized based on their geographic location within the City of Norfolk (i.e., (western, central, and eastern). All alignments would operate between an existing Tide station and Naval Station Norfolk (NSN):

- The seven western alignments would connect NSN with the western portions of downtown Norfolk. These alignments would travel through various neighborhoods in the western portion of the city, including Lamberts Point, Ghent, West Ghent, Park Place, Larchmont/Edgewater, and Old Dominion University (ODU). These alignments could use a combination of exclusive right-of-way (such as on a new bridge over the Lafayette River for a Hampton Boulevard alignment) and shared right-of-way such as with surface arterials including Colley Avenue, Hampton Boulevard, Monticello Avenue, Powhatan Avenue, Church Street, and West 38th Street.
- The five central alignments would all connect NSN with the central portions of downtown Norfolk by traveling through various neighborhoods in central Norfolk, including Ghent, Huntersville, Park Place, Riverview, Belvedere, Roland Park, and Wards Corner. These alignments would use a combination of exclusive right-of-way and right-of-way shared with surface arterials including Monticello Avenue, Church Street, Granby Street, Lafayette Boulevard, Tidewater Drive, and Admiral Taussig Boulevard.
- The four eastern alignments would all connect NSN with the eastern end of the existing Tide alignment near the border between Norfolk and Virginia Beach. These alignments would travel through various areas in Norfolk, including the JANAF (Joint Army Navy Air Force) Shopping Center, Lake Taylor, Norfolk International Airport, Norview, Tanners Creek, and Wards Corner. The alignments would use a combination of exclusive right-of-way and right-of-way shared with surface arterials including Kempsville Road, Military Highway, Little Creek Road, Hampton Boulevard, and Admiral Taussig Boulevard.

All alignments have the potential to connect many activity centers in Norfolk, attract new transit riders, and slow growth in automobile congestion by providing an alternate means to and from NSN. Depending on the route, the alignments would provide varying levels of direct access and mobility to/from NSN and downtown Norfolk, and this would affect each alignment's ability to attract riders. All of the alignments would begin at an existing Tide station, enhance the mobility of the existing Tide system, and provide additional regional connectivity. The alignments would enable connections that would expand the regional transit network, provide increased interconnectivity between transit modes, and support development of adjacent park-and-ride lots. The themes identified above by the public at the community meetings have been taken into consideration in the development of these alignments, and formed the basis for the criteria identified during the Tier 1 screening analysis. The methodology of that analysis is described in a separate technical memorandum titled: “Tier 1 Screening Evaluation.”

A two-tiered selection process was used to screen the conceptual alignments. The following sections of this report describe the alignments and discuss the ability of each to meet the criteria described above. For simplicity, all alignments are described using a geographic orientation that begins at the existing Tide alignment and ends at NSN, but it is understood that the Tide would operate in both directions (i.e., northbound and southbound). After alignments are selected to move forward from the Tier 1 screening evaluation, the alignment evaluation will be expanded to address traffic operations, vehicle technologies, operating plans, and vehicle maintenance and storage facilities, as well as more detailed cost and environmental impacts, as part of the Tier 2 screening analysis.

Section 2

Introduction

2.0 INTRODUCTION

This report describes the 16 conceptual alignments developed through the public involvement process for the Naval Station Norfolk Transit Extension Study (NSNTES).

2.1 STUDY DESCRIPTION

Hampton Roads Transit (HRT) and the City of Norfolk are the lead partners in the NSNTES, which is exploring the possibility of connecting the existing Tide light rail line to Naval Station Norfolk (NSN). This study is examining the potential impacts, benefits, and opportunities associated with various high-capacity transit alignments throughout the City of Norfolk that would achieve this connection.

The purpose of this report is to describe the proposed alignments developed using input from a series of public meetings held in June and September 2013. The alignments presented in this report were developed in accordance with the study's Purpose and Need Statement.

2.2 BACKGROUND

The study team formulated 16 distinct conceptual alignments based on input from the series of public meetings. The first set of public meetings in June 2013 resulted in the development of the study's Purpose and Need Statement, as well as six themes that were later used to develop the alignments. These six themes are listed in **Table 1**.

Table 1. Six Themes

1	Connect to many points within Norfolk
2	Relieve heavy traffic and congestion
3	Reduce travel time and make travel time more reliable between destinations
4	Provide parking to accommodate riders
5	Provide interconnectivity between transit modes
6	Ensure that the transit system can be expanded in the future

The team presented the six themes at the second series of public meetings in September 2013 and asked the public to comment on which themes were most important and why. In addition, the September meetings included a planning exercise wherein the public nominated corridors for an extension of The Tide system (see **Figure 1**).

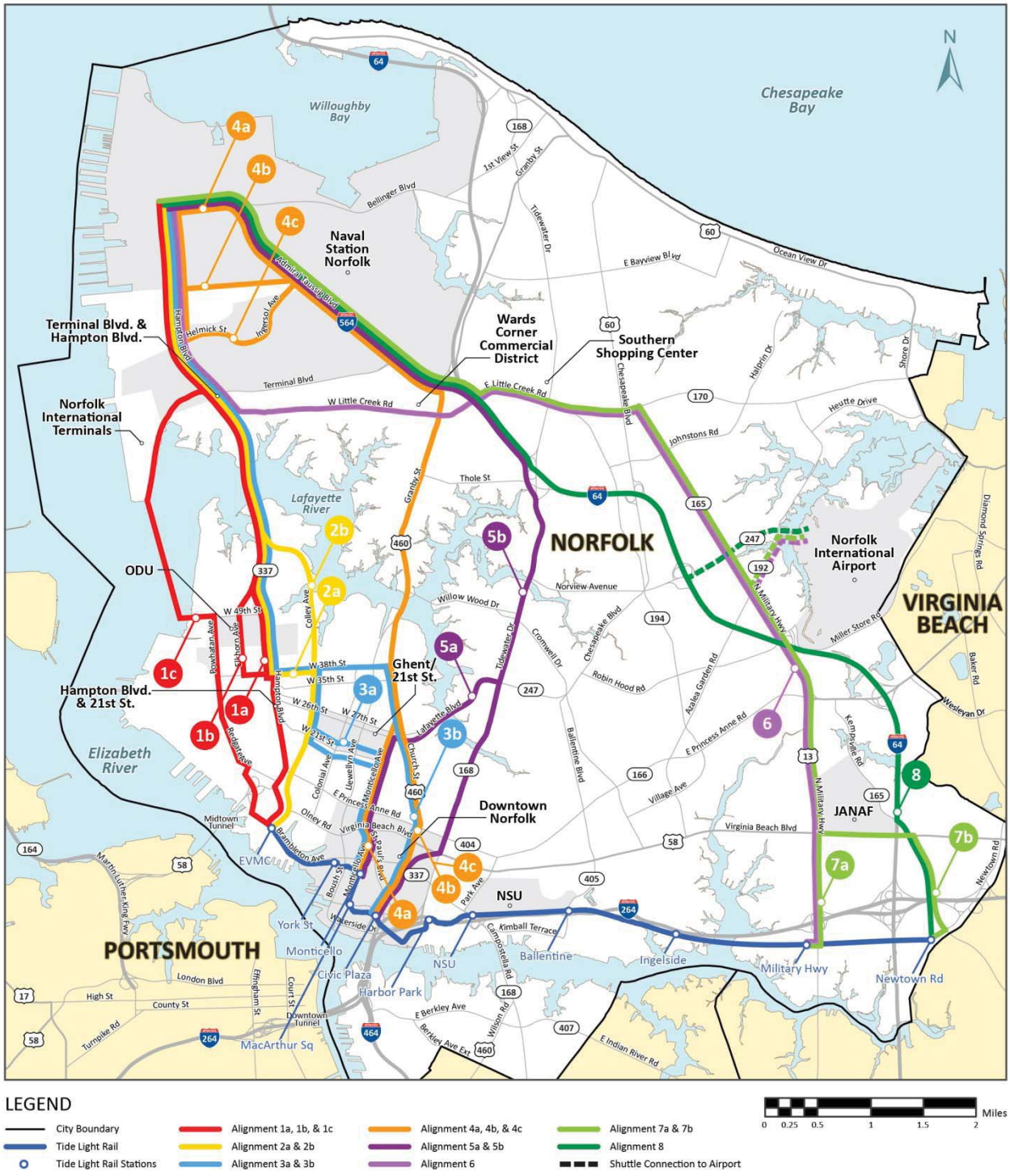
Figure 1. Public Meeting #1 in June, 2013

The September meetings also featured an exercise in which the public was asked to identify the activity centers in Norfolk that should be linked via an extension of the Tide system—this was conducted by asking participants to place pushpins on a map of Norfolk to indicate activity centers and then connect the pushpins with yarn to simulate a conceptual alignment (**Figure 2**).

Figure 2. Yarn/Pushpin Map from Public Meeting

Using the public feedback from both planning exercises and input from HRT and the City of Norfolk, the team created a map of 16 distinct conceptual alignments. These 16 conceptual alignments are described in detail in this report and are shown in **Figure 3**.

Figure 3. Alignment Concepts



Section 3

Alignment Descriptions

3.0 ALIGNMENT DESCRIPTIONS

The 16 conceptual alignments are categorized based on their geographic location within the City of Norfolk (i.e., (western, central, and eastern). All alignments would operate between an existing Tide station and NSN. While there are 16 distinct conceptual alignments, some of them would overlap in part and, therefore, are named according to the general corridor in which they operate (a number from 1 to 8) and distinguished within the corridor using a letter from 'a' to 'c.' The 16 conceptual alignments are as follows:

Western Alignments

- Alignment 1a/1b/1c
- Alignment 2a/2b
- Alignment 3a/3b

Central Alignments

- Alignment 4a/4b/4c
- Alignment 5a/5b

Eastern Alignments

- Alignment 6
- Alignment 7
- Alignment 8a/8b

All alignments shown in **Figure 3** have the potential to connect many activity centers in Norfolk, attract new transit riders, and slow growth in automobile congestion by providing an alternate means to and from NSN. Depending on the route, the alignments would provide varying levels of direct access and mobility to/from NSN and downtown Norfolk, and this would affect each alignment's ability to attract riders. All of the alignments would begin at an existing Tide station, enhance the mobility of the existing Tide system, and provide additional regional connectivity. The alignments would enable connections that would expand the regional transit network, provide increased interconnectivity between transit modes, and support development of adjacent park-and-ride lots. The themes identified by the public at the community meetings have been taken into consideration in the development of these alignments, and formed the basis for the criteria identified during the Tier 1 screening analysis. The methodology of that analysis is described in a separate technical memorandum titled: "Tier 1 Screening Evaluation."

A two-tiered selection process was used to screen the conceptual alignments. The following sections describe the alignments and discuss the ability of each to meet the criteria described above. For simplicity, all alignments are described using a geographic orientation that begins at the existing Tide alignment and ends at NSN, but it is understood that the Tide would operate in both directions (i.e., northbound and southbound). After alignments are selected to move forward from the Tier 1 screening evaluation, the alignment evaluation will be expanded to address traffic operations, vehicle

technologies, operating plans, and vehicle maintenance and storage facilities, as well as more detailed cost and environmental impacts, as part of the Tier 2 screening analysis.

3.1 WESTERN ALIGNMENTS

The following subsections describe the seven western alignments, which would connect NSN with the western portions of downtown Norfolk. These alignments would travel through various neighborhoods in the western portion of the city, including Lamberts Point, Ghent, West Ghent, Park Place, Larchmont/Edgewater, and Old Dominion University (ODU). These alignments could use a combination of exclusive right-of-way (such as on a new bridge over the Lafayette River for a Hampton Boulevard alignment) and shared right-of-way with surface arterials including Colley Avenue, Hampton Boulevard, Monticello Avenue, Powhatan Avenue, Church Street, and West 38th Street. The shared right-of-way could take the form of dedicated lanes with at-grade crossings similar to The Tide in most of downtown Norfolk, or the light rail tracks could share lanes with other vehicle traffic as in a streetcar operation.

3.1.1 Alignments 1a, 1b, and 1c

Alignments 1a, 1b, and 1c would begin near the Eastern Virginia Medical Center (EVMC)/Fort Norfolk Tide station, which is the western terminus of the existing Tide alignment and is located at the edge of downtown Norfolk within the Fort Norfolk district. From the intersection of Brambleton Avenue and Colley Avenue, Alignments 1a and 1b would proceed north within the right-of-way of Colley Avenue to the intersection with Redgate Avenue just north of EVMC. From this point, Alignments 1a and 1b would continue on Redgate Avenue to Hampton Boulevard and then head north through Ghent, West Ghent, Kensington, and Lamberts Point to ODU.

At ODU, Alignments 1a and 1b would diverge. Alignment 1a would continue north past the university's athletic complex and pass within one half-mile of most of the university's buildings, while Alignment 1b would divert off of Hampton Boulevard through the university by traveling along West 38th Street, Elkhorn Avenue, West 49th Street, and Bluestone Avenue before rejoining Alignment 1a at Hampton Boulevard. While Alignment 1a would provide a shorter, more direct route through the ODU campus, Alignment 1b would provide more access to the residential areas within Lamberts Point and the student residences on the west side of the university while still remaining within a half-mile of most of the university's buildings. North of ODU, Alignments 1a and 1b would follow Hampton Boulevard past Larchmont Elementary, the Larchmont Branch of Norfolk Public Library, and the Lafayette River Naval Facility Complex before crossing the Lafayette River. North of the Lafayette River, both alignments would continue within the right-of-way of Hampton Boulevard through the Lochhaven and Meadowbrook neighborhoods before entering NSN.

Alignment 1c would proceed west from the EVMC/Fort Norfolk station within the right-of-way of Brambleton Avenue, wrap around the south side of the EVMC complex, and continue over the entrance to the Midtown Tunnel and to Claremont Avenue, where it would turn right and continue north for one block to Redgate Avenue. At Redgate Avenue, the alignment would turn left to proceed west and then northwest along Redgate Avenue on the western edge of West Ghent to a point near the Norfolk

Southern rail yard at Lamberts Point. Then the alignment would continue north on a grade-separated exclusive alignment over the rail yard and reconnect with the surface street network at Powhatan Avenue near the Powhatan Sports Complex, where it would continue north to West 49th Street within ODU. After passing the student residences at the west end of the university, the alignment would leave the street network again and continue across the Lafayette River on a new seawall to the southwest point of the Port Authority. From here, the alignment would continue along the northern bank of the Lafayette River within the Norfolk International Terminals complex to join at Hampton Boulevard near Terminal Boulevard. The seawall connection would provide a new connection across the Lafayette River and provide a measure of resiliency in case of flooding.

North of Terminal Boulevard, Alignments 1a, 1b, and 1c would provide access to many areas, including the Naval Support Activity Hampton Roads, the Joint Forces Staff College, Virginia International Terminals, Glenwood Park, and NSN. The three alignments would end at the intersection of Hampton Boulevard and Admiral Taussig Boulevard, just outside the gates of Naval Station Norfolk. The three alignments are displayed on a map in **Figure 4** and more detail about Alignments 1a, 1b, and 1c is provided in **Table 2**.

Figure 4. Map of Alignments 1a, 1b, and 1c

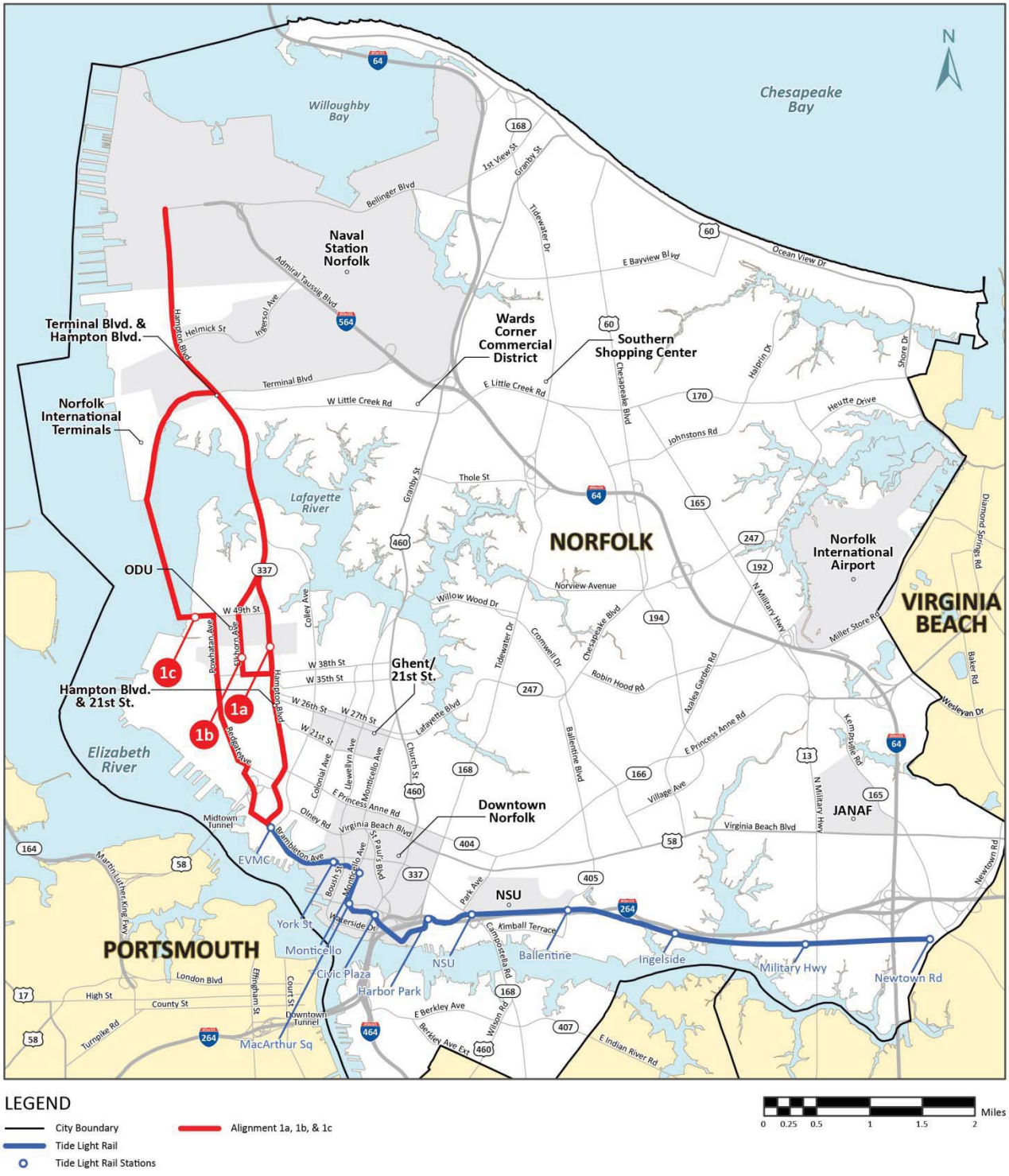


Table 2. Details of Alignments 1a, 1b, and 1c

Item	Alignment 1a	Alignment 1b	Alignment 1c
Alignment and termini	Beginning near the EVMC Tide station, traveling north along Colley Avenue, Redgate Avenue, and Hampton Boulevard past ODU, and connecting with NSN	Beginning near the EVMC Tide station, traveling north along Colley Avenue, Redgate Avenue, and Hampton Boulevard through ODU, with a short loop utilizing West 38th Street, Elkhorn Avenue, and West 49th Street, and terminating at NSN	Beginning at the EVMC Tide station, traveling west along Brambleton Avenue to Claremont Avenue and Redgate Avenue, proceeding north on an exclusive alignment over Lamberts Point rail terminal, and passing north through ODU to an exclusive alignment that crosses the Lafayette River and terminates at the southwest corner of NSN
Transit connection between NSN and existing Tide alignment	• 6.25 miles long • Approximate travel time of 25 minutes	• 6.69 miles long • Approximate travel time of 27 minutes	• 6.97 miles long Approximate travel time of 24 minutes
Travel demand	• 33,200 residents • 46,200 jobs • 24,670 ODU students near alignment	• 34,200 residents • 46,500 jobs • 24,670 ODU students near alignment	
Corridor-level land use	Medium-density residential, hospital, university, commercial strip, and military institution. Activity centers include EVMC, Ghent, West Ghent, Lamberts Point, ODU, Larchmont, NSA Hampton Roads, and Naval Station Norfolk	Medium-density residential, hospital, university, commercial strip, and military institution. Activity centers include EVMC, West Ghent, ODU, Larchmont, NSA Hampton Roads, and Naval Station Norfolk	Some medium-density residential, university, medium-density industrial, hospital, and military institution. Activity centers include EVMC, West Ghent, ODU, NSA Hampton Roads, and Naval Station Norfolk
Connectivity and accessibility to other transportation modes	Connects to seven existing HRT bus routes (Lines 2, 3, 4, 15, 19, 22, and 23)		Connects to six existing HRT bus routes (Lines 2, 3, 4, 19, 22, and 23)
Environmental characteristics	• Uses existing arterial right-of-way for entire length • Passes by 14 parks and two historic districts • Crosses Lafayette River wetlands and wetlands within NSN	• Uses existing arterial right-of-way for entire length • Passes by 15 parks and two historic districts • Crosses Lafayette River wetlands and wetlands within NSN	• Uses new right-of-way and grade separation near Lamberts Point rail terminal • Passes by four parks • Uses new bridge over mouth of Lafayette River and wetlands. Crosses wetlands within NSN
Conceptual-level capital cost	Potentially lower than alignments with large amounts of exclusive right-of-way because most of the length of alignment is shared with arterial roadway, and the amount of structure would likely be less than other alignments		Potentially higher cost due to two new grade separations and right-of-way acquisition for exclusive alignment. Risks and costs associated with seawall construction

3.1.2 Alignments 2a and 2b

Alignments 2a and 2b would begin near the EVMC/Fort Norfolk Tide station. From the EVMC/Fort Norfolk station, the alignments would proceed north within the right-of-way of Colley Avenue past EVMC and through Ghent and the Colley Avenue/21st Street commercial district. North of Ghent, the alignments would cross the Norfolk Southern Railroad line on an exclusive grade separation (overpass or underpass) near the existing Colley Avenue roadway underpass and then continue north along Colley Avenue through Park Place. North of Park Place, the alignments would diverge at the intersection of Colley Avenue and West 38th Street.

From this point, Alignment 2a would turn left on West 38th Street to proceed west toward ODU. At the intersection of West 38th Street and Hampton Boulevard, the alignment would turn right to proceed north on Hampton Boulevard past the university's athletic complex and pass within one half-mile of most of the university's buildings. Alignment 2b would continue north along Colley Avenue to cross over a branch of the Lafayette River near Highland Park and continue into the Larchmont/Edgewater community. From there, Alignment 2b would transition onto Jamestown Crescent and travel northwest toward Hampton Boulevard, passing to the north of ODU. At this point, the alignments would rejoin and turn north toward NSN.

North of ODU, the two alignments would follow Hampton Boulevard past Larchmont Elementary, the Larchmont Branch of Norfolk Public Library, and the Navy's Lafayette River Annex before crossing the Lafayette River. North of the Lafayette River, the alignments would continue north within the right-of-way of Hampton Boulevard through Lochhaven and Meadowbrook before reaching NSN. The alignments would provide access to many areas such as the NSA Hampton Roads, including Joint Forces Staff College, Norfolk International Terminals, Glenwood Park, and the central areas of the base. The northern end of the alignments would be situated at the intersection of Hampton Boulevard and Admiral Taussig Boulevard, just outside the gates to NSN. The alignments are displayed in **Figure 5** and are described in further detail in **Table 3**.

Figure 5. Map of Alignments 2a and 2b

Table 3. Details of Alignments 2a and 2b

Item	Alignment 2a	Alignment 2b
Alignment and termini	Beginning near the EVMC Tide station (western terminus of existing Tide alignment), traveling north along Colley Avenue to West 38th Street, continuing through ODU along Hampton Boulevard, and terminating at NSN	Beginning near the EVMC Tide station (western terminus of existing Tide alignment), traveling north along Colley Avenue and Jamestown Crescent near ODU, continuing along Hampton Boulevard, and terminating at NSN
Transit connection between NSN and existing Tide alignment	• 6.75 miles long • Approximate travel time of 27 minutes	• 6.55 miles long • Approximate travel time of 26 minutes
Travel demand	• 36,900 residents. • 48,300 jobs. • 24,670 ODU students near alignment.	
Corridor-level land use	Medium-density residential, hospital, university, commercial strip, and military institution. Activity centers include EVMC, West Ghent, Park Place, ODU, Larchmont, NIT, NSA Hampton Roads, and Naval Station Norfolk	Medium-density residential, hospital, commercial strip, and military institution. Activity centers include EVMC, West Ghent, Park Place, Larchmont, NSA Hampton Roads, and Naval Station Norfolk
Connectivity and accessibility to other transportation modes	Connects to seven existing HRT bus routes (Lines 2, 3, 4, 15, 19, 22, and 23)	
Environmental characteristics	• Uses existing arterial right-of-way for entire length • Passes by 14 parks, two historic buildings, and two historic districts • Crosses Lafayette River wetlands and wetlands within NSN	• Uses existing arterial right-of-way for entire length • Passes by 14 parks, two historic buildings, and three historic districts • Crosses Lafayette River wetlands and wetlands within NSN
Conceptual-level capital cost	Entire length of alignment is shared with arterial right-of-way. Short length of alignment decreases cost	

3.1.3 Alignments 3a and 3b

Alignment 3a would begin at the Monticello Tide station in downtown Norfolk. It would then proceed through the northern portion of downtown within the right-of-way of Monticello Avenue, past the Norfolk Scope arena to St. Pauls Boulevard. From there, the alignment would travel north on Monticello to 20th Street, where the tracks for each direction would split. The northbound track would continue on Monticello Avenue to 22nd Street, where it would turn west. The southbound track would run in the eastbound direction along 20th Street between Monticello Avenue and Colley Avenue, and southbound on Colley Avenue between 22nd Street and 20th Street. The split rejoins at Colley Avenue and 22nd Street within the Colley Avenue/21st Street commercial district, and then the alignment would proceed north along Colley Avenue under the Norfolk Southern Railroad underpass to West 38th Street through Park Place.

Alignment 3b would begin at the Civic Plaza Tide station in downtown Norfolk and proceed north within the right-of-way of St Pauls Boulevard to the intersection at Market Street near MacArthur Center. At this intersection, the alignment would make a sweeping turn to follow Fenchurch Street, which intersects Market Street 150 feet to the east. Then the alignment would turn left to proceed north within the right-of-way of Fenchurch Street through Tidewater Gardens. North of Brambleton Avenue, Fenchurch Street becomes Church Street. The alignment would travel through Huntersville along Church Street and cross the Norfolk Southern Railroad tracks on an exclusive grade separated structure. North of the railroad, the alignment would continue north along Church Street through Villa Heights and Park Place until it becomes Granby Street. At the intersection of Granby Street and West 38th Street near Virginia Zoological Park, the alignment would turn left to follow West 38th Street through Park Place.

From the intersection of West 38th Street and Colley Avenue, both alignments would proceed west along West 38th Street toward ODU. At the intersection of West 38th Street and Hampton Boulevard, the alignments would turn right to proceed north on Hampton Boulevard past the university's athletic complex and pass within one half-mile of most of the university's buildings. North of ODU, the alignments would follow Hampton Boulevard past Larchmont Elementary, the Larchmont Branch of Norfolk Public Library, and the Lafayette River Naval Facility Complex before crossing the Lafayette River. North of the Lafayette River, the alignments would continue north within the right-of-way of Hampton Boulevard through Lochhaven and Meadowbrook before reaching NSN. The alignments would provide access to many areas such as the NSA Hampton Roads, Joint Forces Staff College, Norfolk International Terminals, and Glenwood Park. The northern end of the alignments would be at the intersection of Hampton Boulevard and Admiral Taussig Boulevard just outside the gates to NSN. The alignments are displayed on a map in **Figure 6** and are described in further detail in **Table 4**.

Figure 6. Map of Alignments 3a and 3b

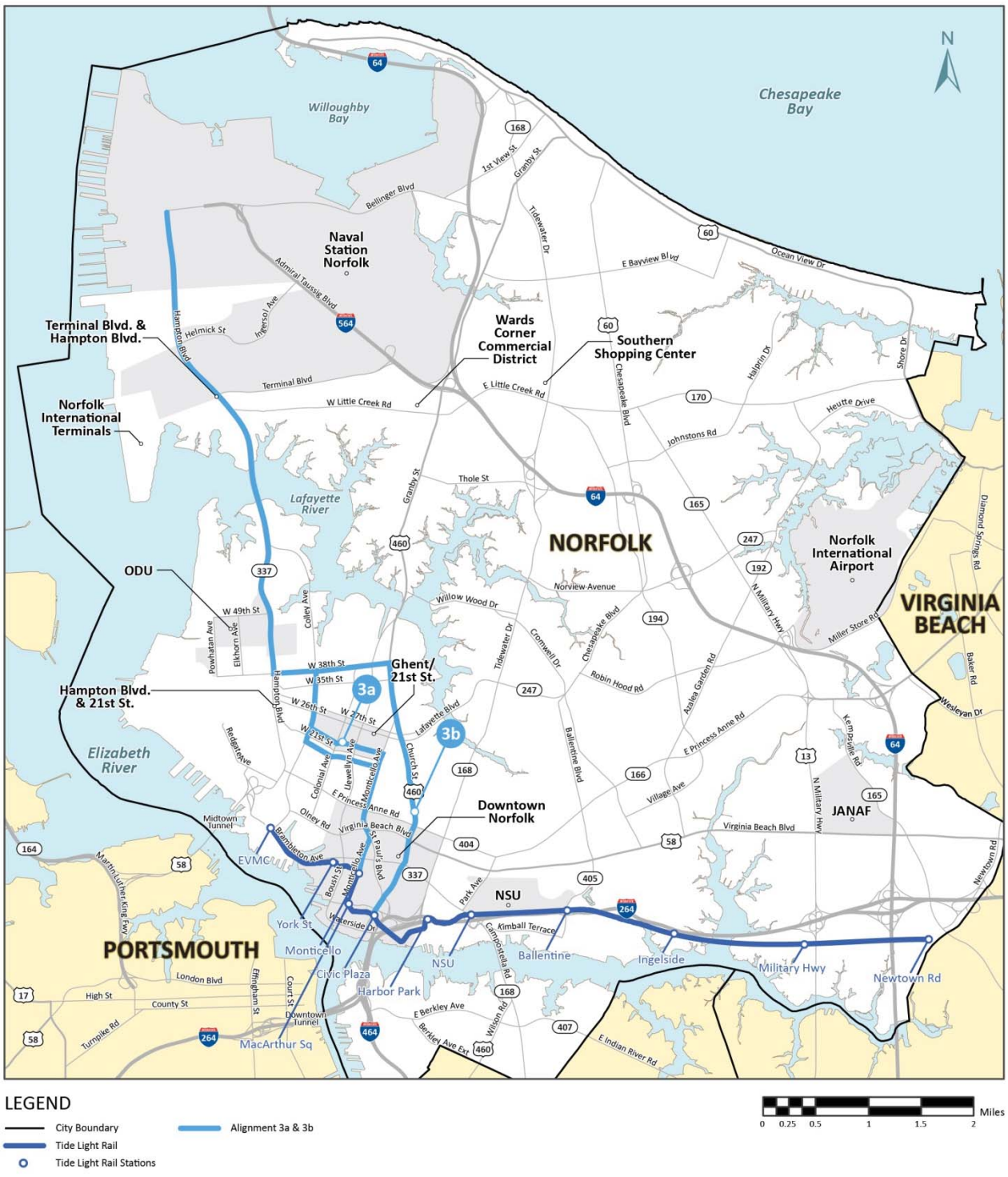


Table 4. Details of Alignments 3a and 3b

Item	Alignment 3a	Alignment 3b
Alignment and termini	Beginning at the Monticello Tide station in downtown Norfolk and traveling north on Monticello Avenue to 20th Street / 22nd Street, then continuing to Colley Avenue and Hampton Boulevard through ODU; and then extending to NSN	Beginning at the Civic Plaza station in downtown Norfolk and traveling north on St Pauls Boulevard, Fenchurch Street, Church Street, and Granby Street to 38th Street; then continuing to Hampton Boulevard and traveling north past ODU; and then extending to NSN
Transit connection between NSN and existing Tide alignment	• 7.63 miles long • Approximate travel time of 31 minutes	• 8.51 miles long • Approximate travel time of 34 minutes
Travel demand	• 45,700 residents • 76,400 jobs • 24,670 ODU students near alignment	
Corridor-level land use	Medium-density residential, university, medium-density office, tourist attractions, commercial strip, and military institution. Activity centers include Norfolk Scope, Ghent, Park Place, ODU, Larchmont, NSA Hampton Roads, and Naval Station Norfolk	Medium-density residential, university, medium-density office, tourist attractions, commercial strip, and military institution. Activity centers include downtown Norfolk, Huntersville, Virginia Zoological Park, Park Place, ODU, Larchmont, NSA Hampton Roads, and Naval Station Norfolk
Connectivity and accessibility to other transportation modes	Connects to 17 existing HRT bus routes (Lines 1, 2, 3, 4, 6, 8, 9, 11, 13, 15, 17, 18, 19, 20, 22, 23, and 24)	
Environmental characteristics	• Uses existing arterial right-of-way for entire length • Passes by 13 parks, three historic buildings, and four historic districts • Crosses Lafayette River wetlands and wetlands within NSN	• Uses existing arterial right-of-way for entire length • Passes by 14 parks, four historic buildings, and four historic districts • Crosses Lafayette River wetlands and wetlands within NSN
Conceptual-level capital cost	Entire length of alignment is shared with arterial right-of-way. Connections near Norfolk Southern Railroad and grade separations at Monticello Avenue and Colley Avenue would increase cost	Entire length of alignment would be shared with arterial right-of-way

3.2 CENTRAL ALIGNMENTS

The following subsections describe the five central alignments, which would all connect NSN with the central portions of downtown Norfolk by traveling through various neighborhoods in central Norfolk, including Ghent, Huntersville, Park Place, Riverview, Belvedere, Roland Park, and Wards Corner. These alignments would use a combination of exclusive right-of-way and right-of-way shared with surface arterials such as Monticello Avenue, Church Street, Granby Street, Lafayette Boulevard, Tidewater Drive, and Admiral Taussig Boulevard.

3.2.1 Alignments 4a, 4b, and 4c

Alignment 4a would begin at the Monticello Tide station in downtown Norfolk and proceed north within the right-of-way of Monticello Avenue through the northern portion of downtown past the Norfolk Scope arena to St Pauls Boulevard, where it would make a left turn to continue north on Monticello Avenue. From there, the alignment would travel north, through a grade separation at the Monticello Avenue/Norfolk Southern Railroad underpass, to Church Street, where it would make a left turn to proceed north on Church Street through Villa Heights.

Alignments 4b and 4c would begin at the Civic Plaza Tide station in downtown Norfolk and proceed north within the right-of-way of St Pauls Boulevard to the intersection at Market Street near MacArthur Center. At this intersection, the alignments would make a sweeping turn to follow Fenchurch Street, which intersects Market Street 150 feet to the east. Then the alignments would turn left to proceed north within the right-of-way of Fenchurch Street through Tidewater Gardens until Fenchurch Street becomes Church Street, later traveling through Huntersville to a grade separated crossing over the Norfolk Southern Railroad. North of the railroad, the alignments would continue north along Church Street.

All three alignments would continue north on Granby Street, passing near Virginia Zoological Park and the Riverview business district, and finally crossing over the Lafayette River. North of the Lafayette River, the alignments would continue north along Granby Street through Belvedere past DePaul Medical Center. North of Cromwell Farms, the alignments would pass Granby High School and Midtown Shopping Center to intersect I-564 at Wards Corner commercial district. Then the alignments would cross over a portion of the I-564/Granby Street interchange on a grade separation and run northwest on exclusive right-of-way parallel to I-564.

Prior to NSN, the alignments would diverge as follows:

- Alignment 4a would run west on I-564 past Chambers Field and under the runway to the point where I-564 transitions into Admiral Taussig Boulevard. The alignment would then continue west to the intersection of Admiral Taussig Boulevard and Hampton Boulevard, just outside the gates to Naval Station Norfolk.
- Alignment 4b would depart I-564 near Chambers Field at the location of a proposed interchange on I-564 (the “Intermodal Connector”). Then the alignment would continue west

within the right-of-way of a proposed arterial to be built just north of the existing railroad that separates NSN from Glenwood Park. From there, it would continue west to Hampton Boulevard just north of the existing at-grade crossing of the Norfolk Southern Railway to Norfolk International Terminals, where it would turn right to proceed north on Hampton Boulevard to the intersection with Admiral Taussig Boulevard just outside the gates to Naval Station Norfolk.

- Alignment 4c would depart I-564 near Chambers Field at the location of a proposed interchange on I-564 (the "Intermodal Connector"). From here, the alignment would turn southwest to follow Ingersol Avenue and Helmick Street, running within those streets' rights-of-way. The alignment would continue to the intersection of Hampton Boulevard and Helmick Street just south of Glenwood Park, where it would turn right to proceed north on Hampton Boulevard to the intersection with Admiral Taussig Boulevard just outside the gates to Naval Station Norfolk.

The alignments are displayed on a map in **Figure 7** and are described in further detail in **Table 5**.

Figure 7. Map of Alignments 4a, 4b, and 4c

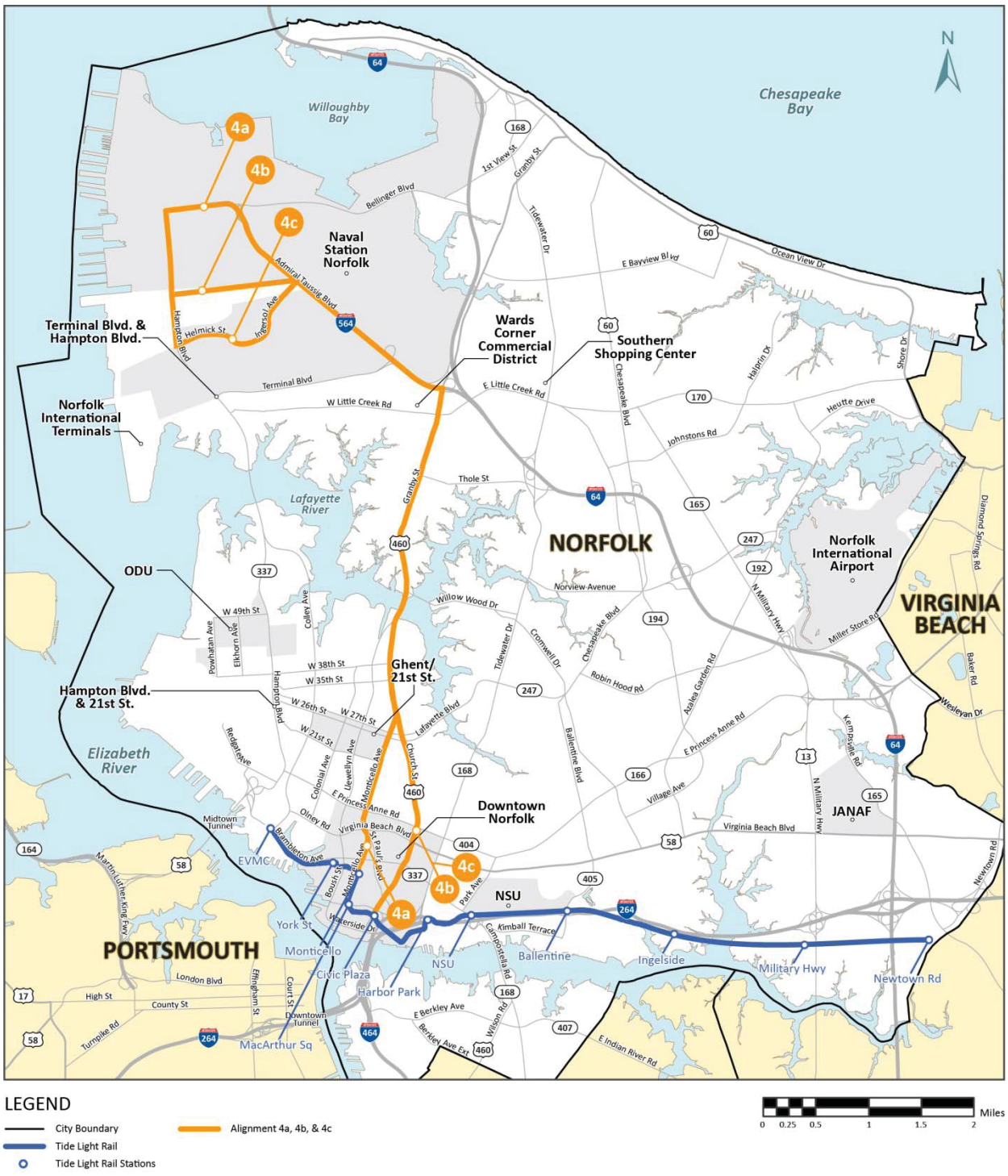


Table 5. Details of Alignments 4a, 4b, and 4c

Item	Alignment 4a	Alignment 4b	Alignment 4c
Alignment and termini	Beginning at the Monticello Tide station in downtown Norfolk, traveling north on Monticello Avenue to Granby Street over the Lafayette River and north to I-564, and continuing along I-564 to NSN	Beginning at the Civic Plaza Tide station in downtown Norfolk, traveling north on St Pauls Boulevard, Fenchurch Street, Church Street, and Granby Street over the Lafayette River and north to I-564, and continuing along I-564 and a new roadway to NSN	Beginning at the Civic Plaza Tide station in downtown Norfolk, traveling north on St Pauls Boulevard, Fenchurch Street, Church Street, and Granby Street over the Lafayette River and north to I-564, continuing along I-564 to Ingersol Avenue and Helmick Street, and continuing to Hampton Boulevard within NSN
Transit connection between NSN and existing Tide alignment	• 8.25 miles long • Approximate travel time of 27 minutes	• 9.13 miles long • Approximate travel time of 31 minutes	• 9.45 miles long • Approximate travel time of 34 minutes
Travel demand	• 40,500 residents • 78,300 jobs		
Corridor-level land use	Medium-density residential, medium-density office, tourist attractions, commercial strip, medium-density shopping areas, and military institution. Activity centers include downtown Norfolk, Norfolk Scope, Ghent, Villa Heights, Virginia Zoological Park, DePaul Hospital, Wards Corner, Chambers Field, and Naval Station Norfolk	Medium-density residential, medium-density office, tourist attractions, commercial strip, medium-density shopping areas, and military institution. Activity centers include downtown Norfolk, Huntersville, Villa Heights, Virginia Zoological Park, DePaul Hospital, Wards Corner, Chambers Field, and Naval Station Norfolk	Medium-density residential, medium-density office, tourist attractions, commercial strip, medium-density shopping areas, and military institution. Activity centers include downtown Norfolk, Huntersville, Villa Heights, Virginia Zoological Park, DePaul Hospital, Wards Corner, Chambers Field, and Glenwood Park
Connectivity and accessibility to other transportation modes	Connects to 18 existing HRT bus routes (Lines 1, 2, 3, 4, 5, 6, 8, 9, 11, 13, 15, 17, 18, 19, 20, 22, 23, and 24)		
Environmental characteristics	• Uses existing arterial right-of-way for two-thirds of alignment length • Passes by five parks, two historic buildings, and four historic districts • Crosses Lafayette River wetlands and wetlands within NSN	• Uses existing arterial right-of-way for two-thirds of alignment length • Passes by five parks, four historic buildings, and three historic districts • Crosses Lafayette River wetlands and wetlands within NSN	
Conceptual-level capital cost	Two-thirds of alignment length is shared with arterial right-of-way. Contains a new grade separation at the Monticello Avenue/Norfolk Southern Railroad underpass	Two-thirds of alignment length is shared with arterial right-of-way	

3.2.2 Alignments 5a and 5b

Alignment 5a would begin at the Monticello Tide station in downtown Norfolk and proceed north within the right-of-way of Monticello Avenue through the northern portion of downtown past the Norfolk Scope arena to St. Pauls Boulevard, where it would make a left turn to continue north on Monticello Avenue. From there, the alignment would travel north through/over/under a grade separation at the Monticello Avenue/Norfolk Southern Railroad underpass to Church Street, where it would make a right turn onto East 26th Street and continue east through Villa Heights to cross the Lafayette River. East of the Lafayette River, the alignment would continue on Lafayette Boulevard, where it would proceed northeast to the intersection with Tidewater Drive in the Lafayette-Winona community.

Alignment 5b would begin at the Civic Plaza Tide station in downtown Norfolk and proceed north within the right-of-way of St. Pauls Boulevard to the intersection at Market Street near MacArthur Center. At this intersection, the alignment would turn to follow Fenchurch Street, which intersects Market Street 150 feet to the east. Then the alignment would turn left to proceed north within the right-of-way of Fenchurch Street through Tidewater Gardens until Fenchurch Street becomes Church Street, following Church Street to the intersection with Brambleton Avenue. At this point, the alignment would continue northeast on exclusive right-of-way through Calvert Square to the intersection of Tidewater Drive and Virginia Beach Boulevard, where it would turn north along Tidewater Drive through Huntersville. Following Tidewater Drive, the alignment would cross the Norfolk Southern Railroad on a grade separation near the Tidewater Drive underpass, continuing north over the Lafayette River to the Lafayette-Winona community.

At the intersection of Tidewater Drive and Lafayette Boulevard, the alignments would proceed north on Tidewater Drive past Lafayette Shores and continue over Wayne Creek. North of Wayne Creek, the alignments would pass through Roland Park and continue over a grade separation near the Tidewater Drive railroad overpass. North of Roland Park, the alignments would intersect I-64, using a grade separation to traverse the I-64/Tidewater Drive interchange. At I-64, the alignments would travel northwest on exclusive right-of-way to the interchange of I-64 and I-564 near Wards Corner, where they would continue northwest on exclusive right-of-way parallel to I-564. Within NSN, the alignments would run west past Chambers Field and under the runway to the point where I-564 transitions into Admiral Taussig Boulevard. The alignments would then continue west to the intersection of Admiral Taussig Boulevard and Hampton Boulevard just outside the gates to Naval Station Norfolk. The alignments are displayed on a map in **Figure 8** are described in further detail in **Table 6**.

Figure 8. Map of Alignments 5a and 5b

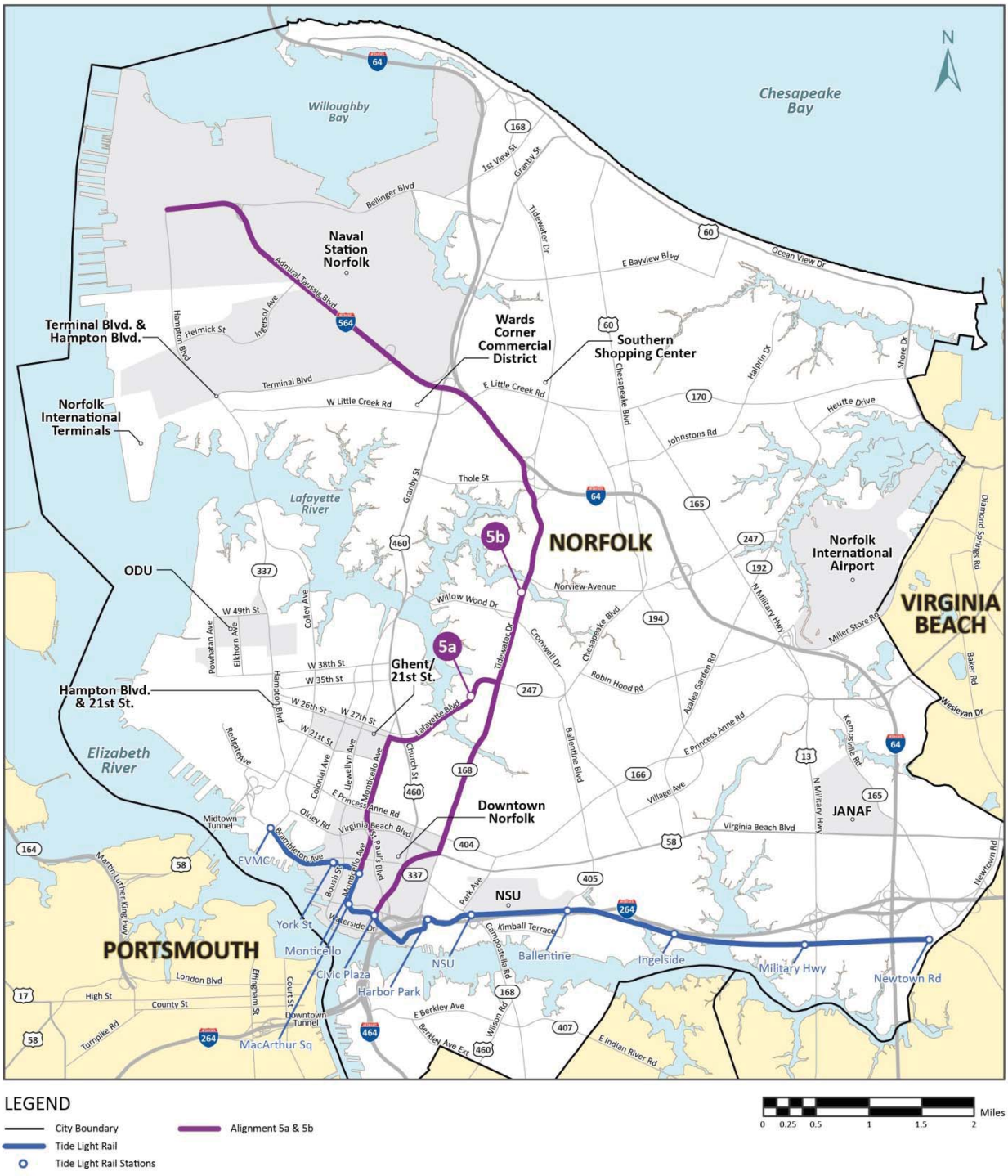


Table 6. Details of Alignments 5a and 5b

Item	Alignment 5a	Alignment 5b
Alignment and termini	Beginning at the Monticello Tide station in downtown Norfolk, traveling north on Monticello Avenue to 26th Street and then Lafayette Boulevard, continuing on Tidewater Drive to I-64 west, and continuing on I-564 and Admiral Taussig Boulevard to NSN	Beginning at the Civic Plaza Tide station in downtown Norfolk, traveling north on St Pauls Boulevard, Fenchurch Street, and Church Street to an exclusive alignment northeast of Tidewater Drive, continuing on Tidewater Drive over the Lafayette River and Wayne Creek to I-64 west, and then continuing on I-564 and Admiral Taussig Boulevard to NSN
Transit connection between NSN and existing Tide alignment	• 9.25 miles long • Approximate travel time of 28 minutes	• 9.23 miles long • Approximate travel time of 28 minutes
Travel demand	• 45,300 residents • 78,200 jobs	• 46,800 residents • 71,300 jobs
Corridor-level land use	Medium-density residential, medium-density office, tourist attractions, commercial strip, medium-density shopping areas, and military institution. Activity centers include downtown Norfolk, Norfolk Scope, Ghent, Villa Heights, Wards Corner, Chambers Field, and Naval Station Norfolk	Medium-density residential, medium-density office, tourist attractions, commercial strip, medium-density shopping areas, and military institution. Activity centers include downtown Norfolk, Calvert Square, Huntersville, Wards Corner, Chambers Field, and Naval Station Norfolk
Connectivity and accessibility to other transportation modes	Connects to 18 existing HRT bus routes (Lines 1, 2, 3, 4, 5, 6, 8, 9, 11, 13, 15, 17, 18, 19, 20, 22, 23, and 24)	
Environmental characteristics	• Uses existing arterial right-of-way for half of alignment length • Passes by five parks, four historic buildings, and three historic districts • Crosses wetlands associated with Lafayette River and Wayne Creek, as well as within NSN	• Uses existing arterial right-of-way for half of alignment length • Passes by six parks, three historic buildings, and two historic districts • Crosses wetlands associated with Lafayette River and Wayne Creek, as well as within NSN
Conceptual-level capital cost	Half of alignment length is shared with arterial right-of-way. Includes crossings over Lafayette River and Wayne Creek as well as new grade separations at the Monticello Avenue/Norfolk Southern Railroad underpass and at the I-64/Tidewater Drive interchange	Half of alignment length is shared with arterial right-of-way. Includes crossings over Lafayette River and Wayne Creek, as well as a new grade separation at the I-64/Tidewater Drive interchange

3.3 EASTERN ALIGNMENTS

The following subsections describe the four eastern alignments, which would all connect NSN with the eastern end of the existing Tide alignment near the border between Norfolk and Virginia Beach. These alignments would travel past various areas in Norfolk, including the JANAF (Joint Army Navy Air Force) Shopping Center, Lake Taylor, Norfolk International Airport, Norview, Tanners Creek, and Wards Corner. The alignments would use a combination of exclusive right-of-way and right-of-way shared with surface arterials such as Kempsville Road, Military Highway, Little Creek Road, Hampton Boulevard, and Admiral Taussig Boulevard.

3.3.1 Alignment 6

Alignment 6 would begin at the Military Highway Tide station, which is located on Curlew Drive in the southwest corner of the I-264/Military Highway interchange. From this point, the alignment would proceed east along Curlew Drive to Military Highway, where it would turn left and cross I-264 on a grade separation to the north. North of I-264, the alignment would continue within the right-of-way of Military Highway past Military Circle and cross Virginia Beach Boulevard on another grade separation. North of Virginia Beach Boulevard, the alignment would continue past the JANAF Shopping Center and Lake Taylor Transitional Care Hospital. Continuing north toward Norfolk International Airport, the alignment would cross over a branch of the Elizabeth River south of Princess Anne Road and cross the I-64/Military Highway interchange just south of the airport. The alignment would then continue to the northwest through Sandy Heights to Azalea Garden Road, where a shuttle to the airport would be planned along Azalea Garden Road. Then the alignment would proceed northwest past the Norview Center shopping area, continuing through Tanners Creek and Meadowbrook to Little Creek Road.

At Little Creek Road, the alignment would turn left to follow the right-of-way of Little Creek Road to the west past the shopping centers near the Tidewater Drive interchange. After crossing over Tidewater Drive, the alignment would continue west past I-64 and Wards Corner to intersect Hampton Boulevard in Larchmont. Then the alignment would turn right onto Hampton Boulevard and continue north within the right-of-way of Hampton Boulevard through Lochhaven and Meadowbrook. Then the alignment would provide access to many areas within the NSA Hampton Roads, including Joint Forces Staff College, Norfolk International Terminals, and Glenwood Park. The northern end of the alignment would be at the intersection of Hampton Boulevard and Admiral Taussig Boulevard just outside the gates to Naval Station Norfolk. Alignment 6 is displayed on a map in **Figure 9** and is described in further detail in **Table 7**.

Figure 9. Map of Alignment 6

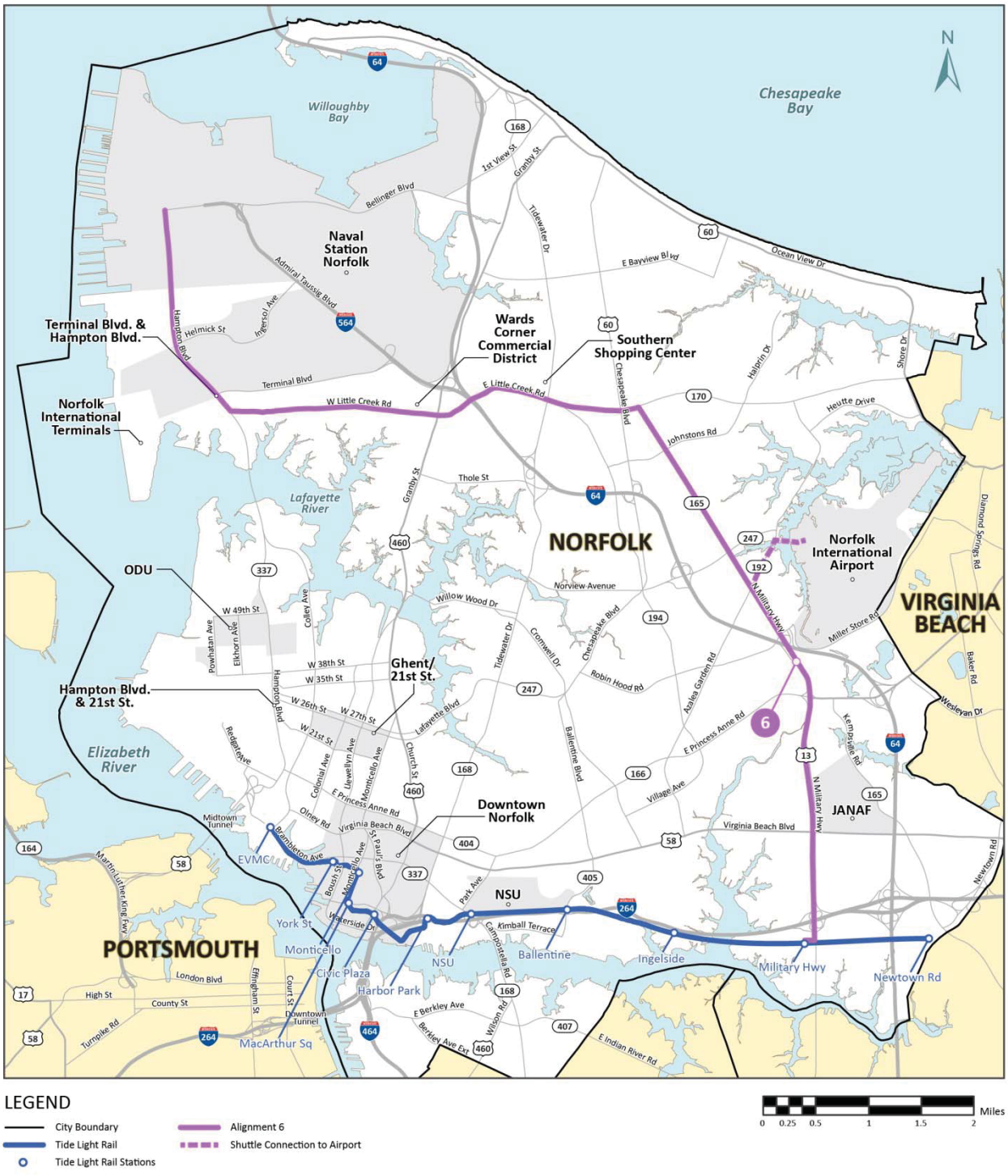


Table 7. Details of Alignment 6

Item	Alignment 6
Alignment and termini	Beginning at the Military Highway Tide station, traveling north on Military Highway to Little Creek Road, continuing west to Hampton Boulevard and NSN, and with a shuttle to Norfolk International Airport
Transit connection between NSN and existing Tide alignment	• 11.74 miles long • Approximate travel time of 47 minutes
Travel demand	• 50,200 residents • 54,000 jobs
Corridor-level land use	Medium-density residential, commercial strip, schools, large shopping areas, and military institution. Activity centers include Military Circle, JANAF, Norfolk International Airport, Tidewater Shopping Center, Wards Corner, Larchmont, NSA Hampton Roads, Naval Station Norfolk Piers, and Naval Station Norfolk
Connectivity and accessibility to other transportation modes	Connects to eleven existing HRT bus routes (Lines 1, 2, 3, 5, 8, 9, 15, 19, 20, 22, and 23)
Environmental characteristics	• Shares arterial right-of-way for entire length • Runs adjacent to nine parks • Crosses Elizabeth River wetlands
Conceptual-level capital cost	Entire length of alignment shared with arterial right-of-way. Includes crossing of Elizabeth River and grade separations at Military Highway/I-64, Military Highway/Virginia Beach Boulevard, and Little Creek Road/Tidewater Drive interchanges

3.3.2 Alignments 7a and 7b

Alignment 7a would begin at the Military Highway Tide station. From this point, the alignment would proceed east along Curlew Drive to Military Highway, where it would turn left and cross the I-264 interchange on a grade separation. North of I-264, the alignment would continue within the right-of-way of Military Highway past Military Circle and cross Virginia Beach Boulevard on another grade separation.

Alignment 7b would begin at the Newtown Road Tide station, which is the eastern terminus of the existing Tide alignment and sits near the border between Norfolk and Virginia Beach. From the Newtown Road Station, the alignment would proceed northeast within the right-of-way of Newtown Road and then turn left to run north on Kempsville Road past Sentara Leigh Hospital. At the intersection of Kempsville Road and Virginia Beach Boulevard, the alignment would turn left to proceed west on Virginia Beach Boulevard past the JANAF Shopping Center to the Military Highway interchange.

North of Virginia Beach Boulevard, both alignments would continue north on Military Highway past the JANAF Shopping Center and Lake Taylor Transitional Care Hospital. Continuing north toward Norfolk International Airport, the alignments would cross over a branch of the Elizabeth River south of Princess Anne Road and would cross the I-64/Military Highway interchange just south of the airport. The alignments would then continue to the northwest through Sandy Heights to Azalea Garden Road, where a shuttle to the airport would be planned along Azalea Garden Road through Azalea Acres. Then the alignments would proceed northwest past the Norview Center shopping area, continuing through Tanners Creek and Meadowbrook to Little Creek Road.

At Little Creek Road, the alignments would turn left to follow the right-of-way of Little Creek Road to the west past the shopping centers near the Tidewater Drive interchange. After crossing over Tidewater Drive, the alignments would continue west to the I-64 interchange. At I-64, the alignments would cross the I-64/Little Creek Road interchange on a grade separation and then travel northwest to the interchange of I-64 and I-564 near Wards Corner, where they would continue northwest on exclusive right-of-way parallel to I-564. Within NSN, the alignments would run west past Chambers Field and under the runway to the point where I-564 transitions into Admiral Taussig Boulevard. The alignments would then continue west to the intersection of Admiral Taussig Boulevard and Hampton Boulevard just outside the gates to Naval Station Norfolk. The alignments are displayed on a map in **Figure 10** and are described in further detail in **Table 8**.

Figure 10. Map of Alignments 7a and 7b

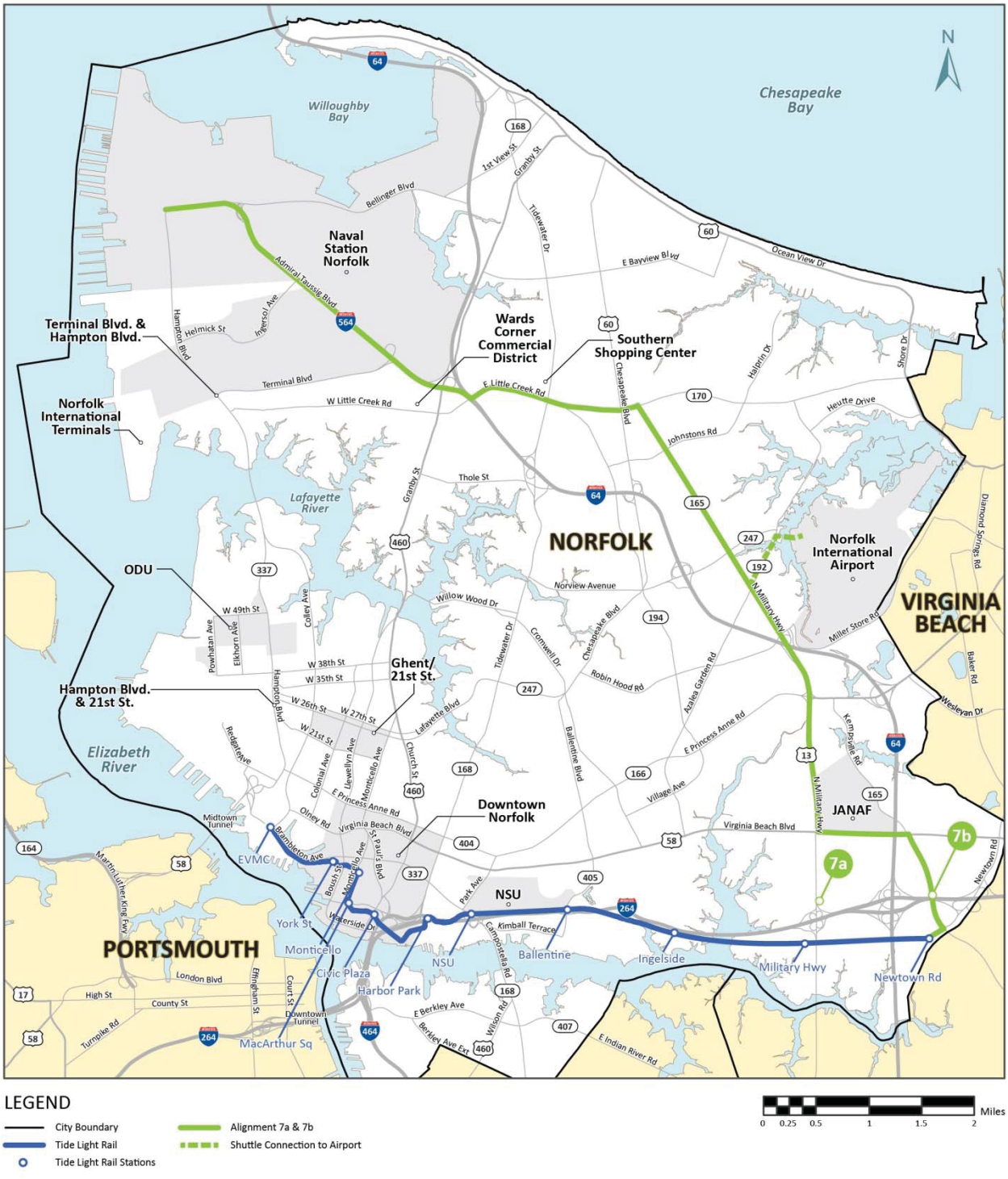


Table 8. Details of Alignments 7a and 7b

Item	Alignment 7a	Alignment 7b
Alignment and termini	Beginning at the Military Highway Tide station, traveling north on Military Highway to Little Creek Road, and continuing west to I-64, I-564, and NSN, with a shuttle to Norfolk International Airport	Beginning at the Newtown Road Tide station, traveling northeast on Newtown Road to Kempsville Road, continuing north to Virginia Beach Boulevard and west to Military Highway, continuing north to Little Creek Road and west to I-64 west, and continuing to I-564 and NSN, with a shuttle to Norfolk International Airport
Transit connection between NSN and existing Tide alignment	• 10.94 miles long • Approximate travel time of 37 minutes	• 11.69 miles long • Approximate travel time of 40 minutes
Travel demand	• 42,400 residents • 59,900 jobs	• 44,000 residents • 67,400 jobs
Corridor-level land use	Medium-density residential, commercial strip, schools, large shopping areas, and military institution. Activity centers include Military Circle, JANAF, Norfolk International Airport, Tidewater Shopping Center, Wards Corner, Chambers Field, and Naval Station Norfolk	Medium-density residential, hospital, commercial strip, schools, large shopping areas, and military institution. Activity centers include Sentara Leigh Hospital, JANAF, Norfolk International Airport, Tidewater Shopping Center, Wards Corner, Chambers Field, and Naval Station Norfolk
Connectivity and accessibility to other transportation modes	Connects to nine existing HRT bus routes (Lines 2, 3, 8, 9, 15, 19, 20, 22, and 23)	
Environmental characteristics	• Shares arterial right-of-way for two-thirds of length • Runs adjacent to four parks • Crosses wetlands associated with branch of Elizabeth River, freshwater emergent wetlands, and wetlands within NSN	• Shares arterial right-of-way for two-thirds of length. • Runs adjacent to five parks • Crosses wetlands associated with branch of Elizabeth River, freshwater emergent wetlands, and wetlands within NSN
Conceptual-level capital cost	Two-thirds of alignment shared with arterial right-of-way. Includes grade separations at Military Highway/I-64, Military Highway/Virginia Beach Boulevard, and Little Creek Road/Tidewater Drive interchanges	

3.3.3 Alignment 8

Alignment 8 would begin at the Newtown Road Tide station. From the Newtown Road station, the alignment would continue northeast on an exclusive alignment to Kempsville Road just north of the I-264 underpass and then run within the right-of-way of Kempsville Road north past Sentara Leigh Hospital and across Virginia Beach Boulevard to I-64 near Fairlawn Elementary School and the JANAF Shopping Center. Then the alignment would again run in an exclusive right-of-way northwest along I-64 past Virginia Wesleyan College and Lake Taylor High School, crossing over Lake Taylor and Lake Wright. At Norview Avenue near the Norview Center shopping area, a shuttle connection would be planned along the right-of-way of Norview Avenue to serve Norfolk International Airport.

Northwest of the airport, the alignment would pass through Norview, Tanners Creek, Coronado, and Chesapeake Gardens and provide a connection to Norview High School and Tanners Creek Elementary School, continuing along I-64 to the I-564 interchange at Wards Corner. At Wards Corner, the alignment would follow I-564 to the northwest toward Naval Station Norfolk. Then the alignment would run west past Chambers Field and under the runway to the point where I-564 transitions into Admiral Taussig Boulevard. The alignment would then continue west to the intersection of Admiral Taussig Boulevard and Hampton Boulevard just outside the gates to Naval Station Norfolk. Alignment 8 is displayed on a map in **Figure 11** and is described in further detail in **Table 9**.

Figure 11. Map of Alignment 8

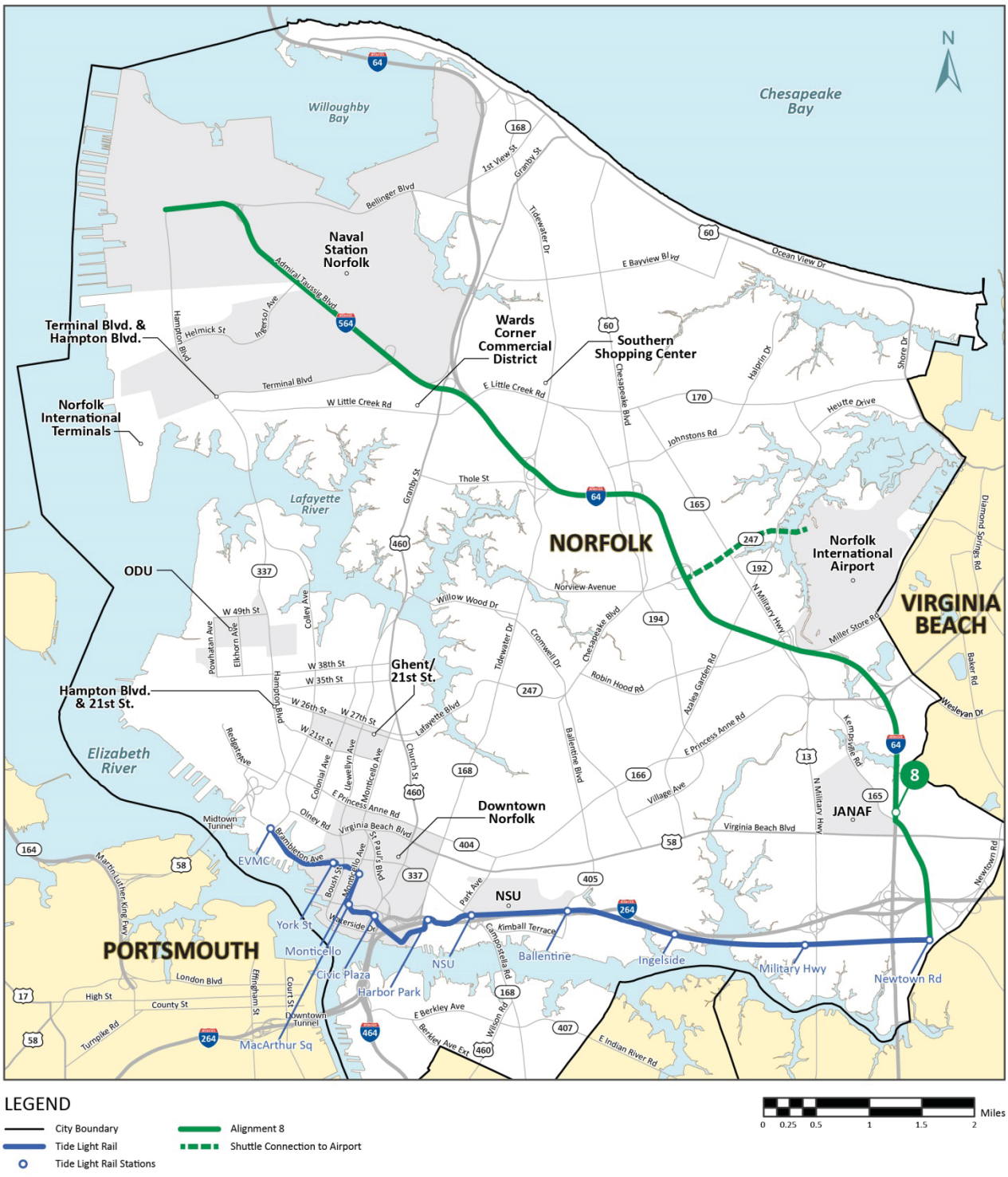


Table 9. Details of Alignment 8

Item	Alignment 8
Alignment and termini	Beginning at the Newtown Road Tide station, traveling north on Kempsville Road to I-64 west, and continuing to I-564 and NSN, with a shuttle to Norfolk International Airport,
Transit connection between NSN and existing Tide alignment	• 11.38 miles long, • Approximate travel time of 26 minutes.
Travel demand	• 41,900 residents, • 64,200 jobs,
Corridor-level land use	Some medium-density residential, hospital, schools, large shopping areas, and military institution. Activity centers include Sentara Leigh Hospital, Norfolk International Airport, Wards Corner, Chambers Field, and Naval Station Norfolk.
Connectivity and accessibility to other transportation modes	Connects to nine existing HRT bus routes (Lines 1, 2, 3, 5, 8, 15, 19, 20, and 22),
Environmental characteristics	• Uses exclusive right-of-way for nearly all of alignment length. • Runs adjacent to seven parks. • Crosses freshwater emergent wetlands and wetlands within NSN.
Conceptual-level capital cost	Nearly all of alignment length runs on exclusive right-of-way with only grade separated crossings north of Virginia Beach Boulevard. Includes crossings over Lake Taylor and Lake Wright.

APPENDIX C
TIER 1 SCREENING EVALUATION TECHNICAL MEMORANDUM

Tier 1 Screening Evaluation Technical Memorandum

DRAFT

Date: May 2, 2014
To: Ray Amoruso and Julie Timm, Hampton Roads Transit
From: HDR, Inc. and Kittelson & Associates, Inc.
cc: Jeff Raliski and Paul Filion, City of Norfolk

INTRODUCTION

The Naval Station Norfolk Transit Extension Study (NSNTES) seeks to define potential transit corridors in Norfolk that will link the Tide light rail transit (LRT) system with Naval Station Norfolk (NSN). The study has three phases. Each phase kicks off with public workshops to facilitate broad community involvement. During the Phase 1 workshops held in June 2013, citizens worked with the project team to identify the travel needs and challenges associated with traveling between the Tide and NSN. The public was able to review demographic, land use, and transportation data through a set of maps, handouts, and a presentation. The information provided by the public at this set of public meetings helped develop the Purpose and Need Statement for the NSNTES and a set of project goals. The second outcome of the Phase 1 workshops was the identification of six key project themes based on the travel needs and goals.

During the Phase 2 workshops in September 2013, citizens helped the study team identify corridors linking the Tide and NSN. The public further identified key activity centers within Norfolk and places they felt an extension should avoid. Using public input and the data generated during the Phase 2 workshops, the study team developed 16 potential alignment options. Using the six themes identified by the public in the Phase 1 workshops, the public provided input that helped translate the themes into criteria that could be used to measure and evaluate the 16 potential alignments based on available socio-economic, demographic, and traffic data. During the Phase 3 workshops in February 2014, the 16 alignments were presented to the public. The public had the opportunity to vote for which corridor they preferred (western, central, or eastern) in addition to a preferred alignment in each of the corridors plus regional connectivity.

The evaluation involves two tiers of screening. The Tier 1 screening process is a method for analyzing the 16 alignments at a broad planning level and seeks to reduce the number of alignments in preparation for the next level of analysis, the Tier 2 screening process, which will provide a more detailed analysis of the remaining alignments. This technical memorandum describes the development of the Tier 1 screening evaluation criteria, the analysis methodology and data, and the results of the Tier 1 screening evaluation. The technical memorandum is divided into sections by theme, and each section includes information about the associated criteria. A Tier 1 screening matrix

was developed to provide a method for evaluating and comparing each of the 16 alignment options. The results of applying each criterion are explained in the body of this memorandum.

A map of the 16 alignment options can be seen in **Figure 1**.

EVALUATION CRITERIA

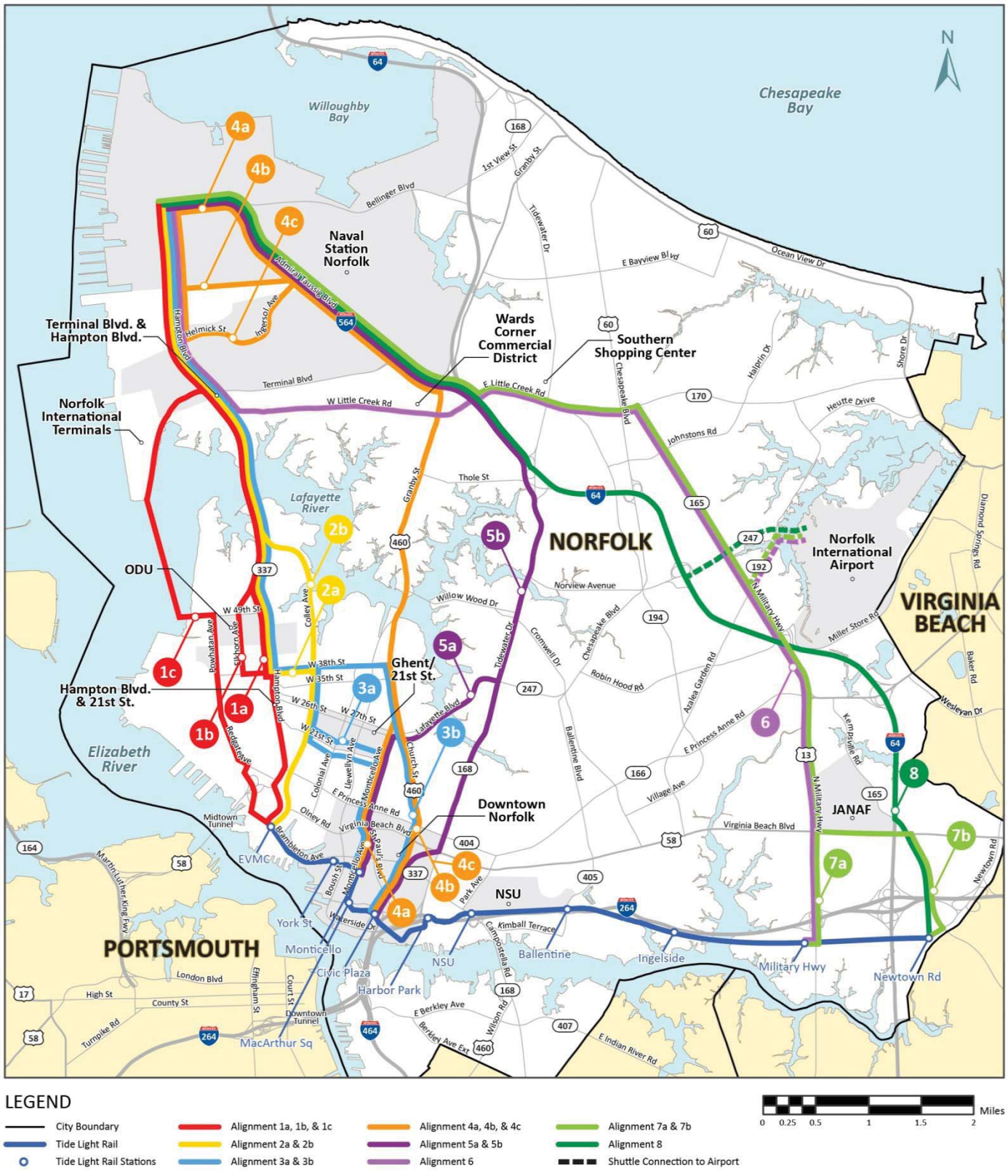
The evaluation criteria reflect the project's Purpose and Need Statement and the six themes that were developed through the Phase 1 and Phase 2 public workshops. Key goals such as providing an alternative to heavy traffic and congestion, providing direct access to NSN, meeting the transportation needs within Norfolk, enhancing transit opportunities to activity centers, and reducing travel times to NSN were mentioned by the public. A seventh "theme" was added by the project team to include evaluation criteria that are important for project planning and were not mentioned by the public.

The project team assigned evaluation criteria to the seven themes as a basis for assessing the alignment options. Part of the process of assigning criteria to themes included choosing a method for evaluating each criterion and picking the data to use in each evaluation. The themes and evaluation criteria used in the Tier 1 evaluation process are listed in **Table 1**. Detailed discussion of each theme and its criteria follow.

Table 1. Tier 1 Evaluation – Themes and Evaluation Criteria

Themes		Criteria	
1	Connect to Many Points within Norfolk	A	Connect to activity centers
2	Provide an Alternative to Heavy Traffic and Congestion	A	Reduce hours of daily roadway congestion
		B	Ability to attract riders
3	Reduce Travel Time – Make Travel Time More Reliable between Destinations	A	Opportunity to increase travel time reliability along alignment corridor
		B	Directness of route
4	Parking – Provide Parking to Accommodate Riders	A	Proximity to Park & Rides
5	Interconnectivity of Transit Modes	A	Ability to connect to other transit services in Norfolk
6	Future Expansion – Ensure That the System Can Be Expanded in the Future	A	Ability to leverage other planned regional transportation system projects
7	Other	A	Environmental considerations
		B	Right-of-way constraints and project cost
		C	Economic development and neighborhood revitalization
		D	Resiliency

Figure 1. Conceptual Alignments



Each alignment option was determined to be "least desirable," "more desirable," or "most desirable" with respect to each criterion. In general, if an alignment scored below the 25th percentile with respect to a given criterion, it was categorized as "least desirable" and represented with an open circle. If an alignment scored between the 25th and 75th percentiles with respect to a given criterion, it was categorized as "more desirable" and represented with a half-full circle. If an alignment scored above the 75th percentile with respect to a given criterion, it was categorized as "most desirable" and represented with a solid circle. Some of the evaluation criteria (e.g. Park & Rides) were not evaluated using the percentile methods and used natural breakpoints to determine each level of desirability. Overall, solid circles represent alignments that scored better in terms of their desirability than alignments receiving half-full or open circles.

THEME 1: CONNECT TO MANY POINTS WITHIN NORFOLK

Improving access to and from employment and activity centers through the transit connection to NSN can provide opportunities to enhance Norfolk's economic potential, attract transit ridership, and reduce vehicle demand. Activity centers generate and attract trips and are located in strategic parts of the city.

Criterion 1A: Connect to Activity Centers

Criterion 1A focuses on access to key destinations (including key employment locations) within Norfolk. Each alignment option was evaluated for proximity to popular activity centers as identified by the public.

Methodology and Data

This criterion was evaluated by determining the number of activity centers that are located within one-half mile of each of the alignment options. The analysis used a list of activity centers developed in the second public meeting, and locations that were identified by at least five people were identified as key activity centers and included in the analysis. The 23 activity centers used in the analysis are shown graphically in **Figure 2**. Using ArcGIS analysis tools, a one-half mile buffer for each alignment was created, and the number of activity centers within that buffer was determined.

Results

The number of activity centers within one-half mile of each alignment ranged from six to 13. Based on the distribution of the results, those alignments with 12 or more activity centers within a half mile (i.e., those alignments scoring at or above the 75th percentile) were determined to be "most desirable" and scored using the full circle. Alignments with between nine and 11 activity centers were "more desirable" and are scored with a half full circle and those with fewer than nine activity centers (i.e., those alignments scoring below the 25th percentile) were determined to be "least desirable" and are scored with an open circle.

Figure 2. Norfolk Key Activity Centers

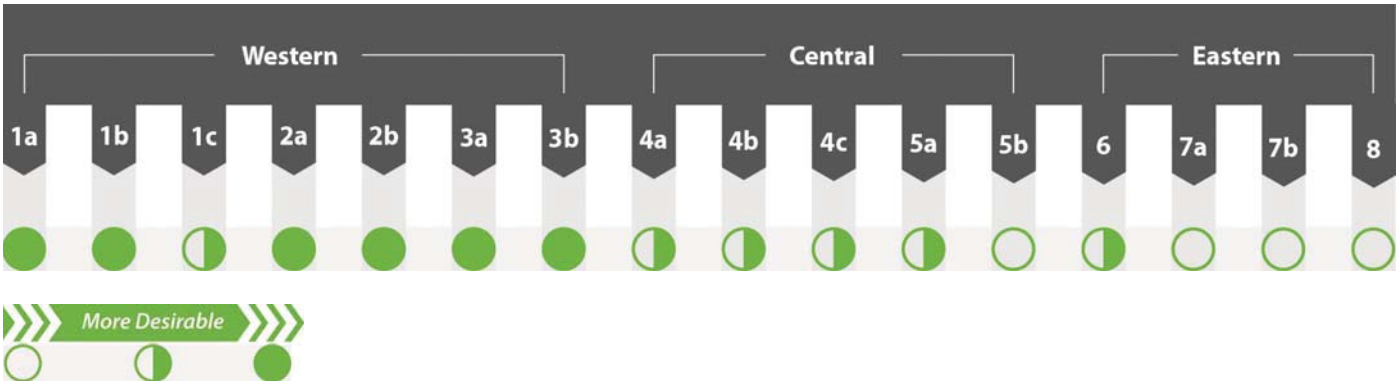
Table 2 shows the number of activity centers within the buffer for each alignment. The names of the activity centers associated with each alignment are shown in **Table A-1** in **Appendix A**.

Table 2. Number of Key Activity Centers within a Half-Mile of Alignments

	Western							Central					Eastern			
Alignment	1a	**1b**	**1c**	**2a**	**2b**	**3a**	**3b**	**4a**	**4b**	**4c**	**5a**	**5b**	**6**	**7a**	**7b**	**8**
# Key Activity Centers	12	12	10	13	13	13	12	10	9	10	9	6	9	7	7	6

Figure 3 shows the summarized results of the evaluation. In general, the western alignments perform better with respect to Criterion 1A. The western alignments typically pass through more activity centers because they are closer to downtown Norfolk, and the public identified more key activity centers in the western portion of Norfolk.

Figure 3. Criterion 1A Evaluation Results



THEME 2: PROVIDE AN ALTERNATIVE TO HEAVY TRAFFIC AND CONGESTION

The movement of people and goods to and from NSN, the region's largest employer, results in congested roadways within Norfolk. The roadways that provide access to NSN, such as I-64 and I-564, are forecasted to experience more congestion in the future. Providing a convenient and attractive transit alternative to driving under highly congested conditions to access NSN would offer the opportunity to increase the potential to attract riders on the system.

Criterion 2A: Reduce Hours of Daily Roadway Congestion

Criterion 2A emphasizes the importance of providing an alternate transit route along a congested corridor. This criterion was evaluated by identifying which alignments travel along congested corridors and have the potential for an attractive transit connection to access NSN.

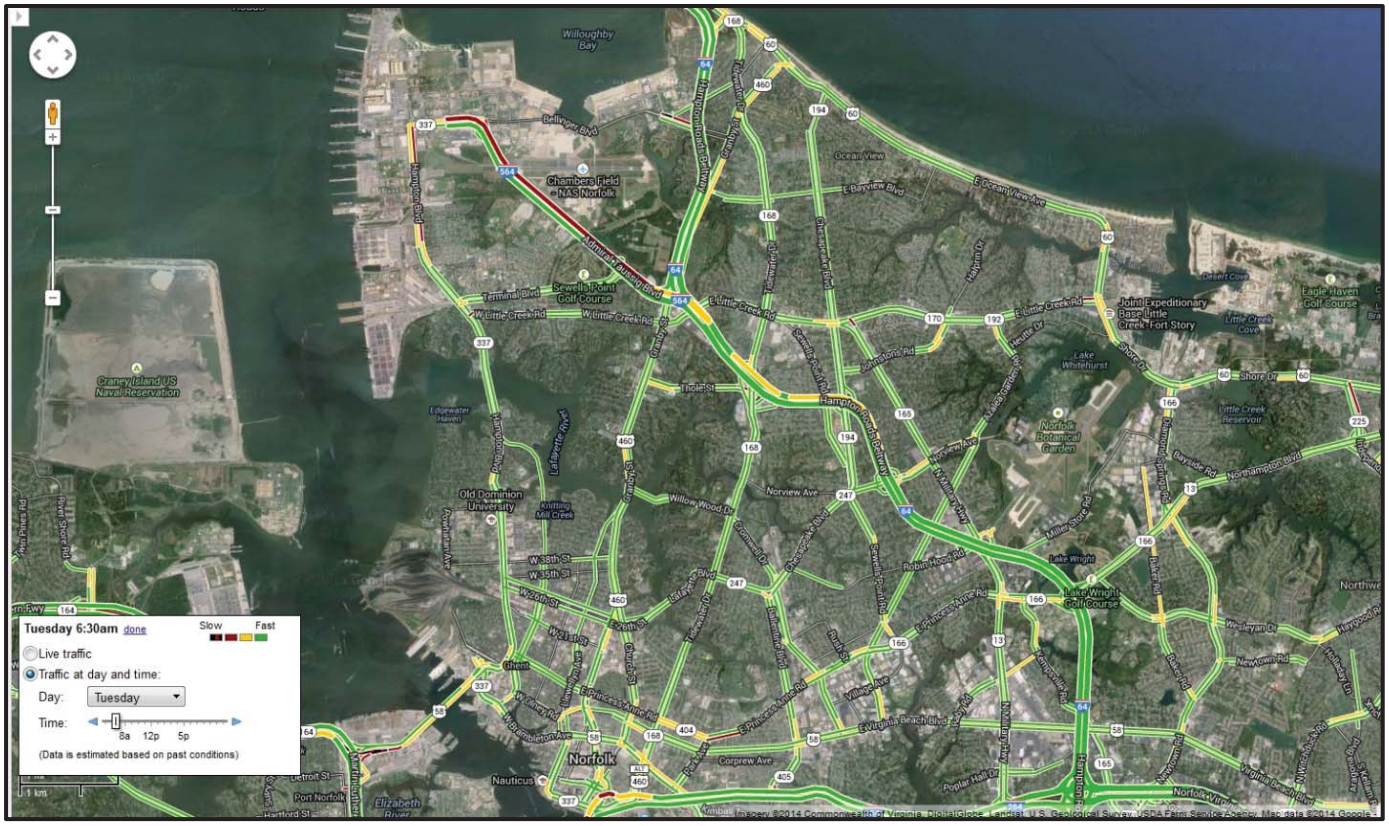
Methodology and Data

Each alignment was analyzed to determine its potential to provide an opportunity for riders to avoid congestion by using the alternative mode if the Tide was extended. This potential was expressed with a "weighted congestion" score. To determine the weighted congestion score, the percentage of the alignment's length that is co-located with different levels of congestion was calculated and weighted such that alignments that are characterized by longer segments functioning with higher levels of congestion were identified as those where transit service is most likely to

succeed in providing an alternative means of travel to and from NSN. For each alignment, a weighted congestion score was calculated separately for the north and south directions and the a.m. and p.m. peak hours.

Google Traffic historical data were used to determine the percent length of each alignment that experienced green, yellow, or red levels of congestion as shown in Google Traffic during the a.m. and p.m. peak hours for the north and south directions. **Figure 4** shows an example of the Google Traffic map.

Figure 4. Google Traffic Map Example of Norfolk, VA



As shown in the equation in **Figure 5**, red segments were considered to be three times as important as green segments in determining a given alignment's potential for congestion reduction. In the equation, Total Length is the one-way length of the alignment (which is shown in **Table 3**), while *G*, *Y*, and *R* represent the length of green, yellow, and red segments in the alignment.

Figure 5. Weighted Congestion Score

$$Weighted\ Congestion\ Score = \frac{[(G * 1) + (Y * 2) + (R * 3)]}{Total\ Length}$$

Table 3. Length of Alignment Option (miles)

	Western							Central					Eastern			
Alignment	1a	**1b**	**1c**	**2a**	**2b**	**3a**	**3b**	**4a**	**4b**	**4c**	**5a**	**5b**	**6**	**7a**	**7b**	**8**
Length	6.25	6.69	6.97	6.75	6.55	7.63	8.51	8.25	9.13	9.45	9.25	9.23	11.74	10.94	11.69	11.38

Once the weighted congestion score was calculated for the north and south directions for the a.m. and p.m. peak hours, the average of the maximum weighted congestion for each peak period was calculated. The alignments were then categorized as "least desirable", "more desirable", and "most desirable" based on whether the average of the maximum weighted congestion score was below the 25th percentile (1.16), above the 75th percentile (1.28), or in between.

Table 4 steps through the process of calculating the weighted congestion and scoring the criterion for Alignment 1a. In **Table 4**, the data used to score the alignment are shown.

Table 4. Criterion 2A Example – Sample Calculation for Alignment 1a

Alignment 1a	Direction	Total Length of Alignment 1a (miles)	G (miles)	Y (miles)	R (miles)	Weighted Congestion Score (from Figure 5)	Maximum Weighted Congestion Score	Average of Maximum Weighted Congestion Scores
AM Peak	North	6.25	5.13	1.00	0.13	1.20	1.20	1.18
	South		5.13	1.13	0.00	1.18		
PM Peak	North		5.69	0.56	0.00	1.09	1.16	
	South		5.25	1.00	0.00	1.16		

The weighted congestion score for Alignment 1a is calculated for the a.m. peak period in the north direction as follows:

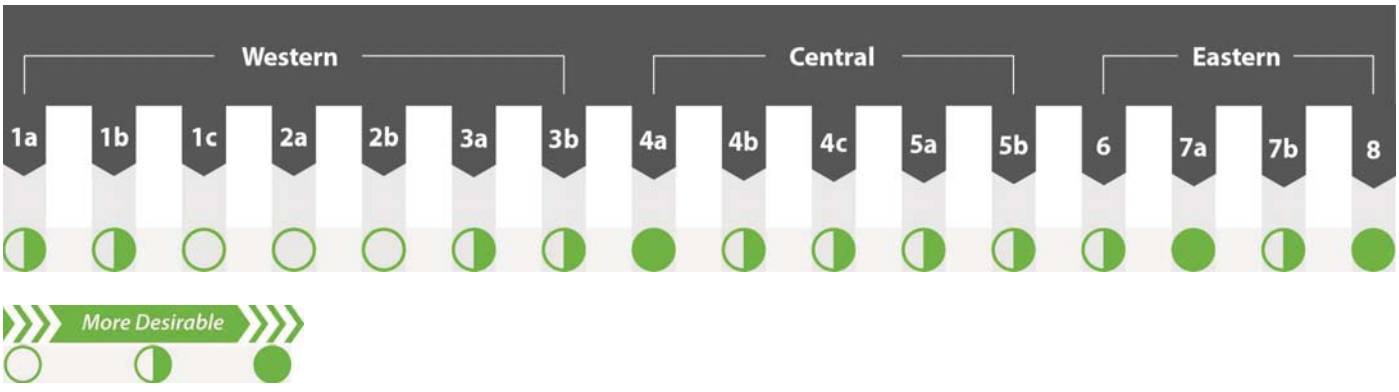
$$\frac{[(5.13 * 1) + (1.00 * 2) + (0.13 * 3)]}{6.25} = \mathbf{1.20}$$

The same calculation was performed for the remaining time periods and directions for Alignment 1a, and the results are shown in **Table 4**. The maximum weighted congestion score for the a.m. peak period was determined to be 1.20 and the p.m. peak maximum congestion score was determined to be 1.16. The average of the maximum weighted congestion score for each peak period was calculated to 1.18. Alignment 1a was categorized as "more desirable" because 1.18 falls in between the 25th and 75th percentiles.

Results

The detailed results of evaluating Criterion 2A are shown in **Appendix A** in **Table A-2**. **Figure 6** shows the summarized results of the evaluation.

Figure 6. Criterion 2A Evaluation Results



In general, the eastern alignments were determined to be "most desirable", the central alignments were determined to be "more desirable", and the western alignments were determined to be "least desirable" in terms of their ability to have a transit alignment reduce congestion in their respective corridors. The eastern alignments travel on an Interstate highway for all of, or a portion of, the route (except for alignment 6), which carry the highest volumes and are the most congested parts of the Norfolk transportation system. The Interstate system is forecasted to be the most congested part of the transportation system in the future. Providing a convenient and attractive transit alternative along or within the corridors served by the Interstates would potentially have the most likelihood to reduce congestion by taking a different mode to NSN.

Criterion 2B: Ability to Attract Riders

Criterion 2B was evaluated for each alignment option by identifying locations where future projected population and future high employment overlap with areas of existing congested transportation facilities (i.e., locations where a future transit option would be desirable).

Methodology and Data

The forecasted population and employment opportunities located within one-half mile of the alignment options were used to evaluate the ability of the transit extension to attract riders, assuming that transit service will be attractive in terms of frequency, travel time, comfort, and other factors. The Hampton Roads Transportation Planning Organization (HRTPO) Transportation Analysis Zone (TAZ) 2034 socioeconomic data were used as the source of the population and employment data. ArcGIS was used to determine the percentage of each TAZ that intersected the half-mile buffer for each of the alignments. This percentage was then used to determine the total number of 2034 residents and jobs that would be within one-half mile of each alignment.

The 25th and 75th percentiles for 2034 employment were 47,800 and 71,400, respectively. Alignments that scored below the 25th percentile were categorized as "least desirable". Alignments that scored between the 25th and 75th percentiles were categorized as "more desirable". Alignments that scored above the 75th percentile were categorized as "most desirable".

The 25th and 75th percentiles for 2034 population were 36,500 and 45,200, respectively. Alignments that scored below the 25th percentile were categorized as "least desirable". Alignments that scored between the 25th and 75th percentiles were categorized as "more desirable". Alignments that scored above the 75th percentile were categorized as "most desirable".

Results

The numerical results of evaluating Criterion 2B are shown in **Table 5**.

Most of the western alignments scored as "least desirable", because those alignments would travel through areas where there would be lower 2034 population and fewer 2034 employment locations relative to other areas in Norfolk. The central alignments traverse areas of high employment, including downtown Norfolk, and score as "most desirable", while the eastern alignments cross through areas of medium employment relative to the other alignments and score as "more desirable".

Table 5. 2034 Forecasted Employment and Population by Alignment

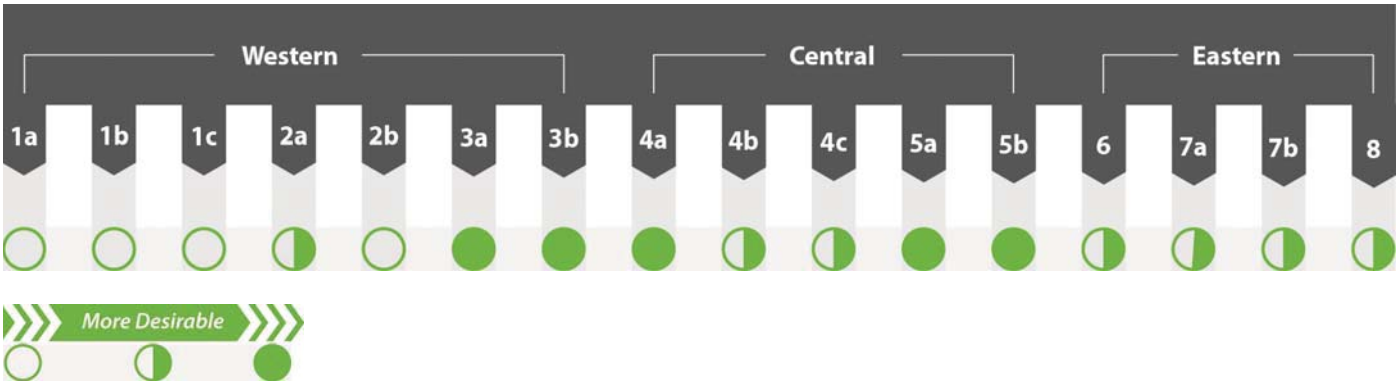
Western			Central			Eastern		
Alignment	EMP	POP	Alignment	EMP	POP	Alignment	EMP	POP
1a	46,100	33,300	4a	77,900	40,400	6	53,600	49,800
1b	46,400	34,200	4b	70,800	40,900	7a	59,400	42,000
1c	38,000	21,300	4c	72,400	43,100	7b	66,900	43,500
2a	48,200	37,000	5a	77,800	45,200	8	63,700	41,700
2b	45,500	35,200	5b	71,100	46,800			
3a	76,100	45,300						
3b	70,800	47,000						

EMP = Year 2034 forecasted employment that would be within a half-mile of the alignment

POP = Year 2034 forecasted population that would be within a half-mile of alignment

Figure 7 shows the summarized results of the evaluation of Criterion 2B.

Figure 7. Criterion 2B Evaluation Results



THEME 3: REDUCE TRAVEL TIME – MAKE TRAVEL TIME MORE RELIABLE BETWEEN DESTINATIONS

Travel time reduction and travel time reliability was identified as one of the key themes. In general, the transit travel time along an alignment should be comparable to and at least as consistent and reliable as the automobile travel time along the same alignment, given the other factors (e.g. potential cost savings, a comfortable ride) in making a transit trip attractive. The two criteria for this theme evaluate each alignment in terms of the level of vehicle travel time reliability and the transit travel time.

Criterion 3A: Opportunity to Increase Travel Time Reliability along a Corridor

Criterion 3A was evaluated using segment lengths and a travel time index (TTI). The TTI is the congested travel time divided by the free-flow travel time and is a measurement of reliability.

Methodology and Data

For this criterion, an HRTPO analysis of INRIX vehicle data as contained in the 2013 *Hampton Roads Regional Travel Time Reliability Study* was used to determine the TTI for each segment of each alignment. Google Earth was used to measure each segment's length. Where an alignment would be able to travel on an exclusive guideway (such as Alignment 1c, which would travel on top of a seawall, or Alignment 7b, which would travel in the median of I-64), the segment was given a TTI of 1.00. A TTI of 1.00 indicates that a segment's congested travel time is equal to it's free-flow travel time (i.e. no congestion exists). From this information, a weighted segment TTI was calculated using **Figure 8.**

Figure 8. Weighted TTI Segment

$$Weighted\ TTI\ Segment = TTI * SegmentLength$$

Figure 9 was used to determine the TTI of the overall alignment. The TTI of the alignment is essentially a weighted average of the individual segment TTIs.

Figure 9. Weighted TTI Alignment

$$TTI\ Alignment = \frac{\sum Weighted\ TTI\ Segment}{Length\ of\ Alignment}$$

Table 6 illustrates the use of the equations in **Figure 8** and **Figure 9**. For each roadway segment in Alignment 1a, a TTI and a weighted segment TTI are provided for the northbound and southbound direction for both the a.m. and p.m. peak periods, as shown in **Table 6**. Using the data in **Table 6**, the maximum weighted alignment TTI for the a.m. peak period (1.27) was averaged with the maximum weighted alignment TTI for the p.m. peak period (1.22), which resulted in a Criterion 3A score of 1.24.

The alignments were then categorized as "least desirable", "more desirable", and "most desirable" based on whether the Criterion 3A score was below the 25th percentile (1.22), above the 75th percentile (1.26) or in between. Alignment 1a is labeled as "more desirable" because 1.24 falls in between the 25th and 75th percentiles.

Results

Table 7 shows the results of the calculation of weighted alignment TTIs. **Table A-3** in **Appendix A** shows the detailed calculations of weighted TTI for each alignment.

Table 6. Alignment 1a WTTI Calculation

Alignment 1a		Length (ft)	Segment TTI				Weighted Segment TTI			
			AM Peak		PM Peak		AM Peak		PM Peak	
Segment From	Segment To		NB	SB	NB	SB	NB	SB	NB	SB
Brambleton Ave	Olney Rd	1,096	1.38	1.17	1.25	1.37	1,513	1,283	1,370	1,502
Olney Rd	Princess Anne Rd	2,061	1.38	1.17	1.25	1.37	2,845	2,412	2,577	2,824
Hampton Blvd	Colley Ave	454	1.22	1.04	1.11	1.00	554	472	504	441
Princess Anne Rd	21st St	2,537	1.20	1.25	1.24	1.85	3,045	3,171	3,146	4,694
21st St	26th St	1,151	1.18	1.20	1.19	1.36	1,358	1,381	1,370	1,565
26th St	27th St	304	1.18	1.20	1.19	1.36	359	365	362	414
27th St	38th St	917	1.28	1.18	1.21	1.22	1,173	1,082	1,109	1,118
38th St	Jamestown Crescent	6,763	1.28	1.18	1.21	1.22	8,657	7,981	8,184	8,251
Jamestown Crescent	Little Creek Rd	6,673	1.23	1.12	1.22	1.12	8,208	7,474	8,141	7,474
Little Creek Rd	International Terminal Blvd	966	1.23	1.12	1.22	1.12	1,189	1,082	1,179	1,082
International Terminal Blvd	Intermodal Connector	6,074	1.30	1.09	1.21	1.07	7,896	6,620	7,349	6,499
Intermodal Connector	Admiral Taussig Blvd	4,109	1.30	1.09	1.21	1.07	5,342	4,479	4,972	4,397
	Sum	**33,105**					**42,139**	**37,802**	**40,263**	**40,261**
	Weighted Alignment TTI						**1.27**	**1.14**	**1.22**	**1.22**

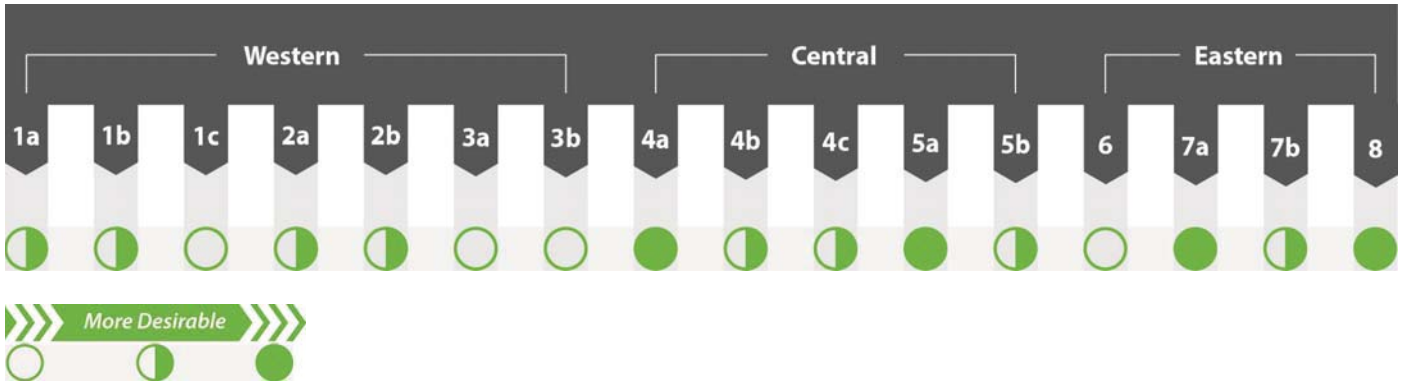
Table 7. Weighted Travel Time Index (WTTI) by Alignment

	Western							Central					Eastern			
Alignment	1a	1b	1c	2a	2b	3a	3b	4a	4b	4c	5a	5b	6	7a	7b	8
WTTI	1.24	1.22	1.11	1.24	1.22	1.21	1.21	1.30	1.23	1.23	1.29	1.25	1.17	1.26	1.26	1.30

WTTI = Weighted TTI (averages AM and PM peak) across all segments in the alignment.

Figure 10 shows the results of the evaluation of Criterion 3A. Alignments 4a, 5a, 7a, and 8 that would parallel heavily segments of congested I-64 or I-564 would have the best opportunity to attract riders by providing an alternative to the least reliable travel routes in Norfolk. Several of the western alignments (1c, 3a, and 3b) would parallel north-south routes that run from downtown Norfolk to NSN that are less congested over their total length when compared with routes that would parallel I-64 or I-564.

Figure 10. Criterion 3A Evaluation Results



Criterion 3B: Directness of Route

Criterion 3B was assessed by analyzing the estimated transit trip travel time from the Newtown Road Tide light rail station to the end of each alignment, then dividing by the total length of the route to normalize the results by distance. The resulting ratio (time divided by distance, where time in measured in minutes and distance in miles) is known as "tardity" and is the inverse of speed[1]. The distance between rider destinations and the speed at which riders can travel by transit are factors in transit travel time.

Methodology and Data

The tardity for each alignment was calculated by taking the following information about each alignment into account: the length of the route from the Newtown Road Tide light rail station, an assumed speed that accounts for stops and dwell times (15 mph for travel in a shared corridor such as an arterial and 30 mph for travel in exclusive right-of-way with no signals or cross traffic), the proportion of the route running on arterials versus Interstates, and the travel time from the Newtown Road light rail station to the transfer Tide light rail station. ArcGIS was used to calculate the length of route for each alignment (shown previously in **Table 3**) while Google Maps was used to identify the proportion of each alignment that is classified as shared-use versus exclusive right-of-way.

Travel time along each alignment was calculated by determining the length of the alignment in shared-use and the length of the alignment in exclusive right-of-way, dividing those lengths by the corresponding assumed average speed, and summing the results. The travel time was divided by the total length of the route to determine the tardity. The formula for this calculation is shown in **Figure 11**.

Figure 11. Travel Time Calculation for Criterion 3B

$$\text{Tardity} = \left[\frac{\left(\frac{\text{Length of Shared Facility}}{15\,\text{mph}} \right) + \left(\frac{\text{Length of Exclusive Facility}}{30\,\text{mph}} \right)}{\text{Length of Route}} \right]$$

The alignments were then categorized based on whether the total value of tardity was below the 25th percentile value of 3.19 or above the 75th percentile value of 3.74. For Criterion 3B, a lower number (below the 25th percentile) indicates a more direct route because for a given travel time, a longer route length (the denominator) decreases the value of tardity. Therefore, values below the 25th percentile of 3.19 are considered "most desirable", above the 75th percentile of 3.74 ("least desirable"), or in between ("more desirable").

[1] http://fhwainter.fhwa.dot.gov/publications/research/operations/tft/chap2.pdf (see page 2-1)

Results

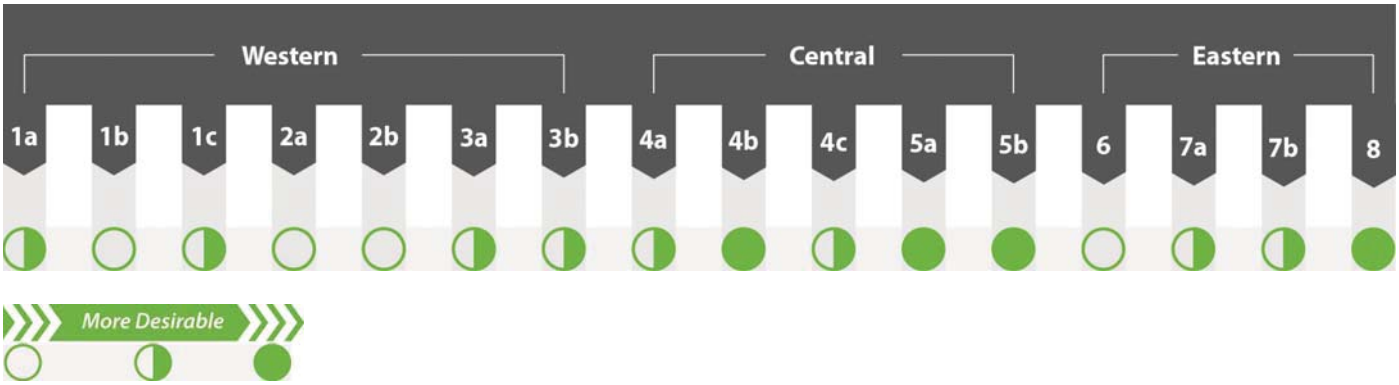
Table A-4 in **Appendix A** shows the detailed calculations for the Criterion 3B evaluation. **Table 8** shows the tardities calculated for each alignment.

Table 8. Alignment Tardities

	Western							Central					Eastern			
Alignment	1a	**1b**	**1c**	**2a**	**2b**	**3a**	**3b**	**4a**	**4b**	**4c**	**5a**	**5b**	**6**	**7a**	**7b**	**8**
Tardity	3.73	3.74	3.50	3.75	3.74	3.67	3.41	3.29	3.04	3.21	3.12	2.83	3.84	3.30	3.45	2.28

Alignment 8 would perform the best out of all the alignments based on the high percentage of the alignment that would travel on exclusive guideway and the alignment's terminus at the Newtown Road Tide light rail station. Several alignments in the central corridor are among the "most desirable" because of their routing along I-564, their length relative to other alignments, and their distance from the Newtown Road Tide light rail station. The western alignments, generally the shortest in length, travel in shared right-of way and are a long way from the Newtown Road Tide light rail station. The western alignments tend to be shorter and more direct routes than the central or eastern alignments, resulting in a shorter total travel time. In general, Alignment 8 is longer than the western alignments but has a relatively similar total travel time because it is along an interstate. **Figure 12** shows the summarized results of the evaluation of Criterion 3B.

Figure 12. Criterion 3B Evaluation Results



THEME 4: PARKING – PROVIDE PARKING TO ACCOMMODATE RIDERS

Another theme identified was the ability to provide parking to accommodate commuters and transit riders that are out of the transit influence area, the area within walking and biking distance to the transit service. Park & Ride locations can increase connectivity between rail stations and surrounding locations and can bridge two forms of transportation.

Criterion 4A: Potential Park & Ride Shed

Criterion 4A was identified by forecasting the potential use of Park & Ride facilities in locations where potential riders would be able to park by counting existing and future Park & Ride locations.

Methodology and Data

ArcGIS was used to create a 500-foot buffer of each alignment and count the number of proposed and existing Park & Ride facilities (currently used for both bus and Tide light rail service) that fell within the buffer. A 500-foot buffer was used for this analysis because this distance provides a reasonable distance for commuters to walk to the transit station from the Park & Ride facility. The Virginia Department of Transportation (VDOT) provided information regarding proposed and existing Park & Ride facilities within the study area, which assumes no new Park & Ride lots developed to serve the future transit extension that is being analyzed as part of this study. The seven Park & Ride facilities used in the evaluation are shown in **Figure 13** and listed in **Table 9**.

Table 9. Park & Ride Facilities within the Study Area

Lot Name	Nearest Intersection
EVMC/Ft. Norfolk LRT Station	W. Brambleton Avenue & Colley Avenue
Harbor Park LRT Station	Park Avenue & Holt Street
Ballentine/Broad Creek LRT Station	Ballentine Boulevard & Interstate 264
Military Highway LRT Station	Curlew Drive & Corporate Boulevard
Newtown Road LRT Station	Newtown Road & Kempsville Road
New Proposed Lot	E. Virginia Beach Blvd & N. Military Hwy
New Proposed Lot	Terminal Boulevard & Hampton Boulevard

The 25th and 75th percentiles associated with the number of Park & Ride facilities with 500 feet of the alignments were 0 and 2, respectively. Alignments characterized as “least desirable” had no Park & Ride facilities within 500 feet while “more desirable” alignments had one or two Park & Ride facilities within 500 feet. Alignments with three or more Park & Ride facilities within 500 feet were characterized as “most desirable”.

Results

Table 10 shows the results of the Criterion 4A evaluation. According to this table, the central alignments are “least desirable” for Park & Ride opportunities while the western alignments are “more desirable”. The western part of Norfolk is more developed and, therefore, the parking would potentially be more accessible.

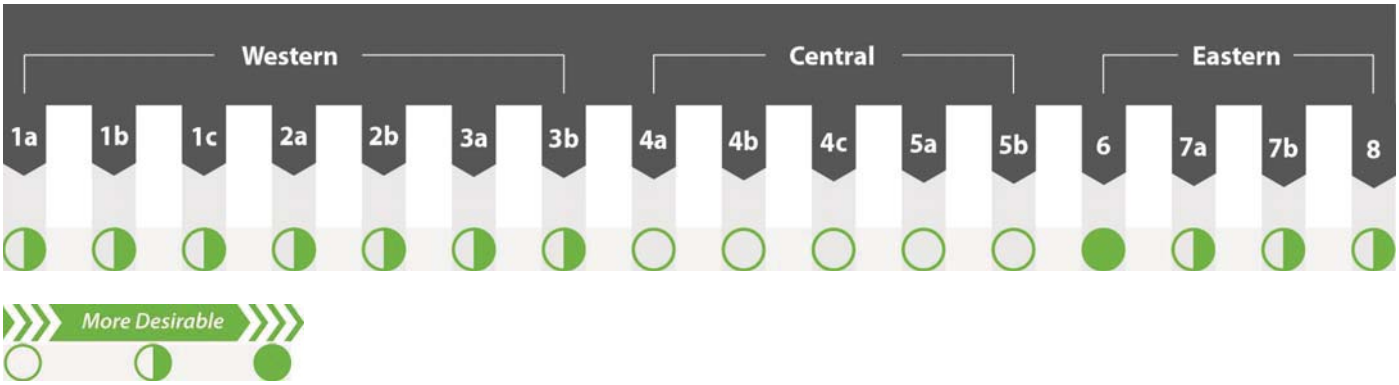
Figure 13. Park & Ride Facilities

Table 10. Number of Park & Ride Facilities within 500 feet of Alignments

	Western							Central					Eastern			
Alignment	1a	**1b**	**1c**	**2a**	**2b**	**3a**	**3b**	**4a**	**4b**	**4c**	**5a**	**5b**	**6**	**7a**	**7b**	**8**
# Park & Ride Lots	**2**	2	2	1	1	1	1	0	0	0	0	0	3	2	2	1

Figure 14 shows the summarized results of the evaluation of Criterion 4A.

Figure 14. Criterion 4A Evaluation Results



THEME 5: INTERCONNECTIVITY OF TRANSIT MODES

Connectivity between the new transit service and the existing system will benefit users. The ease with which users of the system can transfer from one transit mode to another can help create a more efficient overall system.

Criterion 5A: Ability to Connect to Other Transit Services in Norfolk

Criterion 5A was evaluated by determining how many existing bus routes would cross each alignment.

Methodology and Data

There are 21 bus routes within the City of Norfolk. The ability to connect the new transit service to other transit services in the area was measured by counting the number of bus routes that would cross each alignment using a map of the bus routes overlaid on a map of the 16 alignments for visual inspection.

The 25th and 75th percentiles associated with the number of bus routes crossing each alignment were three and 13, respectively. The “least desirable” alignments were crossed by three or fewer bus routes. The “more desirable” alignments were crossed by between four and 13 bus routes. The “most desirable” alignments were crossed by more than 13 bus routes. A map with the bus routes in Norfolk is shown in **Figure 15**.

Results

The number of bus routes that cross each alignment is shown in **Table 11**. In general, the western alignments would be crossed by the fewest number of bus routes while the central alignments would cross the most bus routes, primarily because those alignments would interconnect with downtown Norfolk. The eastern alignments would cross several bus routes in the eastern half of Norfolk that operate along the primary arterials, on I-64, and connect to Virginia Beach.

Figure 15. Current Bus Routes in Norfolk

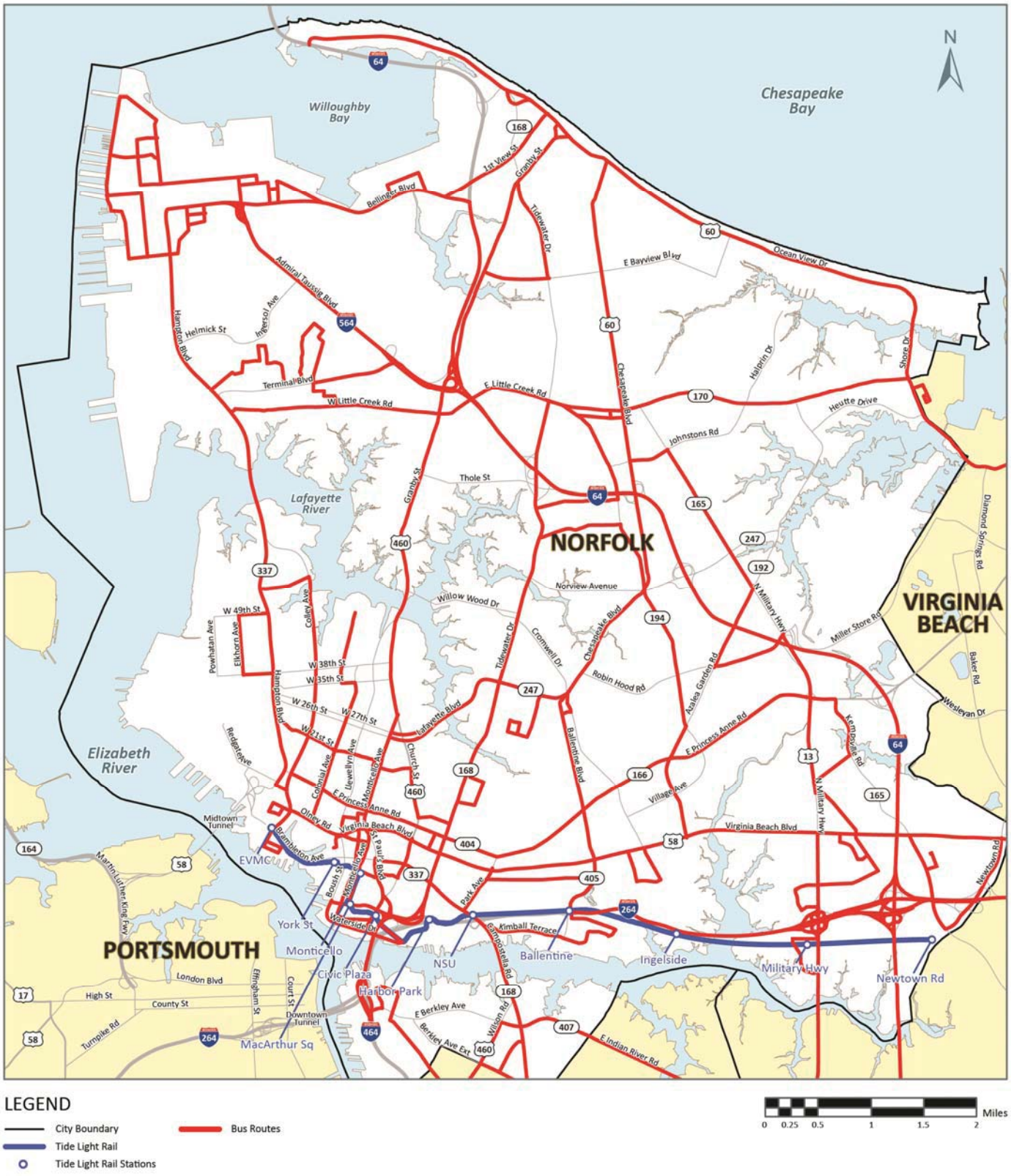
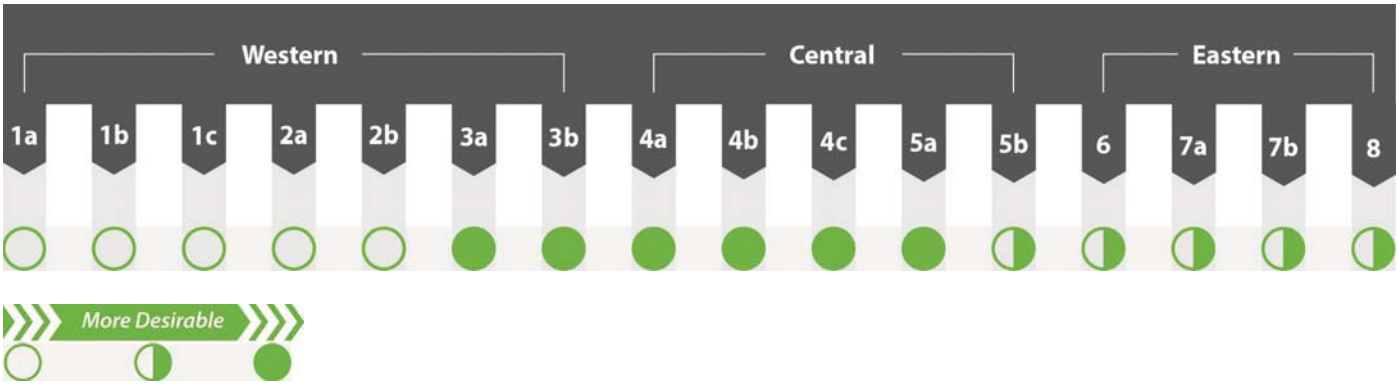


Table 11. Number of Bus Routes Crossing Each Alignment

	Western							Central					Eastern			
Alignment	1a	1b	1c	2a	2b	3a	3b	4a	4b	4c	5a	5b	6	7a	7b	8
# of Bus Routes	3	3	2	3	3	14	14	13	13	13	15	10	10	10	10	7

Figure 16 shows the summarized results of the evaluation of Criterion 5A.

Figure 16. Criterion 5A Evaluation Results



THEME 6: FUTURE EXPANSION – ENSURE THAT THE SYSTEM CAN BE EXPANDED IN THE FUTURE

Future transportation projects from HRTPO, the City of Norfolk, HRT, and others that provide regional mobility were examined in relation to each alignment to determine the extent to which those future projects would complement and help leverage the potential investment in the NSNTES project.

Criterion 6A: Ability to Leverage Other Planned Regional Transportation System Projects

Criterion 6A was primarily evaluated by using the list of Norfolk projects in the Hampton Roads Transportation Project Priorities list[2] published by HRTPO in 2013.

Methodology and Data

A list of regionally and locally significant transportation projects that are components of HRTPO's funded and unfunded priorities lists were identified and evaluated for Criterion 6A. The full lists of projects were culled to retain only those that are within or adjacent to Norfolk. The projects that are within or adjacent to Norfolk are shown as a list in **Table 12** and on a map in **Figure 18**.

Each project in **Table 12** was assumed to have either a positive or neutral impact on an alignment based on the project's proximity to the alignment, its potential to enhance ridership, the provision of a new multimodal

[2] http://www.hrtpo.org/uploads/docs/Projects_Handout_Final_updated_3.25.13_v3.pdf

connection to the alignment, and the potential to improve access to a potential station location along the alignment. The number of regionally and locally significant transportation projects that could potentially have a positive impact on an alignment was then counted.

Table 12. List of Locally and Regionally Significant Projects for Norfolk

Project Category	Hampton Roads TPO Significant Transportation Projects for Norfolk
2034 LRTP Regionally Funded Construction Projects	Downtown Tunnel/Midtown Tunnel/MLK Extension (Hampton Blvd to I-264)
	Military Hwy at Northampton Blvd Continuous Flow Interchange
Unfunded Projects for Future Consideration	I-64/I-264 Interchange (including the Witchduck Interchange)
2034 Vision Plan—Unfunded Highway Projects	Virginia Beach Boulevard from Glenrock Road to Newtown Road
	Brambleton Avenue from the Midtown Tunnel to I-264
	Hampton Boulevard from W. 21st Street to W. 38th Street
	Little Creek Road from Tidewater Drive to Shore Drive
	Newtown Road from Virginia Beach Boulevard to Curlew Drive
2034 Vision Plan—Unfunded Highway Interchange Projects	I-264 Eastbound Ramp from I-64 Westbound from Curlew Drive to Witchduck Road
	Air Terminal Interchange
	I-64 at Military Hwy from Military Highway Northbound to I-64 Eastbound
2034 Vision Plan—Unfunded Bridge & Tunnel Projects	Patriots Crossing from I-564 to I-664 and VA-164
	HRBT/I-64 (8-lane) from the I-64 / I-664 Coliseum Junction to the I-64 / I-564 Junction
2034 Vision Plan—Unfunded Intermodal Projects	Hampton Blvd (Route 337) Interchange - International Terminal Blvd Gate Improvement from Trouville Avenue/Portor Street to Hampton Boulevard

Results

Table 13 shows the number of planned projects that might have a positive impact on each alignment. The eastern alignments scored most desirable because of their proximity to Virginia Beach and the potential to expand transit to the east.

Table 13. Number of Significant Projects within 500 Feet of each Alignment

	Western							Central					Eastern			
Alignment	1a	**1b**	**1c**	**2a**	**2b**	**3a**	**3b**	**4a**	**4b**	**4c**	**5a**	**5b**	**6**	**7a**	**7b**	**8**
# of Significant Projects	6	6	6	5	5	2	2	1	1	1	1	1	9	8	8	7

Figure 17 shows the summarized results of the evaluation of Criterion 6A.

Figure 17. Criterion 6A Evaluation Results

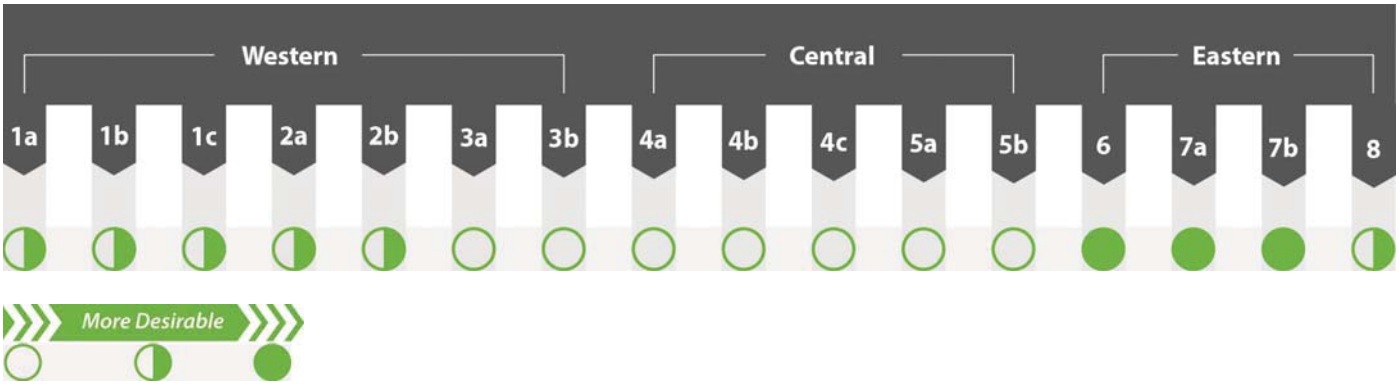
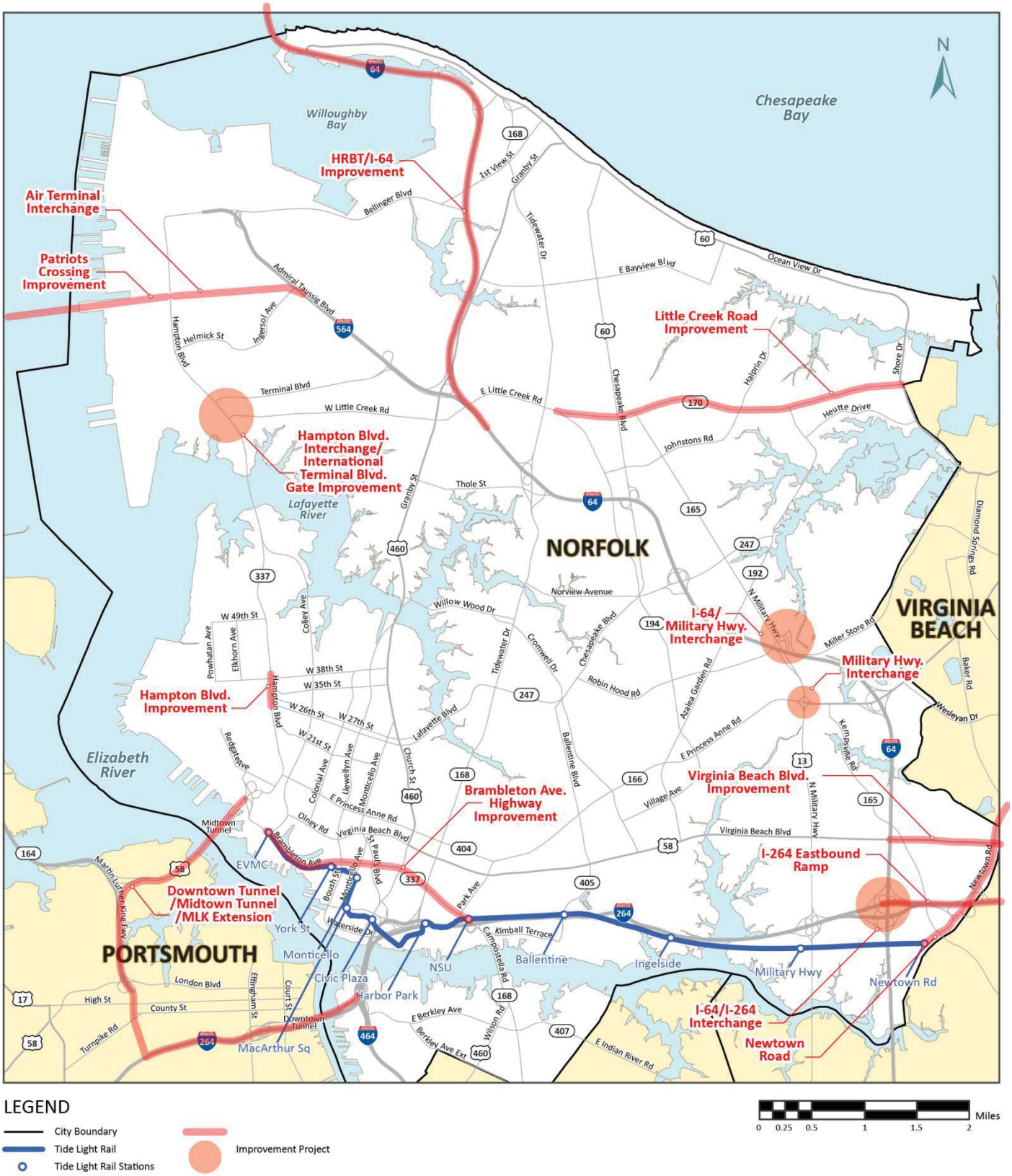


Figure 18. Map of Locally and Regionally Planned Significant Transportation Projects



7: ADDITIONAL EVALUATION FACTORS

In addition to the six themes and criteria, there are several additional factors that were included in the analysis and compared across alignments. While these factors were not specifically mentioned in the public meetings, they were included in the analysis because they are important factors that are typically evaluated in NEPA documents. The additional factors consist of the following: environmental considerations, right-of-way constraints and project cost, economic development and neighborhood revitalization, and resiliency.

Criterion 7A: Environmental Considerations

Criterion 7A includes the evaluation of the number of 4(f) sites (parks, known historic properties, and historic districts) and wetlands within 500 feet of the alignments.

Methodology and Data

ArcGIS-based mapping was used to determine how many 4(f) sites (parks, historic properties, and historic districts) and wetlands fall within a 500-foot buffer of each alignment. Wetlands were impacted by all of the alignments. **Figure 19**, **Figure 20**, **Figure 21**, and **Figure 22** show the parks, historic buildings, historic districts, and wetlands, respectively, within the study area.

Results

The eastern alignments scored most desirable while the western alignments scored more desirable. **Table 14** shows the numerical results of the ArcGIS analysis while **Figure 23** shows the scores for each alignment.

All alignments intersect wetlands on NSN property classified as Freshwater/Forested Shrub Wetland and/or Freshwater Emergent Wetland. The western alignments crossing the Lafayette River also intersect wetlands classified as Estuarine Marine. Additional scoring was attributed to alignments that intersect wetlands classified as Freshwater Emergent, which are prone to temporary and seasonal flooding. A uniform value of one was applied to these alignments, though this value does not reflect the quantity of freshwater emergent wetlands along a respective alignment. Rather, the additional scoring denotes that certain alignments pass through more environmentally sensitive areas where wetlands prone to flooding are present.

Table 14. Environmental Impacts by Alignment

Alignment	Western							Central					Eastern			
Environmental Feature	1a	1b	1c	2a	2b	3a	3b	4a	4b	4c	5a	5b	6	7a	7b	8
Parks	14	15	4	14	14	13	14	5	5	5	6	6	9	4	5	7
Historic Buildings	0	0	0	2	2	3	4	2	4	4	2	3	0	0	0	0
Historic Districts	2	2	0	3	3	4	4	4	3	3	4	2	0	0	0	0
Wetlands	1	1	1	1	1	1	1	2	2	2	2	2	1	2	2	2
Total	17	18	5	20	20	21	23	13	14	14	14	13	10	6	7	9

*All alignments intersect wetlands on NSN property classified as Freshwater/Forested Shrub Wetland and/or Freshwater Emergent Wetland. The western alignments crossing the Lafayette River also intersect wetlands classified as Estuarine Marine. Additional scoring was attributed to alignments that intersect wetlands classified as Freshwater Emergent, which are prone to temporary and seasonal flooding.

Figure 19. Parks

Figure 20. Historic Buildings

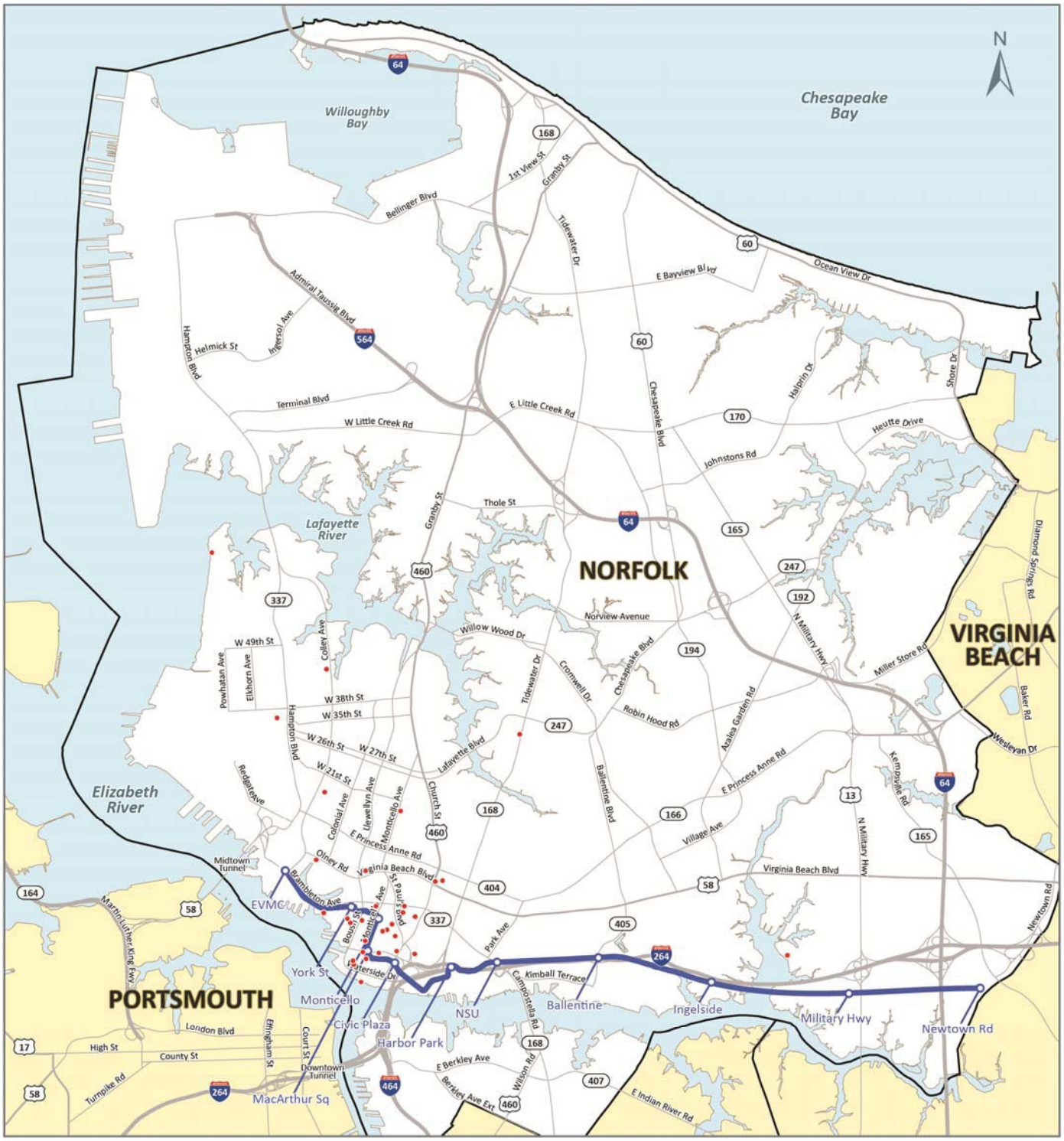


Figure 21. Historic Districts

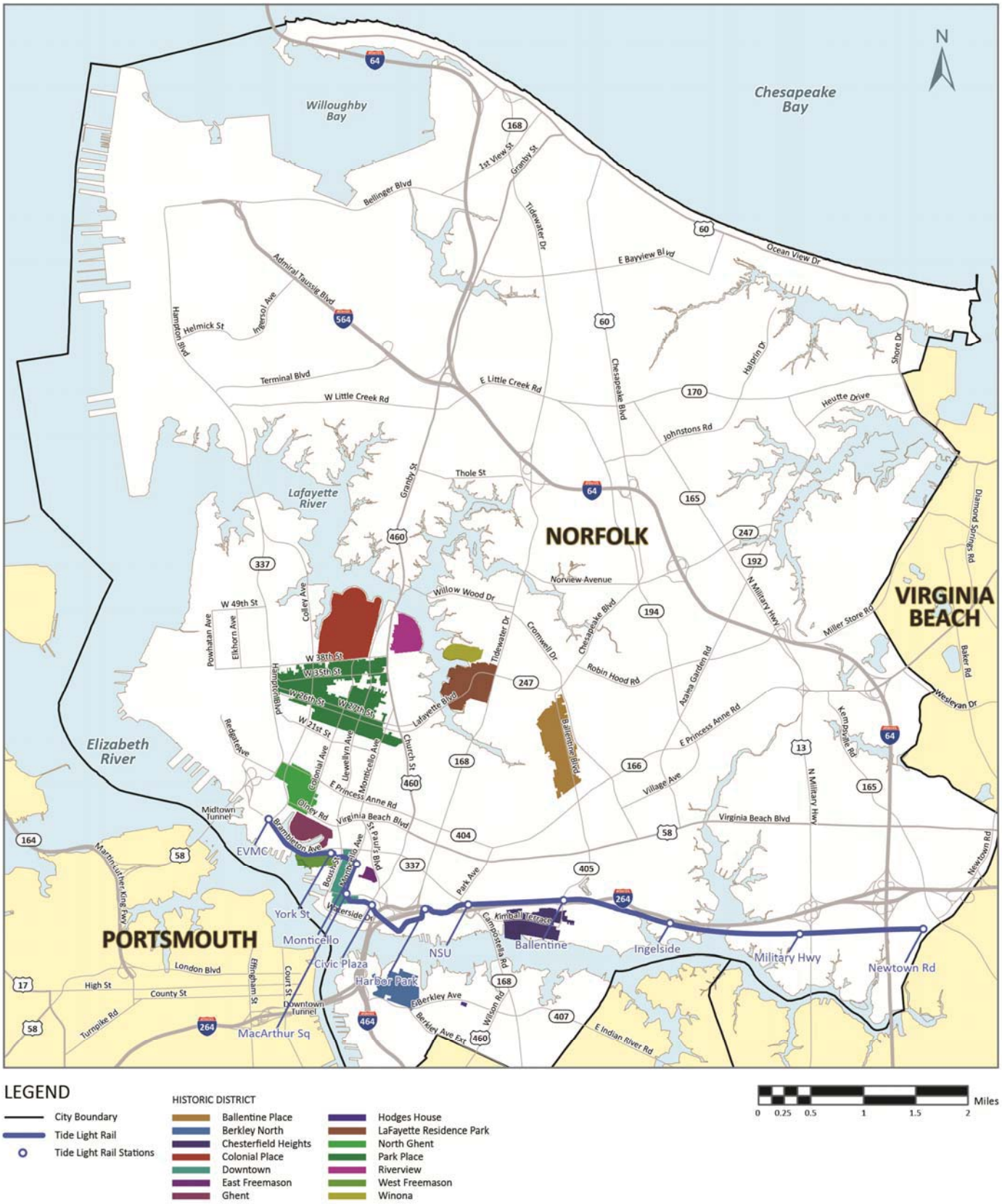


Figure 22. Wetlands

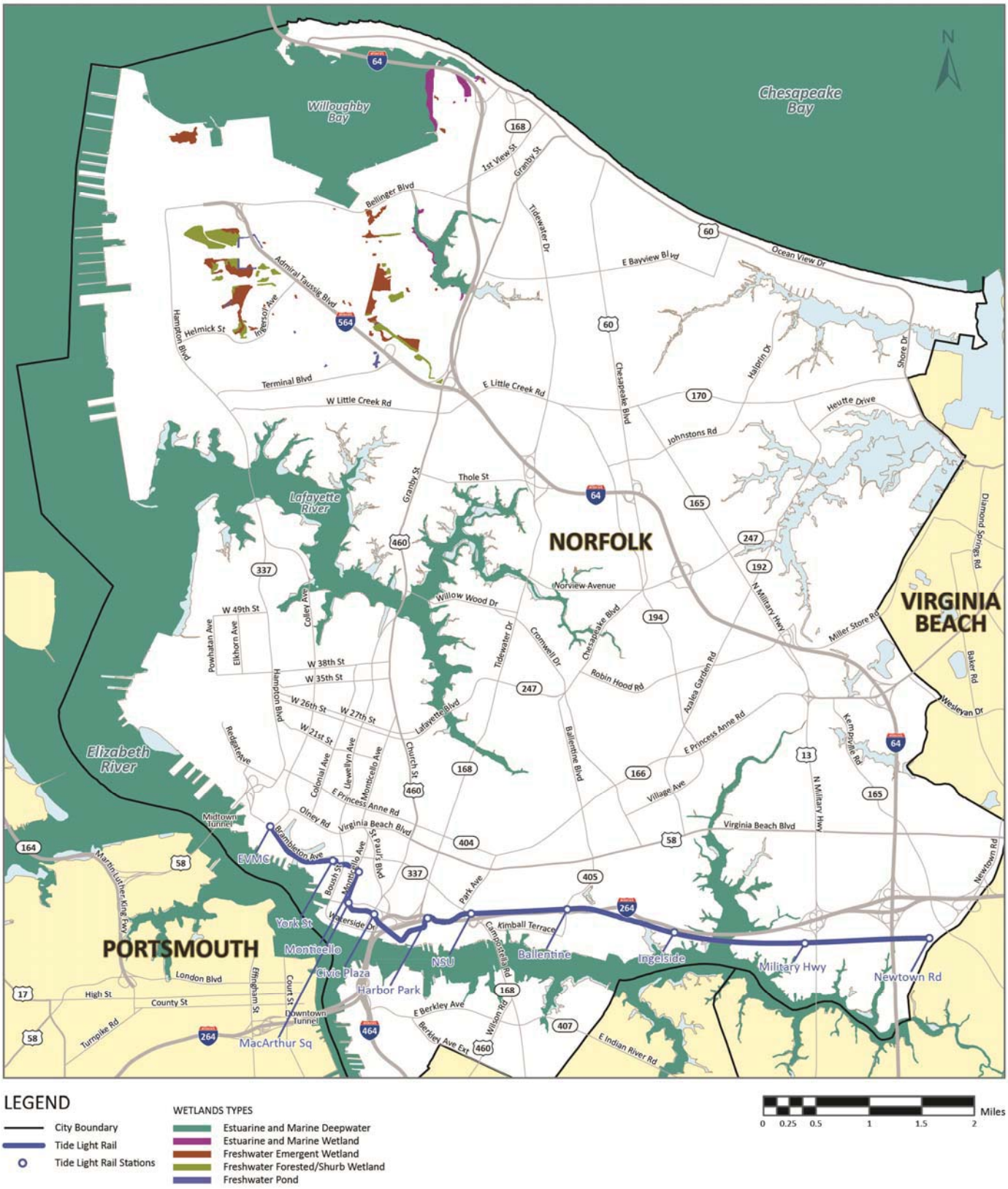
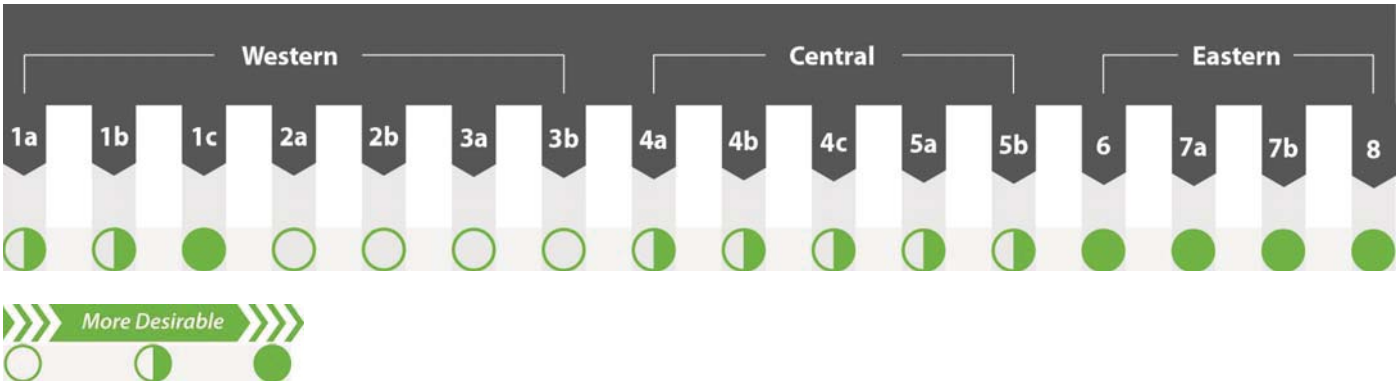


Figure 23. Criterion 7A Evaluation Results



Criterion 7B: Right-of-Way Constraints and Project Cost

Criterion 7B takes into account the constructability of the alignment (including procurement considerations) and the conceptual cost of the alignment (including capital and operating costs).

Methodology and Data

Unit costs per linear foot (LF) were derived using selected projects from the Federal Transit Administration (FTA) Capital Cost Database that are comparable to the Interstate-running sections and arterial-running sections under consideration in Norfolk. The Tasman West (Santa Clara Valley Transportation Authority, California) and Interstate MAX (Portland, Oregon) projects were chosen to represent the street-running LRT projects, and the Mission Valley East project in San Diego, California was chosen to represent LRT projects along an Interstate highway because those projects are representative of typical costs associated with street-running and Interstate highway segments. Elements in Standard Cost Categories 10 (Guideway, Track), 40 (Sitework), 50 (Systems), 60 (Right-of-Way), and 80 (Professional Services, 35 percent of the total of categories 10-50) were used as these elements are more generically applied; elements in the other cost categories can be more project- and/or location-specific. The unit costs from the FTA database were escalated to the year 2014, and the sum of the unit costs for each Standard Cost Category (10, 40, 50, 60, and 80) makes up the total unit cost. Using the FTA Capital Cost Database, the unit costs of $12,050/linear foot (LF) for street-running track (shared facilities) and $16,335/LF for track along an Interstate (exclusive facilities) were calculated.

The length of each alignment on arterials and Interstates was multiplied by the derived cost per linear foot for each roadway type. The seawall in Alignment 1c (a 1.2-mile segment) was estimated to cost $250,000 per foot of roadway in addition to the rest of the cost of the alignment.

The 25th and 75th percentiles for costs were $471 million and $753 million, respectively. Alignments that scored below the 25th percentile were categorized as “most desirable“. Alignments that scored between the 25th and 75th percentiles were categorized as “more desirable“. Alignments that scored above the 75th percentile were categorized as “least desirable“.

Results

The numerical results for Criterion 7B are shown in Table 5**.** Most of the western alignments scored as “most desirable“, because those alignments would be generally shorter than other alignments and travel on shared-

facilities. The exception for the western corridor is alignment 1c, which would be the most expensive option because of the need to construct a 1.2-mile long seawall. The central alignments score as "more desirable", while the eastern alignments score as "least desirable" because they generally are the longest and would travel on I-64 or I-564 for some of their length (except for alignment 6).

Figure 24 shows the summarized results of the evaluation of Criterion 7B.

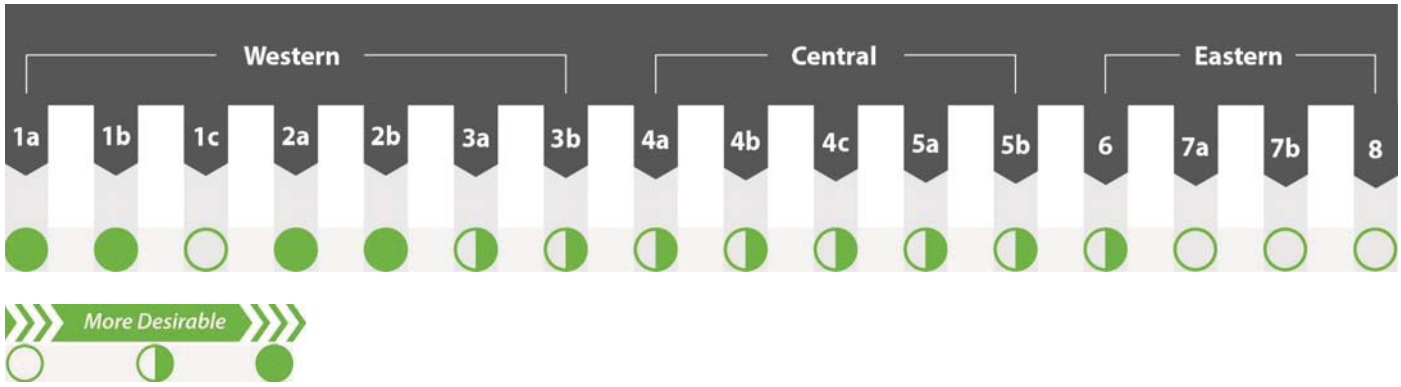
Table A-5 in **Appendix A** shows the detailed calculations for the Criterion 7B evaluation as well as the backup data for the cost calculations, which are broken out by Standard Cost Category; costs for stations, vehicles, or storage/maintenance facilities that would be needed are not included.

Table 15. Estimated Alignment Costs

	Western							Central					Eastern			
Alignment	**1a**	**1b**	**1c**	**2a**	**2b**	**3a**	**3b**	**4a**	**4b**	**4c**	**5a**	**5b**	**6**	**7a**	**7b**	**8**
Cost ($ Millions)	$398	$426	$2,068	$429	$417	$485	$541	$588	$647	$642	$690	$689	$747	$769	$817	$945

Each alignment's desirability, summarized in **Figure 24**, was found to be related to the length of the routes. That is, the shorter routes were most desirable with respect to cost and the longer routes were least desirable with respect to cost. This finding is independent of whether or not an alignment is on an arterial or an Interstate.

Figure 24. Criterion 7B Evaluation Results



Criterion 7C: Economic Development and Neighborhood Revitalization

Criterion 7C consists of two factors to consider for future land use planning. In general, the potential for economic development in the future is higher for alignments that travel through or near commercial/institutional areas.

Methodology and Data

City of Norfolk GIS provided the land uses, mix of residential/commercial/institutional, and densities that were used to evaluate Criterion 7C. The extent that the alignment could be incorporated with the existing neighborhood plans and the agreement with existing neighborhood plan actions were taken into account. ArcGIS was used to determine the type and amount of future land use (residential/commercial/institutional) within 500 feet of the alignments. The land uses used in this assessment are from plaNorfolk2030 and existing neighborhood plans. The results of the land use analysis are shown in **Table 16,** the results of existing neighborhood plan actions agreement are shown in **Table 17** and the final scoring is shown in **Figure 25**.

Results

Table 16. Future Land Use - plaNorfolk2030

Residential			Commercial		Military		Institutional	
Alignment	% Total	% Med/High Density	Alignment	% Total	Alignment	% Total	Alignment	% Total
1b	54%	23%	7b	45%	4a	22%	7b	8%
6	54%	20%	7a	40%	7a	21%	4b	8%
1a	52%	23%	2b	29%	8	21%	4c	8%
2b	49%	21%	2a	28%	4c	21%	8	7%
2a	47%	21%	6	27%	5b	20%	1c	7%
3b	47%	13%	3a	25%	4b	19%	3b	5%
5b	46%	8%	3b	24%	7b	19%	4a	5%
4b	38%	19%	1a	20%	5a	18%	1a	4%
4c	38%	21%	1b	20%	1c	14%	1b	4%
5a	36%	10%	4a	19%	1a	7%	2a	4%
3a	34%	14%	4b	17%	1b	6%	2b	4%
8	30%	9%	4c	16%	2a	6%	7a	4%
4a	24%	14%	5b	12%	2b	6%	5b	3%
7a	23%	11%	5a	11%	3a	5%	6	3%
7b	18%	8%	8	10%	6	5%	3a	2%
1c	12%	4%	1c	4%	3b	5%	5a	2%

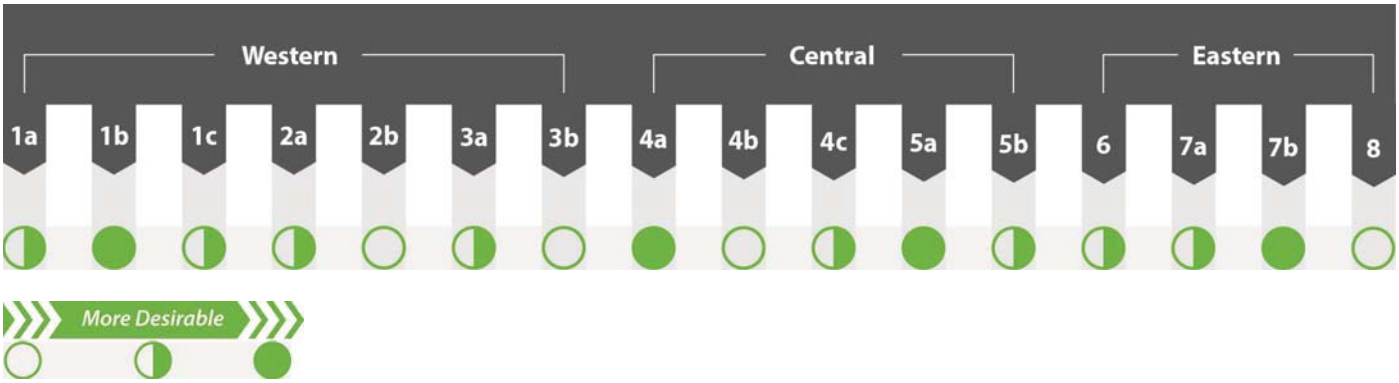
Table 17. Agreement with Existing Neighborhood Plans

	Alignments																
Plan Areas	**1a**	**1b**	**1c**	**2a**	**2b**	**3a**	**3b**	**4a**	**4b**	**4c**	**5a**	**5b**	**6**	**7a**	**7b**	**8**	**Total**
Central Hampton Boulevard Area	X	X	X	X	X	X	X										7
Downtown Area						X		X			X						3
East Little Creek Road Corridor													X	X	X	X	4
Fairmount Park Area												X					1
Fort Norfolk/EVMC Area	X	X	X	X	X												5
Greater Ghent Area	X	X		X	X	X		X			X						7
Greater Norview Area											X	X	X				3
Greater Wards Corner Area								X	X	X	X	X	X	X	X	X	9
Huntersville Area									X	X							2
Mid-town Industrial Area							X	X	X	X	X						5
Military Highway Corridor														X	X	X	3
Park Place Area	X			X	X	X		X			X						6
St. Paul's Area						X		X			X						3
Total	**4**	**3**	**2**	**4**	**4**	**5**	**2**	**6**	**3**	**3**	**7**	**3**	**3**	**3**	**3**	**3**	

X: Denotes that the alignment would travel through an area that currently has a neighborhood plan

Each of the neighborhood plans shown above in **Table 17** has its list of plan actions shown in **Table A-6 in Appendix A.**

Figure 25. Criterion 7C Evaluation Results



Criterion 7D: Resiliency

Criterion Oxford Dictionaries defines the word resilient as such:

- (Of a substance or object) able to recoil or spring back into shape after bending, stretching, or being compressed
- (Of a person or animal) able to withstand or recover quickly from difficult conditions

Synonyms

- flexible, pliable, supple; durable, hardwearing, stout, strong, sturdy, tough

The City of Norfolk citizens, Councilpersons, management, and staff are keenly aware of the challenges they are facing to their quality of life due to natural or manmade stresses. In 1913, 10 percent of the world's population lived in cities. In 2013, 50 percent of the world's population lived in cities. By 2050, it is predicted that 75 percent of the world's population will live in cities. As a city gains population, stresses are sure to increase[3]. The City of Norfolk is preparing for such challenges.

To mark 100 years of service, the Rockefeller Foundation created an innovative effort to drive urban resilience. The effort, 100 Resilient Cities Centennial Challenge, looks at what is needed to build communities that can recover, persist, or even thrive amid disruption. The Centennial Challenge identifies constant learning, rapid rebound, limited 'failure', flexibility, and spare capacity as five components that make a city resilient. In December 2013, Norfolk was named by the Rockefeller Foundation as one of the first set of 33 cities for their 100 Resilient Cities Network and over the next three years will receive technical support and resources to develop and implement plans for urban resilience. In particular for Norfolk, this means help dealing with increased flooding from storm surge, sea level rise, and a sinking landscape.

For evaluation purposes Criterion 7D is interpreted as the ability of a transportation network to respond to a hazardous event with minimal disruption to public safety. The evaluation identified areas that are susceptible to rainfall, tidal, and storm surge flooding and ranked the alignments on their ability to maintain transit service during and after storm events as well as their ability to facilitate evacuations.

Methodology and Data

The alignments were evaluated based on if the transit would avoid areas that are flood-prone so that transit could remain operable in the event of a severe storm with significant flooding. The alignments' utility as evacuation routes was also considered. The alignments and areas identified by the Federal Emergency Management Agency's Flood Insurance Rate Map (FIRM) as AE and VE Zones (shown in **Figure 26**) , those areas most susceptible to flooding in general, as well as areas that would likely be flooded by a Category 1 or Category 2 hurricane or nor'easter storm surge (shown in **Figure 27**). The alignments were evaluated based on the length of segments that travel through flood prone areas either at grade or elevated.

[3] http://100resilientcities.rockefellerfoundation.org/

Figure 26. Flood Insurance Rate Map (FIRM) Zones AE and VE

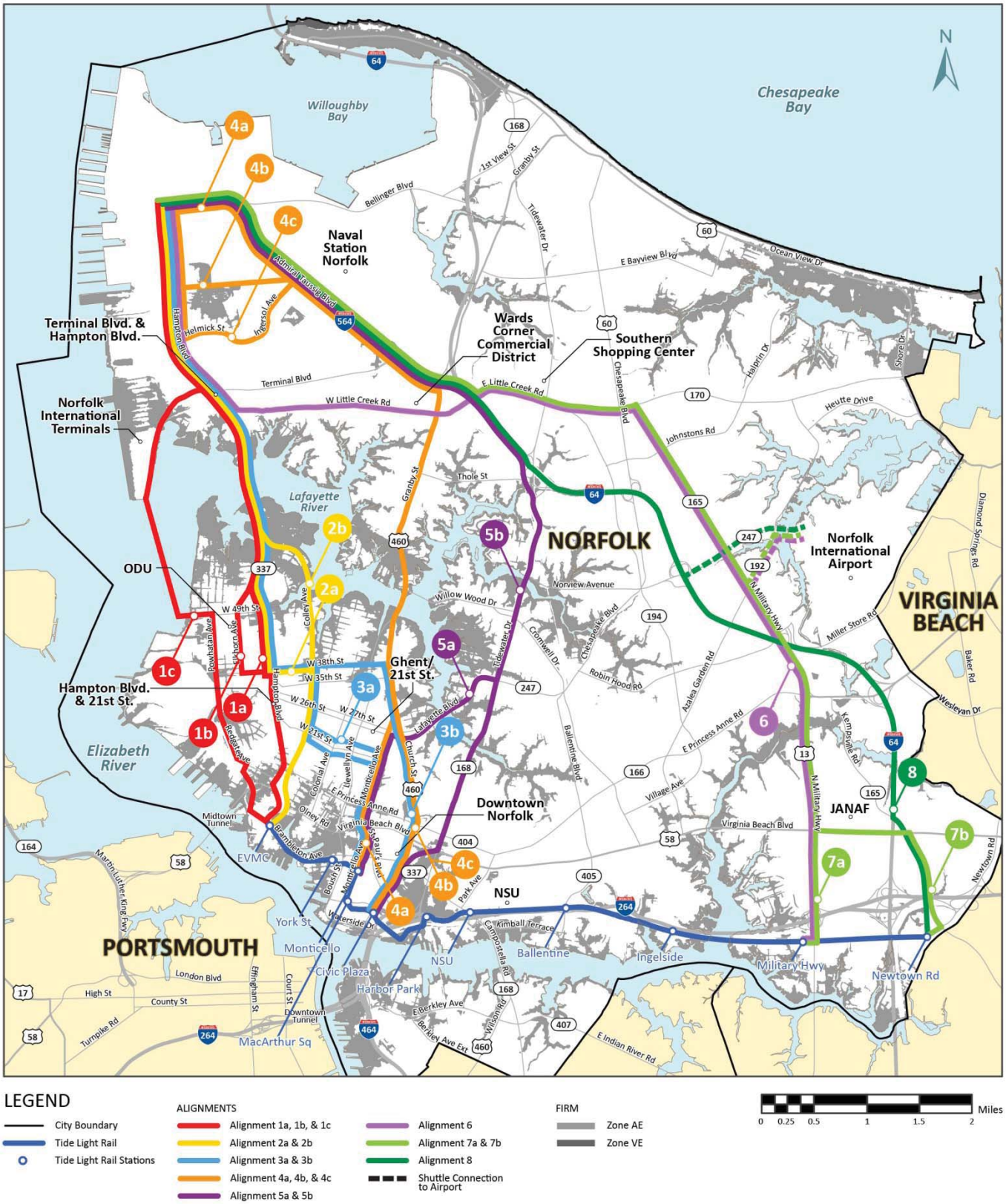
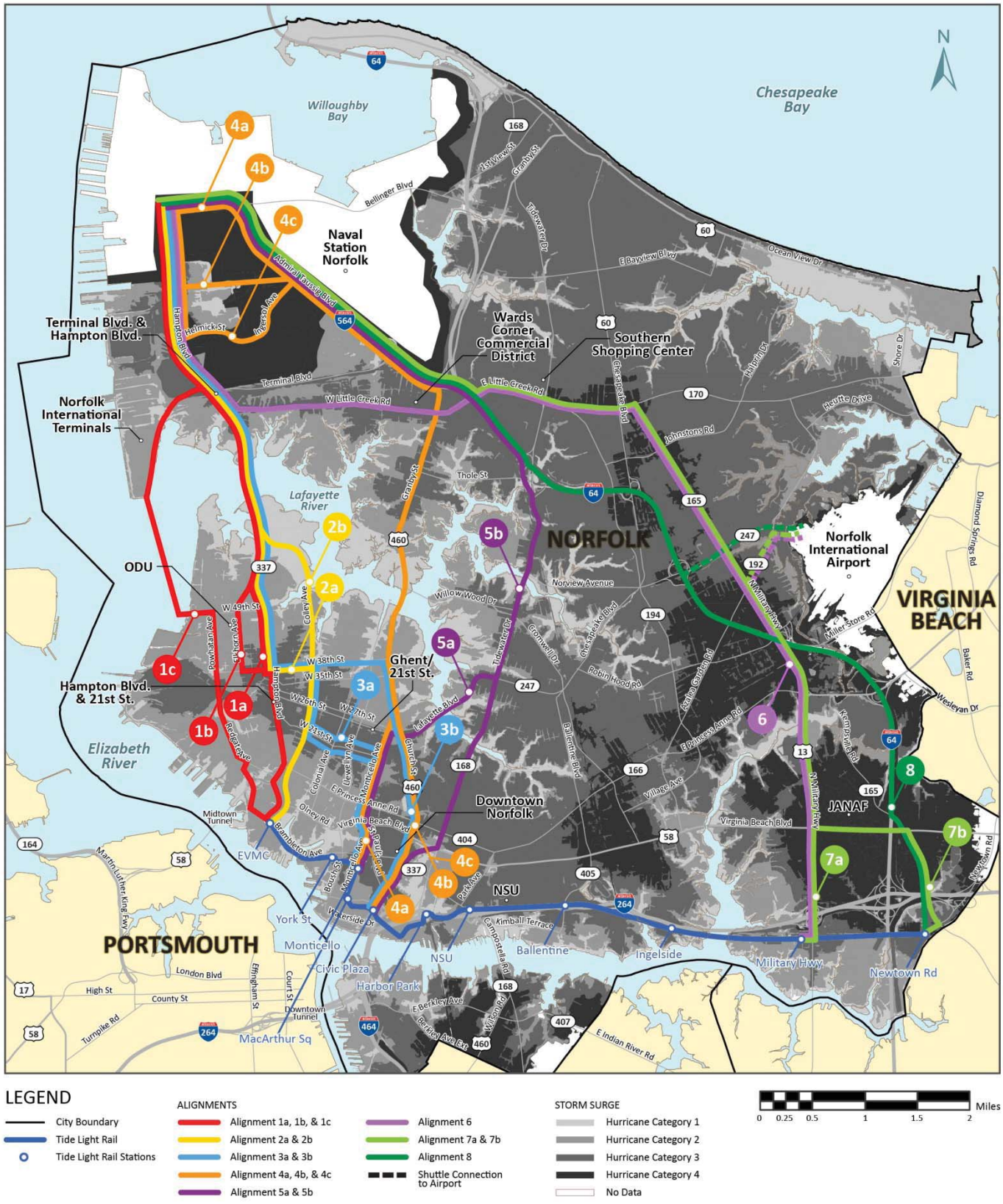


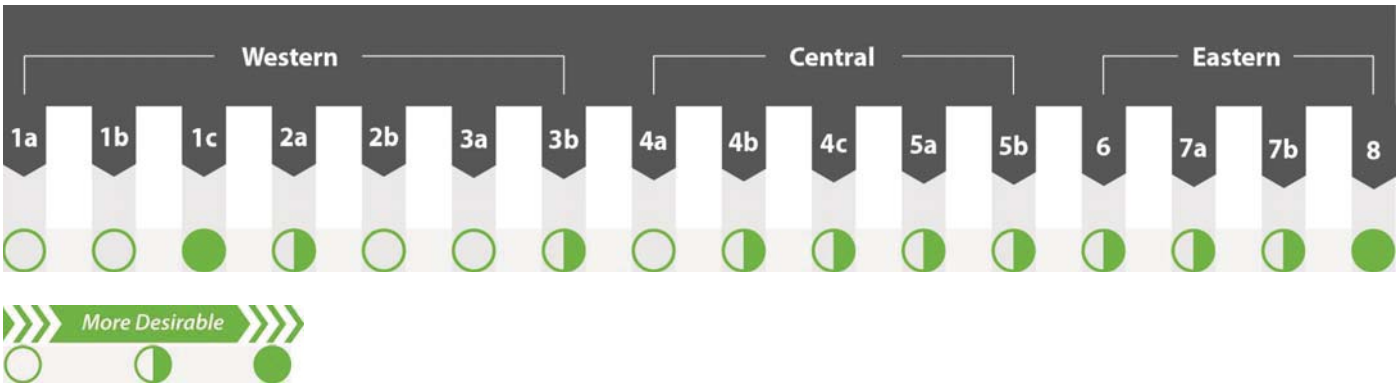
Figure 27. Hurricane Category 1-4 Storm Surge



Results

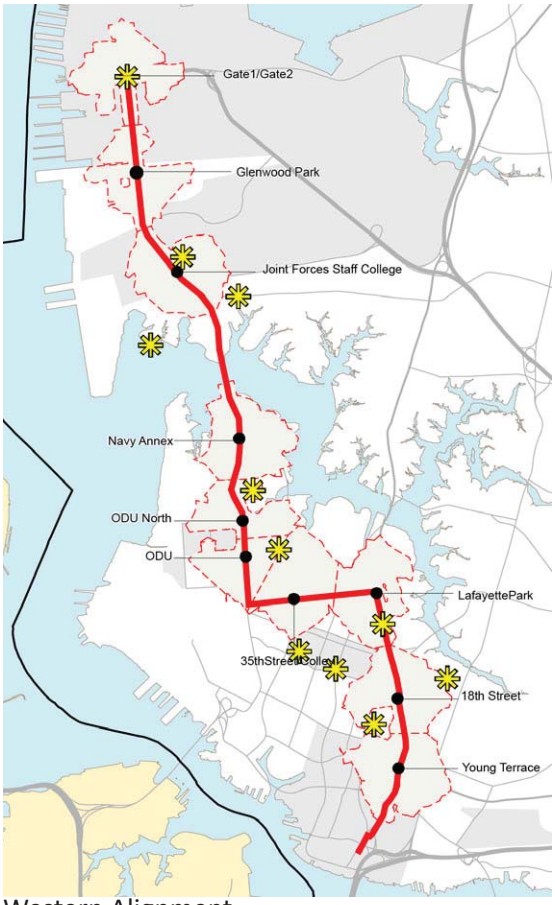
Figure 28 shows the results of the analysis. Alignment 1c scores as "most desirable" because this alignment serves the highest ranked activity center (ODU) and includes a flood wall with a tide gate upon which transit would travel from approximately 49th Street over the Lafayette River and would touch land at the southern tip of Norfolk International Terminals. This alignment is preferred overall because its elevated tracks would serve to protect much of the western side of Norfolk from inundation. Alignment 8 also scores as "most desirable" because it would travel quickly along I-64 and I-564 on elevated tracks that would likely not flood during a storm event. Alignment 8 also is the closest to Norfolk International Airport, the second-highest ranking activity center and another way to evacuate, if necessary.

Figure 28. Criterion 7D Evaluation Results

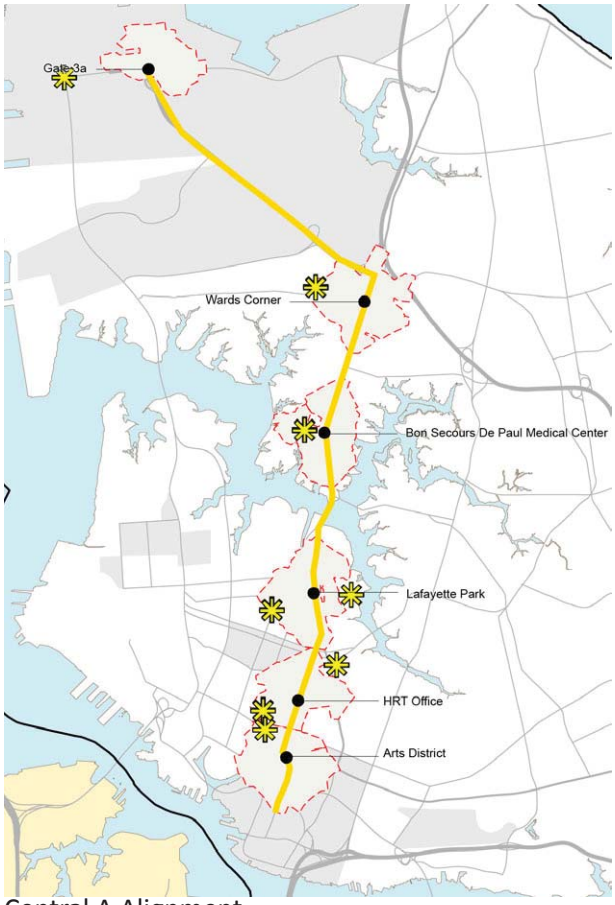


APPENDIX D
STATION SERVICE AREA ANALYSIS MAPS

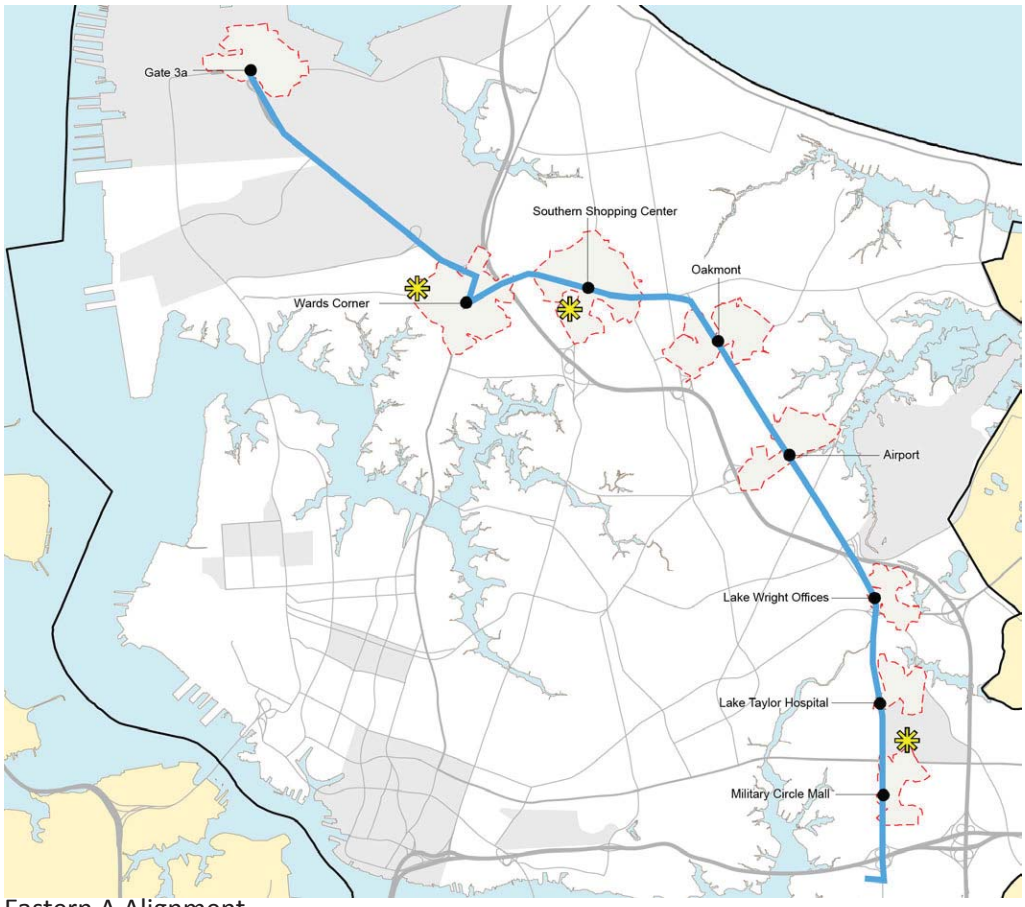
Connect to Activity Centers



Western Alignment



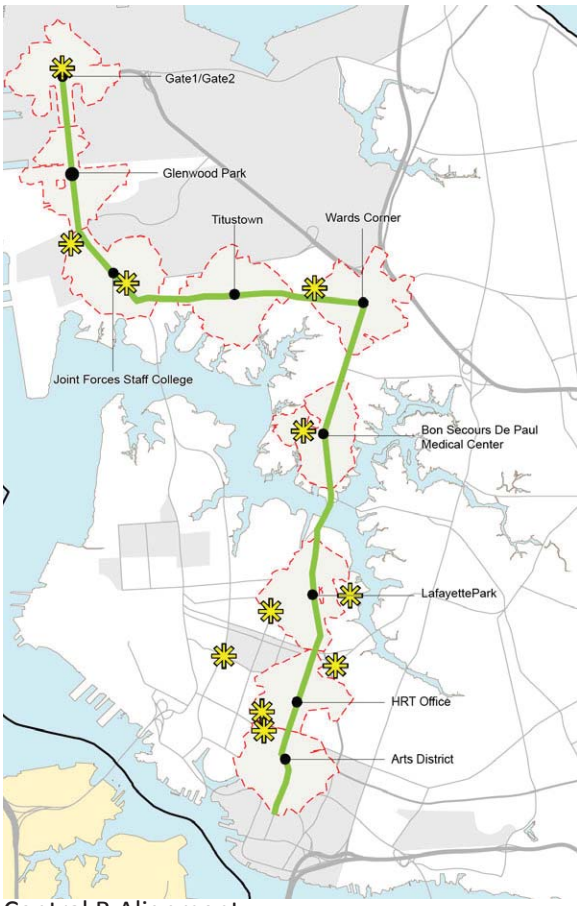
Central A Alignment



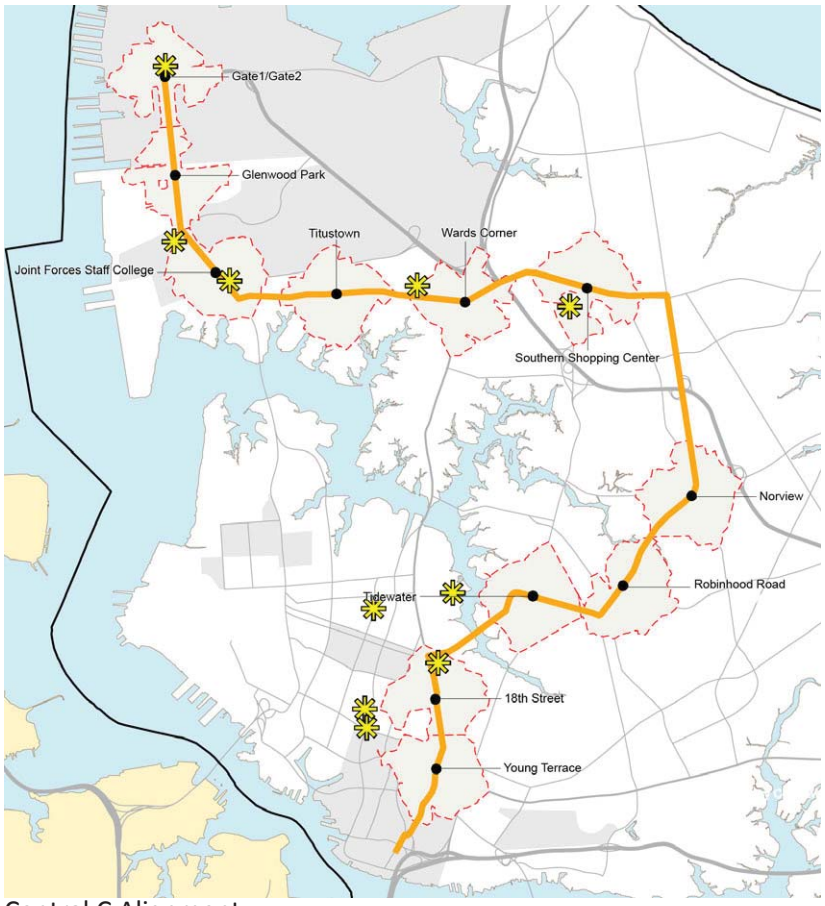
Eastern A Alignment

- Activity Center
- 1/2 Mile Station Service Area
- Western
- Central A
- Eastern A
- City Boundary
- Station Location

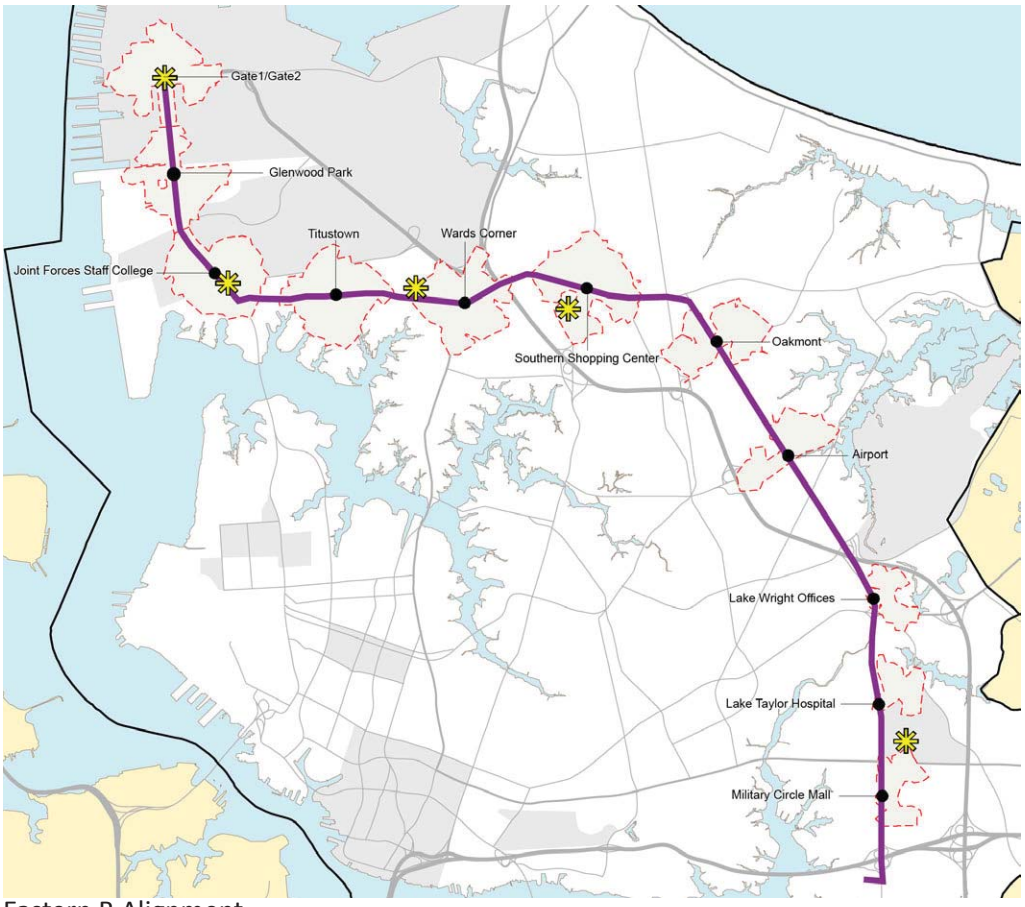
Connect to Activity Centers



Central B Alignment



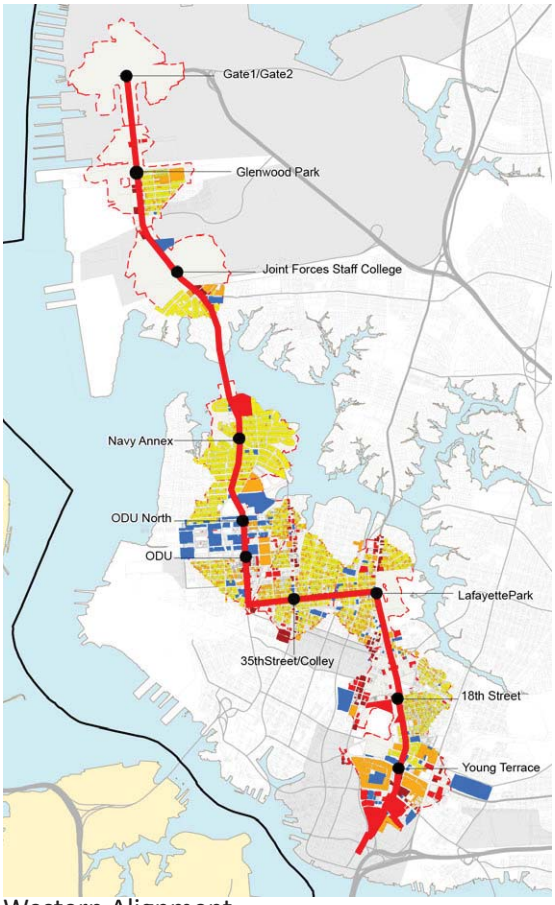
Central C Alignment



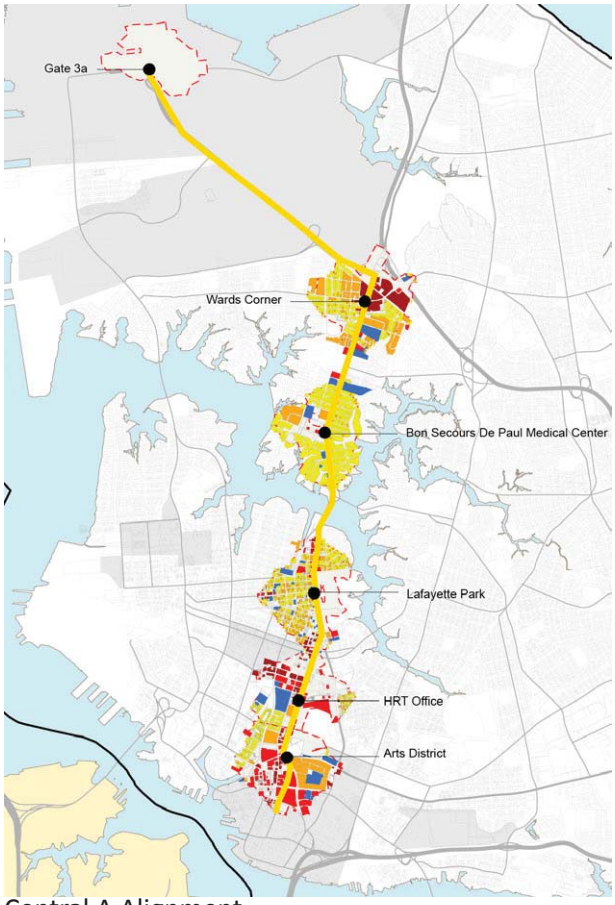
Eastern B Alignment

- Activity Center
- 1/2 Mile Station Service Area
- Central B
- Central C
- Eastern B
- City Boundary
- Station Location

Existing Transit Supportive Land Uses

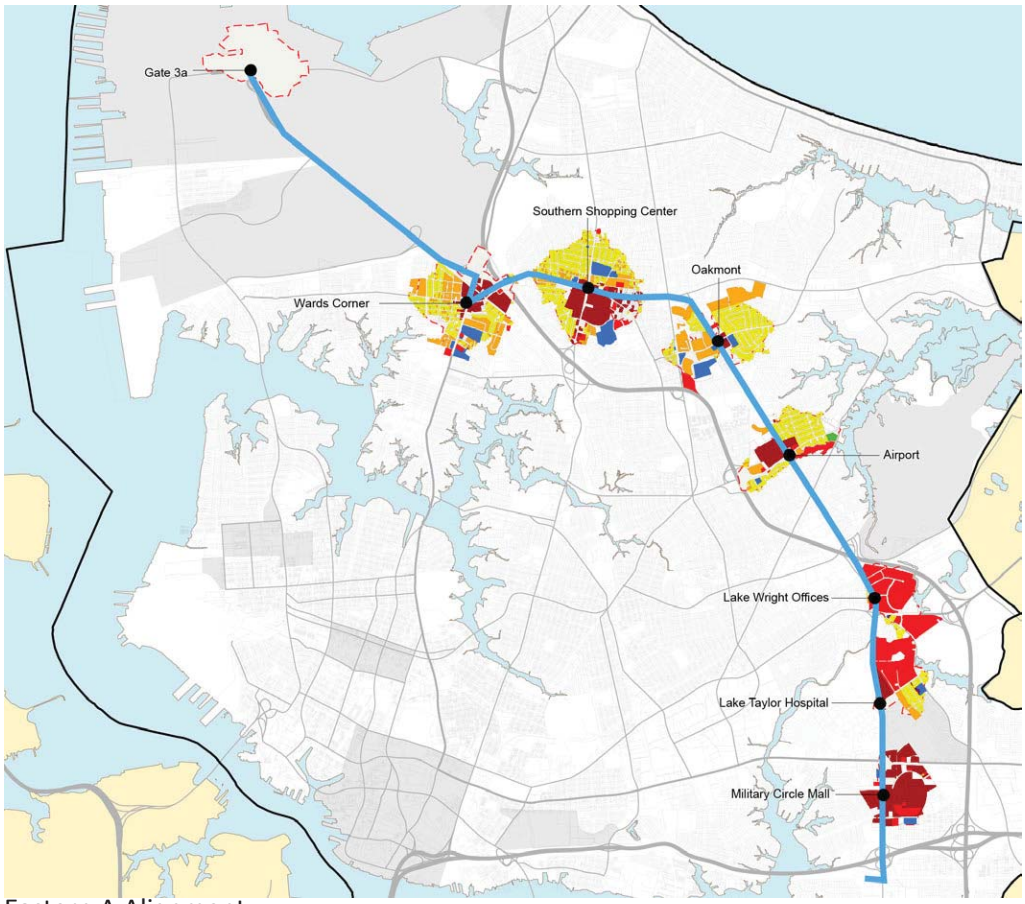


Western Alignment



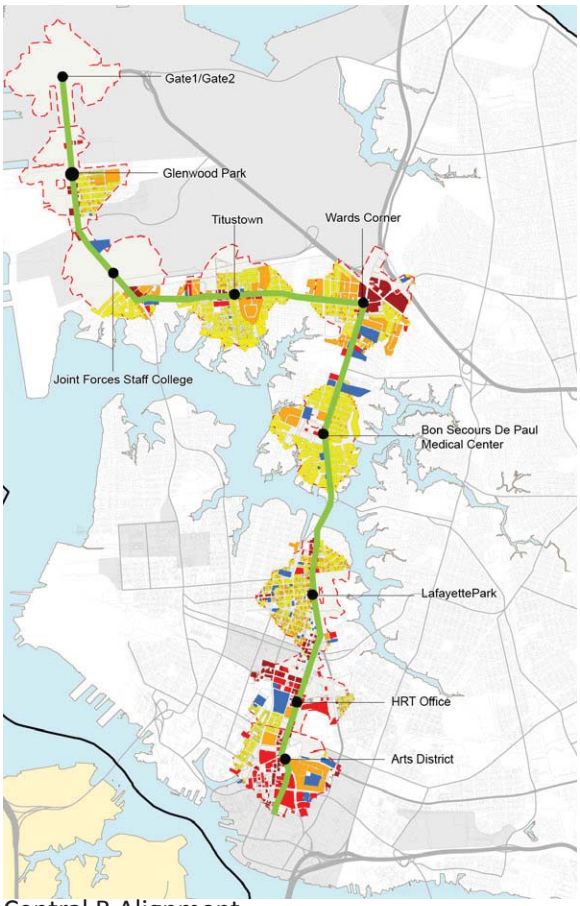
Central A Alignment

- Single-Family Residential
- Multi-Family Residential
- Commercial
- Retail
- Institutional
- 1/2 Mile Station Service Area
- Western
- Central A
- Eastern A
- City Boundary
- Station Location

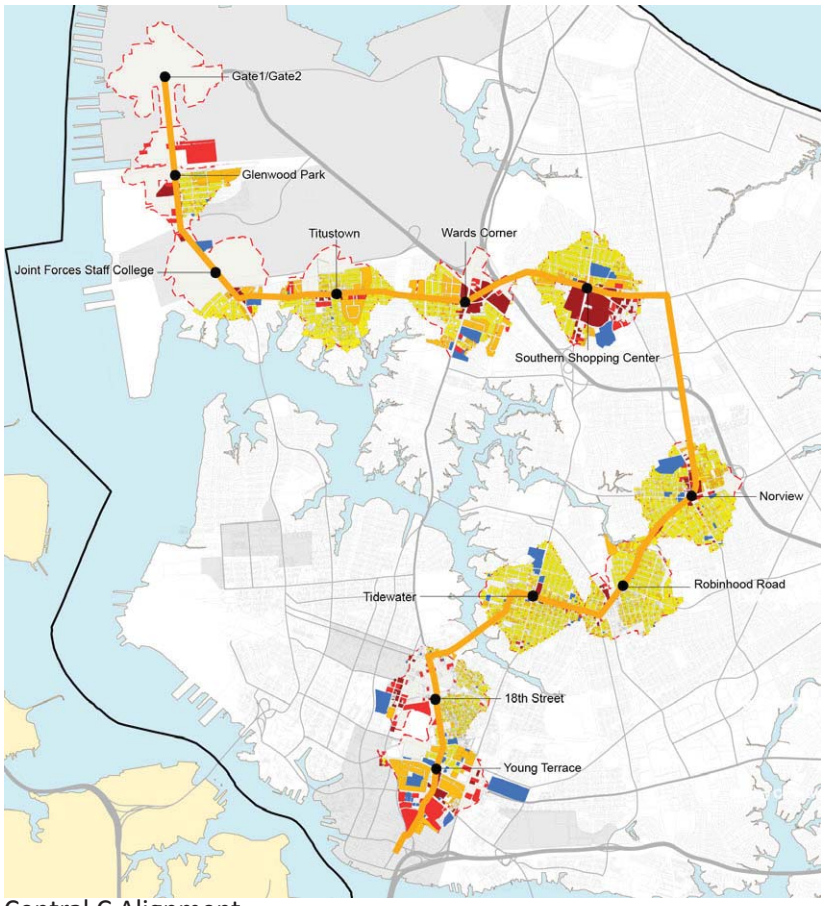


Eastern A Alignment

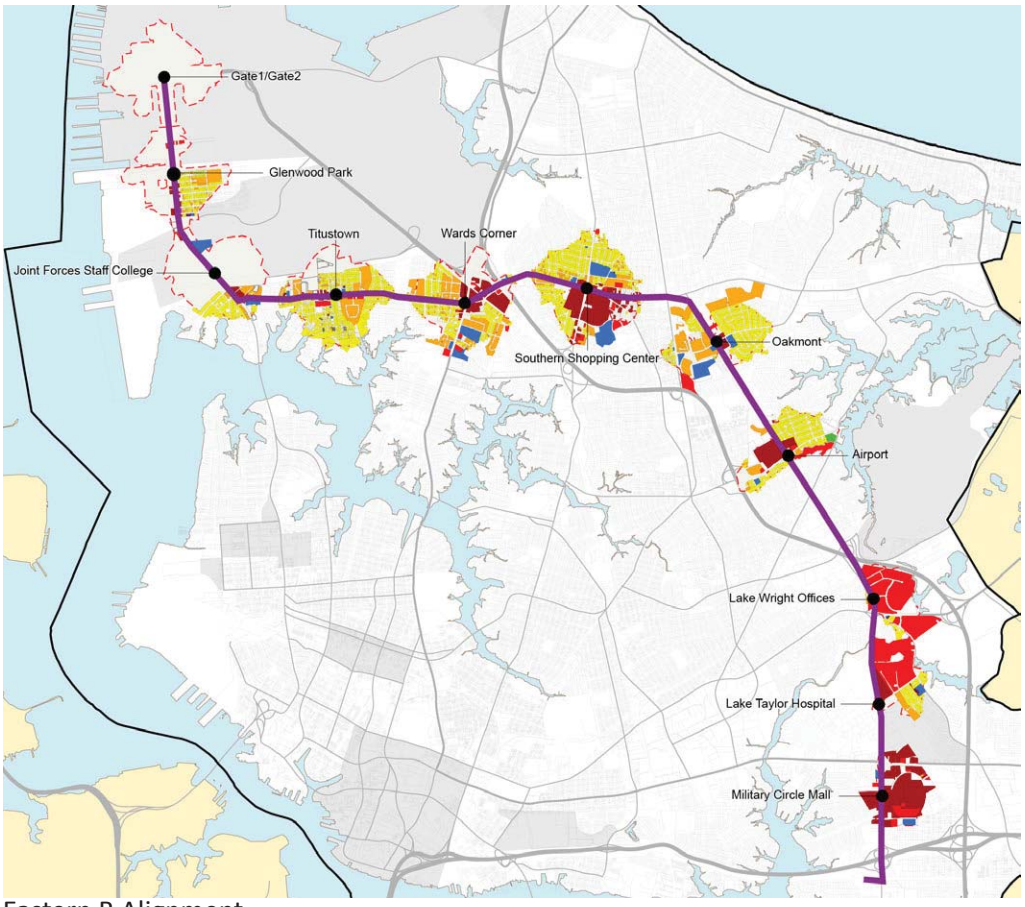
Existing Transit Supportive Land Uses



Central B Alignment



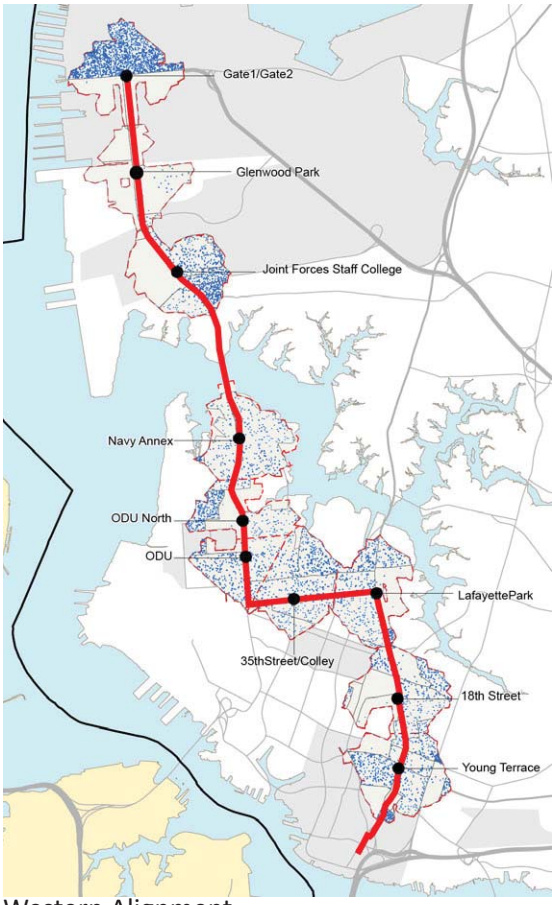
Central C Alignment



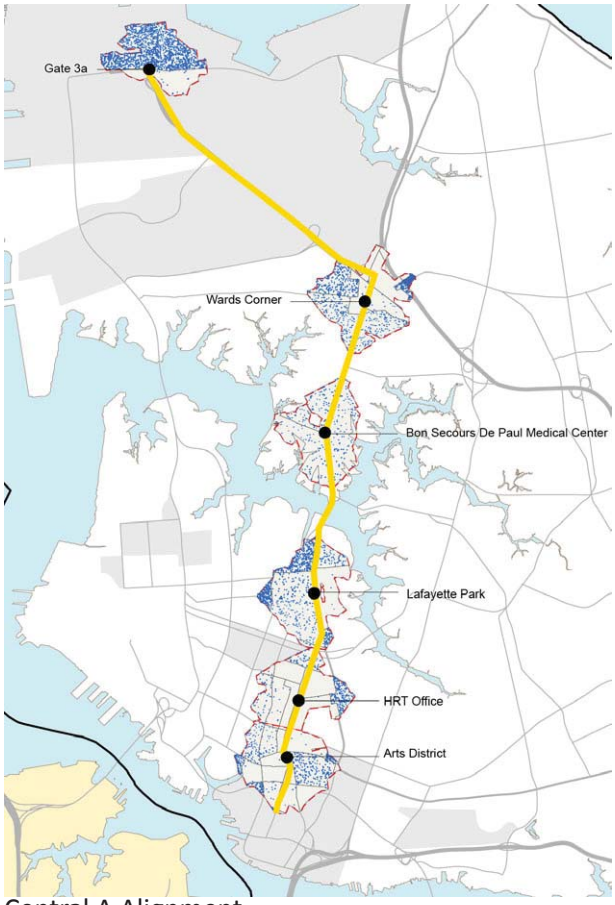
Eastern B Alignment

- Single-Family Residential
- Multi-Family Residential
- Commercial
- Retail
- Institutional
- 1/2 Mile Station Service Area
- Central B
- Central C
- Eastern B
- City Boundary
- Station Location

Population reached within the station service areas



Western Alignment



Central A Alignment

1 Dot = 10 People

1/2 Mile Station Service Area

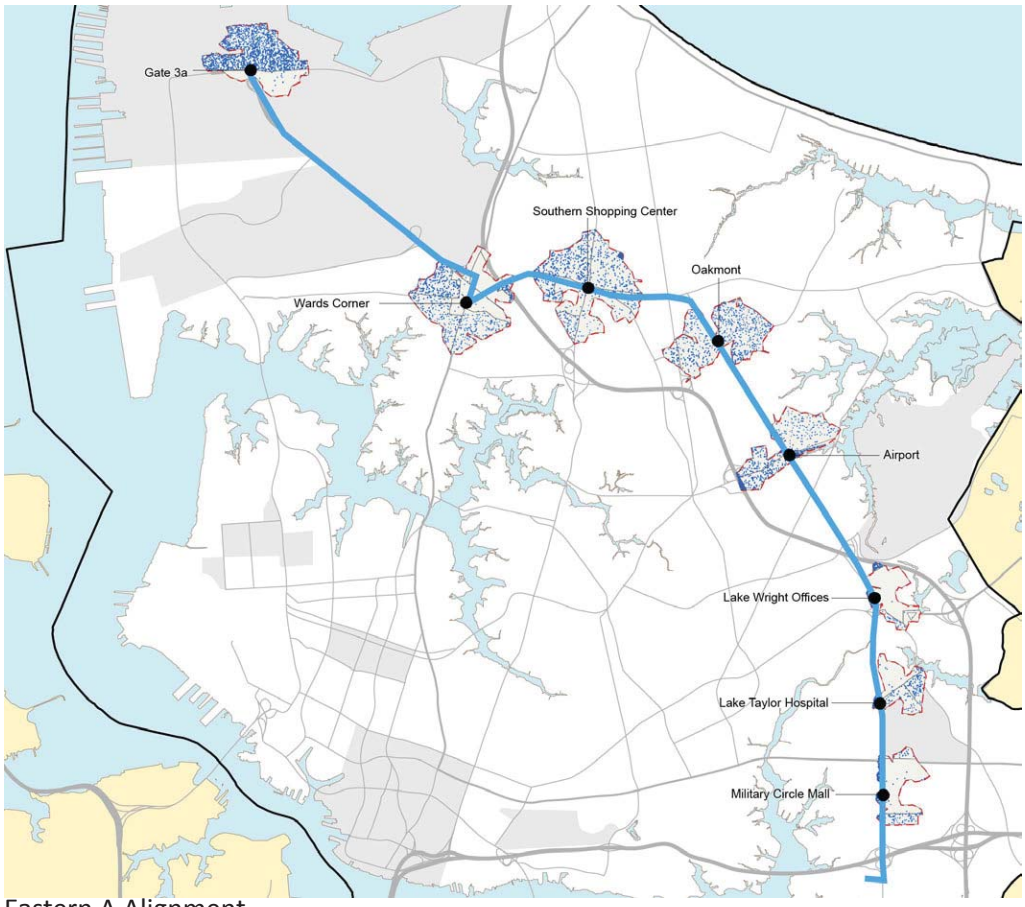
Western

Central A

Eastern A

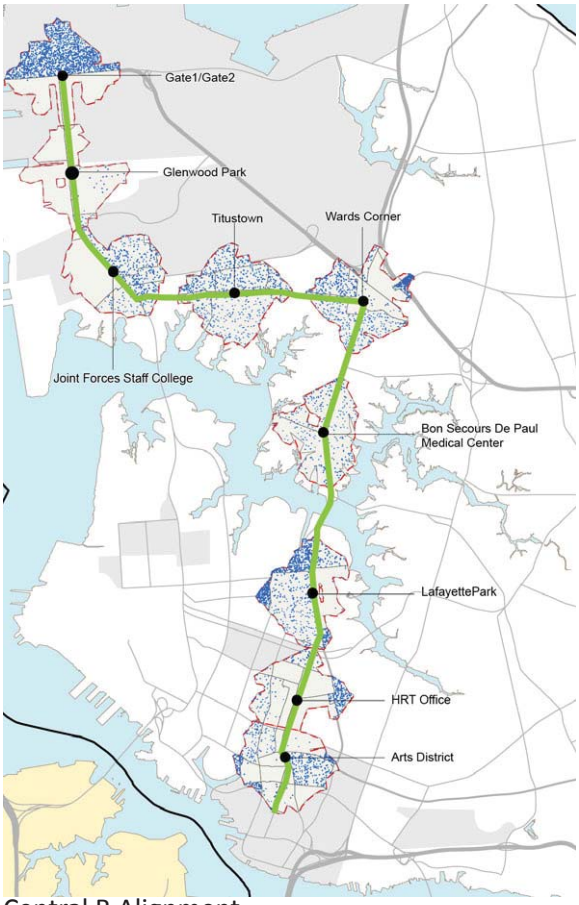
City Boundary

Station Location

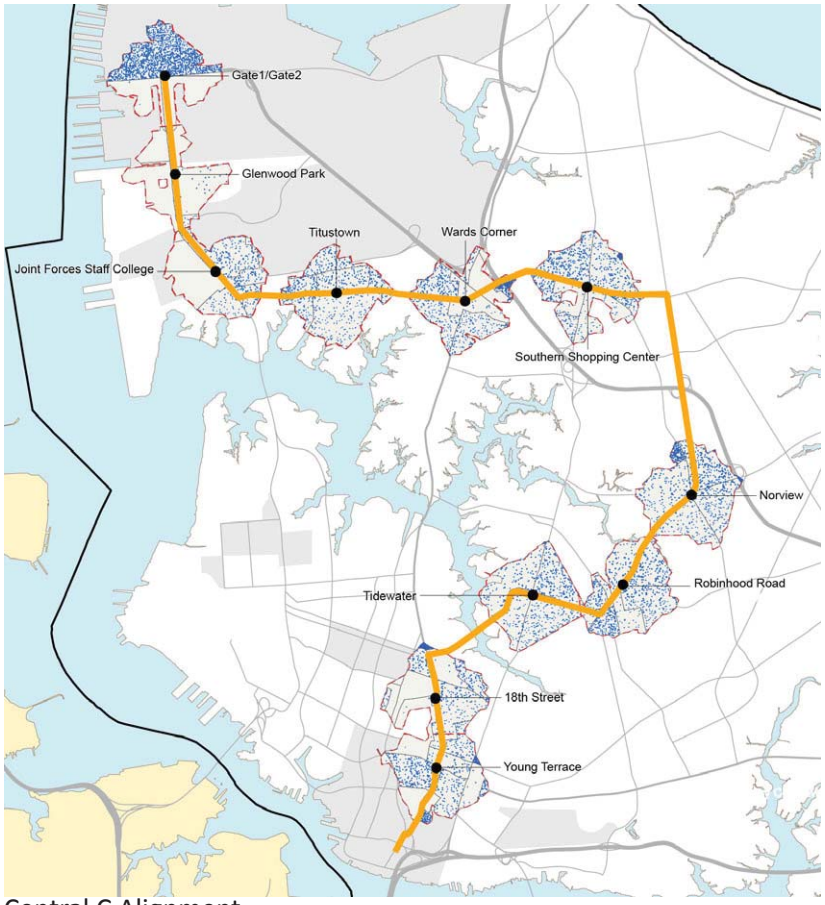


Eastern A Alignment

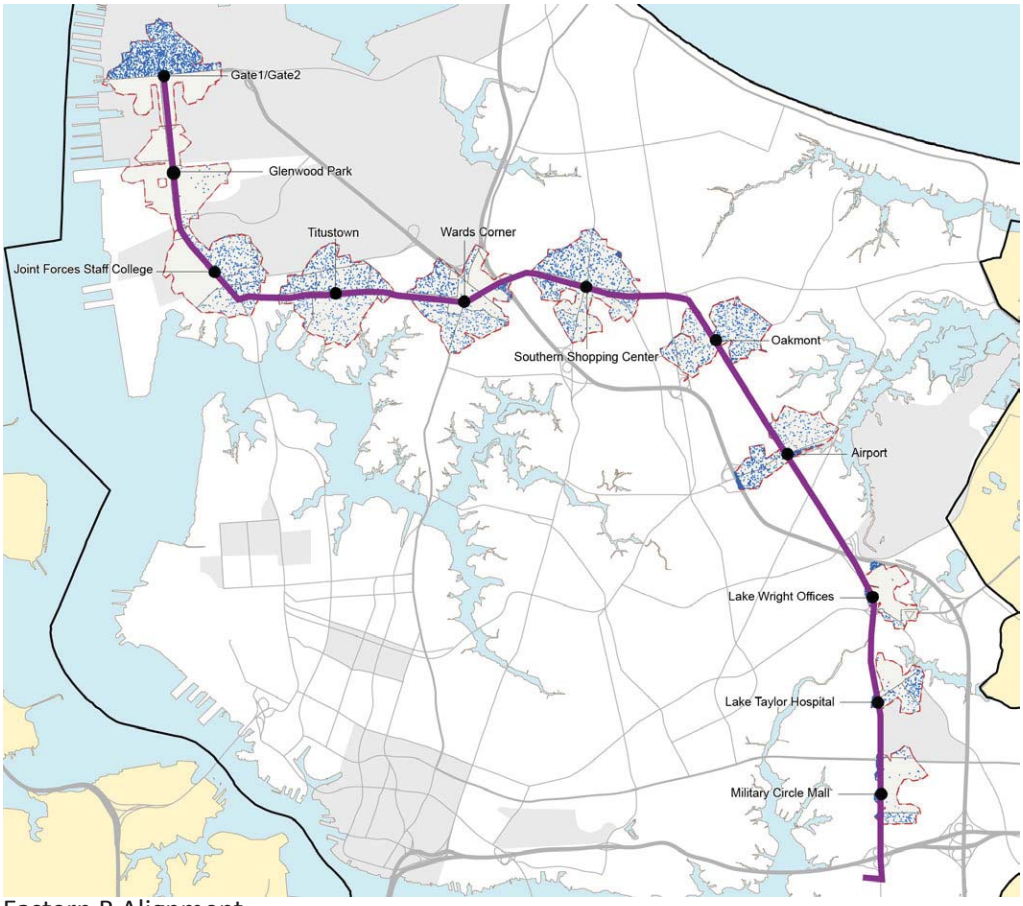
Population reached within the station service areas



Central B Alignment

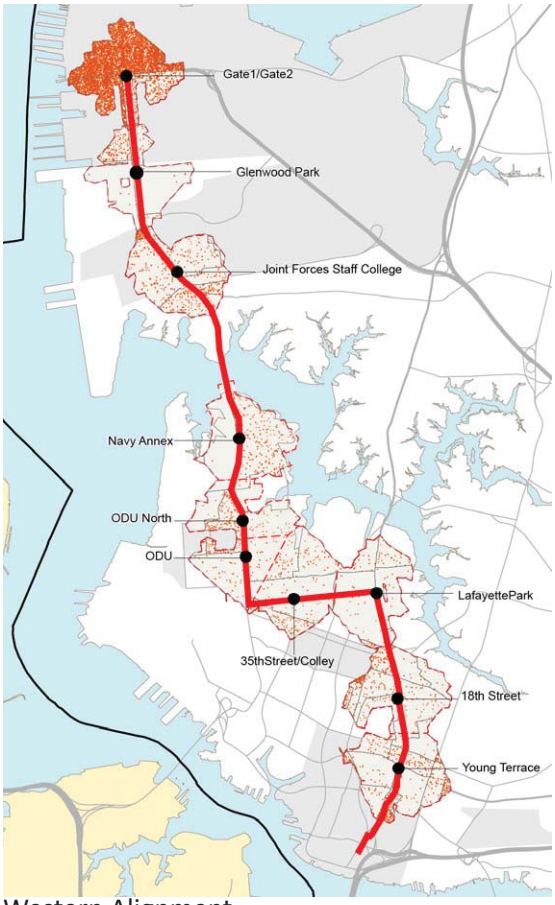


Central C Alignment

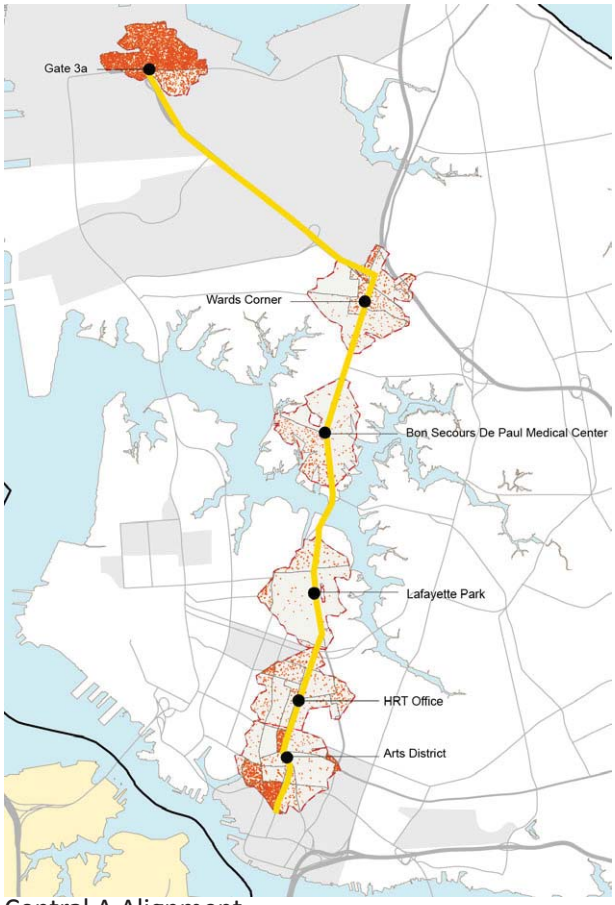


Eastern B Alignment

Employees reached within the station service areas



Western Alignment



Central A Alignment

1 Dot = 10 Employees

1/2 Mile Station Service Area

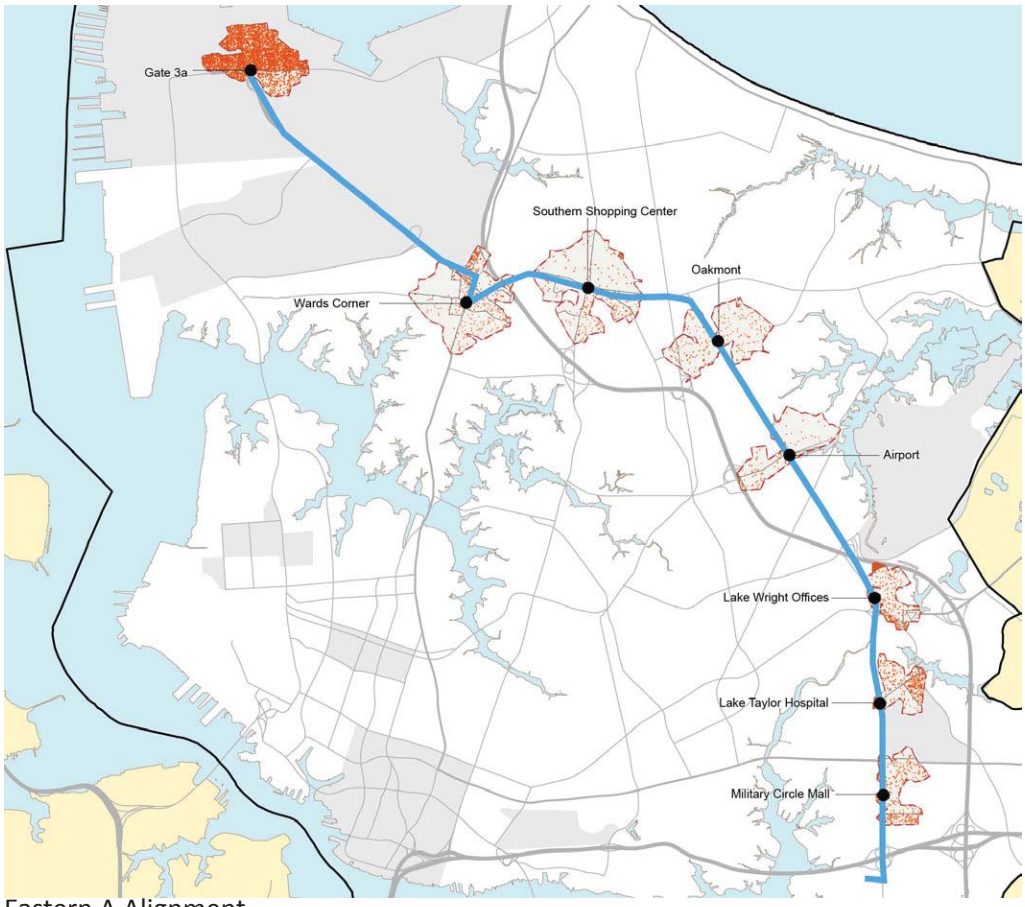
Western

Central A

Eastern A

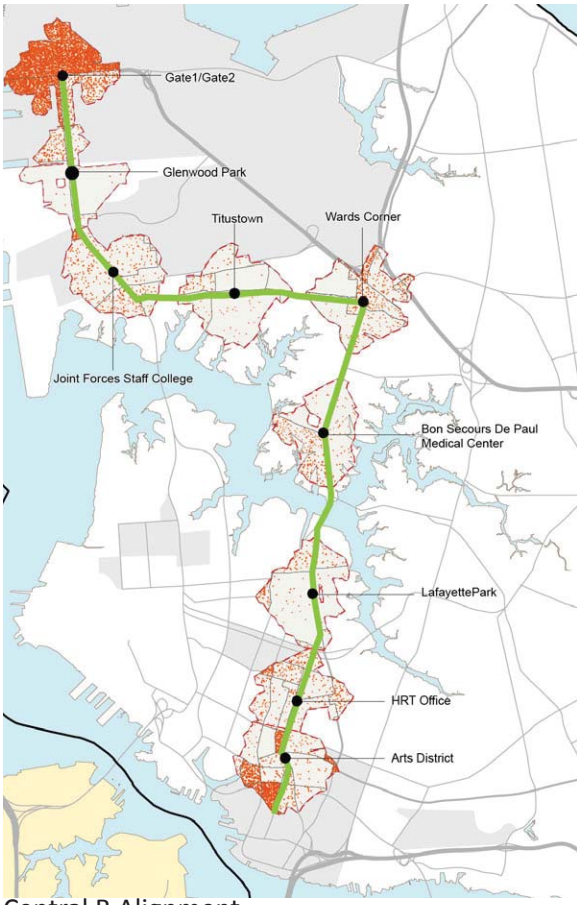
City Boundary

Station Location

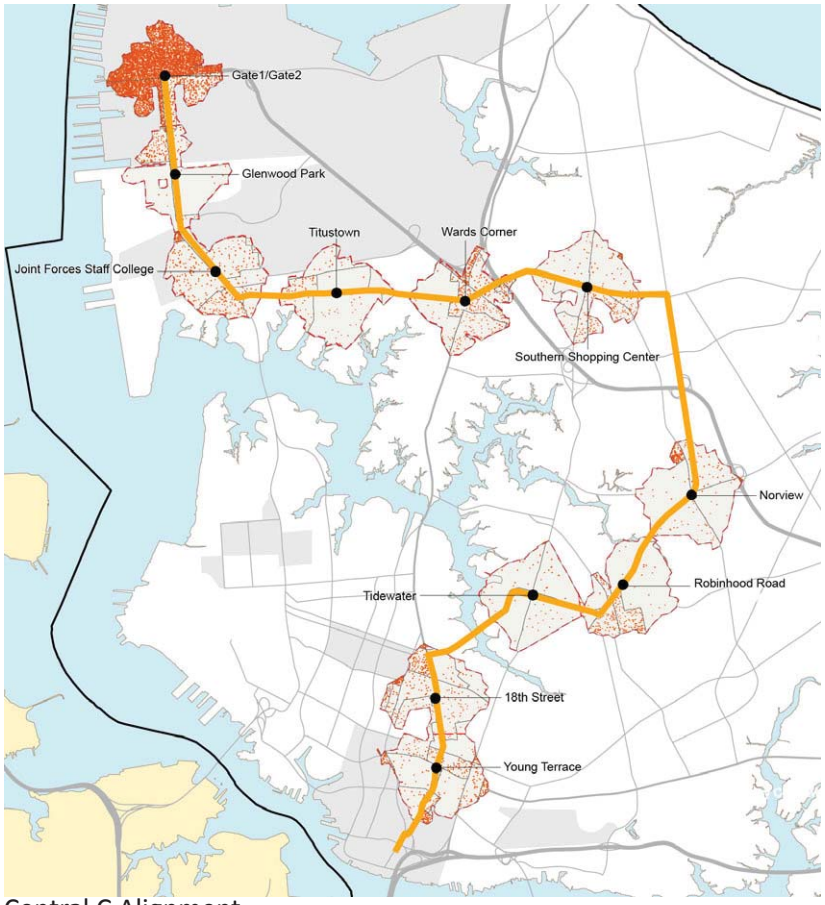


Eastern A Alignment

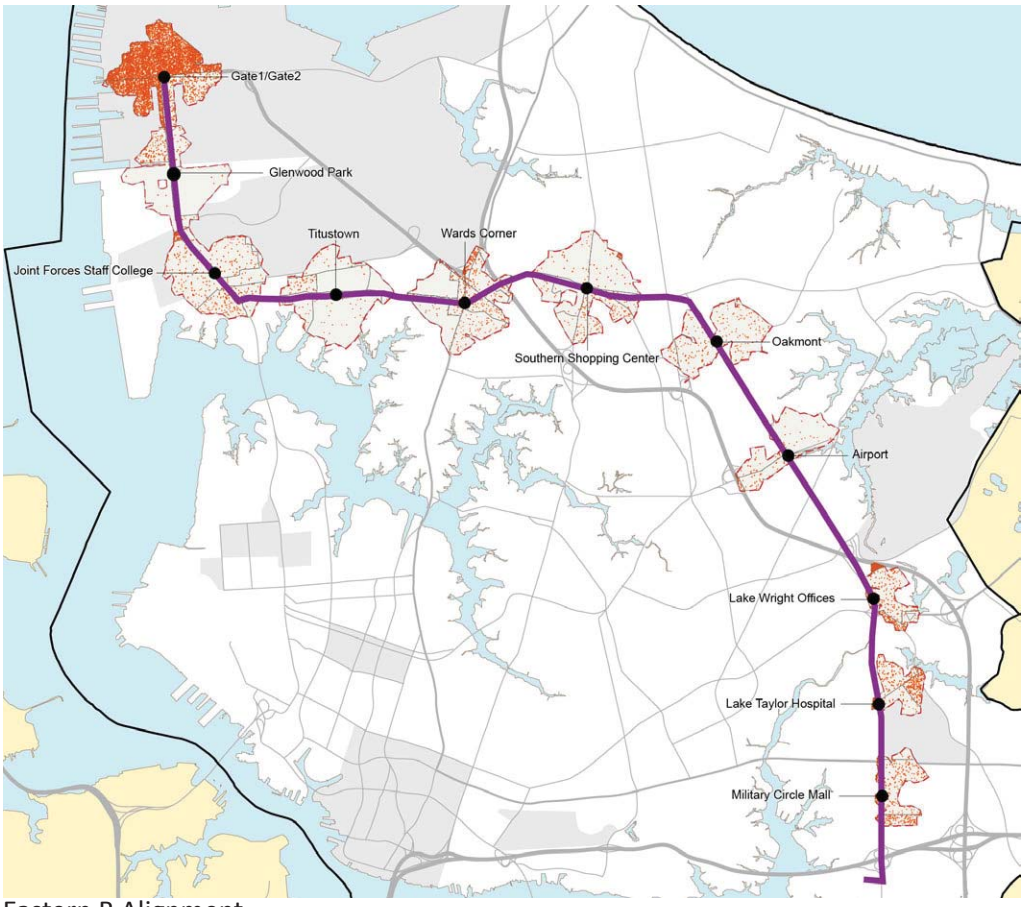
Employees reached within the station service areas



Central B Alignment



Central C Alignment



Eastern B Alignment

1 Dot = 10 Employees

1/2 Mile Station Service Area

Central B

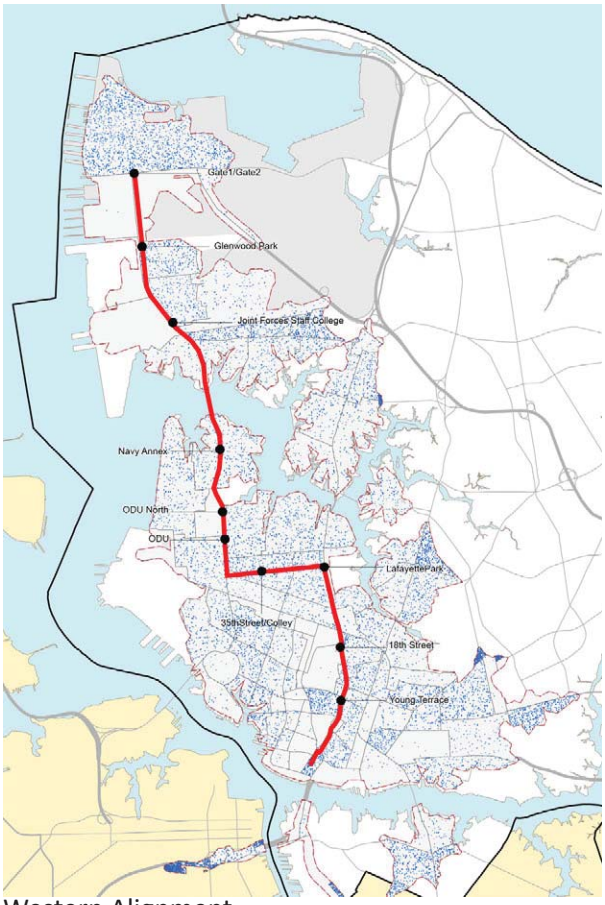
Central C

Eastern B

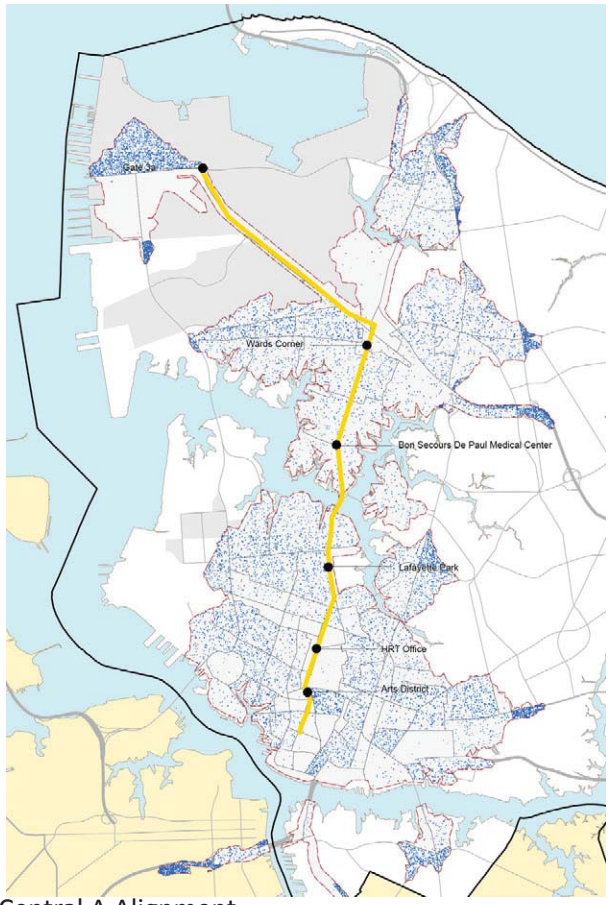
City Boundary

Station Location

Total Population reached within 5-minute Drive from Station Locations



Western Alignment



Central A Alignment

1 Dot = 10 People

1/2 Mile Station Service Area

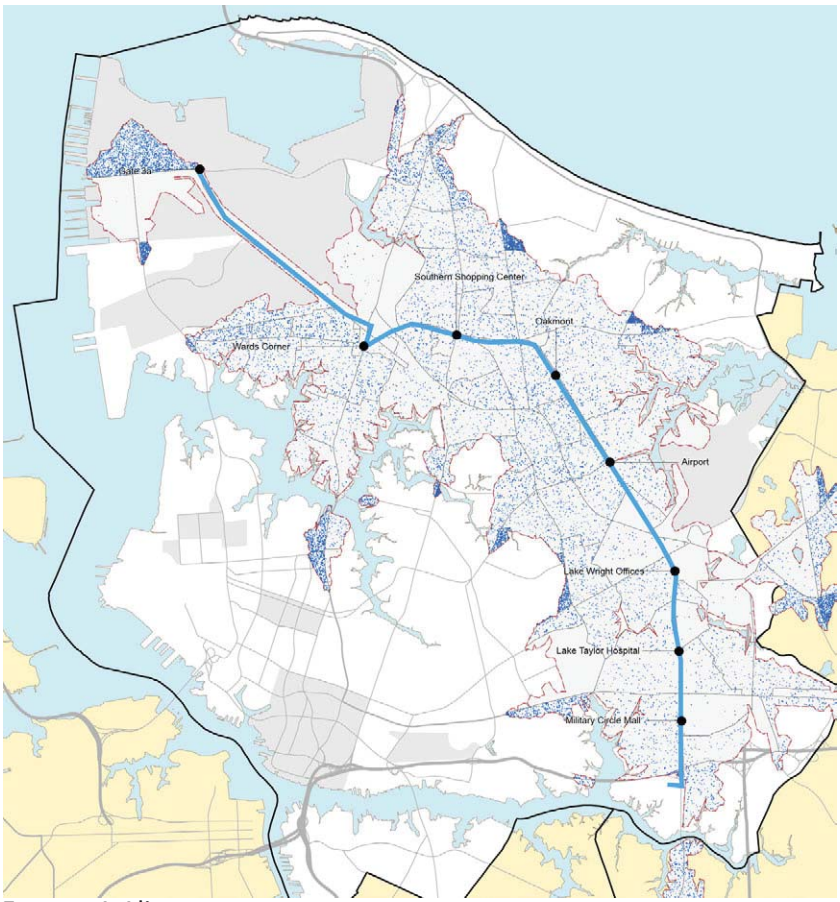
Western

Central A

Eastern A

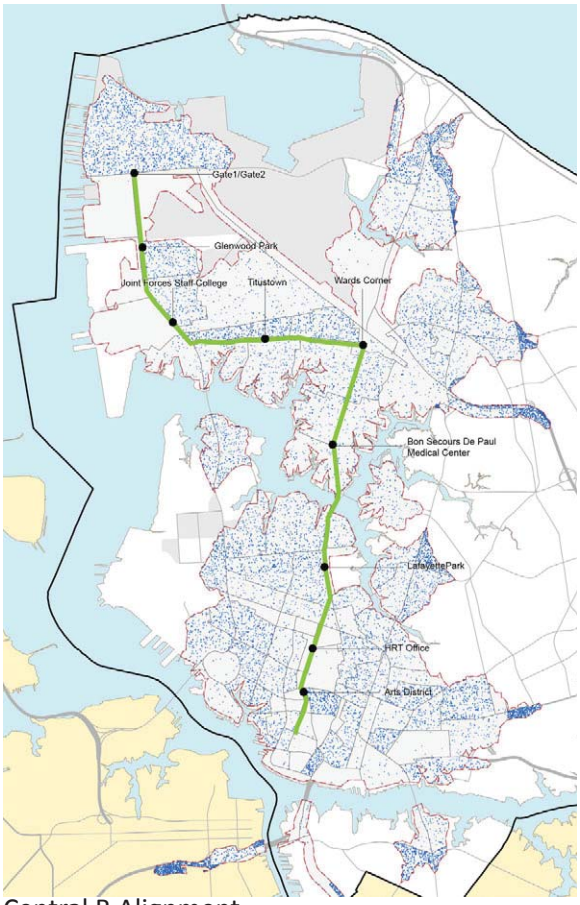
City Boundary

Station Location

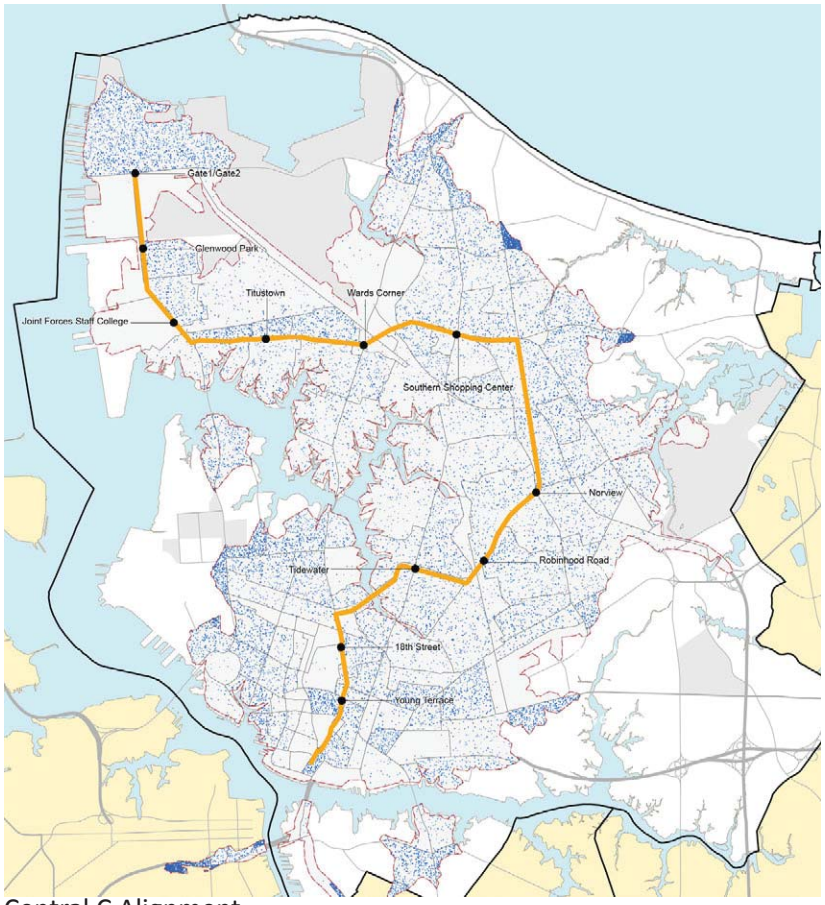


Eastern A Alignment

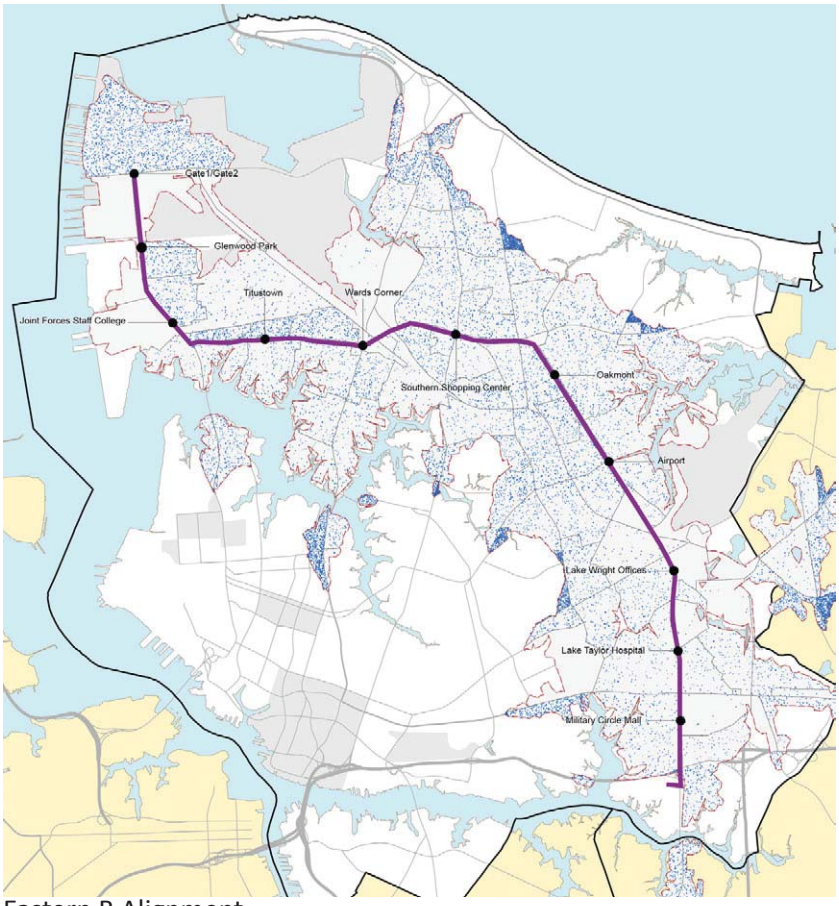
Total Population reached within 5-minute Drive from Station Locations



Central B Alignment



Central C Alignment



Eastern B Alignment

1 Dot = 10 People

1/2 Mile Station Service Area

Central B

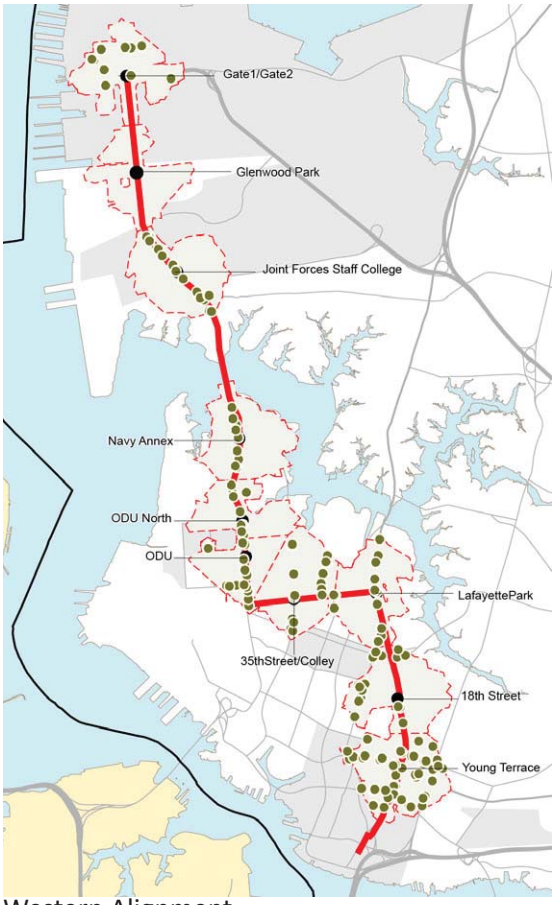
Central C

Eastern B

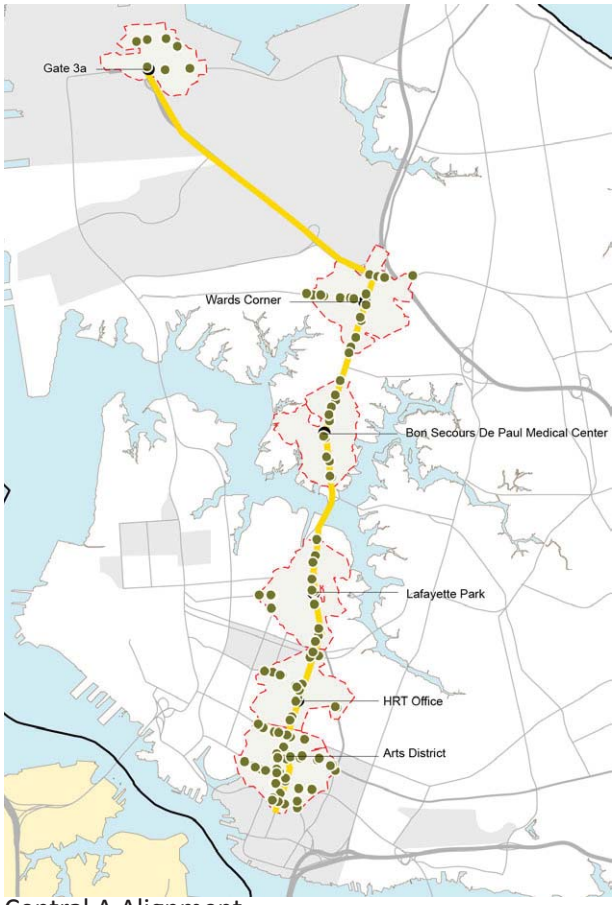
City Boundary

Station Location

Number of transit stops within station service areas

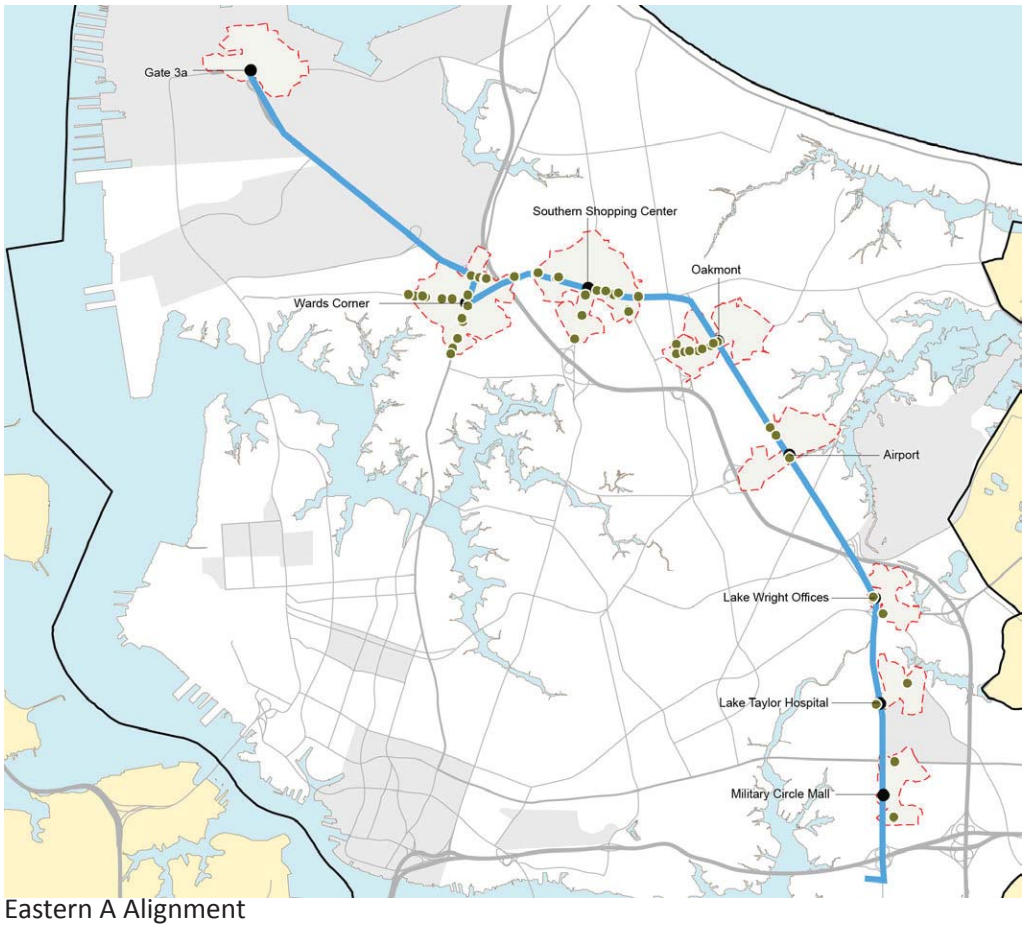


Western Alignment



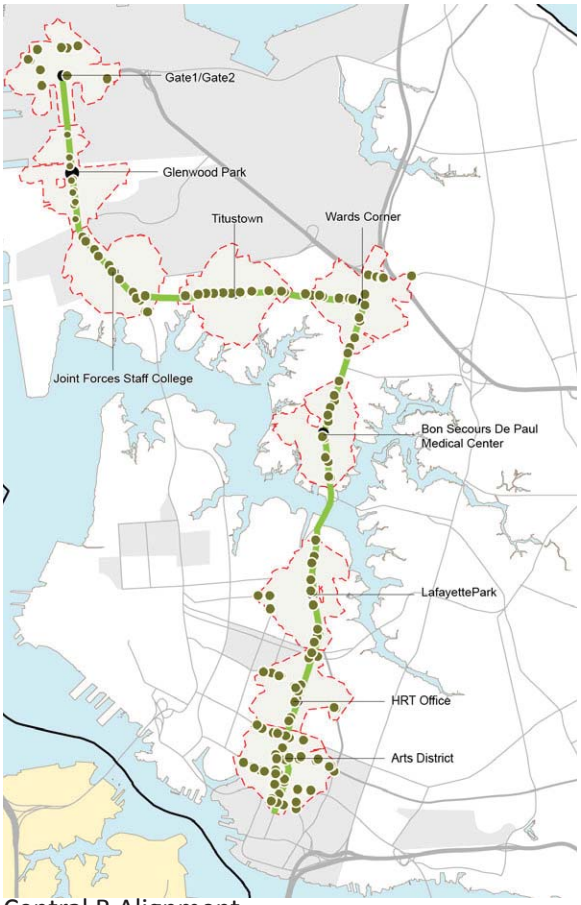
Central A Alignment

- Bus Stop
- 1/2 Mile Station Service Area
- Western
- Central A
- Eastern A
- City Boundary
- Station Location

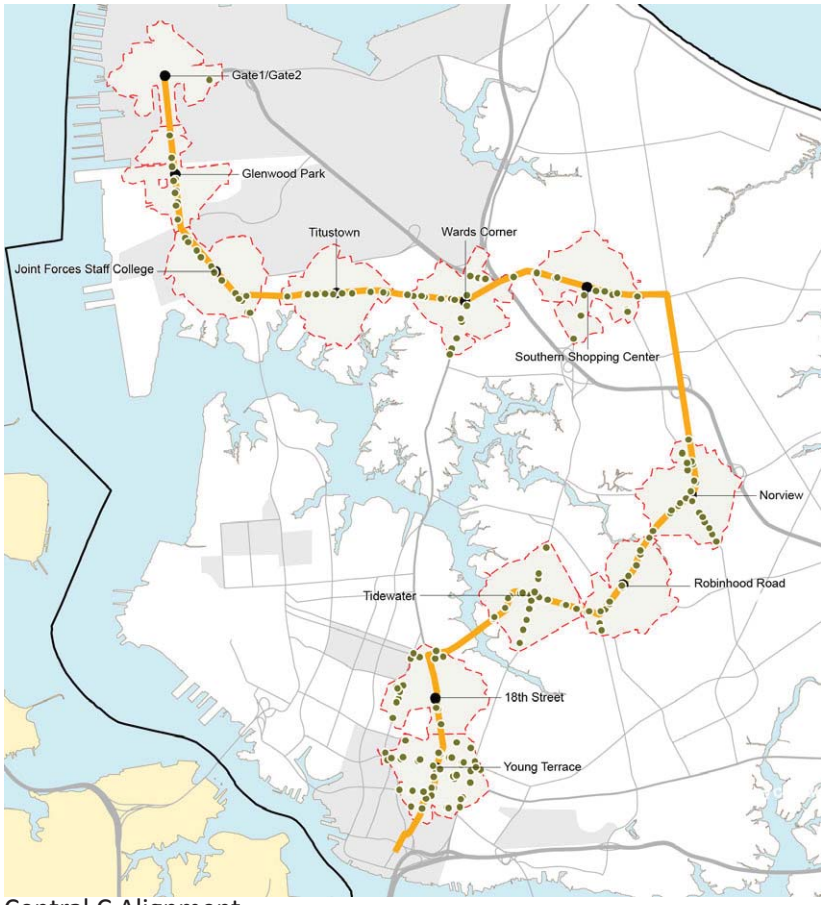


Eastern A Alignment

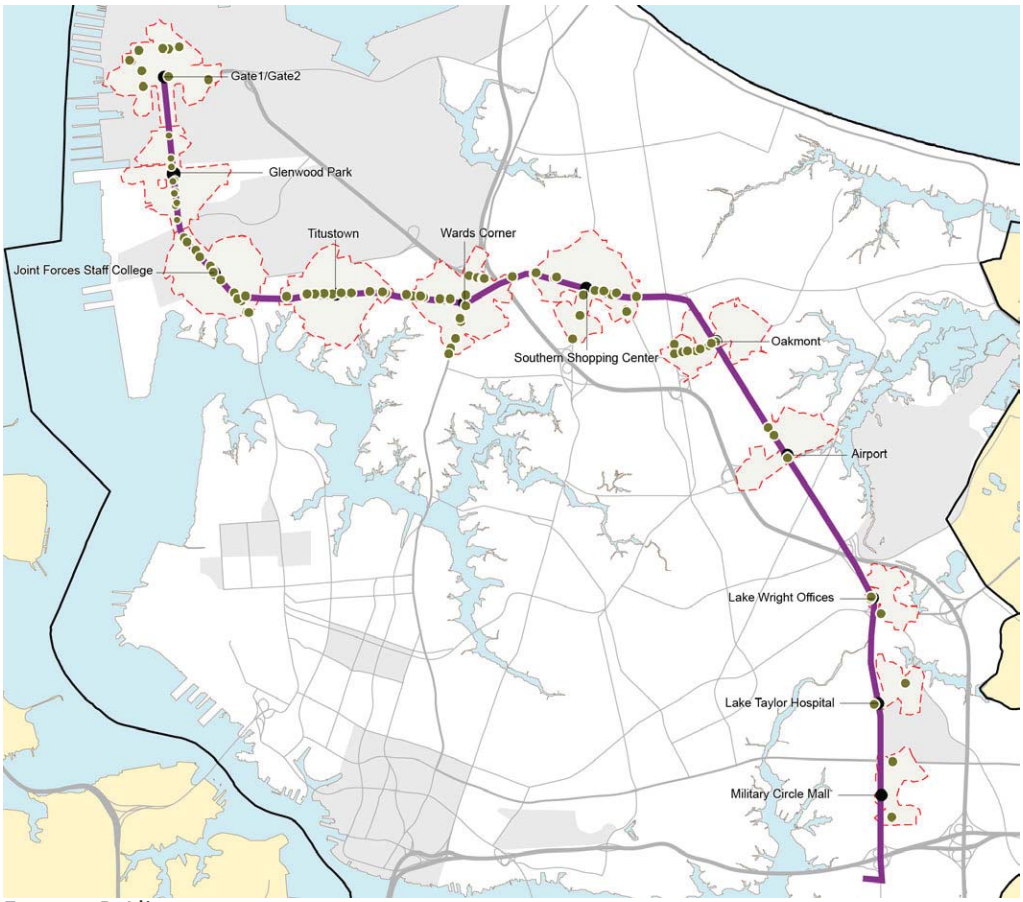
Number of transit stops within station service areas



Central B Alignment



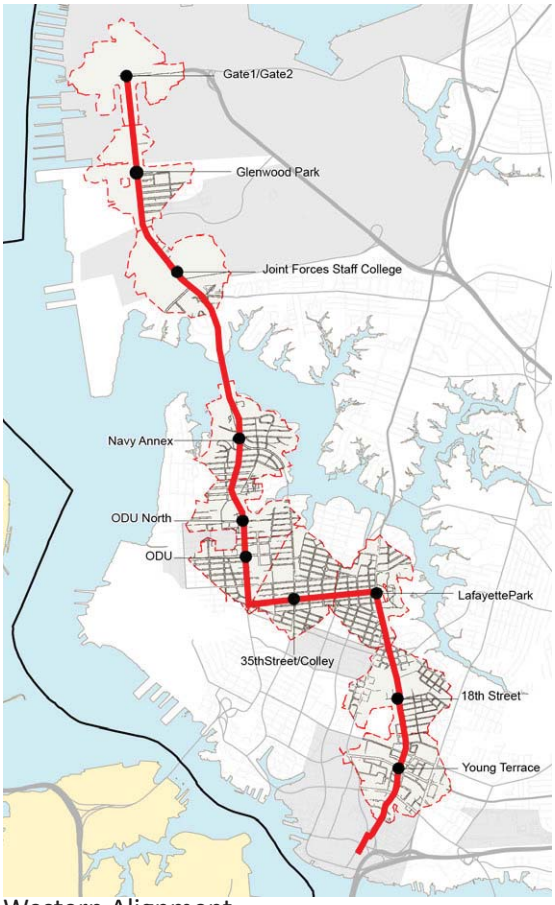
Central C Alignment



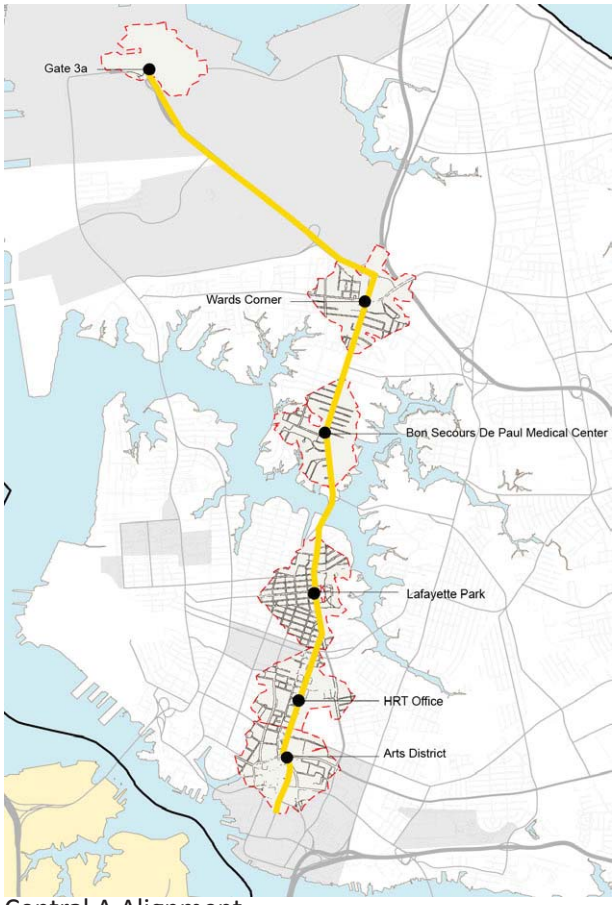
Eastern B Alignment

- Bus Stop
- 1/2 Mile Station Service Area
- Central B
- Central C
- Eastern B
- City Boundary
- Station Location

Sidewalks within station service areas

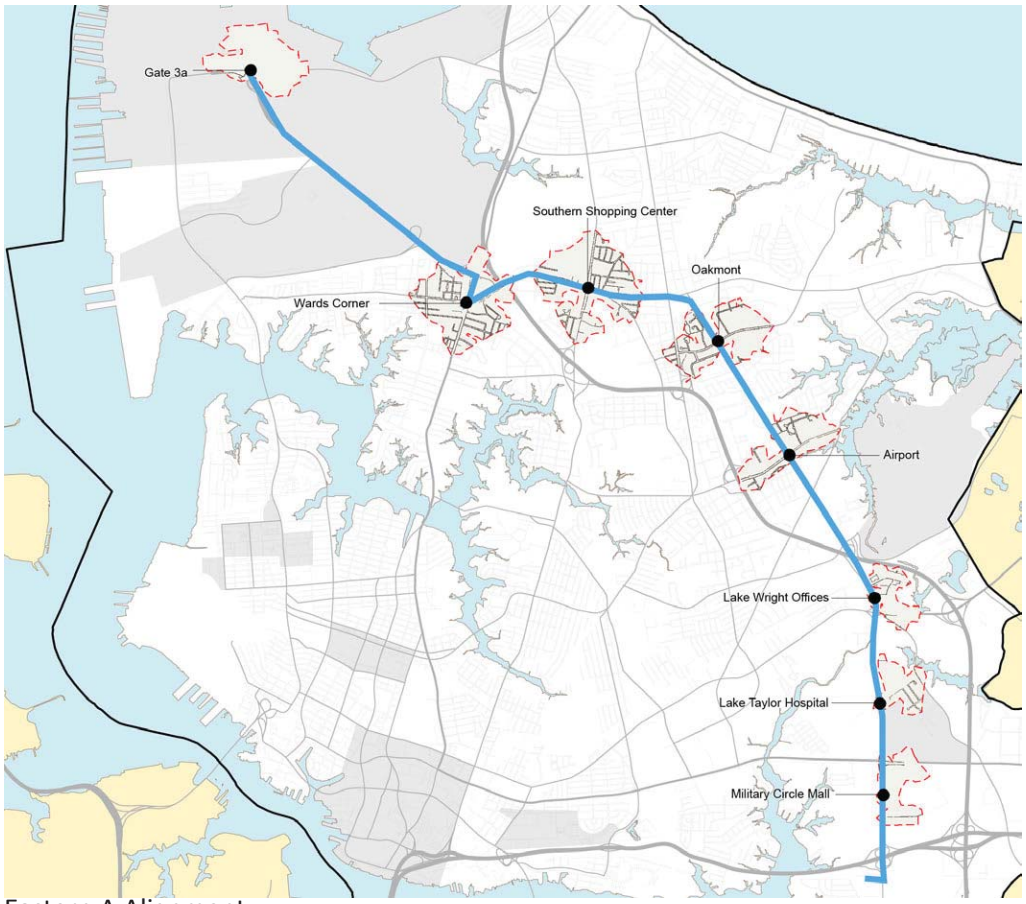


Western Alignment



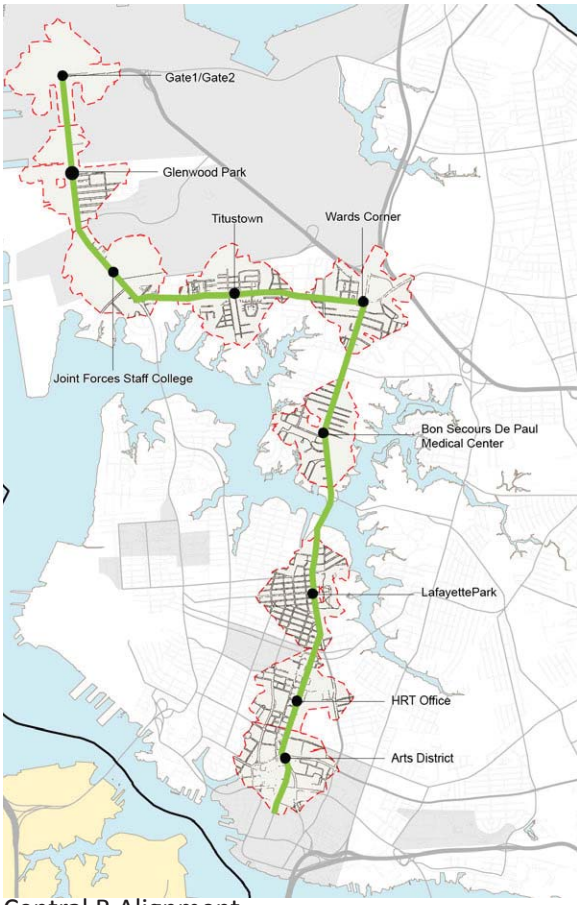
Central A Alignment

- Sidewalks
- Sidewalks within 1/2 Mile Service Area from Stations
- 1/2 Mile Station Service Area
- Western
- Central A
- Eastern A
- City Boundary
- Station Location



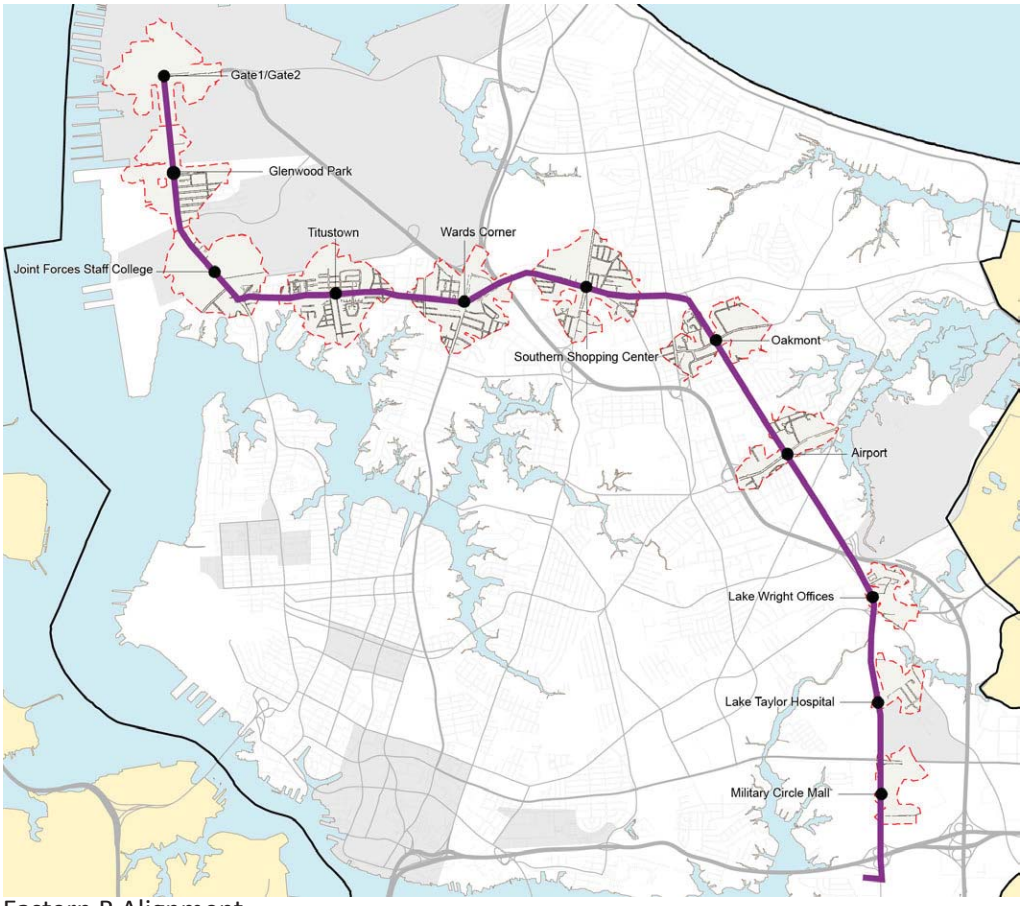
Eastern A Alignment

Sidewalks within station service areas



Central B Alignment

Central C Alignment



Eastern B Alignment

Sidewalks

Sidewalks within 1/2 Mile Service Area from Stations

1/2 Mile Station Service Area

Central B

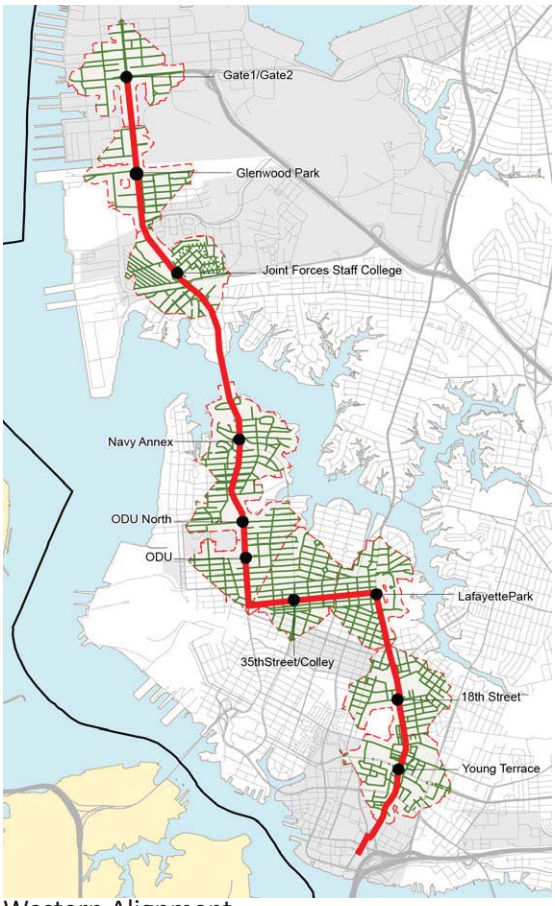
Central C

Eastern B

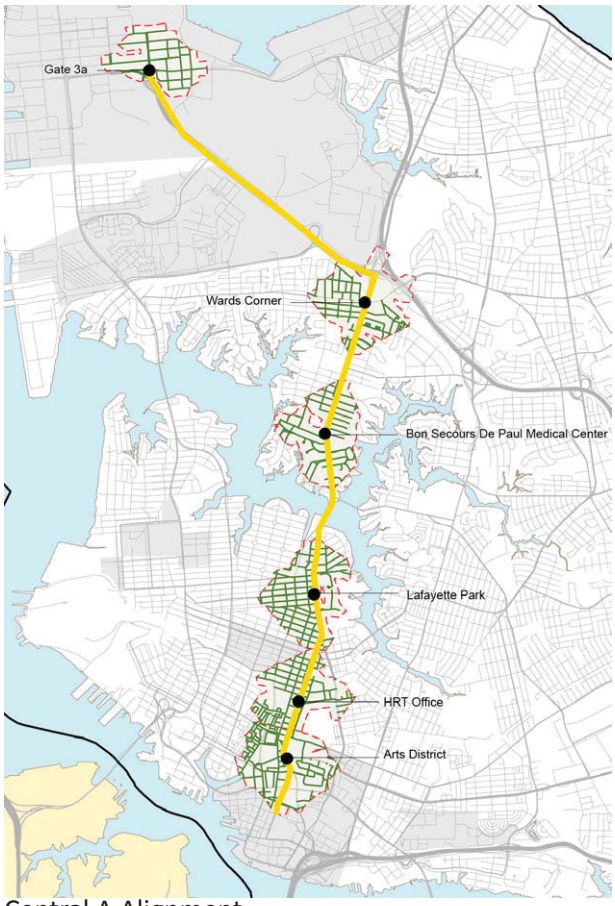
City Boundary

Station Location

Bicycle-friendly Streets



Western Alignment



Central A Alignment

Streets

Streets with under 25 MPH Posted Speed-Limit within 1/2 Mile Service Area from Stations

1/2 Mile Station Service Area

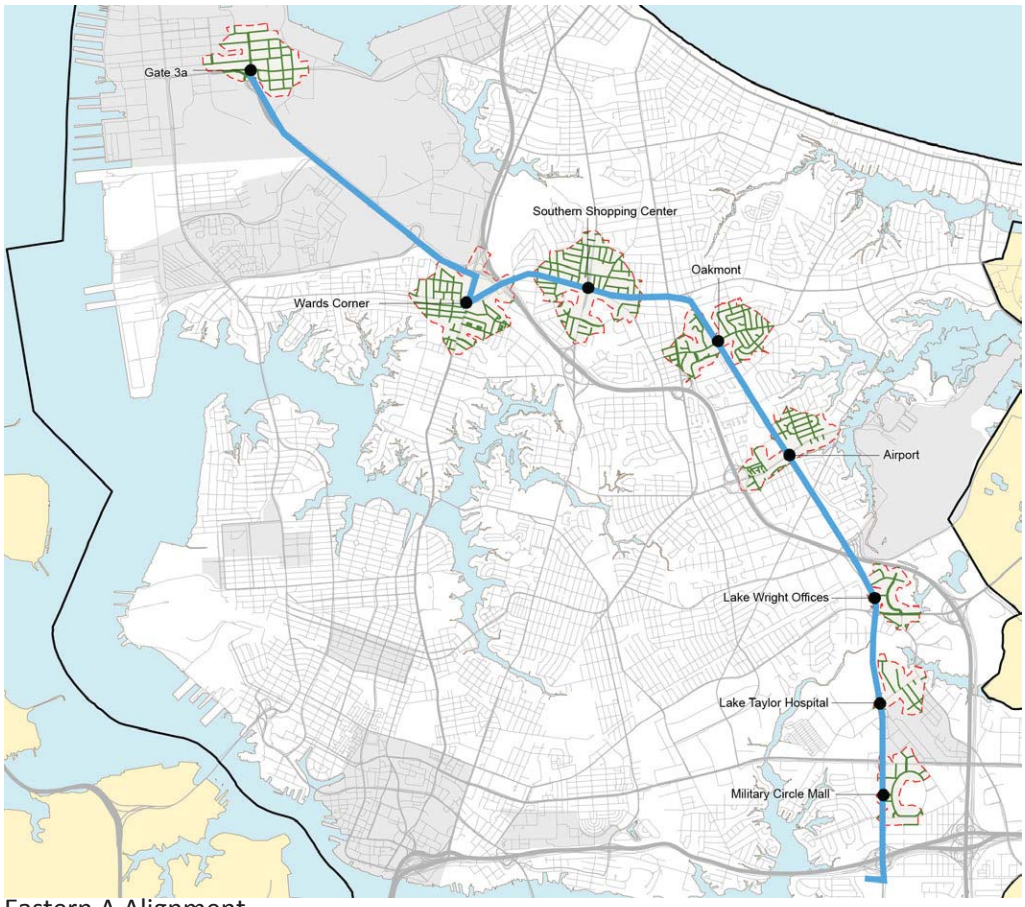
Western

Central A

Eastern A

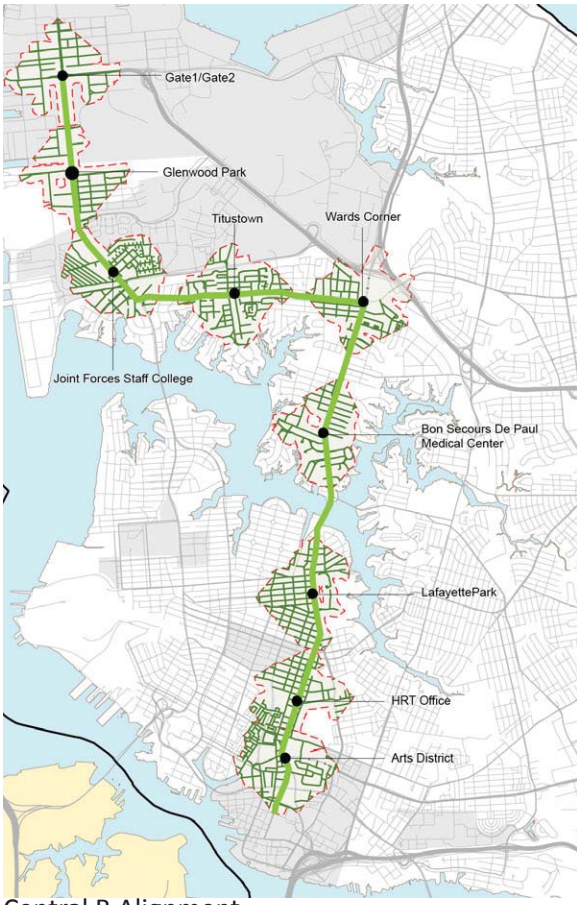
City Boundary

Station Location



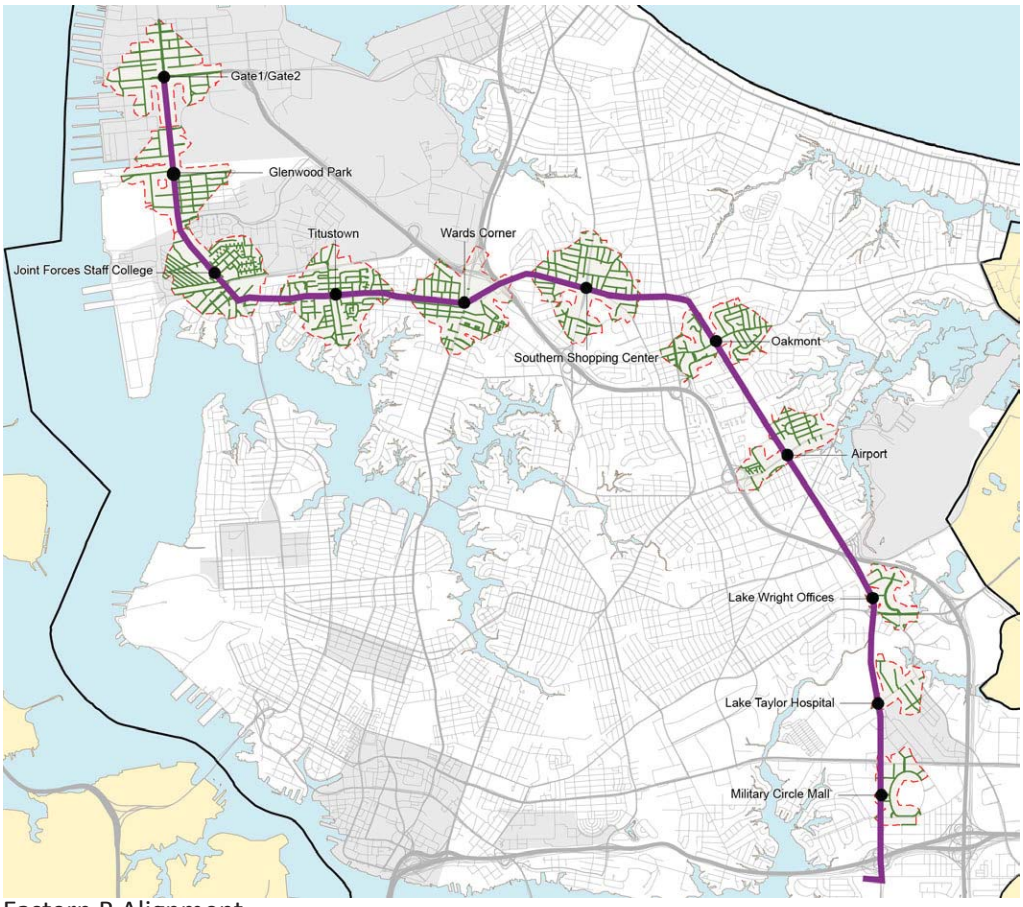
Eastern A Alignment

Bicycle-friendly Streets



Central B Alignment

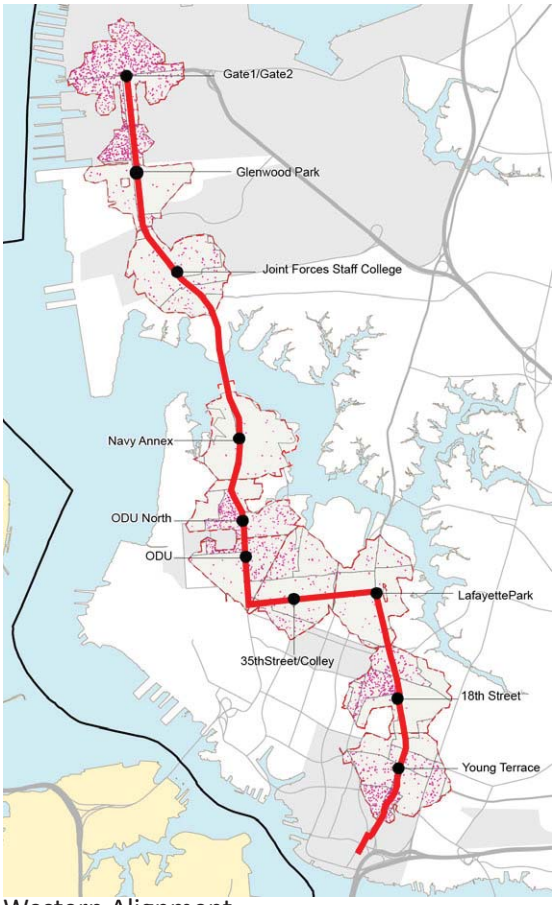
Central C Alignment



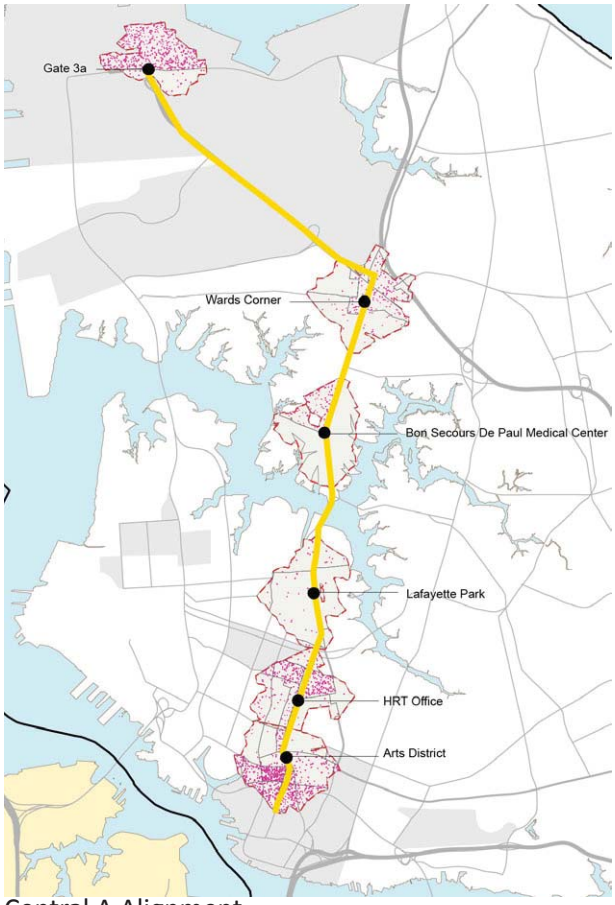
Eastern B Alignment

- Streets
- Streets with under 25 MPH Posted Speed-Limit within 1/2 Mile Service Area from Stations
- 1/2 Mile Station Service Area
- Central B
- Central C
- Eastern B
- City Boundary
- Station Location

Future jobs (2034) within station service areas



Western Alignment



Central A Alignment

1 Dot = 10 Employees

1/2 Mile Station Service Area

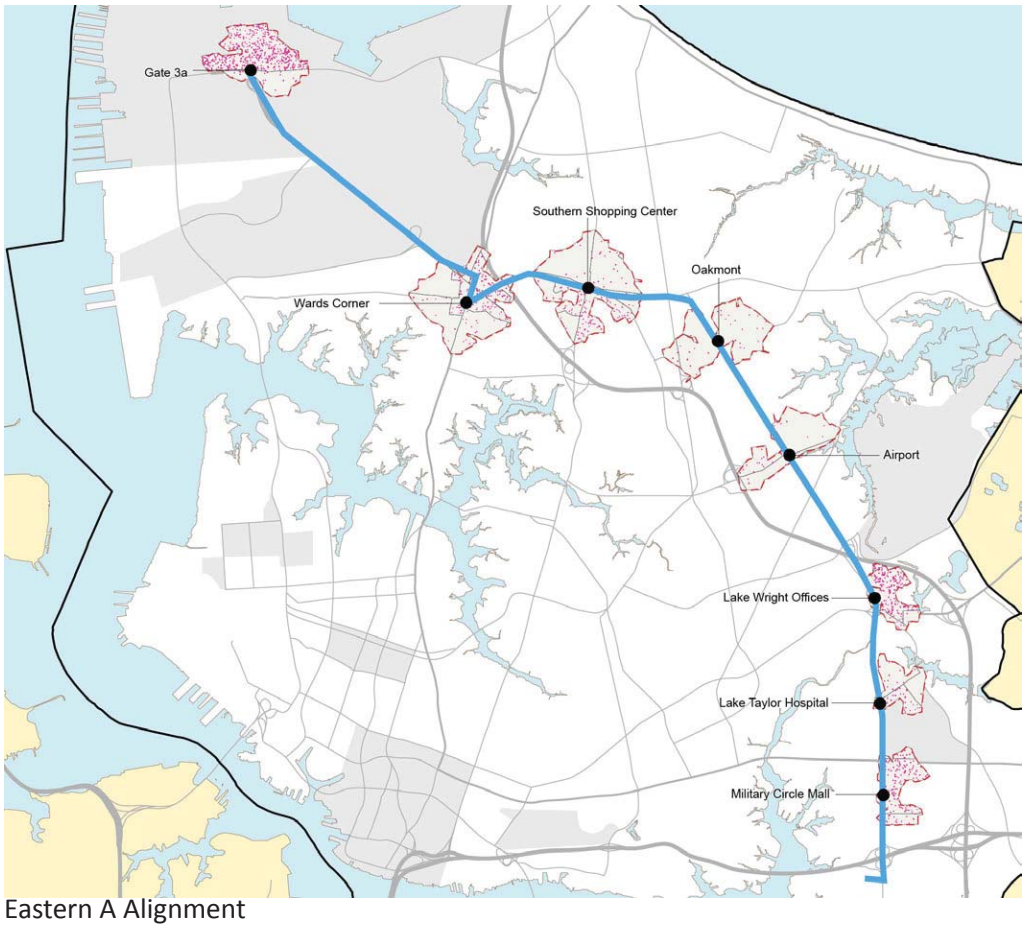
Western

Central A

Eastern A

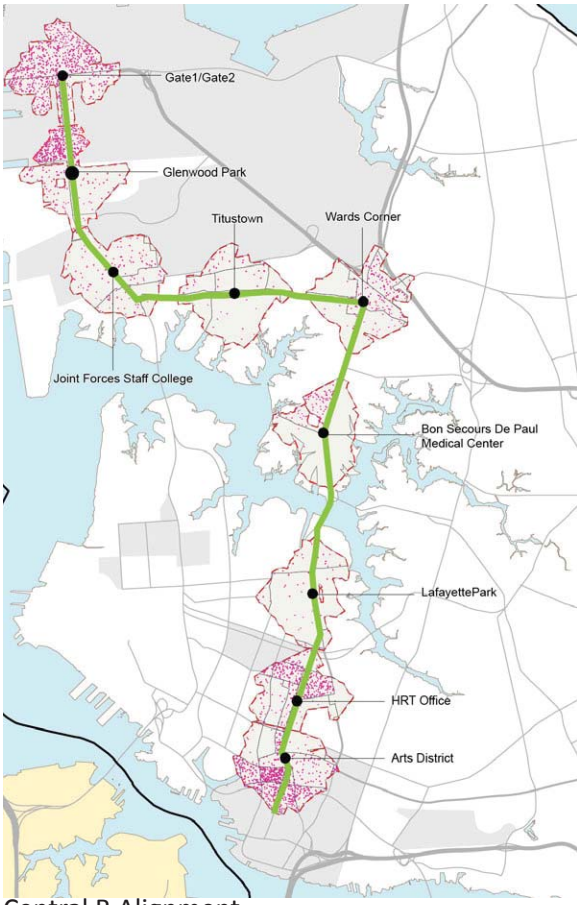
City Boundary

Station Location

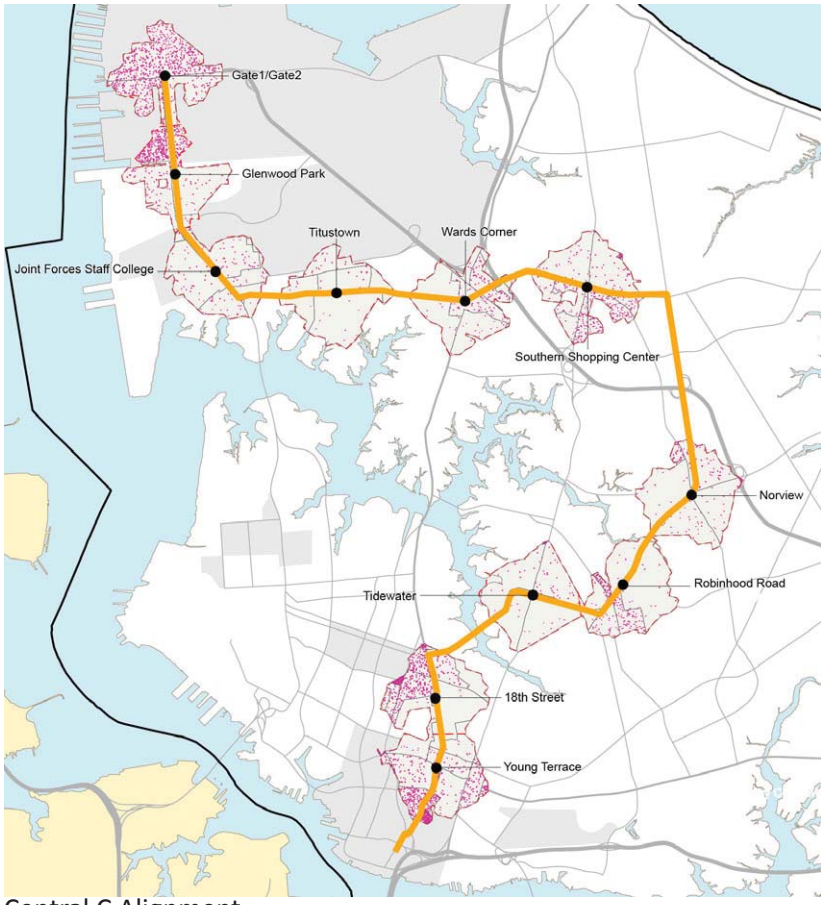


Eastern A Alignment

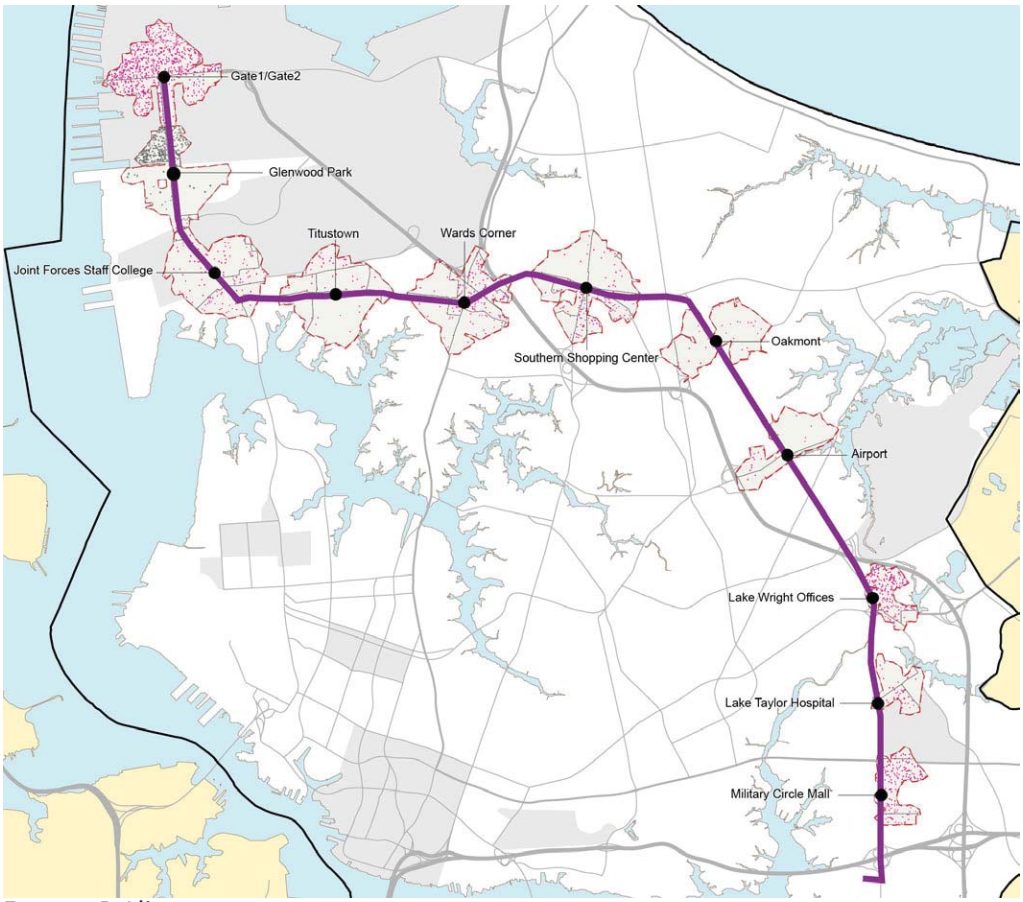
Future jobs (2034) within station service areas



Central B Alignment



Central C Alignment



Eastern B Alignment

1 Dot = 10 Employees

1/2 Mile Station Service Area

Central B

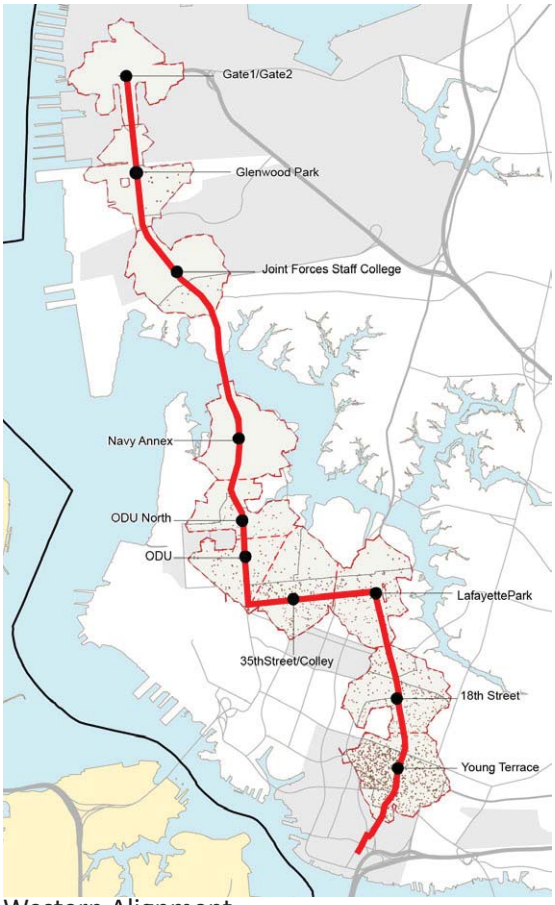
Central C

Eastern B

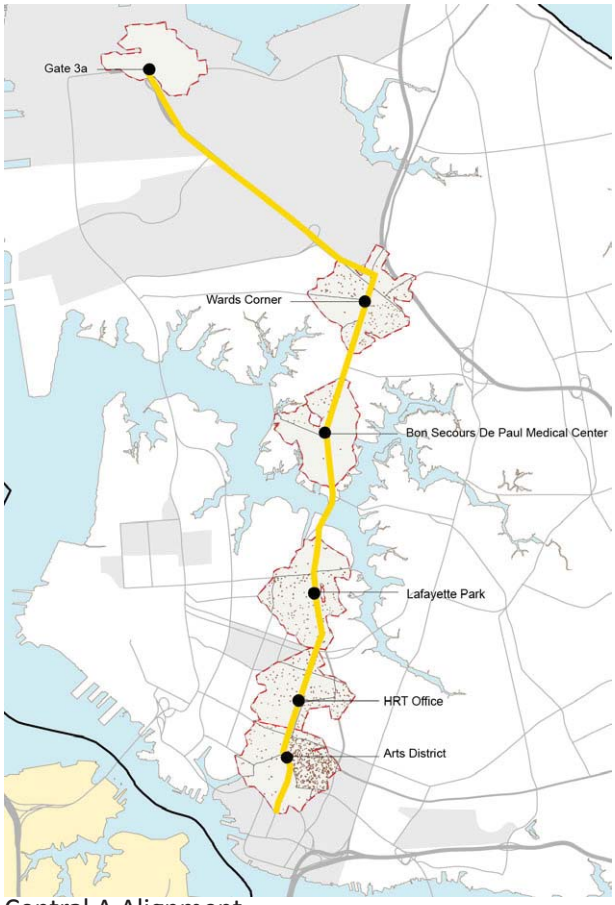
City Boundary

Station Location

Zero-car Households



Western Alignment



Central A Alignment

1 Dot = 1 Household

1/2 Mile Station Service Area

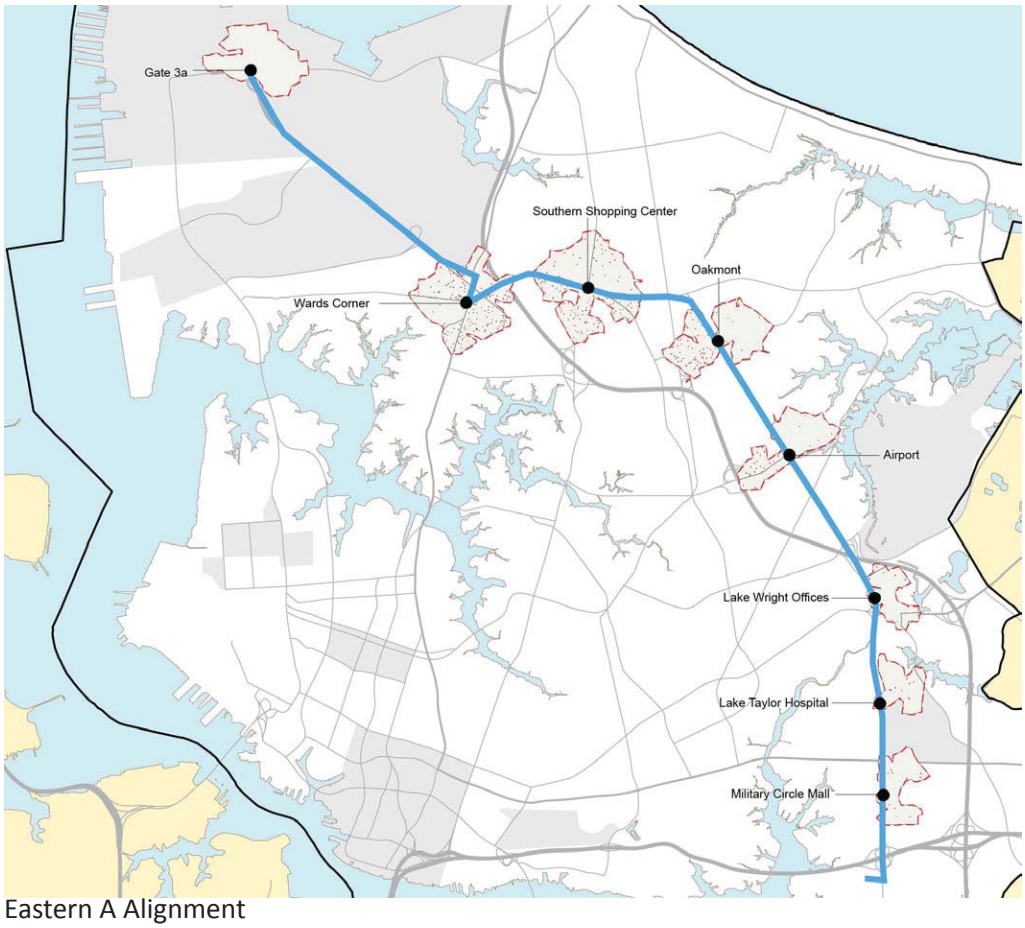
Western

Central A

Eastern A

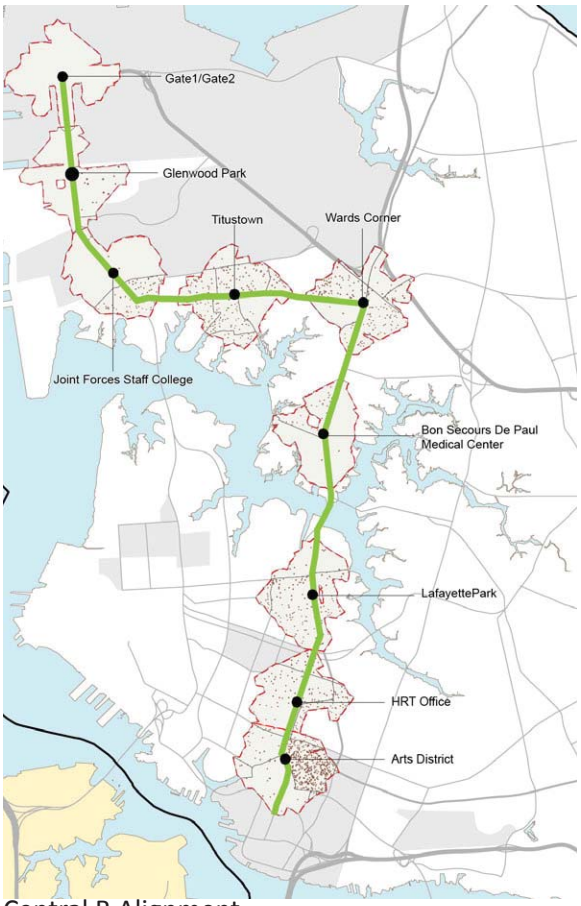
City Boundary

Station Location

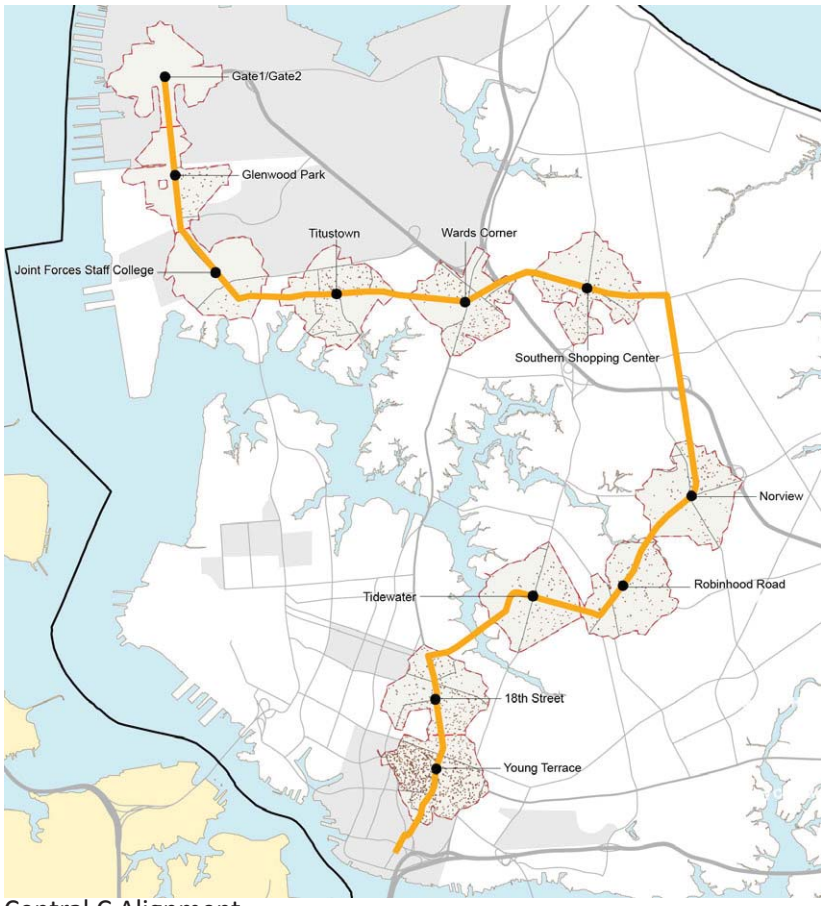


Eastern A Alignment

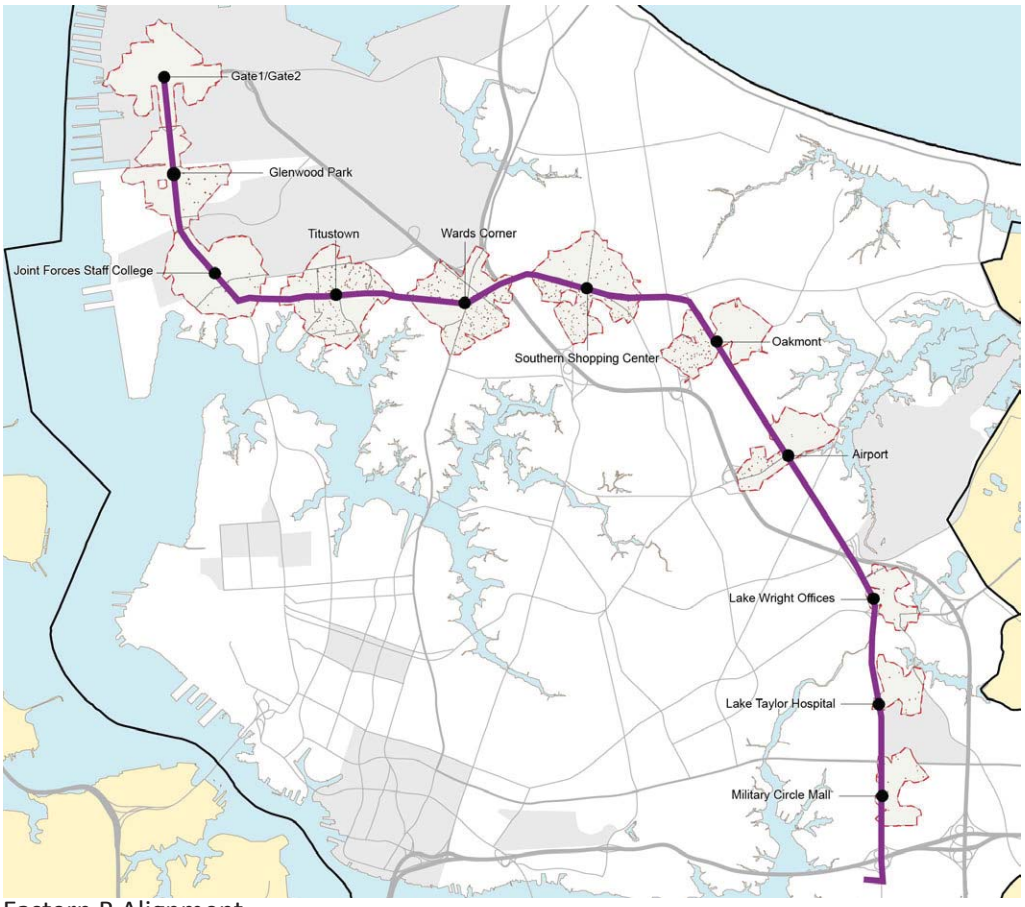
Zero-car Households



Central B Alignment



Central C Alignment



Eastern B Alignment

1 Dot = 1 Household

1/2 Mile Station Service Area

Central B

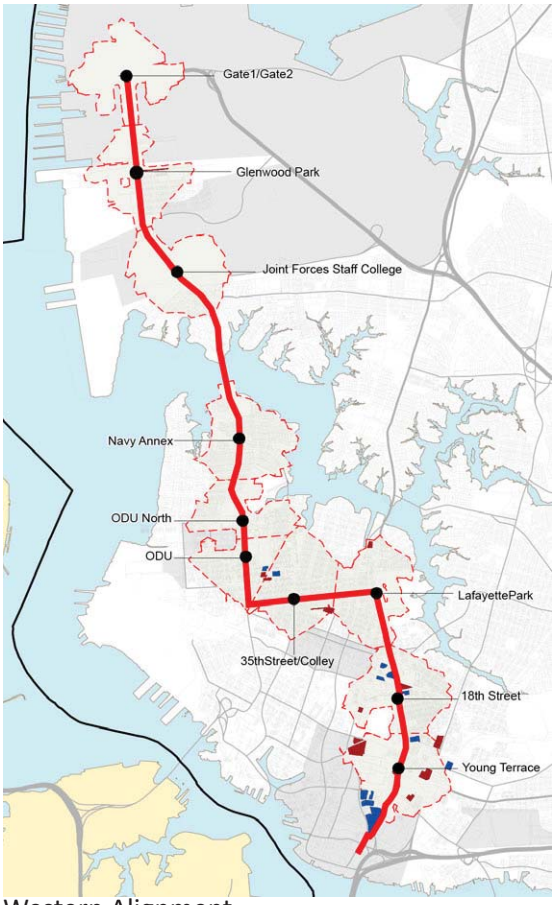
Central C

Eastern B

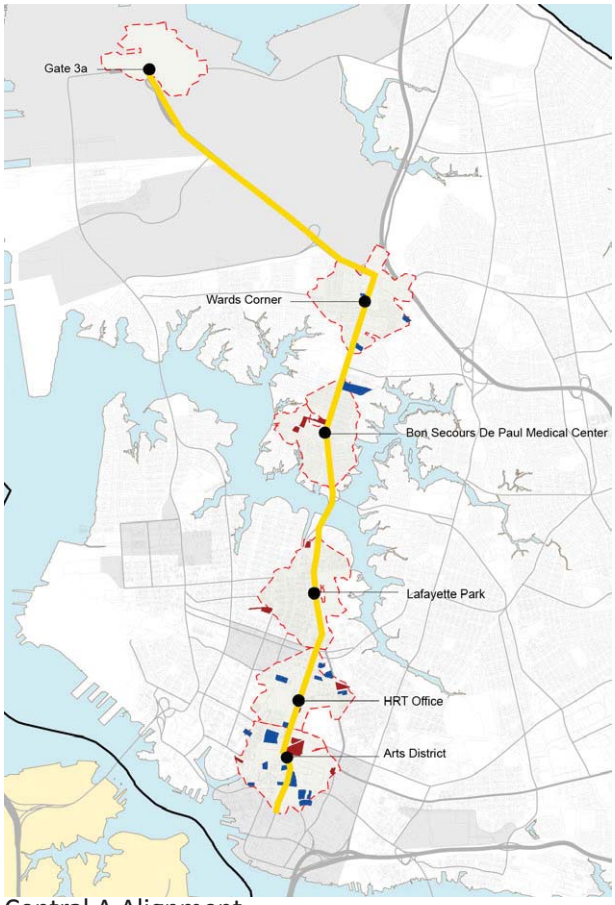
City Boundary

Station Location

Potential for Transit-oriented Development (TOD)



Western Alignment



Central A Alignment

1+ Acres Underutilized Parcels within Half-Mile Service area from stations

1+ Acres Vacant Parcels within Half-Mile Service area from stations

1/2 Mile Station Service Area

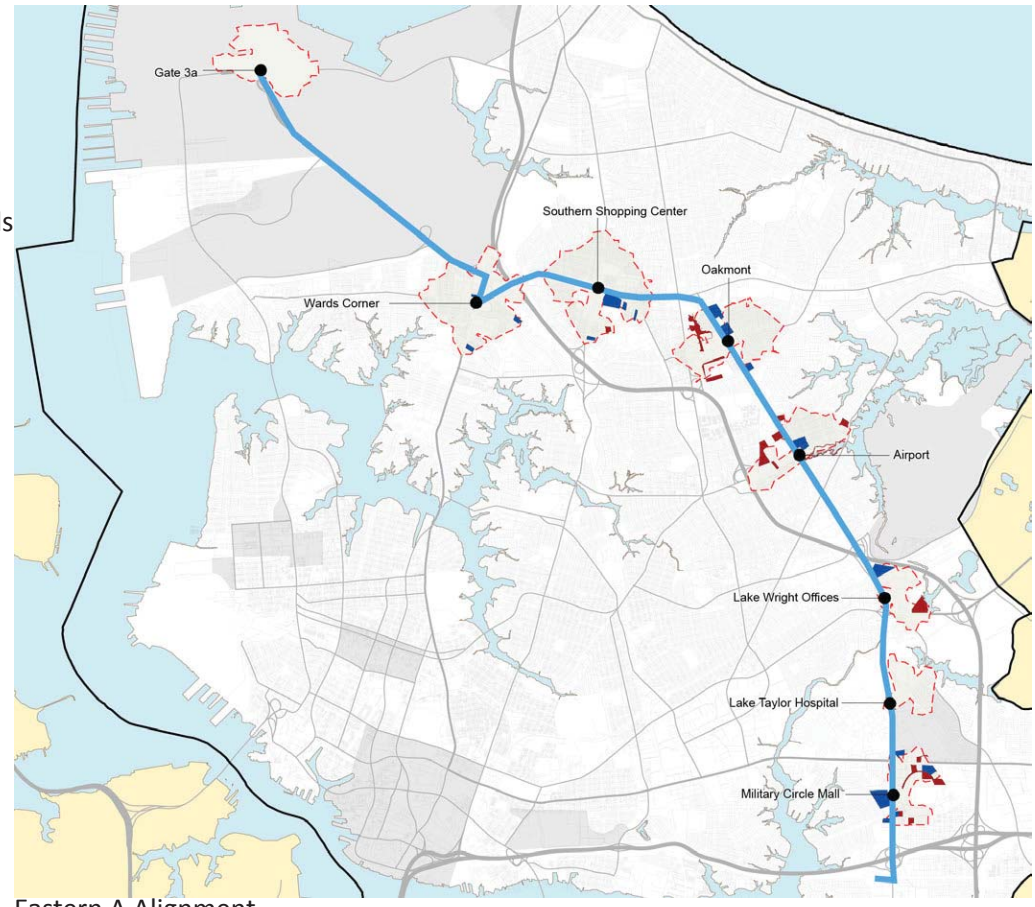
Western

Central A

Eastern A

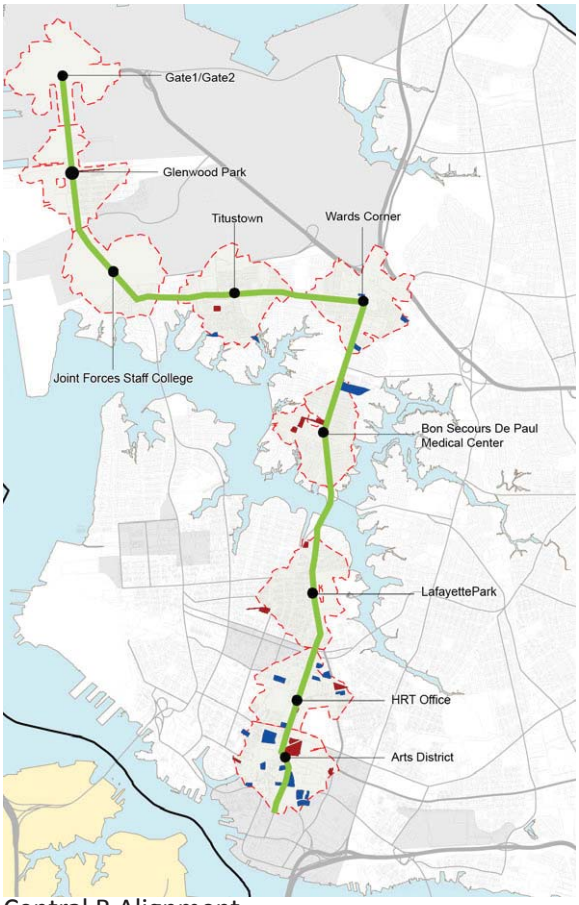
City Boundary

Station Location



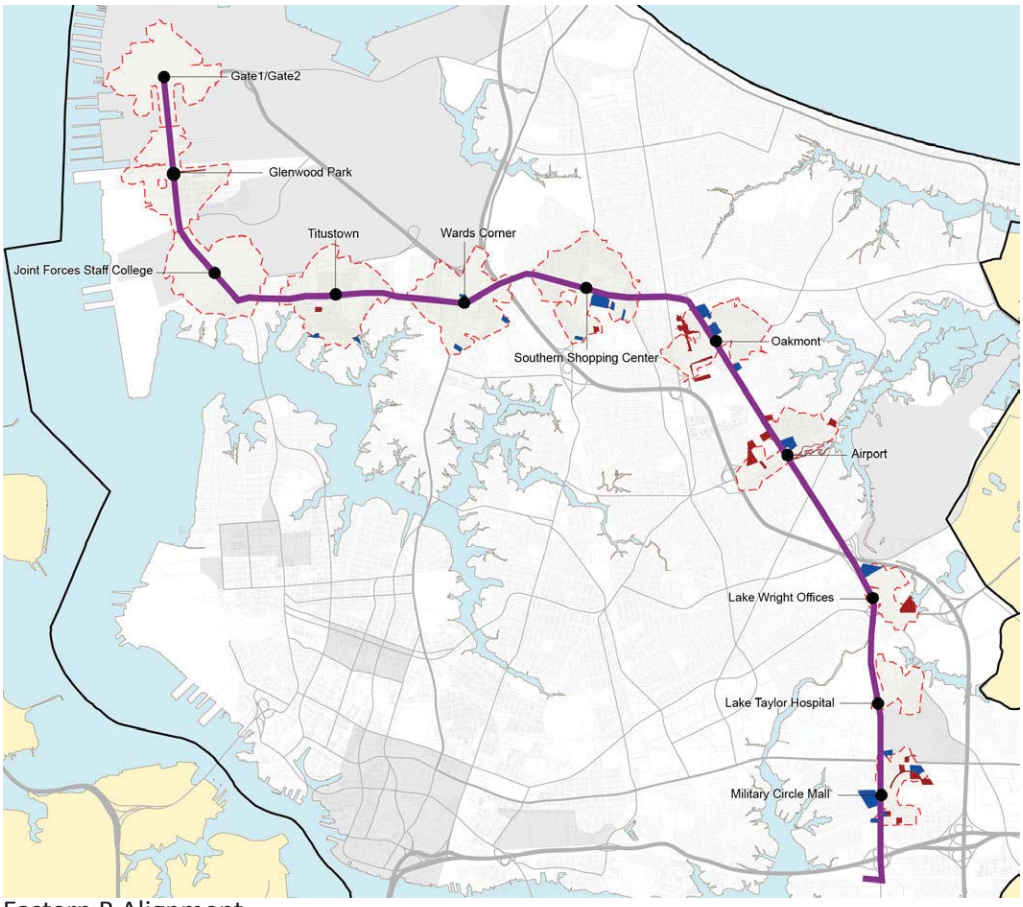
Eastern A Alignment

Potential for Transit-oriented Development (TOD)



Central B Alignment

Central C Alignment



Eastern B Alignment

1+ Acres Underutilized Parcels within Half-Mile Service area from stations

1+ Acres Vacant Parcels within Half-Mile Service area from stations

1/2 Mile Station Service Area

Central B

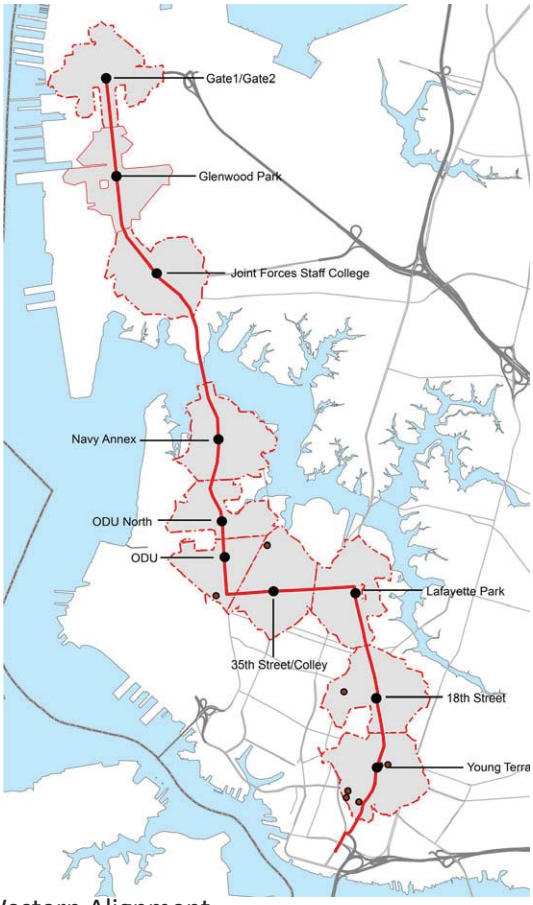
Central C

Eastern B

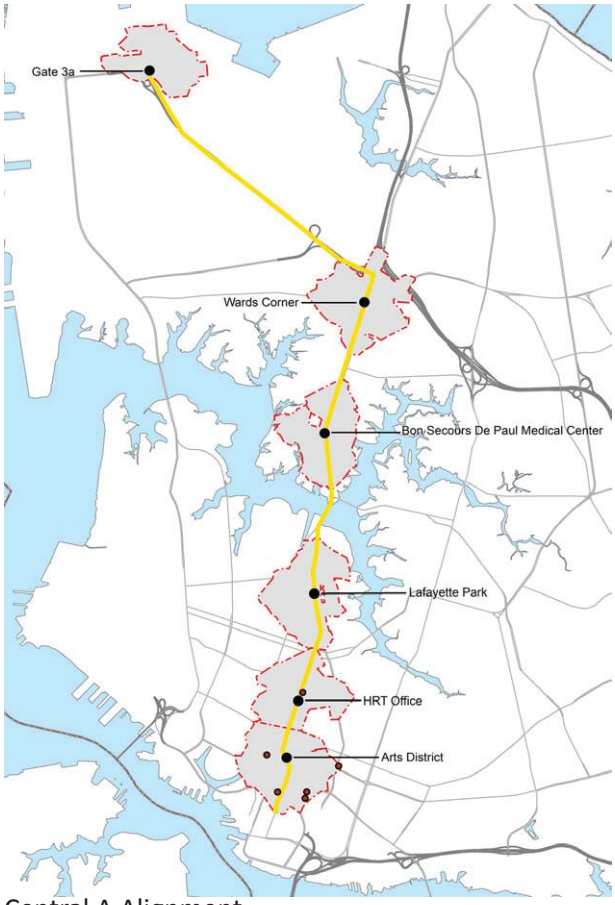
City Boundary

Station Location

Historic Structures



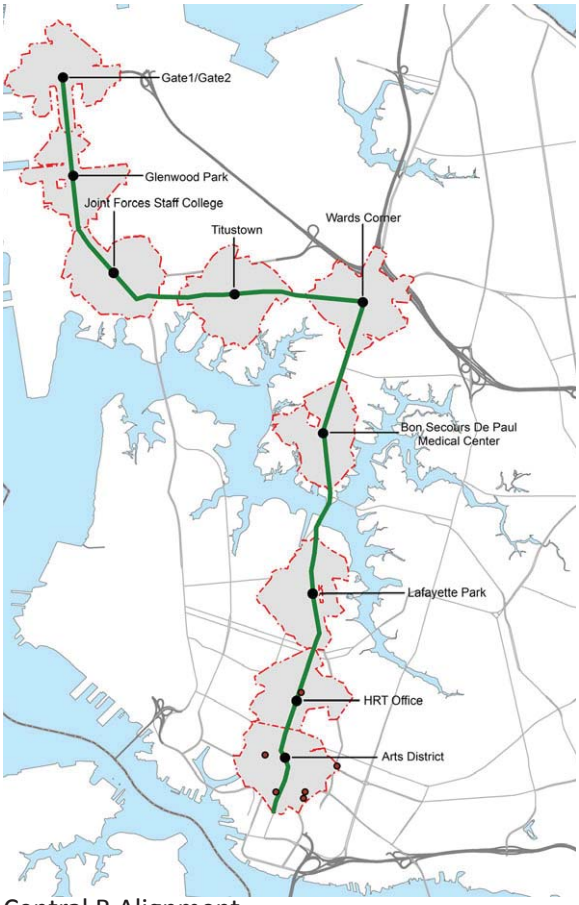
Western Alignment



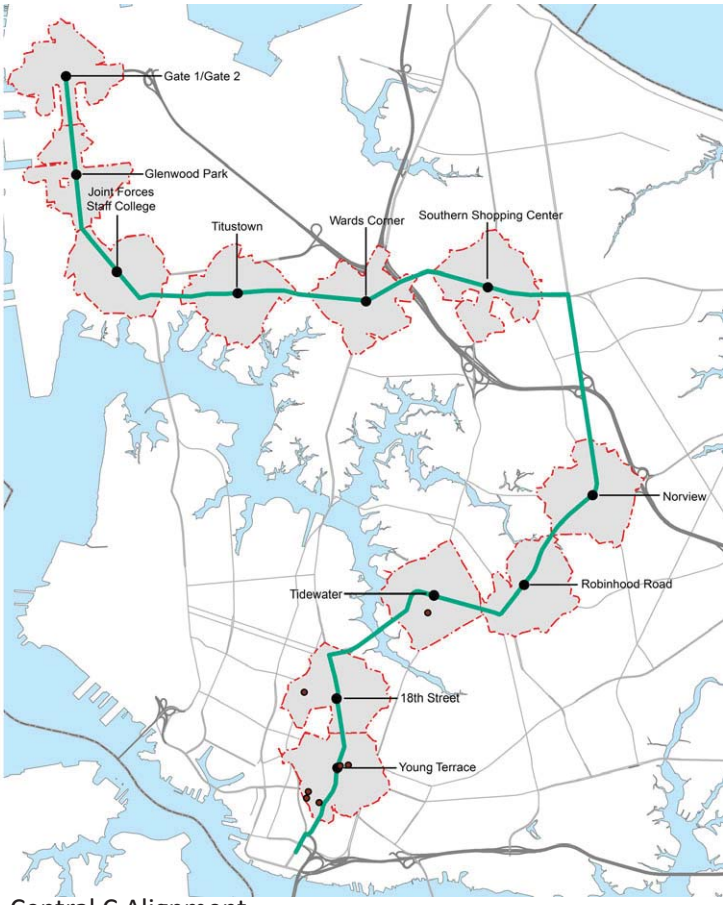
Central A Alignment

- Historic Structure within Half-Mile Service Area from Stations
- 1/2 Mile Station Service Area
- Western
- Central A
- Eastern A
- City Boundary
- Station Location

Historic Structures



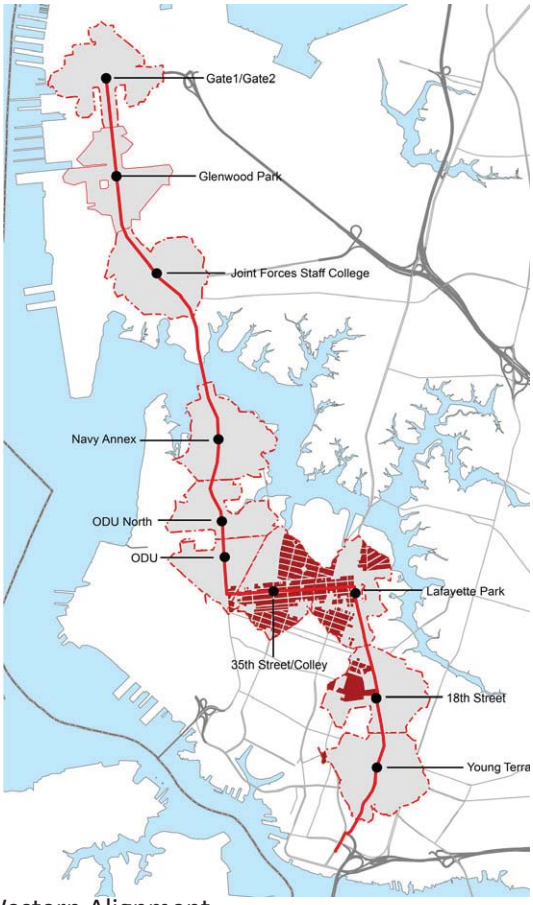
Central B Alignment



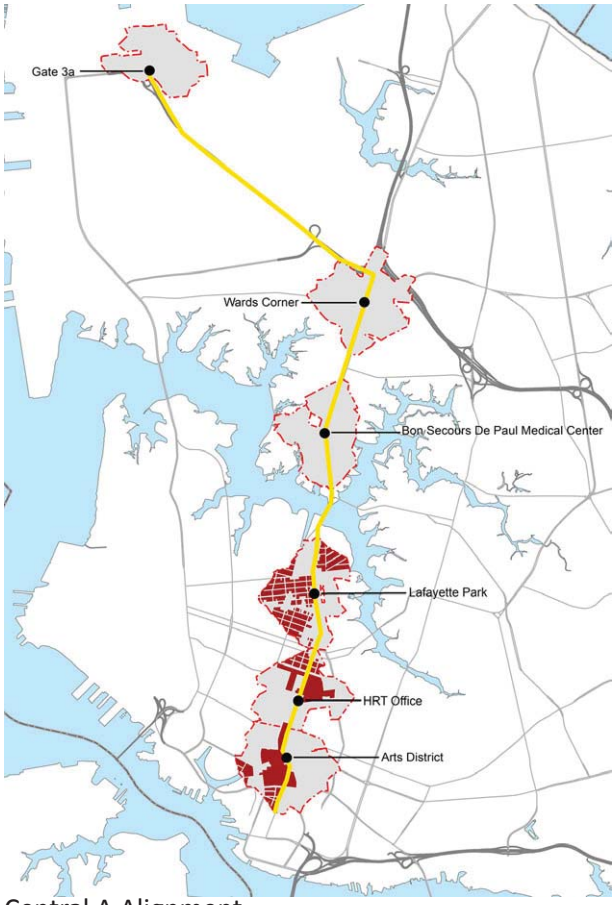
Central C Alignment

- Historic Structure within Half-Mile Service Area from Stations
- 1/2 Mile Station Service Area
- Central B
- Central C
- Eastern B
- City Boundary
- Station Location

Historic Districts



Western Alignment



Central A Alignment

Historic Districts within Half-Mile Service Area from Stations

1/2 Mile Station Service Area

Western

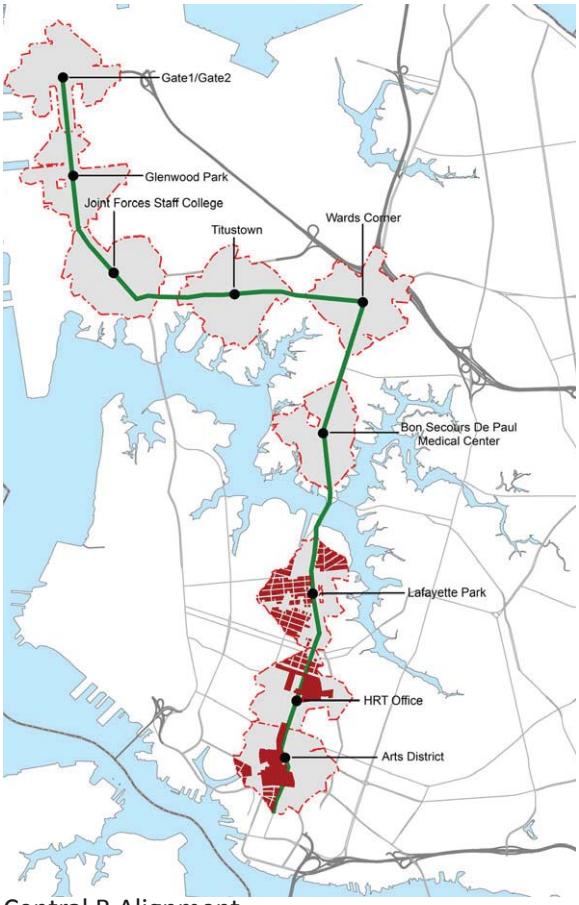
Central A

Eastern A

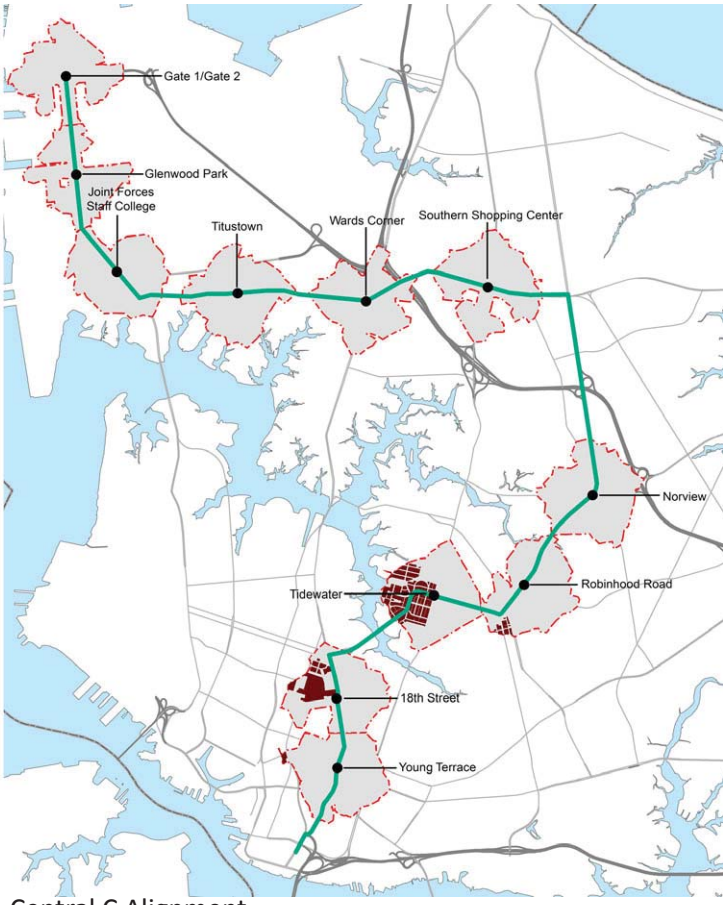
City Boundary

Station Location

Historic Districts



Central B Alignment



Central C Alignment

Historic Districts within Half-Mile Service Area from Stations

1/2 Mile Station Service Area

Central B

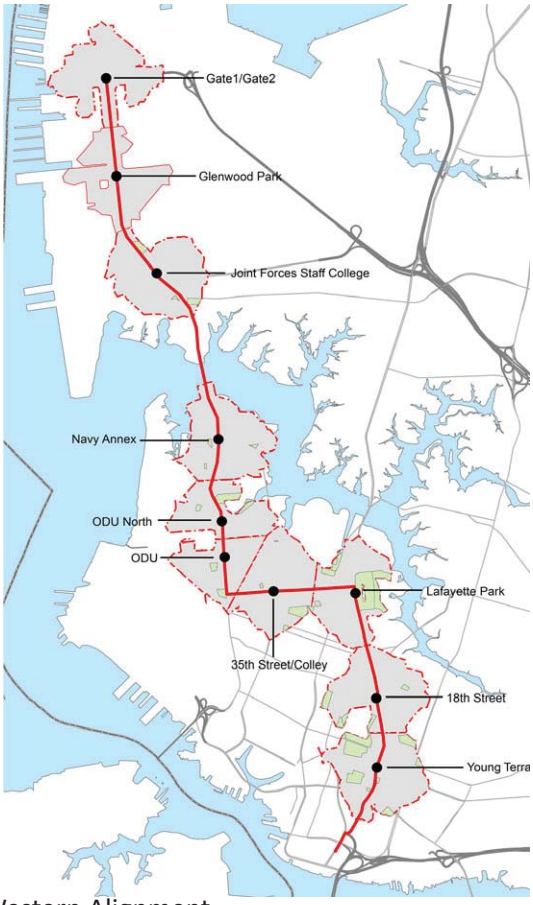
Central C

Eastern B

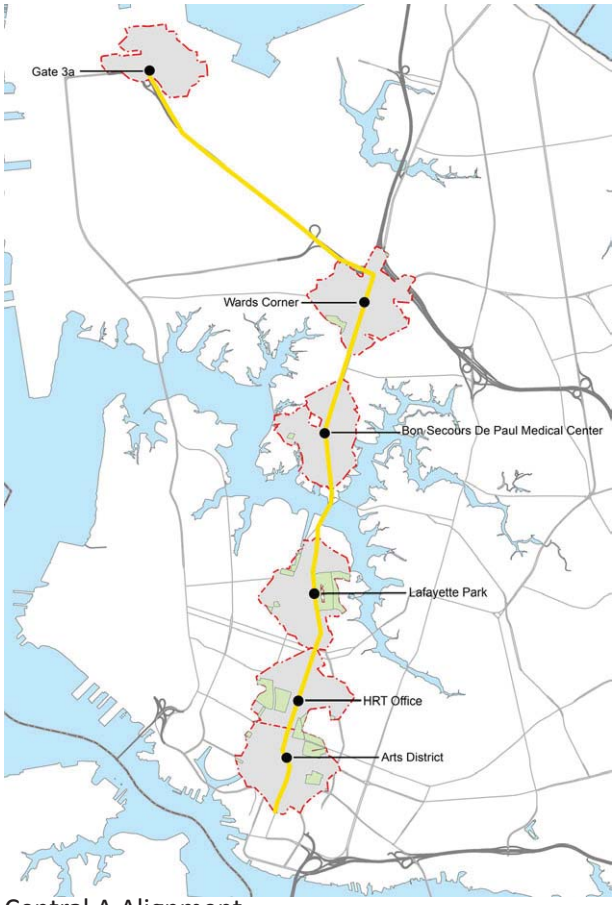
City Boundary

Station Location

Parklands



Western Alignment



Central A Alignment

Parks within Half-Mile Service Area from Stations

1/2 Mile Station Service Area

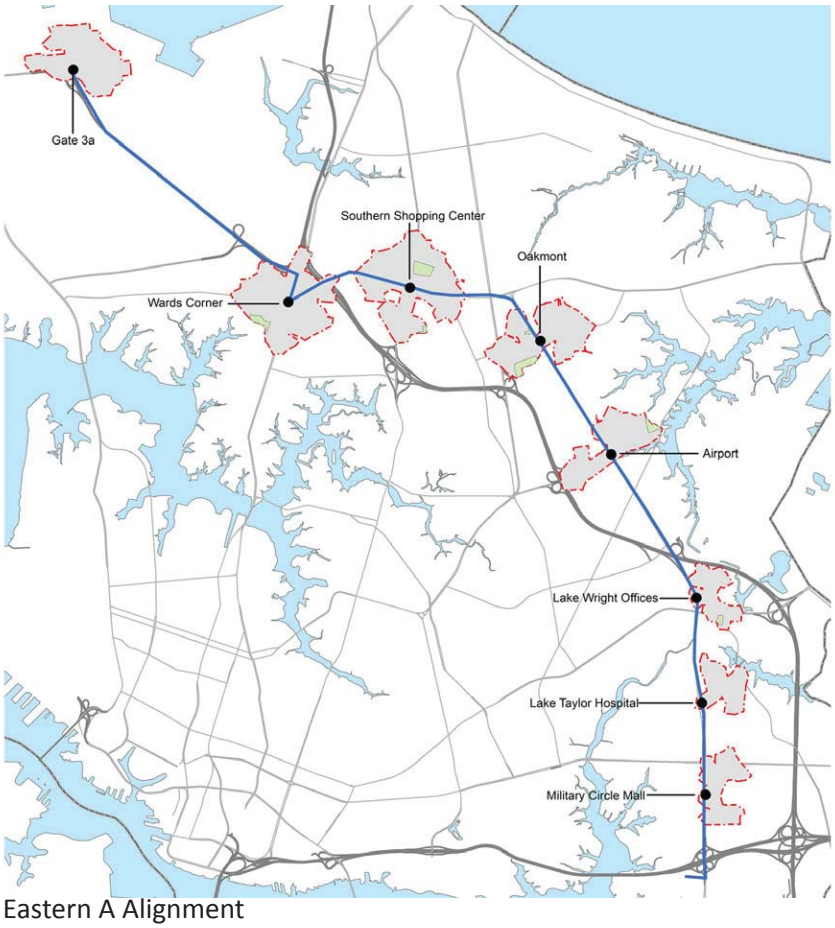
Western

Central A

Eastern A

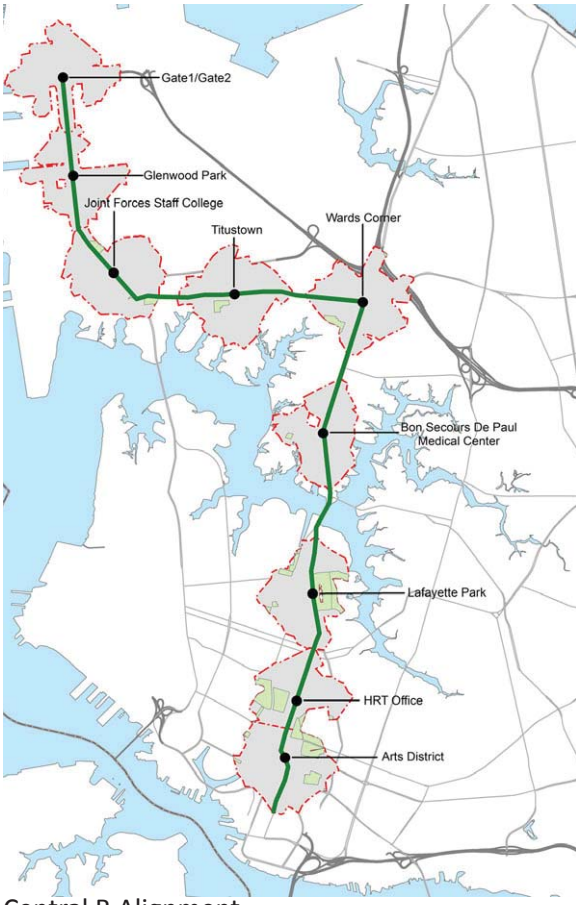
City Boundary

Station Location

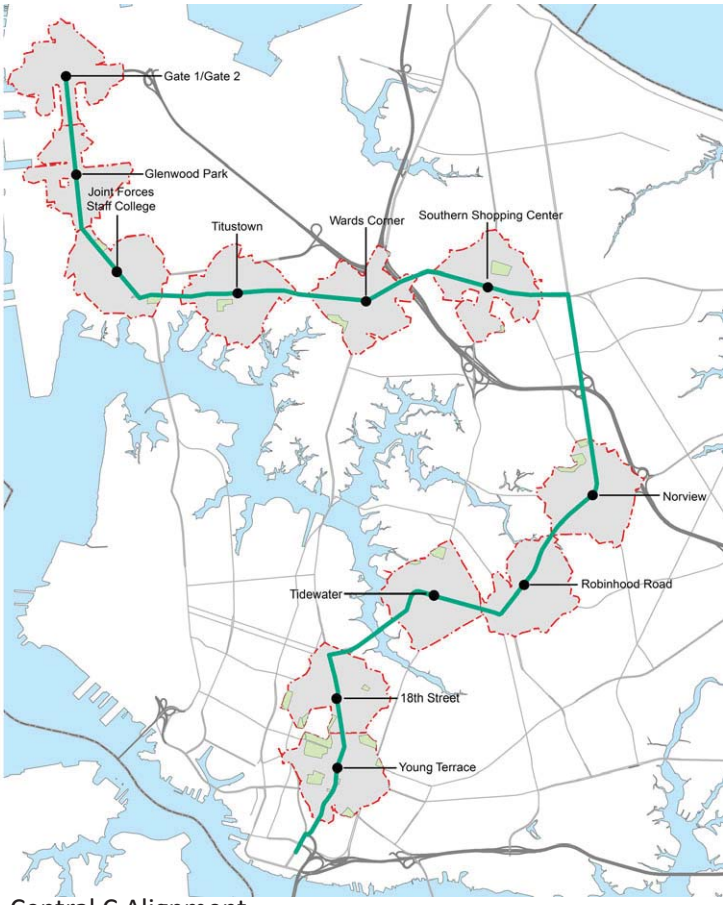


Eastern A Alignment

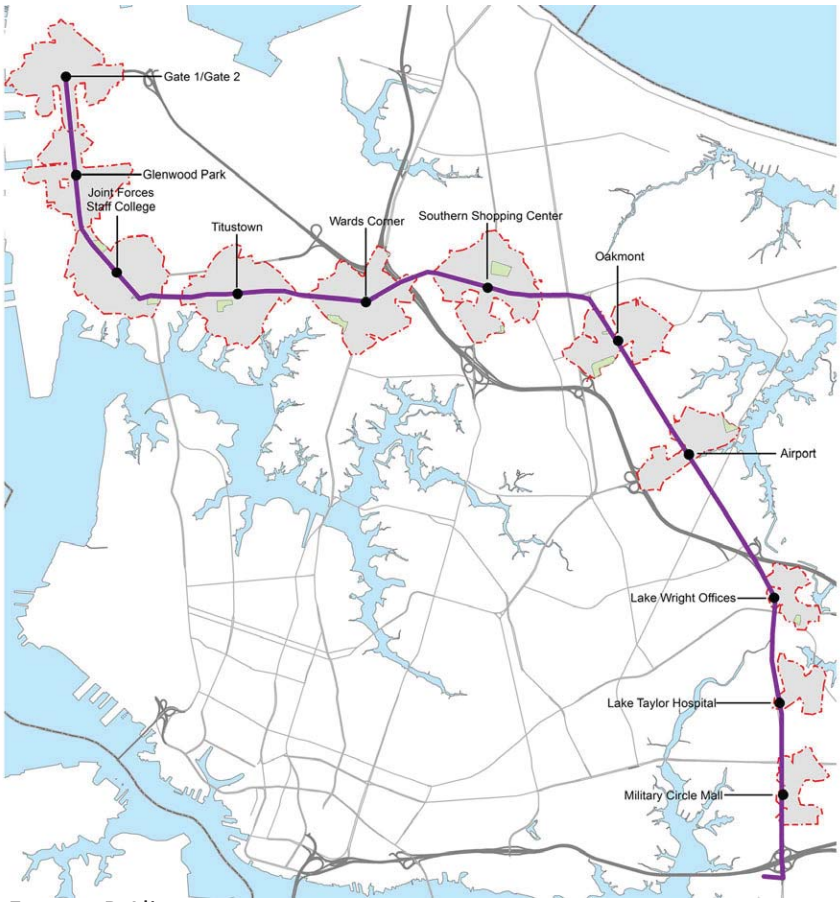
Parklands



Central B Alignment



Central C Alignment



Eastern B Alignment

Parks within Half-Mile Service Area from Stations

1/2 Mile Station Service Area

Central B

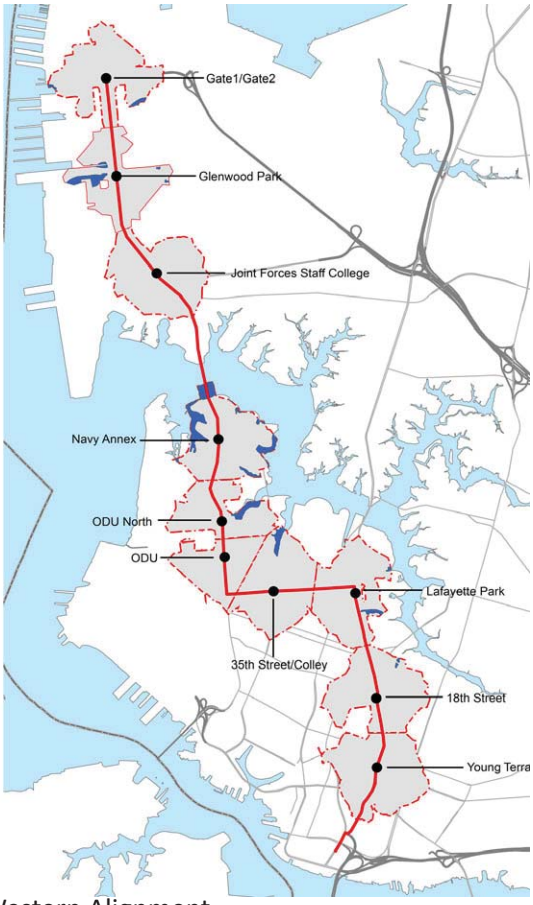
Central C

Eastern B

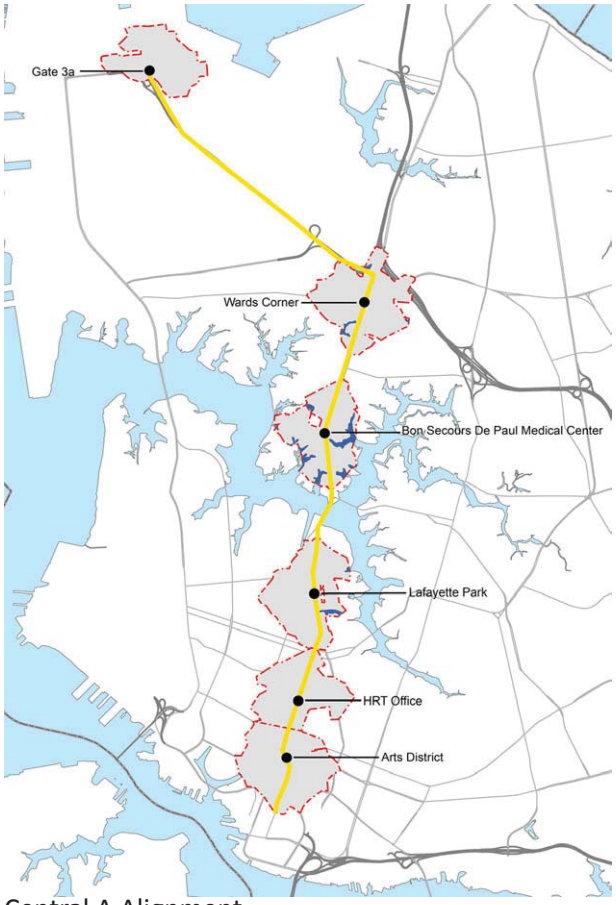
City Boundary

Station Location

Wetlands



Western Alignment



Central A Alignment

Wetlands within Half-Mile Service Area from Stations

1/2 Mile Station Service Area

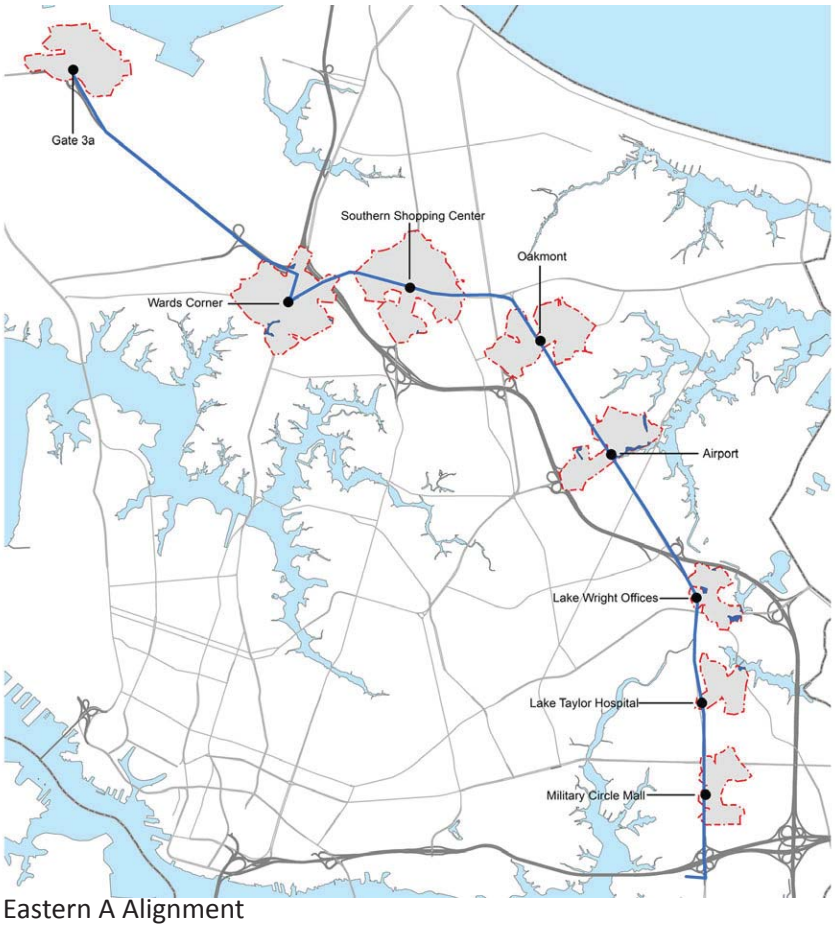
Western

Central A

Eastern A

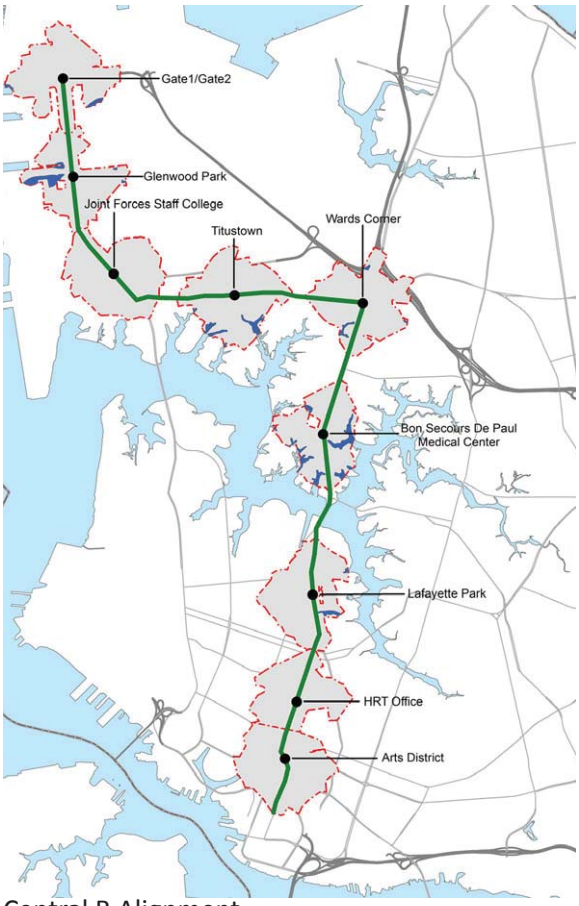
City Boundary

Station Location

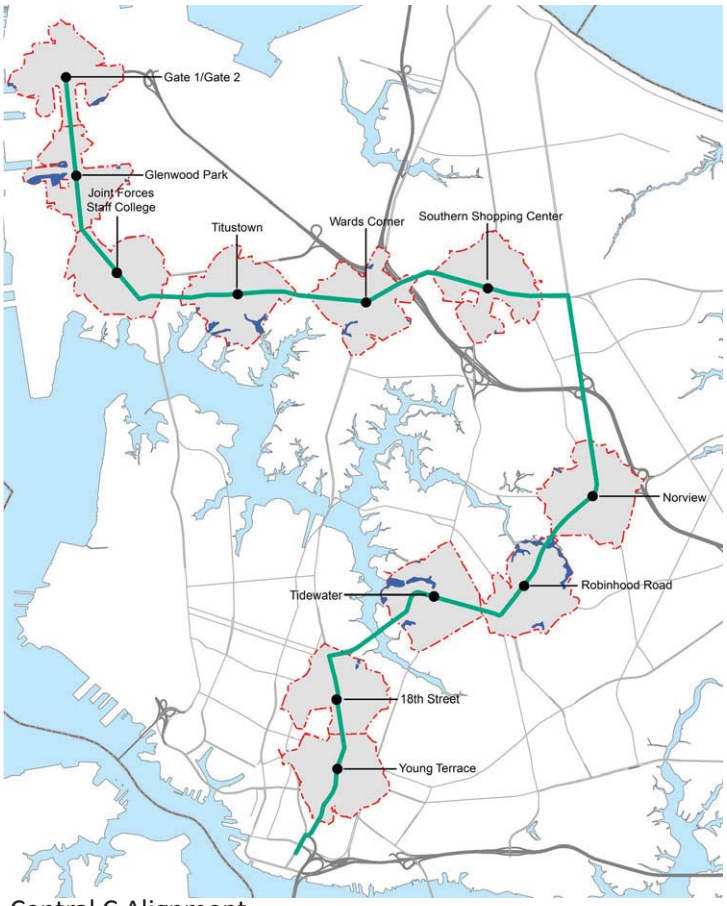


Eastern A Alignment

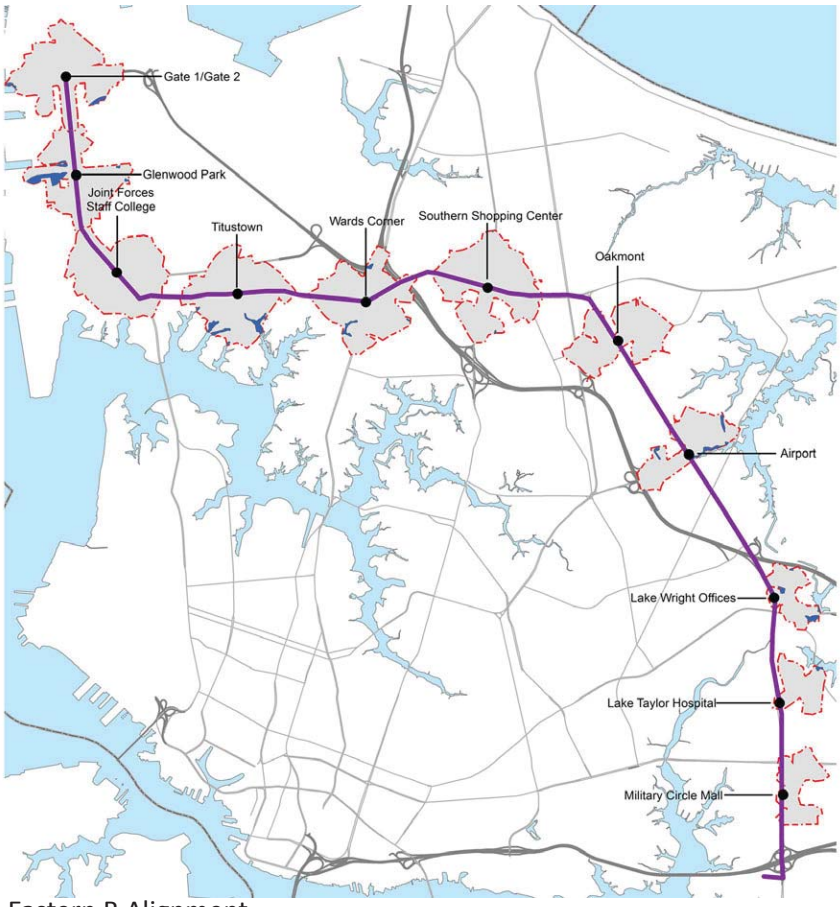
Wetlands



Central B Alignment



Central C Alignment



Eastern B Alignment

Wetlands within Half-Mile Service Area from Stations

1/2 Mile Station Service Area

Central B

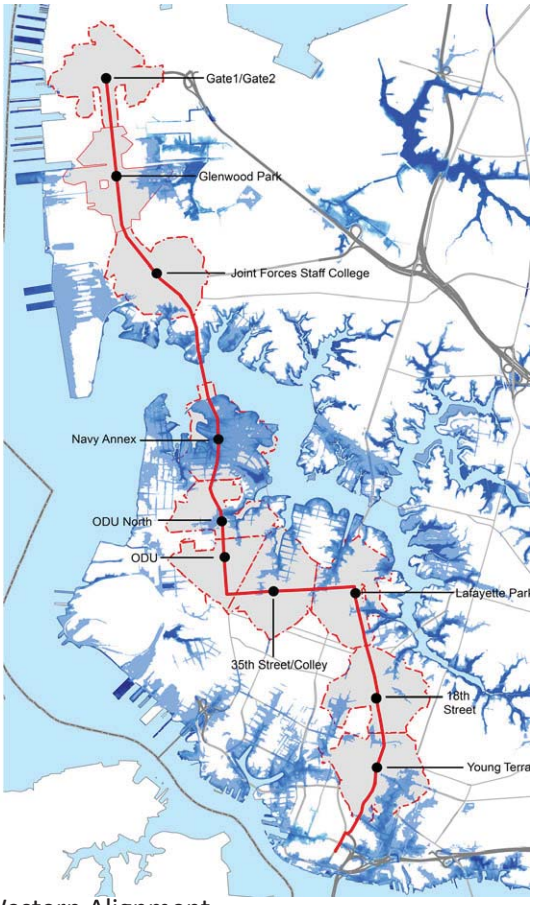
Central C

Eastern B

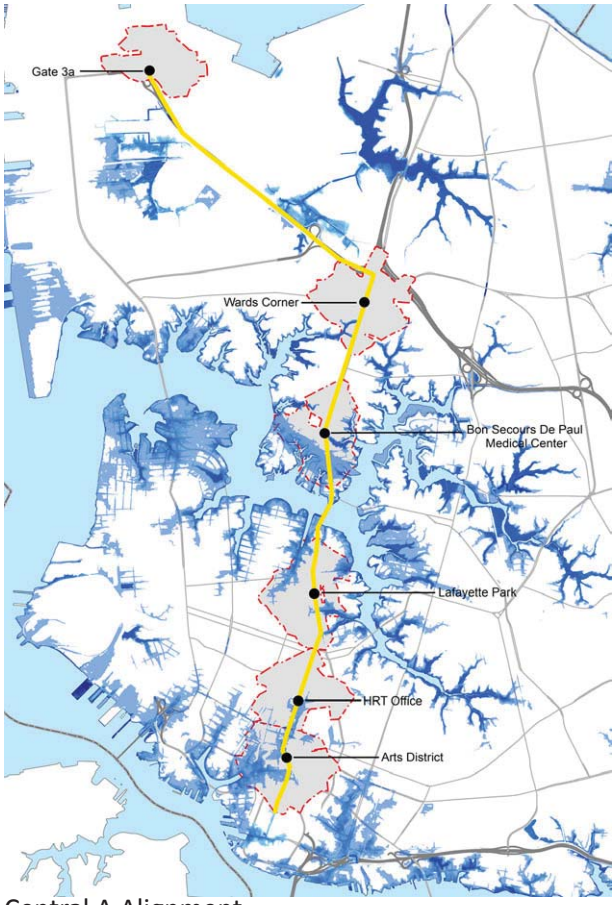
City Boundary

Station Location

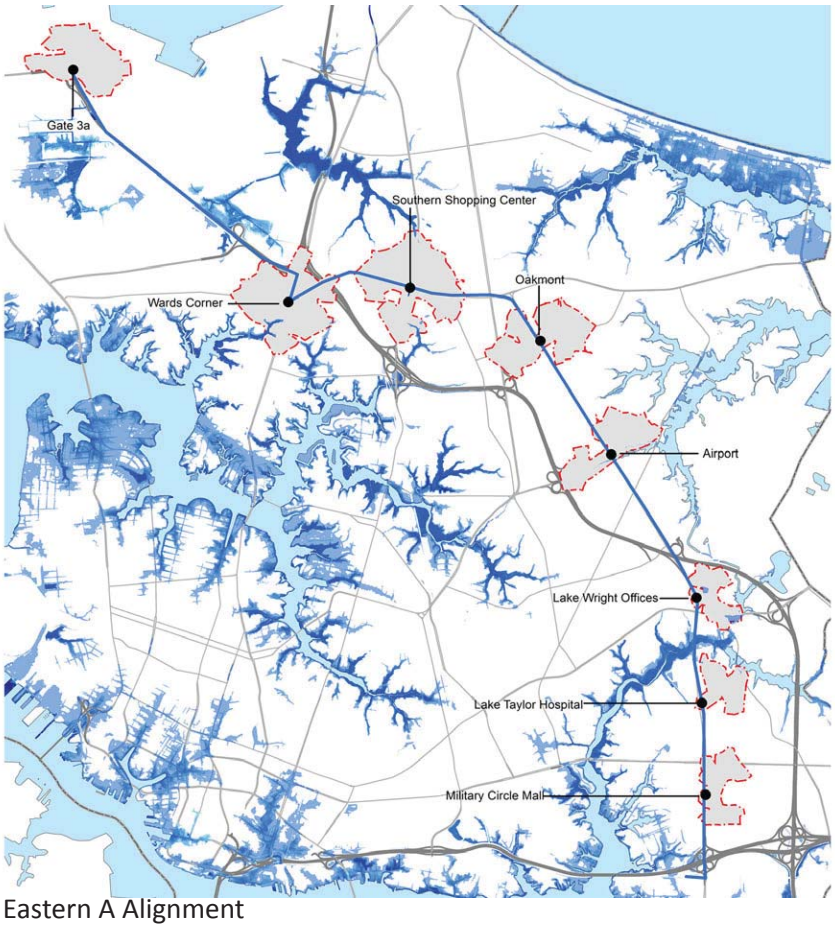
Resiliency



Western Alignment



Central A Alignment



Eastern A Alignment

100 Year Flood Zone

1/2 Mile Station Service Area

Western

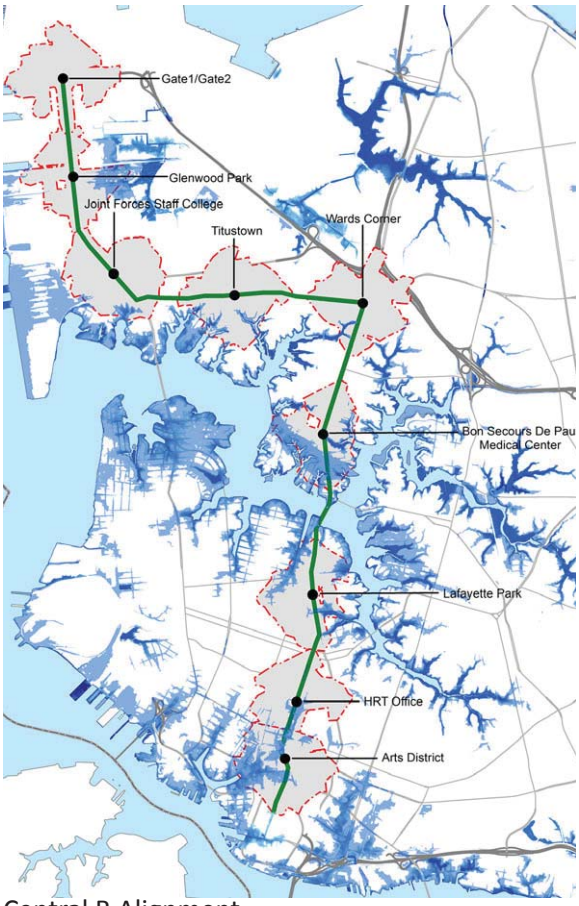
Central A

Eastern A

City Boundary

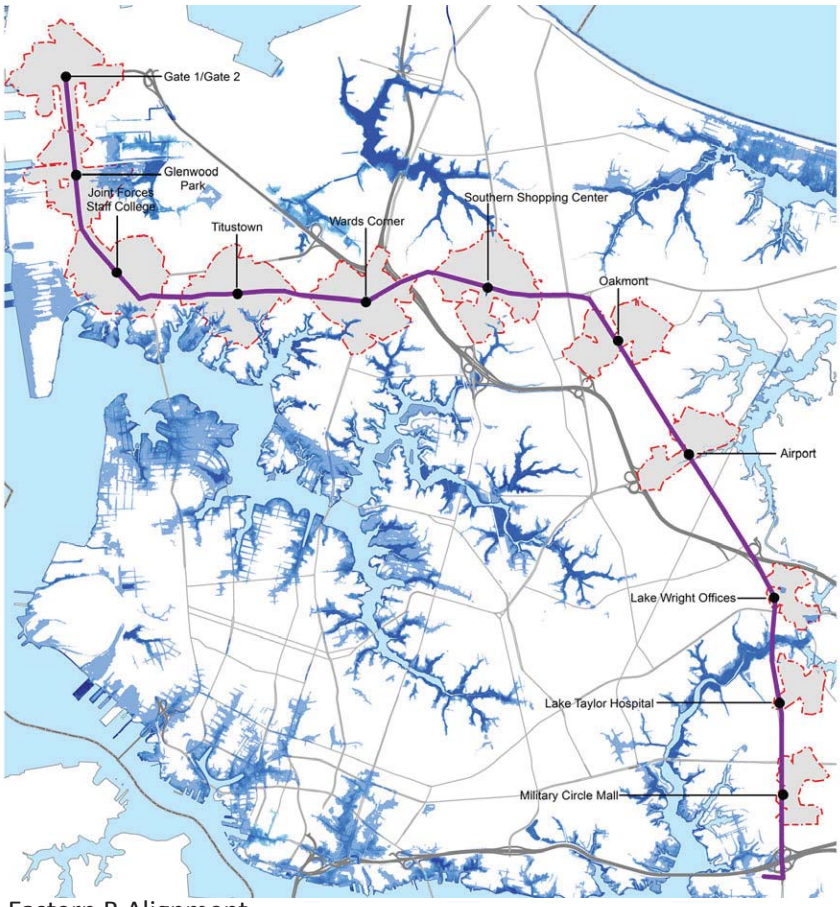
Station Location

Resiliency

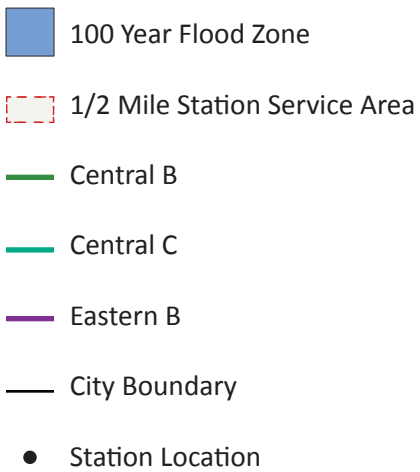


Central B Alignment

Central C Alignment



Eastern B Alignment



APPENDIX E
TRAFFIC ANALYSIS METHODOLOGY

Segment Analysis Methodology

Roadway segments that comprised parts of the six alignments were evaluated using a planning-level analysis. Areas with excess capacity (indicating the potential for the removal of one or more lanes to facilitate a transit alignment) were identified from the calculated volume-to-capacity ratio. The approach for the segment analysis includes the following steps:

1. **Obtain Annual Average Daily Traffic (AADT) data.** The AADTs for each of the alignment segments are contained in the *Volumes, Speeds, and Congestion on Major Roadways in Hampton Roads*, dated June 2013 and provided by HRTPO. The vast majority of the AADTs provided in this report were collected by VDOT in 2011. Most of the segments were partitioned into two or more sub-segments in the HRTPO report, and the remaining steps in this procedure were accordingly performed for each sub-segment.
2. **Determine the lane configuration for each segment.** The number of lanes on each sub-segment was obtained from aerial photographs such as those found on Google Earth.
3. **Estimate the generalized hourly service volume.** Chapter 16 of the Highway Capacity Manual (HCM) 2010 contains a planning-level analysis for urban street facilities. The estimated bidirectional hourly service volumes during the peak hours were computed for each sub-segment based on the following traffic characteristics:
    - AADTs – the generalized daily service volume
    - K-factor – the proportion of the AADT that occurs during the heaviest-traveled hour of the day. The K-factor typically ranges between 0.09 and 0.11 (which corresponds to 9 and 11 percent of the AADT). While most of the sub-segments experience the greatest traffic demand during either the morning or afternoon rush hour, the K-factor is calculated to consider all hours of the day. For example, some sub-segments could experience the greatest traffic demand during the lunch hour or early afternoon (corresponding to school hours).

    While the existing HCM methodology yields the level of service based on computed daily service volumes (Exhibit 16-24 on page 16-27), this methodology uses a more detailed analysis procedure to estimate the volume-to-capacity (v/c) ratios. The v/c ratio is a proportion of the total bidirectional hourly volume divided by the total bidirectional hourly capacity, ranges from 0.00 to 1.00 for baseline conditions, and is a typical measurement of "how full" a roadway is. V/C ratios greater than 1.00 indicates a roadway that operates over capacity. The assumed K-factors are based on VDOT and field-collected traffic count data.
4. **Compute the volume-to-capacity (v/c) ratio for each segment.** The capacity of each sub-segment was computed based on the number of lanes and an ideal saturation flow rate of 1,900 passenger cars per hour per lane (pcphpl). Saturation flow rate represents a baseline number of vehicles that can traverse a one-lane segment of roadway during a one hour period, without adjustments for other factors (HCM Chapter 18, page 18-35). HCM adjustment factors that were applied to the ideal saturation flow rate included the following:
    - Lane width
    - Proportion of heavy vehicles

- Area type (central business district)
- Parking maneuvers
- Bus blockages

The adjustment factors above are described in the HCM signalized intersections methodology (Chapter 18, pages 18-35 through 18-37), but they can be applied to the segment capacity analysis because they are based on traffic flows and conditions, not intersection elements. These factors were chosen because their input values can be obtained from the existing traffic count data and aerial imagery in a time-effective manner.

The following sections describe each saturation flow rate adjustment factor:

Adjustment for Lane Width

The HCM contains an adjustment factor for lane width, dubbed f_w, that accounts for the tendency of traffic to flow at lower rates within narrow lanes. The adjustment factor is 1.0 (meaning that the lane width has no effect on saturation flow rate) for lane widths between 10 and 12.9 feet. Within the study area, all lane widths were found to be within this range, so lane width had no effect on the saturation flow rate of each segment.

Adjustment for Heavy Vehicles

The HCM heavy vehicle adjustment factor f_{HV} accounts for the additional length of heavy vehicles and the tendency of these vehicles to flow at lower rates than passenger cars. The basic premise of the adjustment factor is that each heavy vehicle flows at half the rate as a passenger car, indicated by an equivalence factor E_T equal to 2.0. The adjustment factor can be calculated as follows:

$$f_{HV} = \frac{100}{100+P_{HV}(E_T-1)}$$ (HCM Equation 18-6)

where P_{HV} is the percent of the traffic stream composed of heavy vehicles (%). The heavy vehicle percentages at each segment were estimated using turning movement counts at intersections along or adjacent to the segment.

Adjustment for Area Type

The HCM area type adjustment factor f_a accounts for less efficient movements as a result of unfamiliar drivers within a central business district. This adjustment factor is a binary variable and is equal to 0.9 for a central business district and 1.0 otherwise. The 0.9 adjustment factor was applied to the saturation flow rate of segments that were partially contained within or adjacent to the Downtown Norfolk census tract.

Adjustment for Parking

The HCM parking adjustment factor f_p accounts for the effect of mid-block parking on the lane adjacent to the parking lane. If a segment has no parking, then this adjustment factor is equal to 1.0, but if on-street parking is present, then the factor is computed as follows:

$$f_p = \frac{N - 0.1 - \frac{18 N_m}{3{,}600}}{N} \geq 0.05$$ (HCM Equation 18-8)

where *N* is the number of lanes on the approach and N_m is the number of parking maneuvers per hour (assumed to be two maneuvers per hour for purposes of this analysis).

Once the capacity was estimated by adjusting the ideal saturation flow rate (1,900 pcphpl) and multiplying by the number of lanes, the v/c ratio was obtained from the capacity and generalized bidirectional hourly service volumes. The v/c ratios computed for each segment give a sense of the available capacity remaining in the segment. In turn, this information helps determine whether the removal of one or more lanes keep the roadway segment below capacity.

Adjustment for Bus Blockage

The HCM bus blockage adjustment factor f_{bb} accounts for the effect of local transit stops on saturation flow rate. The factor is computed as follows:

$$f_{bb} = \frac{N - \frac{14.4 N_b}{3{,}600}}{N} \geq 0.05$$ (HCM Equation 18-9)

where *N* is the number of lanes on the approach and N_b is the bus stopping rate (per hour) on the approach. Bus route data provided by HRT was used to identify the number of bus routes along the study segment, and an average headway of 20 minutes was assumed for each route. For example, if three bus routes were identified on a particular segment, then N_b would be equal to nine buses per hour.

Segment capacities were determined by multiplying the ideal saturation flow rate (1,900 pcphpl) by the above factors and the number of lanes. The v/c ratios were then obtained by dividing the generalized bidirectional hourly service volumes by the calculated capacities. The v/c ratios computed for each segment give a sense of the available capacity remaining in the segment, and was used to determine whether the removal of one lane in each direction would keep the roadway segment below capacity.

Intersection Analysis Methodology

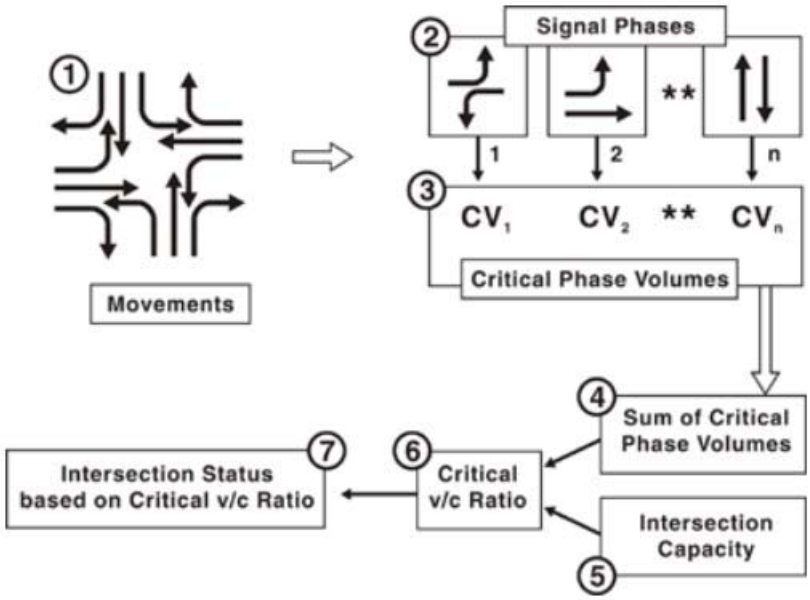
To complement the segment analysis methodology, an intersection-level analysis was conducted for the major signalized intersections on the segments. The intersection analysis also identifies available capacity for transit usage. The focus of this methodology is to examine the major signalized intersections that control the capacity of each segment that forms a potential transit alignment. The approach is as follows:

1. **Obtain traffic volumes for the a.m. and p.m. peak hours.** Turning movement counts were collected during June 2014 at signalized intersections within the alignment segments.
2. **Perform a critical movement analysis for each intersection.** The critical movement analysis technique is a simplified approach to estimate the capacity utilization at each intersection and identifies the maximum number of vehicles that need to be served during each signal phase.

This technique is described as the *Quick Estimation Method* in the HCM 2010 Chapter 31 (pages 31-83 through 31-96).

The graphical summary, shown in **Figure 1**, is taken from the FHWA *Signalized Intersections: Informational Guide*, describes the steps to determine the sum of critical volumes. Typically, for four-leg intersections, the maximum combination of left turn and opposing through/right volumes for the east-west movements is calculated and added to the maximum combination of left turn and opposing through/right volumes for the north-south movements.

Figure 1. Critical Movement Analysis



3. **Estimate the v/c ratio for each intersection.** Based on the estimated number of signal phases and using the sum of critical movement volumes, the volume-to-capacity ratio was computed for each intersection. To allow for lost time, friction such as parking and transit stops, and driver behavior, the following capacities were assumed for each intersection based upon the assumed number of signal phases:
    - 1,400 vehicles per hour for a four-phase signal
    - 1,500 vehicles per hour for a three-phase signal
    - 1,600 vehicles per hour for a two-phase signal

    These values are consistent with a range of intersection capacities presented in the HCM 2010 Chapter 31 (page 31-93). While the HCM uses a more detailed methodology to estimate the capacity of each intersection, this procedure is intended to simplify the analysis and represent typical traffic conditions.

The intersection analysis was performed separately for the a.m. and p.m. peak hours. The larger of the a.m. and p.m. peak hour intersection v/c ratios was used to compare operations. Comparing intersection v/c ratios helps identify the effect of removing of one lane in each direction for two approaches at each study intersection.

Table E.1. Intersection-level Results

#	Intersection	Existing v/c	Future v/c	Lane Removal v/c
1	Hampton Blvd / Terminal Dr	0.44	0.49	0.64
2	Hampton Blvd / Little Creek Rd	0.43	0.48	0.72
3	Granby St / Little Creek Rd	0.67	0.74	1.07
4	I-64 Eastbound Ramps / Little Creek Rd	0.52	0.57	1.04
5	I-64 Westbound Ramp / Little Creek Rd	0.43	0.48	0.73
6	Chesapeake Blvd / Little Creek Rd	0.85	1.03	1.92
7	Military Hwy / Little Creek Rd	0.71	0.78	0.96
8	Chesapeake Blvd / Johnstons Rd	0.85	0.94	1.35
9	Hampton Blvd / 49th St	0.36	0.40	0.52
10	Granby St / Willow Wood Dr	0.57	0.63	0.85
11	Sewells Point Rd / Chesapeake Blvd / Norview Ave	1.12	1.24	1.24
12	Military Hwy / Norview Ave	0.83	0.92	1.25
13	Hampton Blvd / 38th St	0.68	0.75	1.26
14	Colley Ave / 38th St	0.61	0.67	0.67
15	Granby St / 38th St	0.47	0.52	0.92
16	Tidewater Dr / Lafayette Blvd	0.82	0.91	1.40
17	Military Hwy / Princess Anne Rd	0.96	1.06	1.48
18	Church St / Monticello St	0.27	0.30	0.59
19	Church St / 26th St	0.44	0.49	0.71
20	Church St / Princess Anne Rd	0.44	0.49	0.66
21	Monticello St / Virginia Beach Blvd	0.47	0.52	0.93
22	Monticello St / Brambleton Ave	0.48	0.53	0.60
23	Church St / Brambleton Ave	0.50	0.55	0.71
24	Military Hwy / Poplar Hall Rd	0.83	0.92	1.05
25	St Paul St / City Hall Ave	No Data	No Data	No Data

Table E.2. Segment-level Results

ID	Route	Start	End	Existing v/c	Future v/c	Lane Removal v/c
1	St Pauls Blvd	Waterside Dr	City Hall Ave	0.13	0.14	0.22
2	St Pauls Blvd	City Hall Ave	Market St	0.35	0.39	0.59
3	Church St	Brambleton Ave	Virginia Beach Blvd	0.17	0.19	0.39
4	Church St	Virginia Beach Blvd	Princess Anne Rd	0.20	0.22	0.44
5	Church St	Princess Anne Rd	26th St	0.23	0.26	0.51
6	Church St	26th St	27th St	0.16	0.18	0.35
7	Church St	27th St	Monticello Ave	0.13	0.15	0.29
8	Church St	Monticello Ave	Granby St	0.33	0.37	0.73
9	Granby St	Church St	38th St	0.30	0.33	0.71
10	38th St	Colley Ave	Hampton Blvd	0.15	0.17	0.17
11	Hampton Blvd	38th St	Little Creek Rd	0.26	0.28	0.43
12	Hampton Blvd	Little Creek Rd	Intl Terminal Blvd	0.29	0.32	0.48
13	Monticello Ave	Brambleton Ave	St Pauls Blvd	0.04	0.04	0.06
14	Monticello Ave	St Pauls Blvd	Virginia Beach Blvd	0.21	0.24	0.36
15	Monticello Ave	Virginia Beach Blvd	21st St	0.30	0.33	0.67
16	Monticello Ave	21st St	Church St	0.29	0.32	0.65
17	26th St	Monticello Ave	Church St	0.17	0.19	0.29
18	26th St	Church St	27th St	0.15	0.17	0.26
19	Lafayette Blvd	27th St	Tidewater Dr	0.19	0.21	0.45
20	Tidewater Dr	Lafayette Blvd	Cromwell Dr	0.36	0.40	0.80
21	Tidewater Dr	Cromwell Dr	Norview Ave	0.50	0.55	1.12
22	Tidewater Dr	Norview Ave	I-64	0.43	0.47	0.95
23	Admiral Taussig Blvd	I-564	Hampton Blvd	0.38	0.43	0.85
24	Military Hwy	I-264	Virginia Beach Blvd	0.23	0.25	0.31
25	Military Hwy	Virginia Beach Blvd	Princess Anne Rd	0.47	0.52	1.03
26	Military Hwy	Princess Anne Rd	I-64	0.50	0.56	1.12
27	Military Hwy	I-64	Azalea Garden Rd	0.29	0.32	0.64
28	Military Hwy	Azalea Garden Rd	Norview Ave	0.29	0.32	0.63
29	Military Hwy	Norview Ave	Little Creek Rd	0.28	0.31	0.63
30	Little Creek Rd	Military Hwy	Chesapeake Blvd	0.47	0.52	1.05
31	Little Creek Rd	Chesapeake Blvd	Tidewater Dr	0.31	0.34	0.71
32	Little Creek Rd	Tidewater Dr	I-64	0.21	0.23	0.34
33	Colley Ave	Brambleton Ave	Onley Rd	0.19	0.21	0.43
34	Colley Ave	Onley Rd	Princess Anne Rd	0.17	0.19	0.40
35	Colley Ave	Princess Anne Rd	21st St	0.39	0.44	0.44
36	Colley Ave	21st St	27th St	0.22	0.24	0.52
37	Colley Ave	27th St	38th St	0.40	0.44	0.44
38	Granby St	38th St	Llewellyn Ave	0.32	0.36	0.77
39	Granby St	Llewellyn Ave	Willow Wood Dr	0.29	0.32	0.49
40	Granby St	Willow Wood Dr	Thole St	0.28	0.31	0.46
41	Granby St	Thole St	Little Creek Rd	0.26	0.29	0.44
42	Granby St	Little Creek Rd	I-564	0.21	0.23	0.36
43	Little Creek Rd	I-64	Granby St	0.27	0.29	0.60
44	Little Creek Rd	Granby St	Hampton Blvd	0.25	0.27	0.55
45	Boush St	Brambleton Ave	Virginia Beach Blvd	0.10	0.11	0.21
46	Llewellyn Ave	Virginia Beach Blvd	Princess Anne Rd	0.14	0.15	0.31
47	Llewellyn Ave	Princess Anne Rd	21st St	0.12	0.14	0.29
48	21st St	Colley Ave	Monticello Ave	0.30	0.34	0.34
49	26th St	Colley Ave	Monticello Ave	0.16	0.17	0.17
50	27th St	Colley Ave	Monticello Ave	0.15	0.16	0.16
51	35th St	Colley Ave	Monticello Ave	0.14	0.16	0.16
52	38th St	Colley Ave	Monticello Ave	0.16	0.18	0.18
53	Hampton Blvd	Terminal Blvd	Admiral Taussig Blvd	0.21	0.23	0.23

Figure E.1. Existing Traffic Operations

Figure E.2. Existing Traffic Operations with Intersection Impacts

Figure E.3. 2034 No-Build Traffic Operations

Figure E.4. 2034 No-Build Traffic Operations with Intersection Impacts

Figure E.5. 2034 Lane Removal Traffic Operations

Figure E.6. 2034 Lane Removal Traffic Operations with Intersection Impacts