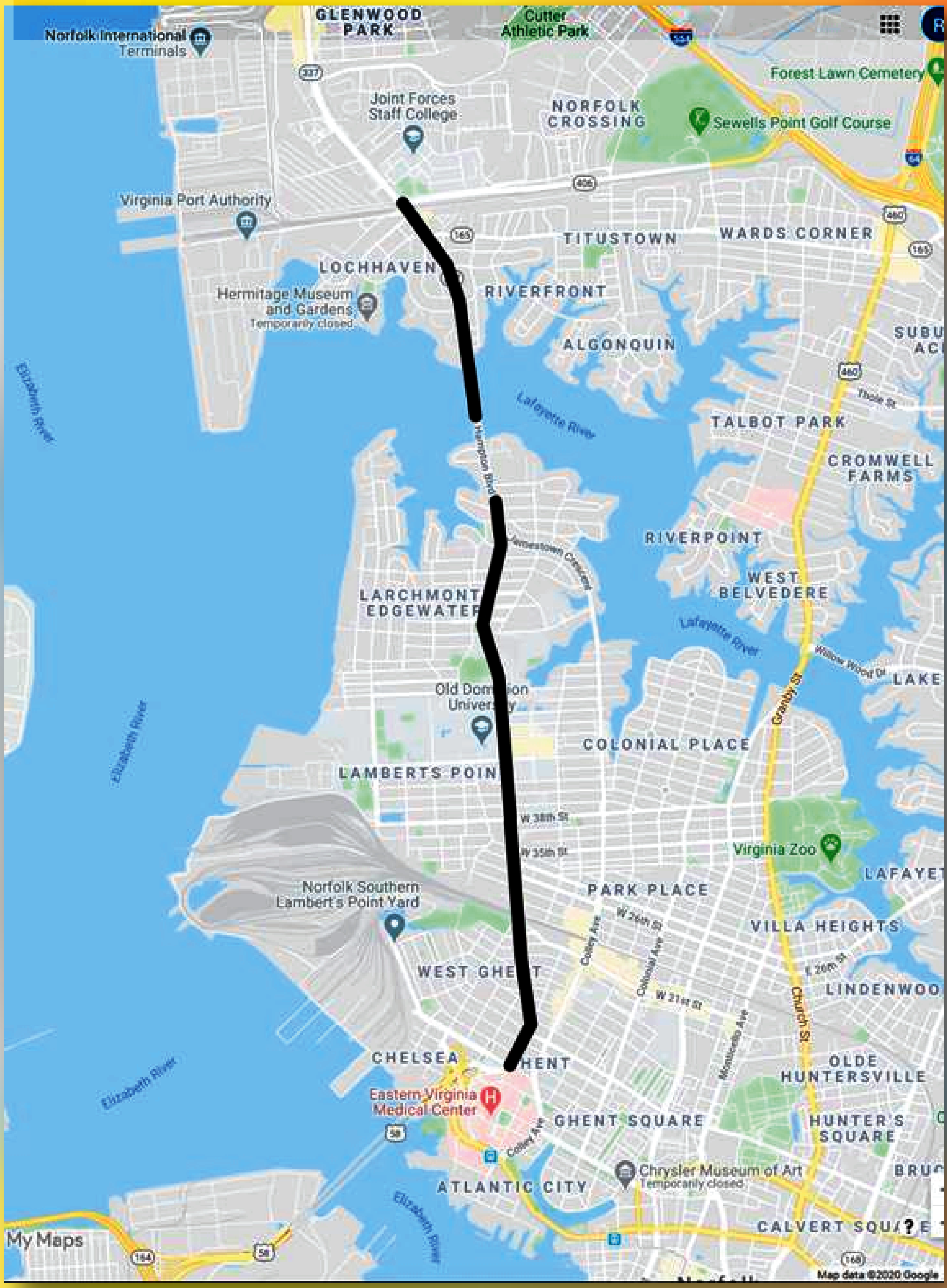
Hampton Blvd Corridor Study



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REPORT DOCUMENTATION

TITLE
Hampton Blvd Corridor Study

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ABSTRACT
Over recent decades, the citizens and government of Norfolk have been concerned about the interaction of modes—truck, pedestrian, auto, rail—on the heavily used Hampton Blvd corridor, which serves the world's largest naval base, a major Port of Virginia terminal, a state university, a regional medical center, and multiple neighborhoods. In response to a request from the City of Norfolk, HRTPO staff analyzed the corridor and provided options for reducing trucks, improving safety, mitigating train conflicts, and reducing flooding.

ACKNOWLEDGMENT & DISCLAIMERS
Prepared in cooperation with the U.S. Department of Transportation (USDOT), Federal Highway Administration (FHWA), and Virginia Department of Transportation (VDOT). The contents of this report reflect the views of the Hampton Roads Transportation Planning Organization (HRTPO). The HRTPO is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the FHWA, VDOT or Hampton Roads Planning District Commission. This report does not constitute a standard, specification, or regulation. FHWA or VDOT acceptance of this report as evidence of fulfillment of the objectives of this planning study does not constitute endorsement/approval of the need for any recommended improvements nor does it constitute approval of their location and design or a commitment to fund any such improvements. Additional project level environmental impact assessments and/or studies of alternatives may be necessary.

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Executive Summary

Over recent decades, the citizens and the City of Norfolk have been concerned about the interaction of modes on the heavily used Hampton Blvd corridor serving the world's largest naval base, one of the two main Virginia ports, a major university, a regional medical center, and multiple neighborhoods. In response, the City and Port have taken several actions, including:

- The City has restricted trucks on Hampton Blvd during certain hours.
- The City and Port successfully pursued the construction of a grade-separated rail line crossing Hampton Blvd near Greenbrier Ave.
- The City and Port successfully pursued the construction of the Intermodal Connector, which opened December 2017, for direct port truck access to/from the interstate.
- The Port reconstructed the North Gate complex, allowing trucks direct access to/from the port via the Intermodal Connector.
- The City has implemented a number of safety improvements on Hampton Blvd, including dynamic speed display signs, pedestrian signal improvements, and protected left-turn signal phases.

Recently, the City worked with a Hampton Blvd Task Force (comprised of the Port of Virginia, U.S. Navy, Old Dominion University [ODU], and civic league representatives) to propose several additional safety measures along the corridor. Some smaller improvements (e.g. protected left-turn signal phases, above) have been implemented while others (including the reduction of regular travel lanes from six to four north of ODU) have not.

In February 2019, the City asked the Hampton Roads Transportation Planning Organization (HRTPO) to conduct a corridor study to address the following issues:

- Number of trucks using Hampton Blvd
- Safety
- Excessive vehicle speeds

In this study, in addition to the above issues, HRTPO staff also addresses the following:

- Port trains blocking arterial roadways
- 2019 Norfolk – Virginia Beach Joint Land Use Study

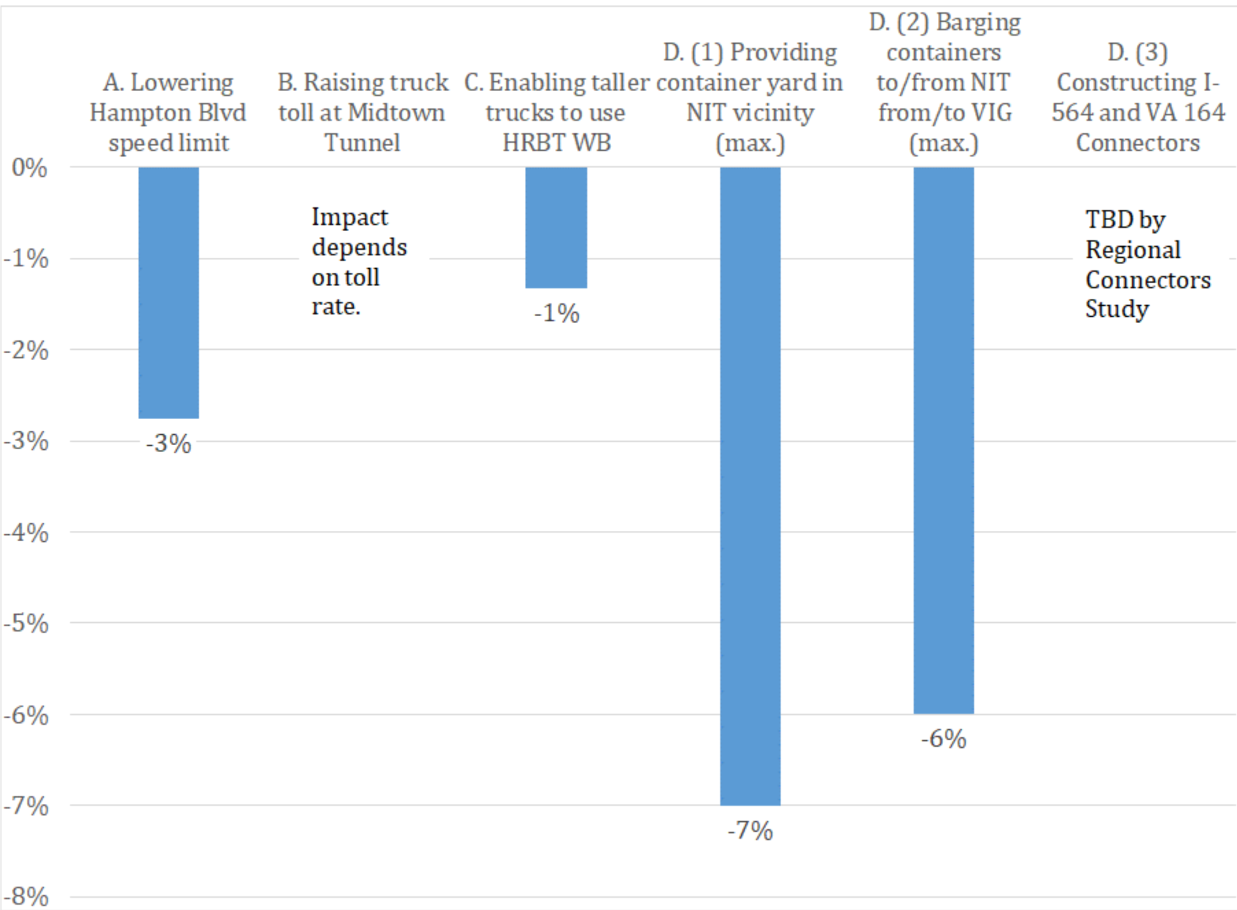
Initiatives Currently Reducing Trucks on Hampton Blvd

Based on the detailed analysis in the study, the Intermodal Connector apparently reduced trucks on Hampton Blvd by 62 trucks per day or 4%.

Another analysis showed that only 4% of Hampton Blvd trucks use Hampton Blvd during prohibited hours, indicating that the implementation of truck hours on Hampton Blvd effectively prevent trucks during prohibited hours.

Reducing Trucks on Hampton Blvd

The options explored for reducing trucks on Hampton Blvd are expected to have the following impact:



Options for Reducing Trucks on Hampton Roads

Source: HRTPO staff

Mitigating Train Conflicts

The City of Norfolk is concerned by the impacts of port-related trains at three at-grade rail crossings on the Norfolk and Portsmouth Belt Line – Hampton Boulevard/Terminal Boulevard, Granby Street, and Little Creek Road. One solution to reduce delays at these three crossings – which can reach as high as 15 minutes – is to provide real-time traveler information on train activity, primarily via variable message signs. A traveler information system comprised of eleven variable message signs, six train detection sensors, and related communications equipment and software was described in this section. The total cost for this system is estimated to be $4.4 million.

Improving Safety on Hampton Blvd

Based on the analysis of corridor data, it can be inferred that a speeding problem exists on Hampton Boulevard. In addition, recent safety improvements by the City of Norfolk were outlined and mapped in this section. Moreover, objectives and strategies in the *Virginia Highway Safety Plan* were outlined, and various countermeasures were detailed. HRTPO staff proposed potential safety countermeasures for bicycle, pedestrian, speed-related, and truck-related crashes for the Hampton Boulevard corridor. A number of candidate speed enforcement and traffic calming techniques were also detailed including various pavement markings, pavement appearance options, and landscaping.

In addition to the guidance provided in this report, a block-by-block investigation of the benefits of various traffic calming techniques options may be valuable.

Joint Land Use Study (JLUS)

Joint Land Use Studies (JLUS) are community-driven, cooperative, strategic planning processes in which local governments work closely with military installations to implement measures that prevent the introduction of incompatible civilian development that may impair the continued operational utility of the military installation, and to preserve and protect the public health, safety, and welfare of those living near an active military installation.

Hampton Boulevard recommendations from the 2019 Norfolk – Virginia Beach Joint Land Use Study include:

- Increase stormwater infrastructure capacity at the following locations:
  - Portions of the Hampton Blvd southbound lanes
  - Hampton Boulevard and Baker Street intersection
  - Add storage and filtration in the area of Baker Street and Leutze Boulevard
- Raise roadway elevation for portions of Hampton Boulevard for adapting the roadway to the long-term impacts of flooding and sea level rise. Potential issues with raising Hampton Boulevard include:
  - Safety and operational considerations
  - Impacts to neighborhood streets and intersections
  - Impacts to private properties and adjacent parcels
  - Stormwater collection system and other utility infrastructure would have to be redesigned
- Proceed with the project identified in the 2040 Long Range Transportation Plan (LRTP) to construct a new rail underpass at the intersection of Terminal Boulevard and Hampton Boulevard

Background

Over recent decades, the citizens and the City of Norfolk have been concerned about the interaction of modes on the heavily used Hampton Blvd corridor serving the world's largest naval base, one of the two main Virginia ports, a major university, a regional medical center, and multiple neighborhoods:

- Residents have been concerned about the number of trucks using Hampton Blvd, particularly container trucks serving the Port of Virginia.
- ODU and Norfolk schools have been concerned about the safety of pedestrians (especially children) crossing Hampton Blvd.
- Auto and truck drivers have been concerned about delays caused by container trains blocking Hampton Blvd before and after serving the port.

In response, the City and Port have taken several actions, including:

- The City has restricted trucks on Hampton Blvd during certain hours.
- The City and Port successfully pursued the construction of a grade-separated rail line crossing Hampton Blvd near Greenbrier Ave.
- The City and Port successfully pursued the construction of the Intermodal Connector, which opened December 2017, for direct port truck access to/from the interstate.
- The Port reconstructed the North Gate complex, allowing trucks direct access to/from the port via the Intermodal Connector.
- The City has implemented a number of safety improvements on Hampton Blvd, including dynamic speed display signs, pedestrian signal improvements, and protected left-turn signal phases.

Recently, the City worked with a **Hampton Blvd Task Force** (comprised of the Port of Virginia, U.S. Navy, Old Dominion University [ODU], and civic league representatives) to propose several additional safety measures along the corridor. Some smaller improvements (e.g. protected left-turn signal phases, above) have been implemented while others (including the reduction of regular travel lanes from six to four north of ODU) have not.

In February 2019, the City asked the HRTPO to conduct a corridor study to address the following issues:

- Number of trucks using Hampton Blvd
- Safety
- Excessive vehicle speeds

In this study, in addition to the above issues, HRTPO staff also addresses the following:

- Port trains blocking arterial roadways
- 2019 Norfolk – Virginia Beach Joint Land Use Study

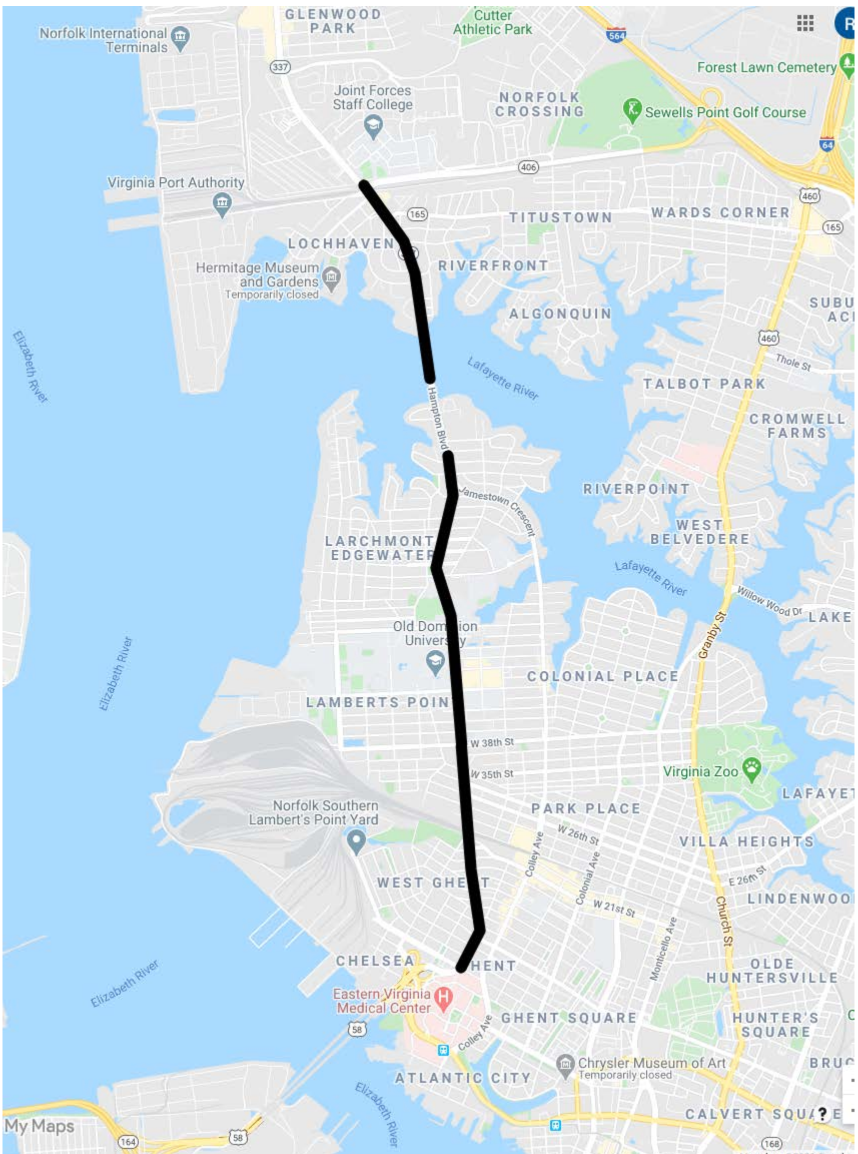


FIGURE 1 Study Area

Source: HRTPO staff, Google My Maps

Reducing Trucks on Hampton Boulevard

Norfolk residents have been concerned about the number of trucks using Hampton Blvd, particularly container trucks serving the Port of Virginia. In response, the City of Norfolk asked the HRTPO to address the number of trucks using this roadway.

This section contains three subsections:

- Existing Conditions
- Initiatives Currently Reducing Trucks on Hampton Blvd
- Options for Reducing Trucks on Hampton Blvd

Existing Conditions

Hampton Blvd being a main arterial roadway with houses fronting the roadway, staff examined similar roadways in the seven cities of Hampton Roads.

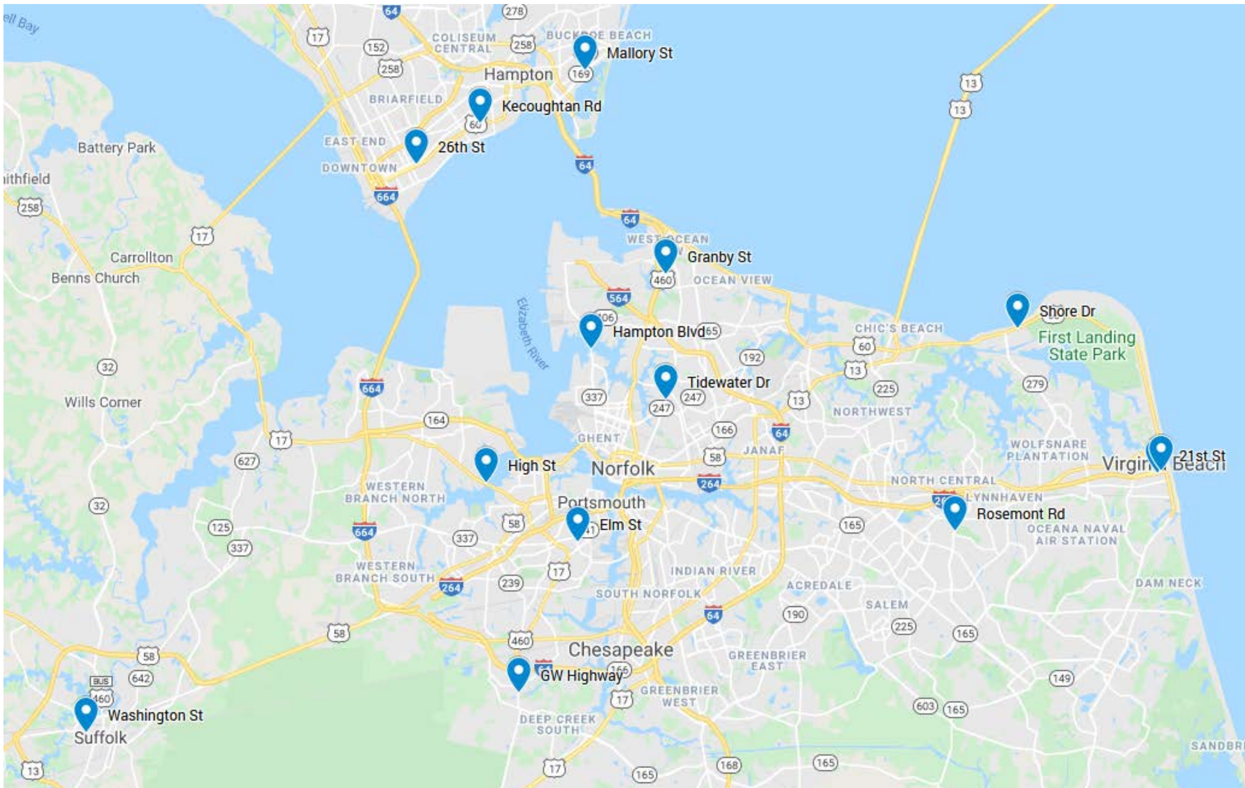


FIGURE 2a Main Arterial Roadways with Houses Fronting the Roadway
Source: HRTPO, Google My Maps

In the seven cities of Hampton Roads, Hampton Blvd carries many more trucks than any of the other main arterial roadways that have houses fronting the roadway, more than twice as many trucks as the second-placed roadway (Tidewater Drive) which is also in Norfolk and also carries port trucks.

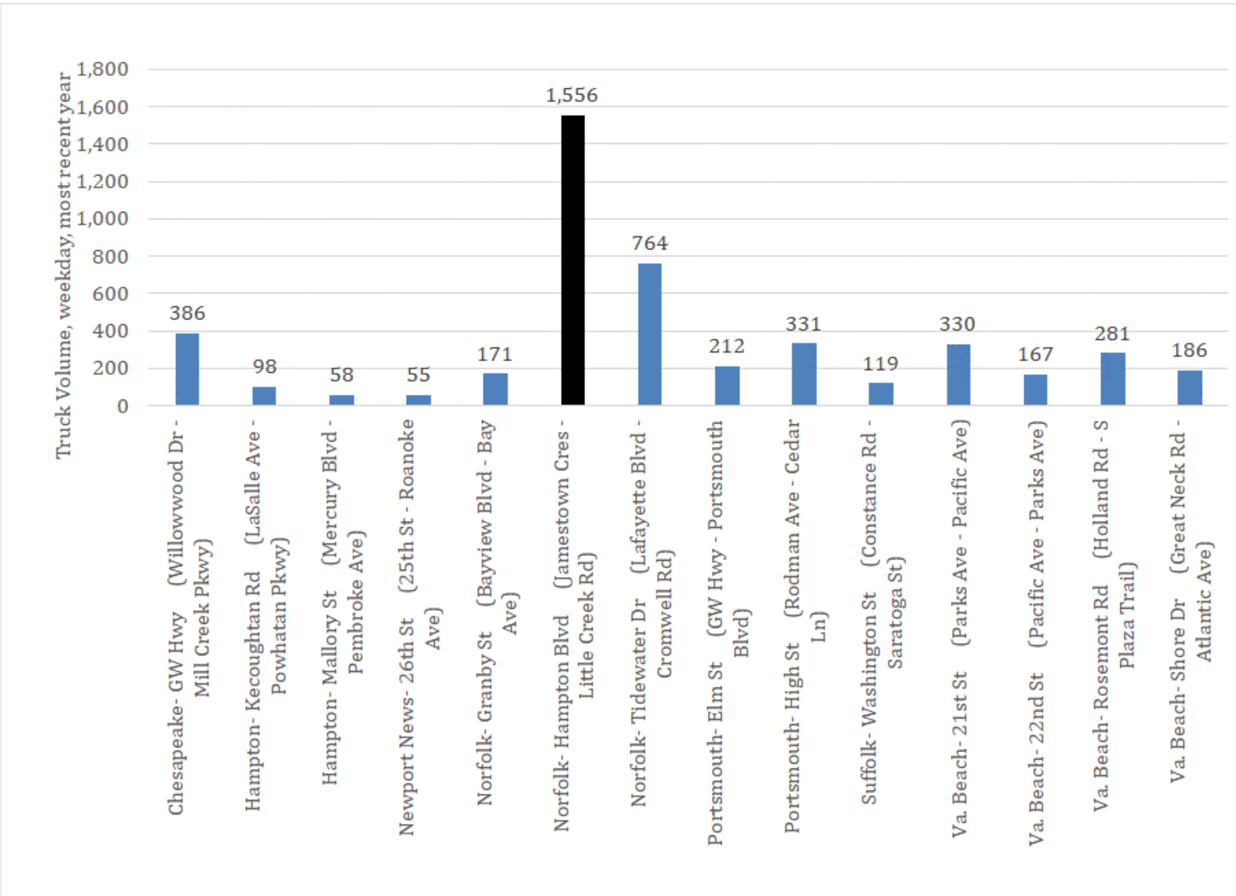


FIGURE 2b Main Arterial Roadways with Houses Fronting the Roadway
Source: HRTPO processing of VDOT data

Hampton Blvd provides access to Norfolk International Terminals (NIT). As shown in the following section, a large portion of the trucks on Hampton Blvd serve NIT.

Hampton Blvd (black bar) carries more trucks than these interstate segments in Hampton Roads.

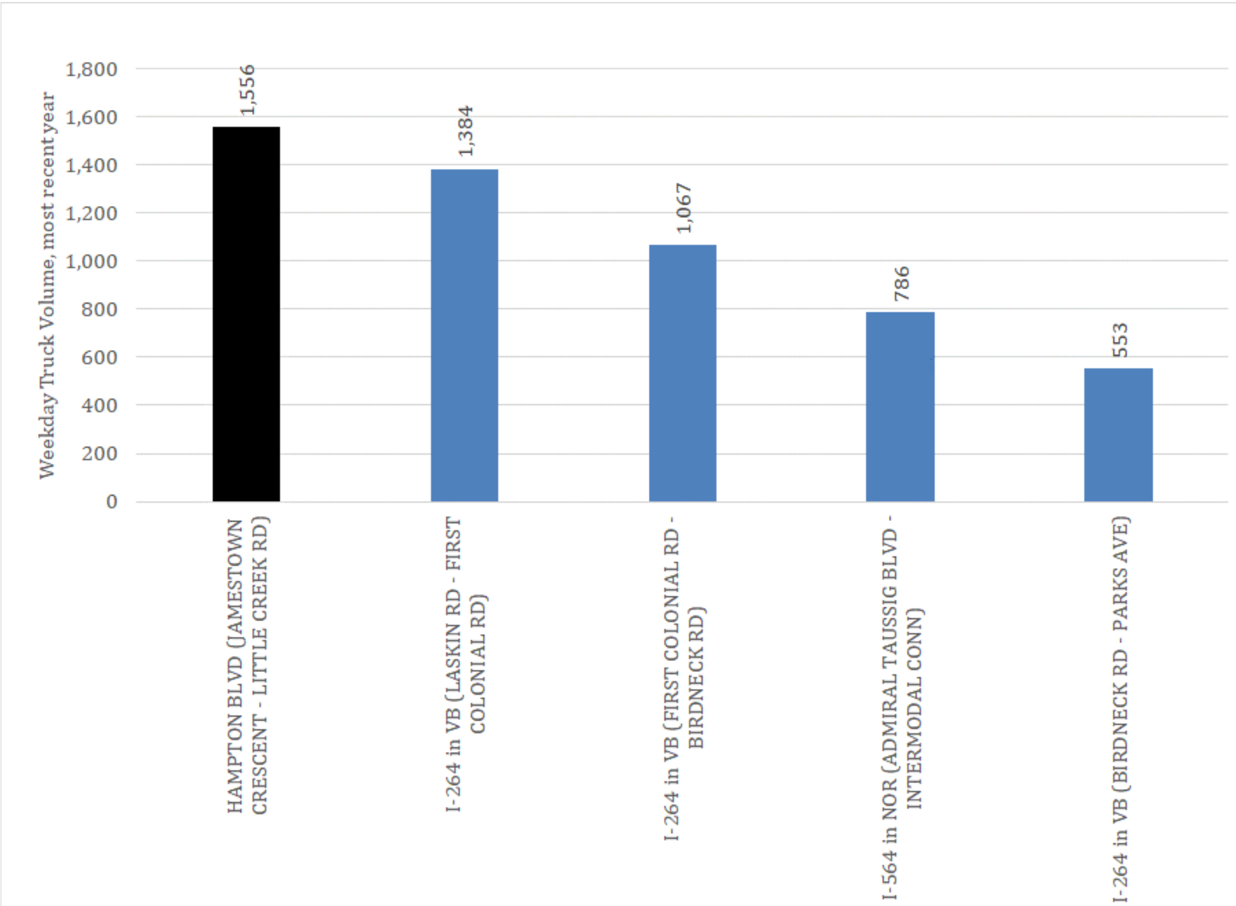


FIGURE 3 Interstate Segments with Fewer Trucks than Hampton Blvd
Source: HRTPO processing of VDOT data

To determine the sources of this large number of trucks, staff measured the portion of trucks on Hampton Blvd which are coming from / going to the Norfolk International Terminals (NIT) port facility.

To measure and track trucks in this study staff often used StreetLight, a mobility analytics provider that collects transportation data via remote devices, processes it, and makes it available for analysis via a web interface. StreetLight truck data come from Global Positioning System (GPS) units in trucks. Given that StreetLight collects data from approximately 12% of the trucks in the US, the sample size for a year of data is very large, typically enabling accurate analyses for specific origins and destinations.

Staff measured the NIT portion of Hampton Blvd trucks using two StreetLight runs[1]:

- southbound Hampton Blvd
- northbound Hampton Blvd

[1] Conducting an analysis via StreetLight involves setting the parameters of the analysis (date range, location, analysis type, etc.), submitting the analysis request to StreetLight, and receiving output from StreetLight- a process referred to as a "run" in this document.

NIT Portion of Hampton Blvd (HB) Trucks- southbound Hampton Blvd

Staff estimated the NIT portion of southbound Hampton Blvd trucks via a StreetLight origin-destination analysis using 2018 data.

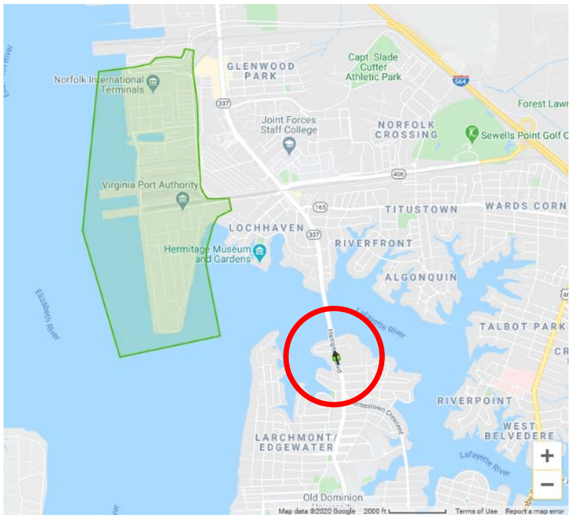


FIGURE 4 Origin (NIT, green) and Destination (Hampton Blvd, red) for NIT-trucks-as-portion-of-HB-trucks Measurement- southbound (SB) Hampton Blvd

Source: HRTPO processing of StreetLight data

Type of Travel	Origin Zone Name	Origin Zone Is Pass-Through	Destination Zone Name	Destination Zone Is Pass-Through	Day Type	Day Part	Average Daily O-D Traffic (StL Index)	Average Daily Origin Zone Traffic (StL Index)	Average Daily Destination Zone Traffic (StL Index)
Commercial	Hampton Blvd	yes	Hampton Blvd	yes	0: All Days (M-Su)	0: All Day (12am-12am)	23,476	23,476	23,476
Commercial	Hampton Blvd	yes	Hampton Blvd	yes	0: All Days (M-Su)	1: HB truck period (6am-4pm)	21,588	21,588	21,588
Commercial	Hampton Blvd	yes	Hampton Blvd	yes	1: Weekday (M-F)	0: All Day (12am-12am)	31,184	31,184	31,184
Commercial	Hampton Blvd	yes	Hampton Blvd	yes	1: Weekday (M-F)	1: HB truck period (6am-4pm)	28,736	28,736	28,736
Commercial	Hampton Blvd	yes	NIT	no	0: All Days (M-Su)	0: All Day (12am-12am)	475	23,476	44,828
Commercial	Hampton Blvd	yes	NIT	no	0: All Days (M-Su)	1: HB truck period (6am-4pm)	466	21,588	39,866
Commercial	Hampton Blvd	yes	NIT	no	1: Weekday (M-F)	0: All Day (12am-12am)	633	31,184	59,832
Commercial	Hampton Blvd	yes	NIT	no	1: Weekday (M-F)	1: HB truck period (6am-4pm)	622	28,736	52,991
Commercial	NIT	no	Hampton Blvd	yes	0: All Days (M-Su)	0: All Day (12am-12am)	14,482	47,779	23,476
Commercial	NIT	no	Hampton Blvd	yes	0: All Days (M-Su)	1: HB truck period (6am-4pm)	13,697	41,665	21,588
Commercial	NIT	no	Hampton Blvd	yes	1: Weekday (M-F)	0: All Day (12am-12am)	19,374	63,831	31,184
Commercial	NIT	no	Hampton Blvd	yes	1: Weekday (M-F)	1: HB truck period (6am-4pm)	18,284	55,383	28,736
Commercial	NIT	no	NIT	no	0: All Days (M-Su)	0: All Day (12am-12am)	16,784	47,779	44,828
Commercial	NIT	no	NIT	no	0: All Days (M-Su)	1: HB truck period (6am-4pm)	15,134	41,665	39,866
Commercial	NIT	no	NIT	no	1: Weekday (M-F)	0: All Day (12am-12am)	22,515	63,831	59,832
Commercial	NIT	no	NIT	no	1: Weekday (M-F)	1: HB truck period (6am-4pm)	20,232	55,383	52,991
						Hampton Blvd Trucks from NIT	18,284		
						All Hampton Blvd (HB) Trucks	28,736		
						NIT portion of HB Trucks	**64%**		

FIGURE 5 Calculation of NIT-trucks-as-portion-of-HB-trucks- SB Hampton Blvd

Source: HRTPO processing of StreetLight data

The above StreetLight run indicated that NIT trucks comprise 64% of southbound Hampton Blvd trucks.

NIT Portion of Hampton Blvd (HB) Trucks- northbound Hampton Blvd

Staff estimated the NIT portion of northbound Hampton Blvd trucks in a similar manor.

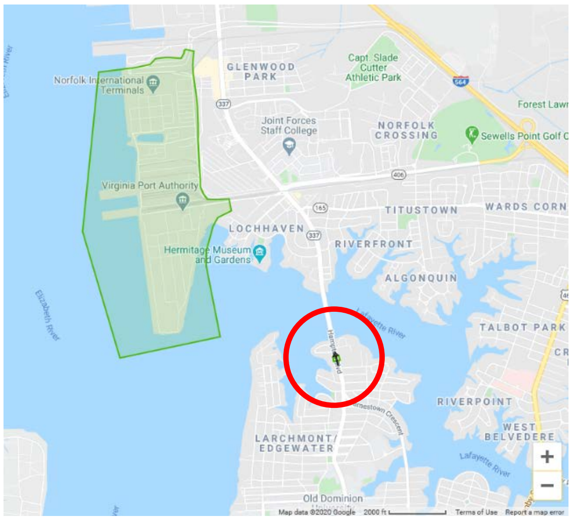


FIGURE 6 Origin (Hampton Blvd, red) and Destination (NIT, green) for NIT-trucks-as-portion-of-HB-trucks Measurement- northbound (NB) Hampton Blvd

Source: HRTPO processing of StreetLight data

Type of Travel	Origin Zone Name	Origin Zone Is Pass-Through	Destination Zone Name	Destination Zone Is Pass-Through	Day Type	Day Part	Average Daily O-D Traffic (StL Index)	Average Daily Origin Zone Traffic (StL Index)	Average Daily Destination Zone Traffic (StL Index)
Commercial	Hampton Blvd	yes	Hampton Blvd	yes	0: All Days (M-Su)	0: All Day (12am-12am)	19,081	19,081	19,081
Commercial	Hampton Blvd	yes	Hampton Blvd	yes	0: All Days (M-Su)	1: HB truck period (6am-4pm)	17,455	17,455	17,455
Commercial	Hampton Blvd	yes	Hampton Blvd	yes	1: Weekday (M-F)	0: All Day (12am-12am)	25,280	25,280	25,280
Commercial	Hampton Blvd	yes	Hampton Blvd	yes	1: Weekday (M-F)	1: HB truck period (6am-4pm)	23,186	23,186	23,186
Commercial	Hampton Blvd	yes	NIT	no	0: All Days (M-Su)	0: All Day (12am-12am)	10,670	19,081	44,828
Commercial	Hampton Blvd	yes	NIT	no	0: All Days (M-Su)	1: HB truck period (6am-4pm)	10,303	17,455	39,866
Commercial	Hampton Blvd	yes	NIT	no	1: Weekday (M-F)	0: All Day (12am-12am)	14,259	25,280	59,832
Commercial	Hampton Blvd	yes	NIT	no	1: Weekday (M-F)	1: HB truck period (6am-4pm)	13,754	23,186	52,991
Commercial	NIT	no	Hampton Blvd	yes	0: All Days (M-Su)	0: All Day (12am-12am)	69	47,779	19,081
Commercial	NIT	no	Hampton Blvd	yes	0: All Days (M-Su)	1: HB truck period (6am-4pm)	61	41,665	17,455
Commercial	NIT	no	Hampton Blvd	yes	1: Weekday (M-F)	0: All Day (12am-12am)	94	63,831	25,280
Commercial	NIT	no	Hampton Blvd	yes	1: Weekday (M-F)	1: HB truck period (6am-4pm)	83	55,383	23,186
Commercial	NIT	no	NIT	no	0: All Days (M-Su)	0: All Day (12am-12am)	16,784	47,779	44,828
Commercial	NIT	no	NIT	no	0: All Days (M-Su)	1: HB truck period (6am-4pm)	15,134	41,665	39,866
Commercial	NIT	no	NIT	no	1: Weekday (M-F)	0: All Day (12am-12am)	22,515	63,831	59,832
Commercial	NIT	no	NIT	no	1: Weekday (M-F)	1: HB truck period (6am-4pm)	20,232	55,383	52,991
						Hampton Blvd Trucks to NIT	13,754		
						All Hampton Blvd (HB) Trucks	23,186		
							59%		

FIGURE 7 Calculation of NIT-trucks-as-portion-of-HB-trucks- NB Hampton Blvd

Source: HRTPO processing of StreetLight data

The above StreetLight run indicated that NIT trucks comprise 59% of northbound Hampton Blvd trucks.

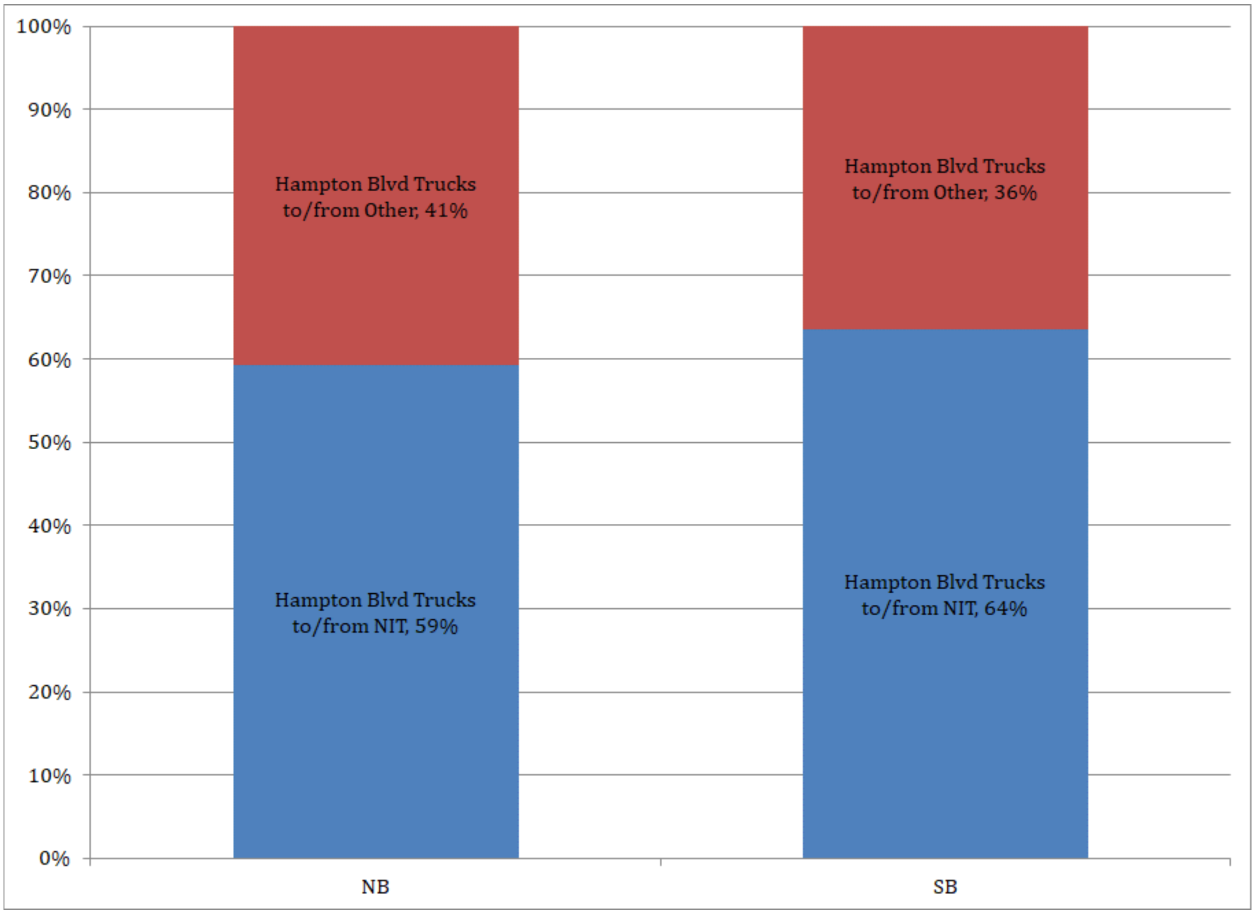


FIGURE 8 NIT Trucks as a Portion of Hampton Blvd Trucks, StreetLight

Source: HRTPO processing of StreetLight data

Averaging northbound and southbound percentages shown in the above chart, **61% of Hampton Blvd trucks run to/from NIT**.

Having estimated the portion of Hampton Blvd trucks that run to/from NIT, staff investigated the destination of those NIT/HB trucks. Staff chose 14 destinations for truck trips from NIT. The local "area zones" are shown in red; the gateway destinations ("external pass-thru zones") are shown in green:

1. Chesapeake Bay Bridge Tunnel (CBBT)
2. Chesapeake
3. Hampton Roads Bridge Tunnel (HRBT)
4. Monitor-Merrimac Bridge Tunnel (MMBT)
5. Norfolk (other than NIT)
6. Portsmouth
7. US 13 (at North Carolina border)
8. US 17 (at North Carolina border)
9. US 17 (at Isle of Wight County border)
10. US 58 (at Southampton County border)
11. VA 168 (at North Carolina border)
12. US 460 (at Isle of Wight County border)
13. Suffolk
14. Virginia Beach

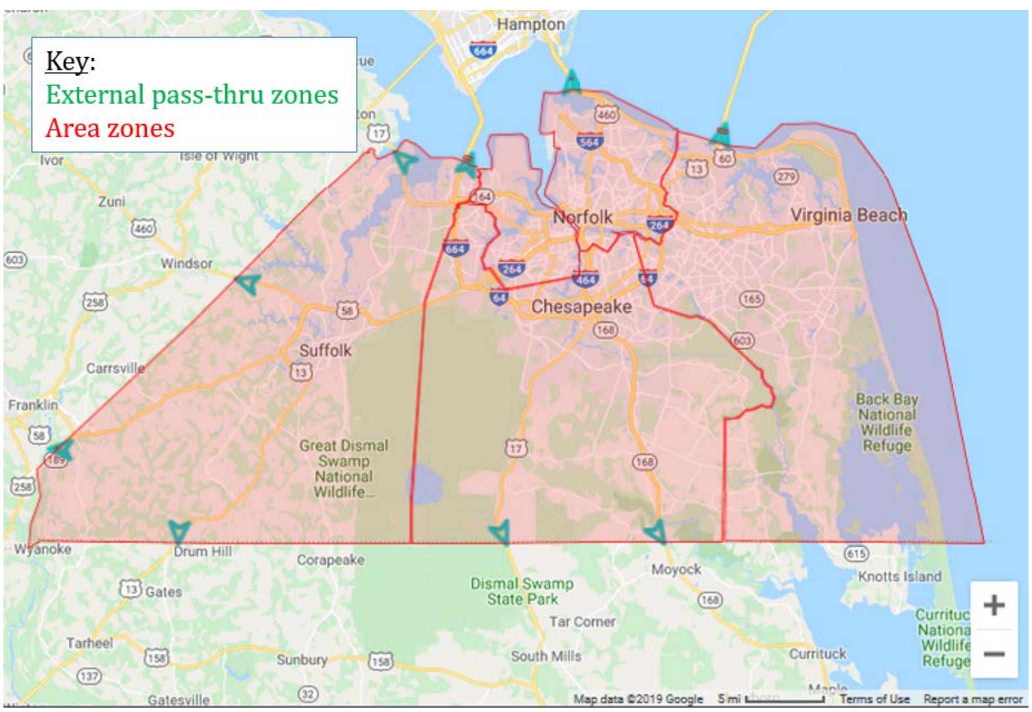


FIGURE 9 Destinations for Model Explaining Selection of Hampton Blvd vs. I-64
Source: HRTPO usage of StreetLight data platform

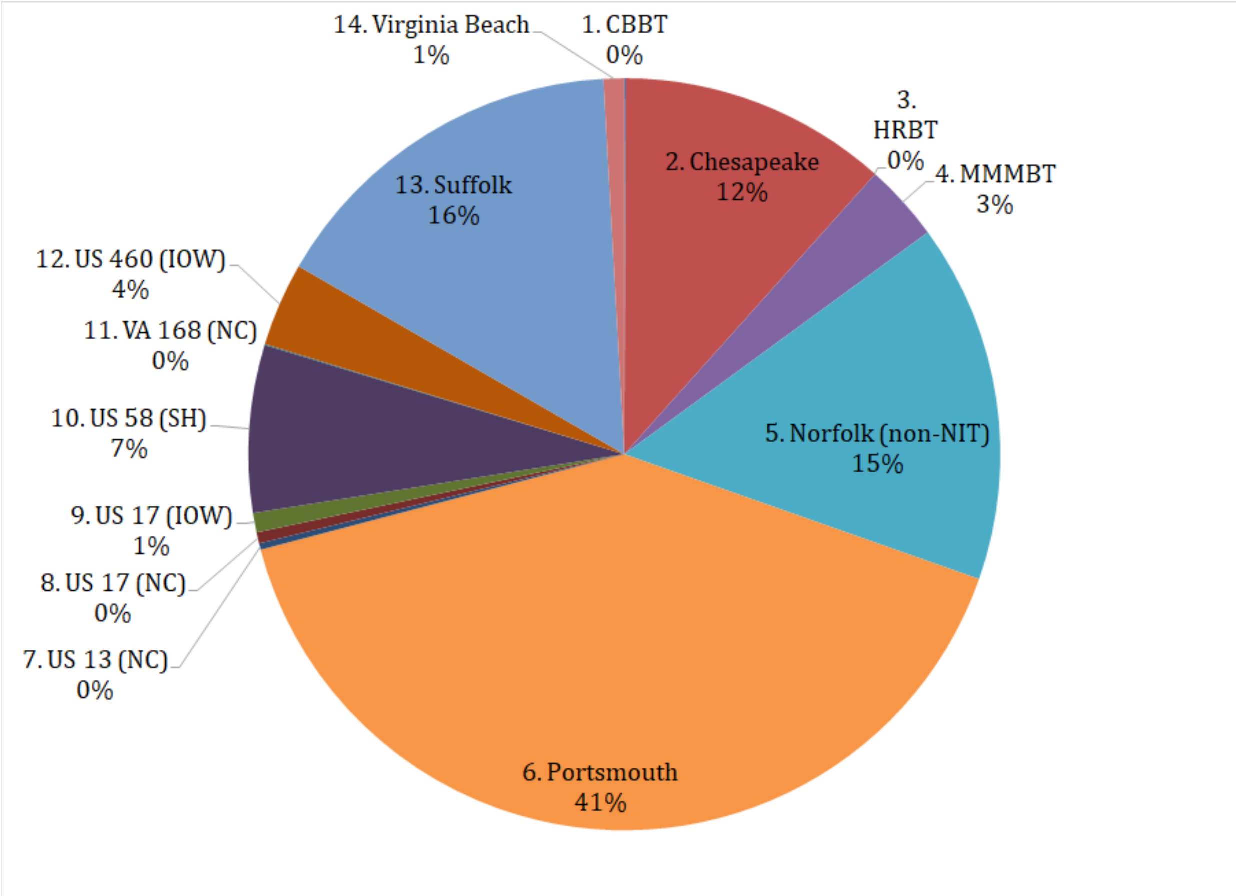


FIGURE 10 Destination (or Gateway) for Trucks from NIT via Hampton Blvd, weekday, Hampton Blvd truck hours, 2018, StreetLight sample trucks

Source: HRTPO usage of StreetLight data platform

Two-fifths of the trucks leaving NIT via Hampton Blvd are destined for Portsmouth where Portsmouth Marine Terminal (PMT) and Virginia International Gateway (VIG) are located.

Initiatives Currently Reducing Trucks on Hampton Blvd

Staff estimated the impact of two initiatives currently reducing trucks on Hampton Blvd:

- The Intermodal Connector
- Hampton Blvd Truck Hours

A. Impact of the Intermodal Connector (IMC) on Hampton Blvd (HB) Trucks

The Intermodal Connector, a fully-controlled access highway joining I-564 and NIT, opened 12-21-17. This section estimates the impact of the IMC on Hampton Blvd trucks in four parts:

- Theory
- Methodology
- Results
- Checking

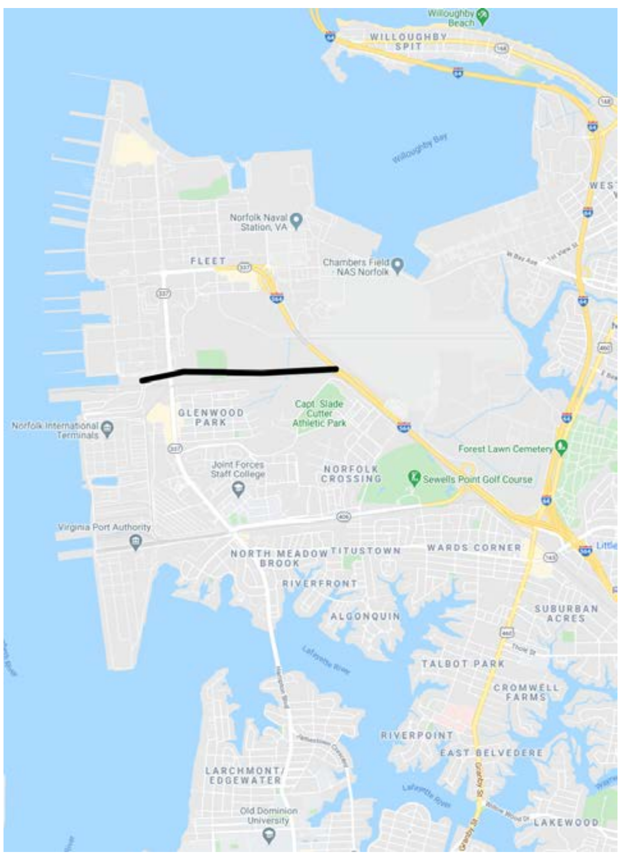


FIGURE 11 Intermodal Connector
Source: HRTPO usage of Google My Maps

Theory

In accordance with sound analytics, staff developed a theory of how the Intermodal Connector might impact the volume of Hampton Blvd trucks, and then tested that theory.

Truck drivers have two basic route choices to/from NIT:

1. I-64
2. Hampton Blvd

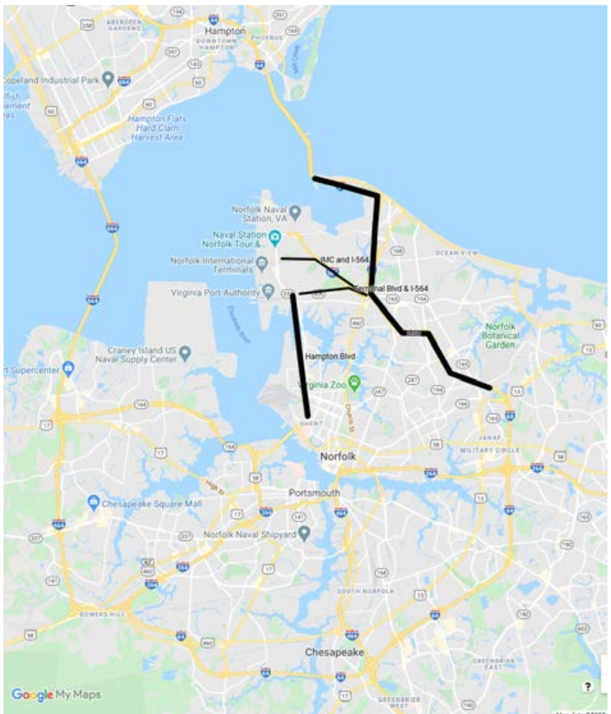


FIGURE 12 NIT Route Choices: Hampton Blvd and I-64
Source: HRTPO usage of Google My Maps

Prior to the December 2017 opening of the Intermodal Connector (IMC), truck drivers using I-64 did so via Terminal Blvd (TB). Since the opening, these I-64 truck drivers have chosen between:

- Intermodal Connector
- Terminal Blvd

Assuming that travel time is the paramount consideration of truck drivers, staff's theory of the IMC impact on Hampton Blvd trucks is: The Intermodal Connector is expected to reduce Hampton Blvd trucks by making the I-64-based NIT trip quicker, either:

- due to on-port travel time—e.g. the NIT end of the trip for NIT North containers being closer to the IMC (and therefore to I-64) than to Hampton Blvd—or
- due to off-port travel time—the IMC being quicker than Terminal Blvd.

Methodology

The before-and-after method—i.e. comparing Hampton Blvd truck volumes before the opening of the Intermodal Connector to those after that opening—would reflect any IMC impact on Hampton Blvd, including the two travel time impacts theorized above. Although a simple before-and-after comparison of Hampton Blvd truck volumes would be desirable for its straightforwardness, using it would allow changes in port volume before and after the Intermodal Connector opening to inappropriately influence the results. Therefore, in order to account for changes in port volume, staff used a *modified* before-and-after method, comparing "without IMC" truck volume—estimated using a model developed with pre-IMC port volume data—to "with IMC" truck volume—actual truck counts during the post-IMC.

To develop a "without IMC" Hampton Blvd truck model, staff regressed Hampton Blvd trucks[2] against NIT trucks[3] during the pre-IMC time period. The result (i.e. the line that best fits the data, and the formula that defines the line) is shown on the chart on the following page.

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[2] Source: Virginia Department of Transportation (VDOT) counts
[3] Source: Port of Virginia (POV)

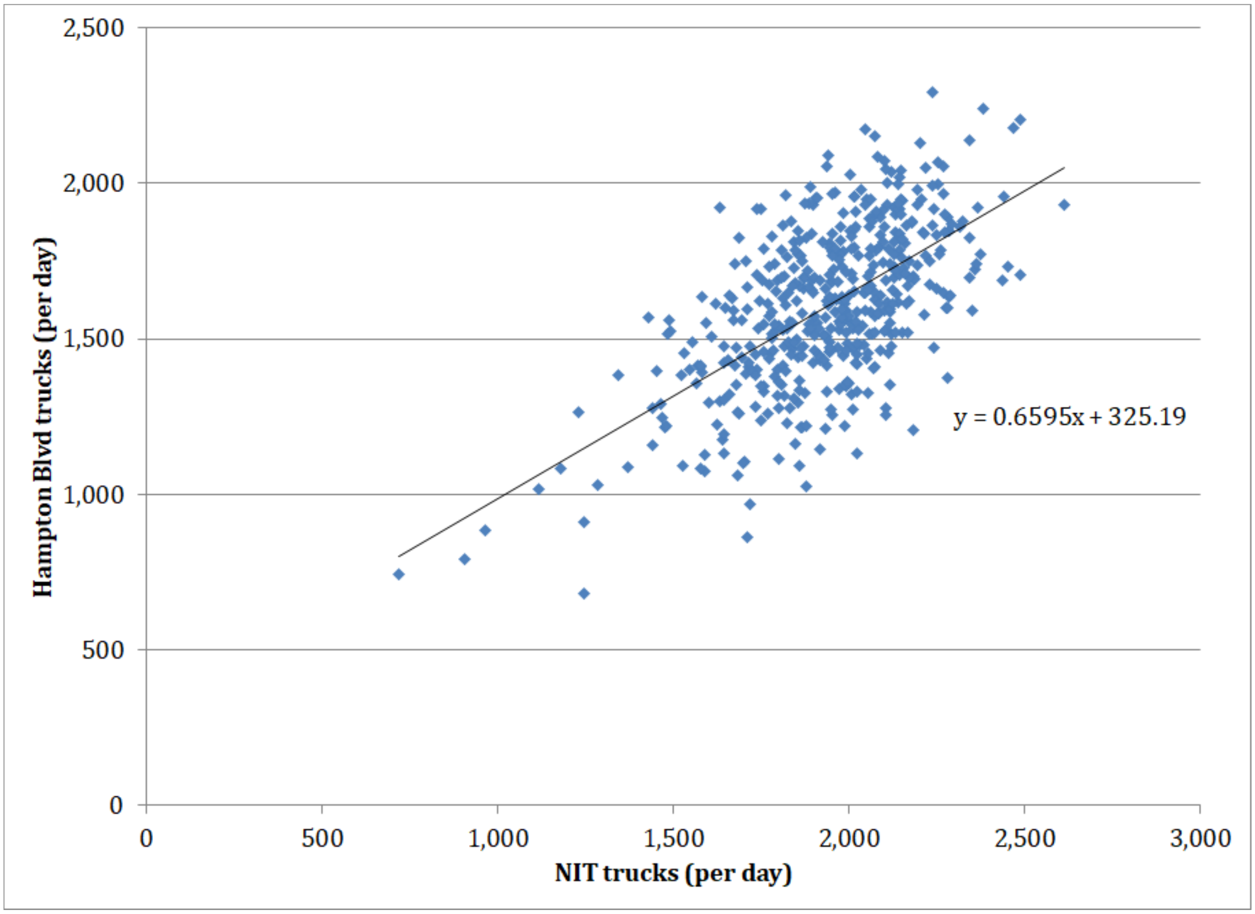


FIGURE 13 HB Trucks vs. NIT Trucks, by day, pre-IMC (Jan 2016 through Nov 2017)
Source: HRTPO processing of VDOT and Port of Virginia data

As one might expect, prior to the opening of the Intermodal Connector, the number of daily NIT trucks was a fairly good predictor of the number of daily Hampton Blvd trucks.

Results

For the with-IMC time period[4], staff:

- plugged NIT trucks into the above model (formula shown on above chart) to estimate “without IMC” Hampton Blvd truck volumes,
- and then compared these estimated “without IMC” Hampton Blvd truck volumes to the actual “with IMC” Hampton Blvd truck volumes (counted by VDOT)

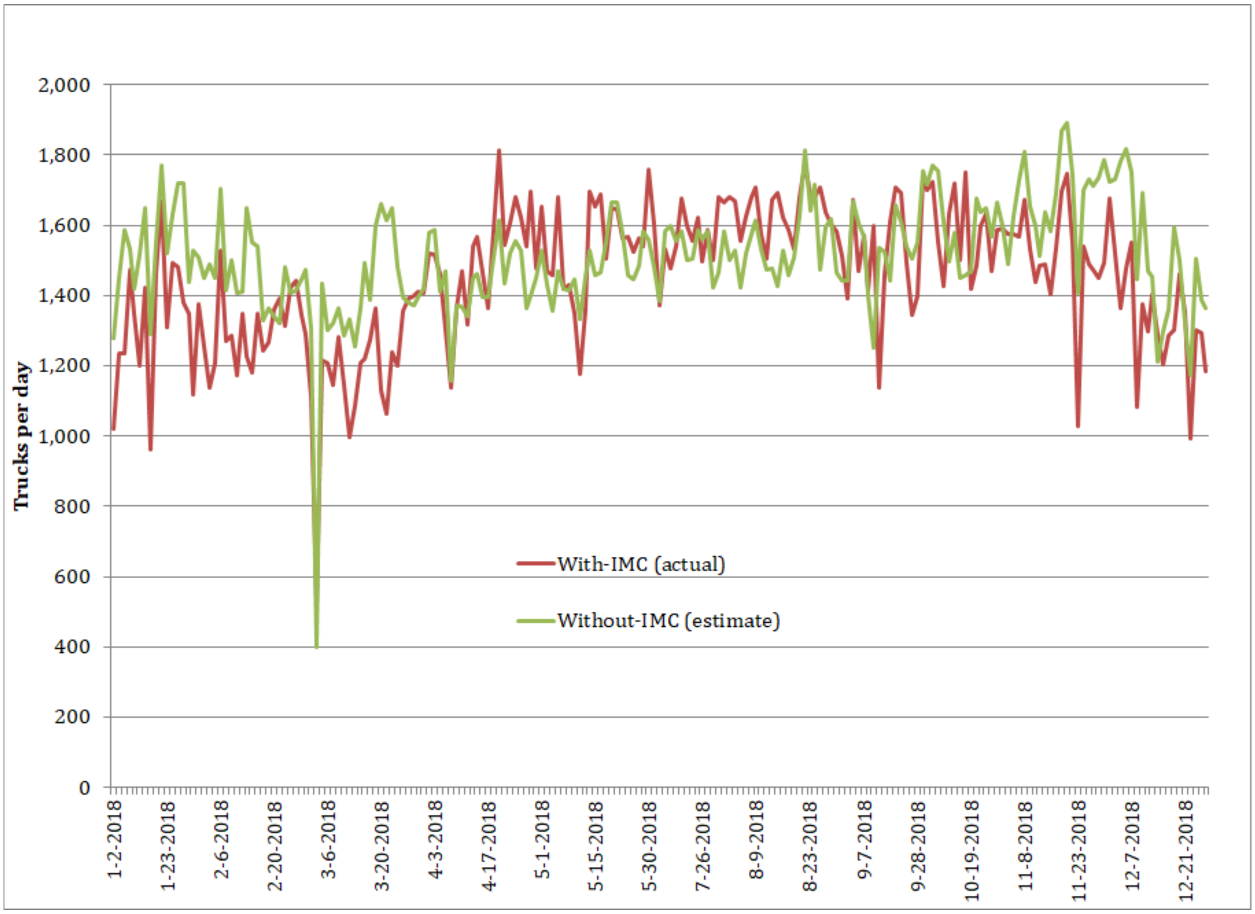


FIGURE 14 Impact of IMC on Hampton Blvd Trucks (during truck hours), 2018
Source: HRTPO processing of VDOT and Port of Virginia data

[4] The IMC opened to traffic December 21, 2017. To represent the with-IMC time period, staff chose 2018 data.

Staff then averaged the two sets of volume data, obtaining the averages below.

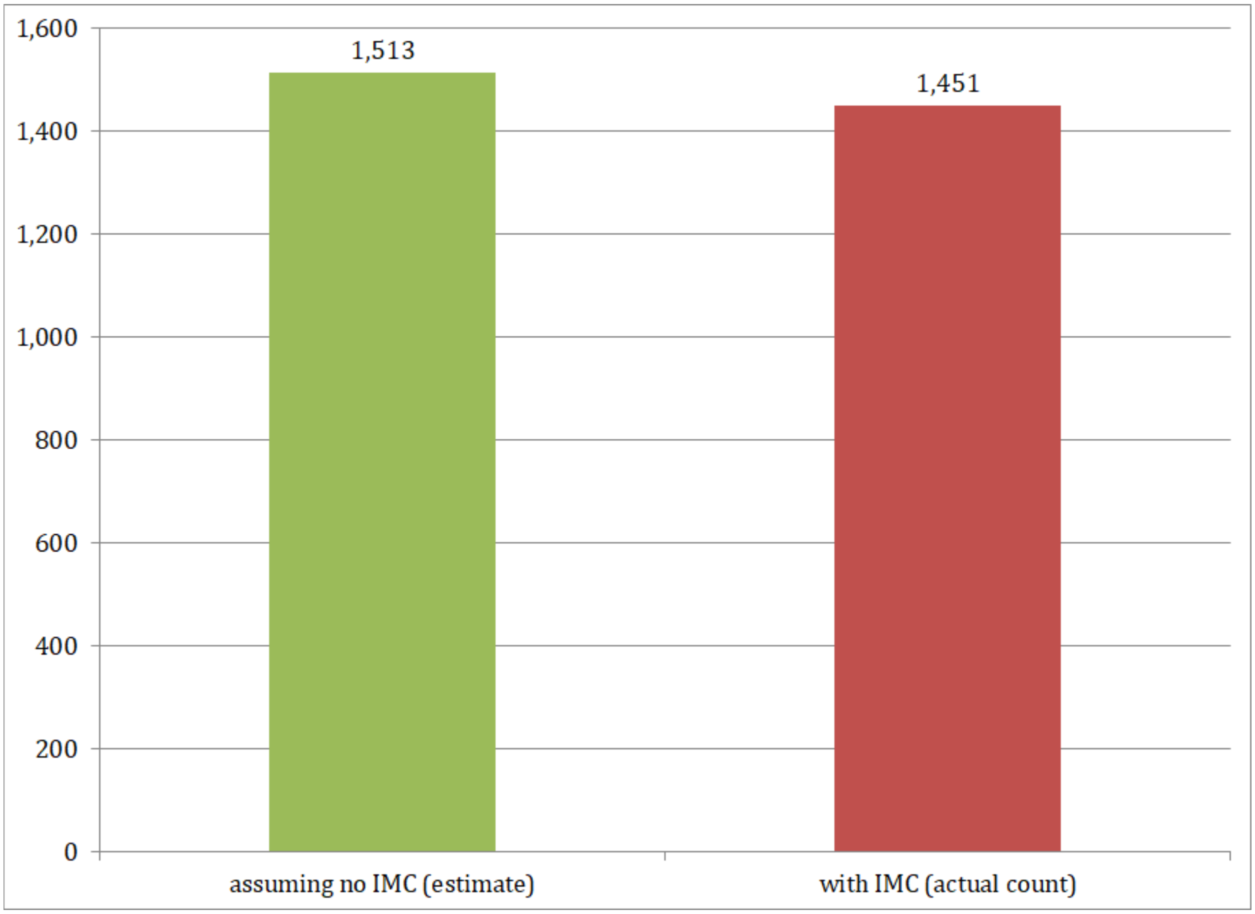


FIGURE 15 Impact of IMC on Hampton Blvd Trucks, average, per day, 2018
Source: HRTPO processing of VDOT and Port of Virginia data

By this method of analysis, the Intermodal Connector apparently reduced the number of **Hampton Blvd trucks by 62 trucks per day or 4%.**

Checking

The impact of the Intermodal Connector on Hampton Blvd being theorized above to be due—in part—to a difference in travel time between the Intermodal Connector and Terminal Blvd, staff examined that travel time difference in order to check the reasonableness of the above result (4% reduction).

HRTPO staff used Google Maps—in both directions, and under differing congestion conditions—to determine the travel time difference between Terminal Blvd and the Intermodal Connector. The set of eight runs is shown below in small icons to show general technique; **full-size copies are included in the appendices** to show detail.

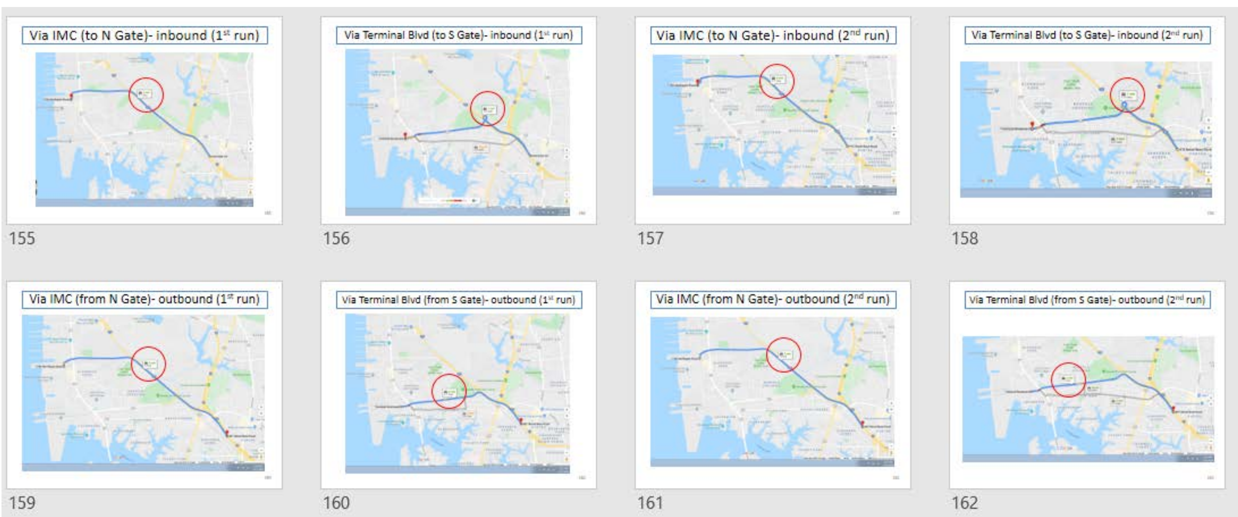


FIGURE 16 Travel Time between I-64 and NIT via Terminal Blvd and the IMC
Source: HRTPO usage of Google Maps

For each of the eight measurements, the Intermodal Connector was one minute quicker than Terminal Blvd. Given this small time-savings, the small impact of the Intermodal Connector on Hampton Blvd trucks (4% reduction) appears reasonable.

B. Impact of Hampton Blvd Truck Hours

The purpose of this section is to measure the effectiveness of allowing large trucks on Hampton Blvd only between 6am to 4pm.[5]

FIGURE 17 Hampton Blvd Truck Hours
Source: HRTPO staff

[5] i.e. prohibiting trucks between 4pm and 6am

To measure the effectiveness of the existing truck hours, staff compared:

- trucks on Hampton Blvd during truck hours and
- trucks on Hampton Blvd during truck-prohibited hours

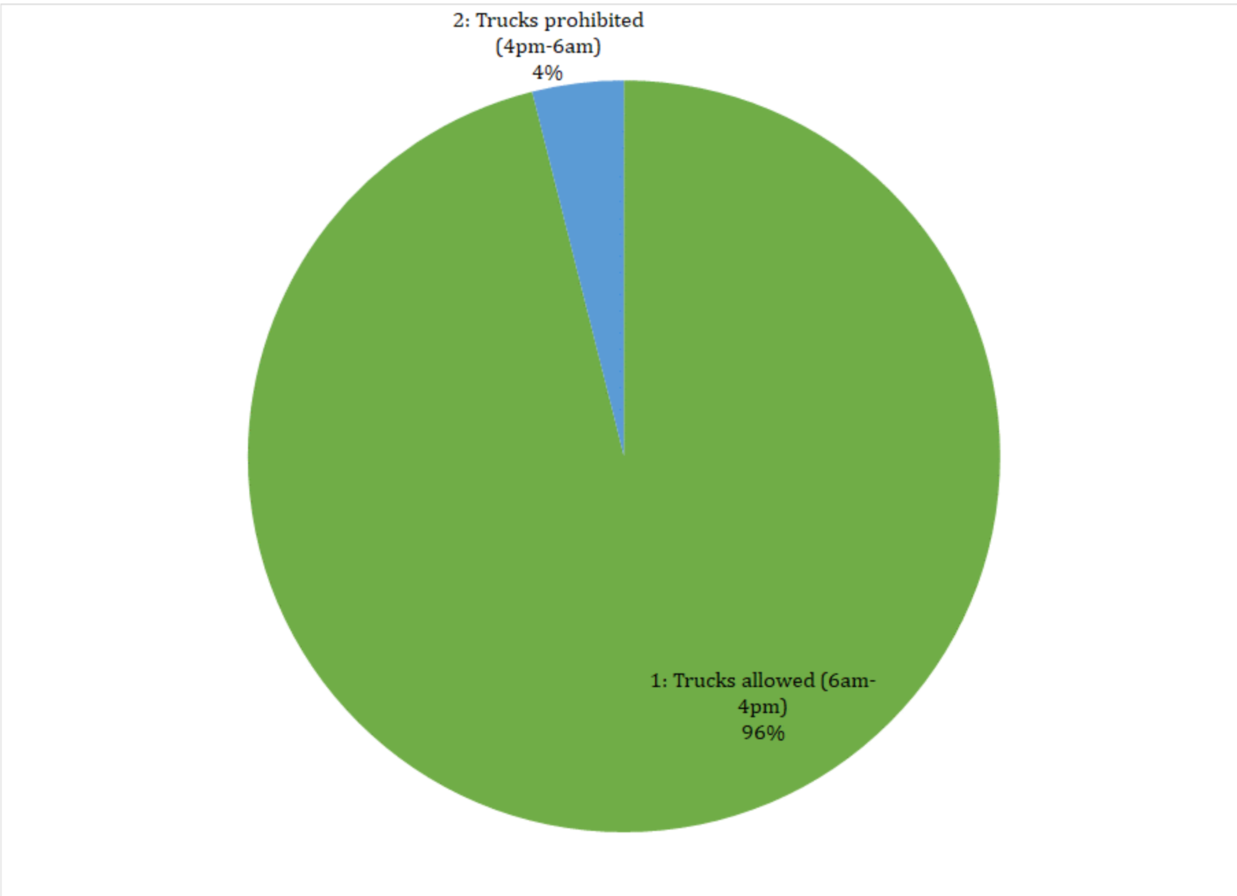


FIGURE 18 Hampton Blvd Trucks, by Truck Hours, 2018, StreetLight Index
Source: HRTPO processing of StreetLight data

Only 4% of Hampton Blvd trucks use Hampton Blvd during prohibited hours. Given the 4% violation rate, it **appears that the implementation of truck hours on Hampton Blvd effectively prevent trucks during prohibited hours.**

Options for Reducing Trucks on Hampton Blvd

In this section, staff estimates the impact which various options would have on the number of trucks on Hampton Blvd.

To develop options for reducing trucks on Hampton Blvd—including methods of shifting trucks from Hampton Blvd to I-64—staff investigated the factors NIT drivers consider when making a choice between these two routes. Given that truck drivers consider travel time and tolls when choosing a route, staff identified options that increase travel time or tolls for trucks using Hampton Blvd. Staff also investigated the existence of additional route choice factors, resulting in the development of "enabling taller trucks to use HRBT westbound" as an option. This additional route choice factor investigation is included as Appendix C.

To address some of the existing challenges that the City of Norfolk is experiencing on Hampton Blvd, HRTPO staff conducted a technical analysis of four (4) options for reducing trucks. For each option, staff estimates the percentage of truck volume reduction expected from implementation of the option.[6] For two options—"raising truck toll at Midtown Tunnel"; "enabling taller trucks to use HRBT westbound"—staff provided expected side effects. For one option—"shifting Norfolk International Terminal / Portsmouth truck trips off of Hampton Blvd"—staff provided feedback from the Port.

These options will require further analysis to better understand the advantages and disadvantages of each approach, and to understand the complex and evolving needs of the communities located near the Hampton Boulevard corridor as well as the evolving needs of the Port of Virginia. Prior to implementing any of the four options for reducing trucks on Hampton Blvd, HRTPO staff recommends that the City conduct more research, and that it do so in collaboration with the freight community (the Port, trucking companies, rail entities, etc.).

[6] For the raising-truck-toll-at Midtown-Tunnel option, staff estimates the amount of truck volume reduction under the current toll rate.

A. <u>Option: Lowering Speed Limits on Hampton Blvd</u>

Staff examined lowering the speed limit as the first option for reducing trucks on Hampton Blvd.

The current speed limits are:

- 30 mph, southern portion (below Westmoreland Ave)
- 35 mph, northern portion (above Westmoreland Ave)

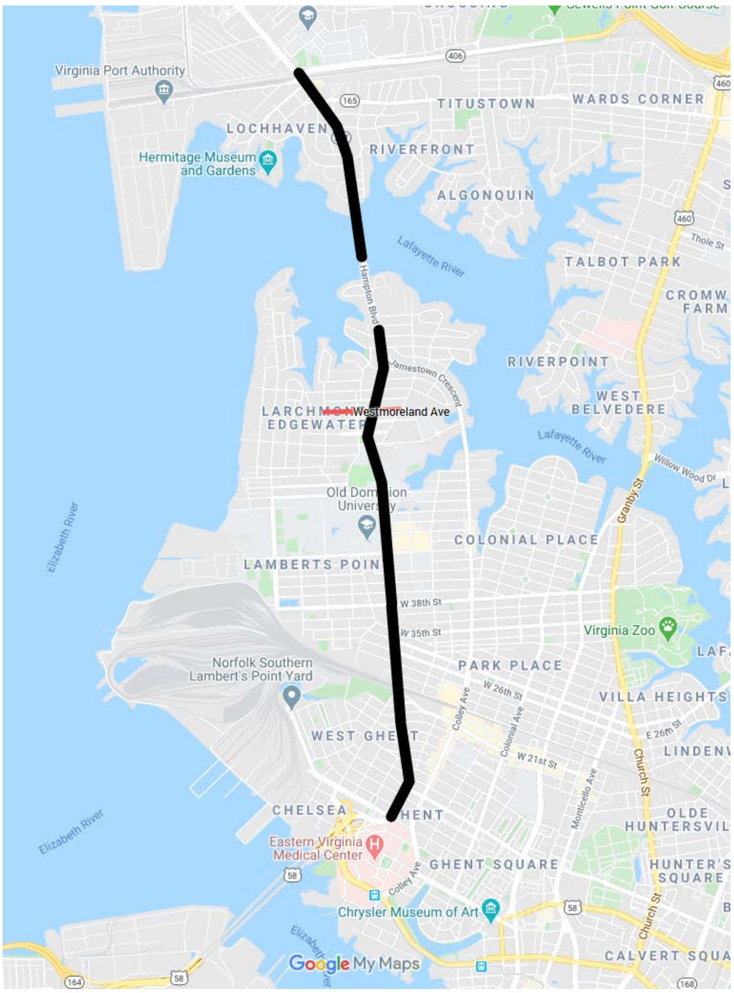


FIGURE 19 Southern and Northern Sections of Hampton Blvd

Source: HRTPO processing of Google My Maps data

The tested speed limits are 5mph lower:

- 25 mph, southern portion (below Westmoreland Ave)
- 30 mph, northern portion (above Westmoreland Ave)

On the following pages, staff estimated the impact of the lower speed limits by:

- preparing a route-choice regression model that "explains" the choice between Hampton Blvd and I-64 (for a truck driver leaving NIT) with the current speed limits, and then by
- running the model with the lower speed limits

A regression model is a formula that uses inputs (the right side of the formula) to estimate an output (the left side of the formula). For example, *weight = height*75 – 250* is a model that uses human height (in feet) to estimate human weight (in pounds). In a choice model, the output is the probability of a certain choice being made, in this case an NIT truck driver choosing Hampton Blvd.

1. Preparation of Route-Choice Model

Staff prepared the model in three steps:

- Designing the model
- Estimating model coefficients
- Testing the model

a. Designing the model

The variable of interest, i.e. the portion of truck drivers choosing Hampton Blvd (over I-64) from NIT is known as the "dependent" variable. Given that the choice of Hampton Blvd depends on the destination, staff chose "destination" as the model's unit of analysis. Looking for "independent" variables to explain the portion of drivers choosing Hampton Blvd, staff chose the industry standard route-choice variable "travel time" as the model's first independent variable. Given that most (but not all) NIT-HB trips require toll payment at the southern end of Hampton Blvd, i.e. the Midtown Tunnel, staff chose "HB toll disadvantage" as the second independent variable. Finally, given that the dependent variable is a percentage, the logistic form of regression was chosen.

The model's design is summarized below.

- Unit of analysis: destination zones (NIT as origin)
- Dependent variable: % using Hampton Blvd (HB)
- Independent variables:
  - Hampton Blvd time savings
  - Hampton Blvd toll disadvantage
- Regression form: logistic

FIGURE 20 Design of Model Explaining Selection of Hampton Blvd vs. I-64
Source: HRTPO

b. Estimating model coefficients

In order to prepare the model for usage, staff estimated the "coefficients" for the dependent variables (time savings and toll disadvantage). Coefficients quantify the degree to which a change in each independent variable explains a change in the dependent variable. Estimating a model's coefficients requires a data set of observed (i.e. existing) values for each variable.

To gather existing values for the dependent variable (% of trucks using Hampton Blvd), staff used the "Top Routes" feature of StreetLight which measures the usage of multiple paths between an origin and a destination, in this case the path that includes Hampton Blvd vs. the path that includes I-64. An example run is shown for *one* destination in the map below, and the results found for *all* destinations are shown in chart on the following page.

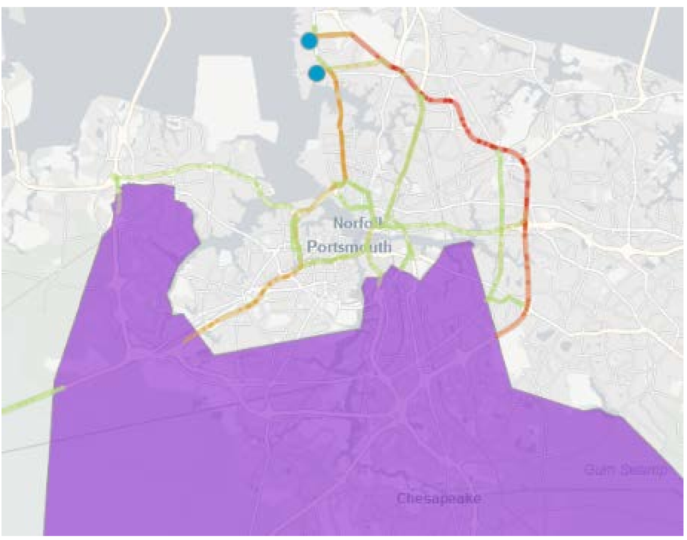


FIGURE 21 Example "Top Routes" Analysis- between NIT and Chesapeake
Source: HRTPO usage of StreetLight data platform

For the Chesapeake example mapped above, 32% of Chesapeake-bound NIT trucks used Hampton Blvd.

The following abbreviations are used in the chart below:

- CBBT Chesapeake Bay Bridge Tunnel
- HRBT Hampton Roads Bridge Tunnel
- MMBT Monitor-Merrimac Bridge Tunnel
- NC North Carolina
- IOW Isle of Wight County
- SH Southampton County

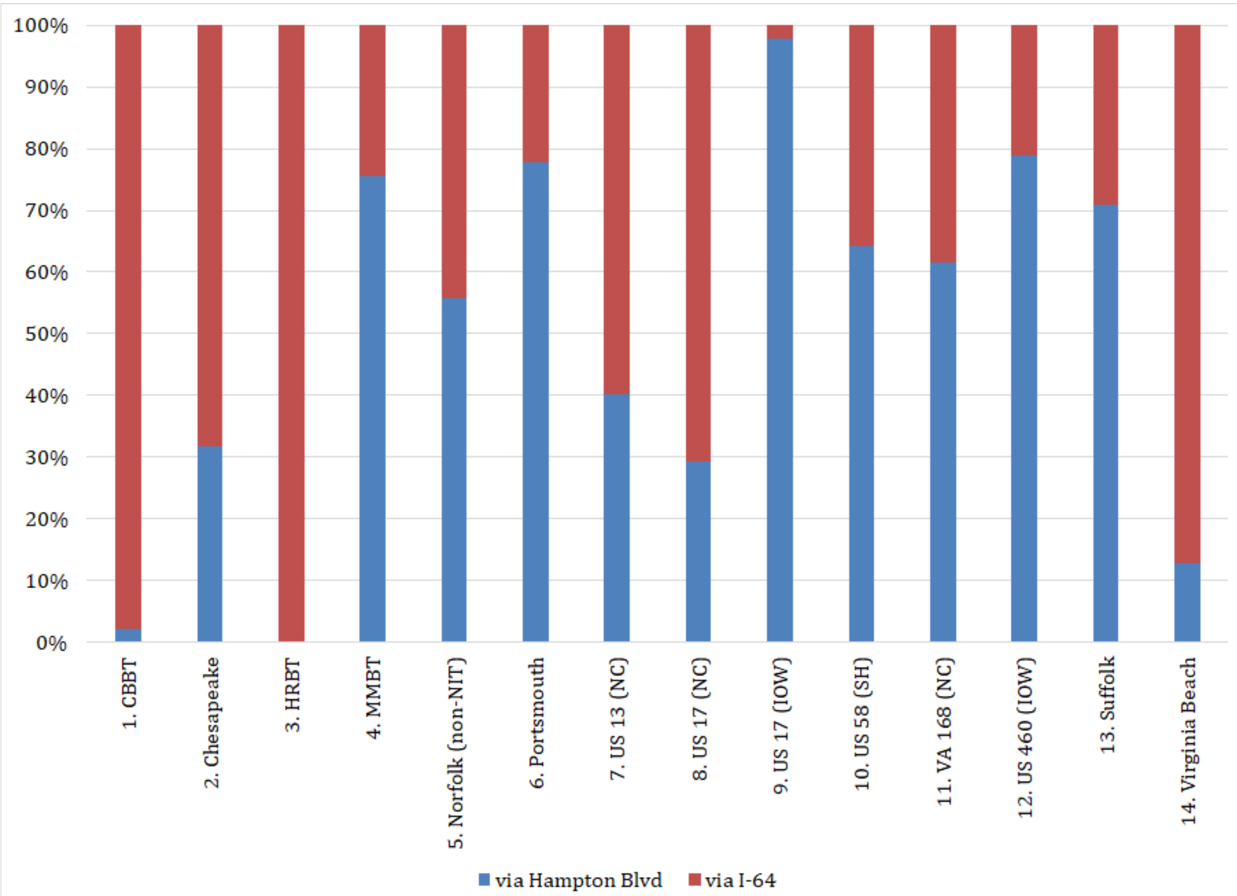


FIGURE 22 Route Choice from NIT (Hampton Blvd vs. I-64), weekday, Hampton Blvd truck hours, 2018, StreetLight sample trucks

Source: HRTPO usage of StreetLight data platform

The chart shows that the choice of route logically varies by destination- for some destinations, drivers favor I-64 (e.g. for the HRBT destination); for other destinations, driver favor Hampton Blvd (e.g. for the Portsmouth destination).

To gather the values for the first independent variable (HB travel time advantage), staff used Google Maps to measure—for each destination—how travel times vary by route choice (Hampton Blvd vs. I-64), as shown in the maps and chart below.

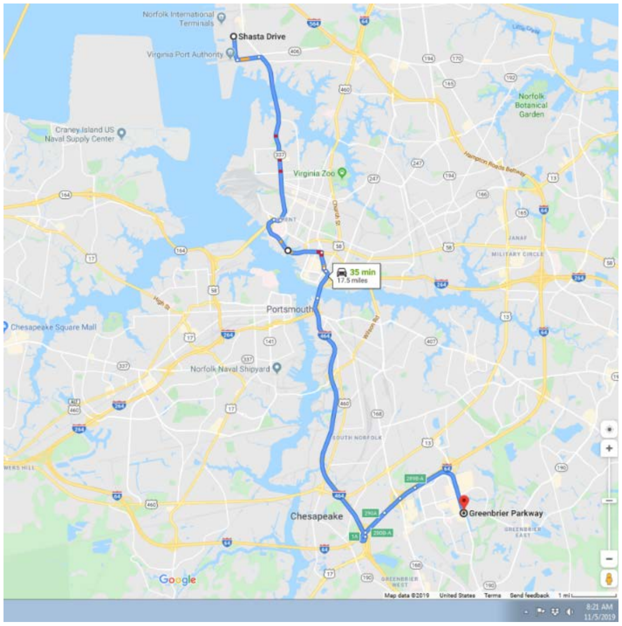


FIGURE 23 Example Travel Time Measurement- between NIT and Chesapeake using Hampton Blvd

Source: HRTPO usage of Google Maps

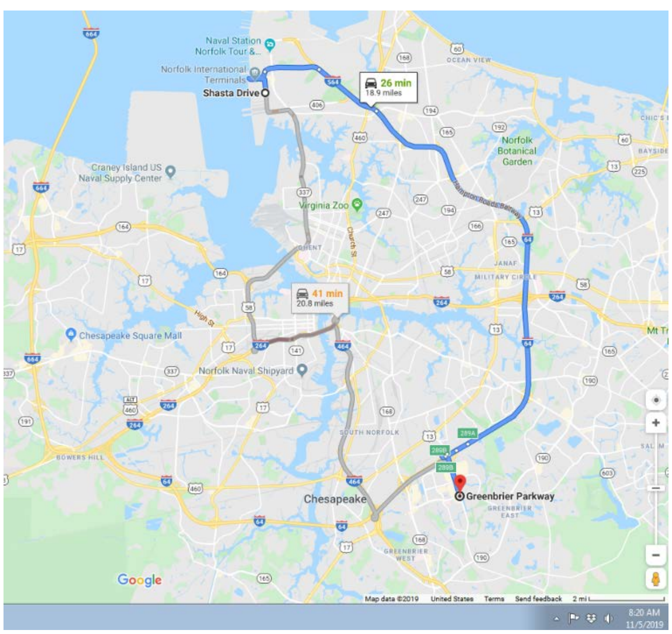


FIGURE 24 Example Travel Time Measurement- between NIT and Chesapeake using I-64

Source: HRTPO usage of Google Maps

The following abbreviations are used in the chart below:

- CBBT Chesapeake Bay Bridge Tunnel
- HRBT Hampton Roads Bridge Tunnel
- MMBT Monitor-Merrimac Bridge Tunnel
- W Nor Br West Norfolk Bridge
- NC North Carolina
- IW Isle of Wight County
- SH Southampton County

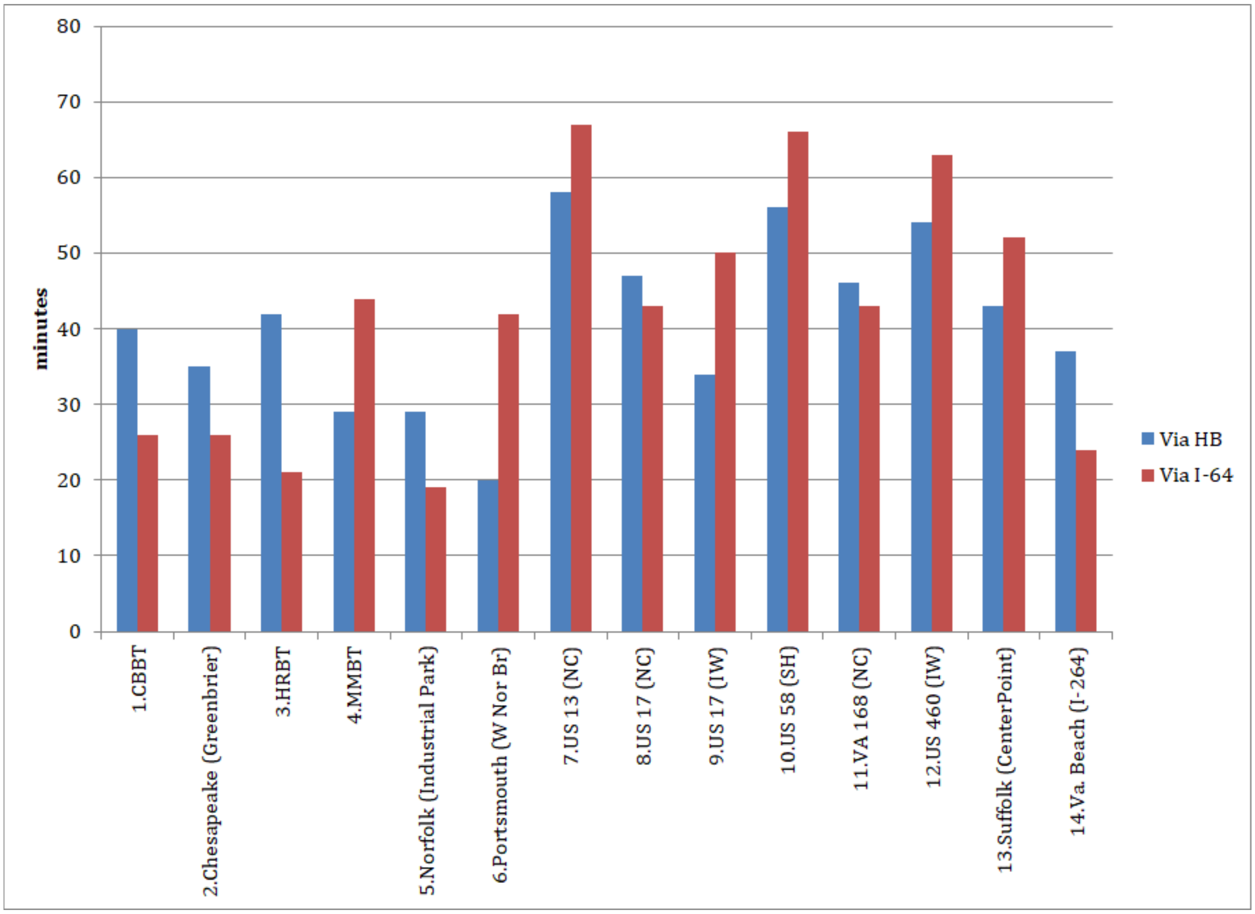


FIGURE 25 Travel Time between NIT and Subject Destinations
Source: HRTPO usage of Google Maps

Staff calculated "HB time savings" by subtracting Hampton Blvd's travel time from I-64's travel time.

Plotting (on the vertical axis) the Hampton Blvd share of trips (from the route choice chart [Figure 22]) against (on the horizontal axis) the travel time savings (calculated from the travel time chart [Figure 25]), by destination, produced the following chart.[7]

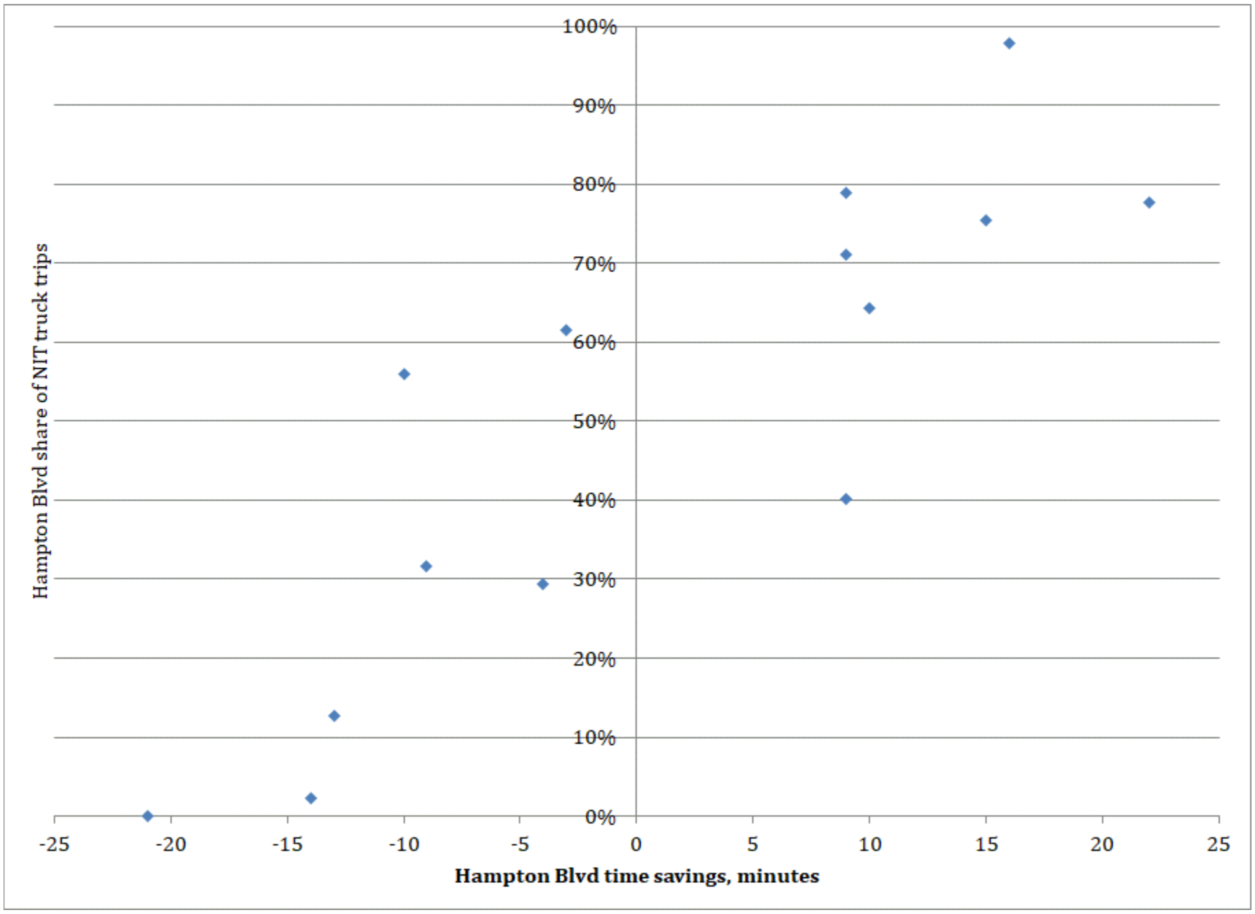


FIGURE 26 Hampton Blvd's Share of Trucks vs. Time Savings, by destination
Source: HRTPO processing of StreetLight and Google Map data

The above chart shows that Hampton Blvd captures a high % of trips (upper half of chart) when Hampton Blvd saves time (right half of chart), confirming the importance of travel time in explaining route choice.[8]

The second independent variable—HB toll disadvantage—being a binary variable (i.e. having one of two values [1 yes, 2 no], staff gave each destination requiring a toll if using Hampton Blvd from NIT (e.g. Portsmouth) a value of 1, and each destination NOT requiring a toll if using Hampton Blvd (e.g. Chesapeake) a value of 0.

[7] Note that, although the general value of these variables can be seen in the chart on this page, the numerical value of these variables is listed in the table on the following page.
[8] Note that—by lowering travel times for trips moving between northern Norfolk and points west of the Elizabeth River—the proposed harbor-crossing Regional Crossing Study (RCS) connectors would reduce the number of trucks and autos using Hampton Blvd, as discussed in section D below.

The input data (prepared as discussed above) is shown in rows below. Staff regressed this data to estimate the model's coefficients, shown in small boxes below.

The following abbreviations are used in the figure below:

- CBBT Chesapeake Bay Bridge Tunnel
- HRBT Hampton Roads Bridge Tunnel
- MMBT Monitor-Merrimac Bridge Tunnel
- W Nor Br West Norfolk Bridge
- NC North Carolina
- IW Isle of Wight County
- SH Southampton County

destination	HB share (actual)	HB time savings	HB toll disadvantage	logit	probability (model)	LL (log likelihood)
1.CBBT	2%	-14	0	-1.653	0.16	-0.212
2.Chesapeake (Greenbrier)	32%	-9	0	-0.886	0.29	-0.626
3.HRBT	0%	-21	0	-2.726	0.06	-0.063
4.MMBT	76%	15	1	1.398	0.80	-0.563
5.Norfolk (Industrial Park)	56%	-10	0	-1.040	0.26	-0.885
6.Portsmouth (W Nor Br)	78%	22	1	2.471	0.92	-0.633
7.US 13 (NC)	40%	9	1	0.478	0.62	-0.768
8.US 17 (NC)	29%	-4	0	-0.120	0.47	-0.670
9.US 17 (IW)	98%	16	1	1.551	0.83	-0.227
10.US 58 (SH)	64%	10	1	0.631	0.65	-0.652
11.VA 168 (NC)	62%	-3	0	0.034	0.51	-0.689
12.US 460 (IW)	79%	9	1	0.478	0.62	-0.583
13.Suffolk (CenterPoint)	71%	9	1	0.478	0.62	-0.621
14.Va. Beach (I-264)	13%	-13	0	-1.500	0.18	-0.393
	50% avg.				0.50 avg.	-7.586 sum

regression results (model coefficients):

intercept	b0	0.494	
HB time savings	b1	0.153	logical positive sign
HB toll disadvantage	b2	-1.396	logical negative sign

FIGURE 27 Outbound NIT Route Choice Data and Model

Source: HRTPO processing of StreetLight and Google Map data

As expected, the regression gave a positive sign to the coefficient of the time savings variable, and gave a negative sign to the toll disadvantage variable, providing confidence in the model design and data.

To further test the validity of the model, staff used a technique called "backcasting" in which one compares the model's choice results to the actual choice results.

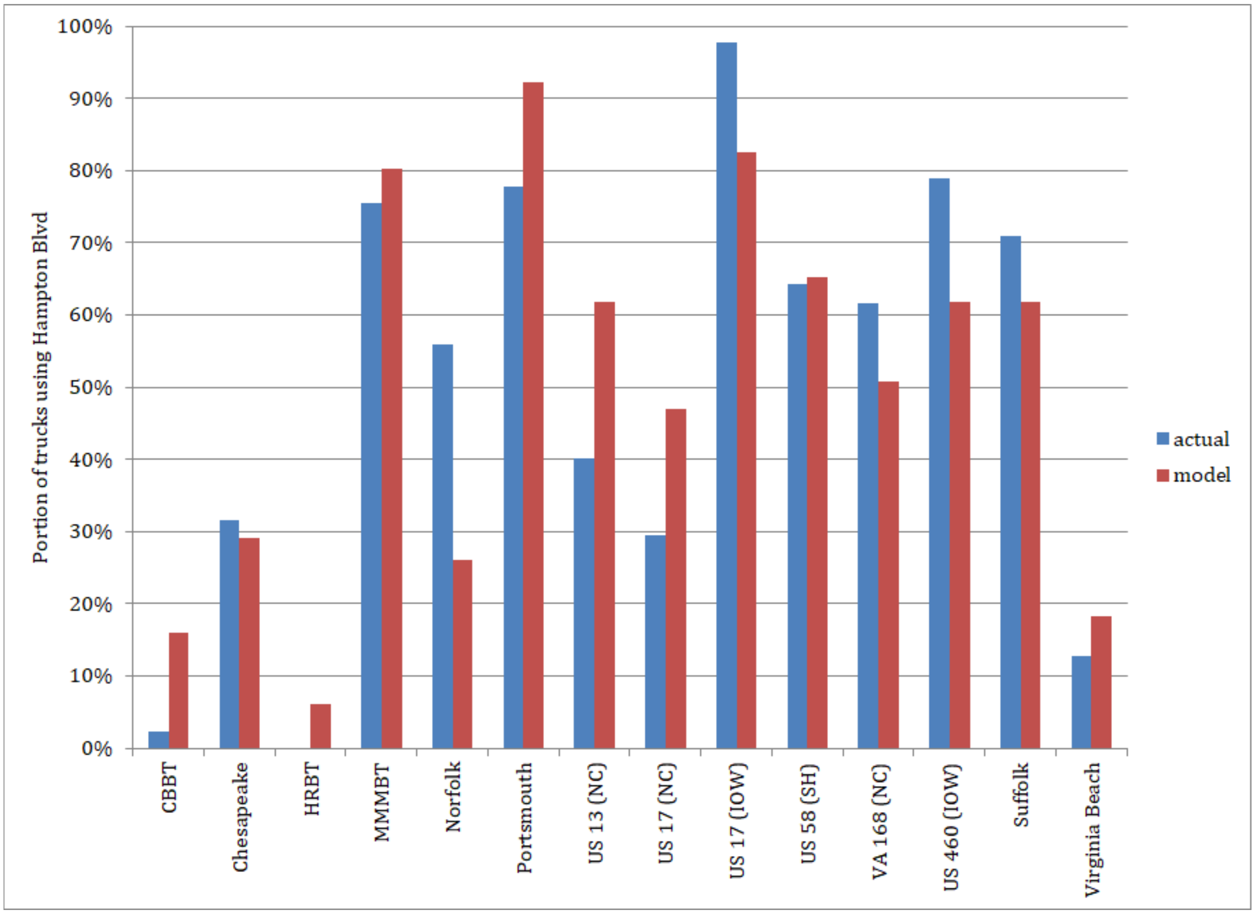


FIGURE 28 Route Choice Model's Goodness of Fit

Source: HRTPO processing of StreetLight and Google Map data

As shown above, the model replicates the actual choice data fairly well, providing even more confidence in the route choice model.

2. Running the Route-Choice Model with Lower Speeds

Given that:

- the model is based (in part) on *travel time*, but
- the proposed change is a change in *speed limit*,

prior to running the model for the proposed speed limit change, staff determined the relationship between speed limit and travel time by conducting several automobile runs.

Staff conducted three usable runs, two southbound (SB) and one northbound (NB). From these runs, staff:

- recorded the actual amount of time running at the speed limit (ASL) (vs. time forced to run below speed limit (BSL))
- using the above time running ASL, estimated the distance in miles running ASL
- using the above distance running ASL, estimated the time required if running at 5mph lower speed limit
- compared the two times to estimate the additional time required for lower speed limit

Date of runs:	11/19/2019, 2:30-4:00pm			
Trip tips:	Redgate Ave (at one end), Terminal Blvd (at the other end)			
Segments:	current speed limit changes at Westmoreland Ave: Northern section is 35 mph; Southern section is 30 mph			
Assumption:	time spent traveling below speed limit [ie in congestion] would not be affected by a change in speed limit			
	Northern Segment	Southern Segment		
actual time running at speed limit:				
Run2 (SB)	2.8	2.5	minutes	
Run3 (NB)	2.4	2.7	minutes	
Run4 (SB)	2.5	2.0	minutes	
avg	**2.6**	**2.4**	**minutes**	
current sp. lmt.	35	30		
estimated distance running at current speed limit:				
avg	1.5	1.2	miles	
lower sp. lmt.	30	25	mph	(5 mph lower than current)
estimated time running at 5mph below current speed limit:				
	3.0	**2.9**	**minutes**	
difference	**0.4**	**0.5**	**minutes**	
	or total of 1 minute difference			

FIGURE 29 Estimation of Additional Time Required with Speed Limit Lower by 5mph

Source: HRTPO collection and processing of travel time data

From these runs, staff estimates that lowering the speed limits by 5 mph would require **one (1) additional minute** for vehicles to traverse Hampton Blvd.

Having estimated that the subject 5mph lowering of speed limits would add one (1) minute to travel times along subject segment, staff entered the longer travel time into the model developed above, with results shown below.

The following abbreviations are used in the figure below:

- CBBT Chesapeake Bay Bridge Tunnel
- HRBT Hampton Roads Bridge Tunnel
- MMBT Monitor-Merrimac Bridge Tunnel
- W Nor Br West Norfolk Bridge
- NC North Carolina
- IW Isle of Wight County
- SH Southampton County

	existing conditions (ie existing speed limits)						with additional trave 1 min.			
destination	HB time savings, minutes	HB toll dis-advantage, yes or no	logit (model)	probability of choosing HB (model)	NIT outbound trucks, StrtLt sample	NIT outbound trucks on HB, StrtLt sample (probability * outbound trucks)	HB time savings, minutes	logit (model)	probability of choosing HB (model)	NIT outbound trucks on HB, StrtLt sample (probability * outbound trucks)
1. CBBT	-14	0	-1.653	0.16	455	73	-15	-1.806	0.14	64
2. Chesapeake (Greenbrier)	-9	0	-0.886	0.29	6,323	1,845	-10	-1.040	0.26	1,652
3. HRBT	-21	0	-2.726	0.06	2,565	158	-22	-2.880	0.05	136
4. MMBT	15	1	1.398	0.80	740	593	14	1.245	0.78	575
5. Norfolk (Industrial Park)	-10	0	-1.040	0.26	4,348	1,136	-11	-1.193	0.23	1,012
6. Portsmouth (W Nor Br)	22	1	2.471	0.92	8,921	8,226	21	2.318	0.91	8,121
7. US 13 (NC)	9	1	0.478	0.62	110	68	8	0.325	0.58	64
8. US 17 (NC)	-4	0	-0.120	0.47	264	124	-5	-0.273	0.43	114
9. US 17 (IW)	16	1	1.551	0.83	136	112	15	1.398	0.80	109
10. US 58 (SH)	10	1	0.631	0.65	1,799	1,174	9	0.478	0.62	1,110
11. VA 168 (NC)	-3	0	0.034	0.51	13	7	-4	-0.120	0.47	6
12. US 460 (IW)	9	1	0.478	0.62	763	471	8	0.325	0.58	443
13. Suffolk (CenterPoint)	9	1	0.478	0.62	3,507	2,165	8	0.325	0.58	2,036
14. Va. Beach (I-264)	-13	0	-1.500	0.18	1,134	207	-14	-1.653	0.16	182
					31,078	16,359				15,624

FIGURE 30 Impact of Speed Limit Change on Outbound NIT Trucks on Hampton Blvd

Source: HRTPO processing of Google Map, StreetLight, and travel time data

The model forecasts that a 5mph lowering of speed limits would reduce outbound NIT trucks on Hampton Blvd by 4% (from 16,359 to 15,624 sample[9] trucks).

[9] The "sample trucks" are those trucks for which StreetLight receives and processes travel data.

Having estimated the above impact on *outbound NIT* Hampton Blvd trucks, staff calculated the impact on *all* Hampton Blvd trucks as follows:

		source
NIT outbound trucks on HB, StrtLt sample		
existing conditions (ie existing speed limits)	16,359	above
with additional travel time	15,624	above
impact of additional travel time on NIT HB trucks	96%	
(assuming the impact for inbound NIT trucks is the same as that for outbound trucks)		
HB trucks, existing conditions (2018), per day (sum of both directions)	1,451	counts
NIT trucks as portion of HB trucks (avg of both directions)	61%	StreetLight
NIT trucks on HB, estimate- existing conditions, per day	892	
portion expected if speed limit lower by 5mph	96%	above
NIT trucks on HB, forecast- with speed limit lower by 5mph, per day	852	
reduction in total HB trucks expected from 5mph speed limit change	40	
(assuming speed limit has no effect on non-NIT trucks)		
	recap	
HB trucks, existing conditions (2018), per day (sum of both directions)	**1,451**	above
reduction in total HB trucks expected from 5mph speed limit change	40	above
HB trucks, forecast- with speed limit lower by 5mph, per day	**1,411**	

FIGURE 31 Impact of Speed Limit Change on Hampton Blvd Trucks
Source: HRTPO processing of Google Map, StreetLight, and travel time data

As shown above, based on the route-choice model developed above, HRTPO staff estimates that a 5mph lowering in speed limits would reduce **trucks on Hampton Blvd from 1,451 to 1,411 trucks per day, or 3%**.

B. <u>Option: Raising Truck Toll at Midtown Tunnel</u>

Given, as shown in the Background section above, that 2/5ths of the trucks from NIT on Hampton Blvd are destined for Portsmouth and therefore mostly using the Midtown Tunnel (MTT), staff analyzed the impact of raising the Midtown Tunnel truck toll rate as an option for reducing trucks on Hampton Blvd.

In order to determine truck sensitivity to tolls, staff measured the impact of the existing toll rates. Vehicles with three (3) or more axles, including the subject trucks, currently pay (via E-ZPass) $5.54 (off-peak) or $9.29 (peak) to use the Midtown Tunnel.

Heavy Vehicles
3 or more axles, includes cars w/ trailers

MONDAY – FRIDAY	E-ZPass	Pay by Plate
12:00am to 5:30am	$5.54	$9.23
5:30am to 9:00am (PEAK)	$9.29	$12.98
9:00am to 2:30pm	$5.54	$9.23
2:30pm to 7:00pm (PEAK)	$9.29	$12.98
7:00pm to 12:00am	$5.54	$9.23

FIGURE 32 Heavy Vehicle Toll Rates for Midtown and Downtown Tunnels
Source: www.driveert.com/#/about-tollrates

To calculate the impact of these existing tolls, staff used the route-choice model developed in the lowering-speed-limit section above because this model estimates Hampton Blvd's share of NIT trucks by destination, given:

- Hampton Blvd's travel time savings (or deficit)
- the presence (or absence) of tolls along the Hampton Blvd route

Staff ran the model with and without a toll at the Midtown Tunnel, comparing the two runs.

The following abbreviations are used in the figure below:

- CBBT Chesapeake Bay Bridge Tunnel
- HRBT Hampton Roads Bridge Tunnel
- MMBT Monitor-Merrimac Bridge Tunnel
- W Nor Br West Norfolk Bridge
- NC North Carolina
- IW Isle of Wight County
- SH Southampton County

	existing conditions (ie with MTT toll)						without MTT toll			
destination	HB time savings	HB toll dis-advantage	logit (model)	probability of choosing HB (model)	NIT outbound trucks, StrLt sample	NIT outbound trucks on HB, StrLt sample (probability * outbound trucks)	HB toll dis-advantage	logit (model)	probability of choosing HB (model)	NIT outbound trucks on HB, StrLt sample (probability * outbound trucks)
1. CBBT	-14	0	-1.653	0.16	455	73	0	-1.653	0.16	73
2. Chesapeake (Greenbrier)	-9	0	-0.886	0.29	6,323	1,845	0	-0.886	0.29	1,845
3. HRBT	-21	0	-2.726	0.06	2,565	158	0	-2.726	0.06	158
4. MMBT	15	1	1.398	0.80	740	593	0	2.793	0.94	697
5. Norfolk (Industrial Park)	-10	0	-1.040	0.26	4,348	1,136	0	-1.040	0.26	1,136
6. Portsmouth (W Nor Br)	22	1	2.471	0.92	8,921	8,226	0	3.867	0.98	8,738
7. US 13 (NC)	9	1	0.478	0.62	110	68	0	1.873	0.87	95
8. US 17 (NC)	-4	0	-0.120	0.47	264	124	0	-0.120	0.47	124
9. US 17 (IW)	16	1	1.551	0.83	136	112	0	2.947	0.95	129
10. US 58 (SH)	10	1	0.631	0.65	1,799	1,174	0	2.027	0.88	1,590
11. VA 168 (NC)	-3	0	0.034	0.51	13	7	0	0.034	0.51	7
12. US 460 (IW)	9	1	0.478	0.62	763	471	0	1.873	0.87	661
13. Suffolk (CenterPoint)	9	1	0.478	0.62	3,507	2,165	0	1.873	0.87	3,040
14. Va. Beach (I-264)	-13	0	-1.500	0.18	1,134	207	0	-1.500	0.18	207
					31,078	16,359				18,501

FIGURE 33 Impact of Midtown Tunnel Tolls on Outbound NIT Trucks on HB

Source: HRTPO processing of Google Map, StreetLight, and travel time data

As shown above, the two model runs indicate that Hampton Blvd would carry 13% more outbound NIT trucks (18,501 vs. 16,359 sample trucks) with no toll at the Midtown Tunnel.

Below staff converts the outbound NIT HB truck impact (above) to a *total* HB truck impact:

		source
NIT outbound trucks on HB, StrLt sample		
without MTT toll	18,501	above
existing conditions (ie with MTT toll)	16,359	above
impact of removing existing MTT tolls on NIT HB trucks	113%	
(assuming the impact for inbound NIT trucks is the same as that for outbound trucks)		
HB trucks, existing conditions (2018), per day (sum of both directions)	1,451	counts
NIT trucks as portion of HB trucks (avg of both directions)	61%	StreetLight
NIT trucks on HB, estimate- existing conditions, per day	892	
portion expected if no MTT tolls	113%	above
NIT trucks on HB, forecast- without MTT tolls, per day	1,009	
reduction in total HB trucks due to MTT tolls	117	
(assuming MTT tolls have no effect on non-NIT trucks)		
HB trucks, existing conditions (2018), per day (sum of both directions)	**1,451**	above
HB trucks, without MTT tolls (estimated), per day (sum of both directions)	**1,568**	

FIGURE 34 Impact of Midtown Tunnel Tolls on Hampton Blvd Trucks
Source: HRTPO processing of Google Map, StreetLight, and travel time data

Based on the route-choice model, HRTPO staff estimates that the existing Midtown Tunnel tolls reduce **trucks on Hampton Blvd at least from 1,568 to 1,451 per day, or 7%**.

The portion of Hampton Blvd trucks reduced by *raising* the MTT truck toll would **depend on the amount of that increase**. Further study would be required, including using the regional 4-step model, to determine truck reductions for various toll increases.

Raising the MTT truck toll would have side effects. Some current MTT trucks would pay the higher toll, and other current MTT trucks would take a longer route, both actions increasing shipping costs. The impact of increasing the MTT truck toll rate on route-choice and cost of NIT trucking would depend on the destination of those trucks, as shown below.

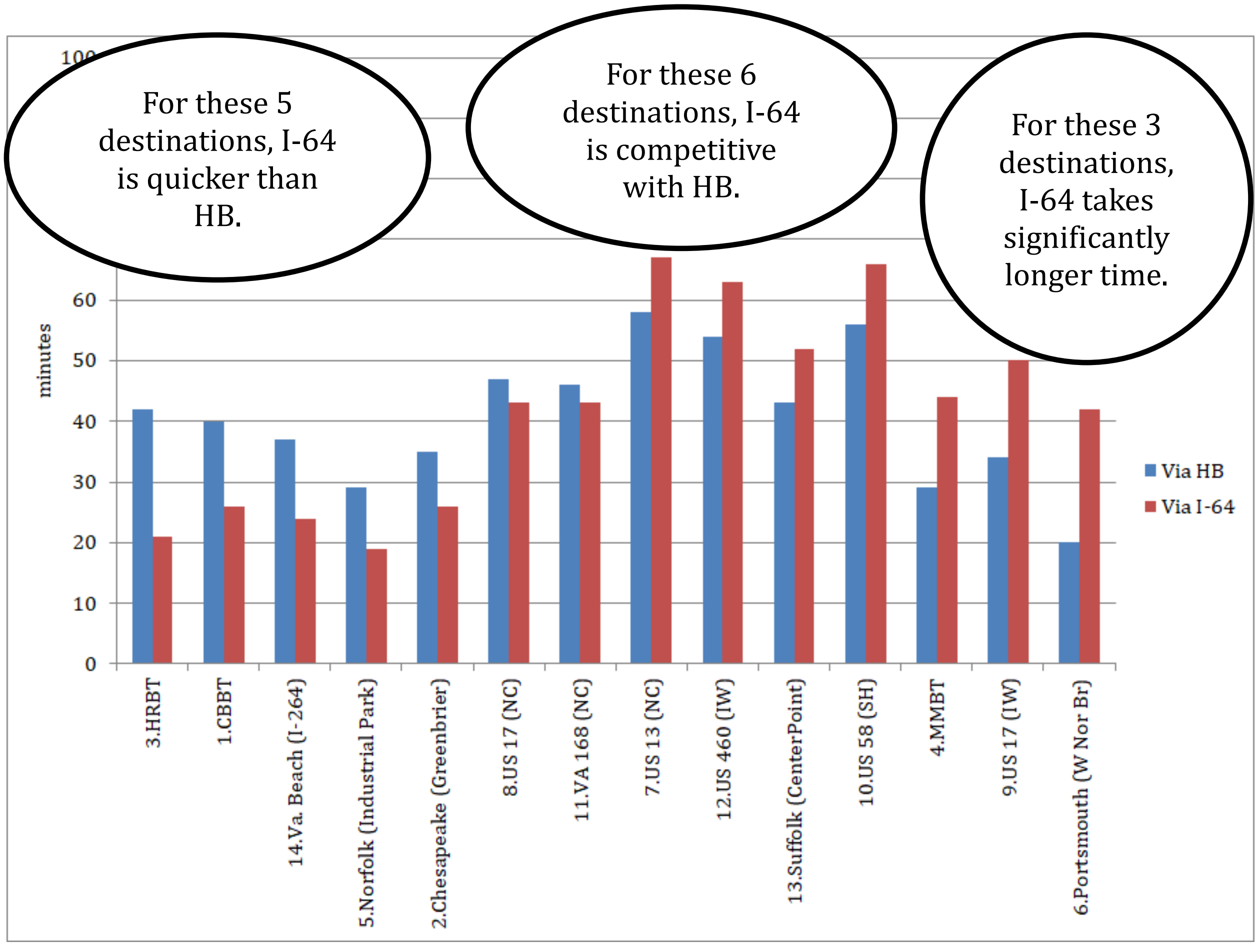


FIGURE 35 Outbound NIT Travel Times by Destination and Route
Source: HRTPO via Google Maps

I-64 being a quicker route for NIT trucks going to/from the first five (5) destinations (e.g. HRBT), an increase in the MTT truck toll rate would not affect these shipments. I-64 being a competitive route for NIT trucks going to/from the middle six (6) destinations/gateways (e.g. US 460), an increase in the MTT truck toll rate would not greatly affect the cost of these shipments. I-64 being a significantly longer-travel-time route for NIT trucks going to/from the last three (3) destinations (e.g. Portsmouth), an increase in the MTT truck toll rate would affect the cost of these shipments, a cost ultimately borne by the public.

Raising the Midtown Tunnel toll rate for trucks—to reduce truck traffic on Hampton Blvd—presents an opportunity for lowering the MTT toll rates for autos. Such a dual rate shift would be expected to produce the following results:

- no net monetary gain or loss to tunnel operator or the public
- increased cost of shipping, borne by the public
- reduced financial burden on local auto drivers
- reduced number of trucks on Hampton Blvd

C. Option: Enabling Taller Trucks to Use HRBT Westbound

Having been built in 1957, the height of the westbound (WB) Hampton Roads Bridge Tunnel (HRBT) tube is less than current standards. (The eastbound [EB] tube, built in 1976, is taller.) The sub-standard height at WB HRBT forces drivers of taller NIT trucks bound for the Peninsula and beyond to use the Monitor Merrimac Bridge Tunnel (MMBT), which is most quickly accessed via Hampton Blvd. As shown on travel time maps on the following page, this circuitous route costs drivers 15 minutes of time, costs them the dollar amount of the Midtown Tunnel toll, and adds trucks to Hampton Blvd.

FIGURE 36 Westbound HRBT
Source: HRTPO staff

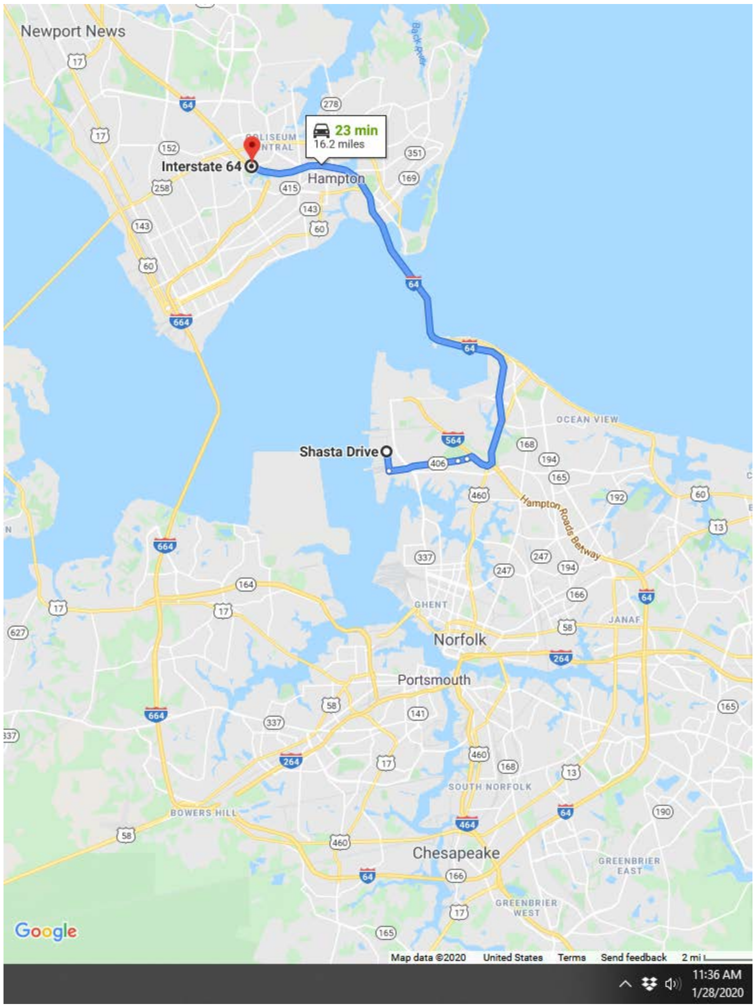


FIGURE 37a NIT to Peninsula Travel Time- via I-64
Source: Google Maps

Traveling from NIT to the Peninsula (and from there to points west and north) takes 23 minutes via I-64.

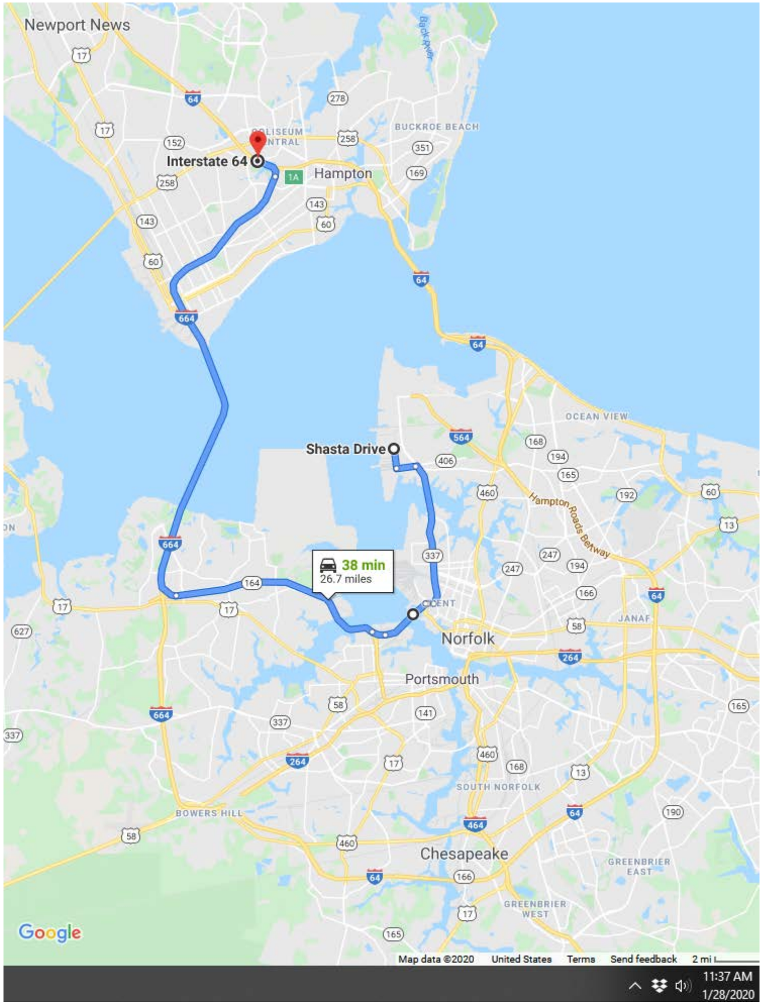


FIGURE 37b NIT to Peninsula Travel Time- via Hampton Blvd
Source: Google Maps

Traveling from NIT to the Peninsula (and from there to points west and north) using Hampton Blvd to avoid the HRBT takes 38 minutes, or 15 minutes longer than using the HRBT.

One-fifth of NIT trucks bound for I-64 on the Peninsula use the MMBT to avoid the HRBT, as shown in this figure.

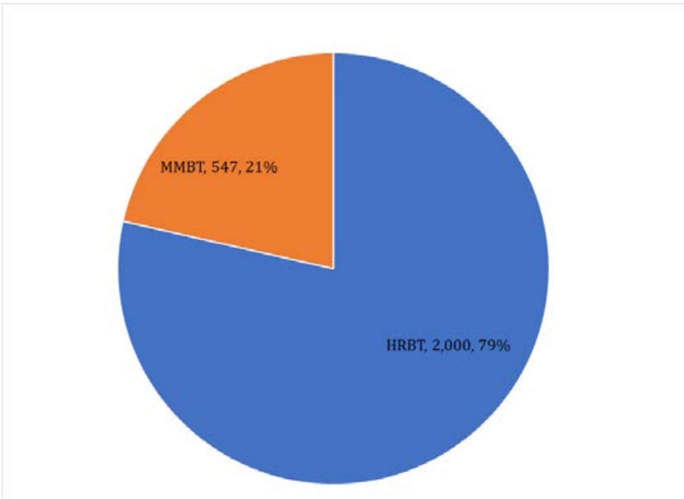


FIGURE 38 Route Choice of NIT Trucks Bound for I-64 Peninsula, 2018, sample trucks

Source: HRTPO staff processing of StreetLight data

The height of the HRBT tunnel may not be the only cause of this circuitous driving. To determine whether HRBT congestion is a cause, staff checked diversion by time of day.

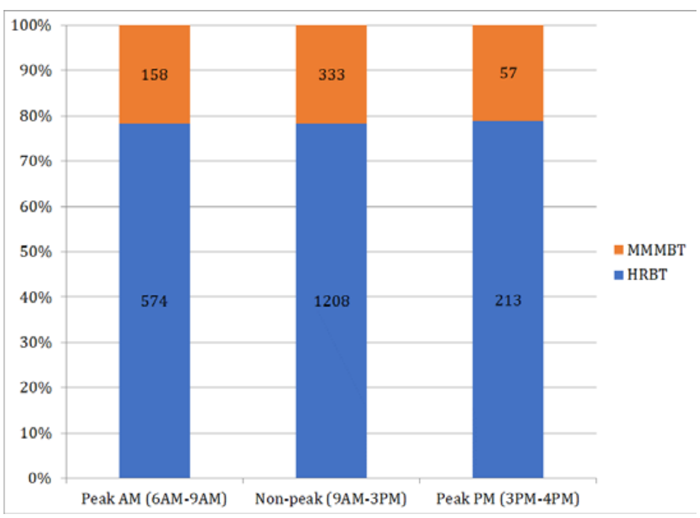


FIGURE 39 Route Choice of NIT Trucks Bound for I-64 Peninsula by Time of Day, 2018, sample trucks

Source: HRTPO staff processing of StreetLight data

Given, as shown in the chart above, that diversion is no greater during periods of HRBT congestion (a.m. and p.m. peak periods) than it is during off-peak, it appears that the drivers who avoid WB HRBT do so due to its lower height.

Staff estimated the impact that a correction of the WB HRBT height would have on Hampton Blvd trucks via a StreetLight origin-destination analysis using 2018 data.

Type of Travel	Origin (O) Zone Name	Origin Zone Is Pass-Through	Middle (M) Filter Zone Name	Destination (D) Zone Name*	Destination Zone Is Pass-Through	Day Type	Day Part	Average Daily O-M-D Traffic (StL Index)	Average Daily Origin Zone Traffic (StL Index)	Average Daily Middle Filter Zone Traffic (StL Index)	Average Daily Destination Zone Traffic (StL Index)
									NIT	HB	664/64*
Commercial	NIT	no	Hampton Blvd	Interchange zone	yes	0: All Days (M-Su)	0: All Day (12am-12am)	296	47,779	23,766	140,701
Commercial	NIT	no	Hampton Blvd	Interchange zone	yes	0: All Days (M-Su)	1: HB truck hours (6am-4pm)	278	41,665	21,864	95,929
Commercial	NIT	no	Hampton Blvd	Interchange zone	yes	1: Weekday (M-Th)	0: All Day (12am-12am)	402	63,813	31,181	178,031
Commercial	NIT	no	Hampton Blvd	Interchange zone	yes	1: Weekday (M-Th)	1: HB truck hours (6am-4pm)	381	55,111	28,695	123,804
Commercial	NIT	no	Hampton Blvd	Interchange zone	yes	2: Weekend Day (Sa-Su)	0: All Day (12am-12am)	20	7,494	4,184	52,542
Commercial	NIT	no	Hampton Blvd	Interchange zone	yes	2: Weekend Day (Sa-Su)	1: HB truck hours (6am-4pm)	20	7,239	3,699	29,663

* 664/64 interchange at Hampton Coliseum

NIT to I-64 Peninsula via HB	381	trucks (index)
All HB trucks	28,695	trucks (index)
	1%	

FIGURE 40 Impact of WB HRBT Height on Hampton Blvd Trucks, 2018, index trucks

Source: HRTPO staff processing of StreetLight data

According to this calculation, trucks avoiding the sub-standard WB HRBT height represent 1% of Hampton Blvd trucks. Therefore, staff expects that **correction of the height problem would reduce Hampton Blvd trucks by 1%.**

Next, staff investigated ways to correct the WB HRBT height problem.

The current $3.8B HRBT expansion project—adding capacity to I-64 from I-564 in Norfolk to near Hampton University in Hampton—does not include increasing the height of the westbound tunnel, therefore, even after the forecasted 2025 completion of this project, WB trucks will still be subject to the WB height problem at HRBT.

Two options for enabling taller trucks to use WB HRBT post-2025 are investigated on the following pages:

- Modifying the HRBT contract to include raising the height of current-WB tube
- Modifying current HOT[10] operations to allow trucks in right-hand HOT lane at WB HRBT

1. Modifying the HRBT contract to include raising the height of current-WB tube

According to the Hampton Roads Transportation Accountability Commission (HRTAC) funding the HRBT expansion project, increasing the height of the current WB tube would cost approximately $100m.

Modifying the HRBT contract to include raising the height of the current-WB tube is expected to:

- eliminate the delays created by over-height truck turnarounds (to/from NIT and elsewhere)
- reduce truck travel distance and expense (as compared to MMBT) for over-height trucks (to/from NIT and elsewhere)
- (as shown above) **reduce Hampton Blvd trucks by 1%**

[10] High-Occupancy / Toll (HOT) lanes can be used by high-occupancy vehicles at no cost, and by single-occupancy vehicles for a fee.

2. Modifying current HOT operations to allow trucks in right-hand HOT lane at westbound HRBT

Virginia, like many states, currently prohibits trucks in HOT lanes. Other states prohibiting trucks in express lanes include:

- California
- Colorado
- Florida
- Georgia
- Minnesota
- Utah
- Washington State
- Washington, DC

These states, however, *do* allow trucks in express lanes:

- Texas (e.g. I-635, I-820, I-35W)
- Maryland (I-95 near Baltimore)

Applying Virginia's current HOT operation at the new HRBT would limit WB trucks to the sub-standard height (current-WB) tube. As shown above, NIT trucks avoiding the WB HRBT currently use Hampton Blvd to reach the MMBT.

The impact of this WB HRBT height problem on Hampton Blvd could be eliminated by modifying current HOT operations to allow trucks in the WB HRBT right-hand HOT lane to be located in the standard-height WB HOT tube (i.e. the current EB tube).

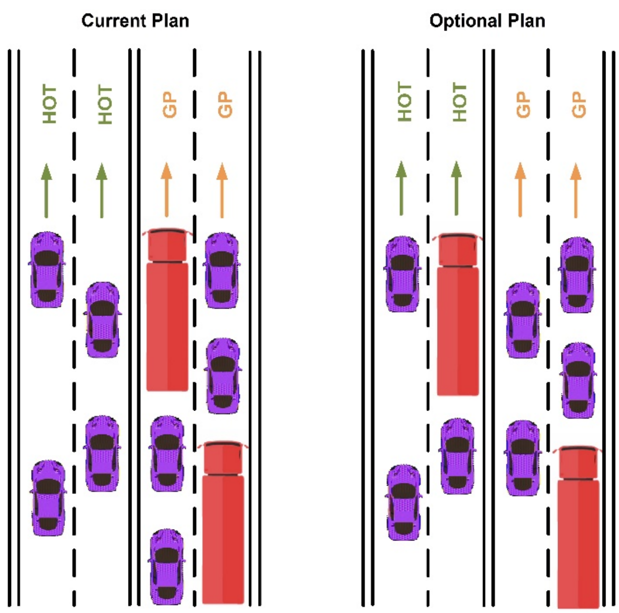


FIGURE 41 Current vs. Optional HOT Operation
Source: HRTPO staff

In order to:

- minimize the change to current HOT operations,
- simplify signage, and
- provide autos a HOT lane without trucks,

this exception to current HOT operations would be applied only to:

- the right-hand HOT lane
- westbound (WB)
- at the tunnel (i.e. not at the approach)
- for the HRBT project,

leaving 1) the remainder of the 9-mile HRBT project, 2) other HOT facilities in Hampton Roads, and 3) other HOT facilities in Virginia unaffected. In order to always provide autos a HOT lane without trucks at the HRBT:

- both HOT lanes at the WB HRBT would be open 24 hours per day, and trucks would be prohibited from the left-hand HOT lane at the WB HRBT
- trucks would always be prohibited from the HOT lanes of approaches (which have only one HOT lane during off-peak).

Modifying HOT operations to allow toll-paying trucks in the WB HRBT right-hand HOT lane:

- would allow regular-height WB trucks—from NIT and elsewhere—to use the HOT lanes at HRBT:
    - reducing trucking time (as compared to slower general-purpose lanes)
    - increasing HOT revenues
- would allow taller WB trucks—from NIT and elsewhere—to use HRBT via the HOT lanes:
    - reducing trucking time (vs. diverting to MMBT)
    - increasing HOT revenues
    - **reduce Hampton Blvd trucks by 1%**

D. Option: Shifting Norfolk International Terminal (NIT) / Portsmouth Truck Trips Off of Hampton Blvd

Investigation of this option is presented under the following subsections:

- The Number of NIT/Portsmouth Hampton Blvd Truck Trips, by Portsmouth Subarea
- Types of NIT Trucks on Hampton Blvd
- Means of Reducing NIT/Portsmouth Truck Trips on Hampton Blvd

The Number of NIT/Portsmouth Hampton Blvd Truck Trips, by Portsmouth Subarea

Prior to examining means of reducing NIT/Portsmouth truck trips on Hampton Blvd, HRTPO staff estimated the volume of these trips via StreetLight, dividing Portsmouth into these subareas:

1. CSX Intermodal Terminal (CSXIT)
2. Portsmouth Marine Terminal (PMT)
3. Pinners Point Container Yard (PPCY)
4. Virginia International Gateway (VIG)
5. Remainder of Portsmouth

Prior to presenting the StreetLight inputs and outputs, each subarea is introduced below.

1. CSX Intermodal Terminal (CSXIT)

CSXIT is a CSX railroad intermodal railyard in Portsmouth (near PMT) where containers are transferred between trucks and trains. Trucks move containers between CSXIT and NIT because the CSX railroad does not currently serve NIT. Although NIT is served by the Norfolk-Portsmouth Beltline (NPB) railroad partially owned by CSX, CSX does not use the NPB because its rates are set by its majority owner Norfolk Southern (NS)[11].

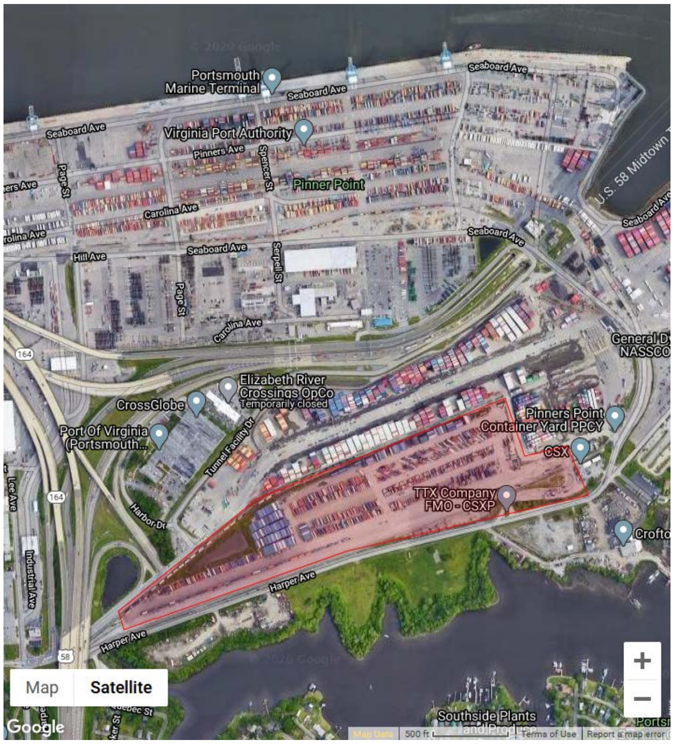


FIGURE 42 CSX Intermodal Terminal (CSXIT)
Source: HRTPO staff via StreetLight

[11] "CSX Fights Norfolk Bid to Derail Antitrust Suit", law360.com, 2-18-20

2. Portsmouth Marine Terminal (PMT)

Portsmouth Marine Terminal is one of two state ports located in Portsmouth, as shown below. According to the Port of Virginia, "Many boxes [containers] can be drayed [trucked] between terminals for staging empty containers for various servicing reasons for customers."[12] Moving containers between NIT and PMT adds trucks to Hampton Blvd.

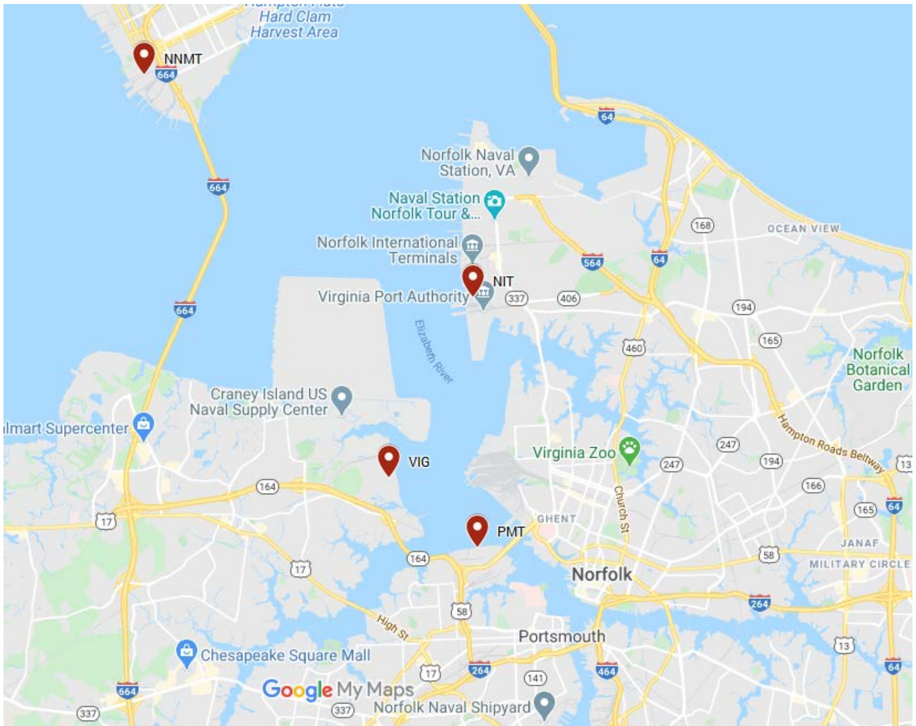


FIGURE 43 State Ports in Hampton Roads
Source: HRTPO staff via Google My Maps

According to the Port's website[13]:

- Portsmouth Marine Terminal (PMT) will be closed to all container traffic
- All ocean carrier container services have been consolidated at Norfolk International Terminals and Virginia International Gateway
- PMT remains a viable multi-use terminal. All future Ro-Ro [roll-on/roll-off], breakbulk and/or project cargo opportunities will be considered.

When measuring truck trips between NIT and Portsmouth via the StreetLight analysis, HRTPO staff considered "PMT" to *exclude* the nearby CSX Intermodal Terminal (CSXIT, discussed above) and Pinners Point Container Yard (PPCY, discussed below).

[12] 7-2-20 email
[13] As of 8-19-20

3. Pinners Point Container Yard (PPCY)

FIGURE 44 Reefer Service Area of the PPCY
Source: HRTPO staff

The Pinners Point Container Yard (PPCY) is a multi-purpose facility holding more than just containers. As shown on the above sign, the PPCY includes Reefer Service Area (RSA). ("Reefers" are refrigerated containers.) And, as shown on the map below, the Portsmouth Chassis Yard (PCY) is in the vicinity. ("Chassis" are the trailers on which containers sit for trucking.) Trucks move empty containers (including reefers) and chassis between PPCY to NIT.

FIGURE 45 Reefer Service Area (RSA) and Portsmouth Chassis Yard (PCY)
Source: https://www.portofvirginia.com/facilities/portsmouth-chassis-yard-pcy/

To measure truck trips between NIT and Portsmouth via the StreetLight analysis (below), HRTPO staff considered the "Pinners Point Container Yard" to *include* the RSA and PCY.

4. Virginia International Gateway (VIG)

Virginia International Gateway is one of two state ports in Portsmouth.[14] As discussed above, according to the Port of Virginia, “Many boxes [containers] can be drayed [trucked] between terminals for staging empty containers for various servicing reasons for customers.”[15] Moving containers between NIT and VIG adds trucks to Hampton Blvd.

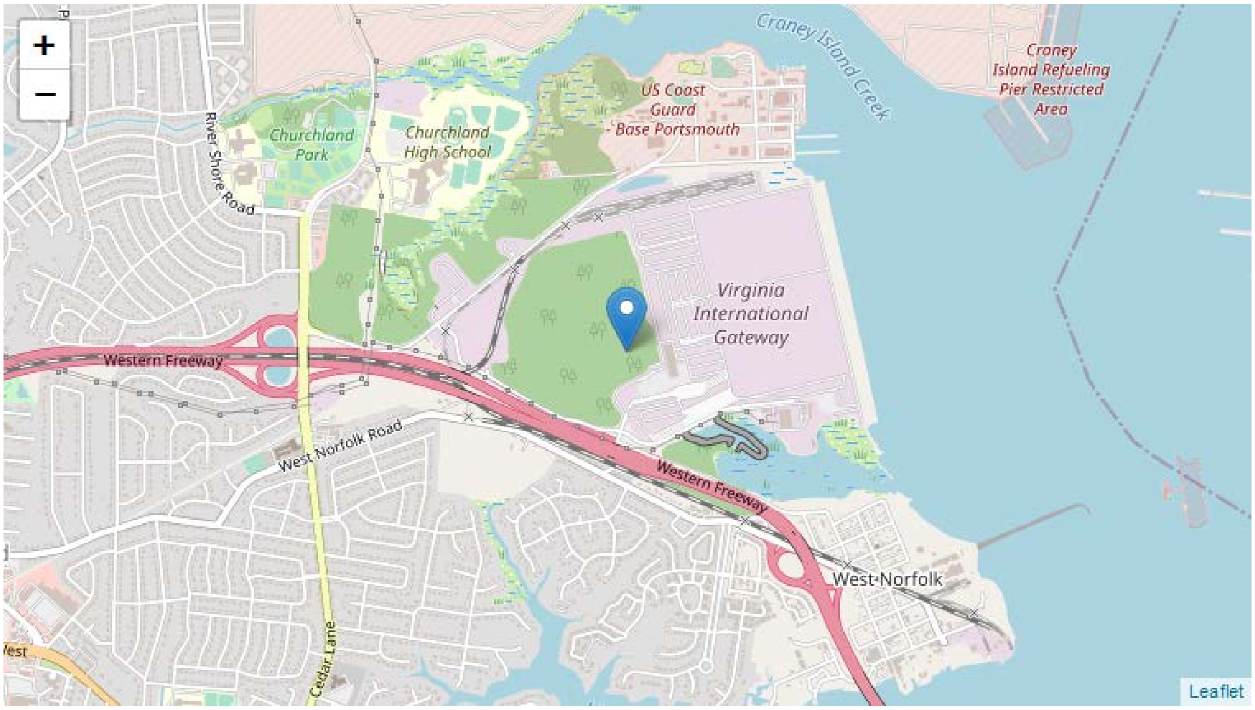


FIGURE 46 Virginia International Gateway

Source: https://www.portofvirginia.com/facilities/virginia-international-gateway-vig/

[14] The other state port in Portsmouth, PMT, is discussed earlier in this section.

[15] 7-2-20 email

5. Remainder of Portsmouth

When measuring truck trips between NIT and Portsmouth via the StreetLight analysis below, HRTPO staff considered every area of Portsmouth other than the above four port-related areas (CSXIT, PMT, PPCY, and VIG) to be "Remainder of Portsmouth".

The five Portsmouth zones described above are mapped in the two figures below:

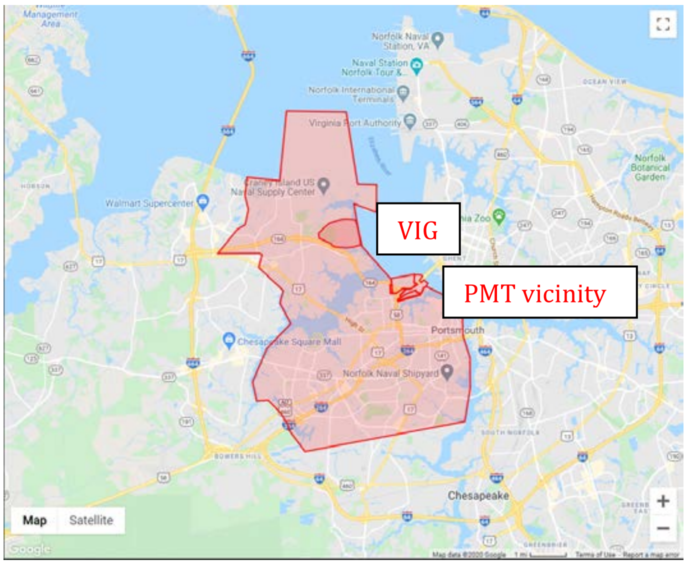


FIGURE 47 Portsmouth Zones- broad view
Source: HRTPO staff via StreetLight

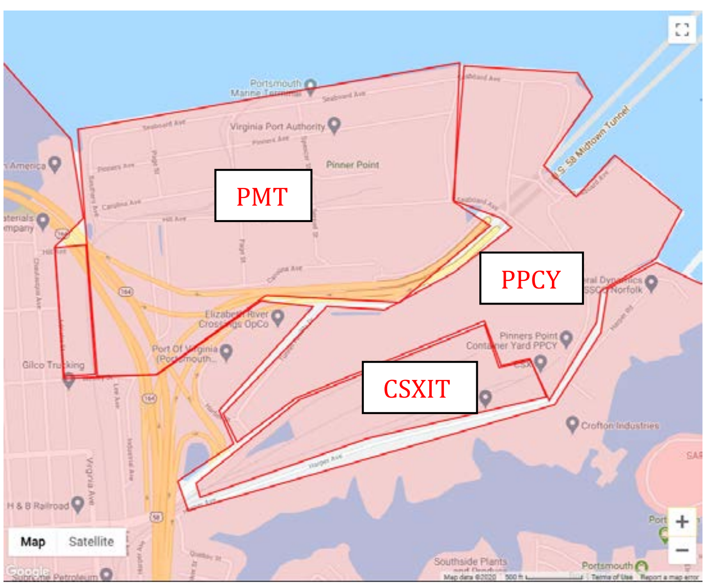


FIGURE 48 Portsmouth Zones- detailed view
Source: HRTPO staff via StreetLight

Staff programmed StreetLight to compare the number of trucks using Hampton Blvd while moving between NIT and Portsmouth ("O-M-D Trucks"[16] in the tables below) to the total number of trucks on Hampton Blvd ("HB Trucks" in the tables below). Staff programmed NIT as the origin (O), Hampton Blvd as the middle point (M), and areas of Portsmouth as the destination (D).

Destination	0-M-D Trucks (sample)	HB Trucks (sample)	Portion of HB Trucks
CSXIT	96	38,661	0.2%
PMT	791	38,661	2%
PPCY	3,714	38,661	10%
VIG	1,856	38,661	5%
Rest of Portsmouth	4,512	38,661	12%

FIGURE 49 NIT-HamptonBlvd-Portsmouth Truck Trips, southbound
Source: HRTPO staff via StreetLight

Origin	0-M-D Trucks (sample)	HB Trucks (sample)	Portion of HB Trucks
CSXIT	25	32,432	0.1%
PMT	683	32,432	2%
PPCY	1,440	32,432	4%
VIG	1,990	32,432	6%
Rest of Portsmouth	4,391	32,432	14%

FIGURE 50 Portsmouth-HamptonBlvd-NIT Truck Trips, northbound
Source: HRTPO staff via StreetLight

Averaging these southbound and northbound results, it appears that serving the NIT/Portsmouth moves related to the Port (i.e. involving the four Portsmouth zones other than "Rest of Portsmouth") via methods other than trucks on Hampton Blvd would reduce Hampton Blvd trucks as follows:

1. Removing NIT / CSXIT trucks from Hampton Blvd: 0.2% of HB trucks
2. Removing NIT / PMT trucks from Hampton Blvd: 2% of HB trucks
3. Removing NIT / PPCY trucks from Hampton Blvd: 7% of HB trucks
4. Removing NIT / VIG trucks from Hampton Blvd: 6% of HB trucks

Of these port-related locations in Portsmouth, the Pinners Point Container Yard (PPCY) produces/attracts the most NIT trucks for Hampton Blvd.

[16] "O-M-D": vehicles passing from an origin (O) to a destination (D) via a point in the middle (M)

Types of NIT Trucks on Hampton Blvd

Hampton Blvd carries port trucks in three configurations[17]:

1. Tractor with chassis and container
2. Tractor with chassis
3. Tractor

FIGURE 51 Tractor with Chassis turning onto Hampton Blvd from NIT

Source: HRTPO staff

[17] Based on field visit by HRTPO staff 4-27-20 and 4-29-20

Means of Reducing NIT/Portsmouth Truck Trips on Hampton Blvd

Options for reducing NIT/Portsmouth truck trips on Hampton Blvd are investigated below under five headings: one for each of the four Portsmouth port-related locations plus one for the Regional Connector Study (RCS) connectors.

1. CSXIT

Given that CSXIT/NIT trucks comprise less than 1% of Hampton Blvd trucks (as shown above), staff did not develop any options for reducing these trucks on Hampton Blvd.

2. PMT

Given that PMT is currently not serving container ships, staff did not develop any options for removing PMT/NIT trucks from Hampton Blvd.

3. PPCY- Providing a Container Yard on/near NIT as an alternative to PPCY

Given, as shown above, that approximately 7% of Hampton Blvd trucks move to/from NIT from/to Pinners Point Container Yard (PPCY), **providing a container yard** on/near NIT **would reduce Hampton Blvd trucks by up to 7%**. Just like the PPCY, an NIT-vicinity "container yard" would store empty chassis as well as empty containers.

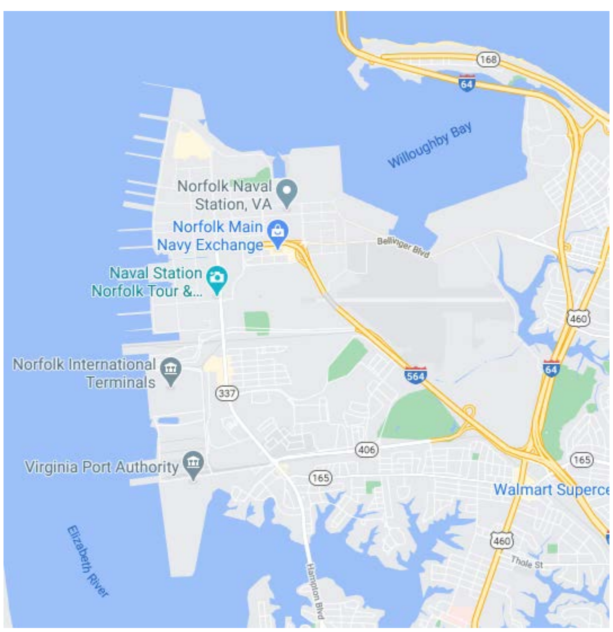


FIGURE 52 NIT Vicinity
Source: Google Maps

The Port[18] indicated that options such as new container yards can be explored in the re-evaluation of its master plan conducted every five years, but noted that other options exist for redirecting the current NIT/PPCY truck trips, e.g. the Regional Connectors Study connectors (addressed at the end of this section).

4. VIG- Using Barges to move Containers to/from NIT from/to VIG

Given, as shown above, that approximately 6% of Hampton Blvd trucks move to/from NIT from/to VIG, **using barges to move containers** to/from VIG from/to NIT **would reduce Hampton Blvd trucks by up to 6%**.[19]

Two means of providing cross-harbor barge service are investigated below:

a. Providing a new cross-harbor barge service

Barging a container between NIT and an inland port (e.g. the Richmond Marine Terminal [RMT] barge service discussed below) requires handling that box two extra times vs. trucking. For example, moving a container from NIT to a business in central Virginia (BCV):

- By truck:
    1. From ship to NIT yard
    2. From NIT yard to truck
    3. From truck to BCV

- By barge (via RMT):
    1. From ship to NIT yard
    2. From NIT yard to barge
    3. From barge to RMT yard
    4. From RMT yard to truck
    5. From truck to BCV

[18] 10-20-20 phone conversation
[19] StreetLight not identifying what [if anything] trucks are pulling, HRTPO staff is unable to measure the number of containers moving to/from the Portsmouth locations. To the extent, as discussed above, that some of those trucks move between the two locations (NIT, VIG) without hauling containers (e.g. a tractor with chassis), barging containers would reduce Hampton Blvd trucks by less than 6%.

On the other hand, cross-harbor barging a container between NIT and VIG requires handling that box the same number of times as trucking. For example, moving a box from NIT to VIG:

- By truck:
    1. From ship to NIT yard
    2. From NIT yard to truck
    3. From truck to VIG yard

- By barge:
    1. From ship to NIT yard
    2. From NIT yard to barge
    3. From barge to VIG yard

HRTPO staff estimated the frequency of the proposed barge service. Given that:

- 6% of Hampton Blvd trucks move between NIT and VIG (as measured above),
- Hampton Blvd trucks total 1,451 per day[20], and
- 6% of 1,451 total Hampton Blvd trucks represents 87 trucks per day,

if (say) 50% of the 87 trucks moving between NIT and VIG daily haul containers, and if half of these containers move from NIT to VIG (and the other half move from VIG to NIT), then an average of 22 containers[21] would be available for each direction per day. Although it would take a week[22] to fill a barge similar to that of the RMT service (shown below) which appears to have a capacity of 120 containers[23], a smaller barge would fill daily.

The Port identified potential problems related to a new cross-harbor barge service:

- Barging would "massively increase the cost and decrease the service (will take more time)".[24]
- "There are no operations to include cross-harbor loads by barge."[25]

[20] During HB truck hours, per weekday, 2018; source: HRTPO staff processing of VDOT data
[21] 87*0.50*0.50 = 22
[22] 22 per day * 6 days per week = 132 containers
[23] From the photo: 5x4x6 = 120
[24] 4-30-20 email from Va. Port Authority
[25] 7-2-20 email from Va. Port Authority

b. Using current barge services

Two barge services currently connect VIG & NIT and ports located further inland:

I. Barges currently run between VIG & NIT and Richmond Marine Terminal (RMT):

- Exports: Tuesday / Thursday / Saturday – Departs Richmond
- Imports: Monday / Wednesday / Friday – Departs Hampton Roads

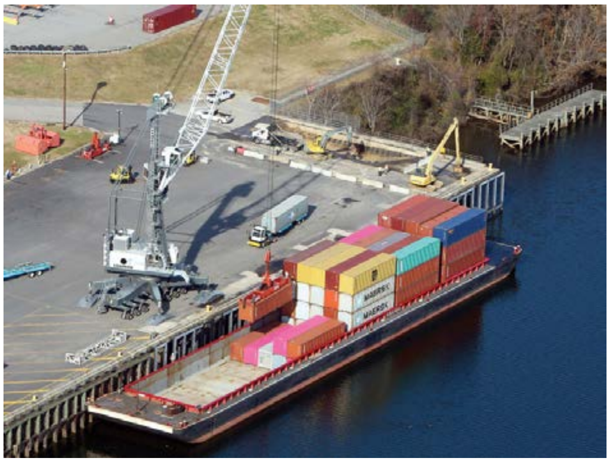


FIGURE 53 RMT Barge Service

Source: https://ajot.com/premium/ajot-port-of-virginia-welcoming-business-with-enhanced-facilities-efficiencies

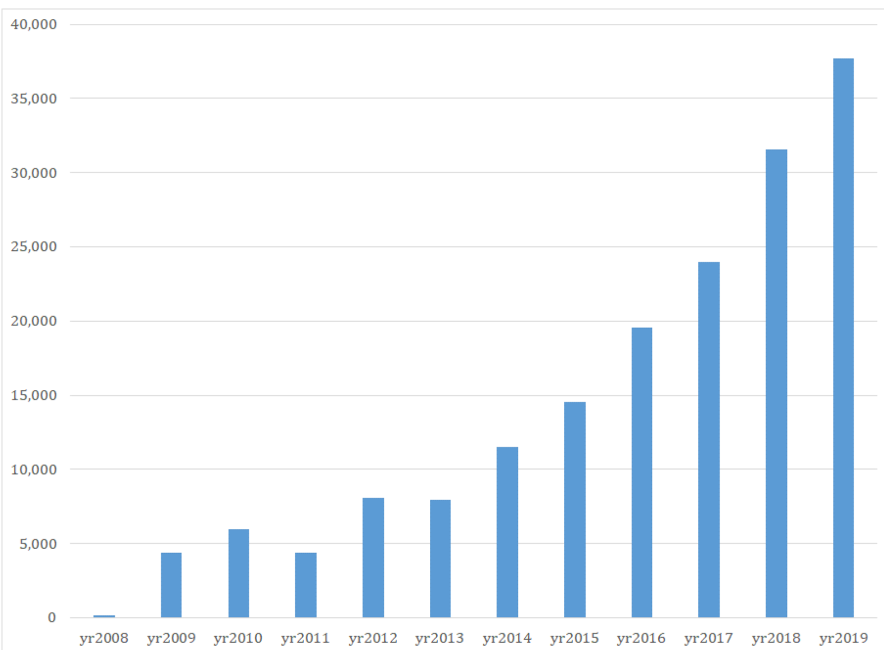


FIGURE 54 RMT Barge Service, containers

Source: HRTPO processing of VPA data

II. Columbia Coastal Transport (CCT) runs barges between VIG & NIT and Baltimore & Philadelphia[26]:

- Friday: Baltimore- discharge imports; load exports
- Saturday: Philadelphia- discharge imports; load exports
- Monday: VIG & NIT- discharge exports
- Wednesday: VIG & NIT- load imports

Based on the above schedules, it appears that the RMT and CCT barges collectively move from VIG to NIT four times per week, and move (in the other direction) from NIT to VIG four times per week, for a total of eight (8) trips per week at the Hampton Roads end of their longer trips. Therefore, by making no additional trips or movements, these barges could move containers between VIG and NIT eight (8) times per week, picking the container up at one port (NIT or VIG) and dropping it at the other port.

It should be noted that the Port's concerns stated in the new barge service section above may also apply to using current barge services for cross-harbor loads.

In summary, using barges (whether new or existing) to move containers to/from NIT from/to VIG may remove a significant number of the 87 daily trucks currently moving between these locations using Hampton Blvd. To the extent, as discussed above, that some of those trucks move between the two locations without hauling containers (e.g. a tractor with chassis), barging containers would remove a portion of these 87 trucks (6% of the total Hampton Blvd trucks).

[26] 4-17-20 phone conversation

5. RCS Connectors

The proposed I-564, I-664, and VA 164 Connectors (mentioned by the Port above, and being evaluated in the current Regional Connectors Study) would provide an alternative to Hampton Blvd for trips moving between northern Norfolk and points west of the Elizabeth River. By providing this alternative, these connectors would remove many of the NIT/Portsmouth trucks from Hampton Blvd—for all four of the Portsmouth facilities explored above—*plus* many other trucks and cars moving between points west of the Elizabeth River and northern Norfolk. The **impact of these connectors on truck volumes on Hampton Blvd may be estimated** by the Regional Connectors Study (RCS) currently underway.

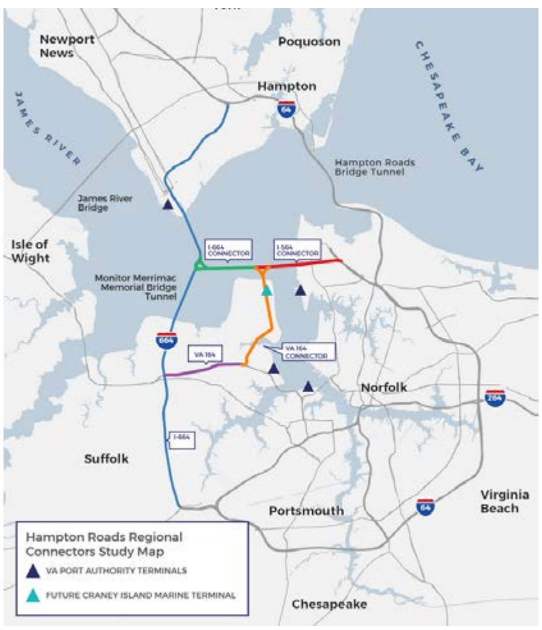


FIGURE 55 Hampton Roads Regional Connectors Study Map
Source: connectorstudy.org/about-the-study

Summary of Options for Reducing Trucks on Hampton Blvd

A summary of the impact of the above options on Hampton Blvd trucks is shown below.

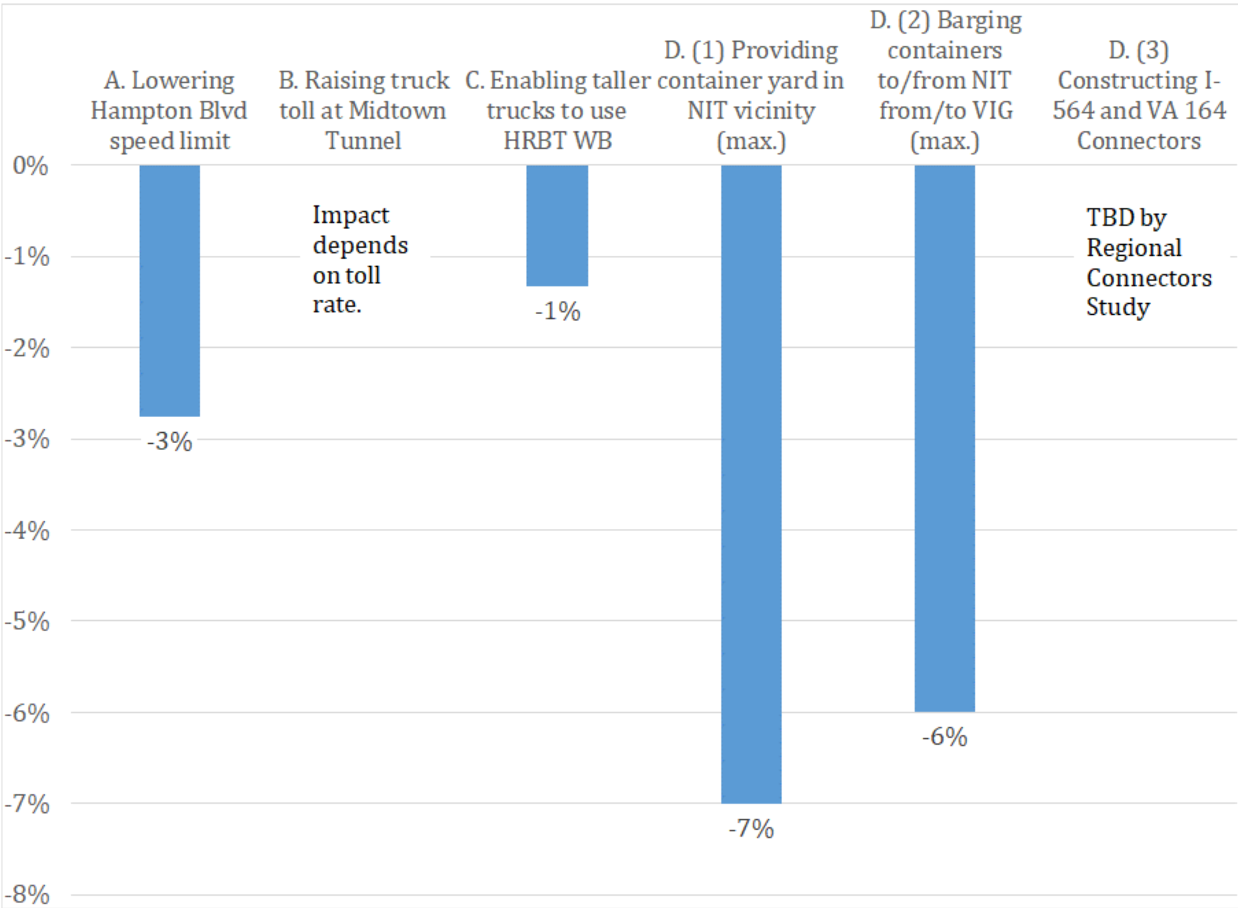


FIGURE 56 Options for Reducing Trucks on Hampton Roads
Source: HRTPO staff

Mitigating Train Conflicts

The Port of Virginia currently transports a higher percentage of cargo by rail than any other East Coast Port. In 2019, 34% of the containers handled by the Port of Virginia, and 40% of the containers handled at NIT, were transported by rail. This percentage is likely to increase into the future as the Port of Virginia has a long-term goal of increasing the amount of cargo transported by rail up to 50% of all containers handled by the Port.

The only rail access to the Port's Norfolk International Terminals (NIT) facility, which is located just to the west of Hampton Boulevard, is provided by the Norfolk and Portsmouth Belt Line Railroad. Although the Norfolk and Portsmouth Belt Line Railroad is jointly owned by Norfolk Southern Railway and CSX Transportation, it solely carries cargo for Norfolk Southern Railway.

The impacts of port-bound trains at three at-grade rail crossings on the Norfolk and Portsmouth Belt Line – Hampton Boulevard/Terminal Boulevard, Granby Street, and Little Creek Road – are of particular concern to the City. Trains crossing each of these arterials can block traffic for up to 15 minutes at a time, severely impacting access on these critical corridors to activity centers such as Naval Station Norfolk, Naval Support Activity Norfolk, and the Wards Corner commercial district. In addition, the at-grade crossings at Granby Street and Little Creek Road are in close proximity both to each other and the off ramps from I-64. This not only leads to gridlock throughout the entire Wards Corner commercial district but can also severely impact safety, particularly when traffic backs up onto the off ramps and to I-64.

Each of these three at-grade rail crossings, which are shown in **Figure 57**, is described in detail below.

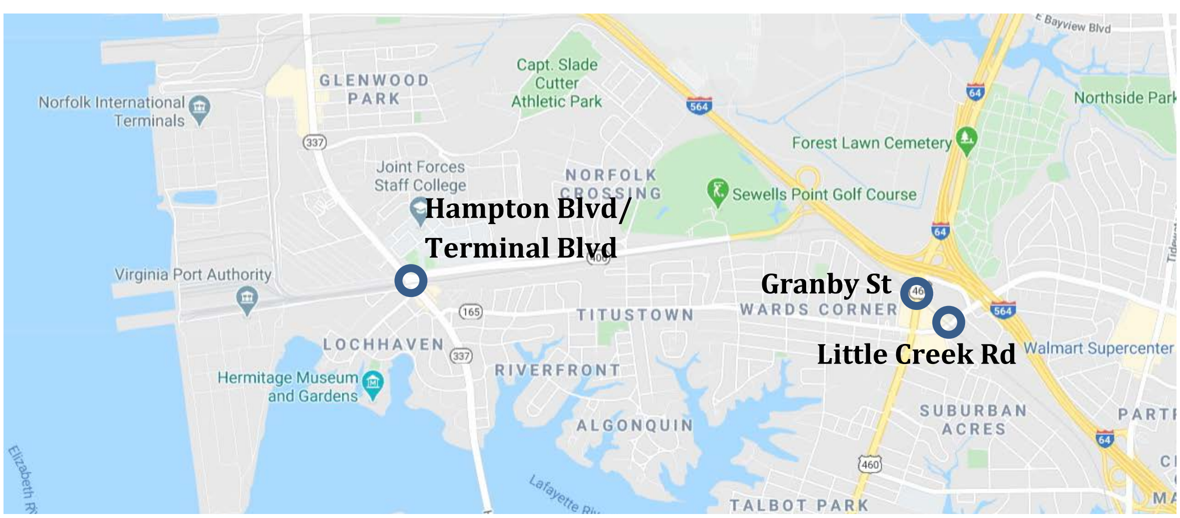


FIGURE 57 At-Grade Rail Crossings Near Norfolk International Terminals

Map Source: Google

Little Creek Road

The railroad crossing of Little Creek Road is in the Wards Corner area, approximately 800 feet east of the intersection with Granby Street and 2.4 miles from the entrance to Norfolk International Terminals. Little Creek Road is classified as a Minor Arterial and carried an average of 27,000 vehicles per weekday at this location in 2019.

Little Creek Road Crossing
Source: HRTPO

The single-track line carries an average of eight trains per day according to the Federal Railroad Administration (FRA), of which three through trains cross between 6 am and 6 pm, three through trains cross between 6 pm and 6 am, and the remaining two trains are considered to be switching trains, which are defined as those trains whose movements primarily involve the pickup and set-out of cars for various industries and/or rail yards. According to the FRA, the maximum speed allowed for trains at this location is 20 mph, with most trains crossing at a typical speed of 10 to 20 mph.

There were no crashes that involved trains at this crossing between 2010 and 2019.

Granby Street

The railroad crossing of Granby Street is in the Wards Corner area, approximately 700 feet north of the intersection with Little Creek Road and 2.2 miles from the entrance to NIT. Granby Street is classified as a Principal Arterial and carried an average of 26,000 vehicles per weekday at this location in 2019.

Granby Street Crossing
Source: HRTPO

Similar to the crossing at Little Creek Road, the single-track line carries an average of eight trains per day according to the Federal Railroad Administration, of which three trains cross between 6 am and 6 pm, three trains cross between 6 pm and 6 am, and the remaining two trains are considered to be switching trains. Also similar to the Little Creek Road crossing, the maximum speed allowed for trains at this location is 20 mph, with most trains crossing at a typical speed of 10 to 20 mph.

There were three crashes that involved trains at this crossing between 2010 and 2019. Crashes occurred at this crossing in 2010 (involving a car and no injuries), 2013 (involving a pedestrian that suffered an injury), and 2015 (involving a motorcyclist that suffered an injury).

Hampton Boulevard/Terminal Boulevard

The at-grade rail crossing adjacent to Norfolk International Terminals passes through the intersection of Hampton Boulevard and Terminal Boulevard. Both roadways are classified as Principal Arterials. Hampton Boulevard carried an average of 28,000 vehicles per weekday to the north of the intersection and 33,000 vehicles per weekday to the south of the intersection in 2019, while Terminal Boulevard carried 25,000 vehicles per weekday.

Hampton Blvd/Terminal Blvd Crossing
Source: HRTPO

The single-track line carries an average of eight trains per day according to the FRA, of which three through trains cross between 6 am and 6 pm, one through train crosses between 6 pm and 6 am, and the remaining four trains are considered to be switching trains. According to the FRA, the maximum speed allowed for trains at this location is 10 mph, with most trains crossing at a typical speed of 5 to 10 mph.

There was one crash involving a train that occurred at this crossing between 2010 and 2019. This crash, which occurred in 2012, resulted in a fatality of a pedestrian.

More information on the operation of this crossing is included in the next section of this report.

Operation of Trains Entering/Existing the Port

As mentioned previously, 40% of the containers handled at NIT (314,740 containers) were transported by rail in 2019. This section details the process of how trains access and leave NIT and how that impacts traffic on Hampton Boulevard.

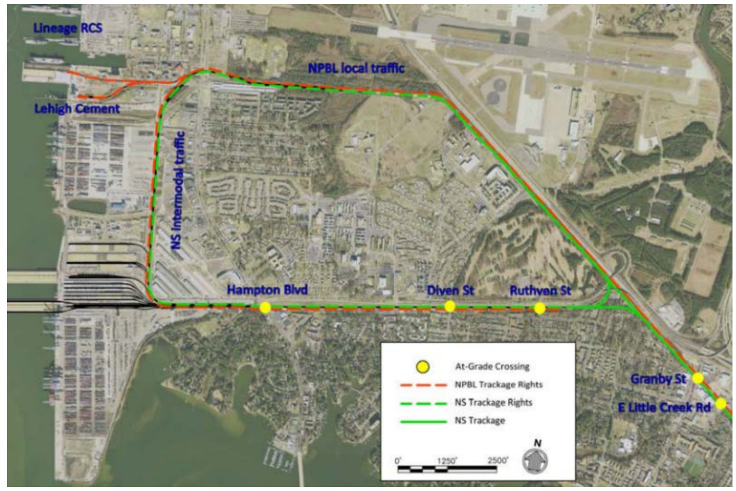


FIGURE 58 Norfolk Portsmouth Belt Line North and South Routes into NIT
Source: Master Rail Plan for the Port of Virginia

The Norfolk and Portsmouth Belt Line Railroad (NPBL) splits into two lines that enter NIT, as shown in **Figure 58**. The northern line runs parallel to I-564 and the Intermodal Connector before entering NIT via an overpass crossing Hampton Boulevard that replaced the previous at-grade crossing in 2015. The southern line runs parallel to Terminal Boulevard before entering NIT via an at-grade crossing that passes through the intersection of Hampton Boulevard and Terminal Boulevard. According to Virginia Port Authority officials, trains currently primarily enter NIT via the southern line and exit NIT via the northern line, although the Port has recently received a $44 million federal grant to improve the Central Rail Yard that would allow for more trains to enter NIT via the northern line. Construction on the Central Rail Yard improvements is expected to be complete by 2024.

Typically, about three Norfolk Southern (NS) trains arrive via the southern line of the Norfolk Portsmouth Belt Line Railroad per day. These trains generally arrive in the late morning (10:00 am – Noon), early evening (6:00 pm), and overnight (1:00 – 3:00 am). Most of these trains, however, do not immediately access NIT but are dropped off to the east of Hampton Boulevard in a marshalling yard as shown in **Figure 59**. Hampton Boulevard does not generally get blocked by these arriving trains.

FIGURE 59 Terminal Boulevard Marshalling Yard
Source: Virginia Port Authority

Once trains are in the marshalling yard, employees from Virginia International Terminals (VIT) shift the train onto the NIT property to the Central Rail Yard (as shown in **Figure 60**). This involves moving the trains across Hampton Boulevard and typically occurs 3-4 times each day depending on volumes and operational needs. There will typically be 1-2 crossings of Hampton Boulevard between 8:15 am and 11:45 am, 1-2 crossings between 1:15 pm and 5:45 pm, 1-2 crossings between 7:00 pm and Midnight, and 1-2 crossings between 1:00 am and 5:00 am. According to Port staff, Hampton Boulevard is crossed a maximum of three times during each of these time periods.

FIGURE 60 Movement between Marshalling Yard and NIT Central Rail Yard
Source: Virginia Port Authority

Trains that travel across Hampton Boulevard are typically transported in approximately 3,000-foot increments due to constraints on the ability to position the freight on the terminal. An engine typically crosses over Hampton Boulevard from NIT 10 minutes prior to the inbound train being transported into NIT, and a gate is opened by VIT staff one minute prior to crossing Hampton Boulevard. Hampton Boulevard can be blocked for up to 15 minutes at a time by these trains entering NIT.

Trains are not allowed to cross Hampton Boulevard into the southern entrance of NIT during peak travel times. These peak times are from 6:45 am to 8:15 am, 11:50 am to 12:15 am, and 12:45 pm to 1:15 pm.

NIT Rail Gate at Terminal Blvd
Source: HRTPO

At-Grade Rail Crossing Traveler Information

Variable Message Sign in Norfolk
Source: Google

The City of Norfolk is concerned about the impacts of port-related trains at three at-grade rail crossings on the Norfolk and Portsmouth Belt Line – Hampton Boulevard/Terminal Boulevard, Granby Street, and Little Creek Road.

As stated previously, trains entering Norfolk International Terminals can block the at-grade rail crossing at the Hampton Boulevard/Terminal Boulevard intersection for up to 15 minutes at a time, and trains can travel as slow as 10 mph at the other two crossings.

One strategy to reduce delays for motorists is to provide real-time traveler information on train activity. This traveler information could include whether the crossing is currently blocked, whether the crossing will be blocked in the near future, and the length of time the crossing is expected to be blocked. This information can be provided to travelers through a number of conventional methods including variable message signs, highway advisory radio, and websites such as 511 Virginia, or through evolving methods such as text messaging, apps, or in-vehicle navigation systems.

Variable message signs, which are also referred to as changeable or dynamic message signs, are the primary method that is looked at for disseminating traveler information in this study due to a request from City staff. In order to determine potential benefits and lessons learned from implementing variable message sign systems for at-grade rail crossings, HRTPO staff researched similar systems implemented throughout the country. Examples that HRTPO staff discovered are described below.

San Antonio

The Texas Department of Transportation (TxDOT) and the City of San Antonio were concerned about traffic queues backing up from an at-grade railroad crossing onto an adjacent freeway ramp and potentially onto the freeway itself. In order to alleviate this issue, TxDOT tested a train detection system called the Advanced Warning to Avoid Railroad Delay (AWARD). The system became operational in the summer of 1998.

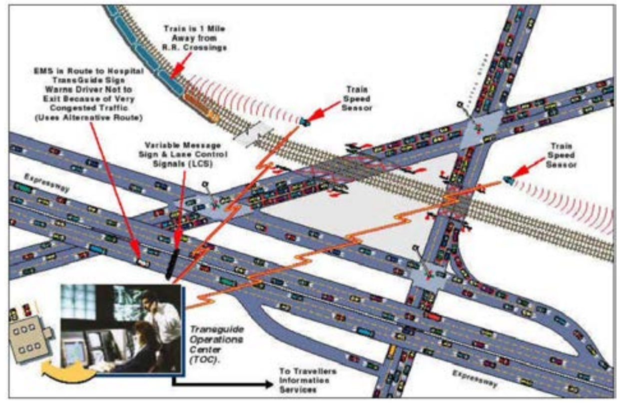
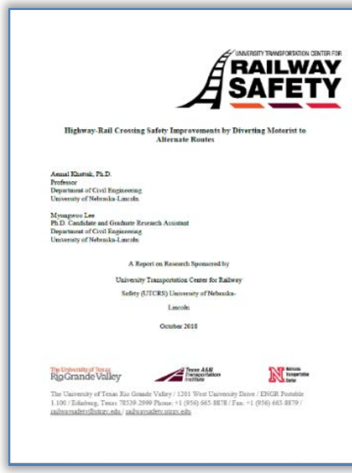


FIGURE 61 AWARD Conceptual Overview
Source: SAIC

The AWARD system includes unobtrusive acoustic and radar sensors placed upstream of three locations near the intersection of Woodlawn Avenue and the Union Pacific Railroad line that runs parallel to I-10. The sensors, which are located on poles mounted on city or state right-of-way and do not interface with any railroad equipment, detect the presence, speed, and length of trains approaching the at-grade crossings. Data from the sensors is transmitted to the TransGuide Traffic Management Center (TMC) where the predicted time and duration that grade crossings at or near freeway exits will be blocked is calculated. This information is then disseminated via variable message signs on the freeway, via the Internet and in-vehicle displays, and to emergency service vehicles.

The potential impacts of the system were calculated at one crossing using simulation. The model estimated that travel time delay would decrease by 19% for drivers who chose to reroute and by 16% for all drivers in the study area if around half of the drivers rerouted based on the traveler information.

UTCRS Study



Highway-Rail Crossing Safety Improvements by Diverting Motorist to Alternate Routes

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Department of Civil Engineering
University of Nebraska-Lincoln

A Report on Research Sponsored by

University Transportation Center for Railway Safety (UTCRS) University of Nebraska-Lincoln

October 2018

The University of Texas Rio Grande Valley

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The University Transportation Center for Railway Safety (UTCRS) at the University of Nebraska-Lincoln sponsored research titled *Highway-Rail Crossing Safety Improvements by Diverting Motorist to Alternate Routes*[27]. The premise of the study is that "Integration of an advanced train detection system with a highway traveler information system is needed at highway rail grade crossings (HRGCs) to improve operational efficiency and safety."

The authors of the study recommended implementing a system that was developed as part of the study called Train Occupancy Time Estimation System (TOTES). The primary goals of TOTES are to detect train movements, estimate its speed and size, calculate the amount of delay that motorists may likely experience, and inform the motorists of the delay.

TOTES is comprised of a Train Detection System (TDS), Detection Control System (DCS), and Variable Message Signs (VMS) system. The Train Detection System uses sets of Laser Beam Sensors (LBS) to detect train movements and direction. Two parallel laser beams from a transmitter are delivered to a receiver, and the sensor detects a train is present when the beams are blocked. Once the train is no longer detected by the set of LBS, the sensor records the amount of time it took to travel through that location. TOTES uses six

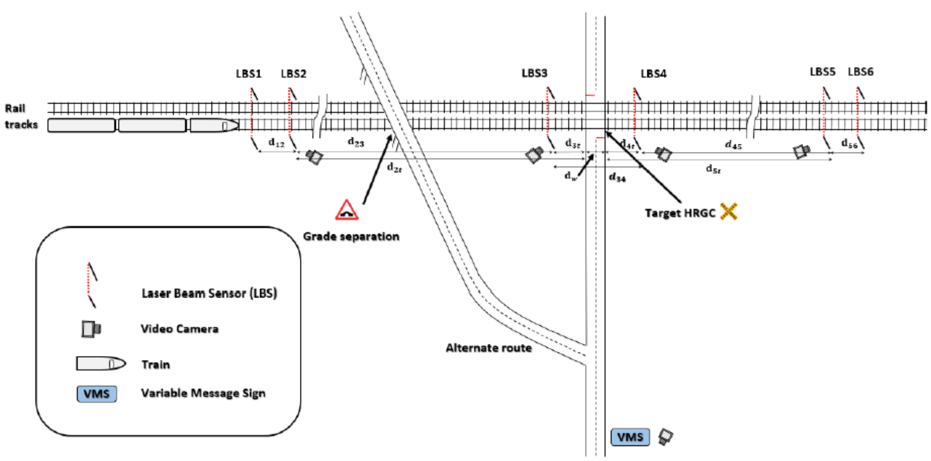


FIGURE 62 Illustration of TOTES at an At-Grade Rail Crossing
Source: Highway-Rail Crossing Safety Improvements by Diverting Motorist to Alternate Routes

[27] Aemal Khattak, PhD, and Myungwoo Lee, *Highway-Rail Crossing Safety Improvements by Diverting Motorist to Alternate Routes*, October 2018.

sets of LBSs as shown in **Figure 62**, and four sets must be located far enough from the at-grade crossing to allow for a sufficient amount of time for motorists to receive the information.

The Detection Control System (DCS) consists primarily of a computer that communicates with LBSs and variable message signs. The DCS determines the train's speed, length, estimated arrival time at the crossing, and estimated crossing occupancy time based on data collected by the sensors in the TDS. The DCS also includes video cameras to monitor sensors and at-grade crossings to verify that the sensors are working and to reveal possible causes of abnormal data.

Motorists are informed of this train crossing information via variable message signs to allow them to determine whether to avoid the delay caused by the arriving train. While the TDS and DCS communicate with each other via radio frequencies, the VMS can be controlled either automatically by the same radio frequencies linked to the DCS or manually by an operator. An example of the types of messages that the signs in this system can display are shown in **Figure 63**.

The study recommends placing the VMS in locations a set distance from major

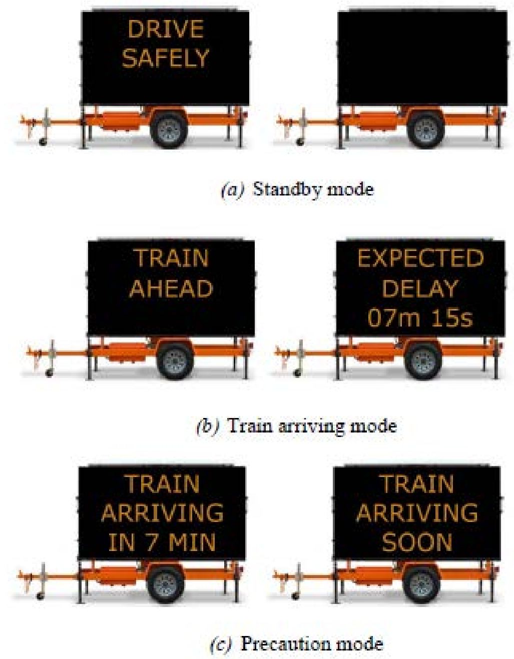


FIGURE 63 Possible VMS Messages by Mode
Source: Highway-Rail Crossing Safety Improvements by Diverting Motorist to Alternate Routes

Table 4.1 Decision Sight Distance (Source: AASHTO Greenbook, 2011)

Design Speed (mph)	Decision Sight Distance for Avoidable Maneuver, (ft.)					
	A		B	C	D	E
25	180	280	400	375	400	525
30	220	350	490	450	535	620
35	275	425	590	525	625	720
40	330	505	690	600	715	825
45	395	590	800	675	800	930
50	465	680	910	750	890	1030
55	535	775	1030	865	980	1135
60	610	875	1150	990	1125	1280
65	695	980	1275	1050	1220	1365
70	780	1090	1410	1105	1275	1445
75	875	1200	1545	1180	1365	1545
80	970	1320	1685	1260	1455	1650
	Rural	Suburban	Urban	Rural	Suburban	Urban

*Note: Avoidance Maneuvers
1. Avoidance maneuver A: Stop on rural road – t = 3.0s
1a. Stop on suburban road – Assume t =6.0s
2. Avoidance maneuver B: Stop on urban road – t = 9.1s
3. Avoidance maneuver C: Speed/path/direction change on rural road – t = 10.2 – 11.2s
4. Avoidance maneuver D: Speed/path/direction change on suburban road – t = 12.1 – 12.9s
5. Avoidance maneuver E: Speed/path/direction change on urban road – t = 14.0 – 14.5s

FIGURE 64 VMS Distance from Decision Points
Source: A Policy on Geometric Design of Highways and Streets

decision points. Diverting rates would decrease if the VMS is located too far in advance of the alternate route, and drivers would not have enough time to change lanes/routes if the VMS is located too close in advance of the alternate route. The authors determined that VMS should be located a set distance prior to major decision points based on decision sight distance criteria in the AASHTO Green Book[28]. These sight distances are shown primarily in Column E in **Figure 64**.

A test site using TOTES was implemented as part of the UTCRS study at an at-grade crossing in Lincoln, Nebraska. A total of 93 trains were observed during the one-week data collection period. The average crossing occupancy time was 3 minutes and 44 seconds, with the occupancy times ranging between 1 minute and 11 seconds and 6 minutes and 52 seconds at the crossing. The distribution of train activities throughout the day did not show any significant concentration of trains at a certain time of day.

When the VMS indicated that a train was present and included the expected amount of delay, 36% of northbound vehicles at the intersection of Old Cheney Road and Warlick Boulevard (which is shown in Figure 62) made a left turn, thereby avoiding the at-grade crossing. When the VMS had a message indicating instead to drive safely, 28% made the left turn. This indicates that there was benefit of providing traveler information on the status of the at-grade crossing.

[28] American Association of State Highway and Transportation Officials (AASHTO), *A Policy on Geometric Design of Highways and Streets*, 2011 edition.

<u>Portsmouth</u>

The City of Portsmouth is home to Portsmouth Marine Terminal, which has seen increased activity in recent years. City officials were concerned that this increased activity would lead to more frequent and longer trains traveling along the CSX Railroad to and from the terminal. Four CSX railroad crossings were of particular concern to the City:

- High Street near the Martin Luther King Freeway
- Frederick Boulevard just west of I-264
- George Washington Highway north of Frederick Boulevard
- Elm Avenue near Norfolk Naval Shipyard Gates 29 and 36

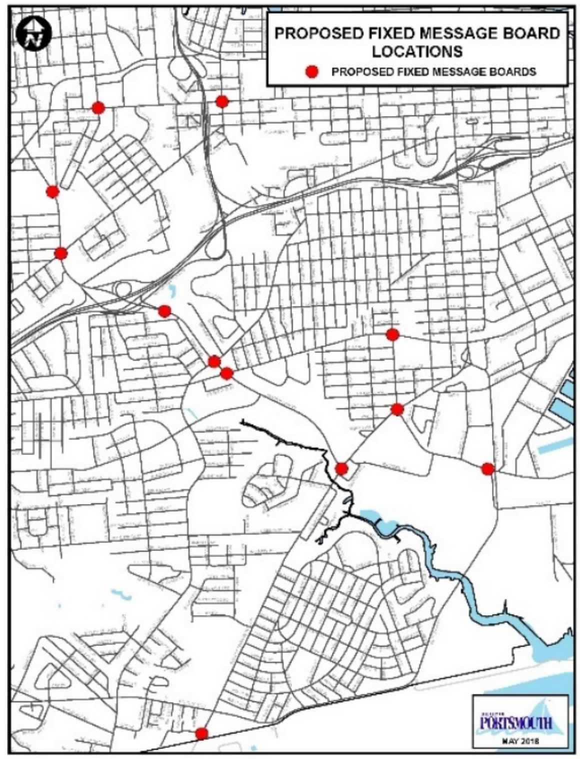


FIGURE 65 Proposed VMS Locations in Portsmouth
Source: City of Portsmouth

The City proposed a project that involved installing changeable message signs and unobtrusive train detectors that would reduce congestion by alerting motorists of train activity which would allow them to take alternative routes. The project is anticipated to include 12 changeable message signs, 8-12 unobtrusive train detectors placed on public right-of-way, and 12 fiber splices (since each roadway already had fiberoptic communications).

The project was submitted by the City of Portsmouth for the SMART SCALE statewide project selection process and was selected to receive funding. The overall cost of the project is estimated to be $754,000, with $570,000 being provided by the state though SMART SCALE and the remaining $184,000 being provided by the City. Construction on the project is currently scheduled to start in late 2023 and conclude in early 2025.

As demonstrated in the three examples described above, there are systems that can be put in place to provide information to travelers on the status of trains approaching at-grade rail crossings.

NIT Marshalling Yard
Source: HRTPO

As described previously, there is a process that VIT undertakes to transport trains across Hampton Boulevard into Norfolk International Terminals. Staff from the Port of Virginia have indicated that they can provide real-time information when crossings of Hampton Boulevard are anticipated, and when the at-grade crossing has been cleared.

For the other two at-grade crossings – Granby Street and Little Creek Road – information on trains would likely need to be provided by other means. Information sharing by railroads is generally an issue for a variety of reasons including liability. The San Antonio, Nebraska, and Portsmouth examples described previously used or are expected to use unobtrusive sensors that can be placed on public right-of-way, and such a system would likely be practical for a similar system in Norfolk. In addition to unobtrusive sensors, sensors can also be integrated into existing railroad crossing signal equipment, similar to traffic signal preemption systems that are installed at rail crossings that are adjacent to signalized intersections.

Information will need to be provided to motorists prior to locations at which they can reasonably alter their route to avoid the trains.   These locations – referred to in this study as decision points – are defined here as practical intersections where motorists could alter their trip to another route based on information on the blockage of the rail crossing. This information would be similar to the University of Nebraska TOTES example, with expected time of crossing blockage information.

Figure 66 and **Figure 67** show the location of likely decision points for the Hampton Boulevard/Terminal Boulevard, Granby Street, and Little Creek Road at-grade rail crossings.

Hampton Boulevard/Terminal Boulevard Crossing

Roadway	Direction	Decision Point
Hampton Blvd	North of crossing	Terminal Blvd Note: Southbound Hampton Blvd traffic can turn left onto eastbound Terminal Blvd when trains are present
Hampton Blvd	South of crossing	Little Creek Rd
Terminal Blvd	East of crossing	Diven St Note: Westbound Terminal Blvd traffic can turn right onto northbound Hampton Blvd when trains are present
Little Creek Rd	Southeast of crossing	Diven St

Granby Street Crossing

Roadway	Direction	Decision Point
Granby St	North of crossing	Patrol Road/I-64 EB on-ramp
Granby St/I-64 off ramp	North of crossing	Admiral Taussig Blvd
Granby St	South of crossing	Thole St
Granby St	South of crossing	Little Creek Rd

Little Creek Road Crossing

Roadway	Direction	Decision Point
Little Creek Rd	West of crossing	Granby St
Little Creek Rd	East of crossing	Admiral Taussig Blvd
Little Creek Rd	East of crossing	Tidewater Dr

FIGURE 66 Likely Decision Points for At-Grade Rail Crossings Near NIT
Source: HRTPO analysis

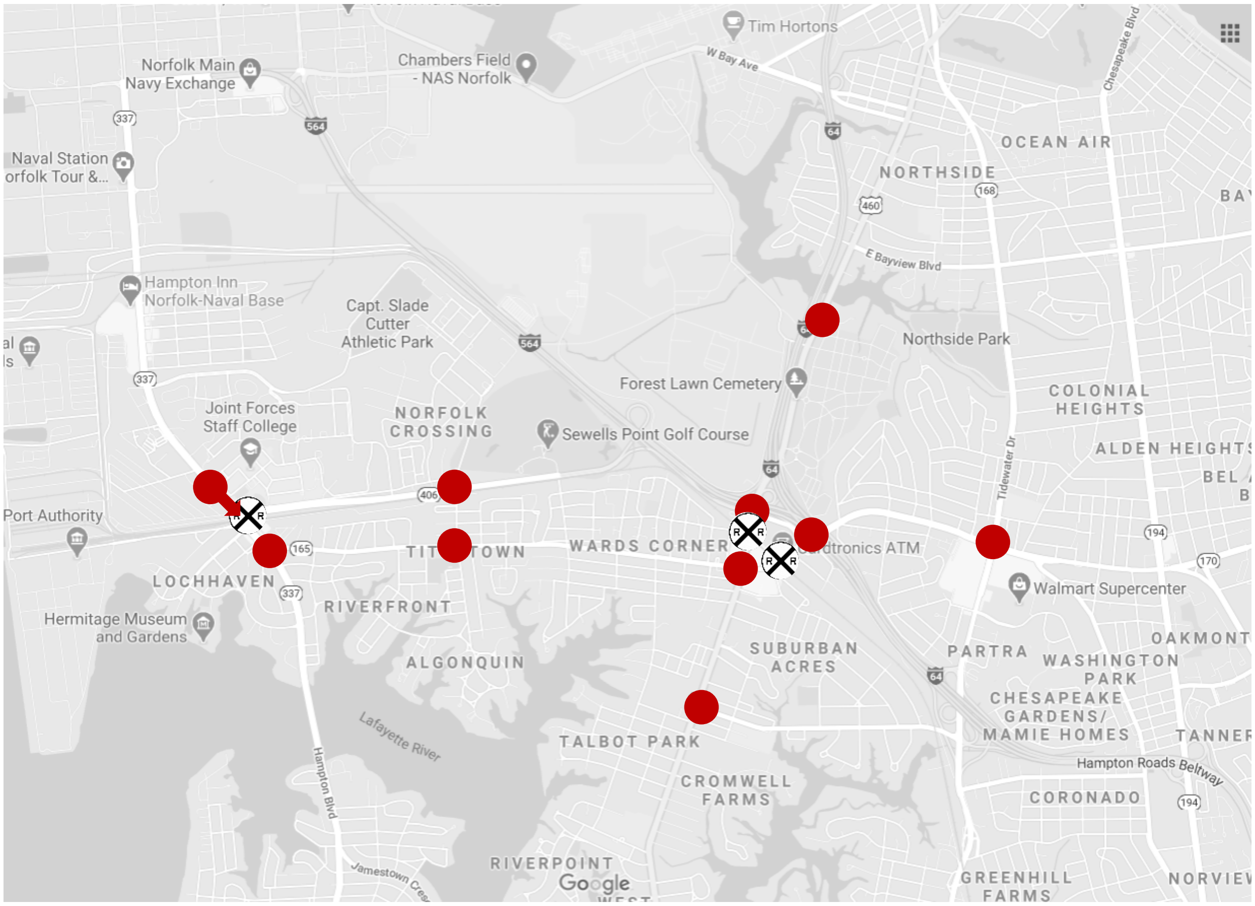


FIGURE 67 Likely Decision Points for At-Grade Rail Crossings Near Norfolk International Terminals

Map Source: Google

Based on the proposed decision points, possible locations for variable message signs were determined using the Decision Sight Distance for speed/path/direction on urban roads from the AASHTO Green Book (as used in the University of Nebraska Study example). The proposed location of variable message signs for each of the three crossings is shown in **Figure 68** below and **Figure 69**. These variable message signs would be tied into the City's fiberoptic communications lines in those corridors where the lines currently exist, or can be connected via wireless communication technologies for locations that are on corridors without city fiberoptic lines.

Hampton Boulevard/Terminal Boulevard Crossing

Roadway	Direction	Location
Hampton Blvd	North of crossing	720' North of Terminal Blvd (near Joint Forces Gate B) Note: Southbound Hampton Blvd traffic can turn left onto eastbound Terminal Blvd when trains are present
Hampton Blvd	South of crossing	720' South of Little Creek Rd (near Runnymeade Rd)
Terminal Blvd	East of crossing	930' East of Diven St Note: Westbound Terminal Blvd traffic can turn right onto northbound Hampton Blvd when trains are present
Little Creek Rd	Southeast of crossing	720' East of Diven St (Just east of Mount Pleasant Ave)

Granby Street Crossing

Roadway	Direction	Location
Granby St	North of crossing	720' North of Patrol Road/I-64 EB on-ramp (Near on-ramp to I-64 WB
Granby St/I-64 off ramp	North of crossing	720' North of Admiral Taussig Blvd (At off-ramp from I-64 EB)
Granby St	South of crossing	720' South of Thole St (Near Brackenridge Ave)
Granby St	South of crossing	720' South of Little Creek Rd (Near Cromwell Pkwy)

Little Creek Road Crossing

Roadway	Direction	Location
Little Creek Rd	West of crossing	720' West of Granby St (Near Victory Dr)
Little Creek Rd	East of crossing	720' East of Admiral Taussig Blvd (Near West Glen Rd)
Little Creek Rd	East of crossing	720' East of Tidewater Dr (Near Old Ocean View Rd)

FIGURE 68 Proposed Variable Message Sign Locations
Source: HRTPO analysis

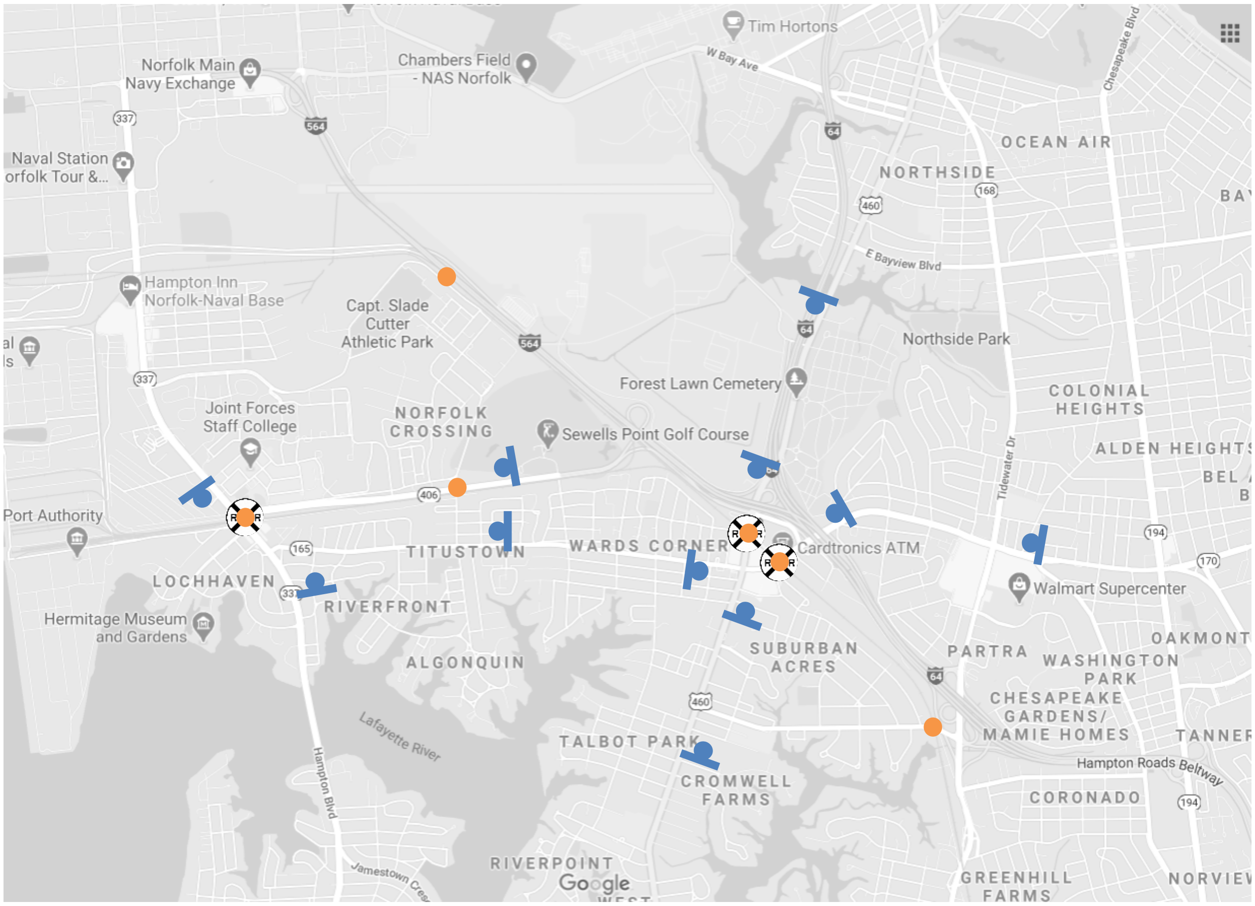


FIGURE 69 Proposed Location of Variable Message Signs and Sensors for At-Grade Rail Crossings Near Norfolk International Terminals
Map Source: Google

System Costs

A planning level estimate of the capital costs for a traveler information system for the three at-grade rail crossings is provided in this section. The unit and total costs used in this section were developed by Kimley-Horn for the SMART SCALE application that they prepared for the City of Norfolk for this system.

The infrastructure that would be required to operate this traveler information system include:

- Variable message signs, structures, and associated equipment (11 locations)
- Train detection sensors (six locations)
- Fiberoptic communications connections, at those locations where the signs can be connected to the City's fiberoptic communications network (seven locations)
- Wireless communications connections, at those locations where the signs cannot be easily connected to the City's fiberoptic communications network (four locations)
- Software to integrate the variable message signs into the City's Advanced Traffic Management System (ATMS)

In addition to the costs related to the infrastructure listed above, there are costs associated with mobilization for the project and maintaining traffic during construction.

Cost estimates for the traveler information system are shown in **Figure 70**. The total projected cost for the system is $4.4 million, with $520,000 for preliminary engineering costs, $19,000 for right-of-way acquisition, and $3.9 million for construction costs. It should be noted that $940,000 is included in the estimated construction costs for contingencies based on 40% of the construction subtotal cost. This is required for the SMART SCALE process, so the actual construction costs for this project would likely be lower than the estimates shown.

Preliminary Engineering

Item	Quantity	Unit Cost	Total Cost
SUBTOTAL	N/A		$394,000
Contingency (12%)			$47,280
Oversight Costs - City			$39,400
Oversight Costs - VDOT			$39,400
RIGHT-OF-WAY TOTAL			**$520,080**

Right-of-Way

Item	Quantity	Unit Cost	Total Cost
SUBTOTAL	N/A		$9,400
Contingency (50%)			$4,700
Oversight Costs - City			$2,350
Oversight Costs - VDOT			$2,350
RIGHT-OF-WAY TOTAL			**$18,800**

Construction

Item	Quantity	Unit Cost	Total Cost
Mobilization	N/A	$713,000	$713,000
Maintenance of Traffic	N/A	$228,000	$228,000
E&S (per site)	11 locations	$2,500	$27,500
Electrical Service	11 locations	$5,000	$55,000
Variable Message Sign - Type 2	10 locations	$50,000	$500,000
Variable Message Sign - Type 2A	1 location	$65,000	$65,000
VMS Structure - Cantilever	10 locations	$37,500	$375,000
VMT Structure - Butterfly	1 location	$27,500	$27,500
Train Detection Sensors	6 locations	$15,000	$90,000
Water Line Offset	50 feet	$500	$25,000
VMS Software Integration	N/A	$60,000	$60,000
Communications - Fiber	7 locations	$20,000	$140,000
Communications - Wireless	4 locations	$10,000	$40,000
SUBTOTAL			$2,346,000
Contingency (40%)			$938,400
CEI (15%)			$351,900
Oversight Costs - City			$117,300
Oversight Costs - VDOT			$117,300
CONSTRUCTION TOTAL			**$3,870,900**

PROJECT COST = $4,409,780

FIGURE 70 Estimated Project Costs for Rail Crossing Traveler Information System

Source: Kimley-Horn

Summary

The City of Norfolk is concerned by the impacts of port-related trains at three at-grade rail crossings on the Norfolk and Portsmouth Belt Line – Hampton Boulevard/Terminal Boulevard, Granby Street, and Little Creek Road. One solution to reduce delays at these three crossings – which can reach as high as 15 minutes – is to provide real-time traveler information on train activity, primarily via variable message signs. A variable message sign system comprised of eleven variable message signs, six train detection sensors, and related communications equipment and software was described in this section. The total cost for this system is estimated to be $4.4 million.

Improving Safety on Hampton Boulevard

Ensuring the safety of roadway users is a priority, particularly in the Hampton Boulevard corridor where so many different modes (passenger vehicles, trucks, bicyclists, and pedestrians) interact. In this safety chapter, HRTPO staff analyzes speed data and crash data, prior to providing potential safety improvements.

Hampton Boulevard Speed Analysis

HRTPO staff analyzed speed data obtained from VDOT at the permanent count station on Hampton Boulevard near Lexan Avenue for the years 2015 to 2019, where the posted speed limit is 35 mph.

HRTPO staff calculated 50th and 85th percentile speeds as part of this analysis. The 50th percentile speed (or speed median) is the speed at which half of the observed vehicles are traveling at or below. Similarly, the 85th percentile speed is the speed at which 85 percent of the vehicles are traveling at or below, and it is used in evaluating and recommending posted speed limits.

The cumulative frequency is the total of each of the numbers (frequencies) added together row by row from lower to a higher speed, and the cumulative percentage column is a running percentage of the cumulative frequency. The 85th percentile speed is determined from the cumulative percent column. If the 85th percentile speed falls between the 35-40 mph range and the 40-45 mph range, for example, a calculation is needed using percentages and speeds from the distribution table to obtain the exact percentile. The formula used is shown below:

$$S_D = \frac{P_D - P_{min}}{P_{max} - P_{min}} \cdot (S_{max} - S_{min}) + S_{min}$$

Where:
S_D – the speed at P_D
P_D – percentile desired
P_{max} – higher cumulative percent
P_{min} – lower cumulative percent
S_{max} – higher speed
S_{min} – lower speed

HRTPO staff calculated 50th percentile and 85th percentile speeds for both directions (Northbound and Southbound) for 2015-2019, which can be seen in **Figure 71**.

Direction	2015		2016		2017		2018		2019	
	50th percentile	85th percentile	50th percentile	85th percentile	50th percentile	85th percentile	50th percentile	85th percentile	50th percentile	85th percentile
NB	36.50	42.20	31.80	37.30	36.40	42.30	37.10	43.10	37.80	43.90
SB	34.60	35.80	29.90	35.80	29.70	41.10	30.10	41.50	30.20	41.70

FIGURE 71 Summarized 50th and 85th Percentile Speeds (in miles per hour) on Northbound and Southbound Hampton Boulevard for 2015 – 2019
Source: HRTPO analysis of VDOT speed data

Figures 72 - 75 exhibit 50th and 85th percentile speeds, which were calculated for each day of the week for the northbound and southbound directions (respectively) for 2015-2019.

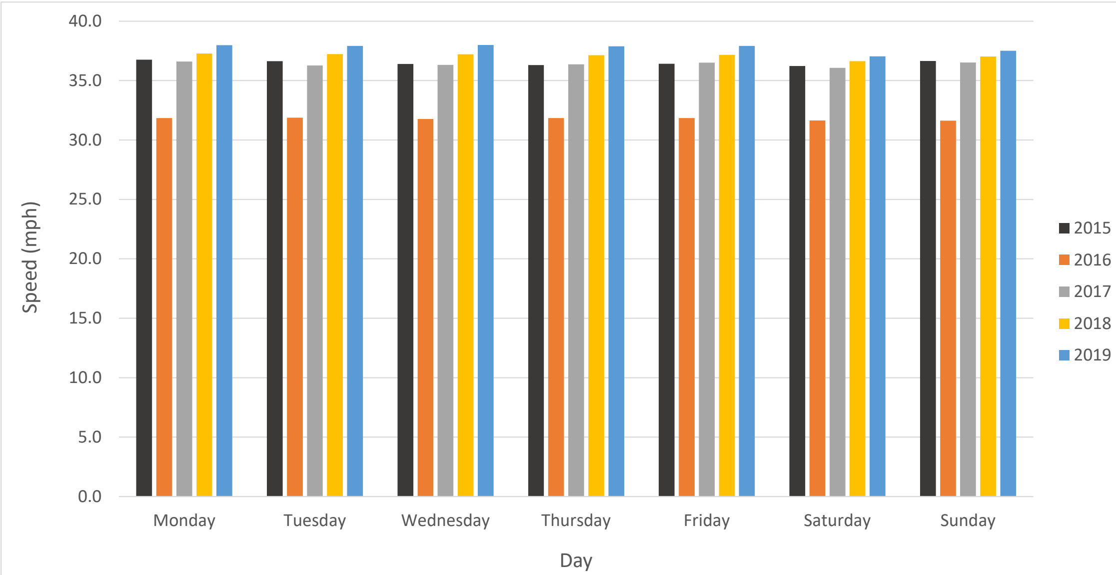


FIGURE 72 Summarized 50th Percentile Speeds by Day of Week for Northbound Hampton Boulevard for 2015-2019

Source: HRTPO analysis of VDOT speed data

The 50th percentile speed for northbound Hampton Boulevard by weekday has the highest values in 2019 (between 37 and 38 mph). The lowest values, on the other hand, were seen in 2016 (between 31.6 and 31.9 mph).

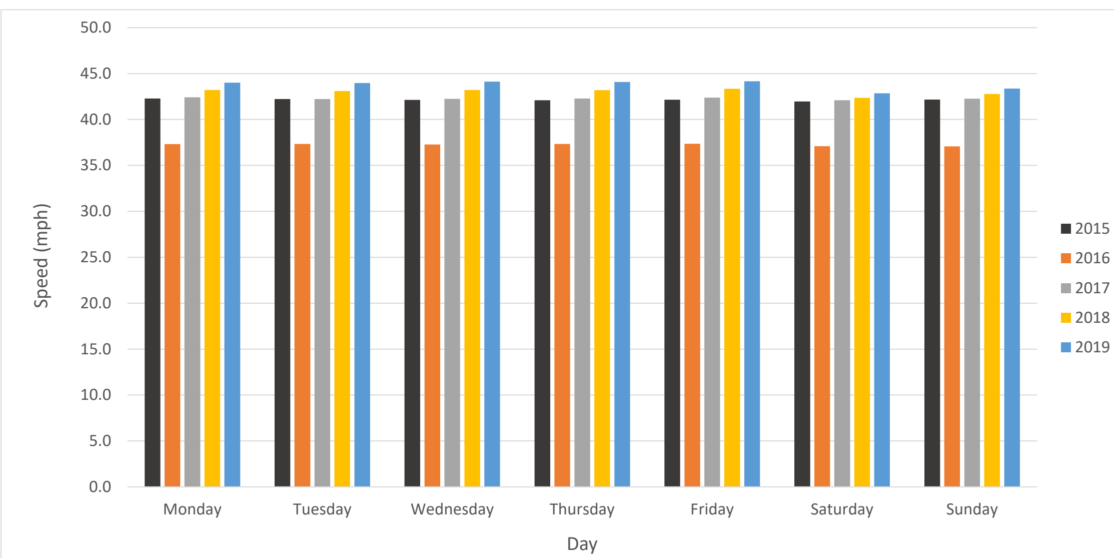


FIGURE 73 Summarized 85th Percentile Speeds by Day of Week for Northbound Hampton Boulevard for 2015-2019

Source: HRTPO analysis of VDOT speed data

Similar to the 50th percentile speed, the 85th percentile speed for northbound Hampton Boulevard has its lowest values in 2016 (between 37.1 and 37.4 mph) and its highest values in 2019 (between 42.8 and 44.2 mph).

Figures 74 and 75 display the 50th and 85th percentile speeds for southbound Hampton Boulevard by day of week for 2015-2019.

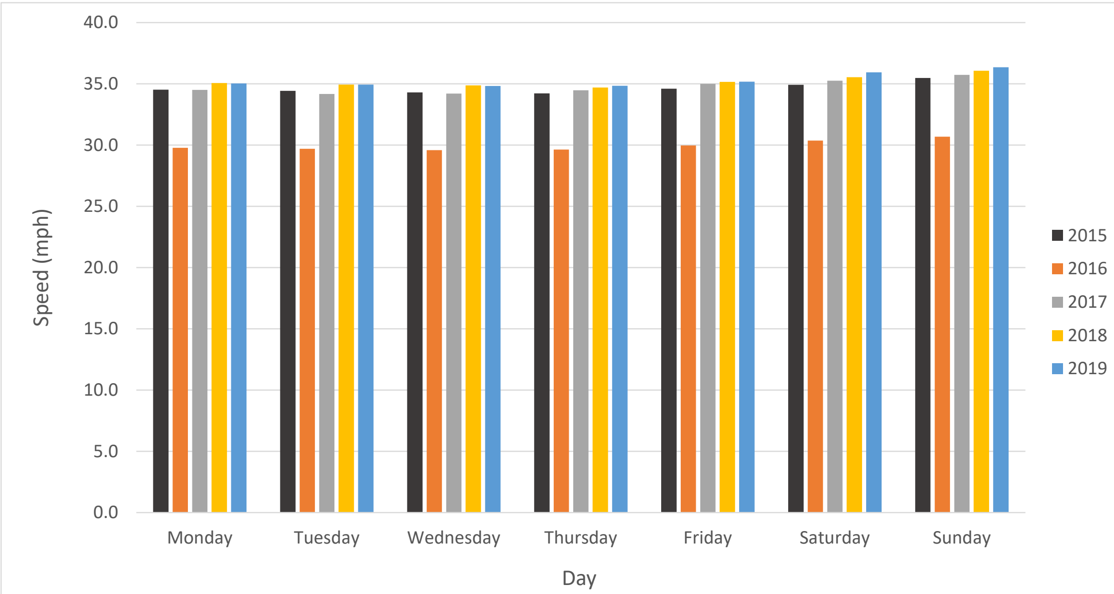


FIGURE 74 Summarized 50th Percentile Speed by Day of Week for Southbound Hampton Boulevard for 2015-2019

Source: HRTPO analysis of VDOT speed data

For the southbound direction, the 50th percentile speed has the lowest values in 2016 (between 29.6 - 30.7 mph), while its highest values are in 2019 (between 34.8 - 36.4 mph).

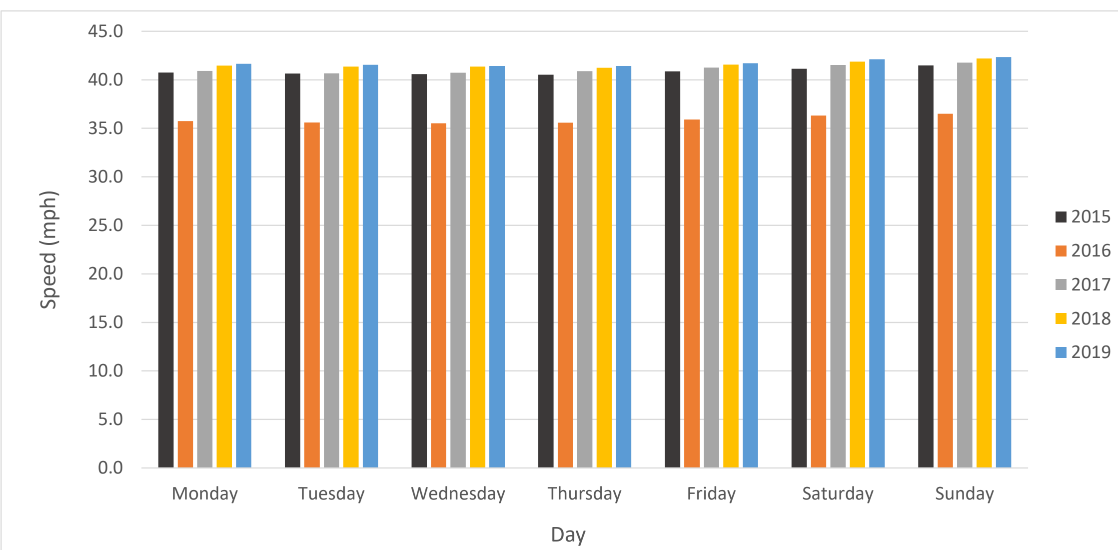


FIGURE 75 Summarized 85th Percentile Speed by Day of Week for Southbound Hampton Boulevard for 2015-2019

Source: HRTPO analysis of VDOT speed data

The highest value of the 85th percentile speed for weekdays for southbound Hampton Boulevard was in 2019 (between 41.4 and 42.3 mph), while the lowest value was in 2016 (between 35.5 and 36.5 mph).

Figures 76 and 77 exhibit the 50th and 85th percentile speeds for northbound Hampton Boulevard by time of day for 2015-2019.

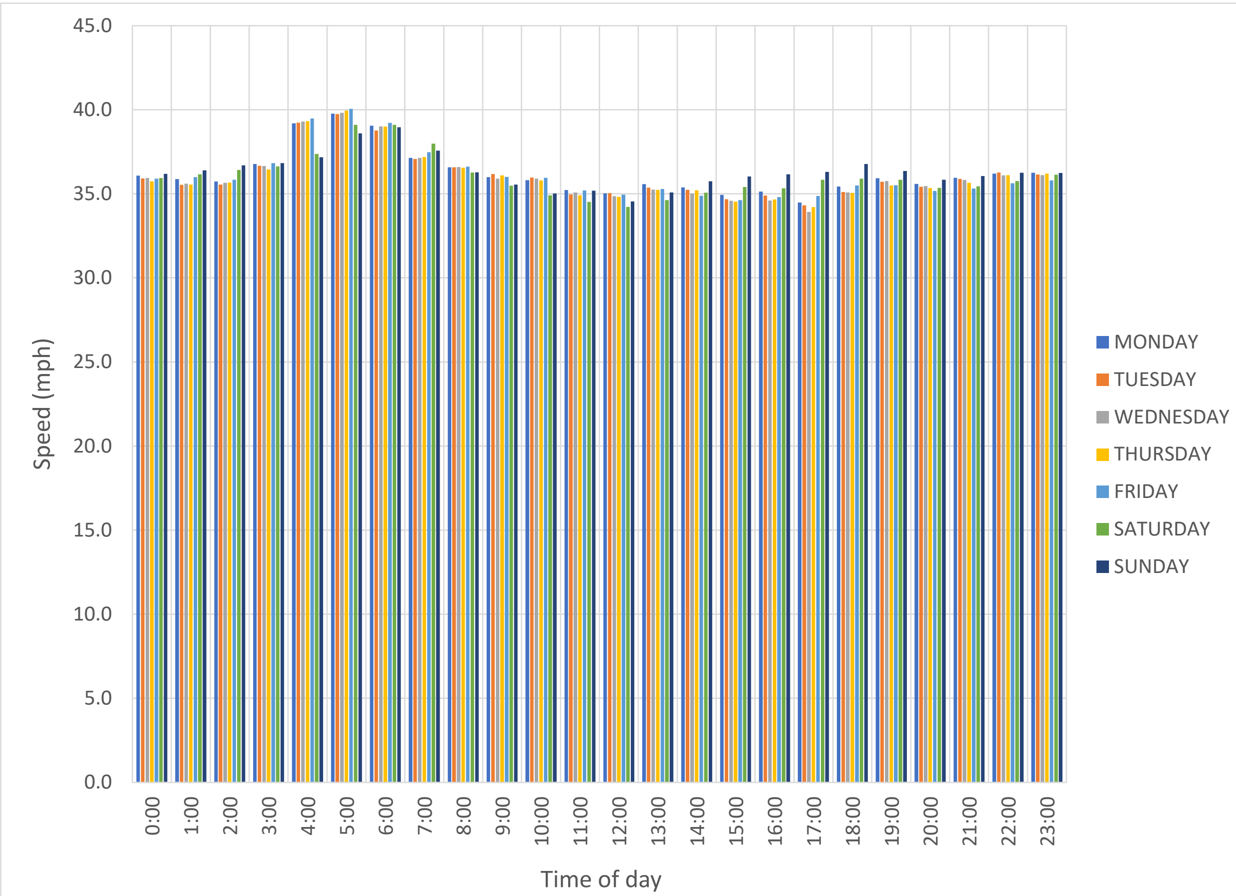


FIGURE 76 Summarized 50th Percentile Speed by Time of Day for Northbound Hampton Boulevard for 2015-2019

Source: HRTPO analysis of VDOT speed data

The 50th percentile speeds vary throughout the day, with much higher speeds occurring in the early morning hours. Between 4 am and 7 am, the 50th percentile speed in the northbound direction generally ranges between 39-40 mph (although it is lower on weekends), while 50th percentile speeds range between 34-36 mph throughout the rest of the day.

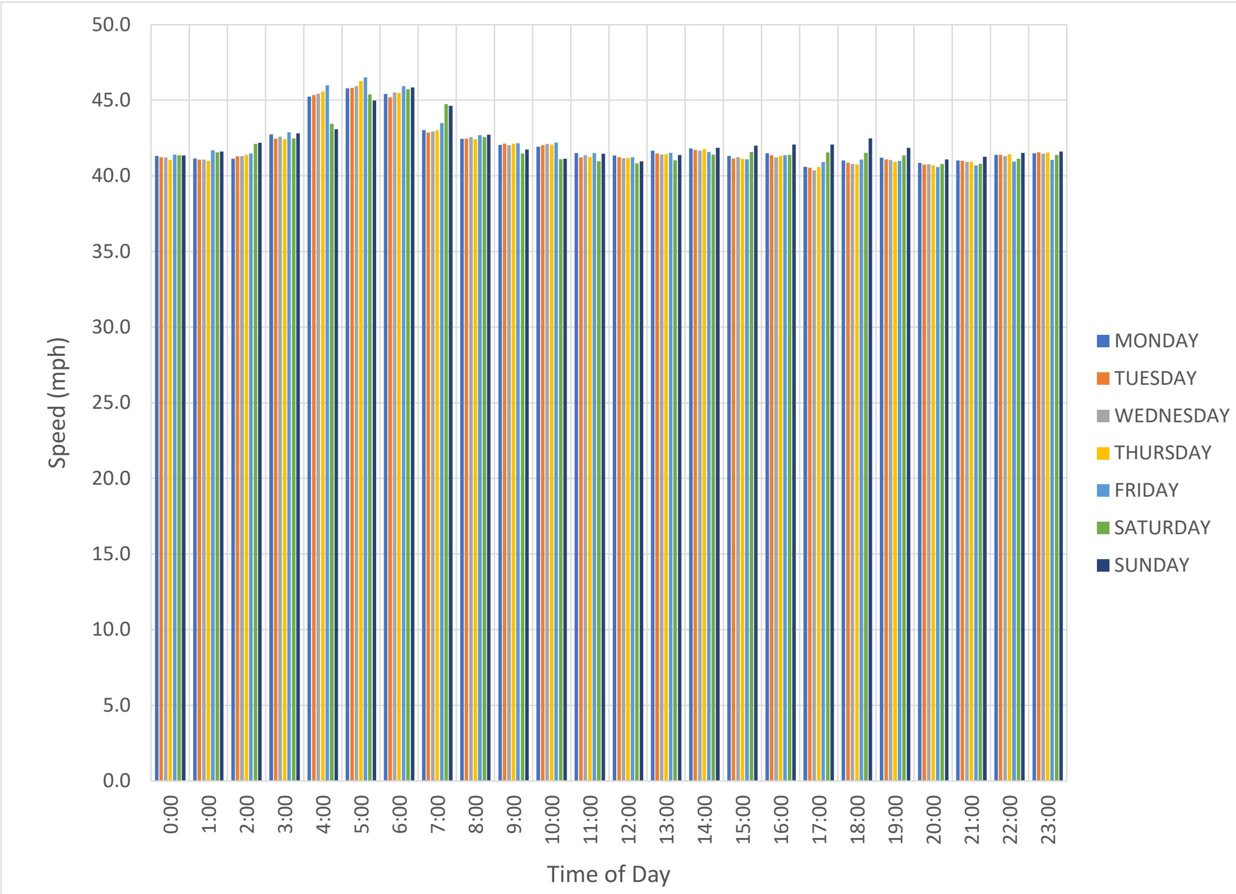


FIGURE 77 Summarized 85th Percentile Speed by Time of Day for Northbound Hampton Boulevard for 2015-2019
Source: HRTPO analysis of VDOT speed data

Similar to the 50th percentile speed, the 85th percentile speed for northbound Hampton Boulevard has its highest values from 4 am – 7 am. The 85th percentile speed is generally between 45 – 47 mph between 4 am – 7 am, while the 85th percentile speed ranges typically between 40 – 43 mph throughout the rest of the day.

Figures 78 and 79 convey 50th and 85th percentile speeds by day for southbound Hampton Boulevard for 2015-2019.

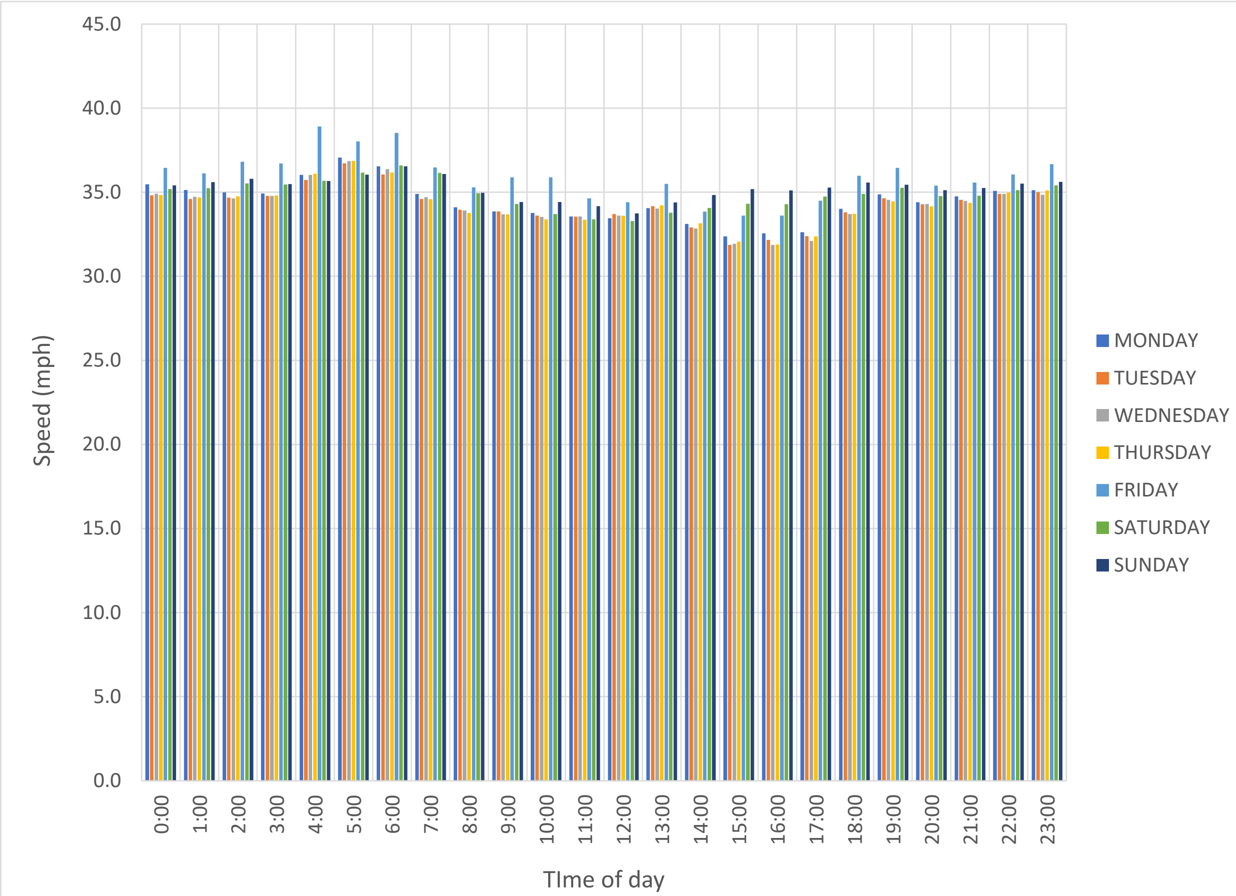


FIGURE 78 Summarized 50th Percentile Speed by Time of Day by Southbound Hampton Boulevard for 2015-2019

Source: HRTPO analysis of VDOT speed data

Unlike the northbound direction, 50th percentile speeds in the southbound direction do not have as high of a peak during the early morning hours. The 50th percentile speeds in the southbound direction are generally between 35 – 37 mph between 4 – 7 am as compared to 34 – 35 mph during the overnight hours. Speeds are lowest during the PM peak period at around 32 – 33 mph.

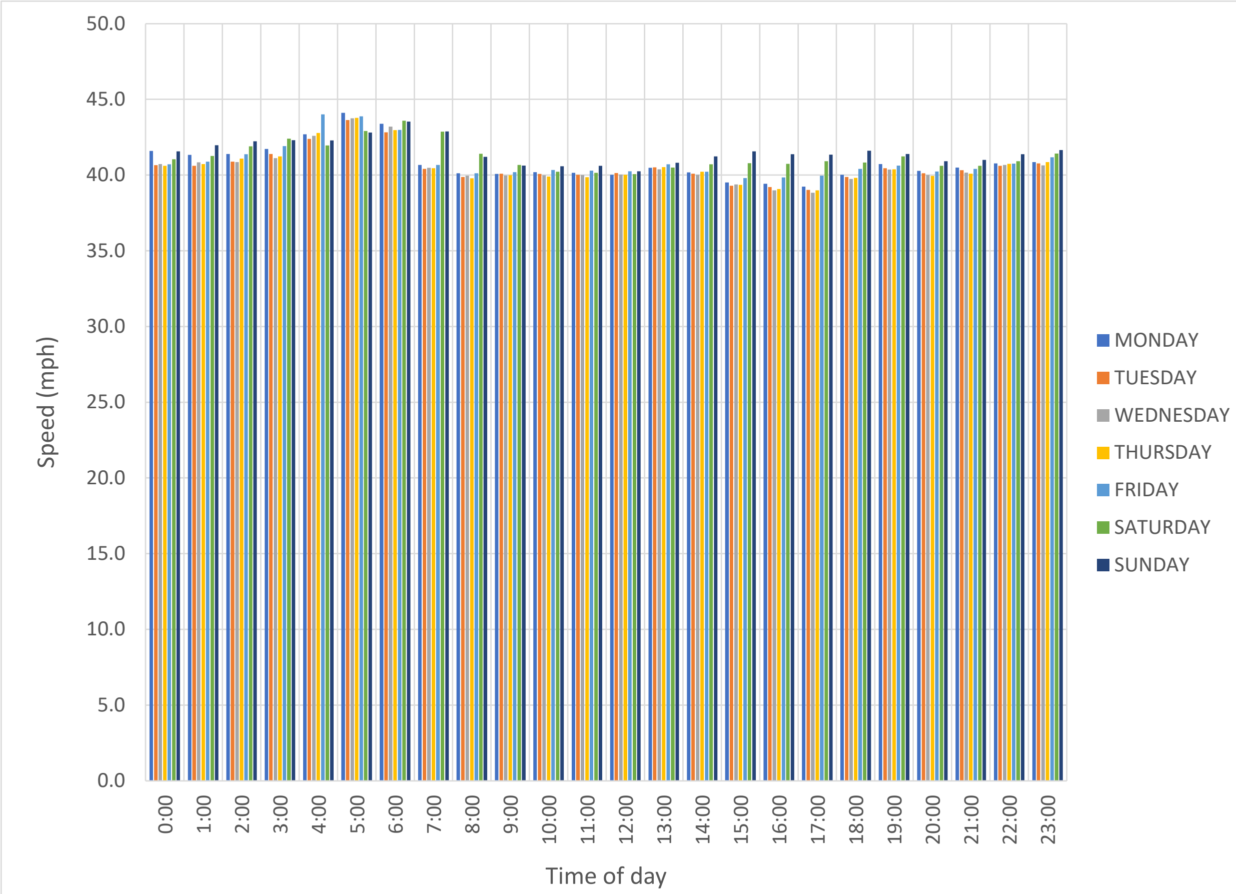


FIGURE 79 Summarized 85th Percentile Speed by Time of Day for Southbound Hampton Boulevard for 2015-2019
Source: HRTPO analysis of VDOT speed data

The 85th percentile speeds are generally lower in the southbound direction than northbound. The 85th percentile speed peaks between 4 – 7 am at 42 – 44 mph, but are generally between 40 – 41 mph throughout the midday and afternoon hours, and 40 – 42 mph in the remaining overnight hours.

Summary

In this section of the study, HRTPO staff calculated the 50th and 85th percentile speeds for Hampton Boulevard just south of the Lafayette River Bridge for the years 2015 - 2019 by direction, day of week, and time of day. Speed distribution was also exhibited by day of the week in 5 mph ranges. Based on the analysis of the data, it can be inferred that a speeding problem exists on the Hampton Boulevard corridor. The safety issues related to speeding are further analyzed in the next section.

Hampton Boulevard Crash Analysis

Hampton Boulevard is a multimodal corridor, serving not only travelers in passenger vehicles but also a large number of trucks, bicyclists, and pedestrians. Ensuring the safety of all travelers along the Hampton Boulevard corridor, and reducing the number of fatalities and serious injuries, is critical.

Staff analyzed all crashes on Hampton Boulevard and within 250 feet on intersecting roadways between Brambleton Avenue and Admiral Taussig Boulevard. The total number of crashes, injuries, and fatalities in the corridor by year is exhibited in **Figure 80.**

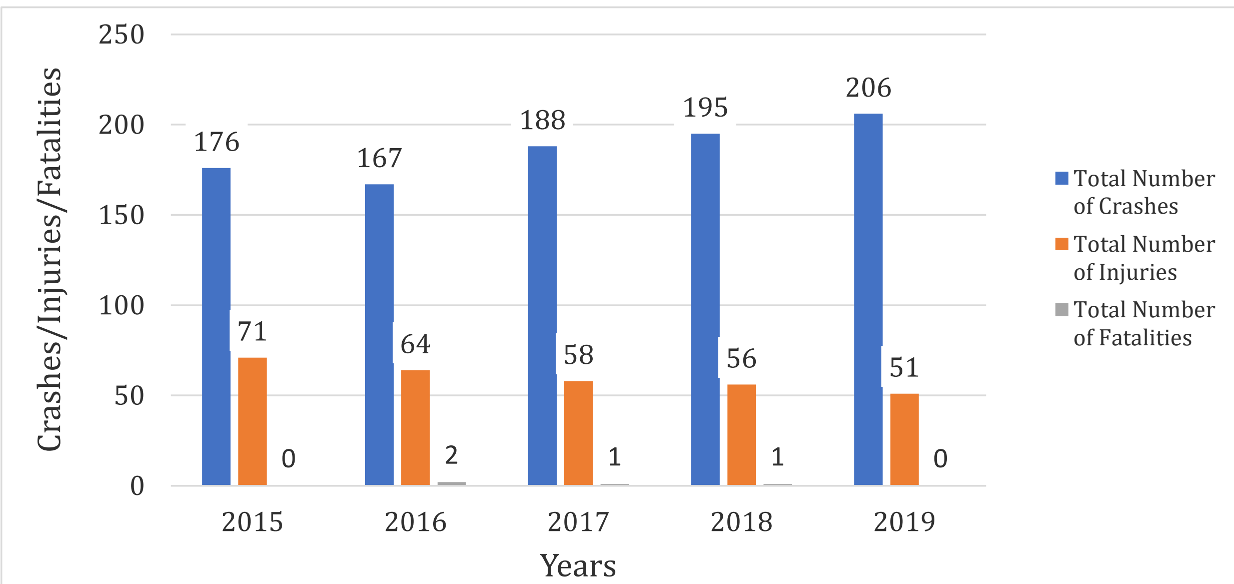


FIGURE 80 Total Number of Crashes, Injuries, and Fatalities by Year (2015-2019)
Source: HRTPO analysis of VDOT crash data

There was a total of 932 crashes in the corridor from 2015-2019, of which 300 crashes resulted in injuries, 4 resulted in fatalities, and 628 were property damage only. The total number of crashes declined in 2016 (from 176 crashes in 2015 to 167 crashes). However, the number of crashes steadily increased to 188 crashes in 2017, 195 in 2018, and 206 in 2019.

In spite of the increasing number of crashes, the total number of crashes with injuries steadily decreased each year between 2015 and 2019. There were 71 crashes with injuries in 2015, 64 in 2016, 58 in 2017, 54 in 2018, and 51 in 2019.

The total number of fatalities was the highest in 2016 (two fatalities), while there was one fatality each year in 2017 and 2018.

Bicycle Crashes

Numerous bicycle facilities run adjacent to Hampton Boulevard, including the popular Elizabeth River Trail. Moreover, Hampton Boulevard passes through Old Dominion University, where there is a strong concentration of students biking. Ghent, a neighborhood along the southern portion of the Hampton Boulevard corridor, also is popular for biking.

The total number of bike crashes, injuries, and fatalities by year is shown in **Figure 81**.

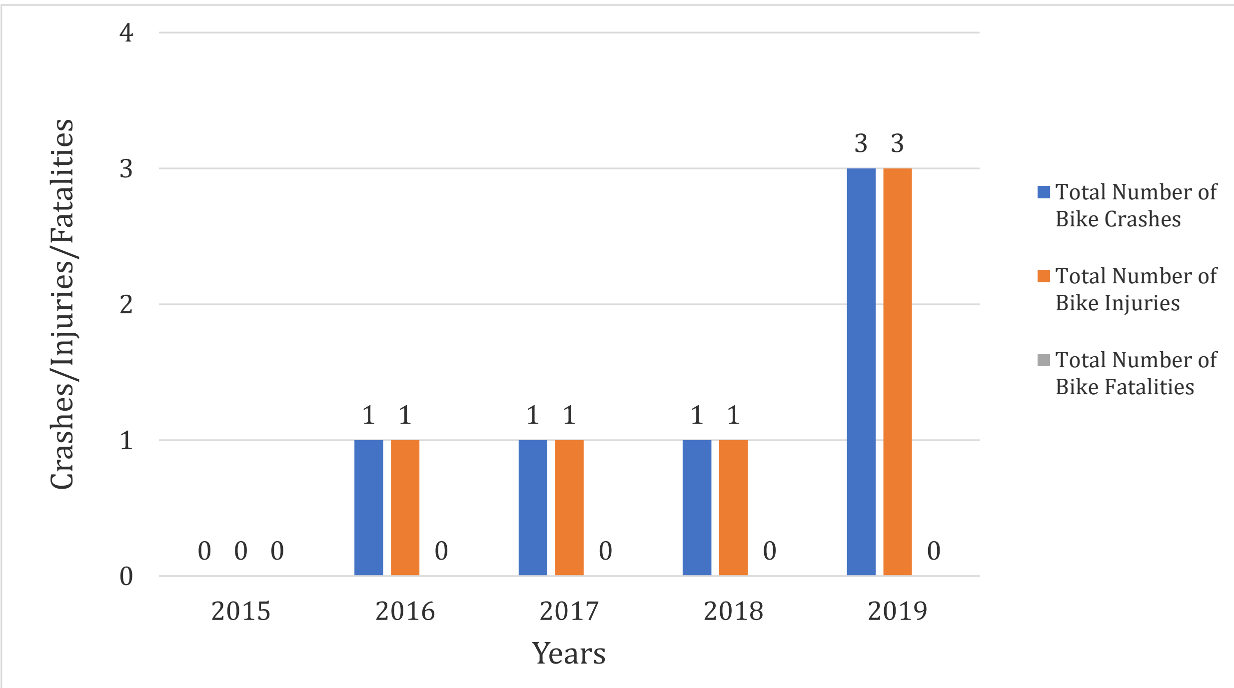


FIGURE 81 Bike Crashes, Injuries, and Fatalities by Year (2015-2019)
Source: HRTPO analysis of VDOT crash data

There was a total of six bike crashes in the corridor for the entire five-year period, and there were no bike crashes in 2015. The total number of bike crashes (which equals the total number of injuries) was steady for years 2016-2018 (one bicycle crash/injury per year), while in 2019, this number increased to three bike crashes/injuries.

The location of each bike crash is shown on **Figure 82**. As shown in the figure, the crashes occurred at Glendale Avenue, Helmick Street, Richmond Crescent/Hanover Avenue/Jamestown Crescent, 41st Street, 35th Street, and Redgate Avenue.


FIGURE 82
Location of Bicycle Crashes in the Hampton Boulevard Corridor, 2015-2019
Bike Crash
Source: HRTPO analysis of VDOT crash data
Hampton (City)
Lafayette River
Elizabeth River
Norfolk (City)
Portsmouth (City)
Lambert Creek (historical)
Elizabeth River
0 0.1 0.2 0.4 0.6
Miles
Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community

Pedestrian Crashes

Similar to bicyclists, there are areas along the Hampton Boulevard corridor where there are a large number of pedestrians. These areas include the Ghent neighborhood, Old Dominion University, and the Larchmont neighborhood. These areas are popular places for people to walk around, and there are many shops, restaurants and retail.

Figure 83 shows the total number of pedestrian crashes, injuries, and fatalities in the Hampton Boulevard corridor by year (2015-2019).

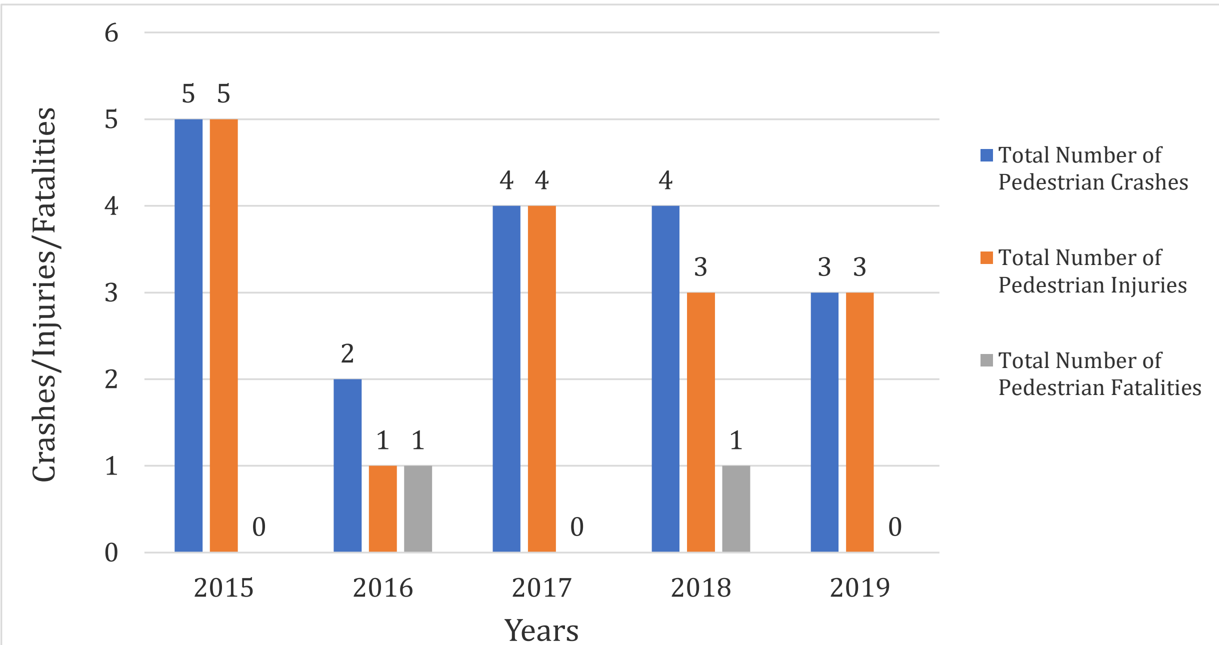


FIGURE 83 Pedestrian Crashes, Injuries, and Fatalities by Year (2015-2019)
Source: HRTPO analysis of VDOT crash data

For the entire five-year period, there were a total of 18 pedestrian crashes, resulting in 16 injuries and two fatalities. The total number of pedestrian crashes decreased from five pedestrian crashes in 2015 (with five injuries) to two pedestrian crashes in 2016 (one fatality and one injury). However, the total number of pedestrian crashes increased to four in 2017 (four injuries) and 2018 (three injuries and one fatality) and then decreased to three pedestrian crashes in 2019 (three pedestrian injuries).

Figure 84 exhibits the locations of pedestrian crashes in the Hampton Boulevard corridor between 2015-2019. There was one crash involving a pedestrian near Little Creek Road, five crashes near Old Dominion University (between 43rd Street and Bolling Avenue), and twelve crashes between Brambleton Avenue and Old Dominion University.

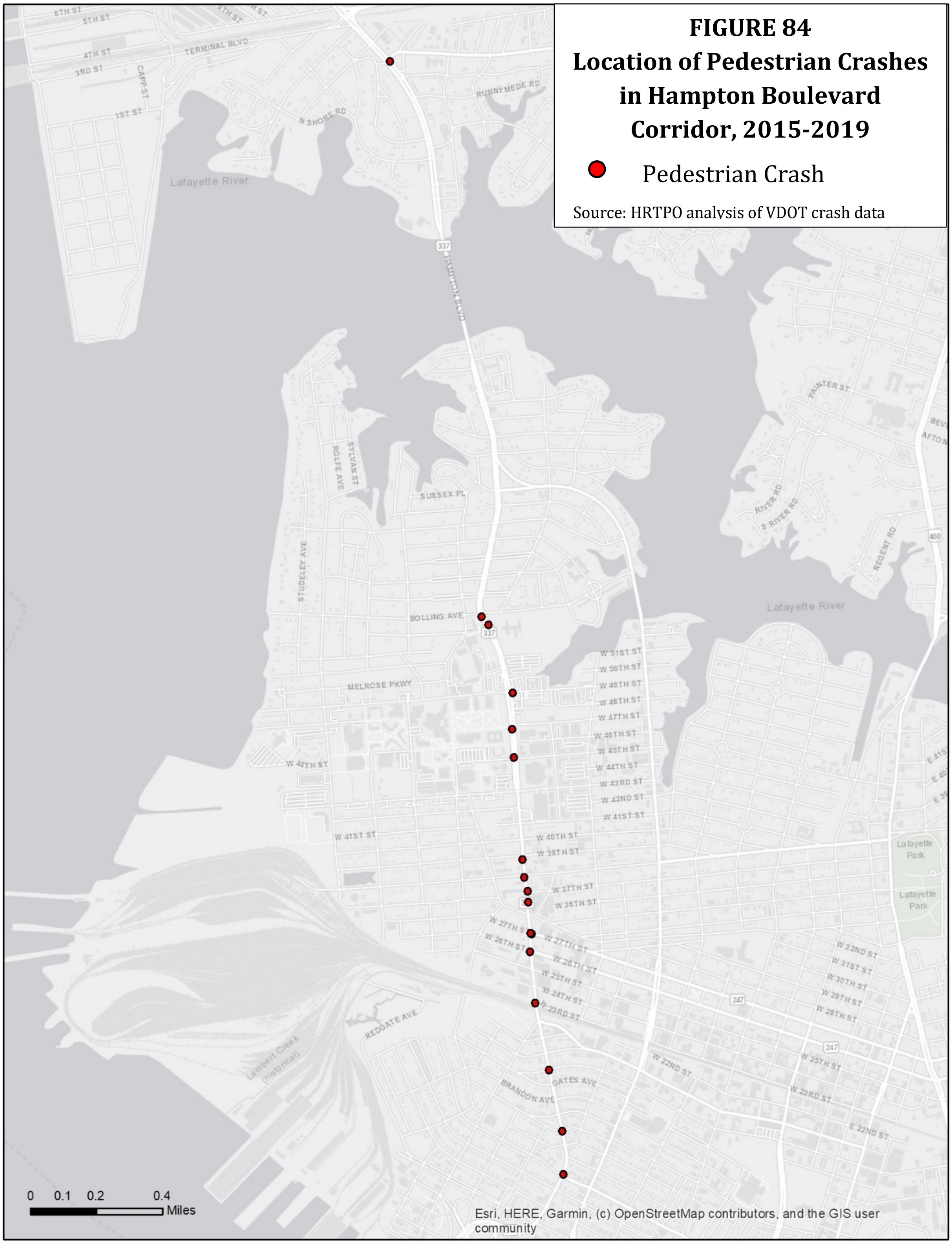


FIGURE 84
Location of Pedestrian Crashes in Hampton Boulevard Corridor, 2015-2019

Truck Crashes

Trucks are an integral part of the Hampton Roads economy because we depend on them to transport vital goods and commodities to our communities. Hampton Boulevard is one of the most significant truck corridors in Hampton Roads, as it connects Norfolk International Terminals (NIT) with the Midtown Tunnel and points west, including the Port's Virginia International Gateway (VIG) facility. Truck safety is an ongoing challenge, mainly due to their size, weight, and inability to slow down as quickly as passenger cars.

The total number of truck crashes, injuries, and fatalities in the Hampton Boulevard corridor is displayed in **Figure 85**.

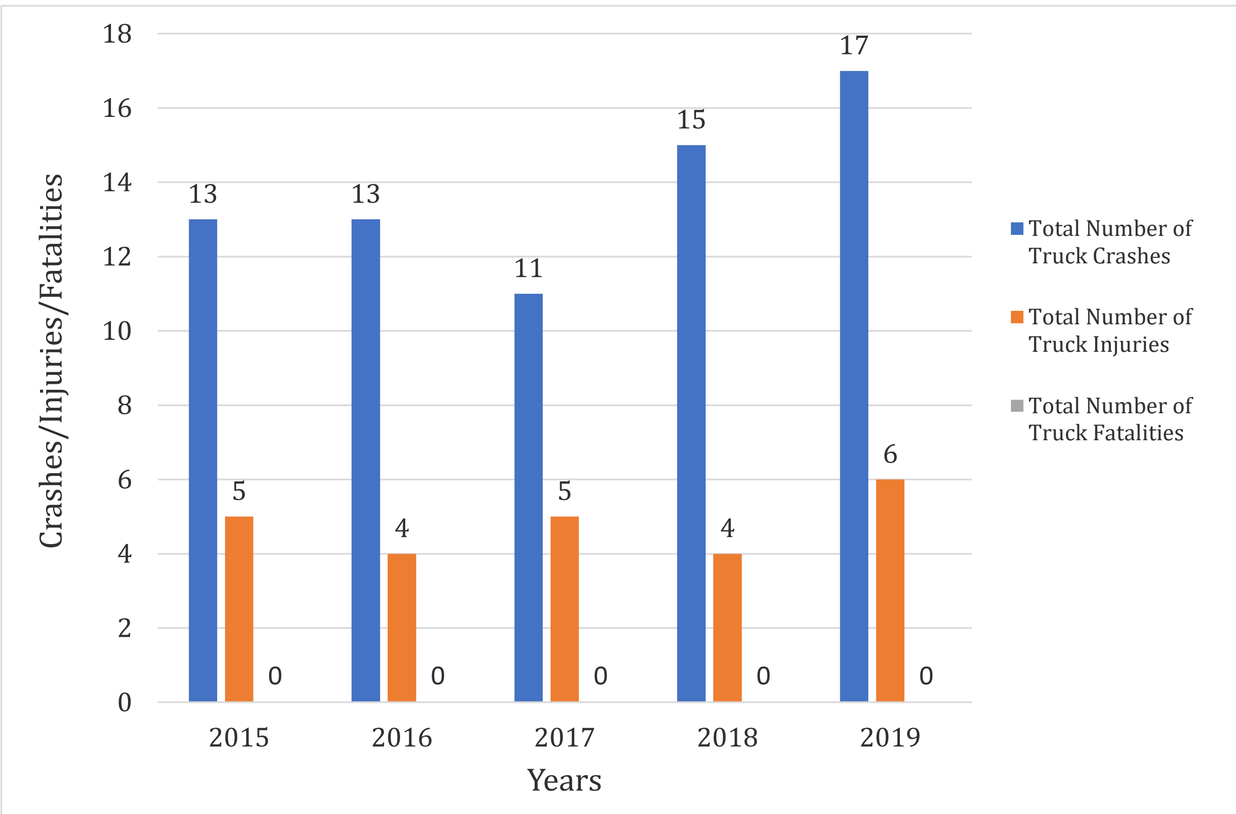


FIGURE 85 Truck Crashes, Injuries, and Fatalities by Year (2015-2019)
Source: HRTPO analysis of VDOT crash data

There was a total of 69 crashes involving trucks in the Hampton Boulevard corridor between 2015-2019, which represents 7% of the crashes in the corridor. By comparison, trucks represent about 4% of the total vehicles on Hampton Boulevard. Out of those 69 truck crashes, 24 resulted in injuries, and none resulted in fatalities. There were 13 crashes involving trucks in 2015 (five injuries and eight property damage only) and 2016 (four injuries and nine property damage only), 11 truck crashes in 2017 (five injuries and six property damage only), 15 truck crashes in 2018 (four injuries and 11 property damage only), and 17 truck crashes in 2019 (six injuries and 11 property damage only).

Figure 87 displays the locations of crashes involving trucks on Hampton Boulevard between 2015-2019. There were 30 crashes involving trucks near NIT (north of Lafayette River), 16 crashes involving trucks near Old Dominion University (between 38th Street and the Lafayette River), and 23 crashes involving trucks near Ghent (between Brambleton Avenue and 38th Street).

Truck on Hampton Boulevard
Source: HRTPO staff

Figure 86 below provides a detailed breakdown of the primary cause of truck crashes. It should be noted that among the 69 crashes involving trucks in the Hampton Boulevard corridor between 2015-2019, the driver of the truck was considered to be at fault for causing the crash in 31 crashes (45%), as compared to 33 crashes (48%) where other drivers were considered to be at fault and five crashes (7%) where no improper action was listed in the crash report. Additionally, six (9%) of the 69 crashes were the result of distracted driving, and 11 (16%) of the 69 crashes occurred when the pavement was wet.

Cause (Driver Action)	Truck Driver at Fault	Other Driver at Fault		Grand Total	Percentage
12. Following Too Close	6	6		12	17%
42. Improper or Unsafe Lane Change	7	5		12	17%
11. Did Not Have Right-of-Way	2	7		9	13%
37. Other	6	2		8	12%
16. Improper Turn From Wrong Lane	2	3		5	7%
21. Disregarded Traffic Signal	1	4		5	7%
17. Other Improper Turn	3			3	4%
8. Cutting In		2		2	3%
40. Fail to Maintain Proper Control	1	1		2	3%
31. Avoiding Other Vehicle	2			2	3%
2. Exceeded Speed Limit		1		1	1%
9. Other Improper Passing	1			1	1%
41. Improper Passing		1		1	1%
34. Hit and Run		1		1	1%
1. No Improper Action			5	5	7%
Grand Total	31	33	5	69	
Percentage	45%	48%	7%		

FIGURE 86 Primary Cause of Truck Crashes (2015-2019)
Source: HRTPO analysis of VDOT crash data

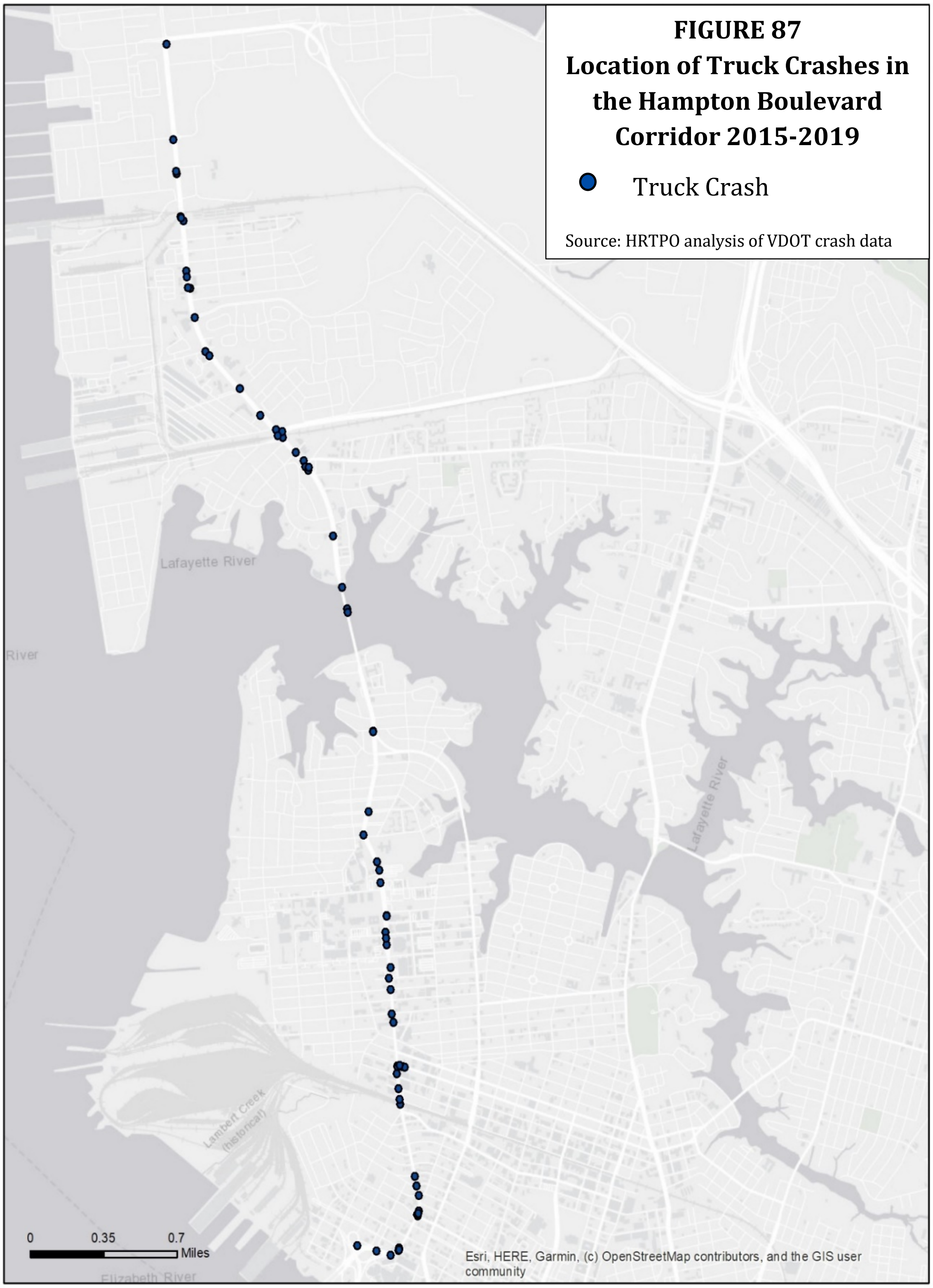


FIGURE 87
Location of Truck Crashes in the Hampton Boulevard Corridor 2015-2019

Source: HRTPO analysis of VDOT crash data

Speed-Related Crashes

Speeding is an issue in the Hampton Boulevard corridor, as shown previously in this report. Just south of the Lafayette River Bridge, the 85th percentile speed was 44 mph in the northbound direction and 42 mph in the southbound direction in 2019, despite a posted speed limit of 35 mph.

This speeding also contributes to many crashes in the corridor. The total number of crashes, injuries, and fatalities resulting from speeding is shown in **Figure 88**.

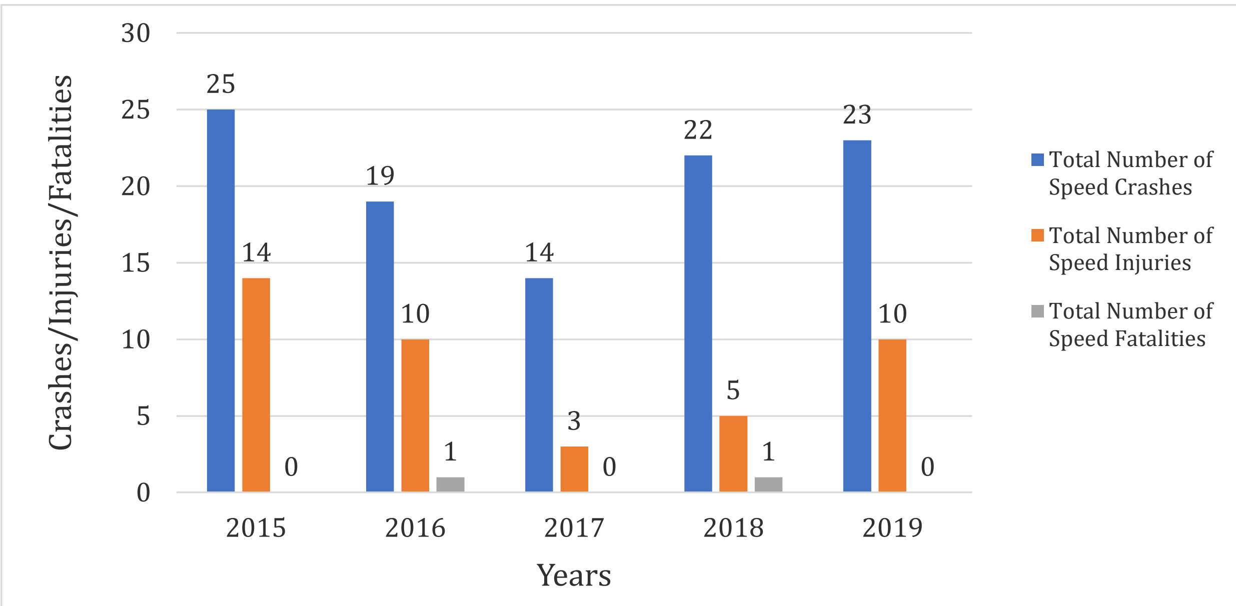


FIGURE 88 Speed-Related Crashes, Injuries, and Fatalities by Year (2015-2019)
Source: HRTPO analysis of VDOT crash data

There were 103 speed-related crashes in the Hampton Boulevard corridor between 2015 and 2019, resulting in 42 injuries and two fatalities. The highest number of speed-related crashes were reported in 2015 (25 total crashes with 14 involving injuries). The total number of speed-related crashes decreased to 19 crashes (resulting in ten injuries and one fatality) in 2016, and 14 speed-related crashes (with five injuries) in 2017. However, the number of speed-related crashes increased in 2018 to 22 crashes (resulting in five injuries and one fatality), and 23 speed-related crashes (with 10 injuries) in 2019.

The locations of speed-related crashes between 2015-2019 are shown on **Figure 89**. There were 45 speed-related crashes near NIT (north of Lafayette River), 31 speed-related crashes near Old Dominion University (between 38th Street and the Lafayette River), and 27 speed-related crashes near Ghent (between Brambleton Avenue and 38th Street).

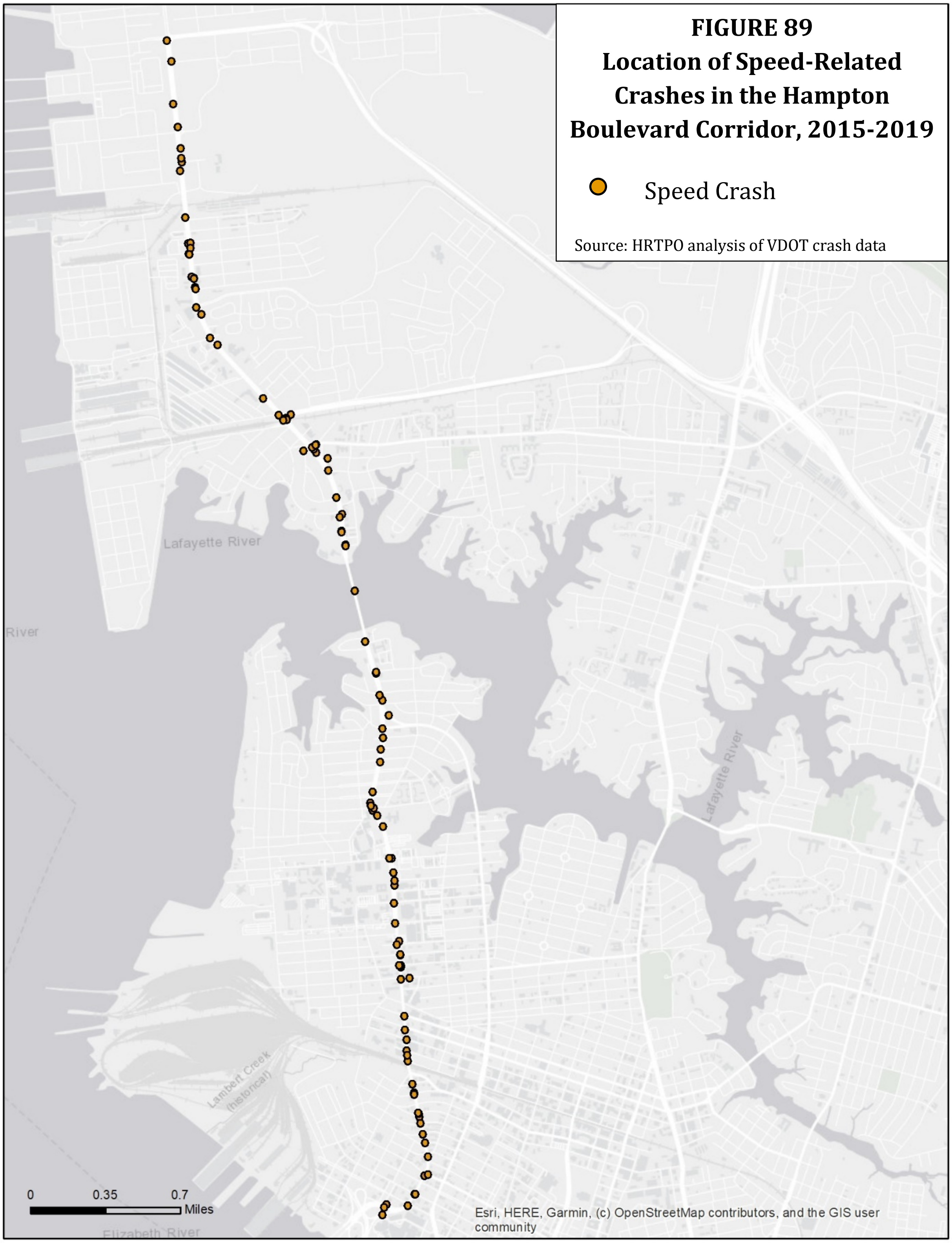


FIGURE 89
Location of Speed-Related Crashes in the Hampton Boulevard Corridor, 2015-2019
Speed Crash
Source: HRTPO analysis of VDOT crash data
Lafayette River
River
Lafayette River
Lambert Creek (historical)
Elizabeth River
0
0.35
0.7
Miles
Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community

Intersections

Staff further analyzed 30 intersections along Hampton Boulevard by looking at the number of crashes, injuries, and fatalities, including those involving bicyclists, pedestrians, trucks, and speeding. The total number of bicycle-related crashes, pedestrian-related crashes, truck-related crashes, and speed-related crashes are exhibited in **Figure 90.**

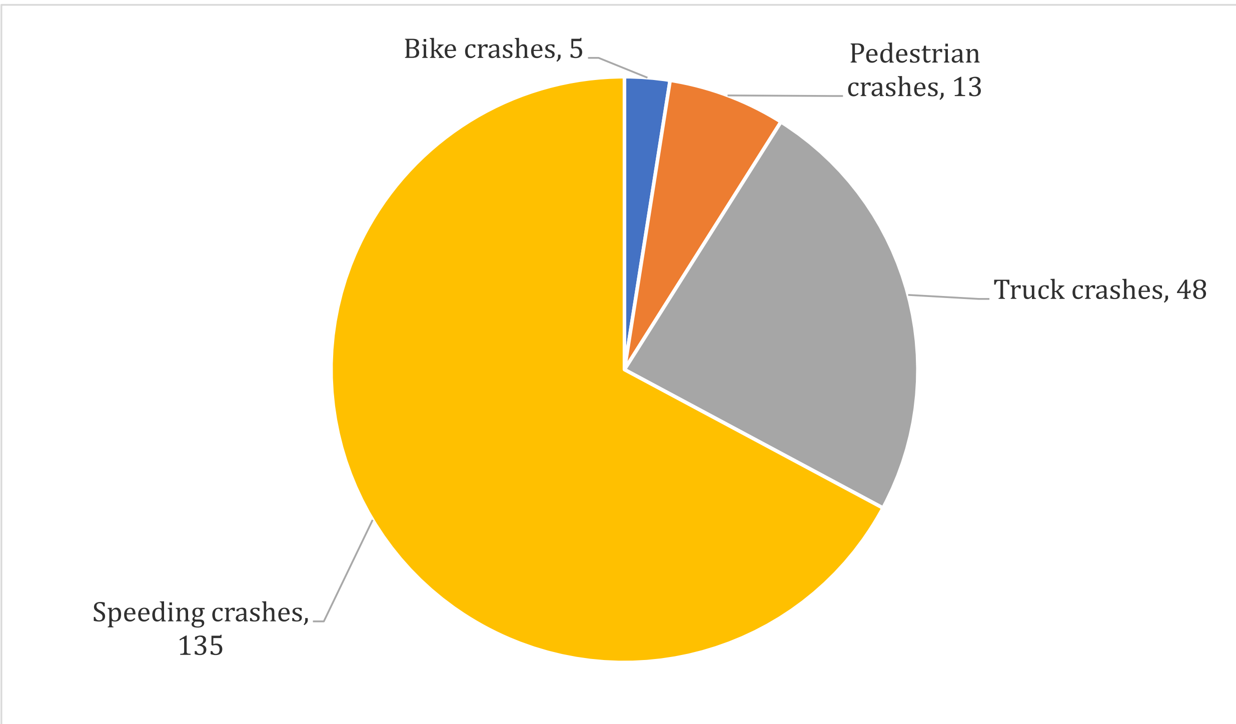


FIGURE 90 Total Number of Bike, Pedestrian, Speed-Related, and Truck Crashes at 30 Reviewed Intersections between 2015-2019
Source: HRTPO analysis of VDOT crash data

There were 201 crashes at the 30 reviewed intersections between 2015 and 2019, out of which there were 135 speed-related crashes, followed 48 truck crashes, 13 pedestrian crashes, and five bike crashes.

Figure 91 shows the number of crashes by type at each of the 30 selected intersections. The highest numbers of crashes (within 250 feet) were at the intersections of Hampton Boulevard and:

- Little Creek Road (16 crashes), out of which one crash involved a pedestrian, four crashes involved trucks, and eleven were speed-related crashes
- Terminal Boulevard (11 crashes), out of which five crashes involved trucks, and six were speed-related crashes

- Six intersections experienced nine crashes over the five years, including Princess Anne Road, 26th Street, 38th Street, 49th Street, Bolling Avenue, and Glendale Avenue. Speeding was the most prevalent issue at all of these intersections except for 26th Street, where trucks were the most frequent issue, and Princess Anne Road, where both trucks and speeding were the most prevalent.

The number of fatalities was the highest at the intersection of Hampton Boulevard and 27th Street (two fatalities). In contrast, the highest number of injuries occurred at the intersection of Hampton Boulevard and Bolling Avenue (six injuries).

Hampton Boulevard at:	Bike crashes			Pedestrian crashes			Truck crashes			Speeding crashes		
	Crashes	Injuries	Fatalities	Crashes	Injuries	Fatalities	Crashes	Injuries	Fatalities	Crashes	Injuries	Fatalities
Redgate Avenue	1	1	0	0	0	0	3	1	0	3	0	0
Princess Anne Road	0	0	0	1	1	0	4	2	0	4	0	0
Spotswood Avenue	0	0	0	0	0	0	1	0	0	4	1	0
Azalea Court	0	0	0	0	0	0	0	0	0	3	1	0
26th Street	0	0	0	1	1	0	6	0	0	2	0	0
27th Street	0	0	0	3	2	1	0	0	0	4	0	1
38th Street	0	0	0	1	0	1	2	0	0	6	2	0
39th Street	0	0	0	1	1	0	0	0	0	5	0	0
40th Street	0	0	0	0	0	0	1	0	0	5	1	0
41st Street	1	1	0	0	0	0	2	0	0	4	1	0
43rd Street	0	0	0	0	0	0	0	0	0	2	1	0
45th Street	0	0	0	1	1	0	3	0	0	4	0	0
47th Street	0	0	0	1	1	0	2	2	0	5	0	1
49th Street	0	0	0	1	1	0	1	0	0	7	1	0
Bolling Avenue	0	0	0	2	2	0	1	1	0	6	3	0
Magnolia Avenue	0	0	0	0	0	0	0	0	0	3	1	0
Surrey Crescent	0	0	0	0	0	0	0	0	0	4	0	1
Richmond Crescent/Hanover Avenue/Jamestown Crescent	1	1	0	0	0	0	2	2	0	4	1	0
Lexan Avenue	0	0	0	0	0	0	0	0	0	4	1	0
Helena Avenue	0	0	0	0	0	0	0	0	0	8	0	0
Little Creek Road	0	0	0	1	1	0	4	0	0	11	3	0
Terminal Boulevard	0	0	0	0	0	0	5	3	0	6	1	0
Baker Street	0	0	0	0	0	0	2	0	0	3	0	0
Helmick Street	1	1	0	0	0	0	1	1	0	6	2	0
Glendale Avenue	1	1	0	0	0	0	2	0	0	7	0	0
Beechwood Avenue	0	0	0	0	0	0	1	0	0	4	2	0
Greenbrier Avenue	0	0	0	0	0	0	1	0	0	4	0	0
90th Street	0	0	0	0	0	0	2	2	0	4	0	0
B Avenue	0	0	0	0	0	0	1	1	0	2	1	0
Admiral Taussig Boulevard	0	0	0	0	0	0	1	1	0	1	1	0
Total	5	5	0	13	11	2	48	16	0	135	24	3

FIGURE 91 Crashes, Injuries, and Fatalities by Crash Type at Intersections on Hampton Boulevard between 2015-2019

Source: HRTPO analysis of VDOT crash data. Includes all reported crashes within 250 feet of the intersection

Potential for Safety Improvement

In addition to analyzing the number or rate of crashes, new methods have recently been created to improve planning for roadway safety. One original method to determine those locations that deserve further study is to examine the difference between the number of crashes that occur at a location and compare it to the number of crashes that would be predicted to occur. This prediction is based on the location's traffic volumes, area type, segment length, intersection control type, etc. This difference between observed and predicted crashes is referred to as the Potential for Safety Improvement (PSI).

Hampton Boulevard at Beechwood Ave
Source: HRTPO staff

VDOT uses PSI as a network screening tool to determine locations for prioritizing Highway Safety Improvement Program (HSIP) funding. VDOT has prepared a list of the top roadway segments and intersections in terms of PSI for each VDOT District. Seven sections of Hampton Boulevard ranked among the top 500 in terms of the highest PSI in the VDOT Hampton Roads District for the years 2014-2018:

- Helmick Street to Beechwood Avenue (Rank=84)
- 40th Street to 44th Street (147)
- Beechwood Avenue to B Avenue (152)
- Terminal Avenue to Helmick Street (156)
- Westover Avenue to Redgate Avenue (239)
- B Avenue to Admiral Taussig Boulevard (385)
- Magnolia Avenue to Jamestown Crescent (436)

In addition to those segments of Hampton Boulevard, three Hampton Boulevard intersections also ranked among the top 300 in terms of the highest PSI in the Hampton Roads District for the years 2014-2018:

- Hampton Boulevard at 26th Street (Rank=77)
- Hampton Boulevard at Beechwood Avenue (262)
- Hampton Boulevard at Little Creek Road (296)

Summary

Crashes on Hampton Boulevard and within 250 feet on intersecting roadways between Brambleton Avenue and Admiral Taussig Boulevard were previously analyzed. In spite of the increasing number of crashes, the total number of crashes with injuries steadily decreased each year between 2015 and 2019. HRTPO staff separately analyzed bicycle, pedestrian, speed-related and truck crashes, and isolated 30 intersections along Hampton Boulevard, and analyzed them in terms of the number of crashes, injuries, and fatalities, involving bicyclists, pedestrians, trucks, and those that are speed-related.

The following sub-chapter outlines possible safety improvements that could be implemented on the Hampton Boulevard Corridor.

Hampton Boulevard Safety Improvements

This section examines the recent improvements that have been made by the City to improve safety in the Hampton Boulevard corridor, and provides potential projects that could be implemented to improve safety.

Recent Improvements

The City of Norfolk has recently completed several projects to improve safety on Hampton Boulevard. These improvements, which are shown on **Figure 92**, include:

- Converting existing protected/permissive left-turn movements on Hampton Boulevard, to protected-only turn movements between 38th Street and Bolling Avenue. Protected-only phasing provides a separate phase for left-turning traffic and allows left turns to be made only on a green arrow signal indication. In contrast, permissive phasing allows two opposing approaches to time concurrently, with left turns permitted after yielding to conflicting traffic and pedestrians. Protected/permissive left turns include both a protected-only phase and an interval where left turns are allowed when there are acceptable gaps in opposing traffic.
- Adding a Leading Pedestrian Interval (LPI) at Redgate Avenue, Princess Anne Road, Azalea Court, Bolling Avenue, 45th Street, and 47th Street. Pedestrians can enter an intersection 3-7 seconds before vehicles are given the green light. Therefore, pedestrians can be in the crosswalk before vehicles begin to make turns. Benefits include:
    - Increased visibility of pedestrians.
    - Reduced conflicts between pedestrians and vehicles.
    - Increased likelihood of motorists yielding to pedestrians.
    - Enhanced safety for pedestrians who may be slower.

Leading Pedestrian Interval at Redgate Ave

Source: Google maps

- Adding an Exclusive Pedestrian Only Operation at Spotswood Avenue. This refers to a pedestrian phase that is active only when all vehicles are stopped on all approaches to an intersection while pedestrians are given a WALK indication.
- Adding two Dynamic Speed Display Signs (DSDS). DSDS are interactive signs that display information about the vehicle's speed as the car approaches the sign, and are increasingly popular for influencing vehicle speed. DSDS has been added on northbound Hampton Boulevard south of Gates Avenue and

Dynamic Speed Display Sign

Source: HRTPO staff

southbound Hampton Boulevard on the north side of the north Lafayette River Bridge.

- Reducing school zone speed limits from 25 mph to 15 mph around Sewells Point Elementary School, Larchmont Elementary School, Saint Patrick Catholic School, Old Dominion University, and West Ghent School.
- Retiming signals on the Hampton Boulevard corridor from Redgate Avenue to Lexan Avenue.
- Making pedestrian signal safety improvements at Little Creek Road, 41st Street, 43rd Street, 45th Street, 47th Street and 49th Street. These improvements include updating existing countdown signal heads, pushbuttons, signs and ADA ramps.
- Adding a pedestrian signal accommodation on Hampton Boulevard & 27th Street that resulted from the meeting with the Lambert's Point Civic League.

Pedestrian Signal Accommodation
Source: HRTPO staff

Additionally, ongoing projects on Hampton Boulevard include:

- Hampton Boulevard/Azalea Court signal replacement project.
- Glenwood Park area safety improvements.

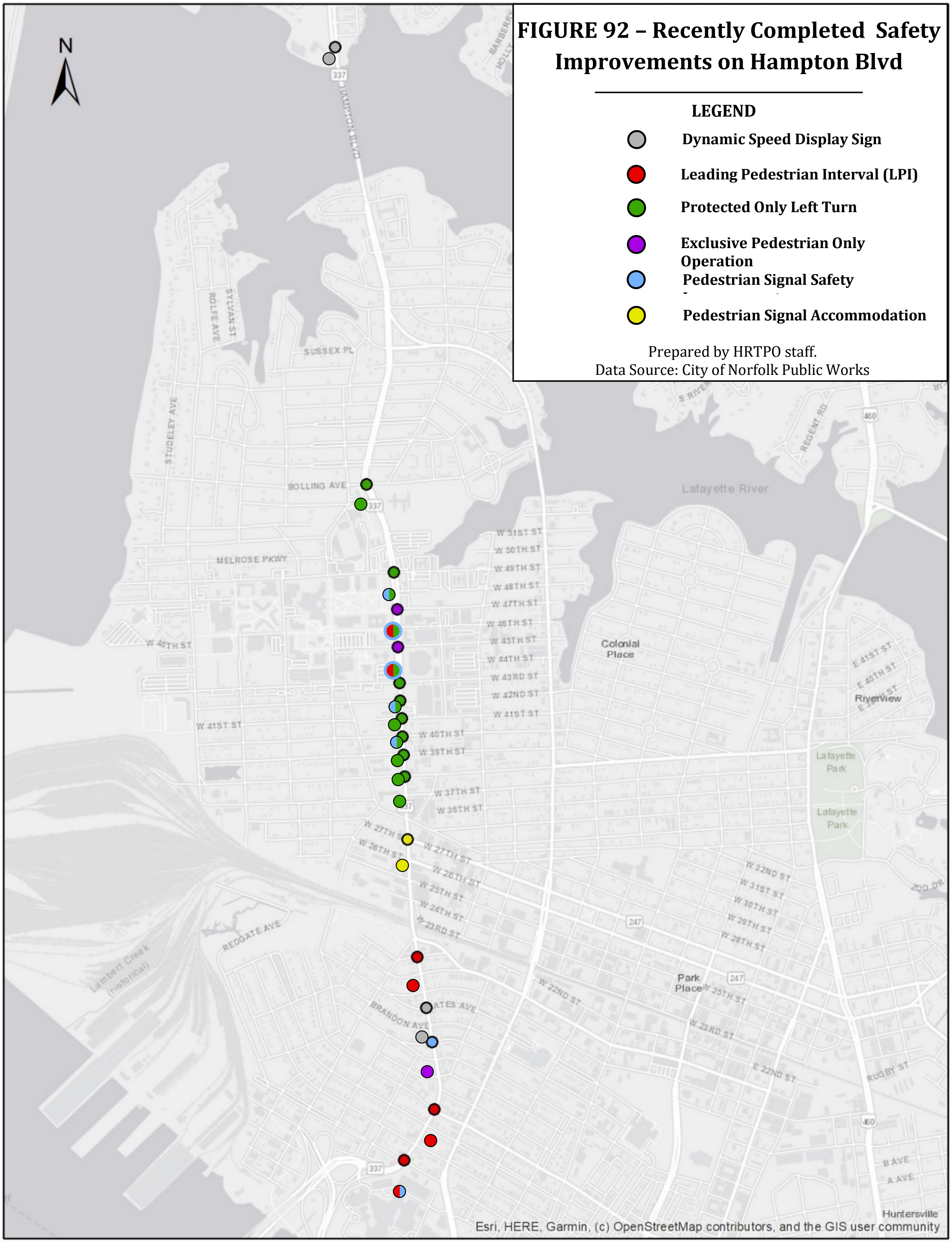


FIGURE 92 – Recently Completed Safety Improvements on Hampton Blvd

Potential Improvements

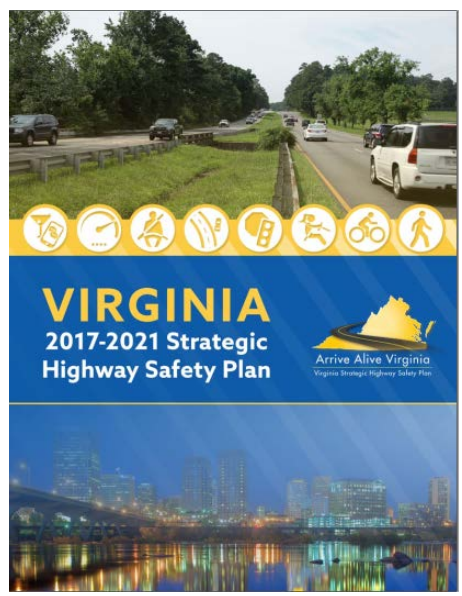
The purpose of this section is to present potential safety improvements along the Hampton Boulevard Corridor. As mentioned, four types of crashes are an issue in the Hampton Boulevard corridor – bike crashes, pedestrian crashes, crashes involving trucks, and crashes involving speeding.

A. Bike/Pedestrian Safety Improvements

Bicyclists are more vulnerable than motorists, and more likely to suffer severe injuries or fatalities when involved in traffic crashes. Bicycling as a way to commute and for leisure has increased in recent years. To improve bicyclist safety, a combination of engineering, enforcement, and education techniques are generally implemented.

Almost every person is a pedestrian at some time during their everyday travel. People walk for purposes of commuting as well as for exercise. Unfortunately, pedestrian fatalities remain high. There was more than a 3% increase in the number of pedestrian fatalities in 2018 compared to 2017 according to NHTSA, totaling 6,283 fatalities in the United States – the most pedestrian fatalities since 1990.

The *Virginia 2017-2021 Strategic Highway Safety Plan (SHSP)*[29] details a number of objectives and strategies in terms of pedestrian/bicycle safety:



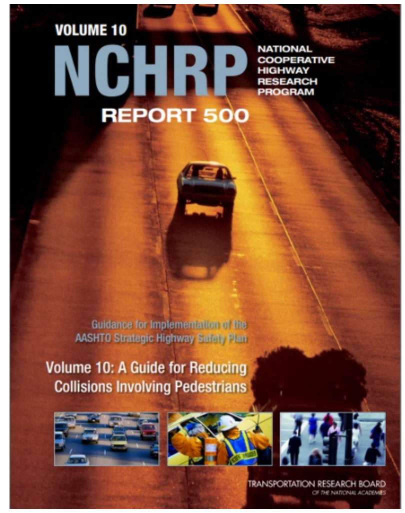
1. Identify corridors and locations having concentrations of pedestrian/bicycle activity or the potential for crashes to apply proven pedestrian/bicycle safety countermeasures.
    a. Improve the collection and use of data needed for pedestrian/bicycle safety planning and programming. Develop a comprehensive database of pedestrian-related and bicycle-related crashes and identify pedestrian and bicycle crash corridors and "hotspots."
    b. Work with localities to develop a data-driven, risk-based approach to identify and prioritize pedestrian and bicycle infrastructure needs and target improvements in areas with existing and anticipated pedestrian and bicycle travel.

[29] Virginia 2017-2021 Strategic Highway Safety Plan, Virginia Department of Transportation

    c. Formalize procedures in the project development process to include the installation of pedestrian and bicycle facilities where they currently do not exist.
    d. Reduce bicycle/pedestrian exposure to auto-traffic and motor vehicle speed by providing geometric and traffic signal improvements during the development process. This would include providing paved shoulders, shared-use paths, trails, bicycle lanes or separated bicycle lanes, implementing compete street design, smaller radii at crosswalks, curb bulb-outs, median and refuge island improvements, etc.
    e. Enhance and deploy policy guidance to encourage new signalized intersections to be designed for all users. Review locations and provide pedestrian/bicycle accommodations or enhancements at new and existing signalized intersections to include high visibility markings, countdown signals, lengthening clearance times and other signal timing approaches.
    f. Collaborate with localities to develop pedestrian/bicycle action plans and submit pedestrian and bicycle projects for state and federal program funding.
2. Educate roadway users on driver, pedestrian and bicyclist awareness and appropriate behavior
    a. Develop or enhance and disseminate outreach materials to educate roadway users on the factors associated with pedestrian and bicyclist crashes, complaints of traffic control devices, and providing proper right-of-way to all road users.
    b. In collaboration with schools, community groups, or local pedestrian/bicycle advocacy groups, conduct pedestrian/bicycle safety outreach and education to targeted populations.
    c. Utilize and provide resources that partners to educate and implement safer walking to schools and Safe Routes to School Programs.
3. Partner with local and state police to enforce traffic laws and to increase compliance with existing regulations.
    a. Conduct targeted enforcement of dangerous behaviors (speeding, jay walking, midblock crossing, red-light running, etc.) to increase compliance with appropriate traffic laws by pedestrians, bicyclists and motorists.
    b. Create or adapt short videos on pedestrian and bicycle laws that serve for both police training and public education across Virginia.

As a follow up to the SHSP, VDOT prepared a Pedestrian Safety Action Plan (PSAP) in 2018. The PSAP considered a number of ways to improve pedestrian safety including identifying and addressing locations with a history of pedestrian crashes along with proactively addressing pedestrian crash risk through identifying priority corridors. Hampton Boulevard, however, was not analyzed as a priority corridor in the study.

National Cooperative Highway Research Program (NCHRP) 500 – Volume 10: A Guide for Reducing Collisions Involving Pedestrians[30] classified strategies and countermeasures to the expected timeframe and relative cost for this emphasis area:



- **Short (less than a year):**
  - *Low cost to implement and operate*:
    - Provide crosswalk enhancements
    - Improve conspicuity of pedestrians
    - Provide school route improvements
  - *Moderate cost to implement and operate*:
    - Implement enforcement campaigns
- **Medium (1-2 years):**
  - *Moderate cost to implement and operate*:
    - Implement road narrowing measures
    - Install traffic-calming measures on road sections and intersections
    - Provide education, outreach and training
    - Eliminate screening by physical objects
    - Signals to alert motorists that pedestrians are crossing
  - *Moderate to high cost to implement and operate*:
    - Install or upgrade the traffic and pedestrian signals
    - Provide pedestrian refuge islands and raised medians
    - Provide vehicle restrictions/diversion measures
    - Implement lighting/crosswalk illumination measures
- **Long (more than two years):**
  - *Moderate to high cost to implement and operate*:
    - Provide sidewalks/walkways with curb ramps
  - *High cost to implement and operate:*
    - Install overpasses/underpasses

Similarly, *National Cooperative Highway Research Program – Volume 18: A Guide for Reducing Collisions Involving Bicycles* classified strategies and countermeasures to the expected timeframe and relative cost for this emphasis area:

- **Short (less than a year):**
  - *Low cost to implement and operate*:
    - Improve signing
    - Restrict right-turn on red (RTOR) movements
    - Improve roadway signage, implement speed enforcement

[30] National Cooperative Highway Research Program (NCHRP) 500-Volume 10: A Guide for Reducing Collisions Involving Pedestrians, Transportation Research Board, Washington D.C., 2004

        - Provide bicyclist skill education
        - Increase rider and bicycle conspicuity
    - *Moderate cost to implement and operate*:
        - Improve pavement markings at intersections
        - Improve enforcement of bicycle-related laws
        - Increase the use of bicycle helmets
        - Fix or remove irregularities
        - Provide route maintenance of bicycle facilities
- **Medium (1-2 years):**
    - *Moderate cost to implement and operate*:
        - Improve signal timing and detection
        - Accommodate bicyclists through roundabouts
        - Provide safe roadway facilities for parallel travel
        - Provide bicycle-tolerable shoulder rumble strips
        - Implement traffic calming techniques
    - *Moderate to high cost to implement and operate*:
        - Improve visibility at intersections
        - Provide contraflow bicycle lanes
        - Improve bicyclist visibility
        - Improve driveway intersections
- **Long (more than two years):**
    - *Moderate to high cost to implement and operate*:
        - Improve intersection geometry
        - Implement access management
    - *High cost to implement and operate:*
        - Provide an overpass or underpass

There were six bicycle crashes in the Hampton Boulevard corridor between 2015 and 2019. For four crashes, drivers were at fault (for three crashes drivers did not have the right-of-way, and for the other crash, a driver disregarded a traffic signal). For the two remaining crashes, no improper action was listed in the crash report.

At the intersection of Glendale Avenue and Hampton Boulevard, a bicycle crash occurred because the driver did not have the right-of-way. We can see from the photo that there are no crosswalks on this intersection. Specific countermeasures/strategies that could be explored are adding crosswalks, adding signage for pedestrians and bicyclists, and adding push buttons for pedestrian/bicycle green time.

The intersection of Richmond Crescent/Hanover Avenue/Jamestown Crescent and Hampton Boulevard is complex with four streets intersecting at the same location. The addition of another crosswalk (on Jamestown Crescent and Hanover Avenue) and better signage such as “yield to pedestrians” sign could improve bicycle and pedestrian safety.

The other four intersections that experienced bicycle crashes have the necessary pedestrian/bicycle crossing facilities, so the following strategies for reducing bicycle crashes should be explored:

- Improve visibility of bicyclists and bicycle facilities
- Improve signal timing and detection
- Improve pavement markings
- Provide bicycle skill education
- Improve enforcement of bicycle laws
- Increase the use of helmets
- Increase conspicuity
- Fix or remove surface irregularities

Hampton Boulevard at Glendale Ave
Source: HRTPO staff

Hampton Boulevard at Richmond Crescent/Hanover Ave/Jamestown Crescent
Source: HRTPO staff

As for pedestrian crashes, the issue is mainly present at Old Dominion University (five pedestrian crashes), and between Brambleton Ave and Old Dominion University (15 pedestrian crashes). Many of the improvements recently completed by the City were to improve bike and pedestrian safety, such as implementing Exclusive Pedestrian Only Operation, Leading Pedestrian Interval (LPI), Dynamic Speed Display Signs (DSDS) and Pedestrian Signal Safety Improvements. Additional strategies to consider are to provide education, outreach and training and implement enforcement campaigns to improve pedestrian and motorist safety awareness.

B. Truck Safety Improvements

Upon review of crash data involving large trucks along Hampton Boulevard, the location between Brunswick Avenue and Bolling Avenue was identified as a problem. In April 2018, a driver of a tractor-trailer lost control of his truck and rolled over on the southbound lanes of Hampton Boulevard at Bolling Avenue (see **Figure 93**). At this location, there is a

FIGURE 93 Truck Crash on the Southbound Lanes of Hampton Boulevard at Bolling Avenue
Source: WTKR

FIGURE 94 Existing Chevron Alignment Signs on the Southbound Lanes of Hampton Boulevard between Brunswick Avenue and Bolling Avenue
Source: Google

horizontal curve with the advanced speed in curve signs for 25 mph and Chevron Alignment Signs (sharp curve).

The Chevron Alignment Signs for the southbound direction appear to be below the minimum mounting height (see **Figure 94**). According to the Manual on Uniform Traffic Control Devices (MUTCD) Section 2C.09 Chevron Alignment Sign (W1-8), signs shall be installed at a minimum height of 4 feet, measured vertically from the bottom of the sign to the elevation of the near edge of the traveled way. However, in Section 2A.18, the minimum mounting height for regulatory, warning, and guide signs on an intersection approach is 7 feet, where parking and pedestrian movements are likely to occur. It is recommended that the Chevron signs be relocated 7 feet above the top of the curb above the existing brick wall and replaced with high visibility or solar LED Chevron Alignment Signs to increase visibility.

The spacing of the four Chevron Alignment signs for the southbound direction is adequately spaced at approximately 65 feet apart. According to the MUTCD Table 2C-6, the required sign spacing is 80 feet for roadways with advisory speeds between 20 and 30 mph.

The Chevron Alignment Signs for the northbound direction appear to be at the minimum height of 4 feet; however, to increase visibility, it is recommended they be increased to 7 feet (see **Figure 97**).

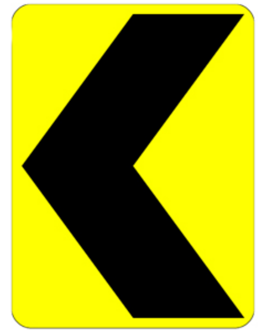


FIGURE 95 W1-8 High Visibility Chevron Alignment Sign

FIGURE 96 W1-8 Solar LED Chevron Alignment Sign

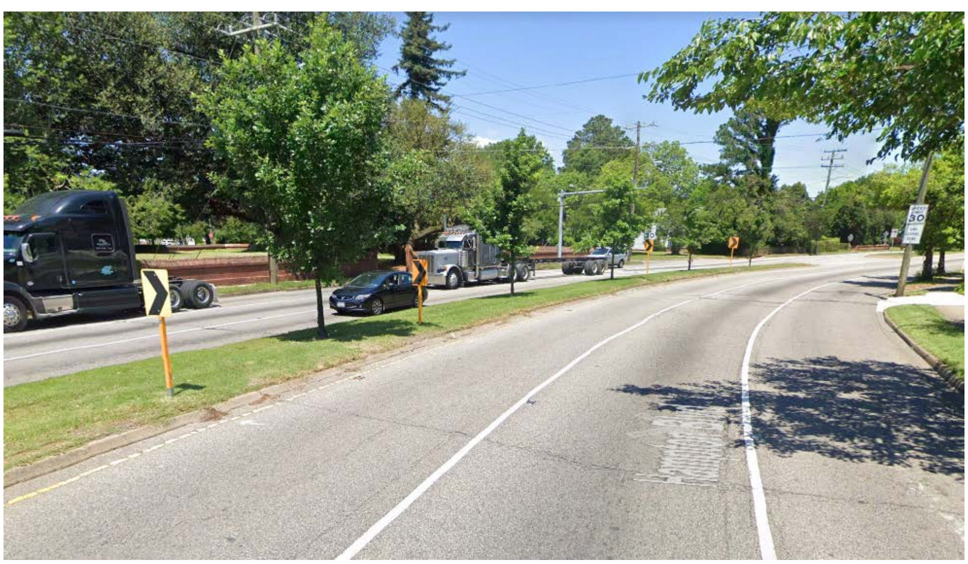
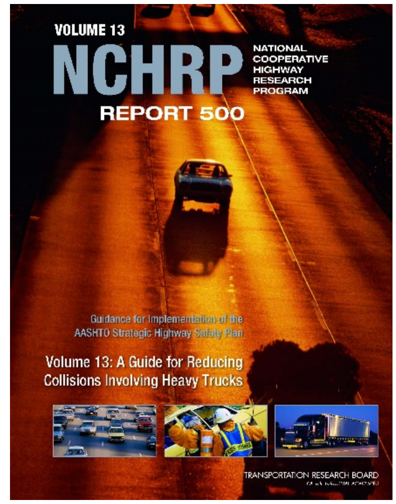


FIGURE 97 Existing Chevron Alignment Signs on the Northbound Lanes of Hampton Boulevard between Bolling Avenue and Brunswick Avenue

Source: Google

For the other crashes involving trucks along Hampton Boulevard, no other specific intersection or midblock location stood out as a particular problem. The National Cooperative Highway Research Program's Report 500 – A Guide for Reducing Collisions Involving Heavy Trucks[31], outlines several general strategies for truck crashes. Many of these strategies, which are described below, could be effective in reducing overall truck crashes in the corridor.



1. Reduce fatigue-related crashes
   Truck driver fatigue is of special concern because of the long hours of driving demanded by trucking and greater potential hazard posed by the heavy vehicle. Strategies may include:
   a. Increase the efficiency of the use of existing parking spaces.
   b. Create additional parking spaces.
2. Strengthen the CDL program
   The commercial driver's license (CDL) established national standards for acquiring a license to operate heavy trucks. It has been fully implemented since April 1992. Although the CDL has achieved major improvements, e.g., reducing the problem of multiple licensing and consolidating driver history information, problems remain. Strategies may include:
   a. Improve test administration for the CDL.
   b. Increase fraud detection of state and third-party testers.

3. Increase knowledge on sharing the road
   In crashes involving a heavy truck and a passenger vehicle, it appears that the principal culpability most often lies with the driver of the passenger vehicle. Consequently, some effort needs to focus on drivers in general to reduce truck fatalities. Drivers need better information on how to share the road with large trucks. Strategies may include:
   a. Incorporate Share the Road information into driver materials.
   b. Promulgate Share the Road information through print and electronic media.

4. Improve maintenance of heavy trucks
   Heavy trucks generally accumulate high mileage. In 2000, combination trucks averaged almost 65,000 miles, compared with almost 12,000 for passenger vehicles. State vehicle inspection programs (and not all states have them) are designed for passenger cars and usually require inspection only once a year. Large trucks need to be inspected much more frequently. Strategies may include:

[31] NCHRP Report 500 – A Guide for Reducing Collisions Involving Heavy Trucks, Volume 13, Transportation Research Board, 2004.

   a. Increase and strengthen truck maintenance programs and inspection performance.
   b. Conduct post-crash inspections to identify major problems and problem conditions.

5. Identify and correct unsafe roadway infrastructure and operational characteristics

   Highway configuration can create hazards for some large trucks. Programs to identify and correct highway segments that pose significant hazards to trucks can reduce crashes. While making changes to the highway is costly, providing information to drivers concerning upcoming hazards and providing real-time feedback on excessive speed for safe maneuvering can be implemented at relatively low cost.

   a. Identify and treat truck crash roadway segments.
   b. Install interactive truck rollover signing.
   c. Modify speed limits and increase enforcement to reduce truck and other vehicle speeds.

6. Improve and enhance truck safety data

   Timely and accurate data are required to identify problems (with both vehicles and drivers), establish priorities, design interventions, evaluate countermeasures, and detect emerging problems. Important data on heavy trucks and their operators come from law enforcement, the judicial system, driver records, vehicle registration, and motor carrier records. Rapid entry and compilation of such data can greatly improve the detection of problems and enable immediate intervention. Strategies may include:

   a. Increase the timeliness, accuracy, and completeness of truck safety data.

7. Promote industry safety initiatives

   Unlike the general population of drivers and vehicles, commercial drivers and trucks operate under management supervision. Effective supervision of drivers and the vehicle fleet requires active and systematic management to ensure compliance with all federal and state regulations. Moreover, regulatory compliance is not the only goal. Many safety management activities of the most safety-conscious fleets go well beyond minimum compliance requirements. Strategies may include:

   a. Perform safety consultations with carrier safety management.
   b. Promote the development and deployment of truck safety technologies.
   c. Implement a formal fleet safety program and review its effectiveness.
   d. Establish company standards for safe driving.
   e. Encourage companies to keep an updated safety manual for truck drivers.
   f. Monitor driver qualifications and driver safety infractions. Recognize and reward safe driving.

C. Speeding-Related Safety Improvements

Excessive speeding is largely the result of driver behavior (consciously choosing an excessive speed) and the driver's response to the environment (failure to perceive the speed environment and, as a result, incur the risk of collision or conflict). According to the National Highway Traffic Safety Administration (NHTSA) factors that contribute to speeding include:

- Traffic congestion – the most frequently mentioned contributing factor to excessive speeding
- Running late – too much to do, running late for work, school, meeting, lesson, or another appointment
- Anonymity – motor vehicles insulate the driver from the world; thus, a driver can develop a sense of detachment (an observer of their surroundings, rather than a participant)
- Disregard for others and the law

Speeding has been involved in approximately one-third of all motor vehicle fatalities in the U.S. for more than two decades (NHTSA) and was involved in 103 crashes on Hampton Boulevard between 2015-2019, resulting in two fatalities and 42 injuries.

The *Virginia 2017-2021 Strategic Highway Safety Plan*[32] (SHSP) outlines several objectives to mitigate speeding:

1. Implement engineering countermeasures to synchronize traffic flow to prevailing conditions and surroundings with particular attention to high-crash locations.
    a. Periodically review the appropriateness of posted speed limits on roadways where speed has been identified as a factor in crashes and post appropriate speed limits based on Virginia and national guidance, standards and prevailing conditions.
    b. Install innovations and countermeasures to enhance the user's perception of vehicle speed and reduce speeds where appropriate.
    c. Implement appropriate timing and synchronization of traffic signal systems to minimize stops and starts while harmonizing traffic flow to the prevailing conditions.
    d. Investigate the further use of Active Traffic Management System (ATMS) practices on freeway corridors to harmonize speed and prevent queue related crashes.
2. Develop and implement a speed campaign incorporating media, enforcement, education, and evaluation where speed-related deaths and severe injuries are elevated.

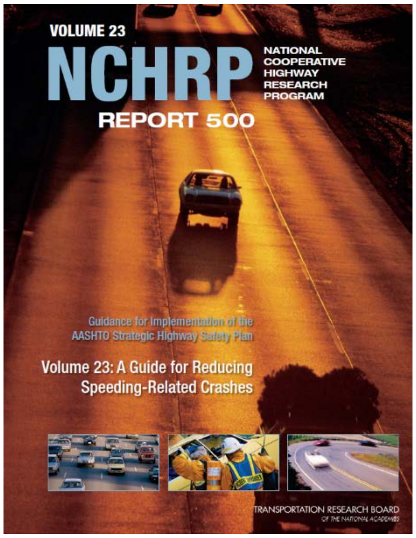
[32] Virginia 2017-2021 Strategic Highway Safety Plan, Virginia Department of Transportation

a. Identify, publicize, and implement enforcement countermeasures in areas where speeding is a problem. Educate drivers on the effects of weather and traffic conditions on appropriate speeds.
b. Promote engineering and public safety partner's collaboration on speed limit setting, including work zones and associated enforcement and response to related incidents.
c. Determine the most effective messages targeting individuals most involved in speed-related crashes through research, and focus groups.
d. Teach children rules of the road through the public-school system.
e. Educate the judicial community on the need for consistent application of the law on speed-related offenses.
f. Enhance the education of police officers on the need for speed enforcement and speed compliance.
g. Provide grant funding for speed enforcement in areas where data indicate a speeding or speed-related crash problem

3. Identify and implement effective speed management measures
    a. Identify and evaluate advanced tools and techniques to reduce speeding and, where necessary, work with the General Assembly to explore the use of these tools.
    b. Implement variable speed limits (VLS) where permitted and feasible and where a safety benefit is predicted.

National Cooperative Highway Research Program – Volume 23: A Guide for Reducing Speed-Related Crashes)[33] classifies strategies by relative cost and time necessary for implementation:

- **Short (less than a year):**
    - *Moderate cost to implement and operate:*
        - Increase fines in particular areas
        - Improve speed limit signage
        - Implement active speed warning signs
        - Provide adequate change and clearance intervals at signalized intersections
        - Optimize signal progression
        - Increase public awareness of the risks driving at an unsafe speed
        - Implement safe community programs



[33] National Cooperative Highway Research Program (NCHRP) – Volume 23: A Guide for Reducing Speed-Related Crashes, Transportation Research Board, Washington D.C., 2004

        - Use targeted conventional speed enforcement programs at locations known to have speeding-related crashes
        - Use in-pavement measures to communicate the need to reduce speeds
    - *Moderate to high cost to implement and operate:*
        - Install lighting at high-speed intersections
- **Medium (1-2 years):**
    - *Moderate to high cost to implement and operate:*
        - Implement automated speed enforcement
        - Implement variable message signs
        - Provide appropriate intersection design for speed of roadway
        - Provide adequate sight distance for expected speeds
        - Implement protected-only signal phasing for left turns at high-speed signalized intersections
        - Reduce speeds and volumes on both neighborhood and downtown streets with the use of traffic calming
    - *High cost to implement and operate:*
        - Effect safe speed transitions through design elements and on approaches to lower speed areas
- **Long (more than two years):**
    - *High cost to implement and operate:*
        - Use combinations of geometric elements to control speeds

According to the analysis of the speed data and corridor crash data, speeding is a problem in the Hampton Boulevard corridor. Hampton Boulevard is a critical corridor for the region, with a significant volume of truck traffic from NIT going through several areas with heavy pedestrian and bicycle uses (Old Dominion University, Ghent neighborhood). Possible countermeasures for the speeding issue on Hampton Boulevard include speed enforcement and traffic calming measures such as pavement markings and landscaping.

Speed enforcement plays a significant role in deterring drivers from traveling at excessive speeds. Speed campaigns typically target speeders through both public awareness programs as well as by providing increased enforcement at specific locations where speeding is a problem. Armour (1986)[34] asserted in his study that increased law enforcement presence will reduce vehicle speeds and that this reduction can be maintained for at least some time after the vehicles have passed the zone of law enforcement presence. However, this study also indicated that the deterrent effect of law enforcement presence is often location-specific for most drivers on urban roads. They decrease travel speeds at locations where motorists know or think law enforcement might be present but speed up after the enforcement zone. Law enforcement officers are not able to enforce speed limits at all times, but automated enforcement technologies offer the opportunity for increased

[34] Armour, M, "The Effect of Police Presence on Urban Driving Speeds", *ITE Journal,* Vol. 56, No. 2, pp. 40-45, 1986

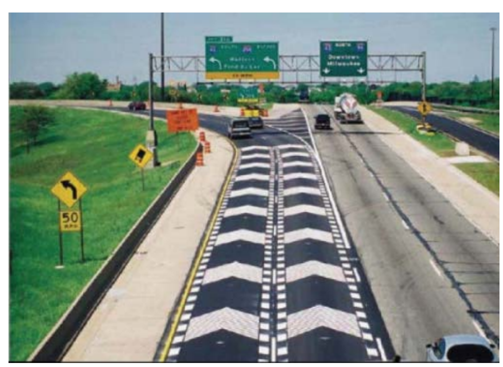
enforcement efforts and public perception that speeding citations are likely. Current technology can be used to deter and document drivers while speeding. Studies in the U.S. indicate that speed cameras have been effective in reducing overall vehicle travel speeds and the proportion of drivers traveling at higher than posted speeds. Virginia police officers can use radar and lasers to identify speeders, but new legislation approved by the General Assembly in 2020 is allowing state and local police to set up speed cameras at highway worksites and school crossing zones.

Traffic calming techniques, which use physical design and other measures to improve safety for motorists, pedestrians, and cyclists, are another tool to combat speeding. Pavement markings and appearance, among many of these techniques, could be considered as another measure to lower speeding in Hampton Boulevard. *National Cooperative Highway Research Program – Volume 23: A Guide for Reducing Speed-Related Crashes* outlines the use of pavement markings, including perceptual and pavement techniques, to encourage drivers to proceed at a safe travel speed. Perceptual pavement markings give the driver the illusion of traveling faster than their actual speed to decrease the driver's comfort at excessive speeds. On sections of Hampton Boulevard where excessive speeding is a problem such as in the vicinity of the Lafayette River Bridge, a converging pattern of pavement markings can be used to give the perception to drivers that they are increasing their speed if they fail to slow down. Perceptual pavement markings have several advantages:

- They have a low cost of application, but the pavement markings must be regularly maintained.
- They are very flexible since they can be used to target speeding in high-risk areas, or for the whole length of the corridor.
- They produce very little noise compared to other traffic control devices such as rumble strips.

Transverse pavement markings
Source: Evaluation of Best Practices in Traffic Operations and Safety: Phase I: Flashing LED Stop Sign and Optical Speed Bars, VTRC, 2007


Peripheral transverse lines
Source: FHWA



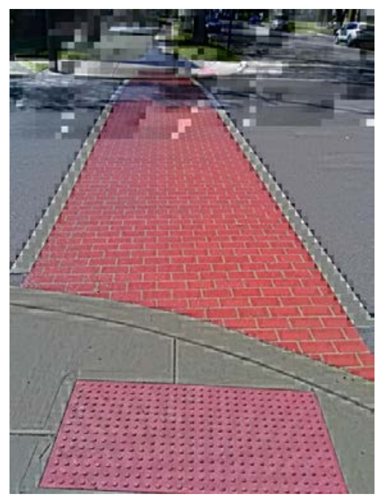
Converging chevrons
Source: Google Images

Several different types of perceptual markings could be applied along the corridor:

- Transverse pavement markings are dashed lines that span the width of a travel lane, which can be used to create the illusion that lane widths are decreasing or narrowing.
- Peripheral transverse lines are used at the edges of travel lanes rather than across the entire lane. Full-length transverse lines tend to decrease vehicle speeds upon entering the zone. However, vehicle speeds tend to increase again after a time.
- Converging Chevrons use a pattern that is characterized by a series of chevrons on the pavement surface that are placed progressively closer together, which are often accompanied by a dashed edge line.

The *Evaluation of Best Practices in Traffic Operations and Safety: Phase I: Flashing LED Stop Sign and Optical Speed Bars*[35] study, prepared by the Virginia Transportation Research Council, evaluated the optical speed bars on Route 460 in the town of Zuni in Isle of Wight County. The vehicle speeds recorded at the 45-mph speed limit sign at the end of the markings decreased for all time periods 90 days after installation on both ends of town. Decreases at the eastern end of town averaged 3.3 mph, which was a 6.1 percent decrease, while at the western end of town decreases averaged 9.5 mph, which was a 16.8 percent decrease. Vehicle speeds, however, increased for all time periods at the two stations in the center of town 90 days after installation. The average speeds of 46.6 mph westbound and 47.0 mph eastbound, however, were only slightly above the posted 45 mph speed limit.

Pavement appearance can be altered through unique treatments that add visual interest, such as painted or pattern-stamped asphalt, concrete, or concrete pavers. Pedestrian crossings and intersections can be painted to highlight crossing areas. Painted and pattern-stamped surface markings are common traffic-calming treatments in Europe and are often used in conjunction with other traffic-calming measures. These pavement markings were applied outside of a small rural community in Iowa[36]. The markings were very effective with reductions in mean speeds up to 7.4 mph and in 85th percentile speeds up to 9 mph. The fraction of vehicles traveling between 5 and 10 mph over the posted speed limit decreased by 30 percent to 44 percent, and the fraction of vehicles traveling 10 or more mph over the posted speed limit decreased by about 40 percent.



Painted/Pattern-Stamped pavement marking
Source: www.pavementsurfacecoatings.com

[35] Evaluation of Best Practices in Traffic Operations and Safety: Phase I: Flashing Led Stop Sign and Optical Speed Bars, Virginia Transportation Research Council (VTRC), Charlottesville, 2007
[36] Hallmark, S., Hawkins, N., Knickerbocker, S., Speed Management Toolbox for Rural Communities, Center for Transportation Research and Education (CTRE), Institute for Transportation, Iowa State University, 2013

Landscaping is often used in combination with other traffic-calming treatments and could also be added to complement the existing landscaping on Hampton Boulevard, particularly in the vicinity of the Lafayette River Bridge. Using landscaping for traffic calming can work in two ways:

- By planting alongside the road or street to make the roadway appear narrower to the driver (The "optical width" of the road is narrowed as opposed to the "physical width"). This should encourage drivers to slow down.
- By communicating a change in the character of the roadway, which is done by changing the nature of planting alongside the roadway.

Landscaping should be placed along the entire length of the street where traffic calming is desired on both sides of the street and the median. Particularly critical is to put landscaping that narrows the optical width of the roadway in the transition zone, where the largest decrease in speed is sought.

Disadvantages to consider when considering landscaping as a traffic calming technique are:

- Can be high-cost depending on the chosen treatment
- Maintenance is required on a regular basis
- Objects in a clear zone can create traffic hazards if not properly designed

Landscaped median
Source: Google Images

Lakewood, Colorado,[37] used a series of landscaped medians and curbside islands to create a narrow serpentine roadway alignment for traffic calming on a collector street. The objective was to reduce speeds but not volumes, due to concerns that traffic would be diverted to other residential streets. Vehicle speeds were compared before and one year after the completion of the project. The percent of vehicles traveling 10 mph over the speed limit (>40 mph) was reduced from 35% to 2%. The 85th percentile speed was reduced from approximately 45 mph to 35 mph, and the mean speed was reduced from approximately 36 mph to 29 mph. Vehicle volumes decreased slightly from 11,400 vehicles/day through the project area to 10,900 vehicles/day one year later.

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37 Buchholz, K., Basket, D., Anderson, L., Collector Street Traffic Calming: A Comprehensive Before-After Study, paper presented at Annual meeting of the Institute of Transportation Engineers, 2000

Road diets, which are a traffic calming measure where the number of travel lanes and/or effective width of the roadway is reduced to improve safety and provide more equitable use of the right of way, were not considered for the Hampton Boulevard corridor. This is due to concerns raised by residents throughout the corridor about the likelihood of higher congestion levels on Hampton Boulevard, which could lead to traffic spillover and more cut-through traffic on adjacent neighborhood streets.

<u>Summary</u>

In this sub-chapter, recent safety improvements by the City of Norfolk were outlined and mapped. Moreover, objectives and strategies in the *Virginia Highway Safety Plan* were outlined, and various countermeasures were detailed. HRTPO staff proposed potential safety countermeasures for bicycle, pedestrian, speed-related, and truck-related crashes for the Hampton Boulevard corridor. Additionally, a number of candidate speed enforcement and traffic calming techniques were also detailed including various pavement markings, pavement appearance options, and landscaping.

In addition to the guidance provided in this report, a block-by-block investigation of the benefits of various traffic calming techniques options may be valuable.

Reducing Flooding (Joint Land Use Study)

Joint Land Use Studies (JLUS) are community-driven, cooperative, strategic planning processes among localities, states, and military installations. The goal of each JLUS is to encourage local governments to work closely with the military installations to implement measures that prevent the introduction of incompatible civilian development that may impair the continued operational utility of the military installation, and to preserve and protect the public health, safety, and welfare of those living near an active military installation.

FIGURE 98 Flooding along Hampton Boulevard at Richmond Crescent During Tropical Storm Jose (9/19/17)
Source: Wetlands Watch via YouTube

In this section, HRTPO staff has summarized recommendations and improvements to Hampton Boulevard that may impact future traffic flow and capacity in the corridor from the Hampton Roads Planning District Commission's (HRPDC) Norfolk – Virginia Beach Joint Land Use Study (completed in August 2019). Since flooding is affecting military operations and access to military facilities in Norfolk and Virginia Beach, this JLUS focuses on identifying specific conditions – including recurrent flooding, coastal storms, and erosion, outside of the military footprint that have the potential to impact Naval operations. Mitigation strategies along the Hampton Boulevard corridor were focused on flood mitigation and stormwater management due to current and future flooding problems. Details of the corridor strategies are provided below, including increased stormwater infrastructure capacity, roadway elevation options, safety and operational considerations, and a rail – roadway grade separation project.

Comprehensive Flood Mitigation and Stormwater Management Strategy – This Action recommends the development of a comprehensive approach to address current and future flooding along the Hampton Boulevard corridor that considers Norfolk, U.S. Navy, and Virginia Port Authority infrastructure. The strategy should explore a range of measures, including increased stormwater infrastructure capacity and roadway elevation options, to address both recurrent flooding today and long-term sea level rise over time, as described below.

- Portions of the southbound lanes are frequently impassable during storm events – a common issue at the intersection of Hampton Boulevard and Baker Street. These issues are compounded during peak gate access times at Naval Station Norfolk and Norfolk International Terminals (NIT).
- Hampton Boulevard North-Conceptual Solution – includes additional storage and filtration in the area of Baker Street and Leutze Boulevard to improve drain inlet infrastructure along Hampton Boulevard. The concept also creates an opportunity to realign Baker Street and, in the process, intercept runoff before it enters the Hampton Boulevard right-of-way. NIT could benefit from this realignment, because it could ease access for port workers and improve access to the NIT gates.
- Raising a portion of the Hampton Boulevard roadway should be explored through a series of roadway design alternatives that fully explore options for adapting the roadway to the long-term impacts of flooding and sea level rise. These alternatives can provide an understanding of potential impacts and benefits associated with a change in the road geometry.
    - **Figure 99** shows the potential additional elevation that would be required along segments of Hampton Boulevard to provide access during minor tidal flooding and 3.0 feet of sea level rise (SLR). The length of roadway that would need to be studied in an alternatives analysis is, at a minimum, 3,000 linear feet.
    - Several issues will need to be addressed as part of any future alternatives study to raise Hampton Boulevard:
        1) Safety and operational considerations of the roadway need to be integrated into the analysis. Since Hampton Boulevard is a heavily traveled corridor, a travel demand analysis of the corridor should be done to understand the impacts on the network from future flooding and sea level rise. Any reductions or modifications to travel lanes that are defined as part of the alternatives analysis should be analyzed. Transportation safety impacts would have to be considered in the design of modified driveway connections to Hampton Boulevard.

2) Raising Hampton Boulevard to the minor tidal flooding threshold with 3.0 feet of sea level rise would require reworking all of the neighborhood streets that connect to the roadway. It is estimated that a minimum of 11 intersections would need to be redesigned, including two signalized intersections. If the study area were extended farther south, there would most likely be additional intersection impacts. Redesigning the intersection of multiple streets by 2 feet or more, in a short distance between Hanover Avenue, Jamestown Crescent, and Surrey Crescent, would be particularly challenging.
3) It is estimated that over 60 parcels are located along the 3,000-linear-foot segment from the Lafayette River Bridge to Rockbridge Avenue. Extending this segment farther south would have an even greater impact on private properties, including some properties not directly adjacent to Hampton Boulevard. Changes to the roadway geometry would likely have an impact on access to adjacent parcels, including driveways (in addition to connecting streets). Obtaining enough right-of-way to accommodate raising the roadway to be passable with 3.0 additional feet of sea level rise may require property acquisition and/or impact the public realm, another added complication.
4) The stormwater collection system would have to be redesigned to collect runoff from adjacent properties that currently drain to the street and its stormwater inlets, as most of the existing drainage pathways would be cut off by raising the road. In turn, modification of the stormwater collection system would have to avoid, or account for, conflicts with other existing buried utilities such as water, sanitary sewer, and gas lines in the right-of-way. Other utility infrastructure, such as water and sewer manholes, telecommunications infrastructure, or electric lines, may also be affected.

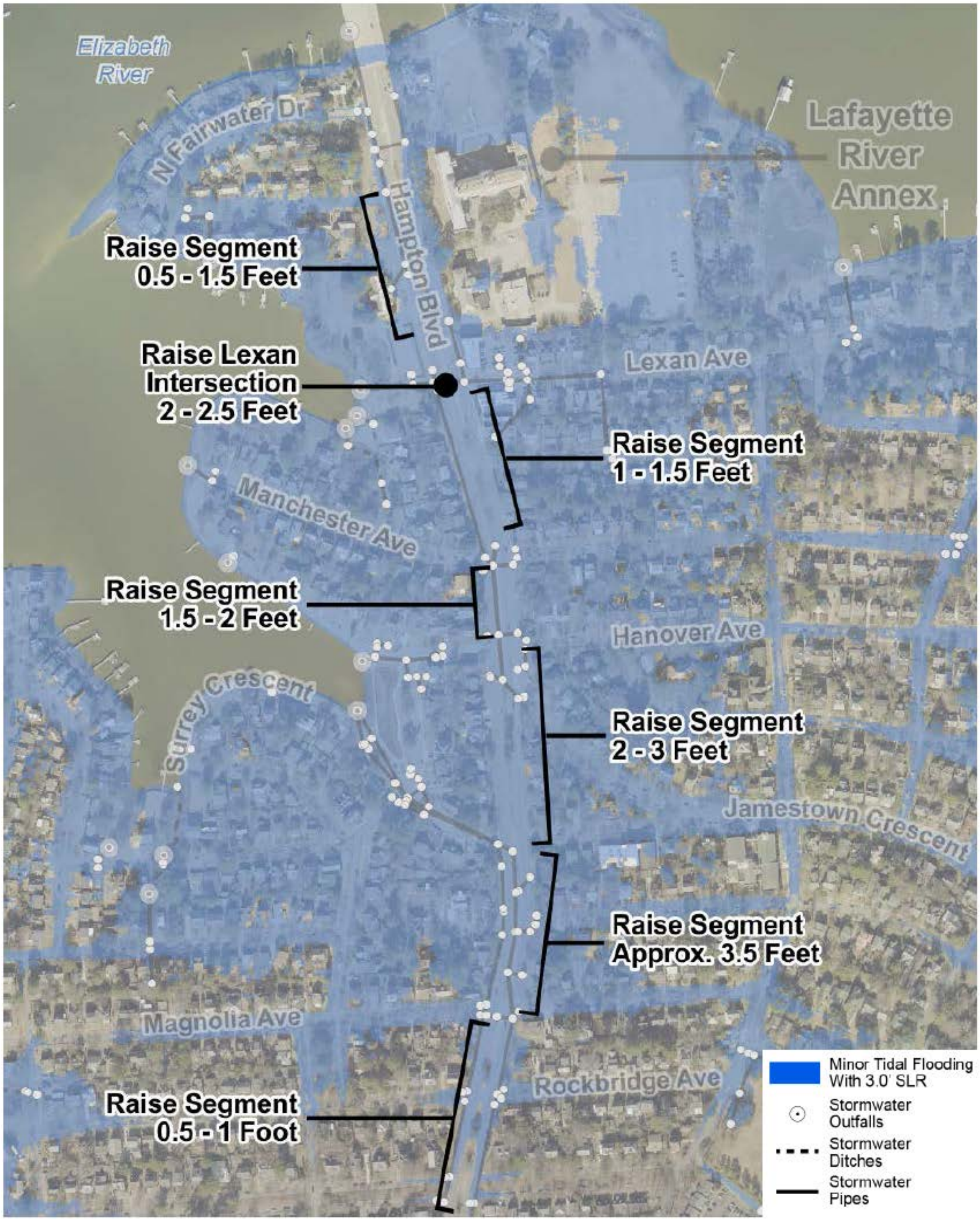


FIGURE 99 Hampton Boulevard Estimated Required Elevation During Minor Tidal Flooding and 3.0 Feet of Sea Level Rise

Source: Norfolk – Virginia Beach JLUS Study, 2019

Terminal Boulevard Rail and Roadway Grade Separation – This Action recommends proceeding with the proposed HRTPO 2040 Long-Range Transportation Plan (LRTP) project to construct a new rail underpass at the intersection of Terminal Boulevard and Hampton Boulevard. The design for the new underpass and grade separation should take into consideration impacts on stormwater and identify opportunities for upgrading the overall system capacity and performance. The design of the underpass may require a pump system to mitigate against flooding; the design should consider storm surge impacts and future sea level rise.

FIGURE 100 Terminal Boulevard Rail and Roadway Grade Separation Location
Source: Google Maps

Summary (JLUS)

Hampton Boulevard recommendations from the 2019 Norfolk – Virginia Beach Joint Land Use Study include:

- Increase stormwater infrastructure capacity at the following locations:
    - Portions of the Hampton Blvd southbound lanes
    - Hampton Boulevard and Baker Street intersection
    - Add storage and filtration in the area of Baker Street and Leutze Boulevard
- Raise roadway elevation for portions of Hampton Boulevard for adapting the roadway to the long-term impacts of flooding and sea level rise. Potential issues with raising Hampton Boulevard include:
    - Safety and operational considerations
    - Impacts to neighborhood streets and intersections
    - Impacts to private properties and adjacent parcels
    - Stormwater collection system and other utility infrastructure would have to be redesigned
- Proceed with the project identified in the 2040 LRTP to construct a new rail underpass at the intersection of Terminal Boulevard and Hampton Boulevard

Appendix A- Truck Counts on Hampton Blvd

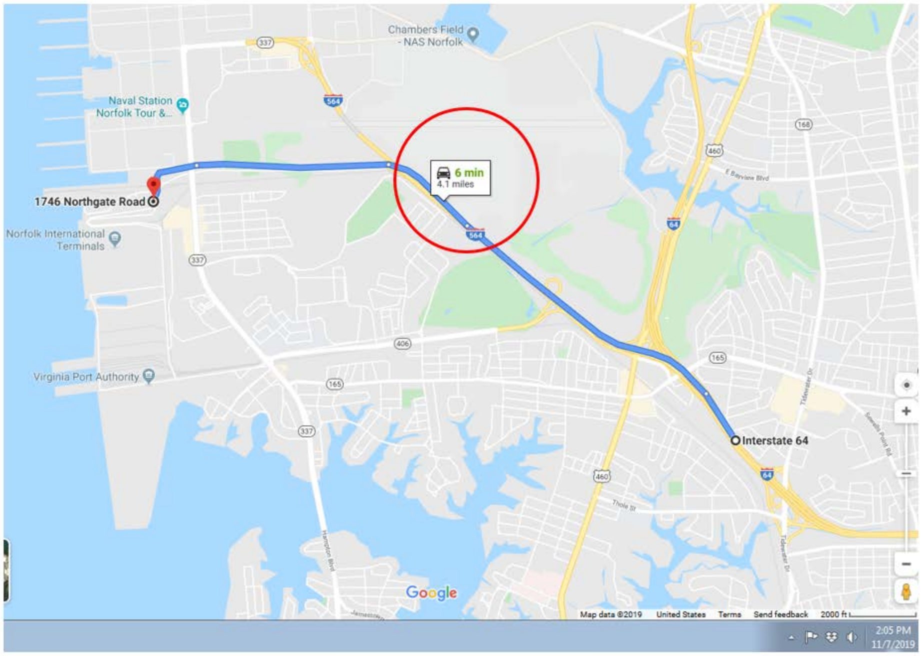
This document uses two different truck counts for Hampton Blvd. The first count (1,556) is the average number of trucks per weekday in 2018. The second count (1,451) is the average number of trucks *during Hampton Boulevard truck hours (6am-4pm)* per weekday in 2018.

Appendix B- Travel Times for Checking Analysis of Intermodal Connector

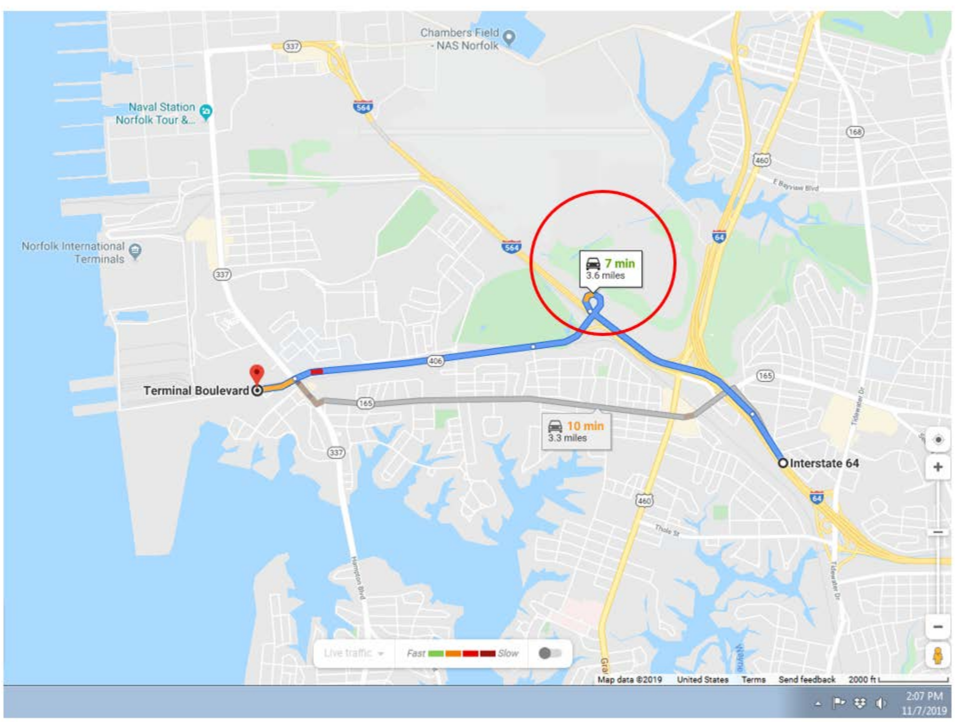
As discussed in the body of the report (under "Impact of Intermodal Connector on Hampton Blvd Trucks"), as part of analyzing the impact of the Intermodal Connector, staff used Google Maps to determine the travel time difference between Terminal Blvd and the Intermodal Connector. These Google Map runs[38] are included below.

[38] Source: HRTPO via Google Maps

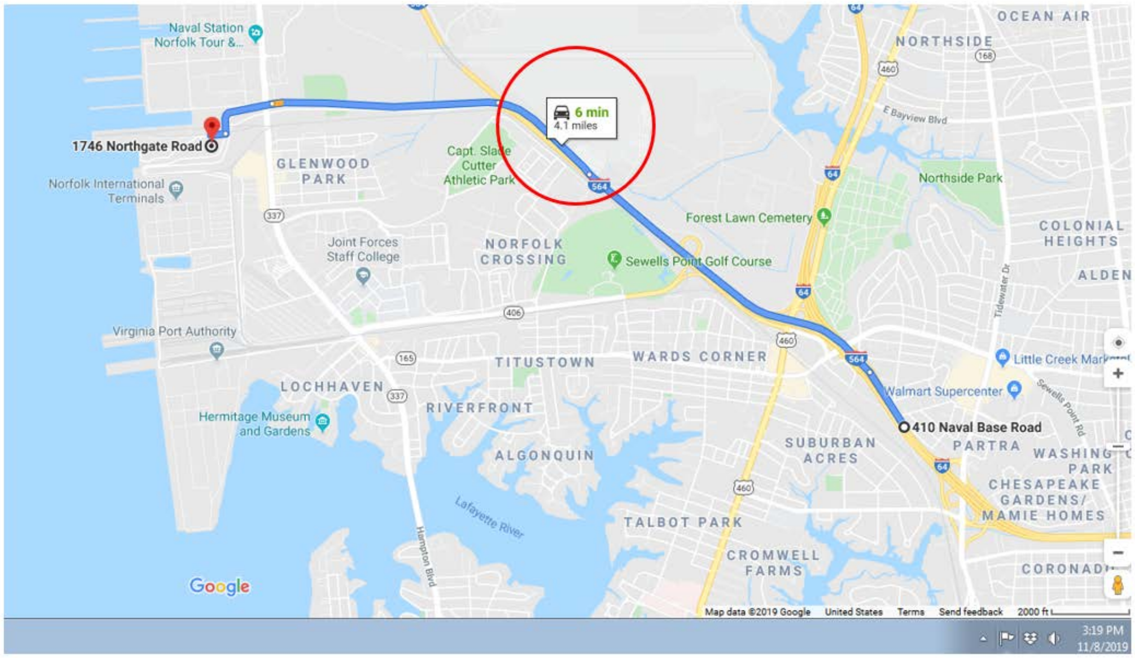
Via IMC (to N Gate)- inbound (1st run)



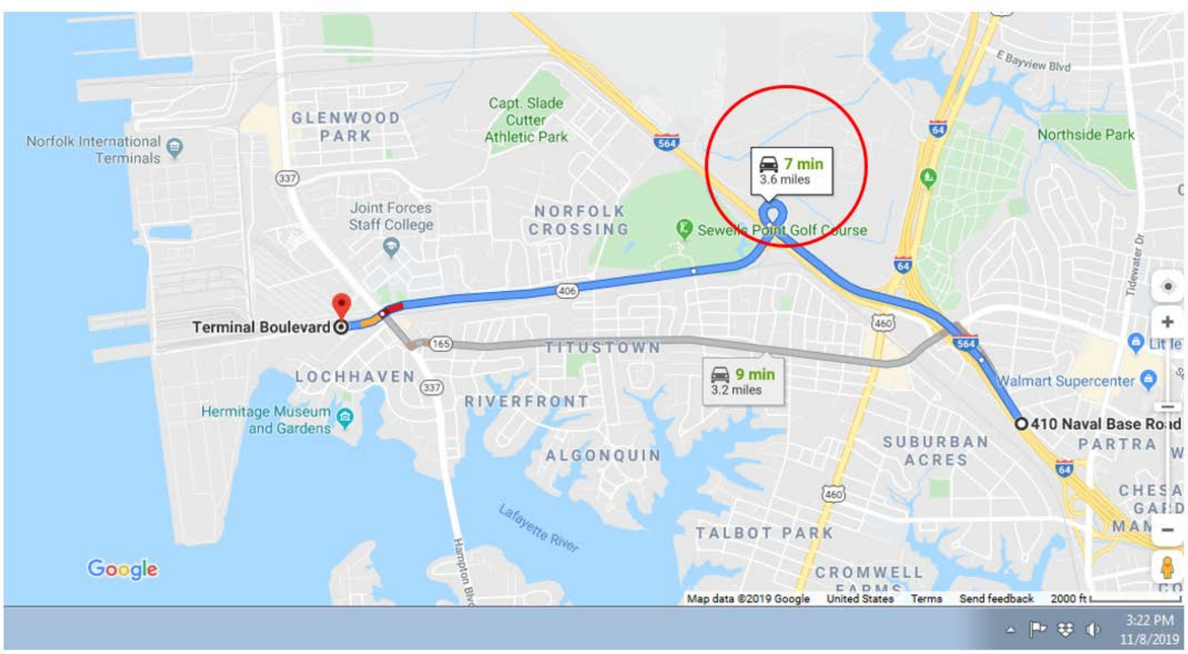
Via Terminal Blvd (to S Gate)- inbound (1st run)



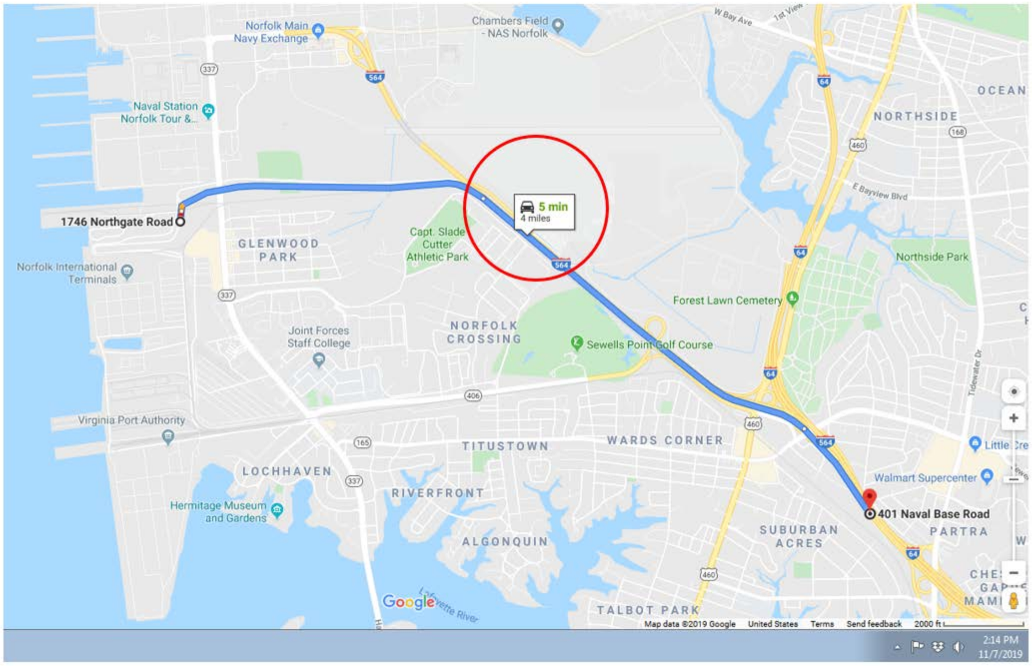
Via IMC (to N Gate)- inbound (2nd run)



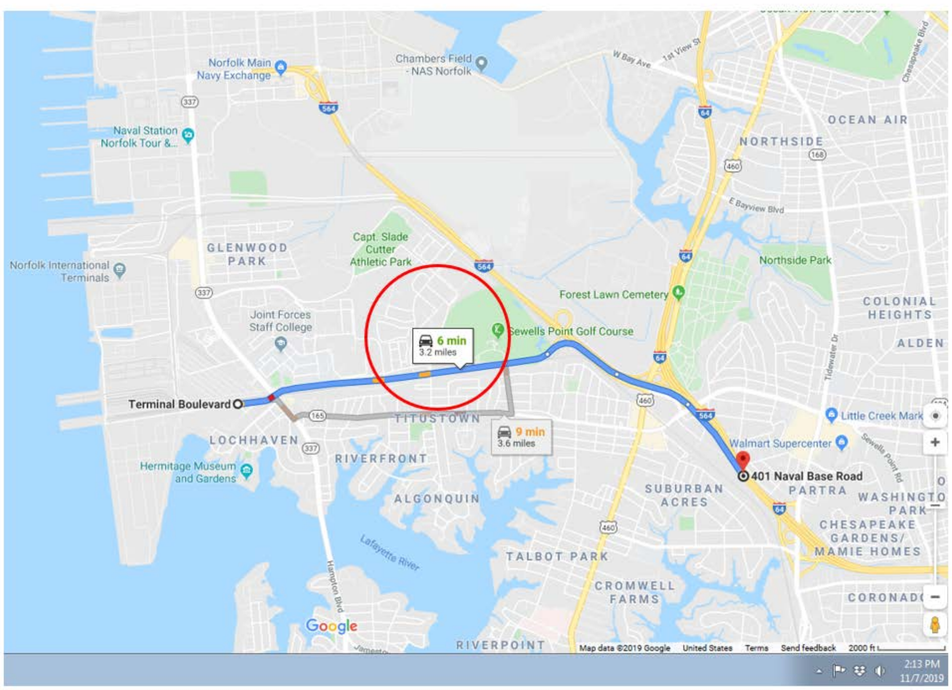
Via Terminal Blvd (to S Gate)- inbound (2nd run)



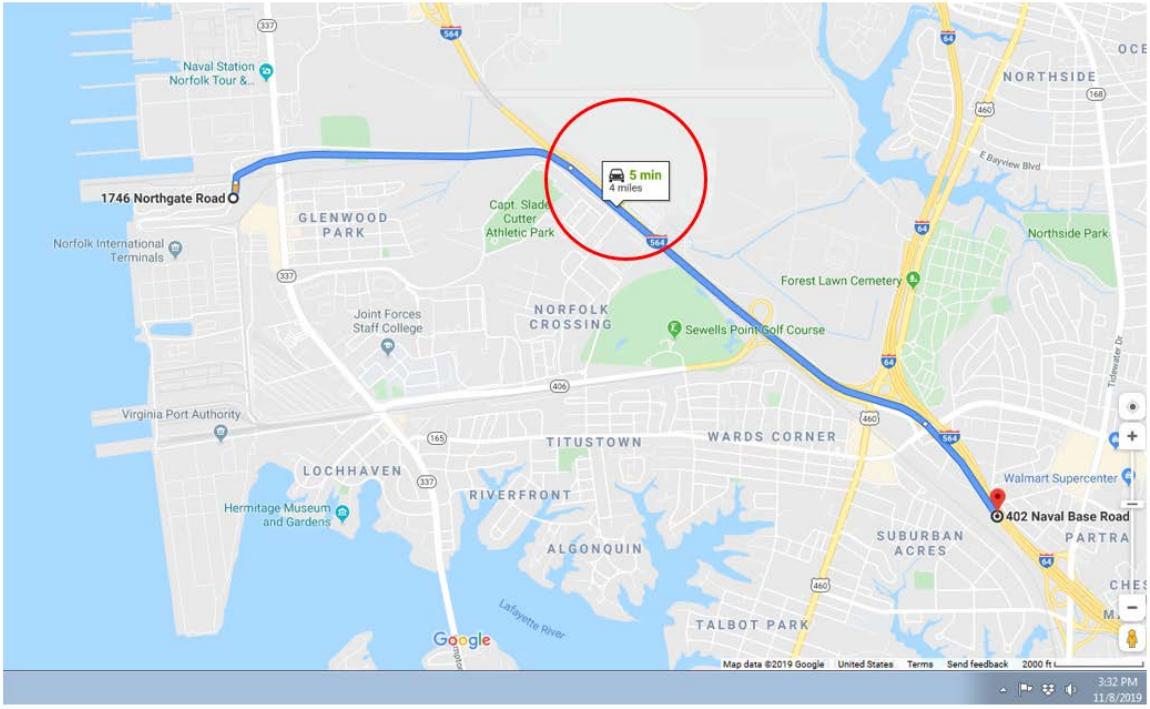
Via IMC (from N Gate)- outbound (1st run)



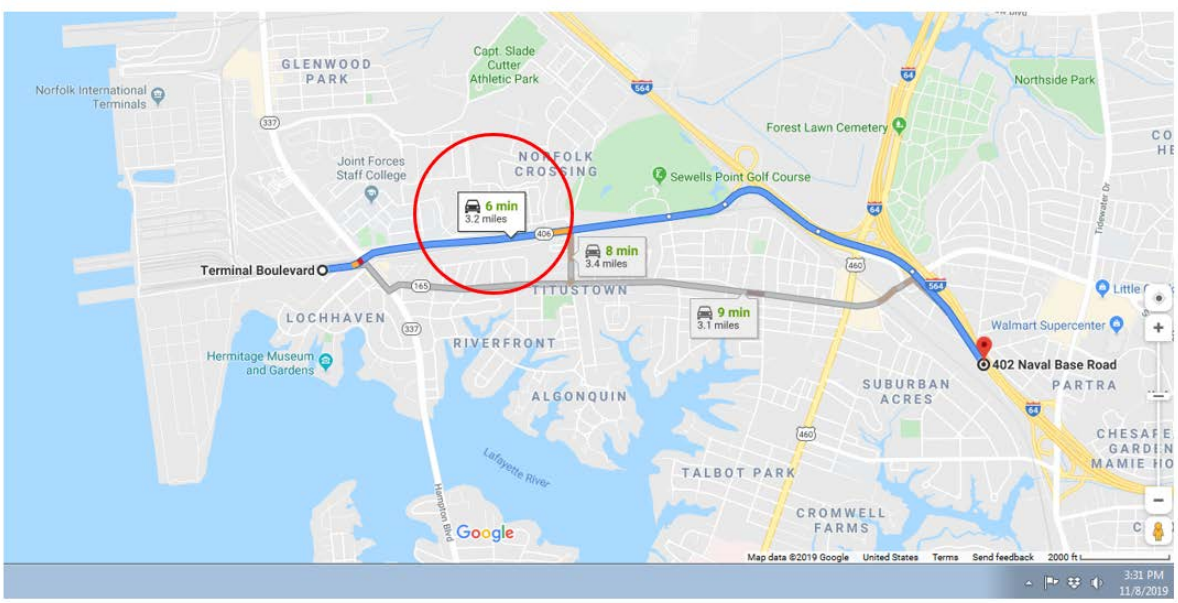
Via Terminal Blvd (from S Gate)- outbound (1st run)



Via IMC (from N Gate)- outbound (2nd run)



Via Terminal Blvd (from S Gate)- outbound (2nd run)



Appendix C- Examining Route Choice Factors to Develop Options for Shifting Trucks from Hampton Blvd to I-64

Prior to developing the options presented in the report body for reducing trucks on Hampton Blvd—including methods of shifting trucks from Hampton Blvd to I-64—staff investigated the factors NIT drivers consider when making a choice between these two routes. Given that truck drivers consider travel time and tolls when choosing a route, staff identified options that increase travel time or tolls for trucks using Hampton Blvd. In case there were additional route choice factors—and therefore related additional options for reducing trucks—staff sought to identify any additional route choice factors that might influence the choice between Hampton Blvd and I-64, as recorded in this appendix. One additional factor was found, and from it an option for reducing trucks on Hampton Blvd was identified.

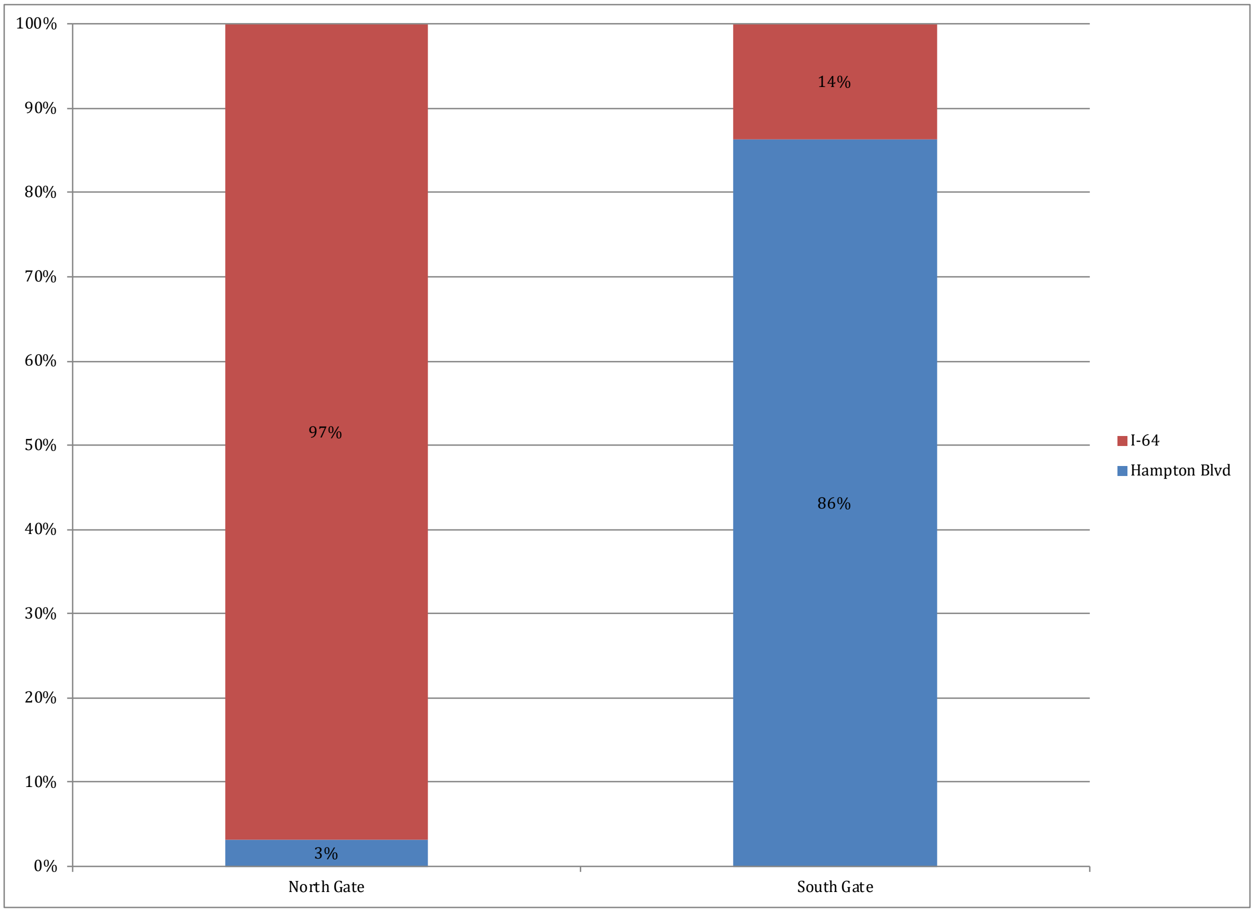
First staff examined NIT gate characteristics as a possible additional route choice factor.

NIT has two gates:

- North Gate-
  - linked only to the Intermodal Connector (IMC) and therefore only to the I-64 route (the Intermodal Connector passes over Hampton Blvd with no interchange)
- South Gate-
  - providing access to/from both routes:
    - I-64 (via Terminal Blvd)
    - Hampton Blvd (via the intersection of Terminal Blvd and HB)

Because the North Gate is linked only to the I-64 route, a gate factor (e.g. one gate processing trucks more quickly than the other) would influence route choice.

To understand the relationship between route choice and gate choice, staff used StreetLight to compare the gates according to the usage of the two route choices.



Route Choice by Gate, NIT Outbound Trucks, Hampton Blvd Truck Hours, 2018, StreetLight Sample

Source: HRTPO processing of StreetLight data

North Gate traffic uses I-64; South Gate traffic mostly uses Hampton Blvd. Therefore, outbound route choice and outbound gate choice are closely correlated. Is one gate inherently better than the other gate, e.g. quicker? According to one local trucking company, concerning gate selection, "Where the driver is coming from is the main issue."[39] The company did, however, indicate that "amenities at the north gate are better, bathrooms, snacks etc."[40] Concerning the subject matter—reducing trucks on Hampton Blvd—improving the amenities at the south gate (associated with Hampton Blvd) would be counterproductive. Based on the above, gate characteristics does not appear to be a useful additional route choice factor.

[39] HRTPO email exchange with Givens Transportation, Inc., dated 10-21-19

[40] HRTPO email exchange with Givens Transportation, Inc., dated 2-3-20

Secondly, staff examined this study's Hampton Blvd route-choice regression model[41] based on travel time and tolls to find possible evidence of additional route choice factors, i.e. factors other than travel time and tolls.

A regression model is a formula that uses inputs (the right side of the formula) to estimate an output (the left side of the formula). For example, *weight = height*75 – 250* is a model that uses human height (in feet) to estimate human weight (in pounds). The number at the end of the formula (*-250*) is known as the "intercept". In a choice model, the output is the probability of a certain choice being made, and the intercept indicates the bias toward making that choice. In this study's Hampton Blvd route-choice model, the output is the probability of an NIT truck driver choosing Hampton Blvd, and the intercept indicates the bias toward (or against) choosing Hampton Blvd.

This relationship between intercepts and bias can be seen by considering a truck destination for which the input variables are zero, i.e. a case in which Hampton Blvd has no travel time advantage (i.e. the travel times between NIT and the destination are the same regardless of using Hampton Blvd or I-64 to get there) and no toll disadvantage (i.e. there is no toll between NIT and the destination regardless of using Hampton Blvd or I-64). In the route-choice model, the only non-zero input value would be the intercept; in a truck driver's mind, the only factor for choosing between Hampton Blvd and I-64 would be something other than travel time and tolls. In a model, the intercept represents this "something other", known as the "bias", i.e. a tendency toward (or against) the subject choice.

[41] developed in the "Lowering Hampton Blvd Speed Limit" option section in the report body

destination	HBshare (actual)	HBtimesavings	HBtolldisadvantage	logit	probability (model)	LL (log likelihood)
1.CBBT	2%	-14	0	-1.65298	0.16	-0.211846
2.Chesapeake (Greenbrier)	32%	-9	0	-0.88635	0.29	-0.625783
3.HRBT	0%	-21	0	-2.72625	0.06	-0.06341
4.MMBT	76%	15	1	1.39787	0.80	-0.563257
5.Norfolk (Industrial Park)	56%	-10	0	-1.03968	0.26	-0.884964
6.Portsmouth (W Nor Br)	78%	22	1	2.47114	0.92	-0.632662
7.US 13 (NC)	40%	9	1	0.47792	0.62	-0.768328
8.US 17 (NC)	29%	-4	0	-0.11973	0.47	-0.670288
9.US 17 (IW)	98%	16	1	1.55119	0.83	-0.226996
10.US 58 (SH)	64%	10	1	0.63124	0.65	-0.651793
11.VA 168 (NC)	62%	-3	0	0.0336	0.51	-0.689412
12.US 460 (IW)	79%	9	1	0.47792	0.62	-0.583262
13.Suffolk (CenterPoint)	71%	9	1	0.47792	0.62	-0.621072
14.Va. Beach (I-264)	13%	-13	0	-1.49965	0.18	-0.393244
	50%				0.50	-7.586318
	avg.				avg.	sum

regression results (model coefficients):

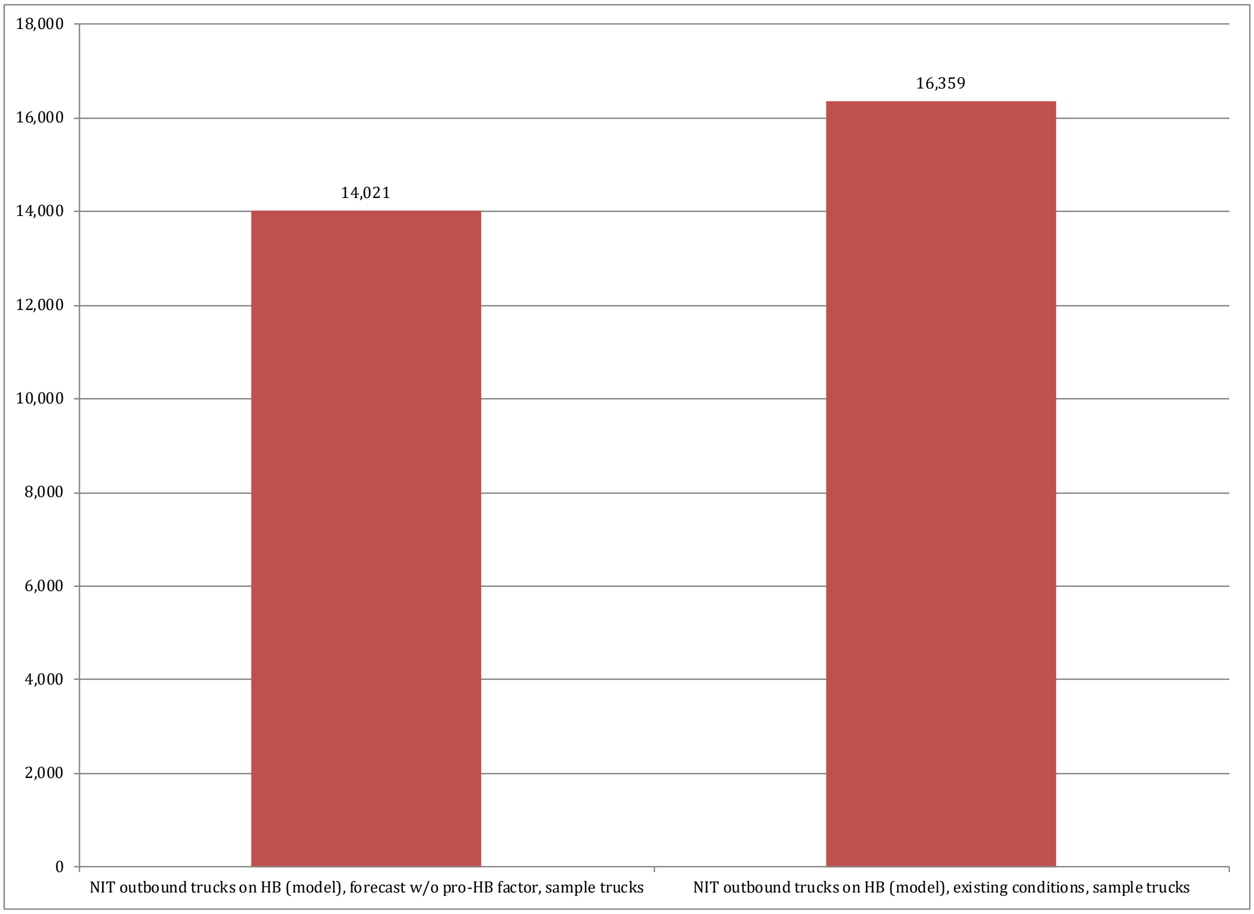
intercept	b0	0.49357	
HBtimesavings	b1	0.15333	logical positive sign
HBtolldisadvantage	b2	-1.39558	logical negative sign

Outbound NIT Route Choice Data and Model

Source: HRTPO processing of StreetLight, Google Map, and HRTPO data

The non-zero value of the intercept coefficient (above) indicates the *existence* of an additional route choice factor, i.e. something other than travel time and tolls that affects the choice between Hampton Blvd and I-64. The intercept value being *greater than* zero indicates a pro-Hampton-Blvd route choice factor, named an “outbound pro-HB” route choice factor in this report.

Prior to exploring what the outbound pro-HB route factor may actually be, staff estimated the size of its impact by running the route-choice model with and without the outbound pro-HB factor.



Measuring the Impact of the Unknown Outbound Pro-HB Factor

Source: HRTPO processing of StreetLight, Google Map, and HRTPO data

The outbound pro-HB route choice factor is significant in size, increasing NIT outbound truck traffic on Hampton Blvd by 17%.

Given the significant size of the outbound pro-HB route choice factor, staff tried to identify that factor by investigating the following candidate factors:

1. Drivers focusing on *distance* (vs. travel time) when comparing routes
2. Drivers having an aversion to *interstate* highways
3. Drivers *ignoring* tolls (when paid by trucking company)
4. South Gate drivers turning right on Hampton Blvd to avoid *signal delay*
5. Drivers using MMBT[42] to avoid *congestion* at HRBT
6. Drivers using MMBT to avoid *lower-height* WB HRBT

If real, the first three candidates would be difficult to address:

1. Distance cannot be changed
2. Aversion to interstates would likely be ingrained
3. Toll payment is a function of trucking company policy

Therefore, staff examined the last three candidate factors for validity, starting with #4:

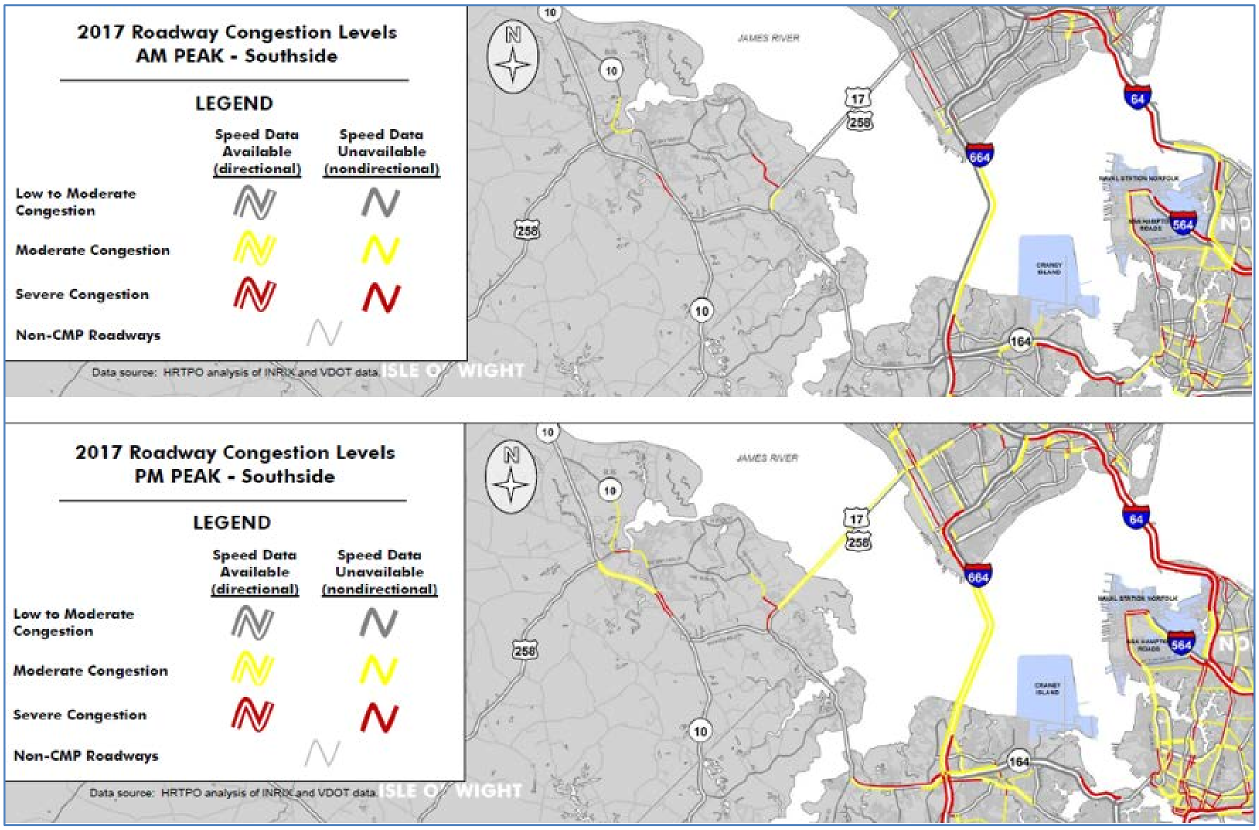
4. South Gate drivers turning right on Hampton Blvd to avoid *signal delay*

Given that the North Gate / I-64 route has no traffic signal, the ease of turning right at the Hampton Blvd traffic signal near the South Gate cannot explain extra usage of Hampton Blvd, i.e. it cannot be the outbound pro-HB factor.

[42] Monitor Merrimac Bridge Tunnel

5. Drivers using MMBT to avoid *congestion* at HRBT

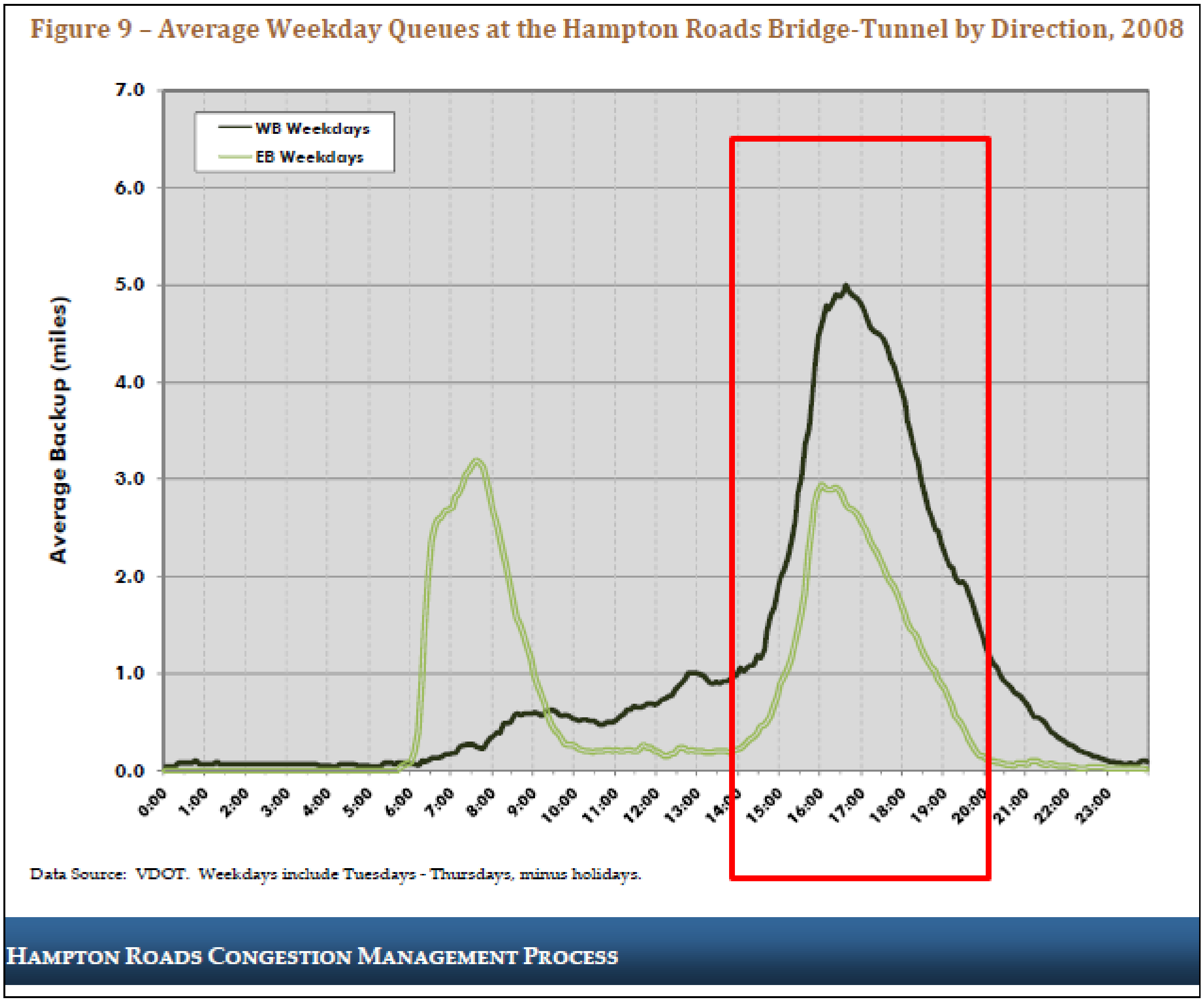
This candidate is based on the HRBT being significantly more congested than the MMBT, as shown below.



Congestion at HRBT and MMBT, AM and PM

Source: HRTPO processing of INRIX and VDOT data

The HRBT being significantly more congested than the MMBT, staff examined delays at HRBT.



Queuing at HRBT

Source: HRTPO processing of VDOT data

Given that WB congestion at HRBT is largely a 2pm-8pm issue, and that most NIT truck trips are made prior to 2pm (Hampton Blvd truck hours end at 4pm), WB HRBT congestion is apparently *not* the outbound pro-HB factor.

6. Drivers using MMBT to avoid *lower-height* WB HRBT

Trucks outbound from NIT with destinations on the Peninsula and beyond use the WB HRBT or MMBT. The WB HRBT tube, having been built in 1957, has substandard height, but the WB MMBT tube, built in 1992, is taller. Given that the lower height of the WB HRBT tube is an "all day" issue, it **appears to be the outbound pro-HB factor.**

In response to finding that the substandard WB HRBT height may add a significant number of trucks to Hampton Blvd, staff has included below "**Enabling Taller Trucks to Use HRBT WB**" as an option for reducing trucks on Hampton Blvd investigated in the report body.

Appendix D- Public Comments

From: Rucker, Ivan (FHWA) [mailto:Ivan.Rucker@dot.gov]
Sent: Thursday, December 03, 2020 1:39 PM
To: Robert A. Crum, Jr.
Subject: Hampton Blvd.

Good Afternoon Bob,

I hope that you are doing well. I thought that I should send you a quick email regarding some language contained in the attached report that is attributed to a brief discussion your staff had with me regarding Hampton Roads Blvd. Specifically, language contained on page 47 states,

"Mr. Rucker indicated that his agency would look favorably on a Hampton Blvd truck prohibition due to HB's absence from the "National Network" (what VDOT calls "Designated Truck Routes")."

To be clear, I did not suggest, infer, or conclude our Agency's position on any matter related to truck prohibitions on HR Blvd., and I ask that you please consider having your staff remove this language from the draft document. Additionally, I am attaching correspondence that reflects the communication on this subject.

Thank you for your attention to this request, and please feel free to call me with any questions.

Ivan

As discussed below under Port comments, HRTPO staff removed the prohibiting-thru-trucks option.

Comments from the Port of Virginia
via 12-18-20 email
(HRTPO staff responses in red)

Good afternoon, Rob,
Thanks to you and the team for the meeting on November 13 following the port's questions at the November 4 TTAC meeting. As agreed at the November 13 meeting, the following comments are provided regarding the draft of report.

- A component of the UPWP work task was to build on the ongoing efforts of the City of Norfolk's Hampton Boulevard Task Force, therefore the input and review comments provided by the task Force should be incorporated into this study.
HRTPO staff described the Task Force and its outcomes in the Background section.

- As an active participant in the task force and UPWP study, and because much of the content builds on port related activity, the port should have had the chance to review the findings and documented conclusions in the report prior to the public release. Further, several noted observations/recommendations in the draft were identified by the port as unfeasible or not relevant and the port specifically asked that these items not be included in the draft report, yet they were. We ask that prior to scheduling this report for review and presentation to the HRTPO policy board that the port have the opportunity to review the revised draft.
HRTPO staff forwarded a second draft report to the Port (and City) prior to public release.

- In providing comments early in the development of the report, the port stated that extending gate hours had been identified many years ago, it did not advance and has not been a consideration for over five years. We implemented the north gate improvements, as well as a Truck Reservation System, both of which have had significant impacts on mitigating extended congestion and producing record breaking efficiencies of turn times at the terminals.
HRTPO staff removed the gate hours option from the report.

• The description of the work effort in the UPWP did not focus on removing trucks from Hampton Boulevard, yet the first section of the report focuses on that topic. Neither the port nor the city requested a study that focused on removing trucks, however nearly 50% of the draft report was dedicated to that topic while the positive impact of the intermodal connector to the port, the military and the larger community was unclear. The gate move splits for trucks between NNIT and SNIT averages a 40:60 split respectively – the impact of the investments of the intermodal connector have been significant.

According to the FY2020 UPWP approved by the HRTPO Board:

> "In February 2019, the City asked the HRTPO to conduct a corridor study to address the following issues:
>
> - Number of trucks using Hampton Blvd (e.g. Impact of Intermodal Connector)
> - Safety
> - Excessive vehicle speeds"

As part of the response to the City request, staff investigated the impact of the Intermodal Connector on Hampton Blvd; its impact on the port, military, etc. being beyond the study scope.

In response to the Port comment above, HRTPO staff changed "removing trucks" to "reducing trucks" where appropriate.

• In the section titled "Removing Trucks from Hampton Boulevard" (pages 7-78), there were a number of topics including: tolling on truck route choice, truck regulations, cross harbor barging, truck O/D within the region, alternative routes, trucks in HOT lanes and others. Further study on these topics are relevant to freight movement across the region and port welcomes the opportunity to have these items as future work efforts in the UPWP and examined at a regional scale with collaboration from the freight community and FTAC. Due to the depth of input required to reflect the significance of these topics, it recommended that these subjects be excluded from this corridor study.

To fulfill the truck portion of the purpose of the study, staff analyzed options for their impact on the number of trucks on Hampton Blvd. Some of the topics the Port listed above are *options* for reducing trucks (e.g. "trucks in HOT lanes"); and some are *tools* for analyzing options (e.g. "truck O/D"). Concerning the *options*, at the request of the City of Norfolk, HRTPO staff removed the prohibiting-thru-trucks option. Concerning the *tools*, it is impossible to estimate the impact of an option on Hampton Blvd without using tools such as "truck O/D" and "alternative routes".

Concerning the Port's mention of "future work efforts", HRTPO staff added a recommendation for "further analysis" including collaboration with the freight community—prior to implementation of any options—at the beginning of the truck options section of the report.

- The UPWP task did identify rail crossings as a topic for this study and the $44 million Central Rail Yard project should be referenced in the study. This project is expected to be completed by 2023-2024 and will have a positive impact on reducing rail related congestion on Hampton Boulevard; we can provide details of the project.

In the Mitigating Train Conflicts section, HRTPO staff added the recent federal grant to the discussion of the Central Rail Yard project included in the first draft.

- There is an opportunity to utilize this planning effort to leverage future work, in particular with rail. The proposed rail improvements with variable message signs combined with the expansion of capacity of on-terminal storage tracks at the Central Rail Yard are anticipated to have significant impacts. If the City is interested in exploring additional efforts related to rail, the port is happy to work to support the effort.

Understood.

The Port of Virginia and the City of Norfolk have been working successfully for a number of years to address issues of mutual concern and opportunity. The joint request by the port and the city in early 2019 for a UPWP effort was envisioned to use the city's Hampton Boulevard Task Force on-going efforts and continue to identify short term safety and operational improvements that could be beneficial for all Hampton Boulevard users.

We appreciate the opportunity to provide comments on the draft report and look forward to the opportunity to review again before it is released to the policy board.

Barb

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