Howard Street Tunnel Project

Noise and Vibration Impact Assessment

Prepared for:

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One Bell Crossings, Selkirk, NY 12158

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Wood Project No.: 643009598

December 2020

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December 18, 2020

Mr. William Parry
CSX Transportation, Inc.
One Bell Crossings
Selkirk, NY 12158

Submitted via email:
William_Parry@csx.com

Subject: Howard Street Tunnel Project
Noise and Vibration Impact Assessment

Dear Mr. Parry,

Wood Environment & Infrastructure Solutions, Inc. (Wood) is pleased to submit to you this Noise and Vibration Impact Assessment report for proposed improvements to the Howard Street Tunnel (HST) and Associated Clearance Projects in Philadelphia, Wilmington and Baltimore (Project).

If you have any questions regarding this report, please do not hesitate to contact undersigned at the numbers listed below.

Sincerely,
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Noise and Vibration Impact Assessment

Howard Street Tunnel Project
CSX's I-95 Rail Corridor from
Baltimore, MD to Philadelphia, PA

Wood Project Number: 643009598

Date of Report: December 18, 2020

Status of Report: FINAL

Confidential and Proprietary

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Document revisions

No.	Description	Date
0	Initial submission	10/01/2020
1	Revision	18/12/2020

Executive summary

Wood Environment & Infrastructure Solutions, Inc. (Wood) was retained by CSX Transportation, Inc. (CSX) to complete a noise and vibration assessment of the proposed improvements to the Howard Street Tunnel (HST) and Associated Clearance Projects in Baltimore (MD), Wilmington (DE), and Philadelphia (PA) (Project).

This report presents a description of the noise and vibration assessment conducted by Wood and the predicted operational and construction impacts resulting from the Project.

Sections 1.0 and 2.0 present a general overview of the Project and the requirements and objectives of the conducted analysis.

Section 3.0 provides a brief description of the twenty-five (25) Project sites, including the name and location of each individual site with photographs taken in the right-of-way (ROW), Project activity description for each site in generic terms, and a description of surrounding land uses.

Section 4.0 describes the framework of the assessment for both direct Project impacts, i.e. impacts related to the operational aspect of the Project; and construction impacts related to the construction stages of the Project.

The operation impact assessment of the Project is described in Section 5.0. and Section 5.1 introduces the impact criteria used for the Project. This includes the criteria established for both operational noise and vibration impacts based on the guidance from the Federal Transit Administration (FTA) "Transit Noise and Vibration Impact Manual", September 2018 (the "FTA Manual"). Section 5.2 lists the major steps considered in the assessment methodology for the evaluation of the noise and vibration levels from the Project during the operational stage. The assessment results are presented in detail in Section 5.3 and Section 5.3.3.2. A summary of the predicted noise and vibration impacts for each Project site can be found in Table 5-12. The results suggest that the Project will not cause direct (operational) noise nor vibration related impacts.

The construction impact assessment of the Project is described in Section 6.0. and Section 6.1 introduces the construction impact criteria used for the Project. Section 6.2 provides descriptions of the methodology used in assessing construction noise and vibration levels. The assessment of construction associated with the HST Tunnel project site was conducted separately since the site has unique construction scenarios and employs significantly different methods when compared to the other clearance sites of the Project. The assessment results are presented in Section 6.3 and Section 6.4 in terms of Zone of Influence (ZOI) setback distances for the general sites and the HST site, respectively. Based on the calculated ZOI and reviews of the aerial map at each site, a series of receivers have been identified within the noise ZOI. The vibration ZOI is also expected to extend to buildings in proximity of the work sites, including two historic buildings in Baltimore, MD. As such, a Noise and Vibration Control Strategy (NVCS) is recommended for the Project to address these temporary impacts during construction and details of the NVCS are described in Section 6.5.

Section 7.0 presents a closure statement of the content of this report. A list of all references used in the report is included in Section 8.0.

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ABN	Air-Borne Noise
APE	Area of Potential Effects
CE	Categorical Exclusion
CREATE	Chicago Rail Efficiency and Transportation Efficiency
CSX	CSX Transportation, Inc.
EA	Environmental Assessment
EIS	Environmental Impact Statement
FTA	Federal Transit Administration
FRA	Federal Railroad Administration
GBN	Ground-Borne Noise
GBV	Ground-Borne Vibration
HST	Howard Street Tunnel
MP	Mile Post
MICA	Maryland Institute College of Art
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NVCS	Noise and Vibration Control Strategy
PPV	Peak Particle Velocity
ROW	Right-Of-Way
RMS	Root Mean Square
TO	Turnout
ZOI	Zone of Influence

1.0 INTRODUCTION

Wood Environment & Infrastructure Solutions, Inc. (Wood) was retained by CSX Transportation, Inc. (CSX) to complete a noise and vibration assessment for the proposed improvements to the Howard Street Tunnel (HST) and Associated Clearance Projects in Baltimore (MD), Wilmington (DE), and Philadelphia (PA) (Project).

The Project includes improvements that address clearance limitations at twenty-four (24) locations (including the HST in the City of Baltimore) along the existing I-95 Rail Corridor between Baltimore and Philadelphia, that restrict passage of modern double-stack intermodal trains. The Project also includes the Bayview Rail Yard in Baltimore, which will be used as a temporary staging and storage area. In addition to clearing the corridor of vertical restrictions for passage of double-stack intermodal rail passage, the Project will improve the overall reliability of CSX's I-95 rail corridor (Corridor) and provide added resiliency to the rail network. The Project will enhance productivity at the Port of Baltimore and improve freight rail performance and capability in the Mid-Atlantic corridor, as evidenced by the substantial public funding commitments from the federal government, and the States of Maryland, Delaware, and Pennsylvania.

Specific project locations are summarized in Table 1-1 below and are depicted in Figure 1-1, Figure 1-2 and Figure 1-3.

Table 1-1: Summary of Project Locations

Site	Location / Name
1	Howard Street Tunnel, Baltimore, MD
2	Mount Royal Avenue Track Lowering, Baltimore, MD
3	MTA Bridge Lowering, Baltimore, MD
4	North Avenue Bridge, Baltimore, MD
5	Sisson Street Track Lowering, Baltimore, MD
6	Huntington Avenue Track Lowering, Baltimore, MD
7	Charles Street Track Lowering, Baltimore, MD
8	St. Paul /Calvert Street Track Lowering, Baltimore, MD
9	Guilford Avenue, Baltimore, MD
10	Barclay Street Track Lowering, Baltimore, MD
11	Greenmount Avenue Track Lowering, Baltimore, MD
12	Harford Road, Baltimore, MD
13	Bayview Rail Yard, Baltimore, MD
14	Lancaster Avenue Track Lowering, Wilmington, DE
15	4th Street Track Lowering, Wilmington, DE
16	Chichester Avenue Track Lowering, Boothwyn, PA
17	Crum Lynne Road Track Lowering, Ridley Park, PA
18	Clifton Avenue Track Lowering, Sharon Hill, PA
19	Boone Tunnel, Sharon Hill, PA
20	68th Street Track Lowering, Philadelphia, PA
21	65th Street Track Lowering, Philadelphia, PA

Site	Location / Name
22	Cemetery Avenue Track Lowering, Philadelphia, PA
23	61st Street Track Lowering, Philadelphia, PA
24	Woodland Avenue Track Lowering, Philadelphia, PA
25	Interlocking Location – 58th Street, Philadelphia, PA

Figure 1-1: Project Map - Baltimore

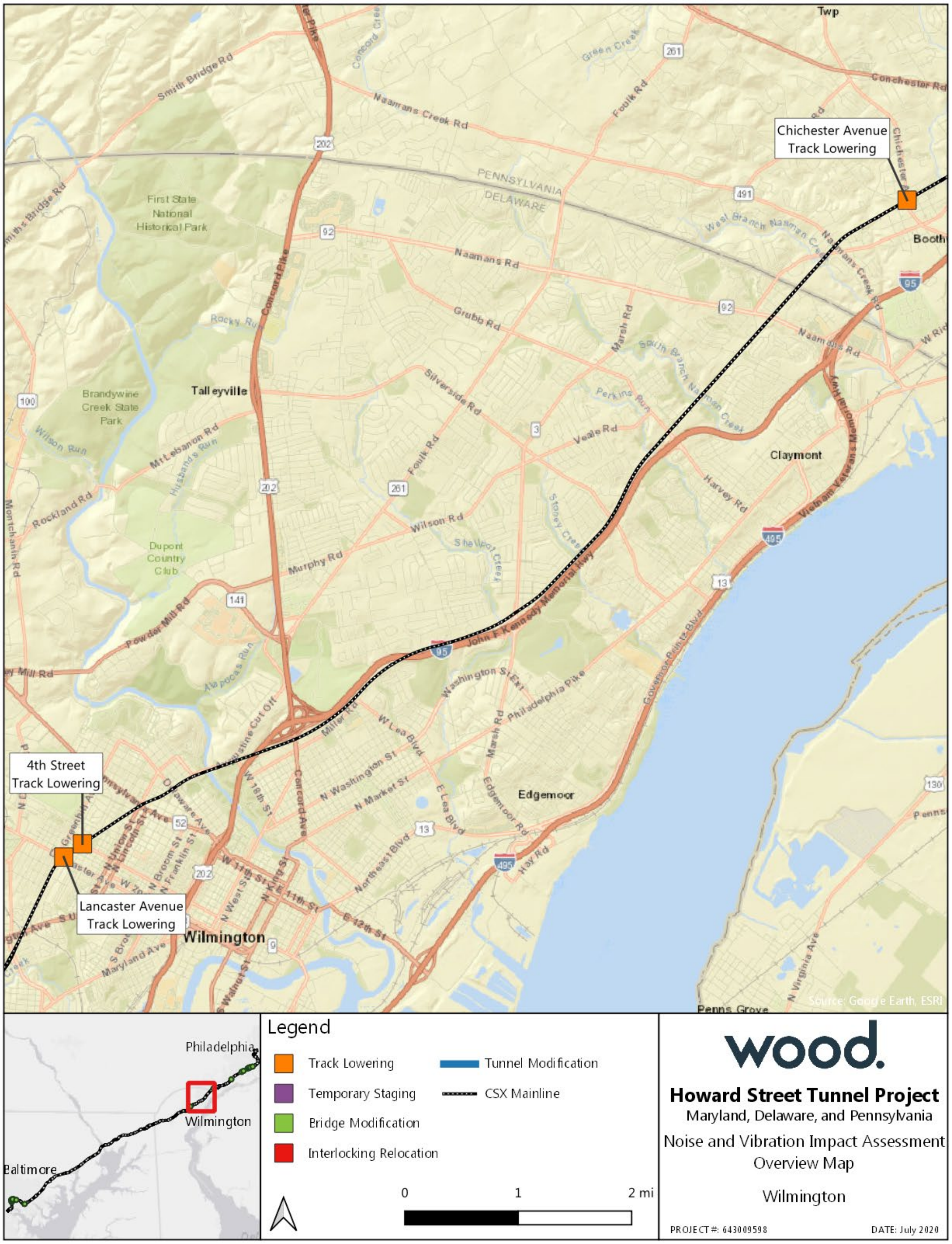

Figure 1-2: Project Map – Wilmington

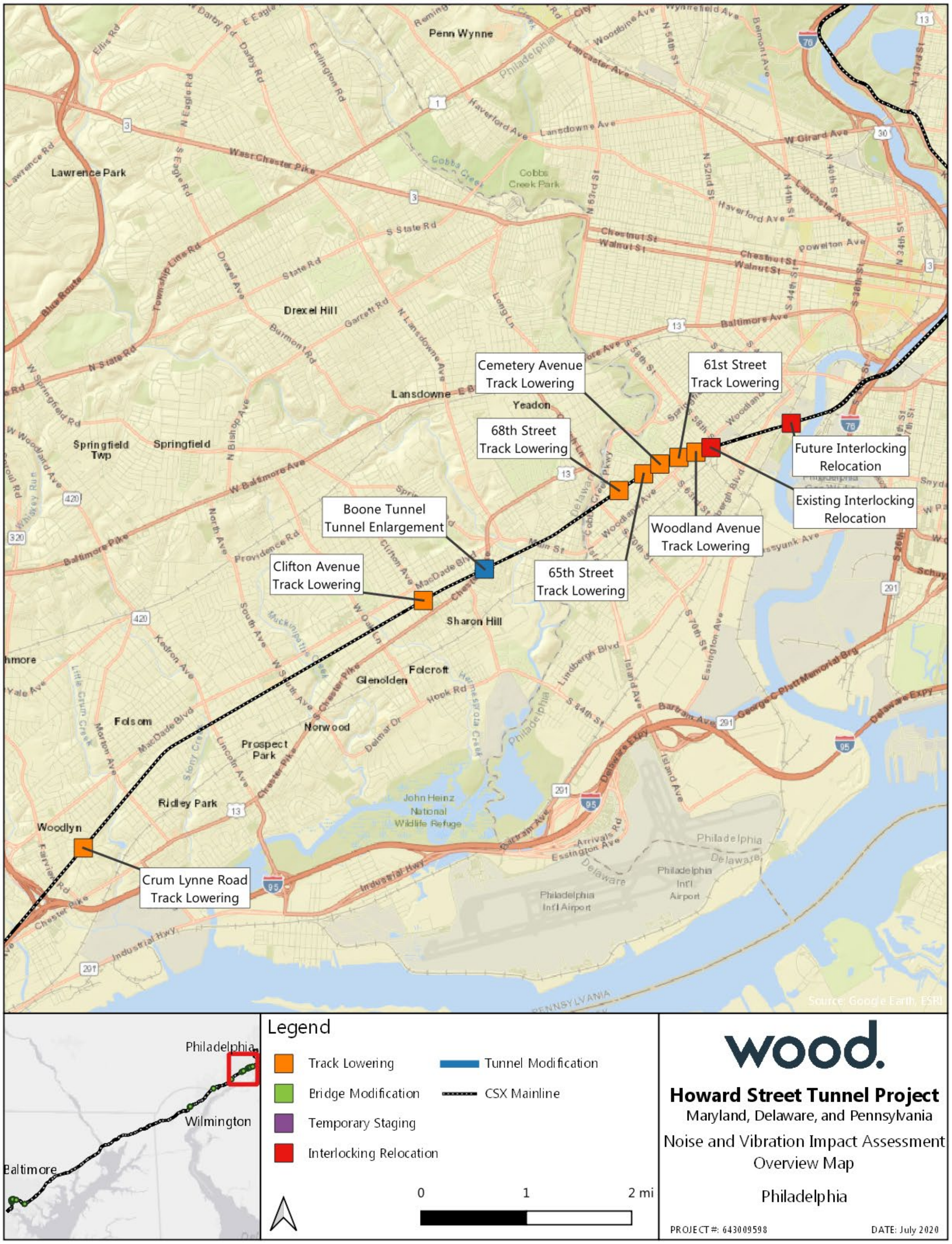

Figure 1-3: Project Map - Philadelphia

2.0 REQUIREMENTS AND OBJECTIVES

The current Project includes modifications to the existing railroad right-of-way ("ROW"), railroad tunnels and roadway bridges to increase vertical clearances in order to allow for the safe passage of double-stack intermodal containers along CSX's I-95 rail corridor. This objective will be achieved by either lowering the tracks (where possible) and/or modifying existing structures (tunnels and bridges) to achieve the proper clearance.

These actions in and of themselves do not generally result in significant environmental impacts and under normal circumstance would fall under a categorical exclusion (CE). However, the need to evaluate impacts due to the existence of historic properties protected by Section 106 of the National Historic Preservation Act (NHPA) has resulted in a determination that an environmental assessment is the appropriate class of action National Environmental Policy Act (NEPA) review for the Project[1].

The Federal Transit Administration (FTA) "Transit Noise and Vibration Impact Manual" September 2018 ("FTA Manual") [1] (*Section 2.1*) provides guidance as follows relative to CE's:

> *"Categorical exclusions (CEs) cover actions that are excluded from requiring an EIS or environmental assessment (EA) because FTA has determined that they do not routinely cause significant environmental impacts. FTA's CEs are located at 23 CFR § 771.118(c) and (d), commonly referred to as the c-list and d-list, respectively. Examples of projects that would normally be CEs include vehicle purchases, maintenance of equipment, vehicles, or facilities, and ROW acquisition."*

On the list of Actions that the FTA has determined to fall within the definition of CE and would therefore not need any further approval are[2]:

> *"Maintenance, rehabilitation, and reconstruction of facilities that occupy substantially the same geographic footprint and do not result in a change in functional use, such as: Improvements to bridges, tunnels, storage yards, buildings, stations, and terminals; construction of platform extensions, passing track, and retaining walls; and improvements to tracks and railbeds."*

From a purely noise and vibration impacts perspective it is expected that the Project will not produce significant environmental impacts.

Nevertheless, the current assessment has been prepared in recognition that an Environmental Assessment (EA) has been determined as the appropriate means of satisfying the "NEPA" requirements for the Project. The objectives of this report are to present, in a systematic manner, all the components that were considered in completing the required noise and vibration analysis. This includes an inventory of the identified sites, the railway operational noise and vibration assessment methodology, the construction noise and vibration assessment methodology, details of the noise and vibration prediction and predicted noise and vibration impacts at identified areas near the construction sites.

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1 23 CFR §711.118.(b)
2 23 CFR §711.118.(c).(8)

3.0 INVENTORY OF SITES AND NEARBY LAND USES

The FTA Manual identifies three main types of land use that are considered for assessment of noise and vibration:

- Category 1 – High Sensitivity;
- Category 2 – Residential; and
- Category 3 – Institutional

A generic description of the Land Use categories is presented in Table 3-1. Further discussion on Land Uses and limits for both noise and vibration is presented in Section 5.0.

Table 3-1: Land Use Categories and Description

Land Use Category	Land Use Type	Description of Land Use Category
1	High Sensitivity	There are two types of spaces: • Outdoor land spaces where quiet is an essential element of its intended purpose; and • Buildings where noise and/or vibration would interfere with interior operation.
2	Residential	This category is applicable to all residential land use and buildings where people normally sleep, such as hotels and hospitals.
3	Institutional	This category is applicable to institutional land uses with primarily daytime and evening use.

The Project is composed of twenty-four (24) individual sites along the existing I-95 Rail Corridor between Baltimore and Philadelphia and also includes the Bayview Rail Yard in Baltimore, which will be used as a temporary staging and storage area. A general description of each site location, the project activity planned and surrounding land use is presented in Table 3-2. The description includes the following information:

- Name and location of each individual site with photographs taken in the ROW;
- Project activity description for each site in generic terms; and
- Description of surrounding land use[3].

When describing the site surrounding land uses, the potential nearest sensitive land use for each site, most importantly residential land use, was reviewed.

3 The surrounding land uses were identified based on geographic information system (GIS) data with information available from the tax or planning departments of the local region.

Table 3-2: Inventory of Sites

Site	Location / Name	Project Activity Description	Description of Surrounding Land Use
1	Howard Street Tunnel, Baltimore, MD 	Clearance through Howard Street Tunnel will be achieved using either a conventional or a non-conventional approach, which are described in more detail in Section 6.4. Specific assessment of each of the approaches are presented in Sections 6.4.4 and 6.4.5 respectively. In general, these approaches include the following work: optimization of track geometry, track lowering, arch modification or reconstruction and invert modification or reconstruction, and drainage upgrades.	The site is approximately 8,700 ft in length and runs under the Howard Street from West Preston Street to Martin Luther King Jr. Boulevard, Baltimore. The open areas of the site (not in tunnel) are approximately 20 ft on the north end and 190 ft on the south end. The tunnel runs under the Howard Street. Above surface and in parallel runs the Light RailLink line Hunt Valley to Glen Burnie line. Along Howard Street the buildings are generally of mixed use (commercial on ground level and residential on upper levels). There are also some buildings that may be considered sensitive due to their nature, such as: the Baltimore Symphonie Orchestra building approximately 250 ft from the tunnel alignment, the Joint Force Headquarters Fifth Regiment Armory approximately 115 ft from the tunnel alignment and the University of Maryland Medical Center Midtown Campus approximately 40 ft from tunnel alignment. Residential buildings can be found also for the open site area on the south end at approximately 230 ft.

Site	Location / Name	Project Activity Description	Description of Surrounding Land Use
2	Mount Royal Avenue Track Lowering, Baltimore, MD 	Track/tunnel underpinning and track lowering.	The site is approximately 1,100 ft in length. The site is located under the Mount Royal Tunnel (approximately 170 ft) and the Mt Royal Station (covered, approximately 46 ft), Baltimore. The closest residential building is located approximately 85 ft from the tracks. Also, in close proximity is the Maryland Institute College of Art (MICA) Station Building.
3	MTA Bridge Track Lowering, Baltimore, MD 	Track lowering.	The site is approximately 623 ft in length located under both the MTA Bridge and the North Howard Street Bridge, Baltimore. Buildings in proximity belong to the Maryland Institute College of Art (MICA). The nearest buildings from MICA are the Bunting Building approximately 190 ft from the tracks and the Brown Building at approximately 30 ft from the tracks.
4	North Avenue Bridge, Baltimore, MD 	Replacement of a portion of the North Avenue arch bridge with a single span, shallow girder bridge. No change in roadway profile.	The site is approximately 605 ft in length located under both the West North Avenue and the Jones Falls Expressway. Buildings in proximity are of commercial nature with the closest one at approximately 95 ft from the tracks.

Site	Location / Name	Project Activity Description	Description of Surrounding Land Use
5	Sisson Street Track Lowering, Baltimore, MD 	Track lowering and footer extension work north of Sisson Street.	The site is approximately 1,180 ft in length located on both sides of the Sisson Street Bridge. The buildings in proximity, on the east side of the ROW south of Sisson Street, are mainly residential and located approximately 90 ft to 130 ft from the track.
6	Huntington Avenue Track Lowering, Baltimore, MD 	Track lowering and footer extension work north of Huntington Avenue.	The site is approximately 1,000 ft in length including an approximately 150 ft section of the Charles Street Tunnel. The buildings in proximity, on the north side of the ROW, are mainly residential and located approximately 150 ft to 225 ft from the track.
7	Charles Street Track Lowering, Baltimore, MD 	Track lowering and track/tunnel underpinning and footer extension; new retaining wall between Charles Street and St. Paul Street.	The site is approximately 1,000 ft in length comprised of the Charles Street Tunnel (approximately 650 ft in length for this site, Charles Street and Mace Street) and approximately 350 ft between Charles Street and St. Paul street. The buildings in proximity are mainly residential and located approximately 100 ft from the track.

Site	Location / Name	Project Activity Description	Description of Surrounding Land Use
8	St. Paul /Calvert Street Track Lowering, Baltimore, MD 	Track lowering and track/tunnel underpinning and footer extension work; new retaining wall between Charles Street and St. Paul Street.	The site is approximately 560 ft in length comprised of the St. Paul / Calvert Tunnel (approximately 400 ft long) and approximately 160 ft East of the tunnel. The buildings in proximity are mainly residential and sit between 60 to 100 ft from the track. North of the tunnel there is a school (Margaret Brent Elementary School) approximately 75 ft from the tunnel alignment.
9	Guilford Avenue, Baltimore, MD 	Bridge modification- replace existing arch with single span, shallow girder bridge.	The site is approximately 410 ft in length located on both sides of the Guilford Avenue Bridge. The buildings in proximity are mainly residential and sit between 60 to 100 ft from the track.
10	Barclay Street Track Lowering, Baltimore, MD 	Track lowering and track/tunnel underpinning.	The site is approximately 610 ft in length located on both sides of the Barclay Street Bridge. The buildings in proximity are mainly residential and sit between 60 to 120 ft from the track.

Site	Location / Name	Project Activity Description	Description of Surrounding Land Use
11	Greenmount Avenue Track Lowering, Baltimore, MD 	Track lowering and track/tunnel underpinning and footer extension.	The site is approximately 1,020 ft in length located on both sides of the Greenmount Avenue Bridge. The buildings in proximity are mainly commercial. Some residential buildings are located in proximity and sit between 60 to 100 ft from the track.
12	Harford Road, Baltimore, MD 	Bridge modification – replace existing arch with single span, shallow girder bridge, retaining wall and track profile adjustment.	The site is approximately 2,100 ft in length located on both sides of the Harford Road Bridge. The buildings in proximity are mainly commercial. Some residential buildings are located south of the ROW and east of the bridge that sit between 160 to 270 ft from the track. North of the ROW and east of the bridge at approximately 140 ft is the REACH! Partnership School building.

Site	Location / Name	Project Activity Description	Description of Surrounding Land Use
13	Bayview Rail Yard, Baltimore, MD 	Temporary staging and storage.	Parts of the yard will be dedicated to temporary staging and storage of materials and equipment for the site. The site is located in an area within a commercial/industrial setting with the Norfolk Southern Bayview yard located just south. The nearest residential building is located approximately 1,300 ft north of the yard.
14	Lancaster Avenue Track Lowering, Wilmington, DE 	Track lowering and new retaining wall.	The site is approximately 1,000 ft in length located on both sides of the Lancaster Avenue Bridge. The buildings in proximity are mainly commercial. Some residential buildings are located north of the ROW and west of the bridge that sit between 60 to 200 ft from the track. South of the ROW and west of the bridge there's the Cathedral Cemetery.
15	4th Street Track Lowering, Wilmington, DE 	Track lowering.	The site is approximately 1,130 ft in length located on both sides of the 4th Street Bridge. The buildings in proximity are mainly commercial. Some residential buildings are located north of the ROW and east of the bridge that sit between 60 to 100 ft from the track.

Site	Location / Name	Project Activity Description	Description of Surrounding Land Use
16	Chichester Avenue Track Lowering, Boothwyn, PA 	Track lowering.	The site is approximately 1,050 ft in length located on both sides of the Chichester Avenue Bridge. The buildings in proximity are mainly residential buildings that sit between 70 to 200 ft from the track. On the North side of ROW, east of the bridge there is a green space, and on the west side commercial buildings.
17	Crum Lynne Road Track Lowering, Ridley Park, PA 	Track lowering.	The site is approximately 1,050 ft in length located on both sides of the Crum Lynne Bridge. The buildings in proximity are residential buildings that sit between 70 to 150 ft from the track.

Site	Location / Name	Project Activity Description	Description of Surrounding Land Use
18	Clifton Avenue Track Lowering, Sharon Hill, PA 	Track lowering.	The site is approximately 1,100 ft in length located on both sides of the Clifton Avenue Bridge. The buildings on the east side of the bridge are of commercial use. On the North side of the ROW, east of the bridge, there is a green area. On the south side of the ROW, west of the bridge there are residential buildings that sit between 90 to 120 ft from the track.
19	Boone Tunnel, Sharon Hill, PA 	Tunnel modification. This includes track lowering and arch modification (notching) at the tunnel section, and track lowering at the open-cut track section which extends approximately 500 ft from either side of the tunnel portals (East/West).	The site is approximately 1,600 ft in length which includes the Boone Tunnel which is approximately 560 ft long. The site extends on both sides of the Boone Tunnel. The buildings in proximity are mostly residential uses with some commercial buildings. The residential buildings sit between 40 to 115 ft from the track.

Site	Location / Name	Project Activity Description	Description of Surrounding Land Use
20	68th Street Track Lowering, Philadelphia, PA 	Track lowering.	The site is approximately 1,150 ft in length located on both sides of the 68th Street Bridge. The buildings on the south side of the ROW are of commercial use. On the North side of the ROW, east of the bridge, there is a recreational park. On the North side of the ROW, west of the bridge there are residential buildings that sit between 75 to 140 ft from the nearest track.
21	65th Street Track Lowering, Philadelphia, PA 	Track lowering.	The site is approximately 940 ft in length located on both sides of the 65th Street Bridge. The buildings in proximity are mostly residential uses with some commercial buildings west of the bridge. The residential buildings sit between 40 to 125 ft from the nearest track.
22	Cemetery Avenue Track Lowering, Philadelphia, PA 	Track lowering.	The site is approximately 950 ft in length located on both sides of the Cemetery Avenue Bridge. The buildings in proximity are of both commercial and residential uses. The residential buildings sit between 40 to 130 ft from the nearest track.

Site	Location / Name	Project Activity Description	Description of Surrounding Land Use
23	61st Street Track Lowering, Philadelphia, PA 	Track lowering.	The site is approximately 970 ft in length located on both sides of the South 61st Street Bridge. The buildings in proximity are of both commercial and residential uses. The residential buildings sit between 40 to 100 ft from the nearest track.
24	Woodland Avenue Track Lowering, Philadelphia, PA 	Track lowering.	Th site is approximately 800 ft in length located near the intersection of Woodland Avenue and South 60th Street. The first row of buildings is mainly commercial with some residential buildings approximately 100 ft North of the site.
25	Interlocking Location – 58th Street, Philadelphia, PA 	Relocation of existing interlocking.	The existing interlocking is located south of S 58th Street with an approximate span of 750 ft. The buildings in proximity are of commercial uses. The interlocking will be removed and added to another existing interlocking located in an area between Lindbergh Boulevard and the Schuylkill River a, adjacent to the Bartram's Garden and an industrial facility.

4.0 FRAMEWORK FOR ASSESSMENT

4.1 Introduction

This report has been prepared consistent with procedures outlined in the FTA Manual [1], which provides guidance for conventional rail noise and vibration impact assessments. The Federal Rail Administration (FRA) has also developed complementary guidance for high-speed rail [2].

The transit noise and vibration impact assessment procedures outlined in the FTA Manual are relied on by FRA in evaluating improvements to conventional passenger rail lines and stationary rail facilities and for assessments of horn noise. Since there are no existing federal guidance documents or methods specifically applicable for the evaluation of freight train traffic noise and vibration a supplemental freight rail analysis guideline was developed for the Chicago Rail Efficiency and Transportation Efficiency (CREATE) program [3] using the FTA procedures with certain modifications to allow for the evaluation of freight traffic.

The assessment of impacts as identified in the FTA Manual[4] are divided into two categories, each with separate and distinct methodologies of assessment:

- Direct Impacts – as they relate to the operational[5] aspect of the Project (see Section 5.0); and
- Construction Impacts – as they relate to the construction stages of the Project (see Section 6.0).

The FTA transit noise and vibration impact assessment procedures, for direct impacts, are organized in three levels of analysis:

- Screening Procedure;
- General Assessment; and
- Detailed Assessment.

These procedures are used to determine potential impacts and the level of analysis required for a specific project. The Screening Procedure, for both noise and vibration, are intended to identify study area receivers. In the case where no sensitive land uses are present in the analysis area, no further analysis is required. In the case where sensitive land uses are present the assessment should proceed with a General Assessment and, if deemed necessary, a Detailed Assessment would be required.

For construction impacts, the FTA transit noise and vibration impact assessment procedures identify two methodologies:

- Qualitative Assessment; and
- Quantitative Assessment.

Unlike the direct impact assessment methods, these two assessment types are designed to address different types of projects. The Qualitative Assessment is generally used for small projects, limited in time and with no expected impacts to nearby sensitive land uses. The Quantitative Assessment is generally required for projects with a month or more of construction in noise-sensitive areas or if particularly noisy equipment will be involved.

4 See FTA Manual Section 8.1.
5 "Direct Impacts" and "Operational Impacts" relate to the continued freight operation on the existing I-95 Rail Corridor upon completion of the proposed Project

4.2 Direct (Operational) Impacts

The FTA Manual defines noise screening distances[6] for fixed guideway transit sources as 750 ft for unobstructed sight lines and 375 ft for sensitive land uses with intervening obstructions. These numbers are considered adequate for Commuter Rail Mainline which is the most approximate designation for the Project alignment since, as noted above, the FTA Manual does not address freight traffic specifically.

The assumptions for the FTA Manual screening distances are based on a different type of trains (i.e. commuter trains) than that of the Project (i.e. freight trains). As such a review of the CREATE screening distances was considered for validation of the FTA proposed screening distances since the CREATE methodology was specific designed to address the assessment of freight trains.

Due to the nature of the Project, it is assumed that the screening distances from the CREATE methodology are more appropriate based on traffic conditions of the alignment for this Project (i.e. freight-based traffic). The CREATE methodology screening distances are presented in Table 4-1. Based on a review of the land use surrounding the different sites of the Project (outlined in Table 3-2) the Normal Suburban Residential screening distances identified in Table 4-1 are used as reference for purposes of screening as per FTA Manual.

Table 4-1: CREATE Operational Noise Screening Distances

Ambient Category	Screening Distances [1] [ft]	
	Unobstructed Sight Lines	Intervening Obstructions
Normal Suburban Residential	1,500	1,000
Urban Residential	1,200	750
Noisy Urban Residential	750	500

Note(s):

1. Based on a "High Freight Train Activity Characteristics" – see Table 4-3 of the CREATE methodology

For vibration screening distances, the FTA Manual defines distances based on the Land Use Category[7]. These screening distances are shown in Table 4-2 for a Conventional Commuter Railroad project type. As was considered for the noise screening distances, a cross-reference to the CREATE methodology was conducted. In the case of vibrations, the CREATE methodology refers back to the screening distances from the FTA Manual[8] as appropriate.

6 See *Table 4-7* of the FTA Manual
7 See *Table 6-8* of the FTA Manual
8 The specific reference in the CREATE methodology, found in *Section 7.1*, refers back to *Table 9-2* of the FTA Manual 2006 Version. The 2006 and 2018 versions of the FTA Manual do not differ in terms of vibration screening distances.

Table 4-2: FTA Manual Operational Vibration Screening Distances

Type of Project	Critical Distances for Land Use Categories [1] [ft]		
	Land Use Cat. 1	Land Use Cat. 2	Land Use Cat. 3
Conventional Commuter Railroad	600	200	120

Note(s):

1. For the Vibration Screening Procedure, evaluate special buildings as follows: Category 1 - concert halls and TV studios, Category 2 - theaters and auditoriums

A review of surrounding land uses was conducted for all Project sites (see Section 3.0). Sensitive land uses are identified within the screening distances identified above. As such the framework of assessment used for Direct Impact for both noise and vibration aspects is the General Assessment Methodology as presented in the FTA Manual.

4.3 Construction Impacts

As previously identified, construction impacts can be assessed either via a by Qualitative or Quantitative Assessment. The Qualitative Assessment is to be conducted for smaller projects with a shorter duration (i.e. less than 1 month). Taking into consideration the scope of work to be conducted at each site, which will likely last more than one month, a Quantitative Assessment is considered to be more appropriate for the Project per the FTA Manual.

5.0 OPERATIONAL ASSESSMENT

5.1 Operational Criteria

5.1.1 Air-Borne Noise

The air-borne noise (ABN) criteria defined in the FTA Manual are established with respect to three different categories of land use based on relative noise sensitivity. Descriptions of these categories are provided in Table 5-1.

Table 5-1: Land Use Categories and Metrics for Transit Noise Impact Criteria[9]

Land Use Category	Land Use Type	Noise Metric (dBA)	Description of Land Use Category
1	High Sensitivity	Outdoor $L_{eq(1hr)}$ [1]	Land where quiet is an essential element of its intended purpose. Example land uses include preserved land for serenity and quiet, outdoor amphitheaters and concert pavilions, and national historic landmarks with considerable outdoor use. Recording studios and concert halls are also included in this category.
2	Residential	Outdoor L_{dn}	This category is applicable to all residential land use and buildings where people normally sleep, such as hotels and hospitals.
3	Institutional	Outdoor $L_{eq(1hr)}$ [1]	This category is applicable to institutional land uses with primarily daytime and evening use. Example land uses include schools, libraries, theaters, and churches where it is important to avoid interference with such activities as speech, meditation, and concentration on reading material. Places for meditation or study associated with cemeteries, monuments, museums, campgrounds, and recreational facilities are also included in this category.

Note(s):

1. Leq(1hr) for the loudest hour of project-related activity during hours of noise sensitivity.

For these land uses, the FTA Manual classifies the levels of impact into three categories. Table 5-2 provides descriptions of the three levels of impact.

Table 5-2: Level of Noise Impact[10]

Level of Impact	Description
No Impact	Project-generated noise is not likely to cause community annoyance. Noise projections in this range are considered acceptable by FTA and mitigation is not required.
Moderate Impact	Project-generated noise in this range is considered to cause impact at the threshold of measurable annoyance. Moderate impacts serve as an alert to project planners for potential adverse impacts and complaints from the community. Mitigation

9 Reproduced from *Table 4-3* of the FTA Manual.
10 Reproduced from *Table 4-4* of the FTA Manual.

Level of Impact	Description
	should be considered at this level of impact based on project specifics and details concerning the affected properties.
Severe Impact	Project-generated noise in this range is likely to cause a high level of community annoyance. The project sponsor should first evaluate alternative locations/alignments to determine whether it is feasible to avoid severe impacts altogether. In densely populated urban areas, evaluation of alternative locations may reveal a trade-off of affected groups, particularly for surface rail alignments. Projects that are characterized as point sources rather than line sources often present greater opportunity for selecting alternative sites. The FTA Manual and FTA's environmental impact regulations both encourage project sites which are compatible with surrounding development when possible. If it is not practical to avoid severe impacts by changing the location of the project, mitigation measures must be considered.

In determining the levels of impact, the FTA Manual offers two ways of presenting noise impact criteria depending on the relationship of a project and existing noise sources:

- **Option A: Project Noise Impact Criteria Presentation**: for evaluating existing noise independently to project noise. This is applicable if the project source is a new source of transit noise in the community, e.g. a new project in an area currently without transit; and
- **Option B: Cumulative Noise Impact Criteria Presentation**: for evaluating existing noise to project noise cumulatively. This is applicable if the project noise adds to or changes existing transit noise in the community, e.g. operations of a new type of vehicle, modifications of track alignments within existing transit corridors, etc.

These options represent different ways of presenting the same underlying criteria based on different project situations.

For the Project described in this report, the Cumulative Noise Impact Criteria Presentation (Option B) is more applicable, as the existing noise changes because of the Project and it is not possible to define the Project noise separately from the existing noise.

Figure 5-1 and Figure 5-2 present the noise impact criteria as an increase in cumulative noise level between the existing and project conditions. The horizontal axis represents the existing noise exposure and the vertical axis is the increase in cumulative noise level due to the project.

As explained in the FTA Manual, the criteria are defined with the expectation that communities already exposed to high levels of noise can only tolerate a small increase. This is reflected in the shape of the criteria curves: as the existing noise level increases, the allowable increase to the total community noise exposure is reduced.

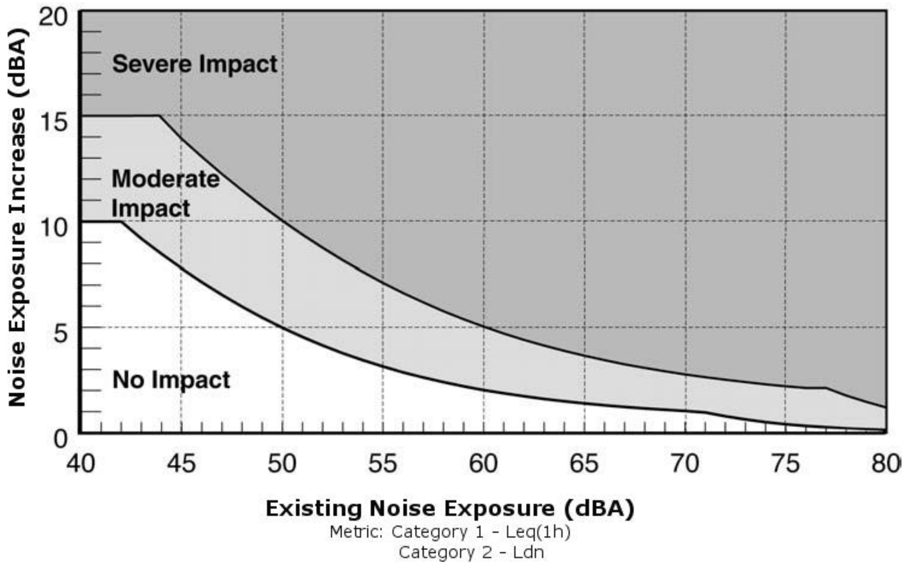


Figure 5-1: Increase in Cumulative Noise Levels Allowed by Criteria (Land Use Cat. 1 & 2)[11]

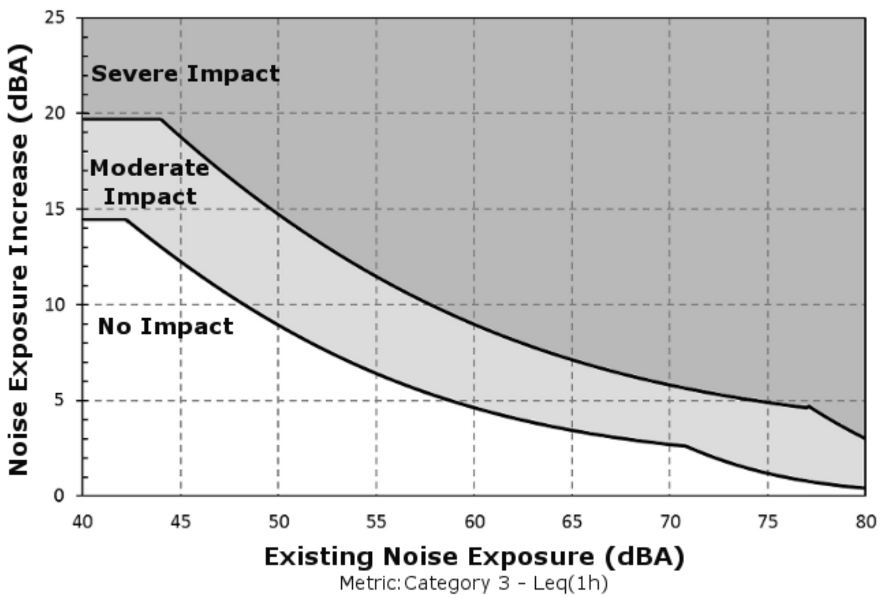


Figure 5-2: Increase in Cumulative Noise Levels Allowed by Criteria (Land Use Cat. 3) [12]

11 Reproduced from *Figure 4-3* of the FTA Manual.
12 Reproduced from *Figure 4-4* of the FTA Manual.

5.1.2 Ground-Borne Vibration and Noise

5.1.2.1 General Criteria

Similar to the noise impact criteria, the vibration criteria defined in the FTA Manual reflect the vibration sensitivity by land use type. The sensitive land use categories for vibration assessment are established in a similar structure as shown in Table 5-1 for noise assessment:

- Category 1 – High Sensitivity;
- Category 2 – Residential; and
- Category 3 – Institutional

The indoor use of the buildings is considered in determining the land use categories as the impact of ground-borne vibration and noise is experienced indoors.

One additional land use type classified as "Special Buildings" is also noted for vibration assessment. This category includes special-use facilities, such as concert halls, television and recording studio, theaters, etc., that are very sensitive to vibration and noise and not included in the other above categories.

The criteria specified in the FTA Manual for a General Vibration Assessment defines the acceptable ground-borne vibration (GBV) in terms of Root-Mean-Square (RMS) velocity levels in decibels, and ground-borne noise (GBN) in terms of A-weighted sound level. Table 5-3 and Table 5-4 present the criteria established in the FTA Manual which account for both variation in land use type and the frequency of events.

Table 5-3: Indoor Ground-Borne Vibration and Ground Borne Noise Impact Criteria [13]

Land Use Category	GBV Impact Levels (VdB re 1µin/s)			GBN Impact Levels (dBA re 20µPa)		
	Frequent Events [1]	Occasional Events [2]	Infrequent Events [3]	Frequent Events [1]	Occasional Events [2]	Infrequent Events [3]
Category 1: Buildings where vibration would interfere with interior operation.	65 VdB [4]	65 VdB [4]	65 VdB [4]	N/A [5]	N/A [5]	N/A [5]
Category 2: Residences and buildings where people normally sleep.	72 VdB	75 VdB	80 VdB	35 dBA	28 dBA	43 dBA
Category 3: Institutional land use with primarily daytime use.	75 VdB	78 VdB	83 VdB	40 dBA	43 dBA	48 dBA

Note(s):

1. *Frequent Events* is defined as more than 70 vibration events of the same kind per day.
2. *Occasional Events* is defined as between 30 and 70 vibration events of the same kind per day.
3. *Infrequent Events* is defined as fewer than 30 vibration events of the same kind per day.
4. This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. For equipment that is more sensitive, a Detailed Vibration Analysis must be performed.
5. Vibration-sensitive equipment is generally not sensitive to ground-borne noise; however, the manufacturer's specifications should be reviewed for acoustic and vibration sensitivity.

13 Reproduced from *Table 6-3* of the FTA Manual.

Table 5-4: Indoor Ground-Borne Vibration and Ground Borne Noise Impact Criteria for Special Buildings [14]

Type of Building or Rooms	GBV Impact Levels (VdB re 1µin/s)		GBN Impact Levels (dBA re 20µPa)	
	Frequent Event [1]	Occasional or Infrequent Events [2]	Frequent Event [1]	Occasional or Infrequent Events [2]
Concert Halls	65 VdB	65 VdB	25 dBA	25 dBA
TV Studios	65 VdB	65 VdB	25 dBA	25 dBA
Recording Studios	65 VdB	65 VdB	25 dBA	25 dBA
Auditoriums	72 VdB	80 VdB	30 dBA	38 dBA
Theaters	72 VdB	80 VdB	35 dBA	43 dBA

Note(s):

1. *Frequent Events* is defined as more than 70 vibration events per day.
2. *Occasional or Infrequent Events* is defined as fewer than 70 vibration events per day.

5.1.2.2 Consideration for Existing Vibration

The FTA Manual also provides guidance for establishing the impact criteria taking into consideration existing vibration conditions. This applies to the Project under assessment as the existing freight operation is considered a source of ground-borne vibration and noise events.

As stated in the FTA Manual, when a project will cause vibration more than 5 VdB greater than the existing source, the existing source can be ignored, and the standard vibration criteria as shown in Table 5-3 and Table 5-4 can be applied. Several scenarios are discussed in the FTA Manual based on future vibration levels and existing frequency of usage of the rail corridor. A flowchart representing the different scenarios is presented in Figure 5-3.

14 Reproduced from *Table 6-4* of the FTA Manual.

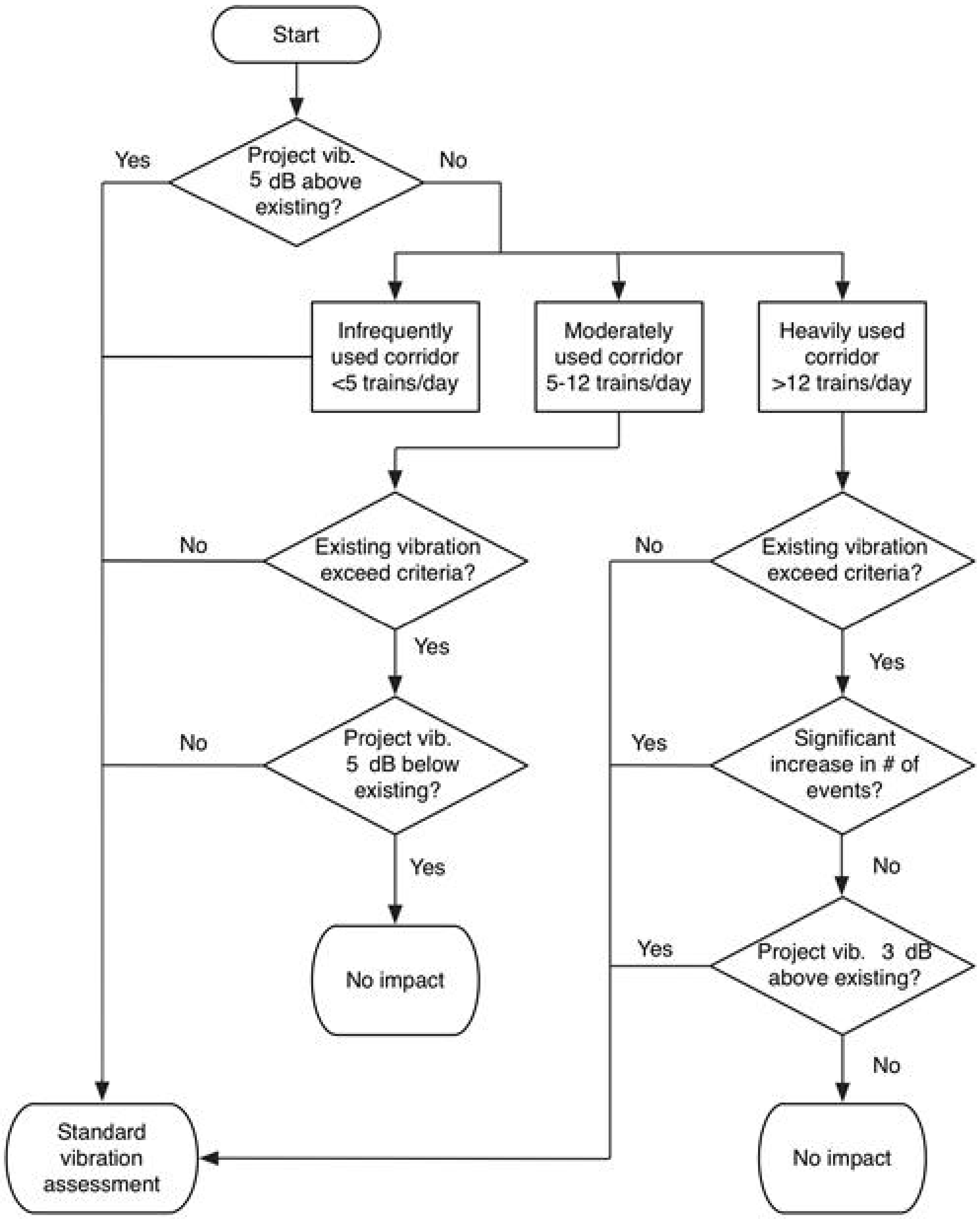


Figure 5-3: Existing Vibration Criteria Flow Chart [15]

5.2 Methodology

5.2.1 General Description

For the assessment of direct impacts, i.e. operational noise and vibration impact, the general assessment procedures described in the FTA Manual were adopted (see discussion in Section 4.2). Two major evaluation aspects are included for both the air-borne noise and ground-borne vibration assessments:

15 Reproduced from *Figure 6-1* of the FTA Manual.

- Source emission: noise exposure levels and vibration levels at the reference distance of 50 ft; and
- Propagation characteristics: adjustment of the source noise and/or vibration exposure as a function of distance.

Section 5.2.2 provides descriptions to the traffic parameters identified for the Project which determines the source emission level for the assessment. Sections 5.2.3 and 5.2.4 provide further discussions on the assessment methodology in terms of noise and vibration levels, respectively.

5.2.2 Project Traffic

The Project traffic scenario is identified in Table 5-5 and the maximum speeds per area of the Project are presented in Table 5-6. The values presented in Table 5-5 and Table 5-6 are considered representative of existing traffic conditions in the alignment, which will be unchanged upon completion of the Project.

Table 5-5: General Input Parameters for Project Train Traffic

Line	Input Parameters	Value [1]	Notes
1	Total Train Traffic Per Day	19	Both Directions
1.a	Daytime Traffic (7AM – 10PM)	12	-
1.b	Nighttime Traffic (10 PM – 7AM)	7	-
2	Typical Train Make-up		
2.a	Number of Locomotives	3	Per Train
2.b	Length of Locomotives	71.5 ft	Per Locomotive
2.c	Number of Cars	66	Per Train
2.d	Length of Cars	85 ft	Per Car
3	Speed	Variable	See Table 5-6

Note(s):

1. The values presented are for typical ranges for operations within the corridor. Variances may occur due to operational conditions.

Table 5-6: Speed Profiles

Section	Area	Maximum Speed [mph]
Bayview North	Eastwick – 58th	25
	58th – Clifton	30
	Crum Lynn – 4th Ave.	50
Bayview South	Harford Rd.	35
	All others	25

5.2.3 Operational Noise

5.2.3.1 General Assessment

Guidelines for performing a General Noise Assessment are documented[16] in the FTA Manual. This section provides a brief description of the major steps taken to predict the air-borne noise levels from a fixed-guideway transit source, which are outlined as follows:

- **Step 1:** Determine project noise source reference levels – This step includes:
  - Determining the reference source noise levels 50 ft from the track for each sub-source (i.e. locomotive, railcar, warning horns, etc.) in terms of Sound Exposure Level (SEL) at a reference speed; and
  - Estimating the project noise exposure in terms of $L_{eq(1hr)}$ or L_{dn} at the reference distance of 50 ft considering operational characteristics (i.e. number of train passbys, train consist, operation speed, etc).
- **Step 2:** Estimate project noise exposure by distance – Estimate project noise exposure at distances beyond 50 ft considering propagation characteristics using a simplified procedure.

For Step 1 of the assessment, reference SEL levels for typical transit source can be found in *Table 4-9* of the FTA Manual. Based on gathered operation data, the noise exposure ($L_{eq(1hr)}$ or L_{dn}) at the reference distance of 50 ft is calculated using the equation provided[17] in the FTA Manual which can be presented as follows:

$$L_{eq(1hr),50ft,i} = SEL_{ref,i} + 10\log(N_i) + Klog\left(\frac{S}{50}\right) + 10\log(V) - 35.6 + Adj_{track}$$

Where

- $L_{eq(1hr),50ft,i}$ is the L_{eq} at 50 ft induced from the i-th source, i.e. locomotives or rail cars;
- $SEL_{ref,i}$ is the applicable reference SEL[18];
- N_i is the average number of locomotives or rail cars;
- K is the speed adjustment factor;
- S is the speed of train;
- V is the average hourly volume of train traffic, trains per hour; and
- Adj_{track} is the track adjustment factor, considered only when calculating the $L_{eq(1hr),50ft,i}$ for rail cars.

An analysis of the equation presented above indicates that the project noise exposure at 50 ft is determined by several major operational factors:

- Train composition, i.e. number of locomotives and cars;
- Train schedule, i.e. hourly traffic volume;
- Trains speed; and

16 See *Section 4.4* of the FTA Manual.
17 See *Table 4-10* of the FTA Manual.
18 See *Table 4-9* of the FTA Manual.

- Special trackwork, e.g. crossover (see discussion in Section 5.2.3.2).

For the Project described in this report, there are no changes in the operational conditions (see Table 5-5) that may impact the noise source emission levels. As such, it is expected that, the noise exposure level at 50 ft will be the same as the existing conditions, except at Site #25 where an existing crossover will be relocated (see discussion in Section 5.2.3.2).

For Step 2 of the assessment, to calculate the project noise exposure at a distance other than 50 ft, a correction factor of $15\log\left(\frac{D}{50}\right)$ is used by the FTA Manual which is illustrated by the propagation curve shown in Figure 5-4.

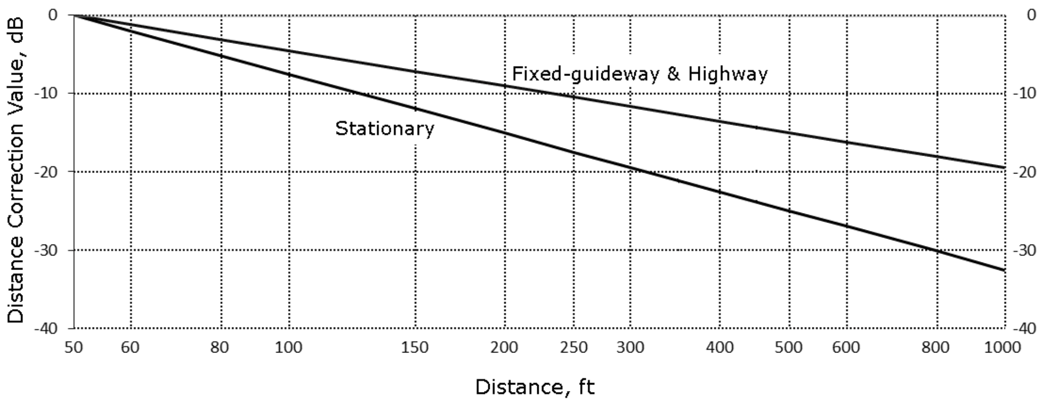


Figure 5-4: Curves for Estimating Exposure vs. Distance in General Noise Assessment[19]

5.2.3.2 Special Trackwork

Special trackwork such as turnout and crossovers can increase noise levels. The FTA Manual recognizes this situation in the general assessment by applying a +5 dB[20] adjustment when the special trackwork is within 300 ft of the receiver.

5.2.4 Operational Vibration

5.2.4.1 General Assessment

Guidelines for performing a General Vibration Assessment are documented[21] in FTA Manual. This section provides a brief description of the major steps taken to predict the ground-borne vibration levels from a transit vibration source, which are outlined as follows:

- **Step 1**: Select base curve for ground surface vibration level - Select a standard vibration curve to represent general vibration characteristics for the source; and
- **Step 2**: Apply adjustments - Apply project-specific adjustments to the standard vibration curve.

For Step 1 of the assessment, Figure 5-5 shows the generalized vibration curves provided by the FTA Manual for vibration assessment. The "Locomotive Powered Passenger or Freight" curve shown in Figure 5-5 is

19 Reproduced from *Figure 4-6* of the FTA Manual.
20 See *Table 4-10* of the FTA Manual
21 See *Section 6.4* of the FTA Manual.

considered to be applicable for the Project. The following equation is provided[22] in the FTA Manual that characterizes the curve:

$$L_v = 92.29 + 14.81\log(D) - 14.17\log^2(D) + 1.65\log^3(D)$$

Where

- L_v is the velocity level in VdB; and
- D is the distance in ft.

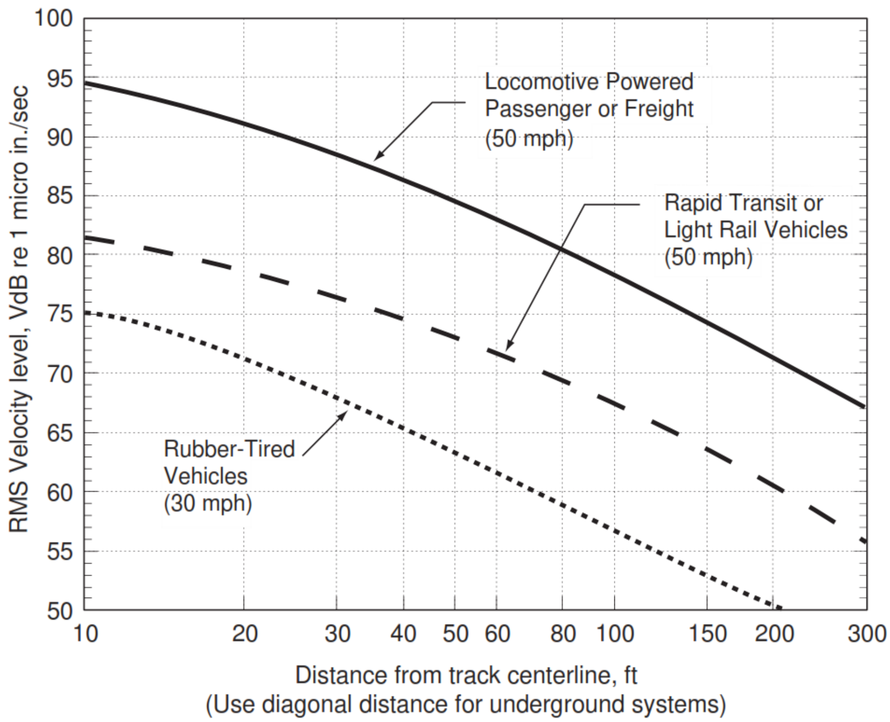


Figure 5-5: Generalized Ground Surface Vibration Curves[23]

For Step 2 of the assessment, the adjustment factors are described[24] in the FTA Manual. The applicable adjustments are generally determined by several factors:

- Train speed;
- Vehicle conditions, e.g. suspension stiffness, wheels condition;
- Track conditions, e.g. special trackwork (see discussion in Section 5.2.4.2);
- Propagation characteristics, e.g. soil conditions, building foundation coupling; and
- Receiver structure amplification or attenuation.

For the Project described in this report, there are no changes in operational conditions (see Table 5-5) that will impact the vibration source emission levels. The only variable that may cause changes to the existing

22 See *Table 6-10* of the FTA Manual.
23 Reproduced from Figure *6-4* of the FTA Manual.
24 See *Tables 6-11*, *6-12* and *6-13* of the FTA Manual.

vibration levels is the relocation of the existing crossover at Site #25 (see discussion in Section 5.2.4.2), and the change in slant distance between the track and a given receiver due to track lowering occurring at Project sites. With no horizontal shift of the alignment, this distance will change marginally with an elevation adjustment of a 1.5-ft lowering of the track.

5.2.4.2 Special Trackwork

Special trackwork such as turnout and crossovers can increase vibration levels. The FTA Manual recognizes this situation in the general assessment by applying the following factors[25]:

- +10 dB when the special trackwork is within 100 ft of the receptor.
- +5 dB when the special trackwork is within 100 ft to 200 ft of the receptor.
- 0 dB when the receptor is more than 200 ft from the special trackwork.

5.3 General Sites

5.3.1 Introduction

This section describes the operational noise and vibration assessments conducted for the individual sites comprising the overall project based on the changes in alignment proposed for each location. Since the only site where changes in horizontal alignment are being considered is at the interlock location at 58th Street site, the operational noise and vibration assessment for the that site is discussed separately in Section 5.4.

5.3.2 No-Build Scenario

Under the No-Build Scenario, freight operations are expected to continue with a planned annual growth of 3%. This continued increase in capacity will likely be absorbed through the addition of more cars to each train and will not significantly affect average operating speeds or the frequency of events per day.

This increase in traffic volume will likely result in marginal increases in noise levels along the Corridor.

Since the operating conditions (train type, operating speed and event frequency) will not change, the magnitude and propagation of vibration also is anticipated to stay the same.

5.3.3 Build Scenario

5.3.3.1 Operational Noise Assessment

Under the proposed build scenario, no additional transit sources will be added to the existing ROW. Freight operations are expected to continue without changes to the traffic parameters as identified in Section 5.2.2. The existing track will be lowered 1.5 ft at the proposed track lowering locations and no horizontal shift of the track alignment is anticipated along the Corridor.

For any specific noise-sensitive receiver and as illustrated in Section 5.2.3, the noise exposure from the freight operation is calculated through the following two major steps:

1. Determining the noise sources and the noise exposure at a reference distance of 50 ft based on the operating conditions; and
2. Estimating the noise exposure at distance beyond 50 ft based on the propagation characteristics as shown in Figure 5-4.

---

25 See *Table 6-11* of the FTA Manual

For the Project described in this report, the resultant noise level at a specific receiver before and after the proposed work is estimated to be the same based on the following considerations:

1. **No changes to noise exposure at 50 ft:** due to the fact that no additional noise sources are introduced, and no changes are identified on the traffic parameters as shown in Table 5-5; and
2. **No changes to noise attenuation:** due to the fact that the track alignment is not anticipated to be shifted (horizontally) closer/away from potential receivers.

As discussed in Section 5.1.1, the noise impact criteria for the Project are presented as allowable increase in cumulative noise level between the existing and future conditions. Based on the estimation of the same noise level at a specific receiver before and after the proposed work, a 0-dB increase in cumulative noise level is anticipated and as such a “No Impact” assessment for the Project.

5.3.3.2 Operational Vibration Assessment

Using the FTA guidance (as presented in Section 5.1.2), and considering the existing freight operations as an existing source of ground-borne vibration and ground-borne noise, the vibration impact assessment for the Project was conducted with the existing conditions taken into account.

Based on the flowchart presented in Figure 5-3, and taking into consideration the Project traffic conditions as identified in Table 5-5, a project-specific flowchart was prepared and is presented in Figure 5-6. The project-specific flowchart indicates that two potential outcomes in terms of impact assessment need to be considered:

1. A determination of impacts based on the Standard Vibration Assessment limits identified in Table 5-3 and Table 5-4; or
2. A determination of “No Impact”.

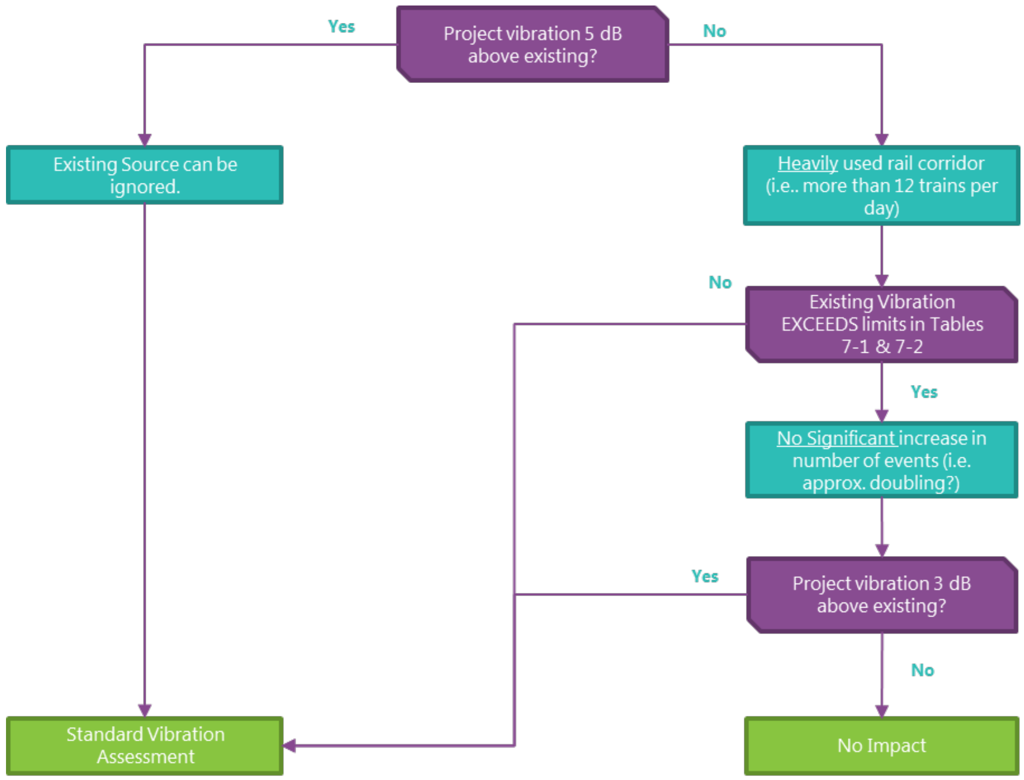


Figure 5-6: Project Scenario when Considering Existing Vibration Conditions

Based on the site description presented in Section 3.0, there are four Project sites where no assessment is warranted. These sites are presented below in Table 5-7 were identified as no changes in horizontal or vertical track alignment were identified and there are no changes to the train operation conditions. Therefore, no assessment was conducted.

Table 5-7: Sites with Proposed Changes not Resulting in Changes in Vibration Levels

Site	Description	Reason
4	North Avenue Bridge, Baltimore, MD	Work relates to bridge modification; the Project will not affect horizontal or vertical alignment of the tracks.
9	Guilford Avenue, Baltimore, MD	Work relates to bridge modification; the Project will not affect horizontal or vertical alignment of the tracks.
12	Harford Road, Baltimore, MD	Work relates to bridge modification; the Project will not affect horizontal or vertical alignment of the tracks.
13	Bayview Rail Yard, Baltimore, MD	No operational changes will occur at the Yard. The yard will only be used for temporary staging and storage.

For the remaining sites, estimated changes in slant distance from the closest receiver to the nearest track centerline were conducted. The corresponding changes in vibration levels, based on the assessment methodology presented in Section 5.2.4, were calculated and are presented in Table 5-8.

Table 5-8: Estimated Changes in Vibration Levels

Site	Location / Name	Minimum Distance to Receivers [1] [ft]	Receiver Terrain Elevation [ft]	Track Elevation [ft]		Change in Vibration Levels [VdB]
				Current ROW	Future ROW	
1	Howard Street Tunnel, Baltimore, MD	33	62	20	18.5	-0.2
2	Mount Royal Avenue Track Lowering, Baltimore, MD	37	106	71	69.5	-0.2
3	MTA Bridge Track Lowering, Baltimore, MD	21	80	80	78.5	< -0.1
5	Sisson Street Track Lowering, Baltimore, MD	85	141	116	114.5	< -0.1
6	Huntington Avenue Track Lowering, Baltimore, MD	148	156	129	127.5	< -0.1
7	Charles Street Track Lowering, Baltimore, MD	100	171	139	137.5	< -0.1
8	St. Paul /Calvert Street Track Lowering, Baltimore, MD	61	170	144	142.5	-0.1
10	Barclay Street Track Lowering, Baltimore, MD	64	179	151	149.5	-0.1
11	Greenmount Avenue Track Lowering, Baltimore, MD	76	185	154	152.5	-0.1
14	Lancaster Avenue Track Lowering, Wilmington, DE	57	133	123	121.5	< -0.1
15	4th Street Track Lowering, Wilmington, DE	59	147	130	128.5	-0.1
16	Chichester Avenue Track Lowering, Boothwyn, PA	65	107	93	91.5	< -0.1
17	Crum Lynne Road Track Lowering, Ridley Park, PA	69	86	65	63.5	-0.1
18	Clifton Avenue Track Lowering, Sharon Hill, PA	91	111	94	92.5	< -0.1
19	Boone Tunnel, Sharon Hill, PA	0	105	82	80.5	-0.4
20	68th Street Track Lowering, Philadelphia, PA	79	65	55	53.5	< -0.1
21	65th Street Track Lowering, Philadelphia, PA	44	79	58	56.5	-0.1
22	Cemetery Avenue Track Lowering, Philadelphia, PA	42	78	58	56.5	-0.1
23	61st Street Track Lowering, Philadelphia, PA	42	81	61	59.5	-0.1
24	Woodland Avenue Track Lowering, Philadelphia, PA	99	84	63	61.5	< -0.1

Note(s):

1. Horizontal distance from receiver to track centerline.

For all the locations identified in Table 5-8, the planned track lowering work results in a marginal increase of the distance between the vibration source (i.e. track) and the nearest receiver. Therefore, as presented in Table 5-8, the vibration level change at the nearest receiver, the proposed track lowering work will either result in no change in vibration levels or will result in a positive change, i.e. reduction of vibration levels, of up to 0.4 VdB.

As such, an individual assessment for each receiver was performed according to the flowchart presented in Figure 5-7 with the expectation of one of the following outcomes:

1. Standard vibration assessment - Existing vibration levels do not exceed the Standard Vibration Assessment criteria. In this case, since the Project vibration is predicted to be less than the existing vibration level, which is below limit, the vibration levels after the Project is completed will remain within the Standard Vibration Assessment limits.
2. No Impact - if existing vibration does exceed criteria.

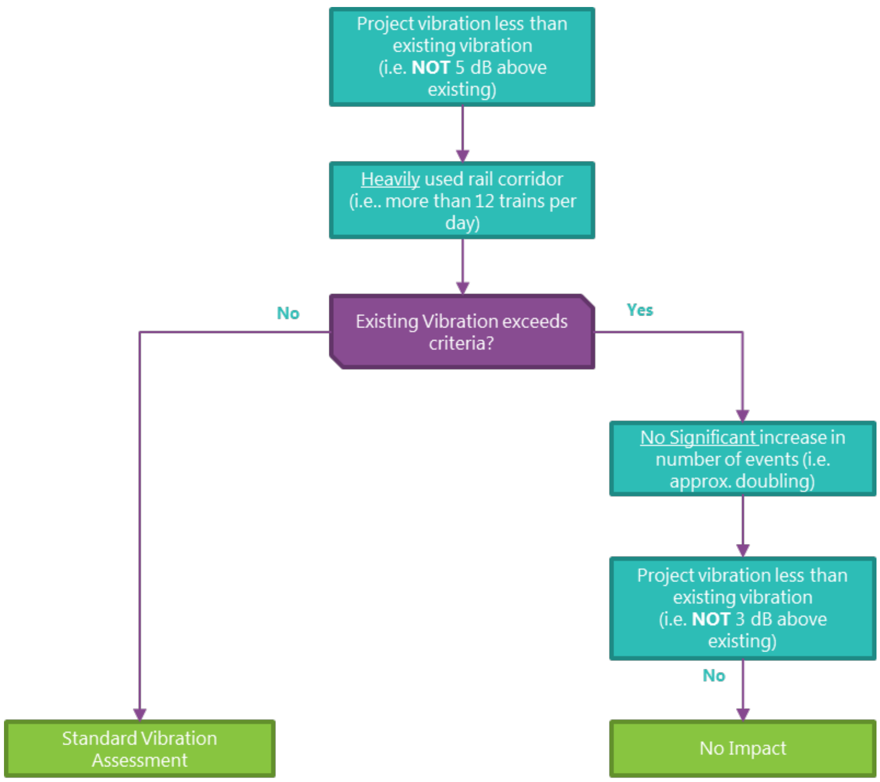


Figure 5-7: Project Scenario for Obstruction Clearance Locations

5.4 Interlocking Location – 58th Street

5.4.1 Introduction

Site #25 (Interlocking Location – 58th Street, Philadelphia, PA), is an existing crossover located just south of S 58th Street, at the northern terminus of the Project in Philadelphia, PA, and will be relocated to an area between Lindbergh Boulevard and the Schuylkill River in Philadelphia, PA.

The Site is divided into two major work areas (see Figure 5-8): Work Area 1 and Work Area 2. The major work associated with each area are listed as follows:

- Work Area 1:

- Installation of a crossover just north of Lindbergh Boulevard;
- Construction of a new track segment of approximately 1,250 ft in extension of the existing double-track layout between Lindbergh Boulevard and the Schuylkill River;
- Installation of a crossover south of the Schuylkill River in replacement of an existing turnout to be retired;
- Alignment adjustment of the 58th Street connector track; and
- Lowering of two main tracks between the new track segment and Grays Avenue.

• Work Area 2:
  - Removal of the existing crossover at 58th street.

5.4.2 No-Build Scenario

Under the No-Build Scenario, freight operations are expected to continue with a planned annual growth of 3%. This continued increase in capacity will likely be absorbed through the addition of more cars to each train and will not significantly affect average operating speeds or the frequency of events per day.

This increase in traffic volume will likely result in marginal increases in noise levels along the Corridor.

Since the operating conditions (train type, operating speed and event frequency) will not change, the magnitude and propagation of vibration also is anticipated to stay the same.

5.4.3 Build Scenario

5.4.3.1 General Description

The crossover is considered a stationary source of noise and vibration of the Project. Its removal from S 58th Street will result in a positive impact – reduction of noise and vibration levels in vicinity of the interlocking.

Given the work to be conducted, changes to the project operation noise and vibration levels are anticipated. Five sensitive receivers have been identified near the site. Figure 5-9 shows the locations of the identified receivers and a summary of changes in track near each receiver is presented in Table 5-9.

Table 5-9: Summary of Changes Nearby Receivers

Work Area	Receiver	Distance to Track [ft]	Changes in Track near Receiver
1	R_25_01	147	Track lowering and addition of new crossover
	R_25_02	325	Track lowering and addition of new crossover
	R_25_03	190	Track lowering and addition of new crossover
	R_25_04	80	Track lowering
2	R_25_05	540	Removal of existing crossover

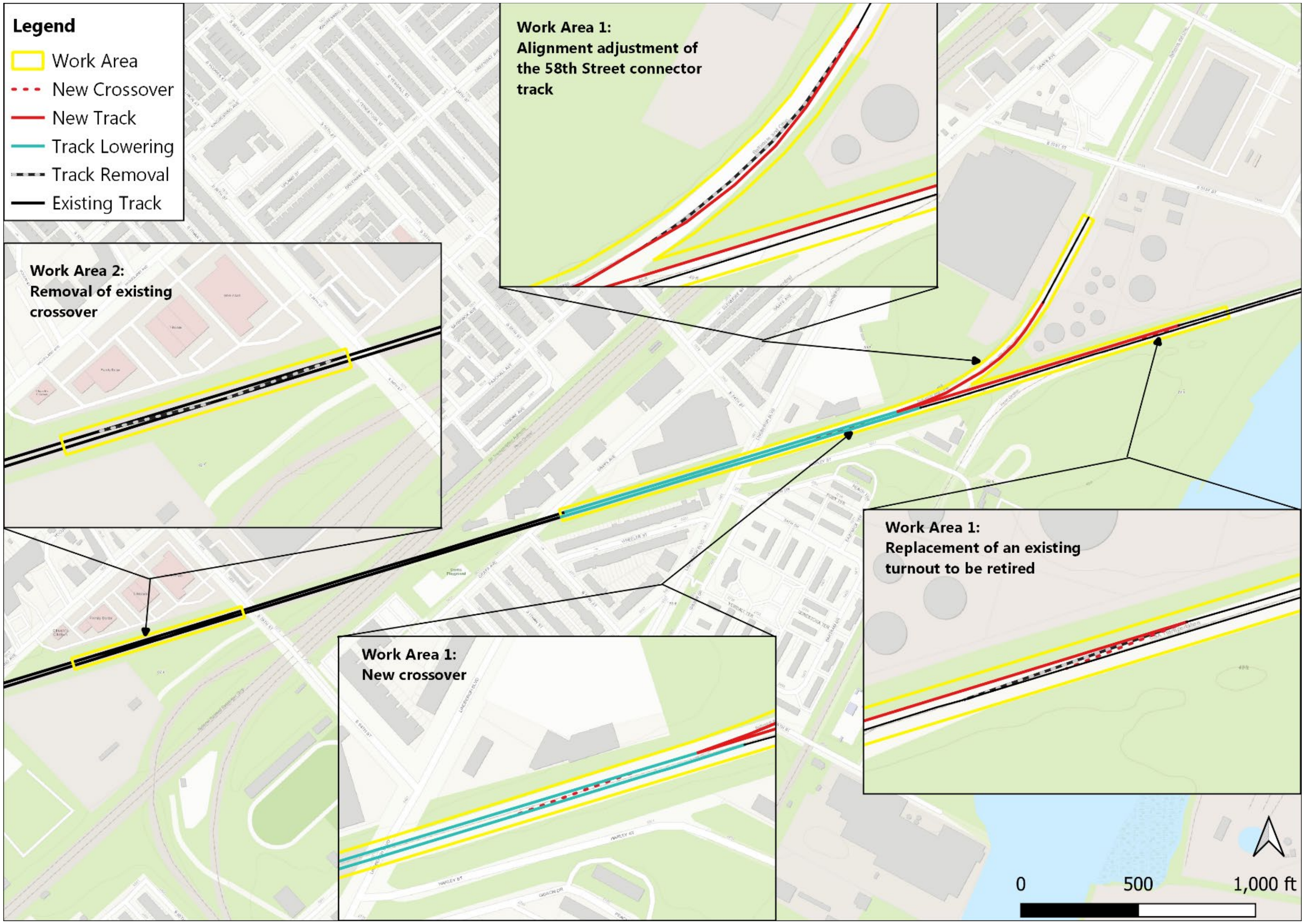
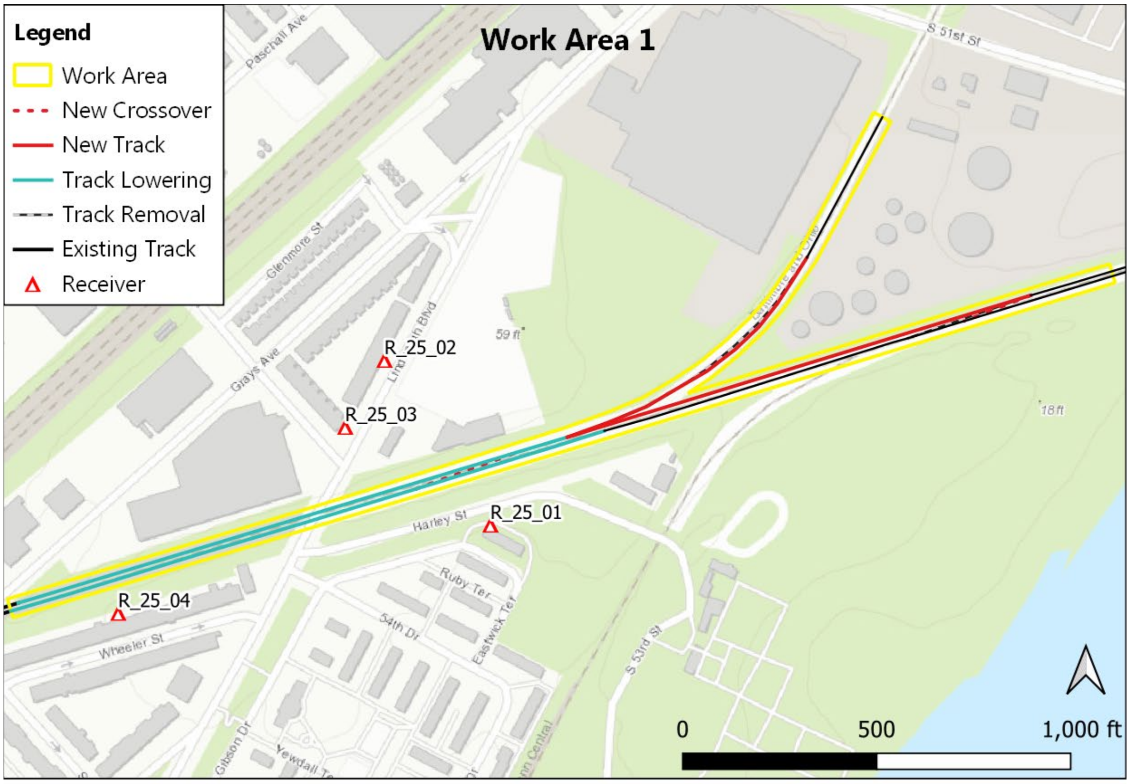


Figure 5-8: Interlocking Location Overview



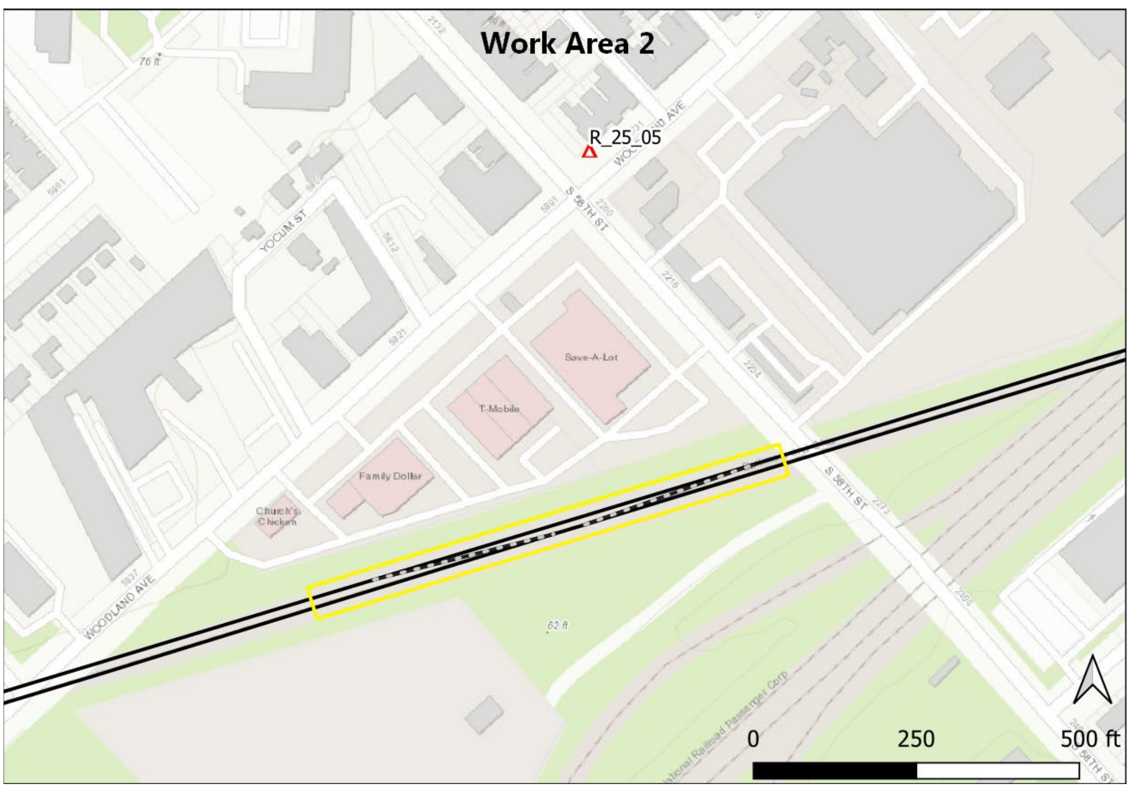


Figure 5-9: Identified Receives Near Site #25

5.4.3.2 Operational Noise Assessment

As discussed in Section 5.1, the operational noise impact criteria are defined as increases in cumulative noise levels between the existing and project conditions. For each receiver identified near Site #25, the operational noise levels was calculated for the existing No-Build Scenario and the future Build Scenario based on the methodologies presented in Section 5.2.

The assessment results are presented in detail in Appendix B and a summary of the impact assessment can be found in Table 5-10. No impacts have been predicted for any of the receivers.

Table 5-10: Interlocking Location (58th Street) – Summary of Noise Impacts

Work Area	Receiver	Distance to Track [ft]	Existing Noise Level [dBA]	Future Noise Level [dBA]	Change in Noise Level [dB]	Impact Assessment [1]
1	R_25_01	147	64	65	1	No Impact
	R_25_02	325	59	59	0	No Impact
	R_25_03	190	62	64	2	No Impact
	R_25_04	80	68	68	0	No Impact
2	R_25_05	540	55	55	0	No Impact

Note(s):

1. Impact assessed based on changes in noise level and FTA Cumulative Noise Impact Criteria.

5.4.3.3 Operational Vibration Assessment

Using the FTA guidance (as presented in Section 5.1.2), and considering the existing operations as an existing source of ground-borne vibration and ground-borne noise, the vibration impact assessment for the Project was conducted with the existing conditions taken into account.

Based on the flowchart presented in Figure 5-3, and taking into consideration the Project traffic conditions as identified in Table 5-5, a project-specific flowchart was prepared and is presented in Figure 5-10. The project-specific flowchart indicates that two potential outcomes in terms of impact assessment need to be considered:

1. A determination of impacts based on the Standard Vibration Assessment limits identified in Table 5-3 and Table 5-4; or
2. A determination of “No Impact”.

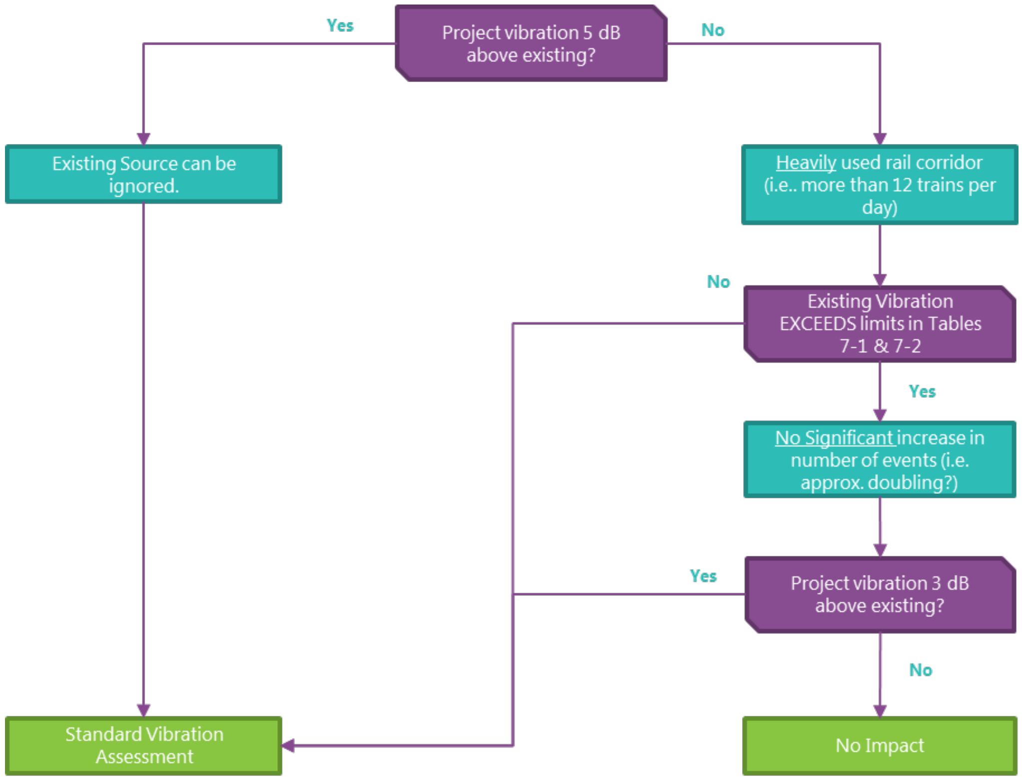


Figure 5-10: Project Scenario when Considering Existing Vibration Conditions

For each receiver identified near Site #25, the operational vibration levels was calculated for the existing No-Build Scenario and the future Build Scenario based on the methodologies presented in Section 5.2.

The assessment results are presented in detail in Appendix B and a summary of the impact assessment can be found in Table 5-11. No impacts have been predicted for any of the receivers.

Table 5-11: Interlocking Location (58th Street) – Summary of Vibration Impacts

Work Area	Receiver	Distance to Track [ft]	Existing Vibration Levels [VdB]	Future Vibration Levels [VdB]	Limit [1] [VdB]	Impacts [2]
1	R_25_01	147	62	67	72	No Impact [3]
	R_25_02	325	61	61	n/a [4]	No Impact [4]
	R_25_03	190	67	67	n/a [4]	No Impact [4]
	R_25_04	80	76	76	n/a [4]	No Impact [4]
2	R_25_05	540	57	57	n/a [4]	No Impact [4]

Note(s):

1. Project limit identified based on receiver land use type and frequency of event as per Table 5-3 and Table 5-4.
2. Impact assessed based on the project-specific flowchart presented in Figure 5-10.
3. The indication of "No Impact" means that the vibration levels are under the Standard Vibration Assessment criteria based on the flowchart of Figure 5-10.
4. Based on the flowchart of Figure 5-10, the use of Standard Vibration Assessment criteria is not applicable and a determination of "No Impact" has been made.

5.5 Summary of Impact Assessment

Based on the assessment results presented in Section 5.3 and Section 5.3.3.2, for noise and vibration respectively, a summary of direct (operational) Impacts is provided in Table 5-12.

Table 5-12: Summary of Direct (Operational) Impacts

Site	Location / Name	Noise	Vibration [1]
1	Howard Street Tunnel, Baltimore, MD	No Impact	No Impact
2	Mount Royal Avenue Track Lowering, Baltimore, MD	No Impact	No Impact
3	MTA Bridge Track Lowering, Baltimore, MD	No Impact	No Impact
4	North Avenue Bridge, Baltimore, MD	No Impact	No Impact
5	Sisson Street Track Lowering, Baltimore, MD	No Impact	No Impact
6	Huntington Avenue Track Lowering, Baltimore, MD	No Impact	No Impact
7	Charles Street Track Lowering, Baltimore, MD	No Impact	No Impact
8	St. Paul /Calvert Street Track Lowering, Baltimore, MD	No Impact	No Impact
9	Guilford Avenue, Baltimore, MD	No Impact	No Impact
10	Barclay Street Track Lowering, Baltimore, MD	No Impact	No Impact
11	Greenmount Avenue Track Lowering, Baltimore, MD	No Impact	No Impact
12	Harford Road, Baltimore, MD	No Impact	No Impact
13	Bayview Rail Yard, Baltimore, MD	No Impact	No Impact
14	Lancaster Avenue Track Lowering, Wilmington, DE	No Impact	No Impact
15	4th Street Track Lowering, Wilmington, DE	No Impact	No Impact
16	Chichester Avenue Track Lowering, Boothwyn, PA	No Impact	No Impact
17	Crum Lynne Road Track Lowering, Ridley Park, PA	No Impact	No Impact
18	Clifton Avenue Track Lowering, Sharon Hill, PA	No Impact	No Impact

Site	Location / Name	Noise	Vibration [1]
19	Boone Tunnel, Sharon Hill, PA	No Impact	No Impact
20	68th Street Track Lowering, Philadelphia, PA	No Impact	No Impact
21	65th Street Track Lowering, Philadelphia, PA	No Impact	No Impact
22	Cemetery Avenue Track Lowering, Philadelphia, PA	No Impact	No Impact
23	61st Street Track Lowering, Philadelphia, PA	No Impact	No Impact
24	Woodland Avenue Track Lowering, Philadelphia, PA	No Impact	No Impact
25	Interlocking Location – 58th Street, Philadelphia, PA	No Impact	No Impact

Note(s):

1. In the case of vibration levels, the indication of "No Impact" means that the vibration levels are either under the Standard Vibration Assessment criteria or a determination of "No Impact" has been made based on the flowchart of Figure 5-7.

Taking into consideration the assessment results presented above it can be stated that the Project will not result in noise nor vibration related direct (operational) impacts.

6.0 CONSTRUCTION ASSESSMENT

6.1 Construction Criteria

6.1.1 Introduction

The FTA Manual presents criteria for construction noise and vibration. However, the FTA Manual (*Section 7.1*) notes the following regarding the criteria presented in the Manual:

> *"While it is not the purpose of this manual to specify standardized criteria for construction noise impact, the following guidelines can be considered reasonable criteria for assessment. If these criteria are exceeded, there may be adverse community reaction."*

As such, criteria in the FTA Manual should be viewed as a first approach to determine whether or not an adverse community reaction may be expected from the Project. Project specific criteria need to be developed based on a combination of sources of references, which may include local ordinances. However, be the FTA Manual recognizes, when setting site-specific criteria that local ordinances may not be the most appropriate for evaluating construction impacts as noted in *Section 7.0*:

> *"Generally, local noise ordinances are not very useful for evaluating construction noise impact. They usually relate to nuisance and hours of allowed activity, and sometimes specify limits in terms of maximum levels, but are generally not practical for assessing the impact of a construction project."*

A review of local and state regulations was conducted. Based on the reviewed documentation [4] [5] [6] [7] [8], the overview leads to a similar conclusion as stated in the FTA Manual, where generally these documents are not applicable to the evaluation of construction noise and vibration impacts. For instance the Baltimore City Code [4] has an exception for railroad facilities (§102.11) while others are general prohibitions in terms of hours of allowed activity. As such, the criteria identified in the following sections are considered to be appropriate for the Assessment conducted in this report to identify potential risks.

6.1.2 Construction Noise

The FTA Manual defines two options of assessment for a Quantitative Construction Noise Assessment. The first option, a general assessment of construction noise, is appropriate for projects in an early assessment stage when the equipment roster and schedule are undefined and only a rough estimate of construction noise levels is practical. The second option is a detailed analysis which accounts for information from a more detailed schedule such as the percentage of time of usage for each piece of equipment.

A general assessment of construction noise was considered for the Project. The assessment was based on the combined noise levels, from the two noisiest pieces of equipment that could be used on the Project, under the assumption that they operate at the same time and location.

The criteria for the general assessment are identified in Table 6-1 which represent noise levels that are not to be exceeded.

Table 6-1: General Assessment Construction Noise Criteria[26]

Land Use	$L_{eq,equip(1hr)}$ (dBA)	
	Day	Night
Residential	90	80
Commercial	100	100
Industrial	100	100

6.1.3 Construction Vibration

During construction activities vibrations from construction equipment are expected. These vibrations may be perceptible at some receptor locations. However, since perceptible vibrations from construction are typically short-term and reversible, the focus of a vibration assessment is typically constrained to potential irreversible building/structural damage, due to expected vibration levels. The limits for building/structural damage are much greater than those for human perception.

The FTA Manual defines the limits for potential damages in structures due to construction vibrations. These limits are identified in Table 6-2.

Table 6-2: Vibration Limits for Damage due to Construction Activities [27]

Building Category	PPV [1] [in/sec]
I. Reinforced concrete, steel or timber (no plaster)	0.50
II. Engineered concrete and masonry (no plaster)	0.30
III. Non-engineered timber and masonry buildings	0.20
IV. Buildings extremely susceptible to vibrations damages	0.12

Note(s):

1. PPV – Peak Particle Velocity.

6.2 Methodology

6.2.1 General Description

During the Project construction, noise and vibration will be produced by the operation of heavy-duty equipment and various other construction activities. Noise levels generated by construction activities depend on a series of variables, including the number and type of pieces of equipment, their general condition of operation, the amount of time each piece operates per day, the presence of any noise attenuating features (e.g. walls, berms) and the location of the construction activities relative to the receivers. The majority of these variables are traditionally left to the discretion of the contractor which makes it difficult to accurately estimate levels of construction noise. Therefore, a professional judgment for the likely means and methods that would be used by the contractor was used. Some construction activities and use of some equipment may result in vibrations levels which could pose potential damage to surrounding

26 Reproduced from *Table 7-2* of the FTA Manual.
27 Reproduced from *Table 7-5* of the FTA Manual.

buildings, depending on the distance from the construction activity to the building. Activities such as pavement breaking and the use of tracked vehicles (e.g., bulldozers) can generate higher ground borne vibration levels. These types of construction activities are anticipated for the Project, e.g. bridge modification is expected at three sites where the use of hydraulic breaker, bulldozer and vibratory roller will likely be required.

6.2.2 Construction Noise

This section describes the methodology for conducting a Quantitative Construction Noise Assessment as described in *Section 7.1* of the FTA Manual.

The FTA Manual provides the following equation for prediction of construction noise impact for major transit projects:

$$L_{eq,equip} = L_{emission} + 10\log\left(Adj_{Usage}\right) - 20\log\left(\frac{D}{50}\right) - 10\,G\log\left(\frac{D}{50}\right)$$

Where:

- $L_{eq,equip}$ = $L_{eq(t)}$ at a receiver from the operation of a single piece of equipment over a specified time period, dBA
- $L_{emission}$ = noise emission level of the particular piece of equipment at the reference distance of 50 ft, dBA
- Adj_{Usage} = usage factor to account for the fraction of time that the equipment is in use over the specified time period
- D = distance from the receiver to the piece of equipment, ft
- G = a constant that accounts for topography and ground effects

For a general assessment of construction noise, the following considerations are taken for the parameters defined in the equation above:

- $L_{emission}$ is determined based on the reference levels provided in the FTA Manual[28]
- Adj_{Usage} is assumed to be 1, indicating a time period of one-hour with full power operation of the equipment
- D is measured from the centerline of the track
- G is assumed to be 0, indicating free-field conditions and ignoring ground effects

The $L_{eq,equip}$ is determined for the two noisiest pieces of equipment expected to be used in each phase of construction. The logarithmic summation of the levels is then used for comparison with the applicable criteria.

6.2.3 Construction Vibration

This section describes the methodology for conducting a Quantitative Construction Vibration Assessment as described in the FTA Manual[29].

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28 See *Table 7-1* of the FTA Manual.
29 See *Section 7.2* of the FTA Manual.

The FTA Manual provides the following equation for prediction of construction vibration impact to assess building damage. The assessment is conducted in terms of peak particle velocity (PPV):

$$PPV_{equip} = PPV_{ref} \times \left(\frac{25}{D}\right)^{1.5}$$

Where:

- PPV_{equip} = the peak particle velocity of the equipment adjusted for distance, in/sec
- PPV_{ref} = the source reference vibration level at 25 ft, in/sec
- D = distance from the equipment to the receiver, ft

The FTA Manual provides a list of vibration source levels[30] (PPV_{ref}) for various types of construction equipment at a reference distance of 25 ft. The PPV_{equip} is determined for each piece of equipment individually and compared with the applicable criteria.

6.3 General Sites

6.3.1 Introduction

This section describes the construction noise and vibration assessments conducted for the individual work areas comprising the overall project based on the type of construction work identified for each location. Since a combination of conventional and non-conventional methods of construction are being considered for the HST Tunnel site, the construction noise and vibration assessments for the HST Tunnel site is discussed separately in Section 6.4.

6.3.2 Construction Noise Assessment

6.3.2.1 Predicted Zone of Influence

Table 6-3 below summarizes the equipment anticipated to be used as part of the construction activities along with the equipment's noise characteristics relative to the four (4) general types of work that will comprise the project. The noise characteristics presented in the table below were taken from either the FTA Manual[31] or the FHWA Highway Construction Handbook [9].

30 See *Table 7-4* of the FTA Manual.
31 See *Table 7-1* of the FTA Manual.

Table 6-3: Expected Construction Equipment and Corresponding Noise Emission Levels

Equipment	Typical Noise Level 50 ft from Source [dBA]	Type of Proposed Work			
		Track Lowering	Bridge Modification	Temporary Storage and Staging	Interlocking Relocation
Air Compressor	80	Y	Y	Y	Y
Backhoe	80	Y	Y	Y	Y
Crane, Mobile	83	Y	Y	Y	Y
Concrete Mixer	85	- [1]	Y	- [1]	- [1]
Concrete Pump	82	- [1]	Y	- [1]	- [1]
Dozer	85	Y	Y	Y	Y
Generator	82	Y	Y	Y	Y
Loader	80	Y	Y	Y	Y
Pile Driver (sonic)	95	- [1]	Y [2]	- [1]	- [1]
Roller	85	- [1]	Y	- [1]	- [1]
Spike Driver	77	Y	- [1]	- [1]	Y
Tie Cutter	84	Y	- [1]	- [1]	Y
Tie Handler	80	Y	- [1]	- [1]	Y
Tie Inserter	85	Y	- [1]	- [1]	Y
Truck	84	Y	Y	Y	Y
Hydraulic Breaker	90	- [1]	Y	- [1]	- [1]

Note(s):

1. Not expected to be used for the identified type of work.
2. Pile driver is expected to be used for the Guilford Avenue site only.

Following the general construction noise assessment methodology described in the FTA Manual, for each of the four types of construction work, the combined noise level in one hour from the two noisiest classes of construction equipment anticipated for the construction work was evaluated. The Zone of Influence (ZOI) for various land uses as defined in Table 6-1 was calculated based on the identified criteria.

Table 6-4 shows the ZOI setback distance for each of the construction conditions. For all types of construction work except for bridge modification, the ZOIs for Commercial and Industrial land uses are not expected to extend beyond the ROW.

Table 6-4: Construction Noise Zone of Influence

Type of Work	Land Use	Distance to Impact (measured from corridor centerline) [ft]	
		Day	Night
Track Lowering	Residential	40	126
	Commercial	-[1]	-[1]
	Industrial	-[1]	-[1]
Bridge Modification[2]	Residential	93	295
	Commercial	29	29
	Industrial	29	29
Temporary Storage and Staging[3]	Residential	38	119
	Commercial	-[1]	-[1]
	Industrial	-[1]	-[1]
Interlocking Relocation	Residential	40	126
	Commercial	-[1]	-[1]
	Industrial	-[1]	-[1]

Note(s):

1. The ZOI does not extend beyond the ROW based an assumption of typical railroad ROW width of 50 ft.
2. For bridge modification, the ZOI is considered to extend from the work zone of the site. The ZOI listed represent the maximum setback distance of the three sites identified with bridge modification work.
3. For temporary storage and staging at the Bayview Rail Yard, the ZOI is measured from the area outlined in Table 3-2 .

6.3.2.2 Identified Sensitive Receiver

As indicated in Section 6.3.2.1, the Project construction is not expected to cause noise impacts for Commercial and Industrial land uses other than at the bridge modification sites. Based on an overview of the aerial map at each site (see Appendix C), the construction noise impacts have been summarized in Table 6-5 which lists the number of buildings that are located within the ZOI.

Table 6-5: Summary of Construction Noise Impacts

Site	Location / Name	Number of Buildings within ZOI	
		Daytime Construction	Nighttime Construction
2	Mount Royal Avenue Track Lowering, Baltimore, MD	0	1
3	MTA Bridge Track Lowering, Baltimore, MD	1	2
4	North Avenue Bridge, Baltimore, MD	0	0
5	Sisson Street Track Lowering, Baltimore, MD	0	2
6	Huntington Avenue Track Lowering, Baltimore, MD	0	0
7	Charles Street Track Lowering, Baltimore, MD	0	20
8	St. Paul /Calvert Street Track Lowering, Baltimore, MD	0	15
9	Guilford Avenue, Baltimore, MD	12	87
10	Barclay Street Track Lowering, Baltimore, MD	0	31
11	Greenmount Avenue Track Lowering, Baltimore, MD	0	20
12	Harford Road, Baltimore, MD	5	21
13	Bayview Rail Yard, Baltimore, MD	0	0
14	Lancaster Avenue Track Lowering, Wilmington, DE	0	6
15	4th Street Track Lowering, Wilmington, DE	0	13
16	Chichester Avenue Track Lowering, Boothwyn, PA	0	7
17	Crum Lynne Road Track Lowering, Ridley Park, PA	0	11
18	Clifton Avenue Track Lowering, Sharon Hill, PA	0	10
19	Boone Tunnel, Sharon Hill, PA	0	35
20	68th Street Track Lowering, Philadelphia, PA	0	19
21	65th Street Track Lowering, Philadelphia, PA	0	69
22	Cemetery Avenue Track Lowering, Philadelphia, PA	0	17
23	61st Street Track Lowering, Philadelphia, PA	0	19
24	Woodland Avenue Track Lowering, Philadelphia, PA	0	1
25	Interlocking Location – 58th Street, Philadelphia, PA	0	35

6.3.3 Construction Vibration Assessment

6.3.3.1 Predicted Zone of Influence

Table 6-6 shows the anticipated pieces of construction equipment, which represent significant vibration sources, with respect to each type of proposed work. The vibration source levels at 25 ft in terms of peak particle velocity (PPV) values are included in the table as well. The levels presented are the same as the values presented in the FTA Manual[32] or the Transportation and Construction Vibration Guidance Manual (CALTRANS Manual)[33] [10].

Table 6-6: Expected Construction Equipment and Corresponding Vibration Source Levels

Equipment	PPV at 25 ft from Source [in/sec]	Type of Proposed Work	
		Bridge Modification	Track Lowering or Interlocking Relocation or Temporary Storage and Staging
Caisson Drilling	0.089	Y	- [2]
Large Bulldozer	0.089	Y	Y
Loaded Trucks	0.076	Y	Y
Hydraulic Breaker	0.240 [1]	Y	- [2]
Pile Driver (sonic)	0.170	Y [3]	- [2]

Note(s):

1. Value obtained from CALTRANS Manual.
2. Not expected to be used for the identified type of work.
3. Pile driver is expected to be used for the Guilford Avenue site only.

Following the general construction vibration assessment methodology described in the FTA Manual and Section 6.2.3, the ZOI for each piece of equipment identified in Table 6-6 was calculated for the building categories defined in Table 6-2. The results are shown in Table 6-7.

32 See *Table 7-4* of the FTA Manual.
33 See *Chapter 7* of the CALTRANS Manual.

Table 6-7: Calculated Vibration Zone of Influence for Construction Equipment

Equipment	Distance to Impact per Building Category [1] (measured from work area boundary) [ft]			
	I	II	III	IV
Caisson Drilling	8	11	15	20
Large Bulldozer	8	11	15	20
Loaded Trucks	7	10	13	18
Hydraulic Breaker [2]	15	22	28	40
Pile Driver (sonic)	12	17	22	32

Note(s):

1. Building category as defined in Table 6-2 as:
   Cat. I. – Reinforced concrete, steel or timber (no plaster)
   Cat. II. – Engineered concrete and masonry (no plaster)
   Cat. III. – Non-engineered timber and masonry buildings
   Cat. IV. – Buildings extremely susceptible to vibrations damages
2. The ZOI for hydraulic breaker was calculated using the methodology described.in CALTRANS Manual based on equipment with a rated energy level of 5,000 ft-lbs, and the vibration attenuation rate is represented with an "n"-value of 1.5 which is consistent with the FTA methodology.

Based on the expected usage of equipment for each type of proposed work, the ZOI for construction vibration impacts has been summarized in Table 6-8.

Table 6-8: Construction Vibration Zone of Influence

Type of Proposed Work	Distance to Impact per Building Category [1] (measured from work area boundary) [ft]			
	I	II	III	IV
Track Lowering	8	11	15	20
Bridge Modification	15	22	28	40
Temporary Storage and Staging	8	11	15	20
Interlocking Relocation	8	11	15	20

Note(s):

1. Building category as defined in Table 6-2 as:
   Cat. I. - Reinforced concrete, steel or timber (no plaster)
   Cat. II. - Engineered concrete and masonry (no plaster)
   Cat. III. - Non-engineered timber and masonry buildings
   Cat. IV. - Buildings extremely susceptible to vibrations damages

6.3.3.2 Historic Buildings

A review of the list of historic buildings[34] within proximity to the general sites of the Project has been conducted. Two historical properties, the Mount Royal Station has been found near the Mount Royal Avenue

34 For the purposes of this assessment, "Historic Buildings" or "Historic Property" refers to those listed or eligible for listing in the National Register of Historic Places (NHRP) located within the Section 106 Area of Potential Effects (APE).

site and the Canon Shoe Company (Fox Building) has been found near the MTA Bridge site. The anticipated construction vibration impact at these locations were assessed in terms of PPV level.

The distance between the Mount Royal Station and the boundary of the construction work area is approximately 30 ft. Based on the methodology presented in Section 6.2.3, the resultant PPV was calculated to be 0.07 in/s, which is below the limit of 0.12 in/s identified for this type of structures (i.e. Building Category IV[35]).

The distance between the Canon Shoe Company building and the boundary of the construction work area is approximately 9 ft. Based on the methodology presented in Section 6.2.3, the resultant PPV was calculated to be 0.38 in/s, which is above the limit of 0.30 in/s identified for this type of structures (i.e. Building Category II[36]).

6.3.3.3 Identified Sensitive Receiver

Taking into account the results presented in Table 6-8, a review of the aerial map at each site (see Appendix C) was conducted. Potential impacts from the construction vibration were identified at six (6) sites, the MTA Bridge, Guilford Avenue, Harford Road, Lancaster Avenue, Boone Tunnel and Cemetery Avenue sites, as summarized below in Table 6-9.

Table 6-9: Summary of Construction Vibration Impacts

Site	Location / Name	Number of Buildings within ZOI per Category [1]			
		I	II	III	IV
2	Mount Royal Avenue Track Lowering, Baltimore, MD	0	0	0	0
3	MTA Bridge Track Lowering, Baltimore, MD	0	1	0	0
4	North Avenue Bridge, Baltimore, MD	0	0	0	0
5	Sisson Street Track Lowering, Baltimore, MD	0	0	0	0
6	Huntington Avenue Track Lowering, Baltimore, MD	0	0	0	0
7	Charles Street Track Lowering, Baltimore, MD	0	0	0	0
8	St. Paul /Calvert Street Track Lowering, Baltimore, MD	0	0	0	0
9	Guilford Avenue, Baltimore, MD	0	0	7	0
10	Barclay Street Track Lowering, Baltimore, MD	0	0	0	0
11	Greenmount Avenue Track Lowering, Baltimore, MD	0	0	0	0
12	Harford Road, Baltimore, MD	0	0	4	0
13	Bayview Rail Yard, Baltimore, MD	0	0	0	0
14	Lancaster Avenue Track Lowering, Wilmington, DE	0	0	1	0
15	4th Street Track Lowering, Wilmington, DE	0	0	0	0
16	Chichester Avenue Track Lowering, Boothwyn, PA	0	0	0	0
17	Crum Lynne Road Track Lowering, Ridley Park, PA	0	0	0	0
18	Clifton Avenue Track Lowering, Sharon Hill, PA	0	0	0	0

35 Building Category IV – Buildings extremely susceptible to vibrations damages
36 Building Category II – Engineered concrete and masonry (no plaster)

Site	Location / Name	Number of Buildings within ZOI per Category [1]			
		I	II	III	IV
19	Boone Tunnel, Sharon Hill, PA [2]	0	0	7	0
20	68th Street Track Lowering, Philadelphia, PA	0	0	0	0
21	65th Street Track Lowering, Philadelphia, PA	0	0	0	0
22	Cemetery Avenue Track Lowering, Philadelphia, PA	0	0	1	0
23	61st Street Track Lowering, Philadelphia, PA	0	0	0	0
24	Woodland Avenue Track Lowering, Philadelphia, PA	0	0	0	0
25	Interlocking Location – 58th Street, Philadelphia, PA	0	0	0	0

Note(s):

1. Building category as defined in Table 6-2 as:
   Cat. I. - Reinforced concrete, steel or timber (no plaster)
   Cat. II. - Engineered concrete and masonry (no plaster)
   Cat. III. - Non-engineered timber and masonry buildings
   Cat. IV. - Buildings extremely susceptible to vibrations damages
2. For the Boone Tunnel site, a projection of the ZOI at ground level was conducted which accounted for the terrain elevation difference between the track and surrounding buildings for each track interval (approximately 100 ft in length). A 5-ft structure depth of the receiver building was also included in the projection which is applicable for typical slab -on-grade buildings.

6.4 Howard Street Tunnel

6.4.1 Introduction

The HST in Baltimore, Maryland extends for 8,700 ft from the West Portal located at STA. 87+00 and the East Portal located at STA. 0+00 – see Figure 6-1. The HST is composed of three distinct sections:

- Concrete Box Section – extending approximately 1,360 ft from the West Portal;
- Cut & Cover Section – extending approximately 1,140 ft from terminus of the Concrete Box Section; and
- Mined Section – extending approximately 6,200 ft from terminus of the Cut & Cover Section to East Portal.

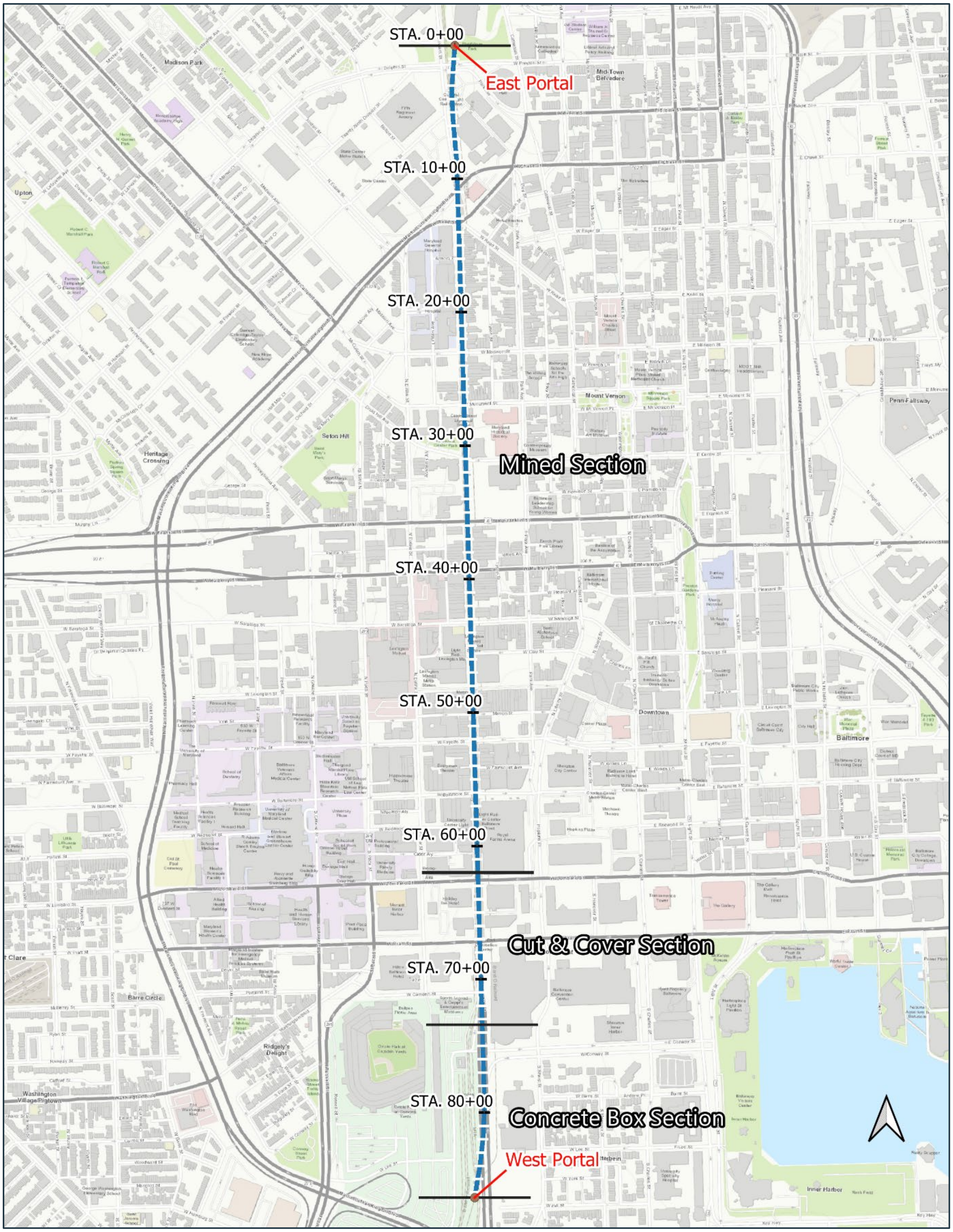

Figure 6-1: Howard Street Tunnel Sections

6.4.2 Construction Methods

The method of construction to be used to create the clearance along the HST have has not yet been finalized. A conventional and a non-conventional approach are being considered, with a feasibility study to evaluate the non-conventional approach currently in process.

The methods identified so far are presented in Table 6-10. For each method considered a description of the construction methodology is presented in high-level terms.

Table 6-10: HST – Construction Methods Under Consideration

Section	Conventional Approach	Non-Conventional Approach
Mined Section	Track lowering, invert modification (cutting), arch modification (notching) (STA. 0+00 – 52+50)	Tunnel Enlargement System (TES) (STA. 0+00 – 60+00)
Cut & Cover Section	Removing and replacing existing invert and lowering track (STA. 52+50 – 73+30) [1]	Cut and cover construction from roadway (STA. 60+00 – 73+30) [1]
Concrete Box Section	Track undercutting (STA. 73+30 – 87+00)	Track undercutting (STA. 73+30 – 87+00)

Note(s):

1. The identified construction method applies to the Cut &Cover Section and part of the Mined Section.

6.4.3 Anticipated Equipment List

Table 6-11 below summarizes the equipment anticipated to be used at the HST work area relative to the three tunnel sections within the work area. The listed equipment is considered to be applicable for both construction methods under consideration based on the type of construction work to be performed. The noise characteristics of the equipment are also included in the table and the noise emission levels presented are the same as the values presented in the FTA Manual[37] or the FHWA Highway Construction Handbook [9].

Table 6-11: HST – Expected Construction Equipment and Corresponding Noise Emission Levels

Equipment	Typical Noise Level 50 ft from Source [dBA]	Tunnel Section		
		Mined Section	Cut & Cover Section	Concrete Box Section
Air Compressor	80	Y	Y	Y
Backhoe	80	Y	Y	Y
Crane, Mobile	83	Y	Y	Y
Concrete Mixer	85	Y	Y [1]	- [2]

37 See *Table 7-1* of the FTA Manual.

Equipment	Typical Noise Level 50 ft from Source [dBA]	Tunnel Section		
		Mined Section	Cut & Cover Section	Concrete Box Section
Concrete Pump	82	Y	Y [1]	- [2]
Dozer	85	Y	Y	Y
Generator	82	Y	Y	Y
Loader	80	Y	Y	Y
Spike Driver	77	Y [2]	Y [2]	Y
Tie Cutter	84	Y [2]	Y [2]	Y
Tie Handler	80	Y [2]	Y [2]	Y
Tie Inserter	85	Y [2]	Y [2]	Y
Truck	84	Y	Y	Y
Roller	85	Y	Y	Y
Hydraulic Breaker	90	Y	Y	- [3]

Note(s):

1. To be used only on non-conventional method described in Section 6.4.2.
2. To be used only on the conventional approach.
3. Not expected to be used for the identified section.

Table 6-12: HST – Expected Construction Equipment and Corresponding Vibration Source Levels

Equipment	PPV at 25 ft from Source [in/sec]	Tunnel Section		
		Mined Section	Cut & Cover Section	Concrete Box Section
Large Bulldozer	0.089	Y	Y	Y
Loaded Trucks	0.076	Y	Y	Y
Hydraulic Breaker	0.240 [1]	Y	Y	- [2]
Caisson Drilling	0.089	- [2]	Y [3]	- [2]

Note(s):

1. Value obtained from CALTRANS Manual.
2. Not expected to be used for the identified section.
3. To be used only on non-conventional method described in Section 6.4.2

6.4.4 Conventional Approach

6.4.4.1 Noise Assessment

The equipment anticipated to be used for the HST site with the conventional construction approach is listed in Table 6-11. The assessment was conducted based on the general construction noise assessment methodology described in the FTA Manual and Section 5.2.3.

For construction on the HST, noise impacts are only expected to occur at the East and West Portal areas. Table 6-13 lists the noise ZOI calculated for these areas. The ZOIs for Commercial and Industrial land uses are not expected to extend beyond the ROW.

Aerial maps can be found in Appendix E which present the extent of construction noise ZOI at the HST site. No impacts were identified from construction activities during daytime nor nighttime.

Table 6-13: HST – Construction Noise Zone of Influence (Conventional Approach)

Area of Work	Land Use	Distance to Impact (measured from corridor centerline) [ft]	
		Day	Night
East Portal	Residential	57	181
	Commercial	- [1]	- [1]
	Industrial	- [1]	- [1]
West Portal	Residential	40	126
	Commercial	- [1]	- [1]
	Industrial	- [1]	- [1]

Note(s):

1. The ZOI does not extend beyond the ROW based an assumption of typical railroad ROW width of 50 ft.

6.4.4.2 Vibration Assessment

Based on the expected usage of equipment for each tunnel section, the ZOI for construction vibration impacts at the HST site has been summarized in Table 6-14.

Table 6-14: HST – Construction Vibration ZOI (Conventional Approach)

Tunnel Section	Distance to Impact per Building Category [1] [ft]			
	I	II	III	IV
Mined Section [2]	15	22	28	40
Cut & Cover Section [3]	15	22	28	40
Concrete Box Section [3]	8	11	15	20

Note(s):

1. Building category as defined in Table 6-2 as:
   Cat. I. - Reinforced concrete, steel or timber (no plaster)
   Cat. II. - Engineered concrete and masonry (no plaster)
   Cat. III. - Non-engineered timber and masonry buildings
   Cat. IV. - Buildings extremely susceptible to vibrations damages
2. Based on the type of construction method identified, the ZOI for the Mined Section is measured from tunnel arch.
3. Based on the type of construction method identified, the ZOIs for the Cut & Cover Section and Concrete Box Section are measured from the work area boundary at track level.

The results presented in Table 6-14 are slant[38] distances measured from the tunnel section to impact contours. A projection of the ZOI at ground level was conducted and the results are presented in a series of aerial maps in Appendix E. The projected ZOI accounts for tunnel coverage for each tunnel interval (approximately 100 ft in length) which was determined with respect to track stationing and based on the track profile (see Appendix D). A 5-ft structure depth of the receiver building[39] was also included in the projection which is applicable for typical slab-on-grade buildings.

Based on a review of projected ZOI at ground level a summary of impacts is presented in Table 6-15. No building is expected to be located within the ZOI.

38 Slant distance refers to the distance measured from point of reception to source of vibration, including changes in elevation – i.e. diagonal distances.
39 A 5-ft structure depth indicates that the point of reception is 5 ft below grade level at the receiver building location.

Table 6-15: HST – Construction Vibration Summary of Impacts (Conventional Approach)

Tunnel Section	Number of Buildings Within the ZOI [1]			
	I	II	III	IV
Mined Section	0	0	0	0
Cut & Cover Section	0	0	0	0
Concrete Box Section	0	0	0	0

Note(s):

1. Building category as defined in Table 6-2 as:
   Cat. I. - Reinforced concrete, steel or timber (no plaster)
   Cat. II. - Engineered concrete and masonry (no plaster)
   Cat. III. - Non-engineered timber and masonry buildings
   Cat. IV. - Buildings extremely susceptible to vibrations damages

6.4.4.3 Vibration Assessment for Historic Buildings

A search of historic buildings within proximity to the HST site has been conducted and seven (7) historic buildings were found along the HST. Based on the methodology presented in Section 6.2.3, the anticipated construction vibration impacts at the identified historic buildings are presented in Table 6-16 in terms of PPV levels.

Table 6-16: HST – Summary of Impacts at Historic Buildings (Conventional Approach)

Historical Building along Howard Street Tunnel	Estimated PPV at Point of Reception [in/s]
Camden Station, 301 West Camden Street, Baltimore, MD	0.08
Wilkens-Robins Building, 308-314 West Pratt Street, Baltimore, MD	0.03
Rombro Building, 22-24 South. Howard Street, Baltimore, MD	0.17
2-6 North Howard & 302 West Baltimore Street, Baltimore, MD	0.14
304 West Baltimore Street, Baltimore, MD	0.04
Siegel, Rothschild & Co. Umbrella Factory, 220-228 West Baltimore Street (1 North Howard Street), Baltimore, MD	0.11
New Howard Hotel, 8 North Howard Street, Baltimore, MD	0.14

Based on a review of publicly available imageries, these historic buildings are identified to fall under "Building Category III: Non-engineered timber and masonry buildings". The limit identified for this type of structure is 0.2 in/s and the resultant PPV was calculated to be below the limit for all seven buildings. The results are consistent with the numbers presented in Table 6-15.

6.4.5 Non-Conventional Approach

6.4.5.1 Noise Assessment

The equipment anticipated to be used for the HST site with the alternative construction approach is listed in Table 6-11. In addition to the noise impacts expected at the East and West Portal areas, as have been previously discussed for the Conventional Approach (see Section 6.4.4.1), noise impacts are also expected to occur along the section of tunnel where a cut and cover construction method will be used from approximately 250 ft north of South Howard Street & West Conway Street to approximately 250 ft north of South Howard Street & West Lombard Street (STA. 60+00 – 73+30).

This construction method will involve excavation, from ground surface, to the existing tunnel structure and the replacement of a new tunnel structure. As such in this case noise impacts may occur in proximity of this section.

Table 6-17 shows the ZOI setback distance for each of the areas of concern. The ZOIs for Commercial and Industrial land uses are not expected to extend beyond the ROW. Aerial maps can be found in Appendix F which present the extent of construction noise ZOI at the HST site. Noise impacts were identified for three hotels buildings, from construction activities during daytime and nighttime.

Table 6-17: HST – Construction Noise Zone of Influence (Alternative Non-Conventional Approach)

Area of Work	Land Use	Distance to Impact (measured from corridor centerline) [ft]	
		Day	Night
East Portal	Residential	57	181
	Commercial	- [1]	- [1]
	Industrial	- [1]	- [1]
Cur & Cover Section	Residential	57	181
	Commercial	- [1]	- [1]
	Industrial	- [1]	- [1]
West Portal	Residential	40	126
	Commercial	- [1]	- [1]
	Industrial	- [1]	- [1]

Note(s):
1. The ZOI does not extend beyond the ROW based an assumption of typical railroad ROW width of 50 ft.

6.4.5.2 Vibration Assessment

Based on the expected usage of equipment for each tunnel section, the ZOI for construction vibration impacts at the HST site has been summarized in Table 6-18.

Table 6-18: HST – Construction Vibration ZOI for Howard Street Tunnel (Non-Conventional Approach)

Tunnel Section	Distance to Impact per Building Category [1] [ft]			
	I	II	III	IV
Mined Section [2]	15	22	28	40
Cut & Cover Section [3]	15	22	28	40

Tunnel Section	Distance to Impact per Building Category [1] [ft]			
	I	II	III	IV
Concrete Box Section [4]	8	11	15	20

Note(s):

1. Building category as defined in Table 6-2 as:
   Cat. I. - Reinforced concrete, steel or timber (no plaster)
   Cat. II. - Engineered concrete and masonry (no plaster)
   Cat. III. - Non-engineered timber and masonry buildings
   Cat. IV. - Buildings extremely susceptible to vibrations damages
2. Based on the type of construction method identified, the ZOI for the Mined Section is measured from tunnel arch. An 8-ft clearance (extending from the top of the existing arch), as required by the usage of a Tunnel Enlargement System, was also considered in the calculation.
3. Based on the type of construction method identified, the ZOI for the Cut & Cover Section is measured from the work area boundary at ground level.
4. Based on the type of construction method identified, the ZOI for the Concrete Box Section is measured from the work area boundary at track level.

The results presented in Table 6-18 are slant distances measured from the tunnel section to impact contours. A projection of the ZOI at ground level were conducted and the results are presented in a series of aerial maps in Appendix F. The projected ZOI accounts for tunnel coverage for each tunnel interval (approximately 100 ft in length) which was determined with respect to track stationing and based on the track profile (see Appendix D). A 5-ft building structure depth (applicable for typical slab-on-grade buildings) was also included in the projection for receivers along the Mined and Concrete Box Sections.

Based on a review of projected ZOI at ground level a summary of impacts is presented in Table 6-19. Vibration impacts were identified for three buildings.

Table 6-19: HST – Construction Vibration Summary of Impacts (Non-Conventional Approach)

Tunnel Section	Number of Buildings Within the ZOI [1]			
	I	II	III	IV
Mined Section	0	0	0	0
Cut & Cover Section	0	2	1	0
Concrete Box Section	0	0	0	0

Note(s):

1. Building category as defined in Table 6-2 as:
   Cat. I. - Reinforced concrete, steel or timber (no plaster)
   Cat. II. - Engineered concrete and masonry (no plaster)
   Cat. III. - Non-engineered timber and masonry buildings
   Cat. IV. - Buildings extremely susceptible to vibrations damages

6.4.5.3 Vibration Assessment for Historic Buildings

The anticipated construction vibration impact with the alternative construction approach at the 7 identified historic buildings is presented in Table 6-20 in terms of PPV levels.

Table 6-20: HST – Summary of Impacts at Historic Buildings (Non-Conventional Approach)

Historic Buildings along Howard Street Tunnel	Estimated PPV at Point of Reception [in/s]
Camden Station, 301 West Camden Street, Baltimore, MD	0.08
Wilkens-Robins Building, 308-314 West Pratt Street, Baltimore, MD	0.04
Rombro Building, 22-24 South Howard Street, Baltimore, MD	0.64
2-6 North Howard & 302 West Baltimore Street, Baltimore, MD	0.13
304 West Baltimore Street, Baltimore, MD	0.03
Siegel, Rothschild & Co. Umbrella Factory, 220-228 West Baltimore Street (1 North Howard Street), Baltimore, MD	0.12
New Howard Hotel, 8 North Howard Street, Baltimore, MD	0.13

Based on a review of publicly available imageries, these historic buildings are identified to fall under "Building Category III: Non-engineered timber and masonry buildings". The limit identified for this type of structure is 0.2 in/s.

Based on the results of PPV estimated for each identified historic building, see Table 6-20 above, the Rombo Building located at 22-24 South Howard Street is the only building that is considered to potentially exposed to vibrations above the 0.2 in/s limit. As such, it is recommended that further considerations be taken in order to assess and, if necessary, reduce impacts from construction activities at this location as the project progresses.

6.5 Noise and Vibration Control Strategy

Based on the potential for sensitive receivers located within the identified ZOI's for both construction noise and/or vibration, a Noise and Vibration Control Strategy (NVCS) will be implemented for the Project at those locations identified in Sections 6.3 and 6.4 where noise and/or vibration were identified as potentially occurring. The overall objective of the project's compliance with local with local ordinances as well as noise and vibration guidance set forth in the FTA Manual at these locations.

The NVCS is a living document that will evolve with the progression of the Project design and construction. As more detail on actual means and methods become available, a more reliable and accurate evaluation of potential risk will be performed at the areas identified in Sections6.3 and 6.4. If potential noise and vibration risks are confirmed, a more detailed evaluation of those impacts will be performed to control and mitigate those impacts as necessary.

The NVCS major items are outlined below, these items do not represent specific Project commitments nor are they the only approach to an effective NVCS.

The NVCS will:

- Identify major noise and vibration producing construction activities and a plan to minimize, monitor and mitigate as necessary noise and vibration levels to the extent reasonably possible consistent with the guidance established in the FTA Manual.
- Include a schedule for implementing proposed activities to comply with appropriate noise and vibration ordinances and the guidance established in the FTA Manual throughout the Project Term.

- Provide procedures for conducting compliance verification measurements, if needed, to confirm that the work performed as part of this project is consistent with the guidance established in the FTA Manual for noise and vibration.

7.0 CLOSURE

This report presents an assessment of Direct (Operational) and Construction Impacts for both noise and vibration related to the improvements that address clearance limitations at the HST in the City of Baltimore as well as twenty-three (23) other clearance locations along the existing I-95 Rail Corridor between Baltimore and Philadelphia plus a staging area at the Bayview Yard.

Based on the information presented within this report the following conclusions can be summarized:

- Direct (Operational) Impacts:
  - Based on the results of the noise and vibration analyses, presented in Section 5.0, a No Impact Determination was made for all sites and potential receivers.
- Construction Impacts at the General Sites (excluding HST Tunnel, but including Bayview Yard staging area):
  - Based on the noise assessment conducted in Section 6.3.2, potential construction noise impacts were identified to occur during a night-time work scenario at twenty-one (21) of the twenty-four (24) sites along the corridor (see Table 6-5). During daytime, only three (3) sites (MTA Bridge, Guilford Avenue and Hartford Road) show potential impacts.
  - Based on the vibration assessment conducted in Section 6.3.3, potential construction vibration impacts were identified at six (6) sites (MTA Bridge, Guilford Avenue, Hartford Road, Lancaster Avenue, Boone Tunnel, and Cemetery Avenue). One of the buildings potentially impacted is identified as a historic building, i.e. the Canon Shoe Company (Fox Building) near the MTA Bridge site.
  - Potentially impacted receivers for each site are identified in the figures of Appendix C.
- Construction Impacts at the Howard Street Tunnel:
  - For the Conventional Construction Approach, based on the analysis presented in Section 6.4.4, no impacts from construction noise and vibration were identified.
  - For the Non-Conventional Construction Approach, based on the analysis presented in Section 6.4.5:
    - Potential construction noise impacts were identified at three (3) receivers located along the tunnel's cut and cover section – see figures in Appendix F.
    - Potential construction vibration impacts were identified at three (3) building structures, including one historic building (Rombro Building) – see figures in Appendix F.
  - Potentially impacted receivers for each construction approaches are identified in the figures of Appendices E and F.

Based on the results of the noise and vibration study and the current status of the project design, a Noise and Vibration Control Strategy will be implemented for the project as discussed in Section 6.5 as a framework to further evaluate potential risks and to mitigate those risks as necessary to maintain compliance with local ordinances and guidance set forth in the FTA Manual.

8.0 REFERENCES

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[3] "CREATE Noise and Vibration Assessment Methodology," Chicago Region Environmental and Transportation Efficiency, 2014.

[4] Baltimore City Department of Legislative Reference, *Building, Fire , and Related Codes of Baltimore City 2015 Edition (As Enacted by Ord. 15-547, and Last Amended by Ord. 16-524),* Baltimore, 2015.

[5] City Council of the City of Philadelphia, *Chapter 10-400. Noise and Excessive Vibration,* Philadelphia, 2016.

[6] Wilmington City Council, *Wilmington City Code,* Wilmington, 1993.

[7] Division of State Documents - State of Maryland, *Code of Maryland Regulations, Maryland, Sec. 26.02.03.02. Environmental Noise Standards,* Annapolis, 2020.

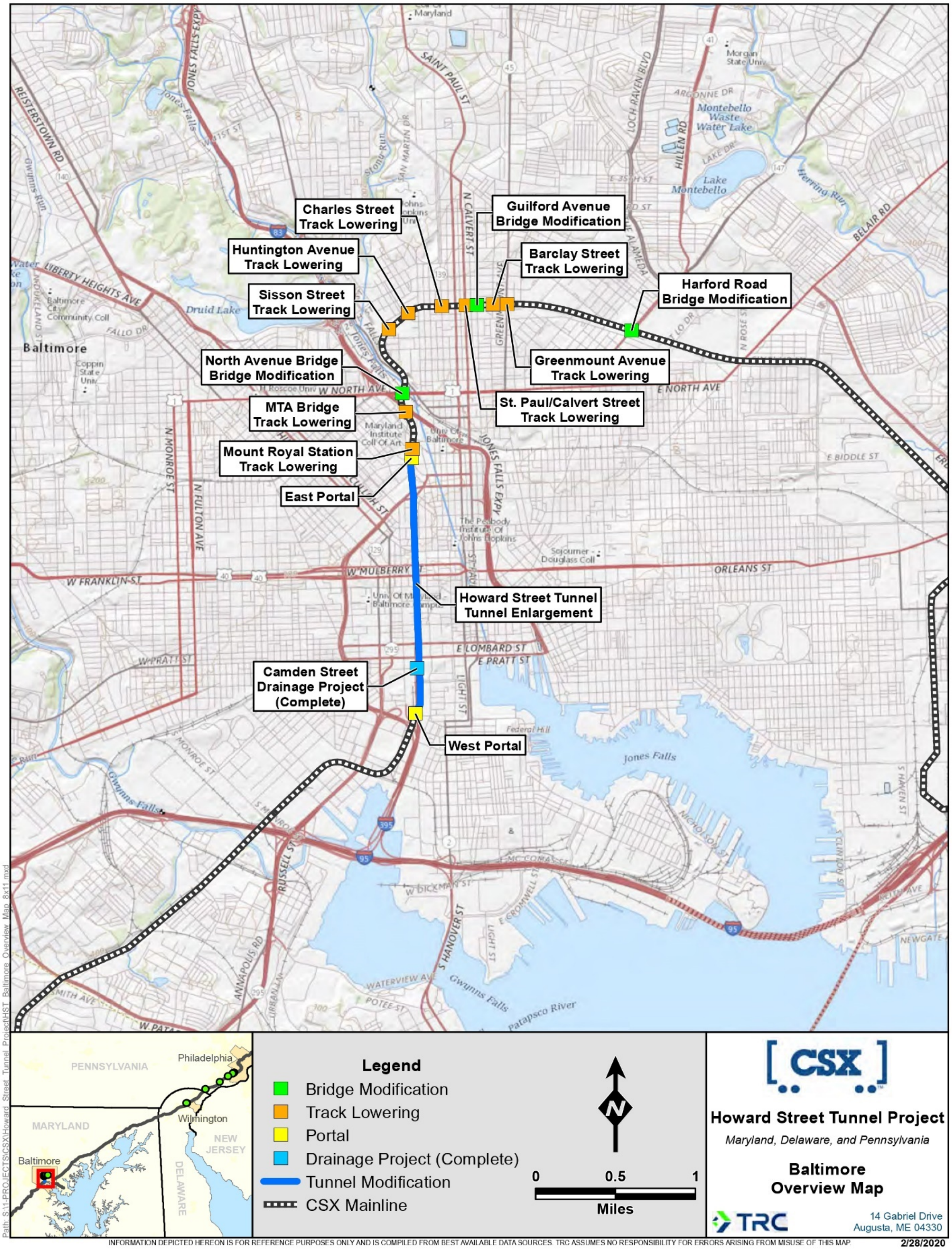
[8] State of Delaware, *Regulations Governing the Control of Noise Per Order No. 82-A-2 of January 20, 1982 As Amended July 8, 1982,* Dover, 1982.

[9] U.S. Department of Transportation, Federal Highway Administration, "FHWA Roadway Construction Noise Model User's Guide," 2006.

[10] California Department of Transportation, "Transportation and Construction Vibration Guidance Manual," September 2013.

Appendix A

Project Mapping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Huntington Avenue Track Lowering
Sisson Street Track Lowering
North Avenue Bridge Bridge Modification
MTA Bridge Track Lowering
Mount Royal Station Track Lowering
East Portal
Guilford Avenue Bridge Modification
Barclay Street Track Lowering
Harford Road Bridge Modification
Greenmount Avenue Track Lowering
St. Paul/Calvert Street Track Lowering
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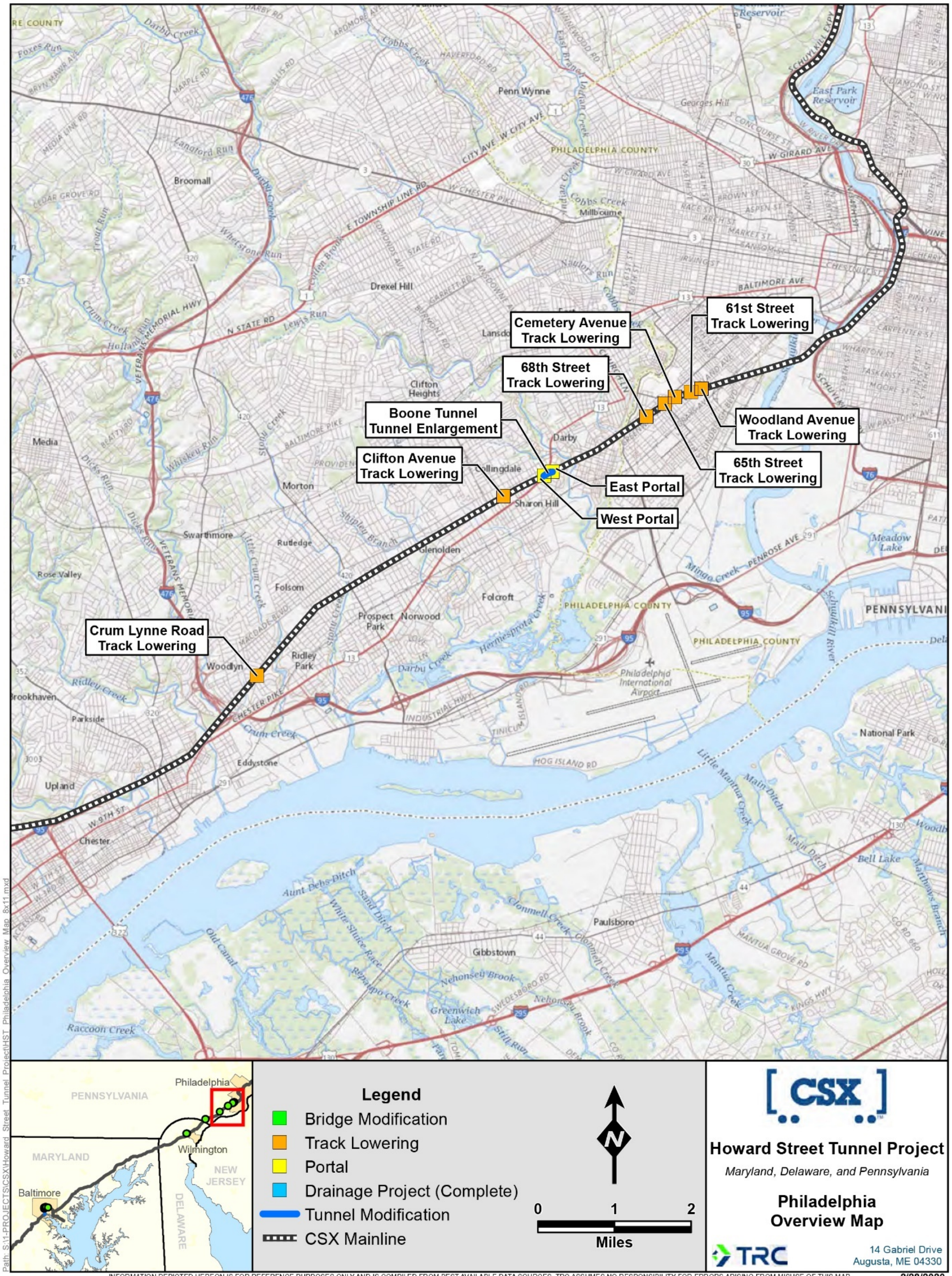
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Clifton Avenue Track Lowering
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Crum Lynne Road Track Lowering
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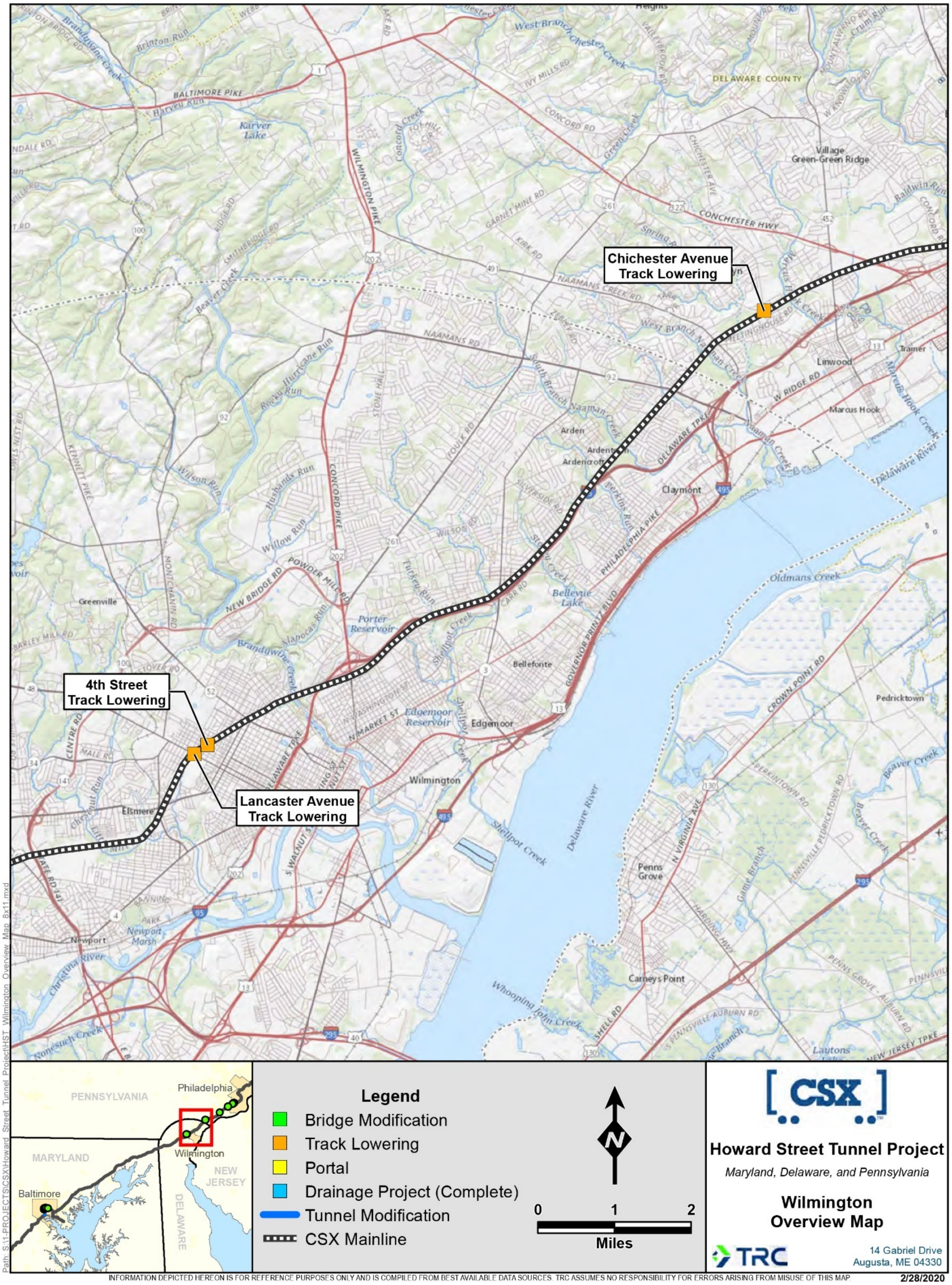
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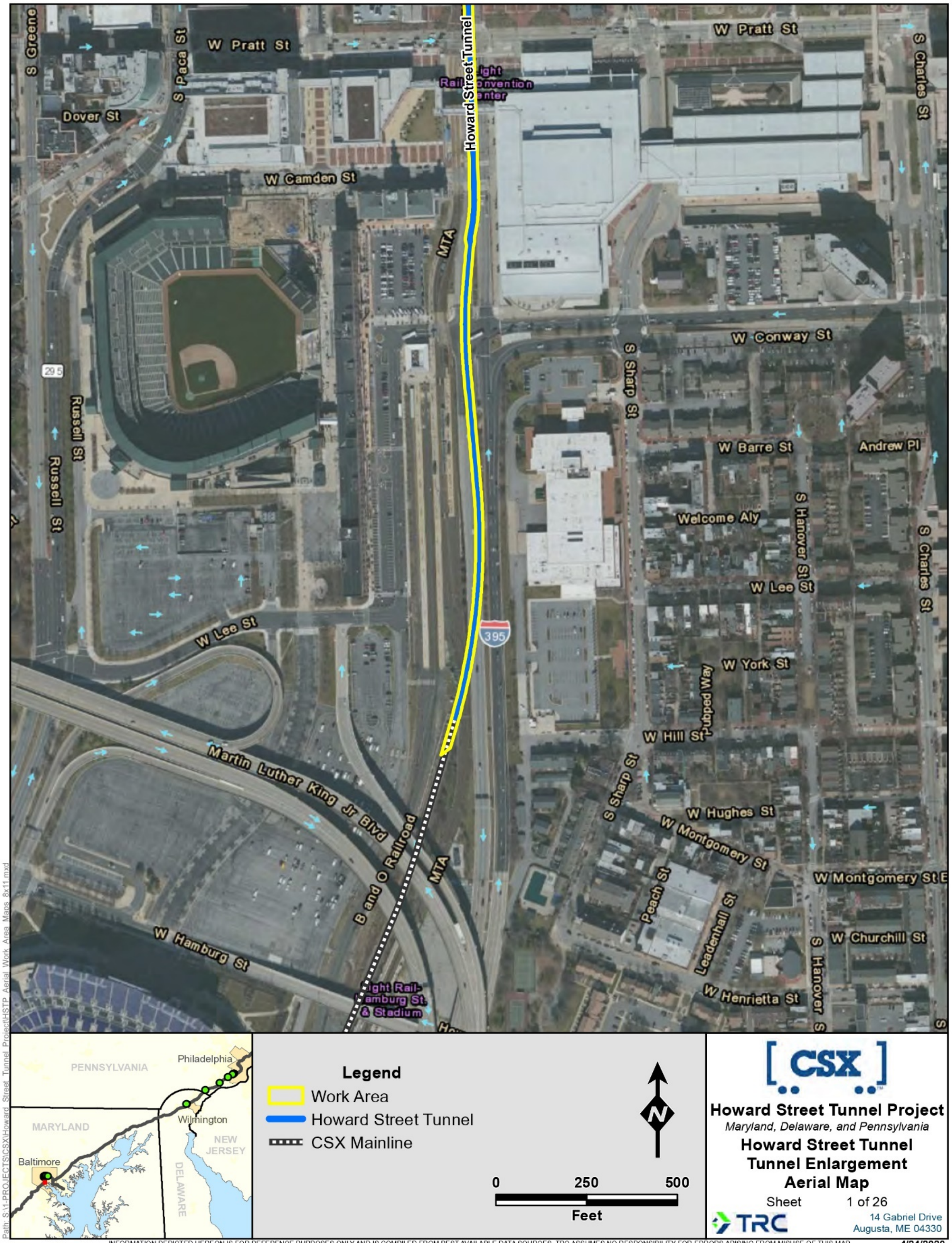
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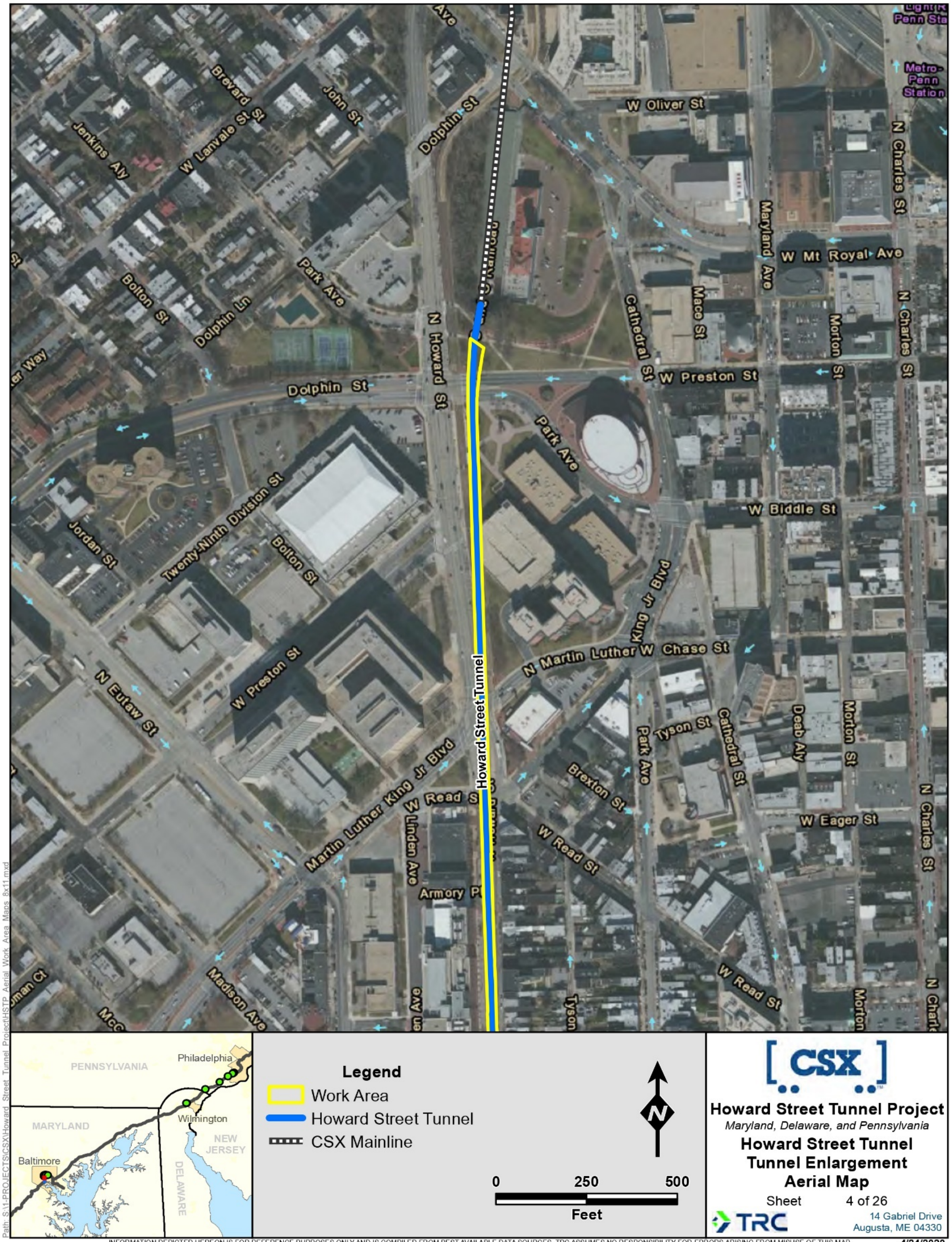
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Tyson St
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Aerial Map
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TRC
14 Gabriel Drive
Augusta, ME 04330
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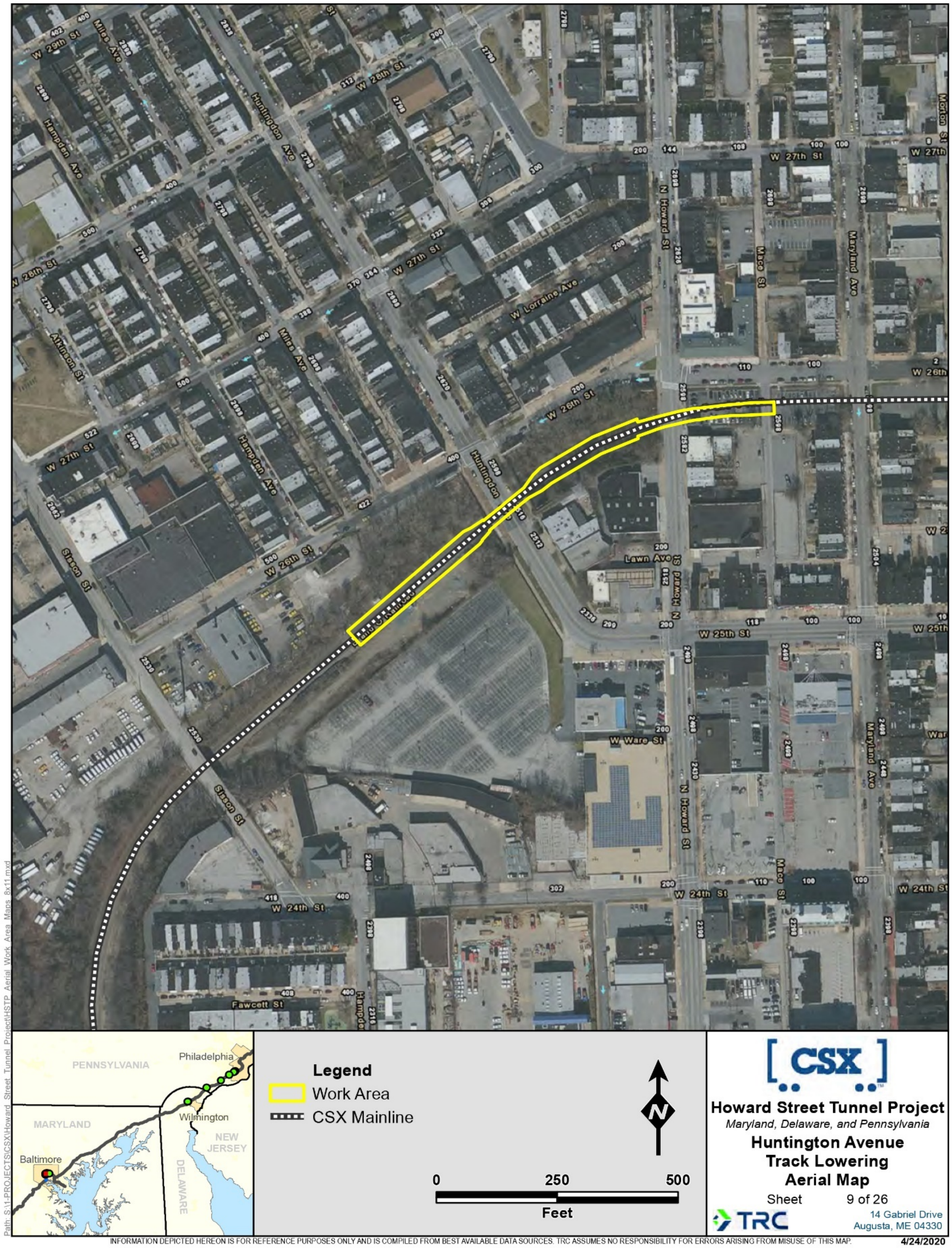
4/24/2020


Legend
Work Area
CSX Mainline
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PENNSYLVANIA
Philadelphia
MARYLAND
Wilmington
NEW JERSEY
Baltimore
DELAWARE
CSX
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Huntington Avenue
Track Lowering
Aerial Map
Sheet 9 of 26
TRC
14 Gabriel Drive
Augusta, ME 04330
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4/24/2020


W 28th St
E 28th St
W 27th St
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W 26th St
E 26th St
W 25 1/2 St
E 25th 1/2 St
W 25th St
E 25th St
Ware St
W Ware St
E Ware St
W 24th St
E 24th St
Creamont Ave
W Lorraine Ave
Lawn Ave
N Howard St
Mace St
Maryland Ave
Morton St
N Charles St
Lovegrove St
Baltimore's Historic Charles St
St Paul St
Hargrove Aly
N Calvert St
PENNSYLVANIA
Philadelphia
MARYLAND
Wilmington
NEW JERSEY
DELAWARE
Baltimore
Legend
Work Area
CSX Mainline
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CSX
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Charles Street
Track Lowering
Aerial Map
Sheet 10 of 26
TRC
14 Gabriel Drive
Augusta, ME 04330
Path: S:\1-PROJECTS\CSX\Howard_Street_Tunnel_Project\HSTP_Aerial_Work_Area_Maps_8x11.mxd
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4/24/2020


W 28th St
E 28th St
Whitridge Ave
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E Lorraine Ave
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Morton St
N Charles St
Lovegrove St
Baltimore's Historic Charles St
St Paul St
Hargrove Aly
N Calvert St
Hunter St
Guilford Ave
Falls Aly
Barclay St
PENNSYLVANIA
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Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
St. Paul/Calvert Street
Track Lowering
Aerial Map
Sheet 11 of 26
TRC
14 Gabriel Drive
Augusta, ME 04330
Path: S:\1-PROJECTS\CSX\Howard_Street_Tunnel_Project\HSTP_Aerial_Work_Area_Maps_8x11.mxd
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4/24/2020


E 28th St
Whitridge Ave
E 27th St
E Lorraine Ave
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E 25th 1/2 St
E 25th St
E Ware St
E 24th St
Baltimore's Historic Charles St
St Paul St
Hargrove Aly
N Calvert St
Hunter St
Guilford Ave
Barclay St
Greenmount Ave
Falls Aly
Brentwood Ave
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Maryland, Delaware, and Pennsylvania
Guilford Avenue
Bridge Modification
Aerial Map
Sheet 12 of 26
TRC
14 Gabriel Drive
Augusta, ME 04330
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4/24/2020


E 28th St
Whitridge Ave
Barclay St
Greenmount Ave
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Guilford Ave
Boone St
Mathews St
E 25 1/2 St
E 25th St
Falls Aly
E Ware St
Brentwood Ave
Gutman Ave
Loch Raven Rd
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PENNSYLVANIA
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Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Barclay Street
Track Lowering
Aerial Map
Sheet 13 of 26
TRC
14 Gabriel Drive
Augusta, ME 04330
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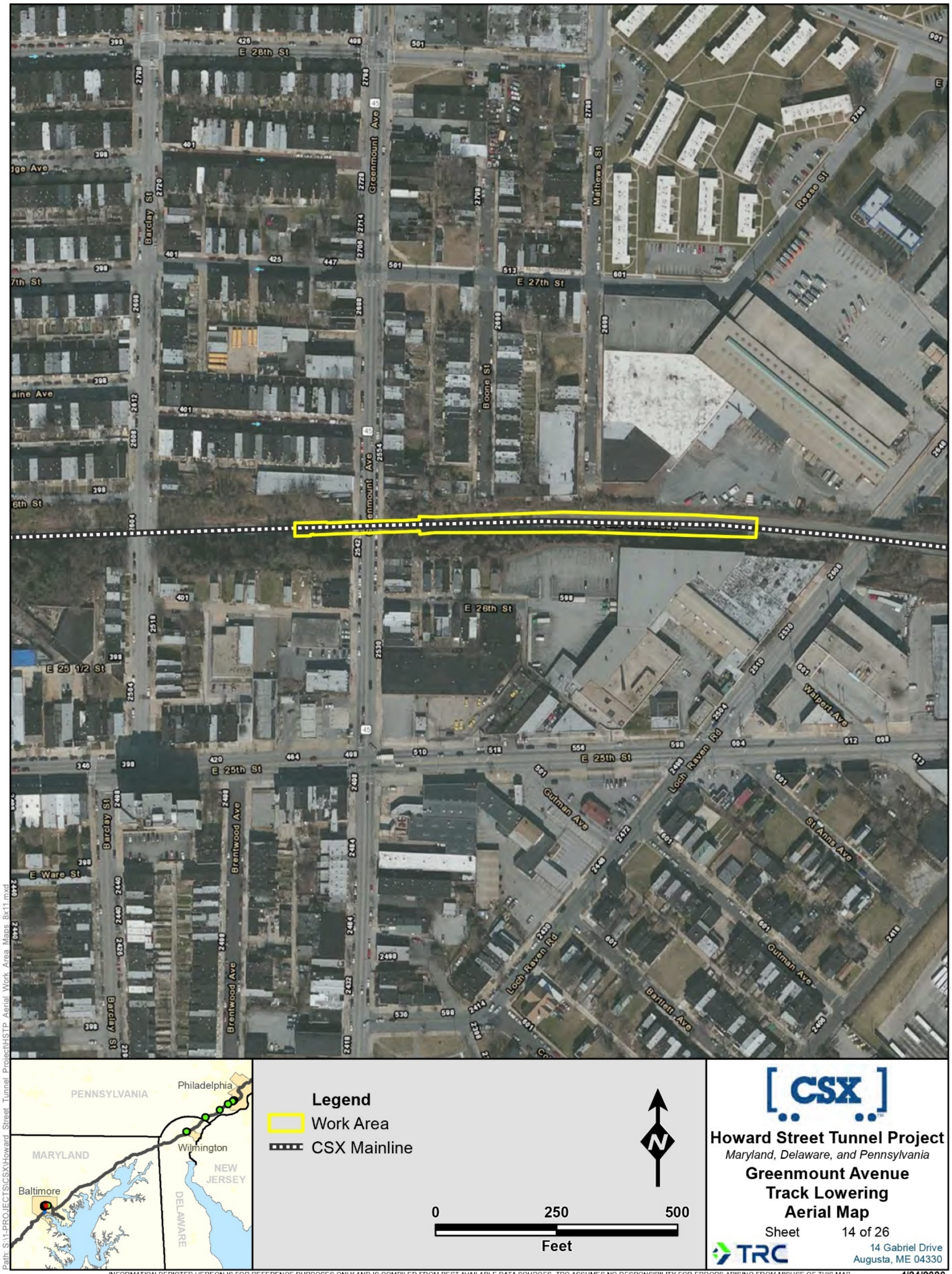
Legend
Work Area
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Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Greenmount Avenue
Track Lowering
Aerial Map
Sheet 14 of 26
TRC
14 Gabriel Drive
Augusta, ME 04330
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4/24/2020
PENNSYLVANIA
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Greenmount Ave
Barclay St
Mathews St
Boone St
Reese St
Loch Raven Rd
Gutman Ave
St Anns Ave
Walpert Ave
Brentwood Ave
Bartlett Ave


Robb
Homestead St
Gorsuch Ave
Friendship St
Garrett Ave
Robb St
Aisquith St
Montpelier St
Harford Rd
147
E 25th St
Aiken St
Cliftview Ave
Clough St
Normal Ave
Cliftview Ave
Cliftview Ave
Sherwood Ave
Germania Ave
Darley Ave
Holy Cross Ln
Harford Rd
N Broadway
N Wolfe St
N Washington St
Sinclair Ln
E 20th St
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Work Area
CSX Mainline
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Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Harford Road
Bridge Modification
Aerial Map
Sheet 15 of 26
TRC
14 Gabriel Drive
Augusta, ME 04330
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Work Area
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Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
4th Street
Track Lowering
Aerial Map
Sheet 17 of 26
TRC
14 Gabriel Drive
Augusta, ME 04330
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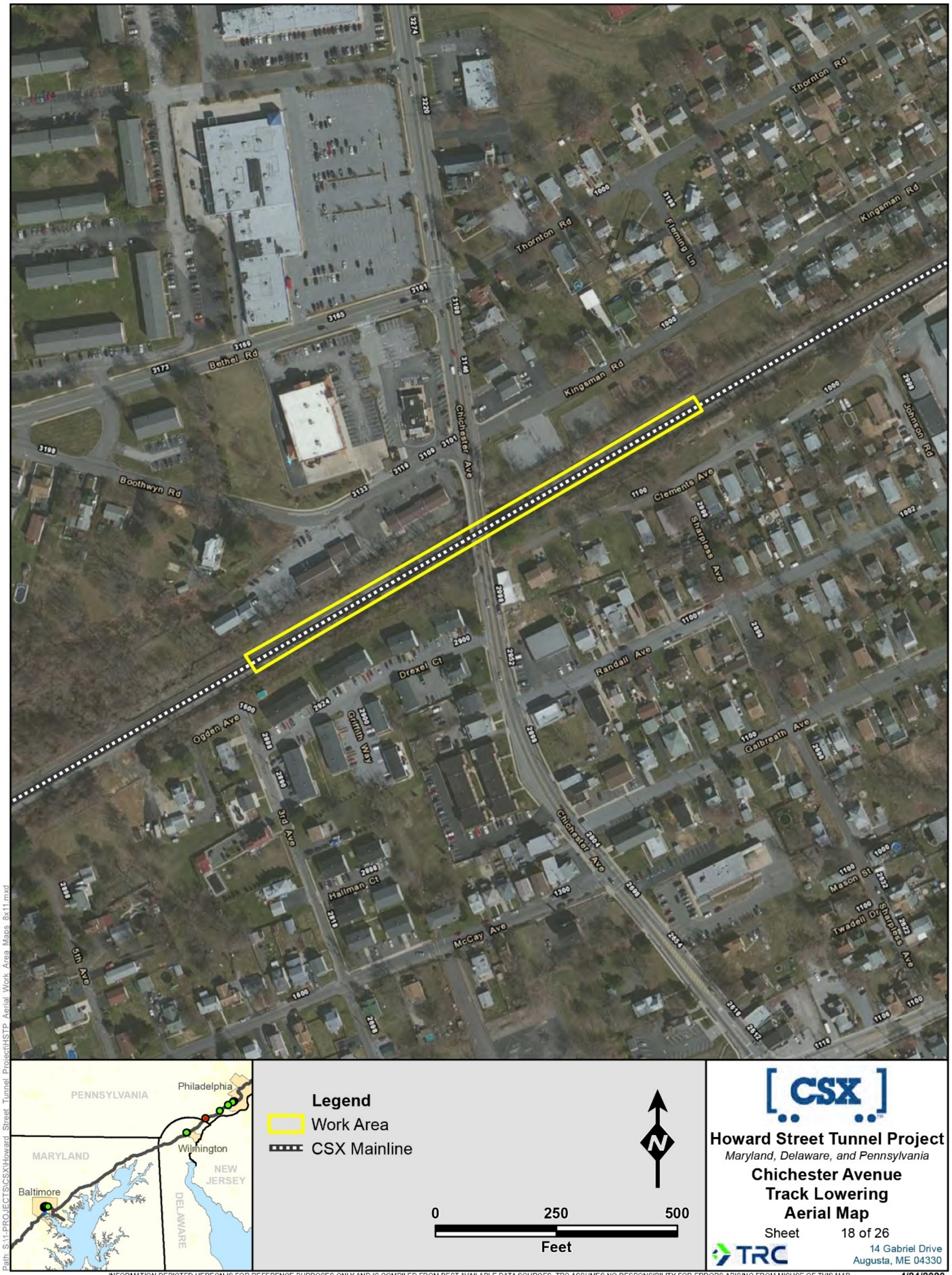
Legend
Work Area
CSX Mainline
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Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Chichester Avenue
Track Lowering
Aerial Map
Sheet 18 of 26
TRC
14 Gabriel Drive
Augusta, ME 04330
PENNSYLVANIA
Philadelphia
MARYLAND
Wilmington
NEW JERSEY
Baltimore
DELAWARE
Thornton Rd
Kingsman Rd
Bethel Rd
Boothwyn Rd
Chichester Ave
Clements Ave
Sharpless Ave
Johnson Rd
Randall Ave
Drexel Ct
Ogden Ave
Griffith Way
Galbraith Ave
3rd Ave
Hallman Ct
McCay Ave
Mason St
Twadell Dr
5th Ave
Fleming Ln
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4/24/2020


Washington Ave
Jackson Ave
Belmont Ave
Garfield Ave
Haverford Rd
Hillside Rd
Tyler Ave
Wilson Ave
Morris Ave
Shaw Rd
Crum Lynne Rd
Nicholson Rd
Bonsall Rd
W Belair Rd
West Cir
West Rd
Morris Cir
Belair Rd
PENNSYLVANIA
Philadelphia
MARYLAND
Wilmington
NEW JERSEY
Baltimore
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Work Area
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CSX
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Crum Lynne Road
Track Lowering
Aerial Map
Sheet 19 of 26
TRC
14 Gabriel Drive
Augusta, ME 04330
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4/24/2020


MacDade Blvd
Clifton Ave
Sharon Ave
Pusey Ave
Juliana Ter
Felton Ave
Upland Ter
Wayne Ave
Burnside Ave
High St
Foster Ave
Frances Ave
Florence Ave
Chester Pike
Coates St
PENNSYLVANIA
Philadelphia
MARYLAND
Wilmington
NEW JERSEY
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DELAWARE
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Work Area
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CSX
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Clifton Avenue
Track Lowering
Aerial Map
Sheet 20 of 26
TRC
14 Gabriel Drive
Augusta, ME 04330
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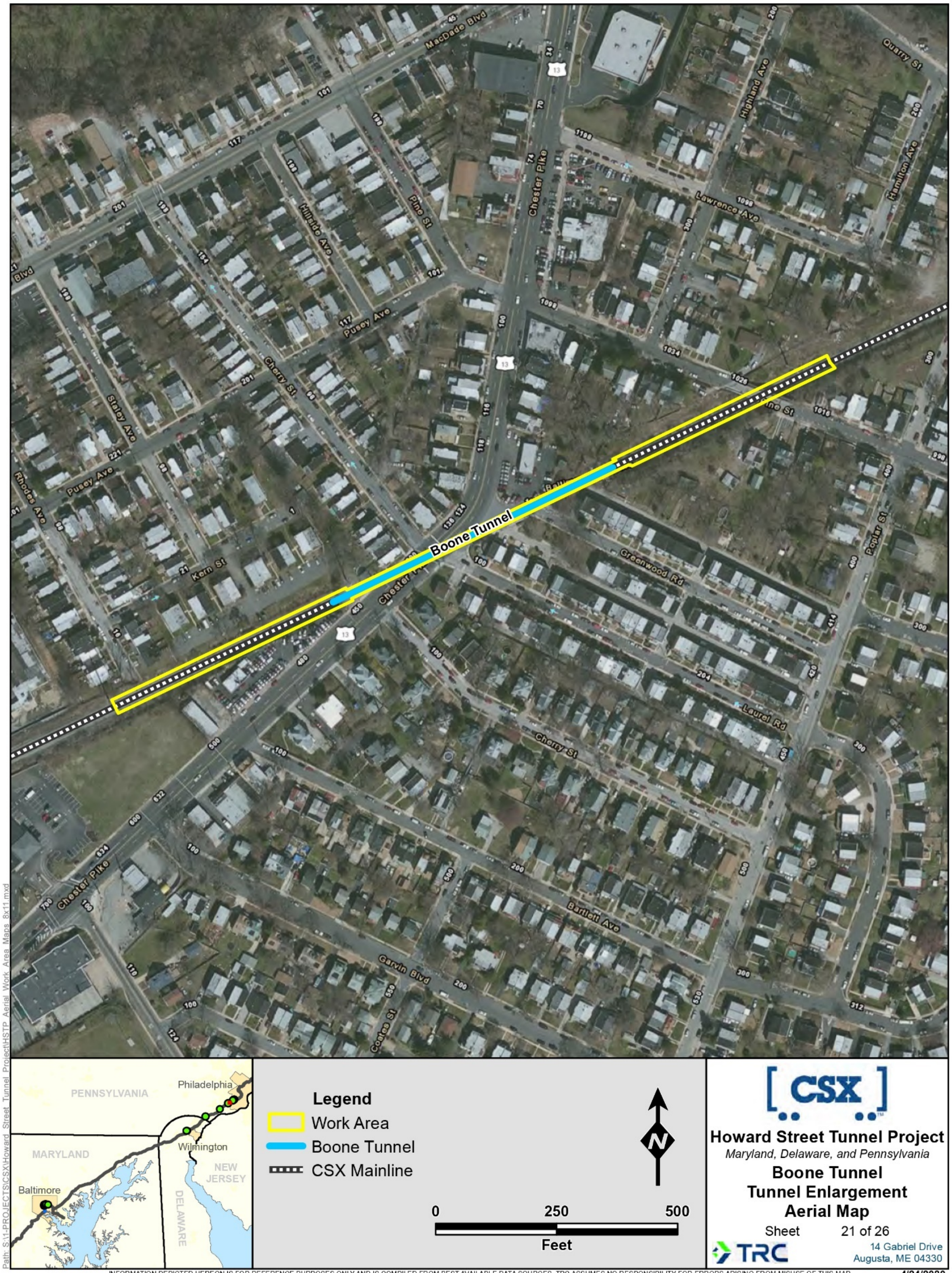
Boone Tunnel
MacDade Blvd
Chester Pike
Pusey Ave
Cherry St
Hillside Ave
Pine St
Staley Ave
Rhodes Ave
Kern St
Greenwood Rd
Laurel Rd
Lawrence Ave
Highland Ave
Hamilton Ave
Quarry St
Poplar St
Bartlett Ave
Garvin Blvd
Coates St
PENNSYLVANIA
Philadelphia
MARYLAND
Wilmington
NEW JERSEY
Baltimore
DELAWARE
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Work Area
Boone Tunnel
CSX Mainline
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CSX
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Boone Tunnel
Tunnel Enlargement
Aerial Map
Sheet 21 of 26
TRC
14 Gabriel Drive
Augusta, ME 04330
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4/24/2020


Chester Ave
Regent St
S 68th St
S 67th St
Trinity St
Kingsessing Ave
Upland St
Greenway Ave
S Aikens St
Bonaffon St
Yocum St
Woodland Ave
S 69th St
S 70th St
S 71st St
S Larry St
PENNSYLVANIA
Philadelphia
MARYLAND
Wilmington
NEW JERSEY
Baltimore
DELAWARE
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Work Area
CSX Mainline
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CSX
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
68th Street
Track Lowering
Aerial Map
Sheet 22 of 26
TRC
14 Gabriel Drive
Augusta, ME 04330
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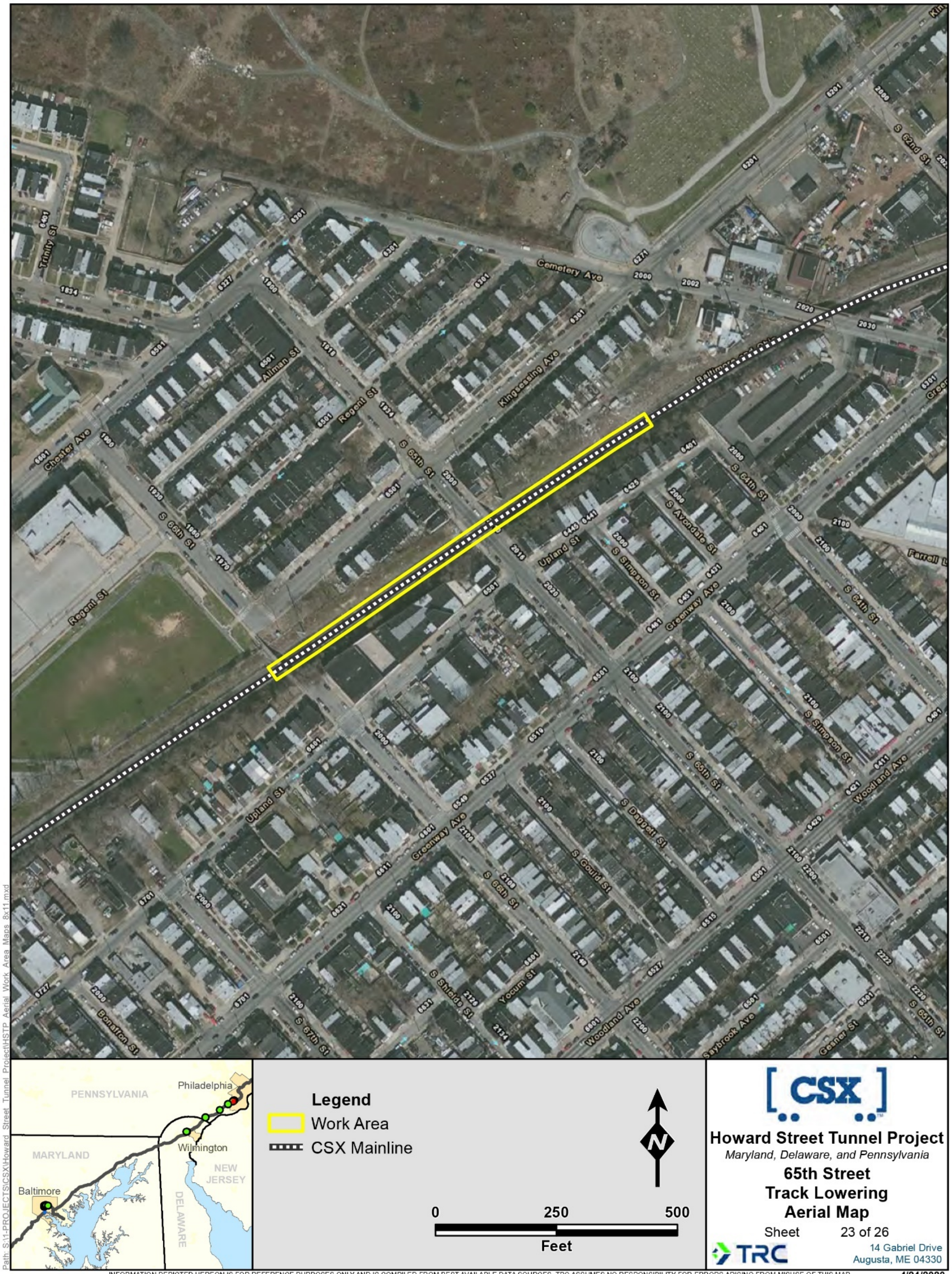
4/24/2020


Cemetery Ave
Kingsessing Ave
Chester Ave
Regent St
Allman St
Upland St
Greenway Ave
Woodland Ave
Saybrook Ave
PENNSYLVANIA
Philadelphia
MARYLAND
Wilmington
NEW JERSEY
DELAWARE
Baltimore
Legend
Work Area
CSX Mainline
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Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
65th Street
Track Lowering
Aerial Map
Sheet 23 of 26
TRC
14 Gabriel Drive
Augusta, ME 04330
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Appendix B

Operational Impact – Interlocking Location

Project: CSX Howard Street Tunnel Noise Impact Assessment
Area: Interlocking Relocation
Date: August 6, 2020
Document: Table with impact assessment

Table Notes:
(A) **Receiver** - Receiver labeling
(B) **Longitude** - Receiver longitude.
(C) **Latitude** - Receiver latitude.
(D) **Train Speed [mph]** - Speed of the train traveling on the segment closest to the receiver. Noted if changes are identified between Existing and Future Scenarios.
(E) **Distance to Alignment [ft]** - Distance from receiver location to track centerline. Noted if changes are identified between Existing and Future Scenarios.
(F) **Land Use Category** - Land use for a receiver as per Table 6-3 of FTA Manual.
(G) **Noise Metric** - Noise metric for impact assessment as per Table 4-3 of FTA Manual.
(H) **Noise Level - Existing Scenario** - Existing noise level calculated as per FTA General Noise Assessment methodology.
(I) **Noise Level - Future Scenario** - Future noise level calculated as per FTA General Noise Assessment methodology.
(J) **Noise Level increase** - Increase of future noise level over existing level.
(K) **FTA Allowable Increase for Moderate Impact** - Moderate Impact threshold as per FTA Manual.
(L) **FTA Allowable Increase for Severe Impact** - Severe Impact threshold as per FTA Manual.
(M) **Impact Under FTA Criteria** - Impact assessment as per FTA Manual.

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)
Point of Reception			Project Alignment		FTA Land Use		Noise Levels		Impact Assessment			
Receiver	Longitude	Latitude	Train Speed [mph]	Distance to Alignment [ft]	Land Use Category	Noise Metric	Existing Scenario [dBA]	Future Scenario [dBA]	Noise Level Increase [dB]	FTA Allowable Increase		Impact Under FTA Criteria
										Moderate Impact	Severe Impact	
R_25_01	-75.214216	39.933060	25	147	2	Ldn	64	65	1	1	4	No Impact
R_25_02	-75.215194	39.934226	25	325	2	Ldn	59	59	0	2	5	No Impact
R_25_03	-75.215553	39.933751	25	190	2	Ldn	62	64	2	2	4	No Impact
R_25_04	-75.217636	39.932428	25	80	2	Ldn	68	68	0	1	3	No Impact
R_25_05	-75.224524	39.932621	30	540	2	Ldn	55	55	0	3	7	No Impact

Project: CSX Howard Street Tunnel Noise Impact Assessment
Area: Interlocking Relocation
Date: August 6, 2020
Document: Table with existing noise levels

Table Notes:
(A) **Receiver** - Receiver labeling, EXT: Existing Scenario, FUT: Future Scenario.
(B) **Longitude** - Receiver longitude.
(C) **Latitude** - Receiver latitude.
(D) **Train Speed [mph]** - Speed of the train traveling on the segment closest to the receiver.
(E) **Distance to Alignment [ft]** - Distance from receiver location to track centerline.
(F) **Land Use Category** - Land use for a receiver as per Table 6-3 of FTA Manual.
(G) **Noise Metric** - Noise metric for impact assessment as per Table 4-3 of FTA Manual.
(H-J) **Noise Level - Track 1** - Noise level at receiver due to train operation on track 1 (closer track), calculated as per FTA General Noise Assessment methodology.
(H) **Noise Exposure at 50 ft** - Determined per FTA methodology based on several major operational factors: train composition, schedule, speed, special trackwork, etc.
(I) **Distance Correction** - Determined per FTA methodology based on the correction factor of 15log(D/50).
(J) **Noise Level at Receiver** - Determined per FTA methodology based on the noise exposure at 50 ft and distance correction.
(K-M) **Noise Level - Track 2** - Noise level at receiver due to train operation on track 2 (further track), calculated as per FTA General Noise Assessment methodology.
(N) **Noise Level** - Combined noise level at receiver.

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)
Point of Reception			Project Alignment		FTA Land Use		Noise Level - Track 1			Noise Level - Track 2			Noise Level [dBA]
Receiver	Longitude	Latitude	Train Speed [mph]	Distance to Alignment [ft]	Land Use Category	Noise Metric	Noise Exposure at 50 ft [dBA]	Distance Correction [dB]	Noise Level at Receiver [dBA]	Noise Exposure at 50 ft [dBA]	Distance Correction [dB]	Noise Level at Receiver [dBA]	
R_25_01 (EXT)	-75.214216	39.933060	25	147	2	Ldn	68	-7	61	68	-8	60	64
R_25_02 (EXT)	-75.215194	39.934226	25	325	2	Ldn	68	-12	56	68	-12	56	59
R_25_03 (EXT)	-75.215553	39.933751	25	190	2	Ldn	68	-9	59	68	-9	59	62
R_25_04 (EXT)	-75.217636	39.932428	25	80	2	Ldn	68	-3	65	68	-4	64	68
R_25_05 (EXT)	-75.224524	39.932621	30	540	2	Ldn	68	-16	52	68	-16	52	55

Project: CSX Howard Street Tunnel Noise Impact Assessment
Area: Interlocking Relocation
Date: August 6, 2020
Document: Table with future noise levels

wood.

Table Notes:
(A) **Receiver** - Receiver labeling, EXT: Existing Scenario, FUT: Future Scenario.
(B) **Longitude** - Receiver longitude.
(C) **Latitude** - Receiver latitude.
(D) **Train Speed [mph]** - Speed of the train traveling on the segment closest to the receiver.
(E) **Distance to Alignment [ft]** - Distance from receiver location to track centerline.
(F) **Land Use Category** - Land use for a receiver as per Table 6-3 of FTA Manual.
(G) **Noise Metric** - Noise metric for impact assessment as per Table 4-3 of FTA Manual.
(H-J) **Noise Level - Track 1** - Noise level at receiver due to train operation on track 1 (closer track), calculated as per FTA General Noise Assessment methodology.
(H) **Noise Exposure at 50 ft** - Determined per FTA methodology based on several major operational factors: train composition, schedule, speed, special trackwork, etc.
(I) **Distance Correction** - Determined per FTA methodology based on the correction factor of 15log(D/50).
(J) **Noise Level at Receiver** - Determined per FTA methodology based on the noise exposure at 50 ft and distance correction.
(K-M) **Noise Level - Track 2** - Noise level at receiver due to train operation on track 2 (further track), calculated as per FTA General Noise Assessment methodology.
(N) **Noise Level** - Combined noise level at receiver.

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)
Point of Reception			**Project Alignment**		**FTA Land Use**		**Noise Level - Track 1**			**Noise Level - Track 2**			**Noise Level [dBA]**
Receiver	**Longitude**	**Latitude**	**Train Speed [mph]**	**Distance to Alignment [ft]**	**Land Use Category**	**Noise Metric**	**Noise Exposure at 50 ft [dBA]**	**Distance Correction [dB]**	**Noise Level at Receiver [dBA]**	**Noise Exposure at 50 ft [dBA]**	**Distance Correction [dB]**	**Noise Level at Receiver [dBA]**	
R_25_01 (FUT)	-75.214216	39.933060	25	147	2	Ldn	70*	-7	63	70*	-8	62	66
R_25_02 (FUT)	-75.215194	39.934226	25	325	2	Ldn	68	-12	56	68	-12	56	59
R_25_03 (FUT)	-75.215553	39.933751	25	190	2	Ldn	70*	-9	61	70*	-9	61	64
R_25_04 (FUT)	-75.217636	39.932428	25	80	2	Ldn	68	-3	65	68	-4	64	67
R_25_05 (FUT)	-75.224524	39.932621	30	540	2	Ldn	68	-16	52	68	-16	52	55

* Special trackwork considered in calculating the noise exposure at 50 ft.

Project: CSX Howard Street Tunnel Vibration Impact Assessment
Area: Interlocking Relocation
Date: August 6, 2020
Document: Table with impact assessment

Table Notes:
(A) **Receiver** - Receiver labeling.
(B) **Longitude** - Receiver longitude.
(C) **Latitude** - Receiver latitude.
(D) **Train Speed [mph]** - Speed of the train traveling on the segment closest to the receiver. Noted if changes are identified between Existing and Future Scenarios.
(E) **Distance to Alignment [ft]** - Distance from receiver location to track centerline. Noted if changes are identified between Existing and Future Scenarios.
(F) **Land Use Category** - Land use for a receiver as per Table 6-3 of FTA Manual.
(G) **Type of Event** - Frequency of event as per Table 6-3 of FTA Manual.
(H) **GBV Limit [VdB]** - Ground-borne vibration assessment limit based on Table 3-1 of FTA Manual.
(I) **GBN Limit [dBA]** - Ground-borne Noise assessment limit based on Table 3-1 of FTA Manual.
(J) **Ground-Borne Vibratin Level - Existing Scenario** - Existing ground-borne vibration level calculated as per FTA General Vibration Assessment methodology.
(K) **Ground-Borne Vibratin Level - Future Scenario** - Future ground-borne vibration level calculated as per FTA General Vibration Assessment methodology.
(L) **Impact Assessment** - Ground-borne vibration impact determined as per FTA General Vibration Assessment methodology.

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)
Point of Reception			Project Alignment		FTA Land Use				Ground-Borne Vibration Levels		Impact Assessment
Receiver	Longitude	Latitude	Train Speed [mph]	Distance to Alignment [ft]	Land Use Category	Type of Event	GBV Limit [VdB]	GBN Limit [dBA]	Existing Scenario [VdB]	Future Scenario [VdB]	Impact Under FTA Criteria
R_25_01	-75.214216	39.933060	25	147.5 (EXT) / 147.6 (FUT)	Category 2	Frequent	72	35	61.6	66.6	No Impact*
R_25_02	-75.215194	39.934226	25	325.8 (EXT) / 325.9 (FUT)	Category 2	Frequent	72	35	61.2	61.2	No Impact
R_25_03	-75.215553	39.933751	25	191.4 (EXT) / 191.7 (FUT)	Category 2	Frequent	72	35	66.9	66.9	No Impact
R_25_04	-75.217636	39.932428	25	80.0	Category 2	Frequent	72	35	75.5	75.5	No Impact
R_25_05	-75.224524	39.932621	30	540.0	Category 2	Frequent	72	35	57.2	57.2	No Impact

* Standard Vibration Assessment criteria used.

Project: CSX Howard Street Tunnel Vibration Impact Assessment
Area: Interlocking Relocation
Date: August 6, 2020
Document: Table with existing vibration levels

Table Notes:
(A) **Receiver** - Receiver labeling, EXT: Existing Scenario, FUT: Future Scenario.
(B) **Longitude** - Receiver longitude.
(C) **Latitude** - Receiver latitude.
(D) **Train Speed [mph]** - Speed of the train traveling on the segment closest to the receiver.
(E) **Distance to Alignment [ft]** - Distance from receiver location to track centerline.
(F) **Land Use Category** - Land use for a receiver as per Table 6-3 of FTA Manual.
(G) **Type of Event** - Frequency of event as per Table 6-3 of FTA Manual.
(H) **GBV Limit [VdB]** - Ground-borne vibration assessment limit based on Table 3-1 of FTA Manual.
(I) **GBN Limit [dBA]** - Ground-borne Noise assessment limit based on Table 3-1 of FTA Manual.
(J-O) **Ground-Borne Vibrating Level** - Ground-borne vibration level calculated as per FTA General Vibration Assessment methodology.
(P-R) **Ground-Borne Noise Level** - Ground-borne noise level calculated as per FTA General Vibration Assessment methodology.

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)
Point of Reception			Project Alignment		FTA Land Use				Ground-Borne Vibration Level						Ground-Borne Noise Level		
Receiver	Longitude	Latitude	Train Speed [mph]	Distance to Alignment [ft]	Land Use Category	Type of Event	GBV Limit [VdB]	GBN Limit [dBA]	Type of Source	Base Level (Figure 6-4 FTA)	Total Source Adjustment [VdB]	Total Path Adjustment [VdB]	Total Receiver Adjustment [VdB]	GBV [VdB]	Peak Frequency of Ground Vibration	Frequency Adjustment [dB]	GBN [dBA]
R_25_01 (EXT)	-75.214216	39.933060	25	147.5	Category 2	Frequent	72	35	Locomotive Powered Passenger or Freight	74.6	-6.0	-10.0	3.0	61.6	Low (<30 Hz)	-50	12
R_25_02 (EXT)	-75.215194	39.934226	25	325.8	Category 2	Frequent	72	35	Locomotive Powered Passenger or Freight	66.2	-6.0	-5.0	6.0	61.2	Low (<30 Hz)	-50	11
R_25_03 (EXT)	-75.215553	39.933751	25	191.4	Category 2	Frequent	72	35	Locomotive Powered Passenger or Freight	71.9	-6.0	-5.0	6.0	66.9	Low (<30 Hz)	-50	17
R_25_04 (EXT)	-75.217636	39.932428	25	80.0	Category 2	Frequent	72	35	Locomotive Powered Passenger or Freight	80.5	-6.0	-5.0	6.0	75.5	Low (<30 Hz)	-50	25
R_25_05 (EXT)	-75.224524	39.932621	30	540.0	Category 2	Frequent	72	35	Locomotive Powered Passenger or Freight	60.6	-4.4	-5.0	6.0	57.2	Low (<30 Hz)	-50	7

Project: CSX Howard Street Tunnel Vibration Impact Assessment
Area: Interlocking Relocation
Date: August 6, 2020
Document: Table with future vibration levels

Table Notes:
(A) **Receiver** - Receiver labeling, EXT: Existing Scenario, FUT: Future Scenario.
(B) **Longitude** - Receiver longitude.
(C) **Latitude** - Receiver latitude.
(D) **Train Speed [mph]** - Speed of the train traveling on the segment closest to the receiver.
(E) **Distance to Alignment [ft]** - Distance from receiver location to track centerline.
(F) **Land Use Category** - Land use for a receiver as per Table 6-3 of FTA Manual.
(G) **Type of Event** - Frequency of event as per Table 6-3 of FTA Manual.
(H) **GBV Limit [VdB]** - Ground-borne vibration assessment limit based on Table 3-1 of FTA Manual.
(I) **GBN Limit [dBA]** - Ground-borne Noise assessment limit based on Table 3-1 of FTA Manual.
(J-O) **Ground-Borne Vibrating Level** - Ground-borne vibration level calculated as per FTA General Vibration Assessment methodology.
(P-R) **Ground-Borne Noise Level** - Ground-borne noise level calculated as per FTA General Vibration Assessment methodology.

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)
Point of Reception			**Project Alignment**		**FTA Land Use**				**Ground-Borne Vibration Level**						**Ground-Borne Noise Level**		
Receiver	**Longitude**	**Latitude**	**Train Speed [mph]**	**Distance to Alignment [ft]**	**Land Use Category**	**Type of Event**	**GBV Limit [VdB]**	**GBN Limit [dBA]**	**Type of Source**	**Base Level (Figure 6-4 FTA)**	**Total Source Adjustment [VdB]**	**Total Path Adjustment [VdB]**	**Total Receiver Adjustment [VdB]**	**GBV [VdB]**	**Peak Frequency of Ground Vibration**	**Frequency Adjustment [dB]**	**GBN [dBA]**
R_25_01 (FUT)	-75.214216	39.933060	25	147.6	Category 2	Frequent	72	35	Locomotive Powered Passenger or Freight	74.6	-1.0*	-10.0	3.0	66.6	Low (<30 Hz)	-50	17
R_25_02 (FUT)	-75.215194	39.934226	25	325.9	Category 2	Frequent	72	35	Locomotive Powered Passenger or Freight	66.2	-6.0	-5.0	6.0	61.2	Low (<30 Hz)	-50	11
R_25_03 (FUT)	-75.215553	39.933751	25	191.7	Category 2	Frequent	72	35	Locomotive Powered Passenger or Freight	71.9	-6.0	-5.0	6.0	66.9	Low (<30 Hz)	-50	17
R_25_04 (FUT)	-75.217636	39.932428	25	80.0	Category 2	Frequent	72	35	Locomotive Powered Passenger or Freight	80.5	-6.0	-5.0	6.0	75.5	Low (<30 Hz)	-50	25
R_25_05 (FUT)	-75.224524	39.932621	30	540.0	Category 2	Frequent	72	35	Locomotive Powered Passenger or Freight	60.6	-4.4	-5.0	6.0	57.2	Low (<30 Hz)	-50	7

* Special trackwork considered in source adjustment

Appendix C

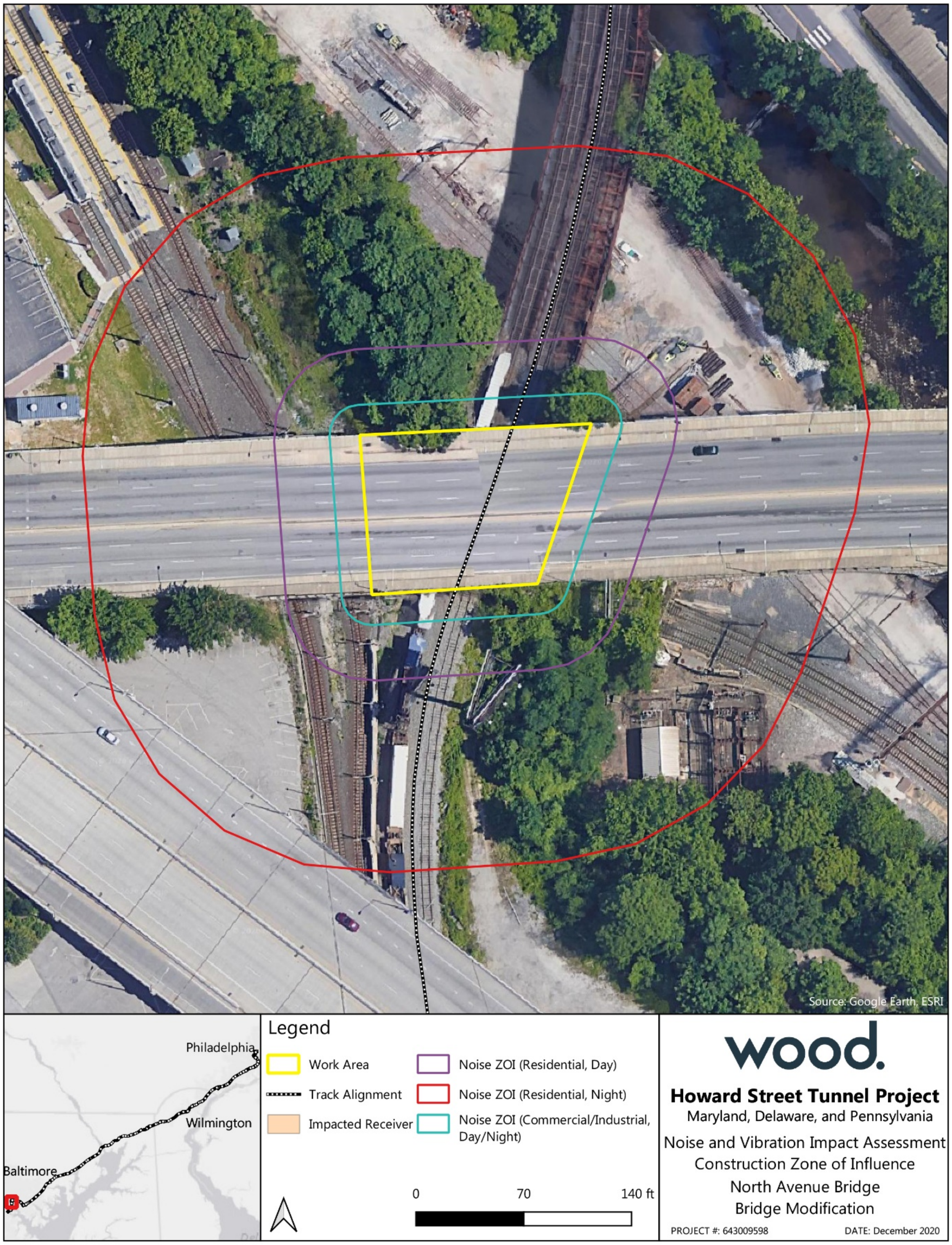
Construction Impact – General Sites


W Lafayette Ave
W Mt Royal Ave
Rutter St
W Lanvale St
John St
Brevard St
Bolton Pl
Dolphin Ln
Park Ave
Dolphin St
N Howard St
MTA
W Oliver St
W Preston St
Cathedral St
Mace St
Maryland Ave
Penn
W Mt Royal
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Mount Royal Avenue
Track Lowering
PROJECT #: 643009598
DATE: December 2020

Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania

Noise and Vibration Impact Assessment
Construction Zone of Influence
MTA Bridge
Track Lowering

PROJECT #: 643009598 DATE: December 2020


Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
70
140 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
North Avenue Bridge
Bridge Modification
PROJECT #: 643009598
DATE: December 2020


Sisson St
W 26th St
W 24th St
Fawcett St
Hampden Ave
W 23rd St
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Sisson Street
Track Lowering
PROJECT #: 643009598
DATE: December 2020


W Lorraine Ave
Huntington Ave
Miles Ave
W 26th St
N Howard St
Lawn Ave
W 25th St
W Ware St
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Huntington Avenue
Track Lowering
PROJECT #: 643009598
DATE: December 2020

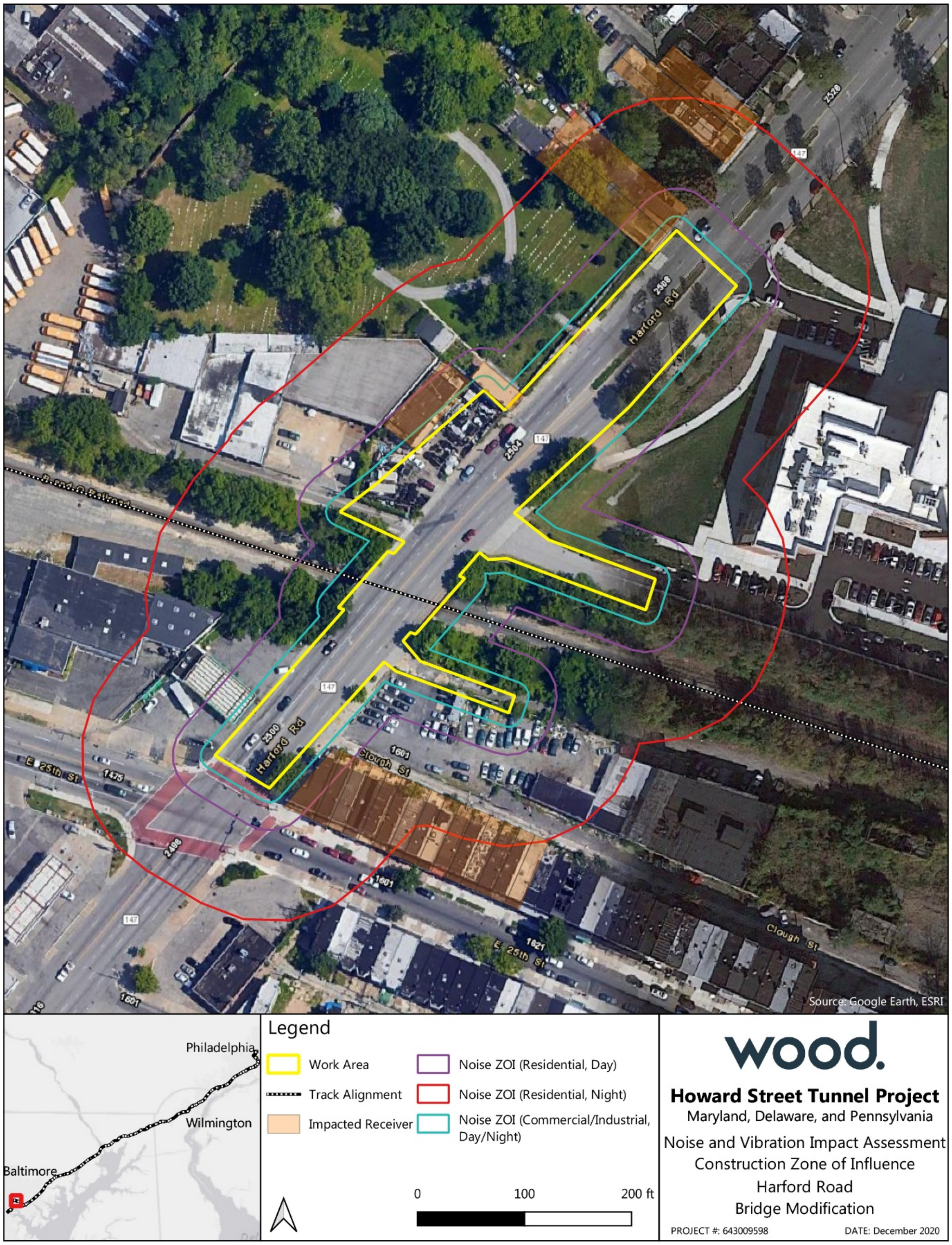

Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
50
100 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Charles Street
Track Lowering
PROJECT #: 643009598
DATE: December 2020


Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
St. Paul/Calvert Street
Track Lowering
PROJECT #: 643009598
DATE: December 2020

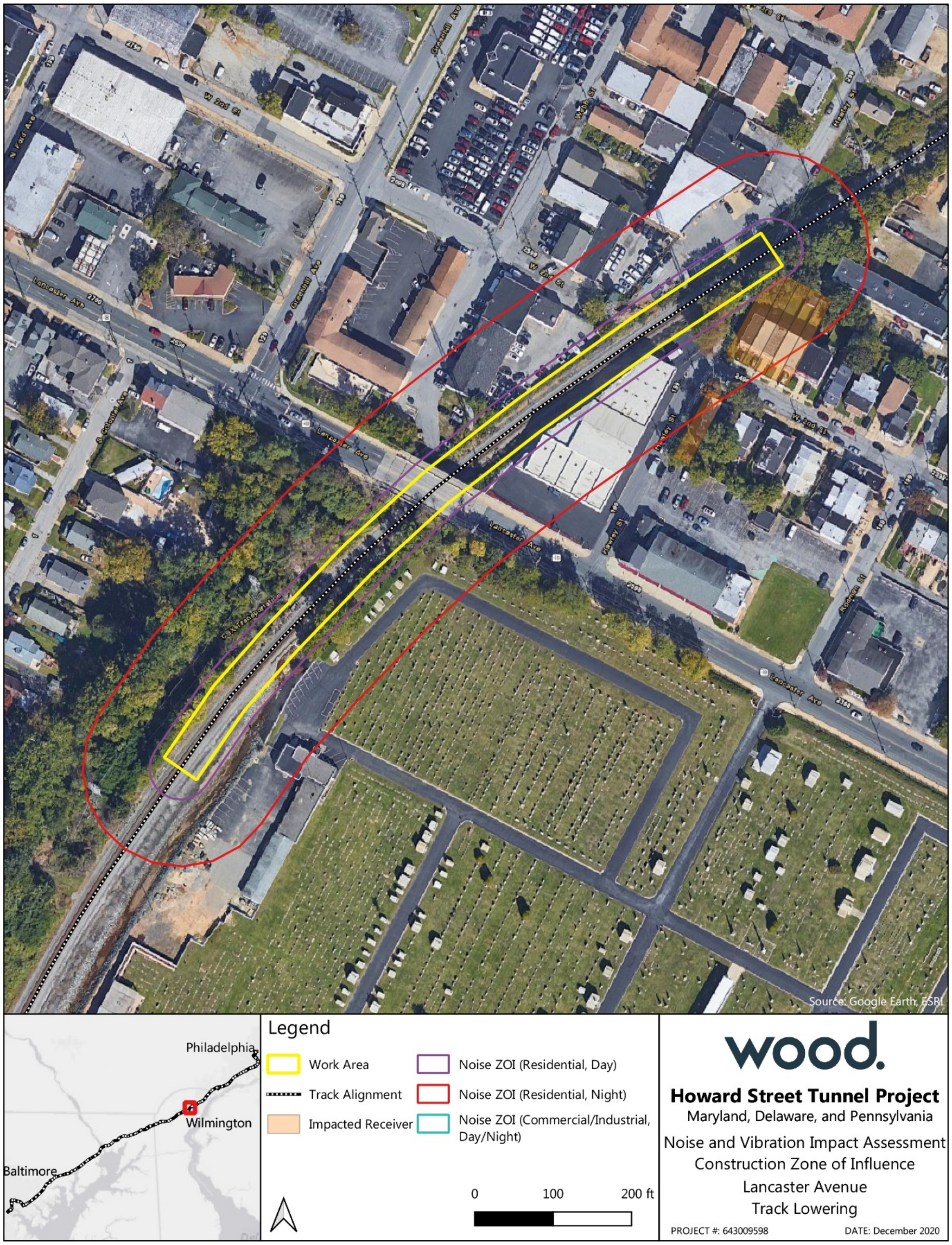

E Lorraine Ave
Hunter St
2620
Guilford Ave
E 26th St
E 26th St
2598
Hunter St
Guilford Ave
N Calvert St
E 25th 1/2 St
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
90
180 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Guilford Avenue
Bridge Modification
PROJECT #: 643009598
DATE: December 2020

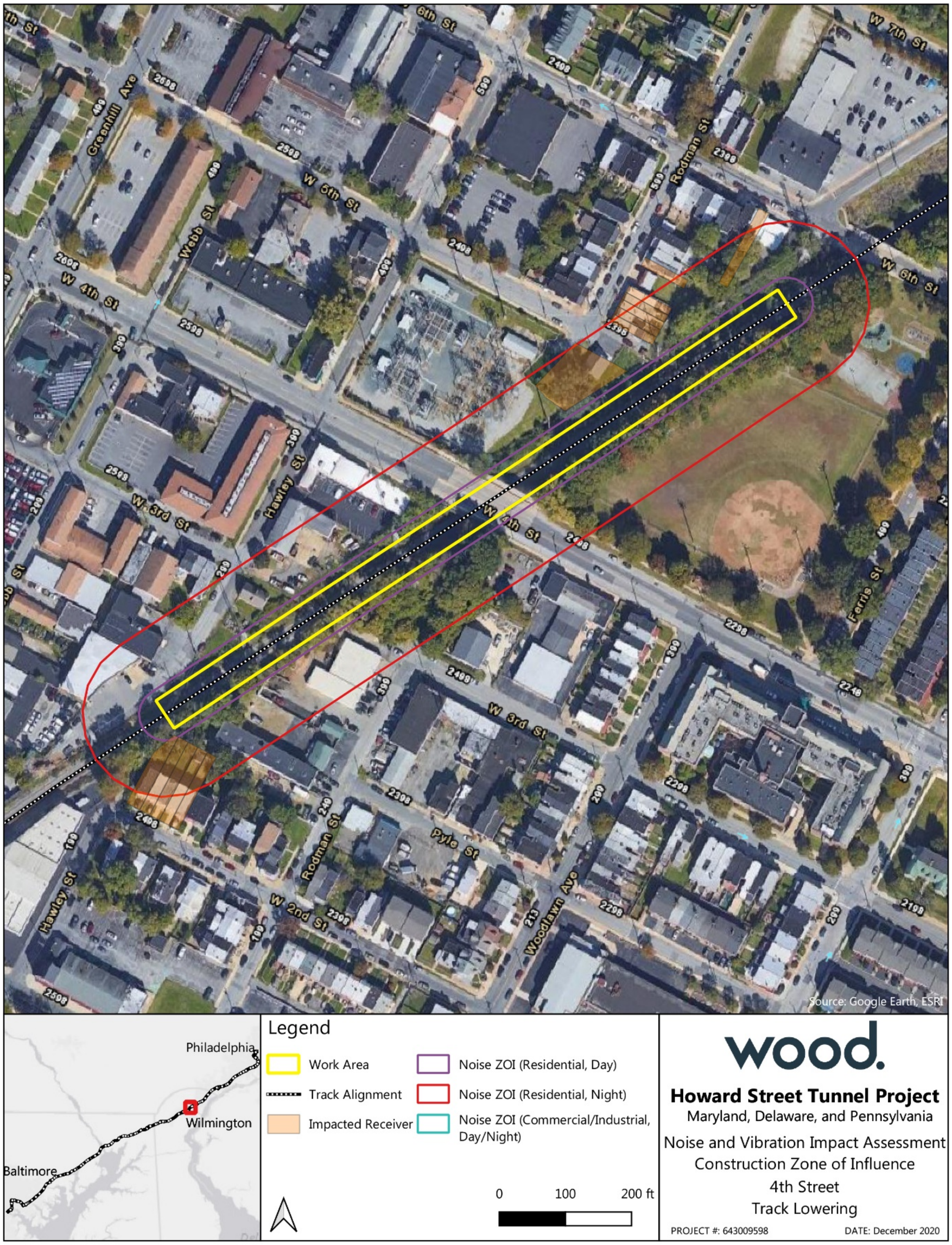

E 27th St
Lorraine Ave
E Lorraine Ave
Barclay St
E 26th St
E 25 1/2 St
E 25th St
Greenmount Ave
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Barclay Street
Track Lowering
PROJECT #: 643009598
DATE: December 2020


E 27th St
E 26th St
E 25th St
Greenmount Ave
Boone St
Mathews St
Reese St
Walpert Ave
Loch Raven Rd
Gutman Ave
St Anns Ave
Brentwood Ave
B and O Railroad
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Greenmount Avenue
Track Lowering
PROJECT #: 643009598
DATE: December 2020


Harford Rd
2508
2504
2500
2528
147
E 25th St
Clough St
1601
1621
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Harford Road
Bridge Modification
PROJECT #: 643009598
DATE: December 2020


Pulaski Hwy
Erdman Ave
Penn Central Railroad
E Lombard St
Quad Ave
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
400
800 ft
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Bayview Yard
Temporary Staging
PROJECT #: 643009598
DATE: December 2020

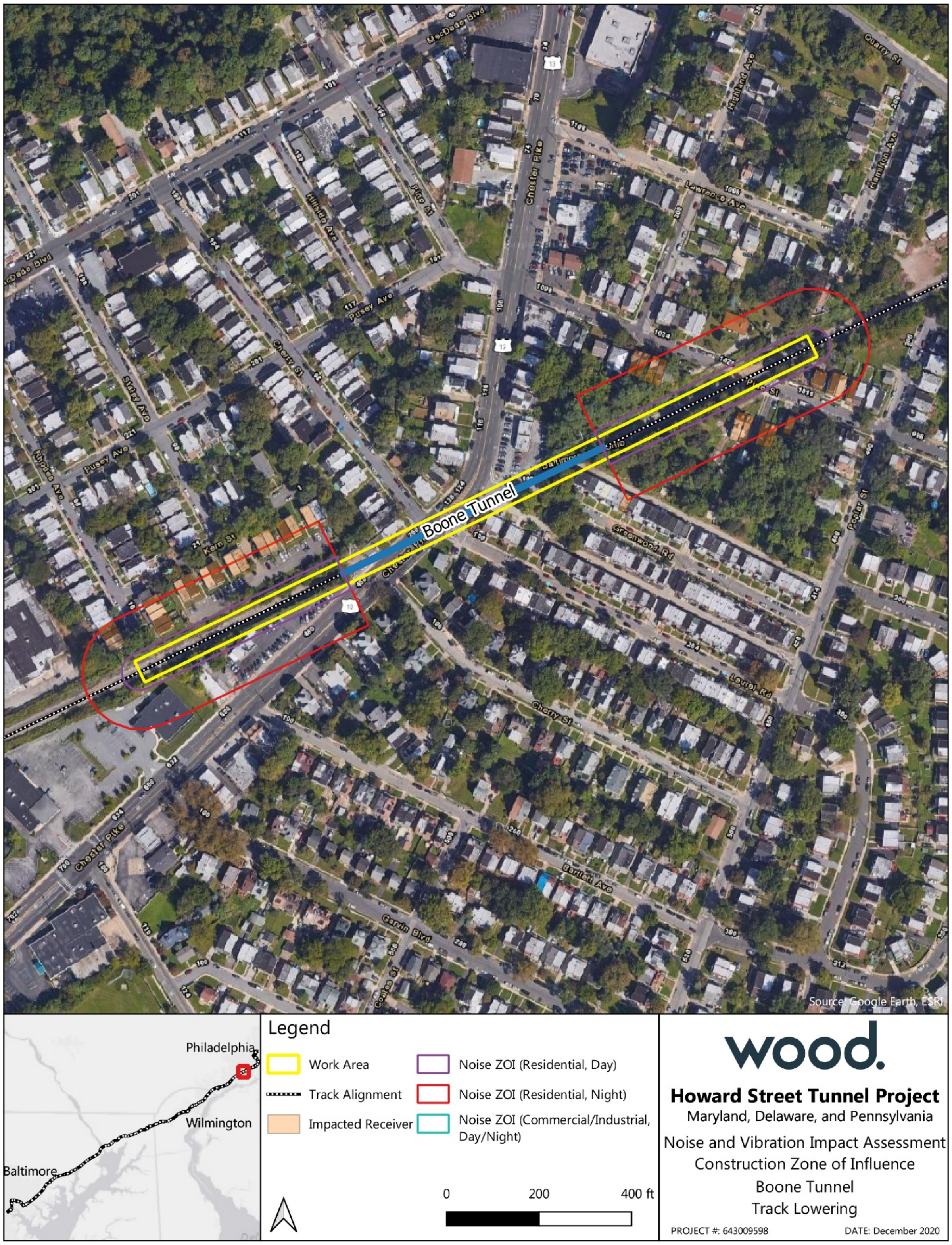

Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Lancaster Avenue
Track Lowering
PROJECT #: 643009598
DATE: December 2020


W 7th St
6th St
W 6th St
Greenhill Ave
Webb St
W 4th St
Rodman St
Hawley St
W 3rd St
W 4th St
W 3rd St
Ferris St
Pyle St
W 2nd St
Woodlawn Ave
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
4th Street
Track Lowering
PROJECT #: 643009598
DATE: December 2020

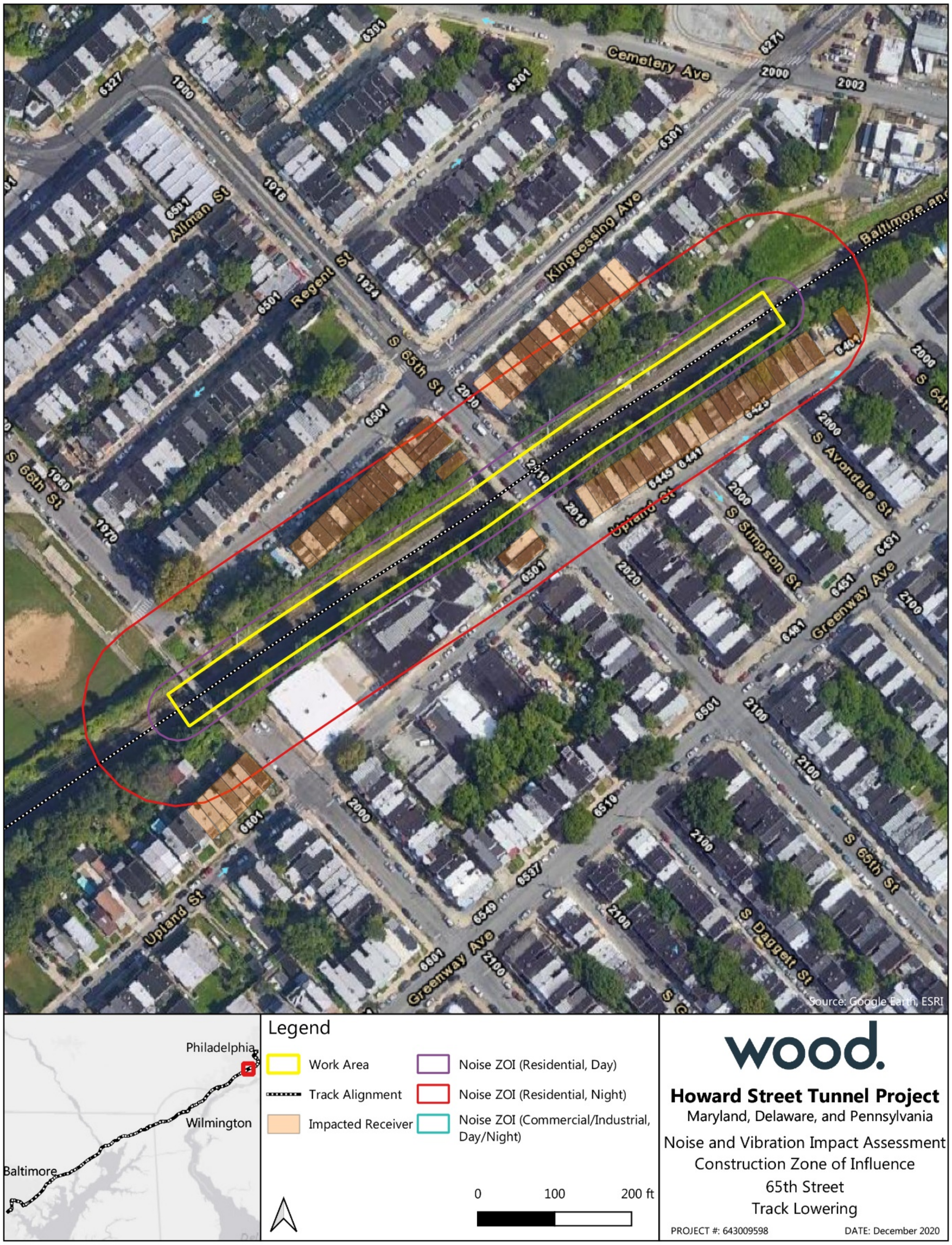

Thornton Rd
Bethel Rd
Kingsman Rd
Chichester Ave
Clements Ave
Sharpless Ave
Randall Ave
Galbreath Ave
Drexel Ct
Ogden Ave
Griffith Way
3rd Ave
Hallman Ct
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Chichester Avenue
Track Lowering
PROJECT #: 643009598
DATE: December 2020

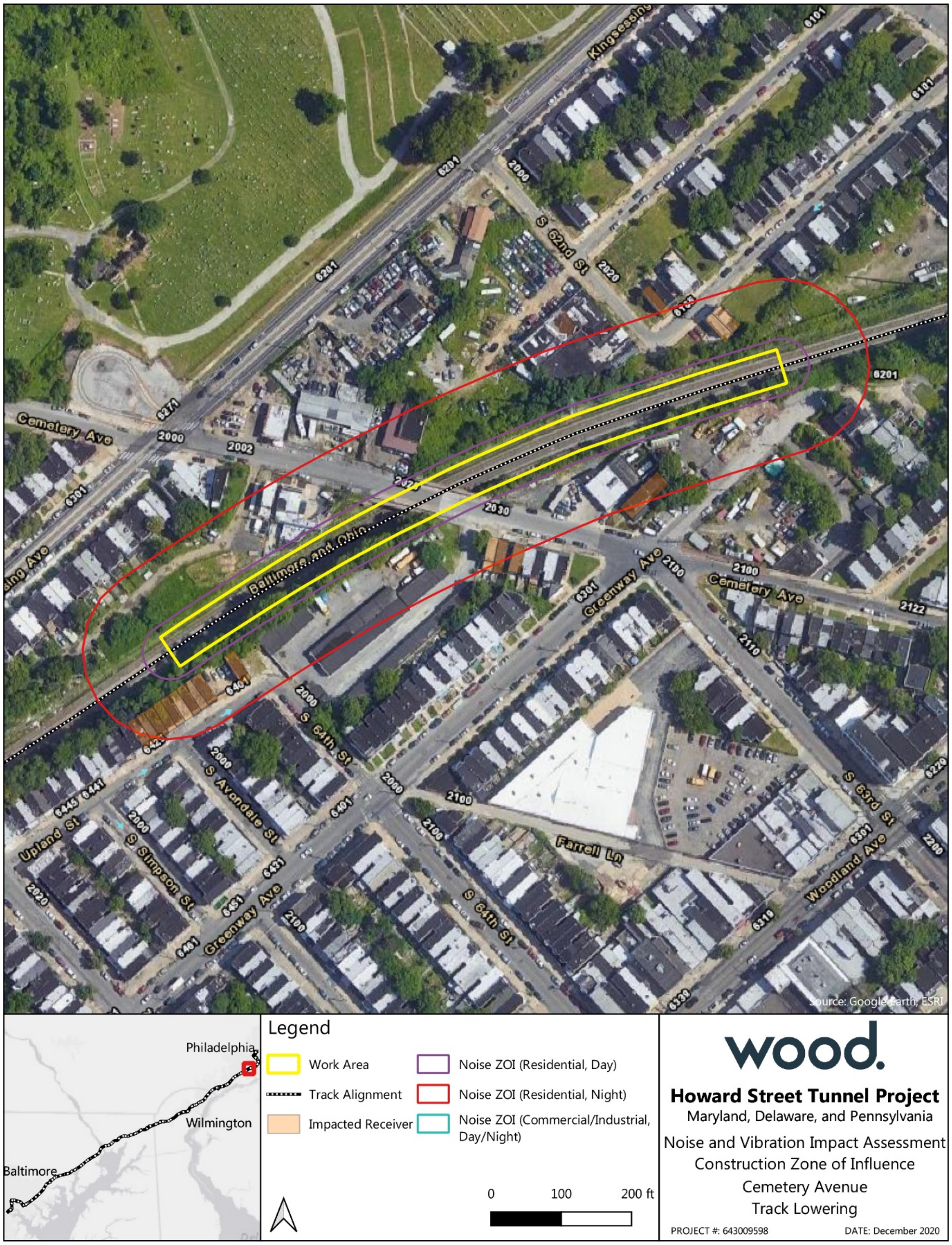

Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Crum Lynne Road
Track Lowering
PROJECT #: 643009598
DATE: December 2020

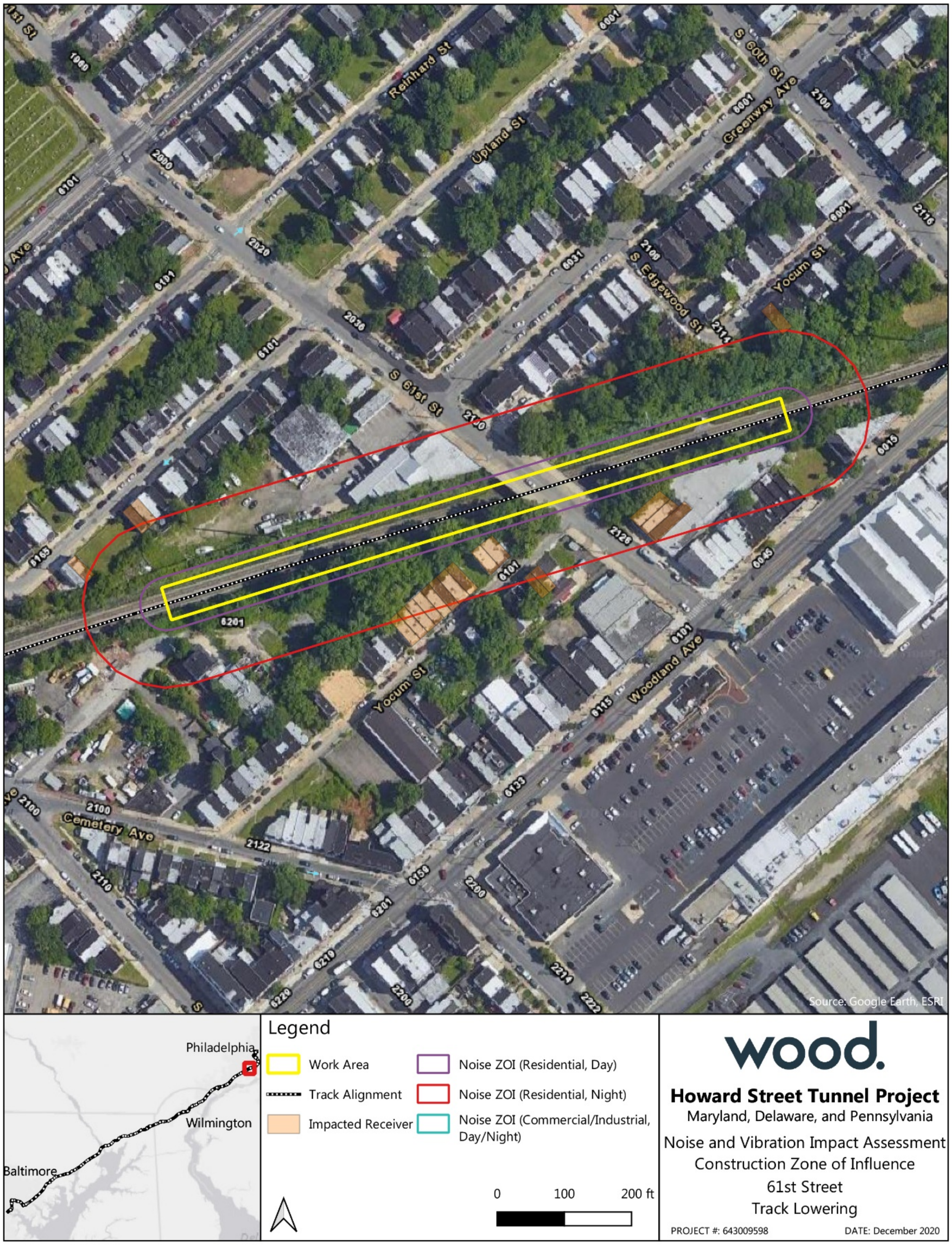

Clifton Ave
Sharon Ave
Pusey Ave
Baltimore and Ohio
Florence Ave
Frances Ave
Foster Ave
Chester Pike
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Clifton Avenue
Track Lowering
PROJECT #: 643009598
DATE: December 2020


Boone Tunnel
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
200
400 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Boone Tunnel
Track Lowering
PROJECT #: 643009598
DATE: December 2020


S 68th St
Trinity St
Regent St
Chester Ave
Kingsessing Ave
Upland St
Bonaffon St
Greenway Ave
S Aikens St
S 69th St
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
68th Street
Track Lowering
PROJECT #: 643009598
DATE: December 2020


Cemetery Ave
Kingsessing Ave
Allman St
Regent St
S 65th St
S 66th St
Upland St
S Simpson St
S Avondale St
Greenway Ave
S Daggett St
Baltimore and
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
100
200 ft
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
65th Street
Track Lowering
PROJECT #: 643009598
DATE: December 2020

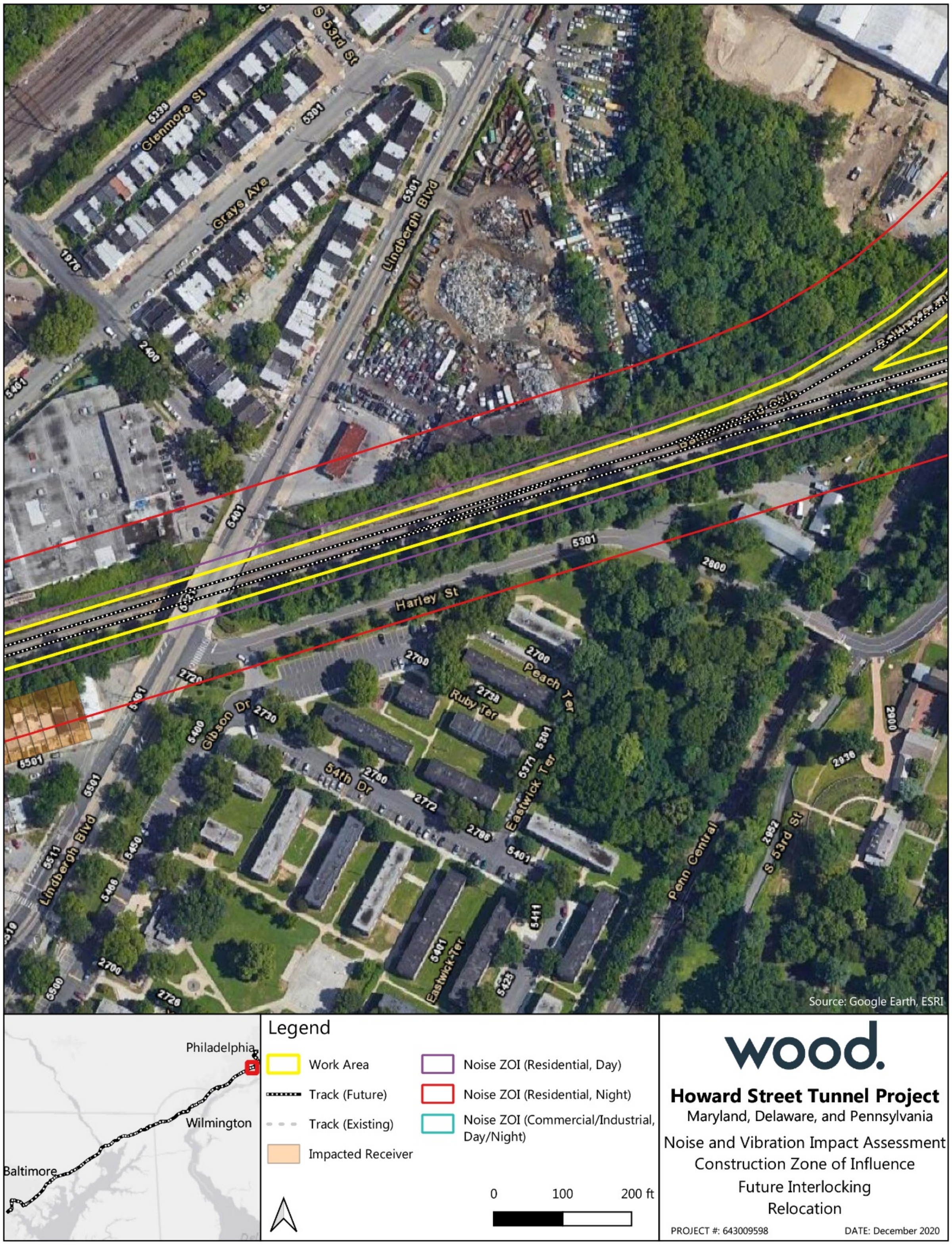

Kingsessing
Cemetery Ave
S 62nd St
Baltimore and Ohio
Greenway Ave
S 64th St
S Avondale St
Upland St
S Simpson St
Farrell Ln
S 63rd St
Woodland Ave
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Cemetery Avenue
Track Lowering
PROJECT #: 643009598
DATE: December 2020

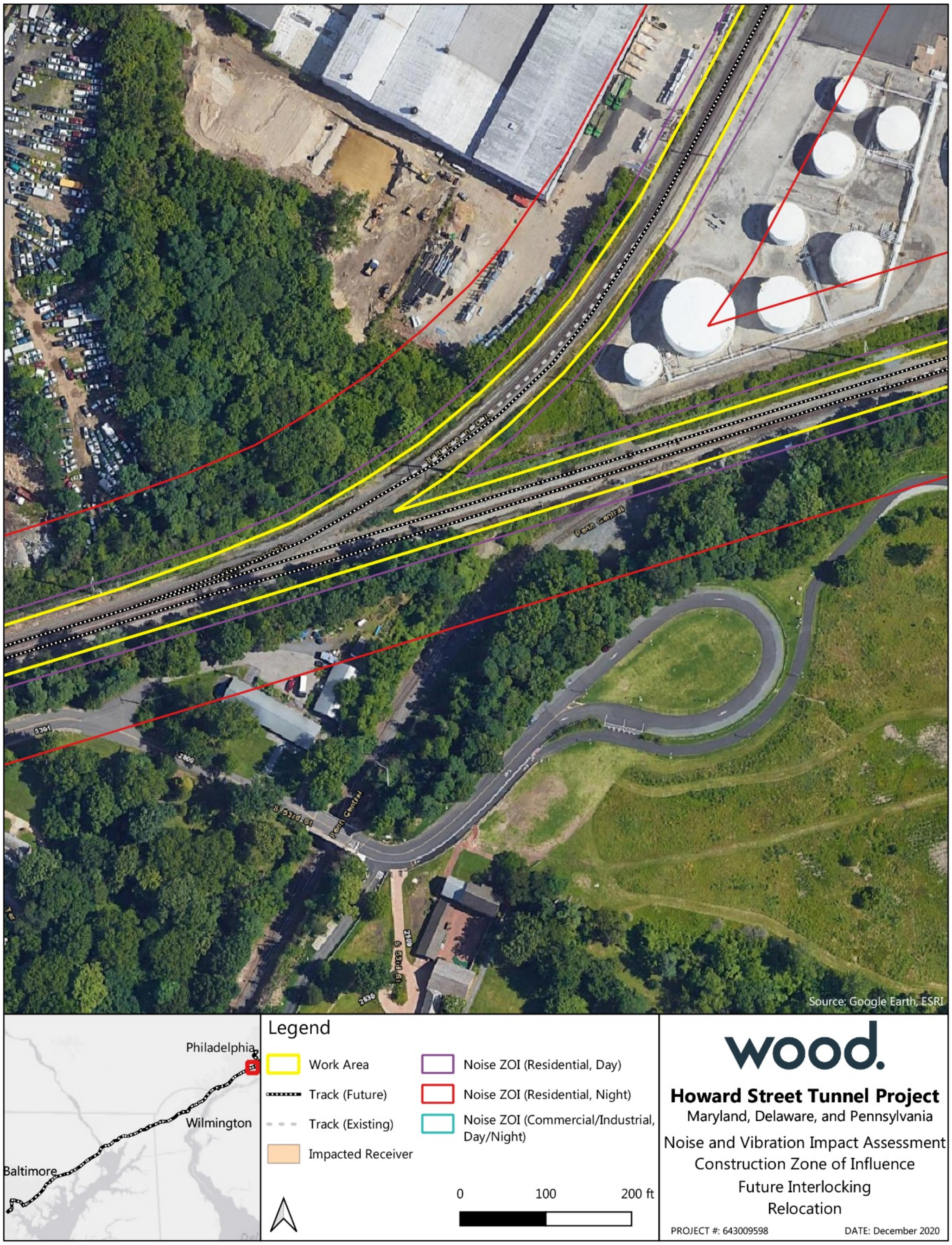

Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
100
200 ft
Philadelphia
Wilmington
Baltimore
Source: Google Earth, ESRI
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
61st Street
Track Lowering
PROJECT #: 643009598
DATE: December 2020

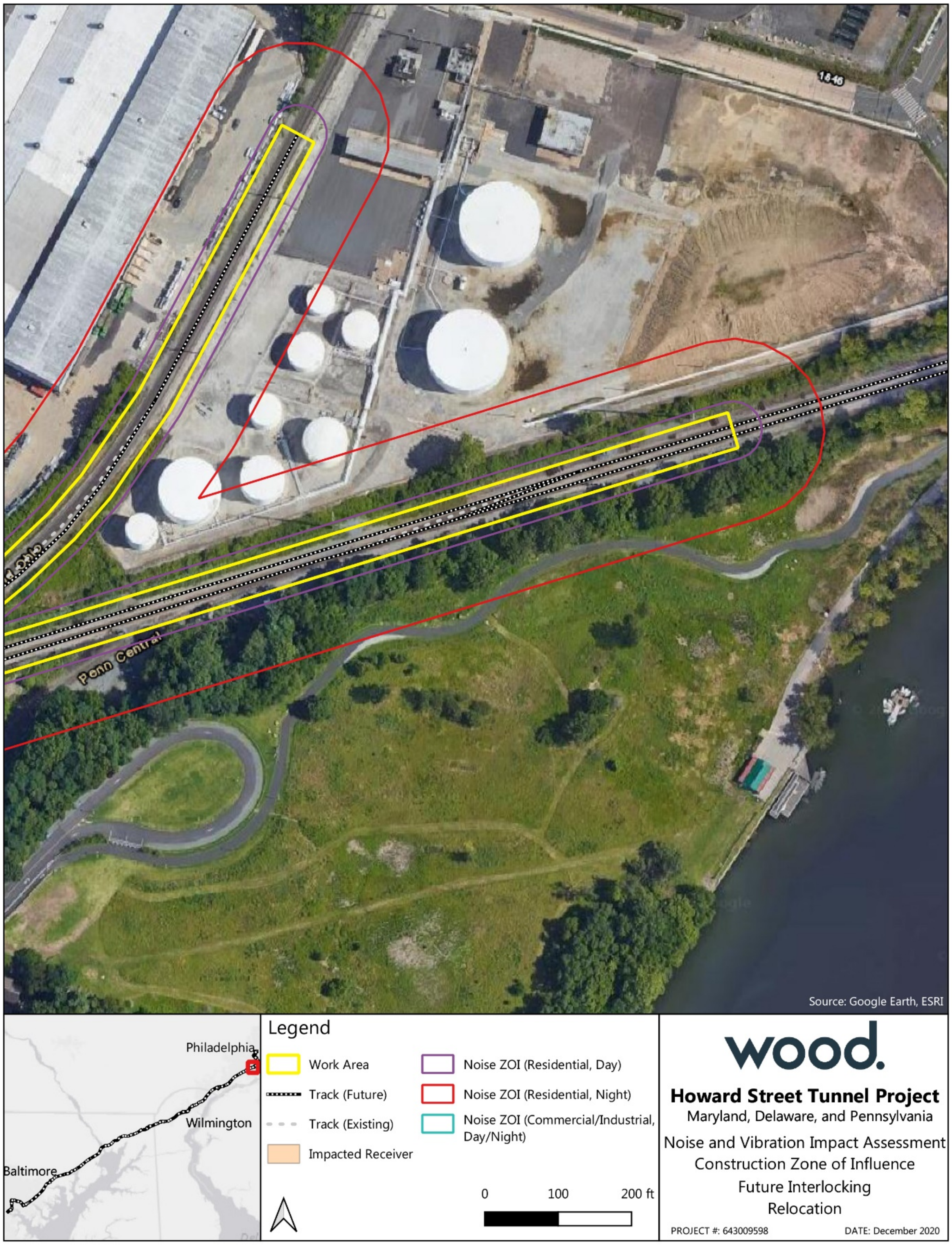

Source: Google Earth, ESRI
Woodland Ave
Greenway Ave
S 60th St
Yocum St
S Edgewood St
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Woodland Avenue
Track Lowering
PROJECT #: 643009598
DATE: December 2020


S 58th St
Yocum St
Woodland Ave
SP Transportation Authority
S 58th St
National Railroad Passenger Corp
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track (Future)
Track (Existing)
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Existing Interlocking
Relocation
PROJECT #: 643009598
DATE: December 2020


Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track (Future)
Track (Existing)
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Future Interlocking
Relocation
PROJECT #: 643009598
DATE: December 2020
Paschall Ave
Linmore Ave
Grays Ave
Lindbergh Blvd
Wheeler St
Gibson Dr
54th Dr
Yewdall Ter
Conestoga Ter
Harley
S 56th St
S Ithan St
S Frazier St


Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track (Future)
Track (Existing)
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Future Interlocking
Relocation
PROJECT #: 643009598
DATE: December 2020


Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track (Future)
Track (Existing)
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Future Interlocking
Relocation
PROJECT #: 643009598
DATE: December 2020


Penn Central
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track (Future)
Track (Existing)
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
Noise ZOI (Commercial/Industrial, Day/Night)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Future Interlocking
Relocation
PROJECT #: 643009598
DATE: December 2020


W Lafayette Ave
Mt Royal Ave
Rutter St
W Lanvale St
John St
Brevard St
Dolphin St
MTA
W Mt Royal Ave
W Oliver St
N Howard St
Park Ave
Cathedral St
Mace St
W Preston St
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Mount Royal Avenue
Track Lowering
PROJECT #: 643009598
DATE: December 2020

Legend

- Work Area
- Track Alignment
- Vibration ZOI (Cat. I)
- Vibration ZOI (Cat. II)
- Vibration ZOI (Cat. III)
- Vibration ZOI (Cat. IV)
- Impacted Receiver
- Impacted Receiver (Historical Building)

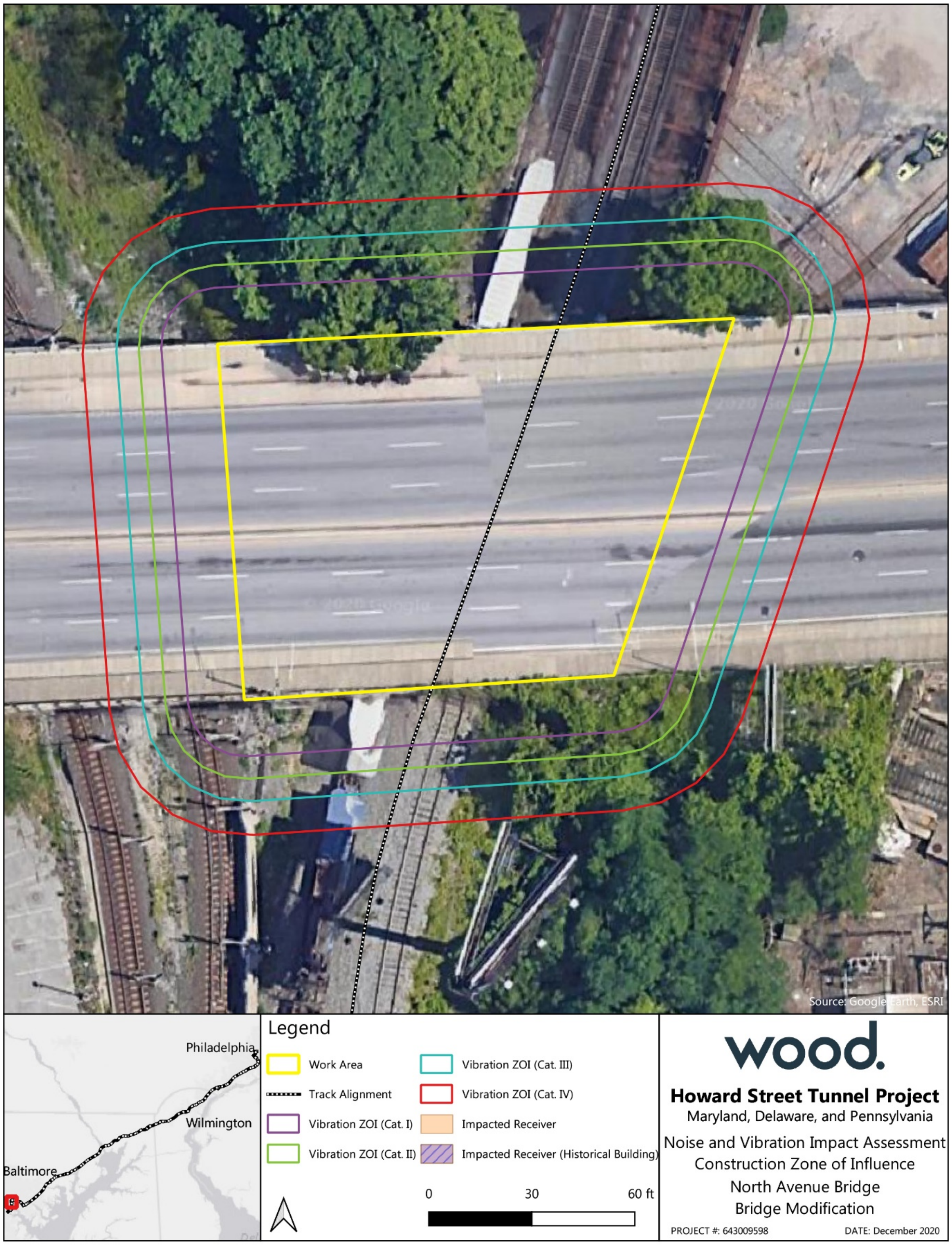
0 80 160 ft

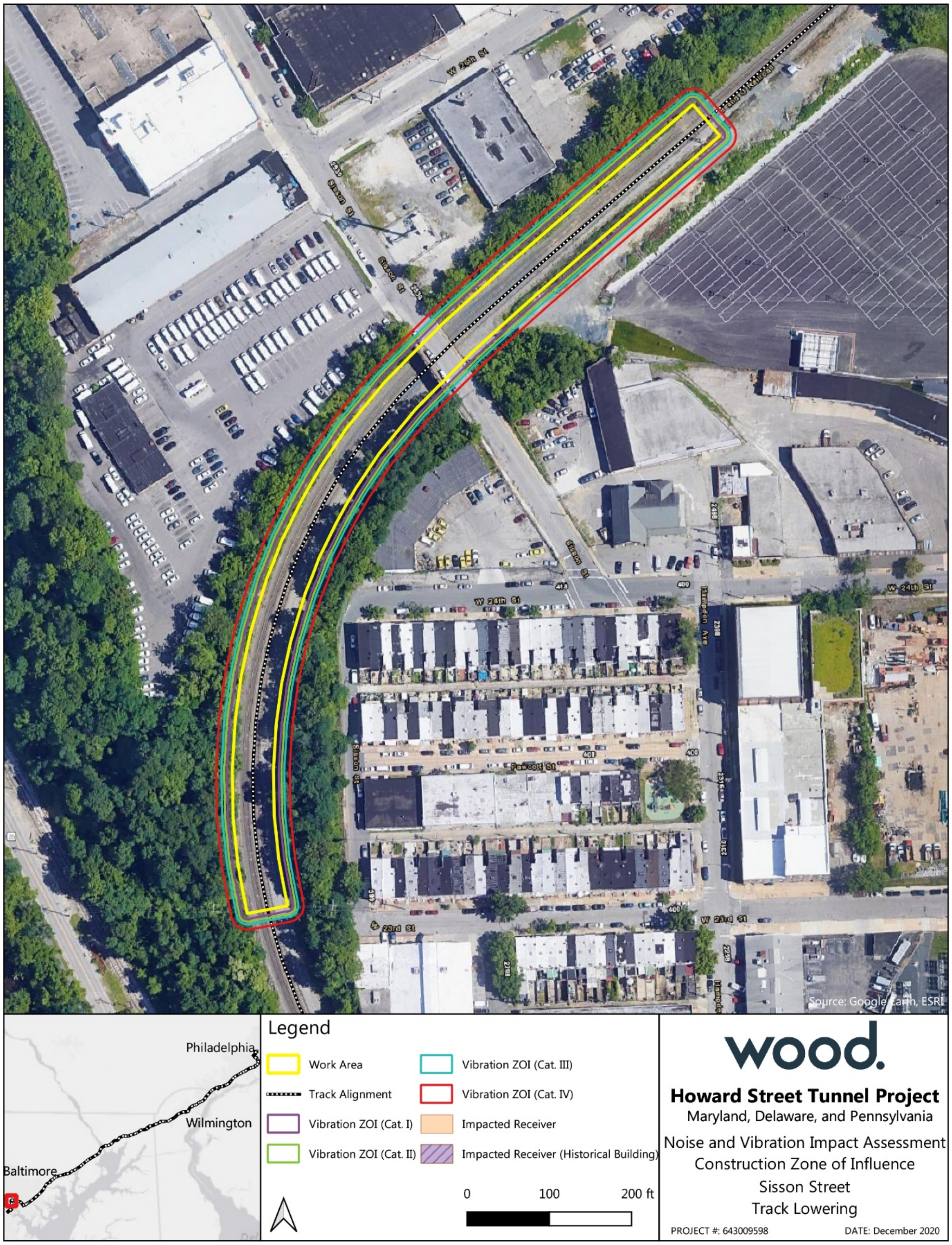
wood.

Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania

Noise and Vibration Impact Assessment
Construction Zone of Influence
MTA Bridge
Track Lowering

PROJECT #: 643009598 DATE: December 2020

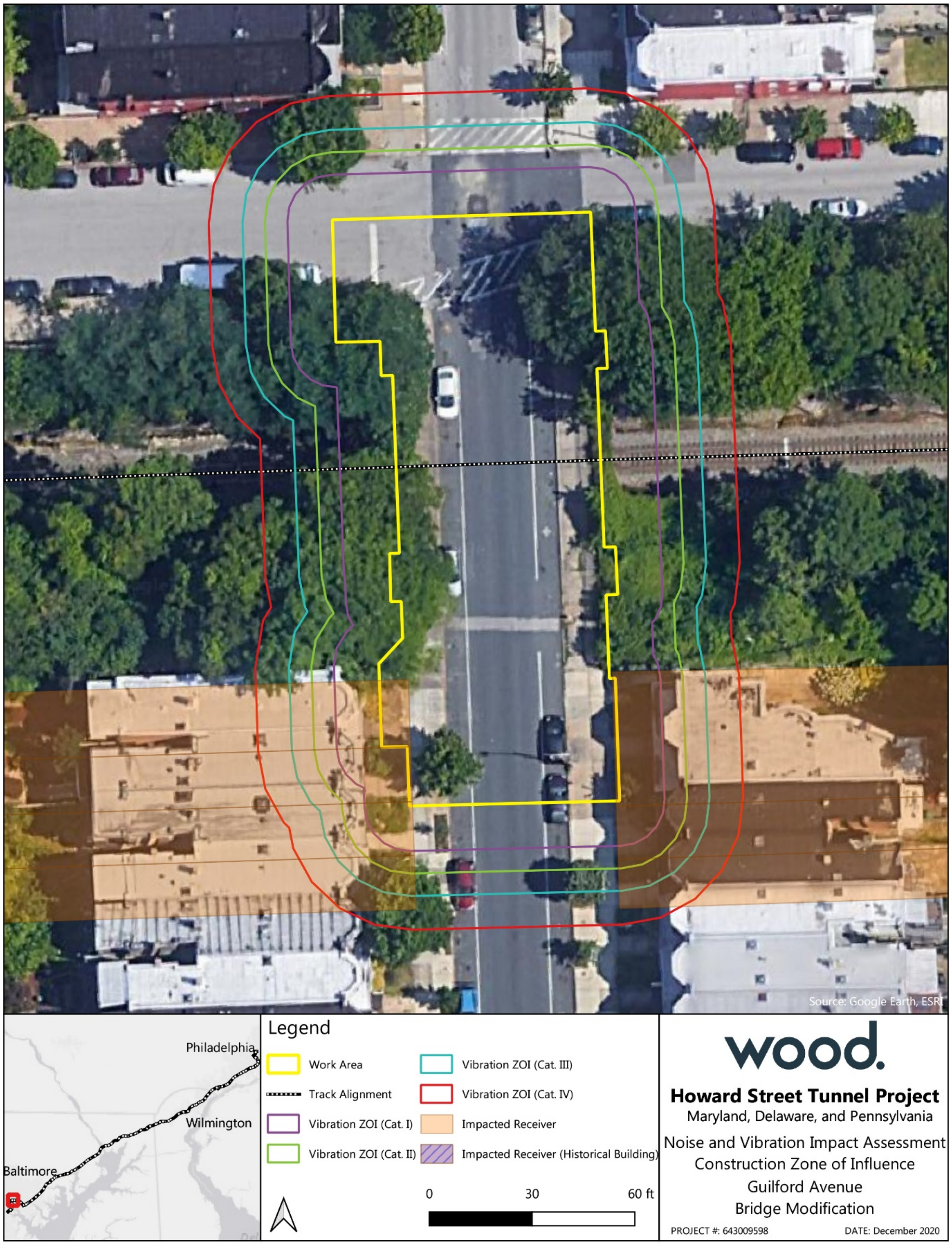

Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
30
60 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
North Avenue Bridge
Bridge Modification
PROJECT #: 643009598
DATE: December 2020


Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Sisson Street
Track Lowering
PROJECT #: 643009598
DATE: December 2020


Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Huntington Avenue
Track Lowering
PROJECT #: 643009598
DATE: December 2020

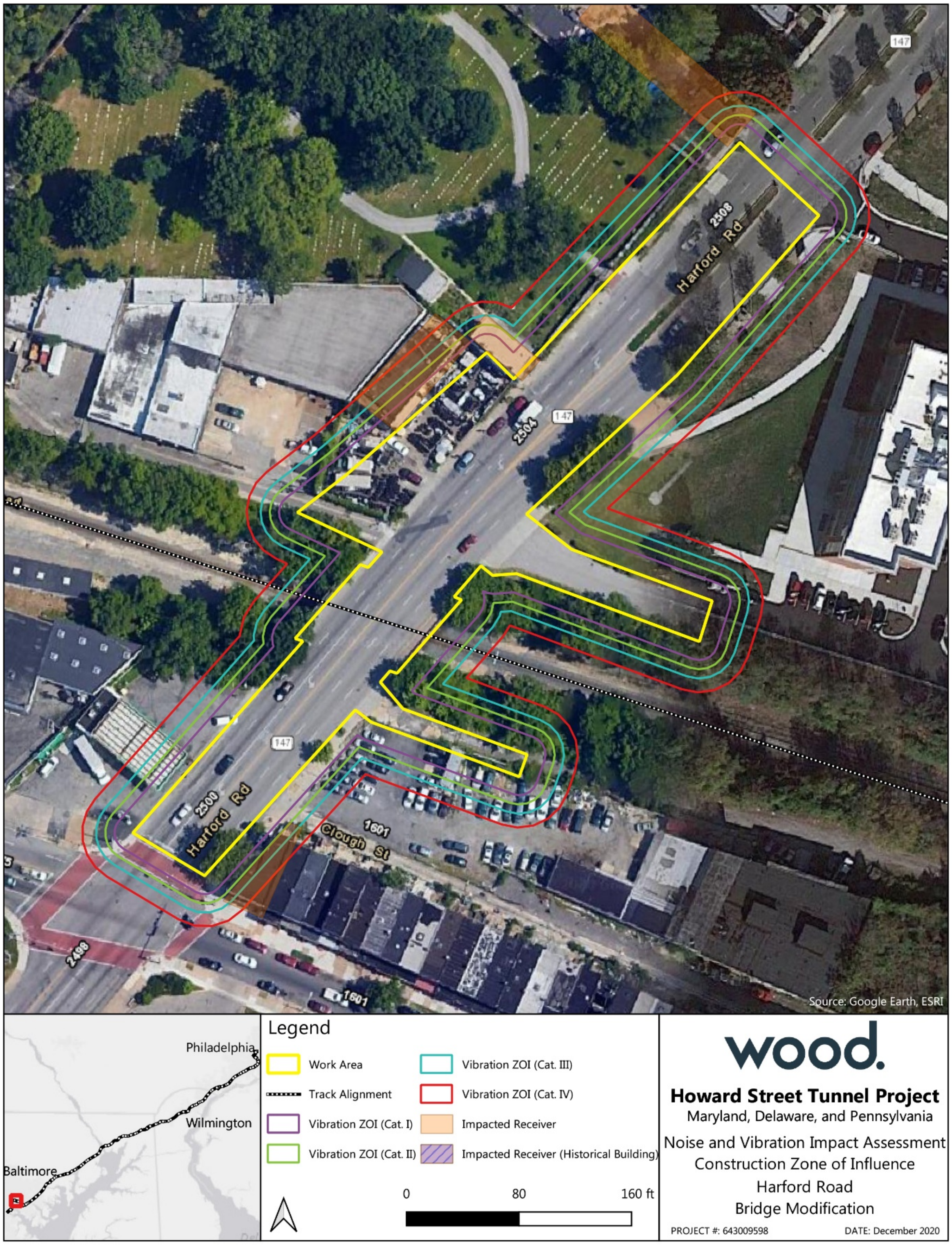

W 27th St
E 27th St
W 26th St
E 26th St
W 25 1/2 St
W 25th St
E 25th St
Maryland Ave
N Charles St
Morton St
Mace St
Lovegrove St
St Paul St
Baltimore's Historic Charles St
B and O Railroad
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Charles Street
Track Lowering
PROJECT #: 643009598
DATE: December 2020


St Paul St
N Calvert St
Hunter St
Hargrove Aly
Baltimore's Historic Charles St
E 26th St
St. Paul St
E 25th 1/2 St
N Calvert St
Hunter St
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
90
180 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
St. Paul/Calvert Street
Track Lowering
PROJECT #: 643009598
DATE: December 2020


Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
30
60 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Guilford Avenue
Bridge Modification
PROJECT #: 643009598
DATE: December 2020

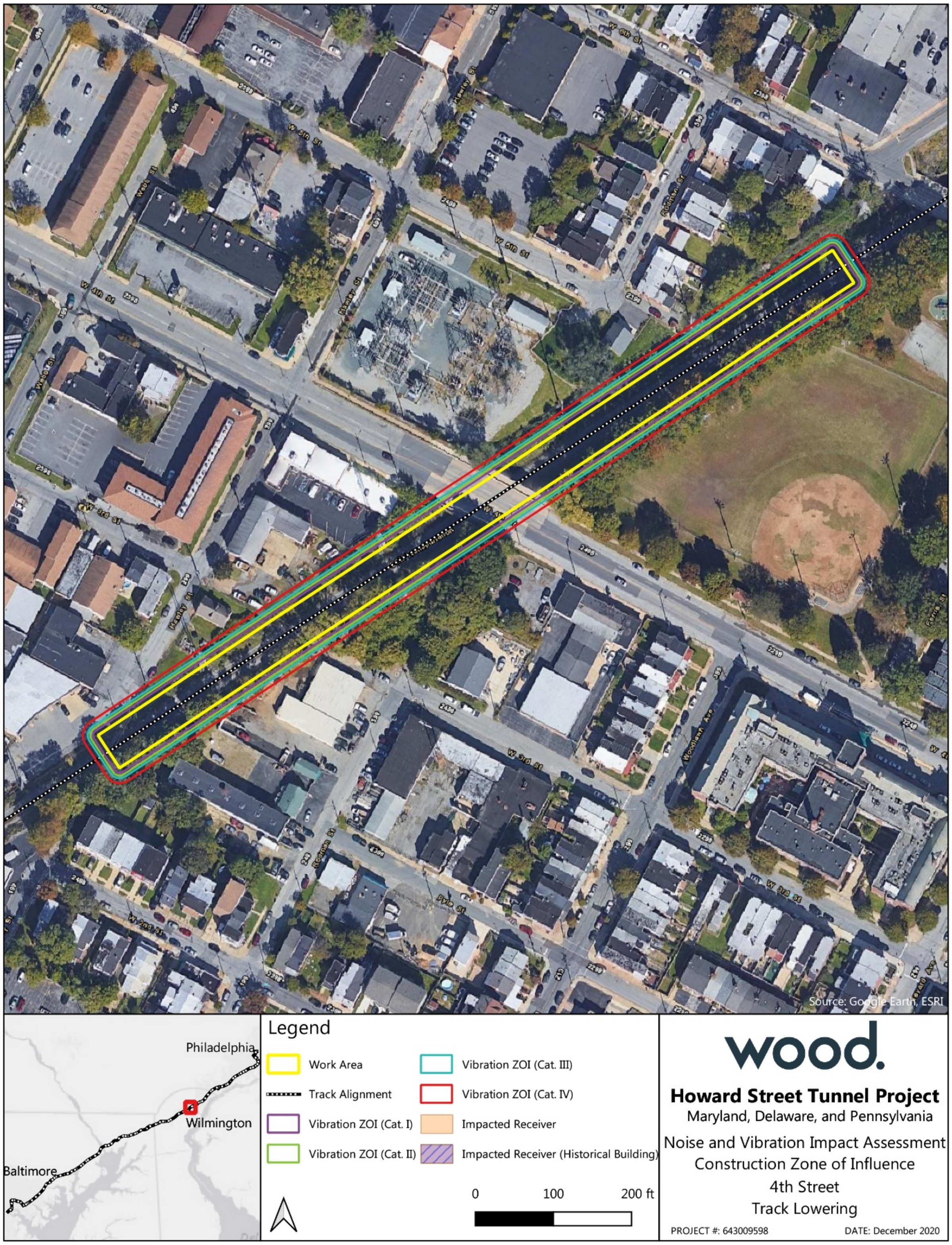

E Lorraine Ave
Barclay St
E 26th St
E 25 1/2 St
398
401
2612
2608
2518
2504
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
90
180 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Barclay Street
Track Lowering
PROJECT #: 643009598
DATE: December 2020


Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Greenmount Avenue
Track Lowering
PROJECT #: 643009598
DATE: December 2020


2308
Harford Rd
2504
147
2500
Harford Rd
1601
Clough St
2498
1601
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
80
160 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Harford Road
Bridge Modification
PROJECT #: 643009598
DATE: December 2020


Rodman Way
Pulaski Hwy
N North Point Rd
Harbor Tunnel Thwy
Quantril Way
Alricks Way
Armistead Way
Spangler Way
Erdman Ave
Debelius Ave
Moravia Ave
Quad Ave
Penn Central Railroad
E Lombard St
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
300
600 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Bayview Yard
Temporary Staging
PROJECT #: 643009598
DATE: December 2020


W 2nd St
Greenhill Ave
Lancaster Ave
Hawley St
W 2nd St
CSX Transportation
S Colonial Ave
Rodman St
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Lancaster Avenue
Track Lowering
PROJECT #: 643009598
DATE: December 2020


Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
4th Street
Track Lowering
PROJECT #: 643009598
DATE: December 2020


Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Chichester Avenue
Track Lowering
PROJECT #: 643009598
DATE: December 2020

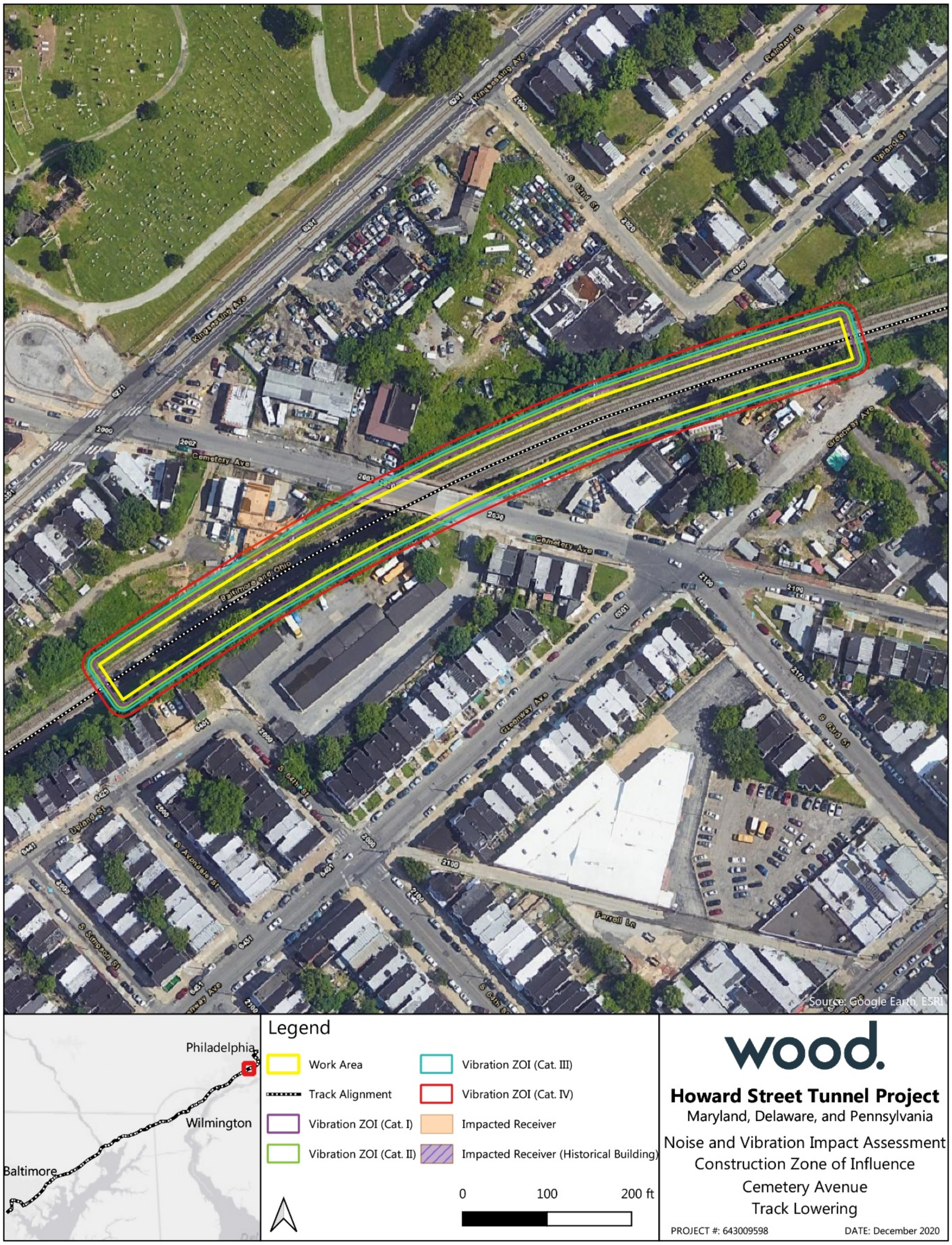

Garfield Ave
Haverford Rd
Tyler Ave
Wilson Ave
Hillside Rd
Crum Lynne Rd
Shaw Rd
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Crum Lynne Road
Track Lowering
PROJECT #: 643009598
DATE: December 2020


Source: Google Earth, ESRI
Clifton Ave
Pusey Ave
Baltimore and Ohio
Foster Ave
Chester Pike
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Clifton Avenue
Track Lowering
PROJECT #: 643009598
DATE: December 2020

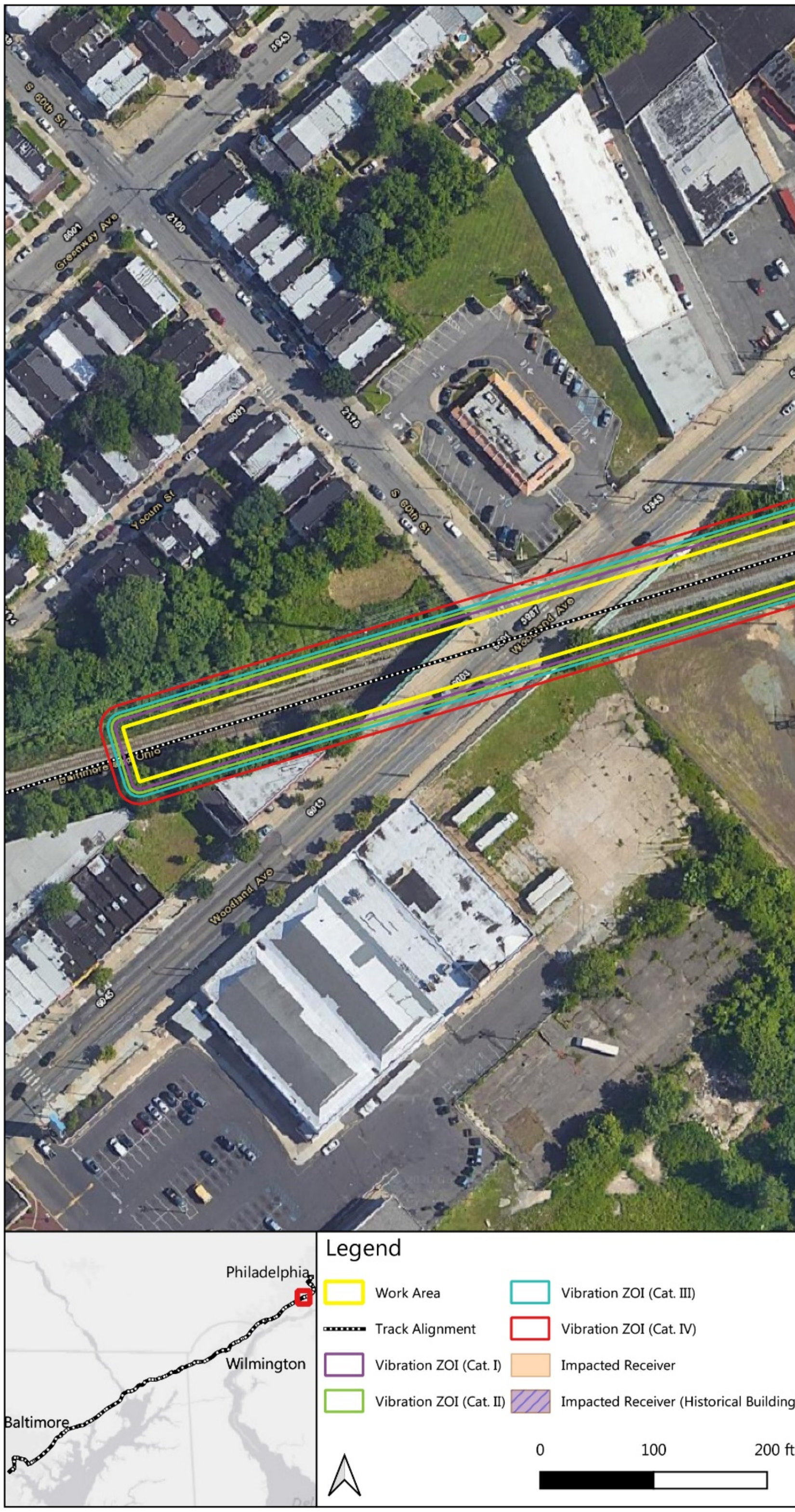

Boone Tunnel
Chester Pike
Pusey Ave
Cherry St
Hillside Ave
Pine St
Lawrence Ave
Kern St
Greenwood Rd
Laurel Rd
Poplar St
Bartlett Ave
Garvin Blvd
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
200
400 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Boone Tunnel
Tunnel Enlargement
PROJECT #: 643009598
DATE: December 2020


Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
68th Street
Track Lowering
PROJECT #: 643009598
DATE: December 2020


Kingsessing Ave
Regent St
Upland St
S 65th St
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
65th Street
Track Lowering
PROJECT #: 643009598
DATE: December 2020


Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Cemetery Avenue
Track Lowering
PROJECT #: 643009598
DATE: December 2020


Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
61st Street
Track Lowering
PROJECT #: 643009598
DATE: December 2020



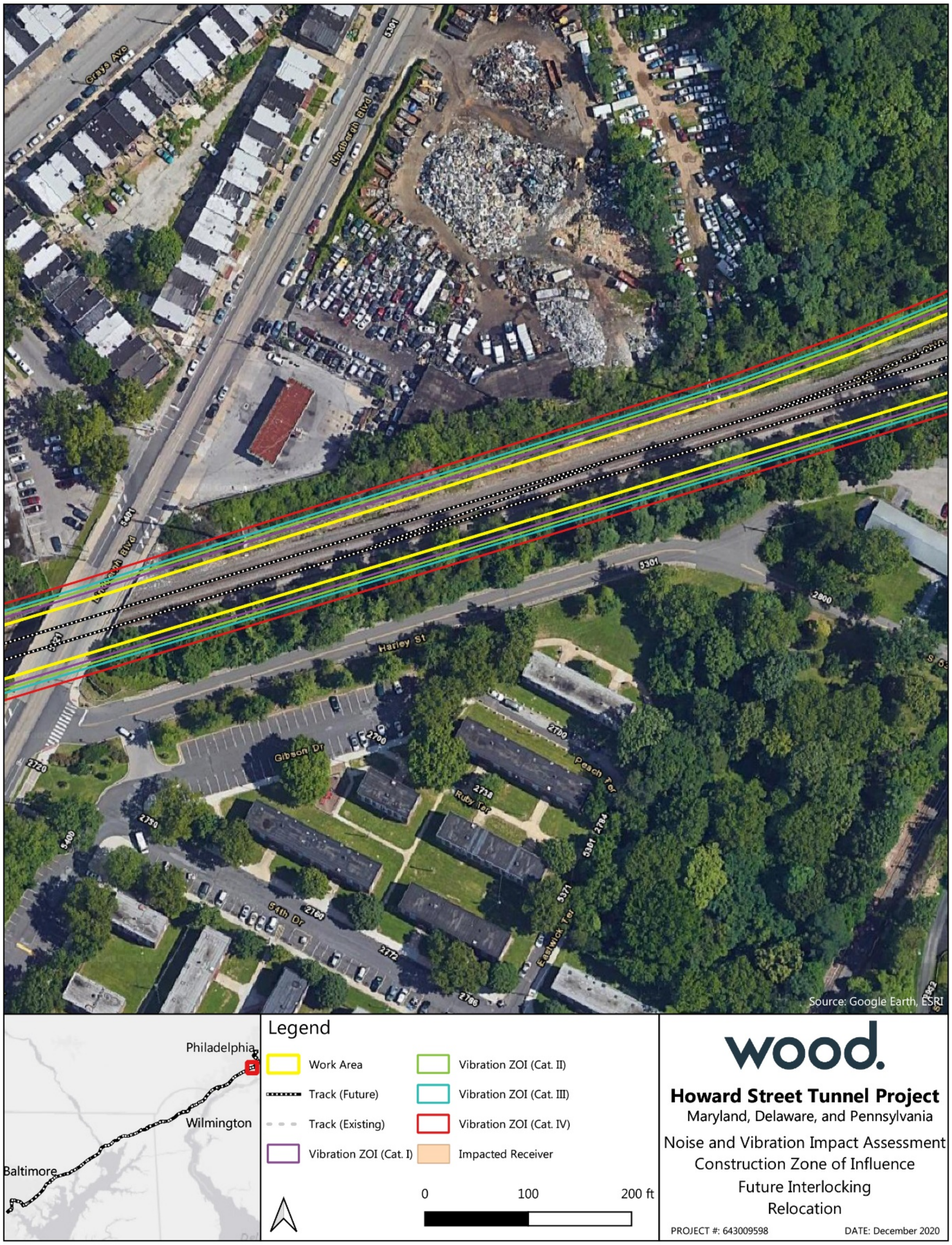
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania

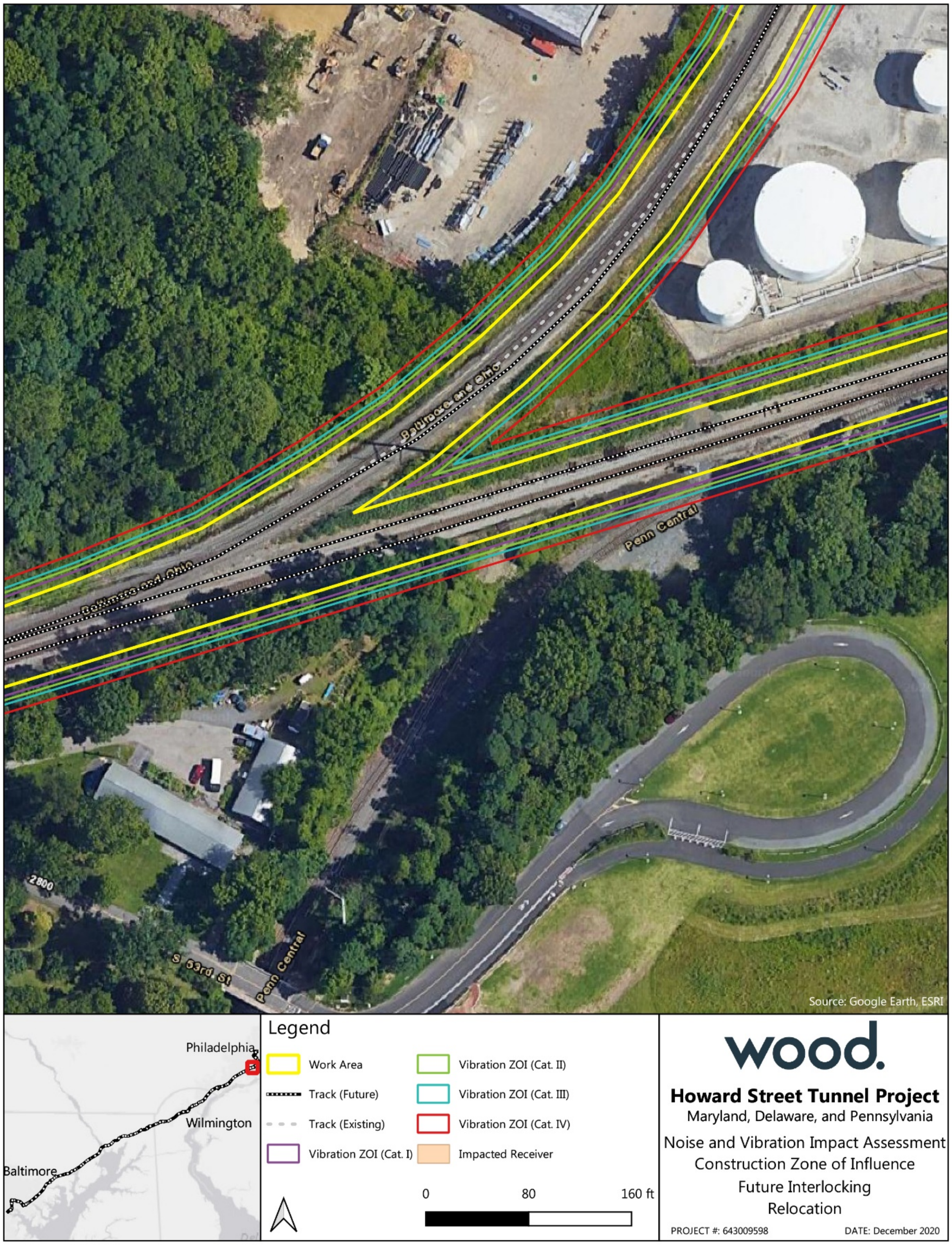
Noise and Vibration Impact Assessment
Construction Zone of Influence
Woodland Avenue
Track Lowering

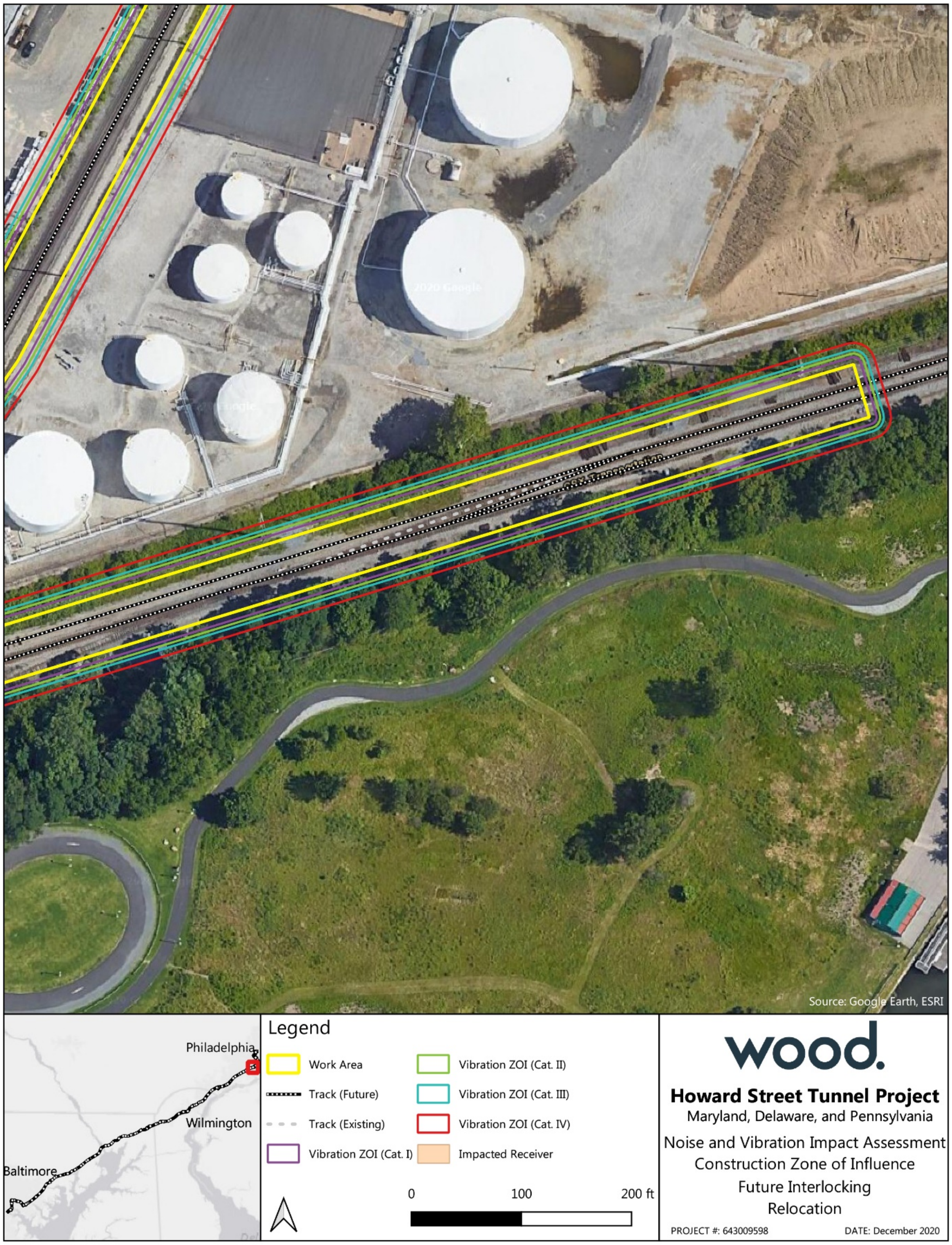
PROJECT #: 643009598 DATE: December 2020


Woodland Ave
S 58th St
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track (Future)
Track (Existing)
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Existing Interlocking
Relocation
PROJECT #: 643009598
DATE: December 2020


Graves Ave
Wheeler St
Lindbergh Blvd
Gibson Dr
S 56th St
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track (Future)
Track (Existing)
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Future Interlocking
Relocation
PROJECT #: 643009598
DATE: December 2020


Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track (Future)
Track (Existing)
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Future Interlocking
Relocation
PROJECT #: 643009598
DATE: December 2020


Baltimore and Ohio
Penn Central
2800
S 53rd St
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track (Future)
Track (Existing)
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
0
80
160 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Future Interlocking
Relocation
PROJECT #: 643009598
DATE: December 2020


Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track (Future)
Track (Existing)
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Future Interlocking
Relocation
PROJECT #: 643009598
DATE: December 2020

Appendix D

Howard Street Tunnel Track Profile

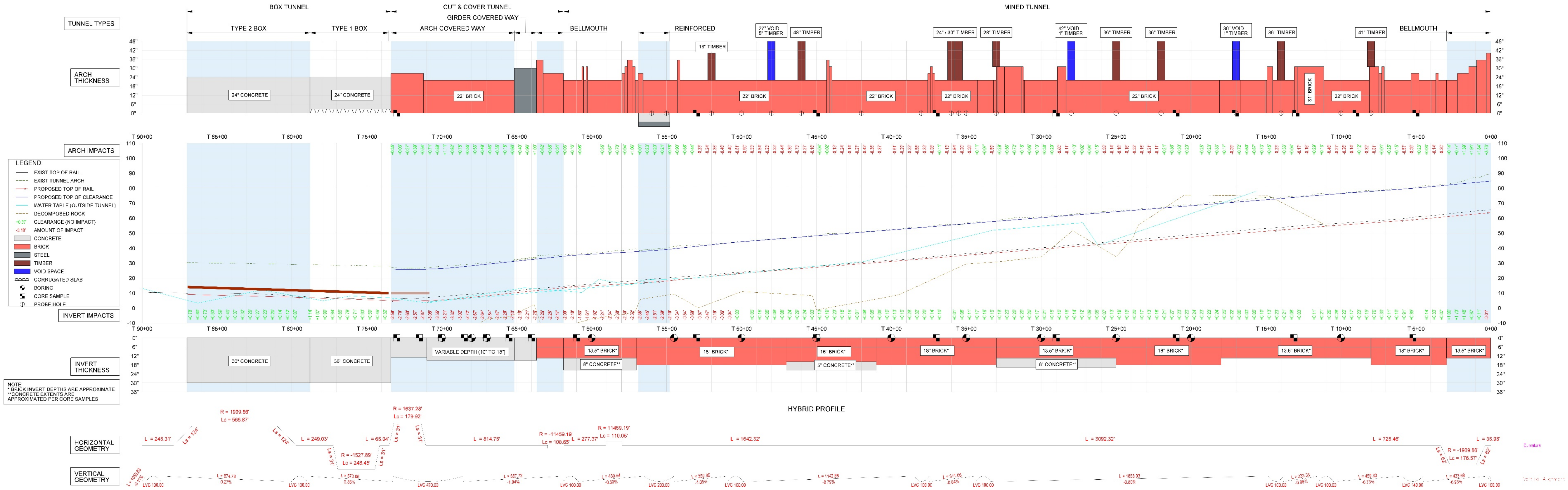
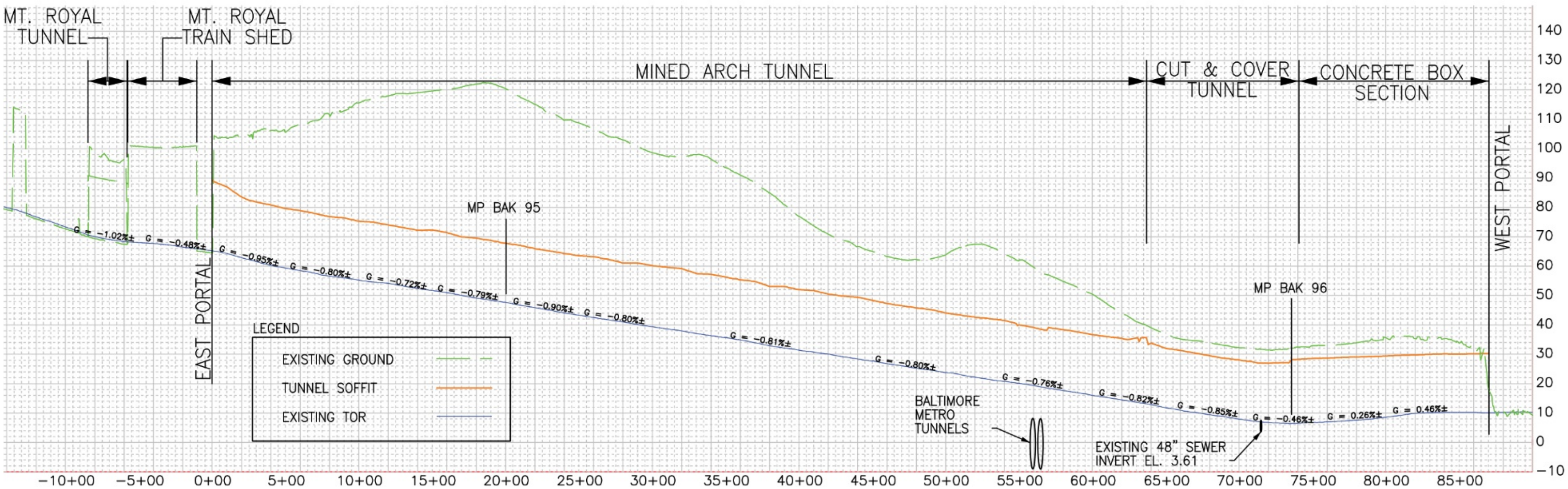
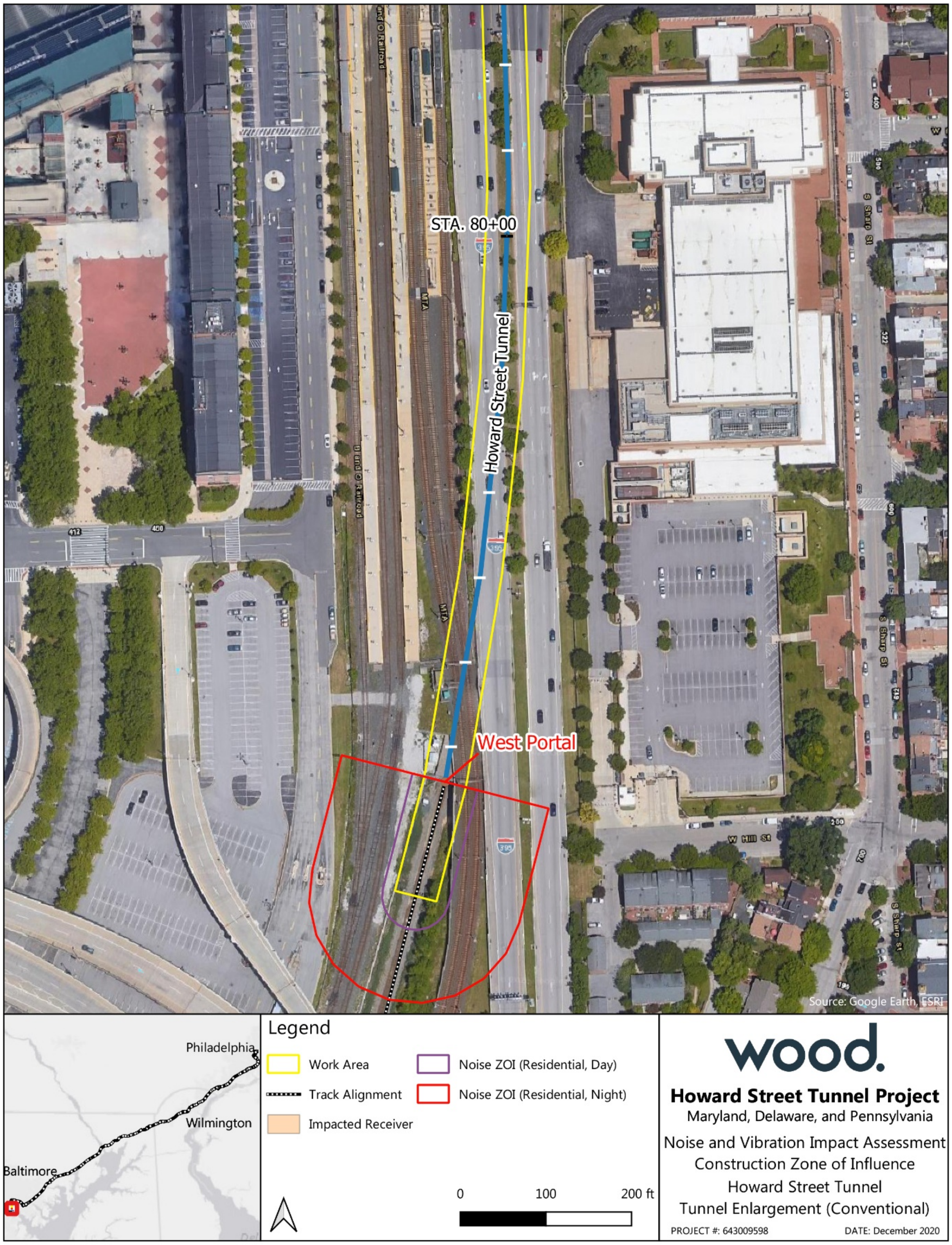

TUNNEL TYPES
BOX TUNNEL
CUT & COVER TUNNEL
MINED TUNNEL
TYPE 2 BOX
TYPE 1 BOX
GIRDER COVERED WAY
ARCH COVERED WAY
BELLMOUTH
REINFORCED
ARCH THICKNESS
24" CONCRETE
22" BRICK
ARCH IMPACTS
LEGEND:
EXIST TOP OF RAIL
EXIST TUNNEL ARCH
PROPOSED TOP OF RAIL
PROPOSED TOP OF CLEARANCE
WATER TABLE (OUTSIDE TUNNEL)
DECOMPOSED ROCK
CLEARANCE (NO IMPACT)
AMOUNT OF IMPACT
CONCRETE
BRICK
STEEL
TIMBER
VOID SPACE
CORRUGATED SLAB
BORING
CORE SAMPLE
PROBE HOLE
INVERT IMPACTS
INVERT THICKNESS
30" CONCRETE
VARIABLE DEPTH (10" TO 18")
13.5" BRICK*
18" BRICK*
16" BRICK*
NOTE:
* BRICK INVERT DEPTHS ARE APPROXIMATE
** CONCRETE EXTENTS ARE APPROXIMATED PER CORE SAMPLES
HYBRID PROFILE
HORIZONTAL GEOMETRY
VERTICAL GEOMETRY

FIGURE B.12: EXISTING PROFILE



Appendix E

Construction Impact – HST (Conventional Approach)

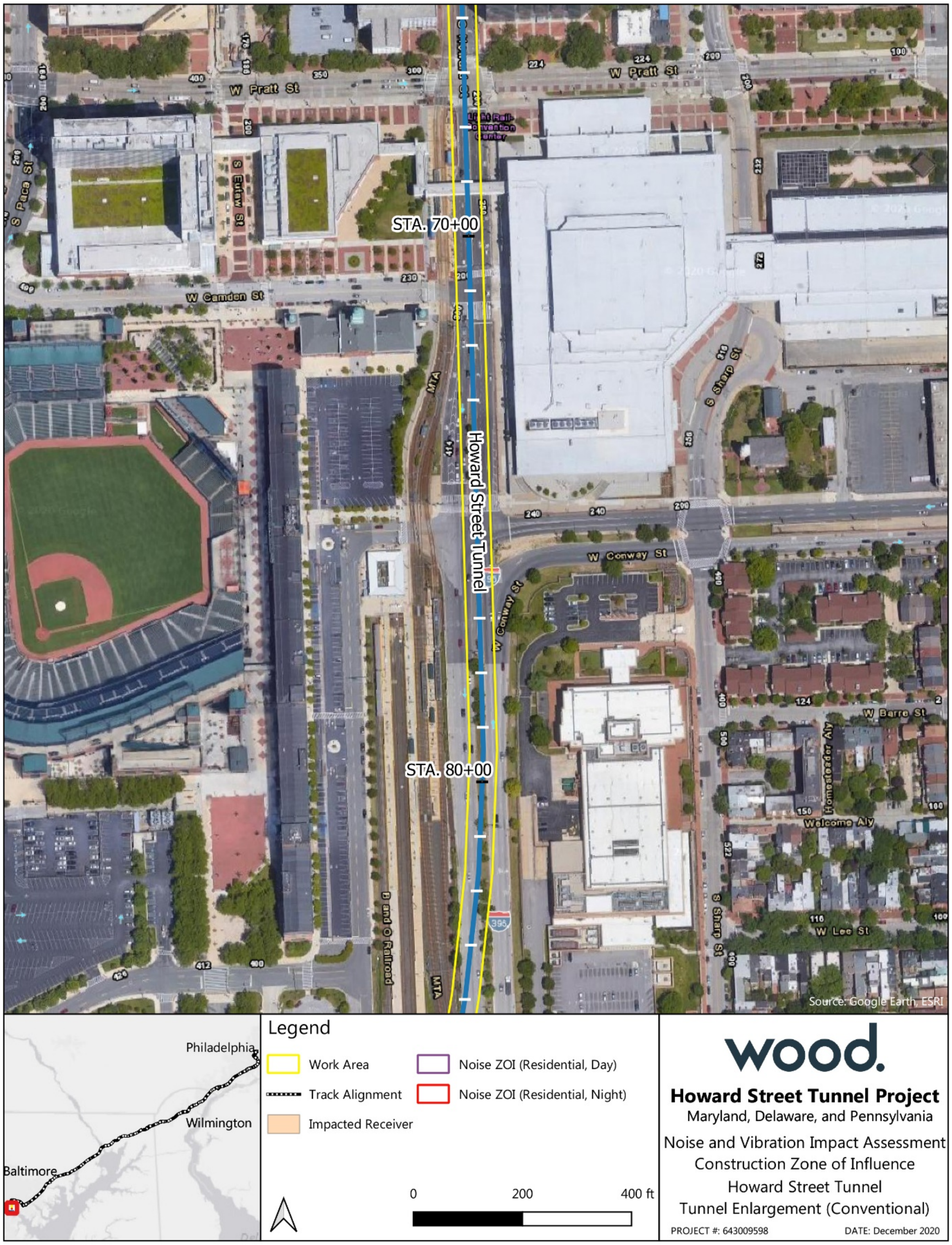


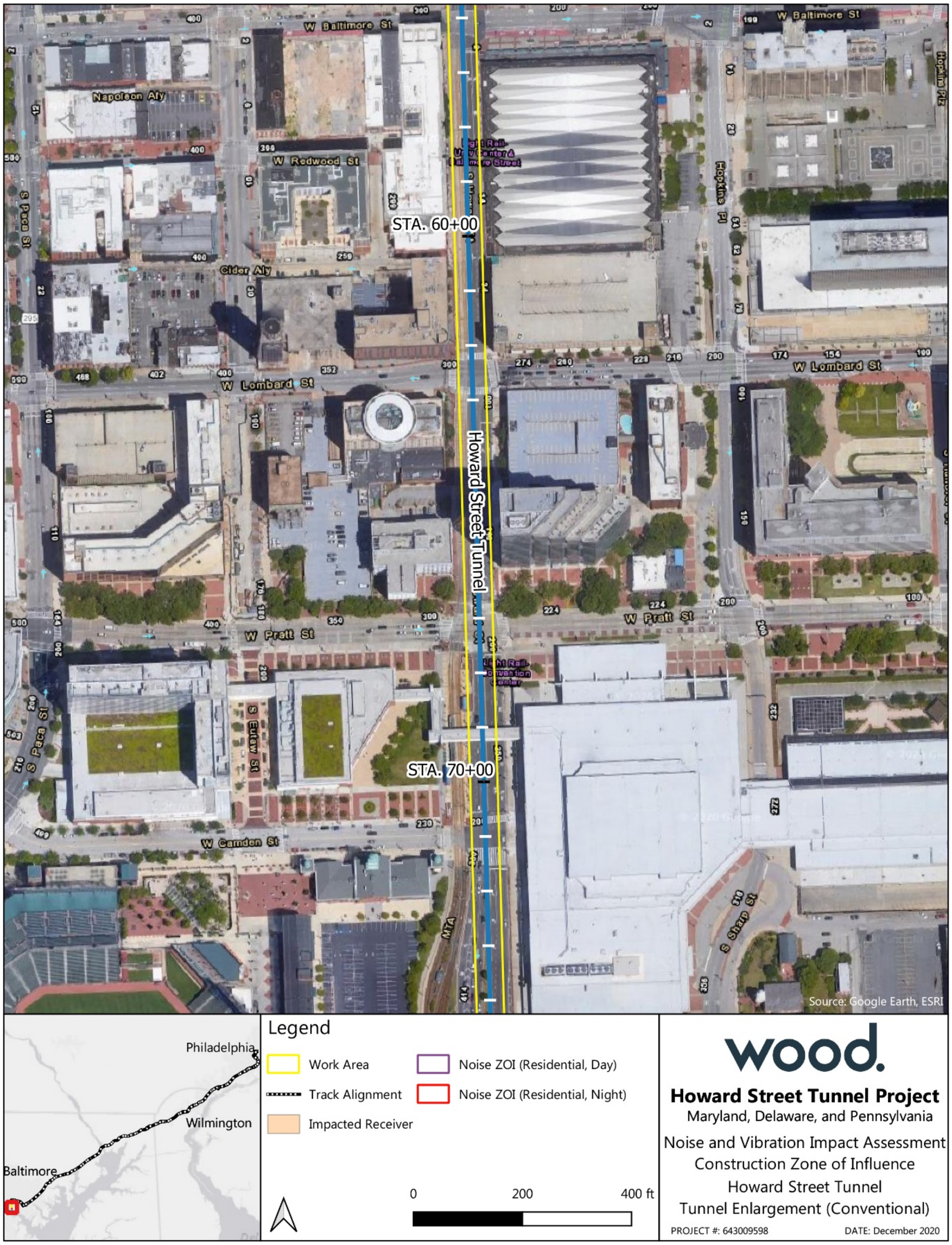
wood.

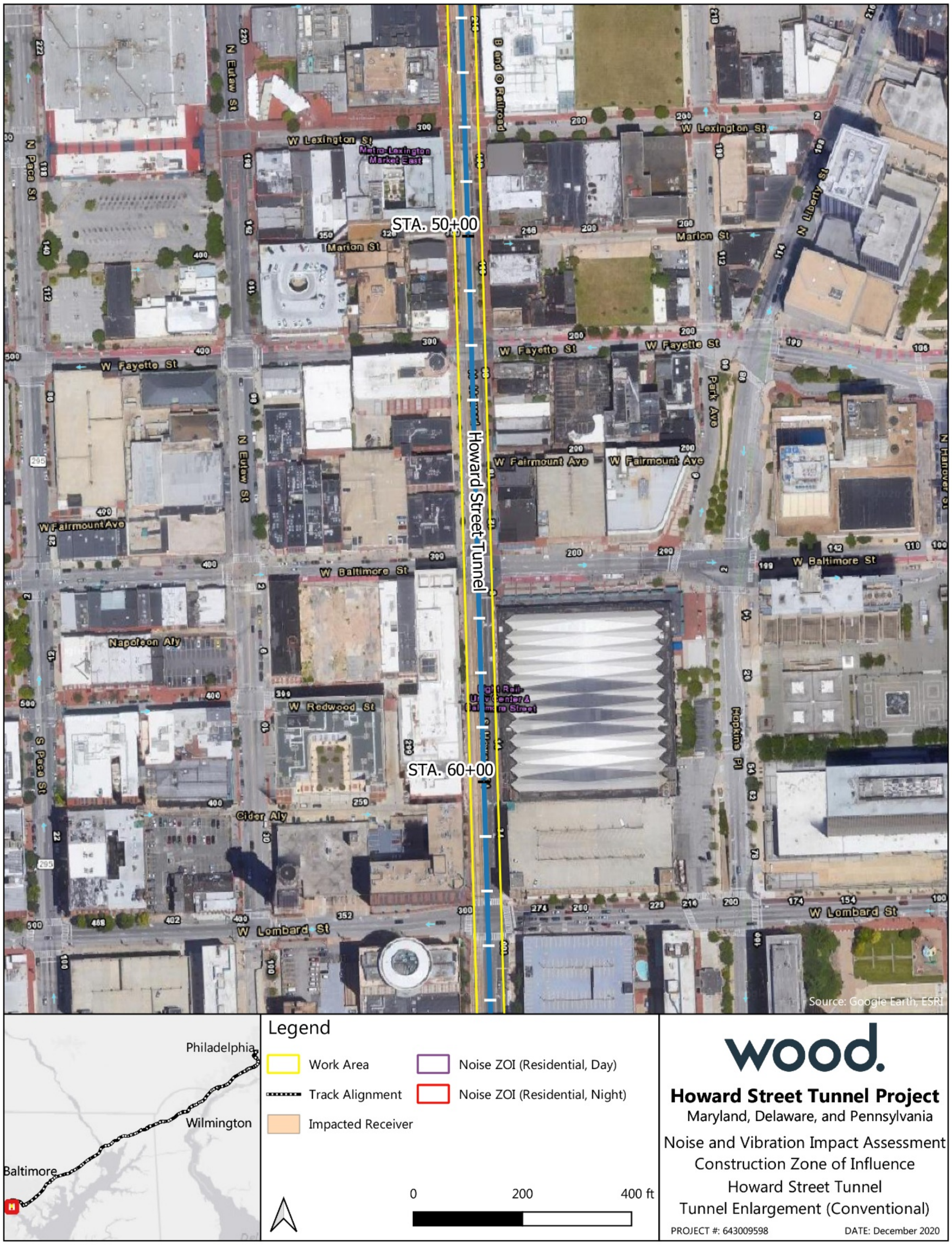
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania

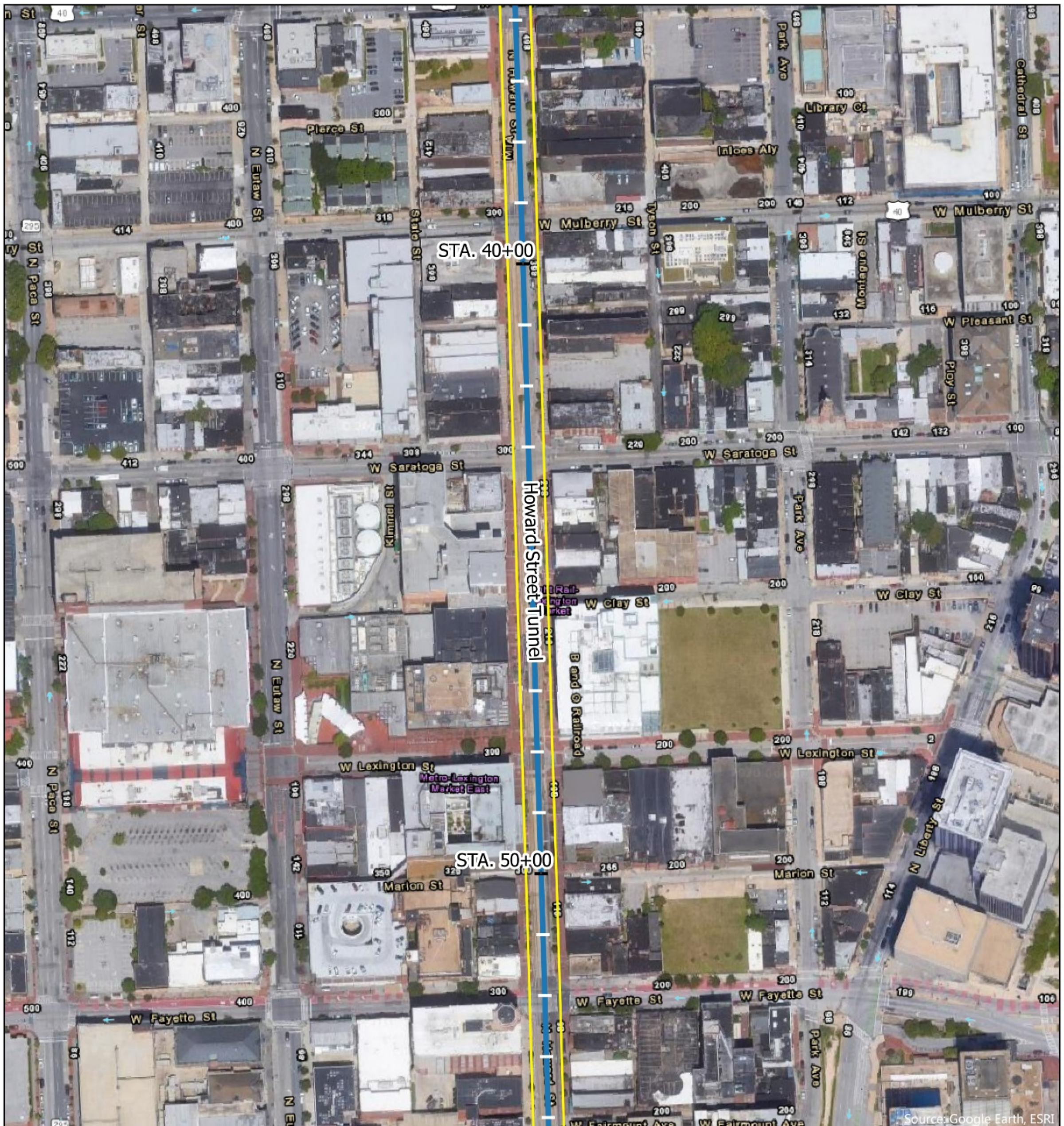
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Conventional)

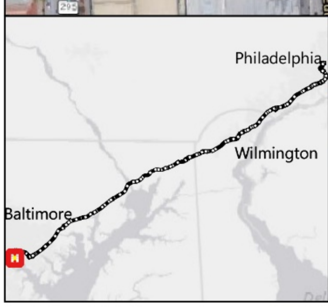
PROJECT #: 643009598 DATE: December 2020


W Pratt St
S Paca St
S Eutaw St
W Camden St
STA. 70+00
Howard Street Tunnel
STA. 80+00
S Sharp St
W Conway St
W Barre St
Homestead Aly
Welcome Aly
W Lee St
B and O Railroad
MTA
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
0
200
400 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Conventional)
PROJECT #: 643009598
DATE: December 2020


W Baltimore St
Napoleon Aly
W Redwood St
Cider Aly
W Lombard St
W Pratt St
W Camden St
S Paca St
S Eutaw St
Hopkins Pl
S Sharp St
STA. 60+00
STA. 70+00
Howard Street Tunnel
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
0
200
400 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Conventional)
PROJECT #: 643009598
DATE: December 2020


STA. 50+00
STA. 60+00
Howard Street Tunnel
W Lexington St
W Fayette St
W Fairmount Ave
W Baltimore St
W Redwood St
W Lombard St
Marion St
Napoleon Aly
Cider Aly
N Eutaw St
N Paca St
S Paca St
N Liberty St
Park Ave
Hopkins Pl
B and O Railroad
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
0
200
400 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Conventional)
PROJECT #: 643009598
DATE: December 2020





Legend

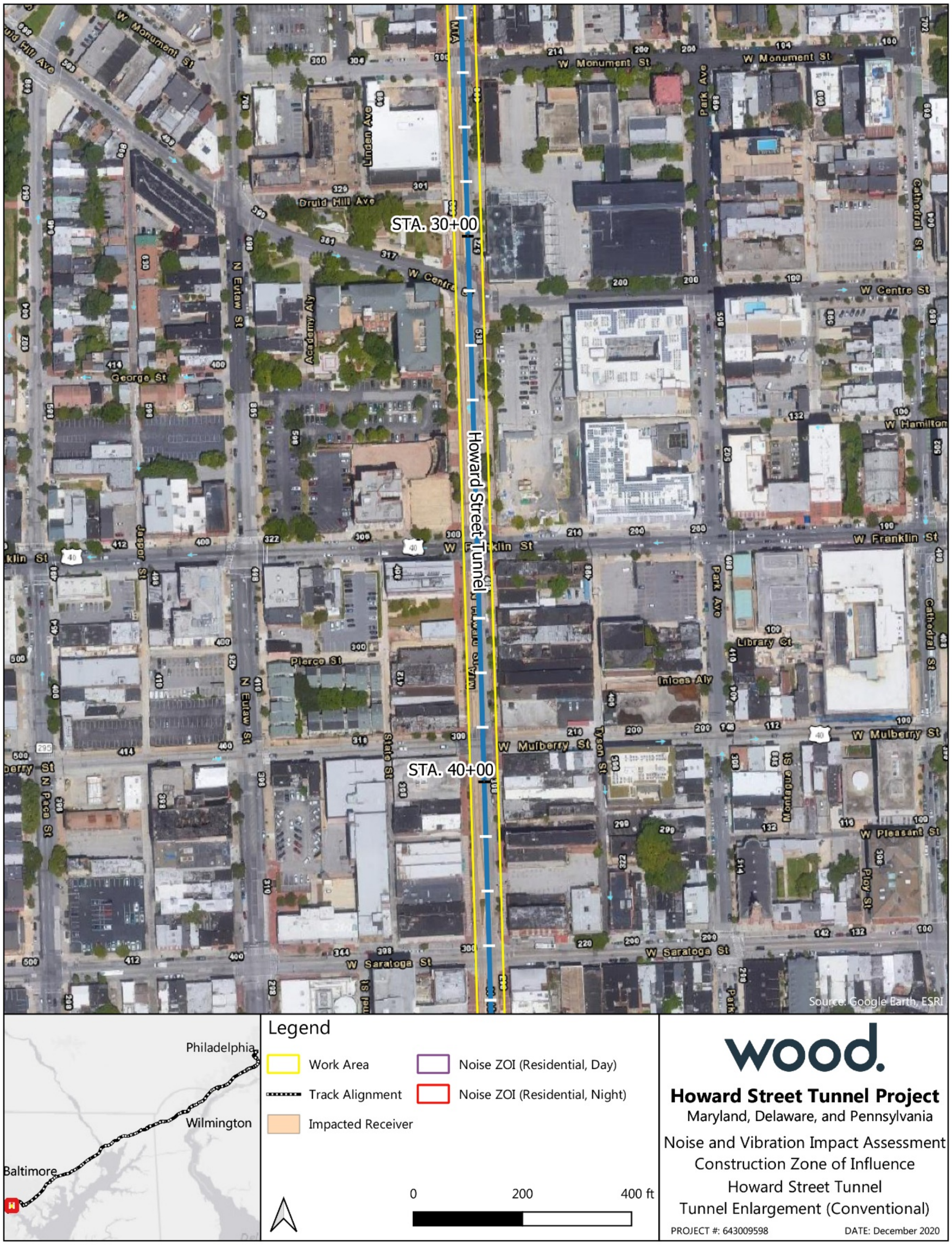
- Work Area
- Track Alignment
- Impacted Receiver
- Noise ZOI (Residential, Day)
- Noise ZOI (Residential, Night)

0 200 400 ft

Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania

Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Conventional)

PROJECT #: 643009598 DATE: December 2020


STA. 30+00
STA. 40+00
Howard Street Tunnel
W Monument St
Druid Hill Ave
W Centre St
George St
W Franklin St
Pierce St
W Mulberry St
W Saratoga St
N Eutaw St
Park Ave
Cathedral St
Linden Ave
Academy Aly
Jasper St
Library Ct
Tyson St
W Hamilton
W Pleasant St
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
0
200
400 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Conventional)
PROJECT #: 643009598
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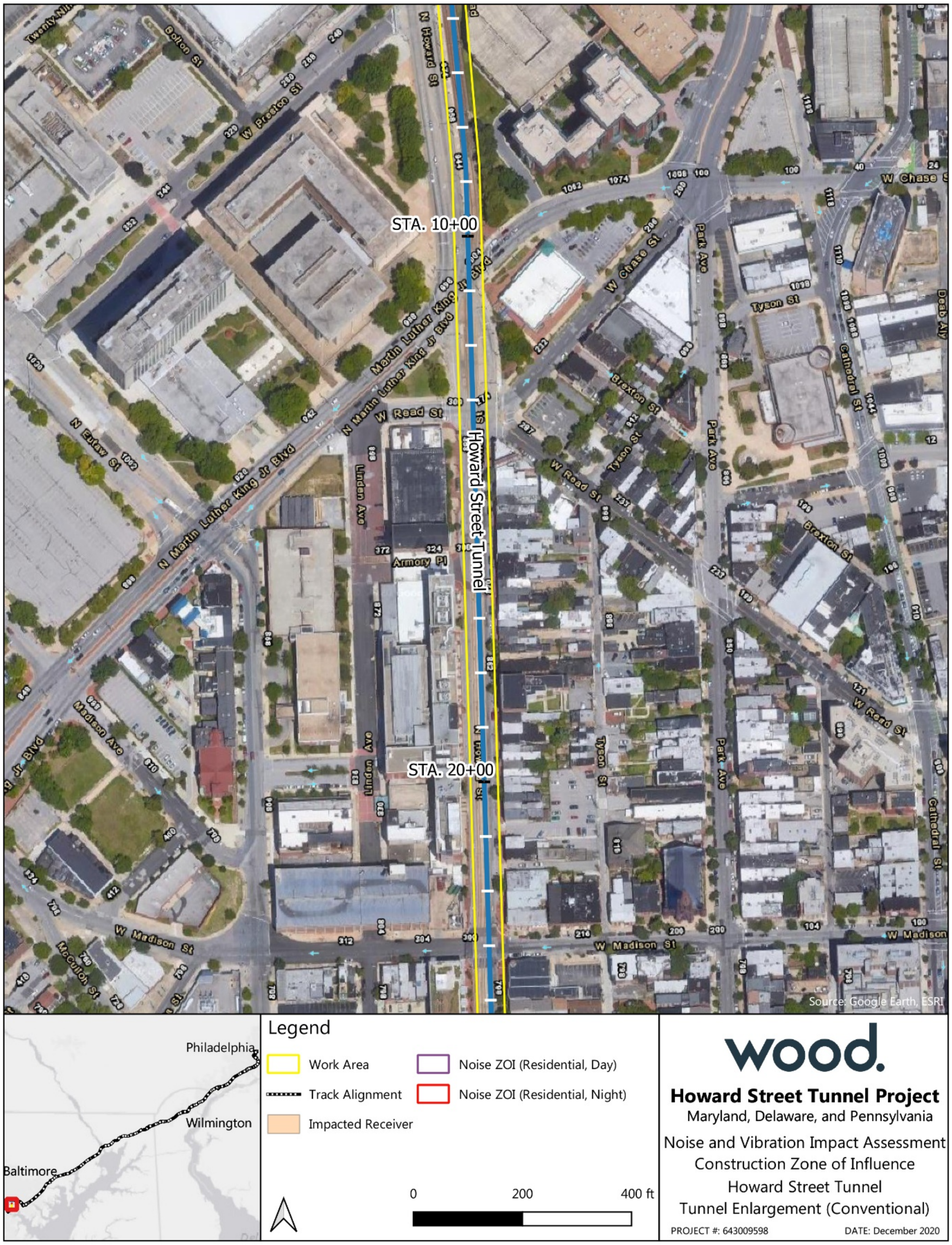
STA. 20+00
STA. 30+00
Howard Street Tunnel
W Madison St
W Monument St
Druid Hill Ave
W Centre St
George St
N Eutaw St
Linden Ave
Tyson St
Park Ave
Cathedral St
W Read St
Armory Pl
Madison Ave
N Paca St
St Mary St
McCulloh St
Academy Aly
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
0
200
400 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Conventional)
PROJECT #: 643009598
DATE: December 2020



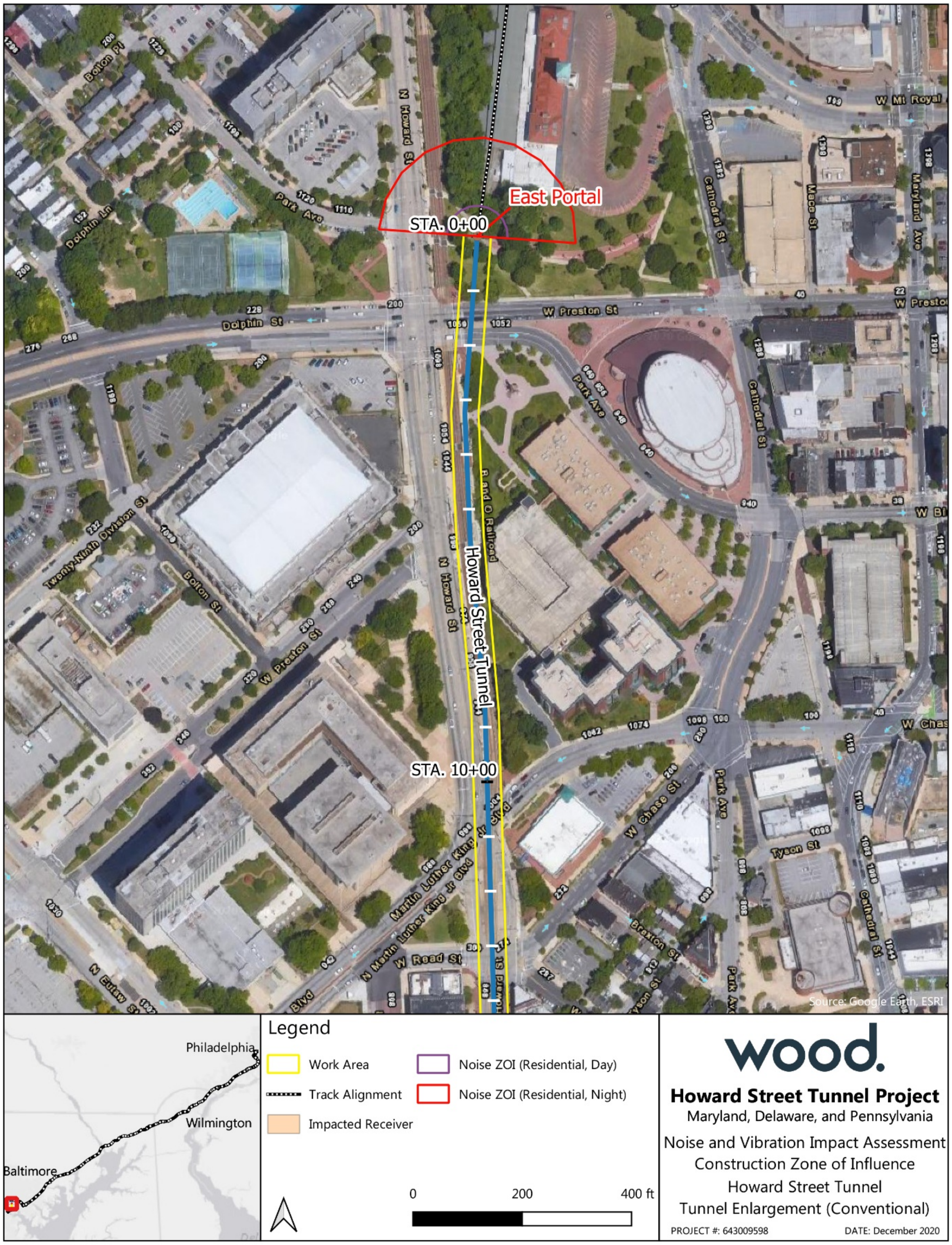
Legend
- Work Area
- Track Alignment
- Impacted Receiver
- Noise ZOI (Residential, Day)
- Noise ZOI (Residential, Night)

0 200 400 ft

Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania

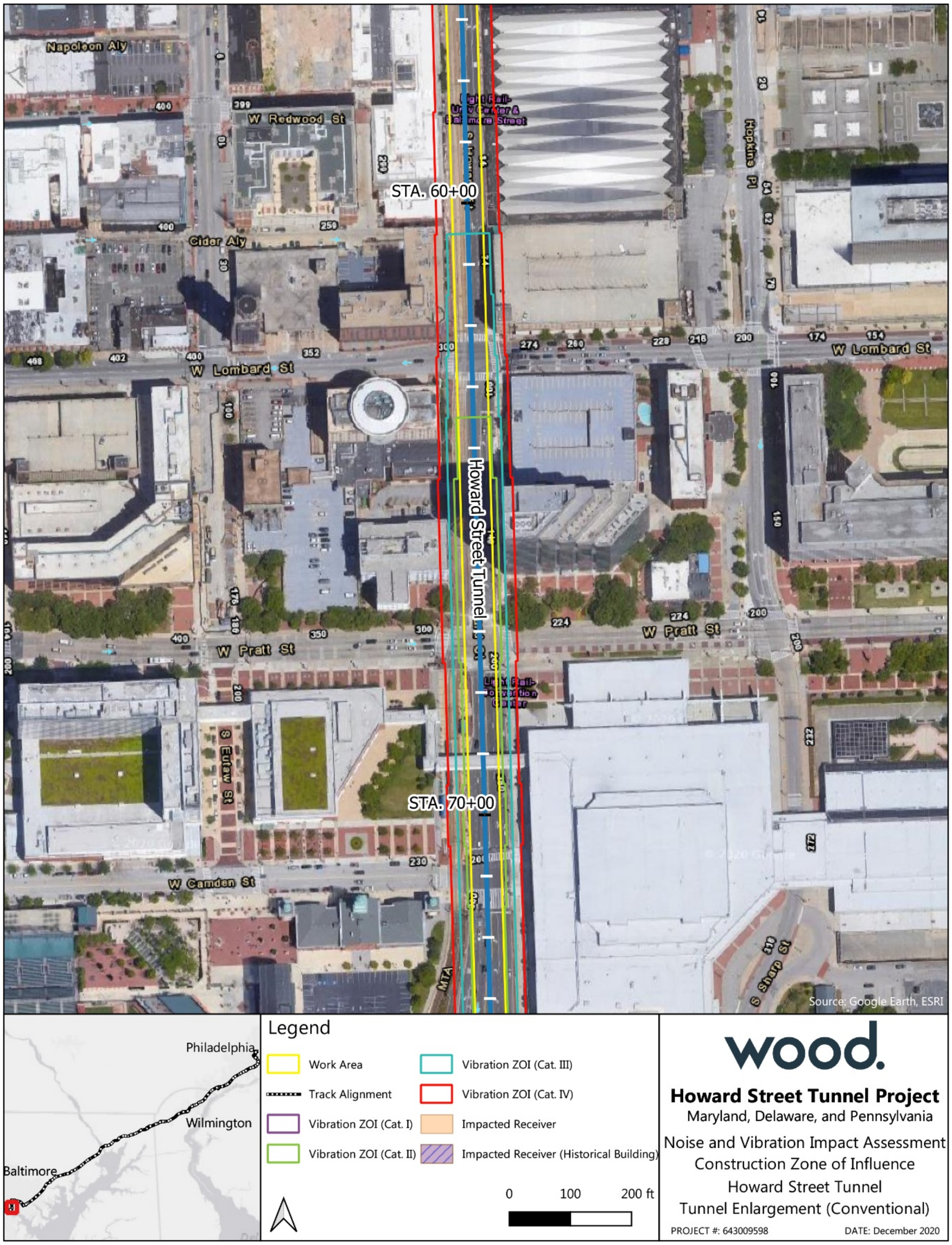
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Conventional)

PROJECT #: 643009598 DATE: December 2020


East Portal
STA. 0+00
STA. 10+00
Howard Street Tunnel
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
0
200
400 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Conventional)
PROJECT #: 643009598
DATE: December 2020


STA. 80+00
Howard Street Tunnel
West Portal
B and O Railroad
W Hill St
S Sharp St
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Conventional)
PROJECT #: 643009598
DATE: December 2020


W Pratt St
S Eutaw St
STA. 70+00
W Camden St
MTA
S Sharp St
Howard Street Tunnel
W Conway St
Conway St
STA. 80+00
B and O Rail
W Lee St
Welcome Aly
Homesteader Aly
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0 100 200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Conventional)
PROJECT #: 643009598
DATE: December 2020


Napoleon Aly
W Redwood St
Cider Aly
W Lombard St
W Pratt St
S Eutaw St
W Camden St
Hopkins Pl
S Sharp St
Howard Street Tunnel
STA. 60+00
STA. 70+00
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Conventional)
PROJECT #: 643009598
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STA. 50+00
STA. 60+00
Howard Street Tunnel
W Lexington St
Marion St
W Fayette St
W Fairmount Ave
W Baltimore St
W Redwood St
W Lombard St
N Eutaw St
Park Ave
Hopkins Pl
N Liberty St
Napoleon Aly
Cider Aly
Metro-Lexington Market East
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Conventional)
PROJECT #: 643009598
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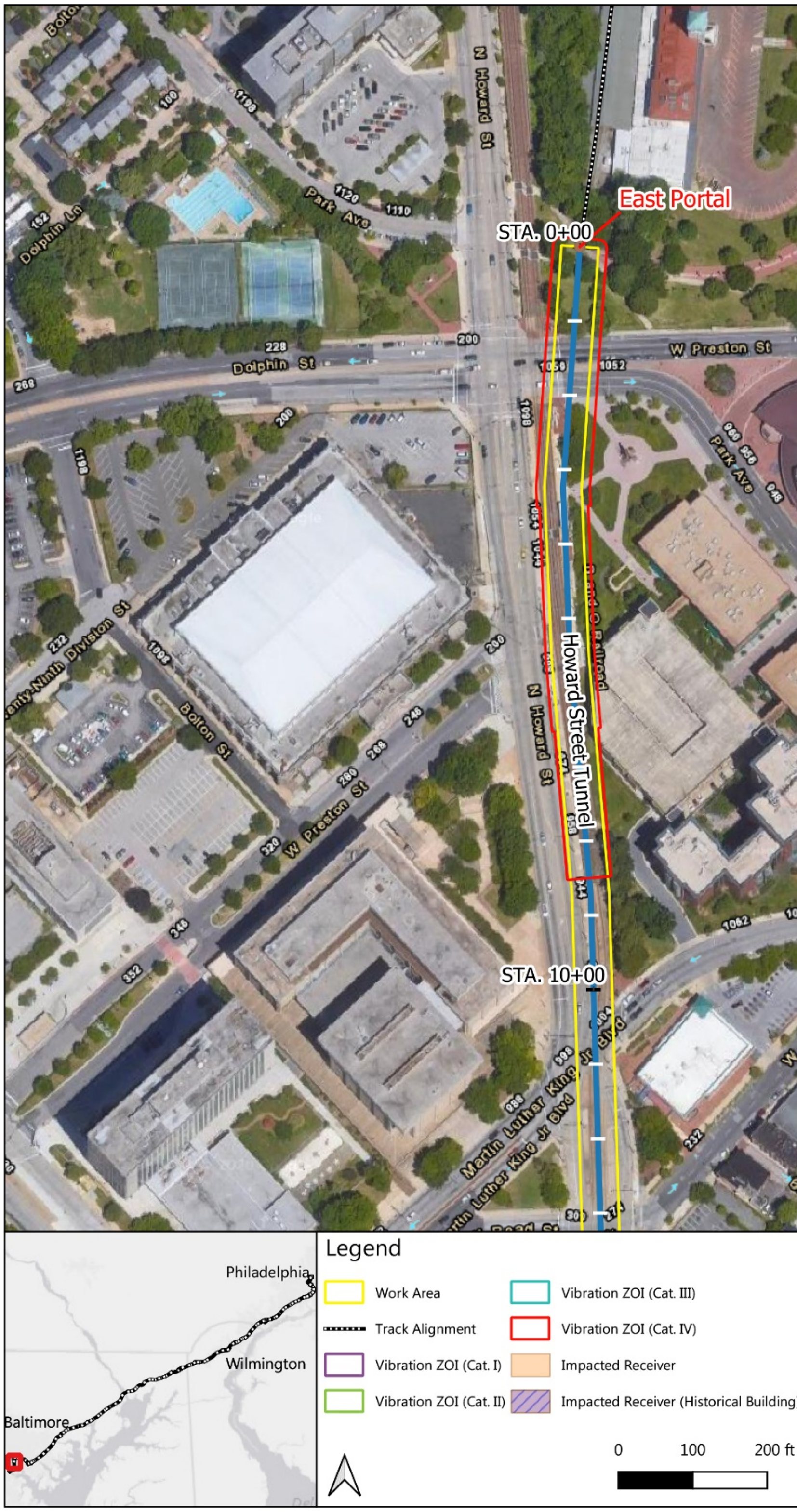
STA. 40+00
STA. 50+00
Howard Street Tunnel
W Mulberry St
W Saratoga St
W Lexington St
W Fayette St
W Clay St
Marion St
N Eutaw St
Park Ave
Pierce St
Library Ct
Inloes Aly
State St
Kimmel St
Tyson St
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Conventional)
PROJECT #: 643009598
DATE: December 2020


W Monument St
Druid Hill Ave
STA. 30+00
W Centre St
N Eutaw St
Academy Aly
George St
Howard Street Tunnel
W Franklin St
Park Ave
Library Ct
Pierce St
Inloes Aly
W Mulberry St
Tyson St
STA. 40+00
State St
Jasper St
Montague St
W Saratoga St
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Conventional)
PROJECT #: 643009598
DATE: December 2020


STA. 20+00
STA. 30+00
Howard Street Tunnel
W Madison St
W Monument St
Druid Hill Ave
W Centre St
N Eutaw St
Linden Ave
Tyson St
Park Ave
N Paca St
George St
Madison Ave
W Read St
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Conventional)
PROJECT #: 643009598
DATE: December 2020


STA. 10+00
STA. 20+00
Howard Street Tunnel
W Preston St
N Martin Luther King Jr Blvd
W Read St
Linden Ave
Armory Pl
N Eutaw St
Madison Ave
W Madison St
W Chase St
Park Ave
Tyson St
Brexton St
Cathedral St
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Conventional)
PROJECT #: 643009598
DATE: December 2020



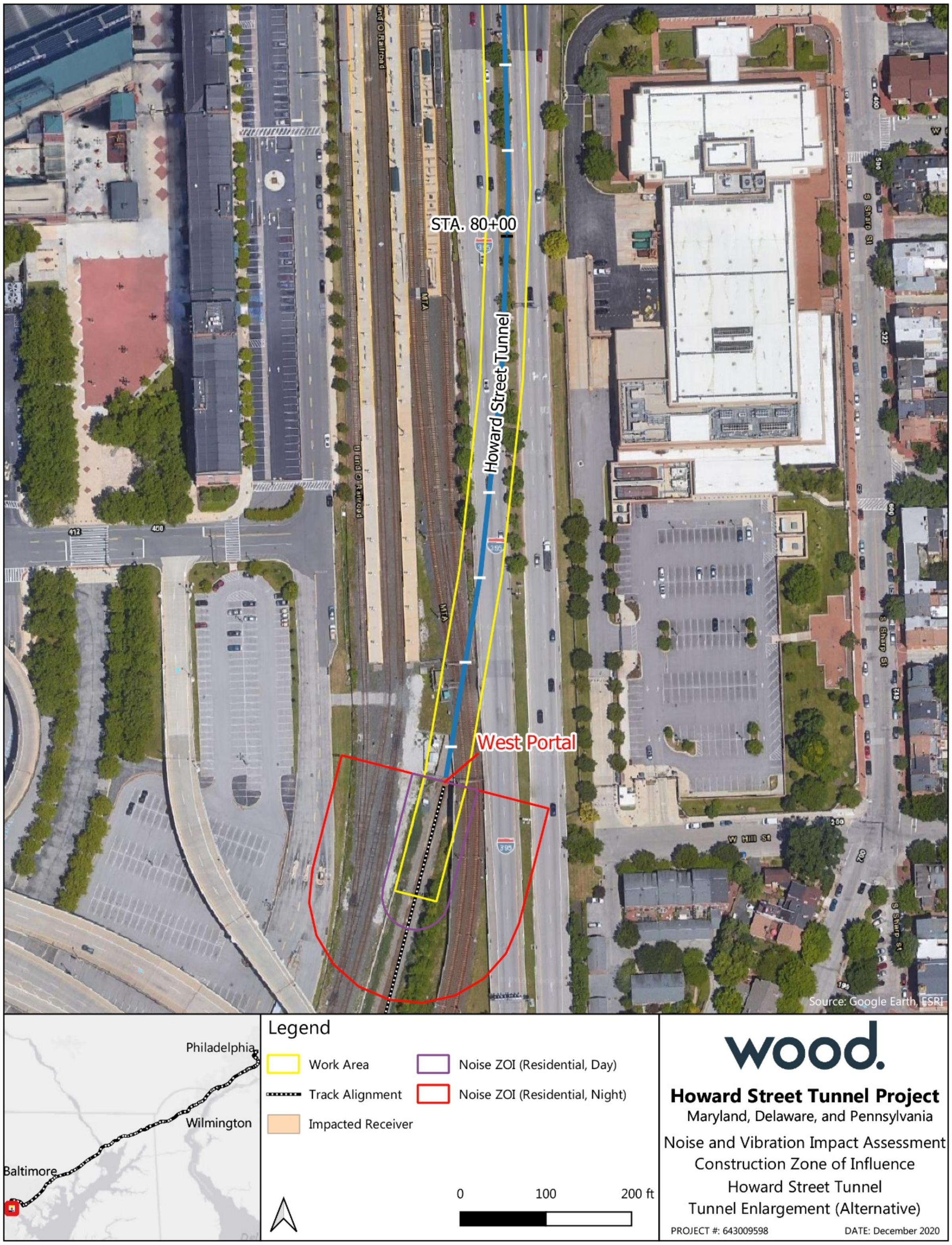
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania

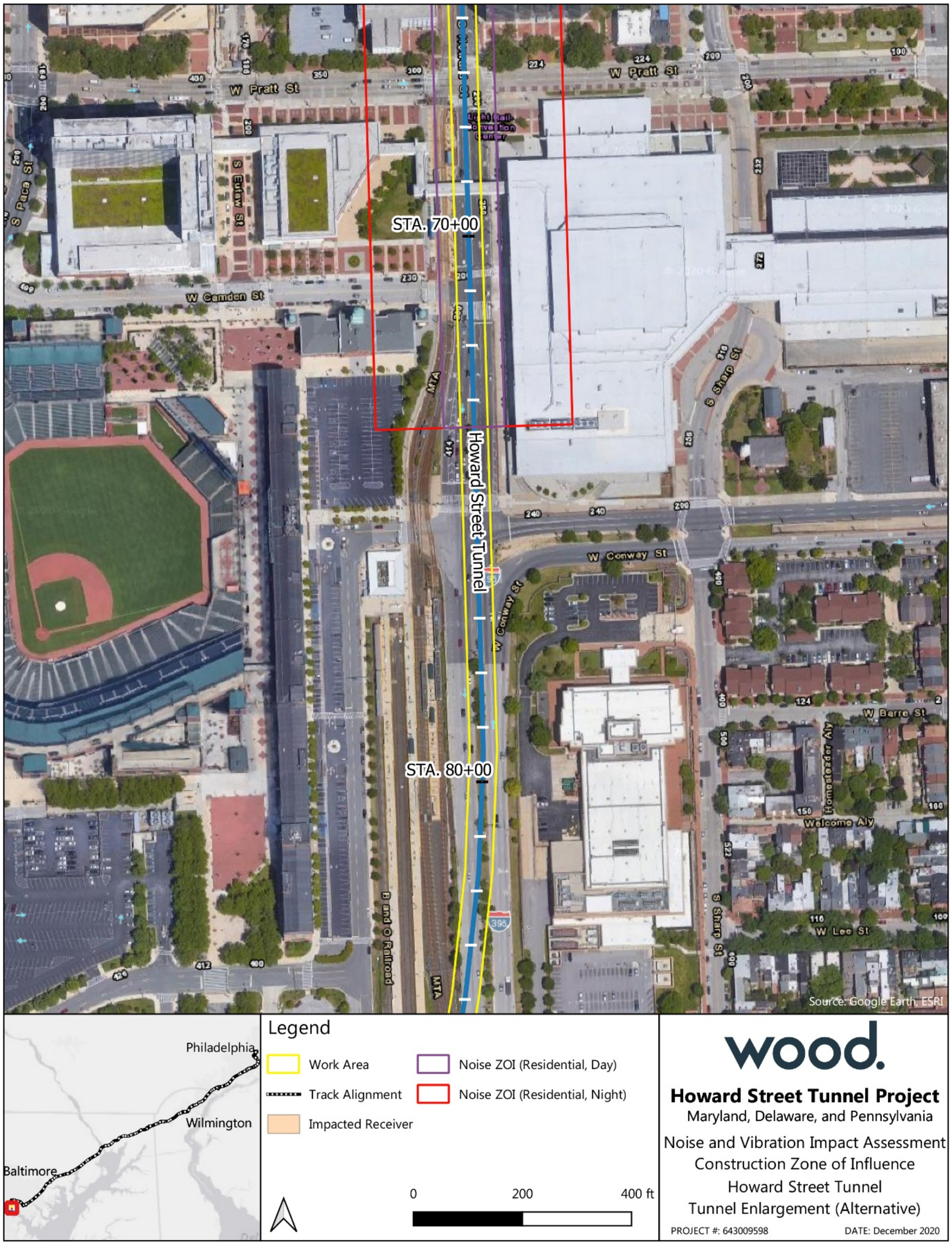
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Conventional)

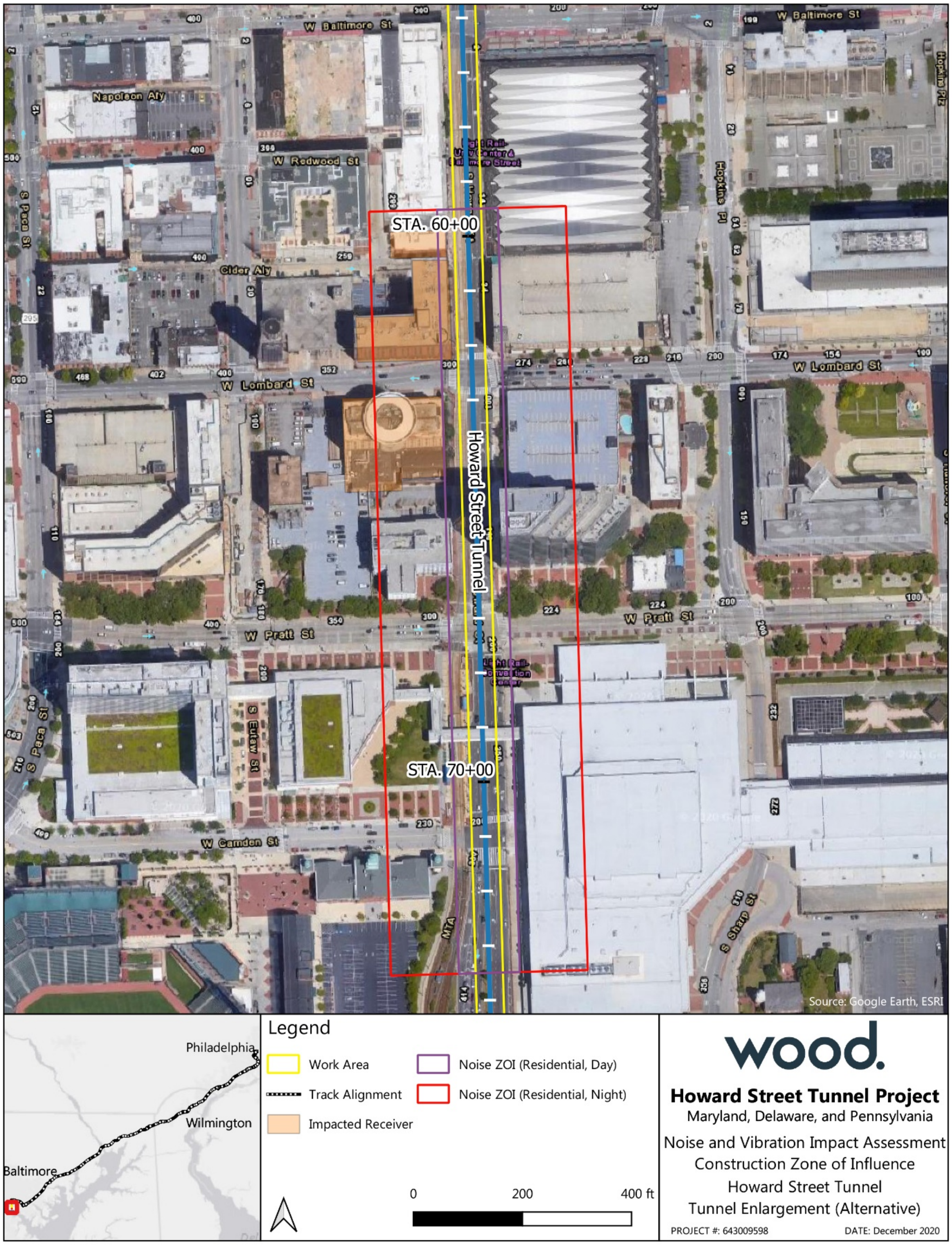
PROJECT #: 643009598 DATE: December 2020

Appendix F

Construction Impact – HST (Non-Conventional Approach)

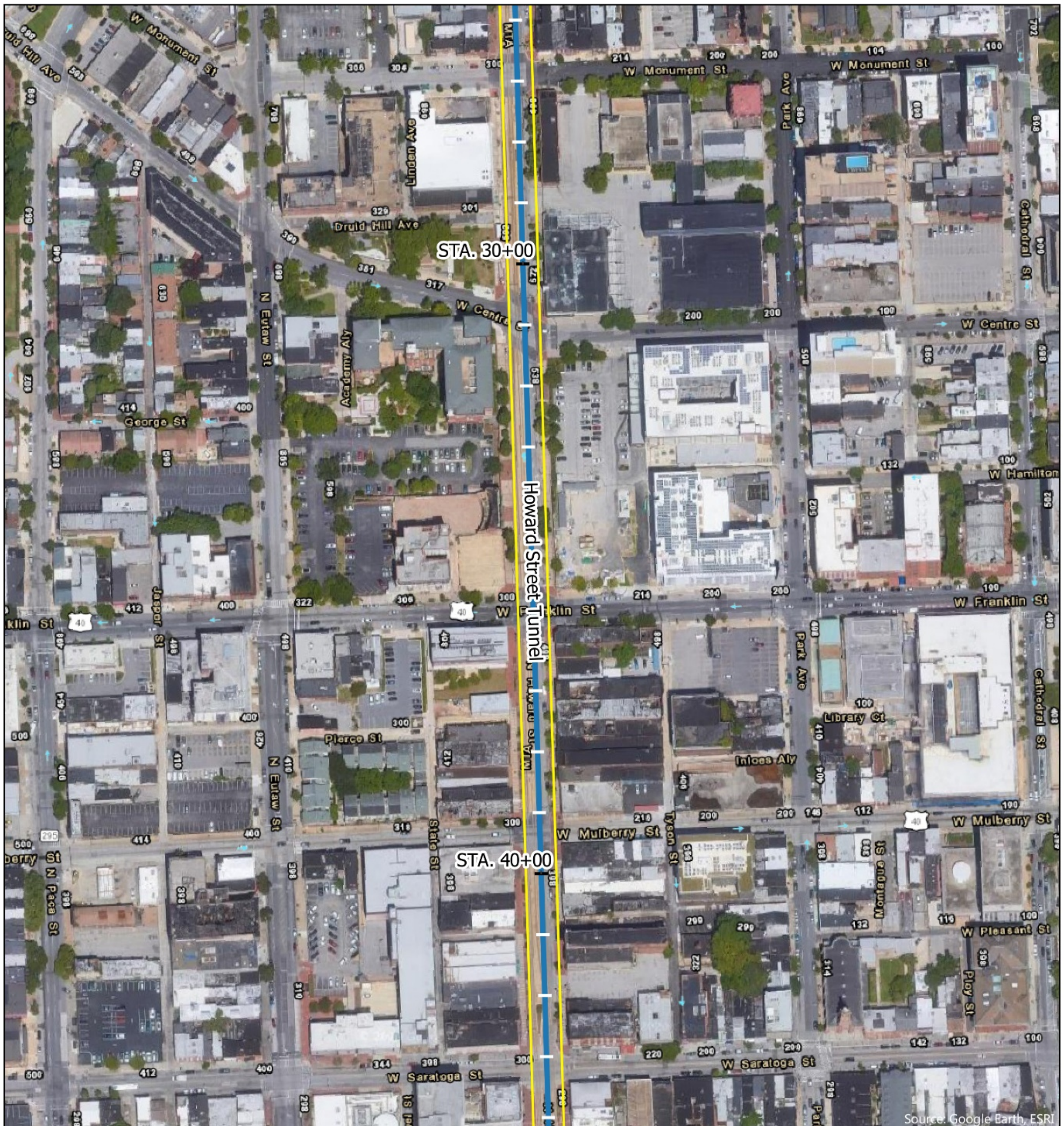

STA. 80+00
Howard Street Tunnel
West Portal
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Alternative)
PROJECT #: 643009598
DATE: December 2020

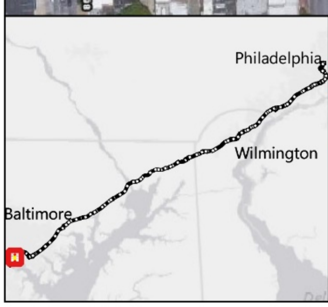

STA. 70+00
STA. 80+00
Howard Street Tunnel
W Pratt St
W Camden St
W Conway St
S Sharp St
S Paca St
S Eutaw St
W Barre St
Welcome Aly
W Lee St
Homesteader Aly
B and O Railroad
MTA
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
0
200
400 ft
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Alternative)
PROJECT #: 643009598
DATE: December 2020


W Baltimore St
Napoleon Aly
W Redwood St
Cider Aly
W Lombard St
W Pratt St
W Camden St
S Paca St
S Eutaw St
Hopkins Pl
S Sharp St
STA. 60+00
STA. 70+00
Howard Street Tunnel
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
0
200
400 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Alternative)
PROJECT #: 643009598
DATE: December 2020


STA. 50+00
STA. 60+00
Howard Street Tunnel
W Lexington St
Marion St
W Fayette St
W Fairmount Ave
W Baltimore St
W Redwood St
W Lombard St
N Eutaw St
N Liberty St
Park Ave
Hopkins Pl
B and O Railroad
Napoleon Aly
Cider Aly
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
0
200
400 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Alternative)
PROJECT #: 643009598
DATE: December 2020


STA. 40+00
STA. 50+00
Howard Street Tunnel
W Mulberry St
W Saratoga St
W Clay St
W Lexington St
Marion St
W Fayette St
W Fairmount Ave
N Eutaw St
N Paca St
Park Ave
N Liberty St
Cathedral St
Pierce St
Library Ct
W Pleasant St
Kimmel St
B and O Railroad
Metro-Lexington Market East
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
0
200
400 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Alternative)
PROJECT #: 643009598
DATE: December 2020





Legend

- Work Area
- Track Alignment
- Impacted Receiver
- Noise ZOI (Residential, Day)
- Noise ZOI (Residential, Night)

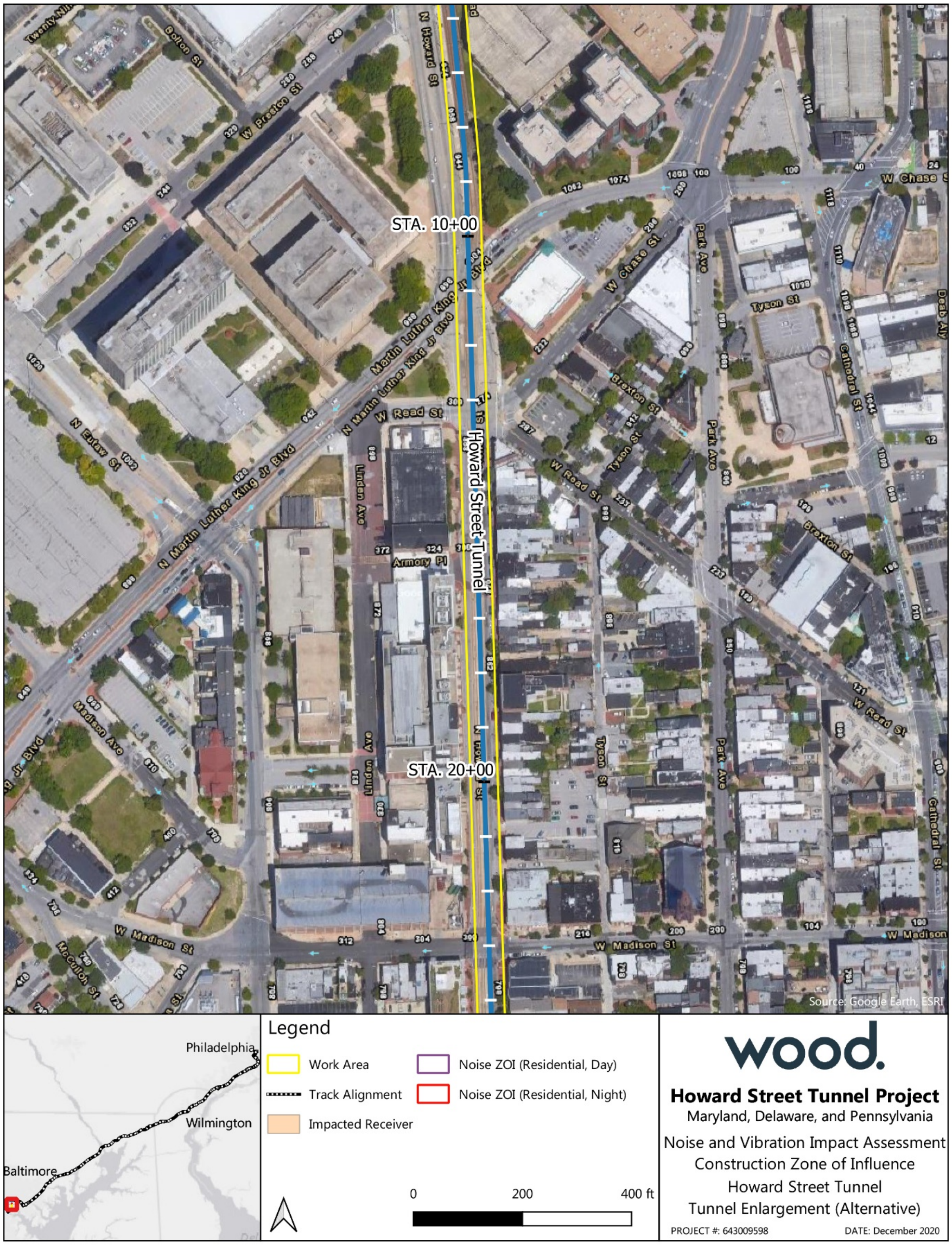
0 200 400 ft

Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania

Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Alternative)

PROJECT #: 643009598 DATE: December 2020


STA. 20+00
STA. 30+00
Howard Street Tunnel
W Madison St
W Monument St
Druid Hill Ave
W Centre St
N Eutaw St
Linden Ave
Park Ave
Tyson St
Cathedral St
W Read St
George St
Academy Aly
Armory Pl
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
0
200
400 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Alternative)
PROJECT #: 643009598
DATE: December 2020


STA. 10+00
STA. 20+00
Howard Street Tunnel
N Howard St
W Preston St
Bolton St
N Martin Luther King Jr Blvd
W Read St
Linden Ave
Armory Pl
Madison Ave
W Madison St
McCulloh St
N Eutaw St
W Chase St
Park Ave
Tyson St
Brexton St
Cathedral St
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Impacted Receiver
Noise ZOI (Residential, Day)
Noise ZOI (Residential, Night)
0
200
400 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Alternative)
PROJECT #: 643009598
DATE: December 2020

wood.

Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania

Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Alternative)

PROJECT #: 643009598 DATE: December 2020


STA. 80+00
Howard Street Tunnel
B and O Railroad
MTA
West Portal
W Hill St
S Sharp St
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Alternative)
PROJECT #: 643009598
DATE: December 2020


W Pratt St
S Eutaw St
STA. 70+00
W Camden St
S Sharp St
Howard Street Tunnel
W Conway St
Conway St
STA. 80+00
W Barre St
Homesteader Aly
Welcome Aly
W Lee St
B and O Rail
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Alternative)
PROJECT #: 643009598
DATE: December 2020


Napoleon Aly
W Redwood St
Cider Aly
W Lombard St
W Pratt St
W Camden St
S Eutaw St
Hopkins Pl
S Sharp St
STA. 60+00
STA. 70+00
Howard Street Tunnel
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Alternative)
PROJECT #: 643009598
DATE: December 2020


STA. 50+00
STA. 60+00
Howard Street Tunnel
W Lexington St
Marion St
W Fayette St
W Fairmount Ave
W Baltimore St
W Redwood St
W Lombard St
N Eutaw St
Park Ave
Hopkins Pl
N Liberty St
Napoleon Aly
Cider Aly
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Alternative)
PROJECT #: 643009598
DATE: December 2020

Legend

Work Area		Vibration ZOI (Cat. III)	
Track Alignment		Vibration ZOI (Cat. IV)	
Vibration ZOI (Cat. I)		Impacted Receiver	
Vibration ZOI (Cat. II)		Impacted Receiver (Historical Building)	

0 100 200 ft

wood.

Howard Street Tunnel Project
Maryland, Delaware, and Pennsylvania
Noise and Vibration Impact Assessment
Construction Zone of Influence
Howard Street Tunnel
Tunnel Enlargement (Alternative)
PROJECT #: 643009598 DATE: December 2020


STA. 30+00
STA. 40+00
Howard Street Tunnel
W Monument St
Druid Hill Ave
Linden Ave
N Eutaw St
Academy Aly
George St
Jasper St
W Franklin St
Park Ave
Library Ct
Inloes Aly
Pierce St
State St
W Mulberry St
Tyson St
Montague St
Ploy St
W Saratoga St
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
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Maryland, Delaware, and Pennsylvania
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STA. 20+00
STA. 30+00
Howard Street Tunnel
W Madison St
W Monument St
Druid Hill Ave
N Eutaw St
Linden Ave
Tyson St
Park Ave
George St
Academy Aly
Madison Ave
N Paca St
W Read St
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
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Howard Street Tunnel
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STA. 10+00
STA. 20+00
Howard Street Tunnel
W Preston St
N Martin Luther King Jr Blvd
W Read St
Linden Ave
Armory Pl
W Madison St
Park Ave
Tyson St
Brexton St
Cathedral St
W Chase St
N Eutaw St
Madison Ave
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
Impacted Receiver
Impacted Receiver (Historical Building)
0
100
200 ft
wood.
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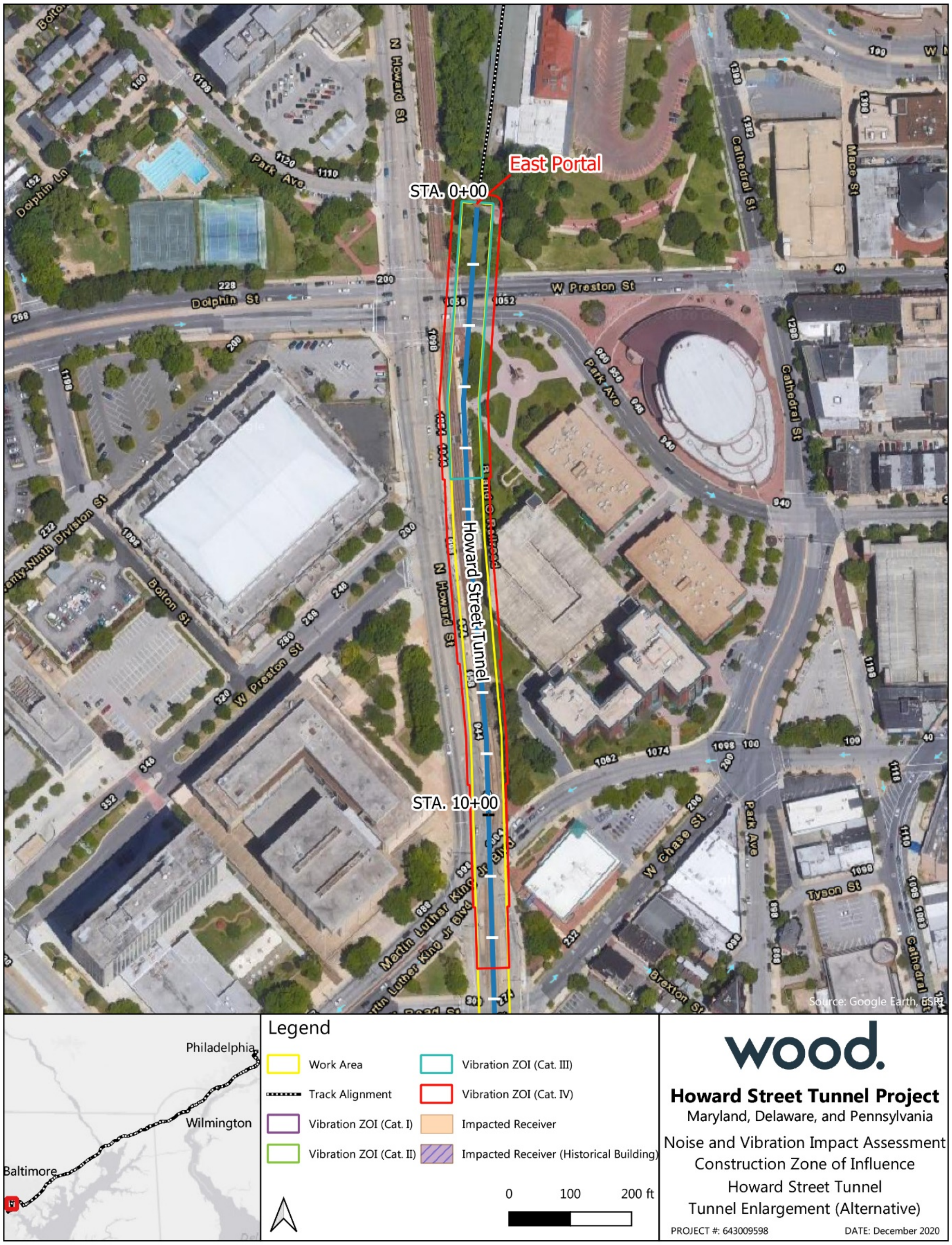
East Portal
STA. 0+00
STA. 10+00
Howard Street Tunnel
N Howard St
W Preston St
Dolphin St
Park Ave
Cathedral St
Mace St
Bolton St
W Chase St
Tyson St
Martin Luther King Jr Blvd
Source: Google Earth, ESRI
Philadelphia
Wilmington
Baltimore
Legend
Work Area
Track Alignment
Vibration ZOI (Cat. I)
Vibration ZOI (Cat. II)
Vibration ZOI (Cat. III)
Vibration ZOI (Cat. IV)
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