ATTACHMENT 11

Noise and Vibration Technical Report

Glassboro-Camden Line FEIS
February 2021

Prepared by:

STV 100 Years

Prepared for:

DELAWARE RIVER PORT AUTHORITY of Pennsylvania & New Jersey

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NJ TRANSIT

Project information contained in this document, including estimated limits of disturbance that could result with construction or operation of the proposed GCL, is based on conceptual design parameters that represent a reasonably conservative basis for conducting environmental analyses. As the proposed GCL is advanced through preliminary engineering and construction, efforts will continue to be made to further refine the design and minimize the project footprint. These refinements may result in the potential to avoid and further reduce the adverse effects outlined in this document and as described within this Environmental Impact Statement.

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Foreword

Following the issuance of the Draft Environmental Impact Statement (November 2nd, 2020), revisions have been made to this Technical Report (Attachment 11, “Noise and Vibration Technical Report”) in preparation of the Final Environmental Impact Statement as follows:

- Section 3.2, Page 2: Revised “The proposed GCL would provide 14 new transit stations (in addition to service at the WRTC), including 12 “walk-up” stations and two park-and-ride facilities, and two potential vehicle maintenance facilities located in Woodbury Heights and Glassboro,” as follows: “The proposed GCL would provide 14 new transit stations (in addition to service at the WRTC), including five “walk-up” stations, four “moderate park-and-ride” stations, and five “park-and-ride” stations, and two potential vehicle maintenance facilities located in Woodbury Heights and Glassboro.”
- Section 6.1, Page 24: Added the following footnote: “Per FRA guidance, quiet zones cannot be included as part of the proposed GCL because individual jurisdictions must apply to FRA directly for a quiet zone designation; however, at-grade crossings are being designed with four quadrant gates, providing the opportunity for jurisdictional entities to apply if so desired.”
- Section 14, Page 47: Added additional sources to the references list
- Minor editorial and typographical revisions, as well as formatting adjustments, have been made as appropriate

1 INTRODUCTION

This technical report provides a summary of both the noise and vibration assessments conducted for the proposed Glassboro-Camden Line (GCL) project, considering both its construction and its operational conditions. Descriptions of the existing noise levels at noise- and vibration-sensitive land uses along the project corridor are provided herein, together with comparisons of estimated project-generated noise and vibration levels, as they relate to the appropriate Federal Transit Administration (FTA) impact criteria used in determining the potential for project noise and vibration impacts. Appropriate mitigation measures, which could reduce or eliminate predicted impacts, are considered and discussed.

1.1 Project Description

The GCL Project is a proposed 18-mile expansion of transit service in Southern New Jersey that would traverse eleven communities between Camden City and Glassboro Borough. These communities, listed from north to south, include the following within Camden County - Camden City, Gloucester City, and Brooklawn Borough - and the following communities within Gloucester County - Westville Borough, Woodbury City, Woodbury Heights Borough, Deptford Township, Wenonah Borough, Mantua Township, Pitman Borough, and Glassboro Borough.

The GCL would restore passenger rail service primarily within an existing Conrail freight right-of-way (ROW) using light rail vehicles similar to the NJ TRANSIT River LINE. The light rail would run on new dedicated tracks and/or be separated from the freight trains temporally, allowing Conrail freight operations to continue. The proposed project would provide 14 new transit stations in addition to an existing station at the Walter Rand Transportation Center (WRTC) and two vehicle maintenance facilities.

The Glassboro-to-Camden corridor comprises substantial railroad ROW and existing rail infrastructure, which interconnects communities in southern New Jersey. Historically, these communities developed around passenger rail service that once had been available in the Glassboro-to-Camden corridor, but which has not been operating since the 1960s. The GCL would reinstate public transportation among these communities and connect them with the broader, regional public transportation network to allow residents access throughout the corridor and to important regional employment centers.

2 PRINCIPAL CONCLUSIONS

Per the guidance in the Federal Transit Administration (FTA) Transit Noise and Vibration Impact Assessment Manual (September 2018), analyses of noise and vibration impacts were conducted for this project. Existing noise levels at noise- and vibration-sensitive land uses along the project were assessed, together with comparisons of estimated project-generated noise and vibration levels, as they relate to the appropriate FTA impact criteria used in determining the potential for project noise and vibration impacts.

As described in this report, future noise exposure levels generated from daily service operations were estimated for GCL operations at representative noise sensitive properties identified along the project corridor. The findings indicate that service operations impacts will occur at 21 out of the 27 representative sites evaluated, with 3 sites (M8, M13, and M15) projected to experience severe levels of noise exposure and 18 sites (M1-M4, M6, M9-M11, M14, M16, M17, Y01-Y-04, and PK02-PK04) exposed to moderate levels of noise exposure. Corridor-wide, a total of 815 dwellings (equivalent single-family units) are projected to experience impacts; these consist of 577 moderate impacts and 188 severe impacts from daily GCL operations. In addition, 50 dwellings will experience moderate noise impacts associated with maintenance facility activities. However, no peak hour noise impacts are expected to occur from daily traffic movement entering and departing the major parking facilities proposed along the corridor.

Noise mitigation measures consists of undercar sound absorption treatment, rail car vehicle skirts and track lubrication to mitigate wheel squeal on tight curves. These abatement measures are expected to eliminate noise impacts at 16 out of 21 impacted properties. The remaining noise impacts are all attributable to horn noise soundings. All predicted rail operations noise impacts would be eliminated with the implementation of “quiet zones” at all at-grade crossings where freight train locomotive horn soundings are currently required. Quiet zones would ensure that locomotive horn soundings, as currently mandated, would not be required as trains approach crossings. However, no municipalities have filed for quiet zone designations, and they are not expected to do so. As such, this noise analysis assumes reasonable “worst case” conditions.

Construction period noise impacts are also qualitatively discussed, and mitigation to avoid or minimize these effects is recommended. The vibration analysis completed for this study supports the determination that ground vibration generated through proposed GCL operations would not exceed FTA impact thresholds during daily service operations. Therefore, no vibration-related mitigation measures would be required. Potential vibration exposure issues during the construction phase are qualitatively discussed, and mitigation measures to minimize construction-period vibration effects are outlined.

3 PROJECT ALTERNATIVES

3.1 No-Action Alternative

The No-Action Alternative is a scenario where the proposed GCL and transit stations are not constructed. This alternative would have no direct or indirect impacts within the project corridor.

3.2 The Proposed GCL

The proposed GCL would restore passenger rail service primarily along an existing Conrail freight rail corridor between Camden and Glassboro. The GCL is an 18 mile-long expansion of transit service in Southern New Jersey that would traverse 13 communities between Camden (Camden County) and Glassboro (Gloucester County). These communities are Camden, Gloucester City, Brooklawn, Westville, Woodbury, Woodbury Heights, Wenonah, Deptford Township, West Deptford Township, Mantua Township, Pitman, Elk Township, and Glassboro.

GCL trains would operate every 15 minutes during the peak and midday periods, and every 30 minutes in the evening hours. The proposed GCL would provide 14 new transit stations (in addition to service at the WRTC), including five “walk-up” stations, four “moderate park-and-ride” stations, and five “park-and-ride” stations, and two potential vehicle maintenance facilities located in Woodbury Heights and Glassboro. The Woodbury Heights Vehicle Maintenance Facility site would have capacity for 24 vehicles and additional storage, whereas the Glassboro Vehicle Maintenance Facility site would have capacity to store up to 36 vehicles. The entire fleet size is 18 vehicles which includes four spares.

The proposed GCL is designed to provide two tracks for light rail use in Camden; one track for light rail uses in Gloucester City, Brooklawn, Westville, and Woodbury, with a passing siding in Westville and Woodbury; and two tracks for light rail use south of Woodbury. In general, this service would operate at-grade, but some portions would be elevated to go over existing roads and waterways. Gated crossings would be used for at-grade roadway crossings along the existing Conrail freight corridor.

4 AFFECTED ENVIRONMENT

As described in this report, future noise exposure levels generated from daily service operations are estimated for GCL operations at representative noise sensitive properties identified along the project corridor. See Figure 1 through Figure 13, “Locations of Representative Measurement Sites,” for detailed maps with locations of representative measurement sites.

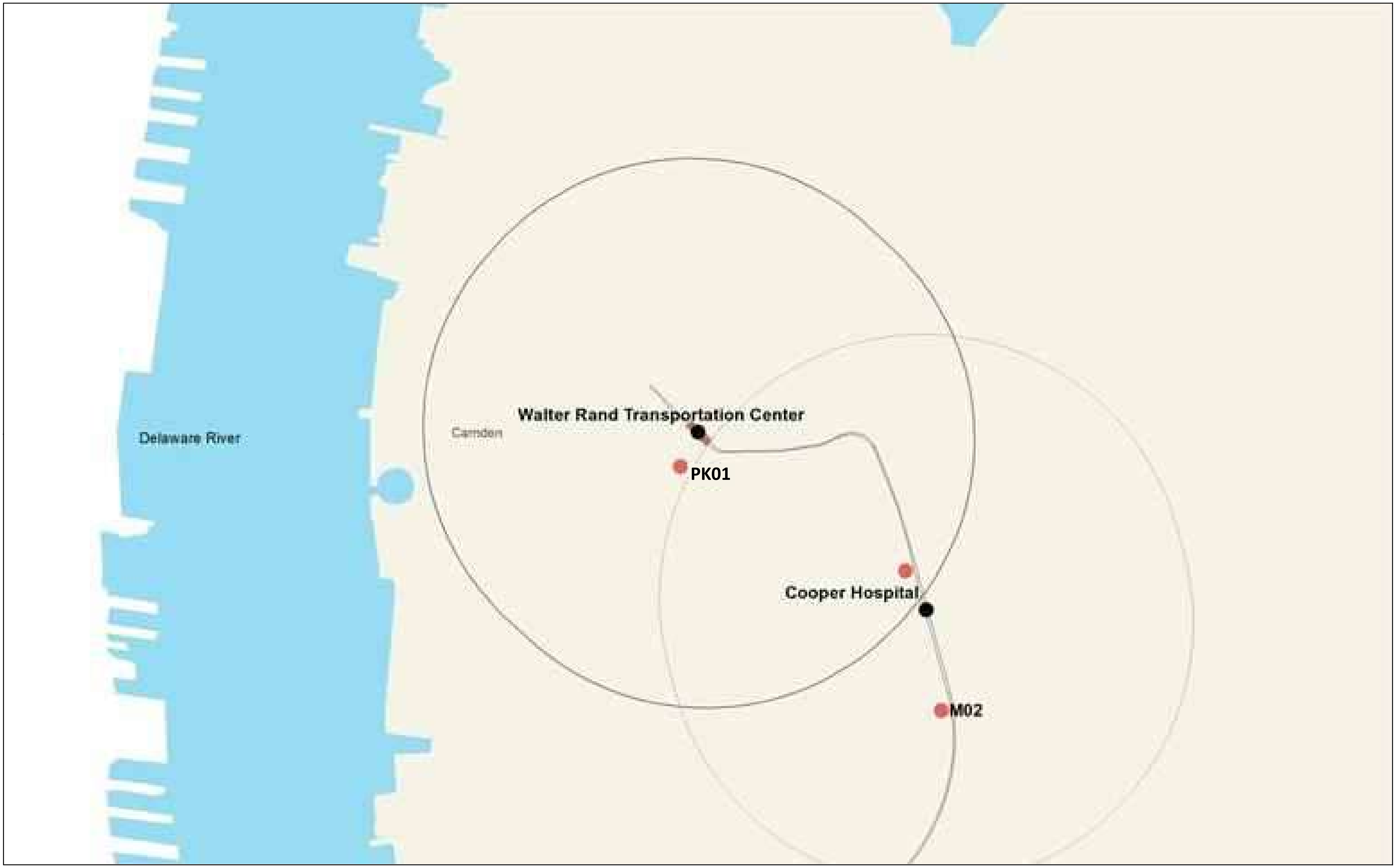
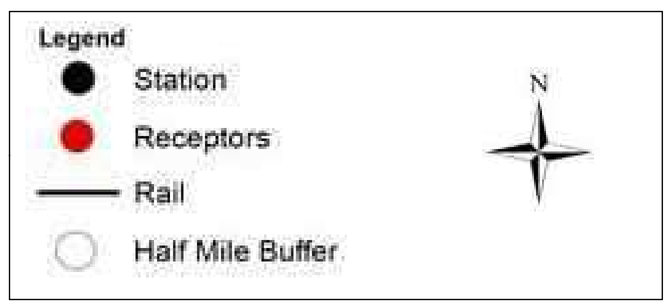


Figure 1: Locations of Representative Measurement Sites



Source: GCL Project Team, 2020.

GLASSBORO-CAMDEN LINE

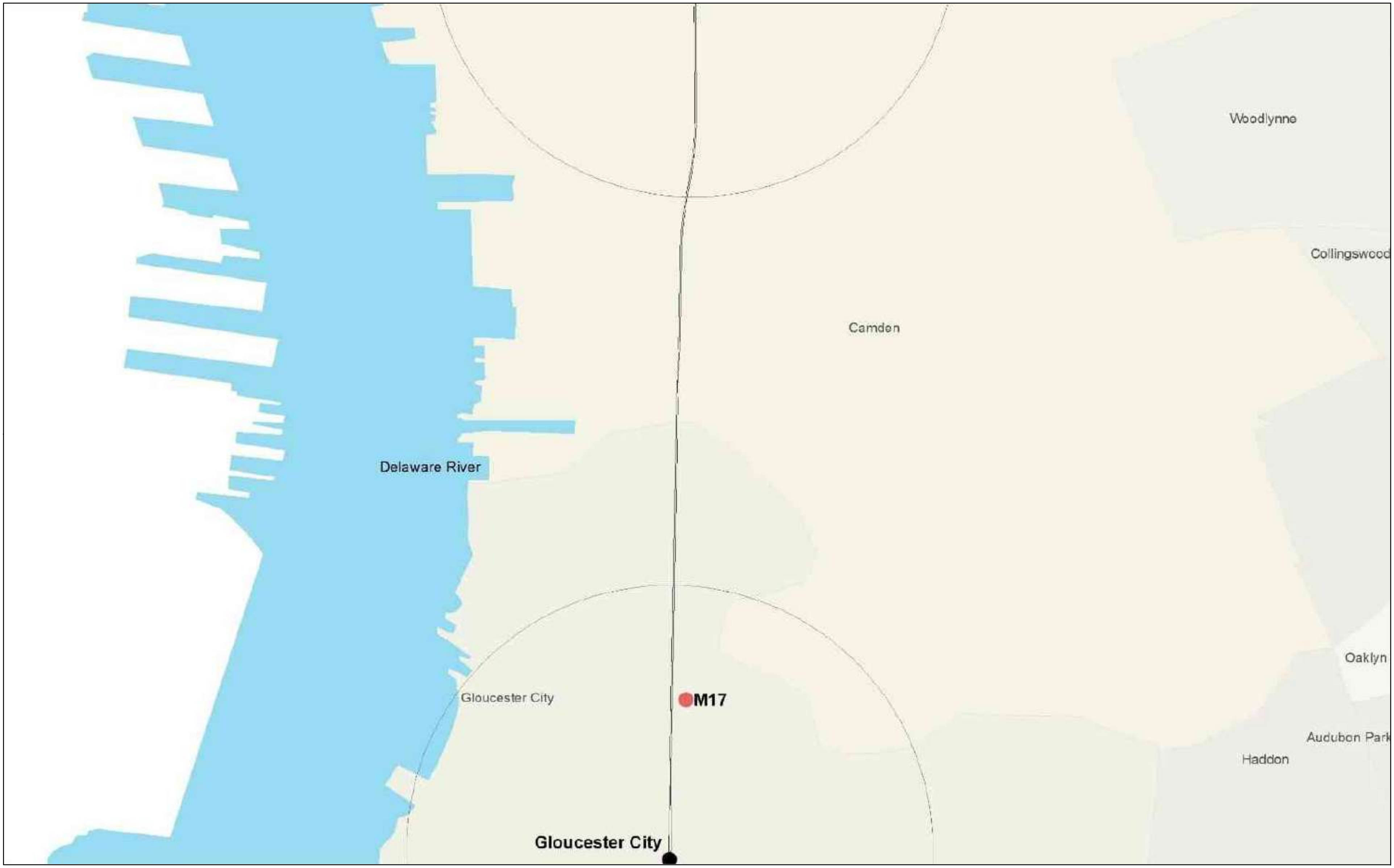


Figure 2: Locations of Representative Measurement Sites

GLASSBORO-CAMDEN LINE

Legend
- Station
- Receptors
- Rail
- Half Mile Buffer

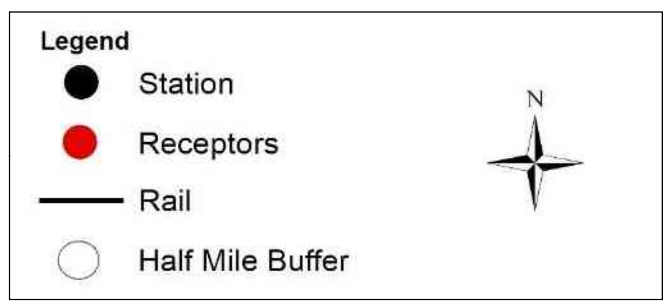
N

Source: GCL Project Team, 2020.

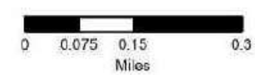
0 0.075 0.15 0.3
Miles

Figure 3: Locations of Representative Measurement Sites

GCL
GLASSBORO-CAMDEN LINE



Source: GCL Project Team, 2020.



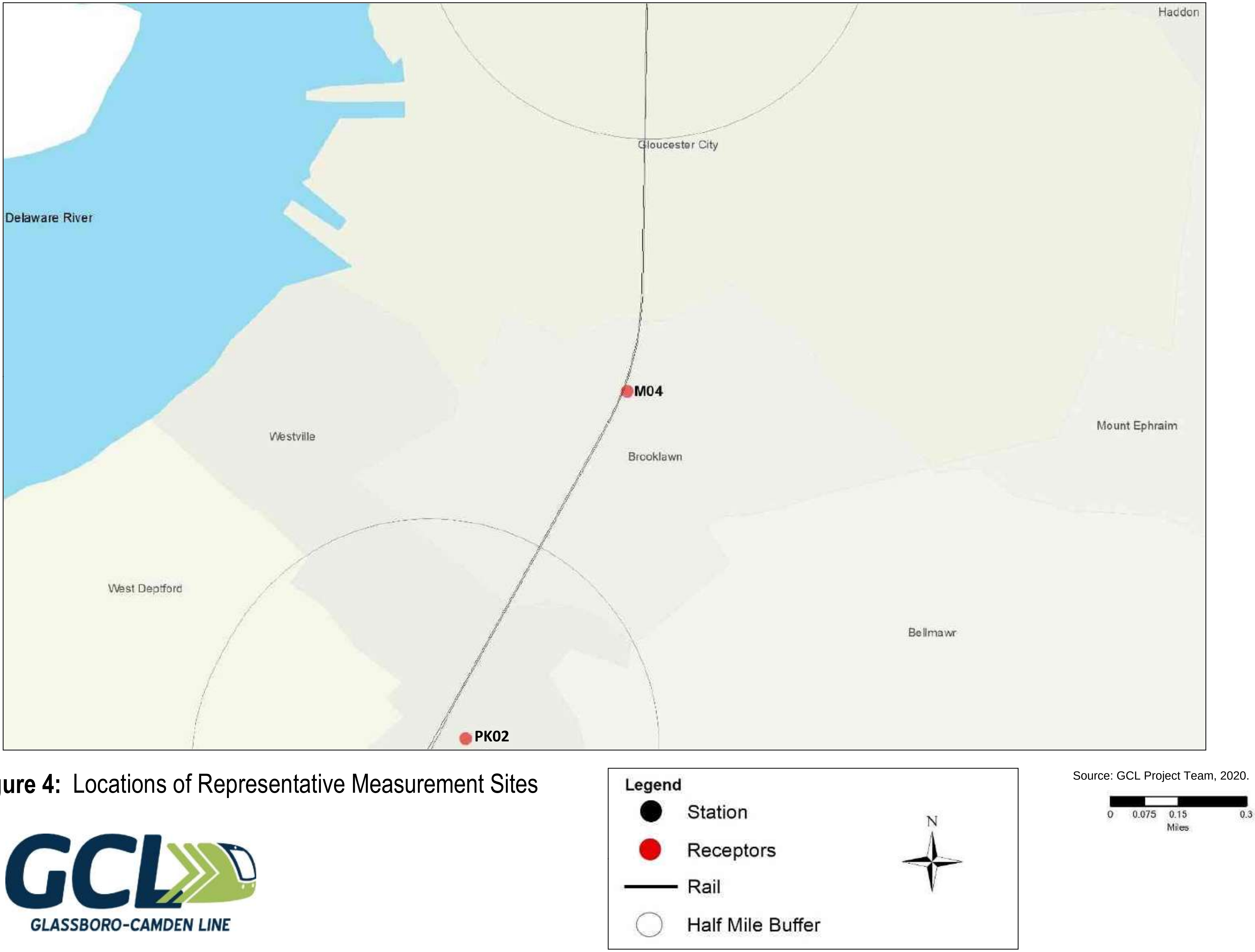


Figure 4: Locations of Representative Measurement Sites

Source: GCL Project Team, 2020.

GLASSBORO-CAMDEN LINE

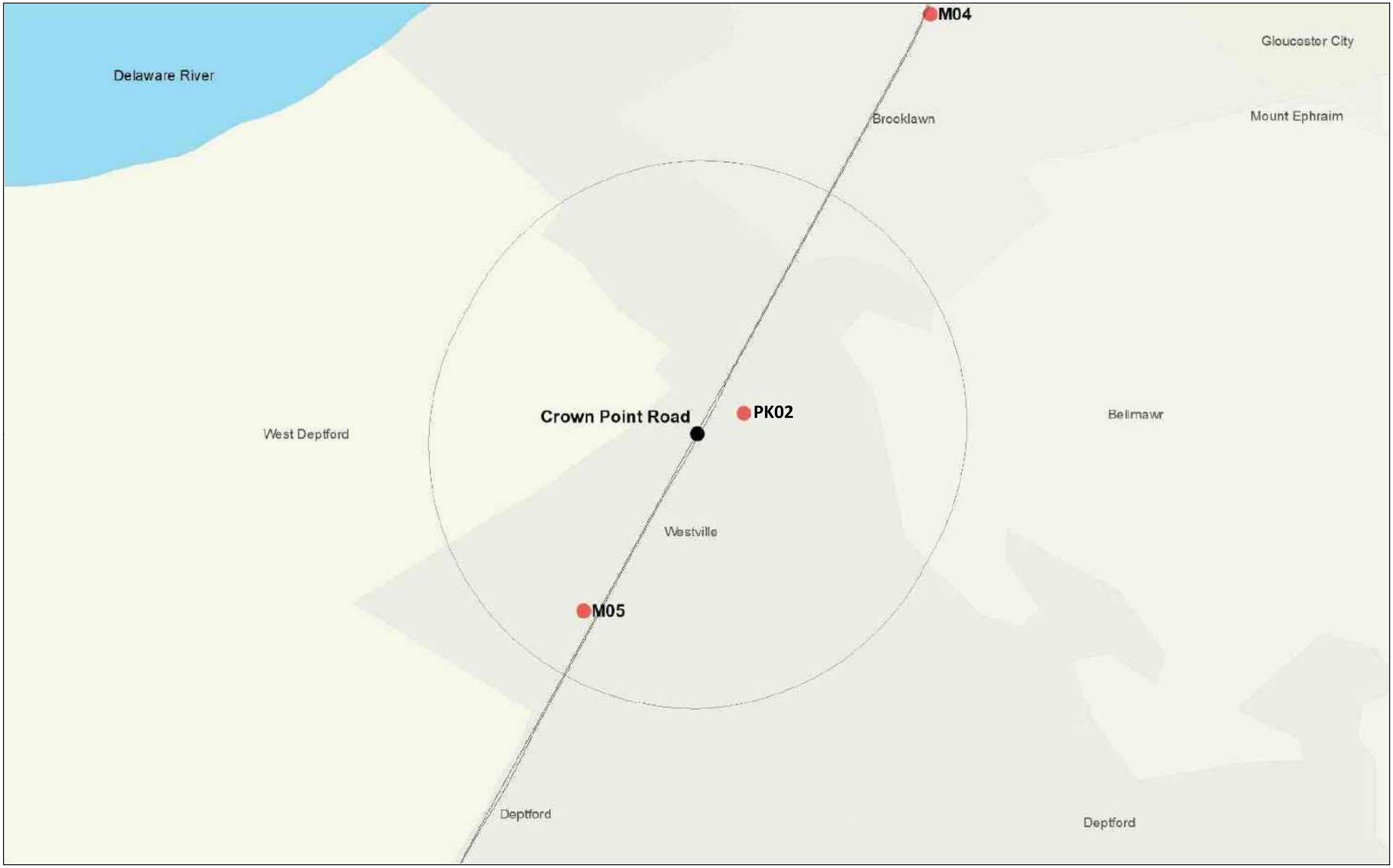
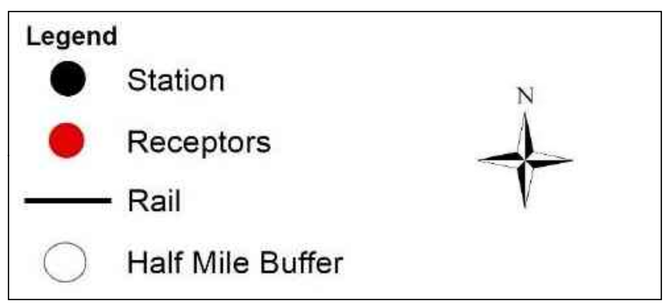
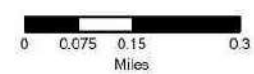


Figure 5: Locations of Representative Measurement Sites



Source: GCL Project Team, 2020.



GLASSBORO-CAMDEN LINE

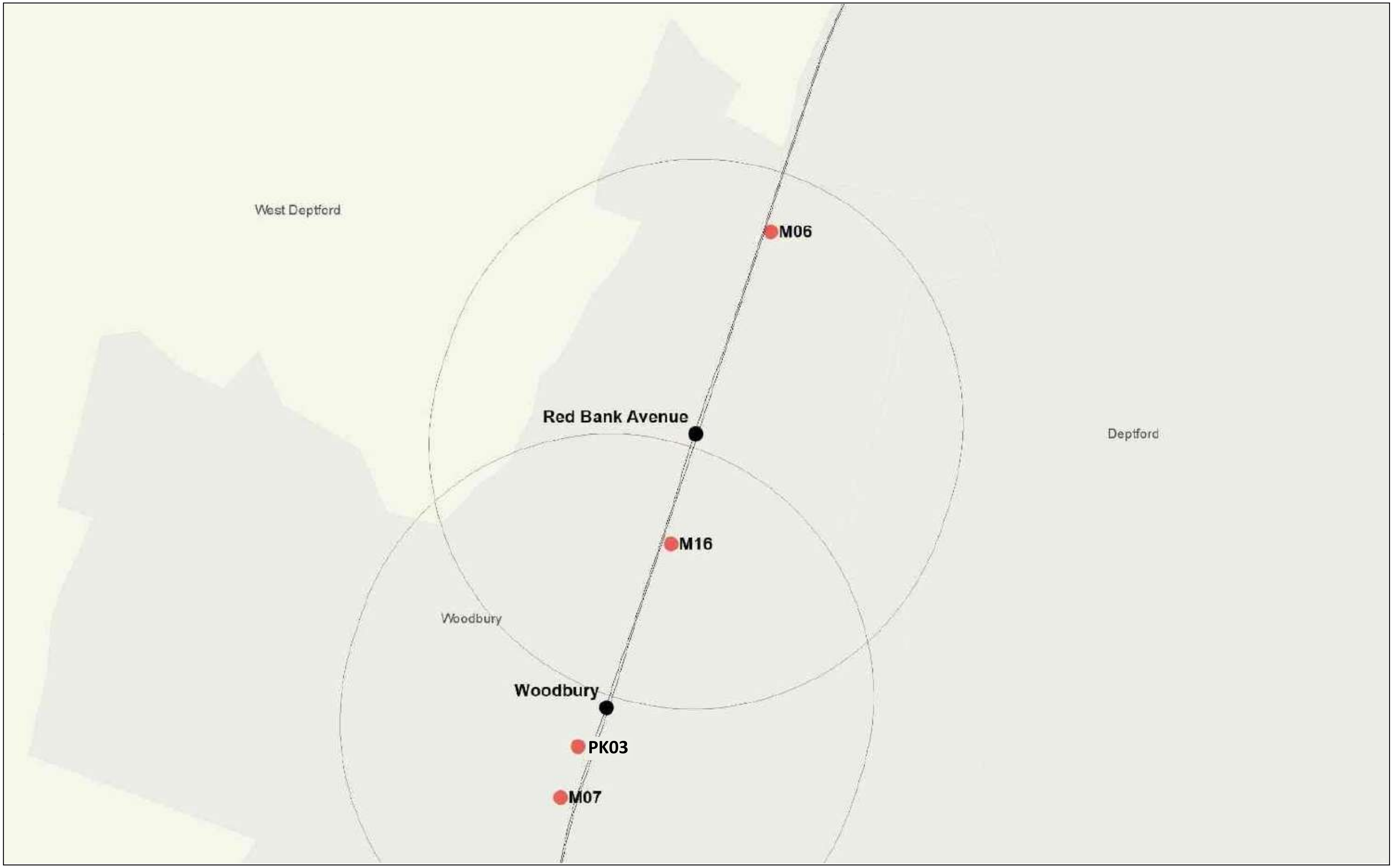
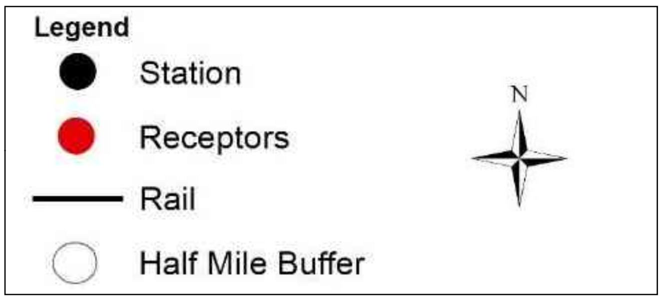


Figure 6: Locations of Representative Measurement Sites

GLASSBORO-CAMDEN LINE



Source: GCL Project Team, 2020.

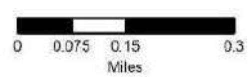


Figure 7: Locations of Representative Measurement Sites

Legend
- Station
- Receptors
- Rail
- Half Mile Buffer

N

Source: GCL Project Team, 2020.

0 0.075 0.15 0.3
Miles

GLASSBORO-CAMDEN LINE

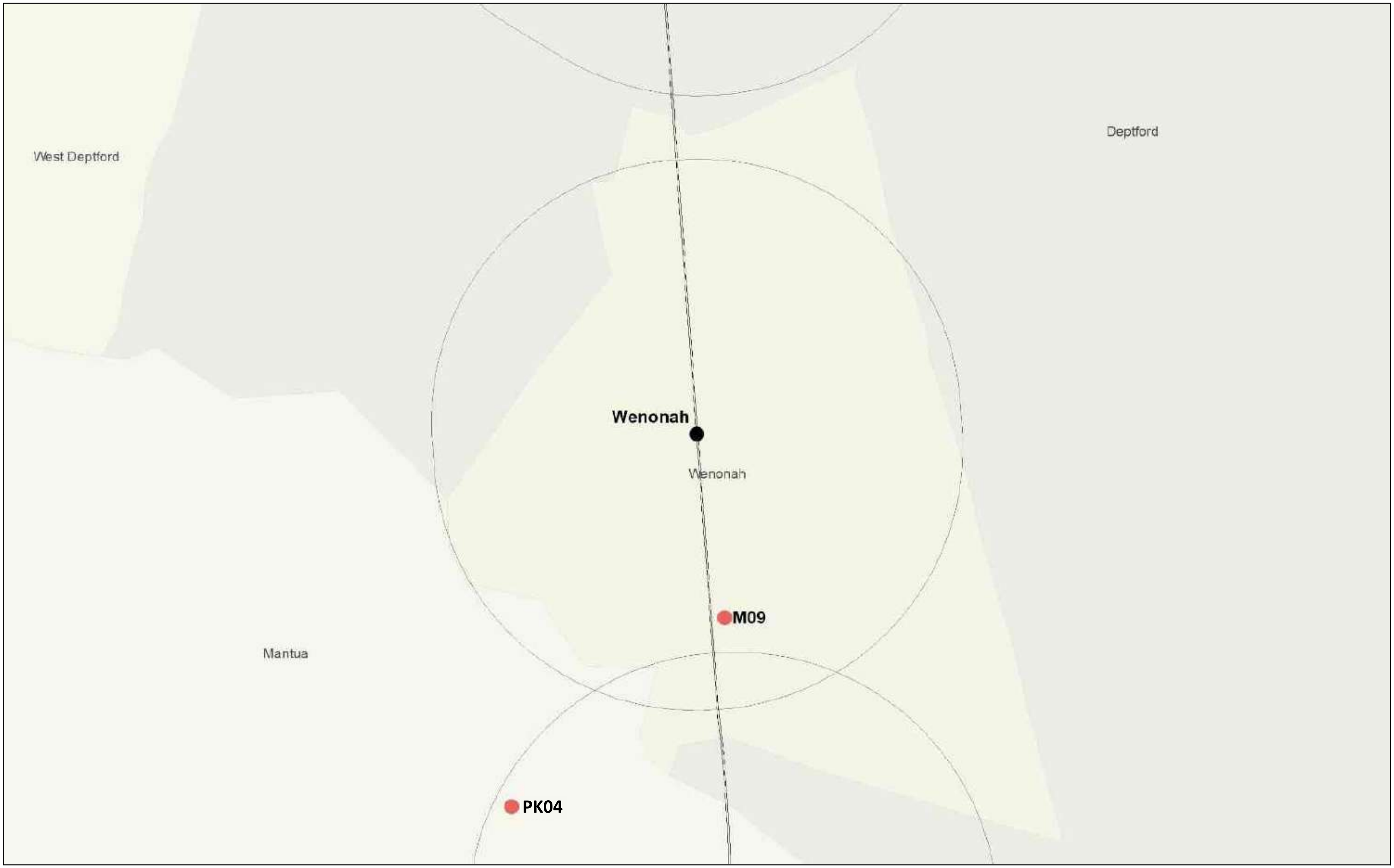


Figure 8: Locations of Representative Measurement Sites

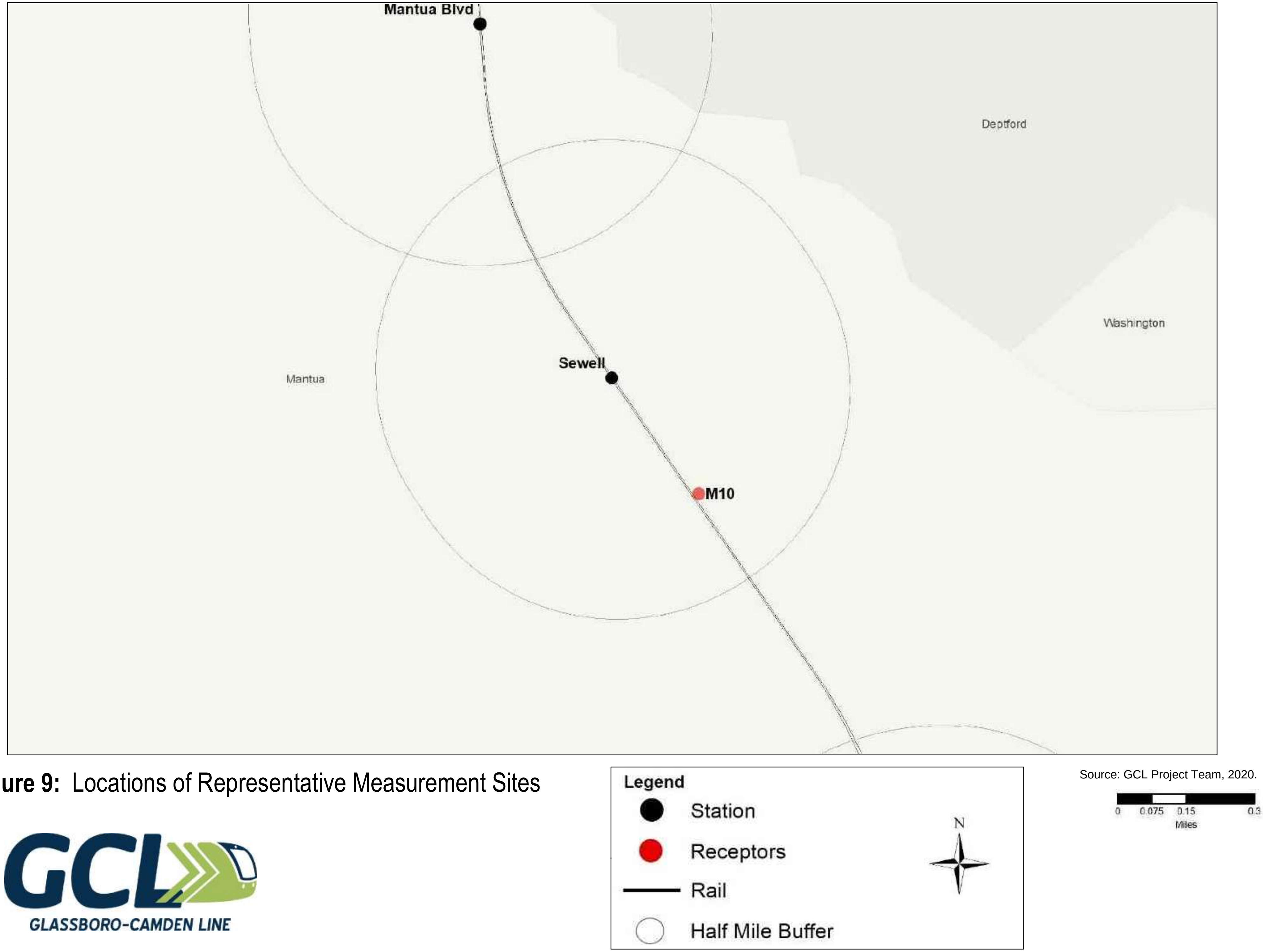
Legend
Station
Receptors
Rail
Half Mile Buffer

N

Source: GCL Project Team, 2020.

0 0.075 0.15 0.3
Miles

GCL
GLASSBORO-CAMDEN LINE



Source: GCL Project Team, 2020.

Figure 9: Locations of Representative Measurement Sites

GLASSBORO-CAMDEN LINE

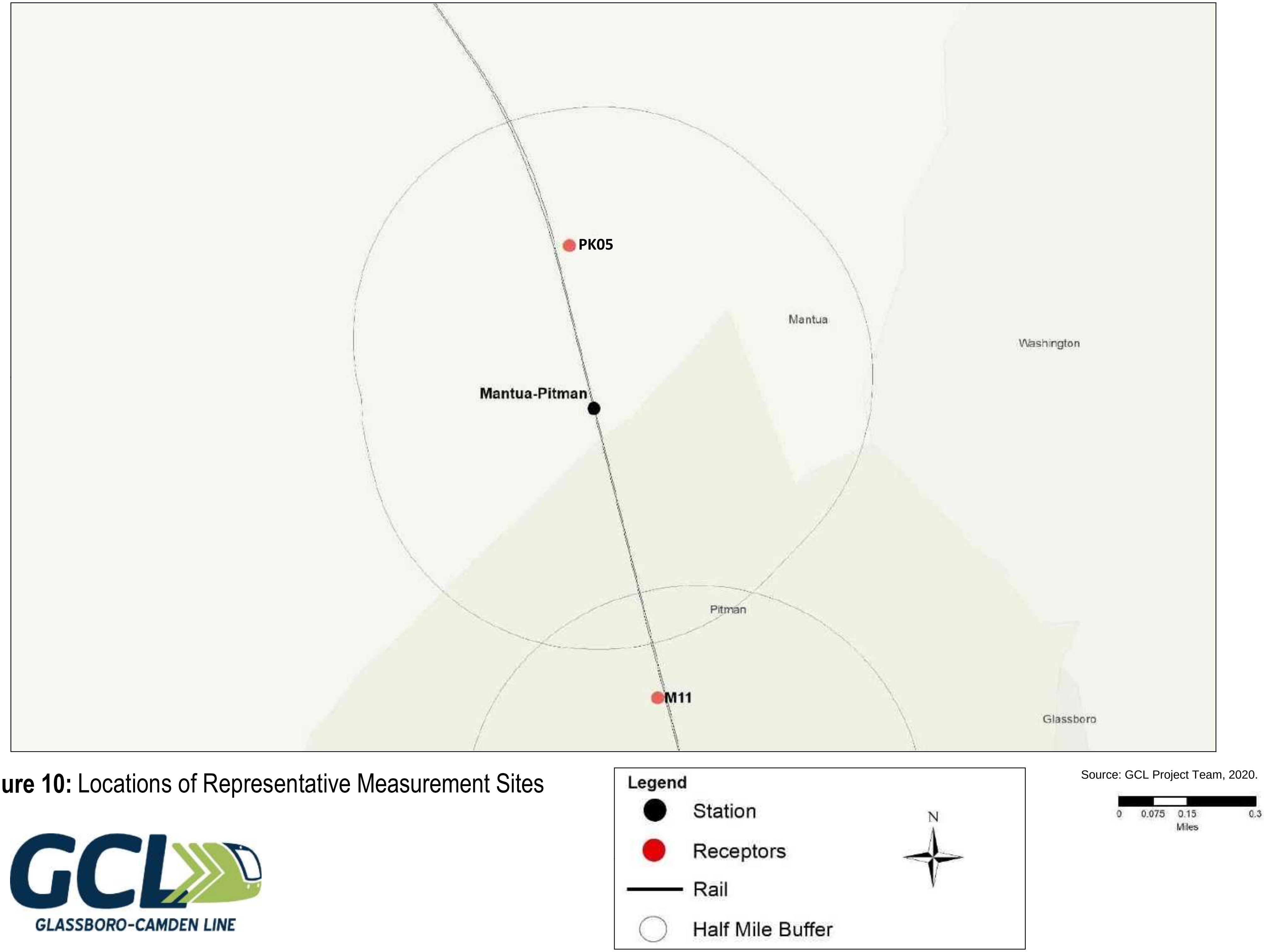


Figure 10: Locations of Representative Measurement Sites

Source: GCL Project Team, 2020.

GLASSBORO-CAMDEN LINE

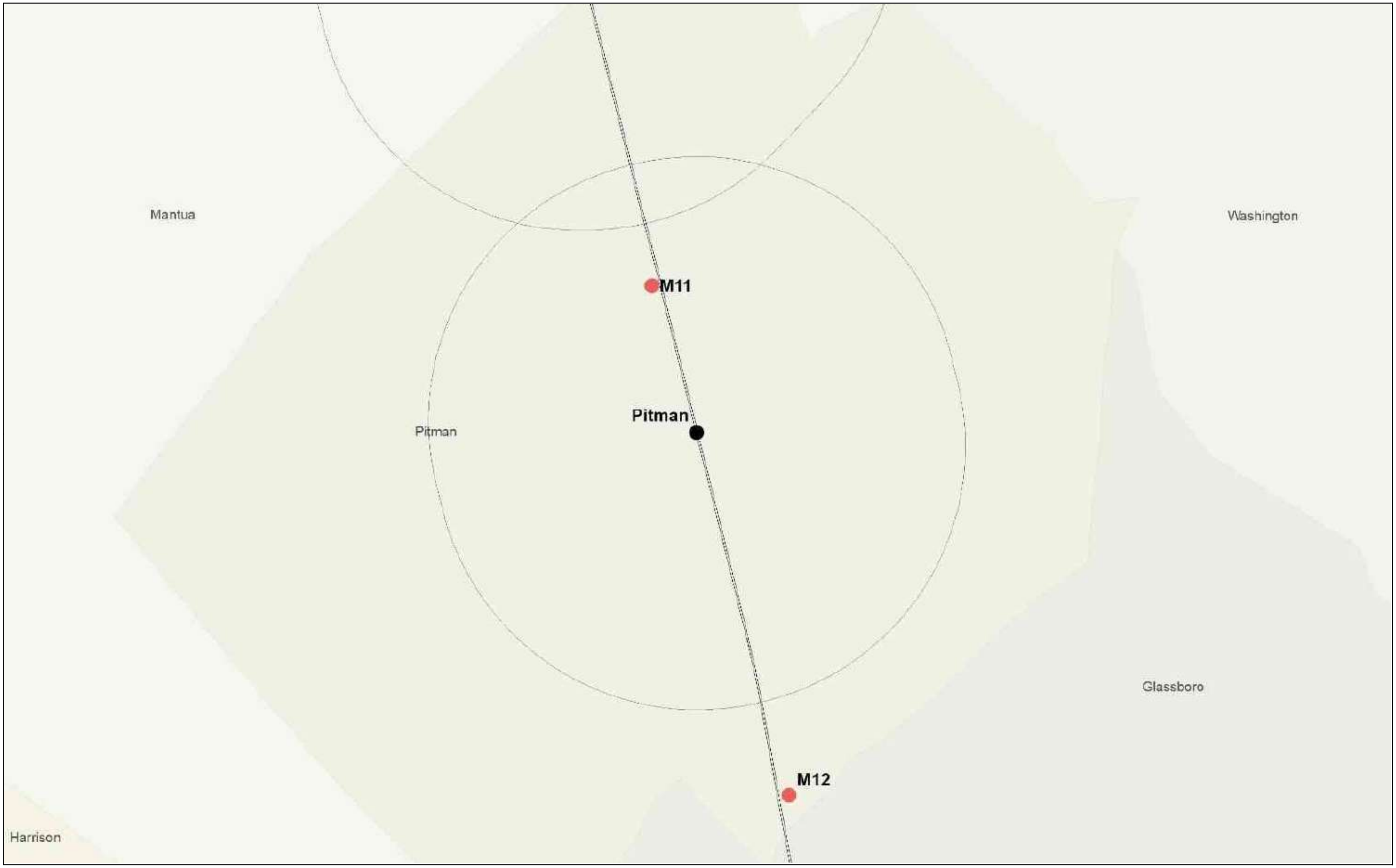


Figure 11: Locations of Representative Measurement Sites

Source: GCL Project Team, 2020.

GLASSBORO-CAMDEN LINE

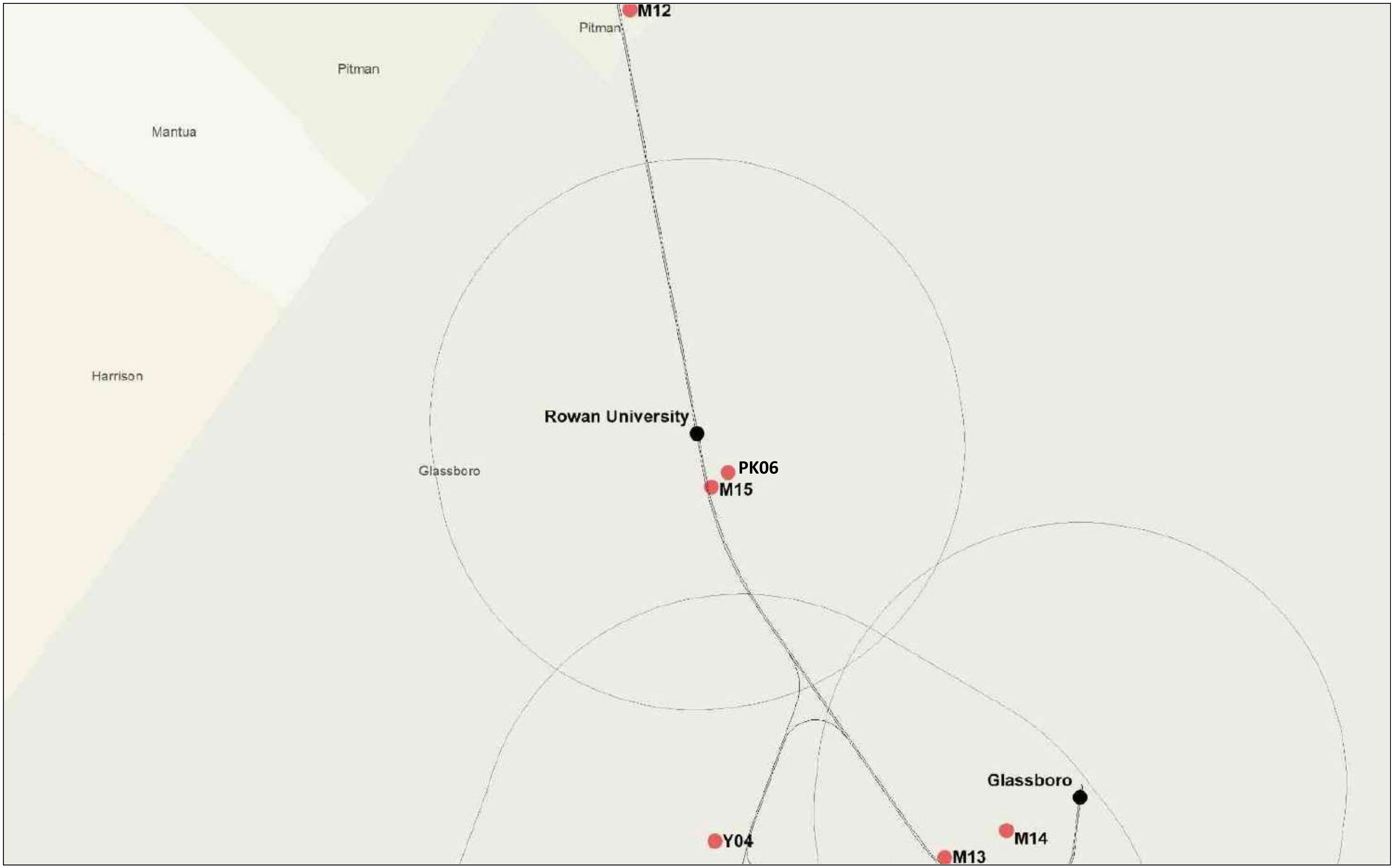
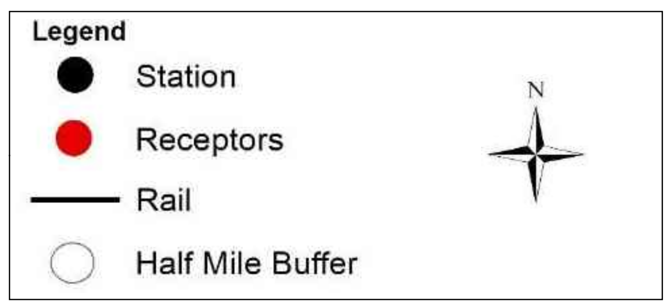
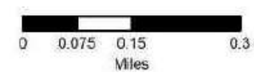


Figure 12: Locations of Representative Measurement Sites



Source: GCL Project Team, 2020.



GLASSBORO-CAMDEN LINE

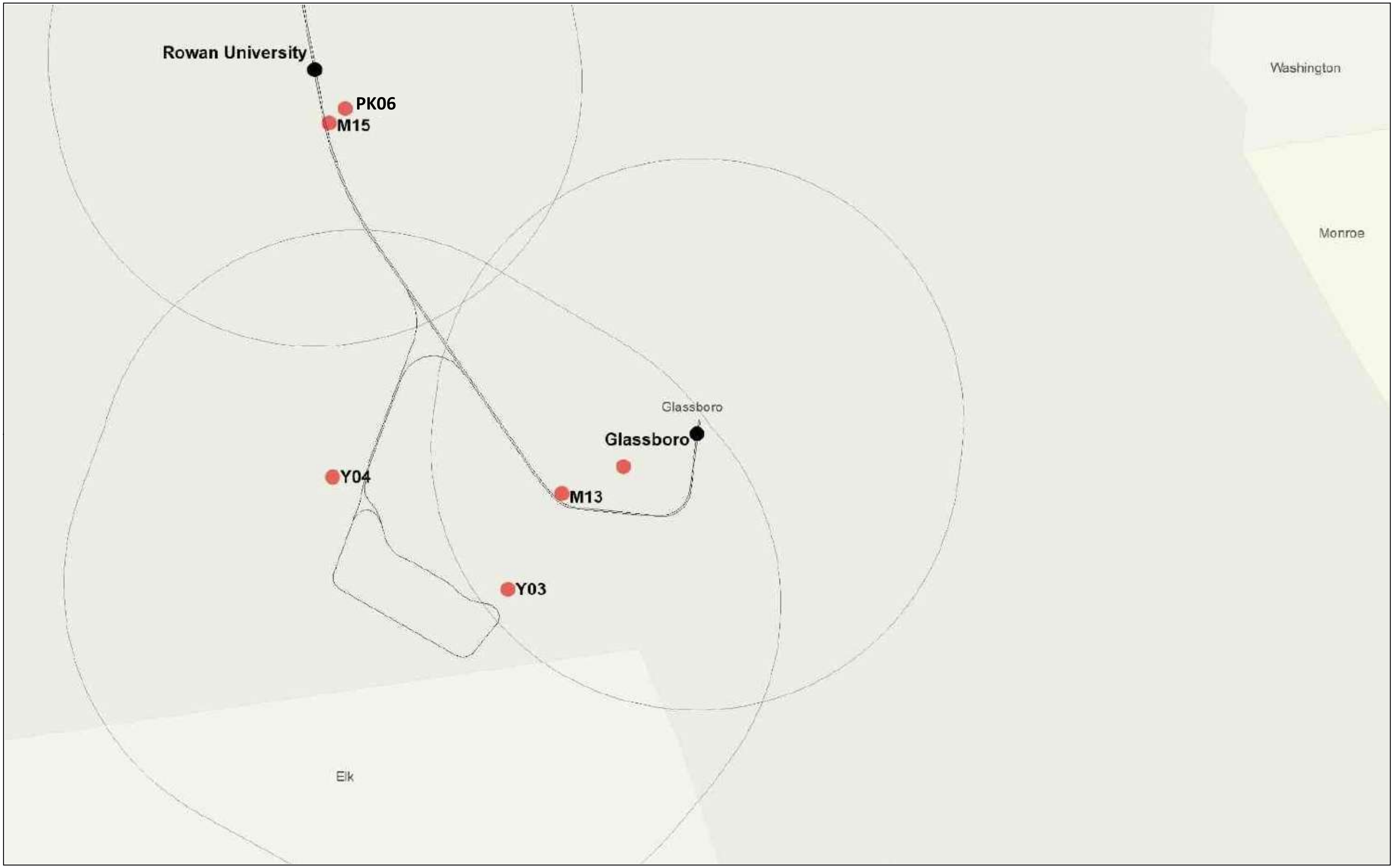
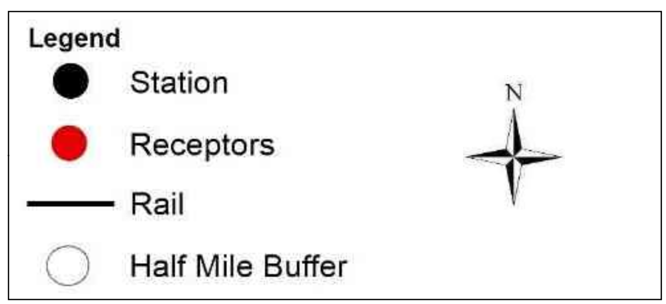
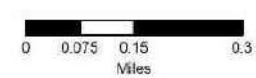


Figure 13: Locations of Representative Measurement Sites



Source: GCL Project Team, 2020.



GLASSBORO-CAMDEN LINE

4.1 Existing Noise Environment

FTA recommends applying a screening procedure to determine the likelihood of project-related noise impacts. The areas defined by the screening distances are meant to be large enough to encompass all potentially affected locations. The FTA screening distance for transit alignments is 350 feet for sites with an unobstructed line of sight to the transit facility. For proposed yard and maintenance facilities, the screening distance is 1,000 feet. A screening distance of 1,500 feet was used for the park-and-ride facilities. These screening distances were applied from the centerline of the transit corridor to determine the study area limits for noise analysis purposes.

Within a given land use category, noise measurements recorded at one site may be representative of existing conditions, as well as future noise exposure, at other similarly located nearby sites. Therefore, noise readings collected at one monitoring location were used to provide site equivalence to other nearby sites exposed to similar background noise conditions. Physical and operational parameters that would produce the worst-case noise effect—such as notable train speeds, frequency of operation, distance to track and maintenance facilities—were factors used in selecting representative noise measurement sites.

Noise measurements were conducted throughout the project corridor from September 2013 to June 2014, when environmental studies for this project were initiated. These measurements were collected during acceptable seasonal, weather, and traffic pattern periods. A recent review of land use throughout the project corridor has confirmed that there have been no major changes in land use or new developments in the area since the noise measurements were conducted. Further, there have been no changes to freight service in the GCL corridor since noise measurements were conducted. As such, current background noise conditions are comparable to those in 2013/2014 and the previously collected noise measurements are considered valid.

All field measurements were collected in accordance with the procedures described in the Federal Highway Administration's (FHWA) Measurement of Highway-Related Noise (Report Number FHWA-DP-96-046, May 1996). Noise measurements were collected using Larson Davis LD-720 sound level meters. The LD-720 complies with ANSI Standard S1.4 for Type 2 accuracy. The outdoor assemblies were mounted at a height of five feet above the ground surface on a tripod and at least six feet away from any sound-reflecting surfaces to avoid major interference with source sound levels being measured. The sound level meters' laboratory calibration was checked before and after sound level readings with a precision Brüel and Kjær Type 4231 sound level calibrator. Noise measurements at all locations were made using the A-weighted decibel scale (dBA), which best corresponds with the hearing perception of humans. The data were digitally recorded and stored in the sound level meters and displayed at the end of the measurement period in one-hour L_{eq} decibel units. All noise measurements were collected during precipitation free weekdays with a wind speed of less than 15 mph.

Twenty-seven representative measurement sites were identified within the GCL project study area corridor. All 27 sites were also chosen as receptors for the noise impact assessment. Seventeen of these 27 sites are in communities where there would be a likelihood of increased noise exposure from daily project-related service operations. The likelihood of impact could be related to their proximity to the proposed track and at-grade crossings. Locations where train speeds would be greatest were also considered. These sites are identified with the "M" prefix. Long-term, 24-hour continuous noise measurements were collected at each of these 17 representative sites. In addition, 24-hour noise measurements were collected at four representative residential properties identified near the proposed storage yard and maintenance facilities. The proposed yards would be located in the communities of Woodbury Heights and Glassboro and are depicted on Figure 7, "Locations of Representative Measurement Sites," and Figure 13, "Locations of Representative Measurement Sites," respectively. Receptor sites near the proposed maintenance and storage yards are designated by the "Y" prefix. Noise measurements were also collected at six FTA Category 3 land use sites identified within 150 feet of the proposed GCL alignment. The six sites consisted of five parks and one public library. As indicated in Table 2, "FTA Land Use Categories and Metrics for Transit Noise Impact Criteria," FTA Category 3 land uses are properties that are primarily associated with daytime usage; they are therefore evaluated for impacts using the peak-hour equivalent noise level [L_{eq} (dB(A))] noise descriptor. These receptors are identified with the "PK" prefix on the figures and summary tables.

A summary of the measured noise levels is provided in Table 1, "Summary of Existing Measured Sound Levels." The day-night average noise level (L_{dn}) values, which are derived from measured hourly L_{eq} noise levels, ranged from approximately 58 dBA L_{dn} at Receptor M08 (single-family residences at 348 East-West Jersey Avenue in Woodbury Heights) to 79 dBA L_{dn} at Receptor M01 (includes the Cooper Hospital area and nearby residences on Haddon Avenue in Camden) and Receptor Site M05 (single-family residences at 800 Gateway Boulevard in Westville). Existing ambient L_{dn} levels estimated near proposed yard maintenance and storage facilities were low to medium for residential areas, varying from 54 dBA at Site Y02 to 65 dBA at Y04. Peak-hour noise measurements at the six FTA Category 3 land uses ranged from 57 dBA L_{eq} at Veterans' Park to 67 dBA L_{eq} at Bowe Park.

Table 1: Summary of Existing Measured Sound Levels

Site ID	Description of Measurement Location	Land Use	Measured Day-Night Noise Levels (L_{dn} dBA)
M01	501A Haddon Avenue, Camden and Cooper Hospital	Residential/Hospital	79
M02	911 South 9th Street, Camden	Residential	71
M03	56 South Railroad Avenue, Gloucester City	Residential	76
M04	5 ½ Railroad Lane, Westville	Residential	65
M05	800 Gateway Boulevard, Westville	Residential	79
M06	926 Washington Avenue, Woodbury	Residential	77
M07	93 Wallace Street, Woodbury	Residential	70
M08	348 East-West Jersey Avenue, Woodbury Heights	Residential	58
M09	1 Cedar Street, Wenonah	Residential	62
M10	870 East Atlantic Avenue, Sewell	Residential	69
M11	304 Montgomery Avenue, Pitman	Residential	67
M12	827 West Jersey Avenue, Pitman	Residential	69
M13	43 Zane Street, Glassboro	Residential	69
M14	11 Church Street, Glassboro	Residential	65
M15	Girard House #14, Rowan University, Glassboro	Residential	69
M16	Stewart Park, Measurement taken at 168 Laurel Street, Woodbury	Residential	65
M17	816 Essex Street, Gloucester City	Residential	65
Y01	560 Chestnut Street near East-West Jersey Ave, Woodbury Heights	Residential	60
Y02	601 Park Avenue, Woodbury Heights	Residential	54
Y03	39 Sewell Street near Highland Ave, Glassboro	Residential	63
Y04	530 Ellis Street, Glassboro	Residential	65
PK01	Gloucester City Public Library, Gloucester City	Institutional	64[1]
PK02	Thompson St and Lane Ave Park, Gloucester City	Park	59[1]
PK03	Green Street Playground, Woodbury	Park	60[1]
PK04	Veterans' Park, Woodbury Heights	Park	57[1]
PK05	Ballard Park, Pitman	Park	59[1]
PK06	Bowe Park, Glassboro	Park	67[1]
[1] Peak-hour Leq (1hr) dBA noise levels.			

Source: GCL Project Team, WSP USA, January 2018

In general, throughout the project study area, the lower L_{dn} noise levels were found to occur in residential communities farther away from either active roadways or freight rail lines. The higher noise levels typically occurred in urban settings adjacent to active roadways or close to the existing freight movements.

5 OVERVIEW OF NOISE

Noise is typically defined as unwanted or undesirable sound. In the natural environment, sound is generated by the vibration of air molecules, which results in small fluctuations in air pressure. As a series of air pressure fluctuations moves through the air, a sound wave is created. Different sound waves may vibrate at different rates or "frequencies"; the faster an object vibrates, the higher the frequency or pitch of the sound wave, while slower vibration rates produce lower sound frequencies.

Noise frequency is expressed based on the rate of the air pressure fluctuation in terms of cycles per second (called Hertz and abbreviated as Hz). The human ear can detect a wide range of frequencies, from about

20 Hz to 20,000 Hz. However, the sensitivity of human hearing varies with frequency. Therefore, when measuring environmental noise, a weighting system is commonly used to provide a single number descriptor that correlates well with human subjective responses to changes in sound frequency and perception of level. Noise levels measured using this weighting system are called "A-weighted" noise levels and are expressed in decibel notation as "dB(A)." The A-weighting of noise levels is widely accepted by acousticians as the best method for describing human response to environmental noise. Most federal and state impact criteria and exposure measures use the dB(A) weighting metric.

The basic parameters of environmental noise that affect human subjective response are (1) intensity or sound level; (2) frequency content; (3) variation with time (e.g., intermittent or continuous); and (4) context (e.g., compared to level and nature of existing sound environment; necessity; time of day). Intensity, or level, is determined by how much the sound pressure fluctuates above and below the atmospheric pressure and is expressed on a logarithmic compressed scale in units of decibels (dB). By using this scale, the range of normally encountered sound can be expressed by values between 0 and 120 decibels. On a relative basis, a 1-decibel change in sound level generally represents a barely noticeable change outside the laboratory. A 3–5 decibel change is readily perceptible, whereas a 10-decibel change in sound level would typically be perceived as a doubling (or halving) in the loudness of a sound.

Because environmental noise fluctuates from moment to moment, it is common practice to condense all of its sound energy into a single number, called the "equivalent" noise level (L_{eq}). L_{eq} can be thought of as the steady noise level that represents the same sound energy as the varying noise levels over a specified time period (typically 1-hour or 24-hour, or period-of-use). Often the L_{eq} values during a 24-hour period are used to calculate cumulative noise exposure. One such measure is the Day-Night Sound Level (L_{dn}). The L_{dn} noise descriptor is the A-weighted L_{eq} for a 24-hour period, with a 10-decibel penalty added to noise levels that occur during the nighttime hours (defined as between 10 p.m. and 7 a.m.).

The L_{dn} descriptor was developed to account for the fact that people tend to be more sensitive to sound during the typical sleeping hours. Many surveys have shown that L_{dn} is well correlated with human annoyance, and therefore this descriptor is widely used to describe how humans perceive environmental noise. Figure 14, "Typical Transit and Background L_{dn} Sound Levels," provides examples of typical noise levels generated by various activities in terms of L_{dn}. While the extremes of L_{dn} typically range from 50 dB(A) in a small town residential environment to near 80 dB(A) in a downtown or industrial area of a city, L_{dn} is generally found to range between 55 dB(A) and 75 dB(A) in most communities. Both the L_{eq} and L_{dn} noise descriptors are utilized in this report.

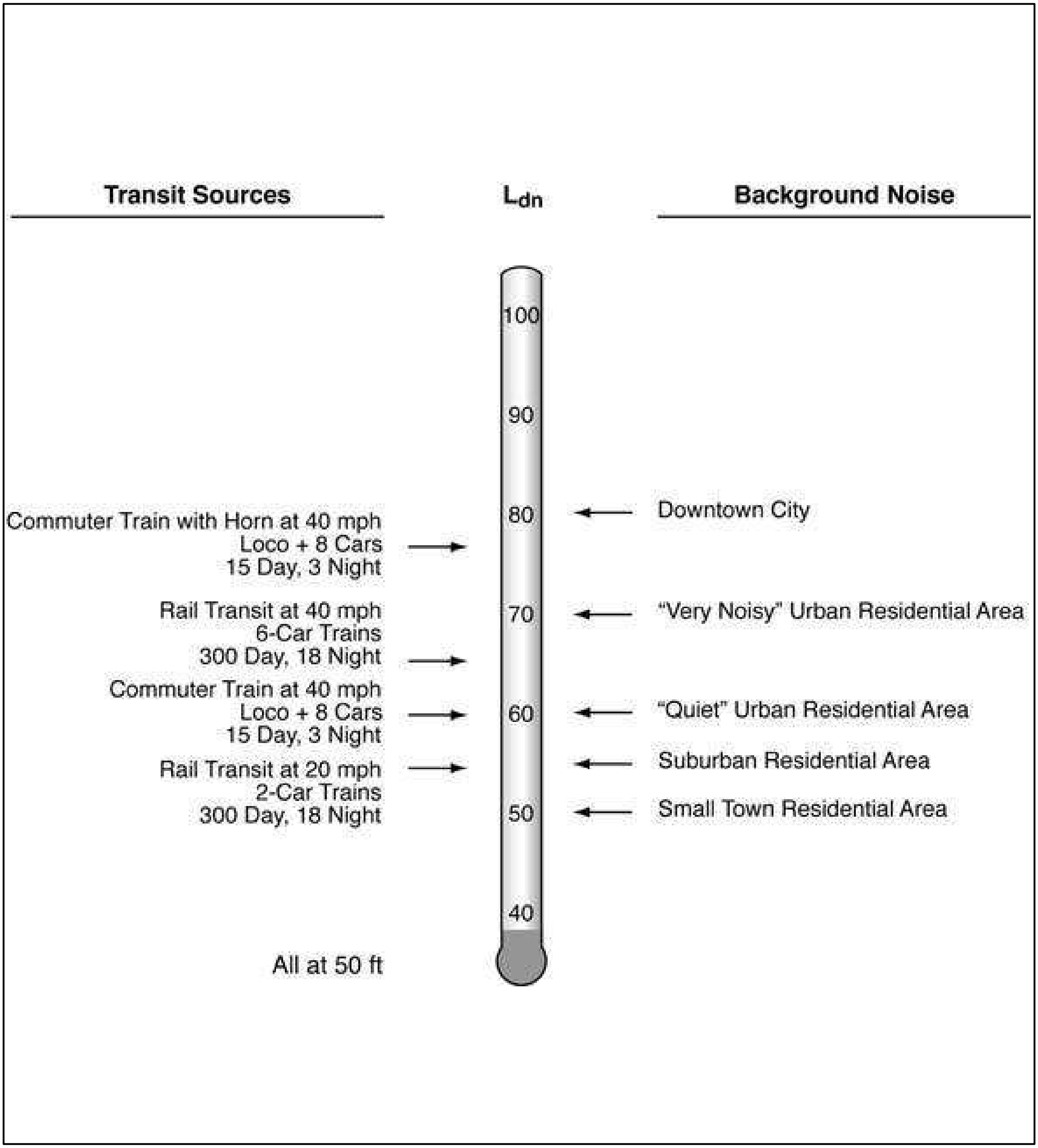


Figure 14: Typical Transit and Background L_{dn} Sound Levels

Source: Federal Transit Administration, Transportation Noise and Vibration Impact Assessment, May 2006; GCL Project Team, 2020.

GCL GLASSBORO-CAMDEN LINE

6 METHODOLOGY FOR DETERMINING NOISE IMPACT AND MITIGATION ASSESSMENT

The assessment of noise and vibration for the proposed GCL followed procedures outlined in the FTA Manual. Based on these FTA procedures, the noise and vibration analysis does not assess the effects of the No-Action Alternative or compare the proposed GCL to the No-Action Alternative. In this technical report, the construction and operations of the GCL are discussed and compared against the FTA impact criteria.

The noise impact assessment was completed in accordance with procedures and analysis methodologies contained in the FTA Manual. The methodologies are as follows:

1. Identify representative noise-sensitive properties and land uses within the study area that potentially would be adversely affected by the operation of the GCL.
2. Measure both 1- and 24-hour existing ambient noise levels.
3. Calculate project-related L_{dn} noise exposure levels for each representative residential receptor location in accordance with the procedures outlined in FTA Manual Table 4-21:

   Existing and future day-night (L_{dn}) noise levels at 50 feet are determined using the following equation:

   $$L_{dn} = 10 \text{ x LOG } [15 \text{ x } 10^{(Lday/10)} + 9 \text{ x } 10^{((Lnight10 + 10)/10)}] - 13.8 \text{ (dB)}$$

   Where,

   L_{day} are the hourly L_{eq} dBA values for the 15 day hours from 7 a.m. to 10 p.m.

   L_{night} are the hourly L_{eq} dBA values for the 9 nighttime hours from 10 p.m. to 7 a.m.

4. Calculate peak-hour L_{eq} (1hr) dBA noise levels at non-residential receptors
5. Compare estimated project noise level to the existing ambient level to determine if the project noise exposure would result in a moderate or severe impact (please refer to Table 3, “Noise Levels Defining Impact for Transit Projects”).
6. Identify reasonable and feasible mitigation measures that would reduce or eliminate project-related noise impacts and incorporate them into the Project.

Certain assumptions have been made in conducting the noise analysis to; account for necessary information not available at this stage of design, ensure comparability of data to analysis criteria, and ensure the analysis is appropriately conservative in the areas to which these assumptions pertain. These assumptions follow:

- The analysis assumes a two-car diesel train. FTA defines the vehicle type under consideration for the operations of the proposed GCL as a Diesel Multiple-Unit (DMU) with a reference Sound Exposure

Level (SEL) of 85 dBA. The project's defined rail vehicle is referred to as a Diesel Light Rail Vehicle (DLRV), which is expected to have similar acoustical characteristics as the FTA-defined DMU rail vehicle. The 85 dBA SEL is the reference noise level provided in the FTA Manual and is derived for a DMU train traveling at 50 mph at a distance of 50 feet from a given receptor. The SEL value represents the cumulative sound energy generated by the single train pass-by event of the rail cars. Thus, the referenced sound-emission level of the DMU identified in the FTA Manual was used in the noise-exposure calculations. While this SEL assumption is not inclusive of horn sounding at grade crossings, the final noise-exposure results do include additional noise-exposure calculations to account for both horn and wheel-squeal noise from the operation of the proposed DLRV.

- In addition to the rail vehicle noise represented by the SEL, the noise-exposure calculations accounted for noise generated by wheel squeal on tight curves, where the radius of curvature on the proposed GCL tracks would be 1,000 feet or less.
- Further, the Federal Railroad Administration (FRA) Train Horn Rule (49 CFR Part 222) requires the sounding of train horns (all trains) when approaching at-grade rail crossings. As a result, the noise-exposure calculations also account for noise generated from future project-related horn soundings. For existing freight, the sounding of transit horns is already part of existing conditions noise monitoring, and therefore is already included in the analysis. The noise-exposure calculation procedures for the operation of the GCL, as described in Section 4 of the FTA Manual, include separate calculations for determining noise contributions for each of these potential project-related noise sources.
- Noise-exposure levels at receptor sites near the proposed vehicle maintenance and storage facilities considered noise generated from both mobile and stationary noise sources. The analysis considered noise generated from on-site stationary activities and from the "In" and "Out" movements of trains entering and leaving the yard that were provided as part of the operational data. The stationary activities in the yard were determined using the FTA generalized assessment methodology applying the 118 dBA SEL for yard and shop activities.
- Project peak travel time traffic volumes near the proposed GCL park-and-ride facilities would not significantly alter traffic patterns. The analysis considered "In" and "Out" movements.
- The DLRV is assumed to be operating on continuous welded rail (CWR) at travel speeds that were determined based on north- and southbound speed profile data derived for the GCL corridor.
- Consistent with FTA methodology, the analysis assumes smooth, well-maintained CWR. The proposed GCL alignment's commitment to installing and maintaining the tracks to Class 4 standards supports this assumption.

6.1 Application of Quiet Zones

FRA requires that locomotive horns be sounded at public road crossings in areas where commuter or light rail operations share tracks or rights-of-way with freight or intercity passenger trains. An exception to this rule is when a community "quiet zone" is established in lieu of horn blowing; no such quiet zones are currently in place or assumed to be in place in the future in communities traversed by the GCL project corridor. To provide an equivalent level of safety at public road crossings, quiet zone designations require that certain supplemental safety measures first be adopted in place of routine locomotive horn soundings serving as audible warnings. The currently proposed GCL conceptual build design is consistent with FRA requirements for quiet zone designation. Municipalities along the corridor have not filed applications to receive the quiet zone designation and are not expected to file. Therefore, the noise impact analysis completed for the present noise analysis does not include the effects of quiet zones. Further refinements to the operational noise impact assessment findings and abatement recommendations are expected during the project's Final EIS phase, if any quiet zone designations are filed for approval.[1] The FTA impact criteria sets forth a methodology by which severity of impact is based on relating the noise introduced to the existing background noise of an environment. This methodology allows for higher project noise exposure where there are higher levels of existing background noise (e.g., Category 3) and is separated into three impact criteria categories (Severe Impact, Moderate Impact, and No Impact).

Project-generated noise in the "No Impact" range is not likely to be found annoying and is considered acceptable according to FTA criteria, thus no mitigation is required. Project-related noise-exposure levels determined to be within the FTA "Severe Impact" range represent conditions with the most compelling need for mitigation.

When mitigation of Severe Impacts are deemed necessary, the goal of noise mitigation is to achieve a substantial noise reduction, not to a level immediately under the Severe Impact threshold. The evaluation of specific mitigation measures includes consideration of the noise reduction effectiveness, cost, the effect on transit operations, and maintenance and any relevant factors that might be caused by the measure.

Noise impacts identified in the Moderate Impact range must also be considered for mitigation. While impacts in the Moderate Impact range are not of the same magnitude as a Severe Impact, the following factors should be considered when determining if mitigation is warranted for Moderate Impacts:

- **The density of residential properties exposed to Moderate Impacts.** The larger the Moderate Impact affected area, the greater the need for mitigation consideration compared with residences in more isolated areas.
- **The degree of the Moderate Impact.** For example, if the anticipated Moderate Impact falls just below the threshold for Severe Impact, the mitigation could differ if the anticipated Moderate Impact is expected to be just above the threshold for No Impact.
- **The noise sensitivity of the land uses to noise exposure.** For example, active recreational parks are less sensitive to noise than passive recreational parks where people seek refuge from noise. Active recreational areas not providing mitigation for Moderate Impact might be acceptable.

[1] Per FRA guidance, quiet zones cannot be included as part of the proposed GCL because individual jurisdictions must apply to FRA directly for a quiet zone designation; however, at-grade crossings are being designed with four quadrant gates, providing the opportunity for jurisdictional entities to if so desired.

- **The acoustic effectiveness of the proposed mitigation measure(s).** The effectiveness of a mitigation measure would vary based upon the adjacent land use.

6.2 FTA Criteria for Noise-Sensitive Properties

The initial review using aerial mapping of land uses within the proximity of the proposed GCL project alignment was completed to identify noise-sensitive land uses and/or receivers of interest within the project study area corridor. Representative sites from this group were identified and selected for noise measurements. In addition, prior to noise monitoring, each proposed representative measurement site was field-inspected to verify the land use and its presumed sensitivity to noise. The noise criteria and descriptors required by FTA to determine potential noise impacts depend upon land use type, as shown in Table 2, "FTA Land Use Categories and Metrics for Transit Noise Impact Criteria." The FTA criteria groups noise-sensitive land uses into three categories, as shown in Table 2, "FTA Land Use Categories and Metrics for Transit Noise Impact Criteria."

Table 2: FTA Land Use Categories and Metrics for Transit Noise Impact Criteria

Land Use Category	Noise Metric (dBA)	Description of Land Use Category
1	Outdoor $L_{eq}(h)$*	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	Outdoor L_{dn}	This category is applicable all residential land use and buildings where people normally sleep, such as hotels and hospitals.
3	Outdoor $L_{eq}(h)$*	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.
* Leq for the noisiest hour of transit-related activity during hours of noise sensitivity.		

Source: Federal Transit Administration. *Transit Noise and Vibration Impact Assessment Manual*; U.S. Department of Transportation Report Number FTA-0123, September 2018

No Category 1 land uses have been identified along the project corridor. Category 2 land uses (daytime and nighttime use) were assessed using the previously-described L_{dn} descriptor, while Category 3 land uses (primarily daytime uses) were assessed using the hourly equivalent noise level ($L_{eq}(h)$) descriptor. Both the $L_{eq}(h)$ and L_{dn} descriptors report noise levels in dBA. FTA criteria do not generally apply to industrial or commercial areas, because those areas are generally not considered noise sensitive and are compatible with places consistent with higher ambient noise conditions.

The FTA impact criteria sets forth a methodology by which severity of impact is based on relating the noise introduced to the existing background noise of an environment. As illustrated on Figure 15, "Noise Impact Criteria for Transit Projects," the severity of noise impact is graphically represented by three areas defined by two curves on a graph; these two curves extend between two vertical axes. The left vertical axis on

Figure 15, "Noise Impact Criteria for Transit Projects," applies to FTA land use Categories 1 and 2 and the right vertical axis to Category 3. This graphic, which is used to interpret impact severity, allows for higher project noise exposure where there are higher levels of existing background noise (e.g., Category 3, or the right axis).

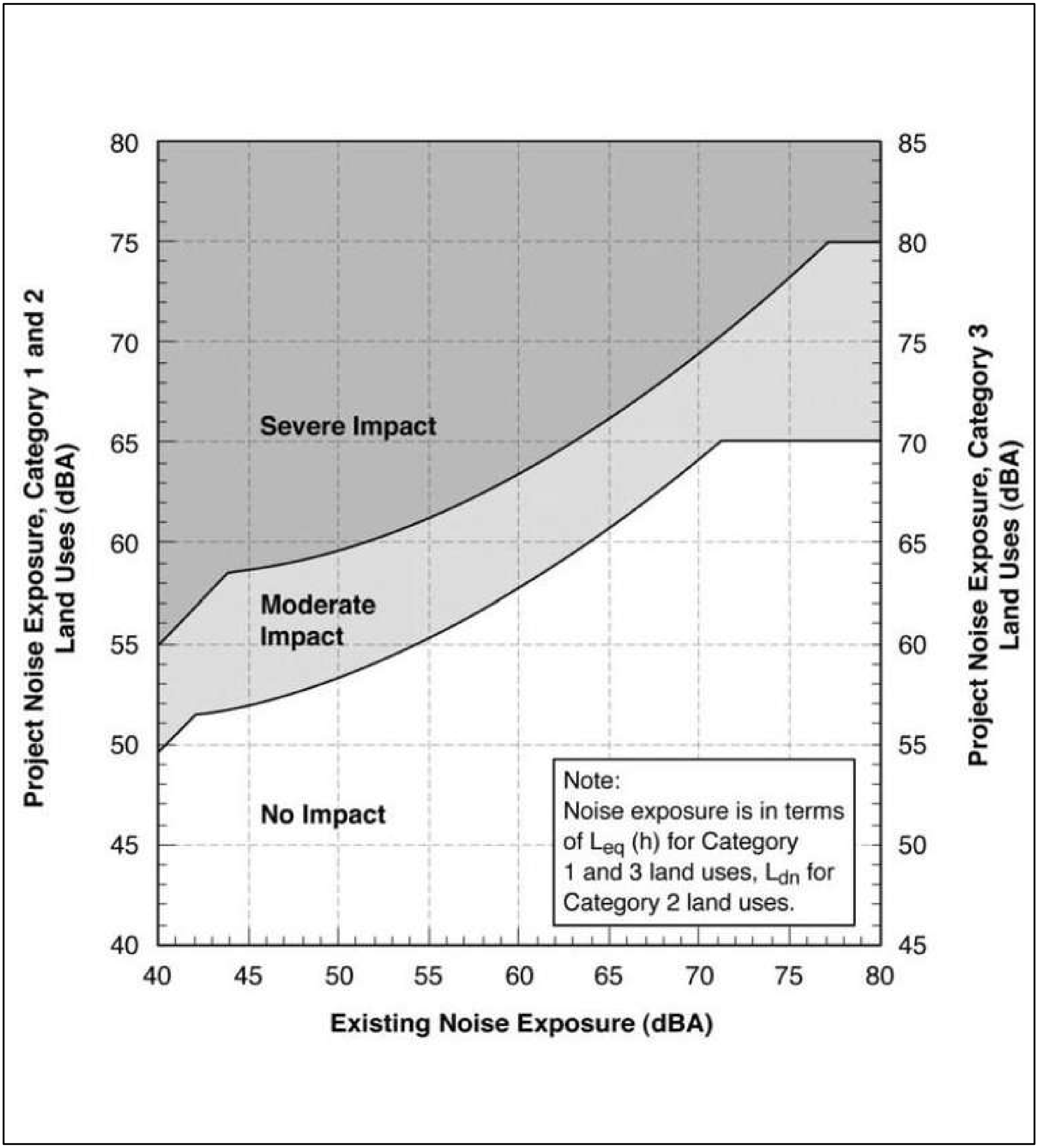


Figure 15: Noise Impact Criteria for Transit Projects

Source: Federal Transit Administration, Transportation Noise and Vibration Impact Assessment, May 2006; GCL Project Team, 2020.

GCL GLASSBORO-CAMDEN LINE

Noise levels above the top curve are considered to cause *Severe Impact*, resulting in a substantial percentage of people visiting, working, or living in the area to likely be highly annoyed by the new noise source. Noise levels in the range between the two curves are deemed to be *Moderate Impacts*, and levels below the bottom curve are deemed to cause *No Impact*. The same information is displayed in tabular format in Table 3, "Noise Levels Defining Impact for Transit Projects."

Project-generated noise in the "No Impact" range is not likely to be found annoying and is considered acceptable according to FTA criteria, thus no mitigation is required. Project-related noise exposure levels determined to be within the FTA "Severe Impact" range represent conditions with the most compelling need for mitigation.

When mitigation of Severe Impacts are deemed necessary, the goal of noise mitigation is to achieve a substantial noise reduction, not to a level immediately under the Severe Impact threshold. The evaluation of specific mitigation measures includes consideration of the noise reduction effectiveness, cost, the effect on transit operations and maintenance, and any relevant factors that might be caused by the measure.

Noise impacts identified in the Moderate Impact range must be considered for mitigation. While impacts in the Moderate Impact range are not of the same magnitude as a Severe Impact, the following factors should be considered when determining if mitigation is warranted for Moderate Impacts:

- **The density of residential properties exposed to Moderate Impacts.** The larger the Moderate Impact affected area, the greater the need for mitigation consideration compared with residences in more isolated areas.
- **The degree of the Moderate Impact.** For example, if the anticipated Moderate Impact falls just below the threshold for Severe Impact, the mitigation could differ if the anticipated Moderate Impact is expected to be just above the threshold for No Impact.
- **The noise sensitivity of the land uses to noise exposure.** For example, active recreational parks are less sensitive to noise than passive recreational parks where people seek refuge from noise. Active recreational areas not providing mitigation for Moderate Impact might be acceptable.
- **The acoustic effectiveness of the proposed mitigation measure(s).** The effectiveness of a mitigation measure would vary based upon the adjacent land use.

Table 3: Noise Levels Defining Impact for Transit Projects

Existing Noise Exposure* L_{eq}(h) or L_{dn} (dBA)	Project Noise Impact Exposure* L_{eq} (h) or L_{dn} (dBA)					
	Category 1 or 2 Sites			Category 3 Sites		
	No Impact	Moderate Impact	Severe Impact	No Impact	Moderate Impact	Severe Impact
<43	**<Ambient+10**	**Ambient +10 to 15**	**>Ambient+15**	**<Ambient+15**	**Ambient +15 to 20**	**>Ambient+20**
43	<52	52-58	>58	<57	57-63	>63
44	<52	52-58	>58	<57	57-63	>63
45	<52	52-58	>58	<57	57-63	>63
46	<53	53-59	>59	<58	58-64	>64
47	<53	53-59	>59	<58	58-64	>64
48	<53	53-59	>59	<58	58-64	>64
49	<54	54-59	>59	<59	58-64	>64
50	<54	54-59	>59	<59	59-64	>64
51	<54	54-60	>60	<59	59-64	>65
52	<55	55-60	>60	<60	60-65	>65
53	<55	55-60	>60	<60	60-65	>65
54	<55	55-61	>61	<60	60-66	>66
55	<56	56-61	>61	<61	61-66	>66
56	<56	56-62	>62	<61	61-67	>67
57	<57	57-62	>62	<62	62-67	>67
58	<57	57-62	>62	<62	62-67	>67
59	<58	58-63	>63	<63	63-68	>68
60	<58	58-63	>63	<63	63-68	>68
61	<59	59-64	>64	<64	64-69	>69
62	<59	59-64	>64	<64	64-69	>69
63	<60	60-65	>65	<65	65-70	>70
64	<61	61-65	>65	<66	65-70	>70
65	<61	61-66	>66	<66	66-71	>71
66	<62	62-67	>67	<67	67-72	>72
67	<63	63-67	>67	<68	68-72	>72
68	<63	63-68	>68	<68	68-73	>73
69	<64	64-69	>69	<69	69-74	>74
70	<65	65-69	>69	<70	70-74	>74
71	<66	66-70	>70	<71	71-75	>75
72	<66	66-71	>71	<71	71-76	>76
73	<66	66-71	>71	<71	71-76	>76
74	<66	66-72	>72	<71	71-77	>77
75	<66	66-73	>73	<71	71-78	>78
76	<66	66-74	>74	<71	71-79	>79
77	<66	66-74	>74	<71	71-79	>79
>77	<66	66-75	>75	<71	71-80	>80

L_{dn} is used for land use where nighttime sensitivity is a factor, L_{eq} during the hour of maximum transit noise exposure is used for land use involving only daytime activities.

Source: Federal Transit Administration. *Transit Noise and Vibration Impact Assessment Manual*; U.S. Department of Transportation, Report No. FTA-0123, September 2018

7 OVERVIEW OF VIBRATION

Ground-borne vibration is described in the FTA Manual as a circumstance where "train wheels rolling on the rails create vibration energy."[2] This energy can lead to shaking and rumbling, resulting in impacts to nearby communities. However, for the purposes of this assessment, the "velocity" is the descriptor used to represent impacts related to ground-borne vibration. When evaluating human response, ground-borne vibration is usually expressed in terms of a root mean square (RMS) vibration velocity level. The RMS is defined as the average of the squared amplitude of the vibration signal. As vibration is a varying quantity, the use of the RMS is the best way to describe its magnitude. To avoid confusion with sound decibels, the abbreviation VdB is used to represent vibration decibels. Because the vibration decibel represents a ratio of the vibration quantity, a reference value should always be specified. For the purposes of this technical report, vibration levels are all referenced to one micro-inch per second (1.0×10^{-6} in/sec).

Figure 16, "Typical Vibration Sources," shows typical vibration levels from rail and non-rail sources, as well as the human and structural responses to such levels. Typical vibration levels range from below 50 VdB to 100 VdB (0.000316 in/sec to 0.1 in/sec). The typical human threshold of perception is around 65 – 70 VdB. Unlike airborne noise, most common environmental ground-borne vibration, though present in our surroundings all the time, are generally not perceptible. However, human annoyance from vibration often occurs when vibration levels exceed the threshold of perception by only a small margin. Common sources of perceptible ground-borne vibration include those generated from steel-wheeled rail transit movements, construction activities and some industrial processes. Conversely, vibration generated from traffic movements on roadways are generally below the threshold of perceptibility. There is substantial knowledge about vibration from rail systems. In general, this collective experience indicates the following:

- It is rare that ground-borne vibration from transit systems results in even minor cosmetic damage to buildings. Therefore, the primary consideration for study purposes is whether vibration would be intrusive to building occupants or would interfere with interior activities or machinery.
- According to the FTA Manual, the threshold for human perception is approximately 65 VdB. Vibration levels in the range of 70 to 75 VdB are often noticeable, but acceptable. Beyond 80 VdB, vibration levels are often considered unacceptable.
- Regarding human annoyance, there is a relationship between the number of daily events and the degree of annoyance caused by ground-borne vibration.

[2] Federal Transit Administration, *Transit Noise and Vibration Impact Assessment*; U.S. Department of Transportation, Report No. FTA-0123, September 2018, section 7-1

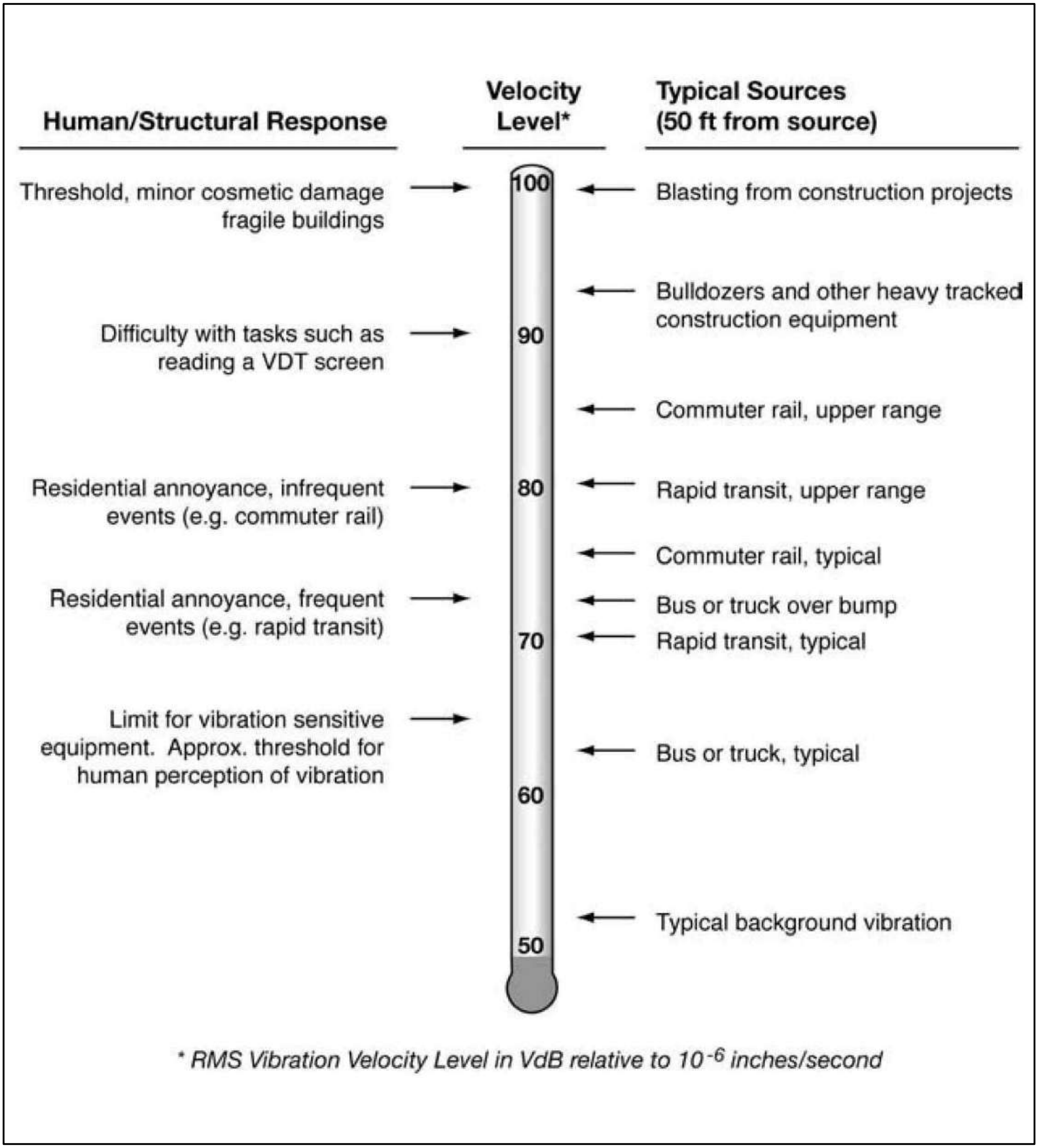


Figure 16: Typical Vibration Sources

Source: Federal Transit Administration, Transportation Noise and Vibration Impact Assessment, May 2006; GCL Project Team, 2020.

GLASSBORO-CAMDEN LINE

An important consideration for rail transit projects is the vibration that is transmitted from rail movement on the tracks through the ground to adjacent buildings. This vibration is caused by the interaction or friction between the wheels and rails, resulting in the transmission of vibration waves through the ground. When these ground-borne waves emerge inside the foundation of a building, they may be perceptible to the building occupants. High levels of ground-borne vibration can cause windows, pictures on walls, and/or items on shelves to rattle. However, although the perceived vibration from rail vehicle pass-by can be intrusive to building occupants, the actual impact from vibration is almost never of sufficient magnitude to cause even minor cosmetic damage to the building structure. Vibration levels from DLRV systems typically range from 70 to 87 VdB at speeds of 50 mph and receptor distances of 50 feet. This vibration level range would lie between those anticipated for rapid transit and commuter rail systems.

7.1 Vibration from Rail Movements

Vibration from train movements is caused by the interaction of the wheels on the rail tracks when moving. The forces caused by this interaction depend upon train speed, the smoothness of the rails and wheels, and the resonance frequencies of the vehicle suspension and track support systems. When vibration does occur, it is then radiated into the surrounding ground. The extent to which the vibration waves propagate away from the track depends upon factors, such as the strength of the original wave, the depth to bedrock, and the soil type. However, the amplitude of the wave is typically diminished with distance. This diminishment in energy results from both the material damping of the wave created by the wave medium and the expansion of the wave front. When the vibration reaches building foundations, it interacts with the building structure and can cause floors, walls, and ceilings in living spaces to vibrate.

Lastly, vibration can also be manifested as ground-borne noise. Ground-borne noise (GBN) is the radiation of acoustical energy from ground and structural surfaces excited by ground-borne vibration. The noise produced is the result of the acoustic energy propagating through rock, soil or a receiving structure medium into the air of an underground room, such as a basement or other below grade structure. However, GBN is generally only an issue for trains that operate underground or in tunnel sections. For systems such as the proposed GCL service, where trains are operating either at or above grade, the airborne noise level is generally significantly louder than the GBN. As a result, GBN would typically be masked by the airborne noise.

8 METHODOLOGY FOR DETERMINING VIBRATION IMPACT AND MITIGATION ASSESSMENT

The FTA ground-borne vibration impact criteria used for the proposed GCL service, as shown in Table 4, "Ground-Borne Vibration and Ground-Borne Noise Impact Criteria for General Assessment," are based on the maximum single-event ground vibration caused by a rail vehicle pass-by. In order to account for differing sensitivity levels with buildings and varying frequency of train service, the FTA vibration criteria utilize three distinct sensitive land use categories and consider higher and lower impact thresholds that are dependent upon the number of daily project-related vibration events. For the proposed GCL service, the number of train pass-by events exceeds the FTA "frequent events" threshold of 70 (Table 4, "Ground-Borne Vibration and Ground-Borne Noise Impact Criteria for General Assessment"). As per the FTA

Manual, this vibration impact criterion would generally only apply to the indoor spaces of buildings, because humans are less sensitive to outdoor vibration. Table 4, "Ground-Borne Vibration and Ground-Borne Noise Impact Criteria for General Assessment," also shows the Ground-Borne Vibration (GBV) criteria threshold for the institutional category. Because their functions are primarily related to daytime usage, these buildings are less sensitive to vibration as residential land uses, where people sleep and sensitivity to vibration is greater.

Table 4, "Ground-Borne Vibration and Ground-Borne Noise Impact Criteria for General Assessment," also includes separate FTA criteria for Ground-Borne Noise (GBN), or the "rumble" that can be radiated from the motion of room surfaces in buildings due to GBV. Although expressed in dBA, which emphasizes the more audible middle and high frequencies, the criteria are set significantly lower than for airborne noise to account for the annoying low-frequency character of GBN. The threshold of human perceptibility for GBN is 25 to 40 dBA. For systems where trains are operating either at or above grade, such as the proposed GCL, the airborne noise level is generally significantly louder than the GBN. As a result, GBN would typically be masked by the airborne noise and, therefore, the GBN along the GCL corridor does not require further evaluation.

Table 4: Ground-Borne Vibration and Ground-Borne Noise Impact Criteria for General Assessment

Land Use Category	GBV Impact Levels (VdB re: 1 micro-inch/sec)			GBN Impact Levels (dB re: 20 micro Pascals/ sec)		
	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 operations	65 VdB	65 VdB	65 VdB	NA[4]	NA[4]	NA[4]
Category 2: Residences and buildings where people normally sleep	72 VdB	75 VdB	80 VdB	35 dBA	38 dBA	43 dBA
Category 3: Institutional land uses with primary daytime use	75 VdB	78 VdB	83 VdB	40 dBA	43 dBA	48 dBA

[1] "Frequent Events" is defined as more than 70 vibration events per day.
[2] "Occasional Events" is defined as between 30 and 70 vibration events per day.
[3] "Infrequent Events" is defined as less than 30 vibration events per day.
[4] N/A means "not applicable." Vibration-sensitive equipment is not sensitive to ground-borne noise.

Source: Federal Transit Administration. *Transit Noise and Vibration Impact Assessment Manual*. U.S. Department of Transportation Report No. FTA-0123, September 2018

9 OVERVIEW OF CONSTRUCTION

9.1 Short-term Construction Noise Exposure Criteria

The FTA Manual presents guidelines that can be considered reasonable criteria for the assessment of construction noise impacts. Noise exposure from activities associated with the construction of the proposed GCL would result in short-term noise exposure at any given location along each segment of the project corridor. Construction would involve a wide range of activities, including clearing the rail right-of-way, construction of grade crossings, bridge construction, yard and maintenance facility construction, laying track, and construction of stations and other system elements.

Table 5, "FTA Construction Noise Criteria," shows the FTA construction noise criteria for noise assessments conducted in accordance with FTA methodologies. Using FTA guidelines, an airborne noise impact would occur if noise levels during construction exceed the FTA recommended values in Table 5, "FTA Construction Noise Criteria." The criteria are applied generally to residential, commercial, and industrial land uses. It should be noted, as reflected in the existing conditions analysis, that the ambient noise levels at sensitive receptors in the study area are relatively high, reflecting their urban/commercial environment.

Table 5: FTA Construction Noise Criteria

Land Use	8-hour L_{eq} (dBA)		L_{dn} (dBA) 30-day Average
	Day	Night	
Residential	80	70	75[a]
Commercial	85	85	80[b]
Industrial	90	90	85[b]

a) In urban areas with very high ambient noise levels (L_{dn} > 65 dB), L_{dn} from construction operations should not exceed existing ambient + 10 dB.
b) 24-hour L_{eq} not L_{dn}

Source: Federal Transit Administration. *Transit Noise and Vibration Impact Assessment Manual*. U.S. Department of Transportation Report No. FTA-0123, September 2018.

9.2 Short-Term Vibration Generated from Construction Activities Criteria

An additional source of vibration would be related to the construction of the proposed GCL. The operation of construction equipment causes ground vibrations that spread throughout the surrounding ground. While these vibrations tend to diminish over distance, depending upon the type of construction equipment and duration of the activity, nearby sensitive receptors could be affected. Human annoyance from construction is typically dependent upon the extent, distance and duration of the vibration-generating activities. As with vibration created from train operations, construction-related vibration rarely causes structural damage to normal building structures. However, some building damage can occur when construction-related activities are near older, more fragile historic buildings. See Attachment 7, "Cultural Resources," for a complete inventory and discussion of historic buildings within the vicinity of the proposed GCL. For the proposed GCL, no blasting is expected; however, pile driving could be utilized at various locations along the project corridor where bridges, retaining walls, and other structural elements are located.

10 METHODOLOGY FOR CONSTRUCTION

GCL construction would include clearing the rail right-of-way; constructing grade crossings, bridges, and yard and maintenance facilities; laying track; and constructing stations and other system elements.

Typical construction equipment that generate noise include backhoes, bulldozers, cranes, concrete mixers, concrete delivery trucks, dump trucks, delivery trucks, front-end loaders, pile drivers, and jackhammers. A general discussion of noise and vibration associated with the major construction operations and work at various yards is presented below.

Noise at construction sites is generated by both mobile and stationary sources. Mobile equipment such as dozers, scrapers, and graders may operate in a cyclical fashion in which a period of full power is followed by a period of reduced power. Mobile equipment, such as delivery trucks, also produce intermittent noise and are generally associated with supply and disposal of materials to and from construction sites. Stationary equipment consists primarily of non-mobile equipment that generates noise from one general area, and includes items such as pumps, generators and compressors. These types of equipment typically produce a constant noise level under normal operation and are classified as non-impact equipment. Other types of stationary equipment such as pile drivers, jackhammers, pavement breakers, and blasting operations produce variable, sporadic noise, and impact-type noises.

During the construction of the proposed GCL project, vibration from operation of construction equipment and construction-related activities could occur at buildings near the construction site. The use of heavy construction equipment, including pile drivers and vibratory rollers, would likely result in the greatest vibration at nearby buildings. It is recommended the contractor conduct pre-construction condition surveys at buildings in close proximity to pile driving activities and monitor vibration levels during construction near fragile buildings. Furthermore, examples of vibration mitigation options for construction pile driving include:

- Use a smaller or alternative method for pile driving such as hydraulic push piles.
- Use a vibratory pile driver for all piles because it generates lower vibration levels than an impact driver.
- Pre-trench or auger drill the pile hole except for the last portion for setting the pile firmly.
- Use drilled pile concrete caissons instead of piles and a pile driver.
- Dig a temporary underground trench between the source and the receptor to decouple the vibration pathway.
- Reinforce and strengthen the receptor structure by injection grouting its foundation area.

11 ENVIRONMENTAL CONSEQUENCES OF THE PROPOSED ACTION

11.1 Transit Service Operations

Project-related noise exposure was estimated for each of the 27 representative sites, as described in Section 4.1, “Existing Noise Environment,” that would be exposed to noise generated from the daily service operations along the GCL alignment. Future GCL noise exposure level estimates were determined in accordance with the FTA calculation methodologies and procedures using the “general assessment” guidelines described in Section 4 of the FTA Manual. The FTA noise calculation process considers such factors as distance between the proposed GCL alignment/yard facilities and noise-sensitive areas, type of track, track grade, train length, train travel speed, and service frequencies (headways). In addition, the total noise exposure at a particular receptor included the noise contribution generated from the soundings of train horns, bells, or other onboard warning devices at certain at-grade crossings (areas where the train and street traffic intersect). The analysis assumed that the device or bell would be activated within approximately 15 seconds of a train approaching a station or grade crossing.

During the refinement of the proposed GCL, the project team considered several operating plans for the light rail service, with trains proposed to operate as frequently as every 7.5 minutes during the peak. Ultimately an operating plan was advanced with trains operating every 15 minutes during the peak, similar to the operation of the River LINE today, to minimize the infrastructure needed in the north half of the corridor and to protect space for current and future freight service.

For purposes of this Noise and Vibration Technical Report, the maximum level of service (peak service of 7.5-minute headways) was assumed. Noise exposure estimates were determined based on this maximum level of service, shown in Table 6, "Operating Service Plan," which represents the "worst case scenario" in terms of potential impacts.

Table 6: Operating Service Plan

Time of Day	Headway (Minutes)	No. of Trips/Hour	Total Number of Trips
5 a.m. to 6 a.m.	15	4	4
6 a.m. to 7 a.m.	10*	6	6
7 a.m. to 9 a.m.	7.5*	8	16
9 a.m. to 4 p.m.	15	4	28
4 p.m. to 7 p.m.	7.5*	8	24
7 p.m. to 10 p.m.	15*	4	12
10 p.m. to 1 a.m.	30	2	6
1a.m. to 2 a.m.	60*	1	1
		Total Number of Trips	**97**

Notes:
*Indicates a headway used as a conservative, worst case scenario value for analysis purposes. For the service plan proposed as a part of the proposed GCL, please refer to Attachment 6, "Transit Analysis Report," Section 5, "Service Plan."
** The proposed GCL would not operate between the hours of 2 A.M. and 5 A.M.

Source: GCL Project Team, January 2018

11.2 Noise Exposure from Future Transit Operations

The predicted sound levels from daily transit operations of the proposed GCL are summarized in Table 7, "Comparison of Projected Transit Noise Exposure Levels and FTA Impact Criteria, for Proposed GCL Transit Service Operations (with Wheel Squeal and Horn Soundings)," for each of the representative noise receptor locations identified along the GCL alignment. The predicted sound levels were compared to the existing sound levels at each location to determine if the future operational noise exposure would result in either an FTA-based Moderate Impact or Severe Impact condition. The noise exposure calculations assumed that the proposed GCL would consist of a two-car DLRV train generating a SEL of 85 dBA. While this SEL assumption is not inclusive of horn sounding at grade crossings, the final noise exposure results do include additional noise exposure calculations to account for both horn and wheel squeal noise from the operation of the proposed DLRV.

Moderate to Severe noise exposure at a total of 754 equivalent single-family residential dwellings is projected to occur throughout the GCL corridor from daily service operations or from yard and maintenance activities. The analysis concluded that Severe noise exposure is expected to be experienced adjacent to three representative receptor sites – M8, M13 and M15 – consisting of 177 equivalent single family residential dwellings. In addition, Moderate noise exposure is projected to occur at 11 residential areas, represented by receptor sites M01 (Cooper Hospital and adjacent residences), M02, M03, M04, M06, M09, M10, M11, M14, M16, and M17, comprising 577 equivalent single-family residential dwellings. For locations representative of FTA Category 3 land uses, Moderate daytime peak-hour noise impacts are expected to occur at three community parks: Thompson Street Park (PK02) in Gloucester City, Green Street Playground in Woodbury, and Veterans' Park (PK04) located in Pitman.

Table 7: Comparison of Projected Transit Noise Exposure Levels and FTA Impact Criteria, for Proposed GCL Transit Service Operations (with Wheel Squeal and Horn Soundings)

Site #	Receptor Site Description	FTA Land Use Category	Average Centerline Receptor to Track Distance Feet	Existing Noise Level Ldn (dBA)	FTA Impact Threshold Levels Moderate Ldn (dBA)	FTA Impact Threshold Levels Severe Ldn (dBA)	Horn Soundings Ldn (dBA)	Projected Noise Exposure from GCL Operations Ldn (dBA)	Number of Equivalent Residential Units Impacted	FTA Impact Determination
M01	Cooper Hospital and 501A Haddon Avenue, Camden	2	100	79	66–75	>75	N/A	67[1]	30	**Moderate Impact**
M02	911 South 9th Street, Camden	2	115	71	66–70	>70	N/A	66	51	**Moderate Impact**
M03	56 S. Railroad Ave, Gloucester City	2	65	76	66–74	>74	70	71	34	**Moderate Impact**
M04	5 ½ Railroad Lane, Westville	2	75	65	61–65	>65	N/A	64	75	**Moderate Impact**
M05	800 Gateway Boulevard, Westville	2	140	79	66–75	>75	61	64	0	No Impact
M06	926 Washington Avenue, Woodbury	2	75	77	66–74	>74	64	67	68	**Moderate Impact**
M07	93 Wallace Street, Woodbury	2	155	70	65–69	>69	N/A	61	0	No Impact
M08	348 East-West Jersey Avenue, Woodbury Heights	2	85	58	57–62	>62	N/A	63	65	**Severe Impact**
M09	1 Cedar Street, Wenonah	2	140	62	59–64	>64	N/A	61	64	**Moderate Impact**
M10	870 East Atlantic Avenue, Sewell	2	70	69	64–69	>69	N/A	64	92	**Moderate Impact**
M11	304 Montgomery Avenue, Pitman	2	85	67	63–67	>67	61	65	50	**Moderate Impact**
M12	827 West Jersey Avenue, Pitman	2	110	69	64–69	>69	N/A	62	0	No Impact
M13	43 Zane Street, Glassboro	2	90	69	64–69	>69	68	79[1]	40	**Severe Impact**
M14	11 Church Street, Glassboro	2	490	65	61–66	>66	64	65[1]	45	**Moderate Impact**
M15	Girard House #14, Rowan University, Glassboro	2	45	69	64–69	>69	66	69	83	**Severe Impact**
M16	Stewart Park, Measurement collected at nearby residences at 168 Laurel Street, Woodbury	2	105	65	61–66	>66	N/A	62	26	**Moderate Impact**
M17	816 Essex Street, Gloucester City	2	150	65	61–66	>66	N/A	61	42	**Moderate Impact**
Y01	560 Chestnut St. near East-West Jersey Ave, Woodbury Heights.	2	310	60	58–63	>63	N/A	60	8	**Moderate Impact**
Y02	601 Park Avenue, Woodbury Heights	2	210	54	55–61	>61	N/A	55	17	**Moderate Impact**
Y03	39 Sewell Street near Highland Ave, Glassboro	2	280	63	60–65	>65	60	65[1]	14	**Moderate Impact**
Y04	530 Ellis Street, Glassboro	2	450	65	61–65	>65	59	61[1]	11	**Moderate Impact**
PK01	Gloucester City Public Library, Gloucester	3	54	64[1]	66–70[1]	>70[1]	N/A	63[2]	NA	No Impact
PK02	Thompson St and Lane Ave Park, Gloucester	3	40	59[1]	63–68[1]	>68[1]	N/A	65[2]	NA	**Moderate Impact**
PK03	Green Street Playground, Woodbury	3	56	60[1]	63–68[1]	>68[1]	N/A	65[2]	NA	**Moderate Impact**
PK04	Veterans' Park, Woodbury Heights	3	45	57[1]	62–67[1]	>67[1]	N/A	66[2]	NA	**Moderate Impact**
PK05	Ballard Park, Pitman	3	107	59[1]	63–68[1]	>68[1]	N/A	62[2]	NA	No Impact
PK06	Bowe Park, Glassboro	3	92	67[1]	68–72[1]	>72[1]	N/A	61[2]	NA	No Impact

[1]Calculation includes noise exposure from wheel squeal at receptor sites M1, M13, M14 and Y3 and Y4 where tight curved tracks are proposed.
[2] Peak-hour Leq (1hr) dBA noise levels.

Source: GCL Project Team, January 2018.

Moderate noise impacts at residential properties adjacent to the proposed vehicle maintenance and storage facilities are expected to occur at each of the two proposed yards located in the communities of Woodbury Heights and Glassboro. The representative receptor sites near the proposed yard in Woodbury Heights are depicted in Table 8, "Comparison of Projected Noise Exposure Levels with Mitigation Measures and the FTA Impact Criteria, for Proposed GCL Service Operations (with Horn Soundings)," as Y01 and Y02, and those near the proposed yard in Glassboro are identified as receptor sites Y03 and Y04 in Table 8, "Comparison of Projected Noise Exposure Levels with Mitigation Measures and the FTA Impact Criteria, for Proposed GCL Service Operations (with Horn Soundings)." The analysis findings indicate that approximately 50 equivalent single-family residential dwellings are expected to experience moderate noise exposure levels from maintenance activities. Further refinement of the maintenance facility activities at the two proposed storage yards would occur during a future project phase at which more details related to the location, types, and duration of various maintenance activities would be developed. These changes may alter noise exposure levels reported at the 25 residential properties represented by sites Y01, Y02, Y03 and Y04.

Section 13.1, "Noise Mitigation," discusses proposed measures to mitigate impacts resulting from the proposed GCL service.

11.3 Noise Exposure from "Park-and-Ride" Peak-Hour Traffic

Throughout the GCL project study area, changes in the projected peak travel time traffic volumes near proposed GCL parking facilities would not significantly alter traffic patterns in the study area. Analysis of traffic volume movements on roadways leading to the proposed parking lots would yield maximum noise level variations in the range of plus or minus one decibel at residential properties located within 1,500 feet of the parking facilities. Noise level changes of one decibel or less are below the threshold level of human hearing perceptibility and would be below New Jersey Department of Transportation noise criteria requiring documentation.

Table 8: Comparison of Projected Noise Exposure Levels with Mitigation Measures[1] and the FTA Impact Criteria, for Proposed GCL Service Operations (with Horn Soundings)

Site #	Receptor Site Description	FTA Land Use Category	Average Centerline Receptor to Track Distance	Unmitigated Projected Noise Exposure from GCL Operations	FTA Impact Threshold Levels		Mitigated Projected Noise Exposure from GCL Operations	FTA Impact Determination with Mitigation[2]
					Moderate	Severe		
			Feet	Ldn (dBA)	Ldn (dBA)	Ldn (dBA)	Ldn (dBA)	
M01	Cooper Hospital and 501A Haddon Avenue, Camden	2	100	67	66-75	>75	60	No Impact
M02	911 South 9th Street, Camden	2	115	66	66-70	>70	59	No Impact
M03[1]	56 S. Railroad Avenue, Gloucester City	2	65	71	66-74	>74	71	Moderate Impact
M04	5 ½ Railroad Lane, Westville	2	75	64	61-65	>65	57	No Impact
M05[1]	800 Gateway Boulevard, Westville	2	140	64	66-75	>75	62	No Impact
M06[1]	926 Washington Avenue, Woodbury	2	75	67	66-74	>74	65	No Impact
M07	93 Wallace Street, Woodbury	2	155	61	65-69	>69	54	No Impact
M08	348 East-West Jersey Avenue, Woodbury Heights	2	85	63	57-62	>62	56	No Impact
M09	1 Cedar Street, Wenonah	2	140	61	59-64	>64	54	No Impact
M10	870 East Atlantic Avenue, Sewell	2	70	64	64-69	>69	57	No Impact
M11[1]	304 Montgomery Avenue, Pitman	2	85	65	63-67	>67	63	Moderate Impact
M12	827 West Jersey Avenue, Pitman	2	110	62	64-69	>69	55	No Impact
M13[1]	43 Zane Street, Glassboro	2	90	79	64-69	>69	68	Moderate Impact
M14[1]	11 Church Street, Glassboro	2	490	65	61-66	>66	64	Moderate Impact
M15[1]	Girard House #14, Rowan University, Glassboro	2	45	69	64-69	>69	67	Moderate Impact
M16	Stewart Park, Measurement collected at nearby residences at 168 Laurel Street, Woodbury	2	105	62	61-66	>66	55	No Impact
M17	816 Essex Street, Gloucester City	2	150	61	61-66	>66	54	No Impact
Y01	560 Chestnut Street near East-West Jersey Ave	2	310	60	55-61	>61	51	No Impact
Y02	601 Park Avenue	2	210	55	53-59	>59	47	No Impact
Y03[1]	39 Sewell Street near Highland Ave	2	280	65	57-62	>62	56	No Impact
Y04[1]	530 Ellis Street	2	450	61	59-64	>64	52	No Impact
PK01	Gloucester City Public Library, Gloucester	3	54	64[3]	66-70[3]	>70[3]	56[3]	No Impact
PK02	Thompson St and Lane Ave Park, Gloucester	3	40	59[3]	63-68[3]	>68[3]	58[3]	No Impact
PK03	Green Street Playground, Woodbury	3	56	60[3]	63-68[3]	>68[3]	58[3]	No Impact
PK04	Veterans' Park, Woodbury Heights	3	45	57[3]	62-67[3]	>67[3]	59[3]	No Impact
PK05	Ballard Park, Pitman	3	107	59[2]	63-68[3]	>68[3]	55[3]	No Impact
PK06	Bowe Park, Glassboro	3	92	67[2]	68-72[3]	>72[3]	54[3]	No Impact

[1] Receptors affected by horn noise soundings,

[2] Noise Mitigation considered, which would address operational noise (not horn noise), consists of undercar sound absorption and shielding, rail car vehicle skirts and wheel-rail lubrication in areas where tight curved tracks are proposed (M1, M13, M14, Y03 and Y04).

[3] Peak-hour Leq (1hr) dBA noise levels.

Source: GCL Project Team, January 2018

12 POTENTIAL CONSTRUCTION IMPACTS

12.1 Noise

Instantaneous noise levels during construction are difficult to predict, and they vary depending upon the type and duration of construction activity and the number and types of equipment used during each stage of work. However, the average noise levels produced by different phases of construction are well documented. More importantly, the location of sensitive receptors in relation to the construction activity, and the duration of construction activities, affect the potential for noise impact. Track-related construction would move continuously along the corridor; therefore, the duration of exposure to track-construction-related noise at any one property would be limited.

Some specialized construction work does have a greater potential to create noise impacts. This includes the following types of work:

- Pile driving.
- Heavy equipment use for the construction of retaining walls, bridges, and elevated structure segments.
- Noise associated with other fixed location activities, such as construction laydown areas.

However, noise from these activities would only impact noise-sensitive receptors located near these specific types of work and would not affect the entire length of the GCL project alignment.

12.2 Vibration

Though the overall length of construction for the GCL project is expected to be approximately 36 months, it is anticipated that disturbances at most individual vibration sensitive receptor locations would likely last for a substantially shorter period of time. Track-related construction would shift continuously along the corridor; therefore, the duration of potential exposure to construction-related vibration at any one property would be limited. In addition, the potential for vibration impacts is even lower for construction activities that use equipment, such as air compressors, rubber-wheeled vehicles, hydraulic loaders, and other light equipment. For these locations, heavy construction, if required, would occur for relatively short periods of time and is not anticipated to result in prolonged annoyance to nearby sensitive receptors.

13 MITIGATION

13.1 Noise Mitigation

Project-related noise impacts require mitigation to provide an adequate level of relief for residents, employees, and visitors within the proposed GCL corridor. Based on the initial noise impact findings of Moderate and Severe noise impacts, FTA requires that noise reduction measures be identified to either eliminate or significantly reduce noise generated from a proposed GCL. Mitigation of noise impacts from transit operations involves treatment at the three principle components of the noise generation problem:

at the noise source; along the source to receiver propagation path; or at the receptor (noise-sensitive area). For the proposed GCL, mitigation measures at the noise source (i.e., the trains) provide the best system-wide solution for abating noise from daily transit operations; this is because these measures would avoid the ROW area, would be effective throughout the corridor, and would not cause disruption to the daily activities of people working and living adjacent to the proposed GCL Alignment. Mitigation measures for the proposed project require all the following recommended actions:

1. Specifying that the trains chosen to run on the GCL corridor be designed to support wheel skirts on the outside body of the train. The Stadler GTW transit vehicles currently operating on NJ TRANSIT's River LINE employ wheel skirts. FTA guidelines indicate that wheel skirts can provide noise reduction up to a range of six to 10 decibels. More recent studies[3] suggest that up to three or four decibels of noise reduction is more achievable. The present analysis took a conservative approach and assumed that a 4-decibel noise reduction could be achieved using vehicle skirts that contain a sound absorptive material coating on the interior surface.
2. Specifying undercar design modifications that provide shielding and acoustical absorption treatment to the train vehicles' undercar components to reduce propulsion noise. The present analysis conservatively assumes that a 3-decibel noise reduction could be achieved using undercar shielding and acoustical absorption treatment.
3. In areas of sharp turns, specifying onboard automated wheel-rail friction modification systems that would eliminate or significantly reduce wheel-squeal noise to a level where it would no longer cause an annoyance. Wheel-squeal generation is a dominate noise source from service operations in the Glassboro area, particularly on track segments leading to the Glassboro VMF adjacent to receptor sites M13 and M14. Wheel-squeal generation is caused by friction when the trains negotiate sharp turns on tracks with a "tight-radius curve" (for DMUs and DLRVs, typically a radius of curvature of less than 1,000 feet).
4. Maintaining the present design of the GCL track system to FTA Class 4 standards. Maintenance of the track would be required to maintain the Class 4 standard, and it would apply to both the future GCL service as well as freight movements along the Camden-Glassboro corridor.

A summary of future project noise exposure levels with the mitigation measures described above is provided in Table 8, "Comparison of Projected Noise Exposure Levels with Mitigation Measures and the FTA Impact Criteria, for Proposed GCL Service Operations (with Horn Soundings)." The findings indicate that noise exposure in the FTA severe range projected at receptor sites M8, M13, and M14 would be eliminated. However, moderate noise exposure would remain at receptor sites M03, M11, M13, M14, and M15, represented by 252 equivalent single-family residential dwellings. Approximately 69 percent (563 dwellings) of all impacts would be eliminated by the proposed mitigation measures. The 31 percent remaining moderate noise impacts are all caused by noise generated from horn soundings. The recommended abatement measures do not include the implementation of "quiet zones" at public roadway/railroad crossings, which would likely eliminate all the moderate noise impacts reported at these

[3] Honolulu High-Capacity Transit Corridor Project. Final Environmental Impact Statement, Addendum 01 to the Noise and Vibration Technical Report, prepared by Parsons Brinckerhoff (June 1, 2010)

remaining properties. Locations where wheel-rail lubrication is necessary to eliminate wheel-squeal noise generated by tight curved tracks include M1, M13, M14, Y03, and Y04.

If local governments file for quiet zone approval at public roadway/rail crossings, further refinement to the noise exposure from daily transit operations would be evaluated in future project phases. The operation of quiet zones at public roadway/rail crossings would likely result in the elimination of all the remaining moderate noise exposure impacts reported in Table 8, "Comparison of Projected Noise Exposure Levels with Mitigation Measures and the FTA Impact Criteria, for Proposed GCL Service Operations (with Horn Soundings)."

13.1.1 Analysis of Potential Transit Operations-Related Ground-Borne Vibration

Project-related vibration levels were estimated for each of the 27 representative sites previously described in Section 4, "Affected Environment." Vibration level estimates were completed in accordance with the FTA calculation methodologies and procedures using the "General Vibration Assessment" guidelines described in Section 6 of the *Transit Noise and Vibration Impact Assessment Manual* (September 2018). The FTA vibration calculation process considers distance to the transit alignment, type of track, train speed, and ground-borne propagation effects (such as coupling to building foundations and amplification due to resonance of floors, walls and ceilings). Estimated vibration levels in the future with the proposed GCL service plan operations are summarized in Table 9, "Comparison of Projected Transit Vibration Levels and FTA Impact Criteria, for Proposed GCL Transit Service Operations." Vibration levels throughout the GCL corridor, including those near the proposed vehicle storage and maintenance facilities (receptor sites Y01 through Y04), were found to remain below the FTA 72 VdB impact threshold shown in Table 4, "Ground-Borne Vibration and Ground-Borne Noise Impact Criteria for General Assessment," for the FTA Category 2 land use category in a "frequent event" transit corridor (i.e., a corridor having 70 or more transit pass-by events per day).

Maximum vibration levels in the 70 to 71 VdB range were found to occur at receptor sites M03, M06, M10, and M15. Because vibration levels at these four receptor sites are just slightly below the 72 VdB impact criteria, there remains the possibility that trains operating at greater travel speeds (e.g., greater than 42 MPH, which was assumed for this analysis) could potentially result in a vibration impact in these areas.

Table 9: Comparison of Projected Transit Vibration Levels and FTA Impact Criteria, for Proposed GCL Transit Service Operations

Site #	Receptor Site Description	FTA Land Use Category	Average Centerline Receptor to Track Distance Feet	Train Travel Speed in Receptor Area (mph)	FTA Impact Threshold (VdB)	Estimated Vibration Levels (VdB re: 1μ-inch)	FTA Vibration Impact (Yes/No)
M01	Cooper Hospital and 501A Haddon Avenue, Camden	2	100	17	72	44	No
M02	911 South 9th Street, Camden	2	115	34	72	55	No
M03	56 S. Railroad Avenue, Gloucester City	2	65	42	72	71	No
M04	5 ½ Railroad Lane, Westville	2	75	42	72	69	No
M05	800 Gateway Boulevard, Westville	2	140	43	72	62	No
M06	926 Washington Avenue, Woodbury	2	75	43	72	70	No
M07	93 Wallace Street, Woodbury	2	155	38	72	62	No
M08	348 East-West Jersey Avenue, Woodbury Heights	2	85	38	72	67	No
M09	1 Cedar Street, Wenonah	2	140	35	72	62	No
M10	870 East Atlantic Avenue, Sewell	2	70	38	72	70	No
M11	304 Montgomery Avenue, Pitman	2	85	37	72	67	No
M12	827 West Jersey Avenue, Pitman	2	110	37	72	65	No
M13	43 Zane Street, Glassboro	2	90	30	72	65	No
M14	11 Church Street, Glassboro	2	490	30	72	52	No
M15	Girard House #14, Rowan University, Glassboro	2	45	30	72	70	No
M16	Stewart Park, Measurement collected at nearby 168 Laurel Street, Woodbury	2	105	29	72	64	No
M17	816 Essex Street, Gloucester City	2	150	29	72	63	No
Y01	560 Chestnut Street	2	155	10	72	62	No
Y02	601 Park Avenue	2	590	10	72	54	No
Y03	39 Sewell Street	2	1,000	10	72	52	No
Y04	530 Ellis Street	2	1,725	10	72	52	No
PK01	Gloucester City Library, Gloucester City	3	54	41	75	71	No
PK02	Thompson St and Lane Ave Park, Gloucester City	3	40	42	75	73	No
PK03	Green Street Playground, Woodbury	3	56	43	75	71	No
PK04	Veterans' Park, Woodbury Heights	3	45	40	75	72	No
PK05	Ballard Park, Pitman	3	107	39	75	65	No
PK06	Bowe Park, Glassboro, Glassboro	3	92	39	75	66	No

Source: GCL Project Team, January 2018

Of the FTA Category 3 sites near the proposed alignment, the Gloucester City Public Library, represented by receptor PK01 on Figure 1, "Locations of Representative Measurement Sites," may be the most vibration-sensitive location. Vibration levels at the library are expected to reach 71 VdB; this is sufficiently below the 75 VdB impact criteria and, therefore, is not of concern under the presently planned operating conditions.

13.2 Vibration Mitigation Measures

Estimated vibration levels from GCL operations were projected to be below the FTA 72 VdB impact threshold at all locations throughout the corridor; therefore, no vibration mitigation measures are necessary for operations. However, vibration levels were projected to approach the 72 VdB impact threshold level at sites M03 (56 South Railroad Avenue, Gloucester City); M06 (926 Washington Avenue, Woodbury); M10 (870 East Atlantic Avenue, Sewell); and M15 (Girard House #14, Rowan University, Glassboro). As the proposed GCL advances, vibration impacts at these sites could warrant additional evaluation and require a "Detailed Vibration Impact Analysis," consistent with the requirements identified in the FTA Manual, to determine if a vibration impact would occur. If an impact remains likely, then vibration mitigation would be considered. For example, the installation of ballast mats below the track ballast layer could provide anywhere from five VdB to 10 VdB vibration reduction at certain frequencies. This type of mitigation would likely provide that vibration generated from trains traveling at higher travel speeds would not exceed the FTA impact criteria.

13.3 Construction Impact Avoidance and Minimization

13.3.1 Noise

As part of the proposed GCL specification documents, performance standards would be established for construction equipment to reduce noise associated with the construction activities. The GCL project would comply with local noise ordinances, in accordance with its own performance standards, which would include, but not necessarily be limited to, the following:

- Conduct construction activities during the daytime whenever possible;
- Conduct truck loading, unloading, and hauling operations in a manner that minimizes noise;
- Route construction equipment and other vehicles carrying soil, concrete, or other materials over routes that would cause the least disturbance to residents;
- Locate stationary equipment away from residential areas to the extent reasonably feasible within the site/staging area;
- Employ the best available control technologies to limit excessive noise when working near residences;
- Adequately notify the public in advance of construction operations and schedules, such as via construction-alert publications; and
- Set up a Noise Complaint Hotline to handle complaints quickly.

13.3.2 Vibration

As part of the proposed GCL specification documents, performance standards would also be established for construction equipment to reduce vibration associated with the construction activities. Control measures would be implemented to reduce or eliminate, to the extent feasible, the potential for vibration-related impacts to humans and damage to buildings. It is expected that a vibration mitigation plan would be prepared when more details regarding construction operations are known, and it may include the following measures:

- Periods of pile driving should be limited to acceptable hours, as defined in the New Jersey State Code. When practical, schedule pile driving activities during hours that would least impact residents at sensitive receptors. For example, pile driving near a residential area can be scheduled to occur primarily during business hours on weekdays, when most people would be at work;
- Construction staging and supply areas should be selected in a manner to limit, to the greatest extent practicable, the number of impact locations along the proposed alignment, and to minimize intrusion of normal daily activities to adjacent residential communities and businesses;
- To the extent possible, earth-moving equipment should be operated far from vibration-sensitive receptors;
- Where possible, the use of vibratory rollers should be limited near vibration-sensitive receptors;
- Heavy trucks and construction equipment movements should avoid sensitive receptors when possible, and attempts would be made to use roadways with fewer residents and sensitive structures;
- Where practicable, use smaller-sized bulldozers or backhoes.

14 REFERENCES

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