4 Affected Environment, Environmental Consequences, and Mitigation

4.14 Noise and Vibration

4.14.1 Introduction

This section presents the potential operational traffic noise and construction-related noise and vibration effects of the No Build Alternative and Build Alternative, including measures that will be implemented to mitigate adverse effects on surrounding sensitive receptors.

4.14.1.1 Resource Definition

- Noise is generally defined as sound that is undesirable because it interferes with speech, causes sleep disturbance, or is otherwise annoying (unwanted sound). The individual human response to noise is subject to considerable variability because there are many emotional and physical factors that contribute to the differences in reaction to noise.
- Vibration is an oscillatory motion, which can be described in terms of displacement, velocity, or acceleration. Displacement refers to the distance an object has moved from its equilibrium position during vibration. Velocity represents the speed at which the object is moving during vibration. Acceleration describes the rate at which the velocity of a vibrating object changes over time. Construction activity can generate varying degrees of ground-borne vibration, depending on the equipment and methods employed, distance between source and receptor, duration, and subsurface conditions.
- Sensitive receptors are defined as land uses that are considered sensitive to noise and vibration impacts. Examples of noise-sensitive receptors include residences, schools, hospitals, libraries, places of worship, hotels, television and recording studios, and passive recreation areas. Vibration-sensitive receptors are generally the same as noise-sensitive receivers but may also include buildings in poor structural condition, and businesses, such as research facilities and laboratories that use vibration-sensitive equipment.

4.14.1.2 Regulatory Context

The Cape Cod Bridges Program is classified as a Type I project[1] in accordance with the following:

- Federal Highway Administration's (FHWA) Noise Regulations (23 Code of Federal Regulations [CFR] 772) — Procedures for Abatement of Highway Traffic Noise and Construction Noise[2]
- Massachusetts Department of Transportation's (MassDOT) Noise Abatement Policies (effective July 13, 2011)[3]

FHWA Noise Regulation 23 CFR 772 and MassDOT's Noise Abatement Policies require that traffic noise levels associated with Type I projects are calculated, the results are compared to the noise abatement criteria, and, if noise impacts are identified, noise mitigation measures are evaluated to reduce noise impacts in a study area. Type 1 projects also require analysis of construction noise and abatement measures and prediction of noise impacts on undeveloped lands to inform local officials on land use compatible planning.

No FHWA regulations are specific to construction-related vibration. MassDOT derived the guidance for the assessment of construction-related vibration effects from the Federal Transit Administration (FTA) Transit Noise and Vibration Impact Assessment Manual.[4]

4.14.1.3 Methodology and Study Area

Operational Traffic Noise

The operational traffic noise analysis involved monitoring existing noise conditions to validate the project-specific noise model and modeling existing 2019 and future 2050 No Build Alternative and Build Alternative noise conditions with the FHWA-approved computerized Traffic Noise Model, version 2.5 (TNM). MassDOT conducted the noise analysis using traffic data that was representative of the Loudest Traffic Hour (LTH), which was identified as the AM traffic peak hour for all Noise Study Areas except the Sagamore North quadrant where the LTH was identified as the PM peak traffic hour. MassDOT used existing 2019 Fall AM and PM peak-hour traffic data to evaluate existing noise levels within the Noise Study Areas. MassDOT used future 2050 Fall AM and PM peak-hour traffic data to

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[1] A Type I project is a project that involves (1) The construction of a highway on new location; (2) The physical alteration of an existing highway where there is either a substantial horizontal alteration or a substantial vertical alteration; (3) The addition of a through traffic lane(s); (4) The addition of an auxiliary lane, except for when the auxiliary lane is a turn lane; (5) The addition or relocation of interchange lanes or ramps added to a quadrant to complete an existing partial interchange; (6) Restriping existing pavement for the purpose of adding a through traffic lane or an auxiliary lane; or, (7) The addition of a new or substantial alteration of a weigh station, rest stop, ride-share lot or toll plaza.

[2] Federal Highway Administration. 2011. Procedures for Abatement of Highway Traffic Noise and Construction Noise. July. https://www.ecfr.gov/current/title-23/chapter-I/subchapter-H/part-772

[3] Massachusetts Department of Transportation. 2011. Type I and Type II Noise Abatement Policies and Procedures. July. https://studylib.net/doc/13043513/massachusetts-department-of-transportation-type-i-and-typ...

[4] Federal Transit Administration. 2018. Transit Noise and Vibration Impact Assessment Manual. September. https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/research-innovation/118131/transit-noise-and-vibration-impact-assessment-manual-fta-report-no-0123_0.pdf

evaluate No Build Alternative and Build Alternative noise levels. Traffic noise impacts were assessed for different categories of noise-sensitive land use using the FHWA Noise Abatement Criteria (NAC), as presented in **Table 4.14-1**. The following sections provide an overview of the Noise Study Areas and methodologies used to support this analysis.

Table 4.14-1. Federal Highway Administration Noise Abatement Criteria

Activity Category	Leq(h)[a]	Description of Activity Category
A	57 (Exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose
B[b]	67 (Exterior)	Residential
C[b]	67 (Exterior)	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings
D	52 (Interior)	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios
E[b]	72 (Exterior)	Hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in A-D or F
F[c]	—	Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing
G[c]	—	Undeveloped lands that are not permitted (without building permits)

Source: FHWA, "Procedures for Abatement of Highway Traffic Noise and Construction Noise" (23 Code of Federal Regulations 772, as amended 75 FR 39820, July 13, 2010; Effective date July 13, 2011). https://www.ecfr.gov/current/title-23/chapter-I/subchapter-H/part-772

[a] Hourly Equivalent A-weighted Sound Level (dBA)

[b] Includes undeveloped lands permitted for this category

[c] "—" indicates no Noise Abatement Criteria value established by the Federal Highway Administration and Massachusetts Department of Transportation

Definition of Noise Study Areas

In general, the Noise Study Areas correspond to the same Study Area described in **Section 4.2, Transportation, Traffic, and Safety**, which consisted of a 2-mile area centered around the Sagamore and Bourne Bridges. Specifically, the Noise Study Areas extend approximately 500 feet beyond the operational limits of the Build Alternative at the Sagamore and Bourne Bridges.

Definition of Criteria for Traffic Noise Impact

FHWA established the NAC for different categories of land use to assess the degree of traffic noise impact on human activity, which are provided in **Table 4.14-1**. The NAC is given in terms of the hourly, A-weighted, equivalent sound level in decibels (dBA). Because most environmental noise (and the A-weighted sound level) fluctuates from moment to moment, it is common practice to characterize the fluctuating level by a single number called the equivalent sound level (Leq).[5]

Traffic noise impact occurs when the predicted future Design Year predicted noise levels approach (within 1 dBA) or exceed the FHWA NAC levels presented in **Table 4.14-1**, or when future Design Year predicted noise levels substantially exceed the existing noise levels. MassDOT defines "substantially exceed" as a 10 dB increase in Design Year noise levels, relative to existing noise levels.

Identification of Noise-Sensitive Land Uses

Identified receptors within the Noise Study Areas were grouped into Common Noise Environments (CNE), which are groups of receptors usually within the same Activity Category that are exposed to similar noise sources and levels. Factors considered in the identification of CNEs included traffic volumes, topographic features, and secondary noise sources such as interchanges, cross-roads, and intersections. **Figure 4.14-1 through Figure 4.14-4** illustrate the boundaries of the identified CNEs within the Noise Study Areas. **Appendix 4.14, Noise and Vibration Technical Report**, provides detailed descriptions of each CNE, including noise-sensitive land use within those boundaries.

Determination of Existing Noise Levels

Noise Measurement Program

MassDOT conducted a noise measurement program to document existing ambient noise levels at noise-sensitive locations in the Study Areas, which consisted of primarily residential land uses. Noise measurements were conducted at 18 sites on May 16, May 17, and May 18, 2023. In general, the short-term measurements characterized existing noise levels in the Noise Study Area but were not necessarily conducted during the loudest hour of the day. **Figure 4.14-1 through Figure 4.14-4** illustrate the noise measurement locations within the Study Areas. **Appendix 4.14, Noise and Vibration Technical Report,** provides additional details related to the noise measurement program.

Noise Model Validation and Prediction of Existing Noise Levels

According to FHWA and MassDOT policies, the accuracy of the noise prediction model must be verified on a project-by-project basis. Therefore, noise model validation was conducted to compare field-measured noise levels to predicted noise levels using the FHWA TNM with field-documented traffic volumes, speeds and vehicle types as well as existing horizontal and vertical roadway geometries. At all 18 sites, the differences between measured and predicted noise levels were within the +/-3 dB(A) tolerance allowed by FHWA. Therefore, the existing noise model is considered validated, and existing

[5] The Leq is the value or level of a steady, non-fluctuating sound that represents the same sound energy as the actual time-varying sound evaluated over the same period. For traffic noise assessment, Leq is typically evaluated over a 1-hour period and may be denoted as Leq(h).

condition year 2019 LTH volumes and vehicle types were used to predict existing noise levels at additional receptors in the Noise Study Area.

Prediction of Future Design Year Traffic Noise Levels

Future 2050 traffic noise levels for the No Build Alternative and Build Alternative were predicted using the FHWA TNM 2.5 with Design Year 2050 LTH traffic volumes, vehicle types, and posted speeds included within **Appendix 4.2, Traffic Engineering Technical Report**. Existing roadway geometry was used for the No Build Alternative models, while proposed roadway design data (including horizontal and vertical geometries) were used as input components for the 2050 Build Alternative models.

Undeveloped lands with issued building permits for future development were identified through coordination with the Town of Bourne and included in the 2050 No Build Alternative noise models. One permitted development was identified within the Sagamore North quadrant (Cape View Way), and one permitted development was identified within the Bourne North quadrant (340 Main Street).

Identification of Traffic Noise Impacts

Highway traffic noise impacts were identified where predicted 2050 Build Alternative highway traffic noise levels at any receptor location approach (within 1 dBA) or exceed the FHWA NAC presented in **Table 4.14-1**. Noise impact would also occur wherever predicted noise levels substantially exceed existing noise levels by 10 dBA or more.

Evaluation of Noise Abatement Measures and MassDOT Criteria for Recommending Noise Barriers

When traffic noise impacts are identified, noise abatement must be considered and evaluated for feasibility and reasonableness. Noise abatement is any measure used to reduce highway traffic noise levels. In general, FHWA-approved abatement measures include traffic management, the alteration of horizontal and vertical alignment, property acquisition for buffer zones, noise insulation (for Category D impacts only), and noise barriers.

For this traffic noise study, MassDOT evaluated noise barriers for feasibility and reasonableness in the areas of predicted highway traffic noise impacts. The feasibility of an abatement measure usually relates to a combination of acoustic and engineering factors. Acoustic factors include the amount of noise reduction achieved by the barrier, while engineering factors consider safety, impacts on drainage and utilities, maintenance of the abatement measure, and access to adjacent properties. Reasonableness considers the combination of social, economic, and environmental factors in the evaluation of a noise abatement measure and implies that good judgment and common sense were used in making a decision about barrier construction. Three primary reasonableness factors that must be achieved in determining if noise abatement is reasonable include cost effectiveness, achieving a noise reduction design goal, and gaining the support of property owners and residents for the abatement measures.[6]

[6] FHWA, "Procedures for Abatement of Highway Traffic Noise and Construction Noise" (23 Code of Federal Regulations 772, as amended 75 FR 39820, July 13, 2010; Effective date July 13, 2011). https://www.ecfr.gov/current/title-23/chapter-I/subchapter-H/part-772

According to MassDOT Noise Policy, noise barrier cost is determined by multiplying the square footage of the proposed noise barrier (as modeled by the FHWA TNM) by a unit cost per square foot. Pursuant to 23 CFR 772.13(d)(2)(ii), state highway agencies will reevaluate noise abatement costs on a regular interval, not to exceed five years. In 2021, MassDOT submitted an updated unit cost to FHWA of $60 per square foot. MassDOT considers a noise barrier to be cost effective if the cost is less than or equal to the Cost Effectiveness Index, which was increased to $10,080 per decibel of noise reduction per residential dwelling unit benefited in 2021 when MassDOT submitted a revised unit cost to FHWA.[7]

Construction Noise

MassDOT conducted a construction noise analysis to generally disclose potential impacted receptors, describe potential ranges in construction noise levels, and identify measures to be included in project plans and specifications. Data on construction equipment noise levels for the analysis is derived from the FHWA's Roadway Construction Noise Model (version 1.1) database.[8]

Construction Vibration

MassDOT derived guidance for the assessment of construction-related vibration effects from the FTA's guidance manual. A quantitative construction vibration assessment was conducted to identify distances within which there would be a potential for vibration-induced structural damage and annoyance from heavy construction activities.

4.14.2 Affected Environment

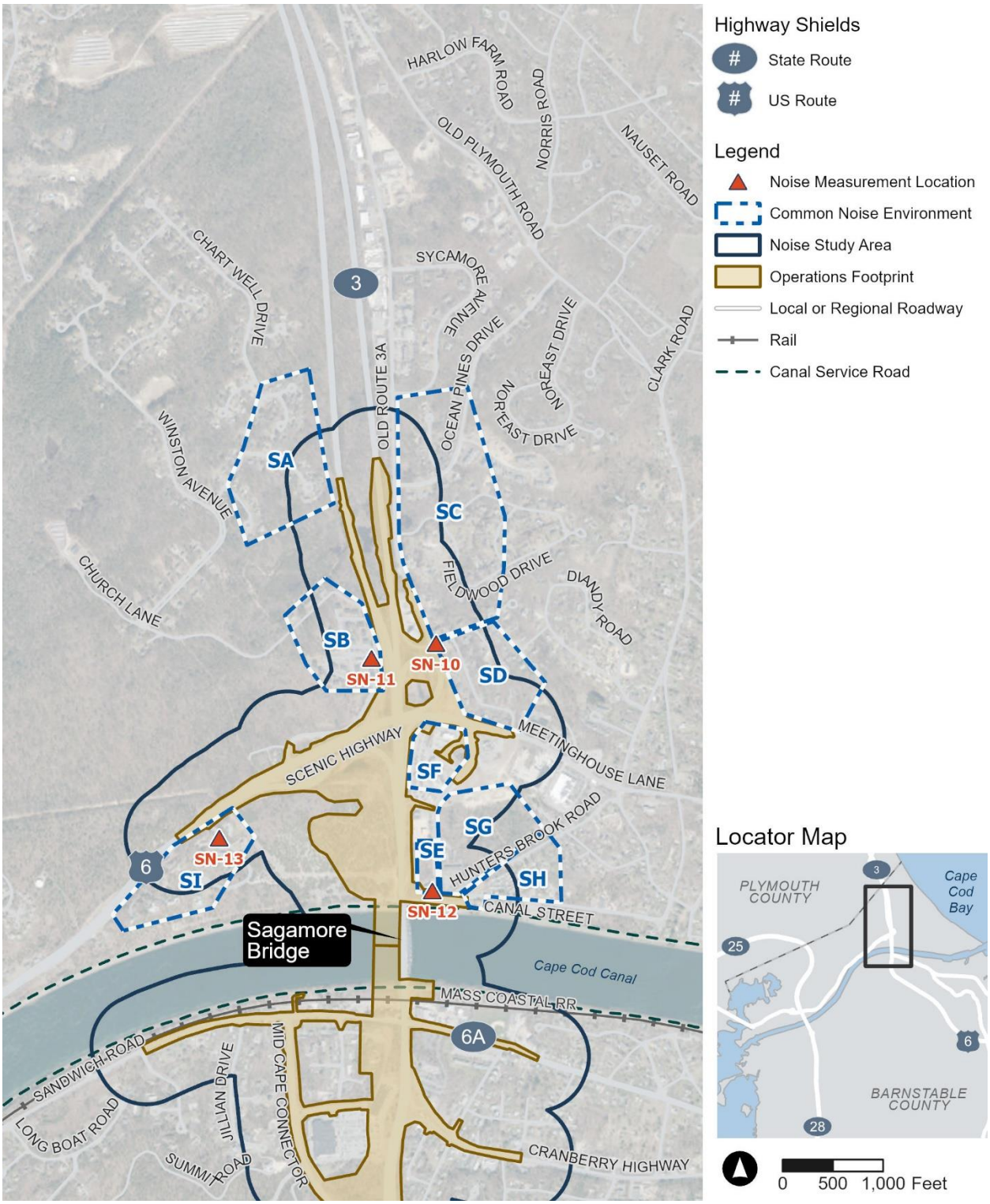
Based on noise measurements conducted in May 2023, the dominant source of noise in the Study Areas was vehicular traffic from automobiles and trucks on State Route 3, U.S. Route 6, State Route 25, and other major arterials. Noise-sensitive land uses within the Study Areas include primarily single- and multi-family residential developments (Activity Category B). Other noise-sensitive land uses that were identified within the Study Areas include parks and recreation areas (Activity Category C), schools with exterior use areas (Activity Category C), as well as restaurants and hotels with exterior use areas (Activity Category E). Noise-sensitive receptor sites within the Noise Study Areas were grouped into 33 CNEs (**Figure 4.14-1 through Figure 4.14-4)**.

Table 4.14-2 and **Table 4.14-3** summarize 2019 existing condition noise levels and the number of receptors predicted to approach or exceed the Activity Categories B and C NAC of 67 dBA Leq and the Activity E Category NAC of 72 dBA Leq within the Sagamore North quadrant and Sagamore South quadrant. **Table 4.14-4** and **Table 4.14-5** summarize the 2019 existing condition noise levels and number of receptors predicted to approach or exceed the Activity Categories B and C NAC of 67 dBA Leq and the Activity E Category NAC of 72 dBA Leq within the Bourne North quadrant and Bourne South quadrant.

[7] MassDOT defines a benefited receptor as one that achieves a noise level reduction of at least 5 dBA with a noise abatement measure. A benefited receptor does not have to be one that is impacted.

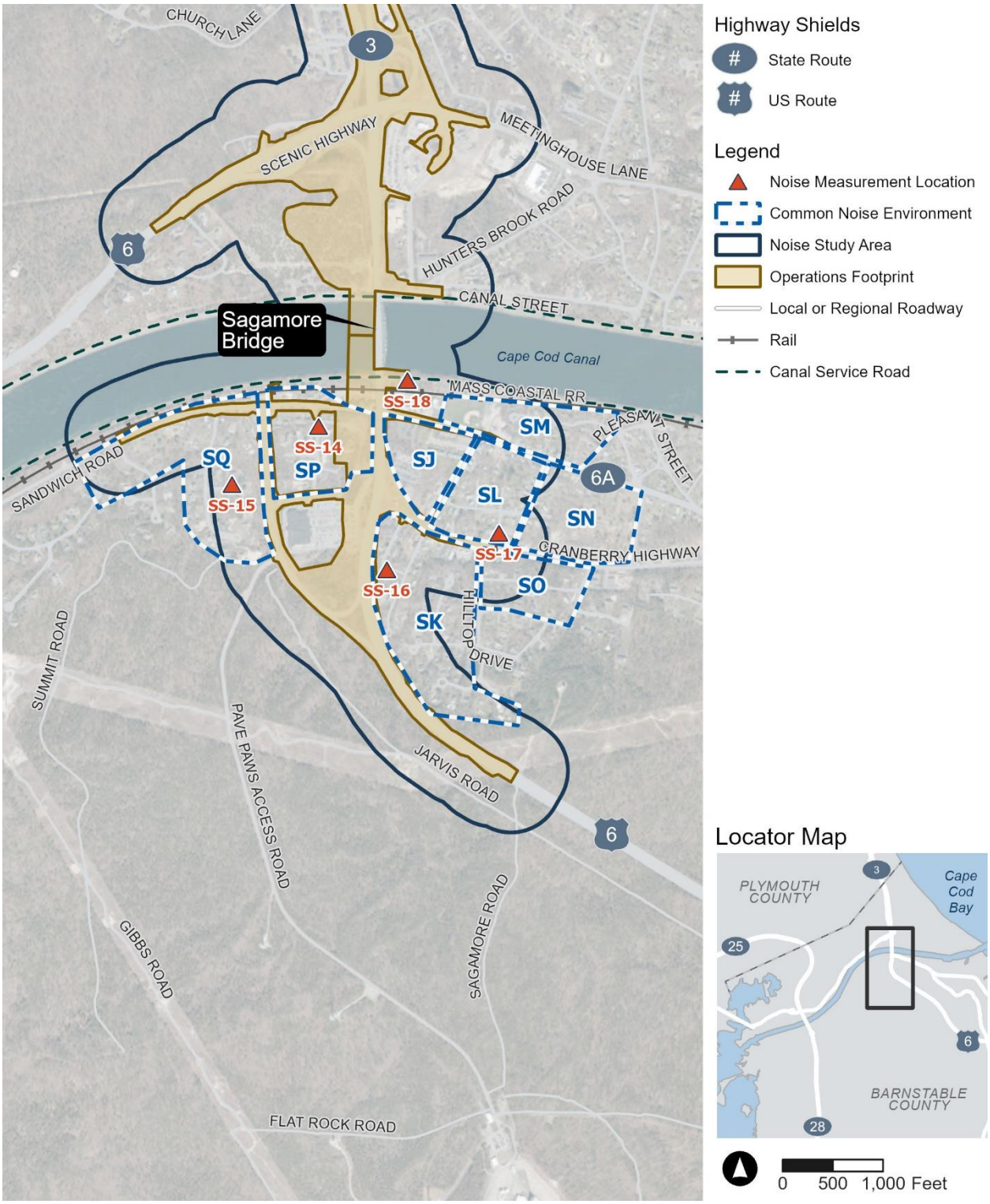
[8] https://www.fhwa.dot.gov/environment/noise/construction_noise/rcnm/

Figure 4.14-1 Common Noise Environment Boundaries and Noise Measurement Locations (Sagamore North Quadrant)



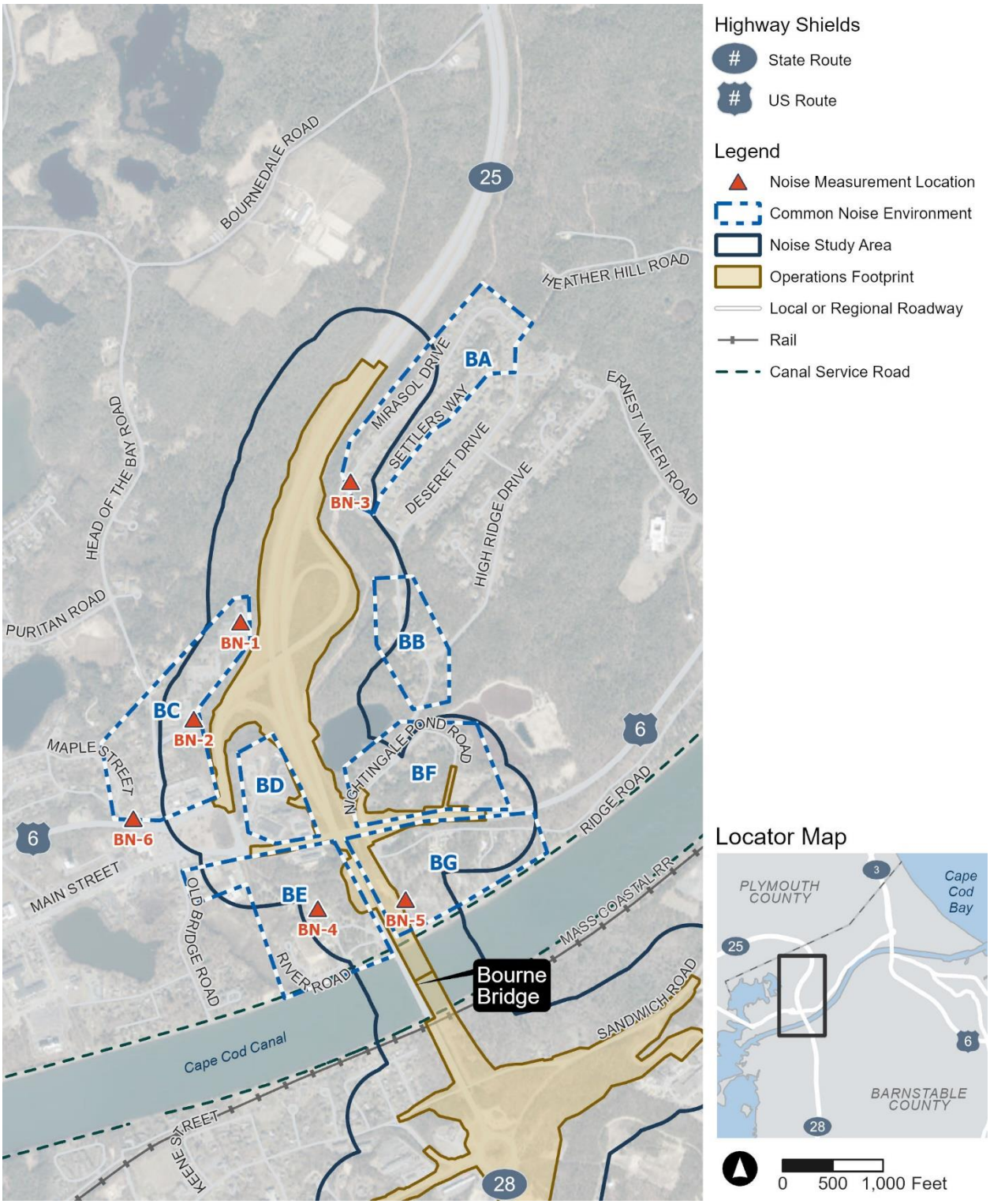
Source: Massachusetts Department of Transportation, 2024

Figure 4.14-2. Common Noise Environment Boundaries and Noise Measurement Locations (Sagamore South Quadrant)



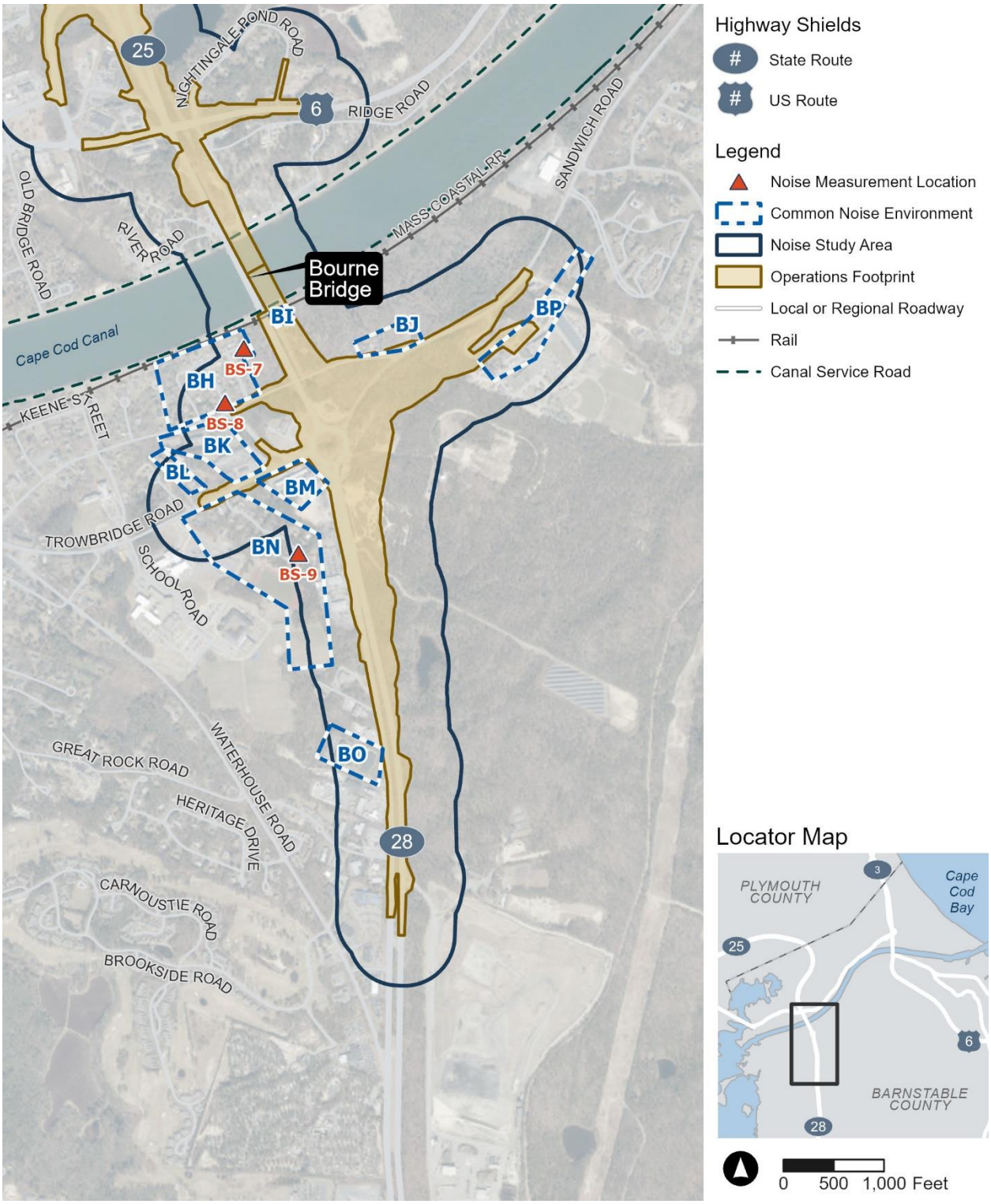
Source: Massachusetts Department of Transportation, 2024

Figure 4.14-3. Common Noise Environment Boundaries and Noise Measurement Locations (Bourne North Quadrant)



Source: Massachusetts Department of Transportation, 2024

Figure 4.14-4. Common Noise Environment Boundaries and Noise Measurement Locations (Bourne South Quadrant)



Source: Massachusetts Department of Transportation, 2024

In the Sagamore North quadrant for the 2019 existing conditions (**Table 4.14-2**), four single-family residential dwelling units within CNEs SC and SD approach or exceed the FHWA Category B NAC. No Activity Categories C, D, or E land uses approach or exceed the respective NAC thresholds for the 2019 existing condition in the Sagamore North quadrant.

Table 4.14-2. 2019 Existing: Loudest Traffic Hour Noise Levels (Sagamore North Quadrant)

Common Noise Environment	Adjacent Roadways	2019 Existing Condition Noise Level Ranges Leq	FHWA Activity Category	2019 Existing Condition Approach or Exceed Noise Abatement Criteria
SA	State Route 3 Southbound	44–60	B	0
SB	State Route 3 Southbound	51–65	B	0
SC	State Route 3 Northbound	49–67	B	3
SD	State Route 3 Northbound	46–68	B	1
SE	U.S. Route 6 Northbound	60–61	B	0
SF	U.S. Route 6 Northbound	61–63	C	0
			E	0
SG	U.S. Route 6 Northbound	55–60	B	0
	Canal Street			
SH	U.S. Route 6 Northbound	49–60	B	0
	Canal Street		C	0
SI	Scenic Highway	52–65	B	0

Source: Massachusetts Department of Transportation, 2024

Note: Refer to **Figure 4.14-1** for Common Noise Environment locations.

In the Sagamore South quadrant for the 2019 existing conditions (**Table 4.14-3**), 36 residential dwelling units approach or exceed the FHWA Category B NAC. Existing noise levels also approach or exceed the FHWA Activity Category C NAC at Keith Field on the field behind home plate in the catcher's position. To determine the number of equivalent receptors predicted to experience noise levels that approach or exceed the FHWA Category C NAC at Keith Field, a schedule of events on the Bourne Recreation website was reviewed.[9] The calendar for booking usage of Keith Field shows that, on average, there is either one game or practice at the field per day. Behind home plate, a maximum of three people per day (i.e., the batter, catcher, and potentially one umpire if the field is being used for a game) for a total of approximately three hours would experience noise levels that approach or exceed the FHWA

[9] https://bournema.myrec.com/info/facilities/details.aspx?FacilityID=14558

Category C NAC. No Activity Category E land uses approach or exceed the respective NAC thresholds for the 2019 existing conditions in the Sagamore South quadrant.

Table 4.14-3. 2019 Existing: Loudest Traffic Hour Noise Levels (Sagamore South Quadrant)

Common Noise Environment	Adjacent Roadways	2019 Existing Condition Noise Level Ranges Leq	FHWA Activity Category	2019 Existing Condition Approach or Exceed Noise Abatement Criteria
SJ	Sandwich Road	54–68	B	20
SK	U.S. Route 6 Northbound	53–71	B	5
	Sandwich Road		C	0
SL	Sandwich Road	51–67	B	2
	Cranberry Highway		E	0
SM	Sandwich Road	48–67	B	7
			C	3
SN	Sandwich Road Cranberry Highway	49–65	B C E	0 0 0
SO	Cranberry Highway	50–64	B	0
SP	U.S. Route 6 Southbound	53–61	B	0
	Mid-Cape Connector			
	Sandwich Road			
SQ	Mid-Cape Connector	49–69	B	2
	Sandwich Road			

Source: Massachusetts Department of Transportation, 2024

Note: Refer to **Figure 4.14-2** for Common Noise Environment locations.

In the Bourne North quadrant for the 2019 existing conditions (**Table 4.14-4**), there are no residential dwelling units that approach or exceed the FHWA Category B NAC. No Activity Categories C, D, or E land uses approach or exceed the respective NAC thresholds for the 2019 existing condition in the Bourne North quadrant.

Table 4.14-4. 2019 Existing: Loudest Traffic Hour Noise Levels (Bourne North Quadrant)

Common Noise Environment	Adjacent Roadways	2019 Existing Noise Level Ranges Leq	FHWA Activity Category	2019 Existing Condition Approach or Exceed Noise Abatement Criteria
BA	State Route 25 Northbound	45–63	B	0
BB	State Route 25 Northbound and northbound/southbound on-ramps	52–55	B	0
BC	State Route 25 Southbound	48–65	B	0
			E	
BD	State Route 25 Southbound	60–65	E	0
BE	State Route 28 Southbound	53–63	B	0
			C	
			E	
BF	State Route 28 Northbound	53–65	B	0
	U.S. Route 6/Main Street			
BG	State Route 28 Northbound	53–62	C	0
	U.S. Route 6/Main Street			

Source: Massachusetts Department of Transportation, 2024

Note: Refer to **Figure 4.14-3** for Common Noise Environment locations.

In the Bourne South quadrant for the 2019 existing conditions (**Table 4.14-5**), no residences approach or exceed the FHWA Category B NAC. One bench on the north side of the Bourne Manor Extended Care facility approaches or exceeds the FHWA Activity Category C NAC for the 2019 existing condition. No FHWA Activity Categories D or E land uses approach or exceed the respective NAC thresholds for the 2019 existing condition in the Bourne South quadrant.

Table 4.14-5. 2019 Existing: Loudest Traffic Hour Noise Levels (Bourne South Quadrant)

Common Noise Environment	Adjacent Roadways	2019 Existing Noise Level Ranges Leq	FHWA Activity Category	2019 Existing Condition Approach or Exceed Noise Abatement Criteria
BH	State Route 28 Southbound	52–60	B	0
BI	State Route 28 Northbound	57–58	C	0
BJ	Sandwich Road	59–64	B	0
BK	Veterans Way	42–64	B	0
	Sandwich Road		C	0
	Trowbridge Road		E	0
BL	Sandwich Road	51–53	B	0
	Trowbridge Road			
BM	State Route 28 Southbound	52–64	E	0
	Trowbridge Road			
BN	State Route 28 Southbound	46–60	B	0
	Trowbridge Road		C	0
BO	State Route 28 Southbound	54–67	C	1
BP	Sandwich Road	28–55	B	0
			C	0

Source: Massachusetts Department of Transportation, 2024

Note: Refer to **Figure 4.14-4** for Common Noise Environment locations.

4.14.3 No Build Alternative

This section presents the operational traffic noise effects of the future 2050 No Build Alternative on noise-sensitive receptors within the Study Area quadrants.

No construction activities would occur for the No Build Alternative. Therefore, no construction-related noise or vibration would be generated.

4.14.3.1 Operational Traffic Noise Effects

Table 4.14-6 and **Table 4.14-7** summarize the 2050 No Build Alternative noise levels and number of receptors predicted to approach or exceed the Activity Categories B and C NAC of 67 dBA Leq and the Activity E Category NAC of 72 dBA Leq within the Sagamore North and Sagamore South quadrants,

respectively. **Table 4.14-8** and **Table 4.14-9** summarize the 2050 No Build Alternative noise levels and number of receptors predicted to approach or exceed the Activity Categories B and C NAC of 67 dBA Leq and the Activity E Category NAC of 72 dBA Leq within the Bourne North and Bourne South quadrants, respectively.

For the 2050 No Build Alternative in the Sagamore North quadrant (**Table 4.14-6**), seven residential dwelling units within CNEs SB, SC, and SD would approach or exceed the Activity Category B NAC for the 2050 No Build Alternative. In addition, one permitted development (Cape View Way) was identified and includes a plan for 42 residential apartment units (FHWA Activity Category B) on five parcels north of Meetinghouse Lane (refer to **Figure 4.14-6f**). A building permit was issued for this development on September 24, 2024, and construction is underway. Due to the development's distance from the State Route 3/U.S. Route 6 mainline travel lanes and Meetinghouse Lane, noise levels would not approach or exceed the Activity Category B NAC for the 2050 No Build Alternative at this development. No Activity Categories C, D, or E land uses would approach or exceed the respective NAC thresholds for the 2050 No Build Alternative in the Sagamore North quadrant.

In the Sagamore South quadrant for the 2050 No Build Alternative (**Table 4.14-7**), 46 residential dwelling units would approach or exceed the FHWA Category B NAC within CNEs SJ, SK, SL, SM, SN, and SQ. The 2050 No Build Alternative noise levels would approach or exceed the FHWA Activity Category C NAC at Keith Field on the field behind home plate in the catcher's position. To determine the number of equivalent receptors predicted to experience noise levels that approach or exceed the FHWA Category C NAC at Keith Field, a schedule of events on the Bourne Recreation website was reviewed.[10] The calendar for booking usage of Keith Field shows that, on average, there is either one game or practice at the field per day. Behind home plate, a maximum of three people per day (i.e., the batter, catcher, and potentially one umpire if the field is being used for a game) for a total of approximately three hours would experience noise levels that approach or exceed the FHWA Category C NAC. No Activity Category E land uses would approach or exceed the respective NAC thresholds for the 2050 No Build Alternative in the Sagamore South quadrant.

For the 2050 No Build Alternative in the Bourne North quadrant (**Table 4.14-8**), two residential dwelling units would approach or exceed the FHWA Category B NAC within CNE BF along U.S. Route 6/Main Street westbound. In addition, one permitted future development (340 Main Street) was identified that includes a plan for 24 townhome-style residences (FHWA Activity Category B) along U.S. Route 6/Main Street behind and west of Bourne Bridge and behind the Sav-On gas station. A building permit was issued for this development on March 5, 2022, and construction is anticipated to commence in winter 2025. Noise levels are not predicted to approach or exceed the Activity Category B NAC for the 2050 No Build Alternative at this permitted development due to their distance from U.S. Route 6/Main Street and the Bourne Bridge mainline travel lanes. No Activity Categories C, D, or E land uses would approach or exceed the respective NAC thresholds for the 2050 No Build Alternative in the Bourne North quadrant.

[10] https://bournema.myrec.com/info/facilities/details.aspx?FacilityID=14558

In the Bourne South quadrant for the 2050 No Build Alternative (**Table 4.14-9**), no residences would approach or exceed the FHWA Category B NAC. One bench on the north side of the Bourne Manor Extended Care facility would approach or exceed the FHWA Activity Category C NAC for the 2050 No Build Alternative. No FHWA Activity Categories D or E land uses would approach or exceed the respective NAC thresholds for the 2050 No Build Alternative in the Bourne South quadrant.

Table 4.14-6. 2050 No Build Alternative: Loudest Traffic Hour Noise Levels (Sagamore North Quadrant)

Common Noise Environment	Adjacent Roadways	2050 No Build Alternative Noise Level Ranges Leq	FHWA Activity Category	2050 No Build Alternative Approach or Exceed Noise Abatement Criteria
SA	State Route 3 Southbound	45–61	B	0
SB	State Route 3 Southbound	52–67	B	2
SC	State Route 3 Northbound	51–69	B	3
SD	State Route 3 Northbound	47–69	B	2
SE	U.S. Route 6 Northbound	61–62	B	0
SF	U.S. Route 6 Northbound	61–65	C	0
			E	0
SG	U.S. Route 6 Northbound	56–61	B	0
	Canal Street			
SH	U.S. Route 6 Northbound	49–61	B	0
	Canal Street		C	0
SI	Scenic Highway	53–65	B	0
Permitted Development – Cape View Way[a]	Meetinghouse Lane	49–52	B	0

[a] Cape View Way is a proposed residential development (FHWA Activity Category B) that received a building permit on September 24, 2024, to construct 42 residential dwelling units.

Note: Refer to **Figure 4.14-1** for Common Noise Environment locations.

Table 4.14-7. 2050 No Build Alternative: Loudest Traffic Hour Noise Levels (Sagamore South Quadrant)

Common Noise Environment	Adjacent Roadways	2050 No Build Alternative Noise Level Ranges Leq	FHWA Activity Category	2050 No Build Alternative Approach or Exceed Noise Abatement Criteria
SJ	Sandwich Road	55–69	B	20
SK	U.S. Route 6 Northbound	54–72	B	7
	Sandwich Road		C	0
SL	Sandwich Road	52–68	B	4
	Cranberry Highway		E	0
SM	Sandwich Road	50–69	B	8
			C	3
SN	Sandwich Road Cranberry Highway	51–67	B	3
			C	0
			E	0
SO	Cranberry Highway	51–65	B	0
SP	U.S. Route 6 Southbound	54–63	B	0
	Mid-Cape Connector			
	Sandwich Road			
SQ	Mid-Cape Connector	51–70	B	4
	Sandwich Road			

Note: Refer to **Figure 4.14-2** for Common Noise Environment locations.

Table 4.14-8. 2050 No Build Alternative: Loudest Traffic Hour Noise Levels (Bourne North Quadrant)

Common Noise Environment	Adjacent Roadways	2050 No Build Alternative Noise Level Ranges Leq	FHWA Activity Category	2050 No Build Alternative Approach or Exceed Noise Abatement Criteria
BA	State Route 25 Northbound	46–63	B	0
BB	State Route 25 Northbound and northbound/southbound on-ramps	53–56	B	0
BC	State Route 25 Southbound	49–65	B	0
			E	
BD	State Route 25 Southbound	61–66	E	0
BE	State Route 28 Southbound	54–65	B	0
			C	
			E	
BF	State Route 28 Northbound	54–66	B	2
	U.S. Route 6/Main Street			
BG	State Route 28 Northbound	54–63	C	0
	U.S. Route 6/Main Street			
Permitted Development – 340 Main Street[a]	State Route 28 Northbound	58–65	B	0
	U.S. Route 6/Main Street			

[a] 340 Main Street is a part of a mixed-use development, where Phase I has been completed and includes six second-story apartment units above first floor commercial property. Phase II includes construction of 24 rental townhome style units behind the commercial property. Phase II building permit was issued on March 5, 2022.

Note: Refer to **Figure 4.14-3** for Common Noise Environment locations.

Table 4.14-9. 2050 No Build Alternative: Loudest Traffic Hour Noise Levels (Bourne South Quadrant)

Common Noise Environment	Adjacent Roadways	2050 No Build Alternative Level Ranges Leq	FHWA Activity Category	2050 No Build Alternative Approach or Exceed Noise Abatement Criteria
BH	State Route 28 Southbound	53–60	B	0
BI	State Route 28 Northbound	59–60	C	0
BJ	Sandwich Road	60–65	B	0
BK	Veterans Way	42–63	B	0
	Sandwich Road		C	0
	Trowbridge Road		E	0
BL	Sandwich Road	52–55	B	0
	Trowbridge Road			
BM	State Route 28 Southbound	53–65	E	0
	Trowbridge Road			
BN	State Route 28 Southbound	47–61	B	0
	Trowbridge Road		C	
BO	State Route 28 Southbound	54–67	C	3
BP	Sandwich Road	29–55	B	0
			C	

Note: Refer to **Figure 4.14-4** for Common Noise Environment locations.

4.14.4 Build Alternative

4.14.4.1 Operational Traffic Noise Effects

Table 4.14-10, **Table 4.14-11**, **Table 4.14-12**, and **Table 4.14-13** summarize the 2050 Build Alternative noise levels and number of receptors predicted to approach or exceed Activity Categories B and C NAC (67 dBA Leq) and the Activity Category E NAC (72 dBA Leq) within the Sagamore North, Sagamore South, Bourne North, and Bourne South quadrants, respectively.

Figure 4.14-5a through i, **Figure 4.14-6a through h**, **Figure 4.14-7a through i**, and **Figure 4.14-8a through g** provide location maps for the CNEs, noise-sensitive receptors and barriers evaluated (refer to **Section 4.14.5.1** for a discussion of evaluated noise barriers) within the Sagamore North, Sagamore South, Bourne North, and Bourne South quadrants, respectively. On each figure, triangles represent noise measurement locations, while squares, pentagons, and hexagons represent impacted receptors with different noise level reductions from evaluated noise barriers (insertion loss). Squares represent impacted receptors as well as impacted receptors that would achieve less than 5 dB noise reduction with noise abatement measures, pentagons represent impacted receptors that would achieve noise level reductions ranging between 5 and 9 dB, and hexagons represent impacted receptors that would achieve 10 dB or greater noise reduction. Large circles represent receptors that would not be impacted but would achieve at least a 5 dB noise reduction with a noise barrier, while small circles represent receptors that would not be impacted and would also not achieve a 5 dB noise reduction.

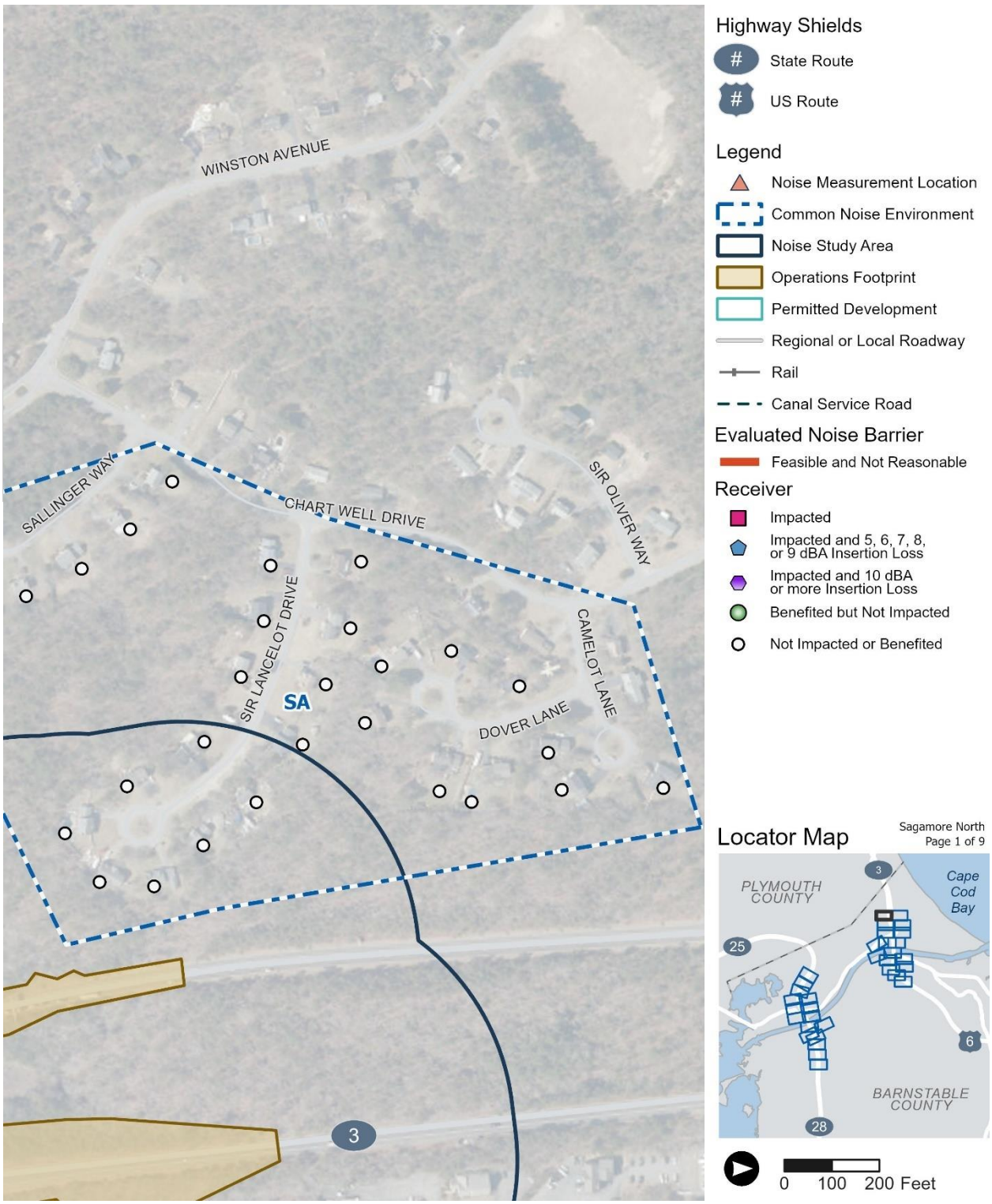
Nine residential dwelling units are within CNEs SB, SC, and SD that would approach or exceed the Activity Category B NAC. The 2050 Build Alternative noise levels are not predicted to approach or exceed the Activity Category B NAC at the proposed Cape View Way permitted development. No Activity Categories C, D, or E land uses would approach or exceed the respective NAC thresholds for the 2050 Build Alternative in the Sagamore North quadrant (**Table 4.14-10**). In addition, no substantial noise increases are predicted within the Sagamore North quadrant.

Table 4.14-10. 2050 Build Alternative: Loudest Traffic Hour Noise Levels (Sagamore North Quadrant)

Common Noise Environment	Adjacent Roadways	2019 Existing Condition Noise Level Ranges Leq	2050 Build Alternative Noise Level Ranges Leq	FHWA Activity Category	2050 Build Alternative Approach or Exceed Noise Abatement Criteria
SA (Figures 4.14-5a, 5c)	State Route 3 Southbound	44–60	46–61	B	0
SB (Figures 4.14-5c, 5e)	State Route 3 Southbound	51–65	52–66	B	3
SC (Figures 4.14-5b, 5d)	State Route 3 Northbound	49–67	51–68	B	3
SD (Figures 4.14-5d, 5f)	State Route 3 Northbound	46–68	48–66	B	2
SE (Figures 4.14-5h, 5i)	U.S. Route 6 Northbound	60–61	62–62	B	0
SF (Figures 4.14-5e, 5f, 5h, 5i)	U.S. Route 6 Northbound	61–63	58–62	C	0
				E	0
SG (Figure 4.14-5i)	U.S. Route 6 Northbound Canal Street	55–60	57–61	B	0
SH (Figure 4.14-5i)	U.S. Route 6 Northbound	49–60	50–62	B	0
	Canal Street			C	0
SI (Figures 4.14-5g, 5h)	Scenic Highway	52–65	54–66	B	1
Permitted Development – Cape View Way[a] (Figure 4.14-5f)	Meetinghouse Lane	N/A	50–52	B	0

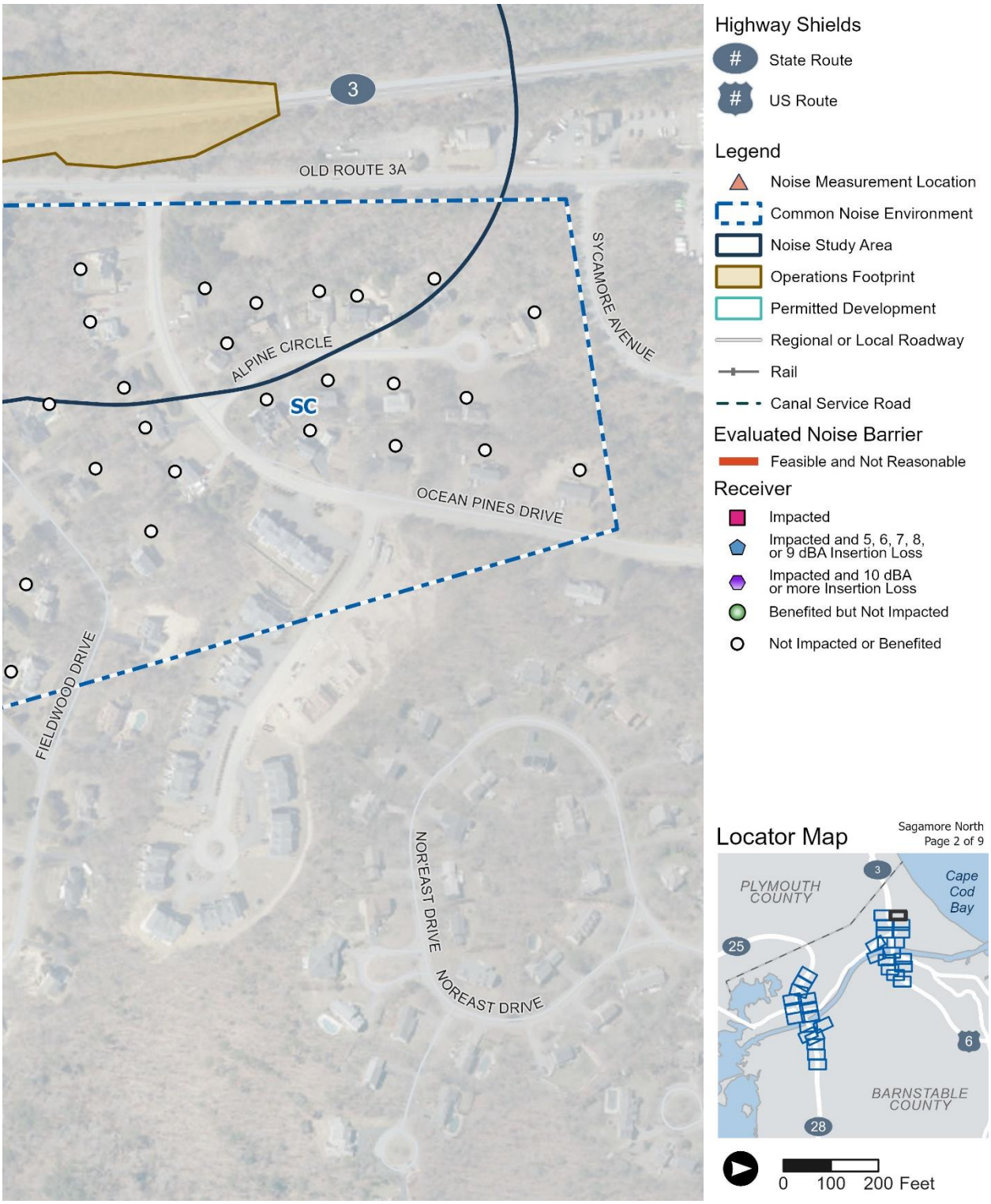
[a] Cape View Way is a proposed residential development (FHWA Activity Category B) that received a building permit on September 24, 2024, for construction of 42 residential dwelling units. The 2019 existing noise levels are not reported for permitted developments because they do not yet exist.

Figure 4.14-5a. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Sagamore North Quadrant)



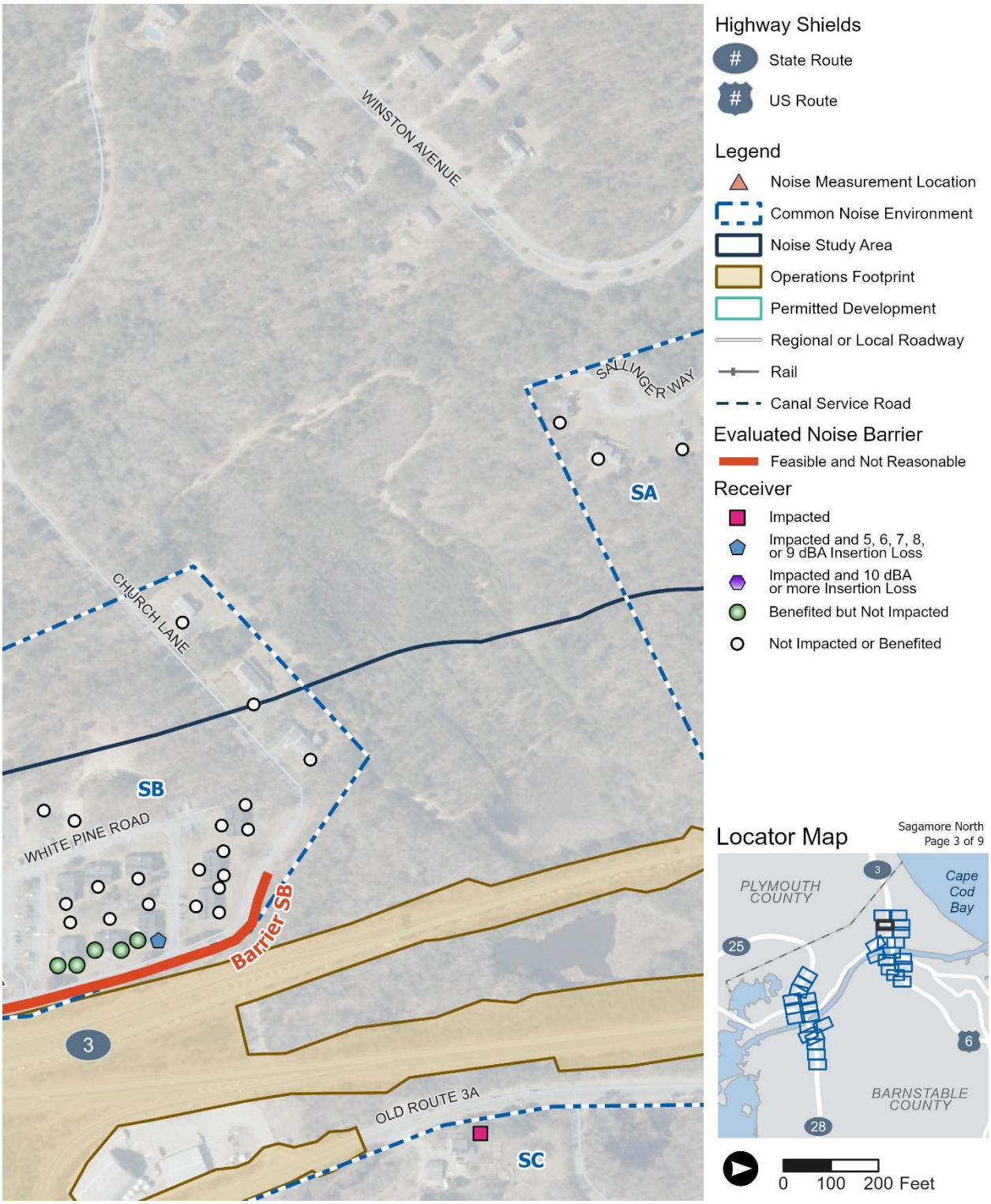
Source: Massachusetts Department of Transportation, 2024

Figure 4.14-5b. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Sagamore North Quadrant)



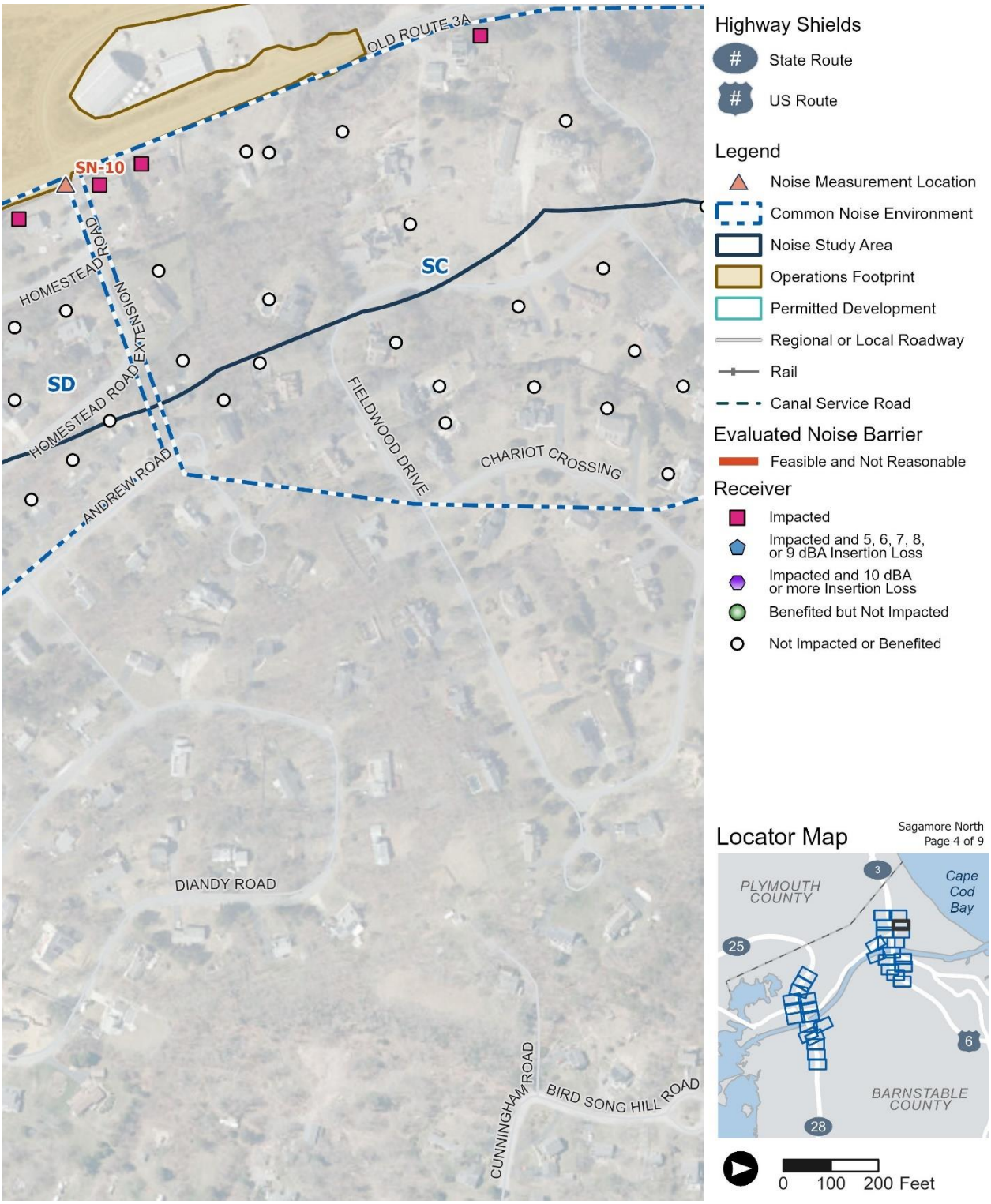
Source: Massachusetts Department of Transportation, 2024

Figure 4.14-5c. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Sagamore North Quadrant)



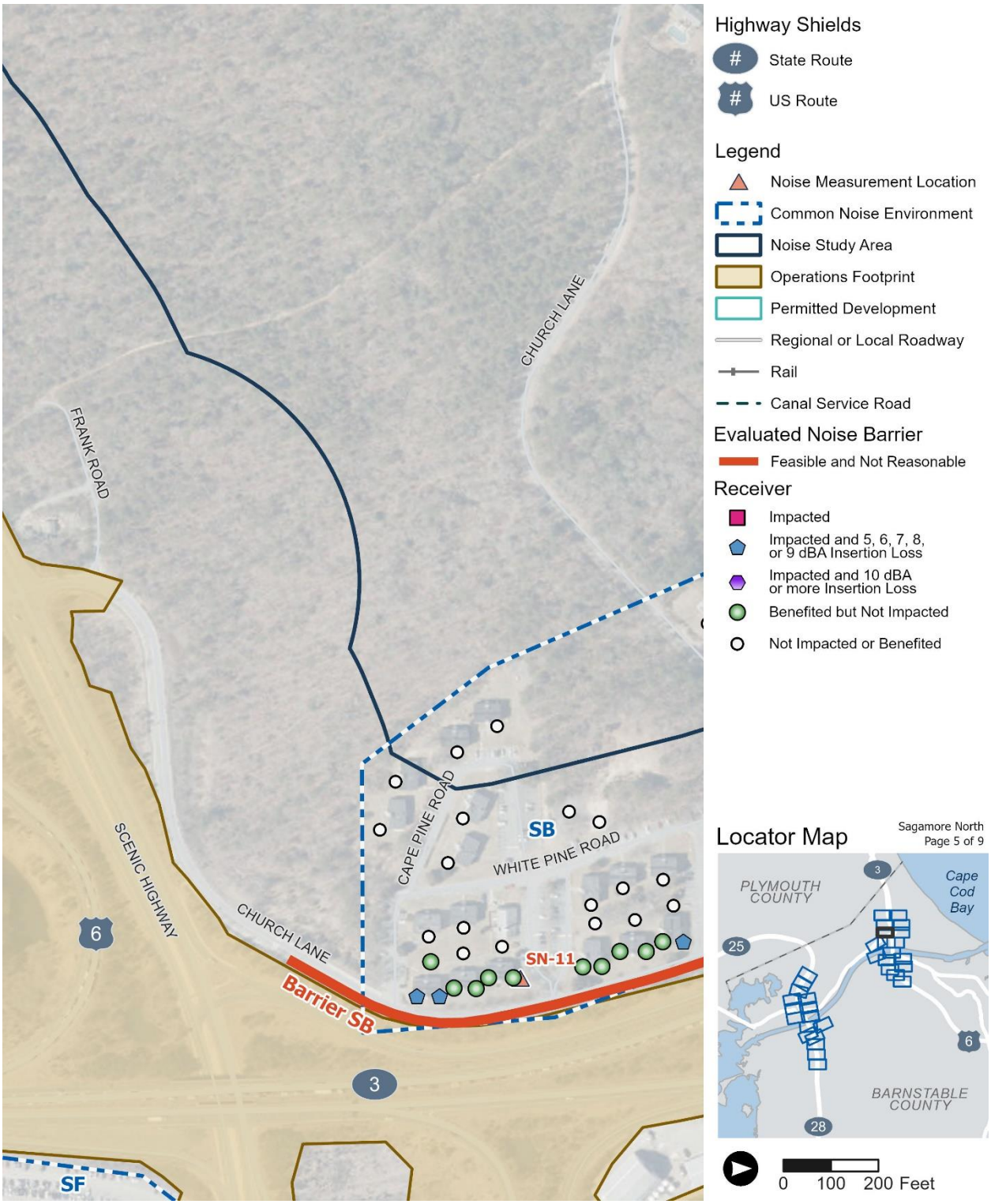
Source: Massachusetts Department of Transportation, 2024

Figure 4.14-5d. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Sagamore North Quadrant)



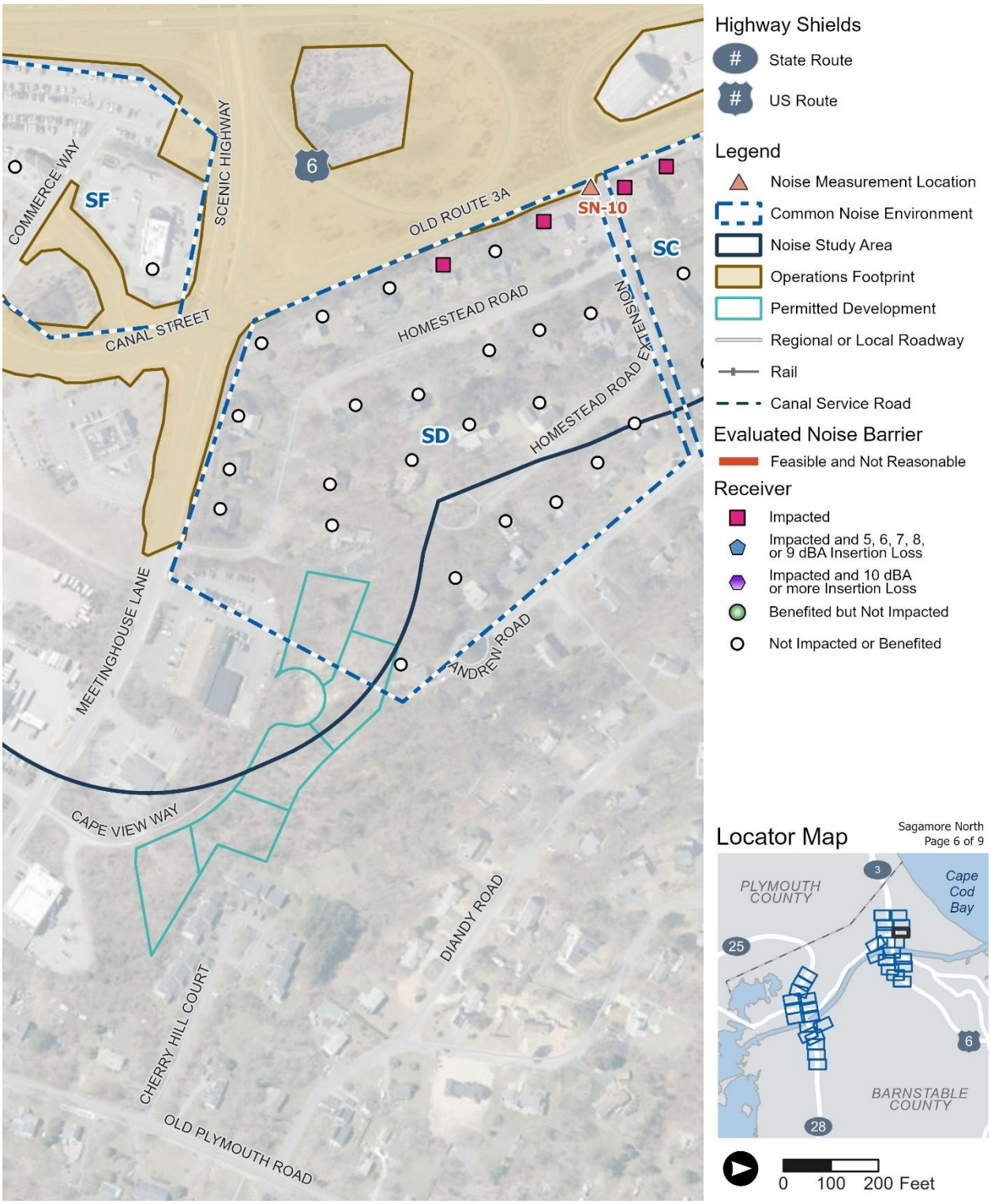
Source: Massachusetts Department of Transportation, 2024

Figure 4.14-5e. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Sagamore North Quadrant)



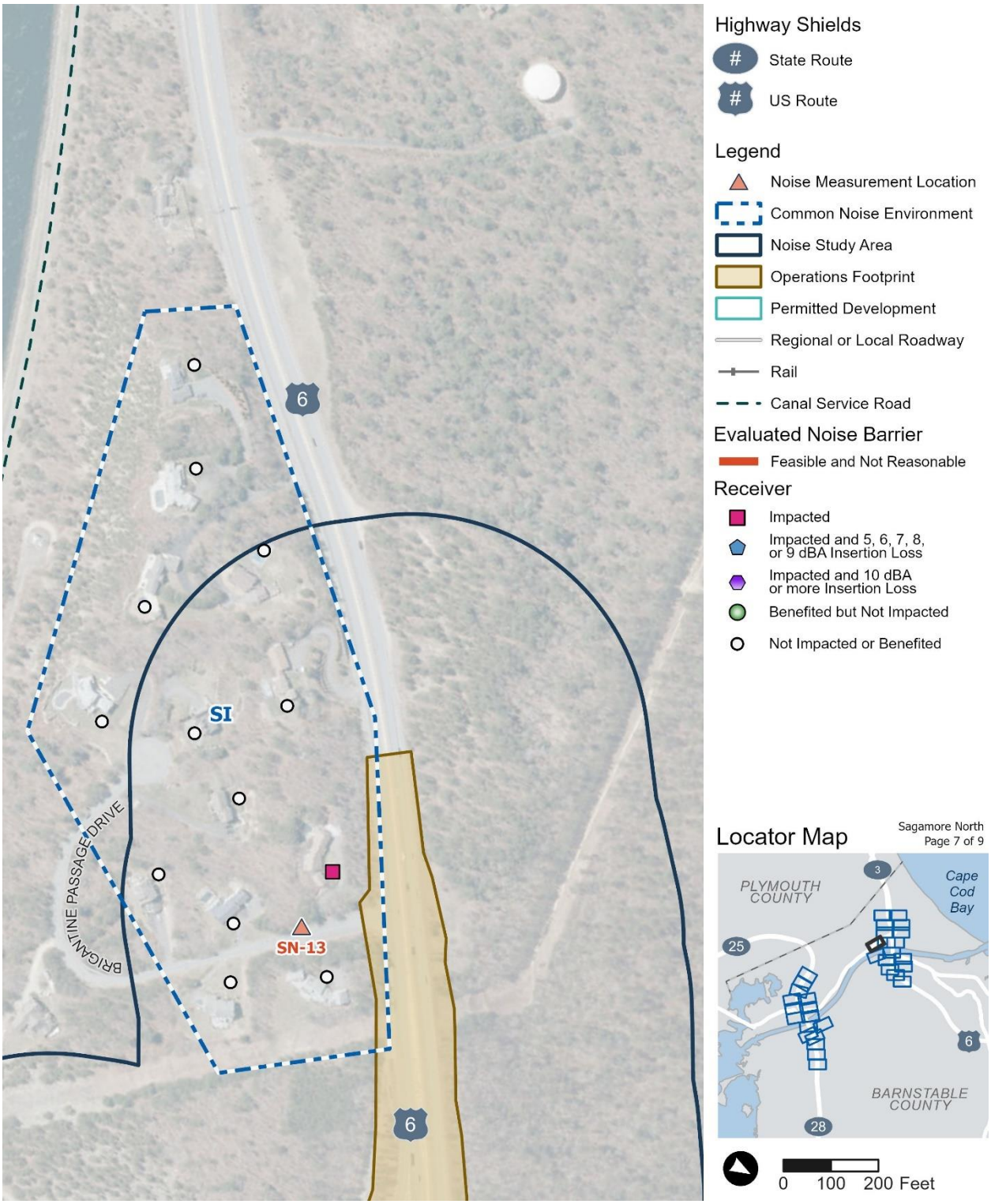
Source: Massachusetts Department of Transportation, 2024

Figure 4.14-5f. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Sagamore North Quadrant)



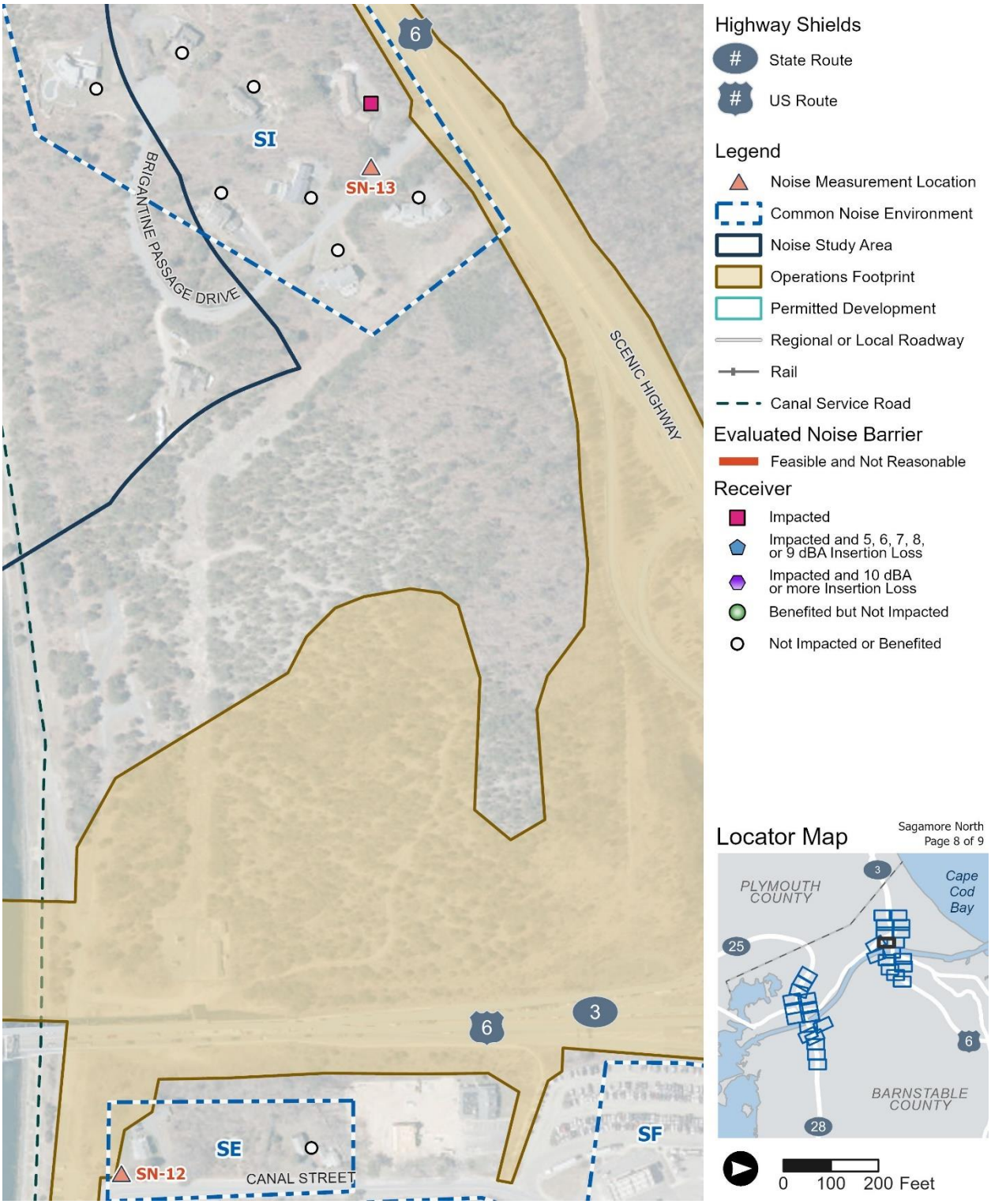
Source: Massachusetts Department of Transportation, 2024

Figure 4.14-5g. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Sagamore North Quadrant)



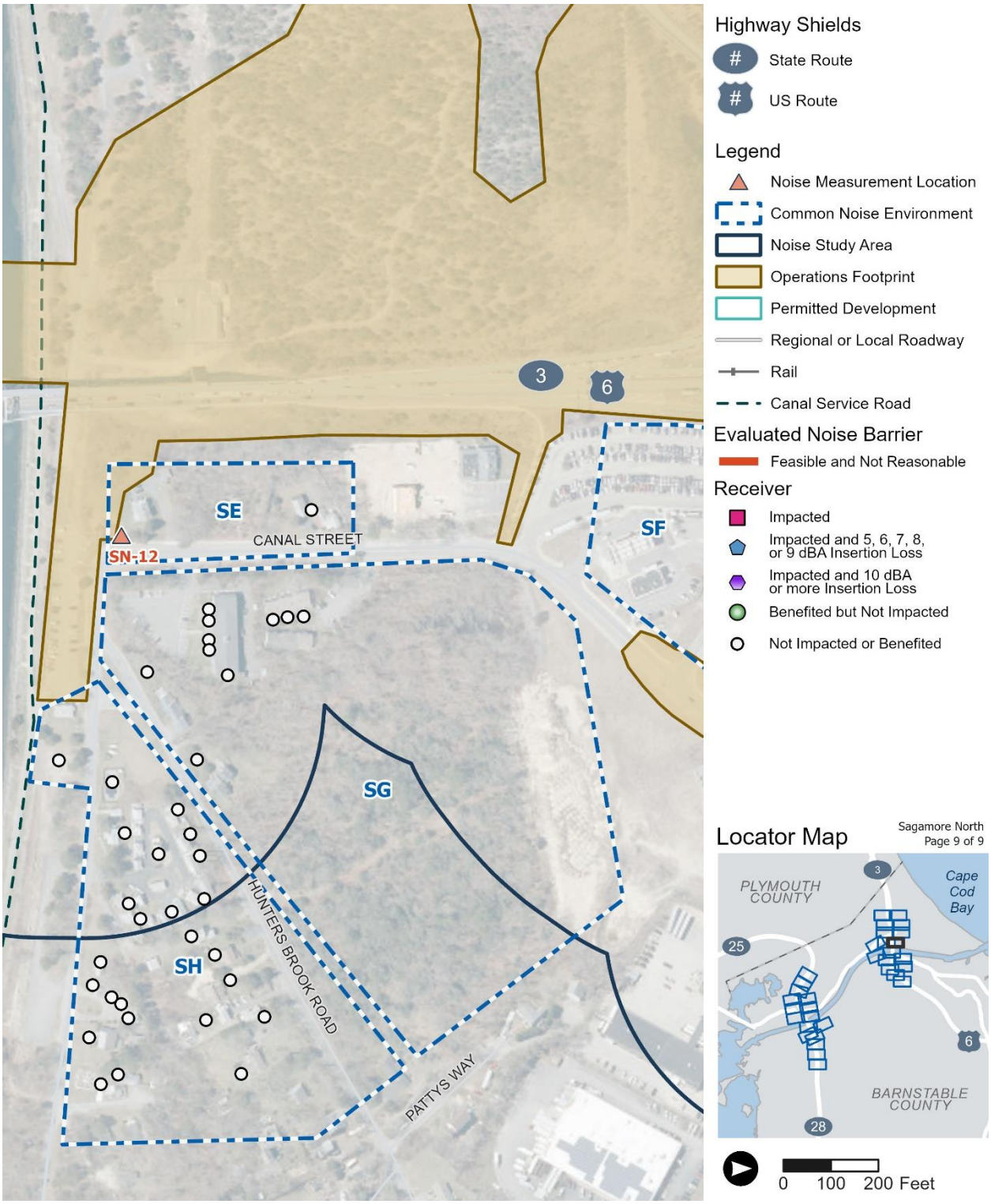
Source: Massachusetts Department of Transportation, 2024

Figure 4.14-5h. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Sagamore North Quadrant)



Source: Massachusetts Department of Transportation, 2024

Figure 4.14-5i. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Sagamore North Quadrant)



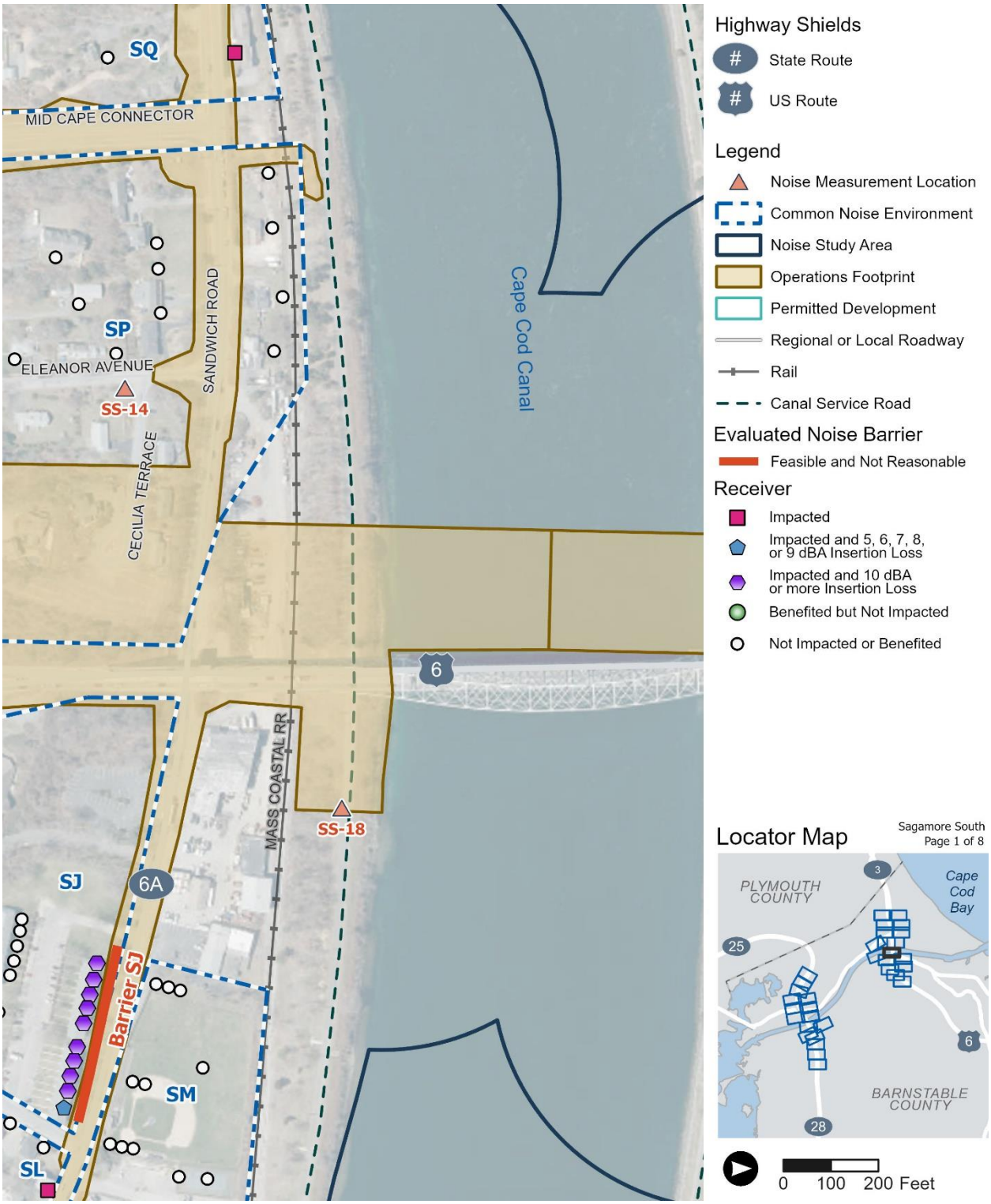
Source: Massachusetts Department of Transportation, 2024

Within the Sagamore South quadrant (**Table 4.14-11**), 45 residential dwelling units would approach or exceed the FHWA Category B NAC within CNEs SJ, SK, SL, SM, SN, and SQ. No Activity Category C, D, or E land uses would approach or exceed the respective NAC thresholds for the 2050 Build Alternative in the Sagamore South quadrant. In addition, no substantial noise increases are predicted within the Sagamore South quadrant.

Table 4.14-11. 2050 Build Alternative: Loudest Traffic Hour Noise Levels (Sagamore South Quadrant)

Common Noise Environment	Adjacent Roadways	2019 Existing Condition Noise Level Ranges Leq	2050 Build Alternative Noise Level Ranges Leq	FHWA Activity Category	2050 Build Alternative Approach or Exceed Noise Abatement Criteria
SJ (**Figures 4.14-6a**, **6c**, **6d**, **6e**)	Sandwich Road	54–68	56–67	B	20
SK (**Figures 4.14-6c**, **6d**, **6e**, **6f**, **6g**)	U.S. Route 6 Northbound	53–71	56–69	B	5
	Sandwich Road			C	0
SL (**Figures 4.14-6a**, **6d**, **6e**)	Sandwich Road	51–67	54–67	B	5
	Cranberry Highway			E	0
SM (**Figures 4.14-6a**, **6d**)	Sandwich Road	48–67	50–66	B	7
				C	0
SN (**Figures 4.14-6d**, **6e**)	Sandwich Road	49–65	52–66	B	1
	Cranberry Highway			C	0
				E	0
SO (**Figure 4.14-6e**)	Cranberry Highway	50–64	53–69	B	1
SP (**Figures 4.14-6a**, **6b**, **6c**)	U.S. Route 6 Southbound	53–61	61–64	B	0
	Mid-Cape Connector				
	Sandwich Road				
SQ (**Figures 4.14-6a**, **6b**, **6c**, **6f**)	Mid-Cape Connector	49–69	52–71	B	6
	Sandwich Road				

Figure 4.14-6a. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Sagamore South Quadrant)

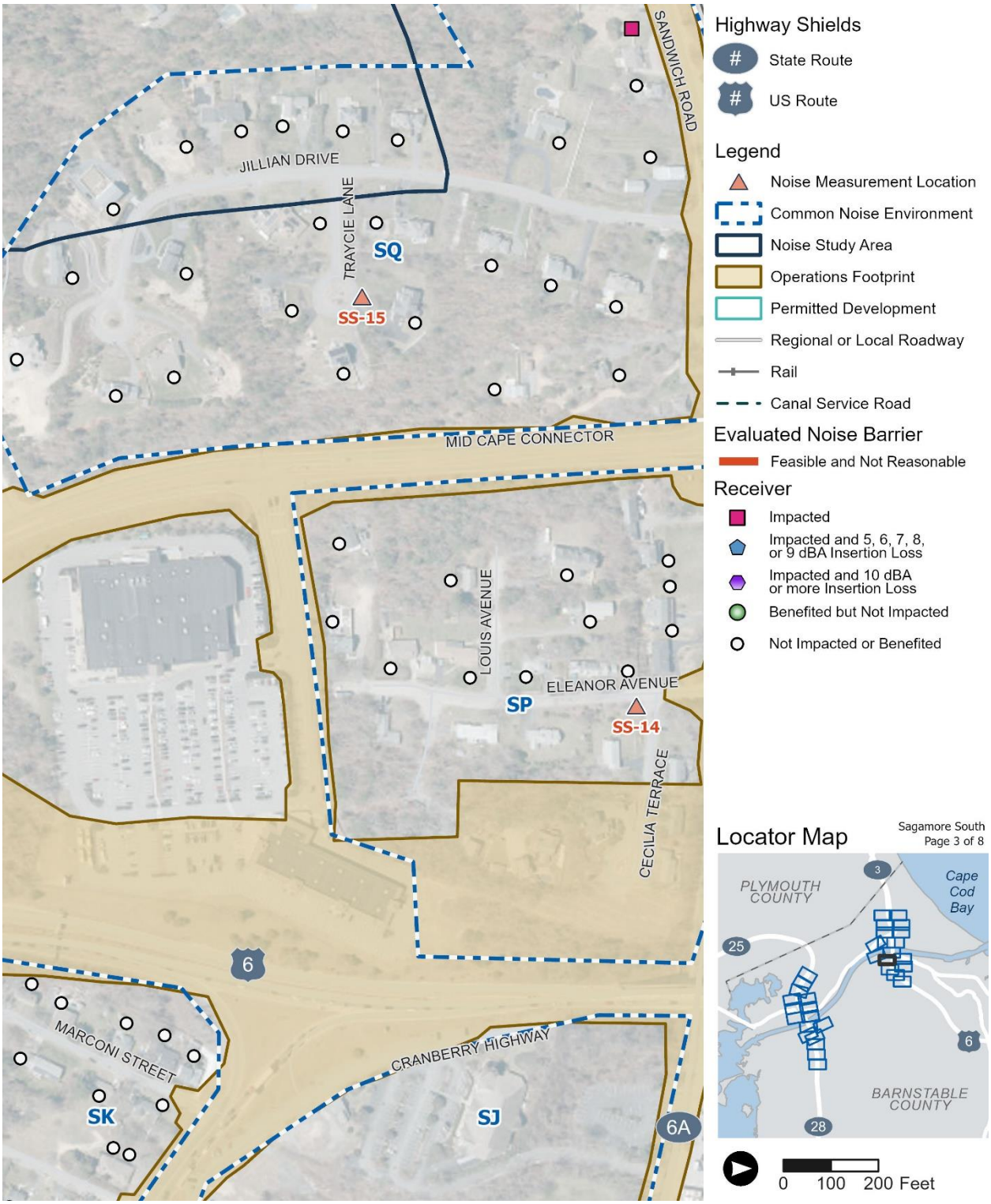


Source: Massachusetts Department of Transportation, 2024

Figure 4.14-6b. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Sagamore South Quadrant)

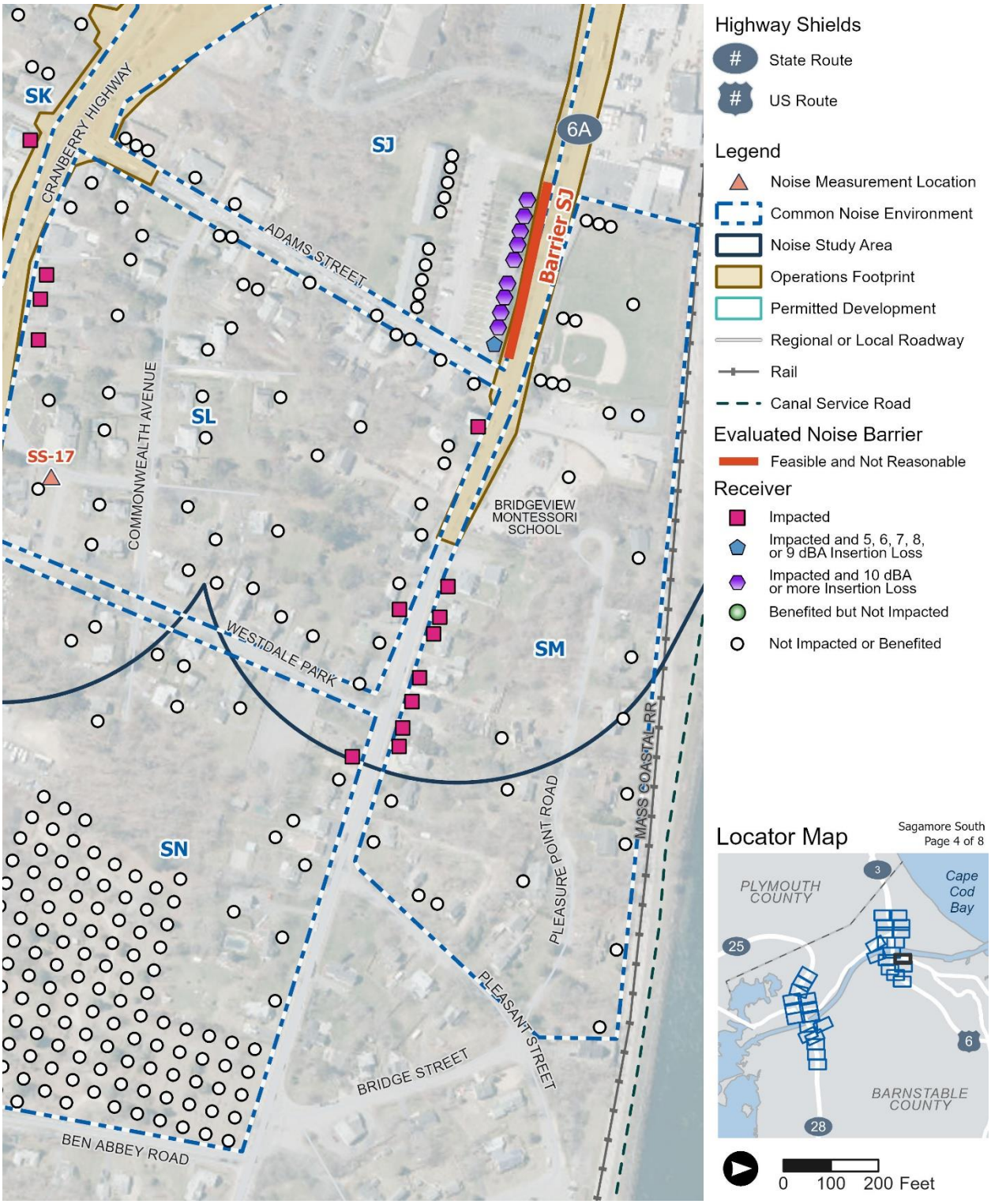
Source: Massachusetts Department of Transportation, 2024

Figure 4.14-6c. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Sagamore South Quadrant)



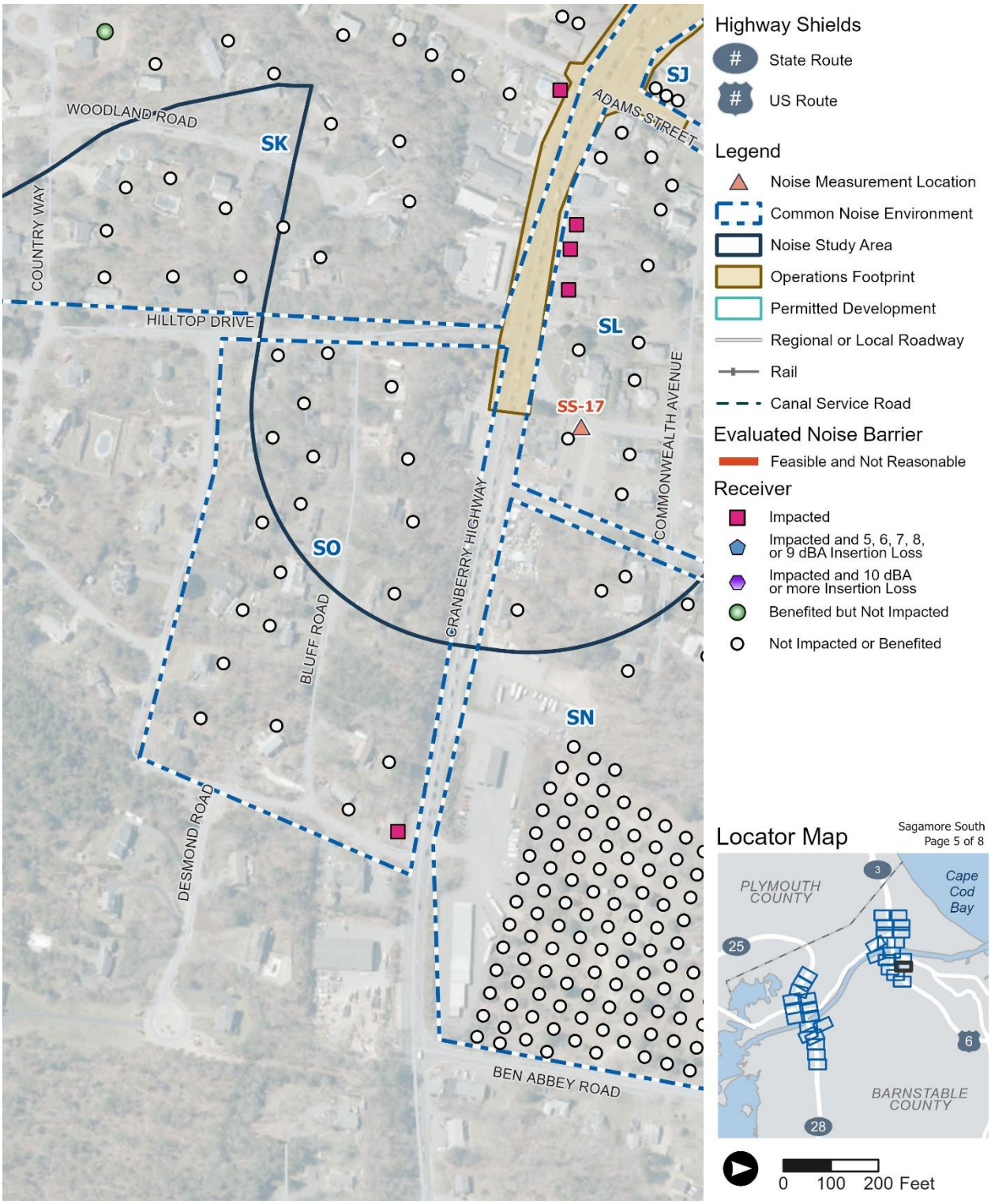
Source: Massachusetts Department of Transportation, 2024

Figure 4.14-6d. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Sagamore South Quadrant)



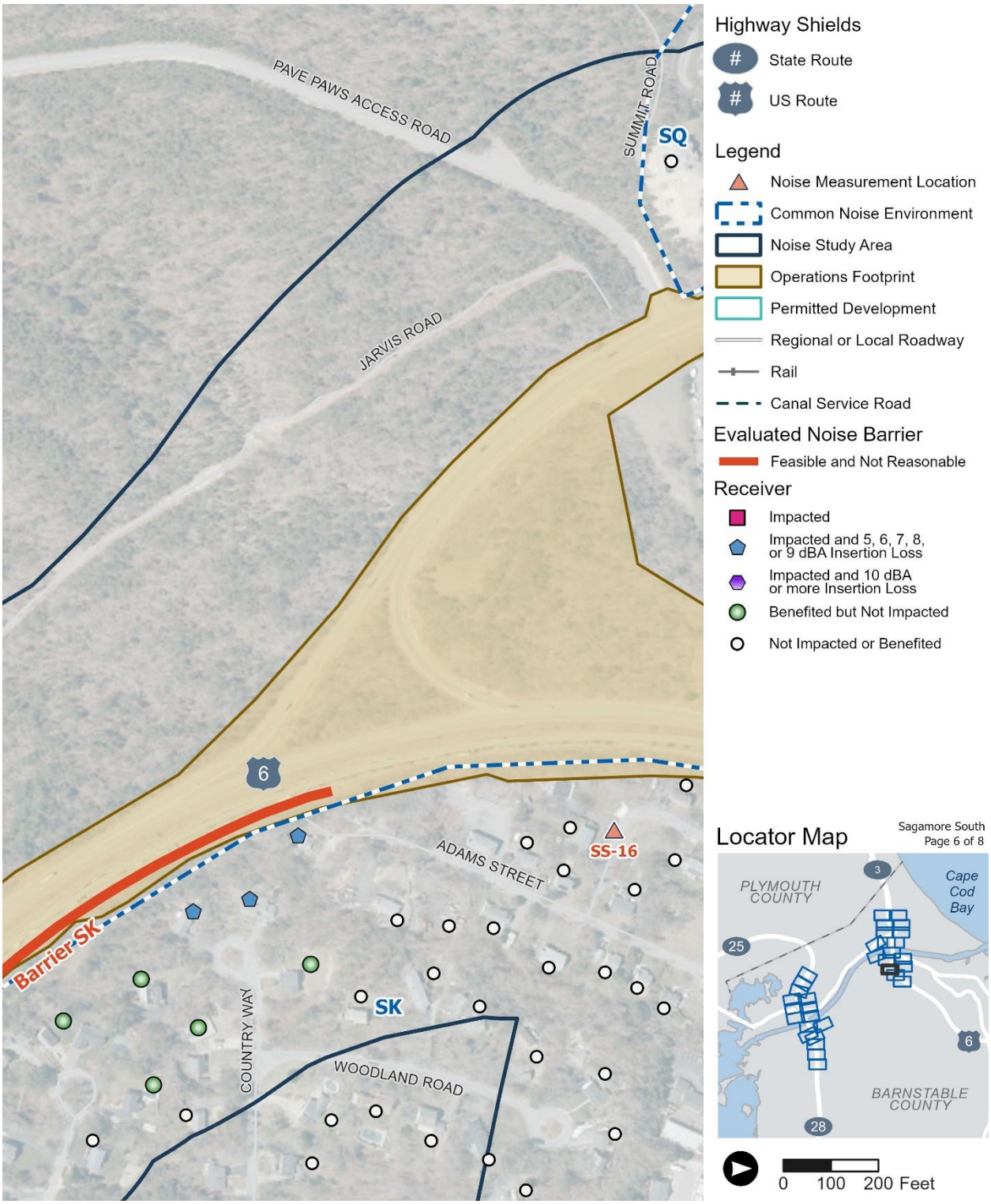
Source: Massachusetts Department of Transportation, 2024

Figure 4.14-6e. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Sagamore South Quadrant)



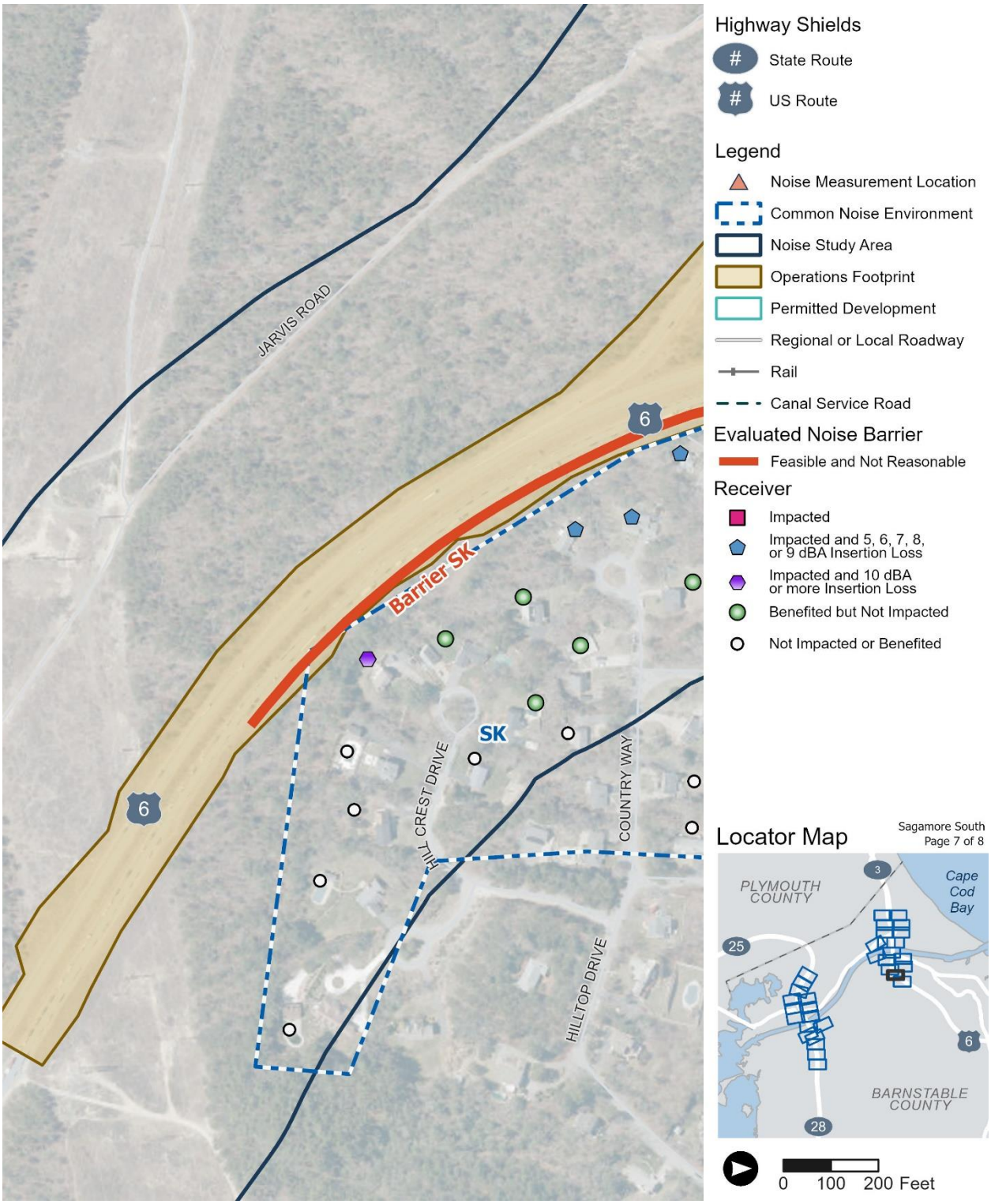
Source: Massachusetts Department of Transportation, 2024

Figure 4.14-6f. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Sagamore South Quadrant)



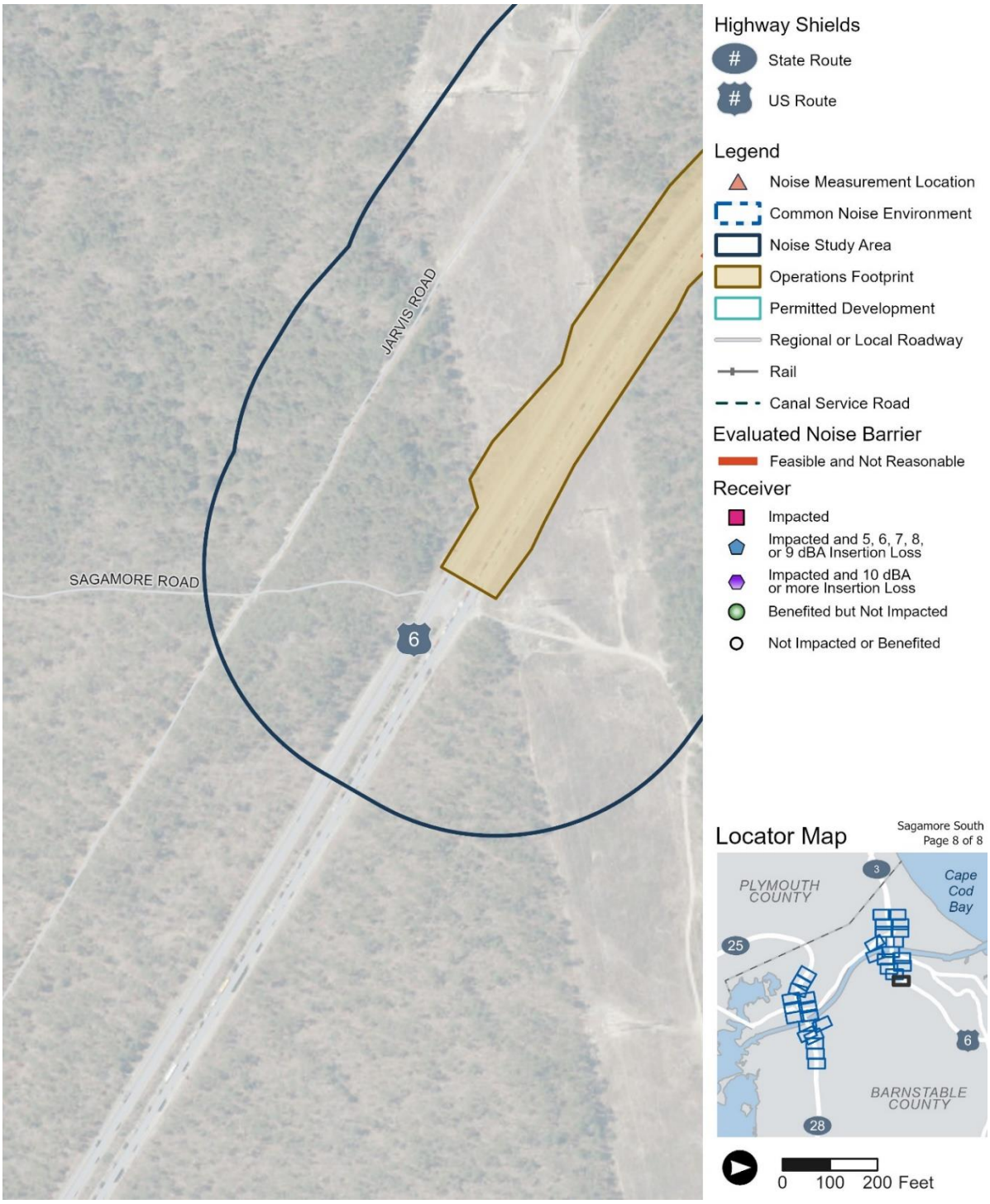
Source: Massachusetts Department of Transportation, 2024

Figure 4.14-6g. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Sagamore South Quadrant)



Source: Massachusetts Department of Transportation, 2024

Figure 4.14-6h. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Sagamore South Quadrant)



Source: Massachusetts Department of Transportation, 2024

Note: Due to the large Operations Footprint, maps are provided in segments. This segment contains no common noise environments, barriers, or receptors, but is included for completeness.

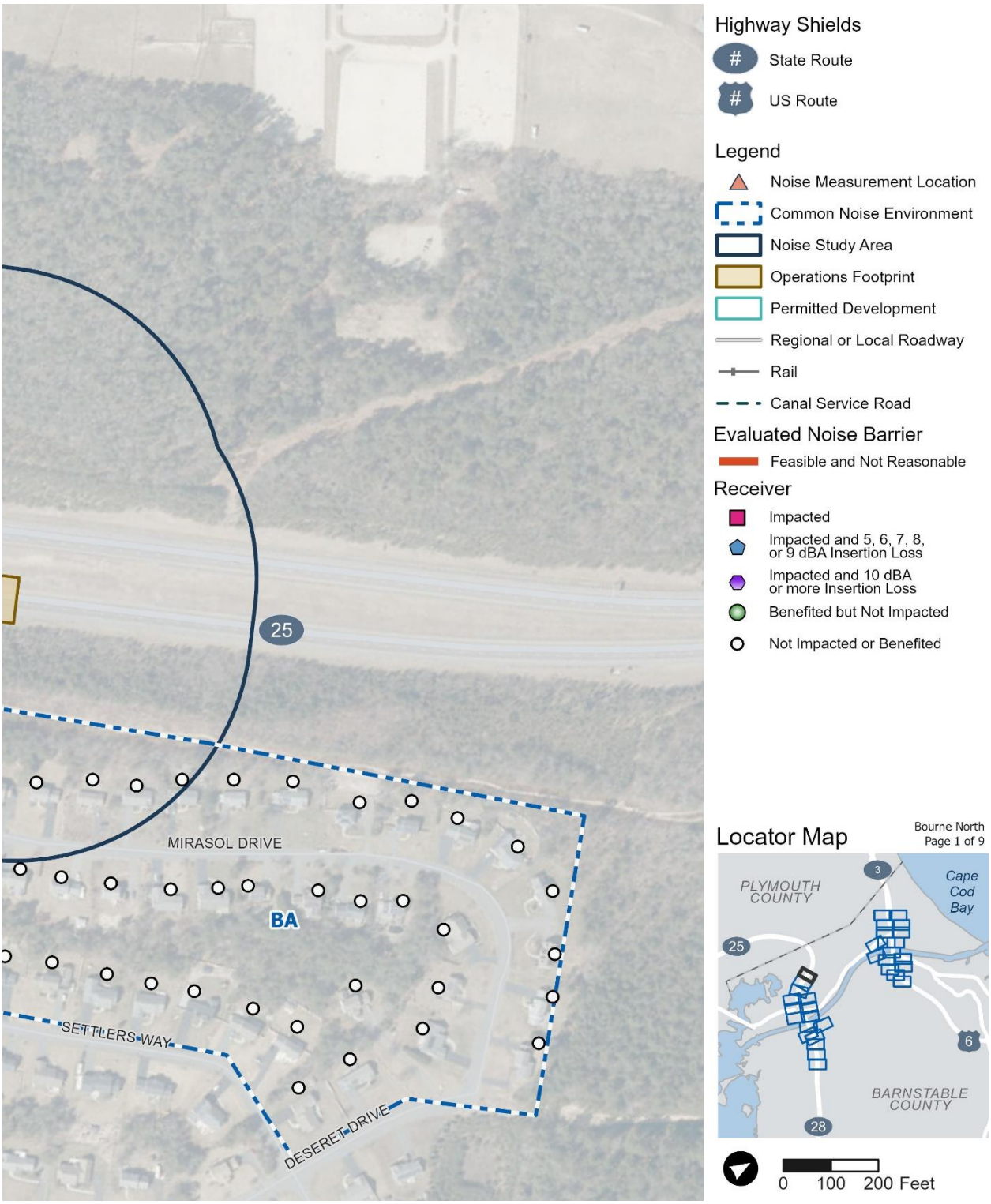
Within the Bourne North quadrant (**Table 4.14-12**), two total residential dwelling units would approach or exceed the FHWA Category B NAC within CNE BC (one single-family residence along Head of the Bay Road) and CNE BF (one residences along U.S. Route 6/Main Street westbound). No impacts are predicted at the permitted proposed development (340 Main Street) for the 2050 Build Alternative. No Activity Categories C, D or E land uses would approach or exceed the respective NAC thresholds for the 2050 Build Alternative in the Bourne North quadrant. In addition, no substantial noise increases are predicted within the Bourne North quadrant.

Table 4.14-12. 2050 Build Alternative: Loudest Traffic Hour Noise Levels (Bourne North Quadrant)

Common Noise Environment	Adjacent Roadways	2019 Existing Condition Noise Level Ranges Leq	2050 Build Alternative Noise Level Ranges Leq	FHWA Activity Category	2050 Build Alternative Approach or Exceed Noise Abatement Criteria
BA (**Figures 4.14-7a**, **7b**, **7c**)	State Route 25 Northbound	45–63	46–64	B	0
BB (**Figures 4.14-7c**, **7e**)	State Route 25 Northbound and northbound/ southbound on-ramps	52–55	52–56	B	0
BC (**Figures 4.14-7d**, **7f**)	State Route 25 Southbound	48–65	48–66	B	1
				E	0
BD (**Figure 4.14-7f**)	State Route 25 Southbound	60–65	59–64	E	0
BE (**Figures 4.14-7g**, **7h**, **7i**)	State Route 28 Southbound	53–63	55–64	B	0
				C	0
				E	0
BF (**Figures 4.14-7e**, **7f**, **7g**)	State Route 28 Northbound	53–65	55–67	B	1
	U.S. Route 6/Main Street				
BG (**Figures 4.14-7g**, **7h**, **7i**)	State Route 28 Northbound	53–62	57–64	C	0
	U.S. Route 6/ Main Street				
Permitted Development – 340 Main Street[a] (**Figure 4.14-7h**)	State Route 28 Northbound	N/A	58–65	B	0
	U.S. Route 6/ Main Street				

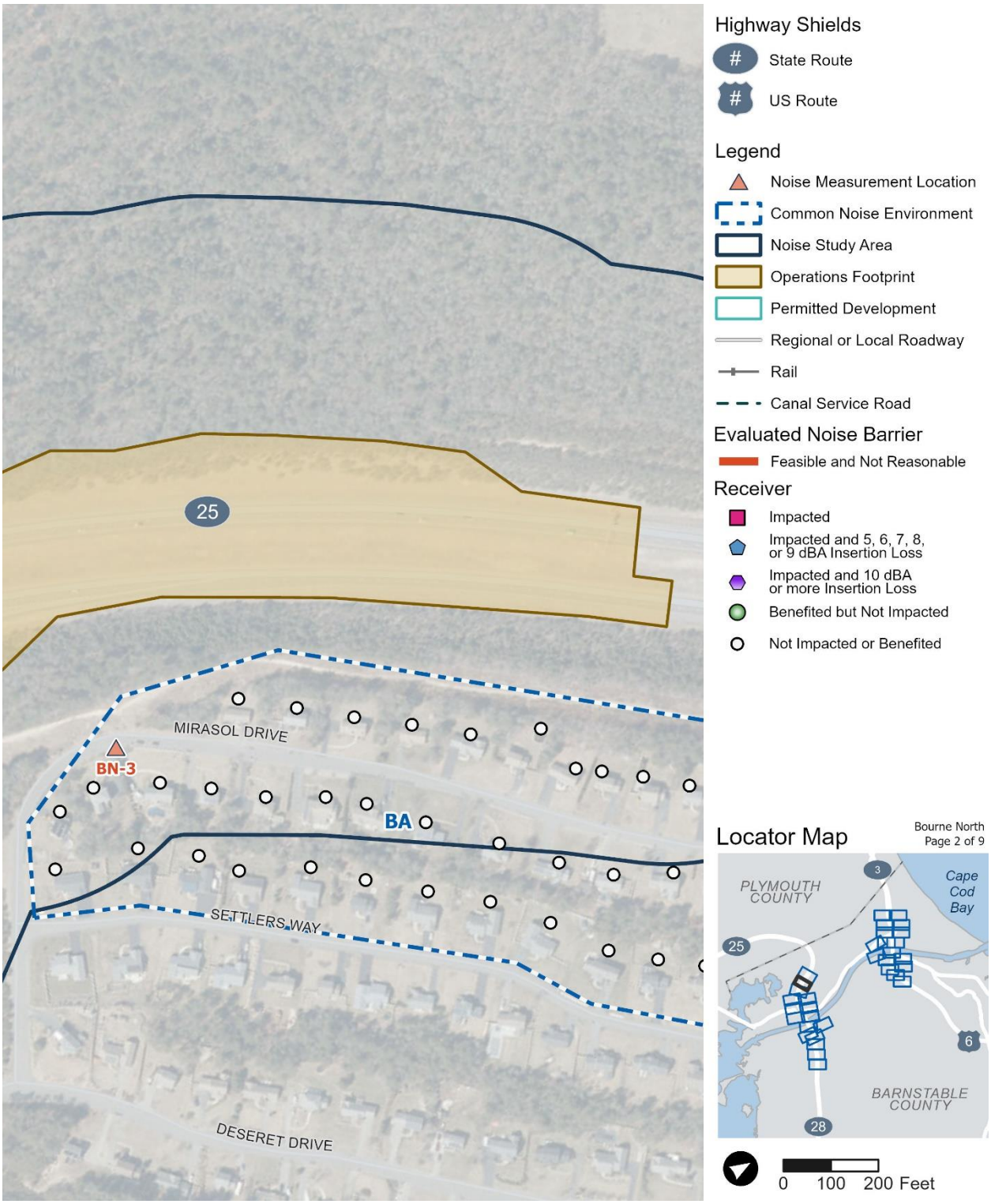
[a] The permitted development at 340 Main Street is a part of a mixed-use development, where Phase I has been completed and includes six second-story apartment units above first floor commercial property. Phase II includes construction of 24 rental townhome style units behind the commercial property. Phase II building permit was issued on March 5, 2022. Since the development does not exist for the 2019 existing condition, reported sound levels for the 2019 existing condition are not available.

Figure 4.14-7a. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Bourne North Quadrant)



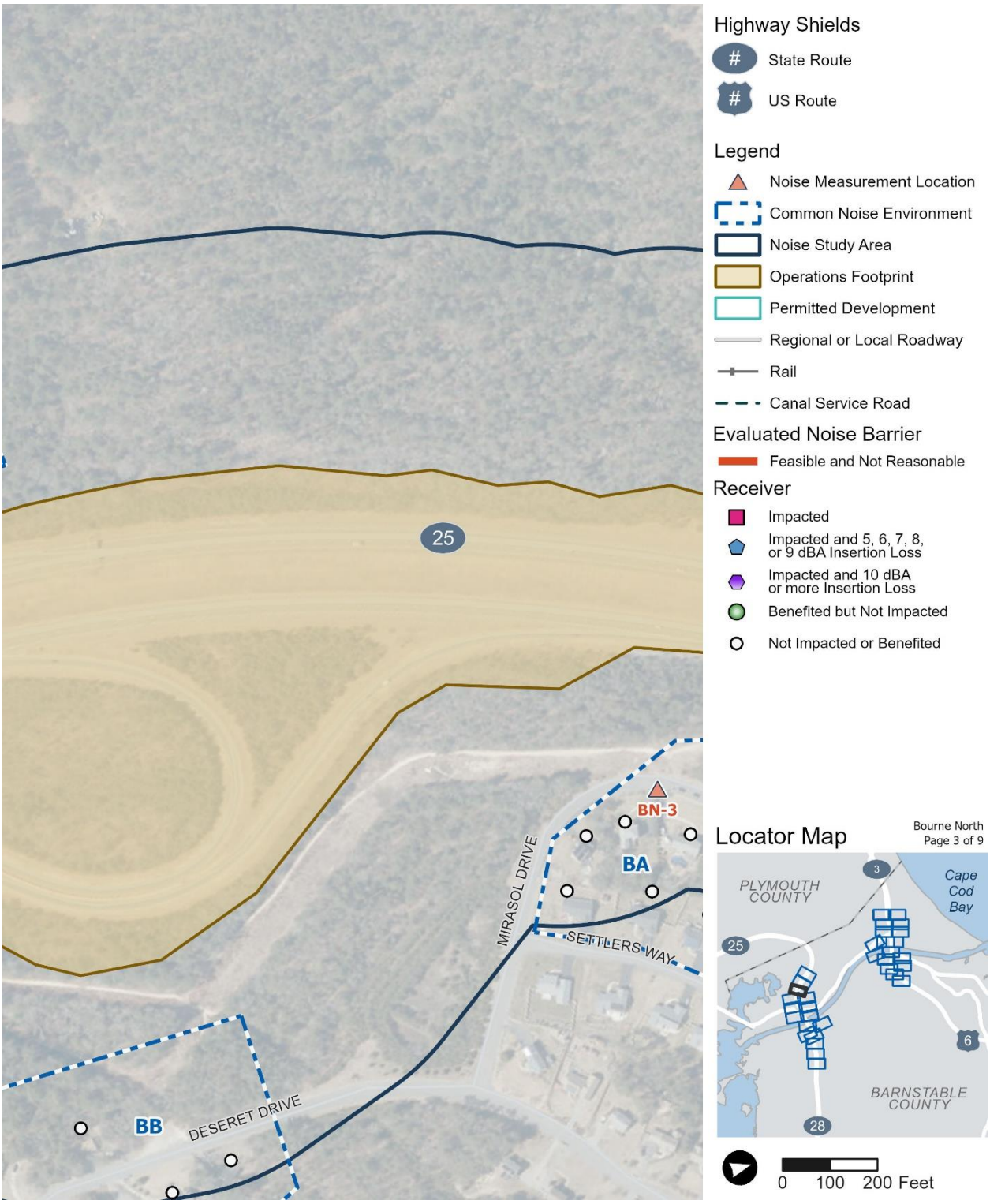
Source: Massachusetts Department of Transportation, 2024

Figure 4.14-7b. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Bourne North Quadrant)



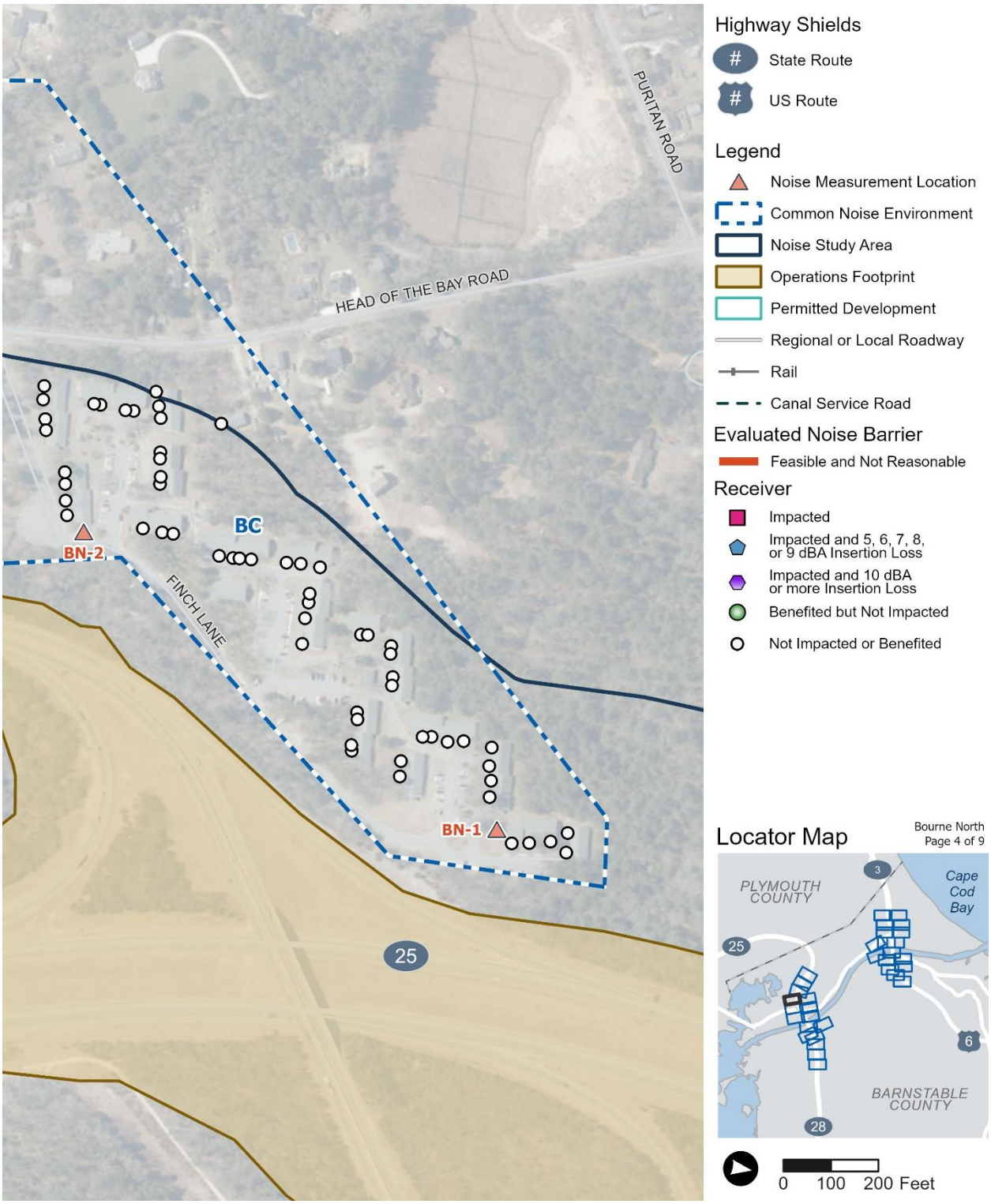
Source: Massachusetts Department of Transportation, 2024

Figure 4.14-7c. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Bourne North Quadrant)



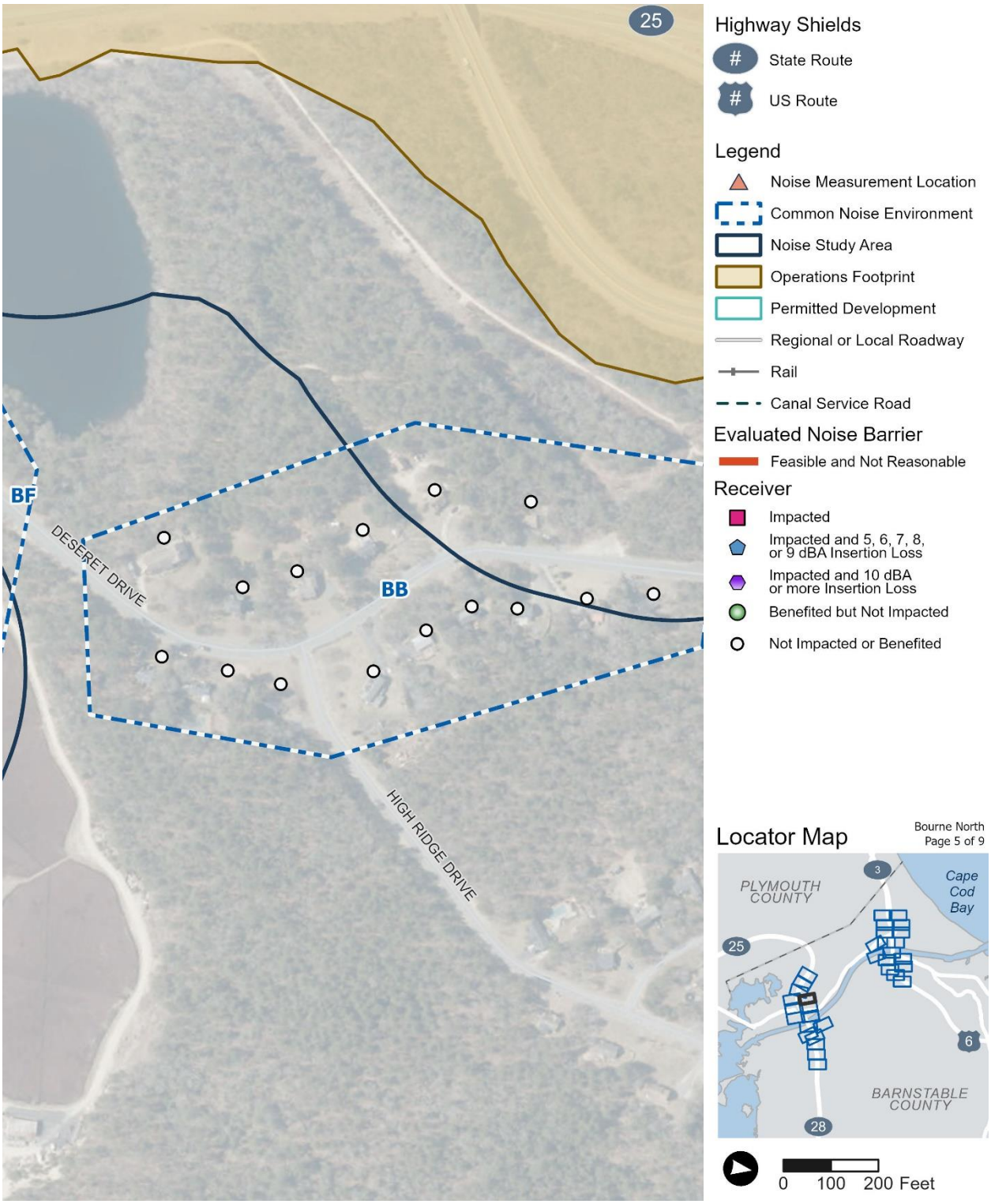
Source: Massachusetts Department of Transportation, 2024

Figure 4.14-7d. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Bourne North Quadrant)



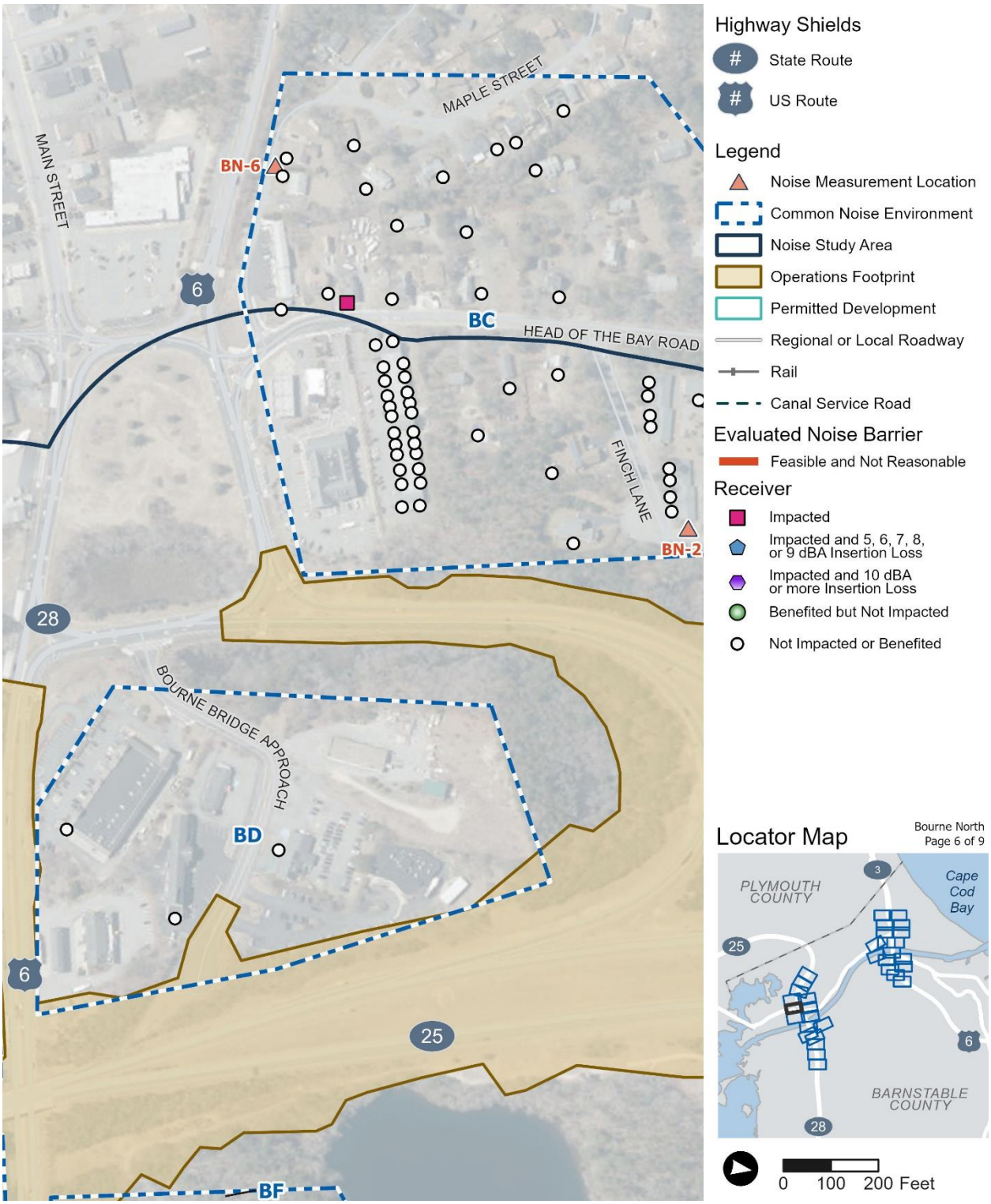
Source: Massachusetts Department of Transportation, 2024

Figure 4.14-7e. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Bourne North Quadrant)



Source: Massachusetts Department of Transportation, 2024

Figure 4.14-7f. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Bourne North Quadrant)

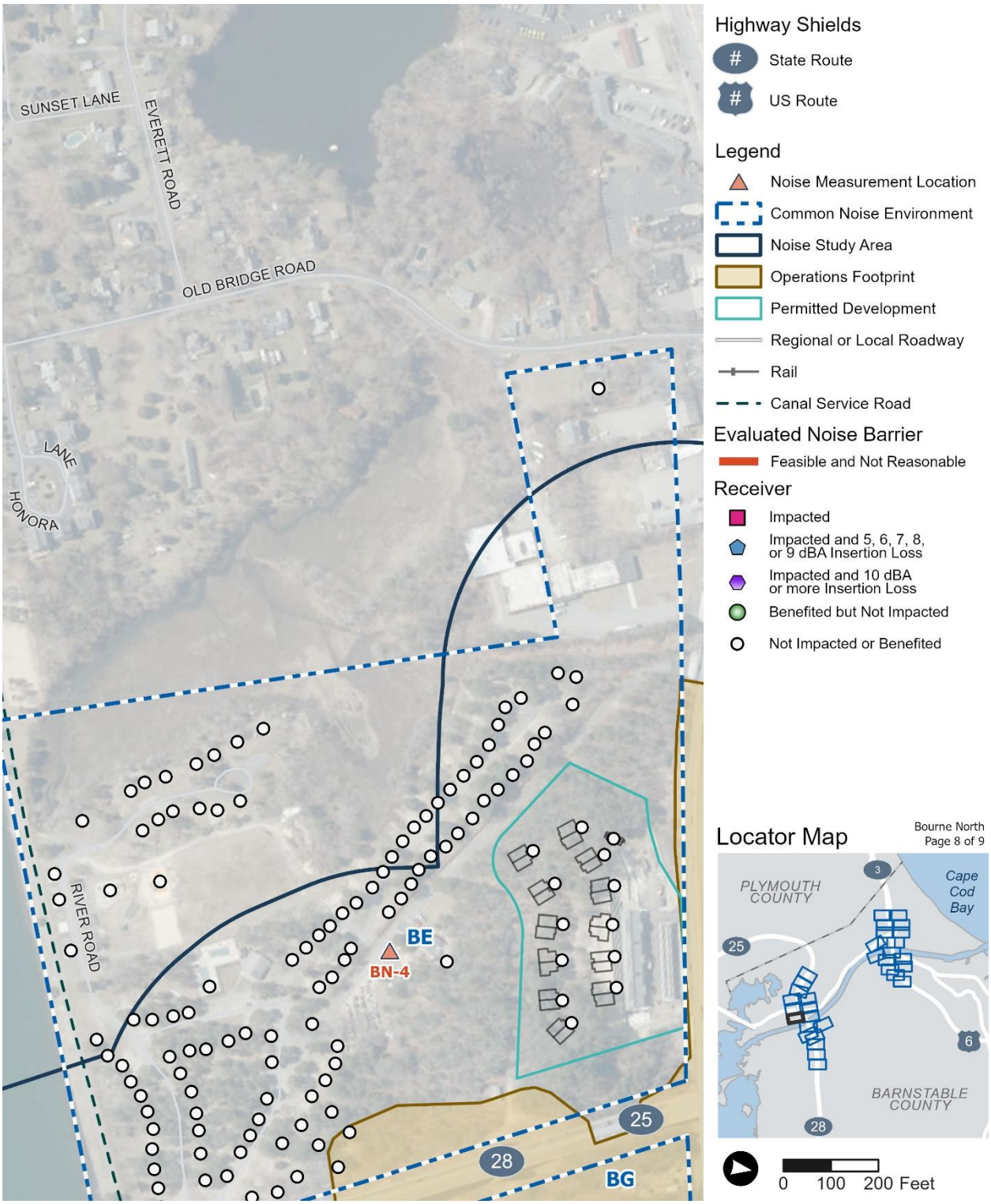


Source: Massachusetts Department of Transportation, 2024

Figure 4.14-7g. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Bourne North Quadrant)

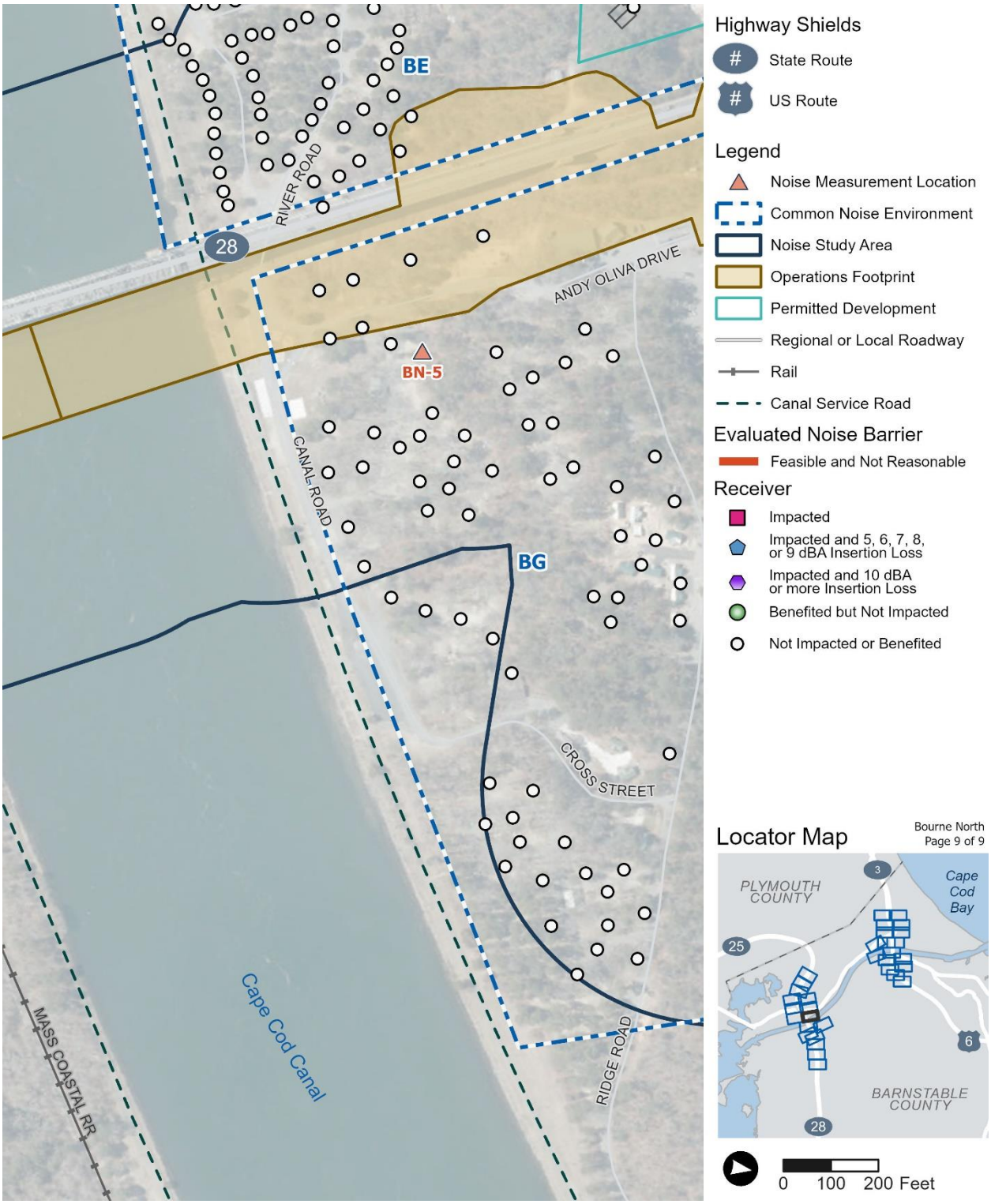
Source: Massachusetts Department of Transportation, 2024

Figure 4.14-7h. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Bourne North Quadrant)



Source: Massachusetts Department of Transportation, 2024

Figure 4.14-7i. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Bourne North Quadrant)



Source: Massachusetts Department of Transportation, 2024

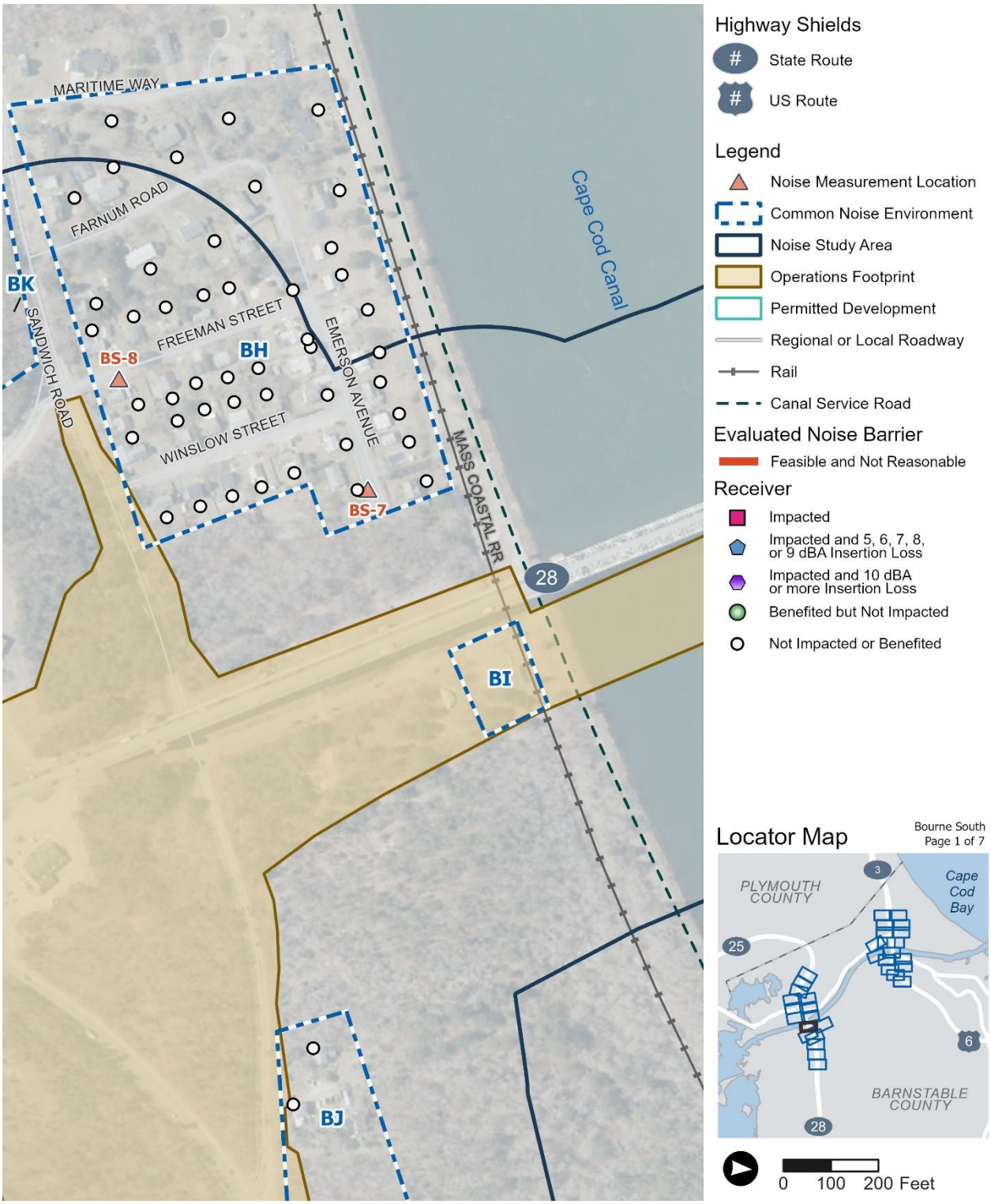
In the Bourne South quadrant for the 2050 Build Alternative (**Table 4.14-13**), no residential dwelling units would approach or exceed the FHWA Category B NAC. Two benches on the north side of the Bourne Manor Extended Care facility would approach or exceed the FHWA Activity Category C NAC for the 2050 Build Alternative. No FHWA Activity Categories D or E land uses would approach or exceed the respective NAC thresholds for the 2050 Build Alternative in the Bourne South quadrant. In addition, no substantial noise increases are predicted within the Bourne South quadrant.

Table 4.14-13. 2050 Build Alternative: Loudest Traffic Hour Noise Levels (Bourne South Quadrant)

Common Noise Environment	Adjacent Roadways	2019 Existing Condition Noise Level Ranges Leq	2050 Build Alternative Noise Level Ranges Leq	FHWA Activity Category	2050 Build Alternative Approach or Exceed Noise Abatement Criteria
BH (**Figure 4.14-8a**)	State Route 28 Southbound	52–60	53–60	B	0
BI (**Figure 4.14-8a**)	State Route 28 Northbound	57–58	*	C	*
BJ (**Figures 4.14-8a, 8c**)	Sandwich Road	59–64	57–59	B	0
BK (**Figures 4.14-8a, 8b**)	Veterans Way	42–64	41–63	B	0
	Sandwich Road			C	0
	Trowbridge Road			E	0
BL (**Figure 4.14-8b**)	Sandwich Road	51–53	52–56	B	0
	Trowbridge Road				
BM (**Figures 4.14-8b, 8d**)	State Route 28 Southbound	52–64	53–61	E	0
	Trowbridge Road				
BN (**Figures 4.14-8b, 8d, 8e**)	State Route 28 Southbound	46–60	47–60	B	0
	Trowbridge Road			C	
BO (**Figure 4.14-8f**)	State Route 28 Southbound	54–67	56–67	C	2
BP (**Figure 4.14-8c**)	Sandwich Road	28–55	30–58	B	0
				C	0

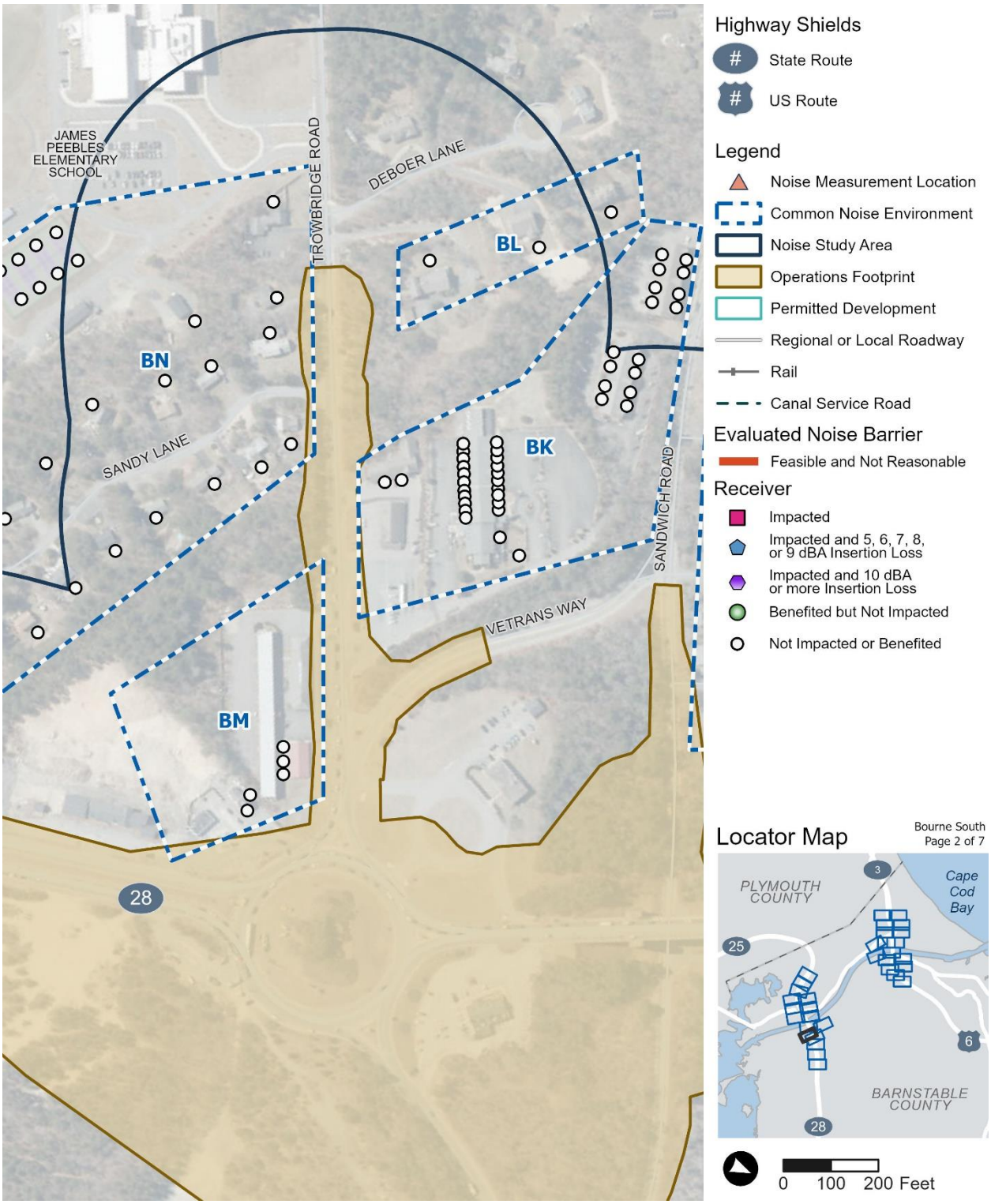
* The Bourne Recreation Area would be relocated for the 2050 Build Alternative. The U.S. Army Corps of Engineers is still determining the relocation site. Therefore, the Build Alternative noise levels for the Bourne Recreation Area will be presented in the Final Environmental Impact Statement.

Figure 4.14-8a. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Bourne South Quadrant)



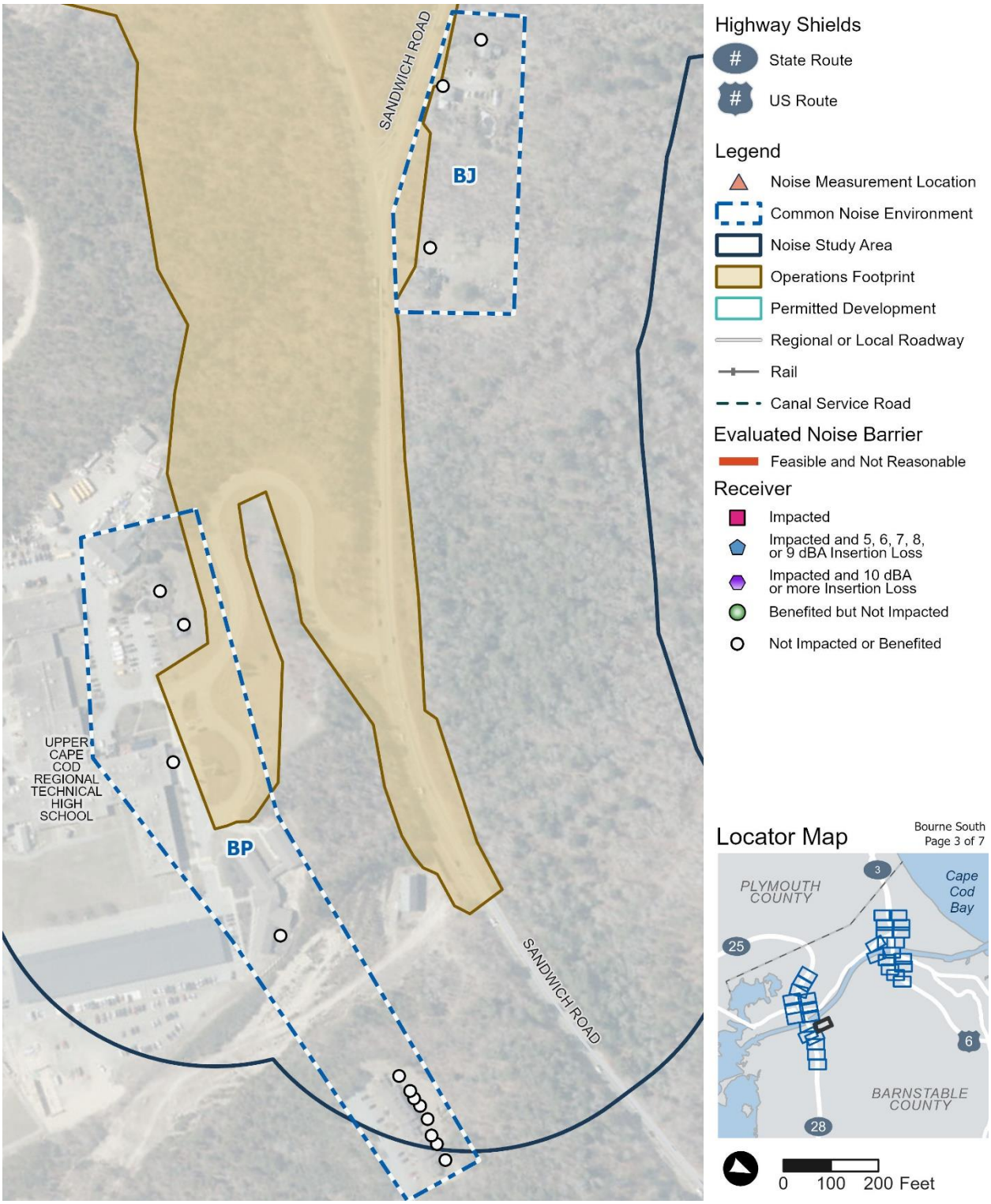
Source: Massachusetts Department of Transportation, 2024

Figure 4.14-8b. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Bourne South Quadrant)



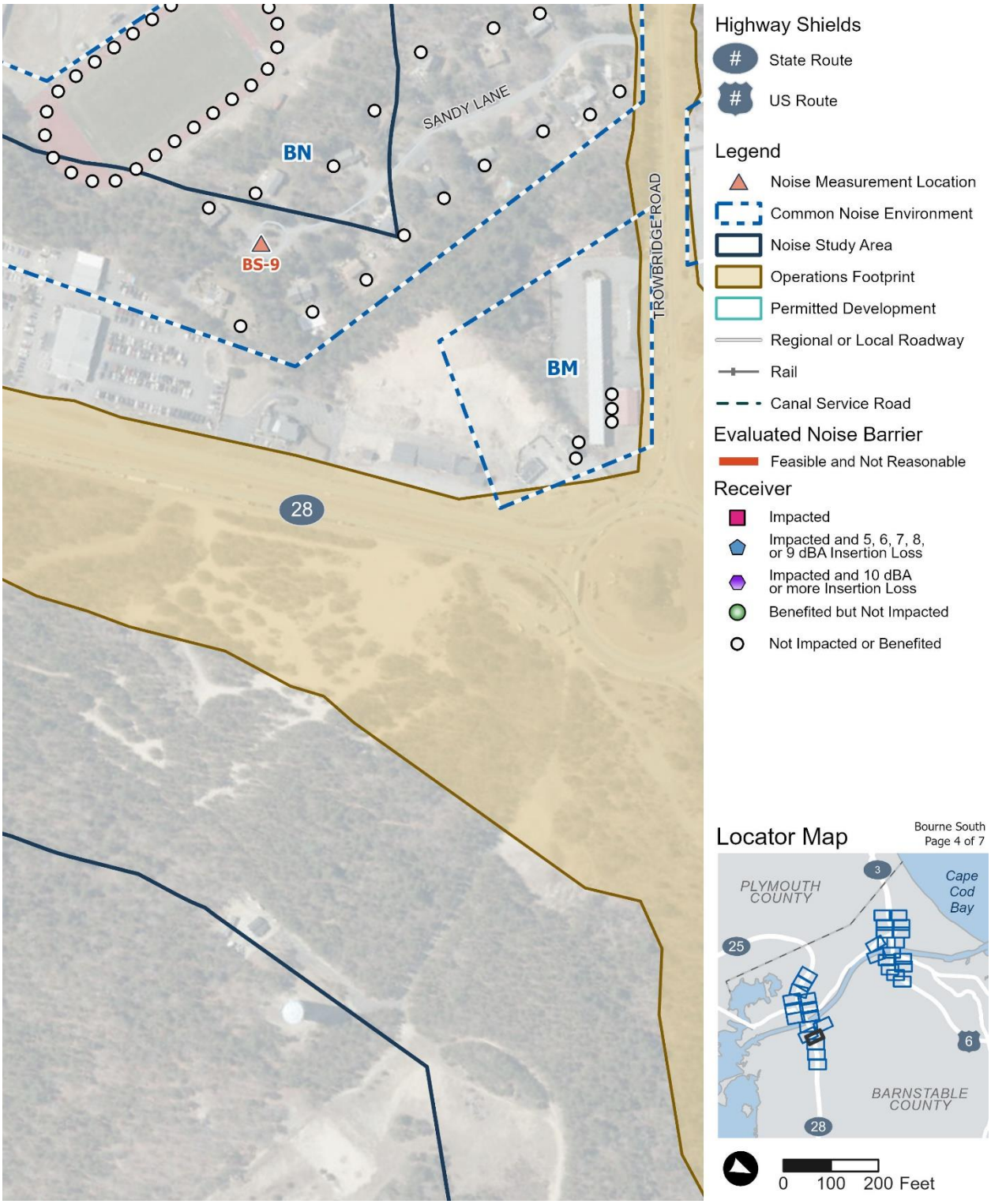
Source: Massachusetts Department of Transportation, 2024

Figure 4.14-8c. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Bourne South Quadrant)



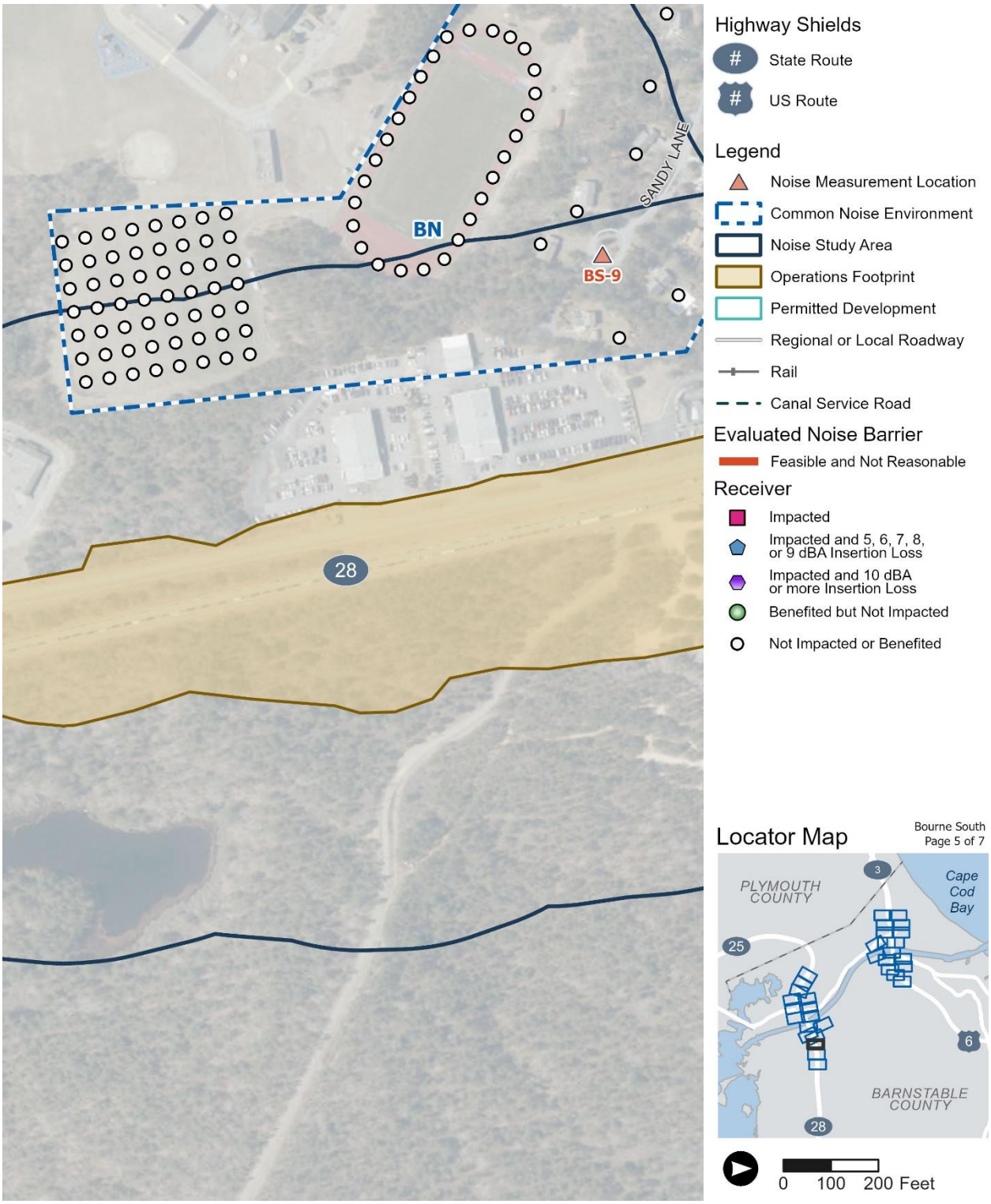
Source: Massachusetts Department of Transportation, 2024

Figure 4.14-8d. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Bourne South Quadrant)



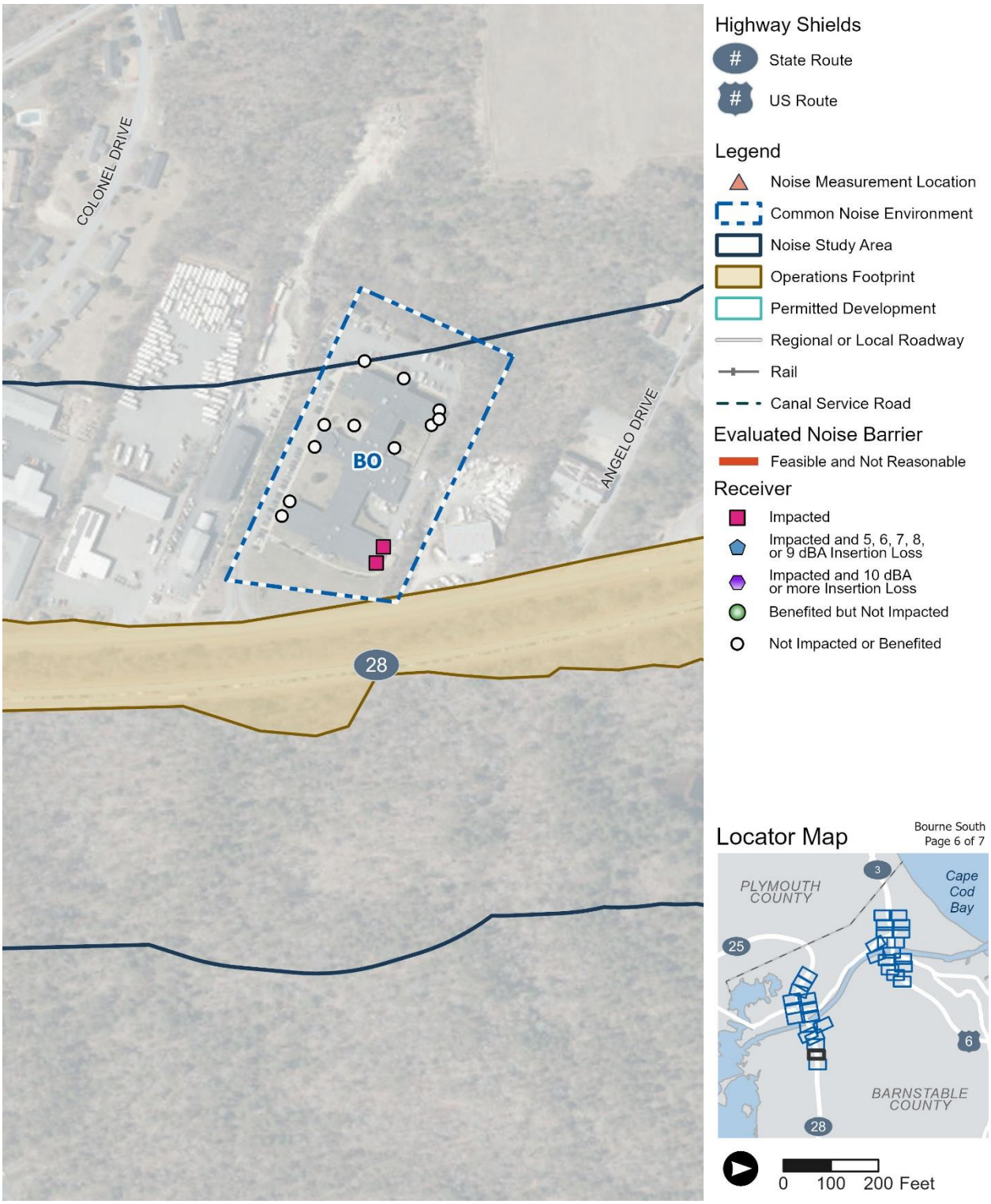
Source: Massachusetts Department of Transportation, 2024

Figure 4.14-8e. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Bourne South Quadrant)



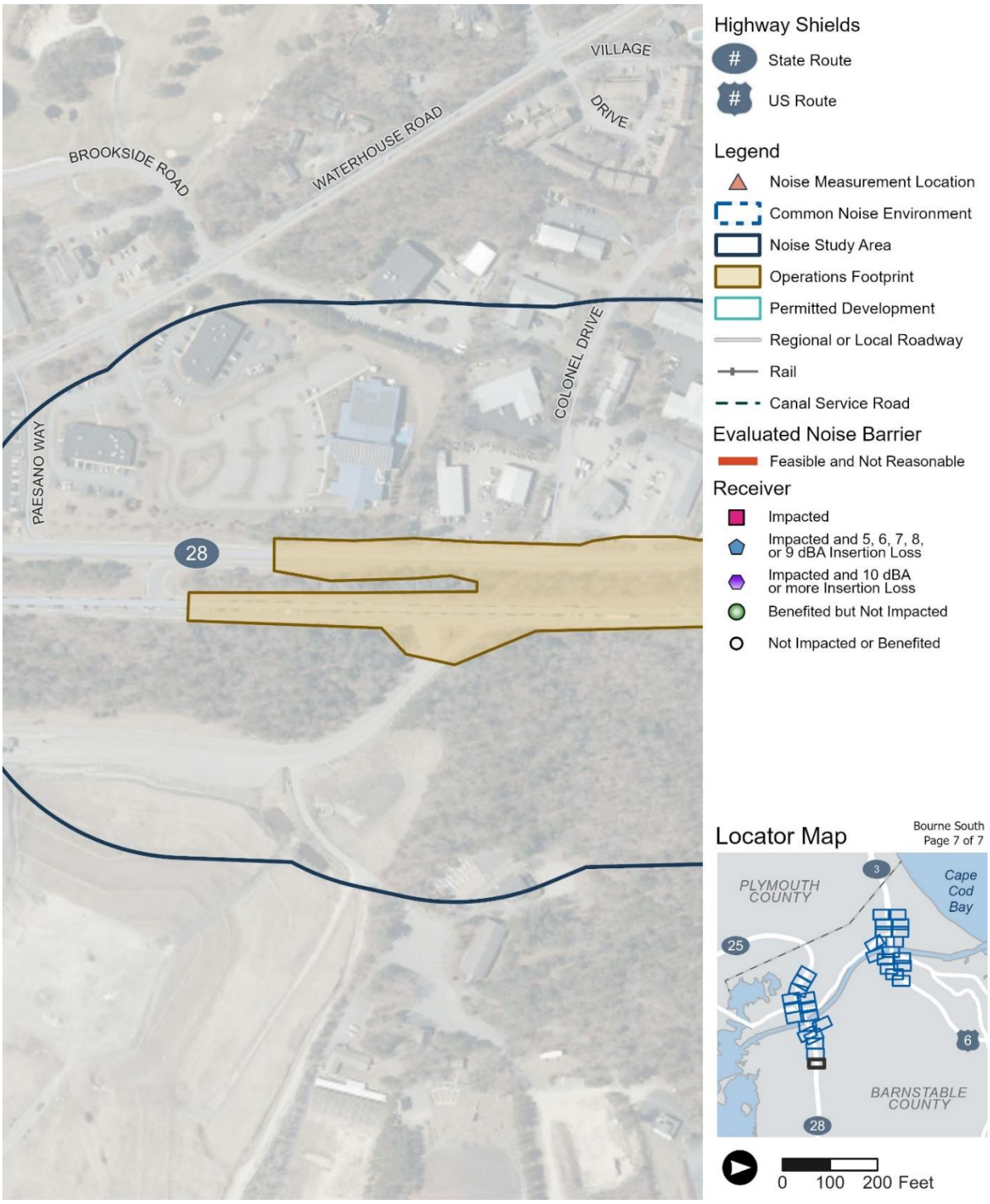
Source: Massachusetts Department of Transportation, 2024

Figure 4.14-8f. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Bourne South Quadrant)



Source: Massachusetts Department of Transportation, 2024

Figure 4.14-8g. Build Alternative: Locations for Barriers, Common Noise Environments, and Receptors (Bourne South Quadrant)



Source: Massachusetts Department of Transportation, 2024

Note: Due to the large Operations Footprint, maps are provided in segments. This segment contains no common noise environments, barriers, or receptors, but is included for completeness.

4.14.4.2 Construction Noise Effects

Construction of the Build Alternative would result in intermittent fluctuations in noise levels due to the following:

- Construction vehicle operations and construction equipment performing earth disturbing work
- Bridge demolition and construction
- Roadway reconstruction

Noise levels from construction would depend on the following:

- Types and number of equipment used
- Condition of equipment
- Type of construction activity being performed
- Construction schedule
- Proximity of operating construction equipment to noise-sensitive receptors

Table 4.14-14 provides a list of common construction equipment and their maximum noise levels at a reference distance of 50 feet. This equipment list is included in the FHWA's Roadway Construction Noise Model (version 1.1) construction equipment database.[11]

Table 4.14-14. Federal Highway Administration Roadway Construction Noise Model Equipment Noise Emissions Database

Equipment Description	Impact Device?	Acoustical Usage Factor (%)[a]	Spec. Lmax at 50 feet[b]	Measured Lmax at 50 feet[b]
All Other Equipment > 5 HP	No	50%	85	NA
Auger Drill Rig	No	20%	85	84
Backhoe	No	40%	80	78
Bar Bender	No	20%	80	NA
Blasting	Yes	NA	94	NA
Boring Jack Power Unit	No	50%	80	83
Chain Saw	No	20%	85	84
Clam Shovel (dropping)	Yes	20%	93	87
Compactor (ground)	No	20%	80	83
Compressor (air)	No	40%	80	78
Concrete Batch Plant	No	15%	83	NA

[11] https://www.fhwa.dot.gov/environment/noise/construction_noise/rcnm/

Equipment Description	Impact Device?	Acoustical Usage Factor (%)[a]	Spec. Lmax at 50 feet[b]	Measured Lmax at 50 feet[b]
Concrete Mixer Truck	No	40%	85	79
Concrete Pump Truck	No	20%	82	81
Concrete Saw	No	20%	90	90
Crane	No	16%	85	81
Dozer	No	40%	85	82
Drill Rig Truck	No	20%	84	79
Drum Mixer	No	50%	80	80
Dump Truck	No	40%	84	76
Excavator	No	40%	85	81
Flat Bed Truck	No	40%	84	74
Front End Loader	No	40%	80	79
Generator	No	50%	82	81
Generator (<25KVA, VMS signs)	No	50%	70	73
Gradall	No	40%	85	83
Grader	No	40%	85	NA
Grapple (on backhoe)	No	40%	85	87
Horizontal Boring Hydr. Jack	No	25%	80	82
Hydra Break Ram	Yes	10%	90	NA
Impact Pile Driver	Yes	20%	95	101
Jackhammer	Yes	20%	85	89
Man Lift	No	20%	85	75
Mounted Impact hammer (hoe ram)	Yes	20%	90	90
Pavement Scarafier	No	20%	85	90
Paver	No	50%	85	77
Pickup Truck	No	40%	55	75
Pneumatic Tools	No	50%	85	85
Pumps	No	50%	77	81
Refrigerator Unit	No	100%	82	73

Equipment Description	Impact Device?	Acoustical Usage Factor (%)[a]	Spec. Lmax at 50 feet[b]	Measured Lmax at 50 feet[b]
Rivit Buster/chipping gun	Yes	20%	85	79
Rock Drill	No	20%	85	81
Roller	No	20%	85	80
Sand Blasting (Single Nozzle)	No	20%	85	96
Scraper	No	40%	85	84
Shears (on backhoe)	No	40%	85	96
Slurry Plant	No	100%	78	78
Slurry Trenching Machine	No	50%	82	80
Soil Mix Drill Rig	No	50%	80	NA
Tractor	No	40%	84	NA
Vacuum Excavator (Vac-truck)	No	40%	85	85
Vacuum Street Sweeper	No	10%	80	82
Ventilation Fan	No	100%	85	79
Vibrating Hopper	No	50%	85	87
Vibratory Concrete Mixer	No	20%	80	80
Vibratory Pile Driver	No	20%	95	101
Warning Horn	No	5%	85	83
Welder/Torch	No	40%	73	74

Source: FHWA Roadway Construction Noise Model (version 1.1) User's Guide, January 2006.

[a] The acoustical usage factor is the percentage of time a piece pf equipment is operating at full power during a construction operation.

[b] "Spec" refers to noise levels provided in the manufacturer's specifications, while "measured" refers to noise levels measured at 50 feet from the equipment as part of the Central Artery Tunnel Project in Boston, Massachusetts.

The noisiest construction activities would generally be associated with existing bridge demolition and construction of new bridge piers, which may require saw cutting and/or hoe ramming to demolish the existing bridge and drilling and/or pile driving for pier construction. Saw cutting and hoe ramming could produce maximum noise levels of approximately 90 dBA at 50 feet, while drilling and/or pile driving of new bridge piers could produce maximum noise levels ranging between 84 and 101 dBA at 50 feet. Construction of interchange approaches and roadways would require site preparation and grading, potentially necessitating backhoes, excavators, dozers, graders, and dump trucks. Maximum noise levels associated with these pieces of equipment may range between 77 and 85 dBA at 50 feet.

Roadway construction would also require pavers, rollers, and dump trucks, with maximum noise levels generally ranging between 77 and 80 dBA.

4.14.4.3 Construction Vibration Effects

During construction, the highest vibration levels would result from pile driving. Pile driving is typically required during bridge construction to install bridge piers and support excavation. Assuming most buildings proximate to proposed construction activities would be non-engineered timber and masonry buildings, structural damage has the potential to occur for these types of structures if they are within approximately 72 feet of impact pile driving and approximately 21 feet of vibratory pile driving. When pile driving occurs beyond these distances, there would be no potential for structural damage to non-engineered timber and masonry buildings. The potential for structural damage to non-engineered timber and masonry structures from auger drilling, hoe ramming, and use of large bulldozers would occur within approximately 11 feet of these activities/pieces of equipment.

Construction-induced vibration is typically considered "infrequent" in nature. Therefore, MassDOT used the applicable annoyance threshold of 80 dBA for FTA Land Use Category 2 to evaluate potential vibration annoyance at nearby residences. The applicable annoyance threshold of 83 dBA for FTA Land Use Category 3 was used to evaluate potential vibration annoyance at nearby institutional land uses (e.g., schools). Based on the annoyance assessment prescribed within the FTA manual, should an impact pile driver be used, the annoyance threshold would be exceeded at any residential (FTA Land Use Category 2) structures within 157 feet and any institutional structures within 125 feet. Should a vibratory pile driver be used, the distance within which residences and institutional land uses would potentially experience vibration-induced annoyance would be reduced to 67 feet and 53 feet, respectively.

During construction activities that would require auger drilling, hoe ramming, and use of large bulldozers, the annoyance threshold would be exceeded at any residential (FTA Land Use Category 2) structures within 42 feet and at any institutional structures within 33 feet. Loaded trucks would cause vibration-induced annoyance when driving within 39 feet of residences and 31 feet of institutional uses.

While these distances offer some guidance on vibration exposure based on receptor to source activity distances, other factors also influence ground-borne vibration effects, including subsurface conditions, vibration frequency, contractor means/methods etc. MassDOT's Contract Specification will include provisions for pre-construction surveys, vibration monitoring, adherence to vibration limit thresholds, and equipment restrictions, as necessary. **Section 4.14.5.3** provides additional information on construction vibration mitigation measures.

4.14.5 Mitigation

4.14.5.1 Operational Traffic Noise Effects

As required by FHWA and MassDOT's highway traffic noise assessment policy, noise abatement was considered for noise-sensitive receivers that were predicted to be impacted by highway traffic noise for the 2050 Build Alternative. **Table 4.14-15** summarizes the noise barrier evaluation results by Study Area quadrant and CNE. **Figure 4.14-5c** and **Figure 4.14-5e (Barrier SB)**, **Figure 4.14-6a** and **Figure 4.14-6d (Barrier SJ)**, **Figure 4.14-6f** and **Figure 4.14-6g (Barrier SK)**, and **Figure 4.14-7g (Barrier BF)** illustrate the locations of all modeled and evaluated noise barriers.

Table 4.14-15. Noise Barrier Evaluation Summary Table

Noise Barrier ID and Location	Barrier SB Sagamore North Quadrant	Barrier SJ Sagamore South Quadrant	Barrier SK Sagamore South Quadrant	Barrier BF Bourne North Quadrant
Average Noise Reduction (dBA)	7	11	7	10
Length (feet)	1,072	380	1,200	442
Height (feet)	25	15	25	15
Surface Area (square feet)	23,821	5,704	29,994	6,626
Total Cost[a]	$1,429,260	$342,240	$1,799,640	$397,560
Number of Impacted and Benefited Receptors[b]	3	20	4	1
Number of Not Impacted and Benefited Receptors	17	0	5	0
Total Benefited	20	20	9	1
Cost Effectiveness Index[c]	$11,489	$1,596	$29,026	$41,848
Barrier Status	Feasible and Not Reasonable	Feasible and Not Reasonable[d]	Feasible and Not Reasonable	Feasible and Not Reasonable

[a] Total cost calculated based on a unit cost of $60 per square foot, in accordance with MassDOT's 2021 cost update, submitted to FHWA, pursuant to 23 Code of Federal Regulations 772.13(d)(2)(ii).

[b] A benefited receptor is a receptor in the Noise Study Area that attains at least a 5 decibel (dB) noise reduction or greater with a noise abatement measure. A benefited receptor does not have to be an impacted receptor.

[c] An index that is based on cost, the average noise level reduction provided by a noise barrier, and the number of receptors that achieve a 5 dB or more reduction in noise levels. The Cost-Effectiveness Index is one of several criteria used to determine the reasonableness[12] of noise abatement.

[d] Barrier SJ was determined to be not reasonable based on the combination of environmental impacts this abatement measure would impose on the Canal View Apartments, which is eligible for listing on the National Register of Historic Places.

One noise barrier (Barrier SJ), at the Canal View Apartments within the Sagamore South quadrant was determined to meet MassDOT's acoustic feasibility criterion as well as the Noise Reduction Design Goal and Cost Effectiveness Index. The Canal View Apartments (South Sagamore Area) is eligible for listing on the National Register of Historic Places. A noise barrier approximately 380 feet in length was analyzed for 20 impacted residential dwelling units (FHWA Activity Category B). The noise barrier was modeled along the eastbound edge of pavement on Sandwich Road at various uniform heights ranging from a minimum height of 10 feet to a maximum height of 25 feet. At a height of 15 feet, the modeled noise barrier would provide a 5 dBA reduction (benefit) to all 20 impacted first-row residential dwelling units and would reduce noise levels by 10 dB at 18 first-row residential dwelling units, thereby achieving MassDOT's acoustic feasibility goal and noise reduction design goal, respectively. The barrier would also achieve a weighted average insertion loss of approximately 11 dBA and would benefit 20 residential dwelling units. Using MassDOT's 2021 updated unit cost of $60 per square foot, the total barrier cost would be $342,240, yielding a Cost Effectiveness Index of $1,596, which would be below MassDOT's 2021 updated Cost Effectiveness Index of $10,080 per decibel of noise reduction (insertion loss) per residential dwelling unit benefited.

23 CFR 772.5 defines reasonableness, specific to noise abatement, as "The combination of social, economic, and environmental factors considered in the evaluation of a noise abatement measure." Given the Canal View Apartments eligibility for listing on the National Register of Historic Places, the installation of a noise barrier at location CNE SJ would likely result in an Adverse Effect under Section 106 of the National Historic Preservation Act, necessitating Individual evaluation under Section 4(f) of the U.S. Department of Transportation Act for the "use" of a historic resource. The installation of a noise barrier at this location would also require the removal of 10 or more mature shade trees that currently provide the only buffer between the apartments and Sandwich Road. MassDOT recognizes the environmental and aesthetic benefits provided by these shade trees. Further, a noise barrier would be a visual obstruction for some residents of the Canal View Apartments and impede views of the Cape Cod Canal, which is a defining attribute of the property. In consideration of this location's existing noise level range (54–68 dBA) and the 2050 Build Alternative noise level range (56–67 dBA), the likely adverse effect to and use of a historic property under Section 106 and Section 4(f), and the environmental conditions described above, MassDOT has determined construction of noise barrier SJ is not reasonable due to environmental impacts.

[12] The combination of social, economic, and acoustical factors considered in the evaluation of proposed noise abatement measures. Reasonableness implies that good judgment and common sense have been applied in arriving at a decision on the construction or installation of proposed noise abatement measures.

Appendix 4.14, Noise and Vibration Technical Report, provides further details regarding additional noise barriers that were evaluated as part of this noise analysis and other areas of impact where noise barriers were not evaluated due to engineering constraints.

4.14.5.2 Construction Noise Effects

MassDOT will include special provisions for noise control during construction. The special provision will require the contractor to submit a Noise Control Plan for approval by MassDOT prior to commencement of construction. The Noise Control Plan will describe the procedure for predicting construction noise levels prior to performing construction activities, including identification of noise reduction measures required to meet the noise level limitations and minimize nuisance noise conditions. An acoustical engineer will develop the Noise Control Plan, which the contractor will employ.

MassDOT will implement the following additional measures to minimize the impacts of construction noise on noise-sensitive receptors:

- For work near residential neighborhoods, schedule the loudest construction activities during daytime hours near residential neighborhoods
- Ensure that all construction equipment is in good working order and equipped with mufflers and other noise reducing features
- Limit the frequency and duration of equipment idling on the construction sites
- Conduct noise monitoring to document compliance with recommended construction noise limits outlined in the Noise Control Plan. Measured noise levels that exceed or approach construction noise limits in the Noise Control Plan will implement corrective action in coordination with local communities
- Route construction-related truck traffic along roads that would cause the least disturbance to residents
- Use noise control measures such as temporary noise barriers/curtain systems and portable enclosures for small equipment (i.e., jackhammers and concrete saws), where feasible
- Implement an active and responsive public outreach program during construction to coordinate construction activities and schedules and work with local communities to address concerns

4.14.5.3 Construction Vibration Effects

MassDOT's contract specifications will include special provisions for vibration control during construction. The special provision will require the contractor to submit a Vibration Control and Mitigation Plan for approval by MassDOT prior to commencement of construction. The Vibration Control and Mitigation Plan will describe the procedure for predicting vibration levels prior to performing construction activities, will provide results of a pre-construction buildings survey (identifying structures of concern), will identify vibration reduction measures required to meet established vibration limits set forth to preclude structural damage and minimize vibration-induced

annoyance, and will provide a third-party compliance monitoring plan. An acoustical engineer or vibration specialist will develop the Vibration Control and Mitigation Plan, which the contractor will employ.

MassDOT will implement the following additional measures to minimize the impacts of construction vibration:

- Establish construction vibration structural damage response action and stop-work levels.
- Sequence operations to reduce total vibration levels by separating significant vibration-inducing activities.
- Limit vibration-inducing activities to daytime hours, where feasible.
- Require selection of alternative means and methods, where conditions permit.